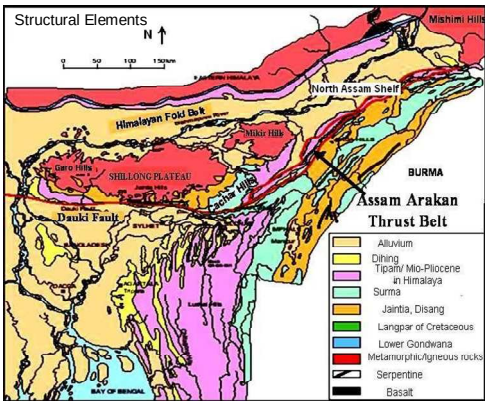
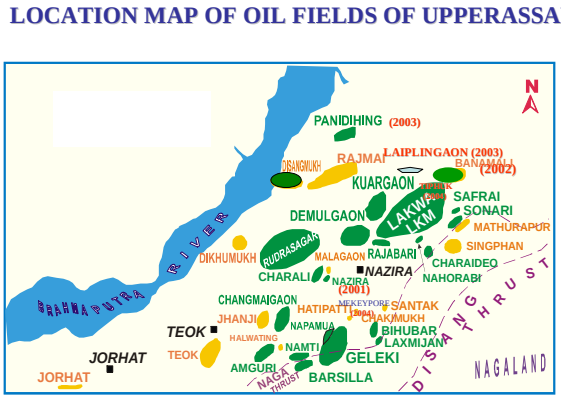
MAYADHAR SAHOO, Oil & Natural Gas Corporation Ltd, Nazira
K.D GOGOI, Department of Petroleum Technology, Dibrugarh University, Dibrugarh, Assam

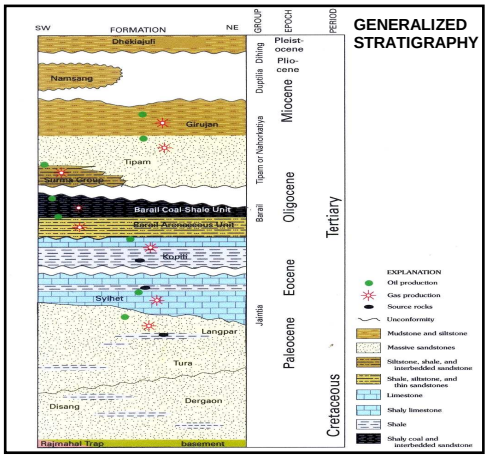
Structural Styles and its Implication on Petroleum Systems of North Assam Shelf, Upper Assam Basin, India.

Introduction

The 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 terminated to the northeast by the Mishimi Hills block and to the Southwest it is partly disrupted by the Shillong plateau basement uplift (Fig.1).







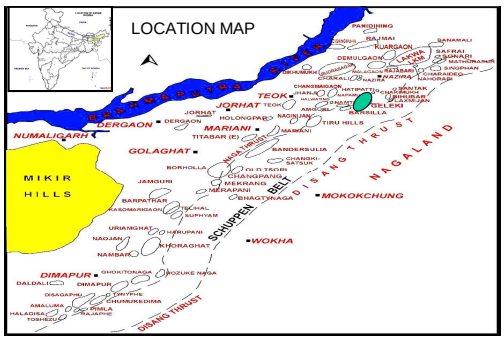


Fig.1 Showing structural elements, location of oil fields, generalized stratigraphy and location of all places of Upper Assam Basin

There are two petroleum systems present in North Assam Shelf of Upper Assam Basin and are described below (Sahoo & Gogoi, 2009):

(A) Paleocene to Middle Eocene- Paleocene to Middle Eocene (!)Petroleum System

The Paleocene to Middle Eocene- Paleocene to Middle Eocene (!) Petroleum System which is oldest and the source rocks of this system is of organic rich carbonaceous shales, coals and thin carbonate units of upper Paleocene – lower Eocene Sylhet Formation and the Upper Paleocene Langpar Formation (Handique and Bharali, 1981). The carbonaceous shale and coal often interbedded with clastic reservoir rocks which are thin to very thin characterized by very high permeability and porosity.

(B) Late Eocene to Oligocene-Oligocene (!) Petroleum System

This petroleum system comprises of thick Kopili shale as major source rock and Sylhet limestone with marginal source rock potential (Fig.1). The lower Kopili is more argillaceous in nature than the upper with a shale content of more than 60% where as in the Sylhet Formation, it decreases to 10-15%.

Structural Styles in North Assam Shelf

The regional structure of upper Assam foreland basin is known from geophysical survey conducted for hydrocarbon exploration. The generalized structure inferred from seismic surveys, that the Assam plains form a broad arch at the basement level with its apex in the region of the present Brahmaputra river course and sloping towards the Himalayan foot hills in north and Naga hills in the south (Fig.2). This arch is dissected by a number of faults with a general strike of NE-SW or ENE-WSW trend parallel to the fault pattern observed in the Mikir hills metamorphic complex. (Ray et.al., 1983) and also parallel to Naga thrust. The structural pattern in the sedimentary cover is controlled by the irregularities in the basement surfaces known from gravity survey and differential movement along these faults.

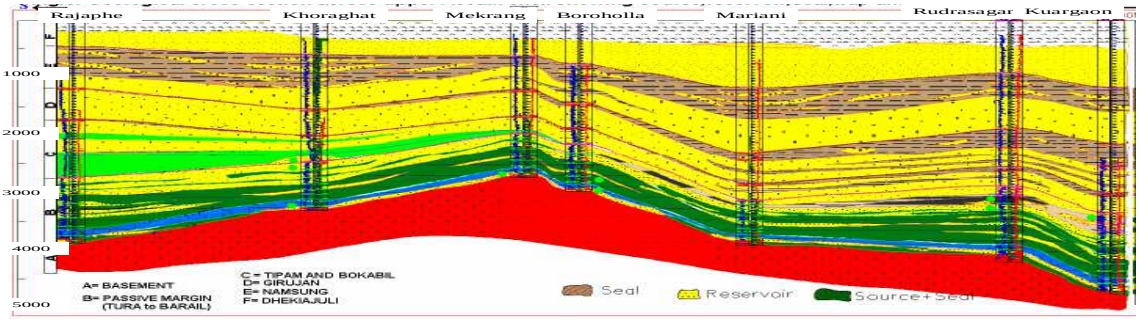


Fig.1 Geological cross section showing, reservoir rock, source rock and seal.

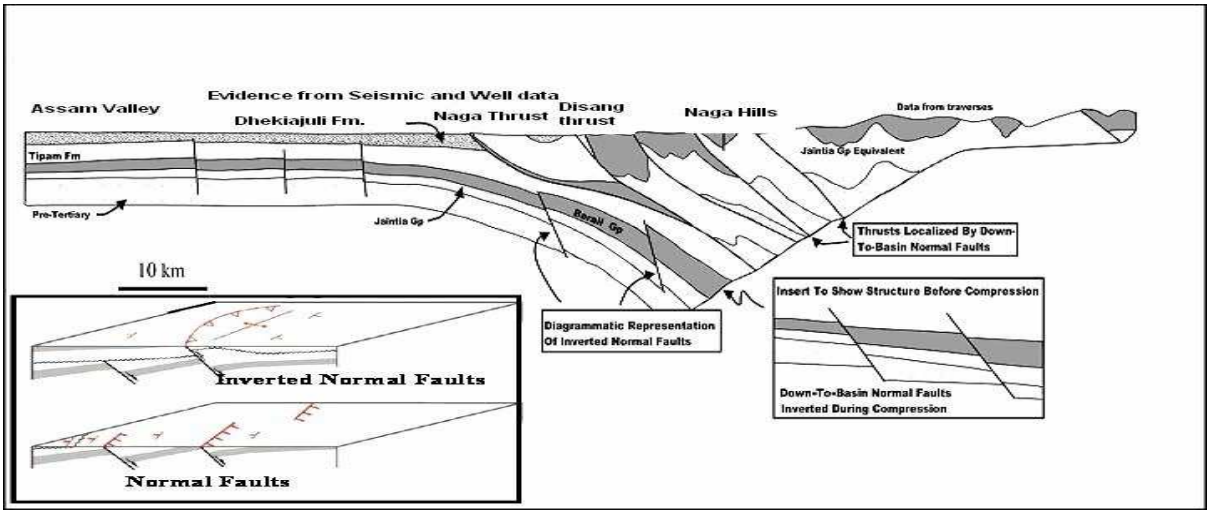


Fig.2 Diagrammatic Section across upper Assam showing normal down to basin faults and latter inverted during compression related to the development of thrust belt (Mathur and Evans, 1964)

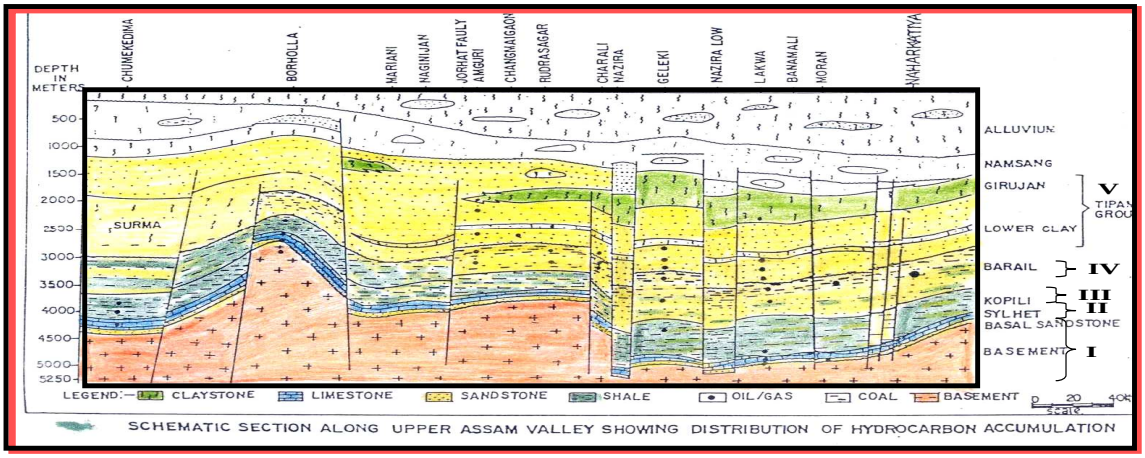


Fig.3 Schematic Geological section along Upper Assam Shelf showing distribution of hydrocarbon Accumulation

Structural Styles in Geleki- Mekeypore Area

In Mekeypur area the structural culminations are the up thrust anticlinal structures formed against the Geleki main reverse fault system originate due to late stage compressional tectonic events in the post Girujan period (Fig.4). In Geleki area, the effect of inversion is more pronounced and the dominant structural features in the form of transversely dissected structural culminations, second order tip line folds, ramp structures and duplexes (Bastia, et.al., 1993). Earlier workers (Bhandari, et.al., 1973, Deshpande, et.al., 1993, Dasgupta & Biswas, 2000) indicated that the possibility of growth fault tectonics and also invoke large scale strike slip movements in the basin (Fig.5). These longitudinal faults are originated in extensional regime in Paleogene time. These faults play a major role in entrapment of hydrocarbon in the area (Fig.3).

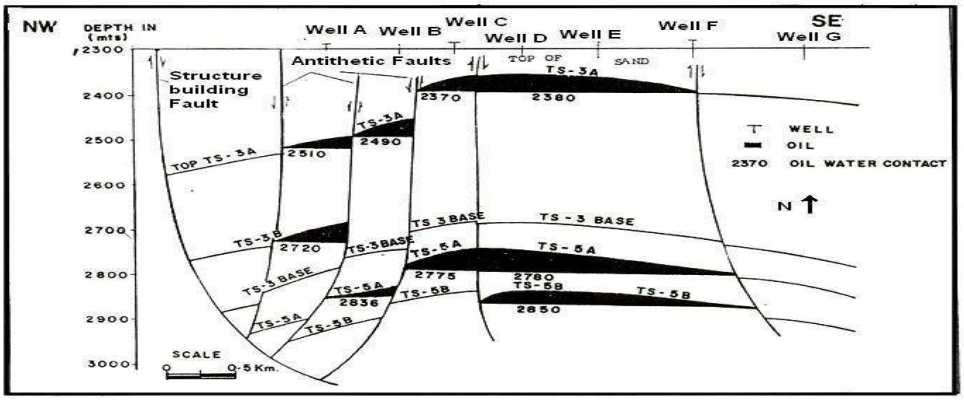


Fig.4 Cross section based on well data showing fault patterns controlling multiple pools in Geleki Field (Sahoo & Gogoi, 2009).

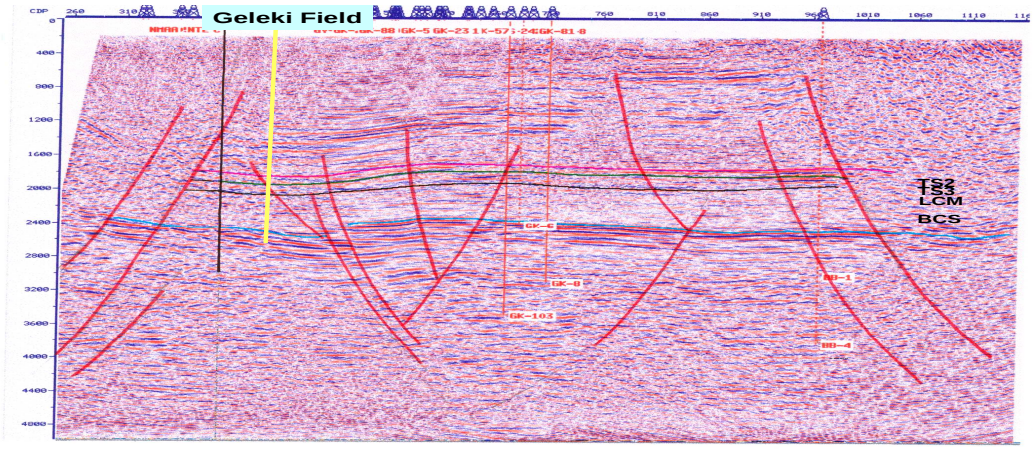


Fig.5 Interpreted Inline passing through northern part of Geleki Field

Structural Styles in Demulgaon Area

The main Demulgaon field comprises a series of tilted fault blocks. The structural elements present in this field at Barail level are dominantly controlled by ENE-WSW trending faults. In Demulgaon area most of the NNE-SSW trending faults take a swing and continue in ENE –WSW trend as shown in seismic section (Fig.6). These structural features are bounded by two prominent depressions viz. Khelugaon low towards northwest and Nazira low to the southeast. These lows are cut across by faults and are probably acting as a conduit for migration of hydrocarbons

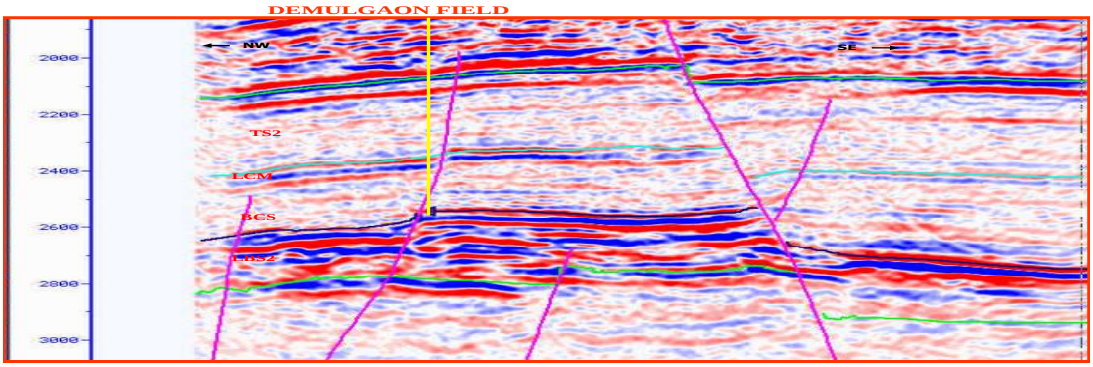


Fig.6 Part of Cross line along NW-SE direction in Demulgaon Field

Structural Styles in Lakwa – Tiphuk - Kuargaon Area

In Lakwa -Lakhmani area, a number of normal faults are interpreted, most of which are related to movement of basement blocks. The fault patterns match with major lineament trends NE-SW and ENE-WSW in the area. Most of these longitudinal high angle normal faults are basement involved and extend up to Girujan level (Fig.7). The Kuargaon and Mahakuti fields are intersected by mainly ENE-WSW trending faults having throw to the southeast. These faults divide the field into different fault blocks, which are occasionally cut by secondary faults having NW-SE orientation. The orientation of antiformal structures resulted due to faulting, generally follow the trend of main faults. The structural features in Kuargaon and Mahakuti areas are bounded by Khelugaon low to the northwest. The faults cutting across these structural lows are believed to have acted as conduits for hydrocarbon migration

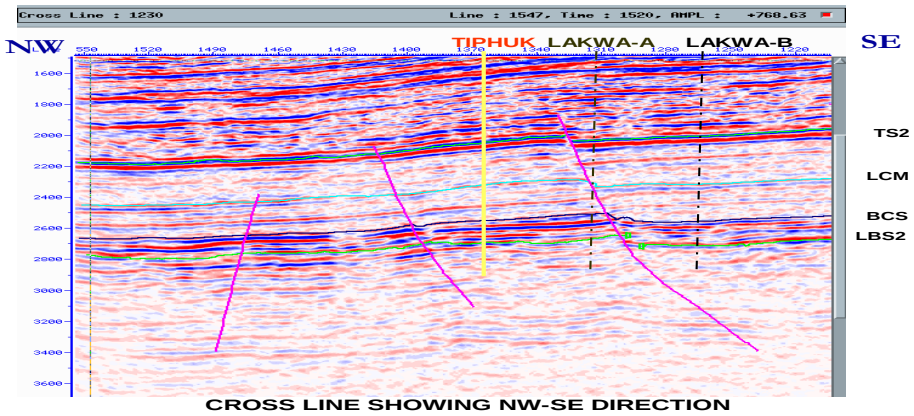


Fig.7 Cross line along NW-SE direction in Tiphuk-Lakwa area.

Structural Styles in Panidihing – Dhondarmukh- Disangmukh Area

In Panidihing and Dhondarmukh area the structural trend in Paleogene time appears to be curvilinear fault geometries having linear ridges with horst and graben features along NNE - SSW direction as shown in seismic section (Fig.9). In Disangmukh area two prominent fault trends i.e NE – SW and E-W have bearing on hydrocarbon accumulation in the area. These fault bounding ridges have yielded hydrocarbons in structural culmination part. Several structural culminations with two distinctive sets of faults i.e. ENE-WSW to E-W and NE-SW to NNE-SSW are observed on seismic sections from Basement to LCM levels (Fig.8).

Discussions:

The occurrence of hydrocarbon in North Assam Shelf block lies along the lineament patterns. The oil and gas prospects lie with the lineaments in NNE-SSW and NE-SW direction. Further it has been observed that, the deep rooted basinal normal faults are associated with antithetic faults. These faults have controls on the building of anticlinal features, where oil and gas has accumulated. The paucity of suitable source rocks in the foreland part, as against large quantity of hydrocarbon reserves reveal the presence of mature source rock below the thrust belts.

Hydrocarbon generation in the area occurred at a time when compressional forces had modified the pre existing structures. As a result of the structures formed due to these forces have ideal locales for entrapment of migrating hydrocarbons (Saikia & Dutta, 1980). The hydrocarbon started migrating from Sylhet and Kopili source rocks about 10-12 million years, when all the structures had already formed. The hydrocarbon expulsion is believed to be in Schuppen belt, where numbers of fault conduits are developed to bring hydrocarbon charge to shallow reservoirs as shown in seismic section (Fig.10). The migration is primarily updip to the northwest along northeast trending slope of the shelf as shown in NW-SE geological cross section (Fig.11). Active thrust tectonics by the end of Pliocene had resulted in reactivation of the structures in the foreland part of the basin. The subsidence during deposition of youngest stratigraphic units of Plio-Pleistocene age is related to tectonic loading of advancing thrust sheet from the south east. This youngest phase of compressional tectonics which is determined the present configuration of structures and is suitable for the entrapment of hydrocarbons in the basin.

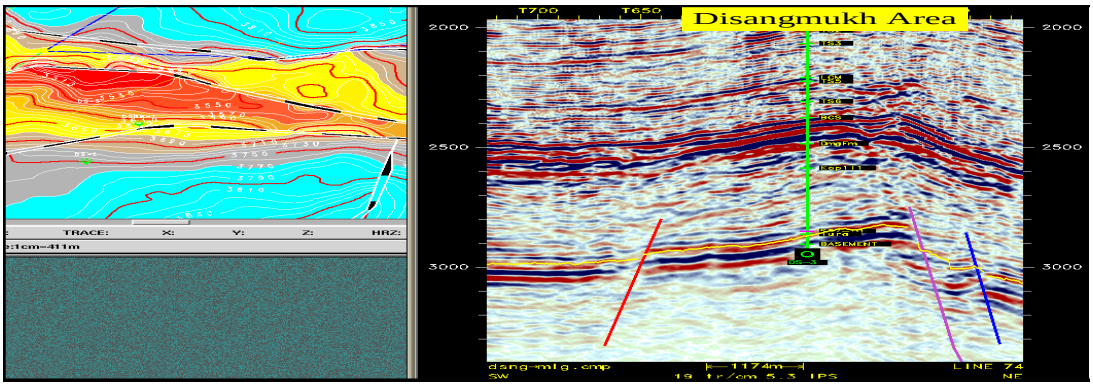


Fig.8 Interpreted Inline along SW-NE direction in Disangmukh field

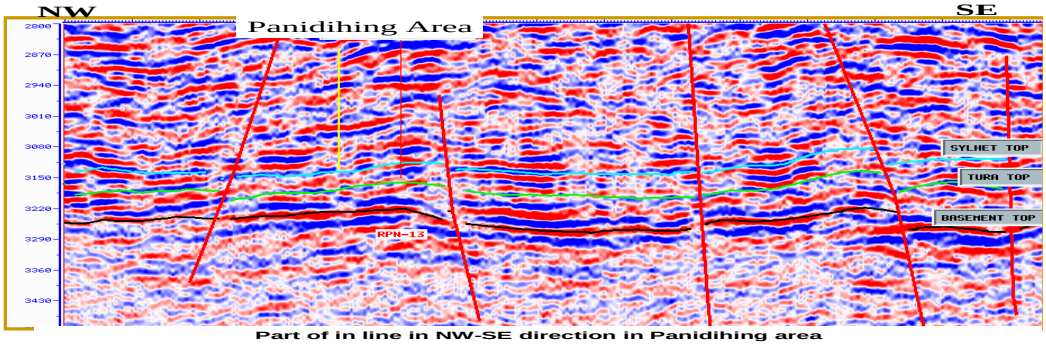


Fig.9 Part of Inline along NW-SE direction in Panidihing area.

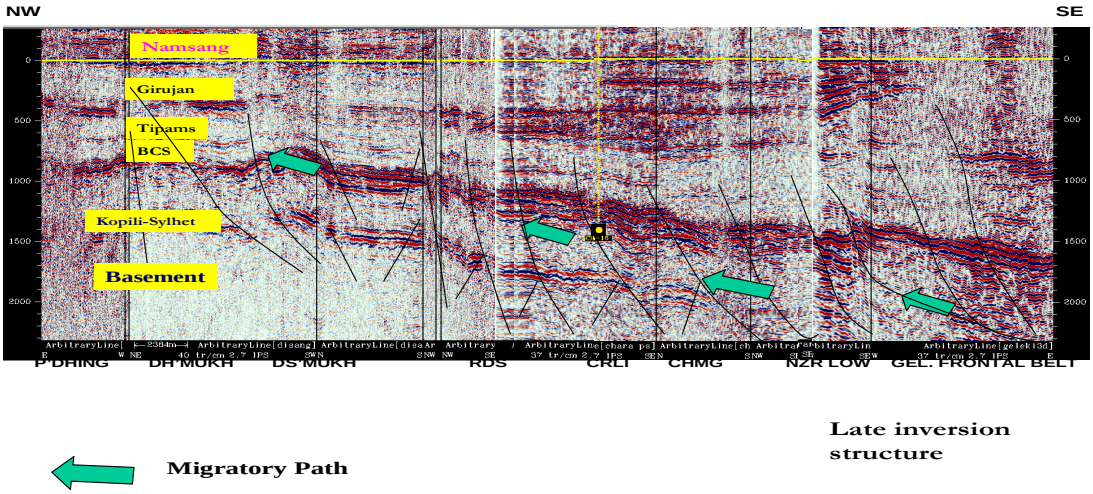


Fig.10 Interpreted Seismic sections along NW-SE direction showing migratory pathways of hydrocarbon

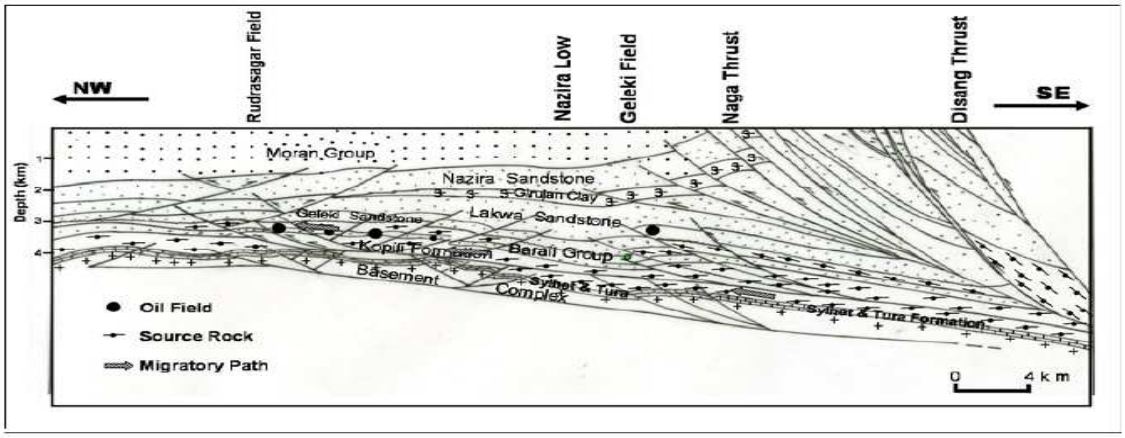


Fig.11 Schematic cross section along NW-SE direction showing migration path.

Conclusions:

The type and orientation of structures mapped along the selected stratigraphic sequences indicate that the structural patterns developed are related to basement fault propagation folds sub parallel to northeast trending Naga thrust suitable for accumulation of significant hydrocarbons on broad crests. Oil generated beneath the thrust sheet might be migrated to the leading edge of the thrust sheet and is primarily updip direction along the northeast-trending slope of the Assam Shelf. The source rocks in many structures are marginally mature, therefore it has been inferred that the oil might have migrated from deeper areas along the Naga thrust.

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