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## **Major Hydrocarbon Trap Types in Dhansiri Valley, Assam and Assam Arakan Basin, India.**

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### **Summary**

*Dhansiri valley is the southern part of Assam Shelf which is a commercial hydrocarbon producing area. The hydrocarbon bearing reservoirs are fractured basement (Pre-Cambrian) and sandstone ranging in age from Paleocene to Miocene. The Tertiary reservoirs are distributed (stratigraphically) within Tura (Paleocene), Sylhet, Kopili (Eocene) and Bokabil, (Miocene) Formations from bottom to top. Shallow marine thick carbonaceous shale of Kopili Formation (Late Eocene) is a proven effective source rock for hydrocarbon generation in the study area. The shale above each producing reservoir forms effective top and lateral seal. The hydrocarbon migrations are through faults and majority of known traps in the study area are mainly structural with stratigraphic element within.*

*The detailed analysis of major hydrocarbon producing structures indicates that there are three types of hydrocarbon entrapment pattern in Dhansiri valley, these are 1) Faulted Horst and Graben structure, 2) Inverted Normal fault and 3) Compressed Normal fault. The entrapment of hydrocarbons is restricted either inverted or compressed part of hanging wall hading towards basinal side, besides in the horst block in faulted horst and graben structure. The accumulations are essentially controlled by the structural element. Even the lenticular sand charged with hydrocarbon is occurring at structurally favorable and highest part. The study helps in identifying potential traps in this area and may contribute towards accretion of hydrocarbon reserve.*

### **Introduction**

Dhansiri valley also known as South Assam Shelf (SAS) is located in the northeastern part of India (Fig.1). Assam shelf consists of sedimentary succession of strata ranging in age from Mesozoic to Recent (Fig.2). It covers an area of about 57,000 Sq Km with the maximum thickness nearly 13 km. in deepest part of the basin. The success in hydrocarbon explorations in Dhansiri valley is marked with the discovery of Borholla field (1970) and Changpang field (1973) where oil have been tested from fractured basement, Basal sandstone and sands within Sylhet and Kopili Formations. Besides gas from Tipam and Namsang sands. Oil has been discovered from Basal sandstone of Mekrang structure 1996. The lenticular sands at lower part of Bokabil Formation proved to be productive and oil was discovered from Tynephy (1986), Uriamghat 1988, Khoraghat 1989, Nambar 1999. East Lakhbari (2003 ),

Kalyanpur(2007), Babejia (2008), Hazarigaon (2008). Kasomarigaon (2009) Oil was tested from Bokabil and Tipam sands.

Hydrocarbon shows/ indication have also been observed from Pre-Tertiary reservoirs from East Lakhbari (2003 ) but its commercial viability is required to be ascertained.



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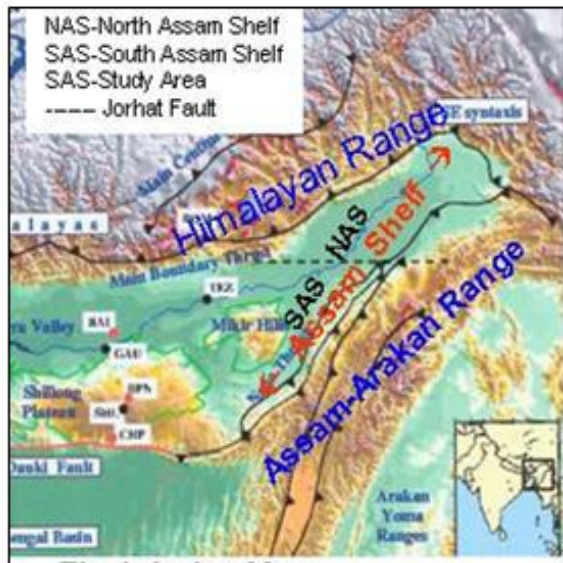


Figure 1: Index Map

### Tectonic Evolution

Tectonically the Assam and Assam Arakan basin is subdivided into Shillong and Mikir Massifs, Himalayan frontal fold belt, Mishmi massif, Assam shelf, Schuppen Belt (Evans, 1964), Indo-Burmese Ranges (Assam-Arakan Ranges) and Compressed thrust fold belt (CTFB) of Tripura-Cachar - Mizo folds & Eastern belt of metamorphics including Ophiolite belt (Fig.3).

The sedimentary rocks in the Shillong Plateau, rest over the Precambrian crystalline basement were studied by the Geological Survey of India. Subsequent drilling has proved the extension of these rocks in the subsurface of Assam Shelf. It has been inferred from the various studies that ENE-WSW and NW-SE trends are two dominant stress trends in the exposed basement. The intensely fractured and highly weathered basement (Ranga Rao, 1983; Bastia, et al., 1993,) has been producing from Borholla-Changpang fields in the study area.

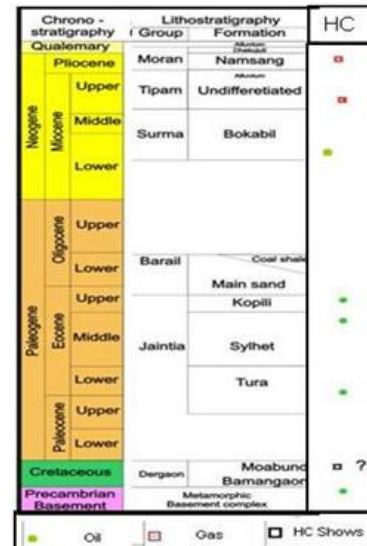


Figure 2. Stratigraphy of Dhansiri Valley

### PreTertiary Rifting and Drifting Phase

Late Jurassic – Early Cretaceous rifting of Gondwanaland and its fragmentation has resulted in a regional extensional regime. This was associated with opening of Bay of Bengal and generation of 'new' oceanic crust between India and Australia-Antarctica, which has resulted in development of a passive margin all along the eastern margin of India.

Pre-Tertiary sedimentary record from Assam shelf preserves imprints of multicyclic tectonic evolution in space and time. The Gondwana sediments were deposited in isolated intra continental rift grabens in fluvial environment followed by marine condition. Sediments of Dergaon group together with Mikir traps correspond to this phase.

### Tertiary Phase

The Paleogene sediments (Jaintia and Barail Group) sediments range in thickness from 150-950m and represent the deposit of pervasive passive margin condition in this sector of eastern margin of India. These conditions continued until Late Oligocene when flexuring of the crust took place owing to oblique eastward collision with the



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Burmese plate. It has resulted in the formation of a fore deep which accommodated clastic sediments of Bokabil and Tipam Formations (Murty, 1983). In the Later phase, northward collision has resulted in the development of northern fore deep (younger) in which Pliocene and younger sediments were deposited.



Figure 3 Tectonic Map of Assam and Assam Arakan Basin

### Source, Reservoir and Cap Rock/Seal

#### (a) Source Rock

The source rock geochemistry data obtained from number of wells of Assam shelf indicates that Shallow marine thick carbonaceous shale of Kopili Formation (Late Eocene) is effective source for hydrocarbon generation in the study area. The organic richness and their maturity increases towards Schuppen belt (Singh, et al., 2008).

#### (b) Reservoir Rock

The sandstone within Bokabil (Miocene), Tura (Paleocene), Sylhet and Kopili Formation (Eocene) are having good reservoir characteristics, besides Fractured basement of Precambrian age. The thickness of multilayered sandstone reservoirs within Sylhet and Kopili Formation varies from 2 to 17 m with porosity variations from 11-29%. The thickness of lenticular sand within Bokabil Formation varies from 3 to 12 m with porosity variation from 15-21 %.

#### (c) Cap Rock/Seal

Shale of Kopili Formation acting as lateral seal in host-graben settings for fractured basement reservoirs. Shale at the top of each reservoir sand within Tura, Sylhet, Kopili, Bokabil Formations are acting as seals for different reservoirs in the area.

### Hydrocarbon Bearing Structures in Dhansiri valley

Borholla-Changpang, Khoraghat and Nambar are the major producing fields from Dhansiri valley which account for more than 90% of the proven hydrocarbon reserve. Study of geo-scientific and production testing data of producing fields indicates hydrocarbons trapped in Dhansiri valley are grouped in to three structural traps:-

- 1) Faulted Horst and Graben structure
- 2) Inverted Normal fault and
- 3) Compressed Normal fault

#### 1) Faulted Horst and Graben Structure

The analysis of geo-scientific and production testing data of Borholla-Changpang field indicates that the hydrocarbon have been trapped in the basement involved "Faulted Horst and Graben" type structure (Fig.4 a & b, Fig.7 a & b). Where thick shale of Kopili Formation and at places shale and limestone of Sylhet Formation juxtaposing against the fractured basement ( Fig.4 b) and forming ideal trap for hydrocarbon entrapment in fractured Basement.

The folding in successive overlying Tura, Sylhet and Kopili Formations over tilted fractured basement forms favorable structural entrapment conditions for hydrocarbon entrapments in these formations (Fig.4 b).



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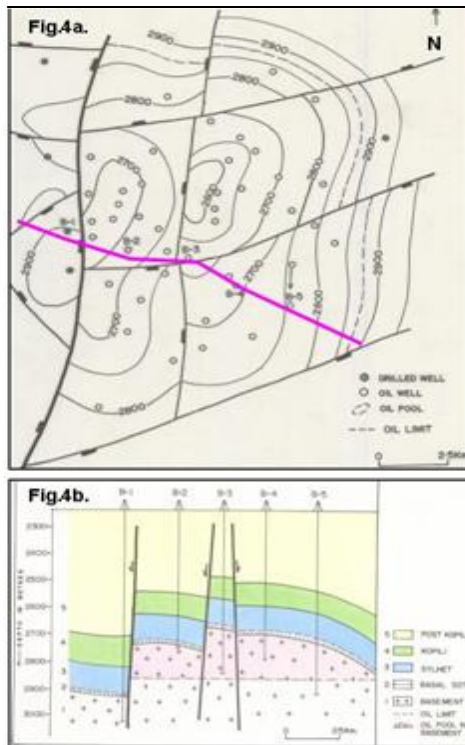


Fig.4a. Structure Contour Map on Top of Basement, Borholla-Changpang Field, Dhansiri Valley.

Fig.4b. Geological Section Along Wells B-1, B-2, B-3, B-4 & B-5 Across Borholla-Changpang Field, Dhansiri Valley.

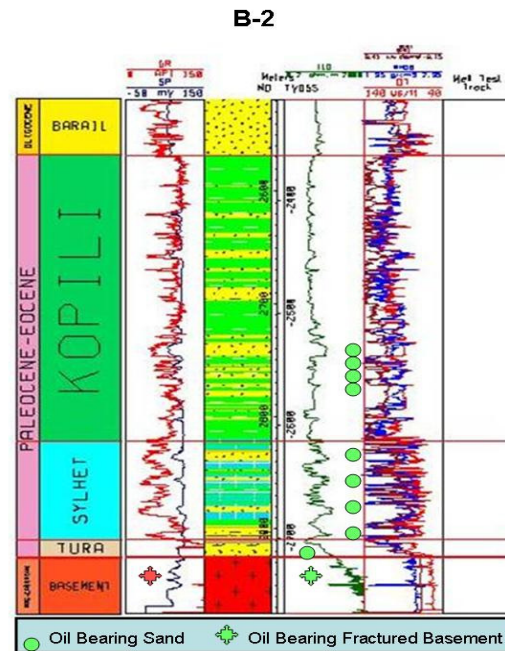


Fig.4c. Log Motif of Fractured Basement and Reservoir Sand within Tura, Sylhet and Kopili Formations





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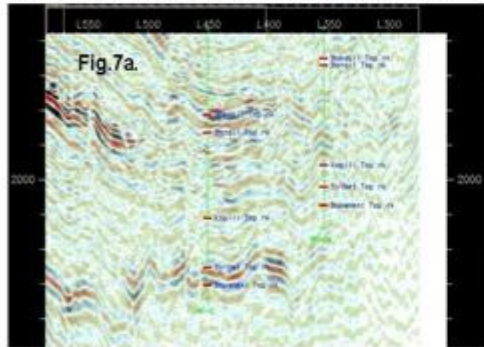


Fig.7a. Part of Un interpreted Seismic Line Passing Through Borholla Str.

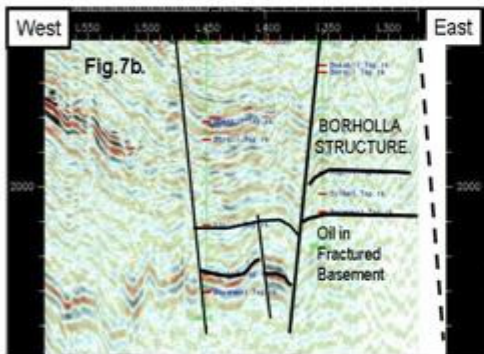


Fig.7b. Part of Interpreted Seismic Line Passing Through Borholla Str.

Basal sandstone of continental origin directly overlying fractured basement forms single hydro-dynamically connected reservoir with fractured basement.

Sylhet Formation composed of multilayered limestone, shale and sandstone alternation, where sandstone is charged with the oil (Fig.4c). Kopili Formation consists of predominantly shale and thin lenticular sand in between at places. These lenticular sands at lower part of Kopili Formation become more arenaceous and oil bearing (Fig.4c).

### 2) Inverted Normal fault

The analysis of geo-scientific and production testing data of another major producing field “Khoraghat main field” indicates the hydrocarbon have been trapped in the inverted hanging wall of Khoraghat main structure (Fig. 5 a & b, Fig. 8 a & b). The critical analysis indicates that the normal fault with reasonable through which got inverted at

the later stage of compressed and ultimately resulting inverted normal fault by the reactivation of normal fault. In which the hydrocarbons are accumulated the crestal part of the inverted hanging wall (Fig. 5 a & b, Fig. 8 a & b). Except two well (were sand within Sylhet and Barail Formation are hydrocarbon producers are having limited areal extent.). The major hydrocarbon producing reservoirs are lenticular sands and are restricted in the lower part of the Bokabil formation in Khoraghat area (Fig. 5 c).

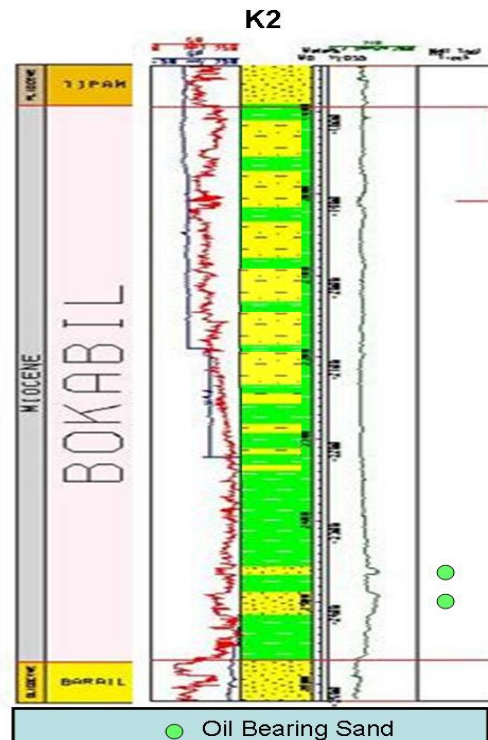


Fig.5c. Log Motif of Reservoir Sand within Lower Unit of Bokabil Formations, Khoraghat Field, Dhansiri Valley



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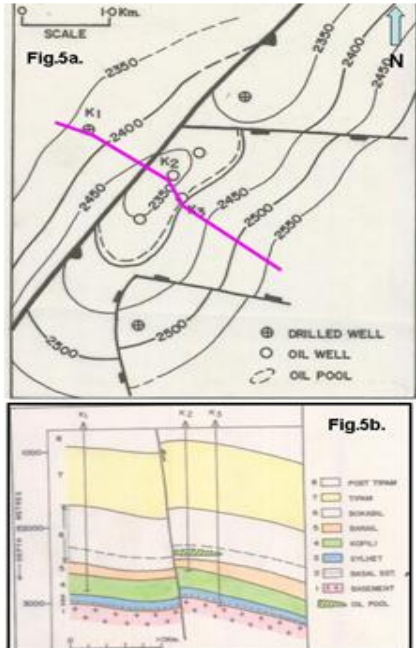


Fig.5a. Structure Contour Map on Top of Bokabil Pay Khoraghat Field, Dhansiri Valley.

Fig.5b. Geological Section Along Wells K1,K2 & K-3 Across Khoraghat Field, Dhansiri Valley

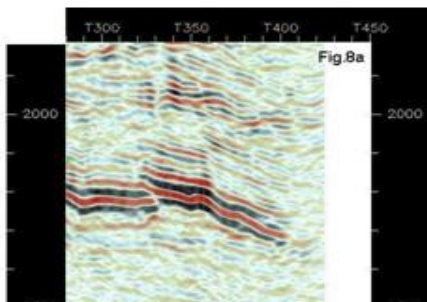


Fig.8a. Part of Un interpreted Seismic Line Passing Through Khoraghat Structure, Dhansiri Valley.

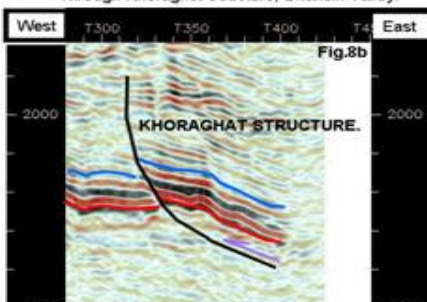


Fig.8b. Part of Interpreted Seismic Line Passing Through Khoraghat Structure, Dhansiri Valley.

### 3) Compressed Normal fault

The analysis of geo-scientific and production testing data of another major producing field “Nambar field” indicates the hydrocarbon have been trapped in the compressed hanging wall, down thrown side of Nambar structure (Fig. 6 a & b, Fig. 9 a & b). The critical analysis indicates that the faulted down thrown side of normal fault with reasonable high throw ( $> 200\text{m}$ ), got compressed and resulted normal fault with compressed faulted down thrown side. Hydrocarbons are accumulated the crestal part of compressed faulted down thrown side (Fig. 6 a & b, Fig. 9 a & b).

The Bokabil Formation consists of shale with lenticular sands at places in between. The upper part of Bokabil formation is composed of thick shale with minorsandstone at few places where as the lower part of Bokabil Formation is composed of alternation of lenticular sands and shale. The hydrocarbon producing reservoirs (lenticular sands) are restricted in the lower part of the Bokabil Formation in Nambar area (Fig. 6 c).

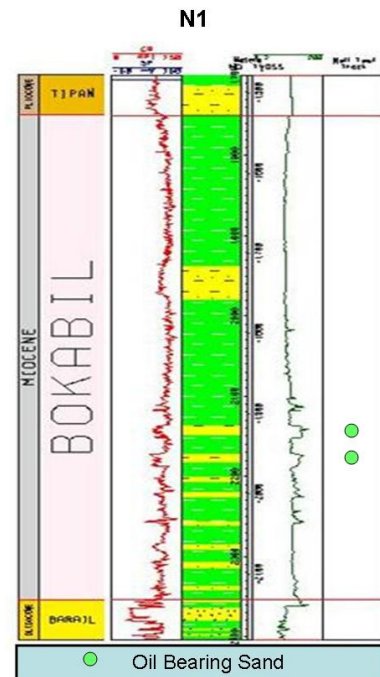


Fig.6c. Log Motif of Reservoir Sand within Lower Unit of Bokabil Formations, Nambar Field, Dhansiri Valley



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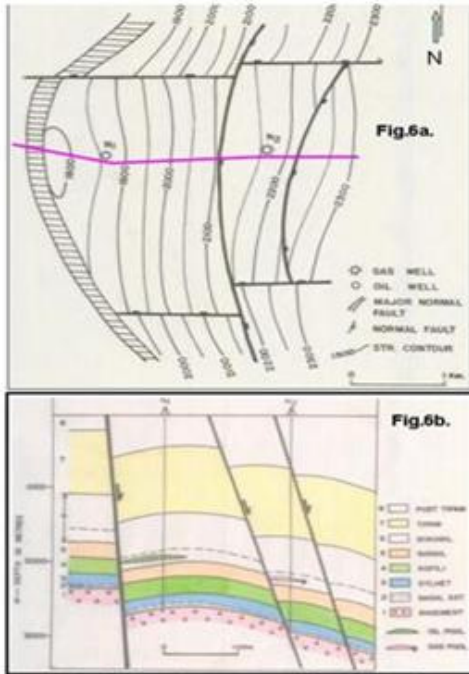


Fig.6a. Structure Contour Map on Top Bokabil Pay Nambar Field, Dhansiri Valley.

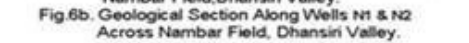


Fig.6b. Geological Section Along Wells N1 & N2 Across Nambar Field, Dhansiri Valley.

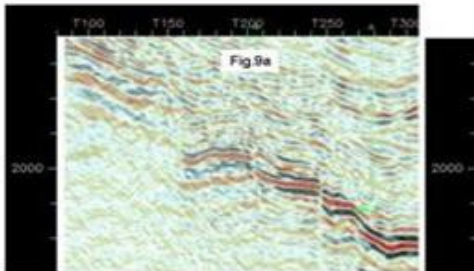


Fig.9a. Part of an Uninterpreted Seismic Line Passing Across Nambar Structure, Dhansiri Valley

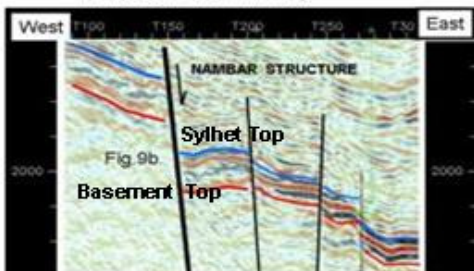


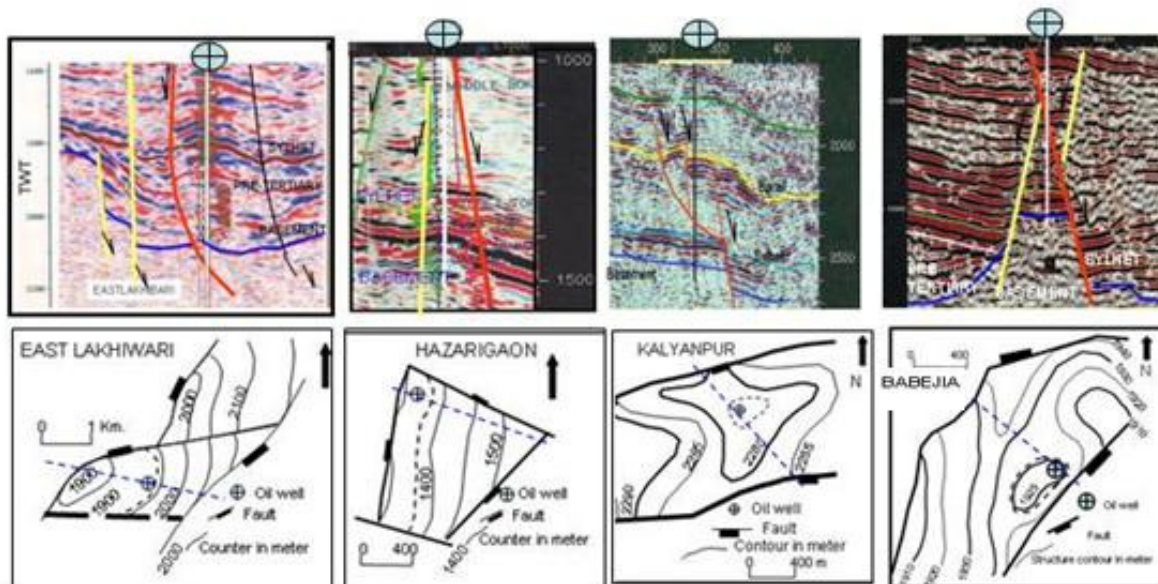
Fig.9b. Part of Interpreted Seismic Line Passing Through Nambar Structure, Dhansiri Valley

The hydrocarbon pools discovered in East Lakhbari, Hazarigaon, Kalayanpur, Babajia etc. are having limited aerial extent and are entrapped in faulted inverted structures (Fig. 10).





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**Fig.10. Structural Pattern of Small Hydrocarbon Pools in Dhansiri Valley**

### Conclusion

1. The thick shale of Kopili Formation and at places Sylhet Formation juxtaposing against the fractured basement are forming ideal trap for hydrocarbon entrapment in fractured Basement.
2. The folding in successive overlying Tura, Sylhet and Kopili Formations over tilted fractured basement forms favorable structural entrapment conditions for hydrocarbon entrapments in these formation.
3. The analysis indicates that the hydrocarbons are accumulated in the crestal part of inverted hanging wall in Khoraghat main structure.
4. The analysis indicates that the hydrocarbons are accumulated in the crestal part of compressed faulted down thrown side of hanging wall in Nambar structure.
5. The hydrocarbon accumulation on the hanging wall associated with the fault hading towards east-Southeast (heading towards basin) in Nambar and Khoraghat structures indicates that fault heading basinal side might be acting as conduit for hydrocarbon migration in addition to the cross fault .

Though the paper addresses major hydrocarbon trap types in Dhansiri valley, but the entrapment of hydrocarbons in most of the known hydrocarbon bearing structures (Fig. 10) are falling in either one or other types of traps discussed above.

The opinion expressed in the paper are of authors not the organization they belong.

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