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Integrated study of gravity and seismic data of Bengal Basin.

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Summary

Regional gravity anomaly map prepared incorporating ONGC vintage data along with gravity data of Bangladesh available in public domain, has brought out the hinge zone trend clearly and the same is validated from seismic data. Gravity modelling shows that there is a depression in the middle of the area under Kolkata-Mymensingh gravity high which may be interpreted as some paleo-sediments below traps. Depth to basement in the western part of basinal low is 2 km increasing more than 15 km in the eastern part near the hinge zone area and east of it

***Keywords**: Bengal Basin, Integrated Interpretation*

Introduction

Bengal Basin lies in the North-eastern part of Indian subcontinent, between Indian Shield to the West and North, and Indo-Burman Ranges to the East, covers Bangladesh, parts of West Bengal and Tripura states of India and the Bay of Bengal (Fig.1). Being a polycyclic basin, it has evolved through two distinct tectonic episodes. It was initiated as an intra-cratonic rift basin within Gondwana land during Late Paleozoic-Mid Mesozoic time and received the continental Gondwana sediments. This phase of basin development ended with wide spread volcanism during which continental flood basalts (Rajmahal Trap) covered the Gondwana sediments. Second phase of basin formation took place when Indian Craton separated out completely from the Gondwana land and kept on moving northwards. During this journey of the Indian plate, the peri-cratonic part on the eastern margin (along with Gondwana sediments) continuously subsided and received colossal volume of sediments from Late Mesozoic through Tertiary to Recent times in a passive margin set-up. In its northern journey, the Indian plate collided with the Eurasean plate and caused up folding and thrusting forming the Himalayan Orogenic belt. Further movement of the Indian plate was in the northeasterly direction, northeastern end of Indian plate collided with the Burmese plate, the former subducting below the latter, and the sedimentary accretionary prism gave rise to the formation of AssamArakan thrust fold belt.

Bengal Basin is traditionally sub-divided into four NE-SW trending tectonic zones. These zones from West to East are as follows:

a) Basin margin zone, characterized by shallow depth of Archaean rocks with down to basement and en echelon fault system
b) Shelf zone, where the Archaean basement maintains a uniform low gradient slope towards east and south east.
c) The Hinge zone (Shelf Break), characterized by sudden increase in the slope which is distinct at the level of Eocene limestone top (Kalighat limestone) as seen in seismic sections.
d) Deep basin zone where basement is not identifiable due to thick sediment cover.

The basin draws exploration interest because of its relation to three spectacular geologic systems—the world's largest orogenic system, the Himalayan Range which is drained by the Ganges–Brahmaputra rivers to develop the world's largest fluvio-deltaic system, the Bengal Delta covering an area of about 200,000 sq.km. Many attempts have been made in the past to establish the hydrocarbon potential of the basin. Though it could add some value to the western margin of the basin but in eastern part it remains as a challenge for geophysicist as most well drilled in the eastern part terminates only in late Miocene only. As seen from the seismic section shown in fig. 2 all the reflectors are dipping

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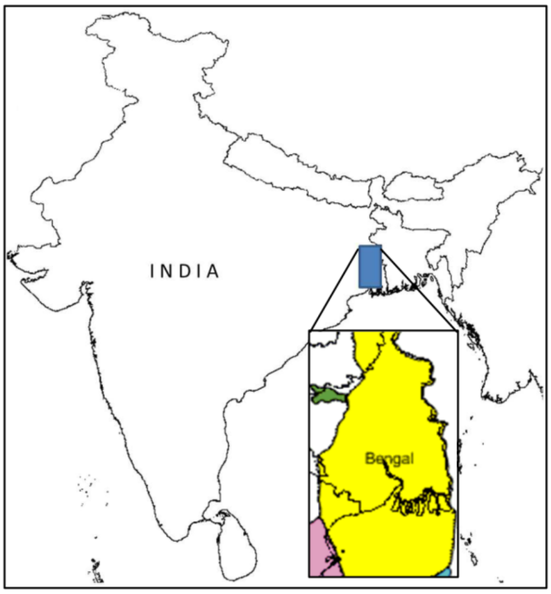

Fig.1. Location Map of the study area

towards the east. Though at some location the shallow basement could have mapped with seismic in many places in eastern part of the basin no good reflection could be seen below the Eocene limestone marker. With new input in the basin an attempt is made to delineate the basement configuration of the eastern part of the basin.

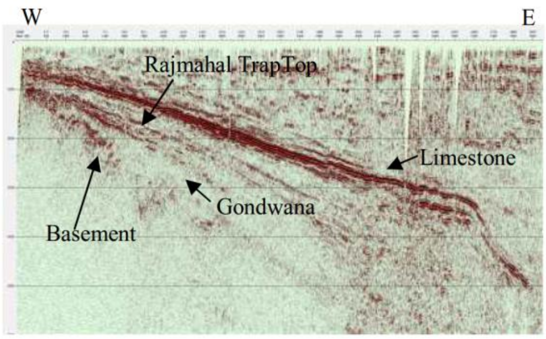

Fig. 2. Seismic profile across the study area

Methodology

A gravity anomaly map is prepared integrating the data available in-house along with newly acquired data and public domain Bangladesh gravity data to have a regional view of Bengal Basin and its surroundings (Fig-3A). The silent feature in the map is a big gravity low trending NNESSW, which bifurcates into two parts, one in the north east direction towards Dauki fault and other in the north west towards Purnea and Madhubani depression, which may be due to deposition of low density Gondwana sediments below Rajmahal traps as seen in seismic section (Fig-2). The gravity high in the west may be due to exposed basement, shallow basement and Rajmahal trap. Gravity high towards eastern part of gravity low, known as Kolkata-Mymensingh gravity high, may be due to contributions of rise up of Moho, thickening of Rajmahal traps and absence or thinning of sub trappean sediment.

Fig. 3B shows residual gravity anomaly map prepared after removing wavelength longer than 40 km to see finer features. It has brought out many isolated gravity lows that may be due to low density Gondwana sediment deposited in the rifted grabens and gravity highs belonging to horst in western part gravity low which is co-relatable with seismic section (Fig-2).

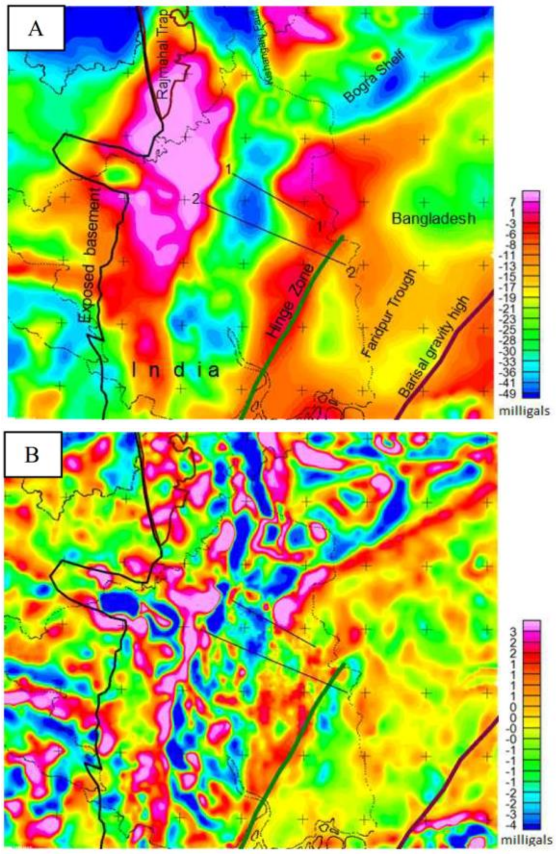

Fig. 3. (A) Bouguer gravity anomaly after merging with public domain Bangladesh gravity data. (B) Residual gravity data after a high pass filter of wavelength ≤ 40 Km.

Horizontal gravity derivative along EW direction (Fig-4A) has brought out clearly shelf margin fault and Kishanganj fault. While NS direction derivative (Fig-4B) brought out the trend of hinge zone from gravity data, which is validated from seismic data. The continuous green line is marked from seismic overlay exactly on dotted line drawn on the basis of derivate map.

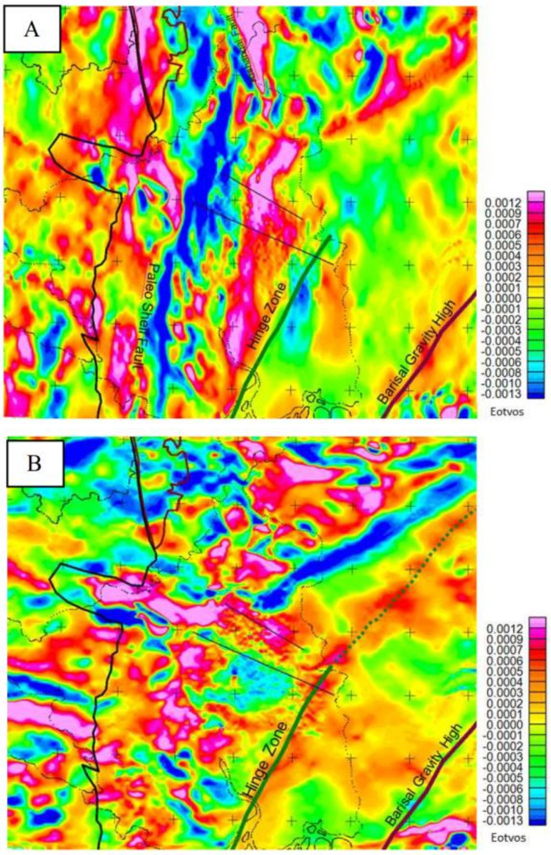

Fig. 4. Horizontal derivatives of Bouguer gravity anomaly (A) along East-West direction. (B) along North South direction.

Modeling approach

Seismic horizons correlated with Wells are picked and converted into depth with interval velocities computed from RMS velocities. These converted horizons are tied with well depths again to remove any ambiguities in seismic horizon depths. These horizons are constrained for gravity modeling along with averaged densities obtained from well logs.

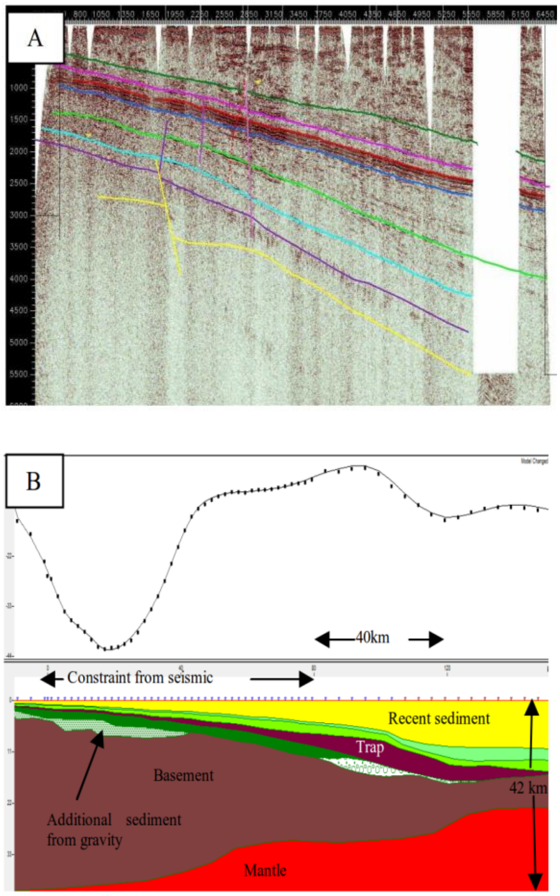

Fig.5 (A) Seismic section along profile 11/ and (B) Gravity modeling of same profile.

Major uncertainties are encountered in deciding densities of sedimentary layers and trap. As sediment thickness is varying roughly from 1 km to 10 km along EW profiles, using a single density for same formation may not be appropriate but applying differential density will be too complex for modeling. Therefore, in order to simplify, though averaged trap density obtained from well data is 2.6 gm/cc (low because of intertrappean), high density of 2.8 gm/cc is used for trap modeling. Taking 2.27 gm/cc for recent sediment, 2.47gm/cc for paleo sediment and 2.27 for Gondwana sediments gravity modeling along the profiles 11/ and 22/ is carried out and shown figures 5B and 6 respectively.

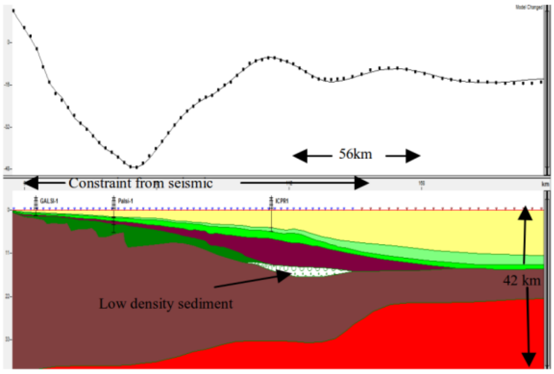

Fig.6 GM modeling along profile 22′.

Gravity modeling shows that Rajmahal trap is varying from few hundred meters in the west to more than 5 km in eastern part of Bengal Basin, thickest near hinge zone.

As demanded in gravity modeling thickness of Gondwana sediment will be more than it appears on seismic in the basinal low part, where gravity low trend is prominent, it may be deep up to 9 km. Also there is low density sediment below the trap in and around hinge zone which may belongs to Gondwana series being thickest near profile 22′ and thinning to the north as well as in the south.

Depth to Moho in the study area is ranging from 40 km in the western part to 30 km near hinge zone and further shallower in the east up to 23 km. Beyond study area estimating sediment thickness or rise up of Moho has no value as the density contrast of the two is complimentary.

Conclusions

Gravity modeling shows isolated gravity depressions belonging to Gondwana sediments may be upto a depth of 9 Km in basinal low area which connect with low density sediment prominent below the traps near hinge zones.

The depth to basement is ranging from 2000 m to 17000 m in the eastern part of the study area while the Rajmahal trap thickness is increasing from 200 m in the western part to more than 5000 m in the east.

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References

Mahmood Alam , M. Mustafa Alam , Joseph R. Curray ,M. Lutfar Rahman Chowdhury , M. Royhan Gani: An overview of the sedimentary geology of the Bengal Basin in relation to the regional tectonic framework and basin-fill history Sedimentary Geology 155 (2003) 179–208

A.A. Khan and T. Rahman: An analysis of the gravity field and tectonic evaluationof the northwestern part of Bangladesh Tectonophysics, 06 (1992) 351-364 Elsevier Science Publishers B.V., Amsterdam

Palmowski D, Schenk O ,Srivastav D K , etal: Understnading of petroleum systems of Gondowana and Paleogene sediments in Bengal Basin including Purnea - A report for KDMIPE September 2011.

Ashraf Uddina, Neil Lundbergb: Miocene sedimentation and subsidence during continent–continent collision, Bengal basin, Bangladesh Sedimentary Geology 164 (2004) 131–146

S.N. Saha, A.K. Roy, C.V. Brahman, C.B.K. Sastry and M.K. De: Geophysical exploration for coal-bearing Gondwana basins the states of West Bengal and Bihar in northeast India Tecfonopkysics, 212 (1992) 173192Elsevier Science Publishers B.V., Amsterdam173 Geological Survey of India, Calcutta, India

Joseph R. Curraya, Frans J. Emmelb, David G. Moorec : The Bengal Fan: morphology, geometry, stratigraphy, history and processes Marine and Petroleum Geology 19 (2003) 1191–1223

P.R. Reddy , A.S.S.S.R.S. Prasad, Dipankar Sarkar: Velocity modelling of Bengal Basin refraction data—refinement using multiples Journal of Applied Geophysics 39_1998.109–120

Abhijit Mukherjee , Alan E. Fryar , William A. Thomas : Geologic, geomorphic and hydrologic framework and evolution of the Bengal Basin, India and Bangladesh Journal of Asian Earth Sciences 34 (2009) 227–2410.