

Structural Modeling and Reserve Re-estimation of Begumganj Gas Field - A Case Study

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Abstract— Six (6) 2D seismic lines out of twelve (12) of Begumganj structure were considered for this study. The lines are BG-03, BG-05, BG-06, BG-08, BG-09 and BG-10. The total length of the studied seismic lines is 93.2 KM. These six (6) seismic sections were interpreted by using PETREL seismic interpretation software. The contour map shows that the structure of the Begumganj Gas Field is NNW-SSE trending doubly plunging low amplitude slightly asymmetric anticlinal fold. The eastern flank is steeper than the western flank. No fault has been identified in any of the seismic sections. The gas zone VII in well no. 1 as interpreted started at 2970m. In time section, depth converted to 2115ms in Two Way Time (TWT). Wireline logs used to mark this gas zone. Correlation of this gas sand to the litholog shows that this gas sand belongs to the Bhuvan Formation of the Surma Group, a well-known petroleum reservoir in Bangladesh. The productive horizon covers the interval 2970-3050m. Gas water contact (GWC) is about 3017m below the surface. A thick shale unit forms the cap rock. The above information summarizes Begumganj gas field as a prospective area in Bengal Basin.

Keywords— Fold, GWC, 2D seismic, Stratigraphy, TWT.

I. INTRODUCTION

Since the dawn of civilization, energy resources have been the prime mover of human race. Coal, Oil and natural gas are the major non-renewable energy sources. As the contribution of greenhouse gases to the atmosphere by burning coal and oil became more alarming, natural gas has become the fastest growing energy source in the present world. As coal and oil were known as fuel of nineteenth and twentieth century respectively, natural gas becomes the prime fuel in the twenty first century 1.

Most of the simple reservoirs have already been discovered which drive the exploration in a complex area. More and more data needed to discover a new field or enhance recovery from an old field. Hence, prospect evaluation in a prospective area becomes more important in the petroleum industries. This study carried out to evaluate the prospect of Begumganj gas field. Six 2D seismic lines and 2 well logs are used for it.

Begumganj gas field lies in Block-10 under Production Sharing Contract (PSC) for petroleum exploration (Figure.1) in Bangladesh. Two wells have been drilled in Begumganj structure. Well 01 was completed in 1976 drilled by Petrobangla and was successfully tested and commercial gas discovery was made in 1980.



Figure 1: Position of Begumganj structure in the Petroleum Exploration Blocks of Bangladesh. (Source- Petrobangla)

Bangladesh state owned oil & gas exploration and production company, BAPEX has completed 2D seismic data acquisition of 37.2 Line Kilometer (LKM) in 1981 and 141.49 LKM in 2005-06 field seasons over Begumganj area. The Cairn Energy has also acquired a 2D seismic line named SH-04-2004 having 42.2 LKM. The present study has been carried out to decipher the subsurface 3D structural configuration of the Begumganj Gas Field.

II. REGIONAL STURCTURAL SETTING

Bangladesh constitutes the major part of the Bengal Basin which is bounded in the west by the Indian Shield of Precambrian rocks, in the east by the Arakan-Yoma Folded system, in the north by the Precambrian Shillong Massif and in the South it plunges in the Bay of Bengal, which is open for a long distance. The Bengal Basin has been initiated during the early Tertiary Period 4. It had been tectonically unstable as the majority of important geological processes occur at the plate boundaries.

Geomorpho-structural features of Bengal Basin like subduction related accretionary wedges and tensional horst-graben system expresses the sign of juxtaposition of active and passive margin setting of the Indian Plate which influenced to make various anticlinal structures in the Fold Belt area. Several sub-basins that are, Sylhet trough, the Faridpur trough and the Hatiya trough characterize the deeper basin zone. The NE-SW trending elevated oceanic crust separates the Faridpur trough and the Sylhet trough from the Hatiya trough. The study area, Begumganj Structure, tectonically located in the junction of Hatiya trough and elevated oceanic crust which in turn can be said lies on the western fringe of the folded belt zone. Geologically the structure is surrounded by Lalmai structure in the north, Feni structure in the east and Shahabazpur structure in the south. This margin experienced the least compression and also underwent folding at a very recent date. The depositional environment was probably deltaic-fluviatile.

The Bengal Basin became a remnant ocean basin⁵ at the beginning of Miocene because of the continuing oblique subduction of India beneath the southeast extrusion of Burma (West Burma Block)⁶. The Begumganj structure is located in one of the world's thickest sedimentary basins and lies to the west of the Eastern Thrust. As the convergence continued, the upper part of the sub-ducted crustal segments and the rigid crust underlying the Sylhet trough was broken and pushed up by high angle thrust including sediments along this crustal break. This line of crustal break, possibly, has been extended along Chittagong-Cox's Bazar coastal belt in the south and in the north it merged with the Dauki Fault. The thrust fault has been named as the "Eastern Thrust"⁷ (Fig. 2).

Moreover, neo-tectonic activity is well documented both onshore and offshore of the Bengal Basin. All the structures developed in the Eastern Folded Belt region and west of the Eastern Thrust are NNW-SSE trending anticlines⁸.

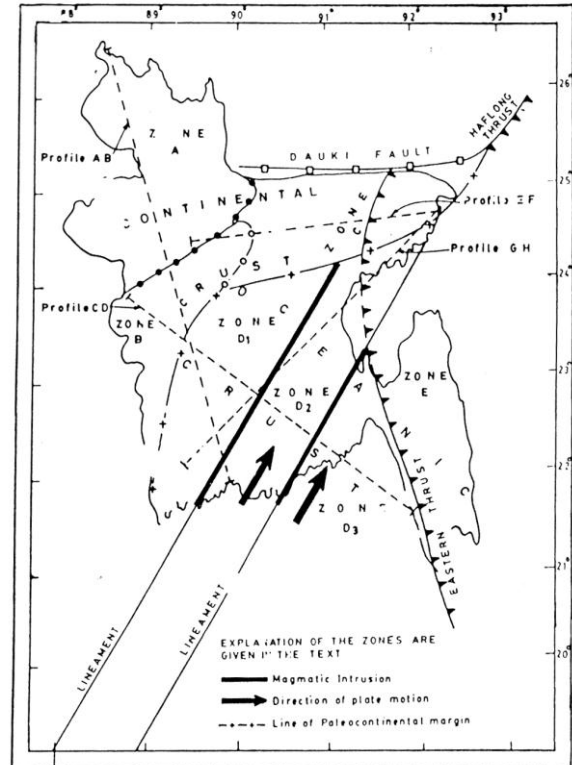


Figure. 2: Geotectonic map of Bengal Basin (Source: Khan, 1991).

III. MATERIALS AND METHODS

For the purpose of the research work, available reflection seismic data and well data have been integrated and reviewed. Six 2D seismic lines and two well logs are used for this study. Table 1 shows the seismic line used in this study. The whole work is divided into two parts. First, structural interpretation was carried out using well logs and seismic data which followed to estimate the volume of hydrocarbon in place. The whole workflow is shown in figure 3.

Table 1:
2D seismic line with acquired year, length and orientation

Serial no.	Seismic line	Acquired (year)	Length (km)	Orientation
3	BG-03	2005-06	21.3	NNW-SSE
4	BG-05	2005-06	21.3	NNW-SSE
5	BG-06	2005-06	8.3	WSW-ENE
7	BG-08	2005-06	13.7	WSW-ENE
8	BG-09	2005-06	12.3	WSW-ENE
9	BG-10	2005-06	16.3	WSW-ENE

Table 2:
Values of TWT, staking velocity and depth of seismic line BG-10

Two Way Time (TWT) ms	Staking Velocity (v) m/s	Depth (Z) m
33.84	1722.74	29.14
488.12	1894.08	462.12
747.81	1996.37	744.62
1111.69	2231.07	1226.56
1538.97	2527.72	1904.25
2117.87	2902.24	2980.65
2466.99	3079.81	3677.34
2840.71	3353.44	4570.87
3631.03	3307.83	5811.05

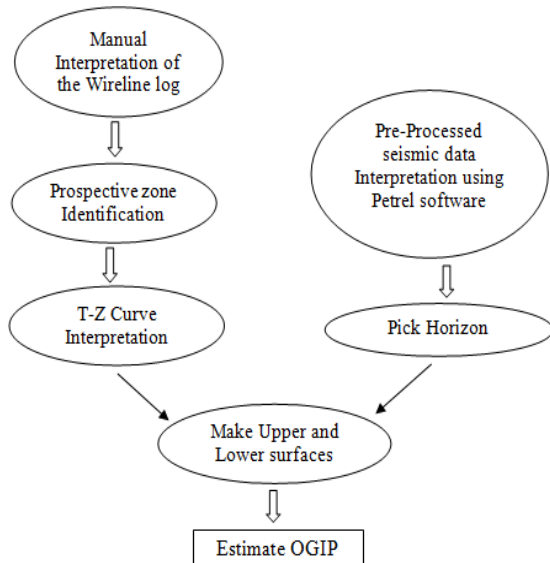


Figure 3: Flow chat of the work

IV. T-Z CURVE

Though the velocity log of the wells were not available, the T-Z Curve (Time-Depth Curve) used in the study is created using the stacking velocity of seismic line BG-10. The values of Two Way Time (TWT), staking velocity and depth of seismic line BG-10 was given in Table 2.

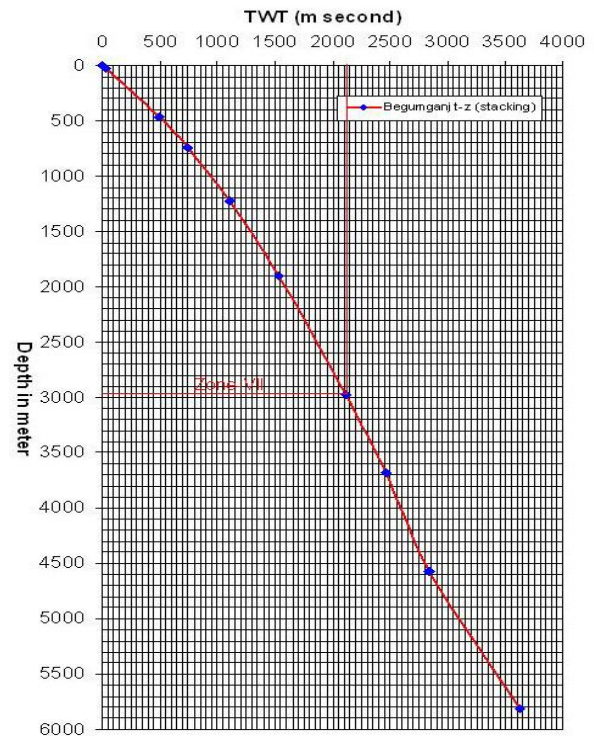


Figure 4: T-Z chart used in the project

The stacking velocity is converted to the average velocity using Dix Formula and this average velocity was then used to convert the two way time to the depth.

The top of the gas zone seven in well no. 1 is marked at 2970 m, which tends to be 2115 ms in Two Way Time (TWT). This conversion is shown in T-Z curve (Figure 4).

V. RESERVE CALCULATION

Reserve is the quantity of natural gas (or oil) that is commercially recoverable from known accumulation under the current economic and operating conditions. In other words, reserve is the quantity of gas that can be extracted from the gas initially in place (GIIP) in the gas field. Gas initially in place (GIIP) refers to the total amount of gas present initially underground (Imam, 2005).

Reserve calculation of a field is a continuous process and never appropriate. It can only be determined accurately after the field is depleted. However, for all practical purposes it is a necessary component to be determined. There are three common procedures such as volumetric, material balance and declining curves methods, by which a good approximation of total and recoverable hydrocarbon reserve can be made. The geologists use volumetric procedure for reserve calculation. On the other hand, the production engineers follow material balance and declining curves methods. For all practical purposes, all these methods should give similar results. Here, in this research work, the volumetric method has been used for reserve calculation.

- GIIP (Gas Initially in Place) in Tcf = $(\text{Area} \times \text{Average effective thickness} \times 10^6 \times \text{Conversion Factor} \times \text{Porosity} \times \text{Gas Saturation}) \div \text{Formation Volume Factor}$
- Recoverable Reserve in Tcf = GIIP $\times$ Recovery Factor (%)

VI. SEISMIC INTERPRETATION

Six (6) 2D seismic lines have been studied in this research. All six (6) sections were interpreted using PETREL software. The total length of the seismic lines used in the study is about 93.2 LKM. The shot point locations of these lines are given in figure 5.

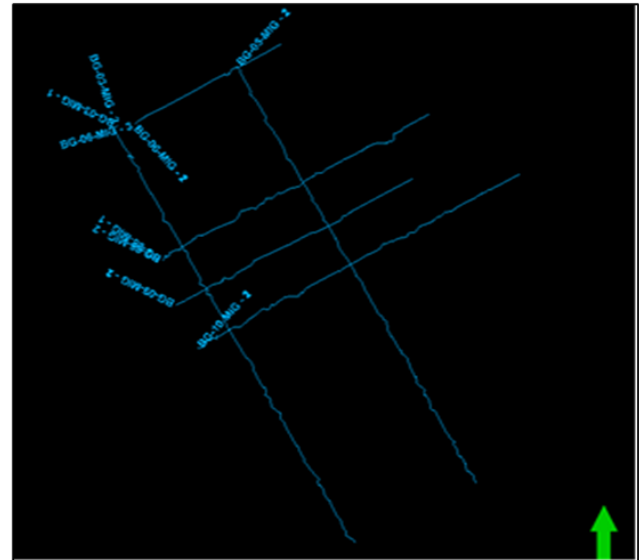


Figure 5: Shot point location on the studied seismic lines.

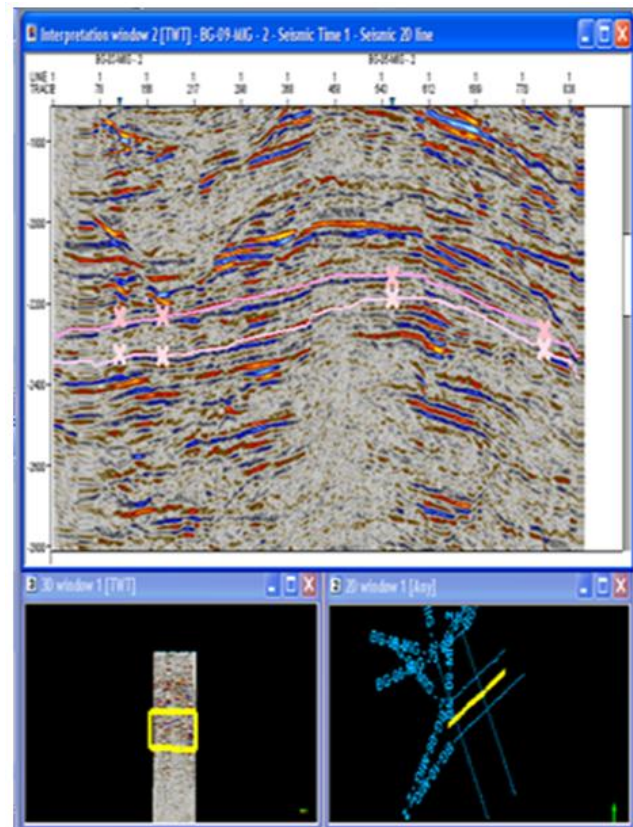


Figure 6: Seismic line BG-09: Showing the Upper and Lower Gas Sand Horizon over Begumganj structure.

The seismic line BG-09 is WSW-ENE oriented line along the dip of the structure with 12.3km length. The seismic lines BG-03, SH-04-2004 and BG-05 intersect the line BG-09 one after another from west to east (Figure 6). This line BG-09 is located to the south of line BG-08. No well is located at this seismic line. The reflection quality of the seismic line is good. The gas sand has been picked in this section.

VII. STRUCTURE IDENTIFICATION

In the present study six seismic lines and the surfaces of the gas sand zone VII are used to construct structural maps using Petrel software. The time contour map made for gas sand (Zone-VII) horizon shows the NNW-SSE structural trends. The structural trend of this gas sand is marked in the contour map. The horizons in the seismic sections show that they are very low amplitude doubly plunging folds (Figure 7). No faulting has been observed in the structure. From the above discussion, it may be concluded that the Begumganj structure is a low amplitude NNW-SSE trending doubly plunging anticlinal structure. This structure is slightly asymmetric. The eastern flank is steeper than the western flank (Figure 8). As no fault is identified in the sections and the gentle appearance of the fold indicates that the structure is free from major tectonic deformation.

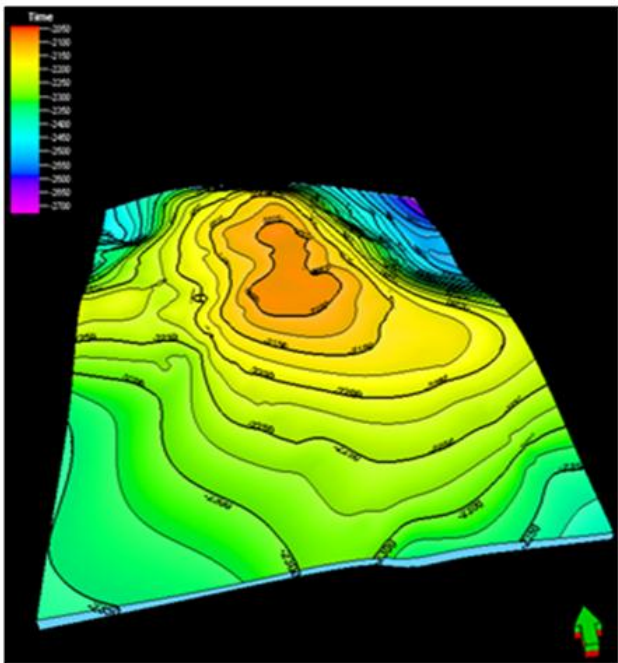


Figure. 7: Low amplitude doubly plunging asymmetrical Begumganj structure

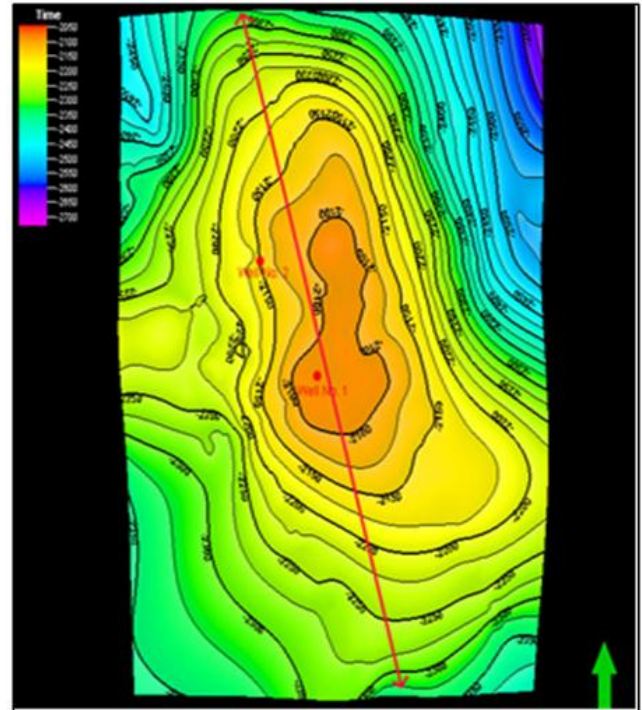


Figure 8: The structural trend of the Gas Sand (Zone-VII) of Begumganj structure.

VIII. HYDROCARBON POTENTIAL

All most all the gas fields of Bangladesh are confined to the anticlinal structures of folded flank of Bengal foredeep. Stratigraphically all the pay zones are within Surma Series of Miocene. In Begumganj only one pay zone was discovered and it is in the Upper Bhuban Formation.

The pay zone is a thin series of sandstones with shale alternation. The cap rock is formed by thick shale. The top of the productive horizon (Figure 9) at crest is 2970 m. In Two Way Time (TWT) section it is 2115 ms. The productive horizon covers the interval 2970-3050 m. In time section the interval is 2115 to 2160 ms. Birds-eye view shows the reservoir sand above GWC with the location of two well (Figure 10). It's possible to identify probable future well location using this snap.

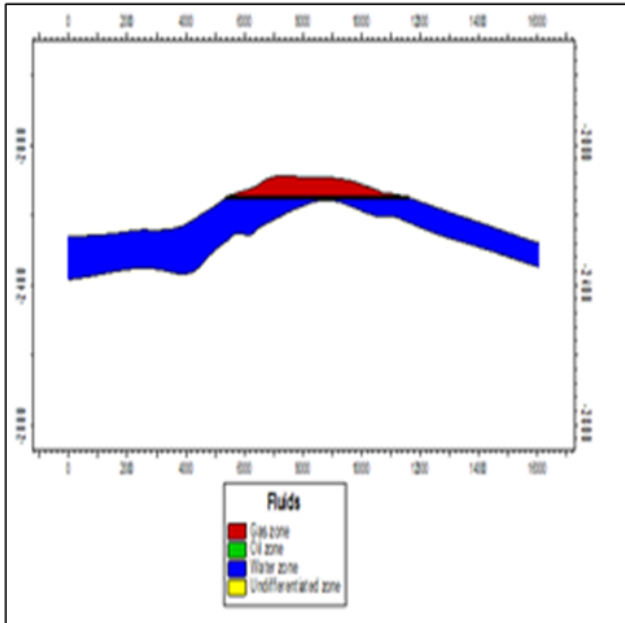


Figure 9: Productive horizon of the Gas sand (Zone-VII).

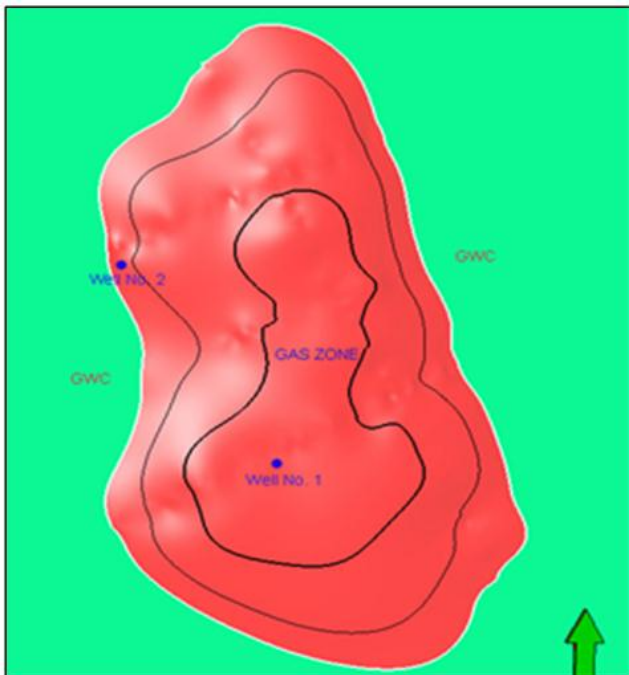


Figure 10: Bird eye view of the Gas sand (Zone-VII) above GWC.

IX. RESERVE ESTIMATION

From the above structural interpretation the reservoir area re-estimated as 46.7 km².

When area (A) is in km² and thickness (h) is in meters, applying unit adjustments, standard ft³ of gas initially in place (GIIP) is obtained with the following equation:

$$G = A \times h \times 10^6 \times 35.3145 \times \phi \times (1 - S_w) / B_g$$

Where, 1 km² = 10⁶ m² and 1 m³ = 35.3147 ft³

$$\begin{aligned} \text{The reserve (GIIP)} &= \text{Area} \times \text{Average effective thickness} \\ &\times 10^6 \times 35.3147 \times \text{porosity} \times \text{Gas saturation} \times 1/B_g = 46.7 \times \\ &8.7 \times 10^6 \times 35.3147 \times 0.14 \times (1 - 0.415) \times 1/0.002956 = \\ &397.53 \text{ Bcf} = 11.701 \text{ BCuM} \end{aligned}$$

$$\begin{aligned} \text{Recoverable Reserve} &= \text{Total Reserve} \times \text{Gas} \\ \text{recoverable Factor} &= 11.701 \times 0.85 = 9.9458 \text{ BCuM} \end{aligned}$$

The previous total recoverable gas reserve of Begumganj gas field was 3.717 billion cubic meter (BCuM) which was estimated by BAPEx. In this research work, the recoverable reserve is 9.9458 BCuM. In this study, other than the areal extent of the reservoir zone, all other properties remain same as BAPEx. So the difference in recoverable reserve is only because of structural re-interpretation.

X. CONCLUSION

Bangladesh state owned oil & gas exploration and production company, BAPEx has completed 2D seismic data acquisition along 12 seismic lines. Six (6) seismic lines have been interpreted by the Petrel software. The lines are BG-03, BG-05, BG-06, BG-08, BG-09 and BG-10. The total length of the seismic lines used in the study is about 93.2 LKM. The gas sand horizon is picked on the basis of the seismic reflection parameter.

The T-Z curve has been prepared using the stacking velocity of seismic line BG-10. The stacking velocity was converted to the average velocity using Dix Formula and this average velocity was then used to convert the two way time to the depth. The top of the gas zone seven in well no. 1 is marked at 2970 m, equivalent to 2115 ms in Two Way Time (TWT).

The time contour map of the gas horizon has revealed NNW-SSE the structural trend of Begumganj structure. This structure is slightly asymmetric very low amplitude doubly plunging fold.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 4, April 2015)

The eastern flank is steeper than the western flank. Absence of fault in the sections and the gentle appearance of the fold indicate that the structure is free from major tectonic deformation and is more potential for hydrocarbon accumulation.

The gas bearing sand horizon (Zone-VII) belongs to Bhuban formation of Surma Group at a depth of about 2970m in well no.1 and 2995m in well no. 2. This productive horizon covers the interval 2970-3050m. The gas water contact is about 3017m below the surface.

In gas bearing sand horizon (Zone-VII) the SP response shows negative deflection while the resistivity log shows resistivity above 40Ωm indicating that the presence of hydrocarbon (gas). A thick shale unit forms the cap rock.

XI. RECOMMENDATION

The 2D seismic lines of the Begumganj structure are of good quality. But for proper identification of structural configuration and estimating the gas reserve more accurately the 3D data set on the Begumganj structure is essential and hence the 3D seismic survey is recommended.

The T-Z curve was made using the stacking velocity of the seismic section BG-10, because the sonic log was not available. Sonic log is recommended to be carried out along with other logs in the future whenever opportunity arises for making T-Z curve and synthetic seismogram. VSP data should also be acquired in any future well drilling in the Begumganj field.

If 3rd well is drilled in Begumganj field, it should be located in 3.5 Km north from the well No. 1, because the probability of finding the gas sand is high in that area.

In short, it can be said that 3D seismic survey is required in Begumganj area for proper structural configuration delineation, identification of the stratigraphic and combination traps, if any, and determination of the prospective zone at greater depth.

Acknowledgement

Herewith the authors would like to acknowledge Bangladesh petroleum exploration & Production Com. Ltd. (BAPEX), for providing all required data, cooperation, analytical explanation and guide line during this research work.

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