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Geological modeling and Hydrocarbon prospects in Up-Thrust Tipams, South Geleki, Upper Assam Basin, India

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Abstract

The Geleki field is a major hydrocarbon producing field in Upper Assam Shelf and is frontal to Naga Schuppen belt. The field lies within a doubly plunging NNE-SSW trending broad anticline having around 40-45 sq.km areal coverage. The southern plunge is cut by the E-W trending Naga Thrust and is evident from the available surface and subsurface G&G data. The present work focuses on defining the structural features and its probable hydrocarbon occurrences in Up-Thrust Tipams in south Geleki as hanging wall prospects of Naga Thrust for the first time. An analogous example of commercial hydrocarbon deposits in up-thrust block of Naga Thrust is manifested in historic Digboi structure way back in 1889.

In the study area, the G&G data generated through drilling of an exploratory well has lately confirmed the presence of Naga Thrust and redefined the structural features for hanging wall Mio-Pliocene sequences along belt of Schuppen. In absence of sufficient well and quality seismic data, the study is largely done conceptually by integrating surface geologic data including satellite imagery and available sub-surface data. The surface geologic data has confirmed an overall E-W trending Naga thrust passing through north of the lead well in conformity with the axial trend of Deopani anticline, which is a prominent geomorphic high in the study area along with Barsila anticline.

In conclusion, the structure and prospectivity of Tipams in up-thrust block has been brought out by integration of surface geologic map, satellite imagery, NW-SE log correlation profile and geological section across Deopani anticline. The NW-SE geological section has clearly explained the hydrocarbon entrapment mechanism and maps of prospective layers have revealed the dimension of the prospects in study area. The proposed model envisaged an areal closure of about 5.0 Sq. Km and the combined volumetric O+OEG of about 8.5MMt.

Introduction:

The finding of Up-Thrust commercial O&G in this geologic province began with the discovery of Digboi oil field way back in 1889. This structurally complex thrust & fold belt has been a challenge to explorationists and since then only few discoveries are made within Belt of Schuppen. Apart from Digboi, fields like Champang, Pengri, Kharsang are known for Up-Thrust commercial hydrocarbon deposits within belt of Schuppen. However, the few seismic surveys and drilling on exposed anticlinal blocks of the Schuppen belt has remained inconclusive, mostly due to lack of quality G&G data. The Geleki field of North Assam Shelf is frontal to Naga Schuppen belt and up till now all commercial hydrocarbon deposits are discovered within undisturbed foreland sequences of the basin. Current exploration and field development activities of Geleki field are mainly confined towards southern part of the field which is proximal to Naga Schuppen belt with few hilly terrains (Fig-1). Due to lack of quality seismic and well data the exploration is primarily driven on geological concepts. The present work tries to analyze the hydrocarbon prospect in up-thrust Tipams in South Geleki through integration of available surface and sub-surface G&G data of the area. Accordingly, based on the recent exploratory lead obtained through drilling of well G-A in the southern part of the Geleki field along belt of Schuppen, the up-thrust prospect of Tipam sands becomes interesting from hydrocarbon point of view (Fig-2).

Objective:

The objective of the present work is to establish the structural features and its probable hydrocarbon accumulation pattern within up-thrust Tipams of Naga Schuppen belt in south Geleki and integration of all the available G&G data for a conceptual geological model.

Methodology:

The data used in the preparation of the geological maps of this up-thrust Tipams are surface geological map of previous workers, satellite imagery, well log correlation profile and geological section generated by authors.

Geology of the area:

The geology of the area is well known both from acquired subsurface and outcrop data. The present day structural configuration is a result of the late stage structural inversion of pre-existing Palaeogene to early Neogene extensional features due to the compressional stresses evolved from Burmese and Himalayan orogenies. The Upper Assam Shelf documents fairly continuous sedimentation from Cretaceous to Recent times apart from sporadic occurrence of Permo-Carbaniferous sediments along few Precambrian weak zones. Fig-3 shows the generalized stratigraphy of the area.

Structurally, the Geleki field is a NNE-SSW trending doubly plunging broad anticline. Its south-eastern flank is comparatively gentler and gradually dipping below Naga thrust whereas the western flank is bounded by the NW hading Geleki main structure bound fault with a maximum throw up to 300m across mid Tipam sequences and is remarkably dying within upper Barail (Fig-7). Apart from this NNE-SSW trending main structure bound fault, the axial trace of this Geleki mega anticline is bounded by few set of sub-seismic similarly trending normal faults. Moreover, the present day structural configuration of Geleki field is framed additionally by few sets of nearly east-west trending cross faults and upon which different estimated O&G blocks of Geleki field are defined.

The Geleki field is proved with multiple reservoirs right from Eocene shallow marine sands of Kopili formation through Oligocene fluvio-deltaic Barail pays to Mio-Pliocene fluvial massive sands within Tipams. Amongst all, the Mio-Pliocene fluvial TS-3 and TS-5 pays within Tipams are the major producer of Geleki field. Tipam sands are generally divided in to six units, TS-1 to TS-6 from top to bottom in that order. The sand units produce hydrocarbons at different stratigraphic levels depend upon the seal available for hydrocarbon entrapment. Shale caps as top seal is well established in the area, however, the lateral seal in the form of fault is also a desired sealing mechanism for trapping the hydrocarbons. These different pays of Geleki field are significant and challenging from both exploration and exploitation point of view as because the structural complexity caused by its steep dipping north-western flank.

Present Study:

The hydrocarbon prospectivity of the up-thrust block is clearly brought out at the first hand by the drilling of exploratory well G-A. As per the processed log data of this well, the different horizons viz. TS-5A, TS-1 and few sand layers within Girujan Clay are interpreted hydrocarbon bearing (Fig-3&4) with probable Oil limits both at TS-5A and at TS-1 level. The log data of well G-A and another earlier drilled well G-B clearly illustrate the repetition of older stratigraphic units (TS-5 and above) upon younger stratigraphic unit (Girujan Clay Formation) and indicates the tectonic impact of Naga Thrust in study area.

The available surface geological map and satellite imagery of the study area reveal an overall EW trending Naga Thrust passing through the north of wells G-A and G-B in conformity with the axial trend of Deopani anticline (Fig-2,8&9). The said data also indicates that Lakhuni thrust, located further south of study area around Tsurang Anticline, takes an eastward swing almost parallel to Naga thrust and joins Cholemsen thrust further east (Fig-2).

Evidence of Thrust:

The effect of thrust is clearly indicated by the log data of wells G-A and G-B and which is illustrated in a correlation profile between both the wells (Fig-4). The well G-B is located about 1km NE of lead well G-A (Fig-2) and it falls up-dip to Naga Thrust. The increase of pack thicknesses of sub-thrust Girujan in well G-B confirms its up dip position along Naga Trust with respect to lead well G-A (Fig-7). The log correlation between both key wells further indicates that hydrocarbon-bearing TS-1 pay sand of G-A in the up-thrust area is fairly well correlatable with that of well G-B (the section is not interpreted & tested). However, the oil bearing TS-5A pay sand of well G-A is absent in well G-B as this litho unit might terminate just down-dip of well G-B and which is well depicted on deduced geological section (Fig-4&7). The well G-B is projected in the produced geological section to visualize overall thrust-fold geometry present in the study area. Moreover, the structural disposition of each up-thrust litho units are well depicted on same geological section and are mostly derived from well picks. Finally, the Naga Thrust is interpreted to cut the individual well at base of respective repeat sections at sub-surface and for its spatial disposition well data and satellite imagery have been used for confirmatory purposes (Fig-7&2).

Hydrocarbon Prospects in Up-Thrust block:

Evidently, the Naga Thrust has brought up both the semi concentric and doubly plunging Deopani and Barsila anticlines along hanging wall of its thrust plane to present day position. The lithological boundaries of different rock types in the hanging wall of a thrust generally trend parallel to the thrust traces (Ref. sl.6). The prospective fault closure identified in present study is envisaged as sub-surface manifestation of Deopani anticline. Now, integrating the effect of tectonic elements of the area with geological, satellite and electro-log data, the structure contour maps are prepared on the tops of TS-1 and TS-5A pay sands. The probable hydrocarbon limits are derived from the processed log data of well G-A. Also, both TS-1 & TS-5A maps are overlain on referred surface geological map for further validation (Fig-8&9).

The hydrocarbon entrapment in up-thrust block of well G-A is explained by juxtaposition of TS-5A against Giruajan clay section (sub-thrust) and TS-1 & Girujan sands against Namsang Formation (sub-thrust) as depicted in the conceptualized geological section (Fig-7). Based on integration of petrophysical data of well G-A and structure contour maps on top of TS-1 & TS-5A pays for study area, an areal closure of about 5.0 Sq. Km and combined volumetric O+OEG of about 8.5MMt is envisaged for the proposed model.

Conclusion:

1. Commercial hydrocarbon deposits in up-thrust block of Naga Thrust is well known in Digboi oil field of Upper Assam since 1889.
2. Present study has examined and evaluated the Structurization and hydrocarbon prospects in Up-Thrust Tipams in South Geleki.
3. The Naga Thrust has been inferred and mapped from surface geological data, satellite imagery and well log data for generating TS-1 and TS-5 structure maps.
4. The proposed model envisaged an areal closure of about 5.0 Sq. Km and combined volumetric O+OEG of about 8.5MMt for the study area.

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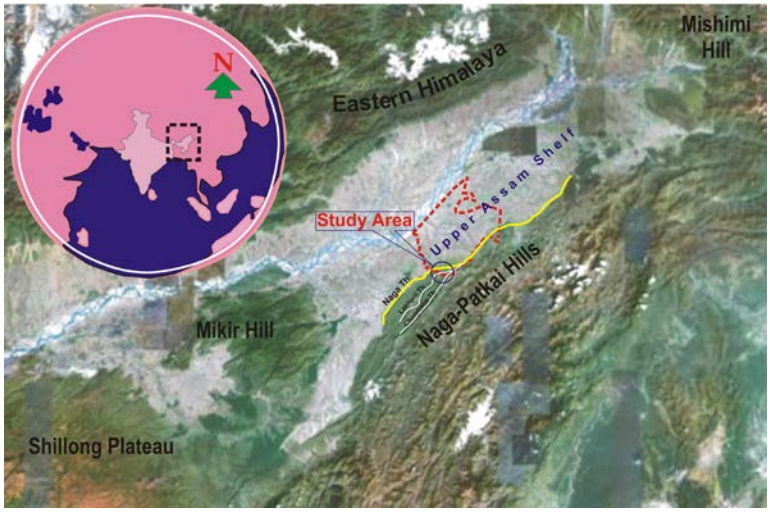

Fig-1: Location Map of the study area showing geomorphic features of the Basin

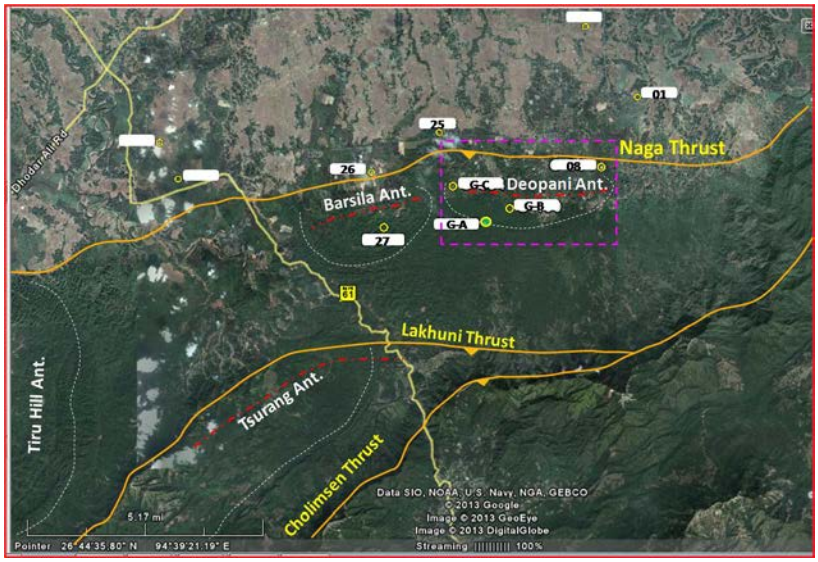

Fig-2: Surface traces of major thrusts and hanging wall anticlines in study area with drilled wells

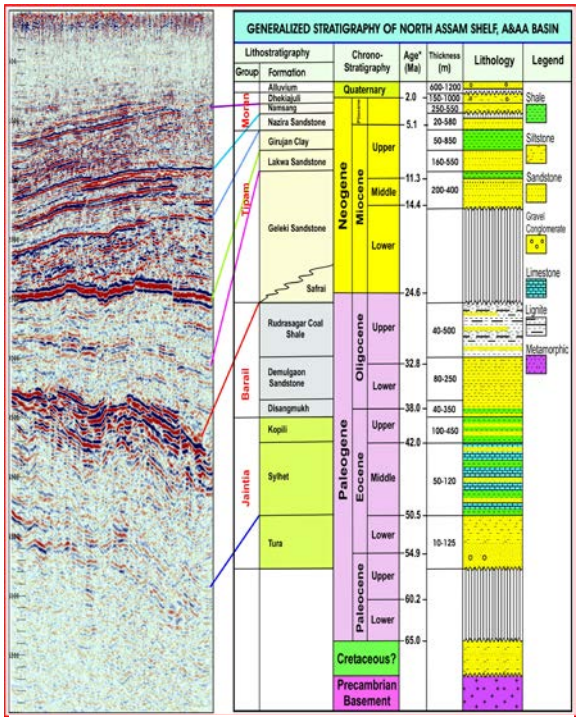

Fig-3: Generalized Stratigraphy of the area

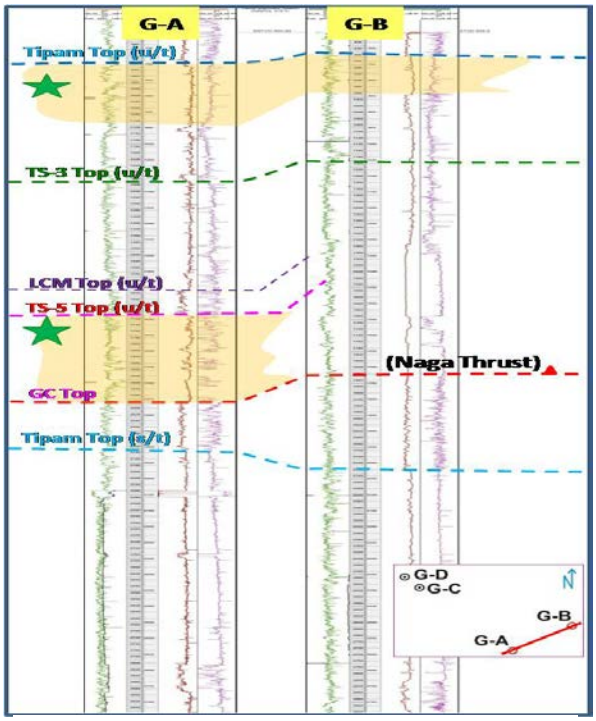

Fig-4: Log Correlation along well G-A & G-B

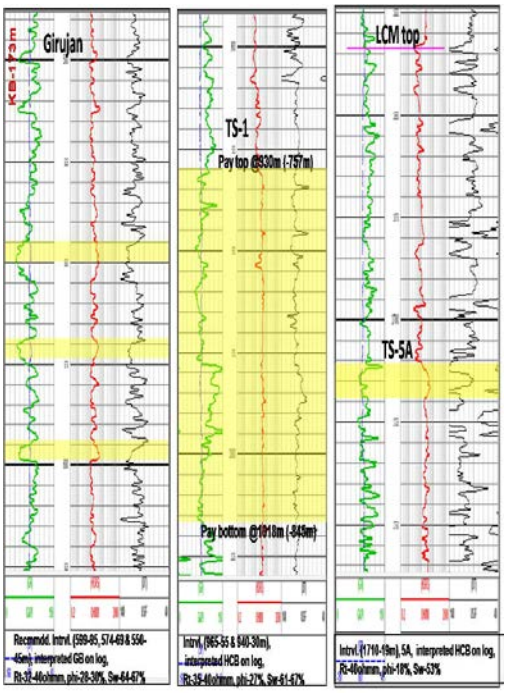

Fig-5: Log motif of well G-A

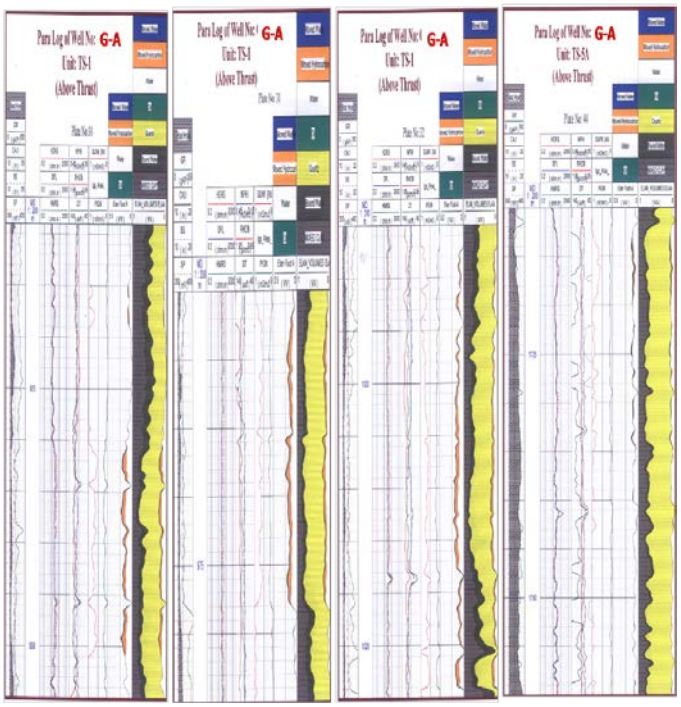

Fig-6: Processed Log of well G-A

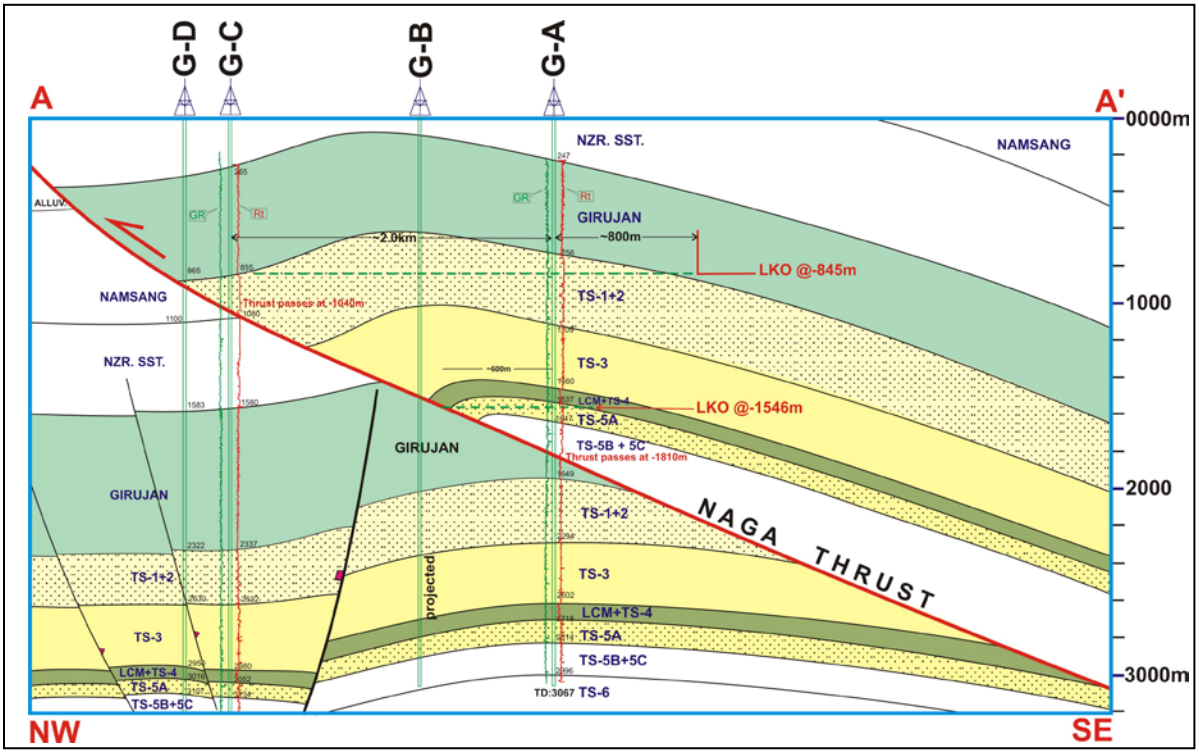

Fig-7: Geological section along wells G-D, G-C & G-A. Well G-B is projected

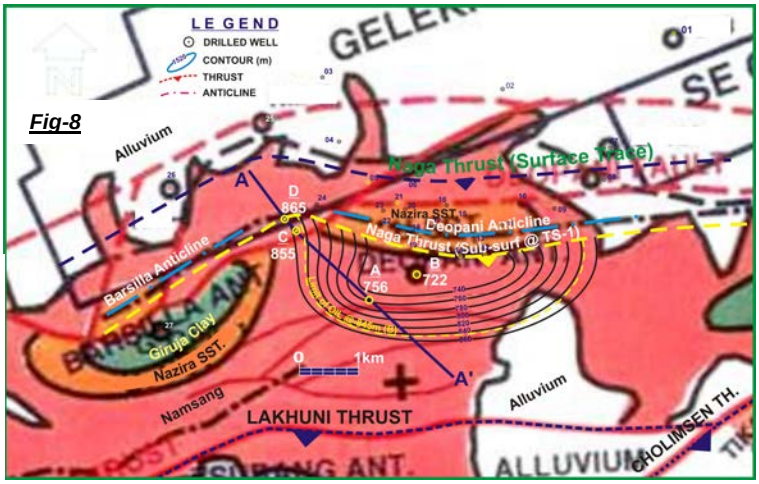

Fig-8: Structure contour map on top of TS-1 pay which is overlain on surface Geological map. The map shows the surface and sub-surface trace of Naga Thrust and line profile AA' of constructed Geological section.

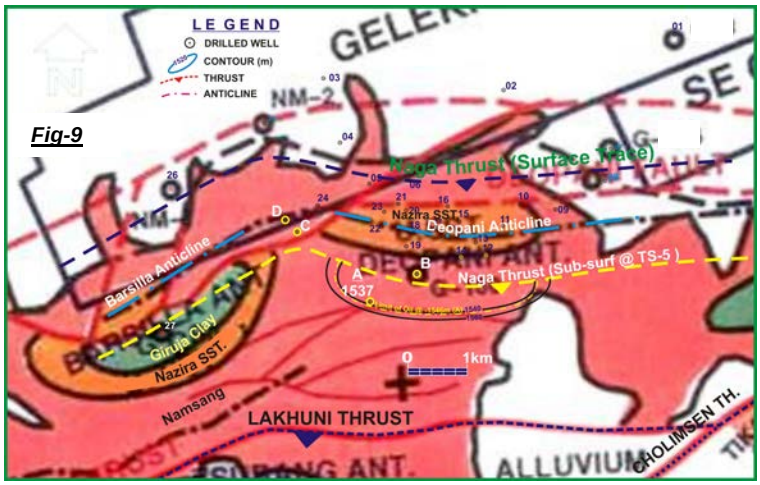

Fig-9: Structure contour map on top of TS-5 pay which is overlain on surface Geological map. The map shows the surface and sub-surface trace of Naga Thrust with other tectonic elements of the study area.