


Annual Report of Department of Mines and Geology

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FOREWORD

Department of Mines and Geology's endeavor to disseminate the knowledge of geoscience and seismicity, mineral and petroleum resources exploration and development, promotion of mineral based industries, is and will be the main objective since its existence.

To meet the above objectives DMG is persistently working in these fields and has been updating and publishing geological maps not only of whole Nepal but also of all the seven provinces and according to the local needs. It has also undertaken geophysical and geo-environmental study to plan and develop accordingly of major urbanizing centers. The study and publications of landslide and seismic hazard map are some other activities that are utmost important for natural disaster risk reduction and management. Similarly, mineral resources exploration and promotion for the development of mineral based industries has played a key role in the national economy by substituting the import of some of the commodities like cement, talc powder etc. More opportunities in other minerals/metals like dolomite, phosphorite, magnesite, copper and iron ore are in offing.

These informations and database are being disseminated to the stakeholders through various means and the Annual Bulletin is one. I am delighted to bring forward the rituals of disseminating the DMG activities into form of research articles and database by publishing the "Annual Report of Department of Mines and Geology, Volume 12". We at DMG believe and have strong determination that the policy-makers, planners, mines developers, stakeholders etc. will recognize the contribution of the geo-scientific studies and development of mineral/petroleum resources for meeting the goal of 'समृद्ध नेपाल सुखी नेपाली' and prioritize this sector in the overall planning process.

I would like to thank all the contributing author, co-author for timely submitting their research article and special gratitude goes to the reviewer and editorial board for their tireless effort on going through the manuscript and compiling all the articles into this volume within short interval of time that being affected by the lock down and COVID-19 pandemic. I hope this volume will be informative for the geoscientists, investors in the mineral sector, students and general public who are keen to know about DMG research activities in coming days.

Ram Prasad Ghimire
Director General

EDITORIAL

Geoscientists, engineers, chemists and other professional staffs in the department find themselves working from home with laboratory closed, fieldwork cancelled, learning and interacting responsibilities shifted to online mode. Due to COVID 19 pandemic each person faces disruption to their lives and livelihood. Despite these challenges, department has been trying to minimize its impact on its scientific and other activities.

DMG is only government organization deals with systematic geo-scientific researches, geo-hazard assessment, regulating mines and mineral resources development activities in Nepal. Geological mapping, the earthquake monitoring and research, the landslide research and the geotechnical/geo-environmental assessments are the major field of study in earth sciences. The one is basically focused on physical and infrastructural planning and the other solely concern to the geo-disaster planning and management. Exploration and promotion of different mineral commodities and regulating mines and mineral based activities guided by the prevailing mining rules and regulations are mandated as the other major work of the department. In order to provide the reliable and trustworthy geological information and the data on potential of mineral resources in the country, DMG plays vital role in disseminating and providing information to the various stakeholders such as planners, geo-scientists, mineral based industries, environmental and geo-disaster researchers, students etc. Department of Mines and Geology has published Annual Report Volume 12 for fiscal year 2076/77 is the continuation of preceding volumes. It consists of different articles related to the various works under annual programme completed in the earlier and current fiscal year. Volume 12 will definitely provide some new insights and information which could be helpful for the different group of stakeholders that are involved in the geo-scientific research and mineral based industries. Since the beginning of publication it was intended that its scope would be extended to utilize sophisticated field equipment and laboratory based investigation rather using minimum invasive method of traditional techniques for mineral exploration and geo-scientific research. Given the fact that the increased volume of work carried out since few years back, we have started to work on geo-electrical imaging, induced polarization imaging, entertained digital based laboratory geotechnical measurement facilities, various seismic equipment to understand ground seismicity (MASW and SPAC), topographical mapping by drone, magnetic mapping, mineral identification in the field by hand held XRF, upgraded chemical laboratory by using ICPMS measurements, AS measurements etc. This upgraded facilities would definitely make the articles better and eventually encourage the governmental and non-governmental stakeholders to work with the DMG in the new domain of geo-scientific research.

Editorial Board greatly appreciate all the reviewers, We are happy to publish this volume and would like to extend its sincere appreciation and express gratitude to all the authors, co-authors and staffs of the Department for their contribution and cooperation to get the work done.

Dr. Rajendra Pd. Bhandari
Chief Editor

TABLE OF CONTENT

Study of Landslides at Thulo Lumpek and Limgha of Gulmi District

Rajendra Acharya (Geologist), **Sulav Kayastha** (Geologist)

ABSTRACT

Landslides often happen where they have already occurred in the past. The diversity in slope components, geometry, site and situation, micro-regional susceptibility to degradation processes, depth of soil, its physical and chemical properties, vegetation, unplanned growth of settlement, road and sewer systems have led to recurring landslides. This report is prepared based on the visual inspection of the landslide and slope failure affected communities but does not include instruments based testing. The study reveals that each slide has its own peculiarities and did not happened by particular single factor. Of the various factors, water has the most deleterious effect. The solution to each problem has to be determined for individual site, though it may mitigate effectively in combination of a few well established methods viz. retaining structure, check dams, cross drainage, bio-engineering, restriction to expansion of settlement etc. for stabilizing hill slopes and gully protection. Some areas need relocation where there is high hit by landslides.

Keywords: micro-regional susceptibility; retaining structure; slope failure; deleterious

INTRODUCTION

Due to intense monsoon rainfall of Shrawan 7, 2076, many landslide occurred in different parts of Satyawati Rural Municipality viz. Thulo Lumpek and Limgha, Gulmi district (Table 1,2). A letter from Ministry of Home Affairs was received at the department requesting for the geological assessment of those areas. This field work aimed to study the geological and engineering geological condition of the landslide and affected settlement.

Table 1: Details of some large landslides of Thulo Lumpek

S. N.	Easting	Northing	Dimension			Lithology	Hill Slope	Seepage	Altitude (Dip Direction /Amount)	Remarks
			Length	Width	Depth					
1	452338	3098595	400	75	1	Slate, Fragments of slate and quartzite	45	At Middle	0/355	Debris
2	451412	3097861	200	50	6	Phyllite, Quartzite	50	Perennial at lower part	350/50	Debris
3	452041	3098283	100	15	2	Slate	55	At bottom	325/50	Plane failure/ Debris
4	454335	3098080	125	20	1	Slate with quartzite	55	-	-	Debris
5	454179	3098016	200	30	3	Slate, Quartzite	45	-	-	Debris
6	454157	3098054	120	70	2	Slate	42	-	325/50	Debris
7	451107	3099467	200	50	5	Colluvial soil, Fragments of slate and quartzite	45	At middle	280/10	Debris
8	451948	309920	400	10	2	Fragments of slate and quartzite	55	During monsoon	265/32	Debris
9	451158	3099799	200	10	1	Dolomite	50	-	-	Debris

Table 2: Details of landslide of Limgha

S. N.	Easting	Northing	Dimension			Lithology	Hill Slope	Seepage	Altitude (Dip Direction /Amount)	Joints
			Length	Width	Depth					
1	448900	3100380	100	30	5	Dolomite	65-70	At middle	230/45	J1-100/70
										J2-190/65
										13-230/45

The study area can be easily reached by motorable road from Kathmandu via Kathmandu - Butwal - Palpa – Ridi - Lumpek road. It is about 370 km from Kathmandu and about 20 km from Ridi Bazaar (Figure 1).

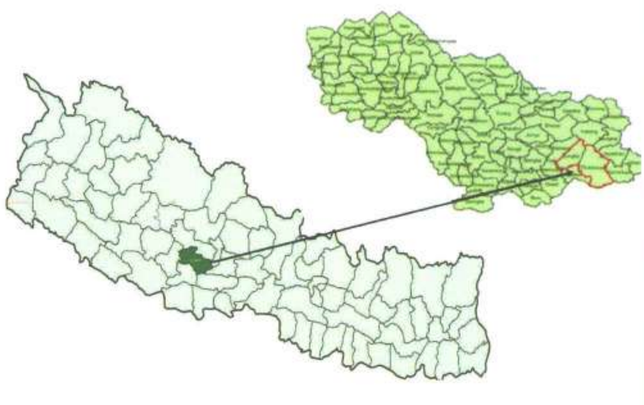

Figure 1: Location of the study area.

Study area lies in the hilly region. Maximum and minimum elevations in the area are 1,703 m and 1,041 m respectively above main sea level. The settlement lies in the relatively high slope in Thulo Lumpek and relatively gentle slope in Limgha. There are forest land, grassland in steep slopes below the cliff and other area are cultivated land around their houses (Figure 2-3).

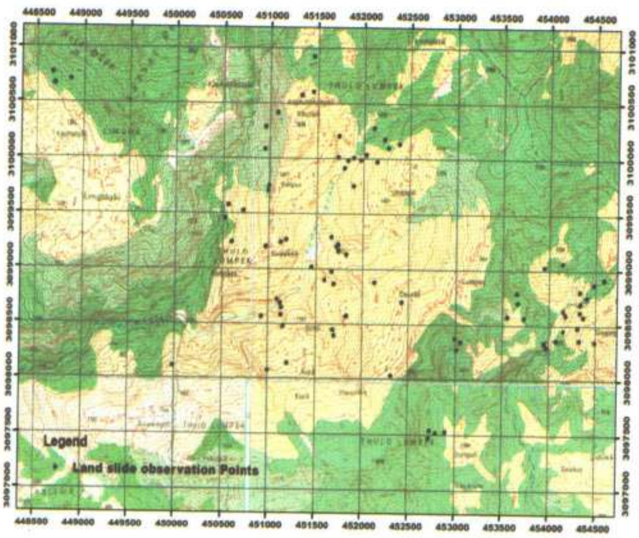

Figure 2: Topographical map of the study area.

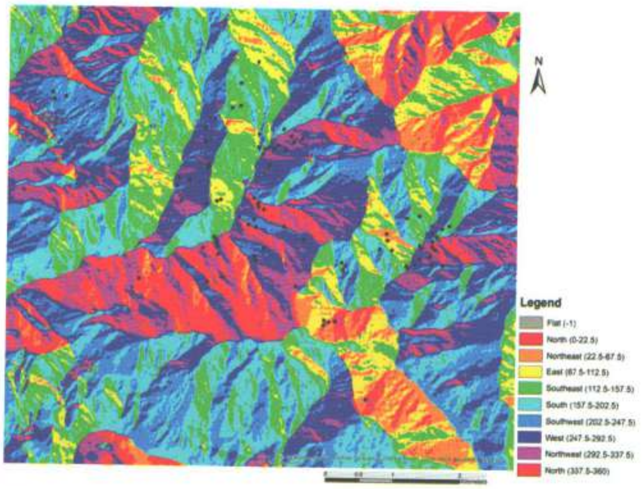

Figure 3: Slope-Aspect map of the study area.

The area is drained by Lumdi Khola, Tardi Khola and their tributaries forming the dendritic drainage pattern. Badigad Khola and Kaligandaki River are the two main river surrounding the study area (Figure 4).

Figure 4: Drainage map of the study area.

According to locals, rainfall in Satyawati area was scattered in nature, where the area around Thulo lumpek received an intense rainfall whereas the area far from Thulo lumpek receive relatively less amount of rainfall. The rainfall data from Department of Hydrology and Meteorology (DHM) was not significant as the rainfall data station lies around 15-20 km far from Thulo Lumpek area (i.e. Ridibazar Rainfall Station). Hence, the average rainfall data of Khaireni (i.e. the area around Satyawati Rural Municipality Office) was abstracted from www.worldweatheronline.com and it shows high rainfall nearby that area in the month of July (Figure 5).

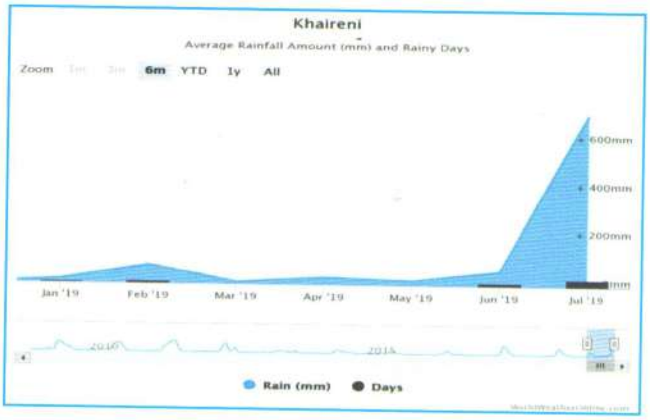

Figure 5: Rainfall data of nearby station.

GEOLOGY OF THE AREA

Geologically the study area lies in the Lesser Himalaya. Rocks of Galyang Formation and Lakharpata Formation are exposed. Galyang Formation consists of grey shale, slates, grey limestone with some calcareous slates. And Lakharpata Formation consists of fine grained grey limestone, dolomitic limestone with thin intercalation of purple shale. Mainly Thulo Lumpek consists of rocks of Galyang Formation (shale, slate and phyllites) whereas the Limgha consist rocks of Lakharpata Formation (Dolomite, shale) (Figure 6).

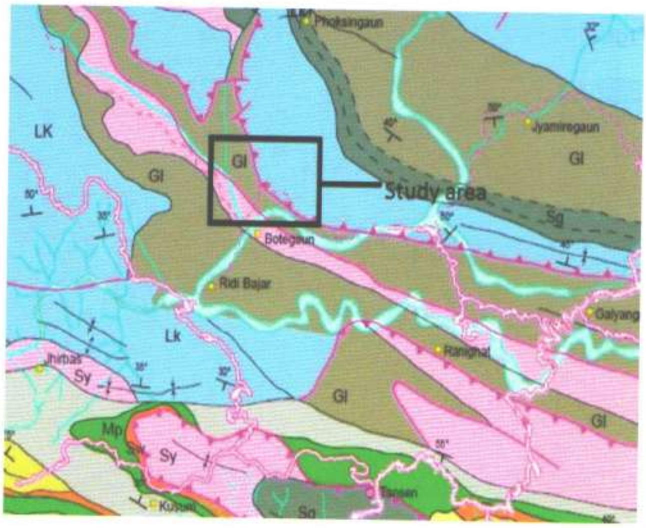

Figure 6: Geological map of the study area.

HAZARD CONDITIONS OF THE STUDY AREA

From the study carried out, it seems most part of Satyawati-3 (Thulo Lumpek) is at risk because of the following factors:

Most of the hill Slope is greater than 45°. Rock is generally dipping towards the hill slope. Lithology is mainly slate and phyllite. Plane failure due to haphazard road cut is quite evident in Singdi landslide (Figure 7 – 9).

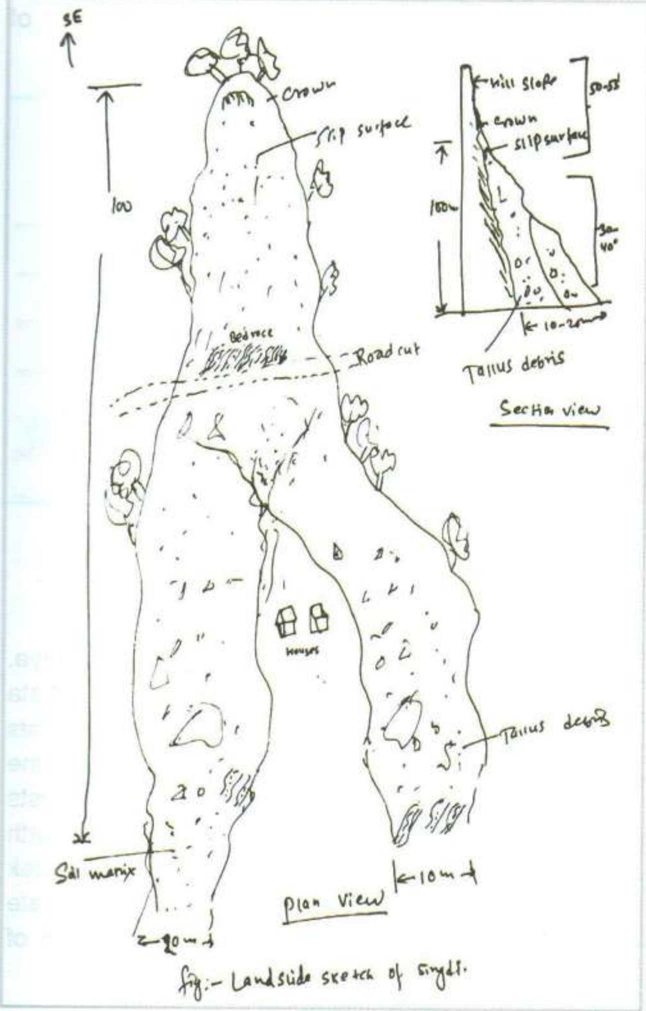

Figure 7: Landslide sketch of Singdi.

Figure 8: Plane failure of Singdi.

Figure 9: Singdi landslide.

Water seepage is observed in Kuraha landslide (Figure 10 -11).

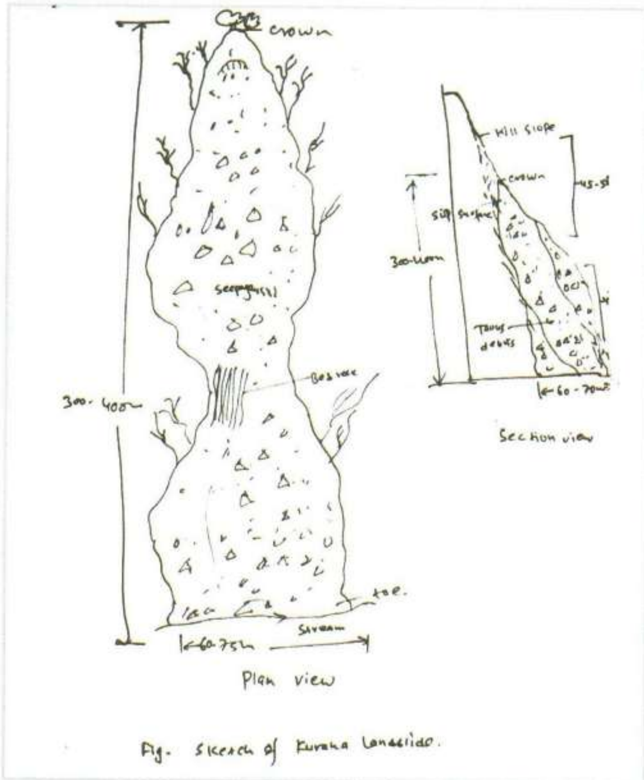

Figure 10: Landslide sketch of Kuraha.

Figure 11: Water seepage at Kuraha.

Figure 12: Cracks developed in ground at Ripdada.

Previously formed creep at Saplek (Figure 13) has not been taken care of and is at high risk.

Figure 13: Saplek landslide.

Haphazard road cut and colluvial nature of soil in Goskot is also a reason for landslide (Figure 14-15).

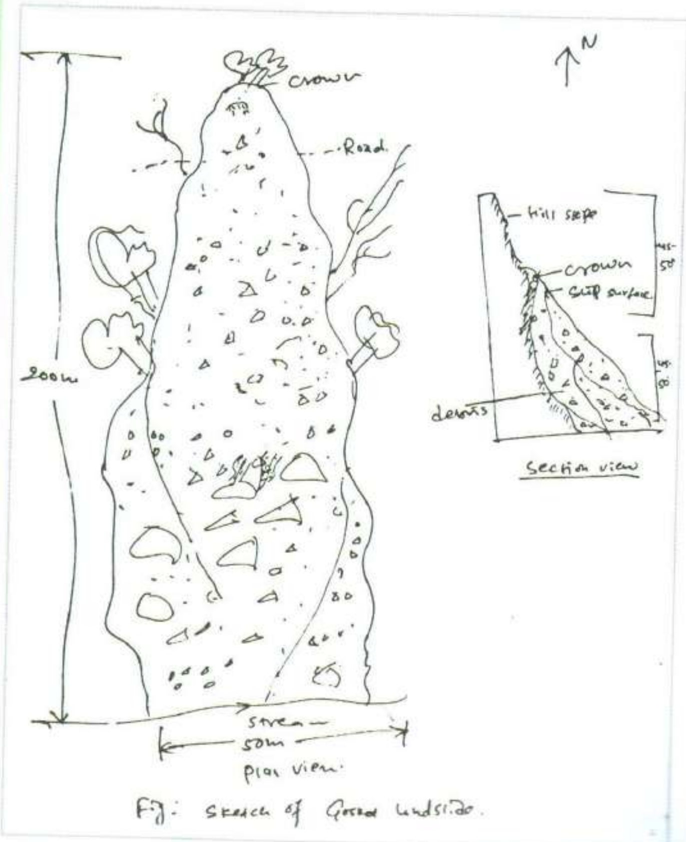

Figure 14: Landslide sketch of Goskot.

Figure 15: Number of landslides in Goskot.

The area just below the landslide of Satywati-4 (Limgha) (Figure 16 – 17) and the adjacent area along the dry stream are at risk due to steep hill slope and existing fractured rock beneath the hillslope. Soil is residual, sandy in nature hence water seeps out easily from the soil and other secondary openings.

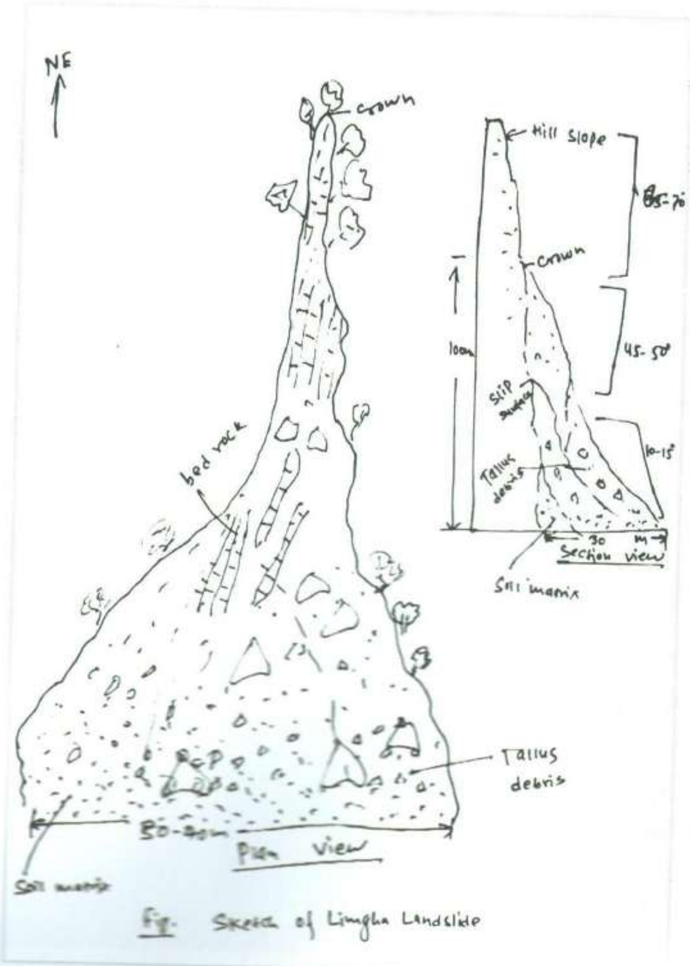

Figure 16: Landslide sketch of Limgha.

Figure 17: Limgha landslide.

CONCLUSIONS

Due to the heavy rainfall many parts of the hillslope of the Satyawati Rural Municipality, Gulmi district are severely affected by many landslides and tensional cracks. This report is only the technical study of the landslide. Due to this event and the following the continuous effect of likely rainfall, the studied villages are under the high risks of slope stability problem. Based on this preliminary study, it is concluded that many parts of these hillslope are still unstable. Other causing factors is the slope factor, the natural hill slope in this area varies from 45° to 65°. The natural stability of hillslope was disturbed by haphazard construction of road led to plane failure in Singdi, Goskot due to which sediments are easily eroded by water. One of the major causing factors is the surface runoff and subsurface inflow. During the intense rainfall maximum infiltration took place and lacking proper drainage in road section finally aggravate the slope failure. Lots of cracks, displacements and land subsidence is observed in Thulo Lumepk area. Hence, it is evident that most of the area of Thulo Lumpek is at risk. Limgha area just below the landslide adjacent to the dry stream likely to damage by debris flow and possibly of rockfall due to highly fractured rock mass posed under threats.

RECOMMENDATIONS

It is recommended to monitor the displacement of the tensional cracks regularly. Filling of these cracks and construction of ground seal will also help in less infiltration of water. It is recommended to construct appropriate surface drainage and shallow subsurface drainage throughout the road-cut section. Construct check dams, retaining wall and gabions to control the erosion due to rock fall and debris flow. Detailed slope stability analysis with instrument based monitoring of the hillslope is recommended. Landslide risk map of the affected area should be prepared. Local people should monitor displacements, subsidence, seepage in cracks and creeping zone.

The risk can be minimised by carrying out these recommendations as soon as possible. The houses near the landslide and adjacent to the dry stream of Limgha should be shifted in safer place.

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Geological Map of Parts of Gulmi and Baglung Districts: Sheet No. 2883 14 (62 P/8), Published under Dept. of Mines and Geology, 2000.

Geological Map of Parts of Parbat, Baglung and Gulmi Districts: Sheet No. 2883 15 (62 P/12) Published under Dept. of Mines and Geology, 2000.

www.worldweatheronline.com

Engineering and Environmental Geological Mapping of Bidur Municipality and its Surrounding Areas, Nuwakot District.

Monika Jha (Senior Divisional Geologist), **Kumar Khadka** (Senior Divisional Geologist),**Tara Pokharel** (Geologist), **Lokendra Pandeya** (Geologist), **Sunu Dawadi** (Geologist).

ABSTRACT

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

Keywords: standard penetration test; soil sample; engineering properties of soil; geological units; geological hazards

INTRODUCTION

Bidur is district headquarters of Nuwakot district situated at about 68 Km north-west of the capital of Nepal, Kathmandu (Figure 1). It spread across 130.01 sq. Km, most of its area is covered by an river flood plain, deeply weathered soil cover and some parts are in mountain areas. The study area can be reached by bus from Kathmandu via Prithivi highway and also, can be reached by Trishuli highway.

The study area lies between 3082000 m to 3094000 m Northing and 609000 m to 619000 m Easting covering about 120 sq. km area. It covers the part of Bidur Municipality and Likhu Gaupalika as shown in Figure 1. The study area lies in the Topo-Sheets No. 2785 01A, 01B, 01C and 01D published by the Department of Topographic Survey, Nepal. Detailed study has been conducted in 50 Sq. Km. area out of 150 Sq. Km of reconnaissance area.

Physiographically the study area lies in the midland having altitude ranges from 450 m to 952 m mean sea level. The main rivers flowing in the study area are Trishuli River and Tadi River. Trishuli River passes right through mid-area of Bidur Municipality, has its main source region at Gosaikunda, Rasuwa. Tadi River and Trishuli River confluence near the Devighat.

The study area consists of sediments of Quaternary deposits (terraces deposits) such as clay, silt, sand, gravels etc in the central part of the study area at Battar and Bidur which is mainly derived from Trishuli River, Tadi River and its tributaries (Figure 2). Surrounding hilly parts lies in the Lesser Himalaya. Rocks belonging to the Kunchha Formation of Nawakot Complex are exposed in the surrounding parts. The climate of the study area is tropical and sub-tropical type.

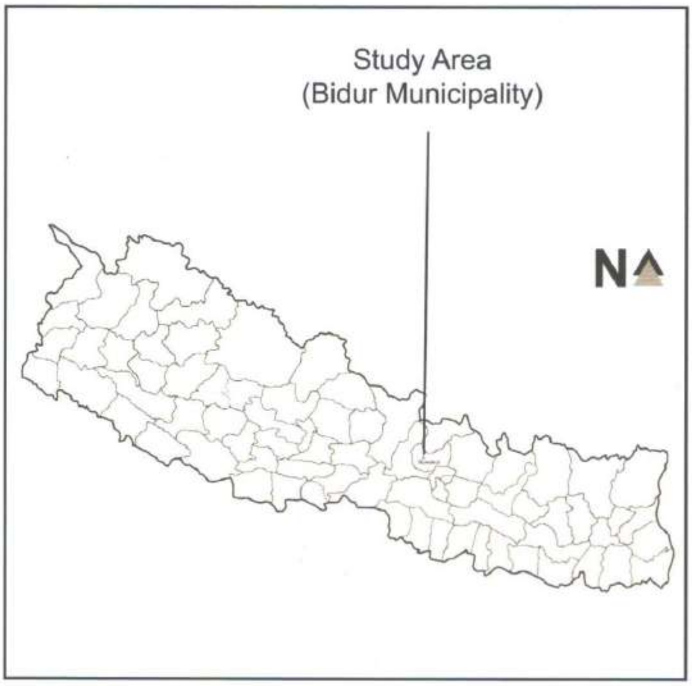

Figure 1: Location of the study area

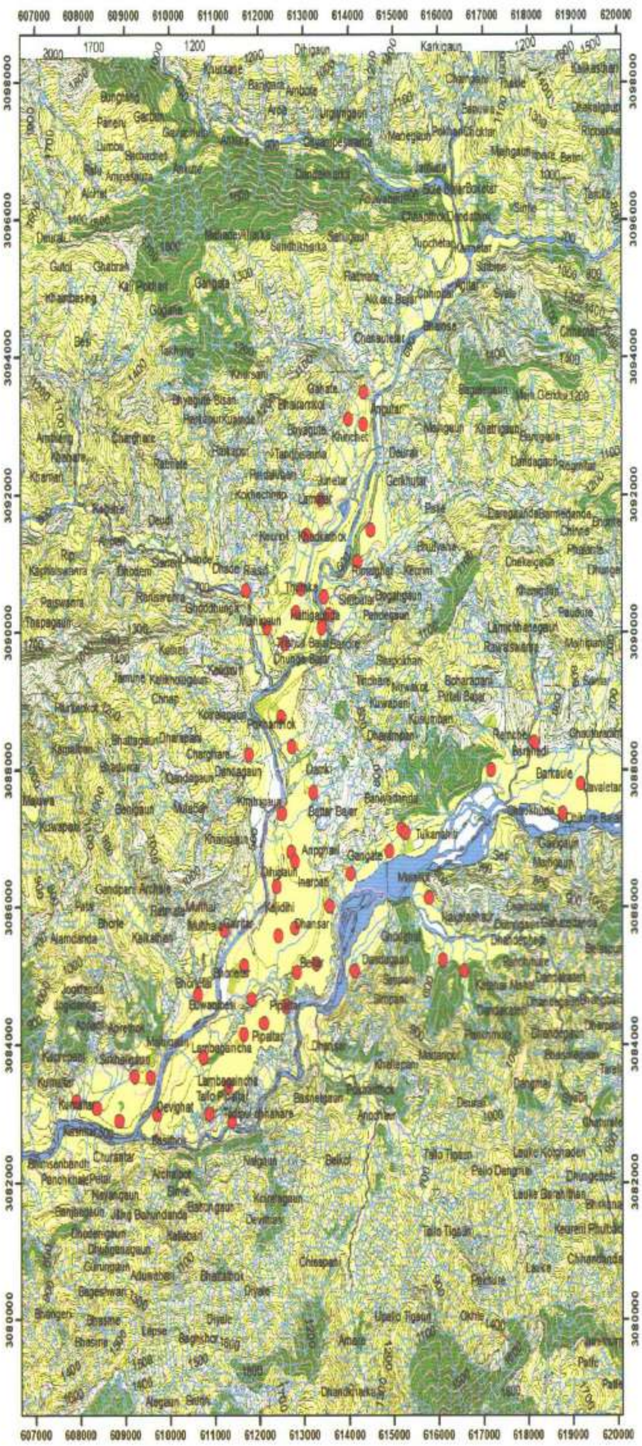

Figure 2: Locations of SPT in the study area (hd dots in map)

OBJECTIVES

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

- To determine the subsurface ground condition of unconsolidated sediments and its bearing capacity
- To provide the engineering properties of different soil units
- To identify the geo-hazardous and risk areas and recommend proper mitigation measures
- To identify the existing environmental problems which will have direct impact on human health
- To provide information on potential mining for natural resources such as gravel, sand and clay available in the study area and give information on haphazard mining of such resources.

LIMITATIONS

- SPT is limited up to 7m depth.
- Hand auger test is limited up to 8m depth.
- The information contained in the map is intended for urban planning in regional scale and infrastructure development activities. It should not be used as only basis for any specific site investigation for individual buildings or any other major structures. Therefore the map cannot replace detail site investigations. It also needs to be upgraded to integrate information according to changes.

METHODOLOGY

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

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

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

FIELD ACTIVITIES

The fieldwork was carried out from 2074-10-02 to 2074-11-02 for 30 days covering 50 sq. km of the area. During the field, related documents were collected from the municipality and other governmental organizations.

Hand auger hole drilling followed by SPT and Power driven auger were carried out in the field to obtain necessary data. 55 SPT and 48 power auger tests were performed during the field (Figure 2). There were 3 SPT conducted up to depth of more than 7m, 1 SPT of more than 6m, 7 SPT of depth more than 5m, 4 SPT of depth more than 4m while others are between 3m to 1m depth. Adequate soil samples were collected from different depths of auger and SPT holes to know the subsurface geology. Outcrops exposed in some of the streams and river was also taken into consideration.

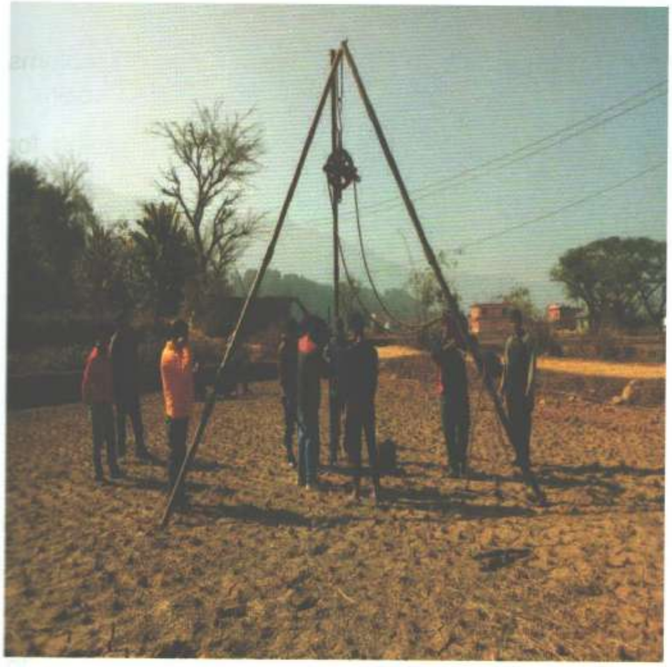

Figure 3: Performing SPT test at Hasintar

Figure 4: Performing hand auger test at gharigaon

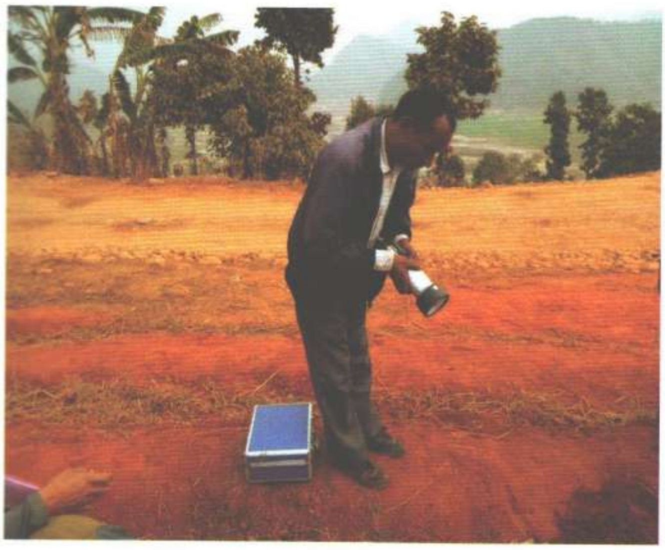

Figure 5: Performing speedy moisture Test at Pipaltar

LAB ANALYSIS

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

- Sieve Analysis
- Liquid Limit
- Plastic limit

In this report only few analyzed data are presented (Figure 6, Table 1)

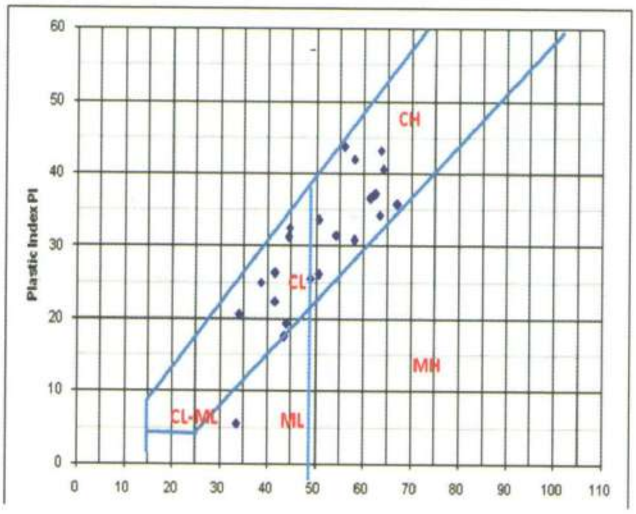

Figure 6: Table showing Liquid limit, Plastic limit and Plasticity index of SPT boreholes data

Table 1: Liquid limit and Plastic limit of the Finer sediments (<0.075mm)

SPT no.	Depth in m.	Liquid limit	Plastic Index	Soil type (plasticity chart)
B4	3-3.45	54.20	31.56	CH
B4	4-4.45	62.50	37.14	CH
B4	7-7.45	61.50	36.58	CH
B5	2-2.45	50.50	26.07	CH
B5	3-3.45	58.00	42.05	CH
B5	4-4.45	67.00	35.84	CH
B10	1-1.45	33.50	5.42	ML
B10	2-2.45	44.50	32.53	CL
B15	3-3.45	63.30	34.34	CH
B15	1-1.45	56.00	43.70	CH
B19	2-2.45	38.50	25.03	CL
B20	2-2.45	34.00	20.54	CL
B20	1-1.45	41.50	22.40	CL
B27	1-1.45	44.00	19.36	CL
B33	1-1.45	58.00	30.91	CH
B35	5-5.45	50.50	33.66	CH
B36	3-3.45	64.00	40.61	CH
B38	1-1.45	49.00	25.57	CL
B39	4-4.45	43.50	17.53	ML
B41	1-1.45	44.30	31.23	CL
B49	3-3.45	41.50	26.26	CL
B53	3-3.45	63.50	43.27	CH

CL-Inorganic clays of low to medium Plasticity or clayey silt

CH- Inorganic clays of Medium to high plasticity

ML- Inorganic silt and very fine sand

QATERNARY GEOLOGY

The geology of Bidur Municipality and its surrounding area can be categorized as unconsolidated sediment deposits (Quaternary deposits). The sediments made up of clay, silt, sand pebbles, cobbles and boulder sized particle. Quaternary deposit of Nuwakot area is mainly derived from Trishuli River and its tributaries. Alluvial fan deposit, fluvial deposit, residual deposit and colluvial deposit has been found in this area. Poorly sorted unconsolidated loose sediment consisting of gravel, sand and silt and clay belong to this type.

Based on subsurface geological information such as type, nature and size of the sediments from the lithologs, the study area is classified into 4 different lithological units based on the dominance of sediment types. In this study instead of the terminology "Formation", units are used. They are as follows;

1. Unit I : Clay Deposits
2. Unit II: Silty clay at top followed by silty sand and gravelly sand at bottom
3. Unit III: Alternate layer of clay, silty clay and silty sand
4. Unit IV: Mixed layers of silty clay, clayey sand and clayey gravel deposits
5. Flood Plain Deposit: Recent river deposits
6. Bed rocks: Kunchha Phyllite and Benighat Slate of Lesser Himalaya

The brief description of the different units and their engineering properties are given below

Unit I

This unit is mainly consists thick layer of clay to silty clay ranging from 3m to more than 7m usually consists of grits of quartz and muscovite as approaching to higher depth (Figure 8,10). The clay is inorganic type with high plasticity. This deposit is residual deposit and mainly distributed along Pipaltar, Beltar, Lambagaincha and Pokharitar area. The clay deposits vary from reddish brown clay to dark red stiff clay and Reddish yellow silty clay. On the basis of field N-values, this area belongs to moderate to low bearing capacity area. Bearing capacity upto depth of 2-2.45m is low but increases to moderate at the depth of 3-3.45m. Because of the clay and silty clay deposits, this unit has low infiltration of surface water and low permeability. This unit is potential for agriculture and good geological barrier for the waste disposal. The clay can be used for the brick factories. Lithologs of unit 1 is presented in Figure 9.

Figure 7: Thick deposit of red clay at Pipaltar

Figure 8: Sample collected at Majhimtar, Bidur-5

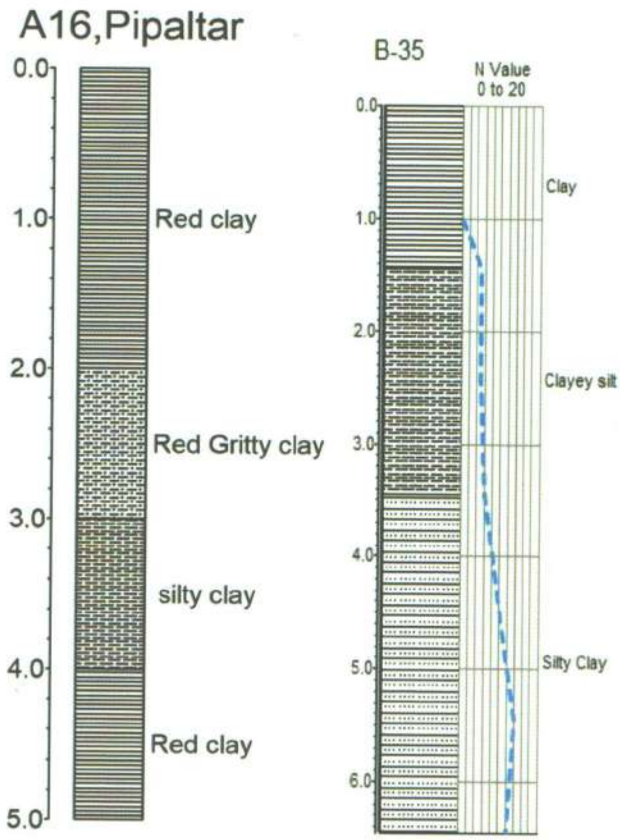

Figure 9: Lithologs representing Unit-I

Unit II

This unit mainly consists of 1-3m silty clay at top followed by silty sand and gravelly sand at bottom. This deposit is distributed along channel bars and recent terraces of Trishuli river including Trishuli bazaar, Battar bajar, Dhikure bazaar, Chandipokhari, Devighat area. Average depth of the area is 4m. The average bearing capacity of this deposit is low to medium. It is moderately good for foundation purpose. Lithologs of Unit II is presented in Figure 11.

Figure 10: Sample collected at Battar Bazaar

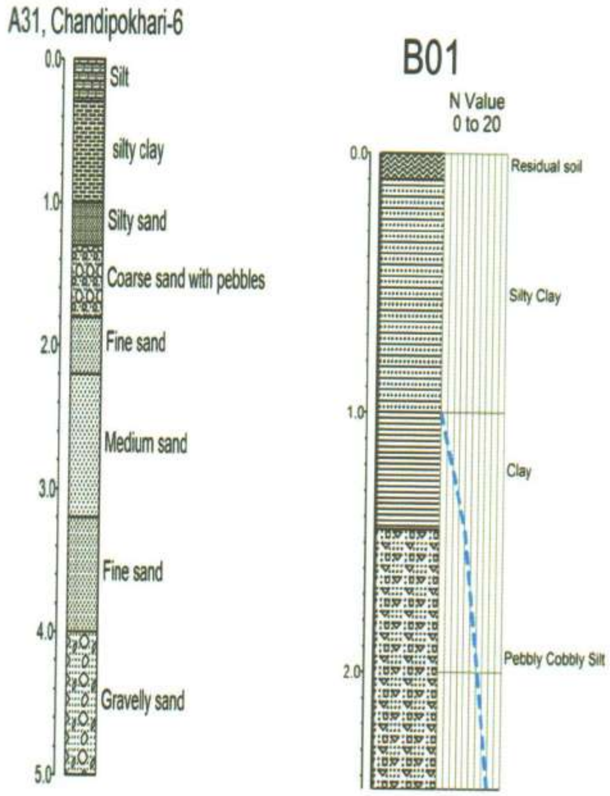

Figure 11: Lithologs representing Unit II

Unit-III

This unit is characterized by alternate layer of silty clay and silty sand, coarse and fine sand. This unit is developed along Ghodghat, Lamabagar, Damki and Tandi river area etc. Bearing capacity is very low to Medium. This unit is not suitable for multi-storey buildings. Sands at the bottom layer are good source of groundwater. Protective measures are to be applied where the bearing capacity is very low. Lithologs of Unit III is presented in Figure 13.

Figure 12: Sample collected at Gharigaon, Bidur-6

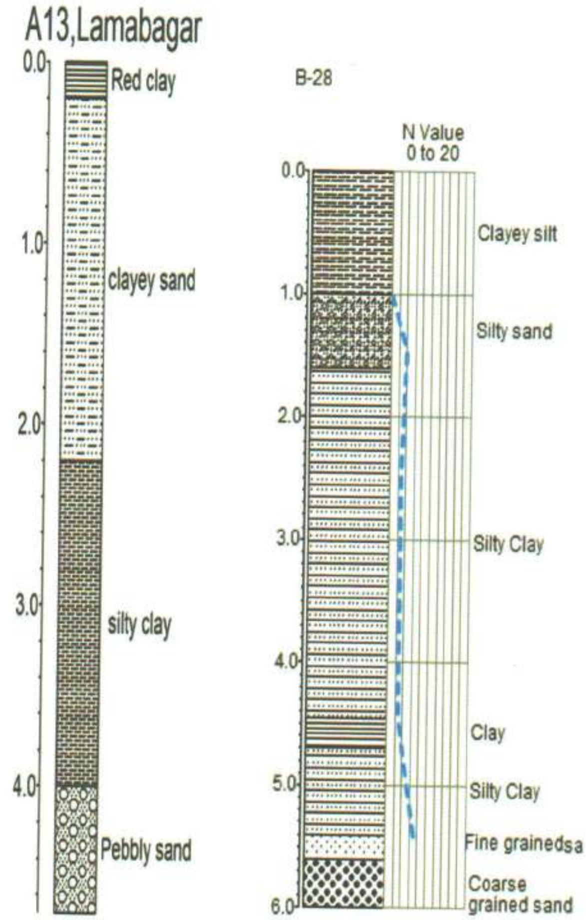

Figure13: Lithologs representing Unit III

Unit IV

This unit mainly consists of mixed layer of silty clay and clayey sand at top and gravelly sand at bottom. This deposit is distributed along the terraces of Tadi khola and well developed at Ranathok, khadkathok, Rimalgaun, serabesi and Chanaute bazaar area. The bearing capacity is low to medium for depth of 2-2.45 while medium to high for depth of 3-3.45m. The average bearing capacity of this unit is medium to high and sound for the building constructions. Lithologs of Unit IV is presented in Figure 14.

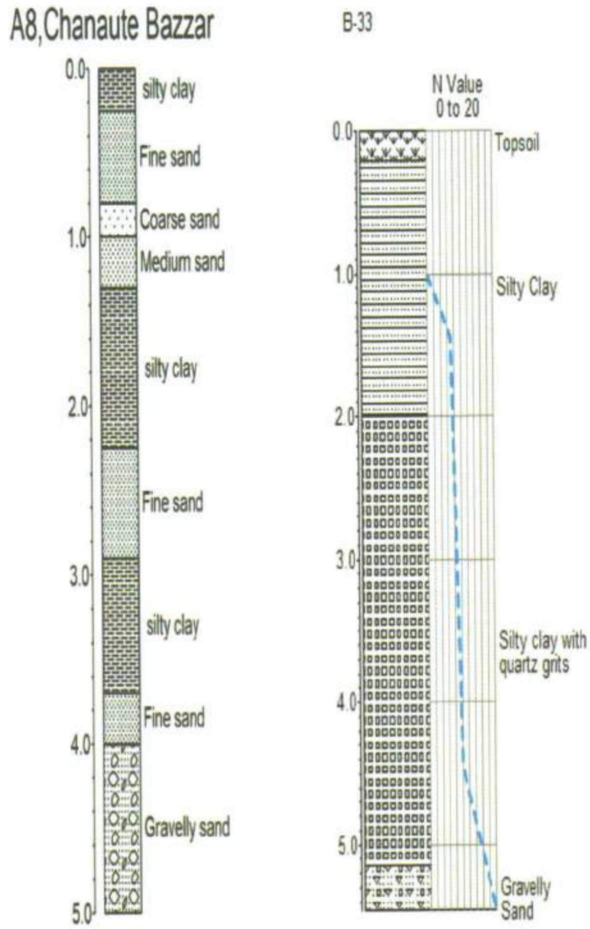

Figure 14: Lithologs representing unit IV

Figure 15: Sample collected at Ranathok, Bidur-9

FLOOD PLAIN DEPOSIT

This unit is characterized by recent fluvial deposits of Trishuli and Tadi Rivers. Deposit is mainly composed of silty clay, clay and sand deposits. This unit is developed along the Tadi River bank. The bottom layer is hard due to cementing of sediments. The upper layer is mainly silty clay with mix sediments of sand to gravel.

BED ROCKS

Bedrock is exposed in surrounding area. Rocks belonging to Kunchha Formation and quaternary deposit are found in the study area. Gritty phyllites and quartzites are main constituents to the Kunchha Formation (Stocklin and Bhattarai 1982). Kuncha Formation, the oldest unit of Lesser Himalaya is non calcareous unit and belongs to Nuwakot Group. Main Central Thrust is present south of the confluence of Trishuli Nadi and Tadi Khola.

BEARING CAPACITY

The load carrying capacity of foundation soil or rock which enables it to bear and transmit loads from a structure is known as bearing capacity. The Bearing Capacity of soil layers depends on the degree of its compaction or relative density. Higher the value of relative density greater will be its Bearing Capacity. Standard Penetration Test (SPT) is one methods widely used for finding out the Bearing Capacity of soil layers. Dense soil will have high N values and consequently high Bearing Capacity. Similarly with the increase of N value the compressive strength of cohesive soil increases giving to high Bearing capacity. Low soil bearing capacity is only found in alluvial soil (mud or silt), wet sand or poorly compacted fill. The field N-Value and bearing capacity are shown in Annex. The bearing capacity is classified as low, medium and high according to Peck et al (1974) ; The N-value > 15 is high bearing capacity , N-value 8-15 is medium bearing capacity and N-value 4-8 is low bearing capacity.

Table 2: Bearing capacity analysis according to Peck et al,1974

Condition	N-value	Bearing Capacity (Kpa)	Quality
Very soft	<2	<25	Extremly Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	5 – 8	51 – 100	Low (L)
Stiff	9– 15	101 – 200	Medium (M)
Very Stiff	16-30	201-400	High(H)
Hard	>30	>400	Very High(VH)

URBAN AND ENVIRONMENTAL GEOLOGY

WASTE DISPOSAL SITE

The main purpose of the environmental geological mapping was to identify the suitability of the site for the municipal solid waste management, landfill areas. Landfills that are located in geologically unsound areas (sand and gravels) have contaminated some groundwater sources. During the field investigation and the discussion with the officials of municipality it was learned that, the municipality does not have its own permanent properly managed sanitary landfill site and the problem of waste disposal was seen to be prevalent in high dense urban core areas. Municipality collects waste materials from the streets and disposes in the small forest near Trishuli River in ward no.18 near the municipality office (Figure 17) which is not a permissible practice. Waste disposes into drainage systems of the urban areas are hazardous to health and cause the blockage of the drainage system during flooding. The proposed landfill is around Gongate Height at the right bank of Tadi River. The auger location no. 37 shows the clay deposits upto 5m and it may be more than 5m clay deposits there. The clay is red to grey in colour and it will help to retain the liquid waste during the waste deposition. Lithologs of existing landfill site is presented in Figure 18.

Figure 16 : Bidur Municipality Truck dumping the waste collected from the municipality area.

Figure17: Unmanaged dumping site for the solid waste in the forest near the municipality office at ward no 18.

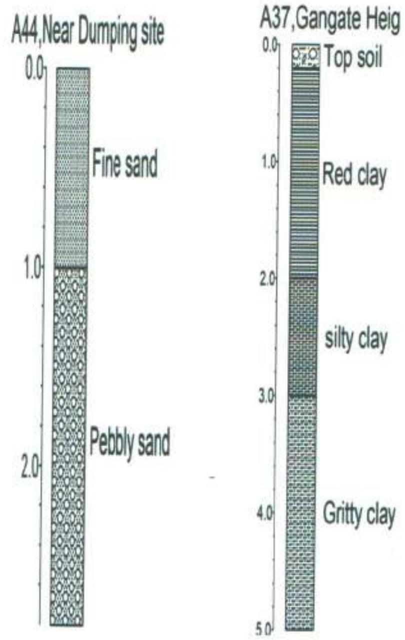

Figure 18 : Showing lithologs of existing landfill site(A44) and proposed site(A37)

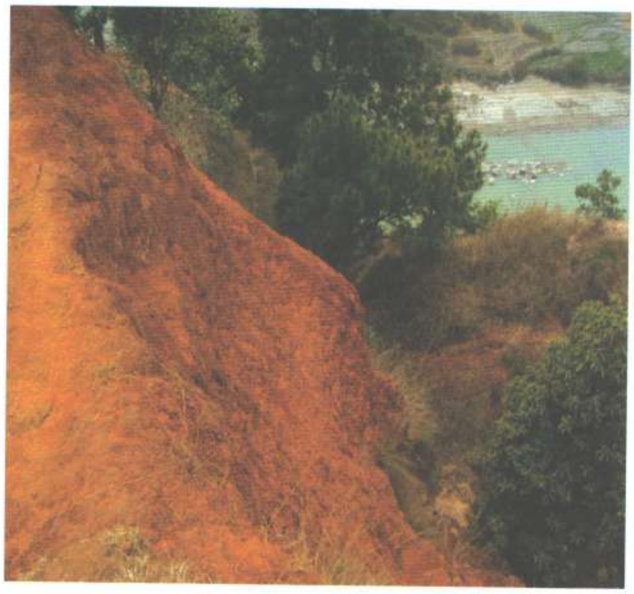

Figure 19: Showing the location of proposed landfill site at right bank of Tadi river near Gangate height.

MINING OF NATURAL RESOURCES

Deposit of construction materials (Gravels) are found in flood plain of Trisuli Nadi and Tadi Rivers. Sand are mining from the southern part at the Pipaltar area (Figure 20)and Mandredhunga near the army camp (Figure 21). In both places the mining activities was not conducted. The sand is mined by the Bidur Municipality for the local people in the Multhala besi area (Figure 22). Near this sand mines clay mines were also conducted to make the local bricks (JB bricks) as shown in Figure 23. Sand and gravel mining is going on the Dhikure area, upstream and downstream of the Tadi bridge near the confluence of Tadi and Likhu River (Figure 24).

Figure 20: Sand mining at Pipaltar area.

Figure 21: Sand mining at Mandredhunga area

Figure 22: Sand mining at Multhala area.

Figure 23: Clay mines and brick factory near the Multhala Besi area

Figure 24: Sand and Gravel mining at Dhikure (near the Tadi Bridge)

ENVIRONMENTAL IMPACTS BY MINING ACTIVITIES

- The sand mining near Pipatar cause the erosion (specially gulley erosion). Several gully erosions can be seen at the Pipaltar area due to the thick red soil (laterite) deposit. It may due to the steep topography.
- There might be depletion of sand and gravel in the Kholas and Nadi in the near future if exploited haphazardly. Severe environmental consequences arise due to the extraction of boulders and gravel from the river bed and lowering its level.
- The increasing trend of river bed mining and its unplanned management is one of the most notorious activities responsible for flooding and inundation.
- Clay mined for the brick factories may cause pollution in air.

GROUNDWATER RESOURCES

The study area depends upon spring water and river water for drinking and irrigation. Due to thick laterite deposits, the possibilities of groundwater is limited to the area where there is porous sediments. Two deep tubewells observed at Pipaltar area and the other west of Hawaghar.

ENGINEERING GEOLOGICAL MAP

Bused on lithologs and the laboratory investigation of soil samples the enginering geological map of the study area is presented in Figure 25.

CONCLUSIONS

The geology of this area can be divided mainly into two parts. The central parts filled by quaternary deposits forming terraces and surroundings parts consist of the rocks of Kunchha Formation of Lesser Himalaya. Present study on subsurface geology has revealed that Bidur Municipality and its surrounding areas have been divided into four different lithological units based on field and lab analysis. The units mainly consist of fine grained sediments like clay, silty clay to silt, fine to coarse grained sand and gravelly sands. The units composed of clay to silt and fine sand have low bearing capacity while the units composed of coarse sand to gravelly sand have high bearing capacity.

The main geological hazard of the area is flood due to Trisuli and Tadi rivers and its tributaries. Others hazards includes river bank cuttings and soil erosion at some places. Haphazard mining of sand, gravel and clay is also one of the major issues.

According to the people of the municipality office, the municipality has not its permanent sanitary landfill site. The solid wastes collected from municipality have been dumped at the governmental land near the district jail which is not so suitable place for landfill site. The proposed landfill site is near Gongate Height at the right bank of Tadi River which is geologically suitable for the development of sanitary landfill site.

Sufficient amount of construction materials like sand and gravel are available as terrace deposits and river bed deposits. The area is also rich in red clay which has been mined for the brick factories.

RECOMMENDATIONS

- Multi-storied buildings should be discouraged in low bearing capacity areas.
- Human settlements encroaching to the banks of rivers and its tributaries should be discouraged by Municipality
- River training works should be done for protecting further loss of land during rainy season.
- Mining should be carried out only under the supervision of the local authority.
- Top humus soil should be rehabilitated after clay mining.
- It is recommended that Municipality should have proper sanitary Landfill site.
- Proper land use planning by municipality is essential for new settlements.

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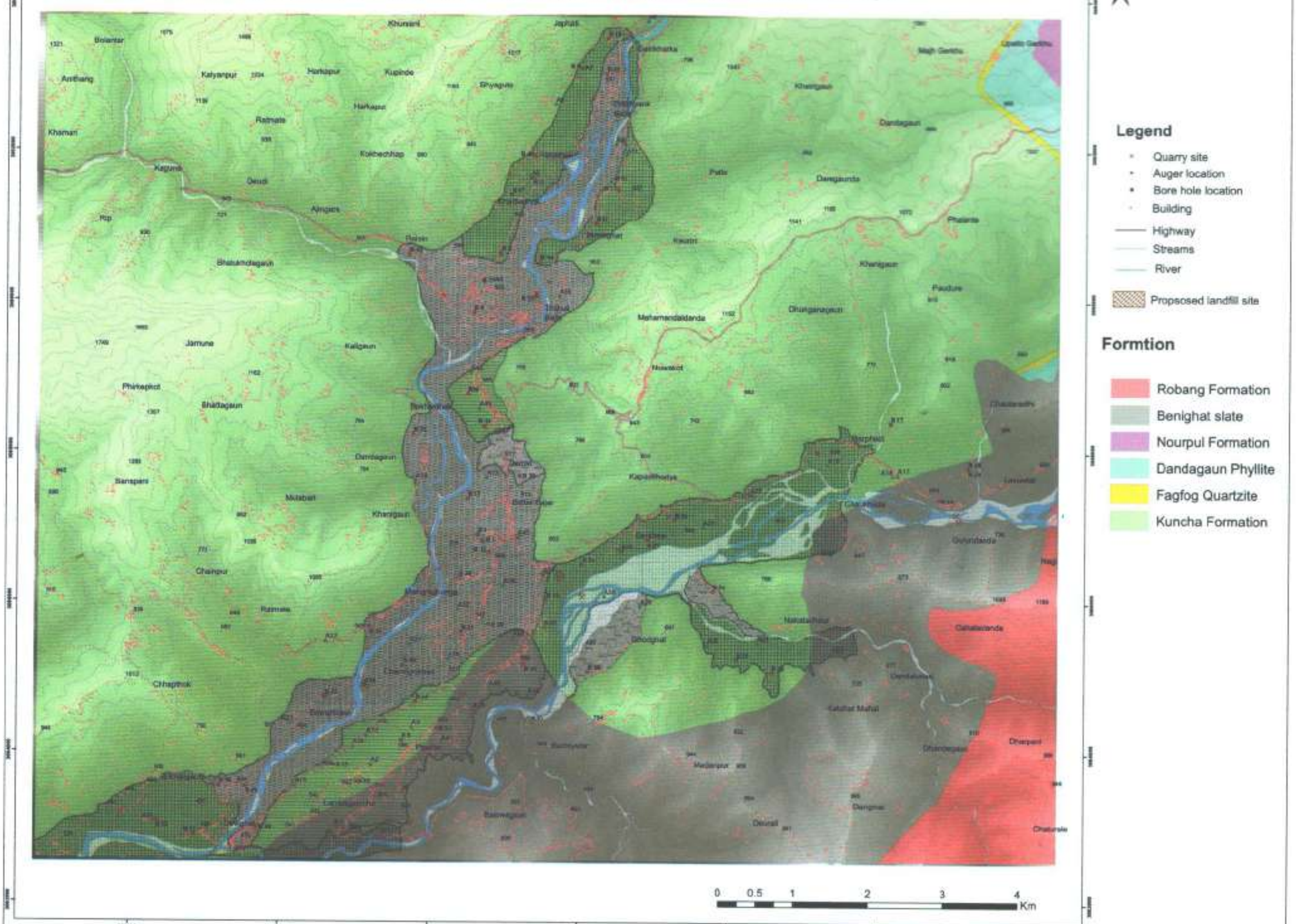
Figure 25: Engineering and Environmental Geological Map of the Bidur Municipality Area, Nuwakot District, Province-3, Nepal



In the bearing capacity study, a total of 60 SPT data were used. The maximum depth of SPT is limited to 7.5m. 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 mainly has low bearing capacity with N Value ranging from 5 to 8.

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

Condition	N-Value	Bearing Capacity (Kpa)	Quality
Very Soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	5 – 8	51 – 100	Low (L)
Stiff	9 – 15	101 – 200	Medium (M)
Very Stiff	16 – 30	201 – 400	High (H)
Hard	> 30	> 400	Very High (VH)

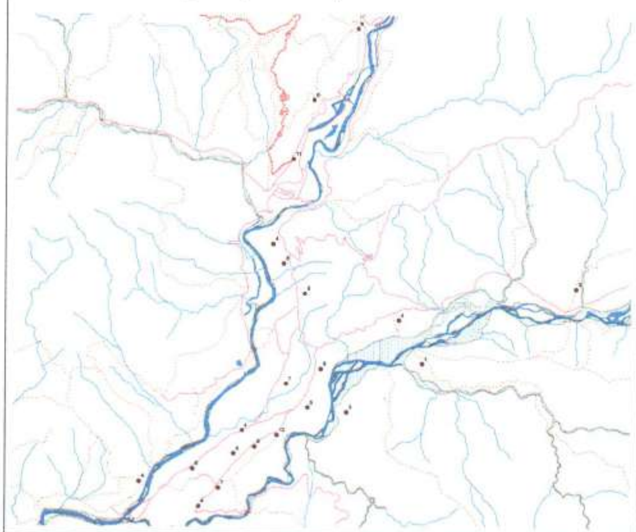
Unit 4 This unit consists of mixed sediments of clay, sand and gravel. It is distributed along the terraces of Tadi khola and in the northern part of the study area including Ranathok, Khadkathok, Rimalgaun,Serabesi etc. Bearing capacity is medium for depth of 3m to 3.45 m whereas it ranges from low to medium for depth of 2 to 2.45m.

Unit 3 This unit is distributed along the Godghat and Damki areas near Tandi Khola. It comprises of alternate layers of clay, silty clay, fine and coarse sand underlain by sandy gravel. Bearing capacity is very low for this layer.

Unit 2 This unit is distributed along channel bars and the recent terrace of the Trisuli Gandga River including Trisuli and Battar Bajar. It comprises mainly of thin soil cover underlain by clayey to sandy gravel. Bearing capacity of the layer ranges from low to medium.

Unit 1 This deposit is distributed around Pipaltar, Lambagaicha and near Pokharitar area. It consists mainly of thick silty clay layer ranging from 3m to more than 7m usually consisting of grits of quartz and unweathered muscovite as approaching depth. Bearing capacity in this layer upto the depth 2-2.44 m is usually low but some places consists of material of medium bearing capacity. But at increased depth of 3 to 3.45 bearing capacity is usually a lie in medium category with few locations of low bearing capacity.

Location map showing N- value at depth from 2m to 2.45m



Location map showing N- value at depth from 3m to 3.45m

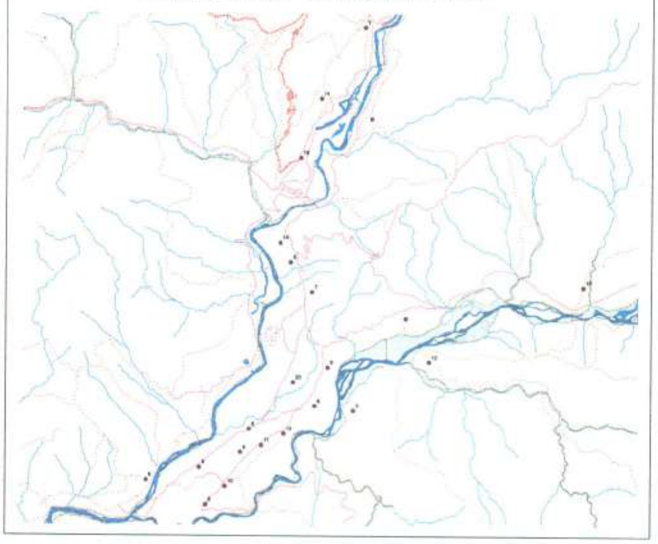
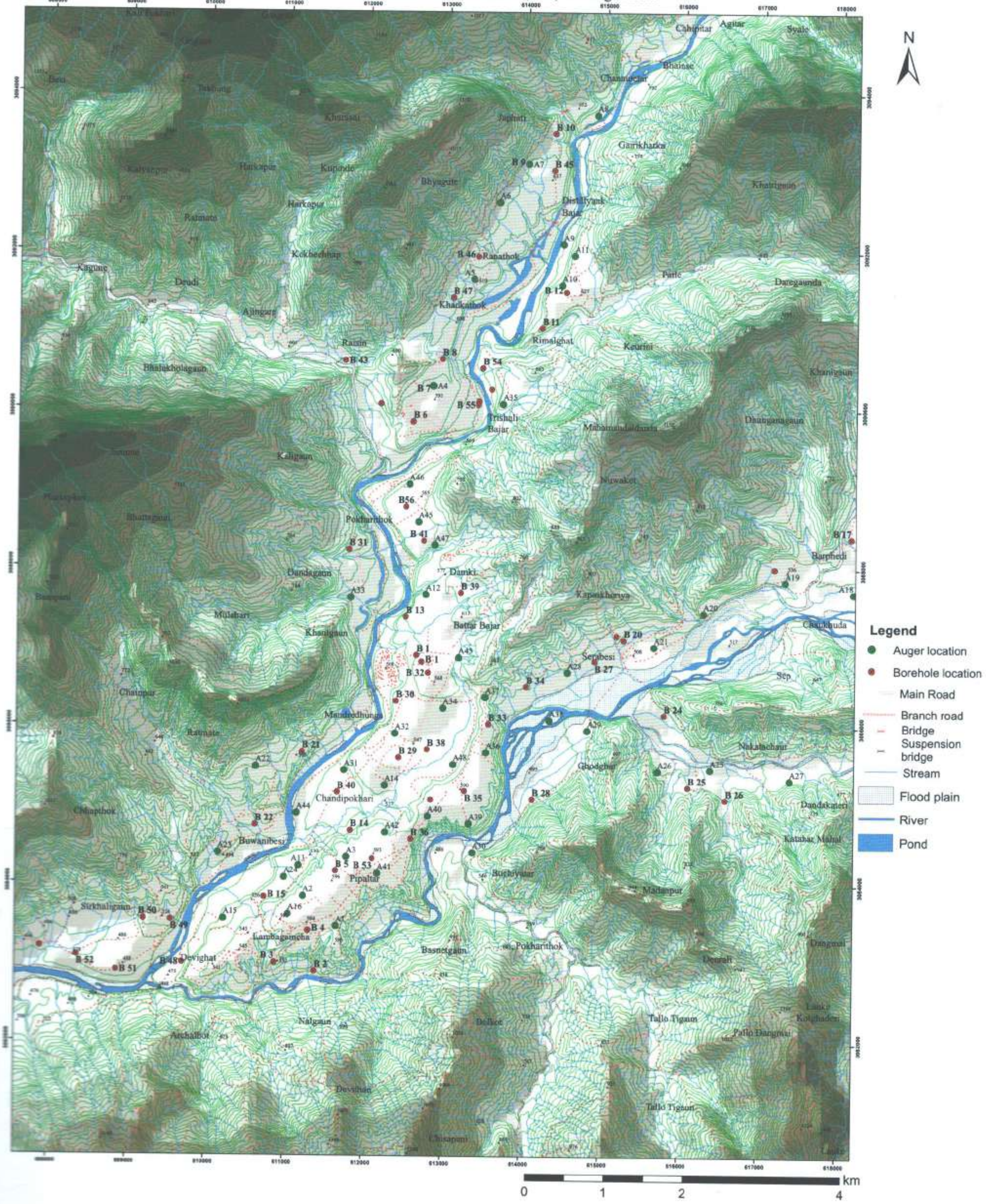


Figure 26: Map of Bidur Municipality showing locations of boreholes (SPT) and auger holes



Brief Description of Proposed Sites for Construction Materials

Kumar Khadka (Senior Divisional Geologist), **Basanta Adhikari** (Research Officer)

ABSTRACT

The natural bedrocks are the good source of construction material since the Stone Age and used in various purposes like in aggregate of construction works, paving, roofing and decoration. The rocks used for construction should be hard, tough and good strength and durability. Under the decision of Government of Nepal for long term supply and management of construction material, Department of Mines and Geology has selected 14 districts in the first phase and done the detailed geological, mining and environmental study and prepare the Mining Scheme and Initial Environmental Examination (IEE) report of 92 mines each of nearly 5 hector quarry area within forest land. The main rock selected for construction material is quartzite and dolomite of Lesser Himalayan Zone. The total mineable reserve of 92 mines is 19,60,34,755.8 m3 and production capacity of each mine is less than 300m^3.

Key words: construction material, mining, quartzite, reserve, mining scheme.

INTRODUCTION

The natural bed rock resources are good source of construction materials since the very early time of human evolution. The rocks like marble, basalt, granite, colored sandstone etc. are used in decoration; phyllite, slates, flaggy quartzite and schist are used for roofing; limestone, dolomite, quartzite, sandstone are used for aggregate in various construction works, paving and flooring. Every year domestic as well as international demand of construction material is increasing due to increasing infrastructure development. Construction aggregates like gravel and sand obtained from mining of river deposits from Terai region is not sufficient to meet the growing demand. People have also been mining aggregates from the hills and rivers of Churia region. Vast amount of river boulders, cobbles, pebbles and sands are mined as construction materials. District Development Committees (DDCs) were the local authorities, who provide licenses to the highest bidders to operate quarries on the riverbeds in annual basis. Huge amount of such construction materials are available in almost all the districts of Nepal.

It is emphasized that excavation and extraction of sand and gravel from the Churia region has rapidly changed the area and is estimated that 6.5 million cubic metres of gravel and sands have been legally extracted every year from the region and the illegal extractions are expected to be twice as much (Rastrapati Chure Conservation Program Coordination Unit (RCCPCU) 2014). The stones used for building construction should be hard, durable, tough, and should be free from weathered soft patches of material, cracks, and other defects that are responsible for the reduction of strength and durability. Stones for construction purposes are obtained by quarrying from solid massive rocks. The Lesser Himalayan Sequence, especially Mahabharat Range is good source of hard construction materials. The range is just north of Siwalik Group rocks.

The study program was planned during the month of Bhadra and Ashwin of the year 2071 B.S under the Departmental program of fiscal year 2071/072. In the first phase, 14 different districts were selected covering all the development regions (Figure 1). Then from the desk study, the hard rocks, mainly dolomite and quartzite band were traced which were near to the existing highway as well as they are nearer to the city area. Geologically, these areas are in the rock of Lesser Himalayan Sequence. DMG has done detailed geological, mining and environmental studied of general construction stone, topogeological survey was done in 1: 1000 scales and prepared the proposal (mining Scheme and IEE Report) of 92 mines in 14 different districts. All these mines are of 0.25 sq. km and cover nearly 5ha quarry area in barren to open forest land. The selected rocks are mainly quartzite and dolomite.

OBJECTIVES

The main objective of this study was to locate the deposit of constructions stone and assessments of the deposits in field from various aspects. The specific objectives of the study were:

- To make assessment of the identified construction rocks in terms of quality and quantity;
- To do the topogeological survey in 1: 1000

scale and prepare topogeological map, mine plan and its geological and mining section
- To prepare Mining scheme and Initial Environmental Examination report of all mines.

METHODOLOGY

The methodology adopted in the field was

- Walkover survey of the study area.
- Tracing of hard rock for construction material mainly quartzite and dolomite.
- Inference of general quality of rocks based on visual estimation.
- Estimation of reserve of rock.
- Topo survey in 1: 1000 scales
- Detailed geological mining study
- Data collection for Environmental study
- Photographs and sketches of necessary outcrops.

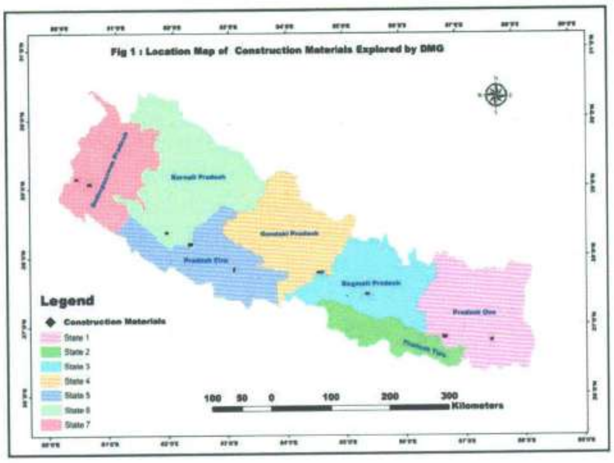


Figure 1: Location map of the proposed mines area.

DETAILED STUDY OF CONSTRUCTION MATERIAL

From the decision of Government of Nepal, dated 2071-04-11, giving direction to Department of Mines and Geology for the long term supply and management of construction materials like sand, gravel and stone, in this scenario, the surface geological investigation of construction material was carried out in the prospecting area.

Detailed study carried out in the Lesser Himalayan range has proven a total deposit of 196034755.8 m3. The infrastructure development works like access road, electricity and others are going on and planned for systematic exploitation in near future. Further more than 50 sites are selected in 45 districts for further study of construction material. Surface geological investigation of construction material was carried out in the following districts.

1. Arghakhanchi	2. Chitwan
3. Doti	4. Dadeldhura
5. Dhankuta	6. Lalitpur
7. Morang	8. Makwanpur
9. Palpa	10. Puythun
11. Salyan	12. Surkhet
13. Sindhuli	14. Udayapur

DETAIL DESCRIPTION

ARGHAKHANCHI

The surface geological investigation of construction material was carried out in the prospecting area. Field investigation was conducted in and around the prospecting area of Thada VDC in Arghakhanchi district. Occurrence of quartzite and dolomite beds were identified to the north of Takura and the deposit extends towards Khibdi to the west from Takura. Locations of the mineral and general descriptions of the prospecting sites are recorded. The area is located at Ward No. 8 and 7 of Thada VDC, Arghakhanchi district in Province 5.

The prospecting area and proposed mining area are in toposheet No 098-05 (Entitled THADA, 1:25,000 Scale) within coordinates of Northing 3084000m to 3090000m and Easting 409000m to 412000m (Figure 2). The total prospecting area was 18 sq. km. and proposed mining area is 1.5 sq.km. The proposed mining area is divided into six blocks based on the strike of the deposit.

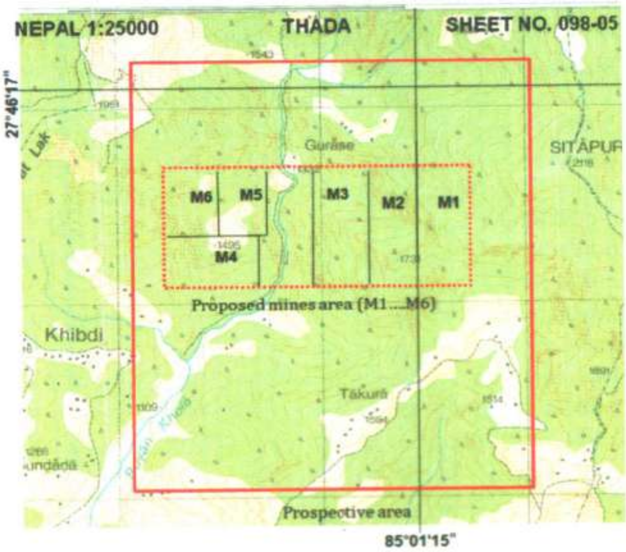


Figure 2: Topomap showing topography, the prospective area and proposed mine areas.

Geologically, the proposed mines area lies within Ramkot Formation of Lakharpata Group. The south and west facing slopes of the hills located to the north of Takura consists of reddish to purple shale, medium to thick bedded reddish, light grey to white quartzite beds containing ripple marks and grey dolomites. The deposit area is mainly forest land with patches of private land and three houses. High hills and spurs are formed by quartzite and dolomite deposit. The attitude of bedding planes in is 85-120° /30-65° (Strike / Dip amount) with NW-NE dip direction. Details of mining of construction material is presented in Table 1.

Table 1: Synopsis of the areas for the mining of construction materials in Arghakhachi district.

Leased No		Leased 1	Leased 2	Leased 3	Leased 4	Leased 5	Leased 6
District		Arghakhanchi					
VDC		Thada					
Ward No.		8	8	8	7	7	7
Co-ordinates	Easting X1	411500	411200	410800	410300	410300	409675 E
	Easting X2	411800	411500	411200	410800	410800	410300 E
	Northing Y1	3085800	3085800	3086000	3085900	3086400	3086400
	Northing Y2	3086635	30866350	3086625	3086400	3086900	3086800
Leased Area, sq. km.		0.25	0.25	0.25	0.25	0.25	0.25
Mines area, Hectares		8.6	8.7	11.77	9.56	10.6	10.85
Quarry Area, Hectares		4.7	4.9	4.8	4.7	4.7	4.5
Rock Type		Dolomite and quartzite					
Mining Method		Mecanized and open cast					
Geological Reserve, cu. M		1958760	1988980	2199155	1628845	1831560	1640820
Mineable Reserve, Cu. M (Volume of breakage stone)		2115460	2148098	2375087	1759153	1978085	1772085
Waste Ratio		1::0.052	1::0.0023	1::0.022	1::0.0027	1::0.0024	1::0.0025
Daily production, cu. M		250	250	250	250	250	250
Mine life, year		31.57	31.82	35.18	26.06	29.3	26.25
Infrastructure		About 6 km roads needs to be constructed from black top road					

CHITWAN

Field investigation was conducted in and around the prospecting area Ward No. 4 and 5 of Darechok VDC in Chitawan District, Bagmati Province, Nepal. Occurrence of quartzite beds were identified to the north of Gothedanda and the deposit extends towards Tamin and Nebedanda to the northwest and towards Warek to northeast from Gothedanda. The prospecting area and proposed mining area lies in toposheet No: 2784 03C (Entitled Mugling, 1:25,000 Scale). The area is bounded within coordinates: 3080000 N – 3083000 N and 550000 E – 561000 E (Figure 3). The total prospecting area is 18 sq. km and proposed Mining Area is 2.7 sq.km

Geologically, the north and west facing slopes of the hills located to the southeast part of Tamin consists of medium to thick bedded light grey to white quartzite beds of the Fagfog Quartzite. The deposit area is mainly forest land with patches of private land. High hills and spurs are formed by quartzite deposit. The quartzite is fine to coarse grained with pale orange to reddish tint, contains ripple marks and intensely fractured. The quartzite band is nearly 400 m thick and extends almost east to west in the prospecting area from Warek to Lopran. The dip amounts ranges from 25° to 42°. The synopsis of construction material is presented in Table 2.

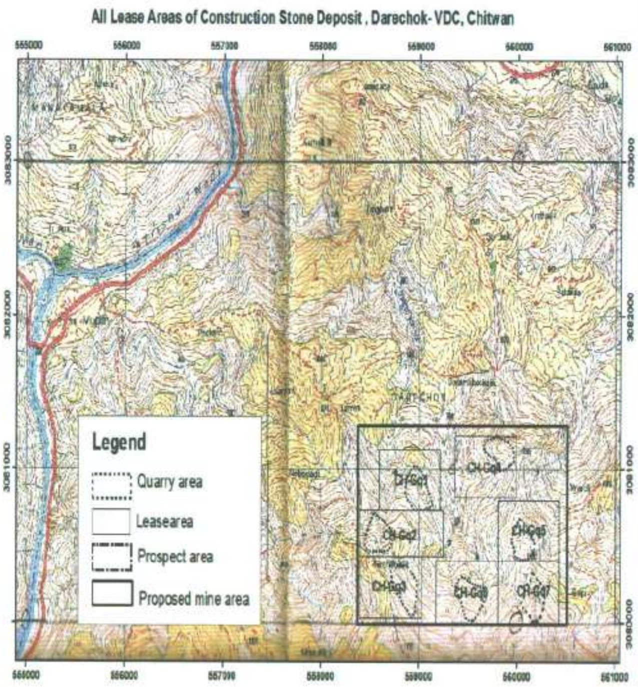


Figure 3: Topomap showing the prospective area and proposed mine areas

Table 2: Synopsis of the areas for the mining of construction materials in Chitwan district.

S. No.		1	2	3	4	5	6	7
District		Chitwan						
VDC and Ward No.		Tamin-4			Gothedanda-4			
Lease No.		M1	M2	M3	M4	M5	M6	M7
Coordinates	Easting X1	558587	558392	558392	559363	559800	559174	559799
	Easting X2	559211	559245	559018	559989	560424	559799	560424
	Northing Y1	3080733	3080433	3080031	3080819	3080399	3080000	3080000
	Northing Y2	3081132	3080731	3080432	3081219	3080799	3080400	3080399
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mine Area in Hectares								
Quarry Area in Hectares		4.9	4.97	4.99	4.44	4.3	4.98	4.7
Rock Type		Quartzite						
Mining Method		Mechanized Open Cast						
Mineable Reserve in m3		2500794	1948320	2420715	1345054	2172895	2502835	2442953
Daily Production in m3		300	300	300	300	300	300	300
Mine Life in Yrs		30.87	24.05	32.27	16.60	26.82	30.90	30.14

DOTI

The prospects of construction aggregate resources have been investigated in parts of Doti District lying to the north of Budar Bazar near Rupaskada. The prospect area lies in the Chhatiwan VDC of Doti district, Far-Western Province, Nepal. The prospecting area and proposed mining area are in toposheet no. 2981 15C (Entitled BUDAR BAZAR, 1:25,000 Scale) bounded within the coordinates 3218000 N to 3222000 N and 456000 E to 463000 E (Figure 4). The total prospecting Area is 21 sq. km and proposed Mining Area is 1.5 sq.km.

Geologically, the exploration area lies in the Ramkot Formation of Dailekh Group comprising of thin to massive bedded, fine to coarse grained white quartzites. Red purple shales of thickness 15 m present in the eastern part of the lease area. Stratigraphically at the basal part of the formation, highly fractured fine grained white quartzites are present while in the top part, thick to very thick and massive fine to coarse grained grey to brownish white quartzite are present. Explorations for quartzite with necessary sampling techniques had been carried out. Within the prospect area quartzite occurrences with varying thickness has been found at several locations. The quartzite at ridge is considered to be suitable for exploitation at present. Details of construction material is presented in Table 3.

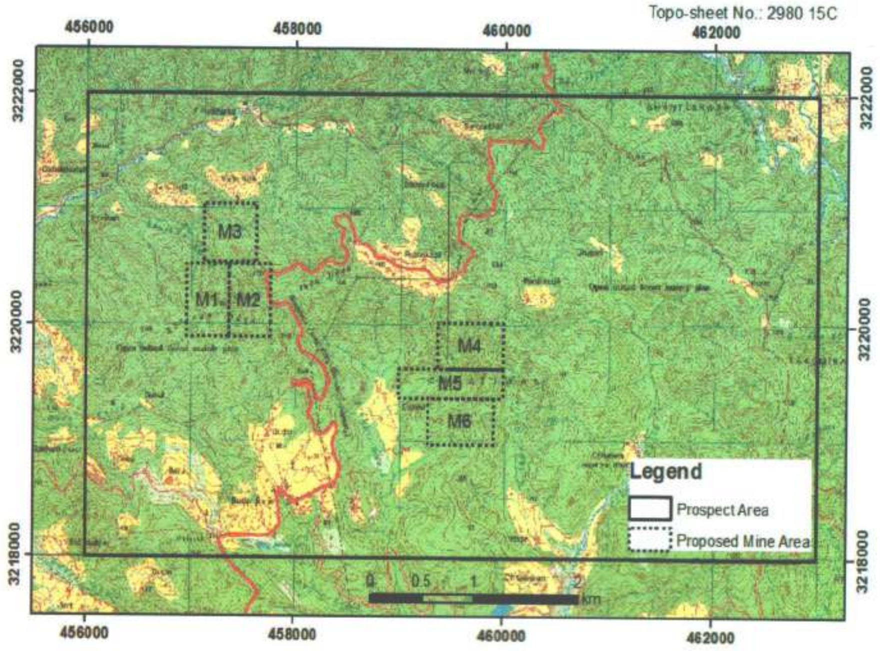


Figure 4: Location map of the prospect area and proposed mine areas.

Table 3: Synopsis of the areas for the mining of construction materials in Doti district.

SI.No		1	2	3	4	5	6
District		Doti					
VDC & Ward Nos.		Chhatiwan - 4 & 9					
Lease No		M1	M2	M3	M4	M5	M6
Coordinates	Easting X1	456960 E	457360 E	457120 E	459365 E	458990 E	459270 E
	Easting X2	457360 E	457760 E	457620 E	459990 E	459990 E	459895 E
	Northing N Y1	3219900 N	3219900 N	3220545 N	3219630 N	3219380 N	3218980 N
	Northing Y2	3220525 N	3220525 N	3221045 N	3220030 N	3219630 N	3219380 N
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25	0.25
Mines Area in hectares		10.57	12.05	10.15	12.61	8.26	10.87
Quarry Area in hectares		4.97	4.8	4.86	4.88	4.84	4.96
Rock Type		Quartzite					
Mining Method		Mechanized open cast					
Geological Reserve in m3		1580400	1196957	1349356	1970550	1608539	1371265
Mineable Reserve in m3		1706832	1292722	1457330	2128194	1737222	1480966
Daily Production in m3		250	250	250	250	250	250
Mine Life in Yrs		25.29	19.15	21.59	31.53	25.74	21.94
Forest Area, Hectares		4.97	4.8	4.86	4.88	4.84	4.96

DADELDHURA

Occurrence of quartzite beds were identified to the north of Jogbudha Bazar near Sirse Village. The quartzite deposit extends from NW to SE. The prospect area lies in the Sirse VDC of Dadeldhura District, Far-Western Province of Nepal. Prospect area and proposed mine areas in Dadeldhura District. The prospecting area and proposed mining area lies in Toposheet No 2981 14A (Entitled JOGBUDHA, 1:25,000 Scale) within coordinates 3226000m to 3229000m Northing and 434000m to 440000m Easting (Figure 5). The total Prospecting Area is 18 sq. km and area proposed Mining is 1.5 sq.km.

Geologically, the whole area under exploration lies in the Ramkot Formation of Dailekh Group. This Formation comprise of thin to massive bedded, fine to coarse grained white quartzite. Red purple shale of thickness less than 2m is found in some locations outside of the lease area. Stratigraphically at the basal part of the formation, highly fractured fine grained white quartzite are present while in the top part, thick to very thick and massive fine to coarse grained grey to brownish white quartzite are present. Explorations for quartzite with necessary sampling techniques had been carried out. Within the prospect area quartzite occurrences with varying thickness has been found at several locations. Among these quartzite occurrences found, the quartzite at ridge and hill top are considered to be suitable for exploitation at present. Brief of descliption of construction material is presented in Table 4.

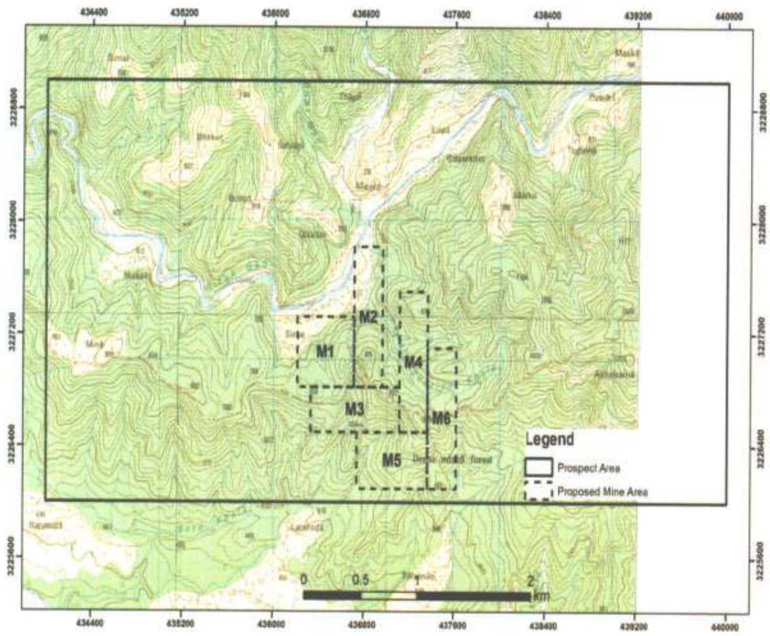


Figure 5: Location map of the prospect area and proposed mine areas.

Table 4: Synopsis of the areas for the mining of construction materials in Dadeldhura district.

Sl.No		1	2	3	4	5	6
District		Dadeldhura					
VDC & Ward Nos.		Sirsha - 4		Sirsha -4, 6 & 7		Sirsha-7	
Lease No		M1	M2	M3	M4	M5	M6
Coordinates	Easting X1	436216 E	436716 E	436334 E	437116 E	436741 E	437366 E
	Easting X2	436716 E	436966 E	437116 E	437366 E	437366 E	437616 E
	Northing Y1	3226820 N	3226820 N	3226500 N	3226500 N	3226100 N	3226100 N
	Northing Y2	3227320 N	3227820 N	3226820 N	3227500 N	3226500 N	3227100 N
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25	0.25
Mines Area in hectares		8.49	9.23	8.77	8.1	11.1	8.46
Quarry Area in hectares		4.625	4.992	4.88	4.428	4.657	4.653
Rock Type		Quartzite					
Mining Method		Mechanized open cast					
Geological Reserve in m3		974257	1441994	1959379	1326996	1064621	1850535
Mineable Reserve in m3		1052197	1557353	2116129	1433155	1149790	1998577
Daily Production in m3		250	250	250	250	250	250
Mine Life in Yrs		15.59	23.07	31.35	21.23	17.03	29.61
Forest Area, Hectares		4.625	4.992	4.88	4.428	4.657	4.653

DHANKUTA

The aggregate deposit lies in parts of Bhedetar VDC of Dhankuta District of Province 1, Eastern Nepal. It lies within the latitude 2973400 To 2973900 N and longitude 530200 to 530700E in the Totosheet no. 2687 02A in the scale of 1:25000 (Figure 6).

Geologically, the deposit area is a part of the Charchare Formation of Gondwana Group and Dubindanda Formation of Lesser Himalaya metasediments as shown in PEPP/DMG (2006) compiled a geological map of the exploration Block 10. The Sanguredanda Quartzite deposit belongs to the Quartzites unit. This lithological unit is topographically distinct and forms Mahabharat ridge in the study area. It is well exposed along the road cut of the Koshi Rajmarg from the Bhedetar to Karkichhap village. The fresh outcrops are also observed along the new road cut from the Bhedetar to Ahale village. The dark green to grey green phyllite and metsandstone of the Black Slates abruptly passes into white quartzites. The contact is transitional but rapid which can be observed near the Bhedetar village along the Koshi Rajmarg. This Quartzite consists of light grey, very fine-grained to cherty, dense, hard but fractured, thin to thick-bedded, massive to blocky as well as slabby quartzite. There are also beds of light pink, grey, white, dark grey to purple quartzite with the parting of green or purple slate. The strike of the beds is NW-SE and NE-SW with varying amount of dipping due north and south with 19⁰-70⁰. The synopsis of construction material is presented in Table 5.

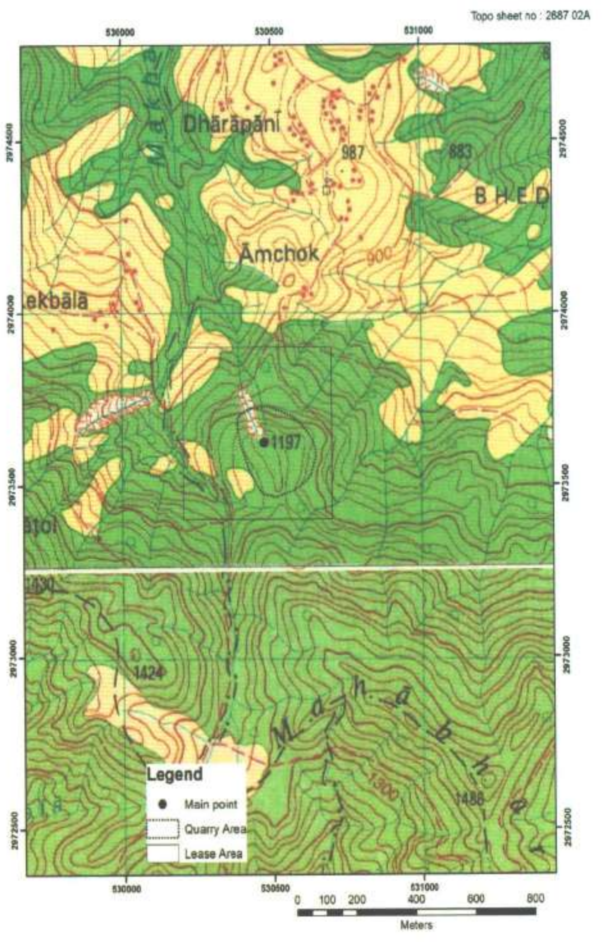


Figure 6: Location map of the study area

Table 5: Synopsis of the areas for the mining of construction materials in Dhankuta and Sunsari district.

Sl no.	1	2	3	4	5	6	7	8	9	10	11	12
Vdc	Bhedetar	Bhedetar	Mahabharat	Mahabharat	Bisnupaduka	Mahabharat			Bisnupaduka			Bisnupaduka
Lease no	Ms1	Ms2	Ms3	Ms4	Ms5	Ms6	Ms7	Ms8	Ms9	Ms10	Ms11	Ms12
Easting X1	530200	530700	529950	529450	529450	529200	528800	528400	528800	529300	529800	528300
Easting X2	530700	531100	530350	529950	529950	529450	529200	528800	529300	529800	530300	528800
Northing Y1	2973400	2973175	2972730	2973230	2972730	2972900	2972900	2972800	2972400	2972230	2972230	2972300
Northing Y2	2973900	2973800	2973355	2973730	2973230	2973900	2973525	2973425	2972900	2972730	2972730	2972800
Lease area in km2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mines area hectares	19	19	23	22	25	22	19	17	25	25	19	19
Quarry area hectares	4.9822	4.4059	4.769	4.8069	4.9659	4.7735	4.7606	4.8778	4.9232	4.6328	4.6976	4.6473
Rock Type	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite
Mining Method	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast	Open cast
Geological Reserve m3	2985080	1473640	3597148	1440461	2211092	2580660	3244850	2209020	2919906	2177700	2347200	2433860
Mining Reserve m3	2686572	1326276	3237433	1296414	1989983	232594	2920365	1988118	3503887	1959930	2112480	2190474
Daily Production m3	300	300	300	300	300	300	300	300	300	300	300	300
Mine life in years	39.8	19.6	48	19.2	29.5	34.4	43.3	29.5	43.3	29	31.3	32.5

LALITPUR

The area is located at Chaughare, Manikhel, Sankhu and Dalchauki VDCs, Lalitpur district in Bagmati Province, Nepal. The prospecting area and proposed mining area are in Toposheet No 2785 06C (Entitled TIkabhairab, 1:25,000 Scale) within Coordinates 3045000 m to 3048000m Northing and 632000 m to 639000 m Easting Figure 7). The Prospecting Area is 21 sq. km. and the proposed Mining Lease Area is 1.5 sq.km.

Geologically, the study area lies in the Tistung formation and Meta sandstones, phyllite and slates are the rocks found in this formation. The main rock type observed during the field visit is grey to dark grey, fine grained, thin to medium bedded, slight to highly weathered and ripple marked metasandstone and quartzite with frequent interlayering and intercalation of grey phyllites . The general strike direction is almost East to West and dip direction towards north with 35 to 30 degree dip amount. The Details of construction material in lalitpur district is presented in Table 6.

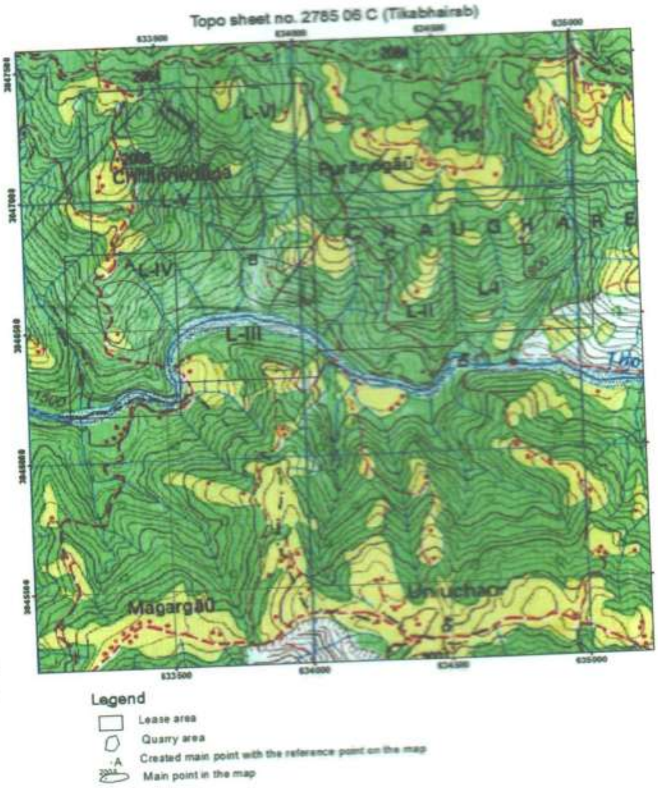


Figure 7: Topomap showing general topography and proposed mine areas

Table 6: Synopsis of the areas for the mining of construction materials in Lalitpur district.

Sl. No		1	2	3	4	5	6
District		Lalitpur					
VDC & Ward Nos.		Chaughare-5,6,8,9					
Lease No		1	2	3	4	5	6
Coordinates	Easting X1 E	634550	634050	633550	633150	633250	633550
	Easting X2 E	635050	634550	634050	633550	633650	633800
	Northing Y1 N	3046450	3046400	3046300	3046175	3046800	3045800
	Northing Y2 N	3046950	3046900	3046800	3046800	3047425	3046800
Lease Area in km2		0.25	0.25	0.25	0.25	0.25	0.25
Mines Area in hectares		19	24.5	13	11	18	21.5
Quarry Area in hectares		4.4	3.1	4.9	4.8	4.6	4.9
Rock Type		Metasandstone					
Mining Method		Opencast					
Geological Reserve in m3		1292760	865560	1510240	2415560	2550600	3212100
Mineable Reserve in m3		1163484	779004	1359216	2174004	2295540	2890890
Daily Production in m3		300 m3	300 m3	300 m3	300 m3	300 m3	300 m3
Mine Life in Yrs		17.2	11.5	20.13	32.2	34	42.8
Forest Area, Hectares		4.4	3.1	4.9	4.8	4.6	4.9

MORANG

The area is located at Battisjure Dada, Ward No. 4 and 6 of Bhogateni and ward no. 9 of Sinhadevi VDC, Morang District in Province 1, Nepal. The prospecting area and proposed mining area are in Toposheet No. 2687 02D (Entitled Hatkhola, 1:25,000 Scale) within coordinates 2965000m to
2965000 m to 296

2969500m Northing and 544000m to 549000m Easting (Figure 8). The total prospecting Area is 22.5 sq. km. and proposed Mining Area is 1.25 sq.km. The proposed mining area is divided into five blocks based on the strike of the deposit.

Geologically, the prospecting area is represented by metamorphic rocks of the Dubidanda Formation of Lakharpata Group of the Lesser Himalayan in eastern Nepal (PEPP, Exploration Block-10, 2000). The quartzite bearing formation exposed in the area is the Dubidanda Formation of late Precambrian age. Thickness of this formation is less than 5km. locally, at the prospecting area this formation can be divided into 5 distinct lithological units. These units in the area generally run northwest-southeast with high dip amounts towards north. The description of construction material is presented in Table 7.

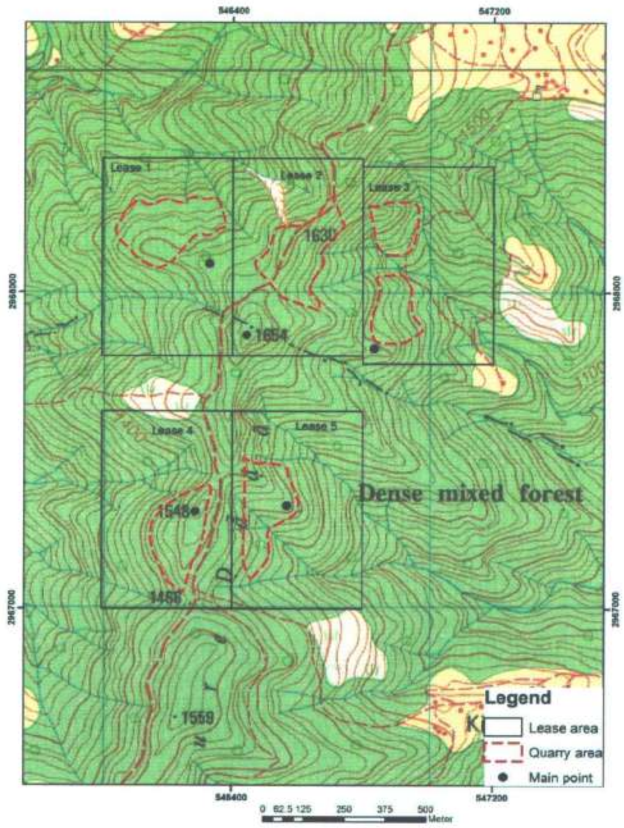


Figure 8: Topomap showing topography, the prospective area and proposed mine areas

Table 7: Synopsis of the areas for the mining of construction materials in Morang district.

S. No.		1	2	3	4	5
District		Morang				
VDC & Ward Nos.		Bhogateni -4 & 6 and Sinhadevi - 9				
Lease No		M1	M2	M3	M4	M5
Coordinates	Easting X1	546000 E	546400 E	546800 E	546000 E	546400 E
	Easting X2	546400 E	546800 E	547200 E	546400 E	546800 E
	Northing Y1	2967800 N	2967800 N	2967775 N	2967000 N	2967000 N
	Northing Y2	2968425 N	2968425 N	2968400 N	2967625 N	2967625 N
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25
Mines Area in hectares		10	10	10	10	10
Quarry Area in hectares		4.816	3.8	4.54	3.801	3.955
Rock Type		Quartzite				
Mining Method		Mechanized open cast				
Geological Reserve in m3		1825040	836480	1650010	1825040	1472165
Mineable Reserve in m3		1642536	752832	1485009	1625220	1324949
Daily Production in m3		300	300	300	300	300
Mine Life in Yrs		24.3	11.2	22.0	24.1	19.6
Forest Area, Hectares		4.816	3.8	4.54	3.801	3.955

MAKWANPUR

Field investigation was conducted in and around the prospecting area of Ward No. 8, Bhaise VDC, Makwanpur District in Bagmati Province of Nepal. Occurrence of quartzite beds were identified to the south of Kitini Village and the deposit extends towards Nayagau to the South-east from Kitini. The prospecting area and proposed mining lease area are in toposheet no. 2785 05C and 9A (Entitled BHAISE and HETAUDA 1:25,000 Scale) within coordinates 3042000m to 3044000m Northing and 600500m to 602300m Easting (Figure 9). The total prospecting area is of 3.6sq.km. and proposed mining area is of 1.25 sq.km. The proposed mining lease area is divided into five blocks based on the strike of the deposit.

Geologically, the proposed mines area lies within Dunga Quartzite of Robang Formation.The main lithology of the area is quartzite. The quartzite is medium to coarse grained medium to thick bedded. Being very near to the thrust it has developed joints and is highly fractured and geologically disturbed. The deposit area is mainly forest land. High hills and spurs are formed by quartzite deposit. About 25 hectare of area was selected for the preliminary exploration which lies along the ridge south of Kitini. Synopsis of mining area is presented in Table 8.

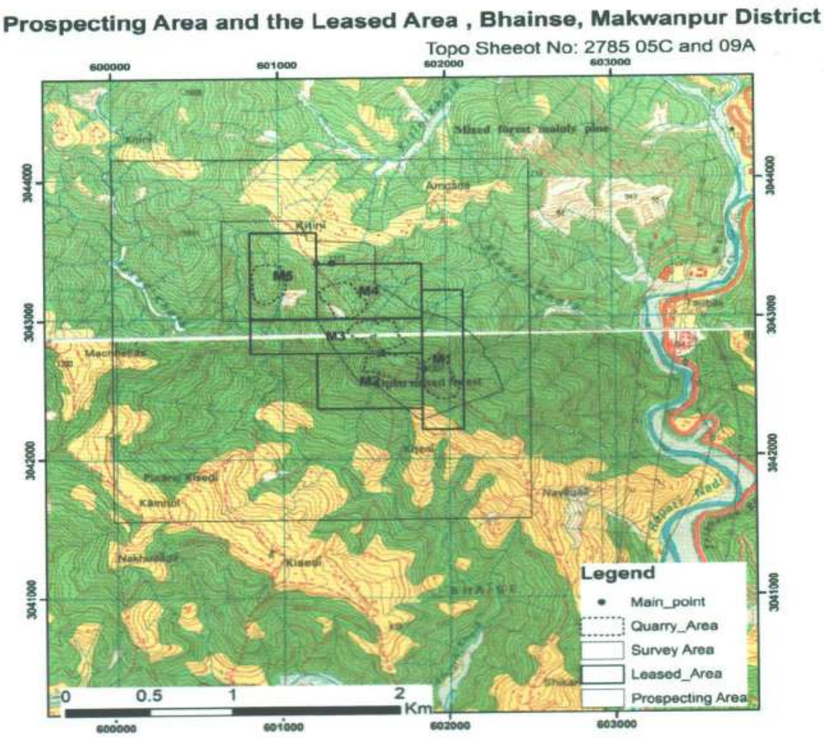


Figure 9: Topomap showing topography, the prospective area and proposed mine areas

Table 8: Synopsis of the areas for the mining of construction materials in Makawanpur district.

S. No.		1	2	3	4	5
District		Makwanpur				
VDC and Ward No.		Kitini-8, Bhainse				
Lease No.		M1	M2	M3	M4	M4
Coordinates	Easting X1	601850E	601225E	600850E	601225E	600825E
	Easting X2	602100E	601850 E	601850 E	601850E	601225E
	Northing Y1	3042200N	3042350N	3042750N	3043000N	3043000N
	Northing Y2	3043200N	3042750N	3043000N	3043400N	3043625N
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25
Mine Area in Hectares		13 ha	13 ha	14 ha	18 ha	24.9 ha
Quarry Area in Hectares		4.82 ha	4.92 ha	4.95 ha	4.90 ha	4.74 ha
Rock Type		Quartzite				
Mining Method		Mechanised Open Cast Method				
Geological Reserve in m3		2270000 m3	1908000 m3	1535950 m3	1964600 m3	2707600 m3
Mineable Reserve in m3		2043000 m3	1717200 m3	1382355 m3	1768140 m3	2436840 m3
Daily Production in m3		300	300	300	300	300
Mine Life in Yrs		30.3yrs	25.4 yrs	20.5 yrs	23.6 yrs	36.1 yrs

PALPA

The area is located at Ward No. 4 and 9 of Masyam VDC, Palpa district in Province 5 of Nepal. Occurrence of dolomite beds were identified to the north of Marangkot and the deposit extends towards Jayantilun. The prospecting area and proposed mining area are in toposheet No: 099-09 (Entitled MATHAGADH, 1:25,000 Scales within coordinates: 3074100m – 3075050m Northing and 451117m – 453632m Easting (Figure 10). Total prospecting Area is 2.39 sq. km. The proposed mining area is divided into eight blocks based on the strike of the deposit.

Geologically, the lower part of frontal slope with cultivated land to the south of Bhainsekati Khola consists of slate and diamictite of the Sisne Formation. High hills and spurs are represented by dolomite deposit. The dolomite is grey, very fine grained, thin to thick bedded, siliceous and fractured. The dolomite occurring around 980m levels seem to be the result of large syncline formed in the Tansen area in the geological past. The Kerabari Formation consisting of dark grey to grey limestone, grey dolomitic limestone and grey dolomite. The dolomite band is nearly 125m thick and extends almost east to west in the prospecting area from Marangkot to Jayantilun. The dip amounts ranges from 35° to 60°. Details of mining area is presented in Table 9.

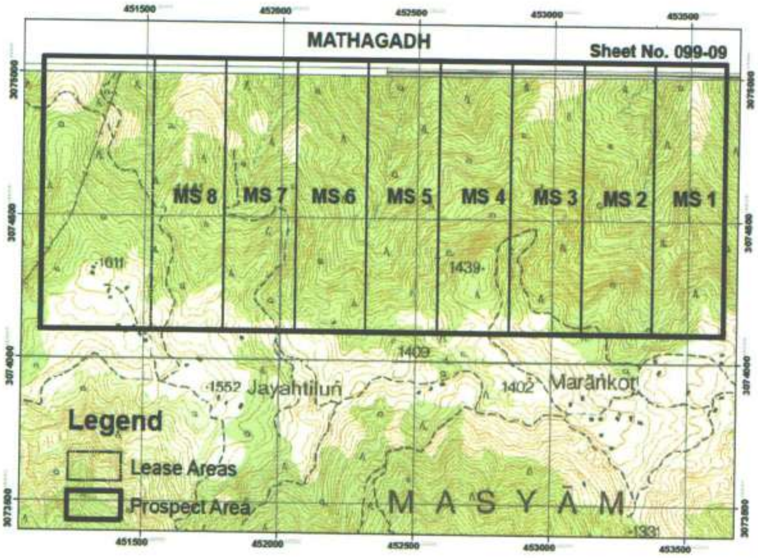


Figure 10: Topomap showing general topography, the prospective area and proposed mine areas

Table 9: Synopsis of the areas for the mining of construction materials in Palpa district.

Sl no.		1	2	3	4	5	6	7	8
District		Palpa							
Vdc		Masyam -4				Masyam -9			
Lease no		Ms1	Ms2	Ms3	Ms4	Ms5	Ms6	Ms7	Ms8
Coordinates	Easting X1	453368.8	453105.6	452842.4	452579.2	452316	452052.8	451789.6	451526.4
	Easting X2	453632	453368.8	453105.6	452842.4	452579.2	452316	452052.8	451789.6
	Northing Y1	3074100	3074100	3074100	3074100	3074100	3074100	3074100	3074100
	Northing Y2	3075050	3075050	3075050	3075050	3075050	3075050	3075050	3075050
Lease area in km2		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Survey area hectares		16.5	18.8	22.6	19.9	18.7	22.4	19.6	17.8
Quarry area hectares		4.8	4.7	4.9	4.8	4.7	4.9	4.9	4.9
Rock Type		Dolomite							
Mining Method		Open cast							
Geological Reserve m3		2237113	3455997	3641086	2700170	2115756	2028164	2706876	3550774
Mining Reserve m3		2416082	3732476	3932372	2916183	2285016	2190417	2923426	3834835
Daily Production m3		300	300	300	300	300	300	300	300
Mine life in years		29.82	46	48.54	36	28.21	27.04	36.1	47.34

PYUTHAN

The area is located at Ward No. 6 of Tiram VDC, Pyuthan district in Rapti zone, which lies in the Province 5, Nepal. The prospecting area and proposed mining area lies in topo-sheet no.

Geologically, the area lies within the Gawar Formation of the Lakharpata Group. Within this area, the rocks are composed of grey, slightly weathered, stromatolitic dolomite with minor shale parting. The dolomite is medium to thick-bedded and appears strong in the field observation. Western boundary of the dolomite is also demarcated by a Fault (?) contact. The beds are generally dipping toward NW with the dip amount ranging 30^0 to 65^0. The Details of mine area is given in Table 10.

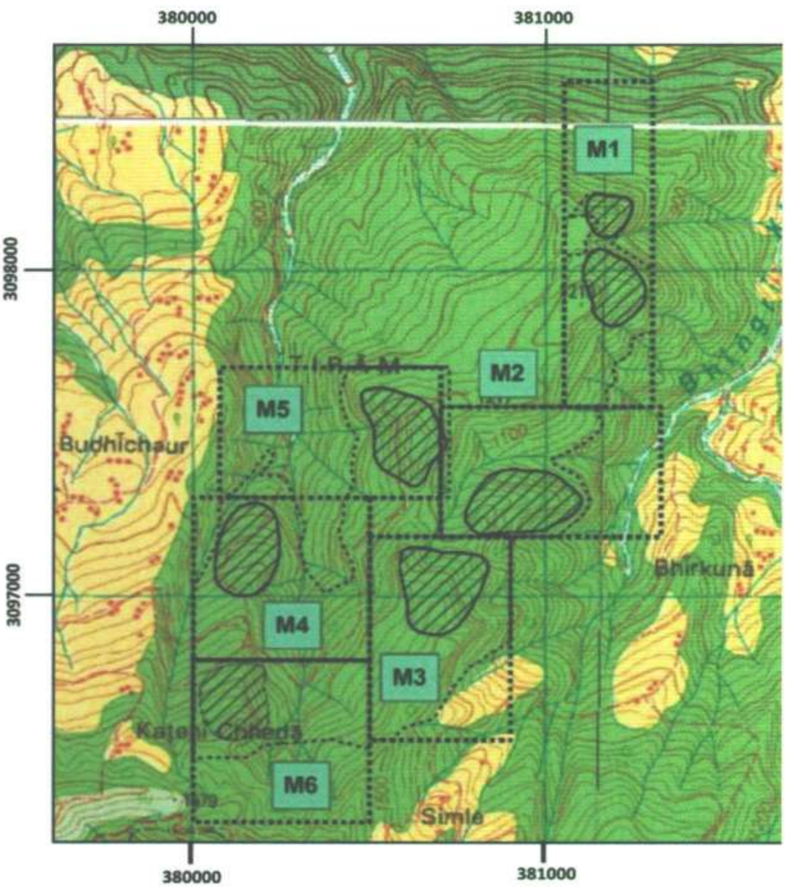


Figure 11: Topomap showing general topography, the prospective area, leased area.

Table 10: Synopsis of the areas for the mining of construction materials in Pyuthan district.

S. No.		1	2	3	4	5	6
District		Pyuthan	Pyuthan	Pyuthan	Pyuthan	Pyuthan	Pyuthan
VDC and Ward No.		Tiram-6	Tiram-7	Tiram-8	Tiram-9	Tiram-10	Tiram-11
Lease No.		M1	M2	M3	M4	M5	M6
Coordinates	Easting X1	381050	38075	380500	380000	380100	380000
	Easting X2	381350	381350	380900	380500	380725	380500
	Northing Y1	3097580	3097180	3096555	3096800	3097300	3096300
	Northing Y2	3098580	3097580	3097180	3097300	3097700	3096800
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25	0.25
Mine Area in Hectares							
Quarry Area in Hectares		4.4	4.97	4.94	4.14	4.77	3.64
Rock Type		Quartzite +Dolomite					
Mining Method		Mechanized Open Cast					
Mineable Reserve in m3		1616898	4079149	3549796	2690659	2863468	3566778
Daily Production in m3		250	250	250	250	250	250
Mine Life in Yrs		23.95	60.43	52.58	39.86	42.42	52.84

SALYAN

The area is located at Dhanwang VDC, Salyan district in Rapti zone, which lies in the Karnali Province, Nepal. The prospecting area and proposed mining area are in toposheet No. 2882 10 C and 2882 14A (1:25,000 Scale) within Coordinates 3124500m to 3129000m Northing and 627000m to 635000m Easting (Figure 12). The total prospecting Area is 36 sq. Km. and proposed Mining Area is 2.504 sq.km. The proposed mining area is divided into ten blocks based on the strike of the deposit.

Geologically, the proposed mines lies within Dubidanda Formation of Dailekh Group. The Tharkot Dada south of Dhanbang forms the prospect. It consists of medium to thick bedded, fractured, moderately weathered, grey to greyish white quartzite. The south facing slope of Tharkot Dada forms the prospect. The deposit area lies in forest land. Hillocks and spurs are formed by quartzite. Detail of the mining of construction material is presented in Table 11.

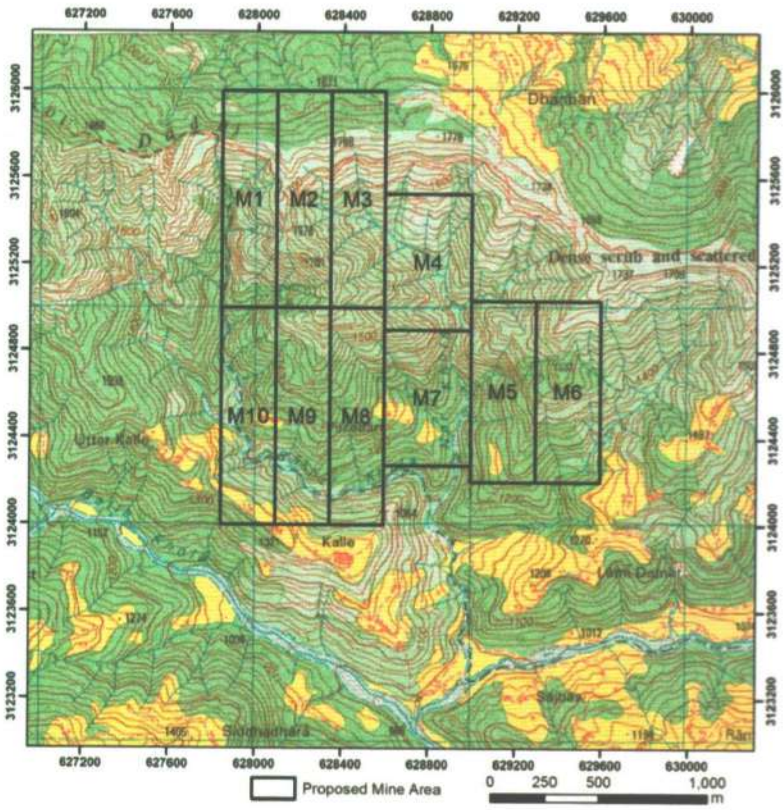


Figure 12. Topographic map showing general topography and proposed mine areas

Table 11: Synopsis of the areas for the mining of construction materials in Salyan district.

S. No.		1	2	3	4	5	6	7	8
District		Salyan							
VDC and Ward No.		Dhanwang-4,5							
Lease No.		M1	M2	M3	M4	M5	M6	M7	M8
Coordinates	Easting X1	627840	628090	628340	628590	628990	629290	628590	628340
	Easting X2	628090	628340	628590	628990	629290	629590	628990	628590
	Northing Y1	3125000	3125000	3125000	3124900	3124200	3124200	3124275	3124000
	Northing Y2	3126000	3126000	3126000	3125525	3125034	3125034	3124900	3125000
Lease Area in Km2		0.25	0.25	0.25	0.25	0.2502	0.2502	0.25	0.25
Mine Area in Hectares		8.7	9.13	8.8	10.26	9.2	9.76	9.4	11.52
Quarry Area in Hectares		4.93	4.69	4.6	4.75	4.82	4.6	4.79	4.97
Rock Type		Quartzite							
Mining Method		Mechanized Open Cast							
Geological Reserve in m3		2419560	2304120	1999010	2236920	1527120	2008500	2078600	1546780
Mineable Reserve in m3		2613125	2488450	2158930	2415873	1649289	2169180	2244888	1670522
Daily Production in m3		250	250	250	250	250	250	250	250
Mine Life in Yrs		38.71	36.86	31.98	35.79	24.43	32.13	33.25	24.74

SURKHET

The area is located at Ward No. 7 and 9 of Sahare VDC, Surkhet district in Karnali Province, Nepal. The prospecting area and proposed mining area are in toposheet No. 2881 12B (Entitled BOTECHAUR, 1:25,000 Scale) within Coordinates of 3143000m to 3147000m Northing and 588000m to 593000m Easting (Figure 13). The Prospecting Area is of 20 sq. km. and the Proposed Mining Area is 1.5 sq.km. The proposed mining area is divided into six blocks based on the strike of the deposit.

Geologically, the proposed mines area lies within Ramkot Formation of Lakharpata Group. The west and northwest facing slopes of the hills located to the north of Puranagaon form the prospect. It consists of medium to thick bedded pinkish, light grey to white, fine to medium grained quartzite beds containing frequent ripple marks. Thin non map able purple shale bands are present within quartzite bands. The deposit area lies in forest land. High hills and spurs are formed by quartzite. The landform and drainage is controlled by discontinuities in the quartzite. The general trend of beds is NW-SE with varying dip amount of 21° to 61°. The description of mine area is presented in Table 12.

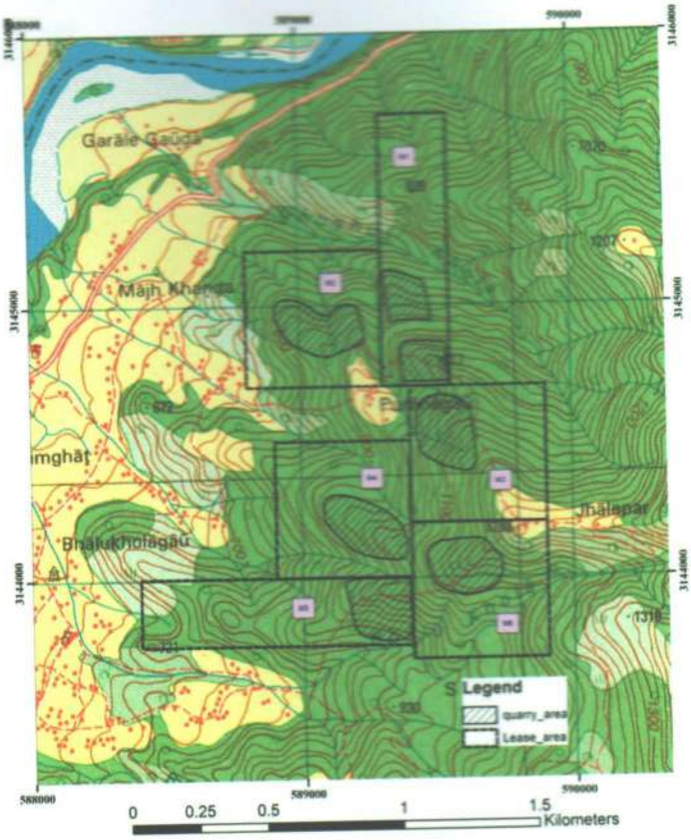


Figure 13: Topographic map showing topography, the prospective and proposed mine areas

Table 12: Synopsis of the areas for the mining of construction materials in Surkhet district.

S. No.		1	2	3	4	5	6
District		Surkhet	Surkhet	Surkhet	Surkhet	Surkhet	Surkhet
VDC and Ward No.		Sahare-7	Sahare-7	Sahare-7	Sahare-7,9	Sahare-7	Sahare-9
Lease No.		1	2	3	4	5	6
Coordinates	Easting X1	589300	588800	589400	588900	588400	589400
	Easting X2	589550	589300	589900	589400	589400	589900
	Northing Y1	3144700	3144700	3144200	3144000	3143750	3143700
	Northing Y2	3145700	3145200	3144700	3144500	3144000	3144200
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25	0.25
Mine Area in Hectares		17.5	22.8	13.3	19.7	8.37	23
Quarry Area in Hectares		4.99	4.95	4.93	4.98	4.8	4.67
Rock Type		Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite
Mining Method		Opencast	Opencast	Opencast	Opencast	Opencast	Opencast
Geological Reserve in m3		1875080	1923210	2852260	2395200	2601860	2572220
Mineable Reserve in m3		2025086	2077067	3080440	2586816	2810009	2777997
Daily Production in m3		250	250	250	250	250	250
Mine Life in Yrs		30.00	30.77	45.63	38.32	41.63	41.15

SINDHULI

Field investigation was conducted in and around the prospecting area of Tinkanya-6 & 7 and Ranichuri-9 of Sindhuli District, Janakpur Zone. Occurrence of Metasandstone beds were identified to the southeast of Ranikholagau and the deposit extends towards Landrangdada. Locations of the mineral and general descriptions of the prospecting sites are recorded.

The area is located at Ward No 6 & 7 of Tinkanya VDC and Ward-9 of Ranichuri VDC of Sindhuli District, Janakpur Zone, which lies in the Central Development Region of Nepal. The prospecting area and proposed mining area are in Toposheet No: 2786 13 A (Entitled BELGHARI, 1:25,000 Scale) Within Coordinates: 3011000 N to 3012000 N and 405000 E to 406000 E covering total prospecting Area of 1. km. The area is accessible through B.P Highway.

Geologically, the proposed mines area lies within Kulekhani Formation of Bhimphedi Group of Kathmandu complex. The south and north facing slopes of the hills located to the southeast of Ranikholagau consists of light to dark grey and dark greenish grey, thin to medium bedded quartzite beds containing rare cross bedding with parting of schist. The schists beds are up to 5 m thick in some places. The deposit area mainly forest land with patches bushes. High hills and spurs are formed by quartzite deposit.

About 25 hectare of area was selected for the preliminary exploration which lies along the ridge north and south facing slopes of study area. Deposit Area extends for about 250 m in east-west and for about 1000 m in north-south directions.

The strike of bedding planes is NW-SE with dip direction towards NW-NE with 25° to 50° dip amounts.

The proposed mining area is divided into four mining lease (ML) blocks based on the strike of the deposit and the coordinates of the blocks are presented in Table below.

Fig.: Location Map of the Lease Area (S1)

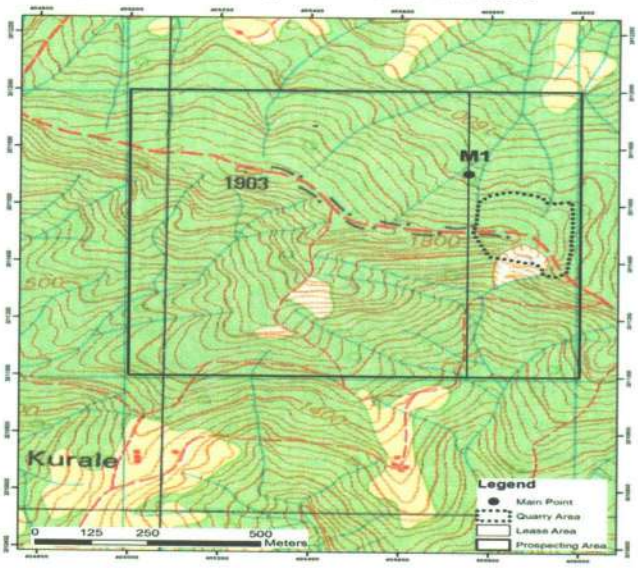


Figure 14: Topographic map showing the prospective area and proposed mine areas.

Table 13: Synopsis of the Areas for the Mining of Construction Materials in Sindhuli District

S. No.		1	2	3	4
District		Sindhuli	Sindhuli	Sindhuli	Sindhuli
VDC and Ward No.		Ranichuri 9 and Tinkanya 6 &7	Ranichuri 9 and Tinkanya 6 &7	Ranichuri 9 and Tinkanya 6 &7	Ranichuri 9 and Tinkanya 6 &7
Lease No.		M1	M2	M3	M4
Coordinates	Easting X1	405750	405500	405250	405000
	Easting X2	406000	405750	405500	405250
	Northing Y1	3011000	3011000	3011000	3011000
	Northing Y2	3012000	3012000	3012000	3012000
Lease Area in Km2		0.25	0.25	0.25	0.25
Mine Area in Hectares		25	25	25	25
Quarry Area in Hectares		4.91	4.82	4.96	4.86
Rock Type		Metasandstone	Metasandstone	Metasandstone	Metasandstone
Mining Method		Open Cast	Open Cast	Open Cast	
Geological Reserve in m3		3213290	1911040	1256800	2007520
Mineable Reserve in m3		2892528	1719936	1131120	1806768
Daily Production in m3		250	250	250	250
Mine Life in Yrs		42.80	25.50	16.80	26.80

UDAYAPUR

The area is located at Ward No. 4, 5 and 6 of Jalpa Chilaune VDC, Udayapur district in Province 1, Nepal. The prospecting area and proposed mining area are in toposheet No 2686 03B and 2686 03D (1:25,000 Scale) within Coordinates 2971500m to 2976500m Northing and 463000 E to 471000m Easting (Figure 14). The total prospecting Area is of 40 sq. Km. and mining Lease (ML) Area is 1.25 sq.km (cumulative). The proposed Mining Lease area is divided into five blocks based on the strike of the deposit.

Geologically, the proposed mines area lies within Gawar Formation of Lakharpata Group. The hillock west of Sukaura forms the prospect. It consists fractured, thin to medium bedded, moderately weathered, bluish grey to grey dolomite. Algal stromatolitic structures are common in dolomite. Typical elephant-skiny weathering pattern can be observed in the dolomite surface. The deposit area lies in forest land. Hillocks and spurs are formed by Dolomite. The landform and drainage is controlled by discontinuities in the Dolomite. The general trend of beds is NW-SE with varying dip amount of 31° to 65°. The detail of the mining area is given in Table 14.

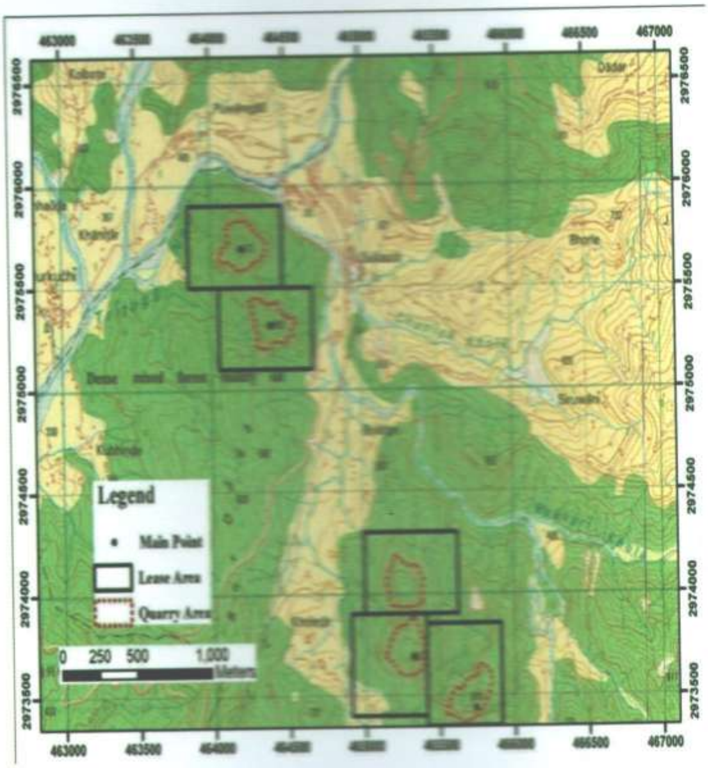


Figure 15: Topographic map showing the prospective area and proposed mine areas.

Table 14: Synopsis of the areas for the mining of construction materials in Udayapur district.

S. No.		1	2	3	4	5
District		Udayapur				
VDC and Ward No.		Jalpa Chilaune-4&6		Jalpa Chilaune-5		
Lease No.		M1	M2	M3	M4	M5
Coordinates	Easting X1	463850	464050	465000	464910	465410
	Easting X2	464475	464675	465625	465410	465910
	Northing Y1	2975500	2975100	2973900	2973400	2973350
	Northing Y2	2975900	2975500	2974300	2973900	2973850
Lease Area in Km2		0.25	0.25	0.25	0.25	0.25
Mine Area in Hectares		24.8	22.6	23.5	22.19	25
Quarry Area in Hectares		4.99	4.73	4.68	4.94	4.86
Rock Type		Dolomite	Dolomite	Dolomite	Dolomite	Dolomite
Mining Method		Open Cast				
Geological Reserve in m3						
Mineable Reserve in m3		1603950	2198000	2092800	2324600	1695800
Daily Production in m3		250	250	250	250	250
Mine Life in Yrs		25.66	35.17	33.48	37.19	27.13

SUMMARY

The 92 quarry site within 14 districts was identified. Most of the quarry area are not accessible by motor able road. 1-5 km road need be constructed. The production is proposed to be 250 -300 m3 of raw stone per day. The mine life of each mines are more than 20 years. So, all of the mines are of medium size with license life of 20 years. The rock is mainly quartzite and dolomite in some mines, which are suitable for aggregate and building stone. The quartzite and dolomite of the area is fine grain, compact, and platy to blocky usable in the making of aggregate. Soft type of like shale rock not good for masonry work are either used to make quarry road, dump yard edge, filling or kept in the dump yard or sold for filling purposes. Constructional work requires both soft and hard rock type. This rock is used for aggregate production. Crushed stone might contains smaller size particle in the form of chips, sand and dust. All form of production can be used in constructional job according to their uses. So depending upon the end uses rocks are separated and sold.

The mining scheme and IEE report are approved from the Department of Mines and Geology. Rock excavation will be done by open cast mining method with a combination of excavator scrapping, hydraulic and manual breaking, loading and dumper transportation depending upon the situation. Mining system of benching extraction from top to down at benches has been proposed which minimizes any negative environmental impact and it also provides enough safety to the workers. Rocks are scraped by an Excavator/Loader. Hydraulic breaker attachment in the Excavator will be used to break bigger size boulder. Excavator cum Loader loads broken rocks into the truck which transport it to loading yard. Loading station will be connected by motorable road for transportation.

The quarrying operation has in some cases positive and in some cases negative impacts. Applying appropriate technology depending upon the local condition and economic factors, positive impacts will be enhanced and the negative impacts will be mitigated. The mining operation is attractive from economic point of view. It would be much more beneficial to people, locality and nature if the proper mitigation measures are fully and truly observed.

ACKNOWLEDGEMENT

I like to extend my sincere gratitude to Mr. Ram Prasad Ghimire, Director General for valuable suggestions before and after the fieldwork. I am very much indebted to Mr. Sarbjeet Prasad Mahato, Former Director General of DMG, Dr. Soma Nath Sapkota Former Director General of DMG for encouragement and facilities provided during the fieldwork. I am equally thankful to entire field team Jay Raj Ghimire, Rupak Kumar Khadka, Dharma Raj Khadka, Lilanath Rimal, Shova Singh, Santosh Dhakal, Kusal Nandan Pokharel, Suresh Shrstha, Shiva Kumar Baskota, Ratna Mani Gupta, Prithivi Lal Shrestha, Saunak Bhandari, Kumar Khadka, Sujan Devkota, Bishow Raj Silwal, Naresh Maharjan, Basanta Adhikari, Chintan Timsina, Gautam Khanal, Janak Bahadur Chand of DMG and survey team for fieldwork in various aspects.

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आकस्मिक पहिरो अध्ययन प्रतिवेदन, टुसाल, बुढानिलकण्ठ नगरपालिका वार्ड न. ५

प्रकाश पोखेल (भुगर्भविद), **प्रमिला श्रेष्ठ** (सि.डि.हाइड्रोजियोलोजिस्ट) र **विनोद ज्ञवाली** (स. भू-संरक्षण अधिकृत)

सारांश

काठमाडौं जिल्ला बुढानिलकण्ठ नगरपालिका वार्ड न. ५ मा गएको पहिरोको जोखिम न्युनिकरणका लागि मिति २०७५।०१।१९ को जिल्ला विपद व्यवस्थापन समिति(काठमाडौंको निर्णयं बमोजिम विविध क्षेत्रका बिज्ञहरु सम्मिलित टोलिले छोटो अबधिमा स्थलगत अवलोकन र सोधपुछमार्फत संकलित तथ्याङ्कका आधार मा यस प्रतिवेदन तयार गरेको हो । चट्टान धेरै मक्किएर माटोमा परिणत भएको भिरालो जमिनमा पानीको निकासका लागी पर्याप्त संरचना नबनाई अव्यबस्थित बस्ती विकास र भौतिक संरचना निर्माणलाई यस अध्ययनले पहिरोको कारक तत्व मानेको छ। भु-उपयोग नितिको अधिनमा रहि सम्बन्धित निकायले गर्नुपर्ने तत्कालिन र दिर्घकालिन कार्यहरु अध्ययन टोलीले सुझाएको छ ।

शब्द कुञ्जी : पहिरो, जोखिम, विपद, भु-उपोग

पृष्ठभूमि

जिल्ला विपद व्यवस्थान समितिको मिति २०७५।०१।१९ मा श्रीमान् प्रमूख जिल्ला अधिकारीज्युको अध्यक्ष्यतामा बसेको वैठकले वुढानिलाकण्ठ नगरपालिका वार्ड न. ५ टुसालमा गएको पहिरोले पुऱ्याएको क्षतिको अल्पकालीन र दिर्घकालिन उपायको अध्यन गरि सुझाव सहितको प्राविधिक प्रतिवेदन पेश गर्न तपसिलका व्यक्तिहरु रहेको समिति गठन गरिएको थियो ।

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३. जियोलोजिस्ट प्रकाश पोखेल - खानि तथा भूगर्भ बिभाग
४. शा.अ. प्रदिप राई - जिल्लाप्रसाशन कार्यालय
५. बरिष्ठ सामाजिक अधिकृत दिपक के.सी. - जिल्ला समन्वय समिती
६. इन्जिनियर दिपक भण्डारी -वुढानिलाकण्ठ नगरपालिका
७. सहायक भू-संरक्षण अधिकृत विनोद ज्ञवाली - वन तथा भू-संरक्षण विभाग

अध्ययनका उद्देश्य

यस अध्ययनका मुख्य उद्देश्यहरु निम्न बमोजिम रहेका छन्:

- पहिरोकोजोखिमवाटवस्तीमापरेकाजोखिमहरुको अवस्थारकारणहरुपहिचानगर्ने,
- पहिरोकोजोखिमन्युनिकरणकालागि तत्कालिन र दिर्घकालिन उपाय सम्बन्धि राय तथा सुझाव दिने ।

अध्ययनका सिमितता

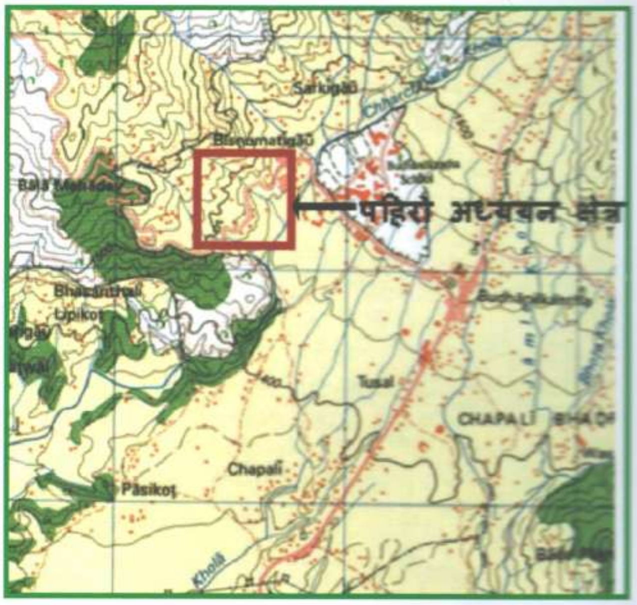
यो प्रतिवेदन एकदमै छोटो समयमा बिना कुनै उपकरण गरिएको स्थलगत निरिक्षणमा आधाररही तयार पारिएको हो । यस अध्ययन टोलिलाई स्थानियहरुले देखाएका बाहेक अन्य स्थानमा परेका वा हुन सक्ने चिरा तथा धाँजाहरुका कारण सिर्जनाहुन सक्ने जोखिमको पनि मुल्याङ्कन गरिएको छैन। हाल गरिएका चिराहरुको वास्तविक गहिराई Visual Observation मा मात्र आधारित भएकाले यसको वास्तविक गहिराई

नाप्नका लागी Geophysical लगायत Topographical Survey को आवश्यकतालाई पनि यस प्रतिवेदनले विस्थापित गर्दैन ।

स्थलगत बस्तुस्थिती

स्थान (Location)

काठमाँडौ जिल्लाकोबुढानिलकण्ठ न.पा. वार्ड न. ५, टुसालमा जोखिम मानिएको पहिरोको जोखिम र यसले मानव वस्तिहरुमा पार्न सक्ने असर वारे अध्ययन गरिएको छ ।



नक्सा १: अध्ययन क्षेत्रको टोपो नक्सा

पहुँच (Accessibility)

काठमाडौवाट रत्नपार्क-बुढानिलकण्ट सडक हुँदै करिव १२ कि.मि. यात्रा गरी टुसालको पहिरो प्रभावित क्षेत्रमा पुग्न सकिन्छ ।

भू-वनोट (Geomorphology)

भौगर्भिक अध्ययन गरिएको क्षेत्र काठमाडौं उपत्यकाको उत्तरी पहाडी क्षेत्रमा पर्दछ। यस क्षेत्रमा भिरालो जमिन, चट्टानी पहरा, साँघुरा र ठाडा खोल्सी रहेका छन् । पहिरो प्रभावित क्षेत्रमा जमिनको सतह करिब ४५० देखी ६०० सम्मको ढल्काईमा दक्षिण-पश्चिम तर्फ फर्किएको छ ।

भू-उपयोग (Land Use)

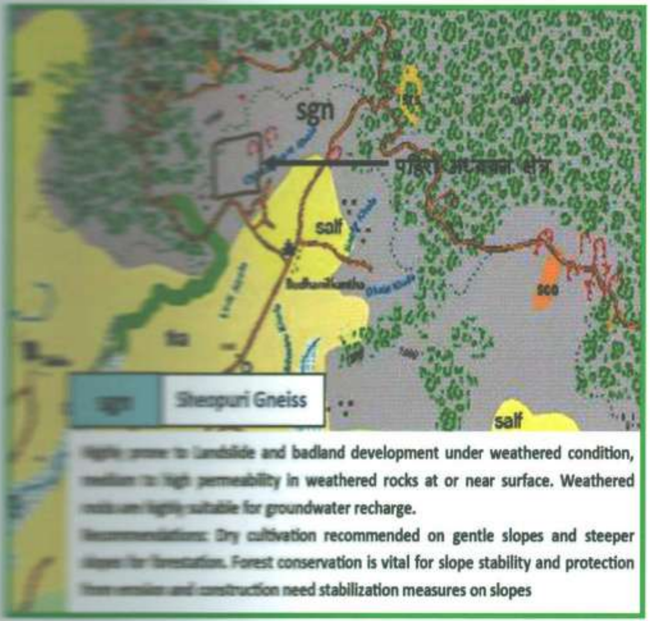
शिवपुरी नागार्जुन राष्ट्रिय निकुन्जको मध्यवर्ती क्षेत्रमा पर्ने उक्त क्षेत्रमा Plotting गरेपछिको वर्तमान अवस्थामा Ground vegetation को रुपमा रुख प्रजाती लगभग शुन्य र केहि घासहरु तथा खाली भिरालो जमिनमा पक्का नगराई, संरक्षणका उपायहरु नअपनाई केहि ठाँउमा मकै खेति गरिएको छ। भू तथा जलाधार संरक्षणको दृष्टिकोणबाट उक्त ३० डिग्री भन्दा माथि भिरालो भएको जमिनमा खेतीपाती नगरी वृक्षारोपण र घासपात हुनुपर्ने हो ।

भौगर्भिक जोखिमको वस्तुस्थिती

पहिरो, नदि कटान, चट्टान खस्ने, जमिन भासिने, जमिनमा चिरा पर्ने आदी भौगर्भिक जोखिममा पर्दछन् । कमजोर भूवनोट र नजमेको (unconsolidated)माटो भएको स्थानमा जमिन भासिने र चिरा पर्ने र माटो मात्रैको लेदो बग्ने हुन्छ भने कडा चट्टान भएको स्थानमा चट्टान खस्ने तथा माटो र चट्टान मिसिएको लेदो (Debris Flow) बग्ने समस्या हुन्छ ।

भौगर्भिक अवस्था

अध्ययन क्षेत्र Lesser Himalaya Crystalline Nappe-zone मा पर्दछ । यस क्षेत्रमा Sheopuri Gneisso Unit Mica Gneiss, Biotite Gneiss तथा Intruded Muscovite Granite जस्ता चट्टानहरु पाईन्छन् । यि चट्टानहरु धेरै मक्किएका तथा चिरा परेका छन् । खानी तथा भुगर्भ विभागले प्रकाशन गरेको Engineering and Environmental Geological Map of Kathmandu Valley, Scale 1:50,000 (नक्सा २) को नक्सा अनुसार यस किसिमको मक्किएको चट्टान (Weathered Gneiss) को भार बहन क्षेमता निकै कमजोर देखि मध्यम सम्म हुन सक्ने, पहिरोको लागि उच्च जोखिम हुने र भुमिगत जलस्रोत भण्डारणका लागि निकै उपयुक्त हुने खालको हुन्छ ।



नक्सा २: अध्ययन क्षेत्रको Engineering and Environmental Geological Map (खानी तथा भूगर्भ विभाग)

जोखिमको अवस्था

यस अध्ययन टोलिले गरेको स्थलगत अध्ययन क्रमको क्रममा स्थानिय वासिन्दाका अनुसार मिति २०७५/०५/१० गते देखी लगभग १ सेन्टिमिटर चौडाई भन्दा साना थुप्रै चिरा देखा परेको र मिति २०७५/०५/१२ गते सम्ममा उक्त चिराहरूको चौडाई बढेर ०.५ मिटर तथा कतिपय स्थानमा सो भन्दा ठूला चिराहरु जमिनको सतह तथा उक्त स्थानमा रहेको घरका भित्ताहरूमा देखा परेका थिए। स्थानीय बासिन्दाका अनुसार उक्त स्थानमा मिति २०७५/०५/१० गते देखि लामो समय सम्म हलुका बर्षा भएको थियो। हाल सो स्थानको करिब १०० मिटर चौडाई र १५० मिटरको लम्बाईको क्षेत्रफलमा उक्त पहिरोको कारणबाट जमिन धेरै ठाँउमा चिरा परेको छ। उक्त पहिरो वाट ४ घर धुरी पुर्ण रुपमा विस्थापित, ५ घर धुरी उच्च जोखिममा र अरु थुप्रै घर धुरीहरु मध्यम तथा सामान्य जोखिममा रहेका छन् ।

सम्भावित कारण

यस अध्ययन टोलिले प्रारम्भिक चरणमा गरेको अध्ययन अनुसार, चट्टान मक्किएर बनेको माटोले बनाएको भिरालो जमिनमा बिना कुनै अध्ययन, अव्यवस्थित ढङ्गले निर्माण गरिएका तथा गर्न लागिएका घरहरु, बाटो तथा घडेरीहरु यस पहिरोका मूख्य कारण हुन । घडेरी तथा बाटो निर्माणका लागि भिरालो जमिनको तल्लो भाग काटेर थप भिरालो बनाउनु, जमिन सम्माउनका लागि निर्माण गरिएका ठूला-ठूला पर्खालहरूमा भूमिगत पानीलाई बिना अबरोध बग्नका लागि प्वाल तथा निकासको व्यवस्था नहुनाले जमिनको सतह मुनिपानीको चाप (pore water pressure) बढी हुन जानुर भिरालो जमिनको उच्च भागमा निर्माण गरिएका पर्खालहरुको जग माटोमा मात्र सिमित हुनु जस्ता मानविय क्रियाकलाप वाट यो पहिरो सिर्जना भएको हो ।

निष्कर्ष तथा सुझाव

यस प्रारम्भिक अध्ययनको क्रममा प्राप्त भएका सुचनाहरु तथा स्थानियहरुले अध्ययन टोलीलाई देखाएका पहिरोहरुको बर्तमान स्थिती तथा यस क्षेत्रको भौगर्भिक स्थितीको मुल्याङ्कन गर्दायस पहिरोबाट सिर्जित चिराहरुले उक्त स्थानको जमिनलाई कमजोर बनाएको तथा सोही स्थानमा निकट भविस्यमा थप पहिरो जान सक्ने अबस्थामा रहेकाले बस्ती रहेको स्थान उच्च जोखिममा देखिन्छ । जोखिम न्युनिकरणको लागी तत्कालिन र दिर्घकालिन रुपमा निम्नाअनुसार कार्य गर्न सकिन्छ ।

तत्कालिन कार्य

- उच्च जोखिममा रहेका घर-धुरीका मानिसहरुलाई बर्षायामको अन्तिमसम्मको लागि सामुहिक रुपमा सुरक्षित स्थानमा स्थानान्तरण गर्ने ।
- चिरा परेका स्थानहरु टाल्ने, चिराहरुवाट पानी छिर्न नदिने तथा पहिले नै निर्माण गरिएका पर्खालहरुमा पानीको निकासका लागि व्यवस्था मिलाउने ।
- पहिरो सुरु भएको उपल्लो भाग भन्दा केही मिटर माथीवाट प्लाष्टिकले छोपिएको (Plastic Lining) उत्तर-पश्चिमवाट दक्षिण-पुर्व दिशामा सानो कुलोको निर्माण गरी पहिरो भन्दा माथि परेको पानीलाई अन्यत्र बग्नेव्यवस्था गर्ने ।
- बर्षा तथा अन्य कारण वाट सो स्थानमा जुनसुकै

बेलापनि पहीरो बग्न सक्ने भएकाले पहिरो बिपद सम्बन्धी पुर्व तयारी गर्ने र बिपद पछिको उद्धार कार्यको लागि सम्बन्धित निकाय उच्च सतर्कतामा रहने ।

दीर्घकालिन कार्य

- यस क्षेत्रको भौगर्भिक स्थितीको मुल्याङ्कन गर्दा पहिरो लगायत अन्य बिपदका जोखिमको हिसाबले बस्ती बसाउन असुरक्षित देखिएकाले यस स्थानमा बस्ती नबसाउने ।
- पहिरोको तल्लो भागमा रहेको बस्तीमा जोखिम न्युनिकरणका लागि पहिरोको तत्काल Detail Survey Mapping गर्ने, चिराहरुको गहिराई, पहिरोको गहिराई सम्बन्धि Geophysical Survey तथा Hydrogeological Survey गरि सो को आधारमा उपयुक्त किसिमका इन्जिनियरिङ्ग संरचना निर्माण गर्ने तथा बर्षाका कारण पर्ने पानीलाई जमिन भित्र कम मात्रामा छिर्न दिने खालका घाँसहरु रोप्ने ।
- उपल्लो भागबाट जोखिम क्षेत्रमा आउने पानीलाई निकास (drain) बनाई सुरक्षित तरिकाले खोलसिमा फाल्ने ।
- स्थानीय तह मातहतका यस्ता प्रकृतिका जग्गाको उपयोग सम्बन्धमा राष्ट्रिय भू-उपयोग २०६९ को अधिनमा रही स्थानीय तहले भू-उपयोग निति, एन तथा नियमावलीर बआस्यक संयन्त्र निर्माण गर्नुपर्ने ।


फोटो १: पहिरो प्रभावित क्षेत्रको Google Earth Image


फोटो २: पहिरोका विभिन्न [illegible]

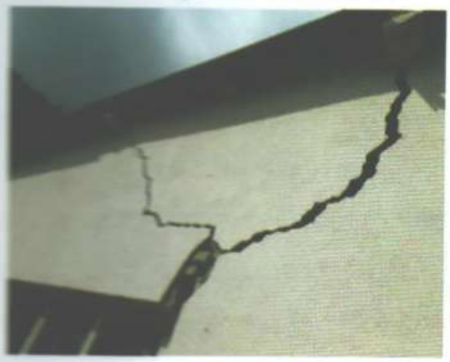

फोटो ३: पहिरोका कारण बाट विनास भएका सँरचना


फोटो ४: पहिरोका कारण बाट बिनास भएको [illegible] सडक


फोटो ५: चट्टान मक्किएर बनेको बलौटे माटो


फोटो ६: पहिरोको उपल्ला भागमा पानीको निकास बिना निर्माण गरिएको पर्खाल


फोटो ७: पहिरो गएको भित्री जमिन र [illegible]


फोटो ८: घरको भित्ता चर्केको

Geophysical Investigation of the Khola Khani Copper Prospect in Tanahu District, Gandaki Province

Prakash Pokhrel (Geologist) and **Thakur Prasad Kandel** (Senior Divisional Geologist)

ABSTRACT

The Khola Khani copper prospect was investigated with geophysical method using the Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) in order to determine the presence of copper deposit in the area. The study area is known for producing the copper ore in ancient times and there are tens of mine adits distributed around the steep hillslope of Aanbu and Khola Khani area. Geologically, the distribution of the old mine works are confined at the contact region between the Dandagaon Phyllites and Nourpul Formation of the Lower Nawakot Group of the Kathmandu Complex. The anomalies presented on profiles recorded with different electrode arrays (Wenner, Schlumberger, Dipole-dipole) show the presence of underground low resistivity zone but the target object's position and size can't be determined with the good precision, so a reliability based approach need to adopt to characterize the result.

Keywords: copper prospect, electrical resistivity tomography (ert), induced polarization (ip), anomaly

INTRODUCTION

The major portion of Nepal lying in the Mahabharat range consisting the Lesser Himalayan rocks are rich in both metallic and non-metallic mineral resources. The growth and development of mineral based industry in Nepal is the prime objective of Department of Mines and Geology (DMG) which is the sole institute to carry out the prospecting, exploration, exploitation, monitoring and restoration of the mines. The mining history in Nepal is very old and copper is the principal metal which was mined extensively amid other mineral resources but only in small scale using the traditional method in last century. There are dozens of localities of the Lesser Himalayan meta-sediment of Precambrian-Paleozoic age, (DMG 1993) where old workings are reported to exist.

In the current study, Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) methods were used based on the different physical properties of rock in order to determine the presence of mineral resource in the area. For this purpose, ERT and IP field readings were obtained along 17 profiles but results from only few profiles will be discussed here.

LOCATION AND GEOLOGY

The Khola Khani copper prospect lies in the Aanbu Khaireni Rural Municipality of Tanahu District, Gandaki Province, Nepal. It covers the southeastern part of Tanahu District as shown in Figure 1. The exact target areas are Charghare, Pauwa, Nayagaon, Khola khani Gaon and surrounding areas. Geographically, the area lies in the Mahabharat range and belongs to topo sheet no. 2784 02B and 03A (Scale 1:25,000) published by the Department of Survey, Government of Nepal. The study area is easily accessible from major cities of Nepal. Actually, the area is only 2 km south from the Prithivi Highway that connects the Pokhara city to the Kathmandu. The distance from Kathmandu to prospect area is about 150 km and there are other several local roads which run within the prospect area.

The Khola Khani Copper Prospect exists mainly in the Dandagaon Phyllites and lower part of Nourpul Formation of Lower Nawakot Group of Nawakot Complex. In some locations the mineralization is observed in the Phyllites of Kuncha Formation and in Aanbu Khaireni area bluish coatings of mineralization is observed in the thick banded white quartzite. The Dandagaon Phyllites in this area consist of Greyish-green Phyllites with rare Quartzites and minor Carbonates. The lower part of Nourpul Formation in this region is characterized by the white to greenish grey ripple marked Ortho-quartzite to impure Quartzite with vari-colored Phyllite intercalations. The old mine workings are distributed along the ridge, spur and valley and there is the sharp bending of the (Figure 2) lithological unit near to the prospect area. The geological beds are dipping towards SW mostly with moderate dip (DMG 1996), shown in Figure 2.

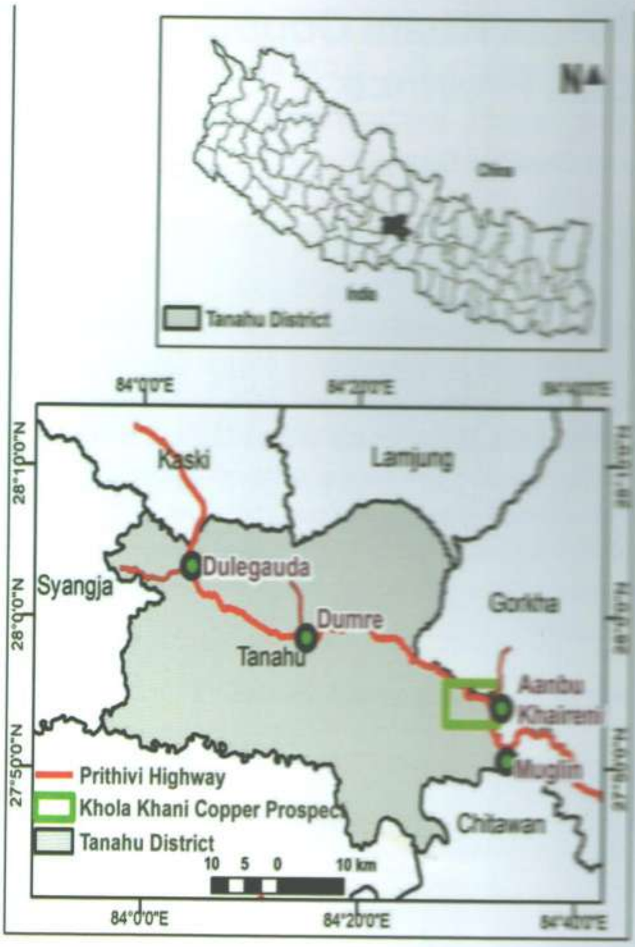


Figure 1: Location map of the study area

GEOPHYSICAL PROCEDURES AND FIELD PLAN

The 2D electrical resistivity profiling is capable of detecting boundaries between unconsolidated materials (overburden), bed rocks, mineralization bands, subsurface water channel due to contrast of resistivity between subsurface materials. Induced polarization (IP) is the Earth's capacity to hold an electric charge over time. IP measures the voltage decay curve after the injected current is shut off. IP is especially useful for mineral exploration applications (Telford et al. 1990). The advancement in the DC technology has made the field data acquisition quick and easy. Traditionally, the electrical properties of sub-surface material were determined by measuring the electrical potential difference between a pair of potential electrodes (P1 and P2 in Figure 3) on the ground surface with a current applied through a pair of current electrodes (C1 and C2 in Figure 3) (Keller et al. 1996; Telford et al. 1990). The apparent resistivity pa in Ohm.m (Ωm) is then computed from Ohm's law (Parasnis 1997).

$$pa = k(\Delta v / I) \text{ - - - - - - - - (1)}$$

Where k is a geometric constant that depends only on the reciprocal positions of the current and potential electrodes; Δv is the measured potential difference in mV; and I is the applied electric current in mA.

However, the recent development in electrical method allows automatic measurements by switching the current and potential electrodes between a series of equally spaced electrodes laid out along a profile (Figure 4). This technique gives the dense sampling of subsurface resistivity variation at shallow depth within a short amount of time. 2-D Electrical Resistivity Tomography have repeatedly fulfilled the expectations for obtaining rapid and cost-effective subsurface information (Sharma 1997). The geo-physical interpretation needs supplementary information such as the specific geological conditions and data from other direct exploration method in order to improve the quality of interpretation results otherwise it may have only limited success or may mislead the whole project. A more accurate model of the subsurface is a two-dimensional model where the resistivity changes in the vertical direction, as well as in the horizontal direction along the survey line. In this case, it is assumed that resistivity does not change in the direction that is perpendicular to the survey line. In many situations, particularly for surveys over elongated geological bodies, this is a reasonable assumption (Loke 2004).

The electrical resistivity prospecting method consists of determining the distribution of a physical parameter that is characteristics of the subsurface (the resistivity) on the basis of a very large number of measurements of apparent resistivity made from the ground surface (Telford 1990). Two-dimensional ERT and IP surveys were carried out using a large number of electrodes, usually 36, connected to a 3 multi-core cable and double take out port is available for conducting ERT and IP at once.

A resistivity meter system with 4 cable leaders as an electronic switching unit was used to automatically select the relevant four electrodes for each measurement. A range of fast automated multi-electrode and multi-channel data acquisition system gives the flexibility in the acquisition of geo-electrical data. The use of multi-electrode/multi-channel systems for data acquisition in geo-electrical surveys has led to a dramatic increase in field productivity as well as increased quality and reliability of subsurface resistivity information obtained (Barker 1981). Multi-electrode survey is a combinational technique of profiling and sounding involving a number of electrodes with a fixed inter-electrode spacing. With the multi-electrode

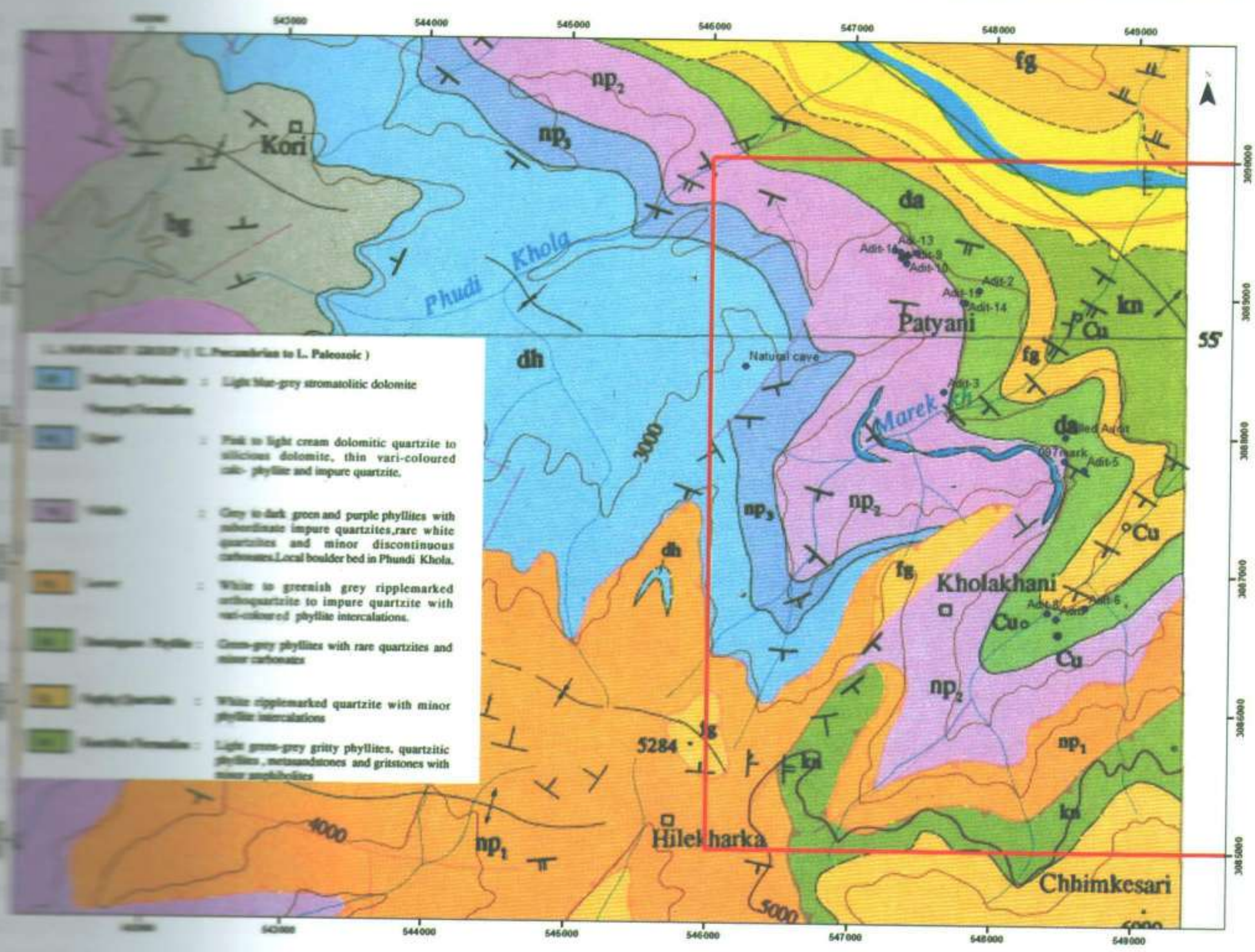


Figure 2: Regional geological map of the Tanahu, Gorkha area after DMG (1996). Red squire represents the study area.

survey one can get lateral as well as the vertical information of the shallow subsurface.

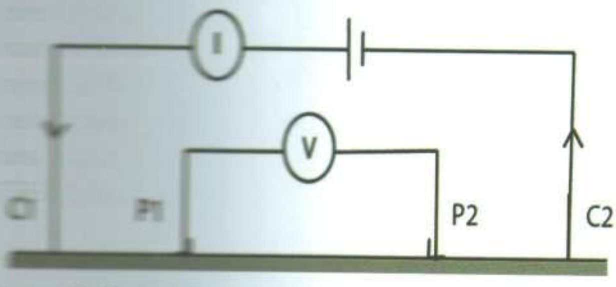


Figure 3: General four electrode configuration for resistivity measurement (Abdelwahab 2013).

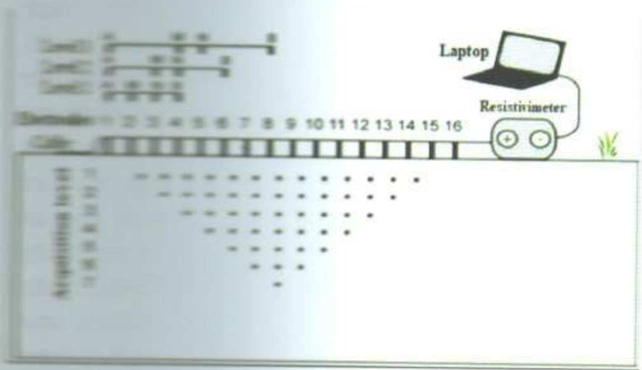


Figure 4: A typical field arrangement for 2D ERT Surveys (Edwards 1997).

Induced polarization (IP) is the Earth's capacity to hold an electric charge over time. IP measures the voltage decay curve after the injected current is shut off. The higher the IP, the longer over time the charge is held—IP decays over time, typically a few seconds but sometimes up to minutes, and will eventually disappear. IP is especially useful for mineral exploration applications. IP is a derivative of resistivity and in order to measure IP, at first resistivity is measured. DC electric current is transmitted into the ground through two electrode stakes (called A and B) that are driven into the ground. The resulting electric potential field is measured between two other electrode stakes (called M and N). Then, a time component is added by turning off the current injection, but the voltage between M and N for a few seconds is recorded. The decay in voltage of M and N over time is the IP. In the time domain, the voltage decay is recorded during a time interval $\Delta t = t2 - t1$ (ms) after the current flow is interrupted. The calculated parameter is the chargeability, given by (B´erub´e 1997)

$$m = \frac{1}{V_0} \int_a^b V_t(t)\, dt$$

The measured apparent resistivity is converted into true resistivity using inversion software in order to produce the 2-D resistivity cross-section image (Tomogram). The Multi-Electrode Imaging system used for data acquisition was GD 10 Supreme and it's accessories. The output from the inversion software displays the inverse model section. To convert the resistivity and chargeability picture into a geological picture, some knowledge of typical resistivity values for different types of subsurface materials and the geology of the area surveyed, is important. The resistivity of rocks and soils in a survey area can vary by several orders of magnitude. In comparison, density values used by gravity surveys usually change by less than a factor of 2, and seismic velocities usually do not change by more than a factor of 10. This makes the resistivity and other electrical or electromagnetic based methods very versatile geophysical techniques (Loke 2004).

The most commonly used arrays in the 2D electrical imaging surveys are conventional arrays such as the Wenner, Schlumberger or Dipole-Dipole arrays. These arrays are often well understood in terms of their depths of investigations, lateral and vertical resolution, and signal–to-noise ratios. Generally, the Wenner and Schlumberger arrays provide good vertical resolution for horizontal structures and high signal-to-noise data (Dahlin and Zhou 2004)

ERT AND IP SURVEY

The location of the all profile surveyed in the field are shown in Figure 5, overlaid in Google Earth Image and Inversion images of the profile discussed in this paper are shown in Figure 6.

The Profile 1 is executed at Bhaledhunga (Patteni Dhap), near to the Rana's house along the dry cultivation land of NW dipping steep hill-slope, the trend of survey line from start electrode (X= 27.92182, Y= 84.48011 and Z= 583.671) to end electrode (X= 27.92233, Y= 84.47982 and Z= 556.81) is 3550. Along the survey line bed rock exposure wasn't found and at surface, slope material is almost homogeneous consisting silty-clay dominantly and sporadically distributed pebble to granule size rock fragments composed of phyllite mostly. The resistivity survey was carried out using the Dipole-Dipole array with 36 electrodes at 2 m spacing. The type and nature of the mineralization was not known and alignment of the array was fixed with reference to the location and orientation of the old mine adit present very close to the survey line. The inversion image of this survey line shows the low resistivity anomaly (blue colour zone, resistivity value less than 200 Ohm.m) at shallow depth (about 5-8m) and distributed all along survey line in the discontinuous patches and thickness is very thin (about 2-5m).

The Profile 5 is the further continuation of the Profile 1 towards the Northwest direction along the

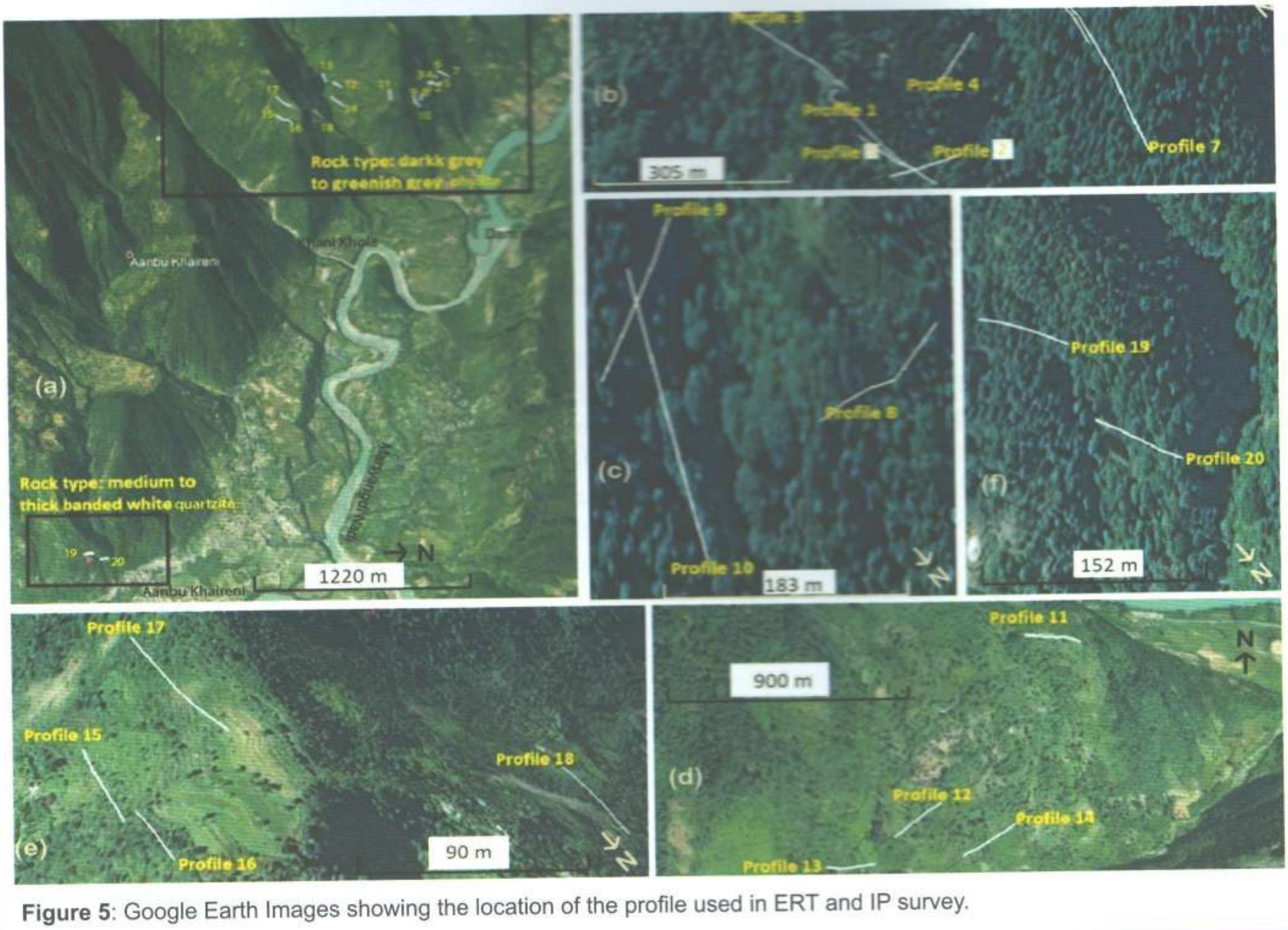


Figure 5: Google Earth Images showing the location of the profile used in ERT and IP survey.

of the slope executed in the trend of survey line from start electrode (X= 84.47993, Y= 27.92226 and Z= 581.404) to end electrode (X= 84.47943, Y= 27.92236 and Z= 534.432) is 3500. The surface geology is similar to the Profile 1. In the inversion image obtained along this survey line by using the Schlumberger array with 30 electrodes at 2 m spacing shows the low resistivity zone (blue colour zone, resistivity value around 200 ohm.m). The depth of anomaly is shallow (5-8 m), thickness about 5m and extended from Southeast part of the profile to the middle of the section. The Southeast part of this profile lies near to the old mine adit.

The Profile 6 is executed at Bhaledhunga (Patteni Dhap), west of the Rana's house along the dense sal forest where organic content rich dark brown soil profile is well developed all along the slope. The trend of the survey line from start electrode (X= 84.47846, Y= 27.92202 and Z= 573.244) to end electrode (X= 84.47948, Y= 27.92261 and Z= 568.26) is 500. Along this profile, resistivity and chargeability, both properties of the sub-surface material were measured using the Dipole-Dipole electrodes with 36 electrodes at 2 m spacing and this survey line is above old mine adits but the inverted depth is not sufficient to locate those adits. Small and discontinuous patches of the blue colour low resistivity anomaly is observed at the depth ranging from 5 to 10 m towards southern end to middle part of the profile in the inversion image. However, in the chargeability inversion image, instead of low chargeability anomaly, a concentration of chargeability value from 0.9 to 2 msec is observed in the region of low resistivity anomaly seen in resistivity inversion image.

The Profile 18 is executed at Nayagaon village along the road pavement consisting silt, clay and rock fragments of Phyllite. The trend of the survey line from start electrode (X= 84.4876, Y= 27.91092 and Z= 630.179) to end electrode (X= 84.48879, Y= 27.91152 and Z= 642.329) is 550. Along this profile resistivity and chargeability, both properties of the sub-surface material were measured using the Dipole-Dipole array with 36 electrodes at 4 m spacing. The low resistivity anomaly zone (blue color zone, resistivity less than 200 ohm.m) is observed at distance 40 m, 60-64 m and 96 m about the depth of 5 m from the surface along the profile in resistivity inversion image. However, the chargeability value at these zones in chargeability inversion image is high, ranges from 3-11 msec.

The Profile 12 is executed at Pauwa village, above the old mine adit. The profile is along the dry cultivation land (first 15 electrodes) and newly constructed road (remaining 21 electrodes). The old mine adit is located below the electrode from 21 to 24 at a depth greater than 25m. The bed rock is well exposed in this survey area along new road section and consists of bluish to greenish grey psammatic Phyllite and few bands with the slaty cleavage. The attitude of bed rock exposed near to the electrode 17 is 305/450 (dip direction/ dip amount). The trend of the survey line from start electrode (X= 84.48093, Y= 27.91265 and Z= 585.867) to end electrode (X= 84.48192, Y= 27.91349 and Z= 580.427) is 350. The resistivity survey was carried out using the Wenner array with 36 electrodes at 4 m spacing. The type and nature of the mineralization was not known and alignment of the array was fixed with reference to the location and orientation of the old mine adit underneath the survey line. The inversion image of this survey line shows the low resistivity anomaly (blue color zone, resistivity value less than 450 Ohm.m) encountered at depth of 10 m from the surface to the optimum depth of the inversion model. High resistivity anomaly is observed just above the middle part of section and towards northeast side of the low resistivity anomaly zone.

The Profile 19 is executed above the Chamare cave, near to the Aanbu Khaireni area. The geology of this survey area is different as contrast to the other survey areas. The bed rock geology in this area consists of medium to thick banded white quartzite with only few cm thick soil profile developed over it. The lithological distribution is almost same along every electrode used in the survey. The trend of the survey line from start electrode (X= 84.53657, Y= 27.89751 and Z= 391.32) to end electrode (X= 84.53634, Y= 27.89809 and Z= 382.135) is 320. Although, this location is named as a cave, the area consists an artificial sub surface opening for mining activities. The presence of azurite can be observed along the road and side wall of the opening and consist of significant amount of copper which was determined by using the Hand-held XRF in the field. The resistivity survey was carried out using the Schlumberger array with 36 electrodes at 2 m spacing. The inversion image of this survey line shows the low resistivity anomaly (blue colour zone, resistivity value less than 400 Ohm.m) encountered at a depth of 5-10 m from surface to the entire model depth and is continuous from 26m to 40m along the profile.

The Profile 20 is executed below the Chamare cave, near to the Aanbu Khaireni area. The survey team has found several old mine openings in this region. The geological condition is almost similar to the survey area of Profile 19 except in this area soil thickness is greater as it lies at the foot of very steep cliff. The electrodes are over the colluvium and residual soil with the rock fragment of quartzite up-to boulder size. The trend of the survey line from start electrode (X= 84.53623, Y= 27.89901 and Z= 334.376) to end electrode (X=

84.53651, Y= 27.89848 and Z= 338.321) is 1600. The presence of azurite can be observed in bed rock and along the roof and side wall of the opening and consist of significant amount of copper (up-to 25%) which was determined by using the Hand-held XRF in the field. The resistivity survey was carried out using the Schlumberger array and Wenner array with 36 electrodes at 2 m spacing. The inversion image of this survey line shows the low resistivity anomaly (blue colour zone, resistivity value less than 400 Ohm.m) towards the middle part of the section and low resistivity anomaly zone is consistent in the inversion image of both arrays. The very high resistivity anomaly (resistivity value greater than 70000 ohm.m) is also observed in both inversion image probably represents the old mine opening.

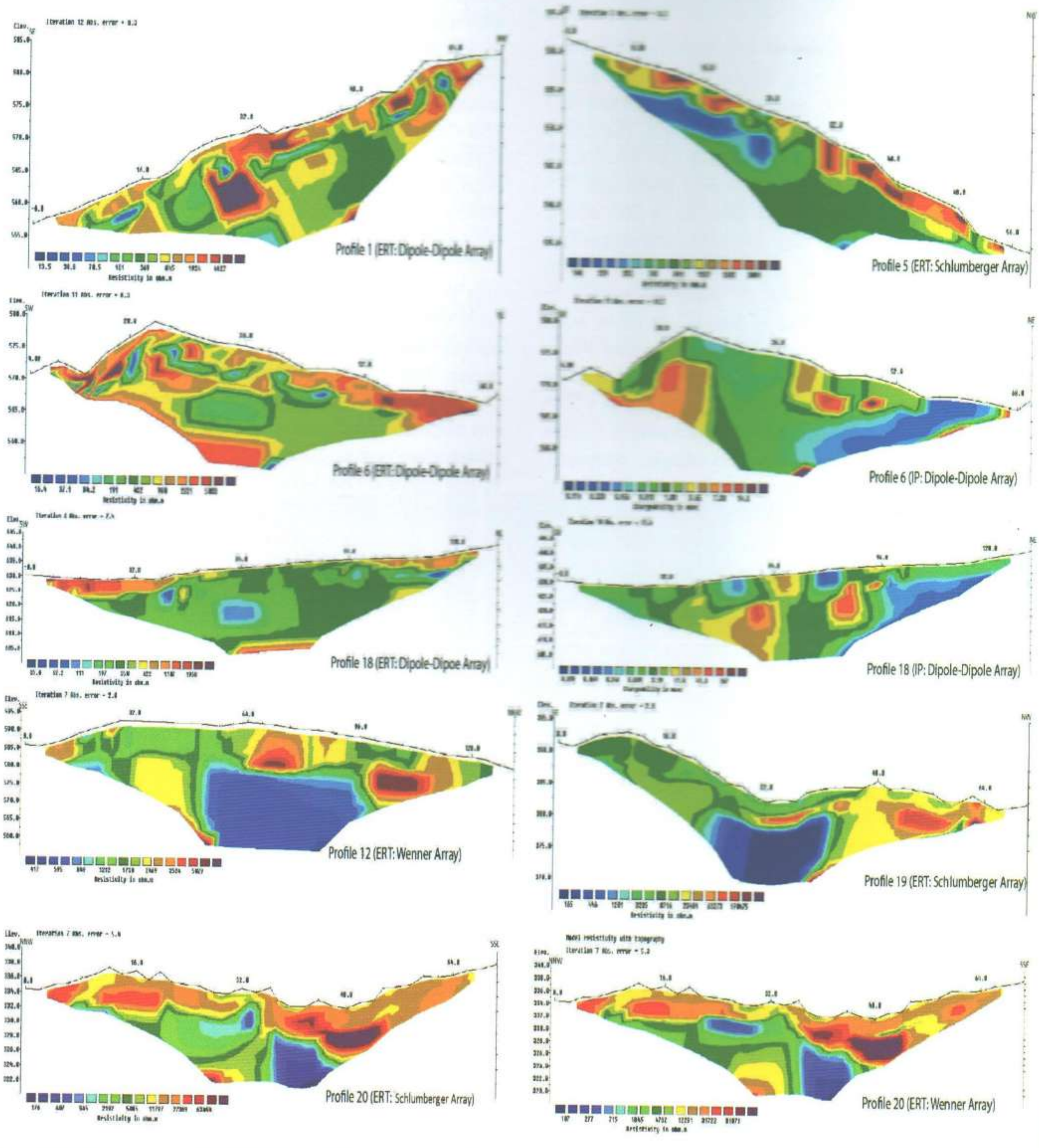


Figure 6: Inversion images of the different profiles used in the data analysis.

CONCLUSIONS AND DISCUSSION

2-D Electrical Resistivity Tomography and Induced Polarization survey were carried out at the Bhaledhung, Nayagaon, Pauwa and Aanbu Khaireni, and the data were analyzed by using the Res2D Inversion software. There are no boreholes and other subsurface data in order to proving geoelectrical section as well as the surface anomaly map to align the survey line. The survey lines were oriented with reference to the old mine adit and topography of the area. The occurrence of mineralization is not observed on the surface exposure and old mine adits except for the Profile 19 and Profile 20 where occurrence of blue color copper mineralization (azurite) is observed in white quartzite and consist of considerable amount of copper (upto 25%) in weathered rock surface measured from the Hand-held XRF. The other profiles were executed close to the old mine adits consisting greenish grey phyllite and percentage of copper (targeted mineral resource) is negligible, varies from 0 to 0.75%. However, the local people claimed that the most of the adits are opened for copper mininig operated approximately 150 years before. ERT and IP investigations were conducted successfully to determine any subsurface geological anomaly that may indicate the presence of mineral resource and finally to evaluate the mining parameters of mineral resource. Based on the interpretation of the 2D (ERT), the blue color zonation in the inversion images presented on Figure 6 represent the low resistivity anomaly zone (resistivity value ranges from less than 50 to 450 Ohm.m). The geology of the area, abundant old mine workings and hydrogeological condition of the survey area indicates that the anomaly may be due to the presence of metallic mineral resources. However, the low resistivity anomaly zone is not consistent in the chargeability inversion image where the value of chargeability ranges from 0.75 to 11 msec. The IP survey is very sensitive to the mineral exploration sulphides ore which tends to have the low chargeability value. The existence of old underground mine openings have been detected with the high resistivity anomaly value in few profiles.

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Annual Monitoring and Inspection of Operating Mines of Nepal

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ABSTRACT

Department of Mines and Geology (DMG) is the sole government organization for the governance and supervision of mines and mining activities in Nepal. Currently, there are more than 300 prospecting and 135 mining licenses for different minerals issued to individual and the company by the department. Every year inspection teams of the department visit mines area to find out current status. In the last two fiscal years, about 50 mines of different minerals were inspected by the authors. Inspection results demonstrate that most of the mines are being operated within approved quarry area with well developed benches and started production. However, all underground mines and few opencast mines are poorly functioning.

Keywords: inspection, limestone, quarry site, machineries, environment

INTRODUCTION

The Department of Mines and Geology (DMG) is responsible for issuing prospecting licenses of different minerals to the individual and the company. After detail study and exploration, they prepare the detailed mining report called Mining Scheme. The department verifies the report in office and proposed mines area. Then DMG issues the mining license, if the scenario follows existing laws and is technically and environmentally feasible. There are all together 135 mining licenses by this fiscal year 076/77. There are about 300 prospecting licenses and among which 50 prospecting licenses has submitted mining scheme and IEE/EIA report for obtaining Mining License.

Some major clusters of mining / opening licenses are in Udayapur district of province 1; Makwanpur, Sindhupalchok and Dolakha districts of Bagmati province; Palpa and Dang districts of province 5; Jajarkot district of Karnali province and Baitadi and Darchula districts of Sudur Paschim province.

In each fiscal year an inspection team from DMG visit mine sites of mining / opening license to identify the present situation. The team has to investigate mine site, topo-geology, mining situation, land conditions and environmental issues during mining. The main aim of inspection is to find whether the proponent has followed the conditions and circumstances provided during licensing or not. The field team normally works for 7-10 days at one time for mine inspection in a particular area. Each team consists of senior divisional geologist or senior divisional mining engineer, geologist and surveyor.

In the past two fiscal years, we have carried out inspection of almost 50 running mines. In the coming section major findings, conclusion and recommendations are discussed.

MINING LICENSE STATUS

The DMG has issued 135 mining licenses of 16 different mineral commodities (Table 1). Some of them were issued before Mines and Mineral Regulation 2056 and some are issued within this year. Among 135 mining licenses, about 80 mines are in operation. 20-25 mines are not operated as they were issued recently within last 3 years. Some 10-15 mines are not operated because of unavailability of infrastructure like road and electricity in mine sites. Some are in process of taking approval from Forest Department to do mining in forest land. Some mining licenses were once started mining previously but not in operation now. Examples like Nepal Orient Magnesite Ltd., Nepal Metal Company Limited, Precious and Semi Precious Stones (Kyanite, Tourmaline, Quartz) mines. Precious and semi precious stone mining are almost stopped the mining operations for the last few years as the government banned the export of such mine products in its raw form, without one step processing. The Description of various mine license in Nepal is presented in Figure.

Table 1: Opening Mining License 2076/2077

S.N.	Mineral	License Count
1	Calcite	1
2	Coal	10
3	Copper	1
4	Dolomite	2
5	Iron	2
6	Kyanite	8
7	Lead	3
8	Limestone	62
9	Magnesite	1
10	Marble	2
11	Quartz	3
12	Quartzite Slab stone	14
13	Red Clay	5
14	Talc	12
15	Tourmaline	8
16	Zinc	1
	Total	135

OBJECTIVES OF MINE INSPECTION

Following are major objectives of mines inspection and environmental monitoring:

- To assure whether the mine is running within the approved quarry area or not,
- To evaluate the mines exploitation process and mining activities carried out by the proponent in the mines and the mine lease area,
- To determine the condition of mines and the objects whether the proponent has followed the approved mining scheme, existing rules and directives given by DMG or not,
- To check the record keeping system of mine operation, transportation of excavated mine goods, production statistics and over or under production situation,
- To know the condition of technical, administrative and production personnel working in the mine, insurance and safety measures of labour, machine operators etc.,
- To inspect the environmental situation of mines, use of Environmental Management Plan (EMP) for betterment of mine environment and how h it follows the IEE and EIA report. To evaluate the effort of mine management to protect environment and it's effect on environment due to mineral production,
- To take actions whether the conditions given during licensing and suggestion / directions of previous inspections were not followed by the license holders or not, and
- To verify the field attributes of mining scheme submitted by the prospect license holder before approving mining scheme and awarding of Mining License.

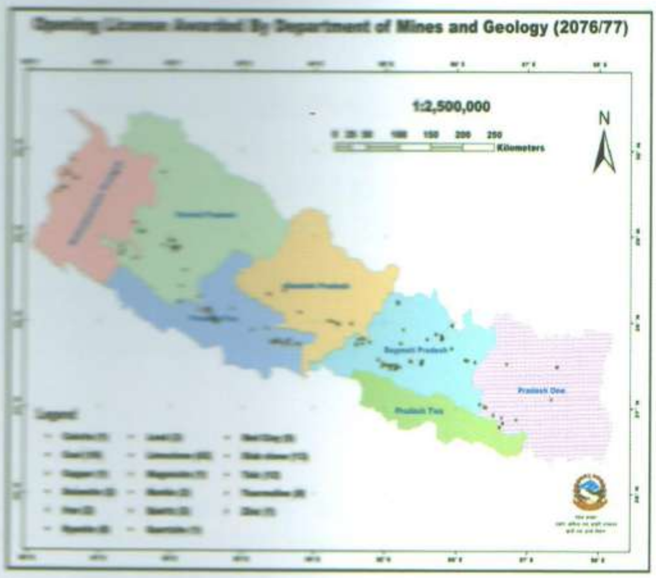

Figure 1: The distribution of opening mining License in Nepal.

INSPECTION OF MINES

The mines are monitored and inspected regularly in each fiscal year. In the fiscal year 2075/76 & FY 2076/77, about 50 mines were inspected by DMG. Other mines cannot be inspected because of lockdown and effect of Corona virus. Among the inspected mines, most of them are of limestone mining.

In Province 1, all the mines were inspected beside quartz mine (remotely placed) and newly issued copper mine. In province 2, no mining license is issued. Regarding Bagmati Province, among 45 mining license, 20 mines were inspected. In Province 5 and Gandaki Province most of the mines were inspected except few mines which were not in operation. Non of the mines from Karnali and Sudur Paschim Province were inspected due to lockdown in this FY. However, all mines of Sudur Paschim Province were inspected in the last fiscal year 2075/76. Some of the mines were repeatedly visited.

The lists of mines inspected by the team during FY 2075/76 & FY 2076/77 are tabulated below (Table 2):

Table 2: List of Inspected mines.

S.No	Mineral	License No	License Holder	District	Local Level
1	Coal	184/071/72	Rishi Khanji Udhyog Pvt. Ltd.	Dang	Ghorahi
2	Coal	25/062/63	Kanchan Coal Company Pvt. Ltd.	Dang	Ghorahi
3	Limestone	80/066/67	Sonapur Minerals and Oil Pvt. Ltd	Dang	Ghorahi
4	Limestone	72/067/68	Bishow karma Mines and Minerals Pvt. Ltd.	Dang	Banglachuli
5	Limestone	116/075/76	Samrat Cement company Pvt. Ltd.	Dang	Banglachuli
6	Limestone	40/075/76	Shubhashree Agni Cement Udyog Pvt. Ltd	Dang	Banglachuli
7	Limestone	44/069/70	Shubhashree Agni Cement Udyog Pt. Ltd	Pyuthan	Naubahini
8	Limestone	213/071/72	Sonapur Minerals and Oil Pvt. Ltd	Rolpa	Runtigadi
9	Limestone	61/066/67	Rolpa Cement Pvt. Ltd	Rolpa	Tribeni
10	Limestone	114/067/68	Sonapur Minerals and Oil Pvt. Ltd	Dang	Banglachuli
11	Limestone	135/074/75	Satya Sai Coal Uddhyog Pvt. Ltd	Rolpa	Runtigadi
12	Limestone	102/071/72	Pradhan Khanji Udhyog Pvt. Ltd.	Rolpa	Runtigadi
13	Limestone	49/073/74	Tirupati Mines Pvt. Ltd.	Rolpa	Runtigadi
14	Limestone	39/055/56	Bhugarva Cement pvt. Ltd	Argakhanchi	Narpani
15	Limestone	180/065/66	Siddartha Minerals Pvt. Ltd	Palpa	Tinahu
16	Limestone	119/064/65	Kanchan Quarries Pvt. Ltd	Palpa	Tinahu
17	Limestone	30/068/69	Cosmos cement industries Pvt. Ltd	Udayapur	Udayapurgadhi
18	Limestone	26/069/70	Udayapur Mineral Tech Pvt. Ltd	Udayapur	Katari
19	Limestone	1/062/63	Nigale Cement Pvt. Ltd.	Dhankuta	Mahalaxmi
20	Limestone	38/055/56	Shaurya Cement Ltd.	Udayapur	Katari,
21	Limestone	303/479/045/46	Udayapur Cement Udhyog Ltd.	Udayapur	Triyuga,
22	Red Clay	39/059/60	Udayapur Cement Udhyog Ltd.	Udayapur	Triyuga,
23	Red Clay	40/059/60	Udayapur Cement Udhyog Ltd.	Udayapur	Triyuga,
24	Limestone	33/072/73	Nepal Shalimar Cement Pvt. Ltd.	Makawanpur	Bhimphedi
25	Limestone	30/075/76	Riddhi Siddhi Cement Pvt. Ltd	Makawanpur	Bhimphedi,
26	Limestone	221/397/45/46	Maruti Cements Ltd.	Sindhuli	Dudhouli
27	Limestone	1599/549/036/37	Hetauda Cement Udyoug Limited	Makawanpur	Bhimphedi
28	Limestone	150/326/042/43	Hetauda Cement Udyoug Limited	Makawanpur	Bhimphedi
29	Lead	53/072/73	Torex Mines Nepal Pvt. Ltd	Darchula	Malikaarjun
30	Talc	59/074/75	Geomineral reserve Pvt. Ltd	Darchula	Dunhu
31	Talc	143/069/70	Seti Mahakali Minerals Pvt. Ltd	Baitadi	Dasharathchanda
32	Talc	29/068/69	Jitendra Bahadur Karki	Baitadi	Dogadakedar
33	Talc	07/071/72	Bhageshwor Mineral Pvt. Ltd	Baitadi	Purchaudi
34	Talc	26/075/76	BM Minerals International Pvt. ltd	Baitadi	Dilasaini
35	Talc	61/074/75	Latinath Soap Stone Pvt. Ltd	Baitadi	Dasharathchanda
36	Talc	95/067/68	Golcha Sharp Stone Pvt. Ltd.	Darchula	Shailyashikhar
37	Iron	147/074/75	Shankar Lal Aggrawal	Palpa	Tinau

METHODOLOGY

Mines area observation, inspection of mine related documents, GPS survey of quarry area and questionnaire methods are used for mine inspection. Following field and document examination are carried out.

- The beginning of mining activity in the fiscal year,
- Record book regarding daily, monthly production in the fiscal year,
- Comparison of quarry development with approved mining scheme,
- Examination of mine boundary and fencing demarcations and pillars,
- Examination of waste materials dumping and management system,
- Installation of weighing bridge in quarry site,
- Infrastructures within quarry and mines area,
- Quality of access road,
- Conditions of safety helmets and boots for mine workers,
- Installation of quarry sign board and other caution board in mine site,
- Check dam on hill slope,
- Siltation pond, drainage system, mineral loading system, stock yard,
- Equipments used, and
- Manpower used etc.

MAIN FINDINGS OF MINES INSPECTION

LIMESTONE MINES

- Most of limestone quarry are running with well developed bench system. Open cast mining practice is being improved in Nepal.
- Almost all the mines use heavy equipments - Hydraulic Excavator, Rock Breaker, Loader, Dumpers & Trippers.
- Few open cast mines are being operated in haphazard way. Steep slopes, lack of proper bench and drainage have made mines hazardous.
- Private sectors have made good progress on mine administration, record keeping system, personnel management and overall mining activities.
- All of these opencast mines are using excavator, backhoe and dozer for exploitation. None are using explosives.
- Mines are being operated under the guidance of technical manpowers like - geologist / mining engineers / mine supervisors / heavy equipment operators etc.
- Mining activities in Nepal is under progression. Especially limestone and few other non metallic minerals mines are growing.
- Many mines need to demarcate their quarry area according to DMG directives.
- During inspection it was found that safety measures were not followed properly. Although the Mining license holders provide the safety appliances, labours were not using them.
- There was no weighing bridge in any of the mines area.

COAL MINES

- During the inspection in 2076/77, only two coal mines in Dang district were in operation.
- These coal mines were manually operated.
- All of the coal mines are adopting underground, manual, timber pillar mining method.
- Underground mining with tunnel is being practise in Nepal since long time especially for coal mining. However, these adits and tunnels are still primitive and dangerous. Those adits are about 50m in length with the diameter of 1m. So it is hard to transport coal from those adits.
- No proper support, ventilation and light systems are installed.
- These mining are not systematic and the safety precautions are not followed.
- Coal mines of Dang are poorly functioning and near to cease.

OTHER MINES - RED CLAY / LEAD / TALC / IRON

- These mines are being operating at lower scale of production by surface mining under no proper technical guidance.
- Iron and red clay mines is being operated by mechanized method, while talc and lead mine, located at remote hilly region of Nepal, are being operated by manual method.
- Most of these mines have not followed the DMG directives mainly for waste management, siltation pond, proper benching, quarry fencing and safety measures.

CONCLUSIONS

About 50 mines of limestone, coal, red clay, talc, lead and iron mineral were inspected in different provinces. Most of the mines were operated in low production capacity but few limestone mines were operated in over production. Coal, talc and lead mines use manual method while limestone, red clay and iron mine uses mechanized method to exploit the deposit.

Except underground mines and few opencast mines, most of the running opencast mines are well functioning. They have well developed benches and mine management system.

RECOMMENDATIONS

- Underground mining of Nepal is in very primitive stage. Technical manpower is not available. Government and private sectors both should aware about these problems.
- Mines should be developed according to mine plan of approved mining scheme and existing rules.
- Proponent should strictly follow mining scheme during bench development and installation of infrastructures.
- Geologist/ Mine engineer should be there in mines area. The mine should be developed according to mining scheme and the instruction of technical team.
- Production record book, Chalani slip should be kept in mine site.
- Approved mining scheme should be kept in quarry site.
- Safety helmets and boots should be used by workers strictly.
- Proper drainage system should be constructed.
- Hoarding board with mines and safety information should be placed in the mine and quarry areas as directed by DMG.

Photographs of Mines Inspection

Photo 1: Overall view of Maruti Cement Ltd. quarry area, Sindhuli

Photo 2: Trippers in the quarry area of Shaurya Cement Ltd for loading limestone, Udayapur

Photo 3: Vertical slopes of the Bishokarma Mines and Minerals Pvt Ltd quarry area, Dang

Photo 4: Haphazard mining of Siddartha Minerals Pvt. Ltd, Palpa

Photo 5: Overall view of Riddhi Siddhi Cement quarry area, Makwanpur

Photo 6: Coal Mine of Kanchan Coal Pvt. Ltd, Dang

Photo 7: Bench developed in Sonapur Minerals mines area, Rolpa

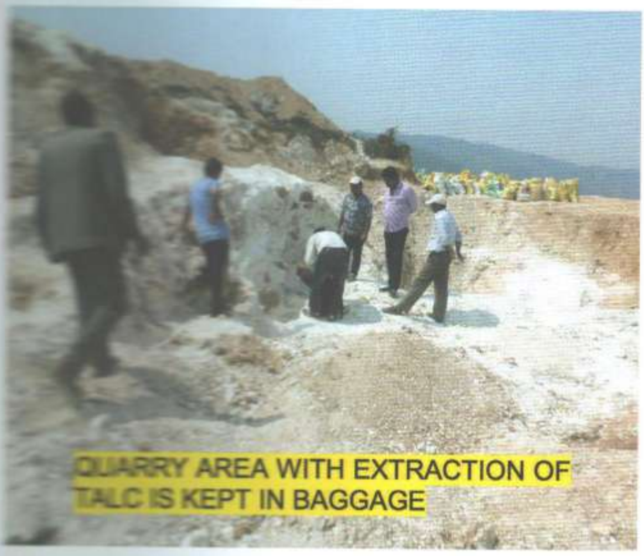

Photo 8: Overall view of Latinath Soap stone Pvt. Ltd Talc quarry area Baitadi.

Photo 9: Talc transportation through ropeway in Baitadi

Photo 10: Talc Mine of Geo Mineral Reserve Pvt. Ltd in Darchula

Photo 11: Lead Mine of Torex Mines Pvt Ltd. ins pection in Dhap, Darchula

Photo 12: Iron ore Mine of Shankarlal Agrawal in Masyam, Palpa

Engineering Geological Study of Jaleshwor Municipality, Mahottari District

Suresh Shrestha (Senior Divisional Geologist), **Sunu Dawadi** (Geologist)

ABSTRACT

An engineering geological study of Jaleshwor Municipality was carried out in order to understand the engineering properties of quaternary sediments. Standard Penetration Test (SPT) was performed to recognize the N-value of the soil. Lab analyses were carried out from the collected sample. Similarly power auger was also performed to extrapolate the subsurface geology. The soil samples collected during the field investigation are subjected to various tests as, grain size analysis, moisture content, liquid limit, plastic limit and unconfined compressive strength. The recent sediments of the Jaleshwor area is classified in to three types as Dhabauli deposit, Nainhi deposit and Ratwada deposit according to the grain size of the sediments. Standard Penetration Test shows the study area have N-value from 1 to 15 having the bearing capacity very low to medium. Almost 70% sample consists of fines (silt and clay) i. e. below 0.075 mm size sediments and only about 30% sample consists of sand size particles. The preliminary qualitative analysis shows the study area consists of sandy deposits have high probability of liquefaction hazard. The deposits having clay and silts have low probability of liquefaction hazard. River bank cutting and erosion along the banks of Ratu nadi and Bigahi nadi are commonly observed during heavy rain which destroyed the cultivated land.

Keywords: Engineering geology, SPT, Jaleshwor, N-value, liquefaction

INTRODUCTION

The rapid development of the urban areas in Nepal has generated concern with regard to the scope and extent of their infrastructural and environmental problems. Jaleshwor is the headquarter of Mahottari, province no. 2 Nepal (Figure 1). It is located in the Terai, on the border with India at Sursand, Bihar, and has a customs checkpoint. Jaleshwor is located 15 km southwest of Janakpur. The country's longest highway- Mahendra Highway, is linked from the city center. The study area lies in Parts of toposheet 2785 08A and 2785 08C. This place is one of fast growing trade Centre of Nepal. The proximity distance to this city from Kathmandu is about 240 km. The total area of Jaleshwor Municipality is about 50 sq.km and population is about 23,533 (Census, 2068). The present study covers the area of Jaleshwor Municipality.

There has been a significant increase in use of geological information in urban planning. The present study "Engineering Geological Study" of Jaleshwor Municipality, central Nepal deals with the engineering properties of Quaternary sediments and gives information on ground condition for urban development. Owing to the rapidly increasing population and accelerated economic growth, the demands on land and natural resources for housing, industry, road construction and other infrastructure developments are increasing rapidly. In this scenario, the present SPT test will provide a fundamental data for proper planning of settlements and other infrastructures. The field study was carried out from 2075-08-26 to 2076-09-26 with the aim of knowing the geological setting and environmental condition of this area, according to annual fiscal program 2075/76 of DMG.

PHYSIOGRAPHY, CLIMATE AND DRAINAGE

Physiographically the study area lies in the Terai region having low altitude. The area represents the southern edge of vast alluvial Indo-Gangetic foreland basin and belongs to the southernmost tectonic division of Nepal. The study area consists of sediments of Quaternary deposits such as sand, silt, and clay etc. The climate of the study area is tropical monsoon type.

The topography of this region is almost flat, so, river in this region flows in very low gradient or in the almost flat terrain. The major river shows the meandering river pattern. The major rivers of this area are Ratu Nadi and Bigahi Nadi.

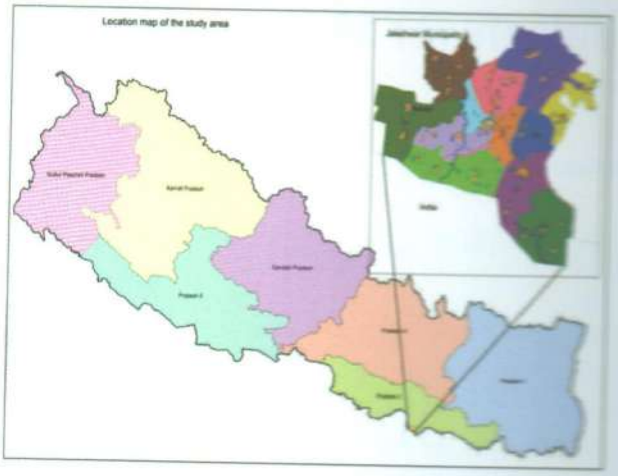

Figure 1: Location Map of the Study area

GEOLOGICAL SETTING OF JALESHWOR AREA

Physio-graphically, Jaleshwor area lies in the south direction from Kathmandu valley. It consists of Quatenary deposits of Terai plain. The age of sediments of Terai plain ranges from pleistocene to holocene. The sediments can be observed south of the Siwaliks. Generally, the Terai can be divided into three different zones from south to north (Dhital, 2015).

- Lower Terai or Gangatic alluvium: It is the southernmost alluvial deposits of Terai. The most part of this zone lies the deposits of terai rivers and its tributaries. It mainly consists of clay, silt and sand with some pebbles.
- Middle Terai or Marshy Land: This zone lies between the lower alluvial deposits and upper BhabarZone. It consists of silt and clay alternating with sand and gravel beds.
- Upper Terai or Bhabar Zone: It lies in the foothill of the Siwaliks. It consists of sand, cobbles, pebbles and boulders derived from the siwalik. It is the groundwater recharge zone for the Terai Plain.

OBJECTIVES

The Strength parameters of soil/Unconsolidated sediment in the region are unknown. Therefore, the main objective of this program is to determine the strength of soil in this region. The major objectives of this study are enlisted below:

- To conduct detail engineering geological study of the Jaleshwor area.
- To determine the N- value of the subsurface soil by SPT Method
- To classify the subsurface soil on the basis of Power Auger.
- To identify the geological hazard prone areas and recommend mitigation measures.
- To prepare engineering geological map of study area.

LIMITATIONS

- SPT: Standard Penetration Test is limited up to 6m depth.
- Power Auger is limited up to 7m depth.
- Liquefaction: The field survey can judge the susceptible to liquefaction hazard but cannot delineate its potential. There are various reasons to cause liquefaction which may not meet during field survey.
- The information contained in the map are intended for urban planning in regional scale and infrastructure development activities. It should not be used as only basis for any specific site investigation for individual buildings or any other major structures. Therefore the map cannot replace detail site investigations. It also needs to be upgraded to integrate information according to changes.
- Bore holes were collapsed due to shallow water table, so difficult to penetrate the deeper depth.
- The collected soil/ sand samples were tested after 1 month or more from field works cause difficulties in weighing samples and to find moisture content.

METHODOLOGY

DESK STUDY

Existing relevant literature on geology, geo-hazard and other information like topo-maps, aerial photographs were collected and reviewed. Topo-maps and google maps were studied to obtain the overall view and plan of the study area. Digital database of the topo-maps and scan topo-sheet of study area is used for the preparation of final map.

FIELD STUDY

Hand Auger hole drilling followed by Standard Penetration Test (SPT) and Power Auger machine were carried out in the field to obtain necessary data. SPT test on 50 bore holes and 54 Power Auger test were performed during the field. The location of the bore hole is shown in the engineering geological map of Jaleshwor. Adequate soil samples were collected either from the Hand Auger boreholes or from the split barrel of SPT tests from various depths for laboratory analysis in the Geo-Technical Laboratory of DMG.

STANDARD PENETRATION TEST (SPT)

The Standard Penetration Test (SPT) is the most commonly used in-situ test especially for cohesionless soils, which cannot be easily sampled (Figure 2). The test is extremely useful for determining the relative density, bearing capacity, and the angle of shearing resistance of cohesionless soils. It can also be used to determine the unconfined compressive strength of cohesive soils.

The Standard Penetration Test is conducted in a borehole using a standard sampling tube. It has mainly three parts (i) driving shoe made of steel tool about 75mm long, (ii) steel tube about 450mm long that split longitudinally into two halves, and (iii) coupling at the top of the tube about 150mm. The inside diameter of the split tube is 38mm and the outside diameter is 50m. When the borehole has been drilled to a desired depth the drilling tools are removed and the sampling tube is lowered to the bottom of the hole. The sampling tube is driven into the soil by a drop hammer of 63.5 Kg falling through a height of 750 mm. The numbers of hammer blow required to drive first 150 mm of the sample is counted. The sampler is further driven by 150 mm and the numbers of blows are recorded. Likewise the sampler is once again further driven by 150mm and the number of blows is recorded. The numbers of blow for the first 150 mm are disregarded. The numbers of blow recorded for the last two 150mm intervals are added to give the standard penetration number (N). In other words the standard penetration number or N-value is defined as the number of hammer blows (hammer weight 63.5 kg, falling height of 750 mm) required to penetrate 300mm into the formation beyond a seating drive of 150mm. If 50 blows are reached before a penetration of 30 cm no further blows should be recorded. If the test is to be carried out in gravelly soils the driving shoe is replaced by the 600 cone. SPT test in 50 boreholes were carried out.

POWER AUGER DRILLING

Power Auger drilling was carried out in the field to know the sub-surface geology of the study area. In this method a meter long sample tube rod that could hold sample was inserted in the ground with the help of Power Auger machine and then that rod with the surface sample was pulled out and a log of sediment below the ground surface was prepared. In the similar manner again a meter long rod was joined with sampler tube rod and sample from the 2 meter depth was extracted. According the ground condition and the density of the sediments the maximum depth that could be explored is 7 meters below the ground surface during the field study.

DESCRIPTION OF LABORATORY TESTS

The soil samples collected during the field investigation are subjected to various tests in departmental geotechnical laboratory to determine their engineering properties, which are generally required for civil constructions. The laboratory tests are conducted in accordance with the standard test procedures. The following tests were performed in the geotechnical lab of the department.

- Grain Size Analysis (Sieve curve)
- Natural Moisture Content
- Liquid Limit
- Plastic Limit
- Unconfined Compressive Strength

Figure 2: SPT in the field.

Figure 3: Power auger test in the field

Figure 4: Sample collected from SPT

SIEVE ANALYSIS

Sieve analysis is carried on soil samples collected during fieldwork according to standard procedure for wet sieving. Since most of the collected samples contain considerable amount of fine materials like silt and clay wet sieving was carried out to ensure complete separation of fines for reliable assessment of their percentage. Grain size distribution curves are prepared for all sieve analysis results.

Standard Penetration Tests (SPT) in 50 bore holes were performed during the field study. 208 samples collected and sieve analysis were done in the geo-tech lab. The study area consists of mainly fine grain size sediments on visual inspection during the field study so wet sieving method was adopted.As from the sieve analysis of the collected sample shows mainly the fine grained sediments. Almost 70% sample consists of fines (silt and clay) i. e. below 0.075 mm size sediments and only about 30% sample consists of sand size particles

NATURAL MOISTURE CONTENT

The natural moisture content of all soil samples collected from auger boring, SPT split spoon sampler and undisturbed sample tubes are determined according to the standard procedure by drying the soil specimen of known weight under 105º centigrade for 24 hours and calculating the weight loss upon drying. The water content Wn of the soil was expressed as a percentage of the weight of oven dried soil as follows:

W_n= Mass of water/Mass of oven dried sample*100

The moisture content of the tested sample was from 2% to 19%.

LIQUID LIMIT AND PLASTIC LIMIT

Liquid limit of the soil samples containing high percentage of fine materials was carried out using Casagrande cup. Water content of each sample is determined after oven drying the sample at 105ºC for 24 hours. Percentage of moisture content is plotted against the number of required drops counted during the test. The percentage of moisture content at the value of 25-drop number is taken as the liquid limit of the test sample.

Plastic limit of the soil samples is determined as the water content in a soil thread that crumbles at a diameter of 3 mm. The Plastic limit values are used with liquid limit value of the same sample for determining plasticity index, which is the value, required for soil classification.

Liquid limit and Plastic limit tests of the 62 soil samples containing high percentage of fine materials was carried in the geo-tech lab. The Plastic limit values are used with Liquid limit value of the same sample for determining plasticity index, which is the value, required for soil classification. The liquid limit of the tested sample is between 29 and 56. Similarly the plastic limit of the tested sample is between 12 and 36.

PLASTICITY INDEX

The Plasticity Index (PI) is a measure of the plasticity of a soil (Table 1). The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay.

Among the samples tested 25 samples from different borehole falls in medium plastic silty clay category, 26 samples falls in high plastic clay category and rest sample in non plastic sand and slightly plastic silt categories.

Table1 : Plasticity index categorization.

Plasticity index	Likely class	Material
0	Non plastic	Sand
<7	Slightly plastic	Silt
7 to 17	Medium Plastic	Silty Clay
>17	Highly Plastic	Clay

UNCONFINED COMPRESSIVE STRENGTH

During the field study samples from different bore hole were collected in the sample tube as undisturbed sample and those samples were tested in the departmental geo-tech lab to determine the unconfined compressive strength.

8 samples from different bore hole were collected in the sample tube as undisturbed sample and those samples were tested in the departmental geo-tech lab to determine the unconfined compressive strength. The unconfined compressive strength of tested soil ranges from 0.3 to 1.7 kg/cm2.The unconfined compressive strength indicate the soils are soft soil to stiff soil.

SUBSURFACE GEOLOGY AND ENGINEERING PROPERTIES OF SOIL

As the study area lies in the southernmost part of the Terai region most of the area consists of fine sedimentary deposits mainly clay, silt and very few sand. 50 numbers of Standard Penetration Test (SPT) and 54 numbers of Auger boreholes were performed during the field survey. The test was carried up to the depth of 4 to 7 meters only because of the constraints in equipment. About 208 soil samples were collected from different auger holes and Lab analysis was done in the Geotechnical laboratory of the Department.

Based on subsurface geological information (type, nature and size of the sediments) and N-values obtained by performing SPT tests, the study area is classified into 3 different deposits. As Dhabauli deposit, Naini deposit and Ratwada deposit.They are briefly described below.

DHABAULI DEPOSIT

Dhabauli deposit consists of grey to dark grey silty clay to clay deposit with alternation of clay silt and very few layers of fine sandy silt or sandy clay. Mainly the Dhabauli, Khaira, Musapati and Patali area are covered by this type of deposits. The thickness of clay is about 1 to 3 meter with the alternation of silty clay or clayey silt with occasional sandy silt/clay interlayering of less than 1m thick.

NAINHI DEPOSIT

Naini deposit consists of grey clayey silt deposit with alternation of clayey sandy silt and few layers of clay deposit. Nainhi, Basapati, Malibara Bela areas are mainly covered by this type of deposit. The thickness of silt is about 0.5 m to 2 m with the alternation of clayey silt or sandy/clayey silt or silty clay.

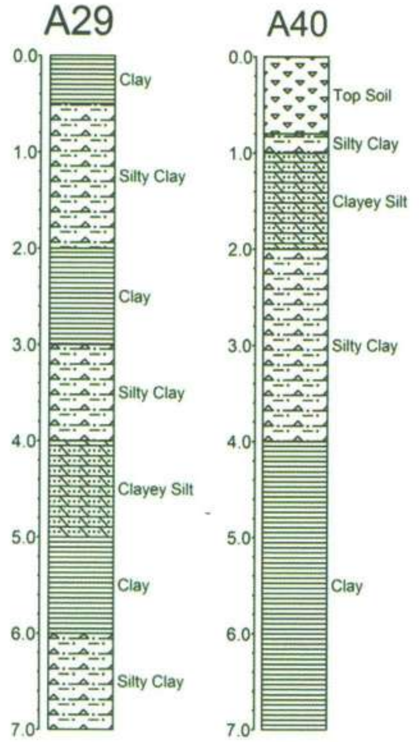

Figure 5: Representive litho-log of Dhabauli deposit

RATWADA DEPOSIT

Ratwada deposit consists of clayey to silty sand deposits with clay and sand layers alternation (Figure 7). Ratwada, Lochana, Bajainhi areas are covered by this type of deposits. The thickness of sand deposits is about 0.5m to 2m with alternation of sandy silt/sandy, clay/silty to clayey sand layers

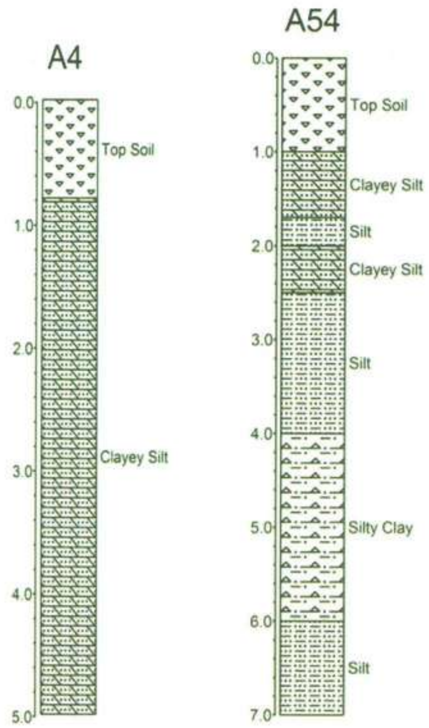

Figure6: Representive litho-log of Nainhi deposit

LIQUEFACTION HAZARD ANALYSIS

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. Also

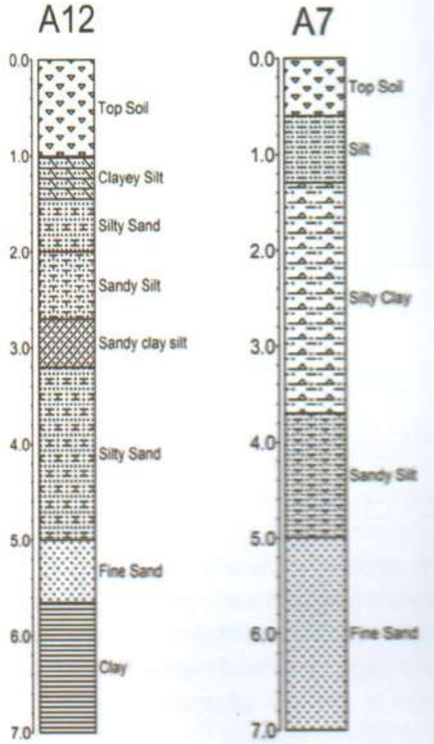

Figure 7: Representive litho-log of Ratwada deposit

in the soil layers composed of fine materials like fine silt and clay size particles the liquefaction will be less likely to occur. For liquefaction to occur, earthquake would be the prime factor.

Various methods of defining the susceptibility of material to liquefaction theories have been proposed. Basically, there are two approaches; qualitative method and quantitative methods. The analysis of liquefaction susceptibility following the qualitative methods has been studied by Iwasaki et al. (1984), and Youds et al. (1978). Quantitative analysis of liquefaction hazard assessment requires enough geotechnical parameters such as N-value, overburden pressure, density etc, which can be only obtained by in-situ measurement using field instruments. But to get such parameters is very difficult and expensive. With the lack of geotechnical data, it is not possible to carry out liquefaction hazard assessment in Jaleshwor area using quantitative analysis method. 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, if yes in what scale, high or low? According to this scale of susceptibility future plan can be made in the particular place for the development activities.

Basic conditions required for this process are,

- Water table situation of the place, less than 10 m
- Holocene deposits
- Evidence for the past occurrences of Liquefaction
- Seismically active areas

If any area is met with these conditions, then the area can be considered as susceptible for liquefaction hazard. In this work 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 twelve 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. All six factors were given appropriate score values depending on their influence to accelerate liquefaction in an area. Factors considered to be more influential were given greater weights. The sums were added and the final score obtained by summation of all the factors is considered to give a better indication of the soils susceptibility to liquefaction. Based on the final score obtained by summation of all the factors, four levels of liquefaction susceptibility have been selected:

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

Using the method adopted by Juang and Elton (1991), liquefaction hazard analysis of the current study area was done. It shows that the area which consists of fine grain sized sand deposits falls in the medium to high categories i.e. high probability of liquefaction during earthquake and the deposits with fines (clay and silt) falls in very low to low categories i.e. very low to low probably of liquefactions during earthquake.

The liquefaction map produced has been prepared by adopting very simple methods and as such is not reliable (unless supported by quantitative analysis) to be used for actual development activities but as a general guide to obtain the preliminary knowledge of the areas for liquefaction susceptibility. The analysis shows that some of the study area is vulnerable to liquefaction hazard in case of strong earthquake. This result however is not intended to be used as a precise tool for the detailed zoning for development planning of the urban areas. This is a first appraisal (assessment) test. If this method shows any risk of liquefaction, quantitative studies have to be performed for better assessment. The output obtained by such a methodology just alerts the users for the possible areas of liquefaction. A more detail investigation with comprehensive merging of geologic, geotechnical and seismological data will be required to carry out precise liquefaction susceptibility mapping for each major development activities.

BEARING CAPACITY ANALYSIS

The load carrying capacity of foundation soil or rock which enables it to bear and transmit loads from a structure is known as bearing capacity.

There are different types of bearing capacity such as Net Bearing Capacity, Safe Bearing Capacity, Gross bearing capacity and Allowable Bearing Capacity. The bearing capacity of soil layers depends on the degree of its compaction or relative density. Higher the value of relative density greater will be its Bearing Capacity. There are many methods used for finding out the Bearing Capacity of soil layers on which the foundation of the engineering structures is to be constructed. Standard Penetration Test (SPT) is one of such methods widely used for finding out the ultimate bearing capacity of soil layers as correlation charts have been established between observed N values and corresponding relative density, stiffness and shearing strength of the soil strata at particular depths. Therefore once the N values are obtained for any soil layers one can easily calculate its ultimate bearing capacity using any one of the empirical formula proposed by different authors. The bearing capacity of the granular soil depends on their relative density at particular level. Dense soil will have high N values and consequently high bearing capacity. Similarly with the increase of N value the compressive strength of cohesive soil increases giving to high Bearing capacity.

The bearing capacity analysis is carried out in this report according to Peck et al (1974) table 2. According to the analysis it is found that the bearing capacity of the study area is medium to very low. The soil condition in the study area varies from very low to medium with SPT value ranging from 0 to 15. The greater value is normally encountered at a greater depth, and hence the bearing capacity gradually increases with the increase in depth. The result shows that most of the areas have low to very low bearing capacity and very few areas have medium bearing capacity. Two maps have been prepared by showing the N-value at the depth 2-2.45m and 3-3.45m.

Peck et al (1974) have given for saturated cohesive soils, correlations between N value and consistency from which we can estimate the bearing capacity of the soil (Table 2). This correlation is quite useful but has to be used according to the soil condition met in the field.

Table 2: Correlations between N value and bearing capacity.

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

NATURAL HAZARD AND ENVIRONMENTAL POLLUTION

The study area lies in the southern most part of the Terai region of the country and the topography is almost horizontal or very gentle so there is very less probability of landslides but the study area is prone to flooding during monsoon. Although there are embankments at the both banks of Ratu Nadi, during Monsoon when there is heavy precipitation in the catchment area sometime the water in the channel over topped the embankments or the natural depression flooding and inundating the settlement area destroying the lives and properties of the people.

The banks of Ratu and Bagahi Nadi is composed of loose silt and sand deposit in many places so those banks are prone to the bank erosion and river bank cutting problem. One can observe river bank cutting problem at Lochana near the bridge over the Bagahi Nadi.

There are lots of natural as well as artificial ponds in the jaleshwor area. But due to the lack of awareness among the local people most of the ponds are polluted as people dispose garbage and waste in or around the ponds. Similarly the drain water from the houses are also not properly managed. Most household drains the used water directly in front of their house and due to poor management of the drain in almost all case water is accumulated in the open drain creating breeding place for the mosquito and other germs and also irritate the people by the foul smell from the open drain system. Wastes and garbage are also thrown everywhere and Jaleshwor municipality doesn't have enough man power for the collection of wastes. There is no fixed waste disposal site developed in Jaleshwor municipality yet. The waste is either used in filling lands or simply dumped at the open area near the Municipality or along the riverbanks. Since a settlement in Jaleshwor municipality is growing rapidly there should be a fixed waste disposal site.

Although there are very few industries in the Jaleshwor area brick factories seems to be one of the industries that is creating air pollution.

Mitigation measures for the natural hazard and environmental pollution

The jaleshwor area lies in the terai region having very low elevation so during monsoon season there is high chance of inundation and flooding of the area. To prevent the inundation the water drain system should be properly managed. Proper maintenance of embankment of the river and early warning system for the flood could help to minimize the loss of properties and lives during the flood.

Similarly sewage water from the house hold should be drained out to the proper place by enclosed sewage drain system which will help to maintain good hygiene within the settlement area and also helps to control the breeding of the mosquitoes and spreading of the diseases.

Jaleshwor Municipality up to now does not have permanent landfill site for the waste disposal. So it is recommend to build the landfill at the area with thick clay deposit which can prevent the percolation of the leachate in the groundwater. Similarly the gabion wall and river training works could minimize the river bank cutting and erosion.

The brick factories should be located far from the settlement area to minimize the effect of air pollution.

ENGINEERING GEOLOGICAL MAP

Subsurface geological classification from the litho-log data and lab analysis data, liquefaction hazard analysis, N-value obtained from SPT test and bearing capacity analysis data were used for the preparation of engineering geological map of Jaleshwor municipality (Figure 8).

CONCLUSIONS

The preliminary investigation of the Engineering Geological fieldwork revealed that the study area mainly consists of alluvial and lacustrine sediments. On the basis of the power auger drilling and bore hole drilling by manual auguring the recent sediments of the jaleshwor area is classified in to three types as Dhabauli deposit, Nainhi deposit and Ratwada deposit according to the grain size of the sediments. Standard Penetration test shows the study area have N-value from 1 to 15 having the bearing capacity very low to medium. The preliminary Qualitative analysis of liquefaction hazard assessment shows the study area having the sandy deposits have high probability of liquefaction hazard and the deposits having clay and silts have low probability of liquefaction hazard.

The study area lies in the Terai region having flat terrain or having very gentle slope so the area is prone to flooding. River bank cutting and erosion along the banks of Ratu Nadi and Bigahi nadi are commonly observed during heavy rain and destroy the cultivated land.

RECOMMENDATIONS

The study area consist of loose sedimentary deposits having the N-value 1 to 15 indicating very low to medium bearing capacity and from the qualitative liquefaction hazard assessment shows high to low probability of liquefaction hazard which should be considered during the infrastructure development. It is recommended to carry out proper site investigation before construction of any kinds of heavy structures to make the structures safe and sustainable.

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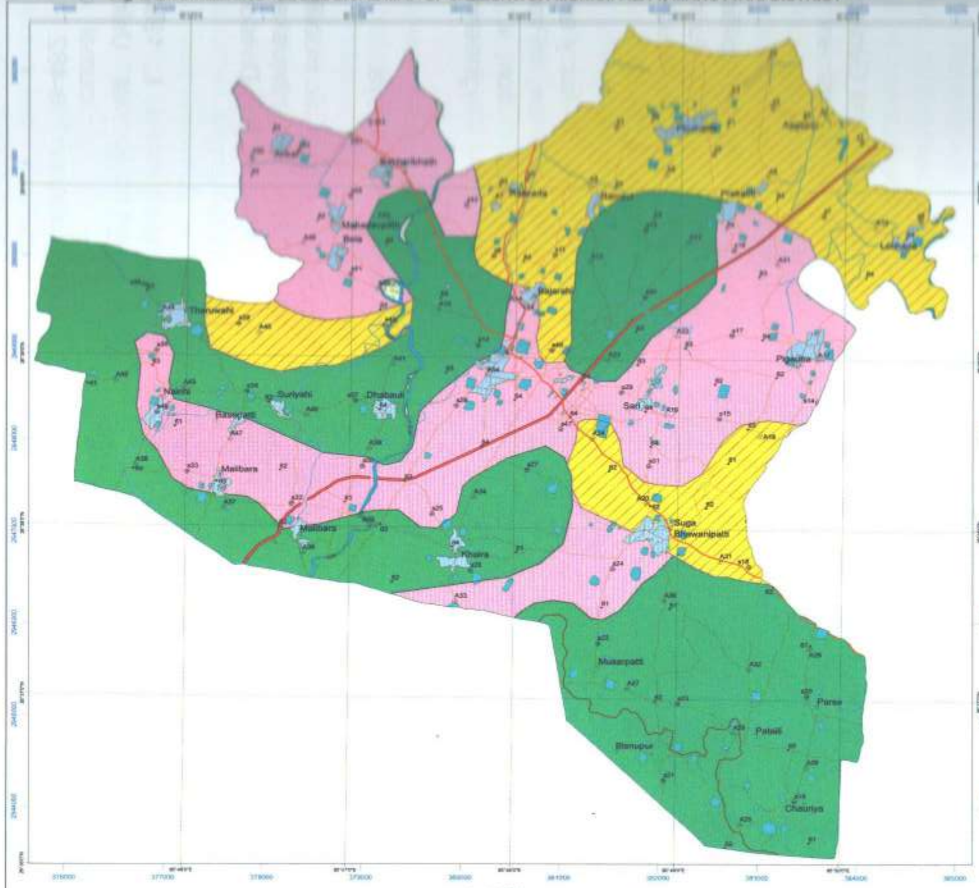
Fig 8: ENGINEERING GEOLOGICAL MAP OF JALESHWOR MUNICIPALITY, MAHOTTARI DISTRICT

(PARTS OF SHEET NO. 2685 08A & C)

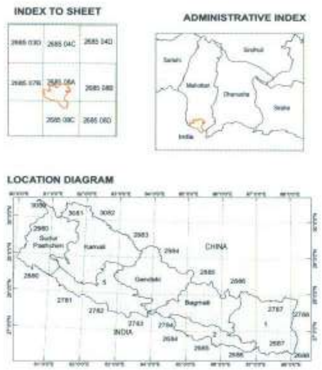


EXPLANATORY LEGEND

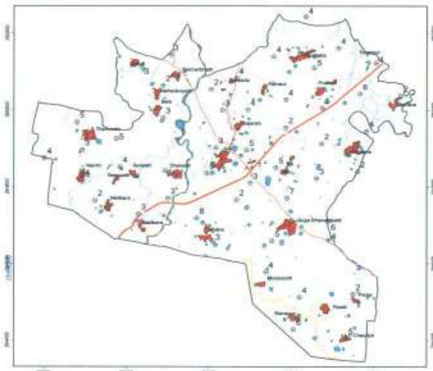
Unconsolidated Sediments — Description

GENERAL SYMBOLS

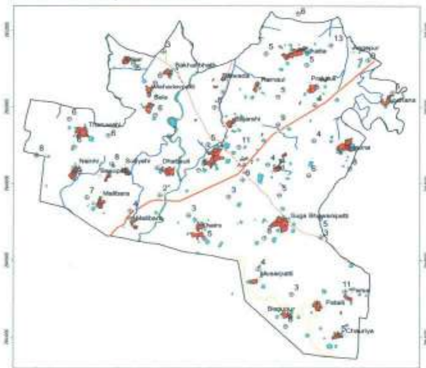
Auger Location with ID; SPT Location with ID; Village; Temple; Area of Medium to high liquefaction; Main Road; Branch Road; Ponds; River/Stream; Sand; Spot Height; Contour (Index/Intermediate)



SPT N value of depth 2m to 2.45m



SPT N value of depth 3m to 3.45m



In the bearing capacity study, a total of 50 SPT data were used. The maximum depth of SPT is limited to 6.5m. 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 mainly has low bearing capacity with N Value ranging from 1 to 15.

Condition	N-Value	Bearing Capacity (Kpa)	Quality
Very Soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	5 – 8	51 – 100	Low (L)
Stiff	9 – 15	101 – 200	Medium (M)
Very Stiff	16 – 30	201 – 400	High (H)
Hard	> 30	> 400	Very High (VH)

HORIZONTAL DATUM

Spheroid: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 87° East
Latitude: 0° North
False co-ordinates of origin: 500000 m Easting
False co-ordinates of origin: 0 m Northing
Scale factor at Central Meridian: 0.9999

Contour Intervals 10 Meters

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

Topographical Base:

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

Note:

Field survey done in November , 2018

Limitation of the Map:

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

Environmental Audit of Operating Limestone Mines for Sustainable Development of Mining

Narayan Banskota (Senior Divisional Geologist), **Sujan Devkota** (Geologist), **Basant Adhikari** (Research Officer), **Ashimbabu Shrestha** (Surveyor)

ABSTRACT

The main purpose of this paper is to explain the ways in which environmental audit can contributes to improve and preserve the environment protection, respecting the concept of sustainable development. The paper uses methods of analysis, synthesis, analogy, and continuity. Environmental auditing is fast emerging as a key practice among mining sector in Nepal. It can be used by any organization for their environmental management system and it helps to determine the environmental performance. An attempt has been made to understand and classify the environmental audit in two operating limestone mines in Palpa as per existing norms of Environment Act and Regulation of Nepal.

Keywords : limestone, mines, mining, environmental audit, environmental impact, responsibility.

INTRODUCTION

The Department of Mines and Geology (DMG) is the sole government organization which is responsible for all types of geological surveys, mineral exploration and administration of Mining Rules and Regulations in Nepal. One of the main works of DMG is to legislative and compliance of Mines and Mineral Rules & Regulations and monitoring of mineral exploration, mining, and mineral-based industries.

Minerals are the nonrenewable natural resources. Sustainable development of such resources helps to strengthen the national economy. Government of Nepal (GON) has prioritized exploration, evaluation and sustainable development of industrial minerals, high price metals, base metals, and fuel minerals, precious and semi-precious stones.

Mineral resources play a vital role in industrial development and an overall increase in the national GDP. Minerals and mine contribute about 0.6% to the national GDP and industries sector based on these just around 2.4% which is not encouraging. It could go above 10% if we can exploit and utilize existing mineral resources appropriately. Mining activities can damage the natural environment and it should be minimized by adopting various mitigation measures and immediate rehabilitation of the mined land.

Environment regulatory work is governed by prevailing Environment Protection Act and Environment Protection Regulation of Nepal. The Mines and Minerals Act and Regulation have also postulated measures regarding environment protection, sustainable use, and conservation of minerals.

Environmental auditing can be defined as "a systematic, periodic, documented and objective review of project activities related to meeting environmental requirements". An audit should assess the actual environmental impact, the accuracy of prediction, the effectiveness of mitigation and enhancement measures, and the functioning of the monitoring mechanism. Further, the review should be systematic and objective.

SELECTION OF CASE AND LOCATION

Limestone mines are most developed mine industry of Nepal among others mineral resources. It is used as basic raw materials (mineral) for the manufacture of cement. Out of the 48 cement factories, only 18 produce clinker, a major raw material used in cement production, and rest of them used clinkers from other sources. A case study on environmental impact assessment on decade long operating limestone mines in Tinau Rural Municipality, Palpa District (Figure 1) is carried out where Open cast fully mechanized mining method has been used to quarry the limestone from less than 7 ha area. This study focuses on mining condition, technical compliance and, its impact on the environment and social sector after the operation.

CASE 1: M/S Kanchan Quarries Private Limited, Tinau Rural Municipality (RM) -3 (Dobhan VDC-5), Palpa District, Nepal is extracting limestone obtained under a Mining License (no: 11/064/65) issued from DMG. This company was extracting 200 Ton per Day (TPD) of Limestone till 2072/73 and upgraded to 1175 TPD in 2073.

CASE 2: M/S Siddhartha Minerals Private Limited, Tinau RM -3 (Dobhan VDC-5), Palpa District, Nepal is extracting limestone obtained under a Mining License (no: 180/065/66) issued from DMG. This company was extracting 100 TPD of Limestone till 2073/74 and upgraded to 1200 TPD in 2074/04/25.

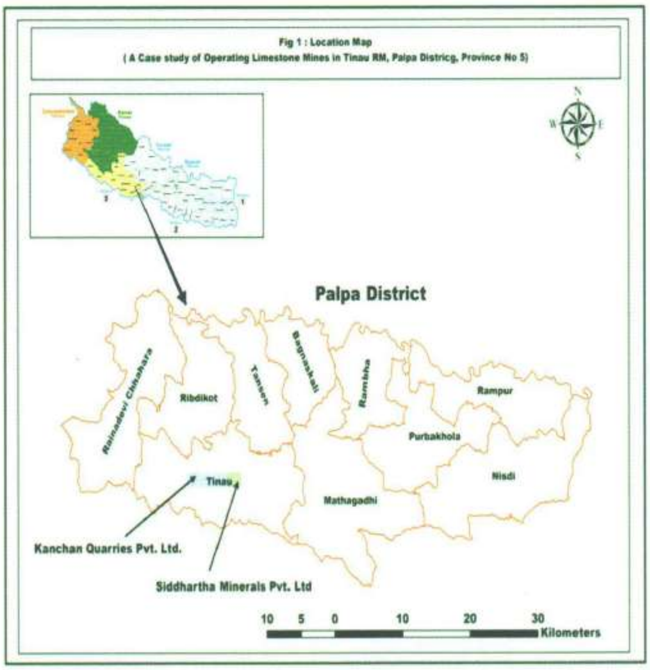


Figure 1: Location of operating mines in Papa District (Case 1, Case2)

OBJECTIVE

The objectives of the study were to:

- Assessment of land use before and after mining of limestone
- Collect post-construction environmental and social data of the project area;
- Find out the accuracy of the impact prediction;
- Assess actual environmental impacts which occurred due to the implementation of the project;
- Evaluate the variations and the effectiveness of implemented mitigation measures;

SCOPE

The scope of the study includes review and assessment of the project documents, collection of field data, collection of local people's and stakeholders' views, review of data from mining scheme and IEE submitted in DMG and as well as co-ordination with the management team in DMG.

The study has covered two components of the project namely: quarry area and transportation along the main highway road.

LIMITATIONS OF THE STUDY

The lack of proper auditing guidelines is the major limitation of the study. The other limitations of the study mentioned in the report are:

- Limited time for the study
- Data of different surveys (pre-project and post-project) might not be comparable due to different methodologies adopted;
- This study lacks dry season data for dust, water quality in dewatered and reduced flow zones.

STUDY METHODOLOGY

DESK STUDY

- Review of mining schemes
- Royalty data submitted in DMG
- Review of files of mine owner
- Google maps
- Topographical maps provided by the proponent

FIELD INVESTIGATION

- The topographic maps at the scal of 1: 1,000 is acquired by the help of Total Station and DGPS. Acquired data were used to compare the recent topographical change and to calculate excavated volume of Limestone.
- Questionnaire survey
- Interaction with mine owner
- Interaction with local people

FIELD EQUIPMENT

i. Brunton compass
ii. GPS
iii. Hammer
iv. Hand lens
v. Total Station
vi. DGPS
vii. Other necessary equipment as per required
viii. Questionnaire template.

ENVIRONMENTAL ASPECTS OF OPERATIING LIMESTONE MINES

Mining industries work' always disrupt the natural ecology; its negative impacts start with exploration, extend through the extraction and processing of minerals, and can continue after the mine closes. The nature and extent of effects can vary throughout the stages of project implementation. Both operating mines in Palpa has been categorized in large-scale mining and have the considerable impact on the environment. Mining activities has impact on physical parameters such as land, air, water, biological-flora and fauna as well as on the social factors which includes individual health and safety, local community lifestyles, cultural survival, social order and economic well-being. However, the majority of the impacts of mining are "localized" only.

ENVIRONMENTAL AUDITING

Environmental auditing is a systematic, periodic, documented and objective review of project activities related to meeting environmental requirements. An audit should assess the actual environmental impact, the accuracy of prediction, the effectiveness of mitigation and enhancement measures, and the functioning of the monitoring mechanism. During the case study the research team gave emphasis on the impact associated with physical, Biological and socio-economic as defined by figure 2 as unit of environmental audit in two different operating menes in Palpa. Selecting and determining the sort of environmental audit for mining is a big challenge as proper auditing guideline is unavailable and it is taken as a major limitation of this study.

AUDITING ACTIVITIES

Auditing activities were properly planned before reaching to the site. Team has collected the maximum data from field with above mentioned limitation using questionnaire and check list. Activities involved for environmental auditing as describe in figure 3 (photo 1,2,3,4,5,6).

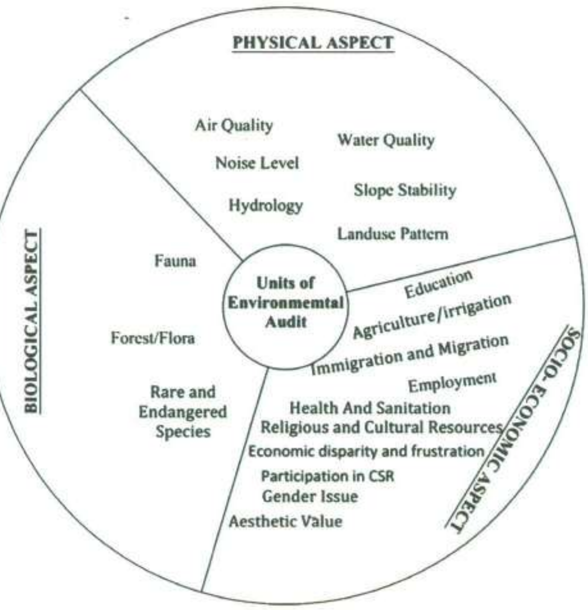


Figure 2: Various parameters used in environmental audit

ASSESSMENT OF ENVIRONMENTAL IMPACTS OF OPERATING LIMESTONE MINES

Assessment of environmental impacts involves complex process that requires the matrix of different environmental aspects from physical, biological and

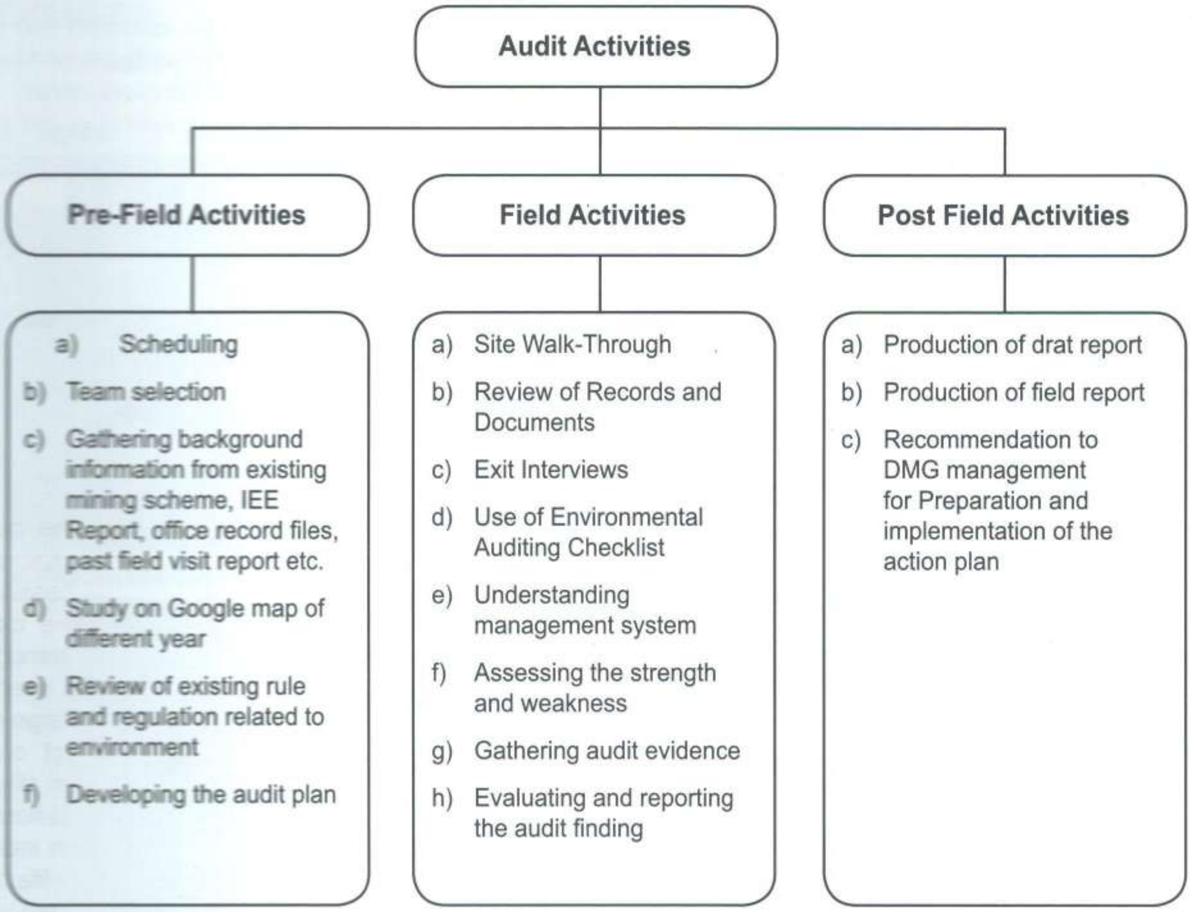


Figure 3. Activities in Audit activities

socio-economical and site verification with experts' judgment. Impacts, finding, outstanding issues, recommended corrective measures and lessons learned gives the assessment of operating limestone mines in Palpa. Two adjacent mines operating in Palpa district were salective for the case study.

MAJOR IMPACT

- Mines area: Topography change from last one decade (Google Image 1, 2), dust and noise, flora and fauna, socio- economic
- Mine approach road: Fatalities, slides, dust and noise along the mine approach road.
- Rehabilitation of people from the mines area
- Slope stability
- Sliding of waste along the slope.

AUDIT FINDINGS

- Retention wall and check dam along slopes is required.
- There must be the plan for mine drainage in rainy season
- Payment of appropriate compensation has been made for the loss of land, house and other assets due to impact of mining activities.
- The project has provided employment for local villager and only few technical manpower are involved from other parts of the country.
- Both Industry are providing fund for different institution and event their social responsibility.
- There is the good harmony among mine owners, workers and local people.

OUTSTANDING ISSUES

The followings are the outstanding issues:

- Lack of waste management plan
- Failure of retention wall in waste yard
- Over production
- Lack of mine expert and other technical manpower.
- Boundary of quarry area is not properly marked.
- Proper drainage and bioengineering along the access road is required.
- Plantation in the mines area and mine approach road.
- Lack of seriousness in using safety measures
- Plantation work is poor in mines.
- Lack of mechanism for grievance handling.
- Lack of awareness about health issues.

RECOMMENDED CORRECTIVE MEASURES

The operating mines are responsible for environmental impact and should go for mitigation measures as well as DMG has major role in monitoring the impact caused by operating mines. So following issues are subjected to be monitored by authority.

- Over production
- Over production has clauses illegal mining and grievance has been started in local people so this problem should be short out as soon as possible.
- Encroachment to the forest
- Demarcation of quarry area
- Control dust in access road through regular water spray.
- More Check dam and siltation pond in slope below the quarry area
- Annual health check program plan for mine worker

LESSONS LEARNED

The followings are the lessons learned during the study:

- Mechanism of grievance of local Community and mine work should be developed by company.
- Company need to allocate some budget every year for the environmental works.
- All mitigation works must be specified and put in the bill of quantities together with the provision of reward and punishment for the mine owner.
- Over production leads to illegal mining environment, social imbalance and high top run of the mines in long term.
- A scheduled and unscheduled monitoring of mines is required.

CONCLUSIONS

This report tries to give an introduction to the environmental audit in operating mines of Palpa district were mining has been carried from decade. The study shows that most of the impacts were predicted accurately before mining; environmental and social condition of the mining area is good where some of the environmental Impact issues were associated to land, forest, dust, social and over production as mentioned and must be address by developer with regular monitoring from DMG. Over production has caused illegal mining and grievance has been started in local people so this problem should be short out as soon as possible.

Audit has been done on the basis of developers mining scheme, IEE reports as well as legislative rules and regulation related to environmental issue on mining. This case study helps to increase awareness to the management on environmental issues so that resource can be use. This study can make a platform for developer and management for discussion on how mining can be done efficiently with minimum impact on environment.

ROLE OF DMG IN ENVIRONMENTAL AUDIT IN MINING

The case study report on environmental auditing and it may help DMG and other stakeholders to improve environmental consciousness on impact associated with present mining activities. The nature of mining activities affects the whole environment of land, water, flora, fauna, forest, etc. The change in land use, noise pollution, dust pollution, water pollution, encroachment of forest, poor waste management; human health risks and socio- economic issues are the major potential environmental risks and the plans to mitigate those risks.

The issues and problems in cases study such as overproduction, mining outside leased area, mining methods, environmental impacts should be address by DMG for sustainable mining. Recommendations given in report will ensure DMG that the mining companies will take an environmental and social responsiblility for their mining activities.

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Google image 1: Change of Landscape in quarry area Kanchan Quarries from 2003 to present due limestone Mining

Google image 2: Change of Landscape in quarry area Siddhartha Minerals from 2003 to present due limestone Mining

Photographs showing field based data for the study

Photo 1: Quarry Area of Kanchan Quarries

Photo 2: Plantation along access road of Kanchan Quarrie

Photo 3: Talc transportation throportation through ropeway in Baitadi

Photo 4: Waste slided along the slope in from the waste yar of Siddhartha Minerals

Photo 5: Check dam and siltauion pond developed in basal part of the Siddhartha Minerals quarry area

Photo 6: Interaction between field team with local people

Mineral Deposits, Mines and Environmental Protection

Dharma Raj Khadka (Senior Divisional Mining Geologist), **Ramanand Prasad Chaudhari** (Mining Engineer), **Naresh Maharjan** (Geologist)

ABSTRACT

The sustainable mineral resource development needs environmental consideration for prospecting, exploration, mining and processing. The approved and submitted IEE reports, mining scheme, mining & environment verification and inspection reports are the basis for analysis. The legal provisions were reviewed. The challenges faced by mineral industry are highlighted and sustainability approaches to overcome these challenges have been proposed for future improvement.

Keywords: mineral deposits, mines, environmental consideration, challenges and future improvement.

INTRODUCTION

A brief account of environmental protection status, environmental consideration for prospecting, exploration, mining and processing have been described along with legal provisions for environmental management and challenges faced by mineral resources based mines basically based on Mining Scheme and Initial Environment Examination (IEE) reports, Mining and environmental report verification and inspection visits as per the annual program of Department of Mines and Geology (DMG) for the Fiscal year 2075/76 and 2076/77.

The main objective of the study is to disseminate environmental protection status and functional areas of environmental protection for prospecting, exploration, mining and processing of mineral resources. It also covers the legal provisions for environmental management and challenges faced for sustainable mineral resource management.

The methodology comprises of review of IEE reports, Mining Schemes of mineral commodities submitted to DMG by the proponents. Furthermore, review is made by the field verification, inspection and monitoring of existing and proposed mines by DMG personnel to formulate status of operating mines keeping in view with technical, environmental and socio-cultural aspects of the proposed mines. A total of 46 approved IEE reports were reviewed. Fourteen mining scheme were verified and 12 operating mines were inspected by the authors during these periods are the basis for this analysis.

STATUS OF IEE REPORTS, MINING SCHEME VERIFICATION AND INSPECTION OF OPERATING MINES

The IEE reports submitted and approved at DMG during FY 2075/76, 2076/77 have been listed in Table-1. The proponent, commodity, quarry area and location have been listed. Altogether 46 IEE reports were examined during the period by environmental committee of DMG.

Table-1: IEE reports submitted and approved

SN	Proponent	Commodity	Quarry area	Easting(m)	Northing(m)	Location
				MP	MP	
1	Sataun Daraun Dhunga Udyog	Quartzite slab stone	2.0ha	480420	3110690	Syangja, Arjun Chaupari RM
2	Gurasmai Slate stone Udhyog	Quartzite slab stone	1.28ha	384650	3077950	Jugal RM, SIndhupalchok
3	Ram Krishna Nirman Sewa	Quartzite slab stone	2.25ha	353650	3047125	Bethanchok RM, Kavre
4	Nepemasal Dhunga khani	Quartzite slab stone	1.13ha	373940	3083275	Jugal RM, Sindhupalchok
5	ASDC Asia	Talc	4.76ha	460750	3145810	Raghu Ganga RM, Myagdi
6	Geo Mineral Reserves	Talc	4.22 ha	472675	3283050	Dilasaini RM, Baitadi
7	Gauri Shanker Khanij Udhyog	Talc	2.64ha	414750	3049975	Tamakoshi RM, Dolakha

SN	Proponent	Commodity	Quarry area	Easting(m)	Northing(m)	Location
				MP	MP	
8	Sabita Kedia	Limestone	10.55ha	3050787.5	593537.5	Kilash RM, Makwanpur
9	Palpa Cement Industries	Limestone	4.75ha	468000	3070552	Mathagadi RM, Palpa
10	Riddhi Siddhi Cement	Limestone	9.86ha	586650	3052525	Raksiran RM, Makwanpur
11	Kiran Coal Udhyog	Limestone	4.58ha	645225	3116487	Rungti Gadi RM, Rolpa
12	Srish Kumar Murarka	Limestone	4.74ha	437975	3077787	Tinau RM, Palpa
13	Himalayan Micron and Minerals	Limestone	3.18ha	603850	3043825	Bhimphedi RM, Makwanpur
14	Tirupati Mines	Limestone	24.01ha	640420	311654	Runtigadhi RM, Rolpa
15	Narayani Cement Udhyog	Limestone	4.73ha	430315	3092185	Panini RM, Arghakhanchi
16	Jagadamba Cement Industries	Limestone	4.84ha	479250	3071825	Nisdi RM, Palpa
17	Cosmos Cement	Limestone	5 ha	455800	2981100	Dumre VDC, Udayapur
18	Samrat Cement	Limestone	4.98ha	368030	3100100	Ghorahi M, Dang
19	Manakamana Mines and Minerals	Limestone	6ha	558775	3076750	Ichhakamana RM, Chitwan
20	Shubhashree Agni Cement	Limestone	5ha	370420	3100180	Bangalachuli RM, Dang
21	Raju Bhandari	Limestone	2.41ha	578900	30736756	Benighat Rorang RM, Dhading
22	Shivam Cement	Limestone	4.73ha	617000	3040750	Thingaon VDC, Makwanpur
23	Annapurna Quarries	Limestone	3.5ha	566163	3077763.5	Benighat Rorang RM, Dhading
24	Panchkanya Cement	Limestone	8.8019ha	620287	3042988	Bhimphedi RM, Makwanpur
25	Makalu Cement	Limestone	6.4ha	421742.5	3081977.5	Paninin RM., Arghakhachi
26	United Cements	Limestone	4.6ha	634750	3049237	Godavari M, Lalitpur
27	Sarbottam Cement	Limestone	4.99ha	442838	3074682	Tinau RM, Palpa
28	Om Prakash Bhattarai	Limestone	5.37ha	358395	3108810	Ghorahi M, Dang
29	AG Lime and Minerals	Dolomite	1.31ha	535300	3095300	Byas M, Tanahun
30	Dong Shan Minerals	Copper	17.13ha	472960	3045000	Mapya Dudhkoshi RM, Solukhumbhu
31	Udayapur Cement Industry	Red Clay	2.2 ha			Triyuga M, Udayapur
32	SM Baluwa Dhunga	Construction stone	1.53ha	606825	3082600	Bidur RM
33	Mining and Mining	Construction stone	3.2ha	608380	3064962	Thaha RM, Makwanpur
34	Gimding Roda Dhunga Udhyog	Construction stone	1.6ha	374628	3043332	Temal RM, Kavre
35	Kalidevi Crosser Udhyog	Construction stone	3.5ha	389250	3035000	Kalidevi RM, Ramechhap
36	Iman Singh BK	Construction gravel stone	1.16ha	495757	3131957	Machhapuchhre RM, Kaski

SN	Proponent	Commodity	Quarry area	Easting(m)	Northing(m)	Location
				MP	MP	
37	Tirupati Roda Dhunga	Construction stone	3.5ha	367556	3046735	Namobuddha M, Kavre
38	Bethanchok Roda Dhunga	Construction stone	1.85ha	352605	3048110	Bethanchok RM, Kavre
39	Birendra Maharjan	Construction stone	1ha	629760	3050640	Godavari RM, Lalitpur
40	Indrawati Mines and More	Construction stone	1.18ha	379300	3069750	Chautara Sangchokgadhi M, Sindhupalchok
41	Suprime Stone	Construction stone	4.3ha	373575	3041850	Roshi M, Kavre
42	Rabina Aggregate	Construction stone	1.1ha	604907	3069970	Thakre RM, Dhading
43	Setidevi Khanij Udhyog	Sand	1.28ha	601820	3072795	Thakre RM, Dhading
44	Across Crosser Udgyog	Sand	1.95ha	620000	3075325	Kakani RM
45	Hillstone sand quarries	Sand	2.1ha	606570	3082632.5	Bidur RM, Nuwakot
46	Sushil Khadka	Sand	1.28ha	628635	3043495	Bagmati RM, Lalitpur

Reference: IEE Report

The 14 mining schemes verified during FY 2075/76 and 2076/77 are listed in Table 2.

Table-2: Mining Scheme Field Verification

SN	Proponent	Commodity	Quarry area	Easting(m) MP	Northing(m) MP	Location
1	Bishwakarma Mines and Minerals	Limestone	4.98ha	367853	3103042	Banglachuli RM, Dang
2	Shubham Khanij Udhyog	Limestone	4.8ha	362855	3105550	Banglachuli RM, Dang
3	Shubham Khanij Udhyog	Limestone	4.7ha	362855	3105550	Banglachuli RM, Dang
4	Subash Chandra Yogi	Limestone	2.8ha	357487.50	3110612.50	Ghorahi M, Dang
5	Samrat Cement Company	Limestone	24.37ha	368030	3100100	Banglachuli RM, Dang
6	Sonapur Minerals and Oil	Limestone	21.74ha	364720	3102812.50	Banglachuli RM, Dang
7	Bethanchok Roda Dhunga Udhyog	Stone	1.85ha	352605	3048110	Bethanchok RM, Kavre
8	Tirupati Mines	Limestone	24.01ha	640420	3116548	Runtigadhi RM, Rolpa
9	Subham Khanij Udhyog	Limestone	4.5ha	646550	3116370	Runtigadhi RM, Rolpa
10	Ram Krishna Nirman Sewa	Quartzite slab stone	2.25ha	353650	3047150	Bethanchok RM, Kavre
11	Gimding Roda Dhunga Udhyog	Stone	1.6ha	374628	3043332	Temal RM, Kavre
12	Gaurishanker Khanij Udhyog	Talc	2.64ha	414750	3049975	Tamakoshi RM, Dolakha
13	Himalaya Mines and Minerals	Dolomite	1ha	569975	3074307	Benighat Rorang RM, Dhading
14	Palpa Cement	Limestone	5.13ha	465265	3070552	Mathagadi RM, Palpa
	Himalaya Mines and Minerals	Dolomite	1ha	569975	3074307	Benighat Rorang RM, Dhading
14	Palpa Cement	Limestone	5.13ha	465265	3070552	Mathagadi RM, Palpa

Reference: Verification Reports

The 12 operating mines have been inspected during FY 2076/77 by this team, Table 3.

Table 3: Operating mines inspection/monitoring

SN	Proponent	Commodity	License No	Location
1	Sarbottam Cement Industry Pvt. Ltd	Limestone	11/069/70	Tinau RM/Palpa
2	Alpha Construction and developers Pvt. Ltd.	Limestone	07/073/74	,,
3	Shankarlal Agrawal	Iron	147/074/75	,,
4	Dolomite Chundhunga Udhyog	Limestone	82/063/64	,,
5	Satyawati Khanij Utakhanan Pvt. Ltd.	Limestone	29/072/73	,,
6	B S Cement Industries Pvt. Ltd.	Limestone	125/074/75	Matthagadi RM/Palpa
7	Palpa Cement Industry Pvt. Ltd.	Limestone	06/073/74	Matthagadi RM/Palpa
8	Jagadamba Cement Industries Pvt. Ltd.	Limestone	04/073/74	Rainadevi Chhahara RM/ Palpa
9	Hongshi Shivam Cement Pvt. Ltd.	Limestone	42/073/74	Nisdi RM/Palpa
10	Pashupati Quarry Pvt. Ltd.	Limestone	211/071/72	Byas M/Tanahu
11	Barahi Quarries Pvt. Ltd.	Limestone	148/074/75	Byas M/Tanahu
12	ADSC Asia Pvt.Ltd.	Talc	24/060/61	Myagde RM/Tanahu

Reference: Inspection Reports

FUNCTIONAL AREAS OF ENVIRONMENTAL PROTECTION

The functional areas of environmental protection for mineral deposits are prospecting, exploration & mining and processing of mineral commodities which are clearly mentioned in Mining Schemes, IEE reports, Environmental audit reports, Field verification reports and Inspection reports.

PROSPECTING AND EXPLORATION

The major environmental criteria for the prospecting and exploration are listed below-

- The environmental effect is minimal during prospecting and exploration activities
- It consists of surface mapping, geophysical survey, geochemical study of soil and rocks, surface excavations like pits and trenches, Diamond core drilling etc.
- The local people have to be satisfied for damage if any compensation and rehabilitation during prospecting and exploration.
- Facilitating employment opportunities to locals is prioritized.
- The local administration and community relation during prospecting and exploration pays a lot for upcoming mining activities.
- The due care should be taken to prevailing natural conditions.
- The environmental baseline databases during prospecting and exploration will be beneficial based on the compilation and evaluation of existing and new data on satellite images, topography, geological maps, sample locations, geochemistry, mineral occurrences, old mine workings, air, water, vegetation, and forests and others which will help to guide the future environmental management program during and after project life.

MINING AND MINERAL PROCESSING

Environmental impacts are high during mining and mineral processing. These operations should focus on safety and E3 (Environment, Economy and Efficiency). The possible strategic areas will be- baseline monitoring, waste, subsidence, fire, contaminants, noise pollution, vibration, water, hazardous chemicals, biodiversity, SIA, CSR, IEE, EIA, EMP, mine closure and rehabilitation management.

EXISTING LEGAL SITUATION FOR ENVIRONMENTAL MANAGEMENT

The Mineral policy 2074, envision the sustainability of mineral resources. The Mines and Mineral Act, 2042 has provisions of protection of mineral deposits, significant adverse effect on the environment by mining operation and environmental protection as described below.

PROTECTION OF MINERAL DEPOSITS

- Minimum effect on the land,
- Maximum recovery of mineral deposits,
- Produce highly valuable minerals as far as possible,
- Utilize maximum of by production produced by the mining operation,

- Minimize the waste.

SIGNIFICANT ADVERSE EFFECT ON THE ENVIRONMENT BY MINING OPERATION

- Dislocation in the use of land and land surface in the course of development of mines and basic structure,
- Deforestation and disappearance of wildlife,
- Water pollution due to the water flowed from the mine and from the dirty liquid wastage produced in the course of ore processing,
- Air pollution due to smoke and dust,
- Sound pollution and vibration due to drilling, blasting and use of heavy machines,
- Soil wastage due to over burden tailings,
- Problems such as lands erosion, landslide, floating of sloppy land, floating of soil and blockage of way that might be produced,
- Diverting water flow and causing inconvenience in water utilization,
- Damage to the cultural, archeological spots and vegetation garden.

ENVIRONMENTAL PROTECTION

- Less effects on the surface and ground water situated in the surrounding of mining area,
- Manage appropriate siltation of wastes, pond and drainage for water flow,
- Affluent treatment measure, as per necessity,
- Follow minimum pollution emitting methods, as far as possible, in the sources of mine where poisonous gas and maximum dust are produced,
- Use gas filter and dust mask to the labors working in mines producing poisonous gas and maximum dust,
- Use minimum sound producing explosive goods or machinery in the mining operation, as far as possible,
- Use silencer as an alternative available to explosive goods,
- Collect the waste produced in the course of mining operation in an appropriate place and make walling, fencing and plantation around it,
- Removing topsoil in the course of mining operation, to store it separately in an appropriate place,
- Rehabilitate the topsoil and to make plantation therein after completion of mining operations
- Follow required safety measures where hazardous substance are used or where possibility of hazardous situation might be occurred in the course of mining operation,
- Carryout mining operation in a manner so that it may cause minimum adverse effect to the flora and fauna,
- Carryout mining operation in a manner so that it causes minimum adverse effect to the natural beauty and cultural heritage.

ENVIRONMENTAL PROTECTION ACT 2053, AND RULES 2054

The Act consists of EIA or IEE for mining projects. It prohibits implementation of projects without approval. It prohibits emission of pollutants beyond the prescribed standards. It protects natural heritage and environmental protection areas. It has provisions for compensations arising from discharge of waste and pollution. It has provision of punishment and right to appeal. The Rules consists of environmental screening, scoping for EIA/IEE assessment, public notification, public hearing, and recommendation letter from mining project development DCOs, RM and Municipalities, disclosure of IEE/EIA reports. It complies with IEE/EIA provision to avoid, missing act and monitor impacts. It has given responsibility of concerned bodies to monitor mining project implementation.

CROSSCUTTING POLICIES, ACTS AND REGULATIONS

Nepal Environmental Policy Action Plan, 2050 has five principles i.e. a) manage efficiently and sustainably nature and physical resources, b) balance development efforts and environmental conservation for sustainable fulfillment of basic needs of the people, c) safeguard natural heritage, d) mitigate adverse environmental impacts of development projects and human activities, e) integrate environmental development through appropriate institution, adequate legislation and economic incentives and sufficient public resources. Industrial Policy, 2049 has provision of rapid industrial development, employment opportunities, income generation and contribution to national economy. The Children Related Act, 2075 bans to involve children below 14 years in hazardous work. The Labour Act, 2074 demands safety of workers, health and 48 hours per week working hours. The Industrial Enterprises Act, 2073 has provision of IEE/EIA for construction and operation of any proposal that falls under schedule 1 or 2 of Environmental Protection Rules, 2054. The Workplace Sexual Harassment Act, 2071 has provisions of maintaining secure, clean, honored working environment for every person without any sexual harassment. The Forest Protection Act, 2070 controls the encroachment into forest areas. The Forest Act, 2049 has provision of lease to establish facilities within the national forest, community forest and leasehold forest for national priority projects if there is no alternative to the plan/ project implementation. The soil and Watershed Conservation Act, 1982 prohibits actions within any protected watershed areas declared. The President Chure –Terai Madesh Conservation Development Board (Formation) Order, 2071 has provision of Chure protection.

CHALLENGES TO ENVIRONMENTAL PROTECTION IN MINERAL DEPOSITS AND MINING AREAS

The mining business has both opportunity and risk. It has challenges to environmental protection. Some of the challenges faced by the mining entrepreneurs as per IEE reports, Mining Scheme verification and Inspection/ Monitoring results include the following:

IEE REPORTS

- Incorporation of baseline information
- Instrumentation for monitoring
- Implementation of EMP
- Forest clearance
- Inspection and Monitoring

MINING SCHEME VERIFICATION

- No reporting as per prospecting plan
- Geological confidence level is poorly constraint as the mineral exploration results are described mostly as probable and possible categories.
- Conventional methods of resource characterization
- Mining parameters based on assumptions
- Environmental baseline data poorly constraint

INSPECTION/ MONITORING

- Mining operation out of quarry limit
- Over exploitation
- Inadequate CSR
- Pollution control
- Local employment
- Demarcation of quarry limit
- Waste management and siltation
- Drainage management
- Top soil management and rehabilitation
- Safety management
- Effects in natural beauty

CONCLUSIONS

To overcome challenges for sustainable mineral resources management the following possibilities are to be considered-

- a state-of-the-art review of the spatial mine inventory, hazard, impact and risk assessment and ranking methods developed by national and international efforts
- Confidence level of geological knowledge on mineral resources exploration is essential and should be used for the environmental assessment of mines
- Experience, knowledge and results are available, but harmonization of these methods, up gradation is still required for the efficient spatial environmental assessment of mine.

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Soil and Watershed Conservation Act, 1982

Workplace Sexual Harassment Act, 2071

Preliminary Follow-up Exploration of Salt and Gypsum in Nursing Khola Area, Mustang District

Dharma Raj Khadka (Senior Divisional Mining Geologist), **Naresh Maharjan** (Geologist)

ABSTRACT

The annual program (FY 2075/76) of Department of Mines and Geology (DMG) is carried out the preliminary follow-up exploration of salt and gypsum within study area of 10 sq. km. in Nursing Khola area of Mustang district. The springs at the base of the slope in the right side of the Nursing Khola have brines coming out of the fracture pores and collected in small caves. The brine water spring at the base of the Tetang village has been traditionally used as medicine. The salt occurrence in this area lies within the limestone beds of Lumechella Formation. The conglomerate cover in the area is slope collapsed part of the Thakkhola Formation from the ridge area. The spring water flows through it and wash over the conglomerate beds resulting salt encrustations on it. The limestone beds show salt encrustations from the Tetang village area around the Nursing Khola gorge. The common salt in the area has a small quantity. The annual extraction during mining period was 10,000kg as reported locally. The quality shows that the salt has concentration of NaCl along with KCl. This shows that the small pockets and layers of salt might have been deposited during depositional period along with alternating limestone beds are now re-circulated with ground water, below water table, forming brines in the caving parts in the inclined beds. It shows that there is almost no possibility of finding large salt deposit in the area. There is a possibility of finding gypsiferous? shale nearby brine seeps outcrop.

Keywords: salt, exploration, characterization, resource evaluation

INTRODUCTION

As per the annual program of Department of Mines and Geology for the fiscal year 2075/76, the preliminary follow-up exploration of salt and gypsum in Nursing Khola area of Mustang district has been undertaken. The study area covers 10 sq km in Nursing Khola section with latitude N3198000m to 3200000m and longitude E484000m to 489000m. The area is accessible with motorable road upto Chhusan, which is 95 km far from Beni via Galeshwor, Jomsom. Tetang is 2 km far from Chhusang through single land earthern village road and Nursing Khola is 3 km far from Tetang. It needs to cross Nursing Khola several times to reach the deposit area. The study area is a part of the Annapurna Conservation area.

The main objective of the study is geological mapping of the exploration area around Narsing khola to find out the area susceptible to salt and gypsum, detail investigation of the gypsiferous beds and salt resources in the area with representative sampling for resource evaluation.

PHYSIOGRAPHY & CLIMATE

The study area is a part of Higher Himalaya having steep gorges and steep to gentle topography in the study area. The area is the southern part of the Thakkhola-Mustang Graben. The altitude ranges form 4120m at the South east corner of the study area to 3020mat the north east corner of the study area nearby Tetang village and having glacial topography. The Narsing Khola is a Tributary of Kaligandaki River originated from Glaciers upstream. The Nursing khola upstream in the area around Tetang village forms a steep gorge. The area has sub-alpine to alpine climate. It has semiarid climate. The thorny cushion plants scatter in the area. The most of the vegetation is represented with Kobressia species which is a fodder for the domestic animals. The area is snowcapped from October to March and almost all season is cold. The wind blows in the afternoon onwards with sand and clay dust.

SOCIO-ECONOMIC CONDITION OF TETANG & CHHUSANG VILLAGES

Tetang village is the nearest village to the salt deposit area. It consists of 30 houses of stone, mortar and mud mostly and a few modern concrete buildings. The population of the village is about 200 people, there is primary school up to grade 3. The village has a hotel for villagers as well as tourists as it follow a trail for trekking upto Muktinath. The people of the village are mostly engaged in agriculture and produce maize, wheat, Uwa, potato, cabbage and others. The villagers have engaged in Chyangra farming. Local employment is possible in Jomsom and Chhusang. The overall economic condition is poor and some of the household have migrated to Pokhara and Kathmandu. Chhusang village has about 40 houses with population of about 300. Economic activity of the area is mainly based on hotel business and farming in a limited farmland. There is a school, health post and a police post. Traditional mud mortar and stone houses are now being replaced by concrete building partly. Tourist stay in the hotel is a main source of income.

METHODOLOGY

The methodology consists of desk field and lab study. The desk study comprises of secondary data collection related to the salt and gypsum in the study area. The data were previous study reports, analysis and geological information. The topographical base map of 1:10,000 scale (enlarge) has been used. Around Chhusang and Narsing khola of Mustang District, Western Nepal, the Survey Department Toposheet no: 2883 04, 10 sq.km, 1:50,000 scale was used. Google maps and images have been referred during the study period. The geological mapping was prepared with field data and traverse made along the river and ridge and spur. The salt encrustations and brine seepage in the natural caves were located and documented. The old adits were cleared to take fresh brine samples and rock chip samples of the host rock. The Brines and rock chip samples were labeled in plastic bottles and sample bags respectively for chemical analysis. The flow rate of the brine was estimated. The collected brine samples and rock chip samples were sent to the Chemical laboratory at DMG for chemical analysis.

EXPLORATION HISTORY

The first man to visit the area in connection with salt deposit was BL Sahai in 1924 and after his recommendation; Mr Hitman Subba underwent a short training for exploitation of the salt in Sambar and processing of the brine to get solid NaCl. He took 25 years license to operate the mine after his return from training in 1925. In 1939, Mr Abdul Majeed, inspector of salt development, Kalabag, visited the area and suggested for consulting a geologist. In 1949, Shree Bagsingh Lamba, geologist and mine superintendent of central excise and salt development, Kalabagh, visited the area and carried out extensive survey of the salt occurring areas.After his survey, He ruled out the possibility of getting salt in Thakkhola area.

Tater, JM and Sthapit , HR (1960) visited the area and concluded that the salt deposit does not seem to be a large deposit.

Tshering, LD and Bhandari, AN (1973), did investigation of the brine sources of the area and opined that the salt solution transported in the past are trapped as connate salt in the recent sediments. The chemical analysis report is shown in Table 1.

Table 1: Chemical analysis report.

Sample no	Total chloride%	% NaCl	%KCl	%Cl	%Ca	%Mg
S	0.046	-	-	-	-	-
S3	1.896	1.319	0.577	1.18	0.565	0.162
S5	1.543	1.075	0.467	0.978	0.505	0.111
S6	1.554	1.057	0.497	1.004	0.665	O.148
S7	1.652	1.123	0.529	1.03	0.633	0.181
S8	0.86	-	-	0.521	0.26	0.153
S9	0.518	0.358	0.160	0.329	0.388	0.07
S10	0.371	0.252	0.119	0.232	0.176	0.167
N2	4.925	3.41	1.515	3.14	1.13	0.296
N2	4.978	3.42	1.558	3.13	1.13	0.296
N3	3.804	2.631	1.168	2.46	1.114	0.221
N3	3.836	2.668	1.168	2.48	1.08	0.233
AN1	4.289	2.938	1,351	-	-	-
BN1	4.292	2.974	1.313	-	-	-
G1	96.62	68.18	28.44	29.01	0.78	0.079
G2	0.065	-	-	0.0312	0.004	0.107
C1	88.12	63.88	24.24	44.3	0.29	0.14
C2	86.98	65.24	21.74	40.31	0.754	1.4
N2	91.88	68.62	23.26	55.42	0.84	0.057
S4	93.44	70.28	23.46	56.61	2.202	0.011
S1	-	-	-	0.026	0.18	0.072
N1	-	-	-	2.65	1.24	o.26
N1	-	-	-	2.71	1.3	0.265

Bashyal, RP (1976) did geological investigation of the salt occurrences in Nursing khola. The collected sample analysis results of salt have been presented. He postulates that the brine solution came out of the cracks and fissures of the conglomeratic zone of Triassic Jomsom Limestone. The flow rate per minute was 550-600cc. the brine solution contains 3%NaCl and 1% KCl on average. He recommended 200-300ft drilling in 3 holes with gravitational survey to locate the salt occurrence.

Aryal, RK (1985) did preliminary reconnaissance survey for salt occurrence in Nursing khola area. He noticed marly beds of variable composition from argillaceous, calcareous and gypsiferous. He recommended detail geological mapping at the scale of 1:10000 scale, study the depositional environment, systematic geochemical sampling. The cracks and joints should be occasionally cleaned as they have series of stalagmites in the walls of the drifts and audits, to increase the flow rate of the brine. He collected 5 samples of brine and analyzed for Na and K. Chemical analysis results are give in Table 2.

Table 2: Chemical analysis results

Sample no.	Specification	% total Cl	%NaCl	%KCl	% Na	%K	%Ca	%Mg
RA/NK1	Salt Encrustations	1.33	2	0.15	5	<0.08	-	-
,, 2	,,	0.09	0.1	<0.05	0.05	0.03	-	-
,, 3	,, Narsing Khola Audit	57.6	93.7	2	37.5	1.6	-	-
NS4	Brine Tetang	2.71	o.1	3.7	0.05	1.96	<0.1	<0.1
NS5	Brine Narsing Khola	1.22	1.6	0,09	0.64	0.05	<0.1	<0.1

GEOLOGY

The Thakkhola-Mustang Graben is an extensional basin in Nepal. This graben is a part of normal faulting system. Thakkhola-Mustang Graben lies on top of the Paleozoic to Cretaceous rocks of the Tethyan sediments. The Mustang-Mugu leucogranites lies to the northwest of the graben. The study area covers the parts of Tethys sediments and Thakkhola graben fill sediments. The Higher Himalaya crystalline crop out in the southern part beyond the study area. The rocks of the Tibetan-Tethys Zone consist of a thick marine sedimentary succession. In this study, lithostratigraphy for the area is given in Table 3 based on Hurtado 2001 and Colchen 1986.

Table 3: Lithostratigraphy of the area

Group	Formation	Lithology	Age
Thakkhola Graben fill Sediments	Thakkhola Formation	Lacustrine siltstone and coarse clastic rocks	Pliocene (8-2Ma)
	--------------------------------Angular Unconfirmity--------------------------------		
	Tetang Formation	Lacustrine siltstone and coarse clastic rocks	Miocene (10.6-9.6Ma)
--Angular Unconformity--------------------------------			
Tethys Sediments	Chukh Formation	Volcanic derived micro conglomerate sandstone and carbonates	Lower Cretaceous
	Spiti Formation	Dark gray to black shale with ammonites	Upper Jurrassic
	Lumechella Formation	Alternation of gray limestone with gray shale and sandstone	Middle Jurrassic

Hurtado 2001, Colchen 1986

THAKKHOLA GRABEN FILL SEDIMENTS

Tetang Formation: This formation crops out in the Tetang village area of southern part of the Thakkhola graben. It consists of siltstone, sandstone and conglomerate with quartzite, limestone, phyllite, shale, sandstone and granite gravels derived from the surrounding areas. The north facing beds of Tetang Formation are well exposed nearby Tetang Village (Photo-1). It is considered to be formed in braided and lacustrine environments. It is unconfirmably overlies Tethys sediments (Figure 1, Table 3).

Thakkhola Formation: This Formation crops out in the whole region north of the Chhusan area, Figure 1. It consists of lacustrine deposits consisting of massive siltstone with mudstone alternating with carbonate layers. Lower parts of the Thakkhola Formation consist of oxidized conglomerate, sandstone and siltstone beds exposed at the Chhusan area (Photo 2). It unconfirmably overlies the Tetang Formation. It is considered to be formed by the northward shift of basin. The thickness of the formation is more than 700m.

TETHYS SEDIMENTS

Lumechella Formation: Lumechella Formation crops out in the Nursing khola area. The beds are exposed along the Khola section. The beds are dipping due NW with dip amount of 32-430. It consists of alternation of gray limestone with gray shale and sandstone. The dominant lithology is limestone with gray tone alternating with gray nodular shale. The salt occurrence lies in this formation (Figure 1). The geological section shows location of salt occurrence in the area. The altitude of the salt occurrence is about 3100 to 3160m.

Spiti Formation: The Spiti Formation crops out in the south western part of the area around road section from Chusan to Kagbeni and northern part of the Kagbeni area (Figure 1). It consists of dark gray to black shale with ammonite fossils.

Chuk Formation: The formation crops out in the southwestern part of the study area along the road section from Chusang to Kagbeni (Figure 1). It consists of conglomerate, sandstone and carbonates.

PROSPECT GEOLOGY

Salt Occurrences are in the limestone and shale of Lumechella Formation. There are 7 brine springs in the area (Figure 1). The water coming out of the spring is salty. The salt crystals are seen on the floor, side and hanging wall of the cave. The water in the cave is collected and sampled for analysis. The production of the salt was about 8-10 tons per year according to the locals. The thin to medium bedded gray sandstone beds of the Lumechella formation are cropping out in the scarps of Nursing khola section, Photo-3. Similarly, cross cutting calcite veins in the gray limestone beds are found in the Nursing khola section, Photo-4.

Photo 1: Alternation of conglomerate, sandstone and siltstone beds, Tetang Formation, Tetang village

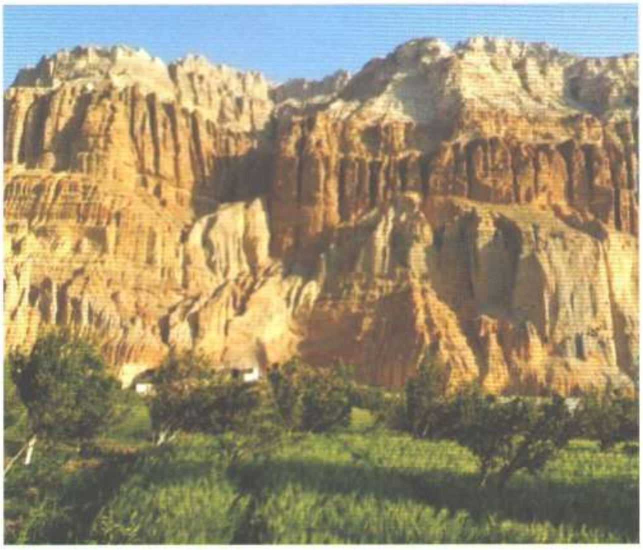

Photo 2: Oxidized beds of sandstone and siltstone, basal part of Thakkhola Formation, Chhusang

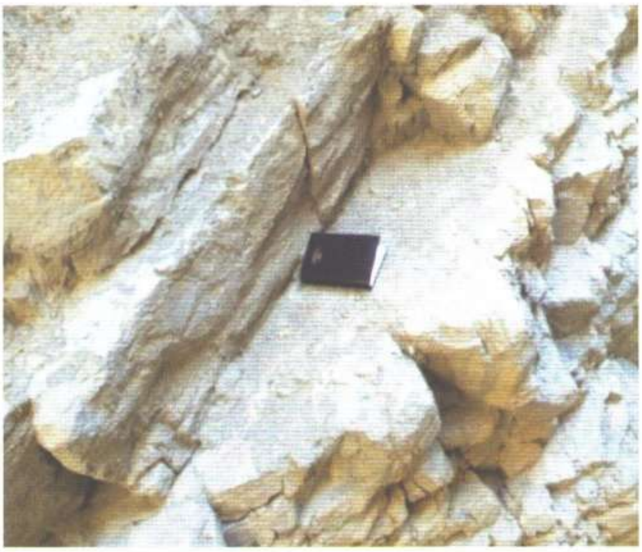

Photo 3: The close view sandstone beds of Lumechella Formation, Nursing Khola section

Photo 4: A close view of limestone with cross cutting calcite veins, Lumechella Formation, Nursing Khola

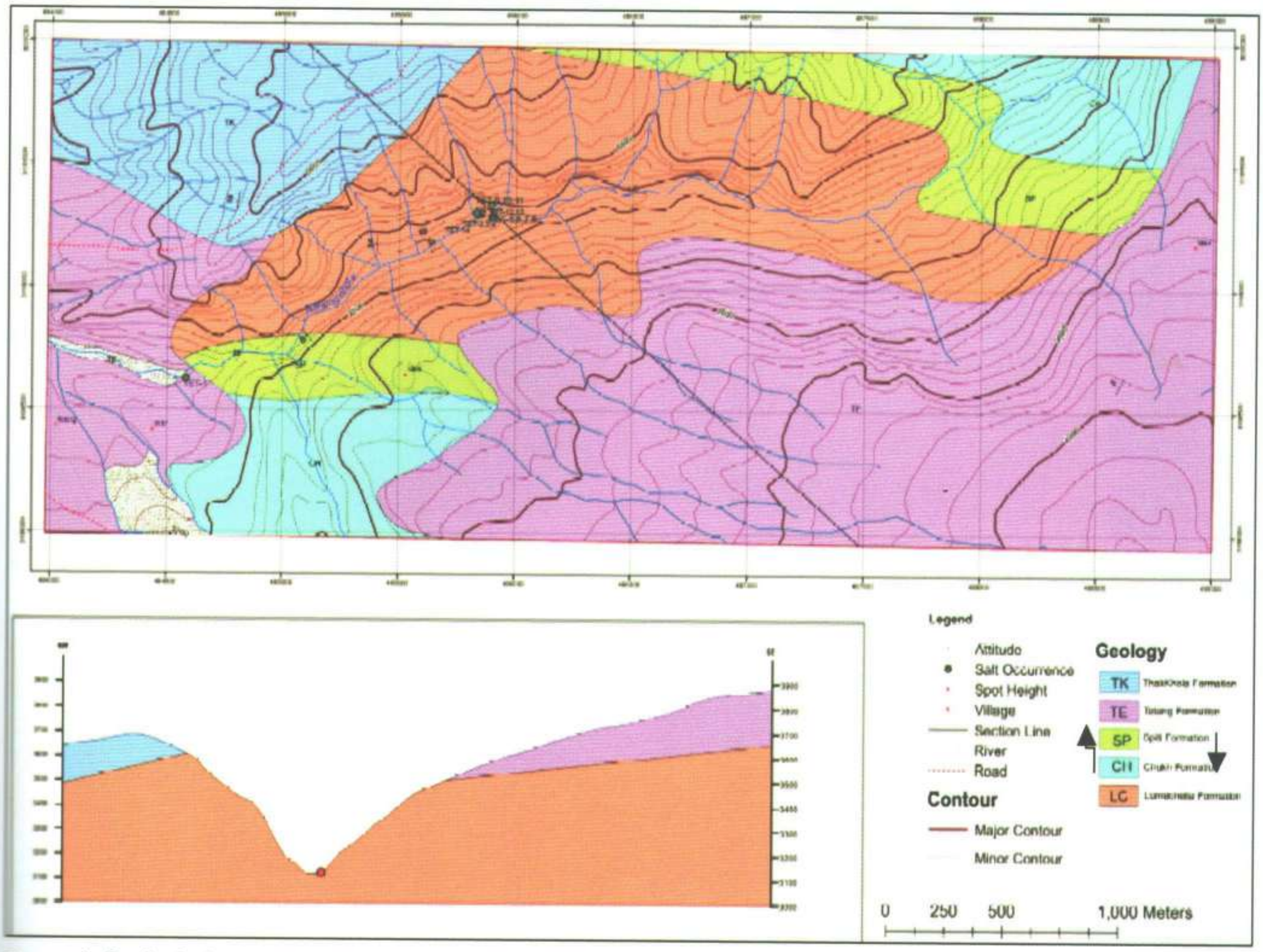

Figure 1: Geological map and section of the prospect area

SAMPLING

The rock chip samples and brine samples location has been given in Figure 1, Table 4. Altogether 13 samples were collected.

Table 4: Sampling

Rock Samples	Description
Rock Chip Samples	
TET-3	Salt
TET-4	Outcrop
TET-7	Outcrop
TET-8	Salt
TET-11	Salt
TET-12	Gypsiferous shale
TET-13	Gypsiferous shale
Brine Samples	
TET-1	Brine
TET-2	Brine
TET-5	Brine
TET-6	Brine
TET-9	Brine
TET-10	Brine

The brine water springs, surrounded by ammonite fossils, at the left side of the Nursing Khola near Tetang village have been sampled as TET-1 for analysis. The colour of the brine is light yellow. The taste is salty. People are using this as a traditional medicine, photo-5. The flow rate of the salt is high in the winter and low in summer. The taste of salt is more salty in summer as flow rate diminished in this season. The brine evaporation ponds were constructed at left bank of the Nursing khola, nearly 100m downstream from the 1stbrine cave-1 [TET-2,3,4], photo-6. The ponds were used for evaporation and collection of salt in summer season, inundated and collapsed due to bank erosion. Salt encrustrations in the conglomerate cover over the limestone cave -3 [TET-5,6,7,8] have been studied, photo 7. The conglomerate cover was due to the collapse of Thak khola Formation conglomerate and surface covered by brine water from the upper level [cave-4,5], [TET-9,10,11]. The salt encrustrations in the conglomerate cover and brine within the limestone beds cave are seen at the right side of the Nursing Khola, photo 8. The brine is within the Cave -2, limestone host rocks, right bank of Nursing Khola, photo 9. The salt encrustrations in the walls of the conglomerate have been observed in the right side of the Nursing Khola near cave 2,3 photo 10. The limestone beds with spheroidal shale have been observed from Nursing khola section, photo

11. The brine water collection ponds, abandoned, are at the right bank of the Nursing khola, photo 12. The brine water caves 4,5,6 Nursing khola, photo 13, [TET-9,10,11] and photo 14 shows the location of brine water cave -7 site. There seems to be a gypsiferous? Shale beds at the right side of Nursing khola near cave 3, photo 15, [TET 12,13]. The Nursing Khola makes deep incision through limestone beds, photo 16.

GEOCHEMISTRY

Rock and brine geochemistry to ascertain grade characteristic are awaited till results of chemical analysis. The available chemical analysis results in the past shows 93.7% NaCl from Nursing Khola salt encrustations, Aryal 1985, and 70.28% NaCl from sample of salt, Tshering 1973.

QUALITY AND QUANTITY

The chemical analysis results, Tshering 1973, shows that NaCl ranges from 0.358% to 70.28% in salt samples and brine. Similarly, the KCl concentration ranges from 0.119% to 28.44% in salt samples and brine samples. The concentration of Cl ranges from 0.026% to 56.6.The chemical analysis results, Aryal 1985, show that NaCl is 93.7% in salt encrustation sample and 2.71% in brine sample. The flow rate of brine seems to be 1-3 liter per hour from the caves. The annual production of salt during mining period was about 80 MURI ie about 10,000kg.

CONCLUSIONS AND RECOMMENDATIONS

The geological map of the study area at the scale of 1:10,000 has been prepared. There are 7 small caves within the limestone beds having brine water. The water brine spring at the base of the Tetang village has been traditionally used as medicine. A total of 11 samples were collected from the wall rock, salt and brine. The chemical results are awaited. The common salt in the area has a small quantity. The quality shows that the salt has concentration of NaCl along with KCl.

The salt occurrence in this area lies within the limestone beds of Lumechella Formation. The springs at the base of the slope in the right side of the Nursing Khola has brines coming out of the fracture pores and collected in small caves. The conglomerate cover in the area is slope collapsed part of the Thakkhola Formation from the ridge area. The spring water flows through it and wash over the conglomerate beds resulting salt encrustations on it. The limestone beds show salt encrustations from the Tetang village area around the Nursing Khola gorge. This shows that the small pockets and layers of salt might have been deposited during depositional period along with alternating limestone beds, are now re-circulated with ground water, below water table, forming brines in the caving parts in the inclined beds. It shows that there is almost no possibility of finding large salt deposit in the area.There is a possibility of finding gypsiferous ? shale nearby brine seeps outcrop. The analytical results are awaited to test it.

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Photo 5: Spring of brine water, ammonites, left side of Nursing Khola, Near Tetang village

Photo 8: Salt encrustation in the conglomerate cover, the brine is within the limestone beds, right side of Nursing khola

Photo 6: The brine evaporation ponds to collect salt, inundated and bank erosion, left bank of Nursing Khola

Photo 9: The brine is within the cave 2, limestone host rock, right side of Nursing Khola

Photo 7: Salt encrustation in the conglomerate cover, the brine is within the cave-3having fractured limestone, right side of Nursing Khola

Photo 10: Salt encrustations in the walls, right side of Nursing khola

Photo 11: Limestone beds with Speroidal shale, Lumechella Formation, Nursing Khola

Photo 12: Brine water collection pond, Cave 2,3, right side of Nursing Khola

Photo 13: Brine water in caves 4.5.6, right side of Nursing khola

Photo 14: Brine water in cave 7, right side of Nursing Khola

Photo 15: Gypsiferous? shale beds, right side of nursing khola

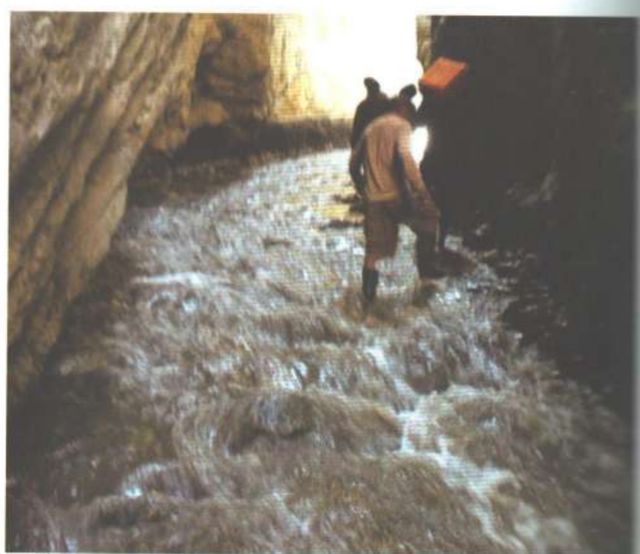


Photo 16: Nursing Khola incision through limestone bed

Geology and Ground Radiometric Survey for U/Th Prospecting and Radiation Hazard Mapping in Parts of Shivpuri Area, Northern Part of Kathmandu Valley

Dharma Raj Khadka (Senior Divisional Mining Geologist), **Madhav Lamsal** (Geologist)

ABSTRACT

The field program based on DMG/IAEA TC Project NEP 2004 for the prospecting of U and Th and radiation hazard mapping in parts of Shivpuri area of northern part of Kathmandu valley based on geological mapping and ground radiaometric survey using Scintillation Counter BGS-1S and Gamma Ray Spectrometer RS 125 over an area of 50 sq. km. has been completed. A total of 104 instrumental data were recorded along with lithological database. The geostatistical analysis and radiation hazard assessment were carried out of the area based on the collected data. Geologically, the study area comprises Shivpuri gneiss, Neoproterozoic Kulekhani Formation consisting of metasandstone of Bhimphedi Group of rocks and Kathmandu Basin sediments consisting of clay, silt, sand and gravel beds of Gokarna Formation and Tokha Formation of younger basin fill of late Pleistocene age. The ground radiometric survey gave instrumental values of U(ppm), Th(ppm), K%, RI (cps) and Absorbed dose rate uGy/hr. Each data were presented with GPS locations. The data were plotted to prepare anomaly maps. Geostatistical analysis were carried out using histogram to calculate min, max, mean, standard deviation, skewness and kurtosis of U, Th, K, RI (cps) and Dose rate . A semivariogram was plotted for U and dose rate. The intensity prediction map was prepared using simple kriging operation. The data shows that the maximum U content was 33.4 ppm (L-3), Th 295 ppm (L-102) in tourmaline granite and weathered gneiss from Sanla area. The Tyuyamunite mineral i. e. weathered uraninite mineral was identified from the temple area of Dharmasthali and Jagat. Absorbed dose rate and Th values are well correlated with coefficient of 0.957 .The anomaly matrix with drainage area 1-2 sq.km. shows that the area is under 3-4 category which is less desirable for follow up prospecting and exploration except few places like Dharmasthali temple area and Jagat area which are susceptible for pegmatite vein type of U mineralization. The radiation hazard analysis was based on the absorbed dose rate uGy/hr data base. Its effects to the biological entities were analyzed using effective dose mSv/yr computed with conversion factors WT and WR. The results shows 1-10 mSv/yr effective dose could be expected from the area. It is recommended that the follow-up prospecting is warranted in Dharmasthali and Jagat areas and national safety standard should be created for radiation hazard.

Keyword: u/th prospecting, radioactive intensity mapping, radiation hazard.

INTRODUCTION

The field program is based on the DMG/IAEA TC project NEP 2004 for prospecting of U and Th and radiation hazard mapping in parts of Shivpuri area of northern part of Kathmandu Valley based on Ground Radiometric Survey for the fiscal year 2073/74. The field work was carried out starting from 2073.11.8 to 2073.11.17 for 10 days. The study area is parts of Toposheet no 2785 06B, 06A and 02C, 1:25000 scale. The area covers about 50 sq. km. It consists of parts of Sanla Khola and Sankhu areas, Figure1.

The Sanla khola area covers over Dhharmasthali, Tokha, Chunigaon, Shivpuri wild life reserve, Thatipipal, Kavregaon, Dalkap, Jhor etc. The Sankhu area covers Brahmakhel, Gagalphedi, Pyakhadol, Khulaltar, Bhumitar, Bhandarigaon, Dhakalgaon, Sundarujal, Indrayani, Salinadi, Manahara Khola, Mahadev khola, Bagmati River etc.

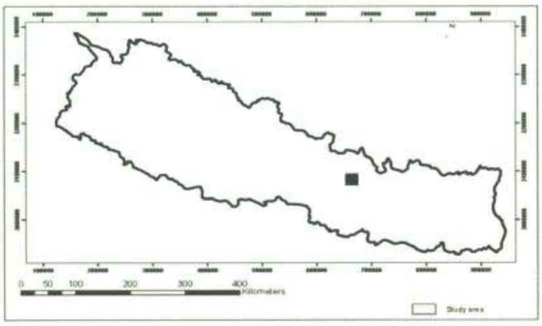


Figure 1: Location map of the study area

The main objective of the study is prospecting U and Th and radiation hazard mapping in parts of Shivpuri area of northern part of Kathmandu Valley. The target area is given in Table 1.

Table 1: Working area.

SN	Toposheet	Districts	Working Area	Total area
1	2785 06 B 2785 02D	Kathmandu	Manahara Khola/ Indrayani, Gagalphedi	21 sq. Km.
2	2785 06A 2785 02 C	Kathmandu	Sangla Khola/ Manamaiju, Phutung	29 sq. Km.
			Total	50 sq. Km.

The methodology consists of desk, field and lab study. Topographic maps, geological map of the area were used as base maps for the prospecting programme. Relevant literature was reviewed before departing the field work. All published and unpublished literature of the area related to the uranium mineralization were reviewed. IAEA publication STI/PUB/434 related to exploration for uranium ore deposits have been reviewed. IAEA-TECDOC-595 related to guidebook on the development of projects for uranium mining and ore processing has been reviewed. Cunney M. and Kyser K. edited short course series (2008), "Recent and not- so- recent developments in uranium deposits and implications for exploration", V 39 by Mineralogical Association of Canada has been reviewed. The field study covers geological mapping and geophysical survey in the area. Geological mapping was carried out based on the ridge and river section walkthrough survey on the topographic base map of 1: 25000 scale. The outcrops were studied with due care to establish the lithological units of the area. Ground radiometric survey was carried out for detecting radioactive beds of the area. To trace the mineralized beds, scintillation counter was used. The respective scintillation counter values were noted down and plotted on the map. The measurement is in a total count value. The gamma ray spectrometer has been used to measure U, Th, K and absorbed dose rate of the area. Arc Map 10.2 was used to prepare maps and sections. Statistical analysis was carried out of the data. After all, collection of primary as well as secondary data has been analyzed. Final report has been prepared along with maps, sections and relevant information. Following works have been completed.

- Geological study over 50 sq. Km.
- Radiation intensity mapping over 50 sq. Km.
- Instrumental data collection from 104 locations
- Geostatistical analysis
- Radiation hazard assessment

ACCESSIBILITY

The area is easily accessible from Kathmandu Center. The road access is as follows-

1. Sanla Khola area

   Kathmandu Center---Balaju----Phutung---Chunigaon----Jhor » 10km

2. Sankhu area

   Kathmandu Center---Jorpati----Thali---Dachhi---Sankhu » 20km

PHYSIOGRAPHY AND DRAINAGE

The Sanla khola area consist of about 1300m height at the valley area and more than 2000m in the Shivpuri Jungle area. Similarly, Sankhu area lies at about 1402m and northern part of it in the Shivpuri wildlife and watershed area consists of about more than 1850m high topography. Sanla khola and its peripheral parts are drained by Bishnumati khola at the east and Mahadev khola at the west. Similarly, Sankhu area is drained by Sali nadi and its tributaries which is also known as Manahari khola downstream. The western part of it is drained by Bagmati river and its tributaries.

PREVIOUS STUDY

Stocklin and Bhattarai 1977, presented geology of the basement rocks which are composed of gneiss, schists, phyllites and limestones of Kathmandu Complex. The northern part consists of gneiss and granite while southern part consists of limestone, marble, phyllite and quartzite of Paleozoic age. Yoshida and Igarashi 1984, carried out stratigraphy of the lacustrine sediments of Kathmandu valley and divided them into eight units in ascending order- Pliocene Lukundol Formation, Pleistocene Pyanggaon Terrace deposit, Chapagaon Terrace Deposit, Boregaon Terrace deposit, Gokarna Formation, Thimi Formation, Patan Formation and Holocene Lower Terrace Deposit. Shrestha et al 1998, classified Kathmandu basin sediments into 7 units in ascending order- Basal boulder bed, Kobgaon formation, Lukundol Formation, Chapagaon Formation, Kalimati Formation, Tokha Formation and Gokarna Formation. Sakai 2001, proposed separate stratigraphic schemes of the basin fill sediments for the southern, central and northern part of the basin. Dill et al 2003, studied infilling history of the younger Kathmandu lake basin sediments during late quaternary period. The Kalimati, Gokarna and Tokha formations were formed during infilling stage of the basin formation. Khan H. R. did radiation intensity mapping in northern parts of the Kathmandu valley using Scintillation Counter. Warner et al 2007, carried out investigation on the groundwater contamination, in Kathmandu valley, by nitrate, ammonia exceeded Nepal guidelines of 45% samples, arsenic and mercury exceed by 10% of samples as per WHO guidelines. Girault et al 2011 carried out measurement of effective radium-226 concentration in soil samples from northern part of Kathmandu valley representing Thimi, Tokha and Gokarna Formations. The effective Radium Concentration (ECRa) from the samples was 0.4 to 43 Bq kg-1 .The radon concentration in dwellings can potentially exceed the level of 300 Bq m-3 for residential areas, a fact that should be seriously taken into account by the governmental and concerned agencies.

REGIONAL GEOLOGY

Geologically, Kathmandu sedimentary basin is a bowl shaped large synclinal intermountain tectonic basin. It lies within the Kathmandu Nappe. The Kathmandu Nappe is composed of crystalline rocks of Bhimphedi Group of Neoproterozoic age overlying with Paleozoic Phulchauki Group of rocks of Tethys sediments affinity in the south and northern part consists of Shivpuri gneiss,Fig-2. The northern slope of the basin consists of medium to coarse grained augen gneiss, banded gneiss, and granitic gneiss with mica schist with intrusion of tourmaline bearing massive granite and pegmatite bodies. The radioactive bands and lenses are present in gneiss, granite and pegmatite bodies. The central part of the valley consists of Phulchauki Group of rocks represented with limestone, slate, marble, metasandstone etc. The basin is filled with upper Pliocene to Quartarnary clay, silt, sand and gravel (Sakai, 2001), Figure 3. Two radioactive zones ie Sanla Khola area and Sankhu area were identified in the northern parts of the Kathmandu Valley around Shivpuri lekh and valley floor sediments, Figure 2.

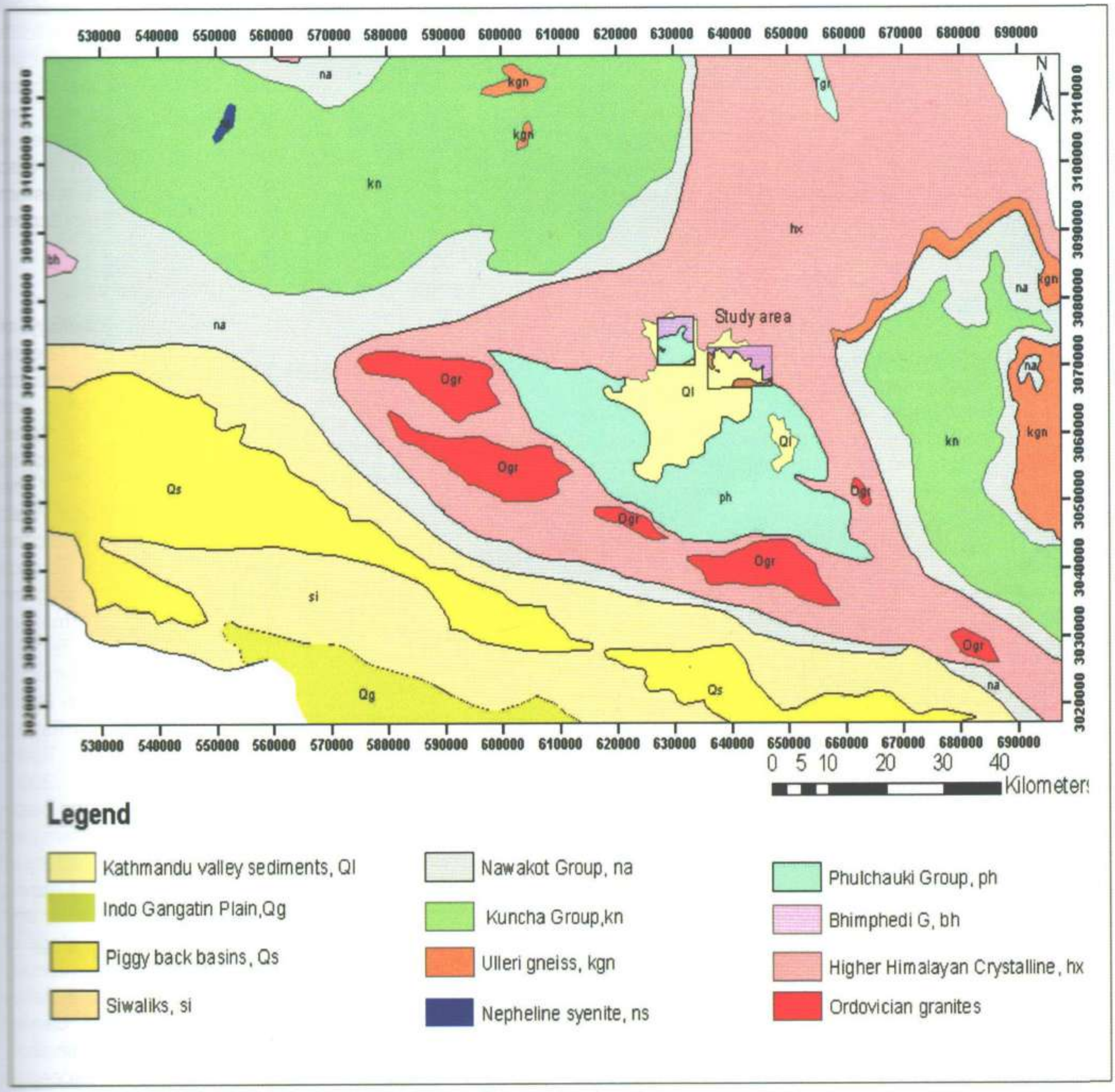


Figure 2: Regional geological map of the area, modified after DMG, 1994.

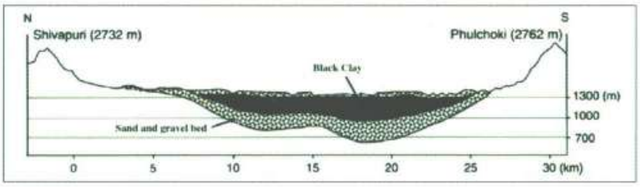


Figure 3: Schematic Geological section N-S , Kathmandu Valley, Sakai, 2001.

LESSER HIMALAYA

In central Nepal, the Lesser Himalaya is divided into two groups, Lower and Upper Nawakot Groups of Proterozoic age. The Kuncha group consisting of Kuncha Formation, phyllite and quarztites, is the oldest formation so far found in Lesser Himalaya in Nepal. The base of the Lesser Himalaya is nowhere exposed in Nepal. The Nawakot Group represented with Fagfog, Dandagaon, Nourpul, Dhading dolomite formations consisting of quartzite, phyllite, ferrogenous quartzite, metasandstone and dolomite are the rocks of this group. The Upper Nawakot Group consists of Benighat Slates, Malekhu Limestone, Robang Phyllites in ascending order. The rocks are exposed around the Kathmandu Valley. The Ulleri augen gneiss and basic rock amphibolites are found intruded.

KATHMANDU NAPPE

The Kathmandu nappe is composed of the rocks of Kathmandu Complex which is divided into Bhimphedi Group and Phulchauki Group. The Bhimphedi group has been considered as of Neoproterozoic in age and Phulchauki group of Paleozoic age. Bhimphedi Group consists of Raduwa, Bhaisedobhan marble, Kalitar, Chisapani Quartzite, Kulekhani, Markhu and Tistung formations represented with garnet schist, marble, biotite-muscovite schist, quartzite, metasandstone, limestone intruded with Ordovician Granites. The unconfirmably overlying Phulchaki group consists of fossiliferous sedimentary rocks like limestone, slate, hematite, metasandstone etc. It consists of Sopyang, Chandragiri, Chitlang, and Godavari Formations in ascending order.

SHIVPURI GNEISS

It crops out in the northern part of the Kathmandu valley aroud Shivpuri Lekh area. The northern slope of the basin consists of medium to coarse grained augen gneiss, banded gneiss, and granitic gneiss with mica schist with intrusion of tourmaline bearing massive granite and pegmatite bodies.The Mahabharat Thrust (MT) separates the Bhimphdi group of rocks with the Nawakot group of rocks. The Kathmandu valley is a synclinal basin.

KATHMANDU SEDIMENTARY BASIN

The sedimentary basin was studied by Yoshida and Igarashi in 1984 and divided stratigraphically into Lukundol F, Pyanggaon Terrace deposit, Chapagaon Terrace deposit, Boregaon Terrace deposit, Gokarna Formation, Thimi Formation and Patan Formation in ascending order. Shrestha et. al. 1998 carried out engineering and environmental geological studies in the sediments and proposed units like Tarebhir Basal Gravel, Nakhukhola Mudstone ans Kaseri–Nayankhadi Lignite, Champi-Itahati Gravel, Kalimati Clays in ascending order. Sakai, 2001 divided central part into Bagmati Formation, Basal Lignite Member, Kalimati Formation and Patan Formation. The age of the basin was considered to be of Plio-Pleistocene to Holocene. The age of the Lukundol Formation was measured with Gauss chron i.e. older than 2.58Ma by Yoshida and Igarashi, 1984. The valley sediments consist of varying proportions of clay,-mud, silt, sand and gravel. The drilling data of Kathmandu valley suggests that the basement topography is irregular. The depth of the sediments varies from > 550m to about 300m at places from central to peripheral parts Figure 3.

The present study area lies in the northern part of the Kathmandu valley consisting of mostly Shivpuri gneiss, Bhimphedi group of rocks represented with Kulekhani Formation quartzites and basin fill sediments represented with Gokarna Formation and Tokha Formation. The radioactive beds and saprolites are recorded from the Shivpuri gneiss and valley floor sediments.

PROSPECT GEOLOGY

The Sanla Khola and Sankhu areas were identified as radioactive zones in the northern parts of valley using BGS 1S Scintillation Counter and Gamma Ray Spectrometer RS-125. The prospect geology of the areas is presented below.

SANLA KHOLA AREA

The Sanla Khola area consists of Shivpuri gneiss, Kulekhani Formation of Bhimphedi Group and Basin sediments represented with Gokarna Formation and Tokha Formation, Figure 4.

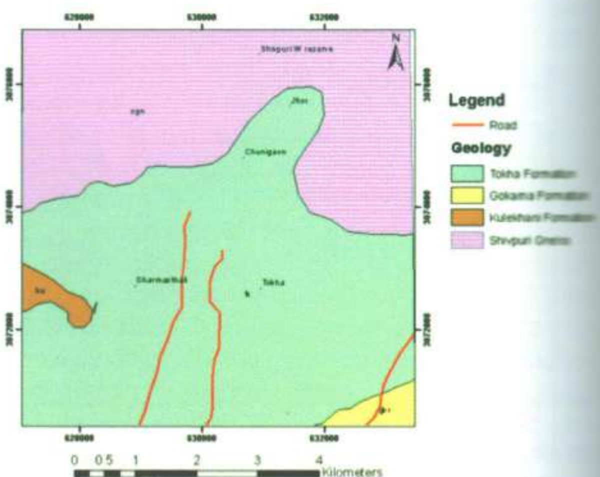


Figure 4: Geology of Sanla Khola area

SHIVPURI GNEISS

The Shivpuri gneiss crops out in the Kavresthali and Jhor gaon areas, Figure 4,5. It crops out in the Kavresthali such as Lamichane gaon, Sanla, Allegau, Kuchipakhel, Upper parts of Chunigaon and Salle areas. The gneiss terrain consists of banded gneiss and augen gneiss. The deep weathered outcrops of gneiss form residual soil, saprolite. The outcrops are moderately to deep weathered banded and augen gneiss. A weathered granite outcrop is observed in the banks of the stream east of Sanla L-24. The weathered gneiss bands are seen at the road cut section of Salle, Photo 1-4. The gneiss outcrops are cross cut with pegmatite veins and bodies which area clearly seen at the Salle area, L-15, Photo 5. They are radioactive at places. The Radiation Intensity was measured in each location, Figure 4,5.

The pegmatite veins have Tyuyamunite mineralization which can be seen on the outcrop of pegmatite veins in Sanla khola and Jagatgau areas. The high grade metamorphic rocks which are represented with paragneiss and orthogneiss as well as mica schist can be seen at places. The augen gneiss is composed of quartz, feldspar, biotite, muscovite and tournmalin. The strong gneissocity is defined by mica layering in banded gneiss and augen gneiss.

BHIMPHEDI GROUP

The Bhimphedi group is represented with Kulekhani Formation in the study area. Kulekhani Formation crops out in the Pahareganesh area of Dharmasthali in the south western part of the study area. The beds are dipping due SW, L-21, 22. It consists of greenish gray metasandstone, Figure 4 and Photo 6.

KATHMANDU SEDIMENTARY BASIN

The Kathmandu Sedimentary basin is a fluvio lacustrine synclinal basin. The basin infilling was a result of dynamic tectonic environment in the region from Pleistocene to Holocene. The study area consists of younger basin fill sedimentary units Gokarna Formation and Tokha Formation.

GOKARNA FORMATION

The Gokarna Formation spreads over south eastern part of the study area nearby Dhapasi and Hepaligaon and Galphutar areas, Figure 4, 5. It consists of alternating dark gray and gray silty mudstone and micaceous fine sand. It has coarsening upward grain size. It has dark silty musdtone at the basal part and sandy beds at the top part. It has channel sands probably sourced from NE. It is very close to the basin edge in front of the crystalline basement of Shivpuri Lekh. It has widespread lense shaped gravel beds inter-bedded with silty mudstone. The age of the formation is considered to be of 28,000-30,000 yr BP (Dill et al, 2003).

TOKHA FORMATION

The Tokha Formation crops out more than half of the study area, Figure 4. It covers over Dharmasthali, Tokha, Phutun, Tokha Chandeshwori, Sanla khola

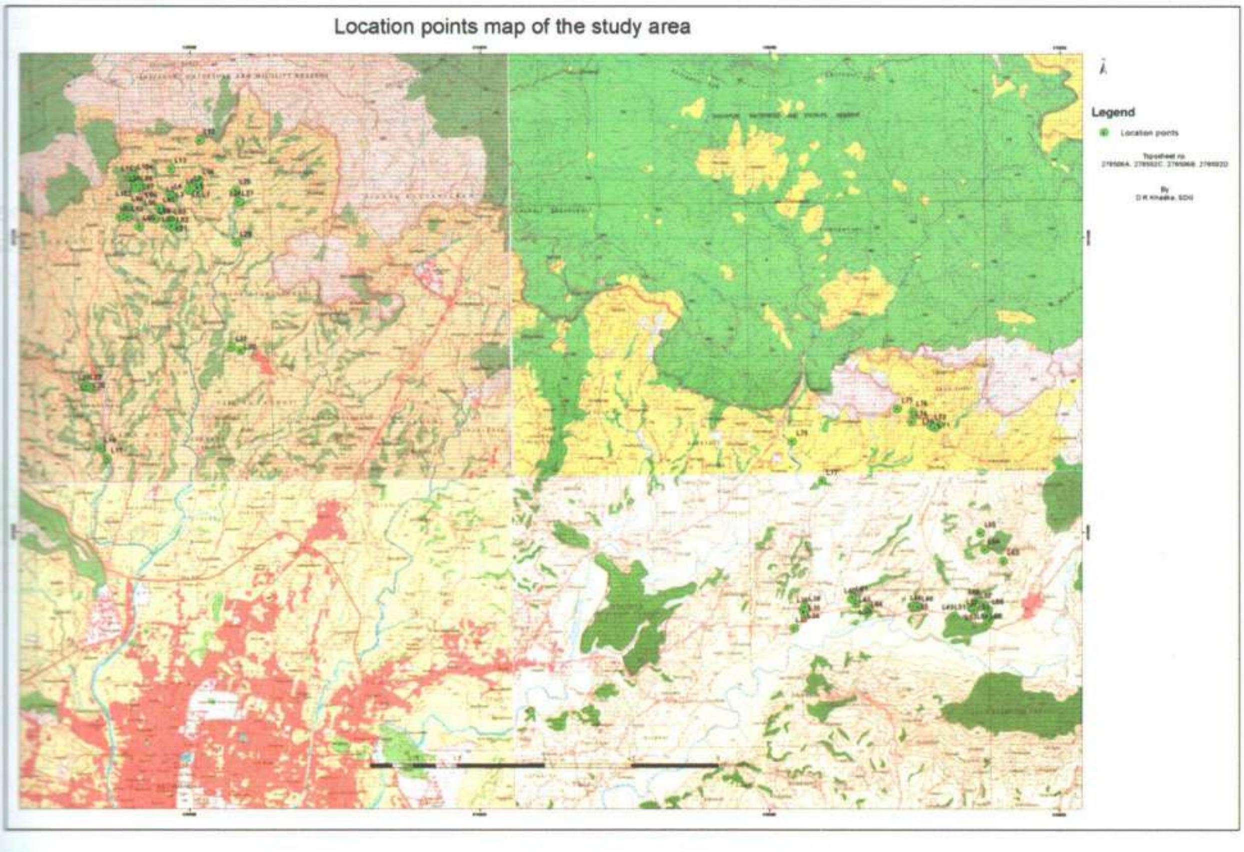


Figure 5: Location points map of the study area

area and Mahadev Khola tributaries etc, Figure 5. The alluvial fan deltas dominated by braided streams of detrirus are found in the proximal part and fine sand and silt and clay at the distal parts. The black mudstone with ferrous concretions from mm to dm in size is seen on the outcrops at the lower sections. It consists of black and gray silty mudstone, silt, micaceous fine to coarse grained sand and gravel bed. It also displayed ripple cross laminations at places. The age of the formation has been considered to be of 19000 yr BP, Dill et al 2003.

SANKHU AREA

The Sankhu area consists of Shivpuri gneiss, Kulekhani Formation of Bhimphedi Group and Basin sediments represented with Gokarna Formation, Figure 6.

bands are seen at the road cut section of Gagalphedi, Photo 15, 18. The gneiss outcrops are cross cut with pegmatite veins are clearly seen at the Gagalphedi road cut section, Photo 17. They are radioactive at places. The Radiation Intensity was measured in each location, Figure 5. The augen gneiss is composed of quartz, feldspar, biotite, muscovite and tourmaline.

BHIMPHEDI GROUP

The Bhimphedi group is represented with Kulekhani Formation in the study area. The Kulekhani Formation crops out in the Adhikarigaon which is SW of Mulpani in the western part of the study area. It also crops out in the Changunarayan and Chhapadada areas in the southern part. It consists of thin to thick bedded, greenish gray to gray metasandstone, Fig-5, 6.

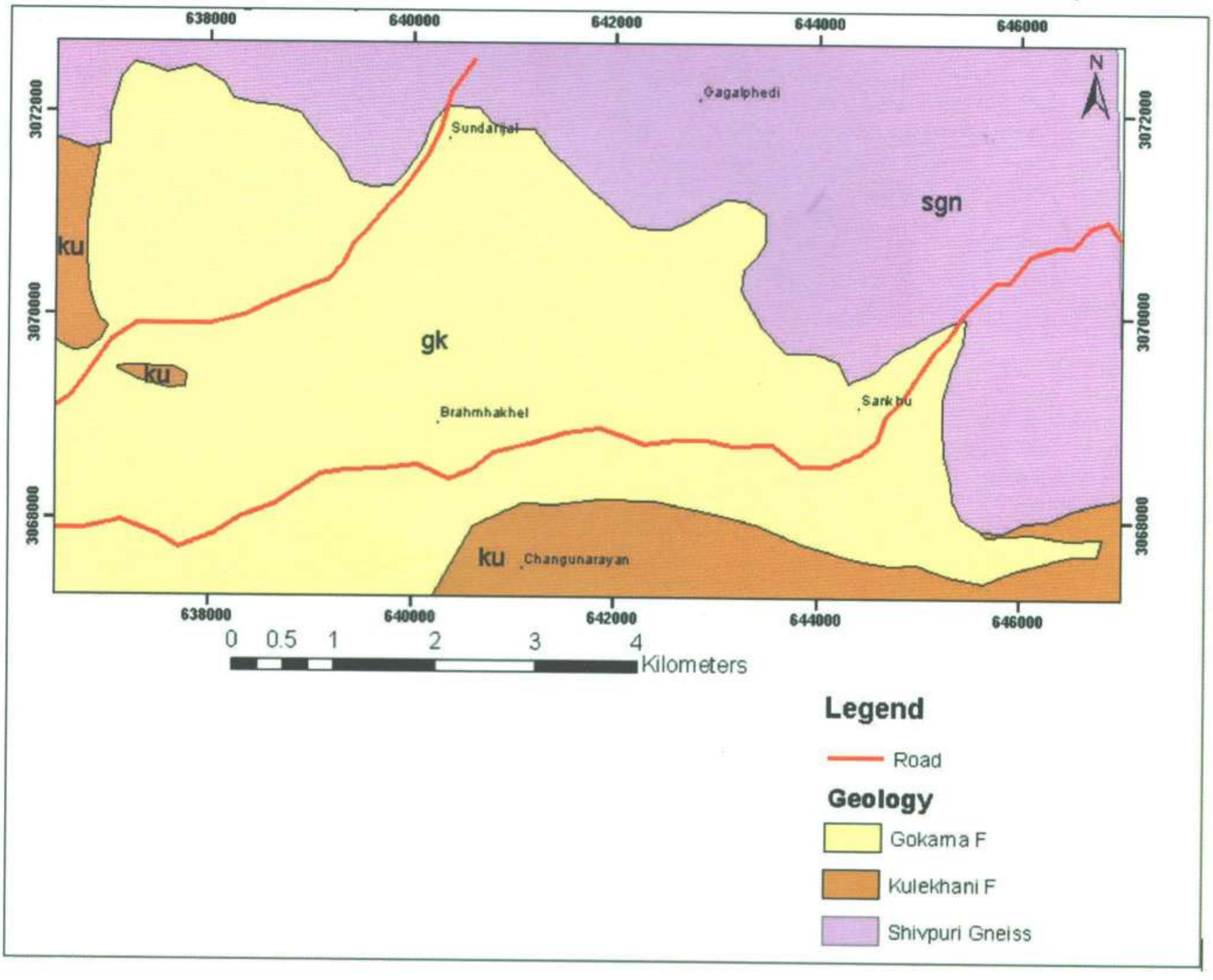


Figure 6: Geology of the Sankhu area

SHIVPURI GNEISS

The Shivpuri gneiss crops out in the Galgalphedi and Sakhu Bajrayogini areas, Figure 5,6. The gneiss terrain consists of banded gneiss and augen gneiss. The deep weathered outcrops of gneiss form residual soil. The outcrops are moderately to deep weathered banded and augen gneiss. The weathered gneiss

KATHMANDU SEDIMENTARY BASIN

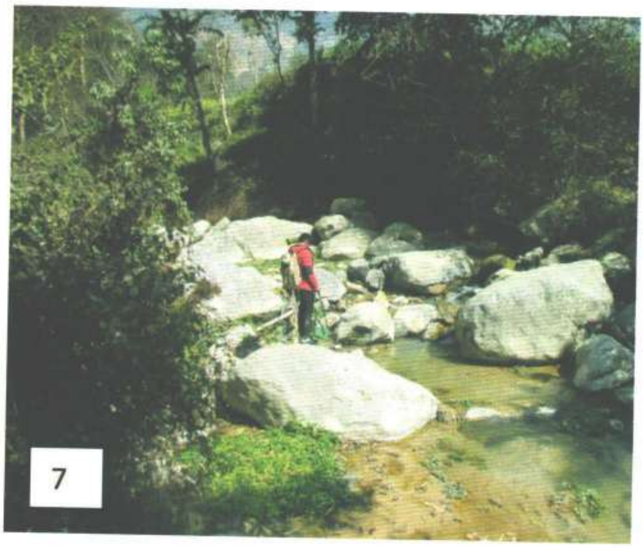
The study area consists of younger basin fill sedimentary unit of Gokarna Formation.

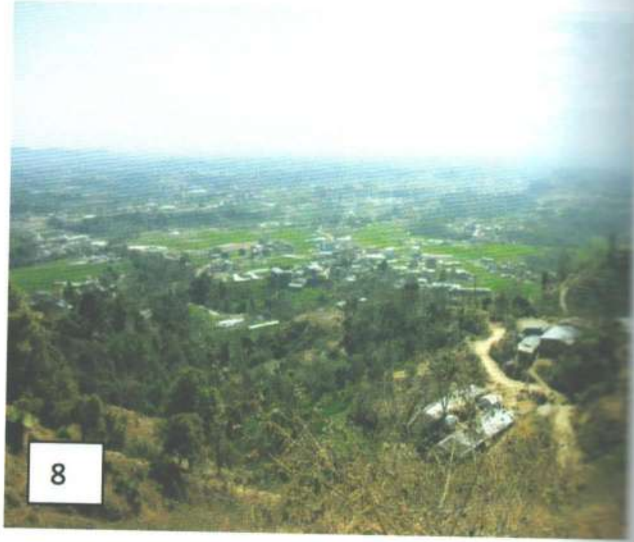
GOKARNA FORMATION

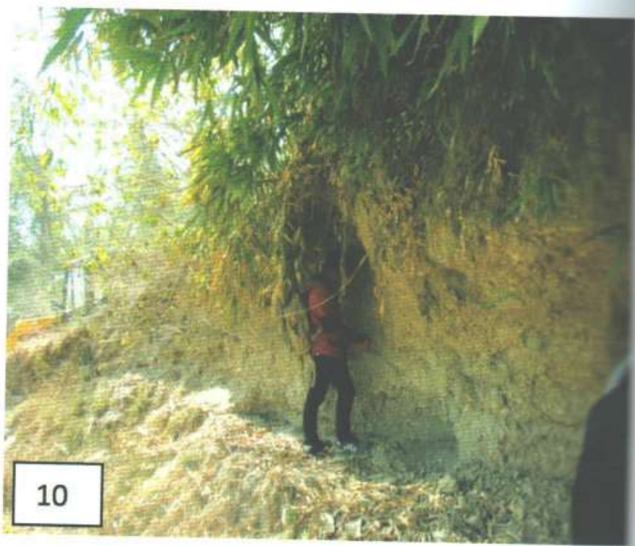
The Gokarna Formation spreads over central part of the study area nearby Sali nadi, Manahara Khola area, Brahmakhel, Pyakhadol, Indrayani, Gagalphedi, Allapot ad Sndarijal areas, Figure 5, 6. It consists of alternating dark gray and gray silty mudstone and micaceous fine sand. It has coarsening upward grain size. It has dark silty musdtone at the basal part and sandy beds at the top part. It has channel sands at places. It is very close to the basin edge in front of the crystalline basement of Shivpuri Lekh. It has widespread lense shaped gravel beds interbedded with silty mudstone. The age of the formation is considered to be of 28,000-30,000 yr BP (Dill et al, 2003).

An interbeddings of black clay and sand beds are shown in Photo 9. The radioactive sand layers are seen at Brahmakhel area, Photo 10, L-32. Interbeddings of black clay and sand beds are clearly seen on the sand minig area of L-38, Photo 11. Radioactive sandy soils are recorded at L-57, Photo 12. The flat plain of Sankhu area consists of clay, silt and sand beds of Gokarna Formation, Photo 13, 14. The radioactive sand beds are seen at Pyakhadol, Photo 16, Figure 5,6.

Photo 1) Weathered gneiss, upper part of Salle, L-3. 2) Weathered gneiss, upper part of Salle, L-3. 3) Weathered augen gneiss, road cut section, Kuchipakhel, L-13. 4) Weathered augen gneiss, road cut section, Salle, L-14. 5) Weathered gneiss cross cut with pegmatite vein, Salle, L-15. 6) Metasandstone of Kulekhani Formation, Dharmasthali, L-21.







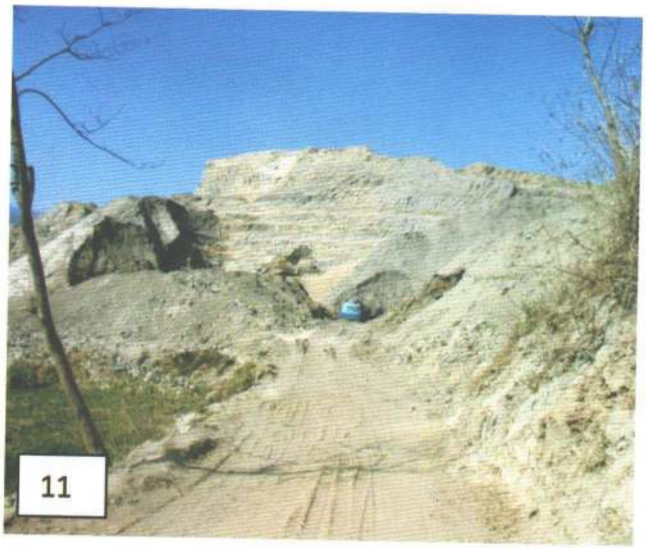
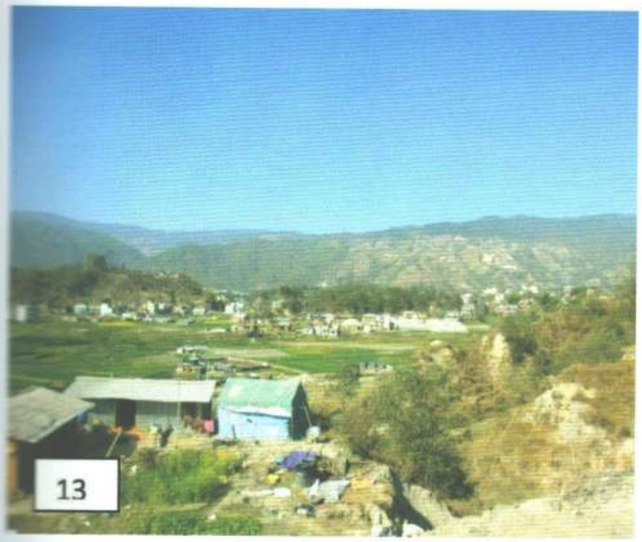
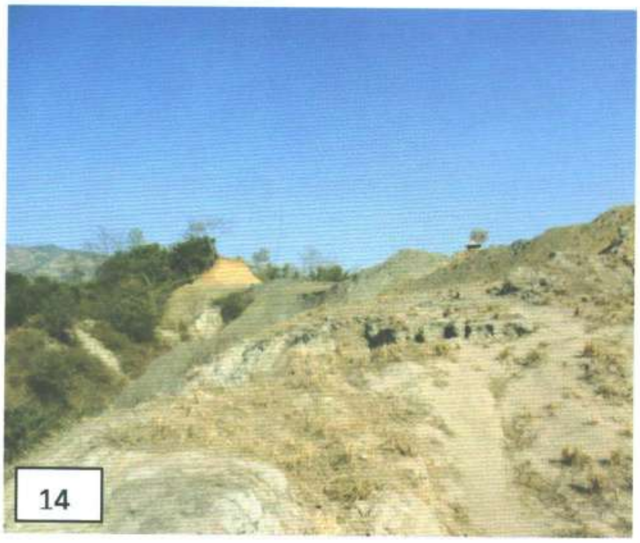


Photo 7) Gneiss boulders, Sanla Khola, L-23. 8) A view of Jhor area from Shivpuri Lekh. 9) Interbedings of black clay and sand beds, Brahmakhel, L-32. 10) Radioactive sand layers, Brahmakhel. 11) Interbedings of black clay and sand beds, L-38. 12) Medium to coarse sand beds L-57.





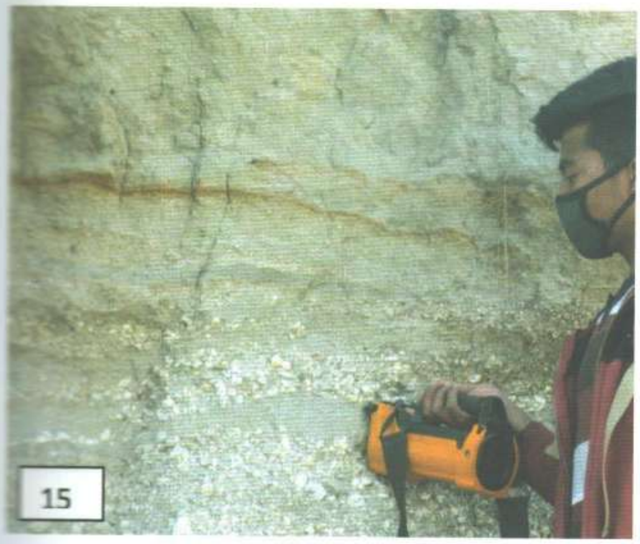


Photo 13) A view of parts of Sankhu area. 14) Interbeddings of sand and clay beds, L-49. 15) Radioactive beds at road cut section, upper part of Sankhu, L-62. 16) Radioactive soil beds, Pyakhadol. 17) Radioactive augen gneiss, Galgalphedi. 18) Radioactive soil layers, Gagalphedi

GROUND RADIOMETRIC SURVEY

The ground radioactive survey was conducted using Scintillation Counter BGS-1 and Gamma Ray Spectrometer, Super Spec RS-125. The former was used to identify the radioactive bed location and the later was used to measure the radioactive intensity value consisting of U ppm, Th ppm, K % and Dose rate (DR) in μGy/hr. Each location was measured with both instruments and GPS data were taken.

The radioactive mineralization zone in the Dharmasthali Mandir area has been traced with Scintillation Counter. Two pegmatite bodies are upto 1m thick with 10m gap in gneiss having 1200 to 2600 cps RI value. It consists of greenish yellow Tyuyamunite uranium mineral. The background value is 150cps. The location was N270 47.356' and E 850 18.206', Photo 19,20.

Tyuyamunite is a very rare uranium mineral with formula Ca(UO2)2V2O8·(5-8)H2O. It is a member of the carnotite group. It is a bright, canary-yellow color because of its high uranium content. Also, because of tyuyamunite's high uranium content, it is radioactive. Tyuyamunite is formed by the weathering of uraninite, a uranium-bearing mineral. Tyuyamunite, being a hydrous mineral, contains water. Yet when it is exposed to the atmosphere it loses its water. This process changes tyuyamunite into a different mineral known as metatyuyamunite Ca(UO2)2(VO4)2·3-5H2 .

Photo 19: Uranium mineral Tyuyamunite , a weathering product of uraninite of carnotite group , in pegmatite veins, Dharmasthali Mandir area

Photo 20: The road access having Tyuyamunite minerals in pegmatite, Dharmasthali Mandir area

GROUND RADIOMETRIC SURVEY IN SANLA AREA

The ground radiometric survey for U/Th in Sangla area has been conducted to trace anomaly areas. The area covers over gneissic terrain and proximal parts of Tokha Formation consisting of interbedings of clay, silt, sand and gravel of various proportions. The observation location points are presented in Figure 9. The radiation intensity mapping was conducted using Scintillation Counter recorded in count per seconds were plotted and prepared an anomaly map, Figure 10. It shows that Shivpuri gneiss zone is radioactively anomalous in the area. The Gamma Ray Spectrometer readings of uranium concentration in ppm were recorded and prepared an anomaly map, Figure 11. The study area has low concentration of uranium. Similarly, Thorium anomaly map is shown in Figure 12. The Thorium concentration is high over uranium concentration in gneissic terrain. The maximum Th concentration is recorded in location no 102 with 295ppm. The uranium concentration is high in tourmaline granite in L-3, 33.4ppm. The K anomaly map is prepared and shown in Figure 13. The maximum recorded absorbed dose rate is given in location 102 with 111.4 uGy/hr in gneiss, Figure 14. The concentration could be higher in high anomalous zone in Dharmasthali Mandir area.

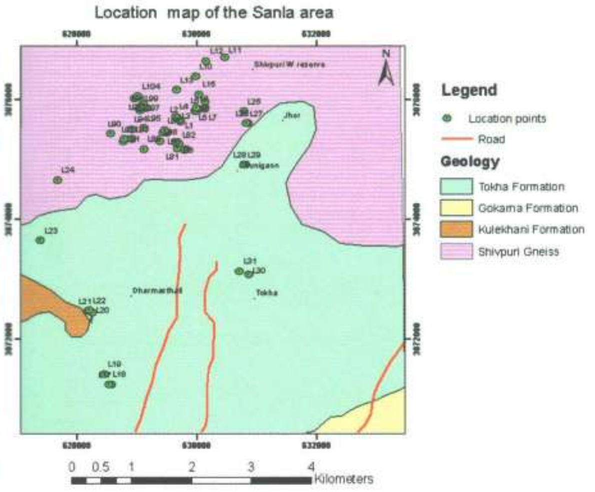


Figure 9: Location points map of Sanla Khola area

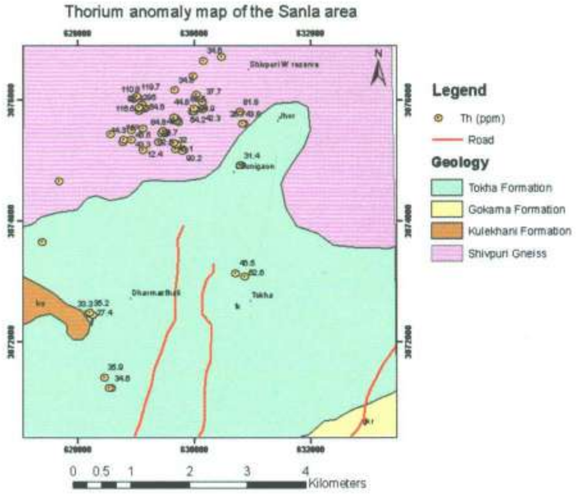


Figure 12: Thorium anomaly map of the Sanla Khola area

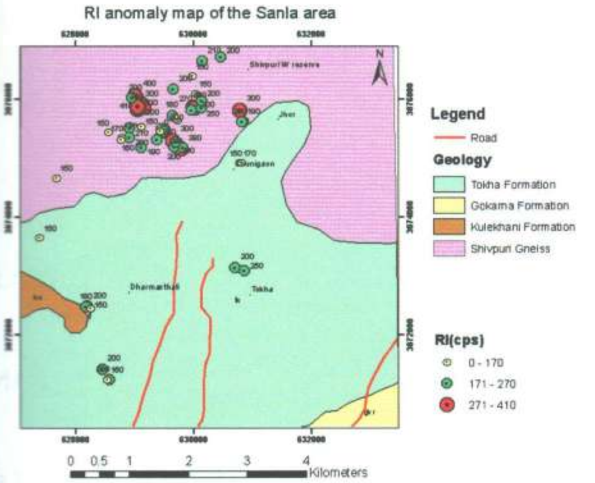


Figure10: Radiation Intensity (RI, cps) anomaly map of Sanla khola area

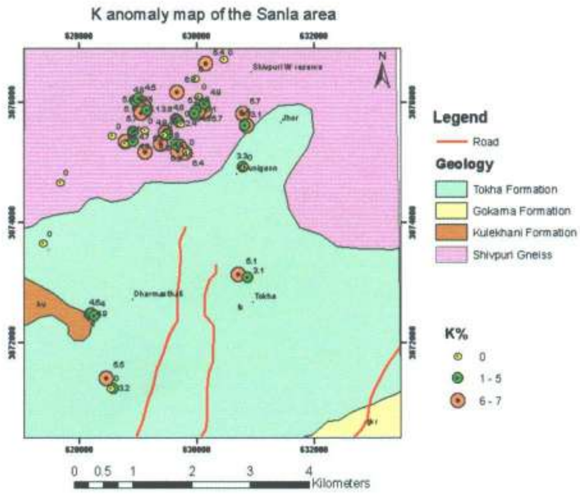


Figure 13: K anomaly map of the Sanla Khola area

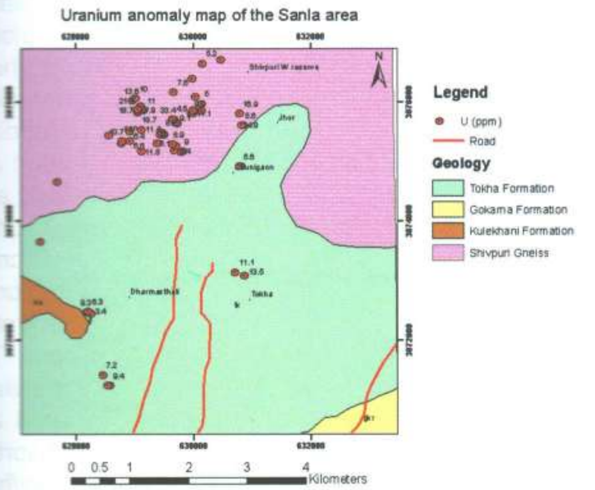


Figure 11: Uranium anomaly map of the Sanla Khola area

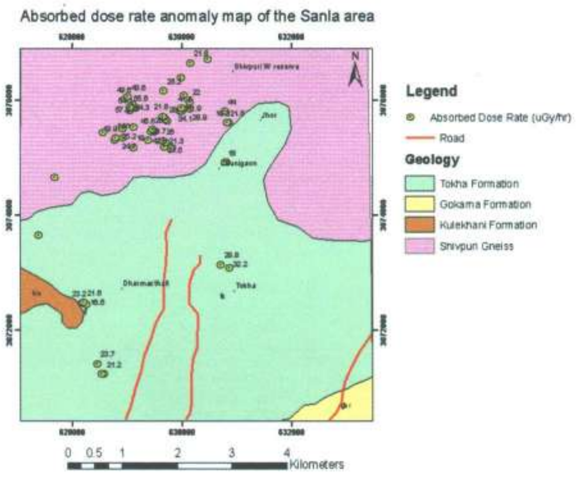


Figure 14: Absorbed Dose Rate (uGY/hr) amp of the Sanla Khola area

GROUND RADIOMETRIC SURVEY IN SANKHU AREA

The ground radiometric survey for U/Th in Sankhu area has been conducted to trace anomaly areas. The area covers over gneissic terrain and proximal parts of Gokarna Formation consisting of interbedings of clay, silt, sand and gravel of various proportions. The observation location points are presented in Figure 15. The radiation intensity mapping was conducted using Scintillation Counter recorded in count per seconds were plotted and prepared an anomaly map, Figure 16. It shows that Shivpuri gneiss zone is radioactively anomalous in the area. The Gamma Ray Spectrometer readings of uranium concentration in ppm were recorded and prepared an anomaly map, Figure 17. The study area has low concentration of uranium. Similarly, Thorium anomaly map is shown in Figure 18. The Thorium concentration is high over uranium concentration in gneissic terrain. The K anomaly map is prepared and shown in Figure 19. The recorded absorbed dose rate is given in location Figure 20.

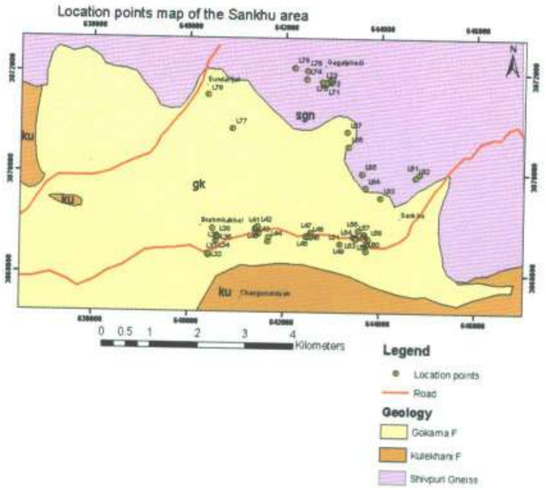


Figure 15: Observation location points map of Sankhu area

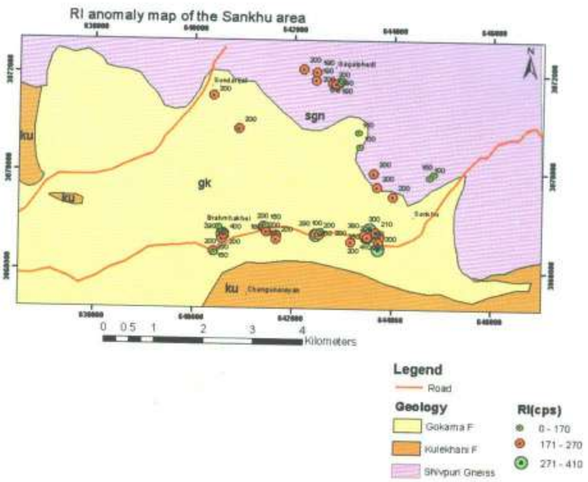


Figure 16: Radiation Intensity (RI, CPS) map of Sankhu area

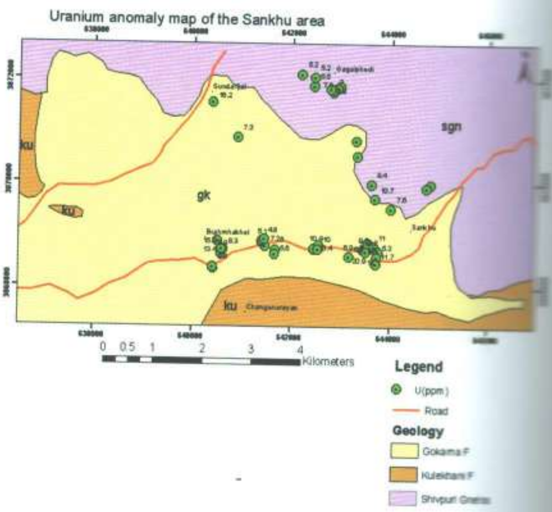


Figure 17: Uranium anomaly map of Sankhu area

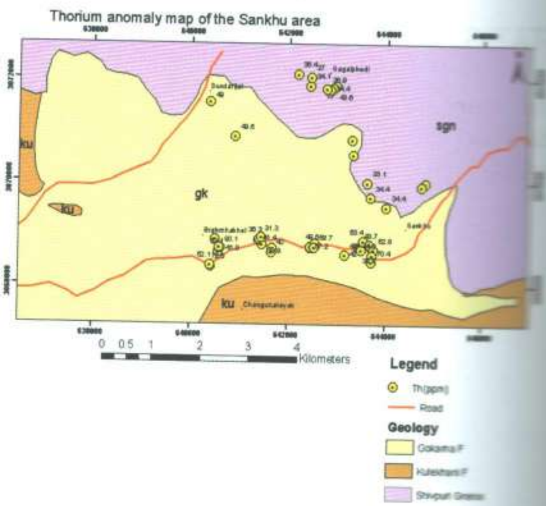


Figure 18: Thorium anomaly map of Sankhu area

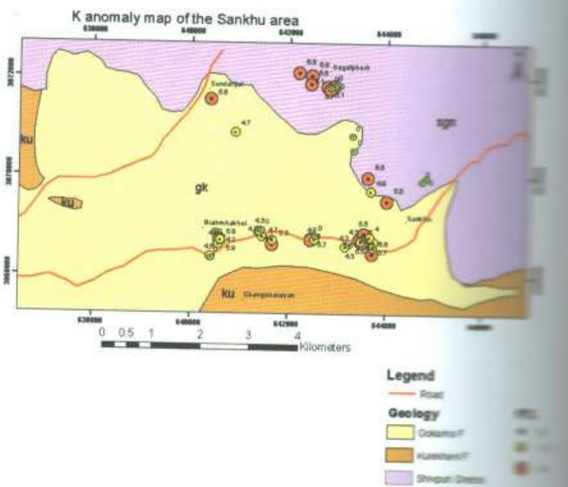


Figure 19: Kanomaly map of Sankhu area

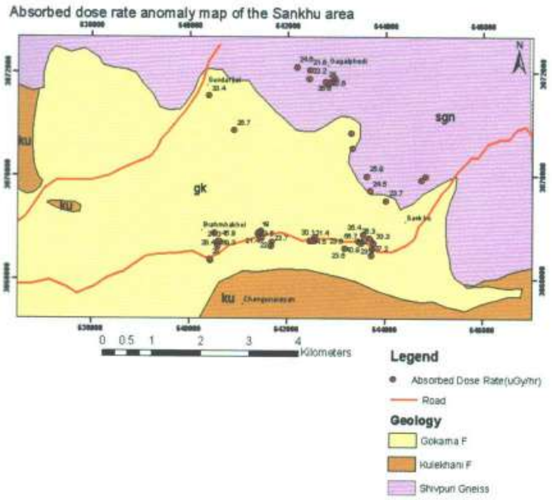


Figure 20: Absorbed Dose Rate (uGY/hr) map of Sankhu area

STATISTICAL ANALYSIS

The statistical analysis of collected U,Th,K and absorbed dose rate and RI values show the following results-

- Radiation Intensity prediction map of Sanla Khola and Sakhu area after interpolation with kriging operation using simple mode shows the Lamichhane gaon, Allapot, Sanla area and Dharmasthali area have high intensity and intensity lowers towards Sankhu areas, Figure 21.
- Geologically, the intensity favors gneiss and pegmatite veins and bodies in the Sanla area where as gneiss in the Sankhu area has low intensity value in prediction map, Figure 22.
- The correlation of U(ppm) and RI(cps) is positive(0.249). U/Th correlation shows positive correlation (o.284), Figure 23.
- The K% and Absorbed dose rate is poorly correlated (0.009) but positive, Figure 23.
- The K and Th are not correlated given rise to flat, probably due to no clay minerals and micas are radioactive, Figure 23.
- The U and Absorbed dose rate are positively correlated (0.459). Similarly, Th and Absorbed dose rate are also well correlated(0.957) which means the area is well dominated with Thorium mineralization over uranium mineralization and the maximum dose effects are due to thorium minerals, Figure 23.

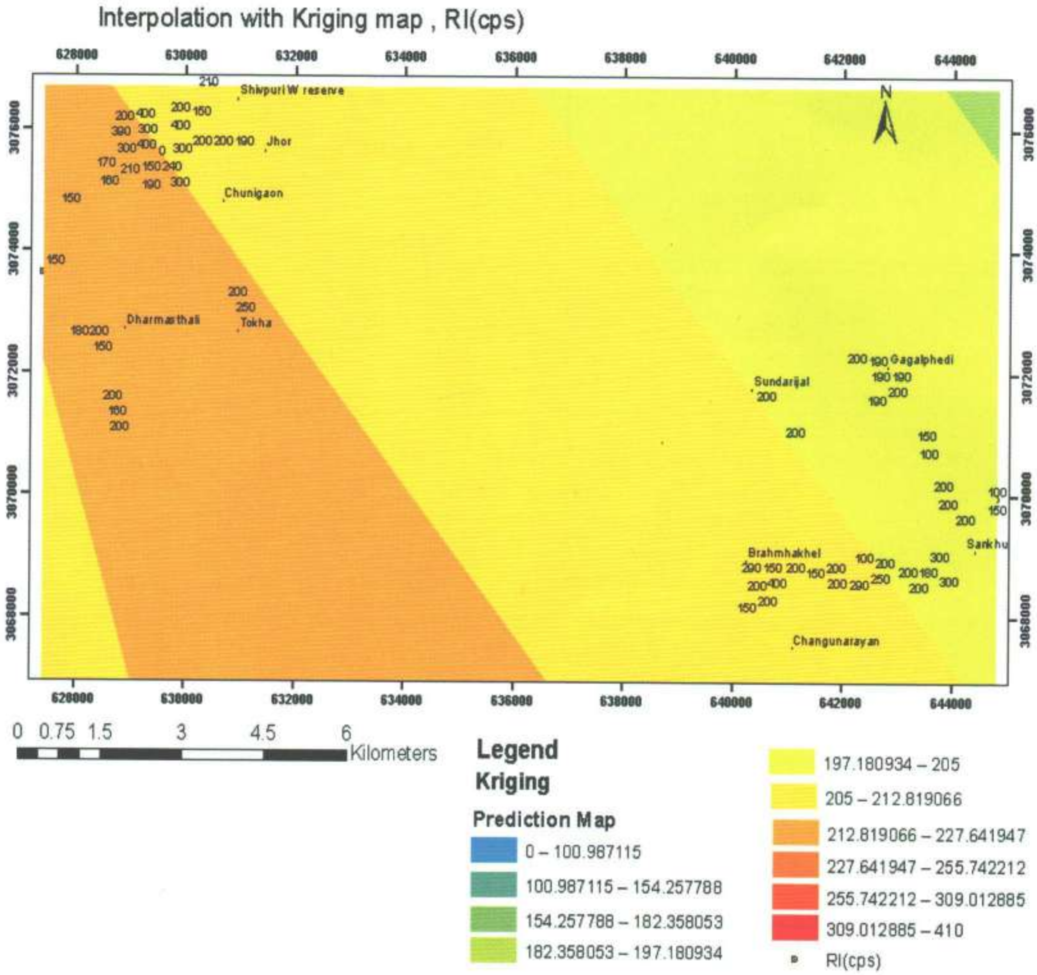


Figure 21: Radiation Intensity prediction map of the Sanla Khola and Sankhu areas

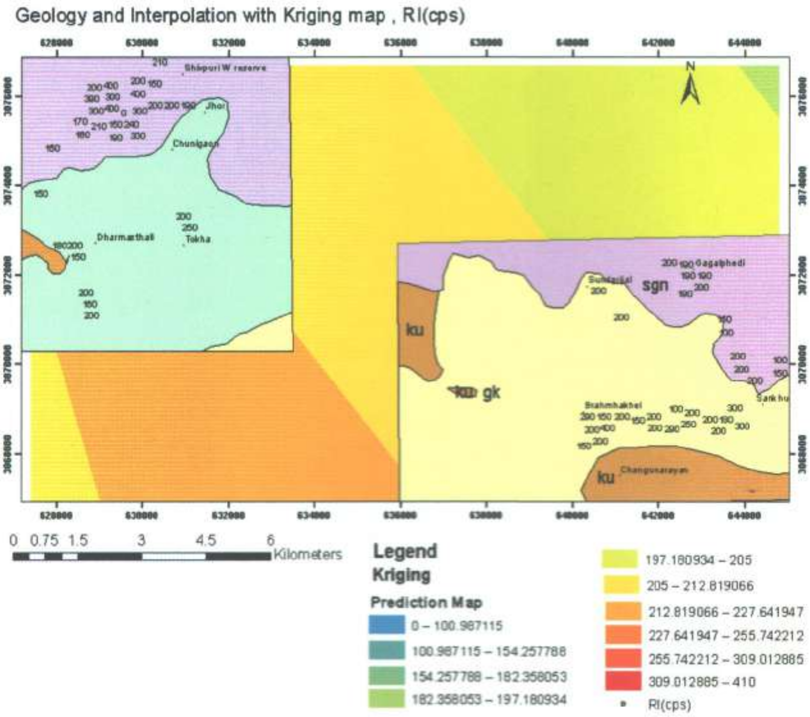


Figure 22: Geology and radiation intensity prediction map of Sanla khola and Sankhu areas

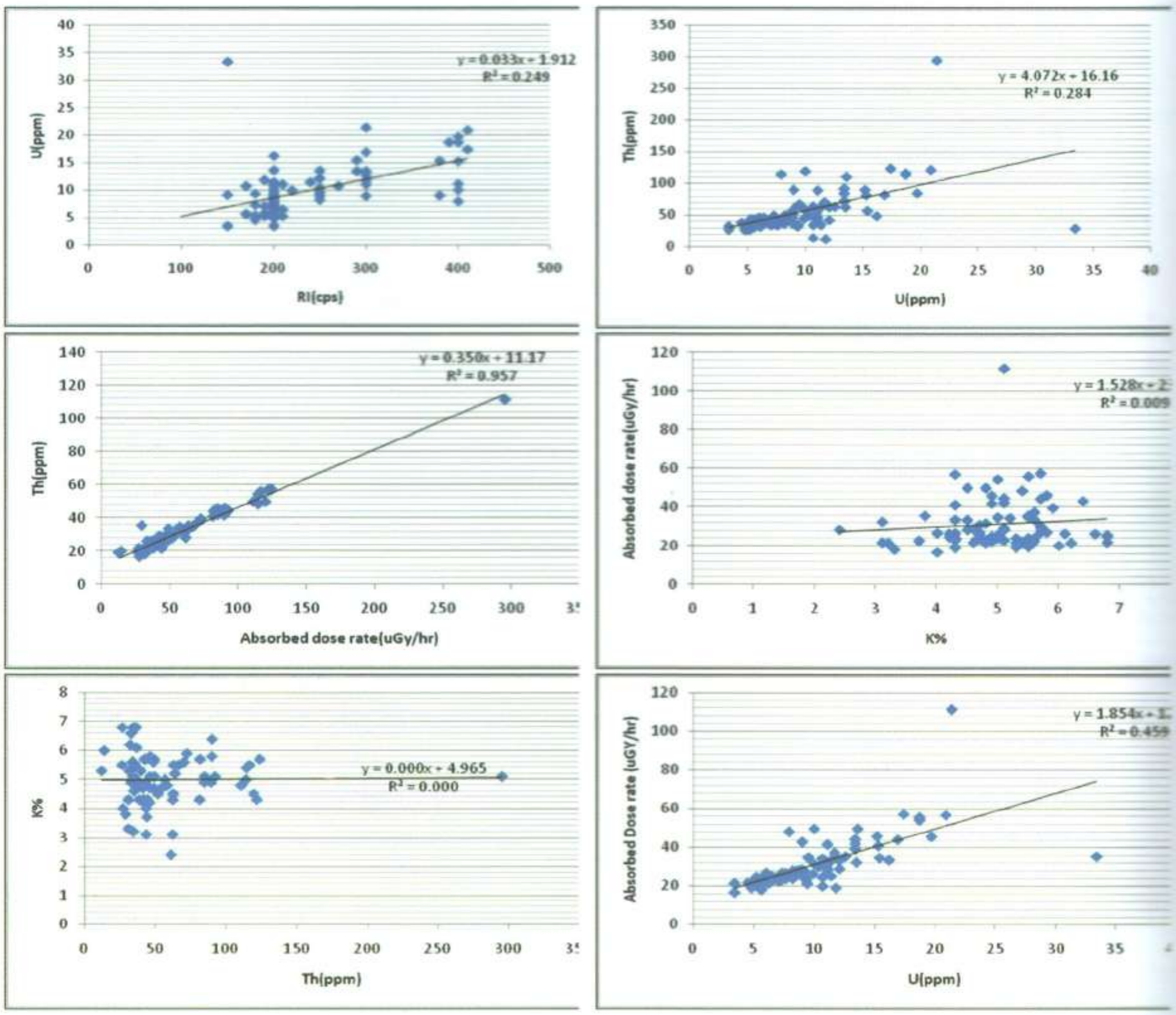


Figure 23: Correlation of U, Th, K and Absorbed dose rate

The calculated statistical parameters show the following results which are presented in Table-2, Figure 24 to 28.

- The database was counted for 80 locations.
- The Histogram of RI (cps) shows that the maximum 410 cps and minimum 150cps with mean 242 cps, Figure 24.
- Histogram of U (ppm) shows that the maximum 33.4ppm and minimum 3.4ppm with mean 10ppm, Figure 25.
- Histogram of Th (ppm) shows that the maximum 295ppm and minimum 12.4ppm with mean 57ppm, Figure 26.
- Histogram of K% shows that the maximum 6.8% and minimum 2.4% with mean 4.9, Figure 27.
- Histogram of Absorbed dose rate shows that the maximum 11.4uGY/hr and minimum 16.5uGy/hr with mean 31.2uGy/hr, Figure 28.

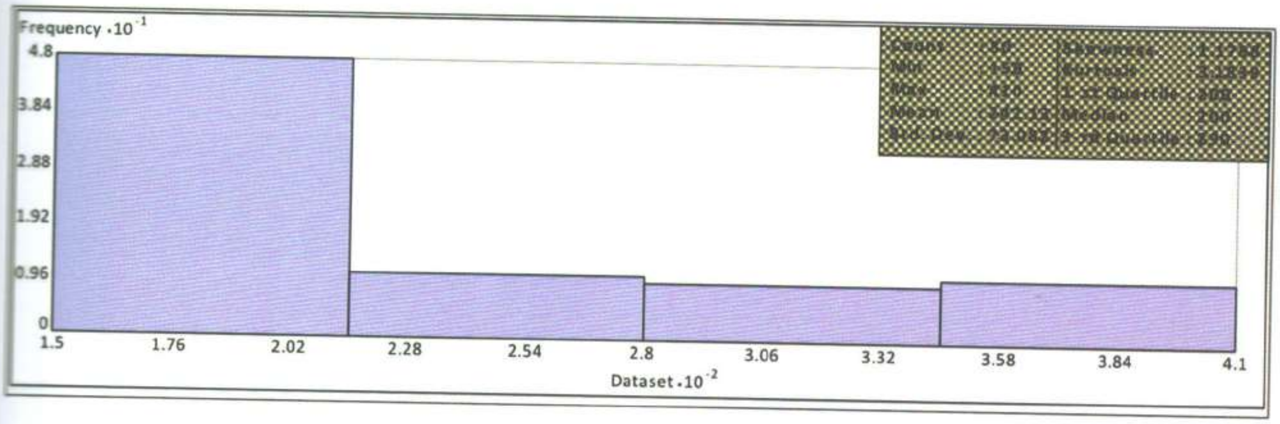


Figure 24: Histogram, RI (cps)

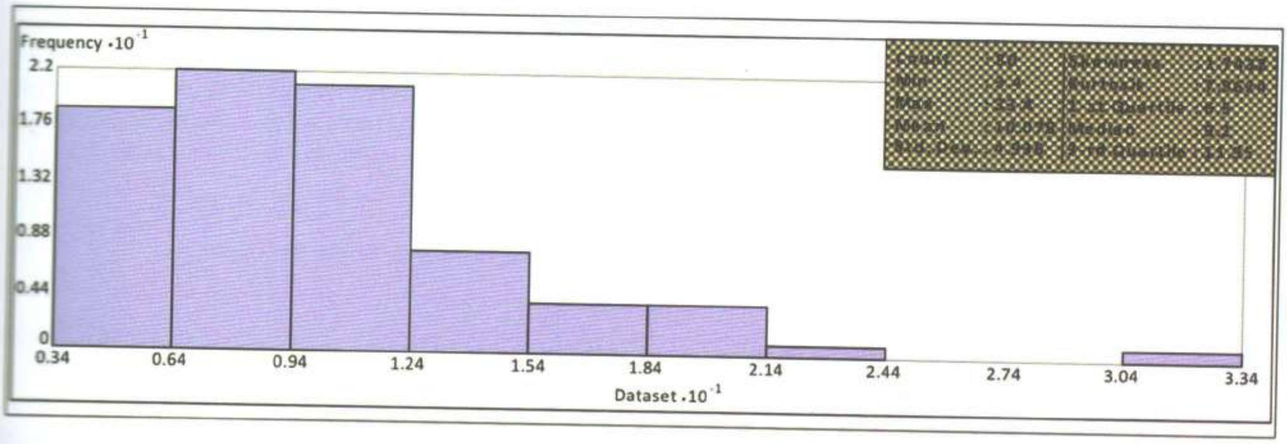


Figure 25: Histogram, U (ppm)

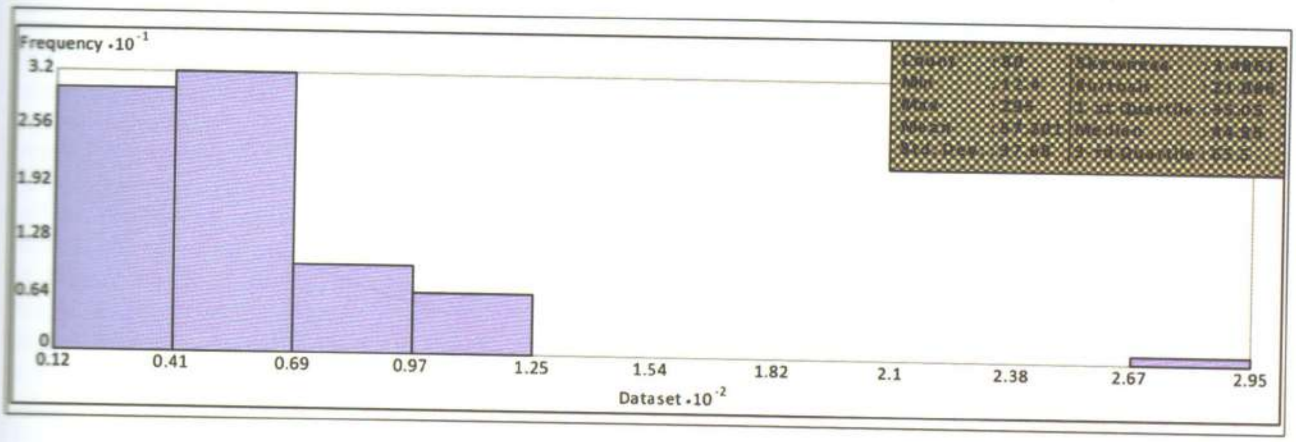


Figure 26: Histogram,Th (ppm)

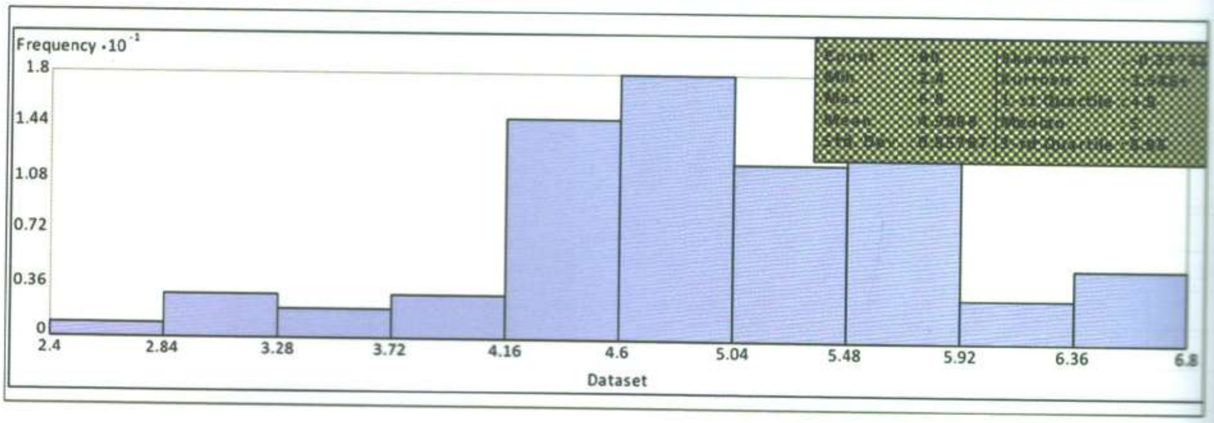


Figure 27: Histogram, K%

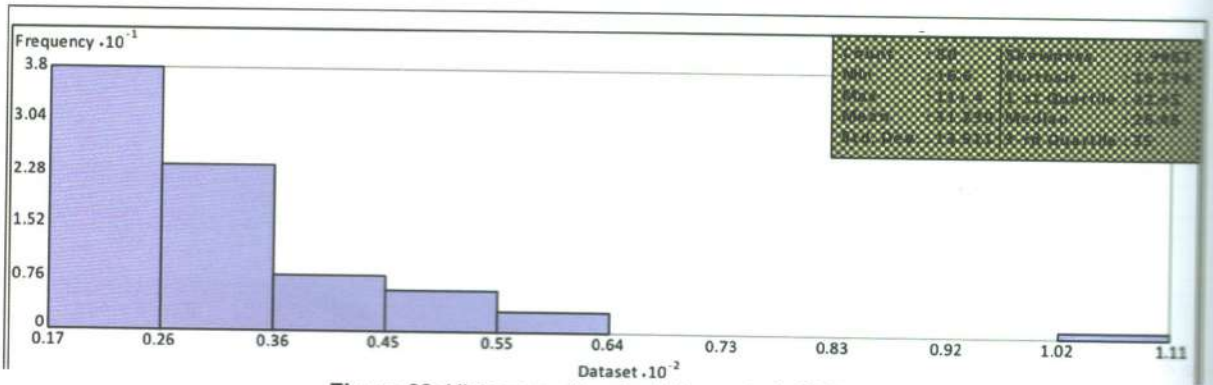


Figure 28: Histogram, Absorbed dose rate (uGY/hr)

The semivariogram of absorbed dose rate uGy/hr and Uranium ppm are shown in Figure 29 and 30 respectively. It shows that the spatial dependence of a spatial random filed. The Uranium variogram no variability over distance, is less predictable while dose rate variogram shows that the distance and variability are corresponding each other meaning larger the distance larger the variability and less predictability.

Figure 29: Absorbed Dose rate semivariogram

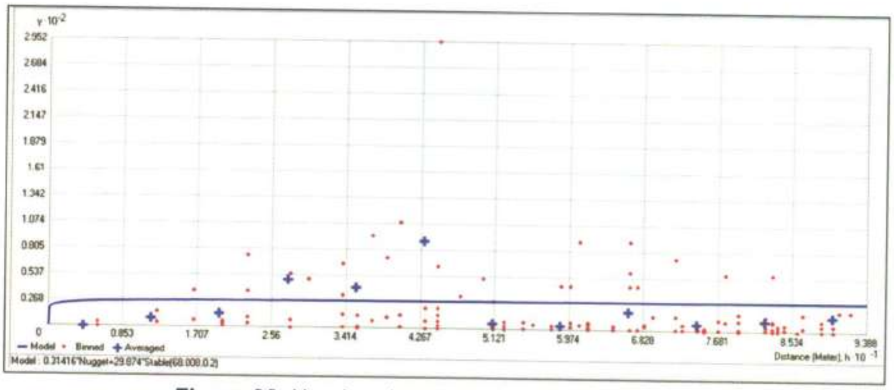


Figure 30: Uranium (ppm) semivariogram

The statistical parameters of analytical results are given in Table 4. This shows RI, U, Th and K% and Absorbed dose rate. Threshold values and anomalous values are given, Table 3. The anomaly matrix with drainage area 1-2 sq. Km. shows that the area is under 3 to 4 category which is less desirable for follow-up prospecting for U/Th but some anomalous pegmatite veins and bodies in Dharmasthali and Sanla areas could be desirable for further follow-up prospecting, Table 4.

Table 2: Statistical analytical results

SN	Content	Count	Min	Max	Mean	Std.Dev	Skewness	Kurtosis	Median
1	RI	80	150	410	242.13	73.082	1.1798	3.183	200
2	U	80	3.4	33.4	10.078	4.936	1.7432	7.962	9.2
3	Th	80	12.4	295	57.201	37.68	3.4861	21.086	44.55
4	K	80	2.4	6.8	4.988	0.8578	o.3373	3.456	5
5	Dose Rt	80	16.6	111.4	31.239	13.511	2.9867	16.778	26.45

Table 3: Statistical parameters of analytical results

SN	Content	Bg/mean	Std.Dev	Threshold(T)	Anomalous value
		X	SD	X+2SD	(>X+2SD)
1	RI(cps)	242.13	73.082	388.294	>388
2	U(ppm)	10.078	4.936	19.95	>20
3	Th(ppm)	57.201	37.68	132.561	>133
4	K%	4.988	0.8578	6.7036	>7
5	A Dose Rate(uGY/hr)	31.239	13.511	58.261	>58

Table 4: Anomaly Category Matrix

Drainage area	x+2SD to 2T	2T to 4T	4T to 8T	>8T
> 4 sq km	2.5	2.5	1	1
2-4	3	2.5	2	1
1-2	4	3	2.5	2
<1	4	4	3	2.5

Note: Category 1 anomaly has high priority for follow-up exploration and 4 has least priority

RADIATION HAZARD

Radiation is the transport of energy through space when the energy of radiation is high enough. It can remove electrons from atoms or molecules of a substance called ionizing radiation. X-rays and gamma rays emit ionizing radiation. The ultraviolet, visible, infrared, microwave and radio waves emit non ionizing radiation. Alpha, Beta and gamma radiation and neutron radiation are blocked by a paper, alumunium plate, lead plate and water/concrete respectively. The sources of ionizing radiation can be natural like radon gases, radiation from radioactive elements. K 40 can be a radioactive element in our body. So radiation is everywhere. Human have no sensors of ionizing radiation and can't be seen, smell, hear and sense it. Risk associated with radiation exposure can only be restricted but can not be eliminated entirely.

Radiation dose: it refers to the absorption of radiation energy per unit mass of observer. 1Gy is 100rad (radiation absorbed dose).

Equivalent dose: It creates biological damage and risk. The absorbed dose can be converted into equivalent dose.

Equivalent dose= WR x WTx Absorbed dose

Where, WR= radiation source weighting factor

WT= radiation weighting body parts factor

The radiation weighting factor for the following are given in Table-5

Table 5: WR and radiation type

Radiation type	WR
Photons	1
Electrons	1
Protons	2
Gamma radiation	1
Alpha particles, Fission fragments	20

Types of radiation hazard

- Internal contamination
- External contamination
- External exposure

Effects of Ionizing radiation

Biological effects: The immediate effects are lens opacities, skin injuries, infertility, death and late effects area cancer and genetic effects.

Effects of radiation exposures

The effects of radiation exposure are given in Table 6.

Table 6: effects of radiation exposures

Exposure(mSv)	Effects
10000	Sngle dose, fatal within week
5000	Single dose, kill half of those exposed within a month
1000	Single dose, could cause radiation sickness, nausea, not death
100	Recommended limit of radiation workers every five years
16	CT scan, heart
10	CT scan, full body
2	Radiation most people are exposed to per year
0.01	Dental X-ray

Source: US Environmental Protection Agency

Recommended dose limit (ICRP, 103)

The ICRP recommended dose limit are given in Table 7,

Table 7: Recommended dose limit

Type of limit	Public
Effective dose	1 mSv/yr

The limits of effective dose are for the sum of the relevant effective dose from external exposure in the specified time period and the committed effective dose from intake of radionuclides in the same period. For adults the committed effective dose is computed for the period up to 50 years.

Natural sources of radiation

- Solar radiation, cosmic radiation ^{3}H, ^{14}C, ^{7}Be
- Be, C,H,K,Rn,Th,U
- Inhaled radionuclide ^{222}Rn
- Terrestrial radionuclides ^{226}Rn, ^{232}Th,^{235}U, ^{238}U

Cosmic radiation

The cosmic radiation are given in Table 8

Table 8: Cosmic radiation

Height	Radiation
15km	10uSv/hr
10km	5uSv/hr
Himalaya(6.7km)	1uSv/hr
2km	0.1uSv/hr
Sea level	0.03uSv/hr

Food

Rice, wheat, pulses, vegetables, milk, diet

Daily intake ^{226}Rn, ^{220}Pb, ^{40}K, ^{228}Th

Equivalent dose= 0.315 mSv/yr

Total dose from natural sources= 1-3mSv/yr

The radiation staff dose limit (ICRP)= 20 mSv/yr

Effective dose calculation of Sanla and Sankhu areas

WR for gamma radiation=1, Mean absorbed dose rate is 31 uGy/hr.

The effective dose calculations are given in Table 9.

Table 9: Effective dose calculation

Absorbed dose (uGy/hr	WR	WT	Effective dose (uSv/hr)	Effective dose (uSv/yr	Effective Dose (mSv/yr)	Body parts
31	1	0.04	1.24	10862	10.82	Thyroid
	1	0.12	3.72	32850	32.85	Lungs
	1	0.12	3.72	32850	32.85	Stomach
	1	0.01	0.31	2715	2.71	Skin
	1	0.04	1.24	10862	10.82	Liver

These effective dose rate are for maximum exposure period of one year from the direct source exposure. The possibility of direct source exposure is minimum in the area for the people around the study area. The background value of RI is 100 cps in the area. So 1/3rd of the calculated effective dose could be generalized for the radiation dose in the area for biological effects.

The results show that the effective dose in the area could range from 1-10mSv/yr depending on the level of exposure and source terrain. This means a radon survey data and this survey are comparable.

CONCLUSIONS

The field program based on DMG/IAEA TC Project NEP 2004 for the prospecting of U and Th and radiation hazard mapping in parts of Shivpuri area of northern part of Kathmandu valley based on geological mapping and ground radiaometric survey using Scintillation counter BGS-1S and Gamma Ray Spectrometer RS 125 over an area of 100sq km area has been completed. A total of 104 instrumental data were recorded along with lithological data bases. The geosatatistical analysis and radiation hazard assessment were carried out of the area based on the collected data.

Geologically, the study area comprises Shivpuri gneiss, Neoproterozoic Kulekhani Formation consisting of metasandstone of Bhimphedi Group of rocks and Kathmandu Basin sediments consisting of clay, silt, sand and gravel beds of Gokarna Formation and Tokha Formation of younger basin fill of late Pleistocene age.

The ground radiometric survey gave instrumental values of U(ppm), Th(ppm), K%, RI(cps) and Absorbed dose rate uGy/hr. Each data were presented with GPS locations. The data were plotted to prepare anomaly maps.

Geostatistical analysis were carried out using histogram to calculate min, max, mean, standard deviation, skewness and Kurtosis of U, Th, K, RI(cps) and Dose rate . A semivariogram was plotted for U and dose rate. The intensity prediction map was prepared using simple kriging operation. The data shows that the maximum U content was 33.4ppm (L-3), Th 295ppm (L-102) in tourmaline granite and weathered gneiss from Sanla area. The Tyuyamunite mineral i. e. weathered uraninite mineral was identified from the temple area of Dharmasthali and Jagat. Absorbed dose rate and Th values are well correlated with coefficient of 0.957.

The anomaly matrix with drainage area 1-2 sq.km. shows that the area is under 3-4 category which is less desirable for follow up prospecting and exploration except few places like Dharmasthali temple area and Jagat area which are susceptible for pegmatite vein type of U mineralization. The radiation hazard analysis was based on the absorbed dose rate uGy/hr data base. Its effects to the biological entities were analyzed using effective dose mSv/yr computed with conversion factors WT and WR. The results shows 1-10mSv/yr effective dose could be expected from the area.

RECOMMENDATIONS

Follow-up prospection is recommended in Dharmasthali and Jagat areas. National Radiation Safety Standard should be prepared to ensure safety from radiation hazard.

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Engineering and Environmental Geological Study of the Birgunj area, Parts of Parsa and Bara Districts, Province-2, Nepal

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ABSTRACT

The present study deals with the engineering properties of Quaternary sediments which gives information on the more favourable ground condition for urban development. This study also investigates about the geological hazards, its impact on environment, and mitigation techniques. The field investigation was carried out by power-driven auguring, hand auguring, and Standard Penetration Test (SPT) equipment. Soil samples were taken from various depths to delineate different quaternary geological units. Several traverses were taken along rivers, tributaries, and road alignments to define the geological units and to identify the area prone to geo-hazards such as flooding and riverbank cutting. Natural resources as sand, gravel, and clay deposits were also assessed.

Keywords: urban, geological hazards, auger, standard penetration test (spt), natural resources

INTRODUCTION

Birgunj Metropolitan is the district headquarters of Parsa District situated at about 135 Km South from the Kathmandu and lies in the North of Rauxal, the border city of India (Figure 1). It is one of the fast-growing cities in Nepal. The border connection with India makes this city the main business centre as well as the industrial city of Central Nepal. The Birgunj Metropolitan city spread across 75.24 square Kilometers, around the flatlands of Terai region.

The study area lies between 2987500 m to 2998200 m Northing, and 581000 m to 593200 m Easting covering about 100 sq. km area. It covers the part of Birgunj Metropolitan and its surrounding areas: parts of Jitpur-Simara Sub-Metropolitan, Bahudarmai Gaupalika, Parsauni Gaupalika, Pheta Gaupalika, Belwa Gaupalika, and Parwanipur Gaupalika as shown in Figure 1. The study area lies in the Topo-Sheets No. 2784 16C and 2784 16D published by the Department of Topographic Survey, Nepal.

Physiographically, the study area lies in the Terai Plain having altitude ranges from 79 m to 99 m from mean sea level (MSL). Geologically the area represents the northern part of Indo-Gangetic plain and belongs to the southernmost tectonic division of Nepal.

The study area consists of sediments of Quaternary deposits such as sand, silt, clay, etc. The climate of the study area is tropical and monsoon type. The Tilabe Nadi, the Sirsiya Nadi, and the Bangari Nadi are the

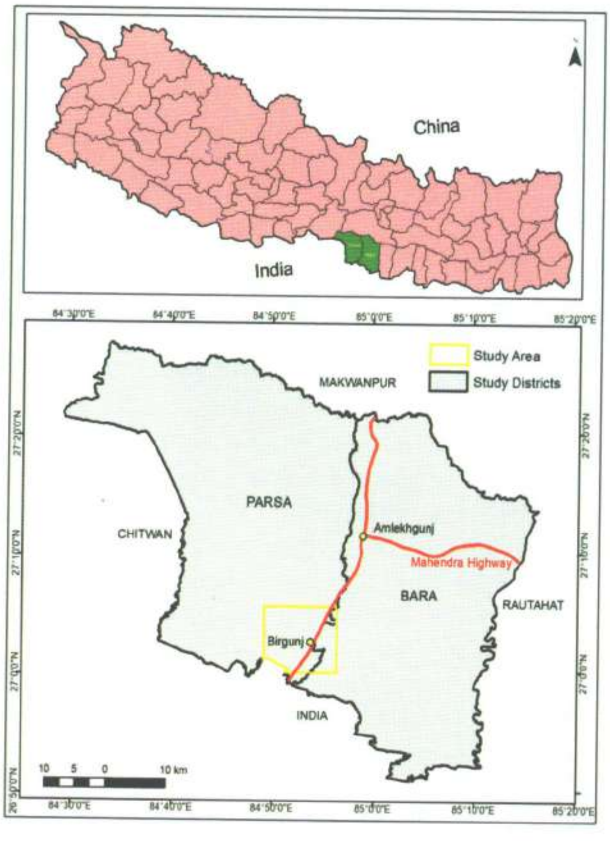

Figure 1: Location map of the study area

main rivers flowing in the study area. Sirsiya Nadi is flowing through the central part of the study area whereas the Bangari Nadi and the Tilabe Nadi following in the southeast and western part. These three main rivers along with its tributaries make the whole drainage system of this area.

OBJECTIVES

The main objective of the study was to prepare an Engineering and Environmental Geological map (1:25,000 scale) of Birgunj Metropolitan and its surrounding area that provides the geo-science information required for sound regional planning, including sustainable development of natural resources, mitigation of natural hazards, and identification of best environmental practices in developing regional and urban infrastructures. It includes the delineation of soil units, natural hazards, and potential location for mineral resources.

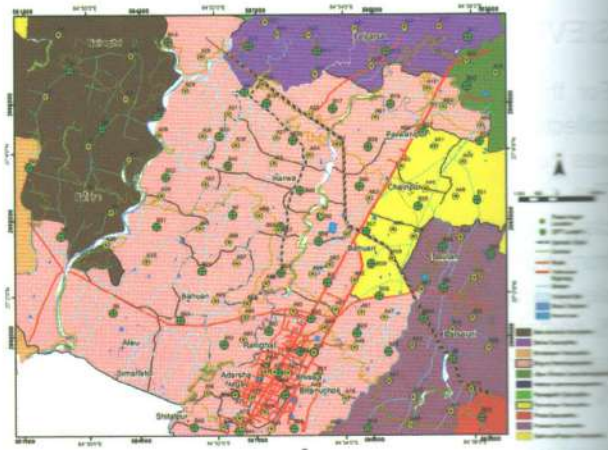

Figure 2: Auger and SPT bore hole locations

METHODOLOGY

Existing relevant literature on geology, geo-hazard, and other information like topo-maps, aerial photographs, and satellite imageries were collected and reviewed before to the field. The geological map of centra Nepal prepared by DMG, 1984 and geological map of petroleum exploration block 6 and 7 published by DMG-PEPP, 2001. Topo-map and satellite imagery were studied to obtain the overall view and plan of the study area. The digital topo-database obtained from the Department of Survey has been extensively used during GIS processing for the preparation of the final map. During fieldwork, auger drilling and SPT were carried out as planned before. Samples collected from the field were tested in the geotechnical laboratory of DMG for Liquid Limit, Plastic Limit, and Sieve analysis. The software used in data analysis are ArcGIS, Winsieve-5, and Rockworks 2015.

Figure 3: Tripod and site preparation for SPT test

FIELD ACTIVITIES

The fieldwork was carried out from 12th of Chaitra 2074 to 11th of Baishakh 2075 for 30 days covering about 100 sq. km of the area. During the field, related documents were collected from the municipality, Central District office, and other governmental organizations. Hand auger hole drilling followed by ASTM-Standard Penetration Test (SPT) and Power-driven auger were carried out in the field to obtain necessary data. A total of 60 SPT and 98 power auger tests were performed during the field shown in Figure 2 below. The maximum depth of the SPT test is 7.5 m whereas power auger is 9 m. Site preparation for the SPT test is shown in Figure 3. Adequate soil samples were collected from different depths of the auger and SPT holes (Figure 4) to determine the type of sub-surface soil units.

Figure 4: Soil sample from SPT tube

LAB ANALYSIS

SIEVE ANALYSIS

For the grain size analysis, 229 soil samples were collected from the 60 SPT holes. The sieve analysis was carried out in the Geotechnical Lab of the DMG. The study area consists of fine-grain sediments like clay, silt, and fine sand mostly which can be recognized from the visual analysis during the field study. The sieve analysis also shows similar results. About 90 % samples contain fine-grained sediments which can pass from the sieve size of 0.075 mm and the rest 10 % samples consist of coarser sized sediment.

LIQUID LIMIT

The liquid limit of the soil samples containing a high percentage of fine materials was carried out with the ASTM-D423 standard using the Casagrande cup. The water content of each sample is determined after oven drying the sample at 105ºC for 24 hours. The percentage of moisture content is plotted against the number of required drops counted during the test. The percentage of moisture content at the value of a 25-drop number is taken as the liquid limit of the test sample.

PLASTIC LIMIT

Plastic Limit of the soil sample is determined as the water content in a soil thread that crumbles at a diameter of 3 mm. The test is carried out according to ASTM standard procedures for the determination of the plastic limit. 54 soil samples containing a high percentage of fine materials were carried in the Geotechnical lab. The Plastic Limit values are used with the liquid limit value of the same sample for determining the plasticity index, which is the value required for soil classification.

PLASTICITY INDEX

The plasticity index (PI) is a measure of the plasticity of the soil. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay. The plasticity chart, ASTM D2487 in which the plasticity index is plotted against liquid limit shows that the "A-line" separates silts from clays (Figure 5). Mostly finer sediments (<0.0075 mm Size) are silts, clayey silts, and silty clays. They are assigned as CL is for low to moderate plastic inorganic clay, CH for high plastic inorganic clay, ML is assigned for organic silts with low plasticity, OL for organic silts of low plasticity, and NP for the non-plastic according to the Unified Soil classification system (USCS) (Arora, 1997).

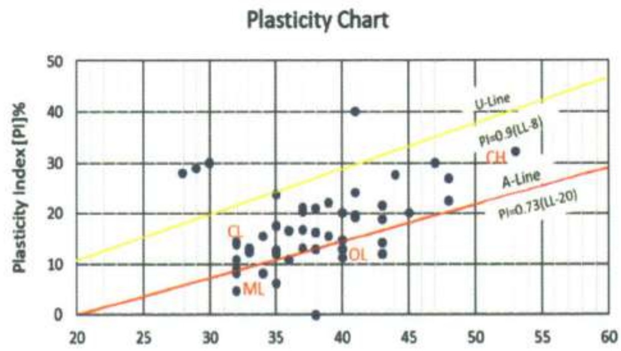

Figure 5: Plasticity Chart showing the Plasticity Index. The A-line separates silts from clay and the data plot above the U-line shows error (Jhonson and De Graff, 1988)

Among the samples tested 41 samples from different borehole fall in low to Medium plastic inorganic clay category, 5 samples fall organic silts of low plasticity category, one sample falls on the inorganic clay with high category, two samples fall on the inorganic silts category and rest 5 samples are falls in non- plastic as shown in Table 1. In above Table 1, CL is inorganic clays with low to moderate plasticity, CH is inorganic clays with high plasticity, ML is silt with low plasticity, OL is organic silts of low plasticity and NP denotes non-plastic.

Table 1: Liquid limit and plastic limit of the finer sediments (<0.075mm)

Borehole No.	SPT no.	Depth (m)	Liquid Limit	Plastic Limit	Plastic Index	Soil type
B1	SPT1	1-1.45	36	19.38	16.62	CL
B3	SPT3	5-5.45	39	23.45	15.55	CL
B5	SPT5	1-1.45	39	16.79	22.21	CL
	2-2.45	40	19.92	20.08	CL	
B9	SPT9	4-4.45	36	25.08	10.92	CL
	6-6.45	47	16.96	30.04	CL	
	7-7.45	35	17.5	17.5	CL	
B11	SPT11	1-1.45	40	25.14	14.86	OL
	2-2.45	40	28.61	11.39	OL	
B21	SPT21	1-1.45	32	18.07	13.93	CL
B22	SPT22	1-1.45	33	19.82	13.18	CL
	3-3.45	43	24.19	18.81	CL	
B24	SPT24	1-1.45	37	16.72	20.28	CL
		2-2.45	40	19.81	20.19	CL
B25	SPT25	1-1.45	48	25.56	22.44	CL
	2-2.45	35	28.87	6.13	CL	
		4-4.45	48	21.07	26.93	CL
B28	SPT28	1-1.45	37	45.49	-8.49	NP
	3-3.45	43	30.95	12.05	OL	
	4-4.45	43	30.95	12.05	CH	
B29	SPT29	1-1.45	29		29	NP
B30	SPT30	4-4.45	41	16.81	24.19	CL
B32	SPT32	2-2.45	38	21.67	16.33	CL
	3-3.45	43	21.37	21.63	CL	

B33	SPT33	1-1.45	35	22.17	12.83	CL
B36	SPT36	1-1.45	40	26.98	13.02	CL
B39	SPT39	6-6.45	43	28.75	14.25	OL
B41	SPT41	1-1.45	53	20.8	32.2	CH
	2-2.45	37	20.14	16.86	CL	
	4-4.45	32	17.5	14.5	CL	
B42	SPT42	2-2.45	32	22.92	9.08	CL
B43	SPT43	1-1.45	30		30	NP
B44	SPT44	3-3.45	38	16.9	21.1	CL
B45	SPT45	3-3.45	38	21.7	16.3	CL
B46	SPT46	3-3.45	38	25	13	CL
B47	SPT47	4-4.44	35	11.19	23.81	CL
B49	SPT49	3-3.45	33	20.56	12.44	CL
B50	SPT50	2-2.45	45	24.87	20.13	CL
	3-3.45	38	38	0	CL	
B51	SPT51	2-2.45	32	20.94	11.06	CL
B52	SPT52	1-1.45	28		28	NP
B53	SPT53	1-1.45	37	15.86	21.14	CL
B54	SPT54	1-1.45	41	21.21	19.79	CL
	4-4.45	37	23.89	13.11	CL	
B55	SPT55	1-1.45	44	22.72	27.72	CL
	5-5.45	30		30	NP	
B56	SPT56	3-3.45	41	21.81	19.19	CL
	4-4.45	34	18.39	15.61	CL	
B57	SPT57	4-4.45	35	22.97	12.03	CL
B58	SPT58	1-1.45	32	27.28	4.72	ML
	4-4.45	32	23.83	8.17	ML	
B60	SPT60	3-3.45	34	25.69	8.31	CL
	4-4.45	41	0.94	40.06	CL	
	6-6.45	40	27	13	CL	

GEOLOGICAL UNITS AND THEIR ENGINEERING PROPERTIES

Based on sub-surface geological information such as type, nature, and size of the sediments from the litholog the study area is classified into three different soil units and they are Pipara Deposit, Gadhaiya Deposit, and Nautan Deposit shown in Figure 6.

PIPARA DEPOSIT

This deposit is distributed around the Bindabasini, Alau, Sitalnagar, Parsauni, Simana Tol, Bairiya, Inarwa, Bairagi Tol, Ranighat, Lalparsa, etc. This deposit consists of grey to brownish-yellow clayey silt of about 2 m thick at the top and followed by silty sand to coarse sand of variable thickness towards depth, Figure 7. The thickness of the sandy sequence varies from place to place generally from 2 to 3 m. The grain size of the sand varies from silty sand to coarse sand. In few locations, 0.5 to 1 m thick dark grey clay layer is also observed below the sandy sequence. The study area mostly covered with this deposit. Bearing Capacity varies from very low to low.

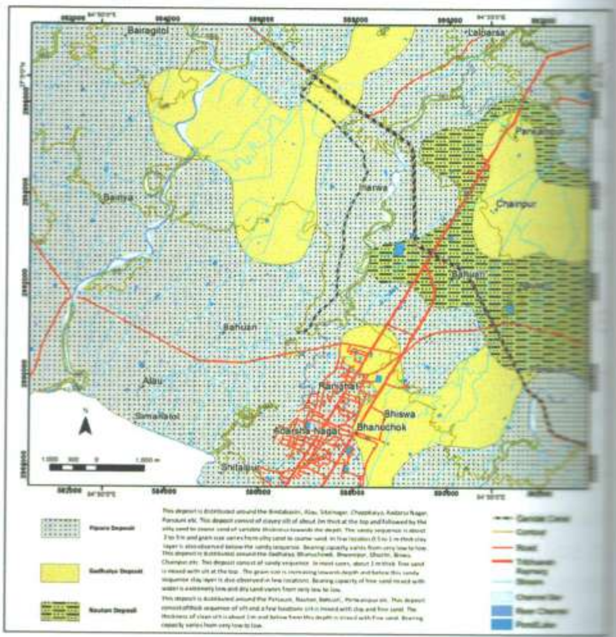

Figure 6: Geological units of the study area

GADHAIYA DEPOSIT

This deposit is distributed around the Gadhaiya, Bhanuchowk, Bhawanipur, Ghurmi, Bishwa, Chainpur, Persauni, etc. This deposit mainly consists of a sandy sequence. In most cases, about 1 m thick fine sand is mixed with silt at the top followed by a coarser sandy sequence, Figure 7. The grain size is increasing towards depth. Below this sandy sequence, a dark grey clay layer of variable thickness is also observed in a few locations. In some locations, clayey silt or silty clay is observed towards the depth followed by sand. In the southern part of the Birgunj, due to the loose material with shallow groundwater level, continuous movement while loading the drive indicates very weak ground. The area is prone to subsidence so multi-storied buildings are discouraged. Bearing capacity of fine sand mixed with water is extremely low and dry sand varies from very low to low.

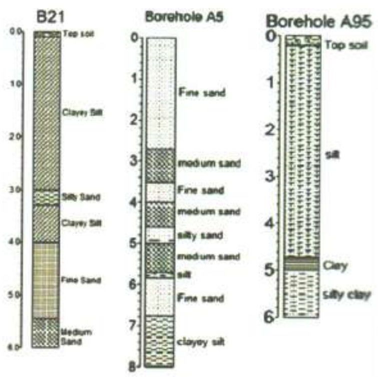

Figure 7: Lithologs of geological units; B21: Pipara Deposit, A5: Gadhaiya Deposit, A95: Nautan Deoposit

NAUTAN DEPOSIT

This deposit is distributed around the Persauni, Nautan, Bahuari, Perwanipur, etc. This deposit consists of a thick sequence of silt and a few locations silt is mixed with clay and fine sand, Figure 7. The thickness of clean silt is about 1 m and below from this depth is mixed with fine sand. In a few locations, the silty sequence is followed by thick clay (>3m) layer. Bearing capacity varies from very low to low.

BEARING CAPACITY

The Bearing Capacity of soil layers depends on the degree of its compaction or relative density. Higher the value of relative density greater will be its Bearing Capacity. Standard Penetration Test (SPT) is one method widely used for finding out the Bearing Capacity of soil layers. Dense soil will have high N values and consequently high Bearing Capacity. Similarly, with the increase of N value the compressive strength of cohesive soil increases giving to high Bearing capacity. Low soil bearing capacity is only found in alluvial soil (mud or silt), wet sand, or poorly compacted fill. In the bearing capacity study, a total of 60 SPT data were used. The maximum depth of SPT is limited at 7.5 m. The bearing capacity analysis is carried out according to Peck et al, 1974, Table 2. According to the analysis, it is found that bearing capacity of the study area has mainly low bearing capacity with N value 5 to 8. The N-value obtained from SPT test from depth 2m to 2.45m is shown in Figure 8 and from depth 3m to 3.45m is shown in Figure 9 below.

Table 2: Correlation of Bearing Capacity and N-value

Soil Condition	*N-Value*	*Bearing Capacity (KPa)*	*Quality*
Very soft	*<2*	*<25*	*Extremely Low(EL)*
Soft	*2-4*	*25-50*	*Very Low(VL)*
Medium	*5-8*	*51-100*	*Low(L)*
Stiff	*9-15*	*101-200*	*Medium(M)*
Very Stiff	*16-30*	*201-400*	*High(H)*
Hard	*>30*	*>400*	*Very High (VH)*

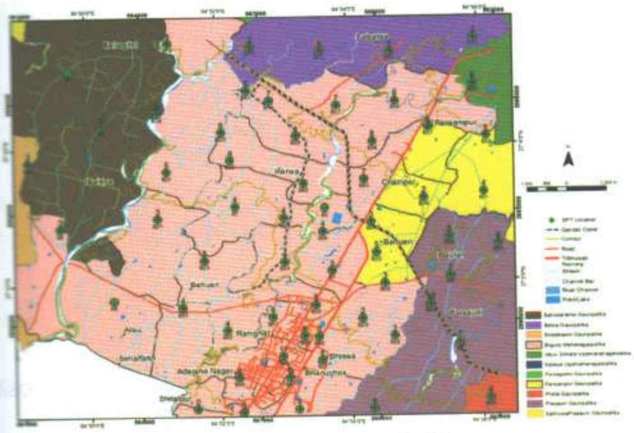

Figure 8: N-value from depth 2.0m to 2.45m

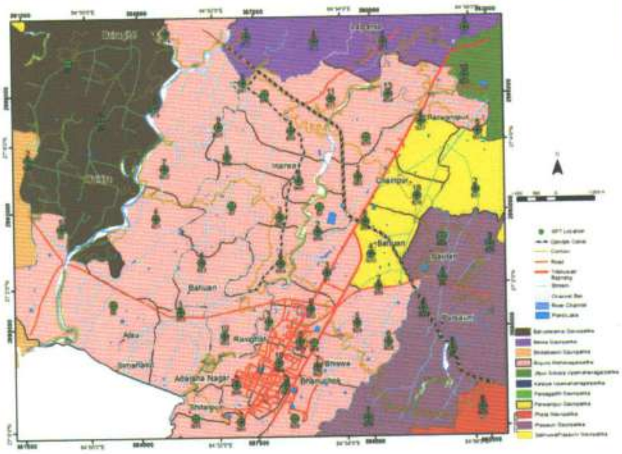

Figure 9: N-value from depth 3.0m to 3.45m

URBAN AND ENVIRONMENTAL GEOLOGY

WASTE DISPOSAL SITE

The main purpose of the environmental geological mapping was to identify the suitability of the site for solid waste management. The potential areas for waste disposal in Kathmandu valley by Kharel et al., 1998 was reviewed along with other supportive information. In the metropolitan city Birgunj, there is no proper management of waste materials. All the waste created from the daily works, industries, and other means is thrown near the roads, canals, and in the rivers (Figure 10). In most places, the waste material produced from industries which include the chemicals and other by-products is thrown directly into the river without any treatment. About 0.5 to 1 m thick industrial waste deposit was also found around the Birgunj industry area. The colour of the river/stream water is dirty black due to the mixing of waste (Figure 10). The city has significant air pollution as well because of gases released from dense traffic, industry, and the pungent smell of decaying material. There are many bricks factories (Itta Vatta) near the city area like Lalparsa area, Nakatawa area Parwanipur area, Pheta area, etc (Figure 11). The smoke from each factory makes the settlement smoky and pollutants.

Figure 10: Unmanaged Waste disposal site of the Birgunj Metropolitan city at the bank of Sarisawa Nadi.

Figure 11: The brick factory in Nakatuwa area causing air pollution

CONCLUSIONS

- The present study area of the Birgunj metropolitan city and its surrounding area mainly consists of fine alluvial sediments mostly clay, silt, and sand rather than cobble pebble gravel, etc. The grain size of the sediment ranges from the clay to the medium sand. The final map prepared including soil map, bearing capacity and it's engineering significance is shown in Figure 12.
- Based on the log obtained from the SPT boreholes, hand Auger drilling holes, and power auger drilling holes, the sediments of the present area are classified into the three soil units namely Pipara Deposit, Gadhaiya Deposit, and Nautan Deposit.
- The bearing capacity of the study area varies from very low to low.
- By virtue of its location, the study area is prone to flood and inundation. The Tilabe Nadi, the Sirsiya Nadi, and the Bangari Nadi are the main sources of flooding. The main causes of flooding/ inundation are heavy rainfall in short duration in the flat morphology along with lack of proper drainage system, dumping the waste at the sides of the river banks, etc. Besides these hazards, riverbank cutting/ erosion are other hazards in this area.
- The Birgunj metropolitan city does not have its own landfill site and the problem of waste disposal was seen to be prevalent in high dense urban core areas. Metropolitan city disposes the collected waste in the bank of Sarisawa Nala border of Nepal and India which is not a suitable area.
- The geologically suitable landfill site is proposed in the area consisting thick clay layer and away from settlement and water resources, such as near to Nautan area.
- The area has many brick factories, so, clay is the main mining resource in this area.

RECOMMENDATIONS

- The study area consists of loose sedimentary deposits like silt clay and sand. All area shows a very low bearing capacity. So, it is recommended to carry out a detailed site investigation before construction of any kind of structure to make the structures safe and sustainable.
- The river training structure with bio-engineering is highly recommended to control bank erosion.
- Top humus soil should be rehabilitated after clay mining in every brick factory area.
- Haphazard mining should be discouraged and mining activities should be carried out only under the supervision of the local authority.
- The wastes created from the industries, households, hospitals, etc. should be properly treated before dumping it. These wastes should not dump into the bank of the river, streams as well as on the sides of roads.
- An establishment of a proper sanitary landfill site is highly recommended in order to manage haphazard disposing of waste materials within the valley.

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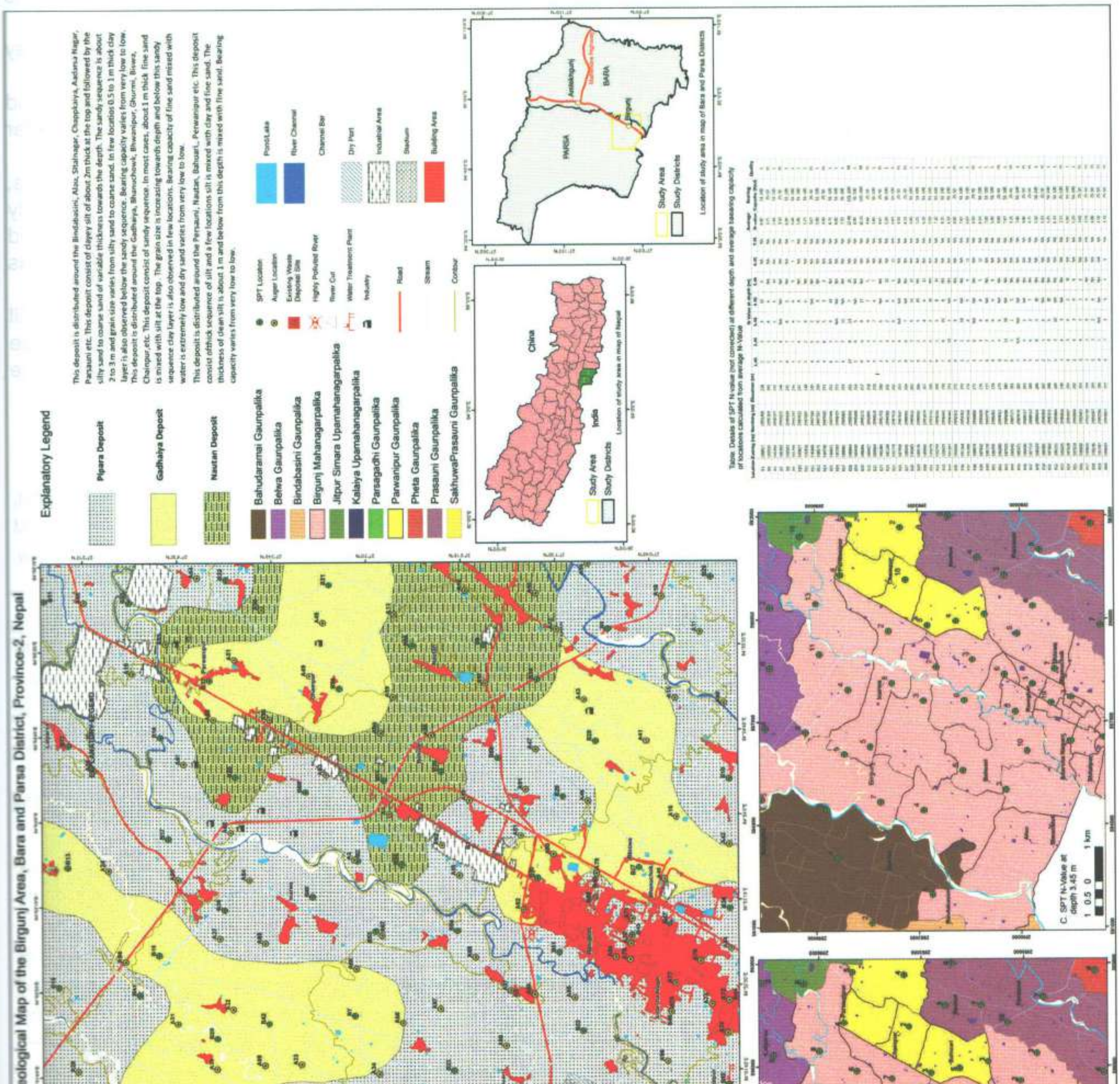

Figure 12: Engineering and Environmental Geological Map of the Birgunj Area.

Geological and Geophysical Investigation of the Kitbhanjyang Iron Prospect in Makwanpur District, Bagmati Province, Nepal

Prakash Pokhrel (Geologist), **Kumar Khadka** (Senior Divisional Geologist) and **Narayan Baskota** (Senior Divisional Geologist)

ABSTRACT

The Kitbhanjyang Iron prospect was investigated in two phases, at first geological study was carried out to locate the occurrence, nature, and host rock of mineralization and in the second phase, a geophysical study was executed in the three zones recommended by the geological study. Geologically, the iron mineralization is found in the white quartzite associated with the meta-basic intrusion in the Lesser Himalayan rocks. The Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) survey was carried out in order to determine the sub-surface nature of the mineralization. The anomalies presented on profiles recorded with different electrode arrays (Wenner, Schlumberger, Dipole-Dipole) show the presence of subsurface low resistivity zone (<600 ohm.m) and site geological condition can be related with such anomaly zones.

Keywords: iron prospect, electrical resistivity tomography (ert), induced polarization (ip), anomaly

INTRODUCTION

The first phase of the preliminary investigation was carried out around Kitbhanjyang area, Makwanpur district, central Nepal to study the geological distribution of iron mineralization in Fiscal Year 2074/075. In the second phase of investigation geophysical survey was carried out in the following fiscal year 2075/076 in the area delineated by the geological study.

The first phase of the study was focused on the delineation of the mineralization body as well as its extension, genesis, and spatial relation with the local geological setting. The present study area is under the restriction zone as the investigation process is ongoing through the Department of Mines and Geology (DMG). The fieldwork was conducted for about three weeks in the month of Poush and Magh, 2074. The fieldwork involves reconnaissance survey, geological traverses, stream sediment sampling, float analysis, Handheld XRF survey, and point sampling in an appropriate location of the target area. The traverse routes are fixed mainly along the river banks, trails, and roads to identify the rock units of the area. The previous literature and morphology of the area were used to make the routes for geological traverses.

In the second phase, a geophysical study including both the ERT and IP surveys were carried out by a DMG crew including Senior Divisional Geologist, Geologist, Sampler, and other survey helpers. The general purpose of this survey is to explore the presence of iron mineralization in the area delineated by the geological study. Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) methods were used based on the different physical properties of rock to determine the presence of mineral resources in the area (Telford et al 1990). For this purpose, ERT and IP field readings were obtained along 21 profiles but results from only a few profiles will be discussed here.

LOCATION AND ACCESSIBILITY

The study area lies in the Makwampur district, Kailash, and Raksirang Rural Municipality (RM) of the Bagmati Province, central Nepal. It covers the northern part of Makwanpur district. The location of the prospect area in the political map of Nepal is shown in Figure 1. The exact target areas are Puranagau, Kitbhanjyang, Jyandruni, Balame, Syansirandanda, Odare, Ramche, and Ghyansintar. Geographically, the area lies in the Mahabharat range, northwest of Hetauda Dun valley. The prospecting area lies in between the coordinates from 597000 m to 590600 m Easting and from 3045000 m to 3049500 m Northing in the topo-sheet no. 2784 8D published by the Department of Survey, Government of Nepal (GoN).

The prospecting area lies about 70 km (aerial distance) south of the capital city, Kathmandu (Figure1). The area can be accessed by using the Kathmandu-Heatuda-Namtar road and from Namtar, there is no motorable road. After 5 hrs of walking along steep foot trails, the area can be reached.

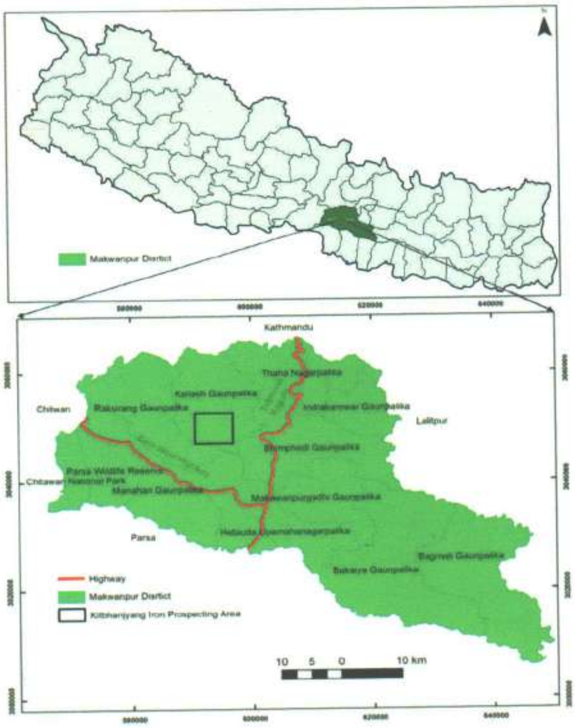

Figure 1: Location map of the survey area

TOPOGRAPHY AND DRAINAGE

The prospecting area is a hilly region consisting of moderate to steep hill-slopes. The north-facing hill-slope is relatively gentle as compared to the south-facing slope because the northern slope is dip slope and south face is counter dip slope. The elevation rises towards the central part of the prospect area which reaches up to 1822 m at Bagaune Danda whereas it descends to 600 m towards south at the Ramche Khola. The Bagaune Danda, Thamila Danda, and Pairag Danda make the continuous ridge in the central part of the target area extending from northwest to southeast Figure 2. The area shows a dendritic drainage pattern where the Manahari Khola and the Ramche Khola are the major tributaries.

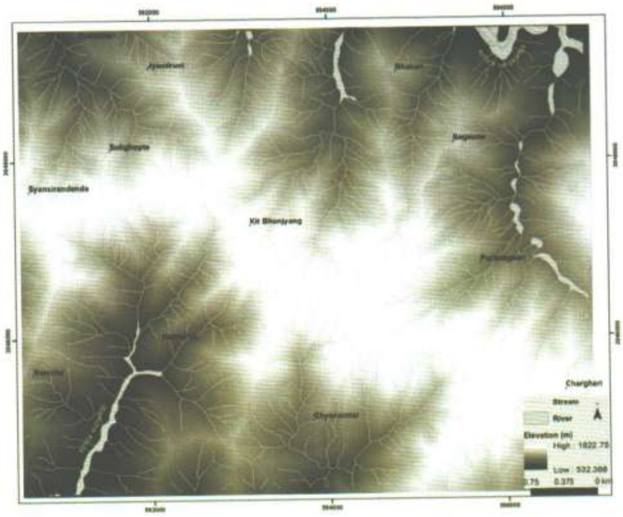

Figure 2: Digital Elevation Model (DEM) of the prospect area

REGIONAL AND SITE GEOLOGY

REGIONAL GEOLOGY

Regionally, the Kitbhanjyng iron prospect lies in the Lesser Himalayan crystalline nappe in central Nepal. The lithological unit of this region corresponds to the quartzite, amphibolites, schist, and marble of Upper Nawakot Group of Nawakot Complex and Bhimphedi Group of Kathmandu complex separated by the tectonic thrust locally called Mahabharat Thrust (MT). The target area is mapped by Stocklin and Bhattarai in 1984 at the scale of 1:250000 and DMG has also prepared the geological map of this area at the scale of 1:50000 by using the compile data in 2007. In the map prepared by the DMG (2007), iron mineralization is shown in two stratigraphic positions, one at Robang Formation and another in Raduwa Formation.

SITE GEOLOGY

In the target area, mainly three types of distinct lithological units are traceable in the base map at a scale of 1:25,000. The lithological description of each unit from older to younger sequence is given below:

QUARTZITE AND AMPHIBOLITE UNIT

This unit is exposed mainly along the southern slope of Bagaune Danda, Thamil Danda, and Pairang Danda. The major rock types of this unit are white quartzite and meta-basic rock (amphibolite), and other rock types are phyllite and slate. The quartzite is milky white in color and some quartzite beds are micaceous. The meta-basic intrusion is frequent within the quartzite bed. The meta-basic rock contains dark mineral, brown to reddish in color, and forms the thick soil horizon due to deep weathering. At few locations, highly weathered grey-greenish color phyllite and dark grey color slate are observed. Most of the beds are dipping towards the north with a moderate dip shown in Figure 3. This Unit is equivalent to the Robang Phyllites (DMG, 2007).

GARNET-MICA SCHIST UNIT

Garnet-mica Schist Unit overlies the Quartzite and Amphibolite Unit is shown in Figure 3. The rocks of this unit are mostly exposed along the north-facing slope of the ridges within the Target area forming the dip slope. The main rock type of this unit is garnet-mica schist, and other rock types are weathered greenish phyllite and micaceous quartzite. Garnet bearing schist is mainly observed along with the contact with the lower Quartzite and Amphibolite Unit. This contact is a tectonic thrust and named Mahabhara Thrust (MT) in the central region. A very thin bed of actinolite schist is also observed within this unit near to the contact with the meta-basic intrusion. This Unit is equivalent to the

Raduwa Formation (DMG, 2007).

MARBLE UNIT

This Unit forms the transitional contact with the lower Garnet-mica Schist Unit. This unit is exposed mainly along the northeast corner of the Target area around the Lickche, Hattipaile, and Bagaune shown in Figure 3. The main rock type of this unit is micaceous marble, and other rock types within this unit are weathered dolomite and Phyllite. The beds are dipping towards the north with a moderate dip. This Unit is equivalent to the Bhainsedobhan Marble (DMG, 2007).

PHYLLITE AND SCHIST UNIT

The Phyllite and Schist Unit is the youngest and exposed in the northern part of the prospect area shown in Figure 3. This unit mainly consists of pelitic minerals rich phyllite and schist. This Unit is equivalent to the Kalitar Formation (DMG, 2007).

MINERALIZATION

The iron mineralization in this area is found in quartzite associated with the meta-basic intrusion of the 'Quartzite and Amphibolite Unit' equivalent to the Robang Formation. There are several bands of iron-rich quartzite and amphibolite. About 2m thick iron mineralization is found at the landslide near to the northern slope of Kitbhanjyang and mineralization dispersed in quartzite is observed at Kitbahnjyang, Figure 4a. The old mine slag is found at three different places, at Kitbhanjayang, Jyandruni, and Odare. The instrumental setup for geophysical survey is shown in Figure 4b. In the Kitbhanjyang area one old mine trench of dimension about 2.5m width and 30m length was found Figure 4c.

The iron slags are disseminated around the cultivation and barren land of this area. According to local people, there is one old mine adit located in the south-facing steep slope. The occurrence of iron, as well as the copper mineralization, is found in this area. In the Majuwa area (Fe-3 in Figure 3), mineralization band lies in the east-facing steep slope and exposed by the landslide.

The float containing mineralization can be seen in the stream. In the Tallo Kitbhanjyang area, near to the Balame village old iron slag and ferruginous quartzite can be seen in the cultivation land (Fe-2 in Figure 3). The float consisting of iron mineralization can also be observed in the upper reaches of the Nimti Khola but the exact location in exposure is not found due to dense vegetation cover and landslide along the bank of Nimti Khola.

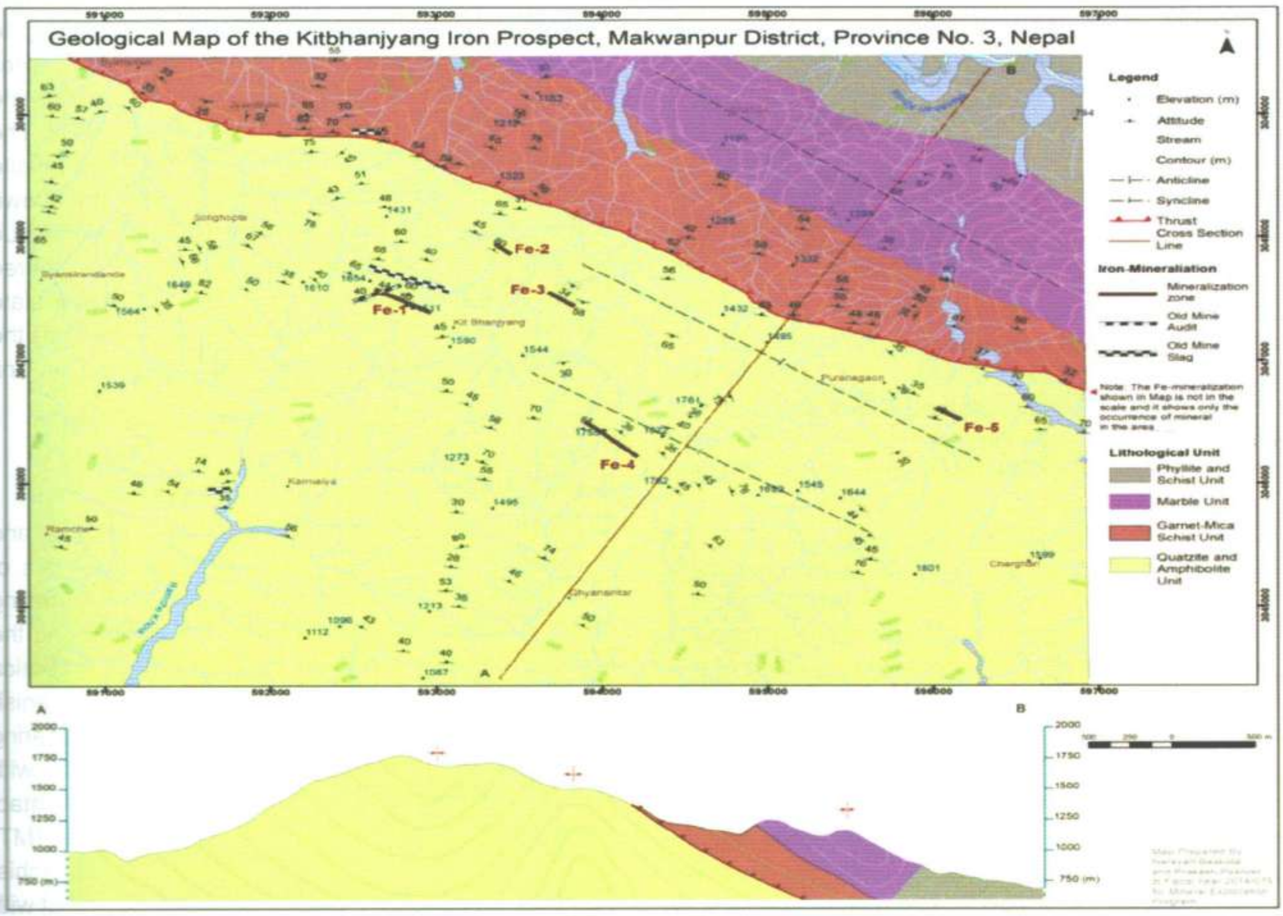

Figure 3: Geological map of the Kitbhanjyang Iron Prospect area

ERT AND IP SURVEY

2-D Electrical Resistivity Tomography and Induced Polarization survey were carried out at the Kitbhanjyang (Target Zone 1), Majuwa (Target Zone 2), and Tallokitbhnajyang (Target Zone 3) shown in Figure 5 and the data were analyzed by using the Res2D Inversion software (Loke 2004).

Figure 4: Field photographs, a: grey quartzite bed rock with mineralization, b: instrumental setup for ERT survey and c: old mine trench(?)

The lithological condition is almost the same in all locations except the variation in the thickness and nature of topsoil cover.

Figure 5: Google Earth Image showing the location of Target zones for geophysical survey

KITBHANJHYANG (TARGET ZONE 1)

The profile1 was executed in the cultivation land consisting of colluviums soil west from the old house at Kitbhanjyang and aligned in the direction from the south (E= 592774m and N= 3047454m) to the north (E= 592787m and N= 3047564m). The soil consists of silt, and rock fragments of quartzite, ferrogenous quartzite, and iron slag. The bedrock consisting of thin to medium banded white quartzite is partly exposed in the survey area. The survey is across the regional orientation of foliation in the area. The mineralization band is not exposed along the survey line. The survey was carried out using the Dipole-Dipole array with 24 electrodes at 5 m spacing. The resistivity inversion image (Figure 6) of this profile shows the low resistivity anomaly zone (less than 450ohm.m) below the topsoil layer in the middle part of the section at a distance of 60m from the start point.

The profile 4 was executed along the foot trail (way from Kitbhanjyang to Ghyansintar) and in cultivation land south from the house at Kitbhanjyang aligned in the direction from the southeast (E= 592937m and N= 3047221m) to northwest (E= 592784m and N= 3047532m). At the surface, the quartzite rock is exposed with a very thin layer of topsoil towards the south-eastern end along the foot trail and towards the north-western end from electrode 27 (260m), the survey line is along with the cultivation land. The mineralization band is not exposed along the survey line and the survey was carried out using the Wenner-Schlumberger array with 36 electrodes at 10 m spacing. The resistivity inversion image (Figure 6) of this profile show the low resistivity zone along with the several parts of the survey line at different depths. A wide low resistivity zone is observed towards the electrode position from 17 (160m) to 23 (220m) at the depth of about 8m from the surface.

The profile 7 was executed from south (E= 592822m and N= 592822m) to north (E= 592813m and N= 3047490m) in the cultivation land near to the old house at Kitbhanjyang. The survey line is across the regional orientation of foliation and old mine trench (?). The survey was carried out using the Wenner-Schlumberger array using the 48 electrodes at 1m spacing. A low resistivity anomaly (Figure 6) is observed towards the middle of the profile, at electrode position from 20 (19m) at the depth of about 1m from the surface. There is another low resistivity zone towards the northern end of the profile from electrode 24 (23m) to the end of the profile.

The profile 8 was taken along the cultivation land near to the house at Kitbhanjyang. The GPS locations of start point (Eastern end) and endpoint (Western end) are 592843m, 3047443m, and 592784m, 3047462m respectively. The survey line is along with the regional orientation of bedding/foliation in the area and old mine trench (?). The Dipole-Dipole array with 48 electrodes at 2m spacing was used in the field for the data acquisition. A low resistivity zone (Figure 6) is observed towards the eastern end of the profile whereas there is no anomaly below the old mine trench (?).

The profile 12 was executed in the cultivation land close to the house from the east (E= 592840m and N= 3047435m) to the west (E= 592798m and N= 3047456m) at Kitbhanjyang. The survey line is along with the regional orientation of foliation and old mine trench (?). The ERT and IP survey was carried out along this profile using the Wenner-Schlumberger array with 48 electrodes at 1 m electrode spacing. In the inversion image of resistivity (Figure 6), a low resistivity zone is observed towards the eastern end of the profile and chargeability value at this zone ranges from 0.20 to 0.30.

MAJUWA (TARGET ZONE 2)

The profile 9 was executed in the barren and cultivation land at the western ridge of a landslide at Majuwa village. The survey line is oriented across the regional orientation of the foliation and in the direction from the north (E= 593889m and N= 3047726m) to the south (E= 592866m and N= 30474635m). The ERT survey was carried out using the Dipole-Dipole array with 48 electrodes at 2 m electrode spacing. The ground contact resistance is very high at this location as compared to other zones. The resistivity inversion image (Figure 6) of this profile shows the small area of low resistivity zone (resistivity value of about 1000 ohm.m) towards the northern end below the slightly high resistive upper geological layers.

The profile 11 was executed along the foot trail from Kitbhanjyang to Majuwa, south of the Profile 9. The objective of this profile was to trace the continuation of the Iron mineralization band exposed in the landslide. A longer profile is used in steep and irregular north-facing slope which consists of continuous exposure of medium to thick banded white quartzite. Along the slope, rock fragments consisting of ferrogenous quartzite and iron-mineralization were observed. The area is very dry. The survey line is aligned in the direction from the south (E= 593749m and N= 3047416m) to the north (E= 593842m and N= 3047615m) and Dipole-Dipole array was used with 48 electrodes at 5m spacing. The resistivity inversion images (Figure 6) of this profile show the high resistivity value range. The lowest resistivity value is seen towards the southern end at electrode 9 (40m) about 18m below the surface but this zone has very low data sensitivity value.

TALLOKITBHANJYANG (TARGET ZONE 3)

The profile 19 was executed in the cultivation land at Tallo Kitbhanjyang village along the north facing moderate slope. The objective of this profile was to find out the location of the mineralization band as rock fragment consisting of iron mineralization and slag are abundant all over the slope and cultivation land at surface. The survey line is oriented from the southeast (E= 593444m and N= 3047896m) to northwest (E= 593361m and N= 3047927m). The Dipole-Dipole array was used with 48 electrodes at 2 m spacing and ground contact resistance along this profile is low as compared to other locations. The resistivity inversion image (Figure 6) of this profile show the low resistivity zone towards the start electrodes (SE end) below the topsoil layers. This is most probably due to the presence of iron mineralization/ferrogenous quartzite in the area.

The profile 20 was executed in the cultivation land at Tallo Kitbhanjyang village. The survey line is almost horizontal and is oriented from the northeast (E= 593397m and N= 3047916m) to southwest (E= 593376m and N= 3047882m). The Wenner array was used with 48 electrodes at 1 m spacing. The resistivity inversion image (Figure 6) of this profile shows the low resistivity zone towards the end electrodes (SW end) below the topsoil layers. The resistivity value of the topsoil layer and the resistivity anomaly zone is almost the same. This is most probably due to the presence of abundant rock fragments and slag consisting of iron on the surface and mineralization band beneath the topsoil cover.

DISCUSSION AND CONCLUSIONS

The geological study indicates the occurrence of the iron mineralization in this prospect area as magnetite crystal are found dispersed within the white quartzite band, about 1.5 to 2m thick hematite band exposed by a landslide near to Majuwa village, ferrogenous quartzite at Tallokitbhanjyang and iron slag in the different parts within the prospect area. The mineralization found in the quartzite seems to be associated with the meta-basic intrusion in the 'Quartzite and Amphibolite Unit' equivalent to the Robang Phylliites of DMG, 2006 and Robang Formation of Stocklin 1984.

In target zone 1, the ERT and IP profiles were focused around the old mine trench and house. Most of the profiles near to the house and northern end of the Profile 1 has the consistent low resistivity value. The area is very dry, the presence of groundwater level must be deep and low resistivity zone is imaged below the top, loose and unconsolidated residual soil developed on colluvium soil and/or bedrock. The presence of the Fe-mineralization can be observed in the bedrock within the survey area. Therefore, the low resistivity zone in those profiles can be inferred to the low resistivity characteristics of Fe-mineralization.

In target zone 2 (Majuwa area), the mineralization band of about 2m is exposed by the landslide in the east-facing steep slope. The overburden thickness is more than 50m and varies along the surface of the ridge. The geophysical survey (ERT) was carried out to determine the continuation of the mineralization band in this area but the low resistivity zone is not observed in the inversion image. This is maybe due to the small dimension of an anomalous body, very irregular and steep topography, high overburden thickness, and high ground contact resistance of white quartzite present in the survey area. According to the site condition, although low resistivity zone is not seen in the inversion image, the presence and continuation of the mineralization band in the area can't be neglected.

In zone 3 (Tallo Kitbhanjyang), the low resistivity zone is found in the profile 19 and profile 20. The bedrock consisting of the ferrogenous quartzite is found in the survey area. The low resistivity value of this zone is about 1000 ohm.m and this value is within the range of resistivity value of the Fe-mineralization band. According to the site condition, the occurrence of low resistivity zone can be related to the presence of Fe-mineralization.

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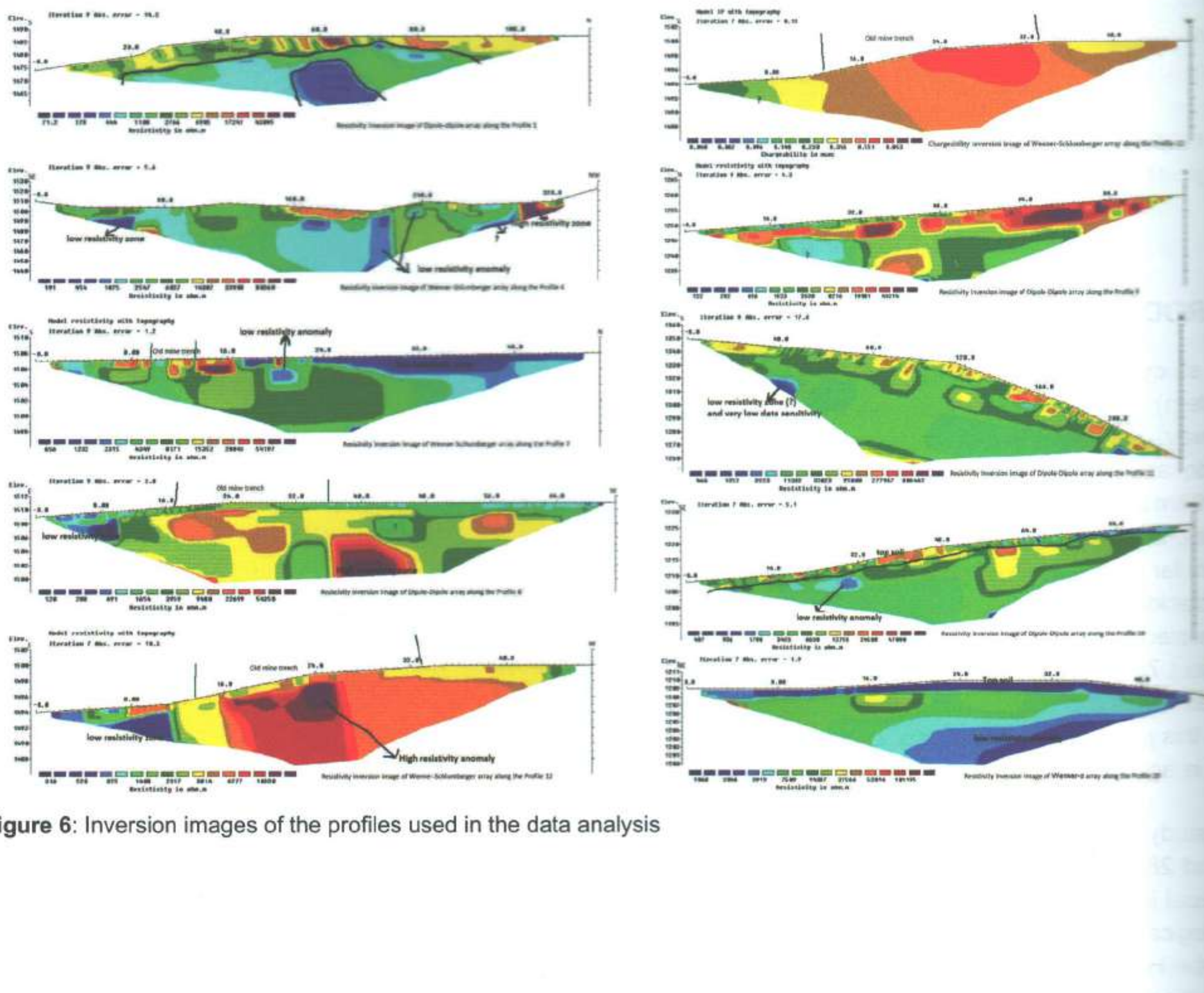


Figure 6: Inversion images of the profiles used in the data analysis

Geological Mapping for Prospecting of Gemstone in Parts of Jajarkot District

Lokendra Pandeya (Geologist), **Sunu Dawadi** (Geologist)

ABSTRACT

Nepal is taken as a rich country in precious and semi-precious stones having major resources located in districts like Sankhuwashabha, Dhanding, Jajarkot, Achham, Kalikot, and many others. Higher Himalayan belt of Nepal has a high quality of precious and semi-precious stones. DMG has been accelerating the activities of the geological investigation on promising places of Lesser Himalayan and Higher Himalayan belt of Nepal. There are many prospects of gems in the Jajarkot District. The present study deals with Geological Mapping in Thalaha- Jajaya-Mainpakha area of the Jajarokot District and to determine the rough sketch of gem mineralization. Field investigation is carried out by geological traverses along the ridges, rivers, roads and foot trails. In the study area, the low-grade metamorphic rocks of Lesser Himalaya consisting of quartzite, phyllite, and metabasites are thrusted by the high-grade rocks of the Higher Himalaya consisting of garnet schist, quartzite, coarse-grained garnet kyanite schist, and garnet–kyanite gneiss. Main Central Thrust (MCT) separates the Higher Himalayan rocks with the lower grade rocks of Lesser Himalaya. The Lesser Himalaya in the area is represented by the rocks of Dailekh Sub Group probably representing the rocks of Ranimata Formation. Higher Himalaya is represented by the Kalikot Formation and the Jajaya Formation. Kalikot Formation has thrust contact with the overlying highly crystalline rocks of Jajaya Formation. Kyanite and Tourmaline bearing veins and rocks lie within the Jajaya Formation. There is a huge possibility of kyanite and tourmaline resources in the northern part of the Thalah- Jajaya- Mainpakha area. Kyanite and Tourmaline are found either in the disseminated form in schist and gneiss or concentrated in veins and lens.

Keywords: gem mineralized zone; prospecting of precious and semi-precious stones; geological mapping of parts of the jajarkot districts; thalaha-jajaya-mainpakha area

INTRODUCTION

The study area is located in Province No. 6 (Mid-Western) Nepal. It is accessible via a blacktopped highway and graveled road. Birendranagar, the Headquarter of the Province No 6 (Mid-Western Nepal), is 590 km far from capital Kathmandu and connected by Mahindra Highway. Cheda of Jajarkot district is about 62 km far from Chinchu, Surkhet, and can be reached via blacktopped road. Thalah of Jajarkot district is connected to Chedda Bazar by graveled road which is about 70 km north from Chedda. The road network limited to this place and geological traverse is started from this place, Thalah, Jajarkot. The rest of the study area is accessible by gravel road and foot trail.

The study area lies in the topo-sheet no. 2881 04 B & D, and 2882 01 published by the Survey Department of Nepal in 1:25,000 and 1: 50,000 scale respectively. Geologically this region lies in the Lesser Himalaya and the Higher Himalaya Unit. The study area covers more than 400 sq km. Location of the Thalah—Jajaya-Mainpakha area, Jajarkot District is shown in Figure 1.

Physiographically, the study area represents the mountainous region. The area consists of gentle to steep slopes of Higher Himalayan ranges. Mostly steep to very steep topography are formed by the counter dip slope of the bedrocks mostly quartzite, schist, and gneiss. The maximum elevation in the area is about nearly 3300 m at the peak of Ratapatan Lek, Paink, and minimum elevation is about 920 m at Thalaha. The area shows a dendritic drainage pattern. Around the study area Saru Khola, Satiya Khola, Suwa Gad, Mujkot Khola are major streams. Locally, parallel drainage patterns can be seen on small territory that is mainly controlled due to the orientation of the joints and parallel discontinuities.

Geologically, the area belongs to the Lesser Himalayan crystalline zone with the high-grade metamorphic rocks. It lies in the in Karnali Nappe west to the Jajarkot Nappe. The Crystalline nappe rocks consisting of garnet schist and quartzite as well as gneiss comprising the Dadeldhura Group are thrusted over the Lesser Himalayan weakly metamorphosed rocks consisting of phyllite, quartzite with metabasic intrusions. The present study area only covers the Ranimatta Formation of the Dailekh Group and the Kalikot Formation and Jajaya Formation belonging to the Dadeldhura Group of Lesser Himalayan Crystalline.

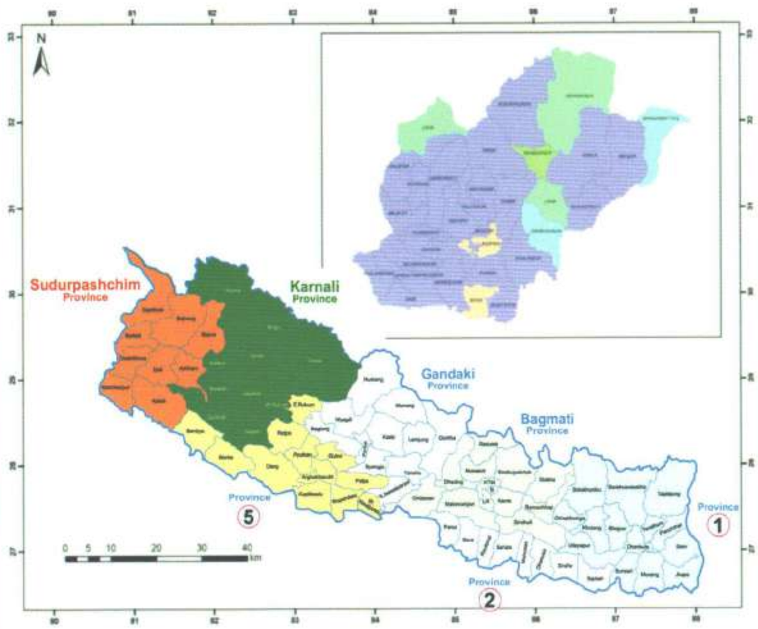


Figure 1: Location of the Thalah—Jajaya-Mainpakha area, Jajarkot District

OBJECTIVES

The objective of the study is

- To carry out geological mapping in 1:50,000 scale.
- To identify mineralized bands especially for the gemstones.
- Field observation of many prospects/mineral resources of the area and target generation for further exploration works.

LIMITATIONS

- The present investigation is limited to the observation of the outcrops along the access routes.
- Due to the limited time frame for geological traverses, there is an extrapolation of geological boundaries. Similarly, identification of the mineral deposit in the field was made based on visible inspection and is not aided by any sophisticated types of equipment or tools.

METHODOLOGY

Existing relevant literature on regional geology, geological controls on gem mineralization, and mineral resources of Nepal were reviewed.

Before the field, the desk study was carried out using toposheet (1:25,000) and a high-resolution satellite image (from Google Earth) for the study of land use patterns, geomorphology, etc.

The fieldwork comprises 25 days walkover survey of the area making geological traverses along different possible sections. Handheld GPS was used for locating the observation points. Detailed columnar sections were prepared in the required sections. Strata are classified following the standard stratigraphic codes.

Representative grab samples were collected from each geological unit and labeled accordingly in the sample bags to bring into the laboratory of the DMG for petrographic analysis. Similarly, samples were collected from each potential mineralized zone for further analysis.

The final geological map is prepared in a 1:50000 scale with delineation of some important rock horizons for gem mineralization.

REGIONAL GEOLOGY

The study area lies in Mid-Western Nepal, Lesser Himalayan Belt. Midland or Lesser Himalayas consists of deformed, relatively weakly metamorphosed rocks delineated by the (Main Boundary Thrust (MBT) to the south and (Main Central Thrust (MCT)) to the north. The Lesser Himalayan sequences are thrusted by crystalline thrust sheets in the form of large crystalline masses forming nappe and clippe. The Higher Himalaya consists of thick slabs of high-grade metamorphic rocks representing the Precambrian basement, a part of the upper crust that had been reactivated due to crustal shortening as a result of a continent collision during the Himalayan orogeny.

Regionally, Ranimatta Formation of Dailekh Group and Kalikot Formation of the Dadeldhula Group of rocks were encountered around the study area. A more metamorphosed succession thrusted over the Kalikot formation is classified as the Jajaya Formation. Jajaya Formation has experienced kyanite grade metamorphism forming different masses of gneiss and coarse garnet- kyanite schist with few granitic masses at some cores of the gneiss. The Kalikot Formation in the area has experienced garnet grade metamorphism. Structurally, the study area lies in the western part of the Dadeldhura Nappe. General stratigraphy of the study areas (after S.B Shrestha et.al, 1987) is presented in Table 1.

Surkhet Group (Cretaceous-Oligocene)	Lakharpata Subgroup	Suntar Formation
	Unconformity	
Dailekh Group (Upper Precambrian-Late Palaezoic)		Lakharpata Formation
Dailekh Group (Upper Precambrian-Late Paleozoic)	Dailekh Subgroup	Ranimatta Formation
		Kusma Formation
		Ulleri Formation
	Thrust	
Dadeldhura Group		Sallyani Gad Formation
		Kalikot Formation with Ghatte Gad Carbonates and Budhi

Table 1: General Stratigraphy of Mid-Western Nepal, Lesser Himalaya (after S.B Shrestha et.al, 1987)

SITE GEOLOGY

In the study area, the high-grade rocks of the Higher Himalayan crystalline consisting of coarse-grained garnet kyanite schist, coarse-grained quartzite, and garnet– kyanite gneiss which is thrusted over the Lesser Himalayan rocks consisting of garnet schist and quartzite (Annex I). The whole sequence is which in turn is thrusted by low-grade metamorphic rocks of Lesser Himalaya consisting of quartzite, phyllite, and metabasites. The lesser Himalaya in the area is represented by the rocks of Dailekh Sub Group probably representing the rocks of Ranimata Formation. The Higher Himalaya is represented by the Kalikot Formation and Jajaya Formation. The generalized lithological column is prepared and shown in Figure 2.

RANIMATTA FORMATION

Ranimatta Formation is exposed around Thalaha, Nauli, Simalgaun, Nare, Dandagaun and Santada Areas. It forms an extensive belt consisting of green, green-grey to dark grey thin to medium- banded pelitic phyllite and schist. The frequent bands of white to gray quartzite containing mica partings are common throughout the Formation. This unit forms relatively moderate topography. The interbanding ranges from few centimeters to tens of meters thick in the exposure. However, greenish-gray phyllite forms the dominant lithology of this formation.

A distinct arenaceous horizon lies within the Ranimatta Formation which is mapped as Quartzite Unit within the Ranimatta Formation. Thick quartzite bands sometimes greater than 150m in thickness are observed within the Quartzite Unit. This unit consists of white to green to gray micaceous blocky quartzite consisting of light to dark gray and sometimes green pelitic as well as psammitic phyllite. A few meters to tens of meter-thick metabasic bands are frequently intruded within the formation. It is well developed in Goya, Batule, and Dhime villages. It forms stiff cliffs at the left bank of the Saru Khola near and around the confluence of Tapuchaur Khola and Saru Khola.

KALIKOT FORMATION

Ranimatta Formation is separated from the Kalikot Formation by the Regional Thrust probably equivalent to the Dadeldhura Thrust. It consists of a distinct mixed unit of thin to thick white-gray to purple quartzite intercalation with greenish-gray phyllite to light to dark gray garnet schist. The quartzite forms yellowish tint on weathering surfaces. This unit consists of thick bands of Slaby quartzite as well. Local-scale mining for slab stone is observed within this Formation. Grey micaceous quartzite observed near Sanakhola, Jajarkot (Kalikot Formation) is shown in Figure 3.

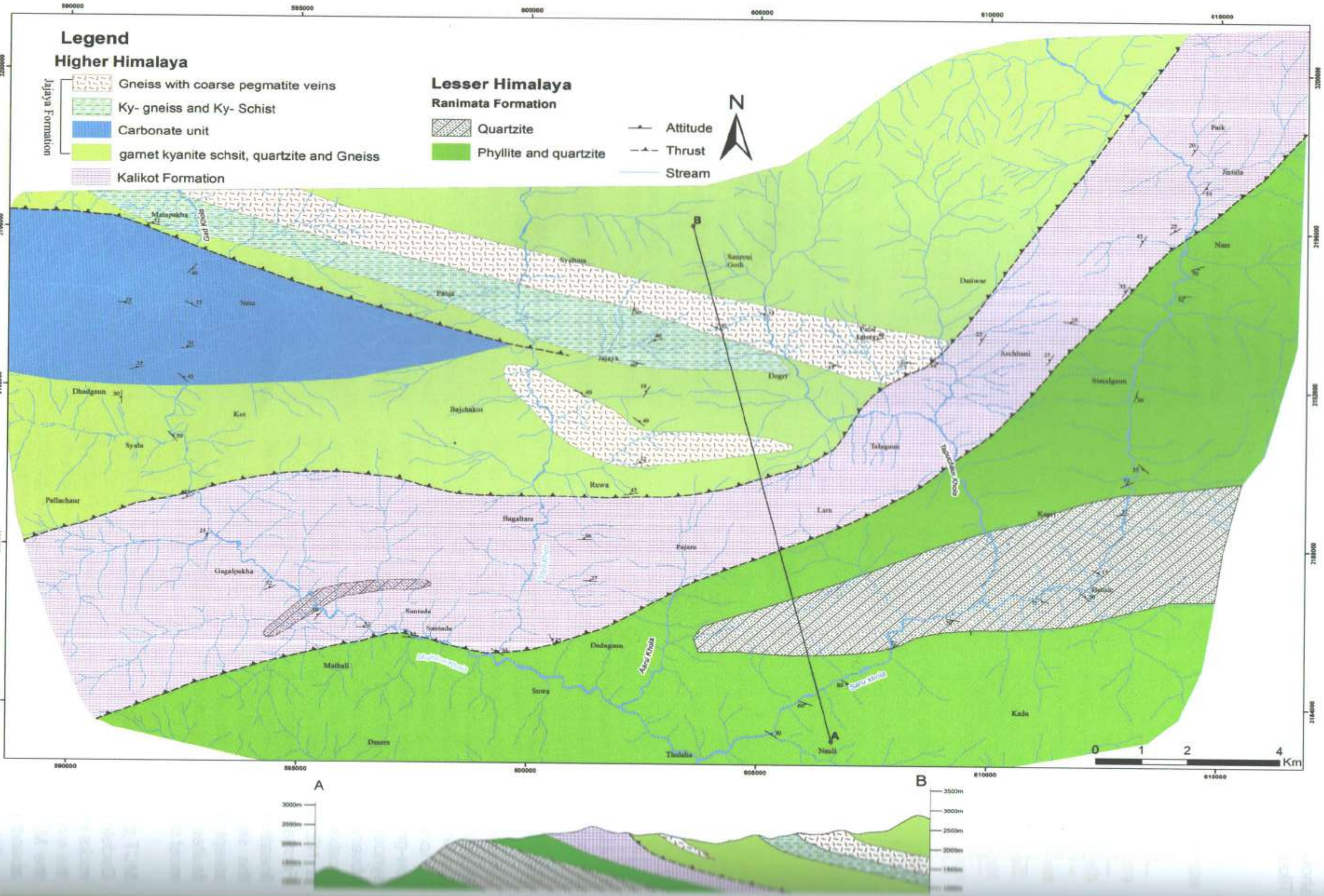
JAJAYA FORMATION

Jajaya Formation is well developed in Dhadgaun, Mainpakaha, Datiwar, Saureni, Jajaya villages. It consists of coarse-grained mica rich schist sometimes consisting of mineralized veins with kyanite as well as tourmaline. Mica rich schist is often intercalated with thin to medium banded white to grey slabby coarse-grained quartzite. It is probably equivalent to the Budhi Ganga Gneiss Unit of Kalikot Formation.

Different bands of gneisses and schists mainly Augen gneisses are the host for different types of gem minerals kyanite, tourmaline, and garnet. Folded gneiss observed at Patalkatera (Jajaya Formation) is shown in Figure 4. Pods and veins of mica- rich and psammitic minerals are frequent which are sometimes provided with rich gem mineralization. Garnet kyanite schist and kyanite gneiss are host rock for significant crystals of kyanite. At places, gneiss consists of pegmatitic veins which are the main host rock for tourmaline mineralization.

A prominent carbonate band consisting of calc schist, garnet schist as well as white coarse-grained quartzite commonly containing garnet grains on the parting surfaces to sporadic calc. quartzite forms the Calcareous Unit within the Jajaya Formation. This Unit is well exposed near Syala, Khara area. Gneiss outcrop

Annex I: Geological map of Thalaha - Jajaya - Mainpakha area, Jajarkot District, Karnali Province



observed at Saureni, Jajarkot (Jajaya Formation) is shown in Figure 5. Banded gneiss outcrop observed at Tikachaur, Jajarkot is shown in Figure 6.

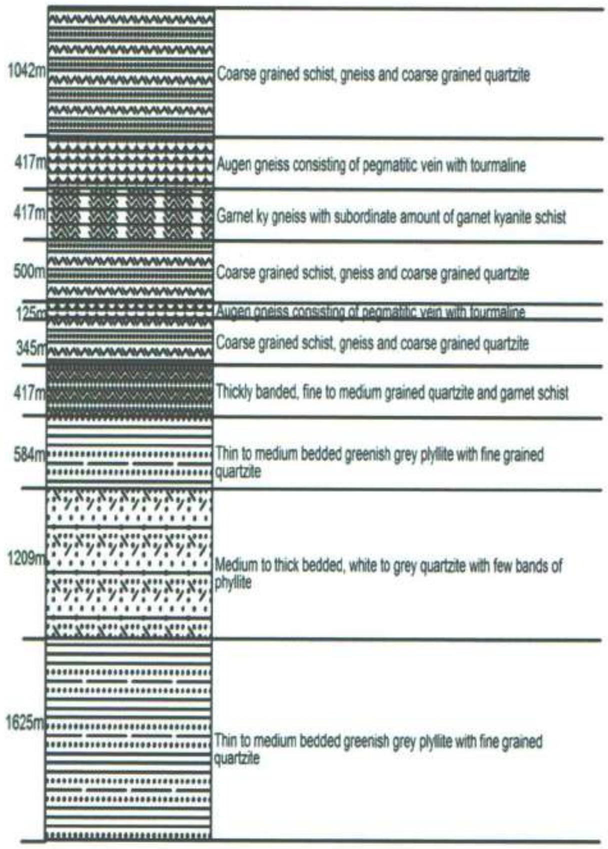


Figure 2: Stratigraphic columns of the rocks of Thalaha-Jajaya-Mainpakha Area, Jajarkot District.

GEOLOGICAL STRUCTURE

The study area lies in the Dadeldhura Crystalline Nappe. As such, the study area also comprises of the deformational or secondary structures of regional to local scale. Similarly, the sedimentary and the low-grade metamorphic rocks well preserve the syndepositional structures. The primary lamination is observed in the quartzite of Kalikot Formation at many locations. Overall foliation in the Ranimatta Formation is NE-SW due North, whereas that in the Jajaya Formation is generally NW- SE due north. Both mineral lineation and stretching lineation are observed in both the sequences. These lineations plunge gently to steeply toward the north. The area is highly folded and faulted. Meso-scale folds and faults are widespread in most of the stratigraphic units.

MCT brings the High-grade metamorphic rocks of the Dadeldhura Group over the low-grade metamorphic rocks of the Dailekh Group. Locally this thrust may be the extension of the Dadeldhura Thrust. The rock near the MCT is highly deformed. Rotated garnet grains, abandoned quartz veins are common in the phyllite and schist near MCT.

Figure 3: Grey micaceous quartzite observed near Sanakhola, Jajarkot (Kalikot Formation)

Figure 4: Folded gneiss observed at Patalkatera (Jajaya Formation)

Figure 5: Gneiss outcrop observed at Saureni, Jajarkot (Jajaya Formation)

Figure 6: Banded gneiss outcrop observed at Tikachaur, Jajarkot

IGNEOUS INTRUSION

Many metabasic bodies are intruded in the Lesser Himalayan rock units. These bodies are limited in thickness and extension which are not mappable in the present study area in a 1:50,000 scale. Relict granite bodies are observed at the cores of gneisses at Jajaya Formation of the Higher Himalayan sequence. Kyanite and Tourmaline mineralized veins are juxtaposed around the igneous intrusion and are significant in terms of gem exploration.

GEM RESOURCES OF THE STUDY AREA

The terms 'Precious' and Semi-precious are being commonly used to categorize the gem minerals in Nepal. Mines and Mineral Regulations, 2056 has categorized gems minerals in two groups – (a) Very Important Minerals as Diamond, Ruby, Sapphire, Emerald and Corundum; and (b) Important and Valuable Minerals as Topaz, Tourmaline, Garnet, Aquamarine, Kyanite, Beryl and Quartz. The Annex-10 of Mines and Mineral Regulations, 2056 for royalty submission has subcategorized these gem minerals into 'Gem Grade' and 'Industrial Grade'. There is a huge possibility of gemstone based industries in Jajarkot District. The establishment of the gem based industries may prove beneficial for the growth of the national economy. At present, the few gem based industries are ill-functioning. The production is low because the export of gems in their raw forms is banned by the government. Therefore, there is an immediate need for the establishment of the cutting and polishing laboratory in the Nation and the DMG is working in that direction for fascinating the gem based industries by encouraging polishing and cutting lab within the country.

There are many prospects of a gem in the present study area. DMG has issued two prospecting licenses for tourmaline and one kyanite in Jajarkot district. Similarly, Ten mining licenses for tourmaline and three licenses for kyanite are issued (source http://gis.dmgnepal.gov.np/dmg/). The present study aims to determine the rough sketch of gem mineralized bands in the targeted areas as far as possible. Gemstone research in gem promising areas should be kept as the priority

With the view of economic mineral deposits, abundant kyanite and tourmaline mineralization are seen in the northern parts of the present study area. Indication of garnet mineralization is seen in some parts of the study area however they show no economic value. The outcome of the mineral exploration during the present study is as follows.

SEMI-PRECIOUS STONE

In the study area promising indication of semi-precious stone is observed. There is a huge propectivity of kyanite and tourmaline in most of the northern parts of the research area. Gneiss with Coarse Pegmatite vein Unit as shown in the geological map of the area is a promising zone for Tourmaline whereas the Kyanite Gneiss and Kyanite Schist Unit is important for kyanite resource. Both units lie in the Jajaya Formation.

KYANITE

Light to dark blue crystals of kyanite blades are disseminated in gneiss and mica- schist. Kyanites are observed in veins and lenses within the gneiss and schist. Rich mineralized areas are usually phlogopite rich very coarse-grained schist. Abundant kyanites are observed in Dandabhauta, near Patal Katera, Saureni, Tikachaur, and Mainpakha area. Good-quality and nicely colored kyanite can be found mainly in Saureni and Dadabhauta area. Kyanite bearing vein observed at Dadabhauta, Jajarkot is shown in figure 7. Abandoned audits of kyanite mines are observed near Saureni. Kyanite crystals observed here are light blue with a significant dimension. Kyanite blades range in size from a few mm to up to 4cm. These are hosted in coarse schist, augen gneiss, and massive pegmatite veins. Abundant Kyanite mineralization in coarse mica schist and gneiss are observed in Mainpakha area also but most of the crystals contain fractures in surface exposure. This area can be taken as a highly promising area for Gem grade Kyanite.

TOURMALINE

Tourmaline ranging from black to petrol and Fanta color and many different colors are observed in many places such as Jajaya, Tikachaur, Ruwa, and Dhogri areas. These are hosted in the coarse mica schist and pegmatite veins within the schist and gneiss of the Jajaya Formation. The tourmaline crystals occurring in pegmatite veins are higher in quality and size. There are some abandoned audits of the Tourmaline mines in the study area is shown in figure 8. Tourmaline observed in Ruwa is black and is of industrial grade. At Jajaya and Tikachaur and Dhagri areas, other different transparent colors are observed ranging from dark gray to clear yellow.

GARNET

There is an indication of garnet mineral widespread in the Jajaya Formation, Kalikot Formation. However, the resources of any economic interest are lacking in the area. Garnet crystals usually are brown to dark impure red which are usually fractured. Large garnet grains are found disseminated in the garnet schist and gneiss in the Kalikot as well as Jajaya Formation.

Figure 7: Kyanite Bearing Vein observed at Dadabhauta, Jajarkot

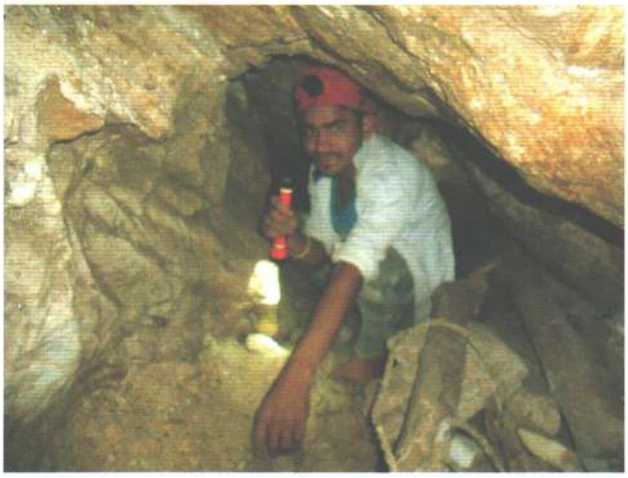


Figure 8: Audit of tourmaline mine observed at Jajaya, Jajarkot

NON-METALLIC MINERAL RESOURCES

The major non-metallic resource of economic interest is quartzite. The quartzite of the present study area is mostly suitable for construction material. Quartzite is commonly found in the rock of the Ranimata Formation and the Kalikot Formation. Quartzite observed in Ranimata Formation consists of micaceous partings at places exhibiting the slabby nature. These quartzites are suitable for construction material purposes as well as for using as slab stone. Slabby nature quartzites are observed in Aulo Khola, Chharagau, Ghogi, Ruwa, and Sana Khola area.

CONCLUSIONS AND RECOMMENDATIONS

Geological mapping in a 1:50,000 scale was conducted in the toposheets no. 2882 01 and 2881 04 C & D covering an area of more than 400 sq. km. This area contains the rocks of Dailekh Group and the Dadeldhura Group separated by a regional thrust known as the Dadedhura Thrust. The rocks are comprised of the rocks of Dadeldhura Nappe.

The Dailekh Group consists of the low-grade metamorphic rocks of the Lesser Himalaya whereas the Dadeldhura Group in the area is composed of the high-grade metamorphic rocks. The Lesser Himalaya is composed of Ranimata Formation. Whereas the overlying Dadeldhura Group consists of the Kalikot Formation and the Jajaya Formation later probably equivalent to the Budhi Ganga Gneiss of the Kalikot Formation and has the thrusted contact with the Kalikot Formation.

In the context of mineral resource, abundant mineralization of kyanite, tourmaline and garnet are observed in many places. Kyanite and Tourmaline are identified as major gem resources in the area. Kyanite is hosted by mica schist and gneiss within Jajaya Formation whereas pegmatite veins within augen gneiss mainly host the good color tourmaline. It is also found disseminated in schist and augen gneiss. The area consists of numerous mine audits, the mining activity is recently halted due ban of export of raw gems in the international market. A sound working environment should be given to these mines and should open them immediately.

Apart from already existing mines, there is huge prospectively for kyanite and tourmaline based mines in the northern part of study areas such as Dadabhauta, Ratapatan, Saureni, Jajaya, Tikachaur, Mainpakha and many other places lying towards north from these places. Further exploration is recommended in each of the specific places to examine the quality, quantity, and extent of each mineralized band.

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Testing of Limestone Samples and its Contributions in Growing Cement Industries in Nepal

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ABSTRACT

Mineral resources are one of the crucial resources which naturally scatter with varied quality and availability across the country. To evaluate mineral quality, validation as well as utilization for promotion of mineral based industry, a chemical laboratory was also established in the premise of the Department of Mines and Geology. This facility is continuously carrying analysis of important minerals, limestone being a high priority these days since it is one of the main raw components for the production of cement. The analysis of limestone sample normally reveals the test result data should be in between the ranges for deciding the quality of sample. A good quality of limestone has generally CaO content of 45 ± 5 % and MgO of < 3%, is regarded as a cement grade limestone. With high demand of cement these days in Nepal, a large number of cement industries have been established.

Keywords: mineral; exploration; analysis; quality; cement

LIMESTONE TESTING IN THE DMG - CHEMICAL LABORATORY

Limestone, chemically known as Calcium Carbonate (CaCO3), is the major component for production of construction material - Cement. The establishment of "The Department of Mines and Geology", chemical laboratory aims for certain chemical testings of any Geological Mineral Commodities (Metallic or Non-metallic or Trace elements) and also evaluation of tested sample in the country.

Initiation of chemical laboratory in this department is a first of its kind as government owned laboratory in Nepal. Geological survey department of USA fully helped with significant assistance with necessary equipment's and accessories. The laboratory was fully equipped for wide range of testing of geological samples from sample preparation activities to conventional analysis and instrumental analysis (Trace elements analysis).

Furthermore, the chemical laboratory has been smoothly operating overcoming lots of obstacles such as, breaking down of old equipment's, machineries, accessories, lacking of man powers and utilities etc. associated with chemical analysis of minerals samples.

All the retired senior geologists, mining engi-neers, and currently working geologists and mining engineers have brought various batches of rock samples from diverse parts of prospected/deposited area of the country every year. So altogether, the laboratory has successfully tested more than fifty thousands of limestone samples till date.

The DMG chemical laboratory has still been testing limestone from almost every part of the country along with its required parameters. Hence, it is a matter of pride of the laboratory itself and pride of this department as well.

There were more than 20 laboratory manpower's (senior chemists, Assistant chemist, and Lab Technician) exists before 30 years. During that time, wide range of chemical testing works of different mineral commodities: Limestone from many different prospectus areas, coal from Dang, soil, water, silicates rocks, metallic (Zn-Pb) ore samples from Rasuwa, magnesite from Dolakha etc. were tested. All staffs were seemingly engaged in the testing works.

These days, there is high demand of limestone for cement production due to which the testing of limestone is also rapidly increasing in the chemical lab with arrangement of sophisticated instruments like Atomic Absorption Spectrometer (AAS), X-Ray Fluorescence (XRF), ICP-MS (Inductively Couple Plasma-Mass Spectrophotometer) for testing of metallic ores and rare earth elements, besides regular volumetric method.

For the testing of limestone samples, the laboratory had already prepared a validated testing manual/ procedure followed by " IS 1760 - I, II, III parts (1992). This helps in adopting analysis of limestone, dolomites and allied materials" since a long time.

A complete chemical analysis work of limestone or any other mineral samples usually tested in the laboratory from following three different units serially as described below.

a. Sample preparation Unit

b. Convention analysis unit

c. Instrumental analysis unit

SAMPLE PREPARATION UNIT

The raw limestone sample as it enters this unit, is registered with essential information and its identification. It is crushed using various crushers and pulverisers. Similarly, the sample volume is also reduced through coning and quartering to about 200 gm. Then, it is prepared to make fine powder (100 mesh size or 0.1 mm) size as it's required for sample digestion and ignition into the convection unit.

CONVENTIONAL ANALYSIS UNIT

The prepared sample from crushing unit is separately registered here keeping record of sample prepared date along with the date of delivery before the testing is carried out in the conventional lab. The sample testing starts with drying in the Oven and then, the dried sample is used for the rest of testing parameters. Loss on Ignition (LOI) is conducted in the Muffle furnace at 10000C for an hour, percent loss is calculated (The percent content of LOI in sample is varied in the range of 40-50 % depends on the content of Calcium and Magnesium carbonate in it). For other parameters determination, sample digestion is carried out with mixture of Hydrochloric acid and few drops of nitric acids solution in beaker. It is heated on a hot plate placed inside Fume hood. The mixture solution is heated until it is dried and baked for a few minutes. Few amounts of acid and water is again added and kept for further heating for complete digestion.

It is filtered on a hot condition. The residue remained in the filter paper is ignited to get the percentage of silica (Insoluble matter) calculated. The percent content of insoluble matter or silica in sample is varied in the range of 5 - 15 % depends on the content of insoluble silica in it. Filtrate is used further for determination of combined oxides (Aluminium oxide and Iron Oxide) which can be detected by mixing the filtrate with ammonia and ammonium chloride and is heated until appearance of precipitate formed suspends in the solution. It is again filtered to get combined oxide in the residue. The percent content of combined oxide R2O3 (mixture of Al2O3 and Fe2O3) in sample is varied in the range of < 1% and filtrate is used further Calcium oxide and magnesium oxide determination. The iron oxide (Fe2O3) is detected by instrumental method using Atomic Absorption Spectrometer.

The filtrate solution remained after separating from combined oxide is used to determine the CaO (Calcium Oxide) and MgO (Magnesium Oxide) by titration method. In this method, known volume of sample is titrated with un-known volume of EDTA (Ethylene Diamine Tetra Acetic Acid) in high alkaline medium. The percent content of both CaO and MgO in given sample is varied in the range of 40- 50% of CaO and 1-5 % MgO depend on the quality of limestone sample.

INSTRUMENTAL ANALYSIS UNIT

The filtrate remained after digestion of sample is left about 50 ml separately for determination of iron oxide. The iron oxide (Fe2O3) is detected by instrumental method using Atomic Absorption Spectrometer at the wavelength of 510 nm. The combination of iron oxide detected by instrument method and aluminium oxide by gravitational method all total give < 1% all total.

The complete analysis of limestone sample with all parameters normally reveal the test result data should be in between the ranges for deciding the quality of sample as given in the Table 1.

Table 1: A sample representation of complete test report of limestone sample.

LOI %	IM (Silica) %	R2O3 (Al2O3 and Fe2O3) %	CaO %	MgO %	Total
40 - 45	5 - 15	<1	40- 50	1- 5	100 ± 3%

A good quality of limestone has CaO % content of 45 ± 5 % and MgO of < 3%, is regarded as a cement grade limestone.

LIMESTONE TEST RESULT AND DISTRICT WISE DISTRIBUTION SCENARIO

Test data (CaO% and MgO%) are collected from Limestone Test Records and Official Test Paper documents stored in the chemical laboratory and presented in Table 2.

Table 2: The ranges of percentage CaO and MgO content in the limestone samples of various districts.

Districts	Fiscal Year	CaO% Range	MgO% Range	Re marks
Arghakhanchi	2060-61	23.0 - 29.92	16.81 - 20.00	Sample tested
Arghakhanchi				
(Bharatpur)	2073-74	35.41 – 49.27	0.97 - 6.62	41

Baitadi	2060-61	45.90 – 50.00	0.4 – 4.0	
Bhimphedi	2061-62	45.90 – 51.00	1.76 – 3.78	3
Dang	2072-73	43.0 – 53.00	0.77 – 3.91	66
Dhading (Mahadevs than)	2073-74	38.8 – 53.95	0.97 – 5.68	52
Dhading				
(Rorang)	2075-76	45.90 – 51.16	0.96-3.54	22
Dhading				
Rorang- 1st Phase	2076-77	42.36 – 51.04	0.5 - 4.33	99
Dhading				
Rorang – 2nd phase	2076-77	40.45 – 49.59	0.89 – 2.61	10
Dhading				
(Kandran gadhi)	2075-76	43.13 - 52.55	0.94 – 5.14	215
Kavre	2061 - 62	45.1 – 51.52	1.76 - 3.78	
Kavre	2062 - 63	42.06 – 50.82	0.63 – 5.29	
Kavre	2064-65	35.4 - 49.07	2.27 – 3.53	
Khotang (Bojhe)	2076-77	50.24 - 53.32	0.52 – 3.49	40
Makawanpur				
(Namtar)	2073-74	34.27 – 51.08	0.35 – 7.33	32
Makawanpur				
(Namtar)	2074-75	38.66 – 50.77	0.95 – 7.38	140
Nawalparasi	2065-66	30.14 – 32.14	2.77 - 20.66	3
Nawalparasi	2066 -67	43.46 – 53.97	1.76 - 4.78	
Palpa	2063-64	30.49 - 52.53	1.01 - 9.58	
Palpa	2064-65	43.11 - 55.73	0.5 – 7.06	
Palpa	2070-71	40.0 – 47.00	6.0 – 11.0	
Salyaan	2060-61	44.25 - 54.67	0.2 – 2.22	45
Salyaan	2065-66	47.69 – 52.93	0.25 – 3.53	29
Salyaan	2066-67	46.26 - 56.43	0.25 - 1.85	59
Surkhet	2067-68	40.00 – 51.00	0.25 – 8.0	
Syangja	2060 – 61	42.43 – 43.46	0.2 – 4.66	75
	2064 – 65	44.86 - 54.67	0.25 – 3.47	149
Udayapur	2060-61	47.00 - 54.11	0.2 – 5.18	26

INTERNAL CEMENT DEMAND AND DOMESTIC PRODUCTION

Mines prospect of limestone commodities has long been explored by the senior geologists and senior mining engineers. The old field work reports are still safely stored in the DMG library. Mineral exploration activities were very high during four decades ago when Department of Mines and Geology (DMG) and UN funded Mineral Exploration Development Project (MEDP) were in action*. However, the demand of limestone raw material was very low till two decades ago since building houses/dam, hydropower construction activities etc. were also very less. There were only two government owned cement factories at that time in Nepal, namely Himal Cement Factory in Chovar, Kathmandu which was established on B S 2030. Due to environmental issues being raised by the local residents, this factory was closed permanently by the government considering local people's health and to keep the envi-ronment clean and safe in the valley and Hetauda Cement Industries Ltd which was established in Hetauda in B S 2033/06/13 undertaking of Nepal government with an aim of producing high volume of cement using the main raw material, limestone, available in the Bhaisedobhan, Makawanpur. It was established at the sites where huge reserved graded raw material could be found for convenient transport of essential raw materials with an economic point of view.

Subsequently, Udayapur Cement Factory was established in Udayapur on 2044/02/31 B. S. with a production capacity of 800 metric ton per day, is the biggest cement factory in Nepal. However, as there were less demand of cement in Nepal, the internal demand was fulfilled by the productions from two factories after closed off of Himal Cement factory on Mangsir 2058 B S.

From a decade, it has gradually increased the rate of demand of cement in the market. The cement produced from these two factories could not meet the existing demands raised in the market. Consequently, the demands were fulfilled by import from the neighbouring country-India.

Nepal Government urge to invite interested national and international investors or entrepreneurs to invest in mining sector for promotion of mineral based industries. It was specifically for Cement Industries to fulfil the current demand of cement and to reduce the import from neighbouring countries continuously.

Few cement industries are already in operation/ production, few others are under construction and quite a few in the pipeline. Present domestic cement production could fulfil about more than 90% (verbal information from cement manufacture association) of the total internal demand. Six new cement industries namely Sivam, Sona-pur, Maruti, Ghorahi, Rolpa, Bishal, Nigale etc cement industries Pvt. Ltd. have started their cement production. Therefore, establishment of more cement factories based on own limestone resources is beneficial to the investors and to the government as well.

Table 3: Potential limestone reserve.

S. N.	Location:	District:	Reserve: (mt)	License Issued :
1.	Narapani Limestone Deposit	Arghak hanchi	17.44	Arghak hanchi Cement (P) Ltd.
2.	Gandhari Limestone Deposit	Dang	15.23	Sonapur Cement (P.) Ltd.
3.	Purandhara Limestone Deposit	Dang	26.5	Dang Cement Industries
4.	Saigha (East) Limestone Deposit	Dang	5.19	Sonapur Cement (P) Ltd
5.	Jogimara Limestone Deposit	Dhading	3.6 &0.95	Hetauda Cement Industry
6.	Nigale Limestone Deposit	Dhankuta	10	Nigale Cement (p) Ltd
7.	Lele Limestone Deposit	Lalitpur	5.19	United Cement (P) Ltd
8.	Okhare and Bhaised hobhan Limestone Deposit	Makawanpur	11 +10.8	Hetauda Cement Industry
9.	Sukaura & Bhudhi chaur Limestone Deposit	Makawanpur	4.97 +9.74	Shivam Cement (P) Ltd
10.	Bhaise Limestone Deposit	Makawanpur	3.09	Nepal Shalimar Cement (P) Ltd
11.	Kachal Limestone Deposit	Palpa	11.36	Sarbottam Cement (P) Ltd
12.	Phoplee Limestone Deposit	Pyuthan	10.2	Subhashree Agni Cement (P) Ltd
13.	Budhagaon Limestone Deposit	Rolpa	108.51	Rolpa Cement (P) Ltd
14.	Nayagaon Limestone Deposit	Rolpa	5.36	Sonapur Cement (P) Ltd
15.	Kajeri Limestone Deposit	Salyan	70	Viswo karma Cement (p) Ltd
16.	Kakurthakur Limestone Deposit	Sindhuli	52.78	Maruti Cement (P) Ltd
17.	Chaukuna Limestone Deposit	Surkhet	31.6	Muktishree Cement (P) Ltd
18.	Sindhali Limestone Deposit	Udayapur	72	Udayapur Cement Industry
19.	Dumre Limestone Deposit	Udayapur	2.54	Cosmos Cement Industry (P) Ltd
20.	Limpatar Limestone Deposit	Udayapur	19.2	Sauriya Cement (P) Ltd

Source: Mineral resources of Nepal*

These cement industries are producing cement using those limestone from mines prospect site of the country. In this way, 90% of internal demand of cement is fulfilled by domestic production. Most of limestone samples were tested in DMG chemical laboratory and their qualities were determined to know whether they were cement grade for production or not. Few infrastructure projects still import cement from India.

Currently in the chemical laboratory, limestone samples are being analysed with all required parameters which are collected from new prospectus areas such as Rorang, Benighat, Bojhe Khotang, and some extension of old mines area in Lakharpata, Surkhet, Rorang, Dhading etc. The initial result shows that most of those explored limestone samples are of good grade. High % (40-50) of CaO and less MgO (< 5 %) can be used for cement production. Like this, our country would be almost independent on cement production to fulfil internal and expected to explore the area for the export in the days to come.

CONCLUSIONS

To sum up, mineral resource is a very important commodities for strengthening the economy of the country. Proper utilization of existing mineral resources play vital role for establishment of mineral based industries and its development as well as overall increase of the national GDP.

Geological investigations and mineral exploration activities are required to find many more mineral deposits/prospect in the country. Periodic upgrade of chemical laboratory facilities of the department would be necessary to increase its capacity of testing in the same pace as the upsurge of the samples in the laboratory for testing due to accelerating exploration activities in the country. More than 90% of existing demand of cement has been fulfilled by domestic production and likely to move forward towards the bulk export.

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1	GM1	Geological Map of Nepal	1:1,000,000	1994	550
2	GM2	Geological Map of Eastern Nepal	1:250,000	1984	475
3	GM3	Geological Map of Central Nepal	1:250,000	1985	330
4	GM4	Geological Map of Western Nepal	1:250,000	1983	330
5	GM5	Geological Map of Mid Western Nepal	1:250,000	1987	330
6	GM6	Geological Map of Far Western Nepal	1:250,000	1987	330
7	GM7	Geological Map of Kathmandu and Central Mahabharat Range	1:250,000	1980	330
8	GM8	Photogeology Map of 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 (62 P/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
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 Parts of Chitwan, Dhading and Makawanpur Districts (72 A/14)	1:50,000	2007	275
30	GM30	Geological Map of Parts of Dhading, Makawanpur, Kathmandu and Lalitpur Districts (72 E/2)	1:50,000	2007	275
31	GM31	Geological Map of Parts of Kavrepalanchok and Sindhuli Districts (72 E/11)	1:50,000	2008	275
32	GM32	Geological Map of Parts of Kavrepalanchok, Ramechhap and Sindhuli Districts (72 E/15)	1:50,000	2008	275
33	GM33	Geological Map of Parts of Baitadi and Dadeldhura Districts (2980 10)	1:50,000	2009	275
34	GM34	Geological Map of Parts of Baitadi and Dadeldhura Districts (2980 11)	1:50,000	2010	275
35	GM35	Geological Map of Parts of Baitadi, Bajhang and Doti Districts (2980 12)	1:50,000	2011	275
36	GM36	Geological Map of Parts of Doti, Dadeldhura and Kailali Districts (2980 15)	1:50,000	2010	275
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39	GM39	Geological Map of Parts of Solukhumbu, Okhaldhunga, Khotang and Udaypur Districts (2786 11 Lower Half, 2786 15A and 2786 15B)	1:50,000	2019	275
40	GM40	Geological Map of Parts of Sankhuwasabha, Taplejung, Terhathum and Panchthar Districts (2787 11 Lower Half, 2787 15A and 2787 15B)	1:50,000	2019	275
41	GM41	Geological Map of Parts of Terhathum, Taplejung and Panchthar Districts (2787 12 Lower Half, 2787 16A and 2787 16B)	1:50,000	2019	275
42	GM42	Geological Map of Parts of Khotang and Bhojpur Districts (2786 12 Lower Half, 2786 16A and 2786 16B)	1:50,000	2019	275
43	GM43	Geological Map of Parts of Bhojpur, Sankhuwasabha and Dhankuta Districts (2787 9C, 2787 9D, 2787 13A and 2787 13B)	1:50,000	2019	275
44	GM44	Geological Map of Parts of Bhojpur, Sankhuwasabha, Taplejung, Dhankuta and Terhathum Districts (2787 10 Lower Half, 2787 14A and 2787 14B)	1:50,000	2019	275

प्रकाशित भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा

क्र.स.	कोड न	नक्शा शिर्षक	स्केल	प्रकशित मिति
१	ENG1	काठमाडौं उपत्यका को भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Kathmandu Valley)	१:५०,०००	१९९८
२	ENG2	पोखराउपत्यका को भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Pokhara Valley)	१:५०,०००	१९९८
३	ENG3	बुटवल क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Butwal Area)	१:२५,०००	२००८
४	ENG4	धरान क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Dharan Area)	१:२५,०००	२००९
५	ENG5	भैरहवा क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Bhairahawa Area)	१:२५,०००	
६	ENG6	विरेन्द्रनगर (सुर्खेत) क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Birendranagar, Surkhet Area)	१:२५,०००	
७		महेन्द्रनगर क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Mahendranagar)	१:२५,०००	२०१९
८		जनकपुर क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Janakpur)	१:२५,०००	२०१९
९		भरतपुर क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Bharatpur)	१:२५,०००	२०१९
१०		बिदुर क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Bidur)	१:२५,०००	२०२०
११		जलेश्वर क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Jaleshwor)	१:२५,०००	२०२०
१२		वीरगञ्ज क्षेत्रको भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्शा (Engineering and Environmental Geological Map of Birjung)	१:२५,०००	२०२०

Landslide Hazard Zonation Map

S.No.	Code No.	Title of map	Scale	Year of publication
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