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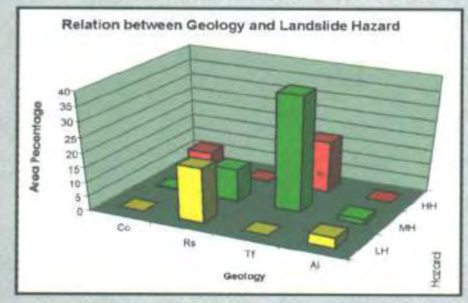

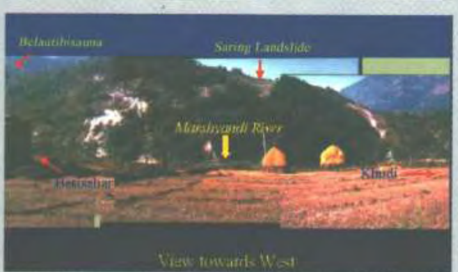

ANNUAL REPORT OF

Collected By
H. Rahman, DDG, DMG

DEPARTMENT OF MINES AND GEOLOGY

Annual Report No. 2, DMG

May, 2005 (Baisakh, 2062 B.S.)

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FOREWORD

The Department of Mines and Geology (DMG) is the only governmental organization entrusted with the responsibility of carrying out all types of geo-scientific researches, mineral resources assessment, exploration, promotion and development including hydrocarbon resources in Nepal.

The Department is pleased to publish this second volume of 'Annual Report as a part of the regular program of the Department of Mines and Geology. Ever since the Department released its first bulletin in 1991, we have been trying to reflect on paper various activities and information related to the department through different kinds of publications such as **DMG News Letter, DMG Précis and Annual Report** etc. As a continuation of the publication of Annual Report, this is only a second volume however it has included various topics related to geo-scientific studies and mineral resources exploration, development and promotion. I hope that this 'Annual Report No. 2' will also be successful in disseminating the outcomes, achievements and prospects of the department for the development of geosciences and mineral sector of the country as well as keep the concerned people informed about its scientific activities.

I would like to thank and appreciate the efforts of all those responsible personnel who are involved in bringing this 'Annual Report No. 2' in time.

N. R. Sthapit
Nanda Ram Sthapit
Director General

EDITORIAL

The Department of Mines and Geology (DMG) is continuing its program of publishing the Annual Report besides other publications. In this regard, the Editorial Board is very pleased to bring up this publication 'Annual Report, Number 2' of the department.

The Editorial Board has been formed under the coordination of Dr. Rajendra B. Shrestha, Deputy Director General with Mr. Krishna Prasad Kaphle, Senior Divisional Geologist, (Planning, Evaluation and Information Section), Mr. Ashok Kumar Duvadi, Senior Divisional Geologist, (Geological Mapping Section) and Mr. Manohar Shrestha, Mining Engineer, (Monitoring and Conflict Resolution Section) as the editors in order to publish annual activities of the department in the form of 'Extended Summary' of technical reports of geological and mining survey activity programs of the department conducted during the fiscal year 2060/061. However, this volume has also included the articles on technical reports of the previous years up to B.S. 2055/056 with a view to facilitate the publication of scientific researches conducted by the department even before the initiation of Annual Report publication. It is believed that it will serve disseminating geo-scientific information to the concerned people and agencies and contribute in fulfilling the objective of the department.

The Editorial Board would like to thank all the geoscientists and staff of the department who have contributed directly or indirectly in bringing up this volume. In this regard, the tedious effort made by the Drafting Section of the department in the preparation of various maps and figures is highly appreciated. The cooperation received from Mr. Hifzur R. Khan, Senior Divisional Geologist in the course of publication of this volume is also appreciated very much.

Dr. Rajendra B. Shrestha
Chief Editor
Editorial Board

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Geology of Madi Khola - Arung Khola Area, Rolpa, Pyuthan and Dang Districts, Mid Western Nepal

Upendra B. Pradhananga
Department of Mines and Geology
Lainchaur, Kathmandu, Nepal

INTRODUCTION

Geological mapping cum field checking of the study area has been carried out according to the departmental programme of the fiscal year 2056/57 B.S. The study area lies in the topo - sheet no 62 L/12 (Scale 1:63,360) of Survey of India and sheet numbers 2882-15A, 15B, 15C and 15D of 1:25,000 scale topographic maps of Survey Department, His Majesty's Government of Nepal. The area of investigation is bounded by latitude 28° 00' 00" to 28° 15' 00" N and longitude 82° 30' 00" to 82° 45' 00" E (Fig. 1).

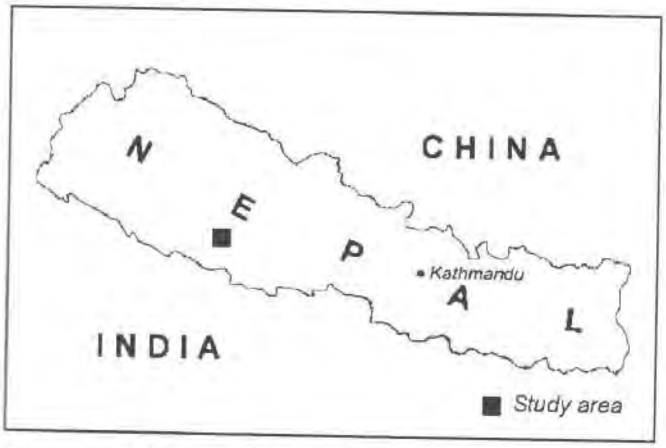

Fig. 1: Location map of the study area

Yadav (1972) mapped the area in 1972 under the regional geological mapping programme of the department. Later on, Kayastha et.al, (1982) had carried out geological mapping of the area. They divided the rocks of the area into the Metasediment Group, Surkhet Group and Siwalik Group. The Metasediment Group had been further divided into Ramkot Sandstone, Gawar Dolomite, Khara Limestone and Katwa Shale. Similarly, the Surkhet Group had been divided into the Melpani Formation, Swat Formation and Suntar Formation. Likewise the Siwalik Group was divided into Lower, Middle and Upper Siwalik Formations.

OBJECTIVE

The main objective of the field study was to carry out geological mapping of 650 sq. km. area in some parts of Rolpa, Pyuthan and Dang districts to compare the litho - stratigraphy of the present study area with that of the Central Nepal and publish an updated geological map.

GENERAL GEOLOGY

Mainly meta-sedimentary and sedimentary rocks and only a few metamorphic rocks represent the study area. Sedimentary rocks occurring in the area are grouped into the Surkhet Group and the Siwalik Group whereas metasedimentary rocks are grouped into the Swargadwari Group (Table - 1). The Swargadwari Group is considered as the equivalent of the Nawakot Complex of the Central Nepal. However, stratigraphy of the Central Nepal cannot be applied directly to the meta-sedimentary rocks of the present study area though similar lithological assemblage and stratigraphy are observed.

In the northern part of the study area, dominant rock formations exposed are Lungri Khola Formation, Khara Formation and Bhalu Khola Slate of the Swargadwari Group. The attitudes of the rock beds of these formations are controlled by Dhanbang Syncline with NW – SE axis (Fig. 2).

Rocks of the Surkhet Group had been deposited over the rocks of the Swargadwari Group with an unconformable contact in the central and southern part of the map area. The unconformity is of angular nature. The contact of the Surkhet Group rocks with the Swargadwari Group is disturbed and in most of the places, local landslides are present in the contact zone indicating tectonic activities after the deposition of the Surkhet Group. Above the rocks of the Surkhet Group, metamorphic rocks of the Dubidanda thrust sheet had been thrusted over in the central part of the map area (Fig. 2) while rocks of the Khara Formation thrusted over in the southern part of the map area.

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Geology of Madi Khola - Arung Khola Area, Rolpa, Pyuthan and Dang Districts, Mid Western Nepal

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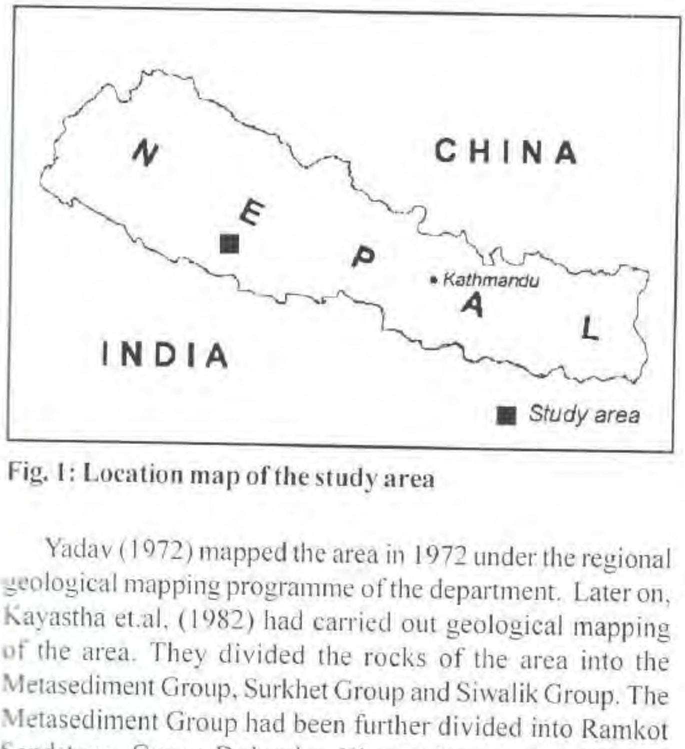

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Table-1: Litho - Stratigraphy of the Area

Siwalik Group	Lower Siwalik Formation	Sandstone alternatively interbedded with shales and clays with bands of marls, siltstone and argillaceous limestone
Surkhet Group	Suntar Formation	Rhythmic interbedding of fine-grained green sandstone and purple and green shale.
	Swat Formation	Gray, dark gray limestone in upper part and pinkish, greenish to dark gray shale with fossiliferous limestone in lower part
	Melpani Formation	White gray, green, crystalline quartzite, green sandstone interbedded with dark gray to black carbonaceous shales.
		Unconformity
Swargadwari Group	Bhalu khola Slate	Light greenish gray to black, laminated slate, shaly slate, phyllitic slate with limestone and quartzite intercalation
	Khara Formation	Thickly bedded, massive light grey to dark grey, fine - grained dolomite with stromatolites and pisolites. Thin pink, green, cream colored limestone and slate at upper part.
	Lungri Khola Formation	Purple green slate, slaty shale, greenish grey to pink dolomite, dolomitic limestone and quartzite. Ripple marks and mud cracks common
	Dubidanda Formation	Greenish gray, gray phyllites, white to brownish white quartzites with bands of gray crystalline limestone, dolomite and basic rocks.

Swargadwari Group

This is the autochthonous and oldest rock group of the area. This group comprises four geological formations. They are the Dubidanda Formation, Lungri Khola Formation, Khara Formation and Bhalu Khola Slate.

Dubidanda Formation

The Dubidanda Formation is the oldest unit exposed in the map area and it is also the oldest formation of the Swargadwari Group. It occurs in the western part of the map area in the form of two separate thrust sheets. In the present study area, they are exposed as inliers where rocks equivalent of the Lower Nawakot Group and rocks of the Surkhet Group surround the rocks of the Dubidanda Formation.

The Dubidanda Formation consists of greenish gray, gray phyllites, white to brownish white quartzites with bands of gray crystalline limestone and dolomite. Basic rock intrusions are also present in this Formation. Quartzites are medium to coarse grained and gritty in nature. This formation is correlated with the Dandagaon Phyllite of the Central Nepal.

Lungri Khola Formation

Rocks of the Lungri Khola Formation are found to occur at many parts of the map area. Wide occurrence of Lungri Khola Formation is due to its repetition by a number of folding and thrusting structures. Rocks of the Lungri Khola Formation are exposed well in Lungri Khola, Kochhap Khola, Ghora Khola, Kapkati Khola, Khurpi Khola, Dabang Khola and Bamla Khola sections. The rocks of the Lungri Khola Formation, in general, has NW-SE trend but at number of places, they have wedge shaped truncation due to plunging anticlinal and synclinal folding of the rocks.

The Lungri Khola Formation consists thin to thick interbeddings of argillaceous, calcareous and arenaceous

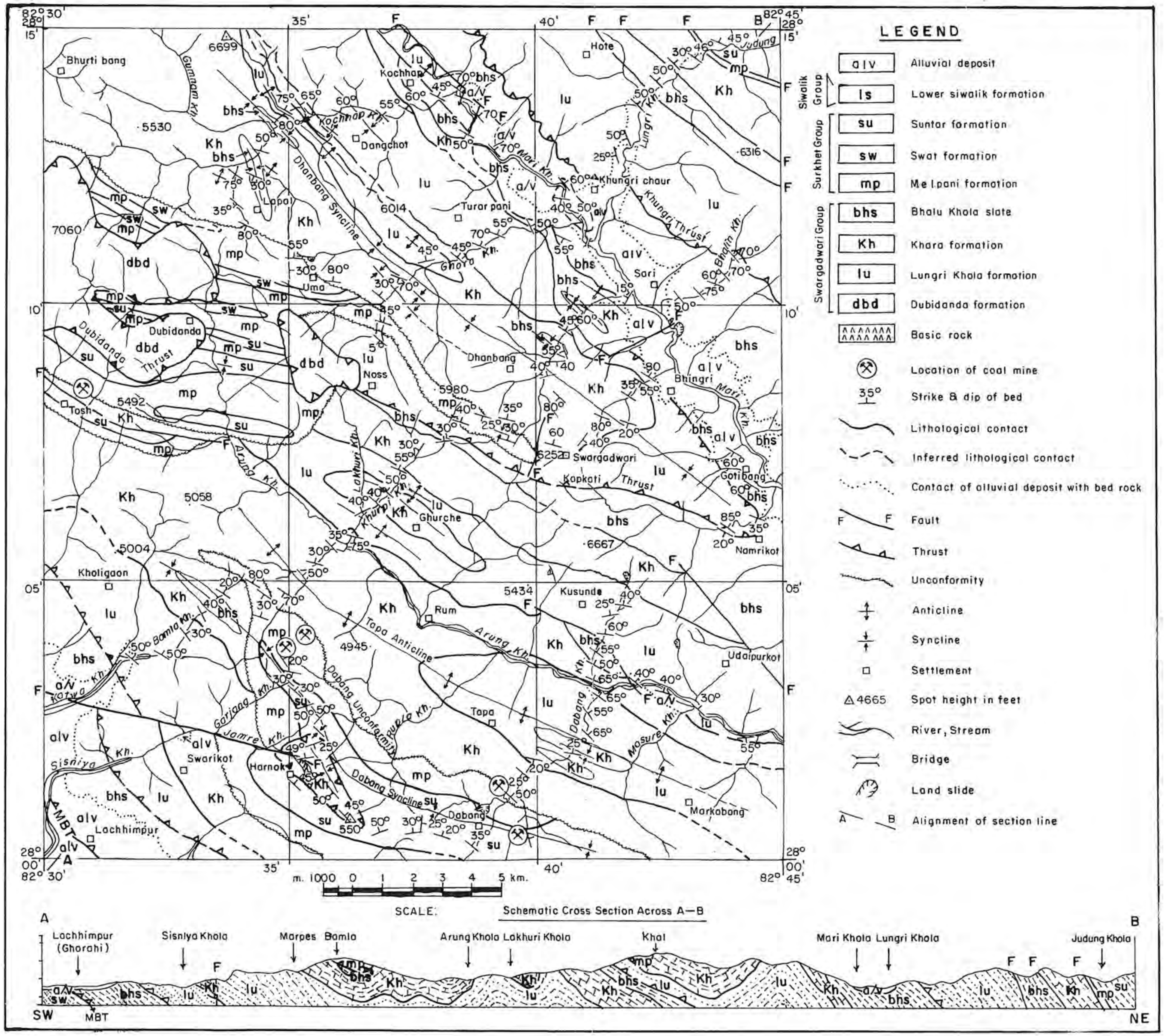

Fig. 2: Geological Map of Madi–Arung Khola Area (Rolpa, Pyuthan and Dang Districts)

rocks. It consists purple, green slate, slaty shale, occasionally dark gray slate, fine grained, pink, greenish and bluish gray, thin to thick bedded dolomite, dolomitic limestone and medium to thick bedded greenish gray, pink, white gray quartzite. Ripple-marks in the quartzites and mud cracks in slates in the Lungri Khola Formation are quite common. This formation is considered as an equivalent rock unit of the Nourpul Formation of Central Nepal.

Khara Formation

The Khara Formation is underlain by the Lungri Khola Formation and is overlain by the Bhalu Khola Slate. It has general trend of NW-SE. It occurs as thin to thick band and extends from southwest to northeast corner of the map area.

At lower part, it consists light gray to dark gray, thick bedded to massive dolomite. It contains black slate intercalation. Stromatolitic, pissolitic and pelletal dolomite bands are present in it. In the upper part of the Khara Formation, there are thinly banded limestone and shale interbeddings. The limestone is light gray, greenish gray, pink, pinkish green to dark gray in color. The shale is purple to light green in colour. The Khara Formation is correlated with the Dhading Dolomite of Central Nepal.

Thickness of the Khara Formation exposed in the upper part of Khurpi Khola is 1.7 km., but the rocks exposed in the core of the Tapa anticline and Dhanbang syncline are 3.5 to 5.0 km. thick where they are repeated by number of anticlinal and synclinal foldings.

Bhalu Khola Slate

This is the youngest formation of the Swargadwari Group and consists dominantly of slates. The slate occurs in the northeastern part of the map area along the Mari Khola and its tributaries. It has a general trend of NW- SE and dipping 50° to 70° towards NE. Its thickness attains up to 5.5 km in the Mari Khola area. The slate is light greenish gray, light gray, lead gray, dark gray to black in color. It occurs as banded slate, and lead gray phyllitic slate. The Bhalu Khola Slate is considered as equivalent to the Benighat Slate in Central Nepal. Intercalation of quartzite and carbonate bands in the slate is comparatively few as compared to that in the Benighat Slate.

Surkhet Group

The Surkhet Group is deposited over the Swargadwari Group. The contact between them is an angular unconformity. This group consists of three geological formations. They are: 1) Melpani Formation, 2) Swat Formation and 3) Suntar Formation.

Melpani Formation

Rocks of the Melpani Formation are distributed in the southern part, middle part and in the northeastern part of the map area. The Melpani Formation consists medium to thickly bedded, yellowish gray to light gray, green, crystalline quartzite and black ferruginous quartzitic sandstone and green sandstone. They are interbedded with dark gray to black fine acicular, carbonaceous, crumpled shale with occasional band of gray, argillaceous limestone and conglomerate at the base. The shale at places contains ferruginous sandstone nodules. The quartzite contains up to 2 m thick black coaly shale. Besides, it also contains thin seams of 1mm to 5 mm thick coal. The conglomerate contains gravels and pebbles of sandstone and gray and pink chert in the matrix of fine to coarse sand. The Swat Formation conformably overlies the Melpani Formation but its basal part, though reported to be unconformable contact, appears to be tectonic in this area as indicated by landslides at the contact zone. Since the Swat Formation is developed only as lenses in the map area, the Suntar Formation directly overlies the Melpani Formation at most of the places in the field.

Swat Formation

Rocks of the Swat Formation are limited in the mid-western part of the map area. This formation consists limestone and shale with lenses and bands of dark gray fossiliferous limestone. Limestones are gray, dark gray to cream colored and shales are greenish gray, dark gray to pinkish in color. Shales are fissile and crumpled in nature. Lower part of this formation is represented by shale, while the upper part is represented by limestone, though, fossiliferous limestone lenses occur within shales in the lower part. The limestone in the Swat Formation bears Nummulites and shales bear gastropods and pelecypods. The Swat Formation is considered to be lower to middle Eocene age from the evidence of the fossils.

Suntar Formation

Rocks of the Suntar Formation occur in southern, mid-western and northeastern part of the map area. The Suntar Formation, being the youngest rock unit of the Surkhet Group occupies the core of the syncline and topographically high altitude location, along the ridge. The outcrop pattern of the Suntar Formation shows that previously this formation had occupied very large part of the area and later, rocks of the Suntar Formation eroded away leaving the rocks only at places of comparatively less eroded part.

The Suntar Formation consists rhythmic interbeddings of sandstone and shale. Thickness of each band of sandstone and shale ranges from 25 m to 40 m. The sandstone and quartzitic sandstone are generally fine grained medium to thick bedded, well packed and green in color. The shale is purple, dark green, reddish brown and dark gray.

STRUCTURE

Rocks of the Swargadwari Group are autochthonous rocks in nature. These rocks are folded and faulted at number of places, causing repetition and omission of different lithological units. The Surkhet Group is deposited over the Swargadwari Group with an angular unconformity in between them. This is the second phase of tectonic activity in the area, the first being the folding, faulting and thrusting of the autochthonous Swargadwari Group. In the third stage, Dubidanda thrust sheet and Harnok thrust sheet thrusted over the rocks of the Surkhet Group. These thrust sheets consist crystalline rocks in Dubidanda Thrust sheet in central part and rocks of the Khara Formation in Harnok thrust sheet in the southern part of the map area. Another major thrust of the area is Kapkati thrust in the central part of the map.

The rocks of the area are also highly folded. There are a number of major and minor anticlinal and synclinal folds. Rocks of the Surkhet Group, in the southern part, are folded into a major synclinal structure. The syncline can be traced from Murkuti in southeast to Karla, upperreaches of Dhau khola. The synclinal axis swings from southeast to north-northwest from Harnok. North of Dabang syncline is Tapa anticline and its anticlinal axis has NW – SE trend.

FINDINGS

The study area is consisted mainly of sedimentary and meta-sedimentary rocks. Sedimentary rocks are grouped into the Surkhet Group, consisting of Melpani, Swat and Suntar Formations and the Siwalik Group consisting of the Lower Siwalik Formation. Meta-sedimentary rocks of the area is represented by the Swargadwari Group, consisting of the Dubidanda Formation, Lungri Khola Formation, Khara Formation and Bhalu Khola Slate. Except few grains of sphalerite and some malachite stains, metallic minerals are not noted in the area but non-metallic minerals like coal and limestone are present in the area.

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Annual Report of Department of Mines and Geology, 2005, No. 2, pp 6-15

Preliminary follow up Gold Exploration along Kali Gandaki Valley in Some Parts of Myagdi, Parbat and Baglung districts, Western Nepal

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INTRODUCTION

According to the annual field program of Department of Mines and Geology (DMG) for the fiscal year 2056/057, a preliminary follow up exploration and assessment of alluvial gold was carried out along Kali Gandaki Valley covering 250sq.km area in some parts of Myagdi, Parbat and Baglung districts, Western Nepal. It covers all along the Kali Gandaki Valley from Kusma (Parbat) to Kopchepani (Dana) section, along Modi Khola from Kusma to Birethanti section and in Myagdi Khola from Beni to Myagdi Tatopani section.

The investigated area lies in between latitude 28° 13' 00" to 28° 32' 00" north and longitude 83° 30' 00" to 83° 47' 30" east (Fig.1). It is a 4 to 8km wide and about 80km long strip. The investigated area lying east and south of Myagdi Bazar can be accessed through Pokhara - Kusma - Baglung - Myagdi Road. Beni - Darbang road and Beni (Myagdi) - Jomsom (Mustang) road are under construction, which pass through some parts of the investigated area. Other areas can be approached by mule tracks and foot tracks leading to villages.

The investigated area is a part of Lesser Himalaya and Higher Himalaya. Kali Gandaki originate in the Himalaya in the far north and flows to the south cutting through the high mountains and hills. At places, Kali Gandaki has made wide valleys like in Tukuche, Dana, Beni, which are suitable for settlements and cultivation. In most parts the valley is quite narrow forming gorges. Kali Gandaki is the trunk river in the investigated area. Modi Khola, Myagdi Khola and Rahu Khola are its major tributaries. Other small tributaries also join them at different places. Kali Gandaki and major tributaries flow from north to south (Fig.1). The highest elevation of the area is 3553m that lies north-east of Kopchepani and the lowest elevation is 712m right at the junction of Modi Khola and Kali Gandaki. The relief is moderate to very high.

Shrestha (1961), Shrestha (1971) and Vaidya (1971) prepared regional geological map of some parts of the investigated area. Bowen (1932), Manandhar (1964), and Singh (1963-64) conducted preliminary prospections of alluvial gold in different parts of Kali Gandaki. Singh (1962/63) did preliminary alluvial gold exploration in Modi Khola, Myagdi Khola and Kali Gandaki. He has reported alluvial gold at Khaniyaghat, Dana, Modipokhari and few other parts of Kali Gandaki section and Dobilla and Birethanti in Modi Khola section. Vaidya (1971) and Joshi (1970 and 1971) have reported a number of copper, iron, lead/zinc old workings in Myagdi and Baglung districts. One of the small-scale copper mine in Okharbot (Myagdi) was in operation till 1996 although annual production was quite small (less than 8 tons of copper metal/year). Most of the previous workers concentrated their work in high floodplains/riverbeds and reported occurrence of fine to very fine gold colours in Kali Gandaki River gravel. They did not tried to look for the primary source.

OBJECTIVE

The main objectives of the present investigation was:

- to carry out preliminary follow up exploration and assessment of alluvial gold and trace their possible primary sources.
- to prepare a geological map at 1:50,000 scale of the investigated area and collect few bulk samples, ore float samples for mineralogical study and chemical analysis for gold content if there is any.
- to collect heavy mineral concentrate samples with a view to know the concentration of alluvial/ placer gold in the river gravel (sediments) and in the river terraces.
- to conduct geochemical stream sediment survey with a view to know about the distribution of Cu, Pb and Zn in the river sediments and the associated ore minerals if any present in the region.
- to identify the promising sites for alluvial gold and primary gold and recommend for further follow up detail investigation.

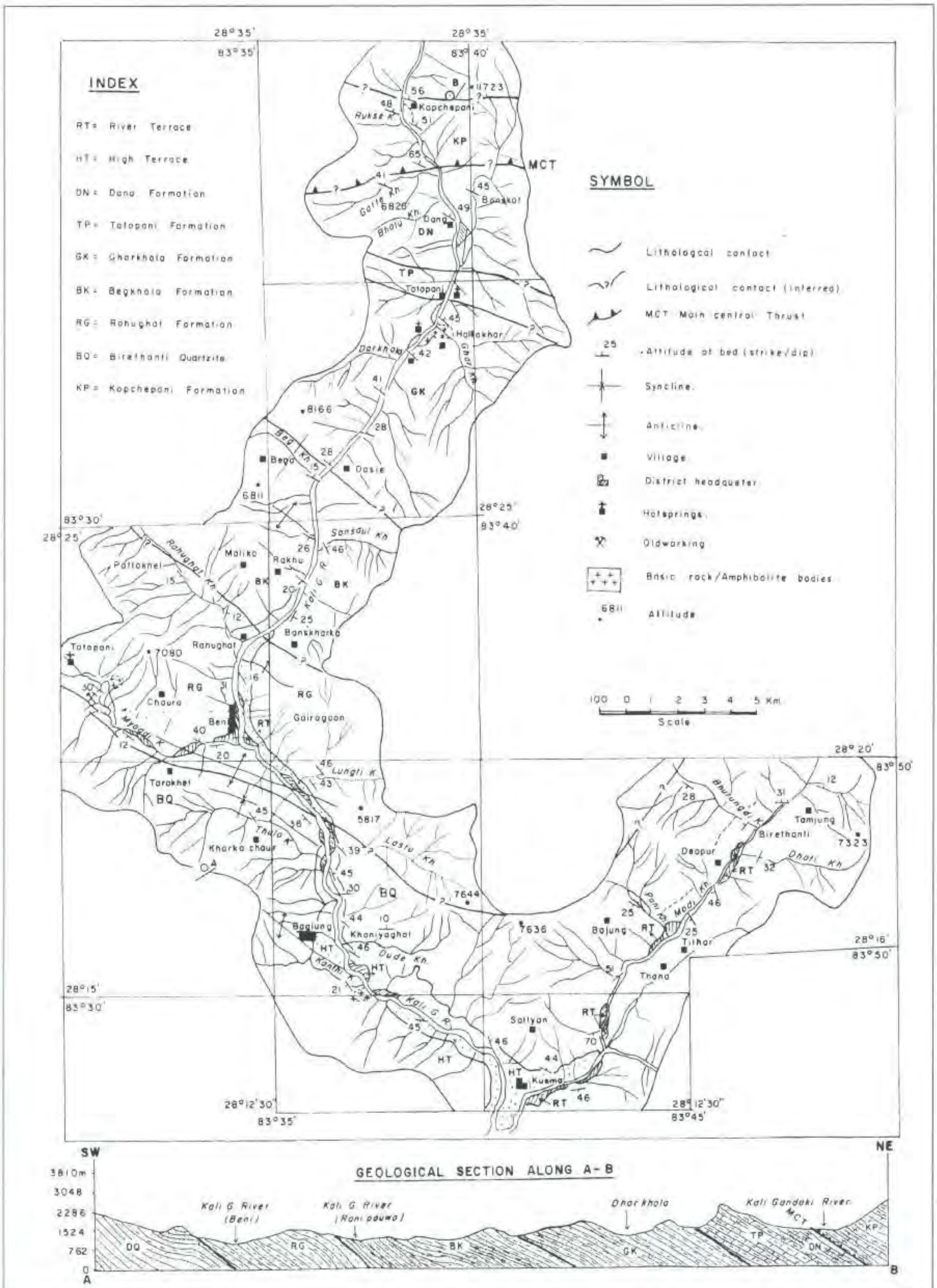

Fig. 1: Geological Map of Some Parts of Myagdi, Parbat and Baglung Districts, Western Region, Nepal

METHODOLOGY

Geochemical survey such as heavy mineral concentrate sampling was the main method applied for gold exploration. Sample from the present riverbed (flood plains) and river terraces were panned with a view to find out the distribution of alluvial gold in them. Rock/ ore float samples were collected and studied to trace the source rock for primary gold. Geochemical stream sediment sampling was carried out only in the selected tributary streams just to know the associated sulphide ore minerals if there is any.

FIELD ACTIVITIES

- Existing information like reports/ literatures, maps, aerial photographs were studied during the preparation of the fieldwork.
- An updated geological map of the investigated area was prepared at 1:50,000 scale (Fig.1).
- River terraces at various levels on the both sides of Kali Gandaki, Myagdi Khola, and Modi Khola were studied and marked as Younger River Terraces and Older High Level Terraces of glacio-fluvial origin in the map.
- Altogether 18 shallow trenches and 3 pits up to 2m deep were dug in the Lower, Middle and Upper River Terraces mainly in Dana area. Lithologs of most of the trenches and pits on the terraces were prepared (Fig.2a to 2p) with a view to know the concentration of gold at various levels.
- Selected amount of sediments (100 to 300kg) from trenches and pits were washed and panned for heavy minerals. Gold content in the Lower, Middle and Upper Terraces varies from >5 to over 160 colours, 5 to 60 colours and 1 to 10 colours/ ton gravel respectively. In all case the size varies from very fine (<0.01mm) to fine (<1mm). Placer gold is absent in the well-cemented older High Level Terraces (HT in Fig.1).
- In total 121 Heavy mineral concentrate samples were panned from terraces, flood plains, riverbeds from different parts of Kali Gandaki, Modi Khola, Myagdi Khola, Rahu Khola and from other tributary streams, terraces and checked for gold content in them.
- Eluvial soil was also collected from the base of the slope represented by high-grade metamorphic rocks lying to the north of MCT and panned to check gold content in them.
- Bulk samples from the garnet bearing calc-silicate and garnet bearing mica rich kyanite schist close to MCT and some ore floats (pyrite rich sulphide ores) were collected and crushed to minus -20 mesh, panned to detect the amount of gold content in them with a view to recognize the primary source rock.
- All the HC samples, ore float samples and few selected rock samples were analyzed for gold content.
- 102 stream sediment samples from different streams were collected for mineralogical study and chemical analysis for gold and base metal (Cu, Pb and Zn).

GENERAL GEOLOGY

The investigated area is a portion of northern part of Lesser Himalaya and southern marginal part of Higher Himalaya. The area lies towards south as well as north of the Main Central Thrust (MCT). The MCT is a prominent structure which can be traced near Dana Village (Fig.1). The investigated area is mainly represented by low grade metamorphic rocks like slate, phyllite, quartzite, dolomite; medium grade metamorphic rocks like calc-mica schist, garnet mica schist, amphibolite; and high grade metamorphic rocks like garnet bearing mica rich Kyanite schist, garnet bearing calc silicate and gneiss of Pre-Cambrian age. Quaternary Terrace Deposits (Quaternary debrisflow deposits as High level terraces and Fluvial / Alluvial deposits i.e. Low level river terraces as Lower, Middle and Upper terraces) are situated at 4 different levels and located in different parts along the sides of the rivers (Fig.1). Seven lithological units and two main types of terraces Younger River/ fluvial Terraces (RT) and Older High Level Terraces (HT) are identified and traced. Considering the grade of metamorphism, structures, rock type etc. the rocks are separated into three groups e.g. Crystalline Group, Metasedimentary Group and Quaternary Terrace Deposits. On the basis of structure, texture and mineral composition each group is further divided into different formations. Brief lithological description of each rock unit/ formation is presented in Table-1 below.

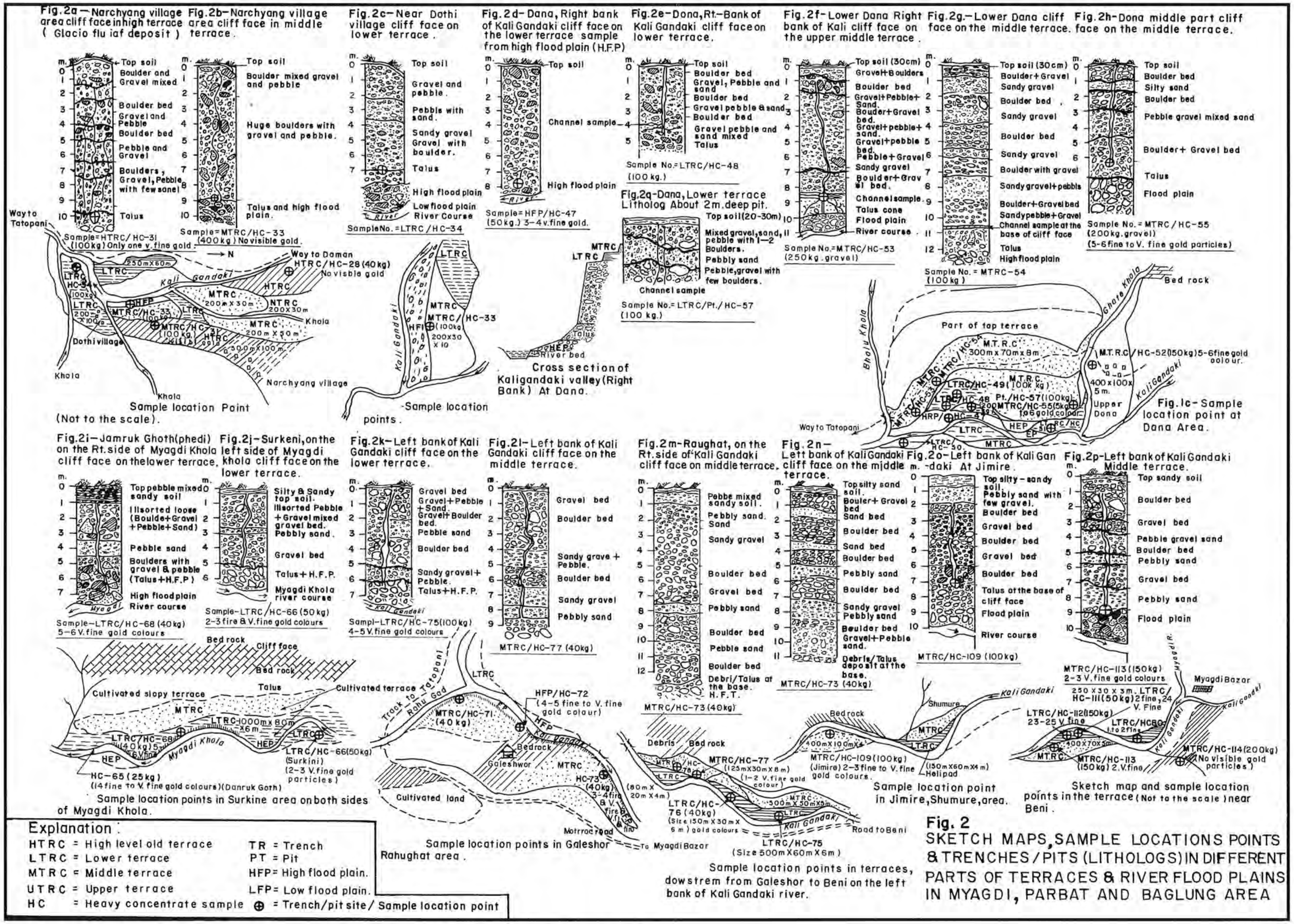

Fig. 2: Sketch Maps, Sample Location, Points and Trenches/Pits (Lithologs) in different parts of Terraces and River Flood plains in Myagdi, Parbat and Baglung Area.

Table-1: Lithological/Rock Units

Age	Group	Rock Units	Description of Lithological/Rock Units
Quaternary	Terrace Deposits	Younger River Terraces (RT)	Loosely packed, non-cemented to very poorly cemented, ill sorted lower, middle and upper river terraces of alluvial deposits.
		Older Glacio-fluvial High Terraces (HT)	Isolated ill-sorted, well-cemented, well packed, compact, fairly hard boulder and pebble conglomerate like sediment with vertical cliff forming nature. High level terraces are the result of glacio-fluvial debris flow deposit.
Pre-Cambrian	Metasedimentary Group	Dana Formation (DN)	Thinly bedded, well foliated, fine to medium grained, compact, shining gray mica schist, calc mica schist and phyllite with numerous barren quartz lenses and veins. At places light gray dolomite beds are present.
		Tatopani Formation (TP)	Repeated interbeds/ interlayers of fine grained light gray to bluish gray dolomite, dolomitic limestone and gray calcareous phyllite.
		Gharkhola Formation (GK)	Light green to greenish gray phyllite (at places micaceous) and quartzite towards lower part. Shining gray to greenish gray phyllite interlayers and few small amphibolite bodies are also present.
		Begkhola Formation (BK)	Thinly bedded, fine grained, gray to greenish gray slaty phyllite and well laminated gray slate. At places shining gray talcosic phyllite and fine grained gray quartzite are common.
		Rahughat Formation (RG)	Thinly bedded, well foliated, fine grained, gray to dark gray micaceous phyllite, greenish gray phyllite, interbedded with gray quartzite. At places purplish gray phyllite with light greenish white quartzite lenses and veins. Few minor amphibolite bodies also recorded.
		Birethanti Quartzite (BQ)	Highly fractured, jointed, thickly bedded to massive fine grained sericitic white quartzite (locally with ripple marks) and interbeds/ intercalations of gritty phyllite. At places small amphibolite bodies also recorded.
MCT		MCT	MCT
Pre-Cambrian	Crystalline Group	Kopchepani Formation (KP)	Fractured, coarse, compact garnet bearing biotite rich kyanite schist, calc silicates and banded gneiss. Occasionally with microgranite and pegmatite patches and lenses. Coarse grained marble bands occur towards far north.

Crystalline Group

It is represented by high-grade metamorphic rocks like Banded Gneiss, Kyanite Schist, Calc Silicates and Marble. In the presently investigated area this group is represented by Kopchepani Formation (KP) only.

Metasedimentary Group

On the basis of texture, structure and mineral composition this group is further divided into 6 formations (Table - 1)

Terrace Deposits

Terraces in the investigated area are mainly of two types:

Older High Level Terraces (HT): These terraces consist of poorly-sorted, but well packed, well cemented, compact fairly hard boulder, gravel and pebble mixed conglomerate like sediment. They occupy the higher level terrace on both sides of Kali Gandaki. These terraces are the result of glacial and glacio-fluvial debris flow deposits. The boulders, gravel and pebbles in these terraces are mainly of gneiss, schist, limestone, dolomite and slate derived from far north. Block separation and vertical cliff forming nature is typical of these terrace deposits. They are well exposed on the cliff face on the left side of Kali Gandaki, north of Beni Bazar and many other places.

Younger River Terraces (RT): It is sorted, loosely packed, non-cemented to poorly cemented alluvial deposits. On the basis of location, these terraces are further divided into **Lower Terraces (LTR), Middle Terraces (MTR) and Upper Terraces (UTR)** (Fig. 3). All the three types of Terraces are quite well preserved in Dana, Galeshor, North of Beni, Khaniyaghat, further down towards Kusma and Dobilla, and few other places (Fig.1, 2 and 3). 18 Trenches and 3 pits were dug on these terraces. 100 - 150kg sediment collected from each trenches and pits were washed and panned for heavy minerals. Heavy concentrates panning of the sediments collected from trenches and pits in LTR, MTR and UTR reveal that gold concentrations are comparatively more in LTR than in the MTR and UTR (Table - 2). This clearly indicates that some of the LTR could be promising for gold. However, almost all these terraces are used for cultivation (Rice and wheat field).

River Flood Plains lie along the river course. On the basis of their location they are divided into High Flood Plains (HFP) and Low Flood Plains (LFP) areas, although the sediment constituents are more or less similar. Preliminary study

Fig. 3: LTRC, MTRC and UTRC on the right bank of Myagdi Khola at Danrukgoth. High Level Terrace (HT) is seen on the left bank of Kali Gandaki River at far distance.

revealed that the sediments/ gravel in HFP is comparatively rich in gold concentration than in the Low Flood Plains (Table-2). In Kali Gandaki River HFP, the gold concentration is found to be up to 4240 colours/ ton sediment (excluding boulders) in sample KK/HC-82 (Table-3) in Kali Gandaki section. Some of these high flood plains are promising for alluvial gold. Gold particles (colours) found in Kali Gandaki, Myagdi Khola, Modi Khola is quite pure and golden yellow in colour. The size varies considerably from <0.01mm (very fine dust like) to 3mm (medium to coarse). Most of the gold particles found in this area are flat and < 1mm in size (Table- 2 and 3).

GOLD MINERALIZATION/ CONCENTRATION

Primary gold mineralization as such was not detected in the investigated area. Only 2 minor copper old working adits were recorded at about 1.5 km southeast of Myagdi Tatopani Bazar on the right side of Myagdi Khola near suspension bridge and one in Beg Khola area (Fig-1). However, alluvial / placer gold can be traced in almost all the heavy mineral concentrate samples collected from the Kali Gandaki, Modi Khola and Myagdi Khola Sections (Table-3). No gold particle (colour) of any size was detected in all other small tributary streams except in two minor streams. That may be due to influence of main river or any other reasons. Placer gold was traced in almost all the Young River Terraces except in highly cemented Old High Level Terraces of ˛lacial/ glacio-fluvial origin. Present study reveal that gold concentration in Upper and Middle Terraces is very low but in Lower Terraces and Floodplains it is fairly high especially in Tatopani – Dana

Table-2: Gold Concentration in the Riverbeds/ Flood plains and Terraces

Location	Total no of Alluvial Gold colours content in gravel/ sediment	Size	Remarks
In River Flood Plains/ Riverbeds			
Kali Gandaki River Flood plains	60 to 4240 gold colours/ ton gravel	0<0.01 – 3mm	Locally fairly high concentration
Myagdi Khola flood plains	200 to 650 gold colours/ ton gravel	<0.01 – 1mm	Locally fairly high concentration
Modi Khola flood plains	225 to 700 gold colours/ ton gravel	<0.01 – 1mm	Locally fairly high concentration
Rahu Khola	10 to 200 gold colours/ ton gravel	<0.01- 0.75mm	Low concentration
Bhalu Khola	2 – 5 gold colours/ ton gravel	<0.01 to 3mm	Very low concentration, it might be due to the influence of Kali Gandaki during high flood time in the past
Rati Khola	0 – 5 gold colours/ ton gravel	<0.01 to 0.5mm	Very low concentration, it might be due to the influence of Kali Gandaki River
In Low Level Younger Terraces (RT), Kali Gandaki Valley			
Lower Terraces (Kali Gandaki Valley)	Up to 160 gold colours/ton sediment	Very fine to fine	Concentration is low, not economic
Middle Terraces	Up to 60 gold colours/ ton sediment	Very fine to fine	Concentration is low, not economic
Upper Terraces	Up to 10 gold colours/ ton sediment	Very fine	Concentration is very low
In High Level Older Terraces (HT)			
	No visible gold colours detected	None	Sediment is barren with respect to gold

sector and Beni to Kusma sector of Kali Gandaki River course; Beni to Tatopani (Myagdi) sector of Myagdi Khola and in Dobilla to Birethanti sector of Modi Khola. These sectors locally appear to be promising for placer gold (Table-2 and 3). The chief minerals identified in most of the heavy mineral concentrate samples from these river/kholas are gold (2 to over 400 colours per 100kg gravel, garnet (3 - 75%), ilmenite (<1 to 2%), magnetite (1 - 50%) hematite/ lemonite (2 - 5%), kyanite (<1-2 %), rutile (<1%), epidote (<1%), tourmaline (<1-1%), Pyroxene and Hornblende (<1%), zircon (traces). Therefore, selective mining/ panning for alluvial gold in the above mentioned promising sectors in HFP appears to be feasible for seasonal panning. It is believed that the Primary source must be lying further north of MCT in crystalline rocks in the Higher Himalaya. Analytical results of the rocks and ore floats will definitely help to trace the primary source.

GEOCHEMICAL STREAM SEDIMENT SURVEY

Geochemical stream sediment survey was also conducted in the same 250sq.km area. Altogether 102 stream sediment samples were collected from the tributary streams with an average sample density of 1 sample per 2.5sq.km area. All the samples were analyzed in the DMG chemical laboratory for copper, lead and zinc content in them. Analytical results were used for statistical calculation to obtain Mean value (x), Standard Deviation (Sd), Threshold value (x+2Sd), Anomalous value (above Threshold) and High Anomalous value (>X+3Sd) of Copper (Cu), Lead (Pb) and Zinc (Zn) separately (Table- 4). Five small anomalous areas e.g. 1 for Copper, 2 for Lead and 2 for Zinc were delineated in the geochemical anomaly map. Each anomaly is categorized according to standard anomaly category (Table 5 and 6). But

Table-3: Gold recovered in the Heavy Concentrate Samples

Sample No.	Location(Refer sample location map)	Total gravel panned (kg)	No. of visible gold colours (Particles)	No of gold colours in 1ton gravel (calculated)	Gold content in concentrate (ppm)	Remarks
KK/HC-1	Kali Gandaki	40	20 f and vf	500	NK	High concentration
KK/HC-2	Kali Gandaki	40	10 vf	250	NK	Moderate concentration
KK/HC-6	Myagdi Khola	40	8f and vf	200	NK	Moderate concentration
KK/HC-9	Myagdi Khola	40	8 f and vf	200	NK	Moderate concentration
KK/HC-27	Bhalu Khola	50	1c (3mm),3 f and vf	80	NK	Low concentration
KK/HFP/ HC-35	Kali Gandaki (Dana)	50	8f and vf	160	NK	Low concentration
KK/HC-41	Kali Gandaki	40	1c and 7f-vf	200	NK	Moderate concentration
KK/HC-43	Kali Gandaki	40	5f and vf	125.	NK	Low concentration
KK/HFP/ HC-47	Kali Gandaki	50	3vf	60	NK	Low concentration
KK/MTRC/ HC-55	Terrace (Dana)	100	6f and vf	60	NK	Low concentration
KK/HC-60	Kali Gandaki	50	6f and vf	120	NK	Low concentration
KK/HC-65	Myagdi Khola	40	14f and vf	350	NK	Moderate concentration
KK/HC-67	Myagdi Khola	40	6f and >20 vf	650	NK	High concentration
KK/HFP/ HC-69	Myagdi Khola	40	5 f and 11 vf	400	NK	High concentration
KK/HC-70	Rahughat Khola	40	8f and vf	200	NK	Low concentration
KK/HC-72	Kali Gandaki	40	2f 10 vf	300	NK	Moderate concentration
KK/HC-74	Kali Gandaki	40	1c, 7f and vf	200	NK	Low concentration
KK/HC-79	Kali Gandaki	100	3c (1 and 2mm)6m,>71f and vf	800	NK	High concentration
KK/HC-81	Kali Gandaki	50	15f and vf	300	NK	Moderate concentration
KK/HC-82	Kali Gandaki	50	2c (1mm)10m, >200f and vf	4240	NK	Very high concentration
KK/HC-83	Kali Gandaki	40	16f and vf	400	NK	Moderate concentration
KK/HC-89	Modi Khola	40	1m, 8f and vf	225	NK	
KK/HC-90	Modi Khola	40	3m, 14f and vf	425	NK	Moderate concentration
KK/HC-93	Kali Gandaki	40	1m, 64f and vf	1625	NK	Very high concentration
KK/HC-95	Kali Gandaki	50	1c, 6m,>100 f and vf	2140	NK	Very high concentration
KK/HC-96	Kali Gandaki	50	5m, 80f and vf	1700	NK	Very high concentration
KK/HC-97	Modi Khola	40	1m, 26f and vf	675	NK	High concentration
KK/HC-103	Modi Khola	50	35f and vf	700	NK	High concentration
KK/HC-104	Modi Khola	40	12f and vf	300	NK	Moderate concentration
KK/HC-105	Kali Gandaki	50	1c, 3m >30f and vf	680	NK	High concentration
KK/HC-110	Kali Gandaki	40	8f and vf	200	NK	Low concentration
KK/HC-111	Kali Gandaki	50	26 f and vf	520	NK	High concentration
KK/LTRC/ HC-112	Kali Gandaki	150	24f and vf	160	NK	Low concentration
KK/MTRC/ HC-113	Kali Gandaki Terrace	150	2vf	6.6	NK	Very low concentration
KK/HTRC/ HC-114	Kali Gandaki High Terrace Debrisflow deposit	200	No visible gold particles	-	NK	No visible gold (Gold absent)

c = Coarse grain, m= Medium grain, f = Fine grain, vf = Very fine grain/ ultrafine grain/ dust, NK=Not known, <50 colours = Very low concentration, 50 -199 colours = Low concentration, 200 - 399 colours = moderate concentration, >400 - 1000colours = High concentration, >1000 = Very high concentration , HFP = High Flood Plain, LFT = Low Flood Plain, LTR C= Low Terrace, MTRC = Middle Terrace, UTRC = Upper Terrace, HT = High Level older Terrace all these anomalous areas are too small in size and too low in metal content. Therefore, none of them comes under anomaly category no. 1 and 2. Therefore, further follow up exploration for copper, lead and zinc in the same area is not recommended.

RESULTS AND FINDINGS

- Geological map and sample location maps are prepared (Fig. 1 and 2).
- Present field and laboratory investigation was able to trace Alluvial/ Placer Gold (<0.01mm to 3mm size) in the heavy mineral concentrate samples panned from the river gravel/ floodplain of Kali Gandaki and its major tributaries like Modi Khola, Myagdi Khola and Rahu Gad sections (Fig. 1 and 2). The gold content of gold in the river gravel/ floodplain varies considerably from 4 to more than 400 colours per 100kg gravel i.e. 220 to over 4240 colours/ton gravel (Table- 2 and 3). On the basis of field observation the promising sites for placer gold are identified in the High Flood Plains in Tatopani - Dana section, Beni - Rahughat section, Beni - Khaniyaghat section of Kali Gandaki, Beni–Tatopani section of Myagdi Khola and Dobilla– Birethanti section of Modi Khola (Table-2, 3 and Fig. 1 and 2).
- All these major rivers are originated in the Himalaya and consist alluvial gold in their river gravel (sediments) where as no gold particle was detected from other minor tributaries coming from the Lesser Himalaya (except in Bhalu Khola and Rati Khola).
- Gold particles were also recorded in almost all the three younger river terraces (except in High level Older Terraces of glacial/ glcio-fluvial deposits) at Dana, Galeshor, Myagdi (Beni) and Khaniyaghat in Kali Gandaki River section and Dobilla areas in Modi Khola section. However, gold content in these terraces varies considerably (from 6 to 200 colours/ ton gravel (excluding boulders).
- Heavy mineral concentrate sampling from riverbeds/ flood plains as well as from terrace was able to trace placer/ alluvial gold. The number/ amount of gold

Table-4: Geochemical Anomaly Calculation for Copper, Lead and Zinc in Stream sediments

Element	Frequency of samples (n)	Mean Value ($\bar{x}$) (ppm)	Standard Deviation (SD) (ppm)	Threshold (ppm)	Anomalous value (ppm)	High anomalous value (ppm)	2 x T (ppm)	4 x T (ppm)	8 x T (ppm)
Cu	99	22.4	13.3	49	62.3	>63	98	196	392
Pb	99	15	7.8	30.6	38.4	>39	61.2	122.4	244.8
Zn	99	72.2	26.9	126	153	>153	252	504	1008

$\bar{x}$ = Mean value, Threshold = $\bar{x}$+2SD, AnomalousValue = >$\bar{x}$+2SD, High Anomalous Value= >$\bar{x}$+3SD

Table-5: Standard Anomaly Category

Magnitude of Anomaly→ / Drainage Area↓	$\bar{x}$+3Sd to 2 x T	2 x T to 4 x T	4 x T to 8 x T	> 8 x T
<1 Sq. km	4	4	3	2.5
1 – 2 sq. km	4	3	2.5	2
2 – 4 sq. km	3	2.5	2	1
>4 sq. km	2.5	2	1	1

$\bar{X}$ = Mean value, SD = Standard Daviation, T = Threshold, 1 to 4 = Anomalous categories where 1 anomaly has top priority and 4 anomaly has least priority for further follow-up exploration

Table-6: Anomaly Category

Location	Element	Drainage area (Size)	$\bar{x}$+3SD–2T (Anomalous)	Anomaly Category
Tributary of Bhurandi Khola	Cu	2 sq km	3 times of T value	3
Lungti Khola	Pb	2.5 sq km	2.8 times of T value	2.5 - 3
Small Tributary of Myagdi Khola	Zn	2 sq.km.	1.4 times of T value	4
Small Tributary of Kali Gandaki	Zn	1.5 sq.km	1.4 times of T value	4
Gatte Khola	Pb	2 sq.km.	2 times of T value	4

colours recovered from the river bed/ flood plain in Kali Gandaki section varies from 60 – 4240 colours, in Myagdi Khola section 200 – 650 colours, in Modi Khola section 225 – 700 colours and in Rahu Khola section <5 to 200 colours/ ton gravel.

- Primary gold mineralization does not exist in the investigated area. However, present investigation clearly revealed that the primary source of alluvial/ placer gold in Kali Gandaki, Modi Khola, Myagdi Khola and Rahugad must be lying somewhere in the higher crystalline rocks like gneisses, migmatites, pegmatites etc. in the Higher Himalayan region (beyond presently investigated area).

- Geochemical stream sediment survey was able to identify 5 small and irregular anomalous areas for copper, lead and zinc. But none of them appears to be encouraging for further follow-up exploration.

CONCLUSION AND RECOMMENDATION

In this area, the alluvial/ placer gold commonly occurs as pure yellow, mostly in flakes, oval or rolled nuggets. They are mostly <0.01mm to 3mm in size in the gravel of Kali Gandaki River. Normally they are of high quality gold (Fineness around 900). Alluvial gold concentration in the river gravel in high flood plain, at places appears promising for small scale seasonal gold panning in the area between Galeshor (Rahughat) to Kusma sector of Kali Gandhi River. However, Beni - Tatopani (Myagdi) sector of Myagdi Khola and Dobilla - Birethanti sector of Modi Khola area could also be the interesting sites for seasonal panning. It is advised to conduct alluvial gold panning in the month of Aswin to Falgun immediately after monsoon every year. High recovery of placer gold also depends on the selection of right sites.

Presence of gold colours in the river beds, flood plains as well as in the river terraces clearly indicate that the alluvial gold are derived from the primary source in the higher crystalline rocks, migmatites, pegmatites etc in the Higher Himalayan region (MCT zone and further north). In some parts of the Kali Gandaki section (e.g. from Beni to Kusma) the recovery of gold in the river gravel reaches up to 4240 colours/ton sediment from high flood plain areas (HFP); 6 to 200 colours/ton sediment from lower terraces (LTR); and only <5 to 60 colours/ ton sediments in middle and upper terraces (Table-2 and 3). Gold colour of any size was not detected in the highly cemented high level terraces of glacial and glacio-fluvial (debris flow) deposit.

Most of the lower, middle and upper river terraces are cultivated and gold content in them as compared to flood plain is very low. Therefore, mining of alluvial gold in the terraces is not recommended because of not only low recovery of alluvial gold but also geo-environmental problem and these are the only fertile agricultural fields available in this area. However, seasonal mining of gold from selected floodplain appears to be promising.

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Reconnaissance Geochemical Survey for Base Metals and Gold in Some Parts of Bajhang and Bajura Districts, Far Western Nepal

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INTRODUCTION

According to the annual field programme of Department of Mines and Geology for the fiscal year 2056/57 B.S. (2000) a 'Reconnaissance Geochemical Survey' was conducted for base metals (Cu, Pb and Zn) and gold in some parts of Bajhang and Bajura districts, Far Western Nepal. The investigated area is bounded by longitude 81° 15' 00" to 81° 30' 00" E and latitude 29° 30' 00" to 29° 45' 00" N covering 650 Km^2 area. Southwestern part of the area lies at a distance of about 7.0 Km towards east of Chainpur, the head quarter of Bajhang district (Fig. 1).

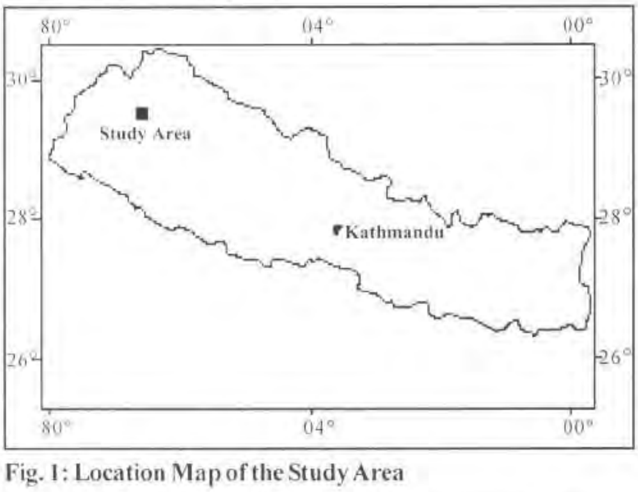


Fig. 1: Location Map of the Study Area

Adhikari prepared a regional geological map of the area in 1978/79. But from the mineral exploration point of view, no activity was conducted in this area before. Khan (1995), Kaphle (1996) and Khan and Khadka (1999) carried out 'Geochemical Exploration' works in the adjoining areas.

OBJECTIVES

The main objectives of the investigation were:

- to carry out stream sediment survey/sampling from all the tributary streams with a view to identify the possible anomalous area for Cu, Pb and Zn and targets the area for further follow-up exploration.
- to carry out heavy mineral concentrate sampling from the main streams and main tributary streams to check the content of gold and other heavy minerals present in them.
- visual checking of gold content in sulphide bearing rocks by crushing and panning.
- to carry out rock chip sampling from the outcrops and ore floats for petrographic study and chemical analysis to look for base metals and gold.
- to update the existing geological map (1:63,360 scale).

METHODOLOGY

- A topographic base map of 1:63,360 scale was used in the field mapping. Traverses were made all along the accessible streams, foot tracks and hills. Lithological units and structural features are identified.
- Stream sediment samples were collected from the tributary streams of the area. Samples were dried and sieved through 80 mesh sieve. Only minus 80 mesh fraction of the samples were collected and stored in a labeled plastic bag.
- Heavy mineral concentrate samples were collected from the main streams and main tributary streams. 30 to 60 Kg gravel mixed sediments were collected and sieved through 10 mesh sieve in a slow motion of water. Minus 10 mesh fractions were washed and panned for heavy mineral concentrates. Similarly sulphide bearing rock chip samples (5 Kg each) were crushed, sieved and panned in the field to look for gold content in them. The concentrates were dried and wrapped in the paper and then packed in a labeled plastic bag.

- Rock chip samples were collected from outcrops and floats for petrographic study and chemical analysis for different elements.

FIELD ACTIVITIES

Following activities were carried out during the field investigation:

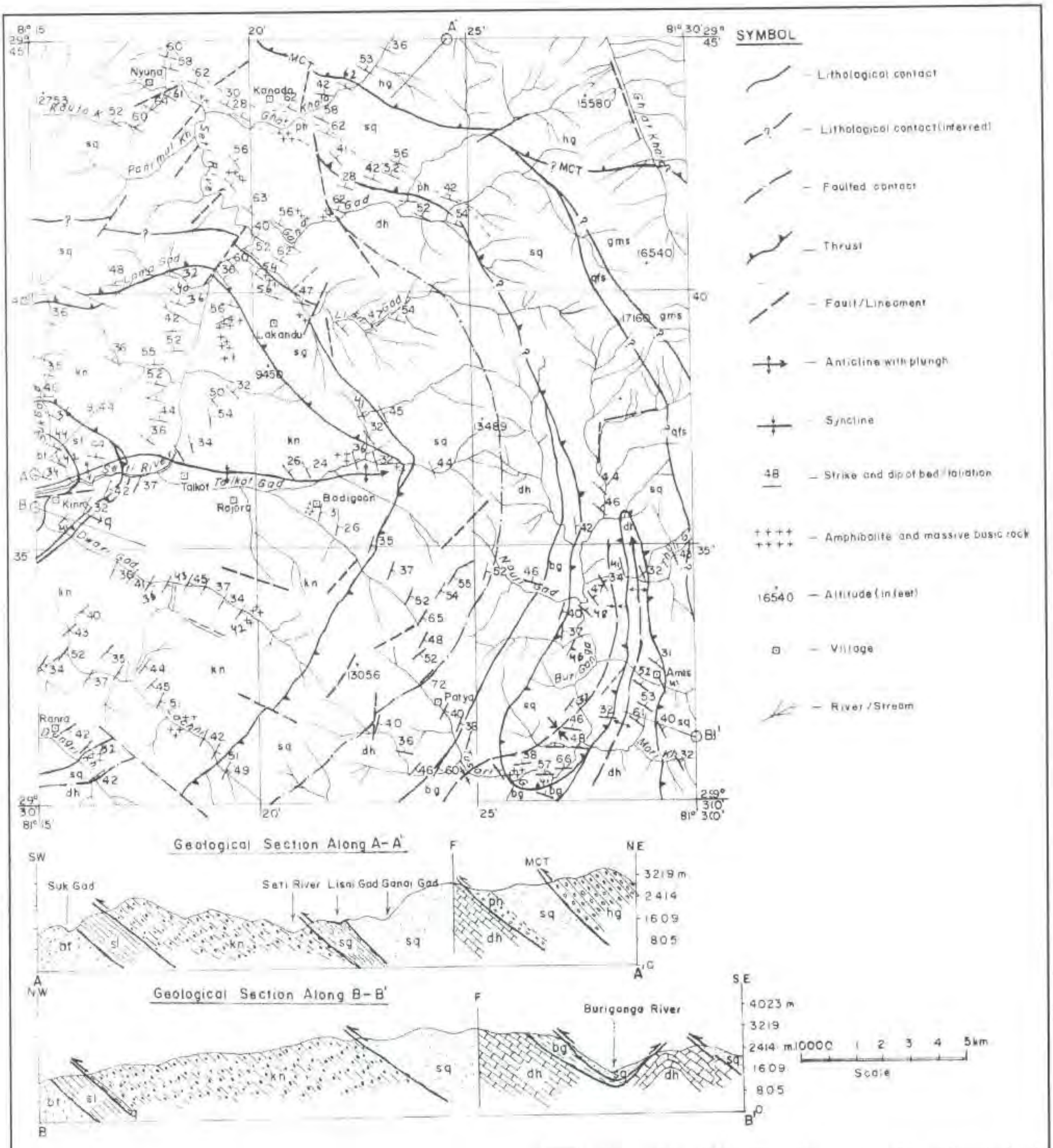
- Reconnaissance stream sediment sampling was conducted in 650 Km² area and 630 stream sediment samples were collected from various tributary streams.
- 64 heavy mineral concentrate samples were collected from the river flood plains of main rivers and main tributaries.
- 17 rock chip samples containing sulphide minerals were crushed and panned to look for gold content in them.
- 48 rock chip samples were collected for petrographic study and chemical analysis for Cu, Pb, Zn, Au, Fe, CaO and MgO.
- An updated geological map of 650 Km² area was prepared (in 1: 63360 scale) after interpretation of aerial photographs, satellite images and field observation data.

GENERAL GEOLOGY

The investigated area can be broadly divided into two Complexes: (1) Crystalline Complex and (2) Metasedimentary Complex. Ten lithological units are identified in the area (Fig. 2). A brief description of lithotectonic units is given in Table-1.

Table-1: Litho-tectonic Units of the Area

Age	Complex	Group	Formation (Rock Unit)	Lithology
Paleozoic to Triassic (?)	Bajhang Metasedimentary Complex	Tapovan Group	Sallabager Formation (sl)	Mainly slates with some dolomite.
			Bhatgaon Formation (bt)	Grey to greenish grey sandstone and purple shale.
THRUST		THRUST		
Paleozoic	Nawakot Complex	Upper Nawakot	Benighat Slate (bg)	Dark grey to black carbonaceous slate with intercalation of dolomite beds.
		UNCNFORMITY (?)		
Late Precambrian		Lower Nawakot	Dhading Dolomite (dh)	Mainly dolomite with intercalation of slate and phyllite
			Kuncha Formation (kn)	Mainly gritty phyllite with quartzite and basic rocks.
THRUST		THRUST		
Precambrian (?)	Lesser Himalayan Crystalline Complex	Metamorphic Group	Garnet Mica-Schist (gms)	Garnetiferous mica-schist with quartzo-feldspathic mica-schist and gneiss bands.
			Quartzo-Feldspathic Mica-Schist (qfs)	Quartzo-feldspathic mica-schist occasionally with garnet mica-schist and quartzite bands.
			Surmasarowar Quartzite (sq)	Sericitic quartzite with phyllite and amphibolite.
			Suni Gad Gneiss (sg)	Mainly augen gneiss with bands of schist.
MCT		MCT	MCT	
Precambrian (?)	Higher Himalayan Crystalline Complex		Higher Himalayan Gneiss (hg)	Augen gneiss and quartz mica-schist with garnet and kyanite.



LEGEND

- sl - **Sallabagar Formation**: Slate and dolomite
- bt - **Bhatgaon Formation**: Sandstone and shale
- bg - **Benighat Slate**: Carbonaceous slate with dolomite beds
- dh - **Dhading Dolomite**: Dolomite with slate and phyllite
- kn - **Kuncha Formation**: Gritty phyllite with quartzite (q) and basic rocks
- gms - **Garnet Mica-Schist**: Garnetiferous mica-schist with gneiss bands
- qfs - **Quartzo-feldspathic Mica-Schist**: Quartzo-feldspathic mica-schist with quartzite bands
- sq - **Surmasarowar Quartzite**: Sericitic quartzite with phyllite and amphibolite
- sg - **Suni Gad Gneiss**: Augen gneiss with schist bands
- hg - **Higher Himalayan Gneiss**: Augen gneiss and quartz mica-schist with garnet and kyanite

Fig. 2: Geological Map of a part of Bajhang and Bajura Districts Far Westersn Nepal.

FINDINGS

Some mineralized bands and lenses (0.5 to 2.5 m thick) are encountered in the investigated area. Likewise some ore floats are also traced. A brief description of mineralized bands/lenses and chemical analysis result of the samples are given in the Table-2.

Table-2: Brief description of mineralized bands/lenses and chemical analysis result of the samples

S. no.	Sample no.	Location	Rock type	Lithological Unit	Thickness of band/lens	Length of band/ lens	Size of Ore float	Cu (ppm)	Other elements	Remarks
1	Bds-1002	Suk Gad	Chp bearing schist	-	-	-	12 cm x 10cm	420	-	This band contains disseminated Py with few Chp.
2	S-1011	Dwari Gad	Py bearing carb. slate	S1	2.5 m thick band	-	-	38	-	
3	Bds-1057	Talkoti Gad	Py, Chp bearing quartz vein within phyllite	-	-	-	25 cm x 15 cm	62	-	
4	Bds-1081	Ganai Gad	Py, Chp bearing quartzite	-	-	-	1.0 m x 0.5m	170	-	
5	Bds-1103	Ghat Khola	Py, Po, Chp bearing quartzite	-	-	-	15 cm x 12 cm	172	-	
6	Bds-1112	Kaula Khola	Py, Chp, Gal, Sph bearing quartzite	-	-	-	15 cm x 20 cm	18	18 ppmPb, 72 ppm Zn	
7	Bds-1113	--	--	-	-	-	15 cm x 10 cm	16	14 ppm Pb, 24 ppm Zn	
8	Bds-1114	--	--	-	-	-	20 cm x 15 cm	890	17 ppm Pb, 57 ppm Zn	
9	Bds-1115	--	Py, Po, Mgt, Chp bearing quartzite	-	-	-	40 cm x 30 cm	40	-	
10	S-1144	Near Dhalaun village	Mal, Py bearing quartzite	sq	2.0 m to 2.5 m thick band	-	-	1320	-	The host rock is slightly calc
11	S-1178	Near Patya village	Py, Chp bearing quartzite	sq	1.0 m thick band	-	-	40	-	-
12	S-1179	--	Ferruginous quartzite	sq	0.5 m thick band	-	-	-	11 % Fe	The host rock contains Hmt and Py
13	Bds-1181	Tusari Gad	Gal bearing quartzite	-	-	-	1.0 m x 0.7 m	-	24 ppm Pb, 18 ppm Zn	-
14	S-1193	--	Mal bearing quartzite	sq	0.5 m to 1.0 m thick lens	2.0 m	-	7770 (0.8%)	-	The lens contains few Py and Chp
15	S-1194	--	--	--	0.5 m to 0.75 m thick lens	1.5 m	-	3710 (0.4%)	-	-
16	Bds-1278	Lachhi Gad	Py, Chp bearing quartz vein within phyllite	-	-	-	25 cm x 18 cm	340	-	
17	Bds-1289	Dungri Khola	Py, Chp bearing quartzite	-	-	-	1.0 m x 0.6 m	280	-	
18	S-1294	Along the road between Baghthala and Deora village	Limestone	-	10.0 m thick band	-	-	-	43.0% Cao, 3.38% Mgo	Out of investigated area (Toposheet no. 62 C/15)
19	S-1295	--	--	-	15.0 m thick band	-	-	-	46.12% Cao, 3.62% Mgo	--

N.B. : 1. Analytical result of gold is not received yet; 2. S denotes the outcrop samples; 3. Bds denotes the float samples; 4. Py = pyrite, Chp = chalcopyrite, Po = pyrrhotite, Carb = carbonaceous, Gal = galena, Sph= sphalerite, Mgt = magnetite, calc = calcareous, Mal = Malachite, Hmt = Hematite

GEOCHEMISTRY

Stream Sediment Sampling:

All the stream sediment samples collected in the investigated area were analyzed for Cu, Pb and Zn. The results of each element are grouped according to lithology of the area. The area is divided into two groups: A and B. The Statistical Parameters for Cu, Pb and Zn of group A and B are given in the Table-3.

Anomalous Area for Copper, Lead and Zinc: Some anomalous areas for Cu, Pb and Zn have been identified inthe investigated area. The anomalies are categorized to rank their relative significance as indications of possible economic mineral deposits. Categories are obtained according to the magnitude of anomaly and drainage area. For this purpose an 'Anomaly Category Matrix' is used (Table-4).

With the help of Table-3 and 4, the anomalous area with categories for copper, lead and zinc has been identified. The anomalous areas for Cu, Pb and Zn and their brief descriptions are given in the Table-5, 6 and 7 respectively.

Heavy Mineral Concentrate Sampling

64 heavy mineral concentrate samples were collected in the investigated area. Some visible fine gold colours are observed in the samples collected from Seti River and Lachhi Gad. The size of gold colours vary from 0.01 to 0.5 mm. Mineralogical study of the samples under binocular microscope reveals that pyrite, magnetite, garnet, ilmanite and rutile as the common minerals. Kyanite is seen in the samples collected from Seti River and Ghat Khola. Some grains of chalcopyrite are recorded in samples of Dwari Gad, Talkoti Gad, Seti River, Ghat Khola, Kaula Khola, Ganai Gad, Lachhi Gad and Buriganga River. Few grains of galena are observed in the samples of Tusari Gad and Kaula Khola.

Table-3: Statistical Parameters of Stream Sediments Result

Lithological Group	Element	Local mean background ($\bar{x}$) (ppm)	Standard deviation (SD) (ppm)	Threshold (T) value ($\bar{x}$+2SD) (ppm)	Anomalous value (>$\bar{x}$+2SD) (ppm)
A (mainly quartzite, schist and gneiss)	Cu	13.6	7.9	29.4	> 30
	Pb	15.0	7.7	30.4	> 31
	Zn	34.7	17.9	70.5	> 71
B (mainly phyllite, dolomite and slate)	Cu	23.7	12.4	48.5	> 49
	Pb	16.7	8.5	33.7	> 34
	Zn	50.5	25.6	101.7	> 102

Table-4: Anomaly Category Matrix

Magnitude of Anomaly→ / Drainage Area↓	$\bar{x}$+3SD to 2xT	2xT to 4xT	4xT to 8xT	>8xT
< 1 Square Km	4	4	3	2.5
1 To 2 Square Km	4	3	2.5	2
2 To 4 Square Km	3	2.5	2	1
> 4 Square Km	2.5	2	1	1

N.B. : $\bar{x}$ = Mean background value; SD = Standard deviation; T = Threshold value; 1– 4 = Anomalous categories, where category 1 anomalies have top priority and category 4 anomalies have least priority for further follow-up exploration work.

Table-5: Anomalous Area for Copper (Cu)

S. no.	Location	Area (Km^2)	Element value (ppm)	No. of anomalous stream (>x+3SD)	Other supporting anomalous element	Category	Lithology of the area	Remarks
1	Dhalaun area	7.0	65 to 959	6	Lead	1	Quartzite, phyllite, amphibolite and dolomite	A 2.0 m to 2.5 m thick band of malachite bearing quartzite containing 1320 ppm Cu is recorded in this area.
2	Ghat Khola area	4.0	35 to 568	4	Zinc	2	Quartzite, schist and gneiss	
3	Kanda area	2.0	39 to 867	3	Lead	2	Quartzite and phyllite	
4	Daya area	9.o	55 to 131	12	Lead and Zinc	2.5	Phyllite, quartzite and amphibolite	
5	Bhatta Gad area	3.0	50 to 164	3	Zinc	3	Phyllite and amphibolite	
6	Jima area	1.5	51 to 103	3	-	3	Quartzite and phyllite	
7	Lisni Gad area	1.5	45	1	-	4	Schist, gneiss and quartzite	

Tourmaline and zircon grains are found in the samples of Seti River and Buriganga River. But none of them appear as economic deposit.

17 rock chip samples (5 kg each) containing sulphide minerals were crushed, sieved and panned in the field to look for gold content in them. But no visible gold colour (flakes) was seen. All the samples were supplied to the chemical lab for gold analysis and the result is awaited. A brief description of the samples is given in the Table-8.

Table-6: Anomalous Area for Lead (Pb)

S. no.	Location	Area (Km^2)	Element value (ppm)	No. of anomalous stream ($>\bar{x}+3SD$)	Other supporting anomalous element	Category	Lithology of the area	Remarks
1	Dhalaun area	4.0	34 to 62	4	Copper	3	Dolomite, quartzite and phyllite	A 2.0 to 2.5 m thick band of malachite bearing quartzite is present in this area
2	Kaula Khola area	2.5	36 to 78	3	Zinc	3	Quartzite and phyllite	Float samples from Kaula Khola show up to 18 ppm Pb, 72 ppm Zn and 890 ppm Cu
3	Daya area	1.0	36 to 90	1	Copper and Zinc	4	Phyllite	

Table-7: Anomalous Area for Zinc (Zn)

S. no.	Location	Area (Km^2)	Element value (ppm)	No. of anomalous stream (>x+3SD)	Other supporting anomalous element	Category	Lithology of the area	Remarks
1	KaulaKhola area	4.0	72 to 304	3	Lead	2.5	Quartzite and phyllite	Float samples from Kaula Khola show up-to 18 ppm Pb, 72 ppm Zn and 890 ppm Cu
2	Daya area	7.5	106 to 196	5	Copper and Lead	2.5	Phyllite, quartzite and amphibolite	
3	Bhatta Gad area	3.0	120 to 172	3	Copper	3	Phyllite and amphibolite	
4	Ghat Khola area	2.0	72 to 136	1	Copper	4	Quartzite, schist and gneiss	
5	Dhungana area	1.0	136 to 144	2	-	4	Sandstone and shale	

CONCLUSION AND RECOMMENDATION

Though the investigated area as a whole seems poor in metallic minerals, some geochemical anomalies of Cu, Pb and Zn of category 1 to 4 are identified. The anomalies which have category 1, 2 or 2.5 are recommended for further follow-up exploration.

- Four anomalous areas of copper that have category 1 to 2.5 are recommended for further follow-up exploration (Table-5). The areas are as follows:

  Dhalaun Area: This area has Cu anomaly of category '1' and supported by lead anomaly.

  A 2.2 to 2.5 m thick band of malachite bearing quartzite containing 1320 ppm Cu is also recorded in this area.

  Ghat Khola Area: This area has Cu anomaly of category '2' and supported by zinc anomaly.

  Kanda Khola Area: This area has also Cu anomaly of category '2' and supported by lead anomaly.

  Daya Area: This area has Cu anomaly of category '2.5' and supported by both lead and zinc anomalies.

- Three anomalous areas of lead have been identified, but the categories of these areas range from '3' to '4' (Table-6). Therefore, further follow-up investigation for lead is not recommended in this area.

- Two anomalous areas of zinc having category '2.5' are recommended for further follow-up exploration (Table-7). The area are as follows:

  Kaula Khola Area: This area is supported by lead anomaly. Some ore float samples from this area show upto 72 ppm Zn, 18 ppm Pb and 890 ppm Cu.

  Daya Area: This area is supported by Cu and Pb anomalies.

Presence of gold in Seti River and Lachhi Gad is an indication of source rock for alluvial gold in its catchment area but they do not appear to be of economic interest.

Table-8: Brief Description of Heavy Mineral Concentrate Samples Obtained from Crushed Rock Samples (Float Samples)

S. N.	Sample no.	Location/ (Crushed sample no.)	Rock Type	Size of float	Heavy minerals obtained
1	HC-502	Suni Gad/(Bds-1)	Py bearing quartzite	75 cm x 25 cm	Mainly Py, few Mgt
2	HC-503	Suni Gad/(Bds-2)	Py bearing basic rock	20 cm x 15 cm	Mainly Hb, some Py
3	Hc-504	Suni Gad/(Bds-3)	Py bearing quartz vein within phyllite	50 cm x 25 cm	Py, Mgt, few galena
4	Hc-505	Suni Gad/(Bds-4)	Py bearing gritty quartzite	1.0 m x 0.7 m	Py and Mgt
5	HC-506	Suni Gad/(Bds-8)	Py bearing quartzite	1.5 m x 1.0 m	Py, Mgt, few Chp
6	HC-508	Suk Gad/(Bds-1001)	Py and Chp bearing schist	10 cm x 30 cm	Py, and Chp
7	HC-510	Suni Gad/(Bds-5)	Py bearing gneiss	12 cm x 10 cm	Mainly Py, few Mgt and Chp
8	HC-511	Suni Gad/(Bds-6)	Py bearing basic rock	15 cm x 10 cm	Mainly Hb, some Py
9	HC-512	Suni Gad/(Bds-7)	Ferruginous sandstone	1.0 m x 0.7 m	Hmt, Mgt, few Py
10	HC-548	Seti River/(Bds-1059)	Py bearing quartzite	25 cm x 15 cm	Py, Mgt, Chp, Po
11	HC-549	Ghat Khola/(Bds-1097)	"	20 cm x 22 cm	Py, Mgt, Chp,
12	HC-550	Kaula Khola/(Bds-1115)	Py, Po, Mgt and Chp bearing quartzite	40 cm x 30 cm	Py, Po, Mgt, Chp and few galena
13	HC-567	Seti River/(Bds-1249)	Py bearing phyllite	15 cm x 10 cm	Py, and Mgt
14	HC-568	Seti River/(Bds-1250)	Py and Chp bearing quartzite	30 cm x 20 cm	Py, Po, Mgt and Chp
15	HC-569	Seti River/(Bds-1251)	Py bearing quartzite	25 cm x 25 cm	Py, and Mgt
16	HC-575	Lacchi Gad/(Bds-1272)	Py bearing quartz vein within phyllite	50 cm x 40 cm	Py, and Mgt
17	HC-576	Lacchi Gad/(Bds-1274)	Py bearing quartzite	25 cm x 20 cm	Py, Mgt and few Chp

N. B.: 1. Analytical result of gold is not received yet; 2. Py = pyrite, Chp = chalcopyrite, Po = pyrrhotite, Mgt = magnetite, Hb = Hornblende, Hmt = Hematite; 3. Sample no. HC-502, 503, 504, 505, 506, 510, 511 and 512 were collected from the floats of Suni Gad (out of investigated area, Toposheet no. 62 G/2, western adjoining part of present investigated area).

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Preliminary Investigation of Limestone in Between Ahalepakha (Sindhuli) and Baruwa Khola (Udayapur) Area, Eastern Nepal

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INTRODUCTION

According to the annual field programme of Department of Mines and Geology for the fiscal year 2056/057 B.S., a preliminary investigation of limestone from Ahalepakha in the west in Sindhuli district (Toposheet 72I/8) to Baruwa Khola in the east, in Udayapur district (Toposheet 72J/7) was carried out. During investigation a Geological Map (scale 1:63,360) covering 135 sq km was prepared. Limestone bands were traced in the field and some trenching works were performed to get fresh limestone sample. Continuous chip samples of 194 m in three sections e.g. 50 m for limestone in Mate Khola, 72 m for Dolomite at Lakure and 72 m for limestone at Kholme were also collected. High-grade limestone occurrences were recorded at Chuladhunga, Ghyampathumka and Kholme areas within a distance of about 8 km in northwest-southeast direction.

The Ahalepakha Limestone Prospect area can be reached from Mirchaiya of East-West Highway via 25 Km long motorable road up to Katari and further passing through 16 km. seasonal road from Katari. The Galtar Limestone Prospect can be accessed from Katari via 7 Km long seasonal roads and then by foot via 5 km long foot track. On the other hand, the Chuladhunga Limestone Prospect can be accessed by motorable road of 34 Km length from Kadmaha Chowk of East-West Highway passing through Sindhali.

OBJECTIVE

The main objective of the investigation was:

- To trace the limestone bands, define their thickness, lateral extension and grade by surface evaluation.
- To select the best suitable area for further follow up works to prove the economically viable cement grade limestone deposit.

METHODOLOGY

- Geological mapping of over 100 sq. km area covering the limestone band and the rock units in the immediate vicinities in 1 : 63,360 scale topo maps using conventional methods.
- Physical exploration by trenching, continuous chip sampling (100m) and grab sampling to ascertain the grade of the limestone along its lateral extensions.

GEOLOGY OF THE AREA

The limestone band is situated in the north of Main Boundary Thrust (MBT). It is underlain by phyllites and quartzite of Benighat Formation and is overlain by coarse textured, garnetiferous biotite schist of Kalitar Formation (?). The lower contact of limestone is a normal, where as the upper contact is thrusted. Limestone is generally dark gray to gray in colour and medium grained in texture. The attitude is NW-SE with dip amount up to 66^0 towards NE. Phyllites are mostly light gray to dark gray in colour. At places it is thin platy and carbonaceous. Phyllite predominates over quartzites (Fig. 1).

In Upper section near limestone the phyllites becomes more sericitic and chloritic, thus importing white greenish gray to silvery gray colour, where as at Ahalepakha the phyllites are thin, platy, greenish gray to green, pinkish gray and purple. Quartzites are gray, whitish gray, greenish gray and at places ferruginous.

Limestone Prospects

Geologist from Geological Survey of India (GSI) Mr. A. S. Narasimhan (1969) has reported limestone occurrences at Ahalepakha and Galtar areas. According to him, a lenticular body of limestone of approximately 2.4km in length and 200m

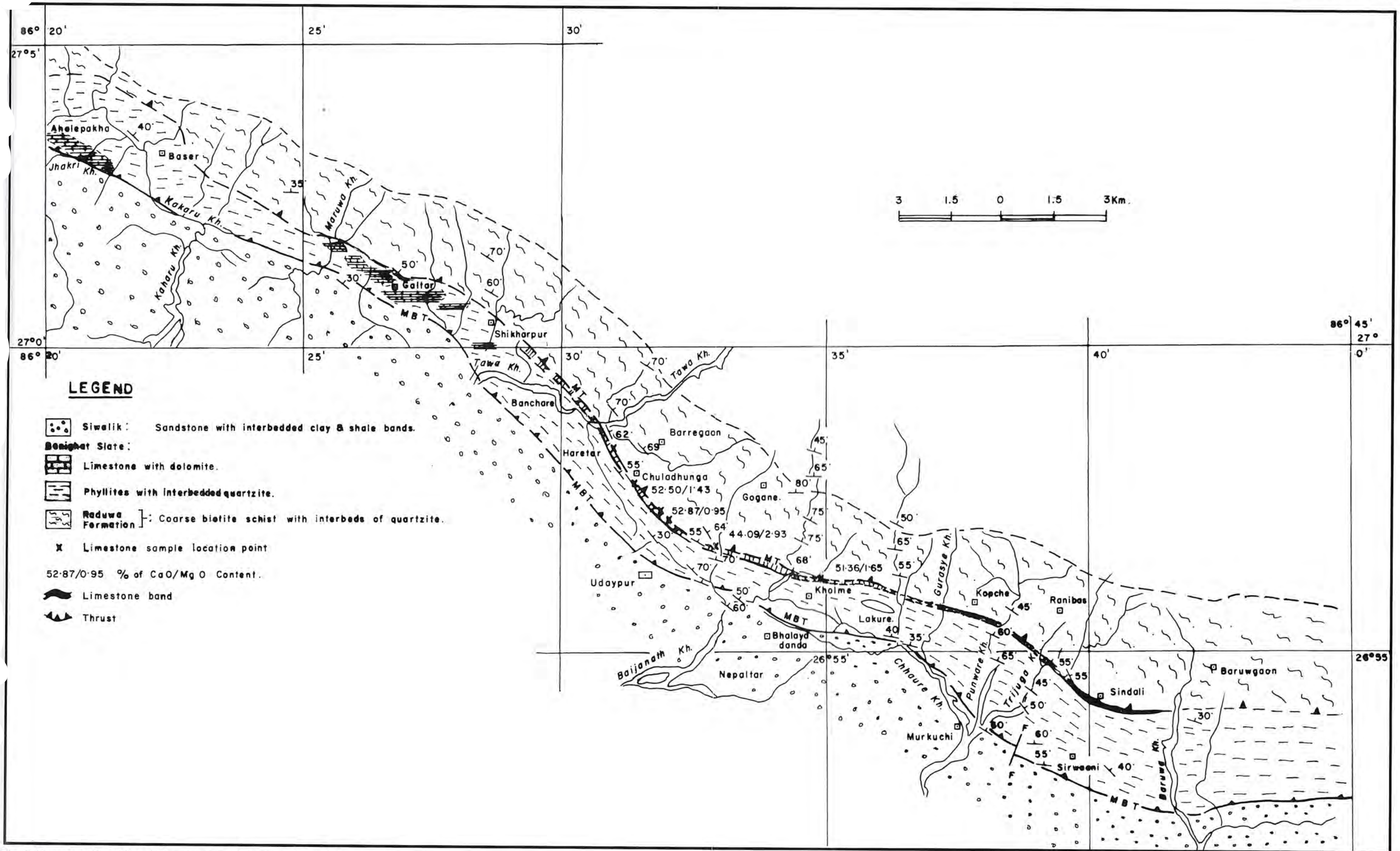

Fig. 1: Limestone Deposit and Occurrences in Between Ahalepakha (Sindhuli District) and Baruwa Khola (Udayapur District)

widths at Ahalepakha and five lenticular bodies of limestone with a strike length of 200m to 2400m with thickness of 85m to 300m widths exist at Galtar area.

Ahalepakha Limestone Prospect

Limestone prospect at Ahalepakha has been leased to M/S Maruti Cement P. Ltd, Mirchaiya of Sindhuli district, Janakpur Zone by DMG, for the establishment of a mini-Cement plant with a capacity of 50 TPD. Under the leaseholder, Maruti Cement P. Ltd, a detailed exploration work has been carried out by Everest Engineering Consultancy, Kathmandu in Sept. 1996. About 26-hectare area was surveyed. 240m lengths of trenches were dug out, 52 Channel samples and 6 grab samples were collected and analyzed. Limestone of this area contains 47 - 49% CaO and <2% MgO. Probable reserve of 3.6 million ton of cement grade limestone has also been estimated. The limestone is light gray in colour and very fine to medium grained in texture. To confirm the exact mineable reserve and the quality of the limestone, an exploration drilling was recommended.

Galtar Limestone Prospect

Exploratory works of Galtar limestone within an area of 2.5 sq. miles was carried out with a view to set up a cement industry in the eastern region in 2042 B.S. The work was done to have an idea about the geological set up, grade of limestone, mining condition, infrastructure facilities, plant site and location of clay deposit. Limestone in this area is dark gray, fine to medium grained and contain CaO 52.53% and MgO 1.32% in average. Probable reserve of about 26 million tons of cement grade limestone, with the strike length 500m, thickness 200m and taking depth of 100m along the dip slope was estimated. For actual reserve estimation drilling was recommended.

Udayapur Limestone Prospect

Kayastha (1977) has reported the limestone occurrences, southeast of Galtar area during the regional geological mapping of Udayapur and Diktel areas. During geochemical drainage survey of the areas falling in toposheet 72J/9 and 72J/5 in Udaypur District, Karmacharya (2038 B.S.) traced the limestone band inTawa Khola to Baruwa Khola area. Thickness of the limestone band is found to be 45m at Tawa Khola, 50m in Mate Khola, 75m in Trijuga Khola to 10m in Baruwa Khola, where the limestone was found to be pinched out. Preliminary investigation showed that the limestone is homogeneous and its grade is high to very high throughout its strike.

Sindhali Limestone Deposit

A 73.5 million ton of high-grade limestone deposit is proved at Sindhali. Based on this limestone deposit, Udayapur Cement Industries Ltd (UCIL), a public sector industries, with 800-tpd capacities is under production since 1988.

Chula Dhunga-Ghyampathumka Limestone Prospect

The visual extension of limestone at Chuladhunga and Ghyampathumka areas seems to be of 450m and 400m and thickness reaches up to 60m and 35m respectively. Continuous chip samples indicated 18m thickness of high grade limestone (44 - 51% CaO, 1.01 - 2.47% MgO at Mate Khola) 19 m thickness at Chhaunde Khola (50.47 - 51.59% CaO, 1.41 - 2.42% MgO) and about 72 m thickness of limestone (50.47 - 51.59% CaO, 1.01 - 2.22% MgO) at Kholme. The quality of limestone is fairly good but its thickness varies from place to place. The mining condition is good as the limestone is exposed on the top of hills. Further works are recommended to ascertain the mode of occurrence, size, shape, qualities and for the estimation of limestone quantity as a relatively high level of assurance.

RESULTS AND FINDINGS

Total length of limestone band is about 35-36km. Out of which the strike length of the limestone from Baruwa Khola to Tawa Khola is about 25km. From Tawa Khola onwards towards northwest, it could not be traced out. It reappears near Banchare and continues up to Shikarpur and then up to Maruwa Khola. From Banchare to Maruwa Khola, the strike length is about 10 km.

Thickness of limestone varies very much. Maximum thickness up to 200m (?) is exposed at Galtar and minimum thickness up to 3m is found to be at Gurasye Khola. At Ghympa Thumka maximum thickness is about 40m and minimum thickness is about 12m.

The grade of limestone as indicated by the chemical analysis results of grab samples taken at major Kholas of the target area e.g. - Trijuga Khola, Punware Khola, Chhaunde Khola, Mate Khola, Tawa Khola etc. is high to very high (CaO 50-55%; MgO 1.0-2.4%)

Continuous chip samples taken at Mate Khola for about 48m thickness of limestone indicated good quality of limestone for about 18m thickness only with MgO less than

3% and CaO from 44.00 to 51.00% (Table-1). For the rest, thickness of the limestone is 28m. The chemical analysis result revealed that the percentage of MgO varies from 3.32 to 4.24% and the percentage of CaO is within 49 to 50.65%. At Chhaunde Khola, continuous chip samples showed 19.30m thickness of high grade limestone with the chemical analysis results of CaO 50.47 - 51.59% and MgO 1.41 - 2.42% and 10m thickness of dolomitic limestone having 4.15 - 5.18% MgO and 47.00 - 50.45% CaO (Table-1).

At Kholme, 6 continuous chip samples, each representing 12m thickness reflected good quality of limestone having

Table-1: Chemical Analysis of Limestone

S. No.	Sample No.		Major elements (Oxide)							Sample Thickness (m)
			CaO %	MgO %	Al_2O_3 %	Fe_2O_3 %	R_2O_3 %	Lns %	LOI %	
1	SK/Chip/Mate	- 1	50.75	1.01	1.11	0.39	1.50	4.34	41.05	6.0
2	,,	- 2	50.80	1.81	1.03	0.42	1.45	3.08	42.79	6.0
3	,,	- 3	44.00	2.47	1.17	0.85	2.02	13.04	38.45	6.0
4	,,	- 4	49.20	4.24	0.96	0.31	1.27	2.44	42.84	6.0
5	,,	- 5	47.05	3.93	1.57	0.23	1.80	1.80	43.24	6.0
6	,,	- 6	50.15	3.32	0.84	0.21	1.05	1.02	43.34	6.0
7	,,	- 7	50.65	3.43	0.56	0.29	0.85	1.48	43.55	10.0
8	,,	- 8	32.90	16.89	0.79	0.43	1.22	1.84	45.92	4.0
9	SK/Chip/Chhamdi kh.	- 1	50.45	4.15	0.64	0.16	0.80	1.30	42.68	5.0
10	,,	- 2	47.00	5.18	3.07	0.43	3.50	1.50	42.82	5.0
11	SK/Chip/Chhaunde	- 3	51.59	1.41	0.72	0.24	0.96	2.76	42.56	5.0
12	,,	- 4	51.03	2.42	0.94	0.08	1.02	2.03	43.08	5.0
13	,,	- 5	50.75	2.22	0.76	0.14	0.9	1.74	42.94	5.0
14	,,	- 6	50.47	2.22	0.65	0.15	0.8	3.94	42.27	4.3
15	SK/Chip/Kholme	- 1	51.03	1.61	0.66	0.18	0.84	3.14	42.35	6.0
16	,,	- 2	50.19	2.02	0.96	0.24	1.2	4.53	41.76	6.0
17	,,	- 3	51.03	1.01	0.68	0.26	0.94	5.04	41.59	6.0
18	,,	- 4	51.59	1.61	0.73	0.19	0.92	2.78	42.32	6.0
19	,,	- 5	51.03	2.22	0.39	0.17	0.56	2.85	42.86	6.0
20	,,	- 6	51.59	1.81	0.52	0.14	0.66	3.36	42.37	6.0
21	SK/Chip/Kholme	- 7	52.15	1.21	1.16	0.24	1.4	2.12	42.62	6.0
22	,,	- 8	51.03	2.02	1.53	0.31	1.84	2.41	42.03	6.0
23	,,	- 9	51.31	1.81	1.35	0.39	1.74	2.3	42.8	6.0
24	,,	- 10	51.59	1.61	1.00	0.34	1.34	2.55	42.4	6.0
25	,,	- 11	52.15	1.21	0.80	0.24	1.04	2.25	42.39	6.0
26	,,	- 12	51.59	1.61	1.00	0.24	1.24	2.17	42.57	6.0
27	SK/Chip/Mate	- 1	49.42	1.26	N/A	N/A	N/A	N/A	N/A	6.0
28	,,	- 2	50.47	1.51	N/A	N/A	N/A	N/A	N/A	6.0
29	,,	- 3	42.3	3.00	N/A	N/A	N/A	N/A	N/A	6.0

(continued ...)

Table-1 (continued)

30	.. - 4	49.77	3.28	N/A	N/A	N/A	N/A	N/A	6.0
31	.. - 5	49.77	3.28	N/A	N/A	N/A	N/A	N/A	6.0
32	.. - 6	49.42	3.78	N/A	N/A	N/A	N/A	N/A	6.0
33	.. - 7	51.52	2.34	N/A	N/A	N/A	N/A	N/A	10.0
34	SK/Chip/Chhaunde - 1	50.47	2.95	N/A	N/A	N/A	N/A	N/A	5.0
35	.. - 2	46.27	5.80	N/A	N/A	N/A	N/A	N/A	5.0

chemical analysis results of 50.19 - 51.59% CaO and 1.01 - 2.22% MgO (Table-1).

At Lakure village, a lenticular body of dolomite of 170 m long and 72m thickness is present. Nine continuous chip samples, each representing 8m thick across its strike gave the chemical analysis result of 16.13 - 20.56% MgO (Table-2).

Limestone outcrops are found mostly at the top of the hills, which makes quarrying easy with less overburden. There is a considerable thickness of overburden in between Chuladhunga and Ghyampathumka and at Hadetar and beyond it towards northwest (Fig.1). The actual limestone and overburden ratio can be calculated only after detail mapping and trenching.

Table-2: Chemical Analysis of Limestone

S. No.	Sample No.	Major elements (Oxide)							Sample Thickness (m)
		CaO %	MgO %	Al_2O_3 %	Fe_2O_3 %	R_2O_3 %	Lns %	LOI %	
1	SK/Chip/Lakure - 1	33.65	16.13	1.06	0.44	1.50	3.32	44.41	8.0
2	.. - 2	32.53	18.55	1.43	0.25	1.68	1.32	45.37	8.0
3	.. - 3	29.72	20.56	1.51	0.37	1.88	1.61	45.32	8.0
4	.. - 4	31.97	18.95	1.15	0.19	1.34	1.58	45.60	8.0
5	.. - 5	31.40	18.14	1.41	0.19	1.60	3.80	44.79	8.0
6	.. - 6	34.77	16.13	0.79	0.39	1.18	2.07	44.73	8.0
7	.. - 7	32.53	18.14	0.56	0.30	0.86	1.55	45.27	8.0
8	.. - 8	31.40	19.35	0.68	0.34	1.02	2.20	45.12	8.0
9	.. - 9	34.21	16.53	1.32	0.22	1.54	2.14	44.84	8.0

At Chuladhunga and Ghyampathumka areas the high-grade limestone (at present visually) are present for about 450m and 400m in strike length respectively.

In general the limestone is dark gray and dark bluish gray, medium grained and fairly homogeneous with or without phyllitic intercalations. But at Mate Khola, individual bands of dark grey sericitic phyllite up to 0.5m thick and dark gray to black carbonaceous phyllite up to 0.8m thick are present in between high grade limestone.

CONCLUSION AND RECOMMENDATION

From field investigation it is confirmed that the strike length of limestone band from Baruwa Khola to Tawa Khola is about 25km and from Banchare to Maruwa Khola it is about 10km. From Tawa Khola onwards towards northwest, it could not be traced out.

The limestone band in between Haresar and Kholme is about 10 km long. It is homogeneous and high grade and hence deserves further detailed investigations.

Furthermore, the limestone occurrences here are quite close to the existing road i.e. within 50 km distance from E-W highway. The nearest approach to road at Nepaltar is only 5-6 km from this area and here other infrastructural facilities are developing rapidly. Therefore detailed exploration is highly recommended and is also rightly justified.

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Exploration of Polished/Dimension Stone in Parts of Makawanpur District, Central Nepal

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INTRODUCTION

The demand of polished/dimension stone is increasing day by day due to urbanization and the people's choice to have better living standards. Marble, granite, Quartzite slabs etc. are available in the market to fulfill these demands. There is an annual demand of 1.8 million sq. ft. of marble slabs in the country (Godawari, 2001). Only a few percentages (20%) of this national demand are fulfilled by existing industries- Godawari Marble Industry Pvt.Company, Lalitpur; Everest Marble Industry, Kavre; Laxmi Lime Industry, Makwanpur. The rest is imported from India and other countries. Apart from these marble industries based on the natural resource, a number of marble trading industries that import marble blocks and do cutting and polishing business are mushrooming in the country.

Based on the growing demand for polished/dimension stone Department of Mines and Geology has included the exploration work for polished / dimension stone in the 10th five year plan. The present annual exploration program is also a continuation of the previous work in the polished/ dimension stone exploration work. The exploration target covers an area of 100 sq. km. including preliminary and follow up investigation of the potential areas in a part of Makwanpur district as recommended by previous studies (Joshi, 1971; UNDP, 1981; Shrestha and Napit, 2001). Those previous studies give geological information of those areas in the regional scale showing the existence of marble, quartzite with intruded granite (Shrestha and Napit, 2001). The present study of the areas is to find out the possibilities of using them as polished/dimension stone.

The preliminary investigation area lies in the Toposheets No. 2785 05 D and 2785 09 B of Survey Department of HMG/ Nepal. (Scale: 1:25,000) within latitude 27° 27'00" to 27° 35'00" N and longitude 85° 07'00" to 85° 10'25" E covering an area of 85 sq. km. Bhimphedi, Deurali, Kulekhani area are accessible through Ganesh Man Singh Marg that leads to Kulekhani from Bhainse (36 km). In addition, the follow-up investigation covering an area of 15 sq. km. is done at Simbhanjyang (8 sq. km); at Kitini khola, Bhainse (4 sq. km.) and at Taubas, Bhainse (3 sq. km.) lying at HMG/N Survey Department Toposheet nos. 2785 05 C and 2785 09 A (Scale: 1: 25,000). These areas are accessible through Tribhuwan Rajpath. Simbhanjyang, the highest pass at an altitude of 2520m lies at 72 km from Kathmandu. Bhainse lies at 12 km north of Hetauda along Tribhuwan Rajpath.

OBJECTIVE

The objectives of the present study are to find out the rocks suitable for polished/dimension stone; to delineate the deposit by examining its durability and suitability; and to give an appropriate recommendation for the next phase of exploration operation.

METHODOLOGY

Methodology includes the literature Review, field investigation and laboratory study.

Literature Review of the previous studies in the target areas, study of the ASTM Specifications, relevant papers and reports on polished stone are pre-requisite to get the knowledge about the polished / dimension stone. ASTM Designation C 119 - 86 has defined *'Dimension stone as a Natural stone that has been selected, trimmed or cut to specified or indicated shapes or sizes with or without one or more mechanically dressed surface. Dimension stone when polished to produce slabs for different purposes such as flooring, wall cladding, mausoleum crypt fronts and custom specialties are called polished stone'* (ASTM, 1996). Its use for different purposes depends upon suitability, durability and color (UNDP 1977).

The field investigation includes geological traverse along the roads, rivers, ridges and along the foot tracks; visual study of the topography from the mining point of view; study of the rock properties for suitability such as appearance, texture, luster etc; taking of geological readings, joint sets, joint spacing etc; visual estimation of weathering, rock strength, roughness, blocks size etc; trenching/pitting (105 m^3) to expose the fresh rock mass and sample collection to represent the areas; preparation of geological maps in the scale of 1:25,000 of preliminary area and in the scale of 1:10,000 for the follow-up areas.

The laboratory study includes chemical analysis; cutting and polishing to check for appearance and suitability; petrographic study; ASTM specified physico-mechanical tests like compressive strength, modulus of rupture, absorption coefficient, bulk density for durability. The results are compared with the ASTM standards.

RESULTS AND FINDINGS

The study area comprises of the rocks of Bhimphedi Group of Kathmandu Complex and Upper Nawakot Group of Nawakot Complex and Palung Granite intrusion. Based on the present investigation, polished/dimension stone exploration map of scale 1: 25,000 (Fig. 1) and of scale 1: 10,000 (Fig. 2,3,4 and 5) are prepared. Fig. 1 gives the geological information at Deurali, Bhimphedi, Bhudichour areas covering different units of quartzite, marble rocks and granite intrusion in the north. Fig. 2 and 3 give the geological information at Simbhanjyang area for Palung granite within 2 km range on west and east of Tribhuwan Rajmarg. Similarly, Fig. 4 and 5 give the geological information at Kitini Khola, Bhainse and at Taubas, Bhainse for Bhainse- dobhan marble and Dunga quartzite respectively.

The main resource rocks in the present study area for the Polished/ Dimension stone are granite, marble and quartzite. The details about their findings are briefly described below:

Granite

Palung Granite : is only a rock unit intruded into north dipping Quartzite, Schist and Calcareous rock. The intrusion is east-west running along the Mahabharat Lekh from Simbhanjyang in the west to Deurali in the east over a distance of about 8 km. Two types of Granite body have been delineated depending upon the grain size and the presence of biotite/ muscovite: 1) coarse grain Biotite-Tourmaline Granite (BTG), and 2) medium grain Muscovite-Tourmaline Granite (MTG). In addition to these granites, fine grain Aplitic Granite (AG) is also found to be intruded in between the granite body. BTG is coarse grain, inequigranular with porphyritic texture. Smoky white grey with black or dark unevenly distributed spots of tourmaline or biotite are present. Chief mineral constituents are quartz, feldspar, biotite, plagioclase, muscovite and tourmaline. MTG is medium grain, more or less equigranular, dirty white to gray. Chief mineral constituents are feldspar, quartz, muscovite, biotite with iron stain on rock surface. Feldspar is highly kaolinized. AG is fine grain, equigrannular, dirty white to gray, with evenly distributed flakes of dark or black colored fine tourmaline or biotite. AG is more frequent in the e..stern part. BTG has heterogeneous distribution of minerals and the grain sizes are not uniform, where as AG has evenly distribution of minerals. Interlocking arrangement of minerals is present.

The central parts of the Mahabharat Lekh consist of BTG, whereas the northern and southern slopes of the ridges consist of MTG. The kaolinization and alternation of feldspar and muscovite/biotite is fairly active in muscovite–tourmaline granite (MTG). The presence of BTG and MTG and hence the weathering and strength of granite are supported by topographical terrain. Along the Mahabharat Lekh the weathering effect changes according to topography. The steeper ridge west of rajmarg shows less weathering effect compared to the flat ridge along the east of rajmarg. Weathering horizon up to 5m depth or even more are observed in the areas. The weathering effect is high as moved further east towards Deurali – Kulekhani area. Furthermore this part of the area is densely forested mainly of Pine trees. Around Deurali area, Kulekhani Hydro Electric dam and High Tension power supply line of 133 kVA passing through the deposit makes this area unfeasible to work.

These parts of granite are characterized by 3 major joint sets generally represented along the drainage pattern north – south with V- dip, along the strike and oblique to the strike. Joint spacing is quite open and is as high as 2 m. The area has abundant joint failure of blocks. Good blocks of granite up to 5 m thick are available.

Based on the study, areas of about 2 km west of Tribhuwan Rajmarg at Simbhanjyang shows easily mineable more competent granite rock mass compared to east of rajmarg.

Marble

Bhainsedobhan Marble of Bhimphedi Group of Kathmandu Complex is medium to coarse, crystalline, white, yellowish white to grey in color with layers and lenses of yellow to pinkish to light grey. The stratigraphy sequence shows Raduwa Formation as underlying rock and Kalitar Formation as overlying rock unit. The bed shows scattered grain of ore (pyrite, iron oxide, galena, magnetite) and mica as impurities. Marble forming ridges are steep. The general trend of the deposit is $110^0 – 135^0$ with $75^0 – 85^0$ N dip. The exposures are limited along the khola, road sections. The marble located at Kitini Khola, Bhainse is of economic interest.

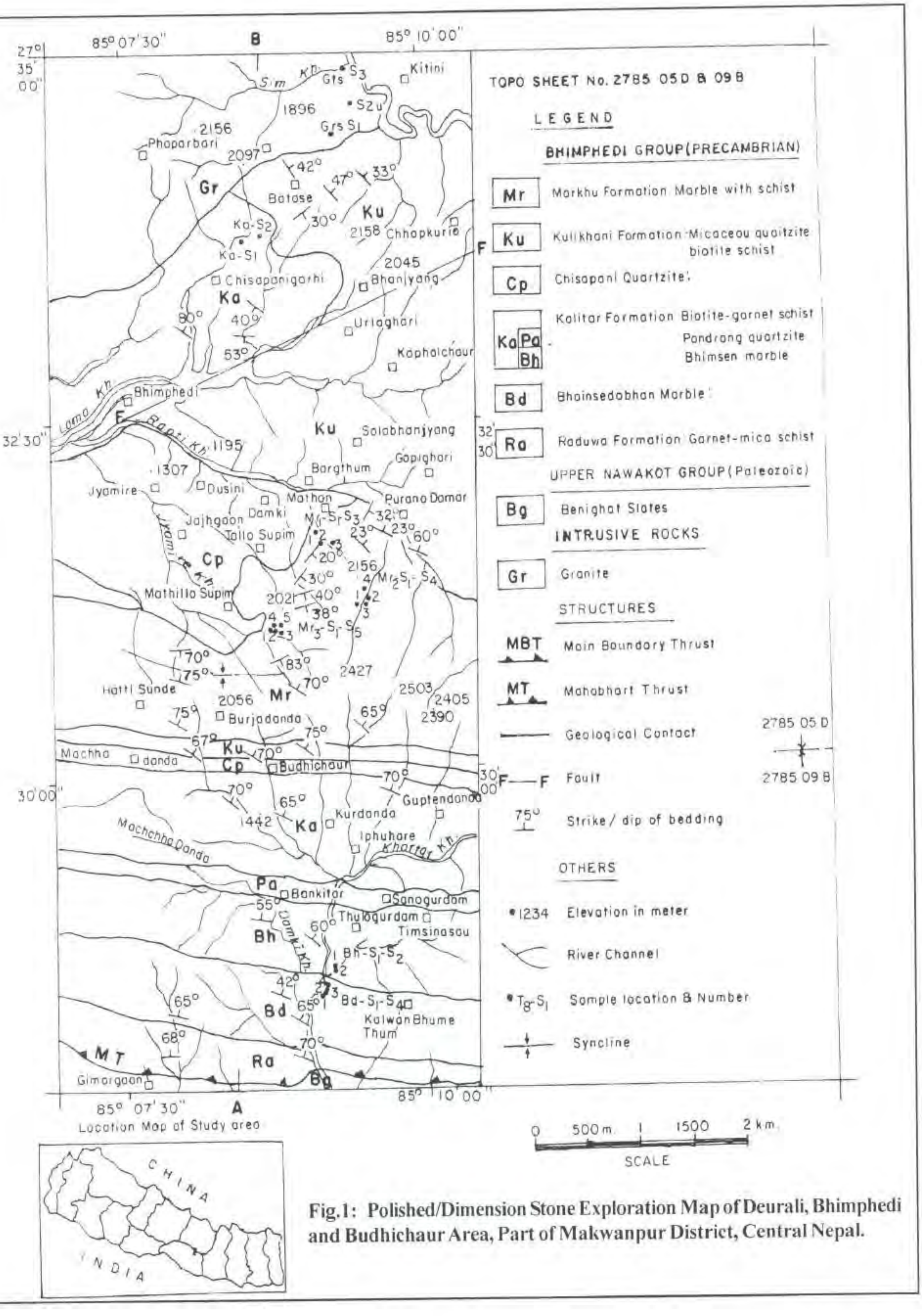

Fig.1: Polished/Dimension Stone Exploration Map of Deurali, Bhimphedi and Budhichaur Area, Part of Makwanpur District, Central Nepal.

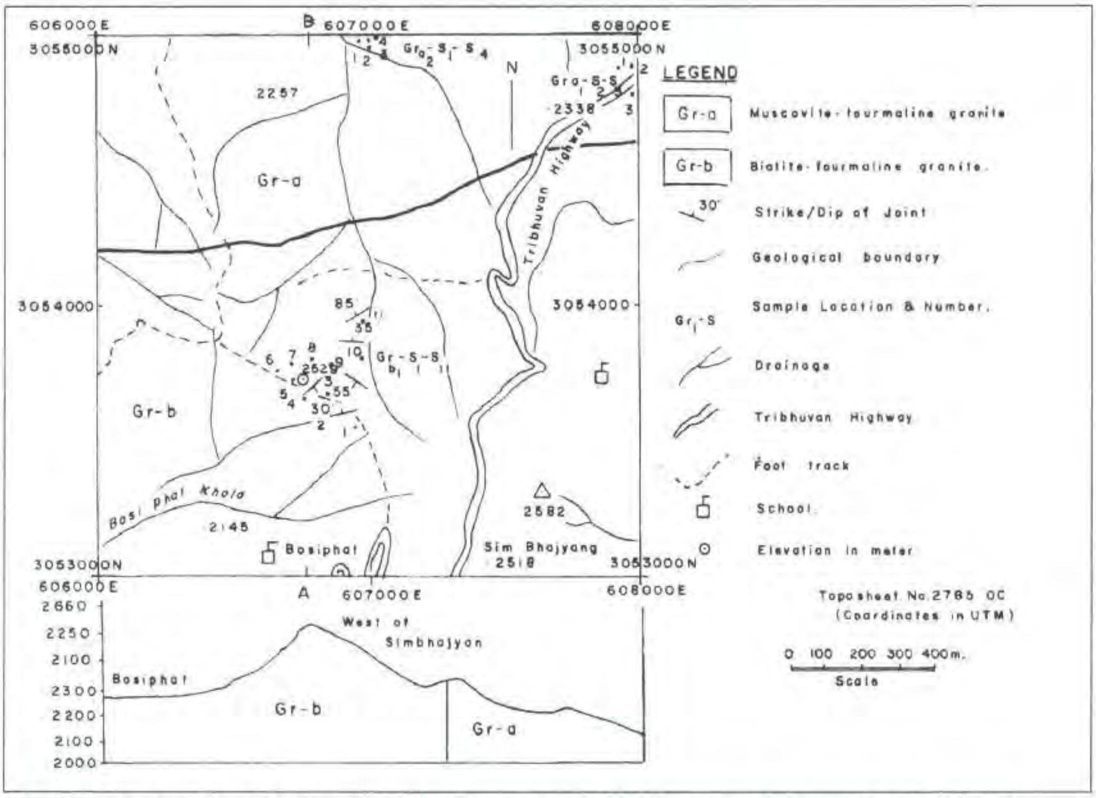

Fig.2: Geological Map of West of Simbhanjyang, part of Makwanpur District, Central Nepal.

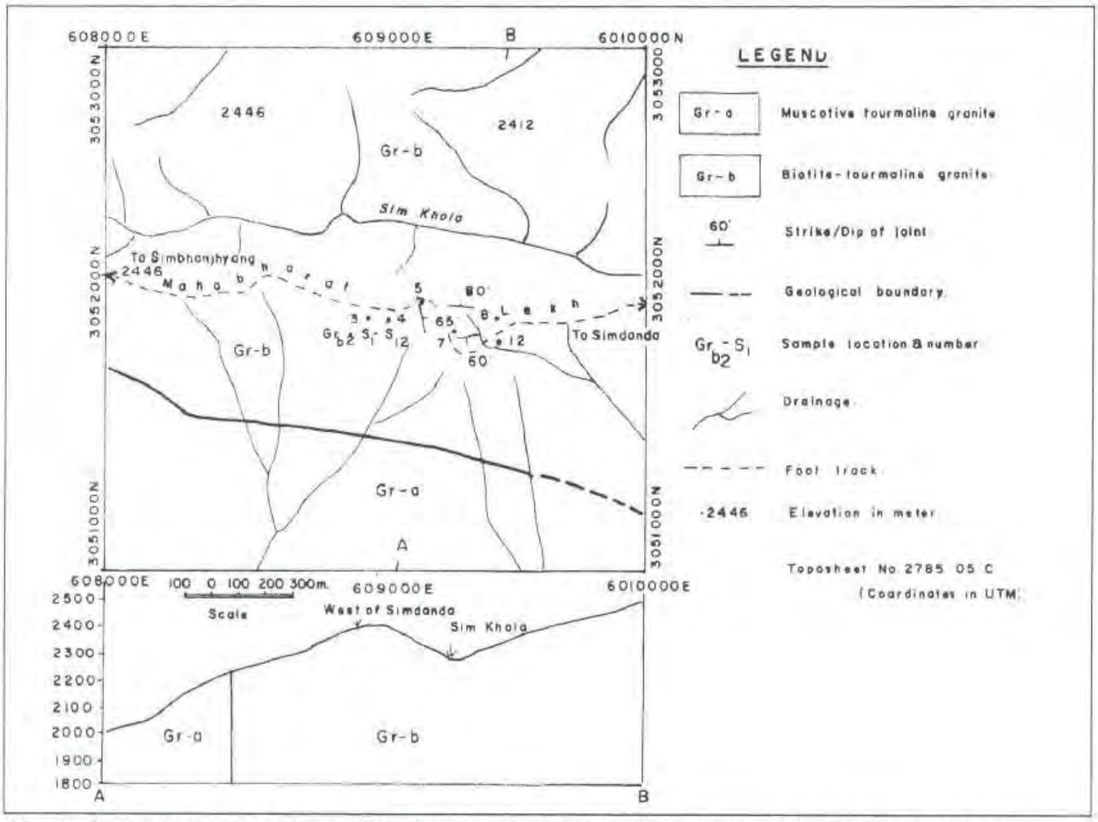

Fig. 3: Geological Map of East of Simbhanjyang, Part of Makwanpur District, Central Nepal.

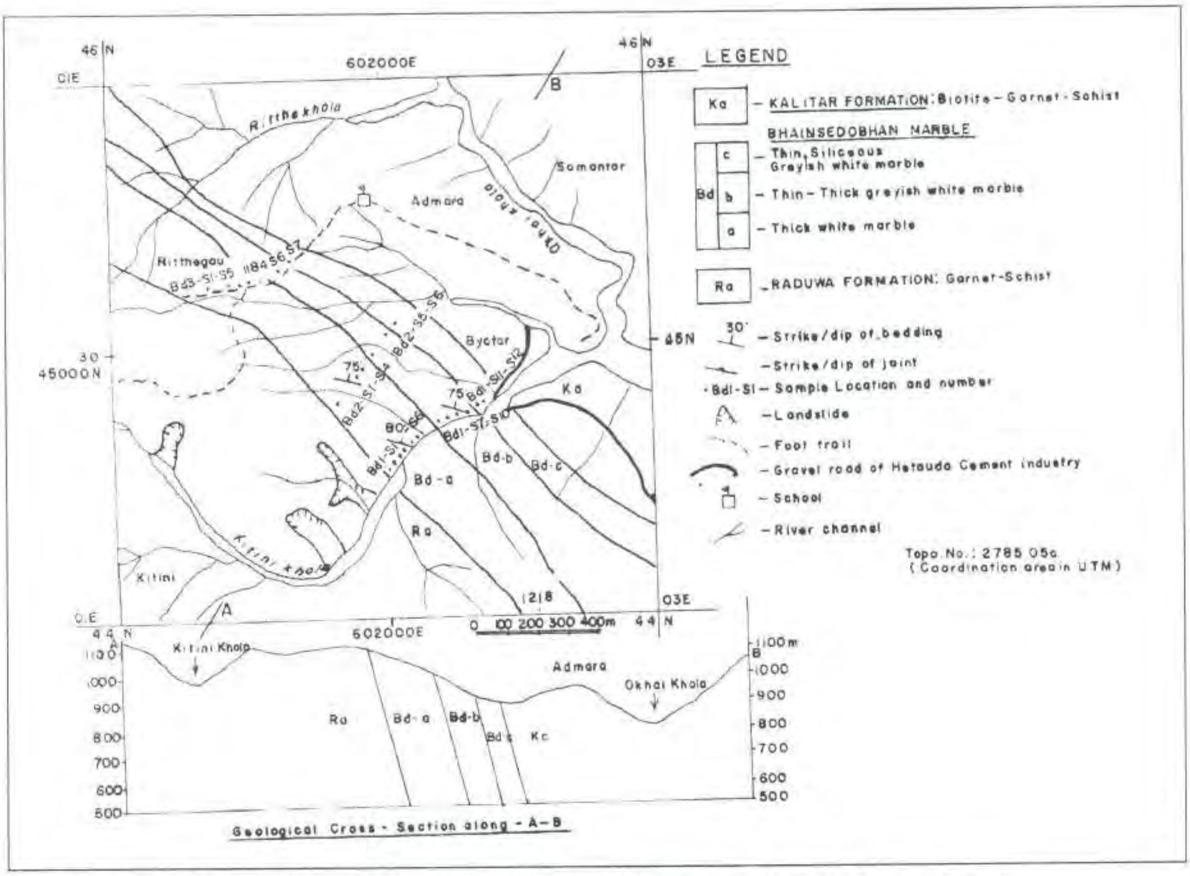

Fig.4: Geological Map of Kititni-Rithegau Area, Part of Makwanpur District, Central Nepal.

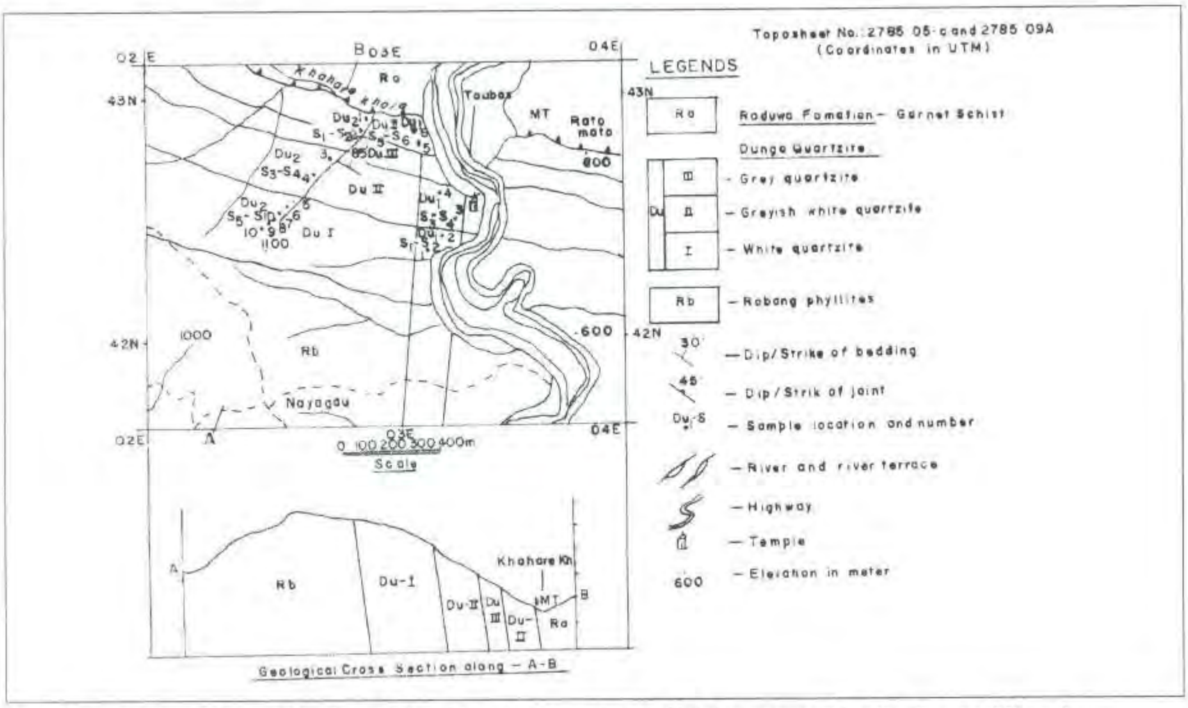

Fig.5: Geological Map of Taubas-Shiva Mandir Area, Part of Makwanpur District, Central Nepal.

Based on the texture and massiveness, the deposit as seen at Kitini Khola section is divided into 3 sub-units from bottom to top as follows:

a) Medium to coarse grain thick white marble
b) Medium to coarse grain thin – thick greyish white marble and
c) Thin siliceous greyish white marble (Fig. 4).

The lower sub-unit 'a' of about 100 m thick is medium to coarse grained, white to pinkish white and is massive except few tens of meters near underlying Raduwa formation contacts. Though the rock has a massive appearance, but close view shows distinct bedding of 50 cm to 1 m thick. Interlayer of muscovite, schist layers of 15 – 20 cm is frequently present. The rock gives medium to high effervescence. The middle sub-unit 'b' of about 75 m thick is medium – coarse grain, white to greyish white and is disturbed. It shows distinct bedding and fine layers having thickness of few cm to 60 cm. Good block sizes for marble purpose is not available. The top sub-unit 'c' of about 70 m thick is fine grained, white to greyish white. It also shows distinct bedding and fine layers having thickness of few cm to 50 cm. The marble gives low effervescence and is siliceous. The pyrite dissemination is high in this sub unit.

The degree of crystalline and hence the grain size decreases as moved from south to north. The color variation along the strike direction is also noticed. On the hilltop, the greyish white nature increases. Two sets of joints noticed are - 312^0 / 85^0 with spacing of about 2 m and $110^0/75^0$ with spacing of about 40 cm. Out of the 3 sub-units, subunit 'a' seems to be feasible for marble extraction and it is located at hill top also.

Bhimshen Marble lies at the Kalitar Formation (Fig. 1). The underlying rock is Bhainsedobhan Marble and the overlying rock is Pandrang Quartzite of same formation. It consists of grey color medium to coarse crystalline marble band showing frequent intercalation of biotitic schist. Bhimshen marble contains individual layers of few centimeters to 2 m thick marble. The thickness of this marble is covered with thin calcareous marl, which is made of soft earthy deposit containing more clay that gradually changes into calcareous clay. It is highly jointed and the joint planes are filled with calcite. The bed strikes more or less east- west and has almost vertical dip towards north. The area under study along Khortar Khola, Budichour shows heavy vegetation with almost vertical cliffs. Good mineable hillocks are not available.

Markhu Marble - The Supin - Sikneghari Marble (limestone) occurrence belongs to Markhu Marble of Bhimphedi Group (Fig. 1). The marble is white to grey, medium grain and crystalline. The main composition is calcite, quartz, biotite and other supplied minerals like pyrite is occurred as dissemination. It gives very fast effervescence on acid reaction. The upper horizon of Markhu Formation shows calcareous horizon represented by marble with interbedded grayish phyllite. Bedding is also exhibited in marble by parallel arrangement of micas of about a few mm apart. Distinct beddings of Markhu Marble ranges in size from few cm to few meters. Due to weathering and erosion cavities gap has extensively developed. The limestone is jointed, folded and fractured at places.

The marble shows strike between 30^0 -120^0 with dip amount varying from 20^0 – 40^0 SE. Marble is widely exposed in the area. Good workable marble is found in Supin, Mathan and Sikneghari area.

Quartzite

Dunga Quartzite is associated with Robang Phyllite of Upper Nawakot Group. The Robang Phyllite and Quartzite are found in a strongly tectonized zone. Khahare Khola separates the Bhimphedi Group from Upper Nawakot Group by Mahabharat Thrust (MT). Based on its color variation, the quartzite of the Dunga Quartzite is divided into 3 sub units in the present study area. The stratigraphy sequence as read from bottom up shows White Quartzite, Greyish white Quartzite and Grey Quartzite as sub units 'a', 'b' and 'c' of Dunga Quartzite. The general trend of the deposit is 116^0 strike and dip varies from 68^0 - 85^0 towards north. The main feature of this quartzite is irregular fracture. At some place, quartz veins are extensively developed.

The upper unit of grey quartzite is about 40 m thick. This quartzite and the greyish white quartzite in contact with MT are thinly bedded and are highly crushed with interbands of schist.

The quartzite south of grey quartzite is medium grain, green-grey colored sericitic chloritic phyllites intermixed quartzite and milky white colored quartzite. The deposit far from MT is more massive, competent and less fractured. Near the contact the quartzite is thinly bedded and fine grain. Distinct bedding thickness up to 1 m is available. The milky white color is of very attractive appearance and lustrous. The main interest of this Dunga Quartzite is the lower sub unit 'a' of white quartzite. Since, it is very competent and weather resistant, it is considered good for dimension / polished stone. The main joint is 090^0 / 75^0 having 5 m spacing and other thin spacing joint is $000^0/75^0$.

The deposit is mineable from hill top. However, near the Rapti khola area, the ropeway lines of HCIL and Hetauda - Kathmandu ropeway line passes through, which makes this deposit to work from a safe distance only.

Quartzite beds lying as meta-sediments of Bhimphedi Group such as Raduwa Formation, Kalitar Formation with Pandrang Quartzite, Chisapani Quartzite, Kulekhani Formation are not suitable for polished stone/dimension stone purpose because of crushed nature and thin beds containing fine mica partings though it is very hard.

RESULTS AND FINDINGS OF LABORATORY TESTS

Laboratory tests are done to supplement the field studies and analysis for delineating the possible resources areas.

Polishing

The polished sections of granite, marble and quartzite are shown in fig. 6. The polished surface of the samples of Palung Granite, Bhainsedobhan Marble, Markhu Marble give good shining luster and attractive appearance, whereas the polished surface of Dunga Quartzite is dull.

Fig. 6: Polished Samples of (a) Palung Granite (b) Bhainsedobhan Marble (c) Markhu Marble (d) Dunga Quartzite

Petrographical Study

Palung Granite - The petrographic study for BTG and MTG show inequigrannular, porphyritic texture, interlocked arrangement of minerals with medium to coarse grain, whereas the AG shows fine grain texture. The mineral description for BTG are as follows: quartz – medium grain anhedral and fractured, feldspar – subhedral with porphyroblastic crystals up to 2 cm, twined having inclusion of quartz and biotite, biotite – black, fine grain, plagioclase – dirty white, subheral to euhedral crystals, tourmaline – black fractured small needles. The chief mineral constituents are quartz: 55 – 60 %, feldspar: 25–30 %, biotite: 6–8 %. The mineral description for MTG are as follows: quartz – subhedral to anhedral and fracture with wavy extinction associated with highly fractured subhedral to euhedral orthoclase feldspar, muscovite occurs as lenticular crystals and some tourmaline crystals occur in minute quantity. The chief mineral constituents are quartz: 40–42 %, feldspar: 45–50 %, muscovite: 5–8 %. AG has fine grain anhedral and fractured quartz with fine grain anhedral orthoclase and muscovite. The chief mineral constituents are quartz: 55 –60 %, feldspar: 30–35 %.

Bhainsedobhan Marble – The coarse to medium grained marble shows inequigranular, crystalline texture. Calcite is the chief mineral constituents having 75 – 80 % and occurs with 3 sets of cleavage associated with subhedral to anhedreal fine grain quartz crystals (15–18%). Opaque minerals (pyrite) are frequently occurring in the mass. The thin siliceous marble shows foliated texture having carbonate rock in abundance (5–80%), and is parallel oriented with very fine grain, subhedral to anhedral quartz. Few muscovite grains occur as lenticular in shape and are foliated in nature. Also few opaque (pyrite) grain is disseminated in the mass.

Markhu Marble – This medium grain crystalline marble has abundance of fine - medium grain subhedral calcite (85 – 88 %) showing rhombohedral cleavage. Quartz (5 – 8 %) and opaque minerals are also fine grained.

Dunga Quartzite - Milky white to grey white quartzite has fine to medium grain texture. The chief mineral constituents are anhedral and fractured quartz (90 – 95 %). Muscovite is also fine grain and elongated.

Chemical Analysis: The chemical analysis of different rock units is as presented in Table – 1.

Physico-mechanical Study

The physico-mechanical tests are conducted in 3–5 test specimens under study. Bulk Specific Gravity (D), Absorption by weight, % (Abs.) @ 24 hours soaking, Uniaxial Compressive Strength and Modulus of Rupture (E) are performed according to ASTM test methods and the test results are compared with ASTM requirements. The results of physico-mechanical tests obtained from laboratory study for granite, marble and quartzite are presented in the Table-2.

Table-1: Results of Chemical Analysis

Rock sample	LOI %	Insoluble %	SiO_2 %	R_2O_3 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %
Paiung Granite								
BTG	0.62	93.36	72.94	4.13	2.65	1.47	1.40	0.50
MTG	1.14	96.18	69.58	0.85	0.45	0.40	1.05	0.25
Marble								
a) Bhainsedobhan Marble	38.27	13.14	-	1.38	0.84	0.53	42.06	5.29
Coarse grain	34.52	20.38	-	1.53	0.83	0.70	42.06	2.52
Fine grain	35.82	15.70	-	1.90	0.96	0.94	43.46	2.27
b) Markhu Marble	39.81	8.08	-	1.65	0.92	0.73	48.72	1.76
Dunga Quartzite	0.52	98.30	92.26	0.60	0.25	0.35	1.05	0.25

Table-2: Results of Physico-Mechanical Tests

Rock Type	Bulk Density, D (Kg/m^3)		Absorption by weight, Abs (%)		Compressive Strength, Cu (Mpa)		Modulus of Rupture, E (Mpa)	
	Required by ASTM	Value Obtained	Required by ASTM	Value Obtained	Required by ASTM	Value Obtained	Required by ASTM	Value Obtained
Palung Granite	2560min.	-	0.4 max	-	131 min	-	10.3 min	-
Biotite Tourmaline Granite	-	2750	-	0.39	-	46	-	80
Muscoviete Tourmaline Granite	-	2620	-	1.65	-	22	-	39
Aplitic Granite	-	2700	-	0.75	-	99	-	189
Bhainsedobhan Marble	2595 min calcite	-	0.7 max	-	52 min.	-	6.87 min	-
Coarse to medium grain	2800 min. Dolomite	2780	-	0.1	-	41	-	65
Fine grain	2690 min. Serpentine	2700	-	29	-	57	-	125
Markhu Marble	2305 min. Travertine	2740	-	0.18	-	49	-	98
Dunga Quatzite	2560 min.	-	1 max.	-	137.9	-	137 in	-
White color	-	2700	-	0.16	-	220	-	612
Grey white color	-	2670	-	0.18	-	76	-	165

CONCLUSION AND RECOMMENDATION

BTG and AG zone has less weathering effect. The polishing surface gives attractive appearance with smoky white to grey color. The physico-mechanical test results meet the requirements specified by ASTM standards. MTG zone has greater weathering effect. The rock does not seem to be durable based on the physico – mechanical tests and cannot be used as decorative stone in commercial scale. The study over Mahabharat lekh area shows that huge easily minable granite body of Biotite Tourmaline Granites lying at west side of Tribhuwan Rajmarg at Simbhanjyang. These granites are suitable for both interior and exterior uses and for house building stone.

All the calcareous units – Bhainsedobhan Marble, Bhimsen Marble and Markhu Marble present in the study area show more or less similar mineralogical composition. All these units meet the specifications required by ASTM standards. However, based on the geological factors, mining conditions and accessibility; Bhainsedobhan Marble at west of Kitini Khola, Bhainse and Markhu Marble at Supin–

Sikneghari area, Bhimphedi are suitable for polished/ dimension stone purpose and need to be followed in detail.

Similarly, out of the quartzite beds - Raduwa Formation, Kalitar Formation, Chisapani Quartzite Formation, Kulekhani Formation and Robang Phyllite with Dung Quartzite member present in the study area, the white to milky white Dunga Quartzite is only suitable and durable rock to work as dimension stone. The present study area for Dunga Quarzite is unworkable due to the local factors like existing ropeway networks. However, the western extension of the deposit towards north of Nayagau and north of Kisedi Khola seems to be viable and needs to be followed.

Further investigations on the recommended areas need to be studied in detail for its weathering profile, possible block size, and estimation of mineable quantity, discontinuity mapping and drilling. Trenching and pitting works is to be carried out as per requirement to expose the rock mass. Intensive sampling and laboratory testing are to be performed to check its suitability and durability.

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Annual Report of Department of Mines and Geology, 2005, No. 2, pp 39-43

Coal Occurrences in Tosh - Seuza Area of Dang District, Mid-Western Nepal

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INTRODUCTION

Department of Mines and Geology (DMG) has planned to evaluate the coal resources of Nepal during the ninth five-year plan. Consequently, the program of systematic geological mapping and evaluation of the coal-bearing horizon in the Lesser Himalayan region were included in its annual program since the fiscal year 2052/053 B.S. During the first year of the exploration, geological mapping at the scale of 1:25, 000 of Tosh-Seuza area was conducted and a detailed exploration was recommended. During detailed exploration, phase-wise drilling was carried out. In F. Y. 053/054, three exploratory drill holes (DDH-1, DDH-2 and DDH-3) covering a total depth of 242.77m at Tosh village of Saigha VDC were carried out. It tested a deposit of 0.7 million tons of sub-bituminous coal occurring as stratified seam within the area. Again, in fiscal year 2055/056, further drilling work of 60m depth (DDH-4) was carried out in the same area and tested an additional deposit of 0.3 million tons of coal. Thus, a deposit of one million ton of coal at Tosh village was tested.

The area of investigation lies in the Topo-sheet No.62L/11 (1: 63, 360) in Dang district of Mid-Western Nepal (Fig.1). The drill holes were located at northern part of Tosh village of Saigha VDC. Tosh village is located about 18 km north of Ghorahi bazaar along Ghorahi – Hollery graveled road. Similarly, Seuza is located about 26km northeast of Ghorahi bazaar along Ghorahi – Piuthan road. Ghorahi bazaar is the main marketplace of Tribhuvan Nagar Municipality of Dang district. A 26km metalled road connects it to Lamahi along the Mahendra Rajmarg, which is about 242 km west of Kathmandu.

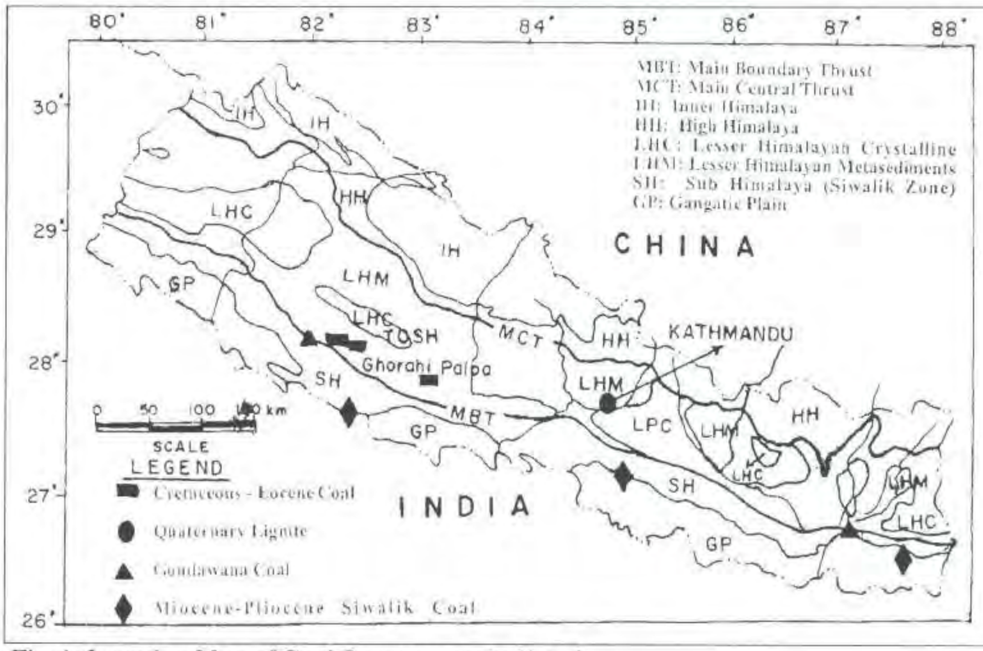


Fig. 1: Location Map of Coal Occurrences in Nepal

Regional geological setting incorporating litho-stratigraphical superposition and tectonic frameworks of the area are available from Kayastha and Shrestha (1982) and Dhital (1989).

OBJECTIVES

The objectives of the field program are broadly categorized as:

- To prepare a geological map at the scale of 1:25,000 of Tosh-Seuza area with coal occurrences and delineate the area for detailed exploration.
- To prepare detailed geological map of the delineated area at the scale of 1:1000.

- To conduct the exploratory drilling for testing available coal deposit of the area.

- To collect coal samples and to determine its grade and calorific value.

FIELD ACTIVITIES

The different works completed during fieldwork are briefly described as:

Geological Mapping incorporating coal occurrences, working coalmines and abandoned coalmines of Tosh-Seuza area at the scale of 1: 25,000 and delineating the area for detailed exploration (2052/053 B.S.).

Topographic mapping of the area delineated for detailed exploration by Plane Table survey at 1:1000 scale. Altogether, fifty-two hectares area was topographically mapped (2053/054 and 2056/057 B.S.).

Detailed geological map showing the exposures and outcrops of coal seams, drill hole sites, and other necessary information at the scale of 1: 1000 of the surveyed area were prepared (2053/054 and 2056/057 B.S.).

Core Drilling

Altogether four water flushing rotary core drilling covering 302.92m by Tone boring machine were carried out at Tosh area. Core was recovered for hard rocks encountered. For soft rocks, in addition to core collection, sludge of returned water was also collected. Wherever carbonaceous shale or coal layers are suspected, mild steel tapered tube made in field that is similar to Standard Penetration Test (SPT) tube was hammered to collect the samples. The help of sludge samples collected and drilling speed and pressure required for drilling, evaluated the thickness of soft layers such as carbonaceous shale and coal seams. Core and coal samples were stored in core boxes.

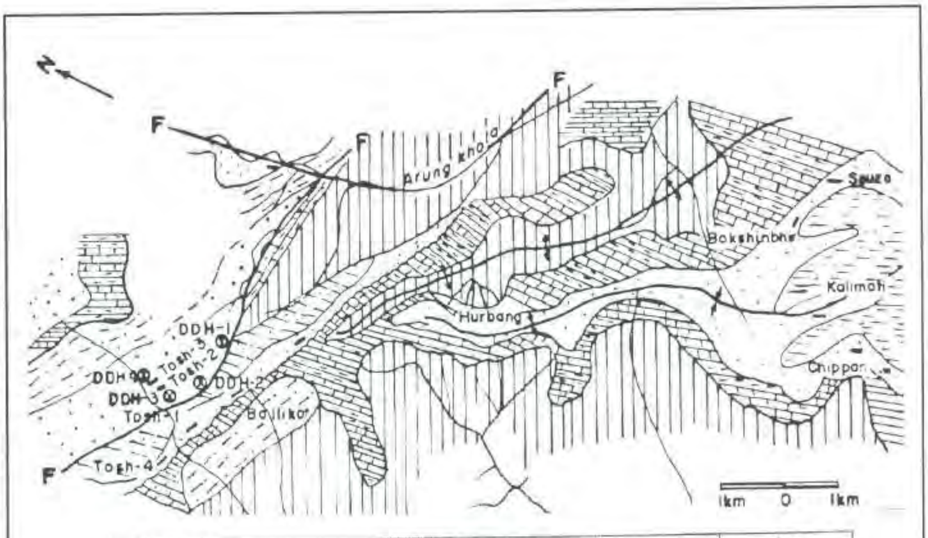
Reserve estimation of the available coal was calculated based on coal seam thickness obtained from drilling and outcrops, its strike extension obtained from detailed geological map and its extension along dip direction of 100 to 150m.

Grade, quality, and heating values are obtained from proximate analysis of the samples collected from exposures and drill holes.

RESULTS AND FINDINGS

Regional Geology of the area

In the regional framework, light green and gray to dark gray Khaki colored quartzitic sandstone occurs in the core portion of a regional syncline. The gray to grayish white quartzites with carbonaceous shale consisting of thin beds of coal occurs on both the limbs of this regional syncline. Due to tight folding and subsequent faulting, the coal seams in the quartzitic bed are highly squeezed. The coal beds appear as small stringers and pocket in the area. However, on detailed examination the coal beds represent a stratified deposit. The beds in the area are generally striking NW – SE with dipping towards NE – SW by 20° to 50° (Fig. 2).



Symbol	Lithological Description	Age
	Brown to Khaki quartzite with red and grey shale; presence of thin Numulatic interlayers at places.	Eocene
	Grey to greyish white ferruginous orthoquartzite with black carbonaceous shale and coal beds. ~~~ Unconformity ~~~	Cretaceous-Paleocene
	Highly folded grey to dark grey shale with dark grey limestone.	Paleozoic (?)
	Alternative bands of purple and green shale with thin bands of pinkish limestone	
	Coal occurrences	
⊗	Drill Hole Sites	

Fig. 2: Regional Geological Map of Tosh-Seuza Area Dang.

The different rock types occurring all around this regional structure represent a part of sedimentary rock of Pre - Cambrian to Tertiary in age. Based on fossil assemblages and their respective position as found elsewhere in western Nepal, different rock types in the area are classified as in Table-1.

Table-1: Litho – stratigraphical Sequence

Lithological Description	Correlation			Age
	DMG	Sakai (2001)	Indian Himalayas	
Brown to Khaki quartzite with red and gray shale; presence of thin numilitic limestone interlayer at places	Swat Formation	Bhainsekatti Formation	Subathu	Eocene
Gray to grayish white ferruginous orthoquartzite with black carbonaceous shale and coal beds. Conglomerate beds at base.	Melpani Formation	Amile Formation	Tal	Cretaceous - Paleocene
Highly folded gray to dark gray shale with dark gray limestone	Katuwa Shale	Kerabari Formation		Paleozoic ?
Alternative bands of purple and green shale with thin bands of pinkish limestone	Khara Slate and Limestone			

EXPLORATORY DRILLING WORKS

Generalized summary of the drilling result are presented in Table-2.

Reserve Estimation

Coal seams at Tosh area were considered to have four different layers namely Tosh – I, Tosh – II, Tosh – III and Tosh – IV. However, Tosh – II and Tosh – III are found to represent the fault repeated beds, while Tosh – I and Tosh – IV represent the same bed in the area. Hence, coal beds found in DDH – 1 and DDH – 2 represent Tosh – I seam. Coal beds of DDH – 3 and DDH – 4 represent the fault repeated Tosh – II and Tosh – III coal seam. The coal reserve tested by drilling at Tosh area nearly comes to be one million ton and is presented in Table-3.

Quality of the Coal

The chemical analysis and the proximate analysis of the limited samples of coal collected from the drill hole and exposures of different coal seams are tabulated in Table -4.

Table-2: Drilling Results of Tosh Area

Hole Number	Hole Azimuth	Drilled Depth, m	Drill Hole Position from nearest Outcrop	Depth of Coal seam, m	Seam Thickness, m	Mineable Coal Seams
DDH-1	Vertical (90°)	52.75	90m along dip direction 100m along dip direction	47.9 to 50.1	2.2	One
DDH-2	Vertical (90°)	100.02	100m down from Tosh – III mines.	30.80 to 32.25 55.10 to 55.35	0.25 1.45	One
DDH-3	S 22° W / 75°	90.00	100 m up from Tosh – III mine	26.40 to 27.90 72.20 to 74.00	0.50 2.20	One
DDH-4	Vertical	60.15		23.20 to 25.00	2.25	One
Total		302.92				

Table-3: Tested Coal Reserve at Tosh

Coal Seam	Drill Hole Numbers	Strike Extension (m)	Average thickness (m)	Extension along dip direction (m)	Volume (m^3)	Density (ton/m^3)	Reserve (tons)
Tosh – I	DDH-1 DDH-2	1000.0	2.0	150.0	300000	1.4	420,000
Tosh – III	DDH-3	1000.0	2.0	100.0	200000	1.4	280,000
Tosh – IIIUpper	DDH-4	1000.0	2.0	100.0	200000	1.4	280,000
Total					-		**980,000**

The coal samples show the average carbon content of 52-60 % with calorific values around 5,500 to 7,200 kcal/kg and belongs to Sub-bituminous grade.

Mining Activities and Coal Production:

The prospect was found at the phase of heavy exploration and exploitation. The exploration license holders are found vigorously exploring for coal and some of them had already obtained mining license for mining out the resources.

To study the consistency and nature of coal deposit down depth, existing adit and underground workings of Tosh – I, II and III mines were also inspected. The continuous coal seams are found to be disturbed by presence of quartzitic boudins and geological structures.

Thickness of Tosh – I coal seam, which is being mined at Tosh-I mine, is found increasing more than assumed average thickness of 2m. With average thickness of coal seam of 2m, a reserve of 0.4 million tons of coal is tested by drilling at Tosh – I. The grade of coal is sub-bituminous.

Table-4: Results of Proximate Analysis of Random Coal Samples

Coal Seam	Moisture Content (%)	Volatile Matter (%)	Ash Content (%)	Fixed Carbon (kcal/kg)	Calorific Value	Remarks
Tosh – I	6.1	27.9	22.2	43.8	5700	Sub-bituminous
Tosh – II	4.8	28.5	10.8	55.9	7000	Sub-bituminous
Tosh – III	1.3	21.7	16.9	60.0	7212	Sub-bituminous

There were two operating mines at Seuza area that produces about 75 tons of coal per day. Similarly, three mines were in operation at Tosh, which produces about 100 tons of coal per day.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on detailed geological investigation and drilling data it can be safely concluded that coal deposit of Tosh region represents a stratified (Tabular) deposit rather than a pocket or lensoid deposit as was assumed before.

There are two mineable coal seams near Tosh – III coalmines. Only the mining of lower coal bed has been started. The total coal reserve of about 0.6 million ton of sub-bituminous grade is tested by drilling.

Mining at Tosh – I, Tosh – II and Tosh – III mines are highly unscientific. Highly crushed and jointed quartzite mass is found left unsupported which ultimately has created lot of rock fall zone inside the adit.

The portals and adits in the area appear as "Rat – holes". They are devoid of proper ventilation and lighting arrangement underground. If this situation prevails, it may cause huge loss of life and property by roof collapse and underground accidents sometime in future.

Due to lack of proper monitoring, the mine owners are only mining the resource near by the surface without proper support system. It may cause problems for maximum extraction of the resources at future due to roof collapse and underground water. Hence, due attention for maximum extraction of the resources should be given.

If the coal deposits of the area were extracted properly, it can substantially substitute a major portion of coal import from India.

Recommendation

The present drilling work in the Tosh area has assessed the status of coal deposit in the area. Likewise, similar type of deposit at Seuza area should also be investigated by drilling for overall assessment of the coal deposit of the region.

Detailed geological investigation to ascertain the nature of coal occurrences should also be carried out in all the places where preliminary investigations had completed.

Thickness of coal seam is found increasing down depth, indicating that there exits a high probability of good coal deposit in the region. Thus, working criteria for mine development and retreating work for maximum possible extraction of the resource should be developed immediately.

The entrepreneurship of the private entrepreneurs for exploiting the coal is highly appreciable.

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Site Investigation of Three Proposed Mines at Different Parts of Jajarkot District, Mid – Western Nepal

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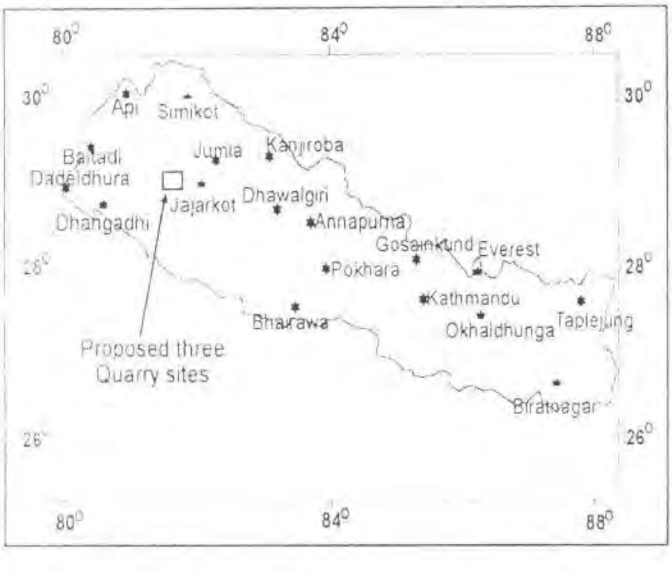
INTRODUCTION

Three proponents, as mentioned below are the holders of Prospecting License (PL) for the past couple of years. Out of three, two of them are prospecting for Tourmaline and other has been prospecting for Kyanite in different parts of Jajarkot District (Fig. 1). During the process of obtaining Mining License (ML), they had produced all the prerequisite documents to the Department of Mines and Geology (DMG) in the year 2060. According to Mines and Mineral Regulations, 2056, a regular site investigation is a must before the approval or rejection of the proposed mining scheme and awarding of mining license. Moreover examination of the mine site for various technical, financial, mining and environment aspects is necessary before issuing a mining license.

(a) Mr. Dharma Bahadur Basnet – Tourmaline mineral at VDC Daha-1, Jajarkot District.

(b) Mr. Krishna Bahadur Shahi – Tourmaline mineral at VDC Garkhakot-9, Jajarkot District.

(c) Star Gems Pvt. Ltd. – Kyanite mineral at VDC Daha-9, Jajarkot District.



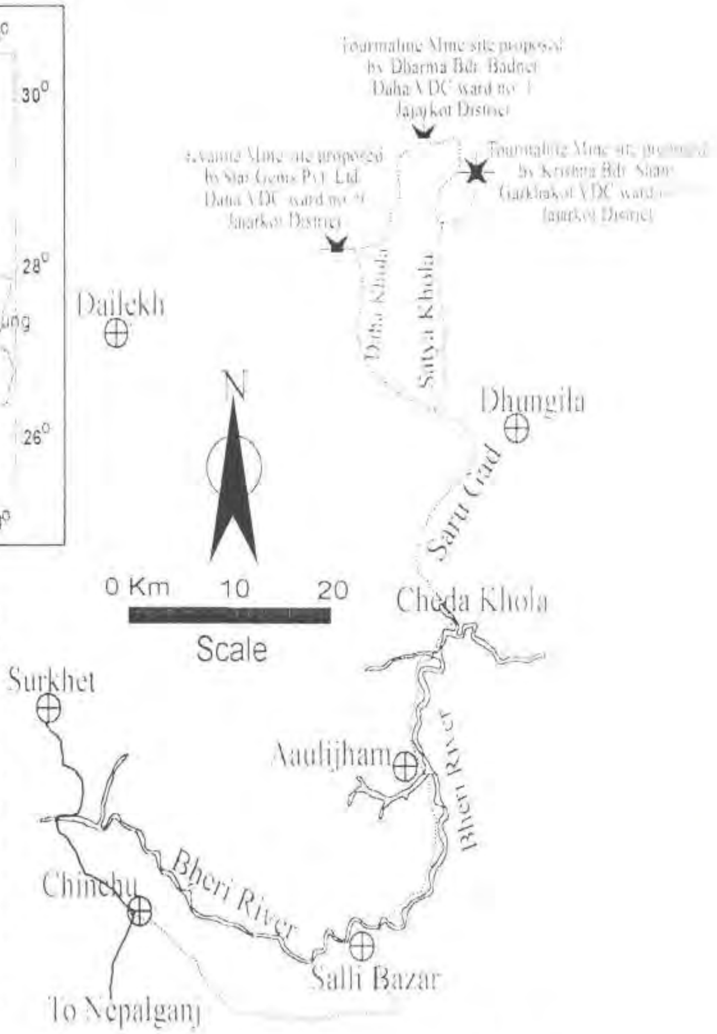


Fig.1: Location map of the purposed mines site.

OBJECTIVES

For the last few decades His Majesty's Government of Nepal aims to develop mineral resources and smooth running of mines under the administration of Department of Mines and Geology. The main objective of the field visit was to find the fact of visualizing the field realities with the facts produced in the mining scheme submitted to the Department of Mines and Geology by the proponent.

Other ancillary objectives of this field- work were:

- Monitoring of the possible environmental impacts that can be caused by the operation of the mining activity in the concern area.

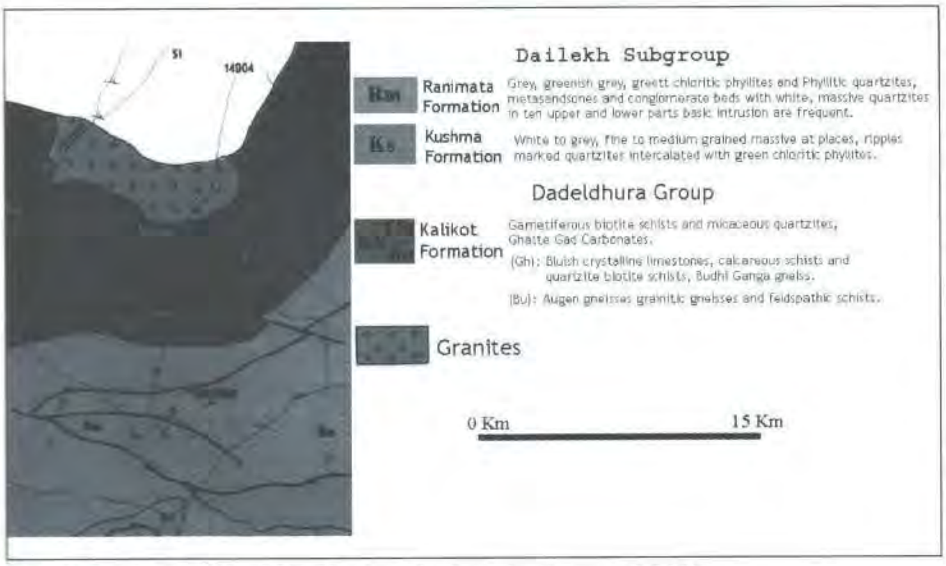


Fig. 2: Geology of the Mid-Western in Nepal (Source: DMG)

- Observe the potential occurrence of the minerals in the area and their economic viability.
- To check suitable mining method to be applied in the field.
- To check the quality of the minerals available in the proposed mine site.

GENERAL

Geology

- The project area lies in the eastern wing of Karnali Nappe in the Higher Himalayan Zone (Fig.2). The rocks of the region are Kyanite – Sillimanite bearing high grade gneiss and garnetiferous biotite schist with appreciable amount of micaceous quartzite. The general trend of the rocks is NW-SE and dipping 30^0-60^0 towards north.

Geology of the Prospect Area

Tourmaline Mine Site at Daha: The mine area lies within the zone of high-grade Kyanite-Sillimanite bearing gneiss and schist. The metasomatic aureole (Pegmatite) containing tourmaline has 15mX15 m size on outcrops and dips inside the hill at an angle of 50^0. Estimation of volume 50m X 14m X 10m is considered as a mass having abundance of tourmaline. Tourmaline crystals observed in the proposed mine area are expected to be of industrial grade.

Tourmaline Mine Site at Garkhakot: Well-foliated garnet and kyanite bearing schist, gneiss, and migmatites overwhelms the proposed tourmaline mine area. Within mine limit the orientation of the bedding is $214^0/19^0$. Tourmaline bearing Pegmatite vein within the gneiss holds the appreciable amount of tourmaline and other minerals like kyanite and beryl (Fig. 3a, 3b).

Kyanite Mine Site at Daha: The proposed mine area lies within the zone of high-grade Kyanite-Sillimanite bearing gneiss and schist's of Higher Himalayan Group. Within mine limit the orientation of the bedding is $239^0/25^0$. Kyanite bearing pelitic gneiss is found in lamination, within an area of about 2.25 hectares (Fig. 4a, 4b).

ENVIRONMENTAL ASPECT AROUND THE PROPOSED MINE SITES

All the three proposed mine sites of above mentioned categories lie far from the settlement and other archeological and religious monuments. Thus they may not cause the direct and severe environmental impacts by the operation of the mines. Natural slopes of all three proposed mine sites are almost stable with of low gradients. Adopting the terms and conditions mentioned in the Environment Protection Act, 2053 (1996) and Environment Protection, 2054 (1997) and following appropriate mining method as -proposed by the miners will probably assist in minimizing long-term and severe environmental and geological hazards and slope instability as well.

Fig. 3(a): Proposed tourmaline mine site (Daha) and pockets of tourmaline crystals found therein.

Fig.3(b): Scattered tourmaline crystals found within the ground of proposed quarry limit at Daha.

SELECTION OF PROPOSED MINING METHOD:

Tourmaline Mine Site at Daha: Host rock (Pegmatite Vein) of the tourmaline deposit dips opposite to the natural slope. Therfore the Mining of the deposit using underground mining method is the only option.

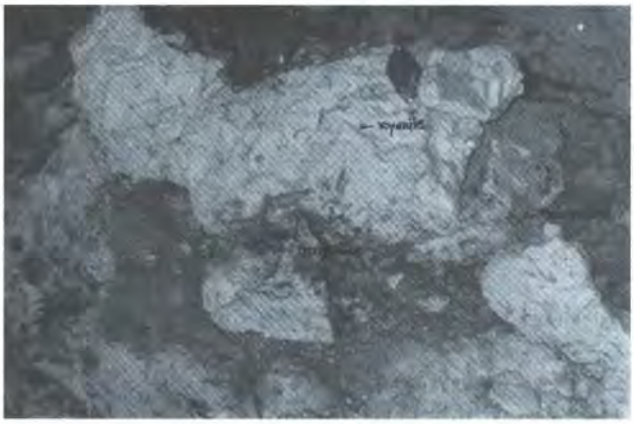


Fig. 4(a): Kyanite crystals seen in the Pegmatite vein within the proposed kyanite mine site at Daha.

Fig. 4(b): Abundance of kyanite in the proposed quarry site at Daha.

It is the future; we have to wait and see the optimum applicability and success of the proposed mining method. At present, it is the only method that seems more applicable while considering natural occurrence of the deposit.

Tourmaline Mine Site at Garkhakot: The pegmatite vein holding the tourmaline deposits at Bangedanda forms low dipping concordant bedding with the kyanite-biotite gneiss (Fig. 5a, 5b) . Low gradient of the bedding favors that the opencast mining with benches in steps. In future when the pegmatite vein deepens, continuation of benching mining method may not remain suitable. However, it is a matter of concern that during field visit one could infer that ample occurrence of extractable mineral was of minimal possibility.

Kyanite Mine Site at Daha: Kyanite bearing gneiss in this locality is found in the form of lamination within the host rock. The gneiss forms low gradient dip with the natural slope. Open cast mining method is the most suitable method of working owing to the nature of the field. Dumping of solid waste must be well managed for environmental friendly mining and special care should be taken to preserve the natural integrity of Daha Khola.

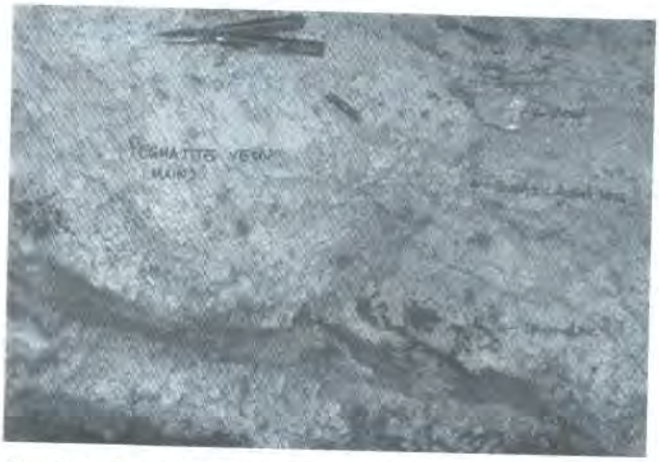


Fig. 5(a): Crystals of tourmaline and other minerals observed at proposed mine at Garkhakot.

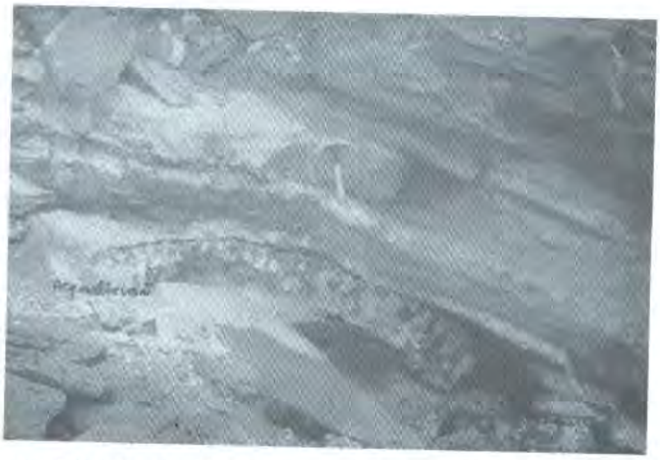


Fig. 5(b): Pegmatite vein, a host rock for the tourmaline deposits at Garkhakot.

CONCLUSION AND RECOMMENDATION

Based on the visual inspection of the Tourmaline and Kyanite minerals and their respective deposits, very few crystals may be of true gem quality rather most of the product fall into industrial grade. Very small amount of Kyanite crystal in the proposed mine site at Daha and negligible amount of Tourmaline crystal at the proposed mine site at Garkhakot may be of gem quality. Tourmaline deposite of proposed mine site at Daha also shows almost insignificant presence of gem quality tourmetine.

All three proposed mine sites are found to produce minimal effect on the environment during their operation phase. Operation of proposed mines promotes local manpower (employment) and adds a fractional increment on the national economy. Field verification shows that all these three proposed mines are of small-scale deposit of industrial grade mineral. However, chances of finding a small quantity of gem quality tourmaline and kyanite crystals in these deposits cannot be ignored if an expert hand carefully segregates the excavated deposit before bringing into market.

In a phase wise level, at least once in a three-month to get hold of the mining activity and producing enforcement in regulating proper mining method and environment friendly working DMG will ask to submit a progress report on these proposed mine sites after operation. Finally all the three proponents should abide by the following Act/ Terms and conditions/amendments made by Government of Nepal.

- Mines and Mineral Act, 2042 (1985)
- Environment Protection Act, 2053 (1996)
- Environment Protection, Regulation 2054 (1997)
- Mines and Mineral Regulation, 2056 (1999)

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Engineering and Environmental Geological Mapping of Bhairahawa - Lumbini Area, Western Nepal

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INTRODUCTION

In total, 233 square kilometers area around Bhairahawa to Lumbini was investigated. The area was covered in two fiscal years. In the fiscal year 2059/60, the area covered lies in between latitudes 27°27' 2. 97" N to 27°3 4' 0. 22" N and longitudes 83° 22' 0. 9"E to 83°29' 39. 09" E while in 2060/61the investigated area lies in between latitudes 27°29' 00" N to 27°3 1' 00" N and longitudes 83° 14' 30" E to 83°22' 05" E as well as latitudes 27° 34' 00" N to 27° 39' N and longitudes 83° 24' 15" E to 83°29' 30" E in the toposheet numbers 63 M/6 and 63 M/7 at 1: 50,000 and 1: 63, 360 scales; and sheet nos. 098 – 16, 104 – 03 and 104 – 04 of JICA at 1:25, 000 scale, 1993. Bhairahawa town of Siddharthanagar Municipality is situated in the Terai Plain of Rupandehi District in Western Development Region of Nepal. The Study area is located 280km southwest of Kathmandu. Sunauli, the nearest Indian border town is in the South of the study area. The elevation of the study area ranges from 146m above msl near Shankarnagar and 93m above msl at Lumbini Development Area suggesting a relief difference of only 53 m. It covers the most parts of Siddharthanagar Municipality, parts of Lumbini and some parts of adjacent areas towards North of Bhairahawa (Anandaban) in Rupandehi district.

The study area lies in the Terai Plain of Rupandehi district within the watersheds of Ghaghar Nala, Tinau and Siyari Rivers from East to West (in the area North of Bhairahawa i.e., Anandaban) and Harewa, Dano and Tilar Rivers from East to West (in the area west of Bhairahawa township around Lumbini). Tinau originates from the Middle Mountain in the North and flows down South through Siwalik range and further southward from the present area. Any settlements and urbanization close to these drainage systems and relatively low lying areas are normally facing problems of flooding during the monsoon season and also the times of cloud bursts in their catchments as the water in the rivers, streams, kholas and nalas increases and runs above the riverbed. Besides that othertypes of natural hazards observed in the area are the riverbank cutting, bank erosion and scouring of the riverbed. These are the common features often seen in these river systems. In addition, inundation and flooding of relatively low lying areas are commonly found in and around Pipara, Madhubani, Chilhiya (North of Kotihawa), Laxminagar and nearby areas of main rivers like Tilar, Dano, Harewa, Tinau and Siyari.

Siddharthanagar Municipality is one of the fast growing urban areas of Nepal. The total population of the municipality is about 70,000 at present according to the municipality sources. The area receives high precipitation during monsoon each year. The temperature ranges from 10 to 43 degrees Celsius.

Infrastructure development activities such as proposed expansion of existing airport to an International airport, construction of industrial buildings, expansion of the settlement areas are in progress. Similarly, Lumbini, the birthplace of lord Gautam Buddha is being developed as "Lumbini Development Area". Large stupas, temples and other buildings are being constructed within and outside the Lumbini Development Area. For proper land use planning and implementation of development activities require the knowledge on the ground where they are going to construct such structures. In such case the planners and engineers must have the knowledge on engineering and environmental geology and likely geo – hazard prone areas. Local authorities are lacking such information for their future infrastructure development planning. Therefore, Department of Mines and Geology (DMG) has initiated to prepare an Engineering and Environmental Geological Map of fast developing areas such as Lumbini and Siddharthanagar with a view to provide basic information on engineering geology, urban and environmental geology and geohazard prone areas. It is anticipated that this map prepared by the study team of DMG will be useful for planning of future development activities in this area.

The target area for Urban Geology and Land Use study lies in the Terai Plain (northern part of Indo – Gangetic Plain) of Rupandehi district. The settlement areas of Butwal and Siddharthanagar are expanding along the Butwal - Lumbini highway and same is the case in and around Lumbini. The area consists of the Quaternary sediments deposited by the drainages flowing within the area. Siddhartha Rajmarga (Butwal - Sunauli Road) connects the study area with East – West highway in the north and with rest of the country at Butwal while the Lumbini Road connects the Lumbini Development Area.

Engineering, urban and environmental geological investigation and Geohazard assessment were carried out in the area with an objective to prepare a comprehensive 'Engineering and Environmental Geological Map' at 1: 25, 000 scale. This map is intended to help the urban planners, engineers and decision makers in land use planning, infrastructure development planning, hazard mitigation, sustainable utilization of natural resources and environmental management. The map includes the information on lithological description of each unit, engineering properties of soil, identifying geohazards (natural and man made) prone areas, mineral resources, potential and features of environmental significance, riverbed mining sites, landfill site, land use and urban geology.

OBJECTIVE

The main objectives of the present study are:

- Recognition of image characteristics of various land use patterns in LANDSAT TM and aerial photos of the area
- Delineation of tectonically weak zones, lineaments.
- Mapping of erosion features.
- Delineation of flood prone areas.
- Pitting for soil section study.
- Delineation of the area susceptible to liquefaction and associated risk to provide suitable preventive measures to reduce its effect on existing environment and structures.
- Preparation of Engineering and Environmental Geological Map at 1: 25,000 scale and the report.

METHODOLOGY

Existing relevant literatures on geology, geohazards and regional geological as well as land use maps were reviewed. Available reports on groundwater prepared by Bhairahawa-Lumbini Groundwater Irrigation Project were studied (Uprety, 1989; Graniii, 1996; Gaihre, 1998 and Khattri, 2004). Additional information was also collected from local individuals. LANDSAT TM Scenes of 1: 125, 000 scale (November 1990); aerial photographs of 1: 15, 000 scale (January 1998) and of 1: 50,000 scale (1978) were studied and necessary interpretations were made. Ortho – photomaps of 1: 10,000 scales prepared in 2002 A.D. based on 1:50,000 aerial photographs of 1992 and 1996 were also referred to verify different features in the field. Lineaments were marked in the TM – Scene that has the orientations mainly in N–S, NW–SE and NE– SW directions. These lineaments could be the deep seated faults or fracture zones or the boundary of the lithological variations and in most cases normally represent the tectonically weak zones. Topo maps of 1: 25,000 scale (1993) was also acquired. The digital database of this map received from Topographical Survey Branch has been used to prepare a base map.

FIELD ACTIVITIES

The fieldwork was carried out in the dry seasons of 2059 and 2060 B.S. It was planned with an aim to verify the previously interpreted work in the field and look for the possible neotectonic features as well as to compare the previously identified thrusts, faults, lithological formations, boundaries, land use and the infrastructures. Field survey enabled to delineate the potential areas of instabilities on the ground (river banks, low lying areas) that endangered the plain areas. This type of work help to furnish the Quaternary geology. Also preliminary survey was made for Siddharthanagar Municipality to find out the suitable sanitary landfill site for waste disposal.

In total, 200 auger holes (Fig. 1) were drilled for the investigation of the subsurface soil layer from which about 300 soil samples were collected from different depth of the boreholes for laboratory analysis. More than 100 Standard Penetration Tests (SPT) was carried out to determine the stiffness of the ground at different locations (Fig. 2). The test was carried out to the maximum depth of 10 meter only because of the limitation of time and the type of the equipment used for the test.

Fig. 1: Performing Auger hole drill in the field

Fig. 2: Performing Standard Penetration Test (SPT) in the field.

Study on liquefaction susceptible area has been carried out using qualitative analysis following the method of Juang and Elton (1991). This method is based on the assigning of scoring values and assigning weight value depending on the importance of the factors considered. Six geological factors namely water table, grain size, depth of burial, capping layer, age of deposit, liquefaction layer thickness have been considered for this purpose as follow:

Finally the total score value is added and classified into four different categories as High, Moderate, Low and Very low susceptibility as below:

- High (score >36): - Significant areas may liquefy under moderate to high seismic loading.
- Moderate (score between 26 and 36): - Some areas may liquefy under high seismic loading.
- Low (score between 20 and 26): - Localized areas (such as ribbon sands) may liquefy under high seismic loading.
- Very low (score <20): - Negligible liquefaction expected even under high seismic loading.

The flow chart for carrying out liquefaction susceptibility analysis is given in Fig. 3.

A number of traverses were taken along riverbanks, trails and roads to identify areas prone to flooding, river bank erosion and riverbed scouring. Soil sections exposed along riverbanks were measured. A number of pits were dug in order to expose the soil section in areas other than river sections. The soil sections were compared with soil types exposed along riverbanks and litho-logs of more than 10m depths recorded by the groundwater project. The sediments up to a depth of 10m. are broadly classified into different lithological units. Sometimes these pit sections are compared with their properties assessed (like grain size analysis) to know the development in different parts. Topsoil (humus soil) is generally represented by gray reddish and or yellowish brown. This work was helpful to furnish the Quaternary geology of the study area.

Field data and information collected from aerial photographs were transferred into the topographical base map. Analyses of collected samples from the field were carried out in Chemical and Geotechnical laboratories for their respective purposes. Geographical Information System (GIS) analysis was carried out using ARC/INFO software. The process here includes the digitizing of the map, input of data and its storage, data processing and plotting and then by producing the Engineering and Environmental Geological Map. A number of layers were created which include polygon, line and point features. Each Arc Info layer was converted into shape (.shp) files using Arc View software. Shape files were transferred to freehand software for final cartographic design of the map.

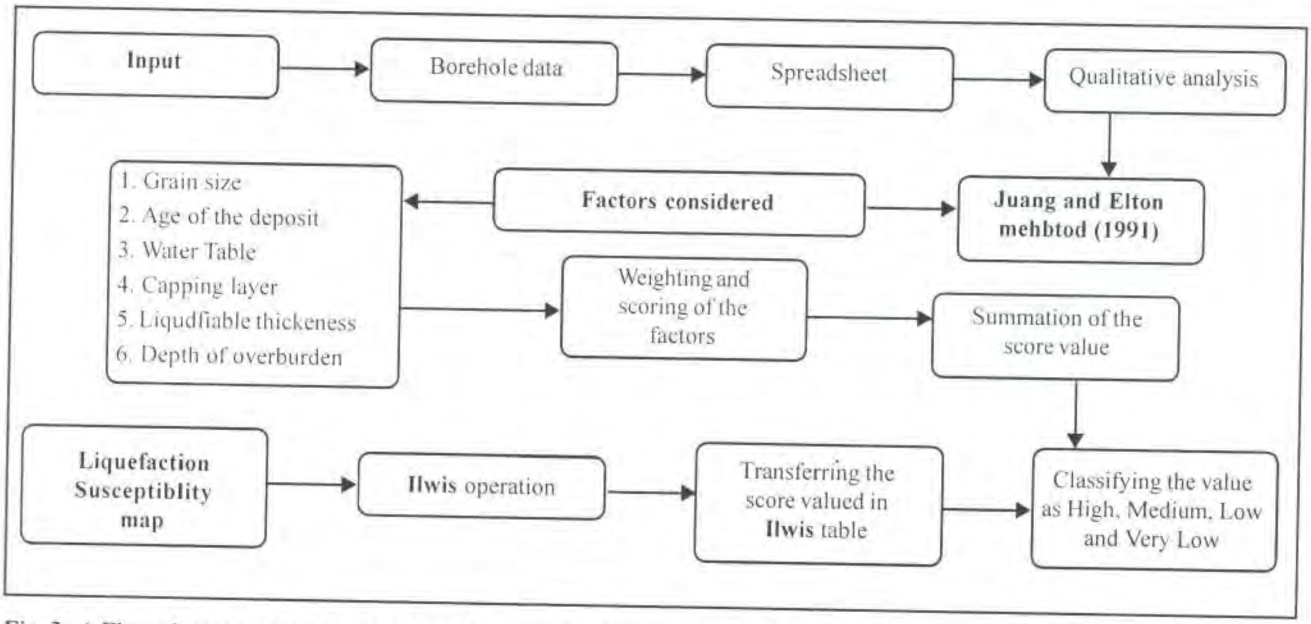

Fig. 3: A Flow chart showing methodology for liquefaction susceptibility analysis.

RESULTS AND FINDINGS

(a) Quaternary Geology

Mainly Quaternary alluvial sedimentary deposits represent the plain in the study area. It is completely confined within the Terai, which is the northern part of Indo – Gangetic Plain. Bedrock geology is not traced in the whole study area. Only the gravels of quartzite, sandstone, limestone/ dolomite with sand and silt derived from the Siwalik foothills and Middle Mountain are found along Tinau and Dano River Beds.

The plain area largely consists of the Quaternary to Recent sediments and at places gravels derived from the Siwalik Hills and Lesser Himalaya (Mahabharat Range) a nd deposited by Tinau and Dano Rivers. Mainly the alluvial and fluvial deposits of Indo – Gangetic Plain (Quaternary – Recent) are found in the area and along the river valleys respectively consisting mainly of silty clay, sand and gravel. The valley floor sediments are described and mentioned according to their composition, degree of compaction and segmentation and the types of cementing material based on the Unified Soil Classification System. Based on the study of soils along river sections, pits and existing litho logs (up to 10m depth) in the area, nine lithological/soil units represent the Quaternary geology of the area. They are described below:

1. Tinau Flood Plain Deposits (tfp)

It occurs along the Tinau riversides and on the flood plain itself. It has alluvial loose, unsorted sediments consisting of gravels mainly of quartzite, sandstone, limestone/dolomite with sand and silt. When mixed with clay it gives rise to the fertile top fine soil suitable for cultivation. The aggregates deposited by the river often provide an excellent source of construction materials like gravels and fine sand. The deposit generally lies in moderate to high bearing capacity and high liquefaction potential zone.

2. Thutipipal Deposit (ttp)

This deposit is represented by 4 m thick gray brown to yellow silty clay sediments. It is underlain by 4 m thick fine to coarse sand. Below this sand, more than 3 m thick gray clay is recorded. Generally an observed average thickness of this unit is 10 meter. Water table is found at 0.65 to 3.00 m depth from the ground surface. Topsoil (humus) is generally represented by brown of various shades (like grey reddish and or yellowish tints). Humus soils are 15–50 cm. thick and consist of clay, silty clay or clayey sandy sediments. This deposit can also be the possible source of sand/gravel deposit for construction purposes. N–value obtained from SPT test is normally higher in this deposit, which range from 1 in Khumsa at a depth of 2 m and up to 32 in Kataiya at a depth of 4 m. Thus the deposit generally lies in moderate to high bearing capacity. Water table recorded at different auger holes and SPT holes in this deposit ranges from 0.45 m in Ground Water Project Office (Anchalpur) to 3.20 m in Balapur. The area has generally low to medium permeability with localized moderate to high liquefaction potential areas.

3. Garasadi Deposit (grd)

This deposit is represented by up to 6 m thick yellow to gray clayey silt. It is underlain by more than 3 m thick dark grey clay representing an observed average thickness of more than 9 meter. Here humus soil of nearly 20 cm. thick with brown, grey tints is found on the top. Water table is generally found at 1–2 meter depth from the ground surface. The area generally lies in low to moderate bearing capacity. N–value recorded from SPT test range from 0 in Sitapur at a depth of 1 m to up to 33 in Misraulia at a depth of 6.5 m. The area lies in low permeability zone and has low liquefaction potential areas.

4. Sukarauli Deposit (skl)

It is represented by 8 cm thick topmost dark gray humus soil followed by 4 m thick yellowish gray silty clay. Below this lies 2 m thick fine sand that is underlain by gravelly sands together with sandy silt. Average thickness of this unit is more than 6 meter. Here the water table generally occurs at 1.0 to 1.55 meter depth from the ground surface. N–value obtained from SPT test range from 3 to 18. The value is increasing with depth. Thus the area lies in low to moderate bearing capacity. It has very low to low permeability and generally moderate to high liquefaction susceptible area.

5. Marchahawa Deposit (mhw)

This deposit often has 4 m thick yellowish, gray brown silty clay that is underlain by more than 5 m thick fine to coarse-grained sand with gravels at places. The grain size is increasing further downwards. Observed average thickness of this unit is more than 9 meter. Water table is found at 1 to 3.5 m depth from the ground surface. This deposit could be the source of sand mining. N–value observed from SPT test range from 3 to 19 in Khadawa village. Normally N–value is increasing with depth but there is sudden decrease in the value at a greater depth, which is possibly due to water enrichment at that depth. It has generally moderate to high bearing capacity, low to medium permeability and lies on moderate to high liquefaction susceptible areas.

6. Bangai Deposit (bng)

This deposit occurs along right (west) bank of Tinau River (close to Gurwaniya) and in Ghaghar Nala (northwest of Mahakolwa village), Barsauli, Sanopakadi and Padarhawa areas around Harewa and Dano Rivers. Observed average thickness is 9 meter. It consists of yellowish brown and dark grey clay and silty clay. This is underlain by fine to medium, grey sand. A layer of fine sand in lenses (0.15 to 2.0 m thick) is present at places within this unit. This deposit could be the possible source of clay. There are few brick factories which use this deposit. The water table observed in different auger hole and SPT holes range from 1.40 m at Gurwania village to more than 6 m at Gargatti village. The SPT value observed at different SPT locations vary from 1 in Doghara village at a depth of 7 m to 31 at the same place. The higher N–value may be due to stiff clay presence. The area falls under moderate to high bearing capacity and moderate to high liquefaction potential areas. It has low permeability. The permeability value on this deposit range from 1.1×10^{-6} to 9.98×10^{-7} mm/s. The selected area occupied by this deposit could be used for landfill site as it consists of suitable geological barrier sediment for leechates. In this deposit normally N–value increases with depth but in some places at lower depth N–value is decreasing which may be due to water saturation of the sediment or encountering very soft sediment.

7. Sisawa Deposit (ssw)

It occurs towards east of Harewa River in Maryadpur area. It is often represented by 4 m thick gray brown to yellow clayey silt which is underlain by 4 m thick fine to medium sand that is followed by more than 3 m thick gray silty clay making an observed average thickness of more than 11 meters in total. There could be the possible source of sand mining in this area. The water table observed in different auger holes and SPT holes range from 0. 55 m at Shankarpur village to 2. 65 m at Doghari village. The N–value observed at different SPT locations vary from 2 at a depth of 2 m to 20 at a depth of 5. 5 m in Sisawa village. Normally the greater N–value is obtained in coarse sand layer and lower value is obtained in sandy silt and silty sand layer. Generally the N–value increases with depth, however, in some cases it is found to be decreased, which may be due to water saturation in the sandy layers or change in the soft sediments. The N–value result shows that the area lies in moderate to high bearing capacity. The Permeability value obtained from the sieve curve analysis range from 1.1×10^{-4} to 8.3×10^{-6} mm/s which shows that the area has low to medium permeability. The area lies in moderate to high liquefaction susceptible zone.

8. Patharganj Deposit (pgs)

This deposit is the continuation from the Butwal area. It is represented by dominantly gravel and sand with clayey to sandy silt layer that is less than 1 meter thick towards top. The gravel layers are very compact at depth with high bearing capacity and lies under moderate liquefaction susceptible zone.

9. Motipur Deposit (mcs)

This deposit also continues from the Butwal area. This is brown-gray to yellow clayey silt and silty clay with fine calcareous concretions at places. It is generally underlain by gravel in Semlar area and stiff clay in Tamnagar area. Alternating sequence of silty clay and clayey silt layers with fine to medium grained sand layers are found up to 4. 0 meter depth at many locations. The materials of this deposit are soft and loosely compact towards top with very low bearing capacity. It has the thickness of 2 to 6 meters. The deposit lies in low liquefaction potential zone.

Several pits were dug in the investigated area with a view to know the distribution of various soil types (litho logs). Sometimes these sections are compared with their properties (like grain size analysis) to know the development in different parts. Topsoil (humus soil) is generally represented by brown of various shades (like grey reddish and or yellowish tints). Humus soils are 15 – 50 cm thick and consist of clay, silty clay or clayey sandy sediments. Groundwater occurs in the pebble, gravelly sand layers.

Dark grey tone marked in the ortho – photos in some locality represent that this particular area is relatively low lying where groundwater level is immediately below the ground surface. Here water gets collected during monsoon season and the surplus water makes its own channel to the rivers. This way the low – lying areas are known to be natural drains for excess rainwater.

Several ox – bow lakes and old river channels are distinctly marked in the ortho – photos. Some of them containing water give rise to the swampy or marshy lands. In the field, these lands are found to be confined within the periphery of newly extended urban settlements that blocked the regular natural drain water. Water when gets collected in marshy lands for a longer time increases the moisture content of the soil and thereby lowers its bearing capacity. Finally they developed into permanent waterlogged lands creating havoc to the nearby urban settlements. Some badlands are recorded in Tinau, Dano and other drainages.

(b) Landfill site

There is no proper sanitary landfill site either in Lumbini Development Area or in Bhairahawa. Dumping of the industrial wastes in Dano River near north of Dano Bridge by Reliance Paper Mills (near Ramawapur) and Tribeni Distilleries (near upstream from Dano Bridge) both located closer to Dano eastern banks are causing river water pollution by draining its sludge into it as marked by black colour and full of white foam in it. Likewise dumping of community wastes along the roadside and within the forest of Lumbini Gram needs to be properly managed. In this connection the land left behind by several brick factories (e.g. Harisiddhi Brick Factory) after excavating clay can be utilized as landfill sites.

Similarly the Siddharthanagar Municipality is also lacking its sanitary landfill site to manage the safe disposal of the daily waste produced from the urban settlement and industrial sites. At present, the local community is temporarily throwing their daily wastes into various rivers, kholas, nalas and by the side of road without considering its environmental impact. It needs to be properly located and managed. In this connection the land left by the brick factories after excavation of clay (i.e., abandoned borrow pits) can be utilized for safe dumping of communal waste.

(c) Natural hazards / Geo- hazards

During monsoon, the water in the rivers, streams, kholas and nalas increases and in many cases resulted flooding to the surrounding areas. The river scouring, bank cutting and erosion is common feature often seen in these river systems. Side cutting causes the gully erosion developing badland topography. Badlands are found to be developed in Tinau and Dano rivers and in their tributaries. In addition inundation and flooding of relatively low - lying areas are commonly found in around Pipara, Madhubani, Chilhiya (north of Kotihawa), Laxminagar and nearby areas of main rivers like Tilar, Dano, Harewa, Tinau and Siyari.

Blocking of water by the highway itself has created marshy lands, which are located to the west and east of Siddhartha highway and to the north and south of Lumbini highway. Water when gets collected in marshy lands for a longer period helps to increase moisture content in the soil and thereby lowers its bearing capacity. Finally they developed into a permanent waterlogged lands creating environmental problem to the nearby urban settlements.

(d) Bearing capacity

Low to moderate bearing capacity areas are concentrated in Garasadi (grd) and Sukarauli (skl) deposits. Garasadi unit has low bearing capacity of up to 2 meters depth with N – value less than 4 while Sukarauli has low to moderate bearing capacity of up to 3. 5 meters depth with N–values less than 5. Sukarauli unit on the other hand has low to moderate bearing capacity of up to 5 meters depth with N values 4–8. Stiff layer exists below 2 m depth with N values 8–12 in Garasadi. It has low permeability and low liquefaction potential. Slightly dense layer occurs at depth below 3.5 meters in Sukarauli. It has very low to low permeability and is generally low to moderate susceptible to liquefaction. In Sisawa unit slightly dense layer exists with N–values 18–30 at a depth of 4–8 meters below which very stiff clay layer is found. It has low to medium permeability and is moderate to highly susceptible to liquefaction. According to the liquefaction susceptible analysis it was found that about 16 percent of the total land is occupied by high susceptible, about 82 percent is by moderate susceptible and the rest by low susceptible areas (Fig. 4) respectively. Very low susceptible does not exist in the study area. High bearing capacity zone is found at shallow depth (4 m) in Thutipipal and in Sisawa deposits. Areas covered by Bangai and at some places by Garasadi deposits have low to moderate bearing capacity. The Liquefaction Susceptibility map is shown as an inset in Fig. 5.

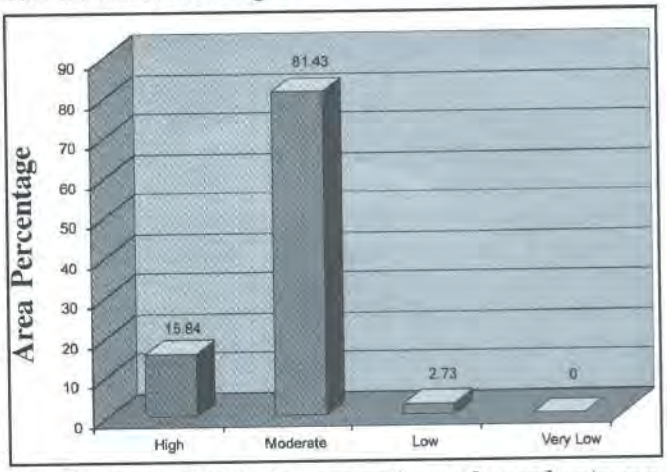

Fig. 4: Area distribution according to hazard category

Lowland areas adjacent to Tinau, Dano and other rivers and streams in the area are likely to be affected by floods. Hence, these lands are not suitable for human settlements but can be utilized for agricultural purposes. A risk of flash flood can always be a threat in these areas and downstream.

The area that is inundated during heavy rain is left barren. However, these areas could be used for the cultivation (both dry and wet) but not for the construction of the buildings. These areas are considered to have high ground water potential and vulnerable to pollution as well. The riverbanks in the area need to be protected by properly designed engineering structures. In this connection a buffer zone of 15–20 m. on either side of the riverbanks should be maintained. It helps to minimize the possible loss of lives and properties. In addition to that dumping of chemicals and petroleum wastes should not be carried out in these areas.

Industrial district and industries, brick factories, stone crushers when located near the settlements and the riverbanks can often create the problem of health hazards. Improper mining of construction materials in Tinau river (near Betahari) have caused land degradation, riverbank scouring and thereby causing the problem of air and water pollution as well as river bank collapse during flooding.

(e) Water resources

Surface and groundwater, river boulders, gravels and sand as well as natural forests are the main natural resources in the area. Proper management of these resources for optimum utilization for the livelihood of people is necessary.

Tinau River is the only perennial river in the area. Dano River is created after bifurcation of Tinau River near Tinau Bridge in Butwal. From here it flows towards west for about 9 kilometers and makes its course continuously to the south for about another 30 kilometers passing through the present area. Other rivers in the area also have very less amount of water during the dry season. As far as the ground water is concerned it occurs in the pebbly, coarse (or gravelly) sand layers and the level of water is found to be at 0.65 m to 4.0 m depths. Ground water is used in drinking and irrigation purposes.

(f) Land use

Various types of existing land uses in the area are agricultural, forests, settlements, industrial, recreation centers (like public parks) and landfill / waste disposal sites. The study area is mainly cultivated land where rice and wheat is grown. Forestlands with Sal trees are found in the area. Patches of mango and leeches trees as garden is seen in most of the villages and in Lumbini Gram where as low lying areas are normally covered by blocked water. 'Lumbini Gram Area' is the only place where forests is reserved. Other small patches of forests (like mango orchard) are found in several localities and at places along the river corridor. It is a religious and sacred place for Buddhists. Other than this there is no recreational or public parks.

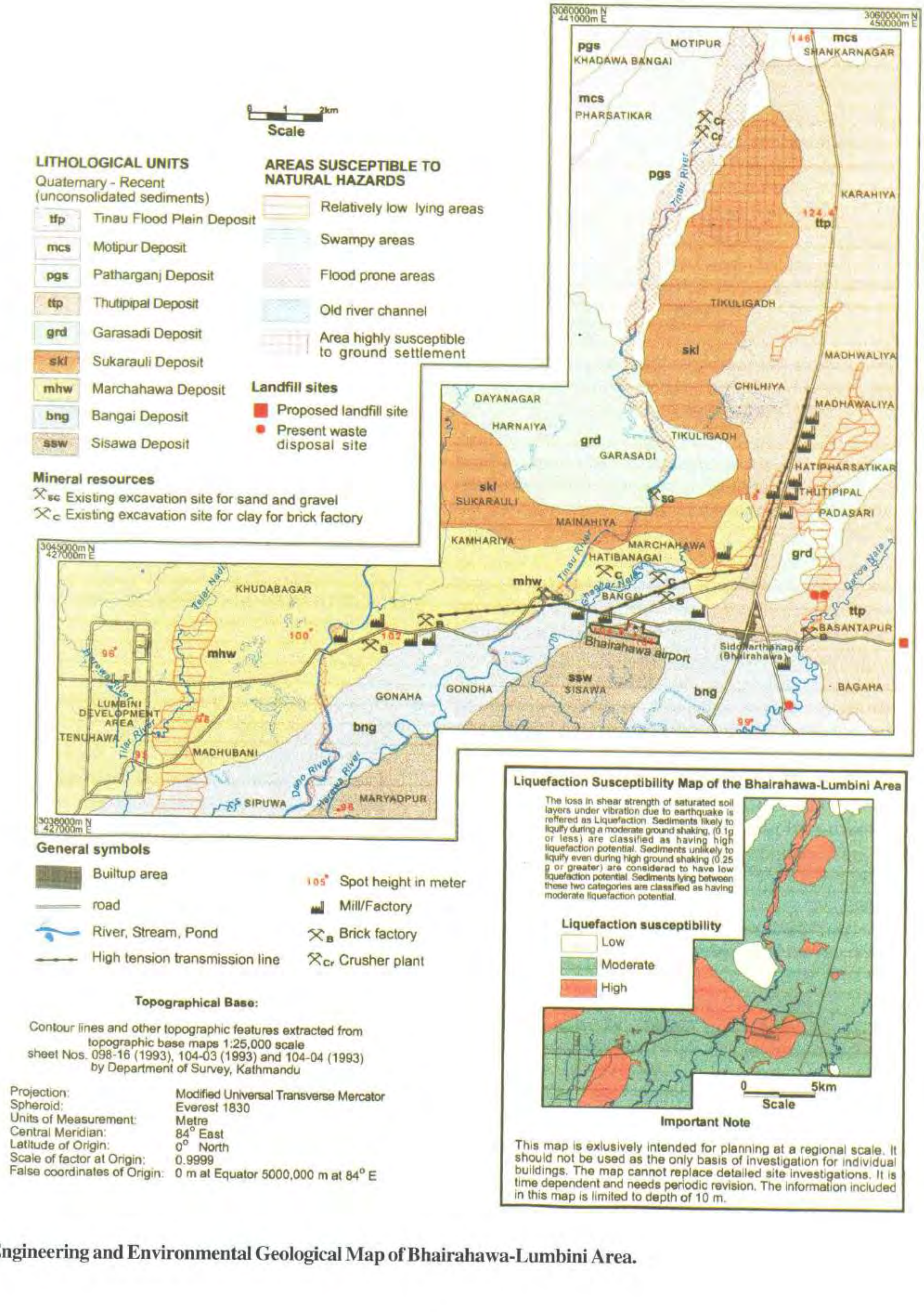

Fig. 5: Engineering and Environmental Geological Map of Bhairahawa-Lumbini Area.

The Engineering and Environmental Geological Map is very much useful for planning at local level (municipality and adjoining village development committees) as it contains geoscientific information that are necessary to the planners, decision-makers, engineers, civil technicians and other users. It can be used for land use indentify planning areas for mining construction materials, hazardous areas, selection for waste disposal sites, urban and regional development planning, environmental protection and disaster management. However, the detailed site investigation is necessary for specific engineering design and construction projects.

RIVER BED MINING AND EXPORT OF BOULDER AND GRAVEL

Sand and gravels deposits along the course of Tinau and Dano Rivers are extensively mined and used as construction material for various purposes. They are also exported to nearby border town in India. The amount of gravel extracted each year is replenished by the redeposition of fresh sediments during flood in monsoon season. According to the local people, the gravel supplied by the river has decreased considerably in the last 10 years. But in reality the riverbed mining has caused the positive effect to minimize the flooding risk along the riversides. District Development committee issue license to mine/extraction of gravel/sand from the central portion of the riverbed suggesting it as the prime mining area. This is good because it promotes to lower the riverbed level so that the chances of flooding are considerably minimized. And this is one technique of training the river to make it flow in prescribed channel and to allow deposit its bed load that is ready to be extracted in the next mining season and thereby maintain the existing riverbed level. This helps to some extent to minimize the flood hazard risk by the river. However, there should not be over extractin of river gravel (boulders, gravel, sand etc.). Besides that the thick clay deposit present in the area between Bhairahawa and Lumbini is mined and widely used for making bricks. Similarly the proper utilization of groundwater is also made for drinking and irrigation purposes by Bhairahawa – Lumbni Groundwater Resources Project (BLGWRP). Until now significant environmental impact is not noticed. However, lowering of pressure of the flowing wells is recorded by BLGWRP.

A short discussion on sales and income from river gravel was held with Mr. Shiva Pathak, secretary of "Roda Dhunga Udyogh Byabasahi Sangh, Rupandehi ". He informed that the gravel mining works in Tinau and Dano Rivers has provided direct or indirect employment for over 40, 000 people every year and a labour could earn about NRs 200.00 per day.

In fiscal year 2059/60 B.S. the total amount of gravel exported to India and the Royalty income to the District Development Committee, Rupandehi is listed below:

Processed aggregate ----- 1, 62, 00, 000 cu.ft.
Unprocessed gravel ------ 1, 90, 00, 000 cu.ft.
The material is sold at 8 – 11 Indian Rupees/cu.ft in India.
The unprocessed gravel is screened to different sizes as per their need.

Every year, the Rupandehi District Development Committee (RDDC) flows tender to mine the river gravel from the Tinau and Dano rivers. In fiscal year 2059/60, the highest bidder (contractor) received a mining contract (license) from RDDC by paying Rs. 89.9 million. The main contractor use to give sub – contract to other people (party) sector wise. During dry season, about 11,000 transport vehicles and 10, 000 people engaged in this riverbed mining, crushing and transportation activities.

In existing system, the entrepreneurs have to pay the taxes at four or five different places while exporting the river gravel. They are suggesting for simplified tax systems to promote the mining and export of gravel effectively.

CONCLUSION AND RECOMMENDATION

Conclusion

- The study area covers on the alluvial plain of Ghagha Nala, Tinau, Siyari, Harewa, Dano and Tilar rivers and their tributaries. The area is represented mainly by Quaternary alluvial sedimentary deposits (a section of the northern part of Indo – Gangetic alluvial plain). Lithologically it is observed that the grain size gradually decreases towards south.
- Based on their lithological characteristics and SPT values sedimentary deposits of up to 10m depths are divided into 9 units .
- Flood Plain Deposits often provide an excellent source of building and construction materials like boulders, gravels and sand.
- River gravel (a renewable natural resource) of Tinau and Dano rivers are extensively mined for construction material and ps,ebased on their lithological characteristics and some of them are also exported to India.

- The thick clay deposit found between Bhairahawa and Lumbini is widely used for brick manufacture.
- Groundwater (shallow as well as deep) is used for irrigation and drinking purpose.
- Marshy lands especially oxbow lakes are natural habitat for endangered bird species and other aquatic life.
- Lumbini Gram Area is the only place where one can roam with peaceful mind. It is a religious and sacred place for Buddhists. Other than this there is no recreational or public parks except few traffic islands with small garden.
- Lineaments observed on the satellite image could not be identified in the field as tectonic faults but areas closer to these features could be regarded as weak zones.
- Areas with fine – grained sand and silt along with shallow groundwater level are prone to liquefaction.
- Relatively low – lying areas are endangered by flooding and water logging during monsoon season. These areas are located close to Tinau, Siyari, Harewa, Tilar and Dano Rivers and Ghagha Nala.
- Water collected in marshy lands for a longer period of time increases the moisture content of the soil and thereby lowers its bearing capacity. Permanent waterlogged lands create havoc to the nearby urban settlements because of increased pore water pressure in the building foundations.
- Proper drainage system in the area is inadequate. Direct connections of sewage pipe drains into Tinau and Dano Rivers have caused pollution of river water.
- Haphazard development of new settlement areas without proper planning has created many problems like water logging, roadside and riverside human encroachment, haphazard dumping of wastes and so on.
- Proper river gravel mining has positive role to minimize the effect of flood hazard in the vicinity of the Tinau and Dano Rivers. However, haphazard mining close to the bridge site, riverbank and settlement area can damage the structures and collapse of riverbanks.

Recommendation

- Sustainable mining and use of natural resources such as clay and gravel etc. is recommended.
- Proper mining of river gravel (construction materials) from identified sites away from river bridges, other structures, river bank and settlements.
- Barrow pits left behind by Brick Factories after clay mining could be utilized for dumping of municipal wastes. Therefore further study specific to land fill site is recommended.
- Existing dumping site should be relocated away from the settlement areas, forests, river valleys, drinking water sources, roadside etc. preferably in brick clay barrow pits located away from the Airport.
- It is suggested to manage properly the community and other waste e.g. industrial, slaughterhouse, hospital etc. by disposing them in a sanitary landfill site. It is advised to dispose hospital waste in incinerator.
- Drainage system in the area is inadequate and need urgent management. Due attention should be paid to control and manage pollution from brick factories, distilleries, cement factories and paper factories. Squatter's settlements do not exist in the area. Their possible creation and promotion in the future by encroaching the riverbanks and flood plains ande road sides should be discouraged.
- Flood prone areas and other areas prone to natural hazards must be avoided while planning new settlement areas and infrastructure development activities.
- It is advised to take necessary measures to minimize the effects of bank cutting and soil erosion in Tinau, Dano, Siyari, Harewa and Tilar Rivers and Ghagha Nala and other river systems.
- Maintain a buffer zone of 15 – 20 m. on either side of the riverbanks to protect riverbanks, infrastructures and loss of lives and properties.
- Proper drainage system should be arranged to drain out the waterlogged areas.

- Arrange properly to drain out water from the marshy lands by maintaining the ecological balance.
- Do not control natural drains while constructing new structures like road, settlement areas etc.
- The riverbanks in the area need improved and properly designed engineering structures. Implement appropriate preventive measures to reduce soil erosion.
- Future settlement and other development activities should be carefully planned.
- The data provided in the map/report are general but not site specific and therefore should not be generalized for planning and design of large structures in specie site. Details site investigations are required for designing specific large and important structures.

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Landslide Hazard Zonation Mapping around the Dhulikhel area of Kabhrepalanchok District, Central Nepal

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INTRODUCTION

The Himalayan region is generally characterized by steep slopes, high relief, highly weathered and densely jointed rocks with unfavorable hydro-geological conditions with respect to slope stability. The landslide is one of the natural catastrophes and has always caused a major problem in the country and it has become an annual phenomenon especially during the monsoon season. Before planning of any development activities in the region the existing stability conditions of the terrain should be assessed to minimize the risk of hazards and finally suitable preventive measures could be planned beforehand.

This paper describes the result of the field investigation carried out in accordance with the DMG's annual field program of F.Y.2060/61 and comprises inventory and distribution of the landslides and creation of other factor maps required for the preparation of landslide hazard zonation map. The study area is located around the Dhulikhel, a district headquarter of Kabhrepalanchok district and includes Dhulikhel municipality and Rabi-Opi VDC covering 25 sq.km areas of Toposheet No. 72 E/10 at 1: 1mile scale. The field investigation entailed fifteen days (13/2/2061 – 27/2/2061) and the area is bounded by 27° 36' 00"N to 27° 39' 00"N latitudes and 85° 32' 00"E to 85° 35' 00"E longitudes and lies in sheet nos. 2785 07A and 2785 07C topographic map at 1: 25,000 scale prepared by HMG - Department of Survey. As the area was found to be vulnerable for natural hazards, the present investigation was mainly focused on the landslide area of Rabi – Opi VDC especially in Ward No. 7. The landslide is located about 3 km north of Dhulikhel and probably triggered on 28th of Bhadra 2041 BS. The investigation was intended to analyze the landslide hazard of the study area by applying statistical model and their integration in GIS techniques for the final output.

The major landslide locally known as "Opi Ko Pahiro" has affected the residents of Chapletidanda village of Rabi-Opi VDC since two decades. According to the local people, the slide initiated before 20 years and damaged the cultivable land, 3 houses and the main trail connecting to Banepa from Panchkhal via Rabi-Opi VDC. After the landslide event, some affected people shifted their houses to relatively safer areas of the same VDC. However, the affect of the slope movement was continuously felt as it repeatedly damaged the newly constructed road to Banepa. In addition, landslides and soil erosion processes are common around ward No. 1 of Rabi – Opi VDC and also affected the cultivated land and parts of forest area. Local authorities lack information regarding the extent of geological hazards and their possible preventive measures.

OBJECTIVES

The present investigation aimed to achieve the following objectives:

- To prepare a landslide distributions map and provide geo-scientific information of the area on natural hazards.
- To register the landslides of the study area in 'Preliminary Landslide Inventory form'.
- To integrate landslide distribution with geological information with various slope morphology and existing landuse for the preparation of landslide hazard zonation map in 1:25,000 scale by optimum utilization of Remote Sensing and GIS techniques.
- To identify the major causes and recommend the possible preventive measures.

METHODOLOGY

- Aerial photographs of 1992 at a scale of 1:50,000 were examined to identify the lithological units, tectonic structures, landslides, erosional feature etc.

- LANDSAT-TM Scene of December 1992 was studied for lineament mapping.
- The topographic maps of 1:25,000 scale from Survey Department were studied and used as a base map.
- The Land capability, Land utilization and Land system maps published by the LRMP, 1994 were studied.
- Existing literature and geological maps of the study area were reviewed.

Fieldwork was carried out using aerial photographs in conjunction with 1:25,000 scale topographic base maps and verification of previously interpreted information was reviewed. Emphasis was given in checking the landslides and other areas prone to further soil erosion by closure observation. Landslide and soil erosion are often observed throughout the study area mostly caused by natural as well as human intervention like deforestation, improper hill slope cultivation, cultivation on colluviums of old landslides, riverbank encroachment, and haphazard stone quarrying activities. Lithological setups, unfavorable structural discontinuities, increases in pore-water pressure, high intensity rainfall, high degree of weathering, and high gradients with excessive mass of bed loads in the lateral rivers are some of the natural causes of landslides and soil erosion observed in the study area. The optimum data required for the present investigation were acquired from various sources of information together with field investigation. All the coverage is stored in the Modified UTM projection and the computation was carried out according to the Flow Chart (Fig.1) using ILWIS 3.0.

GEOLOGY/STRUCTURE

Geologically, the study area is represented by meta-sediments of Tistung Formation (Stocklin and Bhattarai, 1977) and comprises mainly of meta-sandstones and phyllites along with thick residual soil, as well as colluvial, alluvial and recent flood plain deposits. Lineaments along NW-SE, NE-SW and E-W directions are observed from the aerial photograph and passes around the vicinity of the observed slides. A local synclinal axis was noticed along the NW-SE direction close to the south of Dhulikhel within the study area.

Bedrock consists mainly of fine-grained grayish micaceous metasandstone and grayish phyllites. Numerous quartz veins and lenses were observed along the strike with tiny lenses of intrusive granite around Khawa village. In general, rocks are dipping towards N to NE and S to SW with dip amounts varying from 30-60°. Dip slopes around the northern side of the Dhulikhel Khola with intensely fractured and highly jointed rocks are found to be vulnerable and unfavorable for the slope stability condition. In many locations, the bedrock is covered under the colluvium of moderate slopes whereas the steep slopes are formed on the upper part of the hills and the bedrock is well exposed.

INVESTIGATION RESULTS

The landslides are simply the movement of rock mass, debris or earth down the slope and it includes a wide range of ground movements such as rock fall, dip slope failure, shallow debris flows etc. Normally, the movement occurs when the shear stress exceeds the shear strength of the materials. The

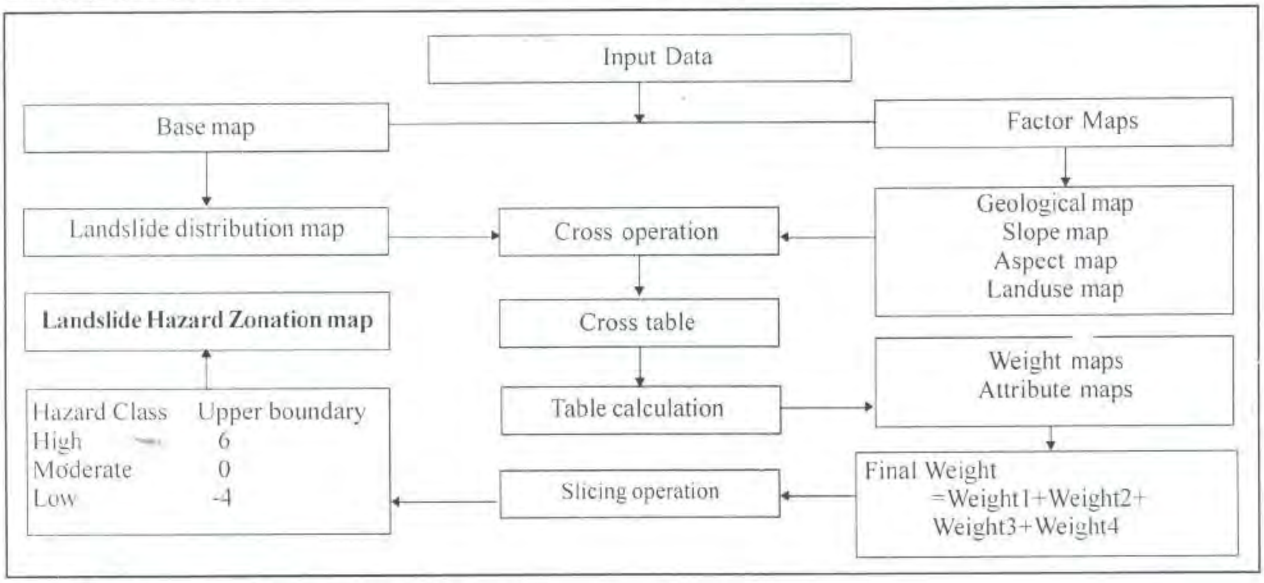

Fig. 1: Flow Chart showing the computation process.

landslide hazard is generally referred to as the probability of occurrence of a potentially damaging landslide within a period of time and area. Landslides and related mass movements, their frequency and severity could be minimized by understanding and evaluating the various causative factors responsible for slope failure. The instability of a slope is mainly governed by terrain parameters such as lithology and structural condition of the rocks, properties of overlying soil, slope gradient, vegetation, landuse and human activities acting on the slope conditions. However, the specific impacts of these causative factors can sometime be mixed among themselves making it very complex and difficult to differentiate. Therefore, the overall hazard potential of any given area is a combination of subjective rating of the area against each of the above factors.

PREPARATION OF FACTOR MAPS

The factor maps of various parameters (landslide distribution, geology, slope, aspect, and landuse) relevant for producing a landslide hazard zonation map was prepared from field mapping, visual interpretation of aerial photographs,

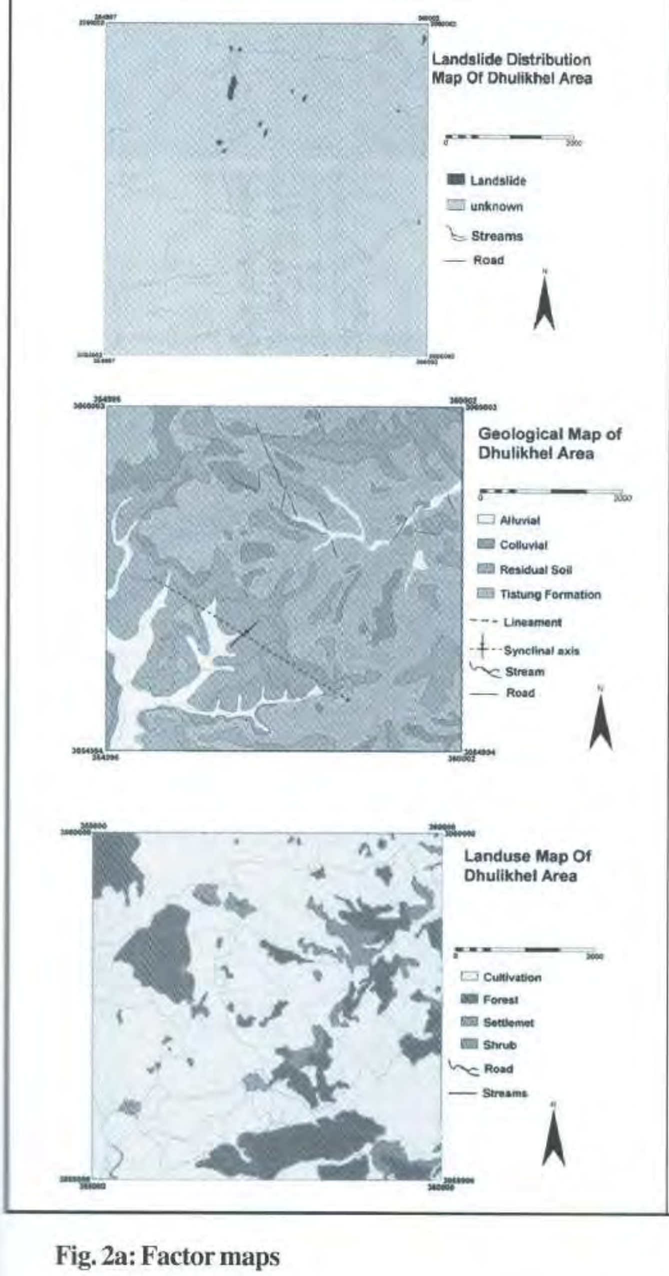

Fig. 2a: Factor maps

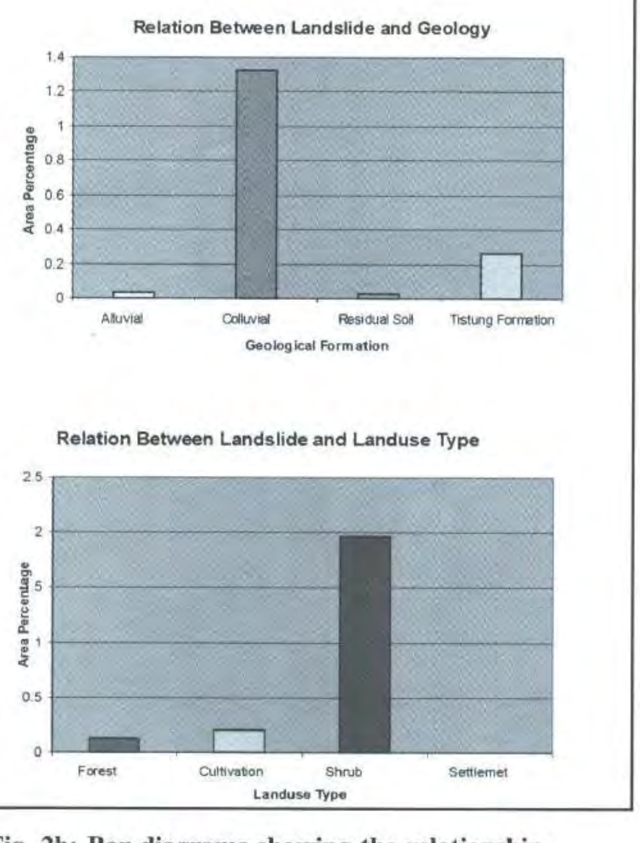

Fig. 2b: Bar diagrams showing the relationship between landslide distributions and the factor maps

digital elevation model, land capability map, land systems map, land Utilization map etc. and finally processed by GIS (Fig 2a and 2b). The relation of landslide distribution (%) to various factors was presented after statistical analysis (Fig 2b).

Application of Remote Sensing and GIS

The remote sensing techniques plays a significant role in landslide study, both in the evaluation of landslide susceptibility and the analysis of specific landslide event at

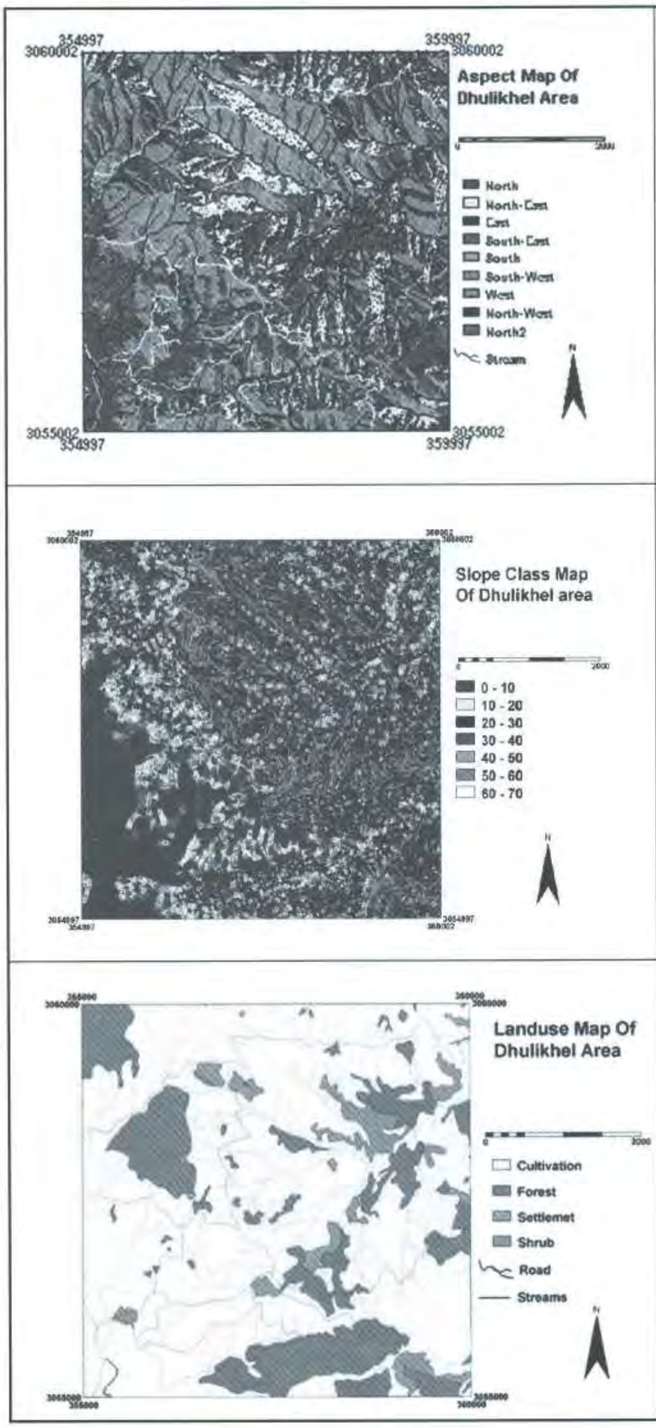

Fig. 2a: (contd.)

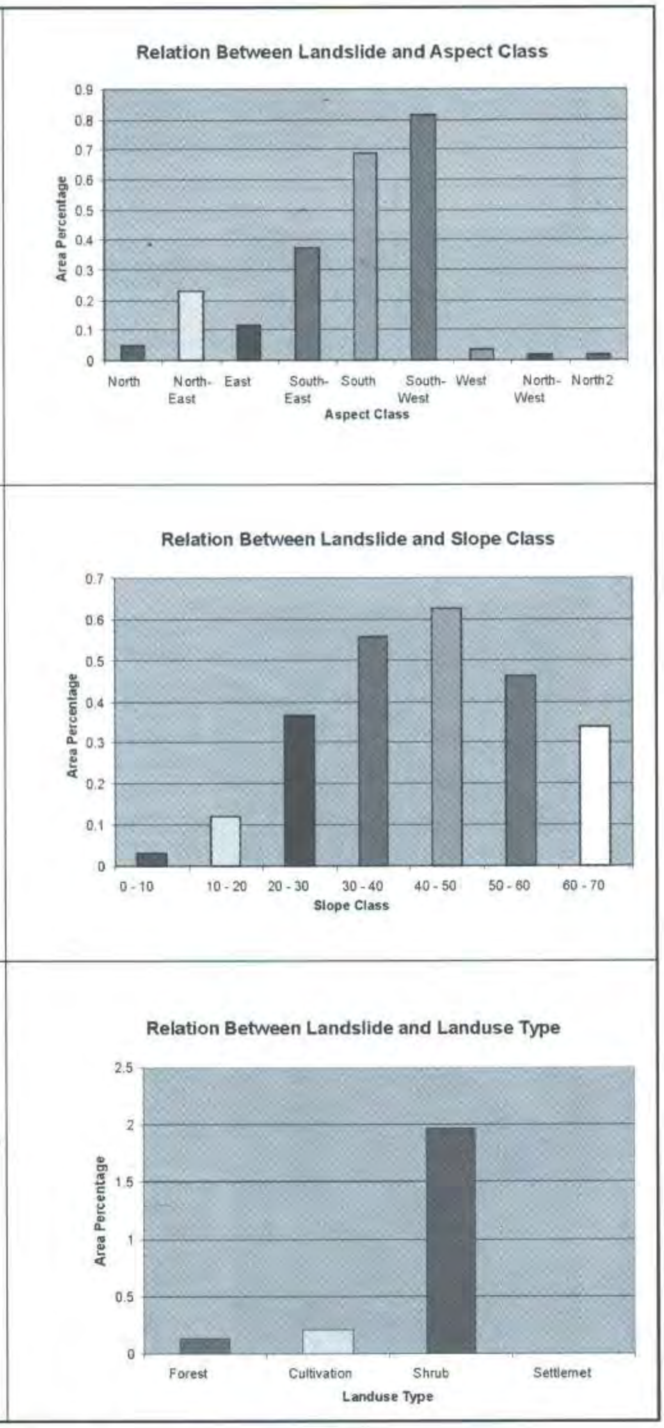

Fig. 2b: (contd.)

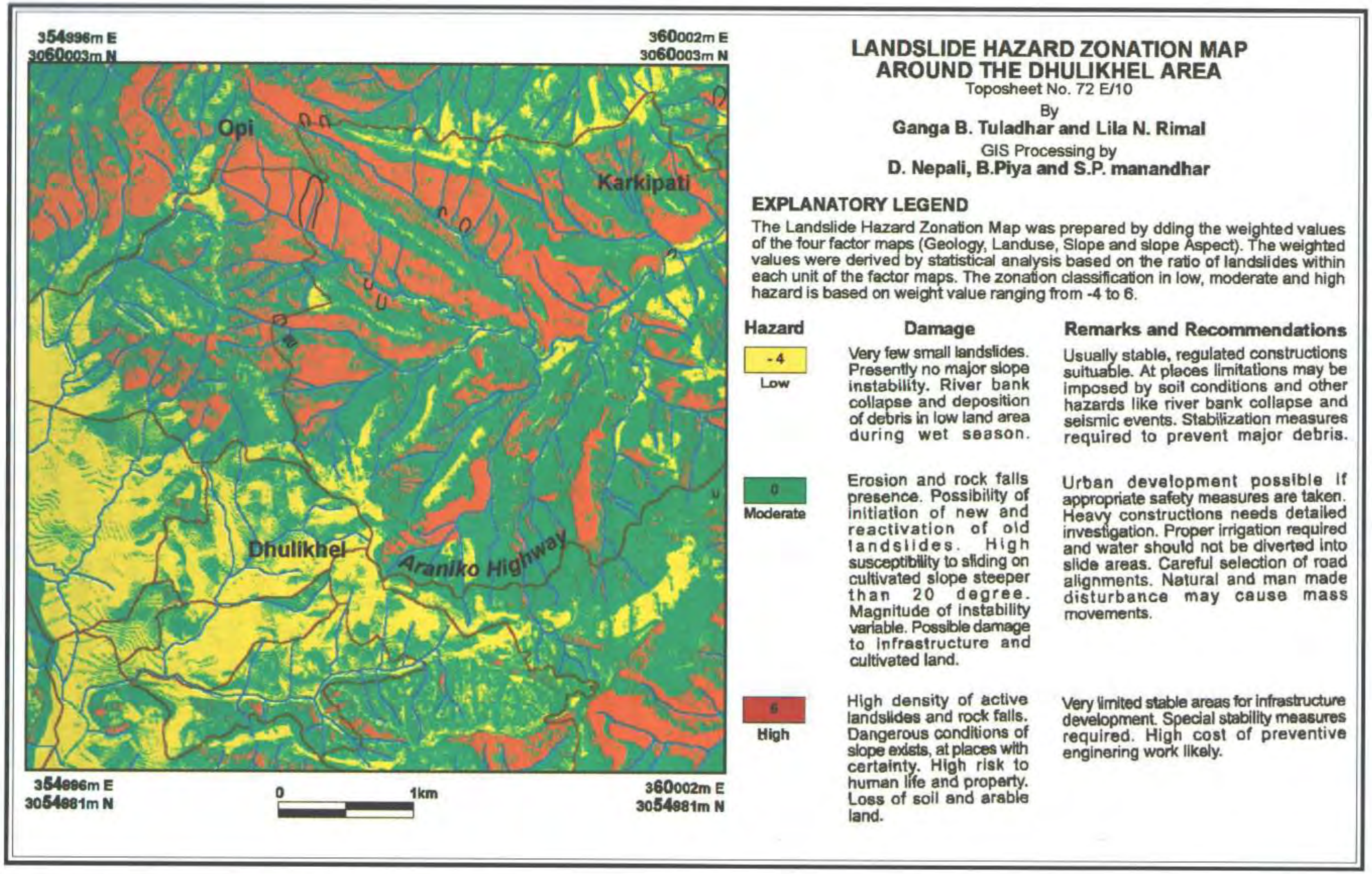

Fig. 3: Landslide Hazard Zonation Map around Dhulikhel area

$$W_i = \frac{Densclass}{Densmap} = \ln \frac{\dfrac{\text{Area of landslide in a certain parameter class}}{\text{Area of certain parameter class}}}{\dfrac{\text{Area of landslide in the entire map}}{\text{Area of entire map}}}$$

Where,

W_i = Weight given to a certain parameter class

Densclass = Landslide density within the parameter class

Densmap = Landslide density within the entire map.

Source: Van Westen (1993)

a particular place. The satellite data has been found to be the most advantageous factor in identification of changes brought out in landscape and surroundings in recent past due to landsliding phenomena. Apart from the remote sensing technique, GIS has tremendous application potential in landslide related studies and provide the users with a tool for effective and efficient storage and manipulation of remotely sensed data and other spatial as well as non-spatial data type for scientific, managerial, and policy oriented information. Hence, the remote sensing and GIS are becoming more popular in landslide hazard zonation studies due to the availability of appropriate data sets and powerful computer processing. Though the several agencies are using different statistical approaches for landslide hazard analysis, the present analysis was carried out by Bivariate-Statistical Model (Westen, 1993). For the calculation of its statistical model, GIS technique was extensively used for integrating the data in a model and preparation of hazard map. Bivariate statistical analysis deals with one of the dependent variable like landslide distribution and other independent variables such as factor maps of various parameters. Since, the statistical methods are considered as one of the most appropriate approach for landslide hazard zonation, the following formula was used for the present study.

Creation of Landslide Hazard Zonation Map

The term landslide hazard zonation is the division of land into homogeneous areas or domains, and their ranking according to degree of actual/potential hazard caused by mass movement' (Varnes, 1984). Similarly, the landslide hazard zonation map (Fig. 3) of the study area was also prepared by dividing the entire area into three categories based on the degree of a potential hazard from landslide. Since each class of the factor map has different weight value, the addition of all the weight value for a certain region was carried out during the hazard calculation. After the calculation of total weight for hazard coverage, the hazard map (Fig. 3) was classified in three different zones as low, moderate and high hazard zones. The weight value of the hazard classification reveals from 4 to 6 as a lower most upper boundary to upper most upper boundary. The larger value 6 represents combination defining upper limit of high hazard while smallest value-4 represents combination defining upper limit of low hazard.

Result of the Statistical Analysis

The landslide distribution map was overlaid with the final hazard map and landslide densities for three zones were calculated in order to check how much of the landslide area falls within the high hazard zone. If the percentage of landslide density appears too low, either the adopted statistical model has to be rejected or additional factors must be included or the class boundaries have to be changed accordingly. In this case, 83% of the landslides were found to be located within the high hazard zone, about 16% in medium hazard zone and the rest in low hazard zone. This indicates satisfactory precision of the presently adopted statistical model for landslide hazard analysis. The final landslide hazard zonation map shows 5.43 sq.km area cover by high hazard zone forming 21.74 % of the total study area whereas about 53.08 % area are on moderate hazard zone and rest on low hazard zone. Similarly, the relationship between the area percentage of various landslide hazard zones and other causative factors such as landuse, geology, slope, and aspect were evaluated to identify the behavior of each factors (Fig.4).

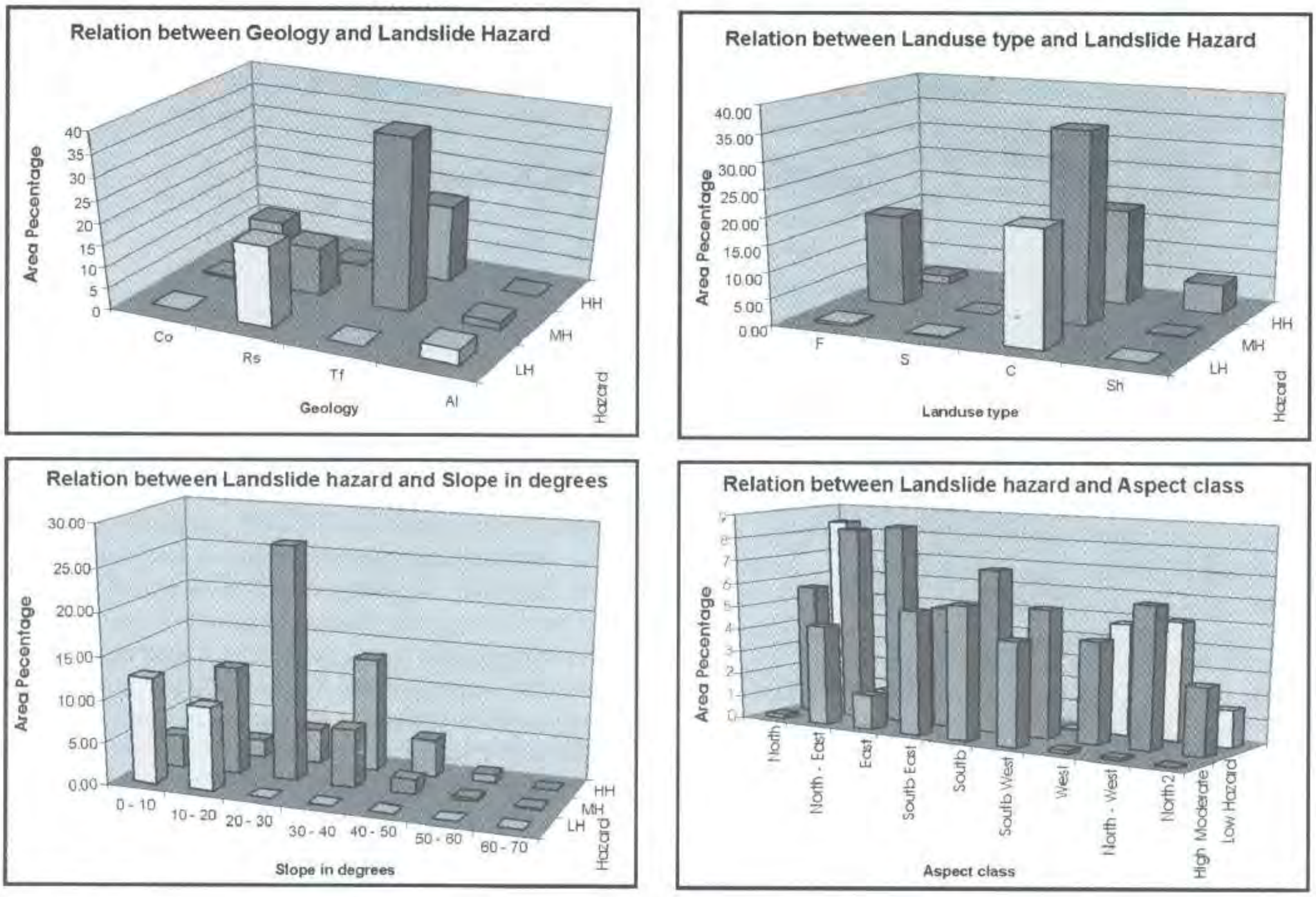

Fig. 4: Bar diagrams showing relationship between Landslide Hazard category and different factor maps

CONCLUSION AND RECOMMENDATION

- The major landslide of Opi Ko Pahiro at Rabi-Bhanjyang area consists of thick colluvial deposit and virtually a part of reactivated old landslide. At present, thereis no proper drainage system to divert the infiltrating water into the slide zone. In general, the hill slopes on the southern side of the Dhulikhel Khola are found to be more stable compared to the northern slopes.

- The final landslide hazard zonation map shows 5.43 sq.km area covered by high hazard zone forming 21.74 % of total study area whereas about 53.08 % area are on moderate hazard zone and rest on low hazard zone.

- The map provides a good basis for the planners, Engineers policy makers and land developers in minimizing the risk of hazards and protecting the environment but cannot be a full replacement for detail site investigation.

- Effect of 'Opi Ko Pahiro' can be minimized by constructing check dams from eroding action of the stream as well as to prevent from toe scouring. It is expected that by preventing toe scouring the moving mass could be slowly stabilized. Scouring of the toe part can be further reduced by constructing support wall as well as by prohibiting collection of boulders from its vicinity.

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Study of the Chandisthan Landslide in Lamjung District, Western Nepal

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INTRODUCTION

The present study area (Chandisthan) is located 4km to the north of Besisahar (district headquarter) in Lamjung district (Fig. 1). The Marshyangdi River, one of the main rivers of Nepal flows almost north south along the eastern border of the study area. The study was conducted for a week from 15th of Mangsir 2060 (1st of December 2003). The field survey was carried out using 1:25,000 scales Topomap enlarged from 1: 1 mile scale. Aerial photographs of 1:50,000 scales taken in 1979 (Nos. 28-30) were also utilized for mapping purpose. Tamrakar (1980) prepared the geological map of the area and the map was also used during this investigation.

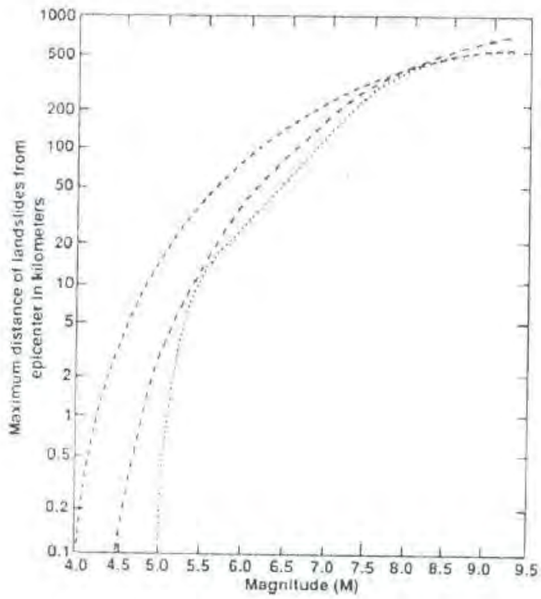
Study was mainly focused around the landslide area of Chandisthan Village Development Committee (VDC) especially in Ward Nos. 2, 4, 5, 8 and Ward No. 3 of Baglungpani. The landslide has threatened the people living in the area and also adversely affected the connecting road (Bhanubhakta Acharya Marg) to Chame (Manang district) from Besisahar. The road was under construction at the time of this study.

The landslide has affected the residents of Chandisthan VDC since long time. Local people said that the slide probably initiated 70 years ago and damaged the cultivated land, houses and the main trail connecting to district headquarters. Some people migrated to other parts of the country, while some people shifted their houses to relatively safer areas of the same VDC due to possible landslide hazard.

On the 9th of Shrawan 2060 B.S. (25th July 2003) at 10 o'clock at night, the slide triggered after 3 days of continuous rainfall. An earthquake of 5.9 magnitudes was recorded by the National Seismological Center of the Department of Mines and Geology (DMG) in 2058 BS in Gorkha Area, which show that the slide was not caused by that earthquake. According to Keefer (1989) the maximum distance from epicenter to landslides as a function of magnitude for three general landslide types is shown in Figure 2. Landslides involving loose, saturated, cohesionless soils on low to moderate slopes commonly occur as a result of earthquake-induced liquefaction. In the present case, the distance from earthquake epicenter (triggered in 2058 B.S) to this landslide seems to be longer than the Keefer's relation of magnitude verses maximum distance to trigger the landslide. Therefore it is not possible to relate here that, this magnitude of the earthquake could have caused this type of landslide.

Belautibisauna, a small village located at the banks of Belautibisauna Khola (a tributary of the Marshyangdi River) was affected by the debris (Fig. 3a) generated by the landslide. Two houses were buried, 4 houses were half damaged and three houses were partially damaged. The road to Chame was blocked and houses situated at the upper slopes at Saring village were also affected. Poles of the power supply and drinking water pipe lines were severely affected. People had to evacuate in safe places.

Fig. 1: Location map of study area



Maximum distance to landslides from epicenter for earthquakes of different magnitudes. - - - -, disrupted falls and slides; — — —, bound for coherent slides, ... , bound for spreads and flows (Keefer 1984).

Fig. 2: Keefer's relation of magnitude of the earthquake versus maximum distance to landslides

OBJECTIVES

The main objectives of the study were:

- To study the landslide and to find out its causes;
- To recommend the possible mitigation measures.

GEOLOGY

The study area is represented by phyllite, quartzite and schists (with garnets) of Kuncha Formation. There are thick colluvial deposits, old river terraces, recent alluvium deposits and recent flood plain deposits. Lineaments of NW-SE, NE-NW and E-W are observed on the aerial photos that pass in the vicinity of the landslides.

The main rock units are green phyllites, white quartzites and schists with garnets. Numerous quartz veins are seen aligned parallel to the schistosity planes of the bedrocks. Sericite and chlorite partings are common in the schists. The Old river terrace deposits along the road section except at few locations cover bedrocks. Rocks are dipping towards northwest against the natural slope of the hill with dip amounts ranging from 10°-50° which is a favorable geological condition for the stability of the slope. However, the rocks are intensely fractured and highly jointed resulting into unfavorable geo-structural condition for the stability of the slope. Bedrocks are also covered under the colluviums on gentle slopes.

Colluvial deposits are distributed on gentle slopes that range from 10°–25° inclination. Thick colluvial deposits are observed around Saring village. It consists of angular fragments of rocks with little amount of silt. The sizes of some boulders are extra large with diameter up to 10m. They are derived from the nearby rocks (Fig. 3a). Colluvial deposits are up to 6m. thick and they are involved in the slope movement processes. The deposits are relatively porous. The area is a wet cultivated land (paddy fields), which allows water for percolation. This process helps to increase the water pressure creating unfavorable situation for the stability of the slope. Most of the landslides are triggered within the colluvial deposits.

LANDSLIDES AND SOIL EROSION

The hill slopes in the area ranges from 14° to 80°. Recent landslides have triggered within an old landslide area (Fig. 3b). There are a number of recent landslide scars. At least 7 major scars are observed within the Chandisthan area (Fig. 4). Among 7 scars, a major scar of the most active slide is located below Saring village and it is named as **Saring Soil Creep** (Fig. 4). The slope angle at the head scar is about 35° and increases at the toe part reaching up to 80 degrees. A second large scar is formed at the upper slopes west of Belautibisauna village, which is called as the **Belautibisauna Landslide** (Fig. 3a and 4). The landslide at Saring village is active and slowly moving down slope forming large-scale soil creep (Fig. 5) which is evidenced by the tilted electric pole and bent trees located within the moving mass. There are large tension cracks measuring 5-15cm wide, 10-20cm deep and 1-8m long. A sag pond is observed on the upper slope area of the Saring village, which is continuously recharging the slope.

FINDINGS

Landslides located between Saring Soil Creep and Belautibisauna are found vulnerable to further sliding and would block the road at places in future (Fig. 3b). Talus deposited on the road has been recently cleared. Large hanging rock boulders situated on the upper slopes of the road are highly vulnerable to slide during moderate to large earthquake which can cause serious accidents and block the road. The Belautibisauna Landslide is prone to further

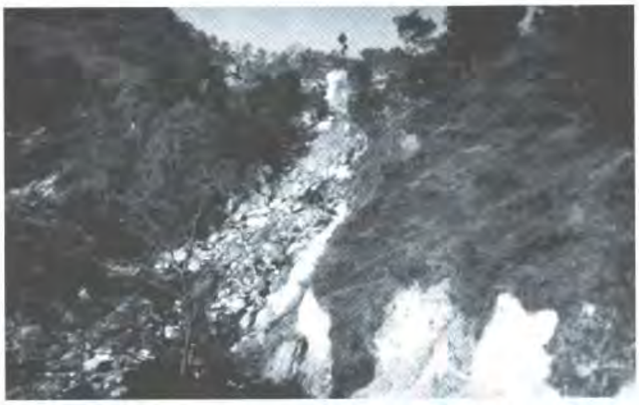


Fig. 3a: Belautibisauna landslide with large boulders in colluvial materials.

Soil Creep (Fig. 3b). Formations of active gullies are indications of soil erosion. Springs and seepages are common in and around landslide areas. There is no vegetation within the slide zone but forest is being preserved in the lower part of the slide area.

CONCLUSION AND RECOMMENDATION

- A sketch map has been prepared which shows landslide distribution within the slide zone. The landslide area of Chandisthan VDC consists of thick colluvial deposit. The recent slide area is part of reactivated old landslide. The Saring Soil Creep and Belautibisauna Landslide are two most active slides in the area. Slopes ranging from 14-80 degrees represent the slide area. The toe part of the Saring Soil creep is almost 80 degrees. Most of the landslide area is wet cultivated. There is no proper drainage system. According to Keefer's relation of Magnitude versus Distance of landslides from the epicenter, the area can be considered as susceptible to landslides in case of larger magnitude earthquakes occurring within the reasonable distance.

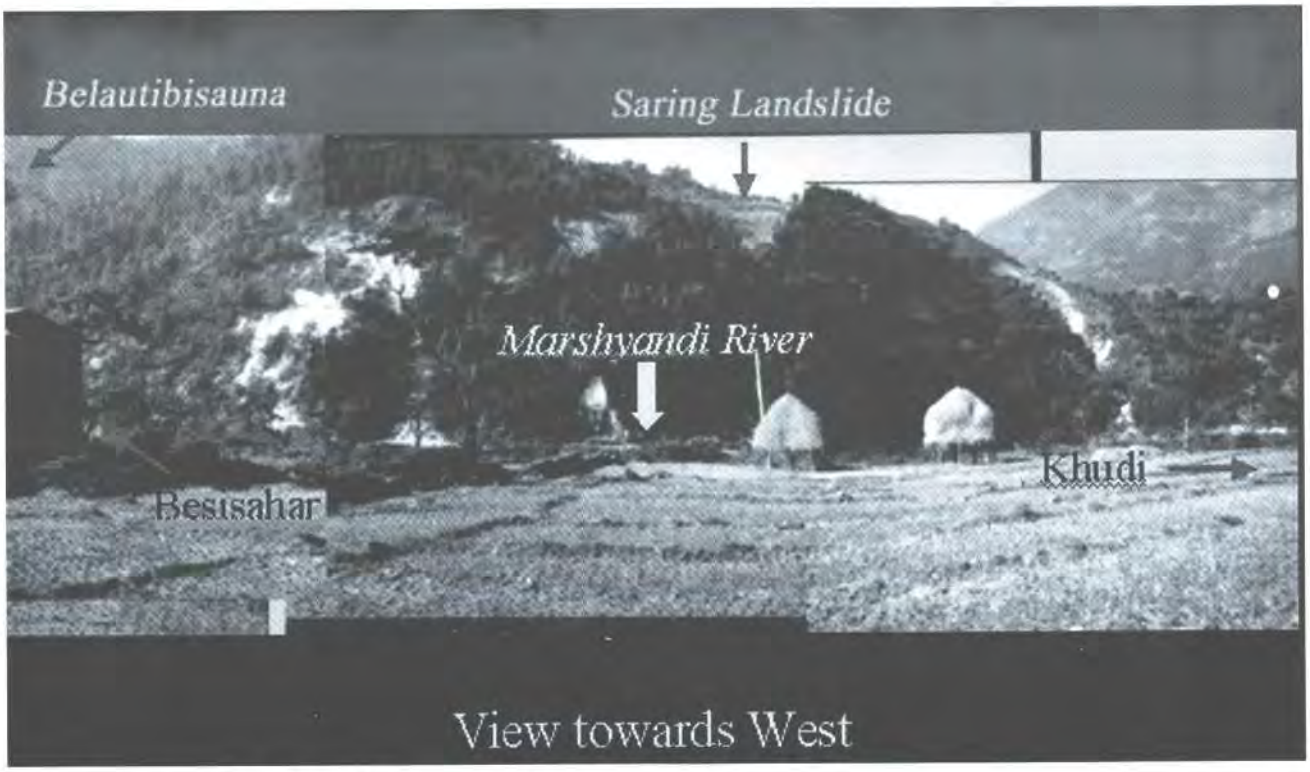


Fig. 3b: Panoramic view of Chandisthan landslide

sliding. There are large wide-open tension cracks and fresh minor scars within the slide area at the upper part. Large loose boulders are present within the detached mass (Fig. 3a). It is expected that huge amount of debris will be generated in the next event, which would further damage property and life in Belautibisauna village. Active gullies are being developed at the upper reaches of the Belautibisauna Khola and in the northeast side of the Saring

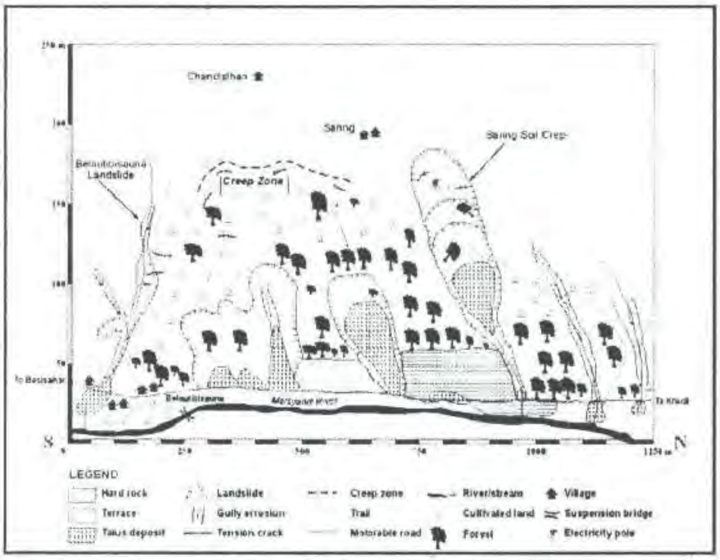


Fig. 4: Sketch map of Chandisthan landslide area

- As road blockage is expected to occur during rainy season particularly between Saring and Belautibisauna due to slides, authorities need to be prepared to repair the road during and after the rainy season. Slope protection works with proper walls should be constructeo at places in the area. If possible the road should be shifted to the east bank of the Marshyangdi River where the ground is stable so that every years expenses in maintenance could be saved.

- New houses should not be constructed at the Saring village. Residents should slowly shift to the stable areas for example: in the vicinity of the present high school area.

- Effect of Belautibisauna landslide can be minimized by constructing check dams across the Belautibisauna Khola just below the first junction of the two tributaries about 200m upstream from the village. Such check dams would decrease the velocity of the debris flood during future landslide events and large boulders of the debris would be deposited upstream of the dams.

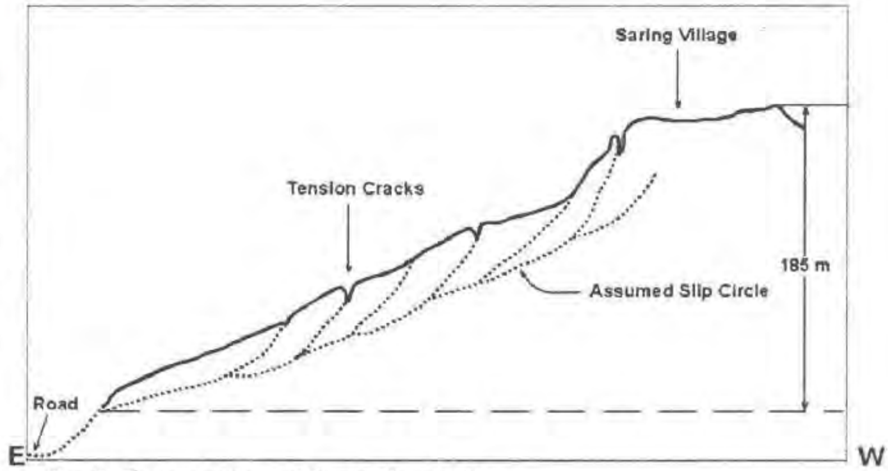


Fig. 5: Cross section of Saring landslide

- Probable effect of flooding in the vicinity of Belautibisauna village can be minimized by constructing sidewalls along the banks of the stream leaving sufficient space between the walls for the stream.

- Proper drainage system should be arranged to drain out the water from the landslide areas including the sag pond.

- Tension cracks should be sealed to prevent the problem of water percolation in the landslide area.

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Inspection and Monitoring of Different Operating Mines at Dhading, Chitawan, Makawanpur, Sindhuli, Udayapur, Jhapa, Tanahu, Kaski, Palpa, Dang, Salyan, Dolakha, Kavrepalanchowk and Sindhupalchowk Districts, Nepal

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INTRODUCTION

Department of Mines and Geology (DMG) is the sole governmental organization to issue both prospecting and mining licenses to exploit mineral resources in the country. It has the obligation and authority to regulate, monitor and inspect all those mines operated by various individual owners or other mineral based industries in the country. Mine Regulation and Administration Sub-Division of the department is responsible for inspection and monitoring of all the prospecting as well as operating mines as per the departmental annual programme.

OBJECTIVES

The main objectives of the inspection and environmental monitoring of mines are:

- to inspect and evaluate the mining activities carried out by the lease holder
- to give necessary suggestions and directions to exploit the deposit by applying proper mining methods in an environment friendly manner in compliance with the existing mineral laws and regulations of His Majesty's Government of Nepal
- to check whether the mining work is satisfactory as per the accepted mine plan or not
- to check whether the directions given during the past inspection visits were followed or not
- to check whether the royalty is paid as per the production and also to collect production statistics

To meet the above objectives, inspection of the operating mines located at various districts and quarries for construction minerals were carried out by three different teams formed as per department's annual program of FY 2060/61 for the total period of 55 days. All together, 33 operating mines were inspected by those teams for one to three times as per the DMG's schedule.

Three different teams include:

Team 1 – Jay Raj Ghimire and Ram Prasad Chaudhary (B.S. 2060/06/29 to 07/06)

Team 2 – Rupak K. Khandka and Nati Babu Khatri (B.S. 2061/02/11 to 26)

Team 3 – Som Prasad Sharma, Prakash Dhakal, Abadheshwor Sharma and Rama Nanda Prasad Chaudhary (B.S. 2061/03/04-10, B.S. 2060/11/12-30, B.S. 2060/07/03-07)

METHODOLOGY

To judge the overall mining operation, all the three teams adopted the inspection methodology taking into consideration the technical (mine plan, mining method, mining parameters, drilling, blasting etc.), environmental (land, water, air, noise, safety aspects etc.) and legal (Mines Rules and Regulations) factors.

STATUS OF INSPECTED MINES AND DIRECTIVES

The regular field inspection reports for all mines/quarries submitted by the teams are hereby listed below and categorized in three different groups based on the types of minerals:

ORDINARY CONSTRUCTION MINERALS

Most of the quarries for ordinary construction minerals were not in operation due to rainy season at the time of inspection. However, some quarries were doing only mine development activity. The stone quarry owned by Indra Prasad Pandey located at Sikre khola, Dhading was stopped as per DMG's directive. The sand quarry owned by Tanka Bhandari located at Baireni, Dhadhing was running under unsafe condition with bench height of about 25 m. There were some administrative problems with local VDC and the community regarding this sand quarry.

Therefore, the licensee was directed to work under proper guidance and supervision of a mining engineer. The licensee was advised to work by making small benches from top to bottom. He was also suggested to work in proper coordination with local people. In addition, he was advised to follow safety measures and provide safety boots and helmets to the workers as prime care and mine out the raw material in environment friendly manner. DMG also directed him to submit the environment audit report in every six month and strictly follow the directions given from time to time.

The only boulder quarry in the eastern region of Nepal, owned by Deurali International Mines (P.) Ltd. is located at Bahundangi VDC, Jhapa. There was no production made from the quarry till Baishakh, 2061. So, the licensee was directed to start quarrying as soon as possible as per the schedule and follow the terms and conditions mentioned while issuing a mining license.

NON-METALLIC MINERALS

Limestone

Out of eight limestone quarries inspected by the team, only four of them were producing limestone. However, two were closed due to rainy season and one owned by Raj Kumar Golcha at Galtar village development committee in Udaypur district had not started production till the month of Baishakh 2061 as it was still under feasibility study phase. The quarry owned by Annapurna Quarries (P.) Ltd. at Jawang khola in Dhading district had undergone for maintenance of road, cleaning of quarry and maintenance of machineries at the time of inspection. All the three inspected quarries had poor waste management system and the mining was carried out without any technical know-how. Tension cracks were developed in that area and there was possibility of debris flow. Safety of workers was not properly cared. Access road to quarry site was not properly maintained. Benches were not developed in proper manner and there was risk of safety in the working area for the labour due to high slopes. Inside the quarry area owned by Annapurna Quarries (P.) Ltd., Jawang khola is flowing nearby which was not properly canalized. Therefore, loose debris and soils were deposited haphazardly along the slope of mine. However, there was not much problem of waste management and negative effects on water and air quality.

Safety of workers was not properly adopted inside the quarry at Okhare of Hetauda Cement Industry Limited, Makwanpur district. Opencast mining method with drilling and blasting in benches or mechanical breaking was the adopted practice for quarrying in that mine. The excavated materials were carried out by dumper to primary crusher, screen and up to cement plant at Lamsure. In Okahre, about one km road was still to be constructed to reach the limestone deposit. However, extraction of limestone from small bed exposed during road construction was undergoing at the time of inspection. Road construction had created erosion and slide problems in this quarry area. Inside the quarry at Bhainse, Makawanpur district owned by Hetauda Cement Industry Limited, the production and development of benches were continued from the western quarry site with the help of heavy equipments. Due to quarrying, there were some effects on land pattern and localized noise pollution due to heavy machineries. However, there was little effect on water and air quality. But the waste disposal site was improperly maintained around the quarry hill slope. Concern of safety of workers was found to be least. Open-Cast mining method including drilling and blasting in benches with 6 m bench height, hole diameter of 100 mm, spacing 2.5 m, burden 2.5 m, loading, transportation to primary crusher was adopted with the help of ropeway to Lamsure cement plant. Mine development and operation was found satisfactory. Proper bench development is still required. There was some problem in regular blasting. Waste disposal along tributary had caused soil erosion problem with other insignificant environmental impacts. In case of the quarry owned by Ajay Raj Sumargi, there was no regular mining but excavation of calcite was done from its vein and collection of limestone boulders from Pandrang Khola. Mine was accessible by seasonal road. No significant impacts were observed due to mining. Open-cast mining method including drilling and blasting in benches with bench height 6 m, hole-diameter 65 mm, sacing 2.5 m, loading was adopted in Jalpa Chilaune limestone quarry owned by Udaypur Cement Factory Ltd. Transportation of limestone to primary crusher was being carried out by ropeway, transportation up to Jaljale cement plant. Mine development and operation was satisfactory. But there was some problem in regular blasting. Environmental degradation due to mining was not significant. Mining of limestone deposit at Kakurthakur village development committee owned by Maruti Cement Ltd. had not started at the time of inspection. However, collection of limestone boulder from Kakurthakur Khola was continued by then. The quarry access road was constructed. But, mine development work was still to be done. There were few natural landslides at two or three places within the lease area. The Production figures for raw limestone from different quarries during different periods in F.Y. 2060/061 is given in Table-1.

that it may not choke the drainage and create landslides in and around the quarry area. In Okhare quarry area owned by Hetauda Cement Industry Limited, DMG directed to stabilize the slopes of working area for limestone extraction mainly along the left and right sides of the quarry road. Also, it was suggested not to dispose the waste or top soils extracted during road development work on nearby kholsis and use of siren during the dumping of limestone through open chute. It was also advised to prepare the work plan for

Table-1: The production figures for raw limestone from different quarries in FY 2060/61.

S. N.	Name of Company	Quarry Site	Production of limestone (in MT)	Remarks
1	Agriculture Lime Industry	Jogimara, Dhading	6,070	up to the month of Asadh 2061
2	Annapurna Quarries (P.) Ltd.	Jawang Khola, Dhading	1,370 10 220 18,650	Shrawan, 2060 Bhadra, 2060 Ashoj, 2060 Total production up to the month of Asadh 2061
3	Hetauda Cement Industry Limited	Okhare, Makawanpur	x x 1,170 1,69,528	Shrawan, 2060 Bhadra, 2060 Ashoj, 2060 Total production up to the month of Baisakh 2061
4	Ajay Raj Sumargi	Bhainse, Makawanpur	1,435 1,261 918 28,299	Shrawan, 2060 Bhadra, 2060 Ashoj, 2060 Total production up to the month of Baisakh 2061
5	Udaypur Cement Udhyog Limited	Nibuwatar, Makawanpur	240.50	Total production up to the month of Baisakh 2061
		Jalpa, Udaypur	1,16,240	Total production up to the month of Baisakh 2061
6	Maruti Cement Ltd.	Kakurthakur, Sindhuli	3,902	Total production up to the month of Baisakh 2061

During mine inspection and environment monitoring from DMG the mining engineers advised all those quarry owners to follow the instructions strictly. They were also advised to take proper measures to manage the mine wastes and not to throw them directly in nearby rivers. The licensees were advised to mine the limestone by making benches from top to bottom under proper guidance and supervision of a mining engineer. In addition, they were directed to take safety measures for workers as well as machinery. They were suggested to take proper management of loose debris so

area undergoing excavation and bench sections at the scale of 1:500 and submit annually to the concerned authorities. Also, it was instructed to submit the explosive consumption data and progress report along with monthly production and royalty. It was suggested not to dispose the overburden material haphazardly and submit the royalties before the seventh day of each month. It was also suggested to start for promotion of production work in full capacity. Ajay Raj Sumargi who is running a limestone quarry at Nibuwatar, Makwanpur was instructed to keep the proper record of limestone production, sales, and stock and submit these records monthly to the concerned authorities. Also, he was advised to inform to DMG about the start and closure of mine operation in time. He was suggested to obtain the information from District Development Committee, Makawanpur about the royalty it has paid for the boulders mining and also submit the environment audit report in every six month to DMG. He was directed to start the mine development work such as construction of quarry road, removal of overburden, formation of bench levels in working zone and then exploit the limestone. In addition to that he was instructed to pay the royalties and other dues or fines to the government along with monthly production report. At the same time he was also directed to produce the proofs of no mining activities of limestone production during FY 2060/61. Udaypur Cement Industry Limited was instructed to pay the royalties to the government by the end of seventh day or earlier of each month and produce the evidence to DMG. It was found that the quarry can be run under regular inspection and supervision by DMG. Raj Kumar Golcha was notified regarding the process of nullifying the mining license if the quarrying work did not start according to approved mining scheme/working proposal. The lessee was instructed to start the necessary infrastructure development work inside the quarry and start mine development work for exploitation of limestone at the earliest in case of quarry owned by Maruti Cement Limited at Kakurthakur Village Development Committee in Udaypur.

Talc

Few talc quarries were running at very low production rates at the time of inspection. Different production figures of talc for FY 2060/61 from the quarries owned by Dust Nepal (P.) Ltd.,Nepal Orind Magnesite (P.) Ltd.,Digvijay Products (P.) Ltd. were 241, 720.44 and 200 tones respectively. The quarry owned by Singh Khanij Udhyog (P.) Ltd. at Pumdi Vumdi Village Development Committee in Kaski district had no production at all due to uncomfortable security situation in the country. The quarry owned by Sharmananda Kandel at Chandibhanjyang, Chitwan was closed because the license was cancelled since he did not follow the directions given by DMG.

Some quarries were doing bench development activities; others had already developed benches in the mine. But waste management system was not effective in all those mines. Therefore, the licensees were instructed to manage the waste disposal effectively to minimize the erosion and siltation problems inside the quarry areas. They were also directed to construct the gabion walls all along the bank of nearby river tributaries and kholsis. They were advised to run the mine in full capacity and pay the royalty in time.

Marble

Out of the two marble quarries one owned by Everest Marble and Allied Industry (P.) Ltd. at Jaisithok Village Development Committee in Kavre district was closed at the time of inspection. Laxmi Lime Products had established a marble block cutting machine inside its factory premises located at Hetauda Industrial Estate, Hetauda. It was producing the marble slabs based on the stone blocks collected from the rivers. But, the licensee was suggested not to start the commercial production of marble slabs until it obtains the mining license from DMG.

Red Clay

Both quarries of red clay owned by Udaypur Cement Factory were running at the time of inspection. Stripping was carried out by loaders from benches of different heights varying from 3m to 6m and the raw material was loaded directly to the dumper. Total production of red clay from quarry at Aapsota Village Development Committee up to Baishakh, 2061 was 16,919 tonnes. However, the red clay quarry owned by the Himal Cement Factory was closed at the time of inspection and there was no environment problem in the working area.

Since both quarries owned by Udaypur Cement Factory lie in the forest area, about 1.5 hectare area had been partially deforested due to mining activities. Therefore, it was advised to minimise deforestation and start plantation in the worked out zone once the mining activities completed. It was also directed to pay the royalties to the government at the end of seventh day or earlier of each month and produce the evidence to DMG.

FUEL MINERALS (COAL)

Most of the mines for fuel minerals coal were running at very low production rates. The production figure of coal for various coal mines till the month of Falgun 2060 varied from only 15 to 44 tonnes. It was because of the hard ortho-quartzite rock in the development face inside the coal mine. One coal mine owned by Ambikeshwori Coal Industry (P) Ltd. located at Devinagar VDC, Palpa was not in operation at the time of inspection.

The roof support system inside those visited coal mines in Dang, Sallyan area was not found effective at the time of inspection. Therefore, the lessees were instructed to give support system effectively in weak zones so that the roof falls may not occur. They were also advised to maintain the drainage in underground properly in order to avoid inundation as well as water logging problems in future. The lessees were also directed to minimise the environment impact and take adequate safety measures beforehand from any mine accidents inside the coal mines. They were instructed to update the production records too.

CONCLUSION AND RECOMMENDATION

Conclusion

Out of 10 mines inspected by the Team -1, it was found that five mines were not in operation because of rainy season and four mines were in operation and that of one was under prospecting status. The inspection showed us that safety aspect of man and machineries had been poorly dealt with. Those inspected mines should continue their operation according to the suggestions and directions given by DMG from time to time. Hence all mines needed to have regular inspection from DMG.

Out of 10 inspected mines by Team -2, three were not in operation, two were operating at very low capacity and other five mines were operating but not at full capacity. The insurgency had negative impacts on mine operation. Therefore, mine owners needed to be directed to operate mines at full capacity as far as possible carrying out the mine development in sustainable manner.

Out of 13 mines inspected by Team -3, four were not in operation, three were operating at very low capacity and other six were operating but not in full capacity. The insurgency had negative impacts on mine operation at the inspection time.

Recommendation

Based on the inspection visits and conclusions, DMG recommends that the frequency of field visits in those areas should be increased and observe how effectively the directives have been implemented. DMG should take stern actions against those quarry owners who fail to follow the given instructions in time. However, DMG would technically guide those quarry owners to achieve the optimum level of productions with cost effective mining methods and minimum environmental degredation.

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Paleoseismological Study in Godavari and Mohana Khola Area, Kailali District, Far–Western Nepal

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INTRODUCTION

The Himalaya falls in one of the active tectonic zones of the world. During the last 100 years, the Himalaya has witnessed four great earthquakes (Fig. 1 and Table-1) of magnitude greater than 8. The East and Central Nepal have records of great historical earthquakes since 1255 but there is no such record in West and Far West Nepal. Great earthquake has not occurred in this area between Bihar-Nepal earthquake of 1934 and Kangra earthquake of 1905 and remains as a seismic gap. This area is likely to experience a great earthquake in near future (Bilham et. al., 2001; Pandey et.al., 1995).

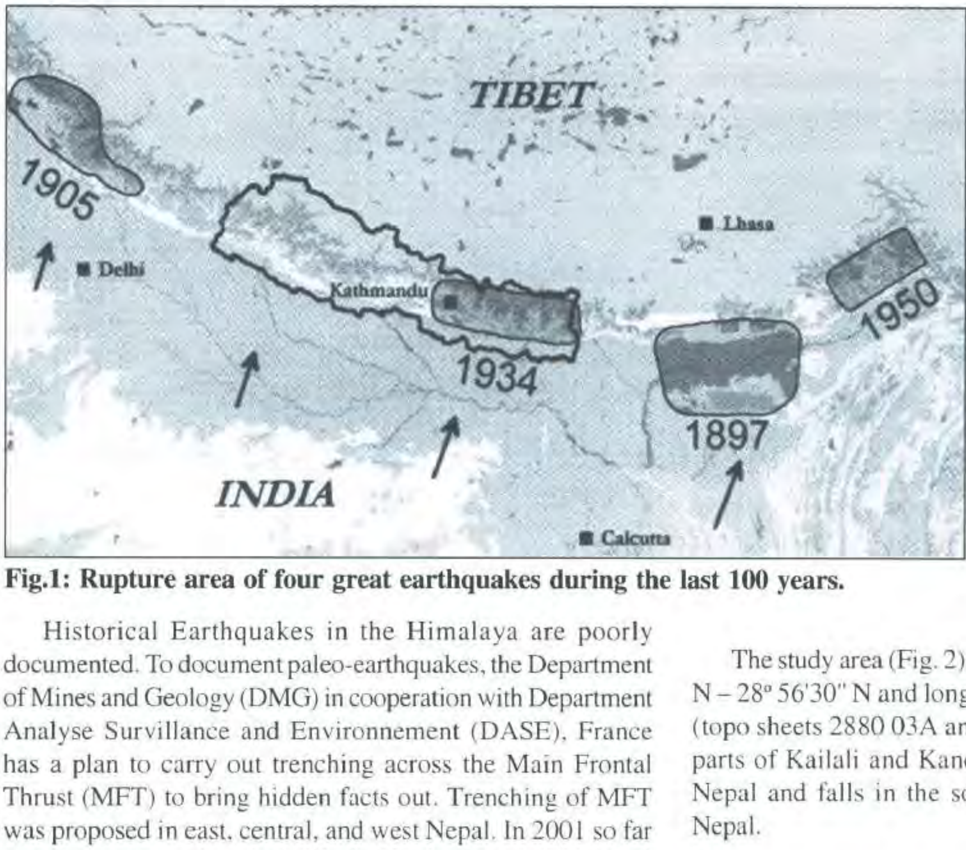

Fig.1: Rupture area of four great earthquakes during the last 100 years.

Historical Earthquakes in the Himalaya are poorly documented. To document paleo-earthquakes, the Department of Mines and Geology (DMG) in cooperation with Department Analyse Survillance and Environnement (DASE), France has a plan to carry out trenching across the Main Frontal Thrust (MFT) to bring hidden facts out. Trenching of MFT was proposed in east, central, and west Nepal. In 2001 so far trenches were made only in Marha Khola Area, in Mahottari District across the western escarp to find out whether the Bihar-Nepal Earthquake (1934) broke the surface or not. Unfortunately, such evidence was not found there. However, some evidences of an earthquake that occurred around 1100 AD and ruptured the front of Himalaya were found over there. Other trenches have been proposed in the Central Nepal and Western Nepal to find more evidences of historical great earthquakes and their return period.

Table-1: Historical Great Earthquakes, which ruptured the Himalaya in the last 100 years.

S. No.	Year	Epicenter Area
1	1897	Assam
2	1905	Kangra
3	1934	Bihar – Nepal
4	1950	Assam

Present study was a preliminary effort to study the seismotectonics of the Western Nepal. Therefore the study was concentrated to find out the suitable sites for deep trenching to look for evidences of the past earthquakes, which are not found in the record of historical earthquakes.

The study area (Fig. 2) falls between the latitude 28° 52'30" N – 28° 56'30" N and longitudes 80° 30' 00" E - 80° 37' 00" E (topo sheets 2880 03A and 2880 03C). This area comprises parts of Kailali and Kanchanpur Districts of Far- Western Nepal and falls in the southern part of Siwalik Range of Nepal.

Fig. 2: Location Map of Study Area

FIELD INVESTIGATION

Geomorphic evidences for active tectonics have been reported from several localities within the Siwalik Hills of Nepal Himalaya (Nakata, 1989). In the study area warped and tilted fluvial terraces are evidences of active tectonics. Fluvial terraces are very useful in tectonics and also provide some information about the rates of rock uplift.

Strath is the surface beveled on the bedrock. The strath terraces are common in the graded river, which maintains a constant profile. During the period of high flow in the river, or tectonically calm period, lateral bank erosion cause beveling of strath terrace. When there is tectonic uplift or decrease in stream power then it leads to enhanced down cutting to compensate for the tectonic uplift to the base level of erosion and it induces the abandonment of terrace.

Preliminary study of last year and present follow up study was able to find interesting terraces along Mohana Khola (Fig. 3). The terraces have been categorized into two levels depending on the colour of capping material and their elevation from the current riverbed. In the figure, dark gray colour stands for older terraces and light gray for younger ones.

We measured the elevation of top of terraces, strath levels and current riverbed along Mohana Khola. These values are shown in Fig. 4. The elevations are plotted against distance from MFT. In this figure the cross hairs represent the elevation of the riverbed, the green triangles represent the top of the terrace 'T1' and the big triangles stand for the top of terrace 'T2'. The square represents elevation of strath of terrace 'T2'. Similarly dip angles of rocks along Mohana Khola, from the MFT towards north, were measured. Sine of the dip angles of rocks versus distance from MFT is plotted in Fig. 5.

The uplift profile (Fig. 4) of the terrace is similar as growing fold so there is a correlation between structural geology and recent uplift according to fault bend fold model. The sin (dip) profile (Fig. 5) projected in a plane striking N25^{0}E is similar to the uplift profile (Fig. 4) in shape. These two profiles reflect recent activities in the Siwaliks of the study area as it is observed in other parts of the Siwalik as well.

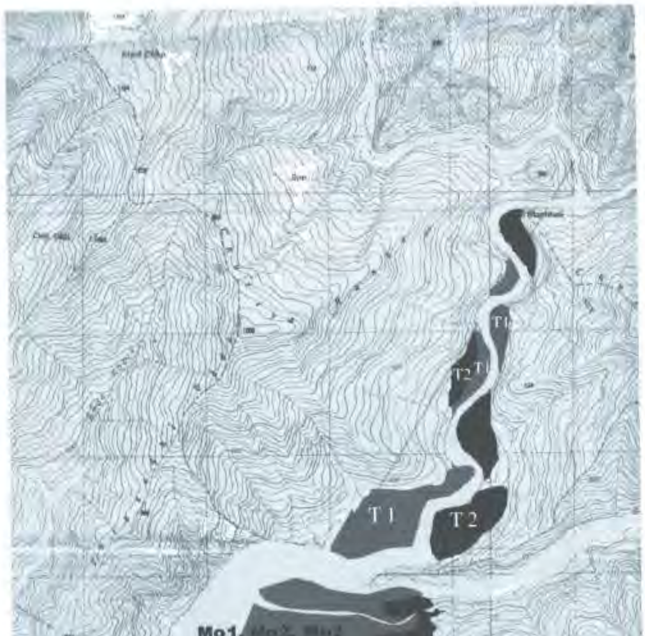

Fig. 3: Terrace distribution in Mohana Khola Area.

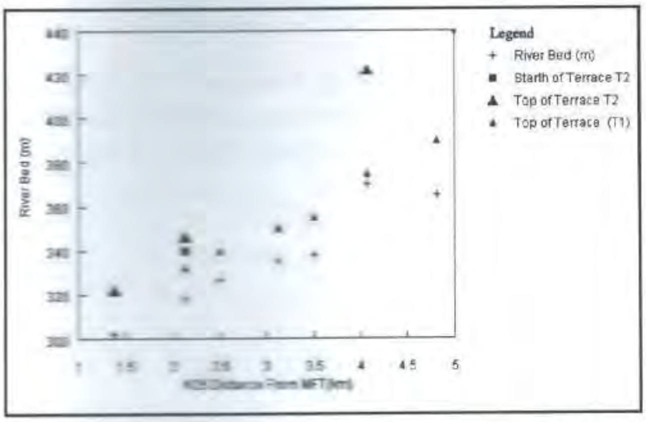

Fig. 4: Uplift profile of different level of terraces in Mohana Khola.

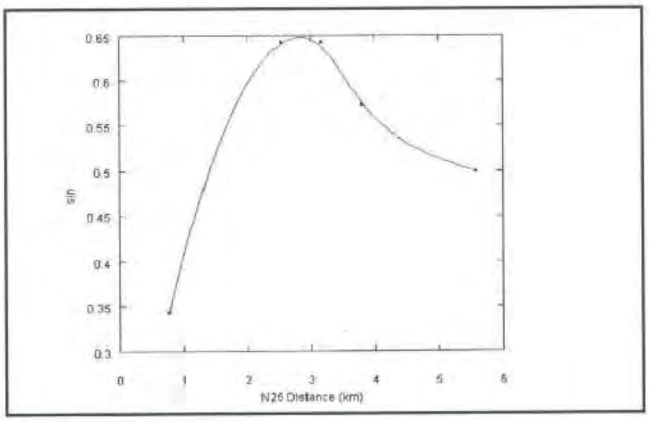

Fig. 5: Sin (dip) profile along Mohana Khola.

We looked for suitable trenching sites in Mohana Khola Area. The most interesting sites are found at the left bank of the Mohana Khola close to the site office of Mohana Irrigation Project. The tectonic scarp cuts through a 1 km wide terrace. This terrace has been largely folded (the maximum amplitude is 40 m) and displays a slightly steeper frontal scarp (Fig. 6). The strath surface has been cut into the Lower Siwaliks claystone and mudstone and is covered by about 4 – 5 m of alluvial boulder gravel with a thin cover of over bank deposits. As we see on the topographic profile of the strath terrace the shortening has been accommodated by folding. Two sites met most of the above-mentioned conditions and were considered for the proposed trenching sites. The two sites are at the southern part of the frontal terrace (Fig. 3). There are two small gullies that have cut the edge of the terrace and they have carried out sedimentation also. The western gully is very small whereas the eastern gully is relatively larger. The eastern gully has incised the scarp and has shifted little due west. It could have left history of the past in its abandoned channel in the east. Therefore, we consider the eastern gully is the best site for trenching and the western one as an alternative.

Fig. 6: A view of the frontal Mohana escarp (View due E).

CONCLUSION

Abandoned fluvial strath terraces are considered as a tool to reveal tectonic history and the growing fold of the area. Record of different levels of terrace treads along Mohana Khola depicts picture of uplift. Uplift profile (Fig. 4) and profile of sines of dip angle of rocks (Fig. 5) are similar in shape and both indicate that fault bend folding is present in that area.

Two sites are for paleoseismological trenching (Fig. 3) in Mohana Khola Area. They are at the southern part of the frontal terrace (Fig. 6). The eastern site is preferred for trenching whereas the western is considered as an alternative. The trenching site is cultivated and so authorization from the farmer is necessary before trenching.

During field work some charcoal (Mo1, Mo2, Mo3) samples were collected from different terraces. Dating of charcoal samples would also help us to derive the shortening rate in that area.

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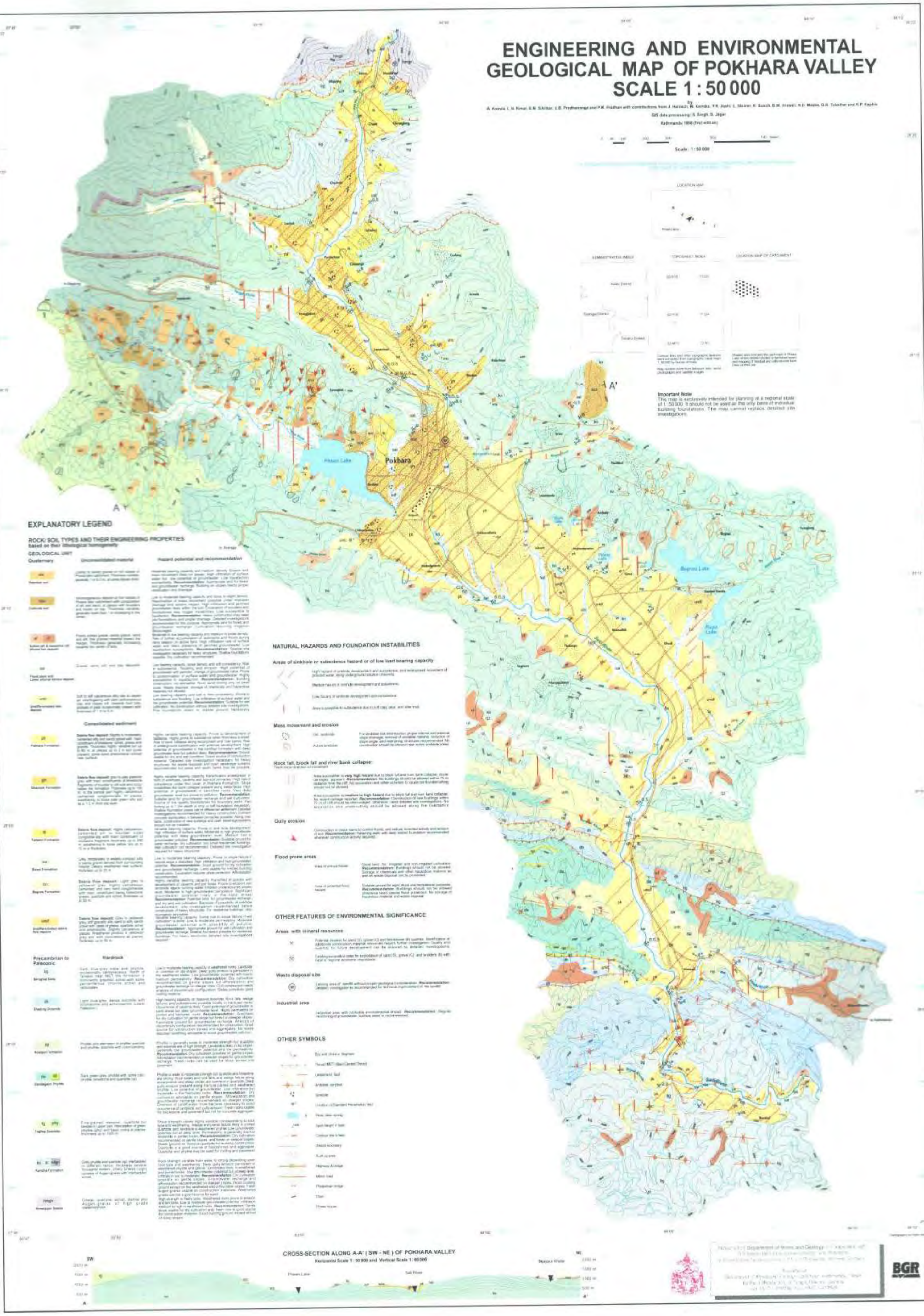

ENGINEERING AND ENVIRONMENTAL
GEOLOGICAL MAP OF POKHARA VALLEY
SCALE 1 : 50 000
Scale : 1 : 50 000
LOCATION MAP
Important Note
This map is exclusively intended for planning at a regional scale of 1:50000. It should not be used as the only basis of individual building foundations. The map cannot replace detailed site investigations.
Pokhara
Phewa Lake
Begnas Lake
Rupa Lake
EXPLANATORY LEGEND
ROCK/SOIL TYPES AND THEIR ENGINEERING PROPERTIES based on their lithological homogeneity
GEOLOGICAL UNIT
Quaternary
Unconsolidated material
Hazard potential and recommendation
Consolidated sediment
Precambrian to Paleozoic
Hardrock
NATURAL HAZARDS AND FOUNDATION INSTABILITIES
Areas of sinkhole or subsidence hazard or of low load bearing capacity
Mass movement and erosion
Rock fall, block fall and river bank collapse
Gully erosion
Flood prone areas
OTHER FEATURES OF ENVIRONMENTAL SIGNIFICANCE
Areas with mineral resources
Waste disposal site
Industrial area
OTHER SYMBOLS
CROSS-SECTION ALONG A-A' (SW - NE) OF POKHARA VALLEY
Horizontal Scale 1 : 50 000 and Vertical Scale 1 : 60 000
SW
NE
A
A'
BGR

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