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Integrated Interpretation of Gravity, Magnetic & Seismic data for delineation of Basement Configuration in Sadiya Block, Upper Assam, India

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Summary

Gravity and magnetic data were collected jointly by National Geophysical Research Institute (NGRI), Hyderabad and Oil India Limited (OIL) during 2005 - 2008 in OIL's NELP-V Sadiya Block. Gravity was collected using Lacoste and Romberg Gravimeter (Model G) with an accuracy of 0.01 mGal. The magnetic data was collected using Scintrex Magnetometer (maintained for Base Station) and Geometrics Magnetometer (used for field data acquisition) with an accuracy of 0.01 nTesla at spacing of 0.05 km to 1.0 km interval.

The main objective of this interpretation was to establish depth to magnetic basement, basement configuration and basement related structural elements. The results of this interpretation strengthen the seismic interpretation. The combined use of gravity, magnetic and seismic data helped in understanding and resolving the geological features and constraining the basement depth during seismic interpretation. The integrated interpretation of these data derived the basement depth, basement configuration, sediment thickness etc. These results have been further refined with 2.5-D/3-D modeling and generated a three dimensional basement configuration map. A number of positive structural features were identified which may provide leads for future hydrocarbon exploration. The computed density model suggests a fault controlled undulating sub surface with maximum basement depth of approximately 6 km in the south-eastern corner and the minimum depth of 4 to 4.5 km in the north-western and north-eastern part of the study area.

The results thus obtained in the integrated interpretation of Gravity, Magnetic and Seismic data of Sadiya Block in Upper Assam in north eastern part of India are presented in this paper.

Keywords: Block, Basement, Integrated Interpretation, Gravity, Magnetic, Seismic.

Introduction

The Sadiya Block is located in Assam-Arakan Basin in northeastern part of India (Refer Figure-1). The Assam-Arakan Basin was developed as a composite shelf-slope-basinal system during Early Cretaceous to close to Oligocene. However, during post-Oligocene time, the different parts of the mega basin witnessed different evolutionary trends, mostly under compressive tectonic forces. The area forms a part of Brahmaputra plain which are bounded by Himalayan range in the north, Naga-Patoki ranges to the south and Mishmi hills form its eastern limit. The general geology and structure of this area were presented in Figure-1.

The study area bounded by 95° 37.48' E to 95°58.12' E longitude and 27° 51' N to 27°58.12' N latitude. Approximately 235 numbers of gravity and magnetic observations were collected jointly by National Geophysical Research Institute, Hyderabad (NGRI) and Oil India Limited (OIL) during 2005-2008 at a station interval of approximately 0.5 to 1.0 km along all roads and available tracks in the area. Bouguer Anomaly and total intensity magnetic maps have been generated and separation of regional-residual fields carried out using appropriate analytical tools. Three selected profiles have been considered for further 2½-D modeling with the available geophysical information from the surrounding areas to delineate basement depth. The available information with seismic and nearby well log data, suggests four layer sedimentary section overlying the basement with density distribution of 2.0, 2.2, 2.5, 2.6 and 2.7 g/cm³ respectively.



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Assam-Arakan basin has been categorized as a proven petroliferous basin. During last decades, several geophysical surveys were conducted in this area (Singh et al., 1996). For the first time in 1999-2000, gravity and magnetic surveys of largely unexplored area within the foreland basin of Upper Assam & Arunachal Pradesh was successfully completed by the NGRI (NGRI, 2000). These studies indicated presence of NE-SW trending basement high east of Jonai and Pasighat, a prominent basement depression south of Namsai and basement high coinciding with the Manabum anticline (NGRI, 2005),

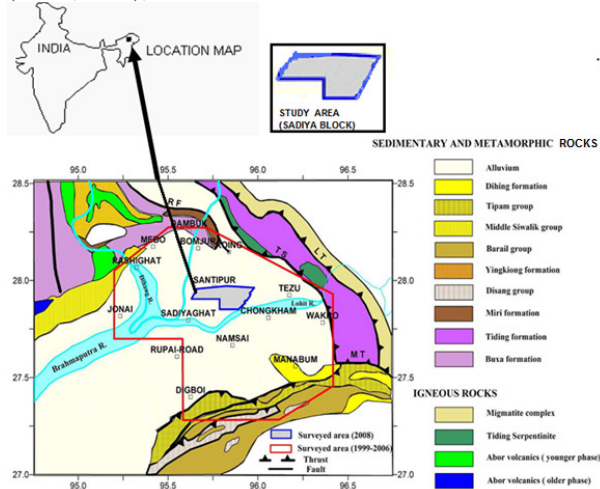


Figure 1: Location of the study area along with geology. LT- Lohit Thrust, MT-Misimi Thrust, TS – Tiding Suture, RF – Roing Fault.

Geological Setting

Sadiya area is situated in the north-eastern most flank of the Upper Assam Shelf close to the syntaxial bend of Eastern Himalayas. The under-thrusting of the sedimentary column towards the east since Miocene (Time of Himalayan Orogeny) has resulted in a relatively deeper Paleogene sequence in the area. The study area is covered by alluvium and the basement rocks are covered by near horizontal to gently dipping Cenozoic sediments except in the eastern most part of the Upper Brahmaputra plain where the sediments are folded due to a southwesterly Mishmi thrust (Gopendra Kumar, 1997).

The interpretation of seismic data and correlation with the data of GM survey & Aeromagnetic data indicate that the

axis of the Central Basement High (CBH) passes through Kabo Chapori, in the westernmost part of the Sadiya Block. The regional structural configuration within Paleogene indicates an oval shaped depression, however, with an easterly dipping general trend towards Sadiya Low.

The regional correlation with north bank of the Brahmaputra and the drilling evidence of well Mechaki-1, which is located about 10 km to the South-Southwest of the block, suggest a relatively thinner column of Paleogene sediments whereas the Neogene to recent sediments are expected to be much thicker and deposited under relatively high energy conditions than the areas in the South Bank of the Brahmaputra. Thus, the source rock thickness within the Barail may be thin, although, coal carbonaceous shales of the Paleocene-Eocene are expected to charge the area from the east (Sadiya Low) and southeast (Namsai Low). The area is also located to the southeast of the Pasighat Low as evidenced by GM data. The expected Basement depth within the PEL block is likely to be quite (more than 6000 m) expect for the western part of the PEL.

Interpretation of Gravity and Magnetic data

The gravity, magnetic and seismic interpretations have been carried out jointly in the study area. The surface is varying from 120 m to 200 m above mean sea level. It is noted that the elevation are gently increasing from south-west direction to the north-east direction. The elevation map of the area is shown as Figure-2. The area is divided into two parts comparatively higher and lower gravity anomaly. Sadiya block appears to have increasing gravity from South-East to North-West direction as shown in Figure-3. The Bouguer Anomaly map is the cumulative effect of anomalous masses at different depth distribution and need regional-residual separation from deep seated to shallow seated anomalous configuration. Figure -4 shows the regional anomaly map and Figure -5 shows the residual anomaly map.

In case of hydrocarbon exploration, we are interested in shallow sources represented by the residual field (Fig.5). There is no infallible unique single method for regional-residual separation. Methods like manual smoothing; polynomial approximation and wavelength filtering are generally applied to obtain the approximate residual gravity field. The maximum depth to the basement is approximately 6.0 km in the SE corner and the minimum depth of about 4.0 km is observed in the NW part of the study area. Since the



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sediments are usually nonmagnetic, magnetic anomalies requires heterogeneous basement blocks with susceptibility varying from 1.0×10^{-5} to 3.0×10^{-3} CGS units.

Three simultaneous gravity-magnetic profiles L6, L8 & L9 as shown in Figure-7 and Figure- 8 to were selected to carry out 2½-D gravity-magnetic modeling. During interpretation of Profile L6 (which is about 15 km in length), it was observed that the depth of the basement across the NW-SE trending profile is in general decreases. The maximum depth to the basement is about 6 km towards the southern part and minimum of about 4.25 km towards northern part of the study area. The final depth section shown in Figure- 9 is obtained after changing the geometry and properties of the initial model using interactive forward and inverse modelling procedures which shows good match between observed and calculated gravity and magnetic anomalies. The magnetic susceptibility of the basement shows large variation ranging from minimum of about 5.0×10^{-5} to maximum of about 3.0×10^{-3} CGS units. In general, basement has higher susceptibility towards north as compared to the southern part of the area.

The another GM Profile L8 about 20 km length which is parallel to seismic line SC-24 and is trending NW to SE direction, where basement depth is decreasing from south to north (Fig-10.). There is gradual decrease of both gravity and magnetic fields from north to south as in the previous profile. However, the rate of change of gravity magnetic field is higher in the middle part as compared to the northern as well as southern parts. There is good match in observed and calculated gravity-magnetic data during crustal modelling. The basement depths are gradually increasing from north to south from 4.5 km upto 6 km.

GM profile L9 which is 20 km long and also trending from NW to SE direction is parallel to seismic line SC-26 and also parallel to other GM lines L6 and L8. The basement depth is undulating and gradually increasing from north to south direction which is varying from 4.5 to 6 km (Fig-11.)

Using 2½-D gravity-magnetic modeling, basement contour maps are generated. (Fig-12). During crustal modeling and analysis three distinct layers are demarcated at different depth of 1050 m, 3000 m and upto 5500 to 6000 m respectively (Fig-9, Fig-10 and Fig-11). First layer marked for Alluvium and Dhekiajuli and the second layer marked for Tippam, Barail and Kopili formations. Third layer comprises

Sylhet and Lakadong formation lying above the crystalline basement.

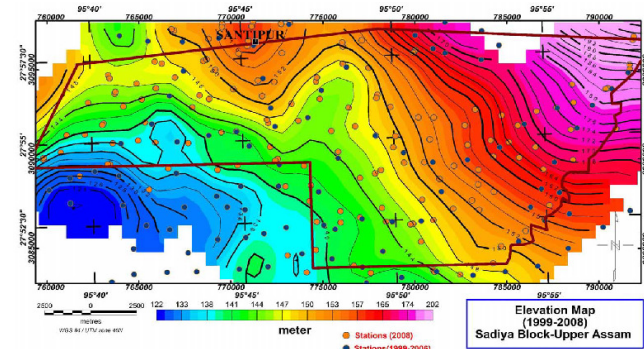


Fig. 2: The elevation map of the Sadiya block area

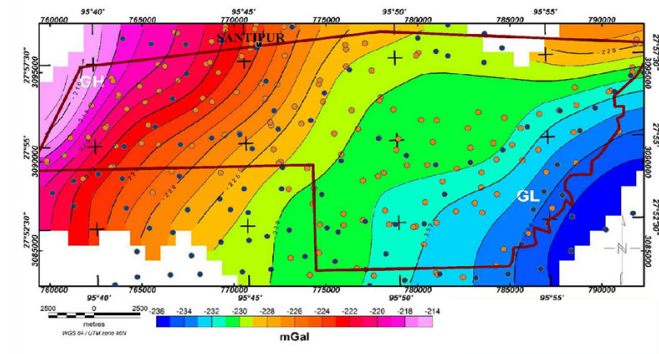


Fig. 3: Complete Bouguer Anomaly Map. Anomaly trend is increasing from South-East to North - West direction.

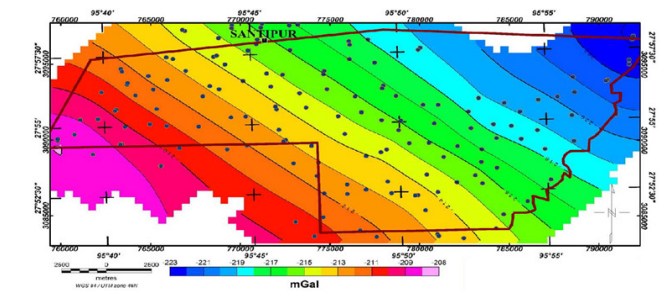


Fig. 4: Regional Anomaly Map of the Sadiya Block



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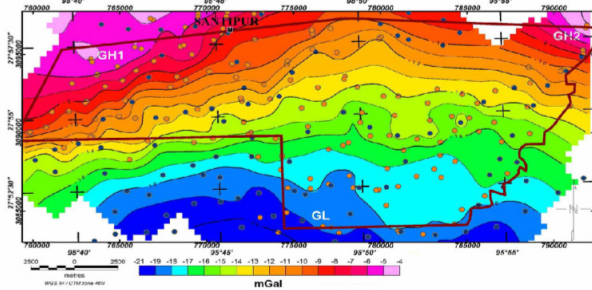


Fig.5: Residual Anomaly map of the Sadiya Block.

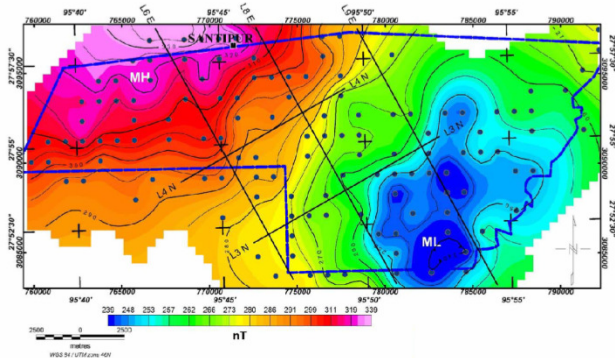


Fig. 8: Magnetic Anomaly Map with the selected Profiles.

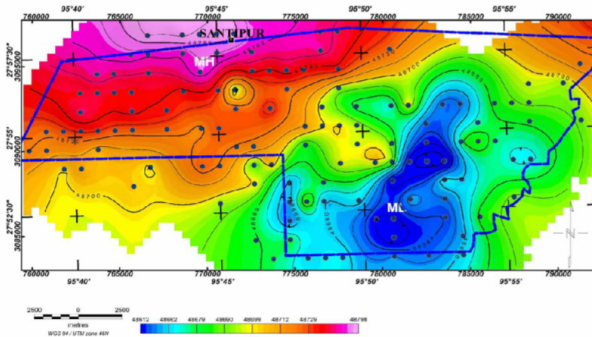


Fig. 6: Total Magnetic Anomaly Map of the Sadiya Block

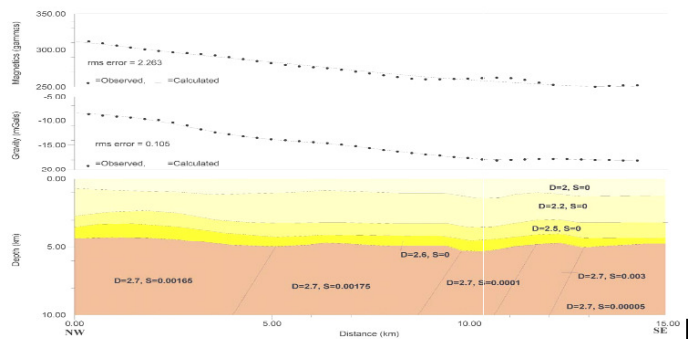


Fig. 9. Gravity and Magnetic modeling and the basement configuration for the profile L6.

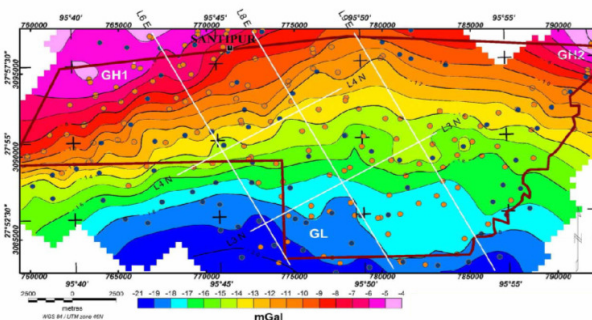


Fig. 7: Residual Gravity anomaly Map with selected Profile.

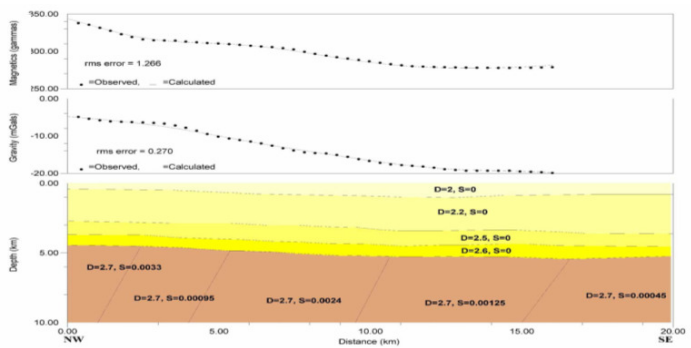


Fig. 10. Gravity and Magnetic modeling and the basement configuration for the profile L8.



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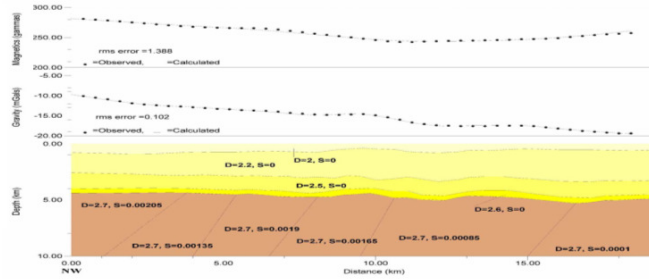


Fig. 11. Gravity and Magnetic modeling and the basement configuration for the profile L9.

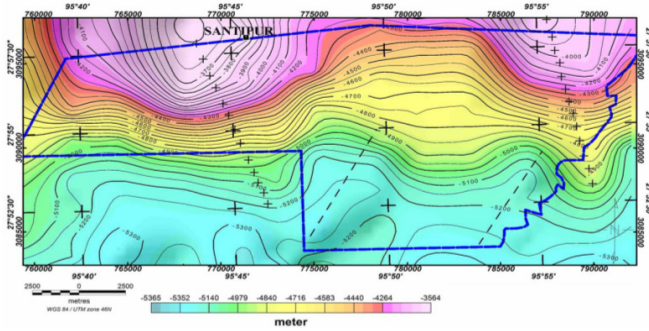


Fig. 12. Basement depth contour map. +++ Indicates High depth and --- shows Low depth.

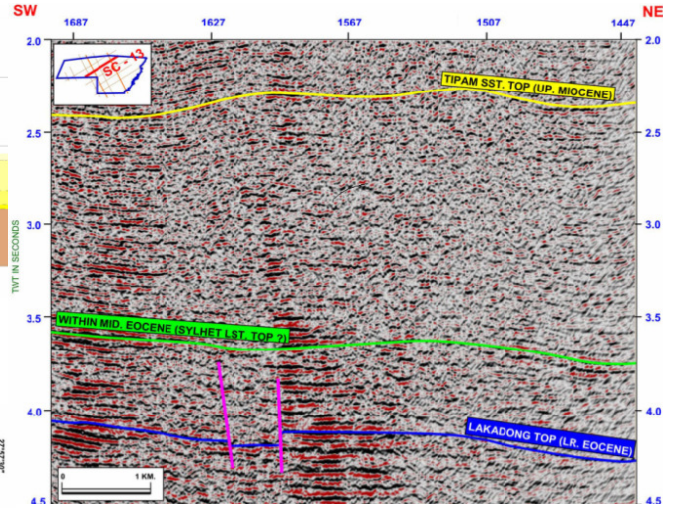


Fig.13: The interpreted 2-D seismic section SC-13 crossing the 2-D Gravity & Magnetic Profiles (L6, L8 and L9).

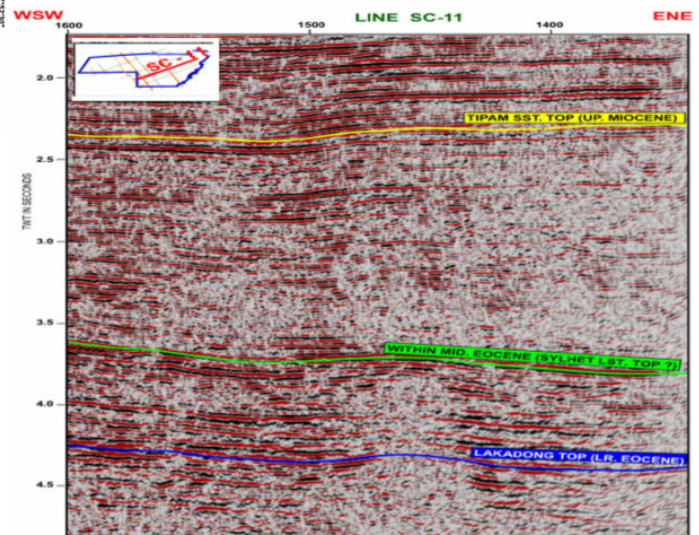


Fig. 14. The interpreted WSW-ENE direction seismic line SC-11 crossing the Gravity & Magnetic profile L6, L8 and L9.



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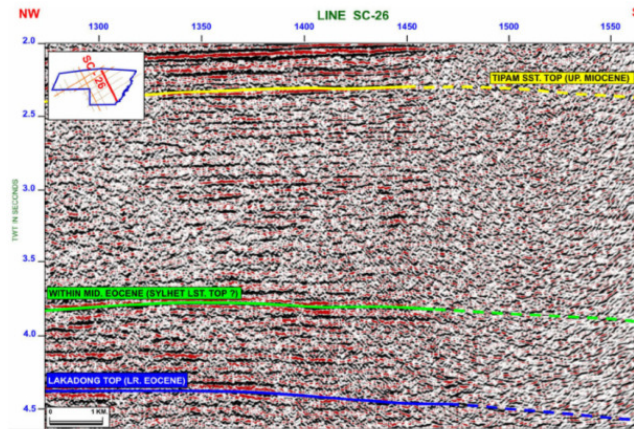


Fig. 15. The interpreted NW-SE 2-D seismic line SC-26 passing parallel to Gravity & Magnetic Profile L9.

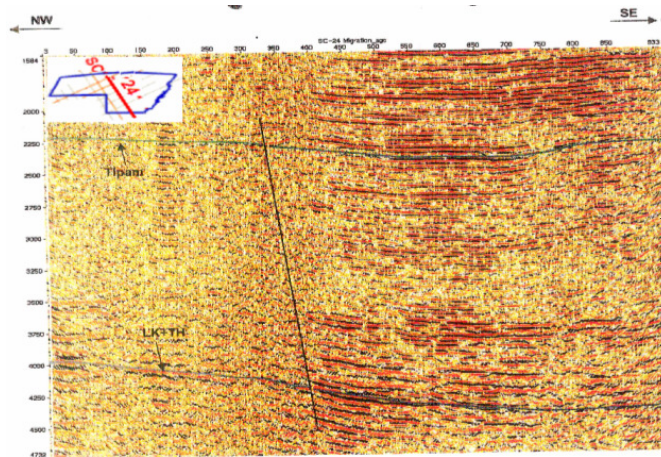


Fig. 16. The interpreted NW-SE 2-D seismic line SC-24 passing parallel to the Gravity & Magnetic Profile L9.

Discussion and conclusions:

The results obtained through gravity-magnetic modeling corroborate the results of seismic interpretation of the area. Basement depth is varies from 4.5 to 6 km. The same increases from north to south in the Block. The Basement depth contour map derived from gravity-magnetic data interpretation was compared with seismically derived depth contour map and found to be reasonably matching. The

basement depth contour map clearly divided the area into two parts i.e. the northern part with shallower basement depth compared to the southern part where the basement is deeper. The results thus obtained will be useful for constraining basement depth while planning for exploratory drilling for deeper Paleocene-Eocene prospects in the block.

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