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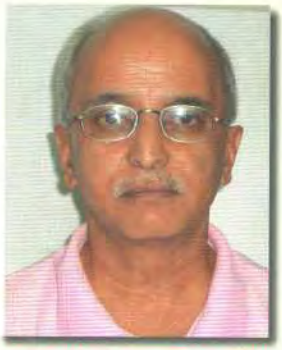

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Foreword

This Annual Report No. 8 of the Department of Mines and Geology is a continuation of publications carried out by the department. The Geo-scientific studies and exploration works undertaken by the department as well as other relevant information/data have been incorporated in this volume. This volume offers a glimpse of technical activities and accomplishments of the department. I hope the report will be helpful for planners, scientists, student, entrepreneurs and others active in the field of geo-scientific studies and mineral based industries.

I would like to express my thanks to all the professionals, contributors and service providers who helped to bring this report in this shape. Thanks also to the members of the editorial board whose valuable contribution and patience had helped to materialize this report on time.

Sarbjit Prasad Mahato
Director General

Editorial

The 'Editorial Board' is highly delighted to bring out this 'Annual Report No. 8' of Department of Mines and Geology (DMG). This volume, like the previous ones, is also the continuation of the publication of Departmental activities. It mainly focuses on different geo-scientific activities conducted by the DMG such as mineral exploration, geohazard, engineering and environmental geology and petroleum exploration etc. In addition some other activities and information are also incorporated in this issue. 'Editorial Board' hopes that this volume will be useful and informative for concerned people.

Members of the 'Editorial Board' would like to extend their sincere gratitude to all the authors and personnel of the DMG for their efforts and contribution to bring out this Annual Report. Suggestions and comments are highly welcomed.

Hifzur Rahman
Chief Editor

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An Assessment of Exploration of Lakharpata Limestone Deposit, Surkhet District, Midwestern Nepal

Dharma R. Khadka (Sr. Div. Geologist), Kushal N. Pokharel (Geologist)

ABSTRACT

Lakharpata Limestone Deposit is a part of Gawar Formation of Lakharpata Group of Lesser Himalaya. It has parallel laminated argillaceous limestone. The limestone is gray to dark gray, medium to thick bedded and homogenous along the strike. It consists of mm to cm scale laminations and argillaceous beds intercalation. The stromatolitic limestone is dominant in the south-eastern part of the prospect. The surface and subsurface exploration was carried out in various phases like preliminary, follow-up and exploratory drilling in the prospect area and west of the present studied area. The surface exploration of the limestone deposit shows that the average value of CaO content of 47.99% and MgO of 2.58%. Based on the available analytical results of surface and subsurface samples, field observations and conventional cross sectional method of reserve calculation, the deposit has a proved reserve of 17.37 MT and possible reserve of 103.28 MT. The total reserve is 120.65MT, which is suitable for cement raw material.

INTRODUCTION

According to the annual field program of Department of Mines and Geology (DMG) under the Mineral Exploration Project for the FY 2009/10 an exploration of cement grade limestone at Lakharpata of Pokharikanda VDC-6, Surkhet district has been undertaken.

The investigated area lies within latitude 28° 43' 16" to 28° 45' 29" and longitude 81° 29' 17" to 81° 31' 03" in the parts of Toposheet no.2881 02D, 03C, 06B, 07A, 1:25000 scale. The limestone prospect covers the Topo-geological survey area of 92 hectors.

Sthapit (1978/79 and 1980/81) investigated cement grade limestone deposit to the western adjoining part of the present prospect. Khadka et al., (2009/10) did preliminary walkover survey for drilling pre-feasibility in some parts of Lakharpata areas of Pokharikada VDC -6 of Surkhet district as per the annual field program of the DMG.

OBJECTIVE

The main objective of the exploration was to determine suitability of cement grade limestone in terms of quality and quantity. The anticipated target was:-

- 25 sq.km. geological mapping of the area,
- 400m diamond core drilling,
- About 80 hectares Topo-geological survey at the scale of 1:1000 with Total Station Instrument,
- Topo-geological mapping at 1:1000 scale of 1 sq.km. area,
- Surface sampling (chip/ grab) as required, and leveling
- Core logging, core sampling to test grade and nature of limestone at depth to estimate the potentiality of the cement grade limestone.

METHODOLOGY

a) **Desk study:** The existing reports, data and available literature were reviewed before departing to the field study.

b) **Field study:** The surface exploration includes continuous chipping and grab sampling of the outcrops. The area was also covered with Topo-geological survey using Total Station Instrument. Wireline Diamond Core Drilling was performed in order to ascertain the quality and quantity of limestone subsurface.

EXPLORATION HISTORY

Preliminary/ follow-up exploration (1978/79, 1980/81)

The preliminary and follow-up exploration works were carried out by N. R. Sthapit in the western adjoining part of the present study area in 1978/79, 1980/81. The anticipated works and results were-

- Channel samples- 6, Chip samples-12, Grab samples-48
- Topogeological survey-1 sq.km, 1:2000 scale
- CaO ranges from 44.86% to 49.93% in 4 units
- MgO ranges from 1.97% to 4.84% in 4 units

The estimated geological reserve was 16.5MT. For further geological reserve proving, it was recommended for drilling during 1980/81 field season.

Detailed follow-up exploration/ Exploratory Drilling (2009/10)

The following works have been conducted by the authors in 2009/10:

- Geological mapping of the area, 1:10000 scale of 25 sq. km.,
- Topo-geological mapping of the prospect area 1;1000 scale of 92 hectares,
- Surface chip sampling 118 nos.,
- Surface grab sampling 41 nos.,
- Exploratory diamond core drilling 265.55m in 3 locations.,
- Core samples 149 nos.,
- Total samples (surface +subsurface=308), and
- Core logging 265.55m

The third hole has been terminated due to frequent core loss as a result of spindle has no longer set fixed in the adjusted dip angle. The plate in the drum has no longer adjustable to fix the spindle. The time to maintain the plate is too short and maintenance in the nearby area is impossible. Ultimately the drilling program was suggested to be stopped.

nomenclature given by Friendenreid et al 1994 and Pradhan et al 2003. The Main Boundary Thrust (MBT) which acts as a floor thrust of the Lesser Himalayan Duplex (DeCelles et. al. 1998) comprises wide crushed zone and topographic depression, separates underlying Lower Siwalik sediments from the Lakharpata Group. A tectono-stratigraphy of the area is summarized in Table 1.

Lakharpata Group

The Lakharpata Group consists of Aru Formation, Katuwa shale, Khara limestone, Gawar dolomite and Ramkot sandstone and Sangram Formations. The investigated area consists of Gawar Formation only.

Gawar Formation

The formation is cropping out in Malchana and Lakharpata areas. Beds are striking NW-SE direction and thickening towards NW and thinning towards SE. It consists of laminated limestone, stromatolitic limestone and dolomite. It has mm to cm scale yellowish to brownish shale intercalation. The beds are thin to thick. Limestone beds readily react with dilute HCL. Beds are almost homogenous along the strike. It has bluish gray to dark gray colored limestone beds. The cross cutting or parallel calcite veins and beds with cm to m scale are

Table 1: Tectono-stratigraphy of Lakharpata area, Surkhet

Group	Formation	Lithology	Age
Surkhet	Suntar Formation	Greenish gray and purple shale and sandstone interbeddings	Oligocene to Early Miocene
	Swat Formation	Gray, greenish gray shale and sandstone	Eocene
	Melpani Formation	Quartzite, ferruginous quartzite and dark gray shale intercalation	Late Cretaceous-Paleocene
Disconformity			
Lakharpata	Gawar Formation	Gray to greenish gray laminated limestone, stromatolitic dolomite and limestone at places, intercalated with shale.	Early Paleozoic to Late Proterozoic?
MBT			
Siwalik	Lower Siwalik	Variegated mudstone, shale and fine grained sandstone and siltstone	Middle Miocene

REGIONAL GEOLOGICAL SETTING

Geologically, the investigated area falls within the Lesser Himalaya of western Nepal (Amatya et. al,1994). Shrestha et al 1987, Friendenreid et al 1994 and Pradhan et. al. used the name Lakharpata Group in their works. Kayastha 1992, placed Lakharpata Formation in Mahabharat Group and divided into Katuwa shale, Khara limestone, Gawar dolomite and Ramkot sandstone members from younger to older sequence in Surkhet area. A disconfirmity has been proposed between the Lakharpata and overlying Surkhet Group of rocks (Shrestha et al 1987, Kayastha 1992 and Friendenreid et al 1994). The Lakharpata Group here is represented by the Gawar Formation following the found at places. The lower contact of the formation is thrusted and called Main Boundary Thrust (MBT). The upper contact of the formation is sharp and the strata on both sides of the overlying and underlying formations are parallel. A disconformity separates both group as discussed earlier. It has a faulted contact with overlying quartzites of Melpani Formation at the Malchana area. The limestone prospect lies within this formation (Fig.1). Similarly, the eastern part of the prospect has also faulted contact with the quartzites of Melpani Formation. An anticlinal axis runs parallel to the ridge. The southern limb has a scarp due to the effect of MBT which is about 500m away from the axis. The northern limb is gentle. A series of discontinuities like tension cracks at the top of the anticlinal axis are abundant. Some of them have

shown normal displacement. They are almost parallel to the regional trend of the anticlinal axis and MBT. These open foldings and brittle displacements could be late stage Himalayan deformation probably related to the southward propagation of the MBT and structuration of Siwaliks.

The stratigraphic thickness of the formation in the area is about 700m. The formation is considered to be of Early Paleozoic to Late Proterozoic in age.

Surkhet Group

The Surkhet Group here is represented by Melpani Formation, Swat Formation and Suntar Formation.

Melpani Formation

This formation crops out at Malchana, Surkhet-Jumla road section, upper parts of the Kalyan Kadh, Barrachaur and Karange Khola right tributary areas. It consists of medium to thick bedded gray and ferruginous quartzite and gray to dark gray shale. The beds are dipping due NE.

The stratigraphic thickness of the formation in the area is about 110m. The formation is considered to be of Late Cretaceous to Paleocene in age.

Swat Formation

This formation crops out at Kalyankadh, Jogidada, Karangekhola and Surkhet-Jumla Road section. It consists of gray and greenish gray shale dominantly to the lower part of the formation and thin bedded gray sandstone beds at the upper part of the formation. The beds are dipping due NE.

The stratigraphic thickness of the formation in the area is about 160m. The formation is considered to be of Eocene in age.

Suntar Formation

This formation crops out at Surkhet-Jumla road section, Jogidada and Karange Khola areas. It consists of fine to medium grained, greenish gray sandstone, purple shales intercalated with greenish gray shales. The formation is considered to be of Oligocene to Early Miocene in age.

Siwalik Group

The Siwalik Group is represented by Lower Siwalik unit in the study area.

Lower Siwalik

This unit crops out to the south of the MBT. It consists of fine grained sandstone with interbeds of purple or red coloured mudstone, shale and siltstone.

GEOLOGICAL INVESTIGATION OF THE PROSPECT AREA

The prospect lies within the Gawar Formation (Fig.2). It consists of laminated limestone and stromatolitic limestone which readily reacts with dilute HCL (Fig.3). The laminae are of mm scale and grades upto cm scale at places. The bluish gray to dark gray, thin to thick bedded limestone has stromatolites to the eastern part of the area. The beds are homogenous and are continuous all along the strike. The presence of tension cracks and cavities has effects on locating Drilling points (Fig.2).

Section AA'

It has bluish gray to gray, medium to thick bedded Stromatolitic limestone and laminated limestone. It has faulted contact with Melpani Formation quartzite. It has tension cracks parallel to the regional structures. The southern part has a scarp due to the effect of MBT. The SW part has normal faults which have produced ridge and valleys. There are some radiated tension cracks around 1210m ridge area and also a few topographic depressions resulted from the normal displacements. The beds have NW to SE strike and dipping due NE with an angle of 10-660 in the northern flank and SW with an angle of 14-370 in the southern flank.

This section has the following sample coverage.

Samples: LL1Cp 1-25, LL4 Cp 1-20, LLG17 to 20, DDH-3/ H3 LK1- 39 (Fig.2)

Section BB'

To the south of DDH-2, series of tension cracks and an anticline passes by road side. No outcrops are there to sample in the southern part of this section. 5-6m thick residual soil covers the area. The beds have NW to SE strike and dipping due NE with an angle of 10-760 in the northern flank and SW with an angle of 14-300 in the southern flank.

This section has the following sample coverage.

Samples: LL3 Cp 1 to 32, LL G1 to10, DDH-2 / H2 LK 1-62 (Fig.2)

Section CC'

The area down to 950m level is covered by forest and residual soil of thickness about 5-6m. It has no outcrops for sampling. The anticlinal axis passes by road side. Topographic depressions are common in the southern part. The beds have NW to SE strike and dipping due NE with an angle of 18-600 in the northern flank and SW with an angle of 17-430 in the southern flank.

This section has the following sample coverage.

Samples: S1Lk Cp 1-22, S1Lk G11, G23, LLG 21-30, DDH-1/ H1 LK 1-48 (Fig.2 and 4)

Section EE'

This section is also lithologically similar to other sections. There is a syncline passes parallel to the regional structure in the southern part of the section. Northern

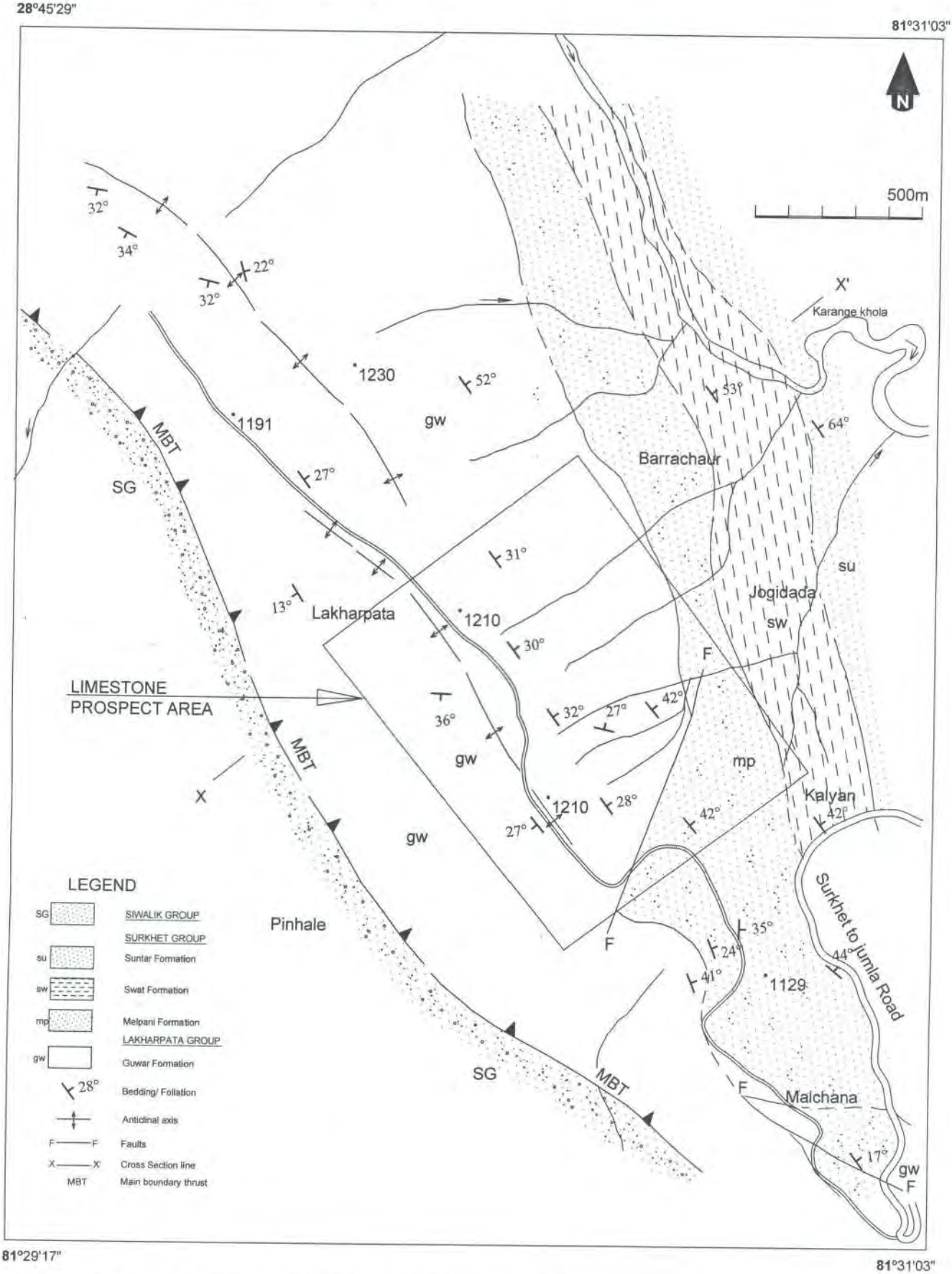

Fig.1: Regional geological map of Lakharpata Limestone deposit, Surkhet

TOPO - GEOLOGICAL MAP OF LAKHARPATA LIMESTONE DEPOSIT POKHARIKADA VDC-6, SURKHET.

Scale 1:1000

(Contour Interval 2 meters)

Geological Legend

- Surkhet Group
  Amiyani Formation(Cretaceous)
  (Quartzite, ferruginous quartzite, shale intercalation)
- Lakharpata Group
  Ciaver Formation (Early Palaeozoic to late Proterozoic)
  (grey, greenish grey, thin to thick bedded limestone, laminated limestone , stromatolitic at places, intercalated with shale and shale bandings)
- Attitude of beds
- Tension cracks
- Fault
- Syncline
- Anticline
- Section line
- Drill hole
- Chip Sample locations (Cp 1-10)
- Dish Sample locations (G1)
- Depression/Ponds

Topographical Legend

SYMBOL	DESCRIPTIONS
	Triangulation Point (With pillar)
	Traverse Station
	Motor track
	Track
	House, Ditch
	Tap
	Water table
	Rowa
	Pond
	Tree
	Stream (Khola)
	Cliff
	Land slide
	Minor contour
	Major contour
	Cultivated Land
	Forest

Trig Pt.

Easting	Northing	Elevation

Trig Pt.

Easting	Northing	Elevation

TOPO-GEOLOGICAL MAP OF LAKHARPATA LIMESTONE PROSPECT

Lakharpata VDC-6, Surkhet

GEOLOGY BY :	Khamma Raj Khatiwada (DOG) Kushal N. Pokhrel (DI)
TOPOGRAPHICAL SURVEY BY :	Ramananda P. Chaudhary (ME)
TOPO SHEET NO. : 2980 DC	CHECKED BY / DATE / DRAWING NO.
SURVEY AREA : 0.05 Sq.Km	

PREPARED BY : DEPARTMENT OF MINES & GEOLOGY
Lainchaur, Kathmandu, Nepal.

part of the Chautara area has an anticline. This is the place for the sporadic barites mineralization. The beds have NW to SE strike and dipping due NE and SW with an angle of 11-360 in the both flanks. This section has the following sample coverage

Samples: LL7 Cp 9-14, LLG 31-39, Cp 1-8 * west of EE' (Figs.2 and 5)

Fig.3: Thin to medium bedded gray limestone at the Lakharpata ridge top

Fig.4: Splited Core samples DDH-1, stromatolitic limestone at places, calcite coatings

Fig.5: DDH-2, Drilling assembly, Acker Drill machine, Lister engine Boyles Pump, Hoisting engine, Tripod, hoist and pully, drilling rods, core barrel, core catcher, casing rods etc

The Drill Hole parameters are summarized in Table 2.

Table 2: Drill Hole Parameters

Parameters	DDH-1	DDH-2	DDH-3
Northing	3180310m	3180631m	3179988m
Easting	549262m	549372m	549560m
Elevation	1192m	1189m	1172.5m
Starting date	067.1.23	067.2.14	067.3.2
Finished date	067.2.10	067.2.31	067.3.14
Azimuth	2350	2600	2350
Hole dip	570	600	570
Hole length	87.1 m	106.45 m	72 m
Core recovery %	73.78%	68.76%	76.59%

QUALITY OF THE DEPOSIT

a) Surface exploration

The average assay values of the collected samples are under the cement grade limestone (Table-3). However some deviation seen as maximum and minimum CaO content is 53.47% and 38.91%. Similarly, the maximum and minimum MgO content is 9.58% and 0.25 % respectively.

Table 3: Average values calculated from the assays of 117 chip samples and 41 grab samples of Lakharpata Limestone deposit

Total chip sample length(m)	LOI %W/W	Acid Insoluble %W/W	Fe2O3 %W/W	Al2O3 %W/W	CaO %W/W	MgO %W/W
558.55	39.01	7.34	0.41	1.16	47.99	2.58

b) Subsurface exploration

Based on core sampling of 3 drill holes, the average values of assay results of the Lakharpata Limestone Deposit will be calculated based on collected core samples. Chemical analysis of the collected core samples are undergoing. 20 samples of DDH-1 and 10 samples of DDH-3 give the following results (Table-4).

Table 4: Average values calculated from the assays of 30 core samples of DDH-1 and DDH-3, Lakharpata Limestone deposit

Total chip sample length(m)	LOI %W/W	Acid Insoluble %W/W	Fe2O3 %W/W	Al2O3 %W/W	CaO %W/W	MgO %W/W
53.45	38.43	8.74	0.44	1.04	47.28	2.0

RESERVE ESTIMATION

Reserve estimation is based on the conventional cross sectional method. The chip sampling pattern is based on the surface exposures. Grab samples were taken to fulfill the gaps and are supposed to be the indicative of the ore. The drill core samples were taken with due care. The drill sections are almost homogenous

throughout the 3 sections. The lower, middle and upper part of the drill sections is almost homogenous in nature, colour and argillaceous limestone present. The average core recovery from 3 drill holes has been calculated and the result is 72.15% for the limestone band since the total limestone thickness is 265.55m and total limestone core recovery is 191.6m. The estimated reserve is given in the Table 5.

Assumptions

1. Beds are homogenous
2. Quality is homogenous along the influence area
3. Specific gravity is 2.6
4. Correction Factor 0.72 based on core recovery

Table 5: Reserve Estimation

Section	Cross sectional area(m^2) (Possible)	Influence length (m)		Reserve (Possible/ category III), MT	Cross sectional area(m2) (Proven)	Reserve (Proved/ category I), MT
		NW(m)	SE(m)			
AA'	57600	104	100	21.99	13500	5.15
BB'	77100	102	104	29.73	17000	6.55
CC'	84400	100	102	31.91	15000	5.67
DD'	44000	55	100	12.76	-	
EE'	35100	50	55	6.89	-	
Total				103.28		17.37

Note: the reserve estimation may subject to change based on the analytical results of the awaited subsurface samples.

INFRASTRUCTURE

The approach to the deposit area from the road head and the nearest market place has been presented. The electricity and the socio-economy of the area have been briefly discussed.

a) Road

KTM to Surkhet	-	585km
Nepalgunj to Kohalpur	-	15km
Kohalpur to Surkhet	-	85km
Surkhet to Bangesimal	-	8km
Bangesimal _ Badichaur_Hattichheda	-	43km
Hattichheda to Lakharpata	-	4km

b) Electricity

Kohalpur - 166Kv Transmission line
Kohalpur-Surkhet - 32Kv Transmission line

c) Socio-economy

- Magar and dalits are main inhabitants. Agriculture is the main occupation of the area.
- Northern slope has a forest cover, drinking water pipeline stretches at the middle of the deposit.
- 12 households are residing within the deposit area at ridge top.
- 12 households are residing on the lower slope of the deposit influence area at Karange.
- Unskilled labors are available. Remittance is another source of income.

DISCUSSION

Parallel and oblique fissures/ cracks could probably be the result of MBT. The shale beds and laminations intercalation may deteriorate quality at subsurface.

Channel sampling is lacking, as a result, the surface weighted average grade of the deposit has not been computed, however the chip and grab sample results are satisfactory. The total prospect area is covered with continuous chip and grabs sampling. The reserve is based on the analytical results of DDH-1 and 3 assuming that the homogeneity of the quality as seen on the results. The proved category result would subject to change as soon as the availability of the results and their interpretation. The overburden is insignificant comparing the deposit. A volume of about 250000m3 top soil wastes could be expected throughout the entire area.

CONCLUSION

- Geologically, the Lakharpata Limestone Deposit is a part of the Gawar Formation of the Lakharpata Group. It has anticlinal ridge top deposit with gentle dip slope exposure in the flanks.
- A total of 158 chip and grab samples of limestone from 10 sections have given rise to average values of CaO-47.99% and MgO-2.67%.
- Analysis of a total of 30 core samples of limestone from DDH-1 and DDH-3 has given rise to average values of CaO-47.28%, MgO-2.0.

The weighted average value of contents of the core samples will be presented after getting the analytical results of all samples.

- The deposit has a total of 120.65 MT reserve of cement grade limestone in which ca. 17.37 MT proven and 103.28 MT possible categories based on the available results and their interpretations.

RECOMMENDATION

- The average grade attributes of limestone including silica, alumina, calcium oxide, magnesium oxide and ferrous oxide can be improved using standard geo-statistical methods of capturing spatial variation of the deposit.

- It is desirable to have bulk testing of limestone to justify grade attributes.

- The quantity of the deposit could be increased by exploring the unexplored areas in the adjacent part of the deposit within the same formation westward. Similarly, the deposit category can be improved if explored the area with further drilling.

- Feasibility study for the establishment of the cement plant is warranted.

ACKNOWLEDGEMENT

We are very much indebted to Director General Mr. S.P. Mahato for the encouragement and facilities provided during the field work and various phases of the assessment of data. We would also like to extend our gratitude to Deputy Director Generals Mr. S.R. Maharjan, and Mr. H. Rahman, for valuable suggestions during the various phases of the project. We thank Mr. K.D. Jha, Planning Chief, and Mrs. Rita Shrestha, Senior Divisional Chemist, for the support. Equally acknowledged are Chemical Section staffs, Drilling Section staffs, and Mr. Ramananda Chaudhary for surveying the area.

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Preliminary Exploration of Cement Grade Limestone and Industrial Dolomite in Parts of Palpa District, Western Nepal

Dinesh. K. Napit (Sr. Div. Geologist) , Jay. R. Ghimire (Sr. Div. Mining Engineer)

ABSTRACT

A preliminary exploration for cement grade limestone and industrial dolomite in parts of Palpa district was carried out within 75 sq. km. area. The area is easily accessible by motorable road and lies in the Purba Khola area. Potential limestone prospect within the area is delineated in the geological map. The limestone is of cement grade and dolomite is of industrial grade at places. A follow up program in an area of 20 sq. km. for limestone prospect around Gangdi-Madanpur-Sarangi Khola (periphery of Purba Khola) area is recommended.

INTRODUCTION

The exploration for the cement grade limestone and dolomite was carried out in the part of Pala district in fiscal year 2065/66. The study area lies in toposheet no 099-07 and 099-11 within latitude of 27°45'00"N to 27°48'40"N and longitude of 84°44'45"E to 84°51'00"E covering an area of 75 sq km. The area lies in the east of Tansen, Palpa. The area is accessible by motorable road from Kathmandu to Pokhara or Butwal , then to Aryabhabjyang, Palpa having total distance of about 300 km and about 20 km earthen road further east from Aryabhanjyang reaching to Purba Khola , northern central part of the study area. Geological mapping, rock sampling were done during the exploration work in the field.

OBJECTIVES

The main objective of the exploration was to locate the cement grade limestone and dolomite band of industrial use and find their extension, thickness and delineate the prospect area and collect the representative samples.

METHODOLOGY

In the field geological traverse was taken along the roads, rivers, ridges for geological mapping of the area and tracing the extension of limestone/dolomite in topographic base map of 1: 25000. Samples of carbonate rocks were collected by continuous chip and grab method and they were analyzed in the chemical lab for identification of the grade.

GEOLOGY

Geological study of the area was carried in the past and geological map of the area has also been published (DMG,1999, PEPP, 1998 and H. Sakai, 1983).

The study area mainly lies in Lesser Himalaya comprising rocks of Nourpul Formation of Nawakot Group, Kerabari Formation of Kaligandaki Super Group and Taltung Formation of Tansen Group (Fig.1).

Nourpul Formation

Rocks of Nourpul Formation occur in the southern and eastern part of the study area. Lower part of this formation consists of medium grained phyllites and quartzite.

Kerabari Formation

Dolomite of Kerabari Formation is found in most of the part of the area. Limestone occurs in the dolomite in northern, central and southern part in thick sequence of dolomites. The dolomite is light grey to grey in color, fine grained. Intercalation of slates is present in the dolomite. Cher beds and nodules are quite common in the middle part. Sakai (1983) correlates this Kerabai Dolomite(Upper Part of Kerabari Formation with Malekhu Formation.

Taltung Formation

Rocks of Taltung formation is found in a small area in the northern part. Along the Purba Khola section conglomerate and sandstone beds are found.

FINDINGS

Limestone Occurrences

Limestone is found in the different parts of the area. The limestones are exposed in Samuga, Hattilekh, Basdada, Sikles, Sathikol, Bettyani, Dhureni dada, Bhutuke, Madanpur (Fig. 2). The rocks are also exposed along the Purba khola, Gangdi khola and Sarangi khola sections.

The limestone is found within a thick dolomite band. Thickness of the limestone band varied from 100m to 200m. The limestone is thin to medium bedded with light and dark colored thin inter-bands. In the field the

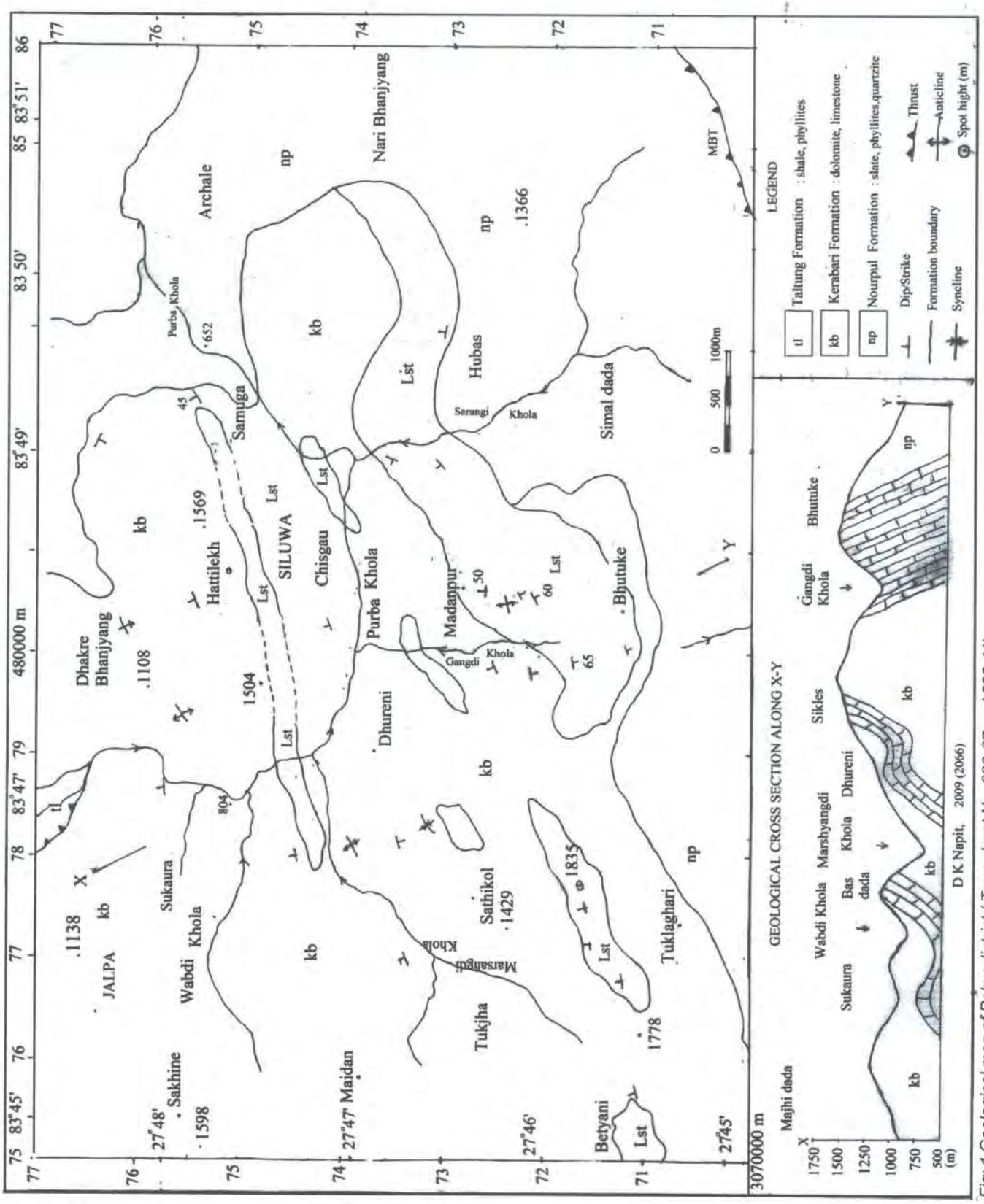

Fig: 1 Geological map of Palpa district (Topo sheet No. 099-07 and 099-11)

initial observation shows more thickness because of the repetition of the band by multiple folding to anticline and syncline structure. The limestone band extends from east to the west. However from the mining point of view with relation to the topography, the extension of individual deposit is up to 600m.

Figure 2: Limestone in Hattilekh area (left) and Purba Khola section (right)

The chemical analysis result of the limestone of different location is given in Table 1.

Table 1: Result of chemical analysis of limestone of the area

Parameters %								Location
Sample No	LOI	Acid Insoluble	CaO	MgO	R_2O_3	Fe_2O_3	Al_2O_3	
SMCP -1	39.37	7.76	45.92	4.28	1.7	0.22	1.48	Samuga
SMCP -2	37.91	10.52	44.86	4.03	2.25	0.36	1.89	Samuga
SMGR-2	38.85	4.66	50.47	3.78	0.28	0.15	0.13	Samuga
SMGR-3	40.45	4.10	51.52	3.02	0.28	0.11	0.16	Samuga
HLCP-3	41.49	4.70	36.80	15.87	1.82	0.39	1.43	Hattilekh
HLCP-4	40.69	5.64	36.45	16.38	1.32	0.30	1.02	Hattilek
BSGR-1	40.66	5.42	50.12	1.76	0.68	0.12	0.55	Basdada
BSGR-4	40.49	3.96	50.82	1.51	0.40	0.09	0.31	Basdada
BSCP-2	40.61	3.92	47.67	4.79	0.80	0.11	0.69	Basdada
BSCP-3	41.17	3.96	47.67	4.03	0.63	0.14	0.49	Basdada
PKCP-2	40.37	6.68	45.57	4.28	0.45	0.13	0.32	Purba khola
PKCP-5	39.30	6.60	45.21	5.29	1.02	0.15	0.88	Purba khola
SRCP-12	38.37	3.70	50.12	5.29	0.75	0.15	0.64	Sarangi khola
SRCP-13	37.95	6.66	50.47	3.02	0.67	0.17	0.50	Sarangi khola
SRGR-4	40.19	6.92	51.87	0.25	0.95	0.14	0.81	Sarangi khola
BHGR-1	40.80	6.34	50.82	1.80	0.70	0.15	0.55	Bhutuke
BHGR-2	39.08	5.76	51.84	2.26	0.90	0.23	0.67	Bhutuke
BHGR-3	40.95	4.46	51.17	1.50	0.55	0.15	0.40	Bhutuke
MDGR-1	41.96	2.12	53.27	1.50	0.87	0.13	0.74	Madanpur
MDGR-2	39.53	9.54	48.71	1.00	1.65	0.28	1.37	Madanpur

Dolomite Occurrence

Dolomite is found in large part of the area (Fig. 1). The dolomite is grey in color, fine grained and thick to massive. At several places cher ts are found in the dolomite. The chemical analysis result of the dolomite is given in Table 2.

REFERENCE

DMG, 1999; Geological Map of Part of Syanja, Palpa and Tanahu district, toposheet no 63 M/13, Department of Mines and Geology, Kathmandu, Nepal.

Table 2: The chemical analysis result of the dolomite

Parameters %								Location
Sample No	LOI	Acid Insoluble	CaO	MgO	R_2O_3	Fe_2O_3	Al_2O_3	
HLCP-2	43.28	2.50	32.24	21.26	1.40	0.44	0.90	Hattilekh
HLCP-3	41.49	4.70	36.80	15.87	1.82	0.39	1.43	Hattilekh
HLCP-4	40.69	5.64	36.45	16.38	1.32	0.30	1.02	Hattilekh
HLCP-6	40.28	4.14	34.34	19.90	1.65	0.24	1.40	Hattilekh
HLGR1	41.60	3.54	31.54	20.92	1.60	0.16	1.43	Hattilekh
BSCP-1	42.83	3.52	32.24	21.16	1.02	0.16	0.80	Basdada

CONCLUSION AND RECOMMENDATION

Cement grade and industrial grade limestone are found in the area. The thickness of dolomite band varies from 350 m- 500m. Limestone mainly occurs in the hill tops with almost no overburden. The area is connected by the road and topography is also favorable. So follow-up exploration for cement grade limestone and industrial grade dolomite is recommended in Gangdi-Madanpur-Sarangi khola area and Hattilekh area respectively

PEPP, 1998: Geological Map of Block 5 Chitwan, western central Nepal, Petroleum Exploration Promotion Project Department of Mines and Geology, Kathmandu, Nepal.

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Preliminary Exploration of Gypsum in Kapurkot area, Salyan District, Mid Western Nepal

Uttam B. Shrestha (Supertintendent Mining Engineer) and Kushal N. Pokharel (Geologist)

ABSTRACT

The Kapurkot area consists of the rocks of Lakharpata and Midland Groups (Lesser Himalaya) and Siwalik Group (Sub-Himalaya). The rocks of the former are thrust over the later along the north dipping Main Boundary Thrust. No gypsum occurrence is reported from the area; however, some collected samples showed gypsum encrustations.

INTRODUCTION

According to the annual field program of Department of Mines and Geology (DMG) for the year 2010, a 'Preliminary Exploration of Gypsum Deposits in Salyan District, Mid-western Nepal' was undertaken. The study area lies mainly in Salyan district, covering also a little part of Dang and Rolpa Districts. It lies within the longitudes 82°19'00"- 82°25'00"E and the latitudes 28°09'30"- 28°15'00"N. The study area extends for about 10 km in E-W and 10 km in N-S directions, covering a total area of about 100 km^2.

The area is accessible by metalled road. It is about 451 km (Kapurkot) from Kathmandu via Tulsipur of Dang. The toposheet No. 288210C, 10D, 14A and 14B encompass the area.

A regional geological mapping was done by Kayastha and Shrestha (1982) including the southern part of the study area. Kansakar and Chitrakar (1983) carried out a study just west of the present study area. They have shown the gypsiferous Beds in their Kochhap Formation and the present study area also consists of equivalent formation- the Sangram Formation (Kansakar and Chitrakar, 1983).

OBJECTIVE AND METHODOLOGY

The main objective of the study was to explore gypsum occurrence in the Kapurkot and surrounding areas. The following methodology was used to achieve the objective.

- Geological mapping of the area to locate the gypsum occurrences,
- Determine the nature and the mode of existence of the gypsum occurrences, and
- Sample collection for chemical analysis.

GEOLOGY

The Kapurkot area belongs geologically to the Lesser Himalaya. The rocks of the Dubidanda unit (Dubidanda Formation), Lakharpata Group and Surkhet Group (older to younger) are mapped in the area. The Lakharpata Group consists of Sangarm, Ramkot, Gawar, Khara and Katuwa Formations (again from older to younger). Similarly the Surkhet Group consists of Melpani and Suntar Formations (Table 1, Fig. 1). The rocks of the younger Surkhet Group share an unconformable and faulted boundary with the older rocks of Lakharpata Group, while the rocks of the Dubidanda Formation are thrust over the rocks of the younger Lakharpata and Surkhet Groups along the north dipping Dubidanda Thrust.

Table 1: Lithostratigraphic divisions of Kapurkot area

Group	Formation	Lithology	Age
Surkhet	Suntar Formation	Sandstone, shale	Oligocene-Early Miocene
Melpani Formation	Quartzite, shale	Early – Late Eocene	
Unconformity/fault			
Lakharpata	Katuwa Formation	Shale, limestone	Late Precambrian - Early Paleozoic
	Khara Formation	Slate, Quartzite	
	Gawar Formation	Limestone, dolomite, slate	
	Ramkot Formation	Sandstone, shale/slate	
	Sangram Formation	Slate/ shale	
Dubidanda Thrust			
Dubidanda		Phyllite, quartzite	Late Precambrian

All the formations in the area generally run northwest-southeast with moderate to high dip amounts. The rock sequences in the area are repeated due to faults. Dubidanda unit

Dubidanda Formation

The rocks of the Dubidanda Formation are the oldest rock present in the area. The formation represents the allocthonous Dubidanda unit. The formation is correlated with the Kunchha Formation of the central Nepal. The formation consists mainly of the greenish-gray chloritic phyllite. In addition, it also consists of gritty phyllite, quartzite and volcanic rock amphibolite.

Lakharpata Group

Sangarm Formation

The main rock type of the formation is grey, dark grey, greenish gray, even black splintery shales with bands of gray limestones and gray calcareous sandstones. In

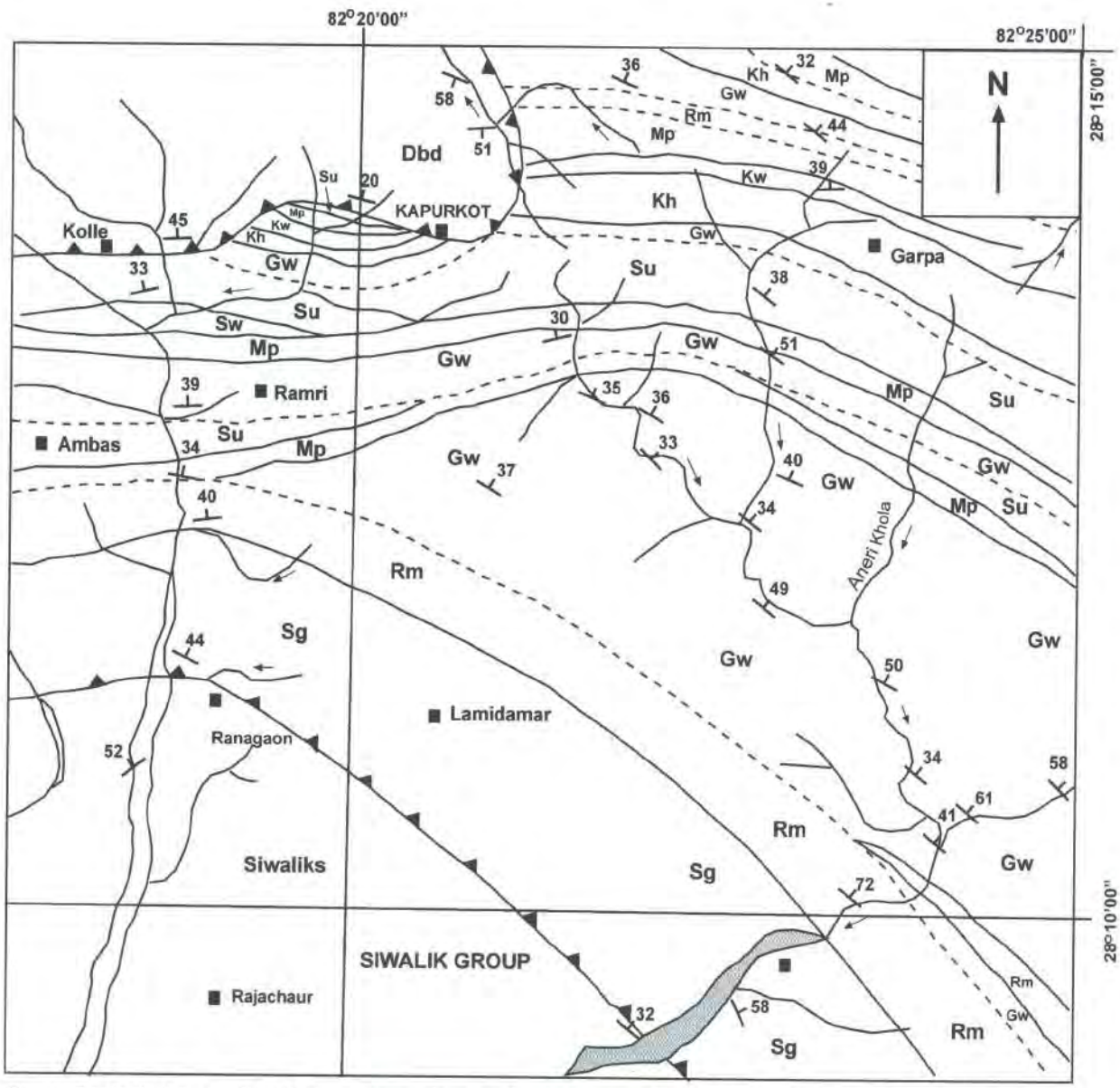

Fig. 1: Geological map of the Kapurkot area showing the study area. The symbols in the figure are Dbd: Dubidanda Formation, Sg: Sangram Formation, Rm: Ramkot Formation, Gw: Gawar Formation, Kh: Khara Formation, Kw: Katuwa Formation, Me: Melpani Formation, Su: Suntar Formation

general they are well laminated and fissile and crumpled in nature.

Ramkot Formation

Sandstones and shales with some dolomite intercalations constitute the Ramkot Formation. Sandstones are pink to gray and shale/slates are purple to greenish gray to gray. Ripple marks and mudcracks are common in both the sandstone and shales.

Gawar Formation

The formation consists mainly of dolomites, limestone, cherty limestone, orthoquartzite and shales. Dolomites are grey, brownish gray, well bedded and sometimes laminated. Algal structures are common in the dolomites. Limestones are gray to dark gray, well bedded and sometimes cherty in nature. Shales are greenish gray to gray, well laminated, calcareous and at places splintery.

Khara Formation

The formation consists of limestone and shales. The limestones are fine-grained, thinly bedded and greenish gray to pink in color. The limestones are interbedded with gray to greenish gray and purple shales. Pinkish gray limestone and pink and purple shales are dominant in the lower part of the formation.

Katuwa Formation

The formation consists of gray to dark gray and even black shales with gray to dark gray limestone. Shales are well laminated, well banded and slaty in nature. Limestones are fine-grained and siliceous.

Surkhet Group

Melpani Formation

The Melpani Formation bears a fault/unconformable boundary with the underlying Katuwa Formation. The formation consists of carbonaceous quartzite, carbonaceous slates, ferruginous quartzites and slates. The formation also consists of thin coal seams. The Melpani Formation passes upward to the Suntar Formation.

Suntar Formation

It is the youngest formation of the Surkhet Group and consists of alternating fluvial sequence metasandstones and shales with marl bands. Sandstones are generally greenish gray and reddish brown in color, fractured and fine-to medium-grained. Ripple marks are also sometimes present in the sandstone. Similarly, the shales are purple and pink in color.

GYPSUM OCCURRENCES AND QUALITY

No obvious and pure gypsum was found in the area, though the suspected gypsiferous soil and rock samples (KGS-1, KGS-2, KGS-3, KGS-4, KGS-5, RGS-1, RGS-2, RGS-3, LGS-1, LGS-2, JGS-1 and PGS-1) have been collected from five locations within the study area. The samples are from the Sangram Formation of the Midland Group and its near contact with the Melpani Formation of the Surkhet Group. The samples have been submitted to the chemical laboratory of the DMG for quality analysis (Gypsum content) and the result is awaited.

CONCLUSION

- The area does not contain any gypsum deposit of economic interest, but some encrustations are seen in slates of Sangram Formation.

ACKNOWLEDGMENT

We would like to express our thanks to Mr. Sarbajit Prasad Mahato, director general of the DMG for providing all the facilities to carry out this study. Mr. Y. P. Parajuli, assistant sampler of the DMG, deserves lots of thanks for accompanying in the field.

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A Short Review of Compositional Variation of some Limestone Deposits of Nepal

Rita Shrestha (Retd. Sr. Div. Chemist), Dharma R. Khadka (Sr. Div. Geologist) and
Hifzur Rahman (Dy. Director General)

ABSTRACT

Analytical results of limestone samples collected from Kumak Formation, Jhiku Carbonate beds of Benighat Slates, Markhu Marble, Kerabari Formation, Dhanpure Limestone and Baitadi Carbonate rock units from nine locations throughout the country reveal that all these rock units are suitable for the exploration of cement grade limestone deposit. The result shows that Kumak Formation is the best for looking chemical grade limestone as well as for white cement raw material. Low content of CaO in Bhaisedobhan Marble of Kavre and Kerabari Formation of Arghakhachi is probably due to lesser number of samples analysed and geologically dolomitic limestone horizons because the same rock units of Makwanpur and Nawalparasi have potential limestone deposits.

INTRODUCTION

The Department of Mines and Geology (DMG) is the sole government organization under the Ministry of Industry. It is responsible for different kinds of geo-scientific activities in the country such as Geo-Scientific Survey and Research, Mineral Exploration, Engineering and Environmental Geological studies and Seismotectonic studies etc.

The limestone resources of Nepal have been assessed based on the geological investigation deposit. The limestone investigation activities of Nepal dates back to the several decades. As a result, we have been using our own product i.e. cement for housing and infrastructure development. The national contribution of the cement is about 35% based on our own raw material. The current situation of the investigated limestone deposits is more than 1500 million tons mostly scattered in the Mahabharat Range from east to west of the country. The upcoming cement industries in near future will fulfill the national demand

DMG on its own efforts has been evaluating the deposits. The Chemical Lab Sub-Division under the Department of Mines and Geology has been established since the existence of DMG with aim to analyze the rocks, minerals, ores and other geological samples collected by the Geologists, Mining Engineers, Explorers, and Researcher of the department. The Chemical Lab Sub-Division and its services are not only limited to the DMG but also to other public and private sectors in the field of rock and mineral analysis. Present report is based on the chemical analysis results compiled for the last 6 years starting from 2003/04 to 2008/09. The collected samples of limestone and their analytical results from different parts of the country are reviewed.

OBJECTIVE

The objective of the report is to evaluate the compositional variation of the limestone deposit of different lithological units based on the chemical analysis results.

METHODOLOGY

Analytical results of limestone samples were statistically treated and the results obtained so far were analyzed.

GEOLOGICAL SETUP OF THE REVIEWED LIMESTONE DEPOSITS

Geological investigation is essential to find out a potential deposit of any mineral. The surface and subsurface investigations are useful for evaluating deposits. In this context, DMG has been conducting fieldworks for limestone investigation in different parts of the country. Since 2003/04 to 2008/09 DMG has carried out limestone investigation in some parts of Salyan, Udaypur, Kavre, Arghakhjachi, Makwanpur, Syangja, Palpa and Baitadi districts and found some potential limestone deposits in these districts. The geological setup, brief lithological description and location of limestone deposits of above mentioned districts are summarized in the table (Table 1).

DISCUSSION

Chemical analysis results of limestone samples collected by DMG personnel during 2003/04 to 2008/09 are shown in Table-2. It reveals that calcium oxide content in Kumak Formation limestone samples from Salyan was found to be 52.17 % in average. Similarly, the sample collected from Jhiku Carbonate of Benigat Slates of Udayapur has calcium oxide 48.52 % in average. The deposit in Kavre district shows calcium content 29.46 % in average in limestones of Markhu Formation and Chandragiri Limestone. However, there are some places with cement grade limestone deposits in the Kavre district and were studied in the past by DMG. Calcium oxide content was found to be only 29.17 % in average in the samples collected from Kerabari Formation of

Table 1: Geological setup and lithological description of reviewed limestone deposits

S.N.	Location of limestone deposit	Group	Formation	Lithological description
1	Kuvindedaha, Salyan	Upper Nawakot	Kumak Formation	Gray to white fine grained limestone
2	Ghyampathumka, Ahalepakha, Galtar,Udayapur	Upper Nawakot	Banighat Slates (Jhiku carbonate beds)	Fine to medium grained, light gray limestone
3	Rosi Khola area, Kavre	Bhimphedi	Markhu Chandragiri Limestone	Fine to medium grained, gray to white marble with subordinate mica specks parallel to the foliation Fine crystalline limestone, siliceous limestone and dolomite
4	Arghakhachi	Kaligandaki	Kerabari	Fine grained, gray to light gray laminated limestone
5	Northern part of Nawalparasi	Kaligandaki	Kerabari	Fine grained, gray to light gray laminated limestone
6	Malta, Kulekhani, Makwanpur	Bhimphedi	Markhu	Fine to medium grained, gray to white marble with subordinate mica specks parallel to the foliation
7	Dhanpure, Syangja	Sirkot	Dhanpure Limestone	Fine grained, gray to light gray laminated limestone
8	Eastern part of Palpa	Kaligandaki	Kerabari	Fine grained, gray to light gray laminated limestone
9	Rahuleshwor, Baitadi	Baitadi Metasedimentary	Baitadi Carbonate	Fine grained, gray to light gray laminated limestone

(Source: Stocklin and Bhattarai, 1981; Sakai 1984; Dhital et al. 2002, DMG annual reports various issues)

Fig.1: Location of limestone deposits as per analytical results of DMG for the past 6 years (2003/04 to 2008/09)

Arghakhanchi, probably due to the marginal parts of the limestone deposits. This district also has a cement grade limestone quarry in operation since few years back. The samples from Kerabari Formation of Nawalparasi, Markhu Formation of Makawnpur, Dhanpure Limestone of Syangja, Kerabari Formation of Palpa and Baitadi carbonate Formation of Baitadi districts have average calcium oxide content found to be 45.39%, 45.05%, 47.88%, 44.55% and 45.73% respectively which shows the limestone deposits of different formations are of same quality in general except Kumak Formation of Salyan, Markhu Formation and Chandragiri Limestone of Kavre and Kerabari Formation of Arghakhachi (Fig. 2). The level of iron and magnesium content in the limestone of Kumak Formation are found to be very low which might be suitable for white cement production. Average content of MgO in the limestone of Markhu Formation and Chandragiri Limestone of Kavre and Kerabari Formation of Arghakhachi is found to be high which might be due to intercalation of dolomite and dolomitic limestone (Fig. 3).

Table 2: Analytical results showing compositional variation of different limestone deposits

Districts	Salyan	Udayapur	Kavre	Arghakhanchi	Nawalparasi	Makawanpur	Syangja	Palpa	Baitadi
N0. of sample	**136**	**148**	**18**	**30**	**44**	**49**	**332**	**77**	**329**
LOI %									
STDEV	1.3	3.51	6.9	3.63	3.33	5.6	2.34	2.09	2.12
MAX	46.43	45.92	27.83	46.87	43.2	42.6	44.5	43.59	43.87
MIN	37.51	14.69	9.74	28.87	28.66	21.69	27.96	31.66	23.2
AVERAGE	41.47	41.63	19.25	42.89	39.34	36.2	39.16	39.2	39.13
Insoluble%									
STDEV	1.96	2.95	7.45	4.7	4.73	6.57	4.28	4.27	3.68
MAX	10.88	13.91	49.6	19.67	25.5	25.42	23.06	20.86	23.71
MIN	0.37	0.57	30.4	0.79	6.5	5.18	2	3	3.88
AVERAGE	2.62	3.06	38.86	5.81	12.37	13.49	7.8	10.43	9.66
Total Oxide%									
STDEV	1.9	0.78	0.64	1.36	3.16	1.02	1.1	1.71	0.98
MAX	11.45	6.25	4.72	7.96	10.55	5.02	9.32	7.62	9.4
MIN	0.23	0.3	2.7	1.5	0.15	0.82	0.4	0.02	0.32
AVERAGE	1.8	1.22	3.65	2.72	4.16	2.19	1.95	1.99	1.66
Al2O3%									
STDEV	1.84	0.63	0.78	0.93	4.53	0.37	1.08	1.66	0.88
MAX	11.13	3.34	2.83	4.74	24.1	1.27	9.12	7.38	7.6
MIN	0.16	0.1	0.71	0.93	0.1	0.04	0.01	0.29	0.04
AVERAGE	1.7	0.9	1.69	2.18	4.18	0.7	1.56	1.71	1.2
Fe2O3%									
STDEV	0.12	0.35	0.32	0.4	0.82	0.68	0.25	0.13	0.31
MAX	0.8	3.83	2.5	2.28	3.9	2.71	1.46	0.99	2.74
MIN	0.01	0.02	1.44	0.12	0.04	0.26	0.06	0.1	0.1
AVERAGE	0.13	0.27	1.9	0.47	0.64	1.06	0.36	0.28	0.45
CaO%									
STDEV	5.23	6.9	2.4	6.24	8.8	4.41	4.01	4.5	5.04
MAX	55.43	54.32	35.4	52.15	53.97	51.52	54.67	55.73	52.43
MIN	5.32	30.49	25.56	8.13	30.14	35.4	28.7	30.49	10.9
AVERAGE	52.17	48.52	29.46	29.17	45.39	45.05	47.88	44.55	45.73
MgO%									
STDEV	2.75	6.28	4.59	5.17	6.6	1.95	1.42	2.14	2.27
MAX	22.68	22.17	15.7	22.17	20.66	9.2	11.84	9.58	16.64
MIN	0.2	0.2	3.27	1	1.76	0.63	0.12	0.5	0.12
AVERAGE	1.85	4.72	10.11	16.81	12.22	2.76	2.77	2.13	2.72

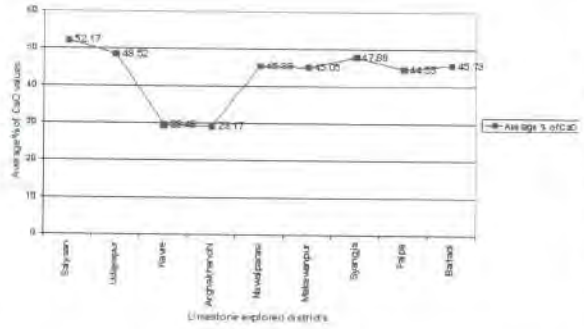

Fig. 2: Average % of CaO of analyzed limestone for different districts

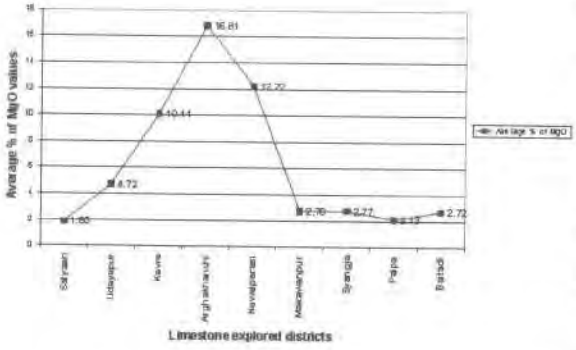

Fig. 3: Average% of MgO of analyzed limestone samples for different districts.

CONCLUSION AND RECOMMENDATION

Analytical results of limestone samples collected from Kumak Formation, Jhiku Carbonate beds of Benighat Slates, Markhu Marble, Kerabari Formation, Dhanpure Limestone and Baitadi Carbonate rock units reveal that all these rock units are suitable for the exploration of cement grade limestone deposit. The overview of these formations shows that Kumak Formation is the best for looking chemical grade limestone as well as for white cement raw material. Low content of CaO in Bhaisedobhan Marble of Kavre and Kerabari Formation of Arghakhachi is probably due to lesser number of samples analysed and geologically dolomitic limestone horizons because the same rock units of Makwanpur and Nawalparasi have potential limestone deposits.

Sustainability of the Industry is very much dependent on the continuous availability of the raw materials. Quality of the product is determined by the quality of the raw materials used which can be ascertained by the laboratory test reports. If the test reports from the laboratory are not right/perfect/true/reliable, it will effect the quality of the end product and ultimately to the whole economy. Reliability of the test report is dependent on the qualification and skill of the analyst as well as availability of the physical resources. To get reliable test report from the chemical laboratory of DMG there is a need to upgrade the laboratory facilities and skill of the involved manpower.

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Mineral Resources Status and Opportunities for Development in Nepal

Ram P. Ghimire (Sr. Div. Mining Engineer)

BACKGROUND

Mineral Resources plays an important role in the development of a nation. They are one of the main natural resources and are valuable for the economic upliftment and development of the country. They constitute the important raw materials for industry as well as the basic needs for the human beings. Mineral resources are essential for the agricultural, industrial development, creation of employments, fulfillment of basic needs, source of fuel, source of public revenue, etc.

Nepal is a Himalayan country with about 83% of its area lying in mountains and 13% lying in the Gangetic Plain. The mountainous region with its geological environment is suitable for metallic, nonmetallic/ industrial and fuel mineral deposits as well as huge amount of construction materials and dimension/ decorative stones. While in the plain, is potential for the fuel minerals. Continues efforts are extremely necessary to find out more mineral deposits, timely exploitation of these known resources and make multiple uses of these mineral commodities for the benefit of the people.

STATUTORY ARRANGEMENT FOR MINERAL RESOURCES EXPLOITATION

The Government of Nepal has formulated timely relevant Acts and Regulations to promote mineral exploration and development in the country. Accordingly, two separate Acts and corresponding Regulations exist to deal with different minerals, categorized into two groups, namely: (1) All mineral resources (except petroleum) and (2) Petroleum. The Acts and Regulations relating directly to mineral resources exploration and development are as follows:

- Mines and Mineral Resources Act, 2042 (1985) with First Amendment, 2050 (1993).
- Mines and Mineral Resources Regulation, 2056 (1999).
- Nepal Petroleum Act, 2040 (1983).
- Petroleum Regulation, 2041 (1985) with First Amendment, 2046 (1989) and Second Amendment, 2051 (1994).
- Petroleum Industry [Income Tax] Regulation, 2041 (1985).

The Mines and Mineral Act, 2042 (1985) as amended in 2050 (1993) and the Mines and Mineral Regulation 2056 (1999) constitute the legal framework for operation, regulation and administration of the mineral development activities in Nepal.

The Act and Regulation give equal access and status to all qualified Nepalese Citizens and foreigners. It is promulgated to operate, regulate and administer exploration and mining of all minerals with exception of petroleum and natural gas.

The regulation categorizes the different Mineral Resources as given in Tables 1 and 2.

The regulations provide two stages of licensing system. Any person having the specific technical and financial capabilities to undertake mining operations can obtain:

- **Prospecting License** for a mineral resource target where the grade and volume has not yet been determined and

- **Mining License** in the case of a mineral deposit of which quality and volume has already been established by the department after certain stages of exploration.

A prospecting license allows the license holder to conduct exploration in an area not less than 0.25sq.km and not more than 250sq.km for an initial exploration period of 2 to 4 years with a provision for an extension of successively 2 years. Exploration activities should be completed within 2 years for ordinary non-metallic minerals where as 4 years for metallic and valuable non-metallic minerals.

A Mining license allows the license holder to conduct mineral exploitation works in an area not less than 0.25 sq. km and not more than 25 sq. km for an initial period of 10 to 30 years depending on the level of mineral works with a provision for an extension of an additional 1 to 10 years.

A Mining license can also be issued to any eligible person for those mineral deposits identified by the

exploration activity of DMG. In such a case, the direct expenses incurred by the department in the exploration of the project can be valued and converted into the share

The regulation provides the following technical and financial capacity provisions before issuing any kinds of License (Table 3).

Table 1 : Categorization of the Minerals according to type

Metallic Minerals	Non-Metallic Minerals
Gold, Uranium, Platinum, Thorium, Tin, Silver, Lead, Copper, Nickel, Cobalt, Zinc, Tungsten, Molybdenum, Beryllium, Niobium, Tantalum, Chromium, Vanadium, Bismuth, Titanium, Aluminum, Iron, Others than the non-metallic minerals	Diamond, Ruby, Sapphire, Emerald, Corundum, Topaz, Tourmaline, Garnet, Aquamarine, Kainite, Beryl, Magnesite, Talc, Natural Gas, Limestone, Phosphate, Crystal Quartz, Feldspar, Calcite, Dolomite, Ammonites and Fossils, Graphite, Gypsum, Salt, Industrial soil, General soil, Fireclay, Silica Sand, Kaolin, Mica, Coal, Lignite, Marble, Granite, Cyanide, Amphibolites, Quartzite, General Construction Materials and Slate, Decorative Stone

Table 2: Categorization of the Minerals according to Importance and Valuability

Very Important Minerals	Important and Valuable Minerals	General Minerals
Gold, Uranium, Platinium, Thorium, Diamond, Ruby, Sapphire, Emerald, Corundum	Tin, Silver, Lead, Copper, Nickel, Cobalt, Zinc, Tungsten, Molybdenum, Beryllium, Niobium, Tantalum, Chromium, Vanadium, Bismuth, Titanium, Topaz, Tourmaline, Garnet, Aquamarine, Kainite, Beryl, Magnesite, Talc, Natural Gas, Limestone, Phosphate, Crystal Quartz, Feldspar, Calcite, Dolomite, Ammonites and Fossils, Graphite, Gypsum,	Aluminum, Iron, Industrial soil, General soil, Fireclay, Silica Sand, Kaolin, Mica, Coal, Lignite, Marble, Granite, Cyanide, Amphibolites, Quartzite, General Construction Materials and Slate, Decorative Stone, Any other minerals which do not fall on Very important and Important and Valuable minerals

Table 3: Technical and financial capacity provision for issuing of licence

Minerals	Experience of the Prospector	Financial Capacity Amount in NRs. per Sq. Km	
		Prospecting	Mining
Very Important	2 Years	400000	3000000
Important and Valuable	2 Years	200000	2000000
General	1 Year	100000	1000000

or they can be recovered from the qualified applicant as the Government desires to do so.

The Mines and Mineral Act and Regulation also outline the following provisions in regards to:

- Right of access to use the land
- Departmental approval to send the samples for laboratory testing and analyzing outside the country
- The Government of Nepal possesses the exclusive right to engage in mineral works either undertaking mining operations directly or have such operations conducted by any other individual by granting a license.
- The Government of Nepal has right to participate in the mineral development activities as a partner in terms of capital sharing or any other form of contributions
- To pay attention to good practice in mining, quarrying, mine safety and miner's welfare.
- Mining activities shall be undertaken in an environmentally responsible manner.

The Regulation entitles the license holder to acquire a mining right over an area of between 0.25 sq. km and 25 sq. km for a period of 5, 10, 20 or 30 years according to the size of mining operations categorized as very small, small, large and very large respectively. Table below describes the Categorization of the Mines according to the size:

The Regulation also offers the lessee to enjoy several rights and benefits while undertaking mining activities. Some of the main features are:

- Right to use the land and material required for the mining activities
- Permission to import machinery and equipment for use in the mining activities.
- Royalty recovered based on the mineral commodities and production
- Right to sale and export the products of mining activities

The royalty of a mineral produced is charged by the government primarily on the basis of mineral production, its type and quality. Accordingly, the minerals are grouped into metallic, non-metallic, fuel and construction minerals. The royalty for a metallic mineral is charged in terms of metal production where as for other mineral it is fixed on the basis of production of the commodity.

The present rate of corporate Income tax is up to 25 percent. Income tax is not levied on the interest on foreign loans. There is a provision for deduction of expenses from taxable corporate income. Expenses wholly or exclusively incurred in the generation of income are deductible from taxable income. In addition, the government also follows necessary action to avoid double taxation on income of foreign investors while concluding the agreement or granting the license.

MINERAL RESOURCES CLASSIFICATION

It is the classification of mineral deposits based on their geologic certainty and economic value.

Mineral deposits can be classified as (Tables 4 and 5):

- **Mineral occurrences** or prospects of geological interest but not necessarily of economic interest
- **Mineral resources** that are potentially valuable, and for which reasonable prospects exist for eventual economic extraction
- **Mineral reserves** or Ore reserves that are valuable and legally and economically and technically feasible to extract.

In common mining terminology, an "ore deposit" by definition must have an 'ore reserve', and may or may not have additional 'resources'.

Mineral reserves are resources known to be economically feasible for extraction. Reserves are either **Probable Reserves** or **Proven Reserves**. Generally the conversion of resources into reserves requires the application of various modifying factors, including:

- mining and geological factors, such as knowledge of the geology of the deposit sufficient that it is predictable and verifiable; extraction and mine plans based on ore models; quantification of geotechnical risk—basically, managing the geological faults, joints, and ground fractures so the mine does not collapse; and consideration of technical risk—essentially, statistical and variography to ensure the ore is sampled properly:

Table 4: Categorization for Metallic Mineral

Mining Type	Very Small	Small	Medium	Large
Underground Mining	Upto 10 Tons/day	Upto 100 tons/day	Upto 500 tons/day	More than 500 tons/day
Opencast Mining	Upto 25 Tons/day	Upto 250tons/day	Upto 1000 tons/day	More than 1000 tons/day

Table 5: Categorization for Non-Metallic Mineral

Mineral Resources	Very Small	Small	Medium	Large
Decorative Stone	Upto 3 cu. m	Upto 15 cu. m	Upto 60 cu. m	More than 60 cu. m
Soil	Upto 25 cu. m	Upto 100 cu. m	Upto 400 cu. m	More than 400 cu. m
General Construction Stone				
1. Stone	Upto 25 cu. m	Upto 150 cu. m	Upto 500 cu. m	More than 500 cu. m
2. Slate Stone	Upto 50cu. m	Upto 600 cu. m	Upto 3400 cu. m	More than 2400 cu. m
3. Concrete	Upto 20 cu. m	Upto 100 cu. m	Upto 400 cu. m	More than 400 cu. m
4. Sand and Gravel	Upto 50 cu. m	Upto 200 cu. m	Upto 800 cu. m	More than 800 cu. m
Natural Gas	Upto 100 cu. m	Upto 10000 cu. m	Upto 50000 cu. m	More than 50000 cu. m
Other Non- Metallic Minerals not listed above				
Underground Mining	Upto 10 Tons/day	Upto 100 tons/ day	Upto 500 tons/day	More than 500 tons/day
Opencast Mining	Upto 20 Tons/day	Upto 200 tons/ day	Upto 1000 tons/day	More than 1000 tons/day

- metallurgical factors, including scrutiny of assay data to ensure accuracy of the information supplied by the laboratory—required because ore reserves are bankable. Essentially, once a deposit is elevated to reserve status, it is an economic entity and an asset upon which loans and equity can be drawn—generally to pay for its extraction at (hopefully) a profit;
- economic factors;
- environmental factors;
- marketing factors;
- legal factors;
- governmental factors; and
- social factors

MINERAL RESOURCES POTENTIAL AND ITS STATUS IN NEPAL

Nepal can be divided into five distinct morpho-geotectonic zones from south to north. From mineral resources point of view, the southernmost Terai Plain is potential for gravel, sand, ground water, petroleum and natural gas. The Sub Himalaya (Churia/ Siwalik foot hills) is the potential area for construction materials, radioactive minerals, petroleum, natural gas and minor amount of coal. Similarly, Lesser Himalaya has prospect for metallic minerals mainly Iron, copper, lead, zinc, cobalt, nickel, tin, tungsten, molybdenum, gold, uranium rare metals etc.; non-metallic minerals like magnesite, phosphorite, limestone, dolomite, talc, clay, kaoline etc.; gemstones like tourmaline, aquamarine/ beryl, garnet, kyanite, etc; fuel minerals e.g. coal, lignite, methane gas, petroleum and natural gas, hot springs and radioactive minerals; and voluminous construction materials crushed gravel as well as river boulders, gravel. The areas in Higher Himalaya are highly promising for precious and semiprecious stones, marble and metallic minerals like lead, zinc, uranium, gold etc. Tibetan Tethys zone is prospective for limestone, gypsum, brine water (salt) and natural gas.

However, because of rugged topography, difficult mountain terrain, complex geology, lack of infrastructures and financial constrain exploration and exploitation of these mineral resources in Nepal is still challenging. The table below presents the status of Mining Activities till the fiscal Year 2067/68.

It can be seen from the Table 6 that around 500 prospecting license had been issued for twenty different kinds of minerals all over Nepal. Till now, it can be observed that much of the entrepreneurs had taken interested in exploration of Limestone followed by gold, tourmaline, copper and talc.

Similarly, 79, (seventy nine) mining license has been issued exploitation of 10 (ten) different kind of minerals. Following the trend of prospecting license, it can be observed that 30 mining license has been issued to limestone, followed by coal, talc, red clay and kyanite. The allocation of Mining license for the limestone has been regionally balanced spreading from Dhankuta in the East to Surkhet in the West, but much of the concentration is in Makwanpur, Palpa and Dang. With this development, new cement Industries has come up in Dhankuta, Hetauda, Rupendehi and Dang. In this trend of development in the cement industries, Nepal will be self sufficient in cement in 3 to 5 years to come.

Table 6: Prospecting and mining licence issued by DMG (up to Fiscal Year 2067/2068)

Sl. No	Prospecting Licence Renewed		Prospecting Licence 2067/068		Mining Licence Renewed		Mining Licence New 2067/68	
1	Limestone	135	Calcite	3	Coal	19	Quartzite	1
2	Magnesite	1	Coal	4	Kyanite	5	Iron Ore	1
3	Quartz	5	Copper	7	Limestone	29	Limestone	1
4	Garnet	1	Dolomite	1	Marble	4	Red Clay	1
5	Quartzite	11	Gold	20	Mica	2	Talc	1
6	Granite	2	Graphite	2	Quartz	1	**Total**	5
7	Iron Ore	15	Iron Ore	7	Quarzite	1		
8	Tourmaline	3	Kyanite	17	Red Clay	6		
9	Kyanite	11	Lead	2	Talc	5		
10	Marble	2	Limestone	45	Tourmaline	2		
11	Red Clay	4	Mica	2	**Total**	74		
12	Talc	20	Placer Gold	17				
13	Placer Gold	20	Quartz	5				
14	Aquamarine	1	Quartzite	6				
15	Coal	21	Ruby	1				
16	Dolomite	8	Talc	15				
17	Copper	30	Tourmaline	36				
18	Lead	6	**Total**	**190**				
19	Gold	10						
20	Mica	2						
	Total	308						

The next promising development in the mineral sector is in Talc, though till now it has been an export commodity only with one step processing (grinding). This mineral is exported to India only. Similarly, minerals like Tourmaline, Kainite and Quartz are extracted and exported in their raw form.

Though the mining license for coal seems to be in large number, but the size and scale of these mines is small and the quality of the coal is very low; generally the peat.

In the metallic mineral sector, one mining license has been issued recently for Iron in Parbat district and one is in process of obtaining in Ramechap.

OPPORTUNITIES FOR MINERAL RESOURCES DEVELOPMENT IN NEPAL

a) Conducive Policy Environment

The existing Mines and Mineral development Act, Regulations, the Industrial Development Policy and other relevant policies provides an ample and conducive environment for entrepreneurs and foreign investors for investing in the mines and mineral industries in Nepal. The government is supporting in building infrastructures, like road, transmission lines and others in the proven mineral deposits together with other facilities like tax exemption in importing machineries etc.

b) Mostly Virgin (Unexplored) Areas (Higher Himalaya)

Department of Mines and Geology is only the sole agency for the research and exploration of minerals in Nepal, other than the private entrepreneurs. Due to limited resources, DMG and other entrepreneurs are not able to explore much of the areas; mainly in the higher Himalayas. Thus most of the areas of Higher Himalaya lie virgin with potentiality of mineral resources.

c) Huge Market Exist

With the exploration and proven minerals resources, there exist huge market in Nepal, along with India and China. China and India being the countries in their full development process are the huge market of any minerals that can be exploited in Nepal.

CHALLENGES IN MINERAL RESOURCES DEVELOPMENT

a) Rugged Mountainous Area

Physiographically, hills and mountains cover almost 83% of the land mass; which is the main challenge for mineral resources development. The rugged terrain of hills and mountains posses challenge in undertaking research and exploration in these areas.

b) Inadequate Infrastructures

Together with rugged mountainous area, the exploration work is further hindered with lack of infrastructures. Limited network of road facilities, electricity and other infrastructure possesses difficulty in the exploration and exploitation of the mineral resources available in the country.

c) Inadequate Skilled Manpower

The above challenges are more aggravated by inadequate skilled manpower in the country. Except for the geologist, other human resources like mining engineers, geo-physicist, geo-chemist, metallurgist and chemical engineers are very few and in few years to come can be counted in fingers.

d) Socio-Environment Constraints

Other than the above challenges, the social and environmental factors are also the main challenges for the development of mineral resources. The understanding and coordination, together with the partnership gap, with the people in the probable areas for exploration and potential areas for exploitation possesses cohesion while undertaking research, exploration and exploitation. Further Industrial output is based on mineral exploitation and is the principal determinant of our standard of living. Industrial output also influences the amount of food produced (both positively and negatively) and the amount of pollution generated (usually negatively).

Mining operations do not occur in isolation and without impact on the society and environment in which they operate. This observation may seem right, but in some cases the most significant impacts are not the obvious, direct impacts of mining-derived metals on the environment.

Designers and managers of mines, especially in developing countries, will have to ensure that such impacts are ameliorated. This can only be tackled by ensuring that mines are run as an integral part of development plans. In Nepal, local and provincial authorities do not have the capacity to engage in the process of mine planning. This must be taken into account during the pre-feasibility stage of mine planning and, just as an environmental protection premium is now a part of any mine costing exercise, a development and capacity building premium must be included into mine valuation.

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Landslide Hazard Zonation Mapping in Parts of Baglung, Gulmi, Myagdi and Pyuthan Districts, Western Nepal (Toposheet No.2883 09)

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ABSTRACT

A Landslide Hazard Zonation map of parts of Baglung, Gulmi, Myagdi and Pyuthan District is prepared using bivariate statistical method at 1: 50,000 scale. Geology, landuse, slope and slope aspect were considered to be the main causative factors for landslides. The study area is classified into high, moderate and low hazard zones indicating likely hood of occurrence of landslides as high, moderate and low respectively. Out of 650 sq.km of the study area about, 218 sq.km is covered by highly unstable zone forming 32 % of the total area. About 51% of the area is on moderate zone and 17% is on low hazard zone. The hazard zonation map is expected to be useful for planning in infrastructure development activities in the region.

INTRODUCTION

Landslide mapping and inventory was carried out to prepare Hazard Zonation map of parts of Baglung, Gulmi, Myagdi and Pyuthan Districts in Western Development Region. The survey covered 650 sq. km area of toposheet no. 2883 09 (62P/3) during a field period of 11 days from 21st Asadh to 31st Asadh 2067. The study is a part of the annual program of the Department of Mines and Geology, fiscal year 2066/67 to collect data on landslides at regional scale.

The area is located between latitudes 28° 15' 00" to 28° 30' 00" N and longitudes 83° 00' 00" to 83° 15' 00"E. Uttar ganga and Barigad river with their tributaries Nishi Khola, Bhuji Khola, Bhim Khola, Khum Khola and Kut Khola are draining the study area. The Uttar Ganga flows almost along west to east direction in the northern most part. The Barigad river flows almost along north-south direction. The lowest elevation in the area is 800 m from msl near Bagah and the highest altitude is 4043 m from msl at Bayali Dhuri located at the northwest corner of the study area.

Traverses were made along river valleys, main trails and along the ridges for verification of erosion features interpreted on aerial photos and satellite images. Field survey was focused on collecting data for landslide inventory and their distribution using 'Inventory Forms' and mapping of various factors that are mostly responsible for triggering landslides. Data collected during field verification and desk level interpretation were integrated for the preparation of factor maps. All collected data were analyzed using GIS techniques to prepare landslide hazard zonation map at 1:50,000 scales.

OBJECTIVES

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

- To record the landslides of the study area using 'Landslide Inventory Form'.
- To integrate landslide distribution and geologic data with slope morphology and existing land use for the preparation of landslide hazard zonation map at 1:50,000 scale by optimum utilization of Remote Sensing and GIS techniques.
- To prepare the regional database of landslides.

BACKGROUND

The Badigad Khola a major tributary of the Kaligandaki River passes through northwest part of the area. Geological Studies have been carried out by a number of researchers in the Badigad Khola area. Jnawali (2039) did the geological mapping covering the target area. The area is represented by metasedimentary rock sequences of Pre-Cambrian age comparable to Upper and Lower Nuwakot Group. Several thrusts, faults and folds of regional scales are also mapped indicating weak tectonic belts.

Information on probability of occurrence of natural disasters such as landslides is not available for this area. In this context present study program has been planned to provide geo-scientific information

especially on landslide hazards beneficial for planning of infrastructure development activities in the region.

METHODOLOGY

Desk Study

Aerial photographs taken on 1979 at 1:50,000 scales acquired from the Survey Department were interpreted to study the landslides, erosion features, tectonic structures, existing landuse pattern and lithological units. The False Color Composite of Landsat-TM images of December 1992 was studied as supplement to the aerial photographs for comparing the landuse pattern, landslides, tectonic structures of regional significance. Land Capability, Land Utilization and Land System maps were studied. The topographic maps at 1:25,000 scales were used as a base map for the field data collection together with aerial photographs. Geological maps and reports were also reviewed. Different Thematic layers, their sources, parameters used and the method of generation are summarized in Table 1.

Field Investigation

Field checking and data collection was carried out taking traverses along different routes using landslide inventory form, aerial photos and topographical maps. Emphasis was given to study the landslides and other areas prone to soil erosion by close observation. Some of the major landslides were studied in details using 'Preliminary Landslide Inventory Form' for regional inventory.

GEOLOGY

Meta-sedimentary rocks such as phyllites, of the Kumkhani Formation (Jnawali, 2039), light grey to dark grey Dolomitic limestone of Kalenchaur Dolomite and purple greenish grey slaty phyllite and shale of Babang Formation are observed around north and north-east part in the catchment area of Bhuji Khola. White to light grey coarse crystalline marble and biotite garnet Schist are observed in the southern part. These rocks are of Precambrian age. Unconsolidated soils such as residual, alluvium and colluvium (including talus) deposits were mapped within the study area. River terraces developed in this area are often covered by colluvium deposits derived from the high hills laying on either side of the river valley. These river terraces are cultivated and have settlements near the riverbanks. However, these areas still lack proper infrastructures like road, electricity and irrigation. Hill slopes are also cultivated except in the remote areas. Improper cultivation practices have often triggered landslides damaging property worth of millions of rupees.

PREPARATION OF FACTOR MAPS

A landslide distribution map (Fig. 1a) was prepared by compiling various sources of information and the data from field checking. In this case, the landslide distribution map contains active and reactivated landslides. Similarly the factor maps with various parameters that are mostly responsible for land sliding were prepared using GIS system by incorporating the data obtained from desk study and field verification.

Table 1: Data overlays, Sources, Parameters and Method of generation

Data overlays	Database /sources	Parameters	Method of generation
Geology	Geological maps from DMG[1], aerial photographs / SD[2], LANDSAT -TM / BGR[3], and ADEOS-AVM/ ICIMOD[4]	Lithology and Rock type	VI[6], FC[7] and GIS
Structure	Geological maps from DMG[1], aerial photographs / SD[2], LANDSAT -TM / BGR[3], and ADEOS-AVM/ ICIMOD[4]	Lineaments, regional structures and Dip slope relationship	VI[6], FC[7], GIS and image processing
Topography	Topographical map in digital format/ SD[2]	Topographic features, slope gradient / direction	GIS based Digital Elevation Model (DEM)
Slope	Topographical map in digital format, and aerial photographs / SD[2]	Classification of slope	FC[7] and GIS
Slope aspect	Topographical map in digital format, and aerial photographs / SD[2]	Classification of slope direction	GIS based Digital Elevation Model
Land use	Topographical map in digital format, maps from LRMP[5] and aerial photographs / SD[2]	Classification of Landuse	VI[6], FC[7] , GIS and image processing
Landslide	Topographical map in digital format, aerial photographs / SD[2] and LANDSAT -TM /BGR[3], and ADEOS-AVM/ ICIMOD[4]	Landslide occurrences and gully erosion	VI[6], FC[7] , GIS and image processing

DMG[1] : Department of Mines and Geology, Kathmandu. SD[2]: Survey Department, Kathmandu
BGR[3] : Federal Institute for Geo-science and Natural Resources, Hanuover, Germany
ICIMOD[4] : International Centre for Integrated Mountain Development, Kathmandu
LRMP[5] : Land Resources Mapping Project, Kathmandu. VI[6]: Visual Interpretation. FC[7]: Field Checking

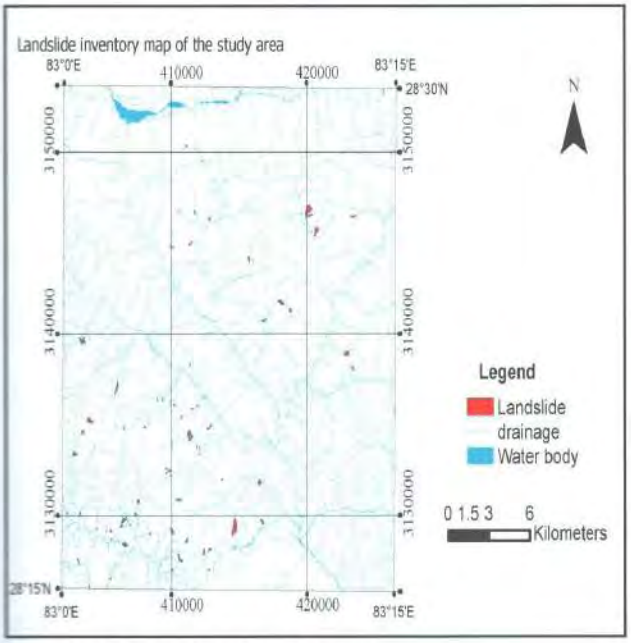


Fig. 1a: Landslide distribution map

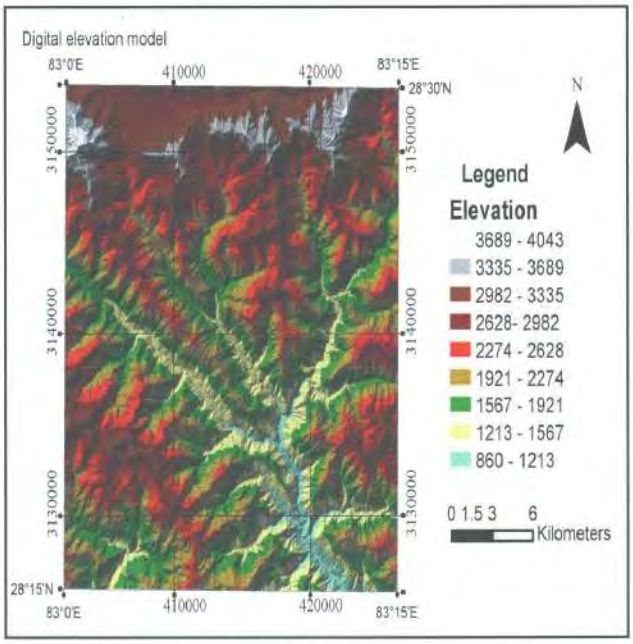


Fig. 1b: Digital Elevation Model

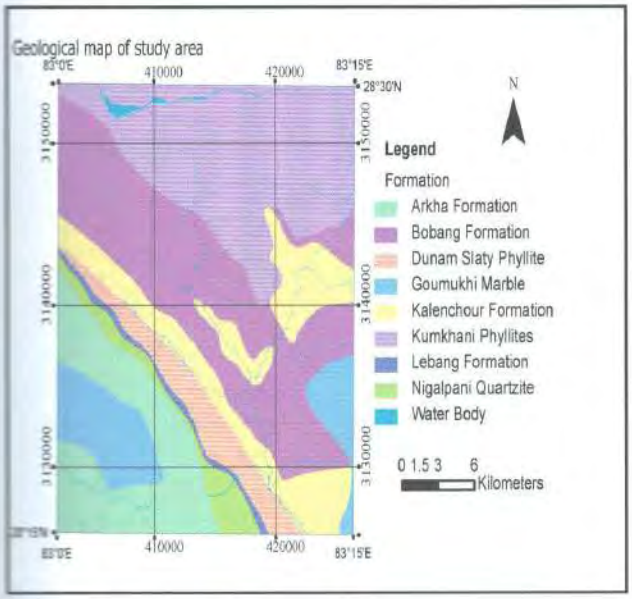


Fig. 1c: Geological Map

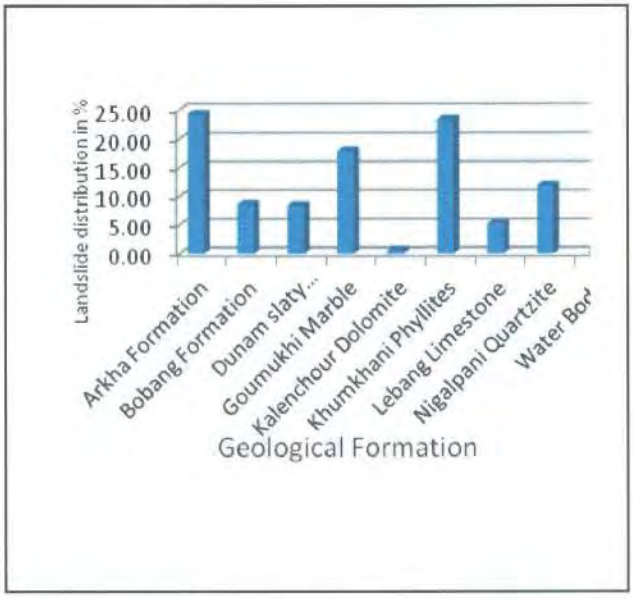


Fig. 1d: Relation between Landslide and Geology

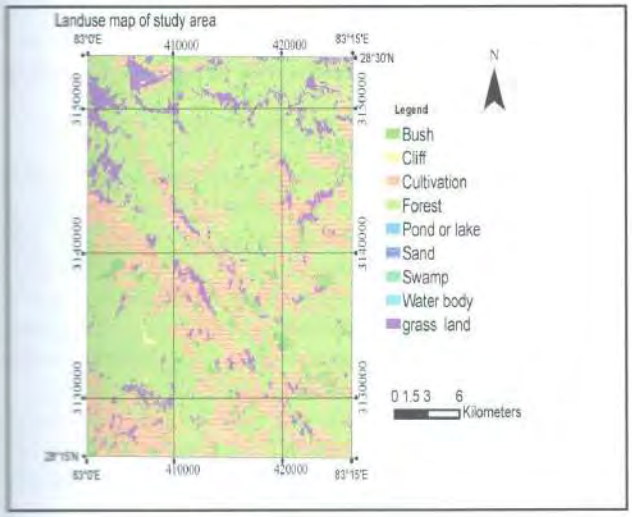


Fig. 1e: Landuse type map

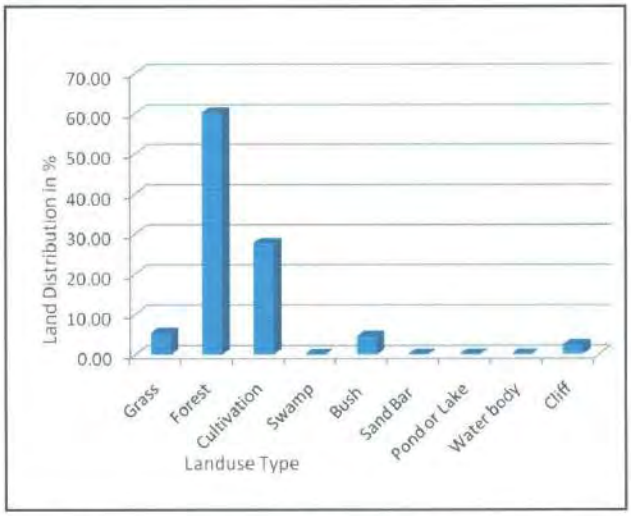


Fig. 1f: Relation between Landslide and Landuse type

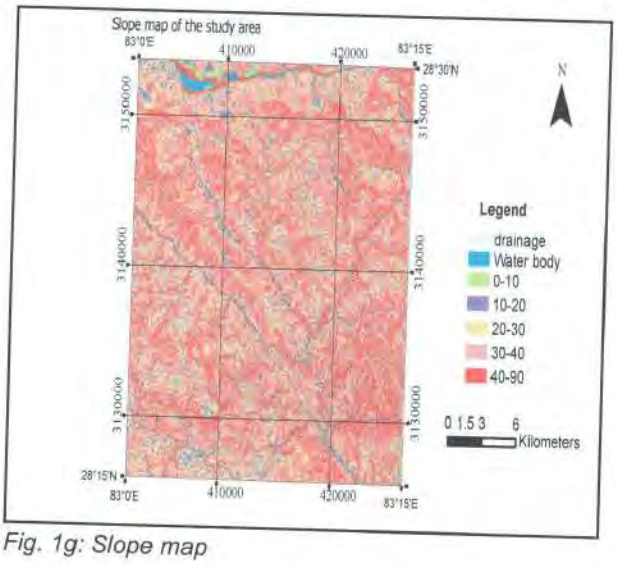


Fig. 1g: Slope map

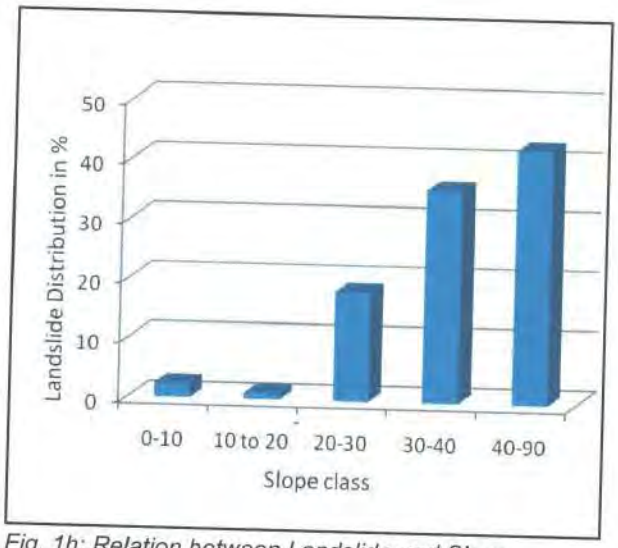


Fig. 1h: Relation between Landslide and Slope

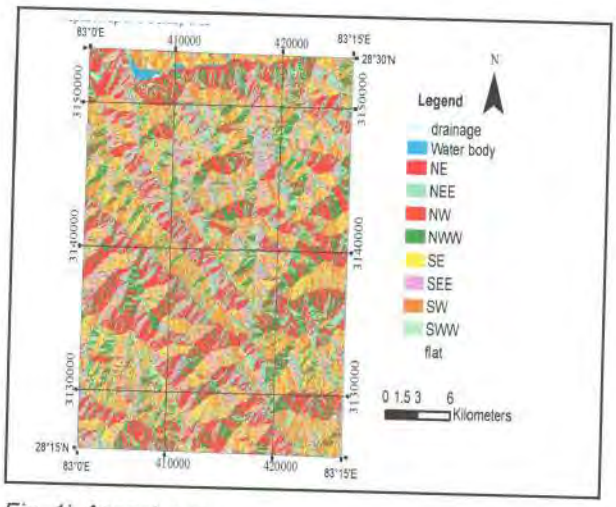


Fig. 1i: Aspect map

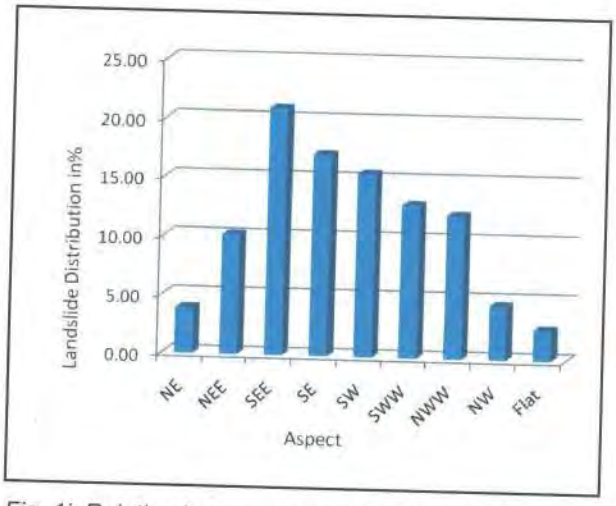


Fig. 1j: Relation between Landslide and Aspect

Fig. 1: Various factor maps showing their relation with the landslide distribution

Slope Map, and Aspect Map were generated using a Digital Elevation Model (DEM, Fig. 1b). In the present study, factors such as geology (Fig. 1c), land use (Fig. 1e) slope (Fig. 1g) and aspect (Fig. 1i) were considered for the assessment of probability of landslide hazard at regional scale. The statistical relationships of landslide distribution to various causative factors are summarized in figures 1d, f, h, and j.

ROLE OF REMOTE SENSING DATA AND GIS IN LANDSLLIDE HAZARD STUDY

Data acquired by the remote sensing techniques are becoming better in resolution and user friendly to integrate in GIS system. In this context, Remote Sensing and GIS are widely used to evaluate the degree of danger from landslide in an area by considering the nature of causative factors in the surroundings. Different models are proposed and used to assess the relative likelihood of landslide occurrence by different researchers. The present study was based on bivariate statistical method and deals with one of the dependent variable like landslide density and other independent variables such as geology, landuse, slope and slope aspect. The following formula was used (after Van Westen, 1993) for the present analysis.

INVESTIGATION RESULTS

Slope failure processes noted on satellite image, aerial photographs, topographical maps and geological maps were verified in the field. Areas prone to soil erosion by gully formation and land sliding were also recorded during field checking. Majority of the slides are soil slides. Rockslides are also triggered in intensely fractured rock mass. Discontinuities affecting rock mass are joints, bedding planes, foliations, thrusts or faults. Wedge and planner failure are common in rock mass. Rotational and translation features were observed in the soil mass resulted mainly due to over saturation and toe scouring of the slope by the rivers.

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

Where,

W_i = Weight given to a certain parameter class

Densclas = Landslide density within the parameter class

Densmap = Landslide density within the entire map.

Road to Burtibang from Wame Taxar is affected by rockslides and soil slides at different locations (Photos 1 and 2). Due to heavy rainfall the newly constructed road is highly affected by the slides at many places.

Based on the field verification, aerial photo interpretation and satellite image interpretation, landslide distribution map was prepared. Various parameters mapped on landuse map, geological map, slope class map and aspect map were used as causative factors for causing the landslide. Landslide inventory map was taken as base to calculate the rating values of causative factors to derive the Landslide Hazard Zonation Map using Arc GIS.

Main causes for the occurrence of landslide in the area can be attributed to intense fracturing of rock mass, difference in relief forming steep slopes, improper slope cultivation practices and toe scouring of adjacent slopes of high gradient rivers or streams and high intensity of rainfall.

Photo 1: Road blocked by slide due to heavy rain on the way to Burtibang from Wami Taxar

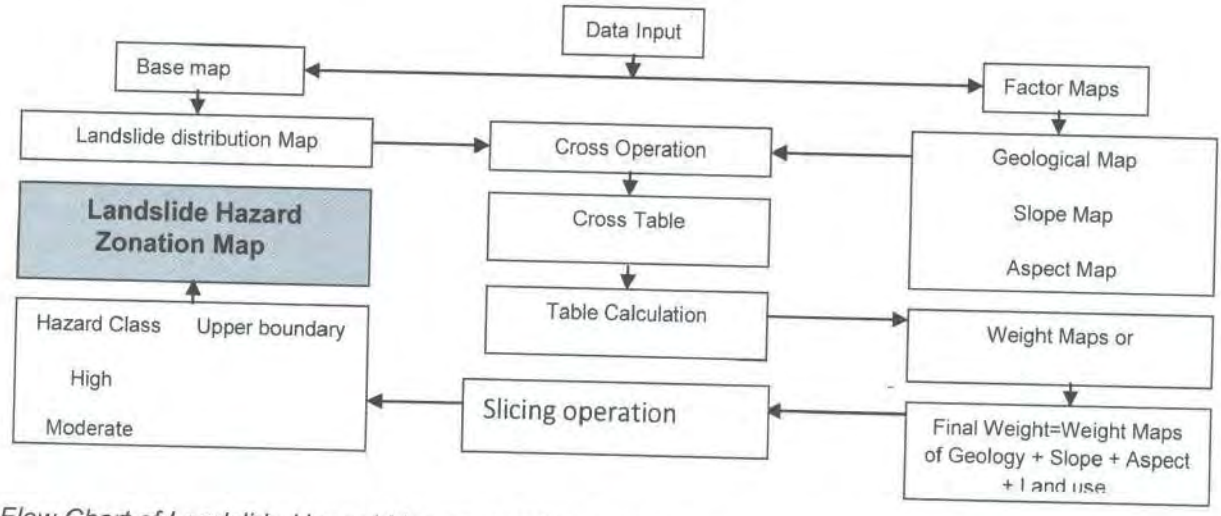
Photo 2: Landslide at the left bank of Barigad River near Burtibang

PREPARATION OF LANDSLIDE HAZARD ZONATION MAP

Based on the density of landslide distribution in each class/unit of the causative factors at present situation a landslide hazard zonation map (Fig. 2) was prepared and divided the entire study area into three categories predicting probability of danger from landslide. Since each unit of the factor map has different weight value derived according to the density of landslide distribution within the unit, the addition of all the weight values for a certain region was carried out during the statistical calculation. After calculation of total weight for hazard coverage the area was subjectively classified into three different zones as low, moderate and high hazard. Process of hazard zonation is summarized in the following flow chart.

RESULTS OF STATISTICAL ANALYSIS

The Landslide Distribution Map (Fig. 1a) was combined with the Landslide Hazard Zonation Map (Fig. 2) using overlay option in Arcview environment. Density of landslide distribution within each hazard zone was calculated. In the present study area 90.59 % of the landslides were found to be distributed in high hazard zone; nearly 8.8 % in moderate and only 0.52 % in low hazard zone suggesting a satisfactory precision of the adopted method for probability of landslide occurrence in this area. The relation between hazard class and causative factors (Fig. 3a, b, c, and d) was also evaluated to assess the effect of various factors for estimating the range of instability in the region in terms of probability of landslide hazard.



Flow Chart of Landslide Hazard Map preparation process

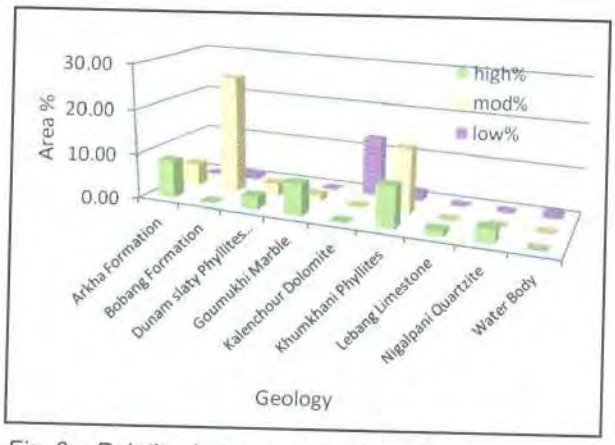


Fig. 3a: Relation between hazard and Geology

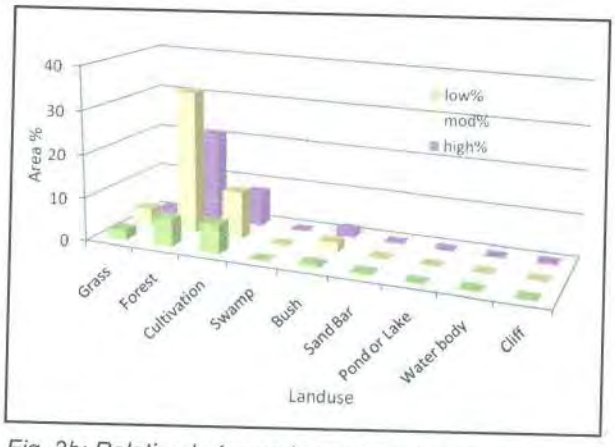


Fig. 3b: Relation between hazard and Landuse

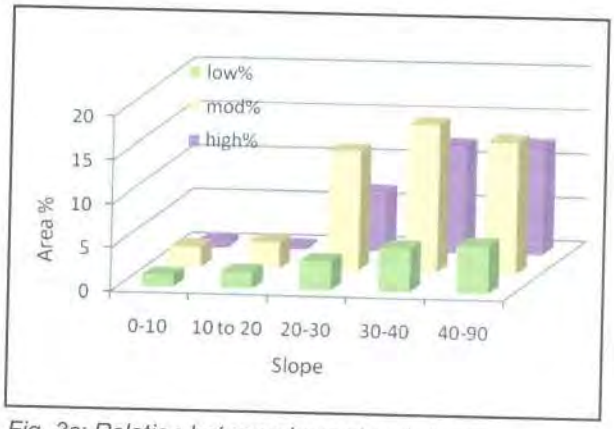


Fig. 3c: Relation between hazard and slope

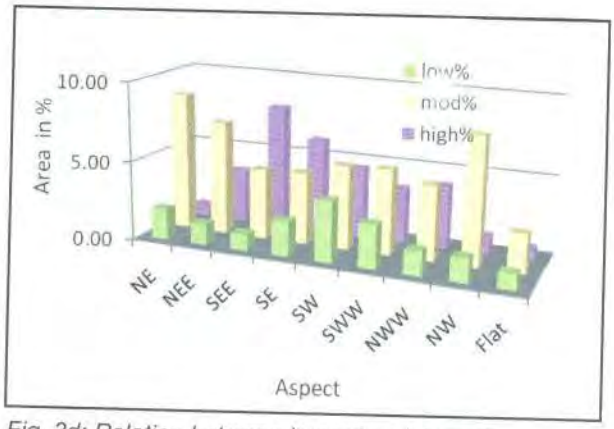
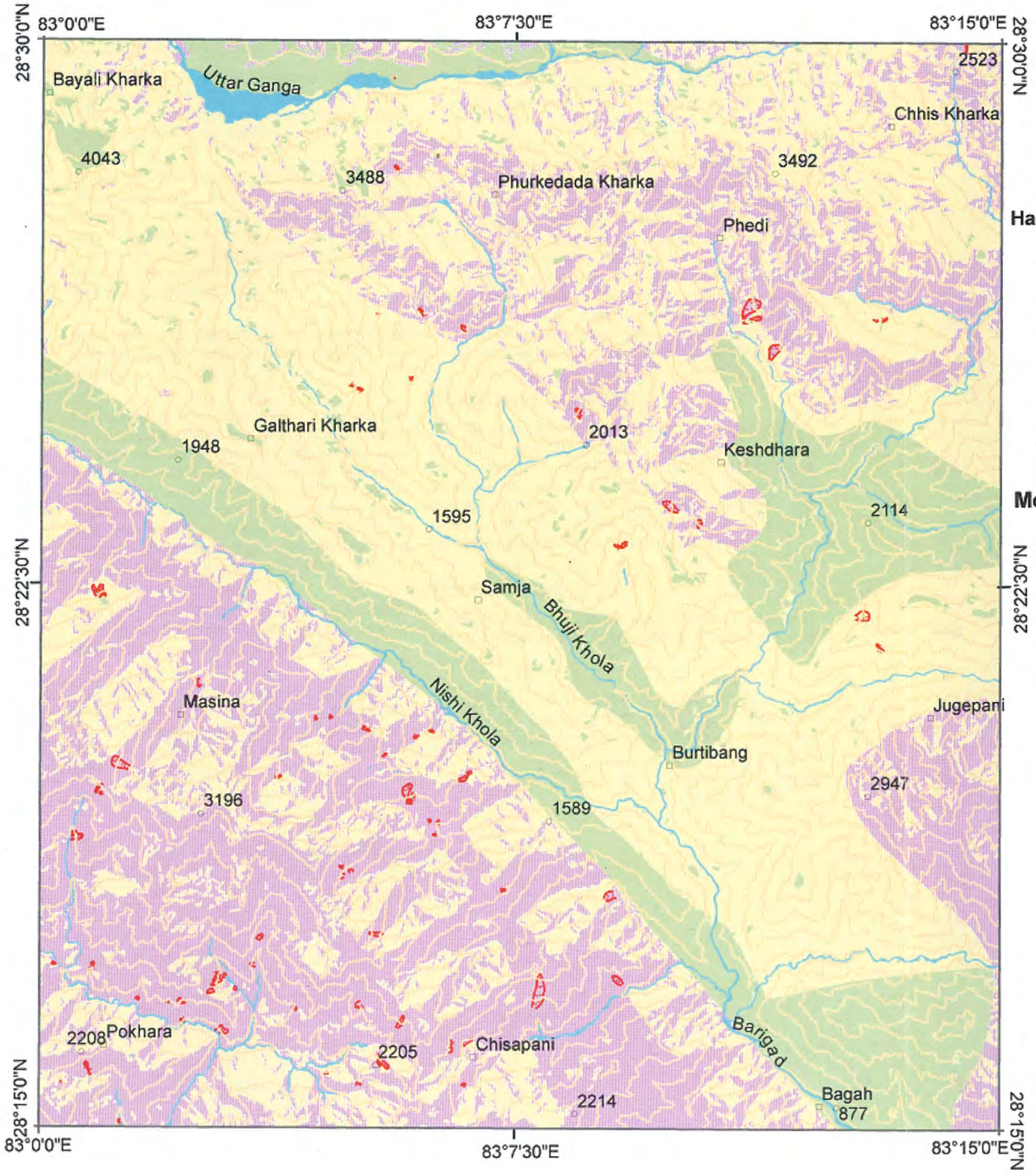


Fig. 3d: Relation between hazard and Aspect

Fig. 3: Figures showing the relationship between Hazard and different elements



Explanatory Legends

The landslide hazard zonation map was prepared by adding the weighted values of the four causative factors (Geology, Landslides, Slope and Slope Aspect). The weighted values were derived by statistical analysis based on the ratio of the landslide within each class of the causative factors. The relative hazard is expressed as low, moderate and high hazard based on weight value ranging from 3.55 to -6.38.

Hazard class	Possible Damage	Remarks and Recomendation
Low	Very few landslides and no major slopes instability at present. Toe cutting and bank collapse along the river. During the wet season deposition of debris in lowland area are likely.	Normally stable and regulated construction suitable. Limitation may impose by soil condition and other hazard like river bank collapse and seismic events at places.
Moderate	Less landslide density and rock fall sand soil erosion presence. Possibility of reaction of old landslides. High susceptibility of sliding within 20°. Possible damage towards the SE, SEE and NWW slope direction.	Urban development activities possible with appropriate safety measures. Proper irrigation needed and water should not be diverted towards slide areas. Careful selection of road alignment and heavy construction needs specific site investigation.
High	High density of landslides and rockfalls. High susceptibility of sliding steeper than 30°. Loss of areable land and soil. High risk of life and property.	Limited stable areas for safe infrastructure development activities. High cost for preventive technical works likely during detail site specific geotechnical works.

Note

This map is mainly based on statistical and empirical evaluation of various causative factors related to slope stability and their relationship with existing landslide distribution within the area. The map relies on the surface information obtained by ground survey of accessible areas and data from aerial photographs. Direct mapping of all individual existing landslides was not possible due to inaccessibility, concealment in densely vegetated areas and limited time. Area close to thrust and faults are tectonically weak zones.

The map is exclusively intended for planning at regional scale. It should not be used as the only basis of investigation for individual buildings. The map cannot replace detail site investigation. It is time dependent and needs periodic revision. Change in any single factor by natural or human activities needs reevaluation because change of a single factor can be sufficient to exceed the threshold for slope failure.

General symbols

River, Stream, Contour, Landslide, Village, Spot height

0 2,500 5,000 10,000 Meters

Fig. 2: Landslide Hazard Zone, Map of Parts of Bajhang, Gulmi, Myagdi & Pyuthan Districts

CONCLUSION AND RECOMMENDATION

- Most of the study area is hilly terrain with gentle to steep slopes. Flat to gentle slopes are formed along the river valleys and on the ridges. Areas of flat to gentle slopes are more stable.

- Slopes with thick soil mass or with highly jointed, deeply weathered, soft rocks such as phyllites are found to be more susceptible to land sliding. Steeper slopes with highly jointed rocks such as dolomite and quartzite are prone to block falls. Most of the landslides are concentrated in the southwest part of the study area.

- Settlements and cultivated lands developed on the river terraces close to riverbanks are also affected.

- Landslide Hazard Zonation Map was prepared by integration of the causative factors related to slope instability and their relationship with existing landslide distribution within the area. The map totally relies on the surface information obtained by ground survey of accessible areas and data from aerial photographs. The map is intended to be useful in planning infrastructure development activities of the region.

- Almost all the existing old and active landslide fall within the high hazard zone indicating satisfactory precision of the used method.

- The total weight values were from –6.38 to 3.55. About 90.59 % percent of the landslides are found to be located within the high hazard zone, 8.8 % percent in moderate hazard zone and only 0.52 % percent in low hazard zone.

- Hazard Zonation Map shows that about 218 sq. km covered by highly unstable zone forming 32 % of the total study area whereas about 51% area are on moderate hazard zone and the rest 17% in low hazard zone.

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

ACKNOWLEDGEMENT

We are grateful to Mr.S. P. Mahato, Director General, DMG for supporting the field program and guidance. Our sincere gratitude is to Mr D.Nepali, Senior Divisional Geologist and Mrs. Shova Singh for their valuable help and suggestions in GIS analysis. Sincere thanks are extended to staff members of Remote Sensing Section as well as other sections for fruitful discussion.

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Jnawali (2039), Geological Map of Parts of Baglung, Gulmi, Myagdi and Pyuthan Districts. unpublished map by DMG.

Van Westen, C.J., 1993, Remote Sensing and Geographic Information Systems for Geologic Hazard Investigation ITC Journal 1993-4 pp.393-399.

Annual Report of Department of Mines and Geology, 2012, No. 8, pp. 43-53

Landslide Hazard Zonation Mapping in Parts of Gulmi and Baglung Districts, Western Nepal (Toposheet No. 2883 14)

Santosh Dhakal (Geologist)

ABSTRACT

Bivariate statistical method is used to prepare a Landslide Hazard Zonation Map of parts of Gulmi and Baglung Districts at 1: 50,000 scale. Slope aspect, landuse, slope, lineament, shape, elevation range and geology were considered to be the causative factors for landslides. The study area is classified into high, moderate and low hazard zones indicating likelihood of occurrences of landslides as high, moderate and low respectively. The study area covers 650 sq. km and about 32% of the area falls on the high hazard zone, 30% of the area on moderate zone and 38% on low hazard zone.

INTRODUCTION

Landslide mapping and inventory were carried out to prepare Hazard Zonation Map of parts of Baglung and Gulmi Districts in Western Development Region. The study is a part of the annual program of the Department of Mines and Geology (DMG), fiscal year covered 650 sq. km. of toposheet no. 2883 14 (62P/8).

The area is located between latitudes 28° 00' 00" to 28° 15 ' 00" N and longitudes 83° 15' 00" to 83° 30' 00"E (Fig. 1).The Badigad River, Daram Khola, Labdi Khola, Hugdi Khola, Chhaldi Khola and Jumdi Khola drain the study area. The Chhaldi Khola flows almost along west to east direction in the northern part. The Badigad flows almost along northwest-southeast direction. The highest elevation is 3163 m, located at the northern part of the study area and the lowest elevation in the area is 517 m near Juhan.

Landslide mapping was made along roads, newly build dirt roads, river valleys and main trails for verification of erosion features interpreted on aerial photos and satellite images. Data for landslide inventory and their distribution using 'Inventory Forms' and mapping of various factors that are mostly responsible for triggering landslides were collected. Field verification data and desk level interpretation were integrated for the preparation of factor maps. To prepare Landslide Hazard Zonation Map at 1:50,000 scales, GIS technique was used to analyze all collected data.

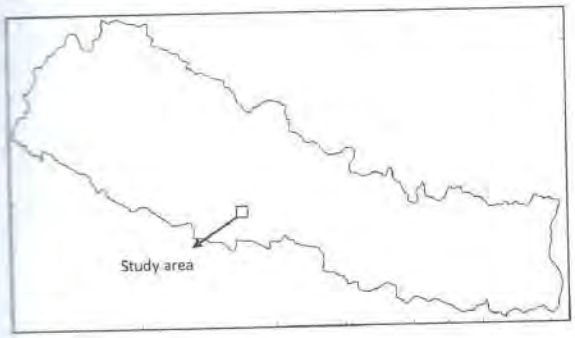


Fig. 1: Location Map of the study area.

OBJECTIVES

Objectives of the study are:

- To record the landslides of the study area using 'Landslide Inventory Form'.
- To integrate landslide distribution and geologic data with slope morphology and existing land use for the preparation of Landslide Hazard Zonation map in 1:50,000 scale by optimum utilization of Remote Sensing and GIS techniques.
- To prepare the regional database of landslides.

BACKGROUND

Badigad Khola a major tributary of the Kaligandaki River present in the area. A number of researchers carried out geological studies in the Badigad Khola area. Joshi (2029), Yadav (2031), Adhikari (2050) and Pradhananga (2055) had conducted geological mapping covering the target area. The area consists of metasedimentary rock sequences of Pre-Cambrian age comparable to Upper and Lower Nawakot Group. The area also comprises thrusts, faults and folds of regional scales.

Llandslide susceptibility information of the area is not available. So the present study program has been planned to provide geo-scientific information especially on landslide hazards, beneficial for planning of infrastructure development activities in the area.

METHODOLOGY

Desk Study

Topographic maps, geological maps, aerial photographs and landsat images were reviewed. Aerial photographs taken on 1979 in 1:50,000 scales acquired from the Survey Department were interpreted to study the landslides, erosion features, tectonic structures, existing landuse pattern and lithological units. The false color composite of Landsat-TM images of December 1992 was studied to know the landuse pattern, landslides, and tectonic structures of regional significance. Geological reports and maps of related area were also analyzed. The topographic maps of 1:25,000 scales were used as a base map for the field data collection.

Field Investigation

Data collection was carried out by taking traverses along different routes using landslide inventory form, aerial photos and topographical maps. Stress was given to study the landslides. Some randomly selected large landslides were studied in details using 'Preliminary Landslide Inventory Form'.

GEOLOGY

The study area comprises meta-sedimentary rocks of Nawakot Group of Pre-Cambrian age. Greenish grey phyllite and seams of dolomite are present in the northeastern corner of the map around Dale Khoriya area. Purple colour shale, slate and grey arkosic quartzite of Nourpul Formation are found in many parts. Rocks belong to Dhading Dolomite, Noupul Formation and Benighat Slates are abundant in the study area. Bands of calcareous rocks (Jhiku carbonate beds) are present within Benighat Slates in the southwest and west part. Pink limestoe and dolomitic limestone of Malekhu Limestone and intercalated green sericitic phyllite and white quartzite of Robang Foramtion are observed in western part. Many faults, folds and thrusts in the area suggest that the area is tectonically weak (Geol. Map, DMG 2000). Thick alluvial deposits are present in many river terraces and colluvial deposits in some river terraces depending on the geomorphology of the area.

PREPARATION OF FACTOR MAPS

A landslide distribution map was prepared by various data from of active and reactivated landslides. Similarly the factor maps with various parameters that are mostly responsible for land slide were prepared using GIS system by incorporating the data obtained from desk study and field verification.

Factors such as geology, land use, lineament, shape, elevation, slope and aspect were considered for the assessment of probability of landslide hazard at regional scale in the study. The statistical relationships of landslide distribution to various causative factors are summarized (Fig. 2a to 2l)

ROLE OF REMOTE SENSING DATA AND GIS IN LANDSLLIDE HAZARD STUDY

Tools like Remote Sensing and GIS are widely used to evaluate the degree of danger from landslide in an area by considering the nature of causative factors in the surroundings. Different models are developed and used to assess the relative likelihood of landslide occurrence by different researchers. The present study was based on bivariate statistical method and deals with one of the dependent variable like landslide density and other independent variables such as geology, landuse, slope, shape, lineament and slope aspect. The following formula was used (after Van Westen, 1993 to analyze the landslide susceptibility.

INVESTIGATION RESULTS

Verification of slope failure processes seen on satellite image, aerial photographs, topographical maps and geological maps were done in the field. Different type of landslides and their features were recorded in field visit. Most of the slides noted in the study area are soil slides. Rockslides are also triggered in intensely fractured rock mass. Joints, bedding planes, foliations, thrusts or faults are ontinuities affecting the rock mass. Failures such as wedge, toppling and planner are common in rock mass. Rotational, translation and also complex features were observed in the soil.

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

Where,

W_i = Weight given to a certain parameter class

Densclas = Landslide density within the parameter class

Densmap = Landslide density within the entire map.

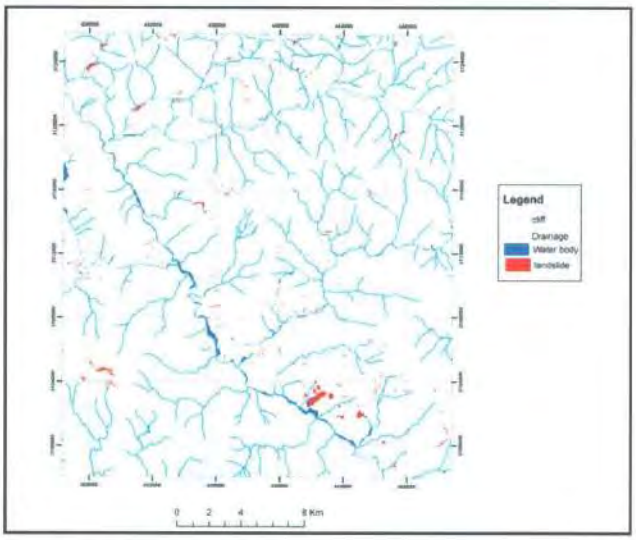


Fig. 2a: Landslide distribution map

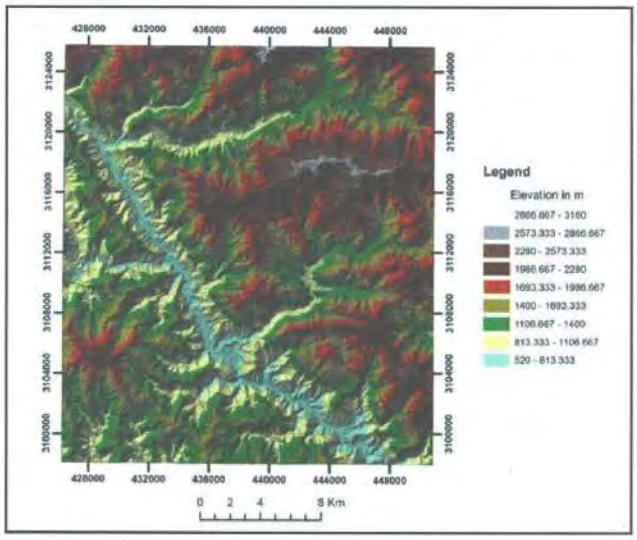


Fig. 2b: Digital elevation model

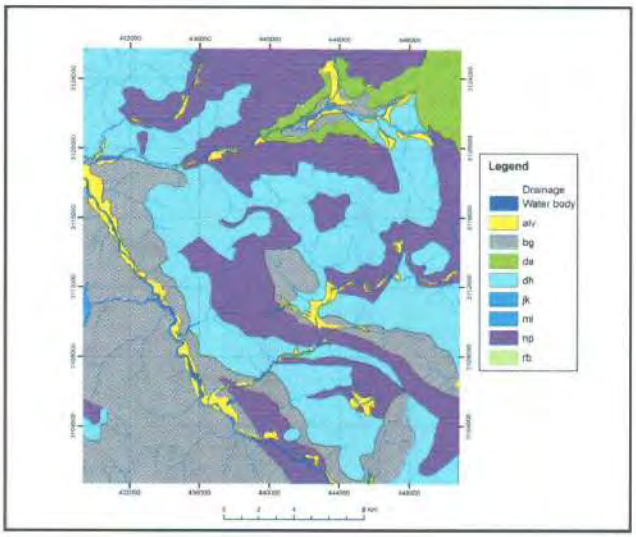


Fig. 2c: Geological Map (DMG 2000)

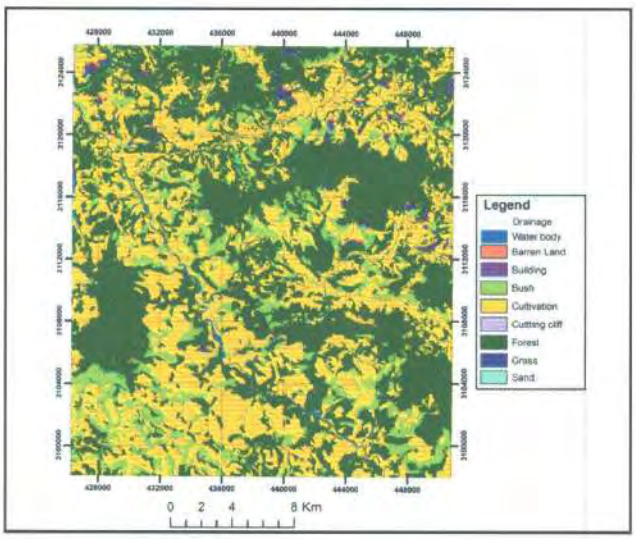


Fig. 2d: Landuse Map

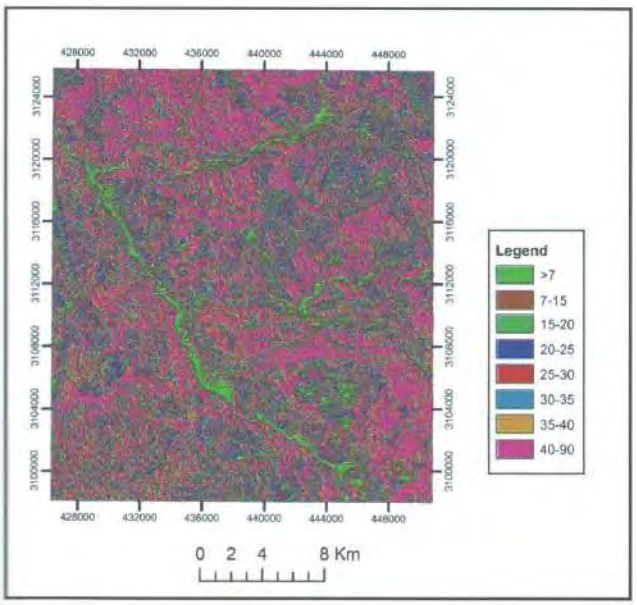


Fig. 2e: Slope Map

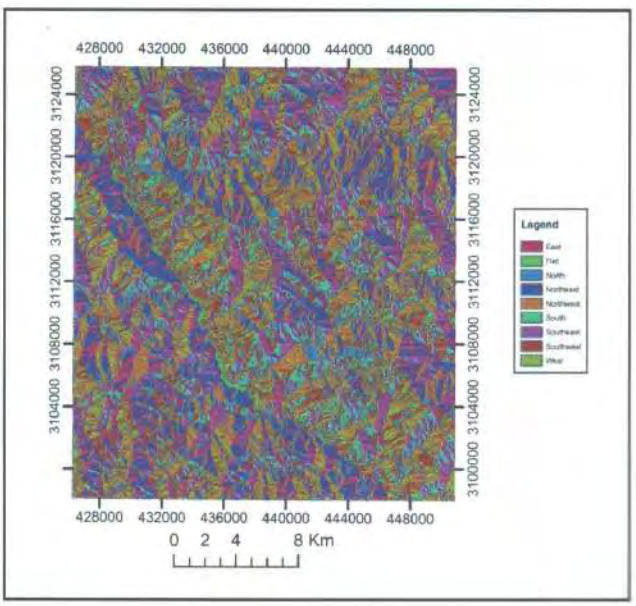


Fig. 2f: Aspect Map

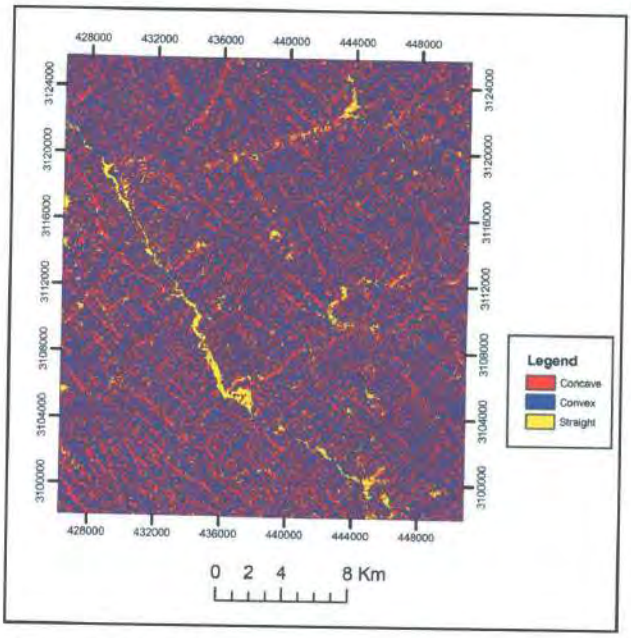


Fig. 2g: Shape Map

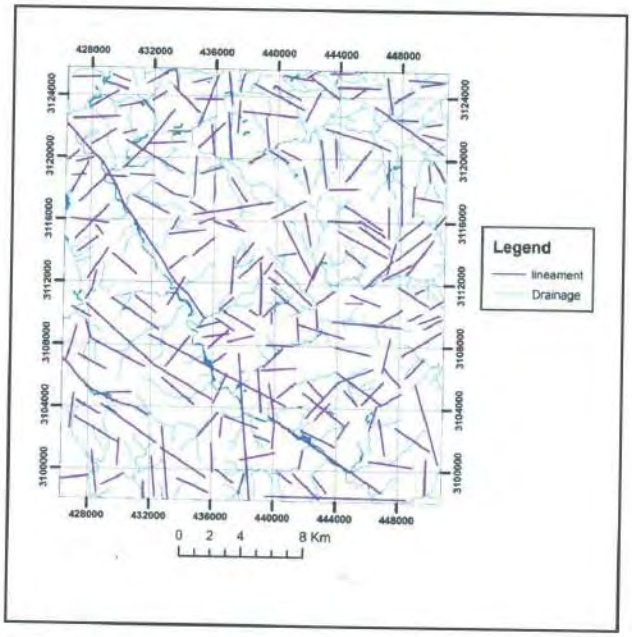


Fig. 2h: Lineament Map

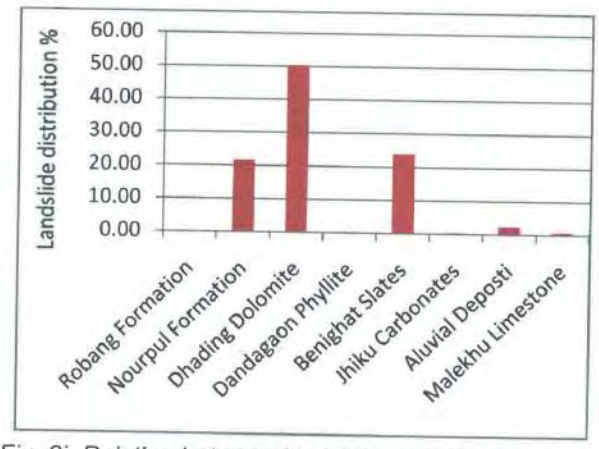


Fig. 2i: Relation between landslide and geology

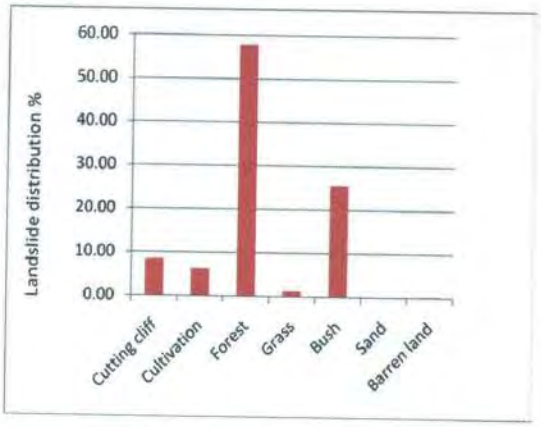


Fig. 2j: Relation between lanslide and landuse

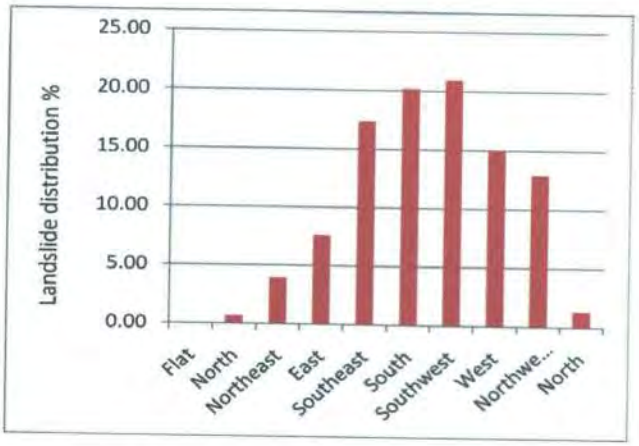


Fig. 2k: Relation between landslide and aspect

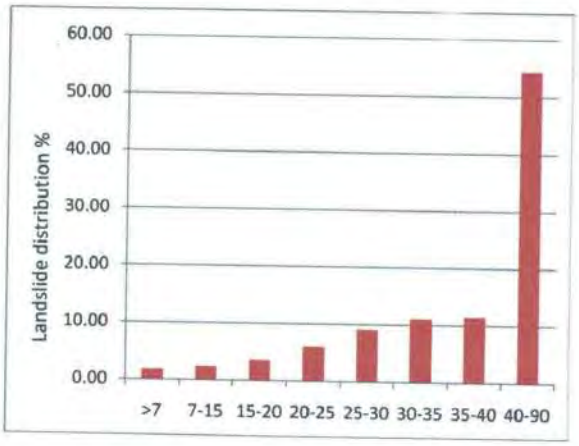


Fig. 2l: Relation between lanslide and slope

Fig 2: Various factor maps showing their relation with the landslide distribution

LANDSLIDE HAZARD ZONATION MAP OF PARTS OF BAGLUNG AND GULMI DISTRICTS

SHEET NO. 2883 14

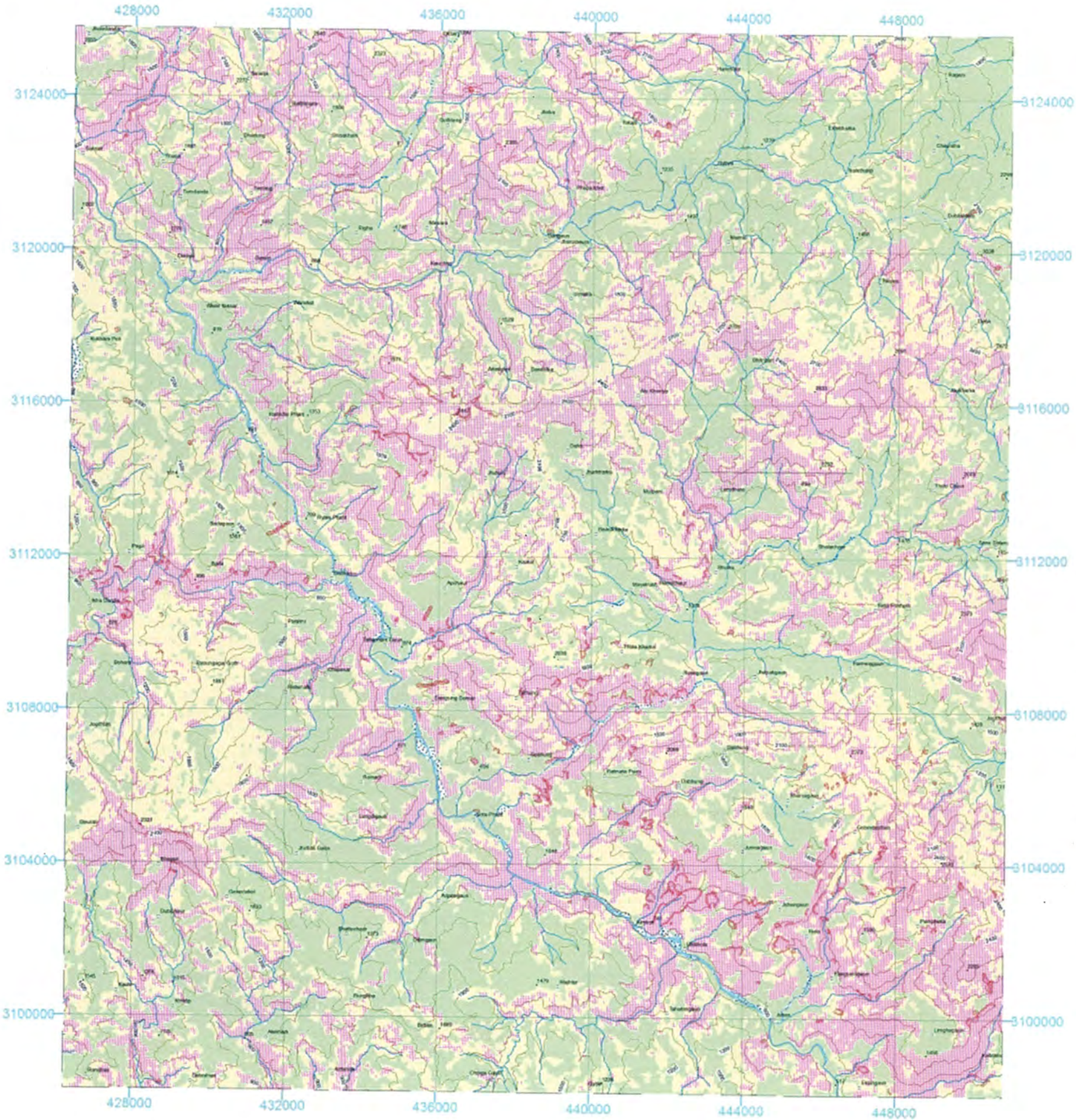


Fig 5: Landslide hazard zonation map of parts of Baglung and Gulmi Districts

EXPLANATORY LEGEND

The landslide hazard zonation map was prepared by adding the weighted values of four maps (Geology, Landuse, Slope, lineament, shape, elevation and Slope Aspect). The weighted values were derived by statistical analysis based on the ratio of landslides within each unit of the factor maps. The zonation classification in low, medium and high hazard is based on weight values ranging from -11.989 to 3-436.

Hazard Class	Damage	Remarks and Recommendation
Low	Very few small landslides. River bank collapse and deposition of debris in low land area during wet season.	Usually stable, suitable for constructions on built up land . At present limitations may be imposed by soil conditions and other hazards like river bank collapse and seismic events.
Moderate	Possibility of initiation of new and reactivation of old landslides. High susceptibility of sliding on cultivated land steeper than 20^{O}.Magnitude of instability variable. Possible damage to infrastructure and cultivated land.	Urban development possible if appropriate safety measures are taken. Heavy construction needs detailed investigation. Proper irrigation required and water should not be diverted into slide areas. Proper selection of road alignment required. Natural and man made activities may cause slope instability
High	High density of active and old landslides. High risk to human life and property, loss of soil and arable land likely.	Limited stable areas available for infrastructure development. High cost for preventive works likely. Construction of new buildings within 75m distance from the cliff along Seti gorge should be discouraged.

NOTE

This map is mainly based on statistical and empirical evaluation of various causative factors related to slope instability and their relationship with existing landslide distribution within the area. The map relies on the surface information obtained by ground survey of accessible areas and data from aerial photographs. Direct mapping of all individual existing landslides was not possible due to inaccessibility, concealment in densely vegetated areas and limited time.

The map is exclusively intended for planning at a regional scale. It should not be used as the only basis of investigation for individual buildings. The map cannot replace detailed site investigations. It is time dependent and needs periodic revision. Change in any single factor by natural or human activities needs reevaluation as change of a single factor can be sufficient to exceed the threshold for slope failure.

General Symbol

Road

Landslides

1200 Contour line with height in metres

Village

River with flood plain

0 1 2 3 4Km.

Contour interval 300 Metres

Wami Taxar -Juhan Roadis affected by rockslides and soil slides at different locations. A large landlside of length about 4 km known as Ghultun Pairo is observed in Kimkot area. Massive amount of material is transported to Badigad Khola forming huge fan (Fig. 3). The newly constructed road is highly affected by the slides at many places due to the heavy rain fall. Benefit of landlside was also seen in the field. Local people were earning money by collecting aggregates from the landslide near Pach Rate to sell it in Tamghas (Fig. 4). Large landlsides are confined around Badigad Khola.

Many reasons behind the occurrence of landslide in the area are intense fracturing of rock mass, difference in relief forming steep slopes, improper slope cultivation practices, and toe scouring of adjacent slopes by rivers or streams and high intensity of rainfall in monsoon season.

Fig. 3: A huge landslide (Ghultun Pairo) at Kimkot and washed materials.

Fig. 4: Local people collecting aggregates (dolomites) from the landlside of Pach Rate.

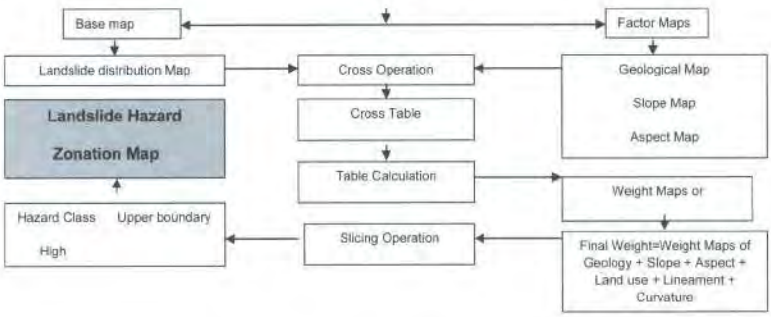
PREPARATION OF LANDSLIDE HAZARD ZONATION MAP

Soil type distribution map and landslide distribution map were prepared using field verification, aerial photo interpretation and satellite image interpretation. Various parameters mapped on soil type map, geological map, slope class map, shape map, lineament map, elevation range map and aspect map were used as causative factors for the occurrence of landslide. Landslide Inventory Map was taken as base to calculate the rating values of causative factors to derive the Landslide Hazard Zonation Map using GIS based ArcInfo system.

Based on the density of landslide distribution in each class/unit of the causative factors at present situation, a Landslide Hazard Zonation Map (Fig. 5) was prepared and the entire study area was divided into three categories, predicting probability of danger from landslide. Process of hazard zonation is shown in the following flow chart:-

RESULTS OF STATISTICAL ANALYSIS

The Landslide Distribution Map (Fig. 2a) and the Landslide Hazard Zonation Map (Fig. 5) was combined in the arcview environment. Density of landslide distribution within each hazard zone was calculated. Distribution of 78.38% of the landslides were found in the high hazard zone, nearly 16.81% in moderate and only 4.81% in low hazard zone.Tto assess the effect of various factors for estimating the range of instability in the region in terms of probability of landslide hazard, the relation between hazard class and causative factors (Fig. 6a, b, c, and d) was also evaluated.



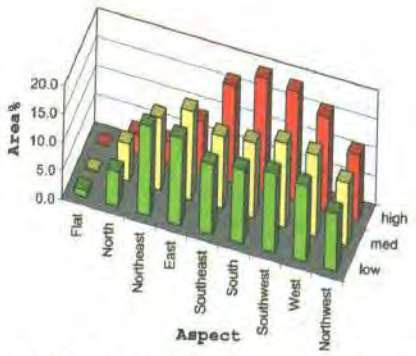


Fig. 6a: Relation between hazard and aspect

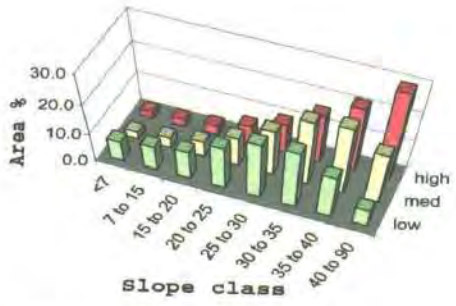


Fig. 6b:Relation between hazard and slope class

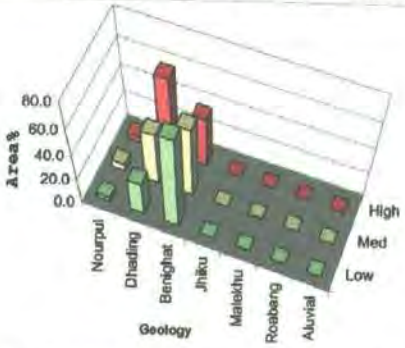


Fig. 6c:Relation between hazard and geology

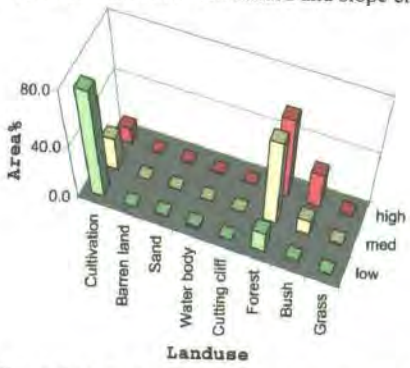


Fig. 6d:Relation between hazard and landuse

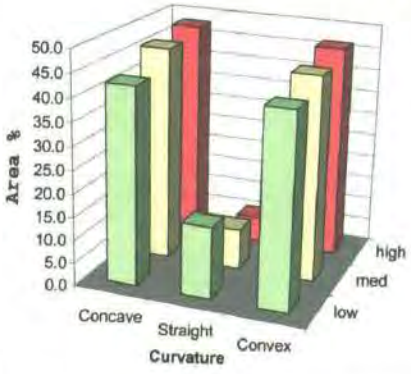


Fig. 6e: Relation between hazard and curvature

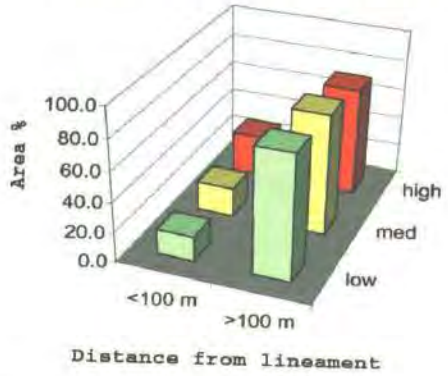


Fig. 6f:Relation between hazard and lineament

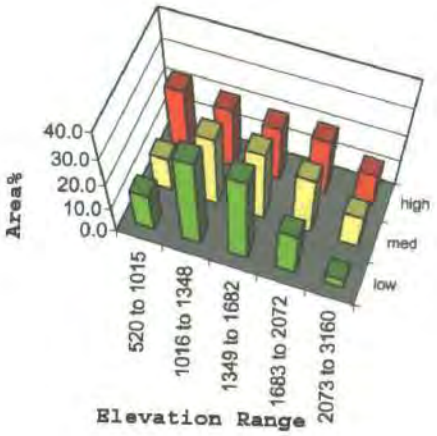


Fig. 6g: Relation between hazard and elevation Range

Fig.6: Figures showing relation between hazard and causative factors

CONCLUSION AND RECOMMENDATION

- Slopes with thick soil mass, deeply weathered soft rocks such as phyllite and highly fractured dolomite are found to be more susceptible to landslide. Steeper slopes with highly jointed rocks such as dolomite and quartzite are prone to block falls. Most of the landslides are concentrated around Badigad Khola. Settlements and cultivated lands developed on the river terraces close to riverbanks are also affected by landslides.

- The Landslide Hazard Zonation Map was prepared by integration of the causative factors related to slope instability and their relationship with existing landslide distribution within the area. The map is based on the surface information obtained by ground survey of accessible areas and data from aerial photographs and satellite

images. The map is intended to be useful in planning infrastructure development activities of the region.

- The high hazard zone consisting majority of old and new landslides satisfy the used method.
- About 78.38 % percent of the landslides are found to be located within the high hazard zone, 16.8 % percent in moderate hazard zone and only 4.81 % percent in low hazard zone.
- About 208 sq. km area of the Hazard Zonation Map falls on highly unstable zone 191 sq. km area falls under moderate hazard zone and the rest 247 sq. km area in low hazard zone.
- This map is not detailed site specific and only used for planning for infrastructure development activities at a regional scale.

ACKNOWLEDGEMENT

The author is grateful to S. P. Mahato, Director General (DMG) for supporting the field program and guidance. Sincere thanks are extended to staff members of the department.

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Engineering and Environmental Geological Mapping of Nepalgunj Municipality and its Surrounding area, Banke District, Bheri Zone

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ABSTRACT

The present study "Engineering and Environmental Geological Mapping" of Nepalgunj Municipality and its surrounding areas deal with the engineering properties of the Quarternary sediment. It also deals with geological hazards and environmental problems and their mitigation. The field survey include power driven auguring, hand auguring and Standard Penetration Test (SPT). Soil samples are taken from various depths to delineate different Quaternary geological units. A number of traverses were taken along rivers, tributaries, trails, and road for delineating geological unit and to identify areas prone to geo-hazard such as flooding, riverbank cutting (erosion) and inundation. Natural resources such as sand and clay (construction materials) were assessed. Environmental concerned topics such as waste disposal sites were also identified.

INTRODUCTION

Nepalgunj Municipality is located in the Banke District of Bheri Zone in the Mid -Western Development Region of the country. Nepalgunj connects the main East-West highway in Kohalpur at a distance of 15 Km. It is one of the fast growing urban areas in Mid Western Development Region of Nepal. Nepalgunj is considered as the main centre for business activities besides medical facilities and academic studies for the western Region of the Nepal.

Fig. 1: Location map of the study area

The study area lies between 3102000 to 3111100m North and 557000 to 568000m East covering about 100 sq. km in Banke District of Bheri Zone. The location of the study area is shown in Fig. 1. The study area covers part of sheet No. 2881 15A 15B, 15C, and 15D at a scale of 1:25,000.The main river is Dundawa Khola which lies in the east from the main city centre and flows from north to southeast direction. The others rivers are Kiran Nala and Amilia Nala.

The present study is intended to provide information on surface and sub-surface geology for selecting suitable areas for future development planning.

OBJECTIVES

- Main objective is to prepare an engineering and environmental geological map of the study area at 1:25,000 scale
- To determine the sub-surface condition of unconsolidated sediment and its bearing capacity
- To delineate the area susceptible to liquefaction hazard.
- To provide engineering properties of different soil units.
- Urban and environmental geological mapping and Geo-hazard assessment at 1:25,000 scale consisting information on Quaternary Geology, Landuse, Waste disposal sites, natural hazards, natural resources.
- To identify the hazardous and risk area and recommend proper mitigation measures.
- To identify the existing environmental problems which will have direct impact on human health.

METHODOLOGY

- Existing relevant literature on geology, geo-hazards and regional geological as well as landuse maps were reviewed.
- Before going to the field, the desk study was carried out using toposheet (1:25,000) and high resolution satellite image (from Google Earth) for the study of landuse pattern, geomorphology and suitable sites to drill auger holes and SPT.

- During field, auger drill holes and SPT (Standard Penetration Test) were carried out as planned before.
- The result obtained from Engineering Geological Mapping and Urban and Environmental Geological Mapping with Geo-Hazard studies were incorporated in the preparation of final Engineering and Environmental Geological Map.
- Samples collected from the field were analyzed in the geotechnical laboratory of the department for Liquid Limit, Plastic Limit, Sieve Analysis, Moisture Content. The softwares used for this study are ArcGIS, Winsieve 5, Rockworks 2015 and Freehand.

FIELD ACTIVITIES

The fieldwork was carried out in dry season of 2066 B.S. for 40 days. Field investigation was carried out using GPS and toposheets in 1:25,000 scale for location. The required data were obtained from the field survey using auger drills and SPT tests. 64 SPT were carried out to determine the stiffness of the ground at different locations and 61 numbers of auger drill holes up to the depths of 9m were carried out at required places to know the sub-surface geology at different depth (Photo 1 and 2). Samples were collected from various depths of auger and SPT holes to test them in the geotechnical laboratory of the department.

A number of traverses were taken along rivers, tributaries, trails, and road to delineate geological unit and to identify areas prone to flooding, riverbank erosion/cutting and inundation. Field survey at various places enabled to delineate areas of waste disposal and area of environmental concerned.

In the field, necessary information was gathered from Nepalgunj Municipality regarding their infrastructure development plan. Some information was gathered from District Office of the Department of Urban Development and Building Construction and also from District Office of Drinking Water and Sewerage for water supply system in urban and rural areas.

Photo 1: Power driven auguring in the soil to investigate sub-surface geology

Photo 2: Preparing for Standard Penetration Test (SPT) to understand bearing capacity of the soil

QUATERNARY GEOLOGY

The necessary information about the Quaternary geology were obtained from field survey, Power Auger Drill, Hand Auger, SPT test to know various sub-surface geology. Quaternary sediments of the study area can be divided into 6 different units based on grain size (Fig. 2). They are as follows:

1. Badripur Deposit
2. Chamarpurwa Deposit
3. Ganeshpur Deposit
4. Lagdahawa Deposit
5. Nayabasti Deposit
6. Floodplain Deposit

Badripur Deposit

It consists of clay, silty clay, silt and sand in varying proportion at different level. Clay layer varies from 0.5m to 3m and concretions are found at few places. Silt varies from 0.5 to 2m. Fine sand varies from 0.2m to 3.5m. This deposit is mainly found near Badripur, Bhikaripur, Bagawannapurwa, Prempurwa (Fig. 3) Chamarpurwa Deposit

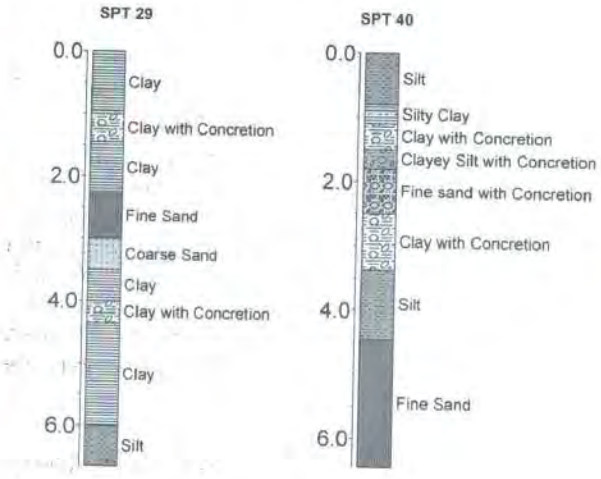

Fig.3: Lithologs representing Badripur Deposit

Chamarpurwa Deposit

This deposit mainly consists of clay. The total average thickness of clay is around 5m. Thin layers of silt and sand are found at some places. The clay deposit found at Rajha (Manikapur-6) is stiff and yellowish brown in colour. The thickness of sand in this deposit varies from 0.1 m to 0.5m. The thickness of silt layer varies from 0.2m to more than 2m. In Gijira (Khajurakhurd-9), the silt layer is found at the top with grits while at Guruwagaon (Belhari-2), the silt layer is found to be at bottom. This deposit is mainly observed in Gijara, Manpur, Ranjha and Chamarpurwa area (Fig. 4).

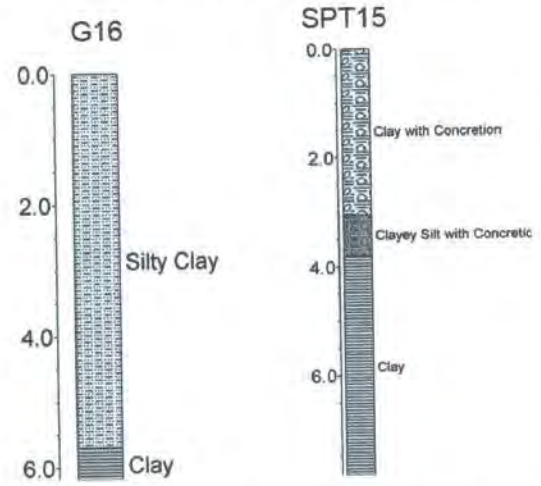

Fig. 4: Lithologs representing Chamarpurwa Deposit

Ganeshpur Deposit

It is a sand and silt dominant deposit with less clay and silty clay. The thickness of clay and silty clay vary from 0.4m to 2m. At Fultekra-7, all sand layers are fine grained, where as in Gagarpur(Puraina-9), sand layers are fine to medium grained. Few grits are observed in sand layers at Jamuni tole (Kohalpur-6), Shamshergunj-9, Chakrapath(Basudevpur-7. The maximum size of grit observed is 1.5 cm. At Guru Dwar, top layer is found as silty clay and rest is found to be fine sand with grits. This deposit is mainly observed near Ganeshpur, Phutaha and Mohanpur (Fig. 5).

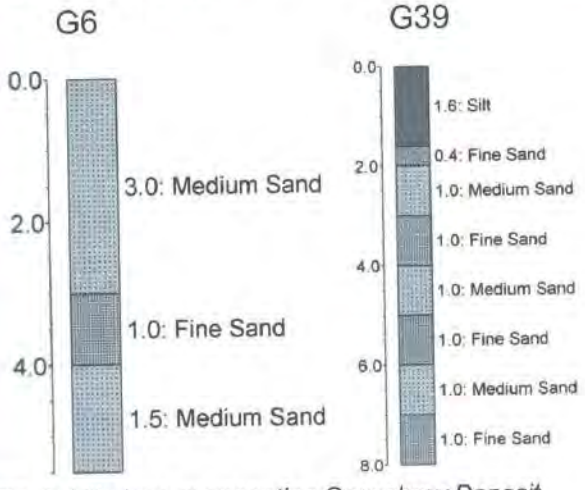

Fig. 5: Lithologs representing Ganeshpur Deposit

Lagduhawa Deposit

It consists of clay or silty clay layers at the top up to 4m underlain by sand layers. In Lagduhawa (Khaskarkandeu-5), the grits up to size of 1.5cm is found in silty clay at the top layer underlain by silt and fine sand up to 5.8m. At Kapase (Ganapur-7), the thickness of clay layer is found to be 4.5m. Carbonaceous black clay is found between 4 and 4.5m and dark grey sand is found between 5 and 5.5m. At Karmahawa (Indrapur-2), 3.6m of clay at the top is underlain by 2.9m of sand and followed by clay. Similarly at JuganBhariya (Khajura khurd-1) 3.6m of clay is underlain by 4.4m of yellowish brown fine sand. In puraina-1, 3m clay layer is underlain by gravelly sand and medium grained sand. The distribution of this deposit is more than other type of deposits and mainly developed in central and southern part of the study area (Fig. 6)

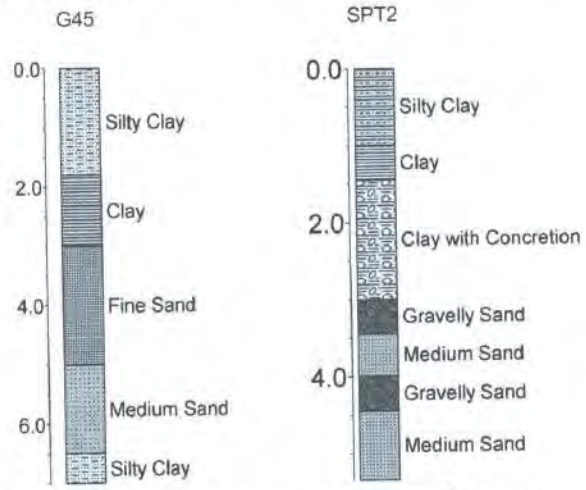

Fig. 6: Lithologs representing Lagdahawa Deposit

Nayanbasti Deposit

It consists of sand and silt layer at the top underlain by clay layer. At Nayanbasti (Manikapur-4), top 4.3m of yellowish brown fine sand layer is followed by 1.5m of stiff yellowish brown clay with grits of size 1.5cm. It is again followed by 0.6m of sand and 0.6m of stiff grayish brown clay. This type of deposit is observed at few locations near Ramnagar and Nayanbasti (Fig. 7).

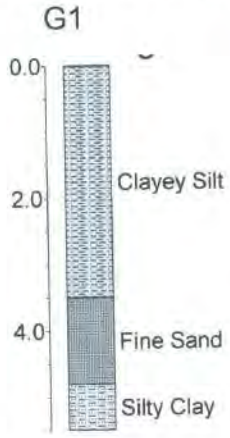

Fig. 7: Lithologs representing Nayabasti Deposit

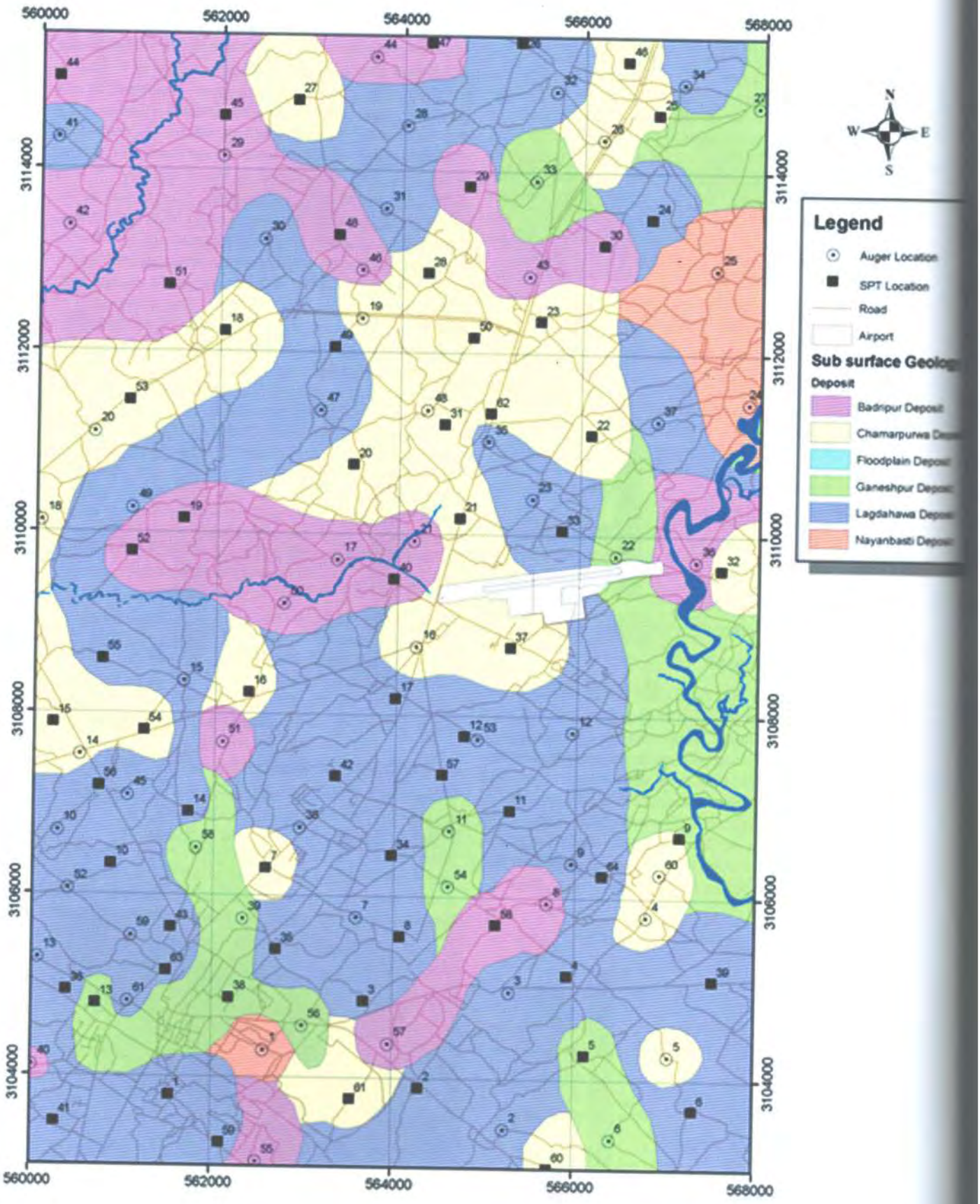

Fig. 2: Subsurface geological map of Nepalgunj area

Flood plain Deposits

The deposit is distributed mainly along the courses of Duduwa Khola in the eastern side of the study area and consists of sand, silt and clay along the river bed deposited by rivers during monsoon season.

Liquefaction Susceptibility Mapping

Liquefaction is the tendency to loose shear strength of saturated soil layers under the stress of earthquake motion. Liquefaction mostly occurs in the saturated soil layers composed of coarse silt to fine sand particles. The liquefaction potential of the soil strata decreases as the particle size of constituting materials and the depth increases. For liquefaction to occur, the area should be prone to the earthquake.

In the liquefaction susceptibility study, a total of 64 shallow boreholes data were used. The depth of all these boreholes is limited up to 8m only due to time constraints and equipment limits.

The qualitative analysis for liquefaction hazard assessment is generally carried out for the preliminary investigation results of the places to know whether the area is susceptible to liquefaction or not.

In this study the method adopted by Juang and Elton (1991) has been used which is based on the analysis of the liquefaction hazard by assigning weight values according to their influence to liquefaction potential. The greater the susceptibility to liquefaction a factor possessed the higher the number of points that is allocated to that factor. They have identified 12 factors that influence the susceptibility of a soil to liquefaction. The main six of them are listed as follows:

- Depth to water table,
- Grain size distribution
- Burial depth
- Capping layers
- Age of deposition
- Liquefiable layer thickness.

These factors are considered to be very important for causing liquefaction at a particular place. Liquefaction susceptibility map with four different zones, High, Moderate, Low and Very low are shown in Fig. 8

Bearing Capacity

For the study of bearing capacity, a total of 64 SPT data were used. Bearing capacity analysis is carried out according to Peck et al (1974). According to the analysis it is found that the bearing capacity of the study area varies from very low to high (Fig. 9) with SPT value ranging from 3 to 16. The study area mainly has medium bearing capacity.

GEO-HAZARD AND ENVIRONMENTAL PROBLEMS

Geo-hazards in the study area include bank cutting, flooding and inundation.

Bank Cutting

Bank cutting are observed at many places like Naya Basti, Kunia, Nanupurwa of the Dundawa Nadi. (Photo 3). Gabion spurs have been constructed at various places east of Mohanpur to control bank cutting, but due to lack of repair and maintenance, they are not effective.

Photo 3: Spurs constructed in the south of Kunia village in the Daduwa Nadi to control bank cutting but their repair and mentainance is poor

Bank cutting is very extnsive in all course of the Daduwa River from Nayabasti to 1 km south of Ladiya Ghat in the study area. Many trees have been uprooted by bank cutting in the Daduwa Nadi near the eastern boundary of Nepalgunj Airport during Monsoon season (Photo. 4)

Photo 4: Uprooting of trees due to bank cutting in Daduwa River east of Airport

The water level varies from place to place. At Naya Basti where bank cutting is high, the level of water is almost 3 m from river bed and level of right bank is 7m high (Photo 5).

Photo. 5: Repeated banks cutting in Naya Basti Village

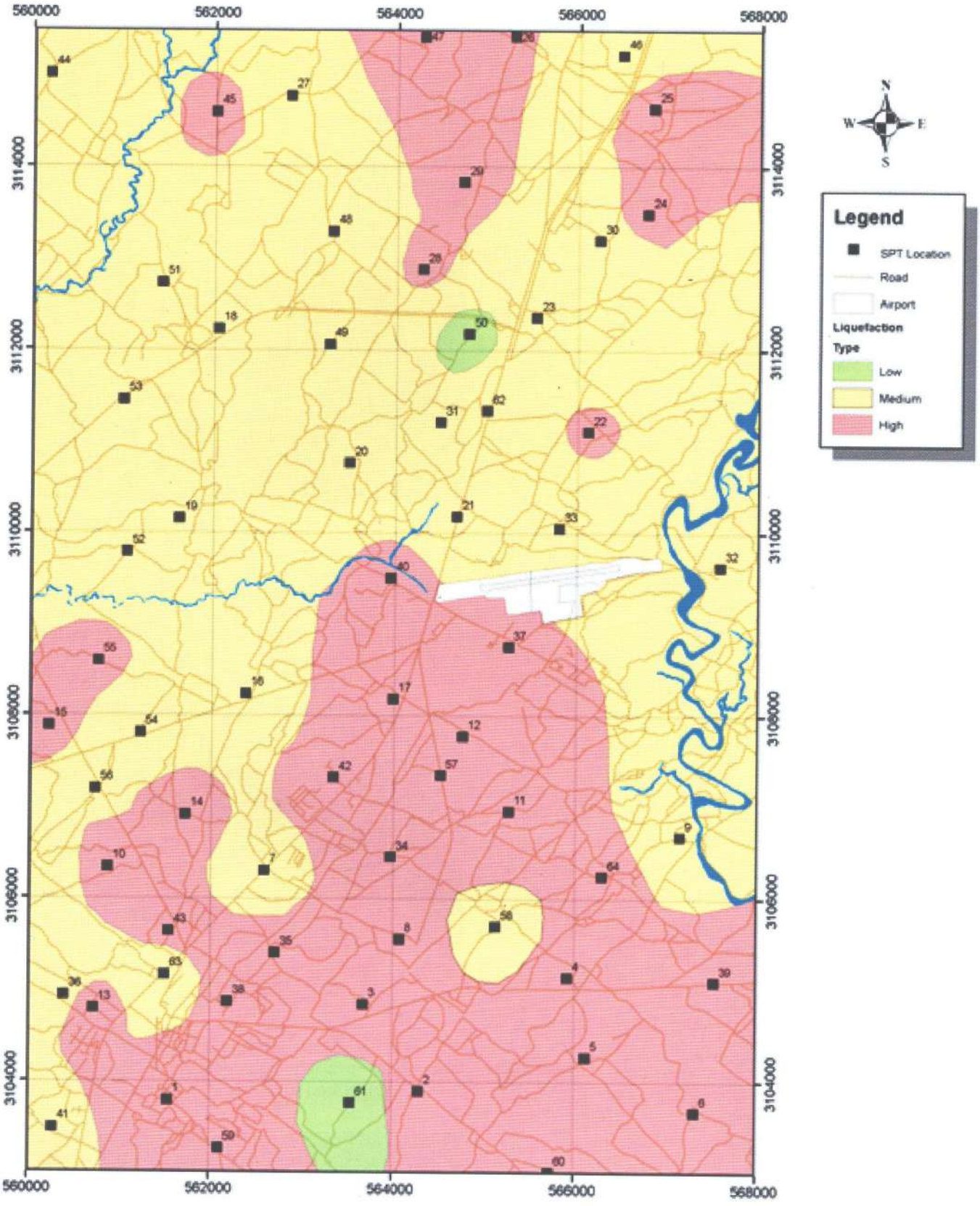

Fig. 8: Liquefaction susceptible map of the study area

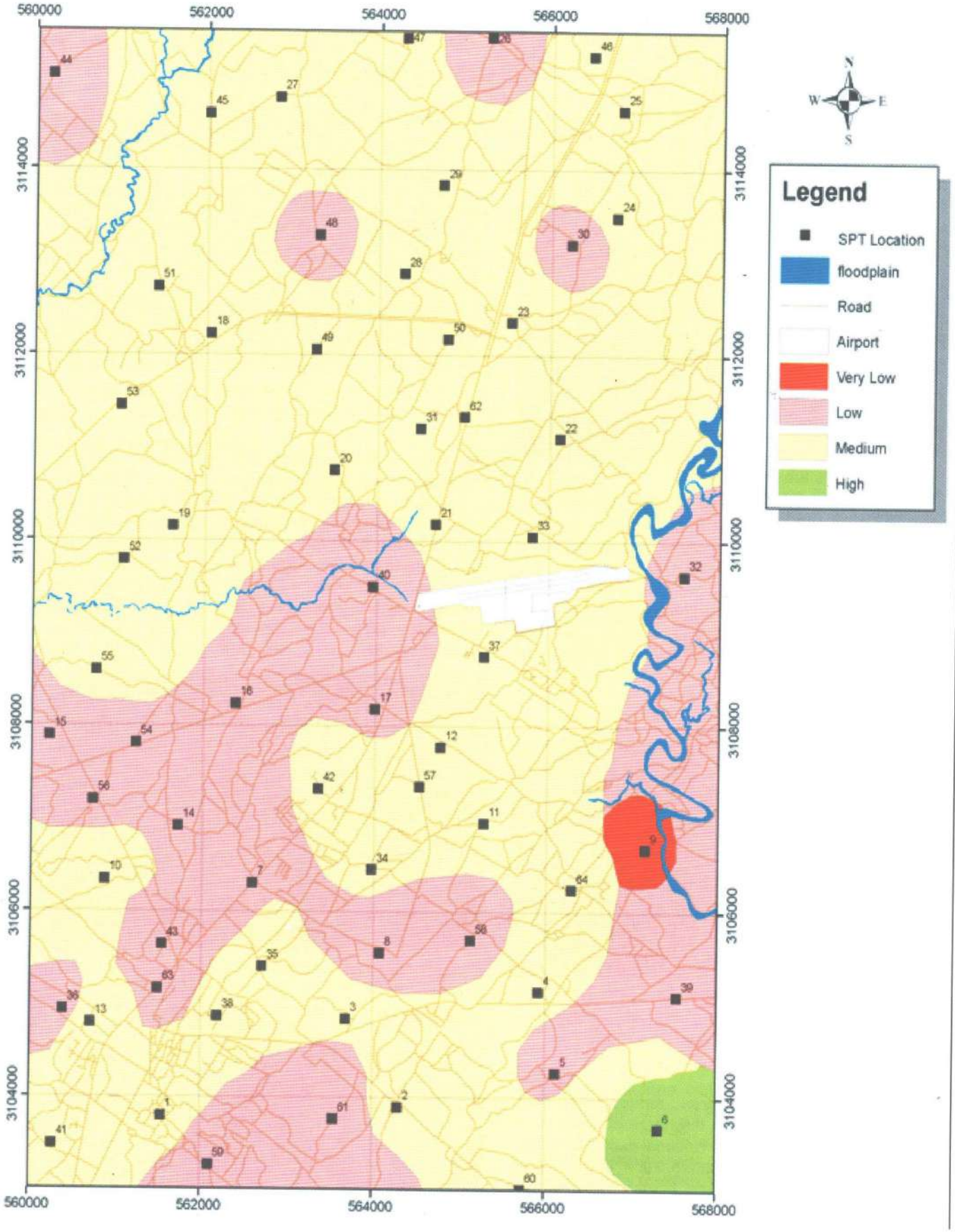

Fig. 9: Bearing capacity map of the study area

Flooding

Flooding is most common in the Dundawa Nadi and other smaller rivers such as Kiran Nala, Murgiha Nala, Amila Nala during Monsoon season, but these rivers are completely dry during dry season except Dundawa Nadi. Places like Ladiyagha, Madanpurwa, Kuniya, Alanagar are the risk areas from flood. A Village situated northeast of Siurajpur has high risk of bank cutting, flooding and inundation during Monsoon Season (Photo 6).

Photo 6: Houses are in risk from Bank cutting and flooding (Northeast of Siurajpur Village)

According to locals, flood during 2063 BS has drowned Nepalgunj area. Water level of 3 feet remains for few hours at Dhomboji (Birendra Chowk) and water level has reached up to 4 feet in New Road area for few hours. The bridge had been collapse during the flood of 1964 near Kunia Babaghat. A new bridge had been constructed and was collapsed during the flood of 2066 due to poor foundation (Photo 7). Now the Department of Road is going to construct a new bridge just 100m upstream.

Photo 7: Remaining of 2 foundation pillar out of 5 in the bridge at Daduwa Khola near Kuniya, Manikapur-3

Inundation

Inundation in Nepalgunj area around the rivers frequently occurs during high discharge of water in the monsoon period. According to National daily Newspaper "Gorkhapatra" dated 13th of Ashad, 2068, one lakh (one hundred thousand people) are in risk of inundation due to construction of Laxmanpur Barrage near Rapti River due to which more than half of VDC in the vicinity like Holiya, Betahani, Fahtepur, Gangapur, Kamdi and Matehiya will be inundated. Due to construction of dam near Holiya in border at a distance of 300m with 22.5 km long and has resulted inundation of 50 villages of more than half dozen VDC turning all agriculture land into flood plain area.

Geo-environment and pollution

Nepalgunj is almost a flat area and flow of sewage is retarded due to low gradient in flow direction. Main sources of waste materials are from houses, shops, factories, small scale industries. According to the report obtained from municipality, out of 54 cum/day of waste product, only 15.8 cum/day are collected and managed. 11.4 cum/day forms as organic waste from agriculture and 4.4 cum/day constitute as plastic, cotton and inorganic waste.

Unplanned urbanization, uncontrolled infrastructure development, haphazard settlement, improper land use, uncontrolled sewerage system, water pollution and improper sanitation lead to environmental degradation. In village almost all use open space as toilet.

According to the report of Blanket Arsenic Testing Programme received from Drinking water and Sanitation Division Office, almost all water of the well have different amount of Arsenic contamination. However all VDC's of the study area have minimum (0-10 ppb) in more than 97% of the tested well. Kamdi, Indrapur, Nepalgunj and Kohalpur have maximum (0-50ppb) in less than 1% of the tested well. Surface drain is not so well managed and at some places their construction is not completed (Photo 8 and 9).

Photo 8: Open drain around BP Chowk that affect human health near medical college

Photo 9: Drain not completed in the road near teaching Hospital

Many toilets have direct connection to drain that cause malfunction of drain and have direction impact on environment producing bad smell. Waste materials are thrown into Dondra Nala which flows near BP Chowk and passes close to Bageshwori temple (Photo. 10).

Photo 10: Dondra Nala highly polluted flowing close to Bageshori temple

Waste Disposal site

Nepalgunj municipality lacks proper waste disposal sites. However municipality in cooperation with local and international organization has played a vital role in managing the waste materials properly to some extent. Some waste materials are burnt out and some are used as filling materials in the newly constructed house to raise the level of ground. Waste materials are disposed at places like Chihan, Naya Basti, between Ramnagar and Bulbuliya (300m from human settlement), eastern part of Fultekra and bus park (Photo. 11).

Photo 11: Disposal of waste materials near the bus park

Natural resources

Construction materials such as sand, clay and silt (Filling materials) are found at number of places. Clay mining is done for brick factories (Photo. 12), filling materials during construction of buildings, for pottery and covering materials over the waste to lessen its bad smell. Stone crushing factories to produce pebble and gravels as construction materials are also found at numbers of locations. However stone is brought from outside Nepalgunj. Soil mining as filling materials is found at Mohanpur at the confluence of Dundawa Nadi and Sinuwa khola. It is important to note that no sand mining is found in the Daduwa Khola flowing in the study area. However mining of silty clay have been found at number of places.

Photo 12: A brick factory in the study area at Manpur, Indrapur VDC-9

CONCLUSION AND RECOMMENDATION

- The investigation revealed that the study area mainly consists of alluvial sediments, which can be classified into 6 different units based on the subsurface geological information.
- The study area is mainly dominant with fine grained sediments like clay, silty clay, silt and fine to medium grained sands. Lack of coarser sediments such as pebbly sand and gravel layer.
- The bearing capacity of the study area vary from very low to high and mostly covers by medium bearing capacity.
- The qualitative analysis for liquefaction hazard assessment is generally carried out for the preliminary investigation results of the places to know whether the area is susceptible to liquefaction or not. The liquefaction potential in the study area is low to high according to the qualitative analysis carried out on it.
- Almost all the river will be flooded during monsoon season and become dry during winter season except Daduwa and Kiran Nala. Gabion wall and spurs should be constructed and repaired in the area where riverbank cutting is high.
- Discourage the people to live in low lying land area to protect them from inundation.
- Due to flat area, water logging occurs frequently. No proper drain to flow sewage materials easily.
- Damaged bridges should be repaired firmly to ensure its resistant at the time of high discharge of water during monsoon season.
- The new sanitary landfill-sites should be selected as soon as possible for proper management of the wastes.

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Geological Section Measurement and Geological Studies of Parts of Udayapur District, Eastern Nepal

Rajendra P. Khanal (Sr. Div. Geologist)

ABSTRACT

The fieldwork involved in carrying out geological section measurement of 50 line km and geological mapping along Saptakoshi, Baruwa Khola, Duwar Khola, Teliya Khola and Hadiya Khola of Udayapur Districts of Eastern Nepal. The study area is represented by sedimentary, metasedimentary and metamorphic rocks belonging to Quaternary sediments of recent alluvial deposits, Siwalik group of Sub-Himalaya as well as Gondwana and Midland groups of Lesser Himalaya. Maximum thickness of Gondwana rocks is about 28 m, whereas Pre-Siwalik Group rocks is about 60 m in the study area. All the rocks of Siwalik Group are exposed in the study area. Lower Siwalik has thickness 320 m in Duwar Khola and 475 m in Baruwa Khola. Thickness of Lower Middle Siwalik ranges from 365 m to 560 m in Duwar Khola and Baruwa Khola respectively, whereas its thickness is 535 m in Taliya Khola. Thickness of Upper Middle Siwalik observed in Taliya Khola is about 490 m.

INTRODUCTION

The field investigation was carried out in accordance with the annual field programme of Petroleum Exploration Promotion Project (PEPP), Department of Mines and Geology for the fiscal year 2066/67 BS. The fieldwork involved in carrying out geological section measurement of 50 km length including geological mapping along major rivers of Baruwa Khola, Duwar Khola, Teliya Khola and its adjacent areas of Udayapur District of Eastern Nepal. This geological investigation is important to identify thickness and extension of petroleum source, reservoir and seal rocks in the study area.

The study area lies in between latitudes 26°43'30" N to 26° 55' N and longitudes 86°43' 45" E to 87°00'45" E (Fig.1) in the parts of the toposheets 2686 03B, 03D 04A, 04B, 04C, 04D prepared by Survey Department, Government of Nepal (Scale 1:25,000) in 1995.

Fig. 1: Map of Nepal with the study area

OBJECTIVES

The objectives of the investigation were:

- to carry out geological section measurement along rivers
- to prepare geological map of the study area, and
- to collect petrogeochemical samples from shale horizon for source rock investigation.

FIELD METHOD

To identify the trace of major structural features such as Main Boundary Thrust (MBT), and Mahabharat Thrust (MT) satellite images Google earth image and aerial photos are studied. Available literatures on geology of eastern Nepal are also reviewed before the fieldwork. The following methods are adopted during the fieldwork:

- Geological mapping and section measurement were carried out using topographic base map in scale of 1:25,000.
- Lithological units and structural features were identified on the basis of field observation. Traverses were made along Baruwa, Duwar, Teliya Kholas, and its adjacent areas of Udayapur District of Eastern Nepal.
- The details of the lithological units were studied and mapped to find out the lateral extension and variation of the different rock types to understand the source, seal, and reservoir potential for hydrocarbon.
- Compass and tape survey method (compass, measuring tape, hammer, chisel and altimeter) were used to measure the geological section and collect the rock samples (Photo 1).

Photo 1: Section Measurement of Gondwana Shale along Dharapani - Duwar Khola

GEOLOGY OF THE STUDY AREA

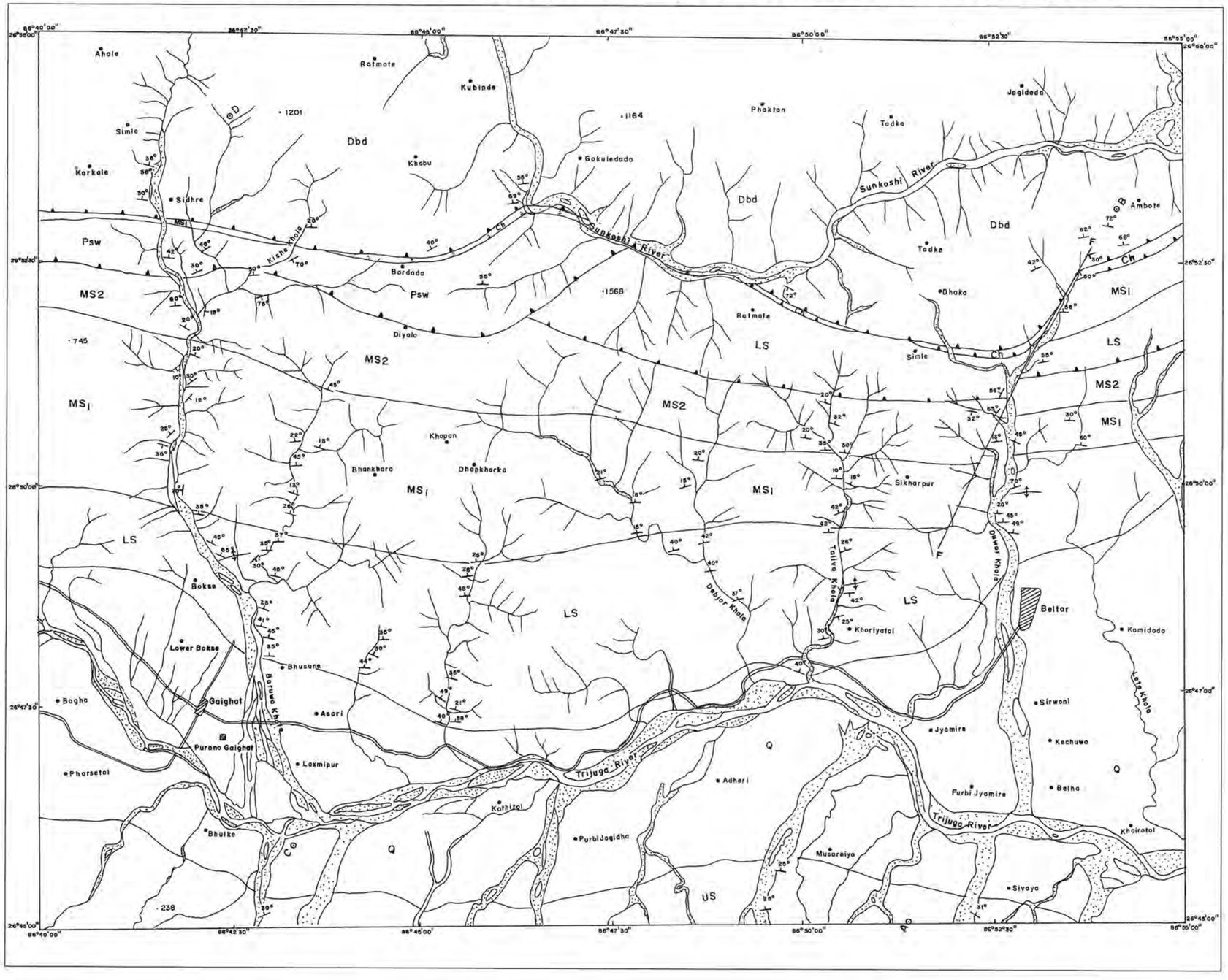
The study area is represented by sedimentary, metasedimentary and metamorphic rocks belonging to Quaternary sediments of river traces, Siwalik Group of Sub-Himalaya as well as Gondwana and Midland Groups of Lesser Himalaya from south to north respectively (Kayastha 1971, Bashyal, 1973, Subedi and K.C. 1995, Shrestha and Sharma 1995, Khanal 2010). The rocks of the Siwalik Group consist of mudstone, siltstone, and sandstone. The Mahabharat Range or the Lesser Himalaya constitutes the sedimentary to metamorphosed rocks like shale, slate, quartzite, dolomite, phyllite etc. (Kayastha 1971, Bashyal 1973). The geological setting and geological cross section of the studied area are shown in Fig. 2. Similarly, the stratigraphic sequence of the studied area is shown in Table 1.

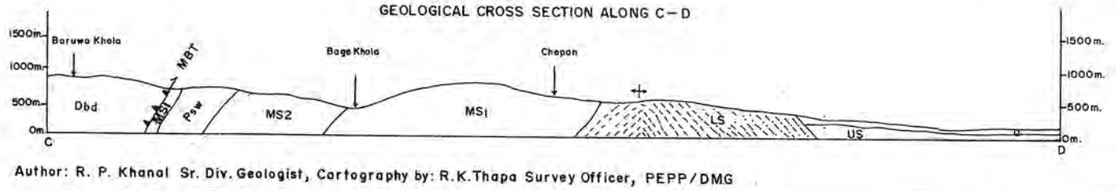
In general, the strike of the rock in the area is NE-SW, sometimes NW-SE and the bed dips NE to NW and sometimes SW at an angle of 20^0 to 78^0.

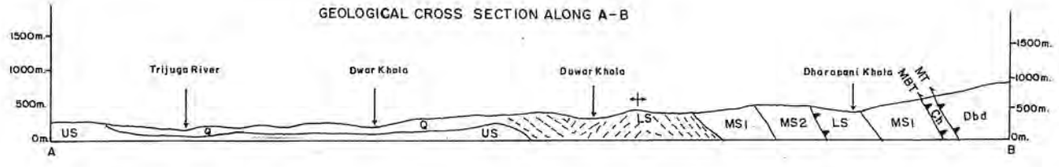
Table 1: Stratigraphic sequence of study area

Tentative Age	Group	Formation	Lithology
Quaternary (Q)			Alluvial, gravels, sand, silt, and clay
Miocene-Lower Pleistocene	Siwalik Group	Upper Siwalik (US)	Conglomerate with subordinate sandstone and mudstone
		Upper Middle Siwalik (MS2)	Medium to coarse grained, light grey to grey, arkosic pebbly sandstones interbedded with grey, dark grey, brown clays. Coal lenses and plant fossils are present
		Lower Middle Siwalik (MS1)	Fine Fine to medium grained sandstone with interbeds of siltstone and mudstone. Coaly materials and plant fossils are present.
		Lower Siwalik (LS)	Fine grained sandstone with interbeds of Variegated shale, siltstone and occasional marl.
Lower Carboniferous - -L Lower Cretaceous	Gondwana Group	Charchare Formation	Grey to dark grey carbonaceous shale with Some quartz veins and diamictites of different clasts
Precambrian-Lower-Tertiary	Pre-Siwalik Group	Gawar Formation (Gw)	Grey to cream grey stromatilitic dolomite with some dark grey shales
Precambrian-Early Paleozoic	Midland Group	Dubidanda Formation (Dbd)	Grey to greenish grey chloritic phyllite, gritty phyllite and white grey quartzites

GEOLOGICAL MAP OF GAIGHAT-BELTAR AREA, UDAYAPUR DISTRICT (PERTOLEUM EXPLORATION BLOCK. 9), EASTERN NEPAL







Author: R. P. Khanal Sr. Div. Geologist, Cartography by: R.K.Thapa Survey Officer, PEPP/DMG

Fig 2: Geological Map Of the study area.

Midland Group

The rocks of the Midland Group are clearly exposed in the northern part of the study area. The rocks of this group are thrusted over the rocks of the Gondwana Group along the Mahabharat Thrust (Fig. 2). It consists of Dubidanda Formation.

Dubidanda Formation (Dbd)

It is the Precambrian rock in the studied area. It consists of grey to greenish grey chloritic phyllite and grey to white sericitic quartzites. It is well exposed along Saptakoshi River, Baruwa and Duwar Kholas. The rock of this formation is highly sheared, folded and faulted (Photo 2).

Photo 2: Greenish grey chloritic Phyllite of Dubidanda Formation in Baruwa Khola

Pre-Siwalik Group

Parallel laminated stromatolitic dolomite with some grey shale of Gawar Formation is observed in the studied area especially in Baruwa Khola section. But it does not appear in Taliya Khola and Duwar Khola sections. In Baruwa Khola its thickness is measured up to 60 m. Its thickness gradually increases towards west and decreases towards east from Baruwa Khola. Parallel laminated, jointed, grey coloured, medium to thin bedded dolomite is clearly observed in the Baruwa Khola and south of Sidhre village (Photo 3).

Photo 3: Laminated structure in Pre-Siwalik Group (Dolomite)

Gondwana Group

Charchare Formation

The outcrop of this formation comprises mainly dark grey to black, carbonaceous silty shale, and quartzites with ferrugionous coatings. The rocks of this formation are clearly observed along Dharapani Khola (Photo 4). No distinct dark grey black carbonaceous shale of Gondwana rock is observed along the Baruwa Khola section.

Photo 4: Dark grey carbonaceous shale of Charchare Formation in Dharapani Area, Northern part of Duwar Khola

The Charchare Formation comprises dark grey carbonaceous shales and some quartzites Shales are very thinly bedded and also found as thin intercalations with quartzites. The shale contains coal bearing materials. These are very soft and crushed. These rocks are presumed to be Lower Carboniferous to Lower Cretaceous in age (Pradhan et.al. 2005).

Siwalik Group

The Siwalik Group (Middle Miocene - Lower Pleistocene) is composed of sandstone, mudstone, siltstone, shale, clay and conglomerates. It is bounded by Main Frontal Thrust (MFT) to the south and Main Boundary Thrust (MBT) to the north. The sandstone of the Siwalik group is medium grained, porous, and permeable. It can be considered as the good reservoir for hydrocarbon accumulation. The Siwalik group has been divided into three formations: Lower Siwalik (LS), Middle Siwalik (MS) and Upper Siwalik (US) on the basis of lithological variations.

Lower Siwalik (LS)

It is composed of fine to medium grained light grey to grey sandstone, and maroon nodular clay. It occupies the southern part of the mapped area such as Hadiya, Kank, Baruwa, Taliya and Duwar Kholas. It is repeated again in Taliya, Duwar and in Baruwa Kholas in the upper part of the Siwalik range.

Sandstone beds are thin to medium bedded and attain upto 85 cm. Mudstone is medium to very thick bedded and having purple to greenish grey colour. The thickness of the individual beds of clay varies from 0.35 m to 4.2 m. In general, the strike of the formation is NW-SE with dip amount 35^0- 67^0 towards north and sometimes south. It is conformably overlain by the Middle Siwalik (MS1).

Middle Siwalik (MS)

The Middle Siwalik has normal and gradational contact with the underlying Lower Siwalik. It consists of fine to medium and coarse grained sandstones, pebbly sandstones interbedded with greenish grey shale and clay. The lower portion of the Middle Siwalik contains alternate bands of sandstone, shales and clays. In the upper horizon, the coarseness of the sandstone increases. The sandstone becomes more coarse, and gritty. The Middle Siwaliks are repeated again in the middle of the mapped area. The Middle Siwalik is also classified into Upper Middle Siwalik (MS2) and Lower Middle Siwalik (MS1) based on the presence of pebbly sandstone horizon and a few conglomerate bands.

Lower Middle Siwalik (MS1)

Lower Middle Siwalik (MS1) consists of sandstone, mudstone, and shale. Sandstone of MS1 is light grey to grey coloured, medium grained and interbedded with green to greenish gray clay. This sub unit MS1 is repeated again in the eastern parts of the study area. It is mainly characterized by arkosic sandstone in the studied area.

Upper Middle Siwalik (MS2)

The upper Middle Siwalik (MS2) is conformably overlies the subunit MS1 with gradational contact. It is mainly composed of gray to grayish white fine to medium grained pebbly sandstone with little intercalation of gray to grayish white shale and clay. Sandstone is very thick to massive and course grained (Photo 9) and proportion of sandstone is greater than mudstone. The individual bed of mudstone varies 0.6 m to 3.8 m in thickness. The thickness of the individual sandstone bed varies from 2 m to even more than 5 m.

Upper Siwalik

The Upper Siwalik (US) is well exposed in the southern part of the study area. It mainly consists of alternation of gravel, boulder, sand and clay. The rocks of this member are poorly bedded to well bedded and dipping towards north-west. The thickness of beds varies from 0.3 m to 1.5 m.

GEOLOGICAL STRUCTURE

The Main Boundary Thrust (MBT) separates Tertiary sedimentary Siwaliks from the earlier Tertiaries and the older rocks in the area. The trend of MBT is almost NW to SE direction. This thrust can be distinguished in the field mainly in Duwar Khola because of strong lithological contrasts across the thrust plane. Landslides, micro folds, joints and shearing effect is the strong evidence for thrusting (Photo 5).

The rocks of the Midland Group are thrusted over the rocks of the Gondwana Group along the Mahabharat Thrust (MT). The trend of MT is almost same as the MBT. The MT separates underlying sedimentary rock to low grade meta-sediments from older precambrian high grade metamorphic rocks of Midland Group. The

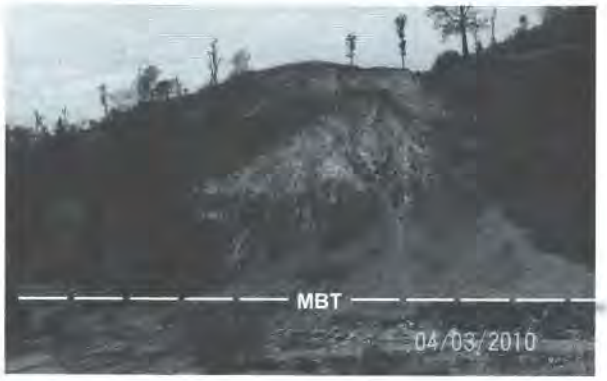


Photo 5: MBT traces observed in the Duwar Khola, Udayapur District

rocks of Midland Group are highly sheared in the study area.

A major anticline fold is observed in the Lower Siwalik (LS) in Taliya Khola north of Bhima and north of Beltar along Duwar Khola. Similarly, cross laminated, course bedded massive sandstone beds are observed along Taliya Khola Section.

A major fault named as Duwar Fault passes nearly along Duwar Khola. Displacement of the rock on either sides of Duwar Khola can be observed (Fig. 2) in the field.

GEOLOGICAL SECTION MEASUREMENT

Thickness of various rock units and formations were measured along Baruwa, Duwar, Teliya Kholas and its adjacent areas, Udayapur District of Eastern Nepal. Real thickness of Gondwana shale has been measured along all sections in the study area. Thickness of different geological formations in various sections is shown in Fig. 3. Gondwana shale has thickness in the range of 21-28m in Duwar Khola area, whereas thickness of the Diamictite measured in Saptakoshi is 22m. Thickness of Pre-Siwalik Group (Psw) rocks is about 60 m in Baruwa Khola. Similarly, thickness of exposed LS ranges from 320 m in Duwar Khola to 475 m in Baruwa Khola. It is clearly observed in all sections. Upper Middle Siwalik (MS2) and Lower Middle Siwalik (MS1) are also

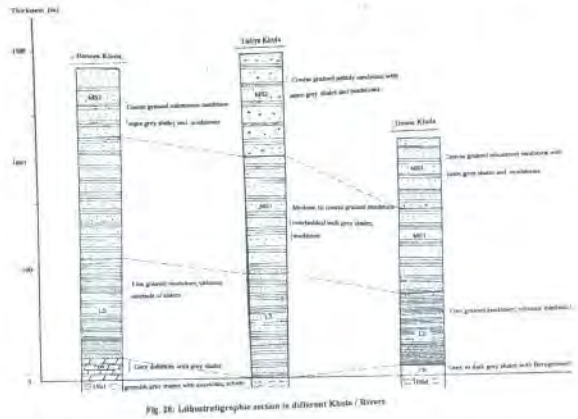


Fig.3: Lithostratigraphic Section measured in various rivers

observed in all sections. Thickness of MS1 ranges from 365 m to 560 m in Duwar Khola and Baruwa Khola respectively, whereas its thickness is 535 m in Taliya Khola. Similarly thickness of MS2 observed in the field is about 490 m in Taliya Khola. Real Thickness of this formation could not measure in the field due to faulted contact with LS.

CONCLUSION

Detail geological sections measurement of different rock units / formations along major streams and river were carried out in the studied area. This geological investigation is very important to identify thickness and extension of Gondawana shales as an important petroleum source rock in the study area. About 28 m thick Gondwana shales are clearly observed along Duwar Khola whereas diamictites are observed in Dhaplanghat area in Sunkoshi. No Gondwana shale is observed in Baruwa Khola Section. However, more and more satellite images of high spatial resolution should be used to identify the thrust / faults and geological contact as well as more precise GPS is needed to locate more accurately in the dense forest area.

ACKNOWLEDGEMENT

The author is grateful to Mr. S. P. Mahato, Director General of Department of Mines and Geology and S. B. K.C, Project Chief of Petroleum Exploration Promotion Project (PEPP), Department of Mines and Geology (DMG) for providing necessary facilities to conduct the fieldwork. I am also equally grateful to Mr. D. N. Subedi, Sr. Div. Geologist for the encouragement of this work. I greatly appreciate to Mr. Rajan Thapa, Survey Officer of PEPP/ DMG for providing help in cartography work as well as all staffs of Administrative, Account, Planning, and Store sections of PEPP/ DMG for providing necessary help to conduct the fieldwork.

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Departmental Activities and Progress in Fiscal Year 2067/68

Krishna D. Jha (Sr. Div. Meta. Engineer) and Suresh Shrestha (Geologist)

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

All the annual activities planned for the Fiscal Year 2067/68 has been completed as per the schedule and the overall progress remained 90% of the target. The programs and the progress are listed in the Table 1 and other progress in Table 2.

Table 1: Program and progress of the DMG for the Fiscal Year 2067/2068

Program/ Activities	Location/ District	Volume of works	Output/ Result	Remarks
(A) Mineral Exploration and Development				
1.Priliminary Exploration of Iron,	Dhaubadhi, Nawalparasi	100 sq.km	100 sq.km	Follow up Exploration will be carry out in next fiscal year 2068/69.
2.Assesment of Labdi Iron deposit	Labdi khola, Tanahu	25 sq.km	25 sq.km	Data package will be prepared.
3.Followup Exploration Limestone	Palpa	25 sq.km	25 sq.km	Explorative Drilling will be carry out in next year.
4. Explorative Drilling of Limestone	Jeitpani, Sallyan	300 meter	291meter	Total deposit of limestone with Quality will be figure out.
5.Promotion of Mineral based industries		5	5	Data package of Baban gaon copper deposit, Dadeldhura, Minamkot copper deposit , Tanahu, Dumariya copper deposit Chitawan along with two deposits of gold of lungri khola has been prepared and notice published in national daily for proposal.
5. Inspection and Environmental Monitoring of Operating Mines	Throughout the country	75 mines (1-3 times)	-The environmental impacts minimized and production data collected	75 Mines were visited for environmental monitoring and data collection.
6. Monitoring of KTM Natural Gas wells.	Different parts of Kathmandu valley	14 Gas Wells	14 Gas wells monitored	Most of the wells appear dry due to lack of proper and timely maintenance.

(B) Geoscientific Survey and Research				
Program/ Activities	**Location/ District**	**Volume of works**	**Output/ Result**	**Remarks**
1. Geological Map Update (Toposheet no.2981-13ABCD)	Doti, Achham	650 sq.km.	650 sq.km.	Map will be published in the next fiscal year.
2. Geo-Engineering & Geo-Environmental Study	Janakapur	300 sq. km.	300 sq. km.	Map will be published in the next fiscal year.
3. Geo-hazard Maping Study Toposheet no. 2981-13BD,14AC	Parts of Achham and Doti	650 sq.km.	650 sq.km.	Map will be published in the next fiscal year.
4. Publication of colored geological Maps (62C/15, 62C/16)	Parts of Dadeldhura, Baitadi, Doti, Bajhang	2 sheets	500 copies each	Digitization of the map is completed and is in the process of publication.
5. Geo-hazard Maps (62P/8,P/3)	Parts of Gulmi, Baglung, Myagdi and pyuthan	2 sheets	500 copies each	Digitization of the map is completed and is in the process of publication.
6. Geo-Engineering & Geo-Environmental map	Surkhet	1 sheet	500 copies each	Engineering and environmental geological map of Birendranagar, Municipality and surrounding area is published.

Table 2: Other departmental progresses of the DMG, for the Fiscal Year 2067/2068

Works	Total
Prospecting license(new)	190
Prospecting license(renewed)	307
Mining license(new)	5
Mining license(renewed)	75
Laboratory facilities	
Chemical analysis of different samples	223
Element determination	1378
Mineralogy and petrology lab. service	4
Ammonia map printing	234
Library facilities	215 person/institution
Seismic events processing	8011 events
Press released earthquakes with magnitude (MI) > 4.0 within Nepal in the FY 2067/68.	10 Times
Talk program held on different topics	9 times
Royalty collected	Rs.2,17,89,575

National Seismological Centre (NSC)

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

The overall budget of DMG is Rs. 6,13,69,000.00 (Development project and General Administration). Allocated Budged and expenses for fiscal year 2067/68 are summarized in the Table 3 and Fig. 1.

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

DMG has selected the best staff of the year for the fiscal year 2067/68. Mr. Purna Kaji Maharjan was selected as the best staff of the year 2067/68 from the DMG. On the occasion of Nijamati Karmachari Day, be was felicitated by Director General of DMG.

Annual Development Programmes for the Fiscal year 2068/69 is summarized below in Table 4.

Table 3: Budget of the DMG for the Fiscal year 2067/2068

General Administration		
	Allocated Budget	Expenses
Capital	Rs.993000.00	Rs.988700.00
Current	Rs.50421000.00	Rs.45996615.00
Total	Rs.51414000.00	Rs.46985315.00

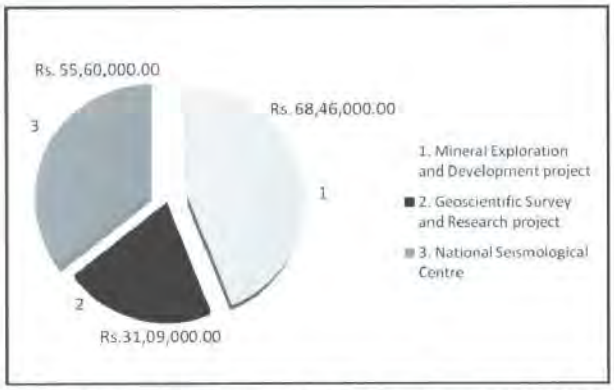

Fig. 1. Budget distribution chart for fiscal year 2067/ 2068

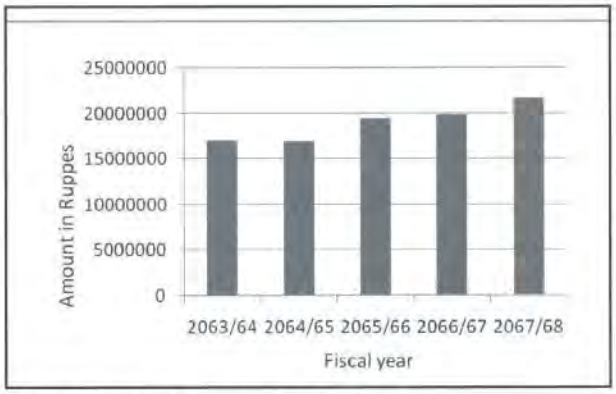

Fig. 2. Royalty Collected in last five years

Table 4: (A) Mineral Exploration and Development programs for the Fiscal Year 2068/2069

S. No.	Programme/Activities	Location/ District	Volume of work	Budget(RS)
1	Follow up exploration of Iron	Dhaubadhi, Nawalparasi	25 sq. km.	2,25,000
2	Priliminary exploration of Uranium	Mustang	150 sq.km	2,25,000
3	Explorative drilling of Limestone	Palpa	300 m	17,50,000
4	Inspection and Environmental Monitoring of Operating Mines	Throughout out the country	75mines	4,50,000
5	Geochemical and Geophysical exploration of Copper	Wapsa, Solukhumbu	300 sq. km	8,00,000
6	Preliminary exploration of semi precious gem	Achham, Kalikot and Dailekh	1000 sq. km	20,00,000
7	Promotion of Mineral based industries 1.Limestone 2.Iron 3.Copper 4.Dimention stone/Limestone 5.Coal	Lakharpata, Surkhet Labdi khola, Tanahu Chirlingkhola, Bhojpur Makawanpur Palpa/Arghakhachi	5 mines	60,000
8	Monitoring of KTM Natural Gas wells	Kathmandu Valley	14 Gas wells	12,75,000
9	Exploration and production of Natural Gas of Kathmandu	Kathmandu Valley	2 Gas wells (800m)	1,00,00,000

S. No.	Programme/Activities	Location/ District	Volume of work	Budget
1	Geological Map Update (1:25000) Toposheet no.2881-03,ABCD	Parts of Dailekh, Achham, Kalikot, Surkhet	650 sq.km	3,30,000
2	Geo-Engineering & Geo-Environmental Study	Dhangadhi	300 sq.km	3,20,000
3	Geo-hazard Maping Study(1:25000) Toposheet no. 2881-03,ABCD	Parts of Dailekh, Achham, Kalikot, Surkhet	650 sq.km	3,30,000
4	Publication of colored Geological Maps (62C/15, 62C/16) Geo-hazard Maps (62P/8,P/3) Geo-Engineering & Geo-Environmental map Regional map of Eastern Nepal	Parts of Dadeldhura, Baitadi, Doti, Bajhang Parts of Gulmi, Baglung, Myagdi and pyuthan Nepalgunj	2sheets (500 copies each) 2 sheets (500 copies each) 1 sheet (500 copies) 1 sheet (500 copies)	8,00,000

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DMG PUBLICATIONS

1. Maps

S.No.	Code No.	Title of Map	Scale	Year of Publication	Price (Rs)
1	GM1	Geological Map of Nepal	1:1,000,000	1994	550
2	GM2	Geological Map Western Nepal	1:250,000	1983	330
3	GM3	Geological Map of Mid Western Nepal	1:250,000	1987	330
4.	GM4	Geological Map of Easter Nepal	1:250,000	1984	475
5	GM5	Geological Map of Far Western Nepal	1:250,000	1987	330
6	GM6	Geological Map of Central Nepal	1:250,000	1985	330
7	GM7	Geological Map of Kathmandu and Central Mahabharat Range	1:250,000	1980	330
8	GM8	Photogeology Map of a part of Central Nepal	1:1,000,000	1982	275
9	GM9	Geological Map of Parts of Tanahun Gorkha and Nawalparasi Districts (72 A/5)	1:50,000	1996	275
10	GM10	Geological Map of Parts of Tanahun and Kaski Districts (71 D/4)	1:50,000	1996	275
11	GM11	Geological Map of Parts of Syangja Kaski and Tanahun Districts. (62 P/16)	1:50,000	1999	275
12	GM12	Geological Map of Parts of Tanahun and Nawalparasi Districts (72 A/1)	1:50,000	1999	275
13	GM13	Geological Map of Parts of Syangja, Palpa and Tanahun Districts (63 M/13)	1:50,000	1999	275
14	GM14	Geological Map of Parts of Parbat, Baglung, and Gulmi Districts. (62 P/12)	1:50,000	2000	275
15	GM15	Geological Map of Parts of Gulmi and Baglung Districts (62 P/8)	1:50,000	2000	275
16	GM16	Geological Map of Parts of Palpa, Syangja and Gulmi Districts. (63 M/9)	1:50,000	2000	275
17	GM17	Geological Map of Parts of Palpa, Arghakhanchi and Gulmi Districts (63 M/5)	1:50,000	2000	275
18	GM18	Geological Map of Parts of Kaski and Parbat Districts (62 P/15)	1:50,000	2002	275
19	GM19	Geological Map of Parts of Myagdi, Parbat and Baglung Districts (62 P/11)	1:50,000	2002	275
20	GM20	Geological Map of Parts of Myagdi, Baglung and Gulmi Districts (62 P/7)	1:50,000	2003	275
21	GM21	Geological Map of Parts of Baglung, Pyuthan and Gulmi Districts (62 P/3)	1:50,000	2003	275
22	GM22	Geological Map of Parts of Myagdi and Mustang Districts (Western Part) (62 P/6)	1:50,000	2004	275
23	GM23	Geological Map of Parts of Myagdi and Mustang Districts (Eastern Part) (62 P/10)	1:50,000	2004	275
24	GM24	Geological Map of Parts of Gulmi, Pyuthan, Arghakhanchi and Baglung Districts (62P/4)	1:50,000	2004	275
25	GM25	Geological Map of Parts of Sindhupalchok and Nuwakot Districts (Melamchi Area) (72 E/9)	1:50,000	2005	275

S.No.	Code No.	Title of Map	Scale	Year of Publication	Price (Rs)
26	GM26	Geological Map of Parts of Sindhupalchok Districts (Barhabise Area) (72 E/13)	1:50,000	2005	275
27	GM27	Geological Map of Parts of Dang, Rolpa and Pyuthan Districts (62 L/12)	1:50,000	2006	275
28	GM28	Geological Map of Parts of Pyuthan and Arghakhanchi Districts (62 L/16)	1:50,000	2006	275
29	GM29	Geological Map of Part of Chitwan, Dhading and Makawanpur Districts (72 A/14)	1:50,000	2007	275
30	GM30	Geological Map of Part of Dhading, Makawanpur, Kathmandu and Lalitpur Districts (72 E/2)	1:50,000	2007	275
31	GM31	Geological Map of Parts of Kavrepalanchoke and Sindhuli Districts (72E/11)	1:50,000	2008	275
32	GM32	Geological Map of Parts of Kavrepalanchoke Ramechhap and Sindhuli Districts (72 E/15).	1:50,000	2008	275
33	GM33	Geolgoical Map of Parts of Baitadi and Kanchanpur Districts (62 C/7)	1:50,000	2009	275
34	GM34	Geological Map of Parts of Dadeldhura and Kanchanpur Districts (62 C/8)	1:50,000	2009	275
35	GM35	Geological Map of Parts of Baitadi and Dadeldhura Districts (2980 11)	1:50,000	2010	275
36	GM36	Geological Map of Parts of Doti, Dadeldhura and Kailai Districts (2980 15)	1:50,000	2010	275
37	GM37	Geological Map of Parts of Baitadi, Bajhang and Doti Districts (2980 12))	1:50,000	2011	275
38	GM 38	Geological Map of Parts of Doti and Kailali Districts (2980 16)	1:50,000	2011	275
39		Geological Map of Petroleum Exploration Block-1, Dhamgadi Far Western Nepal	1: 250,000	2007	330
40		Geological Map of Petroleum Exploration Block-2, Karnali, Far Western Nepal	1: 250,000	2003	330
41		Geological Map of Petroleum Exploration Block-3, Nepalgunj, Mid Western Nepal	1: 250,000	1999	330
42		Geological Map of Petroleum Exploration Block-4, Lumbini, Mid Western Nepal	1: 250,000	2000	330
43		Geological Map of Petroleum Exploration Block-5, Chitwan, Western Central Nepal	1: 250,000	1998	330
44		Geological Map of Petroleum Exploration Block-6, Birgunj, Central Nepal	1: 250,000	2001	330
45		Geological Map of Petroleum Exploration Block-7, Malangwa, Central Nepal	1: 250,000	2002	330
46		Geological Map of Petroleum Exploration Block-8, Janakpur, Central Nepal	1: 250,000	2004	330
47		Geological Map of Petroleum Exploration Block-9, Rajbiraj, Eastern Nepal	1: 250,000	2005	330
48		Geological Map of Petroleum Exploration Block-9, Biratnagar, Eastern Nepal	1: 250,000	2006	330
49		Epicentre Map of Nepal	1:100, 0000	2005	275
50		Seismic hazard Map of Nepal	1:1500,000	2002	275
51		Engineering and Environmental Geological Map of Kathmandu Valley	1:50,000	1998	275

S.No.	Code No.	Title of Map	Scale	Year of Publication	Price (Rs)
52		Engineering and Environmental Geological Map of Pokhara Valley	1:50,000	1998	275
53		Engineering and Environmental Geological Map of Butwal Area	1:25,000	2008	275
54		Engineering and Environmental Geological Map of Dharan Area	1:25,000	2009	275
55		Engineering and Environmental Geological Map of Bhairhawa Area	1:25000	2010	275
56		Engineering and Environmental Geological Map of Biratnagar, Surkhet Area	1:25,000	2011	275

2. Books

1. Mineral Resources of Nepal (Reprint, July 2011) ..... Rs. 300
2. A Guidebook on Geological section of Mechi Highway (Charali-Ilam-Phidim Road), Eastern Nepal , July 2010..... Rs. 275
3. A Guidebook on Geological section of Bhanubhakta Acharya Marg (Dumre-Besisahar Highway), Western Nepal, July 2009 ..... Rs. 275
4. A Guidebook on Geological section of Bhupi-Serchan Marg(Pokhara-Beni Highway), Eastern Nepal , June 2008 ..... Rs. 275
5. A Guidebook on Geological section of Siddhartha Highway (Butwal to Pokhara), Western Nepal, June 2007..... Rs. 275
6. A Guidebook on Geological section along Arniko Highway (Kathmandu-Kodari Road), Central Nepal, June 2006 ..... Rs. 275

3. GIS Data

	Person	Institute
1. Polygon Feature	Rs. 300	Rs. 700
2. Line Feature	Rs. 200	Rs. 400
3. Point Feature	Rs. 100	Rs. 200

Digital data/ GIS data are available for S.N. 4,27,28-34, 37,38 and 51-56.

SOME GEM MINERALS OF NEPAL

1. Aquamarine (Taplejung)
2. Tourmaline (Jajarkot)
3. Kyanite (Jajarkot)
4. Garnet (Nuwakot)
5. Quartz (Dhading)

(Source : K.N. Pokharel)

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