CHAPTER 3
GEOLOGY AND GEOMORPHOLOGY

3:1 INTRODUCTION

Imphal and its adjoining areas form a part of Imphal valley of Manipur region, which in turn form a part of the Indo-Burmese Range (IBR). It represents the collision zone giving rise to the Manipur-Nagaland Orogenic Belt (MNOB). The present chapter deals with the geological and geomorphological setting of the study area which has been discussed in sequel preceded by a synoptic review of regional geology of the area.

3:2 REGIONAL GEOLOGY

The study area lies in the central part of Imphal valley of Manipur state, which is flanked in the east by the International border of Myanmar (Burma). Geologically, study area in turn constitutes an integral part of Manipur-Nagaland Orogenic Belt (MNOB) which in turn forms the northern part of the Indo-Burmese Range (IBR). In the east, it is flanked by Central Burma Basin, in the northeast by Mishmi hills, in the north by the eastern Himalaya, in the northwest by Assam shelf and Shillong plateau and in the south lie, Chin Hills and Arakan Yoma. This belt is made up of volcanic-sedimentary rocks exposed in a linear zone along the eastern margin of the Indian subcontinent comprising northern part of the Indo-Burmese Range (IBR). In Manipur the following litho-tectonic units have been recognised (Fig. 3.1).

3:2.1 Naga Metamorphics

The term Naga Metamorphics was introduced by Brunschweiler (1966), primarily for metamorphic rocks viz quartzite, crystalline limestone, phyllite, marble, mica schist, gneiss, sheared granite and minor serpentinite (Brunsweiler op. cit., Roy and Kacker, 1982; Chattopadhyay et al., 1983) occurring in Burmese side of the Indo-Burmese Range. They also occur on the eastern and northeastern fringes of Nagaland and Manipur respectively. It is thrust over the Ophiolite-Disang group of rocks. Brunschweiler (1966) considered it to be Pre-Mesozoic, whereas Acharyya et al., (1986) assigned Proterozoic age to it.

26
3:2.2 Disang Group

The term was originally introduced by Mallet (1876) for a group of shales with sandstones towards the top, from the type locality of Disang valley in Upper Assam. Later works revealed extensive outcrops of similar sediments occurring in a wide belt of over 60 km in the Assam - Arakan ranges. This constitutes a major rock type in Manipur - Nagaland Orogenic Belt (MNOB). It is bounded on the east by the Ophiolite with a thrust contact. Its relationship with the younger Barail sediments is both gradational and conformable.

The Disang Group represents enormous thickness (> 3000 m) of fine clastic sediments derived from the hinterland. It is made of shale, slate, phyllite, greywacke, subgreywacke, and calcareous shale with minor limestone. This monotonous, folded and thrustsed, argillaceous succession is considered to be a flysch sequence (Mathur and Evans, 1964). The rocks of the Disang Group are exposed mainly in the eastern part of Manipur occurring west of the ophiolite belt and ranges in age from Upper Cretaceous (Pascoe, 1912) to Upper Eocene. The argillaceous sequence in Manipur-Nagaland Orogenic Belt (MNOB) may, tentatively, be sub-divided into two lithologic formations.

3:2.2.1 Lower Disang Formation

This is made of dark grey shale, slate and phyllite interbedded with mudstone and sandstone. This formation extends into eastern Manipur and exhibits argillaceous character. These rocks have been metamorphosed mainly towards the interior i.e. eastern side, where shale has changed to slate, phyllites and schists. They are juxtaposed against the ophiolite belt of Nagaland - Manipur, bordering the easternmost fringe, with a tectonic contact.

3:2.2.2 Upper Disang Formation

This formation corresponds more or less with the Disang of Mallet (1876) from the type area, Disang river section in Assam. In the east of Disang thrust, the Lower Disang Formation passes into a sequence of carbonaceous shales of Upper Disang (Ranga Rao, 1983).

It is mainly composed of shale with minor sandstone and occasional mudstone. The increase in thickness of sandstone marks the Barail - Upper Disang contact. Finely, disseminated carbonaceous matter is distributed throughout this formation. Several workers
have dated the fauna and flora from Upper Disang Formation. The suggested age ranges from Palaeocene to Upper Eocene (Evans, 1958, Nagappa, 1959, Sinha et al., 1982; and Ranga Rao, 1983).

3.2.3 Ophiolite Belt

The Ophiolites of Manipur - Nagaland Orogenic Belt (MNOB) came into existence since the late seventies (Chattopadhayay et. al., 1975) with the recognition of the similar rock types with the ophiolite assemblage (AGI, 1972). The belt shows a thrusted contact with flyschoidal sediments viz. Disang Formation in the west. It has a tectonic contact with the Naga Metamorphics, in the east, and is overlain by shallow - marine to paralic, immature, ophiolite - derived sediments namely Phokhpur Formation (Sengupta et al., 1989).

The belt comprises of highly dismembered composite zone of various rocks occurring as tectonic slices. The Ophiolite rock assemblages are made of dunite, harzburgite, lherzolite, wehrlite, pyroxenite and mafic volcanic rocks. These occur in association with oceanic pelagic sediments (Agarwal and Kacker, 1980, Ghose 1980, Ghosh et al., 1984, Ghose et al., 1986; Prasad et al., 1986 and Acharyya et al., 1984, 1990). Volcanic rocks of this belt are closely associated with radiolarian chert and occasional limestone. In Manipur sector, it splits into isolated bodies of dismembered ophiolites characterised by a number of metallic and non-metallic minerals e.g. nickeliferous magnetite, chromite, sporadic sulphide of Cu-Pb-Fe-Mo, serpentine etc. The rocks of this complex have suffered greenschist and high pressure and low temperature metamorphism giving rise to eclogite and glaucoaphane schist. Serpentinization and minor formation of rodingite give evidence of widespread hydrothermal alteration as well as metasomatism of the ultramafic rocks.

The coccolith and foraminiferal assemblages recorded from the sedimentary sequence suggest Maestrichtian to Palaeocene age (Acharyya et al., 1984, 1986, Acharyya and Ghose, 1986, Mithcell 1981, 1986) obtained an age of 158/148 ± 20 Ma (K/Ar date) for a hornblende pegmatite dyke within serpentine sheet which indicates a pre-late Jurassic age for the generation of ophiolitic crust.
3.2.4 Ophiolite Melange Zone

The term ophiolite melange was introduced in geology by Gansser (1974). He distinguished melange as a unit containing dismembered components of ophiolite. This zone occupies the eastern part of Manipur for a length of more than 150 km long and overlies Disang Group of rocks.

The melange zone is made of gritty sandstone, lithicwacke, conglomerate, siltstone, clay, minor limestone, clasts of these sediments and essentially of ophiolitic rocks like dunite, peridotite, pyroxenite, gabbro, basalt and serpentine. This formation also includes volcanioclastics, tuffaceous wacke and minor volcanics.

The ophiolite melange zone, in general, suggests a Late Cretaceous to mid-Eocene age on the basis of faunal assemblages in olistoliths.

3.2.5 Barail Group

The name was coined by Evans (1932) for a sequence of alternating sandstone and shale (in varying proportion) in Assam, Nagaland and Manipur area. The name is derived after the Barail range, situated in the south-eastern margin of the Shillong Plateau. The Barail Group is generally subdivided into three formations viz. Laisong, Jenam and Renji Formations. The underlying Disang Group, gradually merges into the overlying Barail Group which is mostly arenaceous. It constitutes an enormous thickness (> 6000 m.) of predominantly molassic sediments. Thick argillo-arenaceous sequence, overlying a thick shale sequence in parts of Nagaland - Manipur, has been folded together and shows axial trace bending roughly in the NE-SW direction. On account of this, it occurs in a number of roughly NE-SW trending sections in these states (Sarmah, 1989).

This group consists mainly of sandstone, shale, carbonaceous shale, clay and coal. At some places, individual sandstone bed is more than 100 m thick. This group of rock is exposed in the western part of Manipur. It also occurs as outliers in the core of synclines. At Kongai, the contact of the Barails appears to have angular discordance with the underlying Disang Group of rocks (Anon, 1974).

On the basis of faunal and floral assemblages, the age of Barail Group has been suggested as Upper Eocene to Oligocene (Evans, 1932, Dasgupta, 1977, Sinha et al., 1982, Ranga Rao, 1983).
3:2.6 Surma Group

The name was introduced by Mallet (1876) for a sequence of rocks in Surma valley exhibiting alternating bands of bluish grey, medium to coarse-grained and fine grained sandstone varying in thickness from 4-5 cm to over 30 cm, and bluish grey clay or shale which shows differential weathering (Saxena and Yedekar, 1984).

This group of rocks is exposed in the Belt of Schuppen. The contact is marked by bands of conglomerate. In Manipur, it comes in contact with the Renji Formation near Nungba, in West Manipur. It is considered to be of Oligocene-Miocene age.

3:2.7 Tipam Group

The name of this group was introduced by Mallet (1876) for rocks exposed in the Tipam river section of Upper Assam. It is made of arenaceous rocks consisting of coarse-grained ferruginous sandstone, intercalated with shale, conglomerate and mottled clays with interstratified beds of sandstone, sandy clay. The sandstones are generally massive with layers of intra-formational conglomerate. It is exposed in the western part of the state near Jiribam. On the basis of their stratigraphic disposition and faunal record, it has been considered to be of Miocene to Pliocene age (Ranga Rao, 1983).

3:3 GEOLOGY OF THE STUDY AREA

The study area comes under Imphal valley and is bounded by latitude 25°5' and 24°31' N and longitude 93°45' and 94°10'E. The valley is a large inermontane piedmont alluvial plain, representing a depositional environment (Singh, 1996). It has a general amphitheatre-like north-south extension, surrounded by hills made of Disang and Barail Groups of rock (Fig.3.2). The valley consist of thick sequences of fluvio-lacustrine assemblages of sand, silt and clay. In the study area, there are two major geological sequences made of Disang and Barail Groups of Tertiary age. Some workers have discussed the stratigraphy of Imphal valley (Oldham, 1883, Singh, 1993, Singh, 1996). The stratigraphic succession exposed in the study area is given in Table 3.1.

3:3.1 Disang Group

In the study area, Disang are exposed in the areas east of Imphal valley and also in the sectors north and south of the valley (Fig. 3.2). The rocks consist of dark-grey to
Table 3.1: Stratigraphic succession of Imphal Valley (Singh, 1993).

<table>
<thead>
<tr>
<th>Stratigraphic units and age</th>
<th>Formations</th>
<th>Description of rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluviums (Holocene to Pleistocene(?))</td>
<td>Newer Alluvium</td>
<td>Dark grey to black clay, silt and sand deposits of fluvio-lacustrine origin. Flood plain deposits of the rivers / streams.</td>
</tr>
<tr>
<td></td>
<td>Older Alluvium</td>
<td>Clay, sand, gravel and boulder deposits of the foothills. Possibly lower deposits of the valley.</td>
</tr>
<tr>
<td>Stratigraphic Break</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barail Group (Oligocene to Upper Eocene)</td>
<td>Light to brownish grey, bedded, sandstone alternating with shales. Sometimes considerably thick sand and shale beds are occasionally present. Flysch sediments show turbidite character.</td>
<td></td>
</tr>
<tr>
<td>Disang Group (Eocene to Upper Cretaceous)</td>
<td>Dark grey to black, laminated splintery shales. Intercalations of shales, siltstones and sandstones show occasionally rhythmite nature. Flysch sediments sometimes exhibit turbidite characters</td>
<td></td>
</tr>
<tr>
<td>Basement Rocks</td>
<td>Unseen</td>
<td></td>
</tr>
</tbody>
</table>

buff colour, thinly laminated splintery shales, with distinct intercalations of fine grained sandstones and siltstone as narrow bands and also in isolated lensoid form. The thickness of these bands vary from place to place as also the size of the lensoid bodies. In general, the thickness of the bands ranges between 10m and 15m.

The majority of lineaments observed in satellite images of the study area have trend NNE-SSW to NE-SW in the Disang Group of rocks. The general trend of the lithologic units varies from N-S to NE-SW directions dipping both in easterly and westerly directions. A longitudinal lineament which may probably be extension of Lainye fault, observed in the satellite image, passes along the contact between the eastern boundary of the valley and the Disangs.

The hillocks (remnants of denudo-structural hills) viz., Langol, Langjing, Langthabal, Thanga, Hiyangthang, Ngariyan, Maibam, Ishok, Ithing, Karang etc. are exposed within the valley plain. These hillocks are made up of Disang shales, reddish brown in colour probably due to weathering of these rocks. These hillocks contain
discontinuous bands or lenses of sandstone. The shales, observed in these hillocks, are
characterised by fractures/joints of diverse orientation and are found to be highly
weathered.

The rocks of Disang Group have been assigned Upper Cretaceous to Eocene age
on the basis of faunal assemblages (Singh, 1993).

3:3.2 Barail Group

In the study area, Barail Group of rocks are exposed in the sector west of the
central Imphal valley (Fig. 3.2). This overlies the Disang Group of rocks. At places, Barail
Group are exposed above the Disang Group. The contact between Disang and Barail
Groups has been under discussion for quite sometime. The change in litho facies is the
diagnostic feature for demarcation of the rocks of Disang and Barail groups. The gradual
increase in sand particles/sand bands is predominant in Barail Group. Barail Group in
the study area consists of light to brownish grey, fine to medium grained, thickly bedded
sandstone with shale partings.

Lineaments (fractures/joints/faults) as observed in satellite images (Landsat TM,
FCC) trend in N-S and NNE-SSW direction in Barail Group of rocks. A major lineament
which may probably be extension of Tapu fault is observed at the contact between the
western boundary of the alluvium and the Barail Group of rocks (Singh, 1996). Barail
Group of rocks belong to Upper Eocene to Oligocene age.

3:3.3 Alluvium

Alluvium forms the youngest Pleistocene-Holocene (Singh, 1994) sediments in the
study area. It covers the central valley portion of the study area (Fig. 3.2). The alluvial
deposits in the study area consist of dark grey to black clay, silt and clay, evaporites and
piedmont clastics.

Alluvium in the study area are of two categories viz. Younger/Newer alluvium and
Older alluvium.

3:3.3.1 Older Alluvium

Older Alluvium refers to the earlier cycle of deposition. The alluvium formed in
a large intermontane plain consisting of alternate layers of sand, silt and clay as well as
piedmont clastics consisting of sand, gravel and pebble with silt/clay formed at the foot of the hills are considered to belong to older alluvium in the study area.

3:3.3.2 Younger Alluvium

Younger/Newer Alluvium refers to the late cycle of deposition. The alluvium consisting of gravel, sand, clay and silt formed at either side or along the palaeo streams, and flood plains comprise the younger alluvium in the study area.

The thickness of the alluvium varies from place to place. In the northern part of the study area, at Sekmai, the thickness reaches upto 40m whereas at the eastern margin of the alluvial plain, it goes upto more or less 100 m.

Few sets of lineaments showing varying orientations are observed in the satellite imageries of the study area. Two major lineaments (thrust / fault) trending almost in N-S direction delimit the western and eastern boundary of the alluvial plain. These two lineaments appear to have exerted control over the shape as well as tectonic origin of the valley. The lineament which traverses the western boundary of the alluvium represents part of Tapu fault whereas the lineament crossing the eastern boundary of the alluvium is part of Lainye fault (Jha et al., 1994).

3:4 GEOMORPHOLOGY OF THE STUDY AREA

This section deals with the geomorphology of the study area and is based on satellite image interpretation with field checks (Fig. 3.3).

Geomorphologically, the study area is classified into the following geomorphic units (Table 3.2).

<table>
<thead>
<tr>
<th>Geomorphic Unit (after Singh, 1993)</th>
<th>Geomorphic Unit (after Singh, 1996)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial plain</td>
<td>Intermontane valley (Alluvial plain)</td>
</tr>
<tr>
<td>Flood plain</td>
<td>Piedmont</td>
</tr>
<tr>
<td>Abandoned channel</td>
<td>Structuro-Denudational hill</td>
</tr>
<tr>
<td>Meander Scar</td>
<td>Denudational hill</td>
</tr>
<tr>
<td>Natural leves</td>
<td>Denudo-structural hill</td>
</tr>
<tr>
<td>Point bars</td>
<td></td>
</tr>
<tr>
<td>Structural hills</td>
<td></td>
</tr>
<tr>
<td>Piedmont</td>
<td></td>
</tr>
<tr>
<td>Valley fills</td>
<td></td>
</tr>
</tbody>
</table>
3.4.1 Structural Hill

Singh (1993) identified this geomorphic unit in the study area. Structural hills are those where morphology is controlled by the structure of the rocks (Fairbridge, 1968) which evolved on the earth by the combined processes of denudation and tectonics. These hills are identified on satellite imageries on the basis of typical drainage development and associated landuse pattern (Plate-1, a-c). These hills are confined along the border of Imphal district which further extends into the valley. Langol hills, Naran Konjin and Waithou are few isolated patches of structural hills occurring in the valley. Lithologically, it consists of shales and intercalations of sandstone belonging to the Disang Group. The drainage pattern are of sub-dentritic to sub-trellis. The structural hills are further sub classified into the following:

3.4.1.1 Denudo-Structural Hill

In the study area, it occupy the eastern southern and northern part with the highest relief of about 1866 m above mean sea level (Fig. 3.3). It consists of splintery shales, sandstone and siltstones of Disang Group of Upper Cretaceous to Eocene age. These hills have dendritic to sub-dendritic drainage pattern. The drainage density is moderate to high as studied qualitatively. In the FCC image, these hills are seen in reddish to deep red colour which may be due to variation and type in vegetation cover.

3.4.1.2 Residual Hill (Denudational Hill)

Residual hills are demarcated in the central part of the study area, with relief ranging from 900 to 1100 m above mean sea level. These are flanked on all sides by alluvial plain deposits. These hillocks lithologically consist of splintery shale, with sandstone and siltstone belonging to Disang Group of Eocene to Upper Cretaceous age. Sub-dendritic and radial drainage pattern are observed with moderate to fine drainage texture (Fig. 3.3). In the false colour composite (FCC) image, these residual hills occur as isolated relief with medium to smooth texture and reddish colour.

3.4.1.3 Structuro-Denudational Hill

These hills occupy the western part of Imphal valley with highest relief of about 2331 metres above mean sea level and consist lithologically of sandstone, shale, siltstone
a. SPOT-PLA Scene of November 89-showing various landform units with Structural Hills.

b. Photograph showing Structural Hills and associated landforms.

c. Photograph showing Structural Hills, Flood Plain and associated Flood Plain features.
and mudstone belonging to Barail Group of Oligocene to Eocene age. Sub-dendritic to coarse trellis drainage is observed in these hills. Structural features such as fracture, joints, faults characterise this unit. In the false colour composite (FCC) image these hills appear with reddish tone due to vegetative cover and coarse texture.

3:4.2 Piedmont

It is well demarcated in the western margin of the alluvial valley plain ringing the foot hill (Fig. 3.3). It consists of colluvial and alluvial deposits comprising gravel, pebble, boulder, sand with silt / clay intercalations (Plate-2a), formed by deposition of materials brought down by streams draining from the surrounding hills. The piedmont zone in the study area shows sensorial, coarse, braided and fanning stream patterns. Alluvial fans are prominently seen in this zone, which consists of boulders, pebbles, gravels, sand, silt and clay. In the satellite false colour composite (FCC) image, this unit is characterised by fine to medium texture.

3:4.3 Alluvial Plain (Intermontane Valley)

It occupies the central part of the study area (Fig. 3.3). The elongated intermontane valley consists of thick sequence of fluvial lacustrine deposits (Plate-2b). The average relief in and around Imphal town is about 780 m above mean sea level. The alluvial plain is made of rhythmic layering of sand, silt and clay. This zone shows coarse, meandering to dendritic drainage pattern. The Imphal (Manipur) river is the major river with most of the major stream joining it. This unit, as a whole, was reported to have been a lake and filled in with the sediments brought down by streams training from the surrounding hills. The southern part of the plain is covered by water bodies and marshes which are flooded during rainy season.

Infilled channels seen in the alluvial plains consists of gravel, sand and clay in order of sequence. In the satellite FCC image, these infilled channel appears in the linear to curvilinear form and characterised by light reddish tone. In the study area, a few infilled lake e.g. The Lamphel Pat (Pat locally means lake) has been observed. This has been filled up with sediments.
a. Photograph showing the Piedmont associated with Imphal river, Kanglatongbi.

b. Photograph showing the Alluvial Plains at Sekmai.

c. Photograph showing the Flood Plains at Sekmai
3:4.4 Flood Plain

Flood plain is the essential product of stream erosion. This geomorphic unit was identified by Singh (1993) in the study area. Flood plains are the surfaces or strips of relatively smooth land adjacent to a river channel carved out by the river. It is made of alluvium brought by the river during floods and deposited in the sluggish water. In the study area the flood plains (Plate-2c) are present along the major rivers. The common associated fluvial landforms such as meander scars meander loop, ox-bow lakes, natural leaves and river bars were identified by Singh (1993). Lithologically, it consists of sandy clay, gravel mixed with sand etc.

3:4.5 Valley Fills

Valley fills in the study area were identified near the village Laitalpokpi, Yaingnagpokpi, Kangpokpi (Singh, 1993). This consists of unconsolidated and imperfect unsorted materials comprising of clay matrix embedded with pebbles and boulders.
FIG. 3.2 GEOLOGICAL MAP OF STUDY AND ADJOINING AREA
(Modified after Singh, 1994)
FIG. 3.3 GEOMORPHOLOGICAL MAP OF IMPHAL VALLEY & ITS SURROUNDINGS (Based on remote sensing technique with limited field checks) (modified after Singh, 1996)