GEOLOGY AND MINERAL RESOURCES OF THE BANDIPUR AREA, LESSER HIMALAYA, CENTRAL NEPAL

A DISSERTATION

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BY

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Date:

It is certified that MR. NARESH MAHARJAN has worked satisfactorily for his Master'sDegree dissertation under our guidance and supervision. He has worked enthusiasticallywith sincere interest. The dissertation entitled "**GEOLOGY AND MINERAL RESOURCES OF THE BANDIPUR AREA, LESSER HIMALAYA, CENTRAL NEPAL**" embodies the candidate's own work. We, hereby, recommend the dissertation forapproval.

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The dissertation presented by MR. NARESH MAHARJAN entitled "**GEOLOGY AND MINERAL RESOURCES OF THE BANDIPUR AREA, LESSER HIMALAYA, CENTRAL NEPAL**" has been accepted as the partial fulfillment of requirement for the Master's Degree of Science in Geology.

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ABSTRACT

The present study was carried out around the Bandipur-Hilekharka-Keshavtar areas, west of Muglin, Central Nepal, Lesser Himalaya in an attempt to draw the stratigraphic set up, tectonic structures and mineral resources of the area. It consists of the rocks of the Nawakot Complex. The Fagfog Quratzite is the oldest unit of Lower Nawakot Group which is followed by the Dandagaon Phyllite, Nourpul Formation and Dhading Dolomite in successively higher positions and the Benignat Slate of Upper Nawakot Group but the Malekhu Limestone is missing in the study area. Based on lithology and environment of deposition, Nourpul Formation has been mapped into four members as Purebensi Quartzite, Amdanda Phyllite (laminated phyllile) and Labdi Khola Carbonate (observed in LabdiKhola areas) and Bandipur Slate (observed in Bandipur areas). The monotonous sequence of Carbonaceous Phyllite, well exposed on LabdiKhola-Mastipur section, poorly resembles with Benighat Slate of the type locality.

Different types of erosional and tectonic structures are mapped in the study area. The Dadagaon Phyllite shows a broad inlier around Chipleti area and a small elliptical outlier of Purebensi Quartzite is mapped in Hilekharka area. A prominent thrust contact is mapped in between Dhading Dolomite and Nourpul Formation continuously around Chandrakot, Ripthok, Tilahar, Takmare and Kamalbari areas which is named as Jal Bhanjyang Thrust in present study. Two major folds viz. Bandipur Syncline and Hilekharka Anticline are also observed in the territory.

Different types of sedimentary structures like ripple marks; mudcracks and graded beddings show the right side up sequence of the different units. A large number of tight isoclinal folds with folded quartz veins are observed in the Carbonaceous Phyllite of Benighat Slate. The rock units of the area consist of pelitic, psammatic and calcareous metasediments up to chlorite/sericite grade of metamorphism. Basic plutonic rocks are intruded in the upper part of Nourpul Formation which is sill like in nature and mappable in the field.

Different types of both metallic and non-metallic minerals are found in the study area. Among them, copper deposit of Bhut Khola, hematite of Labdi Khola, roofing quality slate of the Bandipur and graphite deposit of Ghumaune-Labdi section are the potential resources of the area.

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CHAPTER ONE

INTRODUCTION

1.1. Background

The present study has been carried out for the partial fulfillment of the requirement for the Master's Degree of Science in geology. The study area consists of mainly low-grade metamorphic rocks of the Lesser Himalaya, central Nepal. The main purpose of the study is concerning on detailed lithology, stratigraphy, introduction to mineral resources and geological structures of the Lesser Himalaya. The major lithology which covers the study area consists of phyllite, quartzite, dolomite, slate and metasandstone. The major problems faced during geological mapping are deep weathering of rocks, poor exposure in ridges, thick vegetation cover and strong topographic relief. The thesis is an outcome of two months of field work and three month of table work.

1.2. Location

The area lies between the latitudes of 27^o49’00”N and 27^o57’30”N and longitudes between of 82^o22’30” E and 84^o30’00”E (Fig. 1.1). It lies on the vicinity of Dumre Bandipur, Hilekharka and south of Seti Nadi and covers the eastern part of Tanahu and south-west part of Gorkha District. The topographical maps entitled Jugadi Bazaar (Sheet No.278402D), Dumre Bandipur (Sheet No. 2784 02B) published by the Department of Survey, Government of Nepal include the study area. Geologically the area lies in the Lesser Himalayan Zone. Tectonically, it lies in the western closure of the Mahabharat Synclinorium (Fig.1.2).

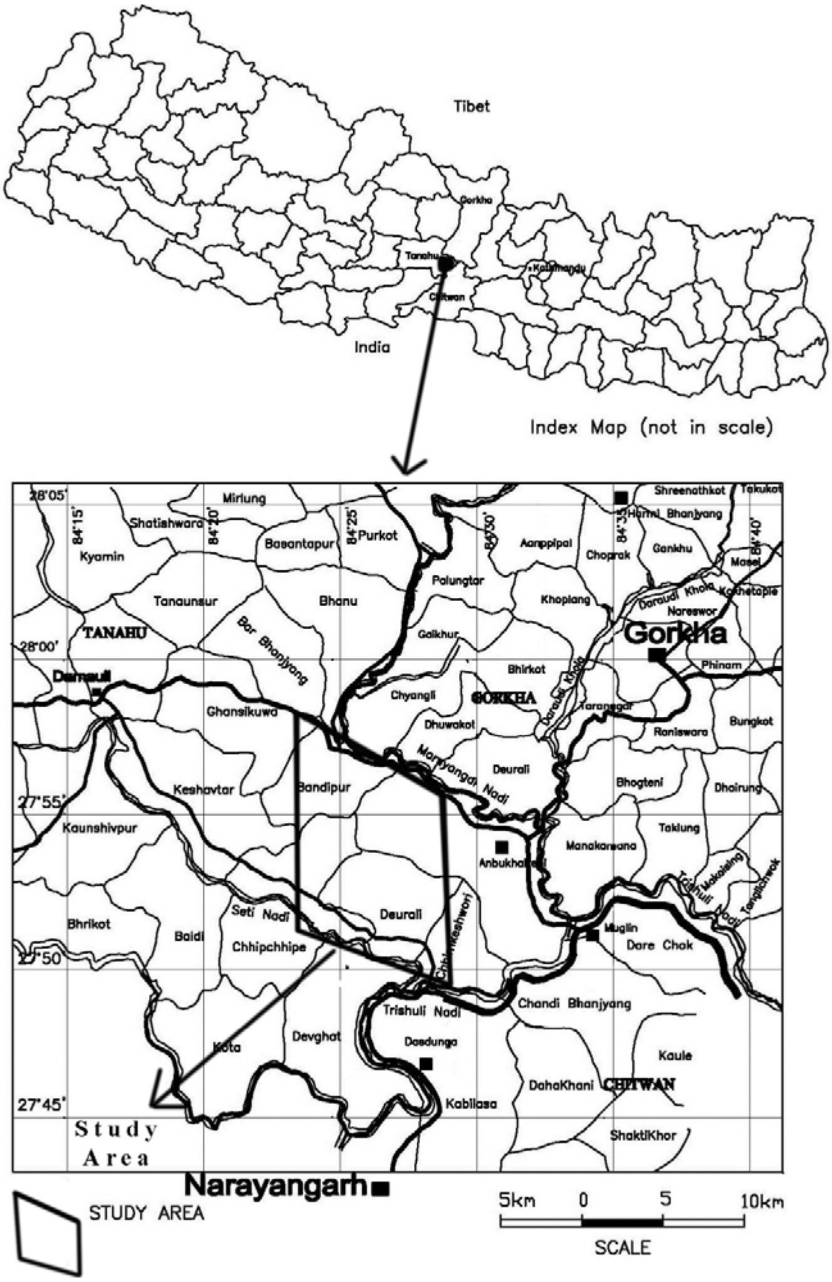


Fig. 1.1: Map showing the location of the study area

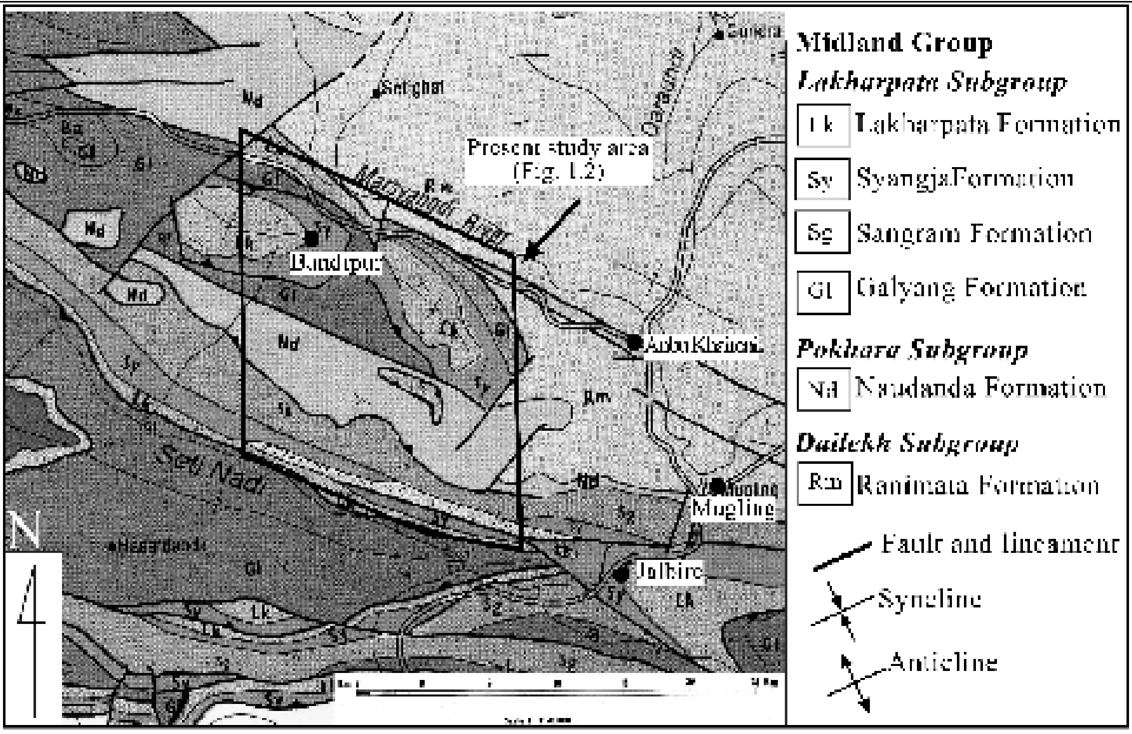


Fig. 1.2: Location of the study area in the geological map of the central Nepal (after Jnawali and Tuladhar, 1996)

1.3. Accessibility

The study area lies at about 90 km west from Kathmandu. The Prithvi Highway and the Ghumaune-Damauli Road makes it well accessible. Many other roads like Dumre Bazaar to Bandipur, Bandipur to Hilekharka and the webbed foot-trails make easy access to most parts of the area. But, some steep slopes and rugged topography are difficult to reach.

1.4. Topography and Drainage

Rugged and steep topography in the study area is manifested by a large fluctuation in altitude (up to 1900 m) in relatively short north-south horizontal span (less than 15km). The altitude ranges from 200 m at Piughare (right bank of the Seti Nadi) to the south to 2130m north from Bhoteshwara, eastward in the geological map. The area is intricately dissected and drained by the networks of steep-gradient streams. The major rivers in the study area is Seti Nadi having the moderate gradient with wide valleys that generally flows northwest-southeast and ultimately it combines with the Trishuli Nadi at Ghumaune. The feeding small river system to Seti Nadi from north to south are Labdi Khola, Bhut Khola, Bagar Khola and many other unidentified minor tributaries. In the Northern side of the study area, Samdi Khola and Pyaudi Khola which flow from Northwest to Southeast and they ultimately meet Seti Nadi. The other Northern small rivers like Khani Khola, Raudi Khola, Khudi Khola, Adhi Khola and Thari Khola which are almost parallel to each other ultimately joins with Marsyandi Nadi. The tributary shows the dendritic drainage pattern but the ultimate drainage pattern in the area is trellis drainage pattern (Fig. 1.3).

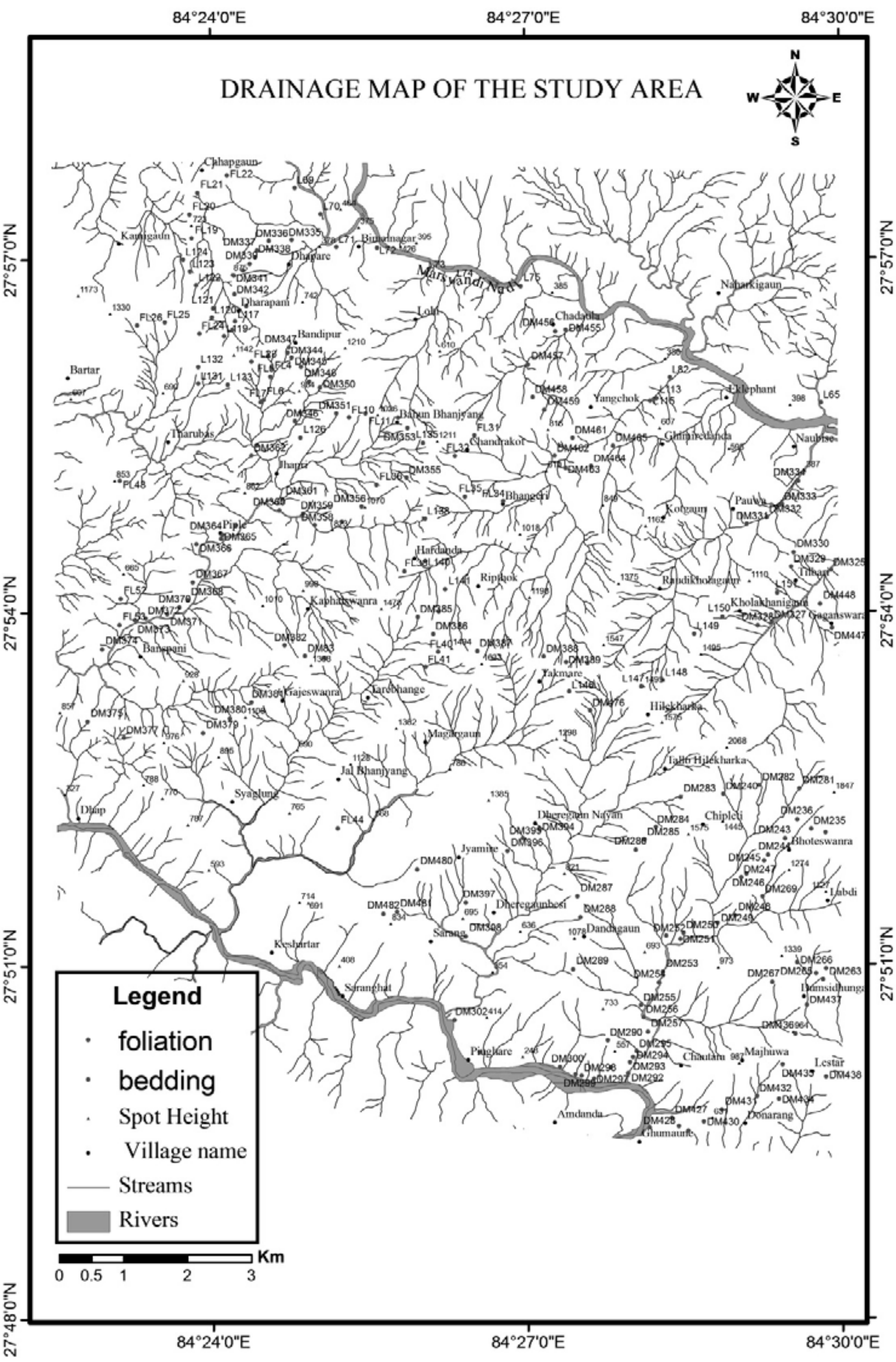


Fig. 1.3 Drainage map of the Study Area

1.5. Regional Geological Setting

The Nepal Himalaya occupies the central part (800km) of the 2400km long southwardly convex Himalayan arc. The major five morphogenetic zones of the Nepal Himalaya from south to north (Gansser, 1964, Hagen, 1969) are given below (Fig. 1.4).

North

Tibetan-Tethys Himalaya

-----South Tibetan Detachment Fault System (STDFS) ---

Higher Himalaya

--------------------Main Central Thrust (MCT) --------------------

Lesser Himalaya

-------------------Main Boundary Thrust (MBT) ---------------------

Sub-Himalaya (siwaliks)

--------------------Himalayan Frontal Thrust (HFT) ---------------

Indo-Gangetic Plain (Terai)

South

1.5.1. Indo-Gangetic Plain (Terai)

This is the southernmost zone of Nepal Himalaya. It represents the northern edge of Indo-Gangetic Plain. It is a foreland basin and owes its origin to the rise of Himalaya. The zone is comprised of the Pleistocene to Recent deposits consisting of gravels, sands and clays with average thickness of 1500 m (Upreti, 1999).The sediment deposition is still continuous.

1.5.2. Sub Himalaya (Siwaliks)

This zone is bounded to the south by Main Frontal Thrust (MFT) and to the north by Main Central Thrust (MCT). It consists basically of the rocks of fluvial origin belonging to the Neogene age. Mudstone sandstone and conglomerate are the exclusive lithology. About 5–15km thick Sub Himalayan sediments (Upreti, 1999) exhibit overall coarsening upward succession.

1.5.3. Lesser Himalaya

The Lesser Himalaya is bordered in the south by the Main Boundary Thrust (MBT) and in the north by the Main Central Thrust (MCT).The Lesser Himalaya consists of the unfossiliferous sedimentary and metasedimentry rocks like slate, phyllite, schist, quartzite, limestone and dolomite ranging in the age fromthe Precambrian to the Eocene. Presence of faults, folds, nappes and klippes make geology more complex.

1.5.4. Higher Himalaya

This tectonic zone lies between the Lesser Himalaya in the south and Tibetan Tethys Himalaya in the north. Kyanite and sillimanite bearing garnet-to mica-gneiss with the high amount of associated metasediments, augen gneiss, migmatite and granite-gneiss are more important lithotype in the Higher Himalaya (Stöcklin, 1980). The MCT is accepted as the lower boundary (Stöcklin, 1980) and a normal fault system named as South Tibetan Detachment Fault System (STDFS) has been recognized as the upper boundary (Coleman, 1996).

This zone consists of about 10km thick succession of the crystalline rock also known as Tibetan Slab (Le Fort, 1975).Gneiss with subordinate phyllite, schist, quartzite and marble constitute this 5–15km thick Higher Himalayan Zone.

1.5.5. Tibetan Tethys Himalaya

The northernmost tectonic zone of Nepal Himalaya starts to the STDFS and ends up against the Indus-Tsangpo Suture Zone. It includes a thick (>10km) and continuous sequence of fossiliferous Paleozoic to the Lower Tertiary rocks indicating a platform type epicontinental environment.

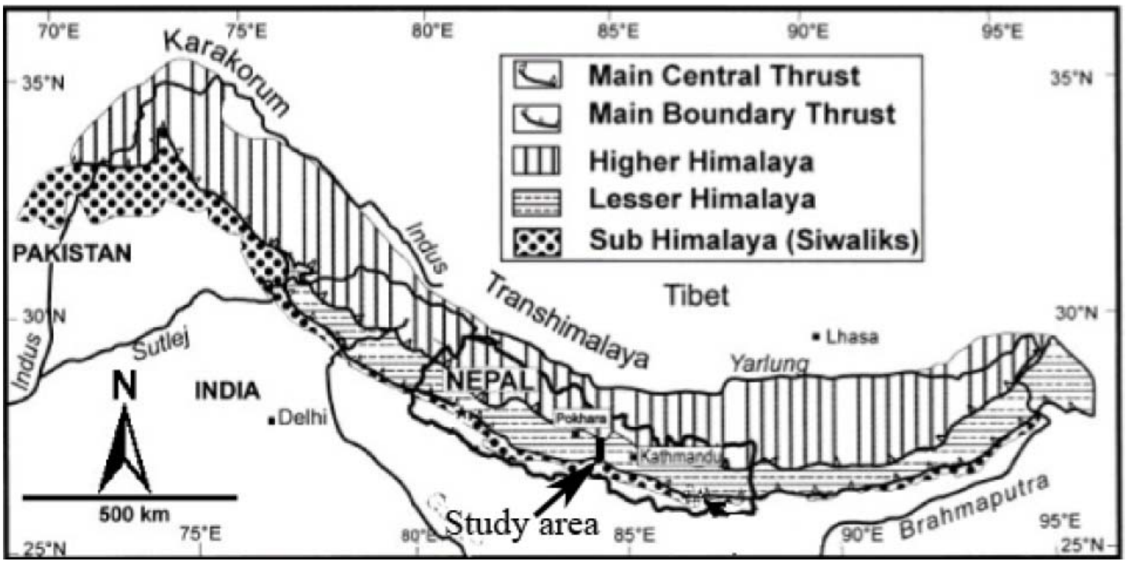


Fig. 1.4 Simplified geological map of the Himalaya showing major litho-tectonic divisions (After Gansser, 1964).

1.6. Regional Geology of Central Nepal, Lesser Himalaya

The Lesser Himalaya is bordered in the south by the Main Boundary Thrust (MBT) and in the north by the Main Central Thrust (MCT). The MBT is a low-angle reverse fault that has brought the older Lesser Himalayan rocks over the much younger Siwaliks. The MCT, on the other hand, lifts the middle level crustal rocks of the Higher Himalaya over those of the Lesser Himalaya. The Lesser Himalaya is a fold-and-thrust belt with complex stratigraphy and structures. There is several thrust sheets stacked one over the other and folded and faulted on a large scale (Valdiya, 1980). Tectonically the Lesser Himalaya is made up of the autochthonous-paraautochthonous units, with various nappes, klippe and tectonic windows.

Central Nepal Himalaya is also a complex tectonic zone with several faults and folds. The area includes Mahabharat Synclinorium (Stöcklin, 1980) in the east, Gorkha-Kunchha Anticlinorium in the north (Arita et al., 1973), Kanhu Syncline (Jnawali and Tuladhar, 1996) in the north west, Tansen Synclinorium (Sakai, 1985) in the southeast and Jajarkot Syncline (Ando and Ohta, 1973) in the west. The Bari Gad-Kali Gandaki Fault (Nakata, 1989) and Phalebas Thrust (Upreti et al., 1980) are the regional faults extending east-west in the area. (Paudel and Arita, 2000) also prepared a simplified geological map of the central Nepal, Lesser Himalaya (Fig. 1.5).

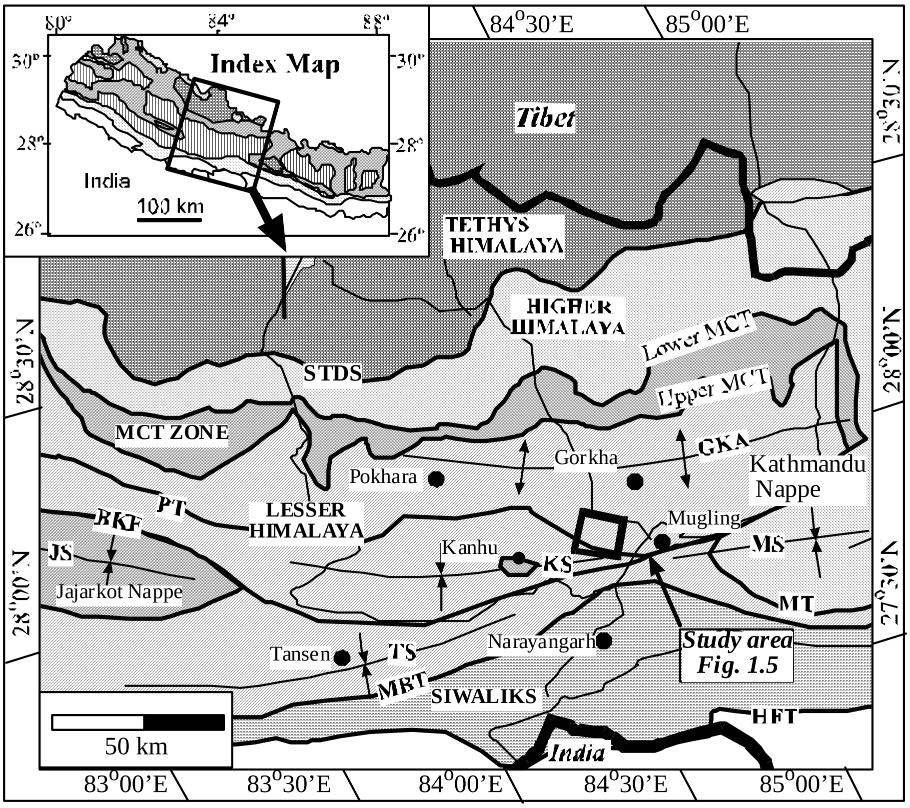


Fig. 1.5 Simplified geological map showing Study area Paudel and Arita, 2000

1.7. Geological Problems

There are a number of problems and controversies on stratigraphy, tectonics and metamorphism of central Nepal as well as in whole Nepal Himalaya. Some of the major problems are described below.

1.7.1. Lack of Detailed Geological Maps

Many parts of the Lesser Himalaya still lack detailed geological maps. Stöcklin and Bhattarai (1977) have prepared a detailed geological map of the Kathmandu area for about 250km along the strike. Westward, it covers up to Muglin. A part of Gorkha–Ampipal area has been mapped by Dhital (1995), western part by Paudel and Arita

(1998).However a considerable area north and western parts of Muglin still lacks a detailed geological mapping.

1.7.2. Stratigraphic Problems

There are number of stratigraphic classification and nomenclatures, which have been done for the same section i.e different researchers have given different stratigraphic classifications. It is very difficult to correlate the stratigraphic unit of one author to that of another. This has created great problem not only for accurate correlation of the sequences in contiguous region but also for structural interpretation and tectonic evolution of the Lesser Himalaya as a whole.

1.7.3. Metamorphism

Inverted metamorphism (structural upwards increase in metamorphic grade) has been recognized in the MCT zone and the Higher Himalaya. Inverted metamorphism of Pokhara region is explained by Paudel and Arita (1998). A little work has been done on the low-grade rocks of the Lesser Himalaya to understand the thermal evolution of the Himalaya. To clarify the vision of inverted metamorphism, a further study on the low-grade rocks of the Lesser Himalaya is essential.

1.8. Objectives

The principal aim of the study is to understand the geology of the Bandipur-Hilekharka area. The following objectives were set up for the purpose.

- To prepare the geological map at the scale of 1:25000 to clarify the stratigraphy of the area.
- To study lithology and geological structures of the area.

- To access the mineral resources of the area.

1.9. Methodology

The methodological schemes used on the present study can be summarized as follows.

1.9.1. Literature Review

Topographic maps, published and unpublished reports and literatures, journals, field manuals and established theories related to the present study were collected from the different sources and studied in detail and made the basis for the field investigation. Topographical maps at 1:25,000 scale published by the Survey Department, Government of Nepal were collected. The toposhets Jugedi Bajar (Sheet No. 2784 02D), and Dumre Bandipur (Sheet No. 2784 02B) were used for the study. Published and unpublished papers, reports and dissertation available at the Central Department of Geology provide a concept on geological conditions of the study area. Based on available information, an investigation program was scheduled for the field works.

1.9.2. Field Work

The field work is based on the field mapping which was carried out by the route mapping on 1:25000 scale topographic maps. The mapping was carried out based on the standard lithological units established by Stöcklin and Bhattarai (1977), Stöcklin (1980) in the Central Nepal, Lesser Himalaya. Geological traverses were made mainly on the roads, rivers, ridges and foot trails. Mesostructures seen in the field were sketched. Samples were collected as far possible for laboratory analysis. Photographs of significant outcrops were taken to interpret the geological data. Brunton compass, geological hammer, chisel, dilute HCl (1:10) were instruments and tools used during the field works.

1.9.3. Laboratory Works

Most of the laboratory works were carried out in the laboratory at the Central Department of Geology, TU, Kirtipur. The lab is well equipped for thin section preparation and petrographic study.

1.9.4. Interpretation and Dissertation Writing

Data obtained from the field and the laboratories were analyzed systematically using accepted statistical tools and techniques. All the available data on stratigraphy, structure and metamorphism were gathered together to interpret the geological setting of the area. The final report was prepared in accordance with the guidelines provided by CDG, TU by incorporating all the analysis, results and data collected in the field.

1.10. Structure of Dissertation

The organization of the report closely follows the guideline provided by the Central Department of Geology. The dissertation comprises six chapters. The first chapter includes a background of the study area, location, accessibility, topography, drainage, regional geological setting, regional geology of the Lesser Himalaya, aims and objectives and methodology adopted during the study. The second chapter deals with the previous studies of the area. The third chapter describes the lithostratigraphy and structures the study area. The fourth chapter includes geological structures seen in the study area. The fifth chapter deals with mineral resources found during field study. The sixth chapter is a conclusion which describes the summary of the whole study.

CHAPTERTWO

PREVIOUS STUDIES

Although, many Himalayan geologists have studied the area north of Kathmandu, there are still some controversies always making the area an interesting and challenging place to work in.

Medlicott (1875) was probably the earliest geologist to work on the geology of Central Nepal around Kathmandu. He described the sedimentary and low grade metamorphic rocks to the south and the high grade metamorphic rocks from the north of Kathmandu.

Auden (1934) is one of the earliest persons who had given the fair detail geology of Central Nepal Lesser Himalaya. He presented several cross-sections across the Himalaya supporting the nappe theory earlier proposed by Argand (1924). He also recognized the synclinal nature of Mahabharat range.

Gansser (1964) gave a boarder framework and geological summary of the Himalaya including the Nepal Himalaya. Hagen (1969) brought forward the nappe concept in the Nepal Himalaya. He reported the Nawakot Nappe made up of low grade metamorphic rocks underlained by a medium to high grade metamorphic rocks of Kathmandu Nappe.

A team of geological researchers from the Hokkaido University, Japan conducted several geological expeditions in Nepal Himalaya from 1955-1975 and published results in 1973 (Hashimoto et al., 1973). It gives the first detailed account of geology, stratigraphy, tectonics and metamorphism of whole Nepal Himalaya.

After1970, a group of French researchers including Bordet, Le Fort, Colchen, Pêcher, had published a detailed geological map and a number of paper related to the tectonics, metamorphism along several sections of Central Nepal Lesser Himalaya. (Bordet et al., 1971; Le Fort, 1975; Colchen et al., 1980, 1986; Pêcher, 1977, 1989).

Stöcklin and Bhattarai, 1977 and Stöcklin, 1980 carried out a comprehensive geological mapping of the Central Nepal Lesser Himalaya and Kathmandu Nappe. Their stratigraphy classification for Central Nepal Lesser Himalaya and Kathmandu Nappe has been still widely adopted. They divided the rocks of this region into two complexes-the crystalline high grade meta-sedimentry Kathmandu Nappe (Complex) and beneath it the non-crystalline, low grade meta-sedimentry Nawakot Complex. The frontal part of the Kathmandu Complex is separated from the Nawakot Complex by the thrust known as Mahabharat Thrust (MT) (Stöcklin, 1980) and is shown to be a direct continuation of the Main Central Thrust (MCT) (Stöcklin, 1980; Fuchs 1981; Pêcher and Le Fort, 1986; Pandey et al., 1995). The rocks of southern part of the Kathmandu Nappe are grouped into Kathmandu Complex; which is subdivided into the Bhimphedi Group (the Late Precambrian rocks) and unconformably overlying essentially fossiliferous sedimentary sequence of the Phulchauki Group (Lower Paleozoic rocks). The low-grade metasedimentry rocks outcropping in the north, west and southwest of Kathmandu Complex has been grouped into the Nawakot Complex (Stöcklin and Bhattarai, 1977, Stöcklin, 1980).

Many foreign and Nepalese geologists have carried out individual researches in central Nepal. Arita (1973) studied the inverted metamorphism in the Modi Khola cross-section and explained the phenomena of the shear- heating along the MCT zone.

Geological map of Gorkha–Ampipal area, Central Nepal, Lesser Himalaya was prepared by Dhital (1995) in 1:50000 scale. The map covers Abu-Khaireni (south), Barpak and

Vachchek (north) the Chepe Khola (west) and Khanchok (east). In his mapped area the Nepheline Syenite bodies are intruded in the Kunchha Formation.

2.1. Stratigraphy based on Stöcklin and Bhattarai, 1977 and Stöcklin, 1980

The Nawakot Complex consists almost exclusively of low grade metasediments. It is subdivided into the Lower and Upper Nawakot Groups, the two being separated by an erosional unconformity (Stöcklin and Bhattarai, 1977; Stöcklin 1980, Table 2.1).

The Kunchha Formation is the oldest unit of the Lower Nawakot Group and of the Lesser Himalaya. It forms monotonous, flysch-like alteration of phyllite, phyllitic quartzite and phyllitic gritstone resembling greywacke. The phyllite is argillaceous, more or less silty or quartzitic and includes extremely fine grained to dense, laminated siliceous varieties. The quartzite is mostly impure, of olive green color and often shows an “oily” luster on fresh fracture planes. Clean ortho-quartziteis an exception. Gritty phyllite consists of mostly quartz, very subordinately feldspar, tourmaline and other minerals, which are loosely disseminated in a phyllitic matrix. Less frequent but equally characteristics are fine quartz conglomerate, the pebbles of which rarely exceed 1 cm in diameter. Graded bedding can often be seen, and few layers of di-basic volcanic materials are locally inter-bedded. The characteristic feature of the Kunchha Formation is a pronounced NNE mineral lineation, which is missing in higher units. Sericite and chlorite are the common metamorphic minerals recognizable in the Kunchha Formation (biotite and small garnets are also reported in some places). Upper contact of the Kunchha Formation with the Fagfog Quartzite is sharp and conformable. The exposed thickness of the Kunchha Formation is more than 3000 m, but the base being nowhere exposed.

Table 2.1: Stratigraphic sub-division of Central Nepal, Lesser Himalaya (After Stöcklin and Bhattarai, 1977 and Stöcklin, 1980).

Complex	Group	Formation	Main lithology	Thickness	Age
Kathmandu Complex	Phulchoki Group	Godavari Limestone	Limestone	300–400m	Devonian
		Chitlang Formation	Slate, quartzite	1000m	Silurian
		Chandragiri Limestone	Limestone	2000m	Cambrian
		Sopyang Formation	Slate, calc. Phyllite	200m	Cambrian (?)
		Tistung Formation	Metasandstone, Phyllite	300m	Early Cambrian Or Late Precambrian
	Bhimphedi Group	Markhu Formation	Marble, schist	1000m	Late Precambrian
		Kulikhani Formation	Quartzite, Schist	2000m	Precambrian
		Chisapani Quartzite	White quartzite	400m	Precambrian
		Kalitar Formation	Quartzite, schist	2000m	Precambrian
		Bhainsedobhan Marble	Marble	800m	Precambrian
		Raduwa Formation	Garnet- schist	1000m	Precambrian
---Mahabharat Thrust---					
Nawakot Complex	Upper Nawakot Group	Robang formation	Phyllite, quartzite	200–1000m	Early Paleozoic
		Malekhu Limestone	Limestone, dolomite	800m	Early Paleozoic
		Benighat Slates	Slate, argillaceous dolomite	500–3000m	Early Paleozoic
	Lower Nawakot Group	Dhading Dolomite	Stromatolitic Dolomite	500–1000m	Precambrian
		Nourpul Formation	Phyllite, Metasandstone	800m	Precambrian
		Dandagaon Phyllites	Phyllite	1000m	Precambrian
		Fagfog Quartzite	White Quartzite	400 m	Precambrian
		Kunchha Formation	Phyllite, Quartzite	3000 m	Precambrian

The Fagfog Quartzite is a medium to coarse-grained white ortho-quartzite with several phyllitic intercalations. It forms a good marker. The quartzite shows yellow, orange and pink colors when weathered. They frequently contain graded bedding, current ripples and trough cross laminae. The contact of the Fagfog Quartzite with Dandagaon Phyllite is transitional. It's thickness in type locality is 200m.

The Dandagaon Phyllites consists of uniform argillaceous to finely quartzitic phyllite of dark, blue-green color. In weathered condition the rock often displays reddish tints.

Green, fine grained sericitic and or chloritic quartzite occurs in places as centimeter or millimeter thin intercalations. Occasionally, thin bands of dense dolomite and calc-phyllite have been reported within formation. The contact with the overlying Purebensi Quartzite (basal member of the Nourpul Formation) found to be sharp but conformable.

The Nourpul Formation is a mixed lithology of phyllitic, quartzitic and calcareous rock types. The Purebensi Quartzite member contains a clean arkosic quartzite of fine to coarse grained. Cross beddings can often be seen and ripple marks are much more frequent in the beds of quartzite. The middle part of Nourpul Formation contains predominately Phyllite with variable amount of quartzitic and calcareous intercalations. Mostly the sequence consists of similar alternation of phyllite and dolomite, Phyllite and quartzite and somewhere pure phyllite only. In the upper part of formation the dolomites and dolomitic quartzite becomes more abundant. A characteristic green/buff or green/orange color banding can be observed due to regular alternation of phyllite (green) and quartzitic dolomite. By a decrease of the phyllite portion these rocks pass gradationally into the Dhading Dolomite. The average thickness of the Nourpul Formation is estimated at about 800m.

The Dhading Dolomite is a well-bedded to massive bluish-grey to fine crystalline carbonate rock occurring abundant stromatolites at many levels. These algal fossils indicate early Paleozoic age to the Early Cambrian. The lower part of the formation is dominated by blue-grey, very fine-grained cherty dolomites inter-bedded with the silver-grey, green and purple slates. The Dhading Dolomite is sharply overlain by the dark grey Benighat Slates of the Upper Nawakot Group.

The Benighat Slates is dominantly a dark-grey, blue-grey to charcoal black, thin-laminated slate with frequent intercalations of siliceous phyllite. Black limestone and calc-slate and quartzitic phyllite are also found. Mostly, slaty cleavage has developed oblique to the bedding. Pure quartzite are absent are extremely rare. In places, the slate and phyllite show a distinct carbonate contact and more prominent zones of such calcareous rocks have been distinguished as ‘Jhiku Calcareous Beds’. The thicker beds of pure limestone or dolomite are rare. Mostly slates are rich in the graphitic matter. There are some reliable evidences of erosional unconformity between the Benighat Slate and the overlying Malekhu Limestone.

The Malekhu Limestone consists of thin, platy, yellow, dense, siliceous limestone with pale-green sericitic partings. Acid reacts the rock only in powder form. Stromatolites are missing but algal mats are frequent in them. Elephant skin weathering and cavernous beds are the characteristics features of the formation.

The Robang Formation and associated Quartzite (Dunga Quartzite beds) is the highest unit of the Upper Nawakot Group. The main lithology is phyllite. White Dunga Quartzite beds (a member of Robang Formation) is distinct. Associated with both the phyllite and quartzite occurschloritic and amphibolitic meta-diabases showing sedimentary relationships, as well as more massive, gabbroic or dioritic bodies showing intrusive contacts. This formation is overlain by highly garnet- schist.

2.2. Revised Stratigraphy of Paudyal and Paudel(2011)

Detailed geological mapping was carried out in the Lesser Himalaya of Mugling-Basnpani area, Central Nepal by Paudyal and Paudel (2011), (Fig. 2.1). The area comprises low-grade metasedimentary rocks of the Lower Nawakot Group. The present mapping was carried out by extending the units of Paudyal and Paudel (2011) westward along strike from Banspani-Labdi areas. It shows that the stratigraphic classification of the Lower Nawakot Group by Stöcklin and Bhattarai (1977) is not valid for the area and a revision is done by Paudyal and Paudel (2011). According to him, Anpu Quartzite does not occupy the base of Nawakot Complex but this is equivalent to the Fagfog Quartzite, the Banspani Quartzite is equivalent to the Purebensi Quartzite, and the Labdi Phyllite is equivalent to the Dandagaon Phyllite. Based on the above observation, a revised stratigraphic classification for the Lower Nawakot Complex has been proposed for the area. According to them, the Kunchha Formation is the oldest unit comprising a monotonous sequence of phyllite, gritty phyllite, metasandstone, Calcareous phyllite and metaconglomerate. The Fagfog Quartzite (~Anpu quartzite, 400m) is composed of white quartzite and uninterruptedly extends from Muglin to Anbu Khaireni, the Dandagaon Phyllite (~Labdi Phyllite, 200m) is made up of alternations of laminated black phyllite, gritty phyllite, metasandatone, dolomite and quartzite. The Nourpul Formation can be divided into three members. The Purebensi Quartzite (~Banspani Quartzite, 420m) is the lover member consisting of grey to white quartzite with phyllite and amphibolite/greenschist. The middle Amdanda Phyllite member comprises grey, finely laminated phyllite and metasandstone with sporadic layers of dolomite. The upper Labdi Khola Carbonate Member consists of mixed lithology of grey and pink dolomite, pink quartzite, phyllite, greenschist and amphibolite. This unit is also characterized by several hematite bands and copper mineralization. The youngest unit is the ridge-forming Dhading Dolomite.

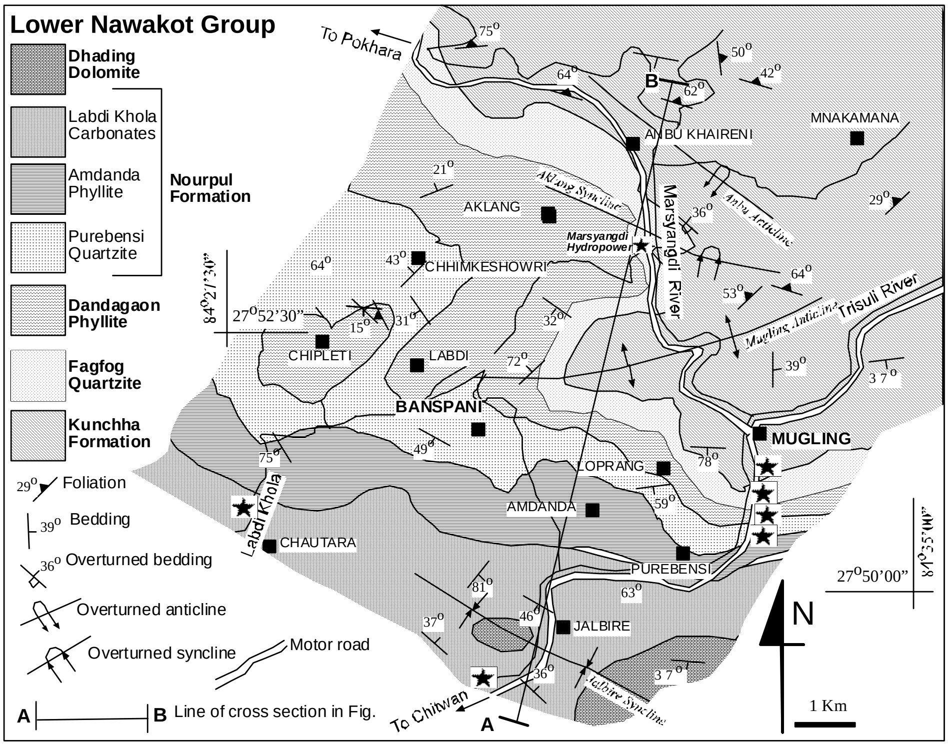


Fig. 2.1 Geological map of Muglin Banspani area, Central Nepal Lesser Himalaya, Paudyal and Paudel (2011)

CHAPTER THREE

LITHOSTRATIGRAPHY

The present study area is a part of Lesser Himalaya and it covers the Bandipur and Hilekharka areas of Tanahu district. It consists of the rocks of Nawakot Complex (Stöcklin, 1980). The rocks of Lower Nawakot Group are distributed south to north west of Mugling and the rocks of Upper Nawakot Group are found south of the Muglin (Fig. 3.1 &3.2). The Kunchha Formation is the oldest unit of the Lower Nawakot Group and then the Fagfog Quartzite, Dandagaon Phyllite, Nourpul Formation and Dhading Dolomite are in higher positions. All the above formations are well-exposed along the Mugling-Bandipur road and Trisuli river sections. The Benighat Slate is the oldest unit of Upper Nawakot Group, and the Malekhu Limestone and the Robang Phyllites are in higher stratigraphic positions respectively. In the present study area, Kunchha Formation, Malekhu Limestone and Robang Formation are not exposed.

Before starting the mapping of this area, a detailed columnar section was prepared along the Muglin-Narayangarh road section to gather the complete lithological information and contact relations between the Fagfog Quartzite, Dandagaon Phyllite, and Purebensi Quartzites which are well developed in road section (Fig. 3.3, 3.4, 3.5). Other formations like Amdanda Phyllite are well observed in Amdanda Village, Labdi Khola Carbonate in Labdi-Khola (Fig. 3.6) and Bandipur Slate around Bandipur Village.

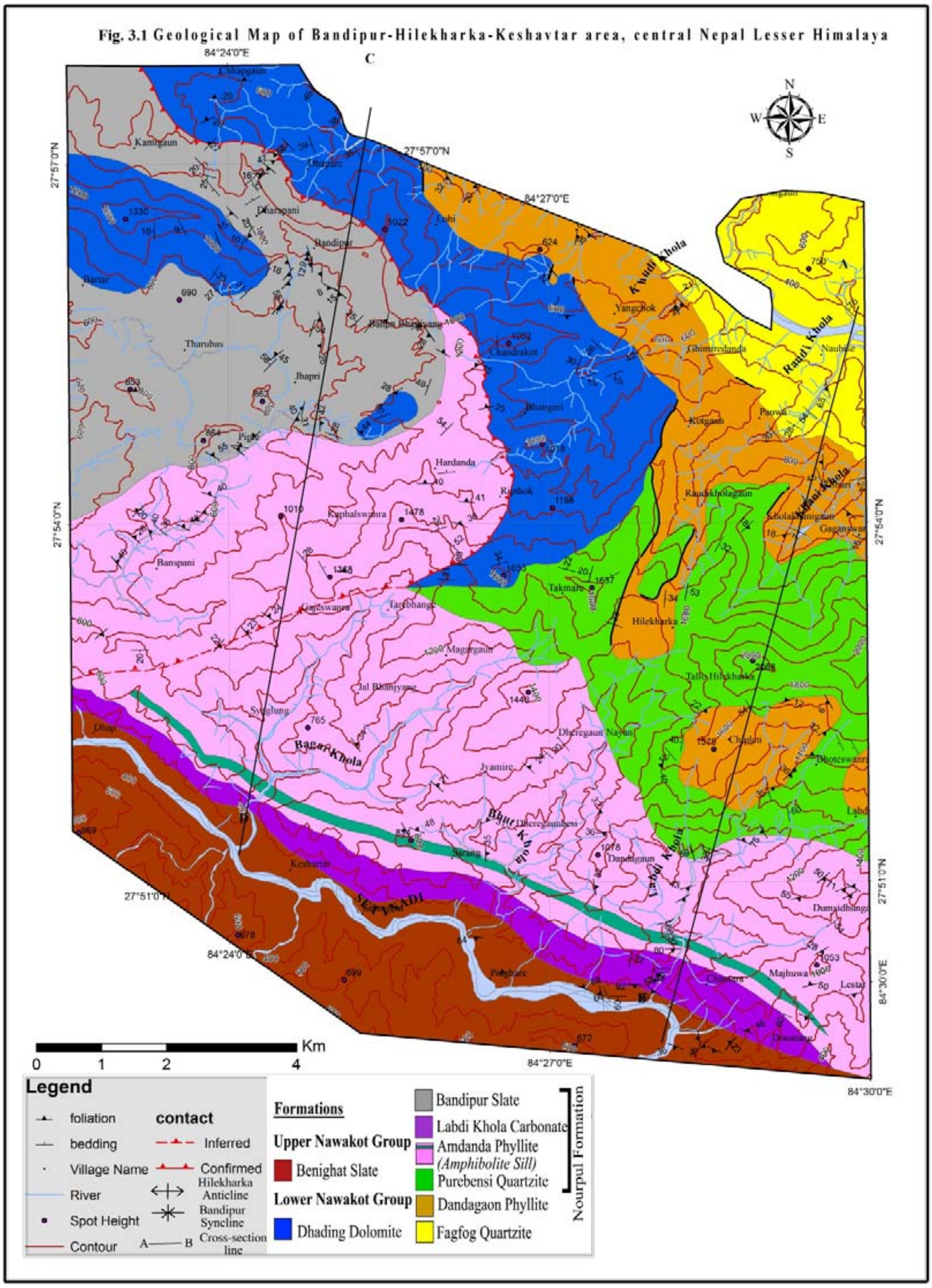


Fig. 3.1 Geological map of the study area.

Geological cross-section of the study area from A (NE) to B (SW)

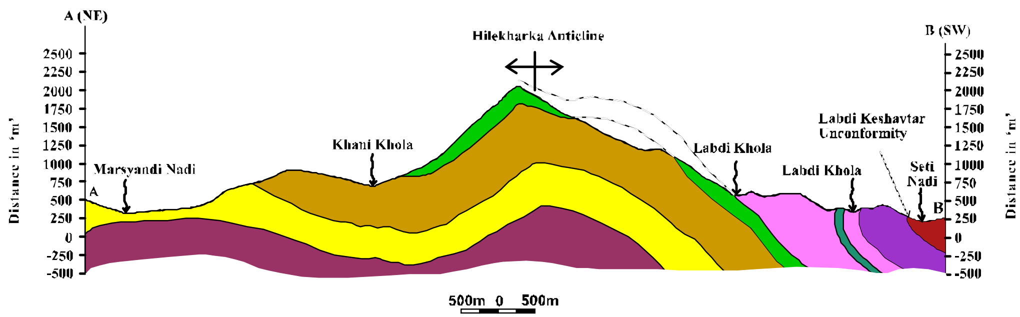
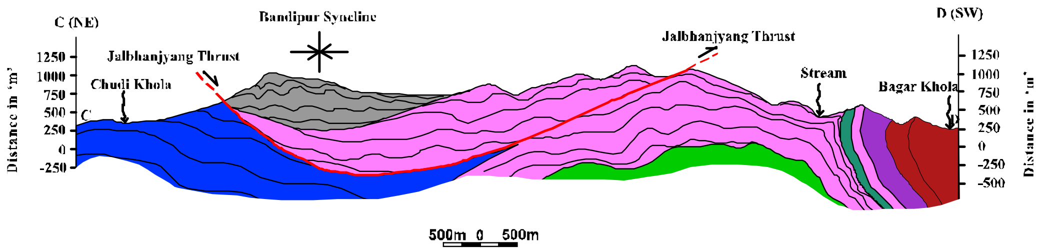


Fig. 3.2 (a)

Geological cross-section of the study area from C (NE) to D (SW)



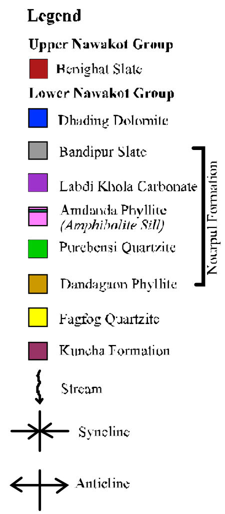


Fig. 3.2 Geological cross-section of the study area from NE to SW

3.1. Lower Nawakot Group

3.1.1. Fagfog Quartzite

This unit is distributed around south of Muglin, Baradi, Anbu Khaireni areas (DM-43, DM-316, DM-311, and DM -77).It is a marker outcrop (Plate 1) and makes steep slope in the territory. It consists of thin to thick-bedded (5 cm to 1.5 m) white quartzite with thin (~1 cm) partings of phyllite. In weathered outcrops, the quartzite shows reddish, yellowish or pale orange color. Graded beddings, parallel-and cross-lamina (Plate 2) and ripple marks (Plate 3) are the prominent sedimentary structures observed in some outcrops (L-82). Thin layers of grey phyllite are rarely intercalated with the competent beds of quartzite. The age of this formation is believed to the Precambrian (Stöcklin, 1980). The contact with the overlying Dandagaon Phyllite is sharp and conformable (Fig 3.3).The average thickness of this Formation is 420 m (Fig. 3.3).

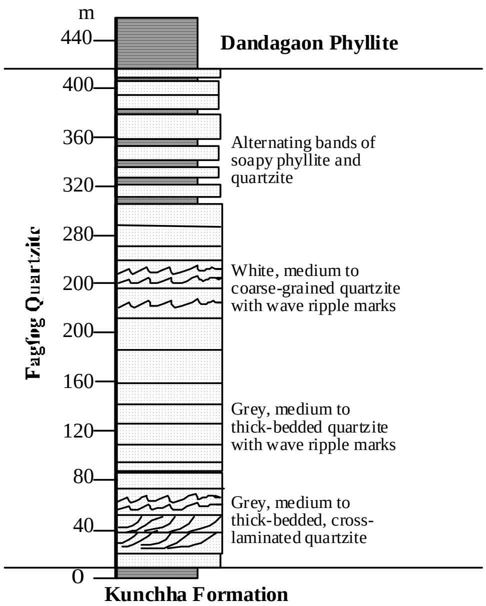


Fig. 3.3 Columnar section of Fagfog Quartzite

3.1.2. Dandagaon Phyllites

It consists of carbonaceous phyllite with thin quartzite bands. This phyllite predominates darker in color and do not contains grity phyllites as in the Kunchha Formation. So it is different than the Kunchha Formation. The rocks of this formation are often strongly deformed and exhibit crenulation cleavage. A few sporadic dark grey to ash grey quartzite and lenticular carbonate bands are intercalated with calcareous phyllite. The contact with the overlying Fagfog Quartzite is found sharp and conformable (Fig. 3.4).

The rocks of this formation are extensively distributed in Chipleti, Hilekharka, and Tilbari areas (Fig. 3.1). The Dandagaon Phyllite in Chipleti area forms an inliar (Plate 4) and consists of grey, compact, laminated, soapy phyllite in alternation with greenish grey, medium to coarse-grained, medium to thick bedded (>60cm) sandstone as a broad inlier surrounded by younger rocks of Purebensi Quartzite. In weathering outcrops, phyllite shows grey coloration whereas metasandstone shows brown, purple and greenish- grey colors (DM-237) and are also lineated (DM-238). On the way to Chipleti from Labdi, metaconglomerate having clast size of (0.2-5cm) and are elongate in shape is observed (BP-14) (Plate 5). Boudinage of quartz (d= 1.5cm) and quartz veins parallel to foliation are observed in phyllites frequently. Phyllites are internally folded lying between two competent beds of metasandstones (DM-229). Almost similar types of lithology of Dandagaon phyllite is observed around the Hilekharka and Tilbari area. In many places around Hilekharka, the rocks of this formation are strongly deformed and frequently exhibit undulating foliation surfaces that change orientation within tens of meters. Quartz veins are folded indicating deformation after their emplacement. The contact of Dandagaon Phyllite with overlying Purebensi Quartzite is sharp and conformable. In

Yangchok area, the Dhading Dolomite unconformably overlies the Dadandagaon Phyllite making an unconformity. The average thickness of this formation is about 210 m in road section. But the thickness is not uniform in all areas and the thickness in the study area reaches to 650 m.

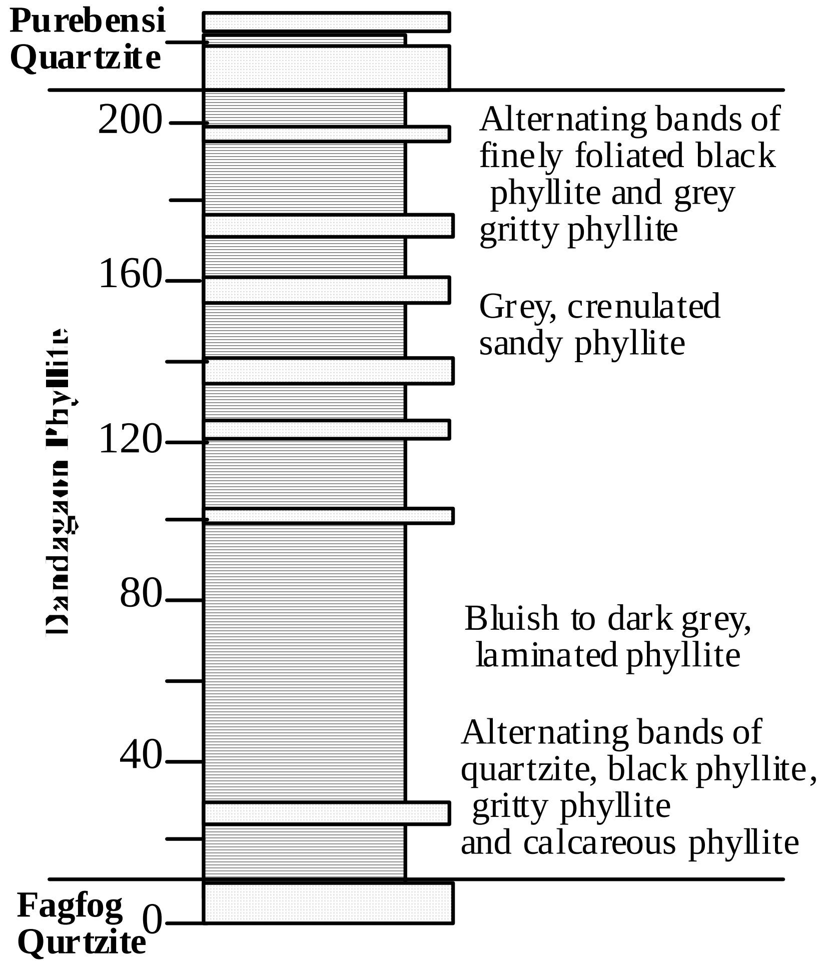


Fig. 3.4 Columnar section of the Dandagaon Phyllite

3.1.3. Nourpul Formation

The Nourpul Formation is exposed in different places and extensively distributed in the study area. The main lithology of this formation includes pink quartzite with ripple marks, purple, calcareous phyllite with mudcraks and siliceous dolomite. Based on the lithological peculiarity, the Nourpul Formation can be divided into three members from bottom to top but difference in lithology in different areas.

3.1.3.1. Lithostratigraphy of LabdiKhola area

The lithostratigraphy lies below the Jalbhanjyang thrust, which consists of following members, i.e the Purebensi Quartzite at the base, the Amdanda Phyllite as a middle member and Labdi Khola Carbonate as an upper member whose detailed description is described below. The generalized lithostratigraphy is shown in (Fig. 3.5).

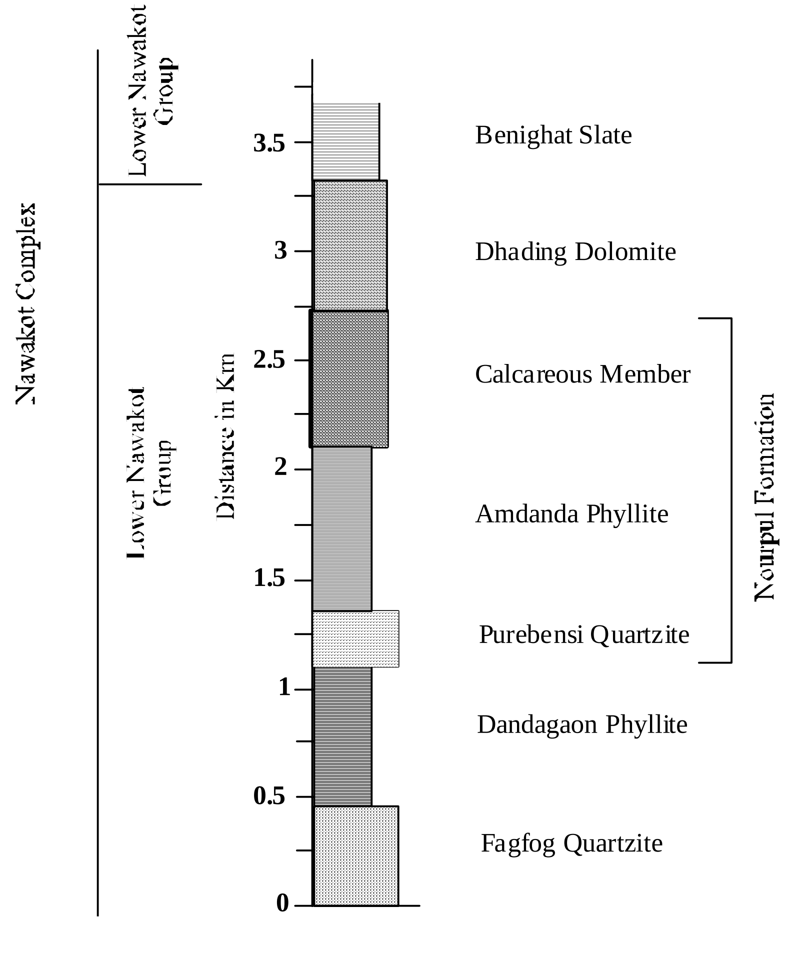


Fig. 3.5 Generalized columnar section of Labdi Khola area.

3.1.3.1.1.Purebensi Quartzite

The Dandagaon Phyllite is sharply followed up section by the Purebensi Quartzite. It is widely distributed to western hills of Muglin. The quartzites on these areas is white, grey to bluish grey, coarse grained, medium to thick bedded (3.0 cm – 1.3 m) with asymmetric ripple marks (Fig. 3.6, Plate 6). A faint weathering on quartzite shows brown, yellow and rusting coloration. The Purebensi Quartzite is not localized around Purebensi area only, it is extensive and mapable to western parts of Purebensi around Bhoteswara, Bagai, Chipleti, Takmare, Hile Kharka, Kharkagaon, Donde and Gaganswara areas (Fig. 3.1). In Hilekharka and Takmare, quartzite outcrop consists of interbeds of quartzarenite (recrystallized quartz crystals) and partings of grey phyllites (DM-338). In Kharkagaon and Dondeareas (DM 446, DM 447, Fig. 3.1), quartzite is ferruginous and slaby in nature forming prominent peaks around Chhimkeswori temple. The total thickness of this formation varies from 250 m to 440 m.

3.1.3.1.2.Amdanda Phyllite

This member represents the middle part of the Nourpul Formation and is well exposed in the Amdanda area (type locality at Amdanda, northwest of Muglin). It consists of finely laminated, grey, sandy phyllite (Plate 7). In many exposures, phyllite alternates with greenish grey, laminated, medium to thick bedded metasandstone. The color of phyllite is bluish green in places with vivid, yellow, pink, purple and violet variations in weathered condition. Quartz veins are frequent and show the cross cutting relation with laminae. The thickness of laminae varies from 1mm-1cm. The outcrop is non-calcareous. The same type of lithology is exposed around the Sinar Khola, Kulmun (DM 396/ 397) and

Purlung (FL-43/44) areas. In the upper part of this formation a thick (150 m) band of greenish grey, massive, parallel to foliation amphibolite is also present (DM 398, DM 482). The contact of this unit with the underlying Purebensi Quartzite is conformable and sharp (Fig. 3.6). The average thickness of this formation is 750 m (Fig. 3.2).

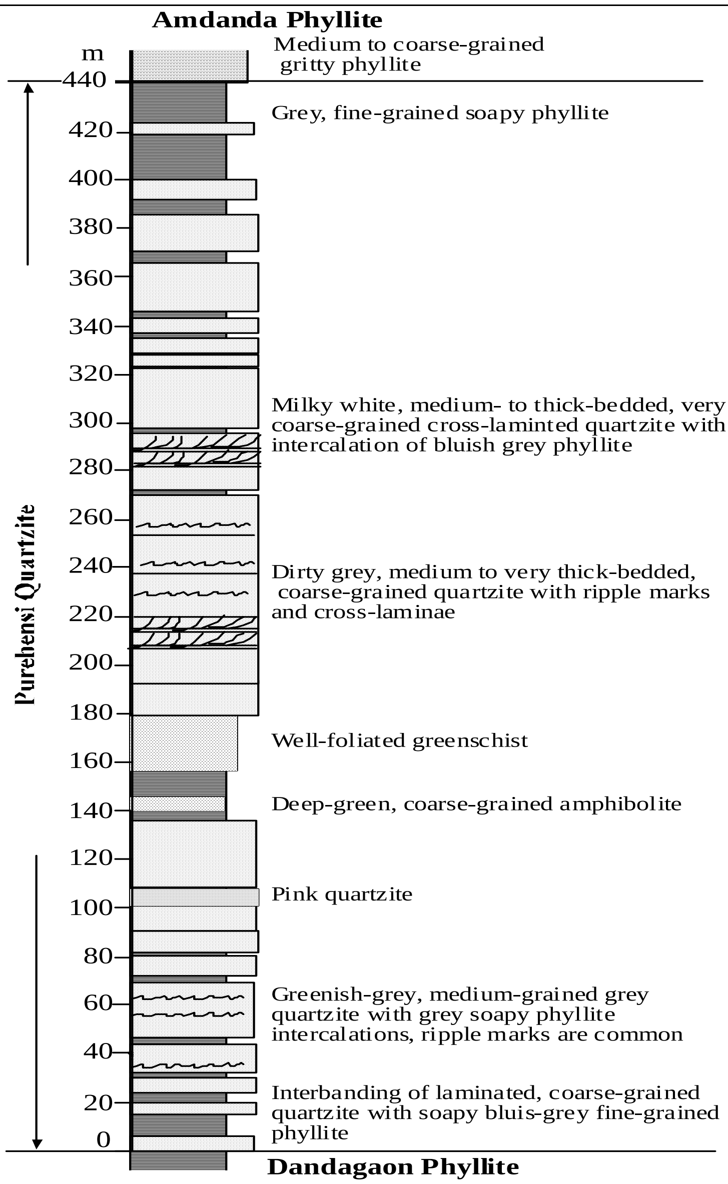


Fig. 3.6 Columnar section of Purebensi Quartzite

3.1.3.1.3. Labdi Khola Carbonate

The upper part of the Nourpul Formation is predominantly phyllite with variable amounts of quartzite, metasandstone and clac-argilaceous rocks (Bhut Khola and Labdi Khola section). The phyllite is grey-green in fresh outcrops whereas in weathered condition, it often shows intense red, purple and brown colors. The quartzite is impure, micaceous, greenish-grey to pink in colour whereas metasandstones are grey to greenish grey, medium to thick bedded and faintly calcareous. Outcrops show regular interbedding of quartzites and phyllites (Plate 8). A cyclic deposit of thinly foliated black phyllite and thin to medium bedded, pink quartzite and white grey to pink, thick bedded, siliceous dolomite is observed in the Bhut Khola section (DM-304). Such cycle repeats up to ten times in the outcrops (Plate 9). Small scale folds (trend/plunge: 270/60) are well observed abundantly in the outcrops.

Both in Labdi Khola and Bagar Khola sections (DM-258, DM-293-296, FL – 45), laminated Amdada Phyllites are followed by ash grey, coarse-grained, medium to thick bedded, metasandstone, orthoquartzite and grey phyllites with sill type metabasics (>50 m thick Fig. 3.1). In Bagar Khola (FL - 45), Bhut Khola and Labdi Khola sections, the topmost part of this calcareous unit is dominated by grey, bluish grey, medium to thick bedded dolomite (FL-46). It consists of abundant algal mats and is brecciated in nature. Mineralization of malachite, azurite, pyrite, chalcopyrite and native copper are extensively developed in siliceous dolomite and orthoquartzites of this unit in Bhut Khola section (DM-303, DM-304, Plate10).Pseudomorphs of gypsum crystals are found in dolomites of upper part of Nourpul Formation. The lower contact with the Amdanda Phyllite is conformable, but the upper contact is with the Benighat Slate, so there is an unconformity between the Labdi Khola Carbonate (the upper member of the Nourpul Formation) and overlying the Benighat Slate. The average thickness of this member is about 615 m (Fig. 3.7).

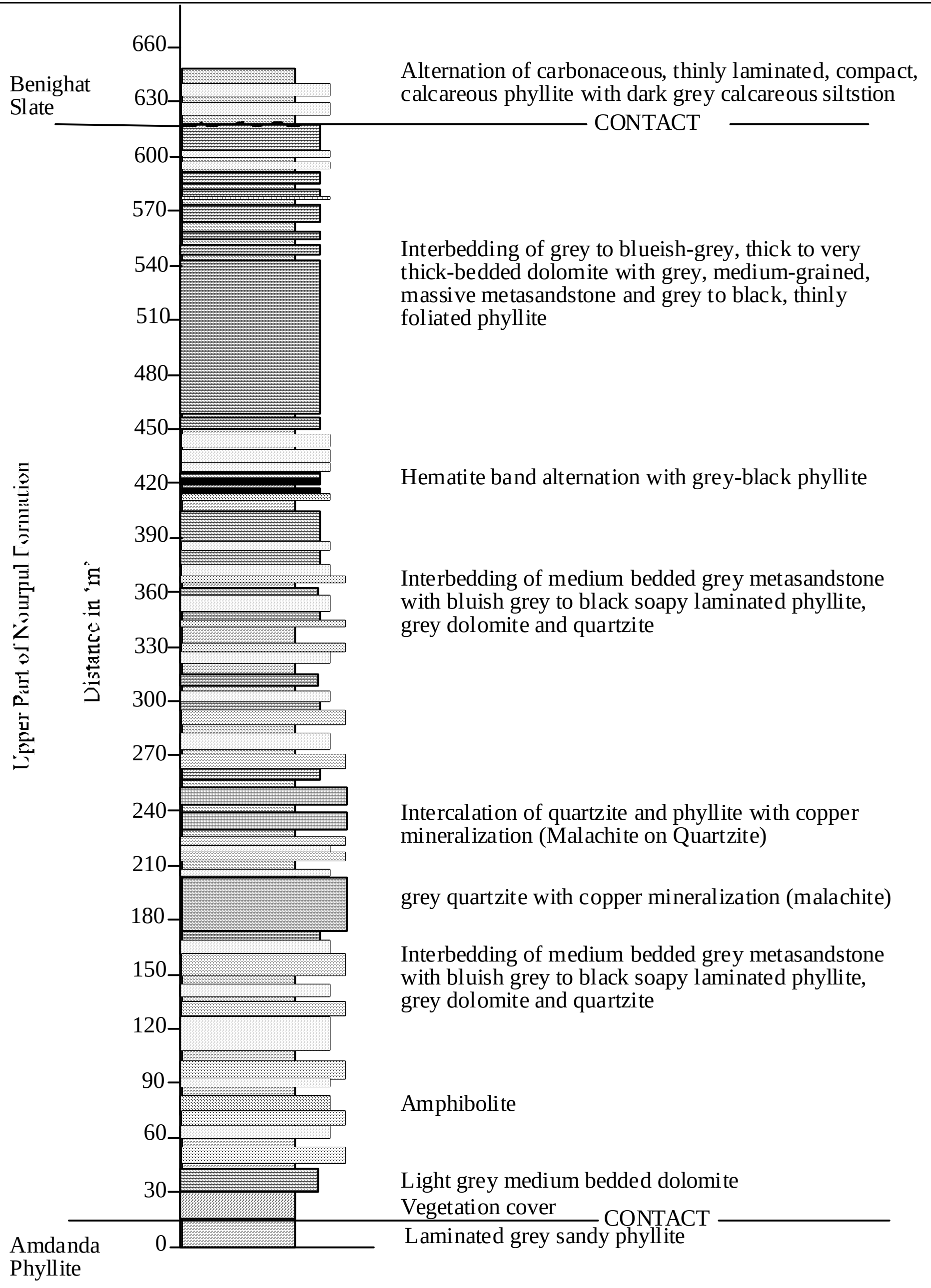


Fig. 3.7 Columnar section of the Labdi Khola Carbonate Member of the Nourpul Formation observed in Labdi Khola.

3.1.3.2. Lithostratigraphy at Bandipur Area

The lithostratigraphy of Bandipur area and Labdi Khola area is not similar in that the Bandipur Slate is developed around Bandipur whereas Labdi Khola Carbonate is limited in the lower part of Jal Bhanjyang Thrust (Fig. 3.8).

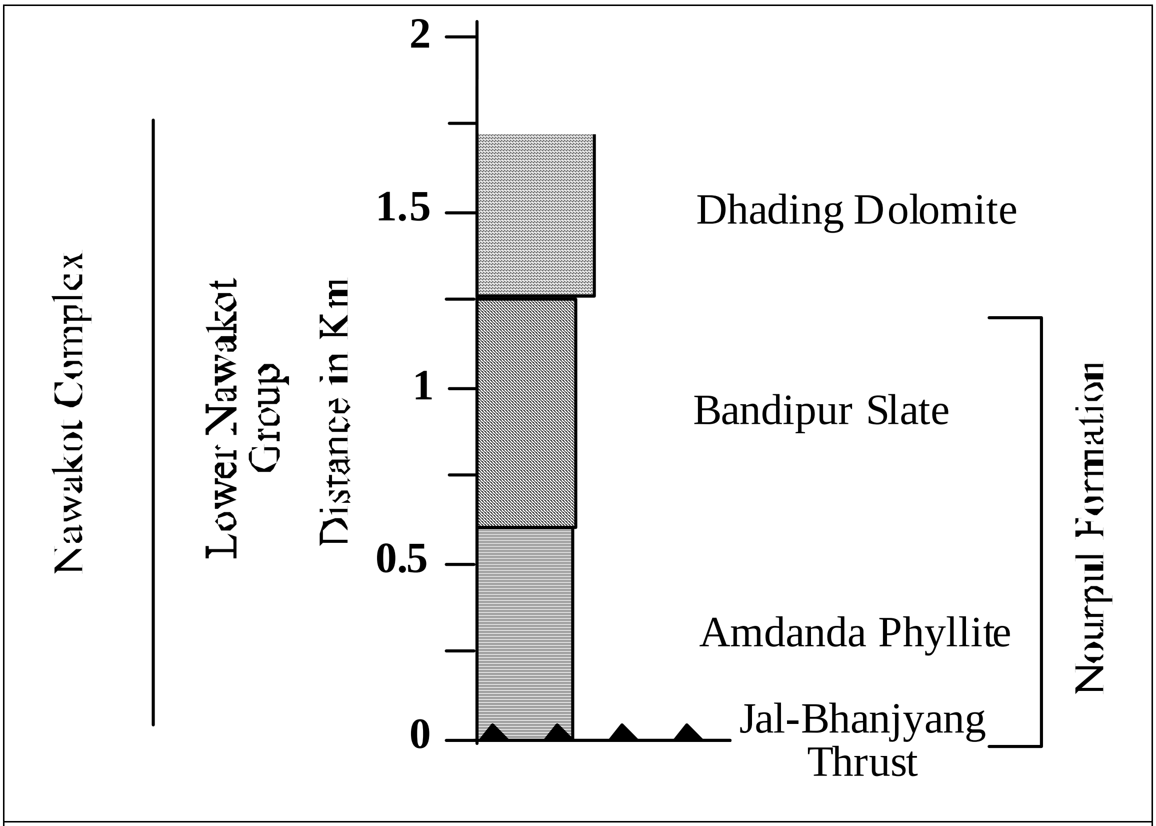


Fig. 3.8 Generalized columnar section of Bandipur area.

3.1.3.2.1. Bandipur Slate

It consists of dark grey to black, thinly cleaved slate with lesser amounts of grey phyllite and greenish grey to ash grey, coarse-grained, medium to thick bedded metasandstone. The slates contain thin strips of carbonaceous matter, which is clearly seen in fresh outcrops. They look typically green-grey and light grey to purple in weathered outcrops.

In the down hills of Bandipur Bazzar, grey, coarse-grained, medium to thick bedded metasandstones with partings of phyllite are observed. Metasandstone beds contain abundant quartz veins and quartz mineralization. Cross lamination is also observed in metasandstone at lower reaches of Bandipur (Plate 11). Cyclic deposition of metasandstone (0.5 cm - 14 cm) and phyllite (3 cm) is significant in some outcrops. Dark grey, well cleaved states are mined extensively for roofing and paving purposes in the territory (Plate 12). Sandy phyllites and metasandstones, that are intercalated with slates are not mined and are left over. This formation does not only contain slate but also phyllite and metasandstone significantly which made the difficulties of correlation with Benighat Slate inserting forceful thrust contact over Nourpul Formation. The average thickness of this formation is >650 m.

Comparison of Lithostratigraphy of Labdi Khola and Bandipur Area

The Labdi Khola area and Bandipur area show difference in lithostratigraphy below and above the Jal Bhanjyang Thrust. The middle member of the Nourpul Formation i.e Amdanda Phyllite in both areas is of same lithology. But the upper member in Labdi Khola area is calcareous containing different mineralization bands i.e Labdi Khola Carbonate Member and in Bandipur area, the lithology is non-calcareous black slate interbedding with metasandstone. The comparison between these two areas is shown in (Fig. 3.9).

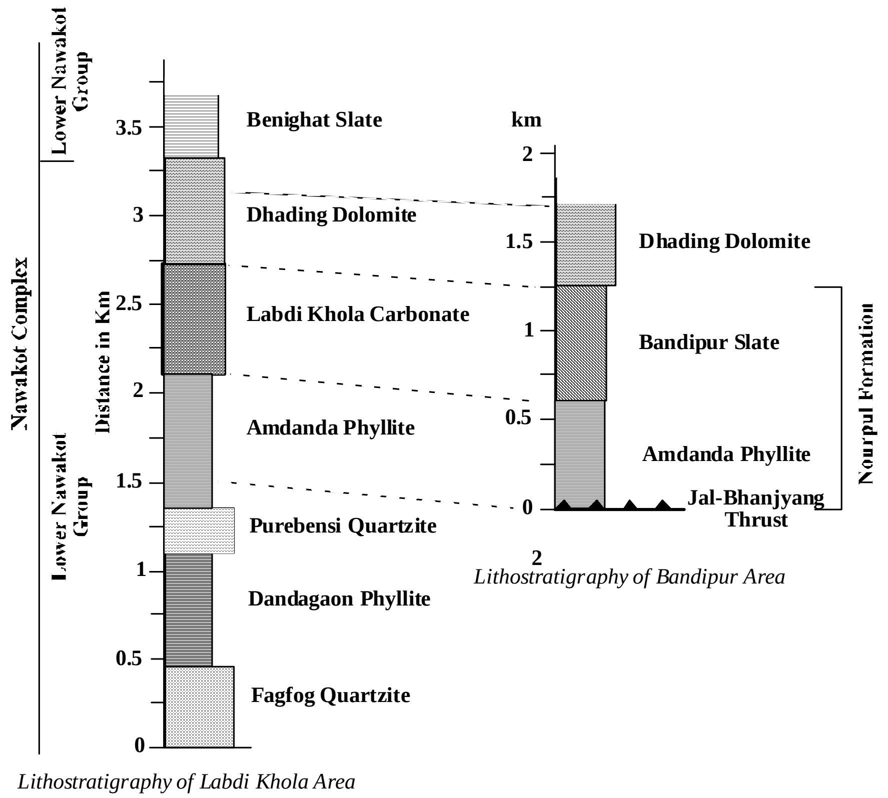


Fig. 3.9 Comparison of lithostratigraphy of Labdi Khola and Bandipur area.

3.1.4. Dhading Dolomite

It consists of grey, medium to thick bedded dolomite (90%) with rare bands of medium bedded, non-calcareous quartzite (10%). Partings of phyllites are also reported with dolomite and quartzite beds frequently. Dhading Dolomite is observed around Dumre Bazzar, lower reaches of Bandipur (L_{69}-L_{72}, DM 335, DM 336, FL-32, FL-35), and Mathillo Jalbhanjyang (FL -40). Poorly preserved algal mats and parallel laminations are distinctly observed in outcrops (Plate 13). Weathered outcrops display elephant skin appearance, honey-comb-structures and some leaching features with many cavernous surfaces. Sometimes, pockets of talk in dolomites are also found in the territory. The same type of lithology is also observed in Takmare and Ripthok areas (DM-387). The average thickness of this formation is > 600m. The variation in thickness is attributable mainly to intense folding and faulting of rocks.

3.2. Upper Nawakot Group

3.2.1. Benighat Slates

In the Malekhu area, the Benighat Slates overlies the rocks of Dhading Dolomite with sharp contact (erosional unconformity?) (Stöcklin, 1980). But in present study area, the Nourpul Formation is directly followed upward by the Benighat Slates. It consists of dark grey, soft weathering, highly foliated, carbonaceous phyllite and slate, mainly argillaceous, subordinately siliceous or finely quartzitic. Also it consists of several folds in different orientations (Plate 14) and the fresh outcrop is dark grey. In some places slate and phyllite show distinct carbonate contents (DM-303).Particularly characteristic of the Benighat Slates are black, highly foliated slate of several meter thick (Plate 15). In Bhut Khola section it consists of dark grey, laminated, fine-grained, calcareous siltstone (40%), intercalated with grey, greenish-grey, soapy phyllite (60%) (DM-303). In the Labdi Khola section (near to Labdi/ Seti Junction), the territory consists of dark grey, thin- to medium-bedded siltstone alternation with carbonaceous slate, almost in the same proportion (DM-292). The characteristic dark slate is usually observed in fresh outcrop along the river banks but in the scree and weathered exposures of the hill slopes show the much lighter color like lead-grey, silver-grey, pink-pale-green etc. The average thickness of this formation is > 350 m.

CHAPTER FOUR

GEOLOGICAL STRUCTURES

Different types of geological structures, regional as well as local structures are found in the study area. Structurally the area is very complicated, and comprises megascopic to microscopic structures of various origin regarding to the geological structures. The structures on the area can be broadly classified into primary and secondary structures.

4.1. Primary Structures

Primary structures are such structures which gives the true information belonging to the structures. The following structures are the structures encountered during field work and have a great importance, which are described below.

4.2.1. Graded Bedding

In our study area graded bedding is observed in the Bandipur Slate, member of the Nourpul Formation at the lower reaches of Bandipur indicating normal stratigraphic position of the area. This clearly indicates that the Dolomite sequence of Bandipur area is younger than the Nourpul Formation.

4.2.2. Cross Bedding

We observed the cross beddings well developed in metasandstone beds of the Bandipur Slate, member of the Nourpul Formation (DM 261, 358). Though cross bedding shows the overturned beds, this is due to the locally folding of the beds (Plate 11).

4.2.3. Ripple Marks

Both wave and current ripple marks are observed in the Purebensi Quratzite of lower part of the Nourpul Formation at Tilbari (Plate 6). This indicates the normal stratigraphic position of the area.

Languid ripple marks are observed on the sandy phyllite of the Upper Part of the Nourpul Formation (Carbonate Member).

4.2.4. Mud Cracks

Mudcracks are observed on the sandy phyllite of the upper part of the Nourpul Formation (Carbonate Member). Mudcrack shows the normal stratigraphic position in the study area (Plate 16).

4.2.5. Biogenic Structure (Stromatolite)

Both planer and columnar types of stromatolites are abundantly observed in the Dhading Dolomite (Plate13). The stromatolitic dolomites are distributed towards North West from Bandipur, Yagchok, Khudi Khola, Samastipur and Dumri Dada. It shows the right side up position of bed in the study area.

4.2. Secondary Structures

The secondary structures are those which are mapable and can be drawn in the map, like fault, fold. The following structures are seen in the study area.

4.1.1. Jal Bhanjyang Thrust

Around Jal Bhanjyang area, thick succession of the Dhading Dolomite is abruptly followed by the older Nourpul Formation. The same type of the rock succession is observed along the Chandrakot, Ripthok, Tilahar, Takmare and Kamalbari areas (Fig. 3.1, 3.2). The Dhading Dolomite consists of grey to light grey, medium to thick-bedded dolomite with columnar stromatolites. The Nourpul Formation consists of laminated phyllite, the middle member. In these localities, the Dhading Dolomite is followed by the typical lithology of the Nourpul Formation and its Bandipur Slate member up section. This is due to the presence of Thrust Fault, which is well studies in the Jal Bhanjyang area and named it as Jal Bhanjyang Thrust in the study. This thrust continuously extends south west of the Jal Bhanjyang as an intra-formational thrust in the Nourpul Formation. This intra-formational thrust is well observed in Kamalbari and Gajeshwara, however due to unfossiliferous monotonous metasedimentary sequence of the Nourpul Formation (laminated phyllite with rare bands of metasandstone) made difficulties to trace the thrust easily in the field.

4.1.2. Hilekharka Anticline

A significant anticline is mapped around Hilekharka area. The core of an anticline is occupied by the Kuncha Formation and Purebensi Quartzite at the top. In the northeastern side this big anticline is followed by syncline (Fig. 3.2 a).

4.1.3. Bandipur Syncline

An adjacent syncline of Hilekharka anticline is mapped around Bandipur area. The core of the syncline consists of the rocks of the Nourpul Formation (Amdanda Phyllite and Bandipur Slate) thrusting over the younger Dhading Dolomite through the Jal Bhanjyang Thrust (Fig 3.2 b). The trend and plunge of this fold is $297^{o}/9^{o}$ as shown in the stereonet (Fig. 3.10)

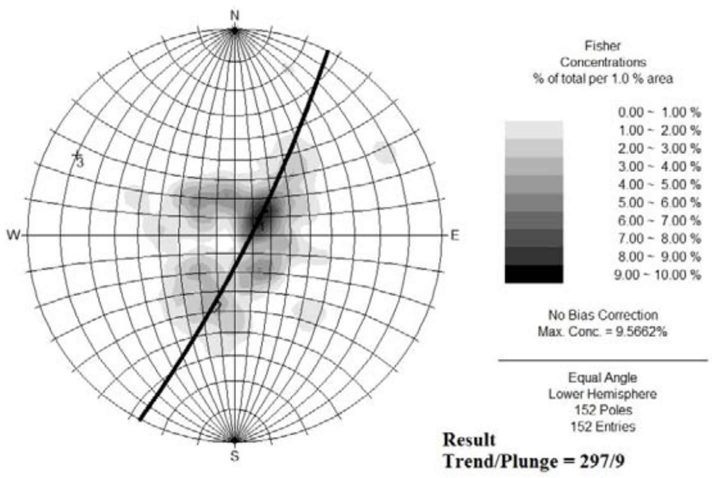


Fig. 3.10 Stereoplot of fold at Bandipur (Bandipur Syncline)

CHAPTER FIVE

MINERAL RESOURCES

Mineral resources play an important role in the development of the country. Detailed geological mapping and further chemical analysis helps in determining the quality of the deposit. The quantity is also important to extract the mineral resources, so reserve calculation is also the main part in determining the quantity of the reserve. The present field work is just based on the detailed geological mapping, where following mineral resources were encountered, but further study is needed to know the quality and quantity of the resources.

6.1. Bandipur Slate

The Bandipur Slate is a member of the Nourpul Formation. Bandipur Slate consists of well foliated slaty flakes of the black slate, which has a great importance and used as roofing stone, paving stone, dimension stone, flooring material, gravestones, and memorial tablets, for electrical insulation and for cladding the buildings (Plate 12). These kinds of qualitative slate cover the extensive areas in Bandipur.

Many old and abandon slate mining areas justify the slate resources of the territory. But due to lack of scientific mining, the extraction of slate is still exploited. In the study area traditional method of mining is operating. The mining is still fully manual in Bandipur slate mines.

The deposit of the good quality slate is not in huge amount. The present slates are also mined haphazardly. Further study is needed to calculate the reserve of the deposit of slate in Bandipur area.

6.2. Bhut Khola Copper Mineralization

Both azurite and malachite copper mineralization (DM-304) are observed in the Bhut Khola (a southern tributary of the Seti Nadi) section (Plate 10). The host rock of copper mineralization is white to pale yellow quartzite. Native ore of chalcopyrite is also observed in grey coloured, thin to medium bedded, siliceous dolomite striking $300^o/74^o$SW (DM-303, 304). To access of the economic deposit and to understand the genesis of the copper mineralization, further study is required.

6.3. Labdi Khola Iron Deposit

More than five bands of Hematite mineralization (thickness of 4cm to 4m) are observed within the beds of quartzite, phyllite and dolomite of upper part of the Nourpul Formation, along the Labdi Khola (Fig.3.11). This iron deposit has been mentioned by Stöcklin and Bhattarai (1977). It is rusting grey to brown in color with high specific gravity (pure) (Plate 17). It has good metallic lustre and cherry red streak.

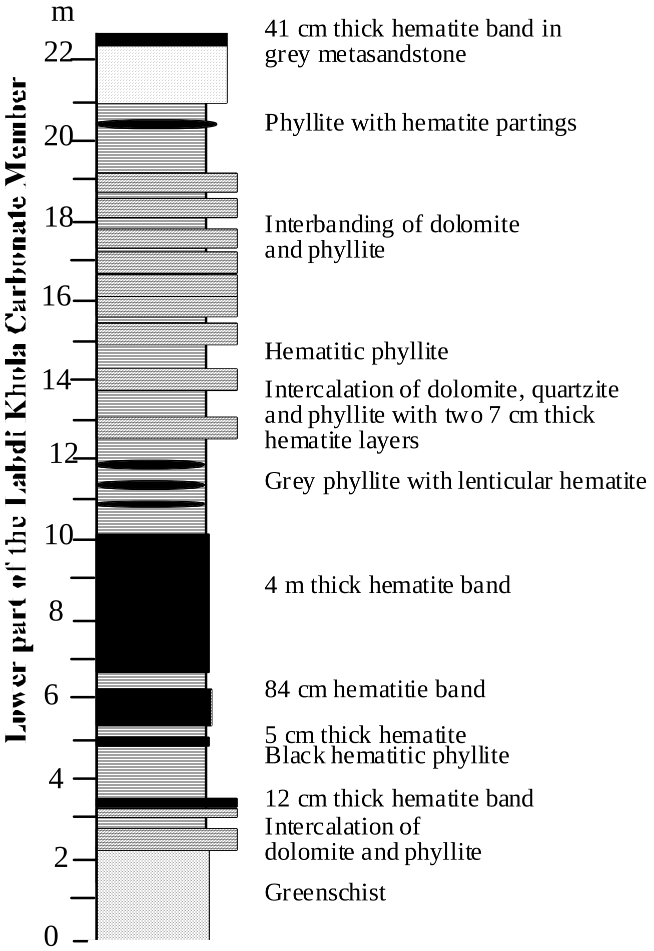


Fig. 3.11 Columnar section showing Hematite bed in the Labdi Khola Carbonate Member of the Nourpul Formation

6.4 Lestar Magnetite Deposit

3m thick grey to dark grey magnetic bands are observed in the lower reaches of Lestar (DM 439). Magnetite deposit is associated with grey, medium to thick bedded fine grained metasandstone (80%) and greenish grey, fine grained phyllite (20%). It has high specific gravity and black streak.

6.5. Graphite Deposit

Extensive graphitic phyllite is observed along the way of Ghumaune–Damauli raod between Ghumaune and Labdi Khola section (Plate 18). It is dark grey to charcoal black in color. It may be economic deposit in the territory. It needs further chemical analysis for the justification of its use as graphite.

Plate 1 Outcrop view of the Fagfog Quartzite

Plate 2 Cross lamination observed in Fagfog Quartzite

Plate 3 Ripple marks on Quartzite bed of the Fagfog Quartzite

Plate 4 Dandagaon Phyllite inliar seen around Chipleti area

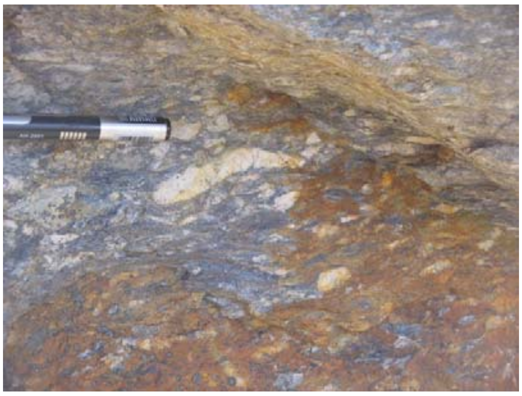


Plate 5 Meta-conglomerate with elongate quartz pebbles in the Dandagaon phyllite at Chipleti

Plate 6 Ripple Marks at Chipleti in the Purebensi Quratzite

Plate 7 Finely laminated sandy phyllite, middle part of Amdanda Phyllite

Plate 8 Outcrop of the upper member of Nourpul Formation (Labdi Khola Carbonate Member at Labdi Khola)

Plate 9 Repetition of pink dolomite alternation with green-grey phyllite in the Labdi Khola Carbonate Member of Nourpul Formation

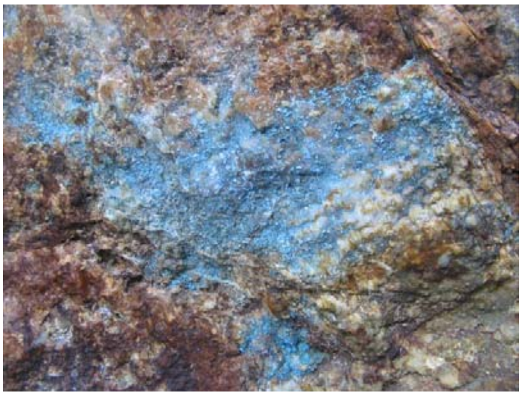


Plate 10Copper mineralization in quartzite boulder, Bhut Khola Section

Plate 11 Cross lamination observed at lower reaches of Bandipur area

Plate 12 Outcrop of Bandipur Slate (Slate Mining)

Plate 13 Stromatolite in Dhading Dolomite, Bandipur

Plate 14 Folded Quartz Veins in the Benighat Slate

Plate 15 Outcrop of the Benighat Slate along Ghumaune to Labdi Section, left bank of the Seti Nadi

Plate 16 Mudcrack showing right side up, in the Labdi Khola Carbonate Member of Nourpul Formation

Plate 17 Haematite band observed in the Labdi Khola Carbonate Member of the Nourpul Formation, Labdi Khola section

Plate 18 Graphite deposit on the way to Labdi from Ghumaune in the Benighat Slate

CHAPTER SIX

CONCLUSIONS

Detailed geological mapping was carried out in the Lesser Himalaya around Hilekharka-Bandipur and Labdi-Keshavtar area. The area comprises low-grade metasedimentary rocks of the Nawakot Complex.

The area comprises the Fagfog Quartzite, Dandagaon Phyllite, Nourpul Formation and Dhading Dolomite of the Lower Nawakot Group and Benighat Slate of the Upper Nawakot Group.

The Nourpul Formation is divided into the Purebensi Quartzite, Amdanda Phyllite, Labdi Khola Carbonate in the Labdi Khola area whereas Bandipur Slate, a member of Nourpul Formation is well developed in Bandipur area. It consists of laminated, grey to dark grey, medium to thick bedded metasandstone, grey sandy phyllite and dark grey to black slate.

The Jal Bhanjyang Thrust, Bandipur Syncline and Hilekharka Anticline are the major tectonic structures in the study area. Many small scale folds are also observed in the area.

Primary structures like ripple mark, mudcrack, graded bedding, foliation and lineation and biogenic structures like stromatolites are also present in the study area.

Economic minerals like copper, iron, slate and graphite are the potential resources of the study area.

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