2.1 Introduction

The investigated area forms an irregular 300 km long and 0.5 km wide non-linear rectangular block along Dibang river valley of Eastern part of Arunachal Himalaya. The trend of the rectangular block is mainly SW-NE from Roing to Hunli and then almost E-W from Hunli up to Rayalli and finally almost S-N from Rayalli to Anini. This nonlinear belt looks like a megascopic “S” from Anini to Roing. Ray and Dutta (1982), Rajesham and Dutta (1983) mapped the area in 1:50000 scale from Roing to Endolin. Burhanuddin and Nandy (2004) mapped the same area on 1:25,000 scale. The Lohit granitoid area is mapped in detail by Dasgupta et al. (1998). Monoj Kumar et al. (2001) have prepared detail traverse map of the area. Gururajan and Choudhuri (2003) have studied the Lohit valley of eastern Arunachal Himalaya and set four tectonic units namely Lesser Himalaya, Mishmi Crystalline, Tidding suture zone and Lohit plutonic complex. Delineation of thrusts, establishment of chlorite to staurolite/kyanite zone exhibiting inverted metamorphism and their correlation to deformation are some of the salient features. Most of the above works are treated as an enlarged extension of earlier works of Thakur and Jain (1975). Geochemistry of the rocks of Trans Himalayan plutonic complex is studied in detail by Gururajan and Choudhuri (2007) and suggested a multiple intrusion cycle ranging from gabbro, diorite, trondjhemite and leucogranite. Choudhuri et al., 2009 have further synthesized the geology and structural evolution of the Eastern Himalayan syntaxis and a detailed picture is delineated. Sarma et al. (2009), have studied the Mishmi Block along
Dibang valley and suggested a tectonic schematic model regarding the tectonic configuration of the Mishmi Block.

There are mainly five main lithotectonic units from lower structural to higher structural levels. Roing Gneiss and its associated units approximately covers $\approx 10\%$, metabasic -quartzite association of Ithun Formation $\approx 15\%$, metasedimentaries of Hunli Formation $\approx 30\%$, mafic and ultramafic rocks of Mayudia complex $\approx 10\%$ and Lohit Granitoid Complex $\approx 35\%$. The study area covers approximately 100 sq.km. Two large scale fold structures are observed and they are named as Mayudia syncline and Ithun anticline (Burhanuddin and Nandy, 2004). Mayudia mafic-ultramafic complex occupies the core of the major syncline whereas Roing gneiss and associated lithocomponents form core of the Ithun anticline.

2.2 Previous Works

The first expedition in Eastern Himalaya was made by Lt. Wilcox (1832) and he was perhaps the first person to give a geological setup of the Mishmi Block. In his report, he has mentioned that the Mishmi Block, a metamorphic Block of the Eastern Himalaya, is intruded by syenitic and granite rocks. During late 19th and early part of 20th Century, a few notable geological history have been delineated which set the foundation of the geology of the Arunachal Himalaya. It was a common belief since the days of Godwin Austen (1875) and Coggin Brown (1912) that there is a orographic bend of the Eastern Himalaya, which has been named as Eastern Syntaxial bend or Eastern Syntaxis. Wadia (1931) and Gansser (1991) suggested that the eastern syntaxis of the Himalaya, Namche Barwa, is traditionally regarded as symmetrical to the Nanga Parbat Syntaxis, the western syntaxis of Himalaya in Pakistan (Fig. 1.1). Burg et al. (1998) have indicated that “U” turn of the Yalu-Tsangpo River (YTR)
around Namche Barwa represents a Paleocene Tethyan suture zone and the fast
growing crystal scale antiform folds the Yalu-Tsangpo suture zone into a sharp
syntaxis. Burg and Podladchikov (1998) have suggested that Siang antiform is
interpreted as the southwestern continuation of the Namche Barwa syntaxis. It is also
a fact that geographically and geologically the Trans Himalayan plutonic belt is linked
around Namche Barwa with the Mishmi granite granodiorite complex (Nandy, 1976;
Acharyya, 1980) or Lohit plutonic complex of Thakur (1986). Chattopadhyay and
Chakraborty (1980) have suggested that the granite granodiorite complex and the
Tidding serpentinite of Lohit Himalaya are intrusive into the enveloping
metasediments and therefore any thrust between them is doubted. Question arises
whether Tutting-Tidding belt is a true ophiolite belt (Sinha Roy and Singh, 2002). It
is not identical to either Tsangpo ophiolite or Naga Manipur ophiolite, rather it is a
hybridized Paro group with granodiorite batholith and basic intrusive
(Acharyya, 1978). Dhaundial et al. (1976) have suggested that the presence of a late Cenozoic
thrust is seen at the western boundary of the Mishmi Hills plutonic complex above the
inbricated low to high grade metasediments intercalated with isolated occurrence of
serpentinite and mafic ultramafic rocks, the latter was designated by Thakur (1998) as
dismembered ophiolite. Burg et al. (1998) finally synthesizes that the western
boundary of the Mishmi block is the continuation of the Tethyan Yalu Tsangpo
suture.

As regards Mishmi Hills, even after independence, the block receives virtually
not much attention mainly because of its inaccessibility, remoteness, hostile climate,
dense vegetation and sparsely distributed population pattern. The northern limit
belongs to China while southern limit ends at Shillong plateau which is concealed
under the thick cover of Brahmaputra plains. On the broader sense, this sequence of
the Arunachal Himalaya is considered to be part of the central Burmese plate which abuts against Indian plate along the Tidding Suture and comprises of metasediments of Precambrian age (?). There is some confusion relating to Mishmi gneissic complex /Mishmi Granite- granodiotitic complex. Are they intrusive into metasedimentary sequences? Are they deformed and metamorphosed totally? Can they be treated as basement which has been tectonically thrust over the metamorphites? Can they be equivalent to the central crystalline complexes of the Higher Himalaya? Tidding serpentinite is considered as intrusive into Metasediments as Nandy et al (1975) have suggested. Nandy (1980) has further considered that the Tidding serpentinite and Mogok belt are continuous and hence they do not have any continuation with Tsangpo-suture to the west. Neither, they had a genetic relationship with the Manipur-Nagaland Ophiolite complex of the NE India. Ghosh and Ray (2003) also studied the Dibang Valley section and detail mineral chemistry of the rocks of Mayudia –Hunli area have been worked out. They have suggested that ophiolites of the Mishmi block of Arunachal Pradesh falls in the extrapolated eastern end of the Indus belt. They have further suggested that subduction related tectonic settings might have played an important role in the emplacement mechanism of such ophiolites which have a deeper geotectonic status specially related to collision of Indo-and Tibetan block during closure of the Tethyan Ocean during Meso- early Tertiary times (Searle and Cox, 1999). Ghosh and Ray (op.cit) suggested that the different litho units of the ophiolite shown affect of progressive metamorphic reconstitution from very low grade to medium / high grade from top downward. Ophiolites and associated rock types of the Mayudia-Hunli section is confined between Lohit thrust to the north and Mishmi thrust to the south with a characteristic litho trend showing NNW-SSE direction showing high to moderate dip (about 50°-70°) towards ENE. The characteristic
findings of Ghosh & Ray (op.cit) are that the suite does not bear evidences of cummulate portion which may be equated with Ligurian ophiolites of Finland (Peltonen et al. 1998). But Ghosh and Rays field evidences are abit confusing. So called ophiolite does not terminate near Hunli at Lohit thrust, rather such discontinuity is seen beyond Endolin. Their field evidences are less informative than the geochemical evidences. Moreover, their inverted metamorphism is a very big question. Therefore, both Lohit Granitoid Complex (irrespective of gneissic transformation) and Tidding serpentine are intrusive into metamorphites which registers repeated metamorphism and deformation. Rajesham and Dutta (1983) and Manoj Kumar et al (2002) have established multideformational events (F1, F2 and F3) imprinted into the rock association of the Dibang Valley region of the Mishmi block. Burhanuddin and Nandy (2004) have named the major folds as Ithun anticline and Mayudia syncline which control the lithosetting of the area and they have suggested a most reliable stratigraphic succession with the incorporation of Dibang Group for the first time. They have suggested that the gneissic basement of the area equivalent to Ziro / Bomdila gneiss of further western part of eastern Himalaya. Their findings regarding the presence of spinifex texture and pillow lava structure along with absence of Lohit Thrust are unique contribution to the regional geology of Dibang Valley. Nandy et al. (2005), Sarma et al. (2006, 2007) have attempted a detailed geological approaches on Lohit Valley and their findings if extended to the Dibang Valley, it would give a clear picture regarding the geological setup of the Mishmi Block. Gururajan and Choudhuri (2003), have suggested that the Mishmi Block is a continuation of the Western Arunachal Himalaya. Structural descriptions are also given from meta volcanic group associations. Detailed geochemical studies are undertaken by Gururajan and Choudhuri (2007) from Lohit valley and they have
established one more thrust named as Walong thrust just above Lohit thrust, which separates the Lohit Granitoid Complex from that of the Lohit Gneissic Complex.

In Lohit and Dibang valleys Lower Miocene to Pleistocene Siwalik sequence is either missing or tectonically pinching out towards east, thus acted as a blind sequence overlain by older sequences (Sarma et al., 2009a). Siwalik sequence is exposed in the Siang valley but they do not extend beyond Mebo (Mishra, 2009 and a discussion by Srinivasan, 2009). The presence of MFT in all the three valleys, are well registered. MFT in Siang sector is marked as floor thrust of Siang antiform and named as North Pasighat Thrust (NPT) by Acharyya and Saha (2008). The position of MBT is confusing in Eastern Arunachal Himalayan Block. Conventionally MBT in both the Dibang and Lohit sectors of Mishmi block is designated as Mishmi Thrust (= Sewak thrust of Mishra, 2009).

Nandy et al. (2005) have given a detail structural and geological setting of the Dibang Valley and suggested a possible occurrence of ophiolites not of Cretaceous time but of Precambrian age with the help of spinifex structure, pillow lava as in the mafic – ultramafic complexes around Mayudia & Hunli areas. They have established different phases of deformations in Proterozoic augen gneisses, Dibang Group of meta sedimentary and meta volcanics, mafic ultramafic complexes and overlying lohit granitoids. They have suggested that the Mishmi block acts as a tectonic roof transported from Myanmar Block and tectonically rest over the two pillars like Indo-Myanmar mobile belt to the SE and Western Arunachal Himalaya to the W. Lithological variation, structural identities, facies variation and structural discontinuity, all lead to the conclusion that the Mishmi Block is not a continuation of Western Arunachal Himalaya. Both Dibang valley and lohit Valley geotransects are lithologically and structurally delineated by Sarma et al (2006, 2007). Variation along
and across strike, presence of large scale structures in the Dibang Valley and their absence in Lohit Valley are some of the important features which indicate that the large scale structures are non cylindrical in habit and their fold axes are dying out towards further east. However, the block deserves attention from geological community and more work yet to be done in such a remote and physically inaccessible terrain. Proper study along and across the Mishmi Block, will throw clues whether they are really an integral part of the western Arunachal Himalaya.

Sarma et al. (2009b) have discussed thrust bound architecture of the Eastern syntaxial bend and a brief discussion is made relating to correlation and coordination of the thrusts between the western and eastern sectors of the Mishmi block of Arunachal Himalaya. Mishmi Block is a thrusted foreign block juxtaposed like a tectonic roof over the two pillars like Western Arunachal Himalayan Block and Indo Myanmar Mobile Belt (IMMB). Structural style, as well as disparity in litho packages totally distinguishes both the block from each other. Therefore, correlation between WAHB and MB, on the basis of thrust tectonics is not justified (Sarma et al., 2009a; Sarma et al. 2010 (submitted).

2.3 Geological overview of the area:

Roing-Mayudia-Hunli-Ardzu-Angolin-Etalin-Anini section of Dibang Valley, Arunachal Pradesh forms a part of NW-SE trending linear belt of Mishmi block in the northeastern Himalaya. A detailed lithostratigraphy from south to north in ascending order include Roing gneiss (Mesoproterozoic), low to medium grade metamorphites of Dibang Group, Mayudia mafic-ultramafic complex and Lohit Granitoid complex (Tertiary). The present study leads to the preparation of a detailed lithological map from Roing to the south and Anini to the north (Fig. 2.1). A large no.
of rock samples has been collected during the field work and numbered them systematically with specific geographic coordinates. They are shown in figure 2.2a,b,c.

In this geotransect, Gondwana exposures of western and central sectors of Arunachal Himalaya is significantly missing while the Pleistocene River Terraces (PRT) is exposed at the lowest level at 1 km north of Roing (28°07'46" N : 95°50'22" E) where from the hills starts (Fig.2.3). The southern limit of the PRT is delineated by Deopani River (28°09'36" N: 95°50'47" E) which marks as a tectonic lineament. The PRT extends about 8 km across the strike and they are thrusted over by Roing gneiss of Proterozoic age (treated as basement). The contact between gneiss and PRT is tectonic and is designated as Mishmi thrust, located at 28°11'52.5" N: 95°48'53.7" E (Fig. 2.1). The Roing gneiss is highly tectonised and separated from the Dibang Group and Mayudia Mafic-ultramafic complex in the north by a ductile shear zone located north of Tiwarygaon.

The gneiss also shows unconformable relationship with the Dibang Group of metasediments in the Ithun River valley. Augen gneiss is associated with amphibolite and quartzite and they are traceable around Tiwarigaon. Characteristic augen shaped feldspar crystals lie roughly parallel to the regional NW-SE striking litholayering (Fig. 2.4). Similar thick augen gneissic horizon and its associates are found at Piyunli and Sukla Nagar. Augens are rotated both clockwise and anticlockwise but never exceeds 45° (Fig. 2.5) with respect to the direction of flow (schistosity). Quartz veins are generally boudinised. Amphibolites and quartzites associated with the augen gneiss are relatively small unit showing thining and thickening, partly boudinaged and occur as tectonic lenses. They are dark in colour, medium grained but schistose. They show NW-SE strike, dip being towards NE at moderate angle (30°-40°).
Fig. 2.1: Lithological map of Dibang Sector, Arunachal Himalaya
Fig. 2.2a,b,c  Sample location map of the study area
The Dibang Group of rocks is divisible into lower Ithun and upper Hunli/Tidding/Yang Sang Chu formations. The Ithun Formation is made up of metabasics with intercalations of quartzite (Fig. 2.6). Beyond Hunli it is best exposed around Ithun River Bridge. Ithun River is flowing in SE to NW direction and the rocks on both the banks show reversal of dip NE to the northern bank and SW to the southern bank indicating the presence of an anticlinal fold (named as Ithun anticline). The core of this anticline is occupied by augen gneiss around Piyunli and Sukla Nagar (28°24’20” N: 95°54’16”E). The above rock sequence is repeated between Sukla Nagar and Ithun More. The Hunli Formation is a thick assemblage of quartz-chlorite + actinolite schist - Carbon Phyllite with thin intercalations of limestone at places and is widely exposed all through the area. The litho sequence show graded bedding and displaying folds of three generations near GB Ghar and are associated with crystalline limestone (28°18’31.8” N:95°57’7”E) near 87 km. GREF camp, Hunli (28°19’25.3”N : 95°57’46”E) and north of Arzu. Garnetiferous graphite schist equivalent to Yang-Sang Chu Formation is only exposed near Nandan Pass (at 65 km) in between Mayudia pass and GB Ghar. These lithounits are highly sheared and intermixed with small bands of leucogranites (Figs. 2.7 & 2.8).

The Mayudia mafic-ultramafic complex tectonically overlies the Hunli Formation and is exposed in a folded structure along the Mayudia hill ranges. It is an assemblage of ultramafics (peridotite / serpentinite) and metabasics (metagabbro /Metabasalt/tuff?). The metabasics encloses thin intercalations of chert, mafic dykes/sills and leucogranite veins. All the rock-bodies are dipping towards NE at moderate to steep dips. These rocks are thickly bedded and also of boulder appearance. Shearing evidence is seen around Mayudia Pass (28°14’51.5”N:
95°55'33.5"E), Tiwarigaon and Chepahu Guest house, (Fig. 2.9) but further towards north, the rocks are associated with metasedimentaries and are highly sheared. As a result the original characters of mafics are almost lost. Spinifex like textures and pillow lava structure (28°15'20" N: 95°54'38"E) are found between 65 km Buddist camp and Mayudia Pass (Figs. 2.10 & 2.11). Folding on the outcrop scale is often observed. Development of asbestos is seen around GB Ghar (28°18'08.5" N: 95°55'29" E) but its extension is very limited. A basic dyke (hornblendite) truncates the generalized NW-SE trending litho association and contains a lot of hornblende megacrysts near Mayudia Pass (Fig. 2.12).
Fig. 2.3 Pleistocene River Terrace exposed at 1 km north to Roing. Figs. 2.4 & 2.5 Augen gneiss showing both dextral and sinistral rotation of K-feldspar; regional foliation is deflected round the megacrysts of K-feldspar (at 8 km post). Fig. 2.6 Interlayering of massive quartzite and amphibolite from Ithun river bridge point showing dip towards NE.
Fig. 2.7: Leucogranitic band associated with garnetiferous phyllite (dipping SW), Location: 65 km at Nandan Pass.

Fig. 2.8: Highly sheared out lenses of leucogranite and quartz veins are enclosed within garnetiferous phyllite. Fig. 2.9: Ultramafic rocks showing evidences of intensive shearing resulting C-S fabrics, wrap round unaltered remnants of ultramafics near Chepahu Guest House. Fig. 2.10: Sphincter texture (radiating) marked by serpentine fibres is observed in ultramafics of Mayudia Hill Complex.
Fig. 2.11 Pillow structure is seen around Mayudia Hill. The individual pillow measures about 1m in length and 0.5m in breadth. Fig. 2.12 Hornblende dyke truncating at high angle to regional trend of litholayer with characteristic hornblende megacrysts found near Mayudia Pass. Fig. 2.13 Near vertical beds of limestone near Rayalli. Fig. 2.14 A highly vulnerable sliding zone on leucogranite is observed near Ithipani Bridge between Ardzu and Endolin.
Relatively large ultramafic sheets like dismembered bodies are observed between Rayalli and Endoline (28°31'41"N: 95°50'40"E). Discrete ultramafic bodies are seen between Endoline and Angoline (28°31'13"N: 95°30'35.1'’E), the latter is exclusively within the Lohit Granitoid complex. A huge limestone beds are seen around Rayalli, dip is nearly vertical (Fig.2.13).

A metavolcanic rock (equivalent to Tuting metavolcanic) showing varying degree of alteration to chlorite-phylrite or chlorite-actinolite with amygdules of calcite is observed in the contact zone of Hunli Formation and Lohit Granitoid Complex just south of earlier defined Lohit Thrust.

The Lohit Granitoid Complex (LGC) forms the most conspicuous unit in the eastern Arunachal Himalaya extending from Namche Barwa in the northwest to Daphabum in southeast abutting against the Naga-Patkoi ranges. It consists of multivariant plutonic rocks of multiphase character with several restites of high grade metasediments like Etalin Formation. The granitoids include diorite, granodiorite, tonalite, hornblende-biotite granite and leucogranite. Leucocratic granite is seen between Ardzu (28°29'27.5"N: 95°49'37"E) and Endoline near the Ithipani Bridge, which is a vulnerable zone for landslide (Fig. 2.14). Discrete ultramafic bodies are seen between Endoline and Angoline (28°31'13' N: 95°30'35.1'E), the latter is exclusively within the Lohit Granitoid complex. About 1 km north of Endoline, Lohit thrust is mapped by earlier workers. The contact between LGC and metavolcanosedimentary sequence is well defined by ductile shear zone. Published geochronological records are totally absent from this region. It is generally accepted that LGC is of Tertiary age and if it is so then the question of Lohit thrust will be a
subject of controversy.

The Etalin Formation mainly comprises of garnetiferous mica schist, garnetiferous-kyanite schist, calc silicate, marble and amphibolite. Both the contact in the south and north is defined by granodiorite gneiss but the contact zone is not defined properly. This Etalin Formation encased within LGC my probably be treated as either megaenclave or the intrusion of LGC is site selective.

The area witnessed at least three major ductile phases and one brittle phase of deformation. The regional orientation of the litholayering is NW-SE with northerly dip or NE at low to medium angle in the northern part of the geotransect. The Ithun anticlinal fold along the Ithun river section and Mayudia syncline along the Mayudia hill ranges are the two major folds observed in the area. The mineral lineation, pinch and swell structure, boudins are defined as L1 accompanying the first phase deformation and are folded by second folding. Effect of such refolding characters is observed in the different limbs of the major Ithun and Mayudia folds. The S0 and S1 show sinuous nature indicating second phase of deformation (D2). A series of outcrop scale anticlines and synclines (F2) showing NW-SE axial orientation are common in the area. Axial planar cleavage (S2) is the most pervasive fabric which transposed most of the earlier structures probably during Himalayan orogeny as in the case of Himalayan belt. L1 lineation is deformed by F2 and make deflection pattern away from axial orientation. The sinusoidal pattern of axial traces of major folds is a clear indicative of superposition of later folding F3. The third phase (D3) is registered in the form by superimposition over the earlier structures and resulted in the development of dome and basin structures on the regional as well as small scales. At places, small scale F2 folds show orientation roughly parallel to the orientation of the F1 therefore, F1 and F2 can be inferred as coaxial. F2 compressive stress is layer parallel or slightly
inferred to be layer oblique type (within $30^\circ$ with respect to $S_0$) and therefore flexural slip mechanism might have played a vital role in the formation of outcrop to regional scale folds in the area.

Major NW -- SE trending ductile shears are observed in the contact zone of Roing gneiss and Dibang Group, between Dibang Group and Mayudia Complex in the south and between Hunli Formation and LGC in the north. Minor subsidiary shears are also observed within the metasedimentaries of Dibang Group. Two sets of shears- layer are very common in the study area.

2.4 FIELD RELATIONSHIP OF DIFFERENT LITHOUNITS

Field work in and around Dibang Valley was carried out from Roing to Anini. For better representation, the entire area is divided into 5 sectors/ traverses from lower to higher structural level along south to north direction respectively. They are:

1. Roing-Tiwarigaon traverse
2. Tiwarigaon –Mayudia-Hunli traverse
3. Hunli-Ithun river traverse
4. Ithun river-Rayalli-Ardzu traverse
5. Ardzu-Endolin-Anini traverse

The bearing of the zig-zag traverses from lower to higher reaches is roughly NS or NNE-SSW. The different litho components are observed systematically and mapped them in order to understand the structural behaviour and their stratigraphic relationship. Form Roing to Anini, huge piles of metamorphic rocks represented by augen gneiss, quartzite, amphibolite, metapelitic and metabasic rocks, mafic and ultramafics, carbonate rocks, hornblendite, serpentinite, crystalline limestone and Lohit Granitoids are observed and mapped them systematically (Fig. 2.1).
The above litho components are categorically classified under

(a) Proterozoic gneisses and schist

(b) Metasedimentary and metavolcanics of Dibang Group

(c) Mafic and ultramafics

(d) Lohit Granitoid Complex

Roing (28°08'15"N : 95°50'18"E), the Headquarters of the Lower Dibang Valley District, marks the entry point of the Himalayan hill ranges and Deopani River sets the boundary between recent alluvium and Pleistocene River Terraces. Huge boulders of augen gneisses, amphibolites, quartzites, metapelites, phyllonite and mafic and ultramafic rocks on the Deopani river bed are the best indicator of the presence of the source rock at a high structural level. Immediately after river terrace, some layered sequences are observed. They are made up of quartzite and thinly bedded phyllitic rocks.

Quartzites are light greenish in colour, nonfoliated showing a generalized trend of NE-SW (20°50'(NW). They are well fractured and the fracture plane is perpendicular to the litho layering. The thinly bedded phyllites are sheared and two sets of folding are observed. Occasionally thinly bedded quartzites are also affected by mylonitisation. Rarely chlorite-actinolite schist is associated with phylitolite. Conventionally these metasedimentary rocks are classified as Lesser Himalayan Sedimentary Sequence (LHSS) and they are overlain by Proterozoic augen gneiss. The affect of mylonitisation / phyllonitisation is more conspicuous towards the contact of augen gneiss. At 8 km from Roing, gneissic rocks are exposed. The rock is highly sheared and characterised by the presence of feldspar augen. The associated foliation is swerving round the augens showing sinistral as well as dextral rotation.
The dominant shear foliation \((S_2)\) is transected by another set of shear foliation \((C-S_3)\) at high angle.
Fig. 2.19 Intensive shearing is observed in ultramafiles of Mayudia Hill Complex. The central part of the lenses are unaltered. Fig. 2.20 Interlayering of quartzite and metabasics are folded showing plunge towards NW. Fig. 2.21 Radiating structure is marked by serpentine crystals in ultramafiles. Location: North of Mayudia Pass. Fig. 2.22 Transverse shearing planes are observed in ultramafiles. The sheared zones show highly anastomosing foliation from Mayudia Hill Complex.
Figs. 2.23 & 2.24 Garnetiferous phyllite showing numerous garnet porphyroblasts from Nandan Pass (65 km), sheared out lenses of leucogranite and quartz vein are enclosed, amphibolite interlayered. Figs. 2.25 & 2.26 Low grade phyllitic rocks showing intricate folding of two generations, quartz lenses lie parallel to foliation. Location: Borgola area.
Fig. 2.27 Highly sheared banded gneisses nearness to the contact of Lohit thrust showing folding of different generation of folding. Fig. 2.28 A panoramic view of the Borgolai area near Hunli, the zig-zag pattern of road from high altitude to Hunli valley is shown. Figs. 2.29 & 2.30 Interlayering of massive quartzite and amphibolite from southern bank of Ithun River. Beds are dipping SW.
Such C-S foliation is mostly marked by realignment of the earlier growth of minerals and sometimes by the development of new minerals (white mica and chlorite) along such shears planes (Figs. 2.15, 2.16). Associated quartz grains are highly flattened and elongated and form ribbon like structures. Such type of mylonitic effect is more conspicuous towards the lower boundary of the augen gneiss, where drastic reduction of grain size is also observed. The direction of tectonic flow is NW-SE and this is the generalized strike direction showing regional dip towards NE, at low to moderate angle (20° to 52°). Stretching lineation is observed on the XY plane. The first phase folds are isoclinal / rootless in nature and tectonically sheared out in the direction of tectonic transport (NW-SE) characterized by thickening of hinges and thinning of limbs associated with axial planar foliation (Fig. 2.17). The axial plane of the fold is dipping towards NE at low to moderate angle. $S_1$ is deformed by later fold ($F_2$) with attendant pervasive foliation $S_2$. $S_1$ and $S_2$ show coaxiality. $S_2$ being dominant planar fabric superposed on $S_1$ leaving relict $S_1$ in the $F_1$ fold hinges only. Top to south west vergence of asymmetric $F_2$ and subsequent superposition of $F_3$ is also seen in the gneisses. The imprints of deformational effect of the augen gneiss are also observed in associated thinly bedded amphibolite which is relatively less in abundance. Thickening and thinning of the amphibolite layers and boudinage structures are observed thinly bedded quartzites are often boudinised and bear the imprints of $F_1$ and $F_2$ folds on small scales.

Around Tiwarygaon (28°13'23"N : 95°50'10"E), 28 km from Roing, association of quartzite, amphibolite and augen gneiss are observed and they are intimately associated with each other showing identical structural imprints. The strike of the layers is 150°40'SW, with a local variation / deviation in the NE-SW direction, dip being recorded as NW and it is apparently due to later folding. The generalized
dip direction is NE at relatively moderate angle. At 4 km from Tiwarygaon towards Hunli (28°13'13"N : 95°51'39"E), a very good exposure of dioritic rock is met with. The rock is massive, boulder in appearance, coarse grained and grey to dark grey in colour. Feebly foliated character can be identified towards the boundary zones of the layer. The dioritic mass may or may not be a counterpart of Proterozoic gneissic terrain. This dioritic body marks the boundary between mafic and ultramafics of the Mayudia Complex to the north and augen gneissic compex to the south. Huge exposures of mafic-ultramafics are observed till 65 km post (Buddhist camp) (28°17'20"N : 95°59'53"E). The characteristic features of these rocks are noted and they are partly sheared showing anastomosing foliation and such features are more conspicuous at the boundary zones of different layers. Planar and linear fabrics are well developed. The layers are affected by folding of two generations and minor faults are seen in many places (Fig. 2.18). The rocks are highly serpentinised. The central parts of the mafic layers are very coarse grained and megascopically devoid of any planar fabrics. Large grains of olivine and pyroxenes are observed. Reduction of grain size with notable development of the both sinistral and dextral C-S foliation and folding are seen all the way upto 65 km post (Fig. 2.19). Radiating/acicular growth of serpentine mineral probably portrays spinifex like structures (Fig. 2.21) in the ultramafics (28°15'22"N : 95°54'20"E). Outcrop scale shear zone transecting the litholayers at high angle are seen (28°16'5"N : 95°54'22"E) (Fig. 2.22). Development of asbestos around GB ghar is observed. From Tiwarygaon to Mayudia pass all litholayers are showing NW-SE strike, dip being towards NE where as from Mayudia Pass to Nandan pass (65 km post), all the litholayers are dipping SW at relatively shallow angle indicating the presence of a large scale synclinal structure named as Miyudia syncline with asymmetric vergence (bottom to the SW).
After 65 km post, a huge slide zone is encountered in Nandan pass (28°17'20"N : 95°55'16"E). In this area, the main rock types are sheared metabasics, leucogranite, and garnet bearing graphite schist. Near Mayudia tourist lodge, a few notable shear zones are observed and they transect the litholayers at moderate angle. Such subsidiary shear zone is a later phenomenon and can be designated as C-S₂ type maintaining dextral rotation. Lenses of metabasites and leucogranite of cm to m scale (less than 10 m) are observed (Figs. 2.23 & 2.24). The long axis of such shear lenses are NW-SE showing near horizontal plunge towards SW. Anastomosing foliation of two generations is conspicuous all through out the mafic sand ultramafics around Mayudia Pass. The amount of dip of layers decreases towards Mayudia pass from both north and south directions and ‘W’ type of mesoscopic folds are seen which indicate that the central part of the synclinal structure lies around Mayudia Pass.

In this area sheared lenses and / or layers of leucogranite displaying folding of two generation are observed. The phyllitic rock is garnetiferous where foliation swerves around the garnet porphyroblasts. Few folds of isoclinal nature with attendant foliation are seen and they may be referred to as second generation (F₂)- syngenetic to Himalayan Orogeny.

From London pass upto Baragolai, metasedimentary rock units of Hunli Formation are well exposed. The metasedimentary rocks are characterized by alternate dark (garnet, mica/chlorite rich) and light (quartz rich) colored bands (Figs. 2.23 & 2.24). There are different components of metapelite- namely quartz sericite schist, quartz muscovite schist, quartz biotite schist and garnetiferous phyllite (±graphite) (Figs. 2.23 & 2.24). Gradational behaviour from quartz sericite schist to garnetiferous phyllite is another feature with increasing grain size is marked in the field. The rocks are medium grained with elongated mica flakes and stretched quartz
ribbon / bands defining foliation are seen. F\textsubscript{2} folds are isoclinal in nature and they show low plunge towards NW (Fig. 2.25). Pinch and swell structures are marked by quartz vein, which at places are stretched, and forms boudines (Fig. 2.26). The boudins are also folded by the later folding. Disharmonic fold of M type is observed at the hinge of the fold. At places kink bands are also observed.

Patches of ultramafic is also encountered in the GB Ghar area (Barogolai). The ultramafics are enclosed within metasedimentary of Hunli Formations (28\textdegree 18' N, 95\textdegree 55' E). They are massive in nature, devoid of foliation, olive green in colour (dunitic). Asbestoes fibres are observed in this area. Cubic as well as octahedral shaped opaque (chromian magnetite) are very common in ultramafics. From Borgolai to Hunli, a beautiful 12 semi circular ptygmatic road (Bara Goloi) is seen (Fig. 2.28)

A huge limestone belt is mapped at 87 km post (3 km before Hunli) associated with carbon phyllite (28\textdegree 18' 08'' N, 95\textdegree 55' 01'' E). The limestone is massive, crystalline in nature, developed two sets of prominent joints- one set is trending 180\textdegree (N-S) and another set trend 285\textdegree (NW-SE). Although the limestones is industrial grade but they are mainly used by Boarder Road Organisation as road materials. The generalized strike of limestone bed is 125/55(SW).

The associated carbo phyllite is very thinly laminated, partly siliceous and minor crenulations are observed with associated axial plane foliation trending NW-SE. Intercalation of highly sheared chlorite-actinolite-epidote schist is very common.

After Hunli, the metasedimentary and metavolcanics is continuing upto Ithun Bridge. After 2 km from Hunli (28\textdegree 19' 24"N : 95\textdegree 58' 9"E), very good exposures of phyllites are observed showing the development of sheath fold and rolled over lineation. The nature of the fold is reclined, S type of lenses is observed in this
outcrop. Layer parallel and layer oblique shear planes are seen and mylonitic shear planes are noted along axial plane of F₂ and F₃ fold axes.

In most of the outcrops, minor dome and basin structures with the development of crenulations are seen. Consistant SW dip of the layers is seen between Mayudia Pass and Ithun Bridge which represents one limb of the major fold structure (Mayudia syncline). Minor fold axes dip 4°–315°. The angle between two sets of lineation varies from 5° to 30°. The sense of shear is both dextral and sinistral.

In the Ithun bridge (28°22'27"N: 95°55'54"E) different type of lithopackages are encountered. On the Ithun river bed, huge exposures of cherty quartzites, interlayering with amphibolite are observed (Fig. 2.29). The quartzite is fine to medium grained, massive with a cherty look. The metabasic is dominant here in comparison to quartzite. Metabasics are generally medium grained but wherever shearing affects are there, it becomes foliated. Ithun bridge point represents the core of the anticlinal structure (Ithun anticline) showing opposite dip (southern bank show SW dip, whereas northern bank dips NE). The closure of the anticline is mapped to the upstream i.e. towards E. SW part of the river is occupied by stratified sequence of quartzite, metabasics and amphibolite (Fig. 2.30). Quartzite is hard and massive showing tectonic attenuation resulting thickening and thinning of the layers. Amphibolite is foliated, medium grained showing faulting and boudinage structure. Layers on the hinge zone are showing NW and/or SW dip. Just below the Ithun Bridge, NS and NW trending two sets of normal faults are observed resulting horst and graben structure (Fig. 2.31). There is a minor variation in the NW-SE fault plane. Fault imbrications are marked by quartz vein within the metabasics.
Near Piyunli village (28°22'43"N : 95°35'51"E), a massive outcrop of carbonate rock is exposed associated with quartzite to the south and augen gneiss to the north.

Just below the Pyunli Village in the north bank of Ithun river, intercalation of augen gneiss and amphibolite is observed. In augen gneiss, lots of isoclinal folds of first generation is seen and marked by quartz vein. Folds of second generation maintaining overturn geometry are observed in gneiss (Fig. 2.32). The attitude of the bed is 025/12(SE). All the augens are stretched in the direction NE-SW. Augens are at places partially rotated and fragmented. Here the feldspars are also folded with the F2 fold. At the junction of Lower and Upper Dibang valley districts open folds are observed in augen gneiss. The plunge of the open fold is 30°→33°. One mafic dyke cutting across the augen gneiss is seen (Fig. 2.33). The orientation of the dyke is NE-SW (065). Within amphibolite tight to isoclinal folds are observed. Fold axis plunge 9°→275°. Augen gneiss and amphibolite sequences are continued upto Sukla Nagar. Amphibolite at places are showing pinch and swell structure. This is due to layer parallel shearing/extension. Comparatively less competent augen gneisses are tectonically transported in a ductile manner along the stretching direction whereas the associated amphibolite, due to its competency, cannot flow and make pinch and swell structure.

Within Sukla Nagar a huge stratified sequence of alternate beds of quartzite and amphibolite is observed showing NE-SW strike with moderate dip towards SE (30/22(SE). The beds are curvilinear showing open folds of later generations with axial plane fracture cleavage trending NE-SW.
Pinch and swell, eyed fold and neck/scar fold are some of the structures seen in this sequence (Fig. 2.35). The orientation of the scar fold coincides with the axial plane fracture, i.e. NE-SW. The axis of the eyed fold plunges 30°–95°.

A thin band of crystalline limestone associated with quartzite and pegmatite is observed. The attitude of layer is 330°/60°(NE).

After the limestone belt, a huge exposure of quartzite and amphibolite is met with before the confluence zone of Ithun and Dibang Rivers. At new Endolin, the general strike of the layers is NW-SE showing moderate to high dip towards NE. At places fold mullions (28°14'2.6"N : 95°52'41"E) in quartzite are observed (Fig. 2.36) with axes plunging 33°–320° and the attitude of the bed is 75/40(NW).

At Rayalli, patches of ultramafics are observed within metasediments. Crystalline limestone with carb phyllite is another association striking NE with moderate dip towards NW. From Rayali (28°27'2"N : 95°51'19"E) to Ardzu (28°29'27"N : 95°49'37"E), metasedimentary units include mainly carbonaceous phyllite, phyllite with small grain of magnetite/ilmenite and limestone are observed.

North of Ardzu, limestone is associated with metabasic/ultramafic (Fig. 2.37). The attitude of the limestone bed is EW/75(N). It is probable that the same limestone band of Rayalli is continuing here. Foliated metabasics are associated with carbonaceous phyllite. Carbonaceous phyllite belongs to Hunli Formation with EW strike dipping 40°N. Location of a huge slide zone is observed at 28°31'12"N : 95°50'54"E, where white coloured leucogranite rock of Lohit granitoid complex is seen (Fig. 2.14). The LGC is associated with the metasediment and metabasics of Hunli Formation. The contact is sheared but sharp with EW trend. Near Endoline, another small patch of ultramafic is exposed in the metasedimentaries of Hunli Formation. Further north small apophyses of Lohit Granitoid Complex (mainly
leucocratic granite) are intruded within the metasedimentaries. On the river bed huge boulders of hornblendite are observed which indicate that a higher reaches hornblendite dykes are emplaced within LGC. Discrete ultramafic bodies are seen between Endolin and Angolin (28° 31' 13" N: 95° 30' 35" E). This is the contact of metasedimentaries of Hunli Formation and Lohit Granitoid Complex and this contact is marked by Lohit Thrust by earlier workers (Fig. 2.1). A few small bands of metavolcanic rocks similar to Tuting metavolcanics of Siang section are exposed in the Dibang Valley and this represents the contact zone of LGC. The rocks are dark coloured, massive, hard very fine grained with amygdules of quartz, calcite and feldspar (Fig. 2.13). The quartz amygdules are highly stressed showing linearity in the direction of NW-SE. Pyritisation and malachite staining is observed in the metavolcanic rocks. A vast area is occupied by granitoids composed of granitic composition with lots of hornblende grains forming a mosaic of granitic fabric immediately after the metavolcanics.

Further north towards Anini (28° 47' N: 95° 54' E), outcrops of hornblendite and granite are found; striking NW-SE, dip being either NE and / or SW (Fig. 2.38). Insitu migmatitites are often observed. Folds of different generations (two sets) are seen and they intersect at high angle (Figs.2.39, 2.40, 2.42). Intensive veining with the development of tourmaline is seen in mesocratic gneiss. In this sector, leucogranite is observed in many places and they are intimately associates with granite gneiss or granodioritic gneiss, the former is mostly affected by migmatisation. Two sets of small veins are seen and they follow NE-SW direction, dip being moderate either towards SE or NW (Fig. 2.41). After crossing Eron, at 8 km towards Anini, the litholayers are identified as hornblendite, granodiorite, leucogranite and hornblende granite. They show occasionally vertical dip. Hornblendite shows slight discordant
relationship with the gneisses but no contact transformation is seen anywhere. Leucogranite bears garnet as porphyroblasts showing left lateral sense of shear.
Fig. 2.35 Scar fold in a sequence of quartzite and amphibolite layers. Location: Ithun River bridge area.

Fig. 2.36 Mullion structure in quartzite from Lower and Upper Dibang district boundary zone.

Fig. 2.37 Huge exposure of limestone from Rayalli area. The beds are dipping NE.

Fig. 2.38 Hornblendite dyke from area.
Figs. 2.39—2.42 Field photographs of Lohit granitoid showed migmatitic banding, enclaves of mafic bodies, discordant acidic veins and folding of two generation from Anim area.