



P 197

Integrated Interpretation of Thrust belt area based on Seismic and Surface Geologic Mapping- A case study from Upper Assam Basin, India

J.P.Singh*, K.L.Mandal and Neeraj Tyagi

Summary

The study area lies in the southern part of Assam Shelf in the Naga thrust fold belt. Within the block, no well have been drilled so far. Seismic survey, mainly 2D, was carried out in this area in different phases. The main objective of this study is to evaluate the 2D seismic data acquired in the area for generation of prospects for exploratory drilling.

With the above objectives in mind, the following workflow has been adopted for evaluation of prospectivity of the area:

- I. Integrate and analyze all the information available in the form of geological outcrop map and available seismic data
- II. Carry out detailed structural mapping of different formations in the area.
- III. Identify prospects and leads for exploratory drilling.

Keywords: Integrated, Exploration, Time-domain, Interpretation.

Introduction

The block measuring 113.5 Sq km pertains mostly to the logistically difficult and rugged terrain in the southern and eastern part of the block mostly covering the Margherita and Disang thrust-fold system. An index map of the study area is presented as Fig-1.

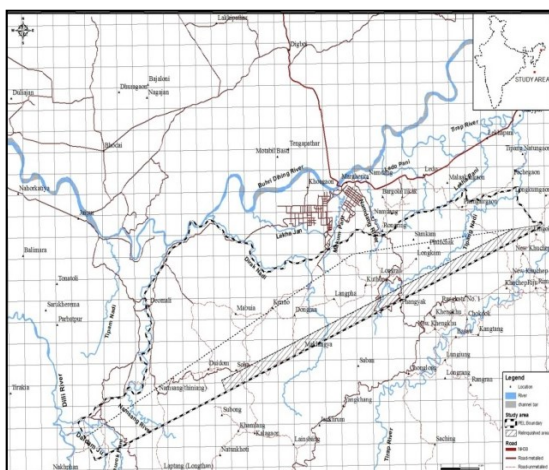


Fig 1: Index Map of the Study Area

The Assam-Arakan sedimentary Basin is a shelf-slope-basinal system. The shelf part of the basin spreads over the Brahmaputra valley and the Dhansiri valley, and the area of study is lying between the Naga thrust and Sinyang thrust. The shelf-to-basinal slope, i.e., the hinge zone lies below the Naga Schuppen belt. The basinal (geosynclinal) part is occupied by the Naga Schuppen belt.

The shelf part rests on Precambrian granitic basement, whereas the basinal part lies on transitional to oceanic crust. The area within the Upper Assam shelf, having high petroleum potential, measures approximately 56000 sq km and contains about 7000m thick sediments of mostly Tertiary period, and the area in the basinal part with moderate to high hydrocarbon potential measures about 60,000 sq km and contains more than 10,000m thick sediments of mostly Tertiary period.

The Upper Assam Shelf of the Assam-Arakan Basin lies mostly below alluvial cover of the mighty Brahmaputra River and its tributaries. Towards south and southwest, the shelf extends to the Dhansiri valley, lying between the Mikir hills in the west and the Naga foothills in the east

to southeast, and then continues westward to North Cachar hills and southern slope of Shillong Plateau. The general elevation of the Dhansiri and Brahmaputra valleys ranges between 85m and 90m above mean sea level (MSL).

The hill ranges of western Nagaland, aligned roughly in NNE-SSW direction and exposing Tertiary sediments which are involved in a complex system of imbricate thrusts, lie on the southeastern side of the Upper Assam Shelf.

The regional stratigraphy is presented below as Fig-2.

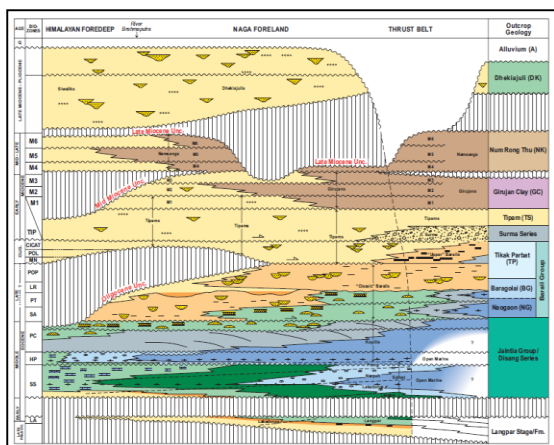


Fig 2: Regional stratigraphy of the study area

The geological map of the area and a few geological cross sections, prepared based on field mapping data shows that the Lower and Upper Barail formations, exposed in the block. A notable structural feature is that the Margherita and the Disang thrusts merge into one and then runs towards southwest as the Haflong thrust. These behaviors of the structural elements have been responsible for the occurrence of outcrops and geosynclinal facies very close to one another in the block.

Methodology

The absence of drilled well information is a major constraint for identification of different formation boundaries in the available seismic data. A geological map showing the surface exposures of different formations present in the study area (refer Fig 3) has been used as the guiding light on which seismic lines were georeferenced so that accurate spatial information regarding the different formations could be tied up with

the seismic data. Two geological cross sections were available trending north-west to south-east across the study area. The geological cross sections marked BB' (refer Fig 4) was used as it was cutting across the seismic lines acquired in the study area. From the prior geological knowledge and drilled wells, it has been observed that the hydrocarbon prospectivity decreases towards the thrust belt hinterland beyond the Disang thrust, while along the foreland areas adjoining Naga thrust the prospects are higher. A regional look at the recorded oil seepages brings out the fact that they are clustered around the Naga and Disangs thrust. It is clear that these two thrust planes act as a major conduit for hydrocarbon expulsion from its source areas with a dominant horizontal component while the subsidiary thrusts acting as a conduit for vertical migration

A total of 76 GLKM of 2D seismic data was acquired mostly in the South-western part of the block. The seismic lines were georeferenced on the geologic map as presented in Fig 5. One exploratory well, located about 20 km from the north-eastern corner of the area in Tinsukia District, Assam, was drilled down to 4750 m within Barails. The well did not establish any commercial hydrocarbon. Another exploratory well, located about 10 km from the block was drilled down to 1640 m within supra Girujan in Supra thrust of Kumchai thrust. The well establishes the commercial hydrocarbon, but it is having altogether a different structural setting.

From the geological map of the block it has been observed that the lowermost Tertiary stratigraphic unit on the shelf is a transgressive unit which was deposited as Disang Shales in thrust belt areas. The Disangs comprise the Lakadongs, Narpuh, Prangs and Kopilis, a series of early to late Eocene near shore, marginal marine to open marine clastic and carbonate sediments. They are thought to rest, for the most part, conformably on the Langpars. These sediments are not penetrated in any of the thrust belt wells, but form folded ENE-WSW trending outcrops to the south of the Disang Thrust. From regional trends identified in the main part of the Assam Basin – the Langpars to Kopilis facies may be slightly older and thicker in the thrust belt compared to the main basin area and certainly compared to the basin area north of the Brahmaputra.

The Barails are divided into two lithostratigraphic unit; the 'Upper' and 'Lower Barails'. The Upper Barails is a new informal unit which strictly speaking relates to the

basal part of the Tipams lithostratigraphic unit. The upper and Lower Barails are typically unconformably separated but are locally conformable in parts of the thrust belt. The late Eocene - early Oligocene Lower Barails are present throughout the Thrust Belt Area. Barails form broadly ENE-WSW trending outcrops and are associated with almost every thrust slice in the Thrust Belt Area. The Lower Barails is the oldest unit penetrated in the thrust belt wells, where it measures up to 700m in thickness. The base of the Lower Barails is conformable with the underlying Kopilis. The two units are interpreted to be part of the same deltaic system where the first major influx of sands marks the base of the Lower Barails. Although the passage from the Kopilis (pro-delta to offshore) into the Lower Barails (delta front/top) is often part of the same progradational phase locally the first major influx of sands is thought to relate to a forced regression (which by definition requires a minor unconformity at its base). The Lower Barails were deposited in a delta front/delta plain setting and are predominantly clastic, comprised mainly of sandstones, siltstones and mudstones with local coals. The shoreline was however probably highly irregular and dynamic reflecting the avulsion and movement of the deltaic system which possibly switched across much of the entire main basin and thrust belt area. The system also periodically underwent marine incursions. Based on these observations the thrust belt was probably more marine than the main basin area. The overall system was more marine during Lower Barails than Upper Barails times. Furthermore, the age of the Lower Barails in the thrust belt area is slightly younger than that seen in the main basin area reflecting the time taken for the delta to prograde from the main basin to the thrust belt area. The biostratigraphic character of the Upper Barails is similar to the Lower Barails. These sediments, found throughout the thrust belt area are typically separated from the Lower Barails by a complex unconformity, but thought to be locally conformable. The Upper Barails thicken to the south and southeast. The observations suggest an overall progradation of the deltaic system to the south or southeast, thereby reducing the marine influence and effecting an overall 'drying out'. The depositional system (thought to be of a similar orientation to that of the Lower Barails) deepens to the south or southeast (i.e. into the thrust belt).

Tipam attains a thickness up to 500 m and as with all of the pre-Miocene unconformity units it thickens (slightly) to the south or southeast. Its base exhibits a local and

minor unconformity with the underlying Upper Barails being otherwise generally conformable. Several discrete, argillaceous units are present within the Tipams, these can be correlated over large areas and can be seen to thicken into the thrust belt area. The Surma Conglomerate is a mapped lithostratigraphic unit which is of unknown distribution and origin. Tipams are low recovery unit, which reflects their primarily non-marine and arid nature. Although essentially an arid braided fluvial channel system, several marginal marine phases are recognized.

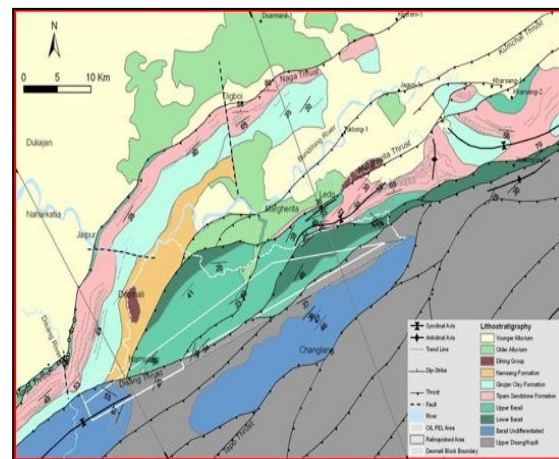


Fig 3: Geological map of the Block and adjoining region of the foreland and thrust belt with outcrop mapping

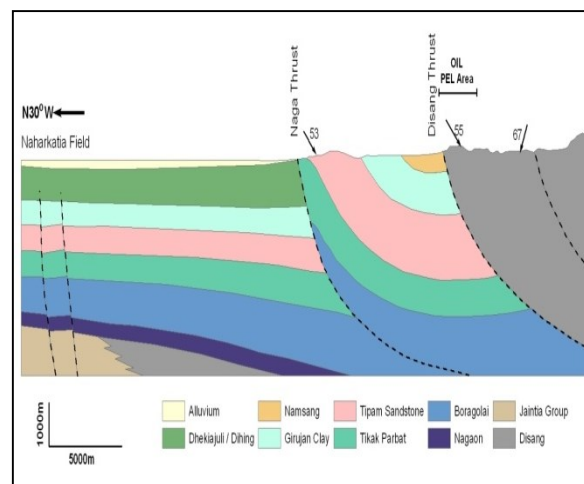


Fig 4: Geological sections across the thrust belt in and around the Block. Position of the section as in Figure 3. BB' depicts the plausible lithological and subsurface structural elements across the block

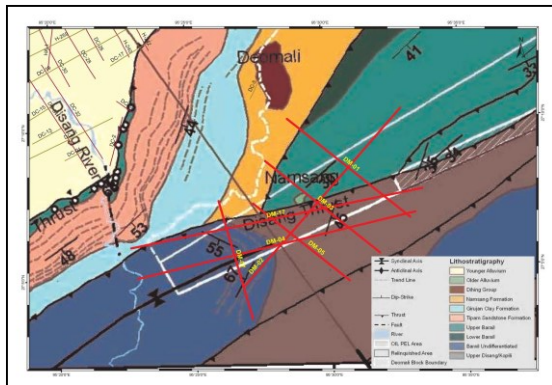


Fig 5: Base Map showing seismic coverage superimposed on surface geological map

Results

The study of the geological map of the area shows various major faults, thrust and signature of different anticlines and synclines. In general, the major tectonic elements in the area trends NE-SW. The NE-SW trending Disang thrust is in the central part of the block. The Margherita thrust is present at the northern part of the block. There is only one major fault is present in the area in addition to the Margherita and Disang thrusts.

At Basement top, the study area is shallow towards south-western part of the block. TWT contour values are in the range from 2670 ms near the anticline in the South-western part to the deepest contour of 3420 ms in the south-eastern part of the area. An anticlinal four way closure has been delineated near shot point 800 of seismic line DM-04 with closure amplitude of about 50 ms (Fig.6). The contour value increases to south-eastern side of the block which is analogous to geological cross section. Disangs are exposed at Disang thrust which is also shown in Geological Cross-section. In general, the TWT contour values are in the range from 2270 ms in the north-eastern part of the block to the deepest contour of about 3420 ms in the south-eastern part of the study area. Expected depth of the Basement varies from 2750 m to 3250 m across the area

Undifferentiated Barail sequence is exposed in the south-western part of the block which is the supra part of the Disang thrust. The barails are exposed in the supra parts of the Disang thrust. Hence, the prospects of hydrocarbon are very feeble due to absence of any regional cap rock or any potential seal. The probability of finding new hydrocarbon reserves will be in the subthrust part of the

region. The TWT contour values of Lower barails are in the range from the shallowest contour of 1800 ms in the north-eastern side of the study area to the deepest contour of around 3060 ms in the extreme south (Fig 7). Expected depth of the formation varies from 1900 m to 2400 m across the area.

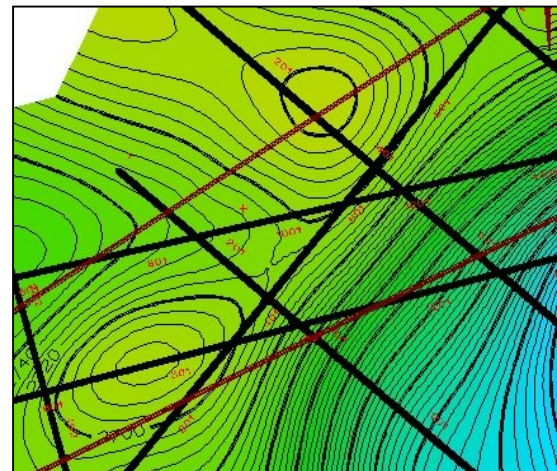


Fig 6: TWT Contour Map of Near To Basement Top

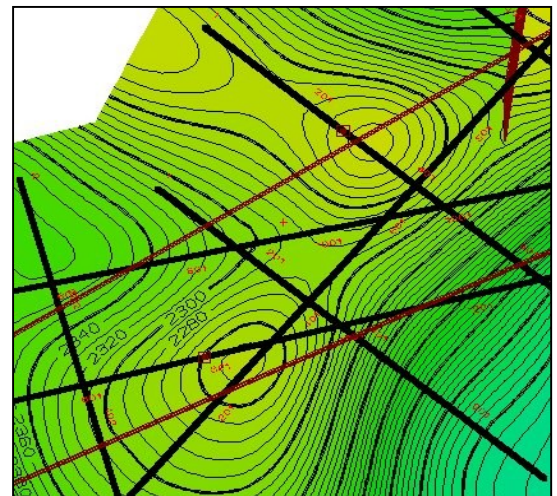


Fig 7: TWT Contour Map of Near To Lower Barail Top

Conclusions

The structural interpretation of the area is carried out based on correlation obtained through an integrated approach as described above incorporating surface geological outcrop map with the help of geological cross sections. Detailed mapping has been done for three (3) prospective formation boundaries pertaining to within Barail, Disangs and close to Basement top and accordingly, Two Way Time maps were generated. The depth maps have been used for the probable prospect generation



of the area for proposal of exploratory drilling. This location will probe the anticline with primary objective to test the Lower Barail with secondary targets at Disangs.

Acknowledgement

The authors would like to thank the management of Oil India Limited for kind permission to publish the work.

References

Acharya, S.K. 1997, Stratigraphy and tectonic history reconstruction of the Indo-Burma-Andaman mobile belt, Indian Journal of Geology, v.69, pp.211-234.

Bhandari, L.L., Fuloria, R.C. and Sastri, V.V., 1973, Stratigraphy of Assam Valley, India., AAPG Bulletin v.57, pp.642-654

Das Gupta, A.B. and Biswas, A.K. 2000, Geology of Assam, Geol. Soc. India, Bangalore, 166p.

Mallick, R.K. and Raju, S.V. 1995, Thermal maturity evaluation by sonic log and seismic velocity analysis in parts of Upper Assam Basin, India. Org. Geochem., v. 23, No. 10, pp. 871-879.