CHAPTER 2

REGIONAL GEOLOGICAL SETTING
2.1.2 Disang Group

Mallet (1876) proposed the name Disang Group for dark grey shales and minor sandstone exposed along Disang (Dilli) river section (23°5' N, 95°23' E) some 24 km south of the Naharkotiya oil field. Evans (1932) later named it Disang Series and opined that owing to great spatial extent of these rocks it would be convenient to have several typical sections, rather than a few formally designated ones.

The Disang Group is made up of dark grey and black, fissile, splintery shales with minor sandstones. Mitra et al. (1974) recognized three distinct units within the Disang as lower dark grey, splintery shales, siltstones and silty sandstones; middle dark grey, splintery shales; and upper concretionary shale, sandy silts and sandstone unit.

The total thickness of Disang varies considerably from around 1600m in type section to over 3000m in the mobile belt. Towards the top, sediments of Barail group with a normal gradational contact overlie the Disang Group (Ganja et al., 1986).

In a few places, the shales and silty sand beds are yielding micro-gastropods, bivalves and foraminifera. Marine foraminiferal assemblages from Disang Group have been reported from time to time. These include Nummulite sp., Discocyclina sp., Dictyoconoides sp., and G. cerroazulensis etc (Evans, 1932; Rao & Prasad, 1982). On the basis of these fossil assemblages, Cretaceous to Late Eocene age is assigned to the Disang Group.
### Table I. Generalized stratigraphic succession of Nagaland, NE Himalaya.

(Compiled after Evans, 1932 and Ranga Rao, 1983)

<table>
<thead>
<tr>
<th>AGE</th>
<th>GROUP/SUB GROUP</th>
<th>FORMATION AND THICKNESS (in m)</th>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleistocene to Holocene</td>
<td>Alluvium</td>
<td>Alluvium</td>
<td>Gravels, silts and clays.</td>
</tr>
<tr>
<td>Pleistocene</td>
<td>Dihing</td>
<td>Dihing (300-1600m)</td>
<td>Pebbles, cobbles and boulders of sandstone in ferruginous coarse sandy matrix.</td>
</tr>
<tr>
<td>Pliocene to Pleistocene</td>
<td>Dupitila</td>
<td>Namsang (800m)</td>
<td>Sandstone, coarse occasionally pebbly and gritty with mottled clay bands.</td>
</tr>
<tr>
<td>Miocene to Pliocene</td>
<td>Tipam</td>
<td>Girujan Clay</td>
<td>Mottled clays, shales of varied colours with medium to fine grained sandstone. Massive sandstone, medium to coarse grained with current bedded structures.</td>
</tr>
<tr>
<td>Miocene</td>
<td>Surma</td>
<td>Bokabil (400m)</td>
<td>Alternations of shales with siltstone and sandstone.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper Bhuban (400m)</td>
<td>Alternation of sandstone and shale.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle Bhuban (450m)</td>
<td>Silty shale with sand lenticles, sandstone medium-grained, soft with current ripples.</td>
</tr>
<tr>
<td>Late Eocene to Oligocene</td>
<td>Renji (900m)</td>
<td>Sandstone medium to thick bedded, fine-grained, well-sorted. Occasional carbonaceous shales. Shales with subordinate sandstone. Sandstones occur as lenticular bodies and as thin bands. Sandstone with minor silty shale. Sandstone thin to thick bedded.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jenam (850m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laisong (1750m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cretaceous to Eocene</td>
<td>Upper</td>
<td>Upper (1800-3000m)</td>
<td>Dark grey, splintery shale with non-calcareous siltstone and silty sandstone Epimetamorphosed sediments of slates, phyllites with lenticular limestone beds. Ophiolites</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>Lower</td>
<td></td>
</tr>
</tbody>
</table>
2.1.3 Barail Group

The rock association included in this group was studied first by Mallet (1876) in Namsang river section of Makum coalfield (27°15' N: 95°42' E) and designated as coal measures. He regarded them as questionable *Nummulitic* and/or middle Tertiary age. Later, Evans (1932) proposed the name Barail and accorded the status of a series of similar rock association exposed in Barail range. This Group is subdivided into three Formations viz. Laisong Formation, Jenam Formation and Renji Formation. The Barails are usually light to brownish grey, fine to medium-grained sandstone, often interbedded with brown to dark grey shales.

The rocks of Barail Group form a series of discontinuous/continuous linear patches in the Kohima-Patkai folded zone, the inner belt of Disang and Barail (Mathur and Evans, 1964, Das Gupta, 1977). They are mostly confined to synclinal parts and occur topographically as mere capping on synclinal hills. In the Schuppen zone of imbricate slices, they occupy long linear tracts of strips and wedges, overriding younger sediments.

Sarmah (1989) studied clay minerals (kaolinite) in the Barail sediments and suggested a continental or near-shore depositional environment for them. Presence of kaolinite with subordinate amount of illite in the Barail sediments may also indicate marine transgression/regression suggesting a possibility of admixture of marine water in the continental or near-shore environment, which ultimately resulted in the transformation of some kaolinite into illite. Mandal (1996) suggested a warm and humid climate due to the presence of *Notothyrites* and *Phragmothyrites*. *Striattrites*, one of the major elements of *Marginipollis* suggests swamplike environment of deposition. The presence of coal-bands also supports the same. The lower contact with Disang Group is gradational, while the upper contact with Surma group is regarded as unconformable, Evans (op. cit.). The thickness of Barail group in Naga-Patkai belt is estimated as over 6000m (Das Gupta, 1977). Ranga Rao *et al.* (1983) collected *Nummulites chavannesi*, reticulate *Nummulites*, *Nummulites* sp. and *Operculina* sp. from the base of the formation of Kiphire-Sitire road, near Chizami and near Lalmati on Kohima-Dimapur road. The foraminiferal fauna is very poor and the general aspect of the fauna is of Late Eocene.
Lithostratigraphically, the sediments of Barail Group of Assam and neighboring areas of Nagaland are dated as Oligocene. The presence of Eocene marker taxa in the assemblage suggests a close similarity with the Middle to Late Eocene assemblages and the appearance of *Polyadopollenites* indicate Late Eocene age of the sediments of Barail Group exposed along Mariani-Mokokchung Road (Mandal, 1996).

### 2.1.4 Surma Group

A thick sequence of shales, sandy shales, mudstones, shaly sandstones, sandstones and thin conglomerates lies above the Barails with a stratigraphic break of regional magnitude and importance. It is known as Surma Group. The term was first introduced by Evans (1932) adopting the name from the Surma valley where it is best exposed. The Surma is divided into 3 Formations viz. Middle Bhuban, Upper Bhuban and Bokabil Formation. In Nagaland, the Middle Bhuban consists of mainly shale and minor sandstone, whereas Upper Bhuban is mainly arenaceous. The Bokabil Formation is dominated by grey laminated shales with a few sandstone beds towards top.

In the Naga Hills Surma Group of rocks are exposed as long linear strips among imbricate thrust slices of schuppen zone. They comprise of alternation of shale, sandstone, siltstone beds, characterized by their susceptibility to change within short space.

The section near Changki (94°23'26" E: 26°25'20" N) in Mariani-Mokokchung sector and around Kimpar nala are considered as typical sections in Naga Hills. A conformable contact with Barail group in early uplifted area is suggested (Evans 1932). Its junction with overlying Tipam Group appears conformable. Estimates of over 900m have been made for Surma equivalents in Naga-Patkai belt while in Surma valley it exceeds 5500m. Faunal evidences and polospore data indicate a Miocene-Pliocene and alternatively a questionable early Miocene age (Ganju *et al.*, 1986).

### 2.1.5 Tipam Group

The term was first coined by Mallet (1876). Evans (1932) subdivided the Group into 2 Formations viz. Tipam sandstone and Girujan clay. This Group is exposed over a vast area in northeast India.

The Tipam sandstone is predominantly made up of coarse grained to gritty ferruginous sandstone. The sandstone is often marked by partings of shale. The Tipam sandstone Formation is characterized by ferruginous sandstone in the Naga Hills. At places,
fossil wood is found and thin lignite bands are quite common. Gritty beds and conglomerates and shale conglomerate occur in various localities.

The Tipam sandstone is overlain by a very distinctive group of rocks predominantly composed of mottled clay. This is known as Girujan clay and named after a river near Digboi. In Naga Hills, the overlying Girujan Clay Formation is characterized by typical blue and mottled clays with argillaceous sandstone beds, which gradually thin out. At places it shows a thickness of 600m.

The Tipam Group is divisible into two distinct units viz. a lower sandy unit and an upper clay unit. The distinction is clear and pronounced all along the exposed tracts in Naga Hills. A total thickness of over 4000m is estimated for the group in the Naga-Patkai belt. No specific paleontological data is available for age determination and the group is dated as ranging from Middle Miocene to Pliocene from order of super-position and regional geological considerations (Ganju et al., 1986).

2.1.6 Dupitila Group

The term Dupitila was first described by Evans (1932) after a type section of hills between Chargola and Langai valleys. They overlie the Girujan Formation unconformably. The type section exposes 500 m sandy shale, and sandstones in almost equal proportion.

The Dupitila Group is poorly exposed. The sediments are generally loose and friable and lack bedding. It comprises variegated, mottled, friable, ferruginous and medium to coarse grained and poorly sorted sandstones rich in chocolate red to pink ferruginous clay matrix. Based on order of super-position and dating of tectonic events, a Mio-Pliocene age is suggested for it in the absence of any faunal criterion (Ganju et al., 1986).

2.1.7 Dihing Group

Mallet (1876) named the pebble beds exposed in the Dihing river section (27°15'-16' N; 95°24'-25' E) and designated them as type section for Dihing Group. Its lower contact with Namsang Formation is marked by an angular unconformity. The outcrops are mostly confined to the synclinal areas. In general, the sequence comprises alternations of pebble beds, light grey sands, mottled sands, mottled sandy clays and coarse grits (Ganju et al., 1986). In the absence of any precise data on dating, a tentative Plio-Pleistocene age for the Dihing Group is suggested (Das Gupta, 1977).
2.1.8 Alluvial beds

This alluvial sequence includes gravels, silts and clays of sub-recent to recent origin, overlying the Dihing Group with unconformable junction in the Naga-Patkai belt and an apparent gradational interface in present clay shelf and basin areas (Ganju et al., 1986). The older alluvium, comprising of clay, coarse sand gravel and boulders deposits occurs at the northwestern flanks of the Naga-Patkai ranges. The newer lower level alluvium comprising of clay, sand, silt and shingle covers vast areas bordering the Naga Hills.

2.2 STRUCTURAL AND TECTONIC SET UP OF NORTH EAST INDIA

The tectonic features of Northeastern India have many unsolved problems. It is termed as a polyhistory type basin, which has more than one phase of sedimentation and tectonism. The evolution of the basin is influenced by three plates, viz. Indian, Eurasian and Burmese plates (Mehrotra, 2002). Fig. 2.1.

The complex evolutionary trend of the northern India, i.e., continental rifting-drifting-convergence collision might have provided the requisite thermo-kinetic conditions for the generation of hydrocarbons in geologic time.

According to Bastia et al. (1993), the Assam-Arakan Basin (including the Assam plains, Cachar, Meghalaya, Nagaland, Mizoram, Manipur, Tripura and parts of Arunachal Pradesh) evolved in four phases (Fig. 2.2). They are as follows;

Phase-I (Cretaceous): The Assam-Arakan Basin came into existence during the Early Cretaceous time due to Continental rifting. Subsequent drifting of the Indian plate from the Indo-Australian plate (Sub Gondwana) took place during the Upper Cretaceous. This resulted in the formation of several horst and graben features.

Phase-II (Paleocene-Eocene): The northward movement of the Indian plate caused subduction of this plate beneath the Burmese plate. This resulted in the formation of the Indo-Burmese trench system east of the Assam shelf. Further east, the peripheral arc continues and merges into the Shan volcanic arc system. The Indo-Burmese trench became the locus of deposition of deep marine sediments i.e. Disang shale. Simultaneously, the Assam shelf part received continental to shallow marine sediments belonging to the Jaintia Group.
Figure 2.1 Geological map of Assam and surroundings (After Das Gupta, 1977)
Figure 2.2  Tectonic evolution of Assam-Arakan basin. (In Bastia et al., 1993)
Phase-III (Eocene-Oligocene): Continued convergence resulted in further rift of the peripheral arc system and narrowing of the intervening sea. Upper Assam foreland basin was evolved in which the Barail deltaic sediments were deposited.

Phase-IV: The convergence finally led to the collision of the Indian plate with the Burmese plate and resulted in complete closure of part of the Indian Ocean and a regional unconformity at the top of the Barail. The collision gave rise to imbricate thrust faults and upliftment as well as over riding of the older sediments, which were finally stacked adjacent to the Assam shelf. Foreland basin was subsequently filled with molassic sediments belonging to Tipam and younger sequences. The synchronous sedimentation further south was dominated by shallow to deep marine facies belonging to the Surma Formation.

2.3 MAJOR STRUCTURAL FEATURES OF NAGALAND

2.3.1 Kohima-Patkai folded zone

East of the Disang thrust is a zone of anticlinal and synclinal reversals named as the Kohima-Patkai folded zone. This includes what has been referred to as Naga folded zone and central Flysch zone (Ganju and Khar, 1985) and also an inner zone of Disang and Barail (Das Gupta, 1977). A characteristic feature of this zone is the reversal in topography with the anticlines forming valleys and synclines those of hills (Ganju et al., 1986). Most of the anticlinal valleys expose older sediments of Disang Group while the Barail is restricted to mere capping of synclinal hills. A number of thrusts viz. Dikhu, Tapu, Yangmun and Yimpang straddle through this zone. The most prominent amongst them is the Tapu thrust that affects the thrust-faulted Mao anticline in south and runs through the entire zone with successive increase in magnitude of overriding movement towards north. The Dikhu thrust affects the western limb of the Longchang syncline and unites with the Disang thrust to form a separate strip. The Yangmun and Yimpang thrust unite south of Tuensang and their unified trace merges with Laniye thrust, which together with Changrang-Zungki thrust alignment forms the eastern limit of Kohima-Patkai folded zone.

Between Laniye and Laruri thrusts is a zone of imbricate thrust slices, which is named as Zungki imbricate zone. These thrusts, namely Changrang, Zungki, Laniye, Moya and Laruri etc. diverge and unite in much the same as brow zone to form individual strips or wedges. The western outline of these strips collectively known as Changrang-Zungki-Laniye thrust alignment thrust defines the western limit of Zungki imbricate zone. To the east, it is
limited by the Laruri thrust, which brings the constituents of the Naga metamorphic complex to override the strips of the Ophiolite suite and epi-metamorphic slates, phyllites and greywackes of Zungki imbricate zone (Ganju et al., 1987).

The Kohima Synclinorium lies in the southwest of the Naga Hills. It occupies an area where the colliding plates were bringing the Indian continental mass at an angle towards Myanmar. Initially, it constituted a funnel shaped wide expanse of the intervening sea, narrowing towards the northeast. As the collision progressed, successive movements narrowed it down further to its present configuration (Gupta and Biswas, 2000).

2.3.2 Ophiolite Belt of Naga Hills

The Ophiolites of northeast India are rootless and of various dimensions, floating in a matrix which belongs to the Upper Cretaceous-Lower Tertiary Disang Group. They consist of a diverse mixture of igneous, sedimentary and metamorphic rocks, of which ultramafics are the main component. They do not constitute a continuous sheet but are made up of units haphazardly juxtaposed along faults or they consist of lensoid slices interbedded with Disang Group of rocks (Bhattacharjee, 1991).

The age of the radiolarians in the cherts indicates that the development of a trench along the western margin of the Burma plate took place during the Middle Cretaceous. This may therefore be taken as the period of time during which the subduction zone between the Indian and Burmese land masses was established. The Burmese plate was most probably welded to the Eurasian plate by the time it came into tectonic contact with the Indian plate (Bhattacharjee, 1991).

2.3.3 Naga Over thrust Belt (Schuppen Belt)

The belt of Schuppen, juxtaposed to the Assam plain is a wide zone of imbricate thrusts. The zone is bounded by the Naga thrust in the west, Disang thrust in the east, Mishmi thrust in the north and Haflong-Dauki compartmental fault in the south. Sediments ranging in age from the Cretaceous to Recent have been encountered in Schuppen belt (Bastia et al., 1993).

According to Rao and Praasad (1982), the ‘Schuppen Belt’ between Naga and Disang thrusts is about 4500 sq. km. in area. The schuppen belt constitutes part of the mobile belt of the Assam-Arakan geosyncline. The belt is sliced by 4-5 prominent thrusts and consequently, units above Barail, totaling about 5500 m thickness are repeated. All the thrusts are of the
same general shape, each repeats the strata and all dip in the same general direction. This type of thrust system was described as Schuppen structure (Rao and Samanta, 1987) or in modern usage as an imbricate zone and the rock sequence overlying each thrust as a thrust sheet.

Rao and Prasad (1982) stated that the ‘Schuppen Belt’ is characterized by folding to a much lesser degree than by faulting. Folding is mostly confined to selected places in the brow zone immediately east of the Naga thrust. According to Bastia et al., 1993, ‘The tectonic evolution of the Schuppen belt has been synthesized with structural complexity, which is closely related to the hydrocarbon potential. The convergence of Indian and Burmese plates resulted in a zone of high crustal mobility leading to major vertical and lateral movements of rock units. Continued convergence of Indian and Burmese plates resulted in the imbricate thrust faults giving rise to the upliftment and over riding of the older sediments, which were finally stacked adjacent to the Assam shelf. Often, earlier formed imbricate thrusts are truncated by younger thrusts forming duplexes which are favourable locales for hydrocarbon entrapment’.

In the area between Dimapur and Kanjang, Ganju et al. (1986) recognized seven major longitudinal thrust faults. Naga thrust is the westernmost thrust, which divides geographically the plains of Dimapur area and the mountain ranges towards East.