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Analysis of Gravity Magnetic and MT signature of Purnea basin ,India for estimation of sediment thickness

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Abstract

Purnea basin is located in eastern part of Bihar and North Bengal bounded by latitude 24.8°N to 26.45°N and Longitude 87.2°E to 88.75°E and bordered in the south by hills of Rajmahal volcanic and to the north by the Siwaliks exposed along Sub-Himalayan foothills. Further it is bounded by the Bhawanipur fault in west and Kishanganj fault zone in the east.Purnea Basin is a Gondwana rift graben with a thin Tertiary layer over an unconformity within the upper Gondwana sequence formed due to rifting like any other east coast basins of India. The Basin has Gondwana sequence at its base overlain by Rajmahal Trap on southern side. The sedimentary package in the Basin comprising Gondwana and Cenozioc sediments directly overlies the crystalline basement. Three wells were drilled so far in this area.

The present study deals with merging processing and analysis of Gravity-Magnetic and MT data covering an area of 6185 sq km of Purnea Basin. The objective of the study is to derive the thickness of trap and then to determine depth to the Basement which can help for better understanding of the sub surface for exploration in the area.

The residual gravity anomaly map of has brought out a corridor of gravity low in N-S direction between two gravity highs in eastern and western side of Purnea basin. The boundary of high and low represent the orientation of Kishangang fault and Bhawanipur fault system of Purnea basin. It is observed that basinal low is sandwiched between two ridges. Two depo-centre basinal lows have been identified structurally by this map. These two lows have been separated by thick Gondowana / trap extension of comparable higher gravity values. Gravity magnetic and MT modelling had been carried out along seismic profiles taking densities from well logs constraining seismic horizons and well data. Results have been validated with well data which indicates basement depth is about two km in western and eastern flank of the basinal low where as in the center of basin it is about five km.

Introduction

Purnea basin is located in eastern part of Bihar and North Bengal bounded by latitude 24.8°N to 26.45°N and Longitude 87.2°E to 88.75°E and bordered in the south by hills of Rajmahal volcanic and to the North by the Siwaliks exposed along Sub-Himalayan foothills. Further it is bounded by the Bhawanipur fault in West and Kishanganj fault zone in the East. The tectonic elements with respect to location of purnea basin is represented in fig-1.

Data source

The Gravity-Magnetic and MT data of Purnea basin was acquired by MSU Geophysics, Russia for ONGC in the year 2010-2011 .The same data was reprocessed and to have regional understanding of gravity signature over Gondwana sequences and composite Bouguer anomaly map of whole Purnea basin has been generated by integrating the data with available data from Gravity Map Series of India, 2006

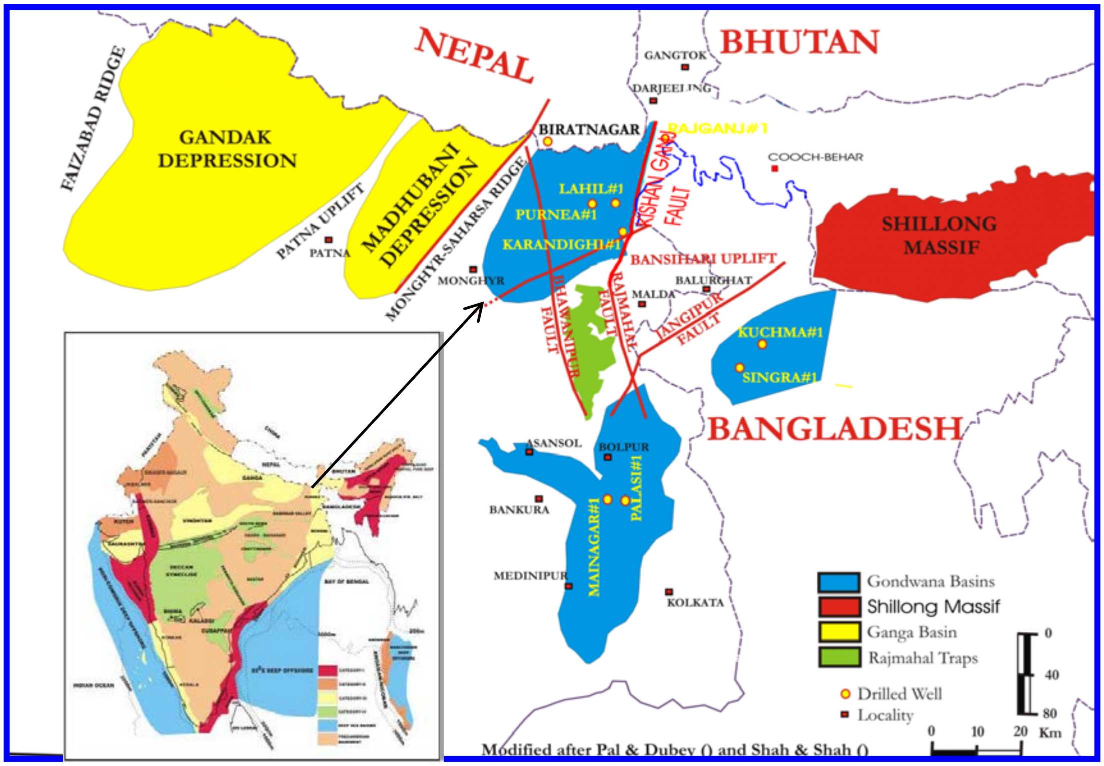

Fig-1: Tectonic elements of Purnea Basin

Interpretation

Bouguer Anomaly Map

The Bouguer anomaly map (fig-2) with 5 mgal contour interval brought out the gravity response of the active tectonic elements of the region understandably. The observed Gravity low in the north is interpreted as part of Madhubani depression which accounts thick pile up of Gondwana sediments deposited.

The major features of the map are

- The axis of the gravity low is in the NNW –SSE direction which is sandwiched between exposed basement high in the east and trap covered Monghyr-Saharsa ridge complex in the west. Kisahnganj fault and Bhawanipur fault marks the boundaries of extension of Gondwana sediments in the basin.

- The most striking feature of the map is a smooth rise of anomaly of the order of -66 mgal from NW near Purnea-1 to SE near Karandighi-1 indicating the direction of Basinal low. The NNW-SSE major gravity low corresponds to the Basinal low. The gravity high trend in the Eastern part corresponds to Bansibari uplift.

Regional Gravity Anomaly Map

The regional gravity anomaly map of Purnea Basin and surrounding area (fig-2) has been prepared, which show a big gravity low in the North and gravity high in the South. The low in the north is explained partly by isostatic effect of the Himalayas. High gravity anomaly in the southwest is due to trap and towards east due to basement.

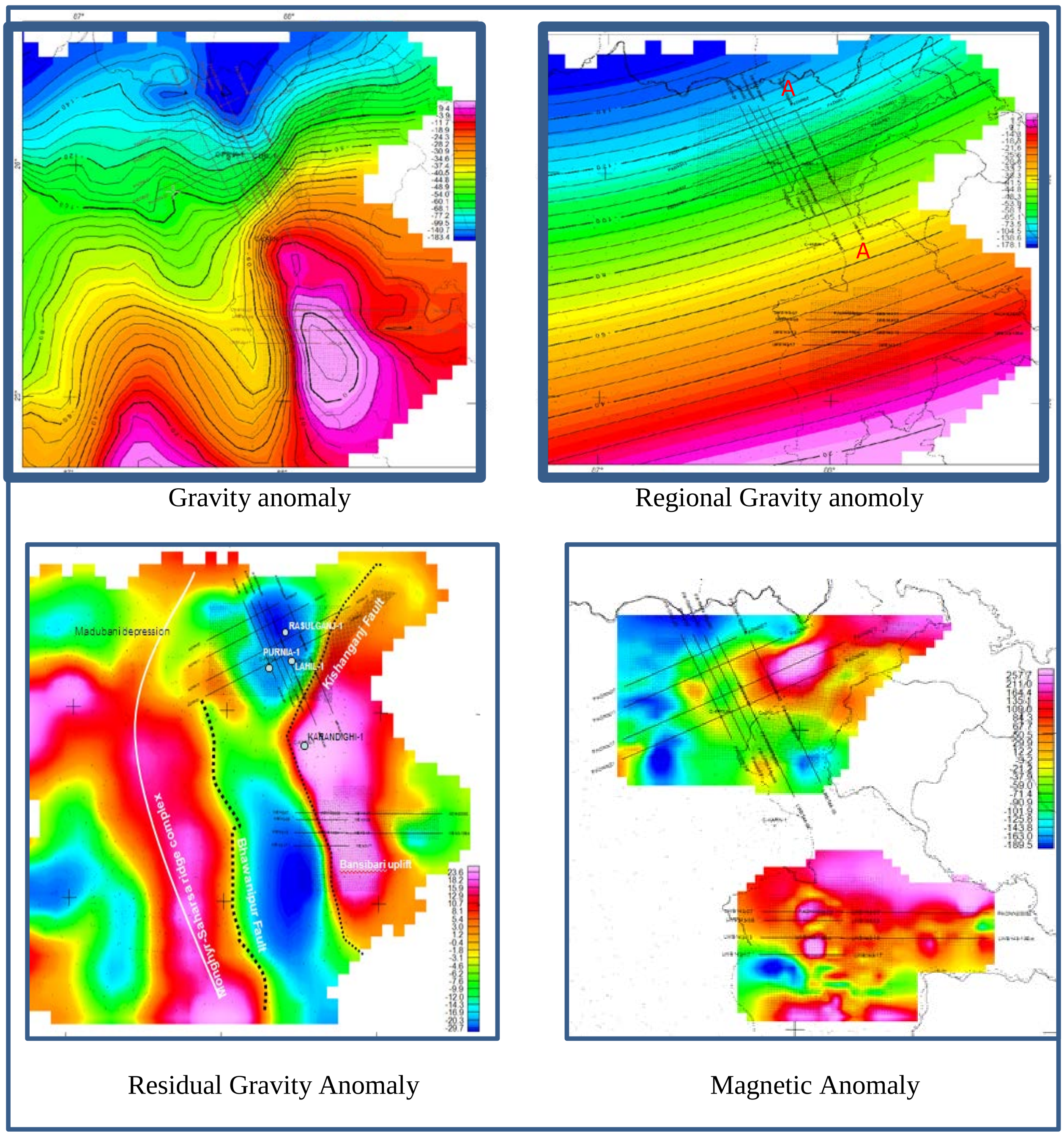

Fig.2: Different anomaly maps of purnea basin.

Residual Gravity Anomaly Map

The residual gravity anomaly map of whole Purnea Basin (fig-2) has brought out a corridor of gravity low in N-S direction between two gravity highs in eastern and western side. The boundary of high and low represent the orientation of Kishangang fault and Bhawanipur fault system of Purnea basin. It is observed that basin low is sandwiched between two ridges. Two depo-centre basinal lows have been identified structurally by this map. These two lows have been separated by thick Gondowana / trap extension of comparable higher gravity values.

Magnetic Anomaly Map

Magnetic anomaly map of Purnea basin has been presented in (fig-2). The southern part shows high magnetic anomaly because of the traps and associated volcanic intrusion. The presence of Magnetic low in the western part of the block bounded by magnetic high clearly indicates the sediment rich area which has been supported by gravity study also.

The upper block shows comparable magnetic low prominently in NW-SE direction of basinal low. The major features in the magnetic anomaly data are discussed below.

- The magnetic high in the Eastern part of the block may be attributed to the presence of igneous rocks present in eastern part of Kishanganj fault.

- The dispersal of the basaltic flow during volcanic eruption and their subsequent deposition in the rift period can be attributed to the orientation of many large and small magnetic highs.

- Many bipolar magnetic features in North-South Linear fashion are observed which may be due to the presence of dykes. The high frequency nature of magnetic fields suggests the causatives are probably shallower.

1. MT Inversion

About 500 MT stations data was recorded northern part. Thirteen MT stations passing through seismic line AA' have been considered for analysis of resistivity-phase curve (fig.-3) so that MT results can be corroborated with the seismic section. The resistivity-phase curve indicates two distinct sequences viz. sediments and basement.

1-D inversion of MT data has been attempted along profile AA which shows that Basement depth is about 4000 m in the gravity low and of about 1000 m in the gravity high which matches depth of basement as brought out by gravity and magnetic modelling**.** The MT model has been incorporated in the seismic section of AA which perfectly matches with the sediment and basement sequence marker of seismic section (fig-3).

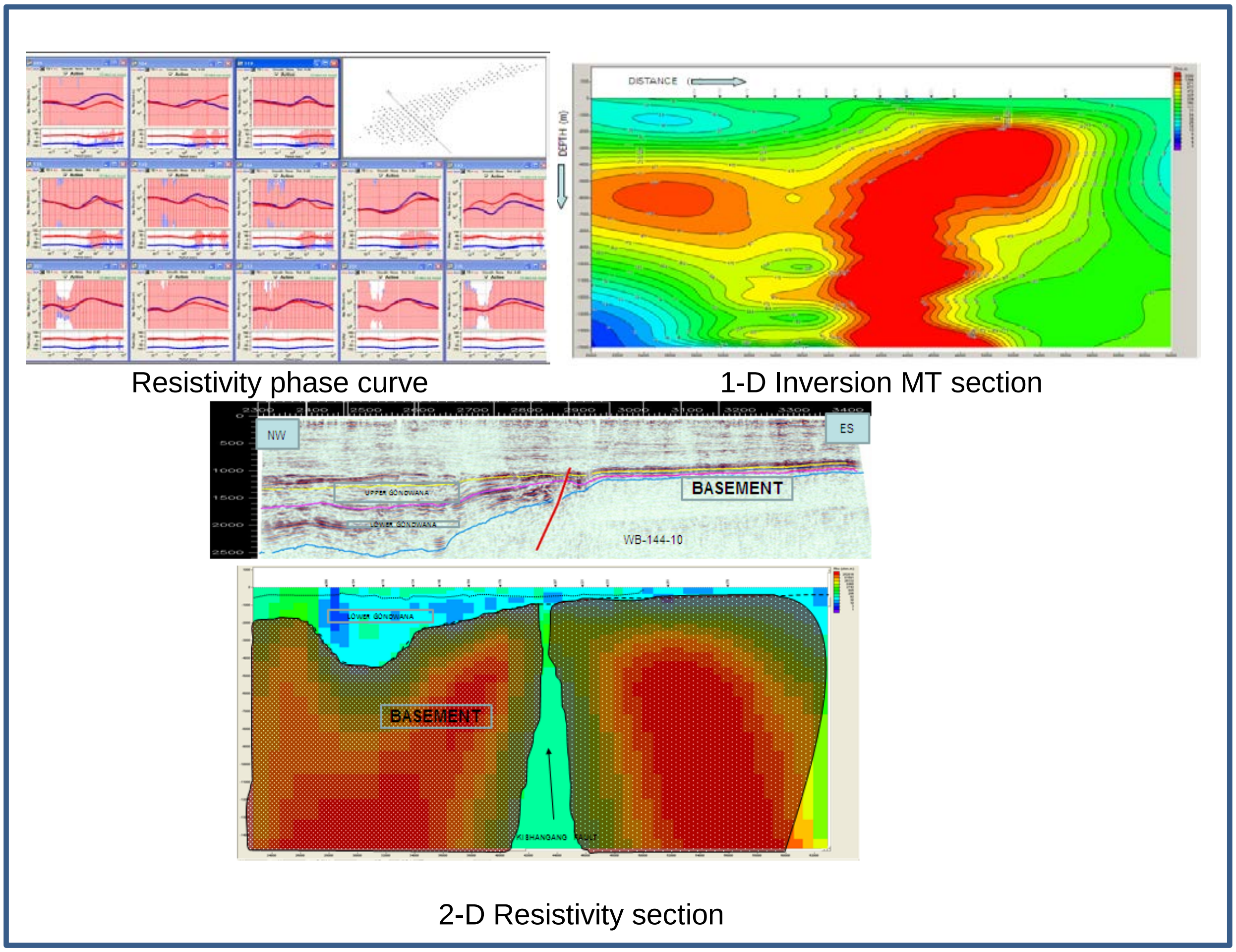

Fig.3: MT anomaly along profile AA

Gravity Modelling

Integrated Gravity modelling has been carried out along five seismic profiles in the dip direction and three along strike direction in northern part of the basin whereas in the southern part modelling has been carried out along two seismic profiles. A few marker horizons on selected Seismic sections are converted into depth sections using interval velocities.

- Well data of all the three wells in the area viz. Purnea-1, Lahil-1 and Karandighi-1 and their density, resistivity, age of the rocks are considered.

- Gravity and Magnetic response has been plotted over the seismic profile. The gravity signature is almost identical with the seismic response qualitatively but magnetic response show reverse trend particularly in the area where the reflectors deepens towards basin low. This anomalous behaviour may be attributed to reversal of magnetisation of basement rocks.3D Gravity effects arising out of the root effect of the Himalayas is taken into account by introducing a low density wedge below the basement for the N-S seismic profiles and 2.75D gravity modelling approach is adopted for the strike direction profiles.

- All together a total of twelve seismic profiles spanning entire basin have been modelled and integrated with MT data. Here only a seismic profile (BB) cutting across basin low is presented for understanding of basement depth profile (fig-4).

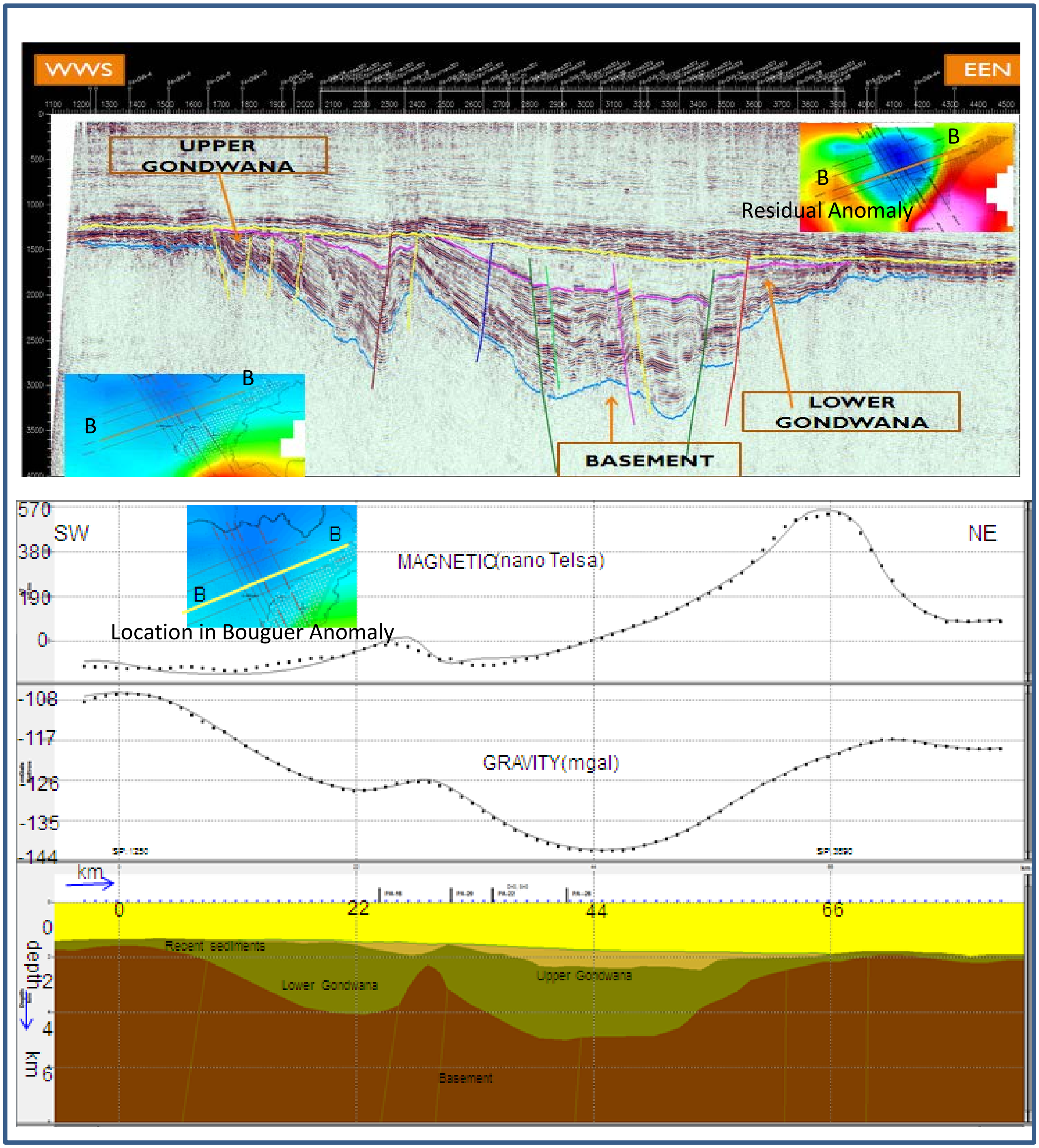

Fig.4: Gravity Magnetic modelling along profile BB

The following data has been considered for Gravity-Magnetic modelling

Sequences	Density	Susceptibility	Remnant Magnetisation
Basement	2.67 gm/cc	0.002-0.007 CGS units	0.0003 - .0006 emu/cc
Upper Gondwana	2.42 gm/cc	---	---
Lower Gondwana	2.37 gm/cc	---	---
Recent Sediments	2.00 gm/cc	---	---

8. Conclusions

- Basement depth is about 2 km in the western flank of basinal low and in the center of the low it is 5km then climbing up narrowly to 2.2km approximately in the eastern flank i.e. near the Kishanganj fault.

- The crust is thickening considerably towards northern margin. Structurally favourable lows with thick sedimentary column devoid of intrusive in the Northern blocks are likely to be good source area for hydrocarbon potential.

10. *References*

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