Annual Report of Department of Mines and Geology

Annual Report No. 11 DMG

July 2019 (Ashadh, 2076 B.S.)

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FOREWORD

Department of Mines and Geology (DMG) is one of the oldest and only government organization responsible for developing mineral based industries, by conducting different geoscientific research activities throughout the country to acquire basic data to attract investor in mineral sector. Our Department is also providing laboratory services through its facility installed in our Geo-chemical, Geo-physical and Geo-techinical laboratories. We are working actively to monitor the seismicity, crustal deformation and strong ground motion by installing different sensors throughout the country. Data from these networks are crucial for infrastructure development and disaster mitigation for safer society. DMG is also coordinating with National Emergency Operation Centre (NEOC) in case of any big geological disasters in the country.

As an outcome of continuous and tireless effort of DMG geoscientist in limestone exploration and government policy for infrastructe (Access road and Electricity), development Nepal is now self-sustained on cement industries which is helping the national economy by reducing the trade deficit. In addition to present activities,DMG will focus on developing metallic, precious and semiprecious stones and other valuable minerals in coming days.

It is my great pleasure to announce that DMG is bringing out a publication entitled 'Annual Report of Department of Mines and Geology' providing geo-scientific and relevant information on mines and minerals that have been undertaken by its different technical teams. I hope this publication will fulfill to provide information who are keen to know the DMG's activities.

I hope the Annual Report will benefit all those who are involved in the field related to geo-sciences. I express my heartfelt thanks for the input of all authors involved in the preparation of this annual report.

A lot of effort has gone into the preparation of this volume to make it a useful and efficient reference. Therefore I would like to thank the Editorial Board for their efforts during the finalization of this volume.

Dr. Soma Nath Sapkota
Director General

EDITORIAL

Information is a lifeline for the development of a nation. The main objective of the Department of Mines and Geology is to generate information about geology, mineralogy, seismology, landslides etc. and use it for the Infrastructural and Mineral based Industrial Development of the country. With the main motive of disseminating these information on geo-scientific research, mapping, mineral exploration and development, geo-environmental studies, seismological research, for the earth scientist, planners, developers and all sphere of stakeholders, Department of Mines and Geology has brought out this Annual Report: Volume 11 for the Fiscal Year 2075/76. Publication and dissemination of this kind of information is a yearly program, but because of the Gorkha Earthquake 2072, and most of the scientist focused on rehabilitation measures, the publication was delayed by three years. After this short interruption in publication, this annual report serves as a continuation of the preceding volumes with some of the significant information gathered over the course of the past three years. The proceeding volumes will also try to accommodate more information which could not make it in this volume.

The Editorial Board is delighted to publish this volume and would like to extend its sincere appreciation and express gratitude to all the authors and staff of the Department for their contribution and cooperation in its publication.

Ram Prasad Ghimire
Chief Editor

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Geological Mapping in Parts of Gorkha, Tanahun, Dhading and Chitwan Districts.

Sujan Devkota (Geologist) | **Sulav Kayastha** (Geologist)

ABSTRACT

This report deals with the results of geological fieldwork carried out in parts of Dhading, Gorkha, Chitwan and Tanahun districts. The present geological study covers the part of the southern limb of Kuncha-Gorkha Anticlinorium, with in the Lesser Himalaya. It consists of the rocks of Lower Nawakot Group of Nawakot Complex. The Nawakot Complex has been divided into Lower Nawakot Group and Upper Nawakot Group, separated by an erosional unconformity. Kuncha Formation is the oldest unit of the Lower Nawakot Group and then Fagfog Quartzite, Dandagaon Phyllites and Nourpul Formation in ascending order represent the present study area. All the above formations are well-exposed along the road and river sections.

INTRODUCTION

The field investigation was carried out in accordance with the approved annual program of the Department of Mines and Geology for the fiscal year 2074/75. The study area lies in Dhading and Chitwan Districts of Province No. 3 and Gorkha and Tanahun Districts of Gandaki Province (Fig 1). This area falls under the topographic sheet no. 2784 03 A & B in the scale of 1: 25,000, published by the Department of Survey, Government of Nepal and bounded by coordinates 84°30'00"E to 84°45'00"E and 27°52'30"N to 28°00'00"N . The study area is about 140 Km west from Kathmandu. It can be easily reached via Prithivi Highway.

There are numerous seasonal roads, foot trails, irrigation canals and ephemeral streams scattered in the area which can be used to take the geological traverses in the area. The elevation ranges from 248 m at Kurenitar to 1714m at north of Manakamana temple. The Trishuli Ganga, Budhi Gandaki, Marshyangdi and Daraudi are major rivers in the study area having the low gradient with wide valleys that generally flow north-south.

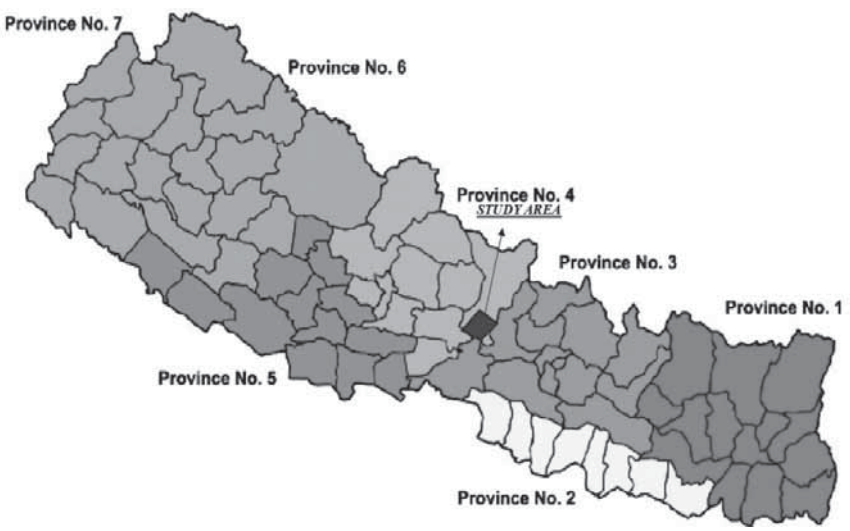


Fig: 1 Location Map of Study Area

OBJECTIVE

The major objective of the present study is to prepare geological map in the scale of 1:50,000 and identify mineral prospect for further exploration in the area.

METHODOLOGY

Previously published geological maps, journals, articles and other related materials were collected and reviewed thoroughly. Further, some inferences were made regarding the geological characterization and potential mineralization in the proposed area. The possible tracks, routes and camping stations were identified prior to the fieldwork.

The bulk exercise of the present investigation was centered on the field study. The geological mapping of the area in the scale of 1: 25,000 was done by detailed field survey. It was prepared by traversing along different river sections, highways, foot trails, newly constructed roads, canals, etc. Sampling was done to represent each rock types from each lithological succession observed in the field. Site sketching, photographs, structural analysis were other activities performed in the fieldwork. Finally, the geological map in the scale of 1:50,000 was prepared in GIS.

PREVIOUS STUDY

Stöcklin and Bhattarai, 1977 and Stöcklin, 1980 carried out a comprehensive geological mapping of the Central Nepal Lesser Himalaya and Katmandu Nappe. Their stratigraphical classification for Central Nepal, Lesser Himalaya and Katmandu Nappe has been still widely adopted (Table 1). They divided the rocks of this region into two Complexes-the crystalline high grade metamorphic rocks of the Kathmandu Nappe (Complex) and the non-crystalline, low grade meta-sedimentary Nawakot Complex.

GEOLOGY OF THE STUDY AREA

The area consists of the rocks of Lower Nawakot Group of Nawakot Complex, Lesser Himalaya namely Kuncha Formation, Fagfog Quartzite, Dandagaon Phyllite and Nourpul Formation (Fig. 6).

Table 1: General Statigraphy of Nawakot Complex

Complex	Group	Formation	Main Lithology	Avg. Thickness	Age
Nawakot Complex	Upper Nawakot Group	Robang formation	Phyllite, quartzite	200–1000 m	Early Paleozoic
		Malekhu Limestone	Limestone, dolomite	800 m	Early Paleozoic
		Benighat Slates	Slate, argillaceous dolomite	500–3000 m	Early Paleozoic
	Lower Nawakot Group	Dhading Dolomite	Stromatolitic Dolomite	500–1000 m	Precambrian
		Nourpul Formation	Phyllite, Metasandstone	800 m	Precambrian
		Dandagaun Phyllites	Phyllite	100 m	Precambrian
		Fagfog Quartzite	White Quartzite	400 m	Precambrian
		Kuncha Formation	Phyllite, Quartzite	3000 m	Precambrian

Kuncha Formation

The formation is well distributed in the north of Muglin and Anbu Khaireni and rest of all study area. It consists of grey, medium to coarse-grained metasandstone and Phyllites with grey to dirty grey, fine-grained small quartzite bands. Outcrop in weathered condition looks yellow-brown. The quartz and feldspar grains in the metasandstone are deformed. The beds are steeply dipping towards south-east and north-west. Beds of dark-grey metasandstone are followed by thin- to medium-foliated, grey, lineated phyllites.

An especially noteworthy feature of the Kuncha Formation is a strong lineation, predominantly in N or NNE direction (Fig. 2). Outcrops of gritty phyllite of Kuncha Formation along the Anbukhaireni to the Gorkha Bazaar road and banks of the Daraudi River show the prominent lineation towards NNE direction. A large territory of this region is covered by monotonous, flysch-like alternation of psammatic phyllite, phyllitic quartzite and purely argillaceous soapy phyllite. Pencil cleavage up to 2 m is developed on strongly lineated phyllite along the road section from Anbu to Gorkha Bazaar. The age of the Kuncha Formation is Precambrian (Stöcklin 1980). The thickness of this formation is more than 3000 m. However base of this formation is exposed nowhere.

Fig. 2 : Lineation Observed in Phylite of Kunchha Formation

Fig. 3 : Ripple Marks in Fagfog Quartzite

Fagfog Quartzite

This Formation is distributed south of Anbu Khaireni and north of Deurali area. It is a marker outcrop forming steep slope in the territory. It consists of white, fine to thick-bedded, medium to coarse grained, rippled quartzite. In weathered outcrops, it seems red-yellow or pale-orange. Graded beddings and ripple marks are the prominent sedimentary structures observed in some outcrops. Thin layers of grey phyllite are rarely intercalated with the competent beds of quartzite. The age of this Formation is Precambrian (Stöcklin, 1980). The contact with the overlying Dandagaon Phyllites is sharp and conformable. The average thickness of this Formation is 400 m.

Dandagaon Phyllites

The Dandagoan Phyllites are well exposed in Apugau, Dharapani, Bhage areas. This unit consists of carbonaceous, finely foliated phyllite with small bands of dark grey quartzites. Thin bands of quartzite are intercalated with thin bands of grey and dark dolomite and calcareous phyllite. The contact with the overlying Nourpul Formation seems to be conformable. The average thickness of this Formation is 350 m.

Nourpul Formation

The Nourpul Formation is exposed only in south west corner of the study area. It is well exposed around west of Kotgaun. The main lithology of this formation includes grey to pink quartzite with ripple marks, purple calcareous phyllite with mudcraks and siliceous dolomite. But in our study area dolomite and other calcareous unit is missing. Based on the lithological peculiarity, the Nourpul Formation can be divided into two members as follow:

Purebesi Quartzite Member

Purebesi Quartzite is widely distributed to south-western hills of Gagansawara, Kotgau and Kalunkholagau. The quartzite on hill areas is light grey, coarse-grained, medium- to thick-bedded (3cm–1.3m) with rare ripple marks. A faint weathering on quartzite shows brown, yellow and rusting coloration. Near Ghokrin, intercalation of metabasic rock (amphibolite) is observed within the Purbesi Quartzite.

Amdanda Phyllite Member

This member becomes the basal member of Nourpul Formation within study area and is exposed west of Apu Gau, Kotgau and Kulunkhola Gau. It consists of fine-laminated, grey and purple phyllite. In many outcrops phyllite alternates with green-grey, laminated, medium- to thick-bedded meta-sandstone. The colour of phyllite is blue-green in places with vivid yellow, pink, purple and violet variations in weathered condition. Quartz veins are frequent and shows the cross cutting relation with lamina. The thickness of laminae varies from 1 mm-1 cm. The contact with the Purebesi Quartzite is conformable and sharp.

Fig. 4: An outcrop of andagaon Phyllite

Fig. 5: An outcrop of Purebesi Quartzite

GEOLOGICAL STRUCTURES

Structurally, the study area is very complicated, and comprises megascopic to microscopic structures of various origin. The different types of structures can be categorized as follows.

Sedimentary Structures

Bedding, laminationa, ripple marks and graded beddinga are the primary sedimentary structures within phyllite, quartzite and slates of the Kuncha Formation, Fagfog Quartzite, Dandagaon Phyllite and Nourpul Formation within the study area.

Tectonic Structures

Manakamana Syncline

The name is derived from Famous Manakamana temple in Gorkha. It is an open and non-cylindrical fold, whose axis passes NW–SE across the whole study area. There are several small folds and shear zones adjacent to limbs of the Manakamana Syncline.

Ludi Khola Anticline

The name of anticline is derived from the tributary to the Daraudi River flowing from NE-SW from Bagdiswara. It is an open and non-cylindrical anticlinal fold whose axis passes NW-SE across the Daraudi River and Ludi Khola. The core of the anticline is observed along the Ludi Khola. Several crenulation folds are observed on the both limbs of anticline.

MINERAL RESOURCES

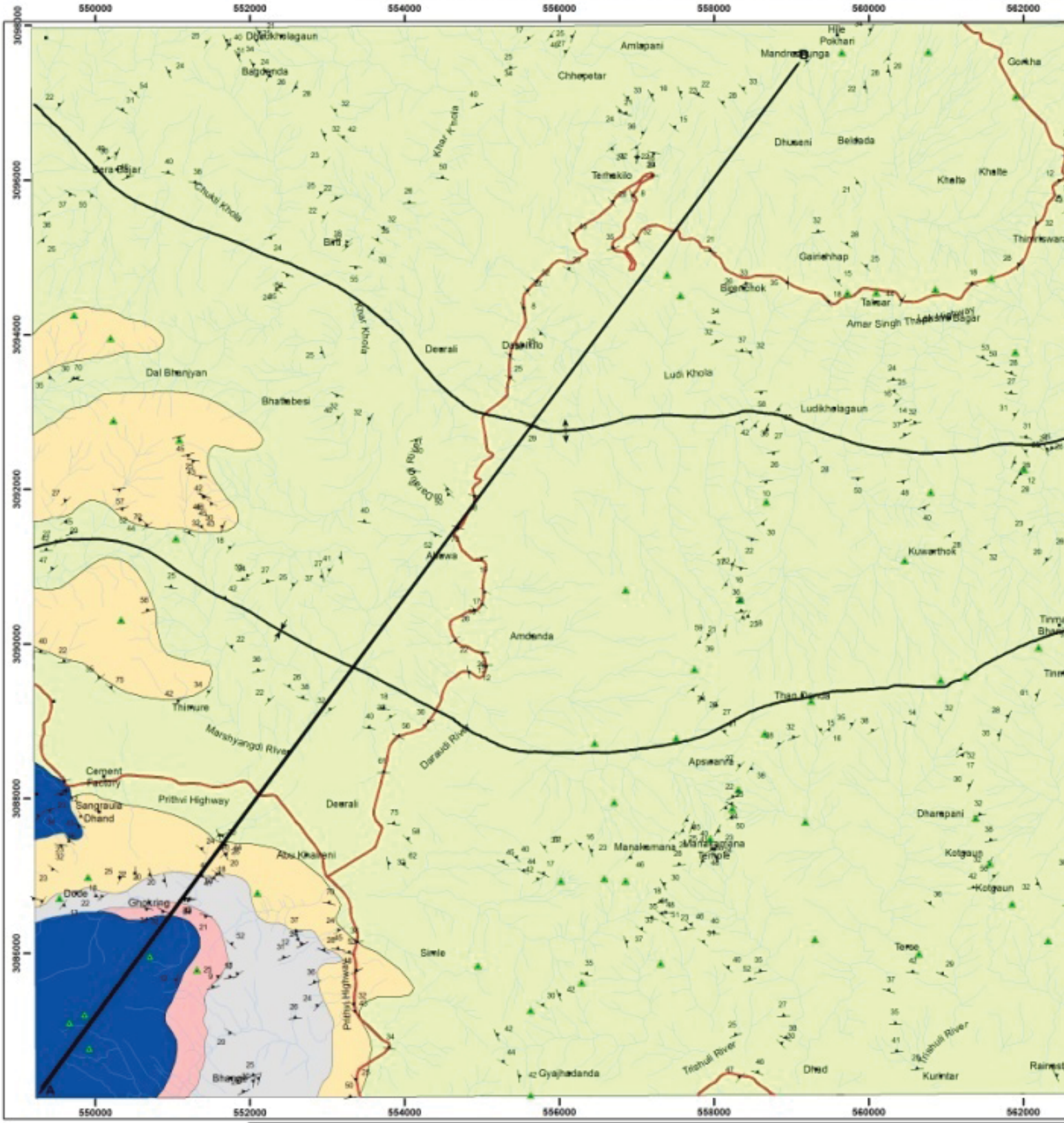
Metallic Minerals

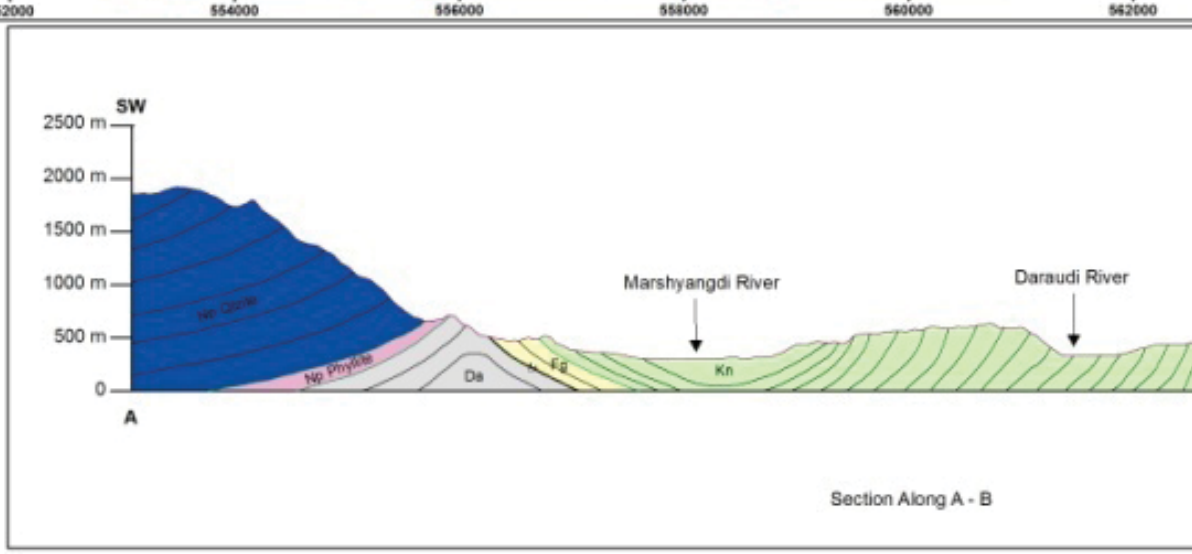
The area is devoid of metallic mineral resources expect copper mineraliztion in two places: within Fagfog Quartzite near Anbu Khaireni (Anbu Prospect, Shrestha et al. 1993), Tanahun district and within kunchha formation, located about 1 km west of Bhanjayan village at Dhuwakot, on the fairly gentle western of Dhuwakot Dada in Gorkha district.

Non-Metallic Minerals

Construction materials like quartzite, sandstone, aggregates are non metallic minerals in the study area which are frequently found in different lithological units of study area. The study area consists of three major tributaries of Saptagandaki River. i.e. Buri Gandaki in east, Daraudi in middle and Marshyangdi in west part of study area. The aggregates deposited at the bank of these rivers are the main sources of construction materials in vicinity area. Numbers of crusher industries are in operation within the study area based on river aggreagates. Sand deposit of the terraces of Burigandaki River seems more economical due to its location and quantity.

GEOLOGICAL MAP OF MANAKAMANA- GORKH





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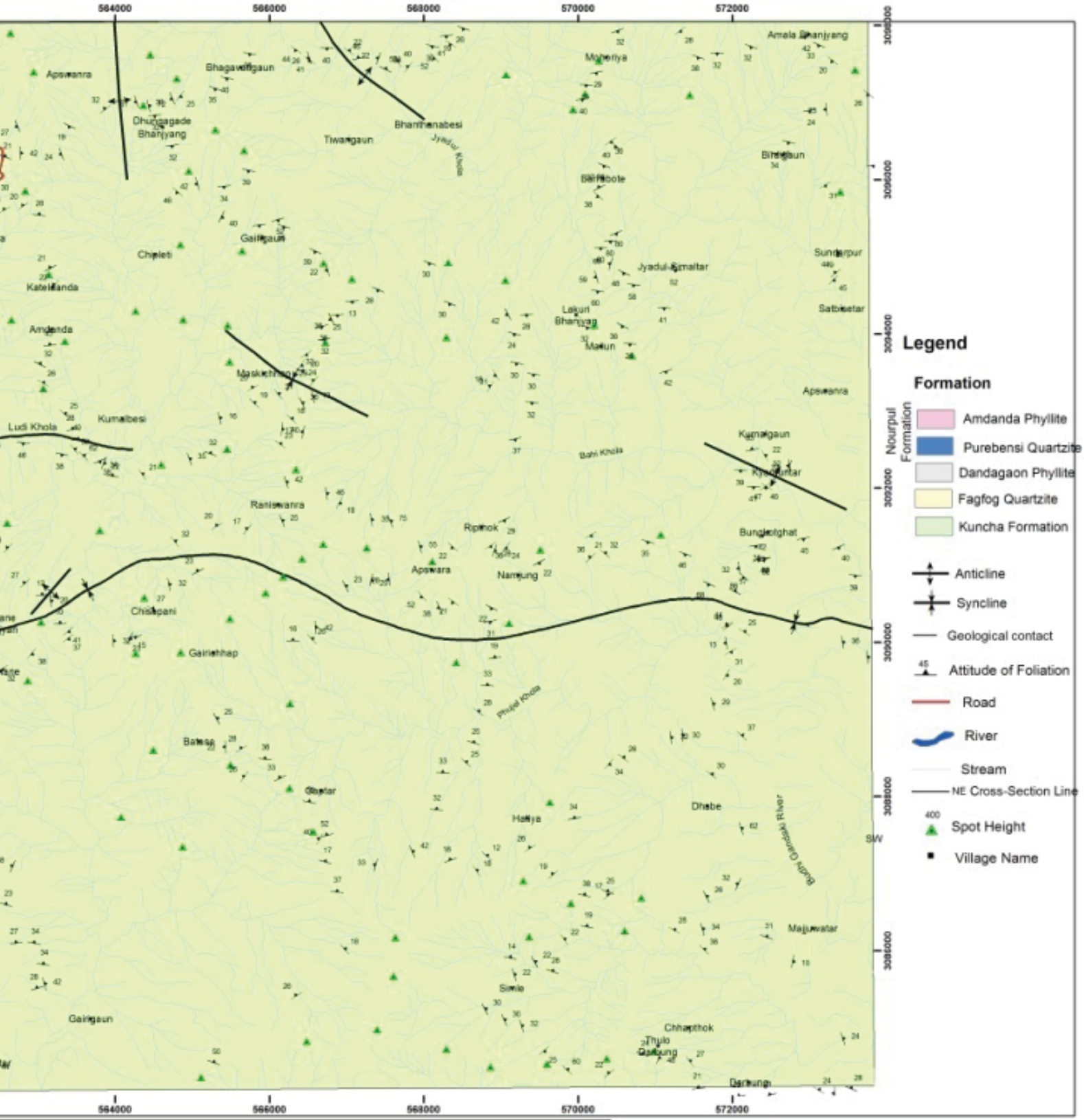
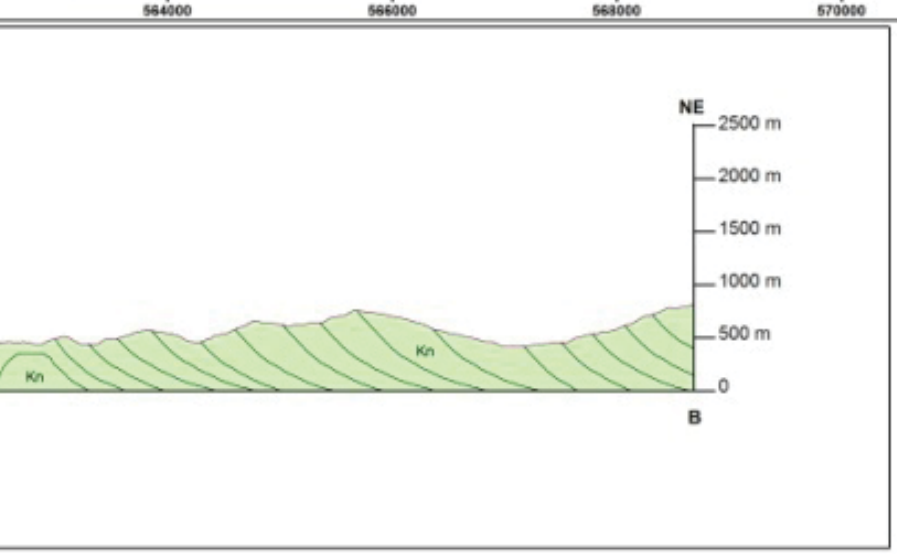
HA AREA (TOPOSHEET NO. 2784 03A & 03B)





CONCLUSION

The present study belongs to the small part of Lesser Himalaya, the metasedimentary rocks of Lower Nawakot Group of Nawakot Complex. The rocks of Kuncha Formation, Fagfog Quartzite, Dandagoan Phyllites and Nourpul Formation of Lower Nawakot Group of Nawakot Complesx are exposed in this area. The Kuncha Formation consists of thinly foliated, light green to grey, lineated phyllite which is followed by the intercalation of grey to dark grey metasandstone. The Fagfog Quartzite is a medium to coarse-grained white orthoquartzite with several phyllitic intercalations. The Dandagaon Phyllites consists of uniform argillaceous to finely quartzitic phyllite of dark, blue-green colour. The Nourpul Formation is a mixed lithology of phyllitic and quartzitic rock types. The Purebesi Quartzite member contains a clean arkosic fine- to coarse-grained quartzite. Cross beddings and ripple marks are much more frequent in the beds of quartzite. The middle part of the Nourpul Formation contains predominately phyllite with variable amount of quartzitic and calcareous intercalations.

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Geological Mapping for Mineral Exploration in Parts of Achham, Dailekh and Surkhet Districts

(Topo sheet no. 2881 02A, B, C &D)

Suresh Shrestha(Senior Divisional Geologist) | **Lokendra Pandeya** (Geologist) | **Manoj Bista**(Asst. Geologist)

ABSTRACT

Geological mapping of Parts of Achham, Dailekh and Surkhet districts (Topo sheet no. 2881 02A, B, C& D) for mineral exploration was carried out as per the departmental program of the fiscal year 2073/074. The study area consist of four sequence of rocks each separated by the two prominent Thrusts and an unconformity. The northern most thrust i.e. Ranimatta Thrust separates the lesser Himalaya crystalline rocks of Dailekh Group from Metasedimentary rocks of Surkhet Group and Lakharpata Group. The rocks of Surkhet Group and Lakharpata Group are separated by an unconformity. Likewise the rocks of Lakharpata Group are separated from the rocks of Siwalik Group by the prominent thrust, Main Boundary Thrust (MBT). The Dailekh group consists of different types of quartzites, phyllites, schist, feldspathic schist and considerable amount of dark grey to green basic intrusive as main rock types. The Surkhet group consists of metasedimentary rocks like metasandstones, shales, quartzites. The Lakharpata group consists of limestone, dolomite, slate and shale as the main rock types with basic intrusive at few places. The Siwalik Group consists of sandstones, mudstones, shale, and conglomerates as the main rock types.

BACKGROUND

Geological mapping for the mineral exploration in some Parts of Achham, Dailekh and Surkhet districts of the Far Western and Mid-Western parts of Nepal were carried out as per the departmental program of the fiscal year 2073/074. The field work was for the 45 days at first phase and 30 days for second phase.

LOCATION AND ACCESSIBILITY

The study area lies in Surkhet, Dailekh and Achham districts with the Topo sheet no. 2881 02 A, B, C &D (Fig:1). The study area is easily accessible by a blacktopped road from Kathmandu to Birendranagar, Surkhet and then to Tunibagar of Dailekh district via Karnali Highway. The distance from kathmandu to Tunibagar is about 740 km.

TOPOGRAPHY AND DRAINAGE

Topographically the study area lies in the Siwalik and Mahabharat region. It consists of highly rugged topography with dissected valleys and lots of cliff along the right and left bank of Bheri River. Similarly limestone dolomite and quartzite also create steep slopes and cliffs along the banks of Karnali River and near the Main Boundary Thrust. The maximum elevation is 2258m at Manpokhari area and minimum elevation is about 220 m near Ghatgaon along the bank of Bheri River. The study area have dentric drainage pattern. Karnali and Bheri Rivers are the main rivers that drain the study area.

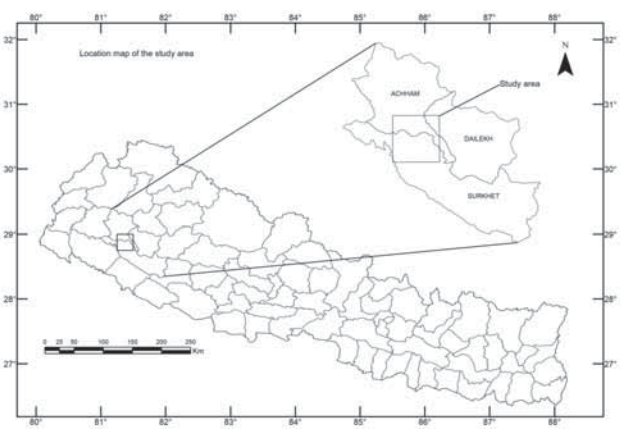


Fig: 1: Location Map of the Study Area.

PREVOIUS STUDY

A number of geological traverses and mapping of the area were carried out by Nepalese as well as by foreign geologists. Among them Nepalese geologists worked in the area to prepare regional geological map and detailed mapping around the Chaukune Limestone Deposit. Kaphle K.P. (1979) carried out geological study of Chaukune Limestone regarding the overall chemical properties of the limestone for the cement production. Khatri D.B. (1986) carried

out the study on Surkhet Limestone Deposit. Sthapit N. R. (1978) carried out the preliminary exploration and detailed study of the cement grade limestone deposit in the Charkune- Surkhet area including the exploration drilling. Jwarchan I. L. (1985) prepared the report on the investigation of Surkhet Cement grade limestone Deposit. Bhaila K. B. (1978) carried out geological mapping around Lakharpata and Chaukune area, in the Surkhet. Pradhan U.M.S (1973) carried out geological mapping of Surkhet and Dailekh districts, Western Nepal. Similarly Thapa G.S. (1985), prepare geological map of portion of Surkhet, Dailekh, Achham, Doti area Western Nepal.

OBJECTIVES

The main objective of the program is geological mapping and to explore the mineral potential of the study area. The objectives can be listed as follows:

- To carry out the geological mapping for evaluating the mineral potential of the area using 1:25,000 scale topographical map as base map.
- To collect necessary data for the publication of geological map at 1:50000 scale.

SCOPE AND LIMITATION OF THE STUDY

The present study was carried out to find the mineral potential of the study area and to delineate the different lithological units by taking traverse in the accessible routes by using brunton compasss and geological hammer with camera to take necessary photographs. A Geological Map of the study area was prepared by the combination of present field study and the previous researches from Department of Mines and Geology. In the present study, due to limitation of time, some of the parts were not studied. So the lithological division of the southern part mainly south of the Main Boundary Thrust covering Sub-Himalaya was taken from the geological map of Petroleum Exploration Block 2, Karnali, Far-Western Nepal Published by Petroleum Exploration promotion Project, 2003.

REGIONAL GEOLOGY

Regionally in the present study area consists of rocks of Siwalik Group and Lesser Himalayan. From the regional map of Far and Mid-western Nepal published by DMG in 1:250000 scale, regional stratigraphy can be summarized as follows (Table No. 1).

Table 1: Regional stratigraphy of the study area (J.N.Shrestha and others, 1985)

Stratigraphy				
Group	Formation	Main lithology	probable age	Approximate thickness
Quaternary	Quaternary	Alluvial gravels, boulders and sands	Pleistocene	
	Upper Siwalik	Boulders, conglomerate, sandy clays	Middle Miocene to early Pleistocene	
	Middle Siwalik	Arkosic pebbly sandstone , clays		6000 ft
	lower Siwalik	fine sandstone , clays, purple shales		9000 ft
Main Boundary Thrust				
Surkhet	Suntar Formation	Shale and limestones	Eocene - Oligocene	4000 ft
	Swat Formation	Shale and limestones		1250 ft
Laharpata	Lakharpata Formation	Limestones, stromatolitic dolomites shales	Late Precambrian -Early Paleozoic	5250 ft
	Syangja Formation	shales, quartzite and dolomte		
	Sangram Formation	shales		
Ranimata Thrust				
Dailekh	Ranimatta Formation	phyllites, quartzites, conglomerates, basic rocks	Late Precambrian	10000 ft
	Kusma Formation	phyllites, quartzites, basic rocks		2000 ft
Dadeldhura	Kalikot Formation	biotite schist and quartzites	Precambrian	

GEOLOGY OF THE STUDY AREA

The study area consists of four sequence of rocks each separated by the two prominent thrusts and an unconformity (Table No. 2 and Fig. 2). The northern most thrust i.e. RanimattaThrust separates the lesser Himalaya Crystalline rocks of Dailekh Group from Metasedimentary rocks of Surkhet Group and Lakharpata Group. The rocks of Surkhet and Lakharpata Groups are separated by an unconformity. Likewise the Lakharpata Group rocks are separated from the Siwalik Group rocks by the prominent thrust, MBT.

Dailekh Group consist of four Formations named as Dhamali Quartzite, Hulakdanda Formation, Shirkot Formation and Thapagaon Formation in ascending order and mostly consists of different types of quartzites, phyllites, schist, feldspathic schist,augen gneisses and lots of dark green basic rocks. Lakharpata Group has only one Formation in the study area and named as Gawar Formation which consists of limestones, dolomites with shales and few slates as the main rock types. Surkhet Group consist of three Formations named as Melpani Formation, Swat Formation and Suntar Formation from older to younger respectively. This group mainly consists of sedimentary and metasedimentary rocks like metasandstones, shale and quartzites. Siwalik group rocks are divided in to three Formations as Lower Siwalik, Middle Siwalik and Upper Siwalik from older to younger respectively. This group consists of fine to coarse grained sandstones, mudstones, shales and conglomerates as the main rock types.

Table no. 2: Stratigraphy of the study area

Group	Formation	Main lithology	probable age
Siwalik	Upper Siwalik	Boulders,cobblepeeble conglomerate, sandy clays	Middle Miocene to early Pleistocene
	Middle Siwalik	Arkosic salt and pepper textured sandstone ,pebbly sandstone , clays and mudstone	
	Lower Siwalik	Variegated mudstone fine to medium grained sandstone, clays, purple shales	
Main Boundary Thrust			
Surkhet	Suntar Formation	Purple, green grey shales and metasandstones	Eocene - Oligocene
	Swat Formation	Pencil clevaged grey Shales	
	Melpani Formation	white and brownish ferrugeneous quartzite	
Unconformity			
Laharpata	Gawar Formation	Limestones, stromatolitic dolomites, shales	Late Precambrian -Early Paleozoic
Ranimata Thrust			
Dailekh	ThapaGaon Formation	Schist, phyllite and quartzite	Precambrian
	Shirkot Formation	Feldspathic schist and augengneisis with basic rocks	
	Hulakdanda Formation	Talcosic, white and grey quartzites, phyllites, schist, basic rocks	
	Dhamali Quartzite	Quartzites, phyllites with basic intrusives	

DAILEKH GROUP

Dailekh Group consist of older most group of rocks in the study area and is divided in to four Formation named as Dhamali Quartzite, Hulakdanda Formation, Shirkot Formation and Thapagaon Formation from older to younger respectively and mostly consists of different types of quartzites, phyllites, schist, feldspathic schist, augen gneisses and lots of dark green basic rocks.

Dhamali Quartzite

It is the older must rock unit of the study area. This Formation is separated in the south by Ranimatta Thrust. The rocks of this Formation are well exposed at Toshi, Dhamali, Rabalde, Tunibagar and along the Karnali River.

It consist of thin to very thick bedded, grey to white coloured, fine to medium grained quartzite with dark grey to greenish grey phyllite. The quartzites are very massive and jointed. Quartzite forms very steep cliff in both side of the streams in many cases creating difficult terrain for the study. Quartzites observed in the base are thin bedded highly fractured and crushed with small scale folds in which phylllite intercalation is common. The phyllites observed are light grey to darkgrey, sometimes greenish grey in colour. Mostly the phyllites observed near the thrust are dark grey to black in colour,with quartz veins, fractured having undulated surface and wavy beds with small scale folds. There are lots of basic intrusives in this Formation. The basic rocks observed are dark greenish grey, fine to coarse grained and well foliated. Outcrop of basic rock near Dhamali area along Phulam Khola, consist of magnetite mineralization. Basic rocks are outcropped mainly in Phulam Khola, Kumalu Khola, Ramgad and Rani Khola area.

Hulakdanda Formation

It is well exposed at Hulakdanda, Sigaudi, Basalikhola. It consist of white to light grey, medium to coarse grained, thin to thick bedded sericitic quartzite with frequent intercalation and interlayering of grey schist and grey to dark grey pyllites. The phyllite consist of lots of quartz veins. Few lens and thin beds of talc are developed but during the traverse economic talc deposit could not be found. Basic intrusives which is coarse to medium grained dark green to grey can be observed at many places.

Shirkot Formation

It is well exposed at the left and right bank of Thar Khola and Basali Khola. It consist of thin to thick bedded coarse to very coarse grained feldspathic schists with white feldspar grains. In some parts the feldspathic schist are metamorphosed to banded gneiss with well-developed gneissic structure and in few cases augen structures are also developed. Basic intrusive which is coarse to medium grained dark green to grey can be observed at many places.

Thapagaon Formation

Thapagaon Formation lies over the Shirkot Formation and well exposed at Thapagaon, Maithum, moyakanda area. Grey to white schist, grey quartzite and dark grey phyllites are main lithologies. In some parts like near Moyakada garnet are also developed in the white schist. Phyllites are highly sheared with wavy beds and consist of quartz veins. As in the other Formation basic intrusive is also observed at many places.

LAKHARPATA GROUP

Lakharpata Group has only one Formation in the study area and named as Gwar Formation which consists of limestones, dolomites with shales and few slates as the main rock types.

Gawar Formation

Gawar Formation is separated by a Main Boundary Thrust (MBT) in the south from the Siwalik group rocks and by an unconformity from the rocks of Surkhet Group in the north. This Formation extends from east to west throughout the study area but the thickness of this Formation at the western part is more than the eastern part. The rocks of this Formation are exposed in Rekcha, Chaukune, Kuwa, Khaud, Chappre, Pokharidanda, Dobata area.

The main rock types observed are limestone, dolomite with few shale and slate intercalation. There are grey to light ash grey coloured, bluish grey, thin to very thick bedded fine grained limestone with few intercalation of grey to purple coloured shale and bluishgrey dolomite. The limestones consist of lots of stromatolites. The limestone near the contact with the siwalik group rocks are highly crushed, fragmented and re-cemented. In many places near the MBT one can observe lots of re-cemented fragments and boulder of limestone covering the rocks of siwaliks. There are lots of solution cavities with recrystallized calcite, caves, sink holes, faults and folds in this Formation.

A thick succession of bluish grey to light grey, thick to very thick, massive, fined grained stromatolitic dolomite can be observed above the limestone. The thickness of dolomite is very little in the eastern part as compared to western part. Similarly dolomite are followed by a dark grey to grey shale, dark grey to black thin to medium bedded limestone and black slate with calcareous concretion and this is the upper part of this Formation. The thick successions of dolomite are only observed in the western part of this Formation.

There are basic rock intrusions in many places in this Formation. The basic rocks observed in this Formation are dark greenish grey in colour, medium to coarse grained and moderately to highly weathered. Villages like Dobata and Athepokhari basic rock are found.

SURKHET GROUP

Surkhet group consist of three Formation named as Melpani Formation, Swat Formation and suntar Formation from older to younger respectively. This group mainly consists of sedimentary and metasedimentary rocks like metasandstones, shale and quartzites.

Melpani Formation

Melpani Formation is separated by an unconformity from the rocks of Lakharpata Group, i.e Gawar Formation in the south and swat Formation conformably lies over this Formation. This Formation

extends from east to west throughout the study area but the thickness is not very thick, only 50m to 100m thick. It consist of dark grey to brownish grey ferruginous thick to very thick bedded quartzite and light grey to grey strong thick bedded, massive quartzite. Basal conglomerate boulders could be observed along the Dabri Khola which consists of limestone and dolomite clast. It also consists of iron concretion in some parts.

Swat Formation

Swat Formation is overlain by the rocks of Suntar Formation and underlain the rocks of Melpani Formation. It extends from east to west throughout the study area. Dark grey to grey, slightly to highly weathered, pencil cleavage, crumpled splintery shales are the main rock types.

Suntar Formation

Suntar Formation conformably overlies the rocks of the Swat Formation and is separated by a thrust called Ranimatta Thrust from the rocks of Dailekh group. The main rock types are different colouredshales and metasandstones. There are thin to thick bedded, fine to medium grained, slightly to moderately weathered red-purple coloured shale, greenish grey shale with grey shale intercalation with the interlayering of red-purple, green to dark grey metasandstone. The rocks are highly fractured, jointed and folded near the thrust. There are lots of quartz veins in both metasandstone and shales near the thrust. Thickness of individual beds of sandstone and shale varies from few centimeters to meters. This Formation is exposed at Tharmare, Jaisur, Nada, Kolimara, Malbela, Amgaon, Kuntegaon and Wadaltodke areas.

There are basic rock intrusions in many places in this Formation. The basic rocks observed are dark greenish grey in colour, medium to coarse grained and moderately to highly weathered.

SIWALIK GROUP

The rocks of Siwalik group can be divided in to three units as, Lower Siwalik, Middle Siwalik and upper Siwalik. There are lots of faults and thrust with in the Siwalik group.

Lower Siwalik

Lower Siwalik is lowermost unit of Siwalik Group rocks and well exposed at low altitude in Gutu, Maital, Bidhyapur, Chour and Biju area. It extends from east to west forming gradational contact with Middle Siwalik rocks in the north and thrusted contact with Upper Siwalik in the south. It consists of variegated green-yellow-purple-grey coloured, fine grained, medium to very thick bedded, slightly to highly weathered mudstone and few siltstone with interbedding and intercalation of grey-yellow-light brownish coloured, medium to very thick bedded, fine to medium grained arkosic sandstone. There are few calcareous and ferruginous concretions with in the variegated mudstone beds. In some cases these beds are only lenticular and extended up to few meters but some places calcareous and ferruginous concretions beds occurs as thin to medium bedded intercalation within mudstones. The thick bedded sandstones are highly jointed. In many cases jointed sandstone blocks fail due the jointed rocks and weathering of soft mudstone which are intercalated and inter layered with sandstone.

Middle Siwalik

Lower Siwalik is followed by the rocks of Middle Siwalik and it extends from west to middle part of the study area and pinches towards east. In the north it is separated from the rocks of Lakharpata Group by the MBT. It consist of medium to very thick bedded , medium to coarse grained, yellowish grey, salt and pepper textured sandstone with inter-bedding of variegated, fine grained, thin to very thick bedded mudstone and siltstone. Near the MBT the sandstone are very hard and seems like quartzite and are highly fractured. The sandstones are moderately to highly weathered forming like loose sand deposit.

Upper Siwalik

Upper Siwalik rocks crops mainly in the southwest part of the study area like Ghatgaon, Kumala, Sunkada areas. Upper Siwalik consist of boulder, cobble, pebble matrix supported conglomerate with minor yellowish grey mud, silt and sand lenses in the conglomerate. It has a thrusted contact with the lower Siwalik in the north. Conglomerates of Upper Siwalik forms cliff at the right and left bank of Bheri River in the Ghatgaon area. In most places the conglomerate rocks disintegrate forming the rounded to sub rounded boulder, cobble and pebble deposit like alluvial deposit making difficult to measure the attitude of beds. The boulder, cobble and pebble of the conglomerate rocks are mostly of quartzites, some limestones and metasand stones, few basic rocks and siwalik sandstone. The quartzictic boulder, cobble and pebble are milky white, pink, dirty grey dark grey brown in colour. The limestone boulder, cobbles are light grey, white, and ash grey and fine grained. In most cases the cementing materials are calcareous in nature.

The rocks of this Formation are mainly exposed in the Kumala and Ghatgaon area.

Fig. 2: Thick bedded ash grey strong quartzite along Ramgad Khola

Fig. 3: White sericitic quartzite near Rambazar

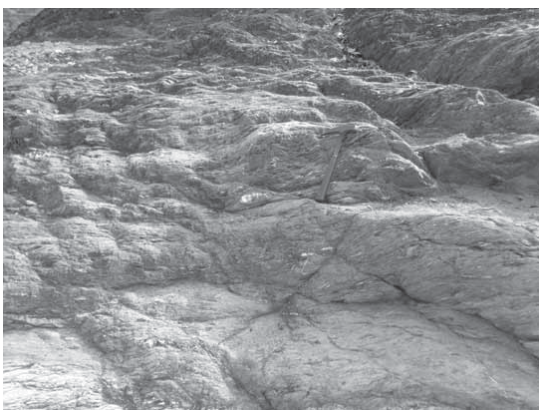


Fig. 4: Dark grey phyllite with quartz veins

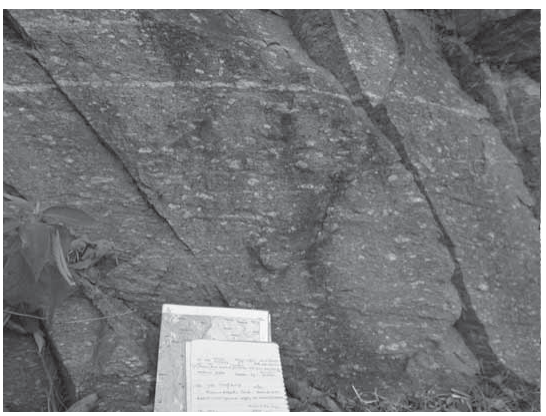


Fig. 5: Dark grey feldspathic schist with conspicuous white feldspar

Fig. 6: Light grey limestone observed at top of Khaud village

Fig. 7: Grey shale of Swat formation observed near

Fig. 8: Red purple shale of Suntar formation near Nada

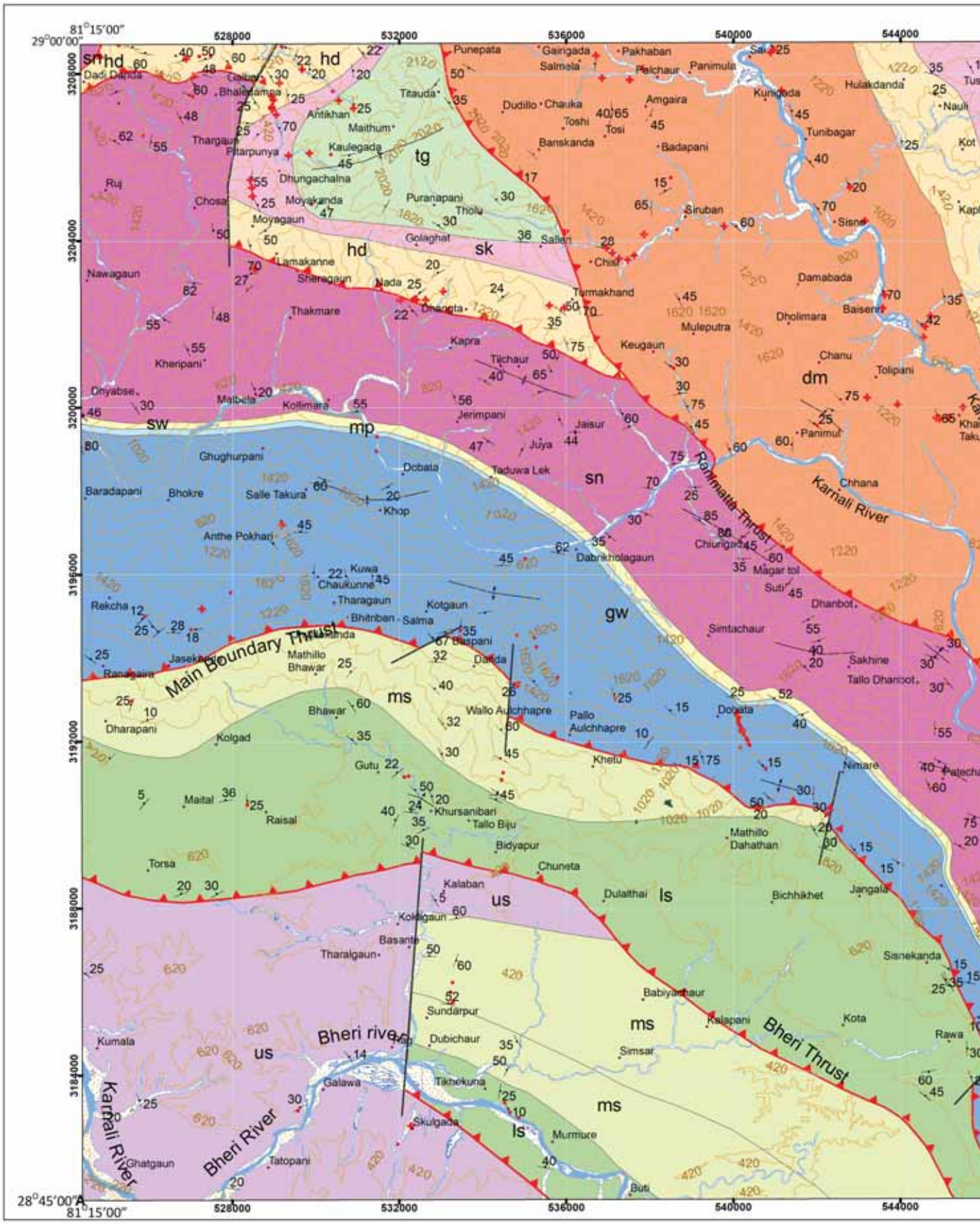
Fig. 9: Very thick bedded conglomerate of upper Siwalik

CHEMICAL ANALYSIS OF LIMESTONE

Chip sampling of the limestone terrain of Gawar Formation was conducted during the field and 102 samples were collected by continuous chipping at five meter interval.

All together 177 samples of different rocks and minerals were collected, among them 127 samples of limestones and other possible minerals were submitted to the chemical lab for the chemical analysis. 102 samples collected from the continuous chipping at 5m interval from limestone terrain of the Dobata area, 12 grab sample from Khaud area both belonging to the Gawar Formation and 8 samples of

Fig. 2.Geological Map of the parts of Surkhet,Dailekh and Achham district, Toposheet no. 2881 02 A



ABCD.

Legend

geology

- us — Upper siwalik
- ms — Middle siwalik
- ls — lower siwalik
- sn — Suntar Formation
- sw — Swat Formation
- mp — Melpani Formation
- gw — Gawar Formation
- tg — Thapagaon Formation
- sk — shirkot Formation
- hd — Hulakdanda Formation
- dm — Dhamali Quartzite
- Basic Rock

PHYSIOGRAPHIC FEATURES

- sample_point
- 1580 Contour
- village name
- Stream River
- 143 Spot Height in metre

STRUCTURE

- Geological contact
- Thrust
- Fault
- Anticlinal axis
- Synclinal axis
- 20° **Attitude of bedding/foliation**

N

0 3.5 7 Km

1:125,000

metallic minerals from the study area were send to the chemical laboratory for the chemical analysis. The chemical analysis of 102 samples from chipping of limestone terrain, shows CaO range from 51% to 16% and MgO 0.95% to 16.23%. The comparative chart of CaO, MgO, Al2O3 and Fe2O3 is shown in the figure below. Similarly the samples from the Khaud area also show the CaO content of 48% to 23% and MgO content 1% to 20%. Seven metallic minerals were tested for the copper and iron contents but the chemical analysis shows very low copper and iron content as 3 to 260 mg/kg and 4.2 to 28.58% respectively. A sample of lead zinc chemical analysis which shows 0.9% Pb, 4.16% Zn, 6.9 mg/kg Ag and 0.39% sulphur.

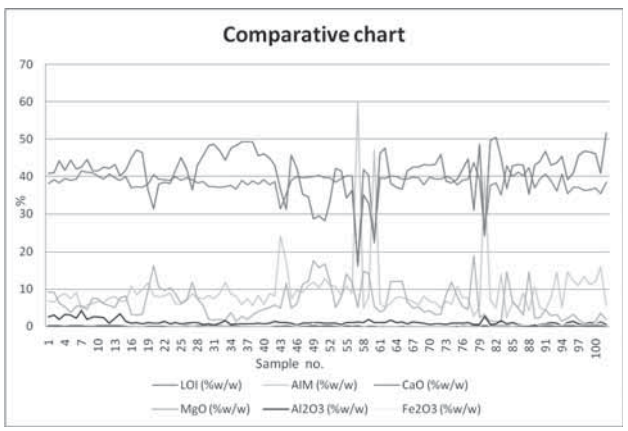


Fig. 10: Comparative chart of the CaO, MgO, Fe_2O, and Al_2O_3 of the chipped samples from Dobata area.

CONCLUSION

The study area consist of four sequence of rocks each separated by the two prominent Thrusts and an unconformity. The northern most thrust i.e. Ranimatta Thrust separates the rocks of Dailekh Group from metasedimentary rocks of Surkhet Group and Lakharpata Group. The rocks of Surkhet Group and Lakharpata Group are separated by an unconformity. Likewise the Lakharpata Group rocks are separated from the Siwalik group rocks by the prominent thrust, MBT.

Besides the main two regional structures i.e. MBT and Ranimatta Thrust there are many small scale faults, folds and thrusts in the study area.

All together 177 samples were collected in the field and among them 112 samples of limestone were send to the chemical Lab for the chemical analysis. 10 grab samples collected from the khaud area's Chemical analysis shows the average CaO and MgO contents 43.9% and 3.9% respectively.

All the samples collected by chipping from the Dobata area and grab samples from Khaud area belong to the Gawar Formation. Chemical analysis of the collected samples shows the average percentage of CaO more than 40% (with in the range of 15 to 51%).

During the field study significant metallic deposit couldn't be found along the traverse route and chemical analysis of few metallic samples collected from different parts of the study area also shows low content of the metal, i.e., copper and iron content as 3 to 260mg/kg and 4.2 to 28.58% respectively.

RECOMMENDATION

Chemical analysis of the grab samples collected from Khaud area and chip sample from Dobata area indicate that limestone might be of cement grade. So further chip and channel sampling is recommended.

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Geological Study of Iron Mineralization Zone Pokhari Area, Hupsekot Rural Municipality, Nawalpur District, Gandaki Province, Nepal

Narayan Banskota, Senior Divisional Geologist | **Naresh Maharjan,** Geologist

ABSTRACT

Pokhari area consist rocks of Lakharapata and Surkhet Groups of Lesser Himalaya and Siwalik Group of Sub-Himalaya, the two being separated by Main Boundary Thrust (MBT). The rocks north to the MBT are folded into an eastern plunging syncline with the rock of Surkhet Group in the core. Hematite band are interbanding within quartzites and slate exposed along the Melapani Formation of the Surkhet Group. The hematite mineralization is mapped almost continuously east-west in the southern limb of syncline in Pokhari area in extension of 2000 m. The mineralization is faulted in many places with displacement in the extension. Hematite which is grey band blue with crimson internal reflection visible coarser grain are 0.02-0.3mm, net-like dense basement partially filled between round quartz sand grains or local Distribution of inclusion particles and Cryptocrystalline gangue minerals mixed with mass aggregates. The fine particles mostly surround the round sand core and consist of an oolitic particle that constitutes a single or multiple laminated layers. Surface and sub-surface detail exploration in Pokhari area has shown average grade of hematite as TFe 36 % with proved reserve of 5 million tons and 20 million tons as probable reserve.

INTRODUCTION

Iron mineralization in Pokhari area of Hupsekot Rural Municipality-5, Nawalpur district, Gandaki Province was preliminarily studied in FY 2068/69. The prospect was then followed and explored in detail during FY 2072/73 and 2073/74. The study area lies is topographic map of 100-09 (entitled DHOBADI) of scale-1:25,000 published by the Department of Survey, Government of Nepal and encompass the area of 6 sq. km. within coordinate (UTM) of 3069000 m to 3071000 m north and 506000 m to 509000 m East 4 (Fig. 1). Pokhari lies about 21 km north from Danda, East-West Highway. The hematite mineralization zone was traced within the strike extension of 2000 m. The paper presents the resource potentiality and it's industrial application.

Fig. 1: Political location of the Mineralization zone

GEOLOGY OF THE AREA

Rocks of Lesser Himalaya in north and Sub Himalaya in south are exposed within the study area. The Lesser Himalaya is thrusted over the Sub Himalaya along north dipping Main Boundary Thrust (MBT). The Lesser Himalaya consists of rock of Lakharpata Group and Surkhet Group. The Surkhet Group rest unconformably above Lakharpata Group. Surkhet Group consists of Charchare Formation, Melpani Formation and Suntar Formation where shale, quartzite, metasandstone are exposed. Similarly Lakharpata group consists of undifferentiated quartzites, slates, dolomite and limestone

Table 1: Lithostratigraphy of Pokhari Area (Adopted after Kayastha, 1992)

Tectonic Unit	Group	Formation	Lithology	Age
Sub-Himalaya	Siwalik	Middle Siwalik	Sandstone, Mudstone, Conglomerate	Middle Miocene-Pleistocene
Main Boundary Thrust				
Lesser Himalaya	Surkhet	Suntar Formation	Metasandstone, Slate/shale	Oligocene-Early Miocene
		Melpani Formation	Quartzite, slate/shale, with hematite	Late Cretaceous-Paleocene
		Charchare Formation	Diamictite, Slate, Conglomerate	Permian-Early Cretaceous
	Unconformity/fault			
	Lakharpata	Lakharpata (undiff.)	quartzite, slates, dolomite, limestone	Late Precambrian-Early Paleozoic

SIWALIK GROUP

The sandstone interbeded with mudstone belonging to the Middle Siwalik are mapped south of the MBT. The pepper and salt sandstone is thick-bedded to masive and is interbedded with variegated siltstone, mudstone and shales. The proportion of sandstone is dominant over the mudstone.

SURKHET GROUP

Three formations of the Surkhet Group are mapped in the area.

Charchare Formation: It is the oldest formation of the Surkhet Group. The formation has an unconformable and faulted boundary with the Lakharpata Group. The formation consists primarily of dark gray to black slate with subordinate amount of gray to greenish gray metasandstone.

Melpani Formation: The Melpani formation has been found to be important geological formation for Iron exploration. The formation consist of black to olive green claystone, green quartzite, thick bedded white quartzite and black shales interbedded with hematite beds.

Suntar Formation: The formation consists predominantly of dark gray to dark greenish gray metasandstone and purple to dark gray shale/slate. The metasandstones are largely massive, but are occasionally medium- to thick-bedded.

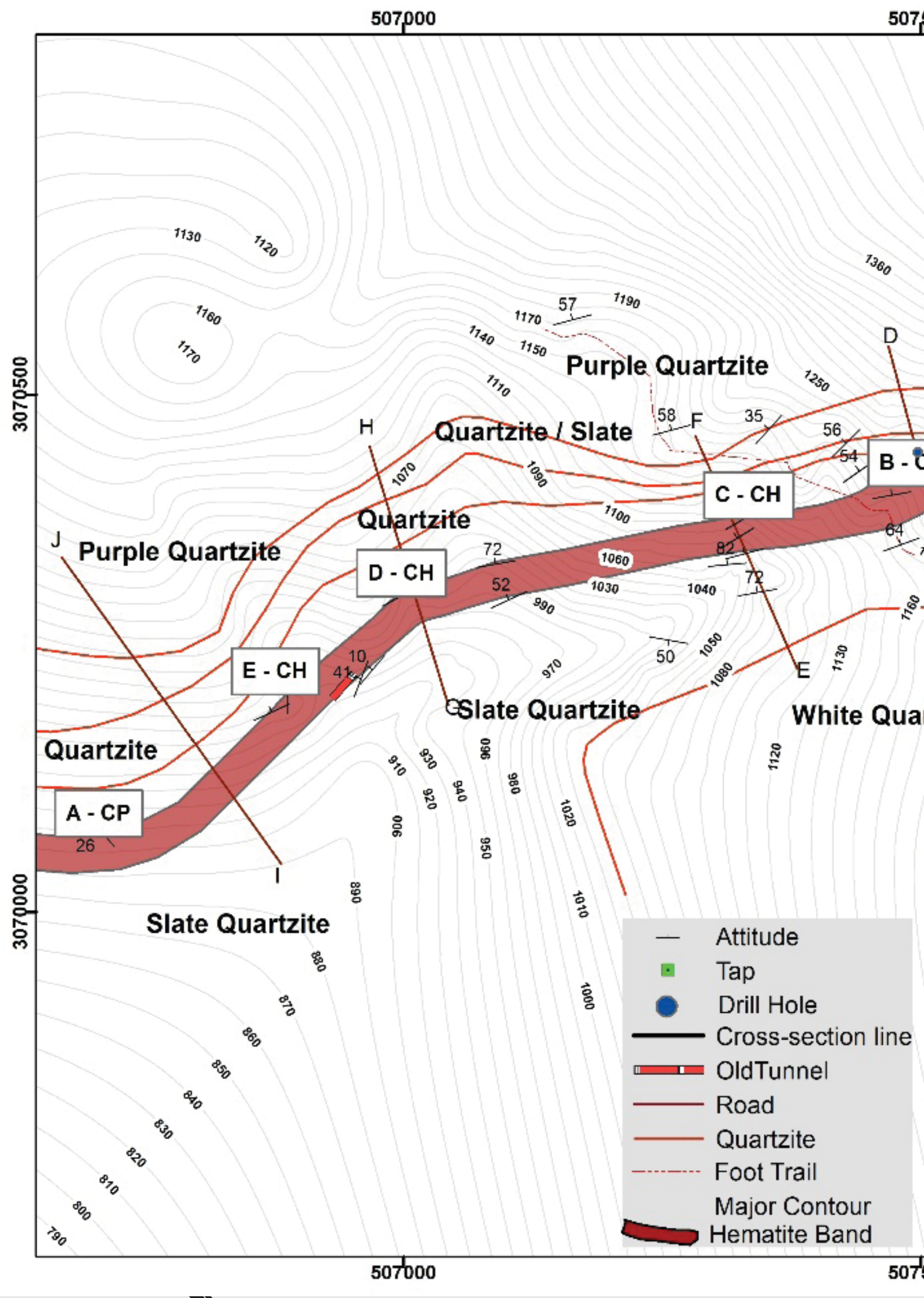
LAKHARPATA GROUP

The Lakharpata Group consists of Ramkot Formation (equivalent to Nourpul Formation) and Gawar Formation (equivalent to Dhading Dolomite). Lakharpata Group in the area is found not important for iron exploration; the formations of the group are therefore mapped as Lakharpata Group undifferentiated. The group consists of gray dolomites, gray limestones, pink quartzites and slates.

MINERALIZATION OF HEMATITE

The Hematite mineralization is found in the Melpani Formation of Surkhet Group. The hematite zone was traced almost east-west extension of southern limb of syncline. However in the northern limb, it is found to be omitted at most places probably by fault. However due to longitudinal and transverse faults, the zone is largely obliterated in the northern limb. About 10 km length of Hematite Mineralization was traced previously with the Melpani Formation of Surkhet Group of Rock.

The mineralized zone consists of black to olive green shale, green quartzite, thick bedded white quartzite and black shales interbedded with hematite beds. Few Hematite beds seems to more siliceous. The mineralized band is displaced by local fault. The average thickness of mineralization band is about 25 m. The hematite is thin to massive bedded and is interbedded with grey to olive green quartzite and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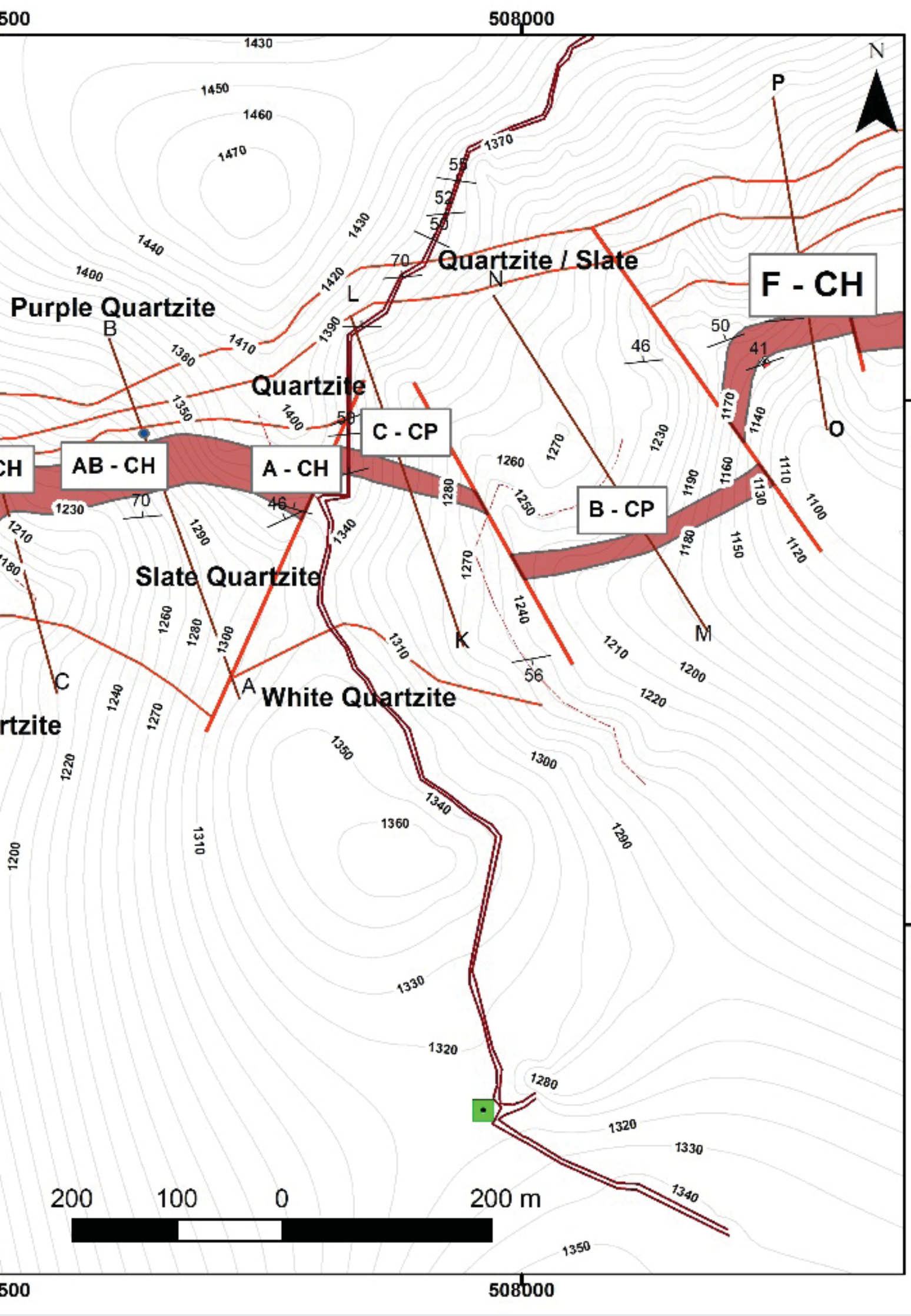
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greenish grey to grey slate. The ore is compact, fine to coarse grained, oolitic and siliceous in the form. The genesis of iron ore deposit of Dhauwadi-Pokhari is of sedimentary metamorphosed hematite–magnetite type as the other important iron deposits of Nepal (e.g. Phulchauki Iron Deposit, Thosey Iron Deposit.

GEOLOGICAL EXPLORATION WORK

For the assessment of the quality and quantity of hematite deposit, the area was geologically mapped for an area of 102 ha. Surface as well as exploratory drilling works have been completed. A total of 57.43 m of chip samples over 4 sample sections contained 56 samples. The area was then channel sampled over 8 sample sections (Fig 2). Total of 190 channel samples were covered within the total meterage of 202.52 m. A total of 105.35 m of drilling was covered by two drill holes (Hole -1: 65.20 m and Hole -2: 40.10 m) to assess the subsurface mineralization. Iron mineralization of 21.21 m was encountered in Hole -1, whereas Hole -2 was abandoned within iron mineralization. The average core recovery was 58%. Detailed explored area covered 20 ha area.

QUALITY ASSESSMENT OF DEPOSIT

The quality of hematite ore is analyzed both mineralogical and chemically. The chemical analysis was done in Chemical Laboratory of Department of Mines and Geology, Lainchaur, Kathmandu and South-West Metallurgical and Geological Testing Center (SMGTC), Chengdu, China under Sichuan Institute of Metallurgical Geology and Exploration, Chengdu, China.

Mineralogical Study of Hematite ore

a. Microscopic study under thin section and polished: All together 9 hand specimen size 10 cm X 10 cm namely HA-1, HA-2, HA-3, HB-1, HB-2, HB-3 HC-1, HC-2, HC-3 was collected from Pokhari area (Pokhari block). The thin section and polished section were prepared and analysis in South-West Metallurgical and Geological Testing Center (SMGTC), Chengdu, China under Sichuan Institute of Metallurgical Geology and Exploration, Chengdu, China.

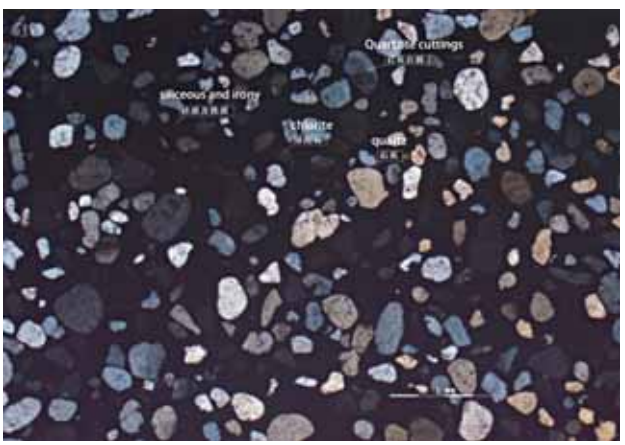

Fig. 2a: Microscope Observation of HA-1, Hematite sample View of thin section with crossed nickel

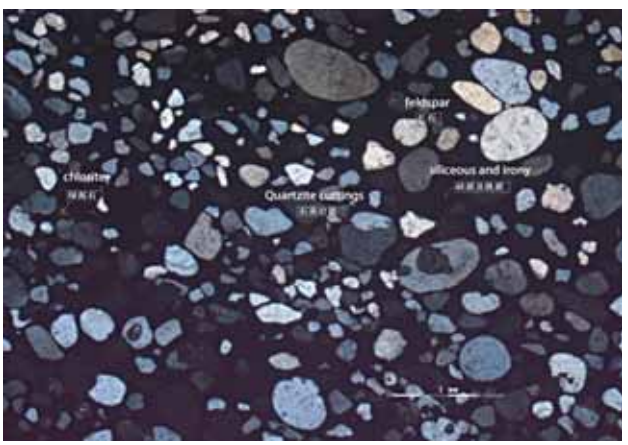

Fig. 2b: Microscope Observation of HC-1, Hematite sample View of thin section with crossed nickel

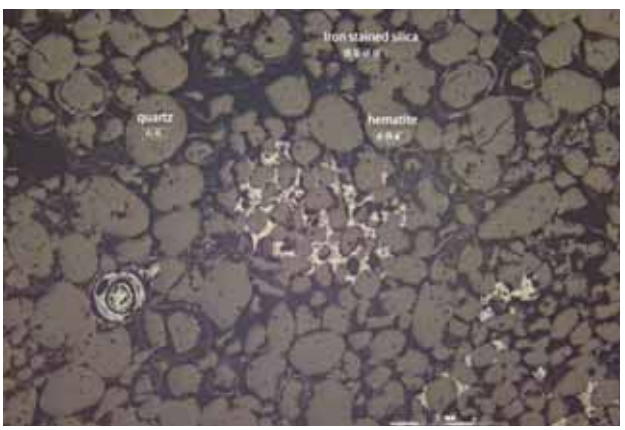

Fig. 3a: Microscope Observation of HA-1, Hematite sample View of polished section

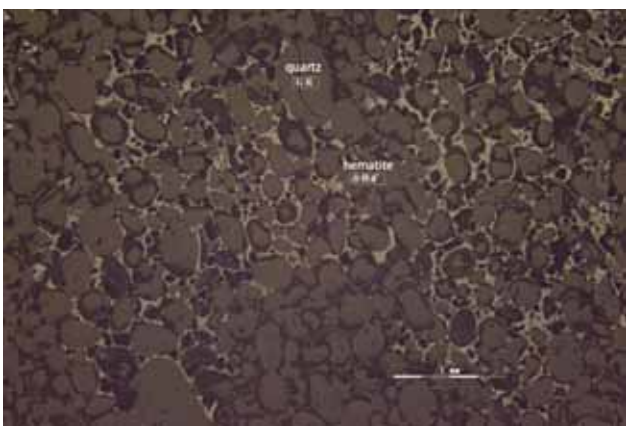

Fig. 3b: Microscope Observation of HC-1, Hematite sample View of polished section

Grain size: Coarse medium grain fine grain quartz detrital structure

Component and content: Rock fragment near % mainly quartz interstitial matter near 50% mainly siliceous irony 10-15% a little chlorite

Size and shape: Fragment particle size 0.05-0.83 mm main part 0.1-0.2 mm. The shape is like a round shape and mainly content is quartz. Interstitial matter mainly contents iron-stained cryptic silicon and some irony and chlorite.

Structure Fine structure, Net-like basement filling structure, oolitic structure

Mass structure: Metallic minerals are hematite: 10-15%.

Hence, Hematite is grey band blue with crimson internal reflection visible. Hardness greater than needle (5.5), coarser one is 0.02-0.3 mm, net-like dense basement partially filled between round quartz sand grains or local distribution of inclusion particles and Cryptocrystalline gangue minerals mixed with mass aggregates. The fine particles mostly surround the round quartz core and consist of oolitic particle that constitutes a single or multilayered layer of laminated layers.

b. Mineral Composition Analysis

X-ray diffraction (XRD analysis) method used to determination of mineral content of the iron ore. The hematite ore sample from Pokhari was grinded to a fine powder, typically in a fluid to minimize inducing extra strain (surface energy) that can offset peak positions, and to randomize orientation. Powder less than ~10 µm (or 200-mesh) in size is preferred and placed in a sample holder or onto the sample surface and analysis in XRD Machine in South-West Metallurgical and Geological Testing Center, Chengdu, China.

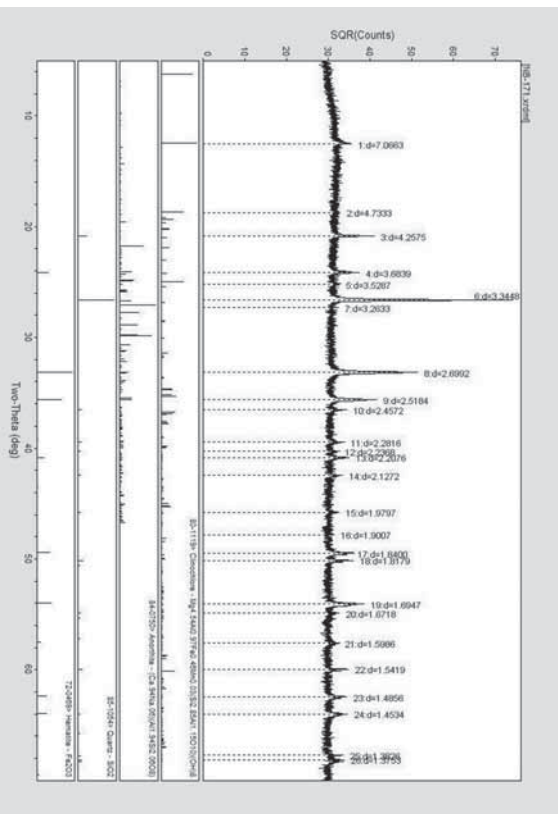

Fig. 4a: X-Ray Diffraction Analysis

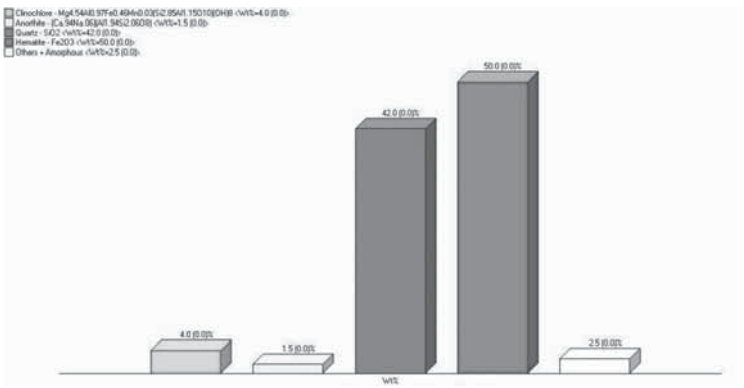

Fig. 4b: semi-quantitative X-Ray Diffraction Analysis

Graph from XRD showing 48% of hematite (Fe_2O_3).

X-Ray diffraction indicates that, the main iron minerals are hematite; non-metallic minerals are quartz and chlorite.

c. Chemical Composition Analysis

The chemical analysis of 246 surface chip and channel samples as well as subsurface 53 core samples from drilling were analyzed in chemical Labotray of DMG. The samples were analyzed in order to determine the content of elements in the test ore sample, chemical composition analysis are made to the ore. The detailed of analysis is tabulated below:

Table 3: Weighted Average of Deposit

S.N.	Section	Thickness (T), m	Fe %	SiO2 %
1	Channel Sampling along NPH'A' section	30.15	40.02029	39.98423
2	Channel Sampling along NPH'B' section	29.62	38.06439	42.13412
3	Channel Sampling along NPH'C' section	31.54	35.76215	46.6229
4	Channel Sampling along NPH'D' section	25.6	36.64735	44.7593
5	Channel Sampling along NPH'E' section	22.58	32.22868	53.66138
6	Channel Sampling along NPH'F' section	24.59	30.5135	53.87225
8	Chip Sampling along NPH'A' section	17.9	31.21665	53.79453
9	Chip Sampling along NPH'B' section	23.24	36.53482	44.47933
10	Chip Sampling along NPH'B' section	14.04	42.38752	37.61352
	Total	**250.49**	**35.26588**	**46.55904**

The analysis results indicate that, the average TFe in the ore is the main recovery composition with content of 35.26~ 36%; the main impurity composition is SiO_2 with content of 46.55~47%; the rest content of Al_2O_3, CaO, MgO, P and S. The drill core shows the average weightage of TFe of 40%.

GEOLOGICAL RESERVE

The geological reserve is estimated simply by vertical section method. Eight geological sections namely AB, CD, EF, GH, IJ, KL, MN and OP were drawn on the topo-geological map prepared after survey of the study area in scale of 1:1000. Reserve calculation is done taking influence length as summation of strike length either side. The drill hole representation gave proved category of reserve and surface sample representation gave probable category of reserve considering dip length of 100 m. The chemical analysis of hematite mineralized bed was considered to be homogeneous laterally along the strike.

Table 4: Reserve Estimation of Pokhari Area

Area	section	Sectional Area (m2)	Strike Length (m)	Specific Gravity	Reserve, ton	% of hema-tite	Reserve, million ton
Probable reserve	CD	2940.73	170	4	1999694	60	1.200
	EF	5384.73	260	4	5600121	60	3.360
	GH	6758.35	290	4	7839683	60	4.704
	IJ	5998.17	330	4	7917583	60	4.751
	KL	3885.70	155	4	2409132	60	1.445
	MN	4515.09	250	4	4515087	60	2.709
	OP	5835.32	215	4	5018376	60	3.011
	Sub Total						**19.980**
proved reserve	AB	3961.00	225	4	3564900	60	2.139
	CD	6901.73	170	4	4693174	60	2.816
	Sub Total						**4.955**

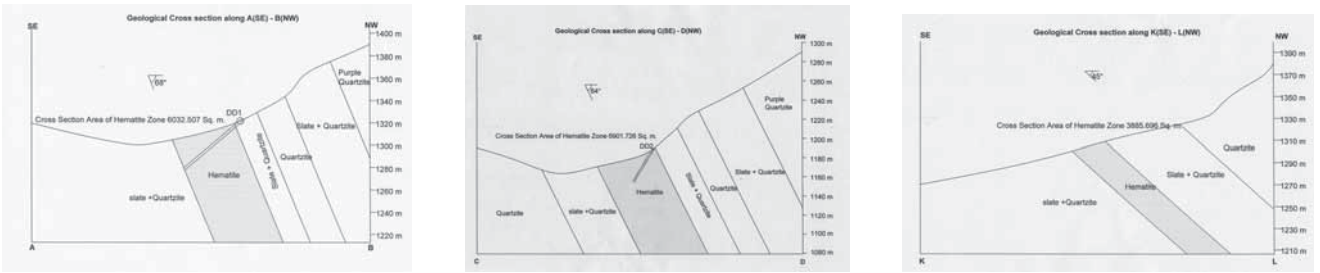

Fig. 5: Geological cross section A-B, C-D and K-L.

Fig. 6: Channel Sampling around NPH-ACH

Fig. 7: Trenching around NPH- BCH

Fig. 8: Survey work

Fig. 9: Drilling

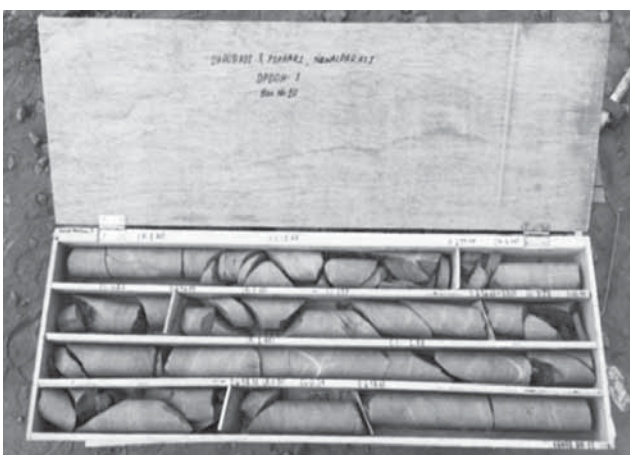

Fig. 10: Core sampling

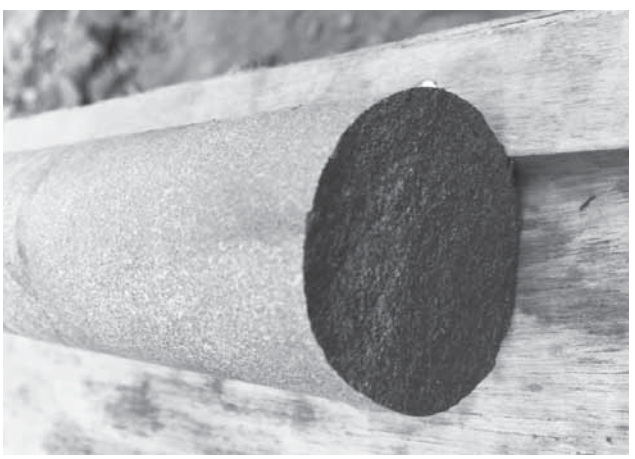

Fig. 11: Oolitic Hematite NQ core

SUMMARY AND RECOMMENDATIONS

Accessibility of mineralization zone is very good because of its locality. In 6.00 sq.km area, follow up and detail exploration work is completed. During the detail exploration 2 drill hole of total length 105.35m is completed. The grade of the hematite band (TFe content) varies from 17% to 58% within the mineralization zone with weightage average value more than 36. Microscopically the fine particles mostly surround the round quartz core and consist of oolitic particle that constitutes a single or multilayered layer of laminated layers. The geological proved reserve of the study area is 5 million and probable reserve is about 20 million ton. Bulk testing and Pilot testing of the iron ore sample needs to be done to assess the economic viability of the deposit.

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Status of Uranium and Thorium Prospects in Nepal

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ABSTRACT

The prospecting of uranium and thorium resources in Nepal started from early eighties. The Tinbhangale prospect was identified with the help of preliminary ground radiometric survey throughout the siwaliks using GAD-6 spectrometer. The Bangabagar-Baghgoth-Gorang prospects were identified in nineties. Since Nepal's membership of International Atomic Energy Agency (IAEA) in 2008, the Technical Co-operation (TC) project started with IAEA and Department of Mines & Geology (DMG) from 2012 onwards. The Tinbhangale prospect geologically crops out in the upper-middle Siwalik sandstone with sporadic coal seams and black clay. The strike length of uranium-thorium prospect is 1400m and average thickness is 2.2m and the speculative uranium resource could be 47 tons. Similarly, Bangabagar- Baghgoth radioactive prospect is a part of serricitic white quartzite intersected with auriferous quartz veins of Banku quartzite and amphibolites dikes of Gokule Schist for about a strike length of 2km and average thickness of 3m. The prospect could have a speculative uranium resource of 212 tons. Moreover, Lomanthang prospect was discovered in 2014 within the Thakkhola Formation siltstone having dark shale fragments and leucogranite pebbles from the vicinity of Tethys sediments and Tertiary granite. The prospective area is spread over 6 sq. km. The speculative resource of uranium in this prospect could be about 128660 tons. These results are based on the Ground radiometric survey using Gamma Ray Spectrometer RS-125 and Scintillation Counter BGS-15. The Ampipal prospect lies in the alkaline massive of Nepheline syenite having fissures and hydrothermal ore shoots of radioactive magnetite within the Kuncha Formation of the Lesser Himalaya. The prospect has thorium concentration higher over uranium concentration. Further detail exploration plan integrated with geochemical analysis, mineralogical and petrological analysis and isotopic analysis is warranted to change these resources into reserves.

INTRODUCTION

A brief study of ground radiometric survey for prospecting uranium and thorium resources in Nepal is undertaken. The prospecting history of uranium and thorium has been described in phase wise from phase I to IV. The objective of the paper is to describe the status of national database on uranium and thorium resources of Nepal in a nutshell. The database was generated using gamma ray spectrometer RS-125 and scintillation counter BGS 15. The resources map has been prepared and the regional geological setting of the radioactive resource is described in brief. The prospect geology and gamma ray spectrometry has been described with results. Based on the results so far an outline of recommendation is made for further studies.

PROSPECTING HISTORY OF URANIUM AND THORIUM

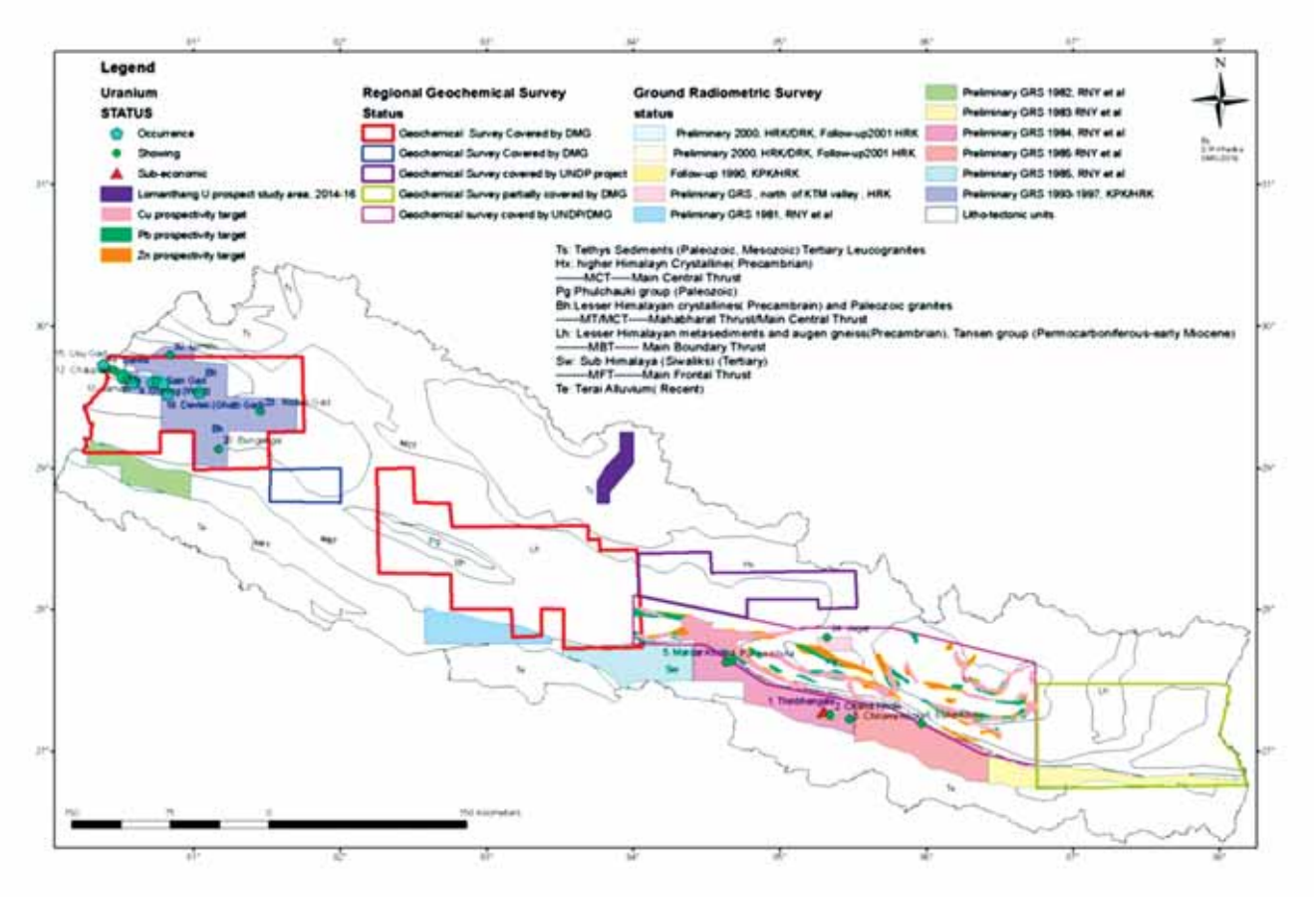

Fig. 1: Resource map of Uranium along with Regional Geochemical Survey status

The prospecting resource map of Uranium has been presented in fig.1 along with regional geochemical survey. The prospecting history of uranium and thorium resources in Nepal will be described in phase wise from phase I to Phase IV

Phase I

The regional geochemical survey for base metal prospecting was conducted in the Central Nepal Lesser Himalaya with support from UNDP under the Mineral Exploration Project of DMG in eighties. It identified some of the cu, pb, zn anomalies, showings , occurrences and old workings in central Nepal with a few locations of radioactive anomaly as shown in fig- . It was extended towards eastern Nepal Lesser Himalaya in the successive years but the radioactive mineralization was not detected any more in the region. The same work was extended towards western Nepal Lesser Himalaya but no anomaly was recorded for radioactive minerals (fig 1).

Phase II

Yadav et al (1981-1985) did preliminary Ground Radiometric Survey in many parts of the Siwaliks except Mid western Nepal using Geiger Muller Counter and GAD 6 Spectrometer. The Tinbhangale and Chandi Khola showings were identified at that time.

Phase III

Kaphle and Khan (1993-1997) did regional geochemical survey for base metals in far western Nepal along with Ground radiometric Survey using Scintillation Counter BGS =15, Scintrex, serial 902212. They have successfully identified some of the showings and occurrences of radioactive minerals in the survey area including Bangabagar showing associated with gold at the road section.

Khan and Khadka (2000-2001) did geochemical survey for base metal in parts of Baitadi and Darchula district and successfully identified Gorang radioactive band. Similarly, they traced Bangabagar-baggoth radioactive beds with scintillation counter.

Khan(2002) did preliminary Ground Radiometric Survey in the Kathmandu Valley using Scintillation Counter and identified some of the anomaly areas.

Phase IV

Nepal became member of the International Atomic Energy Ajency(IAEA) in 2008. The Technical Co-operation (TC) projects of IAEA/Nepal Government were under the focal Ministry of then Science and Technology based on the first Country Program Framework (2010-2015). Department of Mines and Geology (DMG) became counterpart organization in 2012 with launching its first TC project in uranium exploration. The second Country Program Framework (2016-2021) was signed between IAEA and Ministry of Science and Technology in which U/Th exploration in parts of Nepal is highlighted within it. Four cycles of TC projects on U/Th prospecting have been undertaken in parts of the country and the next 2020-2021 cycle project have been proposed through MOEST to IAEA and its under review.

TC Project Cycle 2012-2013

Khadka and Pokhrel (2012) did prelimeinary Ground Radiometric Survey for prospecting radioactive beds In Tinbhangale and Chandi Khola area of Makwanpur District using Scintillation Counter.

Khadka, Maharjan and Chaudhary (2013) did follow up Ground Radiometriic Survey using Gamma Ray Spectrometer RS-125 first in Nepal and got encouraging results in the Tin Bhangale prospect. The area has been topo-geologically mapped in 1:1000 scale with radioactive bed tracing and sampling.

During this period, the project supported 2 pocket dosimeters, 1 Gamma ray spectrometer RS-125, two lead boxes for sample storage and S2 Ranger X-Ray Florescence instrument for lab analysis.

Three experts from IAEA reached DMG and trained about 30 staffs including geologists, mining engineer, metallurgists and chemist in uranium exploration techniques.

Similarly, two fellowships in uranium exploration were granted in Czech Republic and two Scientific visits were made in Australia.

TC Project Cycle 2014-2015

Khadka and Maharjan (2014) did preliminary Ground Radiometric Survey using Gamma Ray Spectrometer RS-125 in Bangabagar-Baggoth and Gorang area and got encouraging results. The area has been geologically mapped in detail with radioactive beds tracing and sampling. The drilling and gamma ray logging program for 2015 was abandoned due to unavoidable circumstances.

The PMO and TO from IAEA reached DMG and discussed and review the project activities.

Similarly, three fellowships in uranium exploration were granted in Czech Republic and two scientific visits were made in Philippines. One fellowship was granted for chemical analysis in Austria.

During this period, the project supported 2 pocket dosimeters, 1 Down Hole Gamma Ray Logger, Winch Assembly and software.

Lomanthnag U/Th project

Khadka, Maharjan and Khan (2014) identified the Lomanthang U/Th prospect following the survey completed in Baitadi. Three U/Th prospects of U/Th were identified in Thakkhola sediments covering 100 Sq Km using Gamma Ray Spectrometer RS -125 and Scintillation Counter. The lower bed of Lomanthang Prospect was identified at this time.

Khadka and Maharjan (2016) did preliminary follow-up Ground Radiometric Survey in the Lomanthang U/Th prospect using Gamma Ray Spectrometer RS -125 and Scintillation Counter to trace the beds and sample collection. The upper radioactive bed was identified at that time.

TC Project Cycle 2016-2017

Khadka and Lamsal (2017) did preliminary Ground Radiometric Survey using Gamma Ray Spectrometer RS-125 and Scintillation Counter in Northern Parts of Kathmandu valley in Shivpuri area for radiation hazard mapping. The area has been undertaken geological mapping and Ground Radiometric survey. Some of the radioactive beds were identified and measured absorbed dose in uGray/hr for radiation hazard analysis.

The PMO from IAEA reached DMG and discussed and review the project activities.

Similarly, two fellowships in uranium exploration were granted in China and two scientific visits were made in the same country.

During this period, the project supported two Gamma Ray Spectrometer RS-125. Multichannel GRS one. One sample preparation pelletizer and accessories.

TC Project Cycle 2018-2019

Khadka , Maharjan and Shrestha (2017) did preliminary follow-up Ground Radiometric Survey using Gamma Ray Spectrometer RS-125 and Scintillation Counter in eastern part of the Lomanthang prospect with 1:1000 scale topo-geological surveys. Channel Samples were collected during this period.

Khadka and Maharjan (2019) did preliminary follow-up Ground Radiometric Survey using Gamma Ray

Spectrometer RS-125 and Scintillation Counter in western part of the Lomanthang prospect. Channel Samples were collected during this period.

The PMO from IAEA reached DMG and discussed and review the project activities.

During this period, the project supported one NIR Gamma Ray Spectrometer. The Laser Survey Instrument and Ore express for Mineral identification are under purchase order and delivery mode.

RAS and INT support

Participants from DMG took part in various workshops and training courses from 2012 onwards in the following countries supported by IAEA- India, China, Finland, Chile, Sri Lanka, Brazil, Mexico, Austria and Australia under the RAS and INT programs.

TC Project Cycle 2020-2021 (submitted)

This cycle consists of U/Th exploration in Ampipal area of Gorkha district in Nepal. It is under review by IAEA.

Preliminary geological mapping and gamma ray spectrometric survey for U and Th in Ampipal area of Gorkha District has been carried out (Khadka and Lamsal 2016/17). About 20 sq km of ground radiometric survey using scintillation counter and Gamma Ray Spectrometer in Ampipal alkaline massif has been carried out. The field program was based on the annual program of Department of Mines and Geology for the exploration of U and Th. Significant anomalies have been detected during that period. The Kuncha formation phyllites and quartzites with amphibolite dykes have been mapped in most of the area surrounding the pluton. The Ampipal area has Nepheline syenite alkaline body. Instrumental readings of U, Th, K and dose rate have been collected to generate potential prospects in the area. Radioactive magnetite ore from the Phalamedata has been sampled for analysis. The measured maximum U content is 200ppm and Th 700ppm. Th concentration is higher than U concentration in the prospects. The detail investigation needs to be carried out.

OBJECTIVE

The overall objective of the U/Th prospection In Nepal, as a IAEA TC Project, is to generate national database for sustainable uranium resource generation. The developmental objective of the project is to support human resource development by scientific visits, fellowships and trainings, equipments support for the field and lab analysis and expert mission to evaluate the results.

METHODOLOGY

Desk Study: The desk study covers the review of IAEA/ TC projects cycle 2012-2013, 2014-2015, 2016-2017, 2018-2019, Project Progress Assessment Reports, IAEA resource books and uranium exploration guidelines, articles, secondary information and consultation. The field reports were reviewed. GIS data base were generated. Map preparation and compilation was done.

Field study: Field study, basically, consist of target generation, geological mapping, Ground Radiometric Survey using Gamma Ray Spectrometer RS-125 and Scintilation Counter BGS-15. Topo-geological survey and sampling for chemical analysis. Gamma Ray Logger will be utilized during drilling operation for resource evaluation.

Laboratory analysis: The samples are kept in Lead boxes for chemical analysis. The chemical analysis of U/Th has not been started yet at our chemical lab due to some difficulties.

Regional Geological Setting

The regional geological setting of Nepal Himalaya is described based on the Geological map od Nepal DMG 1994 with U/Th prospect location and their geological position in fig.2.

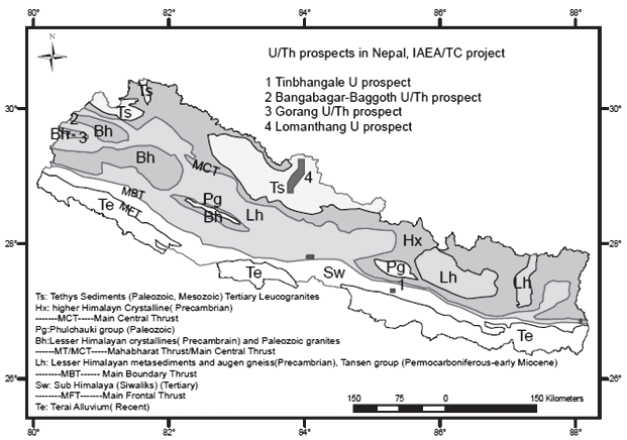

Fig. 2: Geological map of Nepal (modified after DMG 1994) with prospect location

Geologically, Nepal Himalaya has been divided into Tethys Himalaya, Higher Himalaya, Lesser Himalaya, Sub Himalaya and Terai alluvium. The Tethys Himalaya consists of Paleozoic to Mesozoic unmetamorphosed calcareous and siliciclastic sediments. The Tethyan Himalaya thrusting was started in Eocene and ceased in the late Miocene at 11-8Ma (Yin 2006). Paleozoic sediments of Tethyan Himalaya overlie Higher Himalayan high grade metamorphic rocks along the South Tibetan Detachment System (STDS) (Yin 2006). It is also proposed that the Cambrian-ordovician strata

lie in the hanging wall of the detachment. The STDS was active from 27-25Ma to 17-15Ma (Wang et al 2016). Higher Himalaya consists of late Proterozoic to Paleozoic metasediments of upper amphibolites to granulite facies of metamorphism (Kohn 2014)and intruded by Oligocene-Miocene leucogranite(Searle 2003).Upper part of the Higher Himalaya has high grade metamorphism with peak temperature 7000C during 32-25Ma than lower part with peak temp 6000C at 20-16Ma forming a shear zone in between, has been proposed as a discountinuity ie High Himalayan Discountinuity (Wang et al 2016). Main Central Thrust (MCT) is a boundary between High grade metamorphic of Higher Himalaya and underlying metasediments of Lesser Himalaya, creates a broad shear zone. It was active from 23-16Ma (Wang et al 2016). Northern segment was reactivated from 8-3Ma(Catlos et al 2011). There is a Inverse metamorphic zonation in the MCT zone and recently proposed as a result of basal accretion (Bollinger et al 2006). The Lesser Himalayan thrust belt consists of Proterozoic to early Miocene metasediments and sedimentary rocks. The rocks units display tectonically complex configuration having a thin skinned style nappe stacks forming a hinterland dipping duplex in the north and imbricate thrust sheets in the south, thrusting possibly started in the north at 41-35Ma and lasted into late Miocene(Yin 2006). The Main Boundary Thrust(MBT) is the base of the Lesser Himalaya Thrust Belt. It has Cenozoic molasse of Siwaliks in the footwall. Generally, Chlorite and biotite phyllite in the hanging wall seems to form the decollement layer while motion of the MBT has been considered during late Miocene to Pliocene time(Schlling 1992). The Sub-Himalaya consists of Tertiary molasses sediments form the imbricate thrusts with a decollement within the Lower Siwalik sediments(Schilling 1991). The Main Frontal Thrust(MFT) is the outermost thrust fault which overrides the quaternary foreland sediments. The MFT, MBT and MCT all merge into a basal detachment called Main Himalayan Thrust(MHT), (Schilling and Arita,1991). The Gorkha earthquake 2015 ruptured the MHT uplifted the Kathmandu basin and subsided the higher Himalaya. Part of the Indian lower crust is eclogitized and subducted into the mantle (Avouce 2015).

The uranium/thorium prospect of Tinbhangale crops out within the upper Middle Siwaliks, Bangabagar-Baggoth and Gorang prospect falls within the Lesser Himalayan crystalline klippe in far western Nepal. Similarly, the Lomanthang prospect belongs to the Thakkhola formation of Thakkhola graben fill sediments (fig 2) and Ampipal prospect belongs to the Alkaline massif of Lesser Himalaya intruded within the Kuncha Formation . Na- metasomatism in MCT zone and Tethys Himalayan leucogranites and their vicinity will be the future prospect potential areas in Nepal.

Prospect Geology and Ground Radiometric Survey in a nutshell

The prospect geology of the radioactive beds and its vicinity is described in brief in table-1.

Table 1: Prospect geology and GRS anomaly

Prospects	Tin bhangale	Bangabagar/Gorang)	Ampipal	Lomanthnag
Area	25 sqkm	25 sq km	25 sq km	100 sq km
Toposheet	2785 10C	2980 07A, 2980 07C	2884 15C,D	2883 04, 2983 16
Field Session	2013,2014	2014	2017,2018	2014,2016,2017
Geology of U/Th prospects	Siwalik Group, Upper Middle Siwalik Formation, mainly consist of sandstone, siltstone and pebbly cobbly sandstone. Radioactive bed lies in the sandstone beds with intercalation of coaly shale and siltstone. Considered to be of Pliocene in age.	Parchauni Crystalline Group, Banku Quartzite Formation, mainly consists of sericitic white quartzite cross cut with quartz veins and are auriferous and radioactive. The lower unit Gokule Schist consist of amphibolite dykes are radioactive at places. Considered to be of Neo-proterozoic in age.	Lower Nawakot Group, Kuncha Formation consists phyllite and metasandstone intruded with nepheline Syenite of 2 km wide and 10 km in length. It is radioactive especially in the hydrothermal magnetite mineralization areas overshooting the alkaline body. The Kuncha Formation is considered to be of Paleo-proterozoic in age and alkaline massif intruded in Eocene?	Half Graven Sedimentary Group. Thakkhola Formation consists of lacoustine siltstone and dark gray clay with sandstone and pebbly cobbly sandtone interbeds at the basal part. The red oxidized beds interbedded with siltstone. The radioactive beds lie both in siltstone , sandstone and pebbly cobbly sandstone. It is considered to be of Pliocene in age.

Ground Radiometric Survey, RS-125, BGS 15	1400m length 2.2m thick radioactive bed anomaly	Bangabagar- 2000m length, 3m thick radioactive bed anomaly Gorang- 160m long 2 m thick radioactive bed anomaly	20 sq km radioactive anomaly alkaline massif	6 sq km radioactive anomalous zone.

Results of Gamma Ray Spectrometry

Average results of collected GRS RS-125 data are given in table 2 below.

Table 2: An average results of GRS RS-125

Prospects		Tin bhangale	Bangabagar	Gorang)	Lomanthang Lower bed	Lomanthnag Upper bed
eU (ppm)		140.9	136	157.9	179	327.2
eTh(ppm)		17.44	55.6	50.14	27	24.18
K%		3.39	1.66	3.15	4.7	6.8
Dose Rate ugray/hr		97.46	101.72	179.79	523.1	224.28
RI value, cps		200-4300	100-5800	200-7000	100-5000	
Speculative resource (tons)	eU	47	212	13	7091	5759
	eTh	17	86	2.6	1081	600

DISCUSSION

Geologically, the Tinbahngale prospect lies within the Upper Middle Siwaliks and Lomanthang Prospect Lies within the Thakkhola Formation. Based on the lithological characters and stratigraphic position, these radioactive beds could have deposited in the similar age ranges. The Thaakkhola sedimentary basin is a half graven fluvio-lacoustine deposit and consists of leucogranite pebble and fragments with dark gray to black shale fragments from the sorroundng Tethys sediments. The Tinbhangale prospect has coal seams dark gray clay at plaxes within the radioactive zone. Both prospects could have been categorized as Roll front and Tabular type of deposits.

The Bangabagr-Baggoth prospect could have been associated with the metasomatic process as it has undergone cross cutting quartz veins and gold association. The Gorang prospect has ferrogenous quartzite with gold association and could have been associated with the metasomatic process. Both prospects could have been categorized as metasomatic type of deposits.

Ampipal prospect has radioactive magnetite mineralization at the foliation and fracture of Nepheline syenite body. The radioactive magnetite ore shoot at the vicinity of the body could have been categorized as structutal-hydrothermal style of deposit.

The results are only based on field observations, geological mapping, Ground radiometric survey using Gamma Ray Spectrometer RS 125 and BGS 15. The laboratory analysis of the collected samples will improve the quality of data based on XRF, ICP MS. The mineralogical and petrological analysis will be performed with Ore Express instrument in near future. The isotopic analysis will improve the prospect characteristics..

CONCLUSION AND RECOMMENDATION

These prospecting results could be useful to generate best possible exploration models to improve these resources into reserves. The plan of action for detail exploration and pre- feasibility study is warranted to evaluate the data before techno-economic analysis for feasibility study.

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Phosphorite exploration in Bajhang and Baitadi District, Far Western Province, Nepal

Santosh Dhakal (Senior Divisional Geologist) | **Kumar Khadka** (Senior Divisional Geologist) | **Sunita Bhattarai** (Geologist)

ABSTRACT

Phosphate rock as "phosphorite" is sedimentary deposits for NPK fertilizer. In Nepal, the most promising areas for the occurrence of phosphorite are in the Bajhang and Baitadi areas. The study and recognition of the phosphorite in those areas are still lacking. The stromatolitic phosphorite can be observed in the carbonate formations namely the Baitadi Carbonate and the Chamalia Carbonate of the autochthonous metasedimentary complexes. The preliminary prospecting works was carried out around the Chhabis Pathibhera, Durgathali, Kedarsyu and Japhri of Bajhang District, with grade 1 to 20 %. The preliminary and follow-up mineral exploration data shows P_2O_5 % of rock samples variation with maximum value of 11.53 % of P_2O_5. Similarly, the preliminary prospecting works were carried out around the Sangoun, Kotali and Rapana village of Baitadi District. In both prospects, the Phosphorite horizon lie within the medium to thick bedded, bluish white dolomite and light blue cherty dolomite intercalated with grey to dark grey, fine to medium grained slate. The previous study of Baitadi District, Sangoun has higher percentage of phosphate that ranges from 12 to 32 %. In the present follow up exploration of FY 074/75, 50 samples were collected in Sangoun, chemical analysis result is yet to come. The geological reserve of Sangoun phosphorite horizon is estimated to be 1 million ton phosphate rock within 50 hector. From the follow-up exploration and samples of Sangoun and Ratauki area, Baitadi District, there is huge possibility of NPK fertilizer grade phosphorite deposit.

INTRODUCTION

The phosphorite investigation is carried out within latitude 29º 30'N to 29º 34'N and longitude 80º4.5'E to 81º4.5'E in Toposheet no 2980 08 & 2981 05, Bajhang District in two consecutive FY's 2073/74 and 2074/75. The field study for the phosphorite rock is carried out in Baitadi Districts of Far Western Nepal in the fiscal year 2074/75. The phosphorite horizon is identified within dolomite band in the Sangoun-Rapana village and Ratauki-Kotali village, Purchaudi Muncipality-6, Baitadi District. It is about 876 km's far from the Kathmandu. Physiographically the study area lies in the Lesser Himalaya having altitude range from 1500 m MSL to 1788 m MSL near Rapana Village (Figure 1). The main objectives of the study were to assess the phosphorite deposit in order to get the status of the deposit for promotional activity, to have geological mapping of the area to locate the Phosphortie band, its extension and thickness and to get representative samples of phosphorite band to ascertain grade.

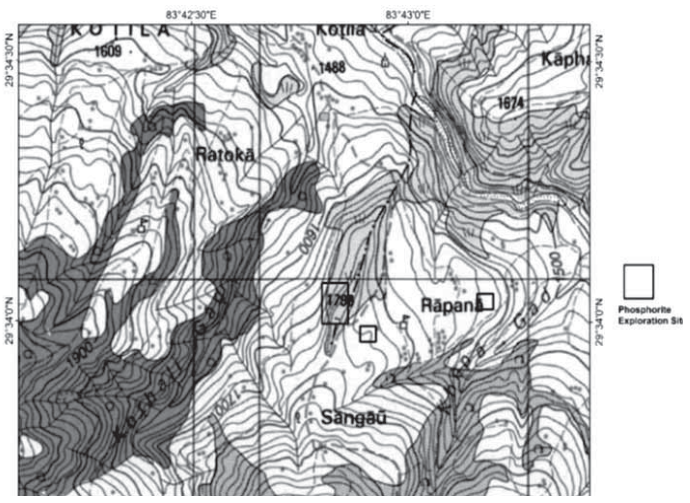

Fig.1a: Topographic maps showing study area in Bajhang district.

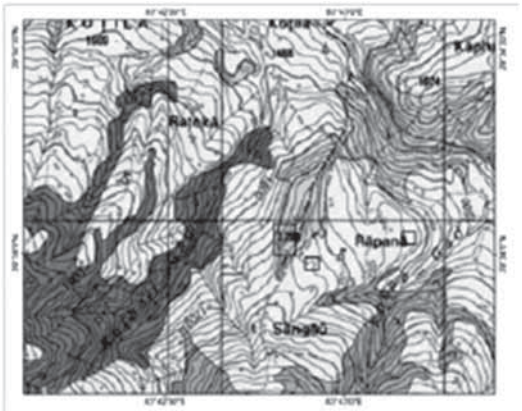

Fig. 1b: Topographic maps showing study area in Baitadi District

PREVIOUS WORKS

Different experts have worked in this area in the past for different purposes. Tony Hagen has traversed many areas of Nepal including Far Western and identified different Nappe structures (Hagen, 1969). In 1979, Nakajima and Pradhan reported the stromatolites in the Carbonate units of Bajhang at Kaligad.Shrestha (1980) carried out the geological mapping of a part of Baitadi and Darchula area. He categorized the rock sequences into six different units. The metamorphic sequences comprising of the feldsphathic schist, quartzite, phylliteare considered to be the rocks of Purchaunri Nappe thrusted over the sedimentary units of Lower Paleozoic to Eocene age.

Bashyal, worked intensively in stromatolitic phosphorites and traced phosphoritic band in east west direction from Seti River uptoMahakali River. He has noted the phosphorite band upto 32m in TarugadJuilgad area. Pradhanaga (1983) carried out the study that confined with stromatolitic phosphorites in the Bajhang District. He traced the stromatolitic phosphorite horizon of 1 m to 23 m in 19 km long distance in Bajhang District. P2O5 % analysis of phosphrite samples show less than 15 % in his study.

Dhital (2008) studied the Lesser Himalaya Tertiary rocks in the Western Nepal and their extension in the Kumaun and described the controversy about the Tertiary rock that the same rock of the Western Nepal of Eocene-Miocene are assigned a Precambrian age in the Kumaun.

There are three types of stromatolitic phosphorite and they are sandy, massive and laminated one (Bashyal, 1981). The phosphotic materials formed the stromatolite. He traced phosphorite band ranging 3 to 5 m thick, poorly to moderately phosphatic containing 10 to 15 % P2O5 in average.Massive, banded and pelletal phosphorite contain 22.16 % P2O5. In the Goragaon-Junkura (Baitadi District), phosphorite horizon can be traced about 2 Km only at present, 4 m thick and contains 14 to 20 % P2O5. The Baitadi Carbonate comprises of thick rhythmic succession of black slate, cherty dolomite, pink and white limestone-dolomite with colored slate, and white quartzite. The stromatolites occurring in Dhik Gad area is moderately phosphatic and seem that they are overturned (Bashyal, 1981).

GEOLOGY

Both the study area comprise of the crystalline rocks and the metasedimentary rocks. The metasedimentary rocks are exposed in the tectonic windows (Table 1).

Bashyal(1981) conducted prospecting and exploration of phosphoritic rocks in parts of Baitadi and Bajhang Districts and differentiate the rock sequences into Parchuni Crystalline Complex that is thrusted over the Baitadi metasedimentary Complex. The crystalline complex consists of Devlek phyllite and quartzite, Banku Quartzite and Parchuni schist. The crystalline complex forms the core of syncline forming a Klippe. The Chamelia metasedimentary Complex is exposed in a tectonic window. The Chamelia Carbonate consists of cherty dolomites, pink and white limestone- dolomite with slates, white quartzite and black slate. The Chamelia carbonate unconformably underlies the shale and sandstone formations named as Tarugad Shale and Sandstone. Phosphate rocks are reported for the first time from the Baitadi Carbonates and Chamelia Carbonate of the metasedimentary complexes.

The crystalline rocks consist of schist, gneiss, and quartzite. Baitadi metasedimentary complex is represented by Patan Shale and Sandstone and consists of bands of purple, red, green shale interstratified with quartzitic sandstones.

The study areas contain low to medium grade metamorphic rock, sedimentary rock and at some locations igneous rocks. The overlying metamorphic rocks of the area lie in the sequence of Nappe rocks and mainly consist of quartzite, feldspathic schist, green schist, phyllite and amphibolite. The underlying sedimentary rocks are shale, slate, limestone, and dolomite. The pebbly sandstone, shale and sandstone of tertiary sequence liesunconformaly above the dolomite and dark slate of sedimentary sequence.

Phosphorite horizon is present in the bluish white dolomite and light blue cherty dolomite band with variation of thickness ranging from medium to thick bedded. The stromatolitic phosphorite occurs within the cherty dolomite. Dolomite occurs within the grey to dark grey, fine – medium grained slate.

Table 1: Litho-stratigraphical Unit of Baitadi District Far Western Nepal (Bashyal 1981, Valdiya, 1965, 1979, 1980)

Tectonic Units	Formations	Lithology
Kalanga Crystalline Complex	Kaligad Gneiss and Quartzite Chainpur Phyllite and Quartzite	Augen Gneiss and micaceous quartzite, chlorite phyllite, quartzite and amphibolite
----------Darchula-Paribagar Thrust----------		
Chamelia Metasedimentary Complex	Juligad Stromatolite	Cherty dolomite with phosphate stromatolites. (Bajhang Phosphortie horizon).
	Targugad Shale and Sandstone	Purple shale and green sandstone
	Chamlia Carbonate	Black slate, dolomite with slate, pink white dolomite, cherty dolomite, limestone with colored slates, white quartzites.
----------Chamlita Thrust (North) ----------		
Parchuni Crystalline Complex	Parchuni Klippe	Mica schist, quartzite and gneiss
	----------Thrust----------	
	Banku Quartzite	Micaceous quartzites with amphibolites
	Devlek Phyllite and Quartzite	Chlorite, sericite phyllite, dirty grey quartzite
----------Chamlita Thrust (South) ----------		
	Baitadi Carbonate	Stromatolitic dolomite (Dhungad stromatolites)
	Patan Shale and Sandstone	Purple, red, green and black shale interstratified with quartzitic sandstones. Cross bedding, graded bedding structures, Rhythmic succession of slate, dolomite, limestone with slate and quartzite.
Baitadi Metasedimentary Complex	Baitadi Carbonate	Stromatolitic dolomite (Dhungad stromatolites)
	Patan Shale and Sandstone	Purple, red, green and black shale interstratified with quartzitic sandstones. Cross bedding, graded bedding structures, Rhythmic succession of slate, dolomite, limestone with slate and quartzite.
----------Chamlia Thrust (South)----------		
Dandeldhura Crystalline Complex	Dandeldhura Phyllite	Lead-grey, carbonaceous, chlorite phyllite, quartzite
	Saukhark Granite-gneiss	Granite-gneiss, augen gneiss schist and quartzite.
	Gaira Schists	
		Mica schist, quartzite, gneiss
----------Gogannpani Thrust ----------		

Table 2: Lithological Units observed during the field study

Bajhang Metasedimentary Unit (Taru Gad Shale)	Shale and Sandstone Unit
Parchauni Klippe	Quartzite and Schist Unit
Baitadi Metasedimentary Unit	Limestone Unit
	Dolomite, Slate and Phyllite Unit
	Limestone and Dolomite Unit
	Shale Unit

OCCURRENCES OF PHOSPHORITE HORIZON

Bajhang Area

In Bajhang, stromatolitic phosphorite was observed around near Kalimati area, in Tarugad section. Beds are dipping due north with dip amount varies from 30 to 50 degrees. North dipping beds are overturned which is revealed by stromatolites in the area. Phosphorites present in the area are laminated as well as sandy. 'Sandy' phosphorite conists of black pellets and it can be identified by naked eyes. Band having thickness of about 30 m in Tarugad section at Tribeni is phosphatic however most of which are weak phosphatic. Weak phophatic is determined by observing chemical reaction with ammonium molybdate nitrate solution in the field. Yellow precipitation was not so bold. This is also revealed by determination of phosphorous pentaoxide in the rock sample in the lab. About 4.5 m band was relatively better than remaining in terms phosphorite contain. Laminated phosphorites are underlain by stromatolitic phosphorites. Cherty dolomite and black slates come underlie the stromatolitec phosphorites in the Tarugad section.

In Juilgad Section phosphatic stromatolites with pellets of phosphate were observed along the trail and phosphatic horizon was traced in the uphill slope based on the boulder information. Debris of quartzites transported in the river also made difficult to visualize bedrock in the Juilgad section north of Mallesi. Vegetation, steep terrain, abundance of leech and rain made hard to reach in the upper part of the hill. Bashyal 1982 reported 15 m sandy stromatolites in the Juilgad section. Purple shales and green sandstones are present near Mallesi which in columnar section is above cherty dolomite with phosphorite horizon and dolomite with black slates (Pradhananga 1983).

Bajhkada area consisted of laminar phosphate and sandy phosphate and observed in the newly constructed road. The 22 m thick horizon, dipping towards south showed phosphatic mineralization and reacted well with ammonium molybdate nitrate solution.

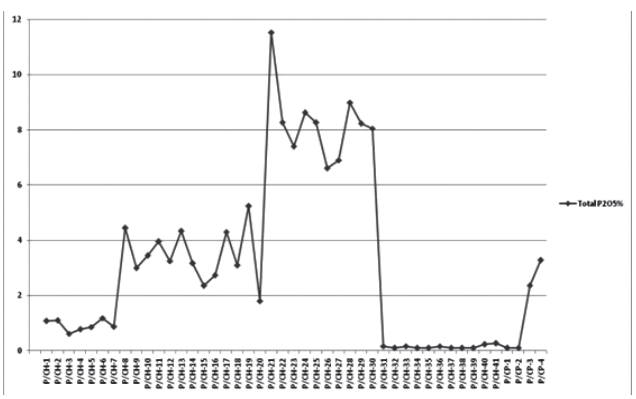

Fig. 2: Chemical result (P2O5%) channel and chip samples

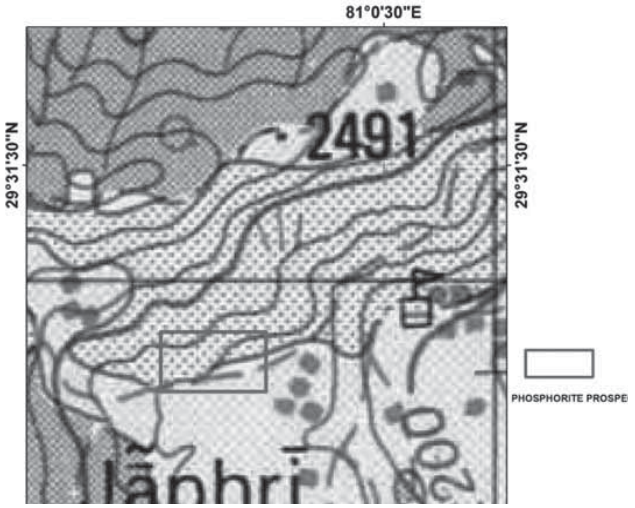

Fig. 3: Topographic map showing phosphorite follow-up exploration in Japhri Village

More than 35 m thick sandy phophorites was traced in more than 70 m distance in Japhri (Figure 3). Phosphorite horizon is dipping towards north and dip amount varies from 400 to 600. Phosphatic stromatolites band is overturned and dipping inward slope in the area. Boulders of phosphatic stomatolites are found throughout Japhri village.

Bhalane area also consists of phosphatic stromatolites with thickness of more than 15m (Photo 2). Boulder of phosphatic stromatolites can be seen along the trail from Japhri to Bhalane. Bulk volume of stromatolites in the rock is more than 25 %.

S.No.	Sample ID	Total P_2O_5%	Length (m)	Location	Tentative coordinates of channels	
					Easting	Northing
1	P/CH-1	1.07	2	Tibeni (Taru Gad)		
2	P/CH-2	1.09	2	Tibeni (Taru Gad)		
3	P/CH-3	0.61	2	Tibeni (Taru Gad)	504465	3266007
4	P/CH-4	0.77	2	Tibeni (Taru Gad)		
5	P/CH-5	0.86	2	Tibeni (Taru Gad)	504439	3266897
6	P/CH-6	1.18	1	Bhalane		
7	P/CH-7	0.87	1	Bhalane	499956	3266674
8	P/CH-8	4.44	1	Bhalane		
9	P/CH-9	3	1	Bhalane		
10	P/CH-10	3.45	1	Bhalane		
11	P/CH-11	3.95	1	Bhalane		
12	P/CH-12	3.25	1	Bhalane		
13	P/CH-13	4.33	1.5	Bhalane	500363	3266633
14	P/CH-14	3.16	1	Bhalane		
15	P/CH-15	2.35	1	Bhalane		
16	P/CH-16	2.73	1	Bhalane		
17	P/CH-17	4.3	1	Bhalane		
18	P/CH-18	3.09	1	Bhalane		
19	P/CH-19	5.23	1	Bhalane	500384	3266824
20	P/CH-20	1.8	2	Japhri		
21	P/CH-21	11.53	2	Japhri		
22	P/CH-22	8.26	1.5	Japhri		
23	P/CH-23	7.4	1.5	Japhri		
24	P/CH-24	8.62	1.5	Japhri		
25	P/CH-25	8.26	1	Japhri	500385	3266834
26	P/CH-26	6.61	1	Japhri		
27	P/CH-27	6.9	1	Japhri		
28	P/CH-28	8.99	1.5	Japhri		
29	P/CH-29	8.23	1.5	Japhri		
30	P/CH-30	8.05	1	Japhri		
31	P/CH-31	0.16	2	Japhri	500404	3266843
32	P/CH-32	0.09	2	Bajhkada		
33	P/CH-33	0.16	2	Bajhkada		
34	P/CH-34	0.1	2	Bajhkada		
35	P/CH-35	0.1	1.5	Bajhkada		
36	P/CH-36	0.16	2	Bajhkada	501812	3266710
37	P/CH-37	0.1	2	Bajhkada		
38	P/CH-38	0.09	2	Bajhkada		
39	P/CH-39	0.09	2	Bajhkada		
40	P/CH-40	0.23	2	Bajhkada		
41	P/CH-41	0.26	2	Bajhkada	501827	3266695
42	P/CP-1	0.097	1	Along the way		
43	P/CP-2	0.097	1	from Japhri		
44	P/CP-3	2.35	1	to Bhalane		
45	P/CP-4	3.28	1			

Fig. 4: Chip Sampling of the study area

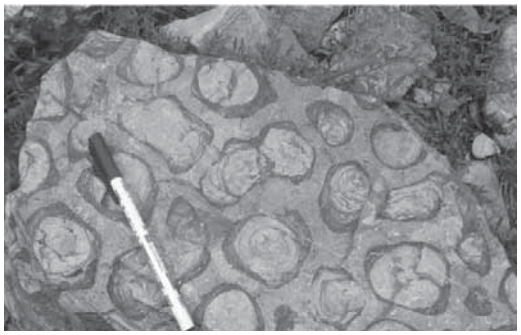

Fig. 5: Channel (CH1 to CH3) in phosphorite horizon in Kele Khola, Tarugad, Bajhang.

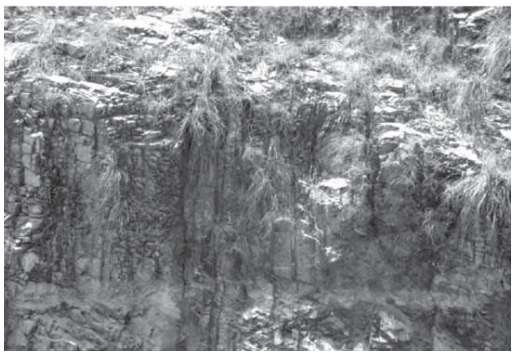

Fig. 6: Phosphatic stromatolites boulder found near Bhalane village.

Baitadi area

In Baitadi, phosphorite horizon was traced over 70m at Sangoun Village towards North East and 40m at Kotali Village towards South East. The recent study was carried out North East to the Sangoun Village and downhill side of the Kotali and Sangoun Village. The horizon mainly occurs in the stromatolitic dolomite, cherty dolomite and dolomite rocs. Stromatolitic dolomite is prominent rock type found in both Sangoun and Kotali Village area. Lithostratigraphic succession description can be found in the report from Bashyal (1981) and Pradhananga (1983).

Systematic chip and channel sampling was carried out to perform chemical analysis. All together 61.5 m long channel was constructed and 41 samples were taken. Chip samples from 4m distance were collected. Analysis of P2O5 % of rock samples in the lab of Department of Mines and Geology shows variation with maximum value of 11.53 %. Comparatively better result is obtained from Japhri area. Rock samples of other areas consisted of less than 6% P2O5 from the chemical analysis done in the lab of DMG. Chemical lab informed that they have done chemical analysis twice in more than 20 samples out of 45 to reduce discrepancy and result obtained was nearly same. Lithostratigraphic succession of the study area included in the report is taken from Pradhananga 1983 as area was covered with vegetation in many places in the current study.

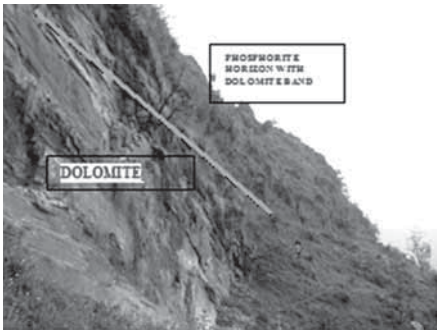

Fig. 7: Boundary between dolomite and phosphorite horizon with dolomite in Sangoan Baitadi.

Fig. 8: Dark grey to bluish white, medium bedded, crystalline dolomite with Phosphorite in Kotali Village

In the Kotali Village, the phosphorite horizon band is about 20 m in total thickness. The band of phosphorite horizon lies within the bluish white, medium to thick bedded, fine – medium grained dolomite (Figure 5). The concentration of phosphorite increases at the downhill side near to the Shree Mahadev Basic School.

Systematic channel, chip and grab sampling was carried out to perform chemical analysis. Analysis of P2O5%, MgO %, CaO %, SiO_2 %, LOI % of rock samples was carried out in the lab of Department of Mines and Geology, Lainchaur. The result and their analysis can be done after the report obtained from the laboratory section of Department of Mines and Geology, Lainchaur.

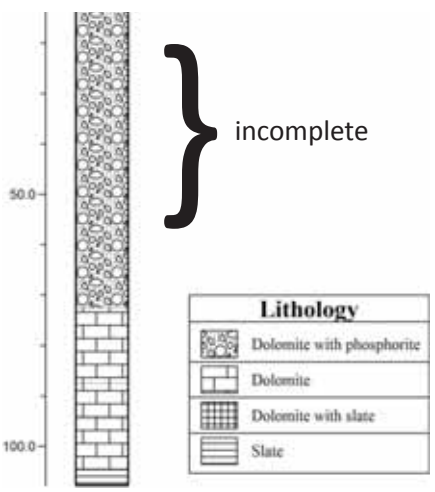

Fig. 9: Columnar section of Phosphorite Horizon

GEOLOGICAL RESERVE

The economic geological reserve of Phosphorite is calculated with consideration of average strike length of valuable grade of phosphorite beds. The reserve calculation was carried in two areas: Along the ridge near Rapana area and along the surface near school.

Total Concentration of phosphorite in dolomite rock = 15 %

Total amount of P205% in 11,08,800 tons of dolomite with 15 % concentration =166,320 tons.

ang District. Thickness of phosphorite horizon varies from 15 to more than 35m. Japhri and Bhalane area show some possibility of being economic from observation as bulk volume of phosphorite is nearly one third in 30 m band however chemical analysis of rock samples obtained from the study area strongly deny the possibility of economic or sub-economic mineral resources.

Phosphatic stromatolite and laminated phosphate are found in the Rapana, Kotali area of Baitadi District. Thickness of phosphorite horizon varies from 15 to more than 50 m. Rapana and kotali both shows possibility of being economic in perspective of field observations. As the area lies at the hill top with no any human settlement and agricultural land. In addition, the thickness of phosphorite band is more than 50 m in the Rapana Village. The quality of phosphorite is yet to come from Department of Mines and Geology, Laboratory analysis center. Analysis of phosphorite and their interpretation can be done after chemical analysis report. The data obtained can be used for Special License offered by Department of Mines and Geology in upcoming fiscal year.

Along with the ridge, Rapana Village						
S.N.	Strike Length	Total Thickness	Strike length, m	Volume, m^3	Tonnage Factors	Geological Reserves, tonnes
1	70 m	35	80	196000	2.8	548000
Along with surface near the school						
2	80 m	25	100	200000	2.8	560000
	Total	60	180	396000		1108800

CONCLUSION AND RECOMMENDATION

Phosphatic stromatolites and laminated phosphate are found in the Traugad-Juilgad area of Bajhang District. Thickness of phosphorite horizon varies from 15 to more than 35m. Japhri and Bhalane area show some possibility of being economic from observation as bulk volume of phosphorite is nearly one third in 30 m band however chemical analysis of rock samples obtained from the study area strongly deny the possibility of economic or sub-economic mineral resources.

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Prospecting for Hematite Ore Deposit in the Dhaubadi-Pokhari Area, Nawalpur District using Geophysical Techniques

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Kumar Khadka (Senior Divisional Geologist) | **Prakash Pokharel** (Geologist)

ABSTRACT

The 2D electrical resistivity Tomography (ERT) and time domain Induced Polarization (IP) survey were undertaken to locate the position and geometry of the hematite ore deposit around Dhaubadi-Pokhari area, Nawalpur district. In this survey mainly four types of array were used and they are Wenner alpha, Dipole-Dipole, Wenner-Schlumberger and Schlumberger. The ERT and IP data were collected along the 37 different survey lines (profiles) by using the GD-10 Geomative instrument around the mineralization area. Result of two profiles were currently analyzed and are presented in this paper. The Differential Global Position System (DGPS) survey was carried out to collect the topographic data for topographic correction during the inversion modeling. Res2Dinv software was used to generate the inversion models of resistivity and chargeability. The results from inversion show that resistivity varies with geological condition and degree of water saturation. The resistivity ranges from 50 – 500 ohm m. in saturated zone and 15,000 – 40,000 ohm m. in dry, highly fracture and rocky terrain. The chargeability ranges from 1-6 msec.

INTRODUCTION

Generally geophysical techniques are based on the contrasts of different physical properties. Electrical methods depend on the contrasts in electrical resistivity (Telford et al., 1990). Both Resistivity Tomography (ERT) and Induced Polarization (IP) surveys were carried out to locate hematite mineralization bands in the part of Nawalpur, Gandaki Province. It was an annual field program of Department of Mines and Geology (DMG) under the mineral exploration project for the FY 2075/76. This report discusses survey procedure, compilation of data, interpretation method, and the results of resistivity and induced polarization (IP) surveys carried out over the Dhaubadi areaof Nawalpur district, Gandaki Province, Nepal.

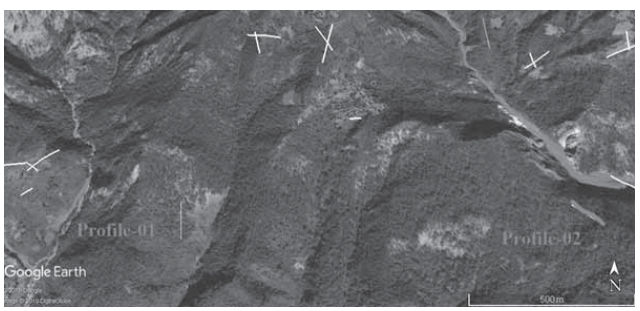

Fig. 1: Location map of the survey area taken from Google Earth.

White and red lines represent the ERT and IP survey profiles in the field study. Two red lines show the profiles lines presented in this report.

The DMG had started the preliminary and follow-up explorations of hematite deposit in Dhaubadi in 2012 and had carried out geological mapping, topographical survey and systematic sampling in the previous fiscal years.

For the convenience of the study, the total area of Dhaubadi Iron prospect is divided into five blocks: Durlunga Block, Pokhari Block, Unexplored Block (Laphe Block), Ramche Block and Dhaubadi Block (DMG unpublished report). We carried out the geophysical survey in Ramche Block, Dhaubadi Block and some part of Pokhari Block, (east of Pokhari School) and covered 37 profiles (lines) during the field period of 45 days from 13 Falgun to 27 Chaitra 2075. Dipole-dipole, Wenner alpha, Wenner-Schlumberger and Schlumberger array were used for ERT and IP surveys.

This area lies about 20km north from East-West Highway. Danda Bazaar and Daldale are the places in east-west highway (in Nawalpur) from where dust road of 21 km and 24 km. run north linking to Pokhari and Dhaubadi respectively.

OBJECTIVES

The general purpose of the survey in this area is to locate the iron mineralization. The geophysical survey aims to trace the vertical and lateral dimension of ore body in the exposed area and as well as in the unexposed area where ore body is displaced by fault or other process.

REGIONAL GEOLOGY

The study area lies in the Lesser Himalaya in north and Sub Himalaya in south. The Lesser Himalaya is thrusted over the Sub Himalaya along north dipping Main Boundary Thrust. The study area consists of black to olive green shale, green quartzite, thick bedded white quartzite and black shale interbedded with hematite beds. Few Hematite beds seems to more siliceous. The mineralization thickness in an average is about 17m thick. The hematite is thinly to massive bedded and is interbedded with grey to olive green quartzite and greenish grey to grey slate. The ore is compact, fine to coarse grained, thin to massive bedded oolitic and siliceous in form(Pokharel and Baskota, 2013).

The Lesser Himalaya consists of rock of Lakharpata Group and Surkhet Group. The Surkhet Group liesunconformabaly above the Lakharpata Group (Kayastha, 1992). Surkhet Group consists of Charchare Formation, Melpani Formation and Suntar Formation where shale, quartzite, metasandstone are found and co-relatable to Tansen Group (Sakai, 1984). Similarly Lakharpata group consists of undifferentiated quartzite, slates, dolomite and limestone.

METHODOLOGY

Theelectrical resistivity tomography and Induced polarization methods are electrical geophysical method. Both methods are capable of detecting boundaries between unconsolidated materials (overburden), bed rocks, mineralization bands, subsurface water channel due to contrast of resistivity between subsurface materials (Telford et al., 1990).

Resistivity Method

In this method, DC current injects into the ground using 2 current electrodes (C1and C2) and a potential difference is measured using 2 potential electrodes. In fact, earth is not the uniform. So we can measure the apparent resistivity. The apparent resistivity is expressed by ρ s (Loke, 2004) in Ω • m, which can be defined as:

$$\tilde{n}_S = K\frac{V_{MN}}{I}$$

K is the device constant value, VMN is the primary field potential difference between M and N, and I is the current that is transmitted to the ground through the transmitting electrodes A and B.

Induced Polarization

Induced Polarization is of various types. We used time domain induced Polarization in this study. Induced polarization (IP) is the Earth's capacity to hold an electric charge over time. IP measures the voltage decay curve after the injected current is shut off. IP is especially useful for mineral exploration applications. When DC current is switched off, voltage electrodes is not suddenly drop to zero but takes finite time to decay with time. This time is measured in milliseconds (msec).

DATA ACQUISITION

Theinstrument GD-10 Geomative was used to collect the data of apparent resistivity and chargeability of the profiles. It consists of GD 10 Main Frame, BP 450 Battery, Cable leader, double takeout cable, solid electrode, solid non-polarizing electrode and banana cable.Mainly four types of arrays were used and they are Dipole-dipole array, Wenner-Schlumberger array, Wenner array and Schlumberger array.Differential GPS (DGPS) survey also carried out in this field. We collected the topographic data from each ERT/ IP profile for topographic correction by using DGPS survey. Beside these instruments, rock drill, hand GPS, Compass hammer and so on, were used to collect the relevant information.

DATA ANALYSIS

Res2DInv software was used to analysis the ERT/IP field data which provide the resistivity and chargeability of the subsurface layer (Loke, 2004). Topographic data of the profile taken by DGPS survey also added to ERT/IP field data before analysis for topographic correction. The resistivity and chargeability inversion image of 2 differentprofiles (lines) are analyzed here.

RESULT AND DISCUSSION

2 ERT/IP profile from Pokhari- Dhaubadi area have been analyzed so far. One profile is selected in saturated zone and other is selected in dry and rocky terrain zone (Fig. 1) .Dipole-dipole,and Wenner-alpha arrays were used for data collection. The Res2DInv software was used for the data analysis (Loke, 2004). The results from inversion images are described profile wise as below.

Profile-01

This profile was taken along the right bank of koi Khola in flood plain (Figure 1). The total length of the profile is 94m and no. of electrodes used in the survey was 48 with 2m spacing. The ERT and IP survey were carried out by using Dipole-dipole and Wenner-alpha arrays.

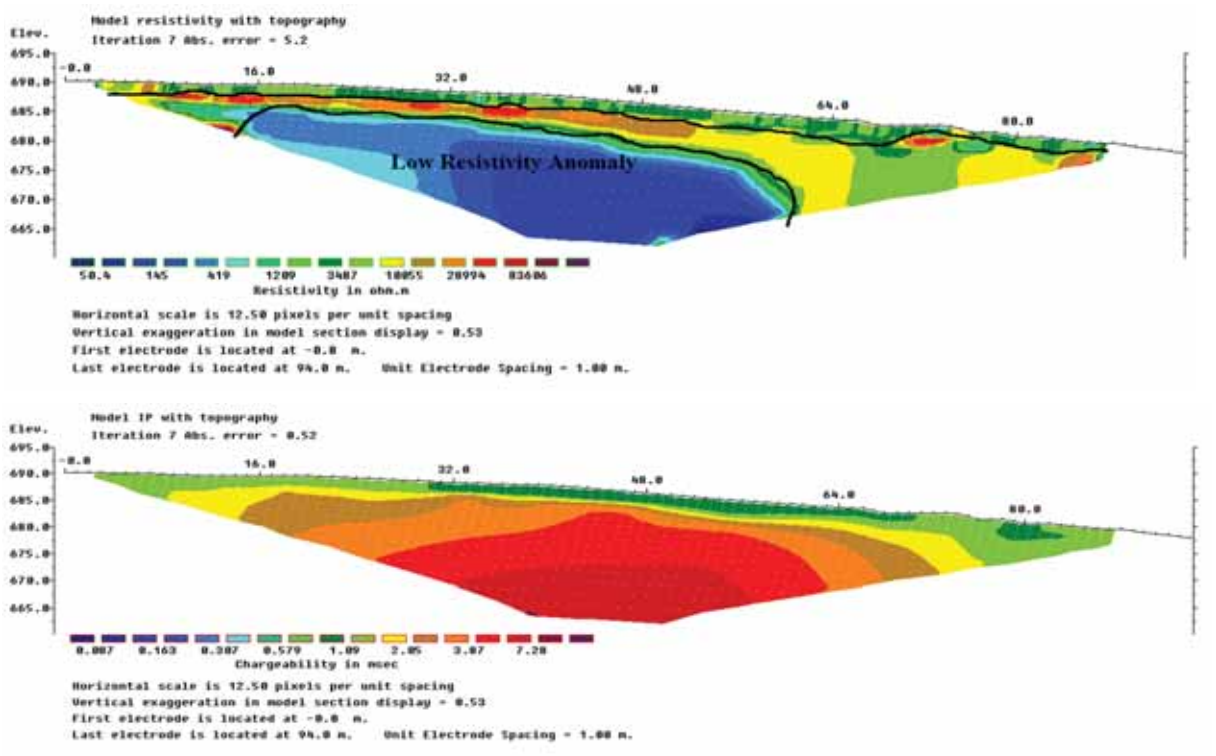

Fig. 2: The resistivity (Upper) and Chargeability (lower) inversion image of Dipole-dipole array along the profile 1. Different colors show the resistivity and chargeability value respectively according to the legend.

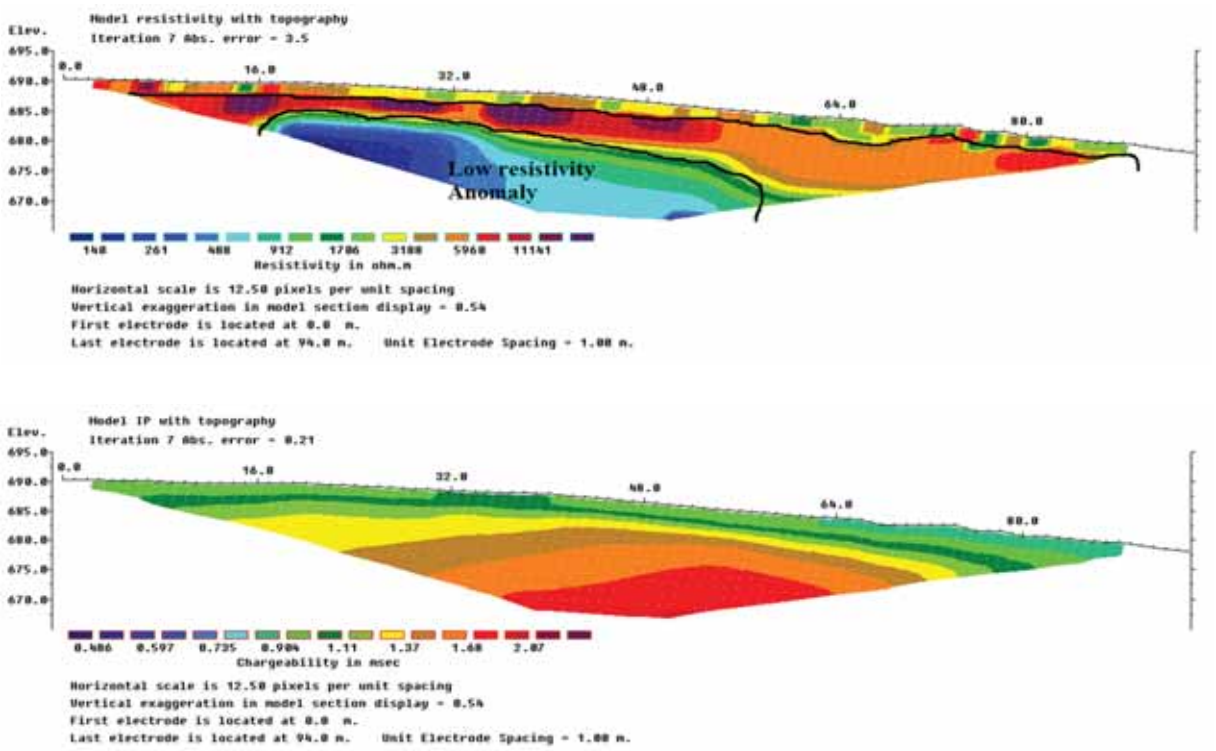

Fig. 3: The resistivity (Upper) and Chargeability (lower) inversion image of Winner Alpha array along the profile 1. Different colors show the resistivity and chargeability value respectively according to the legend.

The resistivity inversion results of profile 1 shows the three layers in the central part of the profile (Figure 2 and 3 upper). Resistivity images from both Dipole-dipole and Wenner-Alpha are almost similar in resistivity layers. A low resistivity value is observed at the center of the profile below the 10m from surface. From field inspection, this area is wet (saturated) due to Koi Khola. The value of resistivity decreases with increase the degree of water saturation in the rock (Bery and Saad, 2012b). According to the regional orientation of the mineralization band, saturated zone, low resistivity value and bed rock exposed in the left bank of the Koi Khola, the low resistivity anomaly zone observed from distance 16m to 64m is due to the presence of mineralization band at the depth of 7-10m below the surface.

The chargeability in Figure 2 lower and 3 lower shows the similar tendency to increase towards depth at center part of the image. There is not sharp contact.TDIP is particularly sensitive to the presence of sulphides and metalic-oxides (Pelton et. Al., 1978 and Gurin et. Al., 2015). The chemical analysis results of hematite ore indicate that, the Fe is the main recovery composition with content of 35.36%, the main impurties composition is SiO2 with content of 44.88%, content of metal-oxides, P and S is respectively 3.96%, 0.04% and 0.02% (DMG report, unpublished). When we compared to the resistivity inversion image, Chargeability of the hematite may be around 2-6 msec.

Profile-02

The profile was taken along the ridge across the regional orientation of the mineralization band in the survey area (Figure 1). The co-ordinate of start electrode (south-east end) 27.75052, 84.11848 and end electrode (North-west end) 27.75112, 84.11774 in decimal degree. The total length of the profile is 105m and no. of electrodes used in the survey was 36 with 3m spacing. The ERT survey was carried out by using Dipole-dipole and Wenner-alpha arrays and IP survey was carried out by using Dipole-dipole array only.

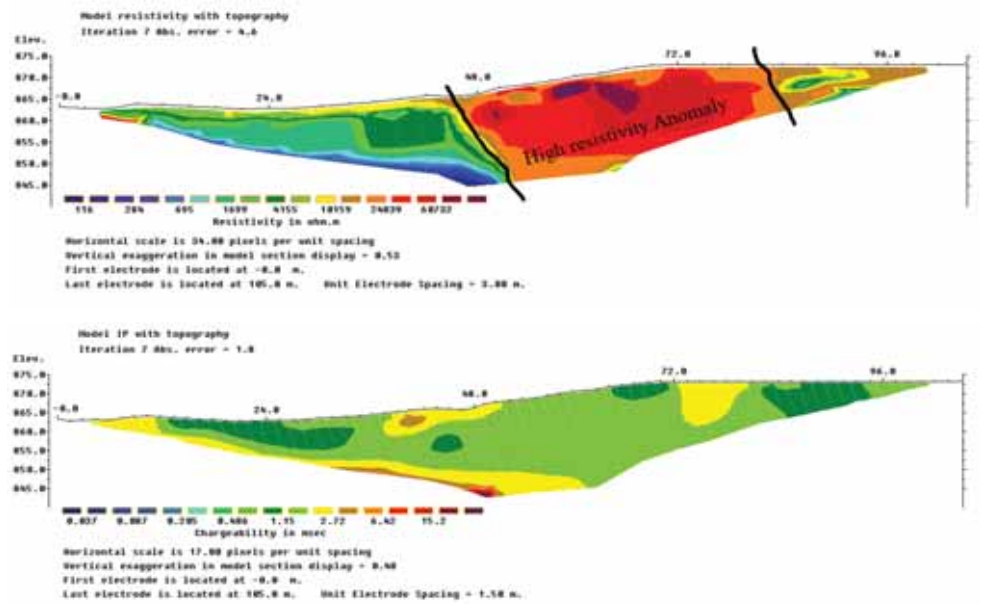

Fig. 4: The resistivity (Upper) and Chargeability (lower) inversion image of Dipole-dipole array along the profile 2. Different colors show the resistivity and chargeability value respectively according to the legend.

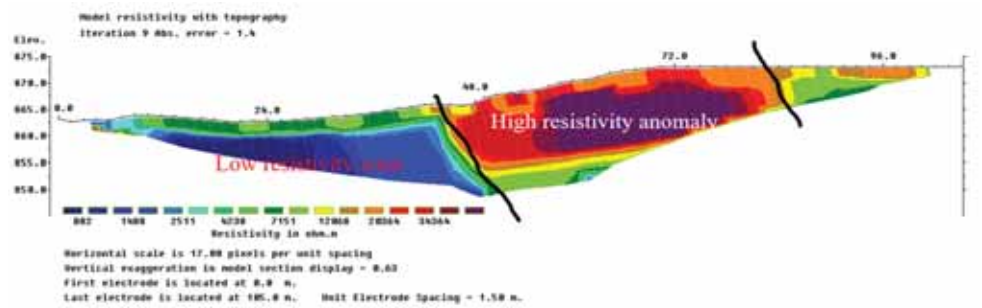

Fig. 5: The resistivity inversion image of Wenner-alpha array along the profile 2. Different colors show the resistivity and chargeability value respectively according to the legend.

The resistivity inversion results of profile 2 shows the tworesistivity zone shown in Figure 4 upper and 5.A low resistivity zone and high resistivity zone are observed at the left and middle to right of the inversion image respectively (Figure 4 upper and Figure 5). From close field observation, this area is dry, highly fractured and hematite band also exposed at the surface just above the high resistivity zone in figure 4 upper and figure 5. Left side of the profile is covered by dense sal forest.

The subsurface resistivity is related to various geological parameters like mineral composition, fluid content, geological situation, porosity and degree of water saturation in the rock (Beryand saad, 2012b). The hematite is thinly to massive bedded, interbedded with grey to olive green quartzite and greenish grey to grey slate, fine to coarse grained (low porosity), oolitic and siliceous in the form(Pokharel and Baskota, 2013). The resistivity of the hematite ore ranges from 0.01 to 10,00,000 ohm m. (John, 2003) and from 0.0035 to 1,00,00,000 ohm m. (Telford et al., 1990).

So, from the above reasons, the high resistivity zone (15000 to around 40000 ohm m.) may be hematite mineralization band. Our measured resistivity value seems slightly higher but lies between the resistivity range of Johe (2003) and Telford et al. (1990).The chargeability image in Figure 4 lower does not provide the sharp contact between mineral band and host rocks.We found the similar results with profile-01.

CONCLUSIONS

We selected and analyzed only two profiles of different geological conditions in this study from 37 profiles that we measured in the field. One profile was taken along the flood plain of Koi khola. Another profile was taken in dry, rocky terrain, sloppy area. We found the two different resistivity ranges from two different profiles. From the resistivity inversion images of profile -01, the resistivity value of the hematite band ranges from 50 – 500 ohm m. The resistivity results from profile-02 show higher resistivity value than profile-01. According to bery and Saad, (2012b), resistivity of the subsurface materials depends on composition, fluid content,degree of water saturation, porosity and geological Situation. The resistivity values of the expected hematite band of profile-02 ranges from 15,000 - 40,000 ohm m. In the other hand, we analyzed same profiles by two different array and got almost similar resistivity layers but Dipole-dipole array provide more depth information as compared to Wenner-alpha array.

In case of chargeability, we also selected same two profiles for analysis. After inversion,there is no sharp contact between mineralization band and host rocks shown in Figure 2 lower, 3 lower and 4 lower. After comparison with resistivity layer of same profile, the chargeability of the expected hematite band ranges from 1-6 msec. It may be due to the presence of sulphides and metallic-oxides impurities in hematite ore.

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Engineering and Environmental Geological Mapping of Bharatpur Metropolitan city and its Surrounding Area, Chitwan District

Kumar Khadka (Senior Divisional Geologist) | **Gautam Khanal** (Geologist)

ABSTRACT

The present study deals with the engineering properties of Quaternary sediments which gives information on more favorable ground condition for urban development. This study also deals with geological hazards, its impact in environmental and their mitigation. The field investigation was carried out by power driven auguring, hand auguring and Standard Penetration Test (SPT) equipments. Soil samples were taken from various depths to delineate different Quaternary geological units. A number of traverses were taken along rivers, tributaries and road alignments for delineating geological units and to identify the areas prone to geo-hazard such as flooding and river bank cutting. Natural resources such as sand, gravel and clay were assessed.

INTRODUCTION

Bharatpur Metropolitan city is located in central-southern part of Nepal in Chitwan District, Province-3. It is the fifth largest city of Nepal occupy an area of 250 sq. km with the population of 199,867 (census 2011) and is one of the fast growing cities of Nepal. It lies on the left bank of Narayani River and serves as a commercial centre of Chitwan district and Province-3 of Nepal. It is located at the centre of Mahendra Highway and Kathmandu - Birgunj (North-South) road corridor. The proximity distance to this city from Kathmandu is 146km, Butwal 114km and Hetauda 78kms.

The study area lies between 3056500 to 3066500m Northing and 533000 to 545000m Easting covering about 114 sq. km area. It covers parts of Bharatpur Metropolitan city and Gaidakot Municipality (Figure 1). The study area lies in the Topo Sheets No. 2784 06A & 2784 06B published by the Department of Topographic Survey, Nepal.

The present study is intended to provide information on surface and sub-surface geology for selecting suitable areas for future development planning and potential areas of natural resources as well as to delineate natural hazard prone locations in the area.

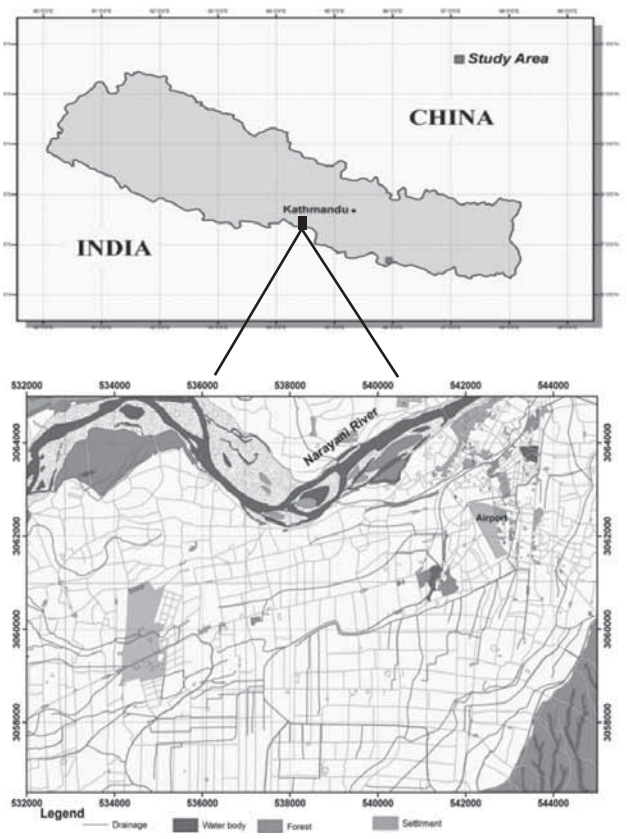


Fig.1: Location map of the study area

PREVIOUS WORKS

Different personnel have worked in this area in the past for different purposes.

- Geological Map of Petroleum Exploration Block-4 (2007) published by Petroleum Exploration Promotion Project, Department of Mines and Geology shows the presence of alluvium deposit (Quaternary-Recent deposit).

Fig. 2: Performing Standard Penetration Test(SPT).

- Geological Map of Central Nepal (1987) at 1:250, 000 scale published by the Department of Mines and Geology shows the occurrence of recent sediments in the area and consisting of alluvium boulders, gravels, sands and clays.
- K. M. Amatya and B. M. Jnawali (1994) compiled the Geological Map of Nepal at a scale of 1:1,000,000. In the map Quaternary Alluvial deposits of Gangetic Plain represent the area.
- Acharya (2001) studied the hydrogeological settings of Bharatpur -Gaidakot area He classified the fluvial sediments of the area into three formations.
- Dangol and Poudel (2004) studied on analysis of satellite imageries and topographic maps of different dates revealing that the Narayani River near Mangalpur migrated about 32 km to the west. Its westward shift is evidenced by the continuation of wetlands parallel to the main river course.

However no Engineering and Environmental Geological map of this area has been prepared before.

OBJECTIVES

Main objective of the study is to prepare an Engineering and Environmental Geological Map of the area at 1:25,000 scale. To meet this aim the following scope of work was incorporated.

- To determine the sub-surface ground condition of unconsolidated sediment and its bearing capacity
- To delineate the area susceptible to liquefaction hazard.
- To provide engineering properties of different soil units.
- To identify the geo-hazardous and risk area and recommend proper mitigation measures.
- To identify the existing environmental problems which will have direct impact on human health.

METHODOLOGY

Existing relevant literature on geology, geo-hazards and regional geological as well as landuse maps were reviewed.

Prior to the field, the desk study was carried out using toposheet (1:25,000) and high resolution satellite image (from Google Earth) for the study of landuse pattern, geomorphology and suitable sites to drill auger holes and SPT.

During field work auger drilling and SPT (Fig. 4 and 5) were carried out as planned before. Samples collected from the field (Fig. 6) were analyzed in the geotechnical laboratory of the department for Liquid Limit, Plastic Limit, Sieve Analysis and Moisture Content. The softwares used for this study are ArcGIS, Winsieve 5, Rockworks 2015 and Freehand.

FIELD ACTIVITIES

In the field, related documents were collected from the Metropolitan city and other governmental organizations. Field investigation was carried out using GPS and toposheets of 1997 in 1:25,000 scale for location. Number of augers and SPT up to the depths of 5.45m were carried out at required places to know the sub-surface geology at different depth. Samples were collected from various depths of auger and SPT holes. Outcrops exposed in some of the streams and river was also taken into consideration.

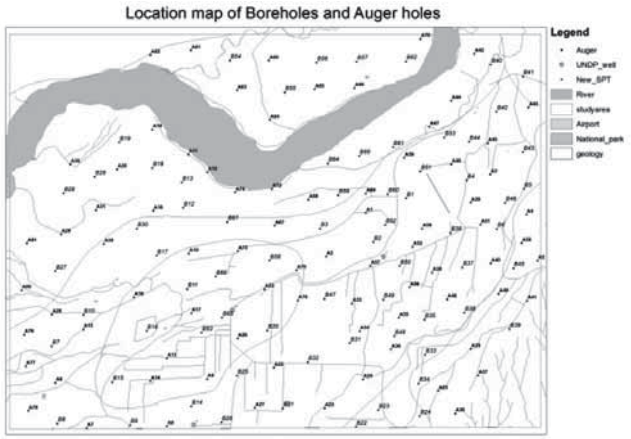


Fig. 3: Map showing the SPT and Auger Location

Fig. 4: Field personnel taking sample after performing SPT

Fig. 5: Performing power auger test

Fig. 6: Samples being recovered by hand auger.

QUATERNARY GEOLOGY

The necessary sub-surface information about the quaternary geology were obtained from field survey, Power Auger Drill, Hand Auger, SPT test (Fig. 2). Based on subsurface geological information such as type, nature and size of the sediments from the lithologs, the study area is classified into 5 different lithological units based on the dominance of sediment types. In this study instead of the terminology "formation", deposits are used. They are named as type locality. They are as follows;

1. Kathsikri Deposit : clay deposits interfringing with fine to medium sand
2. Torikhet Deposit: Upward fining sequence from gravel to fine sand
3. Pulchok Deposit: Coarse sediments (Gravel sand mix)
4. Flood Plain Deposit: Recent Narayani river deposit
5. Siwalik rocks: Mudstone, sandstone and conglomerate

Their brief descriptions are given below:

Kathsikri Deposit:

This deposit is distributed mainly in the south eastern part of the study area. This is soft to stiff clay and silty clay dominate deposits mainly developed at Gaurigunj, Kathsikri, Shivalaya chock, Baruwa of Bharatpur of municipality. Layer of fine to medium sand (Fig. 7) also interfringes within this deposit(A49, B39),. It consists of grey clay to dark grey stiff clay and yellowish silty clay. The field N-values in this area is low to moderate. The sediments in this unit have loose density. Because of the clay and silty clay nature, this unit has low infiltration of surface water and low permeability. This unit is potential for agriculture and

good geological barrier for the waste disposal. The thickness of this unit is more than 6 meters.

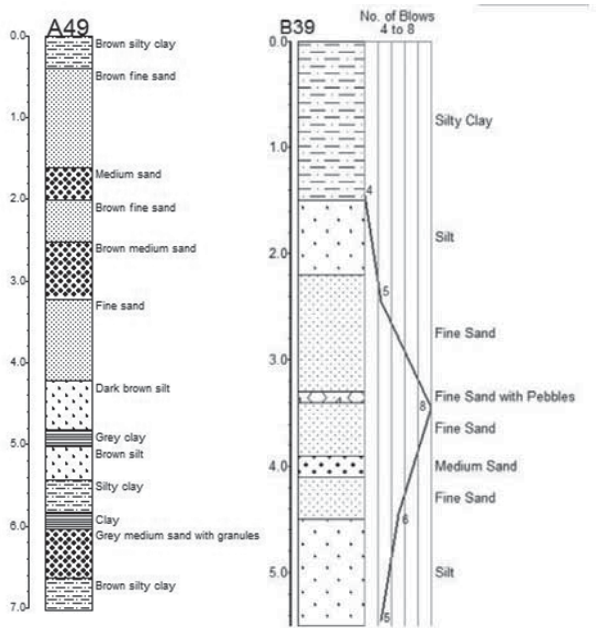


Fig. 7: Geological log of auger holes representing the sediments of Kathsikri deposit

Torikhet Deposit:

This unit mainly consists of fining upward sequence of sediments ranging from fine sand to gravel (Figure 9), found at depth of 3m. At Phulbari (B25, B26), the cycle of fining upward sequence of sediments can be seen clearly. This deposit is distributed in Phulbari, Torikhet, Gitanagar, Narayanpur. The bearing capacity of this deposit is low to High. Groundwater table is 1m to 2.5m deep in general. It is moderately good for foundation purpose; however some protective measures are to be applied where bearing capacity is low. This unit is potential for the groundwater. This deposit lies in the southern part of study area.

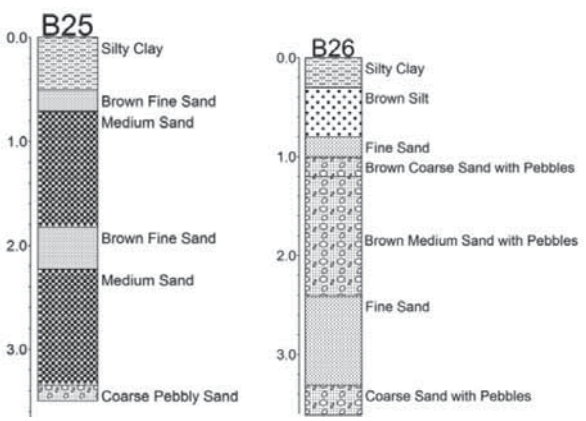


Fig. 8: Geological log of Torikhet deposit.

Pulchok Deposit:

This unit is characterized fine grained sand to gravel from top to bottom (Fig. 9). At few places, layer of silty clay is observed in clay and sand deposit. This unit is developed at Pulchok, Mohanpur, Aaptari, Sharanpur, Gaidakot etc. Bearing capacity is Medium. Groundwater table is 1m to 3m deep in general in this unit. Thick clay layer found at top is good barrier for the waste disposal however sewerage system needs proper lining to protect from groundwater pollution. The clay can be used for the brick factories. This unit is useful for the agriculture purposes. Sands at the bottom layer are good source of groundwater. Protective measures are to be applied where the bearing capacity is low to moderate.

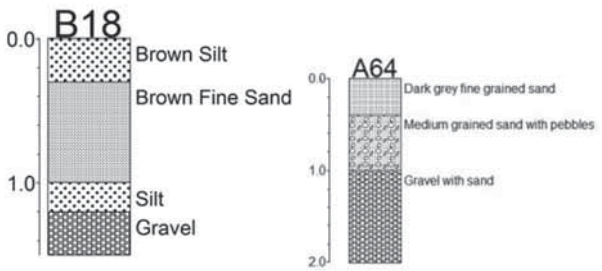


Fig. 9: Geological log of auger holes representing Pulchock deposit

Flood Plain Deposit:

This unit is characterized by recent fluvial deposits of Narayani River (Fig. 10). At few places, layer of silty clay is observed in clay and sand deposit. This unit is developed along the Narayani River Bank. The bottom layer is hard due to cementing of sediments. The upper layer is mainly silty slay, with mix sediments of sand to gravel.

Fig. 10: Flood plain deposit in the left bank of Narayani River 300m below the bridge.

Siwalik Group

The Siwaliks consist of molassic sediments, mainly conglomerates, sandstones and clays of Neogene period. This lenticular shaped longitudinal valley in Siwalik range represent the active front of the Himalayan chain and represent tectonic or structural depression in the post Siwalik time. In the lower and middle Siwalik, these deposits are slightly consolidated sandstones; the upper Siwalik consist of conglomerates. The broad valleys in the Himalayan foothills, the so-called duns, represent geological depressions (synclinals) in the Siwalik. This unit of rock is bounded by Main Frontal Thrust (MFT) in the South and Main Boundary Thrust (MBT) in the North. The age of Siwalik group is considered to be of Middle Miocene to lower Pleistocene.

This Siwalik Group of rock consists of different lithological units as Lower Siwalik, Lower Middle Siwalik, Upper Middle Siwalik and Upper Siwalik as described below from South to North. In this study only Upper Siwalik rocks exposed along the bank of Narayani River in Gaidakot Municipality.

Upper Siwalik (US):

Upper Siwalik is conformably overlies the Middle Siwalik (MS) with gradational contact. This formation exposed along left bank of Narayani River in Gaidakot Muncipality. This unit of rock is composed of gray to light gray coloured conglomerate beds with, medium to coarse grained sandstone with interbedding of siltstone, mudstone, fine grained sandstone. The formation is considered to be of Middle Miocene – lower Pleistocene age.

Fig. 11: Upper Siwalik Group rock.

Bearing Capacity

Bearing capacity analysis is carried out according to Peck et al, 1974 (Table-1). According to the analysis it is found that the bearing capacity of the study area has medium bearing capacity with N Value ranging from 2 to 17. Bearing Capacity map is shown in Figure-10. The greater value is normally encountered at a greater depth, and hence the bearing capacity gradually increases with the increase in depth.

Table 1: Bearing capacity analysis according to Peck et al, 1974.

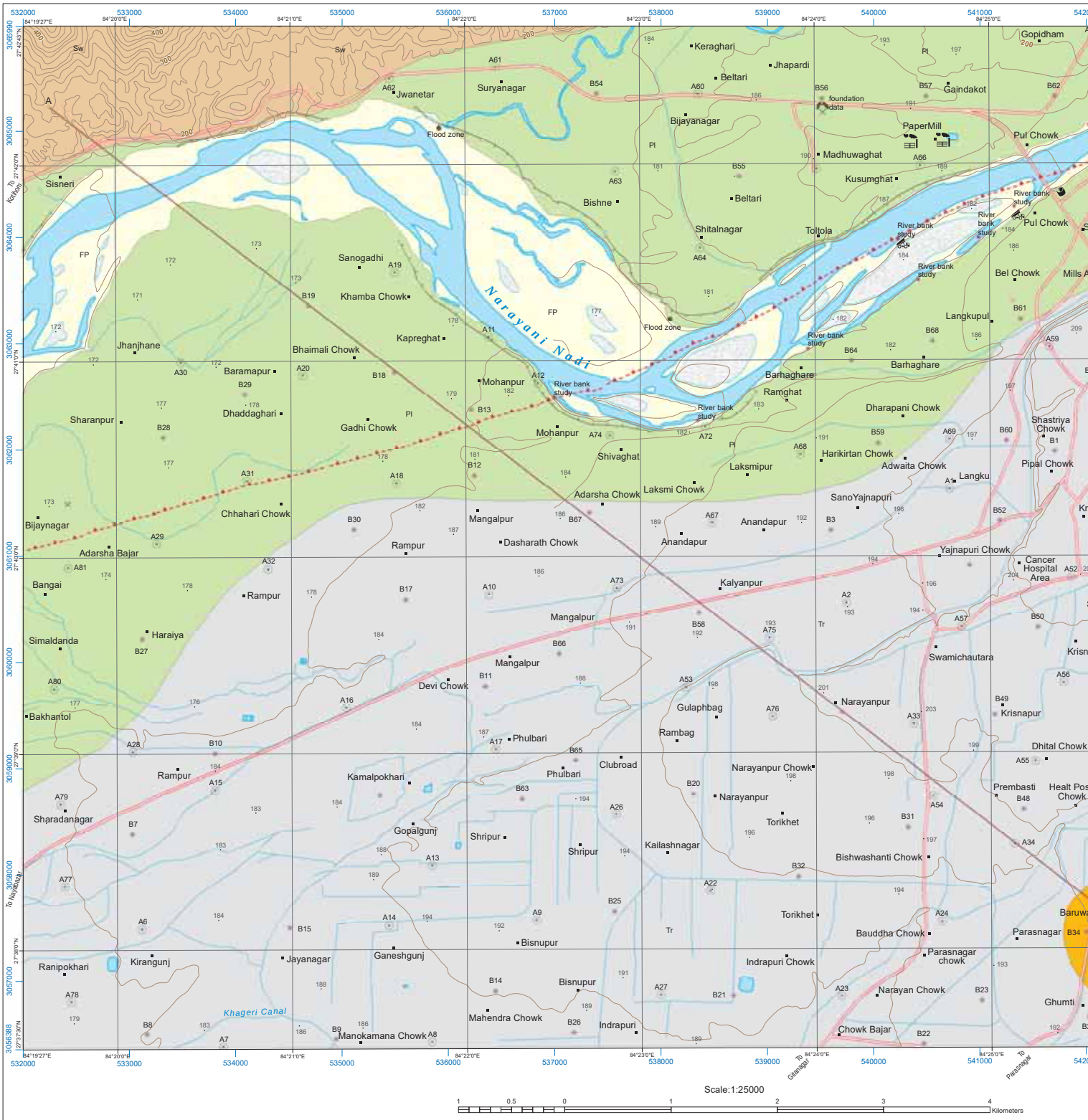
relative density of cohesion less soil		consistency of cohesive soil		unconfined compressive strength	bearing capacity		plasticity	
Term	N value	Term	N value	Kg/cm²	t/m²		Term	%
Very loose	<4	Very soft	<2	<0.25	low	<7.2	none	0-1
Loose	4-10	soft	2-4	0.25-0.5	moderate	7.2-21.6	very low	2-5
slightly dense	11-30	firm	5-8	0.6-1	high	>21.6	low	6-10
dense	31-50	stiff	9-15	1.1-2			moderate	11-20
very dense	>50	very stiff	16-30	2.1-4			high	21-40
		hard	>30	>4			very high	>40

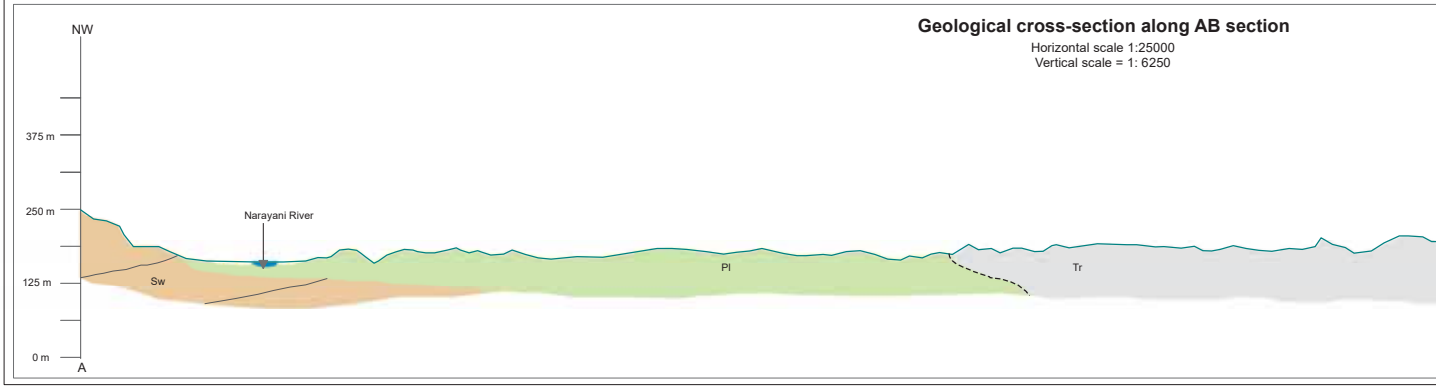
LIQUEFACTION HAZARD AND SEISMICITY

There is not much seismicity in the Chitwan district as depicted from "Epicentre Map of Nepal from 1994 – 2005 AD published by the DMG. However Main Frontal Fault (MFT) lies just 4 km north of the Bharatpur. The study area consists of loose sediment like sand, silt and clay, vulnerable to earthquake shaking and there is possibility of liquefaction during great earthquake.

Table 2: Correlations between N value and Consistency.

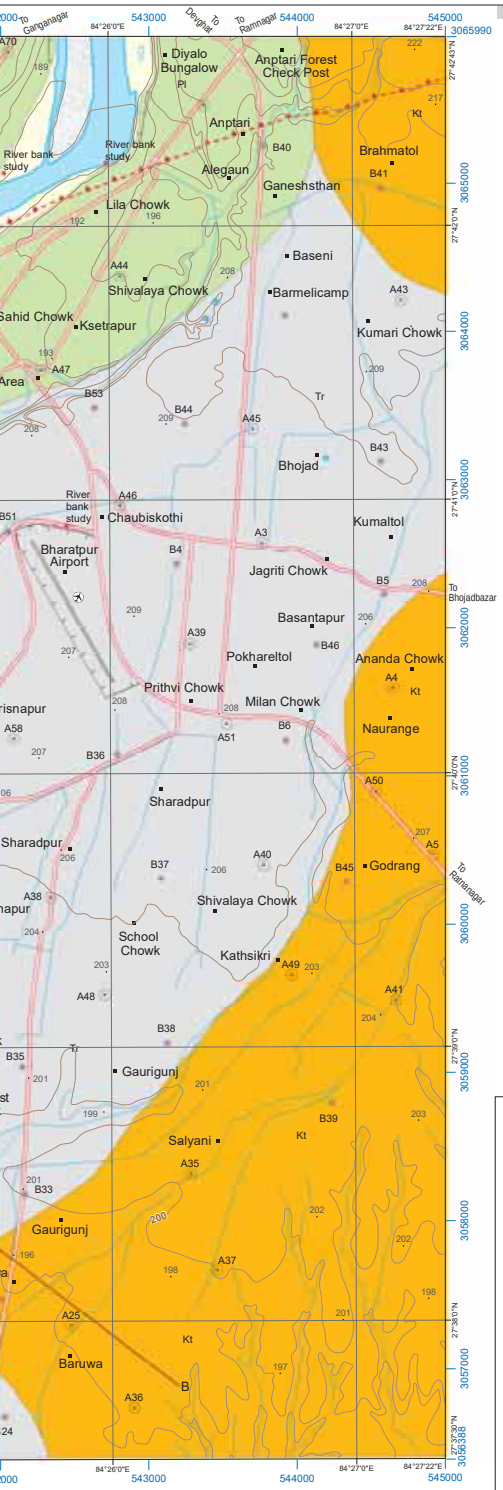
Condition	N-value	Bearing Capacity (Kpa)	Quality
Very soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	4 – 8	51 – 100	Low (L)
Stiff	8 – 15	101 – 200	Medium (M)
Very stiff	15 – 30	201 – 400	High (H)
Hard	>30	>400	Very High (VH)





Geological cross-section along AB section

Horizontal scale 1:25000
Vertical scale = 1: 6250



EXPLANATORY LEGEND

Unconsolidated Sediments (Sedimentary Units)		Descriptions	Engineering Properties and Recommendations
FP	**Flood Plain**	Recent sediments of flood plains and lower alluvial terraces. At the cut banks and bars: mostly gravel deposts up to boulder size. At the depositional bank and upper flood plain: sand.	Low bearing capacity, loose and soft consistency. High potential to bank cutting and erosion. High infiltration, high risk of pollution of ground and surface water. **Recommendation:** Construction of buildings not advisable. Sand and gravel mining advisable on very limited scale but no mining closer than 500m from the bridges. Waste disposal, and storage of chemical and other hazardous materials is strongly prohibited.
Kt	**Kathsikri Deposit**	Grey to brown clay lenses interfingerring with fine to medium sand.	Bearing capacity low. Risk of pollution of ground and surface water. **Recommendation:** Suitable for agriculture. Special site investigation is recommended for building construction. Waste disposal, storage of chemical and other hazardous materials should be restricted.
PI	**Pulchok Deposit**	Quaternary Alluvial sediments forming terraces. alternating layers of coarse sand gravel deposts up to boulder size. Thin humus top soil.	Bearing capacity moderate. Dense cohesionless soil. High infiltration. High risk of pollution of ground and surface water. **Recommendation:** Sand and gravel mining advisable. Waste disposal, and storage of chemical and other hazardous materials should be restricted.
Tr	**Torikhet Deposit**	Fine to coarse sand with occasional thin layers of grey to dark silty clay and clayey silt. Thickness of sand more than 8m at places.	Bearing capacity low to modearte. Iinfiltration high.Risk of pollution of ground and surface water. **Recommendation:** Suitable for agriculture and sand mining. Waste disposal, storage of chemical and other hazardous materials should be restricted.
Lithological Unit			
Sw	**Siwalik Deposit**	Interbedding of thick bedded sandstone and mudstone. Mostly covered by thick vegetation.	Moderate bearing capacity.Potential for landslides and bank erosion. High infiltration. **Recommendation:** Waste disposal, storage of chemical and other hazardous materials should be restricted.

MINERAL RESOURCES

Existing excavation site for gravel mine

FEATURES OF ENVIRONMENTAL SIGNIFICANCE

Landfill

Industry

Sewer processing plant

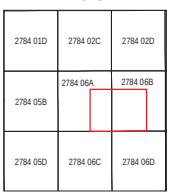
EROSION / BANK CUTTING FEATURES

Bank Cutting / Flood Hazard Zone

GENERAL SYMBOLS

SPT Borehole (B1)
Power Augerhole (A1)
SPT Location (4)
Thrust
Profile Line (A B)
Village
Contour (Index/Intermediate)
Contour (Supplementary)
Road
Airport
River/Stream
Water Body
Sand
Spot Height (205)

INDEX TO SHEET



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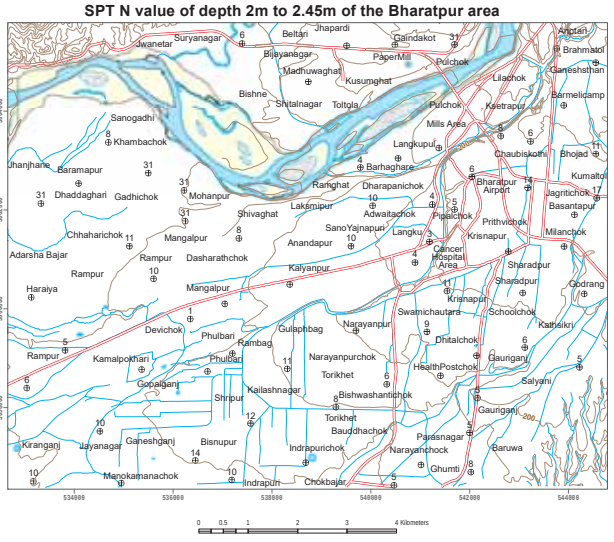
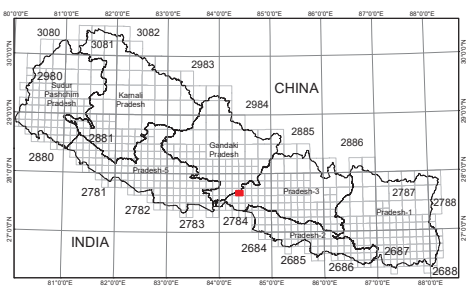
Stiff	9 – 15	101 – 200	Medium (M)
Very Stiff	16 – 30	201 – 400	High (H)
Hard	> 30	> 400	Very High (VH)

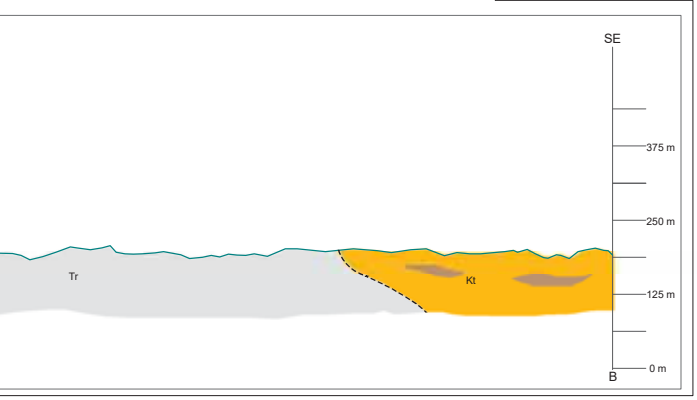
SPT N value of depth 2m to 2.45m of the Bharatpur area



ADMINISTRATIVE INDEX

LOCATION DIAGRAM





HORIZONTAL DATUM

Spheroid: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 84° East
Latitude: 0° North
False co-ordinates of origin: 500000 m Easting
False co-ordinates of origin: 0 m Northing
Scale factor at Central Meridian: 0.9999

Contour Intervals 10 meters

Supplementary Contours at 5 meters
Reference: Mean Sea Level (India)

Topographical Base:

Contours lines, villages, spot heights, roads and river/streams extracted from topographic base maps
Published by Survey Department, Nepal

Note:

Field Survey done in May , 2014

Limitation of the Map:

This map is exclusively intended for local planning. It should not be used as the only basis of investigation for individual structures. The map can not replace detailed site investigations.

Prepared by : Kumar Khadka and Gautam Prasad Khanal

Published Under the authorithy of
Dr. Soma Nath Sapkota
Director General

DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019

GEO-HAZARD AND ENVIRONMENTAL PROBLEM

Geo-hazard of the study area includes river bank cutting, flooding and inundation.

Water flooding is caused because the volume of water falling or flowing on to the surface overwhelms existing drainage systems Water flooding is predominantly caused by short duration, intense rainfall occurring locally and upstream areas. Nepal is known as a hot spot for water floods..

Fig. 12: Induction of land in the bank of Narayani River.

The Narayani River is one of the major river of Nepal. It has a total catchment area of 46,300 square kilometers (17,900 sq mi), most of it in Nepal.). The riverbank cutting/erosion is common phenomena and occurs specially during rainy season, which widens the rivers. River bank cutting is seen along the banks of the Narayani River

Narayani River is a source of gift that deposits good soil and all the land surrounding this river is considered as fertile land and now facing a problem of flooding. Similarly, Bank cutting and eroding is the major problem created by this river.

Fig. 13: Washing away of gabion spur in the Narayani River.

Fig. 14: Bank Cutting in right bank of Narayani River

Fig. 15: Embrankment in Narayani River

Fig. 16: Showing River bank cutting in left bank of Narayani River.

GEO-ENVIRONMENT AND POLLUTION

Geo-environmental degradation is mainly due to rapid population growth, uncontrolled infrastructure development, haphazard waste disposal, unplanned urbanization, haphazard settlement, unplanned sewerage system, water pollution and poor sanitation. Direct contamination of waste materials with the water in the river and kholsi can be seen clearly (Fig. 7).

LANDUSE

The Metropolitancity area has been divided into following area based on their utilization.

a) Conserved area, b) Residential and commercial area, c) Mixed area, d) Institutional area, e) Industrial area f) Agricultural land, g) Public green and open area and h) Cultural heritage.

Fig. 17: Buddha Stupa in left bank of Narayani River in Pulchock, Bharatpur

WASTE DISPOSAL AND DUMPING SITE

One of the main purpose of the engineering geological mapping was to identify the suitable site for the municipal solid waste management, landfill areas. During the field investigation and the discussion with the officials of municipality it was learned that, the municipality does not have its own permanent properly managed sanitary landfill site and the problem of waste disposal was seen to be prevalent in high dense urban core areas.

Fig. 18: Water pollution due to thrown of waste materials into canal.

The inner core area of Bharatpur is not so clean and jamming of drain can be seen in Sahidhock and other areas. Domestic waste are thrown into various places specially at road junction like in

Fig. 19: Waste thrown in the kholsi in Belchok, Bharatpur.

Municipality collects waste materials from the streets and disposes in the small forest Eco-forest in ward no. 18 (Figure 20 & 28) near the municipality office which is not a permissible practice. Waste disposes into drainage systems of the urban areas (street no. 3, 4, 5) are hazardous to health and cause the blockage of the drainage system during flooding period

Fig. 20: Waste thrown in the bank of Narayani River about 500m below highway Bridge.

RECOMMENDATION FOR LANDFILL SITE

The field survey shows that the municipality has not its permanent sanitary landfill site. The solid wastes collected have been dumped into small forest near the municipality office.

Municipality has proposed suitable landfill site at Tilachaur near Ramnagar, northern part of the study area which is geologically suitable for the development of sanitary landfill site.

No buildings lie within 500m from that area. Based on litho-log (Fig. 21) it is suggested to use this area as landfill site. Thick layer of clay present in this area acts as barrier for contamination with ground water. Moreover the area is 6 km far from the airport and 1km east from Highway.

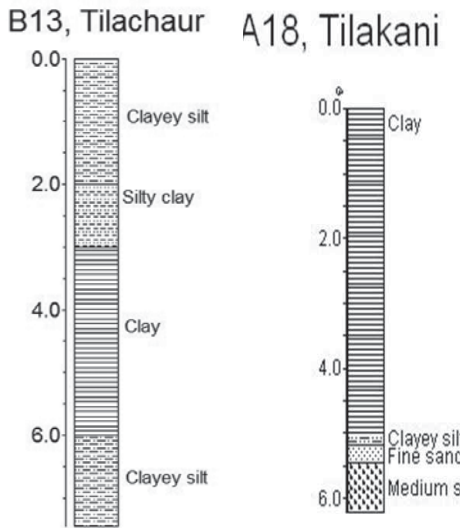


Fig. 21: Lithologs of proposed landfillsite

Fig. 22: Waste thrown of Proposed Landfill site, Tilachaur.

MANAGEMENT OF SEWERAGE DRAIN

The Metropolitancity is upgrading its drainage system for easy flow of sewage and water. Different drainage pipe and canal can be seen in the study area.

Construction Materials

Deposit of construction materials (Gravels) are found in flood plain of Narayani River and northern part of the Rapti Khola (Fig. 23). Clays are mining from the North east and South west of the study area. Pebbles and boulder are brought from these Khola and Narayani River flood plain and crushed to produce gravel and pebble (Figure 23) as construction materials. Sand mining is not available in this area.

Fig. 23: Mining and Transportation of construction material (sand, silt, clay) from private land.

There are many brick factories around VDCs which are used for the construction of buildings (Figure 24).

Fig. 24: Air pollution due to Brick Factory

Water Resources

Bharatpur is well known for the city of water bodies (lakes, ponds). The study area depends entirely upon groundwater either for drinking or irrigation which is obtained from deep wells and shallow hand pumps. The study area has both shallow and deep ground water aquifer. Chitwan district as a hole is bounded by Narayani River to the west, Rapti river to the south and Mohana river to the east.

In the Northern part of the District lies Bhabar zone and Churia hill. Bhabar zone is the main recharge zone of ground water. Perennial river, Narayani is source of the groundwater recharge of the district. The predominant aquifer nature is gravel and sand of coarse to fine grained and are trapped by impermeable bed of clay type.

Figure 25: Bridge over Narayani River

Groundwater is also used for water supply in the Metropolitancity area. Deep and shallow tube well is used for irrigation purposes and domestic purposes. Hand pumps are found everywhere to extract water from the ground to fulfill their domestic needs.

Figure 26: Canal for irrigating agriculture land.

CONCLUSION AND RECOMMENDATIONS

The investigation revealed that the study area mainly consists of alluvial sediments, which can be classified into six different units based on the subsurface geological information.

The study area is mainly dominant with fine grained sediments like clay, silty clay, silt and fine to medium grained sands in upper portion and gravel in lower portion below 2m depth.

Analyses show that the bearing capacity of the study area mainly has medium bearing capacity.

An establishment of a proper sanitary landfill site is highly recommended in order to manage haphazard disposing of waste materials within the valley.

This study is exclusively intended for planning at a regional scale. It should not be used as the only basis of individual building foundations.

More detail work should be carried out for specific planning purposes.

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Geological Map of Central Nepal (1987) at 1:250, 000 scale published by the Department of Mines and Geology.

Engineering and Environmental Geological Mapping Of Mahendranagar Municipality and Its Surrounding Areas, Kanchanpur District.

Shova Singh (Senior Divisional Geologist) | **Kumar Khadka** (Senior Divisional Geologist) | **Shailina Manandhar** (Geologist)

ABSTRACT

The rapid development of the urban areas in Nepal has generated concern with regard to the scope and extent of their infrastructural and environmental problems. There has been a significant increase in use of geological information in urban planning. The present study "Engineering, Urban and Environmental Geological Mapping" of Mahendranagar municipality and its surrounding area, Kanchanpur district, Far Western Nepal deals with the engineering properties of Quaternary sediments and gives information on more favorable ground condition for urban development. This study also deals with geological hazards, its impact in environment and their mitigation.

INTRODUCTION

Mahendranagar municipality is located in Kanchanpur district, in the Far Western Province of Nepal. It is about 700 kms far from Kathmandu (Fig. 1). East-West highway connects the study area with rest of the country. It is the key business centre of Far eastern Province as well as centre for education, health and employment opportunity zone of Far Western Nepal.

The study area lies between 3200000 to 3211000m Northing and 414000 to 427000m Easting covering about 100 sq. km area. It covers parts of Mahendranagar municipality, Suda and Daisy VDC (Fig. 1). The study area lies in the Topo Sheets No. 2880 01 B and 2980 13D published by the Department of Topographic Survey, Nepal.

Physiographically the study area lies in the Terai Plain having altitude ranges from 194m to 424m amsl. The study area consists of sediments of Quaternary deposits such as gravels, sand, silt, and clay etc. The climate of the study area is tropical and monsoon type.

The main rivers flowing in the study area are Gobariyakhola, Bangaonkhola, Bhasikhola, Sukhakhola and ChaudaraNadi. Most of these kholas origin from Siwalik and remain dry during dryseason where as in the monsoon time, they get discharge to aggravate flooding in the study area. There exist two main canals and numerous small canals.

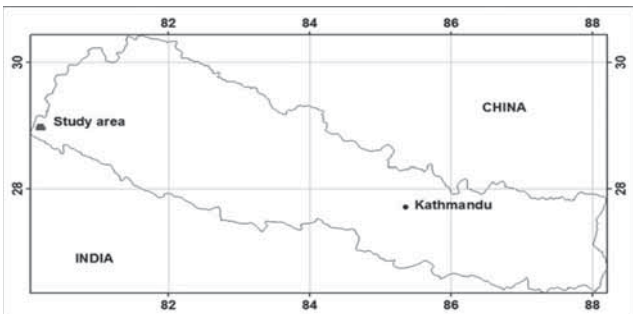


Fig.1: Location map of the study area

OBJECTIVES

The main aim of the study is to prepare an Engineering and Environmental Geological map (1:25,000 scales) of Mahendranagar Municipality and its surrounding areas. To meet this aim the following objectives were incorporated.

- To delineate the area into different soil units with similar properties with respect to their depth wise material composition and to provide engineering properties of different soil units.
- To identify the hazardous /risk areas and recommend proper mitigation measures.
- To select proper landfill site for safe disposal of solid waste.
- To provide information on potential mining for natural resources such as gravel, sand and clay available in the study area and give information on haphazard mining of such resources.
- To prepare Engineering and Environmental Geological Map by compiling different thematic layers.

LIMITATIONS

- Standard Penetration Test (SPT) is limited up to 8m depth.
- The information contained in the map are intended for urban planning in regional scale and infrastructure development activities. It should not be used as only basis for any specific site investigation for individual buildings or any other major structures. Therefore the map cannot replace detail site investigations. It also needs to be updatedby integrating the latest information.

METHODOLOGY

Existing relevant literature on geology, geohazard and other information like topomaps, aerial photographs and satellite imageries were collected and reviewed. Topomaps and satellite imagery were studied to obtain the overall view and plan of the study area. Digital database of thetopomaps received from the Department of Survey has been extensively used during GIS processing for the preparation of final map.

FIELD ACTIVITIES

The fieldwork was carried out from 2nd of Baisakh to 4thJestha 2070 for 34 days covering 100 sq. kmof the area. During the field, related documents were collected from the municipality and other governmental organizations. Hand Auger Hole drilling followed by Standard Penetration Test (SPT) and Power Driven Auger were carried out in the field to obtain necessary data (Fig. 1). 61 bore holes and 69 power auger holes were performed during the field (Fig. 2). 198 no. of Standard Penetration Test (SPT) and 38 no. of Cone Penetration test (CPT) from the 61 bore holes were carried out to obtain necessary data. Adequate soil samples were collected either from the hand auger boreholes or from the split barrel of SPT tests from various depths for laboratory analysis in the Geo-Technical Laboratory of DMG.

Fig. 2: Field personnel performing SPT and Samples being recovered by auguring.

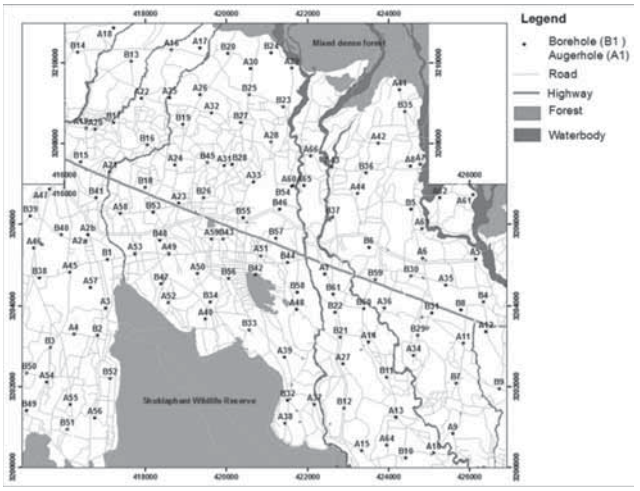


Fig. 3: Location map of boreholes and auger holes.

LAB ANALYSIS

The soil samples collected during the field investigation are subject to conduct various tests in Geo-Technical Laboratory of Department of Mines and Geology in order to determine their engineering properties, which are generally required for civil constructions. Samples were analyzed for

- Sieve analysis
- Liquid Limit
- Plastic Limit

In this report only few analyzed data are presented (Figures 3, 4 and 5)

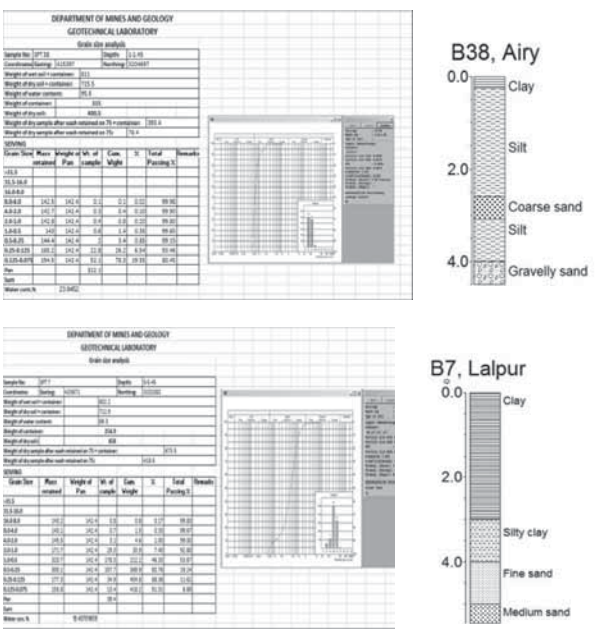


Fig. 4: Sieve analysis of some SPT boreholes with their sieve curves

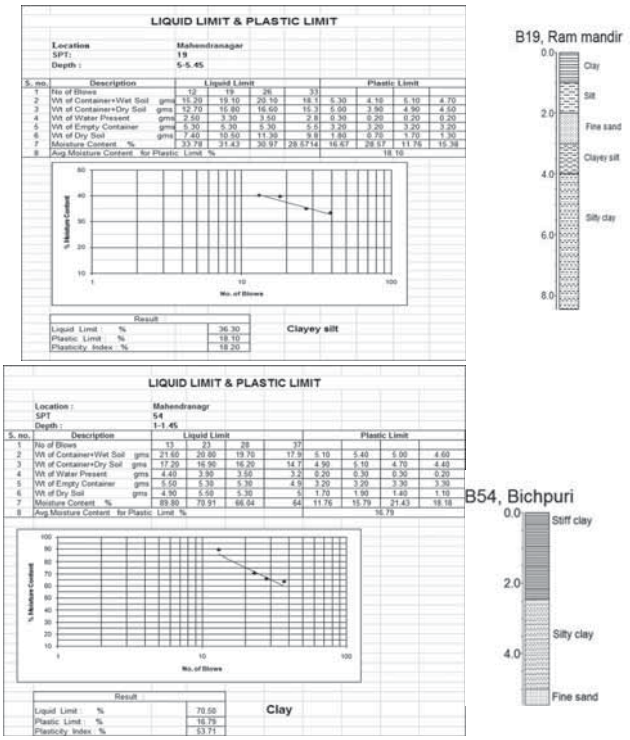
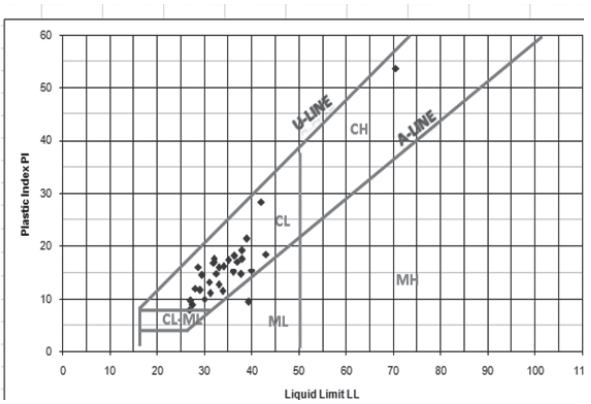


Fig. 5: Atterberg limit (Liquid and plastic limit) tests for finer sediments.

SPT no.	Depth in m.	Liquid limit	Plastic Index	Soil type (plasticity chart)
SPT4	1-1.45	31.20	11.12	CL
SPT6	2-2.45	35.00	17.41	CL
SPT7	1-1.45	37.70	14.80	CL
SPT8	5-5.45	27.50	8.93	CL
SPT9	1-1.45	43.00	18.48	CL
SPT12	1-1.45	33.00	12.71	CL
SPT13	4-4.45	31.90	16.87	CL
SPT13	7-7.45	34.00	16.16	CL
SPT16	1-1.45	32.00	17.07	CL
SPT18	1-1.45	40.00	15.48	CL
SPT18	3-3.45	38.00	17.61	CI
SPT19	5-5.45	36.30	18.20	CL
SPT22	2-2.45	32.00	17.55	CL
SPT22	3-3.45	39.30	9.44	ML
SPT23	4-4.45	29.00	11.64	CL
SPT24	2-2.45	28.00	12.01	CL
SPT25	2-2.45	27.00	9.72	CL
SPT28	6-6.45	33.00	15.98	CL
SPT30	4-4.45	33.80	11.56	CL
SPT37	3-3.45	38.00	19.19	CL
SPT45	3-3.45	32.50	14.84	CL
SPT46	1-4.45	36.00	15.44	CL
SPT54	1-1.45	70.50	53.71	CH
SPT54	2-2.45	42.00	28.38	CL
SPT54	3-3.45	36.00	15.10	CL
SPT54	4-4.45	31.00	13.23	CL
SPT55	1-1.45	28.60	16.08	CL
SPT57	1-1.45	26.80	7.95	CL
SPT59	1-1.45	30.00	10.01	CL
SPT60	1-1.45	29.50	14.56	CL
SPT61	1-1.45	39.00	21.44	CI
SPT61	2-2.45	37.00	17.04	CL



CL: Inorganic clays of low to medium plasticity or clayey silt

CH: Inorganic clays of high plasticity

ML: Inorganic silt

Fig. 6: Table showing Liquid limit, Plastic limit and Plasticity index of SPT boreholes data. In the Plasticity chart A-line separates silts from clay. Data that plot above U-line area in error.

QUATERNARY GEOLOGY AND THEIR ENGINEERING PROPERTIES

The sediments made up of sand, silt, clay, pebbles, cobbles and boulder size particle brought up by the Mahakali River and rivers from the northern part of the hills. Based on subsurface geological information such as type, nature and size of the sediments from the lithologs, the study area is classified into 6 different lithological units based on the dominance of sediment types (Fig. 7).

Bichpuri Deposit

This unit is distributed mainly in the south western and north eastern part of the study area. This is clay and silty clay dominate deposits mainly developed at Lalpurchowk, Bichpuri, Bhasigao and Sisaiyagaon of Suda VDC and Tilachaur of municipality. Layer of silt is also present in Mahuliya and Raipur. It consists of grey clay to dark grey stiff clay and yellowish silty clay (Fig. 8). The field N-values in this area is low to moderate. The sediments in this unit have loose density. Because of the clay and silty clay nature, this unit has low infiltration of surface water and low permeability. This unit is potential for agriculture and good geological barrier for the waste disposal. The thickness of this unit is more than 6 meters. The groundwater table in this region is 0.3m to 6.5m. The area is prone to subsidence so multistoried buildings are discouraged.

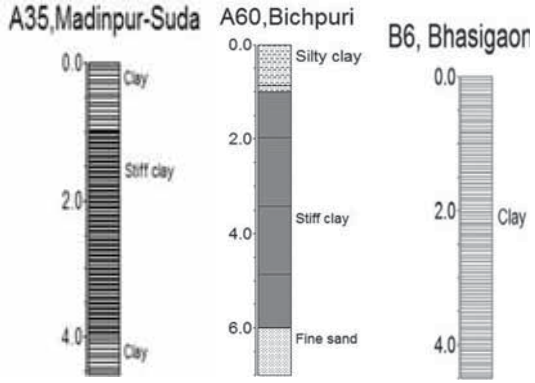


Fig. 8: Lithologs representing Bichpuri Deposit

Tintara Deposit

This unit mainly consists of fine to coarse sand, silt, and clayey silt (Fig. 8), found at depth more than 6m Near Tilachaur (A16),

2m thick layer of clay is also found in sand layer at 4m below depth. This deposit is distributed at Ultakham, Bangau, Kathepul, Ganesh chowk, Tilakpurand Jhaspura. At few places 20-80 cm silty clay layers are found below 1m depth. The bearing capacity of this deposit is low to High. Groundwater table is 1m to 2.5m deep in general. It is moderately good for foundation purpose; however some protective measures are to be applied where bearing capacity is low. This unit is potential for the groundwater.

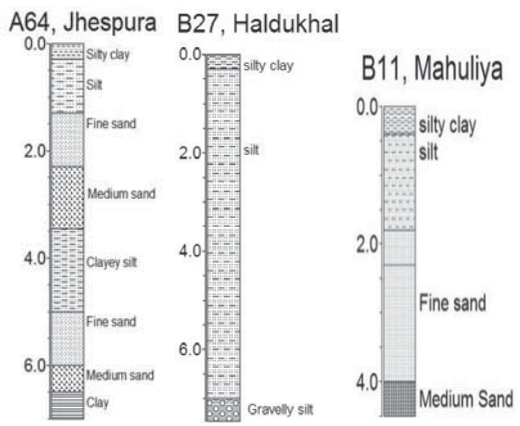


Fig. 9: Lithologs representing Tintara deposit.

Mahuliya Deposit

This unit is characterized by average 2-5 m thick clay on the top followed by fine to coarse grained sand layers up to 6.5m (Fig. 9). At few places layer of silty clay is observed in clay and sand deposit. This unit is developed at Lalpur, Sundarpur, Bagphata, Mahuliya, Jimuwa, Khayerbhatti etc. Bearing capacity is very low to Medium. Groundwater table is a depth of 1-3m in this unit. Thick clay layer found at top is good barrier for the waste disposal however sewerage system needs proper lining to protect from groundwater pollution.The clay can be used for the brick factories. This unit is useful for the agriculture purposes. Sands at the bottom layer are good source of groundwater. Protective measures are to be applied where the bearing capacity is low.

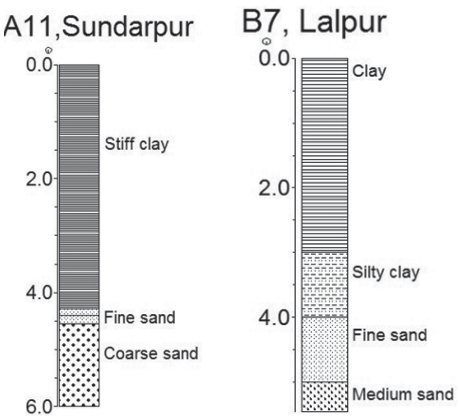


Fig. 10: Lithologs representing Mahuliya deposit.

Ghorsuwa Deposit:

This unit is characterized by clayey silt, silt to fine sand at top followed by silty clay and clay at bottom (Fig. 10). This deposit is developed at Ghorsuwa, gayalnadi, Haldukhal, Chinimilchowk, Sukhasal, Bhasigaon, Chaukhati. Ground Water Table is 2.5 to 6m depth. Bearing Capacity of this unit is low. Multistoried buildings are discouraged. This unit is good source for the groundwater.

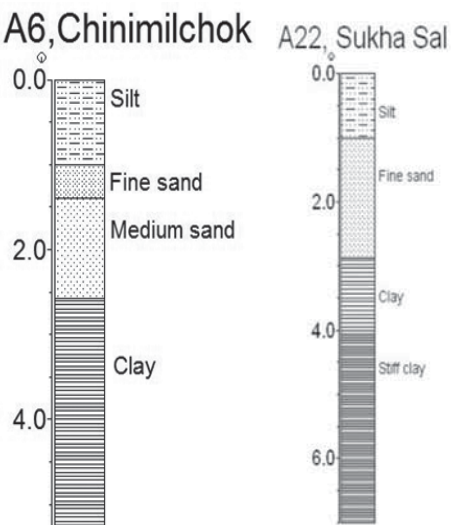
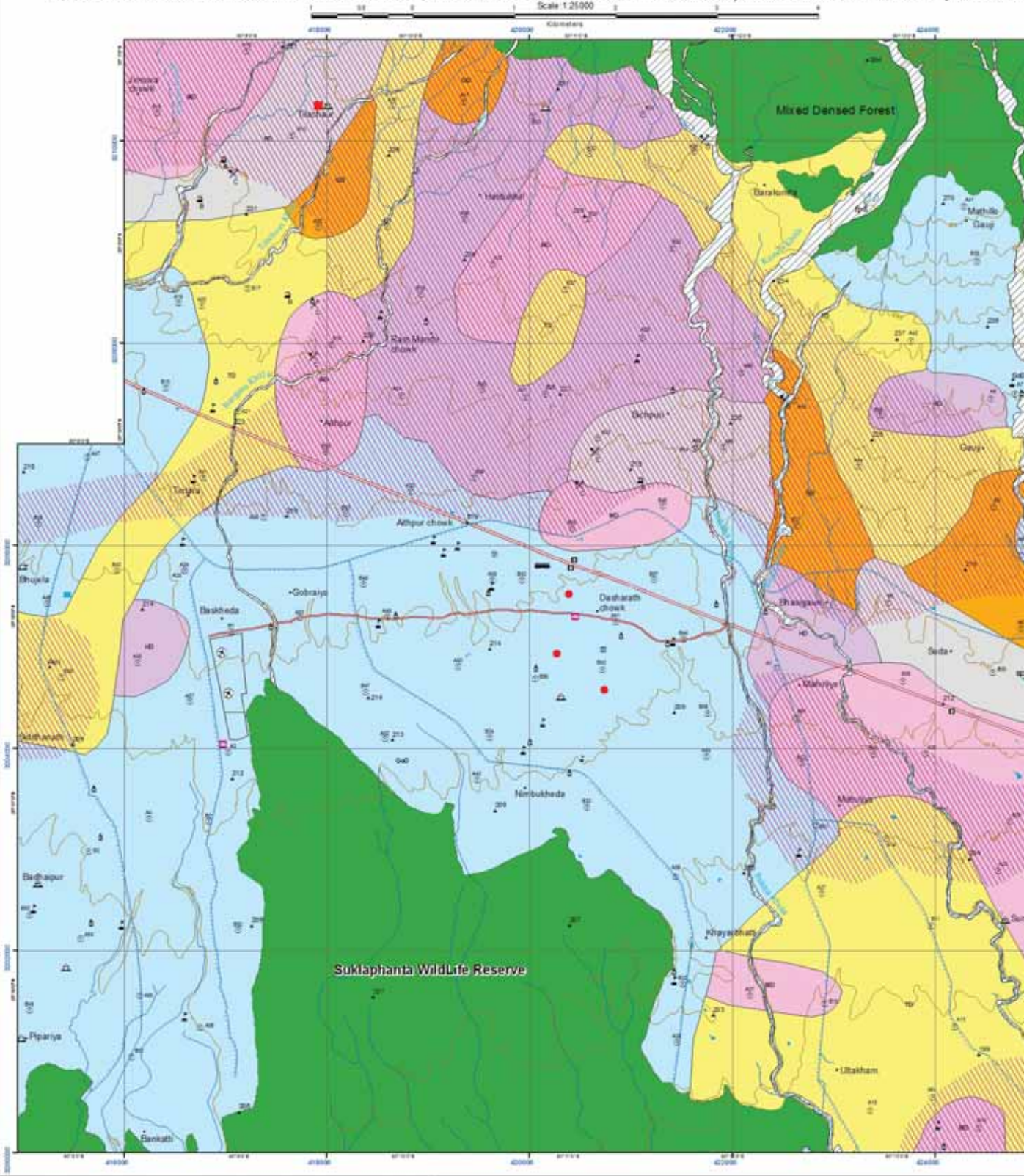
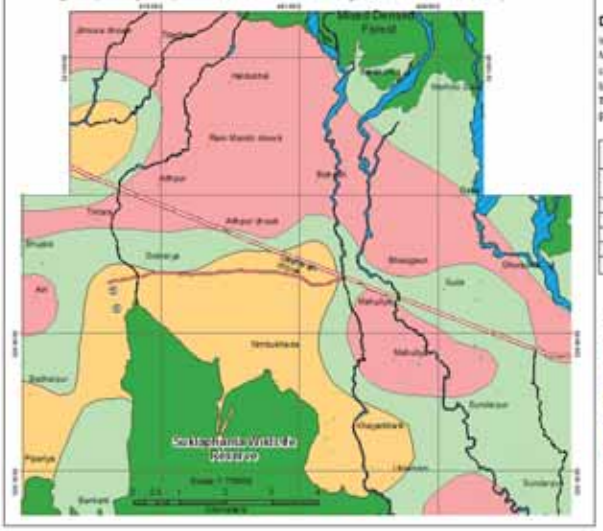


Fig. 11: Lithologsrepresenting Ghorsuwa deposit.

ENGINEERING AND ENVIRONMENTAL GEOLOGICAL MAP OF MAHENDRANAGAR AREA, KANCHANPUR DISTRICT (PARTS OF SHE



Bearing Capacity Map of the Mahendra Nagar Area , Kanchanpur District



Description

In the bearing capacity study, a total of 60 SPT data were used. The Maximum depth of SPT is limited to 8m. Bearing capacity analysis is carried out according to Peck et al, 1974. Based on the analysis, the bearing capacity of the study area ranges from low to high.

Table: Correlation Between N value and Consistency (Peck et al,1974)

Condition	N-Value	Bearing Capacity (Kpa)	Quality
Very Soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	4 – 8	51 – 100	Low (L)
Stiff	8 – 15	101 – 200	Medium (M)
Very Stiff	15 – 30	201 – 400	High (H)
Hard	> 30	> 400	Very High (VH)

Legend

Bearing Capacity Zoning

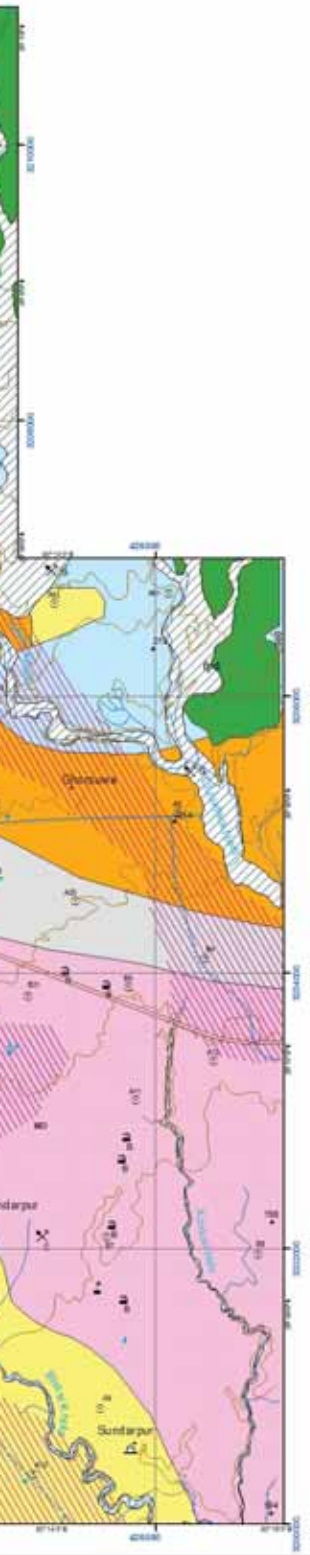
- Low
- Medium
- High

Others

- Water body
- Forest

SPT N value of depth 2m to 2.45m

ET NO 2880 01B & 2880 13D)



EXPLANATORY LEGEND

Unconsolidated Sediments	Engineering / Hydrogeological properties (Bearing capacity from Average Spt N Value)	Recommendations
Flood Plain Deposits This unit consists of mainly gravel to boulders with sand and silt. It is an alluvial loose sediments deposited along the river course.	Low to moderate bearing capacity with risk of subsidence, bank erosion cutting and flooding. Contamination of surface water with ground water.	Not recommended for construction of buildings and waste disposal site. Limited amount of construction materials can be extracted.
Bishpuri Deposit This is clay and silty clay dominate deposits. It consists of grey clay to dark grey stiff clay and yellowish silty clay. Sometimes silt and fine sands are also interbedded. The thickness of this unit is more than 8 meters.	Bearing capacity of this unit is low to moderate. This unit has low infiltration rate of surface water and low permeability. Groundwater table in this region is upto 8.5m. This unit is potential for agriculture and good geological barrier for the waste disposal.	Construction of multistory buildings are discouraged, possibility of settling. Pile type of foundation is recommended for heavy construction.
Tistara Deposit This unit mainly consists of fine to coarse sand and silt with occasional layer of clay or silty caly embedded in sand layer. The thickness of this unit is more than 6m.	The bearing capacity of this deposit is low to high. Groundwater table is 1m to 2.5m deep in general. It is moderately good for foundation purpose. This unit is potential for the groundwater.	Moderately good for foundation purposes with some protective measures where bearing capacity is low.
Mahabiya Deposit This unit is characterized by 2m to 5 m thick clay on the top followed by fine to coarse grained sand layers at bottom.	Bearing capacity is low to medium. Groundwater table is 1m to 3m deep in general in this unit. Thick clay layer found at top is good barrier for the waste disposal. This unit is useful for the agricultural purposes. Sands at the bottom layer are good source of groundwater.	Sewerage system needs proper lining to prevent the groundwater pollution. In shallow water table zone, disposal of waste and hazardous materials is not recommendated. Protective measures are to be applied during the construction where the bearing capacity is low.
Ghorsewa Deposit This unit is characterized by clayey silt, silt to fine sand at top followed by silty clay and clay at bottom.	Ground Water Table is 2.5m to 6m depth. Bearing Capacity of this unit is low. This unit is good source for the groundwater.	Poor for foundation purposes due to low bearing capacity. Heavy construction need pile foundation. Disposal of waste and hazardous materials is not recommendated.
Gobariya Deposit This unit mainly consists of clast of gravels, cobbles and boulders in the matrix of silt and sand. The gravels and boulders are subrounded. The top layer consists of clayey silt and sand.	Groundwater depth is 2 m. Bearing capacity is Medium to High. This unit is potential for the groundwater recharge and the construction material.	This unit is sound for the building constructions. Waste disposal site is not recommendated.
Haldukhal Deposit This unit is characterized by alternate layers of silt, sand and clay.	Groundwater table is 1 m to 2.5 m. Bearing capacity is low.	Due to low bearing capacity, heavy construction need pile foundation. Disposal of waste and hazardous materials is not recommendated where the ground water table is shallow. Sewerage system needs proper lining to protect from groundwater pollution.

MINERAL RESOURCES

- Existing excavation site for gravel and sand
- Existing excavation site for clay

EROSION / BANK CUTTING FEATURES

River bank cutting
Prominent along Sukhita and Bhusi Khola. Chances of further bank failures.
Recommendation: Construction of embankments, plantation, and proper mining of river bed sand and gravels

FEATURES OF ENVIRONMENTAL SIGNIFICANCE

- Brick Factory
- Hospital
- Petrol pump
- Proposed landfill site
- Existing waste disposal site

AREA SUSCEPTIBLE TO HAZARDS

Inundated villages
These villages are inundated during rainy season endangering loss of physical properties.
Recommendation: management of proper drainage

River flood plain
Danger of flooding during rainy season. Construction of building is not recommended. Dumping of waste and hazardous materials is also not recommended.

Highly susceptible to ground settlement area
Highly susceptible to ground settlement due to low bearing capacity
Recommendation: Heavy construction need pile/ deep foundation with proper design

GENERAL SYMBOLS

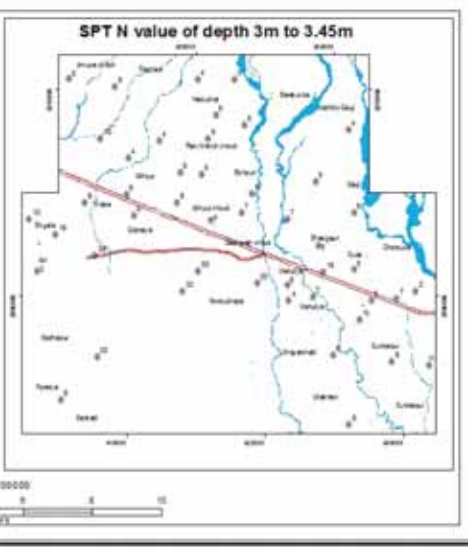
- Police station
- Jail
- Post office
- School campus
- Spot height
- Airport
- Contour
- River/Stream
- Canal
- Bore Hole (SPT) Location
- Auger Location
- Temple
- Bus park
- Bridge
- Forest
- Water body
- Highway
- District road
- Administrative boundary

ADMINISTRATIVE INDEX

INDEX TO SHEET

LOCATION DIAGRAM

SPT N value of depth 3m to 3.45m



HORIZONTAL DATUM
Spheroid: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 81° East
Latitude: 0° North
False co-ordinates of origin: 500000 m Easting
False co-ordinates of origin: 0 m Northing
Scale factor at Central Meridian: 0.9999

Contour Intervals 10 meters

Supplementary Contours at 5 meters

Reference: Mean Sea Level (India)

Topographical Base:

Contours lines and other features extracted from topographic base maps Published by Survey Department, Nepal

Note

Field Survey done in May , 2013
LIMITATION OF THE MAP
This map is exclusively intended for local planning. It should not be used as the only basis of investigation for individual structures. The map can not replace detailed site investigations.

Prepared by : Shova Singh, Kumar Khadka, Sailena Manandhar

Published Under the authority of
Dr. Soma Nath Sapkota
Director General

DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019

Gobariya Deposit

This unit is characterized by clayey silt, silt to fine sand at top followed by sandy gravel at bottom (Fig. 12 and Fig. 13). This deposit is developed atGobariya, Paliya,Bankati, BhujelaChinimilchowk, Sukhasal, Bhasigaon, Chaukhati. Groundwater table is 2.5 to 6m depth. Bearing capacity of this unit is low. Multistoried buildings are discouraged. This unit is good source for the groundwater.

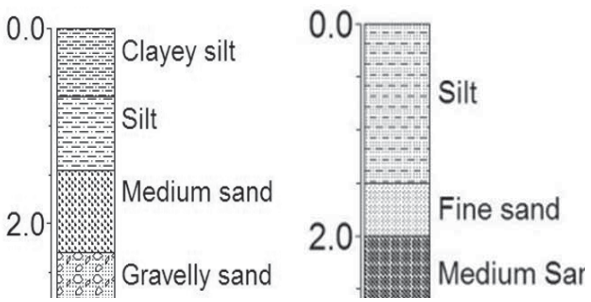


Fig. 12: Lithologs representing Gobariya deposit.

Fig. 13: Sandy gravel beds in coral section at Gobariya near power ouger A49 location.

Haldukhal Deposit

This unit is characterized by alternate layer of silt-sand and clay (Fig. 13) and mainly developed at Haldukhal, Aithpur, Sundarpur, Tilakpur, Basantapur and Mahuliya etc. Groundwater table is at depth of 3m to 5.5m and the Bearing capacity is low. Multistoried buildings are discouraged.

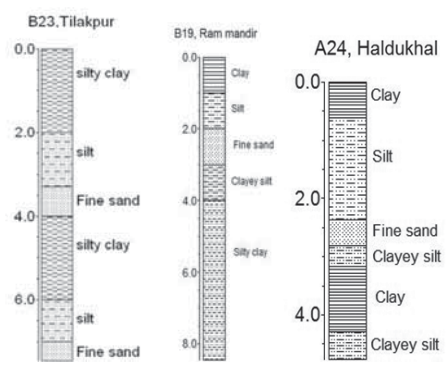


Fig. 14: Lothologs representing Haldukhal Deposit

GEO-HAZARD AND RELATED ENVIRONMENTAL PROBLEMS

The most common geo-hazards in the study area are flooding/ inundation, river bank cutting/ erosion, and liquefaction hazard.

Flooding/Inundation

It is difficult to delineate the exact area of inundation because it is largely defined by the amount of rainfall and direction of flow of water.

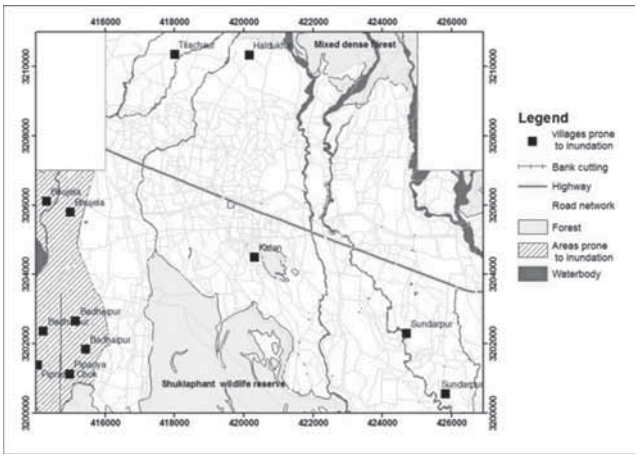


Fig. 15: Map showing flooding/inundated villages and areas susceptible to river bank cutting.

The rainfall events in mid June, 2013 in the western and far western regions of Nepal and India affected 20 districts in Nepal and several districts in the Indian states of Uttarakhand and Himachal Pradesh. The floods and landslides that ensued have left hundreds of people dead or missing and destroyed property worth millions of dollars (2013 Monsoon Floods in Nepal and India, ICIMOD). It is certainly the most severe in the last 50 years and it happened at the beginning of the monsoon when no one was expecting.

In Bhujela village, settlements and school building were swept away by the flood. The land was either cut down to Mahakali or buried under the sediment carried out by the intruding flood before coming out to Mahakali near Piparia village. The effect was substantial in the ward nos. 11, 12 & 13 of Mahendranagarmunicipality (Figure: 13). The effect of flooding, inundation and destruction was observed in various areas under Dodhara and Chandani VDCs. Dodhara and Chandani VDCs are located south-west of the study area.

Most of the urban settlements in the study area are prone to inundation after intense rainfall events due to improper drainage provisions.

In Kanchanpur District, on 22 September, 2008 people were reported killed in Dhodohara VDC. It was found

that about3,000 families were displaced from several VDCs. In Chadani VDC, 32 houses were completely swept away by the flooded Jogbudha River. The flood affected VDCs include Sudha, Daiji, Dhakatbhuli, Krishnanagar, Mahendranagar Municipality ward numbers 1, 3, 6, 10, 11, 12 and 13. Dodhara and Chadani VDCs were cut off from communication and the true extent of damage remains unknown (source: OCHA Situation Report on Floods and Landslides of Western and Far Western Nepal 22 Sept, 2008).

River bank cutting/ Erosion

The riverbank cutting/erosion is common phenomena and occurs specially during rainy season, which widens the rivers. River bank cutting is seen along the banks of the Chaudara Khola, Bhasikhola, Sukha Khola, Kankati Khola, Bankati Khola etc. At many places gabian walls were constructed to prevent from the bank cutting/ soil erosion (Fig. 16, 17 and 18), however high current of river had washed away the gabion wall during monsoon season.

Fig. 16: Road constructed along the right bank of the BhasiKhola, near Bhasigaon was eroded. No preventive measure has been taken.

Fig. 17: Soil erosion taking place near the Kathepul due to construction of road which clogged thedrainage system and construction of the gabion wall at the same place.

Fig. 18: Suspension bridge constructed in the northern part of Sukha Khola, near the forest is endangered due to river bank cutting.

Some mitigation measures to protect from the riverbank cutting/erosion are given below.

- Human settlements encroaching to the banks of rivers and nalas should be discouraged.
- Bank erosion can be partially controlled by constructing gabian wall properly.
- River training works should be done for protecting further loss of land during rainy season.

WASTE DISPOSAL SITE

Landfills that are located in geologically unsound areas (sand and gravels) have contaminated some ground-water sources. During the field investigation and the discussion with the officials of municipality it was learned that, the municipality does not have its own permanent properly managed sanitary landfill site and the problem of waste disposal was seen to be prevalent in high dense urban core areas. Municipality collects waste materials from the streets and disposes in the small forest in ward no. 18 near the municipality office which is not a permissible practice. Waste disposal into drainage systems of the urban areas (street no. 3, 4, 5) are hazardous to health and cause the blockage of the drainage system during flooding period (Fig. 22).

Municipality has proposed landfill site at Tilachaur area (Fig. 14). From the field investigation and analysis from the bore hole (B13) and auger hole (A18) (Fig.14), the proposed waste disposal site is quite suitable for the sanitary landfill site. The key factors of the proposed landfill site are

- Consists of upper 2m clayey silt followed by 4m silty clay to clay (B13) and 5m thick clay deposits (A18)
- Ground water level: about 35 ft (source local people)
- 6 km. away from airport and 3 to 4 km away from highway

- Far from settlement area
- Few schools are conducted in this area

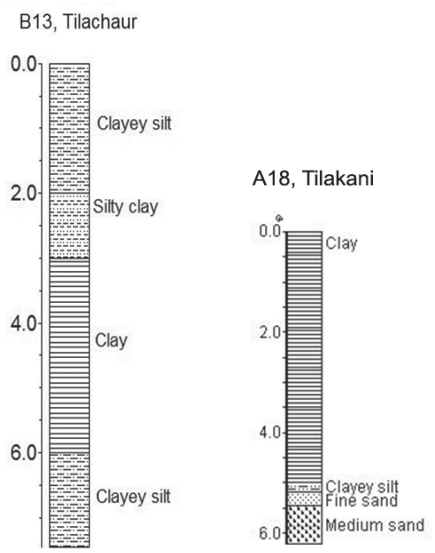


Fig. 19: Lithologs of the proposed landfill site.

Fig. 20: Unmanaged dumping site for the solid waste in the forest near the municipality office at ward no 18.

Fig. 21: Unmanaged dumping site for the solid waste in the urban areas (street no. 3, 4, 5).

MINING OF NATURAL RESOURCES AND IT'S IMPACT ON ENVIRONMENT

Deposit of construction materials (Gravels) are found in flood plain of ChuadaraNadi and northern part of the Bhasi and SukhaKhola (Fig. 20). Clays are mining from the north east and south west of the study area (Fig. 21). Pebbles and boulder are brought from these Khola and crushed to produce gravel and pebble (Fig. 22) as construction materials. Sand mining is not available in this area.

IMPACTS

- The increasing trend of river bed mining and its unplanned management is one of the mostnotorious activities responsible for flooding and inundation.
- There might be depletion of gravel in the Kholas and nadi in the near future if exploited haphazardly. Severe environmental consequences arise due to the extraction of boulders and gravel from the river bed and lowering its level.
- Clays, mined for the brick factories may cause air pollution i (Fig. 24),

Fig. 22: Clay mining from the study area.

Fig. 23: Gravel mining from the northern part of the Bhasi Khola.

Fig. 24: Brick factory near the western part of the highway creating air pollution.

GROUNDWATER RESOURCES

The study area depends entirely upon groundwater either for drinking or irrigation which is obtained from deep wells and shallow hand pumps. The study area has both shallow and deep ground water aquifer. The Municipality and Groundwater Development Project are utilizing the deep aquifer for drinking as well as for irrigation purposes. The quality of groundwaterfor drinking purposes is reported better in deep confined aquifers.

The arsenic contamination in groundwater is very hazardous to public health and has become major health issue problems especially in the Terai region where the population density is very high. The primary sources of arsenic are natural rocks, minerals and ores rich in arsenic. The loose sediments of Terai plain ranging from clay to boulders derived from northern elevation may contain arsenic rich minerals and rock fragments which ultimately mixes with groundwater through river beds or permeable soil layers. WHO standard of arsenic value is 10 ppb and recommended Nepal standard value of arsenic is 50ppb. The result of arsenic blanket testing (NASC, 2005) of Kanchanpur district is as follows.

Table 1:Arsenic test results in Kanchanpur district (Source: NASC,2005).

District	Total no of test	Population using arsenic tested tube wells			
		<10ppb	10 - 90ppb	>50ppb	Max. consent detected
Kan-chanpur	33507	30534	2441	312	450

GROUNDWATER RECHARGE

Kanchanpur district as a hole is bounded by Mahakali River to the west and Mohanariverto the east. In the northern part of the district lies Bhabarzone andChuria hill. Bhabarzone is the main recharge zone of ground water. Perennial river, Mahakali is source of the groundwater recharge of the district. The predominant aquifer nature is gravel and sand of coarse to fine grained and are trapped by impermeable bed of clay type. In the present study area artesian wells were not observed. Gravel beds of the southeastern to middle part and northwestern part of the study areas are good source of ground water recharge.

CONCLUSION

Present study on subsurface geology has revealed that Mahendranagarmunicipality and its surrounding areas has been divided into six different units based on grain size analysis. The units mainly consist of fine grained sediments like clay silty clay to silt, fine to coarse grained sand and gravelly sands. The units composed of clay to silt and fine sand have low bearing capacity and the units composed of coarse sand to gravelly sand have high bearing capacity.

From the field survey and the interaction with the local people flood/inundation has been found as major hazard in this area. Mahakali River has been found as major source of flooding /inundation due to its frequency of occurrence. The river is highly affecting ward no 11, 12, and 13 of the municipality. The city core area has been inundated during monsoon due to lack of proper drainage system. Besides flooding, another hazard prevalent in the study area is river bank cutting/erosion resulting into loss of fertile land and endangering to the buildings and infrastructures constructed near the banks of the streams and rivulets.

The field survey shows that the municipality has not its permanent sanitary landfill site. The solid wastes collected has been dumped into small forest near the municipality office.

Municipality has proposed suitable landfill site at Tilachaur, north east part of the study area which is geologically suitable for the development of sanitary landfill site.The area is rich in clay and gravels which has been mined for the brick factories and construction materials respectively.

RECOMMENDATIONS

1. Buildings should be constructed in the stable ground.
2. Bank erosion can be partially controlled by constructing the gabion wall properly.
3. Human settlements encroaching to the banks of rivers and kholas should be discouraged. Municipality must be very strict to control such activities.
4. River training works should be done for protecting further loss of land during rainy season.
5. Almost in all Terai area, revenues are generated by exporting the river bed gravel material and consequently inviting flooding and inundation. It is very high time to manage river bed mining in a planned, judicious and limited manner so as to sustain the environment and reduce the vulnerability to flooding and inundation.
6. Mining should be carried out only under the supervision of the local authority.
7. Top humus soil should be rehabilitated after clay mining.
8. Gravel beds should be protected for the ground water recharge areas.
9. It is recommended all the industrial effluents, hospital wastes and solid waste from the households should be treatedbefore coming to the water sources or bodies. These wastes should not dump into groundwater recharge areas such as gravels beds and sand areas. It isrecommended thatMunicipality should have sanitary landfill site.

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Mineral Resources, Mining and Investment Opportunities in Nepal

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ABSTRACT

Nepal is divided into five distinct morpho- tectonic zones from south to north as Indo-Gangetic plain, Sub-Himalaya, Lesser Himalaya, Higher Himalaya and Tibetan Tethys Himalaya. Geological investigation and mineral exploration activities in the country has been able to identify more than 63 mineral commodities (metallic, non-metallic, gemstone, fuel minerals and construction materials) of economic, sub-economic and as occurrences. The most potential mineral resources include gravel, sand, petroleum and natural gas, coal, radioactive minerals, copper, iron, lead, zinc, tin, gold, tungsten, molybdenum, cobalt, nickel, silver, limestone, dolomite, marble, phosphorite, magnestie, talc and semi-precious stones. At present, about 300 prospecting licenses of 27 mineral commodities and 130 mining licenses of 15 commodities are issued. Limestone is by far the most important mineral resource of Nepal and is the major commodity that is being mined to produce ordinary portland cement. Old mining activities of copper, iron and lead was present in ancient times. Dead Burnt Magnesite plant of magnesite was commissioned but it failed to produce consistently due to technical reason. Mining of various industrial minerals is mostly by small, private owned mining firms. With country's rugged mountainous terrain, inadequate skilled human resources, inadequate laboratory facilities, insufficient financial resource and other factors have hindered the mineral resource development. However, there are ample opportunities and conducive environment for entrepreneurs and foreign investors for investing in mineral exploration, mining and processing in Nepal.

INTRODUCTION

Federal Democratic Republic of Nepal is a country located in the South Asia in is bounded between China in the north and India in east, west and south. Roughly rectangular in dimensions the area of 147,181 sq. km stretch 885 km from east to west with mean width of 193 km from north to south. The altitude ranges from a minimum of 70 meters to a maximum of 8848 m.

The history of mining activities in Nepal dates back to the hundreds of years. This is evidenced by the fact that a number of villages and streams of Nepalese hills and mountains are named after the old mine sites. Geological studies from the government institution were initiated only after 1928. The then Department of Irrigation and geology had a very limited scope of geological study. The organization was named differently at different time and is running as Department of Mines and Geology since 1976. Department of Mines and Geology is the sole government organization responsible for all types of geo-scientific survey, mineral exploration, development and promotion of mineral based industries including petroleum. Department exercises the existing mining rules and regulations and also supports the government to formulate related policies.

The present paper outlines the geology of Nepal, the mineral resource potential and mining and investment scenario along with the challenges and opportunities in mineral sectors.

GEOLOGY OF NEPAL

Nepal lies in the central part of the Himalaya. The country is divided into five distinct morpho- tectonic zones from south to north as Indo-Gangetic plain, Sub-Himalaya, Lesser Himalaya, Higher Himalaya and Tibetan Tethys Sediment. Each of these morpho-tectonic zones are distinct unit characterized by their specific morphological, geological and tectonic features. The Gangetic Plain represents the great alluvial tract of the Himalayan Rivers. It is geologically monotonous and comprises of recent deposits consisting of gravels, sands, silt and clays. Main Frontal thrust (MFT) separates the Sub-Himalaya belt from the Gangetic plains. The Sub-Himalaya is represented by thick succession of molasses type sediments represented by conglomerate, sandstone, mudstone of Mid-Miocene to Early Pleistocene age. The Main Boundary Thrust (MBT) brings the geologically complex Lesser Himalayan zone in contact with the Sub-Himalayan belt at its north. The Lesser Himalaya consists of a thick sequence of sedimentary to metasedimentary rocks of Pre-Cambrian to early Miocene in age. This region comprises of many Klippes and crystalline nappes. The dominant lithology includes slate, phyllite, schist, quartzite, dolomite, limestone, marble, gneiss, granites etc. The Main Central Thrust (MCT) separates rock units of the Lesser Himalaya and Higher Himalaya. High grade metamorphic rocks of Pre-Cambrian age and granites of Tertiary age lie within Higher Himalaya zone. The Tibetan Tethys sediment has richly fossiliferous sediments representing limestone, sandstone, shale of Paleozoic-Late Cretaceous age. A simplified geological map of Nepal is presented in Figure 1.

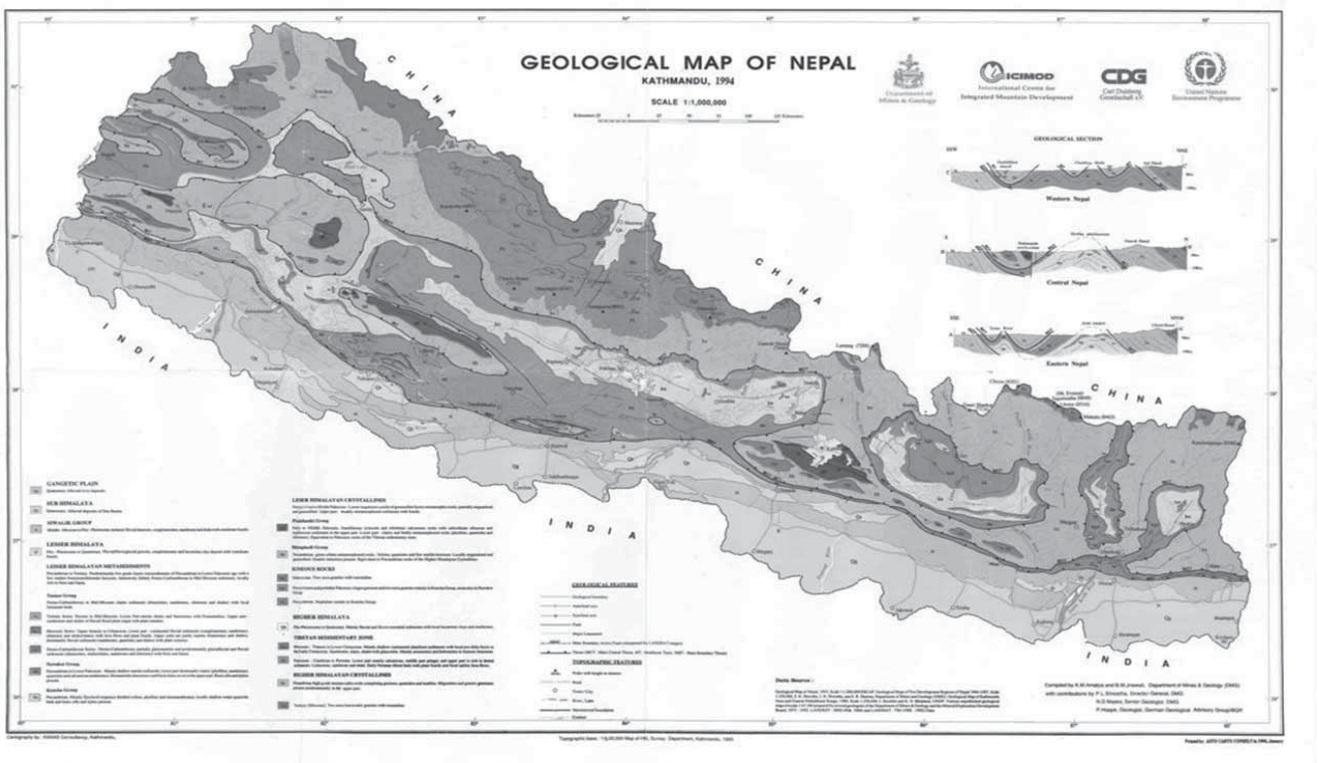

Fig. 1: Simplified Geological Map of Nepal, DMG 1994

MINERAL RESOURCE POTENTIAL

- Altogether 63 commodities have been identified with the categories of mineral showings, mineral occurrences, sub-economic economic deposit
- 21 commodities of the metallic mineral group,
- 23 commodities of chemical, fertilizer, insulator, ceramic, refractory and abrasive mineral group
- 6 commodities of the gem mineral group,
- 9 commodities of construction materials group and
- 4 commodities of fuel mineral and geothermal spring group

The Geological investigation and mineral exploration activities in the country identified more than 60 mineral commodities (metallic, non-metallic, gemstone, fuel minerals and construction materials) of economic, sub-economic and as occurrences till now. The Tarai Plain is potential for construction material, groundwater, petroleum and natural gas. The Sub Himalaya is potential area for construction materials, rare earth elements, radioactive minerals, petroleum and natural gas. Similarly, Lesser Himalaya has potential for prospecting Iron, copper, lead, zinc, gold, magnesite, phosphorite, limestone, dolomite,

talc, coal etc. The Higher Himalaya including Lesser Himalayan crystalline nappes are promising for precious and semiprecious stone and metallic minerals like lead, zinc, tin, uranium, limestone, gemstones like ruby, sapphire, aquamarine, garnet, kynite, sillimanite, and granites for tin, tungsten, uranium and REE. The Tibetan Tethys zone is prospective for limestone, gypsum, salt, natural gas and black shale could be favorable for REE and radioactive minerals. The most part of the Higher Himalaya and Tethys Himalaya area are still unexplored.

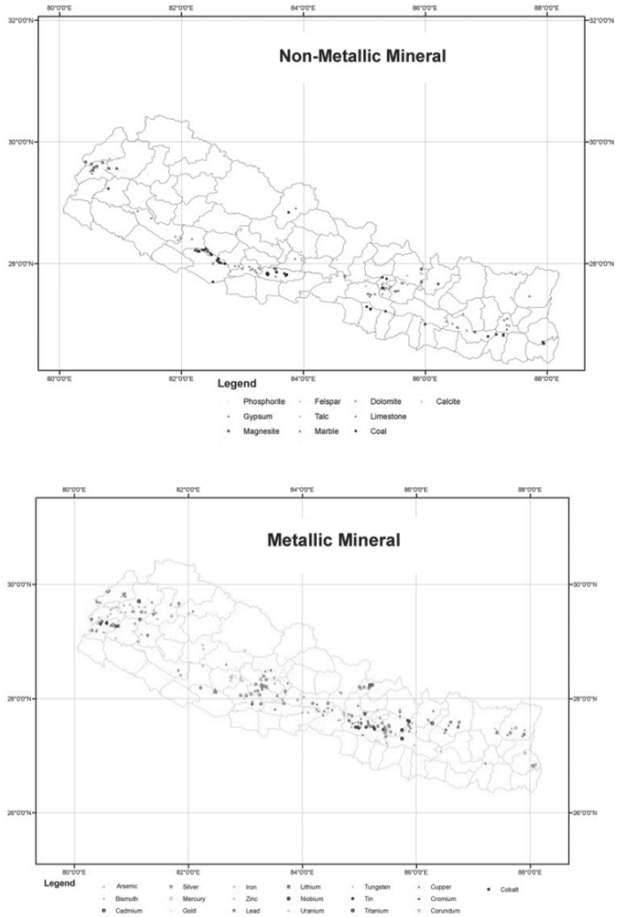

Fig. 2: Maps depicting the potential area for metallic and nonmetallic minerals

Based on the limited exploration, the major mineral potential of the country is identified as in the Table. The table also shows the categorization of the deposits on economic and sub-economic based on the size and the reserve available.

Table 1: Major Mineral Resources in Nepal

Mineral Resource	Tonnage and Grade
1. Kalitar Copper deposit	2.29 Mt, o.5 to 1.5% Cu
2. Wapsa Copper deposit	2.53 Mt. 0.88 to 3.24 % Cu
3. Bamangaon Copper deposit	1.708 Mt, 0.2 to 0.43% Cu
4. Phulchauki Iron de posit	10.67Mt, 54-58% Fe
5. Those Iron deposit	10.5 Mt, 30-66% Fe
6. Labdi Iron deposit	1.08 Mt at Labdi, 38% Fe
7. Dhaubadi Iron deposit	100 Mt. 23-58% Fe
8. Jirbang Iron deposit	0.8 Mt
9. Bagara Iron depsoit	1.53 Mt
10. Ganesh Himal Lead Zinc	2.21 Mt, 13,6% Zn, 2,3% Pb
11. Khairang Pb-Zn	1,54 Mt, 2% (Pb+Zn)
12. Bajhang Phosphorite	Up to 18% P2O5
13. Kharidhunga Talc	0.303 Mt, 30% MgO
14. Limestone	1.5 Bt,
15. Godavari Marble	652000 m3
16. Kharidhunga Magnesite	180 Mt, 24-47.6% MgO
17. Kamphughat Magnesite	20Mt

Limestone is by far the most important mineral resource in Nepal followed by magnesite, iron, copper, zinc and lead. Proven reserve of limestone is estimated to be 1.5 billion metric tons. Proven recoverable reserve of Kharidhunga Magnesite deposit having high grade magnesite is 25 million metric tons with MgO content varying from 88% to 96% on loss free basis. There are few known iron ore deposits - Phulchoki iron deposit with the reserve of 10.67 million metric tons and grade of 54 - 58 % Fe, Those iron deposit with 10.5 million metric tons with 30 - 66 % Fe. Smaller deposit of copper with each reserve less than 2 million metric tons occur that are identified in 8 different locations shows copper content varying from 0.4 - 3.2%. A high grade deposit of Zinc - lead deposit of 1.3 million metric tons with 13.6% Zn and 2.5% Pb with 27 gram per tons of silver occur at Ganesh Himal region. Other potential exploitable minerals include coal, talc, marble, dolomite, gold, gemstone and natural gas. Alluvial gold are being recovered in rivers and tributaries.

All these information indicate that Nepal is potential for metallic minerals. But the exploration activities in the past have revealed that most of them are sub-economic to none economic deposits. Now the price of many metals has gone up significantly. Therefore, further detail investigations in the known areas, evaluation of specific deposits and exploration in the new geologically prospective areas may lead to find the potential economic deposits of metallic minerals.

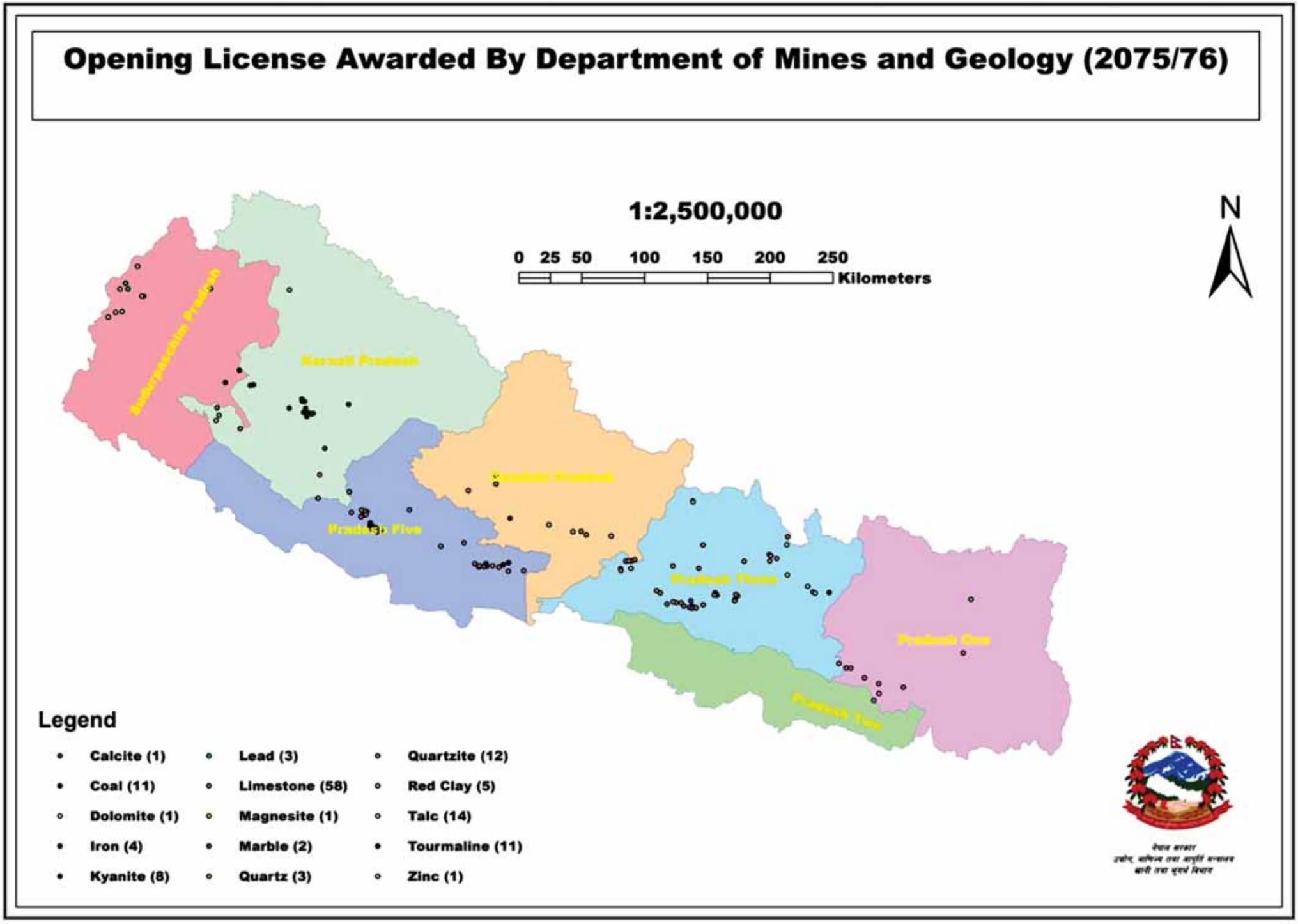

Fig. 3: Map Showing Mineral wise Opening licenses in different provinces of Nepal

MINERAL INDUSTRIAL SET UP

Nepal had many small scales mining industry in ancient times. There is no exaggeration in the saying that Nepal Himalayas is full of old copper, iron and lead mines. Mining of various industrial minerals is mostly by small, private owned mining firms. At present, about 350 prospecting licenses of 27 mineral commodities and 130 mining licenses of 15 commodities are issued like limestone, magnesite, talc, coal, gold, iron, zinc, lead and gem minerals. Map below shows mineral wise opening licenses in different provinces on Nepal. Also table 2 shows database of opening and prospecting license issued.

Similarly the spatial distribution of the mineral resources development is presented in the charts above. In this chart, the database for construction materials are not taken into account. The data shows that much of the mineral resources development activities are in Provinces 5 and 3. Though province 2 is potential for construction materials and petroleum products, It is not taken into account in this database.

Table 2: Opening and prospecting Licenses Database

No. of Opening License, 2018				*No. of Prospecting License, 2018*		
S.N	***Minerals***	***No. of License***		***S.N***	***Minerals***	***No. of License***
1	*Limestone*	*58*		*1*	*Limestone*	*178*
2	*Talc*	*14*		*2*	*Talc*	*18*
3	*Coal*	*11*		*3*	*Coal*	*4*
4	*Tourmaline*	*11*		*4*	*Tourmaline*	*12*
5	*Quartz*	*4*		*5*	*Quartz*	*3*
6	*Kyanite*	*8*		*6*	*Kyanite*	*9*
7	*Marble*	*3*		*7*	*Marble*	*1*
8	*Red Clay*	*3*		*8*	*Red Clay*	*1*
9	*Iron*	*4*		*9*	*Iron*	*7*
10	*Zinc*	*1*		*10*	*Zinc*	*1*
11	*Lead*	*3*		*11*	*Lead*	*2*
12	*Quartzite/Slabstone*	*12*		*12*	*Quartzite/Slabstone*	*50*
13	*Calcite*	*1*		*13*	*Calcite*	*1*
14	*Magnesite*	*1*		*14*	*Magnesite*	*1*
15	*Dolomite*	*1*		*15*	*Dolomite*	*14*
	Total	***130***		*16*	*Beryl*	*1*
				17	*Copper*	*7*
				18	*Corundum*	*1*
				19	*Feldspar*	*1*
				20	*Placer Gold*	*5*
				21	*Granite*	*3*
				22	*Industrial Clay*	*1*
				23	*Kaoline clay*	*1*
				24	*Mica*	*1*
				25	*Polymetal*	*2*
				26	*Silica sand*	*22*
				27	*Aquamarine*	*5*
					Total	***351***

Till now, it can be observed that much of the entrepreneurs had taken interest in exploration of limestone followed by tourmaline, copper and talc.

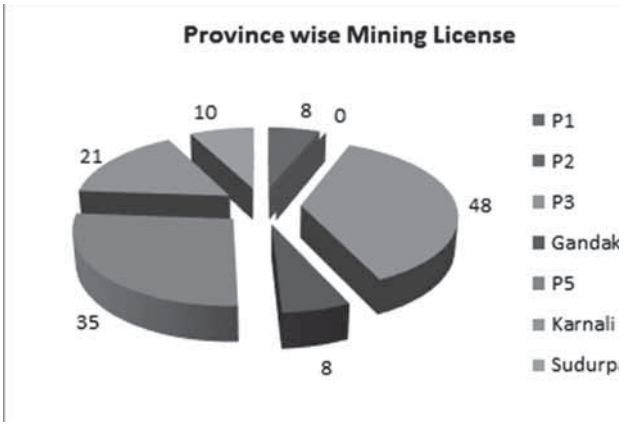

Fig. 4a: Mining license issued (province wise)

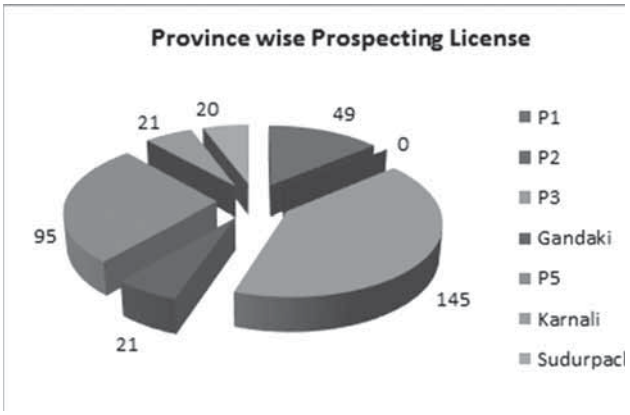

Fig. 4b: Prospecting License issued (Province wise)

CONTRIBUTION OF THE SECTOR TO THE ECONOMY

In the aftermath of the decade long conflict, the mineral and mining based industries have emerged greatly in the country. Currently, nearly 130 mines of 15 different commodities are producing the minerals and the amount of the royalty from their production is rapidly increasing.

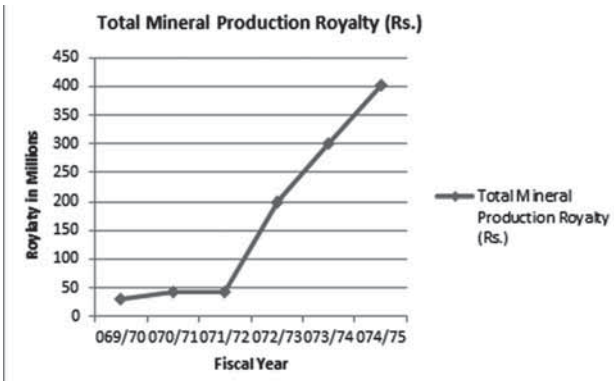

Fig. 5: Graph showing royally (in million) for fiscal year 2069/70 to 2074/75

CONDUCTIVE LEGISLATION

The Government of Nepal has formulated the relevant Act and Regulation to promote mineral exploration and development in the country. Mines and Mineral Resources Act, 1985 and Mines and Mineral Resources Regulation, 1999 constitute the legal framework for operation, regulation and administration of the mineral development activities in Nepal. The Act and Regulation give equal access and status to all qualified Nepalese citizens and foreigners. The regulation provides two stages of licensing system. Any person having the specific technical and financial capabilities to undertake mineral operations can obtain Prospecting License (PL) and Mining License (ML). The Regulation also offers the lessee to enjoy several rights and benefits while undertaking mineral operations. Some of the main features are – right to use the land and material, permission to import machinery and equipments, royalty rate based on the mineral commodities and production, right to export the products of mined minerals.

Other regulatory means are The Company Act, 2006 and amended in 2017 simplifies and make the process of establishing, managing and administering companies more convenient and transparent. Industrial Enterprises Act 2016, simplifies and clarifies the procedures for establishment, operation and closing of industrial enterprises. This Act has the provision for tax incentives, no nationalization of the industries, one window service, etc. Foreign Investment and Technology Transfer Act (FITTA) 2018, provides equal opportunities and treatment to foreign Investment companies, 100% investment allowed and technology transfer in all sector of industries, except that in negative list. And the most important is repatriation is allowed in foreign currency. Also the Banks and Financial Institutions Act 2017 (BAFIA) protects and promotes the rights and interests of depositors, provides quality and reliable banking and financial intermediary services.

CHALLENGES

Country's rugged mountainous area, inadequate infrastructure, inadequate skilled manpower in the field of mineral exploration, mining and processing constrain mineral exploration and exploitation of mineral resource development. The rugged terrain of hills and mountains poses challenges in undertaking research and exploration in these areas. Likewise, limited network of road facilities, electricity and other infrastructure possesses difficulty in the exploration and exploitation of the mineral resources. The above challenges are more aggravated by inadequate skilled manpower in the field of mining, geo-physicist, geo-chemist, metallurgical and chemical engineering. There is no institute in these fields.

In addition, inadequate laboratory facilities to meet with latest technology, insufficient financial resource, lack of advanced exploration techniques and socio-environmental constraints hinder the mineral development.

OPPORTUNITIES

Nepal is a net importer of gold, silver, copper, lead, zinc, iron/ steel, aluminum, gypsum, salt, fertilizer, high grade coal etc. Most of the imported mineral commodities are in the form of finished products. Only few indigenous raw and finished materials like marble, magnesite, talc, garnet, quartz crystals, kyanite, tourmaline and natural aggregates (river boulders, gravel and sand) are exported. In spite of challenges mentioned above, the existing mining laws, the industrial development policy and other relevant policies provide ample and conducive environment for entrepreneurs and foreign investors for investing in the mines and mineral sector in Nepal. Some of the major areas of explorations opportunities are –

- The most of the Higher Himalaya and Tethys Himalaya areas lie unexplored, which may have potential mineral resources.
- Additional exploration with the new technology and methodology can lead to find specific deposits.
- Further Detailed Study on Metallic and Non-metallic minerals may prove economically viable deposits.
- Cooperation program in the field of Geosciences between DMG and Overseas Institutions will be an opportunity to deal with the challenges.
- Potentiality for exporting cement as there is sufficient cement grade limestone to establish new cement plants.
- Industries based on Dolomite, marble, granite, magnesite, semiprecious stones, Iron, Copper, Lead-Zinc, Uranium can be established.
- Study on REE in Nepal remain unexplored.
- Construction materials (aggregate, dimension stones, slates, river boulders, gravel, sand, clay) are in high demand. Exploration and exploitation of River boulders, gravel, and sand in the Plain and Siwaliks area are promising

INVESTMENT OPPORTUNITIES

- **Strategic Location**

  The country being located between two large and rapidly growing economies, China and India, investing in the mining sector in Nepal has strategic benefits with easy access to markets of more than 2.5 billion population.

- **Market Access**

  Open border access to India with duty free facilities, Zero tariff entry facilities for over 800 products to China are additional benefits to the investors.

- **Ease of doing Business**

  Importance of private sector has been recognized in the constitution of Nepal. 100% ownership of a company for Foreign Investors, Repatriation opportunities of Capital and Profits to the investor's home country has been allowed. Also One window service policy has been adapted to facilitate the official procedures.

- **Large pool of work force**

  About 60% of Nepal's population represents working age group (15-59 years). There is relatively low cost of labor and high participation of women in the workforce.

CONCLUSION

Nepal has huge potential of mineral resources with many regions yet to be explored. The statuary frameworks are conducive for investment. Though there are some challenges but have ample of opportunities to develop and promote mineral based industry in the country.

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An Overview of Precious and Semi-precious Stones in Nepal: Opportunity and Challenges

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ABSTRACT

Nepal Himalaya is well known for occurrences for precious and semi-precious stone. These gem minerals are found within the pegmatite, mica-schist, ortho-gneiss and granite in the nearby areas of Main Central Thrust (MCT) and Mahabharata Thrust (MT) zones that extend from Taplejung in the east to Darchula in the west. The potential gem minerals reported in Nepal are – Aquamarine, Beryl, Garnet, Kyanite, Tourmaline, Quartz, Ruby and Sapphire. The mining of few gem minerals - tourmaline, kyanite and quartz are being carried out in limited region of country. Majority of industrial grade of these minerals are produced rather than gem grade. The gem grades are mostly export oriented. However, Nepal Government made ban on export of such gem minerals in its raw form, except the value added products since the beginning of FY 2072/73. At present, these mining industries are in ruined stage; however, there is more potentiality to produce these minerals. There are lots of issues, challenges and opportunities for its promotion. It is high time that the government and private promoters make a combined effort for its promotion and values add of those products.

INTRODUCTION

Nepal Himalayas extends for a length of 800 km and occupies the central part of the Himalayan range. Department of Mines and Geology (DMG) is the sole government organization for geological study and mineral exploration for mining and mineral promotional activities in the country. DMG carries out mineral exploration activities either by itself or issues licenses to private investors. Mining administration and regulation is guided by Mines and Mineral Act (MMA), 2042 and Mines and Mineral Regulation (MMR), 2056. Based on the gem mineral potentiality, DMG has identified six commodities of gem mineral group. Nepal has long history of exploration and mining of mineral activities; however, there seems to be less geological investigation and promotional activities in the field of gem minerals.

GEM MINERALS AND ITS GEOLOGY

A gemstone is the name given to a piece of mineral (or other rock or organic material) that after it has been cut and polished is made into a piece of jewellery or another accessory. The four characteristic of gem minerals are that it should be beautiful, hard, rare and pure. The terms 'Precious' and Semi-precious' are being commonly used to categorize the gem minerals in Nepal. MMR has categorized gems minerals in two groups – (a) Very Important Minerals as Diamond, Ruby, Sapphire, Emerald and Corundum; and (b) Important and Valuable Minerals as Topaz, Tourmaline, Garnet, Aquamarine, Kyanite, Beryl and Quartz. The Annex -10 of MMR for royalty submission has sub categorized these gem minerals into 'Gem Grade' and 'Industrial Grade'. Gem grade has its gem value and industrial grade will be used in industrial application. The royalty rates are defined accordingly. Additionally, the demand of 'Collector Grade' is being raised by investors.

The Lesser Himalaya (Mahabharata/Midland zone) and the Higher Himalaya are the potential zone for occurrence of Precious and semi-precious stone / minerals. These minerals are found within the pegmatite, mica-schist, ortho-gneiss and granite in the nearby areas of MCT and MT zones.

POTENTIALITY OF GEM MINERALS

The potential gem minerals reported in Nepal are – Aquamarine, Beryl, Garnet, Kyanite, Tourmaline, Quartz, Ruby and Sapphire. Thirty districts in the Lesser and the Higher Himalaya area have the potentiality of having gem minerals from Taplejung / Ilam in the east to Darchula in the west. The exploration activities need to be concentrated in these areas. Pegmatites are the main source rock for hosting such

gem minerals. Pegmatites are commonly observed in granite, schist and gneissic rocks in different parts of the country. DMG study shows that the pegmatites so far reported in the country are mainly significant for quartz, feldspar, mica and few gem minerals like beryl, tourmaline etc. Gem minerals occurring in the metamorphic rocks at higher altitude close to the MCT show the huge potentiality of finding and are of high quality. Nepal gems are pure; no colors added and are of high quality. These gem minerals have its own identity in international market as – 'Himalayan Gem'. The potentiality of these gem minerals occurs in different parts of country. The major reported prospects are as tabulated in Table 1 and are shown in Figure 1.

Table 1: Potential area of Gem Minerals

Mineral	District	Local Level	Geological Description
Tourmaline	Taplejung	Phaktanglung	Pegmatite and mica schist Green, Yellow-green, olive green, pink, orange, yellow brown and multi-colored
	Sankhuwasabha	Hyakule Phakuwa, Sabhapokhari	
	Manang	Naje , Nashong	
	Jajarkot	Dhime, Kortang, Rokkayagau, Talegau, , Garkhakot, Tikachaur, Lekhpatan, Daha, Paik, Archhani, Pajaru, Kuse	
Aquamarine	Taplejung	Ikhabu, Kalikhola, Phaktanglung, Lodantar	Occurs in pegmatite body and the rock those hosts the pegmatite bodies are sericitic schist, calc-schist, dolomitic marble and gneisses belonging of Higher Himalaya
	Solukhumbu	Dudhkaushika	
	Sankhuwasabha	Num, Hyakule, Phakuwa, Gunyahang, Sabhapokhari	
	Jajarkot	Garkhakot, Lekhpatan and Tikachuar	
Ruby & Sapphire	Dhading	Ruby Valley	Occur in highly tectonized, sacchoroidal dolomite within highly metamorphosed rocks.
Kyanite Kalikot Dailekh Achham	Jajarkot	Daha, Talegaum, Archhani, Saureni, Garkhakot, Kuse, Junichande, Kalika	Occurs in schist and gneiss
	Bharta		
	Bharta, Bhairabi		
	Barla, Bishale, Panchadewal, Binayak		
Quartz Sankhuwasabha Dhading Myagdi Darchula Humla Bajhang	Taplejung	Ikhabu, Khejenim, Phaktanglung	Occurs in granite and in pegmatite
	Phakuwa, Barhabise		
	Ri, Lapa, Tipling		
	Dhaulagiri		
	Shailyashikhar		
	Sarkegad		
	Talkot, Kanda		
Garnet Sindhuli	Sankhuwashabha	Chainkuwa, Budekhani, Hanglalung, Sunmala, Dhamikuna, Toribesi, Khotak, Himmuwa, Jantaribhir, Num & Swachi	Almandine garnet Found in schist and gneiss of Higher Himalaya crystalline rocks
	Ranichuri		

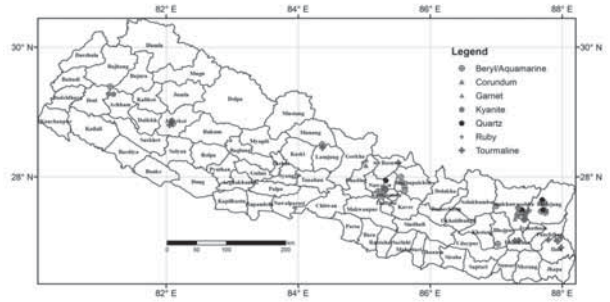

Fig. 1: Gem Mineral Potentiality Map of Nepal, Source: DMG Data

Fig. 2: Tourmaline bearing pegmatite, Jajarkot

Fig. 3: *Kyanite mine at Bharta, Kalikot*

Fig. 4: Rat Hole mining at quartz mining, Humla

Fig. 5: Finished Kyanite crystals.

EXPLORATION AND MINING STATUS

Nepal has long history of exploration and mining of mineral activities; however, there seems to be less geological investigation and promotional activities in the field of gem minerals. Gems have been recovered in Nepal since 1934, when tourmaline and aquamarine were first discovered in Hyakule, Sankhuwasabha district. DMG has carried out limited exploration in potential areas by itself and has issued prospecting and mining licenses to private investors to carry out exploration and mining of such minerals.

The prospecting lease (PL) will be awarded for a period of 4 years and the lease area will be limited to 5 sq. km. So far, prospecting lease is awarded in seven mineral commodities. The graphical representation of prospecting lease award of gemstone minerals for the last 8 years is shown in Figure 2. The maximum of PL awarded for precious and semi-precious minerals was 67 in FY 071/71 that has maximum of tourmaline mineral. The total PL is now limited to 54 in FY 2074/75.

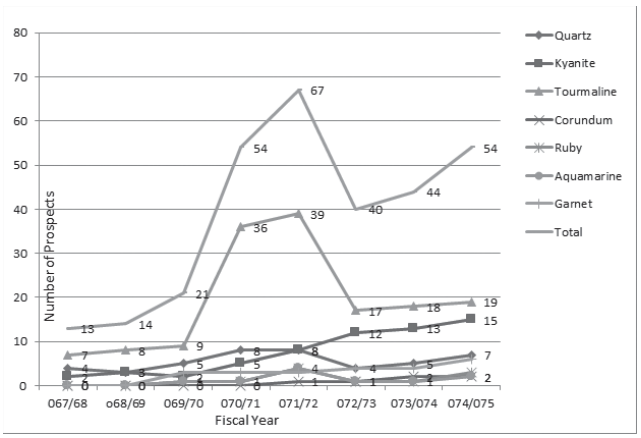

Fig. 6: Prospecting license issued for Gemslime

Once, the mineral exploration works complete, the quality and quantity of the minerals will be defined. The DMG, then will award mining lease (ML) after approval of the mining plan and environment proposals submitted by the proponent. The mining

lease period will be of 10 to 30 years based on the scale of mining. So far, mining lease is awarded only in three mineral commodities. The graphical representation of mining lease awarded for the last 8 years is shown in Figure 3. The total ML is now limited to 21 in FY 2074/75. Most of tourmaline and Kyanite mining activities are concentrated in Jajarkot, Achham, Kalikot districts in western Nepal. Quartz mining lease awarded in Sankhuwasabha, Humla and Bajhang districts.

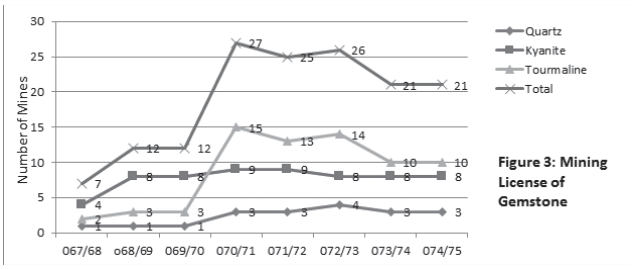

Figure 3: Mining License of Gemstone

Fig.7: Mining License issued for Gemslime

Most of the mines produce industrial grade of these minerals rather than gem grade. DMG has made a threshold percentage for gem grade. A threshold of 10% is considered for kyanite and for quartz minerals, whereas it is taken as 1% for tourmaline. Gem grade tourmaline / kyanite are found within the pegmatite, whereas the industrial grade occurs within mica-schist. Depending upon the color and chemical composition, different species of tourmaline has found in Nepal are -

- Schorl, the black tourmaline, most common species (Higher Himalayan Granites)
- Elbaite, multicolored Gem species (Sankhuwasabha, Taplejung Eastern Nepal)
- Pink color - Langtang Valley, Central Nepal
- Green color - Jajarkot, Central Nepal
- Dravite, Dark brown species, generally occurs in schists and gneisses. (Eastern Nepal, Taplejung)
- Uvite, Yellow-brown to amber color species forms in sericite schist (Western Nepal, Jajarkot)

The production royalty rates are made accordingly. The mining activity was done by the use of rudimentary technology with the use of pick, shovels, chisel and hammer. Mining methodology will follow 'Rat Hole' mining along the vein. These mines are running in small scale. These deposits have had only limited and sporadic production because of their isolated locations, high altitudes and harsh seasonal weather conditions. The produced gem grades are mostly export oriented in India and very few in China, Japan and Europe. The production and export of these gem materials are tabulated below. These minerals were being exported to India at relatively cheaper price, which then gets value added many folds and go to international markets. Haphazard and uncontrollable mining and trading, very low royalty rates resulting poor government benefit and unsustainable use of such products enforced the government to ban the export of such gem minerals in its raw form since the beginning of FY 2072/73.

Table 2: Production of Precious and semi-precious stone

FY	067/68	068/69	069/70	070/71	071/72	072/73	073/074	074/075
Mineral / Production								
Kyanite								
Gem Grade (Kg)	3085.6	2900	1875	1187	184.3	105	27.5	2
Industrial Grade (MT)	27.86	26.10	17.46	10.69	1.74	0.76	67.68	0.02
Tourmaline								
Gem Grade (Kg)	0	30	147.5	696	16.53	1	0	0
Industrial Grade (MT)	42.26	2.97	26.57	68.83	1.64	0.1	0	0
Quartz								
Gem Grade (Kg)	1003	839	1614	4256	22	300	801	0
Industrial Grade (MT)	3.4	16.1	5	37.33	0.05	0	20.82	0

Table 3: Export of Gem Mineral Commodities

Mineral /FY	067/68	068/69	069/70	070/71	071/72	072/73	073/074	074/075
Kyanite	8.00	4.00	13.05	8.24	0	0	0	0
Tourmaline	72.18	39.50	56.60	50.25	0	0	0	0
Quartz	0.14	0.40	0.59	0.27	0	0	0	0
Figures in MT								

Source: DMG, 2019

The table above shows that maximum production of such commodities were in the FY 2070/71, thereafter the production trend gets decline and ultimately resulted to nil at the time being. There may be few reasons beyond the nil production – i) ban on export of such gem minerals in its raw form, except the value added products, ii) the mines have mostly of industrial grade and are not capable to meet the production cost, iii) revision of government production royalty rate at the beginning of FY 2072/73 (Table below). Moreover, the trend of illegal mining and export time and often, lack of availability of trained man-power in cutting and polishing field, lack of market of industrial grade of such materials may be additional reasons to hinder its promotional path. It's high time to cope with the situation and come with some promotional activities to raise the techno-economic status of these mines.

Table 4: Royalty Rate (As per Annex 10, Mines and Mineral Regulation, 2056)

Minerals	Gem Grade	Industrial Grade
Quartz	100 per kg	100 per ton
Corundum (Ruby, Sapphire, Emerald)	25,000 per kg	1500 per ton
Aquamarine, Beryl, Tourmaline	15,000 per kg	1500 per ton
Kyanite, Garnet	1500 per kg	250 per ton
Royalty revision made on B.S. 2072/5/14		

ISSUES AND CHALLENGES FOR PROMOTIONAL ACTIVITIES

Based on the above facts, there are few issues and challenges for its promotional activities. They are - poor coordination among the Central, province and local regulatory bodies, unsystematic mining, remoteness and poor infrastructure condition, insufficient exploration, issues related to forest laws, competitive market with synthetic and heat treated colored stone, more lucrative policy for import oriented rather than export oriented, poor market potentiality to use industrial grade, illegal mining and trading, unavailability of expert personals and equipments and tools, lack of Gem promotional activities, regain the international fame / trade brand, capacity building of DMG for its manpower and equipments with proper laboratory facilities, improper Entrepreneurship development, mine security etc.

FINDINGS

Based on the above outcomes, precious and semi-precious minerals mining are running in very poor stage. It is high time that the government needs to protect such mining and establish industrial zones for its promotion and value add of those products. Proper market is to be made available either in national or international arena. Promotional activities in these gem minerals may results in employment of large numbers of local people and generation of revenue to government. Some of the promotional activities may be i) introduction of community based mining for its sustainable use, ii) search for market for gem and industrial grade, iii) industrialization for the use of industrial grade, iv) training and proper value add technique for gem minerals, v) introduction of 'Collector Grade' for collector piece, vi) introduction of HS Code, viii) capacity building of Department of Mines and Geology for man-power and laboratory establishment along with the capacity building of proponents, ix) proper awareness to local and miners for grade identification, x) establishment of industrial / Collection hub and Exhibition Center, xi) reform of mining laws, xii) institutional set up.

Even though, the supply of precious / semi-precious mineral in Nepal is now very limited, its potential value should not be underestimated. All efforts should be made to encourage its geologic exploration, mining development and promotional activities for the welfare and prestige of the country. It is therefore necessary to open new arenas in the development of this subsector of mining that will encourage government to intensify its activities for gem mineral exploration, mining and industrialization over the potential Himalayan region of Nepal and trading of such gem minerals.

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Status of Seismic Monitoring System in Nepal after the 2015 Gorkha Earthquake

Lok Bijay Adhikari (Senior Divisional Seismologist)

INTRODUCTION

Nepal Himalayan lies in the central part of the 2500 km long seismically active Himalayan arc from Afghanistan in the west to Myanmar in the east. It is an active continent-continent collision zone between Indian plate in the south and Eurasian Plate in the North. The continuing northward motion of Indian plate (relative of Eurasia) at a rate of about 5 centimetres per year induced widespread deformation, faulting and thrusting of its rocks at the collision front giving rise to the world's highest mountains Intense seismic activity in Asia, and in particular along the Himalayan arc,is related to this ongoing orogenic process (lave' and Avouac, 2000). The probability of earthquakes occurrence is very high in this collision zone.

Many destructive earthquakes have been reported in the historical records with in Himalaya arc. Out of which the A. D. 1934 earthquake occurred in Nepal Himalaya (Bilham 1995, Pandey et al. 1999). Recently Big devastative earthquake of local magnitude 7.6 (Mw 7.8) was occurred on 25th April, 2015 at 11.56 AM local time, near Barpak village of Gorkha district which is known as "Gorkha earthquake"(Adhikari et al. 2015). After the establishment of National Seismological Network, the 2015 Gorkha earthquake was the biggest earthquake recorded at National seismological center.Before Gorkha earthquake three Moderate Earthquakes with magnitude greater than 6 (Udaipur earthquake (1988), Bajhang earthquake (1980) and Taplejung-Sikkim border earthquake (2011) within NepalHimalaya were recorded by the National Seismic Network after its installation.

Seismic monitoring in Nepal Himalaya has started since 1978 with one short period seismometer installed in Phulchoki, Lalitpur. Now weak motion, geodetic and strong motion sensors are used to monitor seismic activities in and around Nepal. By the end of 2018 more than 200,000 earthquakes were recorded by this network. Similarly more than 40,000 aftershocks of Gorkha earthquake have been recorded in and around the rupture zone. The Microseismicity map of Nepal Himalaya and aftershocks map of 215 Gorkha earthquake are shown in Figure 1 and Figure 2 respectively.

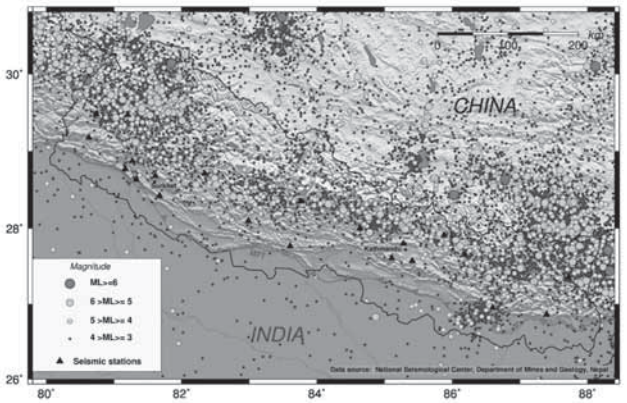

Fig. 1: Microseismicity map of Nepal and adjacent area. Solid circles of different colors represent earthquakes of local magnitude greater or equal to 3 according to their size recorded by National Seismological Network from 1994 to before 2015 Gorkha earthquake. Black triangles represent the Permanent Seismic Stations.

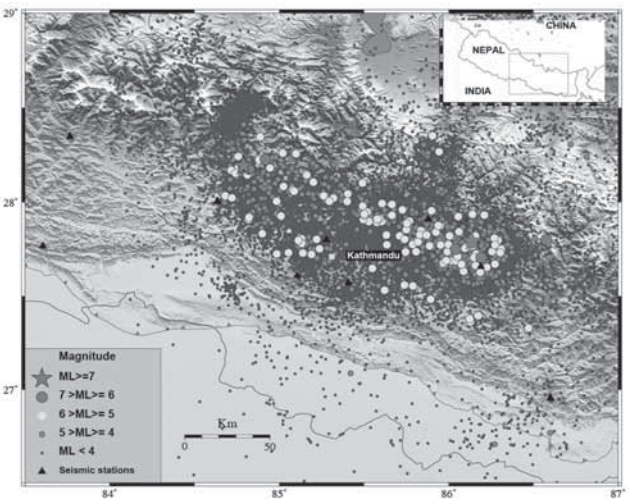

Fig. 2: Latest aftershocks distribution map of the 2015 Gorkha earthquake by NSC. Solid circles of different colors represent earthquakes of local magnitude of different size. Black triangles represent the Permanent Seismic Stations.

National seismological network

Government of Nepal, Department of Mines and Geology (DMG), in collaboration with the then Laboratorie de Geophysique Applique (LGA), Paris University, installed a short period vertical seismometer at Phulchoki hilltop in the southern part of Kathmandu Valley. The signals from this station were telemetered to the then Seismological Laboratory of DMG at Lainchaur, Kathmandu, Nepal. After the successful operation of this station four more stations

were installed in Eastern and Central Nepal. Only after the 1988 Udayapur earthquake, the necessity of a National Network of more seismic stations to cover the entire territory of Nepal was realized.

National Seismological Network project was launched in 1991, with an aim to cover the entire country to monitor the seismicity of the Himalaya. It was completed in 1994, in collaboration with the then Laboratorie de Detection de Geophysique(LDG) of France, now known as the Department Analyse Surveillance Environment (DASE), with two well-equipped independent recording centers. The National Seismological Network consists of two independent recording centers, one in Lainchaur, Kathmandu and another in Birendrangar, Surkhet. National Seismological Network currently has 21 seismic stations operating in the Nepal Himalaya.

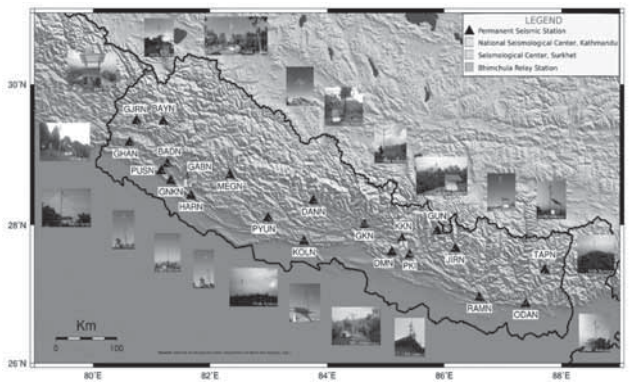

Fig. 3: Location map of the Permanent National Seismological Network with respective photographs. Red lines connected to the stations represent the way of radio transmission for seismic data from stations to the centers.

Data from the 9 seismic stations, west of Pyuthan are telemetered to Regional Seismological Centre at Birendrangar, Surkhet and similarly the data from the remaining 12 seismic stations, east of Pyuthan are telemetered to National Seismological Centre in Lainchaur, Kathmandu, shown in Fig. 3. Upgrading and digitalization of seismic network is completed in 2016 and upgrading of the seismic centre is ongoing.

Before Gorkha earthquake 2015, we had permanent seismic network consisting 21 seismic stations (Fig. 3), 29 GPS stations and 7 Accelerometric stations. After the Gorkha earthquake to increase the detection capability of earthquake, necessity of dense seismic network is realized. With the support from different organizations additional 20 seismic stations (Fig. 4), 22 cGPS stations and 30 strong motion stations were installed. The detail information related to additional stations are shown in table 1. Data from new seismic stations are not integrated to the national permanent network yet. The processed seismic bulletins of local magnitude greater than or equal to 4.5 are distributed to National Earthquake Information Service (NEIS), United States Geological Survey (USGS), Colorado and International Seismological Centre (ISC), United Kingdom (UK). This seismological network is contributing valuable seismic data for global seismic hazard assessment.

Table 1.List of seismic, GPS and accelerometer stations installed after Gorkha earthquake.

Supporting Organization	Number of seismic stations	Number of GPS stations	Number of Accelerometer stations
China Earthquake Administration (CEA), China	10	10	10
JICA (SATREPS), Japan	8	10	18
Regional Integrated Multi-hazard Early warning system (RIMES), Thailand	2	2	2

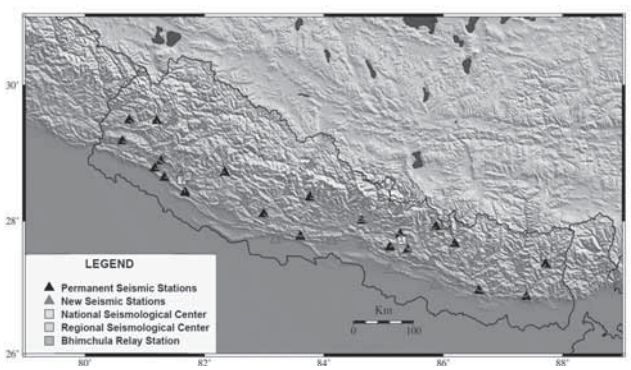

Fig. 4: Location map of the weak motion seismic stations. Red triangles represent the newly installed seismic stations after 2015 Gorkha earthquake. Black triangles show the permanent seismic stations.

1) National Earthquake Monitoring and Research Centre, Kathmandu

This Center records the data from the stations at Lukagoan (Pyuthan), Koldanda (Palpa), Dansing (Kaski), Gorkha (Gorkha), Daman (Makawanpur), Kakani (Nuwakot), Phulchoki (Lalitpur), Gumba (Sindhupalchok), Jiri (Dolakha), Ramite (Udayapur), Odare (Dhankuta) and Taplejung (Taplejung). It is equipped with an electronic maintenance and control laboratory. NSC seismic network is upgraded from analog to digital system in 2016 and Software upgrading work is continuing with the help of DASE, France. Relocation of Seismic labs both in Kathmandu and Surkhet is completed in this year.

It administrates and controls the above twelve stations of the network. The Centre has an automatic Technical Alert System (TAS) in case of technical failure in the network. This center is also equipped with a data processing ethernet network for the routine processing, mixing and analysis of the seismic data acquired by Seismological Centers.The acquired data in Kathmandu and Surkhet centres are also directly linked to the data processing network of Kathmandu Centre. The processing of seismic signals is done in real time. Processing results are linked with GIS system that facilitates the direct plotting of the epicentre on the globe. Processing center is also equipped with automatic Seismic Alert System (SAS) designed to inform the concerned personnel. In case of any earthquake with local magnitude greater than 4.0 occurring inside Nepal, it is reported to concerned authorities and media as soon as possible through SMS, website updates, mobile apps and NTCnotice board service to provide rescue and relief operation at the earliest. The centre runs 24 hours a day. Acquisition of seismic, GPS and strong motion data obtained from different network mentions above are done independently in the Kathmandu center.

Fig. 5: New seismic lab for data processing in Kathmandu.

2) Regional Seismological Centre, (RSC), Birendranagar

RSC is an autonomous centre for recording and processing of the data obtained from nine seismic stations of the National Seismological Network. The centre is responsible for the operation and maintenance of the seismic stations at Ghanteshwar (Dandeldhura), Ganjri (Baitadi), Badegauja (Kailali), Pushma (Surkhet), Bayana (Bajhang), Gainekanda (Surkhet), Gaibana (Surkhet), Harre (Surkhet) and Megha (Rukum).

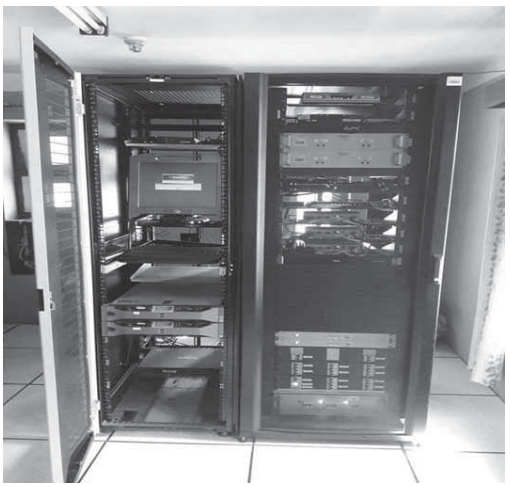

Fig. 6: Data acquisition rack in Regional Seismological Center, Surkhet.

The RSC is equipped with data acquisition, processing and earthquake location facility. It also has Technical Alert System (TAS) and Seismic Alert System (SAS). The RSC seismic network has also upgraded from analog to digital system in 2014. Seismic data are processed regularly and send to the centre in Kathmandu for mixing. The seismic lab is also shifted to newly constructed office building, shown in Figure 6.

Fig. 7: Newly constructed building for data acquisition and analysis in Regional Seismological Center, Surkhet.

Global Positioning System (GPS)

National Seismological Centre has also been carrying out Global Positioning System (GPS) surveys since 1995 in collaboration with French scientists.The aim of such survey is to monitor the crustal shortening because of the continuous movement of Indian Plate towards the north. In 1997, three continues GPS stations were installed in Nepal along the longitude of Kathmandu in technical collaboration with DASE/

France. NSC/DMG has installed 26 continues GPS stations from 2004 to 2011 in technical collaboration with California institute of Technology (Caltech)/USA. The objective of these GPS stations is to monitor crustal deformation across the Nepal Himalaya, both in the area affected by the 1934, Bihar–Nepal Earthquake and in the long-standing seismic gap (Bollinger et al. 2014), west of Kathmandu and east of Dehradun, India.

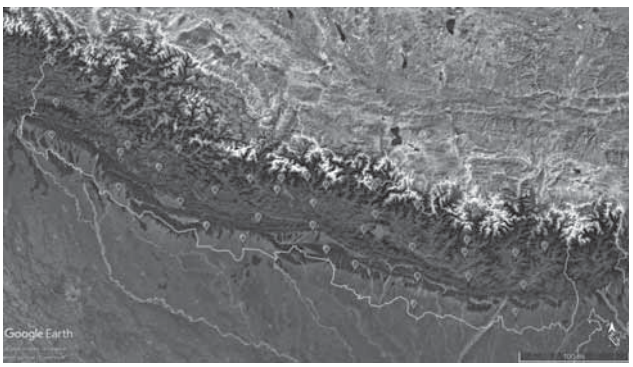

Figure 8. Location map of the cGPS stations up to now shown in Google earth. Red marks with letters C, D,J, R and U represent the cGPS stations installed in different time with collaborations/support of China, DASE, JICA,RIMES and Caltech, USA respectively.

The understanding of the seismic cycle in the Himalaya has greatly improved due to research activities carried out in the field of seismology, geology and geophysics. Over the last decade, geodetic monitoring from continues GPS stations has emerged as the most useful complement to our investigations. These data are used for crustal monitoring before during and after the large earthquakes. In 2003, DMG/CALTECH/ DASE has agreed to install permanent continuous GPS stations encompassing the zone of Interseismic straining across the range to monitor the crustal deformation continuously. Twenty nine continues GPS stations have been installed by 2011 and were working perfectly during Gorkha earthquake 2015. Later on 22 more cGPS stations were installed. Out of total 51 cGPS (Figure 7) stations 23 cGPS stations are collocated with the seismic stations.

Fig. 9: Photograph of Global Positioning System (GPS) station in Humla.

Strong Motion Network

The seismic network allows detecting and locating every earthquake with magnitude greater than ML=2.0 within Nepal. However, their dynamics is not sufficient to determine the magnitude at short distance for the large earthquakes due to instrument saturation. To address this problem, 7 strong motion stations have been deployed by the end of 2011. After the Gorkha earthquake 30 strong motion stations were installed. Out of 37 strong motion stations 26 strong motion stations are collocated with seismic stations. 10 strong motion stations are installed in the Kathmandu valley. This network can determine the peak ground acceleration, velocity and displacement, information which is needed to develop the attenuation equations as an important input parameter to the seismic hazard assessment (Bhattarai et al. 2011).

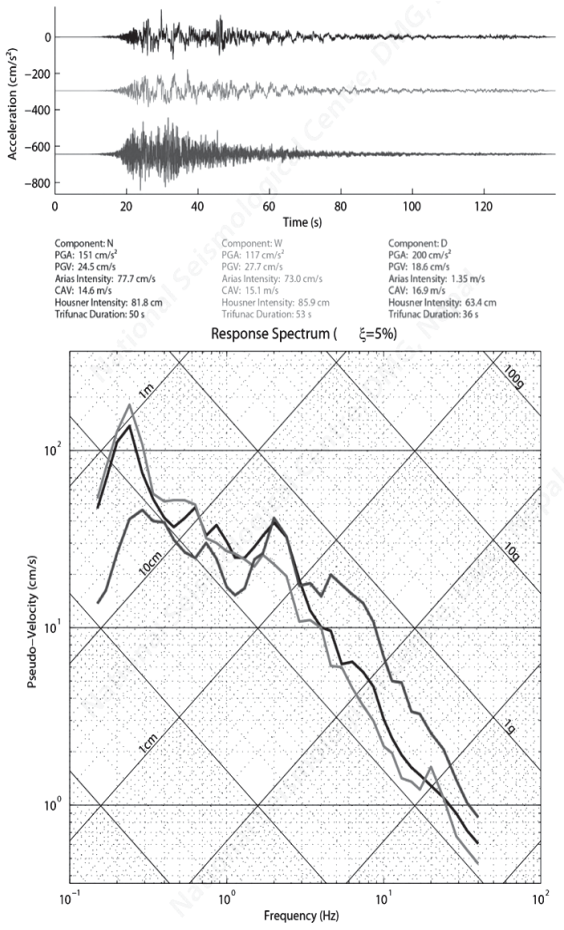

Fig. 10: Seismogram and response spectrum of 25 April 2015, Gorkha earthquake recorded by storng motion station at Lainchaur, Kathmandu.

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Website: National Seismological Centre (NSC), Department of Mines and Geology, Nepal, http://www.seismonepal.gov.np

Status of Chemical Laboratory in DMG and Challenges towards its Accreditation

Gajendra Pradhan, Senior Divisional Chemist

ABSTRACT

With the establishment of Department of Mines and Geology, after merging of Department of Mines with Geological Survey Department in BS 2033 Shrawan, a chemical laboratory sub division was also established in parallel aiming to undertake test of mineral ore, rocks, geo-chemical compounds etc. It is said that this chemical laboratory is the first of its kind as a public laboratory of Government of Nepal. In order to know the existing status of this laboratory, it would be better to review/observe the historic background of it with all kinds of technical constraints that has continuously been facing with time till today, especially for making attempts to get accreditation from internationally recognized body. Nevertheless, the training packages to implement international standard ISO 17025 (General Requirement for the competence of testing and calibration Laboratory) for establishment and operation of this laboratory has been conducting for last couple of year before, which is bounded to taking training only could not be providing service facilities for accreditation until it is going to put into practice. This chemical laboratory has still been able to conduct various mineral based rocks, ore, metallic, non metallic sample with building its capability of undertaking of testing in using some sophisticated electronic instruments i.e. Electron Dispersive X-Ray Fluorescence (ED-XRF) , Atomic Absorption Spectrophotometer (AAS) and Induced Couple Plasma- Mass Transfer (ICP-MS) in accumulation in accumulation. This has made DMG laboratory equipped with and being capable to undertake even radioactive elements and rare earth elements detection, on request. This laboratory had conducted very limit of testing range i.e. limestone, dolomite, magnetite or silicate rocks, coal etc. Now, it has been broaden its area of testing capability to iron ore, copper ore, phosphorus, radioactive mineral, coal qualitatively and quantitatively besides its routine works of limestone regularly, though the laboratory has continuously been facing a lot of challenging steps from beginning of testing processes to the end of result issued out.

INTRODUCTION

A chemical laboratory itself is a hazardous place, house to many chemicals, heating objects where hazardous activity takes place in using toxic chemicals. Using those toxic chemicals and requirement to use them in presence of heating objects makes more lethal situation across the laboratory. Actually, DMG-lab aims to provide best test result with applying all types of possible and available hazardous preventive safety measures. For analyst or chemist, a safe and environmental friendly situation must be made as is a number one priority to conduct the analytical task into the laboratory.

Although chemical laboratory domain plays a vital role to identify and quantify the level of concentration and composition of the supplied ore minerals, rocks, geo-chemical samples in order to take decision on processing, quality control or implementation of legislation; there is still lacking of essential quality infrastructure and adequate no. of man power as it required. The operation of the DMG- Laboratory service had begun almost the same time of the establishment of the DMG. However, the situation and status of the lab's Quality Infrastructure (QI) is in deterioration and no. of man power in declining. Since QI is taken as the totality of the institutional framework of old one governmental laboratory, which requires to establish and implement standardization, accreditation and conformity assessment services. QI along with adoption of international standard ISO 17025 have yet to implement by introducing promotional policy by the government through NEPLAS (Nepal Laboratory Accreditation Scheme) or

internationally recognized accreditation board (NABL) in the neighboring countries. After establishment of laboratory accreditation, the test results presented by this laboratory is internationally recognized and should be capable to perform specific types of testing, measurement and calibration with the technical competence of laboratories as desired by the clients. Generally, the DMG laboratory is undertaking the common test parameters under analysis like Loss on Ignition (LOI), Acid Insoluble (AIM), Calcium Oxide (CaO), Magnesium Oxide (MgO), Combined Oxides (R2O3), moisture, non metallic, metallic ore, Iron, Copper, Lead, Zinc, Gold, Silver etc of the mineral ore, rock sample etc.

Since the introduction of sophisticated modern instrument, ICP-MS (Induced Couple Plasma- Mass Transfer) in the laboratory, it has somehow added more responsible to provide the valid results data in ppb (part per billion) level is much perceptive. Introduction of such advance instrument in this chemical laboratory has made a pride of the whole department for being capable of testing of rare minerals as well as radioactive elements even in ppb level. However, this instrument and test methods applied in it needs to be validated/calibrated/ standardized on a routine basis since it is specially employed to determine the radio-active element – Uranium which was discovered by DMG in some parts of Nepal.

Our country has its prospectus of finding more elements of Rare Earth Elements which are associated with alkaline rocks, granitic rocks etc, a number of metallic and nonmetallic minerals. These are also potential, economically worthwhile deposits and exploration in the new geological prospective areas may further lead to find the potential economic deposits of those minerals lies in different parts of the country. Considering such expanding activities of geo-exploration task in the department, correspondingly it is essential the upgrading and developing of the laboratory also needs to be taken in account in parallel.

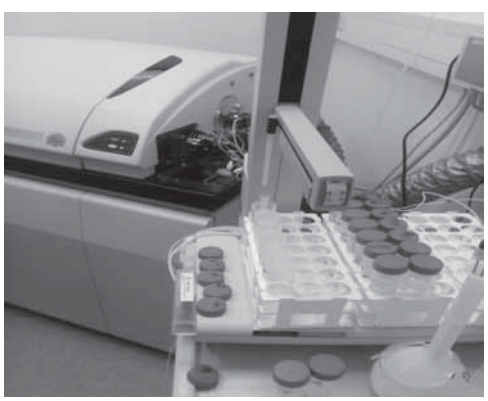

Fig. 1: Setting of ICP –MS in the Instrumental Lab

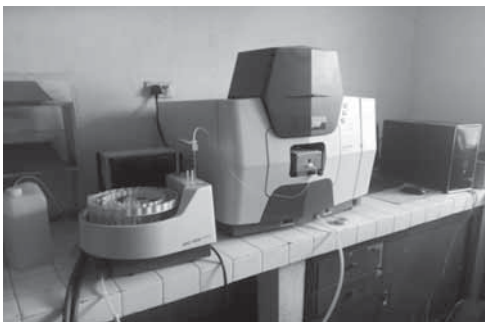

Fig. 2: ED-XRF and AAS in the Conventional Lab for metallic ore analysis in DMG

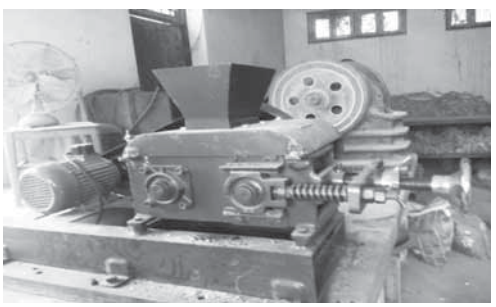

Fig. 3: New Roll Crusher and Pulverizer Grinding Machine for Non–Metallic and Metallic ore crushing in Chemical Lab of DMG

This study on "the status of Chemical laboratory in DMG and Challenges towards its Accreditation" is conducted on the base of the following purposes -

- to amend the infrastructure of testing laboratory of the department
- to support in taking necessary actions in developing their quality system and technical system
- to make attempt to establish laboratory accreditation for international recognition
- to implement and adopt international standard ISO 17025 (General Requirement for the competence of testing and calibration laboratory) through NEPLAS or International accreditation body.
- to help calibration of all used equipments and standardization.
- to take part in PT (proficiency testing/inter-laboratory comparison), adequate training in concerned testing, making availability of CRM (Certified Reference Material), all requirement for better testing services.
- to make management commitment (GLP-Good Laboratory Practice)for development of laboratory and assurance of quality test results.
- increasing qualified man power as it required for speedy work service expectation.

METHODOLOGY AND CHALLENGES

All the information about the current laboratory condition are collected from day by day experience, using questionnaires from laboratory analyst/ chemist and lab worker so that it helped to present the status of the DMG- laboratory openly in account of the following common aspects:

LABORATORY ACCOMMODATION/ INFRASTRUCTURE

Nevertheless the lab is well ventilated, lightened, and adequate spacious to perform the test of commodities, however the damaged wall and the floor of the laboratory is still in risk and vulnerability as any time it may adversely collapse. It should be addressed on time to take action to ensure safety of the workers and protection of the using equipments. Similarly, Conventional lab, Instrumentation lab, Crushing units, analytical balance room should be kept in dust free, tidy and vibration free room with setting of air condition operation all time within in order to avoid dust contamination in test processes, fluctuation in weighing. These needs to be improved speedily in DMG Lab. Chemical waste and wash basin provided are also leaked and ignorance in waste disposal system observed, should be managed.

HUMAN RESOURCES AND TRAINING

Chemist/Analyst or Technical personnel who involves directly in testing of mineral ores needs to be well qualified to perform their assigned job and should also have periodically relevant training/orientation specially in ISO 17025, quality management system and experienced in their respective field. Such key persons are not adequate here in DMG lab for successful and speedy analytical services. Therefore, only trained in about quality standardization of analytic job can provide reliable and effective test results. This will help our DMG laboratory to acquire accreditation in future.

ANALYTICAL INSTRUMENTS AND EQUIPMENTS IN DMG LAB

Normally for undertaking conventional analysis system for assigned parameters, electronics balance, drying oven, muffle furnace, Fume hood (maintenance required), hot plate (maintenance required) are used and for instrumental analysis, we have also AAS, Microwave digester, recently installed sophisticated analytic instrument ICP-MS etc. For the performance of lab test, all of those equipments need to be calibrated and validated the methods before operation of them in order to get accurate and validity of the results. However, those equipments create problems frequently in the lab since low class machines are procured through our governmental law of purchases acts. Actually, equipments are to be regular inspected, maintained, calibrated and then test conducted. F1 Class weight box is used to make internal calibration of the balance and Thermocouple is also used to calibrate muffle furnace and oven internally on a routine basis, which are available in the lab. Electronics instruments like AAS and ICP-MS are used for the detection of rare earth elements in mineral ore in PPM and PPB level respectively are automatic calibrated during testing of samples. Training in measurement of uncertainty and metrological traceability are also necessary to develop skill and confidence of instrument operator that will also help making lab accredited.

QUALITY POLICY/MANUAL AND PROCEDURE

Quality manual is a working document describing the quality system of laboratory inclusive of technical procedure for test processes, made for all analysts' day to day use. Since the aim of DMG-laboratory is to make it accredited in future, quality policy needs to be addressed. Policy states the capability of the laboratory with competence and reliable test results through zero complain/customer satisfaction. For which, lab should make ensure quality of testing through using quality manual documented, quality control of test using reference material, ensuring efficiency of using equipments, appropriate skilled manpower, implementation of quality management system, obtaining of the best possible proficiency results, commitment of the top management in quality related actions/cooperation as well as customer complain verification/customer satisfaction etc. For the DMG lab, it is necessitated to initiate the allocation of required budget for making quality policy and manual.

SAMPLE PREPARATION, HANDLING AND STORAGE OF SAMPLES

The sample preparation unit of DMG-laboratory receives various mineral ore samples from different parts of the country and undertakes sample preparation works using necessary crusher machines in order to make it required size and quantity as stated

in manual. This fiscal year, we have purchased two crushing machines i.e. Roll Crusher and Pulverizer in order to make metallic powder sample and non-metallic powder sample separately. Those prepared samples are prior registered to make records of data with identification code. These records shall include where relevant/location, the sampling method used; sampling plan, date and time of sampling; data to identify and describe the sample state (e.g. number, amount, and name). Handling of prepared sample to delivery/supply to laboratory have defined procedure for the transportation, receipt, protection, storage, retention, and disposal which is very necessary to protect the integrity of the test or calibration item, as well as to protect the interests of the laboratory and the customer. However, precautions are still not taken to avoid deterioration, contamination, loss or damage to the item during handling, transporting, storing/waiting, and preparation for testing or calibration due to lacking of reliable occupational health and safety issue.

USE OF REFERENCE MATERIAL OR CERTIFIED REFERENCE MATERIAL

RM or CRM is the most important material used in to check the quality control of and traceability of the test measurement as a control system of the test. It plays vital roles to build self confidence of analyst whether achieving their performance as homogeneity or stability in test. It is globally approved analytical test method used in DMG instrument lab as well. It is an initiation of emerging to accreditation of laboratory, however, the room should be facilitated from room temperature and relative humidity maintenance and protected from dust and other unnecessary particles to maintain tidy and clean. Still it is requiring certified reference material of ZnSO4 for standardization of EDTA reagent for validation of our routine parameters CaO/MgO test result more accurate.

INTER-LABORATORY PARTICIPATION PT (PROFICIENCY TESTING)

Proficiency testing determines the performance of our laboratories for specific tests or measurements and is used to monitor laboratories' continuing performance or competitive. Proficiency testing is also called inter-laboratory comparison. DMG-Laboratory has once participated in such inter-lab testing program of loss on Ignition (LOI), CaO, MgO parameters of limestone with others governmental lab in Kathmandu e.g. DMG-lab,, NBSM lab, NPRL hosted by NBSM and gave satisfactory test results from DMG-Lab. Such types of participation make self confidence of analyst and lab itself which is so far required frequently in many parameters of routine test of limestone.

LAB SAFETY AND ENVIRONMENT

Safety is first to perform any analytical works in hazardous house. Preventive measure should be taken by installing fire extinguisher, electric shock by proper earthling, keeping first aid box, knowing warning sign, label, using protection equipments provided, proper ventilating, keeping lab neat and tidy in order to protect and being safety from possible occurrence of unwanted incident. It is urgently necessary to keep lab safety place according ISO 17025 and all kinds of environmental safety like light, air, place, clean, risk free zone for laboratory to perform analytical task in good environmental condition. It is still need to be improved in DMG lab as a challenge to adopt international standardization.

CONCLUSION AND RECOMMENDATION

Chemical laboratory is generally established to undertake testing of assigned samples and issues the quality and reliable test results with zero complains. Lacking of any fundamentals requirements as described above offers poor performance and consequently it gives no any consistent and reliable result. It adversely led to dissemination of poor recognition of our working process and DMG-laboratory itself. Therefore, cooperation, support and commitment of top management committee are decisive for successful implementation of quality management system into the laboratory that subsequently provides quality assurance in the test results. To meet the aim of DMG-Chemical laboratory accreditation, good laboratory practice is the start up work to adopt quality management and generate standard quality data. Nevertheless, management has recently approved the training/refreshment courses/workshop on ISO 17025:2005 and safety management workshop for the improvement of existed lab towards good laboratory practice however, it is not adequate for assurance of quality of the testing program. It must be adopted/implemented general requirement for the competence of testing and calibration laboratory for laboratory accreditation. This international standard (ISO 17025:2005), now updated to (ISO 17025:2017) can be used in the laboratory by developing their quality system, management system, technical system through fulfilling following specific requirements:

- Improve quality lab infrastructure and suitable environmental condition for lab activities
- Human Resource Development and Periodic Upgrading Skill/Training
- Calibration of using equipments/glassware and instruments for validity of results and measurement accuracy
- Establishment of Quality policy and Manual stating quality testing processes
- Good handling of sample, sampling management and storage for reference/ retest
- Quality control of testing with using CRM/ RM (Certified Reference Material)
- Participating in Inter-laboratory comparison (Proficiency Test of specified material)
- Ensuring Laboratory Management for overall effectiveness of laboratory activities
- Validation of laboratory developed method, standard method, internal test method

Therefore, top management committee should encourage, support and commit establishing accreditation of DMG Lab from the policy level to implementation level by providing all the necessary requirements (Technical, Quality Management and Systematic) as described above to make internationally recognized competent laboratory in analytical services. Accredited laboratory performs any parameters of assigned commodity in accordance with international criteria and provides valid (Globally accepted) result data minimizing chances of retesting, zero customer complain handling, enhances satisfactory result.

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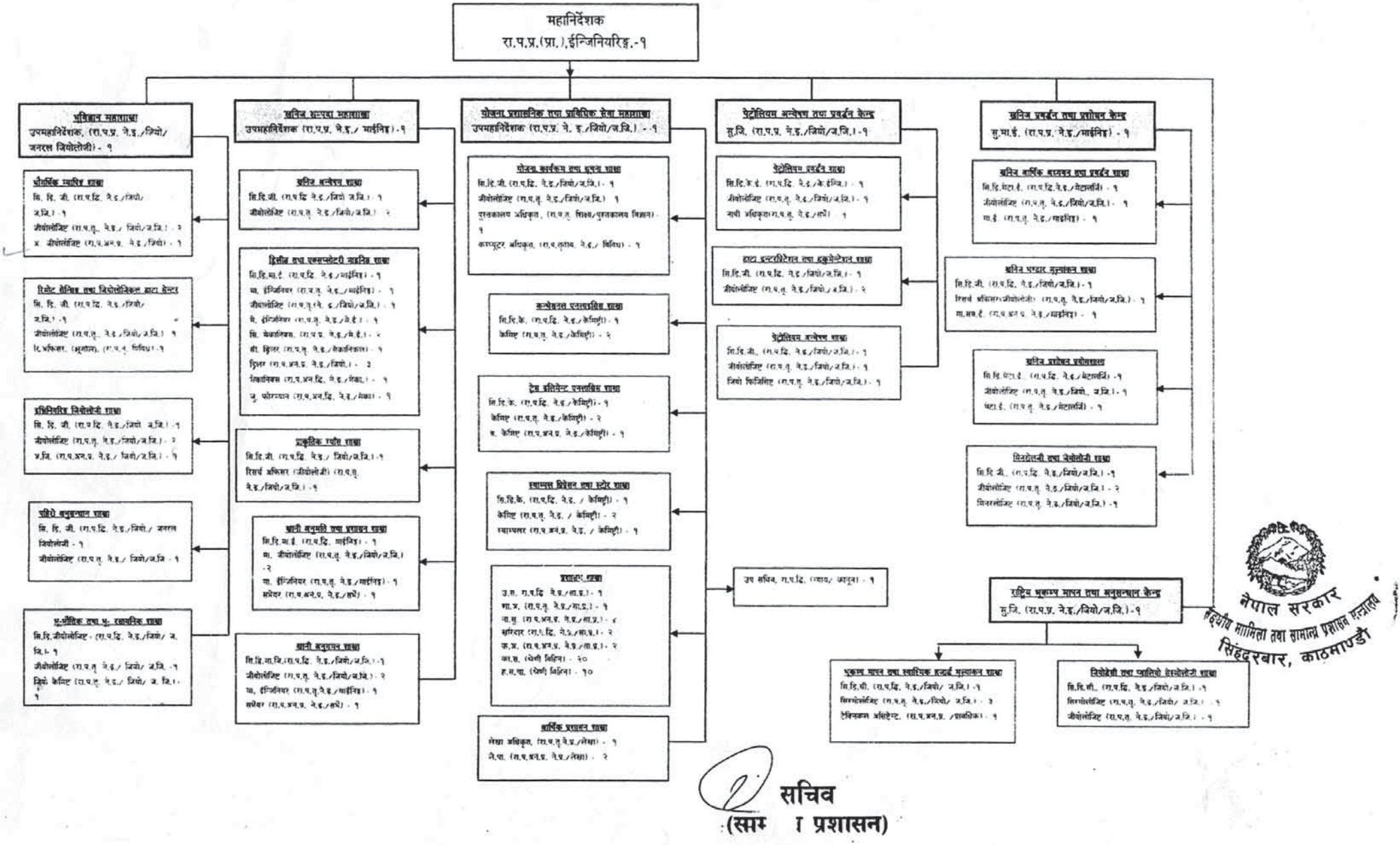
उद्योग, वाणिज्य तथा आपुर्ति मन्त्रालय
खानी तथा भूगर्भ विभागको संगठन संरचना

अनुसूची -३.३.१



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DMG Activities Photos

Nepal International GEMS And Jewellery Expo 2019

Kathmandu

Honorable Prime Minister at the Inauguration Session of Nepal International Gem and Jewellery Expo 2019

Inauguration of the Main Event of Expo

Honorable Prime Minister at the Exhibition Stall of DMG Inquring about Dhaubadi Iron Prospect

Honorable Minister of Indusrty, Commerce and Supplies Observing the Gem Cutting Demostration at the Expo

Activities of DMG
Field Activities

Drilling Work at Dhaubadi Iron Prospect, Dhaubadi, Nawalparasi

Drilling Work at Boje Limestone Prospect, Khotang

SPT for Engineering and Environtal Geological Mapping of Jaleswor Muncipality, Mahottari

Channel Sampling of Limestone at Mahdevsthan, Dhading

Channel Sampling of Limestone at Mahdevsthan, Dhading

Activities of DMG
Field Activities

Topogeological Survey works at Dhaubadi Iron Prospect, Nawalparasi

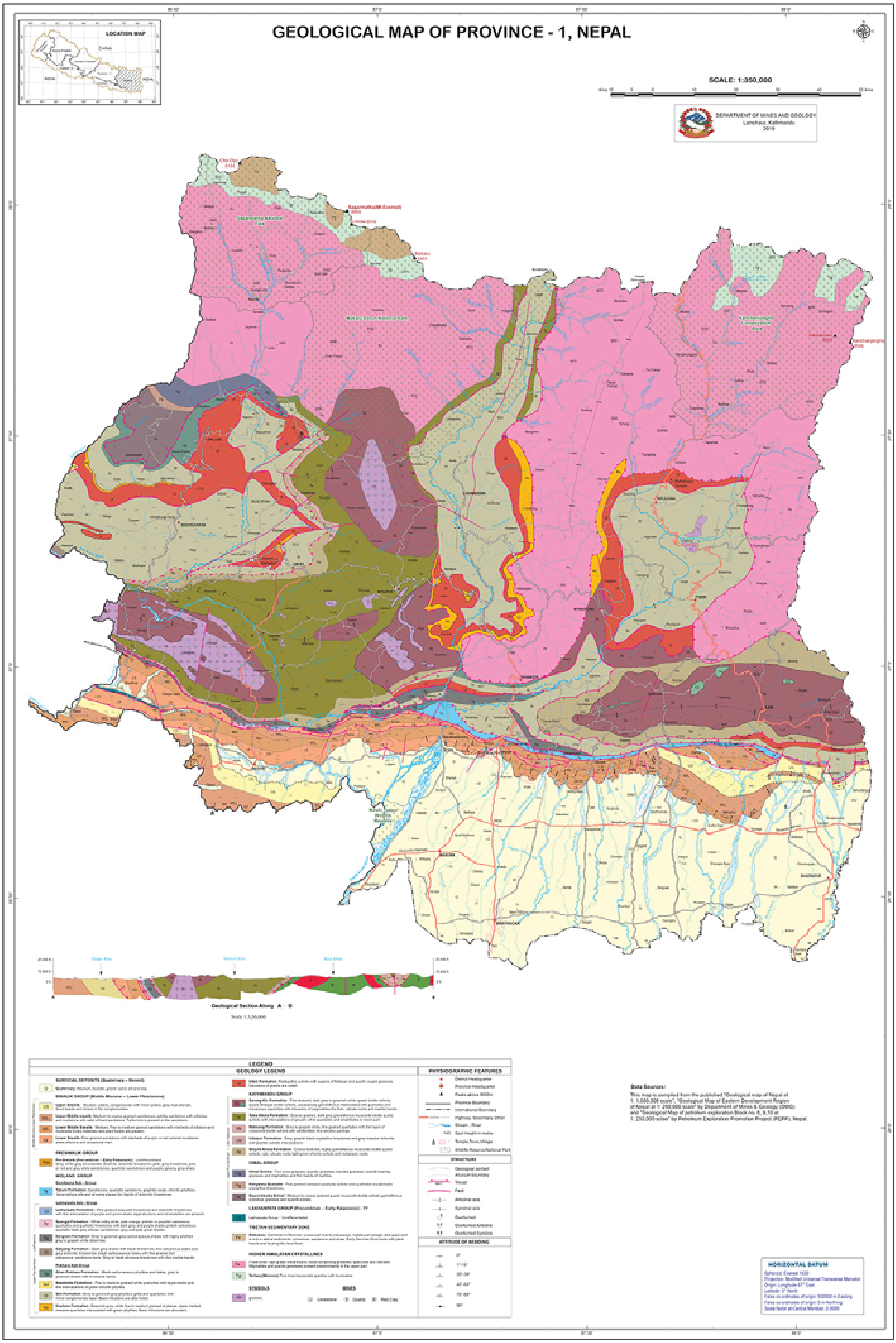
Channel Sampling of Hematite Ore at Dhaubadi, Nawalparasi

Exploration work at the old working of Copper Prospect at Dhusa, Dhading

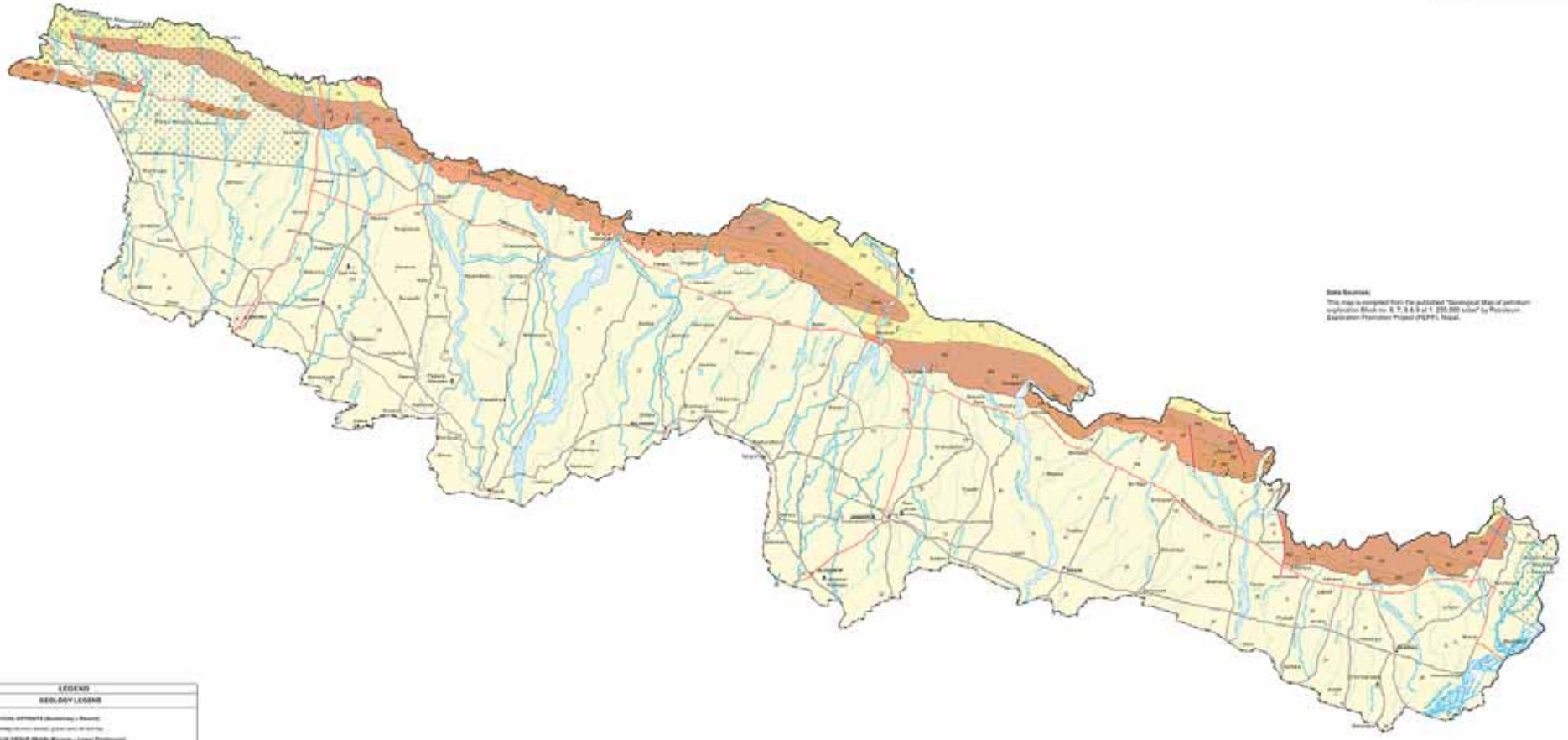
DMG Officaials Interacting with local people about Landslide Hazard at Aglung, Gulmi

Field inspection by senior DMG officials, Phosphorite prospect area, Baitadi

Channel Sampling of Phosphorite prospect area, Baitadi


GEOLOGICAL MAP OF PROVINCE - 1, NEPAL
LOCATION MAP
SCALE: 1:350,000
DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
Geological Section Along A – B
LEGEND
GEOLOGY LEGEND
PHYSIOGRAPHIC FEATURES
STRUCTURE
ATTITUDE OF BEDDING
SYMBOLS
MINES
Data Sources:
This map is compiled from the published "Geological map of Nepal at 1: 1,000,000 scale", "Geological Map of Eastern Development Region of Nepal at 1: 250,000 scale" by Department of Mines & Geology (DMG) and "Geological Map of petroleum exploration Block no. 8, 9,10 at 1: 250,000 scale" by Petroleum Exploration Promotion Project (PEPP), Nepal.
HORIZONTAL DATUM

GEOLOGICAL MAP OF PROVINCE - 2 , NEPAL



Data Sources:
This map is compiled from the published "Geological Map of petroleum exploration Block no. 6, 7, 8 & 9 of 1: 250,000 scale" by Petroleum Exploration Promotion Project (PEPP), Nepal.

LEGEND

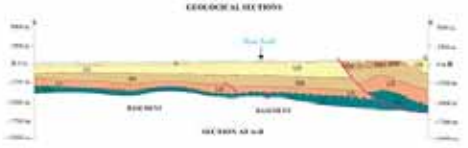
GEOLOGY LEGEND

PHYSIOGRAPHIC FEATURES

STRUCTURE

ATTITUDE OF BEDDING

GEOLOGICAL SECTIONS



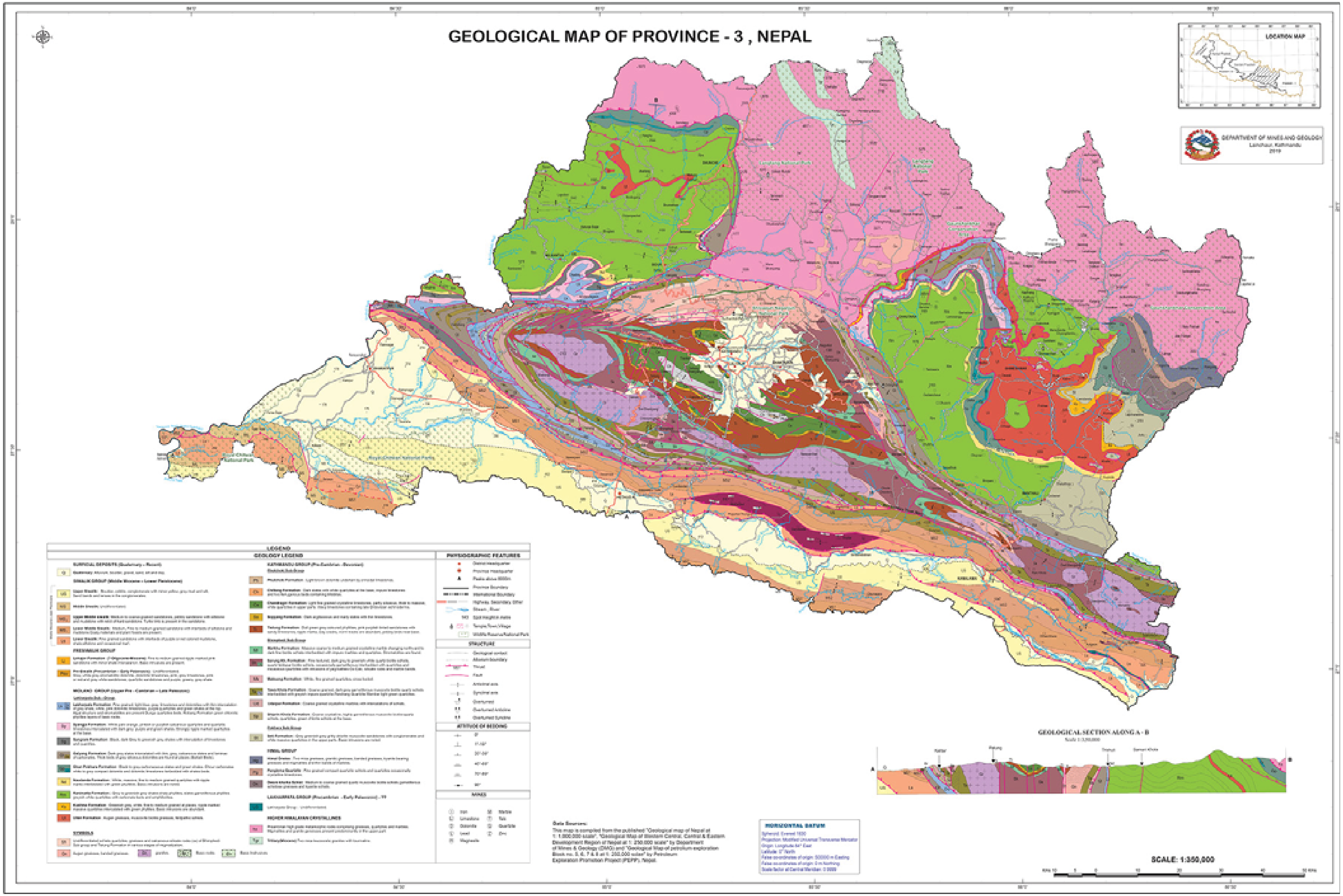
SECTION AT A-B

HORIZONTAL DATUM

Datum: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 87° East
Latitude: 0° North
False coordinates at origin: 500000 m Easting
False coordinates at origin: 0 m Northing
Scale factor at Central Meridian: 0.9996

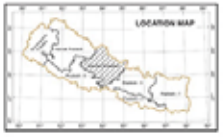
DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019

SCALE: 1:300,000


GEOLOGICAL MAP OF PROVINCE - 3 , NEPAL
LOCATION MAP
DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019
LEGEND
GEOLOGY LEGEND
PHYSIOGRAPHIC FEATURES
STRUCTURE
ATTITUDE OF BEDDING
MINES
GEOLOGICAL SECTION ALONG A - B
Data Sources:
This map is compiled from the published "Geological map of Nepal at 1: 1,000,000 scale", "Geological Map of Western Central, Central & Eastern Development Region of Nepal at 1: 250,000 scale" by Department of Mines & Geology (DMG) and "Geological Map of petroleum exploration Block no. 5, 6, 7 & 8 at 1: 250,000 scale" by Petroleum Exploration Promotion Project (PEPP), Nepal.
HORIZONTAL DATUM
SCALE: 1:350,000

GEOLOGICAL MAP OF GANDAKI PROVINCE , NEPAL

SCALE: 1:350,000



DEPARTMENT OF MINES AND GEOLOGY
LAINCHAUR, KATHMANDU
2019

LEGEND

GEOLOGY LEGEND

PHYSIOGRAPHIC FEATURES

STRUCTURE

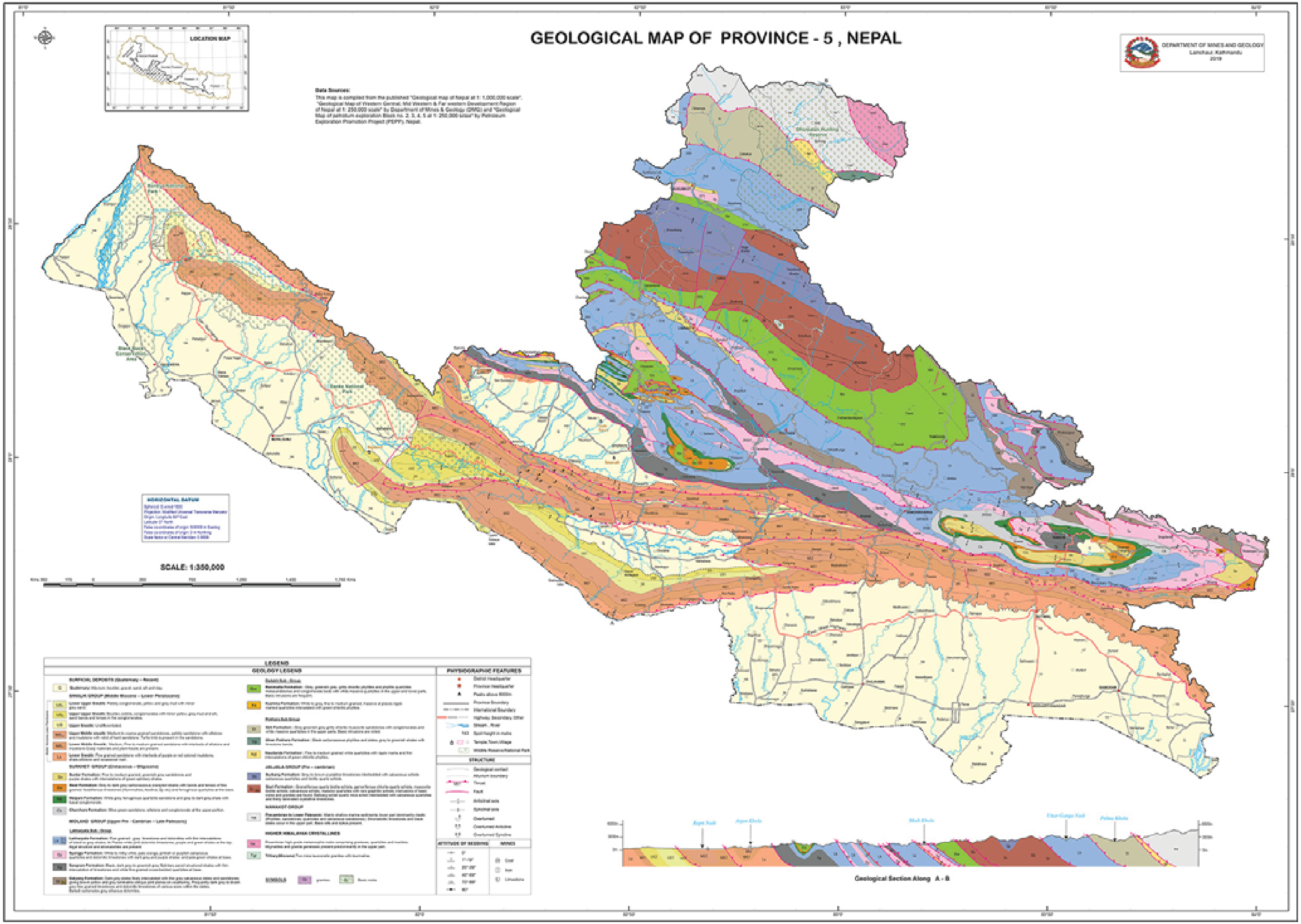
ATTITUDE OF BEDDING

MINES

Data Sources:
This map is compiled from the publishsd "Geological map of Nepal at 1: 1,000,000 scale", "Geological Map of Western Central & Central Development Region of Nepal at 1: 250,000 scale" by Department of Mines & Geology (DMG) and "Geological Map of petrolium exploration Block no. 5 & 6 at 1: 250,000 scale" by Petroleum Exploration Promotion Project (PEPP), Nepal.

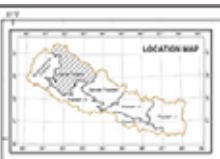
HORIZONTAL DATUM

GEOLOGICAL CROSS SECTION ALONG A - B


GEOLOGICAL MAP OF PROVINCE - 5 , NEPAL
DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019
LOCATION MAP
Data Sources:
This map is compiled from the published "Geological map of Nepal at 1: 1,000,000 scale", "Geological Map of Western Central, Mid Western & Far western Development Region of Nepal at 1: 250,000 scale" by Department of Mines & Geology (DMG) and "Geological Map of petroleum exploration Block no. 2, 3, 4, 5 at 1: 250,000 scale" by Petroleum Exploration Promotion Project (PEPP), Nepal.
HORIZONTAL DATUM
SCALE: 1:350,000
LEGEND
GEOLOGY LEGEND
PHYSIOGRAPHIC FEATURES
STRUCTURE
ATTITUDE OF BEDDING
MINES
SYMBOLS
Geological Section Along A - B

GEOLOGICAL MAP OF KARNALI PROVINCE , NEPAL

SCALE: 1:400,000



DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019

HORIZONTAL DATUM

Data Sources:
This map is compiled from the published "Geological map of Nepal at 1: 1,000,000 scale", "Geological Map of Western Central, Mid-Western & Far Western Development Region of Nepal at 1: 250,000 scale" by Department of Mines & Geology (DMG) and "Geological Map of petroleum exploration Block no. 2 & 3 at 1: 250,000 scale" by Petroleum Exploration Promotion Project (PEPP), Nepal.

LEGEND

GEOLOGY LEGEND

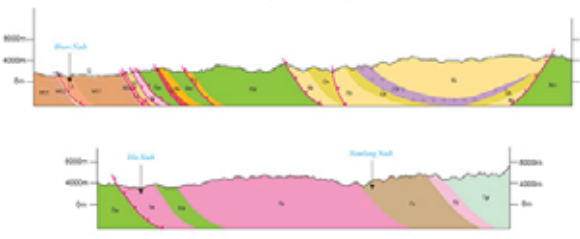
PHYSIOGRAPHIC FEATURES

STRUCTURE

ATTITUDE OF BEDDING

MINES

Geological Section Along A - B

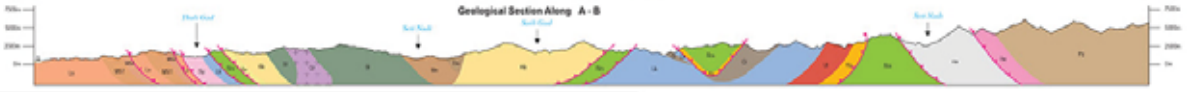


GEOLOGICAL MAP OF SUDUR PASCHIM PROVINCE , NEPAL

DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2019

SCALE: 1:300,000

HORIZONTAL DATUM
Spheroid: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 81° East
Latitude: 0° North
False co-ordinates of origin: 500000 m Easting
False co-ordinates of origin: 0 m Northing
Scale factor at Central Meridian: 0.9996



LEGEND

GEOLOGY LEGEND

SURFICIAL DEPOSITS (Quaternary – Recent)

Q Quaternary: Alluvium, boulder, gravel, sand, silt and clay.

SIWALIK GROUP (Middle Miocene – Lower Pleistocene)

LSs Lower Upper Siwalik: Pebbly conglomerate, yellow and grey mud with minor grey sand.

LMs Upper Upper Siwalik: Boulder, cobble, conglomerate with minor pebble, grey mud and silt, sand beds and lenses in the conglomerates.

US Upper Siwalik: Undifferentiated.

MSs Upper Middle Siwalik: Medium to coarse grained sandstone, pebbly sandstone with siltstone and mudstone with rare/ill-sorted conglomerate. Pebbly limb is present in the sandstone.

MSs Lower Middle Siwalik: Medium, Fine to medium grained sandstone with intercalations of siltstone and mudstone (finely interbedded) and plant fossils are present.

LSs Lower Siwalik: Fine grained sandstone with interbeds of purple or red colored mudstone, shale/siltstone and occasional marl.

PRE-SIWALIK GROUP (Oligocene ?)

Pre Siwalik (undifferentiated)
Grey, white grey, chromatitic dolomite, dolomitic limestones, pink, grey limestones, pink or red and grey white sandstones, quartzitic sandstones and quartz, grey shale.

SURKHET GROUP (Cretaceous – Oligocene)

Sa Surkhet Formation: Fine to medium grained, grey sandstones and purple shales with intercalations of green calcareous shales.

Sm/Ss Seti Formation: Grey to dark grey calcareous variegated shales with bands and lenses of fine grained, fossiliferous limestones (fossiliferous, Arenite, Sp etc) and ferruginous quartzites at the base.

MOLASS GROUP (Upper Pre - Cambrian – Late Paleozoic)

Lk Lk Lathiyadda Formation: Fine grained, grey limestones and dolomites with thin intercalations of black to grey shales. At Places white and dolomitic limestones, purple and green shales at the top. Algal structure and stromatolites are present.

Ky Kunaga Formation: White to milky white, pale orange, pinkish or purplish vuliaceous quartzites and dolomitic limestones with dark grey and purple shales and pale green shales at base.

Dag Dangsing Formation: Black, dark grey to greenish grey, lustrous, pencil structured shales with rare intercalation of limestones and white fine grained cross bedded quartzites at base.

Sa Sa Satyang Formation: Dark grey varies finely interbedded with thin grey calcareous slates and sandstones giving brown yellow and grey dolomitic oolitique joint planes on weathering. Frequently dark grey to bluish grey fine grained limestones and dolomitic limestones of various sizes within the slates. Rarely carbonates grey siliceous limestones.

Bm Bamboshe Formation: Grey, greenish grey, gritty chloritic phyllites and chloritic quartzites, metamorphosed, and conglomerate beds with white massive quartzites in the upper and lower parts. Basic intrusions and limestone.

Ka Kushma Formation: White to grey, fine to medium grained, massive siliceous bluish marbled quartzites intercalated with green chloritic phyllites.

Upd Ulleri Formation: Augen gneisses and feldspathic schists.

(SAISE) SAKURA GROUP (Pre – cambrian)

Dm Dermuga Formation: Grey to greenish grey calcareous quartzites and crystalline limestones.

Mw Malmara Formation: Grey to dark grey chlorites and sericite schists.

Sa Saiburi Gad Formation: Agnitic granite gneisses, augen gneisses and biotite gneisses.

Ks Ks Kalikot Formation: Quartzites, graphitic schists and micaceous quartzites with gneisses.
Shaile Gad Carbonates: Bluish Crystalline limestones calcareous schists and quartz biotite schists.
Kuthi-Kanga Gneiss: Augen gneisses granitic gneisses and feldspathic schists.

NAMMADI GROUP

Ns Precambrian to Lower Paleozoic: Mainly shallow marine sediments, lower part dominantly clastic (Phyllites, sandstones, quartzites and gneissose sandstones). Bimodalitic limestones and black slates occur in the upper part. Basic rocks are lenses present.

TIBETAN SEDIMENTARY ZONE

Ma Mesozoic: Traces to lower proterozoic. Mainly shallow continental platform sediments with local pre-cretaceous to Eocene Orogenesis. Sandstones, shales, shales with glauconite. Mainly carbonates and sometimes in Jurassic Limestone.

Pz Paleozoic: Quartzites to Permian (Lower part mainly calcareous, middle part pelagic and upper part is rich in detrital sediments, Limestone, sandstone and shale. Early Permian Shale bands with giant fossils and fossil spirifer lava flows.

HIGHER HIMALAYAN CRYSTALLINES

Hm Precambrian high grade, metamorphic rocks comprising gneisses, quartzites and marbles. Migmatites and granitic gneissoic present predominantly in the upper part.

SYMBOLS

- Pp Pebbles
- Sm Augen gneisses banded gneisses
- Basic rocks

MINES

- Limestone
- Quartz
- Red Clay

PHYSIOGRAPHIC FEATURES

- District Headquarter
- Province Headquarter
- Peaks above 8000m
- Province Boundary
- International Boundary
- Highway, Secondary, Other
- Stream , River
- Spot Height in metre
- Temple,Town,Village
- Wildlife Reserve/National Park

STRUCTURE

- Geological contact
- Allochoth Boundary
- Thrust
- Fault
- Anticlinal axis
- Synclinal axis
- Overturned
- Overturned Anticline
- Overturned Syncline

ATTITUDE OF BEDDING

- 0°
- 1°-10°
- 20°-30°
- 40°-60°
- 70°-80°
- 90°

Data Sources:

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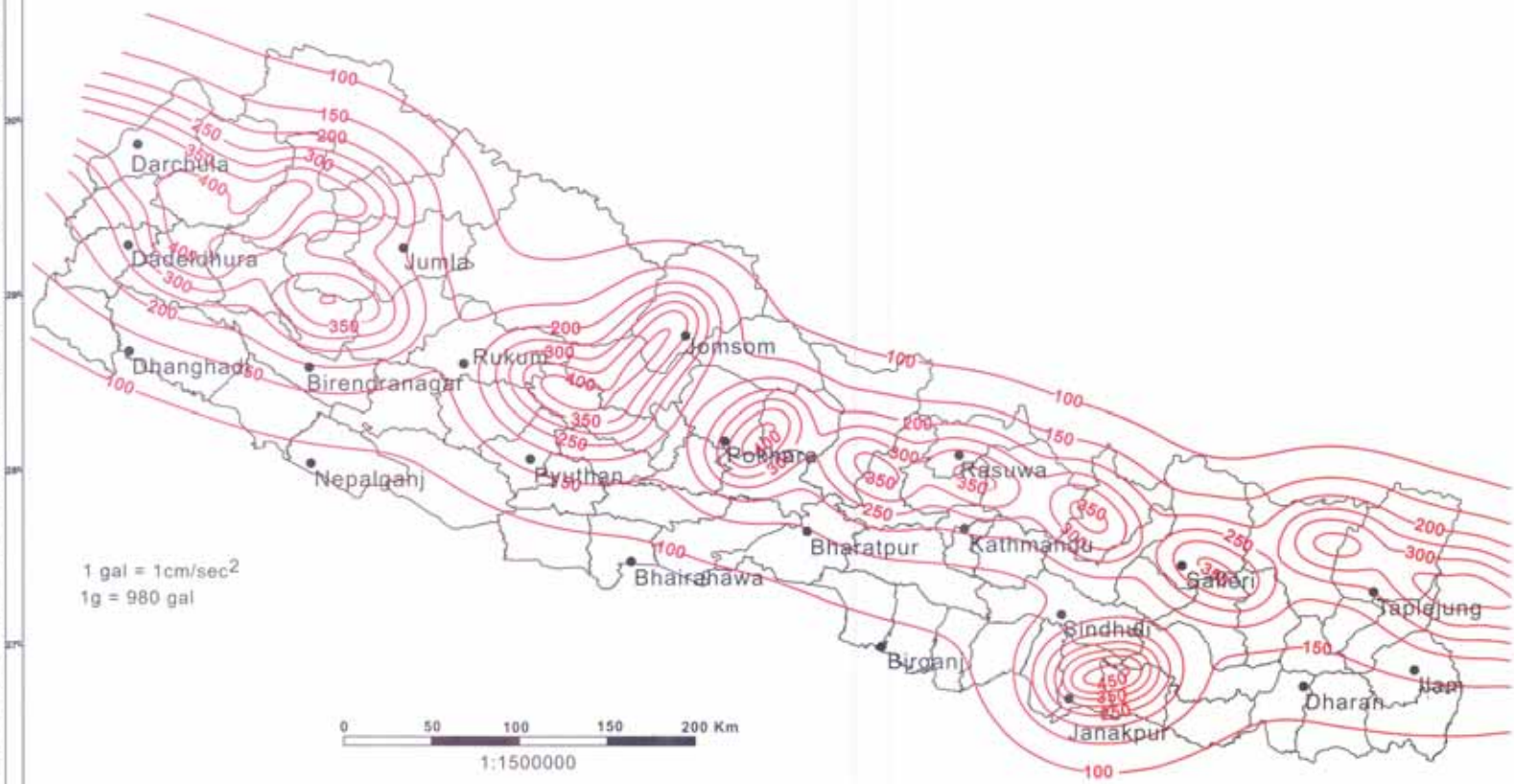
SEISMIC HAZARD MAP OF NEPAL

Bedrock Peak Ground Horizontal Acceleration Contours in gals



Authors : M.R.Pandey, G.R.Chitrakar, B.Kafle, S.N.Sapkota, S.Rajaure and U.P.Gautam

Seismic hazard is defined as the probabilistic level of ground shaking associated with the reoccurrence of the earthquakes. It is realized by depicting levels of chosen ground motion that likely will not be exceeded in specified exposure of time. Such maps are fundamental in the evaluation of seismic risk which is a combined parameter of vulnerability factor and seismic hazard.

Peak Ground Acceleration (PGA) is a short period ground motion parameter that is proportional to seismic forces. Therefore it could be applied in building codes to specify horizontal seismic coefficient in short period structures (one to two storey buildings). PGA also is in good correlation with seismic intensity. It can also be used in the assessment of seismically induced geotechnical hazard.

The map shows **peak ground horizontal acceleration contours in bedrock for five hundred years return period.** It approximately corresponds to **10 percent chance of exceedence in fifty years.**

The hazard analysis has been made using the Probabilistic Seismic Hazard Analysis (PSHA) software CRISIS99. Seismic sources have been defined on the basis of geological, geophysical, seismological, GPS and geodetic research studies carried out in Nepal Himalaya by national and international institutions in the last 25 years. However, many parameters required for PSHA are not available at present. The seismic sources can be realized using rational approaches. Both Poisonian and characteristic source models have been considered in the present study. Seismogenic thrusts and transverse faults with strike length of less than 50 Km. are represented by the Poisonian model. Parameters for such faults are taken to be identical with an upper bounding magnitude at M= 6.3. Keeping in view the matured seismic gap in most of the part of the Nepal Himalaya the sub-horizontal detachment earthquake sources are represented by characteristic earthquake models with time independent magnitude. Segmentation of Nepal Himalaya is correlated with various geological, geophysical and seismological features. These features are used to define the characteristic sources. The assigned magnitude varies from 7.3 to 8.5 depending upon the length and surface area of source. The mean return period is assumed to vary from 350 to 500 years. The attenuation model of R.R. Youngs . et. al. (1997) is used in the analysis.

Acknowledgement

The present result is the outcome of the 25 years long collaboration in seismology and geophysics between Department Analyse Surveillance de l'Environnement (DASE), France and Department of Mines and Geology/HMGS. Thanks to the development of

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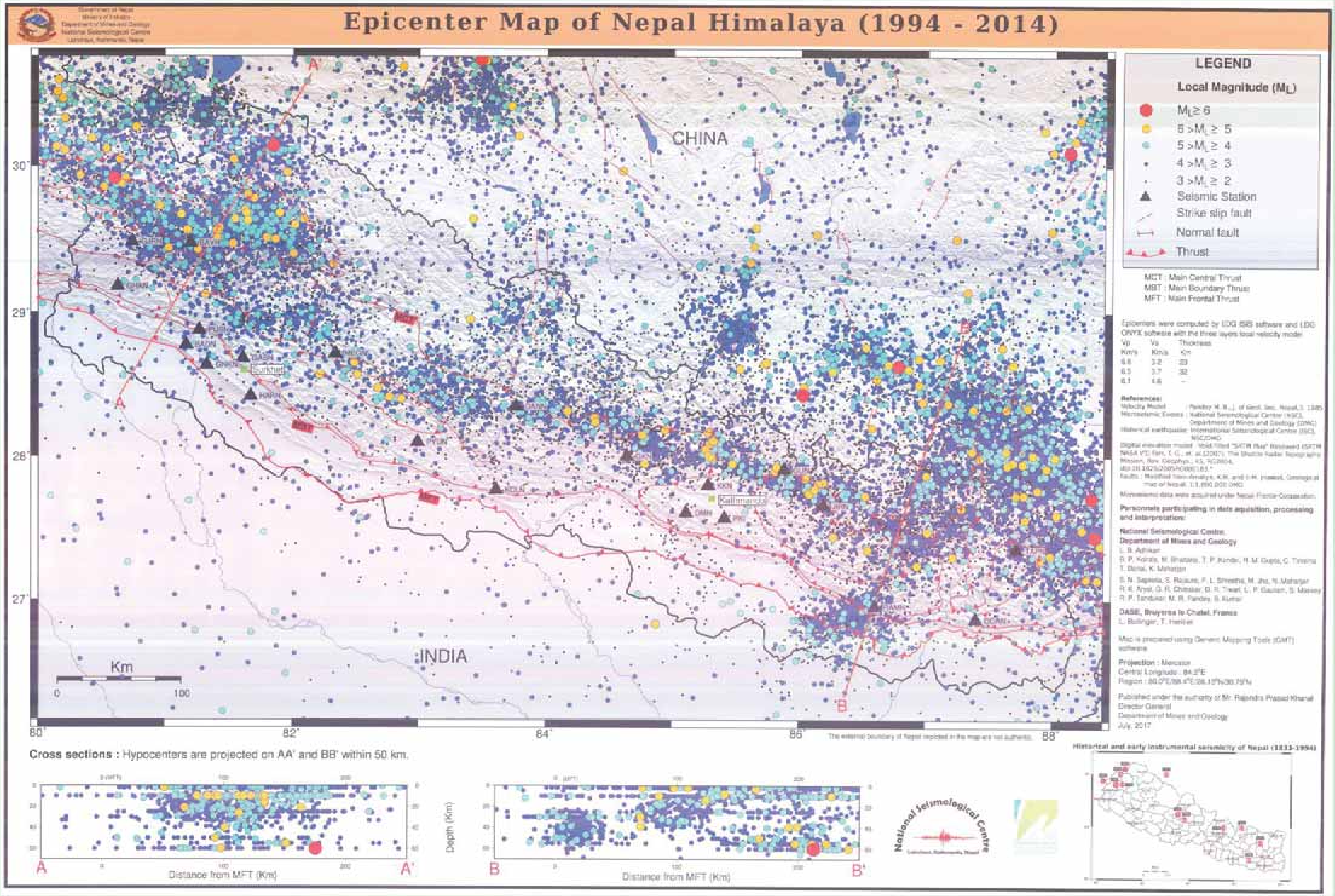
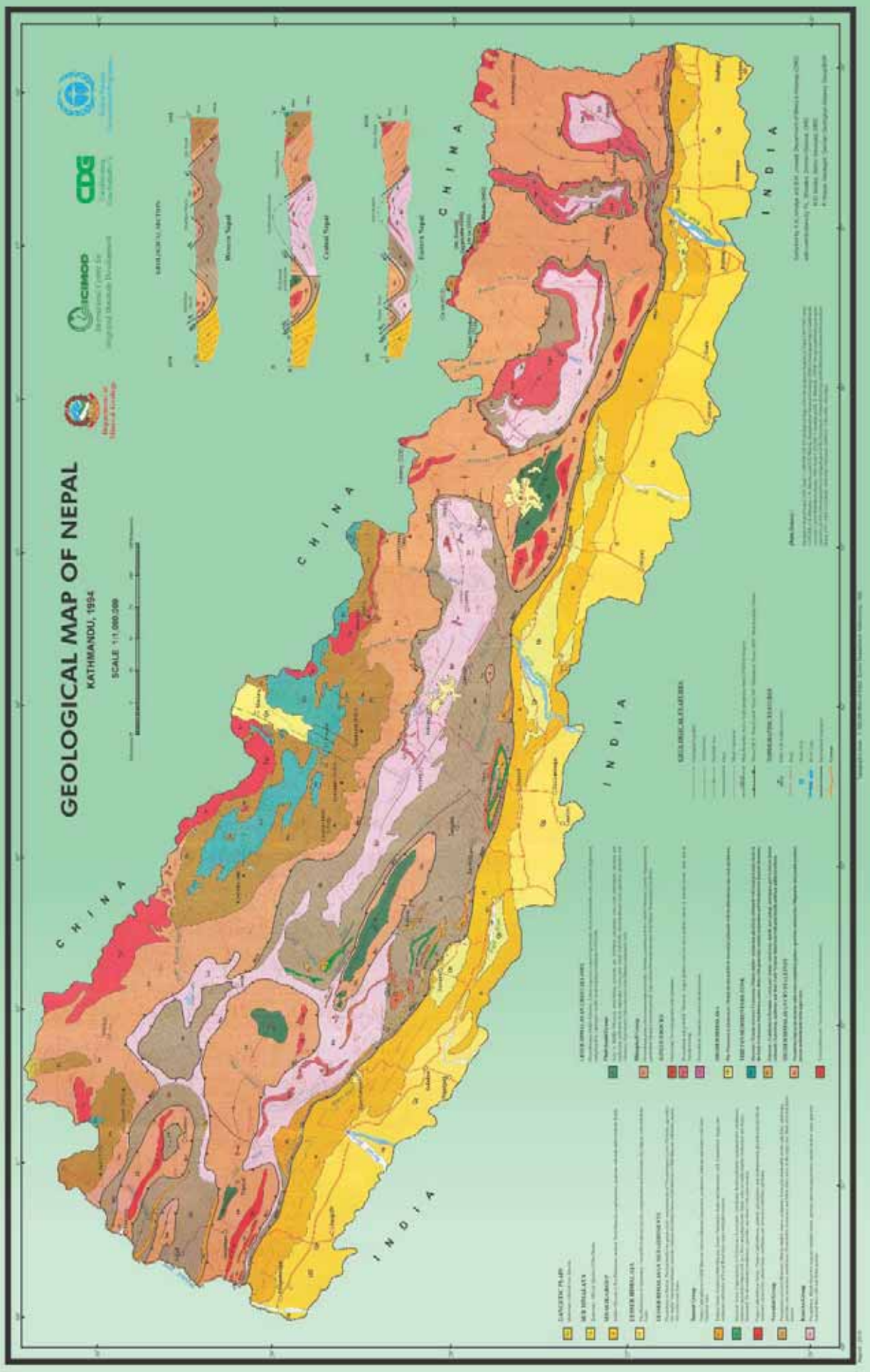

Epicenter Map of Nepal Himalaya (1994 - 2014)
LEGEND
Local Magnitude (M_L)
$M_L \geq 6$
$5 > M_L \geq 5$
$5 > M_L \geq 4$
$4 > M_L \geq 3$
$3 > M_L \geq 2$
Seismic Station
Strike slip fault
Normal fault
Thrust
MCT : Main Central Thrust
MBT : Main Boundary Thrust
MFT : Main Frontal Thrust
CHINA
INDIA
Kathmandu
Surkhet
MCT
MBT
MFT
A
A'
B
B'
Km
0
100
30°
29°
28°
27°
80°
82°
84°
86°
88°
References:
Personnels participating in data aquisition, processing and interpretation:
National Seismological Centre,
Department of Mines and Geology
DASE, Bruyeres le Chatel, France
Projection : Mercator
Central Longitude : 84.2°E
Published under the authority of Mr. Rajendra Prasad Khanal
Director General
Department of Mines and Geology
July, 2017
Historical and early instrumental seismicity of Nepal (1833-1994)
Cross sections : Hypocenters are projected on AA' and BB' within 50 km.
Depth (Km)
Distance from MFT (Km)
Distance from MFT (Km)
A
A'
B
B'
National Seismological Centre



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Ministry of Industry, Commerce and Supplies
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