CHAPTER 2
Geology and Regional Tectonic Setting

2.1 Regional geology and tectonic setup

The Himalayan orogenic belt is the result of Cenozoic Indo- Eurasian plate collision (Gansser 1974, Yin and Harrison, 2000; Aitchison et al., 2007) and represents one of the youngest and the highest mountain range in the world. In Indian shield it is bounded by the Indus in the west and Brahmaputra in the east. Geologically Himalaya is the example of continental collision with diversity in lithology, stratigraphy, tectonic and metamorphic history (Pande, 1975). This mighty mountain range spread along 2400 km and across 240-325 km (Gansser, 1974) spread into the southeast Asian landmass. It has been divided into the western, central and eastern Himalaya along strike length and outer, lesser and higher Himalayan zone from south to north across the Himalayan trend.

North East India is a tectonically distinct geological domain. The Geological history of the region directly or indirectly involves almost all the major geological ages from the Archean to the Recent (Nandy, 1975). The Paleozoic Himalayan sedimentary basin in the north and the Cenozoic Assam – Arakan sedimentary basin in the south are the two most important tectonosedimentary domain in this region. While the Gondwana sediments are recorded from the Himalayan basin, the oldest sedimentary record within the Assam-Arakan basin is found to be Upper Cretaceous. The Siwaliks foredeep molasses in front of the Himalaya and Tipam molasses of Upper Assam basin in front of Indo-Myanmar mobile belt are separated by the Brahmaputra Alluvium that itself represent a basin fill with an enormous repository of Quaternary Alluvium overlying the Cenozoic sequence. Proterozoic to early Paleozoic granites are found in the Shillong Plateau, which are of intrusive in character. On the other hand the Tertiary granites are found in the upper part of the Eastern Himalaya. The Jurassic-cretaceous rocks are found in the Shillong plateau while the Abor volcanic
rocks (Upper Palaeozoic to Eocene) are found in the Himalaya. The carbonatites and ultramafic rocks of Cretaceous time found in the Shillong plateau and Mikir hills. The Gondwana rocks are found in a narrow belt along the foothill of Himalaya, which indicate the rift-drift tectonism. Thus, geological beds ranging from Precambrian to recent periods can be found scattered in the region (Nandy, 1975).

On the northern side of the Brahmaputra Valley the inselberg zone gradually gives way to alluvial plain abutting against the ENE-WSW Siwalik ridge of sub Himalayan trend. In the sub-Himalaya zone trend varies from E-W to ENE-WSW and gradually assume a NE-SW trend (Nandy 2001). On the basis of geology and geomorphology (Burrard and Hayden, 1907), the Himalayan range has been divided into four different longitudinal sections. These sections running parallel to the length of the mountain from south to north are: the Outer or Sub Himalaya, the Inner or Lesser Himalaya, the Greater or Higher Himalaya, the Tethys or Trans Himalaya.

In the Arunachal Himalayan region the older rocks are exposed successively from south to northwards. The outermost hills Neogene clastic of Siwaliks Hills, were folded and uplifted to give rise to Sub Himalayan ranges (Kunte et al., 1983, Kumar, 1997) and demarcated by the HFT (Himalayan Frontal Thrust) from the alluvial of Brahmaputra. The mountain front along with the HFT is suggested to be tectonically active because of southward progression of deformation of the Himalaya (Lave and Avouac, 2001). Gondwana sediments of lesser Himalaya are separated by the Main Boundary Thrust (MBT) from the Neogene sequence of Sub Himalaya. MCT (Main Central Thrust) separate the lesser Himalaya from the central crystalline zone of Higher Himalaya. North of central crystalline rocks, lies the Tethyan belt of Palaeozoic-Mesozoic sediments along Main Northern Thrust (MNT) and further ophiolite zone of Indo-Tsangpo suture belt (Nandy, 1975). The lesser Himalaya succession lies between the MCT and MBT is composed of low-medium grade metamorphic rocks (Nandy, 2001; Kumar, 1997). The Higher Himalayan crystalline zone is composed of high grade, Kyanite-sillimanite bearing schist and gneiss with intrusions of Tertiary leucogranite and quartzite (Kumar. 1997).

Assam and other seven state of Northeast India display tectonically distinct geological setup. This part represents the dynamic frontal part of the Indian Plate and the
relatively stable Central (Chinese) Plate. Arunachal Pradesh comprises of four geotectonic blocks, viz., the Himalaya, the Mishimi Hills, Naga-Patko range and the Brahmaputra Plain (Figure 2.1). These four are characterised by distinct stratigraphy and structure, and separated by Major tectonic lineaments.

The Sub-Himalayan fold and thrust belt of western Arunachal Pradesh includes Miocene and younger sedimentary rocks that comprise northward dipping thrust sheets, structurally below the Main Boundary Thrust (MBT) and above the Himalayan Frontal Thrust (HFT). Three regionally significant faults are developed from north to south and are the: (1) MBT, (2) Tipi Thrust and (3) HFT. These faults are sub-parallel and strike approximately E-W for 200 km from the eastern Bhutan/India border to the Dikrang River, where the strike changes to N50°E and continues NE to eastern syntaxis. (Yin et al., 2004)

Figure 2.1: Regional tectonic elements of NE India and adjoining region draped on SRTM DEM (after Nandy 2001, Murthy et al., 1969)
2.2 Geology of the study area

Geologically the Jia Bharali basin is characterized by a wide spectrum of lithostratigraphic units ranging from Quaternary Alluvium in the south to Precambrian crystallines in the north. The Jia Bharali with a total area of 11,280 sq km. debouches from the Himalayan through a dissected piedmont plain and is restricted within a narrow valley wall. The catchment area covers the outer hills or Sub-Himalaya (Siwalik), Lesser Himalaya and Higher Himalaya. In its course from debouching from Himalaya to the confluence with Brahmaputra River, the river flows on gravel bed upto Ghoramari along straight, braided channel and then flows a slightly sinuous braided path.

The Geology of the lower regime of the Jia Bharali basin area is mainly alluvial terrain with isolated exposure of Precambrian basement. Inselbergs of granitic gneissic rocks, with intruded Quartz veins, having several sets of joints are found in the extreme south of the area on the north bank of river Brahmaputra. The northern part of the catchment from Bhalukpong and beyond is covered by rocks belonging to Tertiary Siwaliks, Gondwanas and Lesser Himalayan sequence, Higher Himalayan Crystalline (Joshi and Chakraborty 1999-2000). The regional trend of rocks in this area is E-W to ENE-WSW. The alluvial segment of the basin is occupied by Quaternary sediments composed of gravel, sand silt and clay and found in the form of different terrace levels. The Quaternary sequence is more than 1000m thick within Brahmaputra valley and they bear signatures of Quaternary tectonics and/or climatic fluctuations resulting in various phases of river rejuvenation.

The Neogene clastics juxtaposed with the Quaternary Alluvium across the Himalayan Frontal Thrust (HFT) are considered equivalent of the Siwaliks (Ranga Rao, 1983) which are divided into Kimin, Subansiri, and Dafla Formation (Ranga Rao and Babu, 1972, Singh and Chowdhary 1990, Kumar 1997). While the Kimin is predominantly a conglomerate- sandstone association, the Subansiri and Dafla represent a predominantly fluviatile deposits of thick sandstone beds and this shale beds. The tectonostratigraphic unit bounded by the MBT and Tipi Thrust consists exclusively of Dafla Formation. The Tipi Thrust is interpreted to flatten into a decollement that is regionally extensive and located at the base-Neogene unconformity. Further north
sandstone, shale and thin coal beds of Gondwana affinity are found exposed along a narrow zone following the Arunachal Himalayan trend. Good Gondwana exposures are found in and around Sessa (92°31'52.3"E 27°06'16.2"N) where the sequence is characterized by thick sandstone beds alternating with thin shale beds and intervening coal seams. The coal bear imprints of various flora of Gondwana.

Northward towards Bomdila and beyond metamorphic rocks composed of mainly phylite, quartzite, schist and gneisses are encountered. These metamorphic shows a general increase in grade towards north and are variously grouped under different lithostratigraphic names viz., Bomdila Group, Sela Group (Bakliwal and Das, 1971, Kumar 1997, Dhoundial, et.al, 1989). Rocks in the upland terrain show a regional trend of E-W to ENE-WSW in conformity with the eastern Himalayan trend. Three major structural and tectonic elements viz., HFT (Himalayan Frontal Thrust) which separates the Siwalik from the alluvial plain of Brahmaputra, MBT (Main Boundary Thrust), which separates the Siwalik rocks from the Lesser Himalayan rocks and MCT (Main Central Thrust) which separates the Lesser Himalayan rocks from the Higher Himalayan crystalline rocks are encountered from south to north.

The study area, Jia Bharali is constituted of four major geological units (Figure 2.1). The Quaternary sediments constitute the alluvial part. The Sub-Himalayan zone consists of Siwalik rocks constituted of indurated sandstone and shale at the bottommost part followed upwards by monotonous soft, massive sandstone along with siltstone, clay and gravel, while the Lesser Himalayan zone comprises of two litho-units, viz. Gondwana Group and Bomdila Group. The Gondwana Group, constituted of shale/slate, sandstone and siltstone with coaly material, is thrusted over the Siwaliks along the Main Boundary Thrust (MBT). Towards the north of the Gondwanas lie the Bomdila Group constituted primarily of gneissic rocks belonging to the Precambrian age (Srinivasan, 2003). Further northwest of the catchment Higher Himalayan crystalline rocks of Sela Group appear along the MCT. Dirang Formation is in between the Bomdila Group of rock and Sela Group.
**Table 2.1  Generalized lithostratigraphy of the Jia Bharali basin**  
*(after Geological Survey of India, 2010, Kumar 1997)*

<table>
<thead>
<tr>
<th>Lithostratigraphic Unit</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quaternary Sediments</strong></td>
<td></td>
</tr>
<tr>
<td>Younger Alluvium</td>
<td>Holocene to Recent</td>
</tr>
<tr>
<td>Older Alluvium</td>
<td>Middle to Upper Pleistocene</td>
</tr>
<tr>
<td><strong>------------------------------- HFT --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Siwalik Group (Neogene Clastics)</td>
<td></td>
</tr>
<tr>
<td>Kimin Formation</td>
<td>Mio-Pliocene</td>
</tr>
<tr>
<td><strong>------------------------------- Subnansiri Formation --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Dafla Formation</td>
<td>Miocene</td>
</tr>
<tr>
<td><strong>-------------------------------- Tipi Thrust --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td><strong>------------------------------- MBT --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Gondwana Group</td>
<td></td>
</tr>
<tr>
<td>Bharali Formation</td>
<td>Permo-Carboniferous</td>
</tr>
<tr>
<td>Bichom Formation</td>
<td>Permo-Carboniferous</td>
</tr>
<tr>
<td>Miri Formation</td>
<td>Lower Palaeozoic</td>
</tr>
<tr>
<td><strong>-------------------------------- Intrusive contact --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Biotite Granite</td>
<td></td>
</tr>
<tr>
<td><strong>-------------------------------- Intrusive contact --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Dirang Formation</td>
<td></td>
</tr>
<tr>
<td><strong>-------------------------------- Unconformity --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Bomdila Group</td>
<td></td>
</tr>
<tr>
<td>Bomdila/Ziro/Daporijo Gneiss</td>
<td>Palaeo-Proterozoic</td>
</tr>
<tr>
<td>Chilliepam (Dedza) Formations</td>
<td></td>
</tr>
<tr>
<td>Tenga Formation</td>
<td></td>
</tr>
<tr>
<td>Khetabari</td>
<td></td>
</tr>
<tr>
<td><strong>-------------------------------- MCT --------------------------------</strong></td>
<td></td>
</tr>
<tr>
<td>Sela Group</td>
<td></td>
</tr>
<tr>
<td><strong>------------------------------- Sela --------------------------------</strong></td>
<td></td>
</tr>
</tbody>
</table>

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Figure 2.2: Geological Map of the Study area (based on GSI Geological map 1977, Kumar, 1997 and satellite image interpretation)
2.2.1 Quaternary Alluvium deposits

The alluvium deposits Jia Bharali basin area was filled up by nonclastic fluvial lacustrine deposits of post Neogen Clastics sediments on the basement of Precambrian in the Brahmaputra foreland basin and on the Paleogene-Neogene sequances of Siwaliks in the foothill region. The Quaternary deposits, viz., alluvial fan, terraces, piedmont deposits, consist of heterogeneous mixture of boulders, cobbles, pebbles, and granules, sands of all grades, silt and yellowish clay. The alluvium deposits is of recent to sub-recent origin and represents cycle of valley fill deposits which were subsequently out or eroded by river. On the basis of oxidation these alluvium deposits broadly classified into Older Alluvium and Younger Alluvium. The alluvium of Brahmaputra plain is separated by Himalayan Frontal Thrust from the Arunachal Himalaya.

Table 2.2 Lithostratigraphy of the Alluvium of Jia Bharali basin (after GSI, 1977, Kumar 1997)

<table>
<thead>
<tr>
<th>Group</th>
<th>Formation</th>
<th>Lithology</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvium</td>
<td>Younger Alluvium</td>
<td>Non-oxidised Sediments of the active channels, Boulders, Cobbles, Pebbles with Sand</td>
<td>Holocene</td>
</tr>
<tr>
<td></td>
<td>Disconformity</td>
<td>~~~~~~~~~~~~~~~~~</td>
<td></td>
</tr>
<tr>
<td>Older Alluvium</td>
<td>Boulders, cobbles, gravel, oxidised sand, silt, clay</td>
<td>Pleistocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unconformity</td>
<td>~~~~~~~~~~~~~~~~~</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basement</td>
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</tr>
</tbody>
</table>

Older Alluvium

Older alluvial plain are the terraces which forms the higher elevation than the younger alluvial plain. The Older Alluviums are found in the different terrace of Pleistocene to Holocene period. The terraces on the either sides of the Jia Bharali river form distinct physiographic features. Older Alluvium consists of oxidised sands (Figure 2.3b) with admixture of cobbles and boulders. The Older Alluvium is of fluvialite origin being carried down by the Himalayan Rivers and deposited along their original area of inundation, which has been later raised to its present position. They are mostly unconsolidated to semi-consolidated sand silt, clay with underlying pebbles horizons.
The high level terraces are represents the Older Alluvium and they are consist of oxidized sediments.

**Newer (Younger) Alluvium**

Younger Alluvium represents the non-oxidised sediments deposits by the river along its course (Figure 2.3c). The valley fills sediments, point bar, sand bar of alluvial river are of recent alluvium. The recent alluviums are found along the active flood plain, swamps area, sand bar natural levees etc. of the different river in the alluvium plain. It consists of flood plains of river Brahmaputra, Jia Bharali, and Bor Dikrai consists of unconsolidated gravels, sands, silts and clays.

The alluvium deposits of Jia Bharali river catchment has been classified into six informal stratigraphic formation (Viswanathan and Chakrabarti, 1977) on the basis of their relative height, type of soil formation, type of sediments, degree of oxidation. These formations named after their locality name.

Table 2.3: Stratigraphic succession of Older Alluvium (after Viswanathan and Chakrabarti, 1977)

<table>
<thead>
<tr>
<th>Flood Plain</th>
<th>Piedmont Plain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuruwani Formation</td>
<td>Recent geavel bar deposits</td>
</tr>
<tr>
<td>Solabari Formation</td>
<td>Seijosa Formation</td>
</tr>
<tr>
<td>Itakhola Formation</td>
<td></td>
</tr>
<tr>
<td>Rangapara Formation</td>
<td>Balipara Formation</td>
</tr>
</tbody>
</table>
| ~~~~~~~~~~~~~~~~~~~~~Unconformity~~~~~~~~~~~~~~~~~~~~~~~
| ? Siwalik Group      | Siwalik Group           |
| ~~~~~~~~~~~~~~~~~~~~~Unconformity~~~~~~~~~~~~~~~~~~~~~~~
| Basement             |
| (Granitoid gneisses of the inselberg of Tezpur, Singri, Bhomoraguri hills and Bishwanath granitoid gneisses) |
Figure 2.3: Deposits of Alluvium a) Alluvial Fan deposits along the foothill; b) Quartzo feldspatic sands with granules and pebbles deposits of Older Alluvium and c) channel bar of recent alluvium deposits in the Bor Dikrai river.
**Rangapara Formation:**

Rangapara formation is exposed in the dissected surface Sessa, Kathalguri, Tarajuli, Naharani, Sonajuli Tea Garden. All along the bank of Diputa Nadi we found well exposure of this formation from Kacharigaon in the north to Binduguri in the south. Exposures of ~16m height are found near the Rangapara town, Namonigaon and Thakurbari.

Figure 2.4: Terrace exposure of the Rangapar Formation along Diputa Nadi (T3 T2- Older Alluvium, T1- Younger Alluvium)

Generally the Rangapara formation is composed in its upper part of ferruginous silty clay with fine sand lenses and followed by a thin bed of clay and light brown clay. A thin sandy-pebbly bed below the thin clay layer is exposed. Again below this layer a brown colour medium to fine sand found with large scale current bedding and followed by some alternate clay and fine sand layer. A thick massive oxidised silt clay layer is found overlain by a non oxidised massive clay layer on which present day river bed is flowing.

**Itakhola Formation:**

The alluvial sediments belong to Older Alluvium comprising the Itakhola Geomorphic surface have been Group under Itakhola formation (Viswanathan and Chakrabarti, 1977). Near Itakhola and others tea garden 2-5m high exposure of medium to fine sands and pebbly sands also exposed in the nala sections. This surface is characterized by a bottom stratum of gravel of very well rounded pebbles, cobbles. Above this layer a 1-3 m alternate beds of medium to fine sands bed found.
**Solabari Formation:**

A small exposure of this formation is found near Salanibasti, Bamgaon area consist of sands and silts with irregular cross lamination. In the bottom a layers of pebbles, gravels and cobbles consist of quartzite, shale and minor carbonaceous material. In the right bank of Jia Bharali River exposes 5 to 6 meters thick sediments of the Solabari Formation cultivated under tea garden. The bottom section seems to be a typical alluvial fan deposits.

![Dissected Solabari Formation near Bamgaon Tea Garden](image)

**Kuruwani Formation:**

The sediments deposited (recent sediments) within the channels and on the flood plain of the active stream system have been classified as Kuruwani Formation (Viswanathan and Chakrabarti, 1977). Recent levees of the Jia Bharali River extends from Ghoramari to Bhmoraguri Hills in the south all along the right bank and from west Jamuguri and Kakma Ghapari upto Laletapu in the left bank. In the flood plains number of levee scrolls and channel fills which belongs to Kuruwani formation.

The lithological section invariably indicate a bottom stratum of cross bedded medium to fine sand and the top section of ripples cross laminates fine sand and silt. The sediments undergo qualitative change with increase in height of the flood plain; portion of clay-silt increases progressively at the expense of the sand fraction.
Figure 2.6: Channel Fill and Bank deposits near Bihiagaon with ripple cross laminations composed of fine sand, silt and minor clay (Younger Alluvium)

Figure 2.7: Vertical Profile Section made along the Ghiladhari river flood Plain of recent or Younger Alluvium. In the lower part (h), the opposite current bedding represents the different flow of the river with a small laminated bed.
In the Figure 2.7, the upper section is silty-loam near about 1m thick (b). Below this an alternate layer of clay and sand found of varying thickness (d). Sand layer are of medium grain with impression of cross bedding (c). In the lower part thickness of clay layer increase and the sand layer are as pocket. Again below this a layer of .75m thick sand with medium grained with laminated structure seen (e) followed by a alternate sand a clay layer of almost same thickness (f). A layer of 30cm laminated sand layer with medium grain size (g). In the lower part of the section a thick layer of sand with two opposite current. In between there is a small layer of laminated sands (h). The different alternate layer represents the cyclic deposits of the river.

**Balipara Formation:**

Balipara Formation is the oldest stratigraphic unit near the foothills resting with profound erosional unconformity on the terraced sediments of moderately northerly dipping Siwaliks (Viswanathan and Chakrabarti, 1977). The alluvial deposits which constitute the dissected upland surface are grouped as Balipara Formation. It comprises semi-consolidated poorly sorted mixtures of gravel, pebble, boulder, coarse sands and minor silts. The sand undergone weathering and pedogeneiss; the matrix is brick red, ochre to chocolate brown coloured silty loam. Along the road side near Chotaigaon and along the Khari Dikrai in the left bank of Jia Bharali good exposure Balipara formation found.

![Figure 2.8: Mara Bharali flood plain and Balipara Surface](image-url)
**Seijosa Formation:**

This formation comprises reddish brown sands and grey clays in the top layers. Whereas the bottom layer is consist of pebbles and cobbles. In general the sand layers are of medium grain exhibit finely current bedding. The sediments are more compact and consolidated and rest upon the Siwaliks.

2.2.2 **Precambrian crystallines**

Isolated hillocks with rounded topped and protruding out in the Quaternary deposits. Inselberg of Granitic gneisses, with intruded Quartz veins, having several sets of joints are found in the extreme south of the study area on the north bank of river Brahmaputra (Figure 2.9). These are isolate hillocks of Precambrian basement. Agnigarh hills near Tezpur, Bhomoraguri hills near Koliabhomora bridge area are well foliated medium to course grained granitic gneisses. Magnetic and gravity survey done by Oil and Natural Gas Commission have proved the existence of basement crystalline rock below the alluvial plain in between the inselberg and the Siwalik ridges in the North.

![Granitic Gneiss of Precambrian near Bhomoraguri Hills](image)
2.2.3 Siwalik

The tertiary Neogene Clastic sequence, Siwalik cropping out in a linear belt all along the Arunachal foothills is rest unconformably upon the Gondwana. The northern limit is defined by MBT while in the south, alluvium of Brahmaputra plain defines the boundary and marked by HFT. It is well exposed in the present study area along Bhalukpong-Bomdila road and in the bank of Bor-Dikarai Nadi near Seljosa. The Tertiary sediments mainly composed of green-grey-earthy brown sandstone; siltstone, claystone, carbonaceous shale etc. are found in the foot hill region of Arunachal Himalayan range. This sequence is devisable on the basis of lithology into three stratigraphic units viz, Dafla, Subansiri, and Kimin Formation (Ranga Rao and Babu, 1972). The Tipi thrust separates the Dafla Formation from Subansiri and Kimin Formation (Kumar 1997). In different published work on the Siwaliks of Arunachal Himalaya reported the presence of fossils in the Siwaliks. Singh and Prakash, 1980 has reported the leaf impression in the shale beds of Dafla Formation. Dutta and Singh, 1980 reported miofloral assemblages in the Subansiri and Kimin Formation.

![Sequence of Shale, Claystone and Sandstone of Swialiks](image)

**Figure 2.10:** Sequence of Shale, Claystone and Sandstone of Swialiks

**Dafla Formation**

The steeply dipping beds of the Dafla Formation are highly distorted and fractured. It consists of alternate beds of sandstone, shale and clay. The sandstone beds are dominantly bluish-grey and brown coloured fine-to medium-grained, well-bedded with minor coal partings and thin clay bands. The Dafla formation is comparatively
hard sandstone than the Subansiri Formation. They are poorly micaceous, quartzite and bear resemblance to the Gondwana sandstones. The clays beds are greenish grey in color and the shales beds are greenish grey to dark grey in colour. Shale beds are comparatively thin than the sandstone beds. The beds are dipping northwest between 20° to 60°. Dafla Formation is bounded by MBT in the north and Tipi thrust in the south and about 3800m thick (Karunakaran and Ranga Rao 1983).

Figure 2.11: Exposure of Dafla Formation along the Bhalukpung-Bomdila road. Medium grain massive brownish sandstone with alternate thin shale bed (92°35’40.2”E 27°05’30.8”N)

**Subansiri Formation**

The Subansiri Formation consist of sandstone beds with trough cross bedding. Sandstone beds are very thick medium to coarse grained. Very few beds of clay bands present with in the sandstone bed. The sandstone beds are grey in colour and poorly micaceous. The sandstones beds have the current bedding and thickness ranges from 0.3 to 4 m. Subansiri is about 4200m thick (Karunakaran and Ranga Rao 1983)
Figure 2.12: a) Exposure of Subansiri Formation b) Cross Bedding in the Sandstone
Subansiri Formation (92°35'42.2"E 27°02'48.3"N)

**Kimin Formation**

The Kimin Formation is dominantly a conglomeratic sequences, consists of alternate beds of pebble conglomerates, coarse-grained sandstone and clays. This Formation is poorly cemented and younger formation of Siwalik formation. The conglomerate beds range in thickness from 1-6m with fragments of pebble to boulder size (Figure 2.13). In the road section Bhalukpong to Tipi, pebbles are oriented parallel to the bedding, and the whole section is dipping 58° towards north with strike of 140°. Lithologically, the pebbles and boulders are composed of gneisses, quartzites and schists in order of their abundance. The sandstones are grey to orange brown in color, fine to coarse grained, gritty and pebbly and are generally soft and massive.

Figure 2.13: Exposure of Kimin Formation (N27°02'07.9" E92°36'21.9") alternate beds of soft sandstone, clay and conglomerate beds
2.2.4  Gondwana

This belt is mainly composed of grey sandstone, carbonaceous shaley slate, siltstone, grey coloured medium to coarse grained feldspatic gritty sandstone and intercalated coal bed. The Gondwana Group exposed along MBT, occurs in an E-W to NE-SW trending narrow linear belt. Gondwana belt is best exposed along the Bhalukpong-Sessa road. Geological Survey of India established the Gondwana sequence is of continental and marine origin. ONGC mapped the area as in west from Dikrang river upto Bhutan Boarder the Gondwana are of continental and while its east the rocks are marine. According to Acharyya et al., 1974, 1975 demarcated it as the continental sequence. Gondwana can be sub grouped as Bharali, Bichom and Miri Formation (GSI, 2010).

Along the Bhalukpong-Bomdila road section the Gondwana sequence is a thick alternating bed of grayish coloured medium to coarse grained sandstone and carbonaceous shales, with patchy occurrences of coal (Figure 2.14b).

Figure 2.14: Exposure of Gondwana a) Gondwana sandstone and carbonaceous shale bed b) Coal occurrences in the Gondwana (92°35'01.3”E  27°05’10.5”N)

Bhareli Formation:

Exposure of Bhareli formation is best exposed near Pinjoli and Sessa along the Bhalukpong-Bomdila road section. Exposure of thick sequence of grey to dark grey feldspathic sandstone and grey shale observed. Some lenticular coal beds found which rich in Lower Gondwana floral assemblage. These represent the continental facies of the Lower Permian sequence (GSI, 2010). Bhareli Formation is conformably overlain the Bichom Formation. Achayya et al., 1975; Bhusan et al., 1989, 1990 have reported the presence of Gloossopteris and Gangamopterys floral assemblage.
Bichom Formation:

Bichom Formation is conformably overlain by Bhareli Formation and composed of dark grey quartzite rock and minor occurrence of phylite similar to Tenga Formation. Exposures are found near Bame. The bed is highly fractured and crashed. It may be due to the effect of MBT. These rocks were also mapped in the lower reaches of Bichom valley as Bichom Formation (Anon 1974, Das et.al, 1975).
Miri Formations:

This formation is composed of conglomerate, sandstone, orthoquartzite-dolomite assemblage. It is mapped in the East Kameng district and it well exposed along the Bana-Palizi road section. It is steeply dipping quartzites of pink and white colours with thin purple shale and unconformably overlying by the Bomdila Group and conformably overlain by the Bichom Formation. GSI, 1973 has marked the Miri formation in the eastern part of the Jia Bharali basin.

Chakraborty et.al, (2002) described a thrusted contact of Bomdila Group with Miri Formation and a conglomerate unit with interbands of quartzite as the passage of Miri Formation to Bichom Formation (marine Palaeozoic). Miri Formation is well exposed below the Bomdila gneiss. Kumar and Singh (1974) and Singh and Singh (1983) lowered the status of Miri Group to a Formation and gave a separate identity between the Bomdila Group and the overlying Bichom Formation. Miri Quatzzite lies unconformably over a unit equivalent to Buxa Group represented by dolomite with a basal conglomerate and a laterite horizon at the base.

Figure 2.17: Showing the sandstone, quartzite beds of Miri Formation (92°55’35.1”E 27°14’01.8”N)

2.2.5 Bomdila Group:

Rocks of the Bomdila Group are exposed over a vast area in the West Kameng District of Arunachal Pradesh. Good exposures are found along the road section approaching the Bomdila town. Bomdila group is low to medium grade metasediments comprising Pink to purple ortho-quartzite with conglomerate lenses, purple shale with diamicite bands Quartzite-Carbonate, Schist/Phyllite association
and Gneisses and intrusive granite. Bomdila group is overlain by Dirang Formation in
the north and by the Gondwana sediments in the south. Lithostratigraphically,
different worker has been classified this group differently. Bhusan (1999) subdivided
into Tenga Formation, Dedza Formation, Dirang Formation and intrusives in
ascending order on the basis of section measurement between the MBF and MCT.
The Bomdila Group and associated acid and basic intrusive (Bhusan et al., 1919) are
well exposed in the West Kameng district. Kumar (1997) subdivided the Bomdila
Group into three formations viz., Khetabari, Tenga and the Chilliepam (Dedza)
Formations and the biotite gneisses according to area of intrusion. Presently GSI,
2010 has been compiled a classification adopted from Dhoundial, et.al, (1989) and
Kumar (1997), with some modifications. Dirang Formation is not considered as a part
of Bomdila Group (Kumar, 1997). Dirang Formation has a unconformable
relationship with Tenga and Chillepam Formation of Bomdila Group.

**Khetabari Formation:**
Constitute of metasediments comprising sericite-quartzphyllite, garnetiferous phyllite
and schists, graphitic carbonaceous phyllite, quartzite. A small occurrences of
Khetabari Formation in the Jia Bharali Catchment, along the Bichom valley and
overlain by Tenga Formation (Kumar, 1997)

**Tenga Formation:**
Tenga Formation is well exposed along the Tenga river. Tenga Formation is
constitute of low grade metasediments of green phyllite, quartzite. Originally
described by Das, et.al, (1975) are referred to as Tenga Formation. In the Arunachal
Himalaya Tenga Formation occurs in a linear belt from Bhutan border in the west and
Subansiri river in the east. Bhusan, et.al, (1989) also divided the Tenga Formation on
the basis of lithostratigraphy into a lower and an upper member and referred as Along
Member and Jameri Member. The Jameri member is separated from the Gondwana by
a series of granite intrusion which leads to the thermal metamorphism along the
intrusions (Kumar, 1997).
Chilliepam Formation:

Chilliepam Formation is exposed along the Bomdial Sheragaon road. Composed of carbonate rock and unconformably overlying the Tenga Formation. This sequence is referred as Chilliepam Formation named after the Chillipam village (Anon 1974, Jain et.al, 1979). Kumar 1997, 1999 broadly divided this formation into two members viz., the lower Kabak Member (after Kabak formation of Roy Chowdhury and Lakshminarayana in Krishnaswamy, 1986), consists of a basal oligometric conglomerate with pebbles and cobbles of quartzite and upper member referred to as Niumi Member (Kumar and Bora, 1984-85) comprises mainly carbonates with alternations of greenish grey, purple and dark grey carbonaceous phyllites.

Intrusive within Bomdila Group

Bomdila Gneiss:

Bomdila gneisses are well exposed along the road side of the Bomdila. Bomdila Gneisses are foliated, augen-bearing, medium to coarse grained, leucocratic and consists of quartz, plagioclase, microcline, biotite and muscovite as essential minerals. Bomdila gneisses consist of a coarse-grained porphyritic gneiss (CPG) comprising of biotite and muscovite and a weakly to non-foliated leucogranite having abundant tourmaline (referred as tourmaline-bearing granite) (Rashid. A. S. 2008).

Exposure of Biotite granite gneiss are found between Jameri and Sessa (92°33’26.2”E 27°09’44.55”N) and around Bomdila Town (92°32’18.3”E 27°06’45.4”N). Bhalla and
Bishnu 1989, made whole rock isochron dating of these two intrusion of 1644±40 and 1676±122Ma respectively. Whereas Dikshitulu et al., 1995 has dated the Augen gneiss of Bomdila as 1914±23Ma (Rb/Sr Isochron dating). The older biotite granite gneiss of Bomdila is foliated, straky Augen bearing. It consist of alternate bands of quartz feldpathic material and mica and the augen are of quartz-Na-Plagioclase (Bhusan et.al., 1991, Dikshitulu et al. 1995)

Tourmaline bearing leucogranite is also found near Eagle’s Nest Pass. Xenolith of fine grained melanocratic rock (?) found in the leucogranite (Figure 2.20). In the Eastern part of Kameng River near Rilo in Pachuk valley biotite granite is reported by Singh and Sharma 1990. Kumar 1997, reported mafic intrusion of sills and dyke of amphybolite is reported in the chilliepam Formation

Figure 2.19:  a, b Exposure of Bomdila gneisses near Bomdila Town, c-Porphyritic granite with thin biotite foliation. d-Quartz vein in the granite
2.2.6 Dirang Formation:

A thick sequence of low grade metasedimentaries comprising garnetiferous mica schist, phyllite, sericite quartzite, calc-silicate and tremolite-actinolite marble unconformably overlying the Bomdila Group and truncated in the north by the MCT has been designated as Dirang Formation. It was first mapped as Dirang Schist in Diggin Valley (Anon 1974, Das et.al, 1975). It is intruded by biotite-augen gneiss (Bhusan et.al, 1991). Similar sequence has been mapped in the Pachuk river section (Singh and Sharma, 1990) and around Rupa and Shergaon (Bhusan, 1999). Bhusan et.al, (1989) in Shergaon-Morshing area, has subdivided the Dirang Formation into five units (A-E).

Figure 2.21: Garnetiferous mica Schist of Dirang Formation
2.2.7 Sela Group:

Sela Group is the oldest sequence and structurally highest unit in the Jia Bharali catchment area, which is separated from the Dirang Formation to the south by Main Central Thrust (MCT). Sela Group is undergoes polyphase of deformation and consist of medium grade to high grade rocks derived its name from the Se La pass in West Kameng district (Bakliwal and Das, 1971). It consists of calc-silicates, marble, kyanite-sillimanite, deformed schists, migmatites, high-grade ortho-augen gneisses and amphibolites, etc. with younger intrusions of hornblende granite (Dikshitulu et al., 1995), tourmaline granite (Bhalla and Bishui, 1989, 1919), pegmatites and aplites.

![Figure 2.22: a. Augen Gneiss; b. Quaterzite-Kyanite-Sillimanite schist of Sela Group](image)

On the basis of difference in Lithology Verma and Tandon (1976) divided the Sela Group into two distinct units, a) Northeren Unit consisting of fine grained biotite-quartz-plagioclase gneiss exposed around Sela. Gneiss is intruded by granite and some place pegmatite veins. b) Southern Unit consist of hornblende gneiss with thin flaks of muscovite. Kumar 1997, GSI 2010, Sub divided Sela Group into two formation- Taliha and Galensinik Formation. Taliha Formation is well exposed in Subansiri river section. Gulensinik is also named after a village of Subansiri Valley consist of high grade gneiss and schist, which are best exposed in and around Sela Pass along the Bomdila-Tawang road. Bhala et al., 1991 reported the tourmaline granite (29±7Ma) intrusion in the Sela Group near Sela, whereas hornblende granite intrusion 481±23 Ma (Dikshitulu et al. 1995) close to MCT.