DISTRIBUTION AND ORIGIN OF POLAR GYPSUM ON MARS. M. Massé[1], O. Bourgeois[1], S. Le Mouélic[1], C. Verpoorter[2], L. Le Deit[3], [1]Laboratoire de Planétologie et Géodynamique, UMR 6112, CNRS, Université de Nantes, 2 chemin de la Houssinière, 44322 Nantes Cedex 3, France (marion.masse@univ-nantes.fr), [2] Department of Ecology and Evolution, Limnology, Uppsala, Sweden., [3]Institute of Planetary Research, German Aerospace Center (DLR), Rutherfordstr.2, 12489 Berlin, Germany.

Introduction: The North Polar Cap of Mars (Fig. 1) is a stack of water ice layers containing various amounts of intermixed sediment. Two distinct units have been recognized in this stack: (1) The sediment-rich Basal Unit (BU) and (2) the upper ice-rich North Polar Layered Deposits (NPLD) (Fig. 2b). In addition to sediments intermixed in the ice of the BU and of the NPLD, polar sediments also exist in the form of: (1) dunes constituting the Circumpolar Dune Field (Fig. 2a); (2) smaller interior dune fields associated with scarps at the margins of the North Polar Cap (Fig. 2c); (3) sedimentary veneers covering the surface of the NPLD and particularly the interior of spiral troughs (Fig. 2d).

On one of the densest portions of this dune field, Olympia Undae, a calcium-rich sulfate (gypsum) has been detected [1] (area contoured in red on Fig. 1). Signatures of hydrated and mafic minerals have been detected on the rest of the polar superficial sediments [2,3,4]. It is unclear however whether the signatures of hydrated minerals correspond to gypsum or to another hydrated mineral.

To constrain the distribution and the origin of polar gypsum, we performed an integrated morphological, structural and compositional analyses of these different kinds of superficial sediments and their associated morphological features.

Data and methods: The morphological, textural, structural and sedimentological analyses are based on the observation of landforms on altimetry data and high-resolution images from MOLA, MOC, THEMIS, CTX and HiRISE. These observa-tions are compared to analogue landforms on Earth. The mineralogical composition is investigated from data acquired by the OMEGA and CRISM hyperspec-tral imaging spectrometers. These are compared to laboratory spectra of ice-gypsum mixtures in simulated Martian pressure and temperature conditions. When gypsum is mixed with ice, several diagnostic gypsum spectroscopic signatures are difficult to distinguish because ice and gypsum absorption bands overlap each other [5]. To analyze Martian hyperspectral data, we thus used an original method based on spectral derivation [6].

Results: We find that the presence of gypsum is not restricted to the Olympia Planum dunes but is also present on all the superficial sediments found in and around the North Polar Cap: the whole Circumpolar Dune Field, the interior dune fields and all kinds of superficial sediments covering the surface of the North Polar Cap.

- *Interior dune fields associated with marginal scarps (Fig. 2c)*. We have previously observed that the gypsum bearing sediments, constituting the interior dune fields, have been released directly from the ice layers as the marginal scarps retreated by sublimation [5]. By the present analysis of all the scarps-dunes associations, we also demonstrate that the source of the dunes is gypsum-rich sand that was previously contained in the BU. The erosion of the NPLD only leads to the formation of a gypsum-rich dust veneer at the foot of the scarps.

- *Circumpolar dune field (Fig. 1).* Gypsum is detected on the whole circumpolar dune field. Gypsum-rich sand, constituting these dunes, has been exhumed from the BU at the marginal scarps or by vertical ablation on Olympia Planum. Katabatic winds descending from the polar high are responsible for the reworking of this gypsum-bearing sand and the formation of the Circumpolar Dune Field (Fig. 2a and b). These gypsum crystals have been transported all around the polar cap by winds and their remobilization has lead to the decreasing of the grains size and the intensity of the gypsum diagnostic absorption bands [7].

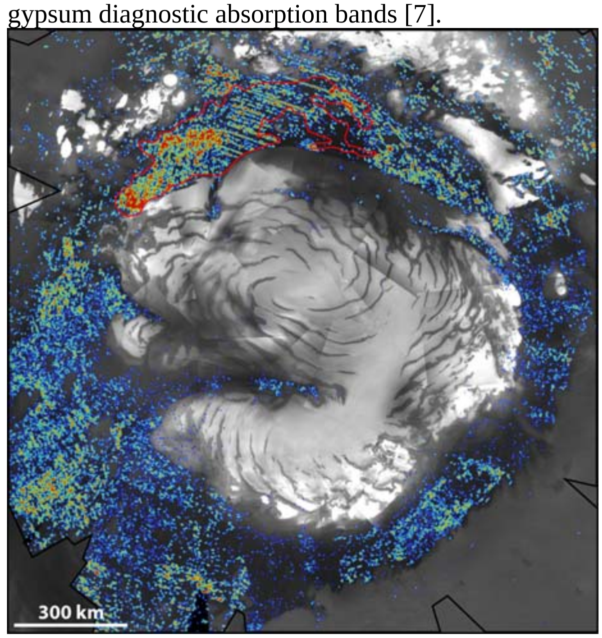

Figure 1: *Maps of absorption bands at 1.94 and 2.21 µm (typical og gypsum) detected by the spectral derivative method on a mosaic of OMEGA cubes. The area where gypsum was previously detected by [1] is outlined in red.*

- *Spiral troughs (Fig. 2d).* The dust veneer covering the interior of the spiral troughs sourced from gypsum-bearing dust that was previously contained in the NPLD ice layers. This dust has been exhumed on the equator-facing slope of spiral troughs by erosion due to katabatic winds [8]. Katabatic winds are responsible to the mobilization of this dust and its accumulation on the pole-facing slope of spiral troughs and more generally at the surface of the polar cap.

Conclusion: Gypsum is present on all the superficial polar sediments. These gypsum-rich sediments derive directly from the ice deposits, including the BU and the NPLD, and have been exhumed from the spiral troughs, the marginal scarps, or by vertical ablation of the ice. This material has beeen reworked by katabatic winds descending along the surface of the North Polar Cap. Dune fields have thus been created from particles released from the BU, whereas the erosion of the NPLD only lead to the formation of dust veneers covering the polar cap. By comparison with chemical reactions observed in Antarctica ice [9], we also infer that the martian gypsum crystals have probably formed direcly in the ice deposits by acid weathering of primary minerals.

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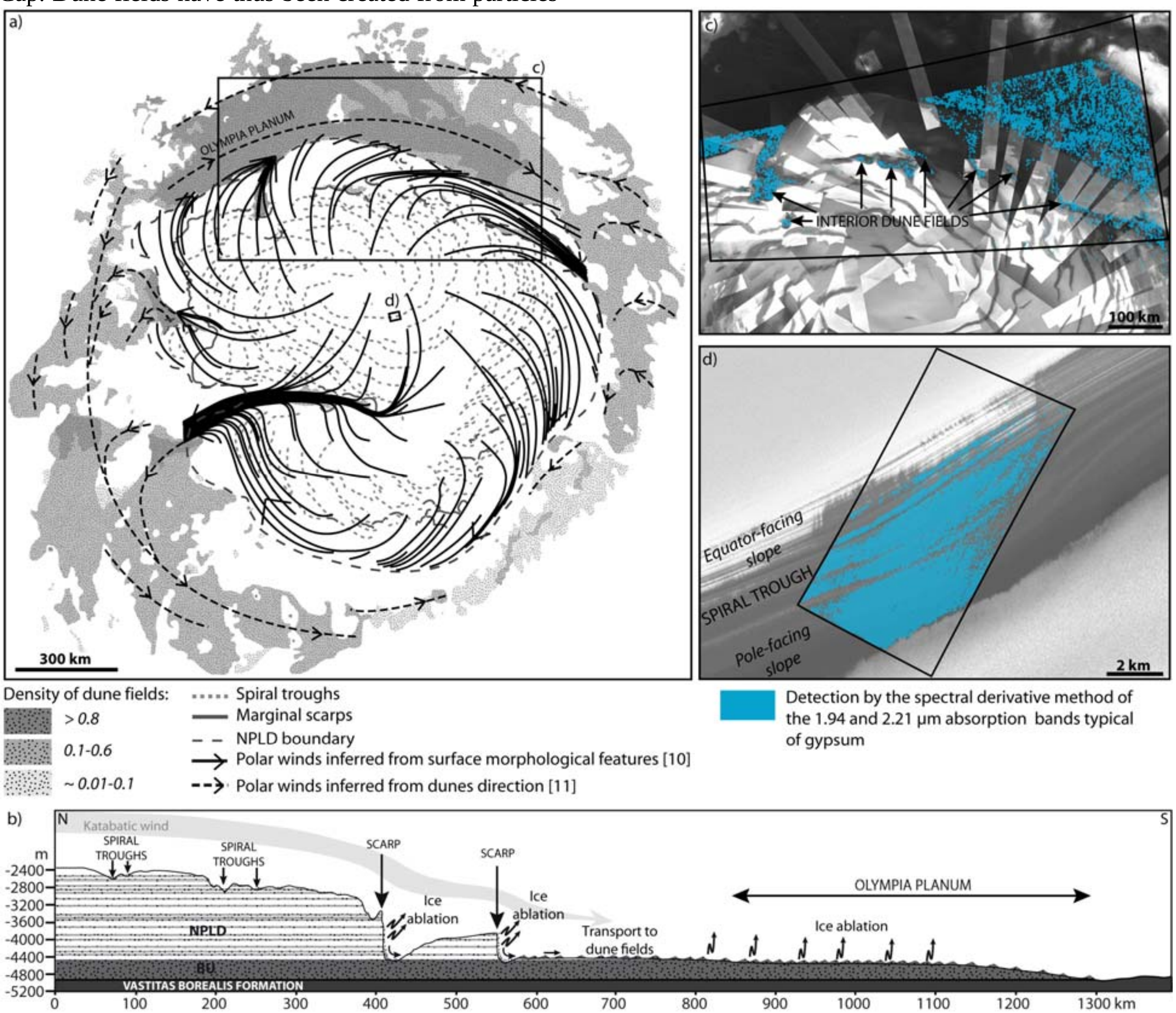

Figure 2: *a) Map of the north polar dune fields, spiral troughs and marginal scarps with superimposition of polar wind flow lines. b) Interpretative scenario for the formation of superficial gypsum bearing sediment in and around the North Polar Cap. c) and d) Distribution of gypsum on the interior dune fields and on a dust veneer covering a spiral trough.*