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HARVARD UNIVERSITY
DEPARTMENT OF
GEOLOGY AND GEOGRAPHY

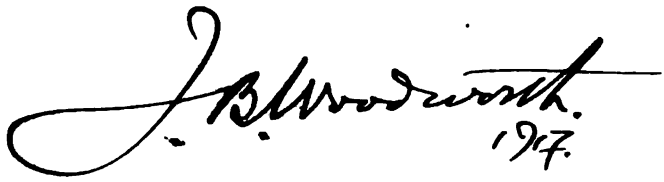



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# REPORT

ON THE

# GEOLOGY,

# MINERALOGY, BOTANY, AND ZOOLOGY

OF

# Massachusetts.

MADE AND PUBLISHED BY ORDER OF THE GOVERNMENT OF THAT STATE:

IN FOUR PARTS:

PART I. ECONOMICAL GEOLOGY.
PART II. TOPOGRAPHICAL GEOLOGY.
PART III. SCIENTIFIC GEOLOGY.
PART IV. CATALOGUES OF ANIMALS AND PLANTS.

WITH A DESCRIPTIVE LIST OF THE SPECIMENS OF ROCKS AND MINERALS COLLECTED FOR THE GOVERNMENT.

ILLUSTRATED BY NUMEROUS WOOD CUTS AND AN ATLAS OF PLATES.

BY EDWARD HITCHCOCK,
Professor of Chemistry and Natural History in Amherst College.

AMHERST:
PRESS OF J. S. AND C. ADAMS.
1833.

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# INTRODUCTORY OR HISTORICAL NOTE.

On the 3d of March 1830 the Legislature of Massachusetts passed a Resolve, authorizing and requesting the Governor with the advice of the Council, "to appoint a Surveyor well skilled in astronomy and in the art of surveying upon trigonometrical principles—to make a general Survey of the Commonwealth, and from such astronomical observations and calculations as may be made, to project an accurate skeleton plan of the State, which shall exhibit the external lines thereof and the most prominent objects within those lines and their locations."

In Governor Lincoln's Message to the Legislature May 29th, 1830, we find the following recomendation.

"I beg leave to suggest to your consideration the utility of connecting with the Geographical Surveys, an examination of the geological features of the State, with a view to the exhibition of them on the map. Much knowledge of the natural history of the country would thus be gained, and especially the presence of valuable ores, with the localities and extent of quarries, and of coal and lime formations, objects of enquiry so essential to internal improvements, and the advancement of domestic prosperity, would be discovered, and the possession and advantages of them given to the public. I am assured that much has already been gratuitously done, by some eminent professors in our colleges, towards the accomplishment of such a work, and that, at a little expense, it might be completed, and the fruits of their generous labors thus far, be secured to the State. This, however, will require the interposition of your authority in increasing the present appropriation, and permitting an application of it, so far as may be necessary, in the exercise of a sound discretion, to the end proposed."

In conformity with these suggestions, the Legislature, on the 5th of June, 1830, "*Resolved*, That his Excellency the Governor, by and with

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the advice of the council, be, and he is hereby authorized to appoint some suitable person, to make a geological examination of the Commonwealth, in connection with the general survey, in order that the same may be inserted on the map which may be published, &c."

On the 26th of June 1830, Governor Lincoln issued a Commission to the author of the following Report, directing him "to make the geological examination of this Commonwealth, in the manner contemplated by said Resolve, performing such duties relating thereto, as are or may be enjoined upon you; and obeying such instructions as, from time to time, you may receive from the proper authority."

February 2d 1831, the Legislature still further authorized His Excellency the Governor, "to direct the person who is appointed to make a Geological Survey of the Commonwealth, to cause to be annexed to his report on that subject, a list of the native Mineralogical, Botanical and Zoological productions of the Commonwealth, so far as it may be practicable to ascertain the same within the limits of the appropriation already made for this Survey."

The first part of the following Report with the Geological Map, having been presented to the Government in the beginning of the year 1832, it was ordered to be printed: and on the 24th of March 1832, the Legislature "*Resolved*, that the 600 copies of the first part of the Report on the Geological Survey of the Commonwealth, provided in pursuance of an arrangement made by his Excellency the Governor with the advice of Council, for the use of Goverment, be delivered to the Secretary of the Commonwealth, and by him be distibuted, as follows, viz.

Four copies to the Governor;

Two copies to the Lieut. Governor;

One copy to each member of the Council;

One copy to each member of the Senate and House of Representatives;

Five copies to be deposited in the Library of the State;

And that the remaining copies be distributed as His Excellency the Governor may direct."

In the early part of 1833, the remaining parts of the following Report were submitted in an unfinished state to the examination of the Committee on Education. Notwithstanding their imperfect state, however, the Legislature on the 25th of Febuary adopted the following very liberal Resolves.

"*Resolved*, that his Excellency the Governor, be, and hereby is

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authorized to cause twelve hundred copies of the Report on the Geological Survey of the Commonwealth; including that part of the Report already made, as well as the part hereafter to be made, with the drawings which shall accompany said Report, to be published in such way and manner as he shall deem proper and expedient: and he is authorized with the advice and consent of Council, to draw his warrant upon the Treasurer of the Commonwealth for such sum, or sums as may be necessary to carry this resolve into full effect."

"*Resolved*, that the said twelve hundred copies, when published, shall be delivered to the Secretary of the Commonwealth, to be distributed in the following manner, Viz:

Twelve copies to the Governor;

Six copies to the Lieut. Governor;

One copy to each member of the Council, Senate and House of Representatives;

One copy each to the Secretary, Treasurer, and to each of the Clerks and Chaplains of the two Houses;

One copy to each town in the Commonwealth;

Five copies to be deposited in the Library of the State;

Two copies each to Harvard, Amherst and Williams Colleges;

One copy each to the Theological Seminaries at Andover and Newton;

One copy to each incorporated Academy in the Commonwealth;

One copy each to the Boston and Salem Atheneums;

One copy to the American Academy of Arts and Sciences;

One copy to the Antiquarian Society at Worcester;

One copy to the Massachusetts Historical Society;

One copy to the Boston Society of Natural History;

Twenty copies to the Geological surveyor; and

One copy to each person who shall have aided him in preparing the Catalogues appended to the Report;

Two copies to the Library of the United States;

One copy to the Executive of each State in the Union,

And the remaining copies to be disposed of in such a manner as His Excellency the Governor shall direct."

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# CONTENTS.

## PART I. ECONOMICAL GEOLOGY.


Explanatory Remarks, - - - - - - - - page 1
Divisions of the Report, - - - - - - - - - 3
Nature of Soils, - - - - - - - - - - 4
Aluvium considered in an agricultural point of view. - 5
Diluvium, - - - - Do. - - - - - - 6
Tertiary formations, - - Do. - - - - - - 7
New Red Sandstone, - Do. - - - - - - 8
Argillaceous Slate and Graywacke, Do. - - - - - 9
Iron Ore, Steatite, Serpentine Limestone, &c, Do. - - 10
Quartz Rock, Talcose Slate, Mica Slate, Gneiss &c, Do. - 11
Greenstone and Porphyry, Do. - - - - - - 12
Sienite and granite, - Do. - - - - - - 13


### USEFUL ROCKS AND MINERALS IN THE STATE.


Granite and Sienite, - - - - - - - - - 13
Gneiss, - - - - - - - - - - - - 18
Greenstone, Hornblende Slate and Porphyry, - - 20
Quartz Rock, - - - - - - - - - - 22
Mica Slate, Talcose Slate and Limestone, - - - 23
Recent discovery of Limestone in Bernardston, - - - 27
Berkshire Marble, - - - - - - - - - 28
Serpentine, - - - - - - - - - - 29
Steatite or Soapstone, - - - - - - - - 31
Graywacke, - - - - - - - - - 33
Argillaceous Slate, Novaculite, Roof Slate, - - - 34
Graphic Slate, New Red Sandstone, - - - - - 35
Porcelain Clay, - - - - - - - - - 36
Potter's Clay, - - - - - - - - - - 37
Clay used as Fuller's Earth, for the manufacture of Alum, and for Manure: Marl, - - - - - - - - - 38
Peat, - - - - - - - - - - - 39
Granular Quartz used for the Manufacture of Glass, - - 40
Buhrstone in Washington, - - - - - - - 41
Coal: Lignite, Bituminous Coal, and Anthracite, - - 42
Graphite, or Black Lead, - - - - - - - - 47


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Substitute for Emery: Tripoli or Rotten Stone: Native Alum, 48
Mineral Waters: Sulphate of Baryta, - - - - - 49
Lithia, Chalcedony, Agates, Jasper, Beryls, and Cinnamon Stone, 50

METALS AND THEIR ORES.

Iron, - - - - - - - - - - - - - 51
Do. in Worcester, and in Sterling with Zinc: Chromate of Iron in Cummington and Blanford, - - - - - - - - 52
Iron in Hopkinton, in Hubbardston, and Hawley, - - - 53
Do. in Bernardston, Somerset, Vt. and Winchester, N. H. and Cumberland, R. I. - - - - - - - - - 54
Do. in Montague and Malden: Hydrate of Iron, - - - - 55
Brown Oxide of Iron in Lenox, Richmond, West Stockbridge, Salisbury, Ct. Bennington, Vt. and Cranston, R. I. - - 56
Bog Ore, - - - - - - - - - - - - 57
Ochres, &c. Lead, in Southampton, - - - - - - - 58
Lead in Northampton, - - - - - - - 59
Do. in West Hampton, Williamsburg, Goshen, and Whately, 60
Do. in Hatfield and Leverett, - - - - - - - - 61
Copper in Greenfield, - - - - - - - - - 62
Zinc: Manganese in Plainfield, - - - - - 63
Manganese in Conway, Hindsdale, and Winchester, N. H.: Tin, 64
Silver: *Gold* in Somerset, Vt. - - - - - 65
*Idle Search* after Gold and Silver, - - - - - 68
Foolish Superstitions, - - - - - - - 70
Concluding Remarks, - - - - - - - - 71

## PART II. TOPOGRAPHICAL GEOLOGY.

Connection between Geology and Scenery, - - - - 73
Saddle Mountain, - - - - - - - - - - - 74
Mount Washington, - - - - - - - - - - 76
Monument Mountain, Alum Hill, and other elevated spots, 77
Mount Holyoke, - - - - - - - - - - 78
The Columns, - - - - - - - - - 80
Titan's Pier: Mount Tom, - - - - - - 81
Sugar Loaf Mountain: Deerfield Mountain, - - - 82
Mount Toby, - - - - - - - - - 83
Wachusett: Blue Hills, - - - - - - - 84
Heights of various Elevations in the eastern part of the State, 85
Vallies of Berkshire, - - - - - - - - - 87
Valley of the Connecticut, - - - - - - - - 88
Ravine of Westfield River, - - - - - - - - 89
Ravine and Gorge of Deerfield River, - - - - - 90
Valley of Worcester, - - - - - - - - - 91
Valley of the Merrimack: Boston Harbor: View from the State House, - - - - - - - - - 92
New Bedford: Narraganset Bay, - - - - - 94

Digitized by Google

Nahant: Cape Ann, - - - - - 95
Nantucket Beach: Cape Cod, - - - - 96
Nantucket and Martha's Vineyard, - - - 98
Gay Head: - - - - - - 99
South Hadley Falls: Shelburne Falls, - - - 101
Spicket Falls: Falls in Fall River: Pawtucket Falls: The Gorge, alias the Glen, - - - - - - 102
Cascade in Leverett: do. and Natural Bridge, &c. on Hudson's Brook, - - - - - - - 103
Canaan Falls: Southampton Adit: Sunderland Cave and Fissure, 104
Caverns in Berkshire, - - - - - 105
Purgatories, - - - - - - - 106
Autumnal Scenery, - - - - - 107
Sketches of Scenery in Massachusetts, - - - 108

## PART III. SCIENTIFIC GEOLOGY.

Preliminary Remarks, - - - - - 111
Names and Classification of Rocks, - - - 112
Additional Explanations of the Map, - - - 113

### STRATIFIED ROCKS.

Alluvium defined, - - - - - - 114
Alluvium of Rivers, - - - - - 115
Coast Alluvium: Salt Marsh Alluvium, - - - 116
Submarine Forests, - - - - - 117
Peat; its origin, - - - - - - 118
Marl: Alluvium of Disintegration, - - - 120
Curious Inscription: Alluvium of Degradation, - - 121
Bog Ore; its mode of Production, - - - 122
Oxide of Manganese; an alluvial deposit, - - - 123
Power of Ice in removing bowlders: Encroachments of the sea upon the coast, - - - - - - 124
Boston Harbor, how produced, - - - - 125
Gain of the Land upon the Sea, - - - - 128
Dunes or Downs, - - - - - - 130
Valleys of Massachusetts: how formed, - - - 131
Terraced Valleys, - - - - - - 134
Change in the bed of Green River, - - - - - 136
Ice Floods, - - - - - - - 139
Valleys of Denudation or Excavation, - - - 140
Diluvium defined, - - - - - 141
Its situation and Extent in Massachusetts, - - - 142
Bowlders, - - - - - - 145
Consolidated Diluvium, - - - - - 150
First Proof of a southerly movement in our diluvium, - - 152
Peculiarities in the Diluvium of Berkshire County, - - 156
Second Proof (diluvial grooves,) of a southerly current, - 159

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Fluvial Hypothesis, - - - - - - 164
Epoch of the last Deluge, - - - - - - 165
Diluvial agency in other parts of the world, - - - 166
Mounds in the Western States, - - - - - - - 168
Stratification of Diluvium, - - - - - - - 169
Minerals and Organic Remains in Diluvium, - - - - 171
TERTIARY FORMATIONS defined, - - - - - 172
The Most Recent Tertiary, - - - - - - - 173
Remarkable Disturbances in its Strata, - - - - 174
Position and Thickness of its Strata, - - - - - 175
Mineral Contents, - - - - - - - - 178
Organic Remains, - - - - - - - - - 182
Theoretical Considerations, - - - - - - 183
Plastic Clay; Its Mineralogical Characters, - - - - 184
Mineral Contents, - - - - - - - - - 188
Organic Remains, - - - - - - - - - 191
Dip, Direction and Superposition of the Strata, - - 196
Plastic Clay in Truro and Duxbury, - - - - 199
Theoretical Considerations, - - - - - - 202
Supposed Volcanic Agency at Gay Head; Geological Speculations of the Aborigines, - - - - - - - 203
RAW RED SANDSTONE: Proofs of its existence in the Connecticut Valley, - - - - - - - - - 206
Mineralogical Characters of this Rock, - - - - 209
Topography of this Formation, - - - - - - 216
Dip, Direction and Thickness of the Strata, - - - - 219
Mineral Contents, - - - - - - - - 225
Organic Remains, - - - - - - - - - 232
Theoretical Considerations, - - - - - - 241
GRAYWACKE: Whether identical with that in Europe, - - 248
Mineralogical Characters, - - - - - - - 251
Topography of Graywacke, - - - - - - - 268
Dip, Direction and Thickness of the Strata, - - - - 271
Mineral Contents: Anthracite, - - - - - - 275
Organic Remains, - - - - - - - - - 284
Theoretical Considerations, - - - - - - - 285
ARGILLACEOUS SLATE: Its definition and classification, - - 286
Mineralogical Characters, - - - - - - - 287
Its Topography - - - - - - - - - 288
Dip, Direction and Thickness of the Strata, - - - 289
Mineral Contents: Disturbances in its Strata, - - - 291
Theoretical Considerations. - - - - - - - 294
LIMESTONE: Encrinal Limestone of Bernardston, - - 295
Berkshire Limestone: Discussion concerning its position and age, 297
Blanford Limestone: Micaceous Limestone, - - - 305
Limestone in Whitingham, Vt. in Bolton, Boxborough, Littleton, Acton, Carlisle, and Chelmsford, - - - - 308
Limestone in Smithfield, R. I. - - - - - 311



Digitized by Google

Limestone in Stoneham and Newbury, - - - 312
Origin of Limestone, - - - - - - 313
Scapolite Rock: Mineralogical Characters, - - - 314
Quartz Rock: Order of superposition in the older rocks, 316
Mineralogical Characters of Quartz Rock, - - 317
Its Topography, - - - - - - - 320
Dip, Direction, and Character of the Strata, - - 322
Mineral Contents, - - - - - - - 323
Theory of Quartz Rock, - - - - - 324
Mica Slate: Mineralogical Characters, - - - 327
Its Topography, - - - - - - - 331
Its Stratification, with the Dip and Direction of the Strata, 337
Veins of Segregation in Mica Slate, - - - 341
Mineral Contents, - - - - - - 342
Theory of Mica Slate, - - - - - - 349
Talcose Slate: Its Definition, - - - - 352
Mineralogical Characters, - - - - - 353
Its Topography, - - - - - - 355
Dip, Direction, and Character of the Strata, - - 358
Mineral Contents, - - - - - - - 359
Theory of Talcose Slate, - - - - - 364
Serpentine: Mineralogical Characters, - - - 365
Topography, Stratification, and Associated Rocks, - - 366
Mineral Contents, - - - - - - - 371
Theory of Serpentine, - - - - - - 372
Hornblende Slate: Dr. Macculloch's Views, - - 373
Its Mineralogical Characters, - - - - - 374
Its Topography, - - - - - - - 377
Dip, Direction, &c. of the Strata, - - - - 380
Mineral Contents: Theory of Hornblende Slate, - - 381
Gneiss: How distinguished from Granite, - - - 382
Its Mineralogical Characters, - - - - 383
Its Topography, - - - - - - - 385
Its Stratification: Dip and Direction of the Strata, - - 390
Mineral Contents, - - - - - - - 395
Theory of Gneiss, - - - - - - 400

## UNSTRATIFIED ROCKS.

Modes in which they occur and their theory, - - - 403
Manner of representing them on the Map, - - - - 404
Greenstone: Its Definition, &c. - - - - - - - 404
Its Mineralogical Characters, - - - - - - - 405
Its Topography, - - - - - - - - - 412
Relative Position of the Greenstone of Massachusetts, - - 417
Veins of Greenstone, - - - - - - - - 425
Chemical effects of Greenstone upon other rocks, - - 429
Mineral Contents, - - - - - - - - 433

Digitized by Google

Lincolnite, - - - - - - - - - - - 437
Theory of Greenstone, - - - - - - - - 439
PORPHYRY: Its definition, - - - - - - - 442
Its Mineralogical Characters, - - - - - - 443
Its Topography, - - - - - - - - 447
Its Geological Position, - - - - - - - - 448
Mineral Contents, - - - - - - - - - 449
Theory of Porphyry, - - - - - - - - 450
SIENITE: Its definition, - - - - - - - - 451
Its Mineralogical Characters, - - - - - - - 452
Its Topography, - - - - - - - - - 455
Its Pseudo-Stratification: Veins in Sienite, - - - 456
Its Geological Position, - - - - - - - 460
Mineral Contents, - - - - - - - - 461
Theory of Sienite, - - - - - - - - - 462
GRANITE: Its definition, - - - - - - - 465
Its mineralogical Characters, - - - - - - - 466
Its Topography, - - - - - - - - 469
Its pseudo-Stratification: Phenomena of Veins and Protruding Masses of Granite, - - - - - - - - - 473
Mineral Contents, - - - - - - - - - 501
Theory of Granite, - - - - - - - - 509
Theory of Central Heat, - - - - - - - - 516
Fluvial Theory, - - - - - - - - - 518

MISCELLANEOUS ITEMS.

Origin of Metallic Veins, Beds, &c. - - - - - - 520
Direction and Dip of Metallic Veins and Beds in Massachusetts, 521
Elevation of Mountains and Systems of Strata in Massachusetts, 522
Explanation of the Sections and Map of the Direction of Strata, 523
Systems of Strata of cotemporaneous Elevation in Massachusetts, 525
Oldest Meridional System, - - - - - - - 526
The Trap System, - - - - - - - - - 528
The Latest Meridional System, - - - - - - - 530
The North East and South West System, - - - - - 531
East and West System, - - - - - - - - 534
Northwest and Southeast System, - - - - - - 535
Ancient Deluges, - - - - - - - - - 537
Theory concerning the Force by which Systems of Strata were elevated at Successive Epochs, - - - - - - - 538
Concluding Remarks, - - - - - - - - 539

## PART IV. CATALOGUES OF ANIMALS AND PLANTS.

Introductory Remarks, - - - - - - 543
Catalogue of Mammalia in Massachusetts, - - - - 544
———— of Birds in do. - - - - 545

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Catalogue of Reptiles in Massachusetts, - - 552
——— of Fishes in do. - - 553
——— of Fishes — additional, - - - 597
——— of Shells on the Sea Coast of do. - - - 554
——— of do. on the Land and in Rivers in do. - - 557
——— of do. on and near the Coast of New England, 559
——— of Crustacea in do. - - - - 563
——— of Areneides or Spiders in the United States, - - 564
——— of Insects in Massachusetts, - - - 566
——— of Radiata in do. - - - - 596
——— of Plants in do. - - - - 599

APPENDIX.

Catalogue of Specimens in the Government Collection of Rocks and Minerals, - - - - - - 653
General Index, - - - - - - - 679

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# REPORT.

To His Excellency Levi Lincoln, Esq.
Governor of Massachusetts.

Having in a good measure executed the commission received from your Excellency, bearing date June 25, 1830, and directing me to make a geological examination of the State; I beg leave to present you with the first part of my Report.

My commission contemplates an exhibition of the different rock formations in the State, upon the map of the Commonwealth now in progress. But as it must necessarily be a period of considerable length before that work can be completed, I have constructed a small map from such materials as already exist, and delineated upon it the various kinds of rock that prevail in the State. These are shown by different colors and simple markings, easily understood by reference to the tablets on the lower part of the sheet.

To avoid confusion, I have placed on this map only so much of topography and geography, as was absolutely necessary. All the mountains and smaller rivers, with the boundaries of the towns, have been omitted; the center of each town being indicated by a small circle. For the same reason, I have employed only six different colors to mark the rocks; although more than twenty kinds are represented. But these, with a few exceptions, may be grouped together, as they are in nature, in a few general divisions; the rocks in each division being so intimately related, that in an economical point of view, they may be regarded as varieties; although, in a scientific point of view, their differences are very important. All the rocks of a group have a common color on the map; and the different sorts are delineated by means of dots, crosses, circles, &c. In short, it has been a great object with me, so to simplify the map as to render it easily intelligible; while it exhibits all that is important to



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the practical man, as well as to the scientific enquirer. In the first part of my Report, I shall explain the different formations on the map, only so far as shall be necessary in illustrating our geology with reference to the useful arts; reserving the most important scientific remarks to a subsequent period.

It will be seen that I have extended the map a short distance into the adjoining states. This was done chiefly with a view to exhibit certain beds of ore, or other interesting minerals, which occur just beyond our limits. In a statistical point of view, these are nearly as important as those found within the State; and for this reason I shall notice such minerals in my Report.

In laying down the geology of the eastern part of Rhode Island, I have been much assisted by the communications of Col. Joseph G. Totten, of Newport. I am not without an apprehension that the region around Providence, particularly in Cumberland, will be found exhibited on the map somewhat incorrectly; as I had not time, when passing over it, to unravel entirely to my satisfaction, the peculiar intricacy of its geology. In laying down the geology of Berkshire, I have been greatly aided by the geological map of that county, published a few years since by Professor Dewey.

It has been my intention to give to each rock, precisely that relative extent on the map, which it occupies on the earth's surface. To do this with perfect accuracy, over an extent of more than seven thousand square miles, would be an almost endless task: especially when we recollect, that over the greater part of the surface, the rocks are covered by loose soil; so that in some instances, no rock in place shows itself to the traveller, for an extent of thirty or forty miles. In such cases, indeed, this stratum of sand, clay, and gravel, has been exhibited on the map under the name of diluvium. Still, under the most favorable circumstances for observation, the effort to give on a map the exact boundaries of each particular rock, must be regarded as only an approximation to the truth. Yet for all practical purposes, such approximation answers nearly as well as entire accuracy. If I have not misunderstood my commission and instructions, I was to have principally in view, in my examinations, practical utility; not neglecting, however, interesting geological facts, which have an important bearing upon science. Under such impressions I have gone over the State as rapidly as seemed to me consistent with the accomplishment of these main objects. In attempting to construct such a map as is appended, in the time that has been devoted to the

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survey, I am not without fears that I shall be thought to have aimed at too much; or that it will be supposed, little dependence can be placed upon it. Had I not previously become acquainted with the geology of nearly one half the State, from my own observation, or the published accounts of Professors Dewey, Webster, and the Danas, I should not have been able to accomplish this object, with any confidence in the correctness of the results. And as it is, I am aware that the map may need several minor alterations; though I feel quite confident of the correctness of its leading features. To obtain such corrections before the completion of the contemplated map of the State, is one strong inducement, thus early, to present this Report, and the accompanying map. For, should the Report in any way be made public, I shall hope that gentlemen of intelligence, in different parts of the State, will do me the favor to communicate any errors, or omissions which they may notice.

I propose to divide my Report into four parts. The *first part* will embrace the ECONOMICAL GEOLOGY of the State; or an account of our rocks, soils, and minerals, that may be applied to useful purposes, and thus become sources of pecuniary profit.

The *second part* will embrace our TOPOGRAPHICAL GEOLOGY; or an account of the most interesting features of our scenery.

The *third part* will consist of our SCIENTIFIC GEOLOGY; or an account of our rocks in their relation to science.

The *fourth part* will consist of catalogues "of the native mineralogical, botanical, and zoological productions of the Commonwealth," so far as they can be obtained; agreeably to a resolve of the Legislature, approved by your Excellency, February 2, 1831. Several gentlemen distinguished for their attainments in natural history, have generously offered to furnish these lists in those branches with which they are most familiar.

To illustrate the first and third parts of the Report, I have in accordance with directions from your Excellency, collected specimens of every variety of rock I could find in the Commonwealth; and in all cases where a rock is quarried, or might be quarried in several places, I have endeavored to obtain specimens from each locality. I have collected likewise, all the ores of importance found in the State, as well as the other simple minerals, which could be obtained without much difficulty or delay. I did not suppose that my instructions authorized me to be at much expense and trouble in procuring every rare mineral that has been described as occurring in the State;

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although this object may still be accomplished, if I have mistaken the intentions of the Government. The collection of specimens, which I have already made for the use of the Government, contains seven hundred and eighty individual pieces: and it is not yet completed; so that I shall not be able to forward it with this part of my Report. I do not know to what use the Government intends to devote this collection. But supposing it would be placed in some public situation, in order to exhibit to the citizens the geology and mineralogy of the State, I have endeavored to obtain from all the important quarries, and beds, whence stones are obtained for the purposes of architecture, or ornament, specimens which would fairly exhibit the qualities and value of each.

I have also in accordance with my instructions, endeavored to collect all the important varieties of rocks and minerals in the State, for the use of each of the colleges in the Commonwealth.

I cannot hope to complete more than the first part of my Report the present season: since some further points remain for investigation, before the third part can be properly finished.

In presenting a view of our economical geology, I shall first make a few remarks upon the different soils found in the state, as connected with the rocks over which they lie. And since it is an acknowledged fact, that all soils, had their origin in the disintegration, or decomposition of rocks, it might seem easy, at first thought, to ascertain the nature of the soil, if we do but know the integrant and constituent parts of the rock underneath it. Thus, in a soil lying above granite, we might expect that siliceous sand would be the predominant ingredient; next, clay with small quantities of potash, lime, magnesia and iron; because these are the constituents of granite. But several causes so modify soils, as to render all conclusions of this kind extremely uncertain. In the first place, the character of a soil depends more, in general, upon the nature and amount of the vegetable and animal matters it contains, than upon the nature of its other ingredients. And in the second place, the agency of running water, not merely of existing streams, but of mightier currents, to which the surface has been exposed in early times, has been powerful in modifying the loose coverings of the rocks. This aqueous agency has often covered one rock with the spoils of another; and sometimes mixed together the worn off fragments of half a dozen, and accumulated them in immense quantities in particular districts.

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These circumstances have rendered the subject under consideration an extremely difficult one; and very few general principles have yet been settled concerning it. Indeed, so far as I know, little attention has been given to it in this, or other countries. Still, there is such a thing as peculiarity of soil, occasioned by the peculiarity of the rock from which it principally proceeded. I shall notice any peculiarities of this kind, that have struck me, in the soils of Massachusetts; but I shall not enjoy the advantage of comparison, not having found more than one or two observations of a similar kind, made on the eastern continent. I shall begin with the stratum that lies above every other:—viz.

*Alluvium.*

In this part of my Report, I shall not enter into a systematic and minute description of the various formations represented on the accompanying map. Such description belongs more appropriately to the scientific part. I shall here describe the different strata only so far as is necessary to the particular purpose I have in view.

Alluvium is that fine loamy deposit, which is yearly forming from the sediment of running waters, chiefly by the inundations of rivers. It is made up, of course, of the finest and richest portions of every soil over which the waters have passed. Hence alluvial meadows have always been celebrated for their fertility. No extensive alluvial tracts occur in Massachusetts; although limited patches of this stratum exist not unfrequently along the banks of every stream, and with the adjoining elevated ground covered by wood and pasture, constitute not a few of the most productive farms in the State. Even where Deerfield river winds its way among the lofty and precipitous spurs of Hoosac mountain, which crowd so close upon the path as almost to throw it into the shade at noon-day, the traveller is sometimes agreeably surprised to see a luxuriant meadow open before him, rewarding the labors of some thrifty farmer. No alluvial tracts, however, have been thought of sufficient extent to deserve a place on the map, except one or two salt marshes a little northeast of Boston, and several meadows along the Connecticut, Deerfield, and Housatonic. Those of Longmeadow, Springfield, Northampton, Hadley, Hatfield, Deerfield, and Northfield, have long been celebrated for their unrivalled exuberance and beauty. Those in Great Barrington, and Sheffield are scarcely less inviting.

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There is one variety of alluvial soil in this State, that deserves more attention from our agriculturalists. I refer to those numerous uncultivated swamps, which have for ages been the reservoirs of rich soil, that has been washed thither by rains and brooks. To reclaim them, does, indeed, require not a little labor and expense. But where the effort has been successful, the great and continued exuberance of these spots, has astonished and amply repaid the experimenter. Even in those cases where they cannot be reclaimed, which I believe to be few, they ought at least to be converted into manure, and spread again over those higher regions around, from which, by slow aqueous agency, they have been washed away. Very many of the most barren regions in the State, might, by this means, be clothed with fertility and plenty.

### *Diluvium.*

This occupies more of the surface in Massachusetts than any other stratum. It is not generally distinguished from alluvium; but it is usually much coarser, being made up commonly of large pebbles, or rounded stones, mixed with sand and fragments of every size, which are often piled up in rounded hills to a considerable height; and under such circumstances, as preclude the probability that it could have resulted from existing streams. Indeed, it is spread over the highest mountains, wherever it could find a lodgment, and appears to have resulted from some powerful current of water, which, in early times, swept over the globe.

In a scientific point of view, this is one of the most interesting formations in the State; and in the proper place, I shall exhibit several facts respecting its relations and mode of occurrence. But in an agricultural point of view, it is the least interesting of all our strata; for of all the soils, it is the most unfriendly to rich vegetation. And as it is spread in a good measure over every kind of rock, it often prevents the formation of a good soil, from the decomposition of the rock. It is in general easily recognized in the most sterile places, in the form of low rounded hills, composed almost entirely of coarse pebbles, or cobble stones, and sometimes larger rounded masses of rock, called bowlders, mixed with coarse sand, and covered with a stinted vegetation. It was evidently deposited by currents rushing violently over the surface; since only the coarser materials, which were driven along, were left; while the finer particles were kept suspended by the agitation of the waters. Some varieties of this diluvium

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may, indeed, be converted into a soil of tolerable richness by manuring it abundantly, and clearing away the stones. And generally too, the rains that have fallen on it for thousands of years, have conveyed its finer particles to the bottom of the vallies and cavities, with which this formation abounds, and these being mixed with much vegetable decayed matter, a soil of good quality is formed. So that within the limits of this formation, much good land occurs. But these fertile spots ought perhaps rather to be denominated alluvion than diluvium.

Had diluvium been represented on the Map wherever it occurs, scarcely any other formation could have been exhibited. I have marked the region as diluvial, only where it occurs in such quantities, as almost entirely to conceal every other stratum. It is most abundant in the south east part of the State; the counties of Plymouth, Barnstable, Dukes, and Nantucket, being almost entirely overspread by it; so that in the three latter counties, I scarcely found any rocks that did not appear to have been broken up and moved from their original bed. Towards the extremity of Cape Cod, and on the island of Nantucket, this stratum is composed almost entirely of sand; which often constitutes those hills called *downs* or *dunes*, that travel inland by the action of winds, and do great mischief, by overrunning fertile spots; and on the eastern continent, by burying even *villages* and cities. The most effectual remedy that nature has provided against these encroachments, seems to be Beach Grass;—(*Arundo arenaria*, Lin. *Psamma arenaria*, Beauv.) which is able, not only to fix itself on the most barren ridge of sand, but also in time to fix the sand itself.

Diluvial tracts of considerable extent, exist in the county of Norfolk; in the Connecticut valley, and along the western base of Hoosac Mountain. None of them however are noticed on the Map. Most of the islands in Boston Harbor, are thus colored; also Plum island in Essex county, and a part of Malden and Chelsea.

### *Tertiary Formations.*

The only difference between these and diluvium, is, that in diluvium, the sand, pebbles, and clay, are confusedly mixed together; but in the tertiary formations, these materials are arranged in regular, and generally, in horizontal layers, one above another. Hence, when the sandy stratum happens to lie uppermost, the soil will be too sandy; but if this be worn away, so that the clay lies at the surface, the soil will be too argillaceous; or if the gravel stratum be ex-

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posed, the soil cannot be distinguished from diluvium. All these varieties of soil thus produced, may be seen in the valley of the Connecticut; where exists the most extensive tertiary formation in the State; extending nearly to Middletown in Connecticut. Upon the whole, there is little to choose in an agricultural point of view, between those tertiary formations that occur in Massachusetts, and our diluvium, although in England, some of these formations, that embrace beds of loam and marl, are very productive. But it is doubtful whether our tertiary formations are identical with any in Europe. At any rate, ours contain no marl, and very little loam; and where the sand is uppermost, much of the soil corresponds to those unimproved and unimprovable tracts, that occur in the immediate vicinity of the English metropolis—composed of what is locally denominated, bagshot sand. Where the clay predominates, however, cultivation and proper manure produce a valuable soil. Of this description are the small tertiary patches on the Map in the vicinity of Boston. There, in fact, the clay near the surface, appears generally to have been disturbed, and to be mixed with loam; and it is doubtful whether they ought not rather to have been colored as diluvium, than as tertiary. It ought also to be remarked, that the sandy plains of the Connecticut river, are very congenial to the growth of rye, and are very easy to cultivate.

### *New Red Sandstone.*

This is found along Connecticut river. Although composed of numerous varieties of rock, the prevailing color is red; and the reddest varieties are most liable to decomposition; viz. a red slate and a red sandstone. No rock in the State disintegrates so easily as this; nor has any other so impressed its peculiar characters upon the soil. In Long Meadow, Wilbraham, Southwick, West Springfield, Easthampton, and Greenfield, it is common to see tracts of considerable extent, where the diluvium and tertiary are chiefly swept away, exhibiting that reddish aspect, which in England, is so characteristic of soils derived from this formation. The Devonshire butchers, it is said, are able to distinguish the sheep raised on this soil, by the color of their fleece; and many local names in that country, originated from the same circumstance; such as Rougemont Castle, in Exeter; Red Hill and Redford, in Somersetshire; Red Brook, in Gloucestershire; Red Mire, Rotherham, &c. in Yorkshire.

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The new red sandstone is said to be associated with some of the most fertile land in England; especially that variety of the rock denominated red marle. It is distinguished for the excellence of its wheat, barley, beans and cider. The sand resulting from the decomposition of the coarser varieties of the rock, produces most of the rye grown in England. In that country, however, this formation contains not a little limestone, either in beds, or impregnating the sandstone. But in Massachusetts, the lime is almost entirely wanting: and hence probably it affords a soil inferior to that produced by the English rock. Still, with us its soil is of a superior quality. Its poorer varieties are excellent for rye. It is also peculiarly well adapted for fruit. The grass grown upon it is of a superior quality; and it affords excellent pasture. The establishment of the Shakers in Enfield, Ct., exhibits a favorable example of the productiveness of this soil, when under a good cultivation. The black, white, and red oaks, with pignut hickory, chesnut, and soft maple, (*Acer rubrum*,) are the forest trees most naturally produced upon this soil.

### *Argillaceous and Flinty Slate and Graywacke.*

The flinty slate is a variety of the argillaceous or roofing slate, which has been indurated, and it occurs only in small quantity at Nahant. The argillaceous slate in the vicinity of Boston, is intimately connected with the graywacke, and probably ought to be considered only as a variety of that rock. It is considerably different from the argillaceous slate of Worcester, Franklin and Berkshire counties. Every variety, however, furnishes by decomposition, a dark colored soil, which, although somewhat apt to be cold, is capable of being made very fertile. The central parts of Quincy, exhibit a favorable example of the soil lying above this rock. The range in Worcester county, is almost every where overspread with diluvium, and in Franklin and Berkshire, this rock is so limited in extent, as not very strikingly to develop the peculiarities of its superincumbent soil. Professor Dewey, however, says, that in Berkshire "the argillaceous district is more fertile and productive than any other portion of the section, except the alluvial."

Numerous varieties of rock, both in color and composition, are associated under the term graywacke: from the fine dark colored shale or slate, containing the anthracite coal of Rhode Island, to the coarse conglomerate, or plum pudding stone, of Roxbury, Dorchester, Dighton, Somerset, and Swansey. Most of these varieties, however, appear



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to furnish a soil of good quality, and sometimes of superior fertility. The island of Rhode Island exhibits the superiority of the soil of this formation, to that of several other islands that surround it. As we proceed northerly, the great quantities of diluvium spread over the surface, obliterate, or greatly modify the soil peculiar to the formation. But in Dorchester, Roxbury, Brooklyn, Brighton, and Newton, it is exhibited to great advantage; presenting the finest examples of exuberant farms and gardens in the Commonwealth; although we must not forget the very superior cultivation that has been bestowed upon that part of the State. Still, such luxuriance as we there witness—such fine fruit especially—could not be produced without a soil naturally excellent.

### *Iron Ore.*

No ore except iron occurs in sufficient quantity in the State to deserve notice in an agricultural point of view. In the west part of Worcester County, the soil for a width of several miles across the whole State, is so highly impregnated with the oxide of iron, as to receive from it a very deep tinge of what is called *iron rust*. This is particularly the case in the low grounds; where are frequently found beds of bog ore. I do not know very definitely the effect of this iron upon vegetation; but judging from the general excellence of the farms in the Brookfields, Sturbridge, Hardwick, New Braintree, Barre, Hubbardston, &c., I should presume it to be good. Certainly it cannot be injurious; for no part of the County exceeds the towns just named in the appearance of its farming interest; and nearly all the County, as may be seen by the map, is of one formation. It would be an interesting problem, which in that county can be solved, to determine the precise influence of a soil highly ferruginous upon vegetation.

### *Steatite, Serpentine, Scapolite Rock, Limestone.*

The next rocks, in an ascending order upon the tablets attached to the map, are steatite or soapstone, serpentine and scapolite rock. But they are of such limited extent as to deserve no notice in this connection. The next rock, namely limestone, is found only in Berkshire County, in quantities sufficient to modify the soil over much extent of surface. But in that county it occupies most of the vallies; while the mountains are chiefly mica slate. And the fertility of these vallies is a striking evidence of the good influence of disintegrated and

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decomposing carbonate of lime upon the soil. Indeed, I believe that it is generally thought in Europe, that soils of this description are more productive than any other, except rich alluvions. And I apprehend that one of the greatest deficiencies in the soil of the principal part of Massachusetts, is the absence of lime. Probably if our farmers could procure this article at a moderate expense, its application as a manure would amply reward them for their trouble. Limestone that contains much magnesia, is, indeed, said to be injurious to vegetation, unless it be upon peaty soil, or soil containing much vegetable matter; and this limestone is common in Berkshire County. But it occurs there in beds, alternating with the pure carbonate of lime, and I apprehend rarely produces any bad effect.

### *Quartz Rock.*

It will be seen by the map that one variety of this rock is associated with mica slate, and another with gneiss; so intimately, indeed, that its agricultural character may be considered the same as that of these rocks. When it occurs in the state of pure quartz, it is so little acted upon by the common decomposing agents, such as air, heat and moisture, as to exert little or no influence upon the superincumbent soil; except in the town of Cheshire, where it produces a pure white sand.

### *Chlorite Slate, Talcose Slate, Mica Slate.*

The first of these rocks occupies too little space to deserve any notice in respect to the soil resulting from it. The second is in general a mere variety of mica slate, talc taking the place of mica, or being superadded to it. Where the talcose slate, however, is most pure, so as in fact to be little else but slaty talc, with more or less quartz, the soil which its decomposition produces, is decidedly inferior to that resulting from mica slate; and probably this is owing to the large quantity of magnesia which talc contains.

Mica slate produces a soil of a medium quality. Some varieties of it underlie tracts of superior quality. But the most extensive tract of mica slate in Massachusetts, consists of the high and mountainous region west of Connecticut river: so that it is difficult to compare the soil lying over it, with that of formations at a lower level. The deep ravines, however, so common in the mica slate, furnish many very fertile, though limited patches of ground; while the mountain sides are very superior for grazing.

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### *Hornblende Slate, Gneiss.*

Gneiss, which differs from granite only in having a slaty structure, occupies more of the surface of the State than any other rock. It sometimes takes into its composition the black mineral called hornblende; even losing its common ingredients; and then it is denominated Hornblende Slate. Sometimes the quartz so greatly predominates over the other ingredients, that it is properly called quartz rock.

The soil resulting from the decomposition of gneiss is so well marked, as not to be easily mistaken by an experienced eye. Its predominant ingredient is a rather fine whitish sand; and sometimes beds of extremely pure sand are found in it; as in Pelham and Shutesbury. Indeed, the appearance of the soil from gneiss, indicates uncommon poverty and sterility. But facts do not correspond to this anticipation; for in no part of the State do we find finer looking farms, or the appearance of more thrift and independence among their occupants, than in the region where gneiss prevails: I refer chiefly to Worcester County, most of which is based on this rock. The western part of the range, however, embracing the eastern part of Franklin, Hampshire and Hampden Counties, is in general characterized by a rather barren soil. But this region is more elevated than the surface farther east. Where it is not so high, as in Monson and Brimfield, we find the same appearance of fertility as in the towns farther to the east. It is a question worthy of attention, however, how far the soil from our gneiss-rock may owe its agricultural character to the iron that so generally accompanies this rock. Certainly the iron gives it an appearance of sterility which does not belong to it.

### *Greenstone.*

This is one of the varieties of rock embraced under the general term *trap rock.* The variety most common in Europe is basalt: and the soil produced by its decomposition is said to be of a superior quality. The greenstone of Massachusetts, however, except some of its rarer varieties, is but little acted upon by ordinary decomposing and disintegrating agents; and is proverbially one of our hardest and most indestructible rocks. Hence the soil that covers it is generally quite scanty. It is, however, very peculiar; and we find upon our greenstone ridges, quite a number of plants, shrubs, and trees, that are not found, except rarely, upon the other formations. The eastern part of the County of Essex is in a great measure composed of greenstone; and its superior agricultural character, in gene-

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ral, produces a favorable opinion as to the influence of this rock upon the soil, though very much must be imputed to good management. This formation in the Connecticut valley furnishes but little arable land, and that of rather a sterile character.

### *Porphyry and Compact Feldspar.*

These rocks differ but little in an agricultural point of view. They are of quite limited extent and are decidedly the hardest and most unyielding of all our rocks. They occupy the greater part of the surface, and the scanty soil that has formed a lodgment in their inequalities, is not of the first rate character.

### *Sienite and Granite.*

Sienite is intermediate in its characters between greenstone and granite, although most commonly it is only a variety of granite. Both rocks are little liable to decomposition, and occupy a large porportion of the surface with their naked and rugged projections. Still, the soil found among them, particularly on the granite, is generally of a superior character, probably from the fact that most of it must have been derived from decomposed vegetable and animal matter. Hence it is usually of a dark color and fine texture, and not coarse and sandy like the soil above the granites of Europe, that more easily suffer decomposition.

Should the preceding cursory remarks be the means of exciting the attention of intelligent agriculturists, to the connexion between rocks and soils, an important object will be attained. I have said enough to show that almost all known varieties of soil exist in Massachusetts. But much improvement remains to be made in our agricultural concerns, before the excellencies of our soil are fully developed. It is but a moderate estimate to say, that the general adoption of an enlightened system of cultivation, would, in a few years, double the produce and the value of our improvable lands. That is to say, such would be the speedy result, if all our farmers were to manage their lands as a few now do.

## USEFUL ROCKS AND MINERALS IN THE STATE.

I shall next proceed to give an account of those rocks and mineral subtances found in the State, which have been, or may be useful in the arts, and are consequently objects of pecuniary impor-

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tance. Those that are employed for architectural or ornamental purposes, first claim attention; because the state is peculiarly rich in treasures of this kind. It will be easy to see, by a reference to the Map, how extensive are the formations from which they are derived; although it must not be concluded that every part of a formation will furnish materials of equal value for economical purposes.

### *Granite and Sienite.*

Much confusion has arisen in the application of these terms. They were originally applied to designate rocks very different, if not in composition, yet in their geological relations. But most of the rock that is generally described as sienite, is a variety of granite. This is certainly the case in Massachusetts. Wherever the granite admits hornblende into its composition, I have considered it as sienite; and not unfrequently the hornblende constitutes the principal ingredient; taking the place, more or less, of the quartz and mica, so as to form a compound of hornblende and feldspar. This compound forms some of the most beautiful varieties of sienite, though extremely hard to work for architectural purposes. But not a little granite that contains no hornblende goes by the name of sienite. Thus, much of the Quincy granite is wanting in hornblende; but being almost destitute of mica, and having the close aspect of sienite, it is called indifferently by either name.

The variety in the composition, color and hardness of these rocks in Massachusetts, is almost endless. The quartz and feldspar are commonly white, yellowish and gray; the latter not unfrequently flesh colored: the mica is very often black, but sometimes of a silver color. When the quartz prevails, the rock is easily broken, but hornblende renders it tough. The predominance of feldspar generally gives the rock a more lively white color and renders it rather easier to work. But I shall not attempt to describe particularly all the varieties of these rocks that occur in the State. An inspection of the specimens which I have collected, will at once give an idea of the kinds obtained at the principal quarries, and of numerous other varieties which I have met with in different localities.

The very coarse varieties of granite, which are found in some parts of the State, do by no means furnish a good building stone: indeed, some of them hardly serve for common walls. Much of the granite in the vicinity of the Connecticut river is of this description; as also a considerable portion of the range which extends from Southboro'

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to Andover; particularly along its northwestern limits. But most of the granite in the eastern part of the State, is of so fine a texture, as to answer admirably for architecture and other economical purposes. Along with sienite, it extends around Boston, running in a curvilinear direction at the distance of fifteen or twenty miles. From Cohasset to Quincy, at the southern extremity of the curve, and from the end of Cape Ann to Salem, on the north, the formation is most fully developed, and is there quarried extensively. The Quincy quarries are probably the best and most generally known; and few citizens of the State are unacquainted with the rock thence obtained, now so extensively used in Boston and elsewhere. The quantities which those quarries (or rather mountains) will furnish, are incalculably great. One railroad, as is well known, has been used for several years to convey the granite from the quarry to Neponset river, a distance of three miles. It is thought, however, that the granite has not reached its *minimum* price. Yet even now, Boston is almost as much distinguished for its granite structures, as the metropolis of the Russian Empire.

Some of the granite obtained on the north of Boston, cannot be distinguished from that of Quincy. I observed the resemblance most strongly in Danvers and Lynnfield. At the former place it is quarried, and fine blocks are obtained. Extensive quarries are also opened in the north side of Cape Ann, in Gloucester. The rock here resembles that of Quincy; but it is generally harder and of a lighter color. At these quarries no railroad (except one of a few rods in length) is necessary to transport the rock to the sea-side; since vessels can approach very near the spot. And, since the demand for this rock must increase, in our country, for many years to come, and Cape Ann is little else than a vast block of it, it seems to me that it must be regarded as a substantial treasure to that part of the State,—far more valuable than a mine of the precious metals. At Squam, in Gloucester, I was informed that blocks of granite had sometimes been split out sixty feet in length; indeed, I saw the face of a ledge from which they had been detached.

At Fall river, in Troy, which lies upon Taunton river, are other extensive and interesting granite quarries. This granite, as the Map will show, is connected with the Quincy range above described. Yet the greater part of the granite in Plymouth and Bristol is coarser than that of Quincy and Gloucester, and more liable to decomposition. But no rock can be finer for architectural purposes than the granite

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of Troy: and immense quantities have been obtained from this locality. The large manufactories at Fall river are built of it, as is also Fort Adams at Newport, Rhode Island. The feldspar of this rock is a mixture of the flesh red and light green varieties; the former predominating: the quartz is light gray, and the mica, usually black. It works easily, and has a lighter and more lively appearance than Quincy granite. Blocks of this granite have been split out from fifty to sixty feet long, as the sign-post at one of the public houses at Fall River, will attest: it consists of a single block. The contiguity of this granite to water transportation, will always render it peculiarly valuable.

The granite range extending from Cohasset and Quincy, through Randolph, Stoughton, Foxborough, &c. into Rhode Island, affords much valuable stone for architectural purposes; and it is wrought more or less in every town through which it passes. About two and a half miles to the west of Providence, (R. I.) it is quarried; and thence were obtained the beautiful and magnificent pillars in front of the Arcade in that place.

That part of this extensive deposit of granite, which is fully developed a little south west of Dedham, furnishes some beautiful varieties of stone. No better example can be referred to, than the elegant pillars of the Court House in Dedham. This granite is very fine grained, and so white, that at a short distance it cannot be distinguished from white marble. The pillars just named were obtained from some large bowlders near the dividing line between Dover and Medfield.

The stone used in Boston, under the name of Chelmsford granite, is found in a range of this rock, not connected with the deposit that has been described above. Nor does it come from Chelmsford; but from Westford and Tyngsborough. In the latter place, it is obtained chiefly from bowlder stones; but ledges are quarried in Westford. I do not know why it has been called Chelmsford granite, unless from the fact that large quantities are carried to Lowell, (formerly a part of Chelmsford,) to be wrought. This rock is pure granite, with no hornblende; and being homogeneous and compact in its texture, it furnishes an elegant stone. Good examples of it may be seen in the pillars of the United States Bank, and in the Market House in Boston. These were from Westford.

Four miles north of Lowell, a quarry of this granite has been opened, in Pelham, (N. H.) Blocks may be obtained from this place of any length under thirty feet. It is a very fine variety, is much used, and appears superior to the Chelmsford granite.

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The Westford and Pelham granite is connected with an imperfect kind of mica slate, in which it seems to form beds, or large protruding masses. In the same mica slate at Fitchburg, a little south of the village, is a large hill of the same kind of granite. This is quarried, though not extensively, on account of the little demand for the stone. This single hill, 300 feet high, and nearly a mile in circumference at its base, might furnish enough to supply the whole State for centuries. Some of it, however, is too coarse for architecture.

The manner in which the granite is usually split out of the quarries is this. A number of holes, of a quadrangular form, a little more than an inch wide, and two or three inches deep, are drilled into the rock, at intervals of a few inches, in the direction in which it is wished to separate the mass. Iron wedges, having cases of sheet iron, are then driven at the same time, and with equal force, into those cavities; and so prodigious is the power thus exerted, that masses of ten, twenty, thirty, and even fifty and sixty feet long, and sometimes half as many wide, are separated. These may be subdivided in any direction desired; and it is common to see masses thus split, till their sides are less than a foot wide, and their length from ten to twenty feet. In this state they are often employed as posts for fences.

Respecting the price of the granite from the quarries that have been described, I have not been able to obtain much information. At Fitchburg, I was told that it was sold at the quarries, well dressed, at forty cents the superficial foot; and at Squam, at forty-five cents.

The cost of hammering and fine dressing granite in Boston, in the style of the Tremont House, I have been credibly informed, is about thirty cents the superficial foot. Ordinary work, however, is from twenty-five to thirty cents; and not unfrequently, even as low as twenty cents.

Concord and Hallowell granite cost about fifty cents per foot in Boston; but are now little used.

Posts for store-fronts, cost about thirty-four cents per foot in Boston. The columns of the Hospital were obtained for about one dollar per foot.

To show how rapidly the price of granite has fallen, I would state on the authority of a respectable architect in Boston, that the cost of the blocks of the Quincy granite for the Bunker Hill monument, delivered at Charlestown in a rough state, was thirteen cents, three mills, per foot; and the cost of the unhewn stone for the church built



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last year in Bowdoin street, Boston, was fifteen cents: but six years before, the rough Quincy granite, for the United States' Branch Bank, cost two dollars per foot.

I have now given an account of the most extensive and important quarries of granite and sienite, in the eastern part of the State. Granite is wrought more or less, however, not merely in all the towns through which its ranges pass, but also in other places, in their vicinity; large blocks of it having been removed thither by diluvial action in former times.

Although the granite in general, in the vicinity of the Connecticut river, is too coarse for architectural uses; yet in Hampshire county are several beds of a superior quality. Perhaps the best is found in Williamsburgh, a few miles from Northampton. This rock, (some of which may be seen in the front of a few buildings in Northampton,) very much resembles the granite found in the vicinity of Dedham, and yields in beauty and value to none in the State. It exists in abundance in Northampton, Whately and Williamsburgh; but has yet been quarried only on a very limited scale.

On the east side of the Connecticut, a very beautiful sienitic granite exists in Belchertown; in which the mica, when the hornblende is wanting, is very black. It is not surpassed in elegance by any rock in the State: but it has not as yet, to my knowledge, been quarried at all. Indeed, very little real granite is employed in the middle or western parts of the State.

This sketch of the granite of Massachusetts, although brief, is sufficient to show that we have a great number of varieties, and an exhaustless quantity, of the most valuable material for durable and elegant architecture. Numerous varieties not mentioned above, which have fallen under my observation, either in ledges or loose blocks, will be found in the collection of specimens; and some of these are peculiarly beautiful. Numerous other varieties have doubtless escaped my observation. Indeed, we may safely assert, that no part of the world is better furnished with this useful and indestructible rock.

### *Gneiss.*

This rock is commonly known under the name of granite; and, indeed, it is composed of the same materials; but in the gneiss, the structure of the rock is slaty, and it splits in one direction better than in others; yet this slaty structure is often hardly perceptible, even in wrought specimens; and hence for all architectural and economical

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purposes, the distinction of granite and gneiss is of small importance; though of much consequence in respect to the science of Geology.

The quarries of gneiss in Massachusetts are perhaps even more numerous than those of granite, though not in general so extensively wrought. It forms an admirable building stone; and is in no respect, that I know of, inferior to granite; while the facility with which it cleaves in one direction, renders it easier to get out and dress; so that it can be afforded at a less price. Accordingly we find that a large proportion of the better class of buildings, in the extensive portion of the central part of the State, where this rock prevails, are underpinned by wrought blocks of it. Its fissile character also renders it an excellent material for common stone walls and flagging stones. The same property enables the quarry-man to split out layers of it of almost any size, and only a few inches in thickness: and their surface is generally so even, as to require but little dressing. Hence it is very common to see such large stones of this description in front of very many of our churches and other public buildings.

It is a curious fact, that in Europe gneiss seems to have been applied to no useful purpose. One of the latest geological writers in Great Britain says, that "this schistose (slaty) body serves no particular purpose in the arts of life."* This rock appears to be more perfectly developed in our country than in Europe. There it seems chiefly to consist of that variety, not uncommon here, in which the layers are so contorted and irregular as to prevent its splitting into parallel planes.

The western part of Worcester County, and the eastern part of Hampden, Hampshire, and Franklin Counties, afford the best quarries of gneiss. That branch of the Worcester range extending into Middlesex County, and the range in Berkshire County, do not furnish so good specimens for architecture, though by no means devoid of interest in this respect.

The quarries of gneiss that are most extensively wrought, and furnish the best stone, are situated in the following towns: Wilbraham, Pelham, Monson, Montague, Dudley, Millbury, Westborough, Boylston and Uxbridge. Much of the stone at these quarries can hardly be distinguished from granite, even by the geologist. The Millbury

* Ure's Geology, p. 100.

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gneiss, for instance, is very much used in Worcester, and does not there present any appearance of stratification, and very little of a slaty structure: while the granite, that is quarried in the east part of Worcester, is distinctly stratified; and would probably be called gneiss, by most persons, rather than the Millbury rock. The Worcester granite, however, affords almost the only example of stratification in that rock in this State.

At these gneiss quarries it is easy to obtain blocks from ten to twenty feet long, which are only a few inches thick. At Dudley, I was told that narrow slabs of this rock, such as would answer for posts, or side walks, could be split out, and delivered in the center of the town, for four cents per foot.

### *Greenstone.*

This is one of the most enduring of all rocks; but it is usually so much divided by irregular seams, into small and shapeless blocks, that it is but little employed, either in the construction of houses, or walls. Its dark color, also, renders it less acceptable than granite or limestone. Still it is beginning to be used for building houses, in its unaltered state. The irregular blocks may be so laid with white mortar, especially in the Gothic style of building, as to form a picturesque and pleasing structure. The Episcopal Church, in the city of New Haven, (Conn.) presents a good example of this kind of architecture.

### *Hornblende Slate.*

I do not recollect to have seen this rock employed in Massachusetts for any useful purpose, except for the construction of common stone walls. But I have noticed some very fine samples of it in the flagging of the side walks of New Haven, obtained, I presume, in Connecticut, from the same range that passes through Monson, Ware, &c. in Massachusetts.

### *Porphyry.*

This term, as it is employed in the arts, embraces several varieties of rock not designated by its strict geological sense. Although upon the Map, I have included in the term, only the porphyry of geologists, yet in this place, I shall describe all those compounds occurring among us, which have been denominated porphyry in the arts.

The first and most extensive of these, is the genuine feldspar porphyry, represented on the Map in large quantities in the towns of

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Medford, Malden, Chelsea and Lynn, on the north of Boston; and in Needham, Milton and Braintree, on the south. This is the oldest and most enduring of the porphyries, and, indeed, the hardest of the rocks. Its basis is generally compact feldspar, reduced to a homogeneous paste, and of various colors; as light purple, red of various shades, brownish black, and greenish gray. The imbedded crystals are either feldspar, or quartz, alone, or existing together in the same rock: and their colors are very various, though more usually white or gray. By these mixtures porphyries are produced, rivalling in beauty the best antique porphyry. This rock is polished with so great difficulty, that it is rarely used in our country, either for ornamental or useful purposes. But it would be strange if an increase of wealth and refinement should not create some demand for so elegant and enduring a rock. Whenever this shall happen, the vicinity of Boston will furnish every variety that can be desired, and in blocks large enough for any purpose.

The porphyry range on the north of Boston, is most perfect in its characters, and in the greatest abundance at any one place; although the southern range spreads over a greater extent of surface. In Lynn, and some other towns, I have observed blocks of porphyry that were brecciated—that is, they were composed of angular fragments of porphyry reunited. This furnishes a beautiful variety for polishing.

### *Sienitic Porphyry.*

When sienite contains crystals of feldspar imbedded in the mass, it is said to be porphyritic; and some varieties of this rock in the eastern part of the State are very elegant. Essex County produces some of the finest specimens, particularly Cape Ann. Sometimes the imbedded crystals of feldspar are white, sometimes flesh-colored, and in Gloucester, I found a rock in which they were of a very rich bronze color. These sienitic porphyries are extremely elegant when polished; but I am not aware that they are employed at all for ornamental purposes, in this country.

### *Porphyritic Greenstone.*

The ingredients of greenstone are often not easily distinguished from each other by the naked eye; and when, in such a case, the rock contains disseminated crystals of feldspar, it becomes porphyritic. If these crystals are greenish white, and the base blackish

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green, the rock is the *green porphyry* of the ancients. In Dorchester, Brookline, and Roxbury, according to the Messrs. Danas, it occurs in rounded masses; and in small quantity, in veins, at Marblehead. But I have found it in large veins traversing sienite, at Sandy Bay, on the north-east side of Cape Ann. Large blocks might be thence obtained; and if polished, it would constitute a truly splendid ornament for the interior of a church, or a private dwelling.

If the feldspar crystals be black, or greyish black, the rock is the superb *black porphyry* of the ancients. This occurs in small beds and rolled masses in Charlestown, and in veins of greenstone at Marblehead. I found it, also, in a rolled mass, in the west part of Ipswich; the feldspar being of a jet black, and of a high lustre. Polished specimens would vie in elegance, to say the least, with the green porphyry.

The hornblende slate in various parts of the State, but particularly in the region of the Connecticut river, is frequently porphyritic; and exceedingly resembles porphyritic greenstone; being, in fact, composed of the same ingredients; and differing only in its slaty structure, and in the more distinctly crystalline character of the hornblende. The disseminated crystals of feldspar are usually white. In Canton and Easton, they are sometimes the compact variety, yet retaining their form perfectly.

The magnetic iron ore in Cumberland, (R. I.) is profusely sprinkled with crystals of feldspar; and would doubtless form no mean substitute for green or black porphyry.

### *Quartz Rock.*

When this rock occurs pure, it can hardly be employed in architecture of any kind, on account of its breaking into fragments so extremely irregular. But when it takes a small proportion of mica into its composition, it is often divided, with mathematical precision, into layers of convenient thickness for building. The best quarry of this kind that I know of, is in the west part of Washington, Berkshire County, about three miles south-east of Pittsfield village. The layers vary in thickness from one or two inches, to one or two feet; thus affording materials for fine flagging stone, as also for walls and underpinning. The quantity of this rock at the quarry is very great.

Although quartz rock is usually, of all others, most easily affected by heat, yet that variety from the quarry in Washington, is remarkable for its power of resisting heat; and it is here employed for the

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hearths and walls of furnaces. Prof. Dewey says that he has "seen this stone after it has sustained the highest heat of the furnace for months, and found its surface merely glazed by the high temperature." It was transported to the iron works in Bennington, Vt. until a similar rock was discovered in that town. It occurs also in Williamstown. What peculiarity this rock possesses, that renders it able to resist a high temperature, I do not know.

Another valuable variety of quartz rock is found near the quarry above mentioned. But its use, as well as that of another variety in Cheshire, will be noticed subsequently.

### *Mica Slate.*

This rock is generally more uneven or tortuous in the structure of its layers, than any rock in the State. But, like gneiss, its layers are sometimes remarkable for their regularity. It then forms an admirable stone for flagging, for hearths, and for situations where there is an exposure to a moderate degree of heat. The variety that occurs in Goshen and Chesterfield, Hampshire county, is perhaps the best in the State for these purposes; and in these places, particularly in Goshen, it is quarried to a considerable extent. In some cases this rock approaches so near to argillaceous, or roofslate, that it is employed for common gravestones. In Halifax, Vt., there is a quarry of this character; and, I believe, also in Chesterfield, Mass. Sometimes it forms excellent whetstones; and from the quarries in Enfield and Norwich, large quantities are obtained and extensively used.

### *Talcose Slate.*

The principle value of this rock, in an economical point of view, is derived from its power of resisting high degrees of heat. The greater the proportion of talc in its composition, the more valuable is it in this respect. A very fine stone of this description, for the lining of furnaces, is quarried in Stafford, Ct., and it is employed to some extent in the furnaces in Massachusetts. I do not know of any quarry of this kind in our own state; but undoubtedly such might be opened; since almost every variety of talcose slate exists here. Indeed, I am informed by the Rev. Mr. Colton, of Amherst Academy, that talcose slate, equal to that in Stafford, may be dug in Monson.

In Plainfield and Hawley a variety of talcose slate occurs, in which are disseminated numerous crystals of black hornblende. The talc

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is green and the quartz white, and the rock admits of a polish. Sometime the talc almost disappears; and then we have a white base with black crystals imbedded. In short, I feel satisfied that this rock would form a beautiful ornamental stone, if wrought into tables, urns, chimney pieces, &c. &c. But of this others can judge from the specimens which I shall place in the collection already referred to. Large blocks of it may be obtained, which would be very firm throughout.

### *Limestone.*

Next to our granite and gneiss, this is the most valuable rock in the State. Little advantage is derived from it, however, by any part of the State except Berkshire. Small beds of it do, indeed, exist in the eastern part of the State; but they rarely furnish blocks sufficiently large and sound, to be wrought into marble. And on account of the high price of wood in the vicinity of Boston, it cannot be burnt into quick lime, so as to be afforded at a less price than the lime brought from Maine. In many places, however, it continues still to be burnt. Judging from the appearance of the quarries, I should suppose that Bolton furnishes a greater quantity of lime at present, than any other locality. The stone here is mostly crystalline, and white, although it is apt to be much mixed, as it is at every other locality in the eastern part of the State, with a variety of minerals, that much injure it for lime. Beds of this limestone occur at Newbury, Bolton, Boxborough, Acton, Littleton, Carlisle, Chelmsford, and Stoneham. That in Stoneham is peculiarly fine; and could large blocks of it be obtained, free from fissures and foreign minerals, it would undoubtedly answer well for statuary. When there shall be a greater demand for a stone of this description, perhaps a farther exploration will bring to light, at this quarry, many larger and sounder pieces.

On the south of Boston, at Walpole, is a bed of limestone of a gray color and probably somewhat impure. It would, however, make good lime; and, indeed, it was burnt in considerable quantity some years ago. But until the lime from Maine and Rhode Island, shall sell at a higher price, this cannot be profitably prepared. It must be gratifying, however, to the inhabitants of the eastern section of the State, to know that such abundant sources of this valuable rock are within their reach, should their present means of supply be cut off.

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The limestone quarries in Smithfield, Rhode Island, are so situated as to be of great importance to Massachusetts, being accessible to a large portion of the southeastern part of our State, and lying close to the Blackstone canal. The limestone here is white and granular; very much resembling that in the towns northwest of Boston,—especially that in Stoneham. It occurs in two principal beds, about two miles apart. I was told by an agent of one of the companies, which own this limestone, that not far from twenty thousand casks of lime, containing from thirty eight to forty gallons each, and worth nearly two dollars each, were annually prepared in the whole town.

Several beds of limestone may be seen on the Map in the eastern part of the range of mica slate in Franklin county, west side of the Connecticut, in the towns of Whately, Conway, Ashfield, Colerain, &c. But this limestone is quite impure, and is not generally distinguished, by the inhabitants of those towns, from the mica slate. It becomes an interesting inquiry, to those residing in the valley of the Connecticut, where quick lime is more expensive than in any other part of the State, whether this stone can be profitably converted into mortar. Very few attempts have yet been made to burn it, and those obviously quite unsatisfactory. Those who made these attempts probably thought that the stone, after burning, would slack with as much energy and readiness as pure quick lime; and because the process went on slowly and feebly, they have inferred that the lime would be of no value. At least, I know this to have been the conclusion in one instance, in which I had procured the burning of a considerable quantity of this limestone, in a regular lime kiln. But the mason, not seeing it slack briskly, did not think it necessary to apprise me of what he was doing, and mixed it with other lime, and defeated the whole experiment. I have, however, burnt a few pounds of this stone in a common chemical furnace, and found it to form a very excellent mortar; although requiring less sand than pure lime. Bricks cemented with it two or three years since, still remain as firmly united as ever.

This limestone contains a large proportion of silex, which, on burning, becomes a harsh sand. Wishing to know how much of pure carbonate of lime was contained in it, I powdered and dissolved portions of it, from different localities, in muriatic acid; and the results were as follows:

1. Purest variety from Whately; 100 parts contain carbonate of lime 78; residuum (chiefly sand) 22 parts



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2. Compact variety from Conway; carbonate of lime 58 parts; siliceous residuum 42 parts.

3. Poorest from Whately; carbonate of lime 67 parts: siliceous residuum 33.

I tried some specimens of our best limestones in the same manner, with the following results:

1. Gray limestone from New Marlborough; carbonate of lime, 98 parts: residuum (chiefly mica) 2 parts.

2. Gray limestone from Walpole; carbonate of lime 92 parts: residuum 8.

3. White crystalline, from Boxborough; carbonate of lime, 99 parts: residuum 1 part.

It is my decided opinion that the limestone along the Connecticut, described above, may be usefully employed either for mortar, or for spreading upon the soil. The beds of it are quite numerous in all the towns where they are occasionally marked. I think, however, that the best variety occurs in Whately, where, should it ever come into use, on the north line of the town, is a hill large enough to supply the whole valley of the Connecticut for centuries. This locality is favorably situated for working, so as to furnish that valley; being not more than two or three miles from the Connecticut, and the whole distance nearly level. I cannot but hope that the attention of some enterprising gentleman may be directed to this subject; and should he succeed in preparing even tolerable lime from this rock, he would confer a great favor upon the inhabitants of that section of the State.

A large portion of the limestone in Berkshire is excellent for burning into quick lime: and even in several towns where none of the rock occurs in ledges, so abundant are the loose masses, transported thither by a current of water in early times, that it is burnt in considerable quantities. This is the case in Windsor, Peru, &c., from whence lime is transported in wagons to the valley of the Connecticut.

Probably, however, a still larger proportion of the lime used in that valley, particularly in its northern part, is brought from Whitingham, Vt., a town lying directly north of Rowe in Franklin county. This limestone is white and crystalline, and it exists in large quantities. It approaches within a few rods of the Massachusetts line, and may even pass over it in some places.

An interesting bed of limestone of a peculiar character, has been discovered, within a few years, in the valley of the Connecticut at

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West Springfield, a few miles south of Mount Tom. It is the bituminous limestone, and is quite impure. But it answers well, and that too on account of its impurity, for water proof cement, or mortar that will harden under water. It was used on the Farmington canal, particularly in the construction of the aqueduct across Westfield river. The same rock occurs at Southington and Middletown, Ct., and I doubt not may be found in many other places, along the river, associated with the new red sand stone. I am not aware that the bituminous limestone has ever before been used as a water proof cement. In Europe, and I believe in New York, the blue argillaceous limestone is employed. Pure lime, however, will answer the purpose, if it be mixed with puzzolana or tarras. The former of these substances is decomposing lava, and the latter decomposing Basalt. I doubt not but that decomposing greenstone will answer as well; and if so, it can be found in abundance on the north of Boston, and along the Connecticut river. Lava, basalt, and greenstone, are so much alike, that I think the latter well worth a trial. Indeed, if I recollect aright, the experiment has already been successfully tried in New Haven, Ct.

As the Springfield limestone is abundant, it would be very desirable to have it tried upon some land in the vicinity: for, if it answers well in agriculture, (and I see no reason why it may not,) it might prove an invaluable acquisition to the farming interest of the Connecticut valley.

### *Postscript.—Discovery of good Limestone in the Valley of the Connecticut.*

After the preceding remarks upon the limestones of Massachusetts were written, I received specimens, through the kindness of Mr. Henry W. Cushman, of crystalline carbonate of lime, found in Bernardston, near the center of the town, and a short distance from the stage road from Greenfield to Brattleborough, Vt. I immediately visited the spot, and found, indeed, a large bed of limestone, in the argillaceous slate, not less than fifty rods long, and three or four rods thick, appearing at the summit of a hill, and dipping nearly south east at a small angle. In the limestone is a large bed of iron ore, which was dug forty or fifty years since, and with the limestone sent to Winchester, N. H. to be smelted. Neither the limestone, nor the iron have been thought worthy of attention since. But a kiln of the former has recently been burnt, and found to produce a very strong lime, although of a rather darker color than the white limestones generally produce. This results from a quantity of the oxide of iron, which

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penetrates the seams of the rock: but this does not injure the stone for mortar, and probably even makes it more valuable. The bed is only three or four miles from the Connecticut, and on the bank of Fall River, a small stream that empties into the Connecticut. By going to Cheapside, in Deerfield, (eight miles,) over a level and excellent road, water communication with the whole valley of the Connecticut, will be reached. I have little doubt, that if this limestone should be extensively burnt, it will reduce the value of quick lime in that valley, from twenty five to fifty per cent.: a benefit superior to any that could be conferred by the discovery of a gold or silver mine.

I dissolved some of this lime, in diluted nitric acid, to see if it contained magnesia. The solution was not milky, and therefore no magnesia was present. I also dissolved 100 grains in muriatic acid, and the siliceous residuum was only a single grain: the 99 grains are probably chiefly carbonate of lime; although whatever amount of oxide of iron was present, would also be dissolved.

### *Marble.*

The limestone of Berkshire is best known for the fine marble which it produces. It is all of that variety denominated primitive marble. It is always more or less crystalline, sometimes very coarsely so. The prevailing color is white; and this is the variety most extensively wrought. Some varieties are snow white, and admit of a very fine polish. From this pure white, the color changes by imperceptible gradations to gray, and dove color. These varieties form delicate marbles. But probably most persons would say that the clouded variety, where the white and the gray are fantastically mixed, is most elegant.

More or less marble is quarried in almost every town of Berkshire county, except a few on its eastern side. But the towns where it is most extensively wrought are West Stockbridge, Lanesborough, New Ashford, Sheffield, New Marlborough and Adams. A few years since, Prof. Dewey stated the amount of marble annually furnished by West Stockbridge, to be sixteen thousand square feet, valued at $25,000 to $30,000: the amount at Lanesborough, seven thousand feet; value $10,000: and in Sheffield, to the value of $8,000. In all the county, the annual value of marble was estimated to be more than $40,000. Still more recently there were in operation in West Stockbridge for sawing marble, nine mills, moved by water power; and two hundred hands were employed. From twelve to fifteen quarries had been opened, and in 1827, about two thousand seven

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hundred tons of marble were exported from this town. The marble used in building the city hall in New York city was chiefly from this town. A part of the marble in the state house in Boston, was from the same place. In 1828, a charge of two hundred and four pounds of powder, was put into the rock in one of the West Stockbridge quarries, and a block from fifty to sixty feet square and eight feet thick, was raised; and as much more loosened.

The Lanesborough marble is of a superior quality, and a good sample of it may be seen in the capitol at Albany. The New Ashford quarries furnish a marble of the same kind; and several quarries are opened. Only one mill is there erected for sawing it into slabs. A mill of the same kind is in operation in Lenox, and another at New Marlborough. In Sheffield, three quarries are opened. In Alford, two. In Egremont, a bed of marble limestone extends nearly through the town.

There can be no doubt that greater facilities for the transportation of the Berkshire marble—such as a rail road to the Hudson—would greatly increase the demand for it, by reducing its price. Such facilities will undoubtedly be provided at some future time. For as a country grows older, and increases in wealth and refinement, its valuable and ornamental minerals and rocks will be more sought after and used. The inhabitants of Berkshire cannot, therefore, but regard their inexhaustible deposits of marble and common limestone, as a rich treasure to themselves, and an invaluable legacy to their posterity.

The limestone of Smithfield, R. I. and of Stoneham in this state, bears a close resemblance to that which produces the celebrated Carara marble of Italy. But as yet, few blocks have been obtained at either of these localities, large enough and free enough from fissures, to be used for statuary.

### *Serpentine.*

In richness and variety of colors, this rock exceeds all others; and is, therefore, eminently suited for ornamental sculpture and architecture. The prevailing color is green, of different shades, spotted or clouded, or veined with other colors; and hence its name, from its spotted and striped appearance, bearing a resemblance to the skins of some serpents. In hardness, it varies very much; being in some instances very hard, and in others as easily wrought as marble.

This rock exists in Massachusetts in great abundance, particularly in the Alpine part of the state, or in the Hoosac mountain range.

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The most extensive bed occurs in Middlefield, in the southern part of the town. This bed cannot be less than a quarter of a mile in breadth and two miles long. The colors of the rock are various, and its hardness unequal. If wrought, it might supply the whole world. It yields both the precious and common varieties. There is another bed in the same town, associated with steatite or soapstone. In the west part of Westfield is found another extensive bed of this rock, extending into Russell, of a much darker color, and containing green talc. This has been used in a few instances for ornamental architecture, and has a rich appearance when wrought. Two beds of a similar serpentine are found in Blanford, and another in Pelham, in the south west part of the town. The color of this last is quite dark, and the quantity of the talc is considerably large. A large bed occurs in connection with soapstone, on the north side of Deerfield river, in Zoar, near the turnpike from Greenfield to Williamstown. Specimens from this place resemble those from the celebrated localities of this rock at Zoblitz, in Saxony. Serpentine also exists at Windsor in two beds; and there is an immense bed of it in Marlborough, in the lower part of Vermont, as also in several other towns in that vicinity.

The only locality of this rock in the eastern part of the state, that I know of, is in Newbury, two and a half miles south of Newburyport, near the Boston turnpike, at an abandoned lime quarry. The precious, or noble serpentine is found here very beautiful, and very much resembling that of Cornwall, in England. No serpentine in the state will compare in beauty with this; but perhaps if the other beds were explored by blasting, they would put on a different aspect. Serpentine also exists at Newport, R. I., but I have not seen it in the bed.

Serpentine and limestone, irregularly mixed, form the noted *Verd Antique* marble. Such a mixture occurs at Becket, according to Prof. Dewey, in a bed of gneiss. The limestone is also sometimes mingled with the serpentine at Newbury and at Westfield. I cannot see why these varieties are not Verd Antique, though I would not decide very confidently. At New Haven and Milford, Ct. extensive quarries of Verd Antique marble have been opened.

Considering the extent and variety of serpentine in Massachusetts, it seems not a little surprising that no efforts, or next to none, have been made to use it for ornamental or architectural purposes. In Europe, it is employed for trinkets, vases, boxes, chimney pieces,

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and even columns of large size. In Spain, it is said that churches and palaces abound with columns of this description. If ever the serpentine of Massachusetts shall be extensively wrought, I doubt not that specimens will be obtained, rivalling the finest varieties of Europe. It is not at present easy to obtain hand specimens, that shall give a fair representation of this rock, because it is injured to a considerable depth, from the surface exposure.

### *Steatite or Soapstone.*

This is the softest of all the rocks employed in architecture. This property, rendering it easy to be sawed or cut without injuring an edge tool, and its greasy or soapy feel, are such striking characteristics of this rock, that most people are acquainted with it. It is sometimes called *potstone*, and sometimes, in this country, *freestone*.

Next to the ease with which it may be wrought, its great power in resisting heat, is the most valuable property of this rock. Hence it is extensively employed for fire places and furnaces.

It is also turned into crucibles and small furnaces for culinary use. Inkstands are made of it in great numbers, and various other articles. As it hardens in the fire, it is used in Europe for imitating engraved gems. It has been employed in various countries as a substitute for soap and fuller's earth. Spanish and French chalk are varieties of steatite. Savage nations are said to mitigate hunger by eating this soft mineral; as however it contains nothing alimentary, it can act only as a palliative of hunger.* Those varieties that are most infusible, are employed in England extensively in the manufacture of porcelain.

Steatite, like serpentine, usually occurs in beds of no great extent. They are numerous in Massachusetts, and very commonly they are associated with serpentine, or in the vicinity of it. This is the case in the northwest part of Middlefield, where one of the finest beds of it, in our State, is found; although it contains small masses of *bitter spar*, which renders it less easy to work. But this quarry has been explored more extensively than any other in the state; and the blocks transported to Northampton, and even to Boston. In Windsor are not less than three beds of this rock, from which the New Lebanon shakers obtain it, for converting into inkstands. I was told that a bed of it exists, in Cheshire. Another occurs in Savoy; one in Hins-

* See Brongniart's Mineralogy.

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dale; one also in Blanford, which is wrought and produces an excellent stone. Two beds occur in Granville, which I have not visited. Another is opened in Zoar, where are two distinct varieties, one nearly white, another of a deep green. In Rowe is another quarry, where these two varieties are equally distinct. At the two last named localities, however, the rock is distinctly green and white talc; and indeed, the two minerals (talc and steatite) are probably in every case identical.

On the east side of the Connecticut river are several beds of this rock, more or less quarried in every instance; but in general not explored deep enough to develop the rock in its unaltered character: for the air and moisture generally affect it for several feet deep. In the south part of Shutesbury is one bed: in the southwest part of Wendell another: and two miles east of the centre of New Salem, a third. The quality of the rock at these places, is not as good as that west of the river; though it has scarcely been explored at all, at the localities above mentioned.

In Groton is a bed of soapstone on which considerable labor has been expended. Its width appears to be 10 or 12 feet, and it descends into the earth towards the southeast; dipping about 30°, and lying between layers of mica slate. It is not of the best quality, being somewhat too hard: yet its proximity to Boston, Newburyport, and Salem, will probably render it an object of importance.

In the states adjoining Massachusetts, and not many miles from its limits, several extensive and valuable quarries of soapstone have been opened. In Vermont, they occur at Marlborough, Windham, and Grafton. In New Hampshire, very fine steatite is found at Francestown. In Connecticut, a bed is wrought in Somers. The Grafton steatite is employed extensively and successfully for aqueducts: the joints being connected by sheet lead. A bed of this rock exists in Smithfield, R. I.; although it is not wrought; there are beds also in several other places in that state.

From the preceding statements it seems, that in this state, and contiguous to it, immense quantities, and every variety of steatite exists. As yet, however, the working of it has hardly commenced; although almost every man is aware of the value of this rock; and there are few who do not sometimes stand in the need of it for economical purposes. As the facilities for transportation are multiplied, and particularly in the mountainous part of the state, its use will undoubtedly be greatly extended. At present I believe, the shops in Boston are supplied from Vermont and New Hampshire.

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### *Graywacke.*

For the most part, this rock furnishes a coarse stone only fitted for a common wall; but sometimes its stratification is so regular, and its grains are so fine, that it answers well for underpinning, step stones, &c. It is quarried I believe in Brighton, and some other towns in the vicinity of Boston. At Pawtucket, on the R. I. side of the river, is an extensive quarry of a fine grained and slaty variety, which I should judge would form a good flagging stone; and immense quantities have been taken away for this object and for other purposes. On Canonicut island in that state, is also a valuable quarry of this rock.

Graywacke is sometimes beautifully amygdaloidal: that is, it contains numerous rounded or almond shaped nodules of some other mineral. In these instance, however, the base of the rock is rather *Wacke*, than graywacke. This wacke (which resembles indurated clay,) often forms the cement of graywacke. In Brighton it is of a reddish color, while the imbedded nodules are sometimes white, and sometimes white feldspar with epidote, which is of a lively green color; and these substances are not only in rounded masses, but in veins of irregular shape. The rock is hard and may be even polished. It then resembles porphyry and is very elegant. A fine example of this may be seen at the residence of H. A. S. Dearborn, *Esq. in* Roxbury, forming a pedestal for the bust of his father. It is only slightly polished, but would generally be mistaken for porphyry.

A similar amygdaloid occurs in Brookline, Newton, and Needham. A variety still more beautiful is found at Hingham. The color of the base is chocolate red; and the nodules are red, green and white. I do not know whether large blocks can be got out.

I think upon the whole, however, that the finest amygdaloid occurs in Saugus, on the hill a few rods east of the meeting house. The base is a pleasant green, and the nodules white, compact feldspar, generally spherical, and thickly interspersed. If polished, it must be exceedingly fine; and I have little doubt that large blocks can be obtained at this locality.

### *Argillaceous Slate.*

A more common name for this rock, at least for the most useful variety of it, is *roofslate:* because it is used for forming the roofs of houses. I have been inclined sometimes to regard the ranges in Quincy, Watertown, Charlestown, and Chelsea, as a fined grained variety of



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graywacke; but this question may be more properly considered in the scientific part of my report. At any rate, this rock, in the towns above mentioned, does not split into layers sufficiently thin for roofing. But it is valuable for grave-stones, the covering of drains, flagging stones, &c; and for these purposes it is extensively wrought in Quincy, Charlestown, &c.

*Novaculite.*

This is a variety of argillaceous slate which is known in the arts under the name of hone, oil stone, turkey stone, and whet stone. It is in beds of argillaceous slate in Charlestown, Malden, and Quincy. It is not however of a very good quality; and I am not aware of its being used for hones, or even for whet stones; although it might answer the purpose, if better materials could not be found elsewhere.

*Roof Slate in Worcester County.*

The range of slate exhibited on the Map in the towns of Boylston, Lancaster, Harvard, Shirley and Pepperell, is associated with the peculiar mica-slate that contains the Worcester coal. It answers for roofing in some parts of the bed and has been quarried for this purpose in Lancaster. It has been wrought considerably in Harvard and Pepperell for grave stones; and is transported a considerable distance for this purpose. The stratum is narrower near the north line of the state: but I have found no time to ascertain how far it extends into New Hampshire.

*Connecticut River Slate.*

Although a large part of Bernardston is represented as composed of this slate, yet its characters are not perfectly developed, till we pass into Vermont. In Guilford, Brattleborough, Dummerston, and even 50 or 60 miles northward, it produces an excellent material for roofs, writing slates, &c.; and extensive quarries are opened in it in those towns. The best slate used in Massachusetts probably comes from this range. In Bernardston it is quarried to some extent for grave stones.

*Berkshire Slate.*

The mica slate of the western section of the State, passes gradually into roof slate, and in most instances the characters of the latter are not very perfectly exhibited, until we have entered New York. There, however, in Hoosac, and other towns, it is quarried extensively for roofing: and the western part of Massachusetts is always sure of a supply of this valuable material from that quarter; if not within its own limits.

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### *Graphic Slate.*

This occurs in small quantities, along with the argillaceous slate, in Lanesborough and Williamstown; also abundantly in Bennington, (Vt.) Prof. Dewey, from whose account I derive this fact, does not state whether it is pure enough to be employed by artificers for drawing lines, and for crayons; uses to which this mineral has been applied in other countries.

### *New Red Sandstone.*

This rock occurs in Massachusetts, only in the vicinity of Connecticut river; along which, on both sides, ranges extend from Middletown, (Ct.) to Vermont. It affords large quantities of good stone for building and other purposes. Some of the numerous varieties of this rock are slaty; and either of a red, gray, or black color. These varieties furnish good flagging stones; and the side walks of all the principal places along the river, are chiefly covered by them. In the more common varieties, the strata are from six inches to two feet or more in thickness; and for the most part, the color is red, though sometimes gray. From hence is obtained most of the rock of this formation used in architecture. The most delicate variety occurs in Long Meadow and Wilbraham. It consists simply of an almost blood red sand, cemented probably by iron. It is remarkably uniform in its color and composition; and forms a beautiful and most valuable building stone; though liable to be easily injured and sometimes disintegrating by exposure. The quantity of this rock is inexhaustible, and it occurs only from three to five miles from Connecticut river; the intervening region being nearly level. A great number of quarries are now explored; but I have no means of determining how great is the demand for the stone. The celebrated Chatham quarries, on the banks of Connecticut river, in Connecticut, are opened in the same kind of rock, although of a coarser variety.

Another variety of the new red sandstone, quarried in many places in Massachusetts and Connecticut, is coarser than the Long Meadow stone; but being harder, it is more enduring, though less elegant. A gray and rather coarse variety is used in some places, e. g. in Granby, (Mass.) This, indeed, with the other varieties mentioned above, forms excellent underpinning, door and window caps, and foundations, and door steps; and, like the Berkshire marble, they are sometimes wrought into sinks and other similar articles. The ease with which the rocks of this formation are wrought, forms a great recommenda-

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tion: and were they as enduring as gneiss and granite, these latter rocks would soon be neglected.

### *Tertiary Formations.*

I suspect there are only two varieties of these formations in Massachusetts: one developed most perfectly in the west part of Martha's Vineyard, and the other, and the most extensive, along the Connecticut river, although common in limited patches all over the State. Neither of these formations furnishes stones sufficiently firm for architectural purposes, although in a few instances, I have observed limited beds of the clay, sand and pebbles, that compose these formations, to be in a state of consolidation. Nearly all our clays, however, are in the tertiary formations, and these are so important in an economical point of view, as to demand a particular description.

### *Porcelain Clay.*

This is the purest of all the clays, and is the only one employed in the manufacture of porcelain, or China ware. It results from the decomposition of granite; and hence we might expect to find it in Massachusetts; since we abound so much in granite. As, however, the manufacture of this ware has but recently been introduced into this country, little effort has been made to discover this clay. It has been announced, as existing in several towns in the State, although the bed in Savoy, described by Prof. Dewey, in his account of the geology of Berkshire, is probably the only one known that merits a notice in this report. It is said to constitute a layer three feet thick, and of unknown extent, several feet below the surface. It contains coarse particles of quartz, which can, however, be separated by sifting. It resembles the porcelain clay of Monkton, (Vt.) which is regarded as of a good quality. It forms a very cohesive white paste, and crucibles made from it, and burned in a common fire, were sonorous when struck. A similar clay is said to occur in large quantity, in Canaan, (Ct.) According to Dr. Porter, it is found likewise somewhat abundantly in Plainfield.

A part of the extensive clay beds on Martha's Vineyard, appears to be porcelain clay; especially in Chilmark: though a large proportion of mica is mixed with it.

### *Potter's Clay.*

This is the clay so extensively employed for common pottery, pipes, tiles, and bricks. And fortunately it is found on almost every

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square mile in the State. We have two quite distinct varieties. The purest, sometimes called pipe clay, is found almost exclusively on Martha's Vineyard. This is white, and contains usually so little iron, that when burnt, it becomes still whiter, and will resist a high degree of heat. Hence it is employed for making what are called fire bricks, which are used for lining furnaces. White pottery is also made from it. But the more common clay turns red on burning, in consequence of the oxide of iron in it; and this renders it much easier to be melted by the heat, and consequently diminishes its value. It is of immense value, however, to the State; because good bricks may be made from it; and because it exists so abundantly in almost every town. The same tertiary formation that supplies clay so plentifully, yields an abundance of sand for the mortar by which they must be cemented. This sand, however, is generally rather fine; and I am inclined to believe, from all that I can learn, that our mortar is generally prepared from sand that is too fine.

### *Substitute for Fuller's Earth.*

The common clay along the Connecticut river, has recently been employed in Northampton, in the place of fuller's earth, in cleansing cloth. A considerable quantity of it has also been sent down the river, for use in other places. This clay is fine grained, and when dry, adheres strongly to the tongue. It is said to answer exceedingly well in the place of fuller's earth; on this point however, I have my information at second hand. A clay of precisely the same character has recently been put into my hands from Leominster, where it occurs in alternating layers with sand. Some of the sand of this tertiary formation, especially in the gneiss region, is of a delicate white color, and quite pure. In some cases, when its finest particles are mixed with clay, it will answer very well for giving a polish to brass and other metals.

### *Clay used in the manufacture of Alum.*

The white clay of Martha's Vineyard, is employed extensively in the manufacture of alum, in Salem; by the process of Chaptal, I suppose; although the details are, I believe, kept secret. By his method, sulphur and nitre are burnt in a chamber with the clay, which, after a considerable time, is lixiviated, and the ley evaporated. There is indeed, a variety of Clay which contains sulphur, that will produce alum without the addition of other materials; but I cannot

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believe that from the Vineyard to be of this description. At any rate the alum which the Salem company produce, is of a good quality, and is made in large quantities. They formerly obtained their clay from Gay Head; but they now procure it of a better quality from the west side of the island, in Chilmark.

### *Clay as a Manure.*

Writers on agriculture, speak of clay as next in value to marl, for manuring light and sandy lands; and I cannot but think that our farmers have yet something to learn on this subject. Marl, they cannot procure, but at a great expense; but clay is usually at hand—and we have very much of the land which it will help. Yet I am not aware that in any instance the experiment has been thoroughly made.

### *Marl.*

Marl for our farmers, scarcely exists in the State, except in a few places in Berkshire county, where it is of little use, because the soil already contains so much calcareous matter. It is said to have been found in Lancaster, but whether in large or small quantities, is not stated. Judging from the nature of the surrounding country, I venture to predict that it will not be found there in abundance. In Duxbury also, it occurs in considerable quantity. In Pittsfield, is a bed of earthy marl, but not extensive. It is found more abundantly, it is said, in Lenox; and it exists also in Williamstown.

### *Peat.*

This useful substance must be regarded as alluvial in its character, since the process of its formation is now going on. It results chiefly from mosses and other plants, more or less decayed. In the eastern part of the State, it is found in great quantities. West of Worcester, it has scarcely been sought after, on account of the comparative abundance of wood. It will probably, however, never be found so abundantly in the western part of the State, as in the eastern. I have ascertained the existence of peat in the following towns, and do not doubt that it occurs in many others. There are two varieties; the fibrous and the compact. In the former, the moss, turf, and roots out of which peat is formed, have not lost their fibrous structure: but in the latter, they are converted into a compact and nearly homogeneous mass.

The fibrous and compact varieties, probably exist at nearly every locality. I am sure of their occurrence in Cambridge, Newton, and

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Lexington; and in large quantities. Peat is abundant in Seekonk, Uxbridge, Cohasset, Duxbury, Hingham, Medfield, Walpole, Wrentham, Dover, Framingham, Sudbury, Topsfield, Ipswich, and Nantucket.

It exists and has been dug in greater or less quantities in Pittsfield, Leverett, Shrewsbury, Lancaster, Southborough, Hopkinton, Medway, Halifax, Stoughton, Boylston, Reading, Milton, Needham, Concord, Billerica, Bedford, Waltham, Watertown, Acton, Wilmington, Danvers, Chelmsford, Hamilton, and in nearly all the towns in Barnstable county; certainly in Yarmouth, Brewster, Orleans, Eastham, Wellfleet, and Truro. I have marked on the Map, only the most important localities.

The value of peat for fuel, is generally known; but I apprehend that it is not generally known that a still more important use may be made of it in agriculture. Peat swamps in Massachusetts are commonly surrounded by light and poor land. While the swamp itself contains too much vegetable matter, imperfectly decomposed, the land around it contains too little. All that is needed, therefore, is to employ the excess of the one, to supply the deficiency of the other. Hence, as an English writer remarks, "peat or vegetable matter, should be carried from the peat moss to the poor soil, and the surface mould from the poor soil to the peat moss." The peat ought indeed to be converted into manure, by lying awhile in a barn yard, or by mixing lime, or other substance with it; and there are particular directions to be observed as to the whole process, which this is not the proper place to explain. But they can be learned in works on agriculture; and whoever undertakes thus to make use of peat, without learning the results of enlightened experience on the subject, will probably fail in his object. But since great benefit has been derived from the use of peat as a manure, in England and Ireland, no reason can be assigned why it may not thus be applied in this country with equal success.

I cannot but regard the existence of so large quantities of peat, on Cape Cod and Nantucket, as a great blessing to the inhabitants. Yet from the little of it, which I observed to be dug there, I am apprehensive they do not realize its value. Most of the soil in those counties is precisely of that kind, which needs the admixture of much vegetable matter. If the peat swamps could be drained, and after the removal of a portion of the peat, be covered with lighter and warmer soil, but few years would elapse before they would become

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fine grass plats; while the sandy and more elevated land, enriched by the peat, would produce large crops of Indian corn, rye, and other vegetables. That this is not mere hypothesis, has been demonstrated on a small scale, at least, upon one farm, that of the Hon. John Reed, of Yarmouth. Since the inhabitants of Cape Cod are beginning to turn their attention more and more to the cultivation of the soil, may we not expect that such a transformation will ere long be common.

A few other mineral substances, interesting in an economical point of view, may perhaps be appropriately noticed in this place.

1. *Granular Quartz and Sand for the Manufacture of Glass.*

From some unknown cause, the granular quartz in Cheshire, Berkshire County, is so much disintegrated, that it easily crumbles into a beautiful white sand. This forms a good material for glass, and has been employed for this purpose a number of years; formerly in Chesbire and Warwick, Mass., and in Utica, N. Y.; and at present in Keene, N. H. It answers well for crown and cylinder glass. The quantity is inexhaustible. It is sold at the road, one mile from the bed, at 6¼ cents per bushel. This sand is employed extensively in Berkshire in the process of sawing marble.

I am inclined to believe that some of the sand associated with the tertiary and diluvial formations in the state, particularly in the gneiss region, is pure enough to be employed in the manufacture of coarse kinds of glass: such for instance as is found in Pelham and Leominster. The purest and coarsest variety, however, that I have met with, forms the shores of Lock's Pond, in the N. West part of Shutesbury. Similar sand, I believe is used for glass making in the eastern part of Connecticut.

When examining the milk white quartz, that exists in mountain masses in the east part of Cumberland, R. I: the enquiry forced itself upon my attention, whether it might not be employed in the manufacture of glass? Those particularly acquainted with that manufacture, can, however, judge better of this matter than myself.

2. *Buhrstone.*

In the same hill that furnishes the fine stratified quartz rock for architectural purposes, in Washington, three miles from Pittsfield, a porous quartz is found, which greatly resembles, and is used instead of buhrstone, for millstones. Whether geologists would allow it to be

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real buhrstone, may admit of doubt; since it is unquestionably a rock of primitive formation; whereas the real Paris buhrstone, is a member of the tertiary formation. But in an economical point of view, this question is of little importance, since the rock seems to answer nearly all the purposes of buhrstone so well that it is employed somewhat extensively for millstones. These are manufactured near the ledge, and sold for seventy or eighty dollars each. I am told that they answer well, especially for the coarser kinds of grain. I should presume that the only difficulty would lie in their being less tough than the genuine buhrstone. The quantity at the ledge is inexhaustible.

Sometimes our citizens employ the finer and more compact varieties of granite for millstones. I have seen even a coarse *conglomerate*, or *puddingstone*, used for this purpose. And while upon this subject, I cannot but express my surprise that no attempt has been made to employ our greenstone, and other hornblend rocks, for millstones. In Great Britain, basalt has been, within a few years, used for this purpose, and found even superior to the French buhrstone; and our greenstone is only a variety of the same rock: indeed, some of our greenstone cannot be distinguished, by the eye, from the European basalt. It is generally extremely compact and tough; and although its preparation might require a little more labor than the buhrstone, yet it would doubtless last enough longer, amply to pay for the additional labor. In the vicinity of Boston and along the Connecticut river, as may be seen on the Map, greenstone exists in great quantities. It also occurs in small beds throughout the whole extent of the gneiss region; and of a kind, which I should suppose from its appearance, would answer the purpose even better than that of the extensive ranges above mentioned.

## *Coal.*

Of this mineral, the object of so much interest in every civilized country, there are found three distinct species; all of which are sometimes employed as fuel. The most common in Europe, which is there considered the best, is the bituminous coal, or that containing *bitumen*. This burns readily with a yellow or white flame. A second species is the anthracite, or *stone coal;* which is generally described as burning without flame, because destitute of bitumen. The anthracites of this country, however, burn with the flame that results from the combustion of hydrogen; this gas existing in a state



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of combination, either with the carbon, or in the water which the anthracite contains; and it is liberated by the heat. The great difficulty in the use of anthracite, consists in igniting it: a difficulty which has almost disappeared before the ingenuity of our countrymen. In Europe, anthracite has been described as of little value: with the exception, perhaps, of Killkenny coal. But our anthracite is either of a quality superior to the European, or we have learned better methods of employing it. All the coal obtained from the inexhaustible beds of that mineral along the Susquehannah, Lehigh, and Schuylkill, in Pennsylvania, is anthracite; and wherever it is skillfully used, I believe it is decidedly preferred to the best bituminous coals of England, or the United States. The coal from Rhode Island, (chiefly from Portsmouth, at the north end of the island,) is also anthracite. The Worcester coal belongs to the same species: indeed, every enlightened man in this country now regards our anthracite as a great national blessing. But in Great Britain, their geological writers speak of the anthracites found in Ireland and on the European continent, as "carbonaceous matters, that can never be profitably worked, so as to become objects of statistical interest."—(Ure.) And Mr. Conybeare, in his admirable view of the English coal formations, speaks of the deposit of bituminous coal, as "the only one capable of being applied to purposes of extensive utility, which appears to exist in the whole geological series." Is not this an example of that hasty generalization, to which geologists are so prone?

A third sort of coal is commonly enumerated, called *lignite*, consisting of wood partially carbonized, and still retaining its form, more or less distinctly. All the kinds of coal, that have been mentioned, are found in Massachusetts; the lignite on Martha's Vineyard; the bituminous coal on the Connecticut river, particularly at South Hadley; and the anthracite at Worcester, and in small quantities, in the north part of Middleborough, in Bridgewater, and West Bridgewater, and near the line of the State in Cumberland, Rhode Island.* But do they occur in sufficient quantity and of such quality, as to render them of any statistical value?

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* Also in the sandstone at the Southampton level. Within a few weeks it has likewise been stated, that good coal, of some sort and in great abundance, exists in Braintree. Through the kindness of a scientific friend, residing in the vicinity, I learn that a company are about boring the rocks near the Rev. Mr. Perkins' Meeting House in search of coal; and he was told that in digging several wells, in the neighborhood, a substance was found resembling coal, which "burnt with a brilliant flame and a strong sulphurous smell," although he could not obtain a specimen.

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The lignite exists only in small quantities in the clay of the Vineyard: and even if it formed extensive beds, it would not be of much importance; although it is used as fuel in some parts of Europe.

Genuine bituminous coal, in sufficient quantity to be worked to advantage, has never been found, except in connection with a particular series of rock, called the Coal Formation. Such a formation has long been supposed to exist along the Connecticut: extending across the whole of Massachusetts and Connecticut; and the strata have been bored in South Hadley, at least, in two instances, and once by a gentleman familiar with the real European coal formations. Several years ago, I myself delineated a coal formation, on a geological map of the Connecticut, published in the American Journal of Science. But further examination has brought me, unwillingly, to the conclusion, that no such formation exists along the Connecticut, and that the one which I then regarded as real coal measures, is in fact the new red sandstone, or its equivalent. In another part of this report, I shall give my reasons for this conclusion. But I would remark, that I do not feel so much confidence in this opinion, that I would urge the entire abandonment of all efforts to find coal: for the facts stated in respect to anthracite, will justify the opinion, that even if the rocks under consideration, are new red sandstone, bituminous coal may exist in it, in sufficient quantities to be worth exploring; although in Europe it occurs in such rocks only in thin seams. Certainly the coal found at South Hadley was of a superior quality.

If, as I suppose, the rock under consideration be the new red sandstone, there is another fact that ought to be recollected, viz. that this rock, in other parts of the world, is associated with rock salt, salt springs, and gypsum. No trace of rock salt has been found along the Connecticut; and as yet only a small quantity of gypsum has been discovered. Professor Silliman found a little of this mineral in the greenstone, associated with the sandstone in Deerfield, and Mr. Davis, Principal of the academy in Westfield, found the same in thin scales, between the layers of the shale, connected with the sandstone, on the banks of Westfield river in West Springfield. These facts, especially the latter, are sufficient encouragement for the research after gypsum. And when we recollect that on account of the softness of this mineral, it is liable to be deeply worn away at the surface, we should by no means despair of its existence in the valley of the Connecticut. I have compared a collection of specimens from the new red sandstone, that contains the gypsum of Nova

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Scotia, with the rocks of the Connecticut valley, and they can hardly be distinguished from each other.

As to anthracite coal, it seems to occupy a wider range among the rocks, than genuine bituminous coal. Generally, however, the former occurs lower down in the rocks—that is in older rocks—than the latter. Sometimes it is found in what are called transition rocks; and sometimes in the primitive. In this country it is found in both these classes of rocks. We have in the United States, at least three extensive deposits of anthracite: the largest is in Pennsylvania; the next largest in Rhode Island; and the smallest in Worcester. I have examined them all, and have come to the conclusion, that all the rocks containing this coal, are at least, as low down in the series as the transition class: and I am rather of the opinion, that they all lie below the Independent coal formation of Europe; I mean on the scale of rocks. I suspect that the Pennsylvania anthracite occurs in the higher beds of the graywacke, perhaps even in the millstone grit, and the Rhode Island anthracite, in the lower beds of the graywacke. There is no geological connection between the Rhode Island and the Worcester coal, as Dr. Meade and others have supposed. By inspecting the Map, the two localities will be seen to be separated by granite and gneiss, from twenty to thirty miles across. The Worcester coal occurs in an imperfect kind of mica slate. It is what Humboldt calls transition mica slate: for a few miles north, it passes into distinct argillaceous slate. Following the range south from Worcester, it becomes more decidedly micaceous, and probably there forms a bed in gneiss. Indeed, in Dudley, I saw the same rock surrounded by gneiss, and highly impregnated with anthracite.

The bed of anthracite in Worcester, is about seven feet thick, and has a moderate dip to the northeast. It has been explored only a few feet, and the operations are now suspended. To continue them advantageously, it will be necessary to go down the hill, and remove the soil so as to find the lateral outcrop of the bed, in order to avoid an accumulation of water. This work has been already commenced.

The Rhode Island beds of this coal were opened several years ago, before the value of it was justly appreciated by the community. The sales not being brisk, the works were abandoned, and have never since been resumed; so that on account of the rubbish, I was unable to ascertain the width of the beds. I have always understood, however, that there was abundance of coal. The beds are less favorably situated for working, than that at Worcester.

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The extensive, and rapidly increasing demand for the Pennsylvania coal, is a conclusive testimony to its first rate excellence. The experiments of Mr. Bull of Philadelphia, as well as those of Professor Silliman, recorded in the eleventh volume of the American Journal of Science, show that the best Rhode Island coal is not greatly inferior. The Worcester coal, burns with more difficulty: but gentlemen who have fairly tried it, and on whose testimony I can depend, assure me, that it may be employed successfully, and comfortably for fuel. There can be no doubt, that its quality is inferior to the coal of Pennsylvania, and also to that of Rhode Island.* But it may be very much inferior, and yet for many purposes, be exceedingly valuable. The fact is, anthracite has to struggle with prejudices wherever it is first introduced, arising chiefly from the comparative difficulty with which it is ignited; and it happens in regard to this substance, as with most things new and untried, that the community generally feel, as if their business was to find as many objections to it as possible; and the man who would bring any new substance into general use, needs no small share of patience, and perseverance. Dr. Meade states, that an experiment, made several years ago at Smithfield, upon the burning of limestone, with the Rhode Island coal, and another upon the burning of brick, in the vicinity of Boston, were thought to be complete failures, because the heat was so intense, that the surface of the lime and of the bricks was vitrified; whereas the fact ought to havet aught the experimenters, that a more careful regulation of the heat would ensure success. Indeed, I predict, that ere long, in nearly every case where a strong and steady heat is required, anthracite will be found superior to all other kinds of fuel; and that the anthracite of Rhode Island, and even that of Worcester, will be considered by posterity, if not by the present generation, as a treasure of great value. The Pennsylvania coal may indeed, for a great many years, command the market: but I apprehend, that the time will come, when the expense of its transportation to the Eastern States, and the increasing demand for it, will lead to the re-opening of the pits, that are now abandoned in New England.

In coming to the conclusion, that the anthracite of Worcester, and even that of Rhode Island, are inferior to the Pennsylvania anthra-

* According to the experiments of Mr. Bull, a pound of the best Pennsylvania anthracite maintained ten degrees of heat in a room, 13 hours and 40 minutes; a pound of the Rhode Island coal maintained the same heat in the same room, 9 hours and 30 minutes; and a pound of the Worcester coal, kept up the same heat only 7 hours and 50 minutes. It is a curious fact that the specific gravity of the Worcester coal, is one third greater than that of the coal from the two former localities.

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cite, geological considerations confirm the results of experiments. Baron Humboldt, who has probably seen more of the rocks of the globe, than any man living, remarks, that "anthracite is a more ancient formation than coal, and a more recent formation than graphite, or carburetted iron. *Carbon becomes more hydrogenated, in proportion as it approaches the secondary rocks.*" This last sentence, divested of its technical obscurity, means, if I understand it, that the newer the rock in which the carbon is found, the greater will be the quantity of hydrogen combined with it: and we know that an increase of hydrogen, will render coal more combustible. Now if I am correct in the opinion, that the Worcester anthracite is contained in older rocks than that in Rhode Island, and the anthracite of Pennsylvania, in rocks still newer than those of Rhode Island, we might expect, that the newer would prove the best for fuel, and the older the poorest, because containing the least hydrogen. The quantity of carbon, however, in the Worcester coal, is believed to be nearly as great, as in that from Rhode Island and Pennsylvania; although no analysis has been made of the former. But carbon is less combustible than hydrogen. Yet I can hardly believe, that a coal, which contains probably not less than 90 per centum of carbon, should not be employed, in some way or other, as valuable fuel.

The formation which I have denominated gray wacke, and which contains the anthracite in Rhode Island, extends northerly in interrupted patches, nearly across the whole of Massachusetts; as may be seen on the Map. The most southern patch, embraces nearly the whole of Bristol and part of Plymouth county: the second extends from Wrentham to Dedham: the third includes several towns in the vicinity of Boston; and the fourth is in Rowley and Newbury in Essex county. I know of no reason, why one part of this formation should contain anthracite rather than another: and hence we may reasonably look for it in any part of the graywacke formation, exhibited on the Map. The transition mica slate, containing the Worcester anthracite, occupies, as the Map will show, a large portion of the northeastern part of the state; and it would not be strange, if other beds of that mineral should be found in it.

### *Graphite, Plumbago, or Black Lead.*

This substance has the color of lead, leaves a trace like that metal upon paper, and bears the common name, *black lead;* but it contains no lead. It is composed of above 90 per centum of carbon, and the rest is

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iron and earthy matter. Hence it differs but little from some varieties of anthracite. It seems indeed to be the form in which carbon occurs in the oldest of the rocks. In Massachusetts it exists in gneiss, at the most important locality, which is in Sturbridge. It there occurs in a bed, varying in width from an inch to about two feet, and traceable along the surface, nearly one hundred rods. A number of years ago this bed was opened; and several tons of the graphite obtained. It was then abandoned; but within a few years the exploration has been recommenced, and already more than a hundred tons have been obtained. In some places the excavation is six or seven feet deep. The quality of the graphite is excellent; and would not suffer by comparison, with almost any in the world. To what extent it may be obtained, it is not possible at present to determine. The fact, that the bed descends, almost perpendicularly, into the earth, is rather unfavorable to the miner. Yet, as it is found upon elevated ground, the mine can be conveniently drained by lateral cuts or adits to a considerable depth; and probably the exploration may be profitably continued for a long time with little machinery.

Graphite is employed for pencils, crucibles, lubricating machinery, &c. It occurs at several other localities in Massachusetts, besides that in Sturbridge, but not in large quantities, except perhaps in Hinsdale. It is said that a good bed of it has been opened in New Hampshire.

### *A substitute for Emery.*

No real emery has yet been found in Massachusetts; but a rock composed of garnet and anthophyllite or augite, occurs in North Brookfield, which is employed as a substitute for that mineral, and it is said to answer well. The powder of the garnet, although much inferior in hardness to real emery, is indeed sometimes called in commerce, *red emery*. The rock in Brookfield is abundant, and may prove valuable.

### *Mineral Waters.*

No mineral springs of much notoriety are found in the state, although chalybeate springs are very common, and are useful in cutaneous and some other complaints. Nearly all these springs rise in low ground containing bog ore. The Hopkinton spring is of this description, and is probably more resorted to than any other in the state. This contains, among other ingredients, carbonic acid and carbonate of lime and iron. The spring in Brookfield is similarly situated, and contains some magnesia and soda, as

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well as iron. It is a place of some resort. A mineral spring exists in Shutesbury, abounding in muriate of lime, and it is somewhat visited. Chalybeate springs exist in South Hadley, Deerfield, and indeed, in almost every town in the state. In Mendon I was shown a mineral well, in the waters of which, chemical tests indicate muriate of lime and carbonic acid in a free state. No use was made of the water, except as a substitute for yeast.

In Williamstown is a tepid spring very much resembling that in New Lebanon, N. Y. Bubbles of gas are constantly escaping, which, according to Prof. Dewey, are atmospheric air, and not simply nitrogen, which is common in such springs. This spring furnishes a convenient place for a bathing establishment; and though the saline ingredients are in small quantity, the water is useful in several cutaneous disorders. In Adams, Pittsfield, and Great Barrington, are springs useful for the same complaints. In Hinsdale is a spring from which issues sulphuretted hydrogen; and from the decomposition of this gas, a deposit of sulphur is made upon the earth around.

*Other non-metallic Minerals; either useful or ornamental.*

It may be well in this place, perhaps, to notice briefly a few other mineral substances in the state, such as are employed in Europe for useful or ornamental purposes. In this country the demand for them is yet comparatively small, and we have few artists devoted to their preparation; so that no demand exists for these minerals, as is the case also with our porphyries.

In Hatfield, is an immense quantity of the sulphate of barytes, of a superior quality. Within a few years, a patent has been taken out in England, for the use of this substance, as a paint, to be employed in those situations where lead paint is liable to be acted upon by moisture, acids and other chemical agents. In such cases, this barytic paint is excellent. I have been in the habit, for several years, of having various articles in the laboratory, such as the pneumatic cistern, gazometer, &c. covered with it; and it answers a good purpose, although I have prepared it, not according to the patent, but simply by grinding it in a plaster mill and mixing it with oil. The greatest defect in this paint, seems to be, that it has less body than lead, although I doubt not that a remedy may be found for this difficulty. When the barytes is thoroughly pulverized, and mixed with boiled linseed oil and lampblack, it is superior to any thing I have ever seen, for labeling glass bottles, &c. in a laboratory, and indeed for any situation exposed to active chemical agents.

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The new alkali, lithia, is found chiefly in two minerals, called petalite and spodumene, which, in Europe, are very rare. But in Massachusetts they occur in very great quantities; particularly the latter. The former is found in Bolton and Westfield, and the latter in Goshen, Chesterfield, Norwich and Sterling. The lithia can now be obtained, by a chemical process, from the minerals of these localities, in any quantity; and should it prove to be a useful substance, as every alkali is likely to be, these minerals may become an object of importance.

Among the minerals in the State, that may be employed by the lapidaries, for ornamental purposes, may be mentioned chalcedony. Almost all its varieties occur in the greenstone ranges, in the valley of the Connecticut, and some of the agates which it forms are quite large, and need only polishing to be elegant. It occurs also in various other parts of the state, and in masses considerably large; but perhaps at none of the localities in such quantity, and of such quality, as to render it worthy the attention of the lapidary.

Agates, both banded and brecciated, are found in the State, made up of quartz, hornstone, chalcedony, &c. of various colors. The largest and most perfect specimen of quartzose agate breccia, which I have found, was shown me at Rochester Centre; and I was told it was broken from a much larger mass, in the same town.

In Saugus, near the center, is a fine locality of red jasper. It is not unfrequently striped, and if needed for ornaments, would undoubtedly admit a fine polish. The bed or vein has not been explored at all, except that a few fragments have been broken off by the passing mineralogist.

We have beryls, somewhat numerous, and sometimes very large; but probably they are not delicate enough, and are too much divided by seams, to be employed for elegant ornaments.

A garnet or cinnamon stone was found by Professor Webster in Carlisle, which, in its natural state, is a splendid gem. Good specimens, however, cannot now be obtained, without farther exploration of the soil or the rock.

The quartz crystals, that occur at several localities, are very perfect, and might be used for watch seals, ring stones, spectacles, &c.; those, for instance, found at Pelham, Southampton and Williamsburgh. The smoky quartz occurs at a few localities, and is fine for ornaments. At Southampton, Pelham and Middlefield, is found the yellow quartz, which, in some instances, can scarcely be distinguished from genuine topaz. The rose red quartz occurs at several places,



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as at Chelmsford, Chesterfield, Chester, Williamsburgh and Blanford; and sometimes, I am inclined to believe, of a good quality to be wrought into ornamental articles; particularly, at one or two localities recently discovered. The amethyst, which occurs in greenstone, along Connecticut river, is of a delicate color, and, if it can be obtained in sufficient quantity, may be employed in the ornamental arts.

Some of the adularia that is common in the gneiss of Brimfield, Southbridge, &c. I presume, would answer well for watch seals, rings and trinkets; particularly, a greenish variety, occurring near the center of the latter place. I have seen an elegant watch seal, cut from the adularia of this locality.

It ought not to be forgotten, that amber has been found in Martha's Vineyard, at Gay Head, and on Nantucket. At the latter place, one or two masses were found, weighing a pound or more. The tertiary formation of these islands is precisely the place where we might expect to find this mineral, especially in connexion with the lignite.

### METALS AND THEIR ORES.

It remains only, in giving the economical geology of Massachusetts, to describe the metals and metallic ores which have been found in the state, and are applicable to useful purposes. I shall begin with the metal most abundant and most useful: viz.

### *Iron.*

The bog iron ore is most common, but I shall give an account of the different species in regular order.

#### *Mine of Arsenical Iron and Carbonate of Iron, in Worcester.*

In the town of Worcester, in mica slate, is a bed of these ores, which was explored to some depth, a number of years ago, in search of the precious metals. A little galena or lead ore is found also, in the same mine. As the excavations are now nearly filled up, it is impossible to judge of the extent of this bed.

Arsenical iron is seldom explored for the purpose of getting malleable iron from it; although it is sometimes employed for the arsenic it contains, and for the preparation of sulphuret of arsenic. The carbonate of iron is an excellent ore; and has received the name of steel ore, because it may be readily converted into steel.

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### *Mine of Carbonate of Iron and Zinc, in Sterling.*

This is a bed, in mica slate, just like that at Worcester; and was extensively explored forty or fifty years ago, for the same purpose which led to the opening of that bed, viz. the discovery of gold and silver. The carbonate is the most abundant ore, and lies scattered about the excavation, in considerable quantities; although the sulphuret is common, which is sometimes arsenical. A reddish, foliated sulphuret of zinc also occurs here, in considerable quantity, and some sulphuret of lead. Whether this mine will be found worth exploring, it is difficult, in its present state, to determine. If it afford the carbonate of iron in large quantities, it will certainly repay the effort. It lies about a mile and a half south east of the center of the town.

### *Chromate of Iron.*

It ought to be recollected, that a small rounded mass of this ore, so valuable in the preparation of the paint called *chrome yellow*, was found, a few years since, in Cummington, by Dr. Porter.

### *Phosphate of Iron.*

The earthy variety of this ore has been found, in considerable quantity, at the mineral spring in Hopkinton. It forms a bed, one or two feet below the surface, and has been employed as a pigment. It is said to exist also near Plymouth.

### *Sulphuret of Iron or Iron Pyrites.*

This is the yellow ore, so frequently mistaken for gold. It occurs more or less in almost every rock; but is of no use, unless it exists in large quantities, and is of that variety which easily decomposes. In such a case, it may be converted into the sulphate of iron; that is, into copperas. The ore is broken up, and exposed to the action of air and moisture, when the change takes place, and the lixivium is evaporated to obtain the copperas. In Massachusetts, one can hardly avoid meeting with iron pyrites, and in the western part of Worcester county, the traveller cannot but notice, that nearly all the rocks are coated over with iron rust. This is the result of the decomposition I have spoken of. In Hubbardston, the sulphate is so abundant, that a manufactory of copperas has been established, and I believe success has thus far attended the enterprise. I should presume, that copperas might be manufactured in several other towns south of Hubbards-

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ton; as in North Brookfield and Southbridge, although the rocks do not appear as highly impregnated with pyrites in any place as in Hubbardston.

The decomposition of pyrites, in large quantities, often produces a considerable degree of heat; and sometimes pieces of rocks are driven off with explosion. This is one of the sources of those numerous stories which one hears in the country, concerning noises heard, and lights with smoke, seen in the mountains. Such occurrences excite the belief of the existence of valuable mines in the vicinity; but they evince the existence of nothing more than iron pyrites.

### *Magnetic oxide of Iron.*

This is a valuable ore, affording from 50 to 90 per cent, of iron. It exists in several places in Massachusetts, and on the borders of the state.

### *Hawley Iron Mine.*

The principal ore here, is the magnetic oxide, which is very good, and the bed is favorably situated for exploration. The ore does not seem to be abundant, the bed being rarely more than one or two feet wide. It has been wrought to some extent; but the operations are at present suspended. It belongs to Hon. Samuel C. Allen. Micaceous oxide of iron occurs at the same bed.

The same bed of ore makes its appearance a mile or two south of the excavation; and, also as I have been told, two or three miles north, in Charlemont.

### *In Bernardston.*

As already remarked in the postscript to limestone, this forms a bed several feet thick in limestone, dipping at a moderate angle to the south east. When the ore was formerly worked, some complaint was made, as if it did not produce the best of iron. But probably the trials then made were very imperfect. The ore is doubtless very abundant, and I should think well worthy the attention of the iron manufacturer.

### *In Somerset, Vt.*

This bed is similarly situated to that in Hawley, and in the same range of talcose slate, although twenty miles north of the north line of Massachusetts. The ore, yielding 78 per cent of iron, is of the

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first quality; and this spot is peculiarly interesting on another account, to which I shall refer in the sequel.

*In Winchester, N. H.*

This bed is only two or three miles north of the line of Massachusetts, and the ore is said to be abundant, though for some reason, the working of it has ceased. The ore very much resembles that from Franconia in New Hampshire.

*In Cumberland, R. I.*

Dr. Robinson says that he has obtained magnetic oxide of iron, from "most of the thirteen mine holes" which he visited in that town. But the principal bed of ore, lies about two miles north east of the meeting house, and constitutes a large hill. It is obtained with great facility by blasting. It contains however several foreign minerals, so that as it is now worked, it yields only about 30 per cent. of iron. This is probably far less than it contains; for it has a high specific gravity. The ore is smelted principally in Massachusetts. It is owned by General Leach of Easton, and will furnish an inexhaustible supply.

Magnestic oxide of iron is found at other places in Massachusetts; as at Woburn, in a vein of greenstone, associated with sulphuret of Copper; but at none of the localities, in quantity sufficient to make it an object for the miner.

*Micaceous oxide of Iron.*

This ore, which is found abundantly at Hawley with the magnetic oxide, furnishes perhaps the most elegant specimens in the world; and I know not why it should not produce good iron. Indeed, I believe it has been smelted within a few years, along with the magnetic oxide.

*Vein of micaceous oxide in Montague.*

Near the mouth of Miller's river is a hill of considerable extent, which appears to be traversed by numerous veins of this ore. The largest which comes in sight, is in the south east part of the hill, at the top of a ledge of mica slate and granite, and is several feet in width. It is favorably situated for exploration, and unless the ore is injured by an occasional mixture of Sulphuret of iron, I do not see why it might not be profitably wrought. Wood is very abundant in the vicinity, and it is not far from Connecticut river. Good micaceous oxide of iron, yields about 70 per cent. of excellent iron.

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According to Professor Webster, thin veins of micaceous iron ore, exists in the porphyry of Malden, which were formerly wrought to some extent. It occurs also in graywacke, at Brighton, and in greenstone at Charlestown, according to the Messrs. Danas.

### *Beds of Brown Oxide of Iron.*

This species of ore is of an excellent quality, and it occurs in the loose soil above the rocks, so as to be easily obtained. Hence it is used to a greater extent, perhaps, in our country, than any other species. A very extensive series of beds of this ore, accompanies the limestone that is so abundant along the western margin of Connecticut, Massachusetts and Vermont; although, as the beds lie upon the clay that is deposited above all the solid rocks, they have no necessary connexion with the limestone.

### *Beds in Lenox.*

These have been explored to some extent in the village, and a mile or two farther west. The ore is good, I believe, but at present it is not used.

### *Beds in Richmond.*

These appear to be numerous and extensive. They are wrought to some extent.

### *Bed in West Stockbridge.*

This furnishes good ore, and is explored more extensively than any other I saw in the county. The farmer who owns it receives thirty seven cents and a half per ton, for the privilege of digging it.

### *In Salisbury, Ct.*

The beds here are very large, and have been extensively explored. The Salisbury iron is known far and wide.

### *In Bennington, Vt.*

Here also the same ore is dug to some extent; and these beds seem to deserve a notice, because they lie, like those in Salisbury, upon the borders of Massachusetts.

In all the beds of brown oxide of iron mentioned above, we find the brown hæmatite in all its forms, the *compact* variety, and the ochrey brown oxide, or yellow ochre. Manganese also is found in them all, and at Bennington, in large quantities; although I have been told, that this locality is nearly exhausted. It was of a superior quality.

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*The red oxide of iron* is found, in comparatively small quantities, at the localities above mentioned. It exists, also, in other places in the State; although it is not, as yet, found in large quantities. Argillaceous oxide of iron is likewise found at most of the hæmatite beds above described.

*In Cranston, R. I.*

From this place General Leach procures, as he told me, very excellent brown oxide of iron, for the supply of some of his furnaces in Massachusetts; and he represents the bed as inexhaustible.

*Argillaceous Oxide of Iron.*

This is the most common species of iron ore in Massachusetts. There are several varieties found here. On Nantucket and Martha's Vineyard, particularly at Gay Head, we find the slaty and nodular varieties; and at the latter place, according to F. A. Green, Esq., is found the columnar variety. On the Vineyard these varieties are abundant enough to be an object for the manufacturer; and during the last war, I was told, they were employed in the furnaces on the continent. In a pond, in Sharon, has been found the lenticular variety of this ore.

*Bog Ore.*

This variety of the argillaceous oxide, is far more abundant than any other, and has been used extensively in the manufacture of cast iron; for which it is chiefly adapted. In the following towns it is found in large quantities: viz. Groton, North, West, and South Brookfield, Carver, Hopkinton, Hardwick, New Braintree, Oakham, Berlin, Sturbridge, Southbridge, Freetown, Dartmouth, Rochester, Troy, Easton and Sharon; and in the following, it exists in greater or less quantities; in Middleborough, Malden, Seekonk, Sheffield, Templeton, Warwick, Williamstown, Greenfield, Northampton, Springfield, Williamsburgh, Dalton, Holland, Wales, Norton, Mansfield, Bridgewater, Stoughton, Spencer, Gloucester, and on Martha's Vineyard; indeed I can hardly doubt that more or less of this ore may be found in nearly every town in the State. It was so common that, at length, I ceased to inquire for it, and the localities are so numerous that I have not attempted to exhibit them all upon the Map.

It ought to be recollected, that the process by which bog ore is deposited, is in many places now going on, particularly at the bottom

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of ponds. The interval between one dredging and another, was so variously stated to me, that I suspect it differs greatly in different places. I presume, however, that it ought never to be less than twenty years. But the fact, that there will be a renewal of the deposit after a certain time is interesting; because it shows that this mineral can never be entirely exhausted.

Gen. Shepard Leach, of Easton, is the most extensively engaged in the iron manufactory of any man in the Commonwealth. He owns one blast and three air furnaces in Easton; one blast furnace in Foxborough, and another in Walpole; and one blast furnace and four air furnaces, in Chelmsford. In these he employs not far from five hundred men. He generally mixes the different sorts of ore, or at least, two or three of them together for smelting. Extensive iron works are also carried on in Wareham. Several furnaces exist in Berkshire, and a few in Worcester county.

The preceding view of our deposits of iron, demonstrates that we abound in this useful metal, and that the demand, for centuries to come, cannot exhaust it.

### *Ochres, &c. used as paints.*

There are two kinds of ochre, the red and the yellow, which are merely pulverulent varieties of the red and brown oxide of iron. The yellow ochre is abundant with our hæmatite and argillaceous ores, and is frequently employed as a pigment. According to Mr. C. T. Jackson, red ochre occurs in Boylston in a bed four or five inches thick, mixed with clay. It has already been mentioned, that the earthy phosphate of iron in Hopkinton, is employed as a blue paint. Prof. Dewey mentions that a yellow earth is found in Williamstown, from which great quantities of yellow ochre are obtained by washing. Dr. J. Porter states, that yellow earth occurs in Monroe, which, when purified, affords a "pale red paint." The process of preparing it he says is now suspended for want of a demand.

### *Lead.*

Several ores of this metal are enumerated by mineralogists, as occurring in Massachusetts; but none is found in sufficient quantity to render it of any statistical interest, except the sulphuret, commonly called *galena;* and all the important veins of this species are confined to the vicinity of Connecticut river. No fewer than thirteen of these occur in that region of sufficient importance to deserve notice.

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All these are in mica slate or granite; or they pass from the one rock into the other.

*In Southampton.*

The vein in the northern part of this town has attracted more attention than any other in the region, and has been several times described. It is six or eight feet wide, where it is has been explored, and traverses granite and mica slate, the matrix or gangue containing the ore, being a mixture of quartz and sulphate of barytes. It has been opened forty or fifty feet deep, in several places, and masses of ore were dug out from half an inch to a foot in diameter. As the vein descends almost perpendicularly into the rock, water soon accumulated in such quantities, as induced the proprietors to attempt reaching the vein by a horizontal drift or adit, from the bottom of the hill to the east. This was a prodigious undertaking, as the opening must be carried nearly a quarter of a mile into the solid rock. It was persevered in however, at a great expense, for a distance of nine hundred feet, when one of the principal miners having died, and the price of lead having fallen two or three hundred per cent, all operations were suspended, and I believe the proprietors wish to dispose of the mine. Had they continued this drift a few feet farther, there is every probability that the principal vein would have been struck, from one hundred and fifty to two hundred feet below the surface. Perhaps, however, the work cannot be successfully and profitably resumed, until the market shall cease to be glutted with lead from Missouri; but as there can be little doubt, that immense quantities of ore may be obtained at this spot, it may then probably be explored with advantage. I do not doubt, however, that those who first examined this mine were mistaken in the opinion, that this vein extends from Montgomery to Hatfield, a distance of twenty miles. Lead may indeed be found at intervals along a line connecting those places. But I have every reason to suppose, that it proceeds from several distinct and independent veins.

The principal ore above described is the sulphuret; but there have been found here also, the carbonate, sulphate, molybdate, muriate and phosphate of lead, along with the sulphuret of zinc, pyritous copper, and fluor spar. Mineralogists will greatly regret, that mining operations have been suspended here, because they were anticipating the development of rich specimens of these and other minerals.



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Another vein of *galena* exists in the south part of Southampton, near the line of Montgomery. It appears for several rods on the surface, but is only a foot or two in breadth. A few years ago, efforts were made to open this vein by a horizontal adit, but the proprietors have become discouraged and abandoned the undertaking.

*In Northampton.*

This vein is only a short distance north of the principal vein in Southampton, above described. The gangue is radiated quartz, and the walls are mica slate. Yellow blende or sulphuret of zinc abounds here; and the vein was formerly explored to a considerable depth. It is several feet wide.

*In Williamsburgh.*

The first galena vein to be noticed in this town, lies near the southern part; extending indeed into Northampton. Its width cannot be ascertained, being covered partially with soil. The gangue is quartz; but the galena is not abundant near the surface, and no exploration has been made. Other minerals occur here which render the place interesting to mineralogists.

The second vein is near the north-eastern part of the town, and probably extends into Whately. It is two or three feet wide, and the gangue, as in nearly every other vein of lead in this region, is quartz. Manganese is found in the same gangue.

A third vein of quartz with galena, occurs in this town, a mile or two north east of the one last mentioned. The quartz, however, appears only in loose masses on the surface, but to such an extent, as can be explained only on the supposition, that a vein exists in the rock beneath the soil. Pyritous copper is found in connexion with the galena at this place.

*In Goshen.*

According to the statements of Mr. Alanson Nash, who has given a map and description of the lead veins and mines of Hampshire county, in the twelfth volume of the American Journal of Science, the same indications of a galena vein appear a little west of the centre of Goshen, as those mentioned in respect to the third vein in Williamsburgh just noticed, viz. the occurrence of masses of quartz containing galena. The rock in the region is mica slate and quartz.

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### *In Whately.*

In this town are three distinct veins, containing lead. One is about half a mile east of the second vein described in Williamsburgh. It extends a short distance into Williamsburgh, and more than a mile into Whately. In its whole course, but particularly at its southern part, it contains oxide of manganese along with galena.

A second vein, three or four feet wide, exists in a high ridge of granite towards the south west part of the town. It may be traced along this ridge about three quarters of a mile.

The third vein is in the north-west part of the town, extending some distance into Conway. Galena, in quartz, is the only ore that appears on the surface. The width of the vein is six or seven feet, and it traverses both granite and mica slate. It runs along the western margin of a high hill, so that if it should ever be explored, a lateral drift would be easily made.

### *In Hatfield.*

About two miles west of the village in this town, we find a vein of sulphate of barytes, from one to four feet wide at the surface, running in a north-westerly direction and containing galena. A shaft has been sunk in two places, from fifteen to twenty feet deep; and the vein was found rapidly to widen in descending. The immense quantity of barytes found here, gives the locality a peculiar interest to the mineralogist.

### *In Leverett.*

Although this town lies on the eastern side of Connecticut river, yet the granite and mica slate, occurring there, exactly resemble the same rocks found on the west side of the river; and there can be no doubt that both belong to the same general formation. Two veins, the ore being chiefly galena, are found of precisely the same character as those on the opposite side of the river. That in the south east part of the town is in granite, not more than a foot or two wide at the surface, and the gangue is sulphate of barytes. The other is a mile and a half to the north of the first; the gangue is quartz, and there is almost an equal quantity of galena and pyritous copper; blende also occurs in small quantities. This vein is several feet wide, and runs through granite and mica slate. Both this and the one first mentioned, have been explored to the depth of a few feet.

It is impossible to form any confident opinion as to the probable quantity of lead, which is contained in the several veins which have

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been described, except, perhaps, in regard to that in Southampton, which has been explored to a considerable extent. In many instances appearances at the surface are quite favorable; but whether the veins become wider, like that in Hatfield, or narrower, as they descend, can be determined only by actual exploration. Of one thing, however, I think we may be assured, from the facts that have been stated; viz. that the central parts of Hampshire county contain extensive deposits of lead, which may be of great value to posterity, if not to the present generation. Probably many more veins will hereafter be discovered, since little examination has been made with a view to bring them to light.

### *Copper.*

This valuable metal occurs in numerous places near the junction of the greenstone and sandstone, in the valley of the Connecticut, between New Haven and Vermont. Several veins of copper ore are found in Connecticut; and the only one in that state, that has been explored to any considerable extent, lies on the borders of Massachusetts, viz. in Granby. It has long been known under the name of Simsbury mines, although it is within the limits of Granby. Many years ago, before the war of the revolution, I believe, this vein was explored to a considerable extent. Afterwards the Government of Connecticut made use of the abandoned shafts and galleries for a State prison. Since the removal of this prison to Wethersfield, the exploration has been resumed, by a new company, I believe, and, I am told, with success. So far as I could ascertain from specimens, which I found there several years ago, and from some recently obtained, the principal part of the ore is the gray oxide, associated, however, with the green carbonate.*

### *In Greenfield.*

In the north eastern part of this town, on the banks of Connecticut river, are two veins of copper, about a mile apart; the most northern one being about one hundred rods below the mouth of a small stream, called Fall river, and the same distance in a direct line from the cataract in Connecticut river, sometimes called Miller's Falls; but lately and more appropriately, Turner's Falls. These veins are several feet in width, and they pass into a hill of greenstone

* They now find the compact red oxide, as is said, in great abundance.

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on one hand, and under the river, on the other hand, into sandstone. The gangue is sulphate of barytes and toadstone, and the ores are the green carbonate and pyritous copper. Actual exploration alone can determine whether these veins might be profitably worked.

On the most southern of the small islands, in the middle of Turner's Falls, has been found pyritous copper, of a rich quality, and in considerable quantity. Indeed, several varieties of the sandstone rocks in the vicinity, appear to be considerably impregnated with copper.

Pyritous copper is associated with iron, in a vein, in greenstone, at *Woburn*; but not, probably, in a sufficient quantity to be worth mining. At several places in Cumberland, R. I., where excavations were formerly made, are found gray oxide of copper, and pyritous copper with the green and blue carbonates.

### *Zinc.*

The sulphuret of this mineral occurs, as has already been noticed, in several of the lead veins in Hampshire County, and in some of them in sufficient quantity, no doubt, to be wrought with advantage, should these veins be ever opened. Those in Southampton, Hatfield and Leverett, abound most in this ore. It is useful in the manufacture of brass and white vitriol.

### *Manganese.*

In a metallic state this mineral is of no use; and indeed, it is reduced to that state with great difficulty. But in the state of oxide, it is extensively employed, both to remove color from glass and to impart colors; also in painting porcelain and glazing pottery, and still more extensively within a few years, in the manufacture of the chloride of lime, now so generlly used in bleaching and for disinfection.

At least two ores of manganese abound in the western part of Massachusetts and on the borders of New Hampshire. It has been already remarked, that more or less of the gray oxide exists in the iron beds of Berkshire and Bennington, Vt. In the vicinity of Connecticut River, however, or rather on the eastern slope of Hoosac mountain, distinct veins and beds of manganese are found.

### *In Plainfield.*

Beds of the oxide of manganese occur in two places in this town—one a mile west of the center, and the other near the south-west cor-

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ner of the town; and both in talcose slate. Two ores are associated at both these places, viz. the common gray or black oxide and the silicious oxide; the former investing the latter as a black crust, and most probably proceeding from its decomposition; while the latter, when newly broken, is of a delicate rose red. I suspect the silicious oxide predominates at these places; and from these beds, probably came by diluvial action, those numerous rounded masses of silicious oxide in the vicinity of Cummington meeting-house; although a deep valley intervenes and the distance is three or four miles. An attempt was made, some years ago, to explore one of these beds, under the impression that the ore was iron. But how extensive either of them is, it is difficult to determine, as each seems to consist of a number of small beds—or rather the ore is interlaminated with the slate. The occurrence of so much silicious oxide at these localities, is very interesting to the mineralogist, because this ore is so rare in Europe.

*In Conway.*

A distinct vein of the black oxide of manganese several feet wide occurs in the southeast part of this town, the gangue being quartz. It has not been explored at all; nor is the manganese ore very abundant at the surface. I do not doubt however, that this ore may be found here in large quantities.

*In Hinsdale, N. H.*

An extensive bed or vein of the black, and silicious oxides of manganese have been found in this town. It appears near the top of a hill and the adjacent rocks are not visible. The ore strongly resembles that from Plainfield.

*In Winchester, N. H.*

Between one and two miles east of the center village in this town, may be seen large quantities of the black and red oxides of this metal of the same character as in Hinsdale. These localities have, as yet, attracted no attention except from a few mineralogists. My information and specimens were furnished me by Mr. John L. Alexander of Winchester.

*Tin.*

I am able to say with perfect confidence that this interesting metal exists in Massachusetts; but can add little more. I found

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only a single crystal of its oxide, weighing 50 grains. But this I dug myself from a block of granite in the north-east part of Goshen, and on reducing it to metallic tin, it corresponds exactly in every respect with that metal from England. I have never been able to find any more specimens, but it ought be to borne in mind that in England, according to a geological writer of that country, "it is generally in the vicinity of a vein of tin ore, that disseminated grains of tinstone are found in the rock."

### *Silver.*

The only place in the state where this metal has been discovered, is at the Southampton lead mines; it there exists in a small proportion —only 12½ ounces to the ton, in the galena. This is a little greater than the average proportion in the English lead mines: but it is hardly worth the labor of separating it. It is not improbable that when several other ores in the state, such as arsenical iron, sulphuret of iron, and zinc, shall be accurately analyzed, they will be found, as in other countries, to contain a larger proportion of silver. I would however, rather repress than encourage, farther researches for this metal; for as I shall soon have occasion to state more fully, greater expense has been incurred, and more weakness and folly exhibited in such researches, than the community is generally aware of.

### *Gold.*

It may perhaps excite a smile, to see gold occupying a place in a description of the minerals of Massachusetts. It has not indeed been found in this state; *but I am able in this place, to announce the existence of a deposit of this metal, in the southern part of Vermont;* and I feel no small degree of confidence, that it will be found in Massachusetts. A statement of the grounds of this belief, may save me from the charge of extravagant expectations.

I have already described an iron mine, as occurring in Somerset, Vermont. It is owned by S. V. S. Wilder, Esq. of Brooklyn, New York, who has erected a bloomery forge near the spot. Sometime ago, one of the workmen engaged in these iron works, saw in the American Journal of Science, a suggestion of Professor Eaton of Troy, that since the gold of the Southern States, and of Mexico, is in talcose slate, we might expect to find it in the same rock in New England; especially about the head branches of Deerfield river. He commenced an examination in a brook near the mine, and was soon rewarded

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by the discovery of a spherical mass of gold, of the value of more than a dollar; afterwards he found other small pieces. At the request of Mr. Wilder, I visited this spot a few weeks ago, and found that an individual conversant with the gold mines in the Southern States, and acquainted with the process of washing the metal from the soil, had just been examining the region now spoken of. The result was a conviction, that over several hundred acres at least, gold was common in the soil. In a bushel of dirt collected in various places, he found about three pennyweights of very pure gold. Mr. Wilder proceeded himself to exhibit to me an ocular demonstration of the existence of gold in the soil, by washing for it. From about six quarts of dirt, taken a foot below the surface, we obtained (although not very skilful in manipulations of this sort) twenty or thirty small pieces, weighing about seven grains. Indeed, by the aid of my knife, I picked two or three pieces from the dirt.

The iron ore is in beds in distinct talcose slate; and a considerable part of the ore is the brown oxide, and contained in a porous quartz. In this quartz, were found several spherical pieces of gold, scarcely larger than a pigeon shot. Whether it exists, as in the Southern States, in finer particles in the yellowish iron ore, has not been ascertained. But specimens of the quartz and iron at this place, cannot be distinguished from what is called gold ore, at the gold mines in Virginia, and North Carolina. Indeed, a suite of specimens from the Somerset iron mine, could not be distinguished, except by labels, from a similar suite from the south.

In every case in which gold has been found at this place, in the soil, it was accompanied by more or less of iron sand, and some distance north of the mine, neither could be found; but how far to the South and East it occurs, has not been ascertained. I am inclined however to believe, that the gold at this locality, will be found to be always associated with the iron.

We were told at Somerset, that several years ago, a mass of gold was found in the bed of Deerfield river, three or four miles to the south of the mine, which was sold for sixty eight dollars, and we had no reason to doubt the statement. Certain it is, that a few years since, a piece was discovered by Gen. Field, weighing eight and a half ounces, in New Fane, a town twelve or fifteen miles east of Somerset.

Upon the whole, it appears to me that the facts above stated justify the conclusion, that there exists a gold region in the lower part of Vermont, of considerable extent and richness. It may be found to be

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very extensive, and probably it is not confined exclusively to the talcose slate formation; for New Fane, I believe, contains but little of this rock. The region west of Somerset is little known: the iron mine there, lies at the foot of the Green Mountains, and it is chiefly a mountain wilderness for sixteen or seventeen miles west of this spot.

The talcose slate formation, containing the iron and gold in Somerset, extends southerly, nearly across the state of Massachusetts; passing through the towns of Rowe, Charlemont, the settlement called Zoar, Florida, Savoy, Hawley, Plainfield, Cummington, Worthington, Middlefield, &c. Indeed, I know of no place, where the formation is so perfectly developed in its characters, as in Hawley and Plainfield. There is then, surely, as much ground for presuming that gold will be found in Massachusetts, as there was for predicting its discovery in Vermont. If an iron mine and porous quartz, with oxide of iron, be necessary, we have these in Hawley, in the talcose slate. And it ought to be recollected, that the Vermont gold was found at the source of Deerfield river, and that this stream runs directly south into Massachusetts; and it would be rather strange, if so violent a torrent did not carry some of the diluvium, containing gold, at least as far as the limits of this state. The place where I suppose gold might be found, in Massachusetts, would be in the vicinity of the Hawley iron mine, or the Plainfield beds of manganese, or along the banks of Deerfield river, in Monroe, Florida, Zoar and Charlemont: nor should the region around the limestone and iron ore, in Bernardston, be forgotten, in an examination for this metal, although the rock there is not talcose slate. Talcose slate occurs also in many other places in the state; particularly in Berkshire county, on the Taconnic range of mountains, Saddle mountain, and other eminences; and here also are porous quartz and oxide of iron. I have found time to make only a slight examination for gold, in one or two of the places above mentioned. The surest method of determining the point, would be to obtain some one, who is conversant with the gold regions at the South, and with the mode of washing it, to examine the places I have mentioned. It may indeed be doubtful, whether the discovery of gold would be a public benefit; since, as your Excellency has well observed, it might lead to "the greedy pursuit of this uncertain gain, and to the sure sacrifice of habits of industry and economy, and virtuous self-denial, which the ordinary pursuits and requirements of business induce. We may doubt even, whether the grass-covered hills of our own New England, are not a better source



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of wealth and contentment, than the precious metals which the earth embosoms." But, however political economy might decide these questions, I suppose there are few individuals who would willingly shut their eyes upon gold mines; and therefore I have made these suggestions on the subject, to prevent expenditure upon useless and ill-planned projects, in search of this precious metal.

### *Idle search after Gold and Silver.*

Were the history of the wild and ill-directed efforts that have been made, even in Massachusetts, in search of the precious metals, to be written, it would furnish many striking illustrations of the importance of your Excellency's suggestions. Permit me here to state a few facts on the subject.

The large quantities of the precious metals carried to Europe from South America, soon after its discovery, naturally produced some expectation of finding similar treasures here. But I cannot learn that our forefathers expended large sums in making excavations, where there was no reasonable prospect of finding any thing valuable. It was reserved for their descendants to exhibit a credulity and superstitious ignorance on the subject, that are both lamentable and ridiculous.

Perhaps, at the present day, a belief in the mysterious virtues of the mineral rod, is the most common of these delusions. Probably many of our intelligent citizens can hardly credit the statement, that there are men in various parts of the state, who profess not a little skill in this enchantment, and are not unfrequently sent for, one or two days journey, to decide whether there be ore or springs of water in a particular place. In general, but not always, these professors of divination belong to the most ignorant classes in society; for not long since, a venerable and respectable man of good education, sincerely thought it his duty occasionally to peregrinate with his divining rod, because *it would work in his hands;* and not a few very intelligent men have a secret belief, that the branches of a witch hazel are attracted downward towards mineral substances, when in the hands of a certain individual.

The following train of circumstances often takes place. A man, ignorant of mineralogy, finds upon his farm, a specimen of iron pyrites, or yellow mica, or galena, which he mistakes for gold or silver. Even if he shows it to a mineralogist and is told that he is mistaken, he suspects that his informant is deceiving him, in the hope of getting

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possession of the prize himself. He resolves to begin an excavation. And he sees enough, in the shining particles of mica and feldspar that are thrown out, to buoy up his hopes, until his purse is well nigh drained.

It was probably in some such way, that the excavations were made in Worcester and Sterling, at the mines of arsenical iron and carbonate of iron; although, in these cases, there would be sufficient ground for obtaining some of these ores, since they do sometimes contain silver. But I cannot conceive why such extensive excavations were made, when a chemist might have easily settled the question as to their nature, by analyzing 100 grains of the ore, unless it was on the erroneous supposition, which I find to be common, that metallic veins generally become much richer and larger, and even change their contents, as they descend into the earth.

The decomposition of iron pyrites, producing heat and sometimes explosion, is supposed by some to be a strong indication of mineral riches in the earth beneath. The man of the witch hazel rod is called, and if he confirms the suspicion, as he usually will, the excavation is commenced; nor is it suspended until a heavy draft has been made upon the man's pecuniary resources. An extensive excavation was made, many years ago, I am told, in Hubbardston, and from the character of the rock there, I suspect that iron pyrites gave the first impulse to the undertaking. In Pepperell, an individual has been engaged for several years, in pushing a drift into the rocks, which he has penetrated eight or ten rods; although individuals who have visited the spot, (I have not,) can discover nothing but iron pyrites.

In the year 1815, an individual succeeded in getting a company formed and incorporated, with a capital of eighty thousand dollars, called the Easton lead and silver mining Company. The fruits of their labor may be seen in an excavation, in red granite, nearly one hundred feet deep, at present nearly filled with water. I could not find a particle of ore, of any kind, in the fragments blasted out. A final stop was put to the work, by the killing of two men in blasting.

Forty years since, a shaft was sunk in Mendon, in search of the precious metals. A little specular oxide of iron occurs at the place.

Not many months since, an individual called upon me, with specimens of black blende or sulphuret of zinc, found in a neighboring town, and which he strongly suspected to be silver. I informed him of its true nature, and seeing that the vision had got strong hold

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upon his mind, I did all in my power to persuade him not to engage in searching for the ore. But the only effect was to stimulate him to commence an exploration with more ardor. The zinc was found in a loose piece of rock, lying in the field. The man's impression was, that even if that ore was of no use, it indicated something valuable beneath. Accordingly, he commenced digging. Ere long his faith was strengthened, by some one's discovering a light, during the darkness, near the spot; and the last time I heard from the man, he had penetrated the soil about seventy feet.

The following case has been stated to me on such authority, that I do not doubt its correctness.•

Some forty or fifty years ago, a farmer residing not far from the center of Massachusetts, knocked off from a rock upon his farm, a piece of ore, which he sold in Boston for a considerable sum, as a rich ore of silver. From that time till the day of his death, he searched in vain for the rock from which it was broken. The inference, which he drew from his ill success, was that Satan, (who is thought, by multitudes, to have unlimited power over the mineral treasures of the earth,) had concealed or removed the precious vein. Conceiving, however, that some of his posterity might have more interest with that personage than himself, he reserved to them the right of digging the ore, in the instrument which conveyed away his title to the land. His posterity were not forgetful of the reservation; but they were convinced that it would be of no use to them, unless they could meet with some individual, who had *entered into a league*, (as the phrase is with the class of people I am describing,) with his Satanic majesty. Last year they heard of such a man, a German, in Pennsylvania, who had obtained possession of a wonderful glass, through which he could discover whatever lies hid beneath the soil. The German was persuaded to visit the spot, and when I passed through the place, a little more than a year ago, an excavation was about to be commenced under his direction. But I have not learned how the enterprise succeeded.

Still more ridiculous than the opinions and practices above mentioned, are some still existing in a few places in the State, relative to deposits of money, said to have been made by one Kid, a celebrated buccaneer of early times. The statement is, that he frequently ascended our streams a considerable distance, and buried in their banks, large sums of money. These are supposed to be guarded with sleepless vigilance by the personage mentioned before. But by

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the use of certain incantations, while digging for the treasure, it may be wrested out of his hands; for instance, perfect silence must reign during the operation, unless it be broken by the reading of the Bible, and all must be done in the night. The last instance of the practice of this mummery, which I have heard of, occurred a few years since on one of the branches of Westfield river. A hundred days' works were expended upon the enterprise before it was abandoned. At one time those employed in this work were greatly discouraged, by the intrusion of my informant, who, in spite of all they could do by gestures, broke silence, and thus dissolved the charm. At another time, courage was revived by finding an iron pot, containing some bits of copper, deposited there, the day previous, by some boys who had learned what was going forward.

I have given these rather mortifying details, partly because I doubt whether nine tenths of our population are aware of the existence of such opinions and practices among us; and partly in the hope that the exposition may be instrumental in entirely eradicating them from the minds of those who have been thus deluded. For, like night fogs, they need only to be brought into the light of day to be dissipated.

### *Concluding Remarks.*

In concluding this summary of the economical geology of Massachusetts, I cannot but allude to the very imperfect development which has hitherto been made of our mineral resources. Judging from what we know at present, our granites, marbles, and other rocks, useful in architecture, are undoubtedly the richest of these resources. Yet it is only a few years, since these rocks (with the exception of some quarries of marble,) have been employed at all for building; and even now, only a few beds, and these very possibly not the best, have been opened. In the vicinity of Connecticut river, the inhabitants are just beginning to learn that they have beautiful granite in their own hills and mountains. The Berkshire marbles are wrought on a stinted scale, compared with what they might be, were a railroad to furnish the means of an easy transportation to the Hudson. And as to our porphyries and serpentines, various and abundant as they are, it is rare to meet with a single polished specimen. Our mineral veins and beds, with the exception of a few mines of iron, and one of lead, lie as yet almost untouched, and probably many of them undiscovered.

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These facts ought to be kept in mind in forming an estimate of our mineral resources. Yet imperfect as is our acquaintance with these, I think we need not fear a comparison, in this respect, with any other part of the country. Other States possess particular minerals which are more valuable and interesting, and calculated to awaken public attention more than ours; yet where is the territory abounding in a greater number of rocks and minerals, of real and permanent utility, whose quality is excellent and whose quantity is inexhaustible? They are, indeed, of such a character, that they will increase in value for several generations to come. That is, we may calculate that the demand for them will increase during that period, and this demand will lead to the discovery of varieties really more valuable.

Thus far we have regarded our geology only in an economical point of view. I hope to show in the subsequent parts of my Report, that it is not less interesting to the man of taste and science.

Respectfully submitted,

EDWARD HITCHCOCK.

Amherst College, Jan. 1st, 1832.

P. S.—Since the above account was in type, I learn, that in Leominster, in Worcester county, there is a rich alum rock. It appears to be a decomposed mica slate, and contains abundance of beautiful plumose, or feather-form alum, like that of Milo, one of the Grecian isles, mixed with the green crystals of copperas, or sulphate of iron. There can be little doubt, that it proceeds from the decomposition of iron pyrites in the rock; the acid, formed from the sulphur, then unites with both the iron and the alumina, and thus forms the two salts. If these salts, and especially the alum, or the materials, which by proper treatment, may easily produce it, should prove to be abundant, the discovery may become practically important. I have not seen the specimens, but derive my information from Prof. Silliman, who has examined them; and who remarks, that it is common in this country, to find alum, formed in mica slate; a fact which appears to have been scarcely observed in Europe, where a variety of clay slate, or shale is the common alum rock.

The Rev. Mr. Boutelle, of Leominster, can give more particular information as to the local facts.

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## PART II.

# TOPOGRAPHICAL GEOLOGY

OF

# MASSACHUSETTS.

To His Excellency Levi Lincoln Esq.
Governor of Massachusetts.

I have supposed that my account of the Geology of the State would be quite imperfect, without some notice of our Scenery. Strictly speaking, indeed, scenery is not geology: and yet, the contour of a country owes its peculiarities in a great measure to the character of the rocks found beneath the soil: So that the geologist, by a mere inspection of the features of the landscape, can form a very probable opinion of the nature of the rock formations. The extended plain, he will pronounce alluvial, or tertiary. The precipitous ridge or mountain, if dark coloured, will indicate trap rocks; if light coloured, granite: If the summit be rounded, and the aspect red or gray, he will suspect it to be made up of sandstone. The more extended and less precipitous mountain ranges, stretching away over many a league, correspond more nearly to primary rocks. In short, the connection between the aspect of the earth's surface and the nature of the rocks beneath, is so obvious, that I have thought it would not be a misnomer, to denominate an account of the natural scenery, *Topographical Geology*. In the following sketch of the scenery of Massachusetts, my principal object will be to direct the attention of the man of taste to those places in the State, where he will find natural objects particularly calculated to gratify his love of novelty, beauty and sublimity. I have not the space, had I the ability, to describe them with the vividness and fullness of the poet or the painter. But by sketching their obvious features, I would hope to induce gentlemen of leisure and intelligence, who are lovers of the beautiful, the sublime, and the picturesque innature, to visit and more minutely to describe them.



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The most striking objects in the scenery of a country, where they exist, are high and precipitous mountains; especially if extensive plains, traversed by rivers, stretch away from their bases. I shall therefore, in the first place, describe those conspicuous peaks and ridges in the State, whose summits afford wide and interesting prospects.

Massachusetts is peculiarly mountainous. But mountain scenery is not particularly interesting, if the slopes are gentle, and the outlines of the hills are much rounded. It needs the sharp towering peak, the craggy and overhanging cliff, and the roaring torrent beneath, to arrest the attention, and excite strong emotions. Such objects are numerous in this state, especially in the western part. Here we find some scenery that is truly Alpine. I begin with the highest point in the state, viz:

### *Saddle Mountain.*

We have in Massachusetts three lofty and extensive ranges of mountains crossing the State from north to south. The summit of the Taconic Range, corresponds nearly with the west line of the State. The Hoosic Range is separated from the Taconic by a valley several miles in width. It occupies all the eastern part of Berkshire County, and the western part of Franklin, Hampshire and Hampden; being from 30 to 40 miles broad, and extending easterly to the valley of the Connecticut. East of this valley is a belt of mountainous country, embracing the eastern part of Franklin, Hampshire and Hampden counties, and the whole of Worcester County; But no specific name has been applied as yet to this range as a whole.

Saddle Mountain does not belong, properly speaking, to any of these chains of elevated land; though generally regarded as a spur from the Hoosic range. But it is in fact an insulated eminence, mostly in the town of Adams, and nearly surrounded by vallies, above which it rises 2,800 feet, and nearly 3,600 above the tide water of the ocean. It is chiefly the insulated character of this mountain, that renders it so striking an object in the scenery. Its summit is supposed to bear a resemblance to that of a saddle; and hence its unpoetic name. The highest point of the summit has a much more appropriate designation, viz. *Graylock*; from the hoary aspect which the upper part of the mountain presents in the winter months. During that season, the frost attaches itself to the trees, which, thus decorated, it needs no great stretch of imagination to regard as the graylocks of this venerable

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mountain. As the cold increases, the line of congelation sinks lower and lower, covering more and more of the mountain with frost work, and a contrary effect results from an increase of the temperature; so that this line is frequently rising and falling during the cold months, producing numerous fantastic changes in the aspect of the mountain.

The best route by which to ascend to the summit of Graylock, passes up the southwestern declivity of the mountain, through what is called the *Hopper;* and over that spur of the mountain denominated *Bald Mountain.* The ascent is so gentle that it may be gained on horseback. Indeed, in one instance I was told that a lady, accustomed to equestrian excursions, reached the summit in this manner: and were the road in the upper part improved as it might be, by a little labor, her example might be easily followed. Another improvement also, should be made before ladies are invited to take this excursion. At present one is obliged to climb a tree, to the height of 30 or 40 feet, in order to get an unobstructed view from the summit; so that either the surrounding trees should be cleared away, or a stone or wooden structure be erected, that would overlook them.

I know of no place where the mind is so forcibly impressed by the idea of vastness, and even of immensity, as when the eye ranges abroad from this eminence. Towards the south you have a view, more or less interrupted by spurs from the Taconic and Hoosic ranges of mountains, of that fertile valley which crosses the whole of Berkshire county. On your right and left, you look down upon, or rather overlook, the Taconic and Hoosic mountains; which from the valley beneath, seem of such towering height and grandeur. Beyond these mountains, on every side, you see the summits of peak beyond peak, till they are blended with the distant sky. The objects in the immediate vicinity, of the mountain do not forcibly arrest the attention; though from the northern point of the summit, I should suppose the valley of Williamstown must be delightfully exhibited. Still, the vast depth of the valley around you, as you stand upon Graylock, contributes no doubt to swell the feeling of immensity and sublimity produced by looking abroad among such a sea of mountains.

Upon the whole, however, I was more interested by the phenomena exhibited in that part, of the mountain, called the Hopper, than by a view from the summit. As the traveller descends from Graylock, let him follow out the naked summit of Bald Mountain nearly

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to its extremity, and then, on turning northerly, he will find before him a gulph at least a thousand feet deep, the four sides of which seem (although it is not strictly so) to converge to a point at the bottom. The slope of these sides, is so steep, that one feels dizzy on looking into the gulph. These steep sides are all covered with trees of various species, among which are occasional patches of evergreens, giving to the whole slope a rich and captivating appearance. On the northeast side, however, may be seen the traces of several *mountain slides*, by which the trees and the loose soil have been swept away from the height, in some cases, of 1600 feet, and of considerable width. It is not more than six or eight years since one or two of these slides occurred; and the paths which they left behind, are yet entirely naked of vegetation. In some instances of earlier date, we perceive the vestiges of the avalanche only in the stinted growth, or peculiar character of the trees, that have sprung up. It is said that one of the most remarkable of these slides, took place in the year 1784; and that one dwelling house was swept away by the inundation, though the inmates escaped.

Scattered through the valley of Berkshire and among the high ranges that bound it on either hand, are many other mountains and peaks that present delightful and extensive landscapes from their summits. There is, however, such a general resemblance in the scenery of the county, that a particular description of each prospect will be unnecessary, after what has been said of Saddle Mountain. In the southern part of the county, the Taconic range reaches a height not much inferior to that of Graylock. That part of the range is called

### *Mount Washington.*

It lies in the southwest corner town of the State, (except a small triangular unincorporated tract at the very angle of the State, called Boston corner,) and as it occupies most of the town, both have the same name. It has two principal peaks; the highest and most northerly of which, rises 2400 feet above the valley of the Housatonic, and 3150 above the ocean. The summit of the ridge is mostly naked rock, with even very little shrubbery. The ascent is easy on the easterly side, and the view of the plain of Sheffield and the valley of the Housatonic generally, is delightful.

A somewhat interrupted range of mountains extends from Stockbridge through the easterly part of Great Barrington and Sheffield, presenting several distinct peaks, which have different names, such as

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Monument Mountain, in Stockbridge, and Alum Hill, in Sheffield. Beartown Mountain extends from Stockbridge through Great Barrington into Tyringham: Rattlesnake Hill is an insulated mountain in Stockbridge. The mountain separating West Stockbridge from Stockbridge, and Richmond from Lenox, is denominated at its northern part, Lenox Mountain: and more southerly, Stockbridge Mountain. In Washington, and extending into Pittsfield, is a lofty and rounded spur from the Hoosic range, called Washington Mountain; a name too much like Mount Washington. In Canaan, Connecticut, a few miles beyond the Massachusetts line, is a noble mountain ridge with a mural front on the southwest, and several miles in extent, called Canaan Mountain. From all these mountains, and others that might be named, magnificent prospects are presented, which, in the midst of a general resemblance, exhibit so much peculiar to each, as amply to repay the traveller for climbing them all.

The same may be said of numerous distinct summits that crown the broad ranges of the Taconic and Hoosic. It is extremely exhilarating to the spirits of the tasteful traveler, as he traverses these regions, especially in summer, to find such a constant variety of landscape attending every change of place. For every new hill that he climbs, he is rewarded by the discovery of some new grouping of the distant mountains; some new peak or ridge rising fantastically in the horizon; some new village crowning the distant hill with its neat white houses and church spire; or some hitherto unseen valley opens before him, through which tumbles the mountain torrent; while the vast slopes of the valley present so much diversity, softness. and richness of foliage, as to form a lovely resting place for the eye.

In such mountainous regions it was natural for the first settlers to select elevated situations for a residence. Hence in many instances the tops of these ridges are crowned with pleasant villages. Among those which are thus situated and afford the most romantic prospects may be named Blanford, Granville, Tolland, Chester, Middlefield, Peru, Windsor, Chesterfield, Goshen, Cummington, Plainfield, Ashfield, Hawley, Shelburne, Rowe, Heath, and Leyden. To one accustomed to reside in a valley, it is interesting to witness in one of these places, the setting, but more particularly the rising of the sun: when very probably he will see a dense fog resting upon the vallies below, and shutting out the sun, while it shines in all its glory upon the hills around the observer.

In the elevated region east of Connecticut river, a still larger number

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of villages have been built upon heights commanding wide horizons: And some of these, being in a superior style of architecture are most attractive objects to the distant traveler. What for instance can be a finer object, than the beautiful village of Leicester, seen at the distance of six or eight miles! or than Shrewsbury, Grafton, Charlton or Rutland! Similarly situated are Dudley, Sutton, Mendon, Hopkinton, Spencer, New Braintree, Hardwick, Barre, Petersham, Shutesbury, New Salem, Templeton, Winchendon, Princeton, Westford, Andover, &c. The extent and beauty of the summer prospect from the last mentioned place have long been the admiration of the traveler.

### *Mount Holyoke.*

We come now to the valley of the Connecticut, where is some of the boldest and most beautiful scenery in the State. Mount Holyoke in Hadley claims the first notice; not on account of its superior altitude, for it is only 830 feet above the Connecticut at its base, and about 900 above Boston Harbour; but on account of its peculiar position in respect to interesting objects around. It is a part of a mountain ridge of greenstone, commencing with West Rock, near New Haven, and proceeding northerly, interrupted only by occasional vallies, across the whole of Connecticut, until it enters Massachusetts between West Springfield and Southwick, and proceeds along the west line of the first named place, and along the east line of Westfield, East Hampton, and Northampton, to the banks of the Connecticut. Until it reaches East Hampton, its elevation is small. But there it suddenly mounts up to the height of nearly a thousand feet, and forms Mount Tom. The ridge crosses the Connecticut, in a northeast direction, and curving still more to the east, passes along the dividing line of Amherst and South Hadley, until it terminates ten miles from the river in the northwest part of Belchertown. All that part of the ridge east of the river, is called Holyoke: though the prospect house is erected near its southwestern extremity, opposite Northampton, and near the Connecticut. And that is undoubtedly the most commanding spot on the mountain, though several distinct summits, that have as yet received no uniform name, afford delightful prospects. It is not generally known, indeed, how a slight change of situation upon a mountain will often put an almost entirely new aspect upon the surrounding scenery. A knowledge of this fact, might often give a tenfold duration to the pleasure of the observer. The man who means to feast to the full upon mountain scenery, should be accoutred in such a manner

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that he can turn aside from the beaten track, urge his way through the tangled thicket, and climb the craggy cliff. There is a peculiar pleasure, which such a man only can experience, in feeling that he has reached a point perhaps never trodden by human foot, and is the first of the rational creation that ever feasted on the landscape before him.

In the view from Holyoke we have the grand and the beautiful united; the latter, however, greatly predominating. The observer finds himself lifted up nearly a thousand feet from the midst of a plain which, northerly and southerly, is of great extent; and so comparatively narrow is the naked rock on which he stands, that he wonders why the winds and storms of centuries have not broken it down. He soon, however, forgets the mountain beneath him, in the absorbing beauties before him. For it is not a barren unenlivened plain on which his eye rests; but a rich alluvial valley, geometrically diversified in the summer with grass, corn, grain, and whatever else laborious industry has there reared. On the west, and a little elevated above the general level, the eye turns with delight to the populous village of Northampton; exhibiting in its public edifices, and private dwellings an unusual degree of neatness and elegance. A little more to the right, the neat and substantial villages of Hadley and Hatfield, and still farther east and more distant, Amherst with its College, Gymnasium, and Academy, on a commanding eminence, form pleasant resting places for the eye. But the object that perhaps most of all arrests the attention of the man of taste, is the Connecticut, winding its way majestically, yet most beautifully, through the meadows of Hatfield, Hadley, and Northampton; and directly in front of Holyoke, as if it loved to linger in so tranquil a spot, it sweeps around in a graceful curve of three miles extent, without advancing in its oceanward course a hundred rods. Then it passes directly through the deep opening between Holyoke and Tom, which its own waters, or more probably, other agencies have excavated in early times. Below this point, the Connecticut is in full view, like a serpentine mirror, for nearly twenty miles. And through a deception, explicable by the laws of perspective, there seems to be a gradual ascent of the river, the whole distance, till at its vanishing place it seems elevated nearly to a *level with* the eye:—just as the parallel sides of a long avenue seem to approach nearer and nearer until they meet.

The valley on the south of Holyoke is not as interesting as that on the west and north; chiefly because the land is less fertile. The village of South Hadley is indeed a pleasing object. But Springfield, one

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of the loveliest spots in America, is too far removed for an exhibition of its beauty. Other places south of Springfield are indistinctly visible along the banks of the Connecticut: and even the spires of some of the churches in Hartford, may be seen in good weather, just rising above the trees. Still farther south in that direction, may be seen the abrupt greenstone bluffs mid way between Hartford and New Haven; and looking with a telescope between these, other low hills may be indistinctly seen, which are probably the trap ridge encircling New Haven, or the shores of Long Island.

Facing the southwest, the observer has before him on the opposite side of the river, the ridge called Mount Tom, rising one or two hundred feet higher than Holyoke, and dividing the valley of the Connecticut longitudinally. The western branch of this valley is bounded on the west by the eastern slope of the Hoosic range of mountains; which, as seen from Holyoke, rises ridge above ridge for more than twenty miles, chequered with cultivated fields and forests, and not unfrequently enlivened by villages and church spires. In the northwest the Graylock may be seen peering above the Hoosic; and still farther north, several of the lofty peaks of the Green Mountains (which are merely a continuation of the Hoosic,) shoot up beyond the region of clouds, in imposing grandeur. Nearer at hand, and in the valley of the Connecticut, the insulated Sugar Loaves and Toby present their fantastic outlines; while far in the northeast stands in insulated grandeur the cloud-capt Monadnoc.

Probably under favourable circumstances, not less than 30 churches, in as many towns, are visible from Holyoke. The north and south diameter, of the field of vision there, can scarcely be less than 150 miles.

### *The Columns.*

Less than half a mile south of the road leading to the prospect house on Holyoke, and in the western face of the ridge, may be seen some interesting examples of greenstone columns. They stand side by side to the height of many feet, and as the lower part of the outer ones has fallen down, their curiously formed tops project from the cliff and seem to threaten the observer with destruction. In the third part of my report I shall describe these columns more particularly. But I think they must prove attractive to every one to whom a visit to the top of the mountain, is interesting. The visitor, however, must not

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expect a very smooth path in reaching them; for he must clamber over a large amount of *debris*, sloping at an angle of 45°.

### *Titan's Pier.*

Standing upon Holyoke and facing the south, one has directly before him, and as it were under his feet, the deep gorge between Holyoke and Tom, through which Connecticut river passes. Following the western side of the mountain, as it rapidly descends to the river, we find it terminating with a naked rock extending several rods into the river, and nearly perpendicular on the side next to the water, from 20 to 100 feet high. A considerable part of this naked rock exhibits a columnar structure; not in general as perfect as the spot above described, yet sufficiently regular to require little aid from the imagination, to be regarded as artificial; though obviously demanding giant strength for its construction. I have said that the columnar structure was not in general very perfect. But if one can work his way along the western face of this precipice at low water, he will find, near where the rock passes under the river, the tops of numerous columns of great regularity; their upper portions having been removed by the force of the stream, which for so many centuries has been battering this cliff with logs and ice. By referring to the next part of my report, a more definite idea can be obtained of these columns. But from what I have now said, every intelligent man will perceive that these columns are very similar to to those on the coast of Ireland, which form *Fingal's Cave* and the *Giant's Causey*. The nature of the rock too, is essentially the same in all these places. Why then may I not be permitted to denominate this rock, *Titan's Pier?* At least, may I not hope by this description to attract the attention of visitors to Holyoke to this spot? Hitherto it has been passed unnoticed.

### *Mount Tom.*

As this is higher than Holyoke and insulated in the same great valley, the view from its summit cannot but be commanding; Yet most of the interesting group of objects around the base of the former, is wanting around the latter. Hence Tom is not much frequented; while during the summer months, Holyoke is a place of great resort.

I obtained from this mountain one summer morning, a striking view, while yet the whole valley of the Connecticut was enveloped in fog, and Tom, with a few other elevated peaks connected with the greenstone range, alone rose above the vapour. The sun shining brightly



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and the wind gently blowing, gave to this fog a strong resemblance to an agitated ocean. To the north and south it seemed illimitable; but on the east and the west, the high mountain ranges that form the boundaries of the valley of the Connecticut, constituted its shores. I could not but feel myself transported back, to that remote period, when this great valley was enveloped in like manner, by water, and Holyoke and Tom formed only low and picturesque islands upon its surface.

### *Sugar Loaf Mountain.*

No object in the valley of the Connecticut, is more picturesque than this conical peak of red sandstone, which rises almost perpendicularly 500 feet above the plain on the bank of the Connecticut, in the south part of Deerfield. As the traveler approaches this hill from the south, it seems as if its summit were inaccesible. But it can be attained without difficulty on foot, and affords a delightful view on almost every side. The Connecticut and the peaceful village of Sunderland on its bank, appear so near, that one imagines he might almost reach them by a single leap.

This mountain overlooks the site of some of the most sanguinary scenes, that occurred during the early settlement of this region. A little south of the mountain the Indians were defeated in 1675 by Captains Lathrop and Beers: and one mile northwest, where the village of Bloody Brook now stands, (which derived its name from the circumstance,) in the same year, Captain Lathop, was drawn into an ambuscade with a company of "80 young men, the very flower of Essex County," who were nearly all destroyed.

### *Deerfield Mountain.*

A sandstone ridge commences at Sugar Loaf, and runs northerly through Deerfield and Greenfield, into Gill, increasing in height as far as the village of Deerfield, where it is 700 feet above the plain on which that village stands. Standing near this point, on the western edge of the mountain, a most enchanting paranoma opens to view. The alluvial plain on which Deerfield stands is sunk nearly 100 feet below the general level of the Connecticut valley; and at the southwest part of this basin, Deerfield river is seen emerging from the mountains, and winding in the most graceful curves along its whole western border. Still more beneath the eye is the village, remarkable for regularity, and for the number and size of the trees along the prin-

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cipal street. The meadows, a little beyond, are one of the most verdant and fertile spots in New England. Upon the whole, this view is one of the most perfect pictures of rural peace and happiness that can be imagined.

### *Mount Toby.*

This is a sandstone mountain of not less elevation than Mount Tom; and it is separated from Sugar Loaf by Connecticut river, lying partly in Sunderland and partly in Leverett. It is separated by a deep valley from the primitive mountains near it on the east. It is a noble mountain, and as yet, is almost covered by forests. The view from its summit is commanding, but it embraces no objects of peculiar and special interest.

It has frequently been stated, and that too by very respectable authority, that the ridges forming East and West Rock, Holyoke, Toby, &c. are a part of the broad mountain ranges, which, commencing at Long Island Sound, rise gradually towards the north into the Hoosic and Green Mountains on the west side of Connecticut river, and into Monadnoc and the White Mountains on the east side. But a slight knowledge of the geological character of these mountains, is sufficient to show that the trap and conglomerate ridges along the Connecticut, differ, *toto coelo*, from the primary ranges on either side. And a slight examination of the topography of these mountains, shows that the former are uniformly separated by deep vallies from the latter, and have no geographical connection except proximity.

What a pity it is, that so many of the most interesting mountains and hills in Massachusetts have got attached to them such uncouth and vulgar names! How must the poets lines

> ——————scramble up and down
> On disproportioned legs, like Kangaroo,

if such words as Saddle Mountain, Rattle Snake Hill, Bear Town Mountain, Mount Tom, Mount Toby, Sugar Loaf, Blue Mountains and Deerfield Mountain, be introduced. Holyoke, Taconic, Hoosic and Wachusett, are more tolerable; though most of them have an Indian origin. It would have been fortunate, if our forefathers had not attempted in any case to supersede the aboriginal designations. For what mountain can ever become an object of much regard and attachment, if its beauties and sublimities, cannot be introduced into a nation's poetry, without producing the most ridiculous associations! Fortunately, there are some summits in the State yet

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unnamed. It is to be hoped that men of taste, will see to it, that neither Tom, nor Toby, nor Bears, nor Rattle Snakes, nor Sugar Loaves, shall be *Saddled* upon them.

In the eastern part of the State, the interesting mountains are few. The loftiest and most striking is

### *Wachusett.*

This mountain is in Princeton, whose general elevation, above the ocean, is 1100 feet: and the mountain lifts its conical head 1900 feet higher, so as to be 3000 feet above Massachusetts Bay. The ascent on foot is not difficult. From the summit, which is little more than naked rock, the eye takes in a vast extent of country on every side. On the east and south the distant hills are comparatively low, and seem to possess an even outline. On the west and northwest, mountain ridges, and peaks succeed one another, becoming more and more faint until the distant Hoosic and Green Mountains fade away into the blue heavens. Several neat villages around the base of this mountain with numerous ponds of considerable extent, give an interesting variety and liveliness to the picture. Probably more of Massachusetts may be seen from this mountain than from any other in the State. It attracts numerous visitors, and a small square wooden tower has been erected on the top.

### *Blue Hills.*

This is the highest and most conspicuous range of hills in the vicinity of Boston. It is most elevated at its western extremity, in the southwest part of Milton, where it rises 710 feet above the ocean. A little to the southeast, and just within the limits of Quincy, the summit is elevated 680 feet. Still farther east it is 570 feet. Northeast a little from this peak, another is 530 feet high. The Monument Quarry in the northeast part of these hills, is 390 feet high; and Pine Hill, to the southeast of this quarry, is 235 feet high. All these summits command extensive and most interesting prospects. And there are some circumstances that impart to these landscapes peculiar interest. One is the proximity of these hills to Boston; whose numerous edifices, masts, spires and towers; and, nobly peering above the rest, the dome of the State House, present before the observer, a most forcible example of human skill and industry, vieing with, and almost eclipsing nature. And the high state of cultivation exhibited in the vicinity of Boston, with the numerous elegant mansions of private

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gentlemen crowning almost every hill, and imparting an air of freshness and animation to the valley and the plain, testify how much taste and wealth can do in giving new charms to the face of nature.

From these hills the observer has also a fine view of Boston Harbor; and this is another circumstance of peculiar interest. For to look out upon the ocean is always an imposing sight; but when that ocean is studded with islands, most picturesque in shape and position, and the frequent sail is seen gliding among them, he must be insensible indeed, whose soul does not kindle at the scene, and linger upon it with delight.

On Monument Hill, is opened perhaps the largest of the quarries of Quincy granite; and from thence a rail road (the only one of much extent yet existing in Massachusetts) runs directly to Neponset river: and this is another circumstance of peculiar interest to the visitor of these hills. Let him ascend the granite tower, which the proprietors of the quary have erected on its site, and he will have before him, not merely the rich variety of natural and artificial objects above described, but this railway, also, stretching away for miles in a right line towards the river, with here and there the cars going and returning. Such conveyances, however, will soon cease to be a novelty in Massachusetts.

Many other hills of moderate altitude around Boston, particularly on the south of the city, might be mentioned as worthy of a visit for the prospects presented from their summits. The heights of the following are given on Hales's beautiful "Map of Boston and its vicinity."

| | | |
|---|---|---|
| In Quincy, near the Common, | - - - - - | 210 feet |
| do. | One mile north, - - - - - | 175 |
| do. | A half mile farther north, - - | 107 |
| do. | A little N.W. of Hon. J. Quincy's seat, | 40 |
| do. | Great Hill, near the eastern extremity of the town, - - - - - - | 94 |
| do. | Squantum, - - - - - - | 99 |
| In Braintree, near the east line, | - - - - | 205 |
| In Weymouth, near the west line, | - - - | 210 |
| do. | Near Town River Bay, - - - | 134 |
| In Hingham, N.W. part of the town, | - - - | 112 |
| do. | On Crown Point, - - - - | 102 |
| do. | A little N.W. of Mr. Brook's M. House, | 107 |

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| | | |
|---|---|---|
| In Hingham, a little south of Mr. Brook's M. House, | | 75 feet |
| do. | Near the east line of the town, - - | 230 |
| In Cohasset, near the west line of the town, | - - | 215 |
| do. | A mile south of Nantasket Beach - | 175 |
| do. | N.E. part of the town, close to the shore, | 110 |
| In Milton, at the Academy, | - - - - | 208 |
| do. | One mile south of this place, - - | 226 |
| do. | A mile west of the last, - - - | 217 |
| do. | N.W. part of the town, - - - | 216 |
| In Dedham, at Mr. White's M. House, | - - | 405 |
| In Dover, Pine Hill, south part, | - - - - | 400 |
| In Waltham, Prospect Hill, | - - - - | 470 |
| do. | Bear Hill, - - - - - - - | 510 |
| do. | Near the N.E. line of the town, - | 570 |
| In Lincoln, Dr. Stearns's M. House, | - - - | 470 |
| do. | Mount Tabor, - - - - - - | 370 |
| In West Cambridge, near the S.W. line of the town, | | 320 |
| In Watertown, N.W. corner, | - - - - | 310 |
| In Charlestown, Prospect Hill, | - - - - | 120 |
| do. | Winter Hill, - - - - - - | 120 |
| In Chelsea, Pulling point, | - - - - - | 84 |
| In Lynn, near Phillips Point, | - - - - | 135 |
| do. | Near King's Beach, - - - - | 147 |
| do. | A mile N.E. of Lynn Hotel, - - | 120 |
| do. | Half a mile north of " " - - - | 125 |
| do. | A mile north of " " - - | 140 |
| In Marblehead, Legg's Hill, | - - - - - | 160 |
| do. | Half a mile N.E. from do. - - | 97 |
| do. | Three quarters of a mile N.E. of the last, | 105 |
| do. | N.E. part of the town, - - - | 135 |
| do. | A little north of the village, - - | 130 |
| do. | On Marblehead Neck, - - - | 137 |
| In Salem, east of Spring Pond, | - - - - | 197 |
| do. | N.W. part of the town, - - - | 145 |
| do. | S.E. part of the town, - - - - | 175 |
| do. | A little west of South Fields, - - | 186 |

Some of the views from the hills around Salem and those on the promontory of Marblehead, are of an imposing character. The extreme rockiness of the coast and islands strikes the observer at first

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as evidence of irreclaimable sterility. But when he sees the luxuriant vegetation of every cultivated spot, and the populousness and elegance of Salem and many of the neighboring villages, the contrast increases his pleasure.

Having thus noticed all the important hills and mountains in the State, with reference to views from their summits, I proceed briefly to sketch the picturesque scenery of particular districts. For we have not seen all that is interesting in the scenery of a country when we have only looked over it from its elevated points. The ever varying prospects which are produced by those elevations, to one winding through the vallies among them, are often of the most romantic character.

### *The Vallies of Berkshire.*

In exemplification of this position, let us suppose an observer to pass from Williamstown southerly through New Ashford, Lanesborough, Lenox, Lee, Stockbridge, Great Barrington, and Sheffield. Till beyond New Ashford, he will be following one of the branches of Hoosic river up the valley of Williamstown. On his right rises the broad slope of the Taconnic range of mountains; while on his left, and near at hand, Saddle Mountain shoots up in imposing grandeur; and more distant, through a lateral valley, a part of the Hoosic range is visible. If it be spring, these mountain sides exhibit numerous species of trees and shrubs emulating one another in putting on their party-coloured foliage; while here and there an Aronia, or a Cornus, is entirely clothed with white blossoms before the appearance of its leaves. If it be summer, these vast slopes are covered from base to summit with a vegetable dress, embracing every hue of green from the dark hemlock and pine, to the almost silvery whiteness of the white oak and poplar. If it be autumn, that same foliage, now assuming almost every colour of the spectrum, and of hues almost as bright, presents one of the most splendid objects in nature.

As the traveler approaches New Ashford, the hills crowd closer and closer upon his path, which winds among them in conformity with the sinuosities of the river; and a succession of romantic and *Alpine* beauties is constantly opening before him.

Having reached the north part of Lanesborough, he begins to descend into the Valley of the Housatonic, which gradually widens before him, and ere he reaches Sheffield, presents to his view a number of most delightful villages, generally in the vicinity of fertile

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alluvial tracts; while on every side, mountains of various altitudes and of almost every shape, form the outline of the landscape. Where, for instance, does the traveler meet in any part of our land with lovelier spots than Pittsfield, Lenox, Lee, Stockbridge, and Great Barrington!

### *Valley of the Connecticut.*

The circumstances that render the scenery of this valley so attractive to the man of taste, are the extent and fertility of its alluvial meadows; the precipitous boldness and irregular outline of its trap and sandstone ranges, already described; and the magnitude and beauty of the Connecticut, and of its principal tributaries, the Westfield and the Deerfield, winding through the secondary basins which their waters or other agencies have produced. Let such a region as this be sprinkled over with villages like Longmeadow, Springfield, West-Springfield, South-Hadley, Amherst, Sunderland, Northampton, Hadley, Hatfield, Deerfield, Greenfield, and Northfield, and it needs the inspiration of poetry to describe its beauties. Unfortunately, however, the Valley of the Connecticut remains yet to be described.

Several of the villages above named are sufficiently elevated to overlook the surrounding region to a considerable extent, though neighboring mountains still tower above them; and thus are combined the beauties and advantages of a location upon a hill, with those to be found in a valley. The upper terrace of Springfield, on which stands the United States Armory, is thus elevated. Still higher is South Hadley, with Holyoke and Tom half encircling it on the west and north, except where the Connecticut has opened a passage between these mountains; serving as a vista through which is disclosed at greater distance the Hoosic range. From the Gymnasium on Round Hill in Northampton is one of the richest views of fertile meadows, and mountains of fantastic shape, to be found in the country. From the Gymnasium at Amherst is a similar prospect; and from the College tower in the same place, one of wider range and more imposing features. From the Seminary in Greenfield, a southern prospect opens of enchanting beauty.

The opening of a new road along the banks of the Connecticut, in the northwest part of South Hadley, has brought to light (I mean, to my own eyes,) a most lovely landscape. Standing on the elevated bank and facing the northwest, you look directly up the Connecticut river, where it passes between Holyoke and Tom; those mountains

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rising with precipitous boldness on either side of the valley. Through the opening, the river is seen for two or three miles, enlivened by one or two lovely islands, while over the rich meadows that constitute the banks, are scattered trees, through which, half hidden, appears in the distance the village of Northampton; its more conspicuous edifices only being visible. Far beyond, and forming the remote outline of the picture, lies the broad eastern slope of the Hoosic mountains. (See Plate IV.)

Another road has been recently opened on the banks of the Connecticut in the north part of Springfield, a mile or two below South Hadley Canal: and here, too, as you face the northwest, a landscape full of interest opens before you. In full view towards the left hand side of the picture, you have the Falls in the Connecticut and the entrance of the Canal on the north shore. A little to the right of the Canal, a well built village occupies a beautiful ampitheatre, whose elevated border is not less than 150 feet high, and mostly crowned with oaks and pines. Beyond this at no great distance, however, Mount Tom occupies the back ground with its bold and imposing outline. (See Plate VI.)

Three miles southeast of Sugar Loaf, in Deerfield, that peak presents one of the most unique views conceivable. Its outlines are so regular, that were the traveler to meet with it in Egypt, he might, at first view, regard it as indebted to human art, for its present shape. At any rate, in that country it would probably have been wrought into a second Sphinx, or some other gigantic monster. But to the student of nature it is no less interesting as the work of God. A little to the left, as seen from the place mentioned above, the southern point of the Deerfield Mountain, sometimes called North Sugar Loaf, appears, as well as the bold western front of that range for several miles: and a little to the right, across the Connecticut, Mount Toby is in full view. The sketch, Plate VII., was taken considerably nearer to Sugar Loaf, and differs somewhat from the above description.

### *Ravine of Westfield River.*

Westfield river has found or formed a deep passage across the whole eastern slope of the Hoosic range of Mountains, through the towns of Westfield, Russell, Blanford, Chester, and Middlefield. The ravine through which it passes, is for the most part very deep and narrow, and cuts across, not only the general direction of the mountain ranges, but across the rock strata also. Hence it might be



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expected that the sides of this ravine would exhibit wild and interesting scenery. Nor will this expectation be disappointed, if the traveler follows the Pontoosuc Turnpike through this defile. Hills and precipicies of every shape will crowd upon his path, now approaching so as to form a narrow gorge, and now gently retiring so as to leave room enough for some industrious farmer to erect his habitation, and gain a subsistence in the deeply embosomed glen. In passing through such a region, the man destitute of taste will be heard speaking only of the roughness, sterility, and gloominess of the country; while the man of taste and sensibility will be absorbed in admiring its beauties and sublimities.

*Ravine and Gorge of Deerfield River.*

Still more remarkable is the gulf through which Deerfield river passes, in a southeast direction, nearly across the whole of the broad mountain range, between the Connecticut and Williamstown valleys. Perhaps the best route for visiting this ravine, is to take the turnpike road from Greenfield to Williamstown. On this route the traveler will not come upon the banks of the Deerfield, until he reaches the west part of Shelburne: but he will obtain a most delightful view of Greenfield, as he ascends the high hills west of that place; and as to the defile, through which Deerfield river runs between Shelburne and Conway, it is so narrow, and the banks, of several hundred feet in height, are so steep, that it is difficult even on foot to find a passage; though full of romantic and sublime objects to the man who has the strength and courage to pass through it. From the west part of Shelburne, however, to the foot of the principal ridge of Hoosic mountain in Florida, a good road leads along the banks of the stream; though in a few places hard pressed between the hill and the river. In one spot it is actually sustained a hundred feet above the river, upon piles driven into the steep and naked declivity of a mountain slide. But through nearly the whole of Charlemont, the hills recede so far from the river, as to form an alluvial valley of considerable width and fertility. The loftiness of these hills, however, and the frequent openings of lateral ravines, through which the small tributaries of Deerfield river disembogue, keep the attention of the tasteful man awake. As he goes westward, these hills approach nearer and nearer to the river, become bolder in their outlines, and steeper in their declivities, till at length, in Zoar and Florida, they shoot up, sometimes, a thousand feet high, in a variety of spiry and fantastic forms, and

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the traveler, as he looks forward, can often see no opening through which the river can find its way. The murmuring of its waters, however, at the bottom of the gulf, sometimes swelling into a roar, as they rush through some narrow defile, tell him that they have found a passage. At length the road leaves the river and ascends the ridge, which in the vicinity is alone denominated Hoosic Mountain, and which is here 1448 feet above the river. It is well to follow this road at least to the height of a thousand feet, in order to look back upon the wild and singular grouping of mountains, among which this river has strangely found a passage; and also to get a view of some of those vast slopes of unbroken forest, which the sides of these mountains present; and which during the twilight, are most splendid objects.

In two or three instances it has happened that I have passed along this ravine in the evening, when the moon was well above the horizon; and I can truly say, that the wildness and sublimity of the scene were thereby immensely heightened; so that I felt it to be a privilege to be thus benighted.

Near the mouth of Deerfield River, in Deerfield, is a remarkable gorge through which that stream empties into the Connecticut. A greenstone ridge of 300 or 400 feet in height, has been cut through in some way or other, in width only sufficient to suffer the river to pass. This pass is in full view from the stage road between Deerfield and Greenfield where it crosses Deerfield River.

### *Valley of Worcester.*

Apart from human culture, this geographical center of Massachusetts would present no very striking attractions to the lover of natural scenery. But this valley possesses precisely those features which art is capable of rendering extremely fascinating. And there is scarcely to be met with, in this or any other country, a more charming landscape than Worcester presents, from almost any of the moderately elevated hills that surround it. The high state of agriculture in every part of the valley, and the fine taste and neatness exhibited in all the buildings of this flourishing town, with the great elegance of many edifices, and the intermingling of so many and so fine shade and fruit trees, spread over the prospect beauty of a high order, on which the eye delights to linger. I have never seen, in a community of equal extent, so few marks of poverty and human degradation as in this valley. And it is this aspect of comfort and independence

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among all classes, that enhances greatly the pleasure with which every true American heart contemplates this scene; since it must be considered as exhibiting the happy influence of our free institutions.

*Valley of the Merrimack.*

The scenery along this river is characterised by beauty rather than sublimity. The hills and mountains are rarely precipitous or very lofty; but generally of gentle ascent and capable of cultivation to their summits. The attractions of the landscape consist of a noble river, beautiful villages, and well cultivated fields and meadows. To the man who loves to see natural scenery modified by human culture, and on every side the marks of an intelligent and happy population, with manufacturing establishments uncommonly flourishing, a ride down this stream on either bank, cannot but be highly interesting. And when he approaches the ocean, let him enter Newburyport from the north, across the chain bridge, and he will have before him a delightful view of one of the most beautiful towns in New England. And if he wishes still farther to witness the riches of the surrounding scenery, let him ascend the tower of the fifth church in that place, and a wide scene of beauties on the land and the sea—natural and artificial—fills the circle of his vision.

*Boston Harbor.*

Let no man imagine that he has seen all that is interesting in the scenery of Massachusetts, until he has made an excursion by water in the harbor of Boston, as far at least as the Light House. A city is always an imposing object when seen from the water, especially, if like Boston, its site be considerably unequal and slope towards the observer. But the numerous islands in this harbor, some of them exceedingly picturesque and even unique in appearance, constitute no small part of the attractions of this delightful excursion.

*View from the State House.*

Upon the whole there is not a more magnificent prospect in Massachusetts, than that from the dome of the State House in Boston; and it will bear a comparison, it is said, with the most celebrated views of a similar kind in Europe. This noble building stands upon Beacon Hill, the highest spot in Boston; and the lantern upon its dome is about 200 feet above the harbor. From this elevation the whole of

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Boston, with its wharfs, shipping, and public edifices; all the islands in its harbor; the shores of the harbor lined with villages and cultivated fields; and within a circle of ten miles, not less than 20 villages, containing, with Boston, more than 120,000 inhabitants, are here surveyed at a glance. Almost every dwelling of this numerous population, is, indeed, visible: and it is rare to see in a circle of so small extent, as many edifices so elegant; and so few that indicate extreme poverty and wretchedness. So richly cultivated is the vicinity of Boston, that it has the appearance of a vast garden. Yet we do not see here the traces of that vandal spirit, which, in so many parts of our land, is making sad havoc with our groves and shade trees; but enough have been spared or planted in this vicinity to give a refreshing and luxuriant aspect to the scenery.

The political and moral considerations which irresistibly force themselves on the mind when contemplating such a scene, cannot fail greatly to increase the pleasure of the observer. What a drawback upon that pleasure must it be, when the traveler is compelled to say, as he cannot but say, when gazing on a large proportion of the interesting scenery of the eastern continent,

"Art, glory, freedom fails, though Nature still is fair."

On the contrary, how refreshing to the benevolent spirit, as it surveys from this eminence the dwellings of 120,000 human beings, to be assured that there is not a slave among them all; and that could the eye take in every part of the commonwealth, it would read on every door post the inscription, "all men are born free and equal;" a maxim which exerts a talismanic influence in defending the feeblest inmate against oppression. Nor should the observer forget that this same maxim forms the basis of every law originating from the edifice on which he stands; and that it is not licentious liberty that is here enjoyed; but liberty guarded by law, and sustained by law: and that it is the general prevalence of knowledge and virtue in the community, that renders it possible to sustain a proper balance between liberty and law. Foreign nations may predict that our beautiful republican system will be ephemeral. It will, indeed, pass away, whenever unprincipled ignorance shall be permitted to bear sway. But so long as intelligence and moral principle predominate in the community, the ark of liberty is safe. At any rate, it is certain that we do now enjoy the blessings of freedom, and the means, widly diffused, of intellectual, moral and religious cultivation. As a consequence, con-

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tentment, competence, and happiness, are found even among the lowest classes in the community. The traveler of a benevolent heart will rejoice to see, as he wanders over the hills and vallies of our commonwealth, how very few in the community have not all the essential means of human happiness within their reach. He need not fear being detained for days in the wildest and most secluded parts of the State. For scarcely will he find the hut, where if really needing shelter, he will not find a welcome, and all that a temperate man needs to make him comfortable. A man who has frequently been thrown into such situations, or in other words, has had opportunity to learn the character and circumstances of the lowest as well as the highest classes in our community, will find his pleasure greatly heightened in surveying our scenery. Let us hope that succeeding travelers, through many generations, may not be deprived of this same happiness; and instead of indulging in gloomy predictions of the downfall of liberty, let every man strive to form and retain that intellectual, moral and religious character, which is its only effectual support.

But I fear that I am wandering beyond my appropriate sphere, by these remarks. I proceed to notice some other objects worthy the attention of the man of leisure and taste.

### *New Bedford seen from its Harbor.*

This flourishing place, already wearing the aspect of a populous city, is seen to great advantage in sailing up its harbor. As the ground on which it is built slopes towards the water, the various objects of interest are thus brought into view, rising above one another in a distinct and pleasing manner.

### *Narraganset and Mount Hope Bays.*

An excursion from Taunton to Newport, Rhode Island, down Taunton river and Mount Hope Bay, and especially from Providence to Newport along Narraganset Bay, conducts the traveler among scenery of great beauty and loveliness. The fertility of most of the country, the neat villages along the way, the numerous irregular contractions and expansion of these bays, forming capes, isthmuses, promontories, bays and harbors in miniature; the islands that are occasionally interspersed, and the interesting historical associations connected with that region, conspire to keep the attention alive and to gratify the taste. Mount Hope, the granite watch tower of the celebrated sachem Phillip, still commands a fine prospect

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of the surrounding region; and we see at once why that sagacious chieftain selected this place for his retreat.

The north and south shores of Massachusetts Bay present much scenery of such a sui generis or peculiar character, as to render it extremely interesting to one unaccustomed to it. As a general fact, there is so great a contrast in the appearance of the two capes that form this Bay, that a visit to the one, only prepares the way for rendering more interesting an excursion to the other. We will suppose the traveler to start from Boston and first proceed along the north shore of the bay.

### *Nahant.*

He will not fail to visit Nahant; which will be the first place of peculiar interest he will meet with along this coast. It is a bold rocky promontory, connected by a low sandy neck of land with Lynn: Or rather, it consists of two islands connected together, and with the main land, by ridges of sand and pebbles. At low water, a perfectly smooth beach of the finest sand is laid bare, which constitutes the road from the mainland; and this sand is so firmly compacted by the perpetual beating of the waves of the Atlantic, that neither horse nor carriage make scarcely a perceptible impression. Hence the ride becomes a delightful one; And although the promontory itself has a very barren and desolate appearance, yet the singularity of the surrounding scenery, the neatness of the houses, built in peculiar style, and the wide extent of the horizon, conspire to render the prospect during the summer of a most attractive character. It is a place of great resort in the warmer months, and a steam boat plies daily between this place and Boston. The vicinity of the spacious hotel at Nahant is very interesting to the geologist: But the particular characteristics of the rocks must be deferred to a subsequent part of this report.

### *Cape Ann.*

I have already spoken of the rockiness of the coast in the vicinity of Salem. As we proceed towards Gloucester, which occupies all of what is properly called Cape Ann, the ledges multiply; and on the Cape the forests are mostly cut down, while the surface is almost literally covered, either with rocks in place, or with bowlders of every size. In the northeastern part of Gloucester particularly, the soil is almost wholly concealed by the countless number of these rounded masses. Over nearly all the Cape, indeed, sienite of every descrip-

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tion meets the eye in immense quantities; and the traveler naturally inquires whither the soil has been carried, which must once have covered them; and what mighty flood of waters could have swept over this region with the fury requisite to produce such devastation. Scenery of this kind, would be regarded as extremely dreary, were not this desolation carried to such an extent as to be interesting by its novelty. It is scarcely possible for any man, however little interested in the *bizarre* of natural scenery, to traverse this region for the first time, without having his attention forcibly and constantly directed to the landscape around him. And hence this must be one of the best excursions for those afflicted with ennui, that can be found. More extensive, however, and in general, finely contrasted with the scenery of Cape Ann, is that along the south side of the Bay.

### *Nantasket Beach and Hull.*

Supposing the traveler to start as before from Boston, the long and narrow neck of land connecting the settlement of Hull with the mainland must not be passed unvisited. To say nothing of the rocks which at the head of this beach constitute almost the entire surface, rivaling even Cape Ann in this respect, and which on the shore present a remarkable and elegant variety of colours, the beach itself, not less than 4 or 5 miles in extent, is much more interesting than that leading to Nahant. The Light House and the Brewster and other islands in view, as one advances towards Hull, are picturesque objects; and then the pleasant and sunny situation of the little village of Hull, furnishes a convenient resting place for the traveler.

In proceeding from this beach to Cape Cod, the traveler should not fail to pass along the north shore of Cohasset — the most rocky place perhaps in the Commonwealth.

### *Cape Cod.*

But after passing Duxbury, the region of sand and gravel commences; and to Provincetown, the extremity of Cape Cod, no genuine ledge of rocks appears; although bowlders of every size, over the greater part of the distance, are common.

The dunes or sand hills, which are often nearly or quite barren of vegetation, and of snowy whiteness, forcibly attract the attention on account of their peculiarity: while the numerous wind mills and vats along the shore, for the manufacture of salt, are scarcely less interesting to one not familiar with such processes. As we approach the

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extremity of the Cape, the sand and the barrenness increase; and in not a few places, it would need only a party of Bedouin Arabs to cross the traveler's path, to make him feel that he was in the depths of an Arabian or Lybian desert. Very different from Bedouins, however, will he find the population of Cape Cod. In the midst of the sands he will find many an oasis, where comfortable and not unfrequently pleasant villages have sprung up, inhabited by a people of mild and obliging disposition, and not deficient in intelligence. A large proportion of the houses on the Cape are, indeed, but one story high. Yet they are for the most part convenient and comfortable; exhibiting the marks of a thrift and independence which one would not expect, when he considers the general barrenness of the landscape. I could name several parts of Massachusetts, where the marks of poverty are far more striking than on Cape Cod.

The sand is so yielding that the traveler will find it more convenient to leave his carriage 20 or 30 miles short of the extremity of the Cape, and proceed on horseback: though it is practicable to proceed with wheels. But for seven or eight miles before reaching Provincetown, he must find his way almost without a track along the margin of a salt marsh during ebb tide. During flood tide, he will be forced to wade through the loose and deep sand higher up the beach. The view of Provincetown along this course, however, is so peculiar, that the traveler feels himself amply repaid for his labor. A semicircular bay is enclosed on the north and east by a sandy beach and low sand hills almost destitute of vegetation, which seem to threaten, and do in fact threaten, to bury the village, and to fill the harbor. The houses, for a population not much short of 2000, are erected on the margin of this bay, just above the reach of the tide, and at the foot of the sand hills. These dwellings are almost as destitute of order in their position, as it is possible they should be: such a thing as a regular street, wide enough for carriages to pass, being scarcely to be found here; and why indeed, should they be, where traveling in a carriage, would be slower than on foot, and where but very little fodder can be obtained, except by transportation, for horses. But the most singular object in this place, is the numerous windmills erected between the dwellings and the harbor, for pumping up the water into reservoirs for evaporation. When set in brisk motion by the wind, standing as they do between the traveler and the dwellings, as he comes from the south, they give to the village a most singular aspect. In short a visit, to Provincetown by land, would probably in most ca-



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ses, be quite as effectual a remedy for ennui and other fashionable complaints, as a resort to Ballston and Saratoga.

In crossing the sands of the Cape, I noticed a singular mirage or deception, which was also observed by my traveling companions. In Orleans for instance, where the ocean is within a short distance on either hand, we seemed to be ascending at an angle of three or four degrees; nor was I convinced that such was not the case, until turning about I perceived that a similar ascent appeared in the road just passed over. I shall not attempt to explain this optical deception: but merely remark, that it is probably of the same kind, as that observed by Humboldt, on the Pampas of Venezuela; "All around us," says he, "the plains seemed to ascend towards the sky."

In crossing the island of Nantucket, in company with Dr. Swift of that place, I noticed the same phenomenon, though there less striking. Afterwards, I saw it for miles on the plain in the southeastern part of Martha's Vineyard. In the latter case, the plain was covered with low shrub oaks.

### *Nantucket and Martha's Vineyard.*

If the traveler wishes to enjoy more of the peculiar scenery of Cape Cod, with some interesting variations, let him pass over to Nantucket and Martha's Vineyard. The former island he will find to be an extended plain, 15 miles in its longest direction, and but slightly elevated above the ocean; containing not one tree, nor a shrub of much size, except in the immediate vicinity of the village. Scarcely a dwelling will meet his eye, except a few uninhabited huts, scattered along the desolate shore, as a refuge to the shipwrecked sailor, Yet from 12000 to 14000 sheep, and 500 cows find nourishment on this island; and in not a few places, especially in the immediate vicinity of the town, may be seen tracts of land of superior fertility. It will strike the traveler at once, as an interesting monument of industry, that nearly every part of the dwellings, stores, &c., for the accomodation of more than 7000 inhabitants, must have been transported from the continent. And on acquaintance, he will find that they still retain the characteristics of industry and hospitality, for which they have long been known; and that the usual concomitants, of these virtues, general intelligence and strong local attachments, are not wanting.

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### *Gay Head.*

The most interesting spot on Martha's Vineyard is Gay Head; which constitutes the western extremity of this island, and consists of clays and sands of various colours. Its height cannot be more than 150 feet; yet its variegated aspect, and the richness of its colors, render it a striking and even splendid object, when seen from the ocean. The clays are red, blue and white; the sands, white and yellow; and the lignite, black; and each of these substances is abundant enough to be seen several miles distant, arranged in general in inclined strata; though from being unequally worn away, apparently mixed without much order. The top of the cliff is crowned by a light house, which commands an extensive prospect. Scarcely a tree is to be seen on this part of the island. It is owned and inhabited by the descendants of the Indian tribes, that once possessed the whole island. It will be seen in the subsequent part of my report, that this spot possesses peculiar attractions for the geologist and mineralogist. During my last visit to the spot, three days were fully occupied in interesting researches.

## Water Falls.

We have one or two water falls in Massachusetts of sufficient magnitude to be denominated cataracts. And as we might expect in a mountainous region, cascades are numerous.

### *Turner's Falls.*

These exist in Connecticut river, near the point where the towns of Montague, Gill, and Greenfield, meet. They are by far the most interesting water fall in the State; and I think I may safely say in New England. At least, to my taste, the much broader sheet of water, the higher perpendicular descent, and the equally romantic scenery of the surrounding country, give to this cataract a much higher interest, than is excited by a view of the more celebrated Bellow's Falls on the same river in Walpole New Hampshire: and probably the latter are generally regarded as the most striking object of this kind in New England.

Above Turner's Falls the Connecticut for about three miles, pursues a course nearly northwest, through a region scarcely yet disturbed by cultivation; and all this distance it is as placid as a mountain lake, even to the verge of the cataract. Here an artificial dam

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has been erected more than a thousand feet long, resting near the center upon two small islands. Over this dam the water leaps more than 30 feet perpendicularly; and for half a mile continues descending rapidly and foaming along its course. One hundred rods below the falls, the stream strikes directly against a lofty greenstone ridge, by which it is compelled to change its course towards the south at least a quarter of a circle.

The proper point for viewing Turner's Falls is from road leading to Greenfield on the north shore, perhaps 50 rods below the cataract. Here, from elevated ground, you have directly before you, the principal fall, intersected near the center by two small rocky islands, which are crowned by trees and brushwood. The observer perceives at once that Niagara is before him in miniature. These islands may be reached by a canoe from above the falls in perfect safety. Fifty rods below the cataract, a third most romantic little island lifts its evergreen head, an image of peace and security, in the midst of the agitated and foaming waters, swiftly gliding by. The placid aspect of the waters above the fall, calmly emerging from the moderately elevated and wooded hills at a distance, is finely contrasted with its foam and tumult below the cataract.

The country around these falls is but little cultivated. On the opposte side of the river the observer will, indeed, perceive a few dwellings and the head of a canal: But a little beyond, wooded elevations, chiefly covered with evergreens, terminate the landscape; while in every other direction, the scenery is still more wild and unreclaimed from a state of nature.

A sailing excursion from the falls, three miles up the stream, has all the attractions of a passage over a mountain lake. And probably the coves along the shore furnish as good spots for fishing as now exist in the river. The geologist too, will find the vicinity of these falls full of interest — but of this, more hereafter.

Three miles above Turner's Falls, Miller's river empties into the Connecticut; and near its mouth is a fall of considerable height. Here also is another dam across the Connecticut, about 10 feet high. I apprehend these falls have been confounded with Turner's; and hence the latter are sometimes called Miller's Falls. They cannot, however, be said to have as yet any well established name. For a reason which will be mentioned below, I ventured some eight or ten years ago, in a geological account which I published of the Connecticut

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valley, to denominate these falls, *Turner's Falls*; and Gen. Hoyt, in his History of the Indian Wars, has given them the same designation. I am aware, however, how very difficult it is to make popular and prevalent, a new name for any natural object; although in the present case, I doubt not, that every man acquainted with the history of this spot, would say that to prefix the name of Capt. Turner to this cataract, is appropriate and just.

About 160 years ago, a party of Philip's Indians, having joined those living in the vicinity, resorted to these falls to take fish. On the 17th of May, Capt. Turner, from Boston, marched from Hatfield, with 150 men, and came by surprise upon the Indian camp the next morning at day light. The Indians being totally unprepared for an attack, fled in every direction: some springing into their canoes without paddles, were precipitated over the falls and dashed in pieces. Three hundred Indians, and but one white man, were killed. Yet the Indians who escaped, being joined by others, fell upon Turner's party as they were returning, and made a dreadful slaughter among them; killing 37, among whom was Capt. Turner. Will not the public do the justice to this brave but unfortunate officer, to send down his name to posterity, associated with that of the spot where he conquered and fell!

During high water, the roar of Turner's falls may be heard from 6 to 10 miles. The magnificence of the cataract is greatly heightened at such a season.

In order to visit Turner's Falls, one must turn aside from every great public road; and although but four miles from the village of Greenfield, this circumstance shows why they are so seldom resorted to by travelers. (See Plate IX.)

### *Falls at South Hadley.*

The descent of the water here being but a few feet, these falls do not in themselves possess any great interest; and yet, as one of the objects in the beautiful landscape which has already been described as existing at this place, their absence would be sensibly felt by the man of taste.

### *Shelburne Falls.*

These occur in Deerfield river where it enters the narrowest part of that deep ravine in the primary strata, between Shelburne and Con-

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way, which has been already described. As a mere object of scenery they are not so striking as Turner's Falls; though they exhibit not a little of wildness and sublimity; and they are especially worth a visit from the geologist, as affording a good exhibition of the effects of a mountain torrent upon the hardest of rocks.

### *Spicket Falls.*

Spicket river is a tributary of the Merrimack, and a few miles above its mouth in Methuen, it falls 30 feet. These falls are in the midst of a flourishing manufacturing village, and are a beautiful object, well worthy the attention and the pencil of the man of taste.

### *Falls in Fall River.*

These are most interesting on account of the economical purposes to which the waters are applied: keeping in motion, as they do, all the machinery of a large and flourishing manufacturing village in Troy. Still, a stream of any size cannot fall 100 feet in the course of a few rods, without presenting natural scenery of some interest.

### *Pawtucket Falls.*

These occur in the Merrimack, between Lowell and Dracut; and their romantic appearance is heightened by the bridge erected at their head.

### *The Gorge, alias, the Glen.*

In the south part of Leyden, a large brook has worn a passage from 10 to 20 feet wide, and from 30 to 50 feet deep, in the strata of argillo-micaceous slate. The layers of the slate are nearly perpendicular, and it is traversed by numerous cross seams, into which the water penetrates, and in winter freezes, expands, and thus assists in removing mass after mass of the rock from its place. A slight inspection of the place will show that such was the mode of its formation; although one cannot but perceive that a great length of time was requisite for the whole process. There is not the slightest appearance of any convulsion at this place, since the original elevation of the strata. The correspondence between the salient and reentering angles on opposite sides of this stream, is no greater than exists in every stream; and all the appearances at the place forbid the sup-

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position often made that these sides have been separated from each other. The length of this gorge is from 30 to 40 rods. Above is a deep glen; and below, the stream passes through a deep ravine. Two water falls near the lower part of the gorge add much to the interest of this spot. And although the geological chronometer here exhibited, is to the reflecting mind, its greatest attractions; yet the wildness and ruggedness of the scenery draw not a few visitors. The term "glen," usually applied to this spot, is certainly a misnomer. For it is a gorge connecting a glen with a ravine.

### *Cascade in Leverett.*

I have recently ascertained the existence of an interesting water fall on the northeast side of Mount Toby, in Leverett. The conglomerate rock of that mountain has been subject to powerful abrasion in early times; and being divisible into masses of great thickness, by fissures nearly perpendicular to the horizon, the sides of the mountain frequently present perpendicular walls of solid rock, and sometimes a succession of precipices in the form of vast steps; while the huge fragments that have fallen down, lie scattered along the base. Such is the case at the spot above referred to; where a large brook, called "roaring brook," comes tumbling down by a few successive leaps from the height of 200 or 300 feet. The waters have worn deep chasms in the rocks, and the scenery around is of the wildest and most romantic character. Every thing there—the lofty forests—the overhanging precipices—and the accumulated rocky masses below—remain unmodified by the hand of man, just as the mighty agencies of nature have left them.

### *Cascade, Natural Bridge, and Fissure, on Hudson's Brook.*

The present falls on this rivulet, which runs through the north part of Adams, are of far less interest than the deep chasm which its waters have excavated in the white limestone. This limestone terminates on the south in a high precipice, over which the stream once fell. But it has worn a fissure from 30 to 60 feet deep, and 30 rods long, in this limestone, and left two masses of rock connecting the sides and forming natural bridges; though the upper one is much broken. The lower one is arched, and the stream at present runs 50 feet below it. The medium width of the stream is 15 feet.

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### *Canaan Falls.*

These are just within the boundaries of Connecticut, on the Housatonic. The water takes two leaps within a short distance; the upper one of 20 feet, and the lower one of 70. It then foams and dashes a short distance and takes a third leap of about ten feet. The effect of the whole scene is imposing.

## CAVERNS AND FISSURES.

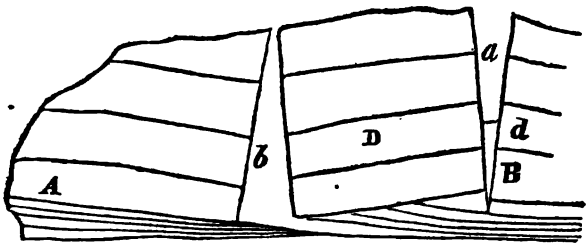
### *Southampton Adit.*

I have alluded in the first part of my report, to this artificial excavation, 900 feet in length, at the lead mine in Southampton. It is a perforation mostly in solid rock, large enough to admit a boat with several persons; and in this manner might be entered with perfect safety. Being unique in this part of the country, it had become a place of considerable resort by gentlemen and ladies during the summer months. At present the entrance is blocked up; but it is to be hoped that ere long the working of this adit will be resumed, and an opportunity again afforded for so fine a subterranean excursion.

### *Sunderland Cave and Fissure.*

The following section will, I apprehend, render intelligible, not merely the form and situation of this cave and fissure, but also the mode of their production. They occur in a conglomerate rock of the new red sandstone, on the northwest side of Mount Toby, in the north part of Sunderland. The conglomerate strata are several feet thick; and immediately beneath this rock lies a slaty micaceous sandstone, which is very subject to disintegration; as may be seen a little north of the cave, where the conglomerate projects several feet beyond the slate, whose ruins are scattered around. The spot is perhaps 300 or 400 feet above Connecticut river: yet there is the most conclusive proof in all the region around, that water once acted powerfully, and probably for a long period, at various elevations on the sides of this mountain: and not improbably this aqueous agency assisted in undermining the conglomerate rock by wearing away the sandstone.

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At *A* and *B*, the rock is but slightly removed from its original position; but in the space between these points, the slate appears to have been worn away so as to cause the whole conglomerate stratum, which is from 50 to 60 feet thick, and consequently of immense weight, to fall down, producing the fissure *a*, and the cavern *b*. . The fissure is nine feet wide at the top, and open to *d*, 40 feet; below which it is filled with rubbish. The cavern is wider than this in some parts, though very irregular in this respect. Its bottom also is rendered quite uneven by the large masses of rock that have tumbled down. In the deepest spot, (56 feet,) the rocks are separated to the surface, so as to let in the light from above. The whole length of the cavern is 148 feet. Its general direction is nearly east and west. But towards its eastern part it turns almost at right angles to the left, in consequence of the rock *A*, having been broken in a north and south direction from the mass of the mountain.

Some who visit this spot are disposed to call in the aid of a convulsion like an earthquake to explain the huge fractures there exhibited. But after seeing so many other marks of the powerful action of atmospheric and aqueous agents on this mountain, I cannot but believe the cause I have assigned to be sufficient. The place is well worth visiting by all who have not examined other caverns and fissures extensively.

On the opposite side of Mount Toby, a little south of the cascade that has been described, one or two other caves occur, more irregular but less extensive than this. They have been produced by the enormous masses of the mountain that have been here mixed *pell-mell* together.

### *Caverns in Berkshire.*

These all occur in limestone; and are so similar, that it is hardly necessary to describe them separately. Two exist in the south part of



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New Marlborough, containing several apartments and some stalactites. In West Stockbridge is a small one. In Lanesborough is one, 100 feet long, narrow and irregular, produced probably by a subterranean stream. In Adams, a mile south of the north village, on the Cheshire road, is a cavern of considerable interest; containing several apartments; the largest of which is 30 feet long, 20 feet wide, and 20 feet high. A similar cave may be seen in Bennington, Vt. And although these caverns will not compare in extent with those in our western states, yet they will afford not a little gratification, to those not familiar with subterranean excursions.

### *Purgatories.*

I know not what fancied resemblances have applied this whimsical name to several extensive fissures in the rocks of New England. The most remarkable case of this kind is in Sutton, 3 1-2 miles south east of the congregational meeting house. It is a fissure in gneiss, nearly half a mile long, in most parts partially filled by the masses of rock that have been detached from the walls. The sides are often perpendicular, and sometimes 70 feet high; being separated from each other about 50 feet.

This is an immense chasm: and I confess myself at a loss to explain its origin. It is natural to suppose that its sides have been in some manner separated from one another. But I can conceive of no mode in which this could have been accomplished, but by a force acting beneath: and this would so elevate the strata, that they would dip on both sides *from* the fissure. But I could discover no such dip. The inclination along the fissure corresponds with that which is common in the region around; viz. about 25° N.E. In the vicinity of the fissure, however, the rocks are often exceedingly broken into fragments:* and this circumstance indicates some early subterranean convulsion. Still, I am rather inclined to refer these fragments as well as the fissure, to the long continued action of the waves of the sea, when the spot was so situated as to form a shore of moderate elevation. The next case of a purgatory which I shall describe, will illustrate the mode in which the waves might have produced such effects.

* Visitors to the Sutton Purgatory should recollect that such broken rocks furnish a fine retreat for the rattlesnake. I met with one among the *debris* of that place. But as he kindly warned me that I was trespassing on his territory, I thought it ungenerous to attack him, and we parted on good terms, mutually willing to be rid of each others company.

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### *In Newport, Rhode Island.*

In the southeast part of this town, (perhaps it is within the limits of Middleton,) the coarse conglomerate rock contains numerous cross seams, which are parallel to one another, and nearly perpendicular to the horizon. In one spot, in a high rocky bluff, two of these fissures occur not more than 6 or 8 feet asunder; and the waves have succeeded in the course of ages, in wearing away the intervening rock, so as to form a chasm about seven rods in length, and 60 or 70 feet deep; the sides being almost exactly perpendicular. This chasm is called Purgatory; and the waves still continue their slow but certain work of destruction.

On the south shore of Newport, a similar fissure occurs in granite. It is, however, much less extensive, not more than 20 feet deep perhaps: and the waves sometimes rush into it with such violence that they are dashed not less than 30 feet into the air. Even granite yields under this everlasting concussion. This spot is called the Spouting Cave.

We have only to suppose the Sutton Purgatory to have been once similarly situated in respect to the ocean, and we have a cause adequate to its production. And yet, what an immense period must the whole work have demanded!

### *Autumnal Scenery.*

Perhaps no country in the world exhibits in its autumnal scenery so rich a variety of colors in the foliage of trees, as our own. But it is particularly beautiful in the more mountainous parts of the land. The trees, whose leaves give the liveliest tints, are the maple, the oak, the walnut, and the sumach; while the pine and hemlock retain their deep green: and if these species be fantastically mixed on a mountain's side, they present a splendid drapery, which, though somewhat approaching to the gaudy, is yet extremely interesting. The change generally commences as early as the middle of September, and does not attain its full perfection till after several frosts of considerable severity. The change proceeds undoubtedly from an increased oxygenation of the coloring matter of the leaves; analogous changes being easily produced in the chemical laboratory by the addition of oxygen to certain compounds,* as for example, the *Chameleon Mineral.* This process in the eyes of a chemist does not

* Annales de Chimie et de Physique, Vol. 38, p. 415.

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seem, as I believe it does to most men, a condition of sickness connected with the decay and fall of the leaf. He views it rather as a beautiful illustration of the means which nature possesses to produce variety. True, it is one of the more advanced steps of vegetable life; but does not seem to be disease. Or if any are disposed to consider it such, it ought to be looked upon as nature descending joyfully in her richest dress into her wintery grave, in exulting anticipation of a speedy resurrection.

Although this phenomena forms an attractive object to the geologist in his wildest excursions among the mountains, at the most delightful season in the whole year for geological research, yet it cannot be regarded as having any connection with geology. But not being aware that any attempt has been made to preserve these autumnal colors on canvas, I have taken the liberty to attempt such a landscape, and herewith transmit it to your Excellency. As it was necessary to watch with great care the proper time for seeing these colors when in their greatest perfection, I have selected a view of the village in which I reside; and if I mistake not it presents a tolerably good specimen of this kind of landscape.

### *Sketches of Scenery Accompanying this Report.*

It has been in my power to obtain sketches of some of the most striking scenery which has been described in this part of my Report; and I take the liberty to forward the same for your inspection. I am indebted for them to Mrs. Hitchcock; as I am for nearly all the drawings and maps accompanying every part of this Report. The landscapes are chiefly confined to the Connecticut Valley; it not having been convenient for her to accompany me to distant parts of the state. They are the following.

1. *Autumnal Scenery.* A view in Amherst. (Plate II.)

2. *A view in Hadley.* This was taken from the south end of the east street in Hadley; standing on the banks of Connecticut river, and looking southerly down the stream and through the gorge between Holyoke and Tom. (Plate III.)

3. *A view from the south through the gorge between Holyoke and Tom.* This was taken from a high bank on the east side of the river, about a mile below the gorge. In looking through the gorge, Connecticut river is seen making several extensive windings through Northampton meadows, while at a distance, a most delightful view of the village of Northampton and the Round Hill School is obtained. (Plate IV.)

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4. *View from Mount Holyoke.* This is a westerly view in the direction of Northampton. It was taken about halfway from the base to the summit of the mountain. But it does not differ essentially from the view at the summit. It is perhaps the most delightful prospect in New England; yet its character is such that it must appear to great disadvantage upon a drawing. The central parts of this landscape are considerably contracted, in order to bring into view the whole of the remarkable curve in the Connecticut on the right. (Plate V.)

5. *View of South Hadley Falls.* The falls are in themselves an object of little interest in this landscape. But the beautiful village at their foot, the wooded amphitheatre in its rear, and Mount Tom, towering in the back ground, with other objects of interest, conspire to render this a very striking view. (Plate VI.)

6. *View of Sugar Loaf Mountain.* This sketch was taken from the plain about a mile south of the base of this conical elevation. On the right, we look up the valley through which the Connecticut runs; and on the left, appears what is called North Sugar Loaf; it being the southern precipitous termination of the sandstone ridge that runs through Deerfield, &c. Both elevations, in order to exhibit a natural appearance, should be colored of a reddish hue towards their summit. (Plate VII.)

7. *View at the Confluence of Deerfield and Connecticut Rivers.* This was taken from an eminence about one mile east of the bridge across Deerfield river between Deerfield and Greenfield. That bridge, seen through a gorge in a greenstone ridge, appears on the left in the drawing; beyond which, Deerfield meadows open; and in the distance, rise the primitive ridges of Shelburne, &c. Deerfield river flows towards the right hand side of the sketch, where it mingles with the Connecticut that comes in from the north. The bridge seen on the right in the drawing, is on the Connecticut, a little above its junction with the Deerfield. After uniting, these streams pass southeasterly, as may be partially seen on the right hand side of the sketch. The bridge across the Connecticut, connects Montague on the east shore with Greenfield on the west. Above the bridge, may be seen an island; and still farther north, the river washes the eastern base of a greenstone ridge, which, in the central parts of the drawing, is covered with woods. These central parts are more contracted than a just proportion would allow, in order to bring both rivers upon the same sketch. (Plate VIII.)

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8. *View of Turner's Falls.* This view was taken from the place on the north or Gill shore, already described as the best point for viewing the cataract. Near the small buildings on the right, is the spot where occurred the bloody battle between Capt. Turner and the Indians of which I have given an account. On the eminence a little beyond, was an Indian fort. (Plate IX.)

9. *Sketch of the Gorge or "Glen" in Leyden.* In this view the observer looks northerly through one of the wildest portions of the ragged chasm; having before him at least two interesting cascades. (Plate X.)

Here I close the second part of my report. It has increased under my pen beyond my expectations. But I could hardly have said less consistently with giving any thing like a correct view of our scenery. If what I have said should lead others to visit and enjoy, as I have done, the spots that have been described, I am sure I shall be the means of imparting much happiness and shall feel a confidence that I have not written in vain.

Respectfully Submitted,

EDWARD HITCHCOCK.

Amherst College, June 1, 1833.

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## PART III.

# SCIENTIFIC GEOLOGY

OF

# MASSACHUSETTS.

To His Excellency Levi Lincoln Esq.
Governor of Massachusetts.

According to the plan suggested in the first part of my Report, I now proceed to a consideration of the Scientific Geology of Massachusetts.

Having already given a view, professedly popular, of our rocks and minerals which are interesting in a pecuniary respect, I shall make no apology for entering into full details in this third part of my Report, of all the geological phenomena in the state, that have fallen under my notice, and seem of any importance to the science. I shall endeavour, however, to avoid all unnecessary prolixity.

No science is making such rapid progress as geology. Even since I received your Excellency's Commission, three years ago, several important principles have been developed by able geologists, which I shall apply to the rocks of this region, so far as I am able. In Europe geological researches have been pushed much farther than in other quarters of the globe: And it is an interesting inquiry, how far the phenomena of rocks in other regions correspond with those in Europe. I hope to show that the rocks of Massachusetts exhibit some analogies of this kind, that prove an identity of the causes that produced them.

The technical terms which I shall be under the necessity of employing, will be used, so far as I understand them, in the sense adopted by the most recent and approved authors. Geology, however, does not abound in terms of this kind; nor shall I employ more than necessity requires.

I ought perhaps to remark that the term *rock*, will be sometimes

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employed, as it is by most geological writers, to include the loose materials and soils embraced in the alluvial, diluvial, and tertiary formations, as well as those solid masses, to which the term is limited in its popular sense.

It is well known that there is not a little diversity among the ablest writers in respect to the names of rocks. Under such circumstances an infallible nomenclature is out of the question. But if, as I intend to do, I describe definitely what is included under each name attached to the accompanying geological map, it seems to me that the difficulty will be in a great measure obviated: especially as I shall present specimens to the Government, of every variety of rock that is described. And should they take measures for preserving this collection, future geologists, may know precisely what is comprehended under each rock mentioned in this report.

Geologists are not agreed whether it is best to describe rocks in a descending or an ascending order; that is, whether they shall commence at the surface with the most recent rocks, or with the lowest hitherto discovered. Each plan has some advantages and some disadvantages peculiar to itself. Without stopping to assign the particular reasons, I shall choose a descending order; that is, I shall commence with the uppermost stratum, viz. Alluvium: and in adopting this course, I follow the example of several of the ablest geological writers of the day, such as Brongniart and De la Beche.

As to the Classification of Rocks, there is also very much diversity among the ablest writers; although there has been great improvement in this respect within the last 15 or 20 years. Yet excepting a few general principles, the different systems for the arrangement of rocks must be regarded as provisional merely, awaiting the revision of some future Linnæus in geology. Among the principles which I regard as established in the science, one is the division of rocks into stratified and unstratified. This division, therefore, I shall adopt. But instead of stopping here to explain the subdivisions of these classes, I shall introduce a Tabular View of the Rocks in Massachusetts, arranged as nearly as possible in the order of their superposition; and opposite their names, I shall put down the most important and ingenious systems of arrangment now in use among geologists; so that a comparative view of them may at once be obtained. (See the accompanying Atlas.) The first column contains the names of the rocks under which I describe them; the second column, the varieties of each rock observed in Massachusetts: the third column, a catalogue

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of the simple minerals found in each rock; and the remaining columns, the various systems above referred to. The simple minerals are put down with little order; without any attempt at classification; it being thought sufficient to refer them to the rocks in which they are found.

In describing the various rocks in the State, I shall, as far as possible, follow a uniform order; giving first the mineralogical characters; next the topography of the formation; next the dip, direction, &c. of the strata; next an account of the organic remains; next of the mineral contents; and finally, add some theoretical considerations. In many instances, however, this order cannot be observed; and in others, some of the above particulars will need no notice.

I was in doubt for a time whether it would be advisable to add any remarks upon the theory of the rock formations, or the explanation of particular phenomena. But such an addition seemed wanting to complete my account of the rocks; and I came to the conclusion to attempt an explanation of all the most important phenomena, which I describe. There will of course be a diversity of opinion concerning many of the theories, and especially concerning the hypotheses, which I shall advance. I have given those which are most satisfactory to my own mind, after consulting several of the most recent, and most able writers upon geological philosophy. While I could not but express plainly, my own decided convictions, I hope I have not done it dogmatically.

A few words more may be necessary in explanation of the geological map. I have striven to reduce it to such simplicity, that its plan and arrangement will be obvious by mere inspection. Some things about it, however, may, need elucidation. To avoid confusion and mistake, I have employed but six colors: which, with the exception perhaps of the blue, are so strongly marked, that they can readily be distinguished by candle light. These colors mark off the rocks of the state into what may be regarded as distinct groups: the members of each group with the exception of the fourth, being so nearly related, that they *might* even be regarded, in most cases, as belonging to the same formation; or if this term be too limited in its meaning, we might resort to the *terrain* of the French geologists; a word to which we have no one in English exactly corresponding. The first group, however, embracing all the unstratified rocks, would include more than one *terrain*, if that term can embrace only the rocks produced during one



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geological epoch, or period.* The second group embraces only gneiss, and those rocks which are so intimately associated with it that they constitute but a single formation. The third group comprehends mica slate and those rocks that are so closely connected with it, as to show great similarity in the causes that produced them; although perhaps not all of them, were formed during the same epoch. The fourth group is miscellaneous, including rocks that have no necessary connection or resemblance. The fifth group includes all the consolidated rocks resulting from sediment; although obviously belonging to at least three distinct formations. The sixth, or tertiary group, takes in all the unconsolidated beds above the chalk, or its equivalent in this country, the ferruginous sand formation.

The tablets attached to the map will show the particular marks by which the members of the different groups are distinguished from one another: And to afford still farther means for accomplishing the same object, and preventing mistakes, I have placed a figure on each tablet, which corresponds with the same figure placed upon the map in every place occupied by that particular rock; so that even if in any case the painter has applied a wrong color, these figures will afford the means of detecting the mistake.

### Stratified Rocks.

The uppermost portion of this division of the crust of the globe consists for the most part of unconsolidated layers of sand, clay and gravel. The lower portion embraces all those solid rocks that are divided by parallel and continuous seams. The stratified rocks occupy in every country by far the largest proportion of the surface.

### Alluvium.

It is well known that a number of causes are daily operating to modify the surface of the globe. In some instances new and solid rocks are gradually forming; in others, and those far the most numerous cases, the rock strata are wearing away, and the fragments, carried by water to the lowest spots, are deposited in the form of sand, gravel, clay, and loam. But all such deposits, whether consolidated or not, are denominated alluvium; excepting only the products of volcanoes.

* See Brongniart's "Tableau des Terrain's" &c. p. 4 Introduction.

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## *Alluvium of Rivers.*

The deposits produced by the overflowing of rivers, are the most common and familiar example of this stratum. They will, of course, consist of that heterogenous mixture which a swollen and agitated stream sweeps along. When first the river issues from the mountains and begins to spread over the plains, coarse gravel and sand, and not unfrequently large bowlders, will be deposited. The finer materials, and most of the vegetable and animal substances, being lighter, will float on farther before subsiding. So that the portion of an alluvial tract which is nearest the mouth of the stream, will generally be most valuable in an agricultural point of view, being made up of the finest and richest loam.

It is quite obvious that the power of rivers in depositing alluvium must be lessened by every successive innundation; since the more elevated the banks, the less frequently will the stream rise above them; and the less the amount of water thrown over the meadows. In some places, along the Connecticut and its tributaries, the banks have already attained such an elevation, that it is only at long intervals that the floods are high enough to surmount them: and yet they are obviously the result of alluvial deposition.

The Connecticut and its tributaries, the Deerfield and the Westfield, furnish the only examples of river alluvium of much extent and importance in the State. Some fine meadows of this description, however, occur on the Housatonic, in Stockbridge, Great Barrington and Sheffield. Indeed, every river in the State, and every brook, present limited tracts of this stratum. But only those along the Connecticut and Housatonic were thought deserving of a place on the Map. In some instances the deposition of the Connecticut, the Deerfield, and the Westfield, is 15 or 20 feet thick. Logs, leaves, walnuts, butternuts &c. are frequently imbedded at that depth, and but slightly changed. Relics of this kind, though of but little importance to the geologists of the present age, may be viewed with great interest in future times, when this alluvium shall have become consolidated and other formations shall be imposed upon it.

The alluvial basin of Deerfield river, in Deerfield, is perhaps the most remarkable example of this formation in the State. It is shut in on all sides by high land, and the river is obliged to force its way to the Connecticut through a narrow gorge in a high ridge of greenstone; and its direction where it empties, is almost opposite to the course of

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the Connecticut. The Deerfield, being a mountain torrent, and of less extent, is raised several hours earlier than the Connecticut after a rain. It even begins to subside before the latter has risen much. But as the Connecticut swells, it throws back the waters of the Deerfield over the broad basin among the mountains, and sometimes retains it there for three or four days, or even a week, until the very finest sediment is deposited. The consequence is, a rapid growth of alluvium, and great fertility of soil.

It is interesting to observe in Deerfield meadows the numerous changes in the bed of the river, that have taken place at no very remote period; though none of much importance since the settlement of the place by the whites. A map of these changes might be instructive as illustrating the operation of existing geological causes. But I did not judge it expedient to construct one, since so many other cases of more importance will require drawings. I remark, however, that as the banks of this river are so easily worn away, constant changes are taking place with much rapidity by the action of the stream, that it must be a fine place for studying fluviatile dynamics.

Patches of river alluvium are represented on the map in Stockbridge, Sheffield, Great Barrington, Longmeadow, Springfield, West Springfield, Northampton, Hadley, Hatfield, Whately, Deerfield and Northfield.

### *Coast Alluvium.*

This sort of deposition is of two kinds. The first is produced by tides and currents in the ocean, which frequently transport large quantities of soil from one place to another, and cause it to accumulate in those situations where their force abates, or is destroyed. In the southeastern part of the State, such cases are numerous: and I have regarded the sandy accumulations of this kind in Provincetown; opposite Chatham and Harwich; on the north shore of Barnstable; and in several places along the northwest coast of Nantucket, as of sufficient extent to deserve a notice upon the map. Deposits of this kind on a smaller scale are very common in the southeast part of the State.

### *Salt Marsh Alluvium.*

Salt marsh alluvium results from the joint action of two, and sometimes three causes: 1. the decay of salt marsh plants; 2. the silt brought over the marsh by the tides: and 3. from the alluvial soil brought down by steams, when these happen to empty through those

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marshes. The Marshes in the vicinity of Boston consist chiefly of a clayey loam, with vegetables more or less decayed, forming in fact an imperfect deposit of peat. The depth of the peculiar pulpy soil of these marshes is rarely more than 6 or 8 feet. In the southeastern part of the State, the salt marshes are much more sandy. In fact, their character depends very much upon the nature of the soil on the coast, since this is carried by the sea into the marshes and deposited. Though salt marshes are numerous along the coast, this kind of alluvium is marked on the map in only two places, viz, in Charlestown and Chelsea.

### *Submarine Forests.*

Though these have not hitherto been noticed in this country, I am inclined to believe that they are not uncommon in the southeast part of the state, and probably all along the Atlantic coast. They consist of the remains of ancient forests, now submerged a few feet below the sea, though sometimes laid bare at low water. The vegetables found in them are generally such as grow in low land; and, indeed, peat not unfrequently occurs. This is the case in the harbor of Nantucket, as I am informed by Lt. Jonathan Prescott, of the U. States army. This gentleman, while superintending the dredging of that harbor, found portions of cedar, maple, oak, and beach trees, some of them in an erect position and accompanied by peat of an imperfect character. All the wood, except the cedar, (*Cupressus thuyoides,*) which was nearly as sound as ever, was very much decayed. These relics were buried by four feet of sand, and were about eight feet below low water mark.

Another submarine forest exists at Holme's Hole, on Martha's Vineyard. It is on the west side of the harbor, and was described by the pilot as having the appearance of a marsh at low water. Stumps have been found there in considerable quantity; of the cedar at least.

Near the southwest extremity of the Vineyard, on the north shore, I was informed that another forest of a similar description may be seen. On the north side of Cape Cod, also, opposite Yarmouth, cedar stumps may be found (as I was informed by the Captain of the Falmouth packet,) extending more than three miles into Barnstable Bay. And Mr. Henry Wilder, of Lancaster, who first directed my attention to this subject, says that the same thing occurs in the bay of Provincetown, on the side opposite to the village. Farther enquiries will no doubt bring to light many more instances of a similar char-

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acter: for my opportunities of observation on this subject have been but few.

Geologists are not a little perplexed, satisfactorily to account for submarine forests. Some of them, it has been thought, might have resulted from the breaking of the barrier of a peat swamp by the ocean; whereby it was drained and the soil rendered more compact so as to subside below the level of the ocean. But in general it has been supposed that these forests have subsided in consequence of earthquakes, or other internal movements of the earth. But if it should be found, as there seems reason for believing, that they exist in every quarter of the globe, and at nearly the same depth beneath the ocean, a cause (like those just named) which is local and irregular in its operation, will hardly explain their occurrence.

### *Peat.*

Various causes are in operation to produce an accumulation of mud upon the bottoms of ponds, lakes, estuaries, &c. In this mud various aquatic plants will take root, and by their decay will swell the deposit. At length the pulpy mass nearly reaches the surface, when sphagneous and other mosses take root in it, along with numerous other plants, and by their gradual decomposition the pond or the lake becomes converted, in the course of ages, into a swamp or marsh. On digging into it, the bottom will be found to consist, near the surface, of interlaced vegetable fibres and roots, with only a small portion of earth: farther down the vegetable matter will be found more decayed and compact, until at length, in many instances, perfect compact peat, with occasional layers of mud, will be discovered.

This is the simple and summary account of the origin of the different varieties of peat. And since the process is daily progressing, it is properly an alluvial formation: though probably a part of the peat in this state was produced previous to some of the latest general and important changes which the earth has undergone. According to this statement, almost any vegetable matters, that have remained for some time beneath the surface of the soil, may be called peat; and it may even be produced beneath the sea by marine plants, such as the *Zostera marina*. It is only within certain limits of moisture and temperature, however, that proper peat can be produced: and hence in the torrid zone, the decomposition is so rapid and perfect, that peat is rarely found. Hence, too, in northern latitudes, the most elevated swamps are the most favorable spots for its production: that is, for

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abstracting the oxygen and hydrogen of the vegetable and leaving the carbon to predominate.

Numerous as are the deposits of peat in Massachusetts, very little need be said concerning it. The localities where it has been found most abundant, are noticed on the map; though doubtless many others would be found equally prolific, if sought after. All the varieties noticed by authors—the marsh—the lake—the forest—the maritime and the transported peat—are found here. Indeed, according to the definition that has been given of this substance, it is perfectly obvious that not a town in the state can be named where more or less of it does not exist. The eastern section, however, is certainly best stored with those varieties that may be employed for fuel. And it is an unexpected fact, that the southeastern parts of the State, which abound with sand, contain also a large amount of peat. According to a survey by Lt. Prescott, the island of Nantucket and the small adjacent islands of Thuckanuck, Muskegut, and Gravel, contain 30,590 acres; of which, 1050 are fresh ponds, and 650 are peat swamps: the beds being from 1 to 14 feet thick, and generally of good quality. This must afford an inexhaustible supply of fuel for the inhabitants; and yet I was surprised to learn, that although the price of fuel is very high there, peat is not much employed. This perhaps results from the habit of bringing almost every article used on the island from abroad; or more probably from the general thrift and comfortable circumstances of the inhabitants, which enable them to employ the kind of fuel that is most pleasant; and who is there that would not prefer wood to peat?

The process by which peat is produced, must be every year less prolific in its results; especially in this country. For many swamps are already so much filled as to raise the plants on their surface too high to receive the requisite moisture. And besides, the trees and shrubs are cleared away from many, and their surfaces converted into fields for producing grass. Some very fine mowing lots of this description may be seen a little west of the village in Nantucket: and over the whole surface of that island, scarcely a tree or shrub is now to be seen, so that here the formation of peat has probably in a good measure ceased. The peat swamps there (as they now are in many parts of the southeast extremity of the State) were probably once covered with the white cedar.

According to the Messrs. Danas, trunks of trees, generally of some

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species of pine, occur in peat, several feet below the surface, in the marshes of Charles river.

### *Marl.*

In limestone regions, the waters generally contain more or less of the carbonate of lime in solution; and this, gradually depositing along with the fine clay or mud held in suspension, produces one of the varieties of marl. In a few places in Berkshire County, such marl is now in the course of formation at the bottoms of ponds. In this marl (No. 12 of specimens)* occur one or two species of Planorbis, one of Physa and a Cyclas; corresponding with existing species in the same region.

### *Alluvium of Disintegration.*

Very few rocks have the power of completely resisting the united influence of air, water, heat and cold. And some kinds are powerfully and deeply acted upon by these agents. Perhaps the new red sandstone is more affected in this manner than any other rock in Massachusetts: and not unfrequently its surface for several feet in depth, is converted into mere sand and gravel. This becomes gradually mixed with the soil, and gives a decidedly red hue to extensive tracts. Next to this sandstone—and I am not sure but even more subject to decay—is our gneiss; especially that in Worcester county. Hence in that part of the State—hilly as it is—we sometimes scarcely see a rock in place, in crossing a whole township. In an excavation which I lately noticed in Spencer, I had an opportunity of observing that a disintegration had taken place in the gneiss, from 6 to 10 feet in depth. I could distinguish the materials resulting from disintegration, from the diluvium lying above them, by observing that in the former the masses of gneiss, remaining undecayed, had a position parallel to that of the layers of the solid gneiss beneath, being considerably inclined; whereas the fragments in the diluvium exhibited no such parrallelism. I have never seen a disintegration so deep as this in the new red sandstone. Some varieties of trap rock, particularly one on Connecticut river, whose base is wacke-like, and some of the sienites in the eastern part of the State that abound in iron, disin-

* In all cases where numbers are included in parenthesis in the subsequent part of this report, they refer to the specimens of rocks and minerals which I have deposited in the hands of Government.

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tegrate, and even decompose, rapidly. Mica slate and talcose slate are similarly affected, though to a less extent, as is also argillaceous slate, and some varieties of slaty gray wacke.

Quartz rock, for the most part, is one of the most indestructible of all our rocks. Those rounded and smooth bowlders of granular quartz especially, that are so common in the western part of the State among the diluvium, appear in general to have bid defiance to all decomposing agencies in past ages, and to be destined to endure unchanged for ages to come. Yet I had recently pointed out to me a rather curious, and somewhat instructive example of these bowlders, lying in the extensive fruit-tree nursery of Mr. Tracy, in Norwich. It was several feet in diameter, and though not as smooth as some bowlders of this kind, yet I should not have suspected that it had suffered the least waste, were it not for an inscription that appears upon it. The name of John Gilpin is marked on its upper surface, in a large fair hand, a few of the letters only being indistinct. These letters are not cut in the stone, nor do they consist of any foreign substance, like ink, or paint, spread over it. But they are rendered visible simply by the lighter color of the surface, where they were originally written; and by passing the finger over them, it is obvious that they project slightly. Hence I infer that these letters were originally written with some kind of paint, which prevented the rock beneath it from decaying; while the decomposing process went on gradually on the other parts of the stone. Now as these letters must have been written since the settlement of that part of the country, we cannot suppose that more than 150 years at the longest have since elapsed: and probably the period is much less. We have here, then, a sort of measure for determining the rate at which hard quartz rock will decay by atmospherical agencies.

### *Alluvium of Degradation.*

Three causes are constantly operating to degrade the mountains and hills and to fill up the valleys; viz. rains, frost, and gravity. That they have not already reduced the earth's surface to a level, is decisive proof that the globe has not existed in its present state eternally. Such a result must ultimately proceed from these causes, if they continue long enough in operation: and that would be to reduce the globe to an uninhabitable chaos: for if the present dry land were



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spread uniformly over the whole globe, the ocean would flow over the whole of it, even with considerable depth of waters.

In precipitous ridges, particularly of trap formation, frost commences the work of degradation. Water, penetrating the fissures of these rocks, expands by freezing and forces them slightly asunder. This makes room for a larger portion of water the succeeding winter; and thus the process goes on until the columnar masses of rock are urged downward by the force of gravity and powerful rains. This is the origin of those extensive slopes of broken fragments, or *debris* of rocks, which arrest the attention on the mural faces of the greenstone ridges in the Connecticut valley. Generally these fragments rise only about one half or two thirds the height of the ridge; though sometimes they continue to the very summit: the process of degradation from this cause having come to an end.

Instances of this kind have been regarded by geologists as a kind of natural chronometer, demonstrating the recent origin of the present state of the globe. No observations, however, have been made on the progress of this leveling process accurate enough to compare it with historical records.

When the three causes of degradation above mentioned combine their maximum energy on the sides of steep Alpine summits, they produce the well known and sometimes terrific phenomenon of *land slips*. Though examples of these on a limited scale are very common in Massachusetts, yet the only one worthy the particular attention of geologists, is on the southwest side of Saddle Mountain, at the place called the Hopper. But this has been particularly noticed in the second part of my Report.

### *Bog Ore.*

In the western part of Worcester County, and over a large extent of territory, the process by which this ore is produced and deposited, is so manifest that it deserves description. The gneiss rock there, abounds with the sulphuret of iron. This is continually undergoing a decomposition by the action of heat, air, and moisture; and becomes changed, first into an oxide, and then, some of it into a sulphate. The oxide usually imbibes more or less of carbonic acid from the atmosphere, and is changed into a carbonate; which is soluble in water. Or this oxide, being washed from the rocks by rain into cavities,

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meets with water containing carbonic acid, by which it is dissolved. Once dissolved, it is readily transported to ponds and swamps, and there deposited by the evaporation of the water. In the region above referred to, this process may be witnessed in all its stages. By breaking the rock we find the sulphuret unchanged; while the surface is coated over with the oxide, sulphate, and carbonate. The soil, also, to a considerable depth, exhibits very strikingly the color of iron rust; and in the low grounds the bog ore is abundant.

Probably a similar theory will apply to the production of this ore in other parts of the State; though I know of no spot where the process is so obvious as in Worcester County. Indeed, the fact that very many of our bog ore deposites are buried several feet deep by soil, and occur on dry ground, shows that in those places the process of its formation has long since ceased. In several ponds in the southeast part of the State, it is said, however, that it is forming rapidly.

Since iron is a mineralizer of organic substances, we might expect to find organic remains in bog ore. In that of Massachusetts, I have noticed only vegetable relics. In New Braintree the culms, spikes, and spikelets of grasses — mostly of carex—are common. The spikes and spikelets especially, are very distinct and perfect. (No. 19) Even the natural color of the fruit is sometimes preserved; and to appearance it seems to be unaltered; but examination shows the whole to be only iron ore.

### *Oxide of Manganese.*

I know not why geologists have omitted this substance in enumerating alluvial deposites. For it seems to have as good claims to be regarded alluvial, as bog ore and peat. I refer particularly to the hydrated oxide, or black wad; which is ordinarily a mixture of manganese, iron, and clay. This is certainly produced daily by a process analogous to that which forms bog ore; that is, the decomposition of rocks containing manganese, exposes that metal to be washed by water into cavities on the surface of the earth, where it either incrusts other substances, or forms a separate deposite. Instances of this incrustation may be seen every where in the primary region west of Connecticut river; and examples of such deposition I have observed in Leverett, Whately, and Conway. These deposites are sometimes a foot in thickness, and occur in low places, covered only by a few inches of soil.

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### *Power of Ice in the Removal of Bowlders in Ponds.*

I am not aware that this phenomenon has been noticed on the eastern continent; and it has been but rarely observed on our own. Its effects in modifying the face of the globe must be very limited; yet they deserve enumeration.

It is well known that water, by an apparent exception to a general law, expands with great force when freezing, and even far below the freezing point. Over a large extent of surface this effect may be very considerable; and when bowlder stones, lying in shallow ponds, become partially enveloped in the ice, they must feel the effect of this expansion, and be driven towards the shore: since the force must always act in that direction. As no counter force exists to bring back the rock to its original position, the ultimate effect must be to crowd it entirely out of the pond; and perhaps to this cause we may impute the fact, that on the margin of some ponds we find a ridge of bowlders; while the bottom, for a considerable extent, is free from them.

The removal of rock masses in this manner was first noticed in Salisbury, Ct.; and a statement published in Vol. 9th of the American Journal of Science. I have seen no similar instance in Massachusetts; but Rev. Sylvester Holmes, of New Bedford, informs me, that an undoubted example of these traveling bowlders exists in a pond in Carver, Plymouth County; and that their track in the mud is quite obvious.

### *Action of the Sea upon the Coast.*

It would not be proper in this place to go into the minute details of this subject. Where the combined and often conflicting agency of breakers, tides, currents, and rivers at their mouths, is to be taken into the account, it is obvious that very complicated effects must result: yet in general it may be stated, that the sea sometimes encroaches upon the land, and sometimes makes additions to it. Whether upon the whole these effects are balanced, is a question upon which geologists are divided in opinion. My object is merely to state such facts as have fallen under my notice in respect to the coast of Massachusetts.

### *Encroachments of the Sea.*

The most remarkable example of this occurs in Boston Harbor. Here, as is well known, are numerous picturesque islands, the inner

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ones, nearly as far as the Boston Light, being composed chiefly of diluvium; though on their shores, at a low level, not unfrequently we find argillaceous slate and other rocks that occur on the main land. But all the islands outwards from the Great Brewster, are merely naked masses of rock, and it would be natural to infer that the diluvium had been removed from these, even if we did not actually detect the process. But on the Great Brewster, the work is going on before our eyes. Its eastern side is a high bank of diluvium, obviously wasting away by the action of the waves that roll in upon it from the wide Atlantic; while the extensive beach along its southern side, is composed of the materials that have been swept away from its outer coast. The same process is seen going on upon the outer side of several other islands; and on Deer Island an extensive wall of stone has been erected by the U. States Government to arrest the progress of this degradation; which, if continued much longer there, would lay open the inner part of Boston Harbor to the fury of the northeasterly storms. From the same cause another of these Island, (I have forgotten which,) when seen from the northeast, exhibits an outline as regular, and with a single house near its center, as fantastic as this drawing.



It seems to me that no man, accustomed to reason correctly from geological facts to their causes, can hesitate, in view of the appearances which these islands exhibit, to infer that all those outside of the Great Brewster have been deprived of their diluvial coat by the action of the ocean. Nor when we consider the frequency and violence of northeast winds and storms upon this coast, need we fear that the cause is inadequate to the effect; although it is not less than two and a half miles from the Great Brewster to the outermost of the Graves. It does not, indeed, follow, that all the intervening space between these outer islands was once solid land; so that the ocean has actually worn away 2½ miles; and yet, this seems highly probable. Indeed, the mind is irresistibly led to enquire whether the whole harbor has not been thus produced by the same cause; and when we see so many islands scattered over its bosom, which seem obviously the wrecks of one continuous diluvial formation, and perceive that the rocks, wherever they occur, are only a continuation of those occurring on the mainland, the most cautious reasoner can hardly avoid the conclusion that such was the origin of this harbor: or, at least, that this was a powerful auxiliary cause in its formation. Nay,

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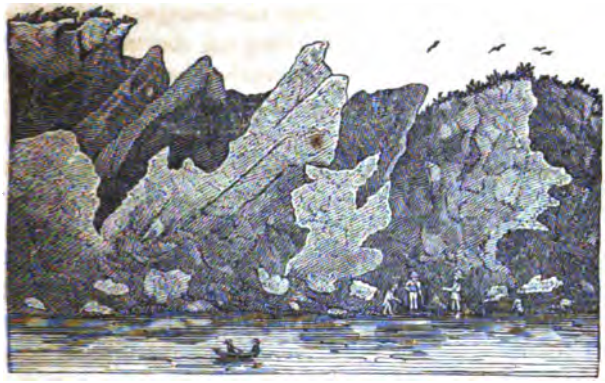
it is difficult to see why the same reasoning will not apply to the whole of Massachusetts Bay; and when we see with what tremendous force the ocean must, for ages, have battered the hard sienitic rocks of Cape Ann, and what an immense accumulation of sand, gravel, and bowlders, has been made along the south shore of this bay, we feel almost prepared to adopt this theory. And yet, we are staggered in our belief when we reflect on the immense period of time requisite for such a work; and doubt whether other geological facts do not indicate a later commencement to the present order of things on the globe.

The proper place for learning the dynamical effect of northeast storms upon our coast, is on the north east side of Cape Ann. Rocks of many tons weight have been in this manner moved from their beds, and driven inward a considerable distance. I regret that I cannot be more definite in this statement. But one has only to visit this coast to be astonished at the marks every where exhibited of the powerful agency of a stormy ocean, and to be satisfied that nothing but the extreme hardness and unstratified structure of the rocks has enabled them to resist its violence. And when we learn that the rocks of Boston Harbour are softer and shistose, we see a sufficient reason why they have given way before the breakers, while Cape Ann, and the shores of Cohasset and Scituate, maintain their position.

Several cliffs of clay and sand along the coast exhibit the combined effects of the ocean, rains, frost, &c. in wearing away the land. In Chilmark, on Martha's Vineyard, is one of these facing the southeast, and at least a mile in length. It is now rare that the breakers rise high enough to impinge directly against the cliff: but they wash away whatever materials have been brought down by the rains. Gay Head, which is the western extremity of the same island, presents a cliff of variegated clays, sands, &c, not less than 150 feet high; and which, standing exposed to the buffetings of wind and waves from the sea, and to the wastes of storms from above, exhibits perhaps the most instructive example along the shore, of the effects of these agents. In the second part of my Report, I described this cliff as a most picturesque object of scenery; but there is not likewise a more interesting spot in the State, to the geologist. And among other things he cannot but notice the numerous fantastic forms into which the lofty masses of clay have been worn, while the numerous bowlders and pebbles along the beach attest the violent action of the sea. The fol-

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lowing sketch, hastily taken, will give some idea of the aspect of the northwestern part of this cliff, as seen by a person standing on the beach below, close to the water—To exhibit it in perfection, the various lively colors of the different kinds of clay should be put upon it.



Oblique View of the Clay Cliffs at Gay Head.

A similar bank of clay occurs at the Light House in Truro, near the extremity of Cape Cod. It lies exposed to the unbroken fury of the wide Atlantic, and the marks of slow encroachment upon the land are quite manifest. Indeed, it is the prevailing opinion in that region, that this Cape is wearing away along the whole extent of its eastern extremity, and extending farther into Massachusetts Bay on the opposite side. I have no doubt that this is the case. For the general current on that coast is towards the south.

The same I presume is true of a considerable portion of the eastern shore of Nantucket. From data, on which Lt. Prescott places considerable confidence, he infers, that in one place, the loss of land within half a century, has amounted to 3 or 4 rods in width.

This advance of the ocean, however, must not all be imputed to the action of currents. For when once a sand bank of considerable height has been raised on the coast, the sea breezes will drive it inwards farther than the land breezes will bring it back. This inland march is quite obvious on Chatham Beach, in the situation of a swamp, which, 50 years ago, was in the center of the beach; but now lies near the eastern shore; the body of the sands having moved farther west. A salt meadow formerly situated on the western side of the beach, adjoining the old north passage into Chatham

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harbor, has been covered up, and now begins to be disinterred on the eastern shore. A similar change of sides has taken place in a peat swamp on Nauset Beach; which lies north of Chatham Beach, joining the main land at Eastham.

I have described, in the second part of this Report, two excavations in solid rock in Newport, Rhode Island; one of which is called Purgatory; and these may be taken as a good example of the action of the sea upon a rocky shore.

### *Gain of the Land upon the Sea.*

Very frequently the materials that have been swept away by the sea, are again deposited by tides and currents along the same coast, forming low beaches. This is the case in nearly all the instances on our coast where the land is wasting away. Perhaps the most remarkable example is Chatham Beach, at the southeastern extremity of Cape Cod, which was probably all formed in this manner. On the Cape I was informed that this beach had advanced southerly, during the last 40 years, at the rate of a mile in 8 years. Des Barres constructed a chart of this coast in 1772, and he says that the gain of this beach, for 30 years previous to that period, was 2 1-2 miles, that is a mile every 12 years.

An intelligent writer in the Barnstable Journal, however, has recently stated that it has advanced southerly only three miles in 70 years. He says that 20 years ago, this beach was an island; and that there was a good harbor near its northern termination, which is now entirely filled up; so that no indentation of the coast marks its former situation. Webb's island, also, formerly situated not far from this harbor, is entirely washed away. In consequence of these changes, it is well known that the harbor of Chatham, once excellent, is nearly ruined; and nothing can save it from complete destruction but the forming of a new entrance.

Nauset Beach, already referred to, has likewise extended, according to the same writer, a mile southerly in 50 years; and it can extend no farther in that direction. In Nauset harbor the salt marsh has so much increased within 40 years, that 300 tons of salt grass are now cut where at that time only flats existed.

Monomoy Beach extends southerly from Chatham towards Nantucket; and has been formed in a similar manner by increments at its southern extremity. Not long ago the sea broke across the northern part of this beach, so that it is now an island.

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Sandy Neck extends eastward from Sandwich nearly across Barnstable harbor, and it continues to advance in an easterly direction. There can be little doubt, also, that nearly, or quite the whole of Provincetown was formed in the same manner, and ought to be regarded as alluvial.

In like manner Smith's Point, which is a low sand beach constituting the southwestern extremity of Nantucket, has been produced by materials drifted thither by tides and currents from the eastern side of the island. When Des Barres constructed his chart, its extent was nearly the same as at present. But since that time, as Lt. Prescott informs me, it has been from one to two miles shorter. Whether the current that forms this beach passes around the northern point of the island, or along its southern shore, has not been ascertained: but it is certain that a current does set around the northern point, and thence along the northwestern shore, as certain facts prove, which I have not time to mention. And probably it is this current chiefly which has formed Smith's Point; and not unlikely, also, the islands of Thuckanuck and Muskegut, as well as the extensive shoals between Nantucket and Martha's Vineyard. It may be likewise, that another current passes along the south shore of Nantucket, aiding in this work, and forming Nantucket Shoals. And perhaps the irregular action of these currents, aided by unequal tides, may sometimes lengthen out, and at other times curtail the low beach of Nantucket called Smith's Point.

In several other places on the shores of Nantucket, there appears to have been an accession to the land, in the manner that has been described. But I am too ignorant of details concerning these spots, to be able to make any statements of interest about their progress or extent.

Considerations like the foregoing often lead a man to feel as if such low sandy islands as Nantucket, and others in its neighborhood, were sliding from under his feet. But that no general change of position has taken place in them is obvious from the fact, that most of the cliffs on the shores of Nantucket at least, exhibit regular layers of sand and clay, demonstrating its general structure to be that of a tertiary formation, which has never been removed since its original deposition. True, if the world exist long enough, and these agencies continue to operate, the whole island will change its position. But as the work has progressed so slowly during the past 6000 years, the time requisite for its completion must be immensely great.



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### *Dunes or Downs.*

Sand is frequently thrown by the spray, or waves, during a storm, so high upon the shore, that the reflux waves do not carry it back. This being dried by the sun, is driven inwards by the sea breezes, and in the course of time forms hills of conisderable elevation. Or sometimes the wind from the sea raises the sand from a cliff of tertiary formation, and carries it inland. Thus are formed those moving sand hills, which on the eastern continent, are called dunes or downs, and which have excited so much interest near the banks of the Nile. As might be expected, these dunes are common along the shore in the southeastern part of Massachusetts. They may be seen in the greatest perfection and on the largest scale, on Cape Cod; particularly near its extremity. They are frequently as high as 60 or 70 feet, and on the east end of the Cape, they move towards the west, but at what rate, in any instance, I was unable to ascertain. A series of these dunes, several miles long, threatens the village and bay of Provincetown, and large quantities of the beach grass have been transplanted to their ridges for the purpose of arresting their progress. I observed, also, that the two species of Hudsonia, which are common on the Cape, present no small obstacle to the advancement of these sands; though never transplanted, that I am aware of, for this purpose.

On both shores of Cape Cod throughout its whole extent, may be seen dunes more or less extensive: and by their snowy whiteness they sometimes give great interest to the landscape. I cannot learn that any of them have been productive of such extensive mischief to farms and villages as has sometimes resulted from their progress on the eastern continent. It would be strange, however, if the future history of Cape Cod should not contain catastrophes of this kind. Indeed, I have stated that they have aided in filling up the harbor of Chatham.

Dunes of smaller extent, and of low elevation, occur on Nantucket, Martha's Vineyard, some of the Elizabeth Islands, and in many places along the coast in the county of Plymouth. Moveable sand hills also occur rarely in the interior of the state; as, for instance, in the Connecticut valley, in Montague, Hadley, and in Enfield, Ct. But concerning these I know of no facts of special interest, except that they are slowly advancing towards the southeast; indicating the predominance of northwest winds.

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## *Valleys.*

Accurately to classify valleys, and assign probable causes for their origin, is one of the most difficult problems in geology. The man who takes only a hasty glance at the subject, is very apt to impute all valleys to the action of existing streams. But it needs only a slight examination to satisfy the observer that such a cause is totally inadequate to the effect. It will not, for example, explain the very common occurrence of one valley crossing another. Hence geologists have been obliged to resort to several causes to explain all the phenomena. The origin of one class of vallies, they refer to the original elevation and fracture of the rocks by a force acting from within the earth. A second class they regard as the result of diluvial action at various periods. A third class they suppose to result from the agency of existing streams.

I am not aware that any attempt has yet been made to classify and point out the origin of the valleys of this country. Nor shall I attempt to do this in respect to all the valleys even in Massachusetts. I have no expectation of doing any thing like justice to so difficult a subject, except where long local residence has afforded ample opportunity for re-examination and reflection. I shall therefore confine myself chiefly to the valleys in the region of Connecticut river; though if I do not greatly mistake, these are by far the most remarkable and interesting in the State.

It is only those valleys which are the result of alluvial action that can be properly considered in this place. But as it will be more convenient to treat of the whole subject together, I shall here offer all the remarks I have to make upon it.

It is now generally admitted by geologists, that all stratified rocks must have been originally deposited in nearly horizontal layers, and subsequently elevated to their present inclined position by a force acting beneath. Such a disturbance must have produced many violent and extensive fractures in the strata and valleys of every shape. And since in the mountainous parts of Massachusetts, the strata are mostly primary and highly inclined, probably this is the manner in which most of our mountain valleys have been produced. If, as is now also generally admitted, the strata were elevated from the bottom of the ocean, the retiring waters must have acted powerfully upon the irregular surface, and considerably modified the forms of the valleys. The agency of rains, snows, and rivers, since that period, must have

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given them still farther modifications. Nor ought we to leave out of the account any other deluges of a date subsequent to that of the elevation of the strata, that may have swept over the land.

The valleys through which the Connecticut and its tributaries flow, are the largest and most remarkable in the State. The ordinary laws of physical geography seem here to be set at defiance; so much so, that a late ingenious writer* doubted whether I had correctly represented the "Geology of the Connecticut," because the course of the rivers, and the direction of the mountain ridges, were described as having so little correspondence with the rock formations. But the features of the geology, as well as of the scenery, along this river, are too obvious to be easily mistaken in their great outlines, which are alone concerned in this enquiry. The relation of the rivers to the different mountain ridges and rock formations, I hope to render intelligible by the aid of the accompanying map, (See Plate XV.) on which are traced only the chief outlines of the surface. To present all the smaller irregularities of surface, I found would only obscure the points which I wish to illustrate.

That portion of the valley of the Connecticut to which I shall specially refer at this time, extends from near the north line of Massachusetts to Long Island Sound at New Haven. It is bounded by broad and generally lofty primary mountains; which, at the northern and southern extremities of the valley, converge until they almost meet, as may be seen on the map. They are farthest asunder about in the latitude of Hartford. This valley is divided diagonally by a ridge of greenstone; commencing on the south with West Rock at New Haven, and extending, with few interruptions, to East Hampton, where it attains an elevation of about 1000 feet, and forms Mount Tom. Here it crosses the Connecticut, and on the opposite bank, forms Mount Holyoke; and continuing a few miles farther, terminates in Belchertown, as already described in the second part of this Report. This greenstone range is separated by vallies from the primary ranges at its extremities; and there are several places where it almost entirely disappears, as at the point in Hamden, through which passes the Farmington Canal: unless any are disposed to regard Mount Carmel, in that town, as the southern extremity of the range, and the hills to the southwest, as a distinct range. Several other

* Darby's View of the United States, p. 164.

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hills and elevated ridges of less extent, occur in this valley; but it is unnecessary in this place to describe them.

In tracing the Connecticut through this valley, the geologist will be surprised to find it crossing the greenstone ridge above described, and that too in its highest part, viz. through the gorge between Holyoke and Tom. For he will naturally enquire, why did not the river flow through that part of the valley west of this ridge; and following the course of the Farmington Canal, empty at New Haven? For it appears from the surveys on that Canal, that in no place is that part of the valley more than 134 feet above the present level of the Connecticut at Northampton; whereas the ridge through which it passes is from 800 to 1000 feet high. But the surprise of the geologist will be still farther increased, when he finds this river at Middletown, quitting the great valley above described, and passing over the remainder of its course through a deep ravine among primary mountains.

What inference shall we deduce from these remarkable facts? Why, surely, that the Connecticut River did not excavate its own bed; for had the barriers at Northampton and Middletown been higher than 134 feet, above its present bed, it must have emptied into the Sound at New Haven. We must seek some other cause, therefore, for the origin of the passage between Holyoke and Tom, and for that through the mountains below Middletown.

Another inference is, that if the Connecticut ever formed a lake in its present valley, it must have been rather limited and shallow. For every place 100 feet higher than Northampton meadows at present, must have been above the waters. It may perhaps be thought that a barrier might have formerly existed at New Haven, which was subsequently worn down. But this would have been too mighty a work for any transient deluge to accomplish; and the idea that the land was for a long time sunk beneath the ocean after the existence of the river, so as to be acted on by currents, cannot be admitted, because this would have destroyed the river. The existence of an extensive tertiary formation along the Connecticut, however, with horizontal strata, renders it probable that this river did once form a lake in its present valley; though I have not been able to determine certainly whether this tertiary formation was formed beneath fresh or salt water.

Not less remarkable than that of the Connecticut, are the beds of its principal tributaries, the Deerfield, the Westfield, and the Farm-

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ington rivers. As may be seen on the map, these all cross a high ridge of greenstone before they reach the Connecticut; and in the case of Deerfield river particularly, the gorge through which it passes, not less than 250 feet deep, appears as if it must have been worn down for the express purpose of suffering the river to pass. And yet, this river has only to rise 80 or 90 feet above its present bed, in order to find a direct passage to Connecticut river on the south side of Sugar Loaf mountain. And so the Westfield and the Farmington might have passed down the western part of the Connecticut valley, and emptied at New Haven, had their beds been from 100 or 130 feet higher than at present. And such must have been the course which all these rivers would have taken, had not the gorges through which they now pass in the greenstone ridges, been excavated for them before they began to flow, at least, to a considerable depth.

The direction of the primary strata, and the general course of the valleys in the mountainous region on the west side of the Connecticut valley, is north and south. But instead of following these valleys, Deerfield and Westfield rivers flow through ravines, running in general across the strata, and across the general course of the valleys. These ravines are, for the most part, very narrow and deep, and the edges of the strata on their opposite sides correspond. It seems difficult to suppose that these rivers have produced these ravines; and yet, since no similar ones occur in the region, one hesitates to say that they were not formed by fluviatile action. There is not certainly the same means of proving their existence previous to that of the rivers, as in regard to the gorges already described, through which these rivers and the Connecticut flow. Concerning the passage of Farmington river through the primary regions, I am too ignorant to be able to make any definite statements.

### *Terraced Valleys.*

Although there is demonstrative evidence that the rivers under consideration did not in all cases first excavate the valleys through which they flow, yet there is on the other hand, evidence scarcely less conclusive, that they have considerably lowered their beds since they began to flow. Between the primary mountains, from whence Deerfield and Westfield rivers, for example, issue, and the greenstone ridges through which they pass, they have formed alluvial basins, somewhat extensive, and sunk about 90 feet below the general level of the bottom of the Connecticut basin. And the banks of these

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basins are in some places curiously terraced; the different terraces being on a level on opposite sides of the basin. If we start from the edge of the stream at low water, and ascend a bank of 10 to 15 feet high, we shall come upon an alluvial meadow, which is frequently overflowed; and is consequently receiving yearly deposits. This may be regarded as the lowest terrace. Crossing this, we ascend the escarpment of a second terrace, 30 or 40 feet in height, which may be seen at intervals on the same level on all sides of the meadow. This second terrace is rarely very wide in any place, and seems to be only the remnants of a meadow, once much more extensive, which has been worn away. Ascending from this second terrace, 40 or 50 feet, up another escarpment, we reach the plain that forms the bottom of the great valley of the Connecticut. This constitutes the upper terrace.

The above description applies to the principal terraces existing on Westfield river, one or two miles west of the village, as well as to those one or two miles east; and to those in Deerfield meadows, as well as to those on the same river in the upper part of Charlemont. Smaller ones occur farther up the stream on Westfield river; also on one of its tributaries; and on Green Rriver, a tributary of the Deerfield. I have also noticed imperfect terraces on Blackstone River, below Worcester. One quite distinct may be seen in West Brookfield, on a small branch of the Chickopee, which passes through that place. In short, terraces more or less distinct, exist on almost every stream of much size in the State, wherever the banks are low enough to admit of alluvial flats.

The banks of the Connecticut are less distinctly terraced in Massachusetts, than the smaller streams that have been noticed. Yet they exist on that river in several places within the limits of the appended geological map. In Vernon, a few miles south of Brattleborough village, two quite distinct terraces may be seen on the west bank of the river. Between Turner's Falls and the mouth of Miller's river, the same number appear, though less distinct. In passing southerly, we find the same number on the west bank, in Pine Nook meadows, in the southeast part of Deerfield. In the south part of Sunderland, and north part of Hadley, on the east side of the river, two terraces appear, although they are at a greater distance than usual from the river. Traces of them appear also, in Springfield and West Springfield. In most of these cases they are discoverable only on one side of the river.

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This peculiar arrangement of the sides of valleys, although scarcely ever noticed by geological writers in this country, appear to be very common on both sides of the Atlantic. Dr. Bigsby notices a striking case in Lower Canada; and Dr. Macculloch represents them as numerous in Scotland. They appear to be a distinct phenomenon from the *Parallel Roads*, so ably described by the last named writer.*

No observer will doubt but terraced valleys were produced, in some way or other, by the streams that now flow through them. And it is natural to impute them to the sudden bursting of the barriers of a pond or lake, through which the stream flowed; or to the sudden removal of an obstruction in a river, whereby its bed was rapidly deepened in soft soil, higher up the stream than the obstruction. If, for instance, the greenstone barrier through which Deerfield and Westfield rivers now pass, had been suddenly sunk a number of feet by some convulsion of the earth, or powerful ice flood, their beds would have been rapidly sunk by the waters in the soft meadows above the barriers; and thus terraces might have resulted. But I may be permitted to doubt whether any such sudden reduction of the river's bed is necessary to account for this phenomenon.

Let us suppose a period, when the bed of Connecticut river, in the mountainous region below Middletown, was yet so elevated as to cause the waters to overflow the great basin between New Haven and Vermont. At that time, the mouths of Deerfield and Westfield rivers would have been on the western margin of this lake, or in the places where they now issue from the primary mountains. As the Connecticut wore down its bed, the lake would gradually drain off, leaving the tertiary formation, which its waters had deposited, perhaps 100 feet thick upon an average, with an almost entirely level surface. The Connecticut, having found its present bed, and the waters being drained from the valley, Westfield and Deerfield rivers must also excavate beds in the tertiary formation, above described, in their course to the Connecticut. Their course would no doubt at first be extremely serpentine, as that of rivers usually is, in flat countries. But as the bed of the Connecticut gradually sunk lower and lower, so would the beds of its tributaries sink: and then, would their waters, often swollen by rains and obstructed by ice, begin to wear away the the projecting banks, and convey them into the Connecticut. At

* Geological Translations, Vol. IV. p. 314.

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length, the banks on either side of the rivers, would be worn down and removed for a considerable extent. In other words, such basins as now exist at Deerfield and Westfield, would be produced; less deep, however, and destitute of terraces. As this basin enlarged, another process would commence. While the stream was confined within narrow limits, the alluvial matter, brought down from the mountains, would be carried along to the Connecticut. But as the basin enlarged, the water, when swollen by rains and melting snows, would spread over it, and becoming more calm, would deposit the mud and sand in suspension. Thus the new formed basin would be gradually filling up, and form an alluvial meadow. But as the bed of the river would continue to sink, ere long the waters would rarely rise high enough to overflow the meadows; and for the same reason they could never be raised by alluvial deposition to the level of the plain through which the river first began to flow. The banks of the river having now become high, the waters would again commence their depredations upon them, and scoop out a second basin from the meadows just described. At length all these meadows would be carried away by the stream, except occasional patches, which would form a terrace around their margin. The second basin, having now become large enough to enable the overflowing waters to begin to deposite their mud and sand, a second meadow would be formed, which would go on rising and the river sinking, until the floods could no longer spread over them; when a third basin would be formed; and so on, as long as the river continued to excavate its bed.

I have confined this illustration to the basins of Westfield and Deerfield rivers, in order to render it more intelligible. But it can easily be applied to the Connecticut, or any other river.

### *Green River.*

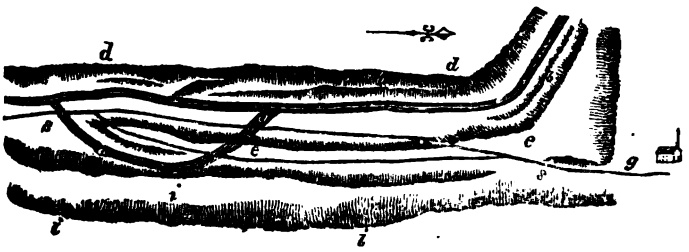
A hundred rods south of the village of Greenfield, on the stage road to Deerfield, Green River, a tributary of the Deerfield, has left indelible traces of having once run in a channel 40 or 50 feet above its present bed. At that elevation, a ledge of sandstone rocks bears the marks of having been once the bed of the stream, as distinctly as if it had run there but yesterday. The water here formed a cataract, 20 or 30 feet high; and below the ledge, a chasm, nearly as wide as the present bed of the river, is worn in the rock several rods long, which communicates with the present channel. The pot holes left in the ledge of rock are some of them 6 or 7 feet deep, and one



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or two feet in diameter. The hill of sand and clay, which now rises abruptly on the west side of the present stream, probably once extended as far east as this cataract and chasm; and here was a ridge, which threw back the waters of the stream over the whole of Greenfield meadows, 4 or 5 miles in extent. For in various places along these meadows, we find terraces; generally two, but never more. The hill of sand and clay at this gorge was probably worn away gradually; and as the surface of the sandstone rapidly slopes towards the west, this would cause the bed of the river to sink, and the terraces to be formed. In this way the bed of the river has changed laterally 10 or 12 rods, and sunk 40 or 50 feet.

Perhaps the following sketch may assist in rendering the preceding statement intelligible. It may not be entirely correct; but it exhibits the principal features of the spot.




*a*, *a*, former bed of the river.

*b*, *b*, terraces: these are in the upper part of the gorge, and not in Greenfield meadows.

*d*, *d*, level of the Connecticut valley: a tertiary hill with steep declivity.

*e*, *e*, sandstone ledge.

*g*, Meeting House in Greenfield.

*s*, *s*, stage road to Deerfield.

*i*, *i*, *i*, successive ridges of sandstone more elevated than *d*, *d*.

### *Beds of other Rivers.*

Judging only by the eye, I think we may safely state that since the Connecticut and its tributaries began to flow through the great valley that has been described, they have excavated their beds nearly 100 feet. The Connecticut at Northampton is still more than 100 feet above tide water at New Haven. At Springfield it is only 64 feet. This

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will give a descent from the latter place to the ocean of only a foot per mile, and considerably less if we subtract the height of Enfield Falls. South Hadley Falls make the principal difference between Springfield and Northampton. Indeed, the medium descent of this river from the foot of Turner's Falls in Gill, is probably less than a foot per mile. This is too small to enable the waters to produce scarcely a perceptible effect in lowering their bed, for centuries, nay, not enough to prevent their filling it up. So that probably the process of excavation in the bed of that river, has nearly ceased.

### *Ice Floods.*

There is, however, one agent of excavation, that still operates to some extent, even in the Connecticut; and that is, *ice floods.* Still more powerful is their effect upon smaller and more rapid rivers. Whoever has not witnessed the breaking up of a river in the spring after a severe winter, when its whole surface has been covered by ice several feet thick, has but a faint idea of the prodigious force exerted at such a time. The ice, high up the stream, is usually first broken in pieces by the swollen waters. Large masses are thus thrown up edgewise, and forced underneath the unbroken sheet, and the whole bed of the stream is blocked up; perhaps too, where the banks are high and rocky. The water accumulates behind the obstruction until the resistance is overcome; and the huge mass of water and ice urges on its way, crushing and jamming together the ice which it meets, and thus gaining new strength at every step. Often for miles the stream, prodigiously swollen, is literally crammed with ice, so that the water disappears; and a slowly moving column of ice is all that is seen. This presses with such force against the bottom and sides of the stream, as to cause the earth to tremble, like heavy thunder, to the distance of miles. Sometimes the body of ice becomes so large, and the friction so great, that the waters are unable to keep it in motion; and it stops, while the river is turned out of its channel, and is compelled to flow in a new bed for weeks and even months.

It is impossible that such floods should not operate powerfully to modify the surface in alluvial regions, and to excavate the beds of rivers. I am confident that no other agent in the mountain torrents of this state is so energetic. One has only to examine the banks and bed of a river after the ice has disappeared, as I have often done in Deerfield, to be convinced of this. But I apprehend that the maximum effect is seen in those rocky ravines, through which such rivers

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as the Deerfield and the Westfield pass, in the primary regions. Masses of rock of various sizes, even 10, 15, or 20 feet in diameter, may here be seen, some of them torn up from their beds and removed a considerable distance, strewing the bottoms of the streams, and at low water almost covering the surface; and others, only partially lifted from the parent rock, and waiting for another convulsive effort of the torrent to detach them, and give them an erratic character. In short, one sees in such streams a cause fully adequate to the production of those numerous bowlder stones that are scattered over the country: I mean, a cause sufficient to detach and round them. Probably, however, the expansive agency of water, frozen in the seams of these rocks, contributes not a little to lift them out of their original beds.

### *Valleys of Denudation.*

When the strata of rocks on the opposite sides of a valley coincide, the conclusion seems inevitable that they once formed a continuous stratum, and that the valley has been subsequently excavated. The appearance in such cases indicates that it has been scooped out by running waters; and yet, this might be the appearance if water had only modified the sides and bottom of a fissure produced by other causes. And in some cases, at least, it seems necessary to call in the aid of other causes.

I am in doubt whether there is more than one valley in Massachusetts that is, strictly speaking, a valley of denudation. And that is the passage between Mount Toby, in Sunderland, and Sugar Loaf Mountain, on the opposite side of Connecticut river. I have already described the appearance, and given a drawing of Sugar Loaf, and the geologist will at once perceive it to be a remarkable outlier, rising about 500 feet above the Connecticut, composed of red sandstone; whose strata dip to the east about 15°. On the opposite side of the river are red sandstone strata, dipping in the same direction. Sugar Loaf appears as if it had been modified by the action of water, even to its summit; and so on the opposite side of the river, I have already shown, in the second part of my Report, that Sunderland cave may be accounted for, by the undermining operation of water upon the softer strata. And the valley of the Connecticut above this point exhibits none of those proofs that the river could not have excavated it, which exists as to the valley in general, and which I have already

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detailed. This subject, however, I shall examine more particularly farther on.

*Valleys in other parts of the State.*

The remarkable and interesting valleys in Berkshire county, deserve long and careful study. After having passed across them and through them several times, my decided conviction is, that for the most part, they are primary valleys which have been more or less modified by deluges and other abrading agencies. The valleys in Worcester county seem to me to have had a similar origin; and I may add also the valley of the Merrimack. I mean that the original elevation of the strata gave to these valleys their great outlines. And the general parallelism of most of these valleys, agreeing also with that of the Connecticut, seems to indicate that nearly all the great valleys of Massachusetts were produced at the same epoch. But I hope to render this subject more intelligible when I come to treat of the systems of elevation that are found in our strata.

If it should seem that I have been very prolix in discussing the subject of Alluvium, I beg it may be recollected that it is one which excites at present an absorbing interest among geologists; and that scarcely no efforts have been made in this country to exhibit the dynamics of causes now in action. I hope this fact will afford me an apology for the imperfection of this effort.

## 2. DILUVIUM.

Under this term I include that coating of gravel, bowlders, sand, and loam, which is spread over almost every part of the surface, and which has been obviously mingled confusedly together by powerful currents of water. Hence geologists have referred it to the agency of a general deluge; and since it occupies the highest place in the rock series, except alluvial and volcanic rocks, most of them have regarded that deluge as identical with the one described in the Christian Scriptures. But recently some respectable geologists maintain, that existing causes, operating as they now do, might, in the course of ages, have produced all the phenomena of the rock formations. Hence they deny the existence of such a deposit as diluvium; or, rather, they impute it to rivers, rains, frost, and other existing agencies, and include it under alluvium. Others, however, regard dilu-

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vium as the result of various agencies, operating at different periods; among which are the floods produced by the elevation of the rock strata at various times. But they do not admit that we have in this diluvium any evidence of a deluge contemporaneous with that described by Moses.

It ought to be remarked, however, that these geologists do not deny the occurrence of such a deluge as is described in the Bible. Some of them, indeed, are clergymen: and they merely say, that geology does not furnish any evidence of such a catastrophe, although it affords no evidence to the contrary, but rather a presumption in its favor, in the fact so abundantly proved by the records of geology, that numerous extensive, if not universal deluges, have occurred since the creation.

That a transient deluge, like that described in the Scriptures, could have produced, and brought into its present situation, all the diluvium which is now spread over the surface of this continent, will not, it seems to me, be admitted for a moment by any impartial observer. It has obviously been the result of different agencies, and of different epochs; the result of causes sometimes operating feebly and slowly, and at other times violently and powerfully. But the conclusion to which I have been irresistibly forced by an examination of this stratum in Massachusetts, is, that *all the diluvium, which had been previously accumulated by various agencies, has been modified by a powerful deluge, sweeping from the north and northwest, over every part of the State; not excepting its highest mountains.* And since that deluge, none but alluvial agencies have been operating to change the surface. I shall now proceed to give a history of this diluvium, with the reasons that prevent me from assigning its present modified state to any other cause than a recent deluge.

The most extensive diluvial deposite on the map, is in Plymouth and Barnstable counties. Indeed, nearly the whole of those counties (with the exception of the north part of the former,) might have been thus colored with perfect justice. But as I had good reason to beleive that a granite ridge occurs where it is marked, concealed by a few feet of diluvium only, I thought myself justified in extending that rock on the map nearly to the extremity of Cape Cod. I saw, however, no example of rocks in place throughout the whole extent of the Cape, except perhaps a single fissured rock, which has been powerfully acted upon by water; and which, if it be in place, is only

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the wreck of a granite ledge. A view of this rock will be given farther on. In Plymouth County, except at its northern part, the granite rarely appears, and but seldom forms a cliff even fifty feet high. Every thing, indeed, is buried by diluvium; and, as the streams are few and small there, it is extremely difficult to ascertain what is its geology, except to say that it is diluvial.

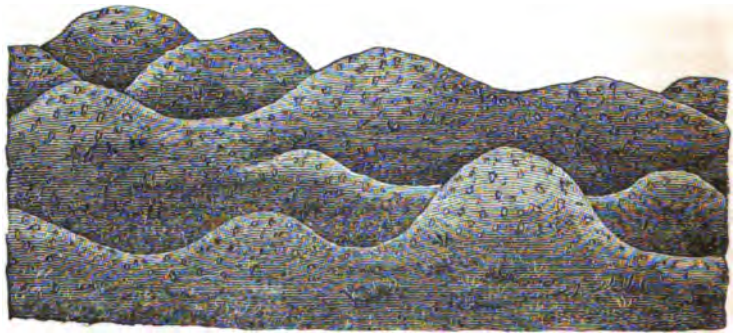
The diluvium of Plymouth and Barnstable counties consists almost entirely of white sand, some pebbles, and a very large number of bowlders of primary rocks. These bowlders consist chiefly of granite, sienite, and gneiss, with occasional masses of gray wacke conglomerate, compact feldspar, and porphyry. They all correspond with the rocks found in place along the coast, in the vicinity of Boston, and on Cape Ann: and no one, it seems to me, can see the marks of degradation along that coast, who will not be convinced that a large portion of the pebbles and bowlders of Plymouth and Barnstable counties, must have come from thence. Along the range of elevated, and for that part of the State, even mountainous land, which is colored as granite on the map, the bowlders are so enormously large, and so thick, that I cannot believe they have been ever removed far from their native beds. They are sometimes from 10 to 20 and even 30 feet in diameter, and frequently occupy nearly the whole surface; so that one can hardly persuade himself, when he examines them from a little distance, that they are not genuine ledges. Indeed, I have repeatedly been deceived by their appearance, until I had gone among them, and ascertained that they were detached bowlders. On the road from Sandwich to Falmouth is perhaps as striking an exhibition of this phenomenon as in any place, unless it be in the western part of Martha's Vineyard, in Tisbury and Chilmark. The same appearance is striking, also, in Brewster, on the Cape; and I doubt not that genuine ledges of granite may be found in those places; although (with the exception of Brewster perhaps,) I did not make the discovery. I have been informed, however, that rocks *in situ*, do exist in Dennis. But I have been so often deceived in this matter in that region, that I dare not state any thing as fact concerning it, which I have not carefully examined with my own eyes. At any rate, I cannot believe that bowlders so large and numerous have been removed many miles; for powerful as has been the diluvial current in the eastern part of the State, I have seen no well ascertained instance where whole mountains have been torn up and transported, as

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they must have been in this case, if they came from the region of Scituate and Cohasset, 40 or 50 miles; and that too, through a region of sand. And although much of the granite of these bowlders resembles that of Cohasset and Scituate, yet I doubt whether it is identical with it. Some of it I know to be quite different.

The sand, which is the predominent ingredient of the diluvium in the counties above named, was undoubtedly derived from a tertiary formation, which has been broken up by diluvial action. Remnants of this formation are occasionally seen on Cape Cod; and in Truro, so lofty and distinct are the cliffs of clay, that they have been noted on the map. Clay is found in other places on the Cape; but not in large quantities, and generally at a low level. On Martha's Vineyard and Nantucket, this formation is much more abundant and obvious along the coast; though covered for the most part in the interior with diluvium several feet thick. Very likely this formation once occupied no small part of Massachusetts Bay, and probably also Buzzard's Bay.

In almost every part of the State the diluvium is piled up into elevations whose surfaces exhibit curves of every description; while the correspondent cavities are of various shapes. These convexities and concavities resemble very much the sandy or gravelly bottom of existing streams, where the current has been very violent; except that generally those in the diluvium are on a vastly larger scale. The sketch below may aid in imparting a correct idea of these diluvial irregularities. It was taken in the southeast part of Amherst, and exhibits several elevations from 10 to 20 feet high, composed entirely of gravel, with no blocks large enough to be called bowlders.



Diluvial Elevations and Depressions: Amherst.

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In Truro, near the extremity of Cape Cod, the magnitude of these elevations and depressions is truly astonishing. One finds himself in a hilly and even mountainous country; the elevations being often from 200 to 300 feet high, and very numerous; and yet these are most obviously diluvial hills and valleys; that is, they are as obviously the result of currents of water, as those inequalities of surface, of exactly the same shape, which we find in the dry bed of a river. The fact is, this Cape, below Orleans, consists almost entirely of coarse sand, which is more easily piled up and scooped out than gravel; and this, explains the striking features of the diluvium in the region of Truro, which is well worth a journey thither to examine. But one has only to look at a map of Massachusetts, to see that the idea of these effects having resulted from the action of any existing stream, is absurd; since no current of water, deserving the name of a river, can exist on that part of the Cape: whereas the Missisippi, or St. Lawrence, pouring down a mountain gorge upon a sandy plain, would be scarcely adequate to produce the effects here witnessed. And as to this being the result of the retiring or returning wave, when the strata were first elevated, I shall take occasion to show, before concluding this section, that the opinion is improbable.

The same idea, of a force vastly greater than any now in action in the State, having been exerted in the production of our diluvium, forces itself upon the attention in many other places besides Truro. All the eastern part of the State presents evidence of having been swept over by a prodigiously strong current of water. Nantucket, Dukes County, and the Elizabeth Islands, are almost entirely covered with a vast quantity of bowlders, gravel, and sand, most of which must have come from the continent. On Nantucket, bowlders and gravel are rare; only four or five large blocks occurring on the island; although those two or three feet in diameter are not unfrequently met with: and these, consisting of granite, gneiss, and quartz, were obviously transported from the continent. On the Vineyard, the bowlders are very numerous, and some of them very large; and although some of them unquestionably proceded from the mainland, yet in one or two places, as in Chilmark, I strongly suspect the existence of granite ledges a few feet below the surface, from the quantity and size of the bowlders: and yet one often sees very large blocks in the diluvial covering of the clay cliffs, as for instance at Gay Head; where one or two of them that have rolled down to the base, are from 20 to 30 feet in diameter. The Elizabeth Islands are



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entirely covered by a thick coat of diluvium of a similar character; and so is the whole coast, from Cape Cod to Rhode Island, except that south of Rochester there is much less of sand; but the quantity of bowlders is prodigious; so that one often travels many miles without seeing a rock in place; although the surface is almost entirely covered by rounded masses of almost every size. This is seen on almost any road from New Bedford to Rhode Island.

Passing northerly from Buzzard's Bay, the whole country east of a line drawn from Providence to Boston, except the summits of a few of the highest mountains, and some alluvial valleys, is covered with diluvial blocks and gravel. But from Boston to the extremity of Cape Ann, embracing a considerable proportion of Essex County, the amount of bowlders is prodigious; and some of them are not less than 30 or 40 feet in diameter; and yet so powerful was the diluvial current, that these must have been removed from their original position, and many of them now occupy the summits of the highest hills in that region; presenting often a most singular outline to the landscape. When one of these erratic blocks is so poised upon a rock in place, as to be easily moved, it constitutes a *rocking stone.* Some of these, weighing from 10 to 100 tons, can be perceptibly moved by the strength of a single man, applied to a lever; though the combined efforts of a hundred men cannot move them but a few inches. Of two of these rocking stones I have taken a sketch, on account of their peculiar appearance.



Rocking Stone in Chelsea.

The preceding sketch represents a mass of porphyry, 10 or 12 feet in diameter, lying on a ledge of the same kind of rock in the north part of Chelsea, near the toll gate, on the Newburyport turnpike. The following is a view of a divided block of gneiss, which is nearly 10 feet high, and is so accurately poised upon a ledge of gneiss, that at a little distance it seems as if it could easily be thrown over; but this

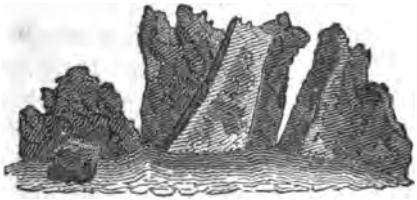
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is no easy matter. It occurs in the west part of Barre, on the road to Dana.



Double Rocking Stone in Barre.

In Brewster, on Cape Cod, is an enormous mass of granite, 16 feet high, and 160 in circumference; of which a drawing is annexed. This is split into 6 or 7 pieces, and appears as if it had been subjected to a powerful action of water, or some other agent, in former times. Its size forbids the supposition that it has been removed from its bed; and probably it is the remains of a ledge which diluvial currents have worn away or buried. The sketch was taken from the west.



A Rent Rock in Brewster, Cape Cod.

I have noticed a rocking stone near the center of Greenwich, weighing 30 or 40 tons, which might be moved by a lever. One may be seen in Chilmark, on Martha's Vineyard. In the 7th vol. of the Am. Journal of Science, is a drawing and description of one, of more than 46 tons weight, in Roxbury; which "a child of six years old can easily move with one hand." Mention is there also made of one on the Salem turnpike; of three in the vicinity of Providence, one in Foster, one in Warwick, R. Island, and one in Framingham. Gen. E. Hoyt, also, describes one in the bed of Deerfield river, in Zoar. Indeed, they can doubtless be found in almost any part of New England.

But Cape Ann, of all other places in the Commonwealth, is the theatre of bowlder stones. Over a great part of the Cape, the trees

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and shrubs have been cut away; and in many places of great extent, the surface is literally covered by these rounded and erratic blocks. "Thus must the world have appeared to Noah, as he came out of the ark," exclaimed my travelling companion, as we came suddenly in view of a wide landscape near Squam, in Gloucester, studded with bowlders. The view is, indeed, a most singular one; and cannot fail to impress every reasoning mind with the conviction, that a deluge of tremendous power must have rushed over this cape. Nothing but a substratum of unyielding sienite could have stood before its devastating energy. The man who views this coast and that of Cohasset and Scituate, is no longer at a loss from what region the countless blocks of granite and sienite, scattered over the southeast part of the State, proceded.

As we proceed westerly from the coast and rise upon the higher lands of Worcester County, the quantity of diluvium decreases; though in many places very abundant. In general the higher parts of mountains exhibit less of diluvial action than the lower regions. But it is usually at an intermediate level, and neither upon the highest nor in the lowest places, that the greatest amount of diluvium is accumulated. On steep and narrow mountains, we could not expect that much of this stratum would be detained, even if we admit that water could accomplish the Sisyphean labor of rolling rounded rock masses up steep and lofty escarpments. And in the lowest grounds, existing streams have to a considerable extent removed the diluvium, and in some instances covered it up. But there is no mountain so lofty in Massachusetts as not to exhibit marks of diluvial action. On Wachusett and Saddle mountains, indeed, very few rounded masses of rock from a distance are to be seen; though their own surfaces have been acted upon by a diluvial current, as I shall shortly state more definitely in speaking of another part of this subject. On the lower and less precipitous mountains of the State, however, bowlders of huge size, as well as gravel and sand, are abundant.

The valley of Worcester abounds in diluvium; especially in the north part of the county. Proceeding towards the Merrimack, through Sterling, Lancaster, and Groton, we find large accumulations of diluvial gravel, exhibiting the irregular convexities and concavities already described. We find in this region, however, much fewer large bowlders than in most other parts of the State. These become more numerous as we follow the Merrimack to its mouth. Much of the diluvium, however, from Worcester to Newburyport, consists of

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*shingle;* by which, I mean partially rounded fragments of slate; that being the predominant rock.

On the south of Worcester, the region of country sloping towards the Blackstone, especially on the west side of the river, exhibits striking traces of diluvial agency. In some places, as in Uxbridge, the bowlders of gneiss are large and numerous. As we proceed towards Providence, this stratum becomes thicker; concealing, indeed, nearly all the rocks in place; and in the vicinity of Providence a large proportion of sand is mixed with the gravel. This proceeds from the tertiary formation which occurs near Providence, as well as in the southeast part of Massachusetts, and which has been torn up in many places by the action of water. The sand abounds on the west shore of Narraganset Bay, nearly the whole distance to Newport.

The valley extending south from Oxford through Webster into Connecticut, contains, especially on its slopes, an abundance of diluvium: so thick a coat, indeed, that the rocks in place are in a great measure hid; and hence it is quite difficult to ascertain the boundaries of the different formations.

Between the Worcester and Connecticut valleys, the country is mountainous; with deep and interrupted valleys, whose general direction is north and south. In some of these valleys the gneiss rock is covered for miles by diluvium, and by alluvium of disintegration. Indeed, this is often the case, in the more elevated parts of this region; though the diluvial waters seem to have exerted less power here, than in the lower land in the eastern part of the State.

The level part of the basin of the Connecticut, exhibits less striking marks of diluvial action than the smaller elevations on the margin of this tertiary plain. Some might even doubt whether the tertiary deposite of this valley is not postdiluvian. But I think that upon the whole, marks of diluvial action are too strong on its surface to be referred to the currents of an ancient lake. For the diluvial coat is several feet thick in almost every place. We could not expect that a general deluge, of depth sufficient to rise above our highest mountains, would act as powerfully upon low and broad plains, as in the vicinity of mountain defiles and gorges, through which the water must have rushed with great power, even though its general movement was moderate. And this view accords with the present disposition of diluvium in Massachusetts. In Bernardston, Franklin county, for instance, which lies at the northern extremity of the Connecticut valley, we find a large amount of diluvium, which was evi-

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dently washed from the region of argillaceous slate lying north, through two or three narrow valleys, running north and south, down which the current must have rushed with great force. Accordingly we here find, on the road towards Northfield, a mile or two east of Bernardston center, an example of diluvial elevations and depressions scarcely equalled in the State; exhibiting, as it were, the very gyrations of the mighty torrent. But when this stream spread out over the broad valley of the Connecticut, its violence and strength would greatly diminish; and hence this diluvium was not driven very far into that valley. Yet at the east end of Mount Holyoke, where it approaches the primary hills in Belchertown, we find a very powerful diluvial agency to have been at work, in consequence of the rush of waters through the gorge between the mountains, and also through the valleys on both sides of Mount Toby and among Pelham hills,to the north. So that in the southeast part of Amherst, and indeed through its whole eastern part, the diluvial sand and gravel are piled up and scooped out in a striking manner. And in general, as we begin to rise from the tertiary plain of the Connecticut basin, we find a greater accumulation of this stratum than on the plain itself, or high up among the primitive mountains.

In passing over the mountainous region between the valleys of the Connecticut and Berkshire, there is little in the character of the diluvium worthy of special notice, till we approach the summit of Hoosac mountain; when we are surprised to meet with an immense number of bowlders, which have been forced up the high and steep western escarpment of that mountain from the valleys of Berkshire. In these valleys, also, we find bowlders in abundance, which have been driven over the Taconnic range from the State of New York. But these facts will be examined more particularly farther on.

Along the western base of the Hoosac range, diluvium is accumulated in large quantities: but in general, this formation is not as abundant to the west, as to the east of Connecticut river.

As we pass from the Taconnic range to the Hudson, we find vast accumulations of diluvium. The fragments decrease in size as we approach the river, and within a few miles of it, diluvial elevations and depressions, composed of gravel and sand, are numerous and striking. The materials seem in part to have been derived from a tertiary formation, whose lower clay beds are still visible, a little east of Troy and Albany.

In Pownall, Vt. three miles north of Williams' College, is an un-

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ique and interesting example of diluvium. It lies on the eastern side of Hoosac river, against a hill of mica slate; and rises, at least, 100 feet. It consists of pebbles of quartz and micaceous and argillaceous slates, from 3 or 4 inches diameter, down to coarse sand: and a part of the mass is consolidated into conglomerate and sandstone. (Nos. 25, 26, 27, and 28.) The cement is carbonate of lime; which having been dissolved in water, has been diffused uniformly through the mass. It is not perceived by the eye; but on applying acid, a brisk efferescence ensues; and hence I infer that it was infiltrated in a state of solution. And although I could perceive but few fragments of limestone among the diluvium, yet as the whole region abounds in this rock, it is hardly possible that it should not exist there, at least, in the state of sand. This being admitted, the consolidation of this stratum is easily explained by causes now in action; and a question might be raised, whether diluvium consolidated in this manner, does not in fact become alluvium. I ought to add, that when thus forming solid masses, it is as distinctly stratified as are most of our secondary sandstones and conglomerates.

How common may be consolidated diluvium, in this country, I cannot say. But I believe no account of any other locality has been published. In Europe, geologists describe a similar rock, if Brongniart's *Terrains Clysmiens*, is synonomous with diluvium: for he says that "the parts of the rocks of that class are sometimes united by a base or cement chemically produced; that is, by solution."* At any rate, the consolidated shingle bed, described by Mr. Mantell in his Geology of Sessex, as occurring at Brighton, in England, must be regarded as of the same character as that in Pownall above described.

The diluvial deposites in Massachusetts, whose topography I have now described, were probably produced originally, by all the abrading and disintegrating agents that were in operation on the surface of the globe, between the time when the solid rocks were deposited, and the last deluge. These agents, so far as we know, were the same as are now operating to modify the earth's surface; and have been described under alluvium. Hence there must be great diversity as to the times when the different portions of this diluvium were produced. But I maintain that all of it has been subject to the modifying influence of, at least, one general deluge of waters in more recent times.

* Tableau des Terrains, p. 66.

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This deluge, as I have already stated, swept over Massachusetts from the north and northwest. The proof of this position I now proceed to exhibit.

The first part of this evidence consists in tracing erratic bowlders to the parent rock from which they were derived.

When I began an examination of the State, I traveled east and west; commencing with the line of towns bordering upon Connecticut, and returning through the line of towns next north. Thus essentially have I gone over the whole State. And I had not thus doubled my course many times, before I found, uniformly, that in order to trace bowlders to their original beds, I must travel north a greater or less distance. The discovery was frequently of great service to me; and I do not recollect that the principle ever failed me. I have, indeed, sometimes found a straggling block east or west, and possibly north of ledges of the same kind of rock; but never any thing more than lonely stragglers. It will be expected, however, that on such a point I should refer to particular instances.

I have already remarked that granite and sienite constitute the great mass of the bowlders scattered over the southeast part of the State; and that these correspond to the rocks of this character on the coast that bounds Boston harbor. But similar rocks also occur in place, occasionally, in the region where the bowlders are found; and, therefore, we cannot be sure that they were transported from a distance; although in many cases the exact correspondence between the specimens would leave little room to doubt that such was the fact. But scattered among these primary bowlders, we frequently find others of porphyry, compact feldspar, and gray wacke conglomerate; rocks, which (except the conglomerate,) occur only within a few miles of Boston, both north and south. I have found masses of porphyry as far down Cape Cod as Orleans; and near the southern extremity of Martha's Vineyard, the pebbles of this rock are quite numerous. In Tisbury I have seen a mass of peculiar blood-red, compact feldspar, which occurs in place in Hingham: which would indicate the course of the diluvial current to be a few degrees east of south. The porphyry pebbles merely indicate a southern direction to the current; since the occurrence of porphyry at Half way Rock, east of Marblehead, shows that this rock might formerly have extended far into the ocean. Gray wacke conglomerate occurs in the the gray wacke formation in patches, from Rhode Island to Newburyport; and the bowlders of it above spoken of, must, therefore,

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have been transported in a direction a little south of east; in order to reach the west part of the Vineyard, where I found them.

We shall find abundant confirmation of this opinion in respect to the last named rock, if we pass from New Bedford to Rhode Island, either close along the coast to Little Compton, or farther north, to Tiverton. The surface is covered with bowlders, chiefly of granite and gneiss. But occasionally we meet with masses of the conglomerate, whose diameter varies from one to twelve or fifteen feet. And by inspecting the map, we shall see that the gray wacke formation, from which they must have been derived, is very extensive in a north and north west direction. Can there be a doubt that such was the origin of these blocks? If it was, then the diluvial current must have been powerful enough to move masses of this size, in some instances, not less than twenty miles. The region of country intervening, however, is not very uneven; and in estimating the power of running water to move rocks, we ought always to bear in mind, that they are but little more than half as heavy when immersed in water as in air.

Another instructive region, in respect to erratic blocks of gray wacke conglomerate, lies on the east side of Taunton river, in Freetown and Troy. Along the river road the bowlders of this rock greatly predominate; and yet I could not find any of it in place: but the rock there, so far as I could ascertain, is granite. These blocks, therefore, must have been transported from the opposite side of the river, in a south or southeast direction, in order to have come from a gray wacke deposite.

In several places, as may be seen by the map, the tracts of gray wacke are bounded on the north by primary rocks; chiefly sienite, granite, and greenstone. And as we approach these primary rocks, from the south, even when eight or ten miles distant, we begin to find their rounded fragments; until at length, and that often at the distance of two or three miles from the primary ledges, they equal, or exceed in number, those of the gray wacke; rendering it often exceedingly difficult to ascertain the boundaries of the different formations. But on the other hand, no bowlders of gray wacke are found in the primary regions, lying north of the gray wacke in place, except those very rare stragglers already alluded to; whose situation can be explained only by supposing a previous deluge in a different direction.

I think, however, that no geologist can examine the surface of the



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eastern portion of Massachusetts, without having the enquiry forced repeatedly upon his attention, whether the gray wacke formation, that now exists only in interrupted basins from Rhode Island to New Hampshire, was not once continuous throughout this whole extent. The direction and dip of its strata, as well as its mineralogical characters prove it to have been mostly produced at the same geological epoch; and the very powerful marks of degradation, which some of its varieties exhibit, especially the conglomerate, favor the opinion of its former continuity. And yet no one will presume to impute such powerful abrasion to any single deluge.

The particular towns, where we find the most striking examples of a mixture of bowlders of granite, sienite, and greenstone, with those of gray wacke, which is the rock in place, are Attleborough, Mansfield, Norton, Bridgewater, Brighton, Newton, Needham, and Watertown. The map will show, that a few miles northerly from these towns, are deposites of granite, sienite, and greenstone. On the other hand, in Stoughton, Randolph, Dover, Dedham, Braintree, &c. we find graywacke bowlders, mixed with those of the rocks in place; and these were obviously derived from the gray wacke formations lying northerly from these places.

Perhaps the example more definite and decisive than any other on the subject under consideration, occurs in Rhode Island. In Cumberland a large hill exists of magnetic iron ore; a considerable part of which contains distinct crystals of feldspar, so as to become beautifully porphyritic. A rock so peculiar cannot be confounded with any other. Now if we pass along the north, east, and west sides of this bed of ore, even very near it, no scattered fragments of it are seen among the bowlders. But on the south side, they occur all the way to Providence, decreasing in size. Whether they may be found on the west side of Narraganset Bay, south of Providence, I cannot say: but I met with several pieces at the southern extremity of Rhode Island, in Newport, of only a few inches in diameter. These must have traveled nearly 35 miles from their bed, in a direction a few degrees east of south.

In several places in the south east part of Worcester county, I met with bowlders of a variety of porphyritic granite, distinguished from every other kind in the State, by its remarkably large imbedded crystals of white feldspar. But it was not till I came to Harvard, that I found this rock in place. On the north of the ledge, I never met with a single fragment. In Waltham, however, I did meet with one bowlder of this rock.

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In the valley of the Connecticut, we meet with abundant traces of a diluvial current from the north. Thus, the diluvium which covers the red sandstone in the south part of Bernadston, and the north part of Gill and Greenfield, is composed almost entirely of detritus from the granite, argillaceous slate, and quartz rock, lying a few miles north. In Amherst, the diluvial pebbles and bowlders are granite, gneiss, hornblende slate, and red sandstone conglomerate; corresponding precisely with similar rocks in place in Leverett and Sunderland, six or seven miles north. But probably a fluvialist would regard all marks of this kind in the Connecticut valley, as having resulted from the action of the river when its barriers were yet unbroken below Northampton and Middletown. And this explanation would probably satisfy the mind, were it not for the evidence already exhibited, that the Connecticut could never have been more than 100 or 200 feet above its present level: an elevation not sufficient to produce the diluvium that has been described.

Another class of facts is still more inexplicable on the fluviatile hypothesis. On the east side of the greenstone and sandstone range, which passes through the west part of West Springfield, and which rises into Mount Tom in East Hampton, we find mixed with the bowlders of sandstone and greenstone, many others of a peculiar sienitic granite, which occurs in place, on the west side of the range above mentioned, in Northampton, Hatfield, and Whately. These must have been driven over the greenstone ridge by a northerly current: and yet, some of them are two or three feet in diameter, and the ridge is several hundred feet high. As we go northerly, still continuing on the east side of the greenstone, the number and size of these bowlders increase. We find them even upon the summit of Mount Tom; though as we ascend this precipitous peak, their number and size diminish; so that on the top, I never saw one more than six or eight inches in diameter. Now this mountain rises nearly a thousand feet above the plain which lies to the northwest; and on that side it presents a mural face several hundred feet high. Yet these bowlders must somehow have been forced up this precipice; since the bed from which they originated lies in a northerly direction from the mountain.

On the banks of the Westfield or Agawam river, in the west part of West Springfield, I found small bowlders of quartz, containing galena and blende. Both the matrix and the ores correspond exactly with those found in Southampton, Williamsburgh, and Whately. All

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the metallic veins in those towns lie in a northerly direction from the spot where the bowlders were found; and there can be little doubt that they originated thence.

If we go to the large beds of serpentine in Middlefield and Blanford, we shall find bowlders of this rock on no side of them but the south. On that side, they are very numerous at first; and continue to decrease in number and size as we recede from the bed. I noticed this fact most strikingly around the most northern bed of serpentine in Blanford. In some instances, however, as in the serpentine bed in Westfield, fluviatile action may have removed the bowlders in a different direction. The Westfield river, in that instance, runs easterly and crosses the serpentine; and of course has carried bowlders of it in that direction.

As we ascend the broad and lofty mountain range, west of Connecticut river, we meet occasionally with rounded fragments of well characterised granular quartz; and their number and size increase till we reach the western base of Hoosac Mountain. But in vain shall we search for this rock in place till we have begun to descend Hoosac Mountain. Along its western base are extensive ledges of this rock, across the whole extent of Massachusetts, and extending far into Vermont. And in going westward, the bowlders increase in number and size till we reach the rock in place. These facts lead to the conclusion, that the diluvial current in this part of the State, came from a direction nearly northwest. This opinion is confirmed by finding numerous bowlders in the valley of Berkshire, of gray wacke; an extensive formation of which, reaching nearly to Hudson river, commences a few miles beyond the western boundary of the State. Some fragments of this rock were found by Dr. Emmons in Chester, on the eastern slope of Hoosac mountain; establishing the same conclusion. The force of this current must have been very great, if it took place since the surface of Berkshire county assumed its present inequalities. For bowlders of several tons weight, are found lodged at various elevations, on the steep western escarpment of Hoosac mountain; and as already remarked, these bowlders, in large numbers, have been actually carried over the top of the mountain, and driven south easterly from 10 to 20 miles. I even found a fragment of quartz breccia, a foot in diameter, in East Hampton, in the valley of the Connecticut. It was of so peculiar a character, that its parent rock, on the west side of the Hoosac, could not be mistaken. To suppose that these quartz bowlders were forced by a current of water

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up the steep side of this mountain, from 1000 to 1500 feet, if that current was at right angles to the direction of the mountain, is absurd. Yet as the direction of the current was very oblique to the direction of the mountain, it is possible that there might have been power enough in it for the work. And it ought also to be stated that the quartz rock in Clarksburg seems to be a spur from the Hoosac range and rises to an almost equal elevation, although a valley of considerable depth intervenes. In the east part of Cheshire, also, the quartz rock exists *in situ*, at a high elevation; especially a variety that is interstratified with gneiss. And no deep valley intervenes between its locality and the top of the Hoosac range. The situation of several valleys, also, along the western slope of this mountain, is very favorable for enabling a northwesterly current of waters to drive bowlders up the declivity.

The gray wacke bowlders which are scattered over the valleys and hills of Berkshire, and which are sometimes of several tons weight, must have been forced over the Taconnic range of mountains. But the western slope of this range is not generally as steep as that of the Hoosac; and in several places transverse valleys occur; or rather depressions of the summit: as for instance, the ravines through which the principal east and west road passes in Hancock, and between Canaan and West Stockbridge. Still, a prodigious force must have been exerted by the waters in carrying over this ridge such an abundance of coarse detritus.

Indeed, some may suppose it necessary to refer this diluvial action to a period preceding the elevation of the strata: for to suppose it produced by that elevation, will not relieve the difficulty; since the wave produced by the rise of the strata, would not act till Hoosac mountain was actually thrown up; and besides, that wave must have flowed from the west to the east; whereas the current that moved these bowlders must have come from a direction not far from northwest; as appears from the diluvial grooves and scratches on the rocks, which I am about to describe. But if these bowlders were removed by currents previous to the elevation of the strata; that is, while they were yet in the bottom of the ocean, how does it happen that the blocks are accumulated along the western base of the Hoosac, and along its steep face, just as they would have been, if they had met with that mountain to obstruct their progress.

Wherever we find valleys passing obliquely up the face of this mountain, especially those running in a southeasterly direction, we

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find them abounding with the peculiar quartz bowlders that have been described, just as would be the case if these had been driven up said valleys by water after their excavation. Had the bowlders been spread over the surface before the existence of the valleys, why should they be so much more numerous in those valleys, than upon the hills? Alluvial agents would, indeed, tend to accumulate them in valleys; yet by no means to the extent to which we now find them, especially in broad valleys.

Upon the whole, I have no hypothesis on this subject to propose, more free from difficulties, than that which imputes the removal of these quartz and gray wacke bowlders, in a southeasterly direction, to the same debacle of waters, which, in other parts of the state, has swept the detritus southerly. What local cause should have deflected the current towards the east, in the western part of the State, and in the eastern part of New York, I can hardly conceive: though, as I shall shortly endeavor to show, there was considerable irregularity in its direction in that region; enough, perhaps, to lead to the suspicion, that the deep valleys and ravines, through which the waters must have rushed, might have considerably modified their course. But I think that the change of a few degrees in the direction of the current, is not so great an objection to this hypothesis, as the Sisyphean task, which must have been accomplished, if it be true, of urging upwards, over so long and steep inclined planes, bowlders so large and so numerous. Making every allowance for the reduction of the gravity of these bowlders when in water, I confess I cannot conceive how such a work could have been effected by this agency. Yet neither can I conceive how those diluvial elevations and depressions, that have been described in various parts of the State, could have been produced by a deluge. For they are on so large a scale, as to transcend by far, the maximum effect, which I can conceive to be produced by a flood of waters. Still it is undeniable that these did result from such an agency. Hence I may underrate the power of that same agency in the removal of detritus.

I acknowledge, however, that I should be inclined to refer the diluvial phenomena in the western part of the State, to a different and an earlier deluge than the last — perhaps to the retiring waves when the strata were first elevated — did not facts forbid it. I have mentioned some of these, and shall soon mention another still more conclusive.

In stating the facts relating to the bowlders of sienite on Mount

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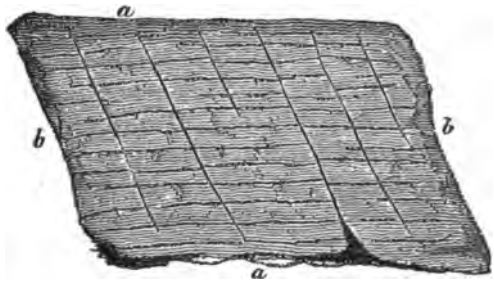
Tom, I have shown that the difficulty of accounting for their situation, is not confined to the west part of the State. Another case still more remarkable, exists on Mount Toby; although not embracing so wide an extent of country. To the height of several hundred feet, the eastern side of that mountain is very steep; forming, indeed, in some places, a mere precipice, very difficult to scale. A narrow valley separates this side of the mountain from the extensive gneiss range lying east, and rising gradually into mountain ranges, nearly as high as Toby. Now on this steep eastern escarpment of Toby, even to its summit, we find scattered bowlders of gneiss, of precisely the characters of the gneiss in the north part of Leverett and in Montague. True, the gneiss range extends so far to the west in Montague, that a current of water from the north, or from a few degrees east of north, would carry detritus towards the eastern slope of Toby. But how is it possible that any aqueous agency could have driven it up so steep a declivity? There are three remarks that may afford the mind a little relief, perhaps, in this difficulty. One is, that on the northeast side of Toby, are several ravines, running northeasterly, with brooks at their bottom; and these might have once presented slopes less difficult of ascent, than at present. Another is, that the conglomerate rock of Toby, may have been much worn away by alluvial agents since the removal of these bowlders, and consequently the eastern slope of the mountain may have been formerly much less precipitous. Indeed, the great quantity of huge rocky masses that lie along the base, renders such a supposition probable. Finally, these bowlders may have been removed to their present situation ere the valley on the east side of the mountain existed, and before the elevation of the strata into their present situation. For I know of no circumstances in the region, that are opposed to such a supposition.

Mixed with the granite bowlders on the eastern slope of Hoosac mountain, are masses of a peculiar kind of granite, distinguished by its unusual tendency to disintegration. The parent rock, from which it was derived, I have never yet discovered; but predict that it will be found along the western side of Hoosac mountain, in Clarksburg, or farther north.

The second argument that shows the direction of the last diluvial current in Massachusetts to have been towards the south and southeast, is based upon the existence of grooves, furrows, and scratches, upon the surfaces of the rocks, that have never been moved from

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their place. The water worn appearance of those rocks, in every part of the State, which are undergoing no disintegration at their surface, must, it would seem, arrest the attention of a very careless observer: although I have been surprised to meet with so few men who have noticed the fact. In some cases, however, the rocks are not merely smoothed, but are grooved and furrowed, as if heavy and irregular bodies had been dragged over their surfaces. The following sketch exhibits a rock of this description near the turnpike, from Boston to Chelmsford, near the line between Bedford and Billerica, and not far from the sixteenth mile stone from Boston. The rock is intermediate between gneiss and mica slate. Its strata seams run in the direction *a, a;* and the grooves and scratches in the direction *b, b.*




Diluvial Grooves in Gneiss: Billerica.

The direction of these grooves is nearly north and south; and this is their general course in every part of the State, east of Hoosac mountain. Commonly, however, they run a few degrees east of south, and west of north. I shall first mention several localities where these furrows correspond in direction to this description, and then notice a few in the west part of the State.

One hundred rods east of the village on Fall River, in Troy, are grooves and scratches on granite. Some of the bowlders lying on the surface here will weigh from 50 to 100 tons.

Similar grooves occur on a road leading from the south part of Scituate to Hanover four corners. The rock is granite.

Also in Abington, Randolph, Canton, Sharon, Dedham, and Dover; on granite and sienite; very common.

Also on the conglomerate in Dorchester.

In passing from Worcester to Berlin, through Boylston, the like appearances present themselves frequently on the surface of the gneiss and mica slate.

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Likewise in several places between Andover and Boston, on granite and sienite.

The high hill of gneiss in the center of Rutland, exhibits the same.

On the top of Wachusett mountain, 3000 feet above the ocean, a few rods northwest from the prospect house, these furrows may be seen; though less distinct than in many other places. The rock generally on that side of the mountain, appears distinctly water-worn.

In Westford, one mile north of the meeting house, on the road to Dunstable, is a fine example, on mica slate.

In Marblehead, on sienite, 15 rods southeast of the residence of the Hon. William Reed, near a meeting house, are quite distinct furrows.

They appear on gneiss, near the meeting house in Petersham, though not very distinct.

At the north end of Federal Street, in Greenfield, and also half a mile northeast of the Episcopal church, on the road to Gill, these grooves are very distinct, on red sandstone.

In the southeast part of Deerfield, near the banks of Connecticut river, about two miles north of Sunderland bridge, they occur on trap rock. Also very distinct and numerous in the north part of Sunderland, from 200 to 400 feet above the river, on sandstone and greenstone. Other cases in the Connecticut valley might be mentioned; but as they might reasonably be imputed to fluviatile action, if there were no other similar cases on higher ground, I shall omit them. Indeed, I am in this case inclined to believe them of fluviatile origin: except perhaps where, as in Gill, we find grooves on the tops of the highest hills.

Between Whitingham and Wilmington, Vt. are numerous cases on gneiss and mica slate.

A very fine example occurs on the lofty hills in the north part of Rowe. This hill rivals even Hoosac mountain in elevation. Near Rowe meeting house, is another example. Fifty rods south of the meeting house in Heath—a point higher than the center of Rowe—are several other, though no very striking examples.

In Blanford is one of the most striking examples of diluvial grooves in the State. The hill half a mile north of the congregational meeting house, where it occurs, is very high; overlooking all the surrounding mountainous country.

A similar example may be seen near the meeting house in Norfolk,



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Ct. Also on Canaan mountain, 4 or 5 miles south of Massachusetts line.

On the conglomerate in the southeast part of Newport, R. Island, may be seen diluvial scratches, running from 10 to 20 degrees west of north and east of south.

From what has been said concerning the distribution of bowlders as we approach the western part of the State, we should expect that these furrows would there have a direction nearly northwest and southeast. Accordingly, near the turnpike from Greenfield to Williamstown, on the top of Hoosac mountain, which is about 2400 feet above the sea, we find grooves on the mica slate, running W. 20° N. This is near the eastern margin of the mountain. They occur, also, near the western margin; having nearly the same direction. In the northwest part of Windsor, just where the Hoosac mountain begins to slope westerly, I found grooves running nearly north and south. But for 3 or 4 miles easterly from the meeting house are numerous distinct cases where the course is almost exactly northwest and southeast.

In the west part of Worthington, which is several miles east of the top of the mountain, these grooves run W. 30° N. But in Middlefield, where they abound near the meeting house, and the residence of Gen. Mack, they run much nearer north and south. On that part of Saddle Mountain, called Bald Mountain, also, are faint scratches, very difficult to examine on account of their coinciding so nearly with the direction of the layers of the rock. But they run not far from north and south. Gray Lock, which is several hundred feet higher than Bald Mountain, is so covered with vegetable mould, that I had no opportunity to discover diluvial furrows, if they exist there.

In passing from Albany, N. Y. to West Stockbridge, Massachusetts, through Greenbush, Schoodack, Nassau, and Chatham, I met with several examples of diluvial grooves upon the surface of the gray wacke; particularly in Schoodack and Nassau. Their direction was almost uniformly N.W. and S.E.; though sometimes approaching a few degrees nearer to north and south. The surface of this rock in general, especially of the slaty varieties, is too liable to decomposition to retain for centuries the marks of former abrasions; and I was rather surprised to meet with any instances. Yet I am satisfied that some rocks retain these marks, although their surfaces have suffered disintegration to a much greater depth than that of the grooves. For since the disintegration takes place at the surface only,

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the grooves and correspondent ridges may remain, although layer after layer scales off. Yet the ridges will be liable to suffer rather the most from atmospheric agents; and, therefore, in some rocks, they will probably soon disappear.

It may be well in this place to suggest a caution against mistaking the structure of the rock as revealed by disintegration, for these diluvial furrows. Some varieties of mica slate exhibit a surface extremely resembling one mechanically grooved. But in that rock, the direction of these pseudo-grooves always corresponds with that of the layers of the rock; and thus the deception may be discovered. But sienite and greenstone, which contain segregated veins, sometimes present cases that are very perplexing. One of these may be seen on the top of Mount Tom, a few rods north of the signal staff, erected for the Trigonometrical Survey of the State. The prevailing direction of the apparent furrows there, is nearly north and south; and did they not run east and west within a rod or two of the spot, I should have put down this as a genuine case of diluvial grooves. But examination, after my suspicions were excited by this circumstance, satisfied me that it is only the internal structure of the rock, that is here revealed by the unequal disintegration of the surface.

But to return to a consideration of the diluvial grooves in the western part of the State: I think it obvious, from the examples that have been adduced, that the general direction of the waters there, as well as in the eastern part of New York, must have been from northwest to southeast. The two exceptions mentioned, I think may be explained by their local situation, in consistency with this supposition.

Now these furrows on Hoosac mountain, and in New York, are as distinct as in other parts of Massachusetts: and, therefore, we must consider them all as produced at the same epoch. Had there been any great difference in the time of their production, especially had one set of them been the result of the elevation of the strata, and the other of the last deluge — events that form almost the limits of geological changes in point of time — the oldest must have been lost, or become obscure. Whatever difficulties attend the supposition, therefore, I think we must regard all these diluvial grooves in the State as resulting from the same deluge.

It would be easy to multiply examples of this kind of diluvial action. But the cases that have been described, occurring as they do in every part of the State, and frequently upon its highest mountains,

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seem sufficient to lead every reasonable man to the conclusion, that these grooves and furrows were produced by the large bowlders, which now strew the surface, and exhibit in their rounded forms and smooth surfaces, the marks of powerful abrasion. And since we uniformly find these bowlders to the south and southeast of their parent rock, how can we doubt that a mighty current of water has sometime or other swept over the surface from the north and northwest. It seems to me, that in regard to Massachusetts, the evidence of such a deluge is complete; and it is difficult to see how it could be more conclusive.

It is maintained by those geologists who account for all geological changes by existing causes, acting as they now do, that most of the stratum which I have described as diluvium, has been produced and brought into its present state by the action of existing streams, rains, frost, and other agents now in operation. But the simple fact that the current must have had a southerly direction in every part of the State, and has left traces of its action on our highest mountains, renders such a supposition, it seems to me, altogether untenable. For how could rivers have risen so high; or how, unless it were a single river, not less than 200 miles wide, could the waters have produced such effects? The same difficulty is in the way of supposing, as do some fluvialists, that the land was once much lower than at present, having been gradually elevated by earthquakes. Admit, if it be wished, that the surface was once much lower than its present level: the difficulty will still be to find a current 200 miles wide.

Other geologists, who perceive the utter insufficiency of such causes to account for diluvium, have imputed very much of it, and also diluvial grooves and furrows, to the retiring waters of the ocean, when first the solid strata were elevated. I doubt not that such was the origin of much of the diluvium that now covers the globe. But I think it quite obvious that all the diluvium in Massachusetts, which was produced by this and other causes, has been modified by a deluge long subsequent to the elevation of our continent from the ocean. For by examining the sections of our rock strata, appended to this Report, as well as the map illustrative of the course of the same, it will be seen that their prevailing dip is easterly, and their general direction north and south. Hence the anticlinal line of these strata, must be sought farther west than Massachusetts; and, consequently, the retiring waters must have rushed from the west at that epoch. But the actual current of the last deluge came from the north and

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northwest, as I have abundantly shown; and, therefore, it could not have resulted from the elevation of the strata.

In the eastern part of the State, however, it will be observed that the strata of the gray wacke formation run generally east and west. But they dip northerly; and hence the current of water, which their elevation produced, must have been towards the north: though if we suppose it to have been southerly, this formation is too limited in extent to account for diluvial action over the whole State.

But there is another circumstance, showing that the last deluge, that swept over this State, was long subsequent to the elevation of the strata. If we admit, what I think is true, that the tertiary formation exhibited on the map along Connecticut river, was deposited before the last deluge, it will follow that the elevation of the strata could not have been the cause of that deluge. For the strata of this tertiary formation are horizontal; and, therefore, must have been deposited after the elevation of the strata of the solid rocks beneath. Otherwise the strata of the tertiary formation would also have been raised and dislocated. Hence there must have been at least an interval long enough, between the elevation of the strata and the last deluge, for the deposition of this tertiary formation. And if we take the statement of Dr. Macculloch,* in respect to the filling up of the lakes of Scotland, as a standard of comparison, this will be shown to have been no ephemeral period. He states that these lakes "shoal" at the rate of half a foot in a century: and I apprehend that the tertiary formation under consideration cannot be less than 150 feet in depth. Nor can we suppose that this is but a small part of the period that actually intervened between these two events; which may be regarded as almost the first and the last of the geological catastrophes that have happened on our globe. This opinion might be sustained by an appeal to facts and principles: but I conceive that this is not the proper place for entering into such discussions.

I may seem here, however, to be advancing opinions contradictory to the Mosaic chronology of the globe. But they are simply opposed to the prevailing interpretation of that record. If we only suppose, what many of the ablest theologians and philologists maintain, and what geological researches imperiously demand, that Moses, after describing in the first verse of his history, the original creation of the universe "in the beginning," passes over in silence a long interven-

* Macculloch's System of Geology. London 1831 — Vol. I. p. 507.

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ing period, before he gives us an account of the earth in its present state, and of the creation of its present inhabitants, all apparent collision between geology and revelation vanishes. Such an opinion I have adopted, not merely because facts in geology demand it, but because it seems equally required by a fair interpretation of the language of Moses.

But to return from this digression; it seems to me that the fair result of all the facts and reasonings which I have presented on the subject of diluvial action is, that a mighty deluge has swept from the north and northwest over every part of Massachusetts; and that it cannot be accounted for by the original elevation of the strata of rocks; nor can our diluvial phenomena be explained by the agency of rivers, rains, frosts, or any other agent now in action. This deluge must, then have occurred since the earth's surface assumed essentially its present form; and was the last of those catastrophes to which this part of the globe has been subject; and which cannot be referred to existing agencies. The enquiry naturally arises, whether this deluge was identical with that described by Moses. I have already remarked that this question can have no very great interest as bearing upon the veracity of the sacred historian; since nearly all geologists agree that their science exhibits no evidence against the occurrence of such a deluge as he has described. Yet, as it is a characteristic of human nature to go from one extreme to another, and as it has been customary to impute almost every geological change to the deluge of Noah, is it not probable that philosophers, disgusted with so much false reasoning on the subject, will be apt to overlook even creditable geological evidence of that event? I have shown, if I mistake not, that the last deluge in Massachusetts was universal, and that it was comparatively recent. The deluge of Noah is described as universal over the globe; and historical records give us no account of one more recent. Where then is the objection against considering them as identical? Until some substantial reason can be given against such a conclusion, is it not unphilosophical to refuse to admit it?

I have thus far reasoned exclusively from diluvial action in Massachusetts. But there is evidence that the last deluge rushed from the north over all that part of North America, between Nova Scotia and Lake Huron. Dr. Bigsby has stated facts in the sixth volume of the Geological Transactions, and the Messrs. Lapham, more recently, in the 22d volume of the Am. Jour. of Science, proving the

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truth of this statement in respect to the country about our western lakes; and Messrs. Jackson and Alger, in their recent, able memoir on the Mineralogy and Geology of Nova Scotia, have drawn the same inference from the present position of erratic bowlders in that country. Do not these facts, in connection with those stated in this report, render it extremely probable, that over the whole breadth of North America, the current came from the north: although somewhat deflected in some places by local causes?

Nor is this all. The facts that have been observed in relation to diluvial action in England, Scotland, Ireland, Sweden, Germany, Russia, and the northern parts of Asia, seem to justify the inference that the last deluge in those portions of the globe, came from the north; though modified in its course by local causes.* Hence it would seem that this deluge, in all the northern parts of the globe, had this direction; and may have been produced by the elevation of an extensive portion of the bottom of the Artic ocean. De La Beche, in his recent able Geological Manual,† seems to regard the "center of disturbance" as situated to the north of Europe; and leaves us to infer that diluvial action in America was merely the result of the mighty wave, proceeding from that center. But so far as I can judge from the accounts which European geologists have given us of diluvial action, in that quarter of the globe, I doubt exceedingly whether it has left traces by any means as striking as in this country. As to grooves and furrows in the rocks, for example, the writer above quoted says, that "Sir James Hall even considers that a rush over the land (in Scotland,) has left traces of its course in the shape of furrows, which the transported mineral substances, moving with great velocity, have cut in the solid rocks beneath." Such language implies that these traces are by no means common, as in our country. Have we not then reason for supposing that the "center of disturbance" might have been situated nearer to this continent than to Europe? although the general direction of the current on both continents seems to imply that its situation was not far from the north pole.

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* Mr. J. Phillips infers from recent examination in Yorkshire, England, that the diluvial current there was from the north and northwest. And Mr. Murchisson finds that the direction of the diluvial markings on the rocks in Brora district, Scotland, is uniformly from N.N.W. to S.S.E. *See Philosophical Magazine, Vol. 2, N. Series, pp. 140 and 150.*

† p. 164.

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The recent profound and splendid generalizations of Elie de Beaumont, in regard to the elevation of mountain chains, at various epochs, seem to have rendered it all but certain, that the deluge of history was produced by such an event. This is the opinion of Beaumont. The elevation of a chain of mountains from the ocean's bed, "would produce effects in countries remote from the spot," says he, "similar to the sudden and transient deluge of which we find traces, and of a uniform date, in the archives of all people." — "If that historical event," he adds, "be nothing else but the latest of the revolutions on the earth's surface, it will be natural to enquire, what chain of mountains was elevated at the same date; and possibly it will reach the case to remark, that the chain of the Andes, whose breathing volcanoes are yet generally active, forms a ridge the most extended, the most decided, and the least changed from the actual external configuration of the terrestrial globe."* If it be true, however, that the diluvium, which I have described, received its present form and position from the historical deluge; and if the direction of the current in all northern countries was from the north; it is difficult to conceive how either the flux or reflux of the ocean, produced by the elevation of the Andes, could have been in that direction. But the history of Iceland proves, that mountains have been elevated in the northern part of our globe by internal forces, within a comparatively recent period; and this circumstance takes away all improbabilities from the supposition that the center of disturbance was there at the time of the Mosaic deluge. And is not this opinion strengthened by the discovery of the antediluvian elephant, incased in ice, on the shores of Kamtschatka; and of the tiger in the frozen gravel of the same regions: showing that the waters of the Arctic ocean were poured over that country when these animals were enveloped, producing such a change of temperature, that not until the present century, did the ice melt away enough to disclose their remains.

Before concluding this subject of alluvium and diluvium, I hope I shall be excused for making a short digression. Although it may seem arrogant in one who has never personally inspected the celebrated mounds of our western states, so universally regarded as the work of man, I hesitate not to advance the opinion with great confidence, that they are almost universally the results of diluvial and flu-

* Recherches sur quelques—unes Des Revolutions de la Surfacedu Globe.—Paris 1830.

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viatile action. To say nothing of their great number and size, which would render their construction a work of ages for all the millions of the globe, there is one fact stated by an acute writer, that must put the question at rest. He says that he "had never examined one that was not composed of different strata of earth, invariably lying horizontally to the very edge of the mound."* Now I take it upon me to say, that it is altogether beyond the art of man to pile up large hills of loam, sand, clay, &c. so as to exhibit the stratified structure here spoken of. Let any man but examine the alluvial or tertiary banks of a river having a stratified structure, and he will at once see that human skill can never imitate this work of water. These mounds, therefore, scattered as they are in immense numbers over the western regions, are the work of God and not of man. They were either piled up by diluvial action, or they are remnants of tertiary formations, that have been mostly removed by rains, land floods, and deluges. We have an abundance of just such mounds in New England, which need only a lively fancy to convert into the products of a once mighty and highly civilized people. The southeastern part of Massachusetts abounds with hills of this description. In the more central parts of the State they are less common. Yet the traveler will frequently meet with elevations of this kind, which viewed in certain directions are regular cones. Such examples may be seen in Franklin and its vicinity. One occurs a mile or two east of the meeting house in Enfield, on the banks of a small stream: and a similar one may be seen in Deerfield, at the foot of Long Hill, two miles south of the village. In making the road, one half this mound has been dug away, so as to exhibit its horizontal strata. Others may be seen on the stage road between Belchertown and Ware. That such elevations should have been selected, both in New England and at the west, for the habitations, the forts, and the burying places of the aboriginals, is just what we might expect. And this circumstance has doubtless given rise to the idea that these mounds are artificial. Nor will the belief that we can point to monuments of human skill more ancient than the pyramids of Egypt, be likely to receive a very strict scrutiny, or be easily abandoned.

### *Stratification of Diluvium.*

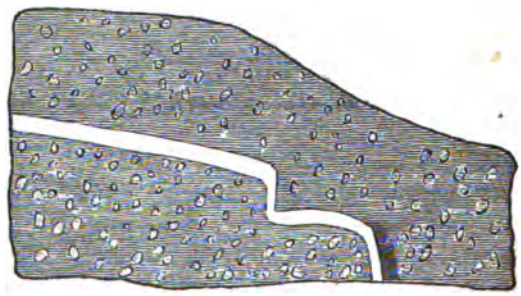
Though in this formation the materials be confusedly mingled to-

* Illinois Magazine Vol. I. p. 252.



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gether, yet it must not be understood that it is entirely homogenous and destitute of stratification. In all deluges, during their swelling and subsiding, there will be more or less of flux and reflux, of violence and quiescence in the waters, and of course the materials deposited will be sometimes finer than at others. This will lay the foundation for stratification, and indeed, most diluvium exhibits as much of it as those coarse consolidated conglomerates in the older rocks, which sometimes alternate with sandstones and even shales. This resemblance in their character is interesting, because it proves an identity of causes in their production. It is not very common, however, to see in our diluvium a very sudden change from coarse to fine materials. I was hence interested in the section of a diluvial hill in Schoodack, N. York, through which (as laid bare by excavating the road,) there extended a stratum of loam, the mass of the hill being made up of coarse gravel. This stratum was only a foot thick at its upper extremity, and dipped a few degrees towards the north. Near its lower extremity, it had been bent downwards nearly at right angles, as shown below; and the upright portions were drawn out, as if in a plastic state when the lower part slid downwards. For to suppose that the hill had thus sunk, will satisfactorily explain the case; and as such an occurrence would be more likely to take place when the whole mass was saturated with water, we should expect that the loam would be in a plastic state. Very probably the inclined position of the whole stratum resulted from a slipping down of that part of the hill which embraced it.



Diluvial Bank: Schoodack, N. Y.

### *Mineral Contents.*

Since diluvium embraces portions of every rock that rises to the surface, we might expect to find in it specimens of all the minerals

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which the rocks in place contain. And it would be easy to enumerate a very extensive list, in this formation, in Massachusetts. But this could be of no use: and I shall only mention the few which are of special interest.

The most important of these is native gold, which exists in diluvium in Somerset Vt. The soil from which I saw it washed, was taken only about a foot below the surface, and consisted of loam, or of sand and clay, containing vegetable matter. Deeper in the ground the materials are coarse. But to what depth the gold extends, has not been ascertained. As I have given an extended description of the features of this gold region in the first part of the report, and shall hereafter more particularly describe its mode of occurrence in the talcose slate, from which it has been washed, I need not dwell upon the subject here.

A few years since a mass of native copper was found in the diluvium of Whately, weighing 17 ounces avoirdupois. Its shape was irregular, and it was partially coated with the green carbonate of copper. There can be little doubt but this proceeded from the new red sandstone or the greenstone; although in Massachusetts, this mineral has not been found in either of these rocks.

Dr. Samuel L. Dana informs me, that recently a small mass of lamellar sulphate of baryta, containing some specks of galena, and with some quartz and feldspar attached to it, was discovered in diluvial gravel in Waltham. This fact is interesting, because, with this exception, no baryta has been discovered in that vicinity. Near the spot, however, rolled masses of quartz have been dug up, containing galena. These facts certainly indicate a vein of these minerals in the vicinity; and I venture to predict, that if ever it is brought to light, it will be found north of the spot where the diluvial fragments occur.

## *Organic Remains.*

I know of no instance in which organic remains of any interest have been found in our diluvium, with the exception, perhaps, of several species of recent shells in two or three places. The Messrs. Danas state, that in Cambridge, a common species of Mya was found, forming a stratum three or four inches thick, in the side of a hill; also strata of Mya, Mytilus, and Ostrea, several inches thick, and from five to ten feet below the surface, at Lechmere Point; and fragments of Mya, 107 feet below the surface, at Jamaica Plains, in Rox-

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bury. Similar beds of shells are also found on Nantucket: such as Natica, Pyrula, Venus, Crepidula, Solen, Pecten, Arca, &c. as will be more particularly described when I treat of Plastic Clay. I am not certain that in any of these cases the shells occur in diluvium; though I regard that as the most probable supposition.

### 3. TERTIARY FORMATIONS.

For a long time these formations were confounded with alluvium and diluvium: but they are clearly distinguished from both, by the much finer state of most of the materials that compose them; by the greater regularity of their stratification; by their relatively inferior position, and by containing peculiar organic remains. As appears from the map attached to the recent geological work of Mr. Lyell,* tertiary strata occupy more than half of the surface of Europe; yet geologists had paid very little attention to them till the publication of the work of Cuvier and Brongniart, on the Paris Basin, in 1811. In our country, although these formations occupy a vast extent of surface, particularly in the southern States; embracing that broad tract along the coast marked on Mr. Maclure's Map as alluvial; yet have they received but very little elucidation. Messrs. Morton, Vanuxem, and Conrad, have, however, recently devoted themselves successfully to this subject.

After the tertiary beds around Paris and London had been described, it seemed for a long time to be taken for granted, that tertiary strata all over the world must be identical with these: as if those spots contained the types of the whole globe. But geologists now find that no formations are more independent than the tertiary; and that it is very difficult to ascertain a precise identity of origin of any two basins, even when near to one another; and as to those that are widely separated, it is no easy matter to determine whether they were deposited during the same geological epoch.

I shall describe the tertiary rocks of Massachusetts under two divisions: 1. The most recent tertiary; and 2. the Plastic Clay. These are distinguished from each other by their mineralogical characters, their organic remains, and the different position of their strata.

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* Principles of Geology, &c. by Charles Lyell, Vol. 2. London, 1832.

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*The most recent Tertiary.*

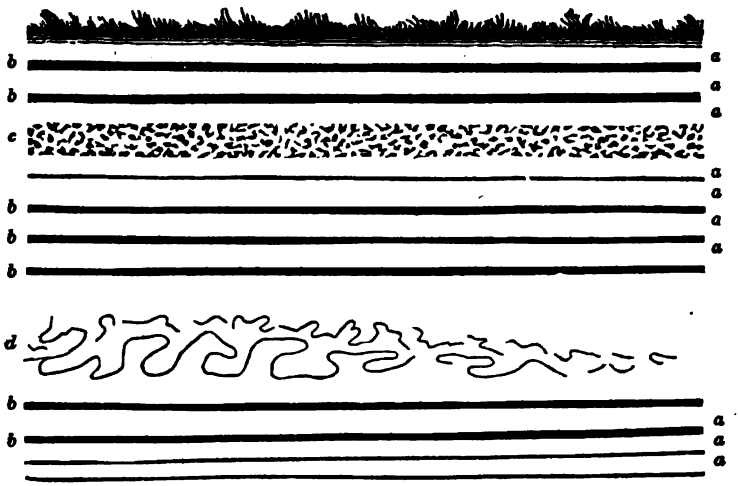
The most extensive deposites of the beds of this class, are in the valley of the Connecticut; where they are marked on the map. They occur also, in small patches in many other places in the State: but they have been marked on the map in no other place, except in Cambridge and Charlestown. The great resemblance in the mineralogical characters of these beds all over the State, their horizontal position, and the almost entire absence of organic remains in them, so far as they have been examined, have made it impossible to describe them as distinct deposites; though I have little doubt, that many of them, at least, are such. Yet probably they do not differ much in age. But I leave to future observers to settle what I have no means of deciding.

These newest tertiary strata consist of horizontal alternating layers of white siliceous sand and blue plastic clay. Along the Connecticut, the sand occupies the highest place in the series; and covers most of the surface. Its upper portion is disturbed and piled up irregularly by diluvial action; and sometimes mixed with transported gravel. But where the streams have worn passages from 10 to 15 feet deep, they have almost uniformly disclosed the stratum of clay. And not unfrequently tracts of considerable extent are entirely swept of sand, whereby the soil is rendered highly argillaceous. Generally the beds of sand and gravel appear to be several feet thick; but sometimes I have found numerous alternations in the height of a few feet, or even a few inches — some of the layers not being more than half an inch thick. Some years since, I obtained the following rough sketch of a cliff, a few feet in height, in Deerfield; the face of which had recently been laid bare by the sliding away of its outer portion. The beds, *a a*, &c. *b b*, &c. *c*, and *d*, represent different horizontal layers of sand and clay; the former becoming often very fine, and the latter sometimes approaching to loam. Some of the layers of clay were not more than half an inch thick; and these in general, with the interstratified sand beds, appeared as if deposited from water perfectly at rest. But the stratum *c*, presented a most remarkable exception. It was composed of angular and rounded pieces of clay, mixed with sand, and obviously resulted from the breaking up of several thin beds of clay and sand, by some unusual agitation of the waters. The stratum *d*, was still more remarkable. It consisted of sand and two layers of clay; the latter being very irregularly bent, as if,

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when in a plastic state, it had been acted on by opposing lateral forces.

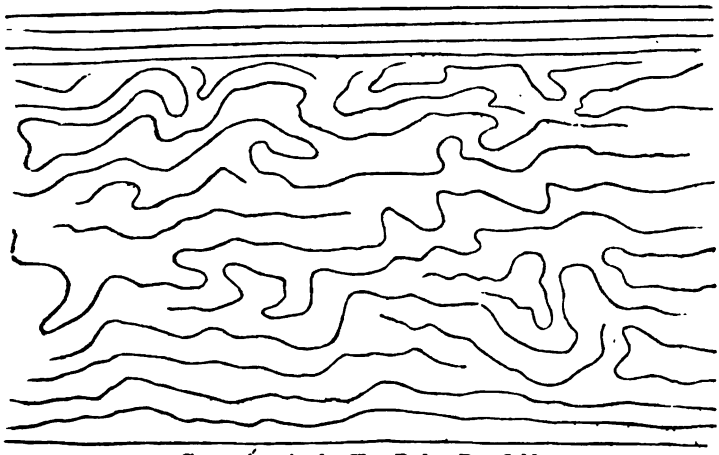
If I mistake not, this section throws light upon the manner in which some of the disturbances in the older rocks may have been produced. Let the stratum *c*, be only consolidated by heat, or otherwise, and we have a perfect conglomerated sandstone, or gray wacke. Let the stratum *d*, be not only consolidated, but partially melted, so as to become in a good degree crystalline; and we have that variety of mica slate or quartz rock, in which the planes of stratification do not correspond with the contorted schistose layers. The undisturbed beds of sand, by the same igneous action, might be converted into quartz rock, or mica slate; and the interlaminated layers of clay, into argillaceous slate, or hornblende schist, or both. Thus from this thin tertiary formation, might result hornblende slate, mica slate, quartz rock, argillaceous slate, conglomerated gray wacke, and sandstone: and these might present much of the regularity and irregularity, peculiar to each rock. And to accomplish all this, and also to give the strata an inclined position, we have only to suppose the the same volcanic agency to be exerted, which we know has been a thousand times employed in the elevation of strata, and in the protrusion of the unstratified rocks.




Section of a Cliff of Tertiary Clay and Sand: Deerfield.

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The preceding section was obtained on the side of a gully, a few rods west of the stage road at Long Hill, two miles south of Deerfield north village. The last year, I obtained the following sketch from a clay pit, recently opened, a few rods east of the Academy, in Deerfield. The contorted portion of the wall of the pit, was about three feet in perpendicular thickness; and above and below, (as shown on the sketch,) the layers of clay were perfectly regular and horizontal. This proves beyond all question, that the disturbance must have taken place during the period of the deposition of the clay; and that the cause must have been a transient one. A few rods farther to the east, however, as we pass up a hill, a similar disturbance of the layers of clay appears at a higher level, and of several rods in length; proving that the cause, whatever it might be, recurred at intervals. This case differs from the one first described, in there being no interstratified layers of sand, as are shown in the preceding sketch.



Contortions in the Clay Beds: Deerfield.

*Position and thickness of the Strata.*

There is no evidence, that I have ever been able to find, to prove that these tertiary strata have been disturbed since their original deposition. Nevertheless, the layers, or strata, are not always exactly horizontal. Where the surface beneath is slightly undulating, the laminae of clay are conformed to the irregularity. This produces a dip sometimes of two or three, or even five degrees, and in one or two cases (the east side of north Sugar Loaf mountain, in Deerfield, and the

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hill a mile south of Brattleborough east village,) it falls but little short of 10°. A less dip may be seen in the clay hill east of Deerfield Academy: and in the east part of Hadley, on the middle road to Amherst, the laminae conform to the gentle swells and depressions of the ground. At the base of steep hills, however, the clay beds are generally horizontal; because, as I suppose, the declivity was too steep to permit of these depositions in a conformable manner. This fact, and the circumstance that in those cases where there is a slight inclination of the clay bed, the dip follows no general law, but conforms to the surface, has led me to conclude that this tertiary formation remains as it was originally deposited. I mean that the few cases of dip which exist, do not prove any disturbing force acting subsequently to the deposition of the formation. And I think we have in these cases, the maximum of inclination in a sedimentary deposite of clay and sand, formed in still water. For since hills of every degree of inclination must have existed in the bottom of lakes, ponds, or the ocean, in which this formation was deposited, the layers of sand and gravel would have remained in a conformable position on every slope that was not so steep as to cause the materials to slide down. I think that in no case the inclination is more than 10°; although I have not applied the clinometer.

The measurement of a base line for a trigonometrical survey of the State, in the valley of the Connecticut, by Col. Stevens, during the year 1831, has furnished another proof that this tertiary formation has not been disturbed since its deposition. For the tracery of that line, (nearly eight miles long,) was made upon this formation; and the two extremities were found to correspond in their level within three feet.

Mr. Smith, in his account of the Connecticut river valley, in Volume 22nd of the American Journal of Science, states that the greatest elevation of clay beds along Enfield Falls, is about fifty feet above the present surface of the river; and this, if I understand him, exceeds the general thickness of the clay beds in that region. But as we descend into the basin in which the village of Deerfield is situated, the clay, without any alternation of sand, is exposed not less than 60 feet in depth; and still the bottom is not seen. A little east of the Academy, in the same town, the layers of clay rise 30 or 40 feet above the plain, and at the same place have been penetrated at the foot of the hill, 25 feet, without reaching the bottom: so that in this valley, this single bed of clay, cannot be less than 60 or 70 feet

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thick; and it may be much more. The stratum of sand above the clay is so much mixed in its upper part with diluvium, that I can form but a very vague idea of its thickness. It can, however, hardly be less than 15 or 20 feet.

I have no evidence that a stratum of sand is found beneath the clay in the Connecticut valley; though, as already mentioned, there are sometimes numerous alternations of the sand and gravel in narrow strata, near the line of junction. Mr. Smith also states, that in excavating the canal at Enfield Falls, the clay beds were entirely cut through; and that between the beds and the new red sandstone, was found a confused mixture of rounded masses of sandstone, greenstone, granite, and other primitive rocks, mixed with red clay from 4 to 20 feet thick. This is an interesting fact; because it proves that in the interval between the deposition of the sandstone and the tertiary formation under consideration, fluviatile and diluvial currents, similar to those that have since existed, must have been in operation.

The surface of the tertiary formation in the vicinity of Boston has been so much acted upon by diluvial currents, that as already remarked, I have been at a loss whether to describe it as tertiary or diluvial. But there is no doubt, I believe, that genuine clay beds, or layers of clay, do exist not far beneath the surface. This clay is represented by the well diggers as extremely hard; and underneath it, are layers of sand and gravel. It is from 70 to 120 feet thick; and when perforated, water rushes upwards with great violence. The only genus of organic remains found in the tertiary of the Connecticut valley, I have discovered also in the clay at Charlestown; unless I have greatly misapprehended its characters. But the same genus occurs also in the clay beds of Nantucket; which I have been inclined to consider as belonging to the Plastic Clay: so that this relic does not seem to afford much aid in determining the relative antiquity of these several beds.

As to other limited patches of tertiary in the State, (excepting the Plastic Clay, which occupies its southeastern part,) I know almost nothing. I have only seen pits opened in them occasionally, for the purpose of making brick. But although the clay appears to be mineralogically identical with that in the Connecticut valley, yet I have met in it with no sort of organic relic. These beds must vary in relative level several hundred feet; occupying as they do, the depressions of the surface in the various formations. This fact precludes the idea of their having been deposited by the same body of waters,



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unless they constituted an ocean deep enough to cover the whole surface of the State. And such a submersion is rendered improbable by the horizontal position of the layers of clay; which shows that no elevating force has acted upon the State since their deposition. Their production in different and independent basins of water, such ponds, perhaps, as now exist in Middleborough, Troy, Falmouth, Webster, &c.* — is the more probable hypothesis.

I call these various deposites the newest tertiary in the State. But my only proof that they are newer than the plastic clay of the southeast part of the State is, that the strata of the latter, at least, at Martha's Vineyard, are inclined at a high angle; while those of the former are horizontal. And we know that the older strata are generally, though not always, more inclined than the newer. I know of no place where these two series of strata are in contact, so that their true relative position may be seen.

### *Mineral Contents.*

I place in this formation the extensive beds of the hydrate of iron, (*Limonite*, Beudant: *Prismatic Iron Ore*, Mohs: *Brown Oxide of Iron*, Cleaveland,) which occur in the limestone valleys of Berkshire county: and in connection with the same range of limestone and mica slate, in Vermont and Connecticut. I am aware that in doing this, I deviate from the opinion of several geologists, who have examined these beds, and seem inclined to regard them as belonging to the mica slate or gneiss.† But I could not find the slightest evidence, at any bed of this ore which I visited, that it is interposed between layers of mica slate, gneiss, or any other solid rock. It is, however, usually associated with more or less of clay; and, therefore, I regard it as belonging to a tertiary formation. Generally, the bed is covered by nothing but diluvium; and diluvial action seems sometimes to have disturbed the ore to a considerable depth, so that my doubt has been, whether it ought not to be placed even as high as diluvium, rather than whether it belongs to the primitive rocks. Professor Silliman does, indeed, speak of a ledge of gneiss, as being brought to view by the excavation at Kent, in Connecticut, in the

* The name of the principal pond in this latter place, although not given on the map, deserves to be mentioned, because it is so laconical and euphonical. It is Chargoggagoggmanchoggagogg.

† Am. Journal of Science, Vol. 2. pp. 213 and 216: also Vol. 8. p. 30.

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upper part of the mine; and he considers this the roof of "the vast bed of clay, which forms the immediate enveloping matter of the ore." Although I have not visited the ore beds in Kent, I must be permitted to doubt whether there be not a deception in respect to this point. For the occurrence of a "vast bed of clay," unconsolidated, in gneiss or mica slate, is such a perfect anomaly in geology, that it cannot be admitted without the strongest evidence. And when I find these ore beds at Salisbury, West Stockbridge, Richmond, and Lenox, most obviously lying above the primary rocks, I cannot but suspect that this is the case also at Kent: though I would not close my eyes against evidence to the contrary.

If it be admitted that this hydrate of iron belongs to a tertiary formation, it by no means follows that its deposition was isochronous with that of the newest tertiary in the valley of the Connecticut: and the occurrence in the former, of so much iron, while it is very sparingly diseminated in the latter, is a presumptive argument against their production in the same menstruum.

The principal beds of the hydrate of iron in Berkshire county, are found in West Stockbridge, Richmond, and Lenox. Out of Massachusetts, the beds at Bennington, Vt. and at Salisbury and Kent, Ct. are best known. The most common varieties are the brown hematite, and compact brown oxide, though the ochrey brown oxide is very common, as well as the argillaceous oxide. The hematite is often beautifully mamillary and stalactical. (Nos. 53, 54, 55.)

No one looks at the stalactical specimens of this ore, without enquiring at once, whether heat must not have been concerned in its production. For the specimens exceedingly resemble certain stalactical varieties of lava, or the products of a powerful iron furnace. And in their natural position, the stalactites usually hang in a perpendicular position, as they would do if formed by the dripping of tenacious melted matter. But after all, there seem to be insuperable difficulties in admitting the igneous origin of hematite. For how could heat have operated powerfully enough upon the hematite to melt it, without melting, or at least indurating, the clay in which it is enveloped? Again, the occurrence of this ore in calcareous spar and quartz, (which are usually of aqueous origin,) shows that it may be produced from water. It is likewise now admitted, I believe, by the ablest mineralogists,* that argillaceous oxide of iron and bog

* Beudant's Minerologie, Vol. 2. p. 702: Dictionaire Classique D' Historie Naturelle, Art. Fer Hydrate or Hydroxide: also Mohs Mineralogy, Vol. 2. p. 410.

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ore, are only impure varieties of hydrate of iron. And the bog ore is daily forming before our eyes by aqueous deposition, and some of it is in fact the same as the compact brown oxide. Only admit, then, that circumstances were favorable to crystallization, when the hematite was in a state of solution in the water percolating through clay, and may we not conceive how that ore was produced?

The oxide of manganese, sometimes delicately radiated, and sometimes investing the hematite, occurs at probably all the beds of hydrate of iron that have been mentioned. I noticed it particularly at the bed in West Stockbridge: and it is well known that it did exist in Bennington, Vt. in the same connection, in large quantity.

Associated with the hydrate of iron in Richmond, in a bed owned by Mr. Gates, there has been found a hydrate of alumina, (alumina, 64. 8, water, 34. 7,) which Professor Torrey has named Gibbsite, in honor of Col. George Gibbs, one of the earliest cultivators, and most munificent patrons of mineralogy in our country. It occurs mamillary and stalactical, of a white color. It may be obtained there abundantly; and a single specimen has been found in Lenox.

The nodular argillaceous oxide of iron and yellow ochre occur occasionally in the tertiary region around Boston, particularly in Charlestown and Cambridge.

### *Concretionary Carbonate of Lime.*

In the clay beds of the Connecticut valley, a curious concretion occurs, which has received the name of claystone, from its resemblance to indurated clay, that has been rounded by the action of water. Indeed, I did not till recently suspect the presence of carbonate of lime: but the application of an acid produces considerable effervescence. The general shape of these concretions is that of an oblate spheroid, sometimes so flattened as to become lenticular, and sometimes nearly spherical. These spheroids are usually joined together with considerable strength. They vary in size from two inches, down to that of the smallest pigeon shot, and some of these smallest are so numerously strung together, as to become decidedly botryoidal. In other instances, the spheroids are so intimately blended, that there are no interstices between them; and only slight convexities are exhibited, in relief, on the surface. Not unfrequently that surface is studded with minute spheroids, not larger than the head of a pin. Sometimes the concretion is not spheroidal, but simply an irregular plate, often several inches across. In no case does the thickness of

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these plates, or a congeries of the spheroids, exceed that of a single layer of the clay, which is rarely more than half an inch.

On breaking these concretions they are found to be perfectly solid and compact; exhibiting in no instance the slightest marks of concretionary structure, such as we see in the oolite. Nor could I bring to light a concentric arrangement of the materials by applying the heat of a blow pipe, even till the surface was fused. Generally, however, the heat of a lamp alone will cause them to burst asunder with considerable force. The mass is obviously composed of carbonate of lime mixed with clay, such as that in which they are found, consisting of alumina and fine sand, with occasional fine scales of mica. The hardness of the concretion is about the same as the common impure compact limestones. It does not constitute any considerable part of the stratum in which it is found. I have observed it in Amherst, Hadley, South Hadley Canal, Chicopee in Springfield, Greenfield, &c.; also in the clay beds along the river Hudson, near Albany.

I have been thus particular in this description, because I have met with but one account of any similar production in any tertiary strata. It is obviously an example of the solid concretionary structure, and must have resulted from chemical agencies. But are concretions the result of crystalographical laws? If so, why are not crystals produced? It seems to me that philosophy is yet in the dark on this subject. At first it occurred to me that these concretions were the oolite in a forming state; and that the consolidation of the clay would develope a concentric structure. But my failure to bring this to light by the application of heat, convinced me that the opinion is untenable.

The single account of similar concretions referred to above, is that of Cuvier and Brongniart, in their description of the Paris Basin. "We find," say they, "towards the surface of that bed of clay, (the Plastic Clay,) masses as large as the head, though often much smaller, of nearly compact limestone, or made up of small compact nodules, aggregated together as if by concretion. These masses of limestone have their edges blunted and their angles both salient and rentrant rounded, as if they had been plunged into a liquid solvent."*

Quite recently I have found in the gray argillaceous sandstone at Sunderland cave, in Mount Toby, numerous reniform concretions,

* Recherches sur les Ossemens Fossiles, par Cuvier, Tome 2. p. 341. Paris, 1825.

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very much resembling those above described. And I find that they effervesce with acids, which proves their identity. Some of them so exactly resemble *Unios* in form, that I at first suspected them to be petrifactions. But a careful examination satisfies me that the similarity is accidental. This fact shows us that the same causes operated when this sandstone (a variety of the new red sandstone) was deposited, as when the newest tertiary was formed. A fact analogous to the one just stated is mentioned by Dr. Macculloch. "In the argillaceous limestones, as well as in the accompanying sandstones," says he, "highly flattened spheroids of large dimensions are found attached in pairs by a crylindrical stem, and imbedded in the surrounding rock."*

### *Organic Remains.*

The newest tertiary in Massachusetts, judging from the examinations which I have made of it, is remarkably wanting in organic remains. Indeed, I have found but a single genus, and even this is in so imperfect a state that I have been unable to ascertain its nature. It was probably some kind of animal: and some of the specimens bear a considerable resemblance to the *Ovulites margantula* of Goldfuss' *Petrifacta*: but I have never seen in it any thing of the "poris minutissimis ad superficiem amussim dispositis," which he represents as belonging to that petrifaction. Other specimens resemble the *Scyphia* of the same author, but the "e fibris reticulatis" is wanting. It is doubtful whether the sketches which I have given of this relic, (Plate XI. Figs. 18, 19, 20, and 21,) represent anything more than fragments of it, worn into an ovoid shape. Fig. 22, however, does certainly represent one extremity of the animal unaltered: for it is still partly enveloped in loam. But the fragments are sometimes cylindrical, varying in size from a quarter of an inch to more than an inch in diameter. These usually perforate the strata of clay perpendicularly; that is, at right angles to the layers; and they are sometimes several inches long. The extremities, however, I apprehend are always similar to Fig. 22. The most decisive evidence of organic structure which these remains exhibit, is a longitudinal perforation of the size of a knitting needle. They are, it is true, easily divisible transversely: but this seems to depend upon the laminated structure of the clay, that chiefly composes them, and not upon the

*System of Geology, Vol. 1. p. 179.

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structure of the animal: for the dividing plane conforms in all cases exactly to the layers of the clay. Since clay forms the principal mineralizer, the outer circumference of these cylindrical and ovoid relics, is often very indefinite: and where exposed to rains, they are often entirely washed away. Along the central part, however, hydrate of iron seems to have considerably indurated the clay; and, indeed, this iron often pervades the whole mass; giving it a rusty aspect, and hardness sufficient to resist the action of rains. In such cases the the relics often stand out in relief upon the surface of the clay, which has worn away around them.

These remains I have found only in clay or loam. I have met with them in three places in Deerfield, viz. a few rods east of the Academy; near the top of Bar's Long Hill; and on the east side of North Sugar Loaf. They are found also in Greenfield, on Green River, southwest of the village: also in South Hadley, at the Canal Falls; and 100 rods south of them. I have found them likewise in Charlestown, in clay; and also on Nantucket in a stratum of ferruginous sand. Among the specimens deposited in the collection, (Nos. 47, to 52,) I apprehend several species may be made out.

### *Theoretical Considerations.*

That these tertiary beds were deposited from a mechanical suspension of their materials in water, can admit of no question. But was it from salt water or fresh? On this question the only organic relic that has been found in these beds, throws no light; because its nature is not understood. Still, I think we have some grounds for forming an opinion in this case. For the horizontal position of the laminae of clay in this formation, shows that no change of consequence has taken place in the level of the surface, since they were deposited. Hence, unless the level of the sea has sunk greatly since that period, it could not then have covered the regions occupied by these beds. They were probably, therefore, deposited from fresh water lakes and ponds. In the valley of the Connecticut, that river must have flowed through the lake; or rather, an expansion of the stream formed the lake. The gradual sinking of its bed at length brought the tertiary strata *sub luce.*

The probable absence of marine relics from these beds, is another argument in favor of this hypothesis; and it would be complete, were the fact certainly established.

In respect to the tertiary strata in Charlestown and Cambridge,

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their low level, and vicinity to the ocean, lead to the supposition that they were deposited from salt water, by a process similar to that which is now going on in the salt marshes in their vicinity.

### *Plastic Clay.*

A cursory examination of the strata of Martha's Vineyard, ten years ago, led me to adopt the opinion that they correspond essentially with the Plastic Clay Formation of Europe: and I gave an account of them under that name in the American Journal of Science. Every subsequent examination has confirmed the opinion then formed. And I have ascertained, also, that the same formation exists in several places on the continent, in the southeastern part of the State; and likewise on Nantucket. Wherever in that region sands prevail extensively, I have reason to suppose this formation exists; though I am by no means sure but some of these sands may belong to a newer formation. At some places, however, variegated clays underlie the sand, and fossils are found corresponding with those on the Vineyard; and such strata I cannot but regard as identical with the plastic clay of that island. It is on the Vineyard, however, that this formation is most fully exhibited; and I shall first describe the strata which exist there, and compare them with the plastic clay in Europe.

There are but two places on the Vineyard where I have found the strata laid bare to any considerable extent and depth. The one is a cliff in the southeast part of Chilmark, laid bare by the action of the ocean, and slowly wearing away from year to year. The other is Gay Head; which is an elevated promontory from 150 to 200 feet high, forming the western point of the island, still owned and inhabited by the mixed descendants of the aboriginees. This spot is the most interesting and instructive. The very heart of the formation appears to be here laid bare. It consists in general of interstratified inclined layers of gravel, conglomerates, sands, variegated clays, iron ore, and lignite.

### *Mineralogical Characters.*

1. *Clays.* These greatly predominate in the cliffs at Gay Head; and by the vividness of their colors, attract the attention of the most careless observer. Their variety in this respect is very great; but the following predominate. 1. *White Pipe Clay.* This generally contains small plates of silvery mica, and obviously results from the decomposition of granite. 2. *Blood Red Clay.* This is doubtless

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colored by the red oxide of iron, and forms an important part of the cliff. 3. *Red and White Clay.* This is a mixture of the two first varieties, and the two colors being often fantastically arranged, give to the cliffs a gay appearance. 4. *Bluish Gray Plastic Clay.* This is the most compact of all the varieties. It often becomes nearly black, where it lies contiguous to the beds of lignite: and when in contact with the white and red varieties, a mixture of them all results.

2. *Sands.* Next to the clays the sands are most abundant: though at Gay Head they do not exist in great quantity. They are there sometimes interstratified with the clays; and indeed, some varieties of the clay contain so large a proportion of sand, that it is not easy to determine whether they should be denominated clays or sands. Of the sands I have noticed the following varieties. 1. *White Siliceous Sand;* generally fine, but sometimes coarse. This is the variety which is spread over almost every part of the southeastern district of New England; generally, however, mixed with pebbles and bowlders, and constituting diluvium. It may be seen in its greatest purity near the extremity of Cape Cod; where it is of snowy whiteness; and also on Nantucket. On the Vineyard it is generally yellowish from the oxide of iron. 2. The same sand, cemented by the yellow hydrate of iron, so as to form a loose sandstone. It is easily crumbled down, however, and is not abundant. I have noticed it at Gay Head; in the cliff in the eastern part of Chilmark; and on Nantucket, a mile northwest of the town. 3. *White Micaceous Sand.* This is in fact a mixture of silex, mica, and white clay; the latter ingredient not being present in sufficient quantity to hold the particles together. Not abundant. 4. *Green Sand;* of a distinct but dull green color. It is sometimes so mixed with clay, as to form a compact mass, even when dry. It is interstratified with the red and white clays at Gay Head, where alone have I noticed it. It is this stratum that contains the greatest variety of the organic remains at Gay Head; and on this account, its exact geological position is important to be known. It has been already remarked, that the strata in this cliff dip nearly north, or rather a little inclining to the northeast, at an angle varying between 20° and 45°. Now the green sand lies near the northern extremity of the cliff, through it is succeeded by other strata of the same clays that constitute the principal part of the cliff. Hence we may infer that the green sand lies near the upper part of this formation, so far as we can judge from this cliff: though,



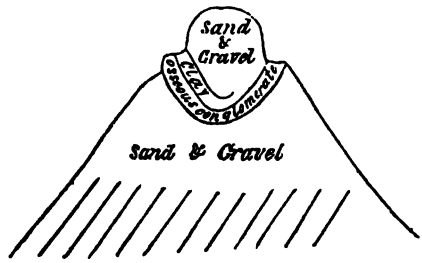
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as the horizontal distance from one extremity of the cliff to the other, across the strata, is not more than 80 rods, and appears to be merely an insulated remnant of the formation, we cannot be sure that the position of the green sand is near the upper part of the original formation. It ought here, also, to be remarked, that the organic remains found in this sand, such as crabs, shells, and alcyonites, are rolled; and were obviously the ruins of some former rock. Indeed, nodules of a peculiar conglomerate are found in this sand, sometimes containing organic remains.

3. *Lignite.* As this constitutes beds sometimes as much as five feet thick, it seems deserving of a description among the strata, rather than as an imbedded mineral. It alternates with the clays, principally with the blue variety, with which it is often intimately mixed. More commonly it is comminuted and forms a dark mass, somewhat resembling peat. But sometimes the woody fibre is very distinct. In short, it seems like a deposite of peat, through which logs are interspersed. It burns but poorly. The principal beds lie not far from the middle of the cliff, and have a dip from 40° to 50° north.

4. *Conglomerates.* The most interesting of these is the *osseous conglomerate;* which consists of rounded quartz pebbles, rarely more than an inch in diameter, with a cement of animal matter, (?) clay, iron, and sometimes a minute portion of carbonate of lime. It abounds in fragments, mostly rolled, of the bones and teeth of animals; some of them very large. It is sometimes as hard, and broken with as much difficulty, as gray wacke: but in other places the coherence is not strong.

The strata of this conglomerate are from one to three or four feet thick, and for some time I supposed that it had been deposited in a small basin on the edges of the elevated strata of clay and sand; for I found the bed, which I first discovered, to lie as in the following sketch.




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It occupies a projecting point of the cliff, covered at the top, and for a considerable extent upon its sides, with sand and gravel, and exposed to degradation from winds and rains. The edges of the conglomerate, however, project through the sand at the extremity of the point where its curved position is obvious; and on one side a layer of clay appears above the conglomerate. Below these beds the sand conceals the regular strata in the cliff; but the inclined lines beneath the sand and gravel, in the above sketch show the dip of these strata in the vicinity, wherever they are visible; nor could I doubt but the conglomerate bed is superior to the clay, and a later formation. And I find that in some of the tertiary strata in Europe, above the plastic clay, occur layers of calcareous, ferruginous, and bony breccia; as in the valley of the Danube, described by Mr. Murchisson.* But on further examination I found in the vicinity of the bed of conglomerate above described, two or three other beds distinctly interstratified with the clay, and exhibiting the same dip. This rock does, therefore, form a part of the plastic clay formation; whatever we may think of the case described above. And I cannot find that the like deposite, containing the bones of vertebral animals, occurs in any plastic clay formation described in Europe; although in England, pebble beds alternate irregularly with the sand and clays, but it does not appear that these are consolidated.†

Another variety of conglomerate at Gay Head, consists of pebbles, chiefly quartz, cemented by a great abundance of the hydrate of iron, and often containing hollow nodules of the same. I am not sure that this alternates with the layers of clay and sand. On account of the great quantity of its debris, that has fallen down upon the face of the cliff, I found it difficult to ascertain its true position in regard to the strata of clay and sand. I was not without a strong suspicion, that it might lie in nearly horizontal strata upon the top of plastic clay; nay, I was led to enquire whether it might not be diluvium consolidated by iron.

A third kind of conglomerate has been already alluded to, as existing at this cliff, in rolled masses, a few inches in diameter, in the sand stratum. It occurs, also, very commonly along the beach; having been probably washed out from the cliff. It is unlike any rock that I have ever met with. The nodules are almost if not entirely

* Philosophical Magazine, March, 1831, Vol. 9. p. 218.

† De la Beche's Manual, p. 235: 2d Edition, London, 1832.

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quartz, and the cement a black compact substance, highly bituminous, and slightly effervescing with acids. It appears like bituminous marlite, finely comminuted. As already mentioned, in one piece I found the remains of a Zoophyte.

At the foot of the cliff, I also found rolled pieces of yellowish gray rock, hard and compact, approaching hornstone. It appears like argillaceous sandstone, which has been subjected to powerful heat by the proximity of trap, such as occurs at Mount Holyoke, on Connecticut river; but I have met with the like rock nowhere else in the State. (No. 81.)

In a kind of ferruginous sand in this cliff, I met with one or two small specimens of a rock of oolitic aspect; (No. 80.) which, however, effervesces but feebly with the acids.

Specimens of all the preceding varieties of clay, sand, lignite, and conglomerate, will be found in the collection made for the Government.

### *Mineral Contents.*

The most interesting and abundant mineral at Gay Head, is the hydrate of iron. The varieties are all argillaceous. The most important are the following.

1. *Nodular.* This is the most abundant variety, and the nodules vary in size, from that of a walnut to a foot in diameter. Sometimes they are spherical, more frequently ovoid; sometimes ovoid flattened; sometimes composed of concentive layers of the compact oxide and yellow ochre, with a nucleus sometimes of sandstone at the center, but more frequently hollow. These nodules are generally mixed with a large proportion of coarse sand and gravel, which unitedly form, as already remarked, a conglomerate. The flat nodules are sometimes slaty; and it is on the laminae of these, that the principal part of the vegetable remains of this formation occur. Sometimes the nodule, when broken open, is seen to envelope a flattened mass of lignite: showing conclusively that the ore originally accumulated around this as a nucleus.

Nodular argillaceous iron ore exists also on Nantucket; as well as in other places on the Vineyard.

2. *Columnar.* Some of the larger nodules mentioned above, being broken open, exhibit, as the result of desiccation, a columnar structure in the interior: the columns varying in diameter from a quarter of an inch, to one, and even two inches; and in length, from half an

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inch to three inches. The sides are generally unequal in size, and various as to their number. The axis of the column is always parallel, I believe to the shortest diameter of the nodule. The space between the columns is generally only sufficient to allow of the introduction of the blade of a penknife. In some instances, where a shrinkage has taken place, no regular forms are produced; but the seams run in all directions. I have not observed any case where the seams reach to the surface of the nodule. The outer portion, from half an inch to an inch thick, is compact gray iron stone.

An examination of these nodules, leads one at first almost irresistibly to the conclusion, that they must have been once in a melted state, and suddenly cooled at the surface: and the glazed iron-black appearance of their internal surface, tends to confirm this opinion. And yet, I doubt whether it is necessary to evoke the god of fire for a solution of this phenomenon. For the mere descication of nodules, containing so much argillaceous matter, will, it seems to me, adequately explain the appearances. Of course the external part would first part with its moisture and become solid: and as the water gradually escaped subsequently from the interior, the shrinking would produce fissures within; since the already compacted crust would not permit the compression of the whole mass. And as to the shape of the pieces, resulting from the shrinkage, it seems to me that if the nodule be spherical, the fissures will coincide essentially with planes passing through the center of the sphere. (See No. 126.) But if the shape be that of a flattened ellipsoid, the greatest shrinkage must take place in the direction of the plane, which coincides with the two longest diameters of the ellipsoid: and, therefore, most of the fissures will be made perpendicular to that plane, so as to produce columnar masses; although there will be a proportionable shrinkage in a direction perpendicular to the plane above mentioned, which will produce at least one termination to the columns: and all the specimens which I have examined, confirm this rationale of the appearances; (See Nos. 124, 125.) as does also the desiccation of clay on the surface of the earth, producing columnar masses, which stand perpendicular to the horizon. I apprehend it will be found, that the true columnar structure exists only in those nodules which are flattened.

The existence, sometimes, of lignite in the center of these nodules, is another evidence that they never could have been completely fused, since the pieces of wood that were enveloped, must have been entirely destroyed. I am aware that coal is sometimes found in trap rocks, or

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between the trap and sandstones: but in such cases, I apprehend that the fusion of the trap was only partial, as we know to be the case with many lavas.

Further: how could nodules of iron, in the midst of clay and sand beds, have been exposed to a fusible heat, and yet the clays and sands have remained unconsolidated?

3. *Mamillary.* The tubercles of this variety are rarely smaller than a buck shot, or larger than an ounce ball. When broken, they exhibit no appearance of a radiated structure; but are massive, though scales of mica and grains of sand are observable in every part of this ore. (No. 120.) I cannot find that this variety of iron is described in the books on mineralogy. I am informed by Thomas A. Green, Esq. that it exists in much larger quantities in the cliffs, four miles east of Gay Head, in the west part of Chilmark, a little east of Monimshi Bite, than at Gay Head, where I found it.

4. *Pisiform.* The grains are rarely exactly spherical, and seldom exceed the size of a small pea. Not unfrequently they are distinctly reniform. Color, externally, blackish brown; internally, yellowish brown. Aggregated into irregular masses with clay and gravel. This ore seems sometimes to be the mineralizer of alcyonia, shells, &c. It is not abundant.

5. *Ochrey Brown Iron Ore.* This occurs mixed sometimes with every variety above described; particularly with the nodular. But it is never seen in large masses.

It is well known that the preceding are valuable ores of iron for smelting; and at Gay Head, particularly, they may be obtained in abundance. That spot is still in possession of the descendants of the Indians of Martha's Vineyard: and it is to be hoped that the Government of the State will take measures to prevent their being defrauded of this ore, which may prove of considerable value.

*Radiated Sulphuret of Iron.* This is very frequent and beautiful in the osseous conglomerate and blue clay of Gay Head. The nodules are sometimes perfect spheres; from one to three inches in diameter; but generally more or less irregular; the surface often exhibiting one face of numerous cubic crystals: but on breaking the mass, the radiation is obvious. Such, however, is the tendency of this ore to decomposition, that it is difficult to preserve specimens long in a cabinet, unless excluded from the atmosphere. Their decomposition produces of course sulphate of iron, and sulphate of alumina and potash, or alum, which effloresce on the clay.

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***Sulphate of Lime, or Selenite,*** exists at the same place in tables and acicular prisms, disseminated in blue clay. (No. 131.)

It is said that amber has been found floating in the ocean near the cliff at Gay Head. I also found it in small quantities, connected with a vegetable relic in iron ore, at the same place. At Nantucket, a mass of light colored amber was found, three or four inches in diameter, which is now in the cabinet of T. A. Green, Esq. of New Bedford.

Native arsenic is said to have been found at Gay Head; but I saw none.

## *Organic Remains.*

Although these are apparently not as numerous in the plastic clay of Massachusetts, as in that formation in Europe, yet since vegetable and animal relics are rare in New England; and some of those in the plastic clay are not found in the same formation in Europe, so far as I can ascertain; I have felt not a little interest in those which I have succeeded in obtaining, with much labor and effort. But I regret, that in consequence of my insulated situation in respect to those gentlemen in our country who have paid particular attention to our fossils, and the short time which has elapsed since I discovered those under consideration, which has prevented my consulting more than one or two of these gentlemen, and every European zoologist, I shall not be able to give their generic and specific names as accurately and confidently as I could wish. And the same remarks will apply to all the organic remains which I shall describe in this Report. But as I shall give accurate drawings of the most important species, whenever it is practicable, I trust the defficiency will not be great. I had rather be regarded as very ignorant on this subject, than by substituting conjectures for knowledge, lead others to form false conclusions. It is a subject perhaps the most difficult of all connected with geology; especially in this country, where there is so great a deficiency of good collections of fossil remains.

## *Fossil Vegetables.*

The lignite beds already described, prove the presence of a large quantity of vegetable matter in this formation. This lignite is sometimes ligniform, of a brown color, and distinctly fibrous: at others, it is hard and brittle; and more commonly, it is friable. I found a mass at the foot of the cliff, which abounded in the impressions of a

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monocotyledonous plant, bearing the closest resemblance to a Zostera. The mass resembled peat.

But most of the vegetable impressions at this cliff are dicotyledonous; and exist only in slaty argillaceous iron. Although these impressions are very distinct, exhibiting the minutest reticulations of the leaf, yet every particle of the vegetable substance is removed. This is true only of those instances where the impressions are leaves. (Plate XI. Figs. 1, 2, & 6.*) The shape of most of these leaves very much resembles that of an Ulmus; but they are wanting in the serratures, which the existing species in this country possess. Fig. 6 has serratures, or rather is crenate, and resembles a Salix. On Fig. 2, may be seen the impressions of pear-shaped seeds.

Figs. 7, 8, and 9, represent different individuals of another variety of vegetable remains, occurring at the same spot, and in the same iron ore. These are not mere impressions; but a scale of carbonaceous matter, mixed with amber, marks the spot where the vegetable was imprisoned. The amber occupies longitudinal ridges, which in the plate are represented by white stripes. It seems to me very obvious, that these remains must be the seed vessels of coniferous plants. The amber shows that they abounded in resin. They resemble unopened flowers of syngenesian plants: but they contain too much resin for these, and have left too much undecomposed matter for so frail a substance. Indeed, although the compound flowers, with their double calyx and strong receptacle, might stand a better chance of being preserved in a fossil state than those of any other kind of plant, yet I am not aware that a flower of any sort has been found in that condition. Near one of the specimens of the vegetable under consideration, I observed an ovoid *carpolithes*, about a quarter of an inch long, exhibiting the shell most distinctly, and different from the pear-shaped ones just mentioned.

### *Animal Remains.*

*Vertebral Animals.* The bones and teeth of these animals are more numerous at Gay Head than any other organic relics. They are found in the greatest abundance in the osseous conglomerate, already described: but they occur also in the green sand, and in a yellowish sand, associated with the green sand. For the most part, the bones are not mineralized; but frequently they are black when broken; and

* All the organic remains that are figured are drawn of the natural size.

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sometimes they are thoroughly impregnated with iron ore. In general they are much broken and often rolled. In one instance, however, I noticed a succession of large vertebrae, one or two occasionally being absent, for a distance of 10 or 12 feet. Some of these are 9 inches thick, and as much in length. The head in this instance was wanting; and, indeed, nearly all the other bones, except the vertebrae. But it is improbable that these could have been moved in so connected a state, far from the spot where this huge animal died. In the green and ferruginous sand, vertebrae are found only occasionally; and they are generally much smaller than those in the conglomerate; but they are not rolled.

It ought perhaps to be mentioned, that the largest vertebrae noticed above, occur in the curved bed of conglomerate which lies apparently upon the edges of the other strata. And yet, the conglomerate and the contained bones, interstratified with the clay, cannot be distinguished from those of this upper bed, except that in this single instance the bones are rather larger and less broken and rounded.

Such of these vertebrae, as I thought it would be of any use to have drawn, are exhibited on Plate XII. Figs. 23, 24, 25, and 28. Pieces of the ribs, (some of them 4 or 5 inches in their greatest diameter,) bones of the head, &c. are in general so broken, that a sketch of them would be useless. They will be found among the specimens. All the vertebrae that are drawn, are from the green and ferruginous sand.

The teeth that accompany these bones, give us some clue to the nature of the animals here entombed. All the varieties of these teeth which I could find, after a protracted search, are exhibited on Plate XI. Figs. 11, 12, 13, 14, 15, and 16. The flat teeth, Figs. 11, 12, and 13, are evidently those of the shark: and Fig. 12, must have belonged to a giant species. Probably also the triangular teeth, Figs. 14 and 15, belong to the shark; and these are more numerous than the others, and rather more broken; though all of them are very often much injured.

Fig. 16 appears to be the fragment of a crocodile's tooth; corresponding with one figured in Cuvier's *Ossemens Fossiles.* It was found in the ferruginous sand, and it differs from all the petrifactions noticed at this cliff, in that it is converted into a substance exactly resembling flint. It is hence not at all probable, that any of the bones that have been described, were connected with this tooth.

It ought to be noticed, that sometimes masses of lignite are con-



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tained in this osseous conglomerate: and that in two instances, I found the bones penetrated by a cylindrical cavity, two or three inches long; pretty obviously the work of some lithodomous shell.

We ascertain, then, with considerable confidence, the remains of the crocodile and two or three species of sharks in this cliff. Very probably an experienced comparative anatomist may detect other species among the bones which I have obtained.

The largest shark's tooth given on the plate, (Fig. 12,) is considerably broken; and, therefore, its exact dimensions cannot be ascertained: but the following measurement certainly does not exceed the truth.

Greatest breadth of the part covered with enamel, measured across the base, - - - - - - - - 2 inches.

The length measured on the enamel of the concave part of the tooth, - - - - - - - - - - 2 inches.

If we estimate the size of the shark to which this tooth belonged, according to the principles adopted by the Count Lacepede and Faujas St. Fond, in the "Annales de Museum," its length must have been about 50 feet! Dr. Knox, however, thinks this estimate too high.* But he describes a shark killed on the coast of Africa, as having teeth which measured 1 1-2 inch in the directions mentioned above. Supposing the relative size of the teeth to indicate the relative size of the animals, the fossil shark at Gay Head must have been about 36 feet long! And some of the vertebrae there, that have been described, correspond with a bulk so enormous. Such was one of the animals that swam in the ancient seas of this latitude! And this result corresponds with the conclusions of European geologists, that the extinct animals were generally much larger than those now existing. The tooth of the crocodile at Gay Head, as well as the great size of some of the sharks bones, show, also, that when these animals swam in the waters of our continent, the climate must have approximated to a tropical character: a conclusion, which, in respect to Europe, has been well established by a multitude of similar facts.

I have already remarked that I had not met with any account of an osseous conglomerate like that at Gay Head, in any of the European formations of plastic clay. But bones of vertebral animals do occur in one place, at least, in the clay beds of the Paris basin. "M. Bequerel," say Cuvier and Brogniart, "has found in the same bank

* Edinburgh Journal of Science, Vol. 5. p. 16.

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of clay and lignite, (at Auteuil,) pyrites in great quantities, bones of vertebral animals, whose class has not up to this time (1825) been determined," &c.*

In 1830, Prevost says that "the remains of reptiles (Crocodiles) and fluviatile shells characterise the plastic clay of the environs of Paris."†

In the cliff in the southeast part of Chilmark, I found a fragment of bone, which undoubtedly once belonged to a bird. It was hollow and apparently about as much changed as most of the bones at Gay Head. It was so enveloped in the clay that I could have little suspicion that it was introduced subsequently to the deposition of the clay.

*Crustacea.* In the green sand at Gay Head we meet with well characterised specimens of the genus Cancer; although they are in general much broken; showing that they originally belonged to a formation which was abraded or destroyed anterior to the production of the green sand. The interior part of the specimen consists of argillaceous matter, probably containing a large proportion of oxide of iron: but the covering of the animal still retains its black shining color, although apparently carbonaceous. The broken state of nearly all the specimens, renders it difficult to determine whether they belonged to more than one species, although they probably did: and for the same reason I have thought that many drawings would not be of use. (Plate XII. Fig. 31.)

Fossil crabs have not, I believe, been found in the European plastic clay; but they occur in the London clay, which is probably only the upper beds of that formation

*Zoophyta.* In the bitummous conglomerate that occurs in rolled masses in the same green sand, I found a branching zoophyte, which may perhaps belong to the genus madrepora; though its characters are indistinct.

In the same green sand, and also in the ferruginous sand associated with it, we find numerous concretions whose interior part appears to be compact argillaceous oxide of iron, with the pisiform ore disseminated. Their shape is so exceedingly like that of several of the alcyonia, that I suspect they are petrifactions of those singular animals. They are generally more or less rolled, though not as

* Ossemens Fossiles, Tome 2d, p. 342.

† Dictionnaire de Historie Naturelle, Art. Terrains.

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much so as the crabs. Plate. XII. Figs. 26 and 27 represent two of these relics. Both of them resemble species of the genus ***Manon*** figured in Goldfuss' Petrifacta. Fig. 27 looks like his ***Manon peziza.***

On the surface of some of these specimens small pebbles are sometimes seen: and I have occasionally found them disseminated through the specimen. In such case it may reasonably be doubted whether an animal once occupied the place of the nodule. Yet if the principal part of it be hydrate of iron, I can conceive how a few pebbles might be introduced along with the iron as it gradually took the place of the animal. Still, I am not in a little doubt as to the origin of these nodules.

*Testacea.* I found in the green and ferruginous sand at Gay Head, the casts of three genera, and as many species of shells. As the shell itself is wanting, the characters are indistinct: and there is evidence that the specimens have been more or less rolled: but the two bivalves are probably referable to the genera Venus and Tellina, and the univalve to the genus Turbo. The mineralizer is the same ferruginous clay, or perhaps argillaceous oxide of iron, which has petrified the crabs and zoophytes. Hence they all probably had the same origin. Plate XI, Fig. 3, is a sketch of the Venus: Fig. 5, of the Tellina: Fig. 4, of the Turbo. The latter is obviously somewhat broken. I could find only two specimens of it. Of the Venus, I found only three or four: but I obtained 20 or 30 of the Tellina.

*Dip, Direction, Thickness, and Superposition of the Strata.*

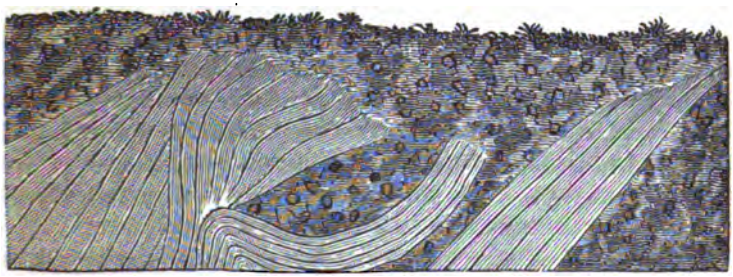
In giving the character of the varieties of this formation, I have anticipated much that properly belongs to this place.

One peculiarity in the clay of this formation, both on the Vineyard and on Cape Cod, is the very general want of a slaty structure. The strata seams are also often indistinct; so that it needs careful examination to ascertain the dip or direction of the beds. Sometimes, however, the schistose layers are obvious, as in some part of the cliff in the southeast part of Chilmark.

I have already remarked, that the strata at Gay Head dip from 20° to 45° a little to the east of north; and of course they run nearly east and west. Without careful examination, however, that cliff would be regarded as an unstratified mass of clay, sand, and lignite. And in respect to some part of it, particularly its southern part, I am still in doubt whether the dip and direction of the beds correspond to the above statement.

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At the cliff in the east part of Chilmark, some of the clay is schistose, and there we find the following section. A considerable part of the cliff there, from 20 to 30 feet high, is covered by diluvium, which has slidden down from the upper part. But where the strata are exposed to view, they present the curved, contorted, and inclined appearance exhibited below. The general dip, it will be seen, is towards the south, as the left hand side of the sketch is the southern extremity of the cliff. The sketch embraces a horizontal distance of about five rods. The geologist sees at once, that such a cliff needs only to be consolidated, in order to constitute a graywacke formation; as I shall show by presenting a similar sketch from a ledge of graywacke in Newport, R. Island, when I come to treat of that rock.



Section in the Plastic Clay: Chilmark.

*Inference.*

After the preceding description, it seems to me that no geologist will hesitate to refer this formation to the Plastic Clay of European authors. The variegated clays, the interstratified lignites with amber, and the intermixture of marine animals with terrestrial vegetable remains, must settle the question. Some peculiarities, have, indeed, been pointed out in the formation at the Vineyard. But they are fewer than we might expect in depositions so widely separated from one another as this is from those in Europe.

*Other places covered with the Plastic Clay.*

*Nantucket.*

I colored this island as underlaid with plastic clay, not without strong suspicions that its surface may be composed of a formation higher up in the series. Its surface is entirely spread over with sand, whose upper part has been disturbed by diluvial action, and in

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perhaps no place do its cliffs rise more than 100 feet above the ocean. But clay exists beneath this stratum of sand, and is somewhat variegated, though generally bluish. In this clay I found a single fossil much disintegrated: but it was a native of the formation, and was contained in ferruginous sand interstratified with the clay. It resembles the genus found in the newest tertiary, as mentioned in the proper place. Twenty or thirty feet higher, in this same cliff, I found worn specimens of *Natica heros*, (Say) and *Pyrula carica*, (Lamark): but I am inclined to regard them as either diluvial or alluvial. Yet Lt. Prescott informs me that similar shells are found all over the island, from 10 to 60 feet below the surface: and he presented me with an uninjured specimen of the Pyrula carica dug up by a well digger, several years ago, 30 or 40 feet below the surface, along with many other shells; among which, were Mactra solidissima, Venus mercenaria, and castanea, Crepidula fornicata, Solen ensis, Pecten, Arca, &c.: all of which now inhabit the neighboring ocean. Can it be that the diluvium is so thick as 30 or 40 feet? Or must we suppose that the spot where the town of Nantucket now stands, where these shells were dug up, is alluvial? Or finally, can we admit that the upper stratum of sand on this island is one of the most recent of the tertiary formations? The second supposition may probably prove the true one.

I was not able satisfactorily to ascertain the dip of the clay beds on Nantucket. But Lt. Prescott, on whose accuracy of observation I place great reliance, is confident that they dip a few degrees to the south: and my own examination of some quite limited clay pits, rather confirms this opinion.

*What is the actual dip of the Plastic Clay?*

In no other place, except those above described, have I observed the dip of this formation. But it will be seen that there is great discrepancy in the dip as observed at two places on the Vineyard, and on Nantucket: and I confess my inability to determine whether there is any prevailing dip in these strata. It is interesting to ascertain that it has a dip at all; since it seems thus more nearly identified with the well known plastic clay of the Isle of Wight, so well described by Mr. Webster; and since also this fact has such an important bearing upon the theory of the formation. But it is doubtful whether its predominant dip can be determined from patches so limited as those which are found in Massachusetts.

Elie de Beaumont represents "the extensive deposites, in part ter-

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tiary, and in part diluvial, which lie between the Alleganies and the ocean on the east, from Nantucket to Florida, as resting directly on the inclined edges of the older rocks, and exhibiting themselves no traces of dislocation."* But unless my senses have greatly deceived me, we have on Martha's Vineyard most decisive evidence of dislocation in one of the higher members of these deposites: for Dr. Morton has proved, that farther to the south, a part of the beds of this vast formation are equivalents of the higher secondary strata in Europe. If, therefore, the inclined position of the strata on the Vineyard be not a solitary case, resulting from local disturbances, Beaumont's position is untenable, and his inferences, dependant on that position, incorrect.

### *In Truro.*

Truro is the extreme town but one on Cape Cod; and on the eastern shore is a patch of plastic clay, large enough for one or two good farms, and on which stands a light-house, as at Gay Head. The clays here are somewhat variegated; though the predominant color is blue. They exhibit also, the same unstratified aspect, as at Gay Head; and are, I doubt not, another remnant of the same formation. I did not, however, give the spot that protracted examination which would be necessary to ascertain the dip of the strata, and whether they contain any organic remains: not being then aware that the formation had such important connections as I now suppose it to have. The spot deserves further examination.

### *In Duxbury.*

Clay is not unfrequently found beneath the sands of Cape Cod; though I am not aware that any cliffs of considerable height occur except in Truro; nor that any organic remains of interest have been found in it. But in Duxbury, in Plymouth county, I have ascertained, since the publication of the first edition of the first part of my Report, that strata and organic remains exist there, identical with those at Gay Head. I am much indebted to the Rev. Benjamin Kent, of that place, for communicating to me a very detailed account of these strata and relics, made out after personal examination. It appears that 30 years ago, a well was dug near the edge of a plain of considerable extent, about 4 1-2 miles from the sea, and nearly surrounded a by swamp. Coarse gravel (diluvium) occupied the surface; next came a layer of

* Recherches, &c. p. 320, Chap. I.

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"vegetable earth," in which, 20 feet from the surface, was found "a large fallen oak (?) tree." Next a stratum of tough blue clay, six inches thick; next strata of "iron ore, or gravel impregnated with it:" "below this, lay the shells, &c. in apparently fresh marsh mud." (green sand?) Here were found a very perfect shark's tooth, (Plate XIII. Fig. 37,) the cast of a small species of Venus, (Fig. 40,) and the same species of Turbo as occurs at Gay Head. (Plate XII. Fig. 4.) Mr. Kent took the trouble of having a shaft sank on the margin of the swamp in the vicinity of this well, and the strata penetrated, correspond with those mentioned above. The water rushing into the opening, however, prevented him from examining thoroughly for petrifactions.

Another well was opened 10 years ago, 80 rods nearer the sea than the first mentioned, and at a lower level. After digging 13 feet, through strata similar to those in the first well, they came to a solid layer of ferruginous sand stone, which arrested their progress. "Angry with disappointment," said the owner of the well, "my man brought a thundering blow upon the rock, and through it went; and up spouted the water. We then cleared away and found a plate of iron (ore) about two inches thick: under this plate lay a bed of strong marsh mud, full of cohogs and clams, and cockles, about two bushels of which we took out. In the center lay plainly *a land animal's bone*, as large as my wrist, and six inches long, fractured, which was given to some Society in Boston." This fine collection has nearly disappeared. Mr. Kent, however, sent me a single specimen, a cast of a Venus, much abraded, not to be distinguished in size and shape from that sketched on Plate XII. Fig. 3. The mineralizer in this case is clay; not so much indurated but that it may be cut without difficulty. And this is the case with all the Duxbury specimens, except the shark's tooth, which is not mineralized, or only partially so. In the specimen from the second well mentioned above, in the cavity occupied by the hinge, is a small quantity of green sand, exactly like that at Gay Head; which proves satisfactorily the identity of the marsh mud and the green sand: and that the green sand of Gay Head is identical with that in England, a comparison of specimens shows.

Thus it appears that the proof is as strong as could be desired, of the entire similarity between the plastic clay of Gay Head, and the fossiliferous formation above described, at Duxbury. True, no variegated clays are mentioned at Duxbury: nor, if I rightly recollect, do

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any variegated clays occur above the green sand at Gay Head: but a blue clay only. And probably by penetrating deeper at Duxbury, the variegated clays might be brought to light. A question hence arises whether the green sand ought to be regarded as belonging to the plastic clay? Some writers do, indeed, limit the plastic clay formation to the variegated clays: but that the lignites and green sand belong to the same formation, (understanding by that term, a consecutive and parallel series of strata produced during the same geological period,) there can be no doubt. Not improbably, however, the green sand in this country occupies the same situation with regard to the variegated clays, as the London clay does in England with respect to those clays. But probably the London clay ought not to be separated from the plastic clay.

The facts discovered at Duxbury render it extremely probable that the extensive sandy deposites in Plymouth and Barnstable counties are underlaid by plastic clays; although the powerful diluvial action to which that region has been subjected, may have spread these sands over other formations. The sands that occur along the west side of Narraganset Bay, in Rhode Island, in the vicinity of Providence, may probably belong to the same formation. It is to be hoped that when more of the cliffs and pits in this formation have been examined, a richer variety of organic remains will be brought to light.

### *Relative Position of Plastic Clay.*

In Europe plastic clay lies immediately above the chalk. But in this country the chalk appears to be wanting; and Dr. Morton has shown satisfactorily that its equivalent is the Ferruginous Sand Formation.* In the middle and southern States, the plastic clay lies immediately above this ferruginous sand. But I have no evidence that this is, or is not the case, in Massachusetts, except analogy; which, in the present case, must be considered very strong in favour of the affirmative. The spot most likely to afford light on this point is Gay Head. But the action of the sea has been so powerful there, that little of the ferruginous sand, if it once existed, has been spared.

### *Extent of the Plastic Clay Formation.*

The patches of this formation that have been described in Massachusetts are doubtless only the remnants of a vast extent of these

* Journal Acad. Nat. Sci. Vol. 6: also Am. Journal of Science Vols. 17 and 18.



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strata, extending at least from Cape Cod to the borders of the Gulf of Mexico; and how far eastward where the Atlantic now rolls, we can form no probable opinion: though there is some reason for supposing that they once even reached Europe; along whose shores similar strata are found at present. As we proceed southward along the coast from Martha's Vineyard, the plastic clay appears on Long Island, in New Jersey, in Maryland, at Natches, at the Chicasaw Bluffs, &c; according to the statements of Mr. Finch.* If this should prove to be one continuous formation, as there is some reason for supposing, it will be by far the most extensive deposite of this kind hitherto discovered. We do know that this and other tertiary formations, with the ferruginous sand, which is the highest of the secondary rocks, occupy nearly all that wide range of level country lying along the Atlantic coast of the Southern States.

### *Theoretical Considerations.*

It is universally agreed that all the tertiary formations have been deposited from materials diffused or dissolved in water: and it is now generally admitted that these deposites took place in independant basins and at various epochs. One of the most remarkable facts in relation to these deposites, is the frequent alternation, or admixture, of marine with fresh water or terrestrial relics. Thus, at Gay Head, we have lignites and dicotyledonous vegetables mixed and probably alternating with the remains of sharks, alcyonites, crabs, and marine shells. In some instances, such facts may be explained by supposing alternate elevations and depressions of the surface, so as to bring salt and fresh water successively over these deposites. But more usually it is probable these strata were deposited in estuaries, which were occasionally inundated by fresh water: and as in early times the earth's surface was perhaps, more level than at present, these inundations might be more extensive than any that now occur.

Another interesting fact, which has been recently established by Beaumont, Desnoyers, Boue, and others, is, that during the period in which these tertiary deposits were proceeding, violent convulsions, succeeded by long intervals of repose, took place; by which some of the highest mountains on the globe were elevated, and portions of these formations elevated along with them; so as now to crown their

* Am. Journal of Science Vol. 7. p. 34: also Conrad's Fossil Shells Vol. 1. p. 14.

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summits. Such facts have opened a new field for chronological geology; and in our country it is as yet entirely untrodden.

Although the newest tertiary in this State appears to have remained undisturbed since its deposition, yet it is interesting to find that our plastic clay has experienced a convulsion, almost equal to that by which its strata, in the Isle of Wight, have been thrown into a vertical position.* As to the period when the strata at Martha's Vineyard were elevated, I can say but little. I have already expressed an opinion that a granite ridge passes along the western side of that Island, not far beneath the surface: But I have searched in vain there for any of the more recent unstratified rocks. At present, then, I must conclude that we have no evidence of the action of any disturbing force since the protrusion of this granite. But in Europe, I believe no rock above the chalk has been proved to have been disturbed by granite: and hence I hesitate to impute the elevation of our plastic clay to that rock, especially on such equivocal evidence as I now possess.

### *Supposed evidence of Volcanic Agency at Gay Head.*

The opinion, I ought, however, to remark, has been advanced by writers too respectable to be passed unnoticed, that there are traces of volcanic action at Gay Head. The great quantity of lignite there mixed with the clay, giving the whole mass an appearance somewhat like cinders, and the ferruginous conglomerate, in which the pebbles are coated over with the brown hydrate of iron, often exceedingly resembling the conglomerated semi-fused mass that is raked out of a furnace, would very naturally lead a person, unpractised in geology, to refer them to volcanic agency. These are undoubtedly the substances intended by Dr. Baylies, when he speaks of "masses of charcoal," and "large stones, whose surfaces were vitrified."† It is now well understood, that neither lignite nor the hydrate of iron, require heat for their production.

### *Geological Speculations of the Aborigines.*

Gay Head being naturally a place of resort for the Indians, they could not but notice its peculiarities. And they had an advantage over geologists of modern times in explaining phenomena. For when a difficulty presented itself, they had only to call in the aid of some

* Geological Transaction, Vol. 2. p. 161.

† Transactions of the Amer. Acad. of Arts and Sciences, Vol. 2. part 1. p. 150.

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mighty spirit, or giant, who once inhabited the spot. This they have done in attempting to account for appearances at Gay Head. I am indebted to C. C. Baldwin Esq. Librarian of the American Antiquarian Society, for an interesting extract, exhibiting the Indian tradition on this subject. He has added another extract, showing the Indian Philosophy of Fogs on the coast: and another from the writings of Cotton Mather relating to some fossil bones found in Virginia, which is a good exhibition of the manner in which such facts were regarded a century ago. I take the liberty to subjoin the entire letter.

Worcester, July 7, 1832.

My Dear Sir,

I will now comply with my promise in relation to the interesting Fossil Remains, which you found in your recent visit to the Elizabeth Islands.

"The first Indian who came to the Vineyard, was brought thither with his dog on a cake of ice. When he came to Gay Head, he found a very large man, whose name was Moshop. He had a wife and five children, four sons and one daughter; and lived in the den. He used to catch whales, and then pluck up trees, and make a fire and roast them. The *coals* of the *trees* and the *bones* of the *whales* are now to be seen. After he was tired of staying here, he told his children to go and play ball on the beach that joined Noman's Land to Gay Head. He then made a mark with his toe across the beach at each end, and so deep, that the water followed and cut away the beach; so that his children were in fear of drowning. They took their sister up and held her out of the water. He told them to act as if they were going to kill whales; and they were all turned into Killers, (a fish so called). The sister was dressed in large stripes. He gave them a strict charge always to be kind to her. His wife mourned the loss of her children so exceedingly, that he threw her away. She fell upon Seconet, near the rocks, where she lived sometime, exacting contribution of all who passed by water. After a while she was changed into a stone. The entire shape remained for many years. But after the English came, some of them broke off the arms, head, &c. but the most of the body remains to this day. Moshop went away, nobody knows whither. He had no conversation with the Indians, but was kind to them by sending them whales, &c. ashore for them to eat. But after they grew thick around him, he left them." — *See Mass. His. Collections, Vol.* 1. *p.* 139.

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"In former times, a great many moons ago, a bird, extraordinary for its size, used often to visit the south shore of Cape Cod, and carry from thence a vast number of small children.

Maushop, who was an Indian Giant, as fame reports, resided in these parts. Enraged at the havoc among the children, he, on a certain time, waded into the sea in pursuit of the bird, till he had crossed the Sound, and reached Nantucket. Before Maushop forded the Sound, the Island was unknown to the Aborigines of America.

Tradition says that Maushop found the bones of the Children in a heap under a large tree. He then wishing to smoke a pipe, ransacked the Island for tobacco, but finding none, he filled his pipe with poke, a weed which the Indians sometimes used as its substitute. Ever since the above memorable event, fogs have been frequent at Nantucket and on the Cape. In allusion to this tradition, when the Aborigines observed a fog rising, they would say, 'There comes Old Maushop's smoke.'" — *See Mass. His. Collections, Vol. 5. p. 57.*

I have made the above extracts, thinking they might interest you in your enquiries in relation to the bones at Gay Head. And I cannot but be of opinion that the above interesting tradition about the existence of the Giant, had its origin with the Indians from their having found the skeletons of large marine animals. Perhaps two hundred years ago, as late a period as the tradition refers to, the bones might have presented very different appearances from what they now do.

In the collections of MSS. belonging to the Society of which I am Librarian, are copies of letters addressed by the Learned Cotton Mather to different persons residing in Europe. They are entitled "Curiosa Americana." Among them are eight letters to Dr. James Jurin. One of these is entitled "A Monstrous Dragon." But before speaking of the particular subject of his letter, he gives an account of all the stupendous snakes which have been described by the ancients. The letter shall speak for itself. It concludes as follows:

"A few months ago, near the Falls of James River in Virginia, Some [persons] digging a water-course for a mill, by a small Run of Water under the Side of an Hill, Ten foot under ground, they found the Back-bone of a snake, lying in such a form as this  . They dug along from the Head to the Tail of it, both which were much decayed, but the earth about the decayed parts was of a different colour from all the earth about it. These, with all the bones, were

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found exactly of the same depth under ground. It was about a mile and half distant from the great River, and about one hundred and fifty miles from the sea. But now for the Prodigy. The Monster extends above one hundred and fifty foot in length. A credible person who measured the Trench out of which it was taken, brings the account unto us, and brings with him one Joint of the Back-bone, which the workmen gave him, and which I find is Five inches and a quarter in depth, Five inches and a half in width, Four inches and an half Diameter backwards and forwards, and though it be grown very dry, and some of it be worn off, yet it weighs thirty-three ounces and an half. *'Monstrum horrendum.*

I shall not go to trouble you with any of my poor speculations on the subject; chusing and wishing rather to be instructed from yours. And so, only praying for your Deliverance from a *greater Dragon* then that whose Bones were lately found in Virginia, I subscribe,

Sir, your most hearty Servant."

COTTON MATHER.

June 3, 1723.

I do not know that this letter has ever been published. That fact may be ascertained by a reference to the Transactions of the Royal Society, or the "Philosophical Transactions." The author of the letter above, had, at the time of its date, in England as well as in America, a high reputation for learning and it is altogether probable that it was published there. I have never heard that it had been published in this country, and presume that it never was.

Accept, I pray you, my best wishes for your health and happiness, and believe me to be with

Very great respect and regard,

Your Friend and Servant,

CHRISTOPHER COLUMBUS BALDWIN, LIB. A.A.S.

### 4. NEW RED SANDSTONE.

Under this name I have included all the sandstone in the valley of the Connecticut; extending from New Haven Ct. to the north line of Massachusetts in Northfield. On a geological map, given in the 6th. volume of the American Journal of Science, I have marked the inferior beds of this formation as Old Red Sandstone. Nor do I

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now deny the existence of this rock in that valley. But I have not discovered marks enough to identify it so clearly, as to be justified in giving it a place on the Map. I think I can identify the upper beds of this formation with the New Red Sandstone of Europe; or rather, show it to be probable that these beds are the equivalent of the new red sandstone. And not improbably the lower beds correspond essentially with the old red sandstone of Europe: For sometimes in that quarter of the globe, the two series are in contact; as in Arran in Scotland;* although generally they are separated by the coal measures. But so long as we have no certain evidence of the existence of the old red sandstone in the valley of the Connecticut, it is better to consider all the beds of the sandstone there, as belonging to the new red sandstone: nor shall we have any difficulty in finding a place for the whole series within the wide range embraced by the usual definition of this rock.

In the paper above referred to, I formerly described the upper beds of the sandstone under consideration, as the Coal Formation; not however without suggesting doubts as to its identity with the coal measures of Europe. Thin seams of genuine bituminious coal, do, indeed, occur in this series, in gray micaceous sandstone; and its resemblance to the coal measures of Europe, has induced men of great experience to explore it for coal. But only a small quantity has ever been found; and it is said that coal occurs also, in the new red sandstone on the continent of Europe: so that the occurrence of coal, is by no means certain evidence, that the rock in which it is found, is the real coal formation of geological writers.

For the most part, the ranges of greenstone in the Connecticut valley separate the upper, from the lower beds of the sandstone under consideration: so that if any should choose to distinguish between them on the map, they can do it, by recollecting that the sandstone on the east side of the greenstone, belongs to the upper beds; and that on the west side, to the lower ones.

I found my opinion, that the upper beds of this formation are the new red sandstone, upon the following facts. 1. The discovery of a vertebral animal several feet long in East Windsor, Ct. in one of the varieties of this rock, 18 feet below its surface. Now, if I mistake not, no vertebral animal (except the relics of a few fish, perhaps,) have ever been found below the new red sandstone; especially

*Macculloch's Geolgy Vol. 1 p, 274.

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bones that are merely preserved, and not at all petrified, as is the case with those at East Windsor. In Europe a few saurian animals have been found in this rock; and probably it was an animal of this description that was found in Connecticut. 2. The occurrence of fossil fish, as at Sunderland; one of the species of which, (*Palaeothrissum freslebenense,*) and the rock containing it so exactly resemble specimens of the same from Mansfeld and Hesse in Germany, that Prof. Al, Brongniart could distinguish them only by their labels. But the rocks in Germany containing these fish, belong to the new red sand stone group. They occur also at Autun in France, and at one or two places in Great Britian, with precisely the same characters; the rock being a member of the new red sandstone. Hence the probability is strong, that the rock containing them along Connecticut river, is the new red sandstone, or its equivalent. 3. One variety of the new red sandstone group in Germany, (the copper slate,) is wrought as an ore of copper: and veins of similar ores occur in the Connecticut valley; frequently passing from the sandstone into the adjoining greenstone; and in one or two cases, I have observed thin layers of sandstone, considerably charged with the green carbonate of copper. This may, perhaps, be considered as corroborative evidence that the formations in the two countries are contemporaneous; or that they were produced under similar circumstances. 4. The sulphates of barytas and strontia are found in the new red sandstone of England; the latter "stellated on carbonate of lime"* near Bristol; and they occur under similar circumstances, as will be more particularly described hereafter, in the sandstone group of the Connecticut valley. Magnetic iron sand also proceeds from this rock here, as on the banks of the Mersey, opposite Liverpool. 5. In Germany, bituminous marlite occurs only in the new red sandstone group. Fetid limestone is there, also a member of the same formation. In Massachusetts, likewise, the same rocks are similarly associated; and I have lately ascertained that a part of the slate containing ichthyolites at Sunderland, is the bituminous marlite. 6. Werner regarded the variegated appearance of the new red sandstone as characteristic of the formation; and hence his name of 'bunter sandstein.' In the Connecticut valley this aspect is not very common. But in Bernardston, the lower beds exhibit it on a large scale: and on the banks of Westfield river are several interstratified layers, according

* Geological Manuel p. 386.

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beautiful examples of this structure in hand specimens; and it is particularly interesting that these cannot be distinguished by the eye from specimens from Nova Scotia, associated with gypsum; and therefore unquestionably belonging to the new red sandstone group. Similar specimens may be obtained at South Hadley Canal on the West Springfield shore.

*Mineralogical Characters of the New Red Sandstone.*

"Taken as a mass" says De la Beche* the group (of new red sandstone) may be considered as a deposit of conglomerate, sandstone, and marl, in which limestones occasionally appear in certain terms of the series; sometimes one calcareous deposit being absent, as the muschelkalk is in England; sometimes the zechstein, as in the east and south of France; and sometimes both being wanting as in Devonshire." "The beds" says Dr. Macculloch,† are sometimes of a conglomerate structure, at others a fine sandstone and occasionally schistose; and in composition, the rock is calcareous, argillaceous, or ferruginous, or all together presenting endless variations of aspect and color."

These descriptions correspond in general to the group which I denominate new red sandstone in the Connecticut valley. Our rock, however, is more deficient in calcareous matter than is usual in Europe: though more or less of lime is scattered through all the members of the group; so that in some cases even the reddish shales slightly efferverse with acids: and might, therefore, be properly called *red marl.* Nearly all the limestone in the group is highly fetid; though in some instances this passes into that which is bituminous; and even into bituminous marlite.

It should be recollected, also, that this formation is wanting in gypsum and rock salt; two minerals found in it almost universally; though as mentioned in the first part of my report, a minute quantity of the former has been found at West Springfield, and South Hadley. I have however, compared a suite of specimens from the new red sandstone containing gypsum in Nova Scotia, with a suite from the Connecticut valley, and with the exception of the limestones, they can hardly be distinguished from one another. Indeed, why may we not suppose gypsum and rock salt to be occasionally wanting in this formation, as well as limestone?

* Geological Manual p. 386.

† System of Geology, vol. 2. p. 227.



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The following distinct varieties of rock compose the new red sandstone in the valley of the Connecticut.

1. *Conglomerates.* A conglomerate, composed almost entirely of the ruins of granite and mica slate, forms, in connection with a sandstone of similar character, all the lower beds of this formation; and these two varieties embrace all the rock that has usually been denominated *old red sandstone.* The two varieties pass into each other by insensible gradations, and even the finest portion of the sandstone is coarse. The strata are from one to two, and even three or four feet thick; and for the most part, the slaty structure is almost entirely wanting. The prevailing and almost uniform color of the rock is red; and even the imbedded nodules, when not very large or compact, are penetrated with this color. Yet where this rock approaches granite and mica slate, as in Bernardston, Greenfield, Deerfield, Whately, and Southampton, it is somewhat variegated; some portions of it being of a light gray color; as if a heat so powerful had been applied to it, as partially to expel the iron, or change it from an oxide into some other compound. The nodules of the conglomerate are sometimes one or two feet in diameter; but for the most part, they are only a few inches thick. A variety occurs in Bernardston, Southampton, &c. (Nos. 135, 136,) which can hardly be distinguished in hand specimens from granite; being composed of fragments, but little rounded, of quartz and feldspar; the latter of a flesh color. Sometimes the nodules, as at Sugar Loaf in Deerfield, are graphic granite, which is often quite beautiful; the feldspar being of a lively flesh color.

In Greenfield and Bernardston, near the junction of the new red sandstone formation with the argillo-micaceous slate, the conglomerate occurs, composed entirely of argillo-micaceous slate and white quartz. This was obviously derived from the detritus of the slate against which it rests. The general color of this rock is red; and even the mica slate on which it reposes, exhibits the same color several feet from the junction. (Nos. 137 to 139.)

Another variety of conglomerate, which is found only in connection with the upper beds of the new red sandstone, is of a dark, reddish gray color, and is composed of fragments of mica slate, talcose slate, chlorite slate, hornblende slate, and slaty quartz rock, with occasional nodules of quartz, feldspar, and granite. The cement appears to be the same materials comminuted. This is the coarest conglomerate in the the Connecticut valley. It constitutes a considerable part of mount Toby in Sunderland, where the imbedded nodules

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are sometimes three or four feet in diameter. It extends through Montague, and at the mouth of Miller's river, as well as on the opposite side of the Connecticut at that place, it may be examined to good advantage. South of Sunderland I have not found it, except at Durham in Connecticut. Unless viewed on a large scale, this rock scarcely exhibits any stratification. The strata are sometimes eight or ten feet thick. (Nos. 140 to 143.)

At Turner's Falls a much finer and more compact gray conglomerate exhibits itself, composed of the same materials as the last, except that it abounds more in quartz and feldspar. (No. 150.)

A reddish conglomerate, made up of nearly the same materials as that first described, (except that it contains more slate,) abounds among the lowest of the upper beds of this formation. (Nos. 144 to 147.) It is not as coarse as the last and the strata are usually less than a foot thick. It is common in mount Toby and on the east side of mount Holyoke in Granby.

*Trap conglomerate* is another variety of no small interest. It reposes on the greenstone on the east side of mount Tom and Holyoke: and consists of a mixture of angular and rounded masses of trap and sandstone, with a cement of the same materials. The nodules are sometimes one or two feet in diameter, and the stratification is not very distinct. I do not doubt but the same rock may be found on the east side of nearly all the greenstone ranges in the Connecticut valley. Its thickness is but small, and its mode of production obscure. (Nos. 151, 152, and 285.)

2 *Sandstones.* The lowest and most abundant sandstone in this formation has been described with sufficient minuteness, in connection with the conglomerate with which it occurs. It is used somewhat extensively for architectural purposes. (Nos. 154 161.)

A sandstone, which, at a little distance resembles that just described, is found among the upper beds of this formation in Longmeadow and Wilbraham; where it is extensively quarried. It differs, however, essentially from the last variety; being composed chiefly of fine siliceous sand, with occasional specks of mica, cemented probably by the red oxide of iron: for its color is almost blood red. Its particles, however, do not cohere strongly; and this forms the only objection to its use in architecture. The extensive quarries in Chatham, Ct. are opened in this rock; or in a variety closely allied to it. Its strata are thick and rarely exhibit a slaty structure. (Nos. 165, 166.)

Gray sandstone is not uncommon in this formation; but it is found chiefly in the upper part of the series; or rather in the vicinity of

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trap rocks; as at Turner's falls, and on both sides of Holyoke and Tom. It is made up of coarse gray sand — sometimes of comminuted granite entirely, as on Holyoke—and varies in color from light to dark gray. In some localities, as in Granby, the strata are thick, and the rock is scarcely schistose; it is there used in architecture. In other places, the strata become thinner. On the banks of the Westfield river, in West Springfield, I noticed a variety that resembles the grindstones brought from Nova Scotia, though it is harder.

*Gray micaceous sandstone.* When the last variety takes mica into its composition, it becomes more easily divisible into laminae; and where that mineral abounds, it is very fissile. Some specimens of this kind, found in the vicinity of trap rocks, can hardly be distinguished, in hand specimens, from mica slate. (Nos. 177, 178, 179.) Gray micaceous sandstone abounds at Turner's Falls, on Mt. Toby, in South Hadley, in West Springfield, &c.

*Variegated sandstone.* This is composed of alternating laminae of light and dark red sandstone, usually somewhat micaceous. The layers are not very evenly arranged; so that their edges present rather a fantastic appearance. I have scarcely met with this rock except on the banks of Westfield river, half a mile west of the village of West Springfield; where the characteristics of the new red sandstone are more fully developed than any where else in the valley of the Connecticut. The variegated sandstone there forms thick and workable strata.

*Brecciated Sandstone.* This is composed of fragments of micaceous sandstone, which seem to have been partially fused and then reunited. It is almost as hard as siliceous slate. It is found about a mile east of Turner's Falls, on both banks of Connecticut river, forming a stratum some 20 feet wide. The stratification and schistose structure are very obscure: but on the north shore, the layers have evidently been forced upwards, so as to give them somewhat of a spheroidal form. I hence infer that a mass of unstratified rocks, probably greenstone, lies beneath the sandstone at no great depth; and that when this was forced upwards in a melted state, it partially fused the sandstone. (No. 174.)

Red micaceous sandstone is not unfrequently a member of this formation. The grain is usually fine, and indeed, it commonly approaches very near to shale, into which it passes; yet much of it is too coarse and contains too much siliceous matter to be called shale. It is very common along the east side of our greenstone ridges, as at Turner's falls and in West Springfield. It is quite remarkable for be-

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ing divided into rhomboidal masses, by one or two sets of parallel seams. On the north bank of Westfield river, in West Springfield, this division is remarkably distinct, and the surface of the rock presents an interesting chequered aspect. The same is the case in the northeast part of Greenfield, just below Turner's Falls.

3. *Shales.* (Nos. 199 to 204.) Under this term I include all the varieties of argillaceous slate, sometimes called *slate clay*, found in connection with the secondary rocks. And in Massachusetts such slate occurs only as a member of the new red sandstone series: of that formation it constitutes a very important part. Its colors are gray, red, and black; and in hardness it varies from that of tender schistose marls, to a degree of induration approaching that of siliceous slate. The red variety is most abundant; especially in the region of Enfield and Hartford, in Connecticut. Sometimes it takes mica and sand into its composition, and then passes into the red micaceous sandstone, as already remarked. When black, it is generally bituminous, as at Sunderland, and at Middletown, Connecticut; where are found upon it the impressions of fish and vegetables. Some of the black colored slate, as at Turner's Falls, splits into irregular, somewhat wedge-shaped pieces; and indeed, easily disintegrates and falls to pieces; when it resembles comminuted coal. It frequently contains sulphuret of iron; which, by decomposition, causes the slate to exfoliate: in some places, also, as at Turner's Falls, and on Chicopee and Westfield rivers, this shale abounds in nodules of argillaceous iron ore, of a poor quality. Some of the black non-bituminous shale of this formation, has almost lost its slaty structure in the process of induration. Thin pieces of it give a ringing sound when struck. This variety abounds in the vicinity of Turner's Falls; as, indeed, nearly every other variety does. There we find a gray variety, which is so soft that it may be impressed by the finger nail.

If it were possible to doubt that the new red sandstone formation was deposited from water, the surface of some of the layers of this shale would settle the question demonstrably. For it exhibits precisely those gentle undulations. which the loamy bottom of every river with a moderate current, presents. (No. 198.) But such a surface could never have been formed while the layers had that high inclination to the horizon, which many of them now present: so that we have here, also, decisive evidence that they have been elevated subsequent to their deposition.

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On Westfield river in West Springfield, both the red and black shales are traversed by numerous veins of satin spar; itself often of a redish hue. They are rarely more than an inch wide, but often several feet long; and run uniformly across the laminae of the slate.

In the same place the black shale, as well as the bituminous marlite, and some varieties of slaty sandstone, contain masses of septaria, or the *Ludus Helmontii.* They vary in size from an inch to 5 or 6 inches in diameter, and are usually flattened or reniform. The envelope appears to be argillo-ferruginous as well as calcareous; and the cavities are lined, and sometimes filled, by white calcareous spar. The interior is divided into irregular masses, or sometimes into polygonal prisms.

The hypothesis which imputes the cavernous structure of these argillo-calcareous masses to dessication, and their subsequent filling up to the infiltration of carbonate of lime in a state of solution, seems to me liable to few objections; and, indeed, is quite satisfactory. But I have already given it somewhat in detail, when speaking of columnar argillaceous iron ore.

4. *Limestones.* (Nos. 205 to 216.) When the black bituminous shale, that has been described, takes into its composition enough of calcareous matter to produce effervesence with acids, it becomes *bituminous marlite.* It is not very common in this sandstone formation. Yet one finds it in considerable quantity on the banks of Westfield river, in West Springfield; and I have ascertained that the stratum of slate in Sunderland, which contains the best preserved relics of fish, is bitumious marlite. Although this rock contains but a small proportion of calcareous matter, yet it certainly does not deserve to be described as a distinct rock; and it may be conveniently mentioned under the head of limestones.

Strongly fetid limestone occurs, interstratified with the micaceous sandstones of this formation, at two places in the northwest part of West Springfield. At the most northern locality, I noticed only a single bed about 10 feet thick: but two miles south from that spot, several beds, not far apart, may be seen, associated with greenstone as well as sandstone. The rock at both places is of a dark gray color and nearly compact. Its fetid odor when struck, is exceedingly strong, so as even to produce nausea. It is wrought to some extent for water proof cement, and it answers well. (Nos. 213 to 215.)

I doubt whether much genuine bituminous limestone exists in the new red sandstone in Massachusetts. Yet when the bituminous

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marlite takes a large quantity of lime into its composition, it becomes bituminous limestone; and perhaps some of this variety may be found in West Springfield. It is also said to occur in Southington and Middletown, Ct: and the fetid limestone, also, (all of them connected with the new red sandstone,) in Northford, Ct.

At Turner's Falls, on the north shore, I found, a few years ago, a stratum of coarse argillaceous limestone a foot thick, which was neither bituminous nor fetid: but the subsequent removal of the dam over Connecticut river, has covered the spot beneath the waters.

On the banks of Westfield river, in West Springfield, we find layers of what appears to be an argillo-ferruginous limestone, interstratified with the slate, and only a few inches thick. Where the water has laid bare this rock, it sometimes presents the whole surface divided into small prisms of only a few inches in diameter and length, whose axes are perpendicular to the planes of the strata. They have four or more sides, though irregular, and their sides do not touch. They appear to have resulted from the same cause as the septaria already described; and I doubt not that both the septaria and these layers of argillo-ferruginous limestone, might be employed, as the former is in Europe, for the preparation of valuable Roman cement.

From this sketch of the mineralogical characters of this group of rocks, it will be easy to distinguish between the lower beds, which have heretofore been considered as the old red sandstone, and the upper ones, which have been called a coal formation. The lower beds are distinctly stratified, but rarely slaty; whereas the upper ones are usually so; although some varieties of conglomerate, scarcely exhibit any marks even of stratification. In the lower beds is no shale. Their color is almost uniformly some shade of red: but as already shown, the upper beds are of various colors and shale is abundant.

The greater abundance of granite nodules in the conglomerate of the lower beds of this formation, than in that of the higher has led some geologists to regard them as belonging to distinct formations.

But as a general principle, it will not answer to conclude that conglomerate to be the oldest rock, which contains rounded masses of granite. For a deposite of granite might be so situated, that an abrading current would tear off large quantities of it, while much later rocks might flank its sides in such a manner as to be almost entirely

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protected from the water. The recomposed rock hence resulting would therefore contain granite nodules chiefly. Whereas it might be that the later rock above spoken of, once covered the granite and was worn away by an agency that could not touch the granite. Hence the earlier mechanical rock thus produced would consist chiefly of fragments of the schists. Besides, geologists now generally admit that granite is a later rock than most of the primary ones; and sometimes even of the same age as the highest of the secondary; since there is evidence that it has been protruded through the chalk: and finally, in the present instance some of the lowest beds of the sandstone under consideration, are composed of fragments of the latest of the primary stratified rocks in the region; as in Bernardston and Greenfield, where the conglomerate is made up chiefly of argillo-micaceous slate.

Extensive ranges of greenstone are connected with the sandstone of the Connecticut valley. But I need spend no time in the present state of geolgical science, to show that trap rock cannot be a member of the sandstone formation, and that it was subsequently introduced. Its characters and relative position will be described when I come to speak of the unstratified rocks.

### *Topography of this Formation.*

With a single exception, all the new red sandstone hitherto described in New England, lies in that part of the valley of Connecticut river, which extends from New Haven to the north line of Massachusetts: and in this State none is found out of that valley. An inspection of the accompanying map, which marks out this valley, (Plate XV) will convey a definite idea of the space covered by this formation. For the hills which are there represented as bounding the valley, commence on the outer edge of the sandstone. All the included space is sandstone, except those ranges of hills which are drawn within the valley, which are greenstone.

The single exception above referred to, embraces a valley 10 or 12 miles long, extending from Woodbury to Southbury in Connecticut, along a branch of the Housatonic river. There we find the same varieties of sandstone, accompanied by analogous greenstone, as in the valley of the Connecticut. The two valleys are separated by a high ridge of primary rocks, through which they have no lateral communication. We hence learn that the causes which produced the new red sandstone group and the intruded trap, were not local in their op-

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eration. In New York, also, according to Prof. Eaton,* this formation commences near Utica, and extends 250 miles in length. East of New England, no new red sandstone has been found nearer than Nova Scotia, where it abounds in gypsum. From the able description of this rock by Messrs. Jackson and Alger, and from specimens furnished me by this latter gentleman, I infer a greater resemblance between the Nova Scotia and New England group, than between the latter and that in New York, and those farther west: although of the last named I have as yet seen only few specimens.

As the general direction of the strata of the new red sandstone in the valley of the Connecticut is north and south, and the dip easterly, it will follow that the lower beds of the group must occupy the western part of that valley. And I have already remarked that the greenstone ridges generally separate the upper from the lower beds. In Gill, Greenfield, and on Mount Holyoke, however, the observer will see schistose sandstones cropping out beneath the greenstone; though in receding westerly from the greenstone, he will find the slaty character of the rock soon to disappear.

In the central parts of the Connecticut valley, from South Hadley nearly to Middletown, the shales and finer sandstones prevail almost exclusively; so that in excavating 15,000 cubic yards of stone at Enfield Falls, not a pebble as large as an acorn was observed.† The prevailing colour of the slate in that region is dull red or chocolate; and being easily decomposed, it imparts a like hue to the soil. If we suppose, what I have always observed to be true, that the prevailing dip of the strata through the whole valley is easterly, we cannot admit, as some have maintained, that these finer strata were originally deposited in its central parts, and the coarser materials on its borders, for then the finer strata must dip on both sides of the valley towards its center, or remain horizontal; and they could not dip under the coarser layers on the east side, as they now do. We ought probably rather to infer, that the higher and coarser strata have been worn away from the central portion of the valley, because they would there be more exposed to abrading agents.

The coarser and the finer beds do not, however, in all cases occupy separate portions of the valley exclusively: but in many places they are interstratified in almost endless variety. The section laid bare

* Survey of the Erie Canal. p. 102.

† Mr. A. Smith on the Connecticut valley. Am. Journal Science. Vol. 22. p. 220.



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by the Connecticut, three miles above, and nearly a mile below Turner's Falls, of which a sketch will be given in treating of greenstone, presents a good example for examination. The coarser varieties, however, are not so abundant here, as at Mount Toby in Sunderland. On the west side of Connecticut river, opposite Sunderland, Deerfield mountain exhibits nearly every variety of the lower beds of the formation. Let the observer pass to the east bank of the river at Whitmore's ferry, three miles north of Sunderland village, and he will land upon a ledge of the coarsest conglomerate that has just been described. Lying directly above this, and, dipping a few degrees easterly, as do all the strata of Mount Toby, he will find the black bituminous shale containing impressions of fish; 10 feet thick. Immediately above this succeeds a coarse conglomerate, scarcely differing from that beneath, and forming a mass 200 or 300 feet thick. Proceeding southeasterly to the top of Toby, not less than 900 feet above the river, he will find numerous alternations of the coarsest conglomerates with the finest red and grey sandstones; or rather shales. And the passage from one variety to the other is not in general gradual, but sudden; so that the line between the finest and coarsest materials is well marked.

It is very obvious, in such cases, that the finer layers of the rock must have been deposited in still waters, and the coarser materials have been the result of powerful abrading currents. And I know not a more difficult point in the theory of the earth, than to explain the cause of so many and so sudden changes from motion to rest and from rest to motion, in the waters in which such rocks were formed. The facts might perhaps be explained by supposing these deposites to have resulted from the long continued action of a river, carrying into the bottom of a lake or the ocean, coarser materials during its floods, and the finer sediment at low water: But the different nature of the materials composing successive layers of the conglomerate strata, show that the current must have swept over and torn up various rocks at different times; and consequently must have come from various directions at successive periods; except perhaps in those rare cases, where it wore away the higher formations entirely. Now we cannot conceive how any river should be made to pass over rocks so different as we find in the alternating beds of Mount Toby, at different periods: it would require alterations in its bed, almost without number.

There is, however, one other mode of accounting for the facts in this case, which may perhaps be thought more satisfactory. It seems to be

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proved beyond all reasonable doubt, that the various mountain chains on the globe were elevated from the bottom of the ocean at various epochs, in the earlier times of our planet. And generally these elevations took place suddenly. Now the inevitable effect of such a protrusion of a huge mountain ridge, would be to produce a wave in the ocean, which would overwhelm the globe. This wave, flowing in every direction from the center of disturbance, would attain its greatest elevation in the antipodes of that center: and then there would succeed a reflux wave. Nor would the waters settle into repose, until several mighty flood and ebb tides had succeeded. Now a moment's reflection will convince any one, that while this wave was rising and falling, it would rush over any particular region in strong currents; but when at its maximum and minimum elevation, the water, for a considerable time, would be nearly calm. Consequently, during the former periods we should expect the materials of the rocks depositsd would be coarse; and fine during the latter period. And as mountains were raised in different parts of the globe, the currents would proceed from various centers, and thus sweep into the same basin the fragments of different rocks. Such powerful convulsions could not have taken place on the globe since man was placed upon it; and it is probable that the new red sandstone was deposited prior to his creation, while the earth was yet "without form and void," that is, a desert and unfurnished waste.

### *Dip, Direction, and Thickness of the Strata.*

Although subject to local variation from local causes, yet the general dip and direction of the strata of this formation are quite obvious. The direction is not far from north and south, and the dip easterly at an angle from 10° to 20°. Fifteen degrees is probably about the medium dip: and I suspect the prevailing direction to be a few degrees east of north. In particular places, however, the dip is found at all angles, from 0° to 80°. This is remarkably the case in the vicinity of Turner's Falls; as may be seen on the section of that place to be given farther on. This extraordinary dip, however, appears to be easily explicable from the proximity of greenstone and granite; as I shall attempt to show when I come to treat of those rocks. Near the eastern extremity of Mount Holyoke, also, these rocks mount up on the ridge of greenstone at an angle of 55° or 60°. Here too the direction of the basset edges is about northeast and southwest. The presence of greenstone in this case, also, as I shall attempt to show,

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will explain these anomalies. In the west part of Westfield, and near the center of Hatfield, the lower beds of this formation have a dip to the west of about 10°. The same is the case also in Bernardston. In the north part of Hadley, I have observed strata running nearly east and west, and dipping 10° north. The probable presence of granite at no great depth in all these cases will readily account for these exceptions.

Although the new red sandstone must come in contact with the primary rocks on both borders of the Connecticut valley, yet I have discovered the actual junction only in one spot. Half a mile south of the "Glen," or Gorge, in Leyden, near a saw mill, the peculiar conglomerate made up of argillo-micaceous slate and quartz, reposes upon that slate, and has a dip to the south from 20° to 30°; while the slate is nearly perpendicular, and the course of its edges nearly north and south. Admitting the elevation of the slate subsequent to the deposition of the sandstone, the southern slope of the edges of the former in Leyden, will explain the southern dip of the latter at this place.

The following are the dip and direction of the new red sandstone in several places in Massachusetts, where it does not seem to have been subject to local deviations.

Between West Springfield and Westfield, along Westfield river, east of the greenstone; direction, north and south; dip, 15° to 20° east.

Mount Tom, beneath the greenstone; direction, north and south; dip, 15° to 20° east.

Most northerly lime quary, West Springfield; direction, north and south; dip, 15° east.

Rock Ferry, (S. Hadley, at Titan's Pier); direction, nearly north and south; dip, 20° east.

Sunderland; direction, generally north and south; dip, between 10° and 15° east. At Whitmore's Ferry, however, the stratum containing the ichthyolites, is nearly horizontal: but this is overlaid by sandstone, dipping east from 5° to 10°.

Deerfield; (Sugar Loaf and Deerfield mountain;) direction, north and south; dip, 10° to 15° east.

Do. at Hoyt's quarries, in the west part of the town; dip, 15° to 20° east.

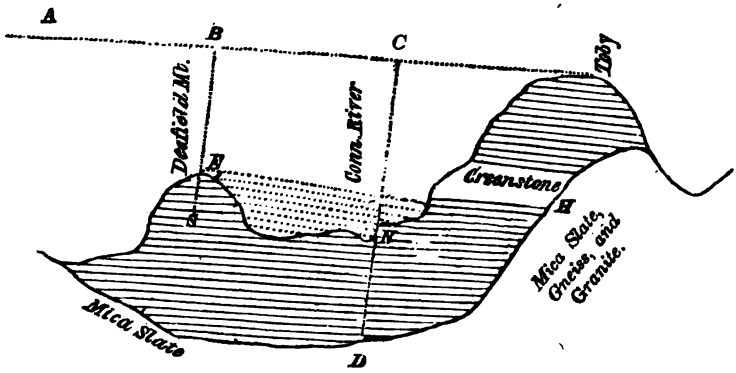
Greenfield; near the village; dip, 20° to 30° east.

Other localities might be cited, but it seems unnecessary. It ought, however, to be mentioned, that as we go south into Connecticut, where

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the breadth of this formation increases, we find the dip to decrease; so as in many places to be almost nothing.

As to the thickness of the formation under consideration, we have not sufficient data for forming a very definite opinion. Perhaps, however, we may obtain a proximate estimate, by examining an east and west section of the formation, across the south part of Deerfield mountain, and the center of Mount Toby. The following sketch is not intended to be precisely accurate; but only to give a general idea of the relative situation of the two mountains and the intervening valley, with the valleys between them and the primary rocks on the east and west. There must always be, as is well known, more or less of distortion and want of proportion in sections of this kind, where the horizontal scale must be much smaller than the perpendicular one.




In the present case, in order to exhibit the proper dip of the strata, the valley through which the Connecticut flows, is represented too wide.

It will be seen by this section,* that the strata, both in Deerfield mountain and Mount Toby, as well as in the valleys, have the medium easterly dip of the formation; that is about 15°, though on a considerable part of Mount Toby it is hardly 10°. Two or three hundred feet above the river, on the east side, may be seen a mass of greenstone; which, so far as I can ascertain, constitutes a dyke or bed

* This section (when it was too late to have it corrected,) was found to be very badly engraved. The dotted lines crossing the valley, should correspond with the strata on the two mountains; and the dip of the lower beds should be several degrees larger.

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in the sandstone, and divides the upper part of the formation from the lower. Deerfield mountain, in its southern part, consists entirely of the lower beds; and the strata on the opposite side of the river beneath the greenstone, correspond in dip and general characters with those of this mountain. Mount Toby is probably not far from 1000 feet above the river, and Deerfield mountain varies from 500 to 700. These are much the most elevated points of the new red sandstone in the valley of the Connecticut: and the enquiry immediately suggests itself to the geologist, whether the formation was originally of this height throughout its whole extent, and has been subsequently worn away, except these ridges: or whether these have been raised so much above the general level by a force acting beneath. The latter supposition would seem most probable, were it not for the proof exhibited by the above section, that no peculiar disturbing force has acted on these mountains. Had that been the case, either their strata would exhibit a different dip from the formation generally, or they would not correspond on opposite sides of the river. It seems to me perfectly obvious, after inspecting both these mountains, that almost the only change their strata have undergone, was their original elevation about 10° to 15°, along with every other part of the formation. And hence we are compelled to suppose, that the top of Mount Toby exhibits nearly the original elevation of the whole formation. For the idea that such insulated peaks and ridges, as those under consideration, were deposited in the form we now find them, is perfectly absurd. Further, we must suppose that the strata of Mount Toby originally extended to the top of Deerfield mountain; as is represented by the dotted line *A C* in the section. Nay, on this supposition, all the strata of both mountains may have extended to the western side of the valley, as at *A*.

The immense period requisite to wear away such a mass of rock as this theory supposes to have once occupied the whole valley of the Connecticut, will seem to most minds the strongest objection against its adoption: I mean supposing it to have been effected by such causes as are operating at present. But this is not a solitary example, in which geological phenomena indicate the operation of existing causes through periods of duration inconceivably long. We may in this case, indeed, as I have already shown, suppose the occurrence of numerous deluges in the earlier periods of our globe. Still even with the aid of such catastrophes, the work must have been immensely protracted. And why should we hesitate to admit the

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existence of our globe through periods as long as geological researches require; since the sacred record does not declare the time of its original creation: and since such a view of its antiquity enlarges our ideas of the operations of the Deity in respect to duration, as much as astronomy does in regard to space? Instead of bringing us into collision with Moses, it seems to me that geology furnishes us with some of the grandest conceptions of the Divine Atributes and plans to be found in the whole circle of human knowledge.

The objection of a writer in the American Journal of Science,* that such a height of waters as would deposite Mount Toby, must have produced a lake nearly to the upper part of New Hampshire, in the Connecticut valley, and thus have caused the same sandstone to be produced higher up that valley than Northfield, loses its force, when it is recollected that this formation was deposited before its strata were elevated. For the elevating force undoubtedly changed the relative level of different parts of the country. In this case, the disturbing force must have acted beneath the primary rocks. And besides, we have good evidence which will be shown by and by, that our new red sandstone was formed beneath the ocean. We cannot then reason on this subject from present levels.

If the preceding statements and reasonings be correct, in order to ascertain the actual thickness of the new red sandstone strata in the Connecticut valley, above the river, we must add the height of Mount Toby above the strata seam *E H*, to the height of Deerfield mountain; that is, *B E* to *E S*=*C N*. It certainly will not exceed the truth to call *B E* 800 feet, and *E S* 400=1200, the thickness of the strata above the bed of the Connecticut. In no place, that I know of, has this river cut through the sandstone: and hence we are almost entirely destitute of means of ascertaining the thickness of the strata beneath the river. If the primary strata have the same slope beneath the sandstone, as above it, this rock cannot be less than 1000 to 2000 feet thick, beneath the river, or *N D*. But this is little better than conjecture; both because the slope of the primary strata is very unequal in different places, and because probably the surface beneath the sandstone, is as uneven as it is in other primary valleys; which is evinced by the curved structure of the sandstone strata in some places.

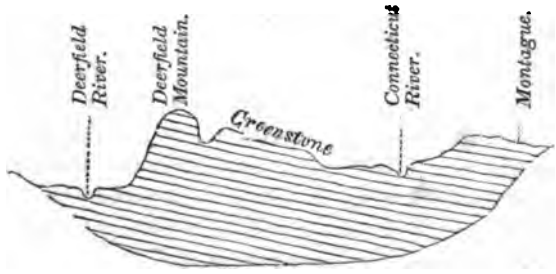
In the second part of this Report I have described the cave and fissure in Sunderland, as having been produced by the wearing away

* Vol. 22. p. 223.

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of the inferior schistose strata, probably by water. There is another fact which the observer will notice in various places on the western declivity of Toby. The thick sandstone and conglomerate strata are often arranged in steps or terraces of great height and thickness. At first view the mountain would seem to have been elevated by successive throes of some internal force; each paroxysm throwing up the central part of the mountain higher, and higher, so as to produce these offsets. But there is too much regularity in the stratification to admit of such a supposition. I should rather impute this terraced structure to the action of those currents of water which have excavated the valley of the Connecticut. The rock exhibits occasionally cross seams of stratification, nearly at right angles to the surface of the layers: hence currents of water, frosts, &c. would remove successive portions as wide as these cross strata. On some of the terraces huge masses of the rock yet remain, raised from their original bed and irregularly mixed, but not far removed.

It will be seen on the accompanying geological map, that the greenstone ridge which is marked in Sunderland, crosses the Connecticut in the north part of that town and then forms its western shore as far north as Gill. The section that has just been given crosses the Connecticut a little south of the place where the greenstone crosses the river; and consequently the greenstone is represented as on the east side of the river with the sandstone beneath and above it. But north of the place where the greenstone crosses the river, through the the whole extent of Montague and Deerfield, the following section represents the relative situation of the two rocks.




Now I cannot but regard this fact as some evidence, that the valley between Deerfield mountain and Toby, has been to a great extent excavated by water. For I can hardly conceive how so deep a gorge

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should have been produced in this greenstone ridge, or dyke, at the period of its protrusion: certainly not without causing great disturbance in the adjoining strata; of which I have seen no traces. The continuity of this ridge is uninterrupted; as are the dip and direction of the sandstone strata. But the whole aspect of this valley, and especially the contour of Sugar Loaf, correspond with the idea of excavation by water. The rocks in place too, on both sides of the river, to the height of several hundred feet, bear the marks, in numerous grooves, of powerful abrading agents.

If such an hypothesis, however, be admitted, this work must have been performed while the region under consideration was in a state quite different from what it is at present; and probably by other streams than the Connecticut and its tributaries. For I have in another place attempted to show, that these streams have not, to any great extent, evcavated their own beds: although the reasoning which proved this position, would not apply to the valley between Toby and Deerfield mountain, except by way of analogy. If water did excavate that valley, probably it was previous to the deposition of the tertiary strata in the Connecticut valley; since no change of consequence has taken place in the surface, (I mean by elevation or subsidence,) subsequent to that period: whereas some change of this kind must have taken place since the excavation of this valley, if other streams than the Connecticut and it tributaries performed the work.

But enough, and probably more than enough, upon a subject which is obviously involved in great obscurity. I confess that the position which I have taken, and the reasoning which I have advanced, do not satisfy my own mind: but at present I can offer nothing better.

## *Mineral Contents.*

### *Copper.*

The veins of Copper ore, occurring at the junction of this formation with the greenstone, are the most interesting mineral treasure of the new red sandstone. Here are found several species: viz. the pyritous copper, red oxide, and green carbonate: and several masses of native copper, have been found in the valley of the Connecticut, which propably originated in these veins. They are quite numerous from New Haven to Northfield, and not unfrequently extend into both rocks, the sandstone and the greenstone. Their gangue is sometimes sandstone, sometimes trap, and sometimes sulphate



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of baryta. On the most southern of the islands at Turner's Falls, the gangue of the pyritous copper is a brecciated sandstone, the vein crossing the regular strata; though coinciding with them in direction. That is, both run nearly north and south; but while the slate dips about 45° easterly, the vein dips westerly. It would seem as if the intrusion of the copper ore had broken a portion of the sandstone into fragments, and the materials had been partially melted, so that on cooling, a chemical union took place between them and the walls of the vein. On the edges of the sandstone strata, for several feet and even rods, around this vein, may be seen numerous crystals of lenticular carbonate of iron. (No. 240)

All the veins of copper ore in the formation under consideration, run in nearly the same direction, so far as I have examined them: that is, nearly north and south; indicating some common cause from which they originated.

The vein of pyritous and the green carbonate of copper, half a mile below Turner's Falls in Greenfield, affords a good example, at low water, of the passage of the vein through the trap and the sandstone. Although it has not been explored, veins of sulphate of baryta, sometimes several inches wide, and accompanied by copper, may be seen passing into both rocks. The trap is that variety denominated toadstone; the base being apparently indurated clay. The red slaty rock connected with the trap, may be regarded as a variety of slate, sometimes a little micaceous. As nearly as I could determine, this vein is perpendicular; and as it passes northerly into a lofty hill of trap, it might in that direction be advantageously explored. A few hundred dollars laid out here, would probably determine the value of the vein.

I have put down a second copper vein on the map, a mile or two south of the one just described. I did it on what I thought good authority; but subsequent examination has led me to doubt whether it has an existence; although I am aware how easy it is to overlook such a locality without a guide.

The copper ore in Granby, Ct. (called the Simsbury Mines,) appears so far as it has been explored, to be a bed lying entirely between layers of sandstone, which dip to the east a little more than 20°, and running between north and south, and northeast and southeast. The red oxide is the principal ore, sometimes mixed with a little of the green carbonate. The gangue appears to be gray sandstone. Since this mine has been reopened, about a thousand tons of

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good ore have been obtained. A new adit is now in progress, which will strike the bed of copper ore about 200 feet below the surface.

Although nothing but sandstone is found where this bed of ore crops out, yet a greenstone ridge appears a few rods distant, and the dip of the bed is towards the greenstone, and must therefore pass under it, or intersect it.

Native copper has been found in small pieces at this mine.

### *Coal.*

It has long been known that coal was found in the sandstone of Connecticut valley: and on this fact mainly has the opinion been based, that a real coal formation exists there. But I think I have satisfactorily shown that this formation must be referred to the new red sandstone group. Yet if this be admitted, shall we infer that there is no hope that it may contain coal in such quantity, and of such quality, as to be useful for fuel? A few years ago, geologists would have peremptorily decided this question in the affirmative: but in the present state of their science, it seems to me we may at least reasonably hesitate, and perhaps draw a contrary inference. It is now generally admitted that all coal has a vegetable origin; and that simply by the long continued action of water, under certain circstances vegetable matters pass into the state of peat, next into lignite, then into bituminous coal, and finally into anthracite: though this last substance more commonly perhaps, results from the action of heat on bituminous coal: and if the heat be powerful enough, even plumbago may be produced; "as wood has been (says Dr. Macculloch,*) in my experiments, and as coal is daily, in the iron furnaces." Such a change he found, in one case at least, produced upon common coal, in the vicinity of a trap dyke: hence he reasonably infers, "that even the plumbago of the primary strata, no less than the anthracite, might as well have originated in vegetables, as that each of these should owe an independant origin to elementary mineral carbon."

According to this theory, why may we not hope to find large quantities of workable coal in any formation where we find it in small quantities? For the same causes that could produce it in thin beds, might reasonably be supposed adequate to the production of large masses. Anthracite is found in almost every rock from lias to gneiss; and bituminous coal occurs in the oolitic and new red sand-

* System of Geology, &c. Vol. 1. p. 298.

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stone series, as well as in the proper coal measures.* True, so far as we yet know, the coal measures contain the principal deposites of the latter species in Europe; and perhaps in this country: though I do not admit that our bituminous coal fields have yet been certainly identified with those in Europe. But who knows whether the circumstances under which our new red sandstone was deposited, might not have been such as to produce extensive masses of coal? This would not constitute so great a difference between our new red sandstone and that in Europe, as the almost entire absence in the former of gypsum and rock salt; minerals which, on the eastern continent, are regarded as eminently characteristic of this formation. In England, it is true, no coal has been found in the new red sandstone: and on the European continent, only occasionally in thin seams: but it has been recently ascertained, that the Brora coal field in Scotland, which is probably the equivalent of the coal field of the eastern Moorlands of Yorkshire in England, and not improbably of that of Tecklenburg—Lingen in Prussia, is contained in the lias;† a formation which lies above the new red sandstone: and, therefore, every presumption is in favor of finding coal in the new red sandstone; since this lies between the lias and the real coal measures. This conclusion is still farther strengthened by the fact, that Humbolt, Daubuisson, and other able geologists, consider the red sandstone group and the coal measures as belonging to the same formation.‡ All these facts prove, it seems to me, that it was a hasty generalization which limited workable coal to the coal measures; and that, therefore, we should not be prevented from searching for coal in the new red sandstone of the Connecticut valley.

The coal in this rock occurs in the form of thin veins and irregular nodules, which are rarely but a few inches in diameter. In almost every instance, it appears to be the result of the carbonization

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* See Brongniart's Tableau de la Succession at de la Disposition des Terrains et Roches, &c. Paris, 1829. Also Conybeare and Phillips's Geology of England and Wales, Vol. 1. p. 329. Al. Brongniart also describes, as occurring in the Plastic Clay Formation of Mount Meissner in Hesse, "a true anthracite — that is to say, a dense carbon without bitumen, sometimes with a dull, sometimes with a shining fracture. We here find a thicker bed of compact, solid bituminous carbon, having a nearly straight fracture, burning with facility, and presenting many of the characters of true coal."—Phil. Mag. vol. 2. N. Series, p. 108.

† Philosophical Magazine, vol. 2. N. Series, p. 101.

‡ De la Beche's Geological Manual, 2d Edition, (London, 1832.) p. 405.

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of a single plant, whose form can be distinctly traced; though it is always broken into fragments, whose length rarely exceeds two feet. At Whitmore's ferry, in Sunderland; in the north part of South Hadley, and on the north bank of Westfield river in West Springfield, the coal is highly bituminous; though least so, at the last named locality. But at Turner's Falls, in Gill; at the Southampton lead mine, and at Enfield Falls, (Connecticut,) it is anthracite. At the junction of this same formation with the greenstone at Berlin, in Connecticut, Dr. Percival has described a vein of bituminous coal penetrating the greenstone. He says, however, that "it more usually has the appearance of cinders so mixed up with siliceous matter as to be hardly combustible."

It becomes an interesting enquiry, whether local circumstances will enable us to explain why the coal at some of these localities is bituminous, and at others anthracite. "We know," says Prof. Al. Brongniart,* "that the coal which is in contact with the veins or dikes of basanite, or trap, that traverse it, and that which approaches masses of porphyry, is less bituminous than other portions of the bed, and that it even loses all its bitumen, and in passing to the state of anthracite, exhibits, as it were, a kind of vitreous texture, &c." Few geologists will now doubt but the proximity of granite produces a similar effect. Now at Turner's Falls we know that a large mass of trap is not far from the coal; and at Southampton, that granite is still nearer; and hence we should expect the coal at these places to have lost its bitumen. I am not aware, however, of the proximity of either of these rocks to the coal at Enfield Falls; though ignorant of its particular location. At Sunderland and South Hadley the trap is so far distant, that we are not surprised to find bitumen. The existence of bituminous coal, however, in the trap at Berlin, Ct. is quite remarkable: and the fact that a portion of it is converted into psuedo-cinders, proves that heat does not necessarily drive out the bitumen. The contorted condition of the strata at the locality of coal in West Springfield, renders it quite probable that trap rock exists a short distance beneath the surface. The pretty uniform dip of the strata, where they are laid bare in that town several miles in width, by Westfield river, is from $15^0$ to $20^0$ east. But at the spot just referred

* Tableau Des Terrains, &c. p. 283.

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to, we find the anomaly which is here sketched. It is a satisfactory explanation of this case to suppose that greenstone, or some other igneous rock, has pressed upwards with such force between *A* and *E*, as to give the the strata a saddle shaped appearance for a few rods. (Four rods from *A* to *E*.) If this hypothesis be correct, we can hardly conceive, as in the case at Berlin, why the bitumen is not expelled from the coal. Upon the whole, the cases that have been mentioned show, that something more than mere proximity to rocks of igneous origin is necessary for the conversion of bituminous coal into anthracite; although heat is undoubtedly the principal agent.

Generally the coal that has been described, occurs in a gray coarse micaceous sandstone. But at the locality at West Springfield, it is found in bituminous marlite. At Sunderland, it is in bituminous shale.

### *Lead, Zinc, and Iron.*

The sulphurets of these metals occur in a vein at the junction of the greenstone and this formation, in Berlin, Ct. as described by Dr. Percival. Galena and Blende, I have observed in small quantities in the fetid limestone of West Springfield, at Paine's quarry, and blende at Meachem's quarry. Sulphuret of iron is quite common in the shale every where. Nodular argillaceous iron ore also occurs in the same rock, at Turner's Falls, South Hadley Canal, &c. The carbonate of iron at Turner's Falls, has been already described: and I suspect No. 241 to be the same mineral from South Hadley Canal: though it resembles cinnabar. But the chemical tests do not indicate the presence of mercury. Yet from its solution in nitro-muriatic acid, prussiate of potash threw down a dense precipitate of the prussiate of iron.

### *Iron Sand.*

Bushels of this substance, highly magnetic, may sometimes be collected on the Montague shore of Connecticut river, 40 rods below Turner's Falls. Probably it proceeds from the disintegration of the

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new red sandstone at the falls. Some of the iron-colored grains are not magnetic enough to be taken up by the magnet, and resemble iserine.

### *Rotten Stone.*

This valuable substance cannot probably be regarded as a simple mineral, since in the present case, it is merely fetid limestone that has been partially decomposed by the action of a mass of greenstone in the immediate vicinity; or by some other cause. It is found at Paine's quarry in West Springfield; and in large quantities. Its quality appears to be very excellent; and in an economical point of view, it deserves attention. It is found also at South Hadley Canal, on the West Springfield shore; though of hardly so fine a quality, and in much less quantity. It is not there associated with limestone. (Nos. 217 to 221.)

### *Fibrous Limestone, or Satin Spar.*

The red and black shales, as remarked in another place, on the banks of Westfield river, in West Springfield, contain numerous veins of this substance from an inch to a mere line wide. Sometimes it forms a thin seam between the layers of slate. The same mineral occurs along with the fish impressions at Sunderland. Common calcareous spar exists in these rocks as well as satin spar.

Concreted carbonate of lime is frequently found in this formation. At West Springfield I found it an inch or two thick between the layers of sandstone, near the southern bed of fetid limestone. At the Sunderland cave, it forms small and imperfect stalactites on the coarse conglomerate: and on the same conglomerate, on the east side of Mount Toby in Leverett, I found a large quantity of it coating over a perpendicular wall several inches thick. (Nos. 226 to 230.) This had obviously been derived from the conglomerate by water; and it shows that carbonate of lime is more frequent in this formation than one would be led to suspect from its general appearance.

### *Sulphate of Baryta.*

This mineral, as already remarked, accompanies the veins of copper ore in the new red sandstone in most instances, both in Massachusetts and Connecticut. In this State, it is most abundant at the copper veins in Greenfield; where it forms veins from six to eight inches wide.

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### *Sulphate of Strontia.*

This mineral occurs in radiated masses upon fetid carbonate of lime in West Springfield. Its specific gravity is about four; and before the blow pipe, it melts and gives a slight tinge of red to the flame.

### *Sulphate of Lime.*

I have already mentioned, on the authority of Mr. E. Davis, that this interesting mineral exists in small quantity on the banks of Westfield river, in West Springfield. I have found it also, in the form of selenite, on gray sandstone at South Hadley Canal, in quite small quantity. These facts are sufficient to encourage farther research after so valuable a substance.

In some of the seams of the fetid limestone of West Springfield, I have noticed thin layers of purple fluate of lime.

It ought not to be forgotten, that in Europe, the new red sandstone group is one of the depositories of salt and gypsum, as well as the rich mines of Mercury in Carniola: nor ought it to be supposed that our new red sandstone has been examined thoroughly enough, to render it certain that the same minerals do not exist here.

### *Organic Remains.*

In Europe the new red sandstone is rather remarkable for a paucity of organic relics. And the same seems to be true in this country. Enough, however, have been found in this rock in the valley of the Connecticut, to throw considerable light upon the circumstances under which it was produced. And judging from the success which I have had in the few direct efforts which I have made for discovering the fossils of this formation, I predict that subsequent examinations will bring to light many more. Much obscurity also, rests upon the nature of several of those which I have found, which farther research will I hope remove.

The remains found in this formation are both vegetable and animal. The former I shall first notice.

Those fragments of vegetables which are not uncommon in certain varieties of the new red sandstone, and which present a thin layer of coal, having the general form of the original plant, might have belonged, in some cases to dicotyledonous plants. And their extremely broken condition shows that they were transported from a distance to

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the places which they now occupy. Mixed with them, however, and much less broken, we find impressions on the shale, in which usually little vegetable matter remains. These are rarely more than an inch or an inch and a half wide; but No. 252 is more than 4 inches wide, and this is the largest I have met with. These impressions are slightly striated longitudinally: and probably belong to the tribe of fossil plants *Calamites;* possibly to the *Calamites arenaceus* of Adolphe Brongniart.* Yet I have rarely noticed any distinct articulations in the specimens. Not unfrequently a thin layer of coal occupies the place of the vegetable; its surface still exhibiting a striated or furrowed aspect. Indeed, I think it possible that even those specimens that are so much broken (No. 253) may belong to the same family of plants.

De la Beche mentions that the *Lycopodites Sillimanni* — a fossil plant peculiar to America — is found at Hadley in Connecticut.† No such town exists in Connecticut; and I can have but little doubt that this is a mistake for South Hadley, Massachusetts; for I know of some gentlemen in Connecticut, who obtained some years ago, several peculiar vegetable fossils at that place; though I have not been so fortunate. Professor Silliman, who probably sent this fossil to Europe, has no recollection concerning it.

I obtained a single specimen several years ago at Sunderland, and gave a figure of it in the 6th volume of the American Journal of Science, which bears considerable resemblance to the rachis of the *voltzia brevifolia*, when destitute of fructification, as figured by Ad. Brongniart in the 15th volume of the Annales des Sciences, and found in the sandstone formation near Strasburg.

In some of the lowest beds of this formation, (those which have been heretofore called the old red sandstone,) I have lately found, in Deerfield and Greenfield, a singular petrifaction, which Dr. Morton says, "evidently belongs to the fossil genus Fucoides, of which Dr. Harlan has described a species from the sandstone of Genesee, New York, under the name of F. Brongniartii. (Amer. Jour. of Geology.) If your specimens were weathered, their specific characters would be more obvious, and would probably prove identical with those from Genesee. Dr. Harlan, however, has used a specific name already in use; for among British fossils, there is a F. Brongniartii enumerated

* Historie des Vegetaux Fossiles, Plate 23. Fig. 1.

† Manuel, p. 419, 2d edition.



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in Woodward's Catalogue, 1830; which species is figured in Mantell's Geology of Sussex."

This Fucoides varies in size from one tenth of an inch to an inch in diameter. More commonly it runs through the rock in a direction corresponding to that of the laminæ; in which case it is considerably flattened. Sometimes it passes obliquely through the layers, and very commonly crosses them at right angles; in which last case it has a cylindrical form. It is rare to see a specimen of any considerable length, that is not more or less curved; and I have never met with one that was branched at all. I have noticed specimens a foot or more in length, and they may be much longer than this, since I have not met with any large mass of rock containing them. The sandstone in which they are found is rather fine and quite soft, and easily disintegrates. They occur near Hoyt's quarries, one mile west of the village of Deerfield; and also a few rods south of the county jail in Greenfield, close by the stage road.

The vegetable matter in these remains is wholly replaced by sandstone. By breaking the specimens transversely, a curious structure is revealed. It may be described, by saying that the cylinder is made up of convex layers of sandstone, piled upon one another: and I observe that in the same rock all the specimens have the convex side of these layers in the same direction; so that on one side of the rock you will see numerous button-like protuberances, and on the other side corresponding concavities. (No. 258.) But I do not know which side is uppermost in the rock in situ. Nor am I familiar enough, either with living or fossil agamous plants, to know whether there is any thing remarkable in this structure.

Plate XIII. figs. 38 and 39 are sketches of two specimens of this Fucoides.

### *Fossil Trunk of a Tree.*

I saw this interesting relic several years ago, in Dr. Smith's collection in Southbury, Ct. It was obtained in that place in the sandstone formation extending from Woodbury to the Housatonic; which, although separated topographically from the new red sandstone of the Connecticut valley, appears to possess precisely the same characters. The specimen to which I refer was cylindrical, eight or ten inches in diameter, highly siliceous, and exhibited the bark very distinctly; which, if I do not misrecollect, was carbonaceous. It was discovered in a swamp, and a laborer, mistaking it for a stump of a

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recent tree, struck it with his axe; and being vexed at the injury his instrument received, he in revenge broke it almost to pieces. The unbroken fragment in Dr. Smith's possession, however, was several inches long.

The circumstances above related, render it probable that this trunk, when first discovered, stood in the position in which it grew; as has been found to be the case in numerous instances in the sandstones of Europe.

### *Animal Remains.*

About thirteen years ago, an interesting discovery of the bones of an animal was made in digging a well near Ketch's Mills, in the east parish of East Windsor, Ct. The rock is a red conglomerate, belonging to the higher part of the new red sandstone, and exceedingly resembles in color and hardness the conglomerate of the lowest beds. The workmen penetrated five feet of soil before reaching the rock, and then blasted it out to the depth of eighteen feet, before reaching the bones. And although little care was taken to obtain these in a proper state for examination, and they were mostly scattered among visitors to the spot, yet the following facts may be depended on.

The most remarkable fact is, that these bones were not at all mineralized; but retained the color and other characters of bones that have long been buried. On exposure to the air, they were much disposed to crumble down. Yet this was not universally the case, as two or three small fragments, still in my possession, testify. These bones belonged to a vertebral animal, about five feet long, which lay horizontally in the rock; and as the caudal vertebræ were quite numerous, projecting in a curve eighteen inches beyond the body of the skeleton, I suspect these bones belonged to a saurian animal; especially since such animals have been found in the new red sandstone in Europe.

Having understood that an individual in East Windsor, (for his own sake I will not mention his name,) had preserved several fragments of these bones, and finding that geologists abroad were beginning to doubt whether any such discovery had been made, I traveled seventy miles, accompanied by an artist, in the hope of being allowed to take sketches of the specimens. But I was not permitted even to look at them. I tried to console myself under so unexpected a disappointment, first, by reflecting that I had not received such treatment any where else; and secondly, by repeating the sentiment — *parvum parva decent.*

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### *Ichthyolites.*

The remains of fish have been found on bituminous shale and bituminous marlite, in Middletown, Ct. at Sunderland, Mass. and also in West Springfield and Deerfield. Sunderland, however, is the only spot where they can now be procured. The shale there forms the bank of the river several feet high: but the ichthyolites are most abundant in the lower part of the bed, which corresponds nearly with low water mark. I have dug out hundreds of specimens at this spot; though perfect ones are very rare to be obtained. On one layer of the rock, fifteen inches by three feet, seven distinct impressions were visible. Indeed, I have not unfrequently met with one fish lying across another, without the intervention of a layer of shale: and from these specimens, I can easily conceive how the mistake should have been made, that among the Monte Bolca ichthyolites, one fish was found in the act of swallowing another!

A thin layer of carbonaceous matter usually marks out the spot where the fish lay; except the head, whose outlines are rendered visible only by irregular ridges and furrows. In some cases, however, satin spar forms a thin layer over the carbonaceous matter, and being of a light gray color, it gives to the specimens an aspect extremely like that of a fish just taken from the water.

We sometimes find the specimens a good deal mutilated; so much so, indeed, that the form of the fish is entirely lost; and the scales and fins are scattered about promiscuously: and this too in the vicinity of other specimens that are entire. Hence we cannot impute this mutilation, as is usually done, to a disturbing force acting on the rock at the time in which the fish was enveloped, or afterwards. But if we suppose that the fish, as they died, were gradually enveloped by mud, it is easy to conceive how some of them might have putrified and fallen to pieces, before they were buried deep enough to be preserved: or it might be, that most of the fish was devoured by some other animal: and in either of these ways, we might expect to find only scattered relics enveloped in the rock.

The great resemblance of these ichthyolites to those found on the bituminous slate of Mansfeld, in Germany, has been already noticed. Probably all of them belong to the genus Palaeothrissum. I am inclined to believe that I have found four species. Plate XIV. Figs. 45 and 48, are probably the same species; the outlines of the latter being sketched, merely because they are more distinct than those of fig. 45. Forty nine fiftieths of the specimens at Sunderland belong

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to this species. Fig. 46 is a smaller species; differing very decidedly from the first, but very rarely met with. Fig. 44 is still smaller; the scales being minute, and I have found only one specimen of it. The fish in this case, as may be seen by the drawing, appears not to have lain upon its side, as they generally do, when it was enveloped in the rock. There is occasionally found a specimen of greater length than any which are sketched; and yet the scales are smaller than those on fig. 45: I suspect this to be a fourth species: but I have no specimen sufficiently perfect to permit a drawing to be taken.

### *Mollusca.*

The only molluscous animal which I have detected in the new red sandstone formation, was found in rolled masses in Amherst: and the only specimen at all distinct, is sketched on Plate XI. Fig. 17; and belongs to the College collection in that place. Although much broken, there can be little doubt but it is an *orthocera.* For a long time I supposed the rock containing this mould, was a wacke-like trap: but I am now satisfied that it is a micaceous sandstone, more indurated than is common. I should not be surprised if it should hereafter appear, that the vicinity of Turner's Falls is the spot from which this specimen originated.

At those falls I obtained the specimen No. 282, on whose surface are some protuberances that much resemble a univalve shell: but they may be concretions.

### *Zoophyta.*

Under this head I introduce a remarkable organic relic, which I recently discovered on the brown shale, or rather fine micaceous sandstone, on the banks of Westfield river, (generally called Agawam river near its mouth,) in West Springfield. It is characterised by grooves and correspondent ridges, which sometimes ramify, and by small somewhat polygonal reticulations, which cover the entire surface of the shale as far as the grooves extend. (Nos. 264, 265.) These reticulations are rarely more than one quarter of an inch in diameter, and they diminish in size as we approach one extremity of the impression. No animal or vegetable matter remains upon the shale, yet the grooves and the reticulations are quite distinct. Plate XIII. Figs. 34 and 35, are sketches of this organic impression; the latter showing the diminution in size of the net work, towards one

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extremity. The reticulations and grooves are of the natural size in both figures.

I found this impression on the north bank of Westfield river, in the west part of West Springfield. The shale containing it passed on one side under the river; the impression still continuing in that direction, as far as the rock could be examined. On the other side, that is, northerly, I found it to extend eleven feet, and at least two feet in width; nor did the margin of the specimen appear in any direction. More recently the spot has been visited by Solomon Lathrop, Esq. of West Springfield, who has uncovered the impression eighteen feet in length, and at least four feet in width. Towards the north, he found the reticulations to become finer, until at length the impression ceased to appear in that direction; but how much farther it extends under the river he could not ascertain. And he says, "how much wider the impression is (than four feet,) I cannot tell, but should presume several feet." Thus we ascertain the existence of an animal or vegetable relic at least eighteen feet long and four feet wide! and it may occupy twice or thrice that extent!

But which is it, animal or vegetable? I have searched in vain for any thing resembling it in Brongniart's *Vegetaux Fossiles*, in Parkhurst's Organic Remains, and in all other descriptions of a similar kind, within my reach. But the reticulations certainly bear a strong resemblance to those on some existing species of Gorgonia, or *sea fan:* to the G. reticulata, for example, as figured in Rees' Cyclopedia; although in this species we see nothing that could have produced the grooves so obvious on the fossil. The fossil Gorgoniae, also, as figured by Goldfuss, especially the G. *ripistena* and *infundibuliformis*,* bear considerable resemblance to the impression from West Springfield: but these species are only an inch and a half long. Yet some of the existing species "in deep bays, and similar situations of the sea, no less favorable to their growth and increase, attain to the gigantic height of ten or twelve feet; and from their number as well as magnitude; their remarkable ramose, and foliated or flabelliform appearance; interwoven structure, or coral-like texture, form a conspicuous portion of those vast sub-marine "groves of coral" that are sometimes seen by navigators in the hotter regions of the globe."†

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* Petrifacta Plate VII, fig. 2, and Plate X, fig. 1.

† Rees' Cyclopedia, Art. Gorgonia.

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Upon the whole, I am strongly inclined to believe that this interesting relic must have been an enormous Gorgonia. True, no discovery has yet been made of the central stem: but who knows that the shale has yet been explored far enough in width to discover it. If so, this specimen may yet be found to be from eight to ten feet in width!*

Plate XIII, fig. 36, is a sketch of an impression found in the same shale, only an inch or two higher up in the rock. (No. 256.) It scarcely differs from the others, except in the absence of the reticulations. Mr. Lathrop, who sent me this specimen, could discover none of these. But I have noticed that frequently the reticulations are attached to a very thin layer of shale, which easily cleaves off and leaves an impression precisely like that in the figure. Hence I suspect that these reticulations will be found connected with the grooves: although I can easily conceive of different species in which the net work should be absent. And Mr. Lathrop says, that such as are represented in the figure are quite abundant, not only at the spot mentioned above, but also half a mile nearer the village of West Springfield, where he says, "the leaves are larger, and in one instance the edge appeared serrated."

On the surface of the same shale, along the same river, we find

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* While the proof sheet of this page was under examination, I received, through the kindness of Professor Silliman, Mr. Witham's "Observations on Fossil Vegetables," Edinburgh, 1831; and his "Description of a Fossil Tree in the Quarry at Craigleith;" Edinburgh, 1833; and I was at once struck with the resemblance between several of the drawings in those works, and those which I have presented of the fossil described in the text. But Mr. Witham's drawings represent sections — mostly transverse — of fossil trees as seen through the microscope; and therefore, the specimens from which they were taken, cannot be remotely allied to the fossil at West Springfield, which consists simply of an impression upon shale.

Professor Silliman has kindly given me his opinion in respect to the character of the sandstones in the Connecticut valley: and I shall take the liberty to insert it here. It will be seen that there is no real discrepancy between us on the subject. He is more confident than I am of the existence of the old red sandstone in this valley; while I merely say, that I have not evidence enough of its existence to justify me in marking it on the map. Professor Silliman, I trust, will excuse the liberty which I take in copying his opinion from a private letter, since it is the opinion of one who examined this subject much earlier than myself, and who, in my earliest as well as latest geological pursuits, I have always regarded as my counsellor, patron, and friend.

"My impression is," says he, "that both the old and the new red sandstone exist in the great formation of Massachusetts and Connecticut: that the old lies the lowest, and is palpably (at least here) granite ruins: that the new lies higher in the series; and that the coal formation may come between them as elsewhere."

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irregularly ramified masses of flint, or siliceous slate, from half an inch to an inch in diameter. I could not resist the impression, that this siliceous matter may have taken the place of a zoophyte: although I have seen no certain evidence of organization. (No. 267.) But if the specimens that have been described are Gorgoniae, there is certainly presumptive evidence that other zoophytes would be found in the same rock.

### *Radiaria.*

Under this name I have a specimen, perhaps still more remarkable than the last, to introduce. It is from the fetid limestone in West Springfield. Plate XII. Figs. 29, 30, 32, and 33, are intended to convey an idea of the most important varieties of this petrifaction, which I have hitherto discovered. Fig. 33 exhibits its most common form. This is composed of numerous cylindrical bodies, usually less than half an inch in diameter, and several inches long, running in a parallel direction through the limestone. On breaking them transversely, they are seen to consist of concentric layers of carbonate of lime, of various shades of color; the outside of the external layers (and, indeed, more or less so of the others,) being covered with small warty protuberances; but showing no marks of transverse septa. Not unfrequently a small perforation occupies the center of the cylinder; and at other times it is occupied by calcareous spar, which probably entered by infiltration. A radiated structure is sometimes not obvious: but if I do not greatly mistake, it is evident when specimens are newly fractured crosswise. (Nos. 268 to 277.)

Fig. 32 exhibits one of these cylinders, terminated by a spheroidal head, and covered over with the warty protuberances that have been mentioned.

Sometimes these cylinders enlarge and several of them (frequently three) become united, so that the outer layers enclose the whole: as is shown in Fig. 30.

In one or two instances, numerous small cylinders become united in this manner, and form a rather confused mass in the center, surrounded, however, by distinct layers. In this case a great enlargement takes place, as in Fig. 29. The lower part of that specimen, which cannot be seen in the sketch, exhibits numerous small and distinct tubes, which, by extending an inch or two, become blended in the confused mass that occupies the central parts, as seen on the upper surface in this figure.

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The appearance of a concretionary structure is so marked in some specimens, that one or two geologists, for whose opinions I entertain a high respect, have even suggested whether this remarkable substance be a real petrifaction; and enquired whether it may not be of a nature similar to the columnar limestone, described by Capt. Bonnycastle with a plate, in the 20th volume of the Am. Journal of Science. Judging from the plate, as well as specimens which I have seen of that limestone, I am satisfied that the specimens from Springfield are of a very different character, and exhibit far more marks of organic structure. Indeed, I cannot doubt but they are real petrifactions; but having examined Goldfuss' Petrefacta, Miller's Crinoidea, Sowerby's Mineral Conchology, Parkinson's Organic Remains, &c. I can find no fossil resembling these. Yet I doubt not but some one more conversant with this subject, will be able to refer them to their proper place. General analogies only, have led me to regard them as having resulted from the petrifaction of radiated animals: though I am by no means sure that they are not of vegetable origin.

The specimens, Nos 265 and 263, were obtained from the shale that forms the north bank of Westfield river, in West Springfield; and from their general aspect, I suspect them to be Encrini: though they may be of the same nature as the remains just described. The mineralizer in this case seems to be argillo-ferruginous limestone, except the central part.

Whether the Nos. 283, 284, are to be regarded as organic relics, I feel unable to decide.

*Theoretical Considerations.*

The new red sandstone series that has been described, consisting chiefly of the fragments of older rocks from the surrounding region, must obviously have been produced chiefly by the agency of currents of water, which first wore away these rocks, and then transported and deposited the fragments where we now find them. By what agent or agents their consolidation was effected, we may not be able, perhaps, in the present state of geological science, to determine. We do know, however, that water, air, and heat, may all, under certain circumstances, accomplish this work. Water may contain in solution some cement, say carbonate of lime, which shall be deposited in the interstices between water worn fragments and thus unite them. Air, it is also well known, by abstracting water from some of the materials that form rocks, does sometimes effect their consolidation.



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Heat, likewise, in the same manner, and if it be sufficiently powerful, by producing also a crystalline arrangement of the materials, will harden them into stone. Now in the case of the red sandstone, all these causes may have conspired to effect its consolidation. The existence of beds of limestone in this formation, and of carbonate of lime diffused through some varieties of the shale and even of the coarse conglomerates, shows that deposition from chemical solution in water, was one of the important agencies concerned in its production. The inclined position of the strata, as well as the character of the organic remains, show that these rocks have been elevated from beneath the water, and of consequence have been, at least in part, hardened by dessication. And the presence of trap rocks in the midst of the formation, not to speak of other proofs of igneous action, demonstrates the agency of heat in its consolidation.

It will naturally be enquired, how the red color, so characteristic of the most important varieties of this rock, could have been produced. Uundoubtedly it proceeds from the red oxide of iron, which, in some way, has been diffused through the mass. But whether heat or water was the agent employed, may be doubtful. We find on breaking open the fragments in the conglomerates, that the smaller ones are penetrated throughout by this coloring matter; while the larger ones are colored only to a certain depth. (See No. 143.) Now, has the iron actually penetrated these nodules, or has water or heat changed the iron, which they originally contained, into the peroxide? The latter supposition appears to me most probable; and though air and water might possibly produce such a change to some extent, yet I think we must call in the agency of heat to explain the very thorough manner in which some of the finer sandstones of this group, have been colored red. For I doubt whether air and water can do much in this process, unless they also produce incipient decomposition.

In another place I have advanced an hypothesis to explain the manner in which such sudden and numerous alternations of the coarsest and the finest materials in this rock may have been produced; viz. by the flux and reflux of mighty deluges, caused by the elevation of mountain chains in various parts of the globe. Some of these waves may have resulted from the elevation of the strata of the older rocks on which the sandstone rests unconformably: for the strata of the former are much nearer to verticality than those of the latter; and, therefore, must have been raised before the deposition of the sand-

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stone, at least to some extent. In some cases, however, there is reason to believe that the abraded fragments were transported southerly. Thus, the conglomerate in Greenfield and Bernardston, near the argillo-micaceous slate, out of whose ruins it was obviously formed, (Nos. 137, 138, 139,) lies south of the parent rock: though a stratum of the slate might once have extended farther south than at present, and have been worn away by the powerful reflux wave which rushed easterly, when the Hoosac range of mountains was elevated. The fragments of the conglomerate of Mount Toby, and in Montague, correspond somewhat with rocks found several miles to the north, within the limits of Vermont and New Hampshire: though it must be admitted that these rocks also, might once have extended farther to the south than they now do.

It is an interesting enquiry, whether the greenstone ranges now existing in the very midst of the sandstone formation, were produced anterior to that rock, or during the same epoch, or afterwards. In all the lower beds of the sandstone formation, I have never found a single fragment of the greenstone; and, therefore, I infer that the latter rock did not exist previous to the deposition of these beds. Nor have I found any of the trap in the conglomerates of the higher beds, except a narrow stratum, which I have described under the name of trap conglomerate; and which lies in immediate contact with the greenstone of Tom and Holyoke, so as to rest upon them. Greenstone must, therefore, have existed in the vicinity before the formation of this conglomerate; and there is only one difficulty in supposing the whole of the greenstone in the Connecticut valley to have been produced immediately subsequent to the deposition of the lower beds of the sandstone. From some facts to which I have already alluded, and which I shall describe more particularly in speaking of greenstone, it would seem that the upper beds of the sandstone, those that lie even higher up in the series than the trap conglomerate, have been disturbed and elevated by the intrusion of the greenstone. Hence I should infer, that the greenstone continued to be produced, until nearly all the beds of sandstone had become consolidated; and that probably the existing trap ridges were the latest erupted. From all these facts, then, I infer, that greenstone began to be erupted not far from the middle of the epoch of the deposition of the sandstone; and continued to be thrown up at intervals, during the remainder of the period in which the sandstone formation was advancing to its completion.

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I have assumed it as a fact, that the sandstone formation under consideration was deposited beneath the ocean and subsequently elevated. The proof is quite conclusive. Imperfect as is the account which I have been able to give of the organic remains in this group, it contains enough, I think, to settle this point. To whatever species the Fucoides that occurs in the lower beds may be referred, we may be sure that it was a marine plant. For, says Adolphe Brongniart, "these plants (the Algae, including the Ulvaceae and Fucoideae) grow almost without exception in salt water; certain Ulvae only being able to develope themselves in fresh water."* This opinion is still farther confirmed by what that same writer says of the species of Fucoides found in the new red sandstone of Mansfeld, in Germany, including of course the bituminous marlite. "Out of seven species," he says, "five, to all appearance, belong to two genera which best characterise marine vegetation in the torrid zone."† If the reticulated fossil, which I have described, be a real Gorgonia, as I suppose, it furnishes another conclusive proof of the marine origin of this formation: for this animal is exclusively marine. As to the fishes found in the shale of this formation, Brongniart says that "many of them may be referred to genera living commonly in fresh water: but others are generally marine;" and he infers from the other fossils that occur in the same rock, that it was deposited in salt water. Concerning the Paloeothrissum, the only genus of fishes yet found in our sandstone, as no similar fish is now known to exist on the globe, we cannot say whether it was an inhabitant of fresh or salt water, except that the other remains found in connection with this, so far as we know their nature, are marine; and, therefore, we infer that this fish was so too.

This conclusion corresponds with those that have been made in other countries, as to the new red sandstone group. Every where it is found, when carefully examined, to have had a marine origin; though some members of the series do contain fresh water remains, or those of land animals, or vegetables; and hence they are sometimes called fluvio-marine: that is, they were formed in estuaries, or shallow seas, into which the organic products of the land and fresh water were occasionally borne by rivers. But in the new red sandstone of the Connecticut valley, no fossil has yet been found, which is decidedly of fluviatile, lacustrine, or terrestrial origin.

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* Historie des Vegetaux Fossiles, I. Livraison, p. 37.

† Idem, p. 43.

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It is certainly an interesting thought, that this delightful valley, which now forms so charming a residence for man, once constituted, and for an immense period, the bottom of a tropical ocean, where gigantic Gorgoniae, certainly 20, and perhaps 40 feet high, formed coral groves, and Fucoideae more numerous, flourished. The astonishing change brought about in the course of ages, exalts our conceptions of the wisdom and extent of the plans of the Deity; and leads us to anticipate future changes, whenever those plans require.

I have said it was a tropical ocean. I mean that its temperature was much higher than that of the ocean which now washes our shores. For otherwise, how could sea-fans, larger than any which our tropical seas now produce, have been sustained. The fact that in early times, while the secondary rocks were depositing, the climate in high latitudes must have been much warmer than at present, is, indeed, so completly established by researches in other parts of the world, that it would be strange if we should not find the same thing to be true on this continent. But the few facts which I have detailed that throw any light on this enquiry, all tend to show that there is no exception here to the general law. New England certainly had a tropical climate when the ocean that deposited the new red sandstone stood over it. And Adolphe Brongniart says, that two species of Fucoides, found in the limestone of Canada, approach very near to a genus of these plants that now grows only in tropical seas: a fact that tends to corroborate the views which have been presented relative to the new red sandstone of the Connecticut valley.

A careful examination of the fossils of this sandstone, will convince any one that their resemblance to any now found living on the globe, is very faint: so that probably they cannot be referred to the same genera, much less to the same species. This too accords with the facts that have been observed in other parts of the world. The farther down in the series of rocks we penetrate, the more unlike living animals and plants are those found in a fossil state. And it seems to be now pretty well established, that there have been several successive creations and extinctions of animals and plants on our globe, before the production of its present organized beings. It is not certainly ascertained how many of these destructions and renewals have taken place. Adolphe Brongniart thinks that four changes of this kind are clearly discernible among fossil vegetables.* Hence

* Dictionnaire D'Historie Naturelle, Art. Vegetaux fossiles.

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he infers, that there have been four periods of vegetation since the creation; each differing from the other by a marked distinction in the species, and even genera of plants, and in the numerical proportion of the different kinds. During the first period, the strata, from the lowest fossiliferous rocks to the lower part of the new red sandstone, were deposited. The second period includes the time during which the new red sandstone series was forming. During the third period, the vegetables lived, which are found between the new red sandstone group and the chalk, including the latter. The fourth period commenced after the deposition of the chalk, and reaches to the highest of the tertiary deposites. During each successive period, the vegetation becomes more perfect; that is to say, vascular cryptogamian plants predominated vastly during the early periods, while dicotyledonous and monotyledonous vegetables prevailed during the last period. The same is true in respect to animals. Those found in the lowest rocks are extremely simple in their organization, and vertebral animals, except perhaps a few fishes, do not appear lower down than the new red sandstone; while land animals begin to appear still higher in the series.

The conclusions of Dr. Macculloch appear to coincide nearly with those of Brongniart: and the former writer takes animals as well as vegetables into the account. "Thus then," says he, "if these views are correct, I have demonstrated four extinctions of antecedent organized creations; while there are two more perhaps less satisfactorily proved"* He seems to be disposed afterwards to raise this number to seven, or even eight, including man and the existing race of animals.

I am aware that such conclusions as these will seem to many at variance with the sacred record. For Moses speaks only of one creation of plants and animals. But if it be only admitted, as it seems to me the principles of a just interpretation demand, that after mentioning the original production of the universe out of nothing, he leaves untouched an indefinite period, of what may be called the semi-chaotic state of the globe, we shall find no difficulty in reconciling every apparent discrepancy. For during this long period, all those creations, which the strata now reveal, may have taken place; and the animals and plants thus brought to light, are of exactly the character which we should expect might exist in a semi-chaotic con-

* System of Geology, Vol. 2, p. 432.

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dition of the globe. But of what possible use, in a moral point of view, and in a revelation for the great mass of mankind, would it have been, to have given an account of the creation and extinction of certain huge ferns, sea weeds, zoophytes, and sea monsters, whose relics would be brought to light, not till several thousand years afterwards, by the researches of geologists?

So far then from finding in these facts and conclusions any objections to the Mosaic records, I find in them a striking evidence of the benevolence of the Deity. For during the long period above spoken of, the globe was evidently preparing for the residence of man, and the other animals that now inhabit it. Before their creation, its temperature was too high, and its surface too liable to be broken up by volcanoes and drenched by deluges, to be a secure and happy abode for the more perfect races of animals that now inhabit it. But it was adapted to the nature and habits of such animals and vegetables as we now find entombed in the rocks. The overflowing benevolence of the Deity, therefore, led him to place such beings upon it; and thus to communicate a vast amount of happiness, which seems to be a grand object in all his plans and operations. The vegetables that existed in those early periods, have been converted, in the course of time, into the various species of coal now dug from the bowels of the earth; while the remains of the animals of those times have become changed into limestone. And even those violent volcanic agencies, by which the successive races of plants and animals have been suddenly destroyed, have probably introduced into the upper part of the earth's crust, various metallic veins, very important to human happiness. And in all this, we see indications of that same benevolent foresight and care, for supplying the wants of his creatures, to which our daily individual experience of God's goodness testifies.

I deduce another moral consideration of no little importance, from the facts and conclusions that have been stated. So constant and uniform are the operations of nature in general, that philosophy has always been prone to regard the universe as a most curious machine, set in motion at the beginning by an all-wise being, who having furnished it with every thing requisite to keep it eternally in play, has left it to run on in the prescribed course, without his interference, and without any need even of his direction and superintendance. Indeed, some have thought this machine so perfect, as to need no creating and superintending Cause, if we only admit it to have been eternally in motion. But these records of geology show us that this

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supposed uniformity has been often broken in upon. For if the geologist can explain how the operation of natural laws might destroy races of plants and animals, he must admit a special miraculous interference in the creation of new ones. The resemblances between the plants and animals in each of the divisions of the strata, that have been mentioned, even to the very limits of each division, and the suddenness of the change that then takes place in their characters, preclude the idea, so much of a favorite with certain philosophers, that all was the result of a gradual metamorphosis. Now if we thus ascertain that God has specially interfered with the operation of natural laws in the instances under consideration, the presumption is, that he may interfere again, whenever the good of his universe demands. Thus do we get rid of a host of atheistical objections, with which the student of natural theology finds his path encumbered. It would have been well, if some, who can see nothing but atheistical tendencies in the principles of geology, had recollected, before filling their pages with uncandid vituperation of this science and its cultivators,* that it is the only science whose principles could furnish such a refutation.

I have here entered only upon the limits of a wide field. I cannot proceed farther. The great interest which every reflecting man feels in speculations of this kind, and the expectation of being misunderstood if I entered into no explanation, (should these labors be made public,) have led me to venture thus far.

### 5. GRAYWACKE.

This term, it is well known, has occasioned much perplexity in geology; and on many accounts, besides its cacophony, it would be well perhaps to expunge it from the science. Yet I could find no term more convenient, as a sort of index, to an interesting group of rocks, partly chemical and partly mechanical in their structure, occurring in several places in the eastern part of Massachusetts. The varieties included in the group are quite numerous; and some of them exceedingly unlike the others in composition and appearance. Among them all it may perhaps be doubted, whether the exact classical graywacke of Werner can be found. But later geolo-

* See Penn's Comparative Estimate of the Mineral and Mosaical Geologies, 2 vols. 8vo.

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gists have given the term a much wider range. "It designates, when taken in a more general sense," says Humboldt,* "every conglomerate, sandstone, and fragmentary or arenaceous rock of transition formation, that is anterior to the red sandstone and coal formation." "Viewed on the large scale," says De la Beche,† "the graywacke series consists of a large stratified mass of arenaceous and slaty rocks, intermingled with patches of limestone, which are often continuous for considerable distances." I use the term in "the general sense" described by Humboldt; and include in it, both the 'graywacke group,' and 'the lowest fossiliferous group,' of De la Beche; though I am not sure that our series embraces any limestone. And since the red sandstone does not occur in the eastern part of the State, nor any other secondary rock, I am not sure that the series under consideration, ought to be regarded as filling up the whole space between the red sandstone and the primary rocks. But every geologist who examines this series, sees at once that some members of it must belong to the oldest of those rocks which some writers denominate *transition*. For the lower beds pass insensibly into primary rocks; and generally, a chemical agency is obvious in their structure, in the veins of quartz by which they are frequently traversed, and in their sub-crystalline aspect. There is, also, a plumbaginous appearance in the anthracite found in these rocks, which does not exist, except in the carbon of the older intermedial and primary rocks, and which increases with the age of the rock in which it occurs. The Rhode Island coal exhibits more of this character than that of Pennsylvania; and that from Worcester appears much more like mineral carbon than either; which gradation corresponds with the opinion I have adopted as to the relative ages of these several coal formations.

Upon the whole we may be certain, I think, that the formation under consideration in Massachusetts and Rhode Island, is a member of the series generally called transition. But whether it is precisely identical with any European member of that series, I suppose we do not yet possess the data for determining. The only organic remains yet found in this formation are vegetable; which will not enable us even to prove that it belongs to the transition series, if a remark of Al. Brongniart be true, that "no species of plant has been found

* Superposition of Rocks, p. 201.

† Geological Manual, p. 433.



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in the transition series, (*terrains hemilysiens,*) which being peculiar to that class, differs essentially from those found in the later rocks."* And we have seen that Adolphe Brongniart regards as belonging to the first period of vegetation, all the rocks below the new red sandstone. De la Beche does, indeed, mention that the crustaceous animal *Calymene Blumenbachii* has been found at Newport, United States: meaning, probably, Newport, Rhode Island. And were this the fact, it would be important in determining the question as to the transition character of the rocks in question; since, according to Al. Brongniart, the trilobites "pertain exclusively to the hemilysian rocks." But on looking into the Tableau des Terrains, &c. of this writer, (p. 429,) from whence De la Beche must have derived his information, we find that he speaks of Newport as near Utica; (*Lebanon sur l'Ohio, et Newport, pres Utica, Amer. Sept.*) a misprint, perhaps, for Lockport. Besides, he describes the fossil as from limestone, a rock which at Newport contains no fossils.

After these explanations, I trust it will be obvious that it is not my object to identify the rocks in question, with the graywacke of Europe: but *simply to describe them as they are.* And though it would be gratifying to find that all our fragmentary and fossiliferous rocks correspond exactly with those of other continents, yet I am more and more inclined to doubt whether such identity can ever be made out. For if, as we have every reason to believe, these rocks were deposited in the beds of former seas and lakes, as similar ones are now forming, why should we not expect as much diversity in their composition and organic remains, in different quarters of the globe, as we should find in the sandstones, conglomerates, and limestones, which would result from the consolidation and elevation of the sand, gravel, and calcareous matter, that constitutes the bottom of existing seas, estuaries, and lakes? Should such a consolidation and elevation take place, we might perhaps find resemblances enough between distant strata to prove them of contemporaneous origin, and the result of the same general causes. Still, we should undoubtedly find much in each group of strata, of a *sui generis* character, and not a few groups entirely peculiar and independant; though produced during the same geological epoch. Hence, then, is it not best to direct one's chief efforts to give a correct description of our rocks, rather than spend the time in efforts to identify them with European formations? Many

* Tableau des Terrains, p. 291.

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writers seem to feel as if nothing were done, until this identity be established. But it may appear hereafter, that their labor has been almost in vain. How much toil and perplexity have geologists endured, in endeavoring to ascertain whether particular formations ought to be referred to the transition class of Werner! And yet, how few geologists there are, who do not now admit that there is scarcely the vestige of a foundation for this class in nature: regarding the introduction of this class into the nomenclature, (in the words of Mr. Greenough*) like an attempt "to increase the list of primitive colors by the addition of mixed tints, or the list of notes in music by telling in the flats and sharps."

In the present case, however, waving all general principles such as have been alluded to, I freely confess that I am not thoroughly enough acquainted with the formation which I denominate graywacke, to be able to decide whether it does, or does not, correspond with any known European formation. Long and patient study of its organic remains and relative position, with the advantage of residence in its vicinity, ought to be bestowed upon it, before we can settle this question. On this account I regard it as premature to describe as new, any of its anomalous varieties; although some of them differ so widely from the general type of the group, that they really deserve distinct names, when these can be applied without the danger of encumbering the science with synonymes. If it be the geologist's object to advance the science, he ought to forego the gratification, and it may be the honor, of affixing new names to anomalous rocks, until they have undergone a most rigid scrutiny. Indeed, in my opinion, very few of the rocks in this country, except perhaps the primary ones, have yet been examined thoroughly enough to render it certain that they are so radically different from those already described in Europe, as to deserve distinct names. Whoever covets the ephemeral honor of applying them thus prematurely, may be sure that every cautious and able geologist will refuse to adopt them; and regard them as more indicative of self-sufficiency and vanity, than of scientific acumen.

### *Mineralogical Characters of the Graywacke.*

This rock varies in texture from the finest argillaceous slate and shale, through all the grades of sandstones, up to the coarsest con-

* Greenough's Geology, p. 233.

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glomerate and breccia. The imbedded nodules in the coarser varieties, consist of almost every sort of primary rock found in the eastern part of Massachusetts; and the prevailing cement is argillaceous: sometimes, however, it is a paste of compact feldspar, and at others of mica, tale, or steatite. Perhaps, however, a particular description of the distinct varieties of this group will convey the most accurate ideas of its characters. I begin with those which probably are most common, and most forcibly arrest the attention, not merely of the geologist, but of the most unpractised observer.

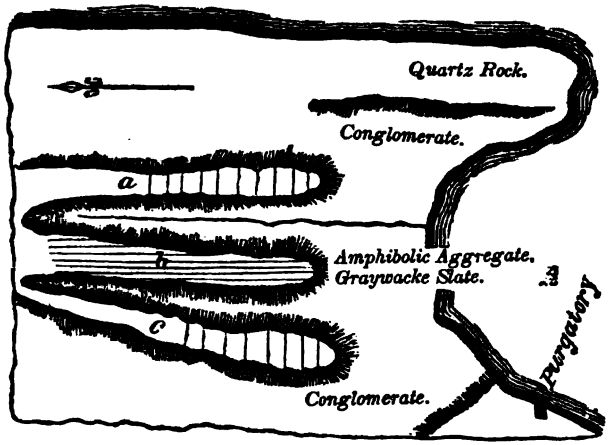
1. *Conglomerates.* The rounded nodules in the variety that abounds most throughout the whole extent of the formation, (Nos. 287 to 292, and 307,) particularly in Roxbury, Dorchester, Dighton, Swansey, and Somerset, consist of granite, sienite, compact feldspar, and pehaps hornstone of various colors, porphyry, quartz, argillaceous and flinty slate, novaculite, serpentine, and nephrite. These vary in size from that of a pea to two or three feet in diameter. The cement appears to be chiefly the same materials in a comminuted state; exhaling, however, an argillaceous odor when breathed upon. Although the imbedded nodules are numerous, yet they have the appearance, as Mr. Maclure describes the older conglomerates, "as if the cement at the time of formation had a consistence sufficient to prevent the particles from touching each other." The cement has generally a semi-crystalline aspect, and adheres very firmly to the nodules. Sometimes the rock is traversed by veins of quartz, which are attached quite strongly to the rock. So thick, and often indistinct, are the strata, that the Messrs. Danas say that "no stratification has been observed in this Graywacke."* But if one traverses the whole formation, he will find abundant examples of this structure; and in most places he will discover it by careful examination: the strata having in general a northerly dip. This rock is also intersected by numerous cross seams, more commonly perpendicular to the layers, and remarkable for the exact division which they make of the imbedded nodules; so that one part of the pebble appears on one side of the seam, and the other part on the opposite side. Veins of trap, also, sometimes traverse this conglomerate.

Another very distinct and most remarkable conglomerate occurs at the south east extremity of Rhode Island, in Middletown, near Sechuest Beach, three miles east of Newport. (No. 294.) It is com-

* Mineralogy and Geology of Boston and its vicinity, 1818, p. 94.

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posed of elongated rounded nodules of quartz rock, and quartz rock passing into mica slate, with a cement of talcose slate. The nodules vary from the size of a pigeon's egg, to four, and even six feet in their longest diameter, and constitute the great mass of the rock. They are so arranged that their longest diameters are uniformly parallel to one another: lying in a north and south direction: which corresponds with the layers of the schistose cement, and also with the general direction of the strata in the vicinity. Both the nodules and the cement abound in small, distinct, octahedral crystals of magnetic iron ore.




The above rough sketch of the southeast point of Rhode Island, will assist in rendering intelligible the relative position of this conglomerate, and also of three or four other varieties of this formation to be hereafter described. About a quarter of a mile from the coast, three precipitous bluffs, *a*, *b*, *c*, several rods wide, separated by salt marshes from 15 to 20 rods wide, rise one or two hundred feet, trending northerly, and converging; so as apparently to unite at no great distance. The two most easterly ridges are very steep, and exhibit evidence of having been powerfully abraded. The outer ridges, *a*, *c*, consist of the peculiar conglomerate above described: the central one consists of a hard graywacke slate, and a very singular and puzzling rock, which I shall venture to describe as an amphibolic aggregate. Half a mile southeast is an aggregate of quartz and mica to be described in the sequel.

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So much of the topography of these rocks, by way of anticipation, seemed necessary in order to explain the peculiar structure of the conglomerate. The layers of the graywacke slate, and amphibolic aggregate run north and south, and dip west, 60° to 70°. And this, as already mentioned, is the direction in which the nodules and schistose layers of the cement of the conglomerate are placed. But no strata seams are to be seen corresponding to the dip and direction of the slate. Yet the conglomerate is divided into horizontal layers, from six to ten feet thick; and also by seams running east and west, perpendicular to the horizon, and parallel to one another, from 10 to 20 feet apart. These fissures divide the thick masses of conglomerate so perfectly, that they seem as if cut through by the sword of some Titan. The nodules through which the fissure passes, are divided very neatly, and the parts present even surfaces, so as to give the rock a quite peculiar aspect. At the southern extremity of the eastern ramification of the range of hills above described, an immense quantity of the conglomerate has been carried away by former diluvial action, and the present bluff is terminated by a perpendicular wall, exhibiting this bisection of the nodules in a most striking manner. On account of the size, number, and parallel position of these nodules, this singular instance of fracture is much more remarkable than in the variety of conglomerate first described.

No one can view this phenomenon without enquiring immediately into its cause. And it is obvious at first thought, that this division of the strata must have taken place since their perfect consolidation: otherwise the nodules, instead of breaking, would have been drawn out of the paste. Nor could mere desiccation have produced such an effect, for the same reason. Nor does any hypothesis afford to my mind the least satisfaction, except that which supposes these fractures to have resulted from a powerful force, acting at right angles to the meridian, beneath the conglomerate, after its consolidation. And when we find large deposites of granite in the vicinity, we have ascertained the existence of a power adequate to such an effect: although we might resort to the hypothesis of Elie de Beaumont, which has of late excited so much interest, and which imputes most of the fractures and dislocations of the earth's crust to the secular refrigeration of its internal parts, whereby its outward envelope becomes too large and partially plicated.

Another important fact in respect to the conglomerate under consideration, is the occurrence in it of numerous veins of quartz. Some

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of them are not less than a foot wide; and they are frequently branched. These veins separate the imbedded nodules, and are chemically united to the divided portions. These veins and the semi-crystalline aspect of the cement of this rock, prove it to be one of the oldest of the varieties which I have included under the term gray-wacke.

2. *Breccias.* These are distinguished from the conglomerates by the angular shape of the imbedded fragments. One variety (Nos. 296, 297,) consists of fragments of reddish and ash colored argillaceous slate, united by an argillaceous or arenaceous cement. This aggregate is slaty, and the cement has a porphyritic appearance. I have observed it only in a few places; as at Natick and Randolph. Another variety, approaching to slaty porphyry, appears to be composed chiefly of compact feldspar, united by a cement of comminuted porphyry. This was found also in Natick. (No. 298.) A third variety, (No. 299,) of which I found only a bowlder in Saugus, consists of gray compact feldspar (?) and indurated wacke. (?) A fourth consists of fragments of gray and yellowish green compact feldspar, united by an unknown dark colored cement. (No. 300.) The yellowish green variety appears as if colored by epidote. This most singular rock occurs at the head of Nantasket Beach, in Cohasset; and when its ledges are moistened by the spray, they present a most fantastic and really a very splendid appearance, resembling exceedingly variegated serpentine. The rock exhibits no regular strata, although divided like the unstratified rocks generally by numerous seams. It is associated with a conglomerate, similar to the variety first described above, and I suspect it to be the rock marked in Cohasset on the map of the Messrs. Danas as 'Petrosilex.' If large blocks can be obtained and it will admit of being polished, it will furnish an elegant ornamental stone.

The conglomerate just mentioned, as associated with the breccia at the head of Nantasket Beach, extends into Hingham; and both in Cohasset and Hingham, it assumes a character intermediate between puddingstone and breccia, by taking into its composition angular and partly rounded masses of poryhyry, greenstone, and amygdaloid. These are sometimes so numerous, that the rock might easily be mistaken for a variety of trap. Neither this rock nor the conglomerate, of which, indeed, it forms a part, exhibit, so far as I could perceive, any evidence of stratification: although being a rock of mechanical origin, it is undoubtedly stratified.

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As we pass from the range of porphyry and compact feldspar on the south of Boston towards the graywacke, and if I mistake not at the junction of the two rocks, (e. g. in Dorchester and Canton,) we meet with a rock of a peculiar character, whose origin appears to be in part mechanical. The compact feldspar seems to have suffered some degree of abrasion after its consolidation, and the fragments to have been reconsolidated into a rock more or less slaty, with the admixture of but few foreign ingredients. (Nos. 301, 302.) It would seem to have been partially fused the second time; or perhaps it might have been produced by the partial cooling of the compact feldspar at its junction with the graywacke, as it was forced through that rock while in a melted state. This would account for its semi-brecciated aspect and slaty structure, and the occasional presence of foreign ingredients. But this rock deserves a more careful examination than I have been able to give it.

Our compact feldspar is slaty in some other places; as at Newbury: but it does not appear to have been recomposed.

3. *Quartz Rock.* I thus denominate two or three most singular varieties of rock in the formation under consideration, because quartz is their predominant ingredient.

The most remarkable of these varieties is developed very distinctly at the southeastern extremity of Rhode Island; as may be seen by the sketch already given of that portion of the Island. It consists of coarse grains of hyaline quartz, of a purple color, passing to deep blue and black, with tale or mica; (it is difficult to say which;) the materials having a schistose arrangement. (Nos. 303 to 306.) The quartz bears a strong resemblance to peliom, and constitutes a large part of the rock. The aggregate exhales an argillaceous odor when breathed upon.

This same rock may be seen at the mouth of Fall River, in Troy, where it is associated with an argillaceous slate, passing into mica slate, and of a quite dark color from the carbonaceous matter it contains. At this place, this slate and quartz rock are contiguous to granite; and they may be seen in Tiverton, lying directly upon the granite. In Newport, also, granite cannot be far distant from the same rock. Do not these facts furnish a clue to the origin of the dark color of the quartz? Was it not penetrated by the carbonaceous matter of the black slate, while in a state of partial fusion by the action of the melted granite?

There can be no doubt but the quartzose rock above described, is

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one of the oldest of the graywacke formation. Its position in respect to the granite is proof of this. In Newport it lies between the very ancient conglomerate that has been described, and the granite; although the granite does not appear, I believe, till we cross an arm of the sea into Little Compton.

Another aggregate, in this formation, which may be called quartz rock, consists of red or reddish hyaline quartz, somewhat in grains, with a small quantity of mica, so that the rock always has more or less of a slaty structure; though this is not always seen but by close examination. (Nos. 309 to 318.) In some instances its layers become quite thin, in consequence of an increase of the mica: but they are still genuine strata; for these layers have a schistose structure, not coincident with their planes. This red quartz rock exceedingly resembles red sandstone at a little distance: but when closely examined, it is found to consist chiefly of red hyaline quartz, which exhibits little evidence of a mechanical mode of production. It passes into a structure distinctly conglomerated, and may perhaps be the equivalent of Dr. Macculloch's "primary red sandstone;" though I have no evidence that it alternates with any primary rock: and it contains no feldspar.

Sometimes this rock abounds with veins of quartz giving it a very rich appearance. I have noticed these veins most numerously in the south part of Wrentham, near the place of explorations for coal. (No. 318.)

4. *Talcose Aggregate*, (*Steachist?* Phillips and Wood) (Nos. 320 to 323.) This is a slaty rock, composed of grains of quartz and sometimes feldspar, with talc or steatite. It lies between the red quartz rock and the primary rocks in Walpole; though not, therefore, older than the quartz rock; since the dip of both is such there, as to bring the talcose rock uppermost. It often exhibits distinct fragments of previous rocks, and passes into a breccia or conglomerate; as in a quarry in Cambridge, two miles west of the University. It is not abundant in the graywacke formation; though many of the oldest varieties of this formation have a talcose appearance.

5. *Classical Graywacke.* I mean by this term to designate the rock described by Werner's ablest commentator, Professor Jameson. He says that Graywacke "is composed of angular or other shaped portions of quartz, feldspar, Lydian stone, and clay slate, connected together by means of a basis or ground of the nature of clay slate, which is often highly impregnated with silica, thus giving to the mass



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a considerable degree of hardness. The imbedded portions vary in size, but seldom exceed a few inches in breadth and thickness." Brochant does not include in the term graywacke any variety of rock "whose grains exceed the size of a hazle nut." Hence the conglomerates that have been described above, cannot be regarded as *classical* graywacke. This is the opinion of Professor Webster;* whose opportunities for a personal examination of European graywacke, give his decision on this point great weight. But associated with these conglomerates, we have rocks of a much finer grain, whose composition corresponds essentially with the above definition; (Nos. 324 to 334,) although every ingredient may not in all cases be present. Sometimes the mass is colored red by the presence of the red oxide of iron; as in Attleborough. But more commonly it is gray, as in Rehoboth. It often becomes fine grained and passes into graywacke slate, as at the quarries in Pawtucket; where it is traversed by numerous veins of quartz mixed with calcareous spar.

6. *Graywacke Slate.* This variety of rock is quite common in this formation. Its colors are either gray or red; and it appears to be composed in a great measure of wacke. Mica, however, sometimes enters into its composition. Its structure is always slaty: but the layers are much more irregular and tortuous than argillaceous slate, and its aspect more earthy; though it is no easy matter to draw a line between them. It is traversed frequently by veins of quartz. (Nos. 335 to 346.)

7. *Argillaceous Slate.* The argillaceous slate in the eastern part of the State is so intimately connected with the varieties of rock above noticed, that it ought in justice to be described as one of the members of the graywacke group; although marked as a distinct deposite on the map. That this is one of the oldest varieties of this group, I have no doubt; but certainly not older than some that have been mentioned. I am aware that fragments of this slate occur in one of the varieties of conglomerate that have been described; and this not only shows the posterior production of the latter, but renders it doubtful whether both rocks were produced during the same geological epoch. But with the knowledge that I possess of this series of rocks, I fear that an attempt to divide them would only introduce confusion into my account. I would not pretend to a degree of accuracy to which I have not attained.

* Boston Journal of Philosophy and the Arts, Vol. 1. p. 269.

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I have no doubt that this argillaceous slate is the 'transition clay slate' of the Wernerians, which they describe as associated with graywacke. In various places in Rhode Island and Massachusetts, it is highly impregnated with carbonaceous matter, so as to become black; and it usually forms the floor and roof of the beds of anthracite. In general its color is dark gray, passing to blue: sometimes of a chocolate color, and sometimes red. It is rarely fissile enough to be employed for roofing, and frequently its layers are two or three inches thick. The laminae, or rather strata, are sometimes much curved; as on Rainsford Island, in Boston Harbor. Not unfrequently it passes into an imperfect novaculite; as in Charlestown, Roxbury, Weymouth, Newbury, and some of the outer islands in Boston Harbor. (Nos. 357 to 370.)

8. *Amphibolic Aggregate.* (No. 374.) Nothing is more difficult in many cases, than to determine the nature of the semi-crystalline minerals entering into the compositon of some of the intermediary rocks. They seem to have undergone some chemical process, which has not been thorough enough to give them a fully developed character. In the present instance the mass appears decidedly crystalline; yet I am in serious doubt whether amphibole is the dark green mineral in it that exhibits a crystalline structure. Another part of the rock presents an argillaceous aspect, and exhales an argillaceous odor when breathed upon. But had I found it among primary rocks, I should have regarded it as by no means an anomaly there: especially after finding in it a vein, four inches wide, of crystallized zoisite. Yet the position of this rock, which has already been pointed out, in describing the conglomerate of the southeast part of Rhode Island, clearly proves it to be a member of what I call the graywacke series: for it is situated between graywacke slate and conglomerate.

9. *Varioloid Wacke.* The rock which I thus designate, has generally been regarded by those who have described the Geology of Boston and its vicinity, as amygdaloid. But it seems to me that there are insuperable objections against the supposition that the nodules in general were introduced by infiltration, or even sublimation; the only modes by which geologists suppose the cavities of amygdaloid were filled. For they consist generally of rounded masses of compact feldspar; a substance which must certainly have been the result of igneous fusion. On the other hand, the rounded form of these nodules, and their non-crystalline structure in general, forbid the arrangement of this rock along with the porphyries. But some writers re-

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gard variolites as rather intermediate between porphyry and amygdaloid,* and such I suppose to be the character of the rock under consideration. By the term varioloid, however, I intend merely to designate the external aspect of the rock; since the mode of its formation seems involved in much obscurity: but its variolous appearance none can deny.

Brochant describes wacke as "substance intermediate between basalt and clay." This description will apply to the base of the varioloid rock under consideration. It is found in Brookline, Newton, Needham, Hingham, Brighton, and Saugus. But its most important varieties are found in the three latter places, and deserve a particular description.

In Brighton the wacke is of a chocolate color, and quite hard. The nodules are mostly rounded, and of the size of a pea; but sometimes they are much larger and irregular, approaching to the form of veins. Compact feldspar, epidote, calcareous spar, and quartz are the principal minerals of which they are composed. Sometimes the external part of the nodule is compact feldspar, or calcareous spar, and the central part epidote: and sometimes quartz occupies the center, invested by epidote. The epidote is crystallized, although the cavities are in almost every instance entirely filled. The foliated structure of the feldspar, and especially of the calcareous spar, is not unfrequently visible, though generally these minerals are compact, and very hard. But the two last seem to be strangely blended, as if they had been partially melted together. (Nos. 373, 377.)

At a quarry about a mile southwest of Brighton meeting house, this varioloid rock may be seen passing into conglomerate, showing that it is only a variety of the graywacke formation.

At Hingham the greater part of this rock is of a deeper red than that at Brighton; though some of it is of a light gray. The basis is harder, owing perhaps to a mixture of compact feldspar. The nodules vary in size from that of a pea to that of an almond; and consist of brownish red and greenish compact feldspar, with carbonate of lime mixed with the latter; or in separate folia. Not unfrequently the red compact feldspar encloses the green, like that in Brighton. This rock is associated with a conglomerate of the gray wacke formation. (No. 374.)

At the head of Nantasket Beach, I found a rolled mass (No. 375)

* Traite de Mineralogie, Par. T. S. Beudant, (Paris, 1830,) Vol. 1. p. 569.

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of the varioloid rock, whose base is brownish gray, and the nodules a greenish compact feldspar.

In Needham this rock has a somewhat slaty structure, is hard, and contains distinct crystals of feldspar of a light green color. (No. 378.) But as the basis is obviously wacke, exhaling an argillaceous odor, I can hardly persuade myself to place it among the porphyries. Suppose this Needham rock were to be subject to a degree of heat sufficient to fuse the feldspar, without essentially altering the wacke, I enquire whether the result would not be a rock very similar to some varieties that have been described as varioloid wacke. And may not this have have been the mode in which some of that rock was produced?

The most remarkable of the varioloid rocks which I am describing, occurs at Saugus. Near the center of the place, and surrounded by granite, we find a rock, forming a hill one or two hundred feet high, composed of a basis of green wacke and white compact feldspar, with an occasional mixture of carbonate of lime. The nodules are rarely so large as a bullet; more commonly about the size of small peas, and in some parts of the rock, so very numerous that it seems hardly possible they could have been infiltrated into cavities previously made. (No. 372.) The basis is a pleasant green. I saw no conglomerate or other variety of graywacke in the vicinity.

It is obvious from the preceding descriptions, that in some instances — particularly at Brighton — the nodules of this varioloid rock must have been at least partially formed by the infiltration of earths from a watery solution: but it would seem that this was only a part of the process. For it is difficult to conceive how such minerals as compact feldspar and carbonate of lime could have been deposited in a compact form from a watery solution; since they crystallize with so much readiness. It seems to me that we must call in the agency of heat, after the infiltration took place, by which the crystals might be converted into a compact mass, and all the cavities be filled, as they are in almost every instance: and if we suppose granite, sienite, &c. to have had an igneous origin, we can be at no loss to provide for the requisite heat. I had been rather disposed to regard much of this rock as an example of the solid concretionary structure, especially that at Saugus. But the occasional evidence of infiltration led me to abandon that hypothesis. If the one hinted at above is more satisfactory, I shall be gratified. The subject is certainly involved in much obscurity.

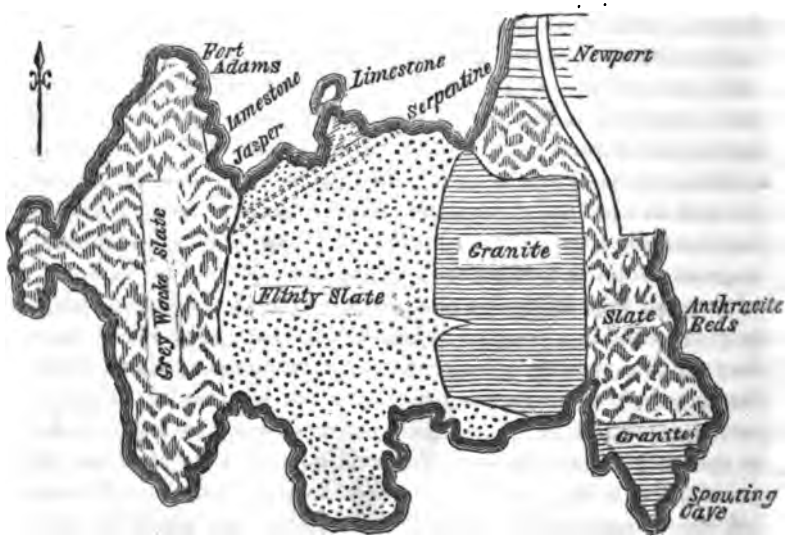
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10. ***Flinty Slate.*** 11. ***Chert.*** 12. ***Jasper.*** I regard these rocks as varieties of other rocks, produced by the proximity of granite, porphyry, or trap: and in Massachusetts they are merely altered varieties of the graywacke formation that has been described. Hence I shall treat of them in this place. The sagacious observations of Dr. Macculloch concerning the origin of these rocks,* receive strong confirmation from their situation in New England. And since this is a subject, concerning which geologists are as yet by no means agreed in opinion, I shall exhibit the relative position of these rocks as intelligibly as possible, from the examinations of them which I have been able to make.

### *Flinty Slate or Siliceous Schist.*

This rock I have found only in two places in the district which I am describing; viz. in Newport, R. Island, and on the promontory of Nahant. It is interesting, however, that in the former place it occurs contiguous to granite, and in the latter, to trap.

It is not this slate alone which in Newport exhibits the influence of the proximity of granite: and it will save space to give an account here of the whole of this interesting spot, to which I was conducted




* System of Geology, vol. 1. Chapter XL.

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by Col. Joseph Totten of the U. S. army, who has become familiar with the geology of that region, and to whose polite attentions I am much indebted.

The preceding rough sketch of the southwest part of Newport, will give a correct idea of the relative position and extent of the four or five rocks which are there associated, on a surface of four or five square miles; viz. granite, flinty slate, graywacke slate, limestone, serpentine, and jasper. The flinty slate, it will be seen, occupies a considerable space immediately contiguous to the granite, and it is separated from the graywacke slate on that side, by a small ravine. The flinty slate exhibits various degrees of induration, and more or less of a mixture of different minerals. One variety has a gray color, an imperfectly conchoidal somewhat splintery fracture, and is rendered porphyritic by small grains of hyaline quartz. Another dark gray variety exhibits greenish and white clouds. A third has a reddish base of an earthy aspect and fracture, less hard than the preceding, and containing numerous light colored, rounded masses, resembling hornstone, from the size of a pin's head to that of a musket bullet; giving it an amygdaloidal aspect. If hard enough to receive a polish, it would form an elegant ornamental stone. A third variety exhibits a semi-crystalline aspect, and contains minute scales of mica. This variety is traversed by veins of granite, composed of quartz and flesh-colored feldspar. (Nos. 380 to 383.)

For the most part, this rock exhibits scarcely no marks of stratification. But not unfrequently, even in the most highly indurated masses, the traces of a former slaty structure are distinctly visible. In short, it is quite obvious, that it is the graywacke slate, which has been subject to a heat so powerful as to indurate, and for the most part, to melt it. I think it would be easy to collect specimens exhibiting almost every gradation from graywacke slate to flinty slate.

In the southeastern part of the above sketch, the granite cuts off the graywacke slate at right angles to the general course of the layers: and the slate is indurated only a few feet from the junction. The junction between the granite and the siliceous slate is obvious in several places, particularly at a ledge at the southwest extremity of the granite: and the two rocks are so firmly united as to separate no easier than in any other direction.

The graywacke slate of this spot has generally the shining or glazed appearance of the oldest varieties of argillaceous slate: but in the extensive excavations that have been made in it, for the con-

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struction of Fort Adams, we see frequent examples of a brecciated or conglomerated structure. It is also traversed by numerous small veins of white quartz, sometimes combined with flesh colored feldspar.

The serpentine is separated from the granite by a strip of flinty slate. At its eastern extremity it seems to lie between the flinty slate and the graywacke slate, and to have a stratified structure. But it probably extends to the southwest, (as shown on the sketch by the crosses,) so as to cut across the northwestern point of the siliceous slate. A valley passes through the flinty slate in the direction in which the serpentine runs, and at its extremity, serpentine appears in small masses attached to the flinty slate. It probably forms a sort of vein in the slate, though hid by the loose soil, and at its northeastern extremity the graywacke slate lies immediately north of it, as shown on the preceding sketch. I am inclined to believe, however, that the serpentine was originally interstratified with, or formed a bed (if that term conveys any definite meaning,) in graywacke slate: though the extreme degree of contortion in the slate, where the two rocks join, renders it not easy to decide that point. The serpentine is compact, very hard, and of a very dark color. It might easily be mistaken for greenstone.

The limestone forms a small island, a little distance north of the serpentine; also a small point projecting into the harbor, near Fort Adams. It is entirely destitute of stratification, is perfectly compact, and nearly as hard as quartz. Its general color is a grayish white; but it abounds in gray spots, which resemble chert. (No. 495.) Indeed, the whole mass seems to be well advanced in the process of conversion into that substance. This seems to be the case referred to by Dr. Macculloch, when he says; "an attempt to the production of this rock (chert) is often observed where the process is still incomplete: and it is evinced by the extreme hardness which such limestones exhibit in the vicinity of granite."* He refers here to the primary limestones, which are intermingled with siliceous and argillaceous matter: and that the limestone at Newport is primary, in the sense in which Dr. Macculloch uses the term, is evident from the fact, that near the serpentine, a portion of it is seen in the form of a bed, between the layers of graywacke slate: and the limestone associated with this rock, is precisely the kind that is apt to contain a considerable proportion of siliceous and argillaceous matter. In ordinary cases, limestone is rendered more crystalline by the proximity of

* System of Geology, Vol. 2. p. 285.

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granite: but where a certain proportion of argillaceous and siliceous matter is contained in it, the effect of heat will be to render it more hard and compact.

A portion of the graywacke slate near Fort Adams is converted into jasper. But a more particular description must be deferred till I have finished what I have to say concerning flinty slate and chert. I shall also have occasion to speak again of the striking evidence, which the group of rocks above described in Newport, furnishes, of the igneous origin of granite.

### *Flinty Slate of Nahant.*

The greater part of this promontory is sienite. But enough of the argillaceous slate remains at its southeastern extremity, to show the geologist the influence of trap veins in passing through it. These are quite numerous, both in the slate and in the sienite; and sometimes the greenstone is intruded laterally between the strata of slate, in the form of beds. Yet the general dip and direction of the slate appear to be but little affected by these veins, although they frequently constitute more than half the rock. For the basset edges of the slate run nearly east and west, and dip northerly; which corresponds with the general direction and dip of the argillaceous slate in that region. Nearly all the slate, however, on this promontory is much indurated; and a considerable proportion of it converted into genuine flinty slate. The slaty structure is rarely lost, except at the junction of the greenstone and slate, where the two rocks are so intimately blended, that it is not easy to fix upon the spot where either of them commences. This corresponds with the opinion of Dr. Macculloch, that nothing but the requisite degree of heat is necessary to convert argillaceous slate into greenstone. (Nos. 383 to 385.)

### *Chert.*

I have already described a conatus for the production of chert from the Newport limestone. But at Nahant the process seems in some cases to be nearly or quite completed. One observes there, that a considerable proportion of the flinty slate contains layers of a light gray substance, somewhat resembling in aspect and fracture, certain varieties of pottery. (No. 386.) On examination we find intermixed with this substance, a compact or even semi-crystalline limestone. In short, we observe every degree of induration and compactness from limestone to chert. There can be little doubt, it seems to me,



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that this is a genuine case of the conversion of argillaceous limestone into chert. For, says Dr. Macculloch, "originating in limestone, the transition from that rock into the chert, is often so gradual, that no precise point can be assigned where the term indurated limestone is no longer applicable."* None of it, however, at this locality has that chalcedonic aspect which highly indurated chert often exhibits.

*Jasper.*

The jasper in Newport, to which I have already referred, occurs a few rods south of fort Adams. Two or three large blocks of graywacke slate lie upon the shore, a considerable part of which has been converted into red jasper, often mixed with a greenish, translucent, siliceous mineral, so as to form an imperfect heliotrope. Before the mouth blowpipe the greenish variety undergoes no change, except a loss of color: but the red variety loses its color, and becomes slightly glazed at the surface. (Nos. 387, 387 1-2.)

The manner in which this jasper has been produced, appeared to me quite obvious: indeed, if I mistake not, we see the various steps of the process. The rock contains a considerable quantity of the magnetic oxide of iron; which, according to the latest writers,† consists of one atom protoxide and two atoms of peroxide. Now the effect of heat would be to convert this moiety of the black protoxide into the red peroxide; and the iron would serve also as a flux for the fusion of the slate; and thus genuine jasper would be produced: for according to Mohs, "jasper, with its various kinds, is formed, if besides the oxide of iron, clay enters into the mixture, &c."‡ Those parts of the rock with which the iron did not mingle, would form hornstone or heliotrope; the latter deriving its green color from the slate, which has a greenish aspect. As the vicinity of this locality exhibits so many marks of the former action of powerful heat, can we doubt that in this manner the jasper was produced? and can we doubt but granite was the powerful igneous agent employed?

Saugus has long been known as a locality of fine jasper. It exhibits a blood red, and generally uniform color; though sometimes striped and clouded with white, so as to be very elegant when polished. (Nos. 388 to 390.) I have been surprised, however, to find

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* System of Geology, Vol. 2. p. 284.

† Thompson's Chemistry of Inorganic Bodies, Vol. 1. p. 487. Edinburgh, 1831.

‡ Mohs' Mineralogy, Vol. 2. p. 328. Edinburgh, 1825.

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how easily it may be fused by the common blowpipe, into a white semi-transparent enamel, containing bubbles: and I can have little doubt but it ought to be referred to compact feldspar, which conducts precisely in this manner before the blowpipe. I am inclined, however, to believe that it contains some argillaceous matter; and it must contain the red oxide of iron to give it its color. It occurs a few rods east of the hill of varioloid wacke, which has been already described, as composed of wacke and numerous nodules of compact feldspar and limestone. Now I suspect that the action of granite on this rock, has converted a part of it into this pseudo-jasper. For granite appears in place only a few feet distant from the jasper; though the actual junction is hidden. If this be the true theory, then the composition of the varioloid wacke is the same as that of the jasper; and since compact feldspar predominates in the former, it probably does in the latter. And if I mistake not, very much of the compact feldspar in the vicinity of Boston abounds in argillaceous matter, as well as iron. In Hingham, indeed, it greatly resembles the Saugus jasper, though of not so rich a color.

13. *Graywacke Limestone.* I have already stated the reasons that induce me to believe the indurated compact limestone of Newport to belong to the graywacke formation: and I have nothing more to add in this connection.

There is one other bed of limestone, which I strongly suspect should be referred to this formation; viz. in the west part of Walpole. When I visited the spot, I had no suspicion that this rock had any connection with the graywacke; especially as I observed sienite within a few rods of it. Nor do my notes furnish any very decisive evidence either way as to this question. The dip of its strata, which is about 45° N. W. is the most important circumstance. For I find that the red quartz rock and talcose aggregate, which have been described as occurring to the west of Walpole meeting house, have nearly the same dip and direction, and are succeeded on the west by sienite. Hence I suspect that the limestone, which lies two or three miles southwest from those rocks, may be connected with them: and especially when I recollect, that in all other cases where I have found limestone connected with sienite, it is very white and destitute of stratification: whereas that at Walpole, as already remarked, is stratified and is of a gray color. Perhaps closer examination would discover organic remains. (No. 494.)

The bed of limestone in Bernardston is associated with argilla-

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ceous slate, or quartz rock, and contains encrinites; so that probably its age corresponds with that of graywacke. But as it is entirely disconnected with the graywacke, I shall defer a description of it till I speak of the limestones.

### *Topography of the Graywacke.*

I have anticipated so much of this head, that brevity may now be consulted. It will be seen by the map that this formation is confined exclusively to the eastern part of Massachusetts and Rhode Island; and that it exists in several detached patches. On the second, or the present edition of the geological map, I have connected the strip of graywacke passing through Dedham, Walpole and Wrentham, with the broad deposite south of the last named place. Nor should I be surprised, if future observers should discover a connection between the graywacke range in Dedham, Canton, and Randolph, and that in Quincy, Dorchester, &c.; although I failed in finding it. The fact is, this rock in no place rises into any thing like mountain ridges; and for the most part, it occupies extensive plains, or gently undulating ground. Diluvium, also, is extremely abundant over almost every part of it; so that it is only occasionally, and often at distant intervals, that graywacke is seen in place. This is particularly the case in the most extensive tract of the graywacke, which embraces the greater part of Rhode Island, with nearly every other island in Narraganset Bay, and a strip of uncertain width on the west shore of that bay, as well as a narrow tract on the east shore in Little Compton; and as it extends northerly into Massachusetts, occupies the surface of nearly twenty towns in Bristol and Plymouth counties. In Swansey and Somerset, the most abundant conglomerate of this formation, (which for the sake of distinction I shall call the Roxbury conglomerate, because in that place its characters are strongly developed,) forms several hills of one or two hundred feet in height, producing striking outliers in the landscape. In Dorchester, Roxbury, Newton, Brookline, and Brighton, the hills of the same rock are of moderate elevation; rarely exceeding 200 feet: yet this is the most hilly part of the graywacke formation in Massachusetts. Now its low level and the abundance of transported fragments that overspread it, render it extremely difficult to ascertain its limits.

On the first edition of the map, I put down a patch of graywacke in Duxbury. But on more mature reflection, I feel satisfied that I have not evidence enough, that the slaty epidotic rock which occurs

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in that place, belongs to this formation. That it is not the classical graywacke, I am certain: nor do I feel satisfied what are the ingredients that compose it; though I suspect the presence of compact feldspar in considerable quantity. Its dip and direction coinciding with those of the graywacke, I was led to suspect that it might be one of the anomalous varieties of that rock. But I shall place the specimens in the collection among those from the gneiss formation; hoping that some geologist will be able to examine this rock carefully in its native situation. This I had not time to do when I passed through the place. And I think it better that it should not be noticed on the map, than be referred to any formation with no more evidence of its true nature than I at present possess.

It appears then, that all of the graywacke formation lying south of the Blue Hills, in Massachusetts and Rhode Island, forms but a single tract. The slaty varieties predominate on the west side of this tract; and on some of the islands in Narraganset Bay, this slate appears to be passing into the primary schists, particularly into mica slate. The red quartz rock is most abundant in the south part of Wrentham near the coal mine, and in that branch of the deposite, which occupies the north part of Randolph. It occurs, also, in the west part of Walpole, as already noticed, and likewise in Abington. And from the bowlders of this rock which I noticed in Scituate, mixed with the granite, I am suspicious that it may be found in place from Abington to the coast, in a northeast direction; though I searched for it in vain.

Around Boston we find another tract of the graywacke, occupying a basin, of which the Blue Hills form a southern boundary; the porphyry hills of Lynn and Malden a northern, and the greenstone ranges of Weston and Waltham, a western boundary. The argillaceous slate connected with the graywacke, is all found along the northern and southern sides of this basin, as may be seen by the map. The central parts are occupied by conglomerates and graywacke slate.

I have already suggested the probability that Boston Harbor was produced by the wearing away of the graywacke formation. That this series of rock once occupied the harbor, is obvious from the character of the islands, which are evidently the remnants of a once continuous formation. It is true that these islands are for the most part covered with diluvium: but sometimes on their shores, we find rocks in situ; and in such case I have regarded the whole island as

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composed of the rock which is thus developed. On this principle, the geological character of the principal islands in this harbor may be set down as follows:—

| | | | |
|---|---|---|---|
| Noddle's | Diluvial. | Moon Island — Conglomerate | |
| Castle | | | |
| Thompson's | | Hangman's Island — Sienite | |
| Spectacle Islands | | | |
| Long Island | | Rainsford Islands | Argillaceous Slate |
| Pedock's | | Middle & Outward Brewster | |
| Gallop's | | Boston Light | |
| George's | | Egg Rocks | |
| Lovel's | | Calf Island | |
| Deer Island | | Green's Island | |
| Apple | | Governor's Island | |
| Great Brewster | | | |

It will be seen that argillaceous slate is the predominating rock on the outermost of these islands. In general it is quite hard, and has so little of a slaty structure, that one might well hesitate to call it argillaceous slate. Frequently it appears to be a coarse variety of novaculite. Argillaceous slate likewise appears on the southern side of the promontory of Hull; although the surface is for the most part diluvial.

There can be little doubt that the peninsula of Boston has a foundation of argillaceous slate. This is, indeed, the only rock that has ever been found there in place. And from the occurrence of argillaceous slate in South Boston, and in Charlestown, with a northerly dip in both places, it would be very surprising if any other rock should be found in Boston; unless it were an intruding mass of trap rock. But the slate on the peninsula is buried deep by clay, gravel, and sand; although, from the quantity of diluvium found there above the tertiary beds, I have been led to color the peninsula as a diluvial deposite.

The only remaining tract of graywacke to be noticed, is one of limited extent, along Parker River in the south part of Newbury, and extending I believe into Rowley. It consists of gray red and variegated slates, slaty compact feldspar, with talc, and a conglomerate resembling that in Roxbury. Red compact feldspar lies between this rock and the sienite; and some of the nodules of the conglomerate consist of the red compact feldspar. This tract of the graywacke appears to be very interesting, and deserves a more thorough examination.

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### *Direction, Dip, and Thickness of the Strata.*

Graywacke is celebrated in other countries for the irregularities of its stratification, and the tortuosities of its slaty varieties. Nor is this rock in New England lacking in these characteristics. The observer will be satisfied, after an extensive examination, that the predominant direction of the strata of this rock is not far from east and west, and the dip northerly, generally approaching to 45 degrees. But he will be surprised to find in the western part of the principal deposit, viz. from Randolph to Providence, and so on to the southern extremity of Rhode Island, that the direction of the strata is nearly north and south, and the dip east. The following table exhibits the dip and direction of this formation in various places, as I find them in my notes.

| | *Direction.* | *Dip.* |
|---|---|---|
| Mansfield, . . . . | N.W. and S.E. | 45° N.E. |
| Berkley, . . . . . | N.E. and S.W. | N.W. small. |
| Attleborough, (west part,) . | North and South. | East, small. |
| do. (center,) . . | do. | 50° West. |
| Walpole, . . . . . | N.E. and S.W. | 50° to 60° N.W. |
| Pawtucket, (Graywacke Slate,) | S. 20° West. | 70° easterly. |
| From Providence to Warren, Rhode Island. | N. and South. | 45° East. |
| Seekonk, . . . . . | do. | 10° East. |
| Portsmouth, R. I. (Slate,) . | N.E. and S.W. | S.E. 40° to 90°. |
| Newport, R. I. near Fort Adams, (Slate,) | N. and South. | 5° to 10° easterly. |
| do. South part, (do.) | E. and West. | Various. |
| do. Southeast part (do.) | N. and South. | 60° to 70° West. |
| do. do. Purple Quartz Rock, | N. and South. | 80° East. |
| West side of Narraganset Bay (Slate,) | N. and South. | 10° to 15° East |
| Middletown, R. I. Blue Quartz Rock, | N. and South. | E. 80° East. |
| do. do. Amphibolic Aggregate, | N. and South. | 60 to 70° West |
| Between Warren and Bristol, Rhode Island, | E. and West. | 10 to 20° North. |

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| | *Direction.* | *Dip.* |
|---|---|---|
| Tiverton Bridge, R. I. (Slate,) | N. and South. | 45° West. |
| Little Compton, (Slate,) | N.E. and S.W. | |
| Fall River, (Troy,) Slate and Quartz Rock, | E. and West. | 45° North. |
| Swansey, (Conglomerate,) | East and West. | 35 to 40° N. |
| West Bridgwater, (Slate,) | do. | 30° North. |
| North Bridgwater, . . | do. | Northerly. |
| Canton, . . . . | do. | 25 to 50° N. |
| Milton, . . . . . | do. (nearly,) | 60 to 70° N. |
| Newton — north part, . | do. | 30° North. |
| Cambridge, . . . . | do. | 60 to 70° N. |
| Watertown, . . . | N.E. and S.W. | 90°. |
| Dorchester, (Conglomerate,) . | S.E. and N.W. | 15 to 30° N.E. |
| Roxbury, (do.) . . | do. | do. |
| Natick, (Slate,) . . . | N.E. and S.W. | 45° N.W. |
| Newbury, (Slate and Conglomerate,) | East and West. | 45° N. |
| Milton, (Argillaceous Slate,) | do. | North, large. |
| South Boston, do. | do. | 50 to 60° N. |
| Nahant, do. | do. | 30 to 40° N. |
| Hull, do. | do. | 60 to 70° N. |
| Rainsford Islands, do. | N.E. and S.W. | Nearly 90° S.E. |
| Charlestown, do. (near the Insane Hospital,) | W. a little N. | 50° S. E. |
| do. do. (in a quarry,) | North and South. | 10° W. |
| do.* do. (Winter Hill,) | East and West. | 15 to 20° N. |
| do.* do. (Near the Powder House,) | E. and W. nearly. | 15° N.N.E. |

The predominant direction of the strata in this formation may be seen on the annexed map, (Plate XVI.) which shows the general direction of all the strata in the State. Local exceptions, unless of great extent, cannot of course be shown on a map of such limited size. These exceptions are so numerous in the preceding table, that one might be disposed to question whether any parallelism in the direction, or uniformity of dip, can be made out. But extensive examination will satisfy any one of the truth of the general state-

* Professor Webster: see Boston Journal of Philosophy, &c. Vol. 1. p. 280, et seq.

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ment made above, that the prevailing direction is easterly and westerly, and the dip northerly, with the exception there named in Rhode Island, and of a tract from Rhode Island to Randolph. Whether there is a particular line along which the strata change suddenly in their direction from north and south to east and west, or whether the change is gradual, I have not been able to determine; though inclined to believe it sudden. The central parts of the tract, near where the change must take place, is so covered with diluvium as rarely to exhibit rocks in place. As to the cause of this anomaly, I am disposed to believe that this graywacke belongs to two systems of elevation; the one running nearly east and west, and the other nearly northeast and southwest. In the conclusion of my Report I shall examine this subject more particularly.

It will be seen from the preceding statement of the direction and dip of the strata, that there is much irregularity in the position of the argillaceous slate connected with the graywacke; particularly in Charlestown. But this in general is easy to be explained, by the intrusion of masses of greenstone, or the proximity of sienite.

The slaty structure of the slates included under graywacke, does not always coincide with the stratified structure. I have observed this to be the fact, particularly with a variety of the red quartz rock, which in Randolph, Walpole, Wrentham, &c. become slaty, by taking into its composition a larger proportion of talc.

In South Boston, and on Rainsford Islands, the argillaceous slate contains a double set of seams, oblique to the strata seams; and thereby the rock is divided, often with great regularity, into tables with rhombic or trapezoidal faces. (Nos. 360, 361.)

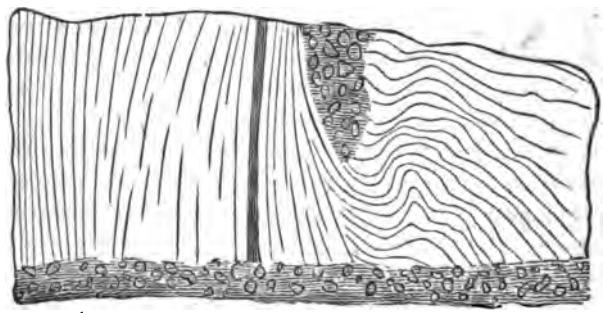
In general, I doubt whether the argillaceous slate and the graywacke slate of this formation, exhibit such striking tortuosities in their layers, as European geologists describe in the corresponding rocks in the eastern world. In some places, however, these curvatures are remarkable enough in New England. On Rainsford Islands the argillaceous slate, although unusually fissile, is bent so as to form a semicircle within the space of a very few inches. (No. 362.) But in the southern part of Newport, Rhode Island, in the vicinity of granite, we find the most remarkable curvatures in the graywacke slate.

The following sketch was taken from a cliff on the south east shore of that town. It is from 15 to 20 feet high, and 30 or 40 long, and the drawing does not at all exaggerate the tortuosities and irreg-



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ularities of the slate. The dark strip is a bed of anthracite a few inches thick; and the dotted part shows where the diluvium has slidden down upon the rock. The slate is so highly impregnated with carbon as to be quite dark colored, and might perhaps be denominated shale. Near the anthracite bed it abounds in vegetable remains. I could discover no strata seams distinct from those that separate the layers of slate; and it is very doubtful whether this rock ought to be regarded as stratified at that place.



Coast Section in Graywacke Slate: Newport R. I.

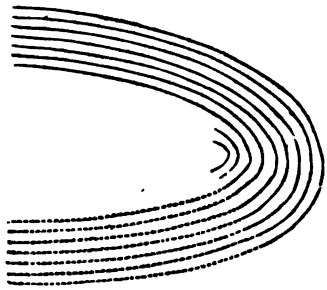
It is obvious that this slate must have been bent into its present form while yet in a plastic state; although its elevation to a nearly perpendicular position, might have been the result of a subsequent convulsion. It will be recollected, that in giving a history of our tertiary strata, I have exhibited some remarkable examples of tortuosity in the clay beds, which bear a strong resemblance to the one figured above; and perhaps both were produced in a similar manner, however difficult it may be to assign any adequate cause. Other similar cases I shall describe when I come to speak of mica slate and gneiss.

In another place on the same coast, near where the preceding sketch was taken, the graywacke slate seems to have assumed the form of a paraboloid, or an ellipsoid, whose longer axis coincides nearly with the meridian. The upper part of this paraboloid having been worn away, leaves the basset edges of the slate as exhibited below.

The dotted portion in the following sketch, is covered by debris and sand; but very probably the position of the laminae is as represented. The dip of the slate is outward on every side; or in such a direction as it would be, if the layers curved around a paraboloid, or ellipsoid, from which a segment had been cut off.

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The proximity of granite explains satisfactorily the very great irregularity in the position of the graywacke slate in Newport.



From the various statements which I have made in relation to the geology of Newport and its vicinity, it will be obvious that it is very rare to find so many objects interesting to geological curiosity brought within so narrow a compass.

As to the thickness of the graywacke formation, I am very much in the dark. I am inclined, however, to believe that its perpendicular thickness must be rather small. The want of lofty hills in this formation, and the marks of powerful abrasion every where exhibited, both in the loose fragments and in occasional outliers, have impressed me with the idea that it was once far more extensive than at present. It might not, indeed, have covered all the space that now intervenes between its several tracts: but I see no reason why much of that space might not have been occupied by it: although I confess that this opinion is little more than hypothesis.

### *Mineral Contents.*

By far the most interesting and important mineral in the graywacke formation is anthracite. Its most abundant and best known locality is in Portsmouth, near the northern extremity of Rhode Island. It was explored there somewhat extensively near the beginning of the present century; and Dr. Meade says, that the vein then wrought, was 14 feet wide; and "with only fifteen workmen, they can raise at present from 10 to 20 chaldrons of coal per day, besides keeping the mine free from water; from which they suffer little inconvenience."* He speaks of the bed of coal as "not horizontal or vertical, but forming an angle of about 75°."

* Bruce's Mineralogical Journal, January, 1820, p. 84.

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A variety of causes led to the abandonment of these explorations: but a few years since they were again resumed; and through the kindness of Dr. Thomas H. Webb, of Providence, I have before me a letter addressed to that gentleman, from J. Clowes, the intelligent agent employed to superintend this second exploration; from which I derive the following facts respecting the anthracite of Portsmouth. The letter is dated February 18th, 1828; which appears to have been about the time when the work was the second time abandoned.

The quantity of anthracite raised at these mines in 1827, by 20 men and five boys, was 2200 tons, and an equal quantity of *slack:* that is, very small coal and dust. The former sold at the mine for $4 1-2 per ton, of 2240 pounds; and the slack for one dollar per ton. The slack was used for burning lime and bricks. The best coal was mostly employed for fires in families, except in New York, where it was used for making glass; for generating steam under the common circular or round boiler; for blacksmiths, and in general for any purpose where anthracites are employed.

The agent regards these mines as capable of furnishing an inexhaustible supply. He represents the coal as occurring in veins; but his descriptions apply rather to beds; and I am almost certain that it occurs in beds. Six of these have been exposed; and more than 30 are said to exist in that part of Rhode Island. Their direction is south west and northeast, and they dip southeast from 40° to 90°.

The following are the strata that were penetrated in sinking a *water shaft*, or *engine pit*, 87 feet; and in fifteen other places they were found to be very similar.

| | |
|---|---|
| Sand and gravel, | 9 feet. |
| Dark colored slate, | 12 |
| Hard compact graywacke, | 23 |
| Soft black slate, | 4 |
| Hard brown slate, | 5 |
| Soft fine gray slate, | 1 |
| Very hard brown slate, | 17 |
| Gray freestone, | 12 |
| Coal, | 4 |

Vegetable remains were found only in one of these excavations, about nineteen feet below the surface.

The failure of the mining operations in Portsmouth, between the years 1809 and 1816, resulted, according to Mr. Clowes, from two general causes: 1. A want of practical skill in those who conducted

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the operations. This prevented as much system in the works as was necessary, and also the introduction of proper and economical machinery. And he says, that "amongst the many losses, which contributed to work their ruin, that was not the least, of allowing, or permitting the workman to have from half a pint to a pint of spirituous liquors during the working hours. We neither allow nor permit any thing of the sort, nor is it allowed or permitted in any mining establishment in Europe. Instead of benefiting a man, it actually incapacitates him: and exclusive of the immoral effects on the passions of the workmen, I consider it a loss to the owners of at least one sixth the whole manual labor."

The second cause of failure, he says, lay in sending the coal from the mines in an improper state; that is, unsorted, and in too large lumps. He says that the R. Island coal does not break easily when ignited, like the Lehigh coal, and that this fact and the amount of impurities which it contained, injured its reputation in the market. He thinks that if mixed in equal quantity with the Pennsylvania or bituminous coal, it answers best for fuel: and he says he has abundant evidence, that one ton of the R. Island coal, mixed with a ton of that from Pennsylvania, are equal to two tons of the anthracite from the latter state.

These facts, coming as they do from a practical and intelligent man, I thought deserving of a place in this Report: for they render it probable to my mind, that the Rhode Island coal may be again wrought ere many years. At present the prejudice against it in market is so strong, that the owners have been obliged to abandon its exploration.

I have already mentioned that beds of anthracite, a few inches thick, occur in the south part of Newport in graywacke slate. In the war of the Revolution, the British troops, after consuming nearly all the wood upon the island, endeavored to find coal at this place; and the marks of their exploration still remain.

On the map I have represented a bed of coal as existing near the east line of Cumberland, another in the north part of Middleborough, a third in West Bridgwater, and a fourth in Wrentham. I could not learn that much of this mineral had been obtained at these places. The search for coal in Weymouth, mentioned in a note to the first part of my Report, first edition, has not I believe been successful.

An exploration is now going on in the south part of Wrentham, principally by boring. In one place they have penetrated 180 feet

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into a dark colored or anthracitous slate, which runs nearly east and west, and dips north about 45°. But in no place have they found pure coal: nor has any bed, even of that which is impure, been discovered more than eighteen inches thick. The specimens hitherto obtained, (No. 401,) are much mixed with pyrites and slate.

It struck me that boring perpendicularly is not the most judicious method of searching for coal at this place. I take it to be quite certain, that the coal always occurs in layers between the laminæ of slate, and never in veins; such a thing as a genuine vein of coal being, as I suppose, inconsistent with the known laws of chemistry. Hence then, as the strata dip 45° at this place, if a trench be dug deep enough to lay bare the basset edges, crossing them at right angles, it must certainly reveal all the beds of coal which the rock contains. And since the loose soil is not more than ten feet deep, this must be certainly the most economical course. The discovery of beds of coal in other places by boring, leads often, I believe, into error: for generally the strata containing coal are horizontal; and then boring alone will bring the beds to light: but where they are highly inclined, it is working to great disadvantage to bore into them perpendicularly. I have found several times that foreign miners, who are ignorant of the principles of geology, have led our citizens astray by assuring them that the coal or the ore they are in pursuit of, lies deep; merely because such was the case in the particular mine in Europe with which they were acquainted.

In all the cases mentioned above, the anthracite occurs in a slaty rock, either gray or nearly black, which is associated with coarser aggregates. Many geologists would denominate this slate *shale:* but I should rather term it argillaceous slate, or graywacke slate; because I prefer the system of Macculloch, which regards no rocks as shale, which lie as low in the series as graywacke.* (Nos. 358 and 395 to 399.)

In no case have I found anthracite in any of those anomalous varieties of the graywacke group, which I have described; such as the breccias, amphibolic, quartose, and talcose rocks. These I regard as the oldest varieties of this formation; and the anthracite I suspect occurs among the higher members of the series. I know of no reason, however, why this mineral should not be found in the oldest varieties. That the slate in which it is found in Rhode Island, is

* Classification of Rocks, p. 455. Also System Geology. Vol. 2. p. 248.

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closely allied to primary rocks, is obvious from the fact it abounds in veins of asbestus — and the same mineral penetrates the anthracite.

So full a description of the external characters of the Rhode Island anthracite has been given by Prof. Silliman, in his Journal of Science,* that it seems unnecessary to repeat it in this place. I shall merely notice some peculiar characters, which, if I mistake not, have an important bearing upon the theory of the origin of this mineral and its connection with plumbago. In comparing this coal with the anthracite from Pennsylvania, one is struck with the superior semi-metallic or plumbaginous aspect of the former; as I have already remarked. But mere resemblance to plumbago is not all: for, says Professor Silliman, "many of its surfaces are covered with a thin film of a substance not to be distinguished from plumbago, as it has the same lustre and softness, and stains the fingers and marks paper in the same manner. A true plumbago is found occasionally among the slates which accompany this anthracite." But in respect to the Pennsylvania anthracites he says, "there is rarely on these surfaces a plumbaginous aspect; and when it exists, it is less remarkable than in the Rhode Island coal." In the Worcester coal, I would also state, that the metallic aspect is much more distinct, and the quantity of the substance "not to be distinguished from plumbago," much greater. Indeed, several tons of it have been ground and sold for plumbago.† The anthracite found at Cumberland, Rhode Island, also, "is more slaty than that of Portsmouth, it soils the fingers more, and approaches graphite."‡ The specimens from the recent exploration in Wrentham, bear a resemblance in appearance to the anthracite from Rhode Island.

Now do we not ascertain from the preceding facts, a gradual passage from anthracite to plumbago? And if my view of the relative age of the Pennsylvania, Rhode Island and Worcester anthracites, as they have been expressed in the first part of my report, are correct; we see that this gradation corresponds to the relative antiquity of the rock containing the mineral: that is, the older the rock, the nearer does the mineral approach to plumbago. I may not indeed, have shown very conclusively that the graywacke formation of Massachusetts and Rhode Island is older than the anthracite formation of Penn-

* Vol. 11. p. 87.

† Robinson's Catalogue of Minerals, p. 78

‡ Cleavland's Mineralogy, vol. I. p. 501.

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sylvania; though the greater dip of the slate, as a general fact, in the former, its more crystalline aspect, and the occurrence in it of crystallized veins of asbestus and quartz, render this opinion probable. But as to the anthracite formation in Worcester, it will be easy to prove, in the proper place, that it is older than either of the others above mentioned: and here it should be recollected we find the nearest approach to plumbago.

The anthracite from these different localities exhibits, in its specific gravity, a correspondent approach to plumbago. According to Dr. Thomson,* the specific gravity of plumbago varies from 1.9 to 2.32: but according to Beudant,† from 2.08 to 2.45. The first named author says, that he has never met with any anthracite whose specific gravity was as great as 1.5: Beudant, however, says it varies from 1.5 to 1.8. Now according to Mr. Bull, the mean specific gravity of the Pennsylvania anthracite, from five localities; is 1.436.‡ He states also the specific gravity of the Rhode Island coal to be, 1.438: But Prof. Silliman, who appears to have conducted the process with great care, states the Pennsylvania anthracite to have the mean specific gravity 1.55, and that from the Rhode Island, 1.75.‖ Mr. Bull places the Worcester coal at 2.104. Upon the whole, though there is not a little discrepancy in the above statements, we may, I think, safely infer, that the Rhode Island coal is heavier than that from Pennsylvania; and the Worcester coal the heaviest of all, and nearly equal to plumbago.

There is another fact that deserves to be noticed in this connection. Plumbago, it is well known, contains so much iron, that some chemists regard it as a carburet of iron. Now from the analysis of Mr. Vanuxem,§ it appears that the Rhode Island anthracite contains a much larger proportion of the oxides of iron and maganese, than that from Pennsylvania; even more than some specimens of plumbago. Do we not in this circumstance perceive another evidence of an approach to that mineral in this ancthracite? I am not aware that the Worcester anthracite has been analysed; nor have I time to attempt its analysis before completing this Report.

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* Inorganic Chemistry vol. 1. p. 155.

† Traite de Mineralogie vol. 2. p. 262.

‡ Chemistry of the Arts. p. 33.

‖ Journal of Science, vol. 11. p. 89 and 92.

§ American Journal of Science, vol 10. p. 102.

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European geologists have satisfactorily traced the progress of vegetable matter from the living vegetable into peat, thence to bituminous coal. They have, also, rendered it probable, that anthracite is only another step in the process; although some of them still doubt the vegetable origin of this variety of coal. And in regard to plumbago, the predominant opinion I believe is, that it has been produced from elementary, rather than organized carbon. Dr. Macculloch, however, says, that "the coal of secondary origin, containing vegetable remains is converted into plumbago by the influence of trap; as wood has been in my experiments, and as coal is, daily, in the iron furnaces; so that even the plumbago of the primary strata, no less than the anthracite, might as well have originated in vegetables, as that each of them should owe an independant origin to elementary mineral carbon."*

Elie de Beaumont has also given an account of anthracite, which is associated in the Alps with graphite in clay slate, reposing on lias. "This graphite," says he, "is found in a bed of argillaceous slate which contains vegetable impressions, similar to those which accompany other deposits of anthracite in that country. This slate exhibits on the surface of these impressions minute veins of anthracite, and it forms a part of a series, in which, both above and below, workable anthracite shows itself: all which proves that the graphite is only a modification of the anthracite. This modification appears to be connected with the presence of certain feldspathic rocks, which are probably only the ramifications of a huge mass of feldspar situated near."† If I mistake not, the circumstances under which these varieties of carbon occur in this country, throw some light on these enquiries, and render probable the suggestions of Dr. Macculloch. The great number of vegetable remains found in connexion with the Pennsylvania and Rhode Island anthracites, must, it seems to me, satisfy every reasonable man of the vegetable origin of this mineral in these instances. But a plumbaginous substance occurs with the Rhode Island coal, and the coal itself seems to be passing into plumbago. Still more near to plumbago do we find the Worcester anthracite, and a part of the bed is probably real plumbago. Here, however, we find no vegetable remains, retaining their organized form, because the rock belongs to the primary class; being for the most part a bastard kind of mica slate. Advancing one step farther, we find in the gneiss rock

* System of Geology vol. 2. p. 297.

† Annals des Sciences Naturelles, Tome 15. (1828.) p. 377.



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of Sturbridge—probably the oldest of all rocks—a bed of well characterised plumbago. How very probable that all these varieties of carbon have the same, and that a vegetable origin? How unphilosophical, when we can thus trace nearly every step of the change, from one variety into another, to call in the aid of other causes to account for the origin of one of them? We see here only the operation of the cause, or causes—whatever they were—by which, as we descend from the newer to the older rocks, they exhibit less and less of a mechanical, and more and more of a chemical arrangement of parts, and fewer and fewer traces of organic remains: until, in the primary rocks, these relics are nearly or quite obliterated. Why should we doubt the operation of such causes upon coal, any more than upon other mineral masses? and if we do grant this, we have an easy and satisfactory explanation of the mode in which all the varieties of carbon were produced, except perhaps the diamond: and from the fact that the diamond breccia of India is surrounded by, and based upon granite, we may reasonably conjecture that this mineral has been produced from vegetable carbonaceous matter, that has been fused, (for Prof. Silliman has proved that it is fusible) and subsequently crystallized.* And if it be true, that secondary coal is sometimes converted into anthracite and plumbago by the influence of trap, why should we doubt but heat has been the agent of those changes in every case; especially as it is difficult to conceive how any other agent could have given to rocks and minerals of a mechanical origin, a crystalline or sub-crystalline structure.

It will be perceived that I have anticipated some statements in respect to the Worcester anthracite and the Sturbridge plumbago. This I have done that I might treat of their origin together, to avoid repetition.

I have said so much in the first part of my report, in respect to the economical uses of the anthracite of our graywacke formation, that I need add nothing here. I cannot, however, but express my surprise, that the ablest European geological and chemical writers should still represent anthracite as of little or no use, except for furnaces; when, for the last ten or fifteen years, so many thousand tons of this mineral have been used in our principal cities, along the whole Atlantic coast, in the parlour, the study, and the kitchen; and so much has been said of its value in our scientific and other periodical journals.

* Edinburgh Journal of Science, Vol. 10. p. 184.

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"In an economical light," says Dr. Macculloch, "it must be fruitless to search for coal below the old red sandstone, and, generally speaking, beneath the mountain limestone; as to mine after primary coal (anthracite as I understand him,) would be a wild project."* "Anthracite," says Beudant, "on account of the difficulty with which it is kindled, cannot be employed but in furnaces with a good draught."† "The difficulty which is experienced in the combustion of anthracite," says Dumas, "is a very great obstacle to every economical use of that body.—It is possible, indeed, that anthracite will one day become useful in deep furnaces; although in almost every other process of the useful arts, its employment can be hardly practicable, on account of the high temperature which it requires to complete its combustion."‡

The other minerals that have been found in the graywake of Massachusetts and Rhode Island, are few and unimportant. It is hardly necessary to mention such common and widely disseminated minerals as iron pyrites, crystalline quartz, and calcareous spar. Magnetic iron ore and the micaceous oxide, have also been found in this group in small quantities: and I have already mentioned crystallized epidote, in the varioloid wacke. In the amphibolic aggregate, in Newport, I found a vein of crystallized zoisite, about four inches wide, and several feet long. In other parts of the globe graywacke is a repository of gold; and the clay slate connected with it, (transition clay slate,) contains the richest veins of silver in New Spain, according to Baron Humboldt.‖ But neither of these metals have been found in these rocks in Massachusetts.

In the varioloid rocks of Brighton, Professor Webster has found sulphate of lime and baryta. The latter is said to occur also in Milton: and also fibrous limestone in thin veins in wacke. Adularia and sulphuret of copper have been found also at Brighton. Efflorescent and massive sulphate of iron has been found, according to the Messrs. Danas, on the argillaceous slate in Charlestown.

Dr. Robinson says that the graywacke, near Providence, is traversed by veins of quartz, containing fluor spar.

In Brighton, in the varioloid wacke, I noticed fibres of green asbes-

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* System of Geology, vol. 2. p. 305. London 1831.

† Traite De Mineralogie, vol. 1. p. 717. Paris 1830.

‡ Traite de Chimie Appliquee aux Arts, vol. 1. p. 606. Paris, 1828.

‖ Superposition of Rocks, p. 105.

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tus traversing quartz, which, by the coloring matter of the asbestus, was converted into prase. (No. 391.)

*Organic Remains.*

Having been disappointed in several efforts to obtain organic relics in the graywacke formation, where I knew them to exist, I am prepared to give only a meagre account of them in this place.

All those which I have met with, were probably of vegetable origin.

In Taunton I was shown several imperfect specimens obtained near the village, which evidently belong to some of the gigantic races of plants now extinct, which flourished in the earlier periods of the world. I recognized them as bearing a strong resemblance to some of the larger species occurring in the coal mines in the valley of Wyoming in Pennsylvania: but having had no opportunity to compare these specimens with drawings, or descriptions, I can describe them only in general terms.

In Attleborough, east parish, a mile south of the meeting house, I found an organic relic in a dark hard slate, which so much resembles the Fucoides found in the new red sandstone of the Connecticut valley, that I cannot but refer it to that genus; not, however, without doubts as to its nature. (No. 400.)

According to Dr. Webb,* vegetable impressions are found on slate in Pawtuxet, which lies on the west shore of Narraganset Bay, south of Providence. They seem to belong chiefly to the fern tribes.

The same is true, I believe, of those found at the coal mines in Portsmouth. It was probably from this locality that the two specimens mentioned in De la Beche's Manual† were obtained. One is the fern *Pecopteris arguta;* and the other, the anomalous plant, *Asterophyllites equisetiformis;* which as yet has been referred to no established class.

In the southeast part of Newport, where occur some narrow beds of anthracite, vegetable remains are common. Of two of these I have given a sketch. Plate XI. fig. 10, bears considerable resemblance to an Equisetum, as figured by Adolphe Brongniart on plate 12, fig. 13, of his Vegetaux Fossiles. Plate XIII. fig. 43 may be a delicate species of Nevropteris of the same author. I noticed there some other species of the same genus.

* Am. Journal Science, vol. 8. p. 225.

† P. 416 and 419, second edition.

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Vegetable impressions have been found in considerable quantity at the excavations for coal in Wrentham. The most common is what I have supposed to be several species of Calamites, of Ad. Brongniart. Some of them are several inches in width; and are marked out on the rock by a plaited layer of green indurated talc—a most remarkable mineralizer! Plate XIII. fig. 41, represents a small portion of one of those Calamites, which exhibits numerous small seams running obliquely across the specimen, like the C. nodosus of Brongniart. On fig. 42 may be seen two quite different impressions: *a* and *b* are furrowed longitudinally, and appear to be branched: perhaps a part of an Equisetum. The other fan-like impression, with radiated stria, may perhaps belong to the genus Cyclopteris of Ad. Brongniart: though I am not without suspicion that this also may be an Equisetum.

### *Theoretical Considerations.*

In general the theoretical views that have been presented in relation to the origin of the new red sandstone, will apply to the graywacke. Two or three circumstances only, in relation to this latter rock, need any additional remarks.

One is the more decided evidence, which the graywacke presents, of the operation of chemical agencies in its production. This is obvious in the more crystalline aspect of the rock in general, and especially of certain varieties; and in the numerous veins traversing this rock, which must have resulted from a play of chemical affinities. It may be difficult, in the present state of geological science, to assign any satisfactory reason, why the older rocks, with some exceptions, are more highly crystalline than the newer. But if it be admitted that internal heat in the earth, which every thing proves must once have been very powerful, has been gradually operating less and less upon the crust of the globe, why is it not a natural inference, that the older the rock the more crystalline would be its structure: that is, if we admit that the heat has been great enough to change the arrangement of the particles of rocks, whose origin was mechanical: and it appears that such a change may take place, to some extent at least, far below a melting heat. Only admit then, that the graywacke is an older rock than the new red sandstone, (and it seems to me that the veins in the former are sufficient to prove this,) and we should expect in it a more chemical structure.

Another peculiarity in the graywacke, so far as we are acquainted

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with its organic remains, is, that all of them are of vegetable origin. Whether all of them grew upon dry land is not so certain; if, as I have suggested, a Fucoides occur in this rock. The beds of anthracite, however, prove that this rock was formed, in part at least, on a surface elevated above the waters. Yet we must call in the aid of powerful currents to account for the accumulation of rounded nodules, which are so abundant and so large in some varieties of this rock: and then the inclined position of the strata proves that they have been elevated since their deposition. Indeed, it seems difficult to explain all the phenomena in this graywacke, or any other formation containing coal, with some marine relics, without supposing at least one or two elevations above, and depressions below the waters, during the period of its deposition. And if we admit that various portions of the earth's crust have from time to time been elevated, it is easy to conceive that other portions must have been depressed.

### 6. ARGILLACEOUS SLATE.

This is one of those rocks whose mineral character is clear; it being composed of schistose clay, more or less indurated. This character, however, applies to the shale of the secondary rocks, which few geologists now include under argillaceous slate. It also applies to some of the slaty varieties of graywacke: and Dr. Macculloch includes under argillaceous slate the whole of the graywacke formation, as well as that argillaceous slate which is associated with rocks older than graywacke. But De la Beche limits the term to this last named slate, excluding the graywacke, which he puts into a separate group. I prefer his arrangement upon the whole; though in adopting it I find myself perplexed to determine whether the argillaceous slate around Boston, belongs to his "Inferior stratified or Non-fossiliferous Rocks," or is a member of the graywacke group; where, for the sake of convenience, I have described it. I am inclined to believe that it should be separated from the graywacke; though with my present information, I cannot say exactly where the dividing line should run. But the fact that no organic remains have been hitherto discovered in this slate, and the occurrence of its rolled nodules in some of the conglomerates of the graywacke, as well as its geological position, render it probable that it is considerably older than most varieties of graywacke.

In respect to the other patches of argillaceous slate exhibited on

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the map, there can be little doubt but they belong to De la Beche's Inferior Stratified or Non-fossiliferous Rocks; though I doubt not but some of them would be placed by a Wernerian geologist among the "transition clay slates." But I regard it as quite unprofitable to enter upon the long agitated question whether our clay slate belong to the transition or primary class of rocks. It will be in season to discuss this point, when any one can show where the transition class begins or ends; and when there shall be even a tolerable agreement as to the place in the series where the primary class commences. A mere inspection of the tabular view of our rocks, which I have given in the Atlas, will show that the answers to these questions will depend upon the system or classification which we adopt. I shall feel satisfied, if I can correctly describe the position of this rock in respect to others. In what follows, I shall leave out of the account the argillaceous slate in the vicinity of Boston.

### *Mineralogical Characters.*

The common argillaceous slate, which in its most perfect state forms roof slate, is the only variety of importance belonging to this formation. This passes by slow gradations into mica slate; so that it is often impossible to say where the one terminates and the other commences. Hence some of the specimens which I place under mica slate, other observers would place under argillaceous slate, and *vice versa*.

The laminae in the best varieties are straight and even: but as it approximates to mica slate, they become minutely undulated, the surface resembling exceedingly that of certain shales of the new red sandstone already described. Some of these intermediate varieties are remarkably contorted: but these I shall describe under mica slate.

In Guilford, Vt. through which the Franklin County range of this slate extends, I have observed that it passes into a fine grained variety of chlorite slate, and even perhaps into novaculite. That range also abounds with tuberculous masses of white quartz. Veins of quartz also occur in it, as I shall have occasion shortly to show more particularly; and in Guilford we find protruding masses of a porphyroid granite, passing into compact feldspar, and a slaty mixture of this last mineral and quartz. The Worcester County range, also, contains granite.

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### *Topography of the Argillaceous Slate.*

With the exception of that in the vicinity of Boston, the map exhibits but three ranges of argillaceous slate; viz. in the counties of Worcester, Franklin, and Berkshire. And it happens that in all these cases, except perhaps the first, the principal part of the range lies out of the state, either in New Hampshire, Vermont, or New York. Two miles south of the center of Halifax, Plymouth County, also, I found a delicate variety of argillaceous slate, which I was informed was discovered in digging wells, and that it lay immediately upon granite. (No. 363.) But whether it exists to any considerable extent in that region, I am unable to say.

### *Worcester County Argillaceous Slate.*

Some geologists would probably regard the slate that forms the roof and floor of the mine of anthracite in Worcester, as argillaceous slate; and maintain that the range of this slate in Worcester County, extends at least as far south as that spot. But I regard that slate rather as a fine mica slate, much impregnated with carbon, which gives it the appearance of argillaceous slate. In almost every case the scales of mica are quite distinct: and at a short distance from the mine, the rock assumes the characters of mica slate distinctly; though here, as in most of the range of mica slate extending from the mouth of Merrimack to the State of Connecticut, much of the rock is so quartzose that it might perhaps be regarded as quartz rock. I have not found any well characterized argillaceous slate, south of Boylston. And north of this place, the country is so much covered with diluvium, and so little hilly, that the slate does not often come into view. I found the range, however, to become narrower on approaching the north line of the State. Its characters appear most fully developed in Lancaster, where it has been quarried for roofing slate; and here the range is broadest. How far it extends into New Hampshire I have not ascertained; though I should not be surprised to find it even crossing that state. In passing from Groton to Townsend, I saw frequent examples of protruding masses and veins of granite in this slate. It passes on either side into the peculiar mica slate, already spoken of in Worcester County; and in this latter rock protrusions of granite are not unfrequent.

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### *Franklin County Argillaceous Slate.*

It will be seen by the map that this range occupies a considerable part of the town of Bernardston, passing into quartz rock on the east, and into mica slate on the west, and embracing a considerable part of two mountains of considerable height. It is not, however, till we pass into Vermont, that this slate assumes its most perfect characters. In Bernardston it is quarried, indeed; but not I believe for roofing slate. But in Guilford, which adjoins Massachusetts, several quarries are opened for this purpose. It there forms hills of considerable elevation; and such is its character farther north. It has been traced northward, in the valley of the Connecticut, 80 or 90 miles, in Vermont; nor do I know that its northern limit has yet been ascertained.

### *Berkshire County Argillaceous Slate.*

This ought perhaps rather to be called the argillaceous slate of Renssalaer and Columbia counties: for the principal part of it lies in New York, in the eastern part of these counties. Near the western line of Massachusetts it passes into mica slate, talco-argillaceous slate, and chlorite slate, by taking mica, talc, and chlorite, more or less abundantly, into its composition. The same rock forms hills and patches of limited extent in Williamstown, New Ashford, Richmond, West Stockbridge, Egremont, and Sheffield. But in no place in Massachusetts will it answer for roofing slate. For this purpose it is wrought extensively in Hoosac, Lebanon, and Hillsdale, N. Y. I doubt very much whether the whole of this stratum in Massachusetts should not be regarded as an imperfect kind of mica slate, similar to an intermediate rock of doubtful character occurring in Hawley, Plainfield, &c. which I have ranked with mica slate. Still, as Professor Dewey, who has examined this rock more than I have, regards it as argillaceous slate, I follow his judgment.

On the west, this range is connected with the graywacke formation of Renssalaer and Columbia counties; and on the east, it is associated with mica slate, and a limestone usually regarded as primitive.

### *Dip, Direction, and Thickness of the Strata.*

Excepting in the argillaceous slate connected with the graywacke, I have not been able to find in this rock planes of stratification run-



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ning in a different direction from the laminae; a circumstance very common, it is said, in Europe. But in general strata seams are discoverable, lying parallel to the slaty structure, as in mica slate. The slate, indeed, contains numerous seams not coincident with those of the strata: but there is rarely any continuous parallelism among them.

The predominant direction of the strata and of the laminae of slate in all the ranges of this rock, except that around Boston, and that in Franklin County, is north and south, and the dip large; as the following extract from my traveling notes will show.

*In Worcester County.*

Harvard and Lancaster; direction, North a few degrees East; dip, 90°.

Shirley; direction, North and South; dip, West, small.

Pepperell and Townsend; direction, North and South; dip, 30° to 60° East.

*In Franklin County.*

Bernardston; direction, North and South; dip, 20° to 90° East.

Guilford, Vt.; direction, between North and Northeast; dip, near 90 degrees.

*In Berkshire County.*

Taconic Range; direction, North and South; dip, 15° to 70° East.

If, as I have supposed, the strata seams are parallel to the laminae of the slate, and the dip approaches 90 degrees, then the actual thickness of this rock will not be much less than its breadth on the surface. As to its perpendicular thickness, I know nothing.

*Organic Remains.*

No vegetable or animal relic in a fossil state has hitherto been found in the argillaceous slate of Massachusetts. Since, however, this rock in the eastern part of the State, is associated with graywacke, and in the western part of the State passes into the same, it will not be strange if organic remains should hereafter be found in it. Every range of this rock, however, in the State, we have reason to believe, belongs to the oldest varieties of argillaceous slate, which geologists have described.

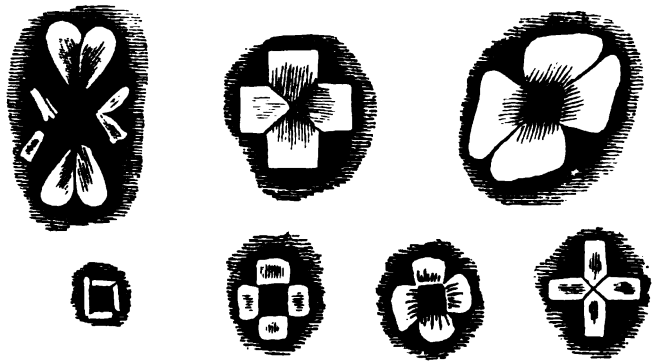
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### *Mineral Contents.*

The slate of the Taconic range sometimes contains octahedral crystals of magnetic oxide of iron, as well as the sulphuret of the same metal.

The clay slate in Charlestown, is frequently traversed by veins of crystallized quartz and calcareous spar.

The most interesting mineral in this rock is the chiastolite, or macle; which is found in Sterling and Lancaster. There is a great variety in the manner in which the prisms are disposed. The following are end views, of the natural size, of some of the most interesting forms.



This mineral is quite abundant in the clay slate in these towns, near the place where the rock passes into mica slate. It changes insensibly into the mineral which has been generally called andalusite; and the opinion of some of the ablest mineralogists of the present day,* that macle and andalusite are the same species, derives support from this locality. I have found this mineral in small crystals in a loose mass of argillaceous slate in the town of Worcester. (No. 404.)

### *Evidence of Disturbances in the Argillaceous Slate.*

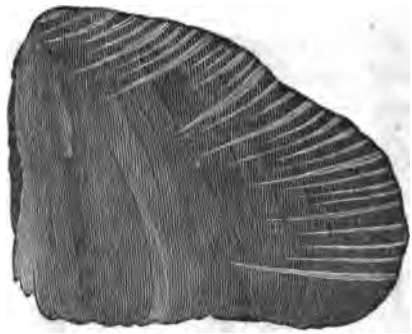
I do not here refer to those agencies by which the layers of this rock have been elevated from a horizontal to a nearly vertical position; nor to those by which its usual flexures have been produced; but to some movements that have taken place in certain anomalous

* Beudant's Traite de Mineralogie, Vol. 2. p. 45.

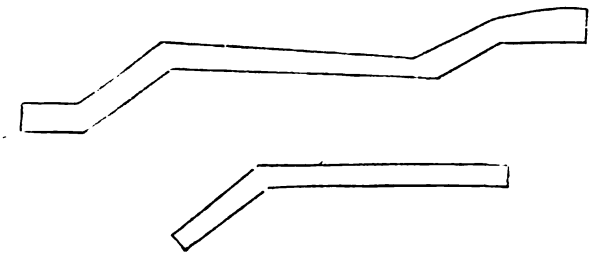
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directions. The instances which I shall refer to, all occur in the Franklin County range, and mostly in Guilford, Vt.

In some instances we find veins of quartz in the slate, as represented below. Here it is obvious, both from the curvatures in the undulating ridges of the slate, and from the wedge-form shape of the veins, that a force must have acted laterally on the edges of the laminae, while they were in a partially plastic state: and that an infiltration of quartz must have taken place subsequently. It is not perhaps difficult to conceive how such a lateral action might have taken place, when the strata were originally elevated. The specimen from which the drawing was taken, (No. 411,) was found near the north line of Guilford, on the stage road.



In the principal quarry of slate, on the stage road to Brattleborough from Greenfield, are seen occasionally cross seams, perpendicular to the horizon, and to the laminae of the slate, which are nearly vertical, and run north and south. Not unfrequently, however, the slate at these cross seams, when its edges are viewed from above, is bent as in the following figures, which exactly represent the specimens. (No. 417 and 418.)



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In the latter case the flexure is so great that the slate is partially broken; and this is the case frequently; showing that when the disturbance took place, the rock was only imperfectly plastic. The quarry where these flexures are exhibited, has been so much excavated, as to leave a wall 20 or 30 feet high; and excepting at these cross seams, the laminae are remarkably even; so that the phenomenon is rendered very striking. It must obviously have resulted from the unequal action of some disturbing force — perhaps that by which the strata were elevated — whereby one portion of the rock was pressed forward, faster than the rest; though in some places not enough to separate, but only to bend, the slate while in a soft condition.

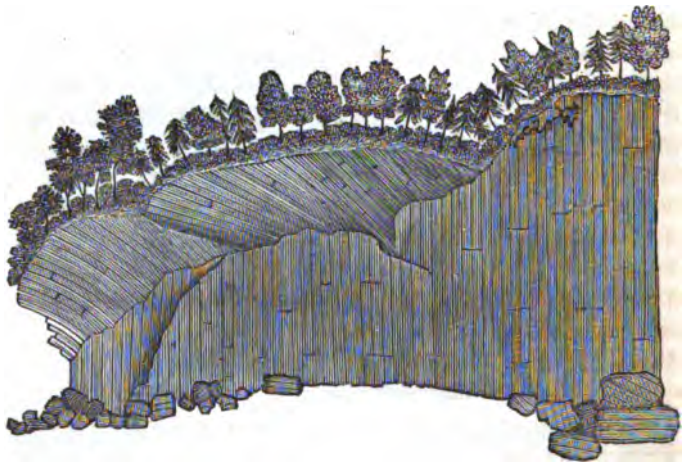
At the Gorge, or Glen, in Leyden, I found a series of such slides on a small scale, exhibited by the slate; as in the following sketch; though perhaps the rock ought to be regarded as mica slate. (No. 416.) Here the echellon movement took place in a direction at right angles to that described above.



Another disturbance, much more remarkable, appears at the quarry in Guilford above referred to. In the following sketch the observer faces the north, and looks directly upon the edges of slate, as it remains at the north end of the quarry, in its natural position. The almost uniform dip of the strata, in every part of this quarry, is nearly 90°; leaning, however, a little to the east. And such is their position at the north end of the quarry, to the height of 15 feet, as represented in the sketch. But from 10 to 15 feet of the upper part of the slate are bent towards the west, so as to incline to the horizon at almost every angle, from 0° to 90°. Where the flexure commences, the laminae of the slate are quite broken off, and not simply bent, as in the case of the disturbance in a perpendicular direction above described. Hence I infer that the former flexure was not produced so soon as the latter; not indeed until the rock had become perfectly consolidated. The quarry lies upon the western slope of a hill of

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slate, one or two hundred feet high; and the facts now related seem incapable of explanation, but by supposing a prodigious blow to have been given to the top of the hill, directed from east to west obliquely downwards. But what natural agent could have exerted such a force on such a point, I confess myself utterly at a loss to imagine. Among the endless variety of geological hypotheses that have been proposed, I could not call one to mind, which would apply at all to this phenomenon, unless it be the supposition formerly advanced, that the last deluge might have been produced by the impinging of a comet against the earth! I confess I could not but enquire whether this might not have been the point of contact!



Disturbance in the Argillaceous Slate: Guilford, Vt.

### *Theoretical Considerations.*

When we consider the nature of the materials composing argillaceous slate, it seems difficult to assign any other origin to this rock, than deposition from water. Indeed, one has only to look at a clay bed, such as occurs in some of the tertiary strata, which we are sure must have been deposited from water, to be satisfied that he has before him clay slate in its unfinished state; since nothing but the consolidation of the clay bed is wanting to convert it into perfect clay slate. But what agency could have effected this consolidation? Mere desiccation would do much; but it is difficult to believe that this could

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have produced so great a degree of hardness, and that shining semi-crystalline aspect which the older clay slates exhibit. Now we find the laminae of the clay beds horizontal, or nearly so, and those of the slate highly inclined; and we trace evidences of a powerful force producing flexures in this rock while in a plastic state. Why not then admit that the agency, by which the strata were elevated and the plastic slate produced, was igneous? And then we can easily conceive how the rock should subsequently have been so thoroughly indurated. Especially why hesitate, when the fused matter protruded at the time of the elevation of the strata, meets us in almost every district of much extent, in the form of trap, porphyry, sienite, or granite?

### 7. LIMESTONE.

No rock is more widely diffused in nature, or less liable to be mistaken, than the carbonate of lime. From alluvial marl to the saccharine limestones associated with gneiss and mica slate, we find an almost endless variety of this rock; but in nearly every case a drop of acid will enable a skillful observer to detect it and distinguish it from its associates. A more formidable difficulty has always met the geologist in assigning to the varieties of this rock their true places in the scale of strata.

Most of the limestone in Massachusetts belongs unquestionably to the oldest varieties of that rock. The newest varieties are the fetid and bituminous, which are associated with the new red sandstone, and which have been already described. I have also given an account of the white compact limestone of Newport, Rhode Island, and the gray limestone of Walpole, with the suggestion that they probably belong to the graywacke series. All the other varieties in the State, I shall describe in this place. And as the localities are rather numerous, and the diversities of composition, structure, and aspect, somewhat great; I shall, to save repetition, follow a topographical arrangement in the description.

#### *Encrinal Limestone of Bernardston.*

Since the first edition of the first part of my report was published, I have had the satisfaction of discovering organic remains, of the family of encrinites, in the bed of limestone in Bernardston. From the highly crystalline character of most of this rock, I had been led

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to suppose it older than the encrinal or transition limestone; and that it formed a bed in the argillaceous slate of Bernardston, which appears to be one of the oldest varieties of that rock. But its organic remains settle the question of its position; and differing in dip and direction from the slate, I have been led to doubt whether it really forms a bed in that rock. The slate in the vicinity runs nearly north and south, and the dip is nearly 90°; but the limestone runs N. E. and S. W., and dips S. E. not more than 20°. Besides, the rock that is found above the bed of limestone, (No. 601,) appears to be mostly composed of quartz, and probably ought to be called quartz rock. It does not lie in immediate contact with the limestone, nor is the slate visible immediately beneath the limestone. Upon the whole, I am of opinion that this limestone lies beneath the oldest variety of the new red sandstone series, which has been described, and upon the argillaceous slate, in an unconformable position. Probably further research might settle this point satisfactorily.

Two species of iron ore occur in this limestone; the magnetic oxide, (*Aimant*, Beudant,) and the bog ore, or hydrate of iron, (*Limonite ocreuse*, Beudant.) The latter is disseminated through a large proportion of the upper layers of the limestone, and also forms masses, several inches thick, between these layers. It exactly resembles the common bog ore, so abundant in our alluvial formations. (No. 504.) This is not the only instance in which I have found this ore between the strata of other rocks, as I shall have occasion to show hereafter; and Beudant mentions several localities in Europe, where the *limonite* is found "between the beds of divers rocks."

The magnetic oxide occurs as a bed in the limestone, lower down than the bog ore. The bed follows the dip of the limestone, and that rock is much impregnated with the ore in the vicinity; so as sometimes to produce a sort of brecciated marble. (No. 472.)

It is very obvious that both these species of iron ore must have been of contemporaneous production with the limestone, since it is impossible to conceive how parallel interstices could have existed between strata so little inclined, long enough to be filled by watery infiltration, or igneous sublimation, or galvanic agency,—the only modes by which metallic repositories have been supposed to be filled. That the bog ore was deposited, as we find the same ore now forming, seems highly probable. But I am not aware of any theory which will satisfactorily explain how the magnetic oxide, which consists of 69 parts

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of peroxide and 31 of protoxide, could have been produced in conjunction with the limestone.

The encrinal remains in the Bernardston limestone are usually quite imperfect; but the transverse septa and the central perforation are generally distinct. Plate XIV. fig. 47, exhibits an end view of one encrinus, about an inch in diameter; and a view of another, lying horizontally in the rock.

### *Berkshire Limestone.*

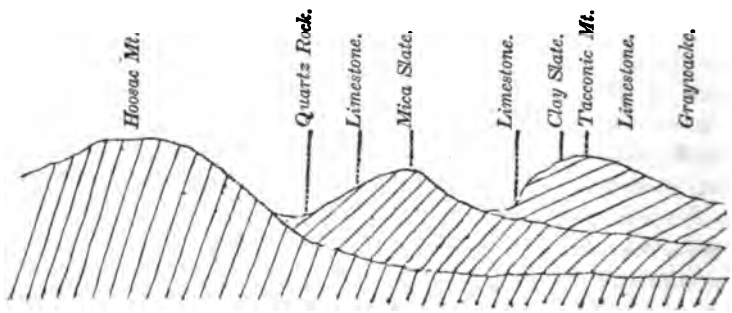
This rock constitutes a portion of that extensive calcareous formation, which occupies the western part of Connecticut, Massachusetts, and Vermont. It is one of the most extensive ranges of limestone in the world, if we regard it as primary, according to the general opinion of writers. That a part of it is primitive, in the Wernerian acceptation of the term, there can be no doubt: for it is interstratified with gneiss and mica slate in the eastern part of the range, and it is highly crystalline in its texture. But as we go westerly, the interstratified mica slate passes into clay slate, and the limestone becomes less crystalline, and assumes a gray, and finally a dark color. Passing still farther west, across the clay slate, into New York, we soon come to a range of limestone decidedly more recent, which Professor Dewey has denominated transition limestone, and Professor Eaton, metalliferous limestone. Crossing this rock, which is only a few miles wide, we reach decided graywacke; and this, with some interruptions of limestone, continues nearly to Hudson river; as may be seen on the Geological Map by Prof. Dewey, in the 8th vol. of the American Journal of Science, and on the Geological Section of Prof. Eaton in his "Canal Rocks."

From this statement the geologist infers at once, that here is a gradual passage from the oldest limestone to that which is associated with graywacke. But a singular anomaly in the superposition of the series of rocks above described, presents a great difficulty in this case. The strata of these rocks almost uniformly dip to the east: that is, the newer rocks seem to crop out beneath the older ones; so that the saccharine limestone, associated with gneiss in the eastern part of the range, seems to occupy the uppermost place in the series. Now as superposition is of more value in determining the relative ages of rocks than their mineral characters, must we not conclude that the rocks, as we go westerly from Hoosac mountain, do in fact belong to older groups? The petrifactions which some of them contain, and



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their decidedly fragmentary character, will not allow such a supposition to be indulged for a moment. It is impossible for a geologist to mistake the evidence, which he sees at almost every step, that he is passing from older to newer formations, just as soon as he begins to cross the valley of Berkshire towards the west. We are driven then to the alternative of supposing, either that there must be a deception in the apparent outcrop of the newer rocks from beneath the older, or that the whole series of strata has been actually thrown over, so as to bring the newest rocks at the bottom. The latter supposition is so improbable that I cannot at present admit it. But perhaps we may explain the anomaly by supposing a deception in the case. It may be that the relative position of the strata is as in the subjoined ideal section.




*Gneiss and Mica Slate.*

In the greater part of the Hoosac range, the strata of gneiss and mica slate are nearly perpendicular in their dip. As we descend that mountain into the valley of Berkshire, we strike first a range of quartz rock, whose stratification is very obscure, and which moreover is much hidden by diluvium; so that the junction between this rock and the mica slate and gneiss of the Hoosac range, is rarely if ever exhibited. As we proceed west, we find successive and sometimes interlaminated strata of limestone, and mica slate; whose connection with the Hoosac range is no where presented, as nearly all the larger streams of water and the vallies run in the direction of the strata. Now may not the strata of Berkshire valley rest unconformably on the mica slate and gneiss of the Hoosac range? Certain it is that the dip of the former, although in the same direction, is considerably less than that of the latter. It may be, also, that another series of strata farther west, (ex. gr. the clay slate, transition limestone,

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and graywacke,) rest unconformably on the edges of the rocks in the valley of Berkshire, which may pass under this series, as the older mica slate, perhaps, does under the quartz rock and limestone, as exhibited on the sketch: or perhaps the rocks of Berkshire valley lie in a basin, whose eastern side is the Hoosac range, and whose western side is the Tacconic range. Then perhaps the transition limestone, clay slate, and graywacke, may fill a second basin farther west. Another series, perhaps, was deposited in a third basin still farther west; and so on till all the earlier rocks are included.

This view of the case is rendered more probable from a fact which may be learnt by examining the sections appended to this report, (Plates XVII. and XVIII.) that the prevailing dip of the rocks in Massachusetts is towards the east. Why then, it may be asked, is there any more difficulty in regarding the rocks of Berkshire valley as resting unconformably on the older strata, than there is in respect to the new red sandstone of the Connecticut valley, which has an easterly dip, like the subjacent rocks? The very great difference of mineral character, between the newer and the older rocks of the latter valley, is one reason why we do not hesitate at all to regard the newer as unconformable to the older: whereas in Berkshire, all the rocks appear to belong to the oldest class; that is, they are highly crystalline and destitute of organic remains. And then the difference of inclination between the varieties of the rocks in Berkshire valley, is much less than in the valley of the Connecticut. Nevertheless, he must be a poor geologist, who does not know that there is often far greater difference in position and mineral character between many members of the primitive class, than between some members of that class and others of the transition, or even of the secondary class. So that the apparently primitive character of the rocks of Berkshire valley, is but a feeble objection against their resting unconformably on those of Hoosac mountain.

The greatest difficulty which I find in the way of admitting the hypothesis above suggested, lies in the fact, that the change from the older to the newer rocks, as one proceeds westerly across Berkshire county, seems to be gradual: whereas on this hypothesis, we should suppose, that since the rocks dip to the east, the oldest members of a series ought to be found on the western margin of the several supposed basins; and that the change ought to be sudden and great in passing into the basin next west. But so different does the limestone of the western part of Berkshire appear from that in the eastern part,

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that Mr. Eaton proposes to give the two varieties distinct names, founded entirely on their mineral characters, that in the eastern part being decidedly the oldest. I think, however, that in considering this question, we ought to leave out of the account every bed of limestone occurring in the gneiss and mica slate of the Hoosac range; since this is unquestionably the oldest of the saccharine limestone. And perhaps the remaining portions of this rock may be found to belong to a single deposit. At any rate, I regard it as premature to assign a distinct name to any part of this limestone range, until one part can be proved to have a different position, in relation to other rocks, from the other. For after what Dr. Maccullock has written on this subject, in his Geology of the Western Islands, and in his System of Geology, it seems to me evident that mineral characters alone can rarely determine even the class to which limestone belongs.

Notwithstanding the difficulties which I have suggested to the hypothesis under consideration, I know of no better explanation of this anomalous case. I am sustained in this opinion by that of Dr. Emmons, of Williams College, whose acuteness of observation and accuracy of discrimination in the various departments of natural history, are well known. It is to be hoped that either he, or Prof. Dewey, whose local situations and geological experience give them great facilities for examining the point, will ascertain the true state of the case, and thus solve an interesting geological problem. Since my attention has been called to it, I have not felt justified by my commission in devoting the time and expense requisite to its solution: since the examinations would delay this Report another year.

The Berkshire limestone passes through numerous gradations of texture and color, from the snow white, coarsely granular and crystalline variety in Adams, to the white almost sandy dolomite of Sheffield, and to the dark gray almost compact variety in Williamstown, and to the variety even darker of West Stockbridge. The specimens that have been polished (Nos. 428 to 442,) will show the principal varieties of marble thence derived. The clouded varieties, although very rich, are less esteemed as marbles, I believe, than the snow white, on account of their liability to be shaky. This tendency results from the nature of these varieties; composed as they seem generally to be, of limestone and argillaceous slate. The different varieties are frequently interstratified at the same quarry.

A large proportion of the Berkshire limestone, especially along its western borders, is the magnesian. In Williamstown this occurs

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crystallized, or as rhomb spar: in Bennington, Adams, Lee, Pittsfield, Stockbridge, Great Barrington, New Marlborough, Sheffield, and indeed in nearly every town in the county, it occurs either coarsely granular, and of a crystalline structure; or so finely granular as to be pulverulent. This latter variety, which is genuine dolomite, abounds most in the south part of the county, especially in Sheffield, where, according to Prof. Dewey, it is sometimes fetid. In Canaan in Connecticut, which lies contiguous to Sheffield, this dolomite, which is of a snowy whiteness, disintegrates abundantly; leaving in many places, loose crystals of white augite and tremolite, which have fallen out. In other places, as in Stockbridge, it is of a gray color.

This appears to be the oldest variety of magnesian carbonate of lime that has been found; corresponding to that described by Beudant, as occurring in St. Gothard, interstratified with mica slate.*

A considerable proportion of the limestone in West Stockbridge, Lanesborough, and New Ashford, is flexible and elastic. Slabs of it a few feet long, and from one to two inches thick, show these properties very distinctly by supporting the ends, especially if they are thoroughly wet. Generally the grain of this variety is coarse and the structure rather loose; though sometimes it is fine grained. Usually it is white, slightly tinged with red; but sometimes gray and dark colored. According to Prof. Dewey, it is the common, and not a magnesian carbonate. The slab in the collection (No. 501) is from New Ashford; where it is abundant. Its peculiar properties seem to depend upon the agency of water: and there are numerous facts that render it probable, that many of the rocks in the interior of the earth are rendered soft and flexible by this same agent: so that although marble and sandstone that will retain their flexibility after being quarried, are rare, yet probably deep in the earth's crust they are abundant.

The non-magnesian as well as the magnesian carbonate of lime in this county, is often fetid. In Stockbridge, this is sometimes the case with that which is white and coarsely granular: in Williamstown, this variety is dark colored and fine grained, and in Bennington, it is nearly black.

The origin of the fetid odor in limestone, quartz, &c. has been variously explained. The natural explanation imputes it to animal matter, which has been imprisoned since the original formation of

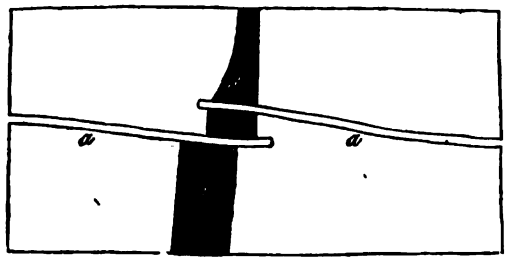
* Mineralogie, Tom. 1, p. 592.

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the rock; and which is liberated in a gaseous form by friction or a blow. The odor is commonly said to be that of sulphuretted hydrogen; though I confess I do not perceive much resemblance. But even if this be the case, putrescent animal matter would furnish this gas abundantly. And if we adopt the opinion maintained by some very able geologists, that all, or nearly all limestones were produced from living beings, we can easily understand whence this animal matter proceeded.

In general the strata of the Berkshire limestone have a dip towards the east, between 15° and 30°. In some instances it is greater; and Prof. Dewey, from whose account of the Geology of Berkshire, in the American Journal of Science, I have derived much assistance, says, that at the base of Saddle mountain, on the northwest side, some of the limestone dips to the west, and some is perpendicular, although the prevailing dip is to the east. He has given also, in the same work, a drawing and description of a singular conformation of the limestone strata near the College in Williamstown.* Not improbably this is only an example of a concretionary structure on a large scale; though possibly it might have resulted from mechanical agencies in early times.

I have never seen either a mass of granite or of trap, or any other unstratified rock, in contact with this limestone; though not improbably such junctions may be found. The following is a sketch of the shifting of a vein of white carbonate of lime, in a slab of light gray-marble, five feet long and three feet wide, taken from a quarry in




New Ashford. *a*, *a*, is the vein of the carbonate of lime, and *d d*, a somewhat wedge shaped mass of dark gray limestone, five inches wide at its base, which is twice cut off, once by each separate portion

* Vol. 9. p. 19.

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of the vein. At present there is no seam at all in the slab, and apparently it would not break more easily in one direction than in another. As to the strip of darker limestone, *d d*, there is no more difficulty in accounting for its presence, than for any other case of close union between different varieties of a rock. But if we suppose the two veins, *a*, *a*, to have been once united endwise, it is extremely difficult to imagine how they could have been so slidden as to be brought into their present condition. Dr. Macculloch has described a similar case of disturbance in a slab of marble from Ireland in the Transactions of the Geological Society.* But in that case it was not difficult to imagine how the fragments of the vein, by a series of slides, might have been displaced in the manner exhibited upon his drawing. In the present case, however, I despair of being able to explain that sort of double *echellon* movement, by which both the vein and the dark mass of limestone have been displaced.

I am not aware that in any case the limestone of Berkshire county forms hills of any considerable altitude. In general mica slate, with quartz rock, composes the peaks and ridges so striking and sometimes so lofty, in the great valley of this county. Whether the low level of the basset edges of the limestone results from the greater liability of this rock to be worn away, or from its geological position, I am not prepared to say; though inclined to refer it to the latter cause.

In general the limestone under consideration retains its characters distinctly to the very line of junction with other rocks. But not unfrequently the two rocks are intermixed near the place of contact. The dark gray limestones, as already remarked, appear to contain a mixture of argillaceous slate. Frequently we find scales of mica disseminated in the limestones, and thin layers of talc. Where the limestone comes in contact with mica slate, in Canaan, Ct. we find a mixture in almost equal proportions, of carbonate of lime, mica, and quartz. (No. 456.)

In Stockbridge and the south part of Lee, two or three varieties of limestone occur of rather a peculiar character. The most abundant of these has externally a dark gray color, occasioned by one or two foreign minerals, which do not decompose so rapidly as the carbonate of lime. When the specimens are broken, the fresh surface is

* Vol. 4. p. 393.

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yellowish. What the disseminated minerals are, I have not ascertained. From the general aspect of this rock where it has been weathered, one would not suspect it to be limestone; and it scarcely exhibits any traces of stratification. (No. 454.) On the east, at the village of South Lee, this rock is succeeded by white dolomite, whose strata dip west about 45°. A mile farther to the east, they are perpendicular.

A little east of the village in Stockbridge, I found specimens which contained quartz and mica, and which appeared to be limestone passing into mica slate, just as in Canaan, Ct. (No. 458.) The same rock I found in the east part of Lanesborough. (No. 457.)

In passing from West Stockbridge to Chatham, N. Y. we find the gray limestone traversed by innumerable veins of white quartz, so that the mass becomes a real breccia. (No. 453.) This rock is quite abundant near the line of the State. As we pass westerly from this line, the limestone becomes of a darker color and rather more compact, and alternates with bastard mica slate and argillaceous slate. Frequently this limestone is traversed by numerous veins of white calcareous spar, giving it a striking appearance. (No. 453.) It is probably interstratified with graywacke slate in Renssalaer and Columbia counties, N. Y.

I have already mentioned the crystallized tremolites and white augite found in the dolomite of Canaan. The same minerals occur in the same variety of rock at Muddy Brook in Great Barrington, and in New Marlborough, and the former in the south part of Lee and in Sheffield. In the 14th vol. of the American Journal of Science, I have described four modifications of the secondary forms of the augite; and Prof. Dewey, in the 8th vol. of the same Journal, mentions a fifth. In Great Barrington, the tremolite is found in beautiful bladed crystals. This mineral is often delicately fibrous, and sometimes radiated. Indeed, all the varieties are found at these localities. In Sheffield the fibres are sometimes more than two feet long, and embrace crystals of iron pyrites. These fibrous masses are mistaken for petrified wood; to which, indeed, they bear a striking resemblance.

Carbonate of lime is often found crystallized in this rock in tabular, lenticular, &c. crystals. It is also more frequently found laminated. The agaric mineral, it is said, is found in a cave in West Stockbridge. Concreted carbonate of lime occurs in the different

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caverns that have been described in the second part of this report. Some of the springs in Williamstown deposite calcareous tufa.

According to Cleaveland's Mineralogy, yellow tourmaline has been found in Dalton, near the Housatonic, in granular limestone.

### *Blanford Limestone.*

After the publication of the first edition of the first part of my Report, Mr. Simeon Shurtleff of Blanford discovered a bed of serpentine in the northwest part of that town, and in the vicinity, a bed of limestone. The former rock will be described in another connection. The latter will be noticed here. Since their discovery, I have had opportunity to examine them personally: but for the specimens in the collection, I am indebted to Mr. Shurtleff.

The bed of serpentine is about four miles northwest of Blanford meeting house, on the northeast side of a pond. Immediately on the west it is succeeded by hornblende slate, which is only a few rods wide, and then succeeds granitic gneiss. The limestone is about one mile south of the serpentine, and about the same distance as the serpentine, east of the granitic gneiss: and although no hornblende slate appears between them, at the surface, probably it exists there. Indeed, no rock except diluvium is seen in place around the limestone. It shows itself at the surface only over a space whose diameter is about a rod. Its stratification is indistinct; though there is an appearance of parallel division, corresponding to a plane which runs east and west, and dips south about 45°.

This limestone is coarsely granular, white, and crystalline; though it is mixed with a foreign mineral, perhaps augite, in considerable quantity; and this may prevent its being profitably reduced to quicklime. It is well worth the trial, however, in a region where no lime stone is found. (Nos. 477, 478.)

No. 476 was broken from a coarsely granular limestone bowlder near the meeting house in Blanford. It contains numerous plates of graphite disseminated through the mass, and much resembles specimens that I have seen from the shores of lake Champlain: Nor should I think it strange, if it should appear that this bowlder was brought from thence by the diluvial current, which, as I have shown in another place, once swept over the western part of the State from the northwest.

### *Micaceous Limestone.*

This rock might very properly be regarded as a variety of mica slate: for usually it contains both mica and quartz, the latter always;



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and much of it is merely mica slate which takes carbonate of lime into its composition. When the carbonate is in small proportion, the schistose structure of the mica slate remains: but when the mica nearly disappears, the slaty structure also vanishes, though still the rock is stratified; the dip and direction conforming to those of the mica slate. It forms numerous beds in the extensive tract of mica slate on the western slope of the valley of the Connecticut; especially along the eastern border of the mica slate, from Whately northwards. Several beds are marked on the map, merely to indicate that they are numerous, but without any intention of giving them their true situation and extent. In some places, as in Whately, these beds occupy half the surface; but in general the mica slate greatly predominates, and for miles the limestone disappears. (Nos. 459 to 467.)

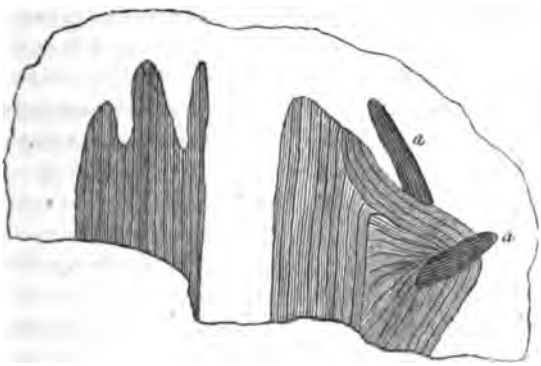
The three varieties of this limestone from Conway and Whately, mentioned in the first part of this report as having been analysed, contain respectively 58, 67, and 78 per cent. of carbonate of lime. More recently I have examined in the same manner a specimen from Southampton, containing only 40 per cent. Another specimen from Williamsburg, from a bowlder to which was attached a mass of mica slate, yielded 63 per cent. of the carbonate of lime. It also contained magnesia, since its solution in nitric acid was milky. It is, however, doubtful whether this specimen, (Nos. 468, 469,) ought to be connected with the micaceous limestone under consideration.

The carbonate of lime in this rock is very liable to be separated from the mica and silex by the action of air and moisture, so as to leave the surface of the rock coated over with a gray porous mass, sometimes even several inches thick. (No. 467.)

This rock is frequently traversed by veins of granite. (No. 465.) The tortuosities of some of these veins is remarkable; of which examples will be given when I come to describe granite. I have not generally observed any very striking effects produced upon the limestone by its proximity to granite. In one case, however, if I mistake not, a large quantity of argentine has been produced by the action of the granite on the limestone. In a very wild and unfrequented spot in the northeast part of West Hampton, (not in the south part of Williamsburg, as all the authorities state,) a huge mass of coarse granite lies in a valley, apparently in situ. At its southern extremity, which is represented on the following sketch, and which is an uneven perpendicular wall from 10 to 15 feet high, project the edges of schistose rocks; most of which is mica slate, but a part is mica-

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ceous limestone. These rocks appear to be merely the fragments which adhered to the granite, when it was raised through the slates, or when these were torn off from the granite. Most of the layers are perpendicular: but some of them towards the eastern side, are much bent and become almost horizontal. Here the argentine, *a a*, appears, lying for the most part between the slate and the granite; penetrating both rocks, indeed, a short distance, but not forming what ought to be called a vein in either. It does not enter the granite, as far as I could ascertain, but a few inches. And it is that part of the slate which lies in the vicinity of the argentine which is micaceous limestone.




**Argentine with Mica Slate and Granite: West Hampton.**

Now my hypothesis is, that when the granite was protruded into the mica slate and coarse limestone, while in a melted state, its heat by decomposition or sublimation, or both, forced the carbonate of lime into the cavities that were produced by the elevation of the rocks, where it assumed the form of that very pure variety of carbonate of lime called *argentine*, or *slate spar*. Whether its intrusion among the sinuosities of mica slate caused it for the most part to assume a similar structure, I do not undertake to decide. Nor do I feel much confidence in any part of this hypothesis, though it seems to me worthy of consideration.

In Vermont limestone is found among the layers of argillaceous slate. Here it is destitute of mica, and is mixed with the argillaceous slate in such proportion as scarcely to be distinguished from it, except by its effervescence with acids: yet it appears to be closely allied to micaceous limestone.

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### *Limestone of Whitingham, Vt.*

This bed of limestone, as may be seen by the map, approaches nearly or quite to the north line of Massachusetts, and lies near the junction of a range of talcose slate and gneiss. It is stratified, and the dip is not far from 30° west, the direction being north and south. By following down a small tributary of Deerfield river, which has laid bare this limestone in the southwest part of Whitingham, a good opportunity is afforded for examining its characters. It is white and decidedly crystalline, though often containing bronze colored mica, and sulphuret of molybdenum in small plates. I found associated with it, also, actynolite, common augite, and mussite. Though a mile or two in length, the breadth of the bed is very inconsiderable. Its geological associations render it certain that this is one of the oldest varieties of limestone.

About 16 miles north of this bed, at the iron and gold mine in Somerset, is a very elegant variety of dolomite, occurring in beds in talcose slate. Some of it exceedingly resembles the purest loaf sugar. (Nos. 483, 484.)

### *Limestone in Bolton, Boxborough, Littleton, Acton, Carlisle, and Chelmsford.*

The geological situation of these limestone masses and their mineral characters are so similar, that one description will embrace them all. They all correspond to the description which Dr. Macculloch gives of the limestone of Tirey, one of the Western Islands of Scotland. "It is," says he, "improperly called a bed, as it is only an irregular rock lying among the gneiss without stratification or continuity. In this respect it resembles the greater number of primary limestones found in gneiss and mica slate, and may be considered as a large nodule."* It will be seen by the map that all these masses are in a gneiss formation, which, however, often passes into mica slate, and contains numerous protrusions and veins of granite. The dip and direction of the gneiss surrounding the limestone are visible at nearly all the quarries: but the limestone itself rarely exhibits any distinct marks of stratification. And as every one of these localities contains a quarry, a good opportunity is presented for examining the structure of the rocks.

* Western Islands, Vol. 1. p. 48.

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In my own opinion, there can be little doubt that this want of stratification results from the agency of granite. At any rate, if this be admitted to be a rock of igneous origin, its contiguity to a bed of limestone, while yet in a melted condition, will explain the obliteration in that bed of the stratified structure: and I can imagine no other cause that will explain it. I did not observe, indeed, the contact of granite with the limestone, except at the principal, or north quarry in Bolton. But at that place the stratified structure is more completely destroyed than at any other. Yet I did not search for granite in the vicinity of the other masses of limestone, as my attention was not till recently particularly called to this subject; and probably it may be found near most of them, if not concealed by the soil. Or if not, there is evidence that gneiss has been subject to a degree of heat little inferior to a melting heat.

Nearly all the limestone at these quarries is coarsely granular and highly crystalline. It is almost uniformly fetid also; sometimes so much so as to produce nausea when struck, in a stomach of much sensibility. This was very unexpected to me in limestone of such great relative age; the fetid limestones of Europe being almost exclusively found in secondary rocks.

Although but a single bed of limestone is marked upon the map in each of the towns mentioned above, yet in most of them there are several; some of them one or two miles distant from one another. In Bolton are two, in Boxborough one, in Littleton three, in Acton one, in Carlisle two or three, and in Chelmsford two or three. Not improbably others exist in the neighboring towns, which escaped my notice.

The simple minerals imbedded in this limestone are numerous and interesting. In general, specimens from the different localities cannot be distinguished; though particular minerals are more perfectly developed at one place than at others; and one or two, perhaps, are found only at one quarry. The most common and abundant mineral is scapolite. It occurs both crystallized and compact; and at all the localities above referred to. The crystallized variety is most abundant at Bolton, Boxborough, Chelmsford, and Littleton; particularly at the two first named places. The crystals are sometimes transparent, more commonly opaque and white, having begun to decompose. Sometimes the crystal exhibits the primary form, or a right square prism, acuminated by four planes set on the lateral planes. More commonly, however, the lateral edges are slightly truncated. Some

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of these crystals are one or even two inches in diameter; though in such cases generally imperfect. Often this mineral is compact, and the color either white or lilac red. This red color, however, occurs also in that which exhibits an aggregation of prisms. Bolton and Boxborough yield an abundance of this beautiful variety.

It is probable that the mineral from Bolton described by Mr. Brooke, under the name of Nuttallite, is only a variety of scapolite.

Augite, actynolite, pargasite, and radiated, fibrous, and brown hornblende, are among the minerals found in this limestone; the two first at all the localities, the third at Carlisle and Boxborough; and the fourth, according to Mr. Nuttall, at Bolton.

Phosphate of lime, sometimes in hexahedral crystals, but more commonly massive, is found at Bolton, Boxborough, and Littleton; usually in scapolite. Its colors are green and purple.

Spinelle, dark green and grayish blue, occurs at Bolton, Boxborough, and Acton, both massive and in regular octahedra. Some of the specimens at Boxborough, incline to rose red; and in the opinion of Mr. Nuttall, are the genuine spinelle ruby.

Genuine petalite, (from which lithia has been obtained,) exists at the south quarry at Bolton, associated with the scapolite.

At Chelmsford small masses of black serpentine occur in the limestone, and at Littleton of a lively green colour.

At Carlisle, close by the turnpike from Concord to Groton, Prof. Webster discovered a few years since, a splendid garnet, which is probably a cinnamon stone. The specimens which can now be obtained, give but a poor idea of the richness of some of those which were first procured. Probably extensive exploration might bring to light finer specimens. The same mineral is found at Boxborough.

At Bolton rhomb spar occurs: and both there and at Boxborough, a beautiful variety of flesh colored calcareous spar in foliated masses.

At Bolton, also, a new mineral has been discovered, which Dr. Thomson has denominated from its chemical composition, ***Bisilicate of Magnesia;*** and Mr. Shepard, with reference to its locality, calls it ***Boltonite.**** It occurs in foliated masses in the limestone. (Nos. 521, 522.)

In the same place, sphene, or silico-calcareous oxide of titanium is not an uncommon mineral at the south quarry — in distinct crystals. Tremolite, also, is said to occur there in fibrous masses: also gado-

* Shepard's Mineralogy, Vol. 1. p. 232.

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linite, according to Professor Webster: also talc in veins at Bolton as well as at Littleton.

Very delicate and beautiful amianthus is found in veins in the limestone, about two miles south west of the centre of Chelmsford. The fibres are sometimes two or three inches long, and resemble the finest and most beautiful white silk. The same mineral in small quantities is found at Bolton. (Nos. 523, 524.)

### *Limestone in Smithfield, R. I.*

There are two principal beds of this rock, a little more than a mile apart; the most easterly one, half a mile from Blackstone river, called the Dexter rock, and the other, the Harris rock. I have examined only the latter; and this occurs in that variety of hornblende slate, which the Werenians call greenstone slate, and transition or primitive greenstone. The slaty structure of a part of the rock is quite obvious, though to a cursory observer, most of the mass resembles very much secondary greenstone. I am satisfied that the Dexter rock occurs in the same slate, which, in fact, appears to be the talco-chloritic slate of that region, passing into hornblende slate. Though the parallel division of the hornblende slate be evident, yet the limestone is destitute of stratification; forming an irregular mass, penetrated by projections from the slate. It is white and distinctly, though not very coarsely granular and crystalline. Some of it is dolomite. (Nos. 498 to 500.) It may be, and has been wrought as marble; though it is difficult to obtain large blocks without fissures. Sometimes it is clouded. (No. 497.)

The imbedded minerals in this limestone are, with few exceptions, very different from those just described in the limestone beds in gneiss in Massachusetts. In the Smithfield rock, talc is one of the most abundant of the minerals, and it is often of a rich silvery white color, associated with large prisms of rhomb and calcareous spar. Some of the nacrite found at the Dexter rock is beautiful. Nephrite exists here, also, in veins and nodules: also limpid quartz in crystals; calcareous and brown spar, tremolite and asbestus.

If, as seems to me extremely probable, the hornblende rock in which this limestone occurs, has been subjected to the action of powerful heat, we have a cause for the want of stratification in the latter. And the occurrence of immense quantities of sienitic granite in the vicinity, shows us whence the heat might have been derived.

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*Limestone of Stoneham and Newbury.*

In both these places the limestone is in irregular unstratified masses in sienite, except that the most northerly bed in Newbury is in greenstone. For the most part, the limestone is either finely granular, or compact, and white. That at Stoneham is translucent on the edges; (No. 496.) and were it not for the numerous seams and cracks in it, would prove a very fine article for statuary and other ornamental purposes. Two or three quarries have been opened at each of these localities, only a few rods apart; but they are now abandoned. At Newbury, the great amount of foreign minerals present renders the limestone of little value, even for the production of quicklime.

Among these minerals precious and common serpentine predominate: and these being disseminated in the granular limestone, form the *ophicalce grenue* of Brongniart,* which he mentions as occurring at Newbury.† Specimens of this variety may be seen among those that are polished in the collection; (Nos. 896 to 899,) although the geological position of this rock, if I have not mistaken it, is not above organic relics (*épizoïque*) as that author supposes it commonly is.

Another beautiful mineral, often running in veins through the *ophicalce grenue*, or the serpentine, varying in width from a mere line to half an inch, is green amianthus. When a specimen is newly fractured, this mineral presents a peculiarly rich appearance. Its color is grass green and yellowish green. (No. 872.) Common asbestus occurs in the same situation.

Fibrous limestone, or satin spar, occurs in the same connection. The fibres are sometimes four or five inches long, though the veins of this mineral are quite thin.

Tremolite in radiated masses is not uncommon in this limestone. Epidote also occurs here in crystals; and white and gray varieties of compact feldspar. Associated with the tremolite and epidote, is found massive garnet.

The limestone at Stoneham is not so much mixed with other minerals as at Newbury. It occasionally, however, contains nephrite. This mineral melts with great facility before the oxy-hydrogen blowpipe, and without difficulty before the common blowpipe, into a yellowish slag or scoria. Another grayish green mineral occurs in

* Classification des Roches, p. 96.

† Tableau des Terrains, &c. p. 325.

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nodules in the limestone, and might easily be mistaken for the siliceous infusible mineral that has been described by many writers under the name of hornstone. But it melts with ebullition, not only before the compound, but also the common blowpipe, into a shining black enamel. I suspect that epidote enters largely into its composition. (No. 507.) It is probably the allochroite, mentioned by Prof. Webster in the Boston Journal of Philosophy, as occurring at Stoneham.

I am not aware that limestone has been found in other parts of the world, entirely embraced in sienite; which is the case at Stoneham and Newbury, unless I am mistaken. At the time I examined these localities, I was not aware of the importance of this fact, and might have been deceived. But I saw no rock in the vicinity of the quarries, but sienite: although, as I shall have occasion hereafter to observe, sometimes the sienite north of Boston possesses a limited slaty structure, forming a kind of hornblende slate, or greenstone slate: the unmelted remnants, perhaps, of the rocks out of which the sienite was formed. That this rock had an igneous origin, seems to be at this day the prevailing opinion of geologists. And admitting this, it is easy to see why the beds of limestone, that have been described above, are destitute of stratification.

## *Origin of Limestone.*

Crystallized carbonate of lime, as we are taught by chemistry, may be produced either by precipitation from aqueous solution, or by the melting of uncrystallized masses of this substance under strong pressure: and probably in both these ways are we to account for the existence of primary limestone. Where this rock is in regular strata, and no unstratified rocks in the vicinity, it is reasonable to refer its origin to aqueous solution and crystallization. But where there is evidence of the agency of heat, long continued, in the irregular position and unstratified structure of the limestone, and the juxtaposition of granite, trap, &c.; it is not improbable that limestones deposited from water or animals, such as chalk, marl, compact limestone, and coral reefs, may have been melted and subsequently crystallized.

Thus far most geologists agree. But another point divides them; viz. whether all limestones have originated in organized substances?



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Dr. Macculloch* leans to the affirmative: but another able geologist, Mr. Lyell,† defends the negative. Mr. Lyell, however, does not object to the idea that "every particle of lime that now enters into the crust of the globe, may possibly in its turn have been subservient to the purposes of life by entering into the composition of organized bodies;" but to the opinion that "lime may be an animal product combined by the powers of vitality from some simple elements." Dr. Macculloch thinks his views of the subject rendered probable, by the great increase of calcareous strata the higher we rise in the series of formations, and by the great extent of existing coral reefs. But Mr. Lyell says that in ponds or lakes, which are not fed by springs containing carbonate of lime in solution, there will be no accumulation of shells producing tufa and shell marl; one race of animals furnishing by their decomposition only calcareous matter enough to supply the next generation; and hence he infers that the animals do not secrete lime. And he explains the greater quantity of calcareous matter in the newer strata, by the constant transfer of this matter from the inferior to the superior rocks by internal heat and springs.

But however this point may be decided, it is certainly an interesting thought that all existing limestone may have once formed a part of organized beings. That much of it in the secondary rocks did enter into the composition of animals, is obvious from the immense quantity of their remains now found in such rocks. But why are the primary rocks destitute of them? Dr. Macculloch says that he has found organic remains in one instance, "in a calcareous quartz rock situated beneath gneiss." But he has also shown conclusively that limestones full of organic remains, when in contact with trap, are converted into highly crystalline masses, and the organic remains entirely obliterated for a certain distance from the trap. Such a change he supposes may have been undergone by all the primary limestones.

It is well known that calcareous soils are of all others most fertile. Now if it be true that the quantity of limestone on the globe is increasing, it will follow that there is a progressive increase of fertility. Such a view would certainly accord with our ideas of the Divine beneficence: but we should not forget the danger of hasty inferences on such subjects.

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* System of Geology, vol. 1. p. 220.

† Principles of Geology, vol. 2. p. 298. London, 1832.

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## 8. SCAPOLITE ROCK.

Associated with the limestone and mica slate of Berkshire County, which extend into Canaan, Ct., extensive beds or strata occur, composed essentially of what I suppose to be compact scapolite. I have traced these strata in the town of Canaan, from six to eight miles in length, and in some places from 100 to 150 rods in breadth. And I have no reason to doubt but they extend much farther in length; probably into Massachusetts on the north; and I cannot judge how far south. No one, it seems to me, could regard masses of such extent and regularly stratified, only as a simple mineral. And if I am not mistaken as to its nature, there can be no doubt it is a new rock; since in other quarters of the globe, scapolite is rare even as a mineral. I thought at first that it might be a compact variety of white augite; since this mineral does occur in connection with the same limestone. But the rock fuses with intumescence and without difficulty into a white enamel: whereas I could not melt the augite from the same locality. The following are all the varieties of this rock which have yet fallen under my notice.

1. *Masses exhibiting Aggregations of imperfect Prisms of Scapolite;* too imperfect, however, to determine their form, though the foliated structure is quite obvious. This rock is liable to partial decomposition at its surface. I have found it only in bowlders. (No. 540.)

2. *Compact Gray Scapolite*, exhibiting a splintery fracture. This is the most common variety. It is very perfectly stratified in most instances, the strata varying in width from half an inch to a foot or more. Generally the surface is partially decomposed to the depth of more than half an inch, resembling some varieties of anygdaloid, or variolite. On account of the evenness of its stratification, it forms an excellent building stone, and is employed for this purpose by the inhabitants of Canaan. Not unfrequently these strata are divided by seams crossing the regular planes of stratification nearly at right angles. (No. 541.)

3. *A mixture of Scapolite and Dolomite.* The proportion of the two minerals is various. The limestone is most liable to decomposition and leaves the scapolite in irregular masses; giving to the rock a most forbidding aspect. (No. 542.)

4. *Compact Scapolite Quartz and Mica.* (No. 543.) This appears to be mica slate or quartz rock containing a small proportion of scapolite.

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5. *Granular Quartz and Scapolite*, containing also tremolite and augite. (No. 544.) This variety is scarcely worth noticing.

The strata of scapolite rock in Canaan run in a direction not far from northwest and southeast, and dip to the northeast at an angle generally as great as 45°. The principal part of the rock seems to lie between the dolomitic limestone beneath, and the mica slate above which forms lofty ridges of mountains in Canaan. I saw none of the scapolite rock in place, however, more than 200 feet above the limestone, though bowlders of it are frequently met with on the mountain east of South Canaan meeting house to its summit, on the road to Norfolk. I did not see the actual junction of the mica slate and scapolite rock, but the dip and situation of the two rocks renders it almost certain that the latter does pass under the former. On the lower side, the scapolite rock passes by a gradual mixture into the limestone; as the specimens will show. Upon the whole, the age of this rock is the same as that of the Berkshire limestone, which alternates with mica slate; and which probably is not as old as that which alternates with gneiss.

It will be seen that the preceding description of this rock does not differ — except in being more extended — from that which I gave in 1828, in the 14th Vol. of the American Journal of Science. If I could have referred it to any known group of rocks, I should not have described it as new. But this was impossible.

### 9. QUARTZ ROCK.

Among the older rocks geologists have not been able to discover any determinate order of superposition; although each one of them is most likely to be found in a particular connection. But the same rocks are also found in several other connections, so as to render all attempts to fix their exact place in the scale unsatisfactory. Our rocks are as unmanageable in this respect as those in Europe, but no more so; showing that the same general causes have produced them on both continents. I have already shown that our limestones are of various ages, and the same is true of quartz rock, hornblende slate, and some others. Amid this great uncertainty as to the place in the series which the older rocks ought to occupy, it is not easy to decide what is the best order of describing them. It will be observed that I do not follow exactly the same order in the account of the rocks which I am now giving, as is followed in the tablets attached to the

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map. The order which I now follow, and which agrees with that given on the Tabular View of the Rocks in the Atlas, accords, as nearly as I can determine it, with the order of nature: whereas on the map, I was obliged to have some reference to convenience of exhibition; one of the groups being miscellaneous.

### *Mineralogical Characters.*

Quartz rock was first described by Dr. Macculloch; and its chief ingredient, as its name implies, is quartz. But it takes into its composition, mica, feldspar, and sometimes blue schistose clay. The following varieties are found in Massachusetts.

1. *Pure Quartz.* This exists in several states. First, hyaline, white: generally in beds in mica slate. Secondly, compact, white, or reddish, or dark blue; in beds in argillaceous slate. It is quite obvious that this blue variety has, in some way or other, been coloured by the slate; either when first deposited from aqueous solution, or when subsequently melted, if it ever has been, by heat. Thirdly, course, granular, color gray, or reddish. These are the most common varieties. Fourthly, fine, granular, or arenaceous; sometimes disintegrated so as to form a beautiful white sand. (Nos. 545 to 565.)

2. *Granular Porous Quartz*, with occasional fragments of foliated feldspar and black hornblende. This is the rock described in the first part of my Report, under the name of buhrstone; for which it is used. It is certainly a remarkable rock. Without close inspection it would not be distingushed from the Paris buhrstone. But it is in fact finely granular; and what is most remarkable, is the occurrence in it of occasional fragments of foliated feldspar and hornblende, rarely larger than a pea, and often not larger than the head of a pin. These have evidently been subject to attrition; and they give to the rock somewhat of a mechanical texture. I have observed also in this rock, traces of mica slate: and the longest direction of the pores corresponds with that of the strata seams, and gives the rock a slight claim to a slaty structure. The pores or cavities are rarely large, but they are disseminated through the whole rock; and most frequently coated with a yellowish substance, which may be hydrate of iron. The quartz in these cavities is slightly mamillary sometimes, showing a tendency to crystallization. (No. 567.)

3. *Quartz and Feldspar;* the former in much the largest quantity. This variety usually occurs in connection with gneiss, and not in large quantity. (Nos. 571, 593, 600.)

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4. *Quartz and Mica.* This differs from mica slate, only in the predominance of the quartz. Usually this mineral is greatly in excess: but occasionally the quantity of mica increases so much, that it is impossible to say of particular specimens to which rock they ought to be referred. In such cases I have taken into consideration the character of the surrounding region. If mica slate predominates, and there be not an actual passage into decided quartz rock, I have thought it useless to describe the rock as quartz rock, even if for a considerable extent the quartz predominates. Such cases as this are common in the mica slate range extending from the mouth of the Merrimack to Connecticut. And on the other hand, if quartz rock predominates, an occasional excess of mica in some of its strata has not prevented me from considering the whole as quartz rock.

The mica in this variety is arranged in a parallel position, and it produces a schistose structure; though sometimes the laminae are so thick that they ought rather to be regarded as strata. In other instances, the schistose layers are extremely tortuous and very distinct from the stratification. I have observed this circumstance only in Berkshire County, as in Lee. (Nos. 572, to 580; and 587 to 592.)

5. *Quartz and Talc.* Some of the talcose slate in Hawley, Plainfield, &c, occasionally becomes a slaty arenaceous quartz, with seams of greenish talc. (No 581 to 583.) Its colour is white, and this rock, seen at a distance in Hawley and Rowe, resembles gneiss. It is obviously a member of the talcose slate formation; and it may be questionable whether it ought not rather to described in connection with that formation.

6. *Quartz and Hornblende.* Instead of talc, the white arenaceous quartz described under the last variety, sometimes contains numerous distinct crystals of black hornblende. (Nos. 584, 585.) It forms a beautiful rock, and if it would admit of a polish, might be employed for ornamental purposes. It is less abundant than the preceding variety. In the gneiss formation, there is a variety in which greenish hyaline quartz contains flattened imperfect crystals of actynolite. (No. 584.)

7. *Quartz and Argillaceous Slate.* I have observed this only in Bernardston, in connexion with the encrinal limestone. (No. 601,) The quartz is white and blue, and exhibits a brecciated structure. It was probably coloured by the slate; but very few fragments or layers of slate are now visible.

8. *Quartzose Breccia.* This consists of angular fragments of gran-

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ular quartz, connected by oxide of iron; or of fragments of mica slate, surrounded by radiated quartz. The variety found in bowlders in Leverett and Amherst, (I have no doubt that the bed from which they were derived is in Leverett,)contains but very little iron, scarcely more than enough to give a part of the fragments a reddish hue. (Nos. 602, to 608.) Another variety I have found in Amherst, in connection with the gneiss formation, in which the cement is magnetic oxide of iron. But the most interesting variety exists in numerous bowlders along the western slope and base of Hoosac mountain. It consists of angular fragments of white and reddish granular quartz cemented by brown hematite. (Nos. 604 to 606.) In the cavities the hematite is often iridescent and mamillary; and the coat investing the fragments, fibrous. The largest bowlders of this rock that I have seen, (6 to 8 feet in diameter,) occur on the Pontoosic turnpike from Pittsfield to Springfield, in the south part of Dalton, at the foot of the Hoosac range. But I have never found this rock in place. It may be that the loose fragments have all proceeded from a huge vein of this breccia. But from their size and abundance, I rather presume that this rock will be found as a bed in the common granular quartz of the vicinity. I found one bowlder of this rock ten inches in diameter, in Southampton; only two or three miles from Connecticut river; affording another proof of a northwesterly diluvial current in former times.

Professor Dewey remarks, that in Great Barrington and Sheffield the fragments of quartz are united by a cement of quartz.

The most common gangue of the lead and manganese ores in Hampshire and Franklin counties, is quartz. In a majority of cases it is radiated quartz investing nuclei of micaceous slate. Thus is produced a very curious kind of breccia. (No. 608,) And since these veins are sometimes 6 or 8 feet thick, the quantity is great enough to deserve a notice in this connection.

9. *Quartzose Conglomerate.* This consists of a paste of quartz and mica, in which are imbedded numerous distinctly rounded pebbles of granular or hyaline quartz. (Nos. 609, 610.) It possesses as completely the characters of a conglomerate as any of the puddingstones of the secondary formation. I have never found it in place; but cannot doubt that it is associated with the quartz rock of Berkshire county. For its bowlders are not uncommon on the west slope and the top of Hoosac mountain. In Windsor I found them unusually abundant. I have even found small bowlders in the Connecticut valley, in Deerfield. It appears to be identical with the Conglomerate Quartz Rock

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of Macculloch.* Ths size of the imbedded pebbles is usually about an inch. It greatly resembles the rock that constitutes the first ridge of the mountain range on the east side of Wyoming valley, in Wilksbarre, Pennsylvania; and which there probably underlies the the anthracite coal formation.

This rock being most decidedly mechanical in its texture, will throw some light on the age of the quartz rock, and associated limestone of Berkshire valley, if it be admitted that it forms a part of the series; of which I think there can be but little doubt.

It will be perceived that the varieties, Nos. 5, 6, and 8, above described, are different from any mentioned by Dr. Macculloch, and so far as I know, by any writer.

In order to have a complete view of quartz rock, as it exists in Massachusetts, we ought to recollect that two varieties (red and blue,) have already been described as comprehended in the graywacke formation.

### *Topography of Quartz Rock.*

On the map I have represented all the quartz rock in the State (except that connected with the graywacke,) as associated with mica slate, talcose slate, or gneiss. It is also more or less connected with other rocks; as with limestone in Berkshire, and with argillaceous slate in Bernardston. But in all other cases, except in regard to gneiss and mica slate, it is little more than a juxtaposition of the two rocks; whereas the quartz rock alternates with, and passes imperceptibly into gneiss and mica slate. And in fact it might be regarded very properly as a member of the gneiss and mica slate formations.

In Cumberland, Rhode Island, I have marked a strip of quartz rock as connected with the peculiar rock that prevails in that place, and which I venture to denominate talco-chloritic slate; although its characters are very obscure. Or rather the quartz rock lies between this slate and the graywacke on the east; and I think also that it alternates with the talco-chloritic slate. In the northeast part of the town, it forms a hill of considerable altitude, of snowy whiteness. More westerly its color is gray, and it is of a coarser texture.

I take this opportunity to remark, that I do not feel confident that even on the second edition of the geological map, and after a re-examination of that region, I have correctly delineated the rocks of Cum-

* Geological Translations, vol. 1. p. 60. Second Series.

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berland and its vicinity. Its geology is certainly very intricate, and deserves the long and careful study of some one who resides in the vicinity; and then it should be exhibited on a map of a larger scale than mine. Since it is not in Massachusetts, I did not feel justified in devoting so much time as was desireable to its examination.

The range of mica slate extending from Webster to the mouth of the Merrimack, often passes into genuine quartz rock, and generally contains a large proportion of quartz. In the south part of this range, in Webster especially, I noticed so much quartz rock that I have represented a patch of it on the map.

The gneiss formation on the east of this mica slate, especially near the southeast part of Worcester county, is associated with extensive strata of quartz rock. In Sutton and the vicinity, it occupies a considerable part of the surface; and there I have delineated this rock on the map. I have noticed it in several of the towns northeast from Sutton, interstratified with gneiss and hornblende slate. In the eastern part of Franklin county, in New Salem and Warwick, I have met with it in strata of a few feet wide, interstratified with gneiss.

Along the western border of the great gneiss range of Worcester county, is another narrow stratum of quartz rock, in some places associated with the gneiss, sometimes with hornblende slate, and sometimes with mica slate. I have represented it on the map as extending only from Leverett to the north line of the State, because south of this place it is very narrow and frequently interrupted. Mica slate is commonly associated with this rock north of Leverett. On the opposite side of Connecticut river, in Northfield, Mass. and Vernon, Vt. quartz rock forms one of the members of a series of mica slate passing into gneiss, hornblende slate, and argillaceous slate. In Vernon it is liable to disintegration and has been employed for the manufacture of glass. In Bernardston, where it approaches the clay slate, as already remarked, it occasionally takes portions of that rock into its composition. But generally in Leverett and Northfield, it is that variety which contains mica.

Berkshire county, however, contains the principal repository of quartz rock. Here it is usually associated with mica slate; and although it is represented as lying contiguous to gneiss, yet I have given my reasons elsewhere for the opinion that its position is unconformable to that of the gneiss. It sometimes forms hills of considerable elevation: as Monument Mountain in Stockbridge, which is more than a thousand feet high. Compared with the mica slate and gneiss



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however, this rock lies generally at a low level; corresponding in this respect with the limestone. The largest proportion of this rock is gray or reddish granular quartz. In Cheshire it is extensively disintegrated, so as to form a good sand for the preparation of glass. For the cause of this disintegration I have sought in vain. The buhrstone in Washington, near Pittsfield, is another interesting variety; and in the same hill the granular quartz is quarried extensively for architectural purposes, on account of the great regularity of its stratification. I observed the variety containing mica, in Lee, Washington, Canaan, Ct. &c.; though this is not the most common variety. The situation of the breccias and conglomerates has been already pointed out.

It is also unnecessary to say any thing farther in relation to the quartz rock containing talc and hornblende.

In connection with the gneiss in the southeastern part of the State, it may be remarked, that quartz rock occurs in considerable quantity, as I have noticed in several places, having an agatized structure. That which I found in Rochester, is quite beautiful, (a polished specimen of which may be seen in the collection.) Some examination since the publication of the first edition of the first part of my Report has led me to suspect that this quartzose aggregate is more abundant and extensive than I had supposed; perhaps extensive enough to deserve a place on the map.

### *Dip, Direction, and Character of the Strata.*

It requires in many cases careful attention to discern seams of stratification in the purely granular quartz of Berkshire county. They are never, however, wanting for any considerable extent. And very frequently there exists a set of cross seams, nearly at right angles to the planes of stratification. The same thing is true of the quartz rock of Leverett and Northfield, in which mica is sparingly interlaminated. (No.577.)

In general, however, quartz rock exhibits great distinctness and regularity of stratification, particularly the variety last mentioned. Where the mica is in small quantity, the thickness of the strata is considerable; but as the mica increases the layers are thinner, until al length the rock becomes schistose. At the quarry in Washington, near the buhrstone locality, the stratified structure is beautifully exhibited; and it results from a minute quantity of mica, in scales scarcely visible to the naked eye. The stratification of the buhrstone, which

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lies at the northern extremity of the same elevation, is much less distinct. But immediately beneath this variety, the rock takes so much mica into its composition as to become slaty,— almost mica slate even. (No. 591.)

In general the dip and direction of the strata of this rock correspond to those of the gneiss and mica slate with which it is connected. In Berkshire I have already remarked that the direction is usually north and south, and the dip east, at rather a small angle. At the quarry just mentioned, however, the dip is from 10° to 15° westerly; but the buhrstone dips about as much in the opposite direction. And in the quarry we find veins of granite, indicating the proximity of a larger mass of that rock; though I did not explore the surrounding region for it: but I think this fact will afford a probable explanation of this anomaly in the dip of the strata. In the northeast part of Windsor, high up the Hoosac range of mountains, this rock dips north about 25°.

The quartz rock in Northfield and Bernardston, west of Connecticut river, dips from 20° to 60° east, and runs north and south. East of the river, its dip approaches 90° east. In Southborough its direction is nearly east and west, and its dip northerly and large. In Oxford and Webster its direction is nearly north and south and its dip from 20° to 45° west; though in the west part of Oxford I noticed a dip of 10° easterly, the rock being interstratified with gneiss. In Sutton the dip is from 30° to 35° north, corresponding to that of the gneiss in the vicinity.

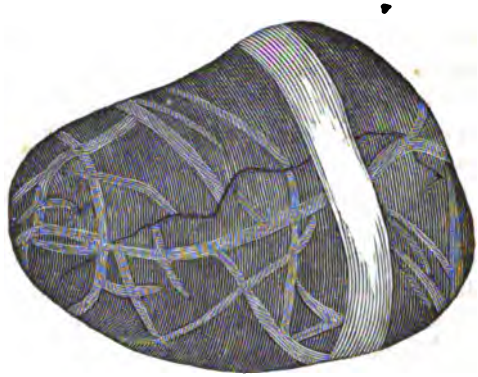
### *Mineral Contents.*

Scarcely any rock in Massachusetts is so destitute of simple minerals as this; unless we include in it those metallic veins of which quartz is the gangue. And these may more appropriately be described under quartz; in which rock these veins for the most part occur. Hematite iron ore, forming the cement of the quartzose breccia in Dalton, is the most interesting mineral in the quartz rock. Sulphuret of iron, also, has been observed in small quantities in that quartz rock which is associated with talcose slate in Hawley, &c. In Pittsfield, Worthington, &c. masses of quartz are found of a yellowish color, and appear to be genuine ferruginous quartz. Sometimes this quartz passes into yellow jasper, and also into chalcedony and hornstone, as at Dalton.

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### *Veins in Quartz Rock.*

In a few instances, as at the quarry of quartz rock in Washington, several times spoken of, veins of granite may be seen. But generally the veins in this rock are quartz; the vein being usually white and opaque, and the rock a mixture of gray granite and mica, — the latter mineral existing, however, in very small proportion. In some instances the rock appears to be what the Wernerian writers denominated primitive siliceous slate. The following is a sketch of a bowlder of about eight inches diameter, found in Amherst. The principal part of it is gray quartz traversed by numerous veins of white quartz.



Quartz Veins in Quartz Rock.

### *Theoretical Considerations.*

The regularity of the stratification in quartz rock, and the fact that silica is soluble in water, have disposed geologists, in all cases where it is possible, to impute to this rock an aqueous origin. But like all the older rocks it appears subsequently to have been subjected to heat of a greater or less degree of intensity, whereby it has been rendered compact. And no doubt in this way some siliceous sandstones have been converted into solid quartz: as in the Isle of Sky in Scotland, where trap comes into contact with the sandstone.

A complete theory of the formation of that variety of brecciated quartz, which in Dalton is cemented by hydrate of iron, it is not easy to form. The chief difficulty seems to be, to imagine how the quartz was broken into such numerous angular fragments: for after these

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fragments were piled together, it is not difficult to conceive that the interstices might have been filled by the iron from solution in water.

The same difficulty occurs in the case of those extensive metalliferous veins that have been referred to, whose gangue is quartz, enclosing masses of mica slate and forming a kind of breccia. But the whole subject of mineral veins has a great deal of mystery hanging over it, and is probably less understood than any other department of geology.

What shall I say of the origin of the Washington buhrstone? We have every reason to conclude that the French buhrstone was deposited from water. And that at Washington differs from it chiefly in being more arenaceous and tender. Probably, therefore, it had a similar origin. But what shall be said of the occasional *fragments* of feldspar and hornblende which it contains? Certainly these give it somewhat of a mechanical character, and their production and introduction are difficult to explain. Can it be, that subsequently to its deposition, it has been subject to the action of a heat so powerful that a partial fusion took place, and a few imperfect crystals of feldspar and hornblende were thus produced? That granite exists in quantity not far from this rock, is rendered probable by the facts already mentioned, viz. that veins of it occur at a quarry of quartz rock in the same hill, and that the strata at this quarry dip a few degrees to the west, while the burhstone dips about as much to the east. And this granite might have furnished the requisite heat.

The conglomerate quartz rock originated probably like other conglomerates: that is, we must first suppose an abrasion of existing strata, and then a consolidation of the materials thus worn off, either by heat or simple desiccation. In the present case, heat was probably an important agent. Otherwise I know not how to explain the marks of a crystalline structure which it exhibits; as much, indeed, as the oldest mica slate. But until this rock is found in place, it will be useless to spend much time upon its theory.

The varieties of quartz rock associated with mica slate, talcose slate, and gneiss, probably had an origin similar to that of these several rocks. That they have all been acted upon powerfully by heat, I cannot doubt; but not until after their deposition. I confess myself inclined to the opinion, that all these strata originally resembled our present secondary strata; and that the agency of the unstratified rocks has rendered them crystalline. Thus the quartz rock that con-

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tains some mica, might have been originally a micaceous sandstone. But more of this hypothesis as we proceed.

It is gratifying to find that the quartz rock of Massachusetts corresponds so closely with that of Europe. But we shall find this to be the case generally with our primary rocks; a proof of uniformity in the mode of their production.

### 10. MICA SLATE.

It is usual to place this rock next to gneiss, or as the second in respect to age among the stratified rocks. And in Massachusetts it is not unfrequently associated with gneiss. But it is also associated with every other rock, as high in the series at least as argillaceous slate: I mean in a conformable position. Hence I have thought it best to introduce it before talcose and hornblende slate and serpentine; because these latter rocks, in the district under consideration, are connected, scarcely without an exception, only with gneiss and the oldest varieties of mica slate.

#### *Mineralogical Characters.*

It is hardly necessary to remark, in respect to a rock so common and well known, that its essential ingredients are quartz and mica: and the anomalies of composition are fewer in this rock than in most others; although the varieties of aspect are numerous. As I understand the subject, however, it is necessary that the mica should be the predominant ingredient, in order to constitute a rock mica slate. But in this case we must look to the whole mass of the rock, rather than to hand specimens: for single specimens may often exhibit the quartz in excess, and yet be regarded as mica slate. The following varieties of this rock I have found in Massachusetts.

1. *Quartz and Mica*: the former granular and laminar; the latter in distinct scales and highly glistening. This variety is associated with the oldest rocks, as granite and gneiss; and is obviously more highly crystalline than the other varieties. The longitudinal arrangement of the mica gives this variety sometimes a fibrous appearance. (Nos. 614 to 626.)

2. *The same, containing a small proportion of Feldspar*, and thus passing into gneiss. (Nos. 627 to 636.) It is only when the mica greatly predominates that this rock can with any propriety be denominated mica slate.

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3. *Passing into Talcose Slate.* In most cases the mica slate, under this variety, takes into its composition scales of greenish talc. But sometimes, I apprehend, the mica becomes tender, almost losing its elasticity, and very much resembling talc, from which it is scarcely possible to distinguish it. When the talc predominates, especially to the exclusion of the mica, the rock then becomes talcose slate. (Nos. 637 to 641.)

4. *Amphibolic and Garnetiferous Mica Slate.* This variety takes into its composition in large proportion, hornblende or garnets; usually both. From the fact that those minerals are commonly found together, I have made only a single variety include them both. (Nos. 642 to 645.)

5. *Staurotidiferous Mica Slate.* In this rock the mica is in very fine scales, and it has the general aspect of argillaceous slate; except that when the strata are viewed edgewise, they exhibit a striped appearance in consequence of numerous layers of staurotide, which appear to be coextensive with the layers of the rock. I should not have regarded this mineral as of importance enough to constitute a distinct variety of mica slate, did I not know that extensive ledges, like the rock just described, extend nearly across the whole of Massachusetts, through the towns of Norwich, Chesterfield, Goshen, Hawley, and Heath; and on the east side of Connecticut river, it has been traced, with some interruptions, from near Long Island Sound to Franconia, New Hampshire, a distance of nearly 200 miles. Where it crosses Massachusetts, however, it is but imperfectly developed. (No. 646.)

I wish here to remark, that when I coin a new term to prefix to a variety of rock, it is rather for the sake of giving a laconic definition, than in the wish or expectation that it will become a permanent name for the rock. Indeed, mere varieties need no distinct names, except when an attempt is made to give a logical account of a formation.

6. *Spangled Mica Slate.* The basis of this singular rock is the same as in the last variety; and the two are associated in Chesterfield, Goshen, Plainfield, &c. Through this base are disseminated numerous thin foliated plates of a deep brown color, resembling mica somewhat, but almost entirely destitute of elasticity and brittle. Their length, (rarely more than a quarter of an inch,) is usually twice as great as their breadth, and there is a decided polarity exhibited in their arrangement: that is, their longer axes all lie in the same direction, and the surfaces of the plates in the same or in parallel planes;

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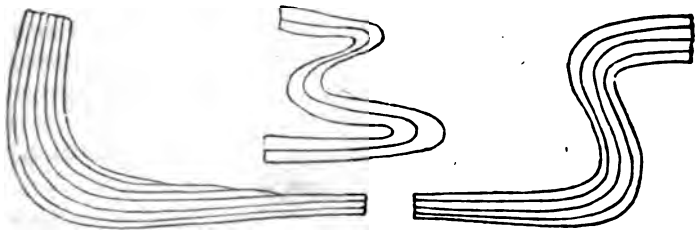
so that light is reflected from many of them at once when the specimen is held in a proper position, and thus a beautifully spangled appearance results. Not being confident as to the nature of this mineral, I have given the rock a designation which indicates merely this obvious property. These spangles are pretty uniformly diffused through the mass, and their surfaces rarely coincide with the layers of the slate. (Nos. 647 to 650.)

I found this same rock in rolled masses in Newport, R. I. And Col. Totten informed me that it exists in place on one of the islands in Narraganset bay, — Canonicut Island, I believe. At Plainfield it is sometimes divided into rhomboidal masses by oblique cross seams. (No. 649.)

7. *Argillo-micaceous Slate.* This exists wherever the mica slate passes by gradations into clay slate; and such places are numerous in Massachusetts. It exists also, in connection with the two last varieties, in the range of slate passing through Chesterfield, Plainfield, &c.; where the strata are perpendicular, and have a broad range of decided mica slate on the east, and a similar extent of talcose slate, hornblende slate, and gneiss, on the west: which position is strong evidence that this rock must be one of the oldest of the primary strata. It does not, however, in this case actually pass into clay slate. And I believe it will always be found to consist of fine scales of mica, closely compacted, so as to give it an argillaceous aspect. This rock sometimes contains large beds of white quartz, which is frequently fetid. (Nos. 651 to 667.)

8. *Arenaceous Mica Slate.* In this variety the quartz is gray, in fine sandy grains, and diffused through the whole mass, not lamellar. (Nos. 668 to 712.) The mica is in fine disseminated scales; although the plates are usually parallel to one another. The mass is usually imperfectly schistose, though more regularly stratified than most other varieties; and sometimes there exists a double set of strata seams. Ordinarily it is not so much contorted in its layers as the older varieties; but an intermediate variety is perhaps of all the mica slates most remarkable for irregularity. The following are sketches of the curvatures, in Nos. 688, 689, and 690, which are from the Gorge or "Glen" in Leyden.

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In Norwich and Enfield this variety has been extensively employed for whetstones: the former locality is far the best, and the latter is now nearly or quite abandoned.

In general this variety occupies the highest place in the mica slate series. Thus we find it on both sides of the Valley of the Connecticut, when first we pass on either side of the river from the new red sandstone; and the whole of the mica slate formation in Worcester County is of this description.

This variety is very nearly allied to quartz rock. Indeed, in respect to extensive tracts, it is often difficult to say whether it should be denominated quartz rock or mica slate. Sometimes it exhibits a double set of strata seams; one set being oblique to the other. It contains also not unfrequently beds or tuberculous masses of white or sometimes blood red quartz.

9. *Anthracitous Mica Slate.* This is simply a very fine grained mica slate, approximating to clay slate, which has been impregnated and rendered black and shining by carbon. I am disposed to regard the rock constituting the immediate roof and floor of the anthracite bed in Worcester, as belonging to this variety, although I am aware that it has been generally regarded as argillaceous slate. But I think that in all cases careful examination will detect the mica. Of this, however, more in another place. This variety occurs, also, in Ward and in Dudley. (Nos. 717 to 719.)

10. *Plumbaginous Mica Slate.* This rock differs from the last only in exhibiting the gray aspect of plumbago, rather than the dark color of anthracite. But probably in most cases very little plumbago is present. Yet the resemblance is often striking. This variety occurs frequently among the newer beds of mica slate; as for instance, on the east side of Connecticut river, in Southampton, Conway, Shelburne, &c. (Nos. 713 to 715 and 718 and 719.)

11. *Conglomerated Mica Slate.* In Haverhill and Amesbury I ob-



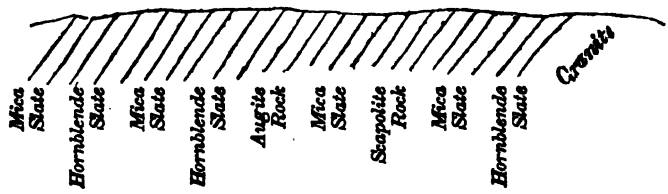
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served fragments of mica slate cemented by the hydrate of iron, so as to form a conglomerate. (No. 716.) It is, however, of very limited extent; occupying only occasional fissures in the rock, and is probably the result of slow disintegration, and the subsequent infiltration of iron from the decomposition of pyrites.

In the vicinity of the sienite in Whatley, I found a bowlder, obviously composed of fragments of mica slate, which were once partially fused. They are cemented together chiefly by feldspar. The numerous nodules of the mica slate imbedded in the sienite at that place will render this explanation rational, as I shall attempt to show in describing sienite. (No. 724.)

12. *Indurated Mica Slate.* In the same region in Whatley, I found a bowlder between quartz and chert, of a dark gray colour, exhibiting traces of an original slaty structure. (No. 725.) As Dr. Macculloch says of a similar variety found in Scotland, "it is not enumerated with the siliceous schists, because it has not been the practice so to do; but it bears a strong analogy to the primary varieties of these."*

13. *Augite Rock.* It may not be expected to see this rock placed in this connection: since the rock of this name described by Dr. Macculloch in Europe, is an unstratified overlying rock, associated with basalt and greenstone. But the one here introduced, is of entirely a different character. It is ordinarily composed of granular and semicrystallized augite, of a greenish or yellowish color, mixed with quartz in small quantity; and is interstratified with mica slate and hornblende slate. And since it occurs in too small a quantity to be described as a distinct rock, I thought the proper course would be to notice it in this connection. (Nos. 726, 727.) I have found it only in Williamsburgh, two miles west of the meeting house, at the locality of smoky quartz and plumose mica; where its characters correspond with those mentioned above. But Dr. Emmons informs me that it exists in Chester in the situation exhibited below: that is, there




* Classification of Rocks, p. 260.

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exists in that town such an alternation of strata. One of the beds of this rock is partly made up of "a variety of *paratomous augite-spar*, which cleaves into thin plates and approaches nearly in some specimens to schiller spar. Yet" says Dr. E. "I should not call the stratum Diallage Rock." (so it had been called) "The loose bowlders which I first found were aggregates of this variety of pyroxene and feldspar. I afterwards found that they came from the mica slate and did not generally resemble granite." Concerning the scapolite rock, placed by Dr. Emmons on the above section, he has given me no information.

### *Topography of Mica State.*

It will be seen by the map that this rock occupies several large tracts in the State. And it exists, also, in smaller quantities, associated in numerous places with gneiss and granite, but not shown on the map. Thus the region in Northampton, Williamsburgh, Goshen, &c, coloured as granite, is in fact nearly half mica slate. But it would be impossible to represent the true relative position of the two rocks; and, therefore, I have coloured the whole space as composed of the predominant rock. And the same remarks will apply to almost every other range of granite that is represented in the central or western parts of the State.

The mica slate of Berkshire is chiefly of those varieties that approximate to argillaceous and talcose slate. It there forms lofty insulated mountain peaks, or continuous ranges. Saddle mountain, nearly 4000 feet high, and the highest point in the State, is composed of this rock. And so is the eastern part of Taconic range: as well as nearly all those broken ranges of mountains extending from Lenox through Stockbridge, Great Barrington, and Sheffield. As a general fact, the limestone occupies the vallies; and this would be deemed conclusive proof that this rock was deposited subsequently to the mica slate, did we not find it sometimes alternating with the slate. Shall we then infer, that the limestone being much more liable to disintegration than the slate, has been decomposed and abraded so as to bring it down to much the lowest level?

As we ascend the Hoosac mountain, the mica slate assumes a much more crystalline aspect and appears to belong to the oldest varieties of this rock. It is essentially of the same character across the whole mountainous range between the vallies of Berkshire and the Connecticut: though as we approach the latter valley, we find it sometimes

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assuming an argillaceous or arenaceous character; and in Leyden it passes into distinct argillaceous slate.

It will be seen by the map, that the Hoosac mountain range, (by which I mean all the mountainous region between the vallies of Berkshire and the Connecticut,) is composed mainly of two wedge shaped patches; the one of gneiss and the other of mica slate; the first having its acute angle towards the north, the other towards the south. And yet, according to the map, which shows the direction of the strata, (Plate XVI.) the strata extend uninterruptedly across both the wedges. And such I believe to be the fact. It is my opinion that the mica slate and gneiss pass laterally into each other; that is, as we go north, the feldspar decreases in quantity until it disappears; and of course the rock is mica slate; and so *vice versa*. But the lateral passage of one rock into another is extremely difficult to prove; because, on account of the diluvium spread over the surface, we cannot trace a stratum with certainty for any considerable distance. Accordingly this is a subject rarely touched upon by geological writers. I recollect, indeed, but a single statement of any fact resembling this: Dr. Macculloch speaks of the beds of red sandstone in Sky, as "changing their composition even according to the line of their prolongations:"* But they merely change from red sandstone into gray quartz rock; which might have resulted from the application of heat. Yet I see no insuperable difficulty in supposing that in one part of an extensive deposit, gneiss might have been produced, and mica slate in another; I mean in the same stratum. Some geologists suppose that these rock were produced by direct crystallization from aqueous solution: and on this hypothesis, I can imagine how one portion of the menstruum might be destitute, or nearly so, of feldspar: while the other part should abound in it; especially if the supposed lake or ocean were shallow. Other geologists suppose these rocks to have been originally deposited in the condition of sediment, and that their crystallization resulted from their subsequent partial fusion by heat. And certainly in consistency with this hypothesis, may the change of composition under consideration be explained. But as to the fact of such a change in the present case, I would not wish to be very positive without farther examination. It is, however, certain, that much of the gneiss in the Hoosac range so much resembles mica slate, that Prof. Dewey was led to describe it as such. But as it does pass into distinct gneiss to-

* Western Islands, Vol. 1. p. 307.

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wards the south part of the State, and especially in Connecticut, I have not hesitated thus to mark the whole formation as far north as the rock contains any noticeable quantity of feldspar. I suspect that careful observation might discover that the rock contains feldspar across the whole State, and that the patch of gneiss represented in Whitingham Vt. is a continuation of the range marked on the map as extending only to Savoy.

Near the central part of this range of mica slate, occurs a range of talcose and chlorite slates, in conformable order, and passing insensibly into the mica slate. Hornblende slate and limestone are connected with it still more intimately, as the map will show.

The mica slate on both sides of Connecticut river in Northfield, is separated from the range just described, by a deposite of argillaceous slate conformably stratified and gradually passing into the mica slate. though the direction of the strata of the clay slate is more towards northeast and southeast than that of the mica slate on the west: On the east, the mica slate becomes decided quartz rock; and this accompanies the mica slate, though often wanting, as far south at least as Leverett.

The narrow stratum of mica slate marked on the map in the eastern part of Hampshire, and Hampden counties, is associated with talcose slate on one side, and with gneiss on the other. From having noticed occasional patches of mica slate among the gneiss as far north at least as Enfield, I have been induced to extend the stratum so far, in doubt, however, whether it be continuous over the whole distance. In many other parts of the broad gneiss range of Worcester county, I would here remark, we find limited beds of mica slate, apparently interstratified with the gneiss. But to exhibit all such cases on the map would require immense labour, and be of little service.

In the northwestern part of the gneiss range of Worcester county, will be perceived on the map, a succession of granite, gneiss, and mica slate deposites. I have not in that case attempted to give the exact extent of these several rocks in that region: but simply to indicate that such a succession of strata exists there; and that the different members of it occupy the surface in about the same ratio as the different colours. I apprehend that here is another example of a different composition in the same stratum prolonged. But I throw out this hint merely to excite others to make that thorough examination which I have not been able to do.

In passing eastward we next come to the Worcester range of mica slate, which has been several times referred to. This rock has hereto-

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fore been regarded, either as graywacke slate, or talcose slate, or both.* But after a careful examination of this formation in various places, from the mouth of the Merrimack to Connecticut line, I am constrained to regard it as one of the latest varieties of mica slate: probably what Humboldt would call transition mica slate. True, I have occasionally met with a limited portion of this rock, which had somewhat of a mechanical aspect: though not much more so than I have found in every range of mica slate which I have examined. In some cases too, there exists a glazing, apparently talcose, on the laminae of the rock; and this variety certainly approximates closely to graywacke slate. Still, these are not the predominant characters of the formation. Generally the rock is composed of gray arenaceous quartz, and mica in minute scales: the rock exhibiting too much of a crystalline structure for graywacke, and containing, moreover, but little if any argillaceous matter. Where it contains a considerable oxide of iron, as in the northeast part of Worcester, it presents at a little distance the dirty appearance of sandstone: but a closer examination will show the characters above pointed out. I saw not the least trace, moreover, of any organic remains in this formation; nor have I any evidence that such have ever been found. In short, though very probably genuine cabinet specimens of graywacke slate may be found in this formation, yet as a whole, I could not, without doing violence to my convictions, refer it to any formation but mica slate. But as I shall place quite a number of specimens from this formation in the hands of the Government, others by inspecting them can form their own opinions as to their nature.

I ought to remark that quartz very frequently predominates in this formation, and the mica almost disappears. Indeed, I am by no means sure that quartz is not the predominant ingredient in the whole formation: and if so, it ought to be denominated quartz rock. And it seems to me that there is much more reason to doubt as to this point, than whether it ought to be referred to graywacke, or talcose slate.

As we approach the east and west sides of this range, the characters of the mica slate become more decided; and in this slate of apparently greater antiquity, the veins and protruding masses of granite are more numerous; though they occur in every part of the formation, and sometimes in the argillaceous slate connected with it. Except that in Worcester, Fitchburg, and Pelham, (N. H.) no at-

* Eaton's Canal Rocks and Geological Text Book.

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tempt has been made to give the actual number and extent of these masses of granite on the map; but simply to indicate where they are most numerous. I regard the frequency of the protrusion of this granite, and the perfection of its character, as some indication that the formation is older than graywacke. A large proportion of the most beautiful granite in the state is contained in this formation; and it is entirely wanting in hornblende; which circumstance, if I mistake not, affords some presumption of its being among the oldest of the granites.

But does not the occurrence of anthracite in this formation at Worcester, decide at once that it cannot be mica slate? Some might, indeed, doubt whether that mineral is actually contained in the rock under consideration; because the slate forming the immediate roof and floor of the mine so much resembles clay slate. But its extent is quite limited, and then succeeds the rock under consideration; and I have already stated that I regard the slate in which the anthracite lies, as an anthracitous mica slate. This is not, therefore, the mode in which I would dispose of the objection to my view of the nature of this rock, derived from the presence of anthracite.

But can there be any doubt that anthracite does occur in mica slate and even in gneiss? The highest European authorities are, I believe, unanimous on this point. If we consult the *Tableau des Terrains* of Brongniart, we shall see anthracite marked in the stratum of gneiss that lies next to granite; in his *Phylladique*, a variety of mica slate superior to the oldest variety of the graywacke series, &c. "It has occurred," says Dr. Macculloch, "in gneiss, in micaceous schist, in primary limestone, and in a conglomerate rock said to belong to the primary rocks."* "It was believed for a long time," says De Lafosse, "that anthracite belonged exclusively to the primitive deposites. But it has been since found that it abounds in the secondary and transition formations," &c.† "Anthracite," says Prevost, "belongs almost exclusively to the oldest of the deposites called transition; where it is met with in beds or veins in the midst of mica slate, of gneiss, and of the *schistes-phyllades*, which overlie vegetable impressions of the family of ferns. For a long time, it is true, it was said that anthracite was found in primitive deposites; but it is probable that this term was applied to rocks and formations which are now

* System of Geology, Vol. ii. p. 296.

† Dictionnaire D'Historie Naturelle, Art. Anthracite.

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placed in the transition formation. It seems almost certain that no primitive anthracite exists."* I asserted in the first part of my Report that some of the anthracite in this country, viz. that at Worcester, occurs in primitive rocks, because it exists in mica slate. A reviewer says that "he has certainly spoken unadvisedly when he asserts that it is so found in this country."† But had he been aware that I reject the transition class, and consequently, following Macculloch, include every variety of mica slate and gneiss, the older varieties of quartz rock, and clay slate, in the primitive class, he would have seen that my statement was in perfect accordance with the authorities quoted above; and their correctness and high standing, I presume, he would not call in question. When Prevost asserts that "no primitive anthracite exists," he means none which he calls primitive. But in the same paragraph he says that this mineral does exist in mica slate and gneiss; every variety of which, geologists of no mean name regard as primitive. If this is all that is meant by the reviewer, there is between him and me no difference of opinion, except in the use of the word primitive.

If it be true, as I suppose, that the Worcester anthracite occurs in mica slate, we see the reason why it approaches so nearly to plumbago, as I have elsewhere shown that it does. For whatever be the cause, as a general fact it is true, that the older the rock in which carbon is found, the more compact it is, and the nearer does it approximate to the semi-crystallized condition of plumbago.

On the first edition of the map a small patch of mica slate was represented in Sherburne. But its extent, as I observed it, was so limited that I have thought it best to omit it. I am not without suspicion, however, that this rock may be found of considerable extent, connected with granite, in Sherburne and in the towns north of that place, as far as Sudbury at least.

The narrow strip of mica slate in Smithfield. R. I. represented on the map as associated with talcose slate, is of rather a peculiar character. It is decidedly arenaceous, and even resembles certain micaceous sandstones. (No. 675.)

The tongue of mica slate exhibited on the map, as extending through the east part of Andover into Middleton, is very probably connected with the Worcester range; since the direction and dip of

* Dict. D'Hist. Nat. Art. Houille.

† Peter A. Browne, Esq. — Bucks County Intelligencer, Sept. 3, 1832.

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the strata correspond with those of that range: and indeed I have traced it nearly to the place of connection with the Worcester mica slate. But commonly it is more decided in its characters, and more crystalline in its texture, than the rock of that range generally; especially where it approaches the coarse granite of Andover.

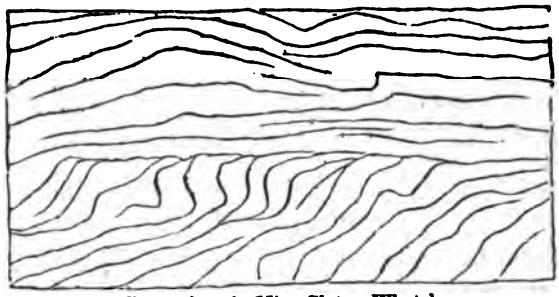
### *Slaty and Stratified Structure of the Mica Slate, with the Dip and Direction of the Strata.*

It is rare to find even a small portion of this rock destitute of a schistose structure. But it is not uncommon to meet with extensive masses in which it is very difficult to trace any strata seams. In other places, however, no rock exhibits more regularity and beauty of stratification. Such differences may in general be explained by local disturbances; but sometimes no appearances will warrant such an explanation of the phenomena. And it seems reasonable to impute something to different proportions of the ingredients in the rock, and to peculiarities in the mode of formation. In general, the less the quantity of mica, the more regular is the stratification. The mica slate in Goshen, Chesterfield, &c. which is remarkably regular in this respect, consists, however, chiefly of mica. Those varieties exhibit most of contortion and undulation in the layers, which are of a plumbaginous aspect, and contain tuberculous masses of quartz.

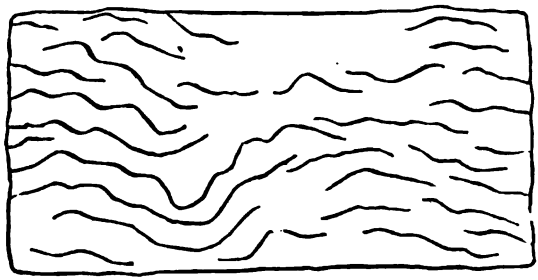
Though our mica slate is sometimes divided by a double set of strata seams, yet I have never met with any examples in which the planes of stratification make an angle with the laminae of the slate. The flexures of the laminae, however, seem in a great measure to be independent of the planes of stratification; and the two structures appear to have resulted from different causes. The two following sketches will illustrate this. In each case a single stratum only is represented; and it will be seen that the curvatures of the laminae have no connection with the strata seams, which are represented by the parallel lines that include the contorted layers. In these cases the strata are two or three feet thick: and they are generally thick; sometimes eight or ten feet, where the slate is much bent. The strata are often bent as well as the laminae, and sometimes the curvatures of the former are parallel to those of the latter.



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Contortions in Mica Slate: Whately.



Contortions in Mica Slate: Conway.

The following extracts from my travelling notes, will show the dip and direction in numerous places of the strata of the different ranges of mica slate that have been described. It has already been mentioned that this rock, in connection with the limestone of Berkshire county, has a direction north and south, and a dip from 15° to 30° east, often greater. Between Cheshire and Lanesborough, for instance, its strata dip from 60° to 90° east; and between Lanesborough and Hancock, from 30° to 40° east.

*Hoosac Mountain Range.*

| | Direction. | Dip. |
|---|---|---|
| Hoosac Mountain, western slope, | N. and S. | 20° to 90° East. |
| Florada, east slope of do. | N. a little W. | 70° to 90° East. |
| From Chester to Becket, | N. and S. | 80° to 90° East. |
| Near Chester village, | E. and W. | 45° North. |
| Goshen, Plainfield, Hawley, Charlemont, and Zoar, | N. and S. | nearly 90° East. |
| Goshen, northwest part of the town, | E. and W. | 25° North. |

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| | Direction. | Dip. |
|---|---|---|
| Westfield to Blanford, | N. and S. | 70° to 90° West. |
| Chester, Worthington, (east part,) Chesterfield, (west part,) Cummington, (east part,) | N. and S. | nearly 90° W. |
| Cummington, (west part,) | N. and S. | nearly 90° E. |
| Heath, | N. and S. | nearly 90° W. |
| Colraine, | N. and S. | nearly 90° E. |
| Whately, | N. several degrees E. | 70° to 90° East. |
| Conway, Shelburne, Leyden, Buckland, and Ashfield, | N. and S. | 20° to 70° East. |
| Leyden, (at the "Glen,") | N. and S. | 90° |

It will be seen that the general direction of the strata in this range is north and south, and the dip very great; for the most part nearly vertical. The most remarkable exception is that which occurs in the northwest part of Goshen, where the strata run almost east and west and have a comparatively small dip. Although these strata are remarkably regular, yet I cannot but believe that this peculiarity has resulted from the protrusion of that vast mass of granite which lies a little east of the slate in that town, in Williamsburgh, Northampton, Whately, &c. I can easily conceive how a vast mass of slate, might be thrown into an anomalous position over a considerable extent of surface, without affecting the continuity of the planes of stratification in limited spaces.

### *In the Connecticut Valley.*

| | Direction. | Dip. |
|---|---|---|
| From Fitzwilliam to Richmond, (N. H.) | N. and S. | East. |
| From Richmond to Winchester, (N. H.) | N. and S. | 30° to 40° West. |
| From Winchester to Northfield, | N. and S. | nearly 90° East. |
| In Northfield, | N. E. and S. W. | 30° West. |
| Do. west side of the river, | N. and S. | 20° to 60° East. |

In this range are frequent alternations of gneiss and protruding masses of granite; and in the lower part of New Hampshire there is a good deal of irregularity in the dip and direction of the strata. That region needs farther examination and elucidation.

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*Worcester and Merrimack Vallies.*

| | Direction. | Dip. |
|---|---|---|
| Webster, | N. and S. | 45° West. |
| Ward, | N. and S. | 70° to 80° West. |
| Worcester, west of hill of granite, | N. and S. | 25° West. |
| Do. east of the same, | various, | 25° to 90° Easterly. |
| From Worcester to Berlin, | N. E. and S. W. | 20° to 90° N. W.? |
| Sterling, | N. several degrees E. | 60° to 70° West. |
| (This last is the most usual dip of this range of mica slate.) | | |
| Leominster, | N. several degrees E. | West, large. |
| Fitchburg to Lunenberg, | do. | 10° to 30° Easterly. |
| Between Lunenberg and Shirley, | do. | Westerly, small. |
| Boxford, | N. E. and S. W. | 25° to 50° N. W. |
| Groton, | do. | 30° to 45° S. E. |
| Pepperell, | do. | nearly 90° N. W. |
| Townsend, | N. and S. | 30° to 60° East. |
| Andover, | E. and W. | 70° to 90° North. |
| Methuen, (Falls,) | E. and W. | 20° to 30° North. |
| Tyngsborough to Dunstable, | | Southeast. |
| Methuen to Dracut, | | Northwest, large. |
| Lowell to Chelmsford, | nearly E. and W. | do. |
| Between Newburyport and Bradford, | do. | Northerly. |

There would seem from the above statement, to be great irregularity in the direction and dip of the strata of this range. Yet it must be recollected, that I was careful to notice all the important anomalies in these respects, that fell under my observation; while I made few records where the usual dip and direction were observed. Hence the statement above made, in respect to the usual dip and direction, may be true, although not taught by the preceding table. And the same remarks are in a measure applicable to other rocks. To prevent any false inferences from such statements, I have drawn the map which exhibits the predominant direction, and the sections appended, which exhibit the predominant dip, of the strata — anomalies being neglected, unless they are of considerable extent. In the range under consideration these inequalities are somewhat numerous. Yet I am inclined to the opinion that the mica slate along the western border of this range, is connected with that system of stratification which is exhibited by the great body of the gneiss in the western part of Wor-

*Plates XV, XVII, and XVIII.

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cester county, where the strata usually run north and south: while the great body of this range is connected with the system of stratification that prevails in the gneiss range, running northeast and southwest, in the east part of Worcester county, and the west part of Middlesex. South of Worcester the western margin of the gneiss lying east of the slate, runs nearly north and south; and hence the mica slate there affects the same direction, except in the vicinity of the anthracite bed; where it curves around the north end of the hill of granite, west of the mine. As we proceed northerly, the gneiss trends away more towards the northeast, and the mica slate conforms to it. Still farther to the northeast, the strata of the mica slate turn more easterly; because the longer axis of the valley of the Merrimack lies in that direction; and in this the slate seems to have been originally deposited.

These suggestions may explain some of the irregularities apparrent in the stratification of this mica slate. And when we recollect, that numerous masses of granite are protruded through it — some of them of great extent, as at Fitchburg, for example, — I think we shall have no difficulty in explaning the remaining anomalies.

The strata of mica slate in Sherburne, run northwest and southeast, and dip northeast about 45°. This small deposit is very obviously connected with that system of strata which appears in the gneiss of the southeast part of Worcester county; as will be manifest when I come to describe that rock.

At Woonsocket Falls in Cumberland, R. I. a peculiar mica slate appears running south several degrees west, and dipping southeast from 60° to 80°.

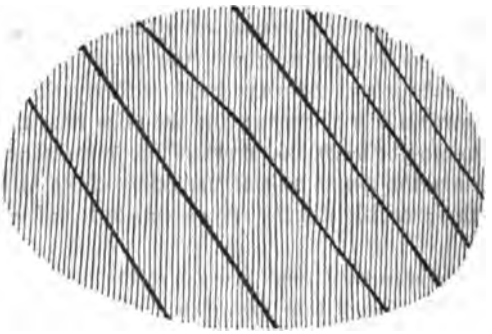
### *Veins in Mica Slate.*

These consist chiefly of granite and quartz; but it will be more convenient to describe them when treating of granite.

Some of the more close grained and imperfectly schistose varieties of mica slate exhibit by disintegration, that kind of structure which has been sometimes denominated *veins of segregation*: that is, veins produced at the time of the formation of the rock, or when it was in a fluid state, by the play of chemical affinities, which in a measure separated the ingredients into different masses; so that when atmospheric agencies wear away the rock, the harder parts remain in relief on the surface, like genuine veins. The following is a sketch of a bowlder of mica slate not more than two feet in diameter,

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which exhibits a double set of these segregated ridges, the smaller ones amounting to fifty-five, and the larger ones not being parallel to one another. I did not notice the direction of the layers in this bowlder, but probably it coincides with that of the most numerous ridges.



Veins of Segregation in Mica Slate: Chesterfield.

### *Mineral Contents.*

More simple minerals occur in this rock than in any other, with the exception perhaps of granite.

To begin with the earthy salts: it is hardly needful to mention one so common as calcareous spar, which always occurs more or less in connection with limestone. It is in distinct crystals sometimes, also, in the mica slate; as at Chester, where several of its secondary forms have been noticed. The laminated variety occurs in connection with the micaceous limestone in Whately, Conway, &c.

The sulphate of alumina and potassa, or native alum, is not unfrequently found efflorescing upon mica slate; resulting from the decomposition of the sulphuret of iron and probably also of feldspar, as this is the most probable source from whence it derives the potassa. In Sheffield it is said that "pounds of it can easily be collected in as nearly a pure state as that of commerce."* The localities mentioned in the first part of my Report, in Leominster and Barre, I am satisfied ought to be referred to the gneiss formation; although in hand specimens, the rock in which the alum occurs can hardly be distinguished from mica slate.

* Robinson's Catalogue of American Minerals, p. 69.

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The phosphate of lime has been noticed in Williamsburgh, Chesterfield, Chester, Middlefield, Norwich, Hinsdale, &c. That in Williamsburg is in hexagonal delicately green crystals, and is doubtless apatite. That in Chesterfield is associated with sappare; as may be seen on No. 750, and almost exactly resembles the chrysoberyl of Haddam; but the ease with which it is impressed by steel, shows its nature at once. In Norwich this mineral occurs in a gray quartz and black mica, and in the vicinity of granite. One of the imperfect crystals which I found, (of which No. 728 is a part,) was three inches in diameter and six inches long.

Quite recently, in Westmoreland New Hampshire, a very interesting locality of crystalized phosphate of lime—in 6 and 12 sided prisms—with limpid and purple foliated fluate of lime and fine sulphuret of molybdenum, has been discovered in the mica slate, which is a continuation of that range exhibited on the map on Connecticut river in Northfield, &c. I have not however, visited the spot; but have seen the specimens. I believe the fluate of lime does not occur in the same spot as the other minerals. (No. 729)

Fluate of lime exists in small quantity in the mica slate in Conway; and a green variety was found a few years since in the same rock in Putney, Vt.

Almost every variety of quartz described in the books, occurs in our mica slate. It is hardly necessary to mention crystallized quartz, which is found almost every where, and in nearly every rock. The white hyaline quartz, passing into white milky quartz, exists in large beds, or tuberculous masses, in almost every part of the mica slate. It is an interesting fact, that a large proportion of this quartz is fetid in the Hoosac mountain range. I have observed this variety on that range from the south part of Connecticut, to the south part of Vermont, over an interval of more than 100 miles. Sometimes this hyaline quartz—as in Shelburne and Colraine—is tinged of a blood red colour, and sometimes of wine yellow, by iron. As the mica slate approaches to clay slate, the quartz becomes bluish and greasy in its fracture. Sometimes also it is pavonine or irised, as in Fitchburg, Leyden, &c. It is found, also, of a rose red colour, in Williamsburg, Chesterfield, Blanford, and Chelmsford. I am not certain that at the two latter places mica slate is its gangue, because I found it only in bowlders: yet I have little doubt that such is the fact. That in Blanford appears to be the finest; and probably if some pains and expense were devoted to getting it out, rich specimens might be procured.

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In the mica slate in the southeast part of Conway, a vein of quartz, six or eight feet thick, and nearly perpendicular to the horizon, runs N. 20° East. It is the gangue of two ores, the red oxide of iron and the gray oxide of manganese: which, however, do not occur in it abundantly at the surface. But they have imparted a great variety of colours to nearly the whole gangue; and rendered a part of it very compact. Hence we find there brown and yellow jasper, and sometimes chalcedony. The various colours, black, white, red, yellow, and brown, are often intermixed, sometimes irregularly, forming breccia agates; and rarely in parallel stripes, forming a banded agate. Some of these, if polished, would form I doubt not elegant ornaments. (Nos. 738 to 743.)

At the same place we find a delicate variety of tabular quartz, in which the lamina are as distinct and thin as the folia of feldspar. Sometimes they are so arranged as to present the appearance of pseudomorphous crystals; and sometimes they so intersect as to form cells. In the cavities of the compact quartz, there sometimes occur minute crystals of quartz, giving the geodes a rich appearance. (Nos. 746, 747.)

About one mile northeast of the College in Amherst, I have recently found numerous bowlders almost exactly resembling those in Conway just described. Chalcedony and hornstone, however, occur here rather more commonly. I cannot doubt but these masses were brought to that spot from the mica slate which occurs a few miles north, both in Amherst and Leverett. The delicate greenish hornstone, found by Mr. Shepard in Amherst and Pelham, some years since, undoubtedly had the same origin. I do not despair of discovering the parent vein.

Some of the quartz of these bowlders is yellow and in small crystals. Yellow and irised quartz also occurs in mica slate in Fitchburg. Jasper is found on the banks of Deerfield and Westfield rivers in rolled masses, and probably originated in mica slate.

The gangue of the lead, zinc and copper ores in Hampshire county, is chiefly crystalized and radiated quartz: and these veins sometimes occur in mica slate: but as they generally traverse granite, I shall describe them in treating of that rock.

Not having visited the beds of manganese and iron marked on the map in Hinsdale and Winchester, New Hampshire, I am not sure that they occur in mica slate, though strongly suspicious that such is the fact. In the first part of this Report I have stated all the facts

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with which I am acquainted respecting these beds; except that I have since ascertained that nearly all of the manganese ore is the ferro-silicate, or Fowlerite. (No. 1027.)

The best locality of fibrolite that has been discovered in this slate, is in Lancaster, near the village. It is found in a bowlder. The fibrous structure is sometimes almost changed into the foliated. The masses are from an inch to three or four inches long, and half an inch broad. It has been met with, also, in some other places in the State.

The localities of sappare are numerous. The best is Chesterfield; from whence large quantities have been obtained; some of it finely crystalized and of a rich colour. Its colours vary from nearly white, to dark blue. It is not possible at present to obtain specimens as fine as No. 750. It is found also in Blanford, Worthington, Middlefield, Deerfield, &c. The Rhoetizite is found in Blanford and Russell, according to Dr. Emmons. In Canton Ct. this mineral occurs crystalized and of a green colour.

Of the situation of staurotide in Massachusetts, I have given a general account in describing the staurotidiferous mica slate. Chesterfield perhaps, near the locality of green and red tourmalines, is as good a spot for procuring specimens as any one in Massachusetts. But no specimens found in this State equal those from the western part of New Hampshire.

Dr. Emmons states in his Mineralogy, that pinite is found in Chester: though he does not mention the rock in which it occurs. I mention it here merely because mica slate is the predominant rock in Chester.

If andalusite and macle are the same species, then the most abundant locality in Massachusetts is in Lancaster, in clay slate. But the mineral which has been generally called andalusite, is most abundant in Westford, in mica slate. And I am happy to state that numerous specimens can be obtained from thence. It occurs in the stone walls, from a hundred rods to a mile east of the center of the village, and may sometimes be found in distinct prisms, greatly resembling specimens from Germany. It is of a reddish colour, and sometimes the masses are 2 or 3 inches across. Generally they are accompanied by a fibrous mineral, resembling talc: but I am not satisfied as to its nature.

Schorl is not common in mica slate. But in Norwich I found a curved specimen of this rock, nearly a foot square, entirely covered



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with prisms of this mineral, of the size of a goose quill, and generally acuminated. The specimen was weathered so as to leave the schorl in bold relief.

Scapolite is found at Chester, as already mentioned; and Dr. Emmons in his Mineralogy says that it exists "in veins in mica slate, associated with hornblende, pyroxene, and garnet; but the crystalization is generally confused and indistinct." It is unnecesary to refer again to other localities of hornblende and pyroxene as connected with mica slate; except to say, that Dr. Emmons mentions "Middlefield, Chester, Hinsdale, and most of the mountain towns in New England," as containing sahlite and coccolite.

Garnet is more widely disseminated in mica slate than any other mineral. It differs in size from an almost microscopic grain, to a crystal of two inches in diameter; and its colours are generally reddish, but sometimes black, even approaching very nearly to melanite. In the slate containing the sappare at Chesterfield, the reddish garnets are very numerous and sometimes quite large. In the amphibolic aggregates, the garnets are usually black. In Plainfield, Dr. Porter has found garnets disseminated in quartz. Garnet and staurotide are usually associated; as at Chesterfield, Middlefield, and Chester. The usual form of the crystal is a rhombic dodecahedron, which is sometimes truncated on its edges.

The mica slate formation in Williamsburg, Middlefield, Chester, Hinsdale, Cummington, Worthington, Plainfield, &c, frequently contains crystals of epidote. Generally they are imbedded in quartz, and frequently associated with hornblende and augite. Zoisite, now regarded by able mineralogists as a species distinct from epidote, occurs also in Goshen, Hawley, Middlefield, Chester, Hinsdale, Chesterfield, Conway, Windsor, and particularly in the north part of Leyden, in large quantities. Indeed, it may be found scattered over nearly every part of the Hoosac Mountain range of mica slate; and on the same range as far northward into Vermont as I have examined.

In the stone walls fifty rods west of the residence of Gov. Lincoln in Worcester, several specimens of Idocrase were found a few years ago, associated with massive garnet and pyroxene. It was crystalized in right rectangular prisms, truncated on the lateral edges so as to produce eight-sided prisms. There can be little doubt that the rock containing this mineral, belonged originally to the mica slate range of Worcester valley. It appears from Beudant's work on mineralogy, that it exists in mica slate in Europe, although generally of volcanic origin. As the Worcester locality is now exhausted, I am in-

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debted to William Lincoln, Esq. for the specimen, No. 765, in the collection. According to Dr. Emmons the same mineral occurs in Chester.

The same gentleman has found stilbite, heulandite, analcime, and chabasie, with hexahedral calcareous spar, on mica slate in the same place. I am not aware that these minerals have before been found in this rock; although stilbite occurs in the Alps in granitic rocks. But the others are confined almost exclusively to trap rocks and metalliferous veins.

The mineral called anthophyllite, which some able mineralogists yet consider as a doubtful species, is found in many places in the Hoosac Mountain range of mica slate. It occurs in fibrous masses, or imperfect prisms, imbedded in the mica slate. In Chesterfield it is associated with sappare and garnets. In Chester it is connected with pyroxene, garnet, and staurotide. It is found also in Blanford in abundance.

The mineral called Cummingtonite from its locality, (Cummington,) is thought by some mineralogists to be a variety of anthophyllite. Prof. Dewey, however, who first described it, regarded it as a variety of epidote. It needs farther examination. It is found in several places in Cummington, and also in some of the neighboring towns. I have found it likewise in Warwick, on the east side of Connecticut river.

It is not uncommon to find a small quantity of sulphur upon the mica slate in a pulverulent state, and proceeding from the decomposition of some sulphuret. But there is no place where it is found in sufficient quantity to be named.

The anthracite which I consider as connected with mica slate, I have already described. Graphite also occurs in mica slate, west of Connecticut river: as at Cummington, Chester, Worthington, &c. But I know of no interesting localities. The magnetic oxide of iron exists in the same mica slate range, in disseminated octahedra: as in Blanford, Chester, &c. Sulphuret of iron is met with likewise in the same situation. In Heath, some very handsome specimens of cubic crystals have been found. In Hawley, it occurs massive in considerable quantity, near the junction of the mica and talcose slate.

On the top of a mountain in Canaan, Ct. there was found, twenty years ago, a small mass of native iron. The mountain is composed of mica slate, Several years ago I visited the spot and was led to the conclusion, that probably a large mass of this mineral might exist

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there, from the irregular action of the magnetic needle in the vicinity. A full description of the spot was given by me in the 14th volume of the American Journal of Science. In the 20th volume of the same work, it has been suggested by Mr. Shepard that the recent discoveries in regard to the magnetic polarity of rocks and mountains, even of those apparently destitute of iron, will explain the facts which I observed on the Canaan mountain, without supposing a mass of iron within it. But if I understand this polarity of a mountain, it affects the needle more or less on every part of its surface: whereas it was affected on the Canaan Mountain only within the space of a few square rods of level ground near the top; although I judged that the whole top embraced hundreds of acres. Hence I infer that we must suppose some local cause acting there on the needle. And why may not this be native iron, since it was near that spot where veritable native iron was knocked off from a bowlder? If this be a reasonable supposition, it would certainly be very interesting to have it confirmed; since native iron, (except the meteoric,) is one of the rarest of minerals.

One mile north of the village of Worcester, an excavation was made several years ago in the mica slate in search of silver, &c. as already described in the first part of my report. It is impossible to ascertain at present how wide is the vein that was explored: but the minerals thrown out, and lying around the opening, are arsenical pyrites, carbonate of iron, and galena. Sometimes the arsenical iron is in distinct crystals in quartz; but I could not ascertain their form. A little west of the village of Worcester, these same minerals occur in the stone walls, along with the idocrase, rendering it probable that this last mineral originated from that metallic vein.

In Sterling, one and a half mile southeast from the village, are two excavations in the same mica slate as that at Worcester; and large quantities of similar ores have been thrown out. Carbonate of iron is most abundant; arsenical iron less common. Blende, of a cherry red color, is found there in considerable quantity; galena also occurs, which is argentiferous, according to Mr. C. T. Jackson. Sulphuret of iron exists in connection with the ores that have been mentioned, and pyritous copper also with the carbonate of iron. Before the compound blowpipe the blende was reduced, and burnt with the flame peculiar to zinc, throwing off the white oxide. Numerous quartz veins traverse the carbonate of iron, and a considerable quantity of red oxide of iron occurs in the quartz, probably proceeding from the decomposition of the carbonate. The lamellae of this car-

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bonate at Sterling, as well as at Worcester, are very much curved and commonly reddish white. These ores at Sterling constitute beds in mica slate, whose direction is several degrees east of north, corresponding to the general direction of the range. The dip at the mines is 60° to 70° west.

The above ores need a careful analysis: for it is well known that in other places they sometimes contain a considerable proportion of silver and gold.

The micaceous oxide of iron described in the first part of the Report as in Montague, is in veins traversing mica slate and granite, chiefly the former. But I have nothing to add to the description which I have given of these veins.

Sulphate of iron is not uncommon in small quantities on the mica slate of this State.

The only remaining mineral to be noticed in the mica slate of Massachusetts, is the red oxide of titanium. It is very common along the eastern margin of the Hoosac Mountain range of mica slate; occurring in four or eight-sided prisms, generally striated and often geniculated. It is usual to find it associated with zoisite, as at Leyden, where numerous specimens have been found. Sometimes it penetrates quartz and sometimes is connected with hornblende. In Shelburne I found it in distinct crystals in the mica slate, without any other mineral. I have found it likewise in Colrain and in Conway. At the latter place I found one or two geniculated prisms, more than an inch thick; also in small crystals having the primary form, that is a right square prism. It is found also in Williamsburg, Chesterfield, Middlefield, &c. In Chesterfield I found a small quantity of what I take to be the titanite, or ferruginous oxide.

Specimens of the greater part of the minerals that have been described above will be found in the collection which is placed in the hands of government. To procure every one of those, which have been described as occurring in the State, if not impossible, would require so much of time and expense, that I have not felt authorized to attempt it without special directions.

## *Theoretical Considerations.*

The prevailing opinion among geologists until recently has been that mica slate and all the older primary rocks have been deposited from a chemical solution of their materials in water. But this opinion appears to labor under insuperable difficulties. It seems to me

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to be opposed by the semi-mechanical character which some of these rocks exhibit. But waving this difficulty, it is impossible to conceive how the materials of all these rocks could have been held in solution by all the waters on and in the globe; since the earths that form them are scarcely soluble at all in water. Yet even allowing such a solution possible, by what unheard of chemistry was it, that so many distinct minerals as enter into the composition of these rocks, or occur disseminated in them, should have been crystalized at the same instant? The supposition is opposed by all that we know of the crystalization of different substances in the laboratory in the same solvent. For they crystalize in succession, not simultaneously. But we know that the melted matter of a furnace, if slowly cooled will separate into different compounds; and the same result takes place in fused basalts, and in the lava of existing volcanoes. Surely then, it seems to me that nature and art both teach us that analogous cases of crystalization in the rocks must have resulted from igneous fusion. But on the other hand, the foliated structure of the stratified primary rocks, proves that water must have been concerned in their formation; and they could never have been in a state of complete fusion. I am inclined, therefore, to the theory which supposes that they were originally mechanically deposited from water, like the existing secondary and tertiary rocks, and that they have subsequently been subjected to such a degree of heat as enabled their materials to enter into a crystalline arrangement, without destroying their structure. That the two things are compatible, seems probable from the change of bulk produced on solid bodies by slight changes of temperature, showing a motion among the particles; from the changes of crystalization that sometimes takes place in solid glass; from the columnar structure assumed by certain sandstones when in contact with trap rocks; and from the experiments of Dr. Macculloch, who "proved that every metal can completely change its crystalline arrangement while solid, and many of them at very low temperatures."* This theory also explains why it is that the primary and transition rocks become less and less crystalline the higher we ascend in the series: for the higher they are, the farther they lie from the source of heat. This theory, however, does not suppose that all cases of crystalline structure in rocks has been the result of fusion: for limestone and quartz rock might have been deposited from aqueous solution. But

* System of Geology, Vol. 1. p. 190.

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if we suppose the source of heat to be in the interior of the earth, it must have operated more or less on every layer in the earth's crust: and, therefore, if this theory be true, probably all the older rocks have been more or less modified by heat. That the crust of the globe has been subject to the action of powerful and long continued heat, it seems to me no one acquainted with geology in its present state can doubt.

According to the theory just described, (I have not space fully to defend and illustrate it, but Dr. Macculloch has done it in his System of Geology,) argillaceous slate is nothing but shale, which has been subject to heat, and perhaps increased pressure: quartz rock may have resulted entirely from aqueous deposition; or it may have been subsequently indurated by heat. Between mica slate and micaceous sandstone, there is a most striking analogy: indeed, it is no easy matter to distinguish by the eye between the specimen of sandstone No. 177. from Northampton, near a mass of trap, and several specimens of mica slate. The same is true of the micaceous sandstone near Turner's falls, which are also in the vicinity of trap. The supposed origin of the other stratified primary rocks, I shall point out in treating of them.

As to the elevation and dislocation of the strata of rocks, particularly the primary, I shall say more in another place. But the manner in which the numerous flexures and contortions which their laminae present, were produced, deserves consideration in this connection; for these are more common in our mica slate than in any other rock; not even excepting gneiss.

These curvatures may have been produced before or subsequent to the consolidation of the rock. I have already pointed out the striking resemblance between the slightly undulating surface of some of the shales in the new red sandstone, and the gentle ridges and depressions at the bottom of almost every large river and pond, or on the margin of the ocean. And if argillaceous and mica slate had that origin which is supposed by the preceding theory, the analogous irregularities, so frequent on the surface of argillaceous and mica slate, may be referred to the same cause as that which produced them on the shale.

By comparing the sections which I have given of flexures in the newest tertiary formation, with those in our mica slate, it will be seen that the latter might have had their origin in the former, if we admit the theory that has been advanced of the origin of mica slate. It may be difficult, indeed, to account for these flexures in the clay: but that they

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were produced by some mechanical force, and not by igneous agency, I think is most manifest. And it seems to me that a power which is adequate to the production of the cases which I have described, is sufficient to account for a large proportion of the minor flexures and contortions existing in clay slate, and mica slate; although I am not aware that any examples similar to those which I have described, exist on the records of geology.

So much for flexures and contortions previous to the consolidation of the rocks. But these causes will not explain all the cases that occur. Sometimes we find alternating layers of quartz in the bent laminae; and it would seem that the rock must have been soft, when such flexures took place. If we suppose the existence of a considerable degree of plasticity in the layers, mere gravity (if the laminae were in an inclined position,) would have produced flexures in them. In other cases the force which elevated the strata might have operated unequally and produced a similar result: though, as I shall attempt to show hereafter, there is reason to believe that this force sometimes acted laterally rather than from the interior of the earth. And some flexures and contortions are explicable only by supposing such lateral pressure.

Some facts lead us to suppose that mere moisture operates powerfully, deep in the earth, to render the strata flexible. Some limestones and sandstones exhibit this flexibility; and even granite in some deep quarries, is easily impressible. Hence the requisite plasticity may have resulted in many cases from water. But if the primary stratified rocks have been partially fused, we have another source from which this plastic state might have resulted.

### 11. TALCOSE SLATE.

I shall include in this formation the three rocks represented on the map under the names of talcose slate, chlorite slate, and steatite. My principal reason for adopting this arrangement, is, that in the works of some of the ablest mineralogists, talc, chlorite, and steatite, are but varieties of the same species: And when mineralogists are not agreed that minerals are specifically distinct from one another, it seems to me improper for geologists to regard those minerals as sufficiently characteristic of different rocks, unless such rocks are widely diverse in their relative situation and structure. But in the district under consideration, it happens that the rocks mentioned above, are, for the most

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part, obviously members of the same formation, using this term too in a very limited sense.

Dr. Macculloch describes talcose slate as differing from mica slate only in the substitution of talc for mica: that is, it consists essentially of quartz and talc. It is this variety that constitutes the principal portion of talcose slate in Massachusetts. But other varieties are found, as the following description will show.

*Mineralogical Characters.*

1. *Schistose Talc.* This variety is more or less distinctly foliated, and varies in color from blackish green to very light green, or greenish white. (Nos. 789 to 793.) It is the least abundant of any of the varieties.

2. *Steatite.* This is obviously only a scaly and semi-granular or partially indurated variety of talc. "We see," says Beudant, "by these analyses, [which he had just quoted,] that the steatites differ from talc only by the presence of water. These substances also occur together and in precisely the same geological position. They appear even to mix in all proportions, and in some suits of specimens, there seems to be a passage from one substance to the other."* These remarks correspond exactly with the steatite of Massachusetts; although we have some beds of steatite which are associated with but a small quantity of foliated talc. But in general, these beds constitute a part of the talcose slate formation.

The color of this variety is usually light gray. In some quarries however, (as in Rowe and Zoar,) it is a delicate green; and in such cases the rock is obviously nothing but foliated talc, which is so compact that it forms a fine stone for economical purposes. In the quarries the green and the gray varieties alternate; although there is no seam between them; and perfectly sound blocks may be obtained, which are partly gray and partly green. (Nos. 794 to 805.)

3. *Chlorite Slate.* Sometimes this variety is foliated and of a dark green color; and in such cases I know of no means of distinguishing it from talc, except perhaps by its darker color. Generally it is slaty in this region, and very minutely scaly. In this case it probably owes its slaty structure to a small proportion of quartz which it contains. But the chlorite slate of the Hoosac mountain range is re-

* Mineralogie, Tome ii, p. 212.



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markably pure and I may add, remarkably regular and continuous in its slaty structure. (Nos, 806 to 816.)

4. *Quartz and Talc.* In this variety the talc is usually scaly, and the quartz arenaceous. Sometimes, however, the latter is coarsely granular, or hyaline. When the talc predominates, and the quartz is in minute grains, they form the whetstone slate. (Nos. 817 to 825.)

In Smithfield, Rhode Island, this rock is extensively quarried for whetstones. I learn from Dr. Webb, that the number annually quarried at this place and sent away, can hardly be less than 5000 dozen. Indeed, so important has this manufactory become, that the General Assembly of Rhode Island have passed an act to regulate the inspection and sale of the whetstones. It is not true, as stated by Mr. Eaton, that all our whetstone quarries are in talcose slate: for those in Norwich and Enfield are in decided mica slate.

This rock is employed, also, as a substitute for fire bricks in the lining of furnaces.

5. *Quartz, Talc, and Mica.* This variety may be considered, either as mica slate, which takes into its composition more or less of talc, or as talcose slate, containing mica. Probably but little of our talcose slate can be found, that does not embrace a small proportion of mica: but talc and mica often resemble each other so exceedingly, that it is very difficult to say whether the rock is talcose or mica slate. I have felt this difficulty most in relation to a considerable part of the slaty rock in Berkshire county. And although I have there marked no talcose slate, yet I hardly expect that all geologists will follow my example. (Nos. 826 to 831.)

The 4th and 5th varieties constitute the greater part of the talcose slate formation.

6. *Talc and Carbonate of Lime.* Sometimes talcose slate lies next to limestone as in Whitingham, Vt. and near the junction of the two minerals, they are mixed together. But the variety is hardly worth naming. (No. 832.)

7. *Talc, Quartz, and Carbonate of Iron.* It might be more proper, perhaps, to describe the carbonate of iron as disseminated through the talcose slate; though the iron most commonly occurs in the variety, No. 4. And this mineral, by its decomposition, imparts a character to this rock which will be noticed every where. It abounds in spots of the color of iron rust, and this is particularly the case where masses of quartz exist of considerable size. If I mis-

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take not, it is in this decomposed carbonate of iron, that native gold occurs. (Nos. 833, 834.)

8. *Talc, Quartz, and Hornblende.* The latter mineral is in distinct though imperfect crystals, scattered through the rock; but it occurs in such quantity, and over so great an extent of country, that it seems proper to make this a distinct variety. It is found along the eastern margin of the talcose slate formation, near its junction with the mica slate in Hawley and Plainfield; and it sometimes passes into distinct hornblende slate. (Nos. 835 to 839.)

9. *Talc, Feldspar, and Quartz.* This variety is intermediate between talcose slate and gneiss; and differs from the latter rock only by the substitution of talc for mica. It is obviously, however, a rock more mechanical in its character than gneiss; the feldspar existing in coarse grains. This description applies particularly to this rock in Smithfield, R. I. (No. 840.) But in Hawley the feldspar is scattered in crystalline masses through the rock, forming a distinct porphyritic, talcose slate; (No. 841,) and it is almost destitute of stratification.

### *Topography of the Talcose Slate.*

The principal deposit of this rock in Massachusetts, is in the midst of the mica slate of the Hoosac mountain range. It occupies a very elevated portion of that range, and is there obviously one of the oldest of the stratified rocks. I have traced this rock 20 or 30 miles into Vermont, where it is associated with limestone and gneiss on the eastern slope of the Green Mountains; and probably it extends much farther north. In Massachusetts it is most perfectly developed in its characters in Hawley and Plainfield; where it is several miles wide. Proceeding southerly this formation becomes narrower, and at length appears to terminate near the southern part of Becket; at least I have not observed it farther south, and between Chester and Becket it is only a few rods wide, alternating with mica slate and hornblende slate. The chlorite slate forms a narrow stratum along the western margin of the talcose slate, and I have not observed it quite as far south as the talcose slate. But northerly I have traced it as far as Whitingham, Vt., although I have not seen it in every place where I have crosed the Hoosac range. But being a remarkably distinct stratum, I have little doubt that it does extend as far, at least, as it is represented on the map, and that it is continuous;

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since it is so narrow that it might in many places easily be hidden by diluvium.

I can have but little doubt that this stratum of talcose slate, like the mica slate with which it is associated, passes laterally into hornblende slate and gneiss: but I have nothing further to add to the remarks already made on this subject.

Several beds of steatite are connected with this range of talcose slate: viz. one in Marlborough, Vt.; one in Rowe; one in Zoar; one in Windsor; one in Middlefield; and farther south, nearly on the line of the strata prolonged, we find a bed in Blanford, and at least two in Granville. The bed of this rock in Hinsdale, that in Cheshire, and that in Savoy, I have not visited; but as the gneiss and mica slate of that region frequently passes into talcose slate, not improbably they are connected with this rock. The bed in the northwest part of Windsor, however, I know from examination to be in gneiss; and perhaps those just mentioned are in the same rock. In Zoar we find mica slate, talcose slate, steatite, and serpentine, interstratified. The most easterly bed in Windsor appears to be embraced in the chlorite slate. That in Middlefield has talcose slate on the east side and hornblende slate on the west. That in Blanford, one and a half mile southwest of the meeting house, is in mica slate; but on one side a huge vein of granite lies in contact with the steatite. The bed in Smithfield, R. I., is in talcose slate.

With respect to the narrow stratum of talcose slate marked on the map in the southeast part of Hampden county, and passing through Stafford, Ct. Monson, &c. I feel quite ignorant. I have satisfied myself only that it lies between the mica slate and the gneiss. The specimens will show that it produces a good lining for furnaces. To this formation I refer the steatite in Somers, Ct., although I have not visited the quarry.

The steatite beds marked in Shutesbury, Wendell, and New Salem, are surrounded by gneiss of the most decided character. That in New Salem contains serpentine, also, of a black color. The bed of serpentine exhibited in Pelham, is a mixture of serpentine and talc; and is marked as serpentine, only because that mineral predominates. It forms a bed in gneiss.

The bed of steatite in Groton occurs in the Worcester range of mica slate. But its situation and extent have been described in the first part of my Report.

In Cumberland and Smithfield, Rhode Island, two strips of talcose

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slate are shown on the map, separated by a range of granite. I am not sure that the granite will be found extending uninterruptedly through these towns as it is represented on the map. But in crossing that region, I have always found one or two large beds of granite or sienite; and probably these rocks exist there in several beds in the talcose slate and mica slate. Yet this alternation could not conveniently be shown on the map.

On the west side of the granite in Smithfield we find a peculiar kind of mica slate, (No. 675,) and a talcose slate, which has been already described as a whetstone slate. The extent of surface occupied by this variety—which is well characterised talcose slate—I am unable definitely to state; though it cannot be but a few miles in any direction unless it be towards the southwest.

In the east part of Smithfield, and on the east side of the granite range or bed, the slate is often distinctly talcose; especially in the vicinity of the soapstone quarry, near the village called Maysville. But as we cross the strata towards the southeast, the characters become very obscure and perplexing. In one place the rock can hardly be distinguished from argillaceous slate; in another it greatly resembles graywacke slate; in another it is distinct chlorite slate; and in another it becomes hornblende slate. Epidote too forms an ingredient in a large proportion of the rock. In short, this series of slaty rocks is one of the most perplexing with which the geologist meets. It extends over nearly the whole of Cumberland, where it is interstratified with quartz rock, and is succeeded on the east by quartz rock and graywacke. The strata of all these rocks run nearly northeast and southwest, and dip to the southeast. Taken as a whole, I am inclined to denominate the predominant part of the series *talco-chloritic slate.* Nor can I resist the impression, that the whole series is the graywacke slate, which, by the agency of heat, has been partially converted into argillaceous slate, talcose slate, chlorite slate, and hornblende slate; the heat not having been powerful enough completely to accomplish the transmutation. And the contiguity of granite and sienite would furnish the heat which this hypothesis demands.

But whatever may have been the origin of this series of rocks, a perusal of Von Oeynhausen and Von Dechen's paper on the junction of the granite and killas rocks of Cornwall, in England, has led me to the opinion, that they greatly resemble the killas of that country.*

* Philosophical Magazine, Vol. 5, N. Y. p. 161.

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The bed of steatite in this talco-chlorite slate in Smithfield, is not of a very interesting character in an economical point of view. That which is gray coloured is so filled with brown spar (?) as to be almost useless. A greenish scaly variety, (chlorite slate?) however, occurs, which is interesting. Fine foliated greenish talc, also, abounds here. Decided chlorite slate is likewise abundant at the quarry and in the vicinity. The steatite lies about half a mile west of Blackstone river and of Maysville.

### *Dip, Direction and Character of the Strata.*

It is hardly necessary to say, that this rock is always schistose in its structure; though in the most compact soapstone, both the slaty and stratified structures are nearly obliterated. Yet in some portions of the bed, they are usually visible. In both these structures this rock corresponds very nearly with mica slate; except that the former is less contorted than the latter. Chlorite slate is particularly remarkable in the Hoosac range, for the evenness and beauty of its layers, comparing in this respect with argillaceous slate. In both structures, so far as I have observed, the dividing planes correspond: and I have never noticed a double set of strata seams.

### *Dip and Direction of the Strata in the Hoosac Mountain Range.*

| | Direction. | Dip. |
|---|---|---|
| Florida, eastern slope of Hoosac Mountain: the talcose slate alternating with mica slate. | N. and S. | 70° to 90° East. |
| Middlefield, | Do. | 70° to 80° East. |
| Plainfield, Hawley, Charlemont, Rowe, Zoar, Cummington, Chester, (west part.) and Worthington, | N. and S. | nearly 90° East. |
| Somerset, Vt. (Iron Mine.) | Do. | 20° to 90° East. |
| Whitingham, Vt. (Limestone beds) | E and W. | 30° West. |
| Rowe, (north part) | Do. | South, small. |
| Whitingham, Vt. (Chlorite Slate,) | N. and S | nearly 90° East, |
| Peru, (Do.) | Do. | perpendicular. |
| Windsor, (Do.) | Do. between 70° and 80° East. | |

It will be obvious from the above statements, that the strata of almost all this deposit stand nearly at right angles to the horizon. Very different is the case with the talcose slate in Smithfield, Rhode

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Island. Its predominant direction is nearly S. E. and N. W., and its dip upon an average, only about 10° to 15° N. E. Indeed, in many places it is nearly horizontal. The talco-chloritic slate in the east part of Smithfield and Cumberland, runs generally about 15° or 20° west of south and east of north, and its dip is 20° to 30° southeast.

The bed of steatite in Groton dips to the southeast at an angle of about 30.°

*Mineral Contents.*

This rock in the Hoosac mountain range, must be regarded as a metalliferous deposit. Perhaps the most important metal which it contains is iron. This is found principally in two places, viz. in Somerset Vt. and in Hawley, Mass. Smaller masses have been noticed in other places; but not in sufficient quantity to be of interest in an economical point of view. At all these localities, the ore is found in distinct beds in the strata; and sometimes it has a slaty structure, having every appearance of a contemporaneous origin with the rock.

I have already remarked, in the first part of my Report, that the iron ore in Hawley embraces two species; the magnetic oxide, and the micaceous oxide. Both of them are of fine quality. The micaceous oxide, especially, is as beautiful as any which has been found on the globe, as the specimens will show. (No. 844.) This bed does not occur, as is usually stated, at the junction of the talcose and mica slate; but two or three miles within the talcose slate—that is, reckoning from its eastern margin.

The most valuable ore at Somerset is the magnetic oxide. With this, however, is associated, often in the same bed, the hydrate of iron. Several of these beds occur in the vicinity, and sometimes they are connected with dolomite. The magnetic oxide is generally granular, and often easily crumbled into powder, which possesses so much brilliancy that it has been used as a substitute for smalt. It is so highly magnetic that it strongly attracts the fragments of the ore that have been broken off, and exhibits decided polarity; so as to form very fine specimens of the natural magnet. (No. 845.)

The largest mass of iron ore in the region that I have undertaken to describe, occurs in Cumberland, Rhode Island. It is chiefly the magnetic oxide, and lies two miles northeast of the center of this place. But no rock is visible for a considerable distance around this large hill of iron. Sienitic granite occurs, however, not far remote in one or two directions, and so does talco-chloritic slate. And upon the

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whole, my belief is that the iron is connected with the latter rock. For the large deposits of this ore in other countries most frequently occur in the older schistose rocks, and rarely in granite.* In Massachusetts too, no mineral is so widely disseminated in talcose slate as magnetic oxide of iron.

A part of the Cumberland ore is beautifully porphyritic by the presence of crystalline masses of white feldspar. In another portion we find a mineral disseminated, which appears to be the ferro-silicate of manganese. Imbedded noddles of what appears to be serpentine are also found in the ore: and these substances probably do not a little injury to the ore. For I was told it did not yield more than 25 or 30 per cent of iron.

In the first part of my Report I have given a full account of the native gold found in connection with this iron. Since that time it has been ascertained that the common gangue of the gold is the hydrate of iron: but whether enough of the metal exists in it to render it an object to separate the gold, has not been determined. Usually quartz exists in connection with the hydrate of iron. This is porous and contains the hydrate, and exactly resembles the gangue in which gold has been found in the Southern States. For comparison I have placed specimens from Somerset and from Virginia in the collection.

This porous quartz and the hydrate of iron are very common throughout the talcose slate of Hoosac Mountain; and the iron results, if I mistake not, as already mentioned, from the decomposition of the carbonate. Whether the hydrate at Somerset had such an origin, I have no means of ascertaining; but if ever gold should be found at other places in this formation, I predict it will occur in connection with this hydrate of iron.

Quartz and hydrate of iron then, appear to be the immediate matrix of the gold of Somerset; and talcose slate the rock in which the quartz and iron are contained. It is rare that we can at once trace this metal so satisfactorily to its original bed. But so far as can be judged by specimens, we may expect that such will be found to be the situation of the gold in the Southern States. For those specimens contain quartz, hydrate of iron, and talcose slate. (Nos. 848, 849, 850.)

This geological situation of the Vermont gold corresponds remarkably with its situation in other countries; particularly in Brazil. It is described as occurring there, disseminated in a rock, called by

* Beudant's Mineralogie, vol. 1. p. 622.

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Al. Brongniart, *Siderocriste*, (*Eisenglimmerscheifer* of Eschwege,) and composed of quartz with the specular and magnetic oxides of iron.* These are the two species of iron ore that occur at Hawley: and it ought to be recollected, that in the vicinity of the iron mine in that place, quartz predominates so much, that I have described the rock as a variety of quartz rock. It is said, indeed, that the siderocriste is connected in Brazil with mica slate. But in the rock at Somerset mica occurs; and I am by no means confident that some geologists would not regard it as mica slate; and besides, the mica and talcose slates are interstratified, and otherwise more intimately mixed; so that I am disposed to believe that the formation which I have called talcose slate, in Massachusetts and Vermont, corresponds to that containing gold in Brazil, as nearly as could be expected in countries so remote. And although at Somerset the gold has been found chiefly in the hydrate of iron, yet it probably exists also in the magnetic oxide, and not improbably in the micaceous oxide at Hawley. The ferruginous breccia that covers the siderocriste in Brazil, and probably contains platina and diamonds as well as gold, has not to my knowledge been found in Vermont or Massachusetts: yet it may be found still, as very few researches have been made on this subject.

We ought to guard against the idea that all gold must occur in talcose slate, because we know that some does; and because the happy suggestion of Mr. Eaton on this subject led to the discovery of that at Somerset. For veins of quartz containing this metal traverse other rocks in France, Peru, and Mexico. They occur in granite, gneiss, mica slate, argillaceous slate, and talcose slate.† Hence we may find it in all these rocks, which are so intimately associated in Massachusetts and Vermont.

Another interesting ore in the talcose slate of the Hoosac Mountain range, is manganese. It exists in beds or interstratified layers in the slate, precisely like the ores of iron above described. These beds are found in Plainfield, and several of them occur near one another, at two principal places, which are represented on the map: that is, we find smaller and larger beds within a few feet or rods of one another. These beds are rarely more than three or four feet thick. Their surface is black or dark gray, apparently the common peroxide

* See Tableau des Terrains, &c. p. 329: Classification des Roches, p. 83: and Dictionnaire D'Historie Naturelle, Art. *Or*.

† Dictionnaire D'Historie Naturelle, Art. *Or*.



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of manganese. But on breaking open the mass, we usually find its interior to be of a beautiful rose red. This ore has been recently analysed by Dr. Thompson, and found to be a bi-silicate of manganese. In the stone walls, a little northeast of the meeting house in Cummington, numerous large blocks of this ore are found, which were probably transported thither from the beds above described, by a diluvial current from the north: though to reach this spot, they must have passed over a deep valley, through which a branch of Westfield river now runs.

One never meets with this bisilicate of manganese, which is not coated over with the black oxide. I hence infer that atmospheric agencies produce this conversion. As the bi-silicate is rare in other parts of the world, (indeed Dr. Thompson regards this as a new species, distinct from the siliceous oxide, on account of the double proportion of silex which it contains,) its great abundance in Plainfield and Cummington is a matter of joy to mineralogists.

Connected with the bowlders of this manganese ore in Cummington, I found small but well characterised masses of carbonate of iron.

The manner in which the above ores of iron and manganese occur in the talcose slate, forbid, it seems to me, the supposition somewhat extensively adopted of late,* that all metallic deposites in solid rocks have resulted from sublimation, through the influence of the heat produced by rocks of igneous origin. For although the layers of the slate are nearly perpendicular, and therefore sublimed matter might easily rise to fill a cavity from beneath, yet there seems to be no more evidence that these ores were thus introduced, than that the folia of the slate had such an origin; for the ores as well as the slate are distinctly foliated, and often both are intimately intermixed. What objection is there, in such cases, against regarding metallic deposites as having proceeded from solution and suspension in water, just as we now find iron and manganese forming; and subsequently rendered compact and crystalline by the heat of the unstratified rocks?

In the beds of steatite that have been described, several minerals of interest occur. Foliated bitter spar exists in almost every one of them; especially at Middlefield, Windsor, Zoar, and Marlborough, Vt. At Middlefield it is sometimes three or four inches diameter, enveloped in masses of delicate green talc; and is either white or of a salmon color, so as to form elegant specimens, as may be seen in the collection

* See an article by A. L. Necker's Philosophical Magazine, Sept. 1832. p. 225.

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In Zoar and Marlborough, and also in connection with the serpentine in Newport, R. I. the columnar variety, called miasite, occurs. In Marlborough and Newfane, Vt. are found also those insulated rhombohedral crystals, which Mr. Brooke describes as a new species, under the name of carbonate of magnesia and iron. In the rhomb spar of Middlefield, sometimes occur tremolite and hepatic sulphuret of iron. The ligniform and compact varieties of asbestus are found in the same steatite bed. They exist also in Zoar, where they are associated with the new mineral picrosmine. At the soapstone quarry in the east part of Windsor, has been found a small quantity of chromate of iron of good quality. Sulphuret of molybdenum is said also to have been found in the Middlefield steatite; and the variety of talc called nacrite, occurs half a mile west of the meeting house in that town.

No mineral is more common at these steatite beds than actynolite. It is in bladed crystals, long and slender, yet generally very distinct, being mostly six-sided. It is found at Middlefield, Windsor, Zoar, &c. But the finest specimens come from Blanford, Mass. and Newfane, Vt. At the former place it is sometimes in radiated masses.

It has been already stated that imperfect crystals of hornblende are sometimes disseminated in one variety of talcose slate. The finely fibrous hornblende I have also found in quartz belonging to this same rock. But the most remarkable variety of this mineral is the fascicular variety. The laminae, sometimes three or four inches long, and generally more or less curved, are disposed perpendicularly to the layers of the slate, so that their edges appear on the surface. When that surface is light colored, as in Nos. 864, 865, the distinctness and regularity of the fascicular and scopiform groups of hornblende are very striking. I am disposed to believe this to be a variety of hornblende not described: and certainly if it deserves a distinct name, none can be mere appropriate than *fasciculite*, under which I long ago described it in the American Journal of Science.

The chlorite slate abounds, throughout its whole extent, with distinct crystals of octahedral iron ore. They exist also in the common talcose slate, but not so frequently. The chlorite slate in Windsor, also, near the most eastern soapstone quarry, contains numerous crystals of the red oxide of titanium, imbedded in the feldspar, or rather in graphic granite, which frequently occupies the seams of the slate, or forms small irregular masses in it. But although the specimens are fine, it is with extreme difficulty that they can be obtained. It is

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a fact worthy of notice, that this rock in Scotland, where it is traversed by quartz veins, abounds in titanite; showing a very great similarity in the causes by which it was produced in distant countries.

Blue and green carbonate of copper are found in several places in Cumberland, R. I., in what I have described as talco-chloritic slate. The same rock abounds in epidote, sometimes finely crystalline, according to Dr. Webb. And I infer from his description, that the yenite associated with magnetic oxide of iron, is contained in the same rock.

### *Theoretical Considerations.*

The views that have been presented relative to the origin of mica slate, are applicable, almost without variation, to talcose slate. The arguments proving that water must have been the earliest agent in the production of mica slate, prove the same of talcose slate; as do those evincing the subsequent action of a high degree of heat. To what circumstance the great abundance of magnesia in the talcose slate is owing, it may be impossible perhaps ever to determine. But its presence being once admitted, it is easy to conceive how talcose, instead of mica slate, might have resulted.

There is, however, one variety of talcose slate, which occurs half a mile west of the meeting house in Hawley, and affords an evidence not found in our mica slate, of the action of heat sufficient to produce an almost perfect fusion. I refer to the porphyritic variety, which I do not find described in European works. It seems to me that every thing which we know of the chemistry of crystalization, forbids the supposition that the porphyritic structure can ever result from any other than an igneous solution. For in what laboratory have distinct crystals been produced in the midst of a mass essentially uncrystalized, except from heat? But it is well known that the porphyritic structure is not unfrequently met with in rocks whose volcanic origin is certain; even in the products of existing volcanoes. What, then, but an unreasonable attachment to hypothesis, should lead us to impute that to watery solution, which, so far as facts have come to our knowledge, has never resulted but from igneous solution?

In the present instance the almost entire absence of stratification and slaty structure in the rock referred to in Hawley, gives additional probability to the idea of its having been once in a state of fusion.

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## 12. SERPENTINE.

Perhaps there is no rock about whose true nature and geological relations so little is known as serpentine. Its external characters are not, indeed, obscure; and analysts have given, probably with accuracy, its ultimate elements. But is it an altered or unaltered rock? If altered, what was the original rock? Is it stratified, or unstratified? primitive, or transition? These are questions on which geologists are not yet agreed. The Dictionnarie Classique D'Historie Naturelle, says, that serpentine is "principally situated in the latest of the primitive rocks and in the intermediate class." Brongniart doubts whether it is found so low as the primary rocks; (*terrains agalysiens;*) and he says that "no rock of this group, (*Ter. Plut. Ophiolithique,*) exhibits even a tendency to stratification."* De La Beche classes it with the unstratified rocks.† But Dr. Maculloch considers it as sometimes stratified and sometimes unstratified; and accordingly ennumerates it in both these classes;‡ and also as a venous rock. He says, also, that it occurs in connection with granite, gneiss, micaceous, chlorite, and argillaceous schists. His account of this rock corresponds most nearly with its characters in Massachusetts; and here, if I mistake not, it is almost always stratified. At least, the exceptions are less important than in the case of limestone; and since I have placed all our limestones in the stratified class, I shall do the same with our serpentines. In almost all cases, also, our serpentines are connected with the oldest rocks; such as gneiss, mica slate, and talcose slate: and if we have any rocks that are primitive, serpentine is one of the number.

### *Mineralogical Characters.*

1. *Compact Serpentine.* This embraces two mineralogical varieties, the common opaque serpentine, and the translucent delicate green noble serpentine. They are of various degrees of hardness, and their fracture is sometimes splintery, sometimes granular, and sometimes foliated-splintery. The colors and their intermixture are very various. (Nos. 870 to 885.)

2. *Serpentine and Talc.* The talc is either foliated or in the con-

* Tableau des Terrains, &c. p. 350.

† Geological Manual, Second Edition, p. 487.

‡ System of Geology, Vol. 2. p. 197.

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dition of steatite. Often it is very obvious that the specimen is in an intermediate state between serpentine and steatite. Indeed, all the gradations between the two rocks may sometimes be seen, particularly in the beds of serpentine and steatite embraced in gneiss, in Pelham, Shutesbury, and New Salem. The color of the rock in these cases is quite black. (Nos. 886 to 893.)

3. *Serpentine, Talc, and Schiller Spar?* In this variety, also, the serpentine, as well as the foliated mineral which I presume to be schiller spar, are black; while the talc is green, and sometimes quite brittle. This variety occurs only in Blanford, Russell, and Westfield, so far as I have observed. (Nos. 894, 895.)

4. *Serpentine and Carbonate of Lime.* The latter mineral in this variety is white, and the former green, or black. The proportions in which they are mixed is very various. The limestone is generally saccharoidal, and thus this rock forms the *Ophicalce Grenue* of Brongniart, who refers to Newbury as one of its localities. (Nos. 896 to 899.)

Other minerals found in serpentine sometimes essentially modify its characters: such as actynolite, asbestus, massive garnet, compact feldspar, &c.: but such varieties are hardly worth noticing in this connection.

### *Topography, Stratification, and Associated Rocks.*

Since I have so particularly described the localities of our serpentine in the first part of my Report, it may be practicable, without confusion, to bring together all that I know of its stratification and associations, in a topographical order.

It will be seen, by the map, that the most numerous and important beds of this rock occur near the central parts of the Hoosac mountain range, and especially in connection with, or in the vicinity of, the talcose slate. In Windsor are two beds. The most easterly bed is only a few rods from a bed of steatite; the latter appears in the hill forming the south bank of a branch of Westfield river, and the former in the opposite bank. Both the beds are obviously interstratified with chlorite slate, not far from the junction of this rock with common talcose slate. Its color is a pleasant rather deep green; its structure between granular and splintery; and it contains small disseminated fragments of chromate of iron. It is distinctly stratified; the strata running north and south, and standing nearly perpendicular; which is the usual dip of the rocks in the vicinity; though the

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chlorite slate, a few rods east of the serpentine, dips east about 70° or 80°. Not only is this serpentine stratified, but I observed here, as well as in the same rock in the west part of Chester, a structure which might properly be called schistose; especially where the rock had been weathered. The slaty laminae, however, are rather thick and irregular, nor do they extend through the whole bed.

The other serpentine locality in Windsor, is in the northwest part of the town, on land of Samuel Chapman. It occurs at the surface only in large bowlders; though I cannot doubt but it exists in place beneath the diluvium. The rock surrounding it is gneiss alternating with mica slate. The serpentine resembles that in Zoar, and like that passes into steatite so insensibly, that the eye cannot distinguish between the two minerals; — and specimens may be found of every intermediate degree of hardness. But the serpentine greatly predominates.

The situation of the serpentine in Zoar, is similar to that of the first bed in Winsdor, just described. It occurs on the north side of Deerfield river; and the lateral edges of the strata are here laid bare. They consist of talcose and mica slate, with green and white steatite interstratified, the strata being not far from perpendicular. As nearly as I could ascertain, there are several beds of the serpentine at this place: though the numerous fragments of the rocks that are broken and mixed along these cliffs, render it difficult to determine all the alternations. It may be of consequence to remark, that in one instance at least, I noticed the serpentine lying next to the steatite. The serpentine at this locality is the common variety, and uniform in its color; but of a lively green. In some instances there is a mixture of the serpentine with the steatite.

In Marlborough, Vt. a little north of the limits of the map, is a very extensive bed of serpentine; some parts of which, at least, are distinctly stratified. In the west part of New Fane is another bed, in which I do not recollect any marks of stratification; though it is several years since I visited the spot. Other large beds occur farther north, in Vermont, as at Grafton and Windham, and they are found in a continuation of the same talcose and mica slate range in which they exist in Massachusetts.

The most northern bed of serpentine in Middlefield is connected with the bed of steatite in that place already described. The bed in the south part of the town is the largest in Massachusetts; being from four to six miles long, and perhaps 80 or 100 rods wide. It extends

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into the west part of Chester, where it appears on the east side of Westfield river, rising to the height of 300 to 400 feet; and is succeeded on the east by talcose slate, which rises still higher. I examined this rock in the south part of Middlefield, and found it distinctly stratified; the strata running a little east of north, and dipping easterly, from 70° to 80°; corresponding, in these respects, with the adjoining strata. On the west this bed is succeeded by distinct hornblende slate, both in Middlefield and Chester. In the latter place the serpentine is stratified with a good deal of distinctness, and exhibits also a slaty structure. The dip, corresponding with that of the talcose slate on the east, and the hornblende slate on the west, is nearly perpendicular; and the direction rather more east of north than in Middlefield. Forming the east bank of the river, the ledges of this rock seem to have suffered much from abrading agents; and the surface is much broken to pieces and the sides very steep.

I observed the Flora of this serpentine ledge to be rather peculiar. It abounded with the sassafras and prunus borealis; the former of which, especially, is scattered rather sparsely over the neighboring hills. Polygala paucifolia, Saxifraga pennsylvanica, and Convallaria bifolia, I noticed also in great quantities. Ilex canadensis I observed likewise, as well as a rare species of Arenaria. Lichens and mosses, however, are rarely seen upon this serpentine.

Specimens that may be called noble serpentine do occur in Middlefield; but for the most part the rock is the common variety, of a pale green color, and somewhat foliated structure, abounding, however, in dark spots from the presence chromate of iron.

Following the direction of the strata southerly from Middlefield a few miles into Blanford, we come to the bed of limestone, discovered since the first part of my Report was finished, and which I have already described. Little more than a mile north of this limestone, and about five miles northwest of Blanford meeting house, on the old road to Becket, and on the northeast side of a pond, there exists a bed of serpentine which shows itself at the surface over a space about 30 rods in diameter, and it rises 30 or 40 feet above the general level. This large bed evidently occupies the same geological position as that in Middlefield; for the hornblende slate, frequently epidotic, lies in immediate contact with it on the west side; and though no rock in place appears on the other side, yet we have much reason to believe that talcose slate, or talco-micaceous slate, exists there. Not improbably this serpentine is connected without interruption with the Mid-

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dlefield deposit. This would make the whole bed only 10 or 12 miles long.

The Blanford bed is for the most part as distinctly stratified perhaps as that in Middlefield; and its tendency to a slaty structure I think more distinct. The dip and direction of the strata seem to correspond to those of the hornblende slate in immediate contact viz. the direction north and south, and the dip east, 60° to 70°.

The chromate of iron, mentioned in a postscript on page 52, is the most interesting, and indeed the only mineral that I noticed in this serpentine. It is disseminated through the rock in grains, and also forms veins or tuberculous masses resembling magnetic oxide of iron; being black and granular, or compact. But I judge it to be chromate of iron for the following reasons. 1. It has communicated a peach blossom color to small portions of steatite or talc that adhere to its surface. 2. The colour of its powder is a dark brown. 3. It is not magnetic. 4. Fused with borax, it produces a beautiful green glass.

Should this mineral be found in considerable quantity at this place, it would be quite important in an economical point of view, since it sells in market from $40 to 60 per ton. I am inclined to believe it disseminated in small grains through nearly all the serpentine of the Hoosac mountain range, and not improbably large masses of it may be found in various places.

Four or five miles south of this bed of serpentine, is another in Blanford, not more than 40 to 50 rods east of the soapstone quarry, 1 1-2 miles southwest of the center of the town, which has been described. This serpentine is in mica slate, which dips easterly; and it is distinctly stratified. There is nothing striking in its appearance. The width of the bed is several rods.

I have reason to suppose that another bed of serpentine exists in the eastern part of Blanford, though I have found only bowlders. But the specimens are of so peculiar a character, that I cannot refer them to any known bed. They consist of green serpentine, talc, and sometimes schiller spar? (No. 892.)

The serpentine bed in Westfield is in mica slate, whose layers lean only a few degrees to the west. I speak here of the most southerly point of its appearance. Here it is about four rods wide. It occurs near the junction of the new red sandstone and the mica slate. This mica slate contains numerous veins and protruding masses of granite; and one mass of this rock lies within 3 or 4 feet of the serpentine, if it does not actually touch it. The serpentine is distinctly stratified; the



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dip and direction of the strata conforming to those of the mica slate. Its predominant colour is black: but it contains a mixture of indurated greenish talc, and an amphibolic mineral of a gray colour. (No. 893.) A considerable part of the rock, however, contains granular carbonate of lime: or rather in some parts of the bed this mineral predominates, and the serpentine is disseminated through it in small pieces. (No. 899.)

Nearly half a mile north of this spot, serpentine again appears on the noth bank of Westfield river in Russell; and I have strong reasons for believing it to be a continuation of the bed in Westfield, just described. The rock in Russell is a mixture of black serpentine with green, the latter being sometimes very compact and traversed by veins of indurated talc (?) or Deweylite. (?) (No. 885.)

I can hardly doubt but many more beds of serpentine might easily be discovered in the Hoosac mountain range, if ever it shall be an object to make such discoveries. I make this inference from the fact that I have found some of those above described, under circumstances the most unfavourable.

On the east side of Connecticut river but few beds of serpentine have been found in Massachusetts. That marked in Pelham occurs in the southwest part of the town, and exhibits itself over an area of only a few square rods. One may doubt whether this rock should be called serpentine, or steatite: for these two minerals enter into its composition. In general, however, the latter, which is of a black colour, predominates. It also contains a considerable quantity of asbestus. This bed lies in gneiss; although the actual contact is hidden by the soil. But at a little distance on both sides this rock appears, and no other rock occurs in the vicinity.

The steatite marked as occurring in Shutesbury appears to be passing in some parts into black serpentine; as may be seen from the specimen No. 805. At the steatite bed in New Salem this change is still more decided, so that large blocks of what must be called black serpentine are found there. (No. 890.)

In giving an account of the limestone found at Newbury, I have mentioned nearly every important circumstance respecting the serpentine of the same spot. It occurs there in veins or irregular masses of only a few inches diameter. It will be seen by the polished specimens that several varieties at this locality are very beautiful; but they are so intersected by various minerals that only small pieces can be obtained.

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At one of the limestone quarries in Littleton, I observed that small masses of green serpentine were disseminated in the rock. (No. 489.)

The only remaining deposite of serpentine within the limits of the map, is in Newport, Rhode Island. And under graywacke I have already given so full a description of the situation and characters of this rock that any thing more seems unnecessary in this place. From that account it is obvious that this serpentine belongs to a much later geological epoch than any which I have described; probably as late as the graywacke; and if there be any example in the region embraced by the map, where the serpentine occurs in a vein of considerable size, Newport is the locality.

### *Mineral Contents.*

Serpentine bears a strong analogy to steatite in its mineral contents as well as in several other respects. Nearly all the simple minerals that have been described as existing in our steatite, occur also in the serpentine. The beautiful green amianthus of Newbury has already been mentioned and the asbestus of Pelham; as well as the amphibolic mineral, (probably actynolite,) in Westfield. At the latter place well characterized actynolite occurs; and according to Mr. Emerson Davis, anthophyllite also. Here is likewise found a mineral occupying a vein nearly a foot in width, which has been called petalite. But in hardness it corresponds more nearly with scapolite. It needs farther and more accurate examination. At the same place, as well as in the serpentine at Newbury, we find massive garnet. In Russell, in a supposed continuation of the Westfield serpentine, are found veins of amianthus traversing the rock, which rock verges towards a mineral that occurs in the Middlefield serpentine, as well as that of Newbury, and has been denominated Deweylite, in honor of Prof. Dewey. Chalcedony is also found in the Middlefield serpentine; and it sometimes passes into hornstone. Large rolled masses of these minerals, sometimes weighing 200 pounds or more, often agatized, have been found in Middlefield and Chester, which probably proceeded from some serpentine locality. Dr. Emmons says, that steatite is crystalized distinctly in the serpentine at Middlefield; and he does not regard these crystals as pseudo-morphous; although mineralogists have generally considered the crystals of steatite as such; and Beudant makes a distinct variety of them under the name of *pseudomorphous steatite*. The crystals at Middlefield certainly correspond in form exactly to those of quartz. In the serpentine of

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that place drusy quartz occurs, which is extremely beautiful. In the serpentine of Newfane, Vt. a similar drusy quartz has been found abundantly. Here also occurs chrysoprase; and sometimes the small crystals of quartz occupying the cavities of the rock have the color of the chrysoprase. At the same place general Martin Field has discovered pimelite.

### *Theoretical Considerations.*

The preceding description will show that the serpentine of Massachusetts corresponds essentially, as to position and character, with those serpentines in Europe that are connected with the oldest rocks. But I am not aware that any statements which I have made, will throw additional light on the obscure subject of its origin. From the statement of Dr. Macculloch* and De la Beche,† as to the connection between serpentine, trap, and limestone, one would be led to infer that the first mentioned rock might have resulted from a mixture of the trap and limestone. But the serpentine of Massachusetts does not favor such an idea. The precious serpentine of Newbury probably lies between the sienite or greenstone and the limestone; and such is its position in the cases described by these writers. The Westfield serpentine also contains a mixture of carbonate of lime, and in one or two other beds it may be found in small quantity. But in general our serpentines are entirely separated from limestone; and in respect to the gneiss east of Connecticut river, containing one or two of these beds, the whole extensive range does not to my knowledge embrace a single bed of limestone. But in all cases, (except perhaps that at Newport,) our serpentines are associated with talc, either pure and foliated, or as steatite, or chlorite slate, or talc and quartz. The two minerals, (talc and serpentine,) are intimately blended together and pass into one another by insensible gradations. And in all the cases described by the writers above referred to, talc was present. Is it not natural then to suspect that serpentine is talc, or talc serpentine, altered by heat? And since the talc is schistose and the serpentine massive, the latter must have been produced from the former. In some cases it is easy to imagine that the internal heat might have been powerful enough to produce perfectly fused, and of course compact serpentine, protruding among other rocks in the form

* Edinburgh Journal of Science, Vol. i. p. 1.

† Manual of Geology, p. 497, 2d edition.

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of veins; while at other times the fusion was only partial, not sufficient to destroy entirely the stratification. The great similarity in the chemical composition of serpentine and talc also favors the idea that they had a common origin. Both are composed essentially of silex and magnesia, with a considerable proportion of water. What the original rock could have been, which, with one degree of heat, or with heat applied under certain circumstances, could have become converted into talc, and with another degree of heat, or with heat applied under different circumstances, could have produced serpentine, I am at a loss to imagine; though we do find talcose rocks among some of the older of those that are fragmentary. But I make these observations with little expectation that they will stand the test of observation. It may be found that serpentine has been produced from various rocks, which contained the necessary ingredients. But that heat has been employed in its production, cannot it seems to me, be reasonably doubted.

### 13. HORNBLENDE SLATE.

I use this name as a translation of Dr. Macculloch's *Hornblende Schist;* and I include under it the same varieties of rocks. These varieties are such as other geologists have described under the names of hornblende rock, hornblende schist, primitive greenstone, and greenstone slate; all of which, I believe, occur in Massachusetts. In reading Dr. Macculloch's masterly description of the primary rocks of Scotland, I can hardly conceive that he is not describing those of New England; so perfect is the correspondence. Hence I have followed that geologist in describing most of the primary rocks; though I reject some of his distinctions. But upon the whole, I know of no geological writer who will compare with him in treating of the older rocks. I can by no means say the same in respect to his account of the newer rocks. For he obviously endeavors to depreciate the value of an accurate knowledge of organic remains found in the secondary and tertiary rocks; and it is but too evident that the reason is, that he himself can make no pretentions to distinction in this department. As to Dr. Macculloch's views of geological theories also, in his last work, "A System of Geology," whatever opinion may be entertained of their correctness as a whole, I think no one who carefully examines them, will hesitate to acknowledge them, every thing considered, as remarkably profound, ingenious, and ju-

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dicious. This remark, however, ought perhaps to be limited to his theories in respect to the primary rocks, for the reason above suggested.*

I have thought it proper to make these remarks, because I have so often in this Report followed the opinions, and applied the theories, of Dr. Macculloch, in the explanation of geological phenomena.

All the varieties of rocks mentioned above, viz. hornblende rock, hornblende schist, primitive greenstone, and greenstone slate, occur, I believe in Massachusetts; and the system which regards them as separate formations, and some of them stratified and others unstratified, has long rendered their history obscure and perplexing. But by uniting them, as Dr. Macculloch has done, and regarding them as mere varieties of the same formation, very much of this obscurity vanishes. In Massachusetts their characters correspond with those given by the writer so often referred to. Although for a limited space the hornblende rock and the primitive greenstone appear, without close inspection, to be unstratified, and wanting in a schistose structure; yet the unstratified character is very limited, and a fresh fracture will commonly reveal an obscure slaty structure.

*Mineralogical Characters.*

1. *Of Hornblende alone.* Sometimes this variety is laminar, and

* After having published so many separate geological works, and so many separate papers in the periodicals and transactions of learned societies, which were distinguished, for the most part, for the calm and dispassionate manner in which they were written, how unexpected to find in this last work, produced in mature years, so much of overweening self-conceit, so much of rude and overbearing intolerance, and of low jealousy and envy towards the distinguished school of geologists that are now advancing the science with unexampled rapidity! While he exhibits the principles of geology with a clearness and power to which I confess I know of no equal, he exhibits also a bitterness of feeling and violence of prejudice, to which, I had almost said, I know of no parallel. What a pity that a work, which might have gone down to posterity as a splendid monument of the commanding geological and chemical ability of its author, and have proved almost the "Principia" of geology, should have infused into it so much of the leaven of depravity, as to excite disgust in the reader, strong enough to destroy almost every feeling of respect! Of the private history and character of Dr. Macculloch I know nothing. His geological writings alone have led me to make these remarks. May he live long enough to publish an expurgated edition of his System of Geology, and thus free his setting sun from that angry fiery cloud in which it is now enveloped.

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sometimes fibrous. When fibrous, it is slaty; when laminar, no slaty structure can be perceived, nor any stratification, even in beds of considerable extent. This is the rock that has been sometimes called *hornblende rock.* (Nos. 914 to 928.)

2. *Hornblende and Feldspar.* Generally the hornblende is crystalline, and the feldspar foliated, or granular; but sometimes both ingredients are compact, and this mixture forms a good example of *primitive greenstone.* In this variety there is usually little appearance of stratification, or of a schistose structure; though this is not generally true of the whole bed. And sometimes, as in Whately, where this rock often assumes a columnar appearance, a schistose structure may still be seen. Sometimes the feldspar in this rock, as in the west part of Northfield, is finely granular, or even assumes a pulverulent appearance; while the hornblende is distinctly crystalline. When the ingredients are both crystalline, the rock furnishes a good example of hornblende slate. This variety is usually interstratified with gneiss and passes insensibly into that rock. (Nos. 929 to 951.)

In Whately is a curious variety of hornblende slate, in which the hornblende is light green and the feldspar white and compact. A casual inspection would leave the impression that the rock was sienite. But a little attention shows a very decided slaty structure. The hornblende also predominates. This is the only example I have met with, in which the slaty variety contains compact feldspar without being porphyritic. (No. 947.)

Associated with a large proportion of the hornblende slate in the vicinity of Connecticut river, is a variety that falls under the present division, that is most decidedly, and sometimes very beautifully porphyritic. The feldspar is yellowish white, between foliated and granular, although sometimes retaining the form of the crystal in considerable perfection. The hornblende is sub-crystalline, and in the greatest quantity. Sometimes scales of mica are present. The slaty structure may usually be seen in this variety, though less distinct than in most other varieties of this rock. There is scarcely a more distinct variety of porphyry in the State than this; and as it admits of being smoothed, and probably polished, it would form undoubtedly an interesting ornamental stone. It is more common to meet with this rock in rolled masses than in beds; and hence I infer that its beds are rather limited. (Nos. 944 to 946.)

I have found a remarkable variety of this porphyritic hornblende slate in Canton and Easton, near the Blue Hills, and also in Waltham, in

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rolled masses. Its peculiarity consists in the feldspar being compact, yet exhibiting the form of the crystal. The feldspar is white and the schistose structure of the rock distinct. (Nos. 948 to 950.) Whence this rock originated I am unable to say; though probably somewhere not far from the outer limits of the granite range, which lies west of the greenstone and sienite around Boston. It is quite obvious that this rock must have been so nearly fused as to destroy the foliated structure of the feldspar, yet without essentially impairing its crystalline form.

3. *Hornblende and Quartz.* (Nos. 952 to 957.) In general this variety probably contains some feldspar also. The hornblende in a crystalline state forms the principal ingredient. The quartz is granular. The rock is slaty; and is sometimes traversed by veins of quartz or granite. It does not form a common variety.

4. *Hornblende, Feldspar, and Mica.* This approaches to gneiss: but I do not call it gneiss, when the hornblende predominates. The mica is usually in small quantity, and the feldspar and quartz sometimes traverse the rock in numerous minute veins, which seem to have been frequently cut off and shifted by one another. (Nos. 958 to 963.)

6. *Hornblende and Epidote.* This latter mineral sometimes constitutes so large a proportion of the rock, that I thought it ought to be regarded as a constituent of one of the varieties of Hornblende slate. Generally it is granular and disseminated through the rock, giving it a peculiar green tinge: but sometimes it is imperfectly crystalized in cavities, and sometimes in veins. (Nos. 964, 964 1-2, 965.)

6. *Hornblende and Chlorite.* This variety is rather uncommon: but I have met with it in Whately, Shelburne, and perhaps some other places. Sometimes it passes into genuine chlorite slate. (No. 967.)

7. *Actynolite Slate.* This is found in gneiss in Shutesbury; and I know of no other well marked locality. It occurs near the mineral well in the center of the town. The rock is slaty and is composed of fibrous actynolite, foliated feldspar, mica, hornblende and quartz, arranged somewhat in layers. It is obviously only gneiss which takes into its composition a large proportion of actynolite. In Belchertown I found a loose specimen, in which the actynolite was granular and in large quantity, and the rock was not slaty. (Nos. 968 969.) Since the ablest mineralogists now regard actynolite and hornblende as the same species, I can not see how Dr. Macculloch can be justified in making a distinct rock of actynolite schist, as he

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has done. It certainly can lay claims to be considered only as a variety of hornblende slate.

I doubt not that other and still more compound varieties of hornblende slate might be found among our rocks: for this rock passes by imperceptible gradations into almost all those with which it is associated. Under talcose slate, I have noticed, for example, a variety containing hornblende, which might as well have been reckoned in this place. Under mica slate, I have also noticed an amphibolic variety, in which the hornblende sometimes predominates.

### *Topography of the Hornblende Slate.*

Every deposit of hornblende slate which I have examined in New England, is associated either with gneiss, talcose slate, mica slate, or quartz rock. The small patch represented on the map in the vicinity of the beds of limestone in Smithfield, R. I., is apparently associated with talco-chloritic slate; though as we go westerly, we find it alternating with gneiss: indeed, I suspect these three rocks are sometimes interstratified. Much of the hornblende slate in the vicinity of the lime quarries, is decided primitive greenstone, and greenstone slate; and it also passes insensibly into the talco-chloritic slate.

Most decidedly associated with gneiss is the range of hornblende slate represented as extending northeasterly from Grafton to Billerica. In some places, as at Marlborough, its hornblende character is fully developed, and it there becomes as nearly greenstone slate perhaps as any rock in the State. But generally this stratum is more or less intermixed with gneiss, so that sometimes one sees only traces of it. Yet as I usually found the deposit well characterised in the region where it is marked, I thought it proper to give it as a continuous range on the map. Generally between this hornblende slate and the granite on the east, the surface is composed of diluvium, so as to hide the junction of the two rocks.

Extending from Stafford in Connecticut, to Athol, in Worcester county, the map exhibits another narrow stratum of hornblende slate, very similarly situated to that just described. I have met with narrow beds of this rock still farther north, and probably it might with truth be extended across the whole State. But I saw it so rarely north of its present termination, that I thought it best not to carry it across the State. This rock is generally crystalline in its aspect, and is mixed with feldspar and quartz in considerable quantity: being obviously in nearly all cases, but a variety of gneiss. And it ought



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here to be remarked, that in many other places in the broad gneiss range of Worcester county, the rock takes so much hornblende into its composition, that it properly becomes hornblende slate. Some of these beds — as in Pelham — bear a closer resemblance to unstratified secondary greenstone than any other member of the primary rocks: (No. 1111.) and I have accordingly placed specimens from them among those of greenstone.

The deposit of this rock in the west part of Northfield, north part of Gill, and east part of Bernardston, is represented as in contact with mica slate, quartz rock, and new red sandstone: and such I believe to be its associations; though recent examination has led me to suspect that gneiss alternates with the mica slate. The hornblende slate of this region is sometimes slaty; but very frequently it is decided primitive greenstone, exhibiting even sometimes a passage into sienite. In some parts of the bed no marks of stratification, or slaty structure, appear: but they are almost uniformly present in other parts. In one instance, at least, a vein of white fetid quartz, nearly a foot wide, traverses this rock. This spot is on the road from Gill to Bernardston. The quartz near the edges of the vein contains foliated masses of feldspar.

Four other deposits of hornblende slate are represented on the map, surrounded by mica slate, in the western part of Franklin county. I have recently ascertained hat the deposit, which extends from Colrain to Conway, is associated with a limited stratum of gneiss, whose characters are fully developed in the east part of Buckland. The hornblende slate lies principally in the west part of Shelburne, occupying a high hill.

In respect to the other three patches alluded to above, I have no remarks to make, except to say that I do not suppose I have very accurately marked out their true limits, or situation. I know that in the vicinity of the spots where they are marked, I have repeatedly found hornblende slate. But I also know, that nearly all analogical reasonings as to the situation of this rock have failed me.

About one mile north of Whately meeting house, we find a limited deposit of hornblende slate, on the west side of the street, probably succeeding the red sandstone. Passing westerly not more than 100 rods, we cross almost every variety of this rock, that has been named: the common hornblende slate, which predominates: also that containing epidote, which is frequently divided into rhomboidal masses of considerable regularity: then we come to primitive green-

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stone, where the slaty and stratified tendency begins to be lost in the trappose or columnar: next we strike the peculiar variety, already described, as containing white compact feldspar: finally succeeds mica slate. In describing sienite I shall refer again to this spot.

The strip of hornblende slate marked along the eastern margin of the gneiss range in the west part of Hampden county, and east part of Berkshire, is so intermingled with the gneiss on one side, and with the mica slate and talcose slate on the other, that it is no easy matter to fix upon its true position or extent. I have exhibited it in those places where I found it most abundant. But viewing it rather as a variety of gneiss, I do not regard its exact situation or extent on the map of any great importance. Traces of this same rock may be seen all along the eastern margin of the talcose slate; and in Plainfield and Hawley, it is not uncommon to find examples of pure hornblende slate: though usually the hornblende forms the least abundant ingredient, and ought perhaps to be considered merely as crystallized hornblende disseminated through talcose slate.

Some of the hornblende rock in Granville and Tolland is laminated, and the size of the laminae is often gigantic. In the latter place, half a mile east of the meeting house, I have seen imperfectly prismatic masses not less than a foot in length and one or two inches wide. I apprehend that this hornblende slate in these towns, is connected with the extensive ranges of that rock which one crosses in passing from Lee to Becket. But I am so doubtful about the true situation of this rock along the western part of the gneiss range in Berkshire county, that I have forebore to represent it on the map. In the east part of Lee and west part of Becket, it is associated with augitic gneiss: and both these rocks are obviously varieties of gneiss.

In respect to the gneiss, hornblende slate, mica slate, and talcose slate, represented on the map as occupying a considerable part of the Hoosac range of mountains, I take this opportunity to remark, that whoever expects in passing transversely or longitudinally over this region, to find as sudden and decided changes in the rocks as are shown on the map, will be disappointed. On a map the change must be represented as sudden: but I have often travelled for miles in that region, in great uncertainty what rock prevailed. In such cases, one can give the line between different formations only by approximation.

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*Dip, Direction, &c. of the Strata.*

I cannot but regard the hornblende slate of Massachusetts, as belonging to the same geological epochs as the gneiss, mica slate, and talcose slate; that is, it seems to me they were all produced by essentially the same causes, and during the same periods of time. Hence we should expect, (if this opinion be correct,) that the dip and direction of the strata would correspond with those of the strata that have been mentioned. And such is the fact: though upon the whole, this rock approaches more nearly to verticality in the dip of its strata, than any other rock in the State; as the following notes will show.

| | Direction. | Dip. |
|---|---|---|
| Middlefield, | N. and S. | 70° to 80° E. |
| Becket, east part, | N. and S. | 90°. |
| do. west part, | N. and S. | 70° to 80° E. |
| Granville, | N. and S. | 90°. |
| Blanford, north part, | N. and S. | 90°. |
| do. northwest part, | N. and S. | 60° to 70° E. |
| Rowe, north part, | E. and W. | South, small. |
| Chester, west part, | N. and S. | 90°, nearly. |
| Shelburne, | N. and S. | 45° to 90° E. |
| Bernardston, east part, | N. and S. | 50° to 60° E. |
| Monson and vicinity, | N. and S. | 45° to 70° W. |
| Westborough, | N.E. and S.W. | 50° to 70° N.W. |
| Marlborough, | N.E. and S.W. | 80° to 90° N.W. |
| Cumberland, R. I. | N.E. and S.W. | 40° S.E. |
| Smithfield, R. I., lime quarries, | S.E. and N.W. | 30° to 45° N.E. |

I have already alluded to the tendency of the hornblende slate to divide into rhomboidal masses. I have observed this no where so distinctly as at Whately. There, also, the masses sometimes affect a columnar form; (No. 938.) though perfect columns of any great extent are rarely the result.

This rock is frequently remarkable for the numerous and complicated contortions which its layers exhibit, often rivalling in this respect, mica slate and gneiss. Not unfrequently these irregularities appear to be increased by the passage of granite veins through the rock, as in Granville.

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### *Mineral Contents.*

So far as it has been examined, no rock in the state appears to be so barren of interesting minerals as this. Garnets are perhaps the most common, and generally they are of a blood red colour—probably in some cases the pyrope. In Rowe, epidote occurs in this rock in a state of such purity that it deserves to be mentioned. In Middlefield and Chester, sphene has been observed in it. In its cavities also, not unfrequently, as in Charlemont and Whately, I have noticed tolerably distinct crystals of feldspar. The immediate gangue of the plumbago mine at Sturbridge is hornblende and feldspar; and the former minerals constitute the gangue, to a considerable extent at least, of the arsenical cobalt of Chatham, Ct. Red oxide of titanium I have also found in hornblende in Leyden. Other minerals will undoubtedly be discovered in this rock, upon farther examination. Hitherto mineralogists have paid very little attention to the geological situation of localities in our country.

### *Theoretical Considerations.*

It is easy to apply to hornblende slate the theory which imputes to the primary rocks an origin partly aqueous and partly igneous. For it is a very fusible rock, and may hence easily be conceived to have been sufficiently heated to enable it to assume the crystalline aspect, which it almost always exhibits. But from what rock did the hornblende slate originate? The researches of Dr. Macculloch appear to have thrown a gleam of light upon this difficult question. "As far as a single fact can prove such a case," says he, "the origin of hornblende schist from clay slate is completely established by the occurrence in Shetland, of a mass of the latter substance alternating with gneiss and approximating to granite. Here those portions which come into contact with the latter, become first, siliceous schist, and ultimately, hornblende schist; so that the very same bed which is an interlamination of gneiss and clay slate in one part, is in another, the usual alternation of gneiss and hornblende schist."* In another place he says, "it would appear, that the fusion of clay slate, whether primary or secondary, is, under various circumstances, capable of generating, either the common trap rocks, or the hornblende schists: nor is it perhaps difficult to explain, by a more gradual cooling, and con-

* System of Geology, vol. 1. p. 210.

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sequently, a slower crystalization, the particular causes which may have determined the latter rather than the former effect."*

This theory, if admitted, explains satisfactorily the approximation of hornblende schist to unstratified trap rocks. For some portions of the clay slate would very probably be so entirely fused as to obliterate all marks of a stratified and schistose structure: and hence by slow crystalization might result hornblende rock and primitive greenstone.

I have observed no facts in Massachusetts very decisive in respect to this theory. But since granite does occur in connection with some portions of our clay slate I doubt not but such may be found here. I have made no examination on the subject worthy to be named. It is my opinion, however, from what I know of the range of slate extending into Vermont and New Hampshire from Franklin county, that in those states would be the most likely places for such facts to be developed. The passage of graywacke slate into talco-chloritic slate, and of this into hornblende slate in Smithfield and Cumberland, Rhode Island, has probably also a bearing upon this theory.

The remarks that have been made in relation to porphyritic talcose slate, will apply with still more force to that variety of hornblende slate which is porphyritic. For in the latter case this structure is more distinct and perfect than in the former. And the more I reflect upon the subject, the more satisfied I am, that a porphyritic structure must, in all cases, have been the result of the agency of heat.

### 14. GNEISS.

This rock occupies more of the surface in Massachusetts than any other: and in all countries of much extent hitherto examined, it is one of the most extensive of the formations. Quartz, mica, and feldspar, are its common and essential ingredients; though hornblende is so often present, that some writers regard its claims to be considered essential, as equal to those of the other three minerals. It is obvious, therefore, that the mineralogical constitution of this rock is the same as that of granite. The only difference, indeed, consists in the stratified and slaty disposition of the gneiss. This character, however, sometimes becomes very obscure; and then it is almost impossible to distinguish between the two rocks. They might, therefore, be regard-

* System of Geology, vol. 2. p. 171.

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ed as varieties of one another: differing only in the mode of their production, as in the case of the stratified and unstratified limestones and serpentines. Little advantage, however, would be gained by such an innovation; and granite and gneiss have so long been considered as classical terms in geology, that if possible they ought to be retained; lest that neological spirit, which vain ambition nourishes, should unsettle every principle of the science.

The gneiss of Massachusetts corresponds almost exactly to that described by European geologists, particularly by Dr. Macculloch. Our gneiss, however, does not to my knowledge alternate with clay slate, as it does in Scotland. I am inclined also to believe, that ours exhibits a greater regularity of stratification, producing a fine rock for architectural purposes.

Although in general the characters of gneiss are tolerably distinct, yet an almost infinite variety of specimens may be obtained, slightly differing in the color, arrangement, or proportion, of the ingredients. They may, however, be reduced to a few leading varieties.

*Mineralogical Characters.*

1. *Granitic Gneiss.* (Nos. 972 to 992.) I suppose this variety to be the granite-gneiss of Humboldt. It certainly approaches very near to granite; and in hand specimens cannot be distinguished from a coarse grained variety of that rock. Even for an extent of several yards, we can sometimes discover no marks of a schistose or stratified structure; but those structures, at least the schistose, usually appear at no great distance, to prevent our regarding the rock as granite. It might, indeed, on a superficial view, be considered as a vein of granite in gneiss. But the masses will be found too irregular for such a supposition; and often they are bounded on all sides by well characterized gneiss. It would explain the mode in which this rock presents itself, to suppose that a slaty rock was once in a state of partial fusion, while some portions of it were perfectly melted, so as to crystallize in the form of a coarse granite; and the principal part of the mass cooling before the slaty structure was entirely lost. In traveling miles I have sometimes been at a loss to decide whether the rock were gneiss or granite, until a very careful examination disclosed a partially obsolete parallelism of the mica. I think, however, that there is a slight peculiarity of aspect in most of the granitic-gneiss of Massachusetts, which would enable me to distinguish it from genuine granite even in hand specimens, which were wholly destitute of a parallel disposi-

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tion of parts. But it is difficult to describe the exact nature of that peculiarity.

2. *Schistose Gneiss.* (Nos. 993 to 1022.) This is probably the most common variety of our gneiss. The structure is foliated like that of mica slate: though sometimes granular with a laminar tendency. Some of the best quarries in the state I regard as belonging to this variety. It passes frequently into mica slate by the disappearance of the feldspar.

3. *Laminar Gneiss.* In this variety the different ingredients occupy distinct layers. When the mica is black, or there is an interlamination of hornblende, the different laminae are remarkably distinct and regular. In some instances, perhaps, this rock may be regarded as composed of alternating layers of gneiss and mica slate, or hornblende slate. (Nos. 1023 to 1040.)

4. *Porphyritic Gneiss.* The structure of this variety is more or less slaty. But it embraces distinct crystalline masses of foliated feldspar. Most commonly these masses are somewhat ovoid; but in some instances they present the regular forms of the crystals. The color is sometimes white or gray: but a reddish hue predominates. The imbedded masses vary in size from a quarter of an inch in their longest direction, to two inches; and they sometimes constitute the largest portion of the rock. This variety sometimes answers well for architectural purposes. (Nos. 1041 to 1050.)

5. *Amphibolic Gneiss.* I thus denominate that variety which takes a small proportion of hornblende into its composition: not sufficient to form hornblende slate. This mineral is usually disseminated in black foliated masses, from the size of a pin's head to half an inch in diameter, through the rock. It occurs only in the vicinity of hornblende slate. (Nos. 1051 to 1054.)

In the southeastern part of Worcester county is a beautiful rock, extensively quarried, which I refer to this variety. One meets with it abundantly in Mendon, Grafton, and the south part of Worcester, in blocks got out for building; but I do not know where are its quarries. The rock appears to be a granitic gneiss, composed almost entirely of quartz and feldspar, through which are disseminated numerous black crystalline masses of hornblende, which have a somewhat parallel arrangement. This parallelism is almost the only mark by which I distinguish this rock from granite. It might with propriety be termed *sienitic gneiss.* (Nos. 983 and 986.)

6. *Epidotic Gneiss.* This variety usually contains hornblende as

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well as epidote. The latter mineral is very frequently in veins and generally compact. It is sometimes, however, disseminated through the rock, giving it a peculiar green tinge. Were this not a common variety of gneiss, especially in the vicinity of hornblende slate, it would not deserve a distinct description. It is closely allied to the epidotic hornblende slate. (Nos. 1055 to 1061.) When the epidotic gneiss happens to be porphyritic, it forms a beautiful ornamental stone. (No. 1043.)

7. *Augitic Gneiss.* This interesting rock is usually composed of quartz, feldspar, and lively green augite, in coarse grains or partially crystalline masses. Occasionally we see present grains of black hornblende. The augite seems generally to have taken the place of the mica. The augite is disseminated in various proportions through the mass and the slaty structure is quite indistinct. (Nos. 1062 to 1065.)

8. *Anthophyllitic Gneiss.* In the west part of Enfield and in Belchertown, anthophyllite is disseminated through the gneiss in such quantity, that it deserves to be considered an ingredient of the rock, if it be proper thus to consider amphibole, epidote, and augite, in the three preceding varieties. This rock is composed almost entirely of feldspar, quartz, and anthophyllite, the mica being rarely present. (Nos. 1066, 1067.)

9. *Arenaceous Gneiss.* I have found this rock only in one well marked locality, viz. at Southbridge, Worcester county; but it seems to me sufficiently peculiar to deserve a distinct notice. It is composed entirely of quartz and feldspar, which, (particularly the latter,) are in a finely granular state; embracing, however, small but distinct crystals of red garnet. Between the layers of the rock we find a substance which approaches to talc. This rock is quarried and is employed for lining furnaces. (No. 1068.) Perhaps it ought to be described under the next variety.

10. *Talcose Gneiss.* This is composed of feldspar, quartz, and talc; the first ingredient in the largest proportion. Its structure is irregularly schistose: but it has the aspect of a rock formed in part by mechanical agency. As I have met with it only in one place, (between Smithfield and Providence, R. I.) and did not there examine it carefully, I am not prepared to say whether it ought to be regarded as the *Protogine* of European geologists. (No. 1071.)

### *Topography of the Gneiss.*

There are in Massachusetts four separate ranges of gneiss: one in



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the Hoosac Mountain range; two in the central parts of the state; and a fourth in the vicinity of New Bedford, in Plymouth and Bristol counties.

### *Hoosac Mountain Range.*

Under mica slate I have already given a general description of the situation of this gneiss, and the reasons that lead me to suspect that it passes laterally, or in the direction of the strata, into mica slate. Throughout nearly the whole extent of Litchfield county, in Connecticut, this gneiss range is most distinctly characterised. As we proceed northerly into Massachusetts, its characters become less decided. The feldspar is less abundant, and the mica more so; and hornblende frequently abounds in it: so that viewed on a small scale, it may often be regarded as mica slate. Along the eastern slope of Hoosac Mountain, the rock becomes sooner converted into mica slate than along the western slope. On this latter side, indeed, distinct gneiss continues nearly across the State, as may be seen on the map; and I am by no means sure but careful research may trace it entirely across the State; so as to connect it with the gneiss that appears in the lower part of Vermont, along the eastern talus of the Green Mountains. At any rate, that Vermont gneiss appears distinctly characterised in the southwest part of Whitingham, near the beds of limestone, as shown on the map; and from thence I have traced it as far north as the Somerset iron mine. Here then we have two wedge-shaped ranges of gneiss, with their acute angles towards each other, while the space between them is occupied by mica slate and talcose slate; and sometimes we find these slates, for a limited space, passing into gneiss. There is certainly then some probability in the supposition that all these schistose rocks may belong to one formation; and that the varieties resulted from local peculiarities in the mode of formation.

In passing from Becket to Lee, we cross strata of decided gneiss, till within three or four miles of Lee, when the rock contains a considerable proportion of hornblende, and at length becomes decided hornblende slate. Still nearer to Lee, the hornblende is replaced by green augite, and augitic gneiss hence results. Within two miles of Lee, we strike upon limestone; which often contains a mixture of augite; and this mineral, being decomposed at the surface, yet projecting beyond the limestone, the whole rock exhibits a brown and very rough and irregular aspect; exceedingly like similar compounds at the lime quarries in Bolton, Boxborough, Littleton, &c. — This au-

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gitic gneiss certainly deserves a more thorough examination than I have been able to give it.

In the western part of this gneiss range in Connecticut, beds of coarse saccharine limestone are common. But I have never been able to find one of this description, in Massachusetts; though I suspect their existence, as in New Marlborough.

The limited patch of gneiss marked on the map, in Buckland and Shelburne, lies chiefly in the ravine through which Deerfield river passes. In its most elevated parts, (as on the western slope of the high land in the west part of Shelburne, and on the opposite side of the river in Buckland, on the stage road between the two bridges over Deerfield river,) this rock is very regular in its stratification: but at the bottom of Deerfield river, at and below Shelburne Falls, it is the granitic gneiss, almost destitute of stratification, and contains hornblende. The feldspar here is in small proportion; and some of the rock might properly be denominated quartz rock.

These facts have led me to inquire, whether the greater regularity of stratification in the higher parts of this deposit, might not proceed from the fact, that the lower parts are nearer to that igneous power, which, according to the theory that I have elsewhere explained, has partially fused some portions of the primary rocks, and entirely fused other portions? Here the upper strata are perfectly regular and continuous: but as we descend, we find the rock approximating nearer and nearer to unstratified granite, yet retaining some faint traces at least of a schistose structure. Is it reasonable to suppose, that a little deeper excavation would disclose perfectly well characterised granite? The light which I fancy this spot throws upon theory, is the most interesting circumstance connected with this deposit.

### *Worcester County Gneiss.*

The broad ranges of gneiss in the central parts of the State, which for distinction's sake may be called the Worcester county ranges, next claim attention. That range, which lies west of the mica slate deposit in Worcester valley, extends across the whole of Connecticut to Long Island Sound on the south, and probably through all the western part of New Hampshire, and I know not how much farther north. The most elevated point of this range in Massachusetts is Wachusett Mountain, in Princeton, which rises 3000 feet above the level of the ocean. This is a remarkably insulated peak, nearly

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twice as high as any other part of Worcester county. Its stratification does not exhibit much of that irregularity, which we should suppose must have resulted from its having been elevated so much above the surrounding country: though its stratification is certainly very obscure. And I am rather inclined to ascribe such an origin to this mountain, than to suppose the surrounding country to have been once equally elevated and subsequently worn away; since the rock composing it possesses no peculiar power of resisting disintegration and abrasion, that is not possessed by the gneiss of the whole range.

I would repeat here, however, a remark made under diluvium, that the gneiss rock of Massachusetts appears to be peculiarly liable to disintegration; especially where it abounds in sulphuret of iron. Hence it is that the gneiss region of Worcester county furnishes so excellent a soil. As we go westerly upon this range, and get into the limits of Hampshire and Franklin counties, more of the naked rock appears; and the soil generally is much poorer. But in Worcester county generally the rock appears in place but seldom; and the hills are much rounded. In the gneiss region of Hoosac Mountain, that has been described, the hills are generally steeper, and the country for the most part more elevated. The soil also is not as rich or deep as in Worcester county.

I have reason to believe, though not from personal examination, that the Monadnoc and White Mountains in New Hampshire, are essentially composed of gneiss, and insulated in a manner similar to Wachusett: being in a continuation of the same range.

Porphyritic gneiss prevails extensively along the western margin of the Worcester county gneiss range, in the towns of Northfield, (Mass.) and Winchester, (N. H.) It appears also very conspicuously on the high hill east of Ware Village. This is one of the most rocky spots in the state; and the crystalline masses of feldspar are here unusually large. This range of porphyritic gneiss extends northerly through Dana, Petersham, &c., lying immediately east of the hornblende slate exhibited on the map. It can be traced south from Ware also through Palmer, &c. Indeed, it is the most extensive deposit of this variety of rock that I have ever found. It appears that the peculiar causes that produced it, operated over a great extent. Judging from the great regularity of the rock formations in this country, I predict that a strip of it may be found extending northerly from Long Island Sound as far as the gneiss reaches.

From Hubbardston, both north and south, to the boundaries of the

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State, and in breadth several miles, the characters of the gneiss are greatly obscured by the iron aspect which the rocks have assumed in consequence of the decomposition of pyrites. The same appearance is frequent in other parts of the range.

Granitic gneiss abounds in various parts of this deposit: but rather more I think in the southern than in the northern part of the State. In the west part of Charlton, for instance, and so occasionally all the distance to Brookfield, one is often at a loss whether the rock be gneiss or granite. In Uxbridge, in the range east of the mica slate, the same variety abounds; and still more frequently on the east side of the Blackstone in Mendon.

That range of the Worcester county gneiss just referred to, which extends northeasterly into Middlesex county, possesses some peculiar characters. In another place I shall attempt to show, from the dip and direction of the strata, that it belongs to a different system of stratification from the gneiss west of Worcester valley. But I refer now to other peculiarities. One is, that it contains numerous beds of limestone, which are entirely wanting in the western range. Another is, that it passes so frequently into mica slate; the two rocks often alternating, and indeed, in some places, the slate predominating. Indeed, it would not be strange if some future geologist should regard a part of this range as mica slate. A third pecularity is, that it abounds, especially towards its northeastern extremity, in veins and protruding masses of granite.

I have found it very difficult to determine the exact eastern limits of the gneiss range under consideration. I mean the line of its junction with the granite. Much of the gneiss near that line is granitic, and of course difficult to be distinguished from granite. In some places the beds and veins of granite increase in number and size as we go easterly, until at length the gneiss occupies only a small proportion of the surface. Near the junction of the two rocks, also, diluvium is very abundant; which increases the difficulty of fixing their limits.

### *New Bedford Gneiss.*

On the first edition of the map, I represented a deposit of gneiss extending from Rochester to Little Compton: but subsequent examination has rendered it doubtful to my mind, whether any thing more than small insulated patches of this rock are to be found west of New Bedford. Gneiss of a peculiar character, does, indeed, appear in

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Little Compton; but in the intervening space I have never met with any rocks in place but granite; and this rarely. For the accumulation of diluvium in that quarter of the State is very great; and, indeed, the towns of New Bedford, Fairhaven, and Rochester, might be regarded as diluvial without impropriety: but as I have met there with gneiss in some instances, I do not hesitate to represent a deposit of gneiss in those places; being, however, much in doubt as to its actual limits.

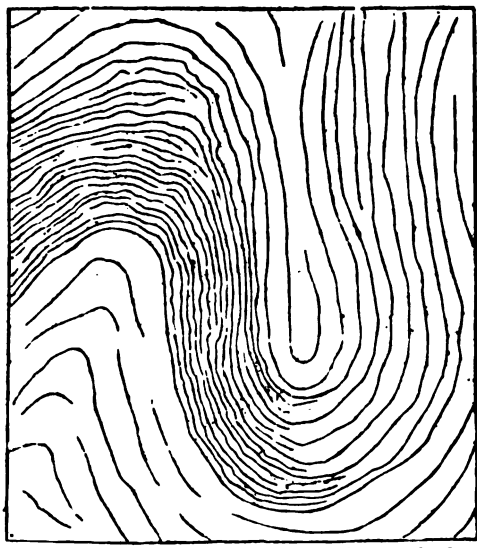
Almost all the varieties of gneiss that have been described, may be found in the vicinity of New Bedford. In that place it is schistose, and passes into mica slate. There, too, we find a beautiful variety of porphyritic gneiss in bowlders; the masses of feldspar being flesh red and about the size of a hazle nut.

### *Schistose and Stratified Structure: Dip and Direction of the Strata.*

In no rock in the State are the slaty and stratified structures so distinctly marked in the same rock, as in gneiss. The strata are usually thick; and where no local cause of irregularity exists, remarkably even and continuous. Hence the facility with which the quarry men cleave out slabs of gneiss, 20 or 30 feet long, and half as many wide. But these same slabs, when dressed, often exhibit a schistose structure of remarkable irregularity, — the laminae being much bent and composed of different ingredients, so as to give to the rock the appearance of a variegated or clouded marble. The underpinning of most of the buildings in Amherst, particularly of the village church, exhibits this appearance most strikingly. The rock, however, will not cleave in the direction indicated by these contorted layers, any easier than in other directions. And hence in strictness of language it ought rather to be regarded as a foliated than a schistose structure. Hence, too, this structure does not injure the rock for architectural purposes.

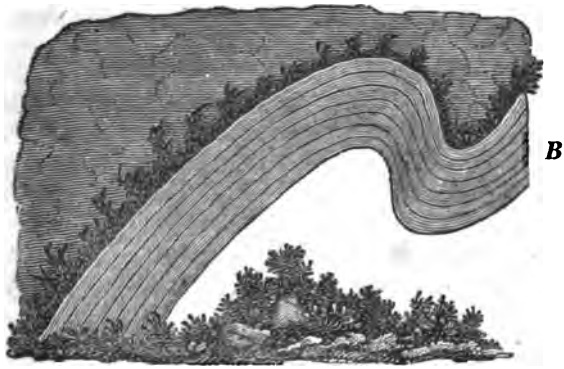
The following sketch exhibits a very striking case of this foliated structure, as it is developed on the surface of a bowlder, several feet square, lying by the side of the road in Colebrook, Connecticut; a few miles south of the Massachusetts line. These curvatures are much larger than is usual and more distinct. They appeared to be entirely independent of the stratification.

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Curvatures in the Folia of Gneiss: Colebrook, Ct.

These curvatures are not, however, confined to the laminae of gneiss, but are sometimes seen in the strata. About one mile before reaching the meeting house near the center of New Marlborough, on the south side of the road, the the traveler will see an overhanging ledge of stratified gneiss, dipping from 40° to 50° east, whose edges are bent as in the annexed sketch. The whole length of the strata here exhibited, (from *A* to *B*,) is 12 feet; and their breadth about four feet.




*A* Curved Strata of Gneiss: New Marlborough.

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This ledge has been described by Prof. Dewey, under the name of mica slate: but I have already given the reasons that have led me to differ from him on this point.

The suggestions that have been made in treating of mica slate, in regard to the causes of such flexures in rocks, are equally applicable to the rock under consideration; and therefore I shall add no more in this place on the subject.

It will appear from the following notes, relative to the dip and direction of the strata of gneiss in Massachusetts, that this rock conforms to at least three systems of stratification. The Hoosac mountain range, and the western part of the Worcester county range exhibit one system: the branch of this latter range, which extends into Middlesex county, belongs to a second without much doubt: that portion of it in the southeast part of Worcester county and in Rhode Island seems to belong to a third, and perhaps the New Bedford gneiss to a fourth. But more of this hereafter.

*Hoosac Mountain Range.*

| | Direction. | Dip. |
|---|---|---|
| Cheshire, east part, - - | N. and S. | 20 to 30° E. |
| Windsor to north part of Peru, | N. and S. | East. |
| Chester to Becket, - - | N. and S. | 80 to 90° E. |
| Colebrook, Ct. to West Granville. | N. and S. | nearly 90° E. |
| Whitingham, Vt. - - | N. and S. | 30° W. |
| Wilmington, Vt. - - - | N. 30° E. | 30 to 70° W. |
| do. to Somerset, | N. and S. | West, large. |
| Buckland, - - - - - | N. and S. | 10 to 20° E., and 10 to 20° W. the latter rather predominating. |

*Range West of Worcester Valley.*

| | Direction. | Dip. |
|---|---|---|
| Brimfield, - - - - - | N. and S. | 45° W. |
| do. to Sturbridge, - | N. and S. | 20 to 80° W. |
| Sturbridge to Charlton, - - | N. and S. | 45° W. |
| Monson to Sturbridge through Wales and Holland, - - | N. and S. | 45 to 70° W. |
| Plumbago Mine, Sturbridge, | N. 30° E. | 60 to 70° N.W. |
| Sturbridge through Southbridge to Dudley, the dip gradually decreasing, - - - | N. and S. | 60 to 25° W. |

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| | Direction. | Dip. |
|---|---|---|
| Oxford, west part, | N. and S. | 10° E.: usually west, and large. |
| Charlton to Brookfield, | N. and S. | 20 to 40° E. |
| Western, | N. and S. nearly | 20° a little S.W. |
| Enfield, | N. and S. | 90° nearly. |
| do. to Amherst, | N. and S. | 10 to 30° E. |
| Spencer, center, | N. and S. | West, small. |
| do. two miles east, | N. and S. | 20° E. |
| Hardwick, | N. and S. | 20 to 30° W. |
| do. to Spencer, | N. and S. | 20° W. |
| New Braintree, | N. and S. | 20 to 30° W. |
| Ware, | N. and S. | 20° W. |
| Leicester towards Worcester | N. and S. | West, small. |
| Pelham, west part, | N. and S. | 20 to 30° W. |
| do. north part, | N. and S. | 15 to 20° E. |
| do. to Prescott, | N. and S. | 20 to 30° E. |
| Shutesbury, | N. and S. | 45 to 90° E. |
| do. Lock's Pond, | N.W. and S.E. | 45° N.E. |
| Leverett, north part, | N.W. and S.E. | 0° to 45° N.E. |
| Petersham, | N. and S. | 40 to 50° W. |
| Hubardston, | N. and S. | 30° W. |
| Rutland, | N. and S. | E. very small. |
| Princeton, embracing Wachusett, | N. and S. | 10 to 20° E. |
| do. towards Sterling, | N. and S. | nearly horizontal. |
| New Salem to Templeton, | N. and S. | nearly 90°. |
| Warwick, | between N.E. and North. | Easterly, |
| Warwick to Royalton, | N. and S. | 60 to 80° E. |
| Winchendon, west part, to Ashburnham, | N. and S. | West, various. |
| Ashburnham to Fitchburg, | N. and S. | West, small. |
| Townsend to Rindge, N. H. | N. 30° E. | 10 to 25° N.W. |
| Rindge, N. H., west part, | N. and S. | 30 to 40° W. |
| Winchester, N. H. towards Northfield, | N. and S. | 20 to 30° E. |



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*Range East of Worcester Valley: North Part of the Range.*

| | Direction. | Dip. |
|---|---|---|
| Bolton, - - - - - - | N.E. and S.W. | 60 to 70° N.W. |
| Boxborough, limestone quarry, - | N.E. and S.W. | 60 to 70° N.W. |
| do. west part, - - | N.E. and S.W, | 90°. |
| Carlisle, - - - - - | N.E. and S.W. | 60 to 90° N.W. |
| Chelmsford, limestone quarry, | N.E. and S.W. | 70 to 80° N.W. |
| Worcester to Berlin, - - - | N.E. and S.W. | 20 to 90° N.W.? |
| Concord, - - - - - | nearly N. and South. | nearly 90° W. |
| Worcester, southeast part, - - | N. several degrees E. | 70 to 80° W. |

*South Part of the Range.*

| | Direction. | Dip. |
|---|---|---|
| Worcester to Grafton, - - | S. several degrees W. | 45 to 90° W. |
| Grafton to Upton, - - - | S.E. and N.W. | N.E. small. |
| Mendon, - - - - - - | S.E. and N.W. | 20 to 30° N.E. |
| Douglass, - - - - - | S.E. and N.W. | 25 to 30° N.E. |
| Westborough to Hopkinton Springs, - - - - - | S.E. and N.W. | 30° N.E. |
| Uxbridge, - - - - - | E. and W. to S.E. and N.W. | 25° N. and N.E. |
| Sutton, - - - - - - | E. and W. | 30° to 35° N. |
| do. Purgatory, - - | S.E. and N.W. | 25° N.E. |
| Burrillville and Smithfield, west part, - - - - - | nearly E. and West. | 25° to 30° N. |

*New Bedford Gneiss.*

| | Direction. | Dip. |
|---|---|---|
| New Bedford, (town,) - - | E. 20° N. | 55° N.W. |
| do. Palmer's Island, | E. and W. | 35° N. |
| Rochester, - - - - - | E. and W. | 35° N. |
| Little Compton, R. I. - - - | N.E. and S.W. | 35° S.E. |

The greatest irregularity in the dip, as shown in the preceding table, exists in the gneiss in the western part of Worcester county.

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Yet the direction is pretty uniform, being usually north and south. And in respect to the dip, I think it obvious that a westerly dip predominates, being rather largest towards the western side of the range. Thus is it represented on Plates XVII. and XVIII. From those sectional views, it will be seen that this westerly dip is most uniform across the southern part of the range. In the central section, the dip becomes east towards the western part, and still more so in the most northerly section.

The smallness of this dip in many places is another striking circumstance in this same range. If we have any rock that would be selected for the oldest described by geologists, it is this gneiss: and hence we see how deceptive was the old rule, which taught us that the relative ages of rocks might be determined by their dip.

### *Mineral Contents.*

In some parts of the world gneiss is remarkable as the repository of a number of the precious stones. In Ceylon, for instance, where gneiss is the prevailing rock, it contains of the quartz family, rock crystal, amethyst, rose quartz, cat's eye, prase, and hyalite: also topaz, schorl, pyrope, cinnamon stone, zircon, spinelle, sapphire, and corundum.* Hitherto the gneiss of Massachusetts has not yielded so rich a supply. But it affords enough of the same minerals, to prove a strong analogy between the causes that produced these deposits in parts of the globe so widely separated. Especially will this be true, if we regard the limestone beds in the northeast branch of the Worcester gneiss range, as a part of this formation; and this is certainly reasonable. For in these beds have been found spinelle, a garnet which is probably cinnamon stone, asparagus stone, nephrite, and precious serpentine: and the following statement will show that several others of the Ceylon minerals have also been found in the gneiss itself.

By far the most important mineral hitherto found in our gneiss, is graphite. As described in the first part of my Report, its most important locality is in Sturbridge. It occurs in other places, however, as in North Brookfield, in Brimfield, in Hinsdale and New Marlborough; though I am not sure that in the two last named localities, the gangue is gneiss. The plumbago in Sturbridge, which is situated

* Geological Transactions, vol. 5. p. 318.

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only two miles north of the Connecticut line, and near the western line of the town, has been explored in some places to the depth of 60 or 70 feet. I have already described it so fully as to render it necessary to add only a few remarks respecting its geological situation and mineralogical characters and associations. It is most decidedly a bed in a dark colored gneiss, which here dips from 60° to 70° west, and runs N. 30° East, and S. 30° West. In immediate contact with the gneiss, we find frequently lamellar brownish hornblende, which is also disseminated to a considerable extent in the gneiss.

The lustre of this plumbago is highly metallic. Its structure is between scaly and fine granular. Sometimes, however, there is an obvious approximation to distinct crystals; though mineralogists are not agreed that this substance has ever been found in such a state. Judging, however, from specimen No. 1075 and from what the workmen told me, I suspect that if crystalized graphite occurs any where, it may be found at Sturbridge.

There is another variety found at this locality, which is distinctly fibrous; the fibres being from one to two inches long. On examination, these fibres are found to be composed of distinct lamellae, which are sometimes so bent as to give the mass a fibrous appearance; as happens in certain varieties of mica slate: but more commonly these lamellae actually separate longitudinally into very narrow prisms, like prismatic mica. (No. 1074.)

At this mine I noticed phosphate of lime in small quantity. At the most southerly excavation, also, I noticed hydrate of iron, in a cross fissure in the gneiss, and forming with the ingredients of the rock a brecciated mixture. Vegetable relics are sometimes seen enveloped in the mass. Half a mile north of the meeting house in north Brookfield, I noticed a similar breccia, forming a bed in gneiss a foot or two in thickness: though here I saw no vegetable remains.

In both these cases, I think we must regard this iron ore as having been infiltrated into cavities in the gneiss, at a recent date; and, therefore, in fact, as an alluvial deposit; although at Brookfield the iron forms a distinct bed in the gneiss. But the rock contains abundance of decomposing sulphate of iron, which, as we have already seen, produces bog iron of exactly the same aspect as that above described: and it is not impossible that from this cause a cavity in the rock that was originally small, might have been much enlarged;

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while the exfoliated fragments would go to make up the brecciated mass above described.

After what I have said under graywacke and mica slate, in respect to the origin of anthracite and plumbago, it will be repetitious to add any thing farther on this subject. It may be that I am too much captivated with the beautiful simplicity of the principle, which refers every variety of peat, lignite, bituminous and anasphaltic coal, and plumbago, to a vegetable origin. But at present, I must regard that opinion as far more probable than any other.

It will be well for observers to bear in mind a remark of Dr. Davy relating especially to the gneiss of Ceylon. "It is worthy of remark," says he, "that graphite is generally found in company with gems. I have had so often occasion to make the observation, that I now never see the former without supposing the presence of the latter."*

A mineral occurring in our gneiss, and often confounded with graphite, is the sulphuret of molybdenum. I have noticed this in Brimfield in scales; and in the north part of Shutesbury, a little east of Locke's Pond, it has been found in hexagonal plates nearly an inch in diameter.

The mineral found in our gneiss, which next to graphite will excite most interest in an economical point of view, is the native alum mentioned in a postscript to the first part of my Report. It is there stated to be found effloresecing on mica slate; but I have satisfied myself that it is that schistose variety of gneiss, which is passing into mica slate. There is mixed with it more or less of sulphate of iron, and both minerals proceed from the decomposition of iron pyrites, and probably feldspar. This last mineral contains, as is well known, a considerable quantity of potassa; and I can imagine no other source from whence this essential ingredient of alum should be obtained. Nor will any one doubt, who has seen how thorough is often the decomposition of the gneiss that contains pyrites, that this potassa might be separated. I am not aware that alum has been heretofore found in gneiss: but since this rock does contain so much potassa, and if it can thus be separated from the feldspar, why may not our gneiss prove a very prolific source of alum? I do not know that any special efforts have been made to ascertain whether it can be procured in much quantity from the rock in Leominster: but recently I have received a specimen from Barre, and it occurs also

* Geological Transaction, vol. 5. p. 323.

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in Ware. And I can have no doubt that any part of the gneiss range, where pyrites is decomposing, will produce it. It may be hoped that a fair trial will erelong be made to obtain this substance. This is not the proper place to make suggestions as to the best mode of proceeding. Suffice it to say, that no effort should be made on a large scale, without consulting some practical chemist.

The Worcester county gneiss ranges contain in many places, an abundance of blood red, often ruby red, and translucent garnets. Often they are extremely minute and perfectly crystalized; but sometimes, as in Brookfield, they are more than half an inch in diameter, and the crystal is very imperfect. At length it becomes perfect pyrope. And it is a curious fact that there is a strip of gneiss, (sometimes approximating to mica slate,) extending from Norwich in Connecticut, half across, and probably entirely across, Massachusetts, which abounds in this mineral. This strip passes along the western part of Wales, Brimfield, Ware, &c. In no place, however, except Brimfield, is the color of this garnet so delicate as in Norwich, Ct. where it is found in mica slate.

The foliated masses of feldspar in the porphyritic gneiss passing through Brimfield, Ware, &c. are frequently a delicate adularia. In Southbridge, in a decomposing ledge of gneiss, near the center of the place, the feldspar is of a delicate green, yet almost transparent; being quite elegant when polished. (No. 1086.) In cavities in the gneiss in Boxborough, I found distinct yet not handsome crystals of feldspar. The same occur with actynolite, augite, and sphene, in Pelham.

Common schorl is frequently seen in the gneiss of Massachusetts, as in Athol, Pelham, and New Braintree. In the latter place, the crystals have distinct acuminations. Often, as in Athol and Pelham, epidote, sometimes in crystals, is associated with the schorl.

In the New Bedford gneiss, as I was informed by T. A. Greene Esq. epidote occurs along with the red oxide of titanium. In the gneiss in Pelham, I have noticed some crystals of sphene as just mentioned. But the sphene which I lately found in the augitic gneiss in the east part of Lee, is finer than any I have met with in New England. (No. 1091.) The crystals are very oblique rhombic prisms, variously modified at their extremities; resembling those represented on Plate XII, figs. 47, 48, and 49 of Beudant's Mineralogy.

It has already been repeatedly stated, that the sulphuret of iron is one of the most abundant of the minerals in the gneiss of Worcester county. In Hubbardston, as I have mentioned elsewhere, this ore is

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wrought for the preparation of copperas. In the gangue of the ore occurs a mineral which exceedingly resembles peliom, though it may be blue quartz. It deserves farther examination.

Magnetic oxide of iron is sometimes met with in small disseminated masses in gneiss, as in Athol and Shelburne.

Arsenical sulphuret of iron is said to occur in Leicester in gneiss.

In Pelham we meet in this rock, with well characterised specimens of anthophyllite.

In that town, also, is a great abundance of finely crystalized quartz. Some of the crystals are quite delicate. They are commonly limpid, though sometimes of a light brown color, and sometimes of a fine topaz yellow, being genuine yellow quartz. Rarely are they amethystine. Not unfrequently large cavities are drusy, and present fine specimens. The crystals vary in size, from two inches in diameter to the fineness of a sewing needle. It is not easy to ascertain the precise situation of this quartz in the gneiss; since it is seen only in loose masses scattered over several acres. Probably, however, it constitutes a vein. I observed no metallic substance in it, except a little sulphuret of iron.

Associated with this quartz are found beautiful specimens of mamillary chalcedony, (No. 1002.) Rarely it is of a milk white color; but commonly of a delicate blue. Sometimes it may be seen investing distinct crystals of quartz, thus showing its origin to be watery infiltration beyond all question.

It has already been mentioned that steatite and serpentine occur in beds in our gneiss. In Millbury, a variety of the former has been found, which has been called *vermiculite*, on account of its singular property of shooting forth vermiform masses, when exposed to heat; thus giving to the specimens, when in the fire, the appearance of worms in motion.

I have seen a specimen of gray copper from Brimfield; and from the geological constitution of that region, I infer that it originated from gneiss.

In Washington, Ct. the gneiss contains mesotype and stilbite; and at Bellows Falls, on the Vermont shore, a radiated mineral of the zeolite family, with another in small and distinct crystals, which I shall describe under greenstone, as a new species, by the name of *Lincolnite*.

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### *Theoretical Considerations.*

Since gneiss is composed of the same simple minerals as granite, it is natural to infer that both must have had a similar origin. And especially are we led to such a conclusion, when we see in granitic gneiss a gradual passage from the one rock into the other. That granite has resulted from heat, instead of aqueous deposition, seems to me to be so well established, that the opinion that imputes to it such an origin, ought no longer to be regarded as hypothesis, but as legitimate theory. Thus it is regarded by nearly all the ablest geologist of Europe; and in the proper place I hope to show that our granite presents equally strong evidence of such an origin as that on the eastern continent. At present I shall assume that theory to be the correct one, which supposes granite to have resulted from the melting down of other rocks; the fused mass having cooled so slowly as to present a confused crystalization. It is at least a probable supposition, that the rock out of which it was produced, was of mechanical origin. and consequently stratified. Now if the central heat was not sufficient entirely to melt this stratified rock, yet it would be powerfully affected a considerable distance upward from the molten mass. The first in immediate contact with the melted portion, would be partially fused, and hence give origin to granitic gneiss. Another portion might be converted in porphyritic gneiss; another into lamellar; another into schistose; &c. All the rock we may suppose so near the fluid granite, and so long in contact with it, before cooling, that a crystalline would succeed to a mechanical arrangement of all its ingredients, without losing the stratified disposition.

The facility with which this hypothesis explains the graduation of gneiss into granite, and the crystalline and especially the porphyritic structure of the gneiss, is the principal argument in its support. Such effects we know might have resulted from heat: but they could not have resulted from watery solution.

As to the mechanical rock from which gneiss was produced, according to this theory, we are left only to conjecture. Most probably it was a coarse micaceous sandstone, which resulted from the disintegration of granite, previously existing. When hornblende slate alternates with the gneiss, we have only to suppose that formerly clay slate was interstratified with the sandstone: and where there is an interlamination of mica slate and gneiss, we have only to suppose that

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in some portions of the sedimentary rock, the necessary ingredients for the production of feldspar were wanting. In the same manner, the quartz rock associated with the gneiss, might have proceeded from a sandstone composed chiefly of siliceous sand.

According to this view of the subject, granite, and perhaps other primary rocks, must have existed anterior to those which now form the crust of the globe; and from the detritus of which, the existing primary rocks were produced; being subsequently indurated and crystalized by a new eruption of granite and other unstratified rocks. Thus we trace a number of successive epochs of renewal and destruction, before the earth assumed its present form: and now we see the process of destruction going forward. To these changes the mathematician who first developed the fundamental principles of this theory saw no marks of a commencement, — no prospect of an end; and hence he has been supposed to defend the hypothesis of the world's eternity, and to exclude a Deity from its creation and government. But surely his own theory did not teach him that the earth had existed in more than two states anterior to the present; viz. the state that preceded the existence of our present primary strata, and that which included these only. And had he been acquainted with the history of organic remains, as the subject is now understood, he might have known that there is no proof of more than five or six extinctions of animals and plants antecedent to the creation of the present races; and still farther, he might have known that each successive creation exhibited a greater degree of perfection in animal natures; thus proving a progressive state of things; which implies a commencement. And the whole history of the rock strata shows a corresponding improvement in the state of the globe, pointing us back to an original beginning. Further, had this philosopher been as well acquainted with the chemistry of nature as with her mathematics, he must have known, that an intensely heated globe could not have existed eternally in that state; and that as there must have been a period when it began, so there will be a period when it will cease to radiate heat; and, therefore, the fundamental principle of his theory should have taught him, that probably the world had a beginning, and will have an end. Indeed if I understand geology aright, so far from teaching the eternity of the world, it proves more directly than any other science can, that its revolutions and races of inhabitants had a commencement, and that it contains within itself the chemical energies, which need only to be set at liberty by the will of their Creator, to accomplish its destruction. Be-



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cause this science teaches that the revolutions of nature have occupied immense periods of time, it does not, therefore, teach that they form an eternal series. It only enlarges our conceptions of the Deity; and when men shall cease to regard geology with jealousy and narrow-minded prejudices, they will find that it opens fields of research and contemplation as wide and as grand as astronomy itself.

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### UNSTRATIFIED ROCKS.

I have already described several rocks, (ex. gr. limestone, serpentine, and one or two varieties of hornblende slate,) as sometimes stratified and sometimes unstratified. But the rocks which I include under the present division, are never stratified in the proper sense of that term. They are, indeed, sometimes divided into parallel masses; but in such cases this peculiar form seems to result from that kind of crystalline arrangement called the concretionary structure. The question so long agitated, whether these rocks, particularly granite, are stratified, seems at last to be satisfactorily settled in the negative. This character, therefore, may with propriety be employed to designate one of the great classes of rocks.

Unstratified rocks occupy but a small part of the surface of any country. In Great Britian Macculloch says they "do not cover a thousandth part of the superficies of the island." In Massachusetts however, as may be seen by the map, they form at least a quarter part of the surface.

These rocks occur in three modes: 1. In irregular protruding masses, intruded in almost every manner among the stratified rocks, and enlarging downwards indefinitely: 2. In the form of veins of various sizes, and often ramified: 3. As overlying masses. It has been stated, also, that they exist interstratified with other rocks: But an examination of all such cases has shown, that such interlaminated masses are always connected with an unstratified mass, and are merely veins, which for a time coincide in direction with the strata.

One cannot examine the unstratified rocks with attention, without perceiving that their mode of production must have been in some respects different from that of the stratified rocks. Not long since

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the general opinion was, that they originated from the crystalization of their ingredients dissolved in water. At this day the belief in their igneous origin has become nearly as universal. In regard to the trap rocks, indeed, this opinion is almost unanimous. Why there should be any more hesitation in assigning a similar origin to granite, I confess myself unable to imagine. I should almost as soon deny that the red rays of the spectrum proceed from the sun, after admitting that the six other colors were produced by that luminary. I am constrained thus early to express my conviction of the igneous origin of all the unstratified rocks: for I have found that opinion marvelously to simplify the history of these rocks; and to clear up may difficulties inexplicable on any other theory. To regard these rocks as they occur in the primary secondary and tertiary classes, as independent of one another, and of the same age of the formations in which they occur, and thus to describe them as primary, transition, secondary, &c. produces in this part of geology a perfect chaos. But to regard them all as merely varieties of the same melted mixture, whose peculiarities resulted from the modes in which they were cooled, and crystalized, and intruded among the stratified rocks, does certainly relieve the mind of a host of doubts and difficulties, and render the history of these varieties comparatively easy, whether the theory be true or false. On this supposition we are no longer surprised to find it impossible to draw any definite line between the different varieties, nor to find them all united in the same mountain mass.

It must not, however, be understood that this view of the subject implies that all the unstratified rocks are of the same age. For in this respect there is evidence of nearly as great diversity as exists among the stratified rocks. And their intrusion among the stratified rocks affords an important clue for determining their relative ages. It is obvious, however, that the intrusion of the former among the strata of the latter, only proves that the unstratified rock was formed posterior to the stratified one. And on this principle it has been shown, that granite has been protruded even since the deposition of the chalk: while basalt has cut through even the supercretaceous rocks; and finally, the products of existing volcanoes overspread diluvium and alluvium.

So well satisfied am I of the correctness of these views respecting the unstratified rocks, that I have been strongly tempted, according to the suggestion of Dr. Macculloch, to treat of all those that occur in Massachusetts as a single family; being convinced with him, that

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"geological philosophy must adopt this (proposal) sooner or later." But if that geologist shrink from taking the lead in such an innovation, well may I. The members of the unstratified class in Massachusetts are not numerous; and I have concluded to treat of them all under four divisions, viz. greenstone, porphyry, sienite, and granite.

There would be some advantages in treating of these rocks in an ascending, instead of a descending order: that is, in beginning with granite, taking sienite next, porphyry next, and greenstone last. For this is the order in which in general they seem to have been produced. But for the sake of uniformity, and to secure some other advantages, I shall invert this order.

A few words may be needful in this place, in respect to the manner in which these rocks are represented on the map. From the intricate manner in which the greenstone, sienite, and granite are mixed together, in the vicinity of Boston, I found it impossible to give them precisely their true relative space in the delineation. I therefore colored the whole space occupied by them all, as granite; and then, having observed that as a general fact the greenstone was first met with, on lines radiating from Boston, then porphyry and sienite, and lastly granite, I represented these several rocks as occupying spaces somewhat in the form of concentric bands. Wherever I observed these rocks intermingled, however, I have endeavored to represent their mixture by scattering dots and crosses somewhat promiscuously in the region. This method of course can give only an approximation to the truth. In the valley of the Connecticut, these rocks are scarcely ever so confusedly mixed together; and, therefore, it is only in the eastern and northeastern parts of the State that such a course has been adopted. The porphyry forms only two ranges, which are distinct; the one on the north, and the other to the south of Boston, except that a narrow strip of compact feldspar, — the base of porphyry, — is marked in the northern part of Essex county. Porphyry, however, passes by insensible gradations into sienite: but the change commonly takes place in a vertical and not in a horizontal direction.

### 15. GREENSTONE.

The most approved definition of this rock makes it to consist of hornblende with compact and common feldspar: some add clinkstone, also; but as this substance does not occur in this part of our country,

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it is of no importance in the present instance, whether it be added or not. A mixture of hornblende and feldspar, the former in much the largest proportion, and both of the minerals exhibiting but little of a crystalline structure, constitutes the great mass of the trap rocks of Massachusetts. Other varieties do, indeed, occur, composed of different ingredients: but as these are found in such small quantity, and are obviously accidental varieties, I have thought it most judicious to describe them all under the term greenstone. Such a liberty I have frequently taken in the case of the stratified rocks: and I think it still less objectionable in the case of the unstratified; because there is much more diversity of opinion among geologists as to the ingredients that compose the latter. These ingredients are often so little crystalline, as to be exceedingly obscure in their characters; and it is, therefore, no wonder that such diversity exists even in the statements of the ablest writers. Especially this is not surprising, when we recollect, that until recently, it was thought essential to a good description of these rocks, that the observer should be able to prove that they belonged either to the primitive, transition, or secondary class of the stratified rocks. It was bad enough to be obliged to stretch the stratified rocks upon this Procrustean bed, although here these artificial divisions had some appearance of naturalness: but in the unstratified rocks, no facts could be found on which to base such an arrangement; and, therefore, imagination must supply the necessary characters. The consequence was, that minute and ever varying mineralogical characters in the trap rocks were studied with scrupulous exactness; while their geological position and chemical and mechanical influence on other rocks, were scarcely noticed.

### *Mineralogical Characters.*

1. ***Hornblende and Feldspar:*** the mixture more or less granular. Commonly the ingredients are so fine that they are with some difficulty discerned by the naked eye. Hence it is not easy to determine always whether the feldspar is compact or foliated. Frequently I believe, however, that both varieties will be found, and that often in the same specimen. The crystalline structure of the hornblende is usually very indistinct. In the eastern part of the State, however, where this rock is associated with sienite, the two ingredients are often very distinct, and the texture crystalline. A variety occurs on Mount Holyoke and in West Springfield, in which the ingredients

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are very coarse, and the feldspar, which is foliated, is of so dark a color as with difficulty to be distinguished from the hornblende. (Nos. 1127, 1128.) The feldspar is arranged in stripes, like a ribbon, as in the sienite near Boston.

The compound that has now been described, constitutes the principal part of the greenstone dikes, ridges, and hummocks, in Massachusetts. (Nos. 1106 to 1135.) The same compound occurs also in other forms; as will be seen in the sequel.

2. *Columnar.* This differs from the preceding variety only in form: for its composition is almost uniformly the same. Nearly all the greenstone in the valley of the Connecticut exhibits more or less of a *conatus* at a columnar structure, except the tufaceous variety. Yet it is the finely granular variety, that exhibits the most perfect forms. A similar conatus appears in some of the beds of greenstone in the eastern part of the State, especially in Charlestown: but these columnar masses are so imperfect, compared with some of those in the Connecticut valley, that I shall limit my remarks entirely to the greenstone occurring in that valley: and as it is more convenient, I shall in this place give the topography of the variety under consideration.

Nearly all the ridges of greenstone in the valley of the Connecticut, (for a reason that will appear in the sequel,) present on their western sides, a nearly perpendicular face. Usually, however, the angular fragments that have fallen from these precipices, have accumulated at the bottom so as to form a steep talus, reaching half or two thirds the distance to the summit; and sometimes entirely to the top. Where the rock appears in the face of the cliff, it is almost always more or less columnar; sometimes as much as 30 or 40 feet in height. In some cases one set of columns is separated from another set, above or below, by a stratum or mass of trap tuff.

There are, however, only a few places where these columns are very perfect. Along the west side of the greenstone ridge that forms the eastern part of Deerfield mountain, in several places, about a mile east of the village, they exhibit great regularity. Usually their diameter here, — and the same remark will apply to every other locality, — is between two and three feet; rarely as small as one foot; and the number of their sides between four and six. They are sometimes distinctly articulated; the joints varying from one to three or four feet in height. The articulations are usually curved, at their ends presenting frequently a convexity on the upper side, and a concavity on

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the lower. The breadth of the sides is considerably unequal; and with this exception, perhaps, these columns might compare in regularity with those of basalt from Ireland.

I have already given a general description, in the second part of my Report, of an exhibition of greenstone columns towards the southern extremity of Holyoke, in the western face of the hill. At that place we see but little of articulation: but a most remarkable disintegration, or rather exfoliation, is there constantly going forward; as the immense number of fragments at the base of the cliff testifies. The pieces that split or scale off, are of almost every shape; but they are commonly rather thin, sometimes in curved laminae an inch or two thick. When the lower part of a column begins thus to scale off, the fissures take such a direction as to leave the under side of the column, still projecting from the precipice, in the form of a hemisphere, or more commonly in the form of paraboloid; and not unfrequently of a lenticular form. And in one spot at least, the upper portion of two or three rows of columns is suspended over the head of the observer, appearing like numerous iron kettles, not less than three feet in diameter, hanging from the rock. This is certainly one of the most singular natural objects that I have ever met with; nor can one feel at perfect ease beneath such a piazza, when he sees by how feeble a hold these masses of immense weight are sustained; and how instantly one of them falling would grind him to powder.

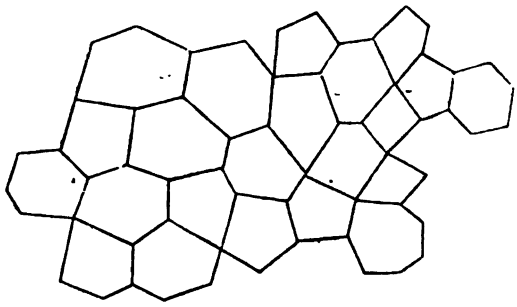
I have been at a loss to decide, whether the exfoliation which is exhibited at this spot, takes place according to an original structure of the rock, or is produced by the natural action of the disintegrating agents; such as air, moisture, heat, and cold, upon rocks of a peculiar form. I can hardly admit the latter supposition; when, on breaking the fragments, they are found, except for a mere line at the surface, to be so entirely unchanged. Yet this curved form of exfoliation is not the only one exhibited on this greenstone range. More frequently the columns split longitudinally, into somewhat irregular pieces, from one to six or more inches in diameter. All along the western side of Mount Tom, examples of this kind may be seen; and the quantity of fragments of this sort, accumulated at the base of this mountain, is immense. Sometimes these fragments are very regular in their forms; producing prisms of three, four, five, &c. sides, and three to six inches in diameter. (Nos. 1136, 1137, 1138.) Again, as at Titan's Pier, described in the second part of my Report,

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concave layers of the rock (No. 1139) cleave off from the upper extremity. A joint of this description will sometimes contain several quarts of water; and I have seen one of them standing by a farmer's well, which was used as a substitute for a wash-bowl! Upon the whole, I am of opinion that the form of these exfoliations depends upon original structure, which the disintegrating agents above mentioned reveal, but do not create.

I know of no spot where so good a view of the ends of these greenstone columns can be obtained, as at Titan's Pier above mentioned. They are exhibited to the best advantage on the west side of the ridge, where it passes under the river: and at low water, we can see the ends of the columns forming the bottom of the river, as far as the eye can reach. The following sketch represents above twenty of these columns, as they present themselves at low water, and close to the water, at the spot just mentioned. The sides were not measured except by the eye, and I am confident that there is quite as much, probably more regularity in the columns themselves, than in the drawing. The sides, it will be seen, vary from four to six. The upper ends of these columns are considerably convex: whereas only one rod farther from the water, as already mentioned, they are decidedly concave. And although it is possible that in the first case the form might have resulted from the action of the river, yet from all that I have seen, I much doubt whether the upper or lower end is uniformly convex or concave.

Both at Deerfield and at Holyoke, one sometimes meets with columns that are considerably curved. In general they are not perpendicular to the horizon, but lean from 10° to 30° towards the east. Hence they stand about perpendicular to the strata of sandstone beneath.



Ends of Greenstone Columns at Titan's Pier.

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The two varieties that have now been described, comprehend the greater part of the *grunstein* of Werner, the *diorite* of Hauy, and the *diabase* of Al. Brongniart. These writers, however, mention only compact feldspar as an ingredient: but Dr. Macculloch very properly adds common feldspar.

3. *Compact.* In this variety, which is almost entirely homogeneous and finely granular in its texture, the different ingredients cannot be distinguished. In some cases it is probably only indurated clay, or wacke, with some dark coloring matter: in other cases, it may be hornblende and feldspar, completely melted together. The aspect of the rock approaches closely to some varieties of basalt; but it is doubtful whether we have any trap rock in this part of America, which was produced at the same epoch, or is composed of precisely the same mixture, as the European basalt. The variety under consideration occurs generally in the form of veins; as at Nahant, &c. (Nos. 1140 to 1143.)

4. *Chiefly Greenish Compact Feldspar?* This is a beautiful rock; but its characters are very obscure. Perhaps it ought to be described under porphyry: but its great resemblance to the traps, has led me to place it here. It occurs in Essex county along with sienite, common greenstone, &c. (Nos. 1144 to 1147.)

5. *Indurated Clay.* This variety is of limited extent; occurring only at the junction of greenstone and shale; as at Titan's Pier. In aspect it approaches to hornstone; being of a light gray color. In the same mass with this rock, we usually find angular pieces of compact trap: so that in fact, it might have been described under *trap tufa.* (Nos. 1148 to 1150.)

6. *Hornblende, Augite? and Feldspar.* The hornblende in this compound is in crystalline fragments; and the mineral which I suspect to be augite, is of a greenish aspect, but scarcely crystalline. The feldspar is sometimes foliated and in small quantity. It occurs only at Nahant, a little distance northwest of the Hotel: and the most remarkable circumstance in relation to it, is its apparent regular stratification. This is the only instance that I know of in Massachusetts where a trap rock exhibits those parallel divisions. I do not, however, regard them as real strata, for reasons that will be hereafter mentioned. (No. 1152 to 1155.)

I should not have noticed the above as a distinct variety, had not its peculiar aspect excited the suspicion that it might be a *dolerite* of the geologists of continental Europe. I do not feel satisfied what is



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its real composition: and I have even had a suspicion whether it may not be the *hypersthene rock* of Macculloch.

7. *Porphyritic.* There is considerable diversity in the composition of the rocks included under this term. Their characters and situation deserve a particular notice, since they are frequently useful for ornamental purposes. (1156 to 1164.)

On Cape Ann a variety occurs, which resembles the black porphyry of the ancients, and appears to be the *trap porphyry* of Werner, and the *melaphyre* of Al. Brongniart. I should describe it as having a base of common greenstone, with large imbedded crystals of greenish foliated feldspar. Sometimes these crystals are more than an inch in diameter. It occurs at Sandy Bay, near the village, in veins in sienite. A similar rock is found in veins at Marblehead, according to the Messrs. Danas; also in rolled masses in Dorchester, Brookline, and Roxbury. I have noticed the same rock in rolled pieces in Easton, except that the feldspathic crystals are white. (Nos. 1156, 1157.)

In Ipswich, west part, I found a rolled mass which appears to be a greenstone with numerous foliated masses of a shining black color, which I at first suspected to be feldspar: but I am satisfied that they are *Karinthin.* (No. 1159.)

A considerable part of the eastern or upper side of the greenstone in the Connecticut valley, is very different in its composition from the principal part of the ridges. The basis of the rock is wacke-like; and some of it is amygdaloidal, and some of it porphyritic. The foliated masses of feldspar, however, are so small and so numerous, that I doubt whether it might not with quite as much propriety be reckoned as common trap. I doubt whether it contains any hornblende. Its general color is gray. (Nos. 1163, 1164.)

Occasionally we meet among the greenstone of that part of the State, with other varieties that are more or less porphyritic. No. 1161, from Deerfield has a compact homogenous base, nearly of the color of brick, with a few small imbedded crystals of feldspar. It is found in the same mass with common greenstone; but seems to have been exposed to a higher degree of heat. No. 1160, from Turner's Falls, has a variegated base, whose, nature is not obvious, with crystals of feldspar.

8. *Amygdaloidal.* This structure, like the porphyritic, is found in nearly all the varieties of greenstone that have been described. The following are the most common of our amygdaloids. (Nos. 1166 to 1175.)

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With a base of hornblende and feldspar: the first variety of greenstone above described. I have never seen any of this amygdaloid very regularly columnar: still it very frequently exhibits a columnar tendency. And it is a curious fact that the cavities often run lengthwise of the column, and are parallel to one another; so that the rock resembles a block of wood, which worms have bored through repeatedly in a logitudinal direction. I have observed some of these cavities a foot or two in length. (No. 1166.) On account of the compactness of this rock, these cavities are usually filled with foreign substances, such as calcareous spar, chalcedony, quartz, chabasie, Lincolnite, &c. The best spot that I know of for obtaining specimens of this rock, is one mile directly east of the academy in Deerfield.

In the same ledge, as well as in other ledges, the amygdaloid abounds in spherical or spheroidal cavities, filled with quartz or calcareous spar.

What particular causes produced these different forms in the cavities, it may not in the present state of knowledge be possible satisfactorily to ascertain. That they were all produced by an elastic fluid, while yet the rock was in a plastic state, seems now generally admitted. Must not the different forms which they have assumed, be imputed to inequality of pressure? And yet the air vescicles in a mass of ice exhibit the same variety of shapes, some of them being cylindrical, some spheroidal, and some spherical: nor can we in this case impute their form to inequality of pressure. But whatever the cause be, as in both instances the effect results from refrigeration, may it not be the same?

The most usual amygdaloid in the Connecticut valley has a base which appears to be wacke. It occupies, as already remarked, the easterly part of the ridges wherever I have examined them. For the most part, it is liable to partial decomposition to a considerable depth from the surface, and the imbedded minerals have entirely disappeared. When they still remain, calcareous spar is the most common. Not unfrequently, however, foliated chlorite occupies most of the cavities; and sometimes, as at Turner's Falls, they are filled with chlorophoeite. Green earth, or earthy chlorite, is still more frequently present. Sometimes the base is of a reddish hue; but commonly of an earthy gray. In such cases the rock exceedingly resembles a toad in appearance, and is probably similar to, if not identical with the toadstone of some of the English geologists. When the cavities are

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empty, the rock can hardly be distinguished from some recent lavas. (Nos. 1170 to 1174.)

All these varieties with a wacke-like base, exhale a strong argillaceous odour when breathed upon.

The greenstone in the eastern part of the State is rarely amygdaloidal.

9. *Concreted.* The argillaceous substance above described, as forming the base of certain amygdaloids, sometimes contains numerous distinct concretions of the same substance, apparently more indurated. They are generally spheroidal; and the concentric crusts not more than a line in thickness. Sometimes I have observed the central nucleus to consist of a rounded mass of amygdaloid enveloped by coats of indurated clay or wacke. The diameter of these concretions is sometimes six or eight inches: but usually not more than two or three. They sometimes occur imbedded in the next variety to be described. Their most abundant localities, which I have noticed in Massachusetts, is in Deerfield, east of the village, and on Mount Holyoke, near the road from Amherst to Granby. (Nos. 1176, 1177.)

10. *Tufaceous.* This embraces all those rocks that are composed of fragments of any of the varieties of greenstone that have been described; whether these fragments are angular or rounded; united by "trap sand," or the same materials in a comminuted state. Sometimes, however, the rock consists of angular fragments of greenstone, cemented by calcareous spar. In this case it is obvious that the spar was introduced by watery infiltration, after the fragments had been piled together. In other cases, it is equally obvious that the fragments have been melted together: for we distinguish the different materials of which they consist, only by the different colors; it being no easier to separate the rock along the line where the fragments unite, than in any other direction: and I do not suppose it possible to unite fragments so firmly except by fusion. (Nos. 1178 to 1186.)

### *Topography of the Greenstone.*

The parts of the State in which greenstone occurs in sufficient quantity to be noticed on a map, are only two. In the eastern and northeastern part of the State, it will be seen that there are extensive ranges. As we pass beyond the gray wacke and argillaceous slate that encircle Boston on the north, west, and south, we usually find greenstone to be the predominant rock. Even on the south, in Milton, &c. where porphyry is represented on the map as succeeding to

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the gray wacke and clay slate, we usually meet with narrow masses of greenstone, probably in some cases interposed among the layers of slate. On the north of Boston, in the slate of Charlestown particularly, such masses or beds of greenstone are common; and some of them so large that I have noted two of them on the map. In this slate also, as well as in the gray wacke in other places, (as at Roxbury,) the greenstone is found in veins. At Nahant they are sometimes forty feet thick, in argillaceous slate and sienite.

If we proceed from Boston, after striking the deposit of greenstone above named, we shall soon find that it is passing into sienite, and mixed with sienite in almost every conceivable mode. In one place the greenstone seems to form a distinct vein in the sienite, the two rocks being well defined at their line of junction. In another place, the sienite seems to form veins in the greenstone; although in such cases it is no easy matter to determine which rock should have the posteriority: But from the general fact, which I think obvious in this region, that the greenstone has been produced subsequently to the sienite, I think we should be cautious in reversing this order without good evidence. In some cases, however, we meet with a reddish sienite containing numerous and sometimes large angular and rounded fragments of greenstone. I give a rough sketch below, of one of these cases, which I observed in Marblehead, a little west of the town. In this case the base of the rock is rather a red granite than sienite, being entirely destitute of hornblende.



Granite and Greenstone: Marblehead.

Instances similar to this are to be seen every where in the region under consideration. And they certainly appear as if the greenstone had been partially melted down in the granite; though the heat was

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not great enough to complete the fusion. Or rather, may it not be probable, that the perfect fusion of the rock out of which these unstratified ones were produced, gave rise to the granite; while those portions that were not so entirely fused as to admit of entirely new and perfect combinations and crystalizations, might have formed those portions of the rock which I call greenstone, although some of it might as well perhaps be denominated sienite. I am aware that it is not yet well ascertained, how the same materials should at one time have produced granite, at another sienite, at another porphyry, and at another greenstone. But some other facts which I have noticed on this subject, and which will be detailed in speaking of granite, render it somewhat probable that the more or less perfect fusion of the materials may have been the principal cause. According to this hypothesis, we might explain how it happens that greenstone and sienite for the most part, were produced since the formation of granite. For geology furnishes abundant evidence that the temperature of the interior of the earth has been gradually sinking, since the commencement of these processes. And then again, the later any rock was erupted the less chance it has had for undergoing a second fusion, which, it may be, is all that is necessary to convert it into some older variety of rock. However, I will not dwell upon a suggestion that is so very hypothetical.

As we proceed farther from Boston, the sienite increases and the greenstone decreases in quantity, and we begin to find granite destitute of hornblende, which at length often becomes extremely coarse; as in Billerica, Andover, &c. The greenstone, however, occasionally appears associated with the perfect granite, as with the sienite; though I do not recollect any instance where the passage from the greenstone to the granite is gradual, as is the case between greenstone and sienite. Generally the greenstone forms veins in the granite. I have sometimes traced them not more than a foot or two wide for several rods, (as in Weymouth,) retaining their direction and width with almost mathematical exactness.

In the manner that has now been described, is the greenstone of the eastern part of the State intermingled with its unstratified associates, as the youngest member of the group. To mark out the precise limits of this rock in that section, would require immense labor, both on account of the great quantity of diluvium that overlies the rocks, and the difficulty of drawing the line in all cases between greenstone and sienite. Nor, if it be correct that all these unstratified rocks

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are mere varieties of the same family, would such a demarcation be of any great use? although I could wish to see it done; since in that way many facts might be brought to light, important to geology.

Rarely does the greenstone under consideration form ridges or elevations of any considerable height. In Weston, Waltham, Lincoln, Lexington, and West Cambridge, this formation attains its greatest elevation; which is never as much as 500 feet above the ocean.

The greater part of the greenstone under consideration is exceedingly hard and compact, and the ingredients are with difficulty distinguished. When passing to sienite, however, they become coarse and highly crystalline. Very frequently the rock has a greenish aspect, from a quantity of epidote which is disseminated in it, or forms narrow veins, or a coating upon the surface. It is not common, except where it is associated with the graywacke, to see it exhibit that brown dirty aspect so common in the trap rocks of posterior date.

Occasionally we find examples of a slaty structure in this greenstone. And it must be regarded as really a slaty structure, not the result of a concretionary deposition.* For the slate generally appears to be genuine hornblende slate, sometimes rather less crystalline, however, than that rock generally is. I recollect at this moment but three places where this slaty greenstone was observed: viz. in Lincoln, on the turnpike between Andover and Boston, in Stoneham, and near the line between Reading and Wilmington. In a theoretical point of view this fact seems to me important; and I shall recur to it in the sequel.

Variety No. 4, that has been described above, is found in connection with sienite, a mile or two north of Byfield Academy. Near the academy we find red compact feldspar: but I do not know that this is at all connected with the greenstone. On the north side of Merrimack river, in Salisbury, opposite Newburyport, this same variety of rock occurs in juxtaposition with sienite. Its aspect not a little resembles the varioloid wacke in Saugus; and I am not without strong suspicions that it may be the same rock highly indurated. And it strengthens this suspicion to find that sometimes in Newbury it exhibits a varioloid structure.

The map exhibits the most northerly of the greenstone ranges in the Connecticut valley with which I am acquainted; though in Ver-

* Dr. Macculloch, however, regards the slaty structure as a variety of the concretionary.

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mont and New Hampshire in this valley, greenstone occurs in connection with argillaceous and mica slate: but probably this is a variety of hornblende slate. The greenstone which I am now describing, is associated with the new red sandstone: and ridges of it may be seen extending almost uninterruptedly from New Haven, Ct. to the north line of Massachusetts. The principal ridge commences with West Rock, at New Haven, and extends from thence, almost in a right line, to Mount Tom in Massachusetts. In Connecticut several other ridges and hummocks of this rock exist to the east of this principal one; as may be seen on a geological map of the Connecticut valley, which I prepared for the 6th volume of the American Journal of Science.

The principal greenstone ridge above noticed, crosses the Connecticut river between Holyoke and Tom, and curving towards the east, terminates in the north-west part of Belchertown. At the southern extremity of Mount Toby, however, we meet with another much more diminutive ridge, or dike of this rock, which almost coincides in direction with the meridian through Sunderland, and crossing Connecticut river near the north line of that town, rises in Deerfield to a much greater altitude, forming the eastern half of that range of hills which occupies the eastern part of that town and Greenfield. In Deerfield the eastern side of the greenstone is very gentle in its slope, and precipitous on its west side. But in Greenfield, although the western side continues to present a mural face, its eastern side also is very steep; being washed by the waters of the Connecticut. This ridge terminates at Turner's Falls in Greenfield. Another parallel ridge commences at the same place, only a few rods distant but on the opposite side of a small river, (Fall river,) in Gill, and extends more than a mile towards the center of that town. Beyond the extremity of this ridge, I have not found any greenstone except that which I have described as a member of the hornblende slate formation. A deposit of this, as may be seen by the map, commences, in the north part of Gill, only three or four miles north of the point where the greenstone already described terminates.

The external aspect of the greenstone in the Connecticut valley, is very different from that of the same rock in the eastern part of the State. Much of the latter is of a dark color, or when examined nearer, of a green aspect, from the presence of epidote. But the former almost universally exhibits a gray or iron rust color, either from incipient decomposition, or from the presence of oxide of iron.

The most common variety of the greenstone in the Connecticut

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valley is a fine grained mixture of hornblende and feldspar. This is sometimes columnar, as already described. Not unfrequently too, it is amygdaloidal; though the more perfect this structure, the less perfect the columnar. Trap tuff is also much more frequent than I formerly supposed. Sometimes we find a mass of it overlaying a mass of columns; and sometimes it forms an irregular layer between the ends of successive stories of columns. A mile east of the village in Greenfield, a variety of tuff constitutes a large part of a ledge of greenstone, which in some places is more than a hundred feet high. I have observed this rock on the west side of Mount Tom, also on Holyoke, and in various other places. It must be carefully distinguished from the *trap conglomerate*, that has been already described as a member of the new red sandstone formation, lying upon the eastern side of Mount Holyoke and Tom. The real trap tuff contains no fragments of sandstone; whereas in the trap conglomerate, the sandstone usually forms the cement. But the two rocks obviously pass into each other.

The boldness and wildness of the scenery in the Connecticut valley result principally from the greenstone ridges that have been described. The summits of these are often very irregular, owing to the peculiarity of the mode in which they were produced, or to subsequent abrasion by water.

In those portions of the State that are composed of gneiss, particularly in Worcester county, we frequently meet with bowlders of a rock that appears when broken, exceedingly like the unstratified greenstone that has been described. It is, however, more decidedly crystalline in its structure; yet I am inclined to believe that it ought to be regarded as unstratified greenstone: certainly in Amherst, where is a bed of considerable extent. The erratic blocks are often two or even three feet in diameter; and in the bed is no appearance of stratification. In two instances, (in Rutland and near the mouth of Miller's river, in Montague,) I have met with genuine veins of greenstone in gneiss; in neither case, however, of much width; in the latter about two feet.

*Situation of our Greenstone in relation to other Rocks.*

This subject has been necessarily somewhat anticipated. But a more particular statement of facts concerning it seems desirable.

It has already been stated that our unstratified rocks occur in three



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modes: first, as protruding irregular masses; secondly, as overlying masses; and thirdly, as veins. The first and last modes are most common.

Since most of the greenstone in the eastern part of the state is not connected with stratified rocks, it must be referred to the first of these modes; except in those comparatively few instances, where it forms veins in the other unstratified rocks. I have never been able to find a satisfactory example, in which the greenstone distinctly overlies either porphyry, sienite, or granite;* although in numerous instances I have found a gradual passage from this rock into the two latter: But this is as likely to take place laterally as in a vertical direction. Examples of this gradual transition between these rocks are common south of the Blue Hills, as in Randolph, Stoughton, &c.

Wherever I have seen this rock associated with the graywacke and argillaceous slate in the eastern part of the state, it either occupies veins, or protrudes itself in some other form, among, or between, the strata. Professor Webster, however, says, that it is sometimes superincumbent upon the clay slate in Charlestown.† It has there also the appearance of being regularly interstatified with the slate: But I am satisfied that this is a deception; that is to say, these supposed beds are connected with some unstratified masses. Yet I think it extremely probable that some of the greenstone in the vicinity of Boston has resulted from the fusion of clay slate; and perhaps it is possible that a particular portion of the slate might be converted into greenstone, while that around it might remain but little changed; and in such a case, the altered rock might at the surface appear interstratified with the other. In such a case, however, we should rather expect that the slate would be converted into hornblende slate: and Professor Webster says that some of the clay slate in Charlestown does pass into hornblende slate: and I would remark that much of the greenstone in the vicinity of Boston resembles exceedingly that variety which is associated with hornblende slate: indeed, as already stated, some of it is associated with hornblende slate. But for the most part it appears to have been subject to so entire a fusion that the schistose and stratified structure is lost; and hence it seems most proper to describe it as unstratified greenstone: although if it be true that all green-

* Professor Webster says that it overlies compact feldspar in Charlestown. Boston Journal of Philosophy, vol. 1. p. 282.

† Bost. Journal Philosophy, vol. 1. p. 285.

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stone results from the same source as hornblende slate, it may be difficult in some cases to distinguish between them.

Professor Webster, in his excellent account of the geology of the region around Boston, states that the veins of greenstone in the graywacke conglomerate of that vicinity, run about 10° W. of South, and 10° E of North. All such veins are probably of nearly cotemporary origin: their parallelism being explicable only on the supposition of their having been produced by the same cause.

The promontory of Nahant presents an interesting exhibition of greenstone veins, both in the argillaceous slate and the sienite. I have, however, described these veins so fully under graywacke, that a few more facts only need be added. Only a small remnant of the slate remains upon this promontory: and this is intersected by so many and so large veins, that nearly one half of the surface is greenstone. And yet the layers of the slate appear to have been but little thrown out of their original position: for their dip and direction correspond essentially with those of the same rock in other places. In such cases it seems to me impossible that the slate should have been solid at the time the greenstone was intruded among it, unless we suppose it to have been cut through with numerous fissures: an occurrence which in the present case is hardly probable; since some of the veins are ten feet thick, and quite numerous; and I cannot conceive how mere dessication should have produced such fissures. But I can conceive how melted matter may have been forced through unconsolidated clay, without disturbing it laterally but a short distance: and perhaps this was the mode in which the veins at Nahant were introduced. If so, it is probable that the consolidation of the slate, and even its conversion into flinty slate, might have resulted from this intrusion.

There is one fact, however, that rather militates against such a supposition. We find there two sets of veins; one of which intersects the other; and penetrates the adjoining slate. We here trace distinctly three epochs of formation for the slate and greenstone. First the slate, secondly the veins that intersect it, and are themselves intersectified by other veins: thirdly, those veins that cross both the first named veins and the slate. As to the intervals between the production of these three varieties of rock, we can scarcely form a conjecture. The slate having been deposited originally from water, must have required a period of considerable length, previous to its consolidation: But the two sets of veins might have been introduced almost simultaneous-

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ly: since this might have resulted from two paroxysmal efforts of the same eruptive force.

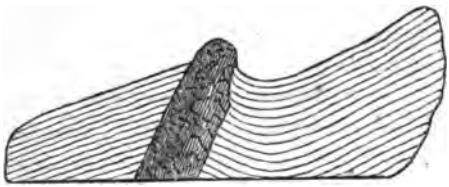
The greenstone occupying these veins at Nahant, varies in texture from the finest siliceous slate, to coarse sienite. The veins sometimes run parallel to the strata, and would be regarded by some geologists as regularly interstratified with the slate. And they would be confirmed in this opinion by the apparently distinct stratification of one of the varieties of the greenstone on this promontory, particularly at a place about fifty rods northwest of the large hotel. The rock here is coarse and appears to be passing into sienite: It is divided into parallel portions by seams a few inches apart; and looking only to this spot, I do not see why the evidence of stratification is not almost complete. But if, as an almost universal fact, greenstone, sienite, and granite, are certainly not stratified, it is a presumptive evidence that they never are so: Apparent exceptions it is reasonable to explain on other principles. And in the present case there is a principle that may afford a solution of such a case as that mentioned above. I refer to the formation of concretions in the unstratified rocks. That they are frequently formed in all the varieties of these rocks, the records of geology will testify. Usually, however, they are only a few feet, or a few inches in diameter. But what reason can be adduced why they may not be produced of mountainous bulk? Their origin is, indeed, obscure: but probably their formation depends upon some modification of the laws of crystalization. And if so, who can tell through how large a mass of matter these laws may operate. In an example of apparent stratification in our granite, which I shall shortly describe, we have an opportunity of ascertaining that the layers are of a spheroidal form, although they cover a mountain of no inconsiderable size. And in all cases which I have met with, it is only a part of the rock that is apparently stratified. This is the case at Nahant. There must then have been a peculiarity in the cause that could thus have affected one portion of the formation and not another. In some instances I have explained a partial and non-continuous stratification in rocks, (ex. gr. limestone and hornblende slate,) by supposing one part entirely, and the other only partially melted. But in the rocks under consideration, the division of the pseudo-strata is too distinct to admit such an explanation: while the schistose structure is always wanting. Upon the whole, it seems to me that in the present state of our knowledge, sound philosophy requires that apparent stratification in rocks

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usually unstratified, should be regarded only as examples of a conextionary structure.

The geologist who may have occasion to spend several days at Nahant, will do well to give the spot a very thorough examination. I do not flatter myself that I have brought to light all the interesting facts which may be there developed; although I have exhibited enough to show it to be an interesting spot.

The protrusion of the unstratified rocks through the stratified ones by internal igneous agency, now admitted by most geologists, has led observers to examine carefully for evidences of mechanical disturbance near the line of contact. They have, I believe, found less proof of such disturbance by the intrusion of greenstone, than in the case of the older rocks, as sienite and granite. Every such case, therefore, deserves to be noticed. If I mistake not, the following sketch of a vein of greenstone in argillaceous, slate is an example of this sort. The dyke is about 10 feet thick, and the general dip of the layers of slate in the quarry, is about 30° southeast. But as shown in the figure, near the greenstone it is considerably curved upwards in the contrary direction. The quarry, where this example occurs, is about half a mile north of the Powder House in Charlestown.



Greenstone Dyke in Clay Slate: Charlestown.

For the most part, the greenstone in the valley of the Connecticut, is interposed in thick masses or beds, between the strata of sandstone. In Massachusetts I have never met with a mass of this rock which I have regarded, strictly speaking, as superincumbent: though in Connecticut, such examples are said frequently to occur. And I am apprehensive that not a few geologists would describe Holyoke and Tom as instances of overlying rocks. For on examining their western precipitous faces, we frequently find the sandstone cropping out beneath the greenstone: and if we go to the other side of these ridges, it is rare that we find the sandstone lying upon the greenstone. Yet this is sometimes the case; and the sandstone always appears

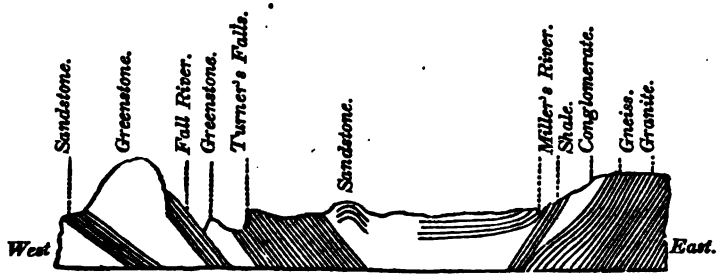
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at no great distance in the valley, having such a dip as would cause it to rise above the greenstone. I hence infer, that originally, nearly all the greenstone was interposed between the strata of sandstone; and that subsequent abrasion has removed the latter rock. Even in those cases where we find insulated masses of the trap lying upon the sandstone, there is reason for supposing that it is the wreck of one of these interposed masses; disintegration and abrasion having effected the destruction of the other portions of both the rocks.

At Turner's Falls, Connecticut river has disclosed, between Montague and Gill, an interesting section across the sandstone and greenstone, not less than three miles long. In the 6th Vol. of the Am. Journal of Science, I inserted a very detailed view of this section: but having examined it recently with more care, I shall give a corrected sketch; which, though less particular, will I trust be found more accurate and instructive. It commences on the western side of the greenstone ridge against which Connecticut river impinges, a little below Turner's Falls, and by which its course is changed from northwest to south. At the western base of this ridge, the sandstone crops out beneath the greenstone, dipping perhaps 20° or 25° east. After passing easterly over this ridge, we find at the mouth of Fall River, another variety of the sandstone, mounting upon the greenstone at an angle of about 45°; that is, dipping easterly by that quantity, and running nearly north and south. Proceeding in the same direction, the sandstone continues only a few rods, perhaps 15, when we find it on the north shore of Connecticut river passing under another ridge of greenstone, 15 or 20 rods thick. On the east side of this second ridge, we find a similar variety of slaty sandstone dipping about 50° east. Several varieties of sandstone, some red, some gray, some fined grained, and some coarse grained, appear, as we pass along the same shore, with a dip between 40° and 50° east, for more than a mile. There we strike a somewhat more elevated ridge, which appears on both banks of the river, consisting of a brecciated indurated sandstone, described among the varieties of new red sandstone, whose strata are somewhat saddle shaped on the north shore, though quite indistinct. Beyond this point the shores for some distance are less bold, and no rock is visible for half a mile. When it again appears, the direction of the strata becomes nearly east and west, and the dip from 30° to 40° south. Hence only the horizontal edges of the strata can be shown on the section. But when we come within 100 rods of the mouth of Miller's river, the sandstone slate or

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shale is suddenly bent upwards several degrees on its eastern edge, so as to dip westerly. On the southern bank the very spot where the flexure takes place is visible. Advancing towards the mouth of Miller's river, the westerly dip rapidly increases, and within a few rods it approaches 90°. Then for a considerable distance succeeds a coarse conglomerate, in which I could preceive no marks of stratification. For a few rods beyond this rock, diluvium hides the rock in place, and then, before reaching the mouth of Miller's river, we strike a formation of gneiss, hornblende slate, and mica slate, with granite-gneiss and granite, which constitute the western margin of the gneiss range of Worcester county. The strata of these rocks, at the mouth of Miller's river, and on the east bank of Connecticut river, (for we have now reached the spot where this river runs southerly,) run a little west of south and east of north, and dip to the west between 30° and 40°.




Section between Montague and Gill.

It will be perceived that the above section is intended to embrace every thing important on both banks of Connecticut river, and is not meant to be geometrically accurate. Those parts which are the most interesting occupy more than their proper proportion of the distance; but this produces no geological error. The part of the section most likely to produce an erroneous impression, is where the sandstone strata are represented by horizontal lines: for these strata, as already stated, do in fact dip 30° to 40° south. This change in the direction of the strata appears to result from the fact, that the greenstone ridges, towards the western extremity of the section, with the accompanying sandstone, take a northeasterly direction for two or three miles, rising into considerable hills, and forming an axis of elevation, to which the strata just referred to are in a measure conformable.

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Not improbably also, the elevating force, which has acted on the side of the gneiss and granite, may have operated in wheeling these central strata still farther, so as to bring their direction nearly east and west.

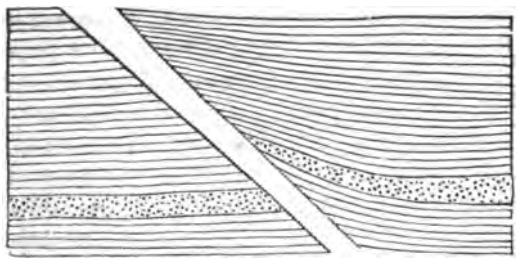
In another place I shall refer to the important bearing which this section has upon the the theory of the origin of our greenstone: but in this place I wish to show more particularly the relative situation of the greenstone and sandstone. It will be seen that the former occurs in somewhat wedge-shaped masses, between the strata of the latter, and I believe that the above section represents the mode in which nearly all the greenstone in the Connecticut valley occurs. On the western slope of Mount Toby, in Sunderland, we find a narrow strip of the greenstone interposed between the sandstone strata; although I cannot say that it is wedge-shaped; the opportunities for ascertaining, the dip being very poor. Along the western and northwestern face of Mount Holyoke, however, we meet with the sandstone in several places, (although not very easy to find,) passing under the greenstone with a dip of 15° or 20°. On the opposite side of the mountain the strata are sometimes found elevated 50° and even 60°; as may be seen where the stage road from Northampton to Belchertown crosses the greenstone ridge; and as we recede from this ridge, towards the east, or southeast, the dip diminishes. In the west face of Mount Tom, we find the sandstone passing under the greenstone at a dip from 15° to 20°: but on the east side of the mountain, it is no greater; and, therefore, I cannot say that this eminence has a wedge-shaped form. South of Tom the sandstone both on the east and west sides of the greenstone ridge, has a less dip then in the cases above mentioned. Still, however, the greenstone seems to form a mass interposed between its strata.

Are we to regard the long ridge of greenstone extending from New Haven to Belchertown, as a vast dyke, or as a bed, or simply as a protruding irregular mass? Its great length, (though not greater than the celebrated Cleaveland dyke in England,) and especially its great width in some places, will hardly permit us to call it a dyke, as geologists usually employ that term. A still stronger objection in the minds of many, would be its general conformity in direction to the strata of sandstone. But near its northern extremity, it is obvious that this conformity is in a good measure lost. For Holyoke, running nearly east and west, evidently crosses the strata in some degree: or rather, these same strata which farther south have their western edges elevated by the greenstone, on the southern

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side of Holyoke, have their northwestern edges raised: although, as the mountain makes a gradual curve to the right, the strata appear to be conformed to its sides. Upon the whole, however, while we must admit, it seems to me, that this extensive range was originally protruded through the strata of sandstone in the same manner as dykes are, yet it may be better to regard it as a protruding ridge, rather than apply a term to it which has not usually been so extended in its meaning.

Genuine and distinct veins of greenstone in the new red sandstone of the Connecticut valley, are not common. In Massachusetts I have not met with one: but in Connecticut, they are more common. The following is a sketch of a case of this kind, which I took several years ago, in a ledge a little east of East Rock, near New Haven, on the turnpike road from thence to Middletown. Most of the ledge is a red rather coarse sandstone, from 20 to 30 feet high. The lowest stratum is a fine grained red sandstone; the next above it, a coarse gray sandstone, about six inches thick. The rock dips from the observer about 25°; so that it must be represented as horizontal on the section. The vein of greenstone is about a foot wide at the bottom, and something more as it ascends. It appears to consist of indurated clay. It ascends through the sandstone at an angle of about 45° with the horizon, and on the upper side of it the different layers of sandstone are elevated, so as not to correspond with the same layers on the opposite side of the vein. This upward flexure extends several inches from the vein. The coarse gray stratum above mentioned, exhibits this effect most obviously.



Greenstone Dyke in New Red Sandstone: East Haven Ct.

The inferences of a theoretical nature from such a case as the above, if there is no mistake in my representation of it, are too obvious to escape the notice of any one. If we have not proof here of



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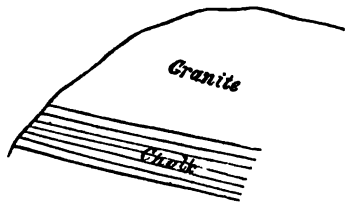
an internal force erupting the matter of the vein, I know not how such proof could be given. But more of this in another place. I thought the case too interesting not to be noticed, although out of Massachusetts; and I shall take the liberty in several other instances, as I have already done in some cases, to introduce examples from other parts of New England, illustrative of important geological principles. In respect to the veins of the unstratified rocks, especially, I shall give the results of my observations for the last twelve or fifteen years in various parts of New England, since the subject is one of special interest.*

* To show how the examples which I shall adduce are regarded by a distinguished geologist in Europe, I take the liberty to subjoin a translation of a letter which I received, two or three years ago, from Counsellor Von Leonhard, Professor of Mineralogy in the university of Heidelberg, Germany, in answer to a communication which I had previously made to him at his request, detailing several of the most striking cases of veins and protruding masses, which are embodied in this Report. I give the letter entire, since several of the examples given by this veteran *savant*, although to be met with in a few works, are yet not commonly to be found.

"Heidelberg, December 14, 1829.

"Sir, Your letter of the 20th October, with which you have favored me, I have duly received. A thousand thanks for the trouble you have taken to enlighten me with so many interesting facts concerning the granitic eruptions of your country. Your observations are of the highest importance, and it is very much to be desired that you should publish them forthwith.* You have requested that I should give some account of the elevation of granite in this country as well as in England and France.

"One of the most interesting observations that have been made on this subject, is that of Weiss, near Meissen in Saxony. Granite, or rather sienite, there appears superimposed upon the *planerkalk* which belongs to the chalk formation.




A hundred paces from my house is a protrusion of granite. The predominant

* In a subsequent letter I requested Prof. Leonhard to make such a use of these facts as he thought proper; and not unlikely some of the cases which I shall produce, have ere this been published in Germany.

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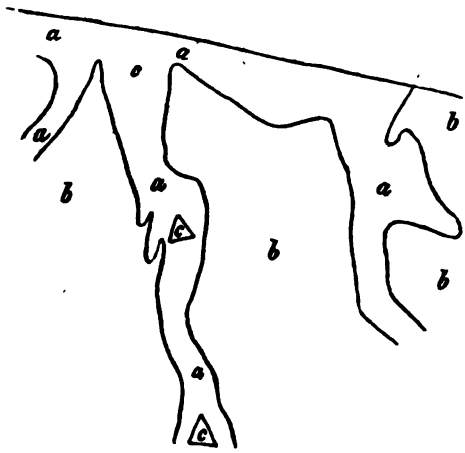
On the northeast side of mount Tom, on the bank of a small stream and close by a saw mill, which is only a few rods from the stage road

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rock in the vicinity is the variegated sandstone. In one place we see the strata of sandstone bent upwards and the granite beneath.




"You are doubtless acquainted with the important observations of J. Hall, in Galloway in Scotland. Veins of granite, *a a*, &c. have penetrated the transition argillaceous schist, *b b*, &c. enveloping also the fragments, *c c c*, of the same, and overspreading the schist in part. The schist has suffered numerous disturbances from the influence of the granite and is changed at the place of contact by the volcanic heat.




"You speak of your greenstone. Is it *diorite* or *dolerite?* From your description I suspect it to be diorite,* that is, a greenstone into whose composition amphibole enters, and not pyroxene.

In the Hartz facts occur similar to those which you have observed. I shall be much obliged to you when you send another box of minerals for exchange to the *Comptoir*, to put in some specimens of greenstone, that I may institute a comparison. In the Hartz we see that the *diorite* assumes an amygdaloidal texture, be-

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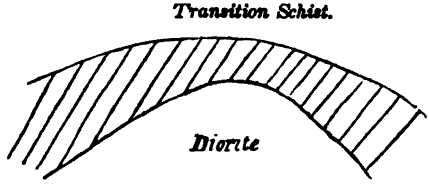
* After what I have written on this rock, it is hardly necessary to say that this conclusion is correct.

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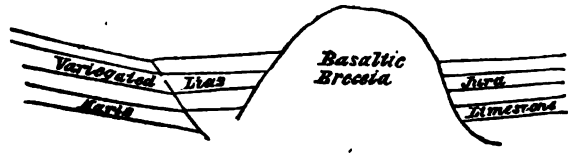
from Northampton to Hartford, the following case occurs in the new red sandstone. A deposit of greenstone, the remains of a large vein or protruding mass, is here seen to lie in an oblique direction upon the elevated edges of the sandstone. Towards the upper part of the section, the layers of sandstone are curved considerably upwards, so as to increase the dip of their upper extremity, raising it, indeed, almost

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coming cellular near its point of contact with the schist. Does any such phenomenon occur with you?*




"Since I had the honor of writing to you, I have continued without intermission to collect facts for my work on the Basalts. But it will be a long time before I can bring it to a conclusion. In 1828 I visited Auvergne. This without contradiction is classic ground as to this matter. You are doubtless acquainted with the work of Scrope, (*Central France.*) But I have ascertained some new and quite interesting facts. Among others the projecting mass of basaltic conglomerate which rises through the beds of lacustrine limestone, (it bears the name of *Puy de la Piquette,*) embraces fragments of that limestone full of many fine crystals of mesotype and apophyllite. — Last summer I visited the Suabian Alps. In these mountains we find a number of important facts. We count there at least thirty eruptions or elevations of basaltic breccias through the beds of Jura limestone; and these conglomerates contain a number of small fragments of limestone, which have been variously modified by the heat of the conglomerates.




"Finally, I pray you to preserve in full, an account of the phenomena of basalt, diorite, and amygdaloid, as well as of the conglomerates which accompany them; and I would request you to send me these details.

* * * * * *

"I have the honor to salute you with the greatest respect:

"Yours with devotion,

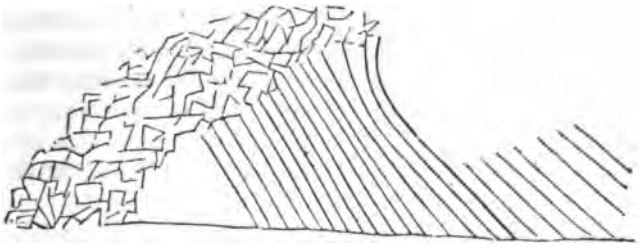
LEONHARD."

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*Precisely the same, as I shall mention more particularly farther on.

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to 90°. Must we not impute this flexure to the protrusive force of the greenstone, when first it was elevated to the day light?



**Junction of Greenstone and Sandstone: Mount Tom.**

### *Chemical Effects of Greenstone upon other Rocks.*

In other parts of the world, it is a common case to find the rocks lying in contact with greenstone, essentially changed in their characters, for a greater or less distance from the place of junction. This is most striking where limestone is the rock invaded by the trap. Similar effects are not wanting in the rocks of Massachusetts, that are traversed by greenstone. Yet it appears to me that they are hardly as common or striking as in some countries; judging from the descriptions of geologists. One reason may be that greenstone here rarely comes in contact with limestone. The following are the principal examples of this phenomenon which I have met with.

The influence of greenstone veins at Nahant, in converting argillaceous slate into flinty slate, and where carbonate of lime was present, into chert, has been fully described under gray wacke.

Professor Webster describes a mass of trap, in Charlestown, as superincumbent upon a rock which he calls compact feldspar, "which has many of the characters of clay slate, and in the immediate vicinity of the trap rock has a degree of hardness, a compact structure, and fracture almost like that of hornstone, — the slate seems to have undergone a great and remarkable change."*

In the Connecticut valley the most striking chemical effects produced upon the sandstone by the greenstone, are induration, a vesicular structure, and change of color. In the 17th volume of the Am. Journal of Science, Professor Silliman has described a most interesting example of all these effects, as they appear in a quarry, nearly a

* Boston Journal of Philosophy, Vol. i. p. 282.

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mile long, at Rocky Hill, about three miles southwest of Hartford. The trap is here superincumbent upon the sandstone, and this latter rock is changed to the depth of about four feet below the junction. Ascending from that depth, it begins to grow firmer; the color grows lighter, the red vanishes and it becomes dark gray — light gray — ash gray, and in some places almost white; while at the same time the firmness is much increased, so that from being a very soft and tender argillaceous sandstone, easily splitting into laminae, it has become hard, and difficult to break, striking fire with steel like an overburnt brick, and its fissile character is almost or quite destroyed."

"But this is not all. At the depth of about two feet, rather less than more, the altered sandstone begins to grow vesicular. Fine pin-hole cavities make their appearance; they are very numerous, and the solid substance which surrounds them becomes semi-yitreous and loses the appearance of sedimentary or fragmentary matter; as we ascend towards the trap the vesicles increase rapidly in size, and at and near the junction they are both numerous and large."

This vesicular structure is still more remarkable in the trap, extending several feet upwards; and near their junction, the two rocks can hardly be distinguished, and appear as if melted together.

Similar phenomena, more or less strongly marked, present themselves both in Connecticut and Massachusetts, where the contact of the two rocks is visible. On the east side of Mount Tom in Northampton, and on the south side of Holyoke, the vesicular character of the sandstone is most obvious: as is that also of the greenstone. (No. 286.) From the description that has been given of the relative position of these rocks in those places, it will be recollected that the sandstone is uppermost. The cavities are sometimes filled with some mineral, as carbonate of lime, subsequently introduced; but the red color of the rock is generally retained: sometimes, however, it is not easy to distinguish this amygdaloidal sandstone from trap, without close inspection. Yet in most cases the line of junction is distinct, and the schistose structure of the sandstone is not lost. The greenstone, as already mentioned, is in these instances much more vesicular than the sandstone, and to an unknown depth. The cavernous base, the cavities not being usually filled, differs but little from indurated clay; and some circumstances have led me to suspect that the rock in fact consists of argillaceous sandstone or shale, which has been fused.

A little below Turner's Falls on the Greenfield shore, the junction of these rocks may be advantageously examined, where they occupy

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the same relative position as above mentioned; that is, the sandstone is the superior rock. There it dips from 40° to 50°: but I did not perceive in it any cavities; nor is the red color or the fissile character destroyed. The Connecticut river here has worn away nearly all the sandstone, except an occasional patch, for one or two miles: but where these patches remain, a fine opportunity is afforded for observing the junction. And in some places I noticed that small rounded masses of the amygdaloid were partially entangled in the sandstone: as if, when the melted mass of greenstone was forcing its way upward, and pressing hard against the incumbent sandstone, portions of the former rock, while yet partially solidified, were worn off and rounded by the latter. More frequently we see fragments of the sandstone insulated in the greenstone; being perhaps unmelted portions of the former rock.

For several feet below the surface of the amygdaloid at this locality, it is not uncommon to see that rock divided into parallel portions, whose surfaces correspond in dip and direction with the strata of sandstone. The thickness of these layers is from one to four feet. But they do not extend through the whole mass of rock, and can, therefore, hardly be considered as genuine strata.

The existence of so much amygdaloidal greenstone on the eastern or upper side of the ridge, (for it must be recollected that such is the dip of the sandstone embracing the trap as to render the eastern the upper side,) while it is comparatively rare and far less porous and irregularly situated in the lower parts of the range, leads naturally to an inquiry as to the cause. It may be sufficient to say, that the gaseous matter extricated by the intense heat of a large mass of rock in a state of fusion, would naturally be forced to its upper part by the greater pressure below: although in the example described by Prof. Silliman, such does not appear to have been the case. Since, however, the base of the rock on the east side of the ranges above named, is more argillaceous and less crystalline than that of the rock on the western or lower side, I am disposed to believe the former more favorable for retaining the gas or vapor than the latter.

When the water is low we have an instructive exhibition of the junction of greenstone with the subjacent sandstone at Titan's Pier in South Hadley. A considerable part of the trap near the sandstone is a breccia; and one of the ingredients is clay, indurated almost to the hardness, and exhibiting the light gray color, of hornstone, although not exactly that substance; especially if a mixture of limestone in the

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original rock be essential to its production. This seems rather to have formed the paste in which are cemented dark pieces of trap. This rock extends but a short distance upwards from the line of junction.

The most interesting effects at this spot are exhibited, however, in the sandstone beneath the trap. Like that near Hartford, for two or three feet its schistose structure is in a great measure obliterated, although its stratification remains. It is also of a light gray colour. On breaking it, it exhibits a semi-crystalline structure, bearing considerable resemblance to some varieties of fine grained granite. (No. 170.) But the most curious fact of all is, that this rock exhibits in some places a decided tendency to a columnar form. I cannot say, indeed, that any perfectly formed prism can be found. Still the sandstone exhibits several unequal sides of a prism, perpendicular to the planes of stratification, and thus coinciding with the less perfect columnar structure of the greenstone immediately above: so that at a little distance one does not perceive the line of junction between the two rocks.

I have met with no geological writer but Dr. Macculloch, who has described examples of columnar sandstone; and he mentions but two cases in nature, both in Scotland. Another case, however, is noticed by him in the hearth stone of a blast furnace.* This last example is very instructive, as showing that heat, if long continued, may produce the columnar structure in sandstone even though not intense enough to melt it. The application of this case in explanation of the columnar structure of the sandstone at Titan's Pier, is too obvious to render its formal statement necessary.

Some of the sandstone of the new red sandstone is highly micaceous: this variety, where it occurs near the greenstone, can hardly be distinguished from mica slate. (Nos. 177 to 179.) I will refer only to two localities of this rock, viz. at Turner's Falls and at the north end of Mount Tom, at the spot where the sketch on page 429 exhibiting the junction of the two rocks, was taken. Can there be any doubt that these examples are in fact a partial conversion of the sandstone into mica slate by the heat of the greenstone?

I know of but one place in the valley of the Connecticut where greenstone comes in contact with limestone; and that is in West Springfield. Perhaps even there an actual contact does not exist, yet

* System of Geology, vol. 1. p. 172.

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the greenstone is separated from the limestone in some places only by a narrow strip of sandstone: And a part of the limestone is more or less frequently converted into tripoli: that is to say, the carbonic acid is expelled, leaving the argillaceous and silicious matter by itself. Probably this was the effect of heat: though I am not very confident that the tripoli was produced in this manner. A part of the limestone at that place is very much indurated, so as to possess almost the brittleness of glass when broken.

### *Mineral Contents.*

It is not unexpected, though gratifying, to find in our greenstone the same minerals as occur in the trap rocks of Europe.

In describing the new red sandstone I have given an account of several veins in that rock of sulphate of baryta and native copper, green carbonate of copper, with pyritous copper and the red oxide of that metal. These veins often extend into the greenstone a considerable distance. But for the particular localities I would refer to the description already mentioned.

According to the Messrs Danas,* a vein of magnetic oxide of iron occurs in the greenstone at Woburn; though not extensive enough to render it an object for the miner. Intimately mixed with this ore is pyritous copper: and this last is invested sometimes with the muriate of copper. Quartz and amygdaloid at Brighton, and rolled pieces of granite at Medford, contain the same mineral. They state also that micaceous oxide of iron exists in the greenstone at Charlestown.

According to the same gentlemen, asbestus is found in fragments of greenstone in Brighton and Dedham; and I have found it in one of the anomalous varieties of this rock at Nahant. Probably however, it is comparatively rare.

Epidote, as already mentioned, exists abundantly in the greenstone around Boston; but never to my knowledge in that in the Connecticut valley. Generally it is disseminated through the greenstone; but sometimes it occurs in veins, and is then usually compact, though often crystalized. At Breed's Hill is a locality; and a much better one at Nahant.

The cavities of the amygdaloid are sometimes occupied by a dull green foliated mineral which appears to be chlorite. The folia have

* Mineralogy and Geology of Boston, &c. p. 66.



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in general a radiated structure, and sometimes invest calcareous spar. (No. 1173.) A little below Turner's Falls in Gill, just at the mouth of Fall River, on the east bank, is the best locality of this mineral with which I am acquainted. More frequently the cavities are occupied with earthy chlorite, and the specimens of this kind are very common along the eastern side of the ranges of greenstone in the Connecticut valley; as in Greenfield, Deerfield, South Hadley, Northampton, and West Springfield.

At the locality just referred to at the mouth of Fall River, occurs the rare mineral chlorophoeite: which has not to my knowledge been found in any other place on this side of the Atlantic. It is abundant in the projecting mass of greenstone that appears at the junction of the Connecticut and the small river just mentioned; on the east bank of the latter; and the spot can hardly be mistaken by any one desirous of finding it. This mineral, when the rock is first broken, is of a dull green color: but after a few hours exposure it becomes nearly black. After long exposure, however, some specimens assume a dark brown color. For the most part the nodules,— often half an inch and sometimes more than an inch in diameter,— exhibit a fibrous structure, the fibres radiating from one or more centers in the same nodule. The mineral is easily scratched with a knife and the powder is of a dull green color. When fractured, however, it appears brittle. Sometimes calcareous spar is enclosed within the chlorophoite: but very rarely are the nodules hollow. If I mistake not, in one or two instances I have observed a foliated structure in specimens. There seems little danger of exhausting this locality. The same rock contains disseminated prehnite, chlorite, and pyritous copper. It is however, but slightly amygdaloidal. Mr. Shepard has recently announced the existence of datholite in Middletown Ct. in a rock exactly resembling that containing the chlorophoeite; nor can I doubt but this mineral will be found in Massachusetts.

Prehnite has been found in the greenstone in the vicinity of Boston, particularly in Charlestown. But it is more common in the valley of the Connecticut. Near the chlorophoeite locality just described, on the Greenfield shore of the Connecticut, it is not uncommon in amygdaloid. There its color is nearly white. In general it is more common on the eastern side of the greenstone ridges, than on the western; for example, where Deerfield river cuts through a ridge of this kind in Deerfield, and on the east side of the same ridge four or five miles farther south, in a part of the town called Pine Nook:

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also in West Springfield. But it is found on the west side of these ridges; as at a spot one mile east of the village of Deerfield, and at another about the same distance nearly east of the village of Greenfield. No very rich specimens of this mineral, however, are met with in our greenstone.

Augite of an iron black color and in imperfect crystals or in veins, is sometimes met with in the tufaceous greenstone of the Connecticut valley: as at a spot one mile east of the village of Deerfield.

Several varieties of the quartz family are found in the greenstone of Massachusetts, principally in that of the Connecticut valley. Limpid crystalized quartz is found frequently in the form of geodes, and sometimes these crystals are amethystine of a delicate though not very deep color. This amethyst has been observed one mile east of the village in Deerfield: on the same range three miles south of this spot and east of the village of Bloody Brook; on Mount Holyoke; and in West Springfield. At the latter place the crystals are sometimes smoky. (No. 1117.)

The quartz that occupies the cavities of greenstone, as at a spot a mile east of the village in Deerfield, is sometimes tabular; and the folia are quite thin and delicate. Sometimes it is radiated, and not unfrequently it contains tabular or prismatic and radiating cavities, once occupied by a mineral. The radiating cavities were perhaps once filled with Thomsonite; at least, they resemble that mineral in form. I have seen them three or four inches in length, and crossing one another from different centers.

Chalcedony is not an uncommon mineral in the greenstone of the Connecticut valley. So far as I know it is wanting in the greenstone around Boston: and this fact, with the almost entire absence of an amygdaloidal structure, are marks of peculiarity well worthy of notice. In the Connecticut valley the chalcedony is usually in small nodules rarely more than one or two inches across. Most frequently its color is milky or smoky gray, and sometimes it appears to be real cacholong. At other times it is of a flesh colour, from the lightest to the deepest shade forming carnelian. Rarely I have seen it yellowish, and closely allied to sardonyx. These varieties are most common in the greenstone range passing east of the villages of Greenfield and Deerfield, and on its western face; but rare on its eastern side.

All the above varities of the quartz family are sometimes arranged concentrically, so as to form agates. Generally they are small: but some specimens found by Dr, Cooley in the south part of Deerfield,

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two miles northeasterly from Bloody Brook meeting house, were quite large. The largest of these specimens, nine by six inches in diameter and weighing 23 pounds, was composed of an outer zone of greenish chalcedony half an inch thick: then a zone of flesh colored chalcedony: the center consisted of an amethystine geode. The best of these specimens which I have been able to procure for the collection (No. 1191,) is about six inches by four: the outer zone is carnelian; the second bluish chalcedony, and the remainder limpid quartz, almost filling the cavity. When the outer coat is broken off, the specimen shows a strong resemblance to the human skull; exhibiting protuberances and depressions enough to satisfy the most sanguine phrenologist. Another specimen, three inches in diameter, exhibited no less than 14 concentric bands, consisting of chalcedony and quartz of various colors. This is a genuine *fortification agate.* Sometimes fortification and eyed agates are exhibited in the same specimen. It is to be feared, however, that this locality is nearly exhausted; at least, until a long period of time shall have decomposed the greenstone much deeper.

Calcareous spar is one of the most frequent of the minerals in the greenstone of Massachusetts; both in that in the eastern part of the State and in the Connecticut valley. Generally it is the laminated variety; sometimes flesh colored, but mostly limpid. Often it constitutes the cement of trap tuff. Sometimes it is in distinct crystals.

A few years since Prof. Silliman detected selenite in amygdaloid from Deerfield. It was white and retained its water of crystalization.

Several species of the zeolitic minerals have been found in this rock in the Connecticut valley. Analcime has been frequently said to be quite common; but I am suspicious that calcareous spar has been confounded with that mineral; and I dare not say that it exists in our greenstone. Nor am I sure that laumonite occurs as far north as Massachusetts, although the greenstone in the vicinity of New Haven contains it. As to chabasie there is no doubt but it has been found in Deerfield, one mile east of the village. It is always crystalized, and almost invaribly in the primary form, an obtuse rhomboid. The crystals vary from 1-50th to 1-4th of an inch on their sides; and these are grouped on tabular and pseudomorphous quartz, on prehnite, and on the greenstone: either in fissures, or more commonly in the cavities of the amygdaloid. This mineral seems to have entered these for the most part at a later period than many of the others with which it is associated. For often we find it in the upper part of a cavity

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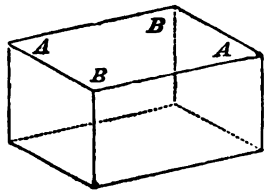
whose lower part is filled with another mineral; but never in a reverse order. The amygdaloid in which this mineral occurs is extremely hard, and hence the chabasie has been preserved. It is, however, quite difficult to obtain good specimens.

In the amygdaloid on the east side of the greenstone range in Deerfield and Greenfield, I have observed a few rather poorly characterised radiated specimens, exceedingly resembling the Thomsonite of Scotland.

In the greenstone one mile east of the village in Deerfield, a mineral occurs, closely allied in external characters to stilbite and heulandite; and hitherto I have described it as stilbite. But in its crystalline form it differs from both those species, and indeed from any known mineral. I shall, therefore, venture to describe it as new; and take the liberty to dedicate it to your Excellency, as the patron of science, under the name of

### LINCOLNITE.

This mineral occurs in minute yet very distinct crystals, which are right oblique angled prisms. Three trials on as many crystals with the common goriometer gave the following results for the angles of the bases.

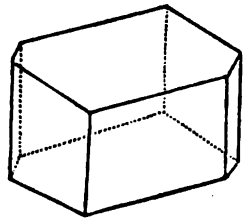



| | | |
|---|---|---|
| First crystal: | Angles *A*, *A*, | 61°. |
| | Angles *B*, *B*, | 119°. |
| Second crystal: | Angles *A*, *A*, | 61°. |
| | Angles *B*, *B*, | 120°. |
| Third crystal: | Angles *A*, *A*, | 61°. |
| | Angles *B*, *B*, | 120°. |

The mean result of all the trials I have made does not vary much from 60° and 120°. But this may vary from the truth half a degree; I think not more. The bases are commonly bright enough for the application of the reflective goniometer: not so the lateral faces.

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I have observed only one modification of this crystal, and that consists of a slight truncation on the acute lateral edges, as represented in this figure. (No. 1202.)



The height of the prism is about equal to the longest edge. It yields to mechanical division only parallel to the bases. It has a lustre somewhat pearly on the cleavage plane, and not unfrequently the folia are slightly curved. It is always white or colorless; sometimes transparent, but generally only translucent. In every other character it corresponds with Heulandite and stilbite. On hot coals it whitens, and before the blowpipe melts into a white spongy enamel.

The crystals of this mineral, (and I am not sure that it ever occurs except in crystals,) are mingled, usually in the least proportion, with crystals of chabasie; either in the amygdaloidal cavities of the greenstone, or in its fissures. I have rarely met with a crystal whose longest side exceeded the tenth of an inch: and most of the specimens in the collection will need a microscope for their examination. It is very rare and obtained with difficulty, though small specimens will reward the persevering collector. (Nos. 1200 to 1204.)

At the same spot in Deerfield a radiated mineral occurs, forming sometimes perfect spheres, of the size of an ounce bullet, which may be Lincolnite, though more probably it is stilbite.

This same radiated mineral is found at Bellow's Falls in Vermont, encrusting gneiss. On examining some specimens which I obtained there a few years ago, I perceive several distinct crystals of Lincolnite, which are quite small.

It is obvious from the preceding description, that this mineral differs from stilbite and Heulandite, only in its crystalographical characters. Stilbite crystalizes in a right square prism. Heulandite comes nearer to Lincolnite; its primary form being a right oblique angled prism. But the angles of its bases are about 50° and 130°; differing 10° from those of Lincolnite. Such a difference cannot be imputed to the imperfection of mensuration; nor can I conceive how it could possibly

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result from any modification of stilbite or Heulandite. There is, therefore, as much reason for making this mineral a distinct species, as there was for separating Heulandite from stilbite. I am aware that mineralogists have of late exceedingly multiplied species by divisions of the stilbite of Hauy. Beudant, especially, in the last edition of his mineralogy, (1830,) has made no less than five: viz, stilbite, Heulandite, epistilbite, hypostilbite, and spherostilbite; the two last being added by himself. He supposes that when the same elements combine in different and definite proportions and under different forms, they should constitute different species; although in external characters they differ but slightly; and surely no scientific man can object to this principle. But recent discoveries have shown that the same elements, combined in the same proportions, are capable of crystalizing in forms incompatible with each other. This may prove to be the case with some of the new species separated from stilbite, and with Lincolnite among the rest. Yet at present it seems as well entitled to a distinct name as Heulandite, and better than hypostilbite and spherostilbite, whose crystalline form has not been ascertained: much better also than epistilbite, since the controversy concerning it that has been carried on in the European Journals. When this subject shall be better understood than it now is, mineralogists may find it necessary to reform the list of species; nor can we now say which of them must be striken out.

## *Theoretical Considerations.*

There has been so decided a change within a few years in the opinions of geologists as to the origin of the trap rocks, and there is now so general an agreement in regarding them as igneous products of early times, that a prolonged discussion of the subject in this place will not be necessary. I shall only state the leading arguments in support of this opinion, that will apply to the greenstone of Massachusetts.

1. *The resemblance in external characters between some varieties of our greenstone and the products of existing volcanoes.* The amygdaloids are the most striking in their resemblance. In the valley of the Connecticut it is easy to collect a suit of specimens of this description, that could hardly be distinguished from specimens that are frequently brought from the craters of volcanoes, except by the greater freshness of the latter. Let a man pass from Bridgman's tavern in the southeast part of Amherst to Granby, over the east part

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of Mount Holyoke, and in the pastures by the road side, he will see hummocks of amygdaloid so much resembling lava, as to remind him of the Phlegrean Fields. And a similar appearance is not uncommon in other spots on the east and southeast sides of Holyoke and Tom.

Some writers regard the minerals peculiar to our greenstone, such as chalcedony, the zeolites, prehnite, augite, &c. as evidence of its igneous origin. But if, as is probable, most of these were infiltrated from solution in water, this proof is not of much weight, especially since they have been found of late in several of the stratified rocks, such as mica slate, gneiss, &c. though I am not aware that they have ever been discovered in rocks of exclusively aqueous origin.

2. *The columnar structure of greenstone.* The same columnar form is assumed by lavas when they are slowly cooled; but in no case by rocks of known aqueous origin. How unphilosophical then, to refer this structure to aqueous agency!

3. *The irregular manner in which greenstone is intruded among stratified rocks.* Water and fire are the only two great agents in nature, as I suppose will by all be admitted, sufficiently energetic to have produced mountain masses of rock; so that we must take our choice between them, unless we can show that both of them were concerned in the work. Now I cannot conceive it possible how any logical mind, that has observed trap rocks in situ, or will attentively consider the manner in which I have shown our greenstone to be intruded in the form of veins and irregular masses among the stratified rocks, can conceive how they could have been deposited in these modes from water. But they are exactly the shapes which melted matter, forced from beneath, through and among consolidated strata, would have assumed. What but a wedded attachment to hypothesis, then, can prevent us from admitting their igneous origin?

4. *The Mechanical effects of Greenstone upon the Stratified Rocks.* I refer here to the evidence that our greenstone has elevated, broken, and dislocated the strata in some instances through which it has been protruded. The section at Turner's Falls, exhibits a good example of these effects, as well as similar effects of the primary rocks, which will be noticed farther on. Nearest the greenstone on the upper side, we find the dip to be greatest, gradually diminishing as we recede from the ridge. That this increase of dip resulted from the protrusion of the greenstone, is evident, it seems to me, from the fact that beneath that rock the dip is less, corresponding to that of the forma-

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tion generally. A similar case I have described on Mount Holyoke in Belchertown. I have also given drawings of less extensive, though not less decided cases of the agency of a mechanical force upon the strata in juxtaposition with the greenstone, whereby a portion of these strata is forced upwards, at Charlestown, Northampton, and New Haven. All these facts, it seems to me, admit but one explanation; and irresistibly lead the mind to the conclusion, that a force must have acted in the interior of the earth, urging the greenstone through the superimposed rocks in a fluid or semi-fluid state.

5. *The Chemical effects of Greenstone upon the Stratified Rocks.* At Nahant we have seen that it has converted clay slate into flinty slate: in Charlestown a similar change has taken place. In the Connecticut valley, much of the sandstone in contact with the greenstone has become vesicular and some of it is highly indurated; and in one case at least, somewhat columnar. Its red color too is often destroyed, its texture rendered somewhat crystalline, and the micaceous varieties partially changed to mica slate. In one case, also, limestone is converted into tripoli: that is, its carbonic acid is expelled.

Now it requires no labored argument to show that such effects as these could have resulted only from the intrusion among the strata of rocks in a state of fusion, or intensely heated. It does not require even a practised geologist to draw this conclusion: for the facts, wherever they exist, impress every man who observes them with this belief.

Upon the whole I cannot see that any thing is wanting to prove the igneous origin of our greenstone. It may be asked, indeed, how it happens, that while existing volcanoes throw up their matter in a conical shape, greenstone forms a continuous ridge, 70 or 80 miles long, with no appearance of a crater or craters. There is reason to believe, indeed, that the mode in which greenstone was erupted, was considerably different from the operation of existing volcanoes; and that probably the protrusion took place under an immense weight of water: nor can it be imagined how a common volcanic force, which acts in the direction of the radii of a circle, should thus operate lineally. But it is easy to conceive how the shrinking of the interior part of the earth by refrigeration, faster than the exterior, would produce such linear openings, into which the melted matter from beneath would readily force its way. But more of this ingenious hypothesis in the sequel.



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The columnar structure of the trap rocks has never yet received a very satisfactory explanation. From the fact that clay when drying divides into columnar masses, it is natural to enquire whether the columns of trap had not a similar origin. There is, however, one insuperable difficulty in such an hypothesis. The desiccation of the clay always causes it to shrink, so as to leave interstices between the columnar masses. But no such shrinking has taken place among the prisms of trap. There are no spaces between them: their sides actually touch. Perhaps in the present state of our knowledge we cannot come nearer the truth, than to consider this columnar structure as one of the forms of a concretionary structure. Yet this solution affords no great satisfaction to the mind, so long as we are in doubt as to the nature of a concretionary structure.

We have seen that greenstone is sometimes divided by parallel planes into masses exceedingly resembling strata. If they are not genuine strata, what is their orgin?

In all the unstratified rocks, small spherical or ovoid concretions occur, composed of concentric layers of greater or less thickness. These concretions vary exceedingly in size, and are sometimes not more than an inch in diameter. Nor do I know of any principles in geology or chemistry that can fix any limits to their size. Suppose now a concretion to have been produced of mountainous bulk. It is obvious that if only a small portion of its surface be laid bare, and only a few of its envelopes penetrated, these layers may have exactly the appearance of strata; because their curvature is so slight for a small extent as not to be perceptible. In this way should I account for the laminar disposition of the trap at Nahant: and I shall apply the same explanation to some examples still more striking in the sienite and granite of the State. In one of these cases I think I have satisfactorily traced out a concretion of mountainous bulk, and thus given a confirmation to the theory I am advocating.

### 16. PORPHYRY.

Porphyry has been for so many centuries used as an ornamental stone, and the term has been so often employed by lapidaries and authors who were ignorant of geology, that its popular acceptation is quite too loose for scientific description. Nor are geologists exactly agreed as to its meaning. "The term porphyry," says Macculloch, "is applied to a rock in which crystals of common feldspar are im-

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bedded in a simple or compound base." "The word porphyry," says a writer in the Edinburgh Review, "signifies at present a rock having a compact basis, through which are scattered crystals of some other minerals." "Since the time of Werner," says the Dictionnarie Classiqe D' Histoire Naturelle, "most mineralogists confin ethe name Porphyry to rocks with a porphyroid structure, composed of a paste of compact feldspar more or less mixed, which envelopes crystals of feldspar ordinarily whitish." Brongniart defines porphyry as having a "paste of amphibolic petrosilex, red or reddish, enveloping obvious crystals of feldspar."

Since porphyry passes into other rocks, we ought to recollect a remark of Macculloch, that "the term porphyry, when used in geological description, must not always be taken too strictly in its mineralogical sense." With the latitude which this remark gives, the porphyry of Massachusetts conforms to the strictest of the above definitions.

### *Mineralogical Characters.*

1. *Compact Feldspar.* (No. 1206 to 1228.) This mineral, more or less changed by other substances chemically mixed with it, forms, I believe, the basis of all the porphyry in Massachusetts. At any rate, I have found none which I was not able to fuse with a common blowpipe: and this fact, in connection with another that the great mass of our porphyry has a base of well characterised compact feldspar, has satisfied me that this is the predominant ingredient in the whole of it. But this compact feldspar, both that which forms the paste of porphyry, and that which contains few or no feldspar crystals, varies exceedingly in color, in toughness, and in the ease with which it can be fused. And to what but to an admixture with more or less of other minerals, can we impute these differences?

It seems to me, that in the present state of geological science, we may take it for granted, that compact feldspar has once been melted. But what was the original rock from which it was produced? Judging from the present constitution of the earth's crust, we must suppose that rock to have been one in which feldspar only predominated, but did not exist alone: or in some cases perhaps, the feldspar formed only a small proportion of the whole. The melting down of such rocks would produce just such varieties of compact feldspar as we find to exist. Sometimes they would be almost pure, while at other times they would contain so much silex, or other earth, that they could

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scarcely be distinguished from hornstone, jasper, quartz, &c; and their fusion would be quite difficult.

Now it seems to me that there is too close a resemblance between this *a priori* reasoning and facts, to permit us to regard the former as mere hypothesis. It obviously gives us a clew to the whole history of compact feldspar, and prepares us to expect as great anomalies in its characters as can present themselves.

Compact feldspar in the vicinity of Boston forms deposits of considerable extent: I mean that variety which is so deficient in crystals of feldspar, that it would not generally be denominated porphyry. It is true, however, that a careful examination of this rock, will almost always detect these crystals in it; and sometimes polishing will bring to light a porphyrite structure where it was not previously obvious. Hence I have not hesitated to reckon compact feldspar as a variety of porphyry. The variety most wanting in feldspar crystals usually lies between genuine porphyry or sienite on the one side, and graywacke on the other. A deposit of it thus situated, extends from Medford to Malden. Another strip of it may be seen in the south part of Dorchester and Roxbury, and in the north part of Milton and Dedham. The same range probably, appears and forms hills in Needham and Natick. It is most likely the other extremity of this range that appears in Hingham. Often a portion of these deposits, especially on that side where they unite with graywacke, exhibits somewhat of a slaty structure; and when describing graywacke, I have mentioned a variety which is conglomerated compact feldspar. This was noticed near Neponset river, not far from the line between Milton and Dorchester.

Although the compact feldspar under consideration assumes almost every variety of color, yet there are certain predominant colors. One of the most common is a grayish white: as in Medford, where some of the rock has the aspect of granular quartz. This variety sometimes assumes a yellowish tinge, as in Newbury; and this appears to be one of the purest varieties of this rock, and the one, which, if any, will answer for Turkey stones. (No. 1206.) A dark gray color is another that prevails; and sometimes it is obvious that the rock embraces fragments of indurated slate, not perfectly incorporated with the feldspar. A more striking and very common variety is red, of various shades, from brownish to blood red. The latter variety abounds in Hingham, where ledges of it may be seen a little north of the village. Specimens of this rock can hardly be distinguished from the jasper

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so called of Saugus; and probably it is essentially the same thing, viz. compact feldspar with a mixture of some other ingredients. Both of them are fusible with some difficulty into a semi-transparent porous glass. They correspond pretty nearly in their characters to the *rose petrosilex* of Sahlberg, described by Berthier in the 36th volume of the Annales de Chimie et de Physique, and which he regards as a distinct species from compact feldspar, and which Beudant has since described as such. However, it seems to me that if we make a distinct species of this variety, we must make a dozen others from the compact feldspar of Massachusetts. He would erect this into a new species, chiefly because it differs from feldspar so much in composition. But if compact feldspar had an igneous origin, should we not expect its composition to vary very much, according to the greater or less quantity of foreign substances that happened to melt and mix with the feldspar: nor would this be a reason for making distinct species, so long as the constituents of feldspar predominated. Some specimens of our compact feldspar of a reddish color exhibit traces of a schistose structure, and are even traversed by thin veins and layers of quartz. These melt with great difficulty.

These are the principal varieties of color that I have met with in the non-porphyritic compact feldspar of Massachusetts. When porphyritic, however, it exhibits several other predominant colors, which will be mentioned in the proper place.

2. *Antique Porphyry.* (*Porphyre antique, Al. Brongniart.*) This variety constitutes the great mass of the porphyry in the vicinity of Boston: and I call it antique because it so closely resembles that used in the monuments and ornamental furniture of the ancients. As to this point we have the testimony of Prof. A. Brongniart, who quotes "Chelsea near Boston;" as a locality of porphyry, and says that "it entirely resembles the antique porphyry."* He might have added that probably as many, if not the same varieties occur in the vicinity of Boston, as were employed by the ancients. The specimens which I have placed in the collection, and the most of which are polished, will render this statement probable. For if I could obtain so many varieties during the little time that I have spent in examining this formation, how extensive a suite might be brought to light by long and careful research!

The compact feldspar that forms the base of these porhpyries pre-

* Classification des Roches, p. 108.

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sents numerous varieties and shades of color. One of the most elegant, is a light green, such as occurs in Chelsea and Malden; (Nos. 1254, 1256, 1257,) or the deeper green that I have met with in Milton. (No. 1255.) Red of various shades is a still more frequent color. (Nos. 1247 to 1253,) A reddish brown is sometimes met with. (Nos. 1240, 1241, 1243, 1258.) A nearly black color more often: (Nos. 1234, 1235, 1236,) A gray color sometimes: (Nos. 1239, 1242, 1244,) and a purple color rather seldom. (Nos. 1232, 1233,) The imbedded crystals are usually of a light color, sometimes white, sometimes brown, and sometimes greenish. Generally they are foliated, very rarely compact, and distinguished from the base chiefly by the color.

3. *Porphyry with a base of compact Feldspar and two or more minerals imbedded.* (Nos. 1258 to 1262,) Feldspar and quartz are the two minerals present; but I have noticed several small plates of mica. It is very obvious, indeed, that this rock is intermediate between sienite and porphyry. In other words, it seems to be the former rock partly melted down into the latter. The porphyry of the Blue Hills is chiefly made up of this variety; though some perfectly formed porphyry is found there. The quartz is usually hyaline and smoky, and sometimes it forms the only imbedded mineral; the feldspar being all compact. In such case especially, where the base is of a light color, the rock exceedingly resembles trachytic porphyry; (Nos. 1261, 1262,) and it will hardly admit of being polished for ornamental purposes. That a porphyry, which, by being thus associated so intimately with sienite, is proved to be one of the oldest varieties on the globe, should so much resemble the most recent variety, proves that similar causes have operated in its production at different and very remote periods.

4. *Brecciated Porphyry.* I know not how to describe this variety better, than by saying that it is composed of angular fragments of porphyry and compact feldspar, re-united by a paste of the same materials, which is itself also porphyritic. Hence it appears that there must have been an original formation of these rocks, (compact feldspar and porphyry,) which was subsequently broken up, either by the mechanical agency of water, or the mechanico-chemical agency of heat, redissolving and mingling the materials. The fragments are of various colors, usually however, gray or red: and this proves that rocks from different localities must have been mixed together. The paste is commonly in the greatest quantity; and the rock is as hard and broken with as much difficulty as any other variety of porphyry. It is not

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a very common or abundant variety: but for ornamental purposes it affords specimens of great delicacy. (Nos. 1263 to 1270.)

### *Topography of Porphyry.*

Only three ranges of this rock are given on the map; and these are all in the eastern part of the state. Two of them, — the principal ones,—lie the one on the north and the other on the south of Boston, having their longitudinal direction east and west. The third is in Essex county, extending easterly from Byfield Academy, nearly or quite to the coast. This strip is chiefly compact feldspar and mostly the red variety. It certainly deserves a more thorough examination than I have been able to give it.

In some places farther south, as for instance on the turnpike between Boston and Newburyport, in Topsfield, I observed a rock in place, intermediate between porphyry and greenstone: and not improbably genuine porphyry may be found in the vicinity.

This rock is most fully developed in its characters in the range a little north of Boston, extending from West Cambrige through Malden and Medford to the east part of Lynn. The southern border of this strip, certainly towards its westerly extremity, is compact feldspar. The porphyry (mostly antique, though sometimes brecciated,) forms a broken ridge of considerable height, generally naked and precipitous on its southern side. On the north it is succeeded by sienite, and the two rocks are so closely connected that the line between them is very obscure and irregular. I am satisfied, however, that this porphyry range has been usually represented too wide. This is the range that will probably furnish the best varieties for ornamental purposes, whenever the public taste shall create a demand.

There is reason to suppose that this range once extended much farther east than at present. For Hon. H. A. S. Dearborn informs me that Halfway Rock, lying in the ocean several miles east of Marblehead, is porphyry. Indeed, specimen No. 1264, which he presented to me, will show that it is the finest brecciated porphyry in the State, which I have met with. Now as this island lies nearly in the direction of the Malden and Lynn porphyry range continued easterly, I infer that it did once reach so far; (and perhaps does now beneath the ocean;) nor can we say how much farther. We see here from whence proceeded the porphyry pebbles that are so common along the southern shore of Massachusetts Bay, and on the islands of Nantucket and Martha's Vineyard.

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The porphyry range south of Boston occupies much more of the surface than that just described; and yet I doubt whether it contains so much genuine porphyry. It extends with some apparent interruptions, (though I doubt whether there are any real interruptions,) from Natick to Hingham, through a part of Needham, Dedham, Milton, Braintree, Quincy, and Weymouth. I have not found it, however, in the latter place, and have marked the deposit of this rock in Hingham as insulated from the rest. This patch is chiefly compact feldspar. The range it will be seen embraces the greater part of the Blue Hills, the most elevated land in the vicinity of Boston, its highest point rising more than 700 feet above the ocean. But it is only the upper part of this mountain that is composed of porphyry, and by no means the whole of its summit neither: for sienite is frequently found there. The porphyry is chiefly that variety which has a trachytic aspect, being evidently intermediate between porphyry and sienite.

I have met with rocks approaching to porphyry in no other places in the State, except one or two. In the sienite of Whately I found a vein of compact feldspar two or three feet wide; but the foliated structure of the feldspar was not entirely obliterated. In the argillaceous slate of Guilford, Vt., a quite distinct porphyroid granite occurs, and with it well characterised greenish compact feldspar. These rocks are so obviously granite, imperfectly melted down, that I have thought it best to describe them under granite, and to place the specimens (Nos. 1467 to 1470,) among those of granite. A specimen (No. 1211,) of the Whately compact feldspar will be found in the collection.

### *Geological Position.*

Of all the questions that have exercised the ingenuity of geologists, none appear to me more perplexing and unprofitable than those which they have raised and discussed relative to the primitive, transition, and secondary character of porphyries. In reading Humboldt's remarks on the transition porphyries, in his Essay on the Superposition of Rocks, I have been reminded of a man benighted in a quagmire. Every effort which he makes to extricate himself, only plunges him in deeper. Am I asked whether the porphyry of Massachusetts belongs to the Primitive, Transition, or Secondary Class? I reply that it belongs to none of them, but is a member of a series of rocks consisting of granite, sienite, porphyry, and greenstone, which have

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been protruded through or among the stratified rocks, subsequent to their deposition. I say protruded: for if there be ground for making any theoretical inferences whatever in geology, it seems to me that it exists in this instance. The mere existence of these rocks, therefore, among those of any particular stratified class, does not prove that they were produced at the same epoch: it rather proves that the unstratified rock was of subsequent production. On the other hand, if we find a stratified rock lying above others which are penetrated by veins of an unstratified rock, while this superior one is never thus penetrated, we may safely infer that it was deposited since the protusion of the unstratified rock. These seem to be the two grand limits of our inquiries in respect to the ages of the unstratified rocks. And if this were all that is meant when the inquiry is whether they are primitive, transition, or secondary, a satisfactory answer might be given. In respect to the relative position of the porphyry of Massachusetts, however, I have but little to say, because but few facts have fallen under my observation. I have never met with an instance in which this porphyry was exhibited in juxtaposition with any stratified rock: except as already remarked, the compact feldspar succeeds to the graywacke as an older rock and gradually passes into porphyry. This porphyry, however, is associated, both on the north and south of Boston, with sienite; and in all cases, so far as I have observed, *the porphyry lies above the sienite*, and there is a gradual transition between the two rocks. This fact is most obvious in the Blue Hill range, where one is often much perplexed to decide whether the rock be sienite or porphyry. The sienite in these cases, however, it is important to remark, is never so far as I know, that variety consisting of compact feldspar and hornblende, which occurs as a member of the overlying family of rocks, but that variety composed essentially of feldspar, quartz and hornblende, which is connected with granite. Hence I infer that our porphyry belongs to the oldest varieties of this rock that have been described.

### *Mineral Contents.*

Although in South America, according to Humboldt, porphyry forms the matrix of gold and some other metals, yet in general this rock is remarkably destitute of foreign minerals. It is so in Massachusetts. In Malden it contains a little specular oxide of iron, and this is the only mineral hitherto announced as occurring in it. A careful



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examination of specimen No. 1222 with a microscope, has led me to the belief that it contains a minute quantity of native gold. The quantity is so very small that an assay cannot be made of it: yet it certainly bears an exact resemblance to native gold. The specimen is an extremely hard variety of compact feldspar approaching flinty slate, from the Blue Hills. I should not allude to this circumstance were not the porphyry of South America rich in this metal.

### *Theoretical Considerations.*

Porphyry, or rather its base, has more the appearance of having once been melted than any of the unstratified rocks, except perhaps some of the vesicular traps. It has been thought by some distinguished writers that compact feldspar ought to be regarded as a mineral species distinct from common feldspar, chiefly because soda is found in it more frequently than potassa, and often exclusively. But one has only to examine the analyses of these two substances, to see that in this respect there is great diversity among both varieties. If compact feldspar is common feldspar or albite that has been melted in connection with other minerals, we ought to expect, as I have remarked in another place, that its composition would not coincide with that of common feldspar. And that it does result from this change in common feldspar, I can hardly doubt, when I often see specimens that have not entirely lost their foliated structure, being intermediate between the two minerals. And then the chemical effects that have been produced on other rocks in the vicinity of compact feldspar, (examples of which have been mentioned under greenstone,) clearly point us to an igneous agency.

I have elsewhere elucidated the argument in favour of the igneous origin of all rocks that are porphyritic, drawn from the chemistry of the subject. If that argument be valid, it is obvious that it will apply with peculiar force to the rock under consideration.

It is not uncommon to meet with specimens of porphyry that exhibit traces of an originally slaty structure in all or a part of the materials composing it. This clearly points us to a slaty rock as the source from which porphyry was derived. And sometimes fragments of this rock, along with fragments of compact feldspar, flinty slate, &c. are scattered through the mass as if partly melted down; very much as fragments appear in the slag of a furnace. They seem to be all but incorporated with the paste, and the whole mass presents an appearance

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of a more perfect chemical union than any rock resulting from aqueous agency ever exhibits, unless it be entirely crystalline.

Under what peculiar circumstances the matter composing porphyry was indurated, so as to prevent the greater part of the mass from assuming a crystalline state, it seems to me difficult to conjecture: and, therefore, I will not indulge in any speculations upon it. The gradual passage of this rock into sienite, without any apparent change of ingredients, seems to indicate that the peculiarities of porphyry did not result chiefly from the nature of the materials employed in its production.

### 17. SIENITE.

Most writers define classic sienite to be essentially composed of feldspar and hornblende: the first ingredient in the greatest quantity. It is essential also, that it should be connected with the overlying or trap rocks. This definition corresponds but to a small part of the sienite of Massachusetts. The greater part of it contains quartz as a constant and somewhat abundant ingredient, and mica is very often present. The most of our sienite is the granitic variety, and might perhaps have been described as sienitic granite. Yet in the eastern part of the state it is very intimately associated with greenstone; and, therefore, I have thought it best to describe all the varieties of rock, between greenstone and porphyry on one side, and common granite on the other, into whose composition hornblende enters, under the name of sienite. Macculloch's definition, which he says "alone rigidly accords with the common definition of sienite," embraces the most important variety of our sienite: viz. a granitiform mixture of feldspar, hornblende, and quartz. And this definition I shall take as the type of the rock now to be described.

The original specimen to which Werner applied the name sienite came from Sienna in Upper Egypt, whence were obtained many of the well known Egyptian monuments, such as Cleopatra's Needle, Pompey's Pillar, &c. But this rock, it is now well known, is nothing but a red granite with black mica and a very small proportion of hornblende; a rock quite different from what Werner supposed. This mistake has occasioned almost endless confusion in geological descriptions. Roziere proposed a remedy. Ascertaining that mount

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Sinai in Arabia is composed of genuine sienite, he proposed to change sienite into Sinaite: But geologists have unfortunately neglected the hint.

*Mineralogical Characters.*

1. ***Feldspar and Hornblende.*** This differs from greenstone by the predominance of the feldspar: and yet it is obvious that in respect to many specimens, and even large deposits, it is difficult to decide whether they should be referred to the former or the latter rock. In almost all cases both the ingredients are more or less crystalline; though sometimes, as at Nahant, the feldspar seems to be passing to a compact state. The hornblende is almost universally black; the feldspar white, greenish, and yellowish. (Nos. 1271 to 1285.)

I apprehend that by a careful examination of the specimens of this variety, nearly all of them would be found to contain more or less quartz: but quartz and feldspar, when seen through a microscope, resemble each other so much, that it is not easy to decide. At any rate, this variety insensibly admits quartz and mica into its composition, and thus approximates to granite. It is hardly necessary to say, that on the other hand it passes into greenstone. This variety, although elegant, is rarely wrought for ornamental purposes, on account of the proverbial toughness of the hornblende.

2. ***Feldspar, Quartz, and Hornblende.*** This variety embraces nearly all the sienite in the State that is employed for architectural purposes, including the quarries at Quincy and those at Cape Ann. Feldspar is the most abundant ingredient. This is foliated, and commonly of a grayish, bluish, or yellowish color. A hyaline quartz, varying in color from quite light to quite dark gray, is very uniformly mixed with the feldspar, so as to exhibit homogeneousness in the midst of variety. In general, the hornblende, which is black, is very sparingly disseminated, and hand specimens often contain not a particle. Indeed, over extensive tracts I have sometimes not met with any. Hence I regard this hornblende as an unessential ingredient; and consequently have arranged under this variety a rock very common in the vicinity of Boston, differing from that just described only by the absence of hornblende. It is most common a considerable distance south of Boston in the counties of Norfolk and Plymouth. In some instances, as may be seen by the specimens, Nos 1286 to 1308, the feldspar is flesh red, or a lilac red, and in others of a blood red color. Its great resemblance in structure and composition to the Quincy

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and Cape Ann sienites, and the remarkable absence of mica, have led me to associate it with the variety under consideration: and in fact it forms a part of the same range. I distinguish this rock from granite only by the absence of mica: yet it must be obvious that this mark is not very satisfactory.

Sometimes the feldspar in this compound of that mineral and quartz, is nearly or quite compact. I have observed this variety most frequently in the north part of Essex county, as in Rowley and Newbury. A like compound is connected with the sienite of other countries.

3. *Feldspar, Hornblende, Quartz and Mica.* In this quaternary compound we have a still nearer approach to granite. And generally it passes into granite by the disappearance of hornblende and the increase of quartz and mica. Yet in all cases where I have noticed it, this rock occupies a position between genuine granite and the newer stratified rocks. Hence I infer, that geologically considered, the difference between it and granite are important to be noticed.

The feldspar and hornblende are the predominant ingredients in this variety. The quartz is in so small grains that it is apt to escape notice; and the mica, being usually black, is very easily mistaken for hornblende. In general all the ingredients exhibit a liveliness of crystalline structure which is observable only in the oldest rocks. The feldspar is ordinarily white, sometimes flesh colored, and the hornblende black. The grain of the rock is commonly finer than that of the 2d variety. As yet it has been but seldom employed for architectural purposes; although it would be beautiful and enduring. (Nos. 1319 to 1340.)

4. *Porphyritic Sienite.* (Nos. 1341 to 1349.) I mean by this term any sienite through which are interspersed crystals or foliated masses of feldspar, so as to give the rock a porphyritic aspect. I do not recollect, however, ever having seen the last variety above described, porphyritic. And indeed, nearly all the rock which I regard as porphyritic sienite in Massachusetts, and specimens of which will be found in the collection, is almost entirely destitute of hornblende; and hence many geologists would regard it as porphyritic granite. But the specimens are rarely wanting in veins and disseminated masses of compact epidote, and I cannot but regard this mineral as more decidedly characteristic of our sienite than hornblende. If this be present and the mica almost or entirely absent, I have little hesitation in regarding the rock as geologically a part of a sienitic deposit.

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The most elegant variety of porphyritic sienite that I have met with in the State, occurs in Abington, and North Bridgwater, and in other parts of Plymouth county. Its base consists of quartz and feldspar, with an abundance of epidote disseminated and in veins. The feldspar crystals that constitute it a porphyry, are of a flesh color. There is also a dark colored mineral diffused through the mass, which may be hornblende or mica. This rock if polished would form it seems to me the most elegant ornamental stone in the State. (Nos. 1344 to 1347.)

The sienite of Cape Ann is often porphyritic. In one place, about half way between Sandy Bay and Gloucester Harbour, I found a variety in which the imbedded feldspar crystals are of a very rich bronze color, approaching in appearance to hypersthene. But when this rock is smoothed its aspect is too dark to be elegant. (No. 1343.)

5. *Conglomerated Sienite.* (Nos. 1350 to 1353.) This is a most interesting variety on account of the bearing which its characters have upon the theory of the formation of sienite. I have met with it chiefly in the compound No. 3, just described. The rock in general does not differ from that variety: but it contains rounded masses of the older stratified rocks. It is in fact a real conglomerate; and in some places the nodules are so numerous that it has very much the aspect of the course puddingstones of the newer rocks. The nodules vary in size from the diameter of half an inch to that of six or eight inches. They are not smoothed, like the pebbles in the more recent conglomerates, by mechanical attrition: but they appear like masses of rocks that have been partly melted down by heat. In almost all cases hornblende predominates in these nodules: and often they consist of distinct hornblende slate. Sometimes they contain mica in considerable quantity, and more rarely they consist chiefly of quartz and mica, the former in excess, forming a kind of quartz rock. Feldspar is also frequently present, especially in those cases where the schistose structure is indistinct; and sometimes the nodule appears to be only a variety of sienite in which the feldspar is in a smaller quantity than usual. Upon the whole, I think I have ascertained the presence of hornblende slate, mica slate, and quartz rock, in these nodules. When the rock is broken they are knocked out without difficulty, like the pebbles from a common conglomerate.

The theoretical inferences deducible from these facts I shall reserve for the sequel.

6. *Augitic Sienite.* The presence of hornblende in this rock and the absence of mica, have led me to call it augitic sienite rather than

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augitic granite; although in position it is associated with granite. There are two varieties. The first is composed of black hornblende, greenish augite, and yellowish feldspar; all the ingredients except the feldspar exhibiting a very distinct and lively crystalline structure. This variety occurs in the northern part of Belchertown. The other variety, which I have found only in bowlders in Amherst, consists of augite and feldspar; the former being so arranged in the latter as to present the appearance of letters. (Nos. 1362, 1363.)

*Topography of Sienite.*

The eastern, and northeastern parts of Massachusetts most abound in sienite. A large part of Essex County is based upon it, as are several towns in Middlesex. On the south of Boston it spreads over a large part of Norfolk county and some part of Plymouth. A glance at the map will show where it prevails most extensively. In all these places it forms hills of moderate elevation with no very striking characters. Its particular situation in respect to greenstone and granite I have already described in treating of the former rock.

The only other place in the State where I have met with sienite in place, is in the valley of the Connecticut. Here I have marked two deposits of considerable extent. The first extends from Mount Holyoke in Belchertown to Chickopee river and a little beyond: the other, on the west side of the Connecticut, occupies a considerable part of Northampton and Hatfield, and extends to the center of Whately.

Although sienite very much resembling that which exists in the valley of the Connecticut occurs in the eastern part of the state, yet none like that which is so commonly employed for architectural purposes in the eastern part of the state, known as the Quincy and Cape Ann sienite, is found in the valley of the Connecticut. Nor have I met with any in that valley which is porphyritic. Indeed, I have arranged all which has come under my observation in that valley, under the quaternary compound described as the third variety in giving the mineralogical characters: although I doubt not but one or more of the four ingredients may sometimes be wanting. Perhaps all of this sienite might properly be described as sienitic granite, or granite which takes a proportion of hornblende into its composition.

The sienite in the Connecticut valley occupies a low level, rarely rising into hills of more than 100 or 200 feet high: And on the west side of the river a considerable part of the formation is buried up by diluvium and tertiary strata.

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The sienite of this valley sometimes exhibits a strong disposition to assume a columnar form. Perhaps this is exhibited no where to better advantage than in the ledge by the road side about a mile north of Northampton village. The columnar masses are only a few inches in diameter, and are much less perfect than those found in greenstone. The fact, however, is interesting, as indicating a similarity in the causes that produced the two rocks.

### *Pseudo-Stratification of Sienite.*

At one of the quarries of this rock at Sandy Bay, Cape Ann, on the road from thence to Squam, a remarkably fine example may be seen of the division of this rock into parallel portions. Their thickness varies from two inches to two feet, and great facility is thus afforded for quarrying the stone.

As this apparent stratification extends only a few rods, while all the rest of the sienite on the Cape that I have met with, is unstratified, we cannot regard this case as real stratification. I consider it an example of the concretionary structure on a large scale. But it is unnecessary in this place to dwell upon this explanation, since I have already discussed it in treating of a similar phenomenon in greenstone.

### *Veins in Sienite.*

These are numerous and various in their probable mode of production, as well as in their composition. Some of them might properly be denominated, "veins of segregation;"* "as they seem to have been formed by a separation of parts during the gradual passage of the mineral masses into a solid state." In most cases they appear to consist only of harder portions of the rock, which become visible only by the weathering of the surface, when they are left in projecting ridges and at a little distance cannot be distinguished from injected veins. I presume that it will be found in all cases, that these veins differ somewhat in composition from the rest of the rock: and indeed, in some cases this is obvious, as they contain more or less of a foreign mineral, such as epidote or quartz.

The greater part of the veins in our sienite consist of materials foreign to the nature of the rock, and introduced subsequently to its original production. I do not say subsequently to its consolidation: for it has appeared to me possible, that while a molten mass of rock,

* Sedgwick's Anniversary Address before the London Geol. Soc. 1831, p. 3.

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say sienite, was in an incipient state of refrigeration, matter of a similar kind, still more intensely heated, might have been injected into it so as to form veins. And the very near approach which some of the veins in sienite and granite exhibit to veins of segregation, has led me to the suspicion that they might have been produced in some such way, rather than by the filling up of open fissures subsequent to the consolidation of the mass of the rock. However, very many of the veins in our sienite were obviously produced in the mode last mentioned: for we find that lateral slides, sometimes of considerable extent, have taken place along the course of the vein; and this could not probably have been done till after a considerable degree of induration.

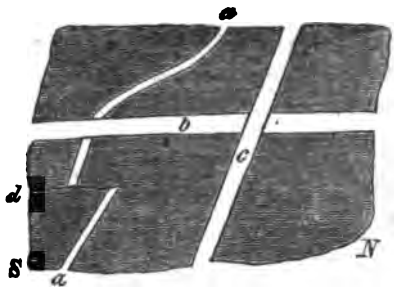
No substance is so common in the veins of our sienite as epidote. Yet the veins of this description are far less conspicuous than others, because they are so thin. Often they are easily mistaken for mere seams. The epidote is commonly very compact and resembles greenish compact feldspar: it has not, however, the toughness of that mineral, and it melts rather easily before the blowpipe into a black enamel. Sometimes the epidote of these veins is semicrystalline and well characterised. I think that the lateral slides in the sienite mentioned above, occur more frequently in connection with these epidote veins than with any other.

The other substances composing veins in our sienite, are granite, feldspar, and quartz. The granite is most common: though generally feldspar is greatly in excess, and frequently no mica is present. Hence the vein by a slight change becomes entirely feldspar, ordinarily of a reddish hue. In one instance only, which has been already mentioned under porphyry, a vein two or three feet wide consisted entirely of compact feldspar. The quartz veins are frequently hollow and abound in delicate crystals of the same mineral.

By far the most instructive exhibition of the veins that have been described, occurs in Whately, a mile or two a little west of south from the congregational meeting house. I subjoin a few sketches of those that struck me as particularly interesting.



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**Veins in Sienite: Whately.**

The above sketch represents an area about 10 feet long and, 6 feet wide. *aa*, is a fine grained granite vein an inch wide at the upper end, and decreasing downward: *b*, another granite vein of fine grain, one foot wide: *c*, a similar one of equal width: *d* is a fissure, or rather an epidote vein.

*aa*, is obviously the oldest vein; for it is cut off by *b*, and this again by *c*. Hence we have here granite and sienite of *four* epochs: 1st the rock of sienite itself: 2d the vein *a*: 3d the vein *b*, protruded subsequently: and 4th the vein *c*, injected last of all. At what epoch the vein *d* cut off *a*, *a*, we have no means of ascertaining; only that it was previous to the formation of the vein *c*, since this is not affected by the lateral slide apparent in *a*, *a*.

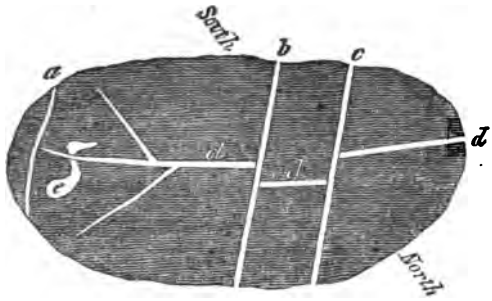
Macculloch says that "there have been granites found where a vein of a *third* granite traversed a vein of a second and different one, which had previously traversed the mass of a first."* The preceding sketch proves a *fourth* production of granite: for there can be no doubt but the sienite of Whately is a variety of granite. But if the suggestion above made, relating to the successive production of different granite veins, while yet the rock which they traverse was in a fluid or semi-fluid state, be admitted; we need not suppose any long interval between the formation of these veins. However, I do not place confidence enough in the suggestion to make it the foundation of any important inference.

The rock in the following sketch is about 15 feet long. *d*, *d*, *d*, is a vein of feldspar, two inches wide at its western extremity: but it ramifies at the other end and almost disappears. *a*, *b*, *c*, are veins of epidote, on each side of which the sienite has become indurated so as

* System of Geology. Vol. 1. p. 503.

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present ridges on the surface of the rock an inch or two in width; the epidote being a mere line in thickness. These veins have cut off the feldspar vein and produced an echellon movement of the central part. *e* is a nodule of some other rock enclosed in the sienite and cut off by the feldspar vein.

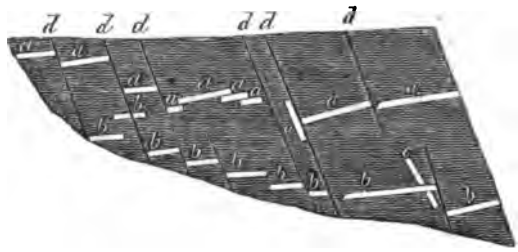



Veins in Sienite: Whately.

We have here only two successive formations of granite, though the epidote veins were protruded at a third epoch. And the lateral movement of the sienite by these veins, indicates, it seems to me, that although the rock was consolidated at the surface, yet not probably to any great depth, when these epidote veins were injected; otherwise I cannot conceive how such a movement could have been produced. A slight heaving of the waters of a stream would break and produce various slides in the ice on its surface when it was quite thin: but let the river be frozen nearly to the bottom, and such movements would be produced with great difficulty.

The following sketch was formerly inserted in the 6th volume of the American Journal of Science: but such a curious succession of echellon movements have been produced in the granite veins *a*, *a*, &c, *b*, *b*, &c. by the epidote veins *d*, *d*, &c, that I thought it deserved a place here. The sides of the rock represented are about 4, 6 and 10 feet, *c* is a fragment of some stratified rock imbedded in the sienite and cut through by the vein *b*. The width of the granite vein varies from one to 2 1-2 inches.

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**Veins in Sienite: Whately.**

It is easy to conceive how the detached portions of these two granite veins might be brought into *alignment*, (to continue the allusion above made to military manoeuvres,) but how they could have been thrown into their present position, except when the rock was in a fluid state, I am unable to conceive. And yet there must have been consistence enough in the veins to prevent their being diffused through the sienite. Does not this example lend some plausibility to the suggestion that has been made, relative to the protrusion of veins while yet the rock was in a partially fluid state? Or must we, in order to explain such a case as the present, suppose a second fusion of the rock?

### *Geological Position of Sienite.*

I am not aware that any of the sienite of Massachusets can be properly called an *overlying* rock: that is, I have found no example where it lies above other rocks. On one side it usually passes by insensible gradations into granite, and on the other into greenstone or porphyry: Or when these rocks are wanting, some of the stratified rocks, such as hornblende slate, graywacke, or new red sandstone, repose upon it. At least this is the impression I have received from all the examinations which I have made of our sienite; although I cannot refer to particular spots where these various rocks are brought into the relations that have been described. The low level at which our sienite is placed, has caused it to be very much covered with diluvium, so as to hide its junction with other rocks. Yet in all cases where this rock occurs, we find it between the oldest granite and greenstone, or the earlier stratified rocks. Hence I infer that a portion of the materials of which granite is composed, under certain circumstances were converted into sienite, and that these circumstances existed generally in that portion of the melted granite nearest the

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newer stratified rocks. Or if we suppose it erupted at a different epoch from the granite, certain causes always forced it upwards between the granite and the newer rocks. Or if we suppose it to have resulted from the melting down of the stratified rocks, then perhaps their more or less perfect fusion produced the difference which we find between granite and sienite. But more of this last suggestion in the sequel.

### *Mineral Contents.*

The limits between sienite and granite, as well as between sienite and greenstone, are so vague and unsettled, that it is not always easy to ascertain to which of these rocks minerals described by different writers belong; since in such a case geologists will be apt to give different names to the same rock. Genuine sienite, I mean that which is best characterised, is in Massachusetts rather barren of simple minerals: not quite so much so, however, as porphyry. By far the most common mineral is epidote; whose characters and mode of occurrence I have pointed out. The sienite used for architectural purposes from the vicinity of Boston, contains less of this mineral than any other variety in the state.

There is an interesting variety in the feldspar of this rock. In Beverly a few years since, a considerable quantity of green feldspar was obtained from a rock near the center of the place. The bronze coloured feldspar of Cape Ann has been already described, and that which is of a lilac colour in Hingham. In Charlestown a variety occurs in which the prisms exhibit stripes of various colors, and some have proposed for it the name *taenite*, on account of its resemblance to a ribbon. On Holyoke and Tom I have described a variety of trap in which this mineral presents a similar appearance. According to Professor Webster, hypersthene occurs in the sienite of Hingham along with hornblende. Amethyst is said to exist in the same rock in that place.

In the sienite of Beverly, fluate of lime and zircon have been found; and the former mineral in the rolled masses of this rock in Seekonk. In that of Charlestown Prof. Nuttall discovered arragonite. Prehnite, according to Prof. Webster, of superior excellence, is found there in the sienite: and that gentleman has recently informed me, that he has discovered in the same rock very superior specimens of chabasie and laumonite.

The veins of quartz abounding in delicate crystals in the sienite

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of Northampton and Whately, have been mentioned. Associated with these, I have sometimes found a mineral crystalized in four sided prisms, which I have been disposed to refer to red oxide of titanium. The best place for obtaining these minerals, particularly the quartz, is in Whately, about two and a half miles south of the meeting-house. Some of the drusy surfaces of this quartz present a curious pseudomorphous appearance. (No. 1369,) It is precisely such an appearance as would result from making random cuts in the quartz, while in the state of a paste, with a thin bladed knife. Obviously it has proceeded from the infiltration of the quartz around some mineral in thin plates, originally occupying the cavities and subsequently decomposing.

Following the eastern margin of this sienite about a mile south into Hatfield, from the locality last mentioned, we find a vein of sulphate of baryta, from one to four feet wide, running by the magnetic needle W. 22 1-2° N. and dipping about 90°. This baryta is the gangue of sulphuret of lead, blende, and pyritous copper. It has been excavated several feet and the quantity of baryta thrown out is immense.

### *Theoretical Considerations.*

Sienite is very rarely found in Massachusetts in continuous veins in other rocks like granite and greenstone. Sometimes, however, as I have formely stated, it penetrates sienite of a different variety, or greenstone, in so many directions and in such large quantity, that the rock so penetrated is divided into numerous fragments forming a kind of breccia. Even in these cases, the sienite which thus forms veins, contains but little hornblende. Upon the whole the argument in favor of the igneous origin of sienite from the mechanical or chemical effects of its veins, is comparatively feeble.

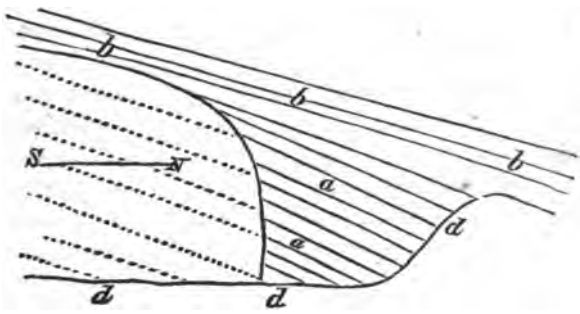
In the conglomerated sienite which has been described, however, I think we have a peculiar and forcible argument in favor of the former fusion of this rock by heat. Some other theoretical inferences also result from the facts in this case, which will need more minute details than have yet been given.

I have frequently observed this variety of sienite in the eastern part of the state. But there the nodules are so much changed in their characters that they seem to be only a variety of sienite. It is in the valley of the Connecticut that the most interesting and striking facts on this subject are developed; and in that valley Whately is the place that most particularly claims attention. The following imperfect

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sketch will give an idea of the situation of the conglomerated sienite there. It is the northern point of a range extending through Hatfield and Northampton southerly: and it here abuts against a limited deposit of hornblende slate, whose strata run nearly N. E. and S. W. as *a*, *a*, and stand nearly perpendicular to the horizon.

This slate is succeeded on the west by mica slate *b*, *b*, *b*, which in-




deed, sometimes alternates with the hornblende slate. On the eastern side *d*, *d*, *d*, the sienite and the slate are covered by the diluvium and new red sandstone of the valley of the Connecticut. The sienite and hornblende slate are elevated not more than 100 or 200 feet above the general level of that valley: but directly west of these rocks the mica slate rises more rapidly into ridges of much greater elevation, forming the eastern margin of the broad range of Hoosac mountain.

Now I have been led by an examination of the spot just described, (whose length is 3 or 4 miles and breadth less than one,) to conclude that the sienite was formed by the melting down of the hornblende slate. I infer this chiefly from the fact that this rock, as has been described, contains nodules of this slate, appearing as if rounded not by mechanical attrition but by heat. Why it should happen that the fusion of this slate should give rise to the production of feldspar, we may not be able fully to understand. And yet, if we suppose the hornblende slate to be composed of hornblende, mica and quartz, as it sometimes is in Whately, or that it alternates with mica slate, as it does there, we shall have in the materials melted down, all the essential ingredients of feldspar, viz. silex, alumina, and potassa. A certain degree of heat may be all that is necessary to enable these elements to enter into the new combination that is necessary to the production of feldspar. At any rate, I think I am not mistaken in the fact, that as the imbedded nodules in the slate approach more nearly

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to sienite in their characters, and recede farther from those of slate, the greater the quantity of feldspar. What can this circumstance result from, but from the greater degree of heat to which such nodules have been subject? Their losing in so great a degree the slaty character proves that they have been more nearly melted.

Another circumstance lends in my opinion a plausibility to the preceding suggestions. Towards the northern extremity of the hornblende slate above described, and at least a mile distant from the sienite, we find the slate composed of compact feldspar and hornblende; and its schistose structure almost obliterated. There is also a tendency in the rock to divide into columnar and rhomboidal forms. Now in these facts we see, it seems to me, the effects of a heat sufficient to produce a partial fusion of the rock, but not an entire obliteration of the slaty structure: sufficient for the production of feldspar, but not for its crystalization. All this indicates a source of heat of great power at a small depth where probably genuine sienite exists.

There is another fact which I have noticed in one portion of this sienite, that lends still farther support to these views. Two miles south of the spot where the sienite and slate meet, I observed the traces of an obsolete stratification in the former rock, running in the same direction as the basset edges of the slate. There is no actual division of the sienite into parallel portions, but only the marks of a former division by a sort of segregated ridges. The existence of the nodules of slate in the sienite proves that the fusion of the rock was never complete; and in these faint traces of original stratification do we not see evidence of the same fact; and in the coincidence of direction between the strata of hornblende slate and these marks, have we not presumptive evidence of the origin that I have imputed to the sienite.

These various facts and inferences have led my own mind to make another inquiry? Do we not here see the reason why one part of a deposit is sienite and another part granite; that is, a rock destitute of hornblende? When the fusion of a rock is complete and the heat carried to a certain degree, may not the production of hornblende become impossible, because those affinities and polarites operate that produce other minerals, especially feldspar and mica? The sienite in the valley of the Connecticut at least, occupies a position generally between the granite and the newer stratified rocks. And if we suppose the heat to have been greater at the time of the production of these rocks in proportion to the depth beneath the surface, it is obvi-

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ous that it must have been greater where the granite was produced than where the sienite is now found. For even if we do not suppose the sienite to have resulted from the fusion of stratified rocks, yet the proximity of its materials to these rocks must have greatly reduced the temperature of these materials: and if the stratified rocks were melted to form it, still more certainly would such be the result. Whether the position of sienite in other parts of the world is similar to that in the place under consideration I know not; nor can I say whether that in the eastern part of Massachusetts will throw any light upon these speculations.

This suggestion as to the ground of difference between sienite and granite, derives some support from the great scarcity of crystalized minerals in the former compared with those in the latter. I can imagine no cause for this difference so probable as a more or less perfect fusion of the materials. The history of porphyry leads the mind to the same conclusion.

These hypothetical views I am aware are new. But I have been led to form them from the facts that have been detailed; and if they are thought by geologists to deserve consideration, I hope that facts derived from other deposits of sienite and granite will be brought to light, to prove their fallacy or correctness.

### 18. GRANITE.

Having included under sienite all those unstratified granitic compounds which contain hornblende as a constituent, the definition of granite becomes easy. It is, indeed, the common definition, which makes it to consist of quartz, feldspar and mica. Dr. Macculloch adds hornblende: but it seems to me that this destroys the usual distinction between granite and sienite. Granite may, indeed, contain disseminated crystals of hornblende, as of garnet, pinite, or any other mineral; but if the quantity of this hornblende is so great that it must be regarded as a regular constituent of the rock, I do not know why it should not take the name of sienite, unless we should merge all sienite in granite: and to this I have no objections. I can conceive, indeed, how the geological relation of granite with hornblende, may be such to granite without hornblende, that it would be preposterous to attempt to separate them: but I know of no such case in Massachusetts. Here sienite occupies, as we have seeen, a constant geological position in respect to the granite about to be described.



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*Mineralogical Characters.*

1 *Common Granite.* This variety embraces nine tenths of the granite in Massachusetts. All those compounds of quartz feldspar and mica are included in it, which differ only in the size of the ingredients, in the greater or less perfection of their crystalline structure, and in their color. In these respects they do differ almost infinitely, as may be seen by the numerous specimens from various parts of the state in the collection. (Nos. 1372 to 1461.) Generally the quartz is gray, sometimes smoky; sometimes blue, and sometimes yellow. The feldspar is ordinarily yellowish white; sometimes green, as in Southbridge; sometimes blue, as in Leverett; sometimes tinged with purple, as in Palmer; and more often flesh colored, as in the coarse granite found in Blanford, Westfield, Amherst, &c, and in the finer grained granite in the southeast part of the state. The mica is more commonly of a silver color; sometimes of a straw or gold yellow, or greenish; sometimes of a brown color; sometimes black; sometimes rose red; and sometimes it is prismatic, as in Russell and Norwich.

In magnitude the ingredients vary from that of masses one and even two feet in diameter, to those so small that they can be distinguished but with difficulty by the naked eye. Those granites that possess a fine grain are the only varieties that are employed for architectural purposes. The coarsest varieties are generally found in veins.

2. *Pseudomorphous Granite.* This is a variety that exhibits a structure so peculiar, that I have thought it deserves a distinct notice. Suppose the quartz and feldspar requisite to form a coarse granite to be united into a solid mass. Suppose the mass to be now penetrated in various directions by the blade of a thin knife, and the cavities thus produced to be filled by plates of mica not more than one fiftieth of an inch thick. Although these plates would form solid angles, they would not intersect one another; and so it is in the rock. The smallest fragments of the quartz and feldspar are often separated by the mica; but I have never seen one plate of that mineral intersect another. The solid angles which these plates form in the quartz and feldspar, however, appear like the projecting angles of crystals, and hence I have applied to this granite the term pseudomorphous. The mica is usually of a deep bronze colour and often the plates are four or five inches across. (No. 1462.)

3. *Porphyritic Granite.* (Nos. 1463 to 1470.) In this variety, besides the ingredients composing the mass of the rock, and which are quartz, feldspar and mica, distinct imbedded crystals of feldspar

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are superadded. In Europe the basis of this rock is said to be fine grained: but in Massachusetts it is more commonly rather coarse grained.

Perhaps the most remarkable porphyritic granite in the state occurs in place in the west part of Harvard. (No. 1465.) It is a gray rather coarse granite with white feldspar, and the imbedded crystals are often two inches across; and being white, they give to the rock a striking appearance; and it has actually been mistaken by some writers for a conglomerate!

In Chester a large protruding mass of granite in the west part of the town is porphyritic. The imbedded crystals are much less than those just described, and of a gray color. The rock resembles porphyritic gneiss; but lacks both the laminar and stratified structure. (No. 1463.)

Probably a part of the rock which I have described as porphyritic sienite in the south east part of the state, as in Abington, N. Bridgwater, Fair Haven, &c, may more properly be regarded as granite. Indeed, as this rock is usually destitute of hornblende, perhaps the whole should be regarded as granite.

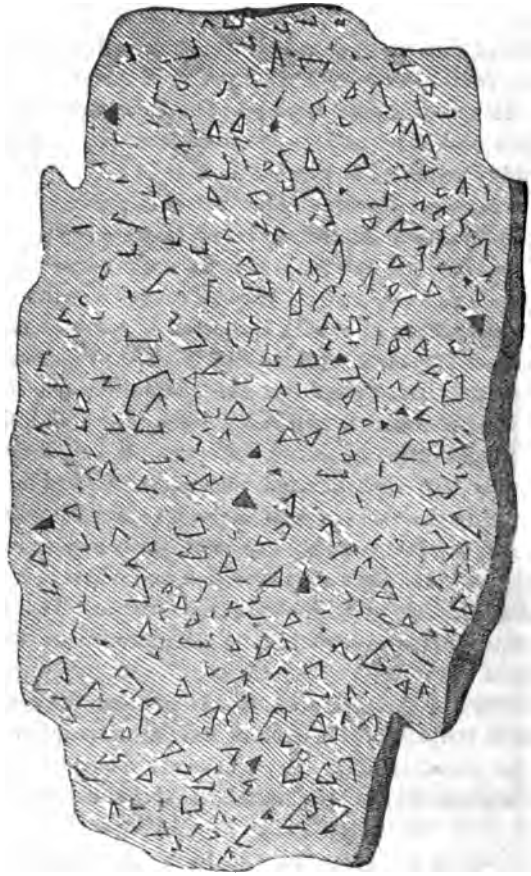
A very peculiar porphyritic granite occurs in the argillaceous slate of Guilford Vt. just without the limits of Massachusetts. I should have described this rock as a porphyry, were it not obviously a granite that has been partially fused. We can easily trace the gradations from the perfect granite to a rock composed of compact feldspar and imbedded masses of quartz. (Nos. 1467 to 1470.) At first we perceive nothing peculiar, except that the granite exhibits occasional spots of feldspar of nearly a milk white color, and a little indistinctness in the foliated structure of the feldspar. At length the feldspar becomes nearly all compact, and the mica, reduced in quantity, is disseminated in the mass as well as the quartz. Finally the feldspar is perfectly compact and only grains of quartz appear in it. The rock now begins to assume a slaty structure, and seems in fact to be argillaceous slate that has undergone a kind of fusion. The granite in this case is fine grained and would form a beautiful stone for architectural purposes.

It may be seen by the specimen No. 1455. that the granite from the quarries in Pelham N. Hampshire, exhibits a porphyroid aspect, similar to that just described. But I have not visited the locality and cannot say whether all the circumstances above described exist in that place.

4. *Graphic Granite.* (Nos. 1471 to 1480.) In this variety, which

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consists of quartz and feldspar only, the ingredients are usually in lengthened prisms, so that the cross fracture presents the appearance of written characters. It is the Pegmatite of the French geologists. Dr. Macculloch thinks it occurs exclusively in veins. But that is not the case in this country, unless every protruding mass of granite be regarded as a vein. In the coarser varieties of our granite, a portion of the mass—generally a small proportion—is graphic: and there is no well marked line of distinction between the varieties. This is particularly the case in respect to the pseudomorphous granite, so common in Conway, Goshen, Williamsburgh, and Westhampton. In Goshen a few years since, I found a specimen which afforded so perfect an example of the graphic arrangement in this rock that I thought it deserved to have its surface copied.



Fac Simile of Goshen Graphic Granite.

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### *Topography of Granite.*

Probably there is not a town in Massachusetts in which more or less of granite does not occur, either *in situ*, or as bowlders. And no rock is probably so generally known as this: though the term is often very loosely applied.

To begin with the eastern part of the State: It will be seen by the map that granite lies between the sienite on one side, and mica slate and gneiss on the other, nearly across the State; from Andover to R. Island. Generally this granite is coarse, and it forms no hills of much altitude. Obviously it has been powerfully abraded by currents of water. In elevation it is intermediate between the greenstone on one side, and the gneiss on the other; that is, as we pass from the coast westward, we gradually ascend; rising slightly from the alluvium to the graywacke; still more as we come upon the greenstone and the sienite; still more to reach the granite, and still more in the region of gneiss. The height of land between the ocean and Connecticut river, is not attained till we pass west of the valley of Worcester. A glance at the sections accompanying this Report will render these statements obvious. (Plates XVII and XVIII.)

The southern part of the range of granite above spoken of, is fine grained and passes into sienite, especially in Rhode Island. In the vicinity of Providence it is extensively wrought for architectural purposes. The splendid columns of fine grained white granite in the Arcade in that city, were obtained from a quarry in Johnstone, 5 miles northwest of Providence. "They are twelve in number," says Dr. Webb, "cut out of solid blocks, 21 feet long, 3 feet in diameter at the base, and weigh 11 tons each. It required 11 yoke of oxen to draw each one into town. It is calculated that it would have taken one man upwards of six months, to have wrought one of these columns. The stone for the first five locks of the Providence and Worcester canal, was also obtained from this quarry."

The broad deposit of granite marked between Narraganset and Buzzard Bays, consists chiefly of the common varieties. Much of it is extremely coarse. But in some places, as at Fall River in Troy, the grain is fine and the rock well adapted to architecture. Along the western border of this range the rock appears in place in great abundance; but as we pass easterly, the surface is almost entirely covered with bowlder stones, mostly of granite. On its northern margin, however, where we approach the graywacke, the loose blocks

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of this latter rock are so accumulated upon the granite, and the country is so nearly level, that it is impossible to ascertain the limits of the two rocks. As we go easterly into the region of the Middleborough ponds, the difficulty increases; and I have put down an extensive patch of diluvium in that quarter on this account. In the vicinity of New Bedford and Rochester the same difficulty has perplexed me in ascertaining the limits between granite and gneiss. Nor shall I be disapointed if the lines which I have finally settled upon shou'd need material alteration.

It will be seen that I have connected the Fall River range of granite on the east, with the sientic granite in Cohasset, Hingham, &c. Two facts have led me to do this. In the first place, as we pass from Marshfield through Pembroke, Plympton, and Carver, to Wareham, we do occasionally meet with a ledge of granite: and secondly the bowlder stones are nearly all granite. It will be seen, however, that a great part of this region I have marked as diluvial.

The map will show, also, that I have extended a strip of granite from Plymouth into Barnstable county as far east as Brewster, and carried another branch into Falmouth. These ranges follow the highest ridges in the south part of Plymouth and in Barnstable counties. And although in no part of these ridges, with one or two exceptions, have I found rocks in place, yet such is the size and number of the bowlders as to satisfy me that they have never been far removed from the parent rock; and I cannot but believe that ledges do exist a little below the surface; and not improbably in some places, which have not fallen under my notice, they may be found at the surface. Where first Cape Cod commences, and nearly half way between Sandwich and Falmouth, appearances are peculiarly indicative of granite ledges: and they continue nearly to the village of Falmouth. As we go eastward they are less striking, until we reach the town of Brewster, where, as I have shown under diluvium, there is reason to suppose the shattered crest of a ledge appears.

I am aware that it would have been accordant with truth to have colored the whole of Cape Cod as diluvial. But my rule has been not to exhibit that stratum when I could ascertain the rocks beneath it. Others must judge, whether the evidence of the existence of granite in place in the region under consideration, is probable enough to justify me in the course I have taken.

That gneiss range in the central parts of the State, which lies east of the Worcester mica slate, abounds in veins and protruding masses

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of granite: but I have thought it useless to attempt to represent them on the map. My opinion is, that in going easterly the granite increases in quantity until the gneiss and mica slate at length disappear.

The Worcester range of mica slate contains numerous large beds or protruding masses of granite; some of them of great interest, on account of their adaptedness to architectural purposes. It must not be expected, however, that in all cases a deposit of granite will be found in the precise place where one is marked on the map, in this mica slate. In Worcester the spot thus coloured is intended to mark out the true situation of an interesting deposit of granite: the only one which I have discovered in the southern part of the mica slate. The spot in Harvard, also, represents a deposit of remarkable porphyritic granite. In Westford, Lowell, and Tyngsborough, the spots coloured as granite, indicate only that numerous masses protrude in that vicinity. In Pelham, N. H., I intended to mark the bed which is now extensively quarried. In Pepperell, Townsend, and Lunenburg, I intended only that the beds marked should stand as the representatives of numerous veins and masses in those towns. The same is particularly true of the spots marked in Leominster and Westminster. In passing from the former to the latter place, granite is very abundant: and the mica slate, sometimes for a considerable distance, disappears. A spot marked in the south part of Fitchburg, is intended to designate the large hill of granite that furnishes so fine a building stone in that town.

Except in the northwest part, I have colored no spot as granite in the extensive range of gneiss in Worcester county. That it exists elsewhere I doubt not: as on the top of the hill in Spencer, where one sees the granite obviously protruding through the pseudo-gneiss strata: But I believe that much, which in that range has been called granite, is nothing but granitic gneiss. It is only after long experience in examining these rocks, that the difference is perceived between granitic gneiss and real granite.

In the northwest part of this gneiss range, especially in the lower part of N. Hampshire, we find the gneiss changing into mica slate, with occasional masses of considerable extent of fine grained granite, generally excellent for economical purposes. The beds of granite and mica slate which are there marked, are not intended to represent the exact relative position and quantity of the three rocks, but only to

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show that such a succession of strata is found there, and that the mica slate and granite occupy a large proportion of the surface.

The narrow range of granite extending from Amherst to the north line of the State, occupies an intermediate level between the alluvial bottom of the Connecticut valley, and the high ridge of gneiss bounding that valley on the east. It is an extremely coarse granite, and for the most part occurs in the form of veins or irregular masses in mica slate and gneiss. And in some places these rocks very much predominate and we lose sight of the granite.

The patch marked as granite in the agillaceous slate of Guilford, Vt., has been described in giving the mineralogical characters of this ock. I would add, that the beds are somewhat numerous, although but one is represented on the map. The deposit in Chester has also been described. The range extending from Conway into Connecticut, alone remains to be noticed. This occupies the space between the sienite on the east, and the mica slate on the west. More or less of the slate is intermixed with it through its whole extent; and on the west, and towards the south, this slate abounds and predominates. The strips of mica slate running into the granite, are intended merely to indicate the fact that they do thus penetrate it, rather than to give an exact representation of the particular places where this takes place.

For the most part the granite of this range is very coarse. Not unfrequently, however, very coarse and very fine granite are associated. In the granite patch extending from Norwich to Chesterfield, (and which implies only that beds are frequent in that region,) the rock is coarser than any that I have found in the state; the plates of mica being sometimes a foot or a foot and a half across. It is these coarse granite veins that are most prolific in minerals of an interesting character.

For the most part this granite range occupies a low level: or rather it is intermediate between the lowest and the highest of the rocks on the western side of Connecticut river. Some of the granite hills in Conway, Williamsburg, Whately, and West Hampton, rise higher than any others of the same rock in the state. Their altitude, however, is only a few hundred feet; and is far inferior to the hills of mica slate lying immediately to the west.

Upon the whole, all the granite of Massachusetts lies remarkably low in respect to other rocks; and one cannot avoid the inference when he examines its situation in almost all cases, that the abrasion of the stratified rocks may have brought the granite to light.

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In the conglomerate of the new red sandstone, at the south end of Sugar Loaf mountain in Deerfield, many of the nodules consist of a delicate variety of flesh coloured graphic granite. Whence it originated I am unable to conjecture.

### *Pseudo-Stratification of Granite.*

I have met with but one distinct example of this peculiar structure in the State: but it is a case of peculiar interest. It occurs in the patch of granite marked in Worcester. It occupies the hill, 200 or 300 feet high, a little northeast of the village. The rock is composed almost entirely of gray quartz and white foliated feldspar, with very little mica, and hardly differs from the sienite of Cape Ann and Quincy; although entirely destitute of hornblende. It is quarried in various places on the sides and the top of this hill, and in several of the excavations it exhibits a very distinct stratification. It is also crossed by numerous seams, nearly perpendicular to the horizon, not having any uniform direction; and generally the apparent strata do not correspond on opposite sides of the seams. This seems to result from their elevation or depression on the opposite sides. I satisfied myself, however, that the pseudo-strata conform on all sides nearly to the slope of the hill, being horizontal at the apex, and extending over the sides like the coats of an onion. If this be a fact, it shows conclusively that this hill of granite is an enormous concretion. The concentric layers, however, do not extend to every part of the hill: and this fact proves that there is no real stratification in the rock.

### *Phenomena of Veins and Irregular Protruding Masses of Granite.*

The only modes in which I have met with granite in Massachusetts are those of veins and protruding masses. In some instances regular masses with parallel planes are seen between the strata of other rocks; and on a superficial view, seem interstratified. But careful examination has always shown me, that such masses either cross the strata in a slight degree, or contract and expand like veins: and seem indeed to be veins coinciding nearly with the strata of the contained rock in direction. I can hardly say that I have met with granite as an overleying rock, though a few cases, which will be described farther on, exhibit this rock in a near approach to such a condition.



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The veins of granite in Massachusetts penetrate only the older rocks; the clay slate being the latest in which they are found. All the older stratified rocks abound in them; though in quartz rock I have rarely met with any. In gneiss they are very common, especially in the gneiss range east of the Worcester county mica slate: also in the vicinity of New Bedford: and in the southern part of the gneiss range in Hampden and Berkshire counties. Mica slate is penetrated by them and broken up by protruding masses of granite, at almost every step, in the granite range on the west of Northampton, particularly in the towns of Westfield, Blanford, Russell, Chester, Norwich, Williamsburgh, West Hampton, Goshen, Chesterfield, Whately, and Conway. In talcose slate they are very rare: In hornblende slate not common: in micaceous limestone sometimes met with: in serpentine I have never found one. In granite and sienite they are very abundant: and almost always the ingredients are much coarser than the granite or sienite that contains them.

For 8 or 10 years past I have been in the habit of taking rough sketches of those spots which I have met with, where granite veins and protruding masses exhibited any peculiarity which I supposed might be interesting to geologists. Of these cases I shall now give an account. I doubt not but a very great number besides these might be discovered by careful research. But to search them out requires a great deal of labor and patience.

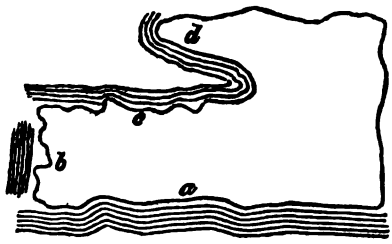
It ought to be premised, that in a large majority of cases, the intrusion of granite veins seems to have produced very little disturbance in the rocks containing them. They would seem to have been open fissures filled by the injection of granitic matter, without materially affecting the walls, except to unite with them chemically. And the same is true to some extent in regard to irregular masses of granite: that is, we do not always see any alteration in the dip and direction of the strata in the immediate vicinity of the granite. Yet in such case we usually find not far distant, an irregularity in the position of the stratified rock.

In giving the details which follow, it will not be easy to state beforehand any definite order that will be adopted. The most that I shall attempt will be to bring into juxta-positon those cases that are analogous.

The sketch below represents the manner in which the edges of the mica slate lie in contact with a protruding mass of granite in the

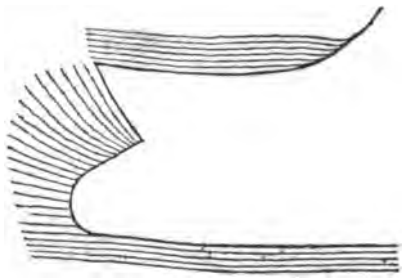
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south part of Conway.* At *a*, the slate runs north and south and dips east: at *b*, it dips south: at *c*, west; and at *d*, southeast. The sketch embraces an extent of only a few square rods.




(1) Junction of Granite and M. Slate; Conway.

No. 2. exhibits a similar case near the village of Blanford, close by the road to Granville. The mica slate here runs nearly north and south, and dips 80° west: except at the end of the mass of granite, where the dip is nearly north, about 70° or 80°.

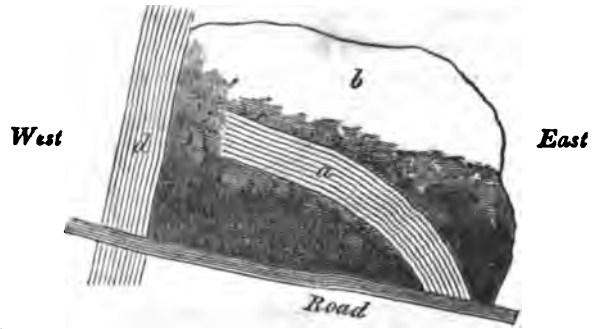


(2) Junction of Granite and M. Slate; Blanford.

The following case I noticed in the west part of Leominster; where the numerous veins and masses of granite in the mica slate, and the great confusion obvious in the latter, made me desirous to spend more time in examining the surrounding region than I was able to do.

* In all the following cases the uncolored part of the sketch represents granite; except that in a few cases (ex. gr. No. 9.) irregular lines are drawn to represent the irregular divisions of granite,

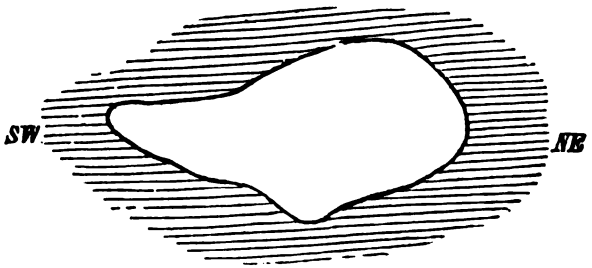
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(3) Junction of Granite and Mica Slate; Westminster.

At *b*, a mass of coarse granite occupies the top of a hill of considerable altitude. As we approach the road, descending from the hill, the granite is mostly concealed by diluvium. At *a*, however, mica slate appears running nearly east and west. A few rods to the west at *d*, it runs nearly north and south; which is the usual direction of the slate in that region. What but the disturbing force of the granite could have turned the mass *a*, nearly 90 degrees.

No. 4 exhibits a protruding mass of coarse granite 20 or 30 rods long in mica slate. The slate does not seem to be disturbed. It has an easterly dip of about 80°. The sketch was taken in the northwest part of Norwich.

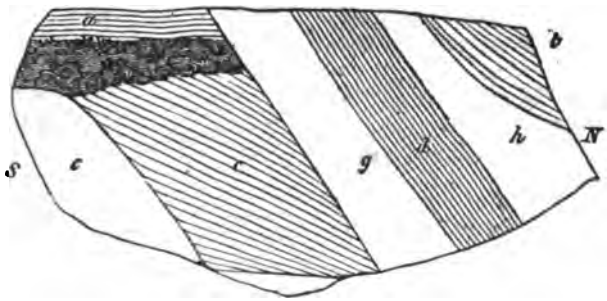



(4) Protruding Mass of Granite in Mica Slate. Norwich.

The following sketch was taken near the road from Norwich to Chester village, a little after we begin to descend the high hill on which Norwich stands. Over many acres in that place the mica slate and granite are mixed in the greatest confusion: but I could sketch only limited patches, and of course it is scarcely possible to give a

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correct view of all the disturbance that has taken place. The sketch below embraces a space about 8 rods long and 3 rods wide. *e*, *g*, *h*, are protruding masses or veins of granite. *a*, *b*, *c*, *d*, show the basset edges of mica slate. At *a*, its strata run nearly north and south and dip rather less than 45° to the west: which is the usual dip and direction in the vicinity. At *b* and *c*, the strata are turned so as to run nearly northeast and southwest; but the dip is increased only a few degrees. At *d* they are still more wheeled, and the dip is as high as 60° or 70°.

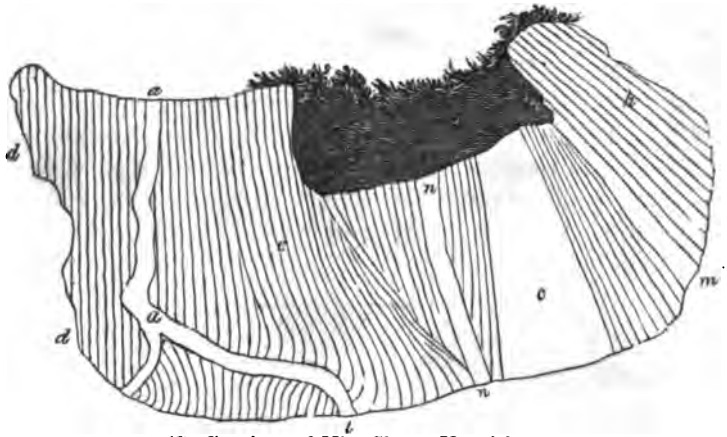



(5) Granite and Mica Slate; Norwich.

The next case is at the same place, and embraces a space about 16 rods long. *a*, *a*, *b*, *n*, *n*, *m*, *m*, are veins of granite from one to two feet wide, and *c*, a mass 10 feet wide. A large mass also lies on the side *d*, *d*. At *h*, the mica slate is deflected only a few degrees from the usual course of its strata, which is nearly north and south. The dip there is 45° northwest. But in every other part of the sketch, it will be seen that the mica slate is turned almost at right angles to its usual course, and towards the lower part of the sketch it exhibits most remarkable curvatures. The dip also, is in general greatly increased; so that in the vicinity of *e*, it is 80° north.

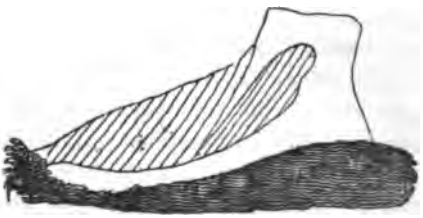
I feel the inadequacy of such sketches to convey a just idea of the very great confusion which this spot exhibits. But if any one can examine such places and still maintain that granite was not forced up through the slate while in a fused state, I can only say that his mind must view facts in a very different light from my own.

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(6) Granite and Mica Slate; Norwich.

The section below was taken at the same place as the two preceding sketches. It shows an irregular vein or mass of granite protruding through layers of mica slate. The granite mass is only two or three feet wide, and the mica slate four feet. It is obvious that the upper portion of the slate has here been forced upwards by the granite, so as to stand nearly perpendicular: the general dip being about 45° west.*



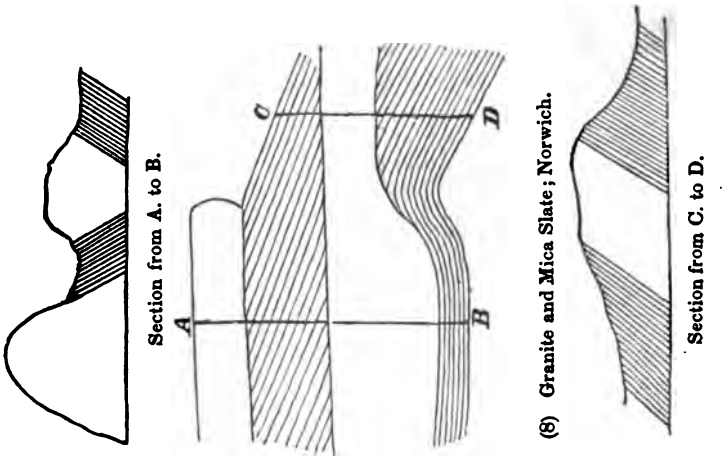
(7) Granite Vein in Mica Slate; Norwich.

In the northwest part of Norwich I sketched No. 8. Two beds or veins of granite are here shown: the central one, or that between the strips of mica slate, from 6 to 10 feet wide, and the outer one, which is but partly exhibited, 4 or 5 rods wide. One object I have in view, is to show the curvature of the mica slate, where the central mass of

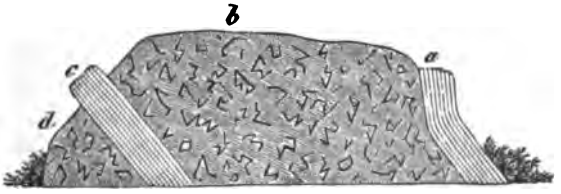
* This sketch is badly engraved. The dip of the layers of slate ought to decrease nearly one half, where it is farthest from the granite.

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granite expands. But the principal object is to show two sections across these rocks, four rods apart. The change in the dip from 80° west, to 80° east, on the section from A to B, is striking; and is explicable alone on the supposition of a disturbing force exerted by these huge masses of granite.




The section below (No. 9.) crosses from west to east, a ridge of mica slate and granite, about four rods wide. The stratum *a*, at its lower part, dips easterly about 25° or 30°; which is the usual dip of the slate in the vicinity; but the upper part of this stratum is thrown up nearly perpendicular; resting against the granite. This granite, *b*, is 3 or 4 rods across; when we find another stratum of the slate, *c*, having an easterly dip of nearly 50°. Below this another mass of granite, *d*, appears; but it is soon hid by the soil. Locality, near the line between Conway and Williamsburg.

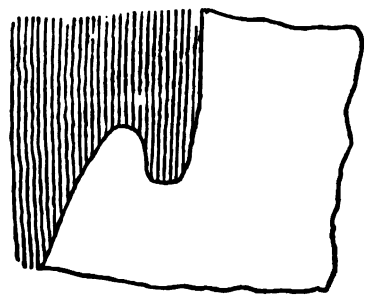



(9) Granite and Mica Slate; Conway.

No. 10 is in the town of Russell, on the road from Westfield to Blan-

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ford. It represents a perpendicular ledge about 20 feet square, where mica slate and granite come in contact. The layers of the slate are perpendicular, and this rock is chemically united to the granite. It is easy to conceive how the two rocks should be thus wedged into each other, if we admit that the granite was erupted while in a melted state; but I am unable to imagine any combination or peculiarity of circumstances, by which such a case can be explained on the theory of the aqueous origin of granite.

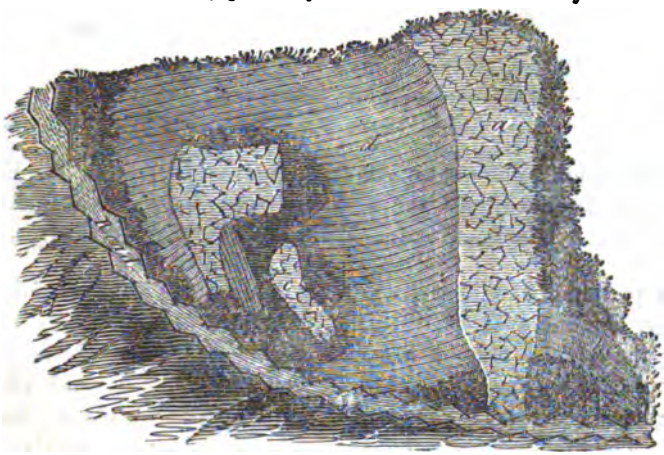


(10) Junction of Granite and M. Slate; Russell.

The next case I regard as one of peculiar interest; chiefly, however, on account of its locality. It is not in Massachusetts: but in Ackworth N. Hampshire, at a remarkable locality of beryls, rose quartz, and crystalized mica. As the traveler approaches this spot, he will observe, while yet several miles distant, a remarkable, conical, half naked peak, chiefly of white granite, shooting up about 300 feet above the surrounding country. This is the hill represented below, as seen on its northwestern side; along which a road passes. The prevailing rock in the vicinity is gneiss; but in this elevation it is cheifly hornblende slate, traversed by an enormous granite vein *a*, and exhibiting at least two protruding masses, *b* and *c*, of granite. The vein varies from one half to four rods in thickness, and the mass *b*, is four or five rods across: *c* is only 10 feet wide. The general direction of the laminae of the slate is north and south, and the dip from 15 to 20° east: but we have here the most decisive marks of its having been irregularly upheaved and disturbed by the protruding granite. Near the foot of the hill the slate is bent upwards so that the chord of the curve is several rods long. But it is a curious fact that the axis of the elevating force seems not to have coincided with the direction in which the vein was erupted. For the highest point of the curve of elevation,

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near the foot of the hill, is to the right of the vein at *h*; and as we ascend the hill, we find the slate curved upwards near the vein more and more, as is shown in the drawing. Indeed, the granite of the vein seems to lie on the elevated edges of the slate; so that the lower side of the vein dips southeasterly: and does not cut the slate perpendicularly. These facts would seem to evince, that the vein made its way through the slate, not along the line of greatest pressure but on the north side of it; probably because the slate there yielded most



**(11.) Veins and Masses of Granite in Hornblende Slate; Ackworth, N. H.**

readily. We may suppose the melted granite below, to have gradually elevated the slate, until at length it burst its way laterally through that rock. Such cases, I believe, do sometimes occur in existing volcanoes.

The masses of granite *b*, and *c*, are probably other examples in which the same molten matter burst its way laterally through the slate. And it is an interesting fact in regard to the mass *b*, that in some places it still projects over the slate several feet, forming in fact an overlying mass. Instances of this kind I have rarely met with in the granite of N. England. I recollect but one case precisely resembling this; and that is in the town of Carlisle, about two miles west of the meeting-house, near an unfrequented road; where the granite has spread over mica slate several feet. But the sketch of that spot I have unfortunately lost.

The following sketch, however, which I took several years ago, appears to have a resemblance to those just described; especially to



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that of the vein *a*, in Ackworth, although I did not then examine the case as carefully as I should now. It occurs two miles north of Chester village in Chester. The granite mass is several rods wide, and the dip of the mica slate on each side of it, about 50° degrees west.



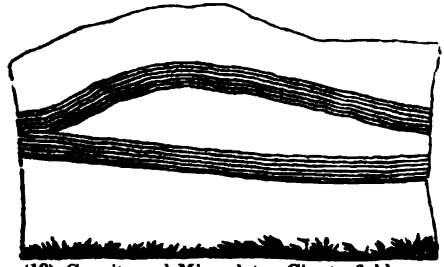

(12) Granite in Mica slate Chester;

In the eighth volume of the American Journal of Science, Dr. Emmons has described an interesting case of overlying granite in Chester, with veins proceeding from it downwards. The mass is 5 rods in length.

A portion of the hornblende slate (on No. 11) is seen running nearly east and west, or at right angles to the usual direction. Below the granite mass *b*, also, the strata are shifted almost 90°.

It is near the apex of this hill, that the interesting minerals above mentioned occur, and on the side of the apex opposite to that represented. The granite here is the coarsest I have ever seen: and probably the largest beryls in the world are found in it.

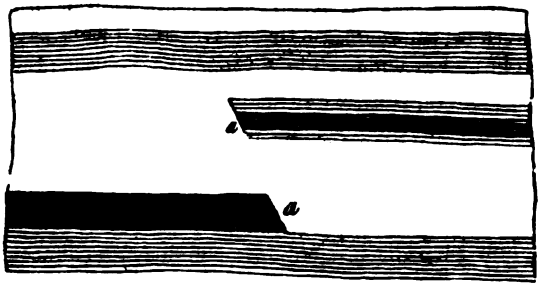
No. 13. exhibits the manner in which mica slate is sometimes enveloped by granite; the latter rock decidedly predominating. The spot here represented is several rods long, and occurs in Chesterfield, a little north of the meeting house. The dip and direction of the mica slate do not differ much from what is usual in the vicinity.



(13) Granite and Mica slate; Chesterfield.

The following case, No. 14, occurs about half a mile east of the meeting house in Williamsburgh. A granite vein about 4 feet wide.

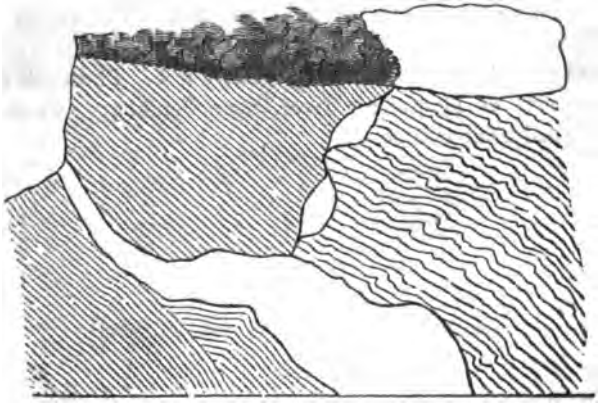
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(14) Granite Vein in Mica and Hornblende Slate. Williamsburgh.

runs here in the direction of the strata of mica slate. The dark stratum *a*, *a*, is hornblende slate, or perhaps amphibolic mica slate: and it appears to have been cut off and separated laterally a few feet. The upper mass of hornblende and mica slate is insulated in the granite, the narrowest vein of granite, however, being only three inches wide.

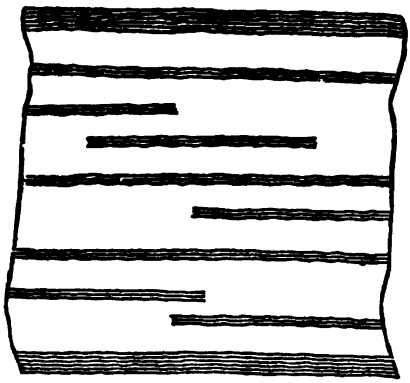
No. 15 represents two irregular masses of granite connected by a vein, or rather by two tubercular masses of the same rock. They occur in hornblende slate, two miles northeast of West Granville meeting house, on the road to Blanford. The strata of this slate usually stand perpendicular. Where thus penetrated by granite, however, the dip varies from 70° to 90° west; and its layers are exceedingly contorted. Their usual direction, also, is very much altered in some parts of the sketch. The sketch embraces a space of several square rods.



(15) Granite in Hornblende Slate: Granville.

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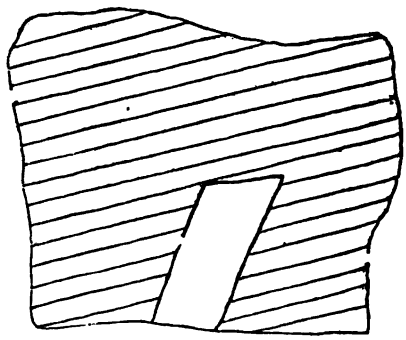
No. 16 exhibits a mass of granite three rods wide, with mica slate on each side, and embracing strips of mica slate from one half inch to six or eight inches wide. The direction of the layers in these insulated strips corresponds with that of the mica slate generally in the vicinity: viz. a north and south direction. This case occurs in Chesterfield, one mile east of the meeting house, on the road to Northampton. It is easy to explain it on the supposition that the granite was erupted from beneath in a melted state: but I find it hard to conceive how such effects could have resulted from aqueous agency.



(16) Mica Slate in Granite: Chesterfield.

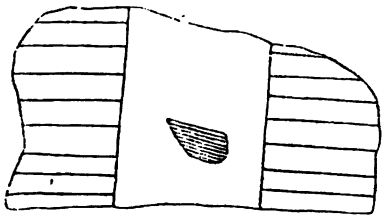
The sketch below represents a nearly perpendicular ledge of gneiss, from 70 to 100 feet high, in the lower part of which a mass of granite appears, which does not rise through the strata. The gneiss has a small dip to the west, though somewhat irregular. The vein of granite is from 10 to 12 feet thick, and rises thirty feet. The locality is on the north side of Housatonic river, near Southbury, Ct. close by what is called Zoar Bridge.

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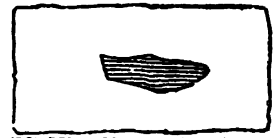


(17) Granite Vein in Gneiss, Zoar Bridge, Ct.

Nos. 18, 19 and 20 are representations of insulated masses of mica slate and gneiss in large veins of granite. The vein in No. 18, which is in the north part of Shutesbury, is ten feet wide, and the insulated mass of gneiss is almost three feet across in its longest direction. In No. 19, which is in Conway, the vein is fifteen inches wide and the mass of mica slate (which is the rock traversed by the vein,) is thirty inches long. In No. 20, the imbedded mass of mica slate is eight feet wide and ten feet high; the layers standing perpendicular, and coinciding with those of the mica slate generally in that place. In all the cases described, it seems impossible to doubt but the schistose rock is perfectly insulated in the granite; and if so, does it not point to an igneous origin for the granite?

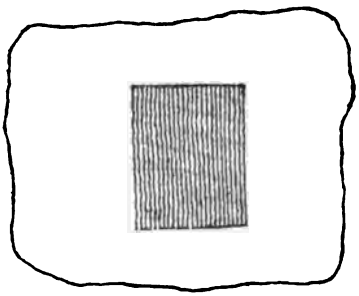


(18) Mass of Gneiss in Granite; Shutesbury.



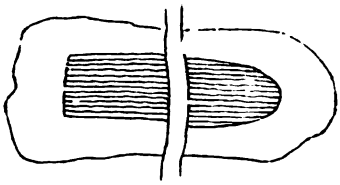
(19) Mica Slate in Granite; Conway.

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(20) Mica Slate in Granite; Chester.

No. 21 differs but little from the preceeding cases. Two granite masses appear to be connected by two veins; the widest of which is two feet, and the other only six inches thick. Thus a piece of mica slate is insulated, and both this and the granite are cut by a more recent vein of granite, fifteen inches wide. This case occurs three miles northeast of the meeting house in Williamsburgh. But I have not personally examined it, and am indebted to Mr. Alanson Nash for the sketch.

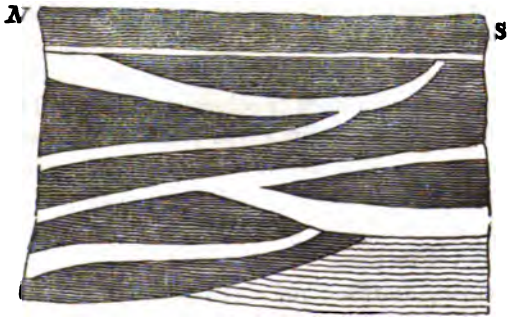


(21) Granite and Mica Slate; Williamsburgh.

Veins of granite traversing granite are more frequent in Massachusetts than in any other rock. Generally the veins are composed of much coarser materials than the rock that contains them; and by this mark alone can they be distinguished, except that sometimes the color of the materials of the vein and that of the containing rock, are different. The following case occurs in the west part of Whately, and exhibits a mass of granite of fine texture, about fifteen feet long and ten feet wide, with mica slate on one side. The dark part of the drawing represents this granite, and the white strips crossing it are veins of coarse granite. Must we not suppose such veins produced

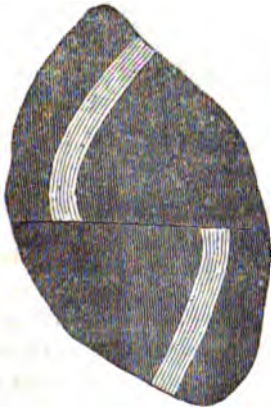
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by the injection of granitic materials through a mass of granite while yet in a plastic state?

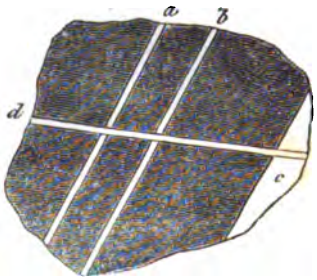



(22) Granite Veins in Granite; Whatley

In No. 23 a coarse vein, made up almost entirely of feldspar, 20 inches wide, traverses a rather coarse granite. This vein has been cut off by a fissure crossing it nearly at right angles, and the two parts are separated seven feet. This lateral movement must have taken place after the consolidation of the rock. The case occurs in the extreme southeast part of Newport, R. Island.



(23) Granite Vein in Granite; Newport, R. I.




(24) Granite Veins in Granite; Gay Head.

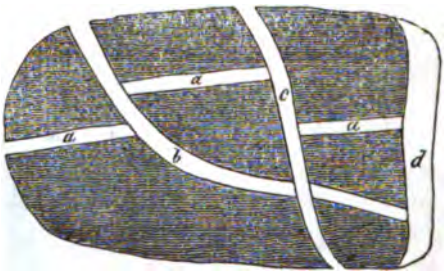
No. 24 represents an enormous bowlder of granite, from 20 to 30 feet diameter, lying at the foot of the clay cliff at Gay Head, Martha's Vineyard. *a*, *b*, *c*, are granite veins of the same epoch; as is proved by their parallelism. These are all cut off by a vein *d*, of subse-

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quent date, crossing them nearly at right angles. Here then we have granite of three distinct epochs.

No. 25 shows us granite of four successive epochs of eruption. It is the sketch of a bowlder, 20 feet long and 10 feet thick, lying in West Hampton. The great mass of the rock belongs to the first epoch. The vein *a*, *a*, *a*, was produced at the second epoch. This was intersected by *b*, at a third or subsequent epoch. This, as well as *a*, were intersected by the vein *c* (and probably at the same time by *d*,) at a fourth epoch. The lateral removal of the middle portion of the vein *a*, seems to have resulted from the intrusion of the veins *b* and *c*, whereby the wedge shaped portion of the rock between them was crowded out of its place.

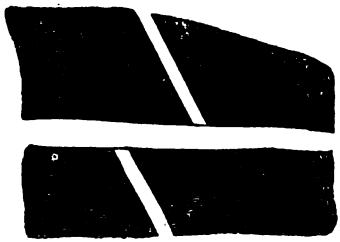
I have heretofore described and sketched a case in which a rock of sienite (sienitic granite,) contains granite veins of three subsequent epochs. The case now described corresponds to that, except that the base of the one sketched below, is genuine granite. Both of them, however, may be regarded as presenting us with granite erupted at four successive epochs: and this is the greatest number that I have ever met with.




(25) Granite Veins in Granite; W. Hampton.

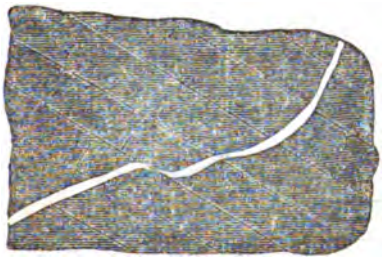
The next case is one of no peculiar interest, hardly worth preserving indeed. The sketch shows a vein of coarse granite, 10 inches wide, traversing a mass of finer granite, and cutting off and removing laterally another vein of coarse granite, 2 1-2 inches wide. It occurs in Southampton, not far from the spot where an adit has been made in the granite to reach a vein of galena.

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(26) Granite Veins in Granite; Southampton.

No. 27 shows a granite vein of a little more than a foot in width, crossing strata of gneiss obliquely. After this vein was injected, the strata of gneiss seem to have slidden down so as to cut off the vein in at least two places, and near those spots the vein is considerably reduced in size, as if in a plastic state when the disturbance took place in the gneiss.

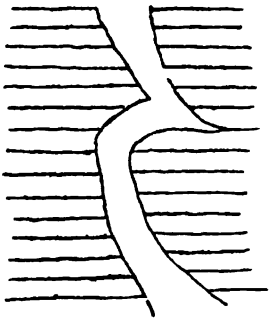


(27) Granite Vein in Gneiss; Shutesbury.

The five next cases viz. 28, 29, 30, 31, and 32, were sketched in New Bedford and Fairhaven: all but Nos. 29, and 31 on Palmer's Island, in New Bedford Harbour. They all occur in gneiss. No. 28 is interesting chiefly on account of the peculiar form of the vein, which varies in width from two feet down to six inches. It exhibits the vein as it appears on the basset edges of the gneiss where the strata dip to the north about 35°.

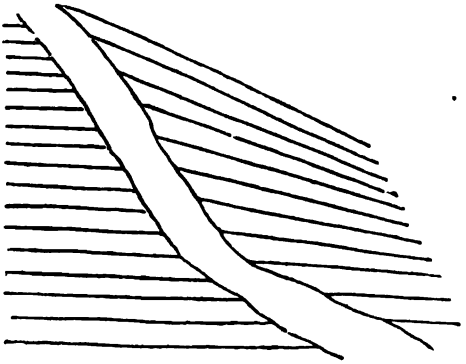


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(28) Granite Veins in Gneiss; Palmer's Island; N. Bedford Harbor.

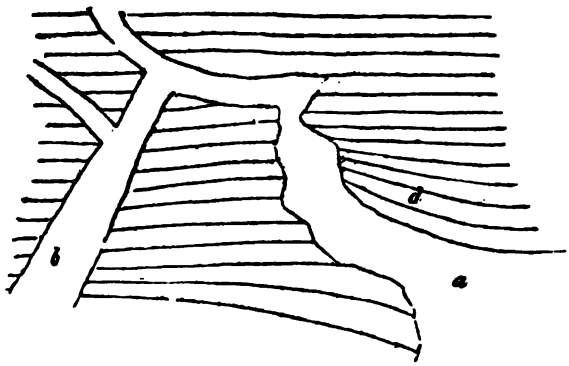
The surface sketched in No. 29 is nearly horizontal; and the strata of gneiss dip as in the last case. On one side the direction of the strata is changed, and apparently through the influence of the vein, as much as 10° or 15°. The vein is 15 inches wide.



(29) Granite Vein in Gneiss: At the fort in Fairhaven.

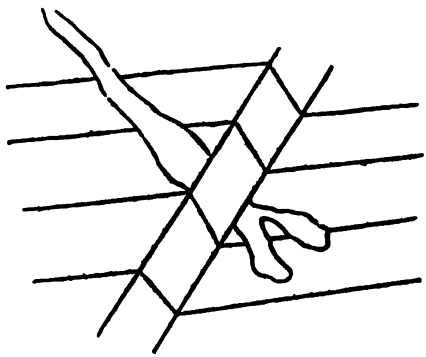
No. 30 exhibits also the basset edges of the gneiss strata where they dip 35° northerly. A mass of granite, *a*, which is several feet wide where it first appears above the soil, sends off a very crooked vein of six or eight inches wide, which connects with another vein, *b*; which last vein also sends off a narrow branch. At *d*, the edges of the strata are curved considerably, obviously in consequence of the granite in their vicinity.

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(30) Granite Veins in Gneiss; Palmer's Island; N. Bedford Harbor.

In No. 31, a vein of granite about six inches wide, is intersected by another a foot wide. The strata of gneiss on one side of the last mentioned vein have also been moved laterally about four inches; so that the seams do not correspond on opposite sides. I am inclined to believe that it is an error in the sketch, that it does not show a similar slide in the vein that has been intersected: though I have no rcccollection on the subject. The basset edges of the strata are here represented.

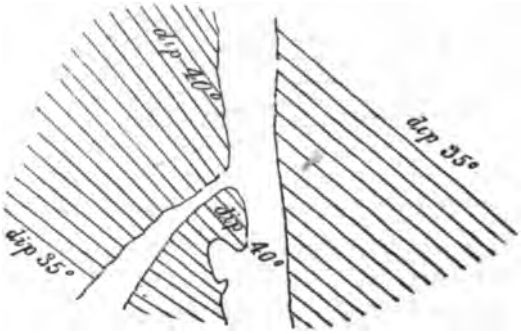


(31) Granite Veins in Gneiss; Fair Haven.

No. 32 is a nearly perpendicular section, running nearly north and south across the strata of gneiss, and showing an irregular branching vein. The principal vein is two feet wide, the branch about one

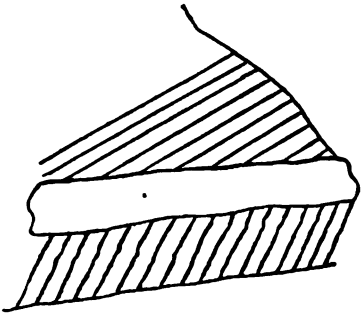
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foot. It will be seen that the general dip of the strata is 35°; and that this is increased to 40° on the lower side of the vein. This is one of those cases which would be apppealed to in proof that veins were filled from above. The disturbance of the strata, however, proves that it was not filled by crystalization from aqueous solution. The lower edge of the section coresponds to high water mark. The spot can be well examined only in a boat.




(32) Granite Vein in Gneiss : Pulmers Island N. Bedford Harbor.

No. 33 was sketched from a bowlder of gneiss in the south part of Tolland. It is traversed by a vein of granite a foot wide. The only object is to show the change in the direction of the strata on different sides of the vein.

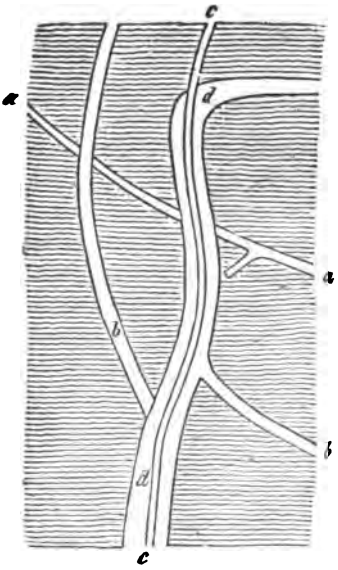


(33) Granite Vein in Gneiss; Tolland

For No. 34, taken in the northeast part of Williamsburg, I am indebted to Mr. Alanson Nash. *a*, *a*, appears to be the oldest vein of granite in mica slate; and is only two inches wide: *b*, *b*, is a second vein; as is proved by its cutting through *a*, *a*, and is of the same

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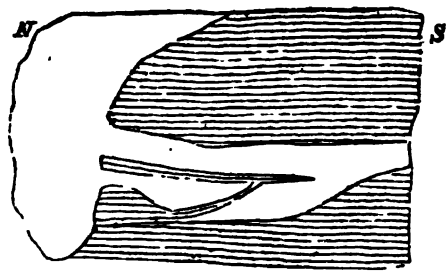
width as *a*, *a*, : *d*, *d*, is a third vein; as is proved by its intersecting the two first. It is six inches wide: *c*, *c*, is a fourth vein, two inches wide, intersecting *d*, *d*, longitudinally, and distinguished from that by being of a much coarser texture. This is a very unusual occurence; one which I have myself never seen; and we have here also granite of four epochs; so that this example, if there be no mistake in its representation, is a very interesting one.




(34) Granite Veins in Mica slate; Williamsburg.

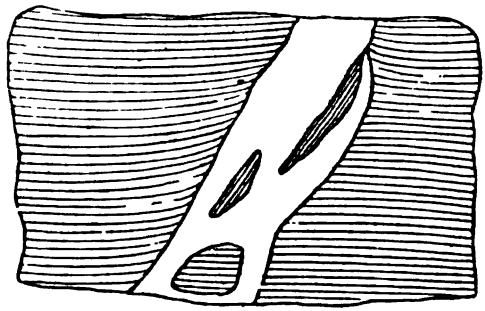
In No. 35 a large protruding mass of granite rises from the soil at the north end of a naked ledge of mica slate, which is two rods wide, as represented on the sketch. From this mass of granite an irregular vein proceeds nearly in the direction of the layers of slate, embracing two or three nearly insulated strips of mica slate. I am not aware that any very instructive inference can be derived from this case, except that it seems to me impossible to impute to deposition from water, a mass of granite thus irregularly intruded among the mica slate. It occurs in the west part of Whately.

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(35) Granite Veins in Mica Slate; Whately.

No. 36 is situated near the same spot. It represents the inclined surface of a ledge of mica slate, through which a granite vein of four feet wide passes. This embraces three masses of mica slate of considerable size, which are evidently separated entirely from the parent rock, except one of them nearest the upper side of the sketch. The layers of the mica slate, in the direction in which the granite was erupted, are obviously considerably curved, as is shown in the figure.

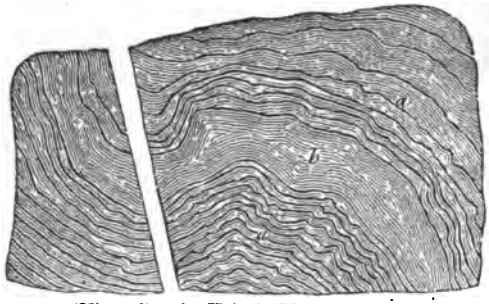


(36) Granite Vein in Mica Slate; Whately.

No. 37 represents a nearly perpendicular ledge of mica slate in Conway, very much contorted, about two miles southwest of the center of the town. *a*, *a*, are strata of common mica slate: *b*, is a stratum of amphibolic mica slate. The whole surface exhibited is 15 feet long and eight feet high. Through this ledge runs a vein of fine grained granite a foot wide. The object of giving the sketch is to show that this vein has produced no derangement of the mica slate: for the different varieties of that rock occupy the same relative position on the different sides of the vein. Hence the vein was introduced subsequently to the consolidation of the slate; and probably it

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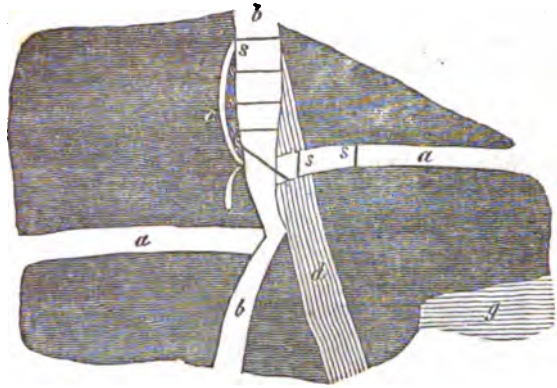
was injected into an open fissure. Hence too we must be cautious in imputing contortions in mica slate, even in the vicinity of granite veins, to their eruptive force.



(37) Granite Vein in Mica Slate; Conway.

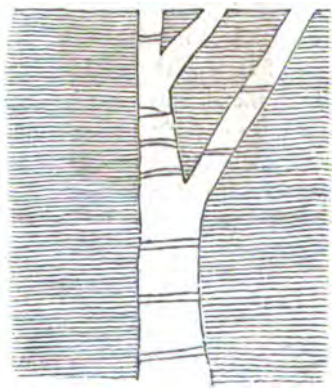
No. 38 was sketched only 100 rods northeast of the congregational meeting house in Conway. It represents two granite and several quartz veins, in coarse micaceous limestone. *a*, *a*, appears to have been the oldest granite vein, and is a foot wide on the right hand side of *b*, *b*, and 20 inches at the other extremity. This is intersected by another granite vein, *b*, *b*, and the two extremities are removed asunder 42 inches. *c* is a curved branch of this vein: *b*, *b*, is from 12 to 18 inches wide. *s*, *s*, *s*, *s*, *s*, *s*, *s*, are quartz veins, from half an inch to 2 inches wide, and one of them it will be seen, intersects both the granite veins; and, therefore, these quartz veins appear to have been of posterior origin to both the granite veins. *d*, and *g*, are masses of mica slate, with which rock the micaceous limestone, (that constitutes the dark part in the sketch,) is interlaminated in the vicinity. The direction of the layers of slate in the mass *g*, corresponds with that of this rock generally in the vicinity: but in what manner the mass *d*, should have been thrown at right angles to this direction it seems difficult to imagine. It is obvious, however, that these granite veins have produced great disturbance in this spot.

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(38) Granite Veins in Micaceous Limestone: Conway.

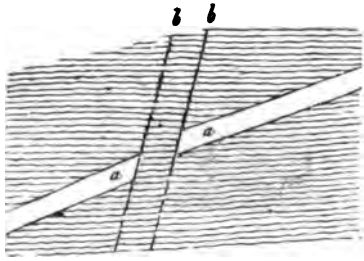
In the same town and near the same spot, may be seen the original of No. 39. We have here a vein of granite, 40 inches wide, which sends off two branches; the first at an angle of 20° and the second at an angle of 50°. Both the branches are 18 inches wide, and the portion of the vein which continues in a direct course is 14 inches wide. Intersecting these veins of granite, we find several of quartz, whose width varies from one inch to 3 inches; and whose direction corresponds with that of the contiguous layers of mica slate. The probability is that these, like most other quartz veins, were the result of the infiltration of siliceous matter into fissures previously produced deccation or mechanical force.



(39) Granite and Quartz veins in Mica Slate; Conway.

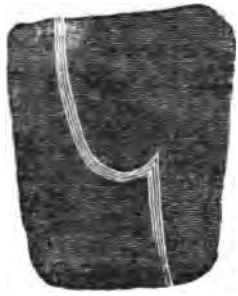
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No. 40 is in the same town. *a*, *a*, is a granite vein corresponding nearly in direction with the layers of mica slate; the two parts of which are separated by mica slate several feet and one extremity is not as wide as the other. The two parts arealso shifted laterally by the two fissures *b*, *b*. I confess myself unable to give any satisfactory solution of the anomalies of this case.




(40) Granite Vein in Mica Slate; Conway.

No. 41 was sketched from a bowlder in Conway, merely on account of the peculiar form of the granite vein which traverses mica slate. The widest part of the vein is only an inch across, and this is reduced to half an inch at the other extremity. I neglected to sketch the direction in which the layers of slate run.



(41) Granite Vein in M. Slate; Conway.

No. 42 appears to be an example of the mechanical effects upon the layers of mica slate, of a protruding vein of granite. It occurs at Narrymore's quarry in the west part of Goshen; where the layers of mica slate are arranged with remarkable regularity. The dip there



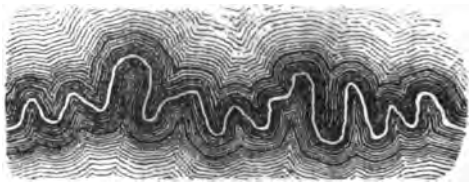
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is about 40° northerly: but where a granite vein of 4 feet wide (*b*,) protrudes in a nearly perpendicular direction, the strata of the slate on the lower side of the vein, for the width of 8 inches, (*a*) are bent so as to stand perpendicularly against the vein. On the upper side of the vein, and immediately in contact with it, the slate is hidden by soil: but it appears again a few feet distant, at *c*. This example was brought to light by the quarrymen, and as it was sketched several years ago, ere this they may have destroyed all traces of it.




(42) Granite Vein in M. Slate; Goshen.

No. 43 represents a vein of granite, only 1-8 of an inch thick, traversing mica slate in Conway, one mile southwest of the congregational meeting house. Strictly speaking it is a bed: for it is interlaminated with the slate and conforms to its tortuosities. It is not perhaps easy to conceive how such a vein could have been intruded between the layers of the slate, on account of its extreme thinness. Perhaps it ought rather to be regarded as one of the layers of the slate, produced in the same manner as the laminae of gneiss.



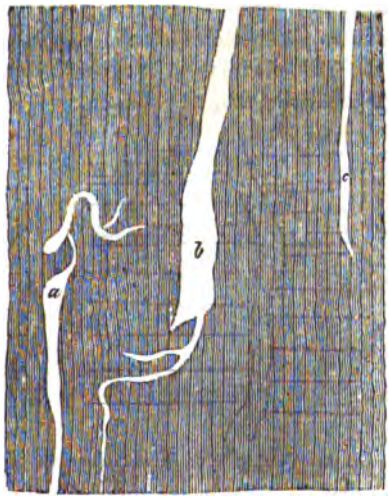
(43) Granite Vein in Mica Slate; Conway.

No. 44 was sketched near the same spot. It represents the edge of a thick stratum of mica slate, whose dip is 50° east: and whose laminae correspond in dip to the strata seams. Among these laminae and running in nearly the same direction, are three narrow and quite irregular granite veins. *a* seems to have been injected from below, and has no apparent connection with *b*, which would seem to have flowed in from above. *c* is a third very narrow vein only 1-4 of an inch wide, which has no connection with the others.

I have sketched this case, because it seems more favorable than any

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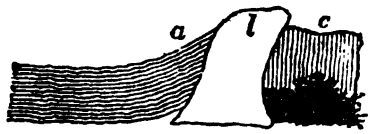
I have met with, to the old Wernerian notion of the filling up of veins by infiltration from water. Yet there is nothing in the case inconsistent with the igneous origin of the granite: for if that rock was originally in a molten state, it would flow horizontally and downwards through any openings that were made for it: and we have only to suppose that *b* and *c* have an unseen connection with a mass of granite that has been forced upward. And that such a mass exists in the vicinity, the vein *a*, having no opening above, shows to be probable. Such masses also appear at the surface in the vicinity.




(44) Granite Veins in Mica Slate; Conway.

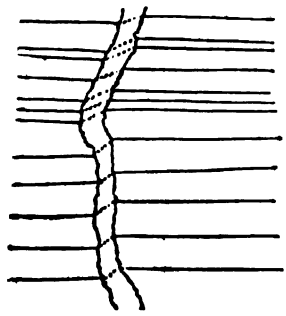
No. 45 occurs in Goshen, not more than a mile or two from No. 42; and it is analogous to No. 42. It may be seen two miles west of the village, on the old road to Cummington, on the margin of a pond. It represents a ledge of mica slate a few feet high, whose strata dip from the observer, and whose basset edges only appear. On coming within 30 inches of the mass of granite *b*, the laminae of slate are bent upwards 20°; and on the other side of the granite, *c*, they actually stand perpendicular or even lean a few degrees from the granite. The width of the protruding mass of granite, which is partly hid by the soil, is from three to four feet. It is common to see mica slate and other stratified rocks as much disturbed in the vicinity of granite as this case exhibits: but it is not common to meet with the disturbance on so small a scale.

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(45) Granite Vein in Mica Slate; Goshen.

The mica slate in the northwest part of Norwich is frequently very regular in its stratification, dipping west 80°: and this is the case where No. 46 was sketched. A granite vein four inches wide crosses the strata nearly at right angles, and the edges of the mica slate show that the layers on opposite sides of the vein have been moved a few inches laterally. The distinctness of the stratification enables us to see this change more easily than is common.



(46) Granite Vein in Mica Slate: Norwich.

Nos. 47 and 48 represents granite veins in micaceous limestone in the west part of Colrain. They are bowlders of about 2 feet in diameter, and the veins only an inch or two wide. The extremely serpentine course of these veins is the most remarkable circumstance about them. For I could not discover any cause that makes them thus serpentize. The limestone appears perfectly homogeneous throughout, and is entirely destitute of any appearance of a laminar, slaty, or stratified structure; I mean so far as these specimens are concerned.

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(47) Granite Veins in Micaceous Limestone Colrain.



(48) Granite Vein in Micaceous Limestone; Colrain.

I shall not in this place deduce any general theoretical inferences from the facts respecting granite veins that have now been detailed. In the sequel, however, I may refer to them again, so far as they have a bearing upon theory.

### *Mineral Contents.*

In every part of the world granite is the repository of very many of the most perfectly crystalized minerals: an evidence that its materials must once have been most thoroughly fluid, either by water or heat. The number of mineral species in the granite of Massachusetts is not quite as numerous as in one or two other rocks: yet it contains several of the most interesting minerals in the State.

Sulphate of baryta is extremely abundant in it; though the most

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prolific locality, — that in Hatfield, — occurs in sienite, and has been described. A considerable part of the matrix of galena, blende, and copper pyrites, at the Southampton mine, consists of this mineral. The most southerly vein of lead ore in Leverett, also, abounds in it, as the gangue of the galena. And both the metallic veins in that place are in granite. The baryta occurs generally in foliated masses: sometimes in tabular crystals. The folia are sometimes curved; and sometimes, as in Leverett, the specimens are coarsely granular. The color is uniformly white.

Carbonate of lime is rare in granite: but in the vein of metallic ores above spoken of at Southampton, we find it in distinct crystals; sometimes of a delicate straw color. I have observed there a dodecaedeon composed of two six sided pyramids: a short six sided prism acuminated by three faces: also the same with all the solid angles of the prism truncated, producing a trapezoedron. This mineral more frequently is laminated.

The situation of the argentine in West Hampton, partly in the mica slate and partly in the granite, renders it proper to speak of it as belonging to either rock: but under micaceous limestone I have given a full description of its geological position, and its mineralogical characters correspond so well with those that are given in the books, that nothing more need be added. The locality cannot for a considerable time, if ever, be exhausted; unless it should be visited by some of those insatiable collectors, who carry away specimens by the ton. (Nos. 1490, 1491.)

This same mineral has been found at the Southampton lead mine.

At the most northerly vein of galena and pyritous copper in Leverett, I have found a few specimens of crystalized brown spar.

In Billerica and Stow, phosphate of lime has been found by Professor Webster in very coarse granite: Also by Mr. C. T. Jackson, in the same rock in Lancaster, in connexion with spodumene.

At the Southampton lead mine, green and purple fluate of lime has been found, but not in large quantities: though should this mine ever be wrought extensively, there can be little doubt that abundance of it will be brought to light.

At the same place we meet with crystalized limpid quartz in great abundance. Sometimes the crystals are penetrated throughout by a yellow colouring matter, so as to form genuine yellow quartz. Radiated quartz forms the greater part of the gangue of the lead and copper ores, in the several veins of these metals that have been described as existing in Hampshire county, in the first part of this report. In

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Chester, the quartz in this rock is sometimes rose red. In Goshen its crystals are sometimes of an extremely delicate smoke color; and in Williamsburgh, this variety occurs uncrystalized in large quantity, about two miles west of the meeting-house. In Bristol, Rhode Island, occur fine specimens of amethyst; which are said to proceed from the granite of Mount Hope. This locality a few years since promised something for the lapidary.

At the Southampton lead mine pseudomorphous quartz is sometimes met with. But the most interesting locality is in the galena vein near the agentine locality, in West Hampton. The pseudomorphous crystals are very perfect, and have the form of *hog tooth spar*, and of cubic fluate of lime. These crystals are hollow, and generally are drusy without and within. It is now, however, very difficult to obtain specimens, especially of the variety, that has assumed the form of fluor spar. (Nos. 1501, 1502.)

In Conway I observed that some of the quartz in coarse granite was highly fetid. The same is found in Chester.

A mineral is sometimes seen at the Southampton lead mine, which appears to be hornstone. (No. 1502.)

Pinite, according to Mr. C. T. Jackson, has been found in granite on George Hill in Lancaster, and of fine quality.

In the 20th volume of the American Journal of Science, I have described a specimen of limpid topaz in granite, found upon the White Hills in New Hampshire. In Haddam, Ct. it is well known, occurs the chrysoberyl in the same rock.

Spodumene abounds in our granite. Goshen is its most abundant locality. About two miles north of the village, it occurs on the road to Ashfield; and also about three miles northeast of the center of the town, on the road to Plainfield, at a locality long celebrated for furnishing several interesting minerals. It is found likewise in Chesterfield, Norwich, and Chester. In all these places its characters are similar. It occurs in prismatic masses whose crystalline form cannot be determined. These masses are sometimes four or five inches across, and sometimes of great length. Dr. Dwight of Cummington showed me a specimen from Chesterfield, containing a prism 21 inches long, yet broken off at both ends. These larger masses are commonly of a white or gray color, and resemble feldspar. But the smaller specimens are frequently of a delicate green color. resembling very much the spodumene from the north part of Europe. A few specimens I have noticed of a light rose color. (Nos. 1504 to 1507)

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This mineral occurs also in Sterling in a granite rock. This spodumene has more of a pearly aspect than that in the western part of the State ; as the specimens in the collection will show. It is also of a more milky white color. (No. 1508)

Dr. Emmons is of opinion that "the large cleaveable variety" of lepidolite occurs in Goshen. Probably he refers to the mineral that has been generally regarded as rose mica.

The varieties of mica in our granite are numerous and interesting. The rose red just referred to, has been found only I believe in the northwest part of Goshen, where it sometimes occurs in oblique rhombic prisms; which is its primary form. In the same place, also, and likewise in the northwest part of Chesterfield, at the tourmaline locality, a delicate yellow mica of various shades is found under the same form: and still more frequently, a transparent or silver colored variety. But the most remarkable locality of crystalized mica is in Ackworth New Hampshire: where are found finer specimens, associated with beryls and rose quartz, than at any other spot in this country. The crystals are distinct six sided tables, disseminated through gray quartz, and attached to fine grained feldspar. They vary in size from half an inch in diameter to an inch and a half. I have some reason to fear, however, that this locality may not prove very prolific.

Prismatic mica is found in Goshen, Chesterfield, Norwich, and Leverett. But the specimens which I found in Russell are the best. (Nos. 1512 to 1514 ) The general color of the prisms is light smoke gray: but we sometimes see in them distinct strips, penetrating deep into the specimen, of a very dark bronze color ; appearing black indeed, except in very thin plates.

Plumose mica (*Mica fibreux*, Beudant,) is quite common in Williamsburg, in several places west and northwest of the village. The name is derived from the resemblance between the arrangement of its lamellae and those of a feather: which indeed is often quite striking.

The granite of Massachusetts contains almost every variety of the schorl family that has been found on the globe. Common black schorl is most abundant. In Chesterfield and Goshen its crystals are sometimes large, but generally quite imperfect. In Norwich its crystals are terminated by pyramids. In Westford, also, I met with it in small very short acuminated crystals. (No. 1547)

Of the tourmalines we have every variety, except perhaps the yellow and the white. Indicolite occurs at the greatest number of lo-

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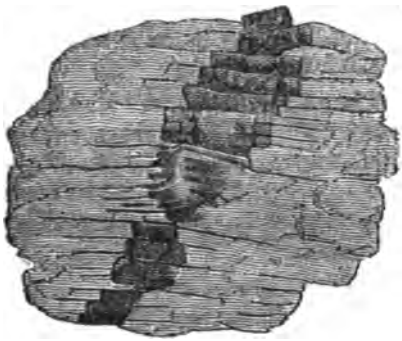
calities. In Chester it is found in large crystals: also in connection with the green and red varieties in the northwest part of Goshen, associated with several other minerals.

The most noted locality of green and red tourmalines is in Chesterfield, on land of Mr. Clark. They are contained in an enormous vein of granite in mica slate, which corresponds nearly in direction with the layers of the slate. This granite is crossed obliquely by a vein, varying in width from six to eighteen inches, of smoky quartz and silicious feldspar: or rather, the quartz forms the central part of the vein, and the feldspar lies on each side of the quartz: the green red and blue tourmalines, with schorl and sometimes beryl, passing through the feldspar and the quartz. This cross vein has been laid open from twelve to twenty feet by blasting; and it is really, in the eye of a mineralogist, a splendid object. I do not see that there is any prospect that it will soon be exhausted; although I doubt whether as fine specimens are now obtained from it as formerly.

The crystals of green tourmaline and rubellite at this locality occur in rounded prisms, deeply striated longitudinally. They have been found an inch in diameter, but generally they are much less, and the red are rarely more than one quarter of an inch: sometimes they exhibit triedral summits. It is very common for the rubellite to be enclosed in the green crystals, and sometimes a thin layer of talc intervenes between the inner and the outer crystals. Col. Gibbs found three of the red crystals in one instance aggregated together, and enclosed by one of green. The green crystals also sometimes embrace indicolite, and sometimes indicolite encloses the green tourmaline, as may bes een by the specimens Nos. 1521 1522 & 1524. The green tourmalines as well as the rubellite are sometimes entirely distinct from each other; especially when they are contained in the quartz. In some instances I have met with marks of rather singular disturbances which took place while the green tourmaline was crystalizing in the quartz. The quartz is fissured into somewhat parallel laminae, and together with portions of the crystal, has been subjected to a sort of *echellon* movement, while in some places it has been so compressd as almost to disappear. This last circumstance seems to indicate that the disturbance took place before the crystalization was completed. The following sketch is intended to represent this phenomenon.



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Crystal of Green Tourmaline in Quartz; Chesterfield.

The colors of the tourmalines in Chesterfield are pretty uniform: but in Goshen they vary exceedingly. The rubellite is rarely met with there; but the indicolite is abundant; and this passes by numerous gradations into green tourmalines. Of some specimens, indeed, it is difficult to say whether they should be regarded as blue or green. There also we meet with a yellowish green tourmaline, (No. ) which is associated with spodumene. Sometimes also I have seen this mineral nearly brown and even approaching to white. At Chesterfield the green variety is opaque: but some of its crystals at Goshen, penetrating mica, are translucent.

All the common varieties of feldspar are of course abundant in our granite. Its ordinary color is white. But in Leverett it is blue; and often the folia are six or eight inches across. In Goshen I have met with it slightly green. The siliceous feldspar, or Cleavelandite, is found as already noticed, at Chesterfield, where it is commonly foliated, but sometimes coarsely granular. At Goshen the same varieties occur: and that which is granular exceedingly resembles sacharine limestone. In Norwich it is found foliated and of a light blue color. At the other localities it is always white. Mr. Andrews, preceptor of New Salem Academy, finds it in foliated masses in that town of the same color. It is found also at Chester. (Nos. 1535 to 1536.

Beryls are frequently met with in our granite: though in general they are not very delicate. Perhaps the most so is a limped beryl, occuring in Goshen along with spodumene, &c. It is rarely distinctly crystalized and is full of fissures. Sometimes it is of a light rose color. (Nos. 1525 to 1528 ) In Norwich and Chesterfield beryls are sometimes found of a great size; — at the latter place a foot in diam-

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eter: but such crystals are irregular and devoid of beauty. In Williamsburgh they sometimes occur smaller, but more valuable. From Pelham I have a specimen of a greenish yellow beryl, of considerable beauty: they are said also to have been found in Worthington: and Dr. Marshall showed me a fine crystal 11-2 inch diameter, found in the granite of Fitchburg. In Stow, also, this mineral has been found in granite.

It has been stated that iolite is found in the granite of Goshen: but I have never met with it.

Garnet is less abundant in our granite than in several of the older stratified rocks. Generally where it does occur, it is in quite small crystals; but it is commonly the precious garnet. In Bedford it is said to be found in large and sometimes perfect trapezoidal crystals.

If No. 1529. do not belong to the zeolite family of minerals, I cannot tell where to refer it. I mean the radiated mineral upon fine granite from Goshen.

I believe that all the veins marked on the geological map, as well as on Plate XVII, as lead veins, in Hampshire County and the south part of Franklin, are either entirely contained in granite, or pass from that rock into mica slate. Hence the minerals which they contain may properly be described in this place.

The gangue of the most southerly vein in Leverett is sulphate of baryta and quartz. It is only a foot or two in width, and is entirely in granite. It contains galena only. The most northerly vein in that town is several feet wide, and is mostly in mica slate. It contains galena and pyritous copper in nearly equal proportion.

The vein in Southampton, to which I have often referred, and which has been explored farther than any other in the State, traverses granite and mica slate; and the gangue is mostly quartz with sulphate of baryta occasionally. Its extent and situation have, however, been already given in the first part of my report with sufficient minuteness. Galena is the principal ore. Blende, however, is frequent, as well as pyritous copper. Here also have been found the carbonate, molybdate, sulphate, phosphate, and murio-carbonate of lead; the blue and green carbonate of copper and vitreous black oxide of iron. Here also we find sulphuret of iron in small oxtahedra, truncated on all their angles. The carbonate of lead is found in tabular prisms with bevelments: also in six sided prisms with four sided acuminations: also in triangular dodecaedra with their apices deeply truncated. The murio-carbonate of lead is in light green groups of cubic

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crystals terminated by tetraedral pyramids. The sulphate of lead occurs in small plates on the galena. The phosphate of lead exists in spherical light green masses.

The vein in the south part of Southampton is said to have a gangue of quartz containing galena, and to be not more than a foot wide. I have not visited it.

About a mile northeasterly from the adit in Southampton, a vein of quartz, mostly radiated, several feet wide, traverses mica slate chiefly, and contains blende and galena; the former in much the greatest quantity. The blende here, as well at all the veins in the vicinity, is foliated, rarely in distinct crystals, and of a honey yellow color.

The vein in West Hampton, near the locality of argentine, is very large, at least 10 feet wide; though I could not ascertain its true width. It is composed entirely of radiated and crystalized quartz, surrounding small masses of some other rock, probably mica slate, the whole mass having a brecciated appearance. Galena, the only ore that has been found here, is very sparingly disseminated. I could not ascertain whether this vein is in granite or mica slate; both of which rocks occur in the vicinity.

The veins in Williamsburgh, according to Mr Nash, occur in granite and mica slate, and the gangue is quartz. Only one of them, however, has been discovered in the rock, their existence being inferred from the loose blocks strewed over the surface. In at least one of these veins, the oxide of mangenese occurs, along with galena. Pyritous copper exists there also, in small quantity: and I found foliated blende. This ore appears to have a strong tendency to decomposition, and often the cavity that contained it, is filled with a dull red powder whose true nature I have not yet ascertained. But it is certainly not the oxide of lead, as Mr. Nash has stated in the 12th volume of the American Journal of Science!

The three veins in Whately have all a gangue of quartz, generally radiated. The most easterly one, according to Mr. Nash, contains oxide of manganese as well as galena. The most northerly one is six feet wide and lies chiefly in granite. It contains blende as well as galena. The two other veins described by Mr. Nash I have tried in vain to find.

According to the Messrs. Danas, muriate of copper has been found in a rolled mass of granite in Woburn.

It is said, also, that specular oxide of iron occurs in Mendon, and in Cumberland, R. Island, in granite.

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In the 16th volume of the American Journal of Science, I have given a very particular account of the single crystal of the oxide of tin, which I found several years ago, at the well known locality of several interesting minerals in the northwest part of Goshen. Its form, if I did not mistake it, was an octahedron with a square base: though the measurements of several of the angles did not coincide with those given in the books. But as to its being genuine oxide of tin, there can be no doubt: especially since the discovery in Europe of this same substance in a specimen sent from Chesterfield, Mass. as mentioned in Mohs Mineralogy.*

Mr. Nuttall suggests with a doubt, that the phosphate of manganese exists in Sterling, in connection with spodumene. The same mineral, whatever it be, is found in Goshen with the spodumene.

Sulphuret of molybdenum has been found in granite in New Bedford and Fitchburg.

The only remaining mineral to be noticed in the granite of Massachusetts, is the columbite at Chesterfield. It was discovered at the tourmaline locality by Mr. C. U. Shepard, in right rectangular prisms with several modifications. The same gentleman found this rare mineral in two places in Goshen, imbedded in spodumene.

### *Theoretical Considerations.*

I have already expressed the decided opinion, that if an igneous origin be assigned to the trap rocks, as is now done almost universally, a similar origin cannot be denied to granite. There is not indeed, so great a resemblance in appearance, between granite and recent lavas, as between these and the trap rocks: nor does granite occur in columnar masses. But except in these two respects, the same arguments which prove the igneous origin of the traps, equally apply and sometimes I think with more force, in proof of the original igneous fluidity and protrusion of granite. And if I mistake not, there are one or two additional arguments in the case of granite. I shall now briefly present these arguments as they apply to the granite of Massachusetts.

1. *I infer the igneous origin of granite from the inclined position of the older stratified rocks.* The stratified and slaty structure of these rocks is conclusive evidence that water was the medium of their original deposition. But if deposited in water, their laminæ could not at

* Vol. 2 p 387. Edinburgh, 1825.

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first have varied much from a horizontal position: for we know of no examples in which depositions take place in water, where the surface is inclined more than a few degrees, except perhaps in those limited cases, where tufaceous masses are deposited from water charged with lime or silex, flowing down inclined planes. But the older stratified rocks are for the most part highly inclined, often vertical indeed, as the accompanying Sections will show. They must, therefore, have been elevated subsequently to their deposition. And when we find that a large proportion of the organic remains in the secondary rocks are of marine origin, can we doubt that existing continents once formed the bottom of the ocean? This opinion must now be regarded as an established principle in geology. But by what power was this elevation accomplished? That it was volcanic, in the sense in which that term is now generally employed, I very much doubt: because it seems to have acted along extended lines, and not from a center or centers. An hypothesis as to its nature, I shall suggest in another place. But I cannot conceive how the stratified rocks could have been elevated as we find them, without admitting two conditions. First, that the solid crust of the globe must have been comparatively thin, in order to give way to any internal force that we can imagine might act upon it: Secondly, that a molten mass must have existed beneath this crust, so that when it was elevated in any particular part and depressed in others, the fluid nucleus might have readily conformed to the sinuosities of its inferior surface. Where, for instance, a long mountain ridge was lifted up, if no such fused matter were forced up underneath it to occupy the cavity thus produced, it is difficult to conceive how it could be sustained through a lapse of centuries. Nay, it is difficult to conceive how such an enormous weight could have been lifted up thousands of feet, if such a molten mass had not been pressing against it beneath with considerable force, and thus lending assistance to any lateral agency that might have been in operation. Now if granite were not this fused plastic mass, we shall search in vain among the rocks to find one that could have been in such a state: for the trap rocks are not in sufficient quantity to answer the conditions of this case; and they are, moreover, usually associated with the newer stratified rocks. But granite corresponds both in its nature and position with such a supposition. And if we exclude the agency of granite, I do not believe we can account for the elevation of the strata which all admit has taken place.

2. *I infer the igneous origin of granite from the manner in which it*

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*is intruded among the stratified rocks.* This argument is far more striking in the case of granite than in that of greenstone. For it is hardly possible to conceive of any anomaly of position which the former rock has not assumed in relation to the stratified ones. Its veins are of every size and shape, and they run in all directions through the superincumbent strata; and similar irregularities exist in its larger and less ramified masses. True, they are rarely superincumbent upon the stratified rocks; and hence some have inferred that they could not have been erupted like trap and lava, which often spread over the surface to a great extent. There is, however, one consideration, — to waive all others, — which it seems to me obviates this difficulty. We have abundant evidence that the surfaceof the earth has suffered powerful abrasion in past ages; and since granite is confessedly older than the traps, it must have suffered most from this cause. Now who can tell but granite did once exist in overlying masses, and that those have been mostly worn away, and their remains entombed in the later rocks which so abound in nodules of granite? If existing causes operate long enough, the overlying masses of trap, now so common in various places, must be thus swept away, and its veins and protruding masses alone remain.

This argument, however, cannot be felt in all its force without connecting it with another circumstance which forms my next argument.

3. *I infer the igneous origin of granite from the mechanical effects which it appears to have exerted upon the stratified rocks in its immediate vicinity.*

To illustrate these effects is a principal object which I have had in view in giving so many sketches of veins and protruding masses of granite. Most of these cases seem to me totally inexplicable on any other supposition than that of the protrusion of the granite while in a fluid or semi-fluid state. But after all, such sketches convey only a very imperfect conception of the actual marks of disturbance, which the stratified rocks in the vicinity of granite exhibit. Their dip and direction are changed in every possible manner,and larger or smaller masses of the stratified rocks are partially or entirely separated from the parent rock, and more or less enveloped in the granite, which is united to them chemically. If any candid man will go into the towns of Williamsburgh, Whately, Conway, Chesterfield, Goshen, West Hampton, Norwich, Chester, Granville, or many others that might be named, and carefully examine the irregularities which the

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mica slate there exhibits, in many places, where granite is in the vicinity, and still maintain that the granite was deposited from aqueous solution, his mind must judge very differently from mine of geological evidence. When I began geological investigations many years ago, my prejudices were in favor of the Neptunian theory. But an examination of such localities as I have above referred to, showed me at once that I must change sides, or abandon the mountains and study the subject only in the cabinet. In Massachusetts the mechanical influence of granite upon the neighboring rocks is a hundred times more striking than in the case of greenstone; nor can I conceive how any effects of this kind could have resulted from the deposition of granite from aqueous solution. But they would be the natural results of the protrusion of the granite in a melted state.

It ought however to be understood, that in very many places, where the granite and the straified rocks are in contact, no evidence of the operation of a disturbing force appears, except the general evidence resulting from the inclined position of the strata. I mean that such cases of disturbance as I have described and sketched, are not common. I explain this in consistency with the igneous origin of granite, by several considerations. In the first place, it is reasonable to suppose, that originally many of the masses of granite that now appear at the surface, were not protruded through the slate; being covered by those strata which have been subsequently worn away. In such case, almost the only effect which we should expect to find from the forcing upwards of the granite, would be the regular and nearly uniform elevation of the strata; since if they were of nearly equal thickness and strength throughout, the molten mass beneath would press almost equally against their entire under surface. In the second place, such a molten mass would soften and partially fuse the strata for a considerable thickness above it; and, therefore, it might send veins through the rock thus rendered plastic, without leaving marks of mechanical pressure and disturbance. In the third place, such molten matter would fill all the fissures and cavities previously existing in the stratified rocks without producing disturbance.

These causes, it seems to me, to suggest no others, are sufficient to show why we do not always find evidence of any peculiar disturbance in the strata in contact with granite. But if these strata were not of equal strength or thickness throughout, or if one part of them was less softened by heat than the other parts, then we should expect protrusions of granite to be the result, with traces of mechanical violence; and

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such probably are the cases which I have sketched. Thus the anomalous as well as the usual modes in which granite occurs, are explicable on this theory: whereas the Neptunian, even if he can show how granite, as it usually occurs, might have resulted from chemical solution in water, cannot by the aqeous theory, explain the anomalies that have been described.

4. *I infer the igneous origin of granite from its chemical effects upon the surrounding strata.*

These effects, so far as I noticed them in the region I have undertaken to describe, have been detailed in various parts of this report; and therefore I need only refer to them in a summary manner.

The conversion of greywacke slate into flinty slate, and of certain ferruginous portions of it into jasper, as well as the induration of the limestone in the vicinity of the granite in Newport R. Island, are undoubtedly the most striking effects of this kind in the region under consideration. I can conceive of no other hypothesis to account for these changes which is not perfectly absurd. Surely no one can think of explaining such facts by any probable operation of an aqueous agency. And if an igneous agency, sufficient to fuse the graywacke and the limestone be admitted, it must have been sufficient also to fuse the granite.

The argument which I have drawn from the existence of apparently semi-fused nodules of the schistose rocks in sienite, in favor of the igneous origin of that rock, will apply also to genuine granite on two grounds. 1. Sienite is only a variety of granite; the two rocks being connected in the same continuous mass, even in the very locality where the conglomerated sienite occurs. And I cannot conceive how one part should have had an igneous and the other an aqueous origin. 2. Similar rounded nodules do occur, though less numerously, in granite. (No. 1486.)

I have often noticed an appearance on the surface of granite in contact with mica slate, which I have not seen described; but which seems to have some bearing on this question. The surface of the granite has a striated appearance; as if, when in a plastic slate it had been crowded against the slate while at the same time it was urged upwards. Usually a layer of quartz envelopes the granite, and this is often of a bluish or muddy aspect, as if the coloring matter of the slate had penetrated it. These effects, partly chemical and partly mechanical, are easily explicable on the supposition that the granite



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was protruded in a melted state through the slate, and therefore lends some support to that theory.

Along the western border of the Connecticut valley, the lower beds of new red sandstone in some places have in part lost their red color so as to become spotted. In the adit, for example, at the Southampton lead mine the rock has become gray throughout. (No. 167.) Here we know that a large mass of granite exists within a few feet of the sandstone. Now I have shown under greenstone, that just such a change of color results in this same rock, from a contact with greenstone: and scarcely no one now doubts that the heat of the greenstone was the cause. Why then should it be doubted in the case of granite?

5. *I infer the igneous origin of granite from its crystalline structure, and the numerous crystalizations of other substances that have taken place in it.*

These same facts I am aware have been adduced to prove the aqueous origin of granite: for since the products of volcanoes are rarely crystalline, and many splendid crystalizations have taken place from solution in water, it has been thought most reasonable to suppose such was the origin of granite. But when has the chemist been able from aqueous solution to obtain a solid crystalline mass of three or four distinct substances at the same time? I believe never. They always crystalize in succession. And the difficulty is increased when we take into the account the numerous simple minerals that are found crystalized and enveloped in the granite; each of the substances appearing as if they struggled with one another for a place at the moment of deposition.

But on the other hand, if the fused materials of which glass is composed, or melted basalt, or lava, be slowly cooled, they will separate into distinct compounds, as has been done in the case of granite. If, however, they be cooled suddenly, a uniform rock, or even a glass will be the result. Does not this fact lead to the probable conclusion, that the degree of crystalization in any rock depends upon the time employed in its refrigeration. Perhaps, however, other circumstances are concerned in causing such a difference in structure as we find between basalt and granite.

This fifth argument was not adduced to prove the igneous origin of greenstone, because the crystalline structure of that rock is so imperfect compared with that of granite. Some of the other arguments are

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much more satisfactory in the case of granite than in that of greenstone. And upon the whole, I cannot see why the evidence in favor of the Vulcanian production of granite is not fully as strong as it is in respect to any of the trap rocks. But as to the origin of the latter there is scarcely any diversity of opinion. We may then safely predict that a like uniformity will soon prevail in respect to granite. Indeed, we are informed on the highest authority, that in Great Britain this uniformity of views already exists. Five years ago, Dr. Fitton, President of the Geological Society, said: "In the speculative department of Geology, nothing has been of late more remarkable with reference to its history in this country, than *the universal adoption* of a modified Volcanic theory, and the complete subsidence, or almost total oblivion, of the Wernerian and Neptunian hypotheses; — so that what, but a few years since, was by some considered as hardihood to propose in the form of conjecture, seems now to be established nearly with the evidence of fact. It is no longer denied, that volcanic power has been active during all the revolutions which the surface of the globe has undergone, and has probably been itself the cause of many of them; and that our continents have not merely been shaken by some mighty subterraneous force, but that strata, originally horizontal, have thus been raised, shattered, and contorted, and traversed, perhaps repeatedly, by veins of fluid matter; — operations which have produced phenomena, so nearly resembling those of volcanic agency, that to have so long disputed the identity of their cause, is one of the most remarkable proofs in the annals of philosophichistory, of the power of hypothesis in disturbing or concealing truth."*

Brongniart and Beudant also, distinguished professors of geology in Paris, and until recently Wernerians, in their Report on a Memoir of Elie de Beaumont, presented to the Acadamy of Sciences in 1829, remark as follows; "The Memoir of M. de Beaumont exhibits certainly one of the newest,boldest,and most ingenious theories which have been proposed for a long time. It seems even to demolish those theories which have the honorable prejudice of an illustrious name (Werner) on their side, as well as the general opinion, and which have been adopted by many of the members of this Academy.†

* Anniversary Address, Feb. 15 th. 1828.

† Rapport, &c, 17.

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### *Theory of Central Heat.*

The logical mind that adopts these views of the origin of the unstratified rocks,is irresistibly led to inquire into the commencement and present state of the internal heat which has produced such mighty effects. As to the condition of the globe when this powerful agent began to modify its crust, little more than conjecture can guide our inquiries. Astronomical observations render it probable that the surface of the moon is composed almost entirely of volcanic matter; and that that planet is gradually cooling and passing into a habitable from a choatic state. Comets also, appear to be in a condition still more chaostic; the matter of which they are composed being actually in some instances expanded into vapor, in consequence of internal heat. The speculative geologist inquires, whether such might not have been the early condition of our globe; and whether it has not been gradually cooling from the beginning to the present time; while such animals have been successively placed upon it as possesed natures adapted to its different temperatures. That its surface must have been torn and ravaged by the most powerful volcanic agency in early times, those who admit the igneous origin of the unstratified rocks must allow: and that its temperature has been sinking, is rendered extremely probable by the almost universal occurrence of animals of a topical character in the fossiliferous strata of high latitudes.

The surface of the globe has probably nearly or quite reached its maximum of refrigeration, as several facts seem to prove. But what is the present temperature of its internal parts? A great number of observations made within a few years in different parts of the world, in mines and other deep excavations, have brought to light the interesting fact, that the temperature increases rapidly as we descend into the earth; indicating even, that at a depth less than 100 miles, a heat exists great enough to fuse all known rocks; and consequently, that the great mass of the globe beneath this envelope, may now be a molten incandescent mass. Startling as such a conclusion may be, to one who is not conversant with the details and reasonings of geology, it seems to receive confirmation from the occasional ejection of just such melted matter as the theory supposes, from more than 200 volcanoes, which seem to form the safety valves of the vast furnace. And then, still more numerous extinct volcanoes testify to the more powerful operation of this agency in former days. The facility too with

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which such a theory applies to the explanation of a multitude of physical phenomena which cannot be here detailed, certainly strengthens the conviction of its truth.

It is but a few years since this theory was formally developed in the sientific world; and although it was viewed by many as the very extravagance of hypothesis, yet it is interesting to see how very rapidly it has gained credence. Nor can this fact be explained without admitting that it carries with it strong marks of truth. The state of opinion on this subject among European geologists, may be learnt from the following paragraph of a recent able French writer on Volcanoes. "If" says he, "I have dwelt long on the ideas of Cordier, it is because they are now professed by the most illustrious geologists of our age. They rest, moreover, on facts so numerous and so well established, that it is impossible not to regard them as a faithful representation of what must have happened at the commencement of things, and of what is now taking place. The hypothesis of central heat, and by consequence that which imputes the origin of volcanic matters to a fiery mass in the interior of the globe, may be placed in the rank of truths the most firmly established. In proportion as observations multiply, this hypothesis is confirmed: the small number of phenomena yet involved in some obscurity, will be explained more easily than those which have been brought to light before: and the systematic minds which still resist the evidence, will soon find themselves compelled to abandon their opinions, which have already fallen into the most profound discredit."*

"As to the central heat" says Dr. Macculloch, "if there is not ample proof of this, I know not that geology can furnish proof of any thing," &c. †

Even the chemical theory of volcanic action, which imputed it to the oxidation of the metalloids, and which seemed a few years ago to be enlisting able advocates in its defence, appears in Europe to be nearly abandoned. Even Sir Humphrey Davy, who originally proposed it, subsequently abandoned it; and says that "the hypothesis of the nucleus of the globe being composed of fluid matter, offers a still more simple solution of the phenomena of volcanic fires than that which has been just developed."‡ His surviving brother Sir John Davy, however, still defends the chemical theory, as does also Professor Daubeny.

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* Considerations sur les Volcans &c. par M. J. Girardin, Paris 1831, p. 152.

† System of Geology, Vol. 2, p. 406.

‡ Philosophical Transactions for 1828. Part 1.

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*Theory of the Sufficiency of Causes now in action, with no increase of intensity, to account for Geological Phenomena.*

Although the theory of central heat has been so generally adopted as to excite at present but little discussion, yet a theory is now in the course of a full and able development by a distinguished geologist,* relating to the dynamics of existing causes, which seems likely to elicit much of talent and feeling in its examination. He maintains that if the causes now in operation be supposed to have acted during immense periods of past time, without any increase of intensity, they may have produced all the phenomena which the records of geology disclose. Those who take the opposite ground are ready to admit that the dynamics of existing causes has been greatly underrated; nor do they suppose that any causes different in their nature from existing ones have been in operation in past times. But they suppose these causes to have acted with far greater intensity formerly than at present: and they appeal to the following facts in support of this opinion, and in opposition to the theory above stated.

1. The spheroidal figure of the earth renders it probable that it was once fluid. Whether this fluidity was igneous or aqueous, the operation of fire or water must have been far more powerful formerly than at present.

2. Perhaps nine tenths of our present continents exhibit evidence that their stratified rocks were formed beneath the ocean; and they must consequently have been subsequently elevated; and this, not by little and little, but by a few paroxysmal efforts of volcanic force. But that force, during the last 4000 years, seems to have been by far too feeble to produce effects to be compared with the elevation of a continent, or even a single mountain chain.

3. The products of volcanic agencies in early times, that is, the unstratified rocks, appear to have been far more abundant than during the last few thousands of years. That is, the deposits of granite, sienite, and porphyry, whose cotemporary production can be rendered probable, are of greater extent than those of basalt, greenstone and trachyte; and these latter more abundant than the lavas of existing volcanoes: thus exhibiting a diminishing energy of volcanic action.

4. A correspondent decrease of violence in this power, obvious in the disturbances and dislocations of the stratified rocks by the pro-

*Principles of Geology by Charles Lyell Esq. Vol. 1. London 1830: Vol. 2 London 1832: Vol. 3, forthcoming.

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trusion of the unstratified. That is, the oldest stratified rocks exhibit far more of disturbance than those of more modern date; many of which have not been disturbed at all. This cannot be explained by supposing that the older rocks have been affected by all the paroxysmal efforts of volcanic power that have occurred, whereas the newer ones have felt only the modern throes: for the latter products of volcanic action, such as basalt, greenstone, trachyte, and lava, appear but in a few instances to have disturbed the older rocks.

5. The vents of existing volcanoes are always situated in the midst of regions exhibiting marks of former and extinct volcanic action; and they occupy but a small proportion of those regions; indicating a comparative repose or diminution of the volcanic power.

6. In correspondence with the preceding facts, we find the older rocks, both stratified and unstratified, more crystalline in their structure than the newer ones: an effect which would result from the diminished agency of heat.

7. The character of organic remains implies a like diminution of temperature: nor can the astronomical theory of Mr. Herschel, making this diminution the result of a gradual change in the ellipticity of the earth's orbit; nor the geographical theory of Mr. Lyell, which refers it to variations in the relative position of land and water, and in the elevation and form of land; afford any satisfaction to the mind.

8. The occasional occurence in the sedimentary rocks of immense beds of conglomerate, indicates the occasional recurrence of powerful debacles of water to form and collect the materials for these rocks. But we know of no cause now in operation adequate to the production of such deluges. Yet if we admit the greater intensity of volcanic power in past times, an adequate cause is provided.

9. Existing diluvium cannot be accounted for by causes now in action. This point, in relation to the diluvium of Massachusetts, has been so fully discussed in the earlier pages of this report, that I need add nothing further in this place, except to say, that the diluvium of other countries appears to be quite as difficult to be accounted for by the fluvial theory.

Upon the whole, it seems to me that however easily a man may persuade himself in his cabinet, of the truth of the theory that has been examined, he cannot go forth among the mountains without meeting its refutation every where; and he must be continually impressed with the vast intensity of force which aqueous and igneous agents have exerted on the globe in former times.

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Here terminates my account of the particular rocks of Massachusetts. A few miscellaneous matters that could not properly be introduced in any other place, will be added in conclusion of the Scientific Geology of the State.

## Miscellaneous Items.

### 1 *Origin of Metallic Veins, Beds, &c.*

The metals sometimes occur in the rocks disseminated through their masses: and in this case it is obvious that they must have existed in the materials out of which the rock was produced, and were separated into small masses by chemical affinities when the rock was passing from a fluid to a solid state. The same was probably true in those cases where the metals exist in tuberculous masses in the rocks. When they occur in strings, that is, in small veins so numerous as to give the rock a reticulated appearance, they were probably segregated from the mass of the rock at the period of its formation; not improbaby filling up the small cracks produced by incipient consolidation. Metallic beds, where the ore is interstratified with the rock, may in many cases have resulted from aqueous deposition, the ores having been subsequently modified by exposure to heat: as I have more fully suggested in describing talcose slate. But when the metals occur in genuine veins, as they usually do, the theory of their origin is involved in great obscurity. The Wernerian dogma, that all veins were filled by aqueous solution from above, is now exploded; though in a few instances they may have been formed in this manner. A more recent and very ingenious hypothesis represents the contents of metallic veins as having been secreted from the rocks by means of galvanic electricity;* and the change that takes place in these contents as the vein passes into different rocks, certainly lends some plausibility to this suggestion: and it would seem probable that the various layers of rocks and minerals that make up the crust of the globe, must form galvanic combinations of great power. A still more recent hypothesis† imputes metallic veins to sublimation by the internal heat of the earth, which causes the metallic substances to rise into the fissures that exist in the crust of the globe. This hypothesis,

* Fox in the Philosophical Transactions for 1830 p. 399.
† Neckar in Philosophical Magazine. Sept. 1832.

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also, is very ingenious; but my own mind is not satisfied with any explanation that has yet been proposed.

I am not aware that any facts which have come to my knowledge relative to the metallic veins in Massachusetts, will throw any light upon this subject. But as yet they have not, except in a few instances, been penetrated far enough to develope facts of much interest.

The direction of these veins is, however, a point that ought not to be passed over in silence. For when we find veins corresponding in direction, especially if in the same formation, we have good reason for presuming that they originated in a common cause, and at the same epoch. On Plate XVI, which shows the direction of the strata in Massachusetts, I have given the course of most of the metallic beds and veins in the State by double arrow heads. The following are the data from which I made the delineation

| | Direction. | Dip. |
|---|---|---|
| 1. Bed of Iron in Hawley; | North and South; | Vertical. |
| 2. Do. Somerset, Vt. | Do. | 20° to 30° East. |
| 3. Bed of Manganese, Plainfield, (S. West part.) | Do. | nearly 90° East. |
| 4. Vein of Lead (most Southerly) Leverett, | Do. | nearly vertical. |
| 5. Do. Whately, (North part) | Do. | Do. |
| 6. Vein of Copper Ore on Island, Turner's Falls, | Do. | Westerly. |
| 7. Vein of Copper Ore in Greenfield, near Turner's Falls, | Do. | Vertical. |
| 8. Vein of Manganese, Conway; | N. E. and S. W. | Do. |
| 9. Vein of Lead, and Copper, Leverett, (most northerly vein,) | Do. | |
| 10. Do. Do. Southampton, | Do. nearly. | Do.? |
| 11. Do. Do. West Hampton, | Do. | Do.? |
| 12. Do. Zinc, chiefly, Northampton, | Do. | Do. |
| 13 and 14. Two veins chiefly in Whately,* | Do. | |
| 15. Bed of Copper, Ore, Granby, Ct. | Do. | 20° S. E. |

* On Mr. Nash's Authority.



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16. Bed Mag. Ox. of Iron, Bernardston, North and South 20° S. E.
17. Bed of Plumbago, Sturbridge, N. 30° E. 60° to 70° N. W.
18. Do. Iron and Zinc, Sterling, N. several degrees East. Do.
19. Vein of Lead, Hatfield, Nearly N. W. and S. E. Vertical?

Regarding only the veins in the above table, and judging merely from their course, we should infer that all of them were produced at two epochs, except the single vein in Hatfield. But the great difference between the age of the new red sandstone, containing the copper veins, and that of the granite and mica slate containing the other veins, renders it probable that those in the former rock must have been formed at a different epoch from those of the latter. On this view of the subject we must refer these veins to four periods: 1. The veins of copper 5 & 6, in the new red sandstone: 2 The veins of lead, 4 and 5: 3. The veins 8, 9, 10, 11, 12, 13 and 14:—4. The vein 19. If the beds be considered as connected in their origin with the veins, the number of epochs of production will not be increased: Since the beds 1, 2, and 3 will belong to the first epoch, and 15, 16, 17 and 18, to the second.

### 2. *Elevation of the Mountains and Systems of Strata in Massachusetts.*

Geologists who saw that the existing continents of the globe had obviously been raised from the bottom of the ocean, had sometimes suggested that different mountain ridges had been lifted up at different epochs. And they seemed to approach very near sometimes to the discovery of the principle by which they could determine the relative ages of these mountains. But it was reserved for Eli de Beaumont to develope the true principles by which we should be guided in such investigations; and perhaps no discovery in geology within the present century, has excited so much interest among geologists as this. I could not, therefore, be justified in closing my report without an effort to apply these principles to the mountains and systems of strata in Massachusetts. But as no effort of the kind has been made in this country, I fear that I shall make but a feeble beginning.

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### *Sections and Map of the Direction of the Strata, accompanying this Report.*

In order to give as correct a view as I am able of the course of our inclined strata and their dip, I have given Plate XVI to illustrate the former, and Plate XVII and XVIII, to exhibit the latter. For on these two circumstances the whole argument for proving the elevation of the different systems of strata at different epoch, rests.

The instruments which I have employed for ascertaining the direction and dip of the strata, are a good pocket compass and a clinometer. I confess, however, that in consequence of the very common oscillation of the dip and direction within short distances, I have been much in the habit of depending upon the *coup d'oeil* to obtain their average: being sure that I knew where the true meridian lay, and having found by long trial that I could be more accurate in this way, and especially in respect to the dip, than by the use of instruments. But after all, every geologist must be aware that all observations of this kind, made in the best manner, can be only approximations to the truth. In most instances, however, they come sufficiently near the truth to form a good basis for reasoning: since it is large differences only, in the dip and direction, on which the conclusions rest.

In strictness, when the direction is given in this report in degrees, about 5 degrees should be allowed for the westerly variation of the magnetic needle.

It is only the predominant or general direction of the basset edges of the strata that I have undertaken to give on the map. The preceding pages of my report contain numerous local exceptions: but unless these are on a large scale, as in Worcester, Goshen, &c. they have not been represented.

Dotted lines are drawn on the Geological Map of the State, (Plate I,) to show where the sections, given on Plates XVII & XVIII, cross the country. Section A, crosses from east to west near the northern part of the State. Section B, is intended to cross near the middle of the State: though it deviates somewhat from a direct course, in order to strike the granite and coal in Worcester. Section C, passes through the southern part of the State; though when it reaches the northeast corner of Rhode Island, it tends more to the south, in order to terminate upon the famous "Plymouth Rock," which is a large bowlder of a rather peculiar kind of granite, (No. 1433.) Section D, passes from the northeast corner of the State to Boston; thence it changes its

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course slightly to reach Newport R. Island. Above sections B & C, a few short sections are introduced of interesting places lying too far north of the line of the general sections to be made part of them. In these minor sections the same scales are employed as in the larger ones.

The horizontal scale used in all these sections corresponds with that on the Geological Map: so that the sections are of exactly the same length as the Map, measured on the dotted lines above described. Hence any particular spot on the section may be found upon the State Map, by laying the one upon the other. The scale for laying off the heights is 1500 feet to the inch. I do not suppose that I have always given the height of the surface with much exactness. I have depended on several surveys that have deen executed within a few years for contemplated canals and railways, and on other admeasurements published by individuals, for the heights of the most important points along the sections. But in some instances the course of these surveys did not correspond with the line of the sections. In such case I could only approximate to the elevation.

The double scale necessarily employed in extensive sections of this kind, gives so distorted a representation of the surface, and consequently of the relative situation of the different rocks, as exceedingly to diminish the value of such representations. Geologists accordingly at the present day place but little dependance upon them: or rather they value them less just in proportion to their distortion. "Such sections," says De la Beche, "are little better than caricatures of nature, and are frequently much more mischievous than useful, even leading those who make them, to false conclusions, from the distortion and false proportions of the various parts."* If to this it be added that there is a strong temptation to make up for a deficiency of observation by giving the relative position of the rocks according to a favorite theory, we shall be persuaded that a large part of the sections hitherto published, have conveyed to the mind nearly as much error as truth. A section which exhibits only the truth, so far as the observer has ascertained it from actual examination, forms too naked and uninviting a sketch to satisfy the taste or the ambition of many. Hence the imagination and the painter are taxed to make up the deficiency.

In the sections appended to this report, however, I have endeavored to present the dip and superposition of the rocks, only so far as I have determined these points from actual observation. Where for in-

*Geological Manual 2d Edition p. 545.

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stance, as in the case of the limestone of Berkshire county, I have not seen the actual junction of different rocks, I have left a blank space between them. Notwithstanding these precautions, I am afraid that these sections will convey some erroneous impressions.

The principal object of these sections is to exhibit the actual dip of the strata: and this I have endeavored to give without reference to the distortions of the surface.

### *Systems of Strata and Mountains of Contemporaneous Elevation in Massachusetts.*

A careful examination of the map and sections that have just been described, will satisfy any one, that although the rocks of Massachusetts belong to several distinct systems of elevation, yet the central ridge, or anticlinal line of not one of these systems perhaps, passes through the State. We may, therefore, hope that correspondent parts of these systems may be discovered beyond the limits of the State. But I shall first endeavor to point out, as well as I am able, in chronological order, the different systems that appear within the State.

A peculiar difficulty, however, meets us in attempting to ascertain the relative epochs of elevation of our strata: for most of the newer strata are wanting in New England; or rather their number is much less than in some other parts of the world. In the western part of this State, for instance, we have only the new red sandstone and a single tertiary formation, not yet identified with any in other parts of the world, to guide our enquiries in respect to the epochs of elevation. And in the eastern parts of the state, graywacke alone affords us any assistance in this matter; since the plastic clay and every other tertiary formation are so insulated from the older rocks, as to form no grounds for any other than hypothetical conclusions. For these reasons I find it impossible to ascertain the exact place in respect to time, which all the systems of elevation, that I think I discover in the State, ought to occupy. Most of these systems appear to be of great antiquity; corresponding perhaps with the oldest that have been described in Europe.

1 *Oldest Meridional System.* The meeting of the new red sandstone of the Connecticut valley with the primary strata of Hoosac mountain range in an unconformable manner, enables us to infer with certainty, that the latter have suffered at least two elevations at different epochs. For the sandstone has a medium easterly dip of 15° or 20°; while the mica slate, talcose slate, and gneiss of the Hoosac range, approach to verticality in their dip. Hence the latter must have re-

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ceived their principal elevation previous to the deposition of the former. There may have been more than one epoch of elevation previous to that time: but we are thus assured of at least one; and the very considerable inclination of the sandstone demonstrates an epoch of elevation subsequent to its deposition. The last elevation seems not to have affected the primary strata on the east side of the Connecticut valley, except perhaps to a limited extent: for the force that raised the sandstone was so applied as to lift up the western edges of the strata: and if there had been a similar force operating on the eastern side of the valley, their eastern edges would also have been thrown up, at least so as to keep them in a horizontal situation, if not to give them a westerly dip.

All the primary strata, therefore, in Massachusetts, west of the valley of Worcester, whose direction is north and south, I regard as belonging to the oldest meridional system: and such is the general direction of all the strata west of Worcester, with the exception perhaps of the argillaceous slate, and associated strata in the north part of Franklin County, whose situation will be more particularly noticed farther on. The Worcester County range of strata may not, indeed, have been elevated at the same time as the Hoosac range: but I know of no facts that will prove that they were not raised at the same epoch; and since the direction of the strata coincides, we must refer them to the same epoch until counter evidence be produced.

I think that an examination of the annexed sections will lead to the impression that the elevating force, or rather the force of plication, which has formed the ridges and furrows of the system under consideration, must have operated in such a manner as to raise up the mountain ridges on the east and west sides of the Connecticut valley, much higher originally than the valley: for amid all the irregularity that is manifest in the dip of the gneiss range east of that valley, we see that the predominant inclination, particularly towards the central and southern parts of the State, is westerly; while on the west side of the valley, it is the reverse; although nearly vertical. This does not prove that the part now occupied by the valley suffered a depression at the epoch under consideration. For even if we suppose it to have been elevated, a valley would have been the result, if the strata on the east and west sides underwent a still greater degree of elevation. At any rate, I think that the actual dip of the strata on the opposite sides of this valley, render it probable that it was originally a valley of dislocation and not of excavation: although, as I have

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argued in other parts of this report, extensive excavations may have subsequently taken place within its limits.

The fact that the rocks of Berkshire valley have a less dip than those of the Hoosac range, leads naturally to the inference that they, like the sandstone in the Connecticut valley, were not elevated during the epoch of the oldest meridional system. Yet their dip b eing considerably greater than that of the sandstone, renders it somewhat doubtful whether the Berkshire rocks were not at least partially elevated earlier than the sandstone: and this fact excites a suspicion that there may have been three epochs of elevation in a north and south direction. The graywacke, however, between Berkshire and the Hudson, has a very high easterly dip, sufficiently great to be regarded as belonging to the oldest meridional system and connected with the Hoosac range. And it is not difficult to conceive how a series of rocks of considerable extent, forming only a part of a system of elevation, may have been tilted up much less than the group generally. So that upon the whole, I am greatly in doubt whether the Berkshire rocks ought to be referred to the oldest or the latest meridional system.

In tracing this oldest meridional system beyond the limits of Massachusetts, it cannot be doubted that all that mountain range from New York to Canada, along the western part of Connecticut, Massachusetts, and Vermont, called in Massachusetts the Hoosac range, and in Vermont the Green Mountain range, constitutes a part of it. Nor can there be any more doubt, that a large part of that broad range forming the eastern side of the Connecticut valley, and extending from Long Island Sound to Canada, at least as far east as a line drawn from the mouth of Thames river through Worcester valley, belongs to the same system. I mean, that if the middle portions of these two ranges belong to the same epoch of elevation, so must their prolongations north and south. The eastern range embraces the highest land in New England; including Wachusett, Monadnock, and the White Mountains. Since these ranges, however, have not been particularly described in New Hampshire and Vermont, other systems of elevation may there be connected with that under consideration. But the continuity of these ridges renders it almost certain that the oldest meridional system extends from one extremity to the other.

According to the best maps, the most elevated parts of the two ranges that have been described, are arranged on a line bearing a few degrees east of north. My own observations on limited portions of

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their strata in Massachusetts, have not been accurate enough to decide as to their course within a few degrees. I have found the direction of the strata to correspond very nearly with the meridian, except in anomalous cases.

Beaumont in his *Recherches sur quelques-unes des Revolutions de la surface du Globe*,* notices cursorily the system that has now been described; and he remarks that "without doubt it belongs to an epoch more ancient than that of the northeast and southwest beds that constitute the Alleganys properly so called." He however makes no distinction between what I call the oldest and the newest meridional system; not being aware probably of any evidence of two epochs of elevation.

In New Jersey and Delaware primary ranges have been described, running nearly north and south, which have been regarded as a prolongation of those along the banks of the Hudson and the Connecticut. They ought rather to be regarded as parallel ridges, belonging however to the same system: and from some hasty observations which I made several years ago in New Jersey, I am disposed to believe that the new red sandstone there, occupies the same relative situation with respect to the primary rocks, as in the Connecticut valley.

Examining the map of America, we perceive that a considerable part of the Rocky Mountains have a north and south direction, and that such is the general direction of the Andes, as well as of several ridges in South America east of the Andes: and we know that some of these ranges at least, are mainly composed of primary rocks. But in every case, except some of the ridges last named, their difference of longitude is so great as to render it extremely uncertain whether they were elevated at the same epoch as the system that has been under consideration.

### 2. *The Trap System.*

The circumstances connected with the greenstone ridges in the Valley of the Connecticut, are such as to lead me, with not a little hesitation, to regard them as erupted at an epoch distinct from all the periods in which the other rocks in the State have been elevated. On page 243, I have suggested the reasons that lead to the conclusion that the greenstone began to be protruded through the sandstone

*Chap. 2, p. 323.

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during the time when the upper beds of the sandstone were depositing. Were it not for the occurrence of a trap conglomerate on the upper side of the greenstone, we might allow that the greenstone was protruded at the same time when the sandstone was elevated, or subsequent to that epoch. This circumstance proves that the higher beds of sandstone, or at least a part of them, were deposited subsequent to the elevation of the greenstone: otherwise, how could rounded masses of the greenstone be found in the conglomerated sandstone. But in several places, as at Turner's Falls, and on the southeast side of mount Holyoke, these higher strata of sandstone are much more tilted up than those beneath the greenstone: which seems to indicate that this latter rock forced its way through the sandstone after the deposition of the upper beds. These facts I confess are difficult to be reconciled: But they prove I think, that the greenstone was elevat a period (more probably at more than one period,) different from that when the sandstone was thrown up.

The prevailing easterly dip of the sandstone containing these ridges of greenstone could not have been the result of the protrusion of the latter rock: for the beds below the greenstone, are, for the most part, quite as much inclined as those above it. This proves that some other agency must have raised the sandstone; except in those few cases alluded to above, where the greenstone seems to have increased the inclination of the strata. Hence only the sandstone in these limited spots can be regarded as belonging to this system of elevation; and it embraces only the trap ranges extending from New Haven to Vermont. These, as may be seen on Plate XV, run in general a few degrees east of north.

I have in another place noticed a limited deposit of new red sandstone and greenstone in Woodbury and Southbury Ct. This formation resembles exceedingly the analagous sandstone and greenstone in the valley of the Connecticut. The direction of the ridges of greenstone in the Woodbury valley corresponds very nearly, also, with that of the trap in the Connecticut valley; indicating a synchronous protrusion. I omitted in treating of new red sandstone to notice a similar formation, about 60 miles long and 30 broad, in New Jersey; and extending northerly into New York, at least as far as the Palisadoes on the Hudson.* Prominent ridges of greenstone intersect this formation, running from north to south, and resting on

* Pierce in Am. Journal of Science, Vol. 2. p. 181.



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sandstone, shale, and conglomerates. Indeed, taken as a whole the rocks of this region extremely resemble those in the basin of the Connecticut. The inclination of the sandstone, however, is in general rather less in New Jersey, and it is westerly; that is, in a direction contrary to that of the sandstone of the Connecticut valley. Consequently, the mural faces of the greenstone ridges in the latter valley, are on the west side of the ranges; while in New Jersey, they are on the east side. But this does not militate at all against the conclusion that the trap ranges in the two formations belong to the same system of elevation. It merely renders it probable that an axis of elevation, or anticlinal line, lies between them.

### 3. *The Latest Meridional System.*

I have presented the reasons that lead me to suppose the Hoosac mountain range to have been elevated a certain distance before the deposition of the new red sandstone. But the inclination of that rock shows that subsequent to its deposition a second elevation has taken place in the same range. The smallness of the dip in the sandstone proves that this second elevation must have been small compared with that which had been previously accomplished in the primary strata west of Connecticut river. Yet there is every reason to believe that this second elevating force acted on all the rocks between Connecticut and Hudson rivers, and probably on those farther west. And very probably much of the greenstone in the Connecticut valley was lifted up along with the sandstone. Hence we are to include in this system all the rocks between Connecticut and Hudson rivers; probably the whole distance between Long Island Sound and Canada. But there is no evidence that the primary rocks east of Connecticut river, which I have included in the oldest meridional system, except in one or two cases of limited extent, were affected by this second elevating agency. For if such had been the case, to as great an extent as on the western side of the Connecticut, the sandstone would either have been elevated without losing its horizontal position, or it would have been tilted up so as to dip in opposite directions on opposite sides of the valley. If then the primary strata east of the river were affected at the epoch under consideration, it must have been in a much less degree than the strata west of the river.

There is, however, in one place, striking evidence that an elevation has taken place in the gneiss east of Connecticut river, since the deposition of the sandstone. I refer to the section which I have giv-

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en in treating of greenstone, which extends from the greenstone ridges west of Turner's falls, to the primary strata bounding the eastern side of the valley. The change in the direction of the dip of the sandstone as we approach the primary strata, can be explained only by supposing an elevation of those strata after the deposition of the sandstone. At least, the evidence that such was the cause of this anomalous dip, is as strong as the evidence that at the other end of the section the protrusion of the greenstone has occasioned the increased dip of the sandstone. But it is easy to conceive how a protrusion of granite might have taken place in particular places, (and the section shows that granite is associated with the gneiss at the mouth of Miller's river,) and have powerfully affected the incumbent strata for a small distance, without producing a perceptible effect over regions of great extent. And upon the whole, I am inclined thus to explain the case that has been referred to.

In the Connecticut Valley no rock intervenes between the new red sandstone and the newest tertiary. The strata of the latter are horizontal, and were therefore deposited subsequent to the elevation of the system under consideration. Hence we can only say, that the period when this system was developed, was that which intervened between the deposition of the sandstone and the newest tertiary. Beaumont, however, who speaks of this system, as it appears in New Jersey and Delaware, says, that there, "the chalk formation covers the prolongation of the ancient beds, which are elevated in a nearly north and south direction, and which form the borders of Connecticut and the river Hudson." If he means, as I suppose he does, that the chalk formation in those states is not dislocated nor elevated, it will follow that the epoch of elevation of this system occurred between the deposition of the sandstone and the chalk.

### 4. *The North East and South West System.*

This system embraces in my opinion a considerable part of the mica slate in the valley of Worcester, all the northern part of the gneiss range, which on the east side of that valley trends away to the north east, and the western part of the gray wacke formation with the talco-chloritic and mica slate in Cumberland, Smithfield, &c. The dip and direction of the strata in the gneiss range exhibit, probably, the most distinct type of this system. They are more uniform in this range than in any other perhaps in the State. The direction is nearly northeast and southwest; though I think rather nearer to north

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and south than to east and west. The medium dip is from 60° to 70° northwest. In the Worcester mica slate, the dip and direction are much more irregular: though for the most part its strata run nearly northeast and southwest and dip northwest at a large angle. But towards the southern part of the range, they run nearly north and south; and towards the northeast part of the range, they run nearly east and west, conforming apparently to the curve which the western margin of the gneiss forms. The western part of this mica slate range appears to belong to the oldest meridional system that has been described. As to the argillaceous slate, contained in this formation, I suspect that also to be connected with the same meridional system: though I have not observed its dip and direction in places enough to enable me to form a very confident opinion on this point.

I am strongly suspicious, that the mica slate of Worcester Valley, will be found to be not perfectly conformable in its stratification to the gneiss on either side of the valley; in other words, that the gneiss was partially elevated previous to the deposition of the mica slate. If so, that epoch of first elevation is probably the oldest in Massachusetts. But there is so much of irregularity in the dip of this rock, that I do not presume to erect another system upon so uncertain a foundation.

An inspection of Plate XV, will show clearly that the graywacke formation belongs to two very distinct systems of elevation: the one running nearly east and west, and the other not far from northeast and southwest. A tract of some width, extending from Walpole to Providence, and indeed to Newport, belongs to the latter system; although on the island of Rhode Island, there is not a little irregularity in the dip and direction. Obviously this part of the graywacke belongs to the northeast and southwest system under consideration. The talco-chloritic slate in Cumberland and Smithfield, also, as well as a part of the mica slate connected with it, appear to belong to the same system; and since the prevailing dip is southeasterly, (although in this there is great irregularity,) it would seem that there may be an anticlinal line between the graywacke and the gneiss east of Worcester which dips in a contrary direction.

Along the western margin of the tongue of graywacke extending towards Sherburne, the direction of the strata corresponds with this system: for example in Natick and Watertown: and probably is to be reckoned as a part of it.

The tendency to a northeast and southwest direction, which I have

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observed in the argillaceous slate of Guilford, Vt. has led me to suspect that this also may belong to the same system. But to render it certain, the formation should be examined farther north, in Vermont and New Hampshire. The mica slate associated with this clay slate on the east in the southwestern part of New Hampshire, should be examined with the same object in view: for I have observed this also to bear too much to the northeast and southwest to belong to the meridional systems, except as a local anomaly.

I have particularly described under sienite, a limited formation of hornblende slate, and mica slate in Whately, running in a direction which corresponds nearly with the northeast and southwest system. If I do not misrecollect, the same series of rocks, embracing serpentine and verd antique marble, west of New Haven, have a similar direction. Perhaps both these cases are insulated parts of this system.

I think it most probable that the northeast and southwest ranges which I have now described, belong to a very extensive system of elevation, of which the Allegany mountains form a part. Another range of strata of vast extent, doubtless a part of the same system, can be traced from the river Saguenai, 100 miles east of Quebec, to Lake Huron. These consist of gneiss, mica slate, greenstone, sienite, &c. and have been regarded by Dr Bigsby as the most recent of the primary rocks.* But if we take Beaumont for authority, even these extensive ridges constitute but a moiety of this system. It is his Pyreneo-Appenine system: and it includes the whole of the Pyrenees, a part of the Appenines, the mountains of the Morea, a part of the Hartz Mountains, Mount Atlas, and other ridges in Africa, particularly in Egypt, the Carpathian Mountains, Mount Carmel and Sinai in Palestine, a part of the Caucasian chain, and of the Ghauts, forming indeed, a set of parallel ridges around the whole globe; and being the most extensive and remarkable system that has yet been traced.

I ought perhaps, however, to suggest the possibility, that the rocks in Massachusetts, which I have described as belonging to this system, may be found connected with some other. For the strata certainly for the most part, run nearer north and south by a few degrees than the general course of the Alleganies.

I have not found any of the more recent rocks in Massachusetts

* Philosophical Magazine Vol. 2. N. Series p. 219.

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connected with this system, by which to judge of the epoch of its elevation. We could learn here only that it took place after the deposition of the graywacke. But according to Beaumont, it took place between the deposition of the chalk, and the oldest of the tertiary strata.

### 5. *East and West System.*

This includes the greater part of the graywacke, granite, sienite porphyry, and greenstone, in the eastern part of the State; and probably the gneiss in the vicinity of New Bedford. Amid many anomalies, the decidedly predominant direction of the strata of graywacke (excepting the portions connected with the last system,) is east and west, and the dip notherly. Not having made many observations upon the New Bedford gneiss, and finding that sometimes its strata tend northeasterly and southwesterly, I was at first inclined to refer it to the last described system. But more probably I think, it should be connected with the system under consideration.

So limited is the graywacke in some portions of the region embraced by this system, as I have stated its boundaries, that it would be desirable to find other evidence that the granite, sienite,porphyry, and greenstone, along the eastern part of the state, belong to the same system of elevation. And fortunately this evidence is presented in the east and west direction of nearly all the mountain ridges and chains of hills composed of these rocks. The most striking example of this fact is the Blue Hills, made up of sienite and porphyry, and forming the most elevated land in the eastern part of the State. The porphyry range a little north of Boston has the same general direction; and so have many smaller ridges to the south of the Blue Hills. In Sharon, Foxborough &c, however, the sienite ridges assume a direction nearly northeast and southwest, or somewhat nearer to the meridian than this. This is the case with the Moose Hill range, for instance, which is more than 400 feet high, and runs. northeast and southwest: and this, with other parallel ridges in that vicinity, obviously belong to the last system of elevation that has been described.* And this is what we might expect, since a portion of the graywacke running through Walpole and Wrentham, and belonging to the northeast and southwest system, occupies the vallies between these ridges.

I have suggested in another place, that the disturbance which the

*H. E. Rogers in the Report on the Providence and Boston Rail Road, p. 59 and 61.

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Plastic Clay Formation on Martha's Vineyard seems to have undergone, may have resulted from the protrusion of granite. If so, that granite was probably a portion of the east and west system under description. According to these data, the epoch of its elevation must have been subsequent to the deposition of the Plastic Clay, and consequently later than the epoch of the northeast and southwest system. But I regard this evidence as little better than conjecture; and therefore, I am greatly in doubt as to the period when this system was elevated.

It is natural to enquire whether any traces of this system can be discovered beyond the limits of Massachusetts. The only means I have of forming any conjecture on the subject, consist of geographical maps, which give the direction of chains of mountains: and even in this respect they are so imperfect, as to the more unexplored parts of our continent, that they leave one in much doubt. I will only, therefore, say, that on our best maps, a range of mountains extends along the southern border of Labrador westward: and that such is the direction of the rivers, which farther west run on the north into Hudson Bay, and on the south into the basin of the St. Lawrence and the great western lakes, as to show that the elevated land if not mountain ridges, in which these rivers take their rise, have a direction nearly east and west. The same is true of the region west of lake Winnipeck, and of a tract several hundred miles long, on the south side of lake Superior, in which the waters that flow into that lake take their rise.

### 6. *Northwest and Southeast System.*

No part of the region embraced by the geological map (Plate I.) has occasioned me so much perplexity to ascertain the direction of the strata, as that in the vicinity of Blackstone river, near the place where it passes into Rhode Island. The direction of the strata of gneiss there, does not generally differ much from the usual course of the river, and the pretty uniform dip is northeast. Yet sometimes we find them running nearly east and west and dipping north: and this circumstance has led me to enquire, whether they might not in fact be connected with the east and west system. I know not that it is yet settled, how much local causes may alter the direction of strata of the same system in different places. But my present impression is, that the strata under consideration can hardly be connected with the east and west system: and, therefore, I place them

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provisionally under a sixth system. But I possess no data for forming even a conjecture as to the epoch of its elevation.

In Dr. Richardson's account of the geology of the northwest part of North America, observed during the recent exploring tour under Capt. Franklin, we find him describing a part of the Rocky Mountains as composed of four chains, terminated by the northern ocean to the west of Mackenzie's River, and running about S. E. and N. W. They consist of primary rocks: and I mention them here, as a pretty strong indication that a system of elevation with such a bearing exists on this continent. Such a direction, however, is not common in North America in our mountain chains, unless we go as far south as the isthmus of Darien.

In comparing the facts which have now been stated in regard to the elevation of our strata, with similar facts developed in Europe, I have been led to conclude that it is a considerably longer period since the elevating force has acted in the United States than in Europe. For we have slight evidence of any extensive disturbance here since the deposition of the strata above the chalk, and not very conclusive evidence of such disturbance even so late as the cretaceous period: Whereas, in Europe, several systems of elevation are reckoned of a later date. And this conclusion agrees with the fact that volcanic agency has not yet ceased on the eastern continent, but in the United States, no traces of its action, since the earth assumed its present state, have been discovered. For if I mistake not, the existence of volcanoes in any region, indicates less thickness in the crust of the globe than in other places; since the melted matter would be forced through the envelope where it is thinest. Accordingly, the only experiments that have been made in the United states upon internal temperature, indicate a less rapid increase as we descend into the earth here, than in Europe; and consequently a greater thickness of the earth's crust on this side of the Atlantic.

All this would lead to the conclusion that our western continent is older than the eastern: at least that such is the fact with its Atlantic border. Beaumont, however, seems to be of a different opinion. It appears "says he, from the description of Messrs, Vanuxem and Morton, that the ancient level, traced on the flancs of the Alleganies by the tertiary deposits and the alluvia, anterior to that of existing streams, which cover their base, is no longer horizontal. It rises gradually from New England to the Mississippi, so that at the Isle of Nantucket it plunges beneath the level of the ocean; and from that

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point even to Greenland, no tertiary deposit has been discovered along the coast. It follows that the American continent has experienced a sort of see-saw movement, (*mouvement de bascule,*) which has raised its western side and sunk its eastern: so that we may attribute a very recent origin to the Andes."* I confess myself rather sceptical in regard to these conclusions. But even if it be admitted that the western side of this continent is of a comparatively recent origin, it may still be true, that its eastern side was elevated at a very early period.

### *Ancient Deluges.*

If it be true that continents and vast chains of mountains were elevated at different periods, and by paroxysmal efforts, it is impossible but that deluges of tremendous violence and universal extent, should have been the consequence. Accordingly we find traces of such deluges in the vast beds of conglomerates that exist in the sedimentary deposits; and also in the frequent extinctions and renewals of animal and vegetable life, which appear to have taken place on the globe. For such deluges must have been fatal to organized existence: at least to a great extent. But I doubt whether geology is yet enough advanced to be able to trace particular destructions of organized beings to particular epochs of elevation with their attendant deluges. In respect to the rocks of Massachusetts, I feel utterly unable to trace any such connections. Yet our rocks show the occurrence of several very powerful deluges in early times. The earliest of these, by which the materials of the Roxbury and Rhode Island conglomerates were accumulated, must have been of great power: and if, as I suppose, the latter conglomerate was deposited much earlier than the former, two such deluges must have been required. The new red sandstone affords evidence of numerous deluges during its deposition, in the numerous alternations of coarse and fine materials of which it is composed. Two periods during its production appear to have been particularly distinguished for powerful diluvial action. In the first, those conglomerated beds, made up chiefly of the ruins of granite and associated with the lower beds of sandstone, were accumulated. In the second, that very coarse conglomerate, cheifly composed of various schists and connected with the higher shales and sandstones, was brought into its present situation. The osseous conglomerate connected with the plastic clay indicates diluvial action

* Recherches &c, Chap. 2. p. 321.



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perhaps, though not of the most violent kind, during the deposition of this formation.

*Theory concerning the Force by which Systems of Strata were elevated at successive epochs.*

Although existing volcanoes often occur at intervals along extensive ridges of mountains, yet there is no evidence that such ridges have been elevated by these volcanoes. Indeed, it is difficult to conceive how a volcannic force can operate except in the direction of the radii of a circle: so that however numerous the *foci*, they could not have produced mountain ridges having a common direction through several degrees of the earth's surface. Volcanic power then, in the common acceptation of the term, could not have produced the systems of elevation that have been examined.

If the theory of internal heat be admitted, however, we are furnished with a power adequate to the production of these systems, as ingeniously suggested by Beaumont. The outer crust of the earth, according to the doctrines of central heat, has nearly reached the limit of refrigeration: at least, it must cool much slower now than the internal parts, if they are intensely heated: and consequently, the internal parts must shrink much more than the exterior. Hence the envelope must from time to time become too large to embrace the internal diminished parts, without a suffering degree of plication. That is, in some places the crust will sink down, and in other places be thrown up into correspondent ridges. Mere gravity, would produce this effect, unless the crust had become extremely rigid. And a little reflection will satisfy any one, that these ridges and vallies will correspond in direction with the semi-circumference of the globe; that is, with a great circle upon it: And such is the direction which Beaumont supposes every known system of strata has taken.

According to this hypothesis, we see how it is that mountains should be elevated at different epochs. For they result from the effort which the crust of the globe is caused to make, from time to time, to accommodate itself to the continually diminishing size of the internal nucleus. Whenever a cavity is thus produced underneath any portion of the crust, its weight will cause its thickest or least rigid portions to sink down upon the heated and it may be fluid nucleus, and this will produce a lateral pressure sufficient to elevate adjoining portions; while the weight of the depressed portion will force the fluid matter into the cavities produced by the elevations; and it may be, even cause it to be erupted through the ruptured summits of the ridges; thus producing unstrati-

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fied rocks, along extensive lines, and not from circular craters, as lava is now erupted from volcanoes. A change of this kind having been effected, all would remain quiet until the secular refrigeration had produced other cavities; when a renewal of the same process would take place. And I think it easy to conceive, that a long series of such changes might take place without so sensibly diminishing the magnitude of the globe, that astronomers should be able to perceive their effects on the earths rotatory motion through decades of centuries. For the elevation would nearly equal the depression.

From this view of the subject, it would appear that gravity has been the principal force employed to elevate systems of mountains. This, in consequence of the diminished size of the internal nucleus of the globe, would produce a lateral pressure on both sides of that portion of the crust which was depressed, sufficient to elevate adjoining portions; and to force up melted matter beneath and even through the ridges; and thus the ultimate effects would be precisely like that of an expansive force within the earth; except that it would operate along extended lines and not in circular foci.

I am aware that many of the views of Beaumont, which I have attempted briefly to develope, have been, and are now, ably and warmly opposed by Boue and other geologists no less distinguished. All, however, agree, I believe, that different formations, and consequently different mountain masses, have been elevated at different epochs; which I regard as the fundamental and most important principle concerned. Even if it be proved that distant parallel mountain chains were not of synchronous elevation, (which is the principal point at issue,) it cannot materially affect the value of Beaumonts researches. He certainly has the merit of bringing together all that was known on this subject and of deducing from thence some masterly generalizations, which must be regarded as forming an interesting epoch in geology.

## *Concluding Remarks.*

In drawing to a conclusion this protracted Report on the Geology of Massachusetts, it is natural to pause and look back upon my labor. And I freely acknowledge that its great deficiency and imperfection are its most striking features. I cannot, indeed, accuse myself of a want of diligence and effort to accomplish the objects of my appointment. It is now a little more than three years since I received my commission; and during that period, in addition to the ordinary labors of my profession, I have traveled 4550 miles for geological pur-

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poses, and collected for the Government and for the three Colleges in the State, not less than 5000 specimens of rocks and minerals: 1550 of which belong to the Government collection.* Yet I cannot but perceive great imperfections and deficiencies in my account of our rocks: and I have become more and more impressed with the idea, that a much longer period was indispensable to enable any man to obtain a full and complete account of the geology and mineralogy of nearly 8000 square miles of surface, so diversified as Massachusetts. Indeed, had I not, previous to receiving my commission, traveled nearly as far, and obtained nearly as much information relative to our geology, as since that period, my report could hardly have been tolerable — if it be so now. As it is, I can regard it only as a commencement of the work of exploring our rocks and minerals. The field yet remains open for the admission of other and more able laborers, who I doubt not may reap many an abundant harvest. If my efforts shall aid or encourage those who may come after me, they will not have been made in vain.

I cannot close without expressing to your Excellency, how gratifing it has been to me, to act in this whole business, under the direc- of one whose views have been so liberal in regard to it; whose counsels and instructions have been so judicious and encouraging; and whose personal attention and kindness have laid me under very strong obligations.

Nor can I omit to mention the universal disposition which I have found manifested by all classes of the citizens of the Commonwealth, and in every part of it, to do all in their power to forward the objects of my commission. This is among the circumstances that gave so much interest to all my geological tours, and renders the retrospect of them among the most delightful recollections of my life. The excursions, I am happy to confess, have greatly exalted my opinion of the kindness, intelligence, and happy condition of our population, and sensibly increased my attachment to my native State.

Finally, and above all, I would not close without acknowledging my supreme obligations to Him whose providential care and kindness have followed me in all my wanderings, not permitting even a hair of my head to be injured; and who has enabled me to bring at length to a conclusion, one of the most laborious enterprises of my days. To Him I desire to consecrate the fruits of this labor and of all the

* Instead of 1200, as stated on page 3.

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subsequent labors of life. And should they prove even slightly instrumental in promoting human knowledge and happiness — two grand objects of the Divine Benevolence—I know that they will be accepted.

Respectfully Submitted,

EDWARD HITCHCOCK.

Amherst College, September 1, 1833.

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## PART IV.

# A CATALOGUE

OF THE

# ANIMALS AND PLANTS

IN

# MASSACHUSETTS.

To His Excellency Levi Lincoln Esq.
Governor of Massachusetts.

In executing the part of my commission which directed me to furnish catalogues "of the native mineralogical botanical and zoological productions of the Commonwealth," I have been greatly dependant upon the assistance of several gentleman distinguished for their acquaintance with particular branches of natural history. Their names will be found prefixed to the catalogues which they have furnished. And I take this opportunity to testify to the prompt and liberal manner in which they have executed this difficult task. I ought also to remark, that the catalogues which follow, being for the most part the first that have been attempted in this quarter of the country, cannot be supposed perfect or complete. They are sufficiently so, however, to furnish a great amount of new and valuable information respecting the organized beings found within the limits of the State.

In respect to the minerals of the State, I have found it more convenient to give an account of them in describing the several rocks in which they occur, and also in the Tabular View of the rocks; and I judge it wholly unnecessary to repeat the list in this place.

Respectfully Submitted,

Edward Hitchcock.

Amherst College, October 1. 1833.

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# I. MAMMALIA.

OR ANIMALS WHICH SUCKLE THEIR YOUNG.

In preparing the following Catalogue of our mammiferous animals, I have been permitted to make free use of notes kindly furnished by Dr. T. W. Harris; a gentleman so well known as an accurate zoologist, that the value of this Catalogue would have been much enhanced, could he have been persuaded to make it entirely his own.

## ORDER 1. CARNASSIERS.

Vespertilio pruinosus, Say. *Hoary Bat.*
Noveboracensis, Linnaeus. *Red or New York Bat.*
Sorex brevicaudus, S. *Short tail Shrew.*
Scalops Canadensis, Cuvier. *Mole.*
Condylura cristata, Desmarest. *Star-nose Mole.*
macroura, Harlan. *Thick-tailed star-nose Mole.*
Ursus Americanus, Pallas. *Black Bear.* *
Procyon lotor, L. *Raccoon.*
Gulo luscus, L. *Wolverene.*†
Mustela (Putorius) vulgaris, L. *Weasel.*‡
erminea, L. *Ermine.*‖
Canadensis, L. *Fisher Weasel.* (Dr. Emmons)
? martes, L. *Pine Martin.*
vison. L. (lutreola, Harlan and Godman.) *Mink.*
Mephitis Americana, Desmarest. *Skunk.*
Lutra Canadensis, Sabine. (Brasiliensis, Harlan and Godman.) *Land Otter.*
Canis (Lupus) occidentalis, Richardson. *Wolf.*
(Vulpes) fulvus, D. *Red-Fox.*
virginianus, Gmelin. (cinereo-argentatus, Say and Godman.) *Gray-Fox.*
? Felis concolor, L. *Cougar, Panther, Painter or Catamount.*
Canadensis, Geoffrey. *Lynx, or Wild-Cat.*
Phoca vitulina, L. *Common, or hair-Seal.*
cristata, L. *Hooded-Seal.*

## ORDER 2. RODENTIA.

? Castor fiber, L. *Beaver.*
Fiber zibethecus, L. *Musquash.*
? Arvicola Pennsylvanica, Ord. *Meadow-Mouse.*
Mus decumanus, Pallas. *Common Brown, or Norway-Rat, Wharf-Rat, and Water-Rat.*
rattus, L. *Black-Rat.*
musculus, L. *Mouse.*
? leucopus, Rafinesque. (agrarius, Godman.) *Field Mouse.*
Gerbillus (Meriones) Canadensis, D. *Jumping Mouse.*
Arctomys monax, Gmelin. *Woodchuck.*
Sciurus cinereus, L *Cat Squirrel.*

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* The long-legged variety is most common on Hoosac mountain, but the short-legged variety has been killed there according to Dr. Emmons.

† On Hoosac mountain rare—Dr. Emmons.

‡ The Weasel becomes white in the winter like the ermine, from which it is not distinguished by hunters.

‖ The ermine in its summer dress, greatly resembles the weasel.

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Sciurus Carolinensis, Gmelin. *Gray Squirrel.*
niger, L. *Black Squirrel.*
Hudsonius, Gmelin. *Chickaree or Red Squirrel.*
(Tamias) striatus, Klein (Lysteri, Ray, and Richardson) *Striped or Ground Squirrel.*
Pteromys volucella, L. *Flying Squirrel.*
Hystrix pilosus, Catesby. (dorsata L.) *Porcupine.*
Lepus Americanus, Gmelin. *Rabbit, or Hare.**
Virginianus, Harlan. (variabilis, Godman) *Varying Hare.*

## ORDER 3. RUMINANTIA.

Cervus Virginianus, Gmelin. *Common, or Fallow Deer.*

## ORDER 4. CETACEA.

Delphinus Delphis, L. *Grampus or Porpus.*†
(Phocæna) gladiator, Lacepede. *Killer, Sabre-finned Dolphin, or Sword Fish.*
Balæna mysticetus, L. *Common Whale.*

Note. It is doubtful whether the animals, to the names of which this character (?) is prefixed, do now exist within the limits of Massachusetts; all of them, except Mustela martes, Arvicola Pennsylvanica, and Mus leucopus, undoubtedly once had here a "local habitation"

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# II. BIRDS.

BY EBENEZER EMMONS, M. D.

*Professor of Natural History in Williams College.*

*Explanations and Abbreviations.*

‖ placed before a species denotes that it is a summer and winter resident.
¶ marks the rare species.
◊ shews that it is a regular visitant, and breeds in this climate.
† shews that it is an occasional visitant.
L.—Linnæus. Briss. Brisson. Gmelin
Lath.—Latham. Ill.—Illiger. Cuv.—Cuvier. Vieill.—Vieillot.
Temm. Temminck. Ranz.—Ranzani. Latr.—Latreille.
Wils.—Wilson. Bon.—Bonaparte.

## SUB CLASS I.

Hind toe articulated on the same plane with the foretoes, and bearing on the ground the whole length, *formed for grasping.*

## ORDER I. ACCIPITRES.

*Accipitres.* L. Gm. Lath. Cuv. Vieill. *Raptatores,* Ill. *Rapaces* Temm. Latr. Ranz.

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* This animal is almost universally called a *Rabbit*, though it is, strictly speaking, a Hare, and never burrows like a Rabbit.

† Not unfrequently but improperly called Porpus. It is the true *Dolphin* of the ancients, but not the Dolphin of Seamen, which is the Coryphæna purpurea.



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*Falco.*

‖ ¶ fulvus, *Ring-tailed Eagle.*
‖ ¶ leuco cephalus, L. *Bald Eagle.*
† haliaetus, L. *Fish Hawk.* Makes its visits up the Hoosic in the Spring.
§ sparverius, L. *Sparrow Hawk.*
§ columbarius. L. *Pigeon Hawk.*
¶ palumbarius, L. *Goshawk.*
§ velox, Wils. *Slate-colored Hawk.* Common. Arrives March 20th.
¶ lagopus, L. *Rough-legged Falcon.*
‖ borealis, Gm. *Red-tailed Hawk.* } Common. Prepares its nest early in March.
‖ hiemalis, Gm. Wils. *Winter-Falcon.*

*Strix.*

† ¶ funerea, Gm. *Hawk Owl.* Autumn.
‖ ¶ virginiana, Gm. *Great-horned Owl.* Inhabits the mountains.
§ otus, L. *Long-eared Owl.*
§ brachyotus, Gm. *Short-eared Owl.* Common.
¶ ‖ Acadica, Gm. *Little Owl.*

## ORDER II. PASSERES.

### TRIBE I. SCANSORES.

### FAMILY AMPHIBOLI.

*Coccyzus.* Vieill. Temm. Ranz. Cuv.

*Cuculus.* L. Briss. Gm. Lath. Ill.

§ Americanus, Bon. *Yellow-billed Cuckoo.*
§ erythrophthalmus. *Black-billed Cuckoo.*

### FAMILY SAGITTILINGUES.

*Picus.* L. Briss. Gm. Lath. &c.

§ auratus, L. *Golden-winged woodpecker.* } Common.—Arrives about Ap. 10th. and migrates south in Oct
‖ pileatus, L. *Pileated Woodpecker.*
§ erythrocephalus, L. *Red-headed Woodpecker.*
† Carolinus, L. *Red-bellied Woodpecker** Common near Rochester NY
§ varius, L. *Yellow-bellied Woodpecker.*
‖ villosus, L. *Hairy Woodpecker.*
‖ pubescens, L. *Downy Woodpecker.*

### TRIBE 2. AMBULATORES.

### FAMILY ANGULIROSTES, Ill.

*Alcedo* L. Gm. Lath.

§ alcyon, L. *Belted King Fisher.*

### FAMILY GREGARII.

*Sturnus* L. Briss. Gm.

§ Ludovicianus, L. *Meadow Lark.* Arrives about March 13th.

*Icterus* Briss. Temm. Ranz.

§ Baltimore, Dand. *Baltimore Oriole.*
§† spurius, Bon. *Orchard Oriole.*

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* Takes the place of the P. auratus in the Western part of the State of New York.

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§ phoeniceus, Dand. *Red Winged Starling.* March 20th.
§ pecoris, L. *Cow Banting.*
§ agripennis, Bon. *Rice Banting.*

*Quiscalus* Vieill.

§ versicolor, Vieill. *Purple Grakle.*
ferrugineus, Bon. *Rusty Grakle.*

*Corvus* L. Gm. Lath. Cuv.

‖ corone, L. *Crow.*
‖ cristatus, L. *Blue Jay.*

FAMILY SERICATI.

*Bombycilla* Briss. Ill.

§ Carolinensis, Briss. *Cedar Bird.*

FAMILY CHELIDONES.

*Caprimulgus* L. Briss. Gm. Lath.

§ vociferus, Wils. *Whip-poor-will.*
§ Virginianus, Briss. *Night-Hawk.* Arrives March 20th.

*Cypselus.* Temm.

§ pelasgius, Temm. *Chimney Swallow.*

*Hirundo* L. Briss. Gm. Lath.

§ purpurea, L. *Purple Martin.*
§ rufa, Gm. *Barn Swallow.* Arrives April 20th.
§ fulva, Vieill. *Rocky Mountain Swallow.* Common.
§ riparia, L. *Bank Swallow.*

FAMILY CANORI. Ill.

*Muscicapa* Briss. Ill. L. Gm.

§ tyrannus, Briss. *Tyrant Fly-catcher.* Arrives between 1 and 12 May
§ crinita, L. *Great crested Fly-catcher.*
§ fusca, Gm. *Pewit fly catcher.* Arrives March 20th.
§ virens, L. *Wood-Pewee Fly-catcher.*
§ ruticilla, L. *American. Fly Catcher.* Common.

*Icteria.* Bon.

† viridis, Bon. *Yellow-breasted Chat* First of September.

*Vireo.* Vieill.

§ flavifrons, *Yellow-throated Fly-catcher.*
¶ Noveboracensis, Bon. *White-eyed Fly-catcher.*
§ olivaceus, *Red-eyed Fly-catcher.* Common.

*Lanius.* L. Briss. Gm. Lath.

† septentrionalis, Gm. *Butcher Bird.* Late in Autumn.

*Turdus* L. Briss. Gm.

† polyglottos, L. *Mocking Bird.* Very rare in the Spring.
§ felivox, Vieill. *Cat Bird.* Arrives between May 1 and 12.
§ migratorius, L. *Robin.* Arrives March 10.
§ rufus, L. *Ferruginous Thrush.*
§ mustelinus, Gm. *Wood-thrush.* Arrives May 1 to 12.
§ minor, Gm. *Hermit Thrush.* Arrives May 1 to 12
Wilsonii, Bon. *Tawney Thrush.* Do. Do.

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*Sylvia.* Lath. Temm. Ranz.

§ aurocapilla, Bon. *Golden Crowned Thrush.* May 1 to 12.
Noveboracensis, Lath. *Water Thrush.*
† coronata, Lath. *Yellow-rump Warbler.* } Passes north in the
virens, Lath. *Black-throated green Warbler.* } Spring, returns in Sep.
¶§ Blackburniae, Lath. *Blackburnian Warbler.* Mountain.
¶ icterocephala, Lath. *Chesnut sided Warbler.* Do.
§¶ castanea, Wils. *Bay-breasted Warbler.*
striata, Loth. *Black-poll Warbler.*
§¶ varia, Lath. *Black and White Creeper*—Mountain.
§¶ tigrina, Lath. *Blue Mountain Warbler.*
§ æstiva, Lath. *Blue-eyed yellow Warbler.*
§ Americana, Lath. *Blue yellow—back Warbler.*
†¶ Canadensis, Lath. *Black-throated Blue Warbler.*
¶ agilis, *Connecticut Warbler.*
† autumnalis, *Autumnal Warbler.* Returns from the North in Oct.

*Saxicola.* Temm. Ranz.

§ sialis, Bon. *Blue Bird.* Ar. about Mar. 10.

*Regulus.* Vieill.

§ cristatus, Vieill. *Golden crested Wren.*

*Troglodytes.*

§ ædon, Vieill. *House wren.*

FAMILY TENUIROSTRES.

*Sitta.* L. Briss. Gm. Lath.

§ Carolinensis, Briss. *White breasted Black-capped Nuthach.*

FAMILY ANTHOMYZI. Ranz.

*Trochilus.* L. Gm. Lath.

§ colubris, L. *Humming Bird.*

*Parus.* L.

‖ articapillus, L. *Black-capped Titmouse.*

FAMILY PASSERINI. ILL.

*Emberiza.* L. Briss. Gm.

† nivalis, L. *Snow Bunting.* Winter.

*Tanagra* L. Gm. Lath. Cuv.

rubra, L. *Scarlet Tanager.*

*Fringilla.* L. Temm. Ranz. Wils.

§ cyanea, Wils. *Indigo Bird.* Common.
¶§ Pennsylvanica, Lath. *White-throated Sparrow.*
§ graminea, Gm. *Bay winged Bunting* Common.
§ melodia, Wils. *Song Sparrow.*
‖ hiemalis, *Snow Bird.* Breeds in the mountains: common in the hedges in Spring and Autumn.
¶ passerina, Wils. *Yellow Winged Sparrow.*
† Canadensis, Lath. *Tree Sparrow.* Winter.
† socialis, Wils. *Chipping Sparrow.*
§ pusilla, Wils. *Field Sparrow.* Common.

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§ tristis, L. *Yellow Bird, or Goldfinch.*
§ pinus, Wils. *finch.*
†¶ linaria, *Lesser red-poll.* Winter.
† iliaca, Merrem. *Fox-colored Sparrow.* Winter,
§ eyrthrophthalma, L. *Towhe Bunting.*
¶ cardinalis, Bon. *Cardinal Grosbeak.*
¶ rosea, Bon. *Rose-breasted Grosbeak*
¶ purpurea, Gm. *Purple Finch.*

*Loxia.* Briss. L. Gm. Lath.

Curvirostra, L. *American Cross Bill.*

FAMILY COLUMBINI.

*Columba.*
§ migratoria, L. *Passenger Pigeon.*
¶ Carolinensis, L. *Turtle Dove.*

## SUB CLASS, II.

Hind toe articulated higher on the tarsus than the fore toes; incapable of grasping, or wanting.

## ORDER III. GALLINÆ.

FAMILY GALLINACEI.

*Meleagris.*
¶‖ Gallopavo, L. *Wild Turkey.* Now become scarce and nearly extinct.*

*Perdix.* Briss Lath. Ill.
§ Virginiana, Lath. *Quail.*

*Tetrao.* L. Gm. Lath. Ill. Cuv.
‖ umbellus, L. *Ruffled Grous.* Common.

## ORDER IV. GRALLÆ.

FAMILY PRESSIROSTRES.

*Charadrius.* L. Gm. Lath. Ill.
† semipalmatus, Bon. *Ring Plover.* A single specimen on the banks of the Hoosic.
§ melodus, Ord. *Ringed Plover.*
§ vociferus, L. *Kildeer Plover* Appears about April. 10th.
§ ruvialis, L. *Golden Plover.*

*Strepsilas.* Ill. Temm. Ranz.
§ interpres, Ill. *Turn-stone.*

FAMILY HERODII. ILL.

*Grus.* Pallas, Ill. Cuv. Temm.
¶§ Americana, Temm. *Hooping Crane.*

*Ardea.*
§ Herodias, L. *Great Heron.*
§ alba, L *Great white Heron.*
§ nycticorax, L. *Night Heron.* More common late in the Summer.

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* Frequently met with on mount Holyoke. E. H.

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coerulea, L. *Blue Heron.*
minor, Wils. *American Bittern.*
§ virescens. *Green Heron.*

FAMILY LIMICOLÆ.

*Numenius.* Briss. Lath. Ill. Cuv.

§ longirostris, Wils. *Long billed Curlew.* Rarely on the Hoos ic.

*Tringa.* L. Lath. Gm.

§ semi-palmata, Wils. *Semi-palmated Sandpiper.*
alpina, L. *Red-backed Sandpiper.*
pectoralis, Ben. *Pectoral Sandpiper.*
§ pusilla, Wils. *Little Sandpiper.*

*Himàntopus.* Briss. Ill. Cuv. Temm.

nigricollis, Vieill. *Long-legged Avocet.*

*Totanus.* Cuv. Temm. Vieill. Ranz.

melanoleucus, Vieill. *Tell-tale Godwit.*
† macularius, Temm.

*Scolopax.* L. Briss. Gm. Lath.

Wilsonii, Temm. *Snipe.*

FAMILY MACRODACTYLI.

*Rallus.* L. Cuv. Vieill.

§ crepitans, L. *Clapper Rail.*
† Virginianus, L. *Virginia Rail.*

*Fulica.*

Americana, Gm. *Common Coot.*

## ORDER V. ANSERES.

FAMILY LONGIPENNES.

*Rhincops.* L. Gm. Lath.

§ nigra, L. *Black-Skimmer*, or *Shearwater.* Visits the coast during Summer.

*Sterna.*

§ hirundo, L. *Great Tern.*
§ minuta. *Lesser Tern.*

*Larus.*

‖ capistratus, Temm. *Brown marked Gull.*
§ atricilla, L. *Black headed Gull.*
§ canus, L. *Common Gull.*
§ fuscus, L. *Silvery Gull.*
argentatoides, Brehm. Common near N. Y.

FAMILY LEMALLOSODENTATI. ILL.

*Anser.*

canadensis, Vieill.
hyperboreas, Pallas. *Snow Goose.*
bernicla, Bon. *The Brant.*

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*Anas.* L. Gm. Briss.

† clypeata L. *Shoveller.*
† boschas, L. The *Mallard.*
§ acuta, *Pintailed Duck.*
Americana, *Widgeon.*
† sponsa, *Wood Duck.*
discors, *Blue-winged Teal.*

*Fuligula.* Bon.

perspicillata, Bon. *Black* or *Surf Duck.*
vallisneria, Stephens. *Canvass-back Duck.*
clangula, Bon. *Golden-Eye.* Rare on the Hudson.
albeola, Bon. *Buffet-headed Duck.*

*Mergus.* L.

Merganser, *Goosander.*

*Sula.*

bassana, Lacep. *Gannet.*

*Podiceps.* Temm. Vieill.

† cristatus, Lath. *Crested Grebe.* Rare on the Hudson.
† Carolinensis, Lath. *Pied-bill Dob-chick.*

*Colymbus.*

§ glacialis, L, *Great Northern Diver*, or *Loon.*
† septentrionalis, L. *Red throated Diver.*

*Uria*

† alle, Temm. *Little Auk.*

*Mormon.* Ill.

† arcticus, Ill. *Puffin.*

*Alca.* L. Gm. Briss.

torda, L. *Razorbill.*

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# III. REPTILIA OR REPTILES.

BY DAVID S. C. H. SMITH. M. D.

## ORDER I. CHELONIA.

*Testudo*, L.

scabra, Shaw, *Common Turtle.*
Pensnylvanica,
serpentina, *Snapping Turtle.*
picta, *Painted Turtle.*
punctata, *Speckled Turtle.*
clausa, } On the authority
insculpta, Leconte. } of Dr. Emmons.

## ORDER II. OPHIDIA.

Coluber.

constrictor, *Black Snake.*
erdinatus, *Striped Snake.*
sipedon, *Water Snake.*
saurita, *Ribbon Snake.*
sirtalis, *Garter Snake.*
striatulus,
punctatus,
eximus, *House Snake.*
vernalis, *Green Snake.*

*Crotalus.*

durissus, *Banded Rattle Snake.*

## ORDER III. BATRACHIA.

*Rana.*

pipiens, *Bull Frog.*
clamata, *Bawling Frog.*
flavi-viridis, *Spring Frog.*
sylvatica, *Wood Frog.*
palustris, *Leopard Frog.*

*Hyla.*

squirella? *Peeping Frog of New England.*
versicolor, *Common Tree Toad.*

*Bufo.*

musiceus,
Not described.

Salamandra, *Salmanders or Slows.*

subviolacea,
faciata,
erithronota,
cinerea,
symetrica.
tigrina. } On the authority
longicauda. } of Dr. Emmons.

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# IV FISHES.

## A Catalogue of the Marine Fishes taken on the Atlantic Coast of Massachusetts.

BY JEROME V. C. SMITH, M. D.

Anguilla muraena, L. Anguilla vulgaris, Cuv. *Common Eel.*
Conger muraena, L. Conger vulgaris, Cuv. *Conger Eel.*
Xiphius gladius, L. *Sword-Fish.*
Gadus morhua, L. *Common Cod.*
Gadus merluccius L. Merluccius vulgaris, Cuv. *Hake.*
Gadus brosme, Gmel. Brosme vulgaris, Cuv. *Torsk.*
Gadus æglefinus, L. *Haddock.*
Gadus merlangus, L. Merlangus vulgaris, Cuv. *Whiting.*
Gadus pollachius, L. Merlangus Pollachius, Cuv. *Pollock.*
Gadus callarius. *Tom Cod.*
Blennius viviperus. *Blenny.*
Blennius ocellaris, Bloch. *Ocellated Blenny.*
Blennius pholis, Bloch. (rare.) *Smooth Blenny.*
Scomber scomber, L. *Mackerel.*
Scomber colias, Gm. *Shore Mackerel.*
Thinnus vulgaris, Cuv. Scomber Thinnus L. *Tunny.*
Perca labrax. *Sea-Perch.*
Sciaena imberbis. *Drum-Fish.*
Pleuronectes flessus. Platessa flessus, Cuv. *Flounder.*
Pleuronectes platessa. Platessa vulgaris, Cuv. *Plaise.*
Pleuronectes solea, L. Solea vulgaris, Cuv. *Sole.*
Pleuronectes maximus, L. Rhombus Maximus, Cuv. *Turbot.*
Hyppoglossus vulgaris, Cuv. Pleuronectes, L. *Holibut.*
Labrus tautoga, Mitchell. *Tautog.*
Labrus squeteague, Mit. *Squeteague.*
Echenius remora, L. *Sucking Fish.*
Perca ocellata. *Bass.*
Cottus scorpinus, L. *Sculpin.*
Cottus quadricornis. *Sea Bull.*
Aspidophorus cataphractus, Cuv. *Armed-Bullhead.*
Clupea harengus, L. et Cuv. *Herring.*
Clupea menhaden, Mit. *Menhaden.*
Clupea alosa, L. *Shad.*
Clupea vernalis, Mit. Serrata? *Alewife.*
Clupea minima, Belknap. *Bret.*
Salmo salar. *Salmon.*
Salmo eperlanus, L. Osmerus eperlanus, Cuv. *Smelt.*
Esox belone, L. Belone vulgaris, Cuv. *Sea-Pike.*
Tetrodon tergidus. *Swell Fish.*
Acipenser sturio. *Sturgeon.*
Synguatus typhle *Pipe-Fish.*
Raia batis. *Skate.*
Raia clavata. *Thornback.*
Squalus zygaena. *Hammer headed Shark.*
Carcharius glaucus. *Blue Shark.*
Selache maximus, Cuv. Sqalus maximus, L. *Basking Shark.*
Squalus catulus, Cuv. stellaris, L. *Catfish.*
Squalus canicula, Cuv. *Dogfish.*
Anarchicas lupus, L. *Sea-wolf.*
Cyclopterus lumpus, L. *Lump-sucker.*
Cyclopterus minutus. *Little Lumpfish.*
Lophius piscatorius, L. *Frogfish.*



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*Fishes found in the Rivers, mountain Streams and Ponds of Massachusetts.*

Perca chrysoptera. *Bream.*
Esox lucius. *Pickerel.*
Salmo fontinalis. *Highland Trout.*
Silurus felis. *Pout.*
Cyprinus leuciscus. *Dace.*
Cyprinus crysoleucas. *Shiner.*
Cyprinus oblongus. *Chub.*
Salmo tructa? of Belk. *Salmon Trout.*
Cyprinus rubiculis. *Roach.*
Cyprinus atronasus. *Sucker.*
Bodianus pallidus. Luciopera of Belk. *White Perch.*
Bodianus rufus. *Red Perch.*
Labrus auritus. *Pond Perch.*
Anguilla vulgaris. *Common Eel.*
Perca fluviatilis. *River Perch.*
Petromyzon. *Lamprey Eel.*
Cottus gobio. *River bull-head.*

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# V. TESTACEA OR SHELLS.

*List of the Marine Shells of Massachusetts, arranged according to the System of Lamarck.*

BY THOMAS A. GREENE, ESQ. *of New Bedford.*

## CLASS IX. ANNELIDES.

### ORDER III. SEDENTARIA.

Pectinaria belgica.
Sabella belgica of Linn.
Terebella conchilega, L.
This has been subdivided into several species, two of which have been seen on our shore.
Spirorbis nautiloides.
Serpula spirorbis of L. On Sea weed.
Serpula vermicularis.
Serpula contortuplicata.

## CLASS X. CIRRHIPEDA.

### ORDER I. SESSILIA.

Balanus tintinnabulum.
On the bottoms of Ships.
Balanus ovularis.
Lepas balanoides of Wood—on plank, timber &c.
Balanus miser.
Very abundant on our rocks.
Balanus punctatus of Montague.
Lepas punctata of Wood and Dilcwyn—also on our rocks.
Balanus fistulosus.

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## ORDER II. PEDUNCULATA.

Anatifa laevis.
Lepas anatifera of L. On the bottoms of ships.
Anatifa vitrea.
Lepas fascicularis. Found at Nantucket.
Cineras vittatus.
Lepas vittata, On the bottoms of ships.

## CLASS XI. CONCHIFERA.

### ORDER I. BIMUSCULOSA.

Teredo navalis.
On the bottoms of ships.
Pholas crispata.
Solen ensis.
viridis.
Not common in the N. England States.
Solecurtus Caribœus.
Rare, found at New Bedford.
Solecurtus costatus, Say.
Common at Nahant Beach.
Solecurtus fragilis.
S. centralis of Say. Found at N. Bedford.
Mya mercenaria, Say.
*Common clam.*
Anatina convexa, Turton. Thracia of Blainville.
Anatina leana, Conrad.
A. prætenuis? of Turton. At Nantucket.
Mactra solida.
Mrctra gigantea, Lam.
M. Solidissima of Dillwyn.
Mactra subtruncata.
Mactra lateralis, Say.
Mactra subtriangulata.
M. arctata of Conrad. Figured in the supplement to Wood's "Index Testaceologicus."
Mactra tellinoides, Conrad.
Solemya velum, Say.
Not uncommon at N. Bedford.
Amphidesma corbuloides.
Mya Norwegica of Wood and Dillwyn.
M. hyalina of Conrad.
Corbula ferruginosa.
Mya ferruginosa of Wood. Not described by Lamarck.
Pandora trilineata, Say.
Found in Nantucket Harbor,
Petricola pholadiformis, Lam.
P. fornicata, of Say. Very common.
Sanguinolaria fusca, Conrad. At Nantucket.
Tellina polita, Say,
Found at N. Bedford.
Lucina divaricata. A single valve found at Chatham.
Crassina danmoniensis.
Astarte castanea of Say. Ocean shore at Nantucket.
Cyprina islandica.
Venus Islandica of Linn. Common in Essex County.
Venus mercennaria. *Common Quauhog or Round Clam.*

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Venus praeparca, Say.
Venus notata, Say.
Cardium Mortoni, Conrad.
Very common at N. Bedford.
Cardium pinnulatum, Conrad.
Cardita.
This species appears to be undescribed.
Arca ponderosa, Say. } These were found at Smith's point,
Arca pexata, Say. } on the ocean shore of Nantucket.
Arca transversa, Say.
Not uncommon in Buzzards Bay.
Nucula margaritacea.
Nucula proxima of Say.
Arca nucleus of Linn.
Nucula rostrata, Montague.
N. limatula of Say.

## ORDER II. UNIMUSCULOSA.

Modiola papuana.
Mytilus modiolus of Lin.
Mytilus edulis.
Mytilus ungulatus.
Mytilus pellucidus.
Mytilus incurvatus.
Mytilus demissus.
Very abundant at N. Bedford.
Pecten magellanicus.
Rare in Mass. Common at Eastport, Me.
Pecten Islandicus.
P. Pealeii of Conrad, Rare.
Pecten concentricus, Say.
*Common Scallop.*
Ostrea Virginica.
*Common Oyster.*
Anomia ephippium.
Abundant in N. Bedford.
Anomia undulata.
Is it a distinct species from the preceding?

# CLASS XII MOLLUSCA.

## ORDER II. GASTEROPODA.

Chiton.
Found ot Nantucket. Not described to my knowledge.
Patella alveus, Conrad.
Patella amoena, Say.
Crepidula fornicata, Say.
Very commou on our coast.
Crepidula glauca, Say.
Crepidula plana, Say.
Found in Nantucket Harbor.

## ORDER III. TRACHELIPODA.

Velutina rupicola, Conrad.
Bulla solitaria, Say.
Found at Martha's Vineyard. Rare.
Natica duplicata, Say.
Natica heros, Say.
Natica triseriata, Say.

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Nerita intricata of Wood's Supplement.
Tornatella.
Common in salt marshes. Not described.
Lacuna pertusa, Conrad.
Turbo obligatus, Say.
Very common in Buzzard's Bay.
Turbo palliatus, Say.
Turbo calathiscus.
Figured by Wood and described by Dillwyn. Very minute.
Turritella bisuturalis, Say.
Fusus Islandicus.
Murex corneus of Wood and Dillwyn.
Fusus corneus of Say.
Fusus cinereus, Say.
Fusus decemcostatus, Say.
Murex carinatus of Pennant.
Ranella caudata. At Nantucket.
Pyrula canaliculata.
Murex canaliculata of Linn.
Pyrula carica.
Nassa obsoleta, Say.
Buccinum novehoracense of Wood's Supplement.
Murex carica of Lin.
Nassa trivittata. Say.
Purpura lapillus.
Buccinum lapillus, Linn.
Purpura imbricata, Lam.
Buccinum undatum, Linn.
Columbella terpsichore.
Buccinum Terpsichore of Wood's Supplement.

## ORDER IV. CEPHALOPODA.

Spirula Peronii.
Nautilus Spirula of Linn.
Found on the ocean shore of Nantucket.

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## *List of Land and Fresh Water Shells in Massachusetts, so far as they have been asccertained.*

BY MR. JOHN MILTON EARLE, *of Worcester.*

### I. BIVALVES.

#### I. GENUS UNIO. *Lam.*

Unio.

complanatus, *Lam.* Purpureus, *Say.*
nasutus, *Say* Ponds in Essex and Plymouth Counties.
ochraceus, *Say* Ponds in Plymouth County.
radiatus, *Say* Do. and Essex Counties.

#### II. GENUS ALASMADONTA. *Say.*

Alasmadonta.

margaritifera, *Linn.* arcuata, *Barnes.*
marginata *Say*, Blackstone River.
undulata, *Say* Do. and streams in Plymouth County.

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### III. GENUS ANADONTA, *Lam.*

Anadonta.

cataracta, *Say.* Common Green Muscle.
marginata, *Say.* Blackstone and French Rivers.
lugubris, *Say.* Ponds in Essex Co.

### IV. GENUS CYCLAS.

Cyclas.

similis, *Say.*
dubia,* *Say.*

And two species not described.

## II. UNIVALVES.

### I. GENUS PALUDINA.

Paludina.

decisa, *Say.*
limosa? *Say.*

### II. GENUS PLANORBIS.

Planorbis.

trivolvis, *Say.*
bicarinatus, *Say.*
armigerus, *Say.*
campanulatus.
parvus, *Say.*

### III. GENUS LYMNAEA.

Lymnaea.

catascopium, *Say.*
heterostropha, *Say.*
columella, *Say.*

And one species not ascertained.

## LAND SHELLS.

### IV. GENUS HELIX.

Helix.

alaboris. *Common Wood Snail.*
arboreus, *Say.*
tridentata, *Say.*
alternata, *Say.*
glaphyra, *Say.*
thypopdus, *Say.*
minuta, *Say.*
hirsuta, *Say.*

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* This does not agree exactly with my specimens of the dubia found in Pennsylvania, but I think it not sufficiently distinct to be separated from that species.

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Helix.
perspectiva, *Say.*
fraterna. *Say.*

V. GENUS SUCCINEA. *Amphibious.*

Succinea.
ovalis, *Say.*
campestris? *Say.*
and one species not ascertained.

VI. GENUS PUPA.

Pupa.
corticaria? *Say*

VII. GENUS CARACOLLA.

One species not ascertained.

---

In addition to the preceding catalogues of the shells of Mass. full and apparently quite accurate, I have received from Col. Joseph G. Totten of the United States Army, resident in Newport R. Island the following list both of marine and land shells observed "on and near the coast of New England." Although this extends beyond the limits assigned me by the government, yet as so little is known of this class of animals, and so few gentlemen have devoted their attention to it, it has seemed to me probable that it would comport with the views of government to annex this catalogue to those already given; containing as it does several species and genera that have not been mentioned.

*List of Shells observed on and near the coast of New England.*

BY COL. JOSEPH G. TOTTEN.

Spiroribis Lam.
one or more species.
Serpula Linn.
one or more species.
Balanus Brug.
geniculatus, Conrad.
tintinabulum, Lin.
fistulosus, Brug.
Anatifa Brug.
sulcatus, Mont.
fascicularis, Solandus.
loevis, Brug.

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Pholas Lin.
one or more species.
Solen Lin.
ensis, Lin.
viridis, Say.
Solecurtus Blain.
cariboeus, Lam.
costatus, Say.
fragilis, Dill. centralis of Say.
Mya Lin.
mercenaria, Lin.
hyalina, Conrad.
Anatina Lam.
convexa, Wood. A. Thracia? of Blain.
leana, Conrad.
Mactra Lin.
solidissima, Chem.
lateralis, Say.
arctata, Conrad.
tellinoides, Conrad.
one or more other species.
Solemya Lam.
velum? Say.
one other species.
Corbula Lam.
contracta, Say.
Pandora Lam.
trilineata, Say.
Saxicava Lam.
distorta, Say.
Petricola Lam.
pholadiformis, Lam.
Sanguinolaria Lam.
fusca, Say.
Tellina Lin.
two or more species.
Lucina Brug.
divaricata, Gmel.
and a larger species.
Astarte Sowerby.
castanea, Say.
Cyclas Brug.
two or more species.
Cyprina Lam.
Islandica, Lin,
Cytherea Lam.
convexa, Say.
Venus Lin.
mercenaria, Lin.
notata, Say.
Cardium Lin.
Mortoni, Conrad.
pinnulatum, Conrad.

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Cardita Brug.
borealis, Say.
Arca Lin.
pexata, Say.
one or more other species.
Nucula Lam.
proxima, Say.
limatula, Say.
Unio Brug.
complanatus, Soland.
and others.
Anadonta Brug.
one or more species.
Alasmadonta Say.
margaritifera, Gmel.
and others.
Modiola Lam.
plicatula, Lam.
one or more other species.
Mytilus Lin.
edulis, Lin.
Pecten Brug.
magellanicus, Gmel.
Pealeii, Conrad.
concentricus, Say.
Ostrea Lin.
one or more species.
Anomia Lin.
ephippium, Gmel.
and another.
Chiton Lin.
marginatus, Lin.
Patella Lin.
amoena, Say.
alveus, Conrad.
a third ?
Dispotea Say.
striata, Say.
Crepidula Lam.
fornicata, Gmel.
convexa, Say.
plana ? Say.
glauca ? Say.
Bulla Lin.
one or more species.
Helix Lin.
albolabris, Say.
alternata, Say.
thyroidus, Say.
2 or more other species.
Succinea Draparnaud.
2 or more species.
Planorbis Brug.
2 or more species.



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Physa Drapar.
one or more species.
Lymnea Lam.
3 or more species.
Paludina Lam.
decisa, Say.
Natica Brug.
duplicata, Say.
heros, Say.
triseriata, Say.
Scalaria Lam.
one or more species.
Turbo Lin.
palliatus, Say.
obligatus, Say.
vestita, Say.
inoratus, Say.
rudis, Say.
one or more other species.
Lacuna Turton.
pertusa, Conrad.
2 or more other species.
Melampus.
3 or more species.
Velutina Blain.
rupicolor, Conrad.
Turritella Lam.
bisuturalis, Say.
one or more other species?
Fusus Brug.
cinereus, Say.
decem-costatus, Say.
corneus, Lin.
one or more other species.
Fulgur Mont.
canaliculata, Lam.
carica, Lam.
Ranella Lam.
caudata, Say.
Purpura Lam.
lapillus, Lin.
Buccinum Lin.
undatum? Lin.
Nassa Lam.
vibex, Say.
trivittata, Say.
obsoleta, Say.
lunata, Say.
Columbella Lam.
avara, Say.
and three or four shells not arranged to their genera.

Total, 61 genera, and at least 125 species.

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# VI. CRUSTACEA

For the means of preparing this Catalogue of our Crustacea, I have been almost entirely dependant upon notes which have been furnished me by Augustus A. Gould M. D. of Boston. But as he had only a very short notice of my wish to obtain such a catalogue, he is unwilling to appear as the responsible author of it. I apprehend, however, without pretending to much knowledge on the subject, that even as I have prepared it, it will not be found very deficient or inaccurate. And had that gentleman consented to make it out himself, I presume it would have been still less defective. Specimens of nearly all of them are in the Cabinet of the Boston Society of Nat. History, and may be found described by Mr. Say, in the Journ. of the Acad. of Nat. Sciences, of Philadelphia.

### ORD. I. DECAPODA.

#### *Fam. I. Brachyura.*

Portunus.
pictus.

Lupa.
hastata. Nantucket. *Blue claw Crab.*

Cancer.
granulatus. Martha's Vineyard and Nantucket. *Sand Crab.*
irroratus. ibid.
limosa. ibid.
and one other.

Ocypode.
pugilator. Martha's Vineyard and Nantucket. *Fiddler Crab.*

Pinnotheres *?*
ostreum. *In Oysters.*
one other species. Cambridge. Marshes, near salt water.

Grapsus.
pelagicus *?* Say. Gulf Stream.

Libinia.
canaliculata. Bost. Harbor, and Cape Cod. *Spider Crab.*

#### *Fam. II. Macroura.*

Astacus.
marinus. Bost. Harbor. *Lobster.*

Hippa.
emeritus. *Fab.* H. talpoida? Say. Cape Cod and Vin. *Sand bug.*

Pagurus.
longicarpus. Inhabits genus Nassa. *Hermit Crab.*
pollicaris. Inhabits genus Natica, Pyrula, &c. *Hermit Crab.*

Palæmon.
vulgaris. Inlets. both the last are called *Shrimps.*

Crangon.
septemspinosus, Say. Inlets,

### ORD. II. STOMAPODA.

Squilla.
empusa, Say.

### ORD. III. AMPHIPODA.

Taliprus.
longicornis. Under Sea Weed. *Sand Flea.*

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Gammarus.
mucronatus ?

ORD. IV. ISOPODA.

Idotæa.
cæca ?
Stenosoma.
irrorata.
Oniscus.
affinis. Sea shore.
Armadillo.
pilularis.

ORD. V. BRANCHIOPODA.

Limulus.
monoculus. Bost. Harbor. *Horse Shoe Monoculus.*
Branchipus.
one species. Stagnant water

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## VII. ARANEIDES. *Latr.*

### THE SPIDERS.

BY PROFESSOR N. M. HENTZ.

The following summary catalogue embraces a wider field than Massachusetts. The species, indeed, have been obtained from various parts of the United States. This arose from a misapprehension on the part of Professor Hentz of the precise object I had in view. Yet I did not think it important enough to request him to alter the list. The interesting notes which acompanied this catalogue, being too extended for this place, were fowarded to the editor of the American Journal of Science, and published in the 21st volume of that work. The whole paper forms, indeed, a valuable monagraph of the Spiders of the United States.

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ARANEIDES, (Latreille.) *Aranea*, (Linnæus.)

| | | | No. of species. |
|---|---|---|---|
| TETRAPNEUMONES. | 8 eyes; 4 mammulæ, 2 very short; tooth of the mandibulæ (chélicères) articulated downward, | Oletera, | 2 |
| | 6 or 8 eyes; 6 mammulæ; tooth of the mandibulæ articulated laterally, | Filistata? | 1 |
| | | Dysdera | 1 |
| | | Segestria? | 1 |
| DIPNEUMONES. | Araneides spinning webs, or wandering; never with *all* the following characters united 4th pair of legs longest, eyes in two rows both bent upward, and six mammulæ of which two very long. — Araneides forming no silken habitation, wandering; legs, 4th pair longest; eyes 8, in two rows, never both bent downward; 6 mammulæ, 2 very long, | Herpyllus | 8 |
| | Araneides making a web, sedentary, | Clubiona | 6 |
| | | Tegenaria | 2 |
| | | Agelena. | 2 |
| | | Theridium | 5 |
| | | Pholcus | 1 |
| | | Linyphia | 5 |
| | | Tetragnatha | 2 |
| | | Epeira | 26 |
| | | Mimetus | 1 |
| | Araneides making no web for a constant residence. | Thomisus | 8 |
| | | Sphasus. | 3 |
| | | Dolomedes | 6 |
| | | Lycosa* | 11 |
| | | Attus | 29 |
| | | Epiblemum | 2 |
| | Species not included in Attus. | | 3 |
| | | | 125 |

The number of 125 species will appear very large, but I could have swelled the list to 150. Spiders differ from true insects, or at least *winged* insects, in their *growing*. They come out from their eggs very minute, and continue to increase in size, probably for several years in many species; whereas, with few exceptions, insects come out of their *pupa* state, at once, with the size which is peculiar to them. The ARANEIDES, in their different ages, present differences of color and marking. The *seasons* also produce a change in the colors of some spiders; and, I am nearly convinced that the first

* The famous Tarantula of the South of Europe, the bite of which, for many years, was supposed to produce a disease that music alone could cure, belongs to this genus: and I found on Round Hill (Mass.) a species (*Lycosa fatifera*, my catalogue) which is probably very closely related to the European species, and which dwells in holes, nearly a foot deep.

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frosts produce a total change in the dress of several described EPEIRÆ which may be refered to one name. These are the considerations which have induced me to be very cautious in adopting new species, and comparing many specimens in different seasons, when possible, before I described them.

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# VIII. INSECTS.

BY THADDEUS WILLIAM HARRIS M. D.

## I. COLEOPTERA. *Beetles.*

### CICINDELIADÆ. *Tiger-beetles.*

Cicindela generosa, Dejean.
vulgaris, Say.
patruela, Dej.
purpurea, Olivier. marginalis, Fabricius.
sexguttata, F.
rugifrons, D.—C. unicolor, D. is merely a variety.
marginata, F. variegata, D.
dorsalis, Say.
duodceimguttata, D.
hirticollis. ? S. repanda, D.
hæmorrhoidalis, Hentz.
punctulata, Olivier.
and one more species.

### CARABIDÆ.

Casnonia Pennsylvanica, Linnæus.
Galerita Americana, L.
Brachinus librator ? D.
fumans, L.
formosus.
perplexus ? D.
cordicollis, D.
medius, Harris.
mniutus, H.
} *Bombardier Beetles.*
Helluo præustus, D.
Plochionus Bonfilsii ? D.
Cymindis pilosus, S.
platicollis, S.
comma.
glabratus.
biplagiatus.
Dromius ? subsulcatus ? D.
Calleida smaragdina, D.
Lebia tricolor, S.
borea, Hentz.
atriventris, S.
pulchella, D.
vittata, F.
solea, Hentz.
ornata S.

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Lebia decora, S.
viridis, S.
and one unnamed species.
Scarites subterraneus, F.
Clivina lineolata, S.
globulosa, S.
Cychrus viduus, D.
Sphæroderus stenostomus, Weber.
Scaphinotus elevatus, F.
Carabus vinctus, Weber. interruptus, S.
sylvosus, S.
limbatus, S.
serratus, S.
Calosoma scrutator F.
callidum, F.
obsoletum, S.
Nebria pallipes, S.
Omophron labiatum, F.
Elaphrus ruscarius, S. formely riparius, S.
Nothiophilus semistriatus, S.
porrectus, S.
Oodes Americanus, D.
amaroides, D.
Chlænius prasinus, D.
laticollis, S.
sericeus, Forster.
tomentosus, S.
nemoralis, S.
pubescens, H.
lithophilus, S.
emarginatus, S.
and one unnamed species.
Rembus impressicollis ? D.
Dicælus dilatatus, S.
elongatus, Bonelli. furvus, D.
politus, D. Leonardii, H.
Panagæus fasciatus, S.
Patrobus longicornis, S.
Calathus piceus, H. gregarius ? S.
Anchomenus extensicollis, S.
decorus, S.
with two unnamed species, and one undetermined allied genus.
Agonum octopunctatum, F.
cupripenne, S.
morosum, D.
nutans ? S. nitidulum, D.
melanarium, D. placidum ? S.
lenum, D.
luctuosum, D. obsoletum ? S.
with two unnamed species.
Feronia (Pœcilus) chalcites, S.
lucublanda, S.
fraterna ? S.
(Argutor) neglecta.
and one unnamed species.
(Omaseus) stygica, S. bisigillata, H.
subpunctata, H. corvina ? D.
polita, H. morosa ? D.
hamata, H. luctuosa ? D.
with two unnamed species.
(Pterostichus) adoxa, S.
with two more species.

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Amara (Leirus) exarata, D.
confinis, D.
obesa, S.
impunctata, S.
impuncticollis, S.
angustata ? S.
basillaris ? S.
and seven other species or varieties.
Daptus incrassatus, D.
Agonoderus lineola, F.
pallipes, F.
Harpalus (Pangus) caliginosus, F.
(Anisodactylus) carbonarius, S.
agricolus, S.
discoideus, D.
Baltimoriensis, S.
rusticus, S.
(Ophonus) sericeus, H. femoratus, D.
erraticus, S. Pensylvanicus ? Degeer.
viridis, S.
bicolor, F.
faunus ? S.
badius ? S.
herbivagus, S.
hylacis, S.
and seven other species.
Stenolophus ochropezus, S. plebejus ? D.
and one doubtful species.
Acupalpus rupestris, S. elongatulus, D.
partiarius ? S. pauperculus ? D.
conjunctus ? S. misellus, D.
and two more species.
Bembidium tetracolum, S.
oppositum, S.
metallicum.
inornatum, S.
and two more species.

## DITICIDÆ. *Long-horned Water-Beetles.*

Dyticus verticalis, S.
fimbriolatus ? S. Carolinus.
fasciventris, S.
(Acilius) fraternus, H.
mediatus ? S,
basillaris, H.
(Hydaticus) fasciaticollis, H.
liberus, S.
and one more species.
Colymbetes sculptilis, H.
binotatus, H.
suturellus, H.
fenestralis, S.
bicarinatus, S.
discolor, H.
obtusatus, S.
tæniolatus, H.
venustus, S.
acuductus, H.
and one other species.

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Laccophilus maculosus, S.
Hydrocanthus?
Hydroporus niger, S.
catascopium, S.
fasciatus, H.
affinis, S.
Hyphydrus punctatus, H.
and one more species.
Haliplus duodecimpunctatus, S.
immaculaticollis, H.

GYRINIADÆ. *Whirling Water-Beetles.*

Gyrinus emarginatus, S.
Americanus, L.
labratus.
limbatus? S. affinis.
analis? S.
arctus.

STAPHYLINIADÆ. *Rover-Beetles.*

Includes nineteen species besides the following.

Oxyporus — four species.
Staphylinus villosus, Gravenhorst.
immaculatus.
maculosus, G.
cingulatus, G.
fossator, G.
prælongus.
cinnamopterus, G.
nigripes.
pallipennis
anthrax, G.
Pæderus littorarius, G.
longiusculus.
Stenus — two species.
Tachinus fimbriatus, G.
memnonius, G.

PSELAPHIDÆ.

Pselaphus — two species.

BUPRESTIADÆ. *Flat Boring Beetles.*

Buprestis Geranii, H. volvulus? F.
Virginica, Drury.
striata, F.
maculiventris, S.
longipes, S.
divaricata, S.
tuberculata.
sylvatica.
obscura? F. corrosa.
lurida? F.
fasciata, O.
fulvoguttata, H.
characteristica, H.



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Buprestis femorata, F.
sexguttata, S.
Harrisii, Hentz.
(Agrilus) ignara? F.
subærata.
ruficollis, F.
virescens.
with 3 other species of Buprestis, and one of Agrilus.
Trachys tessellata, F.
fucata.
Lespedezæ.
and one more species.
Melasis semivittatus.

ELATERIADÆ. *Snapping Beetles.*

Eucnemis longulus.
and one more species.
Elater pennatus, F.
and four allied species.
oculatus, L.
myops, F.
longicornis.
brevicornis, S.
carbonarius.
præustus.
auriculatus.
elongatus, Palisot de Beauvois.
corticinus, S.
decipiens.
spiraculatus.
cylindriformis, S.
plebejus, S.
appressifrons, S.
decoloratus.
xanthopus.
scapularis.
quercinus, S.
cruciatus, L.
hieroglyphicus. S.
lugubris, Pal. de Beauvois.
discoideus, F.
contemptus.
metallicus.
glaber.
vernalis, Hentz.
inflatus, S.
pumilus.
plagicollis.
dorsalis, S.
dilectus, S.
stigma, Herbst.
silaceipes.
atriventris.
and 14 more species.
(Campylus) septentrionalis.
and one more species.
(Nothora) cinereus? Weber.

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Elater dispar? Herbst.
bicolor.
and 2 more species.
(Drapetes) Americanus.
Throscus—

CEBRIONIADÆ

Anelastes? sericea.
Physodactylus? cisteloides.
Sandalus? lineatopunctatus.
Ptylodactyla—
Dascillus—2 species.
Elodes ovalis, S.
bicolor.
Scirtes tibialis.
dorsalis.

LAMPYRIDIDÆ.

Lycus Smithii.
reticulatus, F.
terminalis, S.
perfacetus, S.
Omalisus coccinatus, Say in letters.
scapularis.
quadricollis.
marginellus.
and one more species.
Phengodes plumosa, O.
Lampyris versicolor, F.
centrata S.
angulata, S.
scintillans, S.
corrusca, L.
laticornis, F.
decipiens.
} *Fire-Flies.*
Telephorus rotundicollis, S.
carolina, F.
basillaris, S.
diadema, F.
bilineatus, S.
rufipes, S.
scitula? S.
and four other species.
(Chauliognathus) marginatus, F.

MELYRIDIDÆ.

Malachius vittatus, S.
quadrimaculatus, F.
tricolor, S.
Dasytes terminalis.

PTINIDÆ.

Ptinus fur, L.
Ptilinus ruficornis, S.

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Dorcatoma oculata, S.
Xyletinus thoracicus.
sericeus, S.
Anobium gibbosum, S.
molle ? F.
carinatum, S.
notatum, S.
tenuestriatum, S.
paniceum, F.
} *Death-Watch or Ticking Beetles.*
and one other species.

LIMEXYLIDÆ.

Cupes variegata.
capitata, F.

TILLIADÆ.

Enoplium pilosum, Forster.
onustum, S.

CLERIADÆ.

Seven species besides the following.
Thanasimus latefasciatus.
nigrifrons, S.
analis.
thoracicus, O.
Clerus Nuttallii, Kirby.
Necrobia violacea, L.
ruficollis, F.
} *Bone-Beetles.*

HISTERIADÆ.

Ten species besides the following.
Hister arcuatus, S.
interruptus, Pal. de Beauvois.
merdarius, Paykull.
unicolor, L.
abbreviatus, *F.*
pulicarius.
indistinctus, S.
mancus, S.
punctulatus, S.
elongatus, O.
(Platysoma) deplanata, Gyllenhal.

SILPHIADÆ. *Carrion-Beetles.*

Necrophorus Americanus, O. grandis, F.
orbicollis, S.
marginatus, F.
mediatus, F.
tomentosus, Weber. velutinus, F.
mortuorum, F.
Necrodes Surinamensis, F.
Silpha Americana, L.
marginalis, F.

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Silpha inequalis, F.
caudata, S.

NITIDULADÆ.

Fourteen species besides the following.
Thymalus ———
Nitidula grossa, F.
bipustulata, L.
undulata, S.
variegata, O. colon? L.
Ips fasciata, O.
dilecta.
immaculata.
sanguinolenta, O.
octomaculata.
Dacne fasciata, F.
Byturus unicolor, S.
Cryptophagus cellaris, O.
Scaphidium quadripustulatum, S.
unicolor.

DERMESTIADÆ.

Dermestes vulpinus, F.
lardarius, L.
marmoratus, S.
variegatus, S.
Megatoma pellio, L.
macellarius, F. and (Dermestes) megatoma, F

BYRRHIADÆ.

Anthrenus museorum ? L. varius ? F.
and 3 more species.
Byrrhus Americanus.
alternatus, S.
and 2 more species.

PARNIADÆ.

Heterocerus maculatus, S. in letters.
Dryops———
Elmis———
Macronychus glabratus, S.
Hydera ?

HYDROPHILIDÆ. *Short-Horned Water-Beetle.*

Hydrophilus triangularis, S
obtusatus, S.
glaber ? Herbst.
nimbatus, S.
globosus, S.
ovalis.
rotundatus, S.
striatus, S. undatus ? F. signaticollis.
nebulosus, S.
and 3 more species.
Elophorus———

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SPHAERIDIIDÆ.

Sphaeridium occallatum, S.
rufum.
and 4 more species.

SCARABÆIADÆ.

Ateuchus lævis, Drury. volvens, F. *Tumble-Dung.*
nigricornis, S.
Onitis sulcatus, Drury. Nicanor, F.
Onthophagus Hecate, Panzer. latebrosus, F.
(Varieties of this insect have received distinct names, such as furcicollis and Lama.)
subæneus, Palissot de Beauvois. ovatus? L.
Phanæus carnifex, L.
Copris anaglypticus, S.
minutus, Drury. Ammon, F.
Aphodius obliquatus.
femoralis, S.
vittatus, S.
strigatus? S.
terminalis, S.
rubeolus, Palissot de Beauvois.
and 2 more species.
Geotrupes exaratus.
dilatatus.
Blackburni? F. rusticus.
cupreus.
and one other species.
Odontaeus filicornis, S.
Trox porcatus.
echinatus.
serrulatus? Palissot de Beauvois. hispidus.
and two other species.
Scarabaeus Jamaicensis, Drury. Satyrus, F.
Maimon, F. Antaeus? Drury.
relictus, S,
tridentatus, S.
gibbosus, Degeer.
and two more species.
Rutela (Pelidnota) punctata, L.
lanigera, L.
Melolontha (Anomala) arboricola, F.
cœlebs.*
occidentalis, L. variolosa, Hentz.
(Rhisotrogus) Quercina, Knoch. fervens? Gyllenhal.
This insect and the eight following are commonly called *Dorr-bugs* or *Beetles*.
porcina, Hentz.
hirstitula, Knoch.
fraterna.
balia, S.
Georgicana? Gyllenhal.

* This insect has generally been referred to the varians, F. which it cannot be; it is considered as undescribed by Prof. Germar.

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Melolontha (Rhisotrogus) hirsuta ? Knoch.
? pilosicollis, Knoch.
? longitarsa, S.
? moesta, S.
? sordida, S.
(Serica) vespertina, Gyllenhal.
sericea, S. sericea ? Illiger.
iricolor, S.
and one allied species.
(Dichelonyx) linearis, Gyllenhal. elongatula ? F.
(Macrodactyla) subspinosa, F. *Rose-Bug.*
Hoplia oblonga.
and two more species.
Amphicoma vulpina, Hentz.
Trichius eremicola, Knoch.
scaber, Palissot de Beauvois.
dispar.
maculosus, Knoch.
piger, F.
lunlatus, F.
Cremastocheilus Hentzii, H. canaliculatus, Kirby.
Harrisii, Kirby.
Castaneae, Knoch. Sayii, H.
Cetonia fulgida, F.
Inda, L. barbata, S.
(Gymnetis) nitida, L.

LUCANIADÆ.

Lucanus Capreolus, L. Dama. F. *Horn-Bug* or *Stag-Beetle.*
latifrons.
parallelus, S. Voeti ? Schoenherr.
Platycerus piceus, Weber.
securidens, S.
Passalus cornutus, F.

BLAPTIADÆ.

Scotinus inequalis.
Dendarus (Heliophilus ?) rorulentus.
interruptus, S. (opatrum, Say.)

TENEBRIONIADÆ.

Boros pusillus.
Upis rugosus.
clavipes.
Pennsylvanicus, Degeer. lævis, Oliv.
reticulatus, S.
saperdoides, O. (Helops spinipes, F. Tenebrio anthracinus, Knoch.
rufipes, S.
femorata, F. fulvipes, Herbst.
? melandroides.
Tenebrio granarius. *Meal Worm.*
punctulatus.
badius, S.
reflexus, S.

DIAPERIADÆ.

Uloma fodiens.

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Phaleria testacea, S.
and another species.
Diaperis maculata, O. Hydni, F.
orbiculata.
erythrocera.
flavipes, F.
bicornis? F. viridipennis? F.
Leiodes? humeralis? F.
Eledona cornuta, F.

HELOPIDÆ.

Helops vittatus, O. micans, F.
obliquatus, F.
antennatus.
and two other species.
Pytho nitidus.

CISTELIADÆ.

Cistela fuliginosa.
marginata.
mæsicata.
collaris.
tersata.
atra, S.
obscura, S.
sericea, S. (Long's Expedition.)
sulphurea? L. sericea, S. (Journ. Acad. Nat. Sc.

SERROPALPIADÆ.

Orchesia—two species.
Eustrophus bicolor, F.
tomentosus, S.
Dircæa—3 species, allied to the *discolor* of Fabricius.
Melandria striata, S.
? maculata.
Hypulus——
Serropalpus corticinus.
linearis.
quadrimaculatus, S.

ŒDEMERIADÆ.

Œdemera (Dytilus?)præusta, F.
Mycterus.————

LAGRIADÆ.

Lagria ænea, S.

PYROCHROADÆ.

Dendroides canadensis, Latreille.
Pyrochroa flabellata, F.
infumata, Hentz.
elegans, Hentz.
and 3 other species.

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MORDELLIADÆ.

Rhipiphorus (Pelecotoma) 2 species.
Mordella nigra, S.
pruinosa.
scutellaris, F.
and 4 more species.

ANTHICIDÆ.

Scraptia — two species.
Notoxus anchora, Hentz.
monodon, F.
Anthicus cinctus, Say.
and two more species.

HORIADÆ.

Horia sanguinipennis, S.

CANTHARIDIDÆ. *Blistering Flies or Beetles.*

Meloe angusticollis, S.
and two other species.
Cantharis marginata, F.
ænea, S.
vittata, F.
cinerea, F.
atrata, F. Pennsylvanica, De Geer.

BRUCHIADÆ.

Rhinaria ? tæniolata.
Anthribus marmoreus, O. lunatus ? F.
and another species.
Rhinomacer ———
Bruchus Pisi, L. *Pea Bug or Beetle.*
and 3 more species.

CURCULIONIADÆ. *Weevils.*

Attelabus analis, Herbst.
pubescens, S.
bipustulatus, F.
Rhynchites bicolor, F.
hirtus ? F.
collaris, O. rubricollis, S.
and another species allied to the last.
(Pterocolus) ovatus, F.
Apion porosum.
rostrum S.
and another species.
Brentus septentrionis, Herbst. maxillosus ? O.
Curculio (Thylacites) crinitus.
(Sitona) lineatus, S. in letters.
tricarinatus.
(Aphrastus) tæniatus, S.
(Hadromerus) hilaris, Herbst.
(Otiorhynchus) one species much like *rugosus*.
(Hylobius) Abietis, L. multiguttatus ? O.
another species of Hylobius and
5 more of Curculio, F.



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Lixus — two species.
Rhynchænus (Balaninus) nasicus, S. } *Nut-Weevils.*
rectus, S. }
and another species.
(Pissodes) Strobi, Peck. *White-Pine-Weevil.*
Rhynchænus (Orchestes)—one species.
(Baridius) modestus.
and 4 more species.
(Cryptorhynchus) argula, F. Nenuphar. Herbst.
Cerasi. Peck. *Plum and Cherry*
maculipennis. [*Weevil.*
porcatus.
tormeinalis.
Juglandis.
and 3 more species.
(Ceutorhynchus) acephalus, S.
(Mononychus) vulpeculus, F.
and 2 more species of Rhynchaenus, F.
Calandra pertinax? O.
cariosa.
obliterata.
callosa? O.
Oryzæ, L. Introduced. *Rice-Weevil.*
and one more species.
Cossonus cylindricus. corticalis? F.
and one more species.

BOSTRICHIDÆ.

Ten species besides the following.
Hylurgus terebrans, O.
septentrionis.
(Tomicus) Pini, S.
dentatus, S.
(Scolytus) Pyri, Peck. *Pear-Tree Scolytus.*
Apate basillaris, S.

CISIDÆ.

Cis———
Cerylon———
Monotoma———

MYCETOPHAGIDÆ.

Three species besides the following.
Lyctus— 2 species.
Mycetophagus flexuosus, S.
and another species.
Latridius— 2 species.
Silvanus Surinamensis, L. frumentarius, F.
and 2 more species.
Trogosita mutica? Palissot de Beauvois. brevicollis.
cinnamomea, S.

CUCUJIÆ.

Cucujus clavipes, O.
rufus, O.

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Cucujus biguttatus S.
and 2 more species.
Uleiota dubia, F.
and another species.
Parandra brunnea, F.

CERAMBYCIDÆ. *Capricorn Beetles.*

Prionus laticollis, Drury. brevicornis, F.
laevigatus.
unicolor, Drury. cylindricus, F.
Cerambyx (Callichroma ?) one species.
(Stenocorus) atomarius, Drury. Marilandicus, F.
cinctus, Drury. garganicus. F.
undatus, F.
quadrigeminatus, S.
putator, Peck. *Oak-Pruner.*
and another species.
(Clytus)speciosus, S.
pictus, Drury. Robiniæ, Foster. flexuosus, F. *Locust-tree Borer.*
fulminans, F.
undulatus, S.
villicus, O.
hamatus, S.
caprea, S.
palliatus.
verrucosus, O. gibbosus ? F.
erythrocephalus, F.
supernotatus, S. Pini ? O.
and 4 more species.
(Callidium) foveicolle.
juvencum.
bajulus, L.
violaceum. L.
janthinum.
undatum ? L.
ligneum, F.
variabile, L. fennicum, F.
Necydalis (Stenopterus) rufus, L.
(Molorchus) bimaculatus, S.
Lamia (Acanthocinus) acanthura. subfasciata.
anetnnator ? F.
and 2 more species.
(Tetraopes) tetropthalma, Forster. tornator, F.
arator, Germar.
(Monochamus) titillator, F.
dentator? F. Caroliniensis ? O.
sutor, L.
pruinosa.
bifasciata.
and 2 more species.
(Mesosa) macula, S.
divaricata.
nebulosa ? L.
aspersa, S.
and 3 more species.
(Saperda) calcarata, S.
vestita, S. Append. to Long.
bivittata, S.
tridentata, O.

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Larmia (Saperda) triuncata.
lateralis, F.
plumbea ? O.
Rubi.
and 3 more species.
Leptura (Desmocerus) palliata, Forster. cyanea ,F.
(Rhagium) lineata, O.
(Rhamnusium) decolorata.
(Pachyta) Leonaradii.
canaliculata.
and 2 more species of Pachyta.
atrata.
annulata.
Canadensis, O.
velutina, O.
Rosarum.
nitens, Forster. Zebrata, F.
rubrica. S.
proxima, S.
vittata, O.
lineola, S.
scalaris, S.
luteicornis, F.
and 6 more species.

CRIOCERIDÆ.

Donacia palmata, O.
metallica, *S.*
chalybata.
pusilla, S.
and 14 more species, or remarkable varieties.
Orsodachna vittata, S. *var*, hepatica, S.
Crioceris trilineata, O. trivittata, S.
collaris, S.
Auchenia tuberculata.
and another species.

HISPIADÆ.

Hispa vittata, F.
suturalis, F. rosea, Weber.
quadrata, F. marginata, S.
pallida, S.
obsoleta, S.
and 2 more species.

CASSIDADÆ.

Cassida Argus, Herbst.
clavata, F.
aurichalcea, F.
quadrisignata.
vicina.
Convolvulvi.

CRYSOMELIADÆ.

Clythra dominicana, F.
quadriguttata, S.
Chlamys gibbosa, F. plicata F.(Bruchus and Clythra) tuberosa,Kn.
Cryptocephalus quadriguttatus, S.

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Cryptocephalus luridus, F.
and 2 more species.
Eumolpus auratus, F.
Pini, S.
varians.
Colaspis Quercus, S.
decemnotata, S.
puncticollis, S.
striata, S.
ovata, S.
and 6 more species.
Chrysomela trimaculata, F.
scalaris, Leconte.
Philadelphica, F.
hybrida, S.
pulchra, F.
elegans, O.
cæruleipennis, S,
teres.
and 2 more species.
(Prasocuris) scripta, F.
trivittata, S.
and 1 more species.
(Megalamera) Rhois, Forster. meticulosa, O.
Galeruca tomentosa, L. Baccharidis, Weber.
puncticollis, S.
vittata, F. *Cucumber-Bug or Beetle.*
Gelatinariæ, F.
sordida.
rufosanguinea, S.
duodecimpunctata, F.
chalybata.
and two more species.
(Adimonia ?)—2 species.
Haltica (Œdionychis) thoracica, F.
abdominalis, O.
vians, S.
fimbriata, Forster. suturella, S.
subvittata.
and one more species.
Caroliniana, F. alternata ? Illiger.
glabrata ? F.
tæniata.
triangularis, S.
collaris, F.
collata, F.
ænea ? O.
chalybea, Illiger. amethystina ? O.
ignita, Illiger.
nana, S.
striolata, F. var. bipustulata, F.
Cucumeris.
and two more species.
(Dibolia) — one species.

EROTYLIDÆ.

Ropalocerus fasciatus.
Tritoma humerale, F.
Triplax thoracica, S.
Languria, elongata.

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Languria Mozardi, Latreille.
and one more species.

ENDOMYCHIDÆ.

Endomychus lineatus, F. and O. Eumorphus distinctus, S.
angustatus, S. (Eumorphus, S.)
vestitus, S. (Lycoperdina, S.)
ferrugineus, Leconte. (Lycoperdina, Lec.)
biguttatus, S.
and one more species.

COCCINELLIDÆ. *Lady-Birds.*

Coccinella borealis, F.
Mali, S.
novemnotata, F.
transversa.
transversoguttata, S.
bioculata, S.
geminata.
immaculata, F.
ursina, F.
vigintimaculata, S.
abbreviata, F.
decemmaculata, F.
tibialis, S.
parenthesis, S.
and six more species.
(Chilocorus) Cacti, L.
normata, S.

Scymnus parvulus.
Querci.
Cissi.

## II. ORTHOPTERA.

BLATTIDÆ. *Cockroaches.*

Blatta orientalis, L. introduced.
and four more species.

MANTIDÆ.

Spectrum femoratum, S.

ACHETADÆ. *Crickets.*

Gryllotalpa — one species. *Mole Cricket.*
Acheta nivea, De Geer.
and five more species.

GRYLLIDÆ. *Nocturnal Grasshoppers.*

Gryllus (Ephippiger) — one species.
(Pterophylla) concavus, S. (in letters.) *Katy-did.*
oblongifolius, De Geer. laurifolius, L,
curvicaudus, De Geer.
agilis, De Geer.
fasciatus? De Geer.
and one more species.
(Conocephalus) tuberculatus? De Geer.
and another species.

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LOCUSTIADÆ. *Diurnal Grasshoppers.*

Acrydium obscurum ? F.
flavo-fasciatum ? De Geer. vittatum, O.
sanguinipes ? F.
femur-rubrum, De Geer. erythropum, Gm.
Locusta Carolina, L.
tuberculata, F.
equalis, S.
sulphurea ? F.
vividifasciata, De Geer. } Virginiana, F. / chrysomela, Gm.
sulphurea, Palisot de Beauvois. } hemiptera, Beauvois.
eucerata,
cerineipennis.
and two more species.
Tetrix laterale, S.
parvipenne.
and six more species.

## III. HEMIPTERA. *Bugs.*

PENTATOMADÆ.

Scutellera (Tetyra) fimbriata, S.
alternata, S.
dubia, Pal. de Beauv. cinctipes, S.
(Thyreocorus) subviridis, S. letter. unicolor ? B.
Pentatoma arborea, S.
Pensylvanica, De Geer.
obesa, S.
punctipes, S.
punctipes ? Pal. de Beauvois.
and fifteen more species.
(Cydnus) bilineata, S. cincta ? Pal. de B.

COREIDÆ.

Coreus galeator, F.
tristis, De Geer. ordinatus, S. *Squash-Bug.*
and two more species.
Berytus spinosus, S.
Lygæus turcicus, F.
and eleven more species.
Salda pedunculata, S.
and two more species.
Myodocha—one species.
Astemma—one species.
Miris—one species.
Capsus—one species.
and nineteen more of the Coreidæ.

CIMICIDÆ.

Syrtis erosa, F.
Tingis —
Aradus sanguineus, S.
and two more species.
Cimex lectularius, L. *Bed-Bug.*
Nabis — two species.

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Reduvius personatus, L.
multispinosus, De Geer. raptorius, S.
and three more species.
Zelus — three species.
Ploiaria — one species.

HYDROMETRADÆ.

Gerris — three species.
Velia? —

NEPADÆ.

Belostoma Americana, F.
and two more species.
Nepa — one species.
Ranatra — one species.

NOTONECTIADÆ. *Water-Boatmen.*

Corixa interrupta, S.
and another species.
Notonecta Americana, F.
and five more species or varieties.

## IV. OMOPTERA.

CICADIADÆ. *Harvest Flies or Locusts.*

Cicada tibicen, L,
pruinosa, S. *Common Harvest-Fly or Locust.*
septemdecim, L. *Seventeen year Locust.*
and one more species.

FULGORADÆ.

Otiocerus Coquebertii, Kirby.
Degeerii, Kirby.

CERCOPIADÆ.

Thirty one species besides the following.
Flata — one species.
Membràcis bimaculatus, F.
Cissi.
latipes, S.
binotatus, S.
sinuatus? F.
bubalus, F.
Tettigonia octolineata, S.
coccinea, Forster.
Vitis, H.

APHIDIDÆ.

Thrips —
Aphis Caryæ.
and many other spècies.
(Eriosma) lanigera, L. Mali, Leach, *American Blight.*

COCCIADÆ.

Coccus arborum linearis, Geoffroy. *Bark-Louse.*

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cryptogamus, Dalman. *Oyster-shaped-Bark-Louse.*
Hesperidum, L.
Adonidum, L.
and several other species.

## V. NEUROPTERA.

### LIBELLULADÆ. *Dragon-Flies or Devil's Needles.*

Libellula pulchella, Drury. bifasciata, F. versicolor? F.
Lydia, Drury. trimaculata, Degeer.
Eponina, Drury.
Berenice? Drury.
and 12 more species.
Æshna heros, F.
Gomphus Junius, Drury.
and five more species.
Agrion Virgo gamma, Drury.
and another species.
Calepteryx—three species.
Lestes—seven species.

### EPHEMERADÆ.

Ephemera (Baetis)—six species.
(Cloeon?)—two species.
one species of Ephemera proper.

### PANORPIADÆ.

Panorpa fasciata, F.

### MYRMELEONTIDÆ.

Ascalaphus maculatus? O.

### HEMEROBIIDÆ.

Hemerobius irroratus, *S.*
perla? L.
and another species.

### SEMBLIDÆ.

Corydalis cornutus, L.
Chauliodes pectinicornis, L.
serricornis, S.
denticornis.
Sialis—one species.

### PERLIADÆ.

Perla immarginata, S.
and four more species.

### MANTISPIADÆ.

Mantispa pagana, S.

### TERMITIDÆ.

Termes—three species. *White-ants or Wood-lice.*



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Psocus—four species.

PHRYGANEADÆ.

Phryganea semifasciata, *S.*
subfasciata, S.
and seventeen more species.
(Leptocerus) variegatus.
maculicornis.
and 3 more species.

## VI. HYMENOPTERA.

TENTHREDINIDÆ. *Saw-Flies.*

Cimbex Ulmi.
and another species.
Tenthredo (Schyzocera) compar ? Leach.
and another species.
(Hylotoma) erythrosoma, Leach.
and 3 more species.
(Allantus) Sambuci.
and 13 more species.
(Selandria) Vitis, H.
pygmæ ? S.
? Cerasi, Peck. *Slug-Worm.*
and three more species.
(Dosythaeus) sericeus, S.
arvensis, *S.*
collaris, var ? S.
and 4 more species.
(Emphytus) ornatus ? S.
and 3 more species.
(Craesus) septentrionalis, F.
(Nematus)—eight species.
(Cladius)—two species.
(Lyda)—six species.

XIPHYDRIADÆ.

Xyela ferruginea, S.
and another species.
Cephus abbreviatus, S.
and three more species.
Xiphydria—two species.

UROCERIDÆ.

Oryssus—three species.
Sirex albicornis, F.
abdominalis.
Tremex columba, L.

EVANIADÆ.

Paxylloma ? one species.
Fænus—one species.
Evania appendigaster ? Latreille.
Pelecinus polycerator, F.
and another species ? or sex?

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ICHNEUMONIDÆ.

Eighty-eight species besides the following.
Pimpla atrata, F.
lunator, F.
Ophion imbecillis, S.
Anomalon Cecropiae.
flavicornis, S.
Ichneumon? fulvus, F.
and an allied species.
Ichneumon concitator, S.
Hispae.
devinctor, S.
multor, S.
basiator, S.
alternator, S.
ferrugator? S.
centrator, S.
cingor, S.
unifasciatorius, S.
lusorius, S.
Bracon populator, S.
Chelonus —two species.

DIPLOLEPIDIDÆ.

Diplolepis Pini.
Potentillae.
and eleven more species.

CHALCIDIDÆ.

Leucospis affinis, S.
Chalcis—one species.
Torymus Rosarum.
Azaleae.
and another species.
Pteromalus Arctiae.
Vanessae.
Clisiocampae.
and two more species.
Eurytoma Hordei, H.
and two more species.

PROCTOTRUPIADÆ.

Proctotrupes cordatus, S.
and two more species.
Psilus (Jurine)—one species.

CHRYSIDIDÆ.

Chrysis nitidula? F. cærulans? F.
and three more species.

FORMICIADÆ. *Ants.*

Formica—nine species.
Myrmica—one species.

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MUTILLIADÆ.

Mutilla — four species. *Stinging Ants.*
Methoca — one species.

SCOLIADÆ.

Tiphia inornata, S.
and another species.
Plesia — one species.
Scolia — one species.

SAPYGIADÆ.

Sapyga — two species.

POMPILIADÆ.

Ceropales bipunctata ?S. binotata ? S.
and two more species.
Pompilus tropicus, F.
and ten more species.
Miscus — one species.

SPHEGIADÆ.

Sphex ichneumoneus, L.
flavipes, F.
cæruleus, L.
apicalis, S.
fulvicaulis, S.
and four more species.

BEMBECIADÆ.

Bembex fasciata, F.
Monedula — one species.

LARRIADÆ.

Astata unicolor? S.
Larra argentata, Pal. de Beauvois.
and three more species.
Nysson — one species.
Tripoxylon — three species.
Oxybelus quadrinotatus, S.
and six more species.

CRABRONIADÆ.

Crabo decemmaculatus, S,
gryphus.
scutellum. var. S.
and seven more species.
Cemonus — one species.
Pemphredon concolor ? S.
Mellinus — one species.
Stigmus ? — one species.
Cerceris deserta, S.
and four more species.

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Philanthus vertilabris, S.
and five more species.

VESPIADÆ. *Wasps and Hornets*

Three species besides the following.
Vespa (Odynerus) quadricornis, L. cincta,
[De Geer. uncinata, F.
pluricincta, S
incincta? F,
and 6 more species.
(Pterochilus?) one species.
(Eumenes) fraterna, S.
and another species.
(Polistes) fuscata, *F. Common Wasp.*
and another species.
maculata, L. *Common Hornet.*
arenaria? L.
maculifrons, S.
and one more species.

ANDRENIADÆ. *Solitary Bees.*

Fifteen species besides the following.
Hylaeus sericeus, Forster. viridulus, F.
amœnus, S.
and three more species.
Andrena annularis, Drury.

APIDÆ. *Social Bees.*

Eleven species besides the following.
Xylocopa victima, S. *Wood-cutter Bee.*
Osmia metallica? F. caerulea, S.
Epeolus mercatus, F.
and another species.
Nomada decora, Say.
and three more species.
Cœlioxys — one species.
Megachile latimana, S.
and several other species. *Leaf-cutter Bees.*
Ceratina? — four species.
Bombus Americanorum, L. *Humblebee.*
elatus, F.
and twelve more species.
Apis mellifica, L.—introduced. *Honey Bee.*

## VII. LEPIDOPTERA. *Butterflies & Moths.*

PAPILIONIADÆ. *Butterflies.*

Papilio Turnus, L.
Asterius, Cramer.
Troilus, L.
Pontia oleracea, H.
Colias Philodice, Godart.
Argynnis Idalia, Drury.
Aphrodite, F. *var.* Daphnis, Cramer. Cy-
Melitaea Phaeton, Drury. [bele, F.
Myrina, Cramer.

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Melitaea Cocyta, Cramer. Pharos? Drury. Tharos? [Cr.
Vanessa Antiope, L.
Urticae. L.
interrogationis, F.
Progne, Cramer, and Godart.
furcillata, S.
Cynthia Atalanta, L.
Cardui, L.
Huntera, F. Belladona, Petiver. Iole, Cr.
Lavinia, F. Orythia, Smith — Abbot.
Hipparchia Alope, F. & Godart.
Andromacha, Hubner.
Eurytris, F. Cymele, Cramer.
semidea, S. fortunata ? F.
Limenitis Ephestion, Stoll. Ursula, F.
Arthemis, Drury.
Misippus, L.
Danaus Archippus, F. Flexippus, Cramer.
Lycaena phlæas ? L.
Thecla Damon, Cramer.
Pan ? Drury.
and five more species.
Polyommatus Argiolus, L.
and two more species.

HESPERIADÆ. *Skippers or Skipper Butter-flies.*

Hesperia Clarus, Cramer. Tityrus, F.
Bathyllus, Smith-Abbot.
Juvenalis, F.
Juvenalis, *var.* Smith-Abbot.
and eight more species.

SPHINGIADÆ. *Humming-Bird or Hawk Moths.*

Smerinthus excaecata, Smith-Abbot.
integerrima.
myops, Smith-Abbot.
geminata, S.
Juglandis, Smith-Abbot.
Sphinx lineata, L.
Epilobii.
Carolina, L.
Ligustri ? L.
gordius, Cramer.
Kalmiae, Smith-Abbot.
Crantor, Cramer. Achemon, Drury.
satellitia, L. Licaon ? Cramer.
Hylaeus, Drury. Prini, Smith-Abbot.
pampinatrix, Smith-Abbot. Myron ? Cr.
Azaleae ? Smith-Abbot. Chœrilus ? Cr.
and three more species.
Thyreus Abbotii, Swainson.
Macroglossa Nessus, Cramer.
Scsia pelasgus, Cramer.

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ÆGERIADÆ.

Ægeria tricincta.
Cucurbitæ, H.
exitiosa. Persicæ, Barton. *Peach-tree Borer.*
fulviornis, S.
fulvipes.
Pyri, H.
Tipuliformis, L.
and four more species.
Thyris maculata.

ZYGÆNIADÆ.

Glaucopis pholus, F.
Aglaoped ispar.

BOMBYCIADÆ.

Hepialus argenteomaculatus.
Cossus Robiniæ, Peck. *Locust-tree Cossus.*
crepera.
Attacus Luna, L.
Polyphemus, L.
Cecropia, L.
Promethea, Drury.
Saturnia Proserpina, F.
Jo, F.
Ceratocampa regalis, F.
imperialis, F.
Dryocampa senatoria, Smith — Abbot. Astynome? O.
rubicunda, F.
Gastropacha velleda, Stoll.
and another species.
Clisiocampa castrensis, Smith — Abbot. "*Caterpillar.*"
neustria, Smith — Abbot.
pyxidifera? Smith — Abbot.
Bombyx mori, L. *Introduced Silk Worm.*

NOTODONTIADÆ,

Pygæra? albifrons, Smith — Abbot.
ministra, Drury.
and another species.
Notodonta anguina, Smith —Abbot.
concinna, Smith — Abbot.
unicornis, Smith — Abbot.
aurora, Smith —Abbot.
? grata, F.
and four more species.
Clostera — two species.
Cerura — two species.
Limacodes scapha.
and another? species.

ARCTIADÆ.

Arctia isabella, Smith — Abbot.
acria, Drury. male, caprotina, Drury.
Virginica, F.
textor, H. *Autumnal Web Caterpillar.*
virgo, Smith — Abbot.
phyllira, Smith — Abbot.
figurata, Drury.

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Arctia phalerata.
Egle, Drury.
tessellaris, Smith — Abbot.
Caryæ.
and another species.
Dasychira ? Firmiana, Cramer. torrefacta, Smith — Abbot.
and another species.
Orgyia antiqua ? L.
and two more species.

LITHOSIADÆ.

Psychemorpha maculata.
Callimorpha ? militaris.
Lithosia Bella, L.
and seven more species.

NOCTUADÆ.

Erebus odorus, Drury.
Catocala nupta, L.
consors, Smith, Abbot.
Epione, Drury.
and six more species.
Noctua pyramidea ? L.
Aceris, Smith, Abbot.
præmordens. *Cut Worm.*
oleracea.
verruca, F.
Jota, Cramer.
cingulata.
Brassicariae ? F.
libatrix, F.
Emmedonia, Cramer.
Erichtea, Cramer.
lunata, Drury.
squamularis, Drury.
and ninety more species.

GEOMETRADÆ.

Geometra vernata, Peck. brumata ? L. *Canker-Worm.*
catenaria, Drury.
undulata ? F.
sospeta, Drury.
transversata ? Drury.
vibicaria ? Cramer.
serrata, Drury.
and fifty-nine more species.
Platypteryx erosa.

PYRALIDÆ.

Herminia — eight species.
Margaritia ? — one species.
Pyralis farinalis, L.
atralis ? F.
and five more species.

TORTRICIDÆ.

Tortrix Pomona, L. *Apple-Worm.*
and thirty-two more species.

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TINEADÆ.

Galleria cereana, F. *Bee-Moth.*
and three more species.
Crambus nivalis, Drury.
Humuli.
aspergillus, Coquebert — Bosc.
and twenty-six more species.
Yponomeuta — two species.
Tinea glandis.
pellionella, L. *Clothes Moth.*
and ten more species.
Pterophorus — four species.

## VIII. STREPSIPTERA.

Xenos Peckii, Kirby.

## IX. DIPTERA.

CULICIDÆ. *Musquetos.*

Culex damnosus, S.
cingulatus, F.
and twenty species besides.

TIPULADAE *Gnats.*

Tipula—ten species.
Pedicia—one species.
Ptychoptera clavipes, L.
Chionea—one species.
Sciara—one species.
Bibio brunnipes, F.
albipennis, S.
and three more species.
Dilophus—one species.

STRATIOMYIADÆ.

Stratiomys—seven species.
Nemotelus—one species.
Sargus—three species.

XYLOPHAGIDÆ.

Xylophagus—four species.

TABANIADAE. *Horse-Flies.*

Tabanus cinctus, F.
lineola, F. occidentalis? L.
divisus.
and seven more species.
Chrysops ferrugatus? F.
and six more species.

RHAGIONIADAE.

Seven species besides the following.
Calobata antennaepes, S.
and two others.



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ASILIADÆ.

20 species besides the following.
Midas filata, Latreille. clavata ? Drury and F.
Laphria thoracica, F.
atribarbis, S.
flavicollis, S.
posticata, S.
fulvicauda, S.
sericea, S.
Asilus sericeus, S.

ANTHRACIDAE.

Anthrax morioides, S.
and three more species.
Thereva—one species.
Bombylius aequalis, F.
and one other species.

SYRPHIADÆ.

45 species besides the following.
Xylota ejuncida, S.
proxima, S.
haematodes, S.
Rhingia nasica, S.

CONOPIADÆ.

Sixteen species besides the following.
Conops sagittaria, S.
calcitrans ? L.

MUSCIADÆ.

Forty-eight species besides the following.
Sphyracephala brevicornis, Say.
Musca cerasina, S.
vomitoria, L.
carnaria, L. *Flesh-Fly.*
caesar, L.

ŒSTRIADÆ.

Œstrus cuccatus ? F. Cuniculi ? Clarke.
Equi, L. *Bot-Fly*, or *Bot-Bee.*
Bovis, L.
Ovis, L.
and three more species.

HIPPOBOSCIADÆ.

Ornithomyia Falconis.

## X. APTERA.

Pulex irritans, L. *Common Flea.*

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NUMBER OF SPECIES.

| | |
|---|---|
| I. Coleoptera | 994 |
| II. Orthopera | 44 |
| III. Hemiptera | 102 |
| IV. Omoptera | 54 |
| V. Neuroptera | 91 |
| VI. Hymenopetera | 388 |
| VII. Lepidoptera | 428 |
| VIII. Strepsiptera | 1 |
| IX. Diptera | 247 |
| X. Aptera | 1 |
| | 2350 |

The insects enumerated in the preceding list, with the exception of about half a dozen, are contained in my cabinet; and most of them were collected in the vicinity of Boston. With them are included some, which, though found beyond the boundaries of the State, may eventually be detected in Massachusetts. For these and an immense number of duplicates I am indebted to my friend the Rev. L. W. Leonard, who has still more increased my obligations to him by his disinterested liberality in sending me even the rare and undescribed insects of which he possessed no duplicates. Dr. D. S. C. H. Smith has kindly supplied me with a suit of insects from Sutton, Massachusetts, among which were nearly a hundred species new to my collection. My acknowledgements are due also to Wm. Oakes, Esq. of Ipswich, particularly for the water-beetles; and to Prof. N. M. Hentz, formely of Northampton, to Drs. Pickering, Gould, and J. S. C. Greene, Mr. John Randall, Mr. T. Nuttall, Mr. John Bethune, and Miss D. Dix, for several interesting insects.

Even with these augmentations the present list must fall far short of the actual number of species or kinds existing in this Commonwealth. The proportion of insects to plants has been stated to be six species of the former to one of the latter. The flowering plants of Massachusetts amount to above 1200 species; hence our insects cannot be much less in number than 7000 species.

Entomology, within a few years, has engaged the attention of some of the first naturalists of Europe; and, since the days of Linne and of Fabricius, vast accessions have been made to the number of known insects, and great improvements in the science have been introduced. The results of this augmented knowledge have not yet reached us, and are beyond the means of most individuals in this country. Should any of the sons of New England have the inclination to turn their attention to this interesting branch of Natural History, they must, for want of the necessary books on the subject, remain in ignorance of the labors of their European contemporaries; and, although they may have discovered many curious and valuable facts respecting our native insects, they must resign to foreigners the honor of making known the objects of their investigations.

A long list of names in a dead language may perhaps be considered as a pedantic and useless exhibition. As an apology for this it may be stated that but a very few of our insects have received *popular* names, and that therefore I have been compelled to give only the scientific names by which they are known to naturalists. It is a matter of deep regret to me that even this list of hard names is so very imperfect, and that so many species have been left unnamed. For this omission no other excuse can be offered than a reference to the obstacles and difficulties already mentioned, which unavoidably arrest the American naturalist in the midst of his investigations.

To the names of insects which have been ascertained through published descriptions I have added the names or initials of the first describers, together with some of the most common synonyms, which have been subsequently imposed. A few names, without any authorities annexed will also be found on this list; they are applied to species, which, as far as I can ascertain, do not appear to have been published: these it is my hope soon to make known by means of necessary descriptions.

T. WILLIAM HARRIS.

Cambridge, (Mass.) Feb. 1833.

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# IX. RADIATA.

This extensive class of animals has yet received but little attention in Massachusetts; comprehending as it does, creatures of not much use to man, and for the most part inhabiting places out of the reach of common observation. In respect to some of them, also, it seems not yet to be agreed, whether they ought to be regarded as animals or plants. Through the assistance of Dr. Gould, I am able to mention a few genera and species. But I hope the deficiency of the list will lead those naturalists who are favourably situated for examining these animals, to enlarge and perfect it.

Similar remarks might be made in respect to our Annelides; a much less numerous class of animals. A few of these indeed, such as the leech (Hirudo) and earth worm, (Lumbricus,) are very common and well known; but in general they possess but little interest or importance.

## I. ECHINODERMATA.

Asterias spinosus. *Sea-Star.* Cape Cod. &c.
Echinus granulatus. Cape Cod, Boston Harbor. &c.
Scutella pentaphora. Cape Cod.
trifaria.

## II. INTESTINA.

Filaria—various species.
Tricocephalus Do.
Ascaris Do.
Taenia. inhabiting man, the cat, rabbit, &c.

## III ACALEPHA.

Medusa—one or two species on the coast.

## IV. POLYPI.

Actinia—one species, Nahant.
Madrepora—several species.
Spongia fluviatilis, L. In ponds. Leverett, Chesterfield, &c. and at least two other species at Chelsea and Charlestown.

## V. INFUSORIA.

Vibrio aceti.
And many other genera and species in the various kinds of infusions of vegetable and animal substances.

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## POSTSCRIPT.

Since the Catalogue of Fishes on page 553 was printed, I have received from Dr. Smith, a corrected and enlarged list; and I take the liberty, without consulting the Government, to insert it here: presuming that they would be unwilling to have so much additional information omitted. It is but justice to Dr. Smith to say, that the Catalogue already printed was prepared a year or two since; and that he has continued since that time to study our fishes with great diligence. As several changes of names appear in the following list, I have thought it best to give it entire; although this renders some repetition unavoidable. I give it likewise in the precise form, *verbatim et pene literatim*, in which it was sent: and I would here take occasion to observe, that an adherence to this rule, so far as possible, is the reason why there is so much of diversity in the manner of printing the several catalogues in this part of the Report.

Petromyzon Marinus—*Sea Lamprey.*
Petromyzon Fluviatilis—*Fresh water Lamprey*—in fresh water.
Scyllium Canicula—*Sea-dog—a small Shark.*
Scyllium Catulus— " "
Carcharias Vulgaris—*White Shark.*
Carcharias Vulpes—*Fox Shark or Thrasher.*
Zygæna Vulgaris—*Hammer-headed Shark.*
Seleche Maximus—*Basking Shark.*
Torpedo Vulgaris—*Numbing Fish.*
Raia Clavata—*Thornback.*
Raia Batis—*Skate.*
Trygon Pastinacea—*Sting Ray.*
Accipenser Sturio—*Sturgeon.*
Aluteres Monoceros—*File fish.*
Ostracion Triqueter—*Mailed or trunk-fish.*
Ostracion Bicaudalis— " " "
Tetraodon Turgidus—*Swell-fish.*
Syngnathus Typhle—*Little pipe fish.*
Salmo Salar—*Salmon*—in Salt and fresh water.
Salmo Trutta — *Salmon Trout*—in fresh and Salt water.
Salmo Fario—*Common Trout*—fresh water.
Salmo Hucho—*Hunchen Trout*—" "
Osmerus Eperlanus—*Smelt.*
Clupea Harengus—*Common Herring.*
Clupea Menhaden—*Bony fish-Menhaden.*
Clupea Alosa—*Shad*
Clupea Vernalis—*Alewife.*
Clupea Minima—*Brit.*
Esox Lucius—*Common Pike or Pickerel*—fresh water.
Esox Belone—*Sea Pike.*
Exocetus Mesogaster—*Flying fish.*
Cyprinus Auratus—*Golden Carp*—fresh water.
Cyprinus Crysoleucas—*Shiner*—fresh water.
Cyprinus Atronasus—*Minow*—fresh water.
Cyprinus Oblongus—*Chub*—fresh water.
Cyprinus Teres—*Sucker*—fresh water.
Abramis Chrysoptera—*Bream*—fresh water.
Leuciscus Rutilus—*Roach*—fresh water.
Leuciscus Vulgaris—*Dace*—fresh water.
Leuciscus Alburnus—*Bleak*—fresh water.
Leuciscus Cephalus—*Head or short Chub*—fresh water.
Silurus—*Horn Pout*—fresh water.
Gadus Morrhua—*Common Cod.*



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Gadus Rupestris—*Rock Cod.*
Gadus Arenosus—*Shoal Cod.*
Brosmus Vulgaris—*Cusk or Torsk.*
Gadus Merluccius—*Hake.*
Gadus Æglefinus—*Haddock.*
Merlangus Vulgaris—*Whiting.*
Merlangus Pollachius—*Pollock.*
Gadus Taucaud—*Tom Cod.*
Blennius Viviperus—*Blenny.*
Raniceps Blennioides— "
Hypoglossus Vulgaris—*Holibut.*
Pleuronectes Vulgaris—*Flounder.*
Platessa Vulgaris—*Plaise.*
Solea Vulgaris—*Sole.*
Rhombus Maximus—*Turbot.*
Cyclopterus Lumpus—*Lump Fish.*
Cyclopterus Minutus—*Small Lump Fish.*
Echeneis Remora—*Sucking Fish.*
Echeneis Naucrates—*Indian Sucking Fish.*
Anguilla Vulgaris—*Common Eel.* fresh or salt water.
Murœna Conger—*Conger Eel.*
Anarchicas Lupus—*Sea Wolf.*
Labrus Tautoga—*Tautog.*
Labrus Coricus—*Blue perch.*
Labrus Squeteague—*Weak-fish.*
Labrus Maculatus—*Spotted-fish.*
Crenilabrus Merula—*Blue back.*
Scorpœna Porcus—*Yellow Sculpin.*
Scorpœna Scrofa— " "
Scorpœna Gibbosa—" "
Mullus Barbatus—*Red mullet.*
Perca Fluviatalis—*River perch*—fresh water.
Bodianus Leucos—*Silver perch*—fresh water.
Bodianus Rufus—*Red perch*—fresh water.
Bodianus Pallidus—*White perch*—fresh water.
Bodianus Flavescens—*Yellow perch*—fresh water.
Perca Labrax—*Striped bass*—salt or fresh water.
Uranoscopus Scaber—
Trigla Palmipes—*Web-fingered Gurnard.*
Cottus Gobio—*Bull-head*—fresh water.
Cottus Quadricornus—*Sea-bull.*
Cottus Scorpius—*Sculpin.*
Cottus Cataphractus—*Armed bull-head.*
Batrachus Grunniens—*Grunting bull-head.*
Loppius Piscatorius—*Mouse-fish—angler.*
Scomber Grex—*Chub-mackerel.*
Scomber Vernalis—*Spring mackerel.*
Scomber Crysos—*Yellow mackerel.*
Scomber Plumbeus—*Horse mackerel.*
Scomber Macculatus—*Spanish mackerel.*
Scomber Scomber—*Common mackerel.*
Mullus Surmuletus—*Surmullet.*
Scomber Thynnus—*Tunny.*
Centronotus Ductor—*Pilot fish.*
Zeus Faber—*Common dory.*
Chrysotosus Luna—*Moon fish.*
Xippius Gladius—*Sword fish.*
Seserinus Alepidotus———
Fistularia Tabacaria—*Tobacco-pipe fish.*

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# X. CATALOGUE OF PLANTS,

## GROWING WITHOUT CULTIVATION.

In the arrangement of the following Catalogue, I have followed,—as the latest and most accurate,—the Natural System of Prof. Lindley, as adapted to North American Plants by Professor Torrey. The sources from which I have derived materials for constructing this list, are mainly the following: First, Professor Bigelow's "Collection of Plants of Boston and its vicinity." (1824.) Secondly, "A Catalogue of Plants Growing without cultivation in the vicinity of Amherst College;" (1829,) with such additions and corrections as I have been able to make since the time of its publication. Thirdly, Professor Dewey's Catalogue of Plants found in the County of Berkshire, (1829,) inserted in the History of Berkshire. Fourthly, the manuscript communications of Thomas A. Greene Esq. containing a notice of such plants as he has discovered in the vicinity of New Bedford and on the island of Nantucket, not mentioned in the last edition of Bigelow's "Florula Bostoniensis."

To the Latin or scientific names of the plants, I have attached their common names, whenever I could ascertain that they have excited attention enough to receive a common name. But it will be seen that comparatively few of our plants have received common names.

When a capital A. is attached to a species, it implies that the plant grows in the vicinity of Amherst: B implies that it occurs in the vicinity of Boston: N. B. that it is found in the region around New Bedford; and B—e that Berkshire County is its place of growth. In other cases, especially where the species is very rare, the name of the town where it occurs is mentioned. When no local designation is annexed, I have reason to suppose that the plant may be found in any part of the State of considerable extent. In some of the flowerless plants, however, there is an exception to this remark; as will be mentioned under Muscoideae.

In reducing our plants to the Natural Orders I have received the assistance of Dr. John Blodget of Amherst.

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## ABBREVIATIONS.

? Indicates a doubt as to the species.

§ Prefixed to those plants that have been introduced or naturalized.

### *Names of Botanical Writers.*

| | |
|---|---|
| Ait. | for Aiton. |
| Brid. | — Bridel. |
| Big. | — Bigelow. |
| R. Br. | — R. Brown. |
| Bull. | — Bullard. |
| De. Cand. | — Decandolle. |
| Dicks. | — Dickson. |
| Dill. | — Dillenius. |
| Ehrh. | — Ehrhart. |
| Ell. | — Elliott. |
| Fr. | — Fries. |
| Hall. | — Haller. |
| Hedw. | — Hedwig. |
| l'Herit. | — l'Heritier. |
| Hook. | — Hooker. |
| Hoffm. | — Hoffman. |
| Jacq. | — Jacquin. |
| Lamb. | — Lambert. |
| L. | — Linnæus. |
| Lmk. | — Lamarck. |
| Mx. | — Michaux. |
| Mx. f. | — Michaux filius. |
| Muhl. | — Muhlenberg. |
| Nutt. | — Nuttall. |
| P. de B. | — Palisot de Beauvois. |
| Pers. | — Persoon. |
| Ph. | — Pursh. |
| Salis. | — Salisbury. |
| Schaeff. | — Schaeffer. |
| Schk. | — Schkuhr. |
| Schrad. | — Schrader. |
| Schreb. | — Schreber. |
| Schw. | — Schweinitz. |
| Sibth. | — Sibthorp. |
| Sm. | — Smith. |
| Spreng. | — Sprengel. |
| Sw. | — Swartz. |
| Tor. | — Torrey. |
| Tourn. | — Tournefort. |
| Vent. | — Ventenat. |
| Walt. | — Walter. |
| Wang. | — Wengenheim. |
| Web. & M. | — Weber & Mohr. |
| W. | — Willdenow. |

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## CLASS I. — VASCULARES

OR

# FLOWERING PLANTS.

## SUB CLASS I. — EXOGENAE OR DICOTYLEDONS.

### TRIBE I. — ANGIOSPERMAE.

#### 1 *Polypetalous, Apetalous, and Achlamydeous Plants.*

##### ORDER ARALIACEÆ.

Aralia L.
- hispida, Mx. *Bristly Stem-Sarsaparilla.*
- nudicaulis, L. *Wild Sarsaparilla.*
- racemosa, L. *Spikenard.*

Panax L.
- quinquefolium, L. *Ginseng.* A.
- trifolium, L. *Dwarf Ground Nut.*

##### UMBELLIFERAE.

Aethusa L.
- § cynapium, L. *Fool's Parsley.* Boston.

Angelica, L.
- triquinata, Mx. *Atropurpurea, L. Angelica.*

Cicuta L.
- bulbifera, L. *Bulbiferous Cicuta.*
- maculata, L. *American Hemlock.*

Conium L.
- maculatum, L. *Poison Hemlock.*

Daucus L.
- §carota, L. *Carrot.* B—e.

Discopleura De Cand.
- capillacea, De Cand. *Ammi capillaceum* Spreng. N. B. *Bishop-Weed.*

Heracleum L.
- lanatum, Mx. *Cow Parsnip.*

Hydrocotyle L.
- americana, L.
- umbellata, L. B.
- vulgaris, Mx. N. B.

Ligusticum L.
- scoticum, L. B. *Lovage.*

Pastinaca *L. Parsnip.*
- § ativa, L.

Sanicula L.
- Marilandica, L. *Sanicle.*

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Sison L. *Chaerohyllum.* Pers.
Canadense L. *Hone-Wort Mock Sanicle.*
Sium L.
latifolium, L. *Water Parsnip.*
lineare, Mx.
Smyrnium L.
aureum, L. *Sison aureus Spreng. Thaspium aureum, Nutt. Meadow Parsnip.* A.
Uraspermum Nutt.
claytoni, Nutt. *Sweet Sicily. Scandix dulcis, Muhl.*
hirsutum, Big. B.

RANUNCULACAE.

Actæa L.
albs, Big.
rubra, *Bane-berry. W.*
Anemone L.
nemorosa, L. *Low Anemone.*
thalictroides, L. *Rue Anemone.*
Virginiana, L. *Wind-Flower.*
Aquilegia L.
canadensis, L. *Columbine.*
Atragene L.
Americana, Sims. *Atragene.*
Caltha L.
palustris, W. *Cowslip.*
Clematis L.
virginiana, L. *Virgins Bower.*
Coptis Salisbury.
trifolia, Salis. *Gold Thread.*
Hepatica W.
triloba, W. *Liverwort.*
Ranunculus L.
abortivus, L.
acris, L. *Buttercup.*
bulbosus, L.
cymbalaria, Ph.
fascicularis, Muhl.
filiformis, Muhl.
flammula, L. *Spear Wort.*
fluvitalis, L. *River Crowfoot.*
hirsutus, Curtis. B—c.
multifidus, Ph. B.
Pennsylvanicus, L. B.
recurvatus, L.
repens, L.
sceleratus, L. *Celery Crowfoot.*
Thalictrum L.
dioicum, L. *Meadow Rue.*
corynellum, Decand.

PAPAVERACEAE.

Chelidonum L.
majus, W. *Celandine.*
Sanguinaria L.
Canadensis, L. *Blood Root.*

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NYMPHAEACÉAE.

Nymphæa L.
odorata, Ait. *White Pond Lily.*
Nuphar Sm.
advena, Ait. *Yellow Water Lily.*
kalmiana, Ait.

HYDROPELTIDEAE.

Hydropeltis Mx.
purpurea, Mx. *Water Shield.*

PODOPHYLLEAE.

Podophyllum L.
peltatum, L. *May Apple.*

CRUCIFERAE.

Arabis L.
falcata, Mx. *Canadensis*, W.
hastata, L. *Hairy Tower Mustard.*
hirsuta, Smith.
rhomboidea, Ph. B.
thaliana, L. *Spring Cress.* B—e.
Barbarea R. Brown.
vulgaris, R. B. *Erysimum barbarea*, L. *Water Radish.*
Brassica L.
§ napus, L. *Kale.*
Cakile L.
maritima, Nutt *Bunias maritima*, Ph. B. *Am. Sea Rocket.*
Cardamine L.
Pennsylvanica, W. *Water Cress.*
Virginica, W. B—e.
teres ? Mx. A. Dr. G. White.
Cochlearia L.
§ armoracea, L. *Horse Radish.*
Dentaria L.
diphylla, Mx. *Tooth Root.* A.
laciniata, W. A.
Draba L.
verna, L. N. B. Bigelow.
Erysimum L.
officinale, L. *Hedge Mustard*
Lepidium L.
Virginicum, L. *Wild Peppergrass.*
Raphanus L.
§ raphanistrum, L. *Cadlock, Wild Radish.*
Sinapis L
§ nigra, Smith. *Mustard.*
Sisymbrium L.
amphibium, L. *Water Radish.*
nasturtium, L. *English Water Cress.*
Thlaspi L.
bursa-pastoris, L. *Shepherd's Purse*
campestris, L. *Yellowseed.*

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FUMARIACEAE.

Corydalis Vent.
cucullaria, Pers. *Colic Weed.*
formosa, Ph. A.
fungosa, Pers. *Climbing Colic Weed.*
glauca, Ph.

Fumaria L.
officinalis, L. *Fumitory.*

MAGNOLIACEAE.

Liriodendron L.
tulipifera, L. *Tulip Tree.* A. and N. B.

Magnolia L.
glauca, L. *Beaver Tree. Swamp Laurel. Gloucester.*

LAURINEAE.

Laurus L.
benzoin, L. *Spice Bush. Fever Bush.*
sassafras, L. *Sassafras.*

BERBERIDEAE.

Berberis L.
vulgaris, Mx. *Barberry.*

Leontice L.
thalictroides, L. *Caulophyllum thalictroides*, Mx. *Poppoos Root. Cohosh.*

MENISPERMEAE.

Menispermum L.
Canadense, L. *Moonseed.* A.

MALVACEAE.

Althaea L.
officinalis, L. *Marsh Mallows.* B. and N. B.

Hibiscus L.
palustris, L. B. *Marsh Hibiscus.*

Malva L.
rotundifolia, L. *Low Mallows.*

Sida L.
abutilon, L. *Indian Mallows*, A.

TILIACEAE.

Tilia L.
glabra, Vent. *Bass Wood.*
pubescens, Vent. *Bass Wood.*

HYPERICINEAE.

Hypericum L.
angulosum, Mx.
ascyroides, W. *Saint John's Wort.*
Canadense, L.
corymbosum, W.
cystifolium, Lmk. A.
parviflorum, W.
perforatum, L. *St. John's Wort.*
sarothra, Mx. *Sarothra gentianoides* L.
virginicum, L. *Elodea campanulata* Ph.

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SAXIFRAGEAE.

Chrysosplenium L.
Americanum Hooker. oppositifolium, L. *Golden Saxifrage.*
Mitella L.
cordifolia, Lamb. B—e.
diphylla, L. *Currant Berry.* A.
Parnassia L.
Caroliniana, Mx. *Parnassus Grass.*
Saxifraga L.
Pennsylvanica, L. *Water Saxifrage.*
Virginiensis, Mx. *Rock Saxifrage.*
Tiarella L.
cordifolia, L. *Mitre Wort.*

HAMAMILIDEAE.

Hamamelis L.
virginica, L. *Witch Hasel.*

GROSULARIAE.

Ribes L.
cynobasti, Jacq. B — e *Wild Gooseberry.*
gracile, Mx. A.
floridum, L'Herit. *Black Currant.*
lacusrre, Ph. A. & B — e *Gooseberry.*
prostratum, L Herit. A.
rigens, Mx. B & A.
triflorum, W. *Wild Gooseberry.*
trifidum, Mx. B — e.

CACTEAE.

Cactus L.
opuntia, L. Nantucket T. A. Greene. *Prickly Pear.*

ONAGRARIAE.

Epilobium L.
coloratum, Muhl.
lineare, Muhl. *rosmarinifolium,* Ph.
molle, Torrey. A.
spicatum, Lam. *Willow Herb.*
Isnardia L.
palustris, L. *Water Purslane.*
alternifolia, De. Cand. *Seed Box. Ludwigia alternifolia L.*
Œnothera L.
biennis, L. *Scabish. Tree Primrose.*
fruticosa, L. Plymouth. T. A. Greene.
pumila, L.

HALORAGEAE.

Myriophyllum L.
ambiguum, Nuttall. N. B.
procumbens, Big. Danvers.
spicatum, L. B.



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Myriophyllum.
tenellum, Big. Tewksbury and Plainfield .
verticillatum, L. *Water Milfoil.*
Proserpinaca L.
palustris, L. *Mermaid Weed.*
pectinacea, Lam. N. B.

CIRCAECAE.

Circæa L.
alpina, L. *Enchanters Night Shade.*
lutetiana, L. *Canadensis.* Muhl.

LOASEA.

Centaurella Mx.
paniculata, Mx. *Screw Stem.*

SALICARIAE.

Ammannia L.
humilis, Mx. B.
Cuphea Jac.
vicosisima, Pittsfield. Dr. G. White.
Lythrum L.
hyssopifolium, L. B.
salicaria, Ph. N. B.
verticillatum, L. *Swamp willow Herb.*

MELASTOMACEAE.

Rhexia L.
virginica, L. *Meadow Beauty. Deer grass.*

ARISTOLOCHIAE.

Asarum L.
Canadense, L. *Wild Ginger.*

SANTALACEAE.

Nyssa L.
biflora, W. *Sour Gum.* A. and Plymouth T. A. Greene.
Thesium L.
umbullatum, L. *False Toad Flax.*

THYMELEE.

Dirca L.
palustris, L. *Moose Wood. Leather Wood.*

SANUGISORBEAE.

Sanguisorba L.
Canadensis, L. *Burnet Saxifrage.* A. & B.

ROSACEAE.

Agrimonia L.
eupatoria, L. *Agrimony.*
Dalibarda L.
fragrarioides, Mx. B—e and A.
repens, Lmk. Greenfield and Princeton.

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Fragraria L.
virginiana, L. *Strawberry.*
Geum L.
rivale, L. *Purple Avens.*
strictum, Ait. *Upright Avens.*
virginianum, L. *Avens.*
Potentilla L.
anserina, L. B.
argentea, L. *Silver Five Fingers.*
Canadensis, L. *Five Finger.*
confertiflora, Torrey. *Bootia sylvestri*, Big. *Geum argrimonioides.* Ph. *arguta Ph.* Hooker.
fruticosa, L.
Norwegica, L. *Cinquefoil.*
palustris, Scop. *Comarum palustre*, L. B—e and B.
simplex, Mx. B.
tridentata, Ait. Hoosac Mountain and Wachusett.
Rosa L.
corymbosa, Ehrhart. *Carolinia*, L. *Swamp Rose.*
lucida, Ehrh. B—e.
micrantha, Sm. B.
parviflora, Ehrh. *Caroliniana*, Mx.
§ rubiginosa, L. *Sweet Briar.*
Rubus L.
Canadensis, L.
frondosus, Big. B.
obovalis, L.
occidentalis, L. *Black Raspberry.*
odoratus, L. *Flowering Raspberry.*
setosus, Big. B.
strigosus, Mx. *Red Raspberry.*
saxatilis, Mx. *Stone Raspberry.* B.
trivialis, Mx. *Dewberry.*
villosus, Ait. *Blackberry.*
Spiraea L.
salicifolia, Mx. *Hard Hack.*
tomentosa, L. *Steeple Bush.*

POMACEAE.

Crategus L.
coccinea, L. *Thorn Bush.*
crus galli, L. B. *Thorn Bush.*
punctata, Jacq. *Thorn Bush.*
Pyrus L. *Aronia Pers.*
Americana, De Cand. *Sorbus Americana, Ph. Mountain Ash.*
arbutifolia, W.
botryapium, L.
ovalis, W.
sanguinea, Ph. Western part of the State? Bigelow.

AMYGDALEAE.

Prunus L.
Americana, Marshall. *Wild Plum.* A.
borealis, Ph.
Canadensis, W.

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Prunus.
depressa, Ph. *Sand Cherry.*
littoralis, Big. B.
mollis, Torrey. B—e.
pumila, L. A.
serotina, Ehrh. *Choke Cherry.*
Virginiana, L. *Wild Cherry.*

LEGUMINOSEAE.

Amphicarpa Ell.
monoica, Nutt. *Pea Vine.*
Apios Moench.
tuberosa, Ph. *Ground Nut.*
Baptisia Vent.
tinctoria, R. Brown. *Wild Indigo.*
Cassia L.
chamaecrista, L. *Partridge Pea.*
Marilandica, L. *Wild Senna.*
nictitans, L. Hadley, Springfield, and N. B.
Crotolaria L.
sagittalis, Mx. *Rattle Box.*
Genista Lam.
tinctoria, L. *Dyer's Weed.* B.
Hedysarum L.
acuminatum, Mx.
bracteosum, Mx.
Canadense, L. *Bush Trefoil.*
ciliare, Nutt. B—e.
cuspidatum? W. B.
humifusum, Muhl,
nudiflorum, L.
obtusum, W. A. and N. B.
paniculatum, W.
rotundifolium, Mx.
viridiflorum, L.
Lathyrus L.
palustris, L. B.
Lespedeza Mx.
angustifolia, Ell. Plymouth. T. A. Greene.
capitata, Mx.
polystachia, Mx.
procumbens, Mx.
prostrata, Muhl. B.
reticulata, Nutt.
sessiliflora, Mx.
violacea, Pers.
Lupinus L.
perennis, L. *Wild Lupine.*
Medicago L.
lupulina, L. B. and Cummington. Dr. Porter.
Phaseolus L.
trilobus, Mx. B. *Bean Vine.*
Pisum L.
maritimum, L. *Sea Pea.* B. *Lathyrus maritimus,* Big. L. pisiformis, L. Hooker.
Robinia L.
pseudacacia, L. *Locust Tree.*

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Tephrosia Ph.
Virginica, L. *Goat's Rue. Galega Virginiana*, L.
Trifolium L.
agrarium, L. Cummington.
arvense, L. *Field Clover.*
officinale, L. *Melilot.*
pratense, L. *Red Clover.*
procumbens. L.
repens, L. *White Clover.*
Vicia L.
cracca, L. *Vetch.*
pusilla, Willd. B. *Ervum tetraspermum, L.*
sativa, W. *Tare.*

URTICEAE.

Boehmeria W.
cylindrica, W. *False Nettle.*
Humulus L.
lupulus, L. *Hop.*
Parietaria L.
Pennsylvanica, L. *Sugar Loaf*, Deerfield.
Urtica L.
Canadensis, L. *Yellow Nettle.* A.
dioica, L. *Common Nettle.*
procera, Muhl. B—e.
pumila, L. *Stingless Nettle.*
urens, L. *Dwarf Stinger.*

ULMACEAE.

Celtis L.
occidentalis, L. *Nettle Tree.* Deerfield and Waltham.
Ulmus L.
Americana, L. *Elm.*
fulva, Mx. *Slippery Elm.*

ARTOCARPEAE.

Morus L.
§ alba, L. *White Mulberry.*
rubra, L. *Red Mulberry.* Deerfield ?

CUPULIFERAE.

Castanea Tourn.
Americana, Mx. *Chesnut.*
Corylus L.
Americana, Walt. *Hazel Nut.*
rostrata, Ait. *Beaked Hazel Nut.*
Fagus L.
ferruginea, Ait. *Beech Tree.*
Quercus L.
alba, W. *White Oak.*
bicolor, W.
ambigua ? Mx. et fil.
Banisteri, Mx. *Shrub Oak.*

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Quercus.
coccinea, Wang. *Scarlet Oak.*
montana, W. *Chesnut Oak.*
palustris, W. *Pin Oak.* A.
prinos-chinchapin, Mx. A. *Chinquapin,* 2 to 6 feet high.
prinos-discolor, Mx. *Swamp White Oak.*
rubra, L. *Red Oak.*
tinctoria, Mx. *Black Oak.*

BETULINEAE.

Alnus W.
glutinosa, L. A.
serrulata, Willd. *Alder.*

Betula L.
excelsa, Ait. *Yellow Birch.*
glandulosa, Mx. B—e. *Shrub Birch.*
lenta, W. *Black Birch.*
papyracea, W. *Canoe Birch.*
populifolia, Ait. *White Birch.*
rubra, Mx. fil. *Red Birch.* B—e.

Carpinus L.
Americana, W. *Horn Beam.*

Ostrya Mx.
Virginica, W. *Iron Wood. Hop Hornbeam.*

SALICINEAE.

Populus L.
balsamifera, Wang. *Balsam Poplar.*
candicans, Ait. *Balm of Gilead.*
§ dilatata, L. *Lombardy Poplar.*
grandidentata, Mx. *Poplar.*
tremuloides, Mx. *White Poplar.*

Salix L. *Willow.*
§ Babylonica, L.
conifera, W.
cordata, W.
discolor, Willd. B. *Bog Willow.*
eriocephala, Mx. *Swamp Willow.* B.
falcata, Ph.
grisea, W.
lucida, Muhl.
Muhlenbergiana, W.
myricoides, W.
nigra, W.
pedicellaris, Beauv.
prinoides Ph. B—e.
rigida, W.
vitellina L. *Yellow Willow.*
viminalis, L. *Osier Basket Willow.* B.

PLATANEAE.

Platanus L.
occidentalis, L. *Sycamore. Button-Wood.*

MYRICEAE.

Comptonia Gaert.
asplenifolia, Ait. *Sweet Fern.*

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Myrica L.
cerifera, L. *Bay Berry.*
Gale, L. *Sweet Gale.*

JUGLANDEAE.

Carya Nutt.
alba, W. *Common Hickory.*
amara, Mx. *Bitter Nut.* Deerfield&Sheffield
porcina, Mx. *Pig Nut.*
squamosa, Mx. *Shag Walnut.*
Juglans L.
cinerea L. *Butternut.*
§ nigra, *L. Black Walnut.*

EUPHORBIACEAE.

Acalypha L.
virginica, L. *Three Seeded Mercury.*
Euphorbia L.
maculata, L. *Spotted Spurge.*
hypericifolia, W.
polygonifolia, L. B.

CELASTRINEAE.

Celastrus L.
scandens. L. *False Bitter Sweet.*

RHAMNEAE.

Ceanothus L.
Americanus, L. *New Jersey Tea.*
Rhamnus L.
alnifolius, l'Herit. *Dwarf Alder.* Deerfield.
§ catharticus, L. *Buckthorn.*

STAPHYLEACEAE.

Staphylea L.
trifolia, L. *Bladder Nut.* Mt. Holyoke, [Deerfield and Weston.

ACERINEAE.

Acer L.
dasycarpum, Ehrh. *Silver Maple.*
Pennsylvanicum, W. *Striped Maple. Moose-* [*Wood.*
rubrum, L. *Red Maple.*
saccharinum, L. *Sugar Maple.*
spicatum, Lmk. *Mountain Maple Bush.*

VITEES.

Ampelopsis Mx.
quinquefolia, Mx. *False Grape. FiveFinger.*
Vitis L.
aestivalis, Mx. *Summer Grape.*
cordifolia, Mx. *Frost Grape.*
labrusca, L. *Plum Grape. Fox Grape.*

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ANACARDIACEAE.

Rhus L.
- aromaticum, Ait. *Fetid Sumach.* B—e.
- copallinum, L. *Sumach.*
- glabrum, L. *Sumach.*
- toxicodendron, L. *Poison Ivy.*
- typhynum, L. *Sumach.*
- venenata, De Cand. *vernix* L. *Poison Sumach. Dog Wood.*

XANTHOXYLEAE.

Xanthoxylum L.
- fraxineum, W. *Prickly Ash.*

GERANIACEAE.

Geranium L.
- dissectum, Willd. B.
- maculatum, L. *Crow-Foot Geranium.*
- robertianum, L. *Herb Robert.*

OXALIDEAE.

Oxalis L.
- acetosella, L. *Wood Sorrel.*
- stricta, Jacq. *Yellow Wood Sorrel.*
- violacea, L.

BALSAMINEÆ.

Impatiens L.
- fulva Nutt. *biflora*, Walt. *Jewel Weed.*
- pallida, Nutt. *noli-tangere*, Ph. ¾ *Touch-me.not.*

POLYGALEAE.

Polygala L.
- cruciata, L. B.
- paucifolia, W. *Flowering Wintergreen.*
- polygama, Walt. *rubella* Muhl.
- sanguinea, L.
- verticillata, L. *Dwarf Snake Root.*

VIOLACEAE.

Viola L.
- acuta, Big. B and A.
- blanda, W. *Smooth Violet.*
- Canadensis, L. *Woods Violet.*
- cucullata, Ait. *Common Violet.*
- Muhlenbergii, Tor. *debilis*, Ph. *Spear Violet.* B.
- lanceolata, Ait.
- obliqua ? Schwein. *Weak Stem Violet.*
- striata, Ait. *ochroleuca*, Schwein. Amherst.
- ovata, Nutt.
- palmata, L. *Hand Violet.*
- pedata, L. *Bird foot Violet.*
- pubescens, Ait. *Yellow Violet.*
- rostrata, Muhl. *Beaked Violet.*

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Viola.
rotundifolia, Mx. *Ground Violet.*
sagittata, Ait. *Arrow Violet.*
§ tricolor, L. *Garden Violet.*
villosa, Nutt.

CISTINEAE.

Helianthemum Tourn. *Cistus* L.
canadense, L. *Rock Rose.*
ramuliflorum, Mx. N. B.

Hudsonia L.
ericoides, L. *False Heath.* Cape Cod and Nantucket.
tomentosa, Nutt. B. *Poverty Grass.* Cape Cod and Nantucket.

Lechea L.
major, L. *Pin Weed.*
minor, L.

SARRACENIEAE.

Sarracenia L.
purpurea, L. *Sidesaddle Flower.*

DROSERACEAE.

Drosera L.
longifolia, L.
rotundifolia, L. *Sun Dew.*
tenuifolia, Muhl. B.

LINEAE.

Linum L.
Virginianum, L. *Wild Flax.*

CARYOPHYLLEAE.

Agrostemma L.
githago, *L. Cockle.*

Arenaria L.
lateriflora, W. *Sand Wort.* Springfield.
peploides, L. B.
rubra, L. B. & A.
§ serpyllifolia, L.

Cerastium L.
§ arvense, L.
hirsutum, Muhl A ?
oblongifolium, Torrey.
§ semidecandrum, L.
tenuifolium, Ph.
§ viscosum, L.
vulgatum, L. *Chickweed.*



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Cucubalus L.
behen, L.
stellatus L. B. *Star Campion.*
Dianthus L.
armeria, S. *Pink.* B. and Banks of Ct. River near Mt Tom.
Mollugo L.
verticillata, L. *Carpet Weed.*
Saponaria L.
§ officinalis, L. *Bouncing Bet.* Soap Wort.
Silene L.
antirrhina, L. *Sleepy catch Fly. Snap Dragon.*
Pennsylvanica, Mx. *Pink Catch Fly.*
Sagina L.
procumbens, L. *Pearl Wort.*
Spergula L.
arvensis, L. *Spurry.*
Stellaria L.
lanceolata, Torrey.
longifolia, Muhl. *Longleaf Starwort.*
media, Smith. *Alsine media, L. Chickweed.*

PORTULACEAE.

Claytonia L.
virginica, L. *Spring Beauty.*
Portulacca L.
oleracea, L. *Purslane.*

CRASSULACEAE.

Penthorum L.
sedoides, L. *Virginian Orpine.*

ILLCEBREAE.

Queria L.
Canadensis, L. *Fork Chickweed.*

AMARANTHACEAE.

Amaranthus L.
§ blitum, Willd. B.
hybridus, Willd.
§ oleraceus, L? *Pot Amaranth.*
pumilus, Nutt. Nashawn Island.

SCLERANTHEAE.

Scleranthus L.
annuus, L. *Gravel Chickweed.*

CHENOPODEAE.

Acnida L.
cannabina, L. *Water Hemp* B.
Atriplex L.
arenaria, Nutt. N. B.
patula, L. B.

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Blitum L.
- capitatum. L. *Strawberry blite.*

Chenopodium L.
- § album, L. *Pigweed. Hogweed.*
- §botrys, L. *Oak of Jerusalem.*
- §hybridum, L. *Tall Goosefoot.*
- rubrum, L. *Rusty Pigweed Red Goosefoot.*

Salicornia L.
- herbacea, L. *Samphire. Glass Wort.* B.
- mucronata, Big. B.
- ambigua, N. B.

Salsola L.
- Caroliniana, Mx. B.
- kali, L. B. Canadensis.
- salsa, Mx. B

PHYTOLACCEA.

Phytolacca L.
- decanda, L. *Poke weed.*

POLYGONEAE.

Polygonum L.
- arifolium, L. *Knotweed.*
- articulatum, L.
- aviculare, L. *Joint Weed.*
- cilinode, Mx.
- coccineum, W. B.
- convolvulus, L. *Bind Knot weed.*
- § fagopyrum, L.
- lapathifolium, L. A.
- mite, Pers. *Tasteless Knotweed.*
- § orientale, L. *Princes Feathers.*
- persicaria, L. *Heartease.*
- Pennsylvanicum, N.B.
- punctatum, Ell. *Biting Knotweed.*
- sagittatum, L. *Prickly Knotweed.*
- scandens, L. *Climbing Buck wheat.*
- tenue, Mx. *Slender Knot Grass.*
- Virginianum, L.

Rumex L.
- acetosella, L. *Field Sorrel.*
- acutus? L.
- Brittanica, L. B.
- crispus, L. *Dock.*
- obtusifolius, L. *Broad Leaved Dock.*
- pallidus, Big. B.

PODOSTOMEAE.

Podostemum L.
- ceratophyllum, Mx. *Thread Foot.* A.

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CALLITRICHINEAE.

Callitriche L.
linearis, Ph. A. & N. B.
verna, Muhl.

CERATOPHYLLEAE.

Ceratophyllum L.
demersum, L. Nantucket.

## II *Monopetalous Plants.*

ILICINEAE.

Ilex L.
Canadensis, Mx. *Mountain Holly* B.
opaca, Ait. *Evergreen Holly.*

Prinos L.
ambiguus, Mx. B.
glaber, L. B.
verticillatus, L. *Winter Berry. Black Alder*

ERICEAE.

Andromeda L.
calyculata, L *Leather Leaf.*
ligustrina, Muhl. *White Bush.*
paniculata, Mx. B.
polifolia, L. A.
racemosa, L. B.

Arbutus L.
uva ursi, L. *Bear Berry.*

Azalea L.
nudiflora, L. *Honey Suckle.*
viscosa, S. *White Honey Suckle.*

Clethra L.
alnifolia, L. *Spiked Alder.* B and Worcester.

Epigaea L.
repens, L. *Trailing Arbutus.*

Gaultheria L.
procumbens, L. *Partridge Berry.*

Kalmia L.
angustifolia, L. *Sheep Laurel.*
glauca, Ait. *Swamp Laurel.*
latifolia, L. *Laurel.*

Lasicopa Torrey M. S.
hispidula, For. *Gaultheria hispidula, Muhl.*

Ledum L.
latifolium, Ait. *Labrador Tea.* Amherst.

Rhododendron L.
maximum, L. *American Rose Bay.* Medfield & Dedham.

Rhodora L.
Canadensis, L. *False Honeysuckle.* A. and B.

VACCINEAE.

Oxycoccus Pers.
macrocarpus, Ph. *Cranberry.*
vulgaris? Pers. *Cranberry.*

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Vaccinium L.
corymbosum, L. *Giant or Swamp Whortleberry.*
frondosum, L. *Blue Whortleberry.*
hirtellum, Ait. B.
Pennsylvanicum, Lam. *Black-blue Whortleberry.*
resinosum, Ait. *Black Whortleberry.*
stamineum, L. *Squaw or Green Whortleberry. Deer Berry.*
tenellum, Ait. B.
virgatum, Muhl. B.
vitis-idea, L. Lynn.

PYROLACEAE.

Monotropa L.
lanuginosa, Mx. *Pine Sap. Hypopithys lanuginosa*, Nutt.
uniflora, L. *Bird's Nest. Tobacco Pipe.*

Pyrola L.
asarifolia, Mx. *Winter Green.*
elliptica, Nutt.
maculata, L. *Spotted Winter Green. Chimaphila*, Ph.
rotundifolia, L. *Shin-leaf Wintergreen.*
secunda, L. *One-sided Wintergreen.*
umbellata, L. *Prince's Pine. Wintergreen. Pipsissawa.*
uniflora, L. Lynn, Mr. Oakes.

CAMPANULACEAE.

Campanula L.
aparinoides, Ph. *Prickly Bell Flower.*
perfoliata, L. *Clasping Bell Flower.*
rotundifolia, L. *Hair Bell.* A.

LOBELIACEAE.

Lobelia L.
cardinalis, L. *Cardinal Flower.*
dortmanna, L. A. and B.
inflata, L. *Wild Tobacco.*
kalmii, L. A. and B.
Nuttallii? R. and S, Ludlow and Springfield.
pallida, Muhl.
syphilitica, L. B—e.

CUCURBITACEAE.

Momordica L.
echinata, W. Hadley and Deerfield.

Sicyos L.
angulata, L. *Single Seed Cucumber.* A.

PLANTAGINEAE.

Plantago L.
lanceolata, L. *Rib Wort.*
major, L. *Plantain.*
maritima, L. B. *Sea Plantain.*

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PLUMBAGINEAE.

Statice L.

limonium, L. *Marsh Rosemary.* B.

DIPSACEAE.

Dipsacus L.

§ sylvestris, L. *Wild Teasel.* Sheffield.

COMPOSITAE.

Achillea L.

millefolium, L. *Yarrow.*

Ambrosia L.

elatior, W. *Hog Weed. Anakim.*
heterophylla, Muhl. B.
trifida, W. *Wild Wormwood.*

Anthemis L.

cotula, L. *May Weed.*

Apargia W.

autumnalis, W. *False Hawkweed.* B.

Arctium L.

lappa, L. *Burdock.*

Artemesia L.

Candadensis, Mx. *Wild Wormwood.* A. and B.
§ vulgaris, *L. Garden Wormwood.* Naturalized on the hil-
[ly parts of the State.

Aster L.

acuminatus, Mx.
amplexicaulis, Mx. B.
amygdalinus, Mx. *umbellatus*, Ait.
conyzoides, W.
cordifolius, L.
coryfolius, Muhl. B.
corymbosus, Ait.
cyaneus, Hoff.
diversifolius, Mx.
dumosus, L.
ericoides, N. B.
laevis, Willd. B.
linariifolius, W.
macrophyllus, Ait.
miser, L. *a* divergens; *b*. diffusus.
multiflorus, W.
mutabilis, W. B.
Novi-Angliæ, L.
Novae-Belgii, L.
paniculatus, Ait. B—e.
phlogifolius, W. B—e.
prenanthoides, W. B—e.
puniceus, L.
rigidus, W. A.
salicifolius, W.
solidaginoides, W.
sparsiflorus, Mx. N. B.
spectabilis, Ait. N. B.
tradescanti, W.
subulatus, Mx. Mashfield and B.
umbellatus, Ait. B.

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Bidens L.
- cernua, L. N. B.
- chrysanthemoides, W. *Daisy Beggar Ticks.*
- connata, W. A.
- frondosa, L. *Burr Marygold.*
- tripartita, L. B.

Carduus L. *Cnicus* W.
- altissimus, W.
- arvensis, Pers. *Canada Thistle.*
- discolor, Muhl. *Common Thistle.*
- lanceolatus, W. *Common thistle.*
- glutinosus, Big. B.
- horridulus, Ph. B.
- pumilus, Nutt. B.

Centaurea L.
- § nigra, L. B. Hardwick and Bristol, R. I.

Chrysanthemum L.
- leucanthemum, L. *Oxeyed Daisy.*

Cichorium L.
- intibus, L. *Succory.*

Conyza L.
- camphorata, Muhl. *Marsh Flea Bane.*

Coreopsis L.
- trichosperma, Mx. B.
- rosea, Nutt. Plymouth. T. A. Greene.

Erigeron L.
- bellidifolium, W.
- Canadense, L.
- heterophyllum, Muhl.
- integrifolium, Big. B.
- Philadelphicum, L.
- purpureum, Ait.
- strigosum, Muhl.

Eupatorium L.
- ageratoides, W.
- aromaticum, W. B.
- hyssopifolium, L. N. B.
- maculatum, L. B—e.
- ovatum, Big. B.
- perfoliatum, L. *Thorough Wort.*
- pubescens, Willd. B.
- purpureum, L. *Joe Pye.*
- sessilifolium, L.
- teucrifolium, L.
- verticillatum, W. *Joe Pye Weed.*

Gnaphalium L.
- decurrens, Ives.
- Germanicum, Sm. N. B.
- margaritaceum, L. *Life Everlasting.*
- plantagineum, L. *Do.*
- polycephalum, Mx. *Sweet-Scented do.*
- purpureum, W. A.
- uliginosum, L.

Helianthus L.
- altisimus, L.
- decapetalus, L. A. and N. B.

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Hellianthus L.
divaricatus, L. B.
truncatus, Schw.
§ tuberosus, L. *Artichoke.*
Helenium L.
autumnale, L. B—e.
Hieracium L.
Gronovii, L. A.
Kalmii, L.
marianum, W.
paniculatum, *L.*
venosum, L. *Hawkweed.*
Inula L.
helenium, L. *Elecampane.*
falcata, Ph. N. B. and Nantucket.
Iva L.
frutescens, L. *High Water Shrub.* B—e.
Krigia L.
amplexicaulis, Nutt. A. *Hyoseris amplexicaulis*, Mx.
Virginica, W. *Dwarf Dandelion.*
Lactuca L.
elongata, W. *Wild Lettuce.*
integrifolia, Big. B. and A.
sanguinea, Big. B.
Leontodon L.
taraxacum, L. *Dandelion.*
Liatris L.
scariosa, W. *Gay Feather.*
Mikania W.
scandens, W. *Climbing Thorough Wort.* A. and B.
Onopordum L.
§ acanthium, L. *Cotton Thistle.*
Prenanthes L.
alba, L. *White Lettuce.*
altissima, L.
cordata, W.
virgata, Mx.
Rudbeckia L.
laciniata, L. *Cone Flower.*
Senecio L.
aureus, W. *Rag Wort.*
balsamitae, W. *Balsam Groundsel.*
hieracifolius, L. *Fire Weed.*
obovatus, W.
vulgaris, L. *Groundsel.*
Solidago L. *Golden Rod.*
altissima, W.
arguta, W.
aspera? Ait.
bicolor, L.
caesia, W.
Canadensis, L. B—e.
ciliaris? W.
gigantea, Ait.
lanceolata, Ait.

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Solidago L. *Golden Rod.*
latifolia, Muhl.
livida, W.
nemoralis, Ait.
odora, Ait. *Sweet scented golden rod.*
rigida, Ait. South Hadley Canal.
serotina, W.
speciosa, Nutt. A.
squarrosa, Nutt. Mt. Holyoke.
stricta, W.
tenuifolia, Ph. Nantucket, T. A. Greene.
ulmifola, W.

Sonchus L.
acuminatus, W.
leucophaeus, W. *Sow Thistle.*
oleraceus, L.
spinulosus, Big. B.

Tussilago L.
farfara, W. *Colt's Foot.*
palmata, Ait. Sunderland.

Tanecetum L.
§ vulgare, *L.* *Tansey.*

Vernonia L.
noveboracensis, *L.* *Flat Top.*

Xanthium L.
strumarium, *L.* *Clott Burr.*

STELLATAE.

Galium L.
aparine, L.
asprellum, Mx. *Rough Bed Straw.*
boreale, Ph. *Septentrionale*, R. and S.
circaezans, Mx. *Liquorice.*
lanceolatum, Torrey. *Torreyi*, Big.
obtusum, Big. B.
pilosum, Ait.
tinctorium, L. *Dyers Cleavers.*
trifidum, L. *Bed Straw. Small Cleavers.*
triflorum, Mx.
verum, L. B.

CINCHONEAE.

Cephalanthus L.
occidentalis, L. *Button Bush.*

Mitchella L.
repens, L. *Checker Berry. Eye Bright.*

CAPRIFOLIACEAE.

Caprifolium Goldie.
pubescens, Goldie. Lonicera hirsuta, Eaton.

Cornus L.
alba, L. B.
alternifolia, l'Her. B.
Canadensis, L. *Dog Wood.*
circinata, l'Her.
florida, L.
paniculata, l'Her.
sericea, l'Her.

Diervilla. Tourn.
humilis, Pers. *Bush Honeysuckle.*

Linnæa. Gron.
borealis, W. *Twin Flower.*



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Lonicera L.
parviflora, Lmk.
Sambucus L.
Canadensis, *L. Elder.*
pubens, Mx. *Red Berried Elder.*
Triosteum L.
perfoliatum, *L. Fever Root.* Deer. & Cam.
Viburnum L,
acerifolium, *L. Maple Guelder Rose.*
dentatum, *L. Arrow Wood.*
lantanoides, Mx. *Hobble Bush. Tangle legs.*
lentago, *L. Sheep Berry.*
nudum, *L.*
‖ oxycoccus, Ph. *High Cranberry.*
pyrifolium, Lam. Williamstown.
Xylosteum. Tourn.
‖ ciliatum, Ph. *Fly Honey Suckle.*
‖ villosum, Mx. Deerfield & Williamstown.

ASCLEPIADEAE.

Asclepias L. Milk Weed.
incarnata, *L.*
‖ obtusifolia, Mx.
phytolaccoides, Lyon.
quadrifolia, Jacquin.
purpurascens, *L.* B.
syriaca, *L. Common Milk Weed.*
tuberosa, *L. Pleurisy Root. Butterfly Weed.*
variegata, *L.*
verticillata, *L.*
viridiflora, Ph. B. and Leicester.

APOCYNEAE.

Apocynum L.
androsaemifolium, *L. Dog Bane.*
cannabinum, Mx. *Pubescens,* Brown.
hypericifolium, Ait. *John's Dog Bane.*

GENTIANEAE.

Gentiana L.
crinita, *L.*
‖ quinquefolia, *L.* Charlemont & Hoosac Mt.
‡ pneumonanthe, L. B.
saponaria, *L. Soap Gentian.*
Houstonia L.
coerulea, *L. Venus Pride.*
longifolia, Willd B.
Menyanthes L.
trifoliata. *L. Buck Bean.* B. & A.
Sabbatia Adanson.
chloroides, Ph. B.
stellaris, Ph. N. B.
Villarsia Gmelin.
lacunosa, Vent. B. *Spur Stem. Floating Heart.*

CONVOLOULACEAE.

Convolvolus L.
arvensis, L. B.

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Convolvolus L.
sepium, L. *Field Bind Weed.*
stans, Mx. *Dwarf Morning Glory.*
Cuscuta L.
Americana, L. *Dodder.*

OLEACEAE.

Fraxinus L.
Americana, W. *White Ash.*
juglandifolia, W. *Swamp Ash.* A.
sambucifolia, W. *Black Ash.* A.
Ligustrum L.
vulgare, L. *Privet or Prim.* A. & B.

PRIMULACEAE.

Anagallis L.
arvensis, L. *Scarlet Pimpernel.*
Hottonia L.
inflata, L. B. & N. B.
Glaux L.
maritima, L. Barnstable & Yarmouth, Dr. D. K. Underwood.
Lysimachia L.
capitata, Ph. A. & B.
ciliata, Mx.
hybrida, Mx. B. & N. B.
quadrifolia, L.
racemosa, Lmk. *Loose Strife.*
Samolus L.
valerandi, L. *Brook Weed.* B.
Trientalis L.
Americana, Ph. *Chick Wintergreen.*

LENTIBULARIAE.

Utricularia L.
cornuta, Mx. *Leafless Bladder Wort.* A. & B.
gibba, Gron. B—c.
inflata, Walt. B.
purpurea Walt. B.
resupinata, Green. M. S. Tewksbury.
striata, LeConte. A.
vulgaris, L. *Bladder Wort.*

ORBANCHEAE.

Epiphagus Nutt.
Americanus, Nutt. *Cancer Root.*
Orobanche L.
Americana, L. Mount Holyoke.
uniflora L. *Cancer Root.*

SCROPHULARINEAE.

Antirrhinum L.
Canadense, W. *Flax Snap Dragon.*
elatine, L. Haldley. Dr. George White.
linaria, L. *Snap Dragon.*

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Chelone L.
glabra, L. *Snake Head.*
Gerardia L.
flava, L.
glauca, Eddy. *Fox Glove.*
maritima, Nutt. B.
pedicularia, L.
purpurea, L.
tenuifolia, L. B.
Gratiola L.
aurea, Muhl. *Hedge Hyssop.*
Virginica, L *Neglecta, Torrey.* A
Leptandra Nutt.
Virginica, Nutt. *Culvers Physic.*
Limosella L.
subulata, Ives. *Mudwort.* Nantucket.
Lindernia L.
attenuata, Muhl. *False Hedge Hyssop.*
dilatata, Muhl. B. & A.
Mimulus L.
alatus, L. A.
ringens, L. *Monkey Flower.*
Penstemon L.
pubescens, W. B—e.
Scrophularia L.
Marilandica, L. *Fig Wort.*
Veronica L.
agrestis, L.
anagallis, L. *Brook Pimpernel.*
arvensis, L. *Wall Speedwell.*
becca bunga, L.
officinalis, L. *Speedwell.*
peregrina, L. N. B.
scutellata, L.
serpyllifolia, L.

RHINANTHACEAE.

Bartsia L.
coccinea, L. *Painted Cup.*
Melampyrum L.
Americanum, Mx. *Cow wheat.*
Pedicularis L.
Canadensis, L. *Louse Wort.*
pallida, Ph. A.
Rhinanthus L.
crista galli, L. *Yellow Rattle.* Plymouth Bigelow.

SOLANEAE.

Datura L.
stramonium, L. *Thorn Apple.*
Hyoscyamus L.
niger, L. *Hen Bane.*
Nicandra Adams.
physaloides, Pers. N. B.
Physalis L.
obscura, Mx. *Hen Bane.* A.
Pennsylvanica? L. A.

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Solanum L.
§ dulcamara, L. *Bitter Sweet.*
nigrum, L. *Deadly Nightshade.*
Verbascum L.
blattaria, L. *Sleek Mullein.* B. and A.
thapsus, L. *Mullein.*

VERBENACEÆ.

Phryma L.
leptostachia, L. *Lop Seed.*
Verbena L.
angustifolia, Mx. A.
hastata, S. *Vervain.*
urticifolia, L. *Nettle Leaf Vervain.*

LABIATÆ.

Ballota L.
§ nigra, L. *Black horehound.* B.
Clinopodium L.
vulgare, L. *Field Thyme.* A.
Collinsonia L.
Canadensis, L. *Horse Balm.*
Galeopsis L.
§ Ladanum, L. B. *Hemp Nettle.*
§ tetrahit, L. *Flowering Nettle.*
Glechoma L.
hederacea, L. *Gill-grow-by-the-ground.*
Hedeoma Pers.
pulegioides, Pers. *Pennyroyal.*
Hyssopus L.
nepetoides, W. *Giant Hyssop.*
Isanthus Mx.
coeruleus, Muhl. *False Pennyroyal.*
Lophanthus Benth.
nepetoides, Benth.
Lamium L.
§ amplexicaule, L. *Hen Bit. Dead Nettle.*
Leonorus L.
cardiaca, L. *Motherwort.*
Lycopus L.
Europaeus, Mx. *Water Horehound.*
Virginicus, L. *Bugle Weed.*
Marrubium L.
§ vulgare, L. *Horehound.*
Mentha L.
borealis, Mx. *Horsemint.*
§ piperita, Sm. *Peppermint.*
viridis, Walter. *Spearmint.*
Monarda L.
clinopodia, L. B—e.
didyma L. B—e.
‖ hirsuta, Ph. Cummington.
oblongata, Ait. B—e. and B.
Nepeta L.
cataria, L. *Catmint.*
Prunella L.
Pennsylvanica, W. *Heal All.*
Pycnanthemum Mx.
aristatum, Mx.

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Pycnanthemum.
incanum, Mx. *Mountain Mint.*
lanceolatum ? Ph.
linifolium, Ph. *Virginian Thyme.*
‖ verticillatum, Pers. B—e.
Scutellaria L.
galericulata, L. *Scull Cap.*
laterifolia, L. *Mad-dog Scull Cap.*
Stachys L.
aspera, Mx. *Hedge Nettle.*
sylvatica, L. A.
hyssopifolia, Mx. N. B.
Teucrium L.
Canadense, L. *Wild Germander.*
Trichostema L.
dichotoma, L. *Blue Curls.*
Thymus L.
§ vulgaris, L. *Thyme.* Longmeadow.

BORAGINEAE.

Cynoglossum L.
§ officinale, L. *Hound Tongue.*
Virginicum, L. B—e.
Echium L.
vulgare, L. *Vipers Bugloss*, B.
Lithospermum L.
arvense, L. B. *Common Gromwell.*
‖ officinale, L. B—e.
Lycopsis L.
§ arvensis, L. A. and B. *Wild Bugloss.*
Myosotis L.
§ arvensis, Sibth. *Forget-me-not.*
palustris, Ph. B.
Virginiana, *L.* *Mouse Ear.*
Onosmodium Mx.
hispidum, Mx. Monson and Nantucket. *False Gromwell.*

HYDROPHYLLEAE.

Hydrophyllum L.
Canadense, *L.* Windsor, Dr. Porter.
Virginicum, *L.* *A. Water Leaf.*

## Tribe II. Gymnospermae.

CONIFERAE.

Cupressus L.
thuyoides *L.* *White Cedar.* A. B. and especially N. B.
Juniperus L.
communis, *L.* *Juniper.* Mt. Tom and B.
Virginiana, *L.* *Red Cedar.*
Pinus L.
alba, Lamb. *Spruce.*
balsamea, W. *Fir Tree. Balsam Tree.*
Canadensis, *L.* *Hemlock Tree.*
fraseri, Ph. Saddle Mountain. Dewey.

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Pinus L.
nigra, Lamb. *Black Spruce.*
pendula, Ait. *Hackmatack. Tamarack.*
resinosa, Lamb. *Norway Pine.* A. and Worcester Co.
rigida, *L. Pitch Pine.*
strobus *L. White Pine.*
Taxus L.
Canadensis, W. *Dwarf Yew.* A. Very common.

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## Sub-class II.—ENDOGYNAE OR MONOCOTYLEDONOUS PLANTS.

### Tribe I.—Petaloideae.

#### ALISMACEAE.

Alisma L.
plantago, *L. Water Plantain.*
Sagittaria L.
acutifolia, Ph. *Arrow Head.*
heterophylla, Ph.
obtusa, W. N. B. Var. of S. Sagittif.
sagittifoila, *L. Arrow Head* α latifolia. β *gracilis.*

#### HYDROCHARIDEAE.

Udora Nutt.
Canadensis, Nutt. *Serpicula verticillata,* Muhl.
Vallisneria L.
spiralis, L. *Tape Grass.* Cambridge and Connecticut river.

#### XYRIDEAE.

Xyris L.
Caroliniana, Lam. *Yellow-eyed Grass.*

#### HYPOXIDEAE.

Hypoxis L.
erecta, L. *Star Grass.*

#### IRIDEAE.

Iris L.
versicolor, L. *Wild Iris. Blue Flag.*
Virginica, Torrey. *Gracilis,* Big. *Boston Iris.*
Sisyrinchium L.
anceps, *L. Blue-eyed Grass.*

#### ORCHIDEAE.

Aplectrum Nutt.
‖ hyemale, Nutt. *Putty Root. Adam and Eve.* Conway.
*Cymbidium hyemale,* W.

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Arethusa L.
bulbosa, *L.* B. and Belchertown.
Calopogon Brown.
pulchellus, Br. *Grass Pink. Cymbidium pulchellum*, W.
Corallorhiza Brown.
odontorrhiza, Nutt. *Coral Teeth. Dragon Claw. Cymbidium odont*, W.
Cypripedium L.
humile, Sw. *Ladies Slipper.*
pubescens, Sw. *Yellow Do.*
spectabile, Sw. *Do.* Deerfield.
Goodyera Brown.
pubescens, W. *Neottia pubescens*, W. *Rattle Snake Leaf.*
‖ repens, Wild. B.
Habenaria L.
blephariglottis, Hooker. A. and B.
‖ bracteata, R. Brown. *Satyrium bracteatum*, Ph.
‖ cristata, R. Brown. Fair Haven, T. A. Greene.
ciliaris, R. Brown. A. and B.
‖ dilatata, Ph.
‖ grandiflora, Big. B. and A.
‖ herbiola, R. Brown. A. and N. B.
‖ incisa ? Spreng.
fimbriata, R. Brown.
‖ macrophylla, Goldie. Mt. Holyoke.
‖ orbiculata, Ph.
psycodes, Spreng. B—e and A.
Listera R. Brown.
cordata, Brown. *Epipactis Convallarioides*, Ph. Plainfield.
Malaxis Sw.
liliifolia, Sw. *Tway-blade.*
‖ loeselii, Sw.
Mycrostylis Nutt.
ophioglossoides, Nutt. *Adder Mouth.*
Neottia Sw.
tortilis, Sw. *Ladies' Tresses.* β *gracilis*, Torrey.
cernua, Sw. *Nodding Ladies' Tresses.*
Orchis L.
spectabilis, *L. Orchis.*
tridentata, W. B—e. A. and N. B.
Pogonia. Brown.
ophioglossoides, Brown. *Snake Mouth Arethusa.*
‖ verticillata, Nutt. A.
Triphora. Nutt.
‖ pendula, Nutt. Deerfield. *Arethusa pendula* W.

JUNCEÆ.

Juncus L.
acuminatus, Mx. A.
bufonius, *L.*
bulbosus, *L.*
effusus, *L. Bulrush.*
militaris, Big. Tewksbury.
marginatus, Rotk. N. B.
nodosus, *L.*
polycephalus. Mx.

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Juncus L.
‖ setaceus, Rostk.
tenuis, W.
Luzula De Cand.
campestris, De Cand.
melanocarpa, Desv.
pilosa, W. A

MELANTHACEÆ.

Helonias L.
dioica, Ph. B—e. *Blazing Star.*
Veratrum L.
viride, Ait. *Indian Poke. White Hellebore.*

PONTEDEREÆ.

Pontederia L.
‖ angustifolia, Ph. Leverett. *Cordata* B. *angusti.* Torrey.
cordata, *L. Pickerel weed.*
Schollera Schreb.
graminea, Vahl. *Lepanthus gramineus*, Mx.

ASPHODELEÆ.

Aletris L.
farinosa, *L. False Aloe.* A.
Allium L.
Canadense, *L. Meadow Garlic.*
tricoccum, W.
Asparagus L.
§ officinalis, *L.*

SMILACEÆ.

Convallaria L.
bifolia, L.
multiflora, *L. Solomon Seal.*
pubescens, W. A.
racemosa, *L. Clustered Solomon Seal.*
stellata, *L.*
‖ trifolia, *L.* Pelham and Cummington.
umbellulata, Mx. *Lily of the Valley.* A.
Gyromia. Nutt.
virginica, Nutt. *Indian Cucumber. Medeola Virginica. L.*
Similax L.
herbacea, *L*, B—e.
peduncularis, W. *Jacob's Ladder.*
rotundifolia, *L. Green Briar.*
Streptopus Mx.
‖ distortus, Mx. A. & B—e.
roseus, Mx. *Rose Bell Wort.* A. & B—e.
Trillium L.
‖ cernuum, *L. Nodding Wake Robbin.*
erectum, *L. False Wake Robbin.*
‖ grandiflorum, Salisb. Pelham, Dr. G. White.
‖ pictum, *Smiling Wake Robbin.*



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Uvularia L.
perfoliata, L. *Bell Wort.*
sessilifolia, *L.*

DIOSCOREÆ.

Dioscorea L.
villosa, *L.* B.

LILIACEÆ.

Erythronium L.
dens-canis, Mx. *Dog Tooth Violet.*
Lilium L.
Canadense, *L.* *Nodding Lily.*
Philadelphicum, *L.* *Red Lily.*

RESTIACEÆ.

Eriocaulon L.
gnaphalioides, Mx. B—e.
pellucidum, Mx. *Pipe Wort.*

TYPHACEÆ.

Sparganium L.
‖ Americanum, Nutt. N. B.
‖ angustifolium, Mx? B.
ramosum Swartz, *Burr Reed.*
Typha L.
angustifolia, *L.* B.
latifolia, *L,* *Cat Tail.*

AROIDEÆ.

Acorus L.
calamus, *L.* *Sweet Flag.*
Arum L.
‖ dracontium, W. *Green Dragon.* Deerfield.
triphyllum, *L.* *Indian Turnip.*
Calla L.
palustris, *L.* *Water Arum.*
Lecontia. Cooper. "Atrue celadium" Torrey. *Rensselaria Beck.*
Virginica, Coop. *Arum Virginicum*, L. Belchertown.
Orontium, L.
aquaticum, L. *Golden Club.* Southwick. Dr. Porter.
Pothos Mx.
foetida, Mx. *Skunk's Cabbage.*

FLUVIALES.

Najas L.
‖ Canadensis, Mx. *Caulinia flexilis*, W. A.
Potamogeton L.
‖ compressum, W. A. and N. B.
fluitans, L.
‖ gramineum, Mx. A. and B.
‖ heterophyllum, Schreb. A.

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Potamogeton.
lucens, Mx. B.
natans, L.
‖ pectinatum, Sw. B—e. and N. B.
perfoliatum, L.
‖ setaceum, Ph. *diversifolium*, Barton. A. and B.
Ruppia L.
maritima, L. *Sea Teasel Grass.* B.
Zostera L.
marina, L. *Grass Wrack.*

JUNCAGINEÆ.

Scheuchzeria L.
palustris, L. Belchertown.
Triglochin L.
maritimum, L. *Arrow Grass.* B.

PISTIACEÆ.

Lemna L.
minor, L. *Duck-meat.*
polyrrhiza, L. *Water Flax Seed.* A.
trisulca, L. A.

TRIBE II.—GLUMNACEÆ.

GRAMINEÆ.

Agrostis L.
canina, L. B.
clandestina, Muhl. B.
lateriflora, Mx. A. & N. B.
longifolia, Torrey. A.
polymorpha, Hudson and A. *Trimnius alba, L. White Top Grass.*
sobolifera, Muhl. A.
sylvatica, Torrey. B—e.
tenuiflora, Willd. A.
Virginica, L.
Aira L.
flexuosa, L. *Hair Grass.*
Alopecurus L.
geniculatus, Muhl. *Floating Fox Tail.*
pratensis, L. *Meadow Grass.*
Andropogon L.
furcatum Muhl. *Forked Spike.*
macrourum, Mx. N. B.
nutans, L. *Beard Grass.*
purpurascens, Muhl. N. B.
Virginicum ? N. B.
Anthoxanthum L.
odoratum, L. *Sweet Vernal Grass.*
Aristida L.
dichotoma, Mx. *Beard Grass.*
gracilis, Ell. N. B.
purpurascens, Poir. N. B.
racemosa, Muhl. A.
Avena L.
mollis Michx.

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Arrhenatherum P. de B.
avenaceum, P. de B. *Avena elatior.* L.
‖ Pennsylvanicum, Torrey. B—e.
Arundo L.
Canadensis. Mx. B. & A.
coarctata, Torrey. B. & A.
pragmites, L. *Pragmites communis, Trinnius.*
Briza L.
media, L. B.
Bromus L.
purgans, L. B.
pubescens. Muhl. *Broom Grass.*
§ secalinus, *L. Chess Cheat.*
mollis, L.
Cinna L.
arundinacea, L. *Indian Reed.*
Danthonia De Cand.
spicata, P. de B. *Wild Oats. Avena spicata.* L.
Dactylis L.
glomerata L, *Orchard Grass.*
Digitaria Walter.
filiformis. Ell. A. & N. B.
sanguinalis, Scop. *Finger grass.* A. & B— e.
Elusine Gaertner.
indica, Lamb. *Wire Grass.* A.
Elymus L.
glaucifolius, Torrey. *Canadensis, B.*
hystrix, L.
villosus, L. *Wild Rye. Lime Grass.*
Virginicus, L.
Festuca L.
duriuscula, L. N. B.
elatior, L. *Fescue Grass.*
pratensis, Huds. B—e.
nutans. W.
tenella, W. A. & B—e.
Glyceria R. Brown.
fluitans R. Brown. *Festuca fluitans.* L. *Water Fescue.*
Hierochloa Gmelin.
borealis, R. & S. *Seneca Grass.* B.
Holcus L.
lanatus L. *Velvet grass.* B.
Hordeum L.
jubatum, L. B.
Koeleria Pers.
Pennsylvanica, De Cand. A.
truncata, Torrey.
major.
Leersia Swartz.
oryzoides, Sw.
Virginica, W. *Cut Grass.*
Lolium L.
perenne, L. *Darnel Grass.*
Muhlenbergia Schreb.
erecta, Schreb. *Drop-seed Grass.*

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Oryzopsis Mx.
‖ asperifolia, Mx. *Mountain Rice.*
Panicum L.
acuminatum, Muhl. A.
agrostoides, Muhl. A. & N. B.
capillare, L.
clandestinum L. A.
crus-galli L. *Barn-Grass.*
dichotomum. L.
depauperatum, Muhl. A. and B—e.
discolor, Muhl. B.
geniculatum, Muhl. A.
hispidum, Muhl. A. and N. B.
involutum, Torrey. A.
latifolium, L.
macrocarpon, Torry. A.
nervosum, Muhl. A. and B.
nitidum, Lmk.
virgatum. L. A. and B.
Paspalum L.
ciliatifolium, Mx. N. B.
setaceum, Mx. *Paspalon Grass.* A.
Phalaris L.
Americana, Ell. *Ribbon Grass.*
Phleum L.
pratense, L. *Timothy Grass.*
Piptatherum Beauv.
nigrum, Torrey. *Oryzopsis Melanocarpa*, Muhl. *Millium racemosum*, Smith. *Clustered Millet-Grass.*
Poa L.
annua, L.
aquatica. B. *Americana*, Torrey.
Canadensis, Torrey.
capillaris, L. A. and B.
compressa, L.
‖ dentata, Torrey. A. N. B. and B—e.
‖ elongata, Torrey. *Torreyi*, Spreng.
eragrostis, L. A. and B.
hirsuta, Mx. A. and B.
maritima, Huds. B.
nemoralis, L. A. and B—e.
nervata, W.
obtusa, Muhl. B.
palustris, Muhl. A.
pectinacea, Mx. A.
pratensis; L.
reptans, Mx. A.
trivialis, L. A. N. B. and B—e.
‖ uniflora, Muhl. N. B. Var. of capillaris.
Polypogon Des.
glomeratus, W. A.
Psamma Beauv.
arenaria, Beauv. *Arundo arenaria*, L. B.
Setaria P. de Beauv.
viridis, P. de B. *Panicum viride*, L.
glauca, P. de B. *Fox-tail Grass. Panicum glaucum* L.
italica, P. de B. B—e.
verticillata, P. de B. Boston.

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Spartina Schreb.
cynosuroides, W. B. *Rough Grass.*
glabra, Muhl. B.
juncea, W. B.

Stipa L.
avenacea, L. B.
‖ Candensis, Lmk. A. and B. *Milium pungens*, Torrey. *Oryzopsis parviflora*, Nutt.

Trichochloa De Cand.
‖ capillaris, De Cand. *Sugar Loaf*, Deerfield, Dr. Cooley.

Trichodium Mx.
laxiflorum, Mx. *Tickle Grass.*
scabrum, Muhl. A. and B—e.

Tricuspis Beauv.
sesleroides Torrey. *Poa quinquefida*, Ph. A. and B—e.

Trisetum Pers.
palustre, Torrey. *Aira Pallens*, Muhl.
purpurascens, Torrey. B—e.

Triticum L.
repens, L. *Wheat Grass. Quake Grass.* B.

Uniola L.
spicata, L. *Spike Grass.* B.

Uralepsis Nutt.
aristulata, Nutt. N. B.

Zizania L.
clavulosa, Mx. *Water Oats. Wild Rice.* B. and Northampton.

CYPERACEÆ.

Carex L. *Sedge Grass.*
acuta, L. A. and B—e.
alba, Haenke, B—e.
ampullacea, Good. Deerfield.
anceps, Schkuhr. A. B—e and B.
aquatilis, Wahl. B—e.
aurea, Nutt. B—e.
blanda, Dewey. A. and B—e.
bromoides, Schk. A. and B—e.
bullata, Schk. A. and B—e.
Buxbaumii, Muhl. A.
caespitosa, L. A. and B—e and B.
cephalophora, W. A. B. and B—e.
‖ collecta, Dewey. Worthington.
conoidea, Schk. A. and B—e.
crinita, Lamb. A. B—e and B.
cristata, Schk. A. and B—e.
curta, Good. B. A. and B—e.
Davisii, Dewey. A. and B—e.
Deweyana, Schw. A. and B—e.
disperma, Dewey. A. and B—e.
festucacea, Schk. A. and B—e.
filiformis, Gooden. A. and B—e.
flava, L.
flexuosa, Schk. A. and B.
folliculata, L. A. B—e, and B.
‖ formosa, Dewey. A. and B—e.
gracillima, Schw. A. and B—e.
granularis, Muhl. A. and B—e.

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Carex.

‖ Halseyana, Dewey. Westfield.
hirsuta, W. A. and B—e.
‖ Hitchcockiana, Dewey. Williamstown.
hystericina, W. A. and B.
lacustris, W. A. B—e and B.
lagopodioides, Schk. A. and B—e.
laxiflora, Lam. A. and B—e.
limosa, L. Ashfield.
‖ longirostris, Torrey. A. and B—e.
lupulina, Muhl. A. B—e, and B.
marginata, Muhl. A. B—e, and B.
miliacea, Muhl. A. and B—e.
Muhlenbergii, Dewey, B—e.
multiflora, Muhl. B—e.
muricata. B—e.
‖ Novae-Angliae, Schw. A. and B—e.
oligocarpa, Schk. A. and B—e.
pallescens, L. A. and B—e.
paniculata, Mich. A. and B.
pauciflora Schk. Ashfield.
pedunculata, Muhl. A. and B—e.
pellita, Muhl. A.
plantaginea, Lam. A. B—e, and B.
polytricoides, Muhl. A. and B—e.
pseudo-cyperus, L. A. B—e, and B.
pubescens, Muhl. A. and B—e.
pyriformis, Schw. Muhl. B—e.
retroflexa, Muhl. A. and B—e.
retrorsa. B—e and Plainfield.
rosea, Shk. A. and B—e.
scabrata, Schw. A. and B—e.
scirpoides, Schk. A. and B—e.
scoparia, Schk. A. B—e, and B.
Schweintzii, Dewey. B—e.
‖ setacea, Dewey. B—e.
‖ siccata, Dewey. Westfield.
sparganoides, Muhl. A. B—e and B.
squarrosa, L. Hadley.
stellulata, Schreb. A. B—e, and B.
‖ sterilis, W. A. and B—e.
stipata, Muhl. A. B—e, and B.
straminea, W. A. B—e, and N. B.
stricta, Good. A. and B—e.
sylvatica, Huds. A. and B—e.
‖ tenera, Dewey. A. and B—e.
tentaculata, Muhl. A. B—e, and N. B.
teretiuscula, Good. A. and B—e.
tetanica, Schk. A. and B—e.
‖ Torreyana, Dewey. A. and B—e.
tricocarpa, Muhl. A. and B—e.
trisperma, Dewey. A. and B—e.
umbellata, Schk. A. and B—e.
varia, Muhl. A. and B—e.
vesicaria, L. A.
vestita, W. A.
virescens, Muhl. A. B—e, and N. B.
xanthophysa, Wahl. A. B—e, and N. B.

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Cyperus L.
- Nuttallii, Torrey. A.
- dentatus, Torrey. A. and B.
- diandrus, Torrey. A. and B.
- flavescens, L. N. B. and B—e.
- mariscoides, Ell. *Scirpus cyperiformis*, Muhl. A. and B.
- poaeformis, Ph. A. and B—e.
- strigosus, L. A. and B—e.
- uncinatus, Ph. *inflexus*, Muhl. A. and B.

Dulichium Richard.
- spathaceum, Pers. *Galingale.*

Eriophorum L.
- alpinum, L. *See Torrey's Flora.*
- angustifolium, W. A. and B.
- cespitosum, Ph. A. and B—e.
- polystachium, L. A. B. and B—e.
- Virginicum, L. *Cotton Grass.* A. B. & B—e.

Rhynscopora Vahl.
- alba, Vahl. A. B. & B—e.
- glomerata, Vahl. A.
- ‖ macrostachya, Torrey. M. S. Belchertown and Leverett.

Scirpus L. *Rush.*
- acicularis, L.
- acutus, Muhl. B. & B—e.
- atrovirens, Muhl. A. & B—e.
- autumnalis, Muhl. A. & B.
- ‖ brunneus, Muhl. A.
- capillaris, Muhl. A. & B.
- capitatus, L. A. B. & B—e.
- debilis, Muhl. A. & B.
- eriophorum, Mx. A. & B.
- intermedius, Muhl. A.
- lacustris, L. A.
- ‖ lineatus, Mx. Plainfield.
- maritmus, L. B.
- palustris, L. A. & B.
- planifolius, Muhl. A. B. & B—e.
- ‖ subsquarrosus, Muhl. A.
- ‖ subterminalis, Torrey. Leverett.
- tenuis, W. A. B. & B—e.
- trichodes, Muhl. A. B. & B—e.
- triqueter, Mx. A. & B—e.
- tuberculatus, Mx. A.

Scleria Gaertner.
- triglomerata, Mx. *Whip Grass.* Hadley.

Schoenus L.
- mariscoides, Muhl. *Bog Rush.* Belchertown & Leverett.

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# Class II.—CELLULARES

OR

# FLOWERLESS PLANTS.

## TRIBE I.—FILICOID PLANTS.

### EQUISETACÆ.

**Equisetum L.**

arvense, L. *Horse Tail.* A. B. & B—e.
hyemale, L. *Rough Horsetail. Scouring Rush.* A. B. & B—e.
sylvaticum, W. A. B. & B—e.
palustre, L. A.
‖ scirpoides, Mx. A. B. & B—e.
uliginosum, L. *Pipes.* A. B. & B—e.

### FILICES.

**Adiantum L.**

pedatum, L. *Maiden Hair. Mowhair.*

**Aspidium Swartz.** *Brake Fern.*

acrostichoides, Swartz. A. B. & B—e.
asplenoides, W. A. & B.
bulbiferum, W. B—e.
cristatum, Sw. A.
dilatatum, W. A. N. B. & B—e. *intermedium, L.*
tenue, W. A.
goldianum, Hooker. *Felix Mas,* Ph. A. & B—e.
lancastriense, Muhl. B.
marginale, Sw. *Nephrodium marginale,* Mx. H. B. & B—e.
noveboracense, W. A. B. & B—e.
pilosiuscula, W. *Dicksonia, l'Herit.*
spinulosum, W. B—e.

**Asplenium L.** *Brake Fern.*

‖ angustifolium, Jacq. *Spleen Wort.* B—e. B. & A.
ebenum, Ait. B—e B. & A.
melanocaulon, Muhl. B—e. B. & A.
‖ rhizophyllum, L. *Walking Leaf.* B—e B. & A.
‖ ruta-muraria, L. B—e B. & A.
thelypteroides, W. *acrostichoides,* Sw. B—e. B & A.

**Botrychium Swartz.**

fumaroides, W. *Grape Fern.* A. B. & B—e.
simplex, Hitchcock. A.
Virginicum, W. A. B. & B—e.

**Hypopeltis Torrey.**

obtusa, Torrey. *Aspidium obtusum,* W. A. *Woodsia pervinians.* Hook. & Grev.

**Lygodium Sw.**

‖ palmatum, Swartz. *Climbing Fern.* Amherst and Becket.



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Onoclea L.
sensibilis, L. *Sensitive Fern.* A. B. & B—e.
Ophioglossum L.
vulgatum, L. *Adder Tongue Fern.* A.
Osmunda L.
cinnamonea, W. B—e. & A.
interrupta, Mx. B. B—e. & A.
spectabilis, Mx. B. B—e. & A.
Polypodium L.
‖ calcareum, Lm. A. &. B—e.
connectile, W. B. A. & B—e.
hexagonopterum, W. A. & B—e.
vulgare L. *Polypod.* B. A. & B—e.
Pteris L.
aquilina, L. *Common Brake.* B. B—e. & A.
atropurpurea, L. *Rock Brake.* A.
Struthiopteris W.
‖Pennsylvanica, W. A. & B.
Woodsia R. Brown.
ilvensis, R. Br. A. & B.
Woodwardia Smith.
angustifolia, Sw. N. B.

LYCOPODIACEAE.

Lycopodium L. *Ground Pine.*
‖ annotinum, W. A.
apodum, W. A.
clavatum, W. *Club Moss.* B. B—e & A.
Carolinianum, W. B.
complanatum W. *Ground Pine.* B. B—e & A.
dendroideum, W. Do. B. B—e & A.
‖ inundatum, W. N. B.
lucidulum, W. *Moon Fruit Pine.* B. & A.
obscurum, L. B. "var. of dendroideum," Torrey.
rupestre, W. B. B-e. & A.

## TRIBE II. MUSCOIDEAE.

No Catalogues of the remaining Orders of plants have been published in Massachusetts, except for Berkshire County and the vicinity of Amherst College, or the valley of the Connecticut. B—e, as usual is added to those species that are found in Berkshire: and B—e* to the few that are peculiar to Berkshire. All, that have not the Star annexed, occur in Connecticut Valley, and doubtless this list falls far short of the actual number.

MUSCI.

Anictangium Hedw.
filiforme, Hedw. *Hedwigia filiformis P. de Beauv.* B—e.
Anomodon. Hooker and Taylor.
viticulosum, H & T. *Neckera viticulosa, Hedw.*

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Arrhenopterum. Hedw.
heterostichum, Hedw. *Byrum arrhenopterum, Dill.*
Bartramia. Hedw.
crispa? Sw. B—e.
fontana, Hooker.
gracilis, Sm. *Oederi, Schwaegrichen.*
pomiformis, Hedw.
Bryum L.
androgynum, Hedw.
aureum,
argenteum, L. B—e.
caespiticium, L. B—e.
cuspidatum, Schreb. B—e.
nutans, Schreb. *Webera nutans, Hedw.* B—e.
punctatum, Schreb.
roseum, Schreb. *B*—e.
triquetrum, Turner. *Meesia longiseta Hedw.*
turbinatum, Sw.
Buxbaumia L.
‖ aphylla, L.
Catharinea Ehrharst.
undulata, Web. & Mohr. *Polytrichum undulatum, Hedw.*
Climacium Web. & Mohr.
Americanum, Brid. *Hypnum dendroides, L.* B—e.
Dicranum Hedw.
cerviculatum, Hedw.
glaucum, Hedw. B—e.
heteromallum, Hedw. B—e.
orthocapon, Hedw. B—e.
polycarpum, Ehrh.
scoparium, Hookr. & Tay. B—e.
strictum, Brid.
undulatum, Ehrh.
Diphyscium. Web. & Mohr.
foliosum, Web. & Mohr. *Hymenopogon heterophyllum,* P. deB.
Didymodon Hedw.
purpureum, Hooker & Tay. *Dicranum purpureum, Hedw.*
Diplocomium. Web. & Mohr.
longisetum, Web. & Mohr. B—e. *Meesia longiseta.*
Encalypta Schreb.
ciliata, Hedw. Deerfield.
Fissidens Hedw.
adianthoides, Hedw.
taxifolius? Hedw,
Fontinalis L.
antipyretica, L. B—e.
squamosa, J. Porter, Mass.
Funaria Hedw.
flavicans, Muhl. B—e.
hygrometrica, Hedw. B—e.
Grimmia Hedw.
leucophoea, Hook. & Tay.
ovata?
pilifera, Mx.
pulvinata, Smith.

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Gymnostomum Hedw.
Drummondia, Hook. in *Drum.* Musc. *Amer. bor. nec.* D.C.
prorepens, Hook.
pyriforme, Hedw.

Hypnum Hedw.
abietinum, L.
acuminatum, B—e. *
confertum, Dicks.
Cooleyanum, Spreng. B—e.
cristacastrensis, L. B—e.
cupressiforme, Hook. B—e.
cuspidatum, *L.*
denticulatum, L. B—e.
dimorphum, Brid.
filicinum, L.
fragile, Brid.
hians, Muhl.
imponens, Hedw. B—e.
lutescens, Schreb.
minutulum, B—e. *
proliferum.
riparium, Hook..
rutabulum, B—e. *
salebrosum, B—e. *
serpens, L. B—e.
striatum, Schreb.
tenax ? Hedw.
torreyanum, Spreng.
triquetrum, L. B—e.

Leskea Spreng.
acuminata, Hedw. B—e.
curvata, Voit. Deerfield.
obscura, Hedw.

Leucodon. Schwaeg.
sciuroides. Schwaeg.

Neckera. Hedw.
minor, Beauv.
pennata, Hedw. B—e.

Othrotrichum Hedw.
affine, Hook. & Tay.
anomalum, Hedw.
clarellatum.
crispum, Hook. & Greville.
cupulatum, Hoffm ?
Drummondi. Hook. & Grev.
Hutchinsiae, Hook. and Grev.
pumilum, Swartz.
speciosum.
strangulatum, P. de Beauv.
reticulosum.

Polytrichum L.
aloides, Hedw. *brachyphyllum.* Pond. B—e. *
formosum, Hedw.
juniperinum, W. B—e.
perigoniale, B—e. *

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Pterogonium. Swartz. *Pterigynandrum Hedw.*
apiculatum, Brid.
hirtellum, Hedw.
intricatum, B—e. *
julaceum, Hedw.
subcapillatum, Hedw.
trichomitrion, Swartz. B—e.
Sphagnum L.
acutifolium, Hook. and Tay.
latifolium, B—e. *
obtusifolium, Hook. *cymbifolium, Swartz.*
squarrosum, Web. & Mohr.
Tetraphis Hedw.
pellucida. Hedw.
Timmia Hedw.
cucullata, Mx. B—e.
Trematodon Richard.
longicollis, Rich. Deerfield.
Trichostomum Hedw.
pallidum, Hedw. B—e.
Weissia Hedw.
controversa.
microdonta, Hedw. B—e.
viridula, Hedw. B—e.

HEPATICÆ.

Anthoceros L.
levis, L.
Blasia L.
pusilla, L. *Jungermannia Blasias.* Hook.
Jungermannia L.
complavata, L. *Plaited Moss.*
ciliaris L. *sertulariordes Mx.*
pinguis, L.
platyphylla, L.
porella, Dickson. Ware. Mr. Emerson Davis.
scalaris, Schwein.
tamarisci, Martens.
tomentella, Ehrh.
trilobata, Weber.
tridenticulata, Mx.
Marchantia L. *Liverwort.*
conica, L. B—e.
crinita, Mx.
cruciata? L. *Staurophora pulchella, W.*
polymorpha, L. *Brook Liverwort.* B—e.
triceps, Schw. M. S.
Riccia L.
fluitans, L *Forkstems*, B—e. *
natans, L. *Floating Liverwort.* B—e.
lutea, Selus.

CHARACEAE.

Chara L.
flexilis, W.
foliosa, W.
vulgaris, L. *Feather Beds.*

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## TRIBE III.—APHYLLAE OR LEAFLESS FLOWERLESS PLANTS.

### LICHENES.

*According to Acharius, except where other authorities are mentioned.*

Alectoria.
- jubata. *Negro Hair.*

Arthonia.
- punctiformis.
- radiata.

Bæomyces Pers.
- roseus, Pers.

Borrera.
- chrysophthalma. On the coast.

Calicium.
- tigillare, Cummington, Dr. Porter.

Cenomyce.
- allotropa.
- baccillaris clavata.
- botrytes.
- capitata.
- coccifera.
- endivœfolia.
- caespititia.
- gonorega.
- pyxidata.
- rangiferina.
  - *Vars.* 1 sylvatica.
  - 2 alpestris.
  - 3 minor.
- verticillata.

Cetraria.
- ciliaris.
- glauca.
- lacunosa.

Collema.
- furvum.
- juglandii, Schw.
- lacerum.
- tunaeforme.

Cornicularia Schreb.
- fibrillosa.

Endocarpon Hedw.
- miniatum, B—e.
- smaragdulum, Plainfield, Dr. Porter.
- Weberi, do. do.

Evernia.
- prunastri, *Borrera purpuracea*, Spreng.

Graphis Adanson.
- scripta.

Gyrophora.
- deusta.
- Muhlenbergii, B—e.
- papulosa. B—e.
- vellea.

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Hysterium Tode.
- rufescens, Schw.

Lecanora.
- albella.
- atra. *var.* liquatilis.
- brunnea.
- caesio-rubella.
- candellaria.
- fulva, Schw.
- granulosa.
- parella.
- salicina, Plainfield, Dr. Porter.
- sophodes?
- subfusca.
- tartarea.
- tuberculosa.
- varia.
- vitellina.

Lecidea.
- albella, Schw. M. S.
- albo-caerulescens.
- carneola.
- demissa.
- Ehrhartiana.
- immersa.
- oederi?
- parasema.
- subfusca.
- umbrina.

Lepraria.
- sulphurea,

Nephroma.
- resupinata, Spreng.

Pyrenula Spreng.
- enteroleuca, Spreng. Plainfield, Dr. Porter.

Parmelia. *Shield Lichen.*
- aipolia.
- aleurites.
- caesia.
- caperata.
- ciliaris?
- colpodes.
- corrugata.
- crinita?
- cristulata.
- cycloselis.
- herbacea.
- olivacea.
- parietina.
- perforata.
- physodes.
- physodoides, Schw. M. S.
- placorodia, Muhl.
- plumbea.
- rutilans, Plainfield, Dr. Porter.
- saxatilis.
- scortea.

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Parmelia.
stellaris.
tiliacea.
ulothrix.
venusta.
Peltidea.
apthosa.
canina.
horizontalis.
scutata. *Turget Lichen.*
venosa.
Porina.
fallax.
papillata.
pertusa.
Ramalina.
fastigiata.
fraxinea.
polymorpha.
Stereocaulon Schreb.
paschale.
Sticta Schreb.
aurata, Smith in Rees' Cyc. Western, Dr. Porter.
pulmonacea.
scrobiculata.
sylvatica.
Usnea Schreb.
florida, Hoffm.
plicata, Hoffm.
Variolaria Pers.
corallina, Plainfield, Dr. Porter.
velata.
Verrucaria.
gemmata.

FUNGI.

Aecidium Pers.
helianthi mollis? Schw.
solidaginis, Schw. and many others.
Agaricus L.
alneus, L.
campestris, L. B—e.
coccineus. B—e.*
cbriaceus, Bull.
disseminatus, *Pers.*
papyraceus. B—e.*
salignus, Pers.
trabeus? Pers.
velutipes, Curtis. And several decades more undetermined.
? Amanita Pers.
cesareus, Schaeff.
livida? Pers.
Arcyria Pers.
punicea, Pers.

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Boletus L.
- adustus, W. *Polyporus adustus*, Fries.
- alneus, Pers. *P. cuticularis*, *Fr.*
- badius, Pers. *P. varius*, *Fr.*
- betulinus, Bull. *P. betulinus*, *Fr.*
- bovinus, L.
- brumalis, Pers. *P. brumalis*, *Fr.*
- carbonarius, Schw. M. S.
- cinnabarinus, Jacq. *P. cinnabarinus*, *Fr.*
- citrinus, Planer. *P. sulphureus*, *Fr.*
- communis. B—e.*
- conchifer, Schw.
- delicatulus, Schw. M. S.
- ferrugineus, Schaeff.
- igniarius, L. B—e.
- isabellinus, Schw. *P. isabellinus*, *Fr.*
- leptocephalus, Jacq. *P. leptocephalus*, *Fr.*
- lucidus, Curtis. *P. lucidus*, *Fr.*
- lutans, B—e.*
- mucidus, Pers. *P. mucidus*, *Fr.*
- nigro-marginatus, Schw.
- nitidus, Pers. *P. nitidus*, *Fr.*
- perennis, L. *P. perennis*, *Fr.*
- polycephalus, Pers. *P. umbellatus*, *Fr.*
- ramosus, Bull. *P. imbricatus*, *Fr.*
- reticulatus, Pers. *P. reticulatus*, *Fr.*
- salicinus, Pers. *P. salicinus*, *Fr.*
- squamosus, Hudson. *P. squamosus*, *Fr.*
- tulipiferae, Schw.
- varius, Pers. *P. varius*, *Fr.*
- velutinus, Pers. *P. velutinus*, *Fr.*
- versicolor, L. *P. versicolor*, *Fr.*

Bovista Dillenius.
- nigrescens? Pers. *Puff ball.*

Cantharellus Adanson.
- pusillus, Fries.
- undulatus? Fries.

Clavaria Vaillant.
- aurantiaca, Pers.
- coralloides, L.
- helveloides? Withering.
- pistillaris, L.
- rufa? Muhl.
- tenuis, Sowerby.

Daedalea Pers.
- albida, Schw. *Sistotrema violaceum*, *Pers.*
- cinerea, Fries.
- confragosa, Bolton.
- latissima, Fries.
- quercina.
- sepiaria, Wulfen.

Fistulina Bull.
- hepatica, Fries. *Boletus hepaticus*, *Pers.* Plainfield, Dr. Porter.

Fuligo Pers.
- rufa? Pers.



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Geastrum Pers.
hygrometricum, Pers.
rufescens, Schaeff.
Geoglossum Pers.
hirsutum, Pers.
Glonium Muhl.
stellatum, Muhl.
Gyropodium Schw. M. S. *Mitremyces lutescens*, Schw. *in Synopsi* Fungorum Carolinae.
coccineum, Schw.
Helotium Pers.
aciculare? Pers. *Peziza Helot. acic. Fries.*
Helvella L.
albida, Bull.
esculenta, Pers.
mitra? L.
Himantia Pers.
candida, Pers.
domestica, Pers.
Hydnum L.
coralloides, Scop. Conway and Ashfield.
coriaceum, Torrey. M. S.
cyathiforme, Bull.
gelatinosum, Scop.
imbricatum, L.
occarium, Batsch.
repandum, L.
tomentosum? L.
Hysterium Tode.
publicare, Pers.
rufescens, Schw.
Leotia Hill.
chlorocephala, Schw.
Licea Schrader.
variabilis, Schrad.
Lycogola Pers.
miniata, Pers.
Lycoperdon L. *Puff Ball. Smoke Ball.*
bovista, Pers. non Bull. B—e.
excipuliforme, Scop.
molle? Pers.
pratense, Pers,
pyriforme, W. B—e.
Merisma Pers.
cristatum, Pers. *Thelephora. Meris. crist. Fries.*
Merulius Haller.
agaricoides, Schw. M. S.
cantharellus, Pers. *Cantharellus cibarius Fries.*
cornucopioides, With. *Cantharellus Corn. Fries.*
elegans, Pers.
tremellosus, Schrad.
Morchella Dill.
esculenta, Pers.
patula? Fries.

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Mucor L.
herbariorum, Wigg.
mucedo, Pers.
Næmaspora Spreng.
crocea, Pers.
Nidularia Bull.
campanulata, Sibth. *Cyathus olla Pers.*
striata, Bull. *Cyathus striatus. Hoffm.*
Peziza L.
acetabulum, *L.*
auriformis, Schw.
brunnea, Fries.
citrina, Batsch.
clypeata? Schw.
hemispherica, Wigg.
inquinans, Pers.
lenticularis, Bull.
mitrula, Schw.
nigrella, Pers.
scutellata, L.
umbrina, Pers.
Phallus Mx.
impudicus, L. B—e.
Physarum Pers.
cinereum? Pers.
Polyporus Micheli.
abietinus, Fries. *Sistotrema violaceum Pers.*
croceus, Fries.
Racodium Pers.
xylostroma, Pers. *Oak Leather. Punk. Xylostroma giganteum Tode.*
Rhizomorpha Pers.
subcorticalis, Micheli.
Scleroderma Pers.
cervinum, Pers.
Sclerotium Tode.
radiciforme, Schw. M. S. A remarkable subterranean species. Conway.
Sistotrema Pers,
cinereum, Pers.
Spermoedia Fries.
clavus, Fries. *Sclerotium Clavus De Cand. Ergot. B—e.*
Sphæria Hall.
bulbosa, Pers.
concentrica, Tode.
curvirostris, Schw. M. S. *non curvirostra Sowerby.*
decolorans, Pers.
fragiformis? Pers.
gyrosa, Schw.
lata, Pers.
militaris, L.
nivea, Hoffm.
polymorpha, Pers.
rubiginosa, Pers.
scoparia, Schw.

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Stemonitis Gleditsch.
fasciculata, Pers.
Thelephora Ehrhart.
aurantia, Ehrh.
caryophyllaea Schaeff.
crispa, Pers.
fasciata, Schw.
ferruginea, Pers. No. 9.
flabellaris, Fries.
frustulata, Pers.
gigantea, Fries.
hirsuta, W.
hydnoidea, Pers.
incarnata, Pers.
laevis, Pers.
multipartita, Schw. M. S.
palmata, Fries.
polygonia, Pers.
purpurea, Pers.
quercina, Pers.
rubiginosa. Schrad.
rugosa, Pers.
spadicea ? Pers.
terrestris, Ehrh.
verrucosa, Schw. M. S.
Tremella Dill.
mesenterica, Retz.
Trichia Haller.
varia, Pers.
Tubercularia Tode.
castanea, Pers.
pezizoidea, Schw. M. S.
rosea, Pers.
vulgaris, Tode.
Tubulina Pers.
fallax ? Pers.
fragiformis, Pers.
Uredo Pers.
caricis, Pers. *On Carex varia.*
flava, B—e°
linearis, Lamb. *On the leaves of Oats, rye, wheat, &c.*
zeae, Schw. *Smut on Indian Corn.*
Xyloma Pers.
acerinum Pers.
andromedæ, Pers.

ALGAE.

So far as I know, scarcely any attention has been given to this order of plants in Massachusetts.

Conferva L. *Frog's Spittle.*
fontinalis, L. et plures aliae.
Fucus L.
nodosus, L. } On the coast with
vesiculosus, L. } other species.
Lemania Agardh.
fluviatilis, Agardh. Turners Falls.

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Solenia Agardh. } On the Coast.
compressa, Agardh. }

Spongia L.
fluviatilis, L. Leverett and Chesterfield. Enumerated among the radiated animals. But most probably it is a plant.

Sphaerococcus Agardh. } On the coast.
confervoides, Agardh. }

Ulva L.
latissima, L. On the coast with several other species.

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POSTCRIPT.

Professor John Torrey of New York having obligingly examined the preceding Catalogue of Plants has added several species and made several corrections. Most of these have been inserted in the proper places but the following were not received in season.

UMBELLIFERAE.

Crantzia Nutt.
lineata, Nutt. Near Boston: found by Mr. Nuttall. B. D. Greene Esq.

RANUNCULACEAE.

Thalictrum.
cornuti, L. *pubescens Ph. revolutum, De Cand.*

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*Summary of the Genera and Species of Plants in the preceding Catalogue.*

## FLOWERING PLANTS.

| | *Orders.* | *No. Gen.* | *No. Spe.* |
|---|---|---|---|
| 1 | Acerineae, | 1 | 5 |
| 2 | Alismaceae, | 2 | 6 |
| 3 | Amaranthaceae, | 1 | 4 |
| 4 | Apocyneae, | 1 | 3 |
| 5 | Amygdaleae, | 1 | 9 |
| 6 | Anacardiaceae, | 1 | 6 |
| 7 | Araliaceae, | 2 | 5 |
| 8 | Aristolochiae, | 1 | 1 |
| 9 | Aroideae, | 6 | 7 |
| 10 | Artocarpeae, | 1 | 2 |
| 11 | Asclepiadeae, | 1 | 10 |
| 12 | Asphodeleae, | 3 | 4 |
| 13 | Balsamineae, | 1 | 2 |
| 14 | Berberideae, | 2 | 2 |
| 15 | Betulinae, | 4 | 10 |
| 16 | Borragineae, | 6 | 11 |
| 17 | Cacteae, | 1 | 1 |
| 18 | Callitrichineae, | 1 | 2 |
| 19 | Campanulaceae, | 1 | 3 |
| 20 | Caprifoliaceae, | 8 | 24 |
| 21 | Caryophylleae, | 11 | 25 |
| 22 | Celastrineae, | 1 | 1 |
| 23 | Ceratophylleae, | 1 | 1 |
| 24 | Chenopodeae, | 6 | 13 |
| 25 | Cinchonaceae, | 2 | 2 |
| 26 | Circaeaceae, | 1 | 2 |
| 27 | Cistineae, | 3 | 8 |
| 28 | Compositae, | 37 | 146 |
| 29 | Coniferae, | 4 | 13 |
| 30 | Convolvulaceae, | 2 | 4 |
| 31 | Crassulaceae, | 1 | 1 |
| 32 | Cruciferae, | 14 | 23 |
| 33 | Cucurbitaceae, | 2 | 2 |
| 34 | Cupuliferae, | 4 | 15 |
| 35 | Cyperaceae, | 8 | 126 |
| 36 | Dioscoreae, | 1 | 1 |
| 37 | Dipsaceae, | 1 | 1 |
| 38 | Droseraceae, | 1 | 3 |
| 39 | Ericeae, | 10 | 18 |
| 40 | Euphorbiaceae, | 2 | 5 |
| 41 | Fluviales, | 4 | 12 |
| 42 | Fumariaceae, | 2 | 5 |
| 43 | Gentianeae, | 5 | 10 |
| 44 | Geraniaceae, | 1 | 3 |
| 45 | Gramineae, | 46 | 126 |
| 46 | Grossulaceae, | 1 | 8 |
| 47 | Halorageae, | 2 | 7 |
| 48 | Hamamelideae, | 1 | 1 |
| 49 | Hydrocharideae, | 2 | 2 |
| 50 | Hydropeltideae, | 1 | 1 |
| 51 | Hydrophylleae, | 1 | 2 |
| 52 | Hypericineae, | 1 | 9 |
| 53 | Hypoxideae, | 1 | 1 |
| 54 | Ilicineae, | 2 | 5 |
| 55 | Illecebreae, | 1 | 1 |
| 56 | Irideae, | 2 | 3 |
| 57 | Juglandeae, | 2 | 6 |
| 58 | Juncagineae, | 2 | 2 |
| 59 | Junceae, | 2 | 12 |
| 60 | Labiatae, | 21 | 35 |
| 61 | Laurineae, | 1 | 2 |
| 62 | Leguminoseae, | 17 | 44 |
| 63 | Lentibulariae, | 1 | 6 |
| 64 | Liliaceae, | 2 | 4 |
| 65 | Loaseae, | 1 | 1 |
| 66 | Lobeliaceae, | 1 | 7 |
| 67 | Lineae, | 1 | 1 |
| 68 | Magnoliaceae, | 2 | 2 |
| 69 | Malvaceae, | 4 | 4 |
| 79 | Melastomaceae, | 1 | 1 |
| 71 | Melanthaceae, | 2 | 2 |
| 72 | Menispermaceae, | 1 | 1 |
| 73 | Myriceae, | 2 | 3 |
| 74 | Nymphaeaceae, | 2 | 3 |
| 75 | Oleaceae, | 2 | 4 |
| 76 | Onagrariae, | 3 | 9 |
| 77 | Orchideae, | 14 | 32 |
| 78 | Orobancheae, | 2 | 3 |
| 79 | Oxalideae, | 1 | 3 |
| 80 | Papaveraceae, | 2 | 2 |
| 81 | Phytolacceae, | 1 | 1 |
| 82 | Pistiaceae, | 1 | 3 |
| 83 | Plantagineae, | 1 | 3 |
| 84 | Plataneae, | 1 | 1 |
| 85 | Plumbagineae, | 1 | 1 |
| 86 | Podostomeae, | 1 | 1 |
| 87 | Podophylleae, | 1 | 1 |
| 88 | Polygaleae, | 1 | 5 |
| 89 | Polygoneae, | 2 | 25 |
| 90 | Pomaceae, | 2 | 8 |
| 91 | Pontederiae, | 2 | 3 |
| 92 | Portulaceae, | 2 | 2 |
| 93 | Primulaceae, | 6 | 10 |
| 94 | Pyrolaceae, | 2 | 10 |
| 95 | Ranunculaceae, | 10 | 27 |
| 96 | Restiaceae, | 1 | 2 |
| 97 | Rhamneae, | 2 | 3 |
| 98 | Rhinanthaceae, | 4 | 5 |

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| | Orders. | No. Gen. | No. Spe. | | Orders. | No. Gen. | No. Spe. |
|---|---|---|---|---|---|---|---|
| 99 | Rosaceae, | 8 | 36 | 112 | Thymeleae, | 1 | 1 |
| 100 | Salicariae, | 3 | 4 | 113 | Tiliaceae, | 1 | 2 |
| 101 | Salicineae, | 2 | 21 | 114 | Typhaceae, | 2 | 5 |
| 102 | Sanguisorbeae, | 1 | 1 | 115 | Vaccineae, | 2 | 12 |
| 103 | Santalaceae, | 2 | 3 | 116 | Verbenaceae, | 2 | 4 |
| 104 | Sarracenieae, | 1 | 1 | 117 | Violaceae, | 1 | 17 |
| 105 | Saxifrageae, | 5 | 7 | 118 | Vites, | 2 | 4 |
| 106 | Scleranthеae, | 1 | 1 | 119 | Ulmaceae, | 2 | 2 |
| 107 | Scrophularineae, | 11 | 28 | 120 | Umbelliferae, | 15 | 20 |
| 108 | Smilaceae, | 6 | 20 | 121 | Urticeae, | 4 | 8 |
| 109 | Solaneae, | 6 | 9 | 122 | Xanthoxyleae, | 1 | 1 |
| 110 | Staphylaceae, | 1 | 1 | 123 | Xyrideae, | 1 | 1 |
| 111 | Stellatae, | 1 | 11 | | | | |
| | | | | | Whole No. | 442 | 1223 |

## FLOWERLESS PLANTS.

| Orders. | No. of Genera. | No. of Species. |
|---|---|---|
| 1 Algae, | 7 | 8 |
| 2 Characeae, | 1 | 3 |
| 3 Equisetaceae, | 1 | 6 |
| 4 Filices, | 15 | 43 |
| 5 Fungi, | 49 | 175 |
| 6 Hepaticae, | 5 | 19 |
| 7 Lichenes, | 28 | 109 |
| 8 Lycopodiaceae, | 1 | 10 |
| 9 Musci, | 31 | 107 |
| Whole No. | 138 | 480 |

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## GENERAL SUMMARY.

### *Of the Catalogues of Animals and Plants.*

| | *No. of Genera.* | | *No. of Species.* |
|---|---|---|---|
| I. Mammalia. | | 27 | 45 |
| II. Birds, | | 57 | 160 |
| III. Reptiles, | | 7 | 33 |
| IV. Fishes, | | 56 | 102 |
| V. Shells, (Marine.*) | | 52 | 91 |
| Do. (Land & Fresh W.†) | | 12 | 44 |
| VI. Crustacea, | | 21 | 26 |
| VII. Spiders, | | 20 | 125 |
| VIII. Insects, | | 423 | 2350 |
| IX. Radiata, | | 12 | Undetermined. |
| Total of Animals. | | 687 | 2976 |
| X. Plants, (Flowering.) | 442 | 1223 | |
| ——— (Flowerless.) | 138 | 480 | |
| Total of Plants. | 580 | 1703 | |

* Only Mr. Green's Catalogue is here reckoned; since that of Col. Totten embraces the whole coast of New England.

† In order to make out these numbers, we must add to those contained in Mr. Earle's Catalogue on page 557, the following genera and species ascertained by that gentleman since his list was printed, and received only in time to insert in this place.

GENUS VALVATA.

Valvata arinifera? Lea.

GENUS HELIX.

Helix labyrinthica, Say.
and two other species.

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# APPENDIX.

## A CATALOGUE

### OF SPECIMENS OF ROCKS AND MINERALS

### ILLUSTRATING THE REPORT OF A GEOLOGICAL SURVEY OF MASSACHUSETTS.

*Made by Order of the Government of the State.*

This collection, which I have made by direction of the State, and which I now present to its constituted authorities, can be regarded as by no means perfect. Several of the rarer and less important minerals in the State will not be found in it: nor can I flatter myself that I have obtained every variety of rock that exists in our limits. Yet have I done all in my power, during the three years that have been devoted to the geological survey, to procure a fair and full representation of our rocks and minerals. Not improbably, however, the proprietors of some of the quarries of stone in the Commonwealth, will conceive that their own are not fairly represented: for in many instances I could only procure such samples of the rock as presented themselves to my view at the quarries. But it will be easy for any who are disposed to do it, to substitute for the specimens in this collection others of a better character. And I would respectfully invite all, who feel an interest in having this collection exhibit a fair and full collection of the mineral resources of the State, to supply its deficiencies as they have opportunity. In general I have reduced the specimens to rather a small size: always intending, however, that they should fairly exhibit the characters of the rock or mineral from which they were broken: The great number of specimens which I was obliged to collect, (one suit for the government and one for each of the colleges in the State,) compelled me to consult utility almost entirely; and hence the collection contains little display of large and splendid specimens.

The specimens in this Catalogue are arranged in the same order as the rocks are described in the proceding Report. The specimens of the rocks are first given, and then those of the simple minerals which they contain.

About 130 of the specimens have been smoothed or polished; and this is mentioned under each number, where such is the case. Those specimens that have been only smoothed, have been varnished; and this process will need to be renewed occasionally. I found that in this way the true character of the rock could be brought to light quite as distinctly as by polishing: and thus the expense was considerably reduced.



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## STRATIFIED ROCKS.

### *Alluvium.*

| *No.* | | *From* |
|---|---|---|
| 1 | Alluvial sand, | Lock's Pond, Shutesbury. |
| 2 | Alluvial loam, (polishing powder,) | do |
| 3 and 4 | Peat, | Pittsfield. |
| 5 | do | Leverett. |
| 6 | do | Hadley. |
| 7 and 8 | do | Weston. |
| 9 | do | Northborough. |
| 10 | do | Shrewsbury. |
| 11 | do | Wilbraham. |
| 12 | Marl, | Pittsfield. |
| 13 | Planorbis parvus and bicarinatus in marl, | Pittsfield. |
| 14 | do trivolvis | do do |
| 15 | Lymnaea heterostropha and catascopium, | do do |
| 16 | Cyclas (*nondescript, J. M. Earl,*) in marl, | do |
| 17 | Bog Ore, | Brookfield. |
| 18 | do | New Braintree. |
| 19 | do petrified carex, | do |
| 20 | Black Wad, (earthy oxide of manganese,) | Conway. |
| 21 | do | Leverett. |
| 22 | do | Whately. |

### *Diluvium.*

| | | |
|---|---|---|
| 23 | Diluvium, | Leominster. |
| 24 | do ferruginous, | do |
| 25, 26, 27, and 28 | do consolidated, | Pownal, Vt. |
| 29 | Pyrula Carica, (47 feet below the surface,) | Nantucket. |
| 30 | do do worn, | Nantucket. |
| 31 | Natica — Heros, | do |
| 32 | Crepidula Fornicata, | do |
| 33 | Venus Castanea, | do |
| 34 | Mactra, | do |

### *Tertiary Formations. Newest Tertiary.*

| | | |
|---|---|---|
| 35 | Clay, | Amherst. |
| 36 | Sand, | do |
| 37 and 38 | Clay, | Leominster. |
| 39 | do loamy, | do |
| 40 | Sand, | do |
| 41 | Argillo-Calcareous Coneretions in Clay, | South Hadley. |
| 42, 43, and 44 | do | Amherst. |
| 45 | do | Hadley. |
| 46 | do | South Hadley. |
| 47 and 48 | Organic Remains in Clay and Loam, | Deerfield. |
| 49 and 50 | do do | South Hadley Canal. |
| 51 | do do | Deerfield. |
| 52 | do do | Charlestown. |
| 53 | Brown Hematite, Stalactical, | Richmond. |
| 54 | do do | West Stockbridge. |
| 55 | do pavonine, | do |
| 56 | do compact, | Richmond. |
| 57 | do mamillary, | Lenox. |
| 58 | do with yellow ocre, | West Stockbridge. |
| 59 | do with red oxide, | do |
| 60 | do with radiated manganese, | do |
| 61 | Gibbsite, | Richmond. |

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## *Plastic Clay Formation.*

62—68 Clay of various colors, Gay Head, Martha's Vineyard.
69 and 70 Sand agglutinated, yellow, do
71 do white, do
72 do green, do
73 do with clay, do
74, 75, and 76 Lignite, do
77 Quartzose conglomerate—cemented by iron, Gay Head.
78 and 79 do cement, argillo bituminous do
80 Specimen of oolitic aspect, do
81 Indurated Clay, do
82, 83, and 84 Impressions of Leaves on argillaceous iron ore, Gay Head.
85 Impression of a seed vessel; Gay Head.
86 Vegetable Remains, do
87 Cast of a Venus? do
88 Cast of a Selina, do
89 Cast of a Turbo? do
91, 92, 93, and 94 Alcyonia? do
95 Unknown animal relic in ferruginous sand, Nantucket.
96 Fossil Zoophyta inconglomerate, Gay Head, Martha's Vineyard.
97, 98, and 99 Fossil Crabs in green sand, do
100, 101, and 102 Sharks' teeth in green sand and conglomerate, Gay Head.
103 Crocodiles' tooth changed into flint, Gay Head.
104—108 Vertebrae (104 and 107 mineralized,) do
109 Fragment of a rib, do
110 and 111 Fragments of bone, do
112 do with lignite in quartzose conglomerate, do.
113, 114, and 115 do in do Gay Head.
116 do perforated do
117 and 118 Radiated and Fibrous Pyrites, do
119 Hydrate of Iron, pisiform, do
120 do mamillary, do
121 do nodular perforated by lignite, do
122 and 123 do do do
124, 125, and 126 do columnar, do
127—130 do compact and slaty, do
131 Selenite in clay with lignite, do

## *New Red Sandstone.*

132 Conglomerate, coarse, Greenfield.
133 and 134 do variegated, Deerfield.
135 do of comminuted granite, Bernardston.
136 do do Westfield.
137 do from the ruins of argillo-micaceous slate, Greenfield.
138 and 139 do do Bernardston.
140 do from mica slate, talcose slate, granite, &c. Mount Toby.
141 do do do Mouth of Miller's river.
142 do do do epidotic do
143 Nodule from same conglomerate, do do
144 Conglomerate from the ruins of Granite, South Hadley Canal.
145 do do Mt. Holyoke.
146 do do Belchertown.
147 do do Amherst.
148 do with a ferruginous concretion, South Hadley Canal.
149 do chiefly a nodule of granite, Amherst.
150 do gray, Turner's Falls.
151, 152, 153 Trap Conglomerate, Mount Tom, Northampton.
285* do do

* Added to the Collection since the tickets were pasted upon the other specimens.

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154 Coarse red Sandstone, (Hoyt's Quarry,) Deerfield.
155 do Westfield.
156 do Whately.
157 do water worn. Greenfield.
158 do do
159, 160 Reddish Sandstone, West Springfield.
161 Gray do (Hoyt's Quarry,) Deerfield.
162 Reddish do Westfield.
163 do do Longmeadow.
164 do with pieces of fine red micaceous sandstone partially imbedded, Turner's Falls.
165 Fine red do (smoothed,) Longmeadow.
166 do do do
167 Coarse Gray do from the Adit, Southampton Lead Mines.
168 Light Gray do Mount Holyoke.
169 Darker do Turner's Falls.
170 Variegated do and sub-crystalline in contact with trap, Titan's Pier, Hadley.
171 Gray, fine do West Springfield.
172 do do Amherst.
173 Coarser do Turner's Falls.
174 Brecciated do near do
175 Micaceous, gray do South Hadley.
176 do do under the trap, Mt. Holyoke.
177 do do do Mt. Tom, Northampton.
178, 179 do do Turner's Falls.
180 do do under the trap, Mount Tom.
181 Amygdaloidal do near the trap, do
182 do do do Granby.
286* do Northampton.
183 Micaceous do passing into shale, South Hadley.
184 do do , Sunderland Cave.
185, 186 Nodules of concretionary carbonate of Lime from micaceous sandstone, do
187 Micaceous Sandstone with carbonate of Copper, Turner's Falls.
188 Variegated do Agawam river, West Springfield.
189 do do Turner's Falls.
190 do do South Hadley Falls.
191, 192 Red shale, slightly micaceous, divided by cross seams, near Turner's F.
193 Reddish fine micaceous sandstone, under the trap, Titan's Pier.
194, 195 do on shale, Turner's Falls.
196, 197, 198 do do South Hadley Canal.
199 Shale breaking into wedge-form masses, Turner's Falls.
200 do gray, hard, micaceous, do
201 do yellow decomposing, (a bowlder,) Amherst.
202, 203 do black, South Hadley Canal.
204 do do West Springfield.
205, 206, 207 Bituminous Marlite, do
208 do Sunderland.
209 do variegated, West Springfield.
210 do glazed, do
211, 212 Bituminous (fetid ?) Limestone, Paine's Quarry, do
213 Fetid Limestone, very hard and brittle, do do
214 do with a singular fracture resembling an organic relic, do do
215 do Meachams' Quarry. do
216 Argillo-ferruginous Limestone, Agawam River, do
217, 218, 219 Tripoli, Paine's Quarry, do
220, 221 do South Hadley Falls, on the W. Springfield shore.

* See note on preceding page.

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|---|---|---|
| 222—225 | Septaria or Ludus Helmontii, | West Springfield. |
| 226, 227 | Concreted Carbonate of Lime, | Mount Toby, Leverett. |
| 228 | do | Sunderland Cave. |
| 229 | do | Paine's Quarry, W. Springfield. |
| 230 | do stalactical, | Sunderland Cave. |
| 231 | Calcareous Spar in Veins in black shale, | W. Springfield. |
| 232, 233, 234 | Satin Spar in red and black shale, | do |
| 235 | Sulphate of Baryta, | below Turner's Falls, Greenfield. |
| 236 | Sulphate of Strontia on fetid carbonate of Lime, | Meachams' Quar. W. Springfield. |
| 237 | Bituminous Coal in bituminous marlite, | W. Springfield. |
| 238 | do. do with blende, | do |
| 239 | Blende and Galena in fetid limestone, | do |
| 240 | Carbonate of Iron in lenticular crystals, | Turner's Falls. |
| 241 | do ? | South Hadley Canal. |
| 242 | Iron Sand, | Turner's Falls. |
| 243 | Red Oxide of Copper in Sandstone, | Simsbury Mines, Granby, Ct. |
| 244 | Pyritous Copper in Sandstone, | Turner's Falls. |
| 245 | Green Carbonate of Copper, (poor specimen) | Greenfield. |
| 246 | Bituminous Coal in sandstone, | South Hadley, north part. |
| 247 | do do | South Hadley Canal. |
| 248 | Anasphaltic Coal do | Turner's Falls. |
| 249 | Incrustation of purple fluate of lime on fetid Limestone, | Paine's Quarry, W. Springfield, |
| 250—254 | Vegetable Remains on bituminous shale, (calamites ?) | Sunderland, north part. |
| 255 | do | W. Springfield. |
| 256 | do | Sunderland. |
| 257, 258 | Fucoides in new red sandstone, | Deerfield. |
| 259 | do do | Greenfield. |
| 260, 261 | do do | Deerfield. |
| 262, 263 | Encrinite (?) shale, | W. Springfield. |
| 264, 265 | Gorgonia on shale, | do |
| 266 | do without reticulations, | do |
| 267 | Zoophyta (?) converted into Flint in shale, | do |
| 268—277 | Unknown Organic Remains in fetid Limestone, | W. Springfield. |
| 278, 279 | Icthyolites (Palaeothrissum) in bituminous shale, | Sunderland. |
| 280 | do two fish in contact, | do |
| 281 | do only scattered fragments of the fish, | do |
| 282 | Concretion (?) or Organic Relic (?) in shale, | Turner's Falls. |
| 283 | Moulds of Organic Relics (?) | South Hadley Canal. |
| 284 | Organic Relic (?) in shale : or veins of Clay, | do |
| 285, 286 | (See the numbers following 153 and 182.) | |

## *Graywacke.*

| | | |
|---|---|---|
| 287 | Conglomerate the variety most common, | Dorchester. |
| 288 | do do | Swansey. |
| 289 | do do with a vein of quartz, | Brookline. |
| 290 | do do | Attleborough. |
| 291 | do do reddish, | Roxbury. |
| 307* | do red, | Attleborough. |
| 292 | do gray, | Natick. |
| 293 | do nodules chiefly mica slate, | Bradford. |
| 294 | do nodules fine mica slate or quartz rock, containing mag. ox. iron, | Middletown R. Island. |
| 292 | do quartzose brecciated, | Attleborough. |
| 296 | Breccia fragments of slate reunited, | Natick. |
| 297 | do do | Randolph. |
| 298 | do fine, do | Natick. |
| 299 | do fragments compact feldspar-cement indurated wacke, | Saugus. |

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| 300 | do angular fragments of compact feldspar reunited, | Nantasket Beach. |
| 301 | do somewhat rounded, do slaty, | Dorchester. |
| 302 | do do do | Canton. |
| 303 | quartz rock-dark purple quartz & mica or talc | Middletown R. Island. |
| 304 | do do chiefly, | do |
| 305, 306 | do do with mica or talc and argillaceous matter, | Fall River, Troy. |
| 307 | see No. following 291. | |
| 308 | graywacke slate passing into mica slate, associated with Nos. 305 & 306 | do |
| 309 | quartz Rock, red with red oxide of iron, | Attleborough. |
| 311 | do do | Wrentham. |
| 312 | do chocolate color, | Rehoboth. |
| 313 | do do | Walpole. |
| 314 | do do | Abington. |
| 315 | do do | Canton. |
| 316 | do do slaty, | Wrentham. |
| 317 | do do very slaty, | Randolph. |
| 318 | do do with veins of white quartz, | Wrentham. |
| 319 | do red, | Greenbush, N. York. |
| 320 | Talcose Aggregate (Steachist ?) conglomerated, | Canton. |
| 321 | do slaty, | Cambridge. |
| 322 | do do | Walpole. |
| 323 | do do | Newbury. |
| 324 | Classical graywacke, gray, | Rehoboth. |
| 325 | do reddish, | do |
| 326 | do red, | Attleborough. |
| 327 | do do (bowlder) | Hull. |
| 328 | do gray, | Newton. |
| 329 | do with veins of quartz, | Pawtucket. |
| 330 | do with do | Stephentown, N. Y. |
| 331 | do with do | Attleborough. |
| 332 | do | Rehoboth. |
| 333 | do with anthracite, | Troy, N. Y. |
| 334 | do gray, | Stephentown N. Y. |
| 335 | Graywacke Slate, gray, | Newton. |
| 336 | do do | Watertown. |
| 337 | do do | Pawtucket. |
| 338 | do light, do | Newbury. |
| 339 | do do glazed, | Newport, R. Island. |
| 340 | do do | Watertown. |
| 341 | do do | Natick. |
| 342 | do do epidotic, | Newton. |
| 343 | do do | Taunton. |
| 344, 345 | do deep red from oxide of iron, | Attleborough. |
| 346 | do gray, | do |
| 347 | do reddish, | Newbury. |
| 348 | do do with quartz veins, | Pawtucket. |
| 349 | do do divided by cross seams, | Wrentham. |
| 350 | do do do | Pawtucket. |
| 351 | do do variegated, | Newbury. |
| 352 | do do | Milton. |
| 353 | do red (argillaceous slate ?) | Newbury, Thents Island. |
| 354 | do reddish variegated, | Hull. |
| 355, 356 | do gray, | Nassau, N. Y. |
| 357 | Novaculite. | Charlestown. |
| 358 | Argillaceous Slate—coal mine, | Portsmouth. R. I. |
| 359 | do variegated, | Charlestown. |

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360 do rhomboidal, Rainsford's Islands.
361 do do South Boston.
362 do laminae curved, Rainsford Islands.
363 do light gray, Halifax.
364 Argillaceous Slate with veins of calcareous spar. Watertown.
365 do variegated. Quincy.
366 do Hull.
367 do (Novaculite?) Boston Light House.
368 do (do?) Hingham.
369 do (do?) Spring Street, Roxbury.
370 do (do?) Watertown.
371 Amphibolic Aggregate Middletown, R. Island.
372 Varioloid Wacke, Saugus.
373 do Brighton.
374 do Hingham.
375 do Nantasket Beach.
376 do Hingham.
377 do nodules quartz and epidote, Brighton.
378 do approaching to porphyry Needham.
379 Wacke from a vein in granite—lead mine, Easton.
380 Amygdaloid passing into siliceous slate, Newport, R. Island
381 Siliceous Slate, porphyritic, do
382 do do
383 do with vein of granite, do
384, 385. do Nahant.
386 Passing into Chert, do
387 Jasper, Newport, R. Island.
387 1-2 Heliotrope, do
388 Clouded Jasper (Compact Feldspar?) (polished) Saugus.
389, 390 Jasper, do
391 Prase with asbestus, Brighton.
392 Zoisite from the amphibolic aggregate, Middletown, R. Island.
393 Cubical Pyrites in anthracitous slate, Wrentham, coal mine.
394 Asbestus in slate, Somerset.
395 Impressions of ferns &c, on slate, Newport, R. Island.
396 Equiactum?. on anthracitous slate do
397 Unknown impressions on do do
398 Calamites, Wrentham, Coal Mine.
399 Neuropteris? &c, on slate, do
400 Fucoides? on hard schistose rock, Attleborough.
401 Anthracite from graywacke, Wrentham.
402 do do Portsmouth, R. Island.
403 See the No. following No. 803.

## *Argillaceous Slate.*

404 Macle in argillaceous slate, (bowlder.) Worcester.
405 Common argillaceous slate, Guilford, Vt.
406 do Lancaster.
407 do Shirley.
408 do Harvard.
409 do Pepperell.
410 do passing into mica slate, Bernardston.
411 and 412 do with quartz veins, Guilford, Vt.
413 do wavy surface, Glen, Leyden.
414 and 415 do contorted, Guilford.
416 Micaceo-argillaceous Slate *in echellon*, Glen, Leyden.
417 Argillaceous Slate much bent, Guilford, Vt.
418 do do do

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419 do exhibiting a double flexure, do
420 do red, Sand Lake, N. Y.
421 do gray beneath limestone, Chatham, N. Y.
422 do epidotic, Hancock.
423 Chloritic Slate, Guilford, Vt.
424 and 425 Passing into Novaculite, Guilford, Vt.
426 Chiastolite in argillaceous Slate, Lancaster.
427 A card of macles, do

*Limestone.*

428 and 429 White marble polished Adams.
430 and 431 do do West Stockbridge.
432 do do Lanesborough.
433 and 434 do do New Ashford.
435 White Saccharine Limestone (bowlder.) Peru.
436 Granular white Dolomite, Sheffield.
437 Gray Marble (polished.) Lanesborough.
438 do do W. Stockbridge.
439 and 440 Gray Marble clouded (polished.) New Ashford
441 do do do West Stockbridge.
442 Dove colored Marble clouded (polished.) Great Barrington.
443 Gray Limestone, Sheffield.
444 do Lee.
445 do nearly compact, Lanesborough.
446 do do West Stockbridge.
447 do light, Pittsfield.
448 Dark gray limestone nearly compact, Williamstown.
449 and 450 do do Stephentown, N. Y.
451 do Canaan, N. Y.
452 do compact with veins of calc. spar, Chatham, N. Y.
453 do with numerous veins of quartz, do
454 Yellowish coarse Limestone with a foreign mineral, Stockbridge.
455 Micaceous Limestone do
456 do with mica and quartz, Canaan, Ct.
457 do do Lanesborough.
458 do do South Lee.
459 do do Whately.
460 do do Colrain.
461 do do Conway.
462 do do Heath.
463 do do Southampton.
464 do do with veins of quartz and calc. spar, Conway.
465 do do with veins of granite, Colrain.
466 do with veins of argentine, West Hampton.
467 do decomposed at the surface, Guilford, Vt.
468 and 469 Gray Limestone in mica slate (bowlders.) Williamsburgh.
470 and 471 Encrinal Limestone, Bernardston.
472 do brecciated (polished.) do
473, 474 and 475 Disintegrating Encrini in do do
476 Coarse white limestone with graphite (bowlder.) Blanford.
477 and 478 do do
479 do Whitingham, Vt.
480 do micaceous, do
481 do with chlorite (a bowlder, Conway.) originally from do
482 and 483 Dolomitic (?) Limestone, Somerset, Vt.
484 Fine granular Dolomite, do
485 White crystalline fetid Limestone, Bolton.
486 Petalite, do

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487 and 488 do Boxborough.
489 do with serpentine, Littleton.
490 do do
491 and 492 Coarse granular whitish Limestone, Chelmsford.
493 do Acton.
494 Gray do do Walpole.
495 Compact light gray do Newport, R. Island.
496 Compact white translucent marble (polished.) Stoneham.
497 Granular clouded limestone, Smithfield R. Island.
498 White do Harris Rock, do
499 do do Dexter Rock, do
500 Flesh coloured do do
501 Flexible Marble Slab, New Ashford.
502 Laminated Calcareous Spar, Bernardston.
503 Crystalline, do do
504 Hydrate of Iron, do
505 Magnetic Oxide of Iron, do
506 Nephrite Stoneham.
507 Allochroite? do
508 Specks of Serpentine in limestone, Boxborough.
509 Crystalline Augite in calc. spar, do
510 Calcareous Spar, wine yellow in lime. do
511 Actynolite, in do do
512 do radiated in do do
513 Compact purple scapolite &c. do
514 Lilac do Bolton.
515 Crystallized do in gray quartz, do
516 Dark gray do (Nuttallite) do
517 Sahlite, do
518 do with compact scapolite Acton.
519 Diopside, Whitingham, Vt.
520 Actynolite, Chelmsford.
521 and 522 Bisilicate of Magnesia, (Boltonite.) Bolton.
523 and 524 White amianthus, Chelmsford.
525 Limestone and white talc, Smithfield, R. Island.
526 Crystalline augite scapolite and cinnamon stone, Carlisle.
527 Cinnamon Stone and pargasite, do
528 do do
529 Crystallized Scapolite, Littleton.
530 Actynolite, do
531 Phosphate of Lime in scapolite. Littleton.
532 Sphene with scapolite and petalite Bolton.
533 do do Littleton.
534 do with augite and scapolite, Carlisle.
535 White crystallized Augite in dolomite, Canaan. Ct.
536 Carbonate of Lime and Augite, Lee.
537 Tremolite in Dolomite, do
538 do do Canaan, Ct.
539 do Sheffield.

## *Scapolite Rock.*

540 Scapolite Rock somewhat crystalline, Canaan, Ct.
541 do compact (the common variety.) do
542 do with dolomite do
543 do with mica passing into mica slate, do
544 Quartz, scapolite and augite, do



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## *Quartz Rock.*

545 White hyaline Quartz from mica slate, Heath.
546 do do Plainfield.
547 Whitish Quartz nearly opaque do Saddle Mountain.
548 do do from a vein in hornblende slate, } Gill.
549 do containing argillaceous slate, Guilford, Vt.
550 Fine white granular Quartz, Cumberland, R. Island.
551 Reddish granular do Berkshire Connty.
552 do do Cheshire.
553 and 554 Gray, do Pittsfield.
555 Dark gray, do Windsor.
556, 557 and 558 Arenaceous disintegating Quartz, Cheshire.
559 Granular Quartz, striped, Conway.
560 Hyaline dark smoky Quartz, Amherst.
561 do do in argillaceous slate, Guilford, Vt.
562 do light smoky, do Sterling.
563 Reddish compact Quartz, Leverett.
564 do do Prescott.
565 Bluish compact quartz, Amherst.
566 Greenish do Cumberland, R. Island.
567 Porous Quartz (Buhrstone) Washington.
568 Arenaceous Quartz with actynolite associated with gneiss, Pelham.
569 Gray fine granular quartz, Cumberland R. Island.
570 do do Framingham.
571 Gray hyaline or coarsely granular quartz with feldspar. Pelham.
572 Light gray granular Quartz with small scales of mica, Lee.
573 do do stratified (Buhrstone locality) Pittsfield.
574 The same with more mica and contorted folia, Lee.
575 Gray hyaline quartz with mica; associated with gneiss, New Salem.
576 Brecciated particolored quartz with mica, Amherst.
577 Rhomboidal quartz with mica, Northfield.
578, 579 and 580 Compact gray quartz with mica, Bernardston.
581 Quartz and talc, Webster.
582 and 583 do Hawley.
584 Quartz with Actynolite connected with gneiss, Pelham.
585 do with crystals of hornblende, Hawley.
586 Argillaceous slate with quartz veins, S. Hadley Canal.
587 Quartz granular and mica connected with gneiss, Windsor.
588 do Webster.
589 do associated with gneiss, Mendon.
590 do Webster.
591 do under the Buhrstone, Pittsfield.
592 do Dalton.
593 Quartz mica and feldspar passing into gneiss, Bernardston.
594 Quartz and mica, Framingham.
595 do Cumberland, R. Island.
596 do passing into mica slate, Zoar at the Bridge.
597 Arenaceous quartz and mica, Plainfield.
598 Quartz and mica vesicular, Chesterfield.
599 do Conway.
600 Quartz mica and feldspar passing into gneiss, Mendon.
601 Quartz with argillaceous slate near the lime bed, Bernardston.
602 Brecciated Quartz, Leverett.
603 do Amherst.
604, 605 and 606 do cement hematitic iron, Dalton,
607 do cement iron? Amherst.
608 do quartz and micaceous slate, Williamsburgh.

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609 Quartzose Conglomerate (bowlder.) cement mica slate. Windsor.
610 do do do Adams.
611 Quartz with disseminated iron pyrites, Windsor.
612 do ferruginous, bowlder, Worthington.
613 do passing into yellow jasper, Chesterfield.

## *Mica Slate.*

614 Mica Slate, common, quartz laminar, mica scaly shining, Colrain.
615 do do do do Peru.
616 do do do do Blanford.
617 do do do do Smithfield. R. I.
618 do do do do Shelburne.
619 do do do do Florida.
620 do do do do Framingham.
621 do do do do Cheshire.
622, 623 do of a fibrous aspect, Northfield.
624 do do do do West Stockbridge.
625 do very even and shining do Bolton, Ct.
626 do layers tortuous, quartz tuberculous, Stockbridge.
627 do do feldspar and quartz tuber. passing to gneiss, Pittsfield.
628 do with feldspar passing to gneiss, mica shining, Colrain.
629 do do do do Westfield.
630 do do do do Leverett.
631 do do do do Montague.
632 do do do do Granville.
633 do do do do do
634 do do do do Florida.
635 do do do do Ware.
636 do do do do Wachusett, Princeton.
637 Talco-micaceous Slate, Enfield.
638 do Saddle Monutain.
639 do Florida.
640 do West Stockbridge.
641 do Saddle Mountain.
642 Mica Slate amphibolic and garnetiferous, Norwich.
643 do do do with phosphate of lime, Conway.
644 do do do Colrain.
645 do garnetiferous, Chesterfield.
646 do staurotidiferous do
647 do spangled, Goshen.
648 do do Plainfield.
649 do do rhomboidal, do
650 do do Norwich.
651 Argillo-micaceous Slate, Goshen.
652 do with seams transverse to the layers, Greenfield.
653 do rhomboidal, do
654 do Charlemont.
655 do Hawley.
656 do Heath.
657 do Lanesborough.
658 do glazed, with quartz, Glen, Leyden.
659 do do contorted, Guilford Vt.
660 do Hancock.
661 do with undulating surface, Bradford.
662 do contorted with layers of quartz, Guilford Vt.
663 do do Whately.
664 do do Guilford Vt.
665 do Bernardston.

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| 666 | Argillo-micaceous slate, contorted with layers of quartz, | Williamstown. |
| 667 | do | Saddle Mountain. |
| 668 | Arenaceous Mica Slate, | Norwich. |
| 669 | do passing into gneiss, | Bolton. |
| 670 | do mostly quartz, argentine locality, | West Hampton. |
| 671 | do | Norwich. |
| 672 | do vescicular (see No, 598) | Chesterfield. |
| 673 | do | Chester. |
| 674 | do | Norwich. |
| 675 | Arenaceous Mica Slate, Woonsocket Falls, | Cumberland, *R.* I. |
| 676 | do | Chester. |
| 677 | do with feldspar, | Enfield. |
| 678 | do | Chester. |
| 679, 680 | do whetstone slate, | Enfield. |
| 681 | do do | Norwich. |
| 682 | do | Sherburne. |
| 683 | do used for monuments. | Halifax, Vt. |
| 684 | do | Greenfield. |
| 685 | do with seams oblique to the surface of the layers, | Deerfield. |
| 686 | do | do |
| 687 | Argillo arenaceous Slate, reddish, at the junction with the new red sandstone, | Glen, Leyden. |
| 688, 689, 690, | do bent, | do |
| 691 | Arenaceous Mica slate, | Worcester. |
| 692, 693 | do anthracite locality, | do |
| 694 | do with a talcose aspect, | do |
| 695, 696, 697 | do | do |
| 698 | do with veins of granite, | Lunenburg. |
| 699, 700 | do mostly quartz, | Groton. |
| 701 | Talco arenaceous slate—bowlder, | Worcester. |
| 702 | Arenaceous Mica Slate, | Dracut. |
| 703 | do passing into clay slate, | Woreester. |
| 704 | do talcose, | Lowell. |
| 705 | do | Methuen. |
| 706 | do mostly quartz, | Worcester. |
| 707 | do | Andover Bridge. |
| 708 | do with veins of quartz, | Worcester. |
| 709 | do | S. Hampton, N. Hampton. |
| 710 | do | East Sudbury. |
| 711 | do | Webster. |
| 712 | do | Oxford. |
| 713 | Plumbaginous Mica Slate, contorted, | Worcester. |
| 714 | do | Ward, |
| 715 | do | Amesbury. |
| 716 | Brecciated Mica Slate, | do |
| 717 | Anthracitous Mica slate, | Dudley. |
| 718 719 | do anthracite locality, | Worcester. |
| 720 | Plumbaginous Mica Slate, | Hawley. |
| 721 | do | South Hampton. |
| 722 | Mica Slate, mica and quartz, laminar, | Northfield, west of Ct. River. |
| 723 | do do | Conway, |
| 724 | do conglomerated passing into sienite, | Whately. |
| 725 | Indurated mica slate, | do |
| 726, 727 | Augite Rock associated with mica slate, | Williamsburg. |
| 728 | Phosphate of Lime in mica slate, | Norwich. |
| 729 | Fluate of Lime, | Westmoreland, N. H. |
| 730 | White milky quartz, | Warwick. |

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731 Fetid hyaline quartz, Goshen.
732 Fetid quartz, crystallized, Williamsburgh.
733, 734 Rose red quartz, Blanford.
735 do Chelmsford.
736 Yellow hyaline quartz, Colerain.
736 Blood red do do
737, 738, 739, 740, 741, 742, 743, 744, Quartzose brecciagate, Conway.
745 do Amherst.
746 Tabular or foliated quartz, Conway.
747 do with a pseudomorphous aspect, do
748 Yellow quartz, Amherst.
749 Fibrolite in Mica slate, Lancaster.
750 Sappare with phosphate of lime, Chesterfield.
751, 752 do do
753 do Chester.
754 Staurotide in mica slate, Chesterfield.
755, 756 Andalusite, crystallized, Westford.
757 Fibrous Talc? associated with andalusite, do
758 Schorl in quartz, Blanford.
759, 760 Garnets in mica slate, Chesterfield.
761 Crystallized Epidote in amphibólic mica slate, Goshen.
762 do do Williamsburgh.
763 Zoisite? with specular oxide of iron and carbonate of lime, Goshen.
764 do quartz Chesterfield.
765 Idocrase epidote calcareous spar &c. Worcester.
766 Anthrophyllite in mica slate, Chesterfield.
767, 768 do Blanford.
769 Cummingtonite quartz and garnets, Warwick.
770 do Cummington.
771 Black mica. Westfield.
772 do Norwich.
773 Fibrous Talc? Blanford.
774 Anthracite from mica slate (coal mine) Worcester.
775 Plumbago; or anthracite passing into plumbago, do
* 1549 Amianthus, at the anthracite mine, do
* 1550 Bucholrite? do
776 Red oxide of iron from the vein of manganese, Conway.
777 Oxide of manganese, do
778 do with siliceous sinter, Amherst.
* 1027 Ferro-silicate of Manganese, Hinsdale.
779 Micaceous Oxide of iron, Montague.
780 Arsenical Iron, Worcester.
781 Crystallized Arsenical Sulphuret of iron, do
782 Massive, do do
783 Carbonate of iron, do
784 do Sterling.

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* I found these two minerals at the anthracite locality in Worcester, only a few days before the printing of this catalogue, and after the Scientific Part of my Report was through the press. The amianthus is very delicate and occurs in abundance. If the other fibous mineral be not Bucholrite, I am unacquainted with it. Before the common blowpipe it is infusible. Bucholrite is now I believe, generally regarded as a variety of fibrolite. This specimen, however differs considerably in appearance from the fibrolite of Lancaster; but very much resembles the Bucholrite reccently found in Delaware.

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| | | |
|---|---|---|
| 785 | do with pyritous copper, | Sterling |
| 786 | Galena and blende, | do |
| 787 | Reddish sulphuret of Zinc, | do |
| 788 | Red Oxide of Titanium, | Conway. |

*Talcose Slate.*

| | | |
|---|---|---|
| 789 | Scaly greenish Talc, serpentine locality, | Westfield. |
| 790 | do near the steatite, | Middlefield. |
| 791 | Foilated light green do | Rowe. |
| 792 | do | Middlefield. |
| 793 | do | Windsor. |
| 794 | Green steatite or nearly compact talc, | Zoar. |
| 795 | Steatite with rhomb spar, | do |
| 796 | do | Windsor, N.W. part. |
| 797 | do with bitter spar, | do N. E. part. |
| 798 | do with brown spar, | Smithfield, R. I. |
| 799 | do | Middlefield. |
| 800 | do bored for aqueduct pipe, | Grafton, Vt. |
| 801 | do very fine, | Blanford. |
| 802 | do | Somers, Ct. |
| 803 | do | Groton. |
| *403 and 1548 | do from Gneiss, Worcester. | |
| 804 | do asbestus, | New Salem. |
| 805 | do passing into serpentine, | do |
| 806 | Between steatite and chlorite form a bowlder originally from Whitingham Vt. | Conway. |
| 807 | Dark green scaly chlorite with feldspar | Cummington. |
| 808 | Finer grained, do | Goshen. |
| 809 | Slaty Chlorite, | Smithfield R. I. |
| 810 | do with the steatite. | Middlefield. |
| 811 | Chlorite Slate, | Peru. |
| 812 | do with red oxide of titanium and feldspar, | Windsor. |
| 813 | Talco-chloritic Slate, | Little Compton, R. I. |
| 814 | do | Smithfield R. I. |
| 815 | do epidotic, | Cumberland R. I. |
| 816 | do do and pssing into hornblende slate, | Smithfield R. I. |
| 817 | Talcose Slate—talc and quartz, | Little Compton R. I. |
| 818 | do do nearly white, | Stafford. |
| 819, 820 | do do do | Hawley. |
| 821 | do do greenish soapstone quarry, | Middlefield. |
| 822 | do do do | Plainfield. |
| 823 | do do whetstone quarry. | Smithfield. |
| 824 | do do | Florida. |
| 825 | do do | Lenox, |
| 826 | Talcose Slate, talc, quartz, and mica, | Hawley. |
| 827 | do do | Iron Mine, Somerset, Vt. |
| 828 | do do | east side of serpentine, Chester. |
| 829 | do do | Barre. |
| 830, 831 | do do | Rowe. |
| 832 | Talc and Limestone, | Whitingham, Vt. |

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*I was not apprised of the existence of steatite in Worcester till it was too late to notice it in the proper place. Although I have not visited the spot, I have reason to believe that it occurs in gneiss, in the southeast part of the town. The owners informed me that they had penetrated the bed as yet only about five feet. The specimens will show that it is the handsomest steatite in the State yet discovered: and should the bed prove to be a large one, its situation near the Blackstone Canal, will render it of high value.

Worcester ought also to be mentioned among the towns that abound in peat.

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833 Talc, quartz, and Carbonate of Iron, Hawley.
834 Quartz with Hydrate of Iron, do
835 Talc, Quartz, and Hornblende, do
836 do Charlemont.
837, 838, 839 do Hawley.
840 Talc, Quartz, and Feldspar, Smithfield, R. I.
841 do porphyritic, Hawley.
842 Talcose Slate, with octohedral oxide of Iron, Hawley.
843 do do Blanford.
844 Micaceous Oxide of Iron, Hawley.
845 Mag. Ox. Iron, Native Magnet, Somerset, Vt.
846 do with ferro-silicate of manganese, Cumberland, R. I.
847 do porphyritic with crystals of feldspar, do
848 Porous quartz with hydrate of iron, gangue of gold, Somerset, Vt.
849, 850 do in talcose slate, with do } Virginia.
Put in the collection for comparison. }
851 Gray Oxide of Manganese, Plainfield.
852 Bisilicate of Manganese, Cummington.
853 White bitter spar, Middlefield, Soapstone Quarry.
854 do with green foliated talc, do
855 Salmon colored do, do do
856 Miasite, Zoar.
857 do ? do
858 Picrosmene ? do
859 Asbestus, Pelham.
860 do Blanford.
861 do Shutesbury.
862 Tremolite, probably from Soapstone Quarry, Middlefield.
863 Fibrous Hornblende in Quartz, Plainfield.
864, 865 Fasciculite in talcose slate, do
866 Crystallized Actynolite, in talc, Blandford.
867 do Windsor.
868 do from Soapstone Quarry, Blanford.
869 do radiated, do do

## *Serpentine.*

870 Compact noble Serpentine, polished, Lime Quarry, Newbury.
871 do with massive garnet, polished, do
872 do with green amianthus, do
873 Common Serpentine, compact, Newbury.
874 do do Chester, west part.
875 do do polished, Middlefield.
876 do slaty, Chester, West part.
877 do with grains of chromate of iron, Windsor, N. E. part.
878 do do N. W. part.
879 do in place, Blanford.
880 do a bowlder, do
881 Black compact Serpentine, Newport, R. I.
882 Variegated do do
883 Dark green compact do, a bowlder, Leverett.
884 Dark gray compact do Lime Quarry, Chelmsford.
885 Dark green do with veins of amianthus and Deweylite ? Russell.
886, 887 Compact do with a talcose glazing, Zoar.
888, 889 Serpentine steatite and brown spar, do
890 Black do and talc, or talc passing into serpentine, New Salem.
891 do and do polished, Pelham.
892 Dark green do with do do Blanford.
893 Black do with do and actynolite, Westfield.
894 Light green compact do with schiller spar ? polished, Russell.
895 Black compact do with talc, do and calcareous spar, polished, Granville.

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896, 897, 898 Serpentine and carbonate of lime, (Ophicalce *grenue*, Al. Brongn.) polished, } Westfield.
899 Serpentine and carbonate of lime, Westfield.
900 Compact Feldspar, Lime Quarry, Newbury.
901 Compact Scapolite? resembling petalite, Westfield.
902 Mamillary Chalcedony, Blanford.
903 Yellow Jasper, Middlefield.
904 Chalcedony? do
905 Drusy Quartz, do
906 Satin Spar, Lime Quarry, Newbury.
907 Tremolite, do do
908 Mussite, Blanford.
909 Massive Garnet? Westfield.
910 Actynolite, do
911 do resembling asbestus, Westfield.
912 Chromate of Iron, massive, Blanford.
913 do in Serpentine, do

## *Hornblende Slate.*

914 Lamellar black Hornblende (hornblende rock,) Granville.
915 do Belchertown.
916 do with garnets, Norwich.
917 do Belchertown.
918 Finer do (hornblende slate,) South Hadley Canal.
919 Fibrous Hornblende, do Enfield.
920 Somewhat granular do do Middlefield.
921 Fibrous hornblende, Leverett.
922 do do Florida.
923 Compact do (greenstone slate,) Lincoln.
924 do do do Smithfield, R. I.
925 do do do Marlborough.
926 Fibrous do (hornblende slate,) Shelburne.
927 do do do Banks of Merrimack R.
928 do do do Whately.
929 Hornblende and Feldspar, Sudbury.
930 do do (hornblende slate,) Bernardston.
931 do do rhomboidal, (primitive greenstone,) Whately.
932 do do (hornblende slate,) Ware.
933 do do compact, (transition greenstone,) Smithfield, R. I.
934 do do not slaty, (primitive greenstone,) Gill.
935 Quartz and feldspar, a vein in primitive greenstone, do
936, 937, 938 Hornblende and Feldspar, (primitive greenstone somewhat columnar, } Whately.
939, 940 Hornblende and Feldspar, coarsely granular, (hornblende slate,) } Ware.
941 do chiefly hornblende, (hornblende slate,) Mouth of Miller's R.
942 do feldspar in distinct layers, do Dana.
943 Hornblende, Feldspar, and Mica, Plumbago Mine, Sturbridge.
944 do porphyritic, (smoothed,) Heath.
945 do do (bowlder,) South Hadley Canal.
946 do do do Amherst.
947 do and compact feldspar, Whately.
948 do and feldspar, the latter compact and with a crystalline form, } Easton.
949 do do Canton.
950 do do? Plymouth.
951 do do Whately.
952 do and Quartz, with a vein, Becket.
953 do do with a vein of graphic granite, Williamsburg.
954 do do Shelburne Falls.

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955 do do with a vein of quartz, Warwick.
956 do do hornblende fibrous, Hawley.
957 do do and feldspar, the hornblende fascicular, Conway.
958 Hornblende, Feldspar, and Mica, Amherst.
959 do with augite, Becket.
960 do Stow.
961 do passing into sienite, Dracut.
962, 963 do with granite, Leverett.
964 Hornblende and Epidote, Granville.
964 1-2 do in contact with serpentine, Blanford.
965 do rhomboidal, Whately.
966 Crystalized feldspar in hornblende slate, do
967 Hornblende and Chlorite, do
968 Actynolite Slate — actynolite quartz and feldspar, Shutesbury.
969 do Belchertown.
970 Hornblende Slate, with a layer of epidote, Pelham.
971 Crystals of Hornblende in hornblende slate, do

## *Gneiss.*

972 Granitic Gneiss, Pelham.
973 do Templeton.
974 do Brookfield.
975 do New Braintree.
976 do Pelham.
977 do Paxton.
978 do Petersham.
979 do granular, Monson.
980 do Athol.
981 do Princeton.
982 do Blanford.
983 Sienitic Gneiss — Gneiss with Hornblende, Mendon.
984 Granitic Gneiss? texture somewhat mechanical, Bolton.
985 do Worcester.
986 do do
987 do chiefly flesh colored feldspar and granite, Sudbury.
988 do slightly talcose, North Brookfield.
989 do somewhat schistose, Rochester.
990 do do Oxford.
991 do Sudbury.
992 do (smoothed,) Billerica.
993 Schistose Gneiss, Dudley.
994 do Purgatory, Sutton.
995 do granular, Wilbraham.
996 do Mouth of Miller's River, Montague.
997 do Buckland.
998 do Shelburne Falls.
999 do Amherst.
1000 do mica predominating, New Bedford.
1001 do passing into mica slate, Worcester.
1002 do do Paxton.
1003 do do Hardwick.
1004 do Pelham.
1005 do feldspar in tuberculous masses, Worcester.
1006 Junction of granitic gneiss and mica slate, do
1007 Schistose Gneiss, Westborough.
1008 do passing into mica slate, (bowlder,) Colrain.
1009 do Windsor.
1010 do feldspar gray, Little Compton, R. I.
1011 do Monson.
1012 do chiefly feldspar, Oxford, Eastpart.
1013 do Florida.



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1014 Schistose Gneiss, passing into mica slate with pyrope, Western,
1015 do do Shrewsbury.
1016 do western base of Wachusett, Princeton.
1017 do Grafton.
1018 do Charlton.
1019 do somewhat porphyritic, Harvard.
1020 do talcose? Framingham.
1021 do do? Leverett.
1022 do do with veins of chlorite, Bolton.
1023 Laminar Gneiss, Windsor.
1024 do Webster, west part.
1025 do Amherst.
1026 do Grafton.
1027 See the No. following No. 778.
1028, 1029 Laminar Gneiss, Pelham.
1030 do Norfolk, Con.
1031 do feldspar, hornblende and slate interlaminated, Enfield.
1032 do do Warwick.
1033 do Savoy.
1034 do Windsor.
1035 do Dalton.
1036 do Becket.
1037 do with a vein of granite, Pelham.
1038, 1039 do Douglas.
1040 do becoming porphyritic, Ward.
1041 Porphyritic Gneiss, Pelham.
1042 do feldspar, flesh colored, Amherst.
1043 do with epidote, (smoothed,) Pelham.
1044 do coarse, New Braintree.
1045, 1046 do do Ware.
1047 do Methuen.
1048 do scarcely porphyritic, Paxton.
1049 do Montague.
1050 do passing into schistose, Tolland.
1051 Amphibolic Gneiss, containing disseminated masses of hornblende, Montague.
1052 do Leverett.
1053 do Enfield.
1054 do Pelham.
1055 Epidotic Gneiss, Amherst.
1056 do Pelham.
1057 do Amherst.
1058 do Grafton.
1059 do Amherst.
1060 do? Duxbury.
1061 do? containing compact feldspar, Duxbury.
1062—1065 Augitic Gneiss, Lee.
1066, 1067 Anthophyllitic Gneiss, Enfield.
1068 Arenaceous Gneiss, Southbridge.
1069, 1070 do? Smithfield, R. I.
1071 Talcose Gneiss, do
1072 Gneiss with a serpentine granite vein, Enfield.
1073 Plumbago, the common variety, Sturbridge.
1074 do apparrently fibrous, do
1075 do partially crystalline, do
1076 Fuller's earth? In the Plumbago mine, do
1077 Hydrate of Iron, (bogore) in do do
1078 do do in gneiss, North Brookfield.
1079 Garnet and Sulphuret of Molybdenum in gneiss, do

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1080 Native Alum and Sulphate of Iron on gneiss, Leominster.
1081 do do Barre.
1082 Pyrope Garnet in gneiss, New Braintree.
1083 do with adularia, Brimfield.
1084 do in gneiss passing into mica slate, Norwich, Con.
1085 Crystalized feldspar in gneiss, Boxborough.
1086 Green Adularia, with mica (polished) Southbridge.
1087, 1088 Adularia, Brimfield.
1089, 1090 Schorl in quartz from gneiss, Pelham.
1091 Crystalized Sphene in augitic gneiss, Lee.
1092 Crystalized augite and scapolite (?) do
1093, 1094 Sulphuret of Iron, Hubbardston.
1095 Peliom ? and pyrites, do
1096 Magnetic Oxide of Iron in gneiss, Grafton.
1097, 1098, 1099 Crystalized and Drusy Quartz, Pelham.
1100 Radiated Quartz, Pelham.
1101 Amethystine, do do
1102 Bluish Mamillary Chalcedony in gneiss, Pelham.
1103 Breccia Agate, (polished,) Rochester.
1104 Gray Copper, perhaps from gneiss, Brimfield ?
1105 Actynolite in feldspar, Chelmsford.

## UNSTRATIFIED ROCKS.

### *Greenstone.*

1106 Common Greenstone, hornblende and feldspar, Sunderland.
1107 do do Deerfield.
1108 do do Mt. Holyoke.
1109 do do Turner's Falls.
1110 do do Mt. Tom.
1111 do (Primary greenstone,) do Pelham.
1112 do do epidotic, Chelsea.
1113 do approaching to sienite do Newburyport.
1114 do do Lexington.
1115 do approaching to sienite do Holliston.
1116 do do do Concord.
1117 See the No. following 1205.
1118 Common Greenstone, epidotic, do Waltham.
1119 do do Nahant.
1120 do do from a vein in argillaceous slate, Charlestown.
1121 Coarse Greenstone passing into sienite, hornblende and feldspar, do
1122 Greenstone passing into sienite, coarse, (a bowlder) West Springfield.
1123 do do Holliston.
1124 do do Dover.
1125 do do Stoughton.
1126 do do Easton.
1127 do the feldspar in bronze coloured folia of considerable size, West Springfield.
1128 do do Mt. Holyoke.
1129 do the ingredients distinguished with difficulty, Hingham.
1130 do do Newton.
1131 do passing into sienite, Blue Hills.
1132 do Quincy.
1133 do from a vein in gneiss, Rutland.
1134 do Nahant.
1135 do from a vein in gneiss, Montague.

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1136 Columnar Greenstone, 4 sided prism, Mt. Holyoke.
1137 do 5 sided prism, do.
1138 do 3 sided prism, do
1139 Curved exfoliation from a column, do
1140 Compact Greenstone, the ingredients indistinct, Nahant.
1141 do Blue Hills.
1142 do a bowlder, Framingham.
1143 do from a vein in granite, Foxborough.
1144 Chiefly greenish compact feldspar? Salisbury.
1145 do Rowley.
1146, 1147, 1149, 1150 do Dedham.
1148 Indurated Clay, Titan's Pier, S. Hadley.
1151 Common Greenstone with reddish carbonate of lime, Deerfield.
1152—1155 Hornblende, Augite? Feldspar, Nahant.
1156 Porphyritic Greenstone, (smoothed) Cape Ann.
1157 do Easton.
1158 do (smoothed) Salem.
1159 do imbedded crystals Tharinthin (smoothed) Ipswich.
1160 do reddish, Turner's Falls.
1161 do base reddish, Deerfield.
1162 Greenstone porphyritic and epidotic, with iron pyrites, Topsfield.
1163 do do base wackelike, Turner's Falls.
1164 do do do Deerfield
1165 Slaty Greenstone, micaceous, Reading.
1166 Amygdaloidal Greenstone. nodules calcareous, Deerfield.
1167 do nodules siliceous, S. Hadley Canal.
1168 do nodules calcareous, Deerfield.
1169 do do Turner's Falls.
1170 do cavities empty, toadstone, Gill.
1171 do do do Mount Holyoke.
1172 do nodules siliceous, Titan's Pier.
1173 do nodules foliated chlorite. Turner's Falls.
1174 do nodules earthy chlorite, West Springfield.
1175 do nodules calcareous, Rowley.
1176 Concretion from Greenstone, Deerfield.
1177 do Mount Holyoke.
1178 Trap Tufa, or tufaceous greenstone, South Hadley Canal.
1179 do micaceous, Deerfield.
1180 do Titan's Pier.
1181 do cement calcareous spar, Deerfield.
1182 do Northampton.
1183 do Mount Tom.
1184 do base reddish, Deerfield.
1185 Junction of Amygdaloid and sandstone, Turner's Falls.
1186 Trapp Tufa, West Springfield.
1187 Nodules of Pretinite in greenstone, Greenfield.
1188, 1189 Chalcedony in do Deerfield.
1190 do do Greenfield.
1191 Large Agate, of chalcedony cameliun and quartz, Deerfield.
1192, 1194, Amethyst in greenstone, do
1194 Black Augite do do
1195 Phrenite, Augite and Calcareous Spar, do
1196 Pseudomophous Quartz, with pretinite, do
1197 Calcareous Spar pretinite, &c. do
1198, 1199 Chlorophocite in trap, Turner's Falls.
1200 Lincolnite and chabasie in greenstone, Deerfield.
1201 do do do
1202 do and chabasie do do
1203, 1204 do covering the surface, do
1205 Radiated minerals, perhaps Lincolnite, on greenstone, Deerfield.
* 1117 Crystalised Smoky quartz, from Greenstone, West Springfield.

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## *Porphyry.*

1206 and 1207 Compact Feldspar, Newbury.
1208 do with talc? Sharon.
1209 do with dendritic impressions, Medford.
1210 do with quartz, Natick.
1211 do somewhat foliated, a vein in sienite, Whately.
1212 do somewhat brecciated, Dorchester.
1213 do do Blue Hills.
1214 do a vein in black serpentine, Newbury.
1215 do Nahant.
1216 do slightly porphyritic, Hingham.
1217 do Lynn.
1218 do somewhat foliated, Natick.
1219 do lime quarry, Stoneham.
1220 do variegated Medford.
1221 do passing into siliceous slate, Malden.
1222 do do with a minute quantity of gold? Blue Hills.
1223 do red, passing into porphyry, do
1224 do do Hingham.
1225 do do Milton.
1226 do do Rowley.
1227 do do Ipswich.
1228 do do exhibiting traces of a slaty struc. Kents Isl. Newbury.
1229 and 1230 do variegated somewhat foliated, Dedham.
1231 Porphyry approaching Sienite (polished) Malden.
1232 do with traces of a slaty structure, Nantasket Beach.
1233 do base purple, (polished) bowlder, Orleans.
1234 do base black do Nantasket Beach.
1235 do approaching to amygdaloid, Westborough.
1236 Between greenstone and porphyry, Ipswich.
1237 do porphyry and compact feldspar, Milton.
1238 Porphyry, Blue Hills.
1239 Porphyry dark gray, (polished) Blue Hills.
1240 do do do North of Boston.
1241 do containing quartz nodules (polished), Milton.
1242 do light gray do. do
1243 do reddish, Nastasket Beach.
1244 do? perhaps Varioloid Wacke, Newton.
1245 do containing quartz and feldspar crystals. Milton.
1246 do red and green, (smoothed) Malden.
1247 do red with quartz and feldspar crystals, a bowlder, Newport, R.I.
1248 do red, Malden.
1249 do do Lynn.
1250 do red base, Nantasket Beach.
1251 do do (polished) Blue Hills
1252 do base red do North of Boston.
1253 do do do Nantasket Beach.
1254 do greenish, do Malden.
1255 do lively green, do Milton.
1256 do Needham.
1257 do passing into sienite, Malden.
1258 do reddish brown, crystals of feldspar and quartz, polished, B. Hills.
1259 do green, passing into sienite, (smoothed) Malden.
1260 do base dark green, crystals feldspar and quartz do Blue Hills.
1261 do variegated, feldspar and quartz crystals do do
1262 do base reddish, imbedded crystals chiefly quartz do Quincy.
1263 do do do do Milton.
1264 Brecciated Porphyry, reddish, (polished) Halfway Rock, Atlan. Ocean.
1265 do (smoothed) Lynn.

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1266 Brecciated Porphyry, passing into graywacke, (smoothed) Malden.
1267 do (polished) do
1268 do do Nantasket Beach.
1269 do greenish, Malden.
1270 do betraying a former slaty structure, Nantasket Beach.

*Sienite.*

1271 Feldspar and Hornblende, (smoothed) Newbury.
1272 do passing into porphyry do Nahant,
1273 do do Stoneham.
1274 do brecciated, do Foxborough.
1275 do Concord.
1276 do (smoothed) Dover.
1277 do do Reading.
1278 do do Nahant.
1279 do Norfolk County.
1280 do Rowley.
1281 do Hangman's Island, Boston Harbor.
1282 do hornblende in distinct crystals, (smoothed) Dedham.
1283 do do Randolph.
1284 do Reading.
1285 do Cumberland, R. I.
1286 do epidote, Dedham.
1287 Feldspar, Quartz and Hornblende, Salisbury.
1288 do Manchester.
1289 do Quincy Granite, Quincy.
1290 do do (smoothed) Quincy.
1291 do (bowlder) Mansfield.
1292 do Franklin.
1293 do (smoothed) Danvers.
1294, 1295 do do Squam, Gloucester.
1296, 1297 do do Sandy Bay, do
1298 do do Squam, do
1299 do do North Bridgwater.
1300 Quartz and Feldspar, do Manchester.
1301 do do Foxborough.
1302 do do Easton.
1303 do feldspar mostly compact, (smoothed) West Cambridge.
1304 do do Hingham.
1305 do do Sherburne.
1306 do feldspar blood red, (smoothed) a bowlder, Marshfield.
1307 do and perhaps hornblende do Scituate.
1308 do do Weston.
1309 do Middleborough.
1310 do Weston.
1311 do Foxborough.
1312 do Danvers.
1313 Feldspar and quartz. the former compact, Newbury.
1314 do and cholorite, the feldsdar red and greenish, Saugus.
1315 do do the feldspar compact close to the jasper, Saugus.
1316 Passing into porphyry Newbury.
1317 do Manchester.
1318 do Malden.
1319 Feldspar, Hornblende, Quartz and mica, Belchertown.
1320 do (smoothed) do
1321 do do Northampton.

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1322 Feldspar, Hornblende, Quartz and Mica, Williamsburgh.
1323 do Whately.
1324 do the hornblende predominating, Northampton.
1325 do with veins of epidote, Whately.
1326 do do
1327 do chiefly feldspar, do
1328 do Gloucester.
1329 Chiefly feldspar and talc or chlorite with veins of epidote, Salisbury.
1330 Feldspar, hornblende? and mica, (smoothed) Medford.
1331 do coarse a bowlder, Charlestown.
1332 Feldspar quartz mica and perhaps hornblende, Fall River, Troy.
1333 Chiefly feldspar and mica, Bradford.
1334 do with a little quartz and hornblende, Lincoln.
1335 Feldspar, hornblende, and mica, Salem.
1336 Feldspar hornblende and talc, Newbury.
1337 Feldspar quartz and mica or talc, Franklin.
1338, 1339, 1340 Granite, sienite and greenetone from the same ledge, Stoughton.
1341 Porphyritic sienite, (smoothed) Lexington.
1342 do feldspar and quartz with epidote, (smoothed) Marblehead.
1343 do feldspar bronze colored, do Gloucester.
1344 do base green compact feldspar crystals flesh red foliated; also quartz and hornblende do West Bridgwater.
1345, 1346 do like the last do Abington.
1347 do Plymouth County.
1348 do feldspar quartz mica and hornblende, Essex.
1349 Porphyritic Sienite passing to porphyritic greenstone, the crystals nearly compact. Waltham.
1350 Conglomerated Sienite, Whately.
1351 do do
1352 do do
1353 do do
1354 Junction of two varieties of sienite, West Bridgwater.
1355 Vein of graphic granite in sienite, Belchertown.
1356 Vein of nearly compact feldspar in sienite, Southborough.
1357 Irregular vein of granite in sienite, Northampton?
1358 Vein of compact greenstone in sienite, Nahant.
1359 Veins of feldspar in sienite, Marblehead.
1360 Vein of compact epidote in sienite, Abington.
1361 Vein of red feldspar in sienite, Whately.
1362 Augite, hornblende and feldspar, Belchertown.
1363 Augite and feldspar-the latter almost compact, Amherst.
1364 Sulphate of baryta, Hatfield.
1365 Purple fluate of Lime in sienite, Cumberland, R. I.
1366, 1367, 1368 Drusy crystallized Quartz, Whately.
1369 do with singular cavities, do
1370 Arsenical Iron in quartz from sienite, Newbury.
1371 Galena and Blende in sulphate of baryta, Hatfield.

## *Granite.*

1372 Feldspar, Quartz and mica, common granite, coarse, Russell.
1373 do do do Westhampton.
1374 do do do S. Hampton. adit.
1375 do do do Leverett.
1376, 1377 do do do Amherst.
1378 do do do Granville.
1379 do quartz blue, do do Amherst.
1380 do chiefly quartz and mica, do Westford.

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1381 Feldspar, Quartz and Mica, chiefly quartz and mica, Amherst.
1382 do do do Mouth of Miller's [River.
1383 do do do Framingham.
1384 do feldspar flesh colored, do Blanford.
1385 Feldspar Quartz and Mica, Common Granite, coarse, feldspar red, Granville.
1386 do do do do Amherst.
1387 do do do do New Salem.
1388 do do do do Concord.
1389 do quartz yellow do do Williamsburgh.
1390 do mica yellow, do do Chesterfield.
1391 do do do Norwich.
1392 do in bowlders — do easily decomposing, Florida.
1393 do do quartz dark gray inclining to purple, Adams.
1394 do do feldspar greenish and quartz purplish, Florida.
1395 do mica green, coarse, Cummington.
1396 do quartz smoke gray, do Leverett.
1397 do feldspar bluish, do do
1398 do feldspar blue, do do
1399 do feldspar nearly compact, do Heath.
1400 do do do Amherst.
1401 do (gneiss ?) do Ashburnham.
1402 do of a mechanical aspect, do Granville.
1403 do ingredients dark gray do Fall River.
1404 do (gneiss ?) do Leominster.
1405 do do Smithfield, R. I.
1406 do passing into sienite, rather fine, Bristol R. I.
1407 do junction of coarse and fine grained, Williamsburgh.
1408 do (gneiss ? ) Top of Wachus[ett, Mt.
1409 Quartz and mica, coarse, Westfield.
1410, 1411, 1412 Quartz mica and feldspar, red granite, fine grained, bowlder, [South Hadley.
1413 do feldspar red, (smoothed) Falmouth.
1414 do do do Rochester.
1415 do do do Wareham.
1416 do reddish gray do Framingham.
1417, 1418 do mica black, fine grained, Cumberland, R.I. N.E. part.
1419 do perhaps sienite, do (smoothed) Medfield.
1420 do rather fine grained, Carver.
1421 Feldspar, Quartz and mica or Talc do Weston.
1422 do do Eastern part of the State.
1423 Feldspar, Quartz, and Mica, bowlder, fine grained, Adams.
1424 do feldspar purplish, Belchertown.
1425 do evidently recomposed from a vein, Westfield.
1426 Feldspar Quartz and Mica, fine grained quarried, Ashburnham.
1427 do with small garnets Acton.
1428 do fine grained, Whately.
1429 do do Conway.
1430 do do Holliston.
1431 do chiefly quartz and feldspar, Dedham.
1432 do do Chester.
1433 do feldspar mostly foilated, gray, but some of it compact and greenish, quartz gray approaching to granular, mica black (smoothed) Pilgrim Rock, Plymouth.
1434 do similar to the last. do

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1435 Feldspar Quartz and Mica, fine grained, Acton.
1436 do chiefly quartz, Sudbury.
1437 do passing into porphyry, Halifax.
1438 Feldspar, Quartz, and Talc? Duxbury.
1439 Feldspar and quartz, perhaps sienite, Newbury.
1440 Feldspar Quartz and Mica, approaching to sienite, apparently stratified, Worcester.
1441 do passing into mica slate, Norwich.
1442 do do Colrain.
1443 do mica black, resembling sienite, (smoothed) Dover.
1444 do fine grained, South Hampton Adit.
1445 do quarried, do Tyngsborough.
1446 do do Norwich.
1447 do wrought, do Dover.
1448 do mica nearly wanting, very fine grained, quar'd (smooth'd) do
1449 do fine grained bowlder, Amherst.
1450 do quarried, (smoothed) Concord.
1451 do feldspar reddish, mica scarcely present, (smoothed) [Waltham.
1452 do very fine grained, decomposing at the surface, (smoothed) Sharon.
1453 do quarried, (smoothed) (Chelmsford granite) Westford.
1454 do do do Fitzwilliam, N. H.
1455 do do do porphyritic, Pelham, N. H.
1456 do do do Fitchburg.
1457 do do do Ashby.
1458 do do do Williamsburgh.
1459 Feldspar, Quartz and talc, Dedham.
1460 Feldspar, Quartz, and mica resembling sienite, Cumberland, R. I.
1461 Feldspar Quartz Mica and Talc, coarse, bowlder, Amherst.
1462 Pseudomorphous granite, Williamsburgh.
1463 Porphyritic Granite, Chester.
1464 do bowlder, Shutesbury,
1465 do very coarse, Harvard.
1466 do fine grained feldspar nearly compact bowlder, (smoothed) Turner's Falls.
1467 1468 do feldspar chiefly compact in argillaceous slate, Guilford Vt.
1469 1470 Chiefly compact feldspar and quartz, do do
1471 1472 Graphic Granite, Williamsburgh.
1473 do Leominster.
1474 do from a vein in quartz rock, Washington.
1475 do Goshen.
1476 do reddish, bowlder, Amherst.
1477 1478 do flesh red, from red sandstone, Deerfield.
1479 do Warwick.
1480 do with garnets, Goshen.
1481 Junction of Granite and Mica slate, Conway.
1482 Vein of Granite in Mica Slate, do
1483 do do Williamsburgh.
1484 do in the Worcester County Mica slate, Leominster.
1485 Granite at its junction with micaceous limestone, Conway.
1486 Granite with a nodule of mica slate, bowlder, Deerfield.
1487 1488 Laminated and Tabular Sulphate of baryta, Leverett.
1489 Crystallized calcareous spar, Lead Mine, Southamton.
1490 Argentine, Westhampton.
1491 do showing its junction with granite, do
1492 do Lead Mine, Southampton.
1493 1494 1495 1496 Crystallized Quartz of various colors, Lead Mine, do



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| | | |
|---|---|---|
| 1497 | Radiated crystallized quartz, | Southampton. |
| 1498 | Purple Quartz in granite. | Florida. |
| 1499 | Crystallized smoky Quartz, | Goshen. |
| 1500 | Massive do | Williamsburgh. |
| 1501 | Pseudomorphus Quartz, form of hogtooth spar, | Westhampton. |
| 1502 | do form of fluate of Lime, | do |
| 1503 | Hornstone Lead Mine, | Southampton. |
| 1504, 1505 | Gray and greenish Spodumene, | Goshen. |
| 1506 | do light rose color. | do |
| 1507 | do green and translucent | do |
| 1508 | do white and pearly, | Sterling. |
| 1509 | Straw colored Mica, Tourmaline locality, | Chesterfield. |
| 1510 | do in distinct crystals, | Goshen. |
| 1511 | Rose colored Mica, do | do |
| 1512 | Prismatic Mica, | Russell. |
| 1513 | Variegated prismatic mica. | do |
| 1514 | Black mica, | do |
| 1515 | Plumrose Mica, | Williamsburgh. |
| * 1547 | Schorl with terminations, in granite, | Chelmsford. |
| 1516 1517 | Indicolite, | Goshen. |
| 1518 | do light blue, | do |
| 1519 | do or green tourmaline, | do |
| 1520 | Yellowish Green tourmaline, | do |
| 1521 | Indicolite embraced in green tourmaline. | Chesterfield. |
| 1522 | Green red and blue tourmalines, | do |
| 1523 | Green tourmaline in quartz, | do |
| 1524 | do enclosing rubellite. | do |
| 1525 | Limpid Beryl in granite, | Goshen. |
| 1526 | do rose red, | do |
| 1527 | Massive Beryl with spodumene, | do |
| 1528 | do | do |
| 1529 | Radiated mineral or granite, of the Zeolite family: probably stilbite, | do |
| 1530 | Fibrous Talc? | Norwich. |
| 1531 | do? | Blanford. |
| 1532 | Common Feldspar, | Williamsburgh. |
| 1533 | Blue do | Leverett. |
| 1534 | Greenish do | Goshen. |
| 1535 | Siliceous do Cleavlandite, foliated. | Chesterfield. |
| 1536 | do do | New Salem. |
| 1537 | Foliated silicious Feldspar, | Goshen. |
| 1538 | Silicious Feldspar coarsely granular, | Chesterfield. |
| 1539 | do finely granular, | Goshen. |
| 1540 | Galena in Quartz, | Southampton. |
| 1541 | do with Blende, | Whately. |
| 1542 | do with Carbonate of Lead, | Southampton. |
| 1543 | Blende in Quartz, | Northampton. |
| 1544 | Pyritous Copper in Quartz, | Southamton. |
| 1545 | Blende, Galena, and Pyritous Copper, | do |
| 1546 | Blende decomposing in quartz, | Williamsburgh. |
| 1547 | See the No. following No. 1515. | |
| 1548 | See the No. following No. 803. | |
| 1549 | See the No. following No. 774. | |
| 1550 | See the No. preceding No. 775 | |

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# GENERAL INDEX.

## A.


| | Page. |
|---|---|
| Aboriginals, their geological speculations, | 203 |
| Adularia, | 51, 398 |
| Actynolite, | 342, 397, 363, 398 |
| Agates, | 50, 435 |
| brecciated, | 322, 344 |
| Alum Hill, | 77 |
| native, | 48, 342, 397 |
| Allochroite, | 313 |
| Alluvium, | 5, 114 |
| of rivers, | 115 |
| of the coast, | 116 |
| of disintegration, | 120 |
| of degradation, | 121 |
| Amber, | 51, 191 |
| Amethyst, | 503, 435 |
| Amianthus, | 311, 312, 371 |
| Amphibolic mica slate, | 327 |
| Amygdaloid, | 411 |
| Analcime, | 347, 436 |
| Andalusite, | 291, 345 |
| Animals in Massachusetts, Catalogue of | 543 |
| Animal Fossil in new red sandstone, | 235 |
| Anthophyllite, | 399 |
| Anthracite, its geological position, | 335 |
| in Rhode Island and Worcester, | 44 |
| in graywacke, | 275 |
| in new red sandstone, | 227 |
| in Portsmouth, R. I. | 276 |
| in Wrentham, Middleborough, &c. | 277 |
| in mica slate, | 347 |
| passing into plumbago, | 279 |
| its origin, | 281 |
| Anthracitous Mica Slate, | 329 |
| Arcade in Providence, its granite pillars, | 16 |
| Argentine, | 502 |
| how produced in Williamsburgh, | 307 |
| Arenaceous Mica Slate, | 328 |
| Argillaceous Slate, its economical uses, | 34 |
| of Worcester County, | 288 |
| of Franklin and Berkshire, | 289 |
| its place among the rocks, | 286 |
| its mineralogical characters, | 287 |
| dip and direction of its strata, | 289 |
| its mineral contents, | 291 |
| associated with graywacke, | 258 |
| its agricultural character, | 9 |
| disturbances among its strata, | 291 |
| its theory, | 294 |


Digitized by Google

Argillo-micaceous Slate, 328
Argillaceous Oxide of Iron, 57, 188
Arsenical Pyrites, 348
Asbestus, 433
Asterophyllites in graywacke, 284
Augite Rock, 330
white crystallized in Limestone, 304
actynolite, &c. 310, 398, 435
Autumnal Scenery, 107

B.

Baldwin, C. C. letter from 204
Beach Grass used for fixing sands, 7
Beaumont Elie de on graphite and anthracite, 281
on the elevation of mountains, 522, 539
Beartown Mountain, 77
Belchertown Granite, 18
Bennington iron mine, 56
Bernardston iron mine, 54
Beryl, 50, 506
Birds in Massachusetts, Catalogue of 545
Bitter Spar, 362
Bituminous Limestone and Marlite, 214
Blende, 230, 348, 462, 507
Blue Hills, 84
Bog Ore, its localities, 57
petrefactions in 123
theory of its origin, 122
Boston Harbor, its scenery, 92
hypothesis of formation, 125
Bowdoin Street Church, its granite, 17
Bowlders, 146
Boltonite, or Bisilicate of Magnesia, 310
Brown Spar, 502
Buhrstone in Washington, 41, 317
its origin, 325

C.

Calamites in new red sandstone, 233
in graywacke, 285
Calcareous Spar, 52, 436
Cape Ann Sienite, 15
scenery of 95
Cape Cod, scenery of 96
clay cliffs upon 127
Carbonate of Magnesia and Iron, 363
of Copper, 296, 364
Carnelion and Cacholong, 435
Caverns and Fissures, 104
in Berkshire, 105
Cascade in Leverett, 103
and Natural Bridge in Adams, 103
Central heat, theory of 516
Chabasie, 436, 461
Chalcedony, 50, 323, 371, 399, 435
Chatham Beach its gain upon the sea, 128
Chelmsford Granite, 16
Chart, 265
Chiastolite, 291
Chlorite, 434
Slate, 353
its agricultural character, 11
Chlorophoeite, 435

Digitized by Google

Chromate of Iron, - - - - - - 369
Chrysoberyl, - - - - - - 503
Chrysoprase, - - - - - - 372
Cinnamon Stone, - - - - - 50, 310
Clays Variegated, - - - - - - 184
Clays used for Fuller's Earth, - - - - 38
for making alum, - - - - - 38
as a manure, - - - - - - 38
Cliffs at Gay Head, - - - - - 126
Cleavelandite, - - - - - - 506
Climate formerly tropical in New England, - - 245
Cobalt, Arsenical, - - - - - 381
Coal in new red sandstone, - - - - - 227
its varieties, - - - - - - 42
Columns of Greenstone on Holyoke, - - - 80, 407
at Titan's Pier, - - - 408
in Deerfield, - - - - 406
Columnar Argillaceous Iron Ore, - - - - 189
Compact feldspar, - - - - - - 443
Concluding Remarks, - - - - - 71, 539
Concord Granite, - - - - - - 17
Concretionary Carbonate of Lime, - - - - 180
Conglomerated Mica Slate, - - - - - 329
Contortions in Rocks, how produced - - - 348
Copper, veins of in Greenfield and Granby, Ct. - - 62
carbonate of and pyritous, - - - 507
muriate of - - - - - 508
native and carbonate of and pyritous, - - 433
&c. in new red sandstone, - - - 225
&c. veins of in new red sandstone, - - 226
Crabs, Fossil at Gay Head, - - - - - 195
Cranston, R. I., Iron Ore in - - - - - - 56
Crocodile's Tooth, Fossil at Gay Head, - - 193
Crustacea in Massachusetts, Catalogue of - - 563
Cumberland, R. I. Iron mine in - - - 54
Cummingtonite, - - - - - - 347
Cyclopteris in graywacke, - - - - - 285

D.

Danas Messrs. assisted by - - - - - 3
Davy, Sir Humphrey, his chemical theory of the earth, - 517
Dedham Granite, - - - - - - 16
Deerfield Mountain, - - - - - - 82
Deluge of Noah, how probably produced, - - 168
Deluges, Ancient - - - - - - 537
Dewey, Prof. assistance from, - - - - - 3
Deweylite, - - - - - - - 371
Diabase, - - - - - - - 409
Diluvial Current in Massachusetts, its direction, - 142
proofs that it was southerly, 152, 159
elevations and depressions, - 144
bowlders or rocking stones, - 146
grooves in the rocks, - - 159
Diluvium, how produced, - - - - 141
of Plymouth and Barnstable, - - 143
of Cape Ann, - - - - 147
of Worcester County, - - - - 148
of the Connecticut Valley, - - 149
of Hoosac Mountain and Berkshire, - 150, 156
on Mount Tom, - - - 155
on Mount Toby, - - - - 159
in Europe and Asia, - - - 166
its mineral contents, - - - 170

Digitized by Google

Diluvium, its organic remains, 171
its stratification, 169
its agricultural character, 6
Dionite, 409
Dip and direction of the strata of Plastic Clay, 196
of new red sandstone, 219
of graywacke, 271
of argillaceous slate, 289
of quartz rock, 322
of mica slate, 337
of talcose slate, 358
of Hornblende Slate, 380
of gneiss, 390
Direction of the Strata, Map of, 523
Divine Benevolence, proofs of from geology, 247
Dolerite, 409
Dunes or Downs, 7
how formed, 130

E.

East and West System of Strata, 534
Economical Geology of Massachusetts, 1, 3
Elevation of Mountains and Systems of Strata, 522
Emmons, E. Prof. his Catalogue oi Birds, 545
his sketch of Strata, in Chester, 330
Epidote, 346, 398, 438
Equisetum in graywacke, 284
Eternity of the globe considered, 401

F.

Fall River Granite, 15
Falls, Turner's 99
South Hadley and Shelburne, 101
Sphicket, 102
in Fall River, 102
Pawtucket, 102
Canaan, Ct. 104
Fasciculite, 363
Feldspar, green 398, 461
blue and siliceous, 506
Fetid Limestone at West Springfield, 214
Fibrolite, 345
Fishes in Massachusetts, Catalogue of 553
additional, 605
Fitchburg Granite, 16, 17
Flinty Slate, 263
Fluor Spar, 283, 343, 461, 503
Fluvial Theory, 141, 164, 518
Fowlerite, or ferro-silicate of manganese, 344
Fucoides in new red sandstone, 233
in graywacke, 284

G.

Gadolinite, 310
Galena argentiferous, 348
Garnet, 312, 346, 398, 507
Garnetiferous Mica Slate, 327
Gay Head, its scenery, 99
Girardin on central heat, 517
Gneiss, its agricultural character, 11
its use in architecture, 18
quarries of in Massachusetts, 19
how it differs from granite, 382
its mineralogical characters, 383
granitic, 383

Digitized by Google

Gneiss, schistose, laminar, porphyritic, amphibolic and epidotic, 384
augitic, anthophyllitic arenaceous and talcose, - 385
its topography, - - - - - 385
dip, direction, &c. of its strata, - - - 390
curvatures in its laminae, - - - - 391
its mineral contents, - - - - - 395
its theory, - - - - - - 400
Gold, native, - - - - - - 459, 65, 360
and silver, idle search after, - - - - 68
Gorge or Glen, Leyden, - - - - - 102
Gorgonia, fosil, - - - - - - - 238
Gould, Dr. A. A. his Catalogue of Crustacea, - - - 563
Granite, its agricultural character, - - - - 13
its use in architecture, - - - - - 13
how split, - - - - - 17
its price when wrought, - - - - 17
defined, - - - - - - 465
its mineralogical characters, - - - 466
common, pseudomorphous and porphyritic, - 466
porphyritic, - - - - - 466
graphic, - - - - - - 467
its topography, - - - - - 469
its pseudo-stratification, - - - - 473
its veins and protruding masses, - - 473
sketches of its veins &c. in Conway and Blanford, 475
in Westminister and Nowich, 476
in Norwich, - 477
in do - - 478
in Norwich and Conway, 479
in Russell, - - 480
in Ackworth, N. H. 481
in Chester and Chesterfield, 482
in Williamsburgh and Granville, 483
in Chesterfield, - 484
in Ct. Shutesbury and Conway, 485
in Chester and Williamsburgh, 486
in Whately, Newport & at G. Head, 487
in West Hampton, 488
in Southampton and Shutesbury, 489
in New Bedford and Fairhaven, 490
do do 491
do and Tolland, 492
in Williamsburgh, - 493
in Whately, - 494
in Conway, - - 495
in do - - 496
in do - - 497
in do and Goshen, 498
in do - - 499
in Goshen and Norwich, 500
in Colrain, - - 501
its mineral contents, - - - 501
its theory, - - - - - 509
Graphic Slate, - - - - - - 35
Graphite, - - - - - - 47, 395
Gray Copper, - - - - - 399
Graywacke, its agricultural character, - - 9
its economical uses, - - - 33
defined, - - - - - 248
its peculiarities in Massachusetts, - 249
its mineralogical characters, - - 251
conglomerated, - - - 252
brecciated, - - - - 255
quartzose, - - - - 256
talcose, - - - - 257

Digitized by Google

Graywacke, classical, 257
slaty, 258
amphibolic, 259
limestone, 267
its topography, 268
dip, direction &c. of its strata, 271
section in at Newport, 274
its mineral contents, 275
its theory, 285
Green River, a change in its bed, 137
Green Sand, 185
Greenstone, its agricultural character, 12
its uses in architecture, 20
porphyritic, used for ornament, 21
defined, 404
its mineralogical characters, 405
columnar, 406
porphyritic and amygdaloidal, 410
concreted and tufaceous, 412
its topography, 412
its position with respect to other rocks, 417
its veins or dykes, 419
its chemical effects upon other rocks, 429
its mineral contents, 433
its theory, 439
in new red sandstone, when protruded, 243

H.

Harris, Dr. T. W. assistance from, 544
his catalogue of Insects, 566
Hawley Iron Mine, 53
Height of Hills around Boston, 85
Hentz, Professor, his Catalogue of Spiders, 564
Hematite, iron ore, 56, 323
Heulandite, 347
Holyoke, mount, 78
Hornblende crystalized, 363
Hornblende Slate, its agricultural character, 11
used for flagging stones, 20
Dr. Macculloch's view of, 373
its mineralogical characters, 374
porphyritic, 375
its topography, 377
dip and direction of its strata, 380
its mineral contents, 381
its theory, 381
Rock, 375
Hornstone, 503
Hubbardston, copperas manufactured in, 53
Huttonian Theory, 515
Hydrate of Iron, 178, 188, 296, 396
Hypersthene, 461

I.

Icthyolites in new red sandstone, 236
Ice, how it removes bowlders, 124
floods, their excavating power, 139
Idocrase in Worcester, 346
Indicolite, 504
Inscription on Quartz rock, 121
Insects, Catalogue of in Massachusetts, 566
Iolite, 507
Iron, native, 347
carbonate of, 52, 348, 362

Digitized by Google

Iron, micaceous oxide of, 349
sulphate of, 349
Red Oxide of, 343
vitreous, black oxide, 507
sand, 230
ore its agricultural character, 10
chromate of, 53, 369
phosphate of, 53
sulphuret of, 52, 396
magnetic oxide of, 53, 359
arsenical, 52, 348
its manufacture in Massachusetts, 57

J.

Jasper used for ornamental purposes, 50
at Saugus and Newport, 266
in Quartz Rock, 323

K.

Karinthin, 410
Kidd's money, foolish notions respecting 70

L.

Landscapes accompanying the Report, 108
Lathrop Solomon, his account of fossils, 239
Laumonite, 437, 461
Lead ore of, in Southampton, 507, 58
in Northampton, 508, 58
in Westhampton, 60, 508
in Goshen, 60
in Whately, 60, 508
in Hatfield, 61, 462
in Leverett, 61, 507
in Sterling, 52, 348
sulphuret, carbonate, sulphate, molybdate, muriocarbonate and phosphate of 507
Zinc and iron in new red sandstone, 230
Lenox iron mine in, 56
Lepidolite, 461, 437
Lignite, 43, 186
Limestone, its agricultural character, 10
in the eastern part of the State, 24
micaceous its analysis, 305, 25
fetid, 26, 301, 309
encrinal of Bernardston, 27, 295
bituminous, 27, 295
magnesian, 300
flexible, 301
of Berkshire, 28, 297
in Blanford, 305
in Whitingham, Vt. 308
in Bolton, Boxborough, Littleton, Acton, Carlisle and Chelmsford, 24, 308
in Smithfield, R. I. 24, 311
in Walpole, 24, 267
in Stoneham and Newbury, 24, 312
its origin or Theory, 313
Lincolnite, 399, 437

M.

Macculloch's Views of, Geology, 373
System of, Geology, 374
87

Digitized by Google

Magnetic Oxide of, iron, . . 296, 347, 359, 363, 399
Macle, . . . . . 291
Malden, vein of iron ore in, . . . . 55
Mamillary argillaceous iron ore, . . . . 190
Mammalia, Catalogue of, in Mass. . . . . 544
Manganese Oxide and Bisilicate of, . . . 361
in Plainfield, . . . . 63
in Conway, . . . . 64
in Hinsdale, N. H. . . . 64
in Winchester, N. H. . . . 64
earthy oxide of, how produced, . . 123
oxide of in mica slate, . . 344
Map Geological of Mass. how constructed, . 2, 113
Marble of Berkshire, . . . . 28
Marl, . . . . . 38
how produced, . . . . 120
Market House, Boston, its granite, . . . 16
Martha's Vineyard, iron ore in, . . . 57
scenery of, . . . 98
Mather Cotton ore fossil bones, . . . 205
Meridional System of Strata, the Oldest, . . 525
the Largest, . . 530
Metals and their Ores in Mass. . . . 51
Metallic Veins and beds their origin, . . 520
Mica Slate its agricultural character, . . 11
its economical uses, . . . 23
its mineralogical characters, . . 326
staurotidiferous, amphibolic, garnetiferous and spang. 327
argillo micaceous and arenaceous, . . 328
anthracitous, plumbaginous, and conglomerated, 329
indurated, . . . . 330
its topography, . . . 331
of Worcester Valley, . . . 333
dip, direction, &c. of its strata, . . 337
contortions in, . . . 338
veins of segregation in, . . . 341
its mineral contents, . . . 342
its theory, . . . . 349
Mica, crystalized, prismatic and plumose, . . 504
Micaceous Oxide of Iron, . . . 359, 433
Mineral Rods, . . . . 68
Waters, . . . . 49
Miscellaneous Items, . . . . 520
Molybdenum Sulphuret of, . . . 397
Monomoy Beach its gain upon the sea, . . 128
Monument Mountain, . . . . 77
Hill, Quincy, . . . . 85
Mosaic Chronology, how reconciled with geology, . 165
Moshop, Indian Giant, . . . 204, 205
Mounds in the Western States, not artificial, . 168
Mount Hope Bay, . . . . 94

N.

Nahant, . . . . . 95
Nantasket Beach, . . . . 96
Nantucket iron ore in, . . . . 57
its scenery, . . . . 98
Narraganset Bay its scenery, . . . 94

Digitized by Google

Native alum, 342, 397
arsenic, 191
gold, 359, 459
copper, 433
Nauset Beach, its gain upon the sea, 128
Nephrite, 311, 312
Nevropteris in graywacke, 284
New Bedford seen from its harbor, 94
New red sandstone, its agricultural character, 8
its uses and quarries, 35
in the Connecticut Valley, 206
proofs of its occurrence there, 207
its mineralogical characters, 209
its topography, 216
of New York, Nova Scotia, 217
of New Jersey, 529
its dip, direction, and thickness, 219
its mineral contents, 225
its theory, 241
Noachian Deluge, 142, 166
Nodular argillaceous iron ore, 188
Northeast and Southwest System of Strata, 531
Northwest and Southeast Do. 535
Nuttallite, 284

O.

Ochres, their localities and uses, 58
Ochrey Brown Oxide of Iron, 190
Old Red Sandstone, whether it exists in Massachusetts, 207
Ophicalce Grenue, 312
Organic Remains, in plastic clay, 191
in new red sandstone, 232
in graywacke, 284
Orthocera in new red sandstone, 237
Osseous Conglomerate, 186
Oxide of manganese, how produced, 123
of tin, 509

P.

Pargasite, 310
Part IV. 543
Peat, its localities and uses, 39
its extent in Nantucket, 119
theory of its production, 118
Pecopteris in graywacke, 284
Pelham, (N. H.) granite in 16
Peliom, 399, 507
Petalite, lithia in 50
in limestone, 310
Phosphate of lime, 502, 343, 310, 396
of manganese, 569
Pimelite, 372
Pinite, 345, 503
Pisiform argillaceous iron ore, 190
Plants in Massachusetts, Catalogue of 599
Plastic Clay, its history, 184
its mineralogical characters, 184
its organic remains, 191
its mineral contents, 188
dip, direction, thickness, of its strata, &c. 196
its theory, 202
on the Vineyard, 184
on Nantucket, 197
in Truro and Duxbury, 199

Digitized by Google

Plumbaginous mica slate, 399
Plumbago, 47, 395
generally associated with gneiss, 397
Porcelain Clay, 36
its agricultural character, 12
Porphyry, its use for ornaments, 20
sienitic, 21, 453
black and green, 21
defined, 442
its mineralogical characters, 443
compact feldspar, 443
antique, 445
brecciated, 446
its topography, 447
its geological position, 448
its mineral contents, 449
its theory, 450
Potter's Clay, 37
Prehnite, 434
Price of wrought and unwrought granite, 17
Primitive Greenstone, 375
Prismatic Iron Ore, 178
Pseudo-stratification of sienite, 456
of granite, 473
Purgatory in Sutton, 106
in Newport, R. I. 107
Pyritous Copper, 225, 493
Pyrope, 398

Q.

Quartz, crystalized, yellow, rose red, &c. 343
and pseudo-morphous. 461, 502
and yellow, 399
drusy, 372
crystalized in geodes, 435
tubular, smoky, and amethystine, 435
fetid, 503
radiated, 508
crystals, their use, 51
Rock, its agricultural character, 11
its economical uses, 22
granular, used as buhrstone, 41
used in making glass, 40
its place among the rocks, 316
its mineralogical characters, 317
its topography, 320
dip, direction, &c. of its strata, 322
its mineral contents, 323
associated with graywacke, 256
Quartzose Breccia, 318
Conglomerate, 319
Quincy Granite or Sienite, 14

R.

Radiaria Fossil at W. Springfield, 240
Radiated Pyrites, 190
Rattle Snake Hill, 77
Ravine of Westfield on Agawam River, 89
and Gorge of Deerfield river, 90
Red Oxide of Copper, 226
Report, how divided, 3
Reptiles in Massachusetts, Catalogue of 552
Rhoetizite, 345
Richmond, Iron Ore in 56

Digitized by Google

Rocks, their nomenclature, . . . . . 112
their supposed changes in the line of their direction, 332
Roof Slate in Worcester County, . . . . . 34
in the Connecticut Valley, . . . . . 35
in Berkshire County, . . . . . 35
Rotten Stone in West Springfield, . . . . . 48
Rubellite, . . . . . 505

S.

Saddle Mountain, . . . . . 74
Salisbury, Ct. Iron Ore in . . . . . 56
Sand, white, siliceous, . . . . . 185
micaceous, . . . . . 185
green, . . . . . 185
Sandstone, gray micaceous, . . . . . 212
variegated, . . . . . 212
brecciated, . . . . . 212
columnar, at Titan's Pier, . . . . . 432
Sandy Neck, its gain upon the sea. . . . . 129
Sappare, . . . . . 345
Sardonyx, . . . . . 435
Satin Spar, . . . . . 231, 312
Scapolite, . . . . . 309, 346
Rock, its agricultural character, . . . . . 10
its mineralogical characters, . . . . . 315
Schorl, . . . . . 345, 398, 504
Scientific Geology defined, . . . . . 3
Part III. . . . . 111
Sea, its action upon the coast, . . . . . 124
Section at Turner's Falls, . . . . . 423
in granite and chalk in Saxony, . . . . . 426
and sandstone at Heidelberg, . . . . . 427
Section in granite and clay slate in Scotland, . . . . . 427
in diorite and transition schist in the Hartz, . . . . . 428
in basaltic breccia lias, &c. in the Suabian Alps. . . . . 428
in greenstone and sandstone, Mt. Tom, . . . . . 429
in Plastic Clay, . . . . . 197
in graywacke, . . . . . 274
Sections accompanying the Report, . . . . . 523
Selenite, . . . . . 191, 436
Septaria, . . . . . 214
Serpentine, its economical uses, . . . . . 39
its agricultural character, . . . . . 10
its definition, . . . . . 365
its mineralogical characters, . . . . . 365
its topography and associations, . . . . . 366
its Flora, . . . . . 368
its mineral contents, . . . . . 371
its theory, . . . . . 372
Shales, . . . . . 213
Shark's bones and teeth at Gay Head, . . . . . 194
Sienite, its agricultural character, . . . . . 13
its use in architecture, . . . . . 13
defined, . . . . . 451
its mineralogical characters, . . . . . 452
porphyritic . . . . . 453
conglomerated, . . . . . 454
augitic, . . . . . 454
its topography, . . . . . 455
its pseudo-stratification, . . . . . 456
veins in, . . . . . 456
its geological position, . . . . . 460

Digitized by Google

Sienite, its mineral contents, . . . . . 461
its theory, . . . . . 462
Siliceous Slate, . . . . . 262
Silliman Prof. his opinion of the Connecticut Valley, 239
his account of greenstone near Hartford. 429
Silver in galena at South Hampton, . . . . 65
Sketches of Scenery, . . . . . 108
Smith's Point, its gain upon the sea, . . . . 129
Dr. David, S. C. H. his Catalogue of Reptiles, . 552
Dr. Jerome V. C. do of Fishes, . 553, 597
Soils, their origin, . . . . . 4
Somerset Vt. iron mine with native gold in, . 54
Spangled Mica Slate, . . . . . 327
Specimens of Rocks and Minerals for the Government, 3, 540
Specular oxide of Iron, . . . . 449, 508
Sphene, . . . . . 310, 381, 398
Spiders in the United States, Catalogue of, . 564
Spinelle, . . . . . 310
Spodumene, . . . . . 50, 503
State House, view from, . . . . . 92
Staurotide, . . . . . 327, 345
Staurotidiferous Mica Slate, . . . . 327
Steatite, its agricultural character, . . 10
its localities and economical uses, . . 31
other facts concerning it, . . 353, 371
Stilbite, . . . . . 347, 399
Stratified Rocks, . . . . . 114
Submarine Forests . . . . . 117
Sulphur in mica slate, . . . . . 347
Sulphuret of Iron, . . . . . 398
Sulphate of Baryta, . . 501, 433, 231, 49, 462, 507
of Strontia, . . . . . 232
Sulphuret of Molybdenum, . . . 397, 509
Sunderland Cave and fissure, . . . 104
Systems of Strata in Massachusetts, . . 525
oldest Meridional, . . . 525
the Trap System, . . 528
latest Meridional, . . . 530
N. E. and S. W. System, . 531
E. and W. System, . . 534
N. W. and S. E. System, . 535

T.

Talc, . . . . . 311, 362
and Serpentine their relation, . . . 372
Talcose Slate, its agricultural character, . . 11
its economical uses, . . 23
its definition, . . . 352
its mineralogical characters, . . 353
its topography, . . . 355
dip, direction, &c. of its strata, . 358
its mineral contents, . . 359
the repository of Gold, . . 360
its theory, . . . 364
Tellina, fossil at Gay Head, . . . . 196
Tertiary Formations, their agricultural character, . 7
their history, . . . 172

Digitized by Google

Tertiary Formations, the most recent in Mass. . . 173
position & thickness of its strata, 175
remarkable disturbances in, 174
minerals in, . 178
organic remains in, 182
theory of, . 183
Theory of Central Heat, . . . 516
of causes now in action, . . . 518
of the Elevation of Mountains, . . 538
Tin, oxide of, . . . . 64, 509
Titan's Pier, . . . . 81, 431, 408
Titanium, red oxide of, . 349, 363, 381, 398, 462
ferruginous oxide of, . . . 349
silico-calcareous oxide of, . 310, 381, 398
Toby, Mount, . . . . 83
Tom, Mount, . . . . 81
Topaz, . . . . 503
Tormaline, green and red, . . . 505
Topographical Geology defined, . . . 73
Trap Conglomerate, . . . 211, 417
Trap System of Strata, . . . 530
Tree, fossil in new red sandstone, . . 234
Tremolite, . . . 304, 310, 312
Tremont House, its granite, . . . 17
Tripoli in West Springfield, . . 48, 231
Turbo fossil at Gay Head, . . . 196
Turner's Falls, . . . . 99
Tynsborough Granite, . . . . 16

U.

United States Bank, Boston, its granite, . . 16
Unstratified Rocks defined, . . . 402
their origin, . . . 403
how represented on the Geological Map, 404
Useful Rocks and Minerals in the State, . . 13

V.

Valley of the Connecticut, . . . 88, 132
how far a valley of excavation, 221
of Worcester, . . . . 91
of the Merrimack, . . . 92
Vallies of Berkshire, . . . 87, 141
how formed, . . . . 131
terraced, how formed, . . . 134
of denudation, . . . 140
Varioloid Wacke, . . . . 259
Vegetable remains in Plastic Clay, . . . 192
Vegetation early on the Globe, . . . 245
Veins in new red sandstone, . . . 425
in graywacke. . . . 254
in quartz rock, . . . . 324
in mica slate, . . . . 341
in sienite, . . . . 456
in granite, . . . . 473
metallic, their origin, &c. . . . 520
their direction and dip, . . 521
Venus fossil in plastic clay, . . . 196
Verdantique, . . . . 30
Vermiculite, . . . . 399

Digitized by Google

Vertebra of animals fossil at Gay Head, . . 192
Volcanic Agency supposed at Gay Head, . . 203

W.

Wachusett Mountain, . . . . . 84
Wacke varioloid, . . . . . 259
Wacke, . . . . . 411
Washington Mount, . . . . . 76
Mountain, . . . . . 77
Water Falls, . . . . . 99
Webster, Prof. assistance from, . . . . 3
his account of trap in Charlestown, . . 429
Wernerian Hypothesis, . . . . . 515
Westford Granite, . . . . . 16
West Stockbridge, iron ore in, . . . . 56
Williamsburgh Granite, . . . . . 18
Winchester, (N. H.) iron ore in, . . . . 54
Worcester, iron mine in, . . . . . 52

Y.

Yenite, . . . . . 364

Z.

Zeolitic Mineral, . . . . 399, 436, 507
Zinc, sulphuret of, its use, . . . . . 52
its localities, . 63, 230, 348, 468, 507
Zircon, . . . . . 461
Zoisite, . . . . . 283, 346
Zoophytes, fossil at Gay Head, . . . . 195
at West Springfield, . . . . 237



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