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Foreword

Department of Mines and Geology (DMG) is the only government organization responsible to conduct various types of geo-scientific investigations and mineral exploration throughout the country in order to fulfill the aim of Government of Nepal to uplift living standard of people through rapid industrialization by utilization of national mineral resources. Our department is also responsible to monitor the seismicity of Nepal and also operate Seismic Alert System in the network.

DMGis bringing out a regular publication entitled 'Annual Report of Department of Mines and Geology' providing geo-scientific and undertaken by the department in order to cater to the needs of professionals, individual/institutions related to mineral and geo-sciences.

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.

Sarbjit Prasad Mahato
Director General

Editorial

The 'Editorial Board' is highly pleased to bring out this 'Annual Report' of Department of Mines and Geology (DMG) and hopes that this volume will also be useful and informative for our readers. Due to some unavoidable circumstances two volumes (Report no. 9 and 10) are combined in this issue. The present issue is an assortment of different articles embracing various disciplines of geoscience such as mineral exploration, geological mapping, geohazards, and engineering and environmental geology, etc. Likewise some other departmental activities and information are also included in this issue.

The 'Editorial Board' is highly grateful to all the authors and personnel of the DMG for their efforts and contributions to publish this report. Suggestions and comments are always welcomed.

Hifzur Rahman
Chief Editor

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Preliminary and Follow-up Explorations of Hematite Deposit in Dahuwadi – Pokhari Area, Nawalparasi District

Kushal N. Pokharel (Senior Divisional Geologist) and Narayan Baskota (Geologist)

ABSTRACT

Dhauwadi-Pokhari area consists rocks of Lakharapata and Surkhet Groups of Lesser Himalaya and Siwalik Group of Sub-Himalaya, the two being separated by the north-dipping Main Boundary Thrust (MBT). The rocks north to the MBT are folded into an eastward plunging syncline with the rocks of Surkhet Group in the core. Hematite beds interbeddded with quartzites and slates are explored from the Melpani Formation of the Surkhet Group. The hematie mineralisation zone is mapped almost continuously in the southern limb of the syncline. However, due to longitudinal and transeverse faults, the zone is largely obliterated in the northen limb. Two areas in the southern limb recommended for follow up study by preliminary exploration is geologically mapped along with chip and channel samplings. The possible geological reserve of hematie ore in Dhauwadi-Pokhari area is calculated about 100 million tons of 23 to 58 percent of iron content.

INTRODUCTION

After chemical analysis of 22 hematite grab samples collected from Dhauwadi-Pokhari area of Nawalparasi District during Preliminary Coal Exploration, Shrestha and Pokharel (2011) made a recommendation for exploration of iron in the area. The Department of Mines and Geology then carried out a Preliminary Exploration of Iron Deposit in 2011. The preliminary study was fairly able to trace extension of hematite mineralisation zone in the study area. Chip and some grab samples were collected and tested for Iron content. The thickness and extension of the hematite zone and optimistic value of iron content led an empetus for follow up study of the resource in the year 2012.

Two areas namely BLOCK A (Dhauwadi Area) and BLOCK B (Pokhari Area) were delineated from the preliminary study for follow up study (Figs. 1 and 2). The areas were so selected that they include the most important parts of the hematite deposit. This paper includes study results of both the preliminary and the follow up studies.

LOCATION AND ACCESSIBILITY

The area is accessible by road and lies west of Kathmandu. Daldale Bazar is a market place in East-West Highway, from where a dust road of about 24 km runs north linking Dhauwadi. Similarly from Chormara in the East-West Highway, a dust road of about 23 km links Pokhari through Jhyalbas. The rest of the area can only be accessed on foot (Fig. 1).

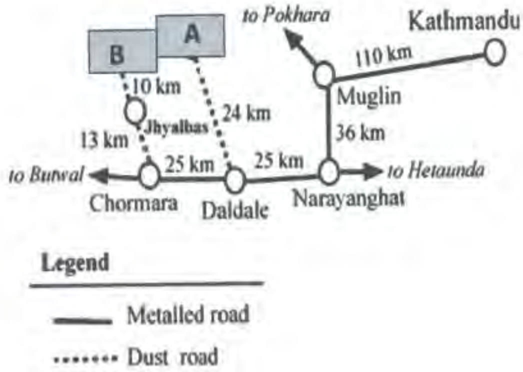

Fig. 1: Accesibility to the Hematite deposit areas

BLOCK A lies in Toposheet No. 100-09 (within Coordinates UTM of 3069000m to 3071500m North and 505500m to 510500m East) and BLOCK B lies in toposheets 100-09 and 100-10 (within Coordinate UTM of 3070000m to 3072500m North, and 510500m to 515500m East). Both the areas extend for 5 km in east-west direction and 2.5 km for north-south direction, each covering an area of 12.5 km^2, with a total of 25km^2.

GEOLOGY

The study area lies in Lesser Himalaya in north and Sub-Himalaya in south. The Lesser Himalaya is thrust over the Sub-Himalaya along north-dipping Main Boundary Thrust (MBT).The Lesser Himalaya consists rocks of Lakharpata Group and Surkhet Group. The Surkhet

Group rests unconformably above the Lakharpata Group (Kayastha, 1992; Table 1, Fig. 2).

Surkhet Group (Kayastha, 1992) is co-relatable to Tansen Group (Sakai, 1983 and 1984). The Surkhet Group consists of Charchare Formation (equivalent to Sisne and Taltung Formations combined), Melpani Formation (equivalent to Amile Formation) and Suntar Formation (equivalent to Dumri Formation).

Similarly, the Lakharpata Group is co-relatable to a part of the Nawakot Group (Stocklin, 1980).

Table 1: Lithostratigraphy of the Dhauwadi- 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

Due to the MBT, the area in the north has developed very complex structures. The rocks are folded into an eastward plunging syncline with the rocks of Surkhet Group in core. There are large number of longitudinal and transverse faults. The faults are well expressed morphologically in the field. A deep fault depression exists in Dhauwadi which is considered largely responsible for omitting of hematite beds in the northern limb of the syncline (Fig. 3).The rocks in the fold closure are found to be overturned for about 1.5 km which becomes normal to the west.

Siwalik Group

The sandstone interbeded with mudstone belonging to the Middle Siwalik are mapped south of the MBT. The pepper and salt sadstone 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.

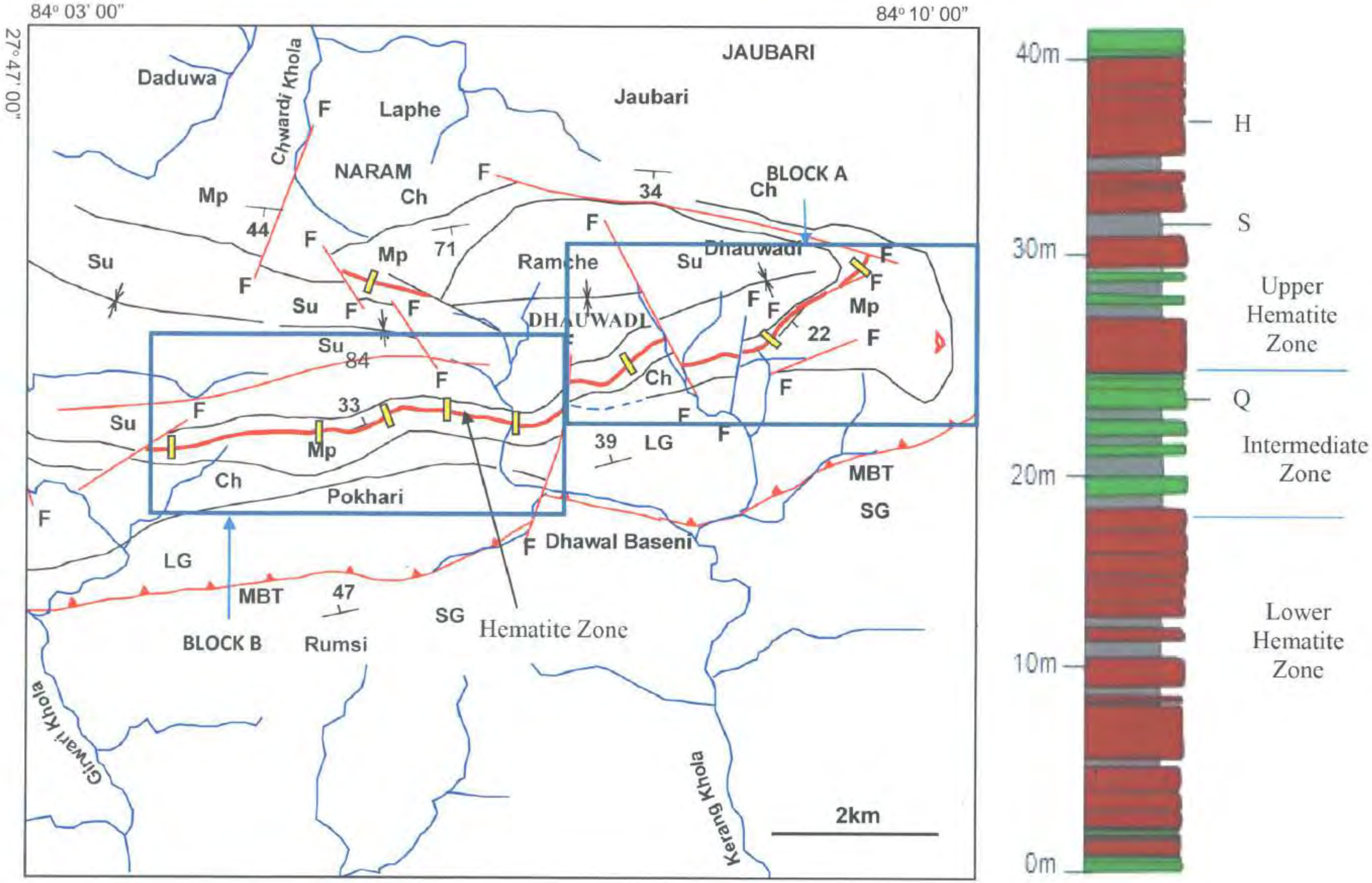

Fig. 2: (a) Geological map of Dhauwadi-Pokhari Area showing the chip and channel sampling sections; (b) representative columnar sections from Dhauwadi Area in Block A. Abbreviations in map: SG-Siwalik Group, LG - Lakharpata Group, Ch - Charchare Formation, Mp - Melpani Formation, Su - Suntar Formation; Abbreviations in section: H - Hematite, S - Slate, Q - Quartzite

HEMATITE DEPOSIT

The hematite beds in the Melpani Formation is mapped as a zone. In general the zone can be divided into the upper and the lower hematite horizons with a non-ferruginous intermediate zone of quartzite and slate in between (Fig. 2).The hematite zone is mapped almost entirely along the east-west extension of the southern limb of the syncline. However in the northern limb it is found to be omitted at most of the places probably by faults and is exposed only in Laphe area. But it is also truncated on either extension by faults. The hematite in the western part of the area was reported before in Damargaon Formation of Tansen Group (Pradhanang, 1994).

There are four major genetic types of iron mineralization in Nepal: (1) Sedimentary metamorphosed hematite-magnetite type, (2) Hydrothermal type, (3) Skarn type, and (4) Magmatic type (UN, 1993). Among these, the 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).

The hematite is thin-bedded to massive and is interbedded with gray to olive green quartzite and greenish gray to gray slates. The ore is compact, fine- to coarse-grained, oolitic and siliceous. The hematite at places consists of hematite clast and faint gradation indicative of a current deposition environment (Figs. 4, 5 and 6).

Only chip samples were collected in preliminary study, which was followed mainly by channel and some chip samplings in follow-up study (Fig. 7).

Chip samples were collected from 5 sections and channel samples were collected from 3 sections in Block A. Similarly, chip samples were collected from 5 sections and channel samples were also collected from 5 sections in Block B. A total of 91 chip samples and 150 channel samples were collected from 18 sections in Blocks A and B. The channel sample length is about 1m whereas the chip sample length is from 1-2m.

The chemical analysis of the chip and channel samples has a shown very wide variation in iron content. The value is in the range of 23 to 58%. The range in Block A is from 24 to 55% Fe and it is 24 to 58% Fe in Block B. Some of the chemical analysis results from different sections are given below.

Table 2: Chemical analysis of hematite samples

S. N.	Sample code	% Iron (Fe)	Remarks	
			Sample	Block
1	NPL/K/cp-71	48.70	Chip	A
2	NPL/K/cp-79	55.60		
3	NPL/K/cp-82	55.60		
4	NPL/K/cp-85	52.50		
5	NPL/K/cp-94	32.50		
6	NPL/K/cp-98	55.00		
7	NPL/K/cp-32	35.70		
8	NPL/K/cp-37	52.50		B
9	NPL/K/cp-42	45.60		
10	NPL/K/cp-54	55.00		
11	NPL/K/cp-60	58.29		
12	NPL/K/cp-63	51.20		
13	NDH/R/ch-7	48.28	Channel	A
14	NDH/R/ch-13	39.38		
15	NDH/H/ch-4	42.07		
16	NDH/H/ch-15	48.01		
17	NDH/D/ch-4	49.57		
18	NDH/D/ch-12	43.80		
19	NDH/D/ch-23	49.72		
20	NPH/KG/ch-1	45.51		B
21	NPH/KG/ch-9	23.57		
22	NPH/GG/ch-11	42.70		
23	NPH/GG/ch-22	50.10		
24	NPH/P/ch-2	47.42		
25	NPH/P/ch-9	55.02		
26	NPH/P/ch-15	48.73		
27	NPH/KK/ch-5	45.80		
28	NPH/KK/ch-15	43.80		
29	NPH/KK/ch-19	48.99		
30	NPH/KK/ch-23	49.72		

GEOLOGICAL RESERVE

The geological reserve is estimated simply by taking the cumulative average thickness, strike length, average dip length and average density. The cumulative average thickness is 17 m in Block A and 18 m in Block B.

Fig. 3: A fault depression in Dhauwadi area, Block A (view towards east)

Fig. 6: An exposure of hematite in Dhauwadi, Block A (view towards east)

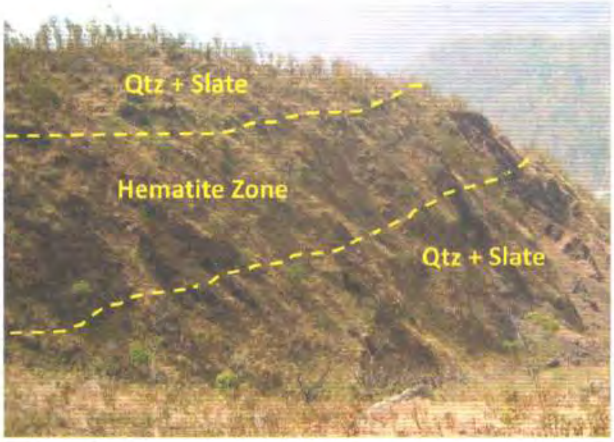

Fig. 4: A distant view of hematite zone in Dhauwadi area, Block A (view towards southeast)

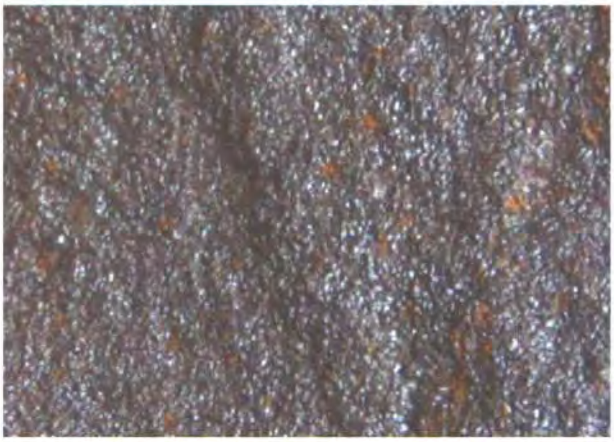

Fig. 7: A close-up view of the oolitic hematite from Dhauwadi, Block A

Fig. 5: An exposure of hematite in Khanigaun, Block B (view towards east)

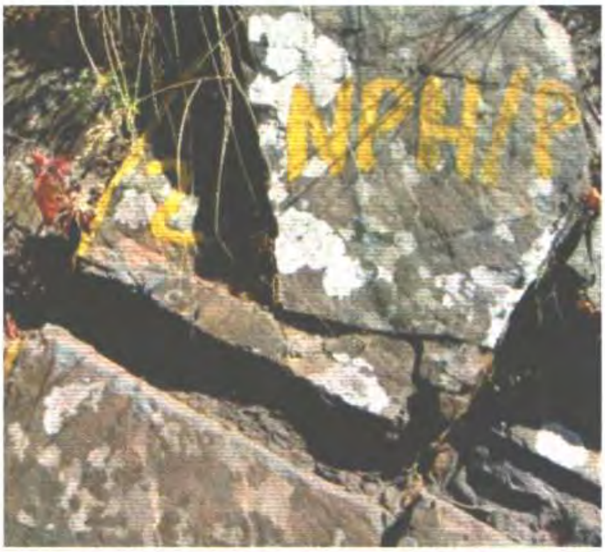

Fig. 8: A channel cut in Pokhari, Block B for sampling (view towads east)

The mineralization zone extends for about 2650m along strike in Block A and 4450m in Block B. The hematite has exposed in altitude as low as 750m and as high as 1500m. It means the dip length of hematite bed is more than 750m. If an average dip length of 200m is considered for both the blocks and density is considered 4gm/cm^3, the reserve is about 36 million tons in Block A and about 64 million tons in Block B. It means at least 100 million tons of possible geological reserve of hematite containing 23 to 58% Fe is expected in Dhauwadi-Pokhari area.

CONCLUSION AND RECOMMENDATIONS

Conclusion

- The possible geological hematite ore reserve is about 100 million tons. It is 36 million tons in Block A and 64 million tons in Block B.
- The hematite has the iron (Fe) content in the range of 23 to 58%.
- The deposit can be the largest deposit of iron ore found so far in Nepal.

Recommendation

- Topographical survey and geological mapping in 1:1000 scale of the Hematite zone is essential for more accurate reserve calculation.
- Detailed sampling in short spacing and their chemical analysis is required to determine the more precise quality of the overall deposit.
- Metallurgical study is required to determine the metallurgical properties and the usability of the hematite.

ACKNOWLEDGEMENT

We would like to thank Mr. Sarbajit Prasad Mahato, Director General of the DMG, for providing all the facilities to carry out this research. Thanks to Mr. Uttam Bol Shrestha and Sriram Maharjan, Deputy Director Generals of the DMG for their valuable suggestion and comments. Thanks to DMG Chemical Laboratory for analyzing the samples. Special thanks go to Mr. Yagya Prasad Parajuli, assistant sampler of the DMG, for accompanying in the field during these exploration works.

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Annual Report of Department of Mines and Geology, 2013, No. 9 & 10, pp.7-12

Assessment of Semi-Precious Stones in Some Parts of Achham District, Far Western Nepal

Shiv K. Baskota (Geologist)

ABSTRACT

An assessment of available semi-precious stones in parts of Achham district has been made. The Balyalta-Bherasain area of study area "A" and Koseri-Rawalgaon area of study area "B" are found to have tourmaline and kyanite mineralization, respectively. Tourmaline mineralization is developed in the form of pockets in sericite-phlogopite schist as accessory mineral at two places namely Talrawa Khola and Bherasain within Khaptad National Park. Tourmaline is black to brown (petrol) colored and semitransparent with well developed crystal faces, meeting industrial grade. Light to deep blue colored, industrial to gem grade kyanite mineralization in schist and gneiss is developed in Rawalgaon, Koseri, Barala and Budhathala areas. Kyanite is distributed in the bedrock as well as in pegmatite veins within the host rock. In general, kyanite found in the foliation and schistosity plane are larger but of low quality where as those found in pegmatite veins are smaller and relatively superior in quality.

INTRODUCTION

This field work was carried out for a month from 30th Jestha 2069 to 27th Ashad 2069 as a part of training cum supervision as per the contract made on consultant services for undertaking "Exploration of Semiprecious, Precious Stones and other Mineral Resources in 1024 sq. km area covering parts of Doti, Achham, Bajhang, Kalikot and Bajura Districts, Mid and Far Western Nepal" on 3rd Baisakh 2069 (15th April 2012) between Department of Mines and Geology (DMG) and Three D. Consultant (P.) Ltd., Kalimati, Kathmandu. The study area allocated to the consultancy was designated as area - A and area – B.

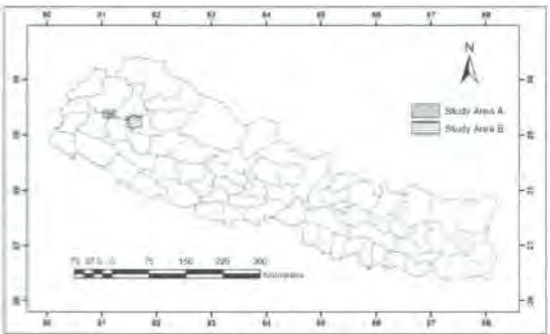

Fig.1. Location Map of the Study Area

The study area "A" falls in parts of Toposheets 2981-9A, 2981-9B, 2981-9C, 2981-9D (1: 25,000 scale) bounded by coordinates 502000E to 524000E and 3241000N to 3257000N with 352 sq. km area. Similarly the study area "B" falls in parts of Toposheets 2981-10, 2981-11, and 2981-15 (1:50,000 scale) and 2981-14B (1: 25,000 scale) bounded by coordinates 544000E to 572000E and 3223000N to 3247000N with 672 sq. km area (Fig.1). Parts of both of the study areas "A" and "B" were visited during the field work and covered about 40 sq. km area of the study area "A" around Balyalta-Bherasain and about 20 sq. km area of the study area "B" around Koseri-Rawalgaon.

OBJECTIVES

The main objective of the fieldwork was to acquire knowledge on assessment of semiprecious, precious stones in field from various aspects. The specific objectives of the study were:

- To acquire knowledge on geological mapping of semiprecious, precious stone prospects on field,
- To make assessment of the identified mineral commodities in terms of quality and quantity, and
- To inspect/supervise the overall work of consultancy team in field.

METHODOLOGY

- The methodology adopted in the field was:
- Walkover survey of the study area,
- Tracing of mineralized bands within the host rock,
- Inference of general quality of commodities based on visual estimation,
- Estimation of abundance of commodities in the host rock, and
- Photographs and sketches of necessary outcrops.

PREVIOUS WORKS

Though many geoscientists have traversed around the present study area in the past, from the perspective of mineral exploration, no major works have been carried out. Sharma (1963) has discussed in his report about occurrence of pegmatite in various parts of Far Western Nepal and within the study area as well. Similarly, Tuladhar (1981) in his "Summary of Pegmatite Occurrence of Nepal" has mentioned about mica in Khaptad areas. Kaphle (1997) and Khan (1998) carried out reconnaissance geochemical stream sediment survey in some parts of Bajhang, Bajura, Doti, Achham and Dailekh districts (Toposheet 62 G/3 and G/8). Regional geological mapping of parts of study area have been carried out by a number of geoscientists from Department of Mines and Geology (then Nepal Geological Survey). Regional geological maps prepared by Kaphle (1997, parts of toposheet 62 G/3) and Jha (1979) cover the study area "A" and Tuladhar, (1977, parts of toposheet 62 G/7), Aryal, (1982, parts of toposheet 62 G/11), Maskey et. al (2033, parts of toposheet 62 G/12) and Shrestha (1977,parts of toposheet 62 G/8) has covered the area "B" in scale 1:1 mile.

REGIONAL GEOLOGY

The study area lies in Lesser Himalayan Crystalline Complex occupying a part of Dadeldhura nappe. Major rock types in the area are gneiss, schist and granite with little quartzites. The crystalline rocks of nappe are believed to be autochthonous lying over the low grade metasdimentary rocks of the Lesser Himalaya (Amatya and Jnawali, 1994).

The major rock types present in the study area "A" are quartz- feldspathic schist, chloritic garnet mica schist, kyanite-garnet-mica schist, granitic gneisses and granites of Pre-Cambrian to Paleozoic age belonging to Crystalline Complex and dolomites, phyllite, limestone and quartzites of Late Pre-Cambrian to Paleozoic age belonging to Metasedimentary Complex.

Similarly, kyanite-garnet-muscovite schist, quartzites, muscovite-biotite schists and gneisses, augen gneisses, calc schist, limestone, garnetiferous phyllite are major rock types in study area "B" belonging to Pre-Cambrian to Mesozoic age (Figs. 2 and 3).

MINERALIZATION

During this field work, an assessment of available semiprecious stones in Balyalta–Bherasain areas of study area "A" and Koseri-Rawalgaon areas of study area "B" is made.

Balyalta-Bherasain Tourmaline Prospect

The Balyalta- Bherasain area lies almost at the core of the syncline of Crystalline Complex and consists of high grade crystalline metamorphic rocks mainly gneiss and schist. The southern part of the area is largely occupied by biotitic-feldspathic gneiss with few quartzite and schist intercalations. It is overlain by intercalation of kyanite and garnet bearing mica schist. In between some augen gneiss layers are common. A NE-SW trending fault passes through the Balyalta village which is evident by slikenside on the rock, and downthrows of kyanite bearing mica schist on the eastern part of the village. Both of these rock types are frequently invaded by pegmatite veins which are distinct in their color and lithology with larger amount of quartz and feldspar and minor mica with small crystals of tourmaline. Millimeter sized black and light brown (petrol) colored few crystals of tourmaline are found in these veins.

Two pockets of tourmaline are identified in Khaptad area, one situated on the northeast facing hill slope south of Talrawa Khola and another on uphill side of Bherasain village. Both of the sites lie within Khaptad National Park. In both areas, host rock is phlogopite-muscovite schist. A 3.5-10m thick phlogopitic schist layer serves as the host rock for tourmaline (Fig. 4). The distribution of tourmaline extends for more than 100 m near Talrawa Khola and about 50 m in Bherasain along the strike direction of host rock. An assemblage of fine phlogopite-sericite matrix and larger crystals of tourmaline is present (Fig. 5).

The host rock is underlain and overlain by augen gneiss in Khaptad area while it is underlain by augen gneiss and overlain by kyanite garnet mica schist in Bherasain area. Tourmaline crystals are more abundant in Khaptad area than in Bherasain. General orientation of rocks is NE-SW with dip towards NW with varying dip amount of 21^0 to 55^0.

Tourmaline found in both of these areas is black to light brown (petrol) colored, semitransparent with well developed crystal faces. Most of the crystals are fractured internally, bear some inclusions and are of industrial grade. The crystal size of tourmaline reaches upto 1 cm in diameter and 3 cm in length.

Koseri – Rawalgaon Kyanite Prospect

Koseri – Rawalgaon area consist of high grade crystalline metamorphic rocks mainly schist, gneiss and a few quartzites, juxtaposed to each other. Southernmost part of the study area consists of dark grey, sometimes graphitic fine grained schist intercalated with medium to coarse grained, white, micaceous quartzite. It is overlain by garnet- mica schist with intercalations of some quartzitic gneiss layers. Garnetiferous schist makes a thick sequence with distribution around Bohoragaon, Ganiule, and Koseri areas.Overlying the garnet schist, a 25 to 100m thick kyanite bearing horizon can be traced over more than 3 km though kyanite distribution is not homogenous. The host rocks for kyanite are schist

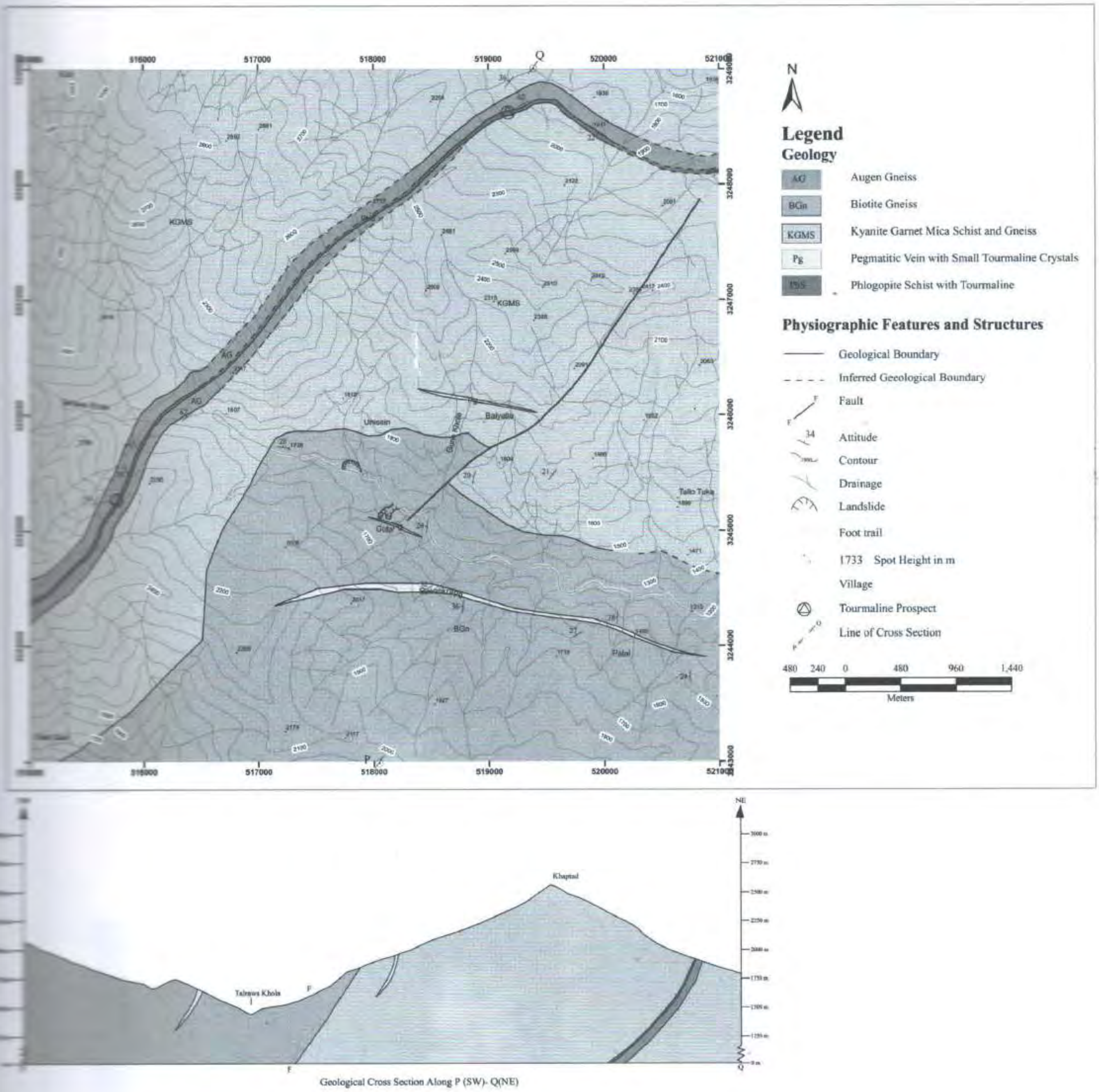

Fig. 2: Geological Map of Balyalta-Bherasain Area (Part of Study Area A)

and gneiss. Kyanite crystals are mainly confined to the schistosity plane of schist (Fig. 6) and to and pegmatite veins (Fig. 7).

Another 1.4 m thick kyanite gneiss band is present north of Ganiule on the way to Koseri, with light blue, translucent tourmaline crystals of size up to 2 cm. It extends more than 150 m in its strike direction though kyanite is not distributed throughout its extension. The general orientation of rock is NW-SE dipping towards NE. The amount of dip varies from 12° to 67°.

In general, the kyanite found in schist both in disseminated form or laths in the schistosity plane are larger in size but of low quality. The crystals are up to 10 cm long and 3 cm thick. They are light blue colored,

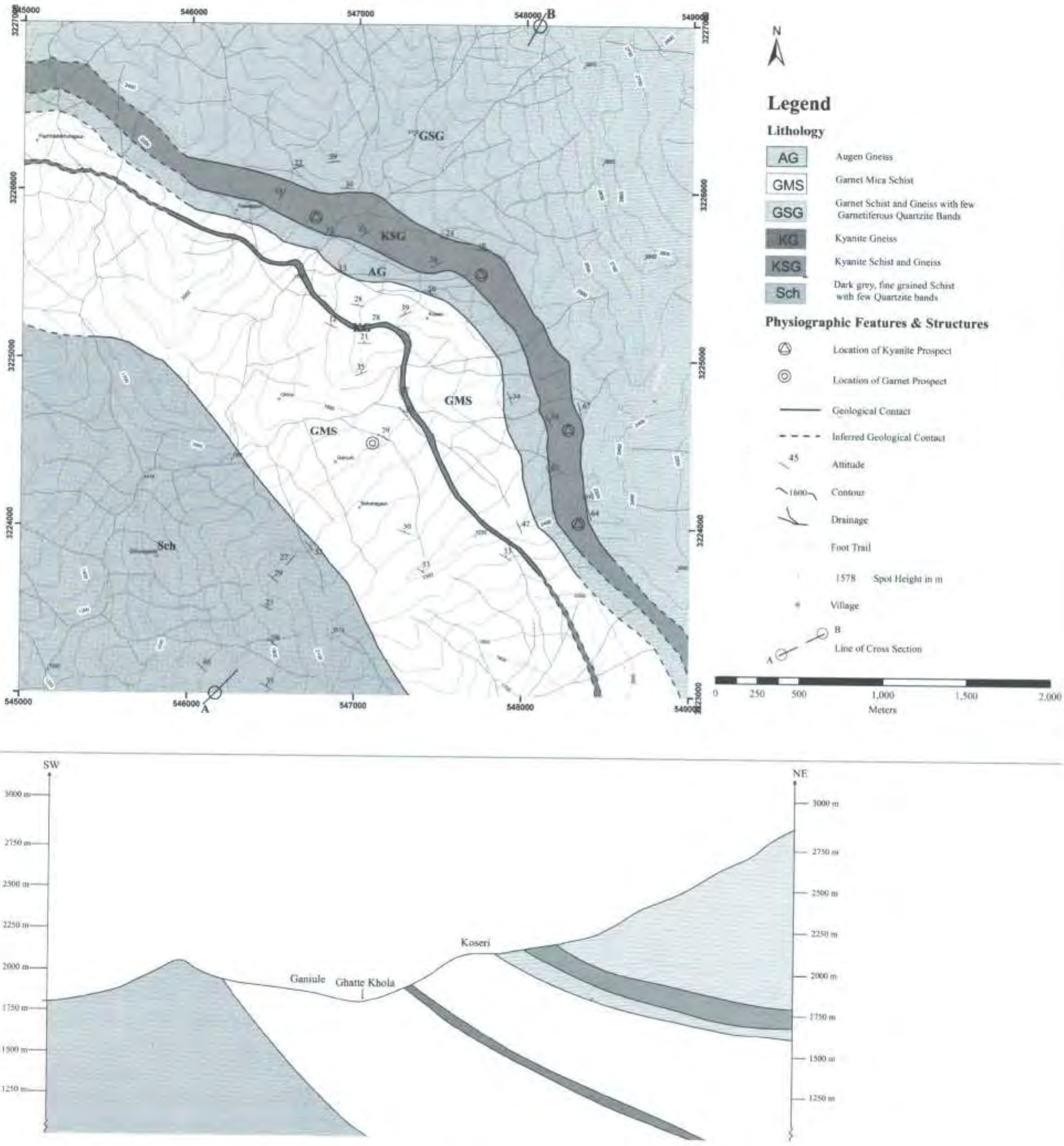

Fig. 3: Geological Map of Koseri-Rawalgaon Area (Part of Study Area B)

translucent and very frequently with black tints as impurities within the crystal. Most of these crystals are thus not of gem quality. However, some disseminated crystals at Rawalgaon and Budhathala area are deep blue, transparent and may meet gem quality. Kyanite in veins and lenses within gneiss are deep blue, transparent but size of most needles is very small (<5mm thick) and has developed excessive twinning so that the kyanite crystals appear as bundle of needles (Fig. 8). Yet some crystals are considerably larger in size (>3 cm in length and 0.5 cm in thickness).

Thus four types of kyanite are found in the area based upon their size and quality as:

- Relatively larger (up to 10 cm long and 3 cm

Fig. 4: Phlogopite schist containing tourmaline, at Khaptad, south of Talrawa Khola

Fig 5: Tourmaline crystal embedded in phlogopitic schist, Bherasain

Fig. 6: Kyanite laths in the schistosity plane of schist, Koseri

Fig. 7: Kyanite bearing quartz vein within host rock gneiss, Koseri

Fig 8: Bundles of kyanite needles in Pegmatite Rawalgaon

Fig. 9: Kyanite waste at processing site, Koseri

thick), translucent to dull, fractured and tinted kyanite laths found in the schistosity plane of host rock schist.

- Translucent to transparent, fractured, and deep blue kyanite crystals of varying size without tints protruded in host rock schist and gneiss across the schistosity and gneissosity plane.
- Transparent to translucent, light to deep blue crystals of varying size confined in the quartz rich pegmatite vein.
- Small, twinned crystals of light blue color found in pegmatite veins.

CONCLUSION AND RECOMMENDATIONS

Two specific sites in Balyalta-Bherasain area are found to have tourmaline mineralization. Both localities contain tourmaline in sericite-phlogopite schist as accessory minerals. Mineralization is developed in the form of pockets. Tourmaline is black to brown (petrol) colored, semitransparent and with well developed crystal faces. Most of the crystals are fractured containing inclusions.

In Koseri- Rawalgaon area, there are four sites of kyanite mineralization-Rawalgaon, Koseri, Barala and Budhathala. The same host rock bears the kyanite at all localities. The host rock is schist and gneiss. Kyanite is distributed in the bedrock as well as pegmatite veins. In general, kyanite found in the foliation and schistosity plane are larger but of low quality where as those found in pegmatite veins are smaller and relatively superior in quality.

The tracing of mineralized bands in and around the adjacent areas of the present study area and their potentiality in gemological aspect is recommended.

ACKNOWLEDGEMENT

I am very much indebted to Mr. Sarbjeet Prasad Mahato, Director General of DMG for encouragement and facilities provided during the fieldwork. I like to extend my sincere gratitude to Mr. Hifzur Rahman, Deputy Director General for valuable suggestions before and after the fieldwork. I am equally thankful to Three D team for their support during the fieldwork in various aspects.

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Assessment of Labdi Iron Deposit, Tanahu District, Western Nepal

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ABSTRACT

The Labdi Iron deposit is a part of the Nourpul Formation of Lower Nawakot Group of Nawakot Complex of the Lesser Himalaya in Central Nepal. It has occurred both in phyllites and quartzites. The geological reserve of 1.16 Million Tons (MT) could be estimated based on the observations in the Chuatara Danda area. The possibility of finding more reserve could not be discarded in the eastern part of it. The collected samples show that the iron ore seems low grade.

INTRODUCTION

The investigated area is located within latitude of 27°48' 39"N to 27° 51' 24"N and longitude of 84° 26' 49"E to 84° 30' 00" E in Toposheet no 2784 02D, Tanahun District. A week long field work was carried out according to the annual field program of Department of Mines and Geology for the Fiscal Year 2067/68.

OBJECTIVE

- Reassessment of the deposit in order to get the status of the deposit for promotional activity,
- Geological mapping of the area to locate the Iron band, its extension and thickness, and
- Getting representative samples of iron ore to ascertain grade.

METHODOLOGY

During the desk study, available reports were reviewed before departing for the field study. Field study was carried out by traversing ridge and valleys to prepare geological map of the area. Representative samples were collected from the identified iron bands.

EXPLORATION HISTORY

The exploration of the Iron ore in Labdi Khola area shows that the area was investigated by various authors in late sixties and seventies.

Pradhan (1961) presented a brief report on iron ore of Labdi Khola region. Singh (1969) traversed to prepare geological map of Labdi Iron Deposit. Pandey (1977) presented a report of IP survey of Ratanpur area. The Government of Japan prepared a survey report on the promotion of Iron and Steel Industry in Nepal in 1966. According to the previous study done by DMG, the deposit has a length of 200-500m and thickness ranges from 1.5 to 12m. The estimated reserve was calculated 1.08MT with an average of 38% Fe. The maximum Fe content is 41.1 % and minimum is 32.37%.

Geologically, it has been proposed to lie within Labdi Phyllite of Kunchha Formation of Lower Nawakot Group of Lesser Himalaya in Central Nepal. Also, the ESCAPE report (1991) shows that the iron has Fe content of upto 57.1% at places.

The present work comprises of preparing a geological map of 25 sq. km area at 1: 25000 scale. The extension and thickness of the three distinct iron bands were traced in Chautara Danda and representative 7 ore chip samples were taken. The 3 ore float samples were also taken from the tributaries below the Majuwa and Lester areas. The collected samples were analyzed in the chemical laboratory to determine the grade.

REGIONAL GEOLOGY

The present study area lies within the Lesser Himalaya of Central Nepal. The Lesser Himalaya is partly represented by Nawakot Complex which is subdivided into Lower Nawakot Group and Upper Nawakot Group of rocks. The study area only comprises the rocks of Lower Nawakot Group (Fig.1).

Lower Nawakot Group

The Lower Nawakot Group is distributed in the Labdi Khola area. It consists of Kuncha Formation, Dandagaon Phyllite and Nourpul Formation from older to younger sequence, respectively. The brief stratigraphy is presented in Table 1.

Kunchha Formation

The Kunchha Formation is found mostly in the northern marginal part of the study area in Chimkeswori VDC.

It is represented by fine grained argillaceous phyllites. The blue green, pink and yellowish colour variation is seen at weathered outcrops. This unit is mapped as Labdi Phyllite Member of Kuncha Formation (Fig.1).

Table.1: Stratigaraphy of the study area

Complex	Group	Formation	Lithology	Age
Nawakot	Lower Nawakot	Nourpul Formation(np) Purebesi Quartzite(pb)	Metasandstone, phyllite and dolomite Quartzite	Precambrian
		Dandagaon Phyllite(da)	Phyllites	
		Kuncha Foramtion(kn) Labdi Phyllite Member(lb)	Phyllites, metasandstones, gritty phyllites Phylites	-

Dandagaon Phyllite

The Dandagaon Phyllite is cropping out at Labdi Khola, Chimkeswori, Trishuli and Seti river areas. The repetition of the beds in the area seems as a result of thrust syncline. The beds in the northern part are south dipping. The southernmost beds of phyllites are north dipping (Fig.1 and 2).

It consists of argillaceous to quartzitic phyllites. Reddish tints are observed while looking into the weathered outcrops. Quartz veins and lenses cross cut the phyllite beds.

Nourpul Formation

Nourpul Formation covers the core of the thrust syncline. Purebesi Quartzite Member is the basal member of the formation and consists of quartzite. It is ferruginous at places.

Above the Purebesi Quartzite, there exists predominantly dark green phyllites with cross cutting calcite and quartz veins. It has red coloration when beds are weathered. Thin quartzite beds are intercalated along with phyllites. The Labdi Iron deposit is associated with Purebesi Quarzite and overlying phyllites.

GEOLOGY OF THE LABDI IRON PROSPECT

The prospect lies within the Nourpul Formation belonging to the Purebesi Quartzite member at the base of the formation and phyllites up-section. The iron bands are seen at about 500m up-section from the confluence of Seti River and Labdi Khola along the Chautara Dada. The Chautara Dada has 3 distinct bands of iron ore. The extension of the lower band is seen at the lower slope where the boulders of quartz type hematite are scattered. They can be seen on the road side and river side also. The extension of the middle and upper bands is covered by residual soil and forest but some of the in situ iron ores are seen on the slope. The lowermost iron band is within the quartzite and is about 1m thick (Fig.2). The beds are south dipping. It has hematite with cross cutting quartz veins. The physical appearance shows that the beds are parallel to the host rock. The middle hematite beds are about 4m thick and are within the phyllite up-section (Fig.3). Similarly, the uppermost hematite band is about 10m thick in phyllite (Fig.4). The beds are parallel to the foliation dipping due SW. The ore also contains some magnetite minerals both in phyllite and quartzite types at Chautara Dada.

Fig. 2: Lower iron band, quartzite type iron ore deposit

Fig.3: Middle iron band, phyllite type iron ore deposit, Chautara Dada

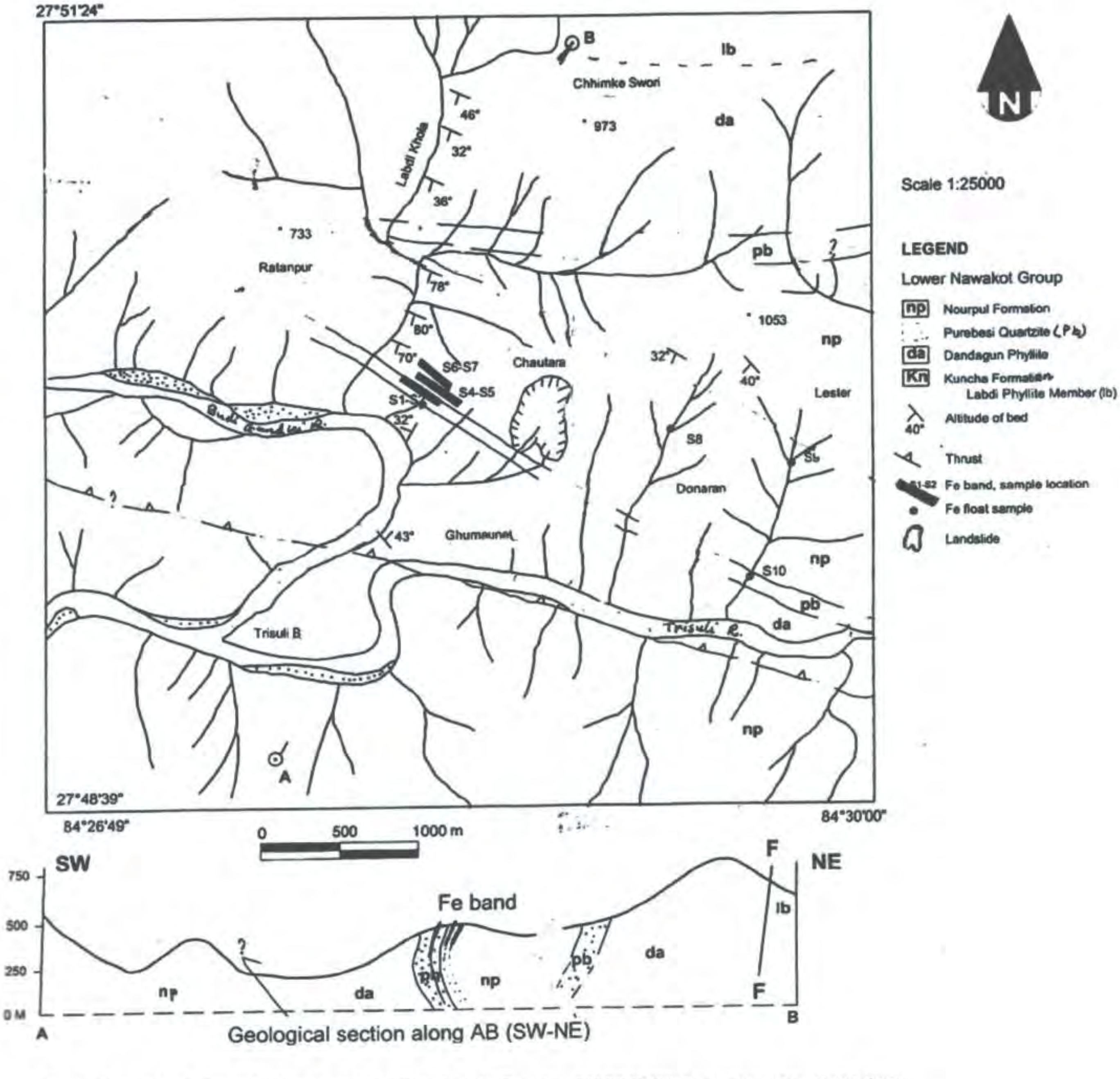

Fig. 1: Geological Map with iron band location, Labdi, Tanahu, FY 2067/68 Topo sheet No. 2784 02D

Fig.4: Upper iron band, phyllite type iron ore deposit, Chautara Dada

QUALITY OF THE DEPOSIT

There are some old audits which are now completely covered by residual soil and forest cover. According to local people, it had been producing iron during Rana period from the deposit. The occurrence of magnetite is as a cross cutting quartz veins.

The occurrence of iron ore in Lester area to the east of this prospect has some ferruginous band both in phyllites and quartzite. The specular hematite is reported in the Lester area. The extension of the hematite bands in the eastern part of the area is possible but it passed through overburden in Chautara Dada and Donaram areas. So the significance outcrops of iron ores at the Chautara Dada are considered for the present evaluation.

Physical characteristics of hematite show that it is a bed rock deposit. It shows earthy red tones and metallic gray lusture. It shows dark red streak. The position of bed shows that the deposit is a syn-sedimentary type low tonnage deposit. It has dominant single hematite ore however cross cut by quartz veins. The presence of magnetite in quartz veins probably is a result of hydrothermal activity.

The wet assaying of Fe metal content was given by Atomic Absorption Spectrometry (AAS) presented in wt. percent. The grade of Iron ore based on the Prisa Minerals, Australia, is as follow:

(1) High (Fe >60%),
(2) Medium/lower (Fe <60%), and
(3) Low (<30% Fe).

The chemical analysis results of the collected samples are given below in Table 2.

Table 2: Analytical results of iron ores

S. N.	LOI % (w/w)	Acid Insoluble% (w/w)	SiO2% (w/w)	Fe% (w/w)
S1	0.2		20.84	29.32
S2	0.38		20.05	12.57
S3	0.26		36.27	29.32
S4	0.20		18.39	11.17
S5	0.32	37.72		22.34
S6	0.25	47.88		25.13
S7	0.05	19.64		27.93
S8	0.47	19.54		13.96
S9	0.24	20.78		15.36
S10	0.26	26.84		22.34

RESERVE ESTIMATION

Assumptions are as follows for the reserve estimation (Table 3).

Beds are homogenous along the strike and estimated specific gravity of the iron ore is 4.0 for quartzite type and 3.8 for phyllite type hematite.

Table 3: Reserve estimation

Type	Strike length (m)	Thickness (m)	Dip length (m)	Reserve (ton)
Quartzite type hematite	500	1	60	120000
Phyllite type hematite (middle band)	400	4	60	364800
Phyllite type hematite (upper band)	300	10	60	684000
Total Geological Reserve				1.16MT

INFRASTRUCTURE

Road

Kathmandu to Mugling = 107km (Prithvi Highway)
Muglin to Ghumaune = 16km (Prithvi Highway)
Ghumaune to Labdi = 3km (Dirt road)

The Trisuli River at Ghumaune has a suspension bridge. It has a provision of concrete bridge construction in near future.

Electricity

The middle Marsyangdi (70MW) and Marsyangdi (69MW) are the nearest hydropower stations in the area. A 132 kv transmission line is passing along the Prithvi Highway nearby Gaighat.

Socio-economy

The area falls within the Chhimkeswari VDC-4. The iron bands lie within the Labdi Khola Community Forest, Chautara Dada. The VDC mainly consists of Gurung, Chepang and Bahun-Chhetri Community. The main occupation of the people in the area is agriculture. Maize, wheat, millet, potato are the main crops. Many people work in the Kathmandu labour market. Some of them are working abroad. Remittance is another source of income.

CONCLUSION AND RECOMMENDATIONS

Conclusion

- Geologically, the area lies within the central sector of the Lesser Himalaya. The Lower Nawakot Group of Nawakot Complex with Labdi Phyllite Member of Kunchha Formation, Dadagaon Phyllite and Nourpul Formation cover the study area.
- Iron bands lie within the phyllites and quartzite of Nourpul Formation. The hematite is the predominant mineral both in phyllite and quartzite type deposit.
- The prospect lies in the Labdi khola community forest.
- The geological reserve is about 1.16MT based on the available data in the Chautara Dada of Labdi Khola area.
- The chemical analysis results of collected samples show that the iron ore seems low grade deposit (<30%Fe).
- It is a sedimentary type low tonnage deposit
- It seems possible that the findings of iron ore in the adjacent region to the eastern part of Lester area as some of the ferruginous bands are cropping out there.

Recommendation

- Further detail study is warranted to find out the mineable quality and quantity of the iron ore deposit.

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Landslide Susceptible Mapping of Part of Achham and Doti Districts, Far Western Nepal Using Frequency Ratio Model (Sheet No. 2981 13D, 14C)

Dinesh Nepali (Senior Divisional Geologist) and Kumar Khadka (Geologist)

ABSTRACT

The objective of this study is to evaluate the landslide hazard of part of Achham and Doti districts using Geographical Information System (GIS). A landslide location map of the study area was prepared from the field survey and interpretation of satellite images (using Google Earth). The factors that influence landslide occurrence such as slope, aspect, curvature and distance from drainage, landuse, geology were considered for landslide hazard analysis. The relationship between the factors and the landslides were statistically calculated using frequency ratio model.

The mountainous terrain in the Nepal Himalayas is generally characterized by steep slopes, high relief, highly weathered and densely jointed rocks. In addition to that, the heavy concentrated monsoon rainfall makes these steep slopes unstable and often leads to different slope failures. Among various causes, landslides triggered by heavy rainfall are the most common throughout the study areas. The Achham district has suffered much landslide damage after heavy rains. Department of Mines and Geology (DMG) has been conducting landslide hazard zonation mapping since last few years and present study covers the parts of Achham and Doti districts (sheet No. 2981 13D, 14C), conducted in accordance with the annual program of DMG for the fiscal year 2067/068 (Fig.1). Seti Ganga Nadi is the main river flowing in the eastern part of study area. Masta Bandali, Muli, Bayala, Ghodasain, Saba and Basti are the major villages lying in the study area. The lowest and highest altitude is 366 m and 2324 m, respectively.

Considerable damages of lives and properties occurred in Balyalta, Upper Tuka, Lower Tuka, Putru and Vedasen of Khaptad VDC by landslides due to intensive rainfall that started during August, 2006. Similar damages had occurred in Guta village of Devisthan VDC (Piya, 2006). In the October, 2009 many landslides occurred in Patalkot, Mangalsen, Marku, Sidheswor, Sokatm Siudi, Payal, Ghodasen, Muli, Binayak, Puletola and Barala VDC of Achham district in which many people lost their lives (Shrestha and Rimal, 2010).

OBJECTIVES

Present investigation aimed to achieve the following main objectives:

- To study the major landslides and register them in the Preliminary Landslide Inventory Form,
- To map all the landslides observed in the field in 1:25,000 scale toposheets as far as the scale permits,
- To prepare landslide distribution map and provide geo-scientific information of the area on natural hazards, and
- To prepare a landslide susceptible map by using Frequency Ratio Model.

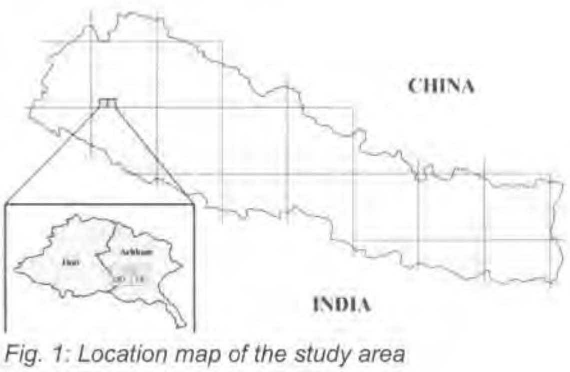

Fig. 1: Location map of the study area

METHODOLOGY

The methodologies used for the study are:

- Walkover survey of the study area,
- Map all the landslides in the field permitted by the base map scale, and additional mapping of landslide location from satellite image (from Google Earth),

- Assign High, Medium or Low landslide hazard to all defined unit slopes and prepare landslide hazard map, and
- Using Frequency Ratio Model in GIS environment, preparation of landslide susceptibility map.

In this study, seven landslide causative factors were considered for the susceptibility analysis (Table 1). Data required for the present investigation were obtained from different source of information together with field work. A landslide location map of the study area was prepared mainly from the field survey and interpretation of satellite images (using Google Earth). A total of 132 landslides were mapped in a study area of 325 sq. km. Toposheet at a scale of 1:25,000 were used as base maps for plotting the data. Landslides were found mainly in the south west part of the study area (Fig. 2).

A Digital Elevation Model (DEM) with resolution of 10m was created from the contours at 20m interval and spot height. The slope angle, slope aspect and slope curvature map of the study area were calculated from the DEM. In the case of the curvature map, a positive curvature indicates that the surface is upwardly convex at that cell, and a negative curvature indicates that the surface is upwardly concave at that cell. A value of zero indicates that the surface is flat. In addition, the distance from drainage was calculated using the river database and classified into 10 equal interval classes.

The unpublished geological map of DMG (62 G/4 and 62 G/8) was used for the purpose of geological data derivation for the preparation of shale, schist, phyllite and dolomite. The sandstone and shale are highly weathered. The landuse map was prepared from the topographical map published by Department of Survey. The factors were converted to a raster grid with 10×10 m cells for application of the frequency ratio model. The spatial relationships between the landslide location and each landslide-related factor were analyzed using frequency ratio model.

LANDSLIDE HAZARD MAP OF THE STUDY AREA

According to the geological map, the study area consists the rocks of Higher Himalaya and Lesser Himalaya. Six formations cover the study area (Shrestha, 1977, 1983). Major rock types are quartzite and sandstone.

Landslide susceptibility assessment using frequency ratio model

The frequency ratio is the ratio of occurrence probability to non occurrence probability, for specific attributes. If the ratio is greater than 1, the greater the relationship between a landslide and the specific factor's attribute; and if the ratio is less than 1, the lower the relationship between a landslide and the specific factor's attribute.

The factors such as the slope, aspect, curvature, distance from drainage, lithology, stream power index and landuse were evaluated using the frequency ratio method to determine the level of correlation between the location of the landslides in the study area and these factors (Figs. 1 to 12).

The landslide susceptibility index (LSI) was calculated by summation of each factor's ratings using equation (Lee et al, 2006):

$LSI = \Sigma Fr$......... (1) or $LSI = Fr1+Fr2+.....+Frn$

Where, Fr is the Frequency Ratio of each factor's class.

Table 1: Data layer of study area

Category	Factors	Data Type	Scale	Remarks
Hazard map	Landslide	Point	1:25,000	Mapping of landslide location based on field survey and satellite images
Topographic map	Slope Aspect Curvature Stream Power Index (SPI)	GRID	1:25,000	Calculate from DEM
Geological map		Polygon	1:50,000	Types of lithology
Land use map		Polygon	1:25,000	Types of land use
River buffer map		GRID	1:25,000	

Photo 1: Big landslide in shale above Beraju village

Photo 2: Shallow landside that ccurred west of Hichma below a school largely affecting agricultural land

Photo 3: Agricultural Land damaged by landslide below Basti Village

Photo 4: Landslide in purple shale at right bank of Chaira khola

RESULTS

The relationship between landslide occurrence and landslide related factors by using the frequency ratio method is presented quantitatively in Table-2. The relationship between landslide occurrence and the slope shows that slope between 26-350have greater landslide probabilities. In the study area high angle slopes are mainly observed in the rocky terrain with less soil development and are found relatively stable. In the case of the aspect, landslides were most abundant on east, west and south facing slopes. In the case of landuse, cultivated and grass land have greater landslide probabilities. The relationship between landslide occurrence and lithology, the shale, sandstone and schist found to be the most susceptible unit having the highest frequency ratio. In the case of the distance from river, closer the distance (<100m) to the river, the greater was the landslide occurrence probability. After calculations using equation (1), the landslide susceptibility index have a minimum value of 293 and a maximum value of 1462. The landslide susceptibility map generated based on the frequency ratio model is shown in Fig. 13.

After assigning the hazard classes an analysis was carried out in order to check how much of the landslide area falls within the high hazard zone. For this, landslide map was overlaid with the final hazard map and landslide density for three classes were calculated. In this respect 67 % of the mapped landslide were located within the high hazard zone, about 30% in medium hazard zone and rest in the low hazard zone (Fig. 13).

CONCLUSION

- Landslide susceptibility map has been prepared using the relationship between each landslide and causative factors.
- Areas susceptible to landslides can be delineated based on the physical factors associated with landslide activity like past landslide history, lithology, slope steepness, slope aspect, curvature, distance from drainage, stream power index and landuse.

Fig 2: Landslide distribution map

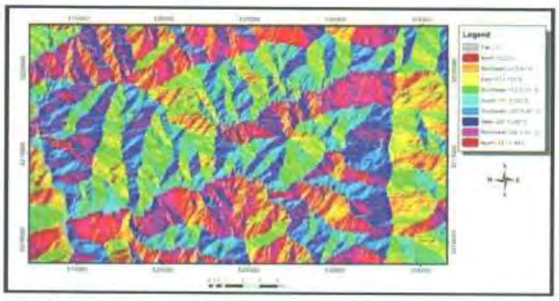

Fig 7: Slope Aspect map

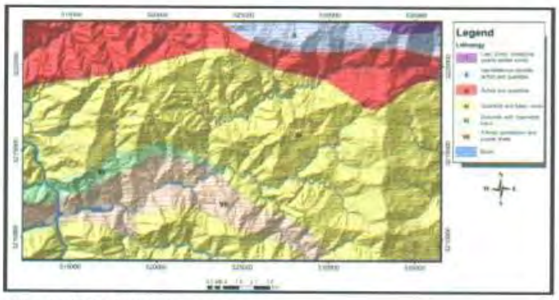

Fig 3: Geological map

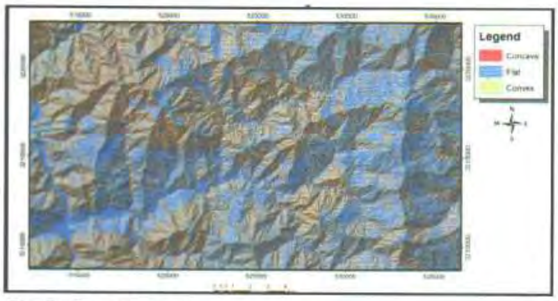

Fig 8: Curvature map

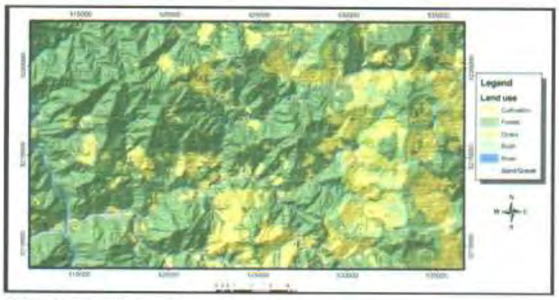

Fig.4: Landuse map

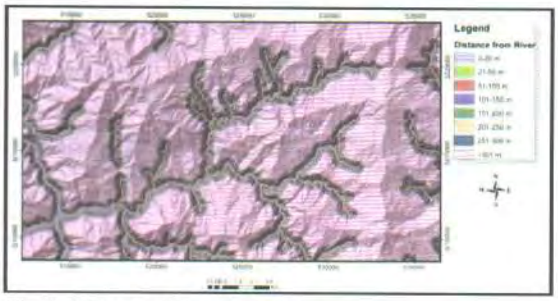

Fig 9: Distance from river map

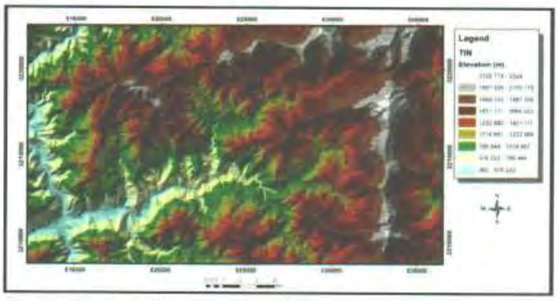

Fig 5: Digital Elevation Model

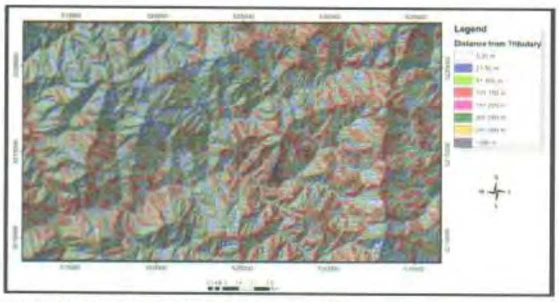

Fig 10: Distance from tributary map

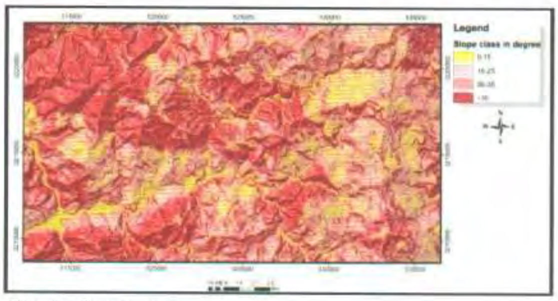

Fig. 6: Slope map

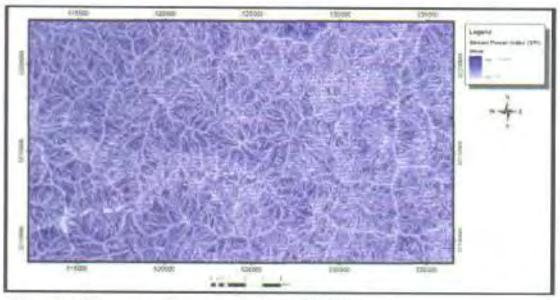

Fig 11: Stream Power Index (SPI) map

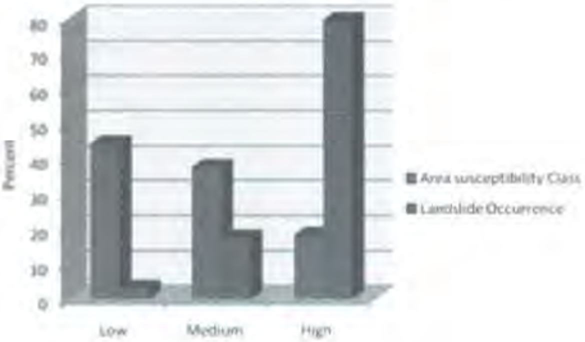

Fig 12. The percentage distribution of the susceptibility classes and landslide occurrence

- GIS is an effective tool that is used commonly in landslide susceptibility mapping to identify in advance potential landslide-prone areas, by applying different models and approaches.
- Most of the landslides were found to be occurring in grass land and cultivated land.
- Sandstone and shale were found to be more vulnerable to landslide than other types of rocks.
- The models used in the study are valid for generalized planning and preliminary assessment purposes. It should not be used as the only basis of investigation for individual buildings. The map cannot replace detailed site investigation.

Table 2: Frequency ratio of landslide occurrences

Factor	Class	No. of pixels in class	% of pixels in class	No. of landslide	% of landslide	Frequency ratio
Slope in Degree	0-15	428535	12.71	8	6.06	0.48
	16-25	870451	25.82	27	20.45	0.79
	26-35	1000005	29.66	60	45.45	1.53
	>35	1072609	31.81	37	28.03	0.88
Aspect	Flat	77834	2.31	1	0.76	0.33
	North	437420	12.97	17	12.88	0.99
	Northeast	395179	11.72	14	10.61	0.9
	East	415876	12.33	20	15.15	1.23
	Southeast	407911	12.1	17	12.88	1.06
	South	381863	11.33	17	12.88	1.14
	Southwest	387757	11.5	14	10.61	0.92
	West	416818	12.36	19	14.39	1.16
	Northwest	450942	13.37	13	9.85	0.74
Curvature	Concave	919351	27.27	61	46.21	1.69
	Flat	1471138	43.63	24	18.18	0.42
	Convex	981111	29.1	47	35.61	1.22
Geology	I	22786	0.68	2	1.52	2.24
	II	175026	5.19	2	1.52	0.29
	III	554157	16.44	4	3.03	0.18
	IV	2080428	61.7	70	53.03	0.86
	V	66068	1.96	0	0	0
	VI	104055	3.09	4	3.03	0.98
	VII	369109	10.95	50	37.88	3.46
Landuse	Cultivation	921376	27.33	43	32.58	1.19
	Forest	2053881	60.92	71	53.79	0.88
	Grass	82815	2.46	9	6.82	2.78
	Bush	247550	7.34	9	6.82	0.93
	Sand/Gravel	58037	1.72	0	0	0
	Water Body	7972	0.24	0	0	0

Table 2. Cont...

Factor	Class	No. of pixels in class	% of pixels in class	No. of landslide	% of landslide	Frequency ratio
Stream power Index(SPI)	1	1298590	38.52	40	30.3	0.79
	2	1037633	30.78	39	29.55	0.96
	3	633704	18.8	30	22.73	1.21
	4	222252	6.59	12	9.09	1.38
	5	81790	2.43	6	4.55	1.87
	6	45482	1.35	2	1.52	1.12
	7	26811	0.8	1	0.76	0.95
	8	14446	0.43	2	1.52	3.54
	9	7021	0.21	0	0	0
	10	3871	0.11	0	0	0
Distance from river(m)	0-20	118046	3.5	1	0.76	0.22
	21-50	91559	2.72	21	15.91	5.86
	51-100	134734	4	20	15.15	3.79
	101-150	130968	3.88	15	11.36	2.93
	151-200	129021	3.83	9	6.82	1.78
	201-250	126611	3.76	9	6.82	1.82
	251-300	121721	3.61	11	8.33	2.31
	>301	2518969	74.71	46	34.85	0.47
Distance from Tributary (m)	0-20	705646	20.93	32	24.24	1.16
	21-50	853934	25.33	38	28.79	1.14
	51-100	913091	27.08	44	33.33	1.23
	101-150	478058	14.18	12	9.09	0.64
	151-200	227416	6.74	5	3.79	0.56
	201-250	108682	3.22	1	0.76	0.24
	251-300	49093	1.46	0	0	0
	>301	35709	1.06	0	0	0

SIGNS OF LANDSLIDE ACTIVITY

- Changes occur in landscape such as steep, curved scarps are common at the top of landslides.
- Walls and floors are tilting.
- Cracks in house.
- Bulging ground at base of slope.
- Tilted trees or utility poles.
- Springs, seeps, or saturated soil in areas that have been typically dry.

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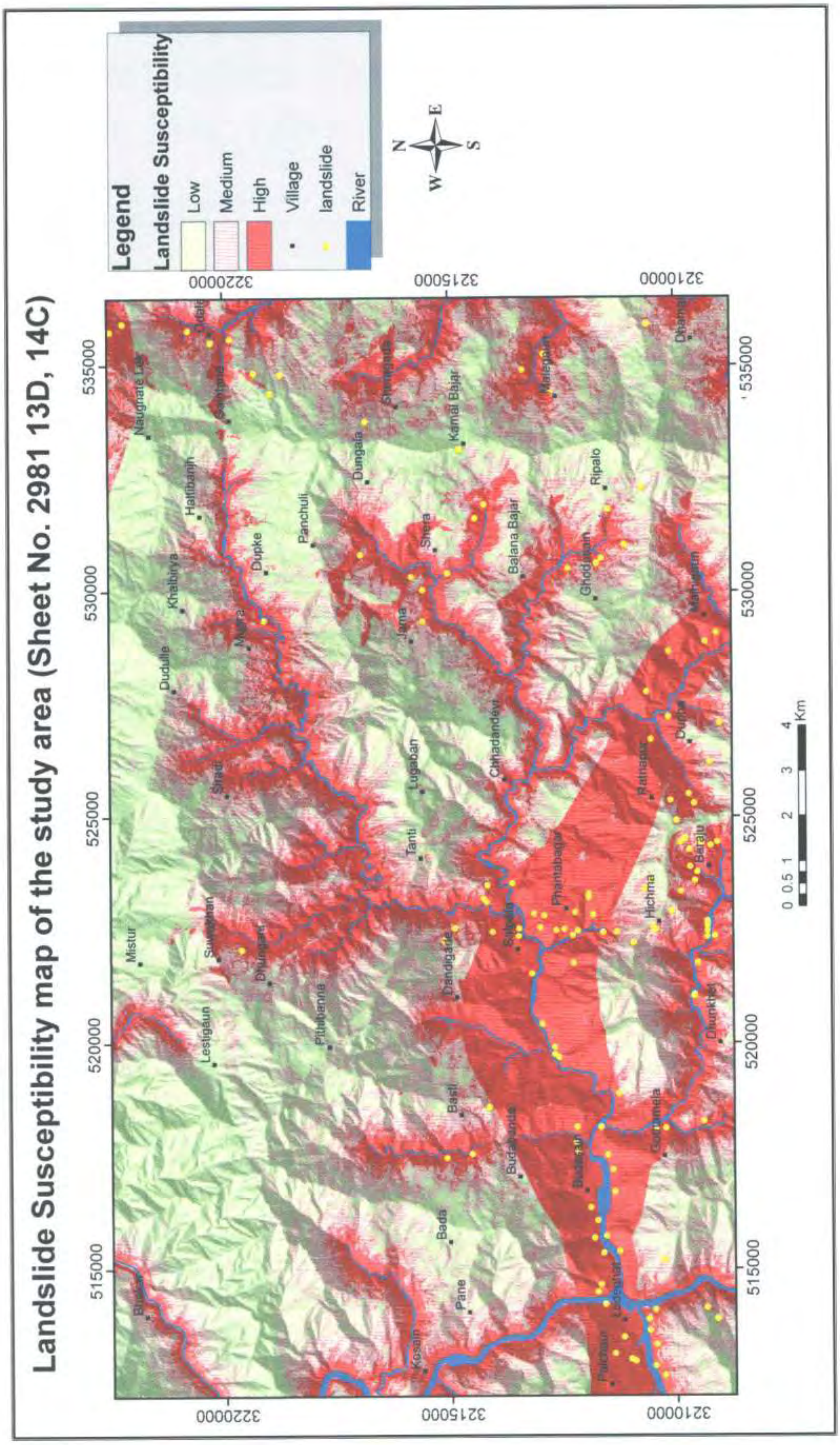


Fig. 13: Landslide Susceptibility map of part of Achham and Doti Districts

Annual Report of Department of Mines and Geology, 2013, No. 9 & 10, pp.27-35

Landslide Susceptibility Mapping in Parts of Achham District, Far Western Nepal (Toposheet No.2981 14A, 13B)

Suresh Shrestha (Geologist) and Ram P. Aryal (Geologist)

ABSTRACT

A Landslide susceptibility map of parts of Achham District is prepared using frequency ratio method at 1: 25,000 scales. Geology, landuse, slope, curvature, distance from river and slope aspect were considered to be the main causative factors for landslides. From analysis it can be said that all selected factors have some positive influence on landslide hazard analysis and improved landslide prediction. The study area is classified into high, moderate and low hazard zones indicating likely hood of occurrence of landslides as high, moderate and low respectively. Out of 325 sq.km of the study area about 15 % of the total area is covered by highly unstable zone where as 69 % of the area is on moderate and 17% is on low hazard zones. The hazard zonation map is expected to be useful for planning in infrastructure development activities in the region.

INTRODUCTION

Landslide mapping was carried out to prepare Landslide Susceptibility Map of parts of Achham District in Far Western Development Region. The field work was done as part of the annual program of the Department of Mines and Geology on fiscal year 2067/68.

The study area covered 325 sq. km of toposheet no. 2981 14A, 13B. The area is located between latitudes 29° 07' 30" to 29° 15' 00" N and longitudes 81° 07' 15" to 81° 22' 30"E (Fig.1). The study area is accessible by road from Kathmandu to Sanfebagar which is about 900 km. The Budhi Ganga Nadi, a major tributary of the Seti River passes through northeast part to southwest part of the area in topo sheet no. 2981 13B. The major tributaries of this area are Kailash, Gairi and Chippre Kholas. The lowest altitude in the area is 596 m near Sanphe Bazzar and the highest altitude is 1972 m near Gadi gaon. Similarly Kailash Khola and Chippre Khola is the main river of the study area in topo sheet no. 2981 14A. Geological Studies have been carried out by a number of researchers in the Doti-Achham-Dailekh area. Among them, Khan, (2055) and Shrestha, 2040, have done the geological mapping covering parts of the target area. The geological maps available in DMG are used as a base for the geological data. Review of existing geological maps suggests that the area is represented by metasedimentary rock sequences of Pre-Cambrian age belonging to Upper and Lower Nawakot Group as well as the rocks of Dadeldhura Crystalline Complex. Several thrusts, faults and folds of regional scales are also mapped indicating weak tectonic belts.

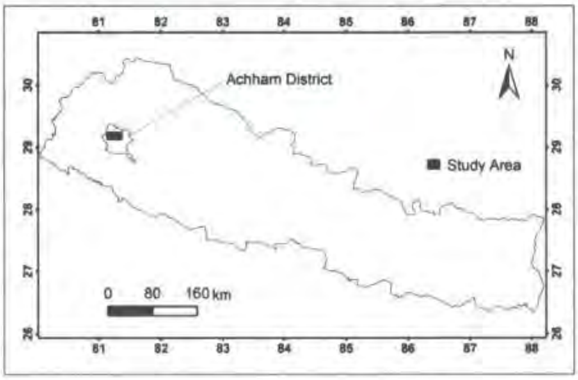


Fig. 1: Location map of the study area

OBJECTIVES

Landslide related disaster destroy life and property in the hilly region of Nepal. Thousands of people are left homeless every year despite government's efforts to minimize the risk. Hazard mitigation works and planning of future development activities are done without the information on areas that are prone to such disasters. In this regard present study is planned for the following objectives:

- To record the landslides of the study area using 'Landslide Inventory Form',
- To integrate landslide distribution and geologic data with slope morphology and existing land use for the preparation of landslide susceptibility map at 1:25,000 scale by optimum utilization of Remote Sensing and GIS techniques, and
- To prepare the regional database of landslides.

METHODOLOGY

Desk Study

Aerial photographs and Topo maps acquired from the Survey Department and Google maps were interpreted to study the landslides, erosion features, tectonic structures, existing landuse pattern and lithological units. The topographic maps at 1:25,000 scales were used as a base map for the field data collection together with aerial photographs. Geological maps and reports were also reviewed.

Field Investigation

Traverses were made along river valleys, main trails and along the ridges for verification of erosion features interpreted on aerial photos, topo map and google maps. Field survey was focused on collecting data for landslide inventory and their distribution using 'Inventory Forms' and mapping of various factors that are mostly responsible for triggering landslides. Emphasis was given to study the landslides and other areas prone to soil erosion by close observation. Some of the major landslides were studied in details using 'Preliminary Landslide Inventory Form' for regional inventory.

Data collected during field verification and desk level interpretation were integrated for the preparation of factor maps. All collected data were analyzed using GIS techniques to prepare landslide hazard zonation map at 1:25,000 scales.

Fig. 2: Landslide at the Left bank of Kailash Khola.

Fig. 3: Landslide due to road construction near Oli Gaon

GEOLOGY

Schist, quartzite, gneiss, phyllite and some basic rocks are the main rock types of the study area. There are two kinds of schists, one is feldspathic schist with considerable amount of feldspar grains and another schist with chlorite and garnet minerals. Calcareous schist is also present in the study area. Phyllite and quartzite beds are found within the schist. A thick band of greenish dark grey colou red basic rock is found in the study area. Phyllite and schists found are with and without garnet. Similarly gneissses are also present in the study area. All collected data were analyzed using GIS techniques to prepare landslide hazard zonation map at 1:25,000 scales.

Basically the study area consists of five geological units/ formations according to the unpublished geological map of DMG by Shrestha (2033) and Khan (2055). First unit (Dhungani quartzite, Khan, 2055), consist of white to light grey sericitic quartzite with few phyllite interlayering and some basic intrusion. Similarly the second unit consists of quartzo feldspathic schist with bands of gneiss and chlorite mica schist and basic intrusive at some places. Third unit comprised of garnetiferous mica schist and phyllites with occasional quartzite. The fourth unit consists of mica schist with few calcareous rocks. The fifth unit consists of kyanite and garnet bearing with few calcite lenticles. River terraces developed in this area are often covered by colluvium deposits derived from the high hills lying on either side of the river valley.

Majority of small scale landslides in the study area were of soil slip due to intense rain fall, in which the top soil with little vegetation less than a meter thick slide down in the slope around 20 to 50°. Most of the big landslide occurred in crushed rocks, highly weathered phyllites and schist (Fig. 2) within tectonically active zone. The landslides caused by anthropologically cause mainly due to road construction (Fig. 3) are also frequent in the study area. Rock falls and slides are also observed in highly fractured and jointed rocks mainly in quartzite and basic rocks.

PREPARATION OF FACTOR MAPS

A landslide distribution map (Fig. 4a) was prepared by compiling various sources of information and the data from field checking. In this case the landslide distribution map contains active and reactivated landslides. Similarly the factor maps with various parameters that are mostly responsible for land sliding were prepared using GIS system by incorporating the data obtained from desk study and field verification. Slope map, curvature map and aspect map were generated using a Digital Elevation Model (DEM, Fig. 4b). In the present study, factors such as geology (Fig. 4c), land use (Fig. 4d), slope (Fig. 4e), aspect map (Fig.4f), curvature map (Fig.4g) and distance from river map (Fig. 4h) were considered for the assessment of probability of landslide hazard at regional scale.

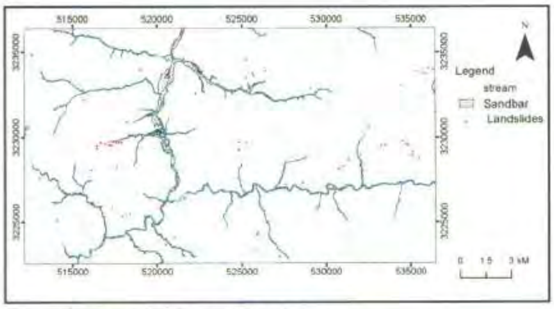


Fig. 4a: Landslide distribution map

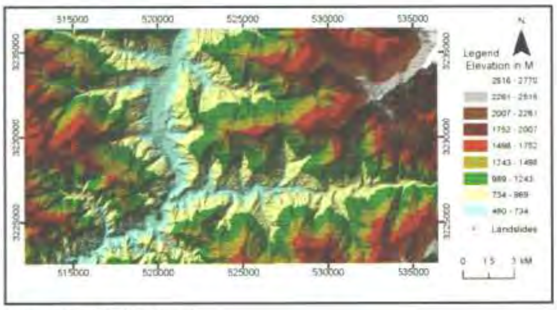


Fig. 4b: DEM map

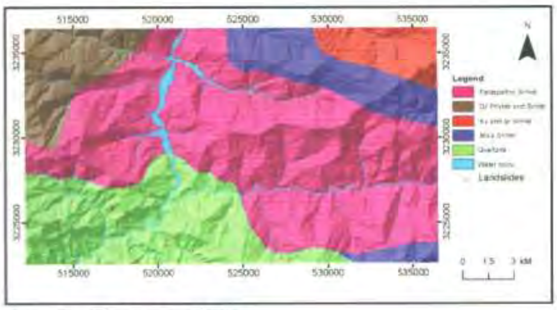


Fig. 4c: Geological Map

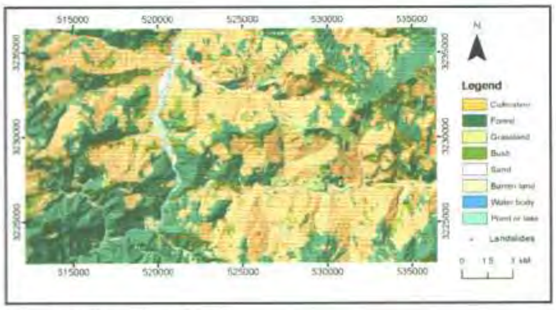


Fig. 4d: Landuse map

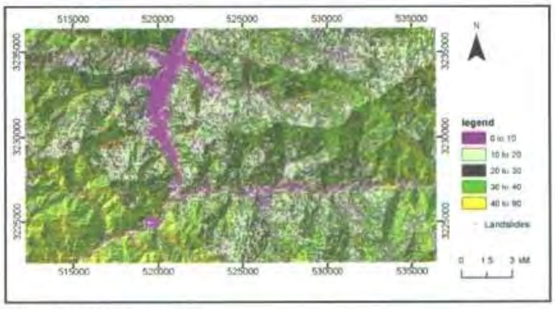


Fig. 4e: Slope map

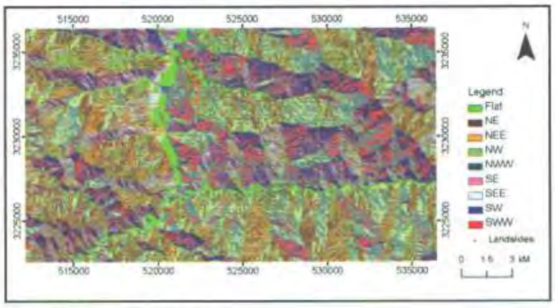


Fig. 4f: Aspect map

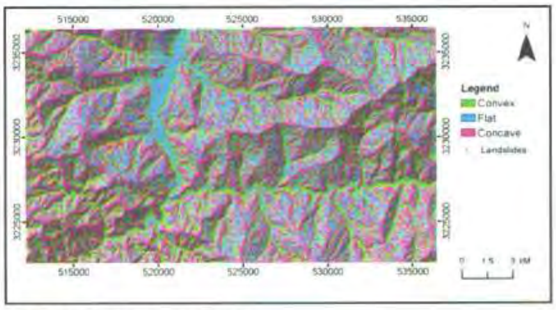


Fig. 4g: Curvature map

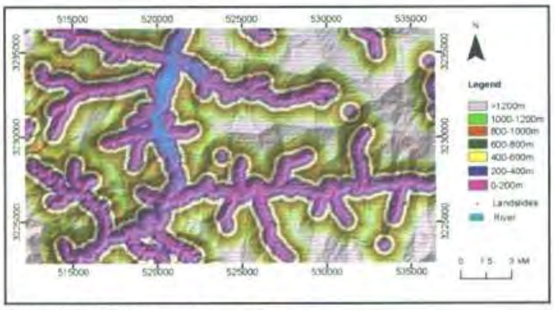


Fig. 4h: Distance from river map

Data acquired by the remote sensing techniques are becoming better in resolution and user friendly to integrate in GIS system. In this context Remote Sensing and GIS are widely used to evaluate the degree of danger from landslide in an area by considering the nature of causative factors in the surroundings. Different models are proposed and used to assess the relative likelihood of landslide occurrence by different researchers. The present study was based on frequency ratio method and deals with one of the dependent variable like Data acquired by the remote sensing techniques are becoming better in resolution and user friendly to integrate in GIS system. In this context Remote Sensing and GIS are widely used to evaluate the degree of danger from landslide in an area by considering the nature of causative factors in the surroundings. Different models are proposed and used to assess the relative likelihood of landslide occurrence by different researchers. The present study was based on frequency ratio method and deals with one of the dependent variable like landslide density and other independent variables such as geology, landuse, slope, slope aspect, curvature, and distance to river. The numbers of landslide occurrence pixels in each class was evaluated, then the Frequency Ratio (Fr) value for each factor's range was calculated, dividing the landslide-occurrence ratio by the area ratio. The level of correlation between chosen factor's ranges (slope, aspect, distance from drainage, lithology, landuse, and curvature) and location of the landslides in the study area were evaluated using the frequency ratio method. Value of one for Fr value is an average value. The greater the ratio above unity means the stronger correlation and lower ratio than unity means the lower correlation between landslide occurrence and the given factors attribute (Lee and Pradhan 2006). So, based on calculated Fr values, the relation of each category's factor with landslide occurrences can be evaluated (Table 1).

Table 1: Various factor maps and their frequency ratio

Factor	S.N	Class	Totl no. of pixels	% pixels	No. of landslide	% landslide	frequency
Geology	1	Water body	90578	2.7	1	1.3	0.49
	2	Gr Phyllite and Schist	287925	8.5	1	1.3	0.15
	3	Feldspathic Schist	1746090	51.8	53	69.7	1.35
	4	Ky and GR Schist	178517	5.3	6	7.9	1.49
	5	Mica Schist	362450	10.8	3	3.9	0.37
	6	Quartzite	704237	20.9	12	15.8	0.76
Aspect	1	NW	443724	13.2	15	19.7	1.5
	2	SW	350677	10.4	1	1.3	0.13
	3	SSW	346748	10.3	26	34.2	3.32
	4	Flat	297340	8.8	0	0	0
	5	SE	304378	9	3	3.9	0.44
	6	NWW	437154	13	5	6.6	0.51
	7	SEE	354154	10.5	9	11.8	1.13
	8	NE	454943	13.5	12	15.8	1.17
	9	NEE	378369	11.2	5	6.6	0.59
Landuse	1	Cultivation	1567880	46.56	24	31.58	0.68
	2	Forest	1266891	37.62	10	13.16	0.35
	3	Grassland	146120	4.34	17	22.37	5.16
	4	Bush	297068	8.82	18	23.68	2.68
	5	Sand	72886	2.16	1	1.32	0.61
	6	Barren land	2126	0.06	6	7.89	125.05
	7	Water body	14588	0.43	0	0	0
	8	Pond or lake	43	0	0	0	0
Slope	1	0-10	463025	13.75	4	5.26	0.38
	2	10-20	717932	21.32	13	17.11	0.8
	3	20-30	1167892	34.68	17	22.37	0.65
	4	30-40	687570	20.42	25	32.89	1.61
	5	40-90	331379	9.84	17	22.37	2.27
Distance from river in Metre	1	0-200	629864	18.7	26	34.21	1.83
	2	200-400	486494	14.45	9	11.84	0.82
	3	400-600	443669	13.17	10	13.16	1
	4	600-800	409353	12.16	8	10.53	0.87
	5	800-1000	360692	10.71	7	9.21	0.86
	6	100-1200	308273	9.15	5	6.58	0.72
	7	>1200	729258	21.66	11	14.47	0.67
Curvature	1	Convex	1125483	33.59	28	36.84	1.1
	2	Flat	802532	23.95	16	21.05	0.88
	3	Concave	1423007	42.46	32	42.11	0.99

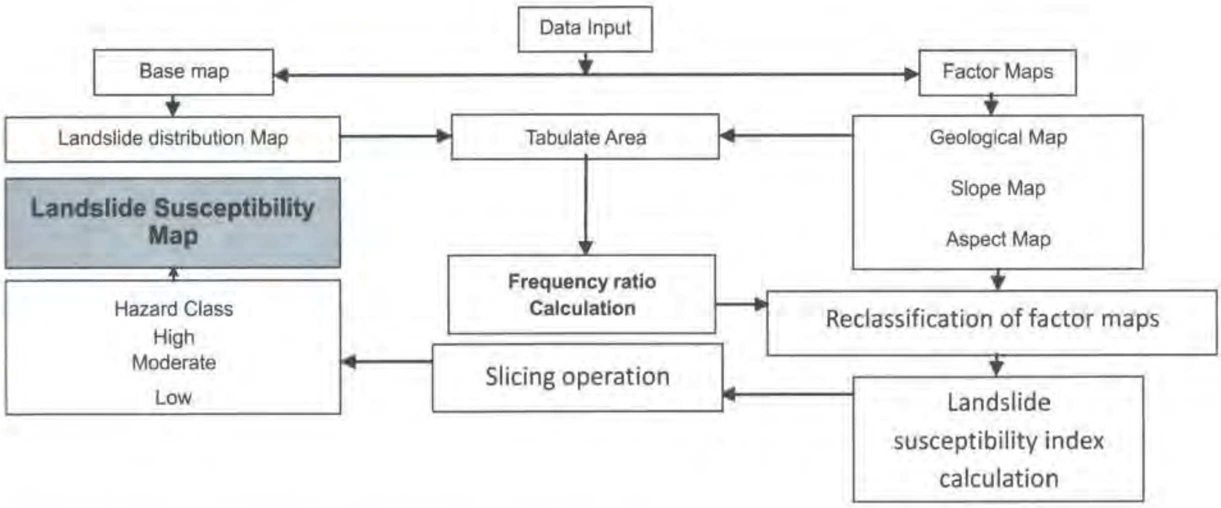
PREPARATION OF LANDSLIDE SUSCEPTIBILITY MAP

After Fr values calculation, Landslide Susceptibility Index (LSI) was calculated for each pixel of the study area. Consider a point x with m (number of layers) pixel values (x1... xm) in a study area. In pixel x, LSI can be calculated by summation pixel values (x1....xm), as formulated in the following:

LHI= $\sum$Fr (1...m) .... (1)

(Lee and Pradhan 2006)

Based on the density of landslide distribution in each class/unit of the causative factors at present situation a landslide susceptibility map (Fig. 5) was prepared and divided the entire study area into three categories predicting probability of danger from landslide. Since each unit of the factor map has different LSI value derived according to the density of landslide distribution within the unit, the addition of all the frequency ratio value for a certain region was carried out during the statistical calculation. After calculation of Landslide susceptibility index value, the study area was subjectively classified into three different zones as low, moderate and high hazard. Preparation process of landslide susceptibility map is summarized in the following flow chart.



Flow Chart of Landslide Susceptibility Map preparation process

RESULTS OF STATISTICAL ANALYSIS

The Landslide Distribution Map (Fig. 4a) was combined with the Landslide susceptibility Map (Fig. 5) using tabulated area in ArcGIS environment. In the present study area 15 % of area was found to be in high hazard zone; 68% in moderate and 17 % in low hazard zone. The relation between hazard class and causative factors (Fig. 6a, b, c, d, e and f) was also evaluated to assess the effect of various factors for estimating the range of instability in the region in terms of probability of landslide hazard. Mainly the factors landuse and geology play a significant role for the occurrence of landslides. Generally all factors have some positive influence on landslide hazard analysis and improved landslide prediction.

Verification of the Landslide Susceptibility Level (LSL) Map

The LSL result was validated using known landslide locations. Verification was performed by comparing the known landslide location data in Landslide Distribution Map (Fig.4a) with the Landslide Susceptibility Level map (Fig. 5). Fig. 7 illustrates how well the estimators perform with respect to the landslides used in constructing those estimators. All pixels are sorted according to the pixel value in descending order. The total number of pixels is divided into a number of classes with equal number of pixels. The first class consists of the pixels with the largest pixel values and the next subsequent class is made up of the pixels with the next largest values. Each class consists of the equal number of pixels (Chung and Fabbri, 1999).To compare the quantitative results, the areas under the curve are recalculated as if the whole area of the total ratio is equal to the value 1, and this means perfect prediction accuracy (Lee and Dan, 2005; Hyun et al., 2010). As a result, taking into account all the factors used, the class of 90-100% (10%), with the highest cumulative landslide, containing 42% of the grid cells at landslide rate was obtained. Similarly, in the case of the 80-100% class (20%) containing 55%, 70-100% class

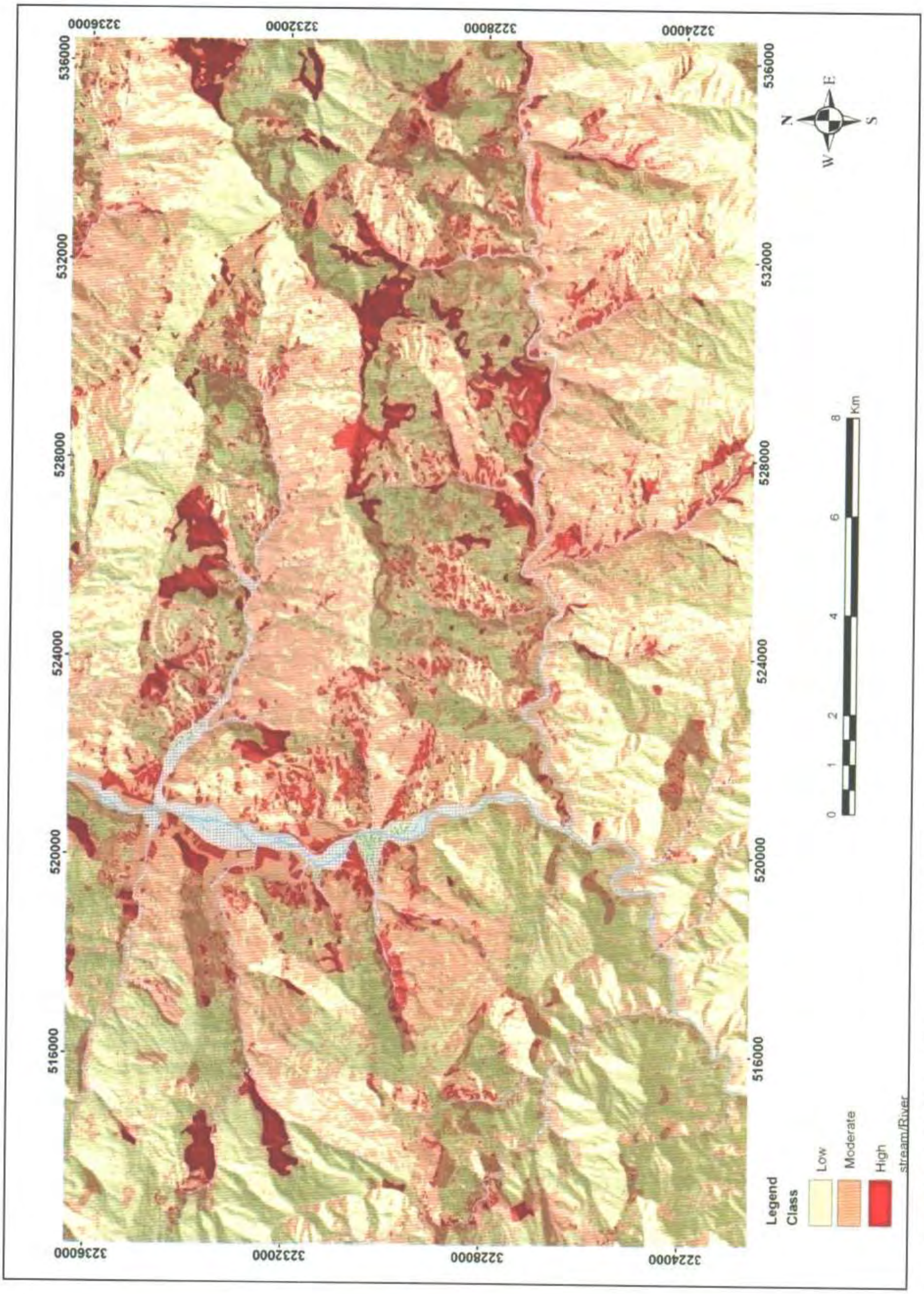


Fig. 5: Landslide Susceptibility map of part of Achham District

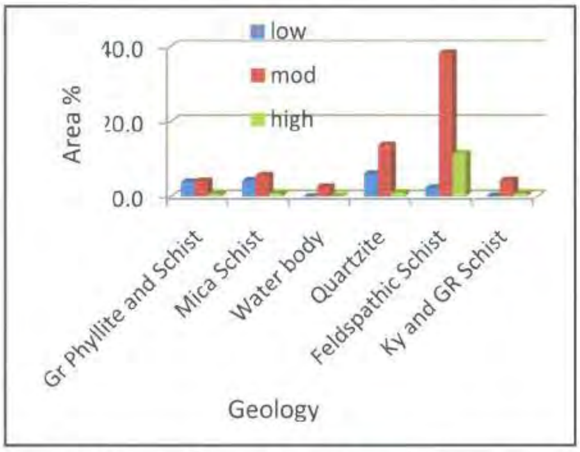


Fig. 6a: Relation between hazard and Geology

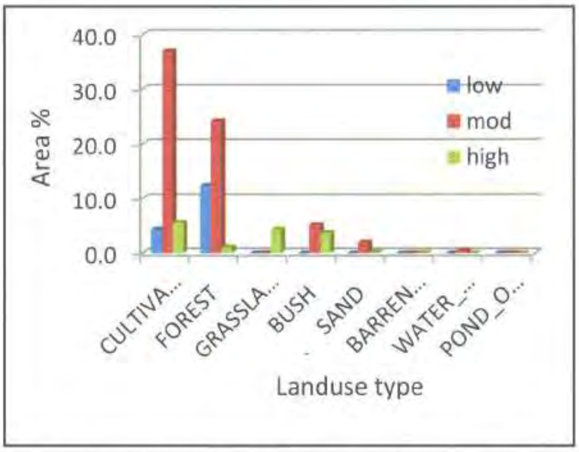


Fig. 6b: Relation between hazard and Landuse

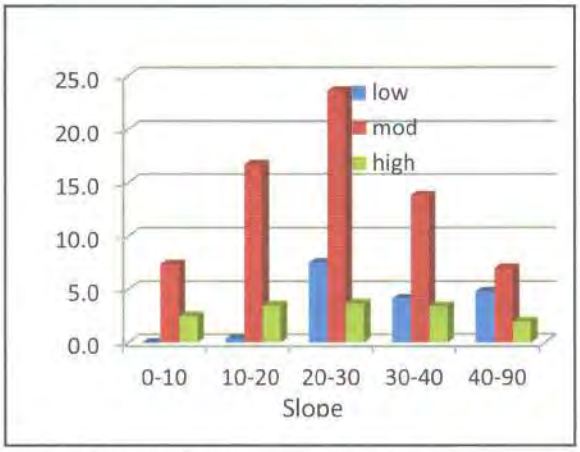


Fig. 6c: Relation between hazard and slope

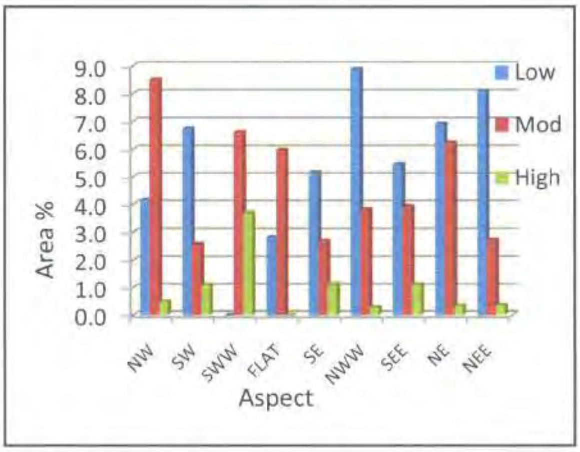


Fig. 6d: Relation between hazard and Aspect

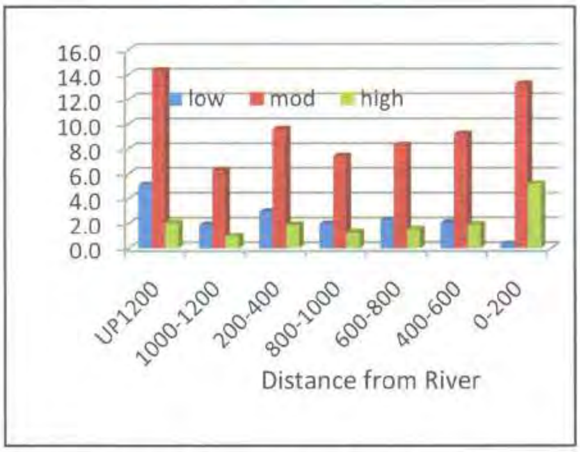


Fig. 6e: Relation between hazard and Curvature

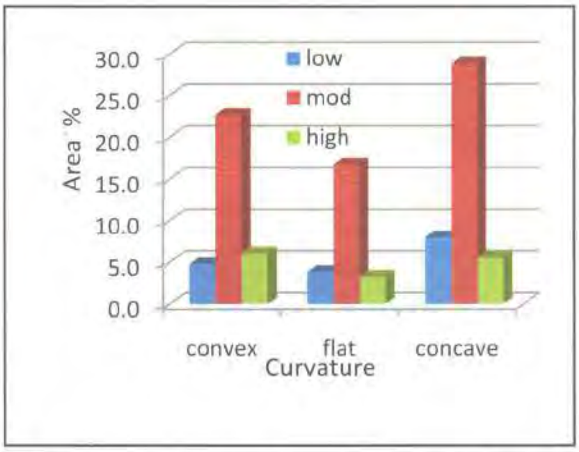


Fig. 6f: Relation between hazard and Distance from River

(30%) containing 75%, and continuously until the calculation of 0%-100% (100%) of 100% of the total area in rates was obtained in this model (Table 2). Thus, the average area under the curve can be used to evaluate the accuracy of predictions. As a result of the calculation and interpretation, the average ratio of the areas under the curve was 0.84%, and thus can be argued that validation prediction accuracy was 84%.

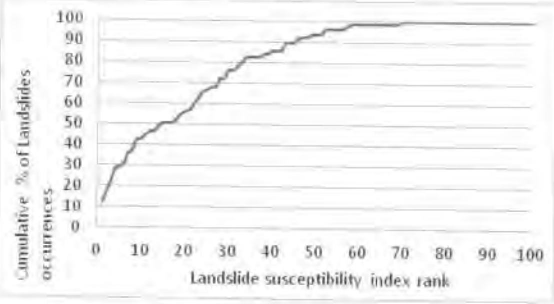


Fig. 7: Illustration of cumulative frequency showing landslide susceptibility index rank (y-axis) occurring in cumulative percentages of landslide occurrences (x-axis)

Table 2: Calculation of the ratio of the average area under the curve

Cumulative value	Class	Area ratio
90-100%	10	0.42
80-100%	20	0.55
70-100%	30	0.75
60-100%	40	0.85
50-100%	50	0.92
40-100%	60	0.97
30-100%	70	0.97
20-100%	80	0.97
10-100%	90	1
0-100%	100	1
	Average	0.84

CONCLUSION AND RECOMMENDATIONS

Landslide Hazard Zonation Map was prepared by integration of the causative factors related to slope instability and their relationship with existing landslide distribution within the area. Generally it can be said that all selected factors have some positive influence on landslide hazard analysis and improved landslide prediction. The map totally relies on the surface information obtained by ground survey of accessible areas and data from topo map, aerial photographs and Google maps. The map is intended to be useful in planning infrastructure development activities of the region.

Generally slope aspect, slope angle 10° to 40°, convex curvature, feldspathic schist in geology, barren and grassland in landuse pattern and up to 200m area from the river have high susceptibility of landslides.

Landslide susceptibility Map shows that about 15 % of area was found to be in high hazard zone; 69% in moderate and 17 % in low hazard zone.

This map is exclusively intended for planning of infrastructural development activities at a regional scale. It should not be used as the only basis of investigation for individual buildings or any major civil structure. It cannot replace detailed site-specific investigations. It is time dependent and needs periodic revision. The major factor precipitation, for the triggering landslide is not included in this study and change in any single factor by natural or human intervention needs re-evaluation as change of a single factor can be sufficient to exceed the threshold for slope instability.

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Engineering and Environmental Geological Mapping of Janakpur Municipality and its Surrounding Area, Dhanusa District, Central Nepal

Gyani R. Chitrakar (Senior Divisional Geologist), Dinesh Nepali (Senior Divisional Geologist), Surya P. Manandhar (Geologist), Suchita Shrestha (Geologist), and Kumar Khadka (Geologist)

ABSTRACT

The present study deals with the engineering properties of Quaternary sediments. 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 and clay were assessed.

INTRODUCTION

Janakpur municipality is located in Dhanusa District, Janakpur Zone in the Central Development Region of Nepal (Fig. 1). It is named after the legendary King Janak. It is a historical and religious place and is famous for Janaki temple. It is about 378 km far from Kathmandu. Janakpur-Dhalkebar road connects the study area with East–West Highway in the north at Dhalkebar. Physiographically the study area lies in the Terai Plain having altitude range from 66m to 91m amsl and consists of sediments of Quaternary deposits such as sand, silt and clay. The main river flowing in the study area is Jaladh Nadi in the east.

The area of field investigation lies between 2953000m to 2966000m North and 491000m to 499000m East covering about 100 sq. km (Part of Toposheets No. 2685 08B and 2685 04D).

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.

PREVIOUS WORKS

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

Geological Map, Block-8, published by Petroleum Exploration Promotion Project (PEPP), Department of Mines and Geology (DMG) shows the presence of alluvium deposit (Quaternary-Recent).

Geological Map of Central Nepal (1987) at 1:250, 000 scale published by the DMG shows the occurrence of recent sediments in the area and consist of alluvium boulders, gravels, sands and clays.

Amatya and 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.

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

Fig. 1: Location map of the study area

Gyani.R. Chitrakar (Senior Divisional Geologist), Dinesh Nepali (Senior Divisional Geologist), Surya P. Manandhar (Geologist), Suchita Shrestha (Geologist), and Kumar Khadka (Geologist)

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 were 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, and
- To identify the existing environmental problems which will have direct impact on human health.

Fig. 2: Field personnel performing SPT

METHODOLOGY

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

Before going 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 drill holes and SPT (Fig. 2) were carried out as planned before. Samples collected from the field (Fig. 3) 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.

Fig. 3: Samples being recovered by auguring

FIELD ACTIVITIES

In the field, related documents were collected from the municipality 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 7.45m 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.

QUATERNARY GEOLOGY

The necessary information about the quaternary geology were obtained from field survey, Power Auger Drill, Hand Auger, SPT test (Fig.4) to know various sub-surface geology. Quaternary sediments of the study area are divided into 6 different deposits based on grain size (Fig. 5). They are as follows:

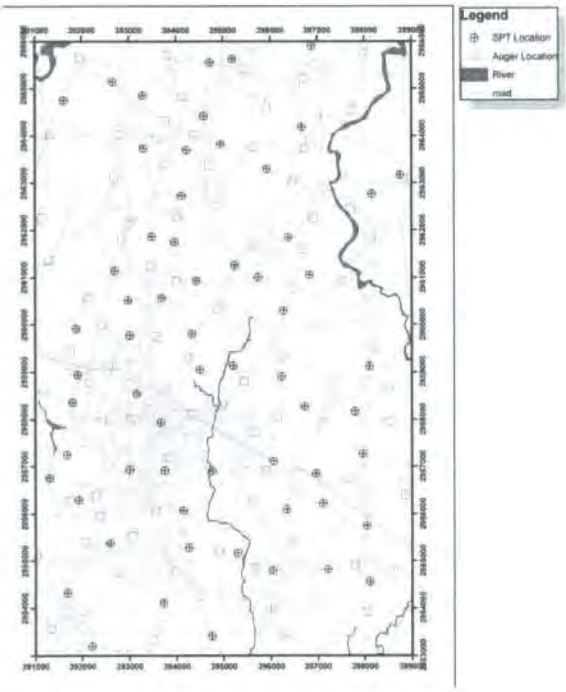

Fig.4: Location map of SPT and Auger

1) Bhoil Deposit,
2) Jamuniya Deposit,
3) Katrait Deposit,
4) Lohna Deposit
5) Sapahi Deposit and
6) Sohani Deposit.

Their brief descriptions are given below:

Bhoil Deposit

Bhoil deposit is differentiated as clay dominat which is mainly distributed over Janakpur municipality,

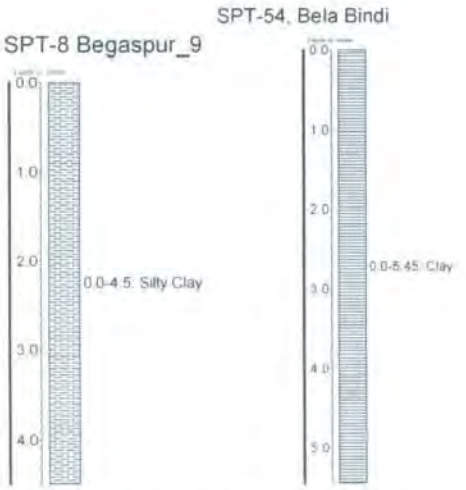

Fig. 5: Geological log of auger holes representing the sediments of Bhoil deposit

Bhoil, Prastoki, and Basahiya VDC as shown in (Fig. 3). It consists of yellowish brown and grayish brown clay. Concretions are observed in clay layers at some locations. The thickness of this unit is more than 5 meters. The groundwater table in this region is deep.

Similarly, this deposit are also found at Kapaleswore, Mahuwa, Anandanagar, Gidha, Vindhi VDC, Agnikunda, Kurtha VDC and Sinurjora VDC. The litholog of this unit is shown in Fig.5.

Jamuniya Deposit

Jamuniya deposit is developed at Jamuniya, Laxminiya-Bagewa, eastern part of Basahiya VDCs and central Janakpur Municipality. It is differentiated as sand dominated. The lithology of this unit are shown in Fig. 6. This deposit is also found at Sapahi area where about 1m thick clay layers are found below 4.40m sand layer.

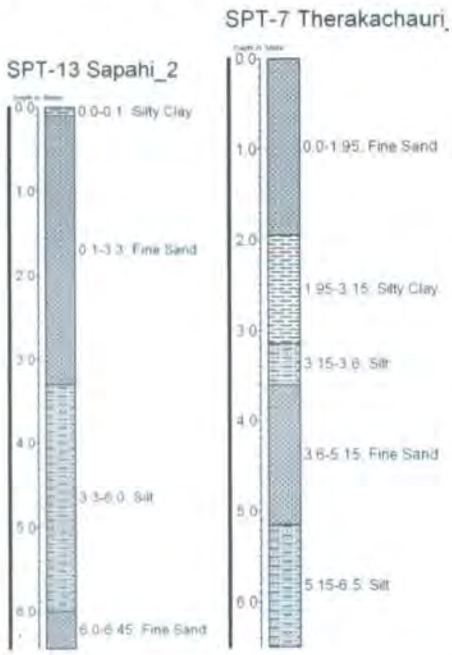

Fig.6: Geological log of auger holes representing Jamuniya deposit

Katarait Deposit

Katarait deposit is developed at Katariat, Thera, Sapahi, north of Laxminiya, Bagewa and Basahiya VDCs and north-east of Janakpur Municipality. This deposit is characterized by average 3.5m fine to medium grained sand layer on the top followed by clay layers (up to 6m). The color of sand is grey to brownish grey while clay is grey to dark grey. Water table is very low and at some places found at ground surface. The litholog of this deposit is shown in Fig.7.

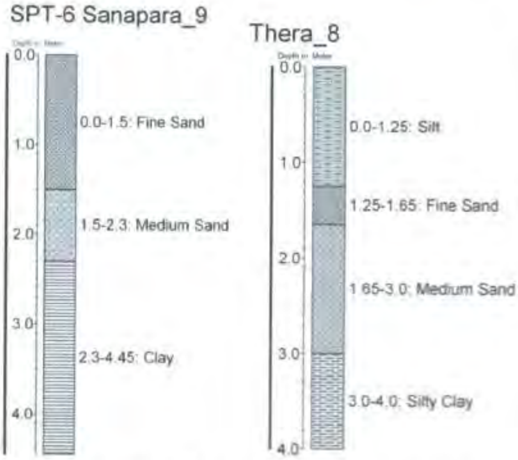

Fig. 7: Geological log of auger holes representing Katrait deposit

Lohana Deposit

Lohana deposit is differentiated by alternation of clay, silt, silty clay, clayey silt and sand layers. The thickness of clay deposits varies from 0.25-3m, silt (0.25- 2m) and sand 0.20-2m, silty clay 0.10– 3.50m and clayey silt 0.30m-2.50m. This deposit is distributed at Sohani, Sapahi, Lohana, Bega Shivpur and Kanakpatti VDCs. The litholog of this unit is shown in Fig. 8.

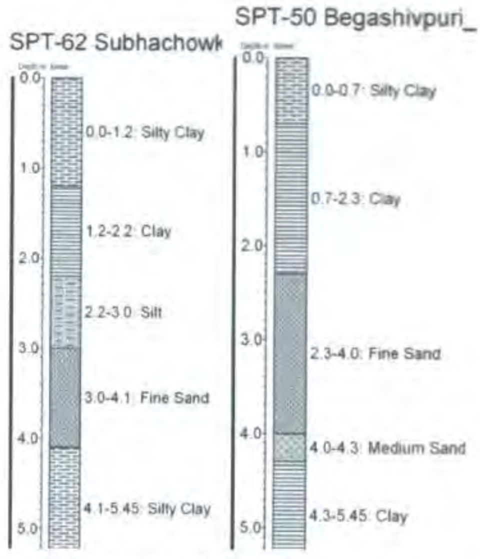

Fig. 8: Geological log of auger holes representing the sediments of Lohana deposit Sapahi Deposit

Sapahi deposit is differentiated by alternation of clay, silt, silty clay, clayey silt without sand layers as shown in fig.3. The thickness of clay deposits varies from 0.40–3.25m, silt 0.10- 3m, silty clay 0.20–2.50m and clayey silt 1-2.50m. This deposit is distributed at Lohana, Bega Shivpur, Mahuwa Jamuniya VDCs, some western and northern part at Mujeliya and Pidari of Janakpur Municipality. The litholog of this deposit is shown in Fig.9.

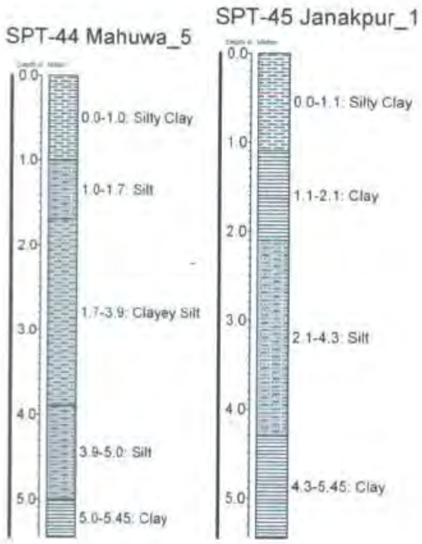

Fig. 9: Geological log of auger holes representing the sediments of Sapahi deposit

Sohani Deposit

Sohani deposit is differentiated by average 3m clay layer on the top followed by fine to medium grained sand layers. The colour of silty clay is greyish brown while the colour of sand varies from grey to yellowish grey. This deposit is distributed at Sohani, Kanakpatti, Lohana, and Mahuwa VDCs. The litholog of this unit is shown in Fig.10.

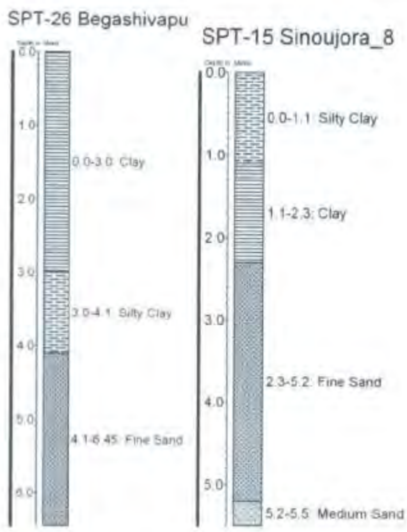

Fig. 10: Geological log of auger holes representing the sediments of Sohani deposit

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 Fig. 11. The greater value is normally encountered at a greater depth, and hence the bearing capacity gradually increases with the increase in depth.

LIQUEFACTION HAZARD AND SEISMICITY

There is not much seismicity in Dhanusha district as depicted from "Epicentre Map of Nepal from 1994 – 2005 AD published by the DMG. However Main Frontal Thrust (MFT) lies just 60 km north of Janakpur. The study area consists of loose sediment like sand, silt and clay, is vulnerable to earthquake shaking and there is possibility of liquefaction during great earthquake. Liquefaction events have been reported in some part of the study area by the Udayapur earthquake of 1988 AD. No damage has occured in Janakpur temples during great earthquake of 1990 BS (1934 AD).

Table 1: Correlation 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)

Fig. 11: Bearing capacity map of the study area

GEO-HAZARD AND ENVIRONMENTAL PROBLEM

Geo-hazard of the study area includes river bank cutting, flooding and inundation. Riverbank cutting is active in Jaladh Nadi and Bigahi Nadi during Monsoon season (Fig.12).

River bank cutting is found in Jaladh River at Andupati Katerate and in Bigahi River northwest of Dohar. In Andupati area, ward no. 4 and 5 had been washed away by bank cutting and later by flooding. The area is now covered with sand and silt. The remains of oil mill in the river bed of Jaladh Nadi can be seen (Fig. 13). High current of river had washed away the gabion spur during monsoon season (Fig. 14).

Fig. 13: River bank cutting and washing away of ward no. 4 and 5 of Andupati Katariat-3 of Uterbari Tole during flood of 2058 B.S in Jaladh Nadi

Fig. 14: Washed away of gabion spur in the Jaladh Khola

The bridge located near Doha village was damaged by high flow of water from upstream which had occurred in 2008 (Fig. 15) and damaged the Janakpur-Jayanagar Railway line due to repeated flooding (Fig. 16). Jaladh River was once a source of gift that deposits good soil and

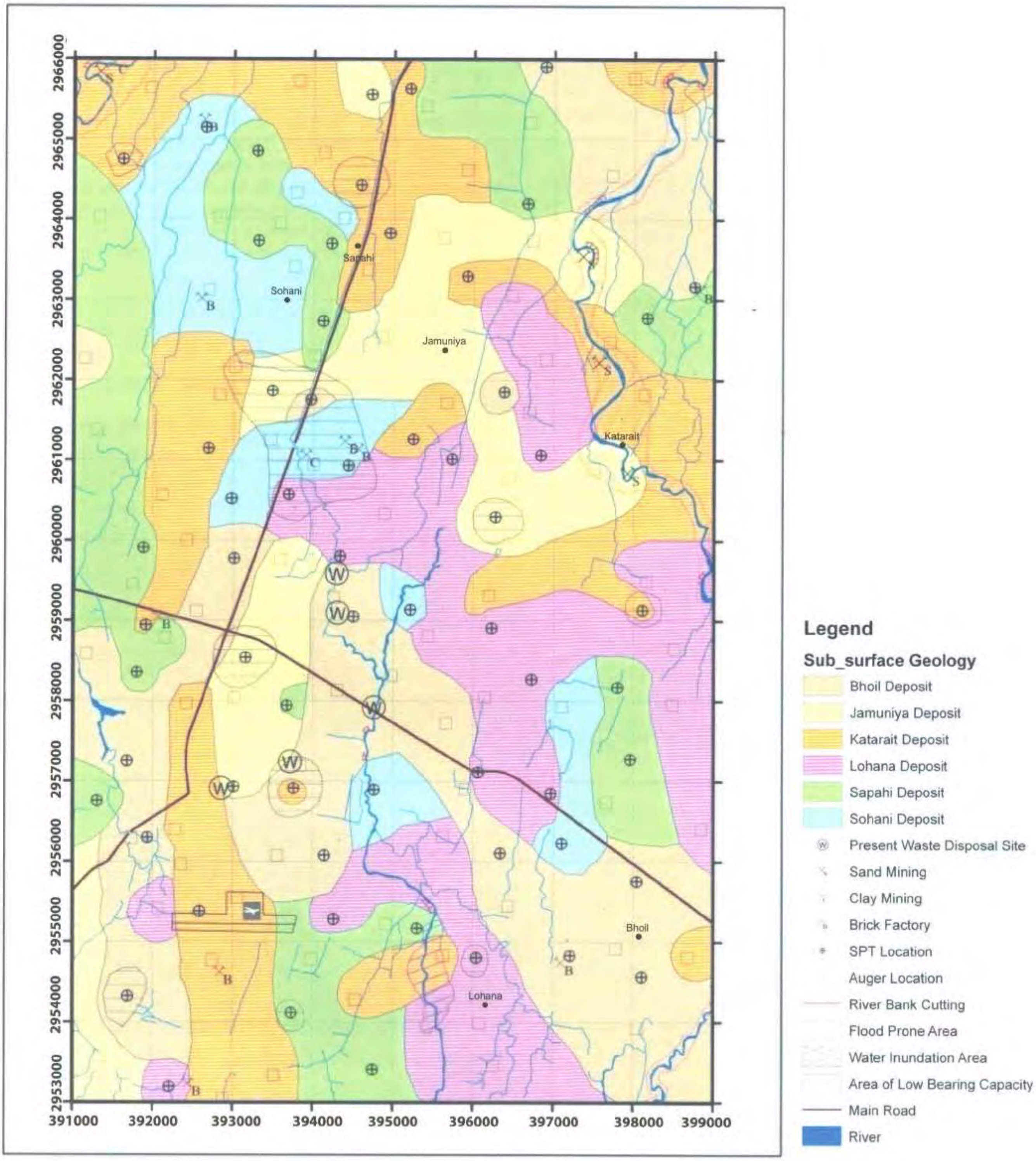

Fig. 12: Engineering and Environmental Geological Map of Janakpur Area

all the land surrounding this river is considered as fertile land and now facing a problem of flooding. According to the local people, each year about 40 bighas of land has been turned into flood plain since 1980.

Fig. 15: Damaged Bridge due to the high flow of water in 2008

Fig.16: Damaged railway awaiting its repair and maintenance line in NW of Janakpur Cigarette Factory

Inundation

Inundation occurs in the Jaladh Khola at the lower central boundary of the study area east of Lohana village. Most settlements and government offices like District Administration Office (DAO), Regional Police Office, Land Revenue Office, and Janakpur Cigarette Factory in Janakpur were water logged. Houses in Kishori Nagar, Bhanu Chowk, Namuna Basti, Kataiya Chowri, Shantinagar, Rajaul, Wakil Tole and Pulchowk, among other areas had been flooded with up to four feet of water.

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 pond can be seen clearly (Fig. 17).

Fig. 17: Water pollution due to mixing of waste materials into Argaja pond

Fig. 18: Janaki Temple of Janakpur

Waste Disposal and Dumping Site

The inner core area of Janakpur is not so clean and jamming of drain can be seen in Kishori Nagar and other areas. Domestic waste are thrown into various places specially at road junction like in Janaki Chowk, Shiva Chowk, Ganga Sagar, around the bridge of Kapaleswore, Pidarichowk, Pulchowk bridge of Jalad River, railway station etc. Municipality disposed waste material into an empty space along the road as in the area northeast of zero mile, close to Hanuman Takiz cinema hall (Fig. 19) and also along the road going to Bega north of Janakpur Cigarette Factory.

Recommendation for Landfill Site

The area 1 km north of Janakpur Cigarette Factory (Road going to Bega) on the right bank of the small stream (tributary of Jaladh Khola) is suitable for first dumping site as well as landfill site as compared to other area of study.

Few buildings lie just 100 m from that area. In the upstream on the right bank there is no settlement up to 1.5 km. The river bed is 2.5m below the surrounding area. Based on litho-log of that area 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 4.5 km far from the airport.

Fig.19: Dumping of waste materials close to Hanuman Takiz Cinema Hall

Management of Sewerage Drain

The municipality is upgrading its drainage system for easy flow of sewage and water. A huge construction of sewage drain was taking place from Janakpur Cigarette to the Pidarichowk and on both side of highway in the amanandachowk (Fig. 20).

Fig. 20: Construction work for sewerage drain in Ramananda Chowk

Construction Materials

Thick deposit of construction materials (Filling materials) are found in flood plain of Jaladh Nadi and Bigahi Nadi in the eastern part and north western part of the study area (Fig. 21). However boulder are brought from Siwalik Hills and crushed in Janakapur to produce gravel and pebble as construction materials.

Fig.21: Transportation of filling material (sand, silt, clay) from flood plain of Jaladh Khola

There are many brick factories around VDCs which are used for the construction of buildings (Fig.22).

Fig.22: Brick Factory at Sinurjora VDC-4 (Aderwa)

The mining location of construction materials are shown in Fig.12.

Water Resources

Janakpur is well known for the city of water bodies (Sagars, ponds). It is said that there are 25 ponds having historical importance. Kamala, Jaladh, Bigahi River and other smaller rivers are used for irrigation purposes.

Groundwater is also used for water supply in the municipality area. Deep and shallow tube well is used for irrigation purposes and domestic purposes (Figs. 23 & 24). Hand pumps are found everywhere to extract water from the ground to fulfill their domestic needs.

Fig. 23: Water pumping station at Pidari, Rani Bazar for irrigation and domestic purposes

Fig.24: Deep tube well boring 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.
- Analyses show that the bearing capacity of the study area mainly has medium bearing capacity.
- Due to flat area, water logging occurs frequently. There is proper drain to flow sewage materials easily.
- 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 Report on Structure and Stratigraphy of the Part of Udaypur, Saptari and Siraha Districts of Eastern Nepal, Petroleum Exploration Block No. 9

Jay R. Ghimire (Senior Divisional Mining Engineer) and Narayan Banskota (Geologist)

ABSTRACT

Parts of Udaypur, Saptari and Siraha Districts of Eastern Nepal consist of vast alluvial plains of the Indo-Gangetic plains in the southern parts, Siwalik Group consisting of molasses sediments occurs in the south of Main Boundary Thrust (MBT). Metasedimentary rocks are exposed north of MBT and midland group occurs north of Mahabharat Thrust (MT). MBT, MT, Main Frontal Thrust (MFT) and Kamala Tawa Thrust (KTT) are major structures of the area with some local scales faults and folds. Siwalik Group could be traced which may be potential source of hydrocarbon in area.

INTRODUCTION

This field program was carried out in accordance with the annual field program of Petroleum Exploration Promotion Project/Department of Mines and Geology (PEPP/DMG) for the fiscal year 2068/69. Structural and Stratigraphical study in the parts of Udaypur, Saptari and Siraha Dristicts of Eastern Nepal, Petroleum Exploration Block No. 9 covers study area of 650 square kilometers. The study area lies in the parts of Udaypur, Saptari and Siraha Dristict bounded by the latitude of 26o37'30" - 26o57'30" and longitude of 86°30'36"- 86°43'00" lying in toposheets 2686 03A, 2686 03B, 2686 03C, 2686 03D, 2686 07A and 2686 07B published by the Survey Department, Nepal (Fig. 1). Study area lies both compilation work for map Publication. It is designed to check the problematic area to correlate the geology and structure of the adjacent area. The problematic area is extracted during the compilation work and are planned to check in the field work so as to complete the compilation work for final map publication and trace the continuity for hydrocarbaon horizon. Field study was conducted by taking selected traverse along the major Khola sections - Trijuga, Andheri, Rupani, Balan, Lohan, Baruwa, Latan and Baidhyanath and along the spurs, ridges and road cut sections. Eight different samples were collected from different litho-units. Geological report of the area was prepared geological map at the scale of 1:50,000 was published.

PEPP/DMG, (2005) has prepared geological map of Petroleum Exploration Block-9, Rajbiraj, Eastern Nepal. Geological mapping of Quaternary deposit, Siwalik Group and the Lesser Himalayan of the area has been carried out in 1:250,000 scale. Subedi, D.N. and KC, S.B., (1996) has prepared geological map of a part of Sunsari, Morang and Udaypur districts that lies in the eastern part of present study area. Khanal, R. P., (2011) has conducted geological section measurement and geological studies in major river section lying in the parts of Udaypur District. The present field program is connected with the north and south of Sagarmatha Highway to Gaighat which 20 km north from Kadamahachowk at E-W Highway.

Fig. 1: Map of Nepal showing study area

OBJECTIVES

The objectives of the field investigation are:

- To prepare a geological map and section of the study area in the scale of 1:50,000,
- To establish litho stratigraphy of the study area considering litho-stratigraphy of the previous work carried out in adjacent areas,
- To cover area with selected sections throughout Siwalik Group of rocks in the Southern part and metasedimentary Group of rocks of the Lesser Himalayan in the Northern part of the study area,
- To collect the samples for the assessing lithology of the area, assess potential source, seal and reservoir rocks, and
- Trace the hydrocarbon horizon (formation) within the study area.

METHODOLOGY

Desk Work: The existing reports, data and available literature were review before going to field.

Field Work: Geological traverse was carried out using Brunton compass, tape, hammer, GPS and topographic base map of 1: 25,000 scale in major rivers and streams. Eight different samples were collected from different litho-units.

Lab Work: After returning from field, final compilation of geological map and its editing was done. Geological section was drawn. Geological map was prepared using GIS. Finally map at scale 1: 50,000 was published followed by report writing.

GEOLOGY OF THE STUDY AREA

The study area consists of alluvial deposit, Siwalik Group, Meta-Sedimentary Unit and Metamorphic Group of rocks. The alluvial deposit of quaternary to recent forms the plain and the Siwalik rocks constitute the foothill range of Churia Hill of Sub - Himalaya. The meta-sedimentary rock is exposed along the northeastern part of mapped area. The metamorphic rocks constitute the Mahabharat Range of the Lesser Himalaya covers which almost northern part of the mapped area. Geologically the rock formation occurring in the study area is tectono-stratigraphically divisible into three groups. Siwalik Group consisting of molasses sediments occurring to the south of Main Boundary Thrust, the metasedimentary rock exposed north of Main Boundary Thrust and Midland Group occurring north to Mahabharat Thrust were mapped in the area. The rock of metasedimentary group is exposed in the northern part of the mapped area which are thrust over the rocks of Siwalik Group along the Main Boundary Thrust (MBT) in where as the Midland Group of rocks are thrust over the metasedimentary group along Mahabharat Thrust (MT). The oldest rocks of metamorphic group exposed in the study area consist of white massive quartzite, phyllite, gritty phyllite interbedded with gritty quartzite. Gray massive phyllites are also noted with quartz lenses and veins along the foliation planes. Stratgraphy of the area is given in Table 1 and the Fig.2 is the geology map of the area.

Table 1: Stratigraphic sequence of the study area

Group	Formation	Lithology	Tentative age
Quaternary deposit (Surfical Deposit)		Alluvial, gravel, sand, silt and clay	Quaternary
Main Frontal Thrust (MFT)			
Siwalik Group	Lower Siwalik (LS)		Middle Miocene – lower Pleistocene
	Lower Middle Siwalik (MS1)	Fine grained sandstone with interbeds of variegated mudstone and siltstone	
	Upper Middle Siwalik (MS2)	Fine to medium grained sandstone with interbeds of siltstone and mudstone. Coaly materials and plant fossils are present	
	Upper Siwalik (US)	Dominantly medium to coarse grained sandstone with subordinate pebbly sandstone interbeddded with siltstone and mudstone	
Main Boundary Thrust (MBT)			
Lakharpata Group	Gawar Formation (Gw)	Grey stromatitic dolomites with chert and inter layer of dark grey shales at places	Precambrian-Early Paleozoic
Gondwana Group	Charchare Formation (Ch)	Dark grey to black carbonaceous shale with coals, ferruginous quartzite and diamictite	Lower Carboniferous – Lower Cretaceous
Mahabharat Thrust (MT)			
Midland Group	Not differentiated (Md)	Grey anf greenish grey chloritc phyllite and white grey quartzite	Precambrian

GONDWANA GROUP

The rocks of this group consists of black, calcareous shale and quartzite and diamictites in some places. Charchare Formation of this group was only mapped within the study area.

Charchare Formation (Ch)

This formation lies below Mahabharat Thrust. The rocks are well exposed along Trijuga Nadi, Baruwa and Latan Kholas, and rocks are of dark grey to black, calcareous shale and quartzite. Thick beds of diamictites of different clasts are present along the Latan Khola section (Fig. 3). This formation terminated at Chhaude Khola by a fault. The formation is considered to be of Lower Carboniferous – Lower Cretaceous age of Gondwana Group.

In general, the strike of the rock in the area is NW-SE, sometimes NE-SW and the bed dips NE to NW in angle of 50^0- 60^0.

Lakharpata Group

The rocks of this group consists of stromatilitic dolomite with chert band, shale, grey gritty sandstone and conglomerate beds. Gawar Formation of Pre-Cambrain to Early Palaeozoic age was mapped in the study area.

Fig. 3: Thick beds of diamictites with clasts along the Latan Khola

Gawar Formation (Gw)

This formation lies above the Main Boundary Thrust (MBT). The rocks are well exposed along Trijuga Nadi, Baruwa Khola and Latan Khola. The rock is composed of stromatilitic dolomite with chert band and layers parting of shale (Fig. 4). Some brown to grey gritty sandstone and conglomerate beds are also observed in upper portion. Well exposed beds are seen in Trijuga Nadi, Baruwa Khola section.

In general, the strike of the rock in the area is NW-SE, sometimes NE-SW and the bed dips NE to NW in angle of 30^0- 50^0.

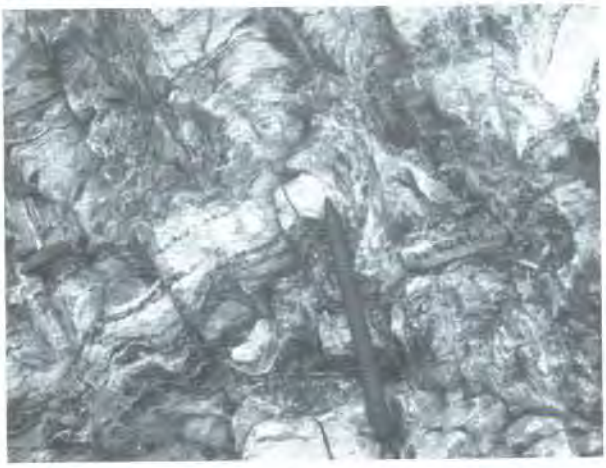

Fig 4: Stromatilitic dolomite exposed along Baruwa Khola near Bel Doban

Siwalik Group

This group of rock is geologically, youngest east-west in the southern part of the Lesser Himalaya. It forms almost 80% of the present study area. This group of rock is bounded by MFT in the South and MBT in the north. It consists of mudstone, siltstone, shale, clay and conglomerate. The age of Siwalik group is considered to be of Middle Miocene to Lower Pleistocene.

This Siwalik Group consists of different lithological units as Lower Siwalik, Lower Middle Siwalik, Upper Middle Siwalik and Upper Siwalik as described below from South to North.

Lower Siwalik (LS)

This is the oldest formation of Siwalik group and found in basal part. The rocks of this formation are well exposed east-west along Baruwa Khola, Apsota Khola, Saraswati Khola, Hoske Khola, Trijuga Khola and Balan Khola lying above KTT. Similarly this formation is also exposed along Baidhyanath Khola and Trijuga Khola in the Northwest part of the study area. The formation is composed of fined to medium grained, light gray to gray colour sandstone, variegated mudstone, light gray fine grained siltstone, and with marl bed (Fig.5) . The formation is considered to be of Middle Miocene Lower Pleistocene age.

In general, the strike of the rock in the area is NW-SE, sometimes NE-SW and the bed dips NE to NW in angle of 30^0- 80^0.

Fig 5: Variegated mudstone exposed along Jaljale Murkuchi Road Section

Middle Siwalik (MS)

Middle Siwalik has normal and gradational contact with the underlying Lower Siwalik. This unit is composed of fine to coarsed grained sandstone; pebbly sandstone is also interbedded with sanstone in few places. Lower portion of this formation consists of fine to medium grained sandstone and coarseness of sand increase towards north with pebbly sandstone. This unit of the rock is further subdivided to Lower Middle Siwalik (MS1) and Upper Middle Siwalik (MS2).

Lower Middle Siwalik (MS1)

This formation has gradational contact with the underlying Lower Siwalik. The rocks of this formation are exposed east to west in the northern part of the study area along Baruwa, Apsota, Saraswati and Hoske khola, Trijuga River and Baidhyanath Khola. It is also exposed in Balan, Chapan and Khado Khola in the southern part. Lower Middle Siwalik is mainly composed of sandstone, mudstone, and siltstone. Sandstone of this unit is light gray to gray coloured, medium grained with interbedding of mudstone and siltstone (Fig. 6). This unit is mainly characterized by arkosic sandstone. The formation is considered to be of Middle Miocene to Lower Pleistocene age.

In general, the strike of the rock in the area is NW-SE, sometimes NE-SW and the bed dips NE to NW in angle of 30^0- 80^0.

Upper Middle Siwalik (MS2)

Upper Middle Siwalik is conformably overlies the MS1 with gradational contact.The rocks of this formation is found on the southern part from east to west and exposed along Khado, Chahaka, Sisubari, Balan and Rupani Khola. Similarly this formation is also exposed along Baruwa Khola in northeast of the study area. This unit of rock is composed of gray to light gray coloured, medium to coarse grained sandstone with interbedding of siltstone, mudstone, fine grained sandstone and pebbly sandstone (Fig. 7). Cross bedding structure are seen. This rock unit is loosely packed with coal seam in few lenses. The formation is considered to be of Middle Miocene to Lower Pleistocene age.

In general, the strike of the rock in the area is NW-SE, sometimes NE-SW and the bed dips NE to NW and sometimes S in angle of 30^0- 50^0.

Fig 6: Thick bedded sandstone exposed along Adheri Khola near Murkuchi

Fig 7: Coarse grained sandstone exposed along the Kharak Nadi near Kalyanpur

Upper Siwalik (US)

Upper Siwalik conformably overlies the Middle Siwalik (MS) with gradational contact. This formation occurs east-west in the central part of the study area and well exposed along Lohan Khola, Sagarmatha Highway, Balan Khola and composed of gray to light gray coloured conglomerate beds with medium to coarse grained sandstone with interbedding of siltstone, mudstone, fine grained sandstone and pebbly sandstone (Fig. 8). The formation is considered to be of Middle Miocene to Lower Pleistocene age.

In general, the strike of the rock in the area is NW-SE, sometimes NE-SW and the bed dips NE to NW and sometimes S in angle of 30^0- 70^0.

Fig. 8: Conglomerate beds exposed along the Dhungre Khola

Surficial Deposit

The surficial deposit occurs in Terai in the southern most and Trijuga River Valley in central part of the study area.

Terai is a rich, fertile and ancient land in the southern part of the study area. It is also called Indo-Gangetic Plains.The vast alluvial plains of the Indo-Gangetic Basin evolved as a foreland basin in the southern part of the rising Himalaya, before breaking up along a series of steep faults known as the Main Frontal Thrust (MFT). The alluvial deposit is of quaternary to recent forming the plain. The alluvial consists of gravel, sand, clay, silt.

GEOLOGICAL STRUCTURE

Mahabharat Thrust (MT), Main Boundary Thrust (MBT), Main Frontal Thrust (MFT), Kamala Tawa Thrust (KTT) are major structures of the area followed by local scales fault and folds.

Mahabharat Thrust (MT)

The low angled reverse fault is called thrust. In the study area, the MT separates the Gondawana Group and Midland Group of Lesser Himalaya into two complexes in the eastern part of the study and Siwalik and Midland Group in the western part.

Main Boundary Thrust (MBT)

The northernmost boundary of the Siwaliks Group is marked by the MBT over which the low-grade metasedimentary rocks of the Lesser Himalaya overlie.

Main Frontal Thrust (MFT)

The MFT which marks the southern edge of the sub-Himalayan fold belt is the considered to be active structure in the area. The MFT cannot be well marked in the study area but this thrust separates the alluvial deposit of plain and sedimentary rock of Siwalik Group.

Kamala Tawa Thrust (KTT)

This thrust extends from east to west in the study area and well exposed along Balan Khola and Trijuga River. This lies over the Upper Siwalik Group and Lower Siwalik.

HYDROCARBON POTENTIAL

The surface geology of Siwalik Group indicates thick and multi - channels of sand of reservoir quality and expected to continue on the subsurface. There is sufficient shale, confined to the lower part of the section, to provide good seals (Lower and Middle Siwalik). Samples of mudstone, sandstone, metasandstone, quartzite, dolomite were taken for laboratory findings. Hydrocarbon potential in aspect of potential source, reservoir and seal rock can be assessed after the laboratory findings only.

CONCLUSION AND RECOMENDATIONS

- The rock occurring in the study area have been divided into the Siwalik Group, Meta Sedimentary Group and Metamorphic. Group, and the boundary between these groups are mainly thrust, causing the thrusting of the older over the younger. The older groups of rocks are confined in the northern part of the study area whereas the younger group of rock are confined in the southern part of the study area.
- Mahabharat Thrust (MT), Main Boundary Thrust (MBT), Main Frontal Thrust (MFT) and Kamala Tawa Thrust (KTT) are the major structures of the area.
- Samples collection was done for the assessing lithology of the area, potential source, seal and reservoir rocks.
- Geological map and section of the study area in the scale of 1:50,000 was prepared and published.
- It is recommended to use the high resolution satellite image and remote sensing technique in correlation with the field works and the collected samples should be sent to laboratory for its hydrocarbon potentiality.

ACKNOWLEDGEMENT

We are grateful to Superintendent Geologist Mr. R P Khanal, Project Chief, Petroleum Exploration Promotion Project for providing valuable guidance to prepare this paper. We are very much grateful to Editorial Board for editing the report and providing valuable suggestions.

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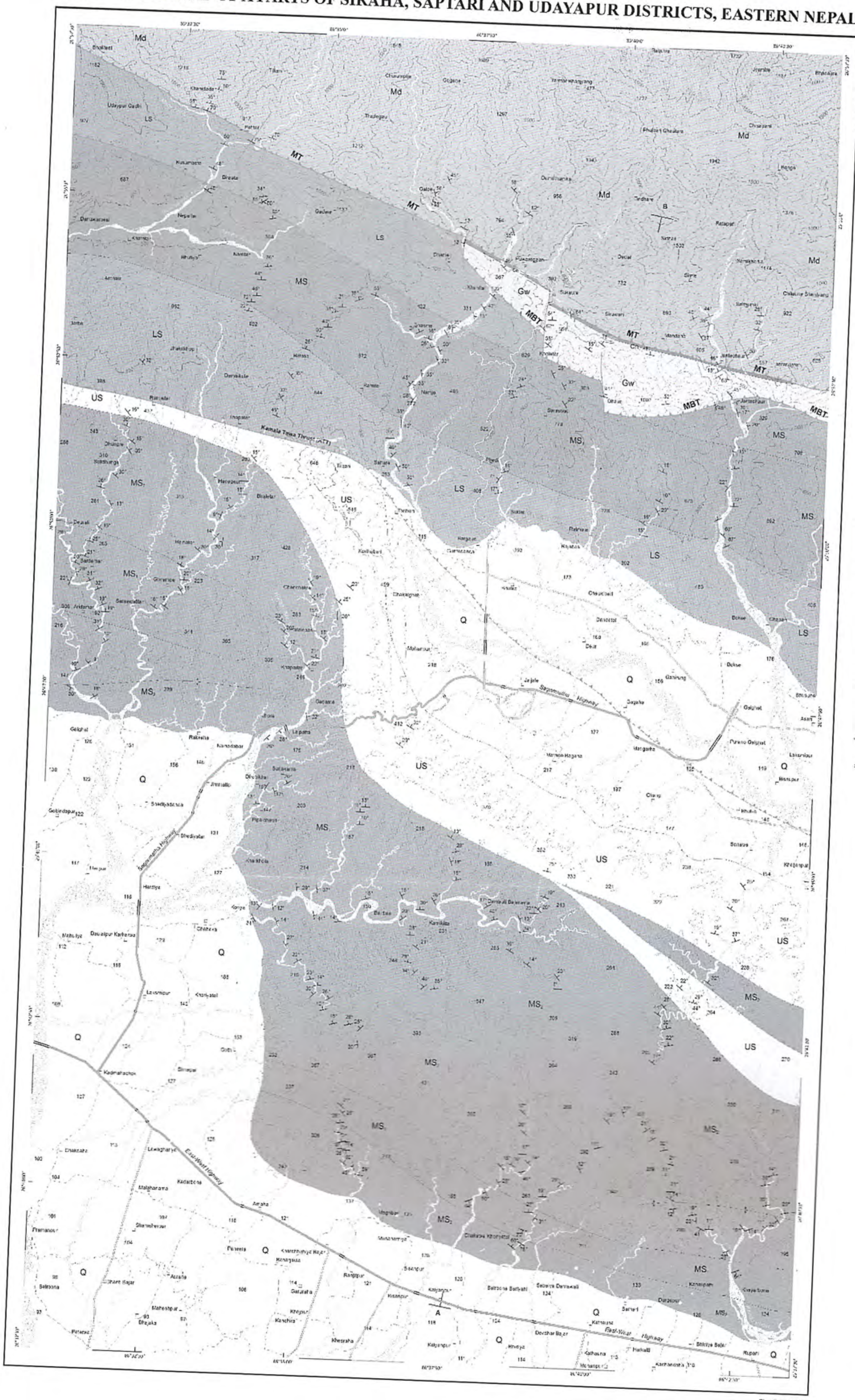
GEOLOGICAL MAP OF A PARTS OF SIRAHA, SAPTARI AND UDAYAPUR DISTRICTS, EASTERN NEPAL



First Edition 2012

LEGEND

SURFICIAL DEPOSITS (Quaternary - Recent)

Q | Alluvium, boulder, gravel, sand silt and clay.

SIWALIK GROUP (Middle Miocene - Lower Pleistocene)

US | **Upper Siwalik :** Boulder, cobble, conglomerate with minor grey mud stone and sand stone bands.

MS_2 | **Upper Middle Siwalik :** Dominantly Medium to coarse grained sandstone with subordinate pebbly sandstone interbedded with siltstone and mudstone.

MS_1 | **Lower Middle Siwalik :** Fine to medium grained sandstone with interbeds of siltstone and mudstone. Coaly materials and plant fossils are present.

LS | **Lower Siwalik :** Fine grained sandstone with interbeds of varigated mudstone and siltstone.

GONDWANA GROUP (Lower Carboniferous -Lower Cretaceous)

Ch | **Charchare Formation :** Dark grey to black carbonaceous shale with coals, ferruginous quartzite and diamictite.

LAKHARPATA GROUP (Precambrian - Early Paleozoic)

Gw | **Gawar Formation :** Grey dolomite with chert bands and inter layer of dark grey shales at places.

MIDLAND GROUP (Precambrian)

Md | Grey and greenish grey chloritic phyllite and white grey quartzites

STRUCTURE

- Geological Contact
- Geological Contact Inferred
- Alluvium Boundary
- Thrust
- Thrust Inferred
- Fault
- Anticlinal Axis
- Synclinal Axis
- A – B Trace of Section
- Attitude of bed
- MBT Main Boundary Thrust
- MT Mahabharat Thrust
- KTT Kamala Tawa Thrust

PHYSIOGRAPHIC FEATURES

- •106 Elevation in meter
- Contour in meter
- River and drainage
- Pond, Canal
- Built-up area, Town, Village
- Highway, Other road
- Trail
- Bridge, Suspension bridge

SCALE 1:50,000

0 0.5 1 2 3 4 5 KM

Contour interval 100 meters

INDEX TO SHEETS

GEOLOGICAL SECTION
Scale 1:50,000

SECTION ALONG A - B

Annual Report of Department of Mines and Geology, 2013, No. 9 & 10, pp.57-61

Geological Mapping of Some Parts of Dailekh and Surkhet Districts, Mid Western Nepal

Suresh Shrestha (Geologist)

ABSTRACT

The study area comprises of rocks of Siwalik, Lakharpata, Surkhet and Midland Groups. The Siwalik rocks are separated from the Lakhapata Group by Main Boundary Thrust (MBT) and the Surkhet Group rocks are separated from the Midland Group by Ranimatta Thrust. The main rock types of Siwalik Group are fine to medium grained, gray sandstones, red mudstones and shale. Similarly, the Lakharpata Group consists of grey to bluish grey limestone with cherty dolomites and limestones along with little sandstones and shale. The Surkhet Group consists of sandstones, shale, and ferrugineous quartzite. Schist, augen gneiss, quartzite and phyllites with considerable amount of basic rocks are the rock types of the Midland Group.

INTRODUCTION

The field investigation was carried out according to the annual field program of Department of Mines and Geology (DMG) in the fiscal year 2068/69 to prepare the Geological map in 1:25,000 scale. The study area lies in Dailekh and Surkhet districts bounded by the latitude 28° 38' 6"N to 28° 45' 0"N and longitude 81° 34' 48" E to 81° 42' 36" E in the topo sheet no. 2881 07A and 02B prepared by Survey Department, Government of Nepal (scale 1:25,000)(Fig.1). The total area covered is about 140 sq. km. Sot, Parajul and Rati Kholas are the major streams that drain the study area. The maximum and minimum altitude is 2255m near Jhandi and 812m near Jyamire, respectively. The study area is easily accessible by vehicle from Kathmandu –Kohalpur – Surkhet –Dailekh road.

OBJECTIVE

The objective of the field work was to update the existing geological map and prepare the geological map of the study area at the scale 1:25,000.

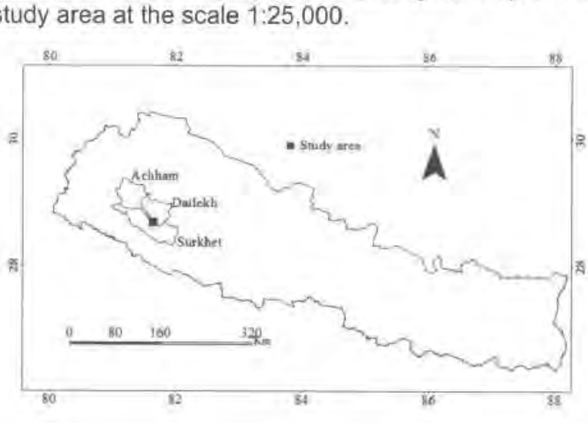


Fig. 1: Location map of study area

METHODOLOGY

Desk study

During the desk study the previous work done by different authors in the area and its adjacent area were studied thoroughly. It includes the study of the geological maps and the reports of the study area. Similarly, different satellite images and Google maps were studied to delineate the tectonic features.

Field study

The geological mapping was carried out with the help of Brunton compass, Geological hammer, GPS,dilute HCl, handlens, magnet and1:25,000 scale topomap of the study area. During the field study, traverse along the valleys, spur and ridges were made to know the geology and to delineate geological contact in the study area. The data obtained from the field and the secondary data from the previous study by different researchers were used to prepare the Geological map of the area at 1:25,000 scale.

PREVIOUS STUDY

Geological studies have been carried out by a number of geoscientists in the Surkhet-Dailekh area. Among them, Shrestha (1972/73), Kayastha (1969/70) had done the geological mapping covering some parts of the study area and divided the study area into different formation according to the lithology and age. Likewise Geological map of petroleum exploration block- 3 Nepalgunj, Mid Western Nepal published by the Petroleum Exploration Promotion Project (PEPP) at 1:2 50,000 scale in 1999 divided the study area into Dubidanda, Gwar, Melpani, Swat, Suntar and Lower Siwalik. Similarly, foreign researcher Gerhard Fuchs also studied the geology of Karnali-Dolpo Region in 1977.

GEOLOGY OF THE STUDY AREA

The study area consists of the rocks of Lesser Himalaya and Siwalik Group. The Midland, Lakharpata and Surkhet Group rocks belong to Lesser Himalaya. The Midland group is divided into two formations as Dubidanda and Nabhisthan Formations and major rock types are schist, phyllites, feldspathic Schist, quartzites, augen gneiss and lots of basic intrusives. There is only one formation (Gawar Formation) of Lakharpata Group in the study area and it consists of dolomite, limestone, shale and sandstone. Similarly the Surkhet Group consists of three formations Melpani, Swat, and Suntar. It consists of shale, sandstone and limestone as major rock types. The Midland group rocks are thrust over the rocks of Lakharpata (Early Paleozoic) and Surkhet Group (Upper Cretaceous and Lower Miocene). Ranimata Thrust separates these two sequences. The siwalik rocks are separated from the Lesser Himalayan rocks by the Main Boundry Thrust (MBT) and the study area consists of fine grained light grey sandstones with red coloured mudstone and shale which belong to Lower Siwalik (Fig. 2).

The general startigraphy of the study area could be summarized as below (Table 1).

Midland Group

In the study area Midland Group consist of two formations as Dubidanda and Nabhisthan Formation. The midland group is thrusted over the Surkhet Group rocks. The age of this group is Precambrian.

Table 1: General Startigraphy of the study area

Age	Group	Formation	Lithology
(Middle Miocene to Lower pleistocene)	Siwalik Group	Lower Siwalik(Ls)	Fine grained to medium grained sandstones and red shale
		-----MBT-------	
(Upper Cretaceous-Lower Miocene)	Surkhet Group	Suntar Formation(Su)	Green to greenish grey sandstones and red shale
		Melpani Formation(Mp)	White and grey ferruginous Quartzite/ sandstones and shale with basal conglomerates and fossils
		----Unconformity-------	
Precambrian to early Paleozoic	Lakharpata Group	Gawar Formation(Gw)	Grey stromatolitic dolomite and limestone with Sandstones and shale
		----Ranimatta thrust----	
Precambrian	Midland group	Nabhisthan Formation(Nb)	feldspathic schist and schist with few augen gneiss and quartzites.
		Dubidanda Formation(Dbd)	Grey to dark geeenish grey phyllites, Dark grey to grey Quartzite, white Quartzite and Greenish Basic rocks

Dubidanda Formation (Dbd): This is the oldest formation of the Precambrian age in the study area. This unit is exposed along the Surkhet- Dailekh road from Lade to Talpokhari, Guranse, Ratanangla and along the Ratikhola. The rocks of this formation are thrusted over the younger Surkhet Group rocks. It is separated from the Surkhet Group rocks by Ranimatta thrust in the south. The main lithologies are dark gray to green phyllites with lots of quartz veins, dark grey to light to dirty white fine grained micaceous quartzite and grey schist with large volume of dark greenish grey medium to coarse grained foliated amphibolites (Fig. 3).The general strike of the foliation plane is NW-SE and dip towards NE except along the local folds. The dip amount varies from 40° to 85°.

Fig. 3: Basic rock within Dubidanda at Lade area

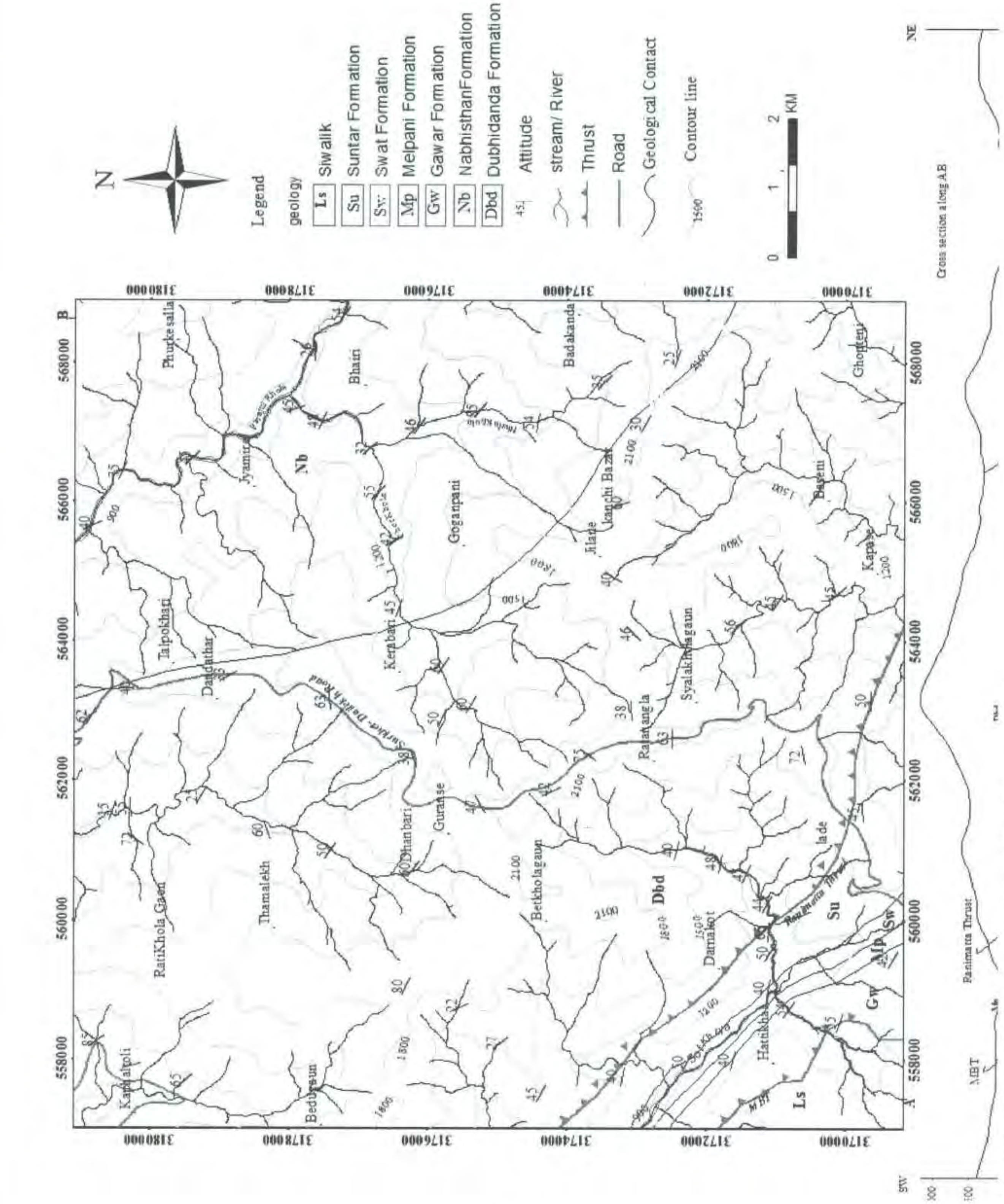


Fig. 2. Geological Map of parts of Surkhet and Dailekh District

Nabhisthan Formation (Nb): Nabhisthan Formation is exposed at the catchment area of Parajul Kola in the study area. Feldspathic schist with porphyroblast of feldspar crystal, augen gneiss, grey to light grey schist (Fig. 4) intercalated with the micaceous quartzite and few grey to bluish grey marble and calc-schist are the rock types found in this formation. Strike and dip direction are NW-SE and NE, respectively. But there are lots of local folds in the schist beds in this formation. The dip amount varies from 30° to 75°.

Fig. 4: Schist from Nabhisthan Formation near Lade Lakharpata Group

Lakharpata Group

Lakharpata Group consists of Sangram, Ramkot, Gawar, Khara and Katuwa Formations (PEPP, 1999). The study area consists of only Gawar Formation. This group is thrust over the Siwalik Group.

Gawar Formation (Gw): Gawar Formation belongs to the Lakharpata Group. Lakharpata Group is thrust over the Siwalik Group and is separated from Siwaliks by the MBT to the south. The rock types of this formation are dolomitic, gray to bluish grey limestone with cherty dolomites and few sandstones and shale. The strike of the beds is NW-SE and dips towards NE with 30° to 55°.

Surkhet Group

The surkhet Group consists of Melpani, Swat and Suntar Formations and is separated from the Lesser Himalaya by Ranimatta thrust.

Melpani Formation (Mp): Melpani Formation belongs to the Surkhet Group according to the startigraphy. It is exposed along the Sot Khola area. This formation is separated from the Gawar Formation by unconformity. The basal part of this formation consists of conglomarates. The lithology are white to brown grey ferrugineous quartzitic sandstones and little grey shale.

Swat Formation (Sw)

This formation comprises the dark grey to black shale with limestone (Fig. 5). The outcrops of this formation are exposed in the Sot Khola area and in Baguwa area. The strike of the beds is NW-SE and dip towards NE with 50° to 85° amount. This formation conformably lies over the Melpani Formation.

Fig. 5: Black shale from Swat Formation along Sot Khola

Suntar Formation (Su): Suntar Formation is the youngest formation of Surkhet Group. It is exposed at Sotkhola Gaon and Baguwa village. In the north it is separated by Ranimatta thrust. The bedded rocks formation are thick to very thick green sandstone with dark red shale (Fig. 6). The strike of the beds is NW-SE and dips towards NE with 30° to 55° amount.

Fig. 6: Red purple shale from Suntar Formation near Sotkhola

Siwalik Group

The Siwalik Group is separated from lesser Himalayan rocks by Main Boundry Thrust (MBT) and consists of sandstone, mudstone, siltstone, shale, and conglomerates. The Siwalik Group can be divided into Lower, Middle and Upper Siwaliks but the study area consist of only Lower Siwalik.

Lower Siwalik (Ls): The rocks at the southern part of MBT are Siwalik Group rocks. The major rock types of this group are fine to medium grained, grey sandstones, red purple mudstones and shale. The strike of the beds is NW-SE and dips towards NE with 35° to 65°.

TECTONIC STRUCTURES

Ranimatta Thrust

Ranimatta Thrust separates the Precambrian rocks from the Paleozoic rocks. The thrust is named by G.N.Dutta after the Ranimatta hill of Surkhet. The thrust is exposed in the northern part of Sot Khola, near Lade and near Bhatti Danda. In almost all area there are basic rocks of Dubidanda Formation along the thrust. The general trend of the thrust is NW-SE. The rocks of either side are highly disturbed.

Main Boundary Thrust (MBT)

MBT separates Siwaliks from the Surkhet Group rocks of upper Cretaceous and Miocene. The thrust is overlain by the dolomitic limestone and shales. The general trend of this thrust is also NW-SE. This thrust can be recognized in the field by the sudden change in the topography and lithology.

CONCLUSION

The study area consists of Siwalik, Lakharpata, Surkhet and Midland Group rocks. The Siwalik Group rocks are separated by MBT from the Lakhapata and Surkhet Group rocks. Similarly Ranimatta Thrust separates the Surkhet Group rocks from the Midland Group rocks.

ACKNOWLEDGEMENT

I am grateful to Mr. S. P. Mahato, Director General, DMG for supporting the field program and guidance. My sincere gratitude is to Mr. Hifzur Rahman Deputy Director General, DMG for valuable suggestions and fruitful discussion. Similarly I am thankful to Mr. Nabin Ghising for his help during field work.

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Annual Report of Department of Mines and Geology, 2013, No. 9 & 10, pp.63-67

Geological Mapping of Parts of Dailekh and Achham Districts of Mid and Far Western Nepal

Kumar Khadka (Geologist)

ABSTRACT

Parts of Dailekh and Achham Districts of Mid and Far-Western Nepal consist of metasedimentary rock of Midland Group and Surkhet group of Lesser Himalaya and Crystalline rocks of Himal Group. Ranimatta Thrust (RT) and Mahabharat Thrust (MT) are major structures of the area. There are many local scales fault and folds.

INTRODUCTION

The field investigation was carried out according to annual program of Department of Mines and Geology of the fiscal year 2068/69. The study area covers toposheet no. 2881 03C and 2881 03D at 1:25000 scale prepared by Survey Department, Government of Nepal in 1999. The investigated area lies between latitude 28^0 45' 00" to 28^0 52' 30" north and longitude 81^0 30' 00" to 81^0 45' 00". The study area covers 350 square kilometers of parts of Dailekh and Achham districts (Fig.1). It has been studied by taking selected traverse along the different khola section, spurs and ridges traverse on the foot of the assigned area. The field program was connected with the compilation work for map publication and was design to check the problematic area to correlate the geology and structure of the adjacent area.

Fig.1: Location Map of the Study area

Geological studies have been carried out by many researchers in and adjacent to the study area. Dhouindal (1958) carried out an investigation with a view to make preliminary examination of the inflammable gas seepage at Siristhan, Nabhisthan and Padukasthan in Dailekh districts. He also studied the geology of the area. Sharma (1968) made some geological traverse from Surkhet to Dailekh and investigated the thrusted pile of metamorphic above the Eocene Formation. Sing (1963, 1965) worked on oil show of Padukasthan. Bhattrai (1973) prepared a regional geological map of the area and gave a fair account of metamorphisim, structure, petrography and igneous activity. Kayastha (1969/70), Shrestha (1972/73), from Nepal Geological Survey have done regional geological mapping of the study area. Khadka (2001) from Department of Mines and Geology has reconnaissance study on geochemical prospecting of base metals and gold in this area.

OBJECTIVE

The study was planned to meet the following objectives:

- To update the existing geological map of the study area,
- To prepare geological map of the study area in 1:25,000 scale, and
- To study the tectonic elements and lithological units.

GENERAL GEOLOGY

The study area is represented by the meta-sedimentary and metamorphic rocks belonging to the Precambrian era. These rocks mainly belong to the Himal Group, Midland Group and Surkhet Group rocks of Lesser Himalaya (Table 1). Review of existing maps suggests that the area is represented by metamorphic and meta-sedimentary rock sequences intruded by igneous rocks. Thrusts and faults of regional and local scale are also mapped in the area indicating weak belts as shown in geological map (Fig.2). The Midland Group is equivalent to the Lower Nawakot Complex of Central Nepal and Surkhet Group is equivalent to the Tansen Group of Central Nepal. However, the stratigraphy of the central Nepal cannot be applied directly to the meta-sedimentary rocks of the present study area as there is missing of some lithlogical rock units in Western Nepal, though similar lithological assembelages and stratigraphy are observed.

Table 1: Stratigraphic sequence of the study area

Age	Group	Formation	Lithology
Cenozoic	Surkhet Group	Suntar Formation (Su)	Garnet-biotite schist, biotite muscovite quartzite interbeddings. Brownish white to greenish white quartzite interbended with garnetiferous schist and phyllites.
-------------------Ranimatta Thrust (RT)----------------------------			
Precambrian	Midland Group	Nabhisthan Formation (Nb)	Dominantly gray to greenish grey phyllite interbanding with greenish gray phyllitic quartzite and white, coarse grained, massive quartzite.
		Dubidada Formation (Dbd)	White coarse grained Quartzite, feldspathic schist and grey gritty phyllite._
---------------------Mahabharat Thrust (MT)-----------------------------			
	Himal Group	DailekhFormation (Da)	Red to purple shale, interbended with green sandstones.

Surkhet Group

This group of rocks is deposited over the rocks of Midland Group. The rocks of Suntar Formation are found in Achham district, South-Western part of the study area.

Suntar Formation (Su): This formation is exposed around Karange Khola, Bhurange village and adjacent of Karnali River, south western part of the study area. This formation is separated from Midland Group rock by Ranimatta Thrust. The main lithology of this formation is brick red to pinkish sandstone and olive green to greenish shale (Fig 3). The rocks are generally NE dipping with dip amount 35^0-70^0.

Fig.3: Brick and cherry red to pinkish sandstone and olive green shale intercalation in Suntar Formation

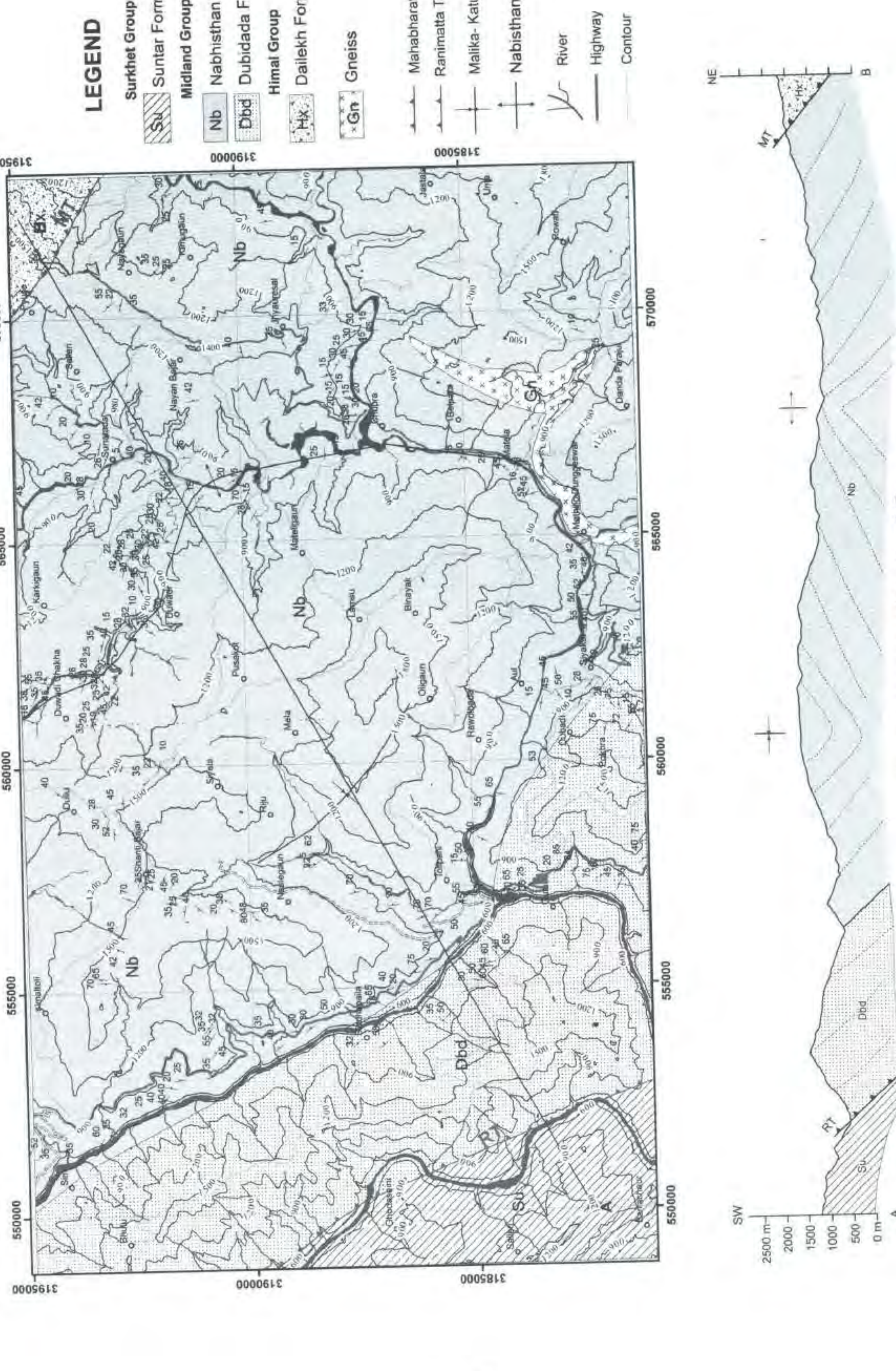
Midland Group

The rock of Midland Group is well exposed all in the study area and is represented mainly by flyscoid sequence consisting of bedded feldsphathic schist, phyllite and metasandstone, locally shallow water quartz beds, sills and dykes and basic rocks (mainly amphibolites). The Midland Group rocks are thrust over the Surkhet Group rocks. It consists of Dubidada Formation and Nabhisthan Formation.

Dubidada Formation (Dbd): It is the Precambrian rock. It consists of white, fine to medium grained, thickly bedded massive quartzite, white feldsphatic schist (Fig. 4) and greenish grey gritty phyllite. This formation is exposed above the Ranimatta thrust which separates the rocks of Midland Group and Surkhet Group rocks. The rocks of this formation are dipping NE with dip amount variation of 300 to 700. They are well exposed along Surkhet-Jumla road, Surkhet-Dailekh Road section and in Achham district of the study area.

Fig.4: White Feldsphatic schist and quartzite along Dailekh Surkhet road near Dungeshwor.

Nabhisthan Formation (Nb): The name "Nabhisthan Formation" was derived from the temple of Nabhisthan in the Dailekh District. It is exposed in the Utiseni khola, Lohore khola, Nabhi khola, Paduka khola, Rama gad, Kure khola, Taraghat khola and Tiperi khola sections. It is characterized by lead gray, serricitic phyllite and psamnatoc phyllite interbanded with greenish gray quartzite, coarse grained, white serictic quartzite and felspathic schist. In quite few places, dark gray garnetiferous schist and quartzite with magnetite were exposed around Nabhisthan, Chuppra and Dailekh. It has general trend of NE and NW forming anticline with dip amount varying from 15° to 74°. The ferruginous quartzite band is exposed along



Geological cross-section along A-B

Fig. 2: Geological map of parts of Dailekh and Achham Districts

Nabhi Khola, north of Nabhisthan Temple. The Ferygeneous quartzite band is 1m to 5m thick which consist of few magnetite and disseminated pyrite crystals (Fig.5). Gas seepage observed in Siristhan, Nabhisthan and Padukasthan show the hydrocarbon gas trapped in the rock of this formation (Fig. 6).

Fig.5: Ferruogeneous quartzite band in left bank of Nabhikhola

Fig.6: Gas Flames in Nabhisthan temple

Himal Group

The rock of this group consists of garnetiferous schist, massive quartzite and few crystalline marble. In the study area, the group constitute Dailekh Formation.

Dailekh Formation (Da): The Dailekh Formation is named after Dailekh District. The rocks of this formation consist of coarse grained, thick bedded, brownish white quartzite and grey garnetiferrous schist. The formation is separated from Nabisthan Formation nearby Bellaspur Temple in Dailekh by Mahabharat Thrust (MT). Few bands of bluish white crystalline marble is well exposed in Goladeu village, east of Dailekh (Figs. 7 and 8). The rocks of this formation are dipping NE with dip amount variation of 15^0 to 45^0.

Fig.7: Marble bed exposed just above MT in Dailekh Formation

Fig. 8: Coarse crystalline Marble

STRUCTURE

Ranimatta Thrust (RT)

It is named after village Ranimatta north of Surkhet along the Surkhet-Dailekh road (Kayastha., 1992). It separates sedimentary rock of Suntar Formation from metamorphic rocks-phyllite and quartzite of the Dubidada Formation. This abrupt change in lithofacies from sedimentary to low grade metamorphic rock defines the presence of the thrust.

Mahabharat Thrust (MT)

Mabharat Thrust separates the crystalline rocks of Himal from the metasedimentary rocks of Midland Group. The thrust is dipping gently towards north. The black crushed materials and highly crystalline marble are exposed in the Bijaura village is an evidence of MT.

Nabhisthan Anticline

Axis of Nabhisthan Anticline runs more or less along the Lohore Khola, Nabhi Khola up to Paduka Khola with NW to SE trend. The rocks are moderately dipping towards NE and SW on the both limbs. This anticline is in the Nabhisthan Formation.

Malika-Katuwal Gau Syncline

This syncline passes from Katuwal Gaun to Malika just above the junction of Sot Khola and Bartadi Khola. Both limbs of syncline dip in angle of 30^0 to 40^0 towards SW and NE directions. This is exposed in the Nabhisthan Formation.

CONCLUSION

The rock occurring in the study area have been divided into the Meta-sedimentary, Metamorphic and Crystalline Group, and the boundary between these groups are mainly thrust. The older rocks of Himal Group are confined in the northern part and that Dubidanda Formation are confined in the southern part of the study area. Nabisthan Formation are confined in the central part where as the younger rocks of Surkhet Group are confined in the southern part of the study area. Mahabharat Thrust (MT), Ranimatta Thrust (RT) and Nabhisthan anticline are the major structures of the area that are traced.

ACKNOWLEDGEMENT

We are grateful to Mr. Sarbjit Prasad Mahato, Director General, Department of Mines and Geology for providing necessary facilities and valuable guidance to conduct the fieldwork. We are very much grateful to Mr. Hifzur Rahaman, Deputy Director General, Ashok Kumar Duwadi, Senior Divisional Geologist, for thier active encouragement and guidance for the report writing and editing. My thanks goes to Mr. Suresh Shrestha, Geologist and Rajan Khadka, Lab assistant for accompanying the field work.

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Activities of National Seismological Centre of Department of Mines and Geology in Fiscal Year 2068/2069

INTRODUCTION

The National Seismological Network of Department of Mines and Geology, Nepal in collaboration with Department Analyse Surveillance et Environment (DASE, France) has been monitoring seismic activity of Nepal Himalaya and its adjacent region. At the moment, this network consists of 21 short periods vertical, one 3-components long period and one 3-components broadband seismic station covering the whole country with two independent recording centers. The records from the stations in Central and Eastern Nepal are continuously transmitted to the National Seismological Center (NSC), Kathmandu using its own radio link and similarly records from stations in Mid and Far Western Nepal are telemetered to the Regional Seismological Center, Surkhet (RSC). The main purpose of the network is to locate and evaluate seismic events and to alert the authorities of the occurrence of all magnitude greater than or equal four within the national territory. By the end of 2011, 135667 earthquakes have been recorded, out of which 48639 are local/regional and 87028 are teleseisms. NSC has recorded 2587 local events in the fiscal year 2068-69 (Figs.1 and 2).

Among them 113 events were above 4 ML (Local Magnitude) and only 44 events were within the national territory were press released (Table 1, Fig. 3).

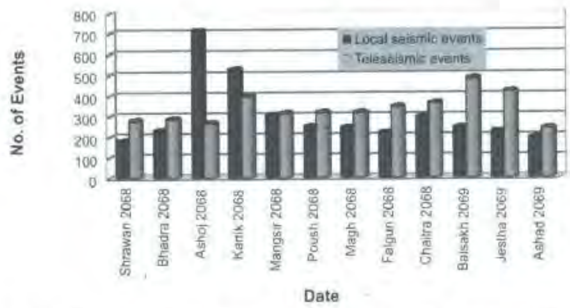

Fig.1: Bar diagram showing number of earthquakes during fiscal year 2068/69

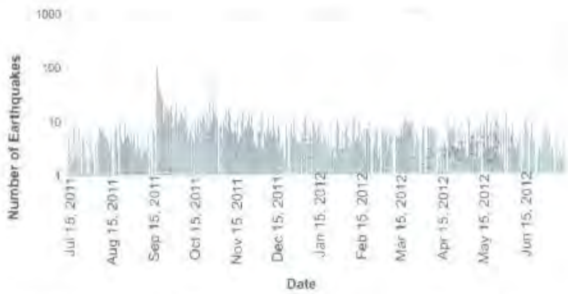

Fig. 2: Frequency of Local Earthquake in Nepal Himalaya (eq/day)

Table 1: Annual press released events (15 July 2011 to 14 July 2012)

Date	Latitude	Longitude	Magnitude ML	Epicenter
17/06/11	30.24	81.48	4.2	Humla
18/06/11	27.83	87.35	4.3	Sankhuwasabha
15/07/11	27.28	87.3	4.5	Sankhuwasabha
29/07/11	27.19	86.76	4.2	Khotang
02/08/11	27.35	86.35	4	Khotang
09/08/11	29.9	81.31	4.3	Bajhang
15/08/11	27.44	86.27	5	Ramechhap
18/08/11	28.21	84.31	4	Lamjung
19/08/11	29.7	81.34	4.9	Bajhang
22/08/11	28.29	83.96	4	Kaski
25/08/11	28.15	82.53	4.4	Rolpa
27/08/11	26.94	86.6	5	Udayapur
18/09/11	27.78	88.32	6.8	Taplejung-Sikkim Border

Table 1 Cont...

Date	Latitude	Longitude	Magnitude ML	Epicenter
01/10/11	30.16	81.81	4.7	Humla
02/10/11	29.55	81.68	4.2	Bajura
04/11/11	28.34	83.66	4	Parbat
08/11/11	27.94	85.55	4.1	Sindhupalchowk
13/11/11	28.2	84.93	5	Gorkha
19/11/11	27.7	86.1	4.1	Dolakha
23/11/11	28.91	81.68	4.2	Dailekh
02/12/11	28.05	85.34	4.2	Rasuwa
08/12/11	27.97	82.86	4	Pyuthan
09/12/11	27.83	88.13	4.2	Taplejung
14/12/11	27.72	88.09	4.9	Taplejung
18/12/11	27.73	88.16	4.6	Taplejung
30/12/11	29.62	81.53	4	Bajura
11/01/12	28.89	81.89	4.2	Dailekh
18/01/12	26.63	86.4	4.5	Siraha
19/01/12	29.73	81.91	4.6	Humla
24/01/12	26.84	86.43	4	Siraha
05/02/12	27.25	88.07	4	Panchthar
14/02/12	27.33	88.03	4.4	Taplejung
14/02/12	27.38	88.11	4.5	Taplejung-Sikkim Border
26/02/12	29.86	81.05	4.9	Bajhang- Darchula border
26/02/12	29.71	81.02	4.4	Bajhang- Darchula border
19/03/12	28.7	82.02	4.7	Karkigaun-Jajarkot
27/03/12	26.12	87.87	5.2	Jhapa-India Border Region
11/04/12	29.55	81.24	4.3	Bajhang
17/04/12	28.5	82.06	4.2	Salyan
30/05/12	27.31	87.88	4.2	Taplejung
09/06/12	28.32	84.17	5.1	Kaski
11/06/12	27.25	88	4.5	Panchthar - Sikkim border
01/07/12	27.27	88.05	4	Panchthar - Sikkim border
11/07/12	29.43	81.03	4.9	Southern Bajhang

(Microseismicity recorded in this region allows us to refine the existing seismotectonic model which gives the exact idea of the earthquake nucleation processes prevailing in this part of the Himalaya.)

ACCELEROMETRIC NETWORK

The seismic network allows detecting and locating earthquake with magnitude greater than 2.0 Richter scale within Nepal. However, their dynamics is not sufficient to determine magnitude at short distance for the large earthquakes due to instrument saturation which makes difficulties to evaluate the ground parameter. To address this problem, 7 accelerometric stations have been deployed by the end of 2011 in collaboration with DASE (Fig. 4). This network can determine the peak ground acceleration (PGA), velocity (PGV) and displacement (PGD), along with other aggressiveness parameter information which is needed to develop the attenuation equations, building code design parameter which are important input to the seismic hazard assessment (Bhattarai, 2010). Till the end of 2012, NSC has recorded more than 400 ground motion records.

GPS NETWORK

NSC/DMG installed 29 GPS stations in technical collaboration with Caltech/USA and DASE/France across the Nepal Himalaya (Fig. 4). This network was designed to monitor slow strain build up in preparation of future earthquakes as well as transient geodetic deformation due to earthquakes, slow slip events and other sources of transient deformation. Result from this network shows that region from 150 km North of MFT is presently locked and stress is accumulating in this region (Bettinelli, 2006 and Ader, 2012). Data from some of the GPS stations are recorded on site and downloaded manually where as data from remaining stations are transmitted online and downloaded from IP address assigned to each stations.

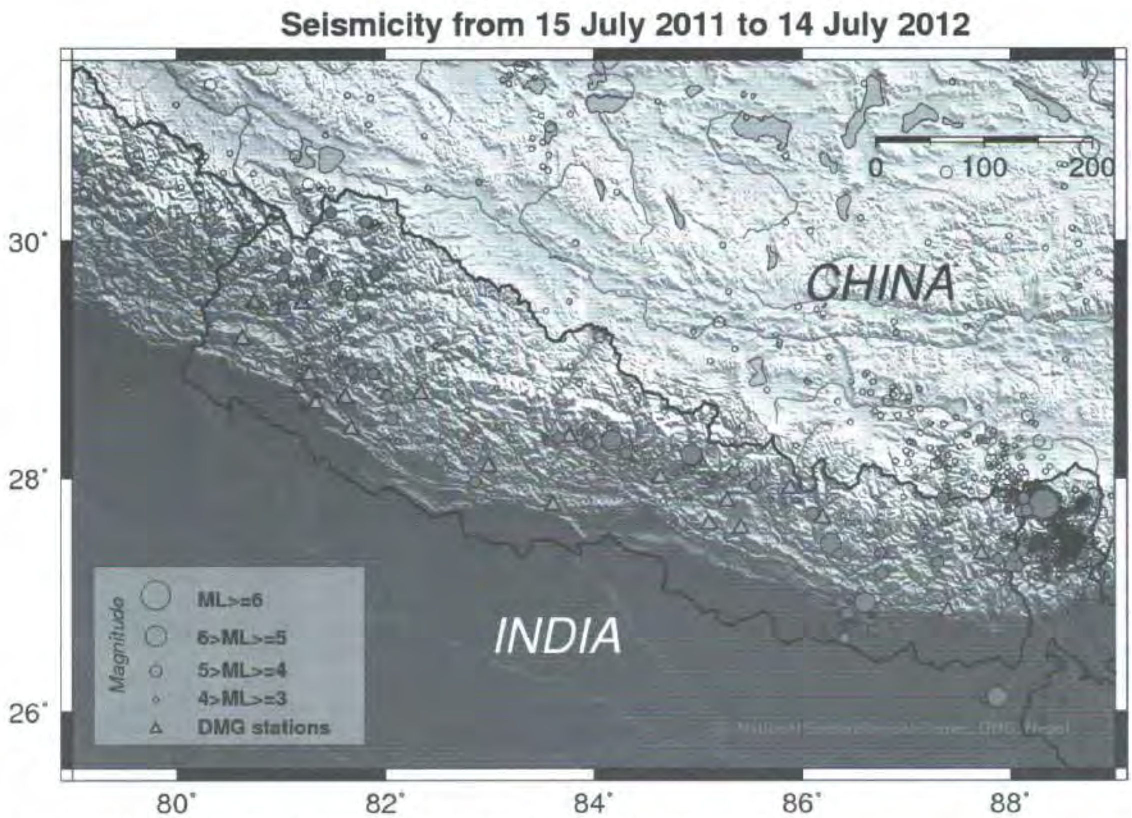

Fig. 3: Annual local seismicity and press released events (filled circles)

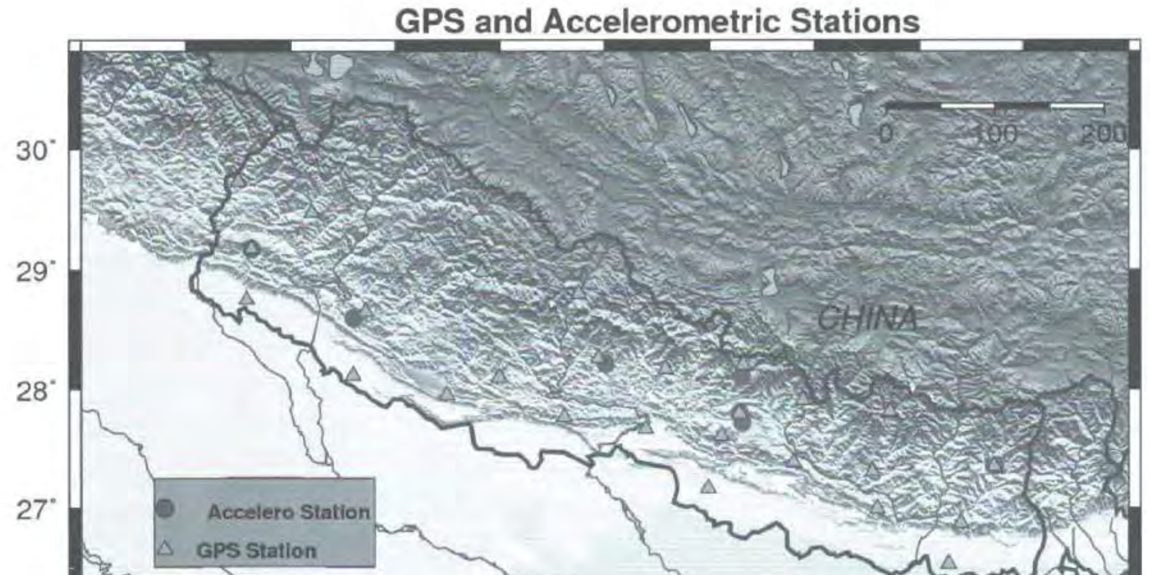

Fig. 4: Accelero-GPS network map

PALEOSEISMOLOGICAL RESEARCH AND DOCUMENTATION OF SURFACE RUPTURE OF 1934 EARTHQUAKE

Historical description of past earthquake is rare in Nepal. Even epicentre of 1255 earthquake which claimed the lives of one third population of Kathmandu. Instrumental recording of earthquake has started around 100 years before. This period is very short in comparision to return period of great earthquake. To describe the seismic risk of the particular region historical and pre-historical seismicity of the region should be fully understood. To address this problem documenting has been started for the surface rupture of the well described earthquake in history like 1934. After knowing the extend of the rupture of the known earthquake the historical and prehistorical earthquakes can be documented. Such studies will give their probable return period, slip and vertical separation as well as appeal good geomorphological and active fault mapping in the areas of surface rupture by these earthquakes (Sapkota 2013). The recent paleoseismological study in the fiscal year 2068/69 includes the active fault and morpho-tectonic mapping along the foothill of Central-Eastern Nepal Himalaya in Mahottari, Dhanusha, Siraha and Saptari districts which is the region of maximum intensity of 1934 earthquake (Fig. 5). More than 50 different river cut (N-S) sections were carefully observed during a month long field work. Due to remarkable geomorphology, good fault exposure and easy accessibility, 8 river cut sections from west to east viz; Sukhla Khola, Dhima Khola, Mainawati Khola, Sarre Khola, Khutti Khola, Chapin Khola, Karak Nadi and Devdhar Nadi were studied in detail.

TAPLEJUNG-SIKKIM POST-SEISMIC CAMPAIGN

An earthquake of 6.8 in local magnitude has struck in the evening of September 18 at NST 6:25 PM. Epicenter of earthquake is reported in the border region of the Nepal and Sikkim. Reported death toll has reached more than 110 by this earthquake out of that 6 in Nepal. NSC has recorded 136 aftershocks within the first 24 hours of the main shock and more than 700 aftershocks by December 2012.

NSC has also performed post seismic campaign in eastern Nepal and deployed three accelerometers at Tumlingtar (TUMA), Ilam and Taplejung (TAPA); four broadband seismic stations at Dhankuta (ODAN), Jhapa, Ilam and Taplejung and few more campaign GPS site in that area (Fig. 6). This deployment helped to better constrain the seismic parameter of this earthquake and seismicity of that region.

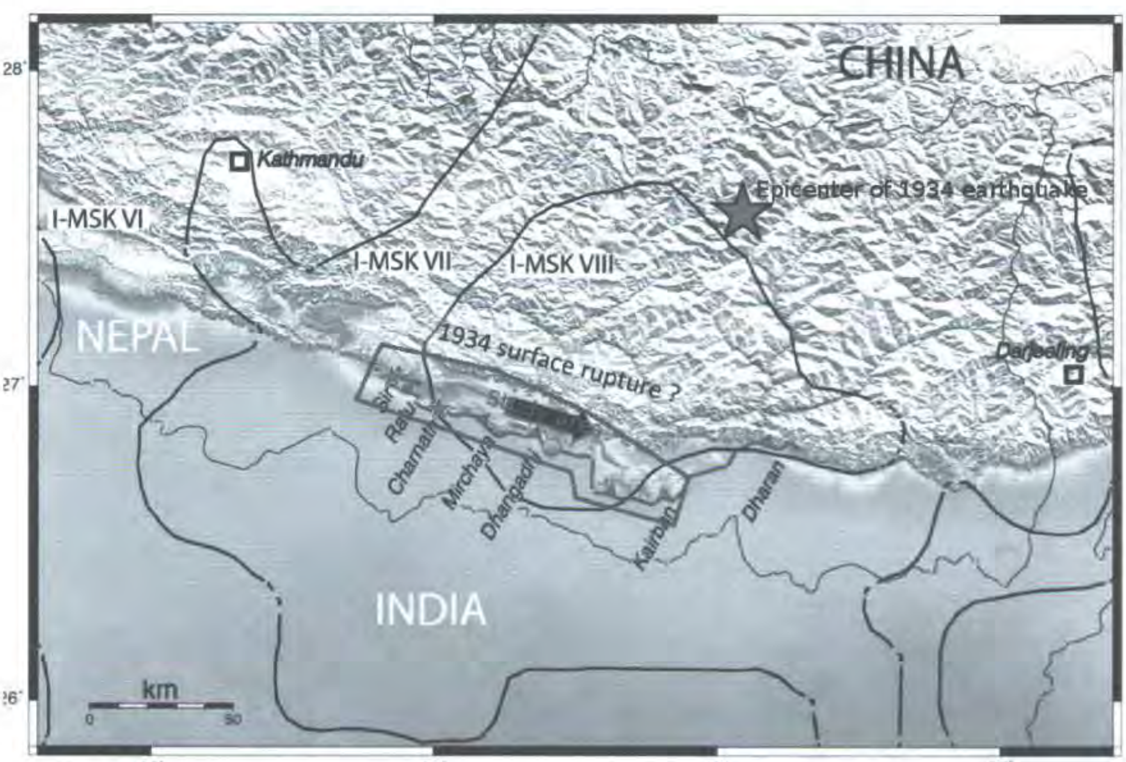

Fig. 5: Location map of active fault mapping

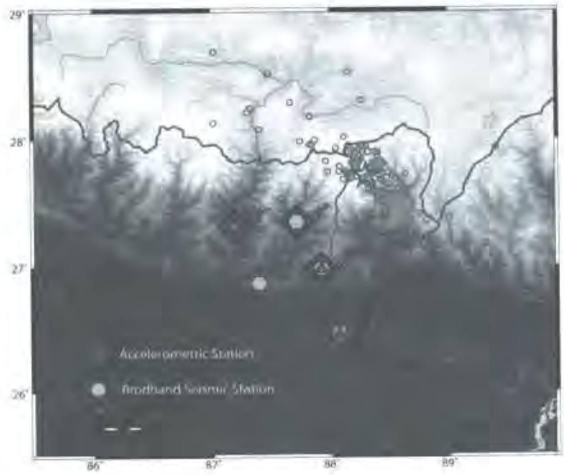

Fig. 6: Taplejung-Sikkim post-seismic campaign

SURKHET BUILDING

To have continuous monitoring even in the disaster period, National Seismological Center has two recording centers to back up each other. One in Kathmandu and another in Surkhet. Surkhet is located in the segment of the Himalayan arc between longitudes 78°E and 85°E, that has not produced any M>8 earthquake over the last 500 years and thus stands as a potential location for the next large Himalayan earthquake. Knowing the fact, it was essential to give priority to have an earthquake resistant building in this region.

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Petroleum Exploration and Promotional Activities in Nepal

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ABSTRACT

Petroleum Exploration Promotion Project (PEPP) was established in 1982 with the main objective to attract national and international investors in the field of petroleum exploration. The potential petroleum prospects over the entire Terai plain and the Siwalik covering an area of about 50,000 sq. km. have been delineated into ten exploration blocks. PEPP has carried out geological, geophysical and geochemical exploration with the multilateral cooperation in regional scale. Additional data in Exploration Block 10 was provided by Shell Company during its regime as Petroleum Operator. At present all the exploration blocks are occupied by four Petroleum Operators as international investors. However, no satisfactory work progress has been carried out by these companies as they fail to fulfill the committed work obligations as outlined in the Petroleum Agreements. The exploration works so far carried out shows potential geological environment to have natural oil and gas within its Terai and Siwalik foot hills with the source, reservoir, and seal rock and trap mechanism. With the government's available resources, PEPP carries out limited exploration works and monitoring of the petroleum operation. Detailed explorations with seismic and exploration wells need to be carried out with a time bound programmes in association with multilateral cooperation or with private investors as per Petroleum Agreement.

INTRODUCTION

Petroleum exploration activities began in Nepal before the establishment of Petroleum Exploration Promotion Project (PEPP) in 1982. Oil and gas seeps at Padukasthan, Sristhan and Navisthan areas of Dailekh resulted in to carry out oil and gas prospect study over the country. The oil and gas seeps in these places are from the time immemorial.

Department of Mines and Geology (DMG) has conducted Airborne Magnetic Survey in 1978-79 over the Terai and Siwalik belts of the country covering an area of 48,000 sq. km. with the help of International Development Agency (IDA)/World Bank. Terai and Siwaliks are thus target areas for hydrocarbon exploration. The petroleum promising areas have been divided into 10 exploration blocks each of approximately 5000 sq. km in size from west to east. The main objectives of PEPP are to carry out geo-scientific research work for Petroleum Exploration and to attract national and international investors for petroleum exploration, development and promotion and to monitor the petroleum operation activities. PEPP has conducted additional exploration programmes thereafter for the generation of data with its own resource and with the multilateral cooperation. The data generated are the main input for the promotion of petroleum exploration opportunities in Nepal. This paper tries to outline the major exploration activities and programmes that have been carried out for petroleum exploration along with the findings and the present status of Petroleum Operators in Nepal.

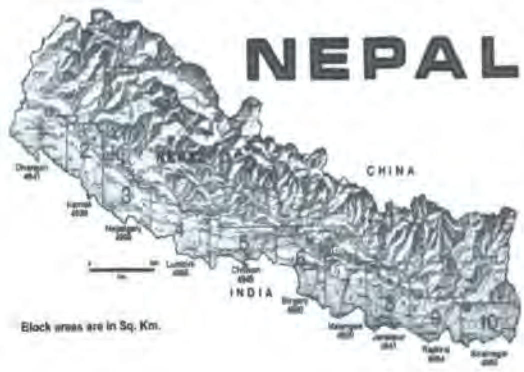

Fig. 1: Petroleum Exploration Blocks over Terai and Siwalik

EXPLORATION ACTIVITIES AND PROGRAMMES

The petroleum exploration and development activity is very risky and capital intensive. It needs advance technology. The exploration activities need to be carried out systematically in phase, wise manner that needs patience as well. With the limited resources at present, we are not in position to do the exploration job ourselves. All these parameters make us to seek for international investor / cooperation to do the major exploration works. PEPP has conducted a series of geological, geophysical and geochemical surveys in the southern part of Nepal with bilateral and multilateral cooperation as:

Airborne Magnetic Survey	48,000 sq. km.
Photo geological Study	60,000 sq. km.
Gravity Survey	23,500 sq. km
Seismic Reflection Survey, 2 D	5,253 line km
Exploration Well	1 no., 3520 m, Block-10 (Biratnagar)
Geological Map of all Exploration	Blocks, (1:50,000 scale) 50,000 sq. km.

Based on these exploration activities, database is formed that contain different Data Sales Packages (DSP's) named "A" through "U" varying in price from US$ 5,000 to US$35,000. Data Package "A", General Report, is pre-requisite for companies wishing to purchase other data or to lodge a formal bid for exploration acreages.

Much of the exploration works has been carried out before 1993 and thereafter no major exploration works are carried out. Exploration Block-10 covers detailed seismic survey of 2000 line km, whereas other Blocks have regional seismic network only. Based on the exploration carried out by Shell Company in exploration Block -10, one exploration well of 3520 m was drilled at Radhanager, Bahuni VDC. The hole was stopped before reaching economic basement but gave much useful and important technical data concerning the source, reservoir, seal rock and thermal maturity. Shell Company outlined six potential basement high areas in Exploration Block-10. The soft copy data available are "magnetic data" and needs to be converted into digital form to avoid the much space and clarity of data.

PEPP also carries out surface exploration works to supplement the data as per annual exploration programmes and do the monitoring of the Petroleum operators activities. The programmes are basically related with the stratigraphy and structural study; source, reservoir and seal study; and study of gas seepage areas. The Project's programmes are categorized in Priority 3 (P3) by the government. PEPP has planned the following programmes for the present and next Fiscal Year (Table 1).

The success of petroleum exploration and production even with a small reservoir of economic size may drastically change the country's economy. The petroleum exploration and promotion activity should be speed up with new technology.

INTERNATIONAL OPERATORS

The international investors are awarded the work contract to do the petroleum exploration, development and production as per petroleum laws of Nepal. The 1st round of bidding was carried out in 1985 and all the Blocks were open for bidding. Shell Nepal BV was awarded to carry out the exploration works in Exploration Block–10 in 1987. Shell Company carried out detailed seismic survey of about 2000 km and one exploration well in the block. The company completed its entire work obligation for initial exploration period and left in 1990. The second, third and fourth round of bidding in Years 1989, 1990 and 1995 could not attract international investors.

Table 1: Program for different fiscal years

Program for Fiscal Year 2069/70		Program for Fiscal Year 2070/71 (Proposed)	
Muktinath Gas Seep Study	50 sq. km.	Source, Reservoir and Seal Study, Surkhet, Dailekh (1:50,000 scale)	650 sq. km.
Stratigraphy and Structural Study, Udayapur, Siraha, Dhanusha, Exploration Block -9 (1:50,000 scale)	650 sq. km	Stratigraphy and Structural Study, Surkhet, Daileh, Exploration Block - 2 & 3 (1:50,000 scale)	650 sq. km
Cartography and Colored Geological map publication, 650 sq .km.	500 pcs	Cartography and Colored Geological map publication, 650 sq .km.	500 pcs
Morang well Protection, Block -10		Morang well Protection, Block -10	

FINDINGS

Based on the exploration activities done so far, the following findings on hydrocarbon potentiality can be drawn:

- In the regional hydrocarbon occurrences, it is noteworthy that the Ganga Basin of Nepal is on trend with the Potwar Basin to the west in Pakistan and Assam Basin to the east in India. Both of which have similar geologic histories to Nepal and have proven to the hydrocarbon bearing with a long history of successful exploration and production operation.

- There are four major rock units of exploratory interest in Nepal. These are Siwalik, Surkhet, Gondwana and Lakharpata (Vindhyan) Groups.
- The potential source intervals are identified in the Sangram Formation of Lakharpata Group, Gondwana Group, Melpani and Swat Formation of Surkhet Group. The shale beds of these groups are found to contain 2 to 20 % (higher in Surkhet Group) of Total Organic Content (TOC).
- The potential reservoir is expected in Lakharpata, Gondwana, Surkhet and Siwalik Groups. In Siwalik Group particularly the Lower Middle Siwalik and Lower Siwalik contain abundant sandstone reservoir type rock. In Western Nepal Melpani sandstone of Surkhet Group has been found filled with solid hydrocarbon.
- The potential seal rocks are found in the Siwalik, Surkhet and Gondwana Group.
- Structural and stratigraphic traps are developed in the subsurface.
- Source rock maturity modeling indicates that Suntar, Swat, Melpani Formation of Surkhet Group and Gondwana Group fall within the oil window, whereas the Lakharpata Group falls within the gas window.

CONCLUSION AND RECOMMENDATIONS

- The geological study reveals that Nepal has potential geological environment to have natural oil and gas within its Terai and Siwalik foot hills.
- The exploration works carried out so far are in regional scale. The detail exploration with abundant seismic and exploration wells need to be carried out with a time bound programmes in association with multilateral cooperation or with private investors as per Petroleum Agreement to access the oil and gas potentiality.
- Many international investors / companies are interested in Nepal for petroleum exploration as an attractive frontier. But the work obligations performed by present Petroleum Operators are not satisfactory.
- GON should allocate substantial budget to manage PEPP data and carry out further exploration activities.

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A Preliminary Study for a Process Approach to Management in Chemical Laboratory

Krishna P. Paudel (Chemist) and Ganga B. Budha Magar (Chemist)

ABSTRACT

Present study enhances the most important two chemical parameters i.e. determination of loss on ignition and iron for rock analysis and mainly concentrates the process mapping i.e. process flow chart which is the fundamental part of a process approach to management. It is also trying to identify and quantify measurement uncertainties during the chemical analysis.

INTRODUCTION

Chemical laboratory is a Sub-Division of Department of Mines and Geology (DMG) which is the backbone of the institution. It is under Technical and Administrational Service Division of DMG.

The chemical laboratory has 3 subsections namely: Sample Preparation and Store Section, Conventional Analysis Section and Trace Element Analysis Section, which altogether provide the following testing services at present.

1. Limestone Chemical Analysis,
2. Silicate Rock Analysis,
3. Coal Testing (with sulphur analysis),
4. Metal/Mineral Analysis, and
5. Water Analysis.

The chemical laboratory also provides the chemical analysis service for outdoor samples. The parameter wise analysis rates given in the Table 1 are for each sample of outdoor customer's samples and the rate may be reduced if the customer needs the analysis of a few parameters only. These outdoor sample analysis services are generally carried out if DMG's annual indoor sample analysis programs are completed.

Among those above mentioned services, the study mainly specifies the Loss on Ignition in limestone and silicate rock analysis. It also specifies the determination of iron for metal/mineral analysis in the laboratory.

ISO 9000:2008 defines a process as: "set of interrelated or interacting activities which transforms inputs into outputs". The processes in an organization are generally planned and carried out under controlled conditions to add value. To perform activities within the process appropriate resources need to be allocated. Data should be gathered to analyze process performance including input and output characteristics. A desired result is achieved more efficiently when related resources and activities are managed as a process. A process flowchart is the first step of documentation of process mapping for process approach.

Measurement Uncertainty is a parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

OBJECTIVE & METHODOLOGY

The basic objective and methodology of the study is process mapping of the test methods. The most important one to note is to quantify the measurement uncertainty components, which is the key indicator of the quality of the process. The objective of the study is to increase reliability and validity of data collected by chemical analysis accurately and precisely for statistical analysis and finally for continual improvement of the chemical laboratory.

PRINCIPLE OF THE TEST METHODS

LOI of rock indicates the superficially absorbed moisture, CO2 released due to decomposition of rock material and any other possible organic impurities. The process flow chart of the process is given in Fig. 1.

Loss on Ignition (LOI)

Determination of Iron by the Stannous Chloride Reduction Dichromate Titration Method

Acid Decomposition

The sample is dissolved in hydrochloric acid. The insoluble residue is removed by filtration, ignited, treated for recovery of iron and added to the main solution.

Reduction of the Iron

The ferric iron is reduced with stannous chloride, followed by the addition of a slight excess of stannous chloride solution. The excess stannous chloride is then oxidized in hot solution with mercuric chloride. The solution is cooled and the reduced iron (in presence of sulfuric acid and phosphoric acid) is titrated with a standard potassium dichromate solution using sodium diphenylamine sulfonate as the visual endpoint indicator. The flow chart of the process is given in Fig. 2.

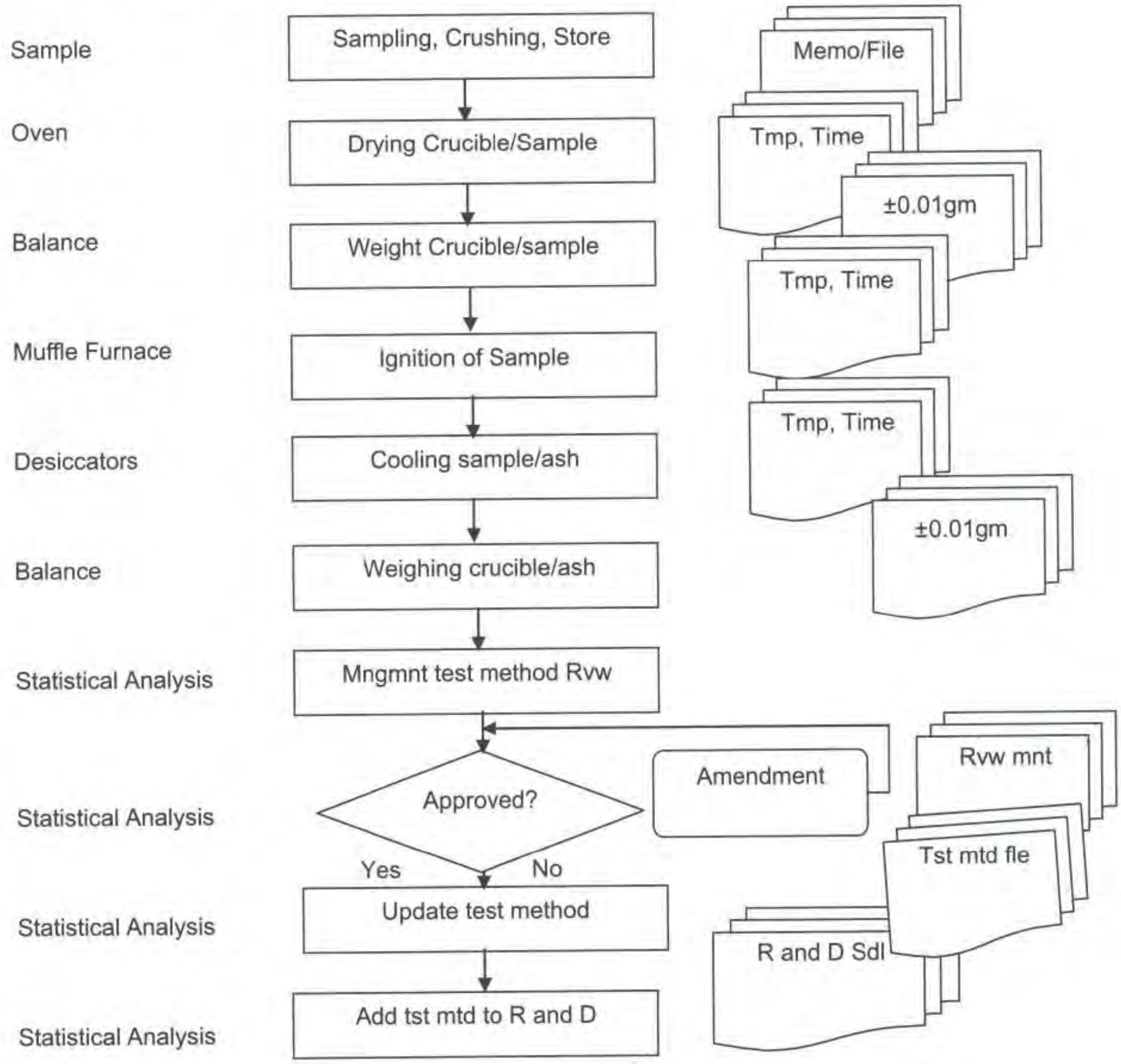

Fig. 1: The Process Flow Chart for Determination of Loss on Ignition Function Process Record

[Note: Mngmnt=Management, rvw=review, mnt=minute, tst mtd fle=test method file, R and D=research and development, sdl=schedule, tmp=temperature]

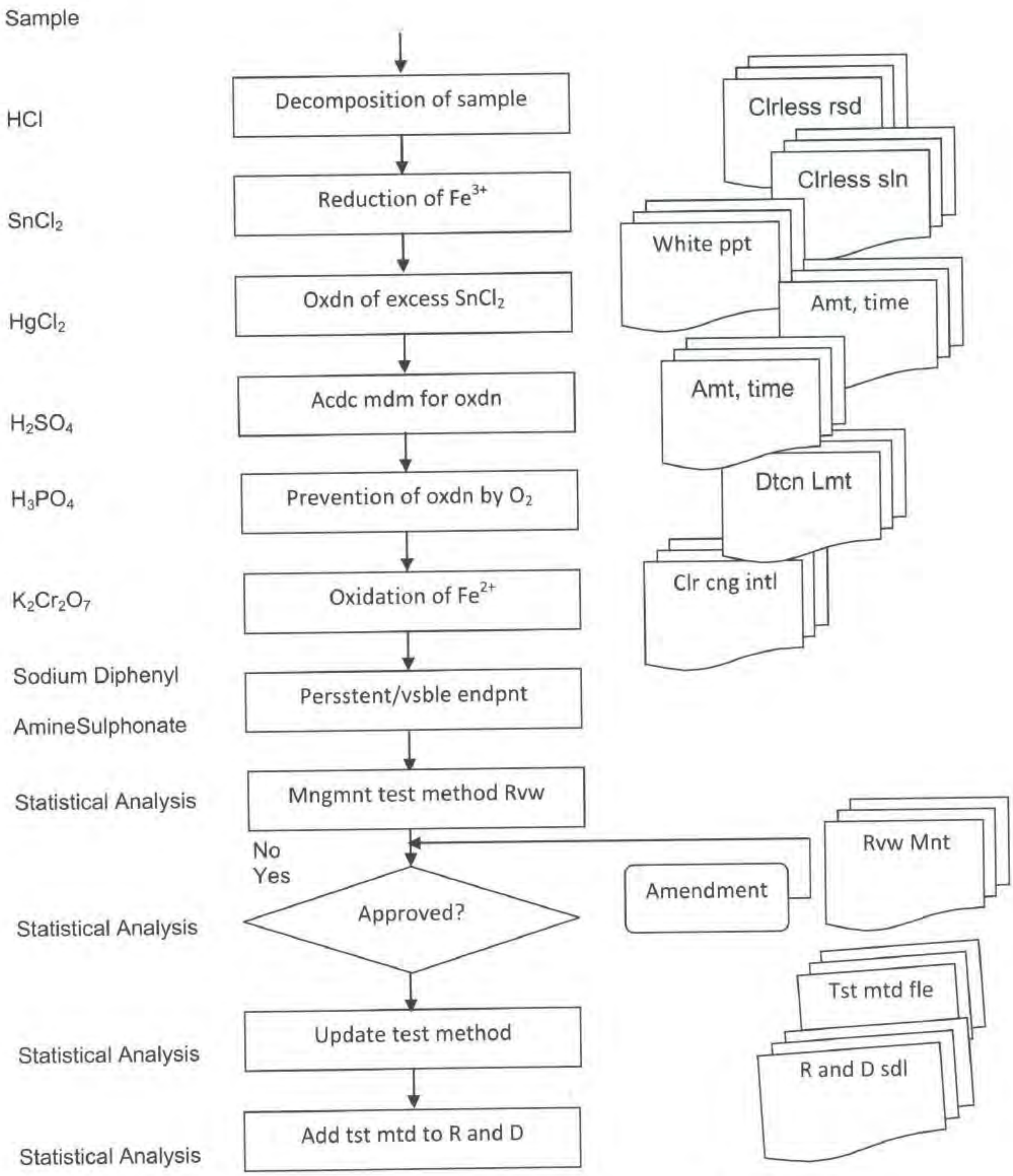

Fig. 2: The Process Flow Chart for Determination of Iron from Iron Ore FunctionProcess Record

Note: clrless rsd=colorless residue, sln=solution, oxdn=oxidation, clr cng intl=color change interval, Persistent/vsble endpnt=persistant/visible endpoint,acdc mdm=acidic medium

Fig.3: Chemist performing the tests in chemical laboratory of DMG

QUANTIZATION OF MEASUREMENT UNCERTAINTIES FOR DETERMINATION OF LOI IN LIMESTONE(CACO3)

The testing for loss on ignition (LOI) of 20 different 99% pure Calcium Carbonate ($CaCO_3$) samples in our chemical laboratory shows the following measurement uncertainties.

Balance

The weight measurement includes the following measurement uncertainties.

Readability=0.0001gm
Standard Uncertainty (U1) =0.0001/√3 = 0.0000578
Calibration (assumed) =0.0009gm
Standard Uncertainty (U2) =0.00009/√3 = 0.000052
Precision (assumed) = 0.00300
Standard Uncertainty for Balance (UB) = √(0.0001/√3)2+(0.0009/√3)2+(0.00300)2
= 0.003045gm

Muffle Furnace

The igniting process in muffle furnace at 1000°Cfor one hour includes the following measurement uncertainties.

Calibration (assumed) =±5°C
Standard (U1) =5/√3
Precision (assumed) =±1.5°C
Standard Uncertainty for Muffle furnace (UMuff) = √(5/√3)2+ (1.5)2
= 3.24°C

LOI for 99% pure Calcium Carbonate (CaCO3)

The testing for loss on ignition of 20 different 99% pure Calcium Carbonate ($CaCO_3$) samples shows the following measurement uncertainties.

Average for 20 determinations=43.47%
Precision=0.15
True value=44%
Chemical Supplier's Certificate=0.5/√3
Standard Uncertainty for Determinations (UD) = √(0.15)2+(0.5/√3)2
= 0.32%

Combined Uncertainty (μLOI/43.47%) = √(0.003045/1)2+ (3.24/1000)2+ (0.32/100)2
Combined Uncertainty (μLOI) =0.0054X43.47% = 0.23%
Expanded Uncertainty=0.23X2 = 0.46%

where 2 is coverage factor for 19 degree of freedom as data taken for uncertainty calculation for 20 determinations.

Result

%LOI in 99% pure Calcium Carbonate ($CaCO_3$) =44±0.46% at 95% confidence interval
The reported uncertainty is an expanded uncertainty calculated using a coverage factor of 2 which gives a level of confidence of approximately 95%.

Quantization of Measurement Uncertainties for Determination of Iron in Iron ore i.e. Haematite (Fe_2O_3):
The testing for iron of 20 different 99.8% pure Ferric Oxide (Fe_2O_3)samplesin our chemical laboratory shows the following measurement uncertainties.

Balance

The weight measurement includes the following measurement uncertainties.

Readability=0.0001gm
Standard Uncertainty (U1)=0.0001/√3 = 0.0000578
Calibration (assumed) = 0.0009gm
Standard Uncertainty (U2)=0.00009/√3 = 0.000052
Precision (assumed) = 0.00300
Standard Uncertainty for Balance (UB) = √(0.0001/√3)2+(0.0009/√3)2+(0.00300)2
= 0.003045gm

Oven

The drying process at 100^{0}C for one hour includes the following measurement uncertainties.

Calibration (assumed) =0.05 = 0.05/√3
Precision (assumed) =0.02 = 0.020C
Standard Uncertainty for Oven (UO) = √(0.5/√3)2+(0.02)2
= 0.2890C

Pipette

The 10mL volume measuring process by using pipette at 20±4^{0}C includes the following measurement uncertainties.

Pipette supplier Certificate (assumed) =0.02mL
Precision (assumed) =0.006
Calibration=0.02/√3
Coefficient of Volume Expansion of water (α) =0.0002/^{0}C
Limits of working Temperature Range=±4^{0}C
Volume Expansion = 0.0002X10X4
= 0.008mL
Standard Uncertainty for Pipette (UP) = √(0.006)2+(0.008)2+(0.02/√3)2
= 0.015mL

Burette

The 50mL volume measuring process by using burette at 20±4^{0}C includes the following measurement uncertainties.
Burette supplier Certificate (assumed) =0.05mL
Precision (assumed) =0.006
Calibration=0.05/√3
Coefficient of Volume Expansion of water (α) =0.0002/^{0}C
Limits of working Temperature Range=±4^{0}C
Volume expansion=0.0002X50X4=0.04
Standard Uncertainty for Burette (UB) = √(0.05/√3)2+(0.006)2+(0.04)2
= 0.0497mL

Volumetric Flask

The 250mL volume measuring process by using volumetric flask (VF) at 20±4^{0}C includes the following measurement uncertainties.
VF supplier certificate (assumed) =0.025mL
Precision (assumed) =0.006
Calibration=0.025/√3
Coefficient of Volume Expansion of water (α) =0.0002/0C
Limits of working Temperature Range =±40C
Volume Expansion=0.0002X250X4=0.2
Standard Uncertainty for Volumetric Flask (UVF) = √(0.025/√3)2+(0.006)2+(0.2)2
= 0.20mL

Iron% for 99.8% Analytical Reagent Ferric Oxide(Fe2O3)

The testing for iron of 20 different 99.8% pure Ferric Oxide (Fe2O3)samples shows the following measurement uncertainties.

Precision for 20 determinations=0.39
True value=69.94%
Chemical Supplier's Certificate=0.1/√3
Standard Uncertainty for Determinations (UD) = √(0.39)2+(0.1/√3)2
= 0.39%

The testing for iron of 20 different 99.8% pure Ferric Oxide (Fe2O3)samples shows the following combined measurement uncertainty.

Combined Uncertainty (µcom)/69.48%
= √(0.003045/1)2+(0.289/100)2+(0.015/10)2+(0.0497/50)2+(0.20/250)2+(0.39/100)2
Combined Uncertainty (µcom) = 0.006X69.48%
= 0.41%
Expanded Uncertainty for Iron% in Ferric Oxide(Fe2O3)=0.41X2=0.82%

RESULT

%Fe in 99.8% pure Ferric Oxide (Fe2O3)=69.94±0.82% at 95% confidence interval

The reported uncertainty is an expanded uncertainty calculated using a coverage factor of 2 which gives a level of confidence of approximately 95%.

CONCLUSION AND RECOMMENDATIONS

This study strengthens the laboratory processes by minimizing measurement uncertainties in various stages of chemical analysis. The result of expanded uncertainties itself states the quality of chemical analysis to be equivalent to the international standard if adequately calibration and other facilities are allocated.

The Technical Test Method Manual has been used for many years but not updated and Quality Manual is not prepared, yet. The apparatus are not calibrated however internal calibration has been done to some apparatus. There is a necessity for laboratory accreditation according to International Standard ISO/IEC17025:2005 to obtain required quality of data. There are more than sufficient infrastructure and equipments for upgrading the laboratory to internationally recognized chemical laboratory.

ACKNOWLEDGEMENT

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Table 1: Parameter Wise Analysis Rate(since1/4/2061)

SN	Type of Sample	Unit Rate (Rs)	SN	Type of Sample	Unit Rate (Rs)
1.	Limestone		4.	Metal/Mineral	
a.	Sample Preparation	40	a.	Cu,Pb,Zn,Fe,Na,Ca,	200
b.	Moisture	35	5.	Mg,Cr,Ni,Cd etc each	
c.	Loss on Ignition	75	a.	Mineral Content Cu,Pb,Zn,Fe,Na,Ca, Mg,Cr,Ni,Cd etc each	200
d.	Acid Insoluble Matter	125	b.	pH	50
e.	Total Oxide	125	c.	Ammonia	200
f.	CaO & MgO	275	d.	Conductivity	50
g.	Iron Oxide	125	e.	Total Hardness	150
	Complete Analysis	800	f.	Acidity/Alkalinity	100
2.	Silicate Rock		g.	Chloride	100
a.	Sample Preparation	40	h.	Sulphate	250
b.	Moisture	35	i.	Total Dissolved Solids	200
c.	Loss on Ignition	75	j.	Total Suspended Solids	150
d.	Silica	325		Complete Analysis	1450
e.	Total Oxide	125			
f.	CaO & MgO	275			
g.	Iron Oxide	125			
	Complete Analysis	1000			
3.	Coal				
a.	Sample Preparation	40			
b.	Moisture	35			
c.	Total Ash	100			
d.	Volatile Matter	225			
e.	Sulphur	250			
	Complete Analysis with Sulphur	650			
	Complete Analysis without Sulphur	400			

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Annual Report of Department of Mines and Geology, 2013, No. 9 & 10, pp.87-89

An Outlook of the Sample Preparation Unit of Department of Mines and Geology

Gajendra Pradhan (Chemist)

ABSTRACT

Being a physically challenging task of sample preparation, it may provide a corrective and error free test result at the end of the analytical work of the true representative sample of bulk as it has still been performing the sample preparation task with application of good handling and good operating practice. It would rather be better if work done at safety and friendly environment so far. Operation of heavy crushing machine itself is a dangerous, unsafe task at the hazardous situation if this unit is not managed well and is operating at dusty, dirty and noisy environment though PPE (Personal Protection Equipment) is provided to the employee. Therefore, utility of personal protective equipment by the employee during crushing task is must and also must train them to know the important of using PPE for this type of prime work.

INTRODUCTION

There are a lot of minerals based substances found in the earth. Our country Nepal is not exception in those substances either found in abundance or in few depositions. The constituents of some of the substances could generally detect through application of various methods of analysis. The result investigated via chemical analysis is the final decision of the test. In fact, these analytical processes are not an easy task as we consider. It would be carried out using a lot of reagents as it required, time it takes, conduction of man power as well as cost-effective. Only analysis can clearly provide the demonstration of what the given sample/material contain in actual.

Now in considering such an important task of chemical analysis work, sample preparation is rather an integral part prior to chemical analysis work. Sample preparation is the first and very important task which would be carried out sensibly with care. It is primitive and serious part of the whole the purpose of detection of unknown substance. The process of extraction of unknown substance of large/bulk quantities to small portion which represents the composition of whole substance is sampling.

Negligence of sample preparation by the employee would make whole the process body might cost the investigation process that goes in vain. Therefore it is expected that concern authorized body will take interest in sample preparation task a greatest challenging work.

Presently, productivity, quality and integrity in work have certainly been a big issue. To get success in such purpose, appropriate person are to be allocated at particular task so that an organization can expect much productive, quality result from them. They are to be mechanized with providing primitive feedback such as training in period, studying the nature of sample and be safety from those materials etc according to nature of work. Then after organization body can be able to monitor and measure the efficiency of operation body of the employee.

In context to the Department of Mines and Geology, it has performed the sample preparation work with overcome of challenge of productivity, quality and integrity result. The department has received a good analytical result through the sample preparation work performing from existed crushing machines till now. However, it may still need to make good operating environment for further the best result in this prime work.

Currently, sample preparation works performed in the sample preparation unit of DMG are not to the desired level due to lack of some of the required equipment and eco-friendly environment and safety management. Changing the working method of sample preparation technique in this unit can anticipate the best result of costing of successive analytical work.

Therefore, the primitive task of chemical analysis could be changed with sound management and handling with care by the employees.

SAMPLE PREPARATION METHOD

Different type of rock/ore samples brought into the unit from various part of our country are always physically in solid state. In this case, difficulties arise for homogeneity. If it is already more or less homogenous in its collection, sample preparation is quite simple comparatively.

Preparation of rock/ore sample is generally common and is being worked on following the manual process as described here briefly.

The principle used for preparing this sample is firstly combine to each sample individually with single geo-code marked. Then, put it into a container and is crushed mechanically to small size using jaw crusher. Then after, it is piled up into conical shape as possible and top of the cone is flatted out. After that, it is divided into 4 quarters where 2 opposite quarters are then removed and rest two quarters are mixed and again is formed small conical pile and make it quarter afterwards. It is repeated until a sample of suitably weight (say 200 g - 300 g) is obtained and is taken to further crushing process. The process is being carried out through the series of crushing devices i.e. roll crusher and pulverizer until it becomes to size of 200 mesh for easy digestion in appropriate acid used.

Mechanical method i.e. using sample splitter (divider) for sample preparation is also used before carrying out the successive crushing process. However, this device is currently not in use being old, requiring repairment.

In this mechanical method, the sample is firstly collected to each container separately. This sample is then divided into the divider (sample splitter). It is collected in to two different collectors. One collector is removed and another collector is again divided into two portions by spreading sample into the divider. In this way, the process is repeated until a sufficient (about 200 gm) sample is obtained and taken to crushing for necessity of suitably sized sample.

Following equipments of sample preparation unit as shown in fig. 1 to 4 represent the systematic ways of crushing and grinding of rock/ore sample as the process of sample preparation.

Fig.1: Small jaw crusher to reduce sample size of 3/4 inch

Fig. 2: Big Jaw crusher use to reduce sample size of 1 inch to < 1 inch size

Fig.3: Roll crusher use for crushing sample to reduce size of 1-5mm

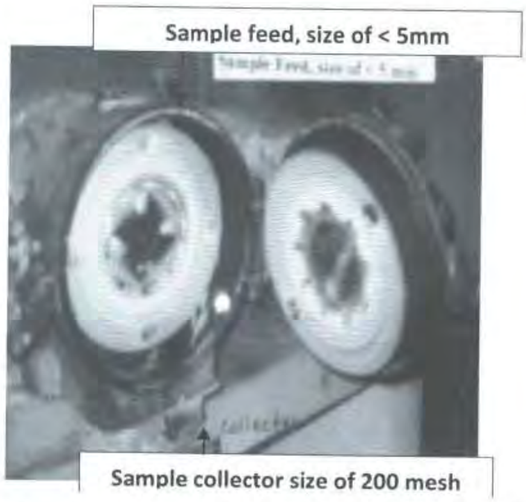

Fig.4: Pulverize to grind the sample into desired 200 mesh size

PERFORMANCE

The sample preparation unit is still performing a good crushing task in the department. Most of the samples are brought in to the unit by the Geologists and Mining Engineers of the department for the chemical analysis of different elements. As DMG also provides the service to private sectors, some samples from private sectors are also brought in this unit. It is estimated that about 1200 - 1400 samples are annually being crushed in this unit including about 300 – 400 samples are from outside clients. Some of samples are brought here in for crushing only. For smooth operation of the crushing work, electricity load shedding has made obstruction and consequently delayed the performance of work However; no samples are left remain as possible in the unit.

IMPROVEMENT

The sample preparation unit is to be managed with necessary changing of following criteria for improvement :

- By applying mechanical method for accurate sample preparation if existed sample slpitters (divider) are repaired, however sample preparation works are now carrying out in manual process.
- By providing capable and qualified employee at allocated work.
- By equipping the unit with completely necessary machines i.e. various size of sample splitters, handy blower.
- By providing safety environment and non-hazardous situation in all means to the employee
- By allocating budget to keep neat, clean and workable environment as possible.
- By displacing unused and non-repairable machinery goods from the crushing unit.

RECOMMENDATION

For anticipating the best test result ever from the cost effective analytical works from chemical laboratory, the very first and primary task of the crushing unit is to be considered through planning the better management. Only correct sample preparation of a representative sample of bulk could provide error free and contamination free for follow up work. Therefore, it is to be considered that small attempt for betterment of the unit makes more productivity, quality and satisfactory result from very first task of analysis process. Let it be more scientific.

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Annual Report of Department of Mines and Geology, 2013, No. 9 & 10, pp.91-93

Departmental Activities and Progress in Fiscal Year 2068/69 and Annual Program of Fiscal Year 2069/70

K.D. Jha (Senior Divisional Meta. Engineer) and S. Shrestha (Geologist)

Department of Mines and Geology (DMG) have been conducting several activities under two development projects: (1) Mineral Exploration and Development and (2) Geoscientific Survey and Research. In addition National Seismological Centre (NSC) of DMG is continuously recording and monitoring earthquakes.

All of the activities planned for the FY 2068/69 have been completed as per the schedule except Exploration and Production of Natural Gas of Kathmandu and Preliminary exploration of Uranium in Mustang. The programs and the progress are listed in the Table 1 and other progress in Table 2.

Table 1: Program and Progress

Program/ Activities	Location/District	Volume of works	Output/ Result	Remarks
(A) Mineral Exploration and Development				
1. Follow up exploration of Iron	Dhaubadhi, Nawalparasi	25 sq.km	25 sq.km	
Priliminary exploration of Uranium	Mustang	150 sq.km		
Explorative drilling of Limestone	Palpa	300 m	272m	Total deposit of limestone with Quality will be fig. out.
Inspection and Environmental Monitoring of Operating Mines	Throught out the country	75mines	-The environmental impacts minimized and production data collected	75 Mines were visited for environmental monitoring and data collection
Geochemical exploration of Copper	Wapsa,Solukhumbu	300 sq. km	300 sq. km	
Preliminary exploration of semi precious gem	Achham, Kalikot and Dailekh	1000 sq. km	1000 sq. km	
Promotion of Mineral based industries		5 mines	2 mines	Data package of Limestone, waling Syangja and Marble, Makawanpur has been prepared and notice published in national daily for proposal.
Monitoring of Ktm Natural Gas wells	Kathmandu Valley	14 Gas wells	14 Gas wells monitored	Most of them appear dry due to lack of proper and timely maintenance
Exploration and production of Natural Gas of Kathmandu	Kathmandu Valley	2 Gas wells (800m)		

(B) Geoscientific Survey and Research

Program/Activities	Kathmandu Valley	Volume of works	Output/ Result	Remarks
Geological Map Update (1:25000) Toposheet no.2881-03,ABCD	Parts of Dailekh,,Achham, and Surkhet	650 sq.km.	650 sq.km.	Map will be published in the next fiscal year.
Geo-Engineering & Geo-Environmental Study	Dhangadhi	300 sq. km.	300 sq. km.	Digital Map will be prepared in the next fiscal year.
Geo-hazard Maping Study(1:25000) Toposheet no. 2881-03,ABCD	Parts of Dailekh, Achham, and Surkhet	650 sq.km.	650 sq.km.	Digital Map will be prepared in the next fiscal year.
Publication of colored Geological Maps (2980 16, 2980 12) Regional map of Eastern Nepal	Parts of Dadeldhura, Baitadi, Doti, Bajhang and Kailali	2 sheets 1 sheet	500 copies each	

NATIONAL SEISMOLOGICAL CENTRE (NSC)

The National Seismological Centre, Kathmandu records earthquake data from 12 Seismic stations located in Eastern, Central, and Western Nepal and Birendranagar Seismological Centre records earthquakes from 9 seismic stations located in Mid Western and Far Western Nepal. Earthquakes greater than 4 Richter scale are immediately released to press by NSC.

Table 2: Other Departmental Progress

Works	Total
Prospecting license(new)	173
Prospecting license(renewed)	389
Mining license(new)	7
Mining license(renewed)	77
Laboratory facilities	
Chemical analysis of different samples	304
Element determination	1,382
Mineralogy and petrology lab. service	7
Ammonia map printing	179
Library facilities	96 person/institution
Seismic events processing	7,152 events
Press releasedearthquakes with magnitude (Ml)> 4.0 within Nepal in the FY 2067/68.	30 Times
Talk program held on different topics	10 times
Royalty collected	Rs. 3,12,29,987

The overall budget of DMG is Rs. 8, 62, 84,000.00 (Development project and General Administration). Allocated Budget and expenses for fiscal year 2068/69 are summarized in Fig. 1.

1: Mineral Exploration and Development project
2: Geoscientific Survey and Research project
3: Department of Mines and Geology

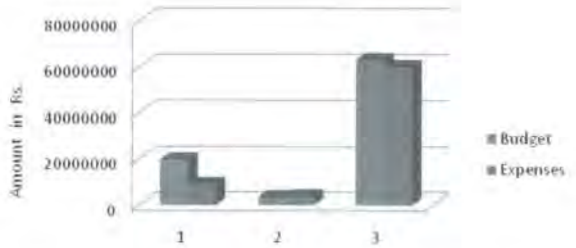


Fig. 1: Bar Diagram Showing

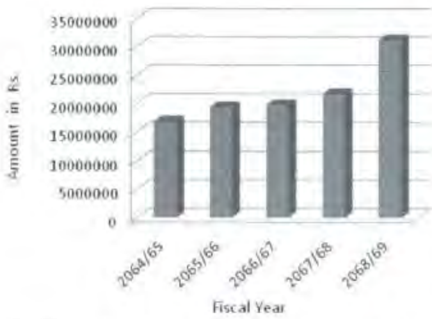


Fig 2. Royalty collected during the 5 consecutive year

DMG collects royalty from issuing license, renewal of license of prospecting and Mining, mineral production and selling its publications and data package. The royalty collected for 5 years is shown in the Fig. 2.

Annual Program for the Fiscal year 2069/70 is summarized below.

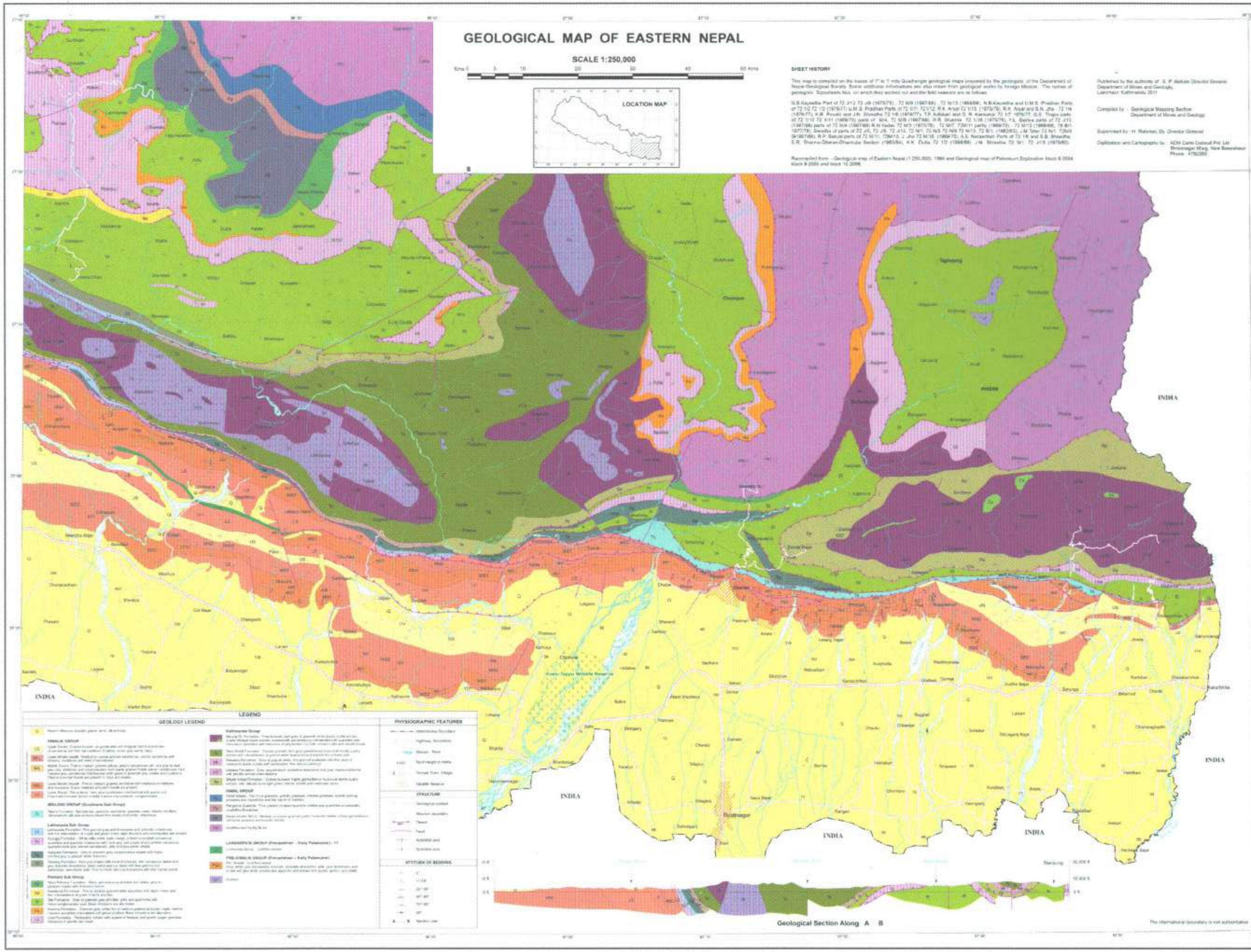
Table 3: Annual Program for the Fiscal year 2069/70

(A) Mineral Exploration and Development

S. No.	Programme/Activities	Location/ District	Volume of work	Budget (RS)
1	Priliminary exploration of Uranium	Tinbhangale, Makawanpur	10 sq.km	2,50,000
2	Integrated program on Geological mapping and mineral exploration	Khotang, Bhojpur and Sankhuwasabha	1300 sq.km	21,38,000
3	Inspection and Environmental Monitoring of Operating Mines	Throught out the country	75mines	7,43,000
4	Preliminary exploration of semi precious gem	Achham, Kalikot and Dailekh	1000 sq. km	9,60,000
5	Promotion of Mineral based industries 1.Limestone 2.Iron 3.Copper	Lakharpata,Surkhet Phulchauki, Lalitpur Wapsa, Solukhumbu	3mines	60,000
6	Monitoring of KTM Natural Gas wells	Kathmandu Valley	14 Gas wells	13,44,000

(B) Geoscientific Survey and Research

S. No.	Programme/Activities	Location/ District	Volume of work	Budget (RS)
1	Geological Map Update (1:25000) Toposheet no.2882-05,ABCD, 06AC	Parts of Rukum, jajarkot, salyan	975 sq.km	5,25,000
2	Geo-Engineering & Geo-Environmental Study	Mahendra Nagar	300 sq.km	3,90,000
3	Geo-hazard Maping Study(1:25000) Toposheet no. 2882-06,BD	Parts of Rukum, Jajarkot and Salyan	325 sq.km	1,95,000
4	Publication of colored Digitization Geological Maps Toposheet no. 2981-13, CD , 1:25000 2981-03 ABC Regional map of Central and mid-western Nepal	Parts of Achham, Dailekh, Surkhet,	1000 sq. km	3,39,000


GEOLOGICAL MAP OF EASTERN NEPAL
SCALE 1:250,000
LOCATION MAP
SHEET HISTORY
INDIA
LEGEND
GEOLOGY LEGEND
PHYSIOGRAPHIC FEATURES
STRUCTURE
ATTITUDE OF BEDDING
Geological Section Along A B

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