



Geleki Structure from Miocene to Recent: A New Insight into the Structural Aspects of the Geleki field, North Assam Shelf

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Summary

Geleki field hosts multiple established hydrocarbon pools in Tipam sands of Lower to Middle Miocene age, Rudrasagar and Demulgaon formations of Oligocene age and Kopili sands of Eocene ages. Present study was carried out using more than 300 well log data by well correlation technique in dip and strike directions. Henceforth, generated structure maps and characterised various structural elements of Geleki field formed as a result of Miocene to recent tectono sedimentary evolution viz. Geleki Main fault, Anticline of East block, Structural high of West block, Naga thrust in South-West and South of the field and Monoclinical structure of Girujan clay surface. Structure plays a very important role in the entrapment of hydrocarbons in Geleki field of North Assam Shelf.

It is inferred that the evolution of Main Geleki Structure (Anticline) was initiated with Post-Oligocene inversion and the gravity fault (GMF) associated with the deposition of Tipam sands. As a result the GMF dissects field into two blocks i.e. east and west block. Naga thrust in the south of the field is also forming some structural highs like Deopani anticline and Barsila anticline. Although, these features render Geleki a structurally complex field of North Assam Shelf with proved hydrocarbon entrapment in almost all layers.

Introduction

The study area belongs to North Assam Shelf encompassing Geleki field. Geleki is one of the major oil field of North Assam shelf discovered in 1968 in which, multiple hydrocarbon pools were established in Kopili, Barails and Tipam sands. The field is located at southern fringe of North Assam shelf within a close proximity to Naga Thrust and has an aerial extent of 27Sq Km (**Figure: 1**). The Geleki structure in North Assam Shelf is a doubly plunging NE-SW trending anticline. The major part of the Geleki represents gentle flat topography whereas

southern part of the field is concealed by Naga Thrust.

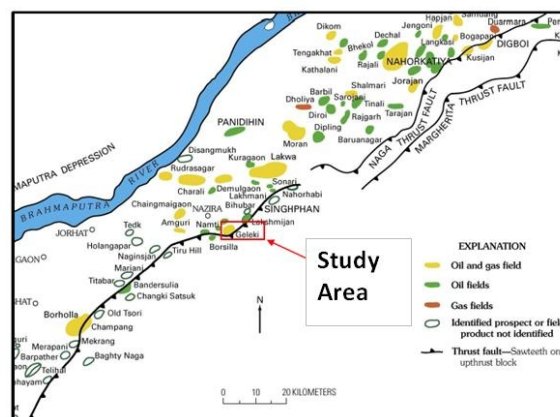


Figure: 1 Location Map of Study Area

The generalized stratigraphic succession of the Geleki Field (*Table-1*) is similar to that of the other major fields located in the North Assam Shelf. The regional tectonic framework which controlled sedimentation in this field / basin gradually changed from a passive margin set-up during Palaeocene-Middle Eocene time to a foredeep setting during Oligo-Miocene time due to the effect of different phases of collision of Indian plate from northward and eastward direction (*after Roy Choudhury S.C. et al, 2011*). Most of the oil reserves in this field are confined within the multi-cycle sandstone reservoirs belonging to the Lakwa and Geleki sandstone of Tipam Group of sediment and the entire Barail Group of sediment.

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AGE	FORMATION / SAND	LITHOLOG	GROSS LITHOLOGY	
Recent	Alluvium		Poorly consolidated coarse sand with sandy clays and clay.	
Pliocene - Pleistocene	Namsang		Dominantly loose medium to fine grained sand with little mottled dominantly red color clay/claystone.	
	Nazira Sandstone		Predominantly grey, medium grained sand with minor grey to brownish grey clay and occasionally siltstone, coal.	
Miocene - Pliocene	Girujan Clay		Mainly red, brown and greenish grey mottled clay with minor fine grained sand at the bottom.	
	Lakwa Sst.	TS-1		Dominantly fine to medium grained grey sandstones with minor light grey soft clay/ claystone.
		TS-2		
		TS-3		
	Geleki Sst.	LCM+TS4		Dominantly clay/ claystone with occasional sand/ sandstones
		TS-5		Intercalation of sand /sandstone with clay /claystone and siltstone.
TS-6				
Oligocene	Barails	Rudrasagar (BCS)	Dominantly shale inter-bedded with coal and minor clay stone with Sand and siltstone	
		Demulgaon (BMS)	Dominantly fine to medium grained grey sandstones with some inter-bedded clay and shale.	
Late Eocene	Kopili		Mainly shale (splintery) alternating with fine grained sandstone and siltstone.	
Middle Eocene	Sylhet		Mainly fossiliferous limestone with shales and thin sandstone bands.	
Early Eocene	Tura		Dominantly sandstone with minor shales.	
Pre - Cambrian	Basement		Leucocratic granite (weathered) with essential minerals e.g. quartz and pink feldspar.	

Table: 1 Generalised Stratigraphy of the Study Area

Present Study

The Geleki field is located towards the basinal part of the Assam Shelf. As a result of this Tipams, Barails, Kopili, Sylhet and Tura Formations occur at deeper depths as compared to other fields like Lakwa, Rudrasagar, and Disangmukh etc. of North Assam Shelf. Scope of present study is limited to structural analysis of the Geleki field from Miocene to recent.

In context of present study, Tipam Group consist of 6 major multi-storied sandstone pays (top three in Lakwa Sandstone, fourth one thinner and confined within the shale section of LCM and the bottom two are in Geleki Sandstone), developed from top as Tipam Sand (TS) 1 to 6, with a number of sub-layers. These sands are extensive, well developed and well correlatable and could be identified easily in well logs. Tipam sands except TS-1 and TS-4 unit were deposited mostly in braided channel depositional set up whereas TS-1 and TS-4 are meandering channel sand. The sediment supply kept in pace with rate of subsidence and was in equilibrium in such a way, that same environment prevailed throughout this period facilitating lateral coalescing and vertical stacking of braided channel sands to form extensive sheet deposits. Whenever the equilibrium tilted towards relatively rapid subsidence, environment shifted to

lower fluvial plain and deposition of low energy sediments like claystone dominated in the area. Lower Clay Marker (LCM) was deposited under such condition. The Claystone markers overlying TS-3 and TS-2 sands, could be deposited under such pulses of tilt in the equilibrium. As far as data availability is concern part of the field i.e. south and south western part is devoid of seismic data. But so far, more than 350 wells have been drilled on the structure and majority are development wells for Tipam sands. Thus, sufficient well data is available to decipher broad structural configuration of the field.

Higher well density facilitated extensive electro log correlation across the field and correlated all the horizons from Rudrasagar Formation top to Namsang top wherever the logs were available in a well. It is observed that sand / formation tops of TS-5, LCM, TS-3, TS-2, TS-1, Girujan Clay (GC), Nazira Sandstone and Namsang are easily discernible in well logs. However, regional correlation of TS-6 is conjectural owing to lesser degree of confidence for correlation due to absence of persistent clay marker.

Structure contour maps from BCS top to Namsang top were prepared along with isopach map to delineate structural elements and thickness variation across Geleki field. Two dip and strike geological cross sections were prepared, incorporating the presence of Naga thrust in south of the field (**Figure: 2a & 2b**). The structure contour maps and isopach maps may be subjected to minor corrections for minor faults and dip of the beds. Missing sections upto 300m were observed in some wells as a consequence of gravity normal fault oriented in NE-SW direction as well as repeat section due to thrusting (of ~1200m) in southern part of the field was observed in the field. Missing sections in various well logs were identified and mapped the fault in structure map. Structural aspects were identified with the help of structure contour map whereas thickness variation comes out through isopach maps. Schematic Geological sections were prepared for depicting the structural highs of Deopani and Barsila anticline formed against Naga thrust.

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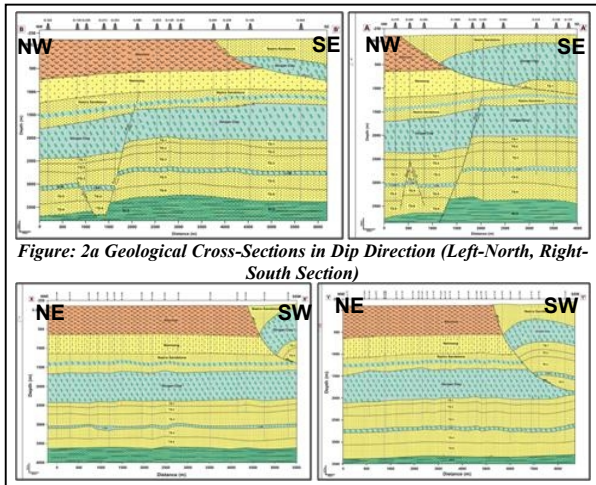


Figure: 2a Geological Cross-Sections in Dip Direction (Left-North, Right-South Section)

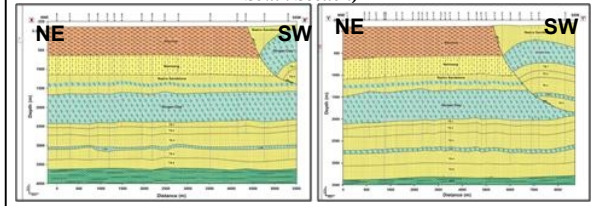


Figure: 2b Geological Cross-Sections in Strike Direction (Left-West, Right-East Section)

Based on existing field observations and inferences, a combined thick /thin skinned model is thought to be able to best express the features seen in the area. First inversion and then thrusting is postulated to occur along with normal faults which form locales of thrusting (after Akhtar S. Md et al.).

Main Structural Elements:

Geleki Main Fault:

A major normal fault named as Geleki Main Fault (GMF), dipping NW has bisected Geleki field into two blocks, the West block (hanging wall block) and East block (foot wall block) (Figure: 3).

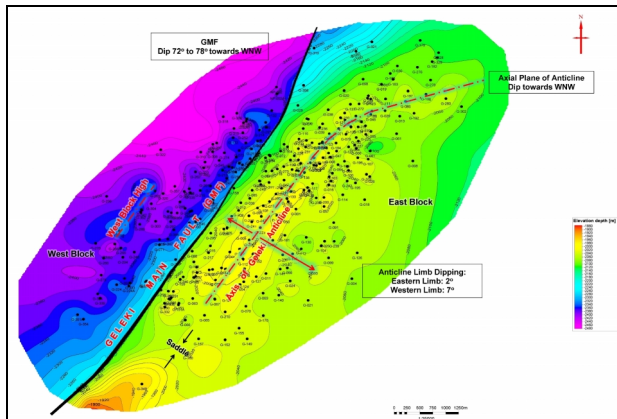


Figure: 3 Structure Contour Map of TS-1 Top Showing Structural Elements of Geleki Field

The dip of the fault varies between 72° to 78°. It is observed that throw of fault is decreasing gradually with each successive younger stratigraphic level. West block is down by 240-260m at BCS level, 320-340m at TS-6 level, 300-310m at TS-5 level, 260-300m at LCM level, 220-260m at TS-3 level, 160-200m at TS-2 level, 160-180m at TS-1 level and 40m at Girujan Clay level. The GMF dies out in the lower part of Nazira Sandstone. Missing sections, part of the horizon or entire horizon i.e. in the range of 100m to 350m were observed from layer Girujan to TS-6 in some wells. The GMF cuts the geological horizons successively at deeper levels from east to west in the field, which decipher the dip direction of the fault plane.

Anticline of East block:

The entire East block is represented by a broad NNE-SSW trending gentle asymmetric anticline plunging in NE direction. In the northern part of the field, the anticline takes a swing towards NE with a saddle. The anticline rises towards SW beyond the present field limits with a saddle. However, we need more subsurface information to prove the extent of further rising trend of Geleki structure towards south. The axial plane of the anticline gently dips towards West. The dip of eastern limb of the anticline is about 2° whereas the western limb dip varies between 3° to 7°.

Structure of West block:

A structural high trending NNE-SSW and oriented parallel to GMF is observed in the West block. A prominent low separates this high from GMF. Further west of the high the structure becomes deeper.

Monoclinial structure:

Monoclinial structure dipping towards west was observed within field limits at all levels of Nazira Sandstone and above (Figure: 4).

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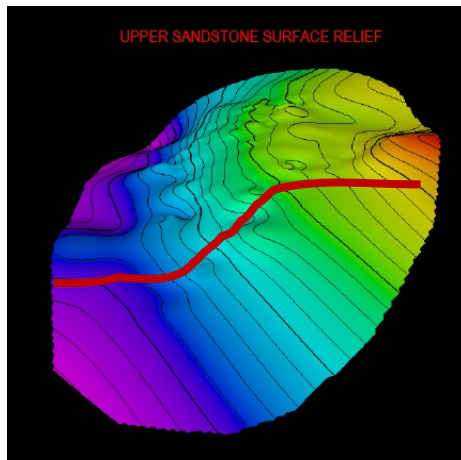


Figure: 4 3D View of Nazira Sandstone Top Showing Monoclinial Structure

Naga Thrust:

In the southern part of the field, repetition of beds due to thrusting is observed both in east and west blocks (Figure: 2a & 2b) (Maximum upto 1100m at Girujan clay level). The Naga Thrust has displaced the stratigraphic section from the bottom part of Girujan clay and TS-5 to Girujan Clay Formation is repeated in the over thrust section (Figure: 5). Further south of field the thrust might have displaced the section from further below of Girujan clay.

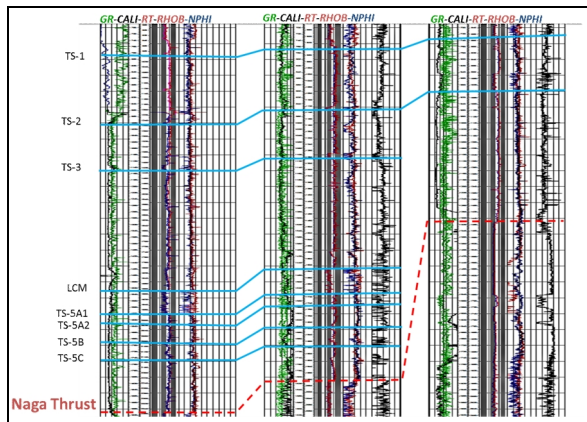


Figure: 5 Well log Showing Repetition Tipam Section above Naga Thrust

Isopach maps:

Isopach maps show that thickness variation of TS-6, TS-5 and LCM in the range of 240m to 320m, 260m to 340m and 40m to 80m respectively and increase of

thickness is observed in East block compared to west block. Thickness of TS-3, TS-2, TS-1, Girujan clay and Nazira sandstone varies from 280m to 380m, 170m-220m, 80m-150m, 650m-850m and 320-500m respectively and a general increase of thickness in west block close to GMF is observed.

Analysis:

1. Main Geleki Structure:

GMF is having lesser throw of 240m at BCS level when compared to throw of 320- 340m at TS-6 level, 300-310m at TS-5 level, 260-300m at LCM level. General increase of thickness of TS-6, TS-5 and LCM is observed in East block compared to the West block. Increase in thickness of TS-3, TS-2, TS-1, and Girujan Clay in west block compared to east block and gradual increase in throw of beds from Girujan Clay to TS-3 near to GMF suggests syndepositional sinking of west block during deposition of these sands. Geleki main anticline in the east block is aligned parallel to GMF and is asymmetric, with western limb having more dip (up to 7°) and eastern limb having dip of 2°. The axial plane dips to the west and the trace of the axis from deeper horizon to shallower is showing shifting to east. Trace of axial plane and GMF were plotted with respective horizon (Figure: 6). The parallel alignment of anticline with westward dip of axial plane suggests that the formation of anticline is probably due to the sagging of beds of western limb along GMF and syndepositional sinking of west block. The dip of eastern limb is comparable to palaeo depositional slope of the basin. Plunge on the north may also due to more relative sinking of basin to the north. The saddles on the anticline in the north and south might be due to cross faults. The anticline losses its amplitude at Girujan top and appears as a terrace feature with monoclinial dip of Girujan top and post Girujan strata towards west indicates tilt of basin towards west.

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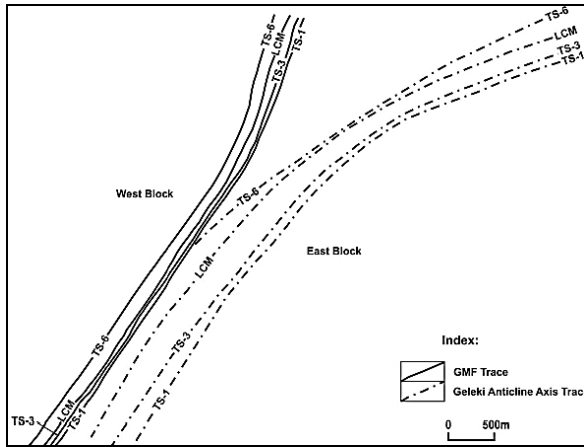


Figure: 6 Trace of Anticline Axis and GMF w.r.t. Each Horizon

2. South West and South Geleki Structure:

This part of the field is covered with very less number of wells but repetition of horizons are very frequent and could be identified on logs also (Figure: 5). Limit of the Naga thrust was demarcated on the surface using field map and well log data (Figure: 7). A conceptual model for upthrust Tipam was prepared using well data and surface geological map which explain the existance of highs like Deopani anticline and Barsila anticline (Dome). Deopani anticline is more or less a nosal feature falttened and gentle dipping whereas Barsila is tighter and appears as a dome like structure (after Srikantaswamy et al, ONGC). Presence of hydrocarbon is proved in both the structures in upthrust section. Geological sections (Figure: 8) are explaining the tightness of Barsila anticline alongwith broader nature of Deopani anticline.

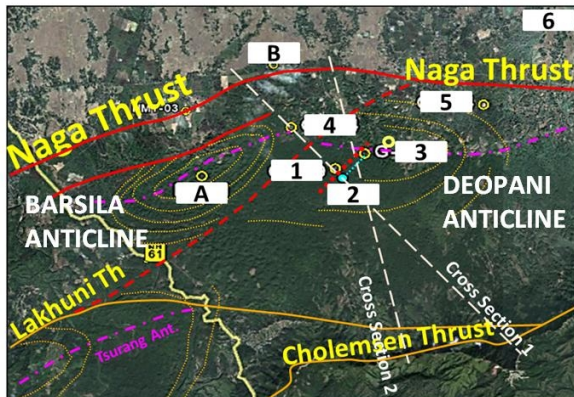


Figure: 7 Satellite Image with Marked Naga thrust, Barsila and Deopani Anticline

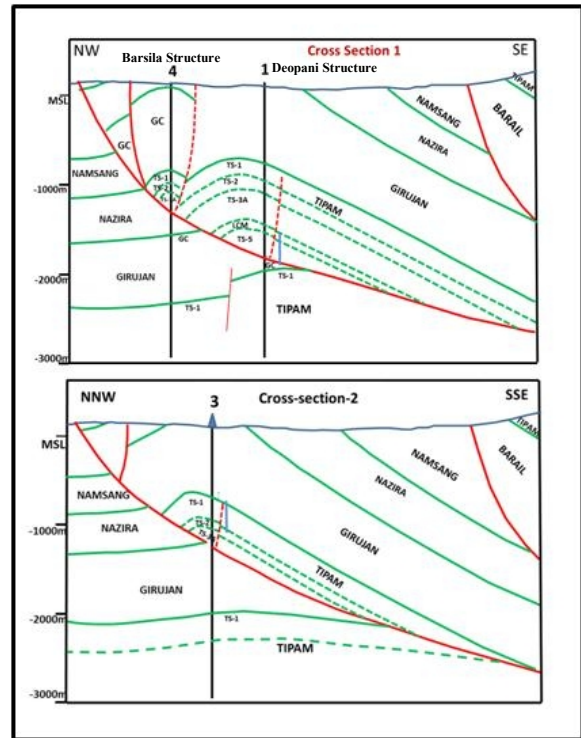


Figure: 8 Schematic Geological Cross-Section along NW-SE (above) and NNW-SSE (below) direction in South Geleki

Results and Conclusions

- The Geleki field is dissected by a normal gravity fault, Geleki main fault (GMF). GMF is dipping towards NW with dip of 72° to 78° and divided the Geleki structure into two blocks, the down thrown West block and upthrown East block.
- Throw of GMF decreases with successive younger formations upto 350m to 30m at Girujan Clay top. GMF dies out within Nazira Sandstone Formation.
- Axial plane of Geleki anticline is running parallel to GMF and dipping in NW direction. Western limb is steeper (7°) compared to eastern limb (2°).
- Geleki anticline is plunging towards NE.
- Geleki structure is further rising towards SW of the field with a saddle to its north.
- Compression started in Oligocene and is active tectonic element prevailed in the basin which is playing a major role in the evolution of Geleki structure as well as restructuring of the structure.
- Naga thrust and its splays are also major component that formed the structure like Deopani

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and Barsila. Wells drilled in these structures are showing repetition of Tipam and are also interesting from HC point of view.

It is well established that North Assam Shelf was subjected to intense changes with time as evidenced by huge thickness variation of Girujan Clay and younger formations and tilt of the basin towards NW direction during this period. The present study elucidates that the evolution of Geleki Structure (Anticline) was initiated in the depocenter, due to the gravitational forces associated with Post-Oligocene inversion and development continued through later period and it is still continuing.

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