BHASKAR MORANG , Oil & Natural Gas Corporation Ltd, NAS Block, A&AA Basin, Jorhat, Assam, **S.S.GUPTE,** Oil & Natural Gas Corporation Ltd, KS Block, WOB, Mumbai

Sedimentation of Tura Formation in North Assam Shelf, Upper Assam Basin, India

Abstract

Tura Formation of Early Eocene age, also known as Basal Clastic, is the oldest sedimentary sequence and it nonconformably overlies Pre-Cambrian granitic basement in entire North Assam Shelf. Time to time, the earlier workers subdivided this sedimentary sequence in three/four units on the basis of lithofacies assemblages, electrolog characters and envisaged depositional environments. In general, Tura lower unit/units have been interpreted to be deposited in distal alluvial fan setting with subordinate fluvial braided channel fill and the upper unit is considered to be deposited in an overall transgressive shallow to marginal marine near shore depositional environment. In present study, Tura Formation have been divided into two parts viz. Tura Lower and Tura Upper, strictly on the basis of log characters. Tura Upper unit is a dominantly sandy unit which gradually becomes shaly towards bottom. Till date, all HC production from Tura formation (Basal Clastic) in North Assam Shelf has been confined to the sands of Tura Upper unit only and sands of Tura Lower unit have invariably produced water with mild gas during initial testing. The sediments of Tura Lower unit do not show any particular trend on logs except the topmost shale/claystone band, which is characterized by high gamma count and generally high resistivity compared to underlying sand. Moreover, a sudden increase in silty kaolinitic clay content is reported in well cuttings across the area close to top of this unit. Based on detailed analyses of selected well logs integrated with sedimentological description of various laboratory reports of entire North Assam Shelf, an attempt has been made for the first time to describe this Tura Lower unit as paleo-soil formed by in-situ weathering of Pre-Cambrian granitic rocks, termed as "regolith". As an additional effort to establish a surface to subsurface correlation, some photographs on newly cut road section along National Highway-37 near Guwahati, where weathered basement is exposed, are shown as evidence of occurrence of this 'regolith'.

Introduction:

Upper Assam Shelf documents fairly continuous sedimentation from Cretaceous to Recent times apart from sporadic occurrence of Permo-Carbniferous sediments along few Precambrian weak zones. Early to Late Ecocene Pre-Barail sedimentary sequence encountered in sub crop of North Assam Shelf (NAS) belongs to Jaintia Group, which is subdivided into Tura, Sylhet and Kopili Formations from bottom upwards. Sedimentation of these clastic sequences occurred in a passive margin set up during drift phase of Indian lithospheric plate towards north.

In recent past, a regional level study has been carried out on Pre Barail sequences of entire NAS Block, based on selective well logs integrated with different laboratory and seismic data to identify regionally correlatable log signature along with some refined sedimentological interpretation across study area. During the course of this study, few new observations are made in respect of sedimentation pattern of Tura Lower unit and generation of new isopach data. The isopach and net lithological maps of different formations/litho units of entire sequences bring out the depositional pattern of the Pre Barail sedimentation.

Basin Tectonic and Stratigraphy:

The Upper Assam Shelf lies in the north eastern part of the Indian subcontinent and is bounded in north by Eastern Himalayas and in the south and southeast by Naga Patkai hill ranges. Mishimi and Mikir hill massifs form the north eastern and south western limit of the area

(Fig-1). The Upper Assam Shelf consists of a portion of Paleocene to Eocene continental shelf of Indian lithosheric plate and which is being overthrust by the eastern Himalayas on the NNW and by Naga hills on the SE. The present day Upper Assam Basin, a cratonic basin, imprints three distinct tectonic phases. The earliest was Late Cretaceous to Eocene block faulting and development of south easterly dipping shelf situated on a passive continental margin. The generation of two phases faulting and continuous compression from south eastern side give rise to wrench tectonics in the basin. During the second phase, in Oligocene time, uplift and erosion occurred. The worldwide 'Oligocene regression' affected the basin, which was manifested in the wide scale erosion of Barail unit. Many basement faults reactivated due to compressional tectonics with evolvement of

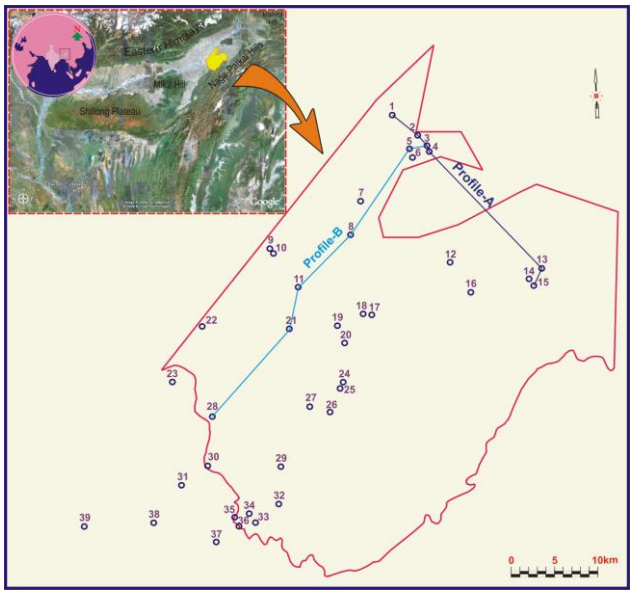

Fig-1: Index Map of North Assam Shelf, Assam

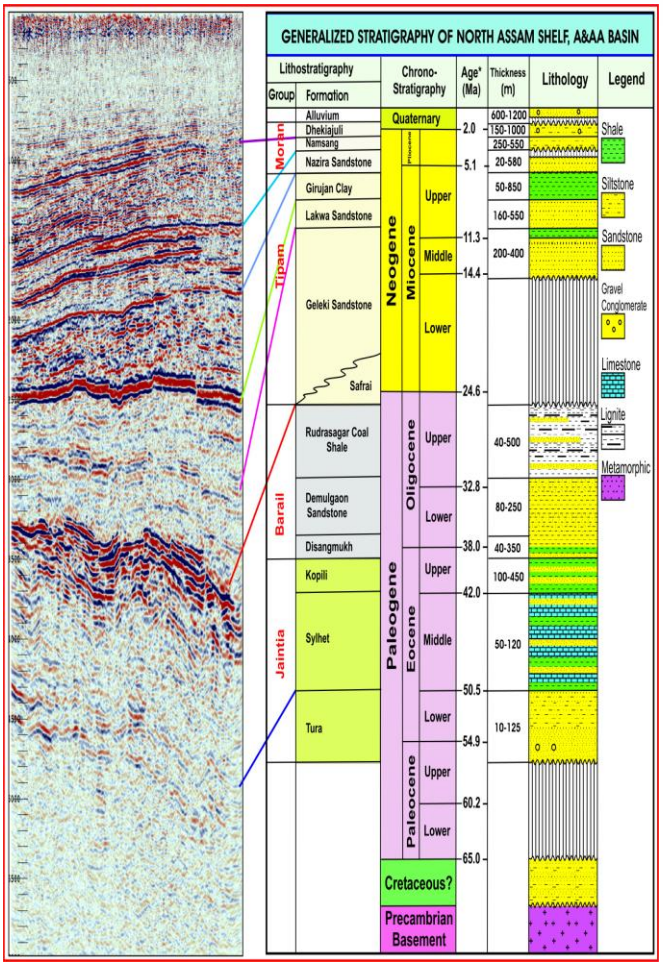

Fig-2: Generalised Stratigraphy of North Assam Shelf

flower structures in the basin until this time. Oligocene uplift and erosion were followed by Late Miocene through Pliocene extensive alluvial deposition. During that time a major tilting of the basin occurred (Fig-2) due to 'hard collision' of the Indian plate with Eurasian plate. The generation of Himalayan foreland and its subsequent narrowing down also initiated around this time. The generalized stratigraphy of NAS is shown in Fig-2.

Tura Sedimentation:

In Upper Assam Shelf, the clastic sequence nonconformably overlying the granitic basement complex and conformably overlain by limestones of Sylhet formation is called Tura formation. In general, the Tura sediments have been interpreted to be deposited under distal alluvial fan setting with subordinate downstream braided channel deposit to transgressive shallow marine beach/littoral depositional environment of Early Eocene age by earlier workers (Deshpande et.al. and P.S.Kataki et.al.). Most of the earlier workers subdivided this sedimentary sequence in three to four units on the basis of lithofacies assemblages, electrolog characters and

envisaged depositional environments. In present study, strictly on the basis of characteristic log pattern integrated with laboratory data, Tura formation has been divided into two parts, viz. Tura Lower and Upper. Top of this formation is marked at the base of about 20-25m thick shale unit with occasional occurrence of limestone stringer/bed towards top (Fig-3A) and in deeper part of the basin, the top is marked at base of a 15-25m thick limestone bed (Fig-3B). Some correlations making use of gamma (GR) and resistivity curves with additional support from density, neutron and sonic curves were attempted to correlate the sub-crop lithological units of Tura formation along with other Pre-Barail sequences. For presentation, two profiles viz. Profile-A and B, one each in NNW-SSE and NE-SW direction respectively are shown in Fig-4A & B.

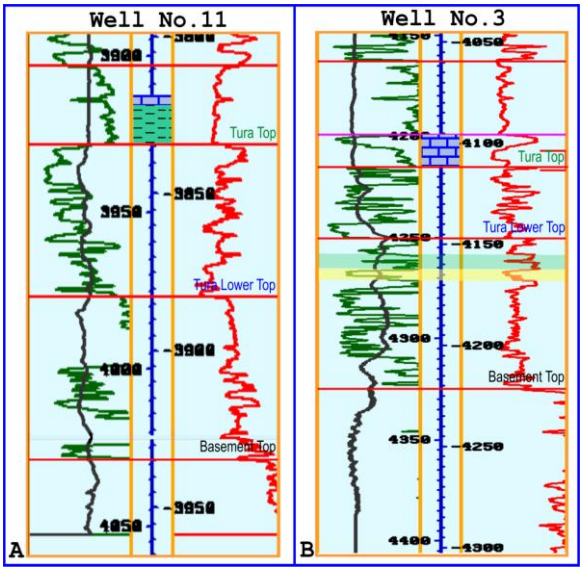

Fig-3: Representative log section from wells
A- Tura top overlain by thick shale
B- Tura top overlain by limestone bed. High GR with high Rt (Green) and clean GR low Rt (Yellow) relationship.

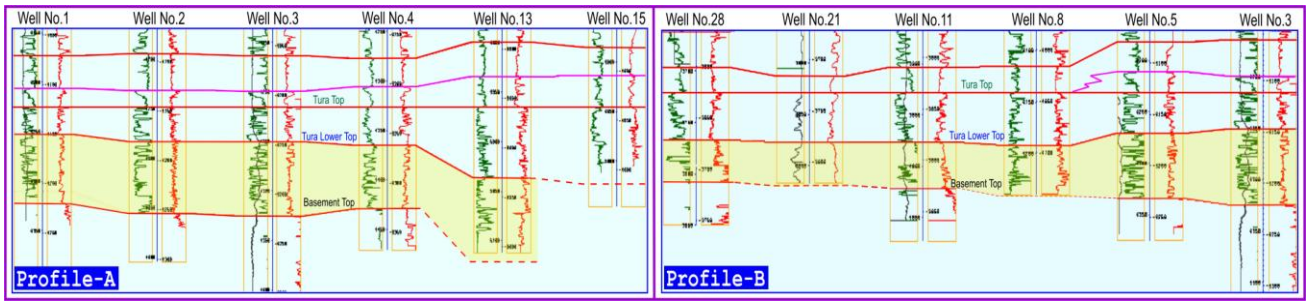

Fig-4: Stratigraphic Log Correlation profiles. **Profile-A**- Connecting wells along NNW-SSE direction and **Profile-B**- Connecting wells along NE-SW direction across the study area.

Top of the **Tura Lower** unit is marked at the top of a highly resistive shale/claystone band. The characteristic high gamma count and resistivity values of this argillaceous band are topped at many wells by a coarsening upward sand sequence (Fig-3A & B). In general, sediments of this unit do not show any particular trend on logs. In few wells like Well-3 and 8 (Fig-1), a sudden increase in the kaolinitic clay content is reported in cutting samples close to top of this unit.

Lithologically, Tura Lower unit contains poorly consolidated, whitish grey, light brown to reddish brown, coarse to medium, occasionally very coarse or silty, medium to fine grained, poorly to moderately sorted, angular to sub angular sandstone associated with some thin hard & compact, brownish to whitish, non calcareous, silty kaolinitic to sandy claystone bands (P.S.Kataki et.al.). Pyrite, leached iron oxide cement and stingers with occasional coal and carbonaceous shale are also reported (Anima Saikia et.al.). Thickness of this unit varies between 40 to 60m. In most of the wells, this unit is devoid of any fossils and the sediments have been interpreted to be deposited under fluvial/distal alluvial fan setting of depositional environment by earlier workers.

Subsequently, **Tura Upper** unit is a dominantly sandy unit which gradually becomes shaly towards bottom (Fig-3A & B). Overall, the sandy inter beds invariably show characteristic

coarsening upward log motif with generally high resistivity compared to shale. In the present study, this unit is considered to be the first depositional sequence of the basin in NAS block.

Lithologically, the sands of Tura Upper are grey to greenish grey, occasionally whitish grey, medium to coarse grained, at places fine grained to silty, glauconitic, generally calcareous and contain occasional shell fragments while the shales are grey, hard and compact, pyretic with disseminated organic matter and silty lenses. A conventional core cut in Well-21 (CC-3 Int 3855.48-3863.39m) shows presence of whitish to yellowish sandstone, dark grey shale with silty intercalations, burrowing, bioturbation, lenticular and wavy bedding. On the basis of microfauna yield from the same well, Early Eocene age has been assigned to this unit and shallow to marginal marine near shore environment of deposition has been interpreted.

Since, the Tura Upper unit has been completely drilled through in number of wells located across NAS, isopach and net sand maps for this unit have been attempted (Fig-6B & C). The isopach map clearly indicates the orientation of paleo-shoreline in NE-SW direction. The gross trends of the contours are oriented with curvature in the vicinity of wells 7 & 8 and 23 & 28, indicating an increase in thickness in those areas. However, it can be interpreted that the paleo-shoreline might have located further towards northwest of wells 1 to 6, as indicated by gradient of the contours. The net sand map (Fig-6C) of Tura Upper shows a distinct pattern of series of shore parallel bars oriented in a NE – SW direction and which depicts a shallow to marginal marine environment of deposition. Additionally, isopach map for total thickness of Tura sediments has also been prepared which also indicates thickening of sediments in the SE direction (Fig-6A).

Discussion:

In the present study, sediments within the Tura Lower unit are considered to represent paleo-soil formed by in-situ weathering of Precambrian Granitic rocks. The result of such weathering is a loose layer of broken rock and mineral fragments in blanket form on the earth's surface, termed as "Regolith". Fragments in the regolith range in size from microscopic to many meters across, but all have been formed by chemical and physical breakdown of parent rocks. Eventually, as larger particle breakdown, the upper most layers, termed as soil, starts support plant and vegetation. As per literature, the typical weathering product of granitic rocks will be quartz sand and clay minerals, as encountered in the subsurface of Upper Assam Shelf.

A Typical weathering profile of granitic rocks is shown in Fig-5.

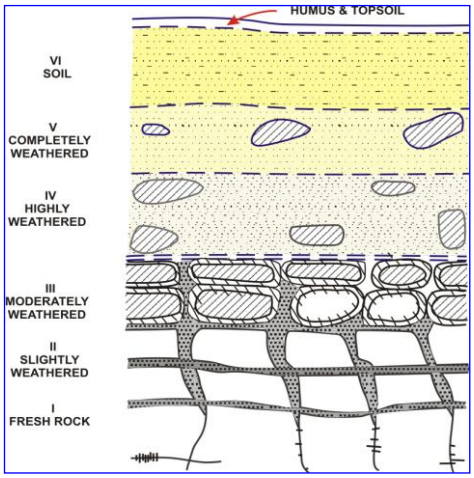

Fig-5: Typical Weathering Profile in Granitic Rock (Little,1969)

Prior to deposition of the 1st sequence of sediments over Pre-Cambrian granitic basement, a huge time gap had elapsed between Pre-Cambrian to Early Eocene. During that long geological time gap, the basement was completely exposed to surface condition and Indian lithospheric plate also experienced the drifting towards north through a hot and humid tropical region. The chemical breakdown of basement rocks across study area might have accelerated in presence of air, water (moisture) and organic matter along with the influence of hot and humid climatic condition prevailed and hence very thick residual soils might form under these conditions. As per the lithostratigrapgy report of Assam-Arakan Basin (vol-I), at the base of Tura formation, a thin

conglomerate band having a framework dominated by quartz vein and gneissic pebbles, set in ferruginous and lateritic matrix is present. A sudden increase of kaolinitic clay in some wells and presence of micaceous & feldspathic gritty sandstone (P.S.Kataki et.al) along with presence of

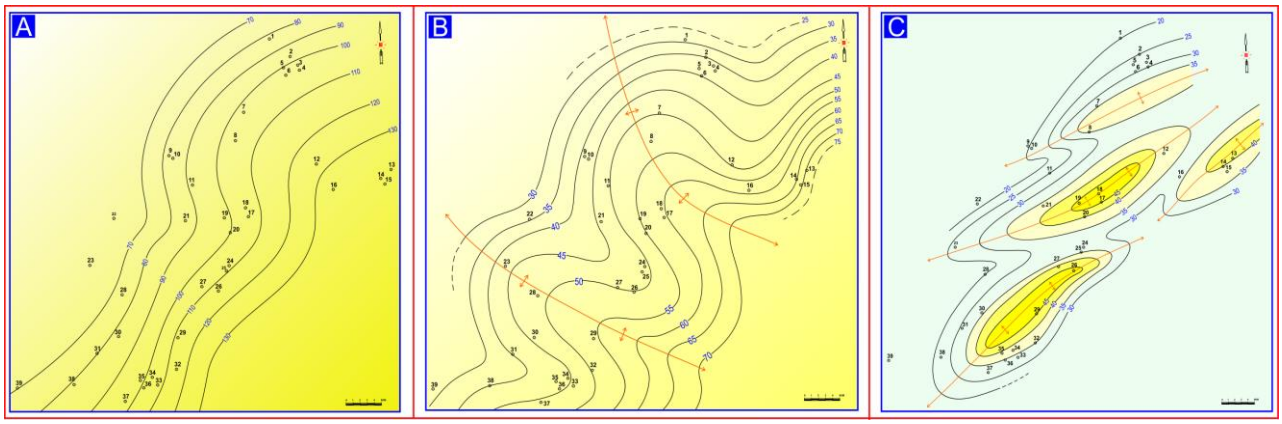

Fig-6: **A**- Isopach map of Tura formation. **B**- Isopach map of Tura Upper unit. **C**- Net sand map of Tura Upper unit.

leached iron oxide cement have supported the authors to interpret Tura Lower unit as product of in-situ weathered residual soil. Moreover, according to XRD analysis, the dominant clay mineral in this unit is the well crystalline kaolinite, which indicates a clear authegenic origin. As an additional attempt to establish a surface to subsurface correlation with reference to present discussion, some photographs on newly cut road section along National Highway-37 near Guwahati, where weathered basement is exposed, are shown as evidence of occurrence of this 'regolith' (Fig-7:A,B,C,D,E,7 F).

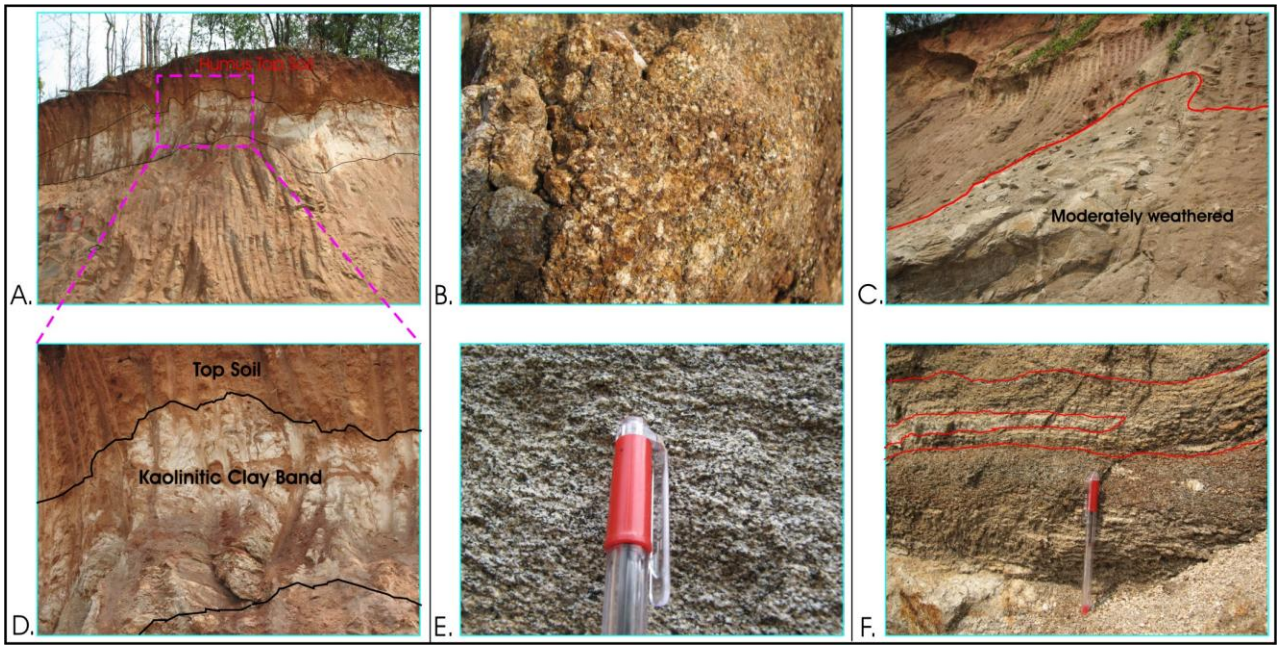

Fig-7: **A**- Showing Kaolinitic clay band with humus top soil & rock materials in transitional stage to form soil towards bottom. **B**- Ferruginous cement as quartz over growth. **C**- Due to high clay matrix content the rock grades into sandy clystone towards top of moderately weathered portion. **D**- Showing Kaolinitic clay band. **E**- Framework quartz grains with micaceous matrix and traces of weathered feldspar grains. **F**- Framework of poorly sorted, sub angular to sub rounded quartz grains shows partial discoloration, and discontinuity is filled by iron rich material as micro laminae.

Conclusion:

The following conclusion can be made from this study:

1. The present work presents first attempt to interpret the lower part of Tura formation as paleo-soil formed by in-situ weathering of Pre-Cambrian granitic rocks and successive upward, Tura Upper unit is considered to be the first depositional unit over this weathered granitic basement.

2. The presence of thin coarse and gritty band, having a framework dominated by quartz vein and gneissic pebble, set in ferruginous matrix along with silty kaolinitic claystone and occasional silica cement as quartz overgrowth across sub crop in drilled wells of NAS in Upper Assam Shelf indicate extensive continental weathering.

3. In most of the wells the Tura Lower unit is devoid of fossil. On the basis of microfauna yield from well 21, Early Eocene age has been assigned to Tura Upper unit and shallow to marginal marine near shore environment of deposition has been interpreted.

4. The newly compiled isopach data and maps of Tura formation and Tura Upper unit along with previous studies show the clear evidence of thickening of basin fill towards south and south east. The net sand map for Tura Upper depicts a clear evidence of its environment of deposition and shows presence of series of shore parallel bars oriented in a NE – SW direction.

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