CHAPTER - II

2.1 INTRODUCTION

Northeast India comprises varying geologic and geomorphic characteristics. It includes the Eastern Himalayas on the north, Mishimi Hills on the east, the Naga-Patkai Ranges on the northeast and the Sillong Plateau on the south. The region can be geologically and tectonically divided into four major zones, viz. the Himalayan folded belt and Tertiary hills and mountains, the Naga-Patkai Ranges, the Shillong Plateau including Mikir Hills and the Brahmaputra Valley in Assam. The Himalayan zone comprises of three topographic units that rise progressively from the south to the north. The lowermost zone is the Sub-Himalayas with an average elevation of 1000 m, which consists of mainly Tertiary sandstones. The Middle Himalayas, having an average elevation of 4000 m, are underlain by Lower Gondwana (Paleozoic) sediments comprising shales, slates and phyllites, which are overlain by a thick horizon of basaltic rocks. The Greater Himalayas, with an average elevation of 6000 m, consist primarily of granites and gneisses. The Naga-Patkai Ranges with an average elevation of 1000 m are composed of Tertiary sediments and are characterised by a large number of active faults. This zone consists of piedmont plains, anticlinal ridges and synclinal valleys with terraced alluvial fills, undifferentiated sharp ridges and narrow valleys, upland valley depressions and plateau remnants. The Shillong Plateau and the Mikir Hills, with an elevation ranging from 600 m to 1800 m, are made primarily of gneisses and schists. The Brahmaputra Valley in Assam is underlain by about 200-1100 m thick Recent alluvium consisting of clay, silt, sand and pebbles
which are being brought down from the rising Himalayas in the north, the Patkai Naga Ranges in the east and southeast and the Shillong Plateau in the south.

2.2 GENERAL GEOLOGY

The study area is mainly situated in the Assam-Arakan Geological province which lies in an active tectonic region. The area covers two geological provinces. One is the Upper Assam and the Naga Hills and the other is the Surma Valley and South Shillong Plateau. A composite stratigraphic succession of both the areas is given in Table 2.1.

The rocks of Tertiary age are very well developed in Assam and Meghalaya where they unconformably overlie the Precambrian Group of rocks and are represented by Jaintia (shelf) and Disang (geosynclinals) Group of rocks of Eocene age of the Lower Tertiary sequence. These are again overlain by Barail (Oligocene), Surma (Lower Miocene), Tipam (Upper Miocene), Dupitila (Mio-Pliocene) and Dihing (Pliocene) Groups of Upper Tertiary sequence (both shelf and geosynclinal facies). The regional geological units of the Surma Valley and South Shillong Plateau, Upper Assam Basin and adjoining Naga Patkai Ranges together as put forward by Mathur and Evans (1964) are described briefly as follows:

Jaintia Group (Eocene)

The rocks of the Jaintia Group are formed in the shelf facies during the Eocene time. They are deposited unconformably over the Precambrian Group of rocks. The Jaintia Group is divided into basal Shella (including the former Therria Sandstone and
overlying Sylhet Limestone) Formation and Upper Kopili Formation. The basal member of the group is the Sylhet (Therria) Sandstone Formation which rests unconformably over the rocks of Archean, Precambrian and Sylhet Trap. The Sylhet Sandstone Formation is succeeded conformably by the Sylhet Limestone Formation. Both of these formations have got restricted occurrences in the North Cachar Hills and the Karbi Anglong districts of Assam. Around Garampani area, North Cachar Hills, the Sylhet Sandstone Formation consists of thick beds of sandstones with interstratified carbonaceous shale and thin (0.3 m) coal seams, over a 2-3 m thick basal conglomerate bed, while the Sylhet Limestone bed represents thick foraminiferal limestone with minor shale and marl bands. The Sylhet Limestone is absent in the Upper Assam Basin but is well developed in the Bengal Basin towards the southwest (Uddin et al., 2007). The limestone of the Sylhet Formations is conformably overlain by the Kopili Formation consisting of alternating shales and sandstones with occasional very thin limestone bands. The Kopili Formation is well exposed in the southern and southeastern parts of the Shillong Plateau and in the Mikir Hills. In the southeastern part of the Shillong Plateau, the Kopili Formation is nearly 500 m thick. In Karbi Anglong district, the rocks of the Jaintia Group extend from Sheelveta in the west through Dilai Parbat in the east and then to Doigrung further northeast.

**Disang Group (Eocene)**

The Disang Group comprises great thickness of shale and inter-bedded bands of fine-grained flaggy sandstones. The Disang Group was first described by Mallet (1876) as a great thickness of splintery gray shales interbedded with fine grained
sandstones and siltstones. In Mallet’s type section in the Dilli River (called Disang River in Sivasagar District), the lowest beds are finely laminated dark gray shales. Higher up in the sequence the rocks are flaggy graywackes and sandstones varying in thickness. The Disang outcrops cover much of the hilly area of the Patkai Range in the southeastern part of the basin. In Assam, the Disang Group has restricted occurrences as a narrow strip to the south of Haflong-Disang Thrust in the central part of North Cachar Hills up to the headwaters of the Dhansiri River. The Disangs become arenaceous towards the top showing vertical as well as lateral passage to the overlying arenaceous Barail Group.

**Barail Group (Oligocene)**

The Disang Group is conformably overlain by about 1200 m thick succession of alternating hard sandstone and shale. The rocks are named as Barail Group after the Barail Range. In Upper Assam and Naga Hills, it is divided into three formations, viz. Naogaon, Baragolai and Tikak Parbat. While in the shelf sediments within the Upper Assam Valley it is not subdivided. The Barails are mostly arenaceous but the sands become coarser in the northwesterly direction (Krishnan, 1968).

**Naogaon Formation**

The Naogaon Formation forms the bottommost part of the Barail Group. The Disangs pass through interbedded shales and sandstones onto hard, grey, fine-grained, thin bedded, often flaggy sandstone with occasional beds of shale, which occasionally becomes sandy and carbonaceous. They are exposed higher up in the Direk near
Wanting and up to the headwaters of the Namsang, Ledo, Likhapani and in Tipang and Tirap Rivers. This formation is overlain by the Baragolai Formation.

**Baragolai Formation**

The Baragolai Formation comprises of hard, massive, bedded sandstones with clay, shale, carbonaceous shale and thin coal beds.

**Tikak Parbat Formation**

The Tikak Parbat Formation consists of medium to coarse, light colored quartzose sandstone with interbedded shale, sandy shale, clay, carbonaceous shales and coal. The formation is separated from the Baragolai Formation by an 18 m thick coal seam at its base.

The Baragolai and the Tikak Parbat Formations are described as coal measures by Pascoe (1930). The major coal field belt of Namdang-Ledo-Tipang-Namchik is made up of these formations.

In the Surma Valley, North Cachar Hills and South Shillong Plateau, the Barails are divided successively into three formations, viz. Renji, Jenum and Laisong. The Laisong forms prominent scarps, well exposed in the Barail Range and consists of well bedded, compact flaggy sandstone and subordinate shales. The Jenum Formation, equivalent to the Baragolai Formation of Upper Assam, consists of shale, sandy shale and carbonaceous shale with interbedded hard sandstone. The overlying Renji Formation consists of mainly massive and bedded sandstones and is correlated to the
Tikak Parbat Formation. There are no coal seams in the Surma Valley but they begin to appear east of the Dhansiri Valley. The rocks of the above formations are exposed along southeastern part of the North Cachar Hills to the south of Haflong-Disang Thrust and part of North Cachar and Mikir Hills to the north of Haflong-Disang Thrust.

**Surma Group (Lower Miocene)**

The Barails are unconformably overlain by the Surma Group of Lower Miocene. It consists of grits, thick conglomerate and a large proportion of argillaceous rocks in the form of shale, shaly sandstone, sandy shale, sandy mudstone and clay, also moderately coarse sandstone and little carbonaceous matter. It is exposed as a narrow strip on the eastern part of the Karbi Anglong district overlapping the older formations and along the coal fields from Ledopani up to Namphuk River. In both the geosynclinals and shelf sediments of Upper Assam and Naga Hills it is not subdivided. In Upper Assam at places, it is represented by about 30-60 m thick sandstone, shale and conglomerate.

The Surma Group covers a large area in the Surma Valley, North Cachar Hills and the South Shillong Plateau. It is subdivided into Bhutan and Bokabil Formations, successively. The Bhutan Formation consists of sandstones, sandy shales and conglomerate intervened by shale, sandy shale and lenticular sandstone. This is succeeded conformably by the Bokabil Formation which consists of shale, siltstone, mudstone and fairly thick lenticular, coarse, ferruginous sandstone. The Surma Group is exposed as inliers in the southern part of the Surma Valley and as a strip in the
northern part of the valley.

**Tipam Group (Upper Miocene)**

The Surma Group is conformably overlain by the Tipam Group. In both the geosynclinal and the shelf facies of Upper Assam and the Naga Hills and in the Surma Valley and South Shillong Plateau, the Tipam Group is divisible into two divisions, viz. Tipam Sandstone and Girujan Clay Formations.

**Tipam Sandstone**

The Tipam Sandstone Formation consists of fairly coarse to gritty, false bedded ferruginous sandstone interbedded with shale, sandy shale, clay and conglomerate. The sandstones are usually bluish grey to greenish (salt and pepper) in colour giving a brownish tint on weathering. They are found to be exposed in the Tipam Range on the low hills on the Jaipur anticline belt immediately southeast of the Naga Thrust. It reappears near Ledo and stretches eastward in the form of a broad tract where it occupies high hill ranges interrupted by magnificent ravines.

**Girujan Clay Formation**

The Girujan Clay Formation is an essentially argillaceous, consisting of mottled clay, sandy mottled clay, sandy shale and subordinate mottled coarse to gritty ferruginous sandstones. There are many large exposures of this formation in Jaipur and Digboi and further northeast.

The Tipams are exposed in many parts of the Surma Valley and in the South
Shillong Plateau.

**Dupitila Group (Mio-Pliocene)**

The Dupitila Group is known as the Namsang Formation in Upper Assam and Naga Hills both in the geosynclinal and shelf facies and Dupitila in the Surma Valley and South Shillong Plateau. The Girujan Clay is unconformably overlain by this group which is mainly arenaceous and contains beds of lignite pebbles. Beds of grit and grit conglomerates are very common especially in the upper portion of this formation. It consist of coarse to gritty, poorly consolidated sandstone, mottled clay and conglomerate which at places are almost entirely composed of coal pebbles derived from the coals of the Barail Group. Excellent sections of the Namsang Beds are seen in the Namsang River after which the Formation has been named.

In the Surma Valley and South Shillong Plateau, the Girujan Clay Formation is overlain by the Dupitila Group with a hiatus at its base. The Dupitis are well exposed in the southern part of the Surma Valley and South Shillong Plateau.

**Dihing Group (Pliocene)**

The Dupitila Group is succeeded by the Dihing Group. It is represented by thick pebble beds alternating with coarse, soft sandstone, clay, grit and conglomerate. The unconformable relationship between the Dihings and the Namsangs (Dupitila) is well exposed along the Dihing river section near Jaipur in Upper Assam. In the geosynclinal sediments in Upper Assam and Naga Hills and in the Surma Valley and South Shillong Plateau it is not subdivided; while in the shelf facies within Assam
Valley it is known as Dhekiajuli Beds.

**High Level Terraces and Alluvium (Pleistocene and Recent)**

The deposits overlying unconformably the Dihing Group are designated variously as “Terrace Deposits”, “Older or High Level Alluvium”, “Unstratified Drifts” or “Red Bank Soils”. Sometimes it is difficult to differentiate these deposits from the underlying Dihings. They are represented by indurated yellowish, brownish or reddish clay mixed up with sands, shingle, gravel and boulder deposits. A major part of the Brahmaputra Valley is covered by Recent alluvium including flood plain deposits and is grouped as Newer or Low Level Alluvium. These deposits comprise of clay, coarse sand, shingle, gravel and boulder and attain a thickness of approximately 200 to 300 m (Purkait, 2004). Pleistocene river gravel terraces are recorded by Macleran (1904) along foothills of Upper Assam in the Dihing Valley, three terraces one above another, the surface of the highest and oldest being about 305 m above the level of the valley. Such terraces are very characteristic near Margherita and Deomali.

**2.3 TECTONIC SETTINGS**

The tectonic settings of the different parts of the study area are not exactly similar. Four geotectonic provinces have been recognised in the Northeast India (Purakait, 2004), which are given as follows:

1. The stable shield area of the Shillong Plateau and the Mikir Hills.
2. The platform area peripheral to the shield, now covering the North Cachar Hills, Bangladesh plains and the Brahmaputra Valley.
3. The Naga-Patkai and the Eastern Himalayan mobile geosynclinal belts and
4. The transitional zones between the platform and geosyncline, probably with
   narrow pericratonic downwarps marginal to the shield.

These four geotectonic provinces are bounded by major tectonic lineaments
which are as follows:

1. The basement faults consisting of -
   a. E-W trending Dauki Fault along the southern margin of the Shillong
      Plateau extending up to Haflong in the North Cachar Hills,
   b. suspected E-W fault along the Brahmaputra Valley which probably has a
tectonic control on the river,
   c. NW-SE trending faults located in the SW of the Shillong Plateau, the
      Mikir Hills and to the east of the latter.
2. NE-SW trending Belt of Schuppen.
3. EW to NE-SW trending frontal Himalayan Thrust Belt.
4. NW-SE trending Mishmi Thrust along the Lohit foothills.
5. Probable northeasterly extension of NE-SW Calcutta- Mymensing to the south
   of the North Cachar Hills through Cachar District (Purkait, 2004).

Over and above these, major and minor lineaments like Kopili
Fault/Lineament, Bomdila Fault/Lineament, Jorhat Fault, Dapsi Thrust, Dudhnoi
Fault, Gumti Fault, Mat Fault, Jamuna, Tista and Siang Fractures cut across Northeast
India which make it a complex structural and geological domain (Nandy, 1980 and
1981; Dasgupta and Nandy, 1982; Nandy and Dasgupta, 1986 and Dasgupta et al.,
The present study includes analysis of the role of neotectonics through drainage patterns, morphometric and morphotectonic parameters of some selected drainage basins in mainly four separate areas of the major geotectonic provinces and geological structures as mentioned earlier. Hence these areas are described separately as follows:

2.3.1 UPPER ASSAM VALLEY AREA (including South Dhansiri River Basin)

The Upper Assam Valley is an ENE-WSW trending relatively narrow valley bounded by mobile young mountain belts. The valley consists of thick alluvium and is the result of uplift and subsidence of the Precambrian crystalline land masses, the remnants of which is now represented by Mikir Hills (Karbi-Anglong Hills) of Assam and Shillong Plateau. They form a ‘Foreland Spur’ (submerged basement of Assam shelf) which has been overthrust from the northwest by the Mishmi Hills and from the southwest by the Naga-Patkai Range during the Tertiary geotectonic cycle. The Upper Assam Valley was involved in tectonic movements during the Upper Tertiary and Quaternary. Flat lying Tertiary shelf sediments overlie the basement whose thickness increases from south to north towards the Himalayas (Nandy, 2001). The structure of the plains is known only from the geophysical surveys as well as drilled wells conducted and bored in search of hydrocarbon by Oil India Limited (OIL) and Oil and Natural Gas Commission (ONGC). At the basement level, various important structural elements, viz. the Brahmaputra arch, the Jorhat-high, Moran saddle, Naharkatiya high and Nazira-Sonari depression have been identified (Desikachar, 1984). The structural
pattern in the sedimentary cover is in general controlled by the irregularities in the basement and differential movements along basement faults. The structures in this valley area are either gentle domes or elongated gentle anticlinal folds, grabens dissected by numerous faults. The faults mainly trend along ENE-WSW, NNE-SSW, NE-SW, NW-SE and E-W directions.

2.3.2 BELT OF SCHUPPEN AREA (Naga Hills)

The Belt of Schuppen, as defined by Mathur and Evans (1964), is a narrow linear belt of imbricate thrust slices which follows the boundary of Assam Valley alluvium in NE-SW direction for a distance of nearly 350 km along the flanks of Naga Patkai Hill Ranges and continues southwest for another 50 km. This belt consists of eight or more overthrusts trending NE-SW and dips towards east along which the Naga Hills has moved northwestward relative to the Foreland Spur (Nandy, 2001). The Assam-Foreland Basin/Foreland Spur is located at the tri-junction of Indian shield, Himalayan geosyncline and Arakan-Yoma geosyncline (Reddy et al., 2008). In addition to these major thrusts, minor ones often truncate the lithological sequences. The thrusts form a complex pattern, one thrust over-riding another. The total horizontal movement of all the thrusts together is estimated to be over 200 km. The belt is about 8 to 25 km wide. The Belt of Schuppen ends near Haflong (Srinivasan, 2007).

According to Srinivasan (2007), the Belt of Schuppen is delineated on the east by the Disang Thrust and on the west-north-west by the Haflong-Naga Thrust. The Haflong-Naga Thrust (frontal thrust of Belt of Schuppen) extends NE-SW over a
length of 410 km along the break in slope separating the alluvial plain in the west from the ridges of Neogene sedimentary rocks in the east. In the southwest at Miyungkhor (in Assam) it is terminated by the Dauki Fault. In the northeast near Digboi it is concealed below the alluvium. The Disang Thrust (rear thrust of Belt of Schuppen) extends NE-SW over a length of 480 km and it defines the eastern margin of Neogene basin. In the southwest near Wadrengdisa, it branches out from Haflong-Naga Thrust and in the northeast it is terminated by the Mishimi Thrust in the right bank of Noa Dihing River. The major thrusts and subthrusts of the Belt of Schuppen dip generally towards southeast. Thus the Belt of Schuppen extends between Dauki Fault in the southwest and Mishimi Thrust in the northeast over a length of about 500 km.

The Belt of Schuppen comprises three major thrusts namely: the Haflong Thrust, Naga Thrust and Disang Thrust. Recent studies in the Belt of Schuppen of Naga Hills demonstrate that the belt comprises well defined lithotectonic units bounded by thrusts on either side (Nandy, 2001). From east to west the tectonic blocks are:

i. Teori Block bounded by outer Naga Thrust and Champang Thrust.

ii. Champang Block between Champang Thrust and the Lakhuni Thrust.

iii. Lakhuni Block between the Lakhuni Thrust and the Sanischungliyimsen Thrust.

iv. Baghti Block between Baghti Thrust and the Sanischungliyimsen Thrust.

v. Changki lithotectonic unit between the Sanischungliyimsen Thrust and the
vi. New Camp Block between the New Camp Thrust and Haflong-Disang Thrust.

2.3.3 KOPILI VALLEY AREA (including North Dhansiri River Basin)

The Kopili River is flowing in between the Shillong Plateau and the Mikir Hills. Its valley is known as Kopili Gap, which represents a lineament named as the Kopili Lineament. This lineament in the Kopili Valley possibly represents a rejuvenated fault (graben) system that separated the two Precambrian massifs on both sides i.e. the Shillong and the Mikir Hill blocks. The Kopili Lineament is also known as Kopili Fault (Kayal et al., 2006). The fault is 300-400 km long trending NW-SE and dips to the northeast. The Kopili Fault is a zone, which is around 100 km wide and is dominated by normal/strike-slip faults. It is believed that the fault zone extends towards northwest below the Himalayas (Kayal et al., 2006). The Kopili Valley comprises Neogene-Quaternary sediments deposited directly over the Archean Basement and bounded by NW-SE trending steeply dipping Kopili Fault in the west and NW-SE trending Dighalpani-Kakijan Fault in the east. The northern part of the valley area is delimited by E-W trending Kalang Lineament. Several studies have reported that the 300 km long Kopili Fault transgresses into the Bhutan Himalaya up to the MCT (Nandy, 2001; Bhattacharya et al., 2002; Kayal et al., 2006). This fault is tectonically active as evidenced by intense seismic activity along this fault (Dasgupta and Nandy, 1982).
2.3.4 DAUKI FAULT AREA

According to Evans (1964), the Dauki Fault extends roughly E-W and is exposed along the southern margin of Shillong Plateau for about 170 km from Jadukata River in the west to Haflong in the east, where it passes into the Haflong-Disang Thrust (Murthy et al., 1969). From the west of Jadukata River, this fault was traced for a distance of 70 km below the alluvium by geophysical methods up to Dalu. The Dauki Fault is a major structural feature defining the limits of the uplifted Shillong Plateau and the alluvial plains of Surma Valley. The northern block of this fault, represented by the Shillong Plateau with the oldest rocks such as the Archean granite gneiss, is considered as the upthrown side with respect to the southern block, represented by the Surma Valley with the youngest rocks such as Neogene to Recent sediments. The overall relief between the Shillong Plateau and the basement of the Sylhet Trough on either side of the fault system is about 20 km (Shamsuddin et al., 1997). Evans (1964) considered it as a dextral transcurrent tear fault along which the Shillong Plateau has moved eastward 250 km relative to the Surma Valley. According to Srinivasan (2005), the Dauki Fault remained as a single normal gravity fault dipping towards south at around 50° throughout its 170 km extension from Dauki in the west to Leike (40 km ENE of Haflong) in the east. The present height of the Shillong Plateau has been achieved mostly by repeated upliftment along the Dauki Fault system over a long span of time (Murthy et al., 1969).

2.4 REGIONAL GEOMORPHOLOGY

Assam is dominated by the alluvial plains of two major rivers: the Brahmaputra
and the Barak-Surma. Amongst these, the Brahmaputra is the larger river, which flows almost through the middle part of the Assam Valley. The Brahmaputra is one of the greatest river systems of the world with a drainage area of about 58,000 km$^2$. The Brahmaputra River comes into being through the confluence of three major rivers near Sadiya, Assam, as these emerge from the Himalaya Mountain. From the east to the west, these are the Lohit, Dibang and the Dihang (the main river). The river is joined by as many as 70 tributaries from the north and 38 tributaries from the south within Assam. In Assam, the river Brahmaputra has many Himalayan tributaries, but most of these have only a short run in the plains before they join the main river. The northbank tributaries have steep slope and shallow braided channels for a considerable distance from the foothills and are subjected to flash floods and carry heavy silt charge. While the southbank tributaries have comparatively gentler slopes, deep meandering channels almost from the foothills, bed and banks of fine alluvial soil and comparatively low silt charge. The important north bank tributaries are: Subansiri, Dhansiri (North), Jia Bhareli, Puthimari, Pagladiya, Manas and Sankosh and the southern bank tributaries are: the Lohit, Noa Dihing, Burhi Dihing, Disang, Dikhu, Jhanzi, Dhansiri (South) and Kopili. Among these, the Burhi Dihing, the Dhansiri (South) and the Kopili have large alluvial plains of their own. A number of long anabranching channels are another characteristic of the Brahmaputra. Innumerable mid-channel bars called locally *chars* and *chaparis* are also found in the Brahmaputra River. Majuli (425 km$^2$ area) is reported to be the world’s largest inhabited river island within the Brahmaputra (Talukdar et al., 2004).
The Barak River originates from the Barail Range situated to the south of Kohima in Nagaland. It receives discharges from many tributaries (both from the Barail Range to the north and the Mizoram hills to the south). It splits into two rivers, viz. the Kusiyara and the Surma, at the Indo-Bangladesh border. The rivers of the southern part of the Shillong Plateau drain into the Surma-Barak Rivers. Most of the tributaries show perfectly trellis type drainage pattern as they flow through the long narrow belts of anticlines and synclines. The entire Barak Valley is interspersed with small hillocks and swampy low lands where floods recur annually. Occurrence of swamps (bils), ox-bow lakes and huge marshy tracks is very frequent in this valley.