CHAPTER - II

REGIONAL GEOLOGY AND TECTONIC SETTING

2.1 Introduction

The Geological Province of Assam-Arakan Basin encompasses a major part of North-eastern India, Myanmar and Bangladesh. The Assam-Arakan Basin is a typical polyhistory basin having more than one phase of sedimentation and tectonism. It is in an inverted funnel-shaped area covering the present day outline of the Assam-Arakan Hills Range, the southern and eastern part of the Shillong-Mikir Massif of Assam-Shillong Plateau and their frontal plains. The basin has accommodated nearly 13 km of Mesozoic and Tertiary sediments in its deepest part. The Upper Assam Shelf spreads over an area of about 56000 sq.km and represents the northern part of the Assam-Arakan Geological Province. The sediments in the Assam Shelf attain a maximum thickness of about 7000m and range in age from Cretaceous to Recent. However, a major portion of the sedimentary column is of Tertiary Age. The sediment thickness in the Fold / Thrust Belt, on the other hand, is thought to be about 10,000m and ranges in age from Palaeocene to Recent.

The geomorphologic features of the Assam-Arakan Basin include the Shillong Plateau and Mikir Massif, Brahmaputra and Dhansiri valleys and Tripura-Cachar & Mizo Hills. The Shillong Plateau and Mikir Massif are highly dissected plateaus and hills, characterised by granitic and gneissic terrain forming the shield areas. The
Fig. 2.1: Geological map of North East India.

Source: www.google.com
Brahmaputra Valley gradually slopes towards southwest and west whereas the slope of the Dhansiri Valley is towards north and then changes to the northwest. In the Naga-Patkai foldbelt, the ridges are north-south and mostly consist of northerly flowing rivers which occupy the valleys. The Upper Assam Shelf, which lies in between the Himalayan Foothill faults to the north and the Naga Thrust to the south, is also the eastern limit and is represented by the rocks of the Mishmi Massif and Naga Metamorphic Complex which are thrusted over by Tertiary sediments. The Mikir Massif to the north of the Shillong Plateau is a part of the Central Basement High (Assam Range). The broad belt of low ground to the south of the Shillong Plateau and North Cachar Hills is the floodplain of River Barak and its tributaries and is known as the Surma Valley.

In different parts of the Assam-Arakan region, the structural pattern varies considerably. The structural framework of Northeast India and the adjoining area is shown in Fig. 2.1. The Tertiary rocks overlain by the Gondwanas in the north characterize the extensive overthrust sheets of the Himalayan foothills. Adjoining the Assam plains is a 25 to 30 km wide NE-SW trending belt of imbricate thrusts / faults known as the ‘Belt of Schuppen’. The Belt of Schuppen is bounded by the Naga Thrust on its northwest edge and by the Disang Thrust on its southeast border. The belt extends for more than 200 km along the strike from the Mishmi Thrust in the northeast to near Haflong of North Cachar Hills where it meets the Haflong Thrust. From northeast to southeast the Belt of Schuppen is subdivided into three segments separated by east-west trending major structural lineaments. The southern segment is characterized by only three thrusts; the middle segment is characterised by four to five
thrusts and the northern-most segment is characterized by six to seven thrusts. Each of
the thrust slices are homoclinal and dipping due south and southeast.

2.2 Geological Setting

During the Tertiary Era, the Shillong Plateau was not subjected to any major
folding and was bounded in the south by an east-west trending monoclinal fold, but in
the Surma Valley and the area extending southwards and also in the northern part of
the Assam-Arakan coast, the country has been folded into long narrow asymmetrical
anticlines separated by broader nearly symmetrical synclines.

The geological setting of the Assam-Arakan Basin can be broadly subdivided
into the following units-

i) Shillong Plateau and Mikir Massif

ii) Eastern Himalayan Frontal Fold belt

iii) Mishmi Massif

iv) Platform areas of Upper Assam, Dhansiri Valley and South
Shillong Front.

v) Belt of Schuppen.

vi) Foldbelt comprising Patkai and Kohima Synclinorium and
Tripura-Cachar-Mizo Folds

vii) Eastern zone of Nagaland –Manipur including Ophiolite Belt.

Nandy (1998), had differentiated north-eastern India and its adjoining regions
into five distinct tectonic domains, though they are related through the unified global
tectonic process. The regional tectonic elements of Northeast India and the adjoining
area (after Nandy, 2001, and Murthy et al., 1969) are shown in Fig. 2.2. They are (i) the eastern Himalayan and Tibetan domain, (ii) the Mishmi Block and Transverse Mountain ranges, (iii) the Patkai-Naga-Chin-Arakan Yoma Belt (outer arc ridge) with associated Central Myanmar Fore-Arc and Back-Arc basins, and the Neogene accretionary complex in Upper Assam Molasse Basin in the north and the Surma Basin to the south, (iv) the Shillong Plateau, Mikir Massif, and the sediments covering the Assam Foreland Spur represent the north-eastern extension of Indian Shield elements with their associated platform sediments, and, (v) Bengal Basin.

The eastern Himalayas and the Tibetan Plateau evolved mostly through post collision tectonics between the Indian and the Eurasian plates and the closure of Neotethys along the Indus-Tsangpo Suture Zone, whereas the Mishmi Block and the transverse mountain range are shaped by intense tectonic forces acting along the north-eastern margin of the Indian Plate due to its post-collision anti-clockwise rotation.

The Palaeogene outer arc ridge developed during Eocene-Oligocene times and represents the arcuate Patkai-Naga-Chin-Arakan Yoma mobile belt in response to subduction of the Indian lithosphere below the Myanmar-Andaman Plate. The western margin of the Sino-Myanmar continent evolved due to oblique rifting approximately along the present Shan-Saigon Fault System during the Jurassic-Early Cretaceous period, thus forming the Central Myanmar Basin, constituted by the arcuate fore-arc and back-arc troughs separated by the median Tertiary volcanic arc. At the close of the Oligocene, the Palaeogene outer arc of the Indo-Myanmar mobile belt became a positive element, to the west of which the Neogene basin developed to the east of
Fig. 2.2: Regional Tectonic Elements of Northeast India and adjoining areas (after Nandy, 2001, Murthy et al., 1969, Courtesy GSI)
Shillong Plateau in the Surma Basin. Continued eastward subduction of the Indian Plate resulted in development of a fold–thrust belt along the Indo-Myanmar mobile belt which became very intense in the Upper Assam area due to resistance put forward by the concealed basement blocks of the “Foreland Spur” whereas south of the Surma Basin, the Neogene outer arc sediments were only folded and faulted with reduced intensity towards the west.

The Indian Shield elements represented by the Shillong Plateau, Mikir Massif and the concealed ‘Foreland Spur’ extend north-eastward from the Garo-Rajmahal gap to Upper Assam. Though there is a record of formation of a Proterozoic intra-cratic basin of the Shillong Group and emplacement of Late–Proterozoic – Early Proterozoic Granite within the plateau, late Mesozoic and Early Cretaceous tectonism is marked by the effusion of Sylhet Trap Volcanics and emplacement of Carbonatite-Ultramafic Complex. Buttressed in between the two mobile belts, the Shillong Plateau has been rising with its platform and shelf sediments along its southern and eastern margins since the Upper Cretaceous till the Recent, mainly along the Dauki Fault System, which is relatively dormant at present.

2.2.1 Upper Assam Shelf

Geologically, the Upper Assam Shelf is the north-eastern prolongation of the Indian peninsular foreland spur through which the river Ganges and Brahmaputtra are deflected southwards to flow into the Bay of Bengal. The basin is a comparatively stable area that extends for an area of about 56,000 sq. km. and it includes the sediment fringe to the south of Shillong Plateau, the Garo, Khasi, Jaintia, Mikir Massif
Fig. 2.3: Regional Geological Cross-section A-A' across the Brahmaputra Valley
(after Fuloria, 1996, in Akhtar et al., 2010).
and Upper Assam Valley. The Upper Assam Plain is a part of the Assam Basin and is geologically referred to as Upper Assam Shelf in which a thick pile of about 7000 m thick Tertiary sediments is buried under the alluvial cover of the Brahmaputra River. In the Mikir Massif and Shillong Plateau, outcrops of about 6400 m thick Cretaceous and Tertiary sediments have been encountered. At the southern and south-eastern edge of the platform, the mobile belt is comprised of very thick molasse and flysch sediments, a counter part of the Assam Shelf facies. The distinction between the shelf and mobile belt sediments is pronounced in the lower part of the stratigraphic column only and is gradually obliterated upward. The Naga Thrust separates the shelf from the mobile sediments (Rao & Murthy, 1969). In the north of Brahmaputra River, the Assam Basin is bounded by the Himalayan Foredeep, exposing the Siwalik Group. The platform is closed in the north-eastern corner in the Mishmi Hills by the convergence of the Himalayas and Naga Hills (Murthy, 1983).

A schematic regional geological cross-section A-A’ across the Brahmaputra Valley, furnished in Fig. 2.3, shows the presence of a broad arch at the basement level (after Fuloria, 1996 in Akhtar et al., 2010). The crestal portion of this arch lies very close to the present course of the Brahmaputra River. The north-eastern extension of the NE-SW trending Brahmaputra arch forms important locations for hydrocarbon entrapment. This basement arch slopes both towards the Himalayan foothills in the north and towards Naga Hills in the south. The Upper Assam domain is separated from the Dhansiri Valley by a major fault system, the E-W trending Jorhat Wrench.
Geophysical surveys have indicated that the basement rocks exposed in the Mikir Massif in the southwest of the Assam Shelf form a broad arch and continue in a north-easterly direction with its apex in the region of the present Brahmaputra River course. The Central Basement High remains concealed under the alluvium that slopes towards the Himalayan Foothills in the north and Naga-Patkai Hills in the south. Although exploration has been extensively carried out in the Upper Assam Shelf, the exploration success as well as the operating and hydrocarbon producing areas of OIL and ONGCL lie mainly on the southern side of this ridge. The geological maps of the Dillighat River section and Margherita-Changlang Road section (modified after Das Gupta et al., 1964) are presented in Fig. 2.4 and 2.5, respectively.

2.3 Stratigraphy

The extensive efforts of many pioneering geologists to present a stratigraphic succession of Assam-Arakan Basin resulted in the present day picture of the different groups and formations of this area. Way back in the year 1876, Mallet did pioneering work in classifying the Tertiary sediments of the Assam Valley. Subsequently, Evans (1932, 1959) contributed a detailed classification of the Tertiary sequence of erstwhile Assam, covering the Assam Valley, Central Assam and Surma Valley. Mathur and Evans (1964) for the first time had worked out a comprehensive classification of both the shelf and geosynclinal facies of this part of the country covering Assam, Nagaland, Manipur, Arunachal Pradesh and part of Myanmar. Subsequent contributions in this direction were made by Ranga Rao (1983), Bhandari et al., (1973), Srivastava et al., (1974), Baruah and Ratnam (1982), Handique et al., (1989), Samanta et al., (1993)
Fig. 2.4: Geological map of Dilligat section (modified after Das Gupta, et al., 1964)
Fig. 2.5: Geological map of Margherita-Changlang road section
(modified after Das Gupta et al., 1964).
and Kar et al., (1994), to name a few. The Tertiary succession of Northeast India (after Mathur and Evans, 1964) has been presented in Table-2.1. A generalised succession of the Tertiary sediments of Upper Assam Shelf by different authors has been presented in Table-2.2.

2.4 Lithostratigraphic Description

2.4.1 Langpar Formation

Medlicott (1869) has named the sediments conformably overlying the Mahadek as Langpar. The Langpar Formation and Tura Formation in ONGCL's operational area, represent the earliest extensive sediments in the Assam Basin. These generally marginal marine sediments rest unconformably on the Pre-Cambrian granitic basement and are typically transgressive initially, then regressive. These sediments are thought to thicken and deepen to the south or southeast and were probably geographically restricted with their distribution controlled by palaeotopography. This clastic sequence overlying the basement and underlying the Sylhet Limestone Formation in the Upper Assam subsurface stratigraphy was named as the Basal Sandstone by Fuloria (1972), Teok Sandstone by Bhandari et al., (1973) and Tura Sandstone Formation by Rao (1983). The Tertiary succession of the Assam Basin commencing with the Langpar Formation, may be a time equivalent of the Langpar Formation of the Shillong Plateau (Dutta, 1982) and the rocks are mostly calcareous in nature. Medlicott (1969) named the sediments, conformably overlying the Mahadek Formation, as Langpar Formation. Ghosh (1940) observed in Meghalaya that the Langpar Beds of calcareous shale and earthy and sandy limestone are more persistent and widespread and it progressively overlaps the
## Table-2.1: The Tertiary Succession of North East India (after Mathur and Evans, 1964)

<table>
<thead>
<tr>
<th>AGE (Approximate)</th>
<th>GROUP</th>
<th>MEMBER AND LOCAL FACIES</th>
<th>SURMA VALEY</th>
<th>UPPER ASSAM AND NAGA HILLS</th>
<th>SHELF SEDIMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECENT AND PLEISTOCENE</td>
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<tr>
<td>PLIOCENE</td>
<td>DIHING</td>
<td>Alluvium and High level terraces</td>
<td>400*</td>
<td>Not subdivided 900*</td>
<td>Dhekiajuli Beds 1800**</td>
</tr>
<tr>
<td>MIO-PLIOCENE</td>
<td>DUPITILA</td>
<td>Up. Dupitila 2800</td>
<td>Namsang Beds* 800</td>
<td>Namsang Beds 600**</td>
<td></td>
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<tr>
<td>MIOCENE</td>
<td></td>
<td>Girujan Clay 1500</td>
<td>Girujan Clay 1800</td>
<td>Girujan Clay 600</td>
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<td></td>
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<td>Tipam Sst 1600</td>
<td>Tipam SSt 1600</td>
<td>Tipam Sandstone 900</td>
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<td>Boka Bil 1500</td>
<td>Not subdivided 900</td>
<td>Not subdivided 900</td>
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<td></td>
<td></td>
<td>Bhuban 4000*</td>
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</tr>
<tr>
<td>OILIGOCENE</td>
<td>BARAIL</td>
<td>Renji 1000</td>
<td>Tikak Parbat 600</td>
<td>Jaintia Group</td>
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<tr>
<td></td>
<td></td>
<td>Jenam 1200</td>
<td>Baragolai 3300</td>
<td>Kopili Altrns 500</td>
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<td></td>
<td></td>
<td>Laisang 2400</td>
<td>Naogaon 2200</td>
<td>Sylhet Lst 500</td>
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<tr>
<td>EOCENE(^b)</td>
<td>DISANG(^c)</td>
<td>Over 1500</td>
<td>Probably over 3000</td>
<td>Therria 100</td>
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<td></td>
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<td></td>
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<td>?100</td>
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</tbody>
</table>

* Local facies names

**NOTES**

Figures give maximum thickness in metres

a) Total original thickness must have been much greater

b) Including Palaeocene

c) May range down to Uppermost Cretaceous
Table-2.2: The Generalised Stratigraphic Succession of the Upper Assam Shelf
(after Ranga Rao (1983), Handique et al. (1989), Samanta et al., (1993))

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</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
<td>Formation</td>
<td>Age</td>
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<tr>
<td>Recent</td>
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<td>Dihing Alluvium</td>
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<td>Pleistocene</td>
<td>Dihing</td>
</tr>
<tr>
<td>PLEISTOCENE</td>
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<td>Namsang</td>
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<tr>
<td>LOWER</td>
<td>Girujan Clay</td>
<td>Miocene</td>
<td>Tipam</td>
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<td>MIOCENE TO</td>
<td>Tipam Sandstone</td>
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<td>PLIOCENE</td>
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<td>SURMA</td>
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<td>(?Surmas</td>
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<tr>
<td>OLIGOCENE TO</td>
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<tr>
<td>UPPER EOCENE</td>
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<tr>
<td>TO LOWER EOCENE</td>
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<tr>
<td>JAINITIA</td>
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<tr>
<td>UPPER PALAEOCENE TO</td>
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<tr>
<td>LOWER EOCENE</td>
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<tr>
<td>TURA</td>
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<td></td>
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<tr>
<td>Upper Cretaceous</td>
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<tr>
<td>Pre-Cambrian</td>
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<td></td>
<td></td>
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<tr>
<td>Basement</td>
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</table>
Mahadek Formation shoreward in a northerly direction. However, in the type section in Meghalaya, the Langpar Formation is divisible into shale with thin limestone and argillaceous sandstone bands at the base, followed by yellowish brown impure limestone bands and arenaceous shales. At the top, the subdivision is comprised of sandstone and arenaceous shale with thin limestone bands. The lithology is comprised of alternations of sandstone, shale and thin limestone. The shales are grey coloured, laminated, occasionally carbonaceous and sometimes associated with whitish clay. The sandstones are friable, medium-grained and sometimes calcareous in nature. The age of the Langpar Formation is assigned as Upper Cretaceous in its type section in the southern part of the Shillong Plateau (Medlicott, 1869).

2.4.2 Therria Formation

The lithological unit that conformably overlies the Langpar Formation is named as the Therria Formation by Mathur and Evans (1964) and it is best developed and exposed at and around Cherrapunji and at Therriaghath. The sandstones are coarse-to-fine-grained, generally ferruginous and friable at the top, becoming hard, compact and quartzitic towards its base. Two sets of joints are more or less a regular feature throughout the area. The surface of the formation is pitted and characterised by shallow holes seen frequently on the riverbeds in the Cherrapunji area where some pyrite nodules have been observed. The formation also contains conglomeratic bands near Sohrarim, a distance of 5 km north of Laitryngnew. The basal calcareous part is massive and it is exposed in the Therriaghath section. The formation is conformably
underlain and overlain by the Langpar Formation and Lakadong Sandstone Member of the Sylhet Limestone Formation.

### 2.4.3 Jaintia Group

The succession conformably overlying the Langpar Formation is the Jaintia Group, which is divisible into Therria, Sylhet Limestone and Kopili formations. In the oilfield areas of Oil & Natural Gas Commission Limited in undivided Sibsagar District, the Sylhet Limestone Formation grades upward into the Kopili Formation and overlies the Basal Sandstone /Teok Sandstone/ Tura Sandstone Formation. In most of the Upper Assam Platform areas, a predominantly arenaceous sequence which overlies the basement rock has been described as the ‘Basal Sandstone Unit’. In the oilfield stratigraphy of Oil India Limited (OIL), the Therria is considered as a formation which rests at the base of the Sylhet Limestone Formation (Handique et al., 1992). Based on palynological evidence of Biswas (1962), Baki (1962), Ghose (1969), Samanta (1968) and Sah and Singh (1974), it is found that the age of the Tura Formation (entire Tura outcrop area in the Garo Hills, in west Meghalaya) is Upper Palaeocene to Lower Eocene and is equivalent to the Therria-Lakadong sandstone stratigraphic succession of the eastern part of Meghalaya. On the basis of the facies of Therria-Lakadong sandstone succession of the Tura Formation, the workers of Oil India Limited do not differentiate the Lower Tertiary beds of the Therria Formation, Lakadong Limestone and Lakadong Sandstone members in their operational areas and all of them are considered as Lakadong+Therria.
The Lower part of the ‘Basal Sandstone’ Formation overlying the basement consists essentially of granite wash with a thin conglomerate band at its base. Upward in the succession, the granite wash is ultimately replaced by grit, coarse- to medium-grained kaolinitic sandstone, and carbonaceous shale. The formation, possibly with a minor unconformity, is overlain by the Sylhet Limestone Formation. The formation is poorly fossiliferous. The stratigraphic interval of ‘Lakadong+Therria’ is comprised of alternations of brownish grey, fine- to medium-grained, friable, sometimes calcareous, sandstone, poorly fossiliferous laminated shale and wacky limestone. The limestones are arenaceous at certain levels. Dutta (1999) based on palynological evidence, fixed the age of the ‘Lakadong+Therria’ as Upper Palaeocene, and grouped the Langpar Formation and “Lakadong + Therria” Formation into the Basal Sandstone Formation and assigned its age as Palaeocene. However, he subdivided the Basal Sandstone into Upper and Lower parts based on lithology. The lower part is arenaceous and upper part is calcareous.

2.4.3.1 Sylhet Limestone Formation

The Sylhet Limestone Formation is divisible into the Lakadong Limestone Member, Lakadong Sandstone Member, Umlatodoh Limestone Member, Narpuh Sandstone Member and Prang Limestone Member in ascending order.

The Lakadong Limestone Member is comprised of dark grey, compact and hard, fine-grained limestone at the base and at certain levels in the middle part the limestone is dolomitic and light brown in colour. The limestone is prolific in forams and contains streaks of calcareous sandstone. The lithounit is conformably underlain
and overlain by the Therria Formation and Lakadong Limestone Member, respectively.

The overlying Lakadong Sandstone Member consists of coal, carbonaceous and argillaceous shales and dominantly fine- to coarse-grained sandstones. The most significant character of the sandstone in its exposed section is the occurrence of workable coal deposits, purple sandstones and pyritous shales at its base. The lithounit is conformably underlain and overlain by the Lakadong Limestone Member and Umlatodoh Limestone Member, respectively. The foraminifers and spore-pollen associations give the age of the Lakadong Limestone and Lakadong Sandstone members as Thanetian (Baruah and Dutta, 1990).

The Umlatodoh Limestone Member is comprised of light grey to dark grey and light pink, poorly bedded, jointed, hard and compact limestone with occasional intercalations of sandstones. The lithounit is conformably underlain and overlain by Lakadong Sandstone and Narpuh Sandstone members, respectively. The age of the lithounit is regarded as Ypresian (Lower Eocene of Nagappa, 1959; Pal & Dutta, 1979).

The Narpuh Sandstone Member at the Therriaghat section is exposed as thin bands of sandstones that are conformably underlain and overlain by the Umlatodoh Limestone and Prang Limestone members, respectively. The sandstones are loose, friable, massive, medium- to coarse-grained, slightly calcareous, yellowish to brownish white in colour, similar to which the sandstone bands of ferruginous
character are also noticed along Cherra-Shella Road Section near Ishamoti. The age of
the lithounit is considered to be Ypressian (Pandey and Dave, 1996).

The Prang Limestone Member is comprised of light to dark grey, hard and
compact, massive and highly fossiliferous limestone. The limestone is rich in larger
foraminifers like Alveolina, Nummulites Assilina and Discocyclina (Krishnan, 1968).
The lithounit is conformably underlain and overlain by the Narpuh Sandstone Member
and Kopili Formation, respectively. In the oilfield areas overlying the ‘Basal
Sandstone’ Formation, the Sylhet Limestone Formation is divisible into
Lakadong+Therria, Narpuh and Prang members. The Lakadong+Therria Member here
consists of carbonaceous shales, dark grey shales, greyish sandstones, occasional coal
seams and brownish oil-bearing sandstones. The Narpuh Member in the oilfield areas
is comprised of alternations of sandstone, shale and limestone. The limestone bands
occur with alternations of shales in the unit. The sandstones are sugary white and grey
coloured and laminated. The limestone is grey coloured and indurated in nature. The
age of the Narpuh is known to be Early Eocene (Pandey, 1998). Overlying the Narpuh
Member, the Prang Limestone Member in the oilfield areas consists of alternations of
thick limestone, shale and minor sandstones which are usually calcareous in nature.
The sandstones are light grey, fine- to medium-grained and poorly to moderately
sorted. The shales are grey in colour and laminated. The age of the Prang Limestone
Member is known to be Lutetian (Middle Eocene; Pandey, 1998).
2.4.3.2 Kopili Formation

Evans (1932) named the shale-dominated sequence overlying the Sylhet Limestone Formation as Kopili Formation. In the type section in Mikir Massif of Assam, the formation is made up of ferruginous sandstones at the base followed by carbonaceous grey shales and sandstones and is overlain by sandy fossiliferous mudstone. Higher-up in the succession, there are alternating grey shale and sandstones; above these comes a shale dominated group with subordinate thin bedded carbonaceous sandstones, followed by subordinate thick hard sandstone.

In the present study area in the Dibrugarh and Tinsukia districts, the Kopili Formation comprises of thick splintery shales with intercalations of sandstone and sparsely distributed streaks of limestone, which are followed by alternations of thick shales and thin sandstones.

In the Shella-Um Sohryngkew River section, the formation is made up of light brown to greyish brown, fine- to medium- grained, well indurated, poorly to moderately sorted sandstones and greyish brown coloured splintery shales. The sand-shale ratio gradually increases upwards in the sections. Sedimentary structures recorded are comprised of small-scale cross stratification, horizontal laminations, flaser bedding, lenticular bedding, planar bedding and erosional bedding contacts, and rare occurrences of bioturbation. At places the shales are iron-stained and gradually change upward into siltstone. Towards the base, in the Um Sohryngkew section, the shales contain streaks of marl and impure limestone.
The Kopili Formation that conformably rests on the Prang Limestone Member of the Sylhet Limestone Formation yields a rich and diverse micro fauna in the lower part while its upper part is made up of arenaceous foraminifers with rare occurrences of calcareous laminations. Based on palaeontological evidence, the age of the Kopili Formation is regarded as Late Middle Eocene to Late Eocene (Dutta and Jain, 1979; Pandey and Dave, 1998).

2.4.4 Disang Group

The geosynclinal facies of the time equivalent of the Jaintia Group of Upper Assam Shelf is the Disang Group. The Disang Series was initially named for a monotonous sequence of dark grey shales with thin beds of sandstone. Since the Disang Series is a lithostratigraphic unit, it was later redesignated as Disang Group. The sandstones are rather more numerous near the top of the group and there is gradual upward and lateral passage into the overlying Barail Group (Mathur & Evans, 1964). In the Assam-Arakan Foldbelt region, the Barail Group conformably overlies the Disang Shales. The lithounit is considered to be the time equivalent of the Jaintia Group of the Upper Assam Shelf. The exact thickness of the Disang Group is difficult to ascertain due to the highly disturbed disposition of the unit on account of extensive tectonic deformation. Although the length of the outcrop is found to be of the order of about six kilometres, due to inaccessible territory it is difficult to ascertain the repetitions. The best estimate for the thickness is perhaps 3,000m, although this may be too small (Mathur & Evans, 1964). The age of the Disang Group is dated to be Upper Cretaceous in it type section.
2.4.5 Barail Group

The name ‘Barail Series’ was first used by Evans (1932) for the predominantly arenaceous sequence of the Barail Range. The initial mapping showed that the Eocene Kopilis and Disangs were overlain conformably in the northern outcrops of Sylhet and Cachar by a thick group of sandstones and shales which formed the spectacular Barail Range of the area. These were accordingly given the name Barail, and the Barail Range became its type area. Since the Barail Series is a lithostratigraphic unit, it was later redesignated as Barail Group. The Barail Group lies conformably over the Disang Group in the geosynclinal facies. The term Barail Group was applied to the strata, mostly of Oligocene age, overlying either the Disang or Jaintia Group and underlying either the Surma or Tipam groups. The age of the Barail is dated to be Uppermost Eocene to Oligocene (Mathur and Evans, 1964).

The Barail Group of the Assam-Arakan Foldbelt is divided into Naogaon, Boragolai and Tikak Parbat formations (Evans, 1932), while in the oilfield areas it is divisible into two broad sub-divisions. In the oilfield areas of ONGCL, the lower unit is named as Barail Main Sand Unit while the upper unit is named Coal Shale Unit. In oilfield areas of OIL they are named as Barail Arenaceous or Barail Fourth +Fifth Sand Unit and Barail Argillaceous Unit, respectively.

The Naogaon Sandstone Formation and Coal Measures of Mallet (1876) were grouped together in the Barail Group by Evans (1932) as he considered this to be a ‘natural grouping’. The Barail Group was further subdivided into Laisong, Jenam and Renji formations (in the southwest of Mokokchung in the Schuppen Belt) and into
Naogaon, Boragolai and Tikak Parbat Formations (in the northeast of Mokokchung in
the Schuppen Belt) (Evans 1932). The same rock types of the Barail Group are also
outcropped in the Margherita-Changlang Road Section and Dillighat River Section.

The Barail Group conformably overlies the Kopili Formation. In the Shillong
Plateau, the rocks of the Barail Group are cropped out towards east of the present area
under study in the Mikir Massif of Assam but often are overlapped by the Bokabil
Formation of the overlying Surma Group. In North Cachar and Naga-Patkai Hills, the
Barail Group attains a maximum thickness of 6000m. In the Upper Assam oilfields,
the shelf sediments of the Barail Group attain a thickness ranging between 500m and
1200m (Mathur and Evans, 1964; Handique and Bharali, 1981), which consists of a
lower arenaceous unit with occasional shale bands and upper coal shale unit. A
variable thickness of the Barail Group has been recorded in Upper Assam that can be
ascribed to the basement undulations and post-Barail erosion. It is presumed that the
Barail Group attenuates in thickness towards the northwest and eventually pinches out
to the north of the Brahmaputra River (Baruah and Ratnam, 1982). The miospore
assemblages, however, give a broad Lower-Middle Oligocene age for the Barail
Group. Evans (1932) has dated the Barail Group as Oligocene.

The Barail Group in the shelf region comprises the following features:

i) A thin development of sandstones and shales conformably overlying the
Kopili Formation in the Garo Hills and relatively thicker sandstone and
shale alternations at Bottom of the undifferentiated Barail Arenaceous
section in the Brahmaputra Valley.
ii) A thicker development of sandstones with some shales, mapped as Laisongs / Undifferentiated Barails at the south-eastern margin of the Shillong Plateau, and,

iii) A variable thickness of sandstone, shales, carbonaceous shales and thin seams of coal, on the south-eastern sloping shelf zones in the Dhansiri-Brahmaputra Valley.

2.4.6 Surma Group

The Surma Group is identified by Evans (1932) in the Surma Valley, southwest of the present area of study unconformably overlies the Barail Group and grades into the overlying Tipam Group. The sediments comprising sand, shale and grits between the Barail and Tipam groups in the Surma Valley were defined by Evans (1932) as the Surma Group. From the best development of the lithostratigraphic unit, the Surma Valley is considered as its type section. Based on lithological characteristics the unit was further subdivided into the Bhuban and Bokabil formations. The bottommost sand–shale sequence named the Bhuban Formation occurs in the type area of the Bhuban Hills southeast of Silchar in Cachar, while the overlying shaly sequence named the Boka Bil Formation developed in a muddy lake on the west flank of the Masimpur anticline in the Cachar District. On the basis of distinct lithological character the Bhuban Formation was subdivided into Lower, Middle and Upper members.

The unit comprises of a thick (3500m) sequence of shale, sandy shale, mudstone, shaly sandstone and thin conglomerate. In the oilfield areas of Upper
Assam, the Surma Group of rocks attains variable thickness between 30m and 100m and consists of gritty and pebbly sandstone with occasional grey shale bands, sandwiched between the underlying Barail Group and the overlying Tipam Group. The Barail-Surma unconformity is distinct throughout the Belt of Schuppen. Handique (1989) reported that its microflora and microfauna are similar to that of the underlying Barail Group whereas its heavy mineral suites are comparable to that of the Tipam Group. However, according to Murthy (1983) absence of coals, occurrence of heavy mineral suite with low ore minerals (45%), presence of montane taxa and reworked Early Permian palynoflora distinguish the Surma Group of rocks from the Barail Group. Based on playnological evidence, Dutta and Singh (1979) dated the age of the Surma as Miocene.

2.4.7 Tipam Group

The Tipam Group derived its name after the low range of Tipam Hills in Upper Assam. The Geology of Assam owes much to Mallet (1876) for his recognition of the group. Mallet (1860), coined the name ‘Tipam Series’ for a sequence of massive sandstones lying between the Dihing River and Digboi in the Schuppen Belt in Upper Assam, while describing the coalfields of Assam. The Tipam Group which overlies the Surma Group unconformably underlies the Namsang Formation. The group consists of two broad subdivisions, viz., Tipam Sandstone Formation at the bottom overlain by the Girujan Clay Formation at the top. The Tipam Sandstone Formation is the name given to a sequence of fine- to coarse-grained, moderately sorted, light grey, massive sandstones with occasional bluish grey, silty and carbonaceous shales. The
sandstones give a salt and pepper appearance. The overlying Girujan Clay Formation consists of mottled and variegated clay with impersistent argillaceous sandstone, and has been named after a streamlet called Giru Jan to the east of Digboi. The Tipam Sandstone and Girujan Clay formations attain a maximum thickness of 900m to 1200m in the oilfield areas of Dibrugarh, Tinsukia and Sibsagar districts. Based on the regional correlation and stratigraphic disposition, the age of the Tipam Sandstone Formation has been assigned as Upper Miocene (Evans, 1964). The palynological evidences suggest the age of the Tipam Sandstone Formation as Late Miocene (Dutta and Singh, 1979) and Deshpande et al., (1993) dated the Girujan Clay Formation as Mio-Pliocene.

2.4.8 Namsang Formation

Evans (1932, 1959) and Bhandari et al., (1973) formally defined the sandstones with clays and lignitic pebbles along the Dihing River type section at Namsangmukh as Namsang Formation. The Namsang Formation is well exposed all along the foot of the uplifted central Disang hills from the Jaipur Anticline to Mana-Bhum range in the Belt of Schuppen. In the present study the formation is best studied in the Burhi Dihing River section at Namsangmukh of Arunachal Pradesh.

The Namsang Formation, reported from the exposed sections in the north-eastern part of the Assam-Arakan Foldbelt, is comprised of loose sandstones and lignitic pebble conglomerates (Evans, 1932). The formation attains a maximum thickness of 2000 m in the foldbelt succession whereas in the oilfield areas it ranges between 400m and 500m in thickness. The formation unconformably rests over the
Tipam Group and gains importance from the hydrocarbon viewpoint near the brow-zone of the Naga Thrust (Murthy, 1983). In the Upper Assam oilfields, the rocks of the Namsang Formation are distinguished by the presence of thin alternating layers of sandstones and clays. Both the lower and the upper boundaries of the formation are unconformable, the former being more pronounced. The age of the formation is Plio-Pleistocene (Bhandari et al., 1973). The Namsang sediments have distinctly lower resistivity than the overlying Dhekiajuli Formation + Alluviums in the Upper Assam oilfields (Handique, 1989).

The Namsang Formation is devoid of fossils with the exception of palynofossils. The age of the formation is considered to be Plio-Pleistocene (Rao, 1983). Dutta and Singh (1979) dated the formation as Pleistocene. Large numbers of fossil wood collected from the present section in Deomali-Namsangmukh area suggest the age as Upper Miocene-Pliocene (Awasthi and Mehrotra, 1993). However, a Pliocene age is accepted for the Namsang Formation.

2.4.9 Dihing Group

Mallet (1876) classified the pebble beds unconformably overlain and underlain, respectively, by the Tipam Group and alluvium as the Dihing Group. The Dhekiajuli Formation which belongs to the Dihing Group is of Pliocene to Pleistocene age. In the north-eastern part of Belt of Schuppen it is well exposed along the Burhi Dihing River section at Namsangmukh area and Mana-Bhum range. Lithologically, the pebbles vary from place to place. They vary from sandstone along the Burhi Dihing section to gneisses at Mana Bum area. In the present area of Namsangmukh a
300m succession of the Dihing Group is found to be unconformably overlain and underlain by the Namsang Formation and Older Alluvium, respectively. These sediments tend to progressively onlap the late Miocene unconformity in a southerly direction. The climate at the time of deposition is thought to have been similar to the present day but perhaps with a significantly higher sediment input. In the north-eastern part of the Belt of Schuppen the thickness varies in between 300 and 1600m. The formation near the Tipong area attains a thickness of about 600m wherein the Namsang is not exposed. No detailed palynological observation is made on this unit so far. Pascoe (1964) considered the age of the formation as Pleistocene.

2.4.10 Alluvium

The Tertiary succession is covered with Older and Recent alluvium deposits. The high level terraces consist of oxidised yellow clay, clayey sand and medium- to coarse-grained sand. It is Quaternary to Recent in age.