Delineation of Basement depth of Lakwa and Geleki oil field from Gravity data

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Summary

Lakwa and Geleki fields are known producers of Hydrocarbons. In spite of extensive seismic work carried out in the area and more than 800 wells drilled, basement is still eluding. In view of Tura formation juxtaposing over basement rocks and recent discoveries from Tura formation the delineation of basement has become important for future exploration in Lakwa & Geleki oil field.

Residual gravity map of the area has brought out the corridor of Nazira low and its extension towards northeast and southwest with associated gravity high and low trends corresponding to Charali, Rudrasagar, Demulgaon, Disangmukh and Charaideo fields.

Basement map has been prepared using gravity data. Faults delineated on residual anomaly map are corroborating with faults identified on basement map indicating that Nazira Low bounding faults are basement related. It also signifies that the fault which separates main Rudrasagar and Demulgaon high and north of Rudrasagar low is basement related. Basement depth is inferred ranging from 4700m to 5600m in Lakwa and Geleki area.

Introduction

The study area is located in between latitudes 26º 43´ N and 27º 11´ N and longitudes 94º 36´ E and 95º 00´ E in Upper Assam plain of India (Fig-1). Naga Hills and Schuppen belt form the south and south eastern boundary of the area (Fig-2). Lakwa area is of 172.49 sq.km. and it is located in the southern bank of the Brahmaputra River. Lakwa and Geleki are two known oil fields in Assam & Assam Arakan Basin of India.. Lakwa-Geleki fields are producing from Tipam, Barail, Kopili and Tura formations corresponding to Mio-Pliocene, Oligocene and Eocene formations respectively**.**

The deepest well in Geleki is W-1which was drilled up to 5001 m (Sylhet) but not encountered basement. Well W-2 met basement around 4700m in Lakwa. Other wells in Lakwa-Geleki which met basement are W-3 (4300m), W-4 (4182m), W-5 (4350m), W-6 (4723m) and W-7 (4800m) (Fig-8). Though these wells met basement still basement delineation over Lakwa-Geleki and adjoining area is difficult because the basement signature on seismic is of poor quality. Some 3D seismic campaigns have been carried out in successive phases in these areas but clear basement signature is still remaining elusive.

In Lakwa many wells are producing from deeper formations of Sylhet and Tura. It is postulated that Tura formation is juxtaposing over basement. Delineation of basement is very much essential in Lakwa-Geleki and its adjoining area for reservoir prospect in Tura and deeper sediments. Moreover, delineation of basement in these fields would give estimation of sediment thickness for future exploration.

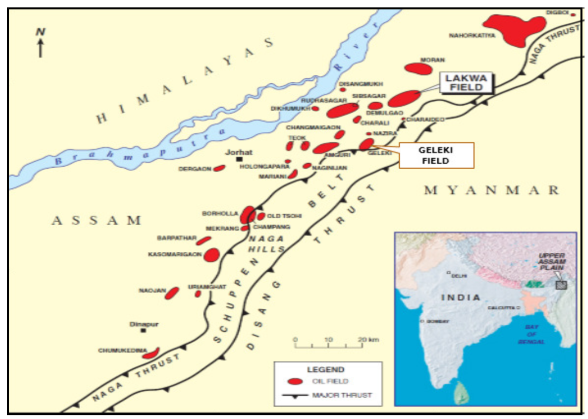

Fig.1. Location Map of the study area

Geology of the area

Upper Assam Basin is a composite foreland basin which is located between the eastern Himalayan foot hills and the Assam - Arakan thrust belt. The basin is confined to northeast by Mishimi Hill block and to southwest it is partly disrupted by the Shillong plateau basement uplift. It is in the northeastern part of the Indian Plate. The compressional forces have generated a number of thrusts outcropping formations of Barail and Tipam groups in folded Schuppen belt to the east and southeast of study area (Fig-2).

The stratigraphic record of upper Assam foreland basin controlled by three variables - eustasy, tectonic subsidence and sediment supply. The sedimentary record of basin was formed during passive margin setting in Paleogene time.

Fluvial to marine coarse clastic sediments deposited in Paleocene to lower Eocene period there after widespread transgression leading to deposition of carbonate sediments in middle Eocene period and shale is dominated in upper Eocene time. During Oligocene and Miocene increased proportion of coarse clastics is attributed to the tectonic uplifts in the provenance as well as falling sea level. There is good correspondence between gravity high in the basement and structures in the sedimentary cover. The structures are platform type, either gentle domes or elongated gently anticlinal folds dissected by numerous faults. The thick pile of Tertiary sediments encountered in the Lakwa-Lakhmani area were deposited under varying depositional environments and tectonic settings. Geleki and Lakwa structures are separated by Nazira Low.

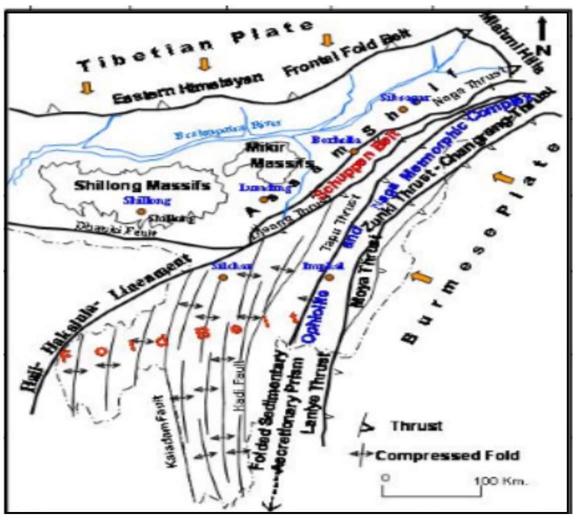

Fig-2 Tectonic map of the Assam & Assam Arakan basin

Data source

Gravity data: Lakwa-Geleki area was covered with Gravity survey in two campaigns namely A-03 and A-22 in the year 1964-65 & 1985-86 respectively. About 1900 Gravity stations were acquired over the study area (Fig-3). North of Lakwa and south of Geleki fields are not covered by these campaigns.

Seismic data: Working area is widely covered by seismic data. But only seismic profiles passing across gravity and magnetic features have been considered for this study.

VSP-data: VSP data of wells pertaining to Geleki and Lakwa field falling on seismic section considered for the study is taken as velocity function for corroborating seismic sequences into depth domain.

Well data: Wells data are considered for density, depth interval of major sedimentary sequences over the study area.

Bouguer anomaly map

Bouguer anomaly map (Fig-3) shows a major gravity low trending NE-SW, which impinges study area from the SW direction. This low can be attributed to Nazira low but cannot be ascertained because of isostatic effect of the Himalayas.

Bouguer anomaly values range from -174 mgal in the Schupen belt area to -187mgal towards Rudrasagar area. This decrease of 13 mgal is partly because of the Himalayan root effect and partly due to sediment thickness. The gravity high in northeast may be due to Naga thrust belt. Compactness of contour with relatively high gradient is observed near thrust side.

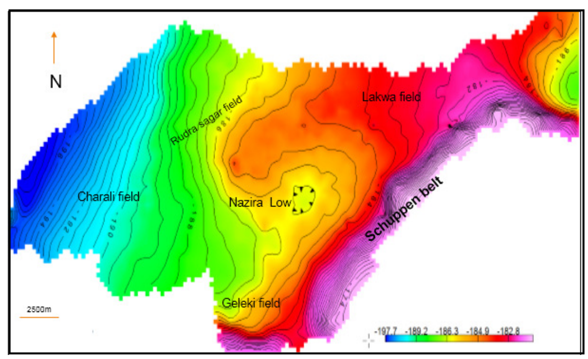

Fig-3 Bouguer Anomaly Map

Regional gravity anomaly map

The regional gravity anomaly map of Lakwa - Geleki and surrounding area (Fig-4) has been made using wavelength filtering technique. Gravity high trend along NE - SW and low trend in the west are seen on the map. This low is explained by isostatic effect of the Himalayas. High gravity anomaly is due to several thrusts originating from Schuppen belt.

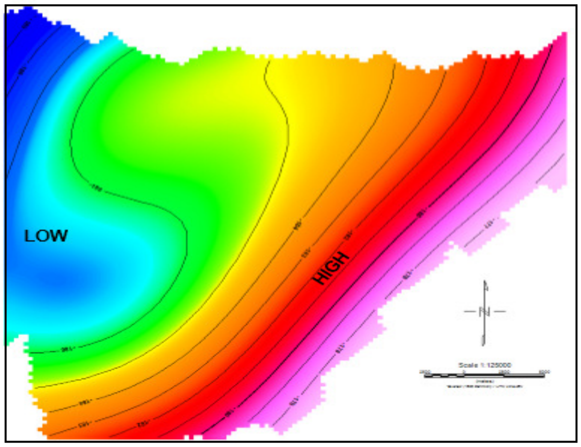

Fig-4: Regional gravity anomaly map

Residual gravity anomaly map

Only four wells encountered basement at about 4000m in the study area. Therefore, the present study needs attention around 4000m depth from the surface for initial conceptualisation. To remove the root effect of the Himalayas, and to preserve the gravity signature associated with shallow causative Residual gravity anomaly map (Fig-5) was prepared where wavelength up to 15 km has been preserved. This map has brought out isolated gravity highs corresponding to different localised oil fields viz. Rudrasagar, Charali, Demulgaon, Disangmukh and Charaideo etc including Nazira low and its extension. This map has also brought out a gravity low towards north of Rudrasagar field which confirms prominent structural low as envisaged from other geophysical data.

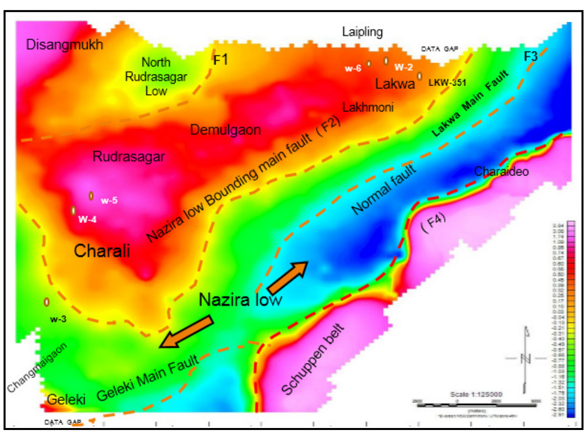

Fig-5: Residual gravity anomaly map

This map also confirmed major fault systems of the area. Two prominent NE-SW faults F2 and F4 have been identified which bounds the corridor of Nazira low. In addition, Geleki main fault and one normal fault F3 passing through south of the Lakwa field can also be delineated. The fault F1 separates North Rudrasagar Low from Rudrasagar Main and Demulgaon field.

Gravity derivatives

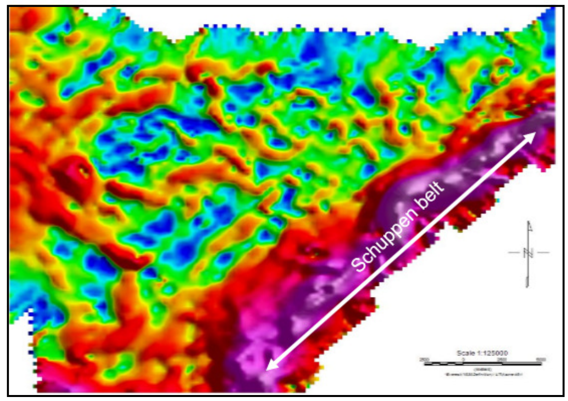

Fig-6: Horizontal gradient of Bouguer anomaly map

Horizontal gradient of bouguer anomaly map along EW direction (Fig-6) shows much subtle east-west gravity highs and lows within study area which may be of localised nature. Structural nature of Schuppen belt is clearly seen on this map**.**

Gravity modelling along seismic profiles

1. Seismic horizons corresponding to Girujan clay, Lakwa sandstone, LCM, Kopili and Basement sequences had been converted to depth using VSP data. Discontinuous basement signature from the seismic is chosen for initial tentative modeling.

2. Depth data corresponding to Namsang, Girujan clay, Lakwa sandstone, LCM,Tipam, BCS, BMS, Kopili, Sylhet, Tura and Basement have been taken from the wells (Table-In addition, other wells data which are falling on modelling profiles are also considered. These depths have been set as constraint for gravity modelling.

3. The rock densities corresponding to different sequences have been taken from density logs of the wells (Table-1).

Now taking constraints from the above mentioned data, gravity modelling on bouguer anomaly along seismic profiles has been carried out. The modelling results of one such section has been presented here Fig-7.

Formation	Density (g/cm^3)
Girujan Clay	2.2
Lakwa sandstone	2.3
Lower Clay Marker	2.35
Barail Top	2.4
Kopili	2.45
Sylhet	2.5
Tura	2.6

Table-1 Density parameters of different formations

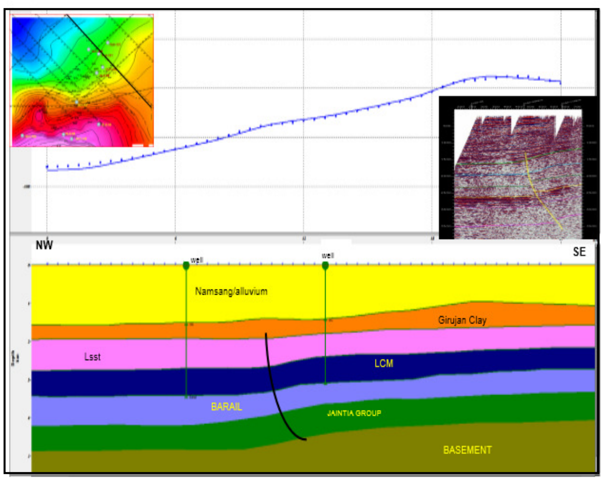

Fig-7: Gravity modelling along a Seismic profile over Geleki area

Gravity modelling over Entire area

The objective is to prepare a basement map for entire study area. It is seen that observed gravity effects arising due to root effect of the Himalayas is masking the true gravity effect of the region. So, residual gravity modelling approach is adopted for gravity modelling of the area. Thirty profiles with a grid interval of two by two kilometres have been constructed over the residual anomaly map of Lakwa-Geleki and adjoining areas for modelling. (Fig-8)

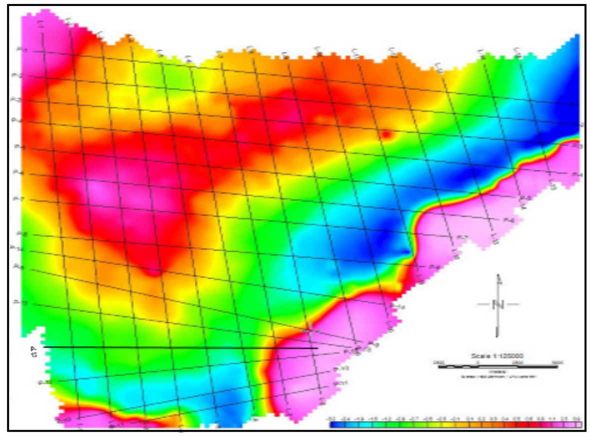

Fig-8: Gravity profiles over residual anomaly map

One of these gravity profiles (Fig-9) have been presented here where only two layers corresponding to basement and total sediments have been considered. The average density for the total sediments is taken as 2.45 gm/cc and for basement it is 2.67 gm/cc. Depth information of basement along these profiles are taken as input for preparing basement depth map of the entire area (Fig-10. While preparing basement depth map three wells which touched basement have been considered i.e. W-3, W-4 and W-6 as constraint. After generation of depth contour map with contour interval of 100m, two more basement touched wells i.e. W-2 and W-5 were posted to validate the output depth map and found that the depth results are matching. Deeper wells more than 4000m are plotted over the map and it also supports the results

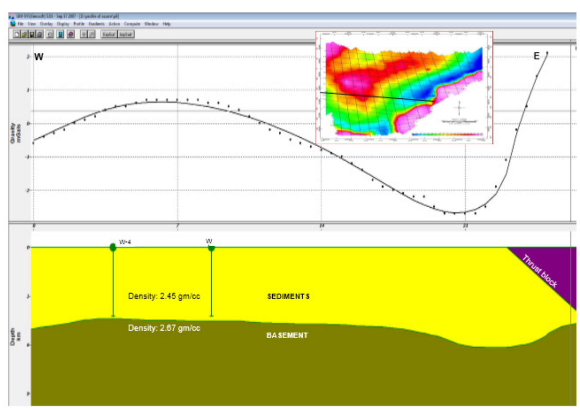

Fig-9: Gravity modelling along profile P-8

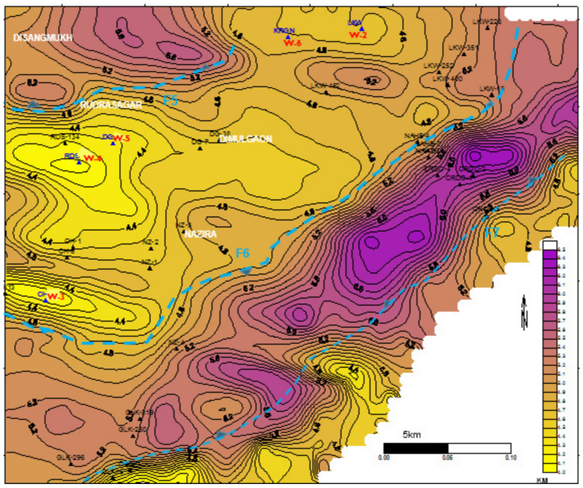

Fig-10: Basement map of Lakwa-Geliki and adjoining area.

Interpretation

2D gravity modelling along seismic profiles has fairly reproduced the sedimentary marker and basement. The basement depth obtained from modelling of these seismic profiles signifies that the basement is much below than what it is reflected in seismic.

The final depth map of basement of Lakwa-Geleki and adjoining area has brought out the basement configuration conforming the expected regional trend over the oil fields like Charali, Rudrasagar, Demulgaon, Charaideo, Disangmukh, Naharhabi, Lakwa and Geleki. The basement depth is varying between 4000m to 6500m within the study area.

Basement is deepening in the direction of NE– SW over Charaideo area and extending towards Nazira and Geleki area towards southwest. Basement is shallowing at Charali and Demulgaon and to some extent of lakwa area. Basement depth also lowers towards Disangmukh and North of Rudrasagar area.

The faults F1,F2 and F4 which were earlier delineated by residual anomaly map (Fig.-5) is corroborating with the faults F5 , F6 and F7 brought-out by the basement map indicating that Nazira Low bounding faults F2 and F4 are basement related. The map also signify that F1 is also basement related fault which separates main Rudrasagar and Demulgaon high and north of Rudrasagar low

There is an EW trend observed in the study area because of rise of the basement in the Charali area which terminates against the Nazira low. This east west trend is observed in reservoir level also in north of Geleki field.

Conclusions

- Basement depth is lowering towards south-southeast then rises at the centre and again it is lowering towards northwest of area.
- Basement is deeper in Geleki area where depth varies between 5000m to 5600m. In Lakwa area it is shallower varying between 4700m to 5100m
- Faults seen on residual map are corroborating on basement map indicating that these faults are basement related.

Recommendations

There is a data gap in the north of Lakwa and south of Geleki area. Acquisition of gravity and magnetic data over these areas will be helpful to know the areal extent of these producing fields.

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