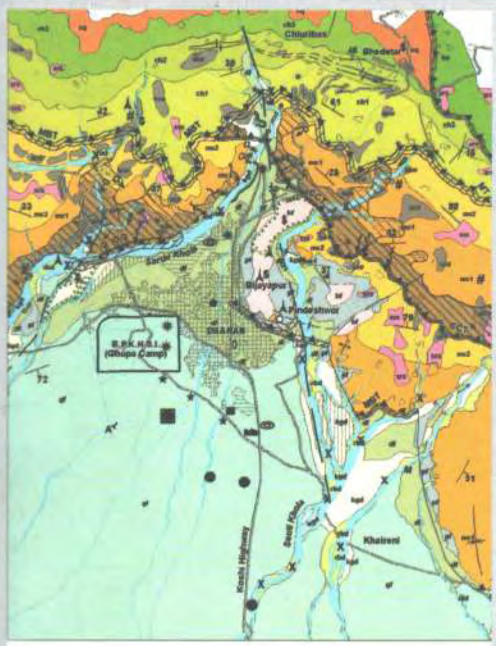

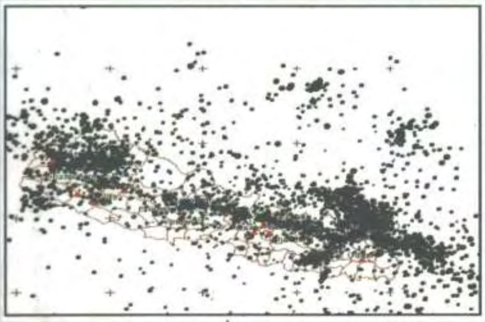

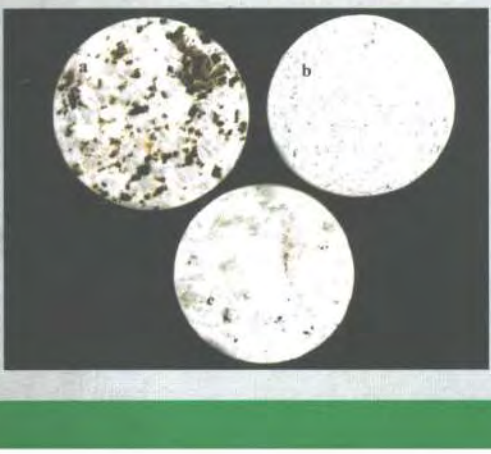

ANNUAL REPORT

of

DEPARTMENT OF MINES AND GEOLOGY

Annual Report, DMG, No. 1

(Fiscal years 2057/58 and 2058/59)

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FOREWORD

Department of Mines and Geology (DMG) is the only governmental organization responsible for exploration, assessment and development of mineral resources and geosciences in Nepal. Its important mandate includes:

- Exploration and evaluation of mineral resources including petroleum in Nepal.
- Promotion of the mineral sector development through provisions of sound mineral policy and laws.
- Regulation and monitoring of mineral exploration, mining and mineral based industries.
- Acquiring the basic data for geoscientific information by geological survey, geophysical prospecting, seismic data acquisition and interpretation and to carry out geotechnical and urban geological investigation etc.
- Technology transfer and expertise services to organizations in mineral sector development, in infrastructure development, in mitigation of natural hazards and in protection of environment.

To exhibit its entire annual outcome, the DMG has published its first bulletin in 1991. It encompasses all the activities and outcomes of the previous year. Due to various reasons, the publication of the bulletin could not be continued for few years. Keeping in mind the need and usefulness of such departmental report, we have tried again to publish it and make it a regular program of the department. I hope this DMG Annual Report will be successful in disseminating the outcomes, achievements and prospects of the department for the development of geosciences and mineral sector of the country.

I would like to thank and appreciate the efforts made by the Editorial Board and staffs of DMG in the preparation of this bulletin.

Nanda Ram Sthapit
Director General

EDITORIAL

The Department of Mines and Geology (DMG) has published its first bulletin in 1991 that encompassed the outcomes of the departmental activities of the previous year. Unfortunately, the publication of the bulletin could not be continued for few years. Though the outcomes of the developmental activities are multisectoral in the field of geosciences and mineral sector development, they mostly remained unnoticed, as they are not regularly published. Realizing this fact, the Director General called upon a meeting of all the Deputy Director Generals and Section Chiefs of the Department in 2059.7.4 and formed an "Editorial Board" for publishing the outcomes of the departmental activities.

The Editorial Board was formed under the coordination of Dr. Ramesh Prasad Bashyal, Deputy Director General with Mr. Krishna Prasad Kaphle (Planning, Evaluation and Information Section), Mr. Uttam Bol Shrestha (Natural Gas and Coal Section), Mr. Ashok Kumar Duvadi (Environmental and Urban Geology Section) and Mr. Prayag Man Pradhan (Geological Mapping Section), as the members. The Editorial Board was assigned the job of publishing the Extended Summary of the departmental annual activities carried out. This publication is to cover the programs of two consecutive fiscal years of 2057/58 and 2058/59 in the form of Annual Report, DMG.

In this context, the Editorial Board requested the different geoscientist of the department to provide their reports of the investigation works carried during these two consecutive fiscal years in the form of "Extended Summary". The Editorial Board carried out the editing of these reports and compiled them into the form of this Annual Report. The Editorial Board hopes that the Annual Report will be able to furnish the information regarding the different departmental geological and mineral exploration activities and their outcomes for these two fiscal years effectively. Full reports of these articles of the different authors are available in the departmental Library.

The Editorial Board is thankful to all the geoscientists of various sections who helped to prepare this Report. Special thanks are offered to Drafting Section for their tedious efforts in preparing various maps and figures to the present format.

R. P. Bashyal

Dr. Ramesh Prasad Bashyal
Deputy Director General,
Coordinator, Editorial Board

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Urban Geological Mapping of Dharan Area (2057/ 58)

Ashok Kumar Duvadi, * Geologist
Environmental and Urban Geology Section

INTRODUCTION

About 130 square kilometers area of Dharan lies in between latitudes 26° 45' 30" to 26° 52' 25" N and longitudes between 87° 14' 30" to 87° 20' 30" E (of toposheets 72 N/1 and 72 N/5 of 1:63,360 and 1:50, 000 scales; and parts of 2687 - 01 D and 2687 – 02C of 1: 25, 000 scales) having the relief difference of 1427 m. msl and covers the parts of Dharan Municipality and adjacent areas in Sunsari District. Its location is precarious with the main settlements distributed in the Fan Deposits of Sardu and Seuti rivers and the foothill of Churiya Range (Siwaliks). The area is often endangered by floods in Bikashtol in the west by Sardu and Nirajanbasti in the east by Seuti rivers respectively during monsoon season. Main Frontal Thrust (MFT) marking the contact between the Siwaliks (Tertiary molasse type of sediments) in the north and the Gangetic Plain (Terai) in the south runs along break of slope and is well exposed in the eastern part of the area near the upper stretches of the Khar Khola.

Engineering and environmental geological investigation was carried out in the area with an objective to prepare a comprehensive "Engineering and Environmental Geological Map" at 1:25, 000 scale. This map is intended to help the urban planners and decision makers in hazard mitigation, sustainable utilization of natural resources and environmental management. The map includes the information on lithological description of geohazards (natural and man made), mineral resources, features of environmental significance, riverbed mining, landfill site, land use and urban geology.

OBJECTIVE

The objectives of the present study are:

- Recognition of image characteristics of various land use patterns in LANDSAT TM and IRS PAN and LISS III - Scenes of the area
- Delineation of tectonically weak zones.
- Preparation of Engineering and Environmental Geological Map consisting of information on present land use, natural as well as man made hazards, settlements and infrastructures.

METHODOLOGY

Existing relevant literatures on geology, geohazards and other regional maps were reviewed. Further additional information was also collected from local individuals. LANDSAT TM Scenes of 1:125, 000 scale taken on November 1990; and aerial photographs of 1:15, 000 scale taken during 1998 and of 1:50, 000 scale taken during 1992 were studied and necessary interpretations carried out. Lineaments were marked in the TM – Scene that oriented mainly in N – S, NW – SE and NE – SW directions. These lineaments could be the deep seated faults or fracture zones or the boundary of the lithological variations and in most cases normally represent the tectonically weak zones. IRS PAN Indian satellite data of the area of 1:12, 500 scale (take in 16th February, 2000) has been used in incorporating the latest changing information and natural effects in the map. Topo maps of 1;25, 000 scale of 1995 of the working area were also acquired. The digital database of this map received from Topographical Survey Branch has been used to prepare a base map.

The fieldwork was carried out in the dry season of 2001. It was planned with an aim to verify the previously interpreted work in the field and look for the possible Neotectonic features as well as to compare the previously identified thrusts, faults, lithological formations, boundaries, land use and the infrastructures. Field survey enabled to delineate the potential areas of instabilities on the ground (hill slopes, river banks) that endangered the valley floor areas. Attitude of the bedrocks

* Mr Ashok Kumar Duvadi has been promoted to Senior Divisional Geologist on B. S. 2060/4/29 (14 August, 2003)

and hill slopes were compared to establish the comprehensive bedrock geology and nature of the overlying soils. This type of work together with that in the valley floor areas help to furnish the Quaternary Geology. Also preliminary survey was made to find out the suitable sanitary landfill site for waste disposal in Dharan Municipality.

Analyses of collected samples from the field were carried out in Chemical and Geotechnical laboratories for their respective purposes. Geographical Information System (GIS) Analysis was carried out using ARC INFO software. The process here includes the digitizing of the map, input of data and its storage, data processing and plotting of the Engineering and Environmental Geological Map. (Refer Figure 1in report by Rimal, L.N. p.8).

RESULT AND FINDINGS

The study area is situated partly on the Siwalik Hill, Middle Mountain and partly on the debris and fan materials derived from northern hills and deposited by Sardu and Seuti rivers. North of it lies the Main Boundary Thrust (MBT) and in northeast corner is Mahabharat Thrust (MT). The rocks north of MT is Kunchha Formation (phyllites, schists and gneisses).

Bedrock in the area is represented by sedimentary rocks of Siwalik Group (Late Miocene to Pliocene age), and Nawakot Group (Precambrian low grade metamorphic rocks like metasandstones and phyllites) as well as medium to high grade (schists and gneisses) rocks of the Lesser Himalaya). These rock sequences are separated by thrust faults.

The Middle Mountain lying North of Siwaliks, mainly, forms the highest hills in the north and northeast part of the area. It is made of low grade metasediments comprising such as metasandstones, phyllites, white quartzites and grey phyllitic shales. The low grade metamorphic rocks are thrusted over by high grade crystalline rocks of schists and gneisses.

Main Boundary Thrust (MBT) separates the Middle Mountain in the north from the Siwaliks in the south. A mylonitic zone (nearly 15 – 20m. wide) with graphitic stain in the rock is observed in the field where MBT is exposed. Siwalik rocks in the area are composed of thick piles of fresh water molasse sediments deposited and lifted during the rising of the Himalayas. The sequence consists of the colourful fine materials in its lower part and medium to coarse pattern in the middle part. Upper part of the sequence is not exposed in the area.

Valley Floor Setting within the study area (on the south of foothill) consists of the Siwaliok sediments derived from the rivers that originate within Siwalik Hills except in the depositional sites of Sardu, Seuti and Sehara Kholas where boulders from Middle Mounatain are also found. Mainly the alluvial, residual and colluvial soils of Quaternary – Recent are deposited on the plain and along the river valleys, on the hill slope and on the elevated terraces as well as flat spaces on the hills respectively. The valley floor sediments within the area are divided into nine units.

In the monsoon season, the landslides are triggered and large volumes of debris are generated. At this time the riverbed is filled up with flood water causing riverbank scouring.as well as gully erosion and finally causing into the development of badland topography.

Various urban settlement (existing, planned, proposed and expanded)areas are marked in the area. However, squatter settlements in the banks of Sardu and Seuti rivers are creating an alarming threat and encroachment of the river banks and flood plain. On the other hand, Bijayapur Danda is the existing public and natural park in the area which has the religious and cultural values where most of dieties are located. Dumping of the municipal wastes in the forest and Seuti river need to be properly located and managed. A buffer zone of 30 m.in the eastern bank of Sardu should be maintained where it is recommended not to have any settlements and construction works so as to allow natural stabilization and better environment.

CONCLUSION

The study area is situated partly on the Siwalik Hill, Middle Mountain and partly on the debris and fan materials derived from the hills in the north by Sardu and Seuti rivers. The area is often endangered by floods particularly at Bikashtol and Raitol in the west by Sardu in its east bank and in Nirajanbasti in the east by Seuti in its west bank.

Three divisions of the Siwaliks out of four is applicable to the area. On the other hand nine units are demarcated for Quaternary Geology.

River bank erosion is going on in almost all streams and erosion of banks of Sardu and Seuti rivers are very severe. Badland development due to this process in these streams is rather severe.

Drainage system in Dharan Municipality area is not proper and inadequate. Direct diascharge of sewage drainage into the Khahare Khola and other streams have polluted the stream water. Also the squatter settlements in Sardu and Seuti flood plains are highly vurnerable to flood hazard. And there is a need to find out a suitable sanitary landfill site for solid waste management.

RECOMENDATIONS

Necessary measures to minimize the effects of landslides in the landslide prone areas should be taken. Also the measures to minimize the effects of bank cutting in Sardu and Seuti river banks are necessary.

Squatter settlements along Sardu and Seuti flood plains should be removed and be properly rehabilitated. Drainage system should be properly managed in Dharan Municipality area. It is suggested to find out a suitable landfill site to manage the municipal wastes scientifically. Disposal of wastes at present dumping sites in the forest, Sardu and Seuti flood plains as well as direct discharge of sewage into the Khahare Khola and other streams should be stopped.

The existing construction materials (river aggregates) collection in Sardu and Seuti flood plains should be properly managed under good supervision. Protection of bank should be properly carried out along Sardu and Seuti banks. At the same time it is suggested to maintain a buffeer zone of 30 m. from the edge of the cliff towards the settlement area (near Phusre – Raitol area).

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Engineering Geological Mapping of Dharan Area

Sugat M. Sikrikar, Research Officer
Engineering Geology Section

INTRODUCTION

Dharan area is one of the rapidly growing city of Sunsari district in far eastern part of the country. Large numbers of people are migrating continuously in this area from surrounding hills and other parts of the country, which has resulted rapid growth of population and infrastructure development. Planning and implementation of different kinds of development activities are taking place to support the demand of increasing population. Hundreds of houses together with large number of other civil structures are constructed every year in this area giving rise to degradation of existing environmental condition. Unplanned and excessive exploitation of construction materials from riverbeds and surrounding hill slopes and human encroachment in the flood plains and riverbanks have further deteriorated the environmental condition and stability of the ground surface of the area.

The engineering geological study of this area was carried out on the gently slopping surface located at the foot slope of Siwalik Hills. The unconsolidated sediments brought down and deposited by emerging rivers from the surrounding hill slopes and their tributaries cover the study area. Tinau, Sardu, Sehera and Khahare Khola are some of the main rivers, which have brought down huge amount of debris from the surrounding mountains and deposited in the flat surface of valley floor forming the gently slopping ground surface of Dharan area.

The Engineering Geological map of Dharan area incorporate basic information on ground condition useful for specific landuse and regional planning. The map also provides important information on engineering properties of different lithological units, natural resources, hydrogeological condition and geodynamic phenomena which can be useful for better landuse, urban and regional planning of the Dharan Area for exploitation of natural resources, human settlement and infrastructure developments. The classification of rocks and soil is based on the physical and the engineering geological properties of rock and soil.

METHODOLOGY

The existing data useful for present investigation were obtained from different sources of information. For field exploration, toposheet of 1:25000 scale and aerial photographs of 1:15000 scale published by Department of Survey were used as base maps for plotting the data.

Data obtained from field observations, field tests records and laboratory test results are used for separating different soil and rock units presented in the map. The lithological boundaries of the unconsolidated sediments of the valley floor are drawn as observed in the Aerial photographs together with field verification. Standard Penetration Tests (SPT) was carried out on cohesionless soil with observation at 1 meter interval wherever the ground condition is favorable to conduct the test. At certain depths, where SPT test could not be carried out due to existence of gravel layers, Dynamic Cone Penetration Tests (DCPT) replaced the test. Auger boring was carried out in the areas covered by unconsolidated sediments for sub - surface investigation.

INVESTIGATION RESULTS

The area is covered by thick unconsolidated sediments deposited mainly by Seuti and Sardu Khola. It is an alluvial fan deposit where the coarser materials are found near the hill slope and the particle size decreases progressively with the increase in distance from the mountain slope. Generally thick deposits of the coarser materials are found in the middle part. The thickness and particle size of the materials decreases in the marginal part. The type and size of the materials brought down by rivers depends on the nature and type of materials in the source area and the velocity and the volume of water in the rivers at that particular time. Therefore, large variation in type and size of the materials within very short distance are found within the mapped area.

The materials underlying Dharan are composed mainly of boulder and gravel derived from the surrounding mountains intermixed with sand and silt with negligible amount of clay. Five levels of alluvial terraces are identified within the area with different composition and thickness. The older terraces, which are found closer to the mountain slopes, are found to be deposited over the Siwalik sandstone. The base of these deposits can be observed along the river sections and near Bindabasini area. The total thickness of these deposits varies from 30 to 70 meters. The base of the younger terraces is below the present river bed. Therefore it was not possible to measure their total thickness. However from the observation made along the river section and dug pits near Ghopa hospital area, the thickness of the lower terrace is estimated to be more than 10 meters. Depending upon the nature, size, composition and characteristic features of the deposit, the Quaternary deposit of Dharan area are separated into five different lithological units (Refer Fig. 1, in report by Rimal Lila N. p. 8).

The field N value record to 2.0 m depth were generally found to be in the range of 4-10. After 2.0m depth densely compacted soil layers of 1-2m thick with N value more than 25 were found. Below this depth again a soil layer of about 1-2 m thick was encountered with the N value less than 15. Generally from 4.0m depth downward the N values are more than 30. The N value records shows that the bearing capacity of the soil strata increases with depth. Moderate to high bearing capacity are found even at shallow depths.

CONCLUSION

The whole area of the valley floor is covered with the debris deposited by inflowing rivers from the northern mountain slopes with characteristic features of fan deposit. The materials are deposited at different period giving rise to very stiff ground condition. Boulder and gravel beds with high bearing capacities exist even at the shallower depth of one to four meters from the surface.

The area, except floodplains, are in general very suitable ground for the development of human settlement and infrastructures. Since the layers of soil with high bearing capacity are found at shallower depths, the construction works can be safely carried out without much of detail site investigations for ordinary structures. There is no possibility to occur liquefaction of the ground through out the study area even during great earthquakes.

Geo-hazard in Dharan Area: A synthesis

Lila N. Rimal, Geologist
Remote Sensing Section

INTRODUCTION

The study area is a part of Toposhets No. 2687- 02C and 2687- 01D (scale 1:25 000) covering an area of 130sq. km. Dharan is situated at the foot of the Churiya and the Mahabharat hills in Eastern Development Region of Nepal. The study area lies between latitudes 26° 45¢ 30^2 to 26° 52¢ 25^2 N and longitudes between 87° 14¢ 30^2 to 87° 20¢ 30^2 E. The elevation of the area ranges from 300 m to nearly 1800 m. Sardu Khola, Seuti Khola and Kokaha Khola are the main river systems draining the area. These rivers join Sapta Koshi River to the southwest of the area.

Dharan is bordered by Sardu Khola and Seuti Khola on the west and east respectively. It is one of the fast growing urban areas in eastern development region of Nepal with 1,21,000 population (Dharan Darpan 2057).

Dharan receives high precipitation with an annual average of 2626 mm. The temperature ranges from 10-15degree Celsius in winter and 25-30 degree Celsius in summer respectively. Landslides threaten the inhabitants of the area during every rainy season. Similarly, debris flows and floods inundate some parts of the area every year. The local authorities lack proper geo-scientific information on natural hazards as well as information on potential areas for future infrastructure development planning.

OBJECTIVE

The objective of the present investigation was to identify areas that are prone to geological hazards. Such hazards may be slope failure, debris flows, and flooding. Factors contributing to these processes such as geology, tectonic structures, soil types, landuse pattern, slope categories, active and old landslides were mapped. Additionally, the study was also carried out to the suggestions provided by the Municipality to supply with necessary information for their future infrastructure development planning.

The main purpose of the survey was to prepare an "**Engineering and Environmental Geological Map (EEG Map)**" Fig. 1 of the area by integrating the information obtained *from the Urban Geological and Engineering Geological field investigations* carried out simultaneously by Mr. A. Duvadi and Mr. S. M. Sikrikan respectively.

METHODOLOGY

Recent aerial photographs of 1:15,000 and 1:50,000 scales were examined to identify various lithological units, recent landslides, erosional features and tectonic structures. IRS-PAN image of Nov. 1999 and LANDSAT-TM Scene of Dec. 1992 were studied for lineament mapping. Existing literature and geological maps were reviewed.

The fieldwork was carried out using recent aerial photographs of 1:15,000 scale and topographical maps of 1:25,000 scale prepared by the Survey Department. Field observation points were located on the aerial photographs. Emphasis was given to check the landslides and other areas prone to further soil erosion. Major landslides were studied in detail.

All collected data were plotted on the 1:25 000 scale topographical base map. A draft map was prepared with all the acquired information. Various thematic layers were created on the tracing paper for digitization purpose. All the layers were digitized using ARC/INFO software available at the Remote Sensing Section. All layers were converted into .shp file using ARCVIEW to make acceptable by Free Hand software. Final cartographic design of the map was performed in Free Hand.

INVESTIGATION RESULTS

Geological investigation has enabled to differentiate the rock sequences as sedimentary rocks (Siwaliks), low-grade metamorphic rocks (equivalent to Nawakot Group) and higher crystalline rocks (*cf.* Central Crystallines). These rock sequences are separated by thrust faults giving rise to three distinct litho-tectonic units.

The Main Frontal Thrust (MFT), the Central Churiya Thrust (CCT), the Main Boundary Thrust (MBT) and the Mahabharat Thrust (MT) are distinct in the area and can be observed at outcrop scale. Areas closer to the location of these thrusts are physically weak. Therefore, buffer zones of weak areas are proposed for different thrusts as following widths:

MT = 50m, MBT = 75m, CCT = 25 m, MFT = 50m

Slopes on the western sides of the Sardu Khola are vulnerable to further sliding. Landslides are generating huge amount of debris forming large fans at the mouth of the tributaries obstructing and diverting the main river towards the opposite banks. As a result, the opposite banks are eroded rapidly. Badlands are developed on the sides of the Sardu Khola due to gully erosion and bank failure. This process is continued, at present.

Similarly, the slopes on either sides of the Seuti Khola are prone to further sliding. A large rotational debris slide located at west bank of the Seuti Khola (west of Kalimati) has affected the main water supply pipe to Dharan Municipality. The slide is locally known as **'Kopbari Pahiro'**. It has also destroyed the private land, a house and some cattle. The water supply pipeline has been reconstructed passing through the loose debris of the slide, which is prone to further activation. In addition, many slides were observed having wide tension cracks. Such slides are always prone to further sliding in the near future.

Extensive riverbed mining for construction materials in Sardu Khola is going on. This process is lowering the riverbed level causing bank collapses. Extraction should be limited only up to the natural riverbed level so that there is no further deepening of the river. River gravel is deposited every year during the rainy season.

Preventive works carried out on the sides of Sardu Khola and Seuti Khola to prevent from flooding seems faulty at places. Most of the gabions have been filled with smaller size blocks than the wire holes. The smaller sized blocks easily escape out from the wire cage and hence the cage loses its strength. Such gabions are easily damaged and washed away during flooding.

CONCLUSION

Geological investigation carried out in the surrounding hill slope area of Dharan Municipality revealed the existence of meta-sedimentary and sedimentary rocks. Quaternary deposits are developed in the form of colluvial residual and alluvial soils.

The meta-sedimentary rocks are tentatively comparable to Lower Nawakot Groups rock of Central Nepal Lesser Himalaya. The sedimentary rocks are lithologically equivalent to Lower and Middle Siwaliks.

The MFT marks the boundary between the Gangetic Alluvium to the south and the Siwaliks to the north. The Siwalik sequence has been repeated once due to CCT. The MBT brings the meta-sedimentary rocks over the Siwaliks. The oldest rock Formation (Kunchha) of the Nawakot Group has thrust over the younger sequence along the Mahabharat Thrust.

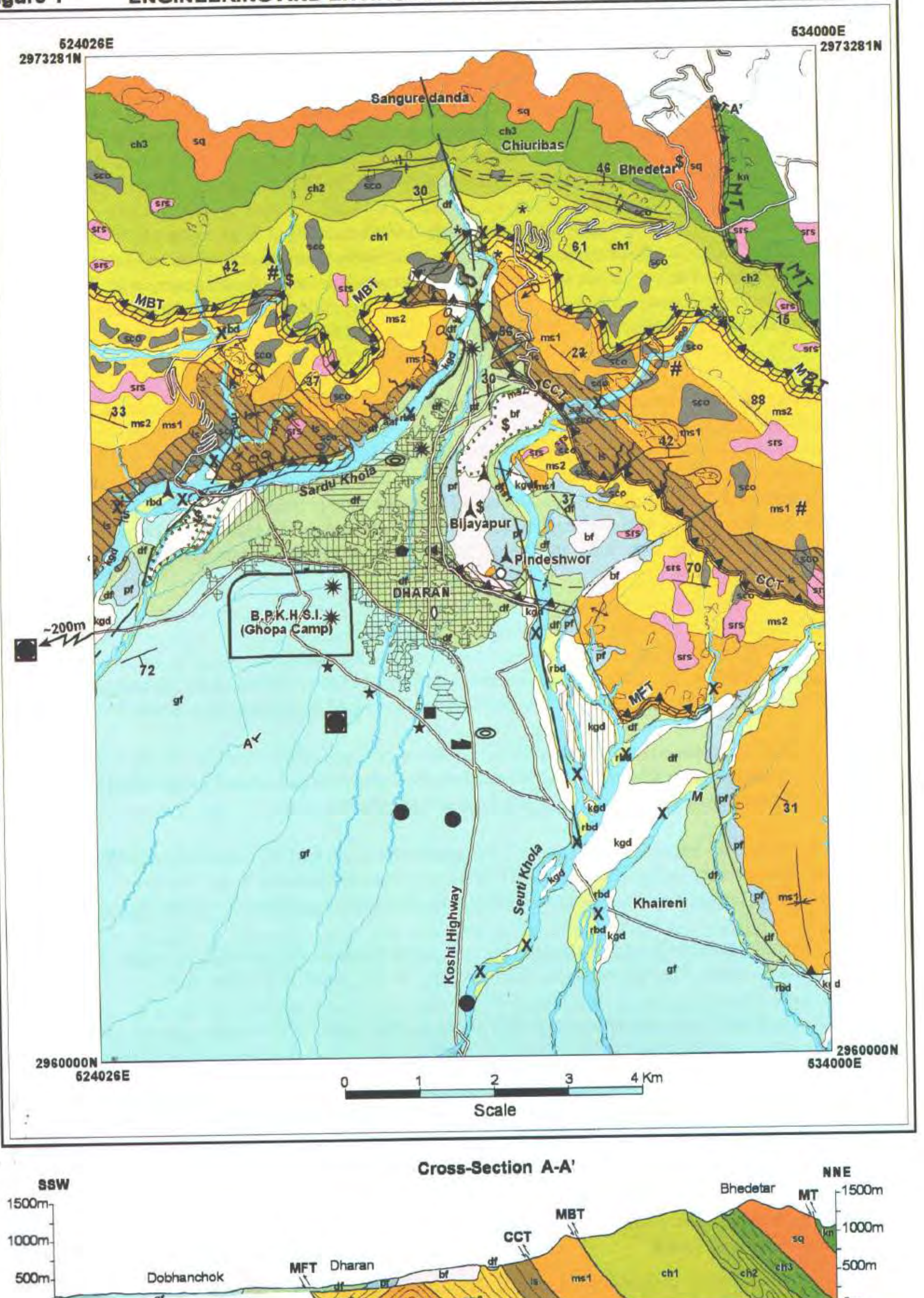
A number of prominent lineaments have been observed in the aerial photographs and satellite image. These lineaments follow the straight river courses. They are oriented mainly in NS, NE-SW, and NW-SE directions.

Tectonically weak zones have been delineated as buffer zones in the vicinity of the major thrusts. Any infrastructures planned through these areas will be susceptible to severe damages during earthquakes. Several landslides are mapped in the areas closer to the thrusts.

Most of the slides are found to occur in Lower Siwalik and lower part of the Lower Middle Siwalik. Thus, the areas within these formations are categorized as high potential to slope failure. Similarly, the subunit2 (ch2) of the Chiuribas Formation is relatively more prone to slides than the other formations (Figure 1).

Bank erosion is going on along most of the rivers. Badland development due to this process is alarming along the east bank of Sardu Khola especially near Raitol.

Figure 1 ENGINEERING AND ENVIRONMENTAL GEOLOGICAL MAP OF DHARAN AREA



Legend

Lithological Units

Unconsolidated sediments (Quaternary-Recent)

- aaf — Active alluvial fan
- rbd — River bed deposit
- kgd — Khaireni gravel deposit
- sco — Colluvial Soil
- srs — Residual Soil
- gf — Ghopa Fm
- df — Dharan Fm
- pf — Pindeshwor Fm
- bf — Bijayapur Fm

Siwalik Group (Late Miocene-Pleistocene)

- ms2 — Upper middle Siwalik Fm
- ms1 — Lower middle Siwalik Fm
- ls — Lower Siwalik Fm

Nuwakot Gr. (Precambrian) Bhendetar Fm(~Nourpul Fm)

- sq — Sanguri Quartzite Unit

Chiuribas Unit (ch)

- ch3 — Upper subunit
- ch2 — Middle subunit
- ch1 — Lower subunit
- kn — Kunchha Fm

Areas Susceptible to Hazards

- Area vulnerable to slope failure
- Area prone to river bank erosion
- Tectonically weak zone

Mineral Resources

- X_s / X — Existing excavation sites for Stone / Gravel, sand

Erosion and Mass Movement Features

- Tensio cracks
- Active landslide
- Old landslide
- Gully erosion

Features of Environmental Significance

- Drinking water reservoir
- Present waste disposal site
- Industrial Area

Recommendation for Sanitary Landfill

- Proposed sanitary landfill site

GENERAL SYMBOLS

- Thrust
- Thrust (Inferred)
- Lithological boundary
- 31 — Attitude of bedding
- Fault
- Major Lineament
- Minor Lineament
- Anticlinal/Synclinal axis
- Built-up area
- Squatter settlement and flood prone area
- Proposed new settlement area
- Public/natural park boundary
- Proposed public extension boundary
- Motor road
- Stream / river
- Spring location
- * — Drinking water intake
- # — Proposed drinking water source
- Well
- Temple/gumba
- Cemetary
- Dharan Municipality Office
- $ — Tourist spot
- 0 — Public toilet
- Stadium
- Stone crushing plant

RECOMMENDATION

Areas closer to the tectonic structures are weak zones. Therefore, before building any infrastructures in these areas, it is essential to evaluate the site by detailed investigation.

Landslide areas should be avoided while planning the infrastructures. Proper stabilization measures should be adopted in the future.

Bank protection works should be continued along the banks of Sardu and Seuti Kholas by constructing appropriate structure.

Debris rich in gravels and boulders deposited during rainy season should only be extracted from the center part of the riverbed. Gravel extraction should be carried out to an amount that is replenished by the natural process.

Haphazard mining of aggregates from Sardu and Seuti Kholas should be discouraged. Mining activities in these river courses should be controlled to some extent and supervised.

A buffer zone to prohibit further construction should be considered near Raitole. The zone should be about 30m from the edge of the cliff towards the settlement area.

Preliminary Field Report on Engineering Geological mapping of Dang Valley

Sugat M. Sikrikar, Research Officer
Engineering Geology Section

INTRODUCTION

Dang Valley is located in Mid-Western Development Region of Nepal. It is an elongated valley extending in WNW-ESE direction which has developed tectonically in Sub-Himalayan zone. It is bounded by Mahabharat Lekh along the Main Boundary Fault that can be easily traced from aerial photographs. To the south of the valley the Sub-Himalayan range separates this valley from the Rapti valley.

Several levels of terrace deposit cover the valley floor. Most of them represent the fan surfaces formed by number of rivers that emerge from Mahabharat Lekh into the valley. At the foot of the Mahabharat Lekh tectonically developed topographic feature called "Pressure Ridge" can be seen through out the area. The materials of such pressure ridge are derived from crushed zones of Main Boundary Thrust (MBT) in the north.

The report provides general overview of engineering geological aspects of the valley floor that includes information of ground condition regarding its composition, stiffness and engineering properties of soil and rock units of the area. Basic information necessary for evaluation of engineering geological condition of the ground for regional planning of human settlement and infrastructures are provided in the report. Information on source and quality of construction material, their uses, and guidelines for safe mining can be obtained from the report.

METHODOLOGY

The study area covers about 1150 sq.km of the valley floor. The investigation is carried between the Main Boundary Thrust (MBT) in the north and Babai River in the south. To the east and west of the valley the investigation is limited to the base of hill slopes.

A total number of 100 auger holes are drilled within the valley for the investigation of the sub surface soil layer. More than 200 soil samples are collected from different depth of the auger holes for laboratory analysis. More than 100 number of Standard Penetration Tests (SPT) are carried out covering all the identified soil units for determining the stiffness of the ground at different locations. The test is carried to the depth of 10 meters only because of limitation of time and type of equipment used for the test. However at many locations even 10 meters depth could not be reached due to presence of gravel and boulder beds at shallower depths. In cases where gravel beds are encountered at near surface, Dynamic Cone Penetration Tests (DCPT) are carried out instead of SPT. Soil samples from different soil type and SPT value are recorded.

INVESTIGATION RESULTS

Depending on the composition and engineering properties of unconsolidated sediments of the valley floor observed during the field investigation of the area by surface and sub surface exploration, unconsolidated sediments of the valley floor is tentatively divided into 6 different engineering geological soil units.

The Residual Deposit is widely distributed through out northern part of the valley. The deposit is characterized by the presence of brownish red soil on the surface that is underlained by thick deposit of gravel to boulder size materials mostly of sandstone, quartzite, and limestone. The thickness of fine materials covering the gravel and boulder beds varies from 1 to 5 meters that generally increases towards south where the landform turns into gently undulating flat surface.

The Terrace Deposit (T-1) is widely distributed in the valley and occupies most part of the valley floor (Figure 1). This deposit can easily be distinguished from the older terrace of residual soil deposit as it lacks the red soil on the surface. The deposit is generally characterized by pale brown to gray silty soil on the surface. Thin layer of gravel bed at 0.5-1.0 meter below the surface is found in this deposit.

The Terrace Deposit (T-2) is found at the margin of the terrace deposit (T-1). More than 4.0 meters thick chocolate color silty clay layer usually characterizes the deposit. This deposit can be separated from T-1 deposit due to its color and lack of gravel beds at the shallower depths.

The Lacustrine Deposit is found in the southern part of the valley mostly within the T-1 formation and at the bank of some of the rivers in the valley. The deposits are usually more than 10 meters in thickness that contain layers of silty clay soil with subordinate amount of humic clay.

Stratified Gravel Bed is well exposed in the Bhamke Khola river section and southeastern part of the valley near Jaspur village. The deposit comprises of thick layer of stratified gravel bed overlying silty soil and lacustrine deposit.

Recent Alluvial Deposit includes lowest river terraces and flood plain of Babai River in the south. The deposit comprises of gravel bed deposited at the bank of rivers in the northern part of the valley and recent soil deposit formed by Babai River in the south.

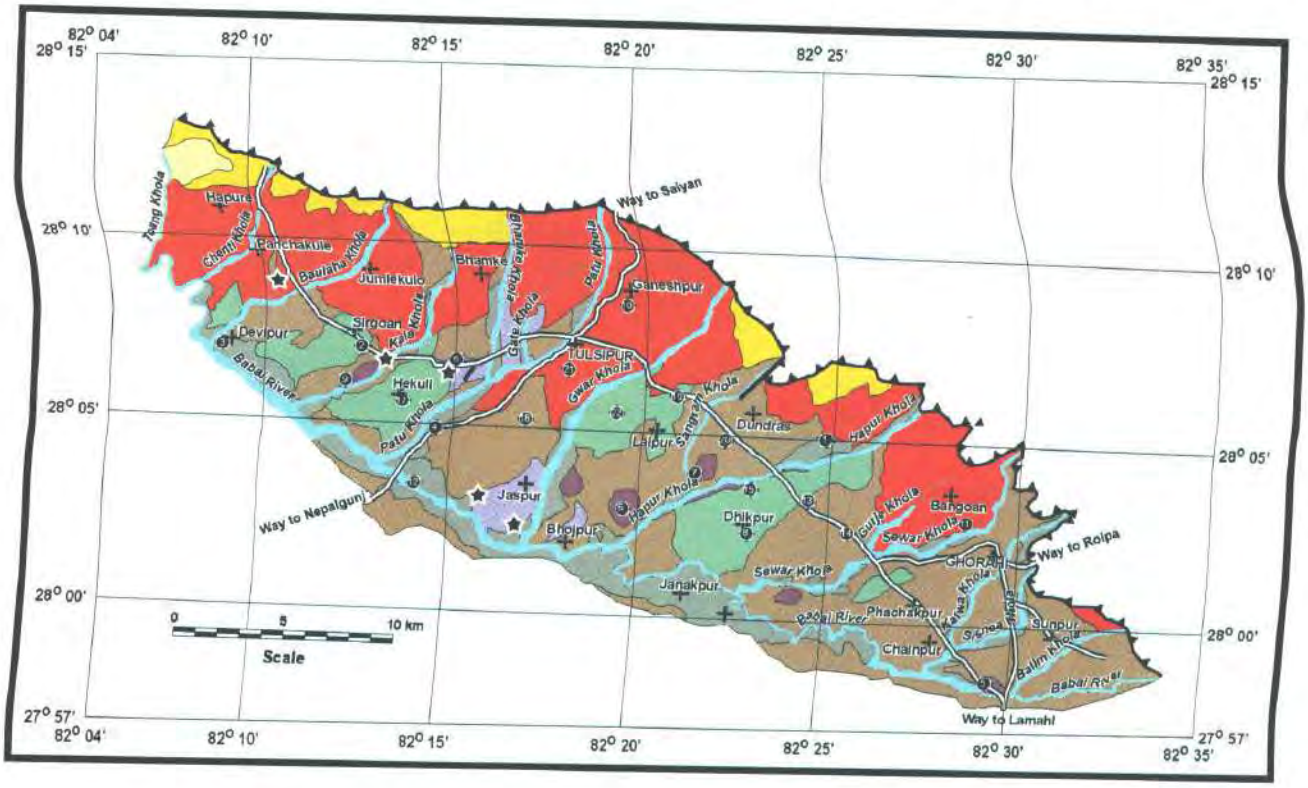
These terrace deposits in the valley floor are regarded as the result of recent tectonic activities taking place in this area. It is assumed that during the time of upliftmen in the northern part, the subsidence of the valley floor was taking place in the southern part where sediments deposition was in process. The recent tectonic activities can be observed at the upper part of Sangram Khola where the terrace deposit is found over the Lesser Himalayan rocks. In the southern part of the valley near Babai River, the minor folding observed in the lacustrines deposit also indicate recent tectonic activity taking place in this area.

CONCLUSION

Unconsolidated deposit of the valley floor is grouped into different soil units regarding its engineering geological properties as observed during field investigation and laboratory test result. The area covered by terrace deposit shows good bearing capacity from shallower depth. Only the recent deposit near the Babai River and the silty clay deposit found at the margin of T-1 deposit are susceptible to ground settlement. The information provided in the report can be used only for small scale engineering works and preliminary planning. The data provided in the report are site specific and therefore should not be generalized for planning and design of large structures. Detail site investigation works are required for designing large and important structures.

Figure 1

Engineering Geological Map of Dang Valley



Legend

Active alluvial fan
Locally deposited debris of angular sandstone gravel brought down by tributaries.

Babai clayey silt deposit
Grey clayey silt and fresh gravel deposit at the bank of rive. Thickness generally < 3.0 m

Aswar stratified gravel depopsit
Few meters thick sub-angular stratified to subrounded graveland boulder deposit mainly of sandstone and quartzites inter mixed with sandy silts material and unconformality overlesses the Babai clayey silt deposit.

Raipur lacustrine deposit
Thick deposit of carbonaceous clay with bands of silty clay layers and generally found with Ghorahi gravelly silt deposit.

Hekuli clay/silt deposit (T_2)
Colourful stratified layers of silt, silty clay and clay with fine calcareous concretions at places.

Ghorahi gravelly silt deposit (T_1)
Slightly stratified deposit of subangular to subrounded pebbles, cabbles and gravels of sandstone, phyllite, quartzite and limestone intermixed with grey coloured clayey silt.

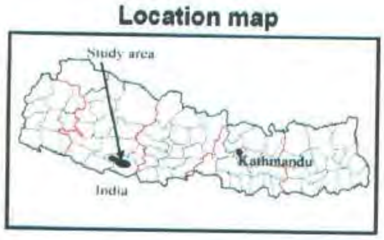
Tulsipur residual clayey silt deposit
Sub-angular to sub-rounded pebble, cobble and boulder size gravels of sandstone, phyllite, quartzite and limestone and silty materials covered by 2-4m thick reddish brouwn clayey silt.

Siwalik
Thick-bedded, medium to coarse grained, medium to hard grey sandstone.

General symbols

- Geological boundary
- Main Boundary Thrust (MBT)
- Fault
- Khola / River
- Road
- Place
- SPT location with number
- Carbonaceous clay sampling location

Location map



Engineering Geological Mapping of a Part of Surkhet District

Omkar Man Shrestha, Geologist,
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INTRODUCTION

Surkhet is one of the five districts of Bheri zone. Birendranagar is the district headquarter of Surkhet district. The area assigned during this fieldwork includes Surkhet valley, Chhinchu area, Ramghat area and adjoining parts. Urban settlements in these areas are fast developing. So it is necessary to have sound geotechnical knowledge of soils and rocks of these areas in order to carry out land use planning effectively.

The mapped area falls in Indian Toposheets No. 62H/10 and 62H/11 of 1:50,000 scale and Toposheets No. 2881 07A, 2881 07B, 2881 07C, 2881 07D and 2881 11B of 1:25,000 scale published by Survey Department of Nepal.

OBJECTIVES OF STUDY

The objectives of present fieldwork are to prepare an engineering geological map of the study area. The map is intended to include following information:

i) engineering geological properties of soils and rocks.
ii) mass movement features like landslides and erosion.
iii) hydrological information - wells, springs, marshes, water tables etc.
iv) potential source areas for construction materials.
v) potential waste disposal sites.
vi) assessment of ground conditions for effective land use planning.

METHODOLOGY

Mass movement features, geomorphological features and soil boundaries were tentatively drawn from air photo interpretations. Available geological maps were studied. Base map was prepared in 1:25,000 scales. Fieldwork was carried out in 1:15,000 scale air photos in Surkhet valley and 1:25,000 scale topomaps in the remaining areas.

Auger hole drilling was carried out for subsurface soil exploration. Soil sections were studied in auger holes as well as in khola sections and other outcrops. All existing wells, springs, marshlands and ponds were noted for assessing groundwater conditions. Water tables were noted in wells and auger holes. Existing construction material sites and other possible quarry sites were investigated. Environmental features were noted. Possible waste disposal sites for Surkhet valley were investigated. Mass movement features like landslides and erosional features and their impacts and possible remedial measures were explored. Finally, Engineering Geological Map was prepared (Fig.1)

FINDINGS

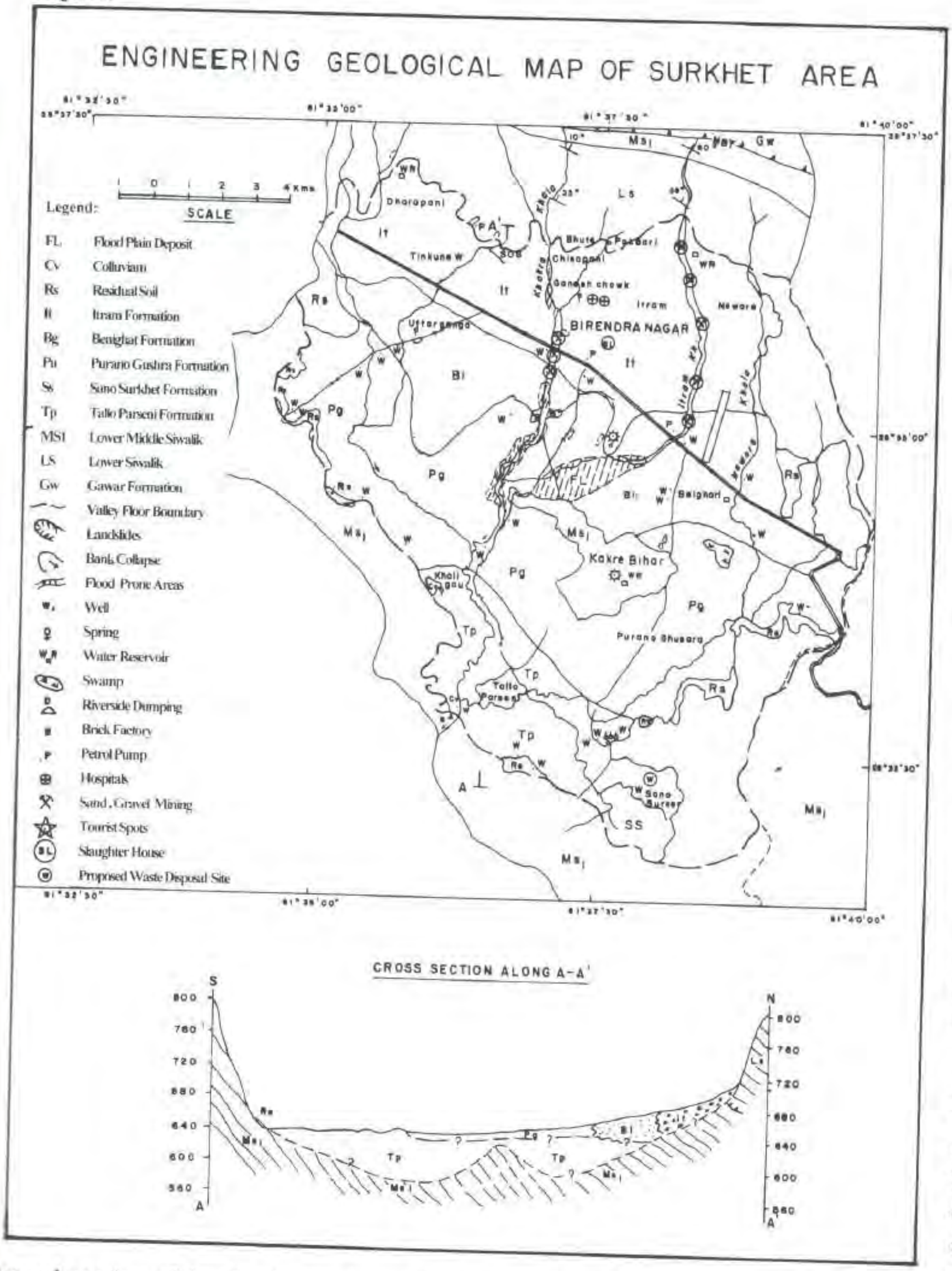
Soil Units:

Surkhet valley is semicircular with centripetal drainage system with following soil units. (Fig.1)

Itram Formation (It): It falls under poorly graded gravel (GP) according to the Unified Soil Classification System (USCS). The type of soil is good for foundation purpose as compaction is medium to high. Allowable bearing capacity is found to be moderate. Free groundwater table is deep (10m-15m) to very deep with high permeability value.

Belghari Formation (Bl): This unit consists of more than 5m thick grey to yellowish grey clayey silt with gravels. Gravels are rounded to subrounded consisting of sandstones and siltstones and occupying about 50% of the volume. Upper part of

Figure 1



this unit consists of light grey to grey clayey silt. This unit is sloping 5° to 10° towards south. According to USCS this soil is silty gravels (SM).

This unit is slightly dense to dense with slight to none plasticity. Though it is good for foundation purpose, lateral bank erosion and shallow ground water level (1~2m) are its constraints.

Purano Ghusra Formation (Pu): This unit occupies not more than 6 m thick central part of Surkhet valley. It consists of light grey, light yellow to bluish grey clay, the silt intercalating with silty clays and the thin carbonaceous black clays at places. Sometimes this formation contains fragments of wood and freshwater molluscs. Black soil was observed at the northwest of Itaura and in between Bhanpur and Dholdhunga. They indicate local marsh deposits.

According to USCS, this soil is ML, CL. Consistency of this soil is soft to firm and the permeability is low to moderate. Plasticity is low to moderate. Free groundwater table is very shallow to shallow (o.5m to 2m). Allowable bearing capacity is low to moderate. Engineering geological constraints to be considered are shallow free groundwater table, lateral erosion of the riverbanks during flooding and possibility of liquefaction during earthquakes.

Sano Surkhet Formation (Ss): This unit consists of light yellow to brownish yellow clayey silt. Silts are mostly coarse. This formation covers only Sanosurkhet valley - southernmost part of Surkhet valley. Sanosurkhet valley is seperated from Surkhet valley by a small ridge and this valley forms tip of the whole valley. This unit is of low plasticity and firm to stiff consistency. Groundwater table is more than 6m deep. This soil has moderate bearing capacity.

Tallo Parseni Formation (Tp): It is distributed in the southern part of Surkhet valley. This formation consists of mainly grey to dark silty clays and black carbonaceous clays. Sometimes silt layers are interbedded. It is mainly lacustrine deposit. Thickness is more than 5m thick. According to USCS this unit is ML CL. Consistency of this soil is very soft to soft and plasticity is intermediate to high (45% to 55%). Allowable bearing capacity is low. Water table is 3m to 5m deep in general. This unit is poor for foundation purpose due to possibility of settling down. Heavy structures should use pile foundation.

Residual Soil (Rs): This soil is developed along hill slopes due to weathering of rocks. It consists of mainly light yellow to greyish yellow sandy gravels and sandy silt. It is developed mainly in Gagreta ridge, Chauke Dhunga and Koldanda. Slopes are generally stable.

Colluvial Soil (Cv): It is developed at the footslopes and gentler slopes consisting of sand, silt and coarser materials. Thickness is more than 1m. This soil is slight to non-plastic, loose to slightly dense and improper drainage may lead to ground movements. It is developed in western parts of Surkhet valley and eastern part of the mapped area.

Floodplain Deposits (FL): This unit is developed along riverbed and riverbanks. It consists of mainly boulders, cobbles and gravels in the matrix of sandy silt and silt. Thickness is more than 1m. It has loose density, high groundwater potential, prone to erosion, flooding and liquefaction.

Construction Materials:

Building materials like boulders, cobbles, gravels, and sand for Surkhet valley are supplied partially from kholas of Surkhet valley and partially from outside the valley. Within the valley, the quarrying activities are going along Itram and Khorke kholas . From outside the valley, construction materials are supplied from Jhupra Khola located in the eastern part of the valley. Surkhet valley will have to depend upon Jhupra Khola for coarse materials in future. Clayey silt or silty clay for brick making is plenty in the valley.

Geological hazards:

Existing geological hazards within Surkhet valley are

- Flooding
- landslides
- low bearing capacity
- liquefaction and
- bank collapse

Groundwater :

Depth of groundwater table in Surkhet valley is variable due to different geological conditions. In the northern part, groundwater table is deep due to thick permeable fan deposits, whereas it is shallow in the middle and southern parts.

Free flowing spouts can also be observed in Surkhet valley. Prominent among them is Bulbule Tal in the Central part of the valley . Other free flowing spouts are in Kholigaun in the southern part, Uttarganga in the western part and Chisapani in the northern part.

Rock units :

The rock units exposed within the mapped area are (Fig.1)

Gawar Fomation: It consists of grey stromatolitic dolomite, limestone with white, grey subordinate sandstone and shale. This formation is exposed in the northern hills of Surkhet valley.

Lower Siwaliks: Lower Siwaliks consist of fine grained sandstone with interbeds of mudstone, shale and siltstone. It is exposed in the north of the valley. Many landslides have developed in it.

Lower Middle Siwaliks: It consists of fine to medium grained sandstone with interbeds of siltstone and mudstone. This formation is exposed in the eastern part and southern part of the mapped area.

CONCLUSION AND RECOMMENDATIONS

- Surkhet valley consists of fluvio-lacustrine deposits.
- Most of the hillslopes around Surkhet valley are stable due to gentler slopes and thick forest cover. Few landslides have occurred in the northern slopes.
- Southern part of the valley consists of areas of low bearing capacity.
- Liquefaction prone areas cover central part of the valley.
- Groundwater table in the northern part is deep, whereas it is shallow in the central and southern parts.
- Itram Formation in the northern part is most suitable for urban development within Surkhet valley.
- Engineering geological field tests should be carried out in the valley sediments.
- Detailed investigations should be carried out for fixing waste disposal site for the valley.

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Landslide Inventory and Hazard Zonation Mapping around the parts of Makwanpur, Kabhrepalanchok, Lalitpur and Kathmandu districts

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Sugat M. Sikrikar, Research Officer, Engineering Geology Section

INTRODUCTION

This paper describes the results of the field investigation carried out in accordance with the DMG's annual program of F.Y. 2057/58. It comprises inventory and distribution of the landslides and preparation of other factor maps required for the final preparation of landslide hazard zonation map, covering 650 sq.km area in parts of the Makwanpur, Kabhrepalanchok, Lalitpur and Kathmandu districts of Toposheet No. 72 E/6 and E/7. The study area includes some of the important highways, local feeder roads, proposed road corridors, and the sites of stone quarries including Godavari Marble Factory. The present field investigation entailed forty days (2058/2/1 to 2058/3/8) and intended to analyze the landslide hazard by statistical model and GIS techniques. It describes calculation of the statistical model for landslide hazard analysis and integration of data in a model for final preparation of landslide hazard zonation map of the study area. .

OBJECTIVES

The Himalayan region is generally characterized by steep slopes, high relief, highly weathered and densely jointed rocks with unfavorable hydrogeological conditions with respect to slope stability. The landslide is one of the natural catastrophes and has always caused a major problem in the country by killing and damaging lives and property every year. It has become an annual phenomenon especially during monsoon season. The stability conditions are further deteriorated by intense human activities and improper land use practices. Before planning any development activities in the region, the existing stability conditions of the terrain should be assessed to minimize the risk of hazards and environmental degradation and finally suitable preventive measures could be considered. Hence, the present investigation aimed at achieving the following objectives:

- to register the landslides of the study area in 'Preliminary Landslide Inventory Form'.
- to integrate landslide distribution and geologic information with various slope morphology and existing land use for the preparation of landslide hazard zonation map in 1:50,000 scale by optimum utilization of Remote Sensing and GIS techniques.
- to provide proper geo-scientific information of the area on natural hazards.
- to prepare ultimately the regional data base of landslides.

METHODOLOGY

Recent aerial photographs of 1992 at scale of 1:50,000 were examined to identify the various lithological units, landslides, erosional features, tectonic structures etc.

LANDSAT- TM Scene of December 1992 was studied for lineament mapping.

The topographic maps of 1:25,000 scale from Survey Department were used as a base map for the field investigation.

The Land Capability, Land Utilization and Land Systems Maps published by the Land Resources Mapping Project (LRMP, 1984) were studied.

Existing literature and geological maps of the study area were reviewed.

Fieldwork and verification of previously interpreted information were carried out using 1:50,000 scale recent aerial photographs in conjunction with 1:50,000 and 1:25,000 scale base map prepared by Survey Department. Emphasis was given in checking the landslides and other areas prone to further soil erosion by closer observation. Remote Sensing Section had studied some of the major landslides within the area in details using recently developed/modified 'Preliminary Landslide Inventory Form' for regional inventory.

Landslide and soil erosion are often observed throughout the study area mostly caused by natural as well as human activities like deforestation, improper hill slope cultivation, cultivation on coluviums of old landslide deposits, riverbank encroachment, and construction activities. Lithological set up, unfavorable structural discontinuities, increase in pore-water pressure, high intensity rainfall, high degree of weathering, and high gradients with excessive mass of bed loads in the lateral rivers are some of the natural causes of landslides and soil erosion observed in the study area.

The following optimum data required for the present investigation were acquired from various sources of information together with fieldwork. All the coverage are stored in the Modified UTM projection.

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

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

INVESTIGATION RESULTS

The results of the field investigation, along with the landslide inventory, their distribution, and other factor maps required for the preparation of landslide hazard zonation map are briefly sumarized.The instability of slopes is caused by number of factors, both natural and by anthropogenic activities or combination of both. When such factors responsible for decreasing the stability condition of slopes are identified and mapped, the whole area can be divided into number of zones depicting the existing nature of the slopes in term of its stability condition. The number of such causative factors acting at particular slopes could be different according to the spatial distribution of the slope in the area. However one can generalize different causative factors into number of groups and classify them into number of classes according to their strength with which it is acting for generating the instability condition of the slope. Beside many possible factors responsible for causing landslides in the area, factor maps of the area namely the landslide distribution map, geology/lithology, slope map, aspect map, land use map, and landslide inventory maps were prepared for deriving hazard zonation map of the area.

Landslide distribution map:

Landslides are very common throughout the area causing the degradation of environmental conditions. The landslides in this area can be grouped as active, old and dormant and reactivated slides. Rock falls are often found in jointed quartzites and carbonates in the areas with steep slopes mostly in the Lesser Himalaya. Both natural and human activities are responsible factors for causing these slides. In most of the cases, the landslides are accelerated by human activities in recent years. The human activities for initiating landslides include cultivation in the colluviums of old landslide deposits and extensive grazing and deforestation of the vegetated areas, cutting of the mountain slopes for construction works and human encroachment of river banks for various purposes. A majority of landslides in this area was found to be triggered by high intensity or prolonged rainfall during monsoon season. Beside this, there are some landslides, which occur, independent of rainfall, and which are due to lithological, structural, hydrogeological conditions and human activities as follows:

- Underlying weak geological formation or weathered rock
- Unfavorably dipping bedding and discontinuity plains.
- Presence of minerals like chlorite and talc in the underlying rocks.
- Change in landuse, particularly by removal of forest cover and its replacement by pasture and agricultural land, which increases infiltration and saturation of soil and also lacks deep anchoring of the tree root.
- Accelerated soil erosion caused by inappropriate land use resulting in formation of gullies, riverbank cutting and bad land formations.

Geological map

The geological map comprises of different type of litological units that are grouped according to their strength and mineralogical composition. Different types of structural units and tectonic features observed during field investigation were presented in the map.

Slope map

The topographical map of 1: 25000 scale was utilized for preparing the slope map of the study area. The map is derived directly from the topographical map. The steps, involved for producing the slope map is presented in the final report. All mountain slopes are grouped into relevant categories regarding their contribution to slope instability.

Aspect Map

Aspect is the direction towards which a slope faces and identifies the steepest down slope direction at any location on a surface. The aspect of the slope has close relation with the slope instability and is characterized by their discontinuities (bedding, joint etc.) In general, any discontinuities dipping towards a slope face are more susceptible to failure than dipping against the slope. The Aspect map of the study area was prepared from the Digital Elevation Model (DEM) using ArcView 3D Analyst. Aspect is calculated for each triangle in Triangulated Irregular Networks (TIN) and for each cell in raster.

Land use map

The land utilization map published by LRMP was used as base map for producing land use map together with the field data, which are utilized during derivation of landslide hazard zonation map. The regrouping of the land use class was carried out regarding the stability of slopes related to present land use practice. The regrouping of the land use classes is mainly based on the type and density of present vegetation cover, nature of cultivation, and land uses management systems, which are being presented in the final report.

Landslide Hazard Zonation Map by GIS Analysis

Finally, all the factor maps were correlated statistically rossed with the landslide distribution map, and prepared by field checking and interpretation of the remote sensing data. Calculation of landslide densities for each parameter class and the overall landslide density in the entire study area was performed using Bivariate-Statistical Model. The model was used for correlation as well as for determining the weightage value for each class in the various parameter maps. The combination of weighted maps were integrated into single map using certain combination rule. In this case, the total weightage values reveals from –13.909 to 3.447. The larger value 3.447 represents combinations defining high landslide hazard while smallest value of the range – 13,909 represents combinations defining low landslide hazard. They were again reclassified to generate the landslide hazard zonation map (Figure 1) of the area into three categories as low, moderate, and high hazard. Finally, the landslide distribution map was overlaid with the final hazard map and landslide density for three zones was calculated in order to check how much of the landslide area falls within the three different hazard zones. In this case, 83.76 % of the landslides are found to be located within the high hazard zone, 16.11 % in medium hazard zone and the rest in low hazard zone. This indicates the reliability and satisfactory precision of the presently adopted statistical model for landslide hazard analysis. Landslide Hazard Zonation Map along with all the factor maps was finally converted to an appropriate format using ArcMap of ArcGIS program. In course of map layout preparation, Landslide Hazard Zonation Map at 1:50,000 scale and other parameter maps at reduced scale of 1:100,000 were presented including the baseline data as well as explanatory legend as a final output for publication.

CONCLUSION AND RECOMMENDATIONS

- The hazard zones were classified as low, medium and high based on statistical evaluation of various causative factors related to slope instability and their relationship with landslide distribution.
- The methodology describes the calculation of the Bivariate-Statistical model for landslide hazard analysis and GIS techniques for integrating the data in a model and final preparation of hazard zonation map at 1:50,000 scale.
- Most of the existing old and active landslide falls within the high hazard zone, indicating good reliability and satisfactory precision of Bivariate-Statistical Model in landslide hazard zonation mapping.
- Rapid increase in the population density, construction works for various development activities and conversion of forestland into agricultural land are mainly responsible for reduction in stability conditions of mountain slopes within the study area.
- The map provides a good basis for the planners, policy makers and land developers in minimizing the risk of hazards and protecting the environment but cannot replace detail site investigation.

REFERENCE

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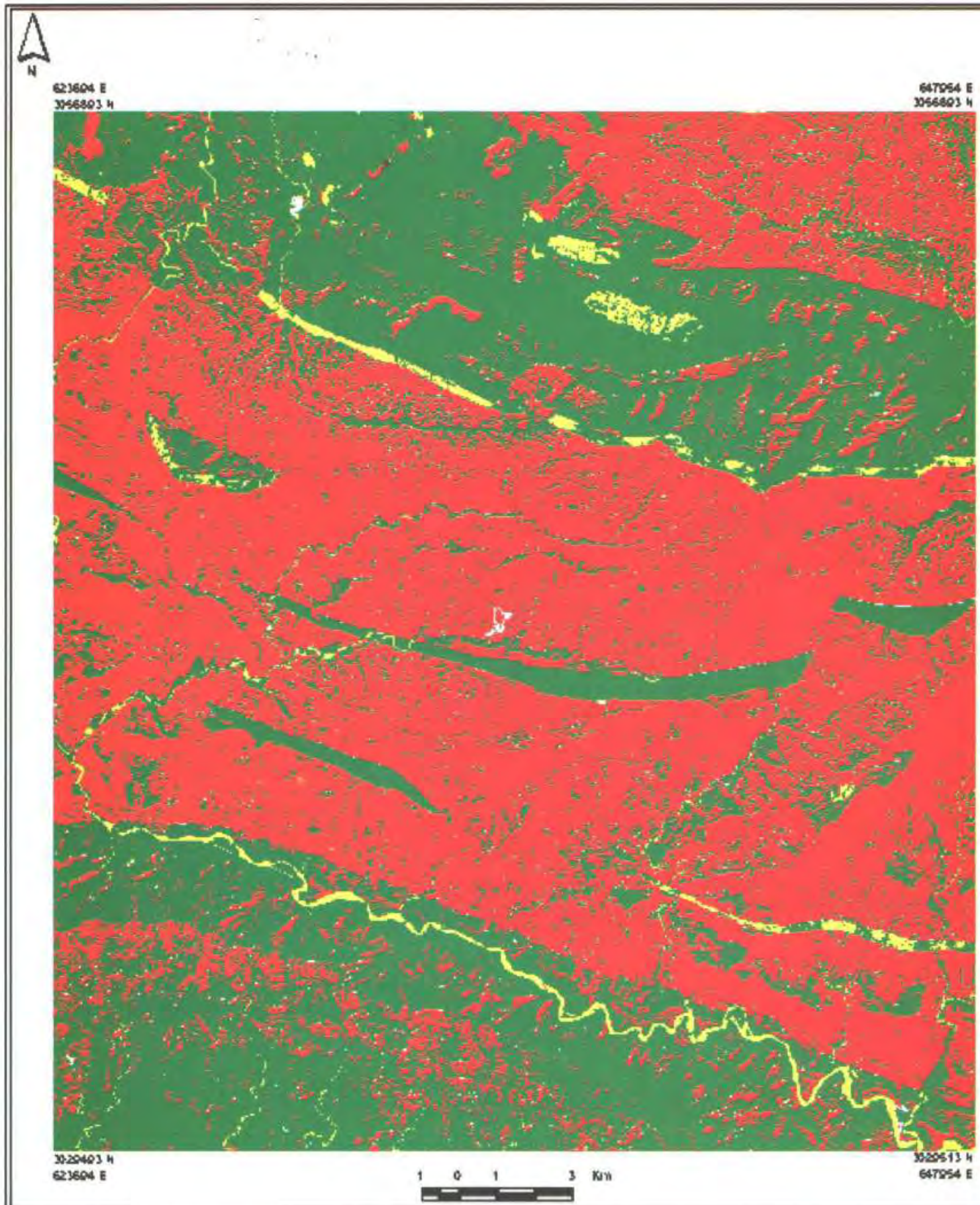
LANDSLIDE HAZARD ZONATION MAP

Toposheet Nos. 72 E/6 and 72 E/7

By

Ganga B. Tuladhar and Sugat M. Sikrikar

GIS Processing by D. Nepali, B. Piya and S. P. Manandhar



EXPLANATORY LEGEND

The Landslide Hazard Zonation Map was prepared by adding the weighted values of the four factor maps (Geology, Landuse, Slope and Slope Aspect). The weighted values were derived by statistical analysis based on the ratio of landslides within each unit of the factor maps. The zonation classification in low, mdedium and high hazard is based on weight value ranging from -13.91 to 3.45

Hazard Class	Damage	Remarks and Recommendations
Low	Very few small landslides. Presently no major slopes instability. River bank collapse and depositon of debris in low land area during wet season.	Usually stable, regulated constructions suitable. At places limitations may be imposed by soil conditions and other hazards like river bank collapse and seismic events. Stabilization measures required to prevent major debris.
Moderate	Erosion and rock falls presence. Possibility of initiation of new and reactivation of old landslides. High susceptibility to sliding on cultivated slope steeper than 20 degree. Magnitude of instability variable. Possible damage to infrastructure and cultivation land.	Urban development possible if appropriate safety measures are taken. Heavy construction needs detailed investigation Proper irrigation required and water should not be diverted into slide areas. Careful selection of road alignment. Natural and man made disturbance caused mass movements.
High	High density of active landslides and rock falls. Dangerous conditions of slope exists, at placed with certainty. High risk to human life and property. Loss of soil and arable land.	Very limited stable areas for infrastructure development. Special stability measure required. High cost of preventive engineering work likely.

Landslide Inventory and Hazard Zonation Mapping around the parts of Makwanpur, Dhading, Lalitpur and Kathmandu districts

Ganga B. Tuladhar, Senior Divisional Geologist, Remote Sensing Section

INTRODUCTION

The Department of Mines and Geology (DMG) is entrusted with acquiring and delivering the basic geo- scientific information and expertise services to institutions and entrepreneurs involved in infrastructure development, mitigation of natural hazards and protection of environment. Accordingly, DMG targeted an ongoing program for the preparation of landslide inventory and user's oriented landslide hazard mapping at 1:50,000 scale to serve as a cost effective and efficient source for sustainable regional and urban planning. Hence, the present investigation was intended to define landslide hazard, evaluate its interface and final preparation of landslide hazard zonation map to address geo-scientific information along with the possibility of natural hazard of the study area.

The study area of the present investigation includes Tribhuvan Rajpath, catchment of Kulekhani Hydropower, Bhaise mine of Hetauda Cement Industry and some sites for stone and sand quarries. The area is bound by latitudes 27^0 30' to 27^{0}45'N and longitudes 85^{0}00' to 85^{0}15' E and lies in Survey of India topographic sheet No.72 E/2 at 1 inch: 1 mile scale and sheet Nos. 2785 05A, 05B, 05C and 05D produce by Survey Department of HMG / Nepal at 1: 25,000 scale. Landslide and slope failure processes are common natural catastrophes within the area and it has become an annual phenomenon especially during monsoon season.

REMOTE SENSING DATA-INPUTS

The available satellite data together with the aerial photographs were studied and found to be one of the most indispensable tools for the present study. In particular, they are advantageous in identification of mass movement features, land use pattern, different geological structures, evaluating the landslide susceptibility, analyzing the specific landslide events and for preparing overall landslide inventory of the area. Image processing was carried out on satellite data using various enhancements, sampling and classification techniques for the delineation of lineaments, demarcation of land use, and identification of landslide related features such as fault scarps and slide debris. The information extracted through these techniques was merged along with the field data during the preparation of factor maps of various parameters.

The study is mainly based on statistical and empirical evaluation of various factors related to slope instability and their relationship with existing landslide distribution. The various causative factors like geology/structure, slope, aspect and landuse significantly contributes to slope instability and they were evaluated after detail field investigation as well as by using existing data sources from various agencies. Digital Elevation Model (DEM) and its derivatives, slope and aspect of the study area were directly derived using ArcView 3D Analyst. It describes the calculation of the Bivariate-Statistical Model used for landslide hazard analysis and GIS techniques for integrating the data in a model during the preparation of landslide hazard zonation map at 1:50,000 scale. All the factors are analyzed in relation to landslide density and are numerically weighted.

Ultimately, the final cartographic display was carried out with categorization of the study area into low, medium, and high hazard zones. As a result, most of the existing old and active landslide falls within the high hazard zone, indicating good reliability and satisfactory precision of Bivariate-Statistical Model in landslide hazard zonation mapping.

Optimum data for the present investigation were acquired from various sources of information together with field investigation. The following table summarize overlays used, sources, types of parameter derived, and the methods of generation.

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

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

PREPARATION OF FACTOR MAPS

The thematic maps of various causative factors such as geology and structure, slope, aspect, and land use, which are generally used for the preparation of landslide hazard zonation map at regional scale were prepared after incorporating the available remote sensing and field data into the GIS system. Landslide and soil erosion are often observed throughout the study area, mostly caused by natural as well as human activities like deforestation, improper hill slope cultivation, cultivation on coluviums of old landslide debries, riverbank encroachment, and construction activities. Lithological set up, unfavorable structural discontinuities, increase in pore-water pressure, high intensity rainfall, high degree of weathering, and high gradients with excessive mass of bed loads in the lateral rivers are some of the natural causes of landslides and soil erosion observed within the study area. The relationship of landslide ratio to various classes of parameter maps was summarized and found to be associated with certain classes of various parameters.

GIS ANALYSIS

Thematic maps were correlated statistically and crossed with the landslide distribution map, prepared by field checking and interpretation of the remote sensing data. Calculation of landslide densities for each parameter class and the overall landslide density in the entire study area were performed using Bivariate Statistical Model. The model was used for correlation, as well as for determining the weightage value for each class in the various parameter maps. The combination of weighted maps were integrated into single map using certain combination rules and reclassified to generate the landslide hazard zonation map of the area into three categories as low, moderate, and high hazard.

Software used: The PC ARC/INFO and ArcView softwares were used in the processing of base data and analyses of data sets for the preparation of the hazard zonation map of the study area. The ARC/GIS Desktop is a comprehensive and integrated GIS system that includes integrated applications with ArcMap, ArcCatalog and ArcToolbox. During the preparation of factor/parameter maps and calculation of Bivariate-Statistical model for landslide hazard, ARC/INFO was fully utilized. DEM and its derivatives were prepared using ArcView 3D Analyst.

Procedure: Bivariate statistical analysis deals with one dependent variables like landslide distribution and other independent variables of various parameter maps. Since the statistical approach is considered as one of the appropriate method for medium scale landslide hazard zonation, all the parameter maps were prepared based on the following formula modified after Van Westen, 1994.

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

Where,	Where,
Wi = we	Weight given to a certain parameter class
Denscla	Densclas = landslide density within the parameter class
Densem	Densemap = landslide density within the entire map

In Bivariate statistical analysis, crossing of parameter maps and calculation of landslide densities form the core of the analysis. The crossing results the landslide density for each parameter class as well as for the entire map. Each parameter is analyzed individually and the data driven approach is based on the assumption, that the important parameters leading to slope failure can be quantified by calculating the density of landslide for each parameter class. Weight value for each parameter class is calculated by relating the landslide density within the class and with the overall landslide density in the map. All the parameter maps are reclassified into the weight values and the hazard zonation map was prepared by adding the weight for individual parameters. Ultimately, the hazard scores are finally reclassified into High, Moderate and Low landslide hazard. The boundaries between the different levels of hazard are adjusted by overlaying the hazard map with the landslide distribution map.

Analysis: Landslide hazards were analyzed statistically by evaluating the factors that have led to landslides in the past and quantitative predictions are made for landslide free areas with similar conditions. After digitization of the landslide distribution map as well as other parameter maps, they were intersected using GIS techniques. The GIS coverage name of various parameters as well as codes and description used for each parameter class, as a separate attribute data was derived simultaneously.

Intersection of landslide distribution map with various parameter maps: Intersecting or overlaying the landslide distribution map on various parameter maps as an input coverage, the association of landslide and the factors controlling landslide occurrences are recognized. In other words, one can distinguish between the existing landslides and those free of landslide activities in each class of parameter maps. It creates a new intersected coverage as output coverage and generates Polygon Attribute Table (PAT). The parameter coverage features can be polygons, lines, or points but the intersect coverage features must be in polygons features.

Calculation of landslide densities: Landslide density is defined as the area of landslides in a given parameter class, divided by the total area of respective class. Intersection of landslide distribution map with all the parameter maps identifies the association of landslide with various classes of each parameter maps. Calculation of landslide densities for each parameter class as well as for the entire map was performed to find out the total area of landslides occurring on each class of the various parameters using the ARC TABLE command.

Calculation of weight values: The weight values were calculated for each parameter class by taking the natural logarithm of the density in the class divided by the density in the map. Virtually, the calculated weight values appears to be negative when the landslide density is lower than normal, and positive when the density is higher than normal.

Creation of weight maps : Weight maps was prepared by joining the created INFO table with Polygon Attribute Table (PAT) of each parameter coverage using the ARC JOINITEM command. All the parameters such as geology, land use, slope and aspect coverage were renamed into Wtgeology, Wtlanduse, Wtslope and Wtaspect respectively after joining the tables.

Creation of Landslide Hazard zonation map: As the main objective of the investigation, landslide hazard zonation map (Figure 1) of the study area was prepared dividing the entire area into three categories based on the degree of a potential hazard from landslide. Since each class of the parameter map has different weight value, the addition of all the weight value for a certain region was carried out during the hazard calculation. After the calculation of total weight for hazard coverage, the hazard map was reclassified in three different zones as low, moderate and high hazard.

RESULTS OF THE STATISTICAL ANALYSIS

The landslide distribution map was overlain with the final hazard map and landslide density for three zones were calculated in order to check how much of the landslide area falls within the three different hazard zones. In this case, 86.87 % of the landslides are found to be located within the high hazard zone, about 11.44 % in medium hazard zone and the rest in low hazard zone. This indicates the reliability and satisfactory precision of the presently adopted statistical model for landslide hazard analysis. Landslide Hazard Zonation Map along with all the parameter maps was finally converted to an appropriate layout format using ArcMap of ArcGIS program for publication as a final output.

CONCLUSION AND RECOMMENDATIONS

The methodology describes the calculation of the Bivariate-Statistical model for landslide hazard analysis and GIS techniques for integrating the data in a model and final preparation of hazard zonation map at 1:50,000 scale.

The total weight values reveals from 16.22 to 1.503.

Most of the existing old and active landslide falls within the high hazard zone, indicating good reliability and satisfactory precision of Bivariate-Statistical Model in landslide hazard zonation mapping.

Rapid increase in the population density, construction works for various development activities and conversion of forest-land into agricultural land is mainly responsible for reduction in stability conditions of mountain slopes within the study area.

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

At present, planning of development activities in high hazardous area may be avoided and afforrestation in the barren mountain slopes are advisable. In case of unavoidable circumstances, high cost may incur for major preventive measures.

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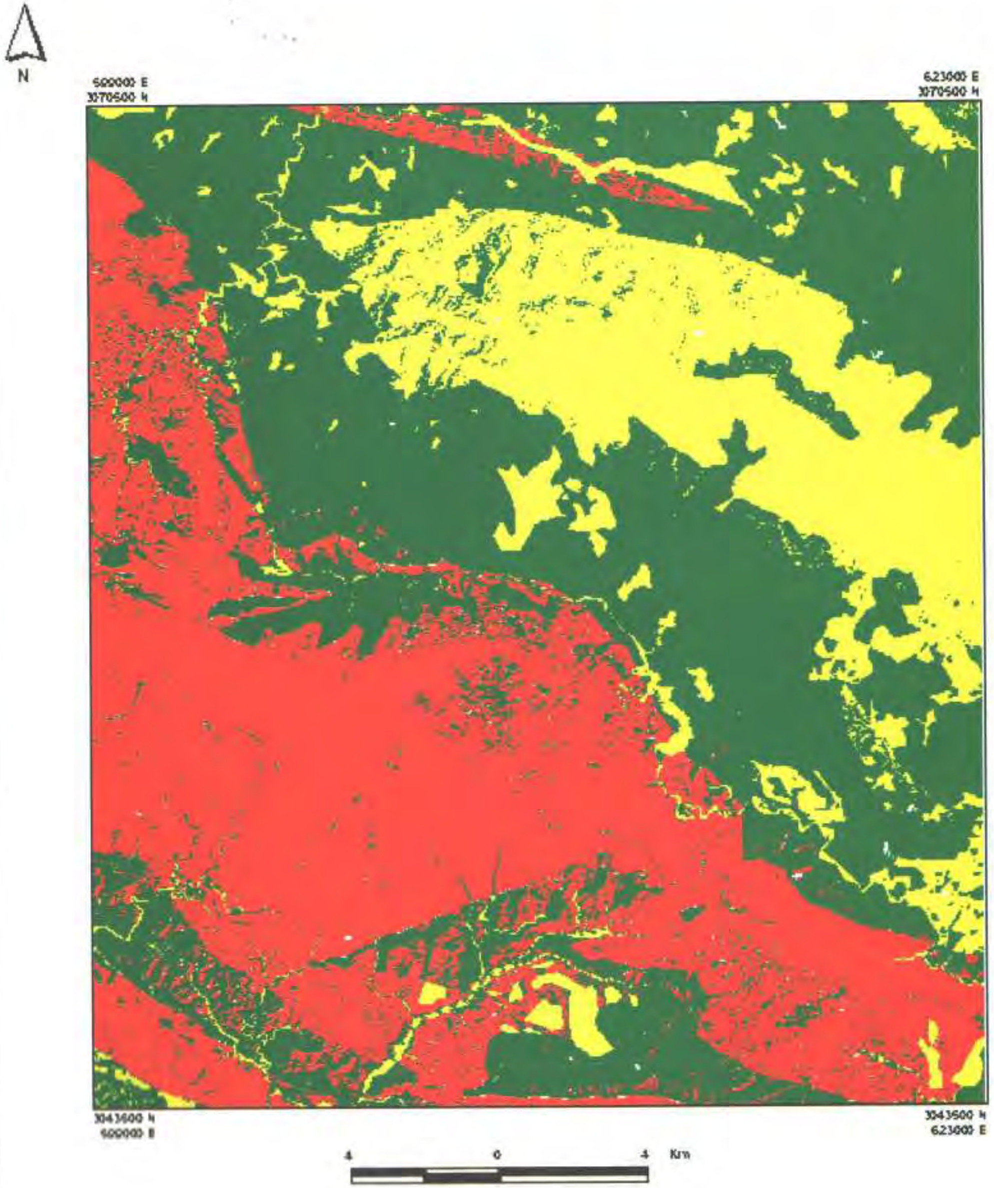
LANDSLIDE HAZARD ZONATION MAP

Toposheet No 72 E/2

By
Ganga B. Tuladhar

GIS Analysis by D. Nepali



EXPLANATORY LEGEND

The Landslide Hazard Zonation Map was prepared by adding the weighted values of the four factor maps (Geology, Landuse, Slope and Slope Aspect). The weighted values were derived by statistical analysis based on the ratio of landslides within each unit of the factor maps. The zonation classification in low, mdedium and high hazard is based on weight value ranging from -16.22 to 1.5

Hazard Class	Damage	Remarks and Recommendations
-16.22 - -5.00 Low	Very few small landslides. Presently no major slope instability. River bank collapse and depositon of debris in low land area during wet season.	Usually stable, regulated constructions suitable. At places limitations may be imposed by soil conditions and other hazards like river bank collapse and seismic events. Stabilization measures required to prevent major debris.
Moderate	Erosion and rock falls presence. Possibility of initiation of new and reactivation of old landslides. High susceptibility to sliding on cultivated slope steeper than 20 degree. Magnitude of instability variable. Possible damage to infrastructure and cultivated land.	Urban development possible if appropriate safety measures are taken. Heavy constructions needs detailed investigation Proper irrigation required and water should not be diverted into slide areas. Careful selection of road alignments. Natural and man made disturbance may cause mass movements.
High	High density of active landslides and rock falls. Dangerous conditions of slope exists, at places with certainty. High risk to human life and property. Loss of soil and arable land.	Very limited stable areas for infrastructure development. Special stability measures required. High cost of preventive engineering work likely.

Preparation of Excursion Guide Book on Geology of Arniko (Kathmandu – Kodari) Highway, Central Nepal

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INTRODUCTION

The Arniko Highway, not only connects Kathmandu with Tibet autonomous Region of the People's Republic of China, but also presents a geological section of the northern parts of the Midland mountains and the Higher Himalayas. Together with the Kathmandu-Hetauda-Birganj road, this highway gives a complete geological cross section across the Himalayas from Terai to Tibet.

Most geo-scientists, researchers of other disciplines and common tourists interested in geology have a great attraction and desire to see and understand the geological section of the Himalayas. This guidebook contains brief information on geology along the road. In total 23 typical outcrops of geological formations and structures as well as other spots of general interest related to engineering geology and Glacier Lake Outburst Flood (GLOF) events are described.

Nepal, lying in the central part of the great Himalayan Range, can geologically be divided into the following five distinct zones, which also correspond roughly to the geographical division of the country from south to north: Southern Terai zone, Sub Himalayas or the Churiya Range, Midland or the Lesser Himalayas, Higher Himalayas and Tethys Himalayas. Main Central Thrust (MCT) and Main Boundary Thrust (MBT) are the major thrusts structures running along the whole length of Nepal separating geologically distinct territories. Both of them dip towards north.

The geology along the Arniko High way from Kathmandu to Kodari is described in different stretches as shown in Figer 1.

GEOLOGY ALONG ARNIKO THE HIGHWAY

0-valley edge (Koteshwor): This part of the highway goes mostly along the flat parts of the Kathmandu valley. The Kathmandu valley is filled with fluvial and lacustrine lake sediments of Quaternary age ranging from 11,000 yrs. to 30, 000 yrs.

The thick sequence of large sediments up to 600 m., consists of peat, clay, carbonaceous clay, sand and gravel which are mostly unconsolidated. These sediments rest unconfirmably on Precambrian basement metamorphic rocks and granites. The sequence is divided into eight stratigraphic units. Many vertebrate fossils such as *Hexaprotodon sivalensis, Elephas planifrons, Stegodon ganesa and Crocodylus sp,* Carbonised fossil wood and pollen samples were collected from these sediments.

Valley edge – Sanga: In this stretch of the highway, the rocks of the Tistung Formation are exposed. This formation is the oldest of the Phulchauki Group of rocks. The formation consists of a fine clastic sequence of metasandstones, phyllites and sandy limestones with ripple marks and cross – beddings. Though sericite and chlorite are the main metamorphic minerals, the biotite is found in the lower parts of the formation.

Sanga – Dhulikhel west edge : The highway passes through the Banepa valley filled with Quaternary and Talus deposits along the valley edge. On the sorrounding mountains rocks of Tistung Formation are exposed.

Dhulikhel west – west Panchkhal: In this segment of the road mainly the rocks of the Phulchauki and Bhimphedi Groups are exposed. Main rock type exposed are the metasandstones, phyllites and sandy limestones of the Tistung Formation, biotitic schists with impure marbles and quartzites of Markhu Formation and well bedded alteration of fine grained biotitic schists and impure micaceous light green, grey coloured quartzites. Marbles of the Markhu Formation contain stromatolitic structures (?).

Panchkhal west – Panchkhal east : The road crosses the valley of Panchkhal through its western parts. The valley is filled in by alluvial and partly lacustrine (?) deposits. Red clay is developed intensively in its northern sides.

Panchkhal east – Chaku Fault (Mahabharat Thrust): In this segment of the road, the rocks of the Bhimphedi Group are exposed. Rocks of the Kulekhani Formation are underlain by those of the Chisapani, Kalitar and Raduwa formations thus exposing the complete sequence of the rocks of the Bhimphedi Group. Chisapani Formation is composed of predominantly white fine grained cross bedded quartzites. The Kalitar formation is represented by grey two mica schists with differentiated intercalations of impure strongly micaceous quartzites. Garnet and amphibole minerals are common in the lower parts. Bhinsedobhan Marbles are coarsely crystalline, well bedded to massive and contain mica in fine dispersion. Coarse crystalline, strongly garnetiferous two mica schists with several quartzite intercalations are the major rocks of the Raduwa Formation. Amphibole and pyroxene minerals are frequently found. A bed of coarse two mica gneiss is associated with the Raduwa formation

Chaku Fault (Mahabharat Thrust) – Indrawati Fault: In this stretch of the road, the upper part of the Nawakot Group namely the Benighat slates and Jhiku carbonates are exposed. Dark argillaceous slates or phyllites containing frequent intercalations of graphitic slates constitute the Benighat slates. Black brown, grey dolomites argillaceous limestones and calc phyllites are the main composition of Jhiku beds, which form lens like bodies within the Benighat slates.

Indrawati Fault – MCT : In this segment of the road, the whole sequence of rocks of the Nawakot Groups is exposed. The Indrawati fault brings into contact the Kunchha Formation, the oldest of the Nawakot Complex with Benighat slates.

The Nawakot Complex is divided into two groups. The exact position of the boundary between the two groups is debatable. Many geologists prefer to put this boundary in-between the Fagfog and Dandagaon Formations, which mark the first appearance of, carbonate material within the Nawakot Complex. A distinct sedimentological and structural hiatus is noted at this boundary.

The Kunchha Formation is composed of phyllites, phylllitic metasandstones, gritstones and fine quartz-conglomerates of light green-grey colour. Layers of diabase volcanic material are also locally noted. Fagfog quartzite is fine to coarse grained white orthoquartzitte with several phyllite intercalations. The Dandagaon phyllites are distinctly darker than rocks of the Kunchha Formation, due to the presence of carbonate materials in the form of laminated calc-phyllites and occasional thin beds of dolomite. The Nourpul Formation has white to pink, strongly ripple marked quartzite, varicoloured slates and pink dolomites. The Dhading dolomite is well bedded to massive light bluish grey, dense to fine crystalline, carbonate rock containing abundant stromatolites at many levels. The Dhading dolomite is succeeded by the Benighat slates which is overlain by the Malekhu limestone. It is composed of thin platy yellow dense siliceous limestone beds with palegreen sericitic partings. The Robang Formation is predominantly phyllite and quartzite with chloloritic and amphibolitic metadiabase..

MCT – Border (Miteri Sangu):

This last stretch of the road passes through the rocks lying above the Main Central Thrust. These high grade metamorphic rocks are designated as the Higher Himalayan Crystallines and are represented by various two mica gneisses, augen gneisses, migmatites, quartzites and marbles.

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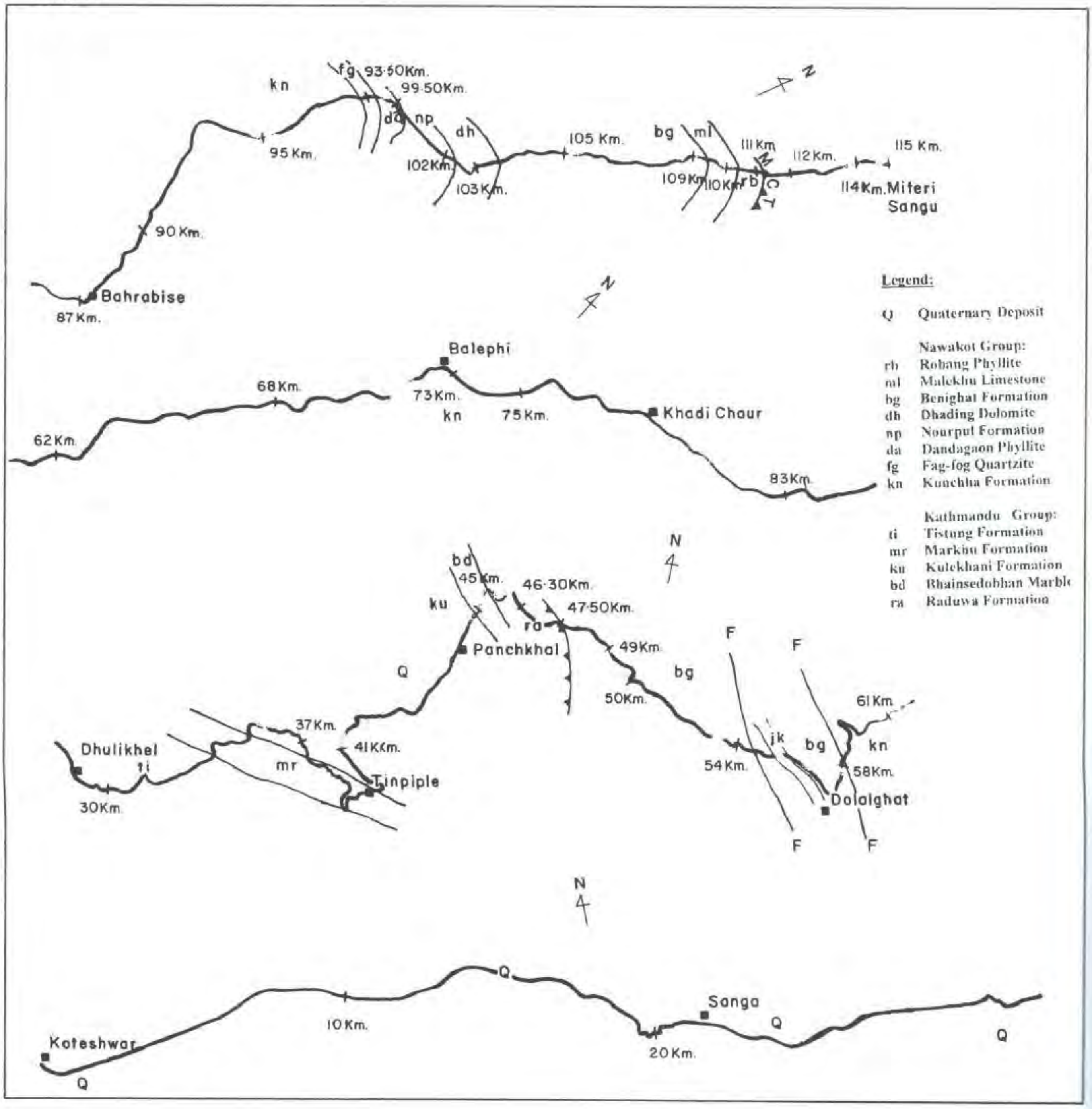
GEOLOGICAL OBSERVATION POINTS ALONG ARNIKO HIGHWAY

0 1 2 3 4 5 km
(Scale)

Figure. 1



Geology of Melamchi and Indrawati Area

U.B.Pradhananga, Senior Divisional Geologist, Geological Mapping Section

INTRODUCTION

Geological mapping of the area was carried out according to the departmental programme of fiscal year 057/58. The area lies in Sindhupalchok district and is bounded by 27° 45' to 28° 30' N latitudes and 85° 30' to 85° 40' E longitudes, encompassing about 440 sq. km. It lies in Indian toposheet no. 72 E/9 and 2785-03A, 03B, 03C and 03D of 1:25000 scale topographical map, published by Survey Department of HMG/Nepal.

OBJECTIVE

Main objective of the fieldwork was to check and study the stratigraphic, lithological and structural problems of western part of toposheet no 72 E/9.

BACKGROUND AND PREVIOUS WORK

The area has been studied by some Nepalese and foreign geologists. Toni Hagen (1960), carried out regional geological mapping of whole of Nepal. He found existence of two nappes: Kathmandu nappe and Nawakot nappe . Major part of the study area, lies in Kathmandu nappes. B.B. Nadgir (1968) carried out systematic geological mapping of the area. He divided the rocks of the area into three main groups: Suparitar series, Bhimmphedi series and Crystalline rocks. The Japanes workers Hashimoto et. al.(1972) covered the proposed area during regional geological mapping of Chautara and Kathmandu region. They divided the rocks of the area into (i) Midland Meta-sediments and (ii) Helambu gneiss. K.D.Bhattarai (1980) prepared photo-geological map of southern part of the study area. He divided the rocks of the area into : (I) Kathmandu Complex (ii) Midland Meta-sediment Group and (iii) Kathmandu Crystalline Zone. B.M. Janawali (19087) carried out geological traverses in the proposed study area and adjoining areas. He divided the rocks of the area into Lower Nawakot Group, Upper Nawakot Group and MCT Group.

RESULT AND FINDINGS

The area consists mainly of crystalline rocks such as gneiss, schists, quartzite, migmatite and feldspathic schist. Rocks of the area are divided into four groups: Lower Nawakot Group, Upper Nawakot Group,MCT Group and Helambu Group. Out of them, Helambu Group is the dominant group in the area and consists of high grade crystalline rocks. Helambu Group is represented by six formations which are Pangang Formation, Simpani Formation, Sermathang Formation, Gyalthung Quartzite, Dhad Khola Formation and Hadi Khola Schist. Dominant metamorphic minerals of the group are mica and garnet, and the metamorphic grade reaches to Silliminite grade in Pangang Fomation. Main Central Thrust occurs in southeastern part of the map (Fig.1).

General Geology: The area is composed of crystalline rocks; gneiss, schists, quartzite, migmatite and feldspathic schist. Rocks of the area are grouped into three groups: Lower Nawakot Group, Upper Nawakot Group and Central Crystalline Group. Out of the three groups, Central Crystalline Group consists of high grade crystalline rocks and it occurs north of MCT. Lower Nawakot Group, and Upper Nawakot Group with low to medium metamorphic rocks occur south of MCT. Metamorphic grade of Central Crystalline Group ranges from biotite grade to silliminite grade. MCT occurs in southeastern corner of the map area.

For the simplicity, the map area has been divided into five tectonic units from southeastern to northeastern corners of the area.

Unit 1, in the southeastern corner consists of Kunchha Formation of Lower Nawakot Group (kn).

Unit 2, lying north of unit 1, consists of Robang phyllite and Benighat Slate of Upper Nawakot Group (rb,bg).

Unit 3, in central part of the map, consists of high grade crystalline rocks of Simpani Formation (si), Sermathang Formation (sr), Gyalthung Quartzite (gy), Dhad Khola gneiss (dk) and Hadi Khola schist (hd).

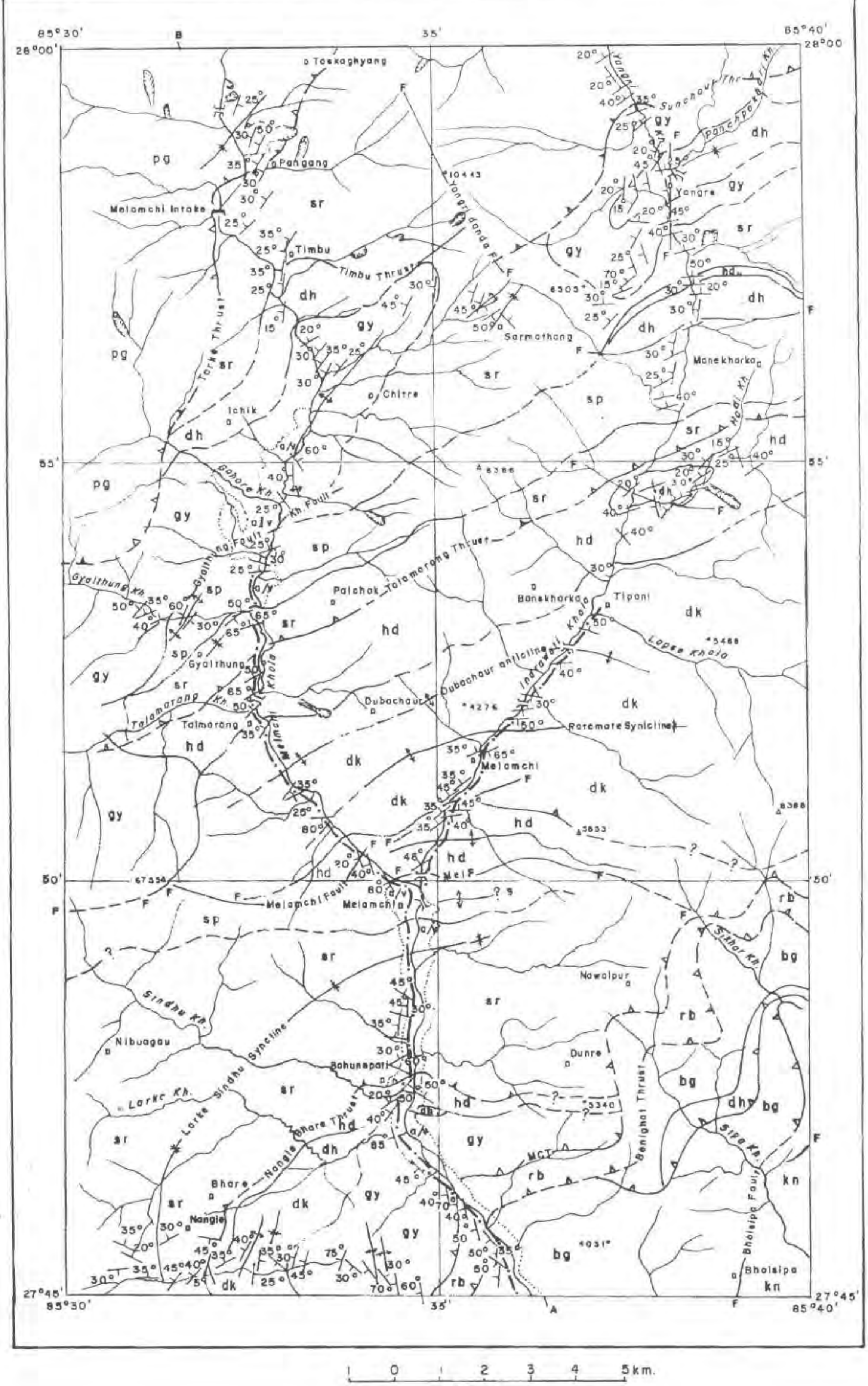
Unit 4, lying in northern part of the map consists of Simpani Formation, Sermathang Formation, Gyalthung Quartzite, and Dhad khola gneiss .

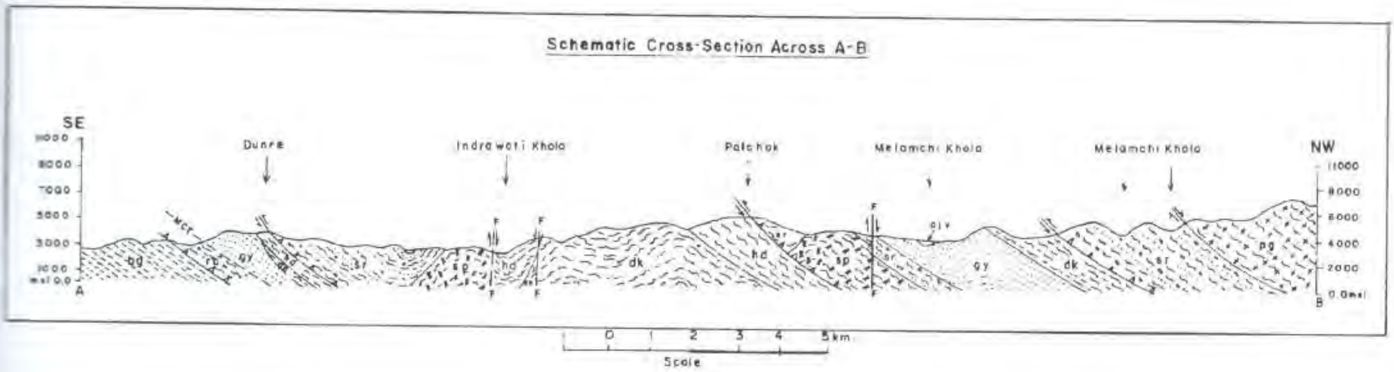
Unit 5, lying in northwestern corner of the map, consists of Silliminite grade Pangang Formation (pg).

Geological Map of Melamchi Indrawati Area

Sindhupalchok District

Figure I





Legend:

alv	Alluvial Deposit	Sand, silt, clay and boulders
hd	Hadi Khola Schist	Garnet biotitic schist, calc. schist with gneiss
dk	Dhad Khola Gneiss	Porphyroblastic gneiss, Augean gneiss and migmatitic gneiss
gy	Gyalthung Quartzite	Quartzite with bands of fine grained schist
sr	Sermanthang Formation	Feldspathic schist, augen gneiss, quartzite and fine grained schist
si	Simpani Formation	Kyanite - biotite schist, quartzite and feldspathic schist
pg	Pangang Formation	Tourmaline - bearing migmatitic gneiss and garnetiferous schist.
rb	Robang Phyllite	Chloritic phyllite with garnet and chloritic gneiss
bg	Benighat Formation	Black slate, sericitic chloritic phyllite and bands of carbonate (jk)
dh	Dhading Dolomite	Dolomite with bands of slate
kn	Kunchha Formation	Greenish grey phyllite and gritty phyllite with amphibolites.

Litho-stratigraphic Succession:

Group	Formation	Lithology
	Alluvial	Sand, silt, clay and boulders
Central Crysta-	Hadi Khola	Fine-grained garnet-biotite Schist,calc-schist
	Dhad Khola	Porphyroblastic gneiss, augen gneiss
lline	Gyalthung Quartzite	Garnet -biotite quartzite and schists
	Sermathang	Feldspathic schists, gneiss and quartzite.
	Simpani	Kyanite biotite schist, gneiss, migmatite,
	Pangang	Migmatitic gneiss and biotite schist.
	Main Central Thrust	
Upper	Robang phyllite	Chlorite-biotite gneiss and calc-schists, phyllite
	Benighat Thrust	
NawaKot	Benighat Slate	Sericitic-chloritic phyllite, quartzite and slate
	Bholsipa Fault	
Lr.NawaKot	Kunchha	Greenish grey gritty phyllite

Structure: The area has witnessed number of folding, faulting and thrusting activities. MCT which occurs in southeastern part of the area, separates the high grade crystalline rocks of the area from relatively low grade metamorphic and meta-sedimentary rocks of southeastern part of the map area. MCT has a NE - SW trend and dip toward NW by 30° to 50°. Other major thrusts of the area are Tarke Thrust, Talamarang Thrust, Timbu Thrust and Sunchaur Thrust. Major folds of the area are Dubechaur anticline, Ratmate syncliIne, Larke-Sindhu syncline and other small anticlines and synclines. Similarly, major faults of the area are Melamchi fault, Gyalthung Khola fault and Yangri Danda fault.

Mineral Occurrences: Except some green malachite coating in gneiss of Dhad Khola gneiss, no special metallic mineralisation is found in the area. Rocks of Gyalthung quartzite could be of great use in the construction of Melamchi project. The gneiss may not be of wide use for the construction material as the feldspar of gneiss weathers easily. Hadi Khola schist contains calc-schist and some thin crystalline limestone layer but no good quality limestone bands are seen in the area. Presence of lot of gneiss and quartzite,in upstream of Melamchi Khola and Indrawati Khola, produce lot of sand.

CONCLUSION

The area consists mainly of high grade crystalline rocks like gneiss, schist, quartzite and migmatite. Rocks of the area are grouped into Lower Nawakot Group, Upper Nawakot Group and Central Crystalline Group. Most parts of the area are occupied by the rocks of Central Crystalline Group, which consists Pangang Formation, Simpani Formation, Sermathang Formation, Gyalthung Quartzite, Dhad Khola Gneiss and Hadi Khola Schist. MCT, occurring in southeastern corner of the map, separates the dominant Central Crystalline Group from sedimentary and meta-sedimentary rocks of southeastern corner. The area has very poor metallic and non metallic minerals but construction materials like quartzite of Gyalthung quartzite and sand in Indrawati river may be of great use in the construction work of Melamchi Project.

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Geological Mapping of southern parts of Sindhupalchok district

T.P. Dhoubhadel, Geologist
Geological Mapping Section

INTRODUCTION

This report deals with the results of geological field investigation undertaken in southern half of the map sheet no 72E/9 and 72 E/13 lying in Sindhupalchok District. Fieldwork was conducted in accordance with DMG' s program of map compilation and publication. Though the area covered by 72 E/9 and 72 E/13 was previously mapped partly by B.B. Nadgir (1968) and B.M. Jnawali (1987) at reconnaissance scale, several inconsistencies in the stratigraphy exist. Studying and analyzing lithological and structural problems designed the field program. The study area forms central parts of Sindupalchok district. It is bounded by longitude 85° 40' 00" E and 85° 50' 00" E and Latitude 27° 45' 00" N to 28° 00' 00" N .The area is connected through two feeder roads of Dolalghat to Syaule Bazar and Simle to Jalbire.

Previous Works: The pioneering work was done in this area by B.B. Nadgir (1967). He proposed Bhimphedi Series and Suparitar Series for the litho-stratigraphic classification of the rocks of the area. D.P. Madhikarmi (1980) first tried to classify the rocks of the eastern part of the Topo sheet No 72 E/13 on the basis of the litho-stratigraphic classification framework of the Central Nepal. In the year 1987-88, B.M. Jnawali prepared a geological map of part of the Sindhupalchok District and proposed the litho-stratigraphic classification frame work of the Central Nepal to classify the litho-units of the area.

OBJECTIVE

The main objective of this investigation was to prepare a comprehensive geological map of the area to confirm and correlate with the established litho- statigraphy of Kathmandu and Central Mahabharat Range as far as practicable with a view to publish it at a scale of 1: 50,000.

FINDINGS

General Geology: In the present area, the high-grade metamorphic rocks belonging to Higher Himalayan crystalline are found to lie tectonically above the low-grade meta sediment of the Nawakot complex by thrusting. The geological succession of the area as adopted by J.Stocklin and K.D. Bhattarai for the central Nepal is as follows. (Fig.1)

Central Crystalline Gneiss

Dark gray Schist with Quartzite

Augen Gneiss

_____ M.C.T _____

Robang Formation

Benighat Slate

_____ Unconformity _____

Danda gaon phyllite

Fagfog Quartzite

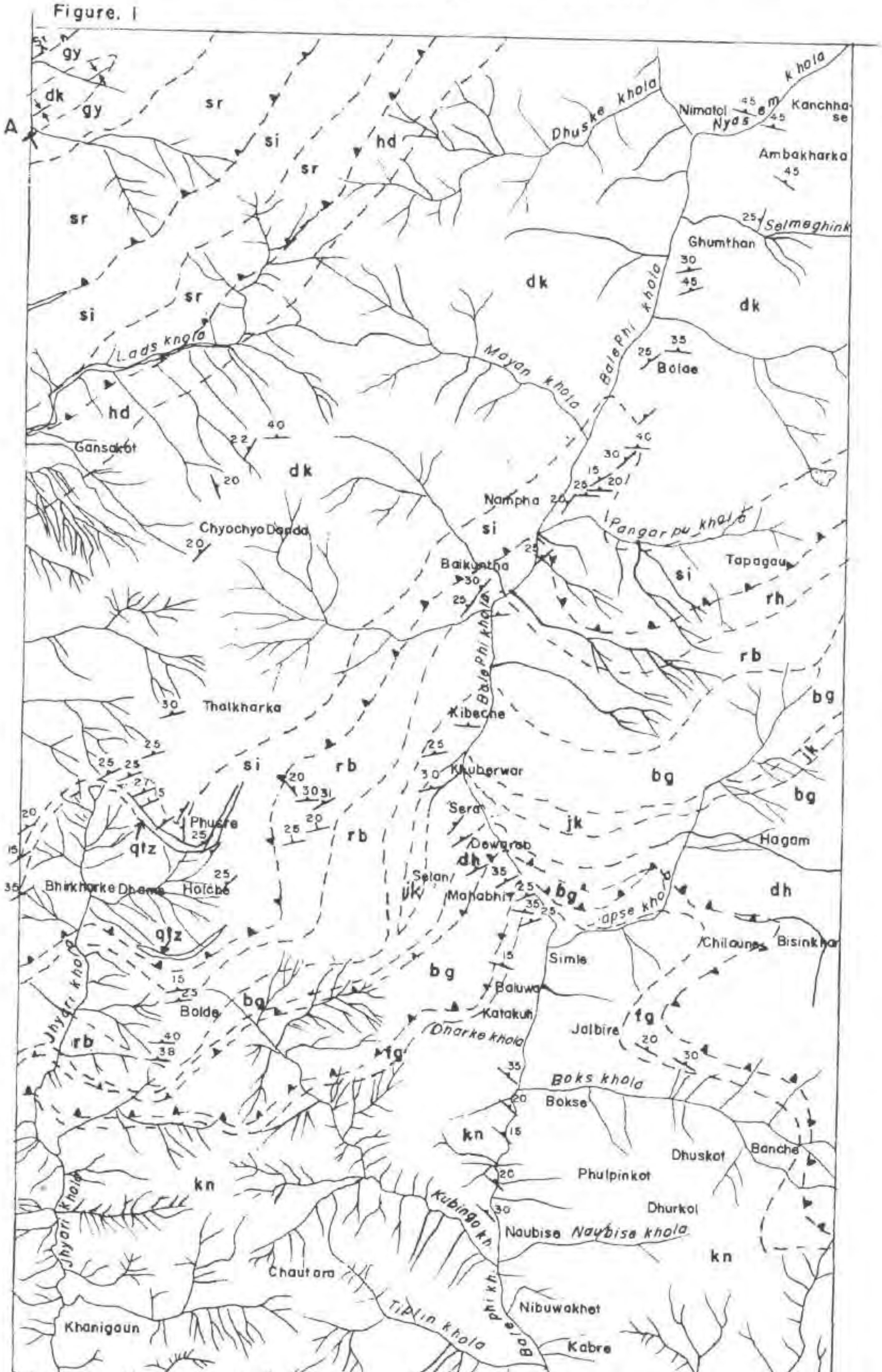
Kunchha Formation

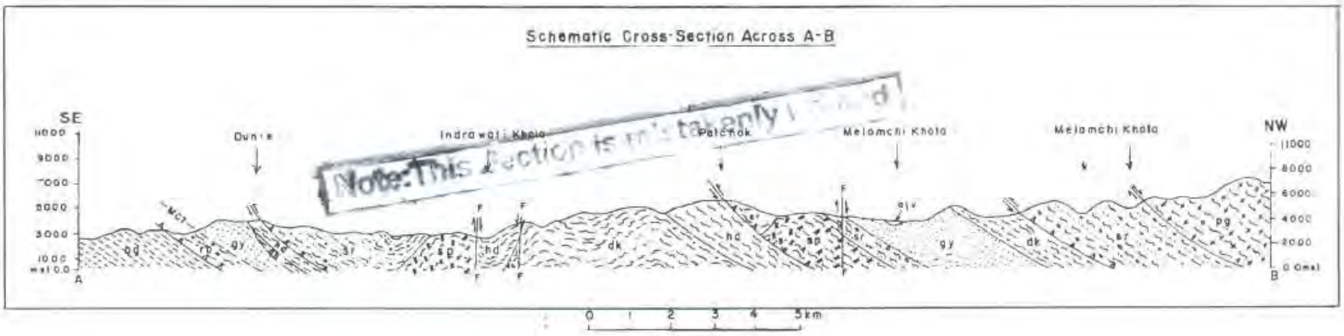
Kunchha Formation: In the study area, Kuncha formation consists of a thick sequence of monotonously alternating green to yellowish gray phyllite, gritty phyllites and various types of white quartzite. In general, the green to gray chloritic phyllites predominate.

GEOLOGICAL MAP OF CHAUTARA — JALBIRE AREA

SINDHUPALCHOWK DISTRICT

Figure. I





Schematic Cross-Section Across A-B

Legend:

alv	**Alluvial Deposit**	Sand, silt, clay and boulders
hd	**Hadi Khola Schist**	Garnet biotitic schist, calc. schist with gneiss
dk	**Dhad Khola Gneiss**	Porphyroblastic gneiss, Augean gneiss and migmatitic gneiss
gy	**Gyalthung Quartzite**	Quartzite with bands of fine grained schist
sr	**Sermanthang Formation**	Feldspathic schist, augen gneiss, quartzite and fine grained schist
si	**Simpani Formation**	Kyanite - biotite schist, quartzite and feldspathic schist
pg	**Pangang Formation**	Tourmaline - bearing migmatitic gneiss and garnetiferous schist.
rb	**Robang Phyllite**	Chloritic phyllite with garnet and chloritic gneiss
bg	**Benighat Formation**	Black slate, sericitic chloritic phyllite and bands of carbonate (jk)
dh	**Dhading Dolomite**	Dolomite with bands of slate
kn	**Kunchha Formation**	Greenish grey phyllite and gritty phyllite with amphibolites.

Fag-fog Quartzite: It consists of thinly bedded, hard, coarse to medium grained, sub- rounded ortho- quartzite with thin intercalation of green to gray phyllites The colour of the quartzite varies from white to pinkish white. The contact between Kuncha Formation and Fag-fog quartzite is gradational.

Dandagaon Phyllite: It consists of thinly bedded sericitic, chloritic phyllites. The phyllites are of argillaceous nature. The colour of the rock is green at fresh outcrop and yellowish green at weathered state. The contact between Fag-fog and Dandagaon phyllite is sharp

Benighat Slate: It consists of dark gray carbonaceous slate, multi coloured carbonates and phyllites. The major constituent of the Benighat slate is thinly bedded dark gray or black carbonaceous slate with sericite. White salty powder in the slate is common. Carbonate beds intercalated in the slate are generally thinly bedded. The limestone is platy gray to grayish white. The thinly bedded phyllites are of argillaceous nature. Its color is gray. The contact between Dandagaon phyllite and Benighat slate is unconformable.

Robang Formation: It consists of thinly bedded sericitic, chloritic, gray to green phyllites with thin intercalation of finegrained quartzite. The quartzite is grayish white colour. Phyllites are of argillaceous nature. Red garnet of 1-2mm size was noticed on the green phyllite of Robang Formation at Syaule Bazar. The contact between Benighat slate and Robang Formation is sharp.

Augen Gneiss: Augen gneiss consists of greenish gray white colour gneiss with augen. The length of the augen varies from 0.5cm. to 25cm. The white coloured augen is composed of feldspar. Visible minerals in augen gneiss are feldspar, quartz, biotite, garnet (2.0mm) and muscovite. Near the MCT, the outcrop of the greenish gray with white spots schistose gneiss occurs .The colour of the schistose gneiss is greenish. The visible minerals are feldspar, quartz, biotite, muscovite and red garnet (2 mm) .The contact between Robang Formation and Augen gneiss is tectonic i.e. MCT

Dark gray schist: It consists of fine to coarse crystalline dark gray hard garnetiferous schist with intercalation of coarse-grained white quartzite. The schist consists of biotite, muscovite quartz and garnets (1 to 3 mm). Two prominent bands of quartzite occur in this unit. The contact between Augen gneiss and Dark gray schist is sharp.

Central Crystalline gneiss: It consists of schistose gneiss with frequent intercalation of the augen gneiss and rare intercalation of dark gray schist. The grayis white schistose gneiss is of coarse crystalline aspect. The visible minerals are biotite, muscovite, quartz, garnets (3mm) and kyanite (4mm). The contact between dark gray schist and Central crystalline gneiss is sharp.

Tectonics/ Structure: Tectonically the study area can be divided into two units. They are the northern "Higher Himalayan Zone" and the southern, "Sunkoshi Tectonic Window". These two units are separated by the MCT. In the study area, the bedding planes are monoclinally dipping towards NW and NE and dip amount varies between 5 to 30. In the argillaceous rocks, well development of secondary cleavage plane could be seen.

CONCLUSION

There is no occurrence of purple rocks equivalent to the rocks of Nourpul Formation above the carbonate rock as shown by Nadgir.

The Benighat slate, Robang Formation Augen Gneiss, dark gray schist and Central Crystalline Gneiss, follow carbonate rock. .

There are no crystalline limestone bands in between garnetiferous phyllite and sericitic quartzite as shown by Nadgir. The field conditions are more compatible to the reports by Jnawali (1987).

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Geology of Kodari – Bhote Koshi Area Sindhupalchok District.

Prayag M. Pradhan, Minerologist
Geological Mapping Section

INTRODUCTION

In fiscal year 057/58 , the team had carried out field work in Sindhupalchok district. This area lies in topo sheet no. 72E / 13 or new topo sheet no. 2738 04 (1: 50, 000scale). It is about 435 sq.km. The target area is on Bhote Koshi River. Bhote Koshi meets Sun Koshi River flowing from eastern part of area. There is Kodari Highway running along the Bhote Koshi and Sun Koshi Rivers that connects China from Kathmandu. There are Sun Koshi and Bhote Koshi hydro – power stations.

OBJECTIVES

The main objective of the fieldwork was to check and study stratigraphic, lithological and structural problems in the study area of topo sheet no. 72E/13.

Previous work:

Toni Hagen (1960) had suggested Kathmandu nappe and Nawakot nappe for this area. The area consists of green phyllite, mica schist and augen gneiss. B.B. Nadgir (1972) had divided Suparitar Group and Bhimphedi Group. He suggested that Suparitar is equivalent to Nawakot Group and Bhimphedi is equivalent to Kathmandu Group. Hashimoto, et al, (1972) carried out field work and divided the rocks of the area into two groups;i.e.,Midland Metasediments and Helambu Gneiss. The Midland Metasediment represents meta sandstones, green phyllite, quartzite and limestone where as Helambu Gneiss represent the upper metamorphic rock with silliminite and kyanite. D.P. Madhikarmi (1980) had carried out geological mapping during geochemical sampling programme. He described the sequence from south to north as Kunchha Formation, quartizite, amphibolite and limestone, augen gneiss and granitic gneiss. B.M. Jnawali (1987) had grouped the rocks into two complexes as Nawakot and Kathmandu. Nawakot Complex is represented by Kunchha Formation and Fagfog quartzite overlain by Benighat Formation. The other rocks are greenish schistose phyllite, amphibolite with graphitic phyllite of Robang Formation. Biotite schist and gneiss and augen gneiss represent Kathmandu Complex. The metamorphic grade of central crystalline varies from garnet – kyanite to silliminite.

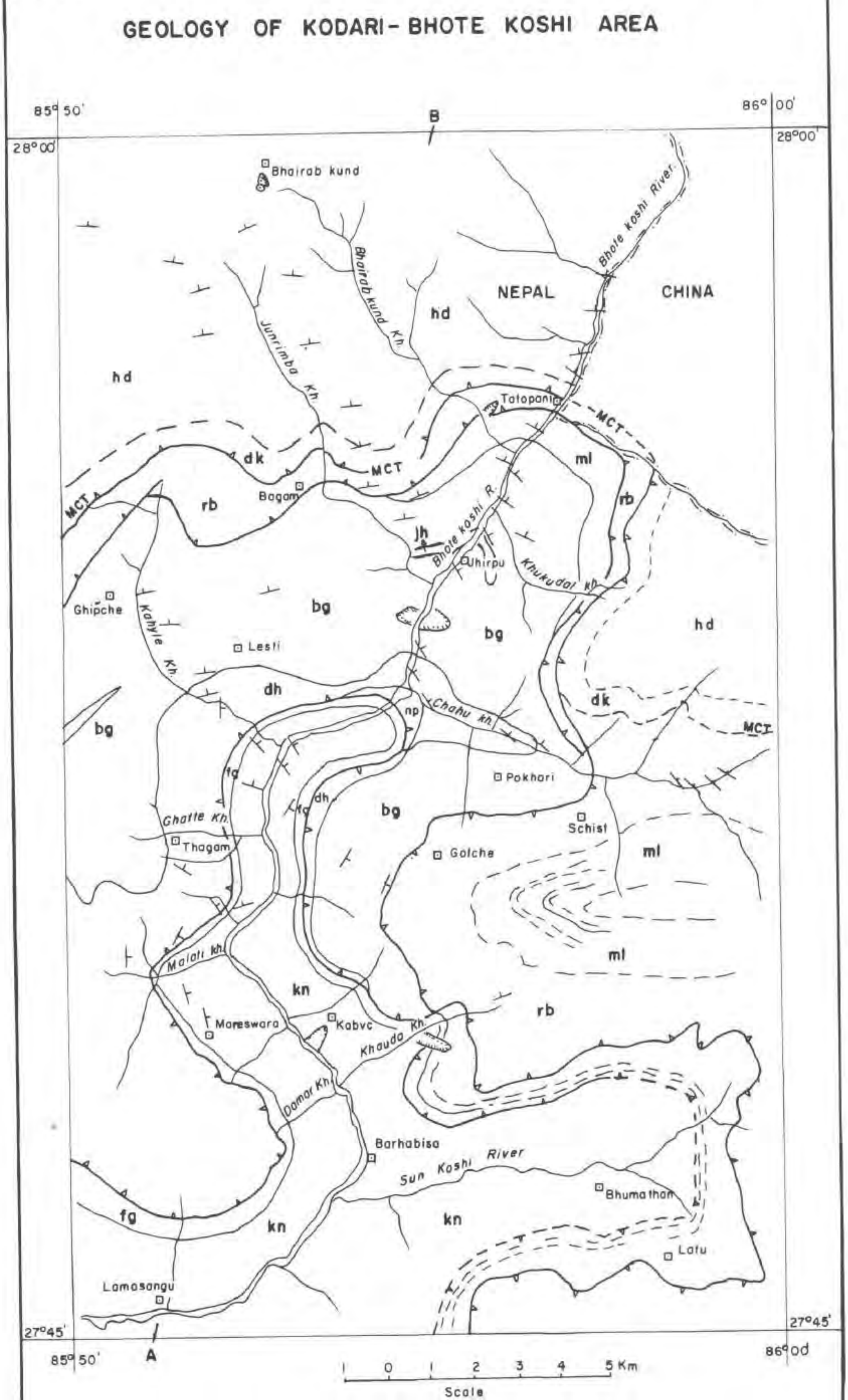
RESULT AND FINDINGS

The study area is mainly comprised of rocks of sandstone, green phyllite, quartzite, amphibolite and limestone, augen gneiss and granite gneiss. They fall under Nawakot and Kathmandu Complexes. The Metamorphic Central Crystalline rocks are of low to high grade (Fig.1)

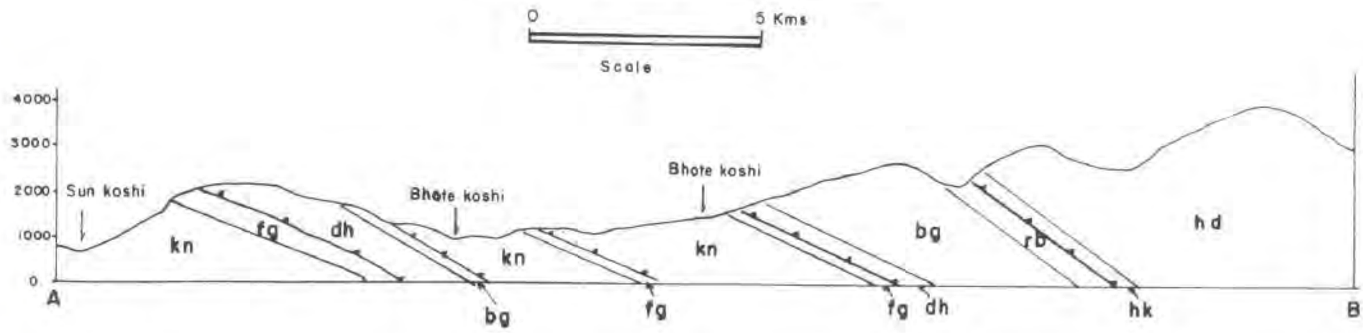
General Geology:
The area consists of high grade metamorphic rocks as augen gneiss and granitic gneiss of Higher Himalayan Crystalline and low-grade metamorphic rocks of Nawakot Group.

The lithostratigraphy of the area as correlated with J.Stocklin and K.D. Bhattrai (1981) is as below:

Figure I


GEOLOGY OF KODARI-BHOTE KOSHI AREA
85° 50'
B
86° 00'
28°00'
28°00'
Bhairab kund
Bhairab kund Kh.
Junrimba Kh.
Bhote Koshi River
NEPAL
CHINA
hd
hd
hd
Tatopani
MCT
MCT
MCT
MCT
dk
dk
ml
rb
rb
Bagam
jh
Bhote koshi R.
Jhirpu
Khukudai kh.
Ghipche
Kahyle Kh.
bg
bg
bg
bg
bg
Lesti
dh
dh
np
Chahu kh.
fg
fg
fg
Pokhari
Ghatte Kh.
Thagam
Schist
ml
ml
Golche
Malati kh.
kn
kn
kn
kn
Moreswara
Kabvc
Khauda Kh.
rb
Damar Kh.
Barhabisa
Sun Koshi River
Bhumathan
Lafu
Lamasangu
27°45'
27°45'
85° 50'
A
86° 00'
1 0 1 2 3 4 5 Km
Scale

Cross - Section along A- B



Legend:

hd	Hadi Kholā Schist	Garnet biotitic schist, calc. schist with gneiss
dk	Dhad Khola Gneiss	Porphyroblastic gneiss, Augean gneiss and migmatitic gneiss
rb	Robang Phyllite	Chloritic phyllite with garnet and chloritic gneiss
ml	Malekhu Limestone	Limestone with dolomite bands
bg	Benighat Formation	Black slate, sericitic chloritic phyllite and bands of carbonate (jk)
dh	Dhading Dolomite	Dolomite with bands of slate
np	Nourpul Formation	Pinkish phyllite with quartzite and dolomite
fg	Fag-fog Quartzite	White quartzite with intercalation of phyllite
kn	Kunchha Formation	Greenish grey phyllite and gritty phyllite with amphibolites.

Hadi Khola Schist

Dhad Khola Gneiss

- -

MCT

Robang Phyllite

Malekhu Limestone

Benighat Slate

Dhading Dolomite

Nourpul Formation

Fagfog Quartzite

Kunchha Formation

The rocks are well exposed all along the Kodari Highway. The MCT is the main thrust lying to the north - east of the working area. The general trend of the rocks is NE – SW dipping with dip amount of 20 to 35° towards north.

<u>Mineral Occurrence :</u>

One of the main magnesite and talc deposits of Nepal lies within the study area around Kharidhunga. This mine is one of the biggest in Nepal with high quality ores. Besides, some small deposits of talc had been exploited in Phupin area. There are several quartzite bands in schist of the area. These quartzites produce quartzitic slabs useful for roofing, flooring and paving.

CONCLUSION

The area mainly consists of phyllite, amphibolite and limestone, and augen gneiss and granite gneiss. The rocks of the area are grouped as Nawakot group and Central Crystalline. The northern part of the area is occupied by crystalline rock while the middle and the southern part are occupied by rocks of Nawakot group. MCT is lying further north of the Nawakot group of rocks and is defined by the feldspathic gneiss.

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Madhikarmi, D.P., 1980, Geological map around BhoteKosi and Balephi Khola (unpublished) DMG.

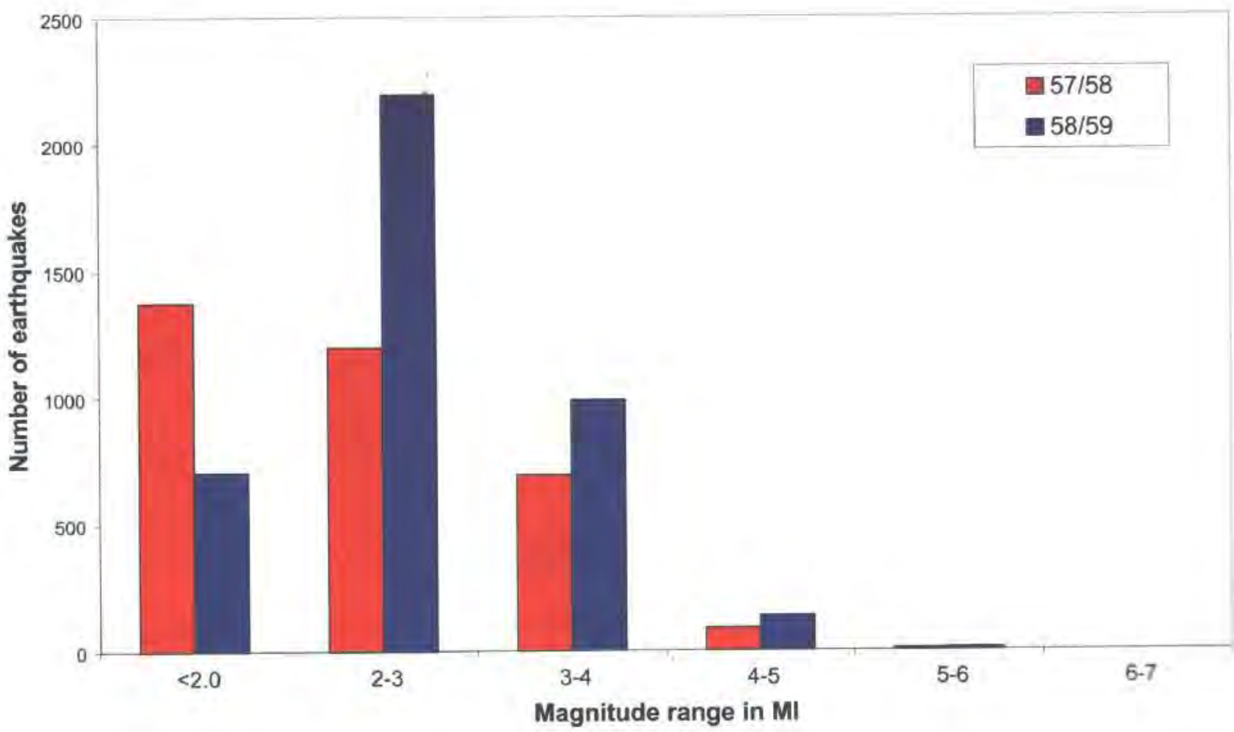
National Seismological Centre (NSC)

Madhav Raj Pandey*, Seinor Seismologist, Natioanl Seismic Network Section

National Seismological Centre (NSC) has been operating 21 short period seismic stations in Nepal to monitor microseismicity in the country and vicinity since the last twenty five years in collaboration with Department Analyse Environnement Surviellance (DASE), France. The operation of the field seismic stations in the fiscal year 057/58 and 058/59 has been affected by the security condition prevailing in the country. Number pf operating stations has been gradually reduced so that in the second half of the fiscal year 058/59, out of 12 stations only 9 stations were operating under Lainchour Centre.

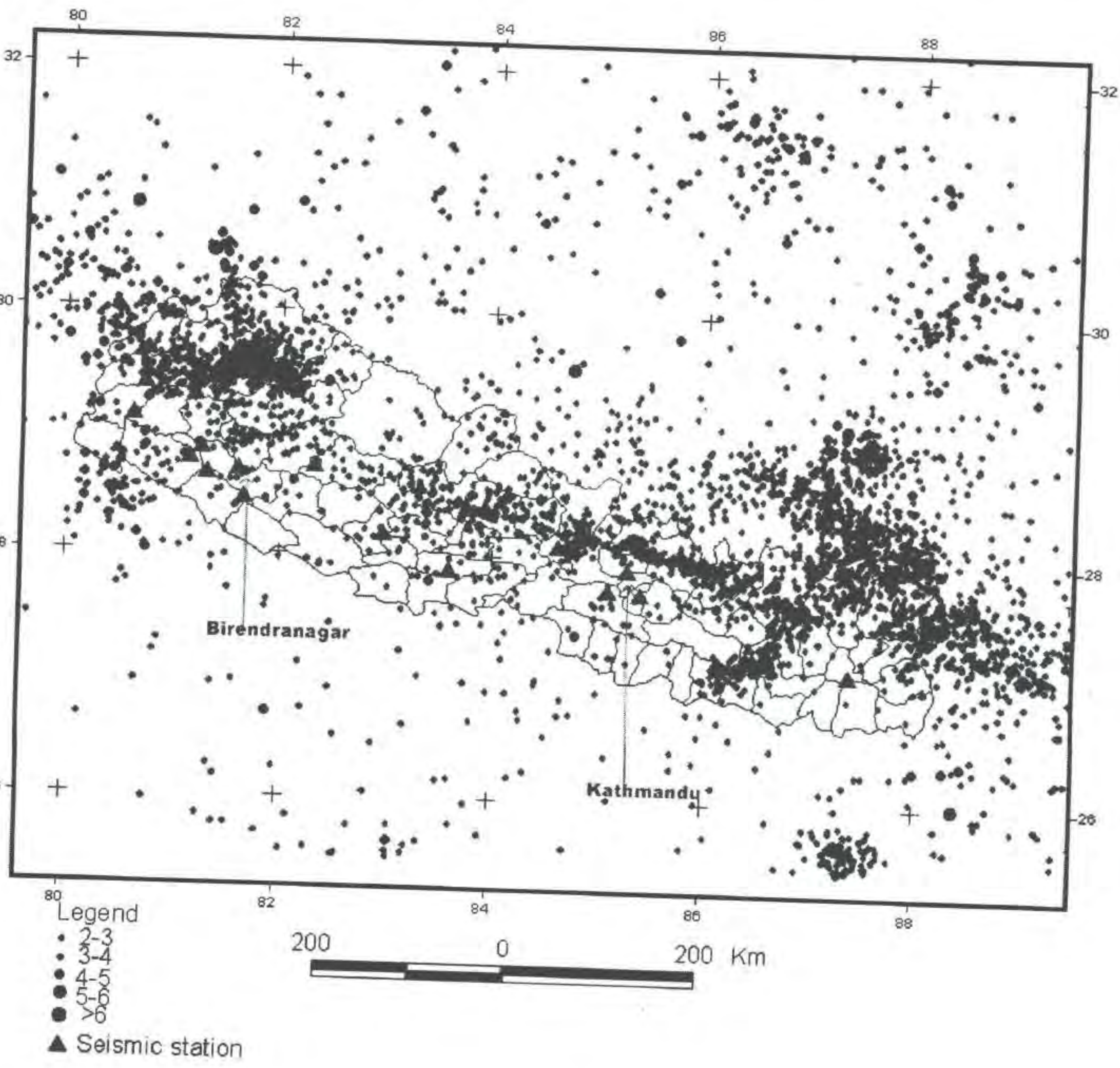
The NSC recorded 8035 and 7938 seismic events in the fiscal year 057/58 and 058/59 respectively. Out of them the number of local and teleseismic events were 3369 and 4666 respectively in 057/58. the number of local events in 058/59 comprised 4038 with 3900 teleseismic events. Their distribution in magnitude range is shown in the chart (Figure 1) and the seismicity pattern is illustrated in Figure 2.

Figure 1 Local Earthquakes for the Fiscal Year 057/58 and 058/59 recorded by NSC



* Senior Seismologist, Mr. M. R. Pandey retired from HMG service on B. S. 2060/3/1

Fig. 2 Epicentre Map of Nepal and its vicinity in the fiscal year 057/58 and 058/59



The epicenter map shows the seismicity pattern developed in the FY 057/58 and 058/59. It shows high seismic activity in the Farwest and Fareastern Nepal Himalaya. There is low seismic activity between the longitude 82°and 83°. Linear trend of seismicity is observed throughout the front of Higher Himalaya.

Preliminary Follow-up Investigation of Cement Grade Limestone in Udaypur district for the Fiscal Year 2057/58

Shankar Lal Karmacharya*
Senior Divisional Mining Geologist, Mineral Exploration Section

INTRODUCTION

According to the Department filed programme for the fiscal year 2057/78, preliminary follow-up works of cement grade limestone in Udayapur district were carried out for about 47 days starting from 2057.10.26 to 2057.12.13. Fieldwork was concentrated mainly in the areas covered by the topo-sheet 72J/9 of Udayapur district.

The background for carrying out this follow – up work is :

- Limestone occurrences, southeast of Galter area, have been reported by N. B. Kayastha, which he noticed during regional geological mapping of Udayapur and Diktel Area in 1975/76 field season.
- The Department of Mines and Geology (DMG) had carried out a detailed exploration work in 1.5 sq. km area in 1976 in Sindali area of Udayapur district. About 73.5 million tonnes of high grade limestone (CaO^3 52%, MgO < 2%) was proved and Udayapur Cement Industries Ltd. (UCIL), a public sector industry, had been set up with 800 tpd. capacity and the cement is under production since 1988.
- A preliminary survey of limestone occurrences in Udayapur district, starting from Ahalepakha in the west (Topo sheet 72 J/8) to Baruwa Khola in the east (72 J/9) was carried out by S.L. Karmacharya in accordance with the annual field programme of DMG for the fiscal year 2056/57 with an objective to test the thickness, grade and the lateral extensions of the limestone. Thickness of limestone is found to be 40m on Tawa Khola, same thickness on Mate Khola, 25m on Chhaure Khola and 50 to 70m at Chauladhunga. The thickness of limestone is thus not uniform and at places more than one band of limestone, separated by phyllites and quartzites, is found. Limestone is dark grey, medium grained, crystalline and homogenous in nature. It is high grade having CaO content 50-55% and MgO content 1.0-2.4% in general.

The further justifications for follow-up works are:

- After the preliminary investigation of Udayapur limestone in the fiscal year 2056/57, and considering the rapid infrastructure development taking place in the district, and having good grade and considerable strike extension of limestone (>30 km), recommendations for further works were emphasized in the " Talk Programme" held at DMG auditorium on 15th Bhadra, 2057. Further follow-up works were planned by DMG and a program was included for the fiscal year 2057/58 accordingly.
- The limestone occurrences are quite accessible and are located close to the main roadways i.e. within 50 km distance from East-West Highway. The nearest approach to road from the limestone occurrence to Nepaltar is about 9 km.

The infrastructure developments in this region are taking place rapidly as compared to other target areas for cement grade limestone exploration works. Electricity is already available at Murkuchi. Furthermore, the completion of Dhulikhel – Bardibas road will enhance the importance of these limestone occurrences.

OBJECTIVE OF THE STUDY

- To discover the limestone deposits for detailed exploration to be economically viable.
- To carry out exploration works in the most favorable areas, extending from Tawa khola in the West to Baruwa khola in the east.

* Senior Divisional Mining Geologist, Mr. Shankar Lal Karmacharya retired from HMG service on B. S. 2060/1/26

METHODOLOGY

The steps followed for the nvestigations are:

- Mapping: Geological mapping of the limestone band and overlying and underlying rocks in 1:25,000 scale by conventional methods, 35 sq. km.
- Trenching: To expose limestone by trenching (450m) to ascertain the thickness, nature of the limestone, gather information of overlying and underlying rock and for sampling.
- Channel Sampling: Continuous channel cutting of limestone manually with the help of hammer and chisels (175m) to test its grade/quality and thickness.

RESULTS AND FINDINGS

General Geology of the study Area: The limestone band (Udayapur Limestone) lies to the immediate north of Main Boundary Thrust (MBT). It represents a marker horizon delineating phyllites and quartizites of Benighat Formation in south by coarse textured, garnetiferous quartz – schist of Kalitar Formation in north. The lower contact of limestone is normal, where as the upper contact is thrusted one. Phyllites are mostly light grey to dark grey, platy and carbonaceous at uper section. The sericite and chlorite impart grey to silvery grey and greenish grey colour to the phyllites. The dolomites do occur, at the lower contact of limestone, and also present in between limestone bands.

The present investigation works helped to delineate a limestone band of 15m-55m thick and of about 8km strike extending from Hasetor in the northwest to Kholme in the south east. (Fig.1)

Limestone is, in general, homogeneous and of good grade throughout its strike length and along its thickness too. It is suitable for the manufacture of Portland cement. The grade of limestone has been determined by the chemical analysis. The samples were taken at Trijuga Khola, Punware Khola, Chhause Khola, Mate Khola, Tawa Khola etc. CaO content in these samples is 50-55% and MgO content is 1.0 -2.4%. The grade of limestone is homogenous and high/very high grade, but the thickness of limestone varies much from 15m to 55m. At Chuladhunga, the thickness seems to be great , but is better to be confirmed by trenching.

Limestones are exposed at the top of the hills, with a little or no overburden, which makes the quarrying easy. At places, thick bushes, cultivated land and houses are present within the limestone area. In such cases, the actual limestone and overburden section can be calculated only after detail mapping, topographical survey and trenching.

Dolomites of immediate economic interest are not encountered. At Lakure village, a lenticular body of dolomite of 170m long x 72m thick is exposed at the hilltop.

There is an acute shortage of water in the prospecting areas even for drinking uses especially at Ghyampathumka. So, if we have to carry out diamond core drilling, estimation of number of water pumps and aggregate length of water pipes required should be done prior to drilling.

The limestone found in the study area is of good grade, quality and suitable for the manufacture Portland cement. The quantity available for a strike length of >8km at the hilltops, with little or no overburden, makes good conditions for mining.

CONCLUSION AND RECOMMENDATIONS

The area between Haretar to Kholme, especially at Chuladhunga and the area from Ghyampathumka to Shriwari are recommended for further detail works including geological mapping, trenching, channel sampling etc. prior to drilling.

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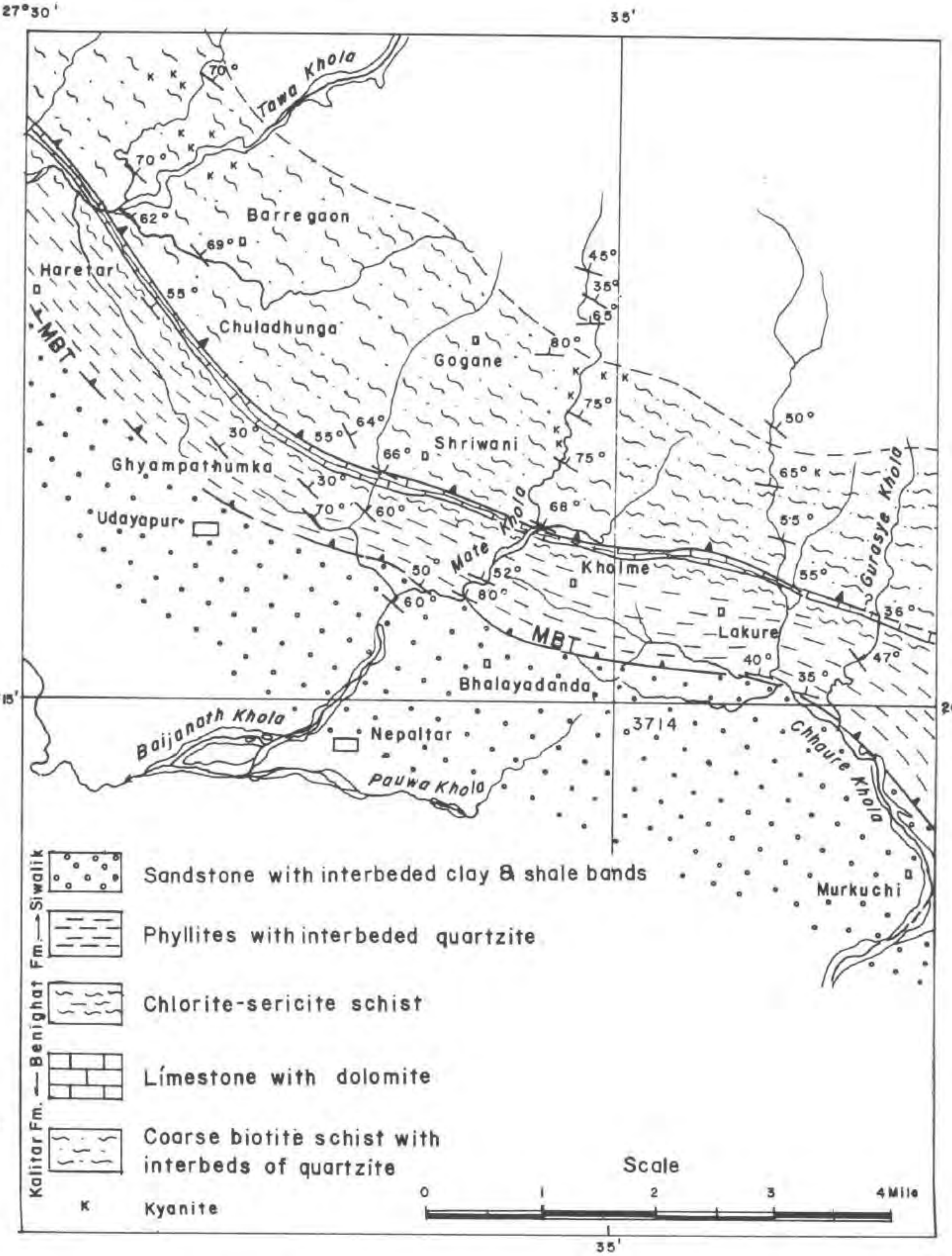
Figure -1

Limestone Resource Map In The North Of Udayapur-Murkuchi Areas of Udayapur District, Toposheet 72 J/9.



Limestone and Dolomite Investigation in Syangja District.

Dhruba P.Madhikarmi*
Senior Divisional Geologist, Mineral Exploration Section

INTRODUCTION

Geological investigation for limestone and dolomite in Syangja district was proposed by the author based on the published geological maps of Department of Mines and Geology, and Department of Geology, Tribhuvan University, Kirtipur. The present work of exploration has been carried out in parts of topo-sheet number 62 P/6, 62 P/16, 63 M/9 and 63 M/13 covering 250 sq. km. area of Syangja district.

OBJECTIVES

- To explore the potentially economical deposits of limestone and dolomite in the area. It comprises of delineating limestone deposits suitable for cement industries.
- To carry out grab sampling, chip sampling (limestone: 1000 line meter and dolomite: 200 line meter), and geological mapping showing limestone and dolomite outcrops in the scale of 1:25,000 within 200 sq. km area.

METHODOLOGY

Since 1958, several workers have carried out geological investigation in different parts of the present proposed area for different purposes (Raina, 1958), (Tater, 1967), (Shrestha, 1983),) and (Hirayama et. al. 1988). Different rock types within the area are correlated with Stocklin and Bhattarai (1981). The litho – stratigraphic succession from younger to older sequence, are Benighat Formation, Dhading Dolomitic, Nourpul Formation, Dandagaon Phyllite and Kunchha Formation.

The field investigation work comprised of geological mapping with section measurement, grab sampling, and chip sampling of the carbonate rocks. A total of 250 sq. km area has been mapped in the scale of 1: 25, 000 with 1582 line meter of chip sampling in limestone and 1915m of chip sampling and 15 numbers of grab sampling in dolomite.

RESULT AND FINDINGS

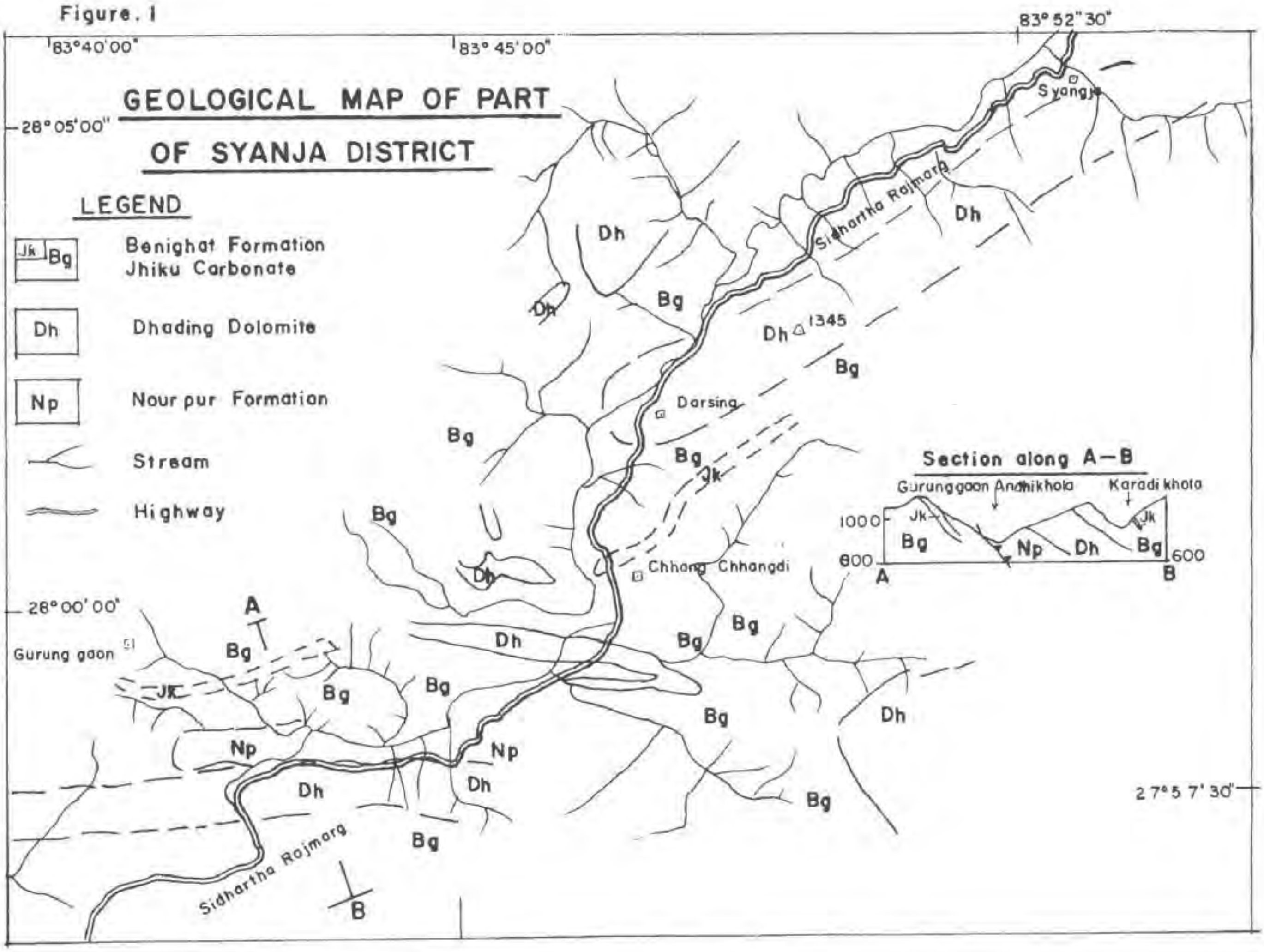
Dolomite: Huge bodies of dolomite are scattered through out the investigated area. Chip sampling areas of dolomite were selected considering the mining conditions such as overburden, infrastructure and habitant nearby. Chip sampled area are Chiure Surkaundi, Darsing and Sundar Khola (Figure 1).

Limestone: Geological investigation on part of the Syangja district revealed six limestone bodies. Based on acid test and nature of chemical weathering, these limestone bodies seem to be of cement grade. The limestones occur at Dandukharka, Dhanpure, Chhangchhangdi, Kerabari and Devisthan. These laminated limestones vary in color from light gray to dark gray. The details are given below in tabular form.

Name and Location	Strike Length	Thickness
Dandakharka limestone, located 4km due north of Sidhartha Rajmarg.	4.5 km	100-150 m
Dhanpure limestone, located 1km north of Waling	3.5 km	600 m
Chhangchhangdi limestone, located 0.5km East of Sidhartha Rajmarg	5 km	100-150 m
Kerabari limestone, located North of Dhanpure limestone	0.75 km	nearly 60 m
Devisthan limestone located near Triyashi	0.5 km	nearly 60 m

* Senior Divisional Geologist, Mr. Dhruba P. Madhikarmi has expired on B. S. 2058/5/18

Figure. I



CONCLUSION AND RECOMMENDATIONS

Conclusion: The investigated area is rich in limestone exposures without overburden and occurring near by Prithvi Highway. Field acid tests and nature of chemical weathering indicate that these limestones could be of cement grade. It may also be useful for block stone. Huge dolomite bodies occurring in this area may be used for construction material. Chemical results are awaited. If the grade is found appropriate, the area will be a major source of industrial dolomite.

Recommendations: Out of five limestone occurrences, Dhanpure is found to be best considering its grade, mining point of view and infrastructure developments. It is recommended to carry out detail mapping, channel sampling and topographic survey on Dhanpure Limestone.

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Report on Follow up Investigation of Limestone Prospects in Baitadi District

Tek Raj Pant, Geologist, Mineral Exploration Section.

INTRODUCTION

Baitadi Carbonate Formation of Far- Western Nepal contains good quality and significant amount of limestone. The follow up program for the limestone occurrences within Baitadi Carbonate Formation has been carried out in 300 sq. km. area covered in the topo-sheet number 2980 07D and parts of topo-sheet number 2980 06D, 2980 10B 2980 11A and 2980 11B of HMG/Survey Department. The fieldwork was carried out in accordance with the departmental programme of the fiscal year 2057/58 to explore and access the cement grade limestone in different parts of the country.

The limestone prospects are located between 29° 29' to 29° 36' N latitude and 80° 30' to and 80° 37' E longitude.

OBJECTIVES

The main objectives of this fieldwork were:

- To explore and delineate the cement grade limestone in previously reported area by performing detailed geological mapping, channel sampling, continuous chip sampling, rock grab sampling and chemical examination of the limestone.

- To find out other potential limestone deposit of economic value in adjoining area.

METHODOLOGY

The fieldwork was carried out with the help of Brunton compass, geological hammers, altimeter, topo-sheet, measuring tape and 10% hydrochloride acid etc. Geological map in 1:25,000 scale was prepared. Semi detail geological map in 1:10,000 scale was prepared with the help of enlarged topo base map. Continuous chip sampling of the limestone bands in 5-10 meter spacing, systematic channel sampling and rock grab sampling has been carried out.

The different works completed are:

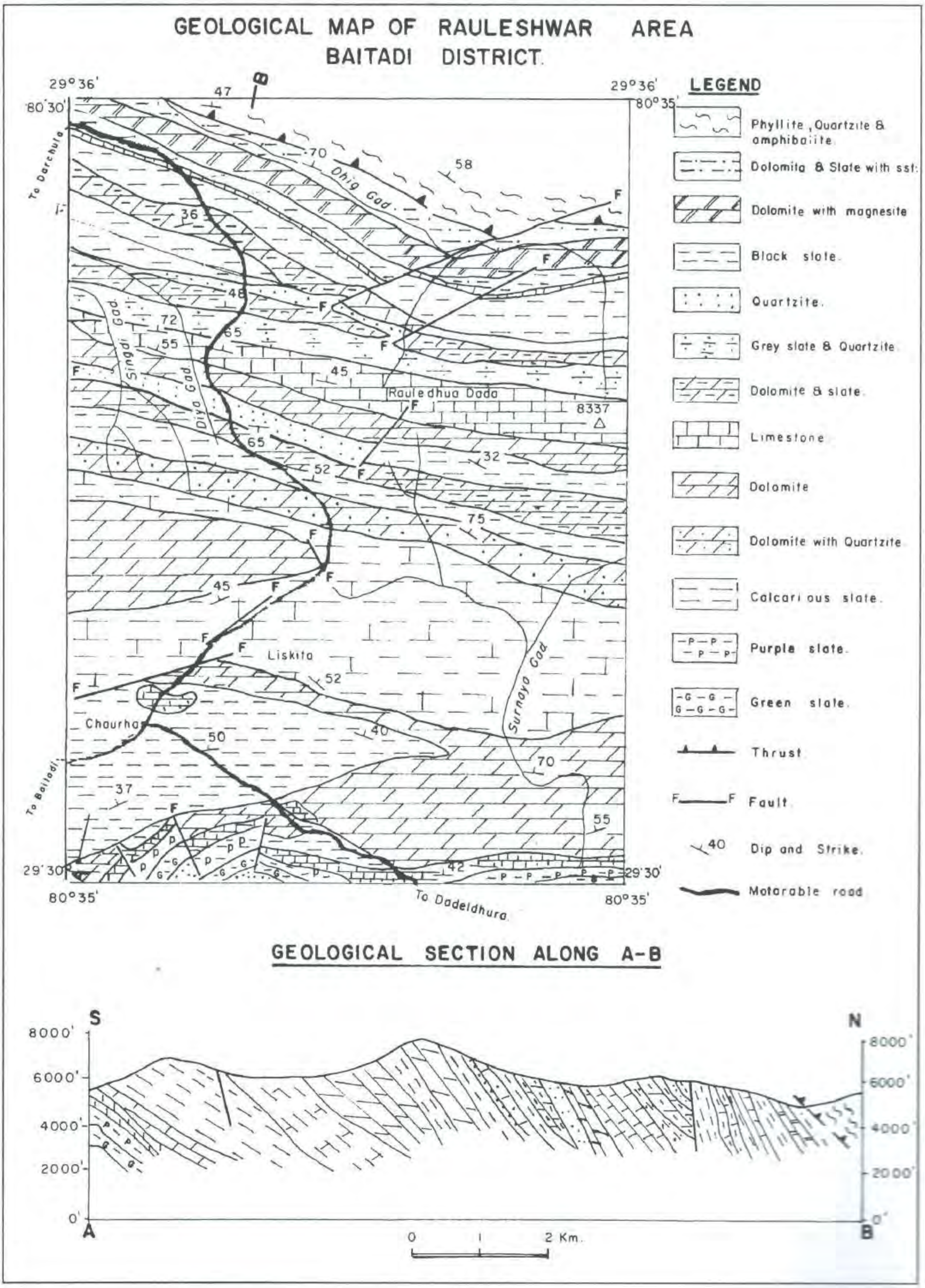
- Geological mapping of 300 sq. km. in 1:25000 scale.
- Geological mapping of 25 sq. km. in 1:10000 scale.
- Channel sampling 380 meters (250 samples) from four section.
- Continuous chip sampling (5-10 meters sampling) 500 meters (72 samples from six section)
- Rock grab sampling, and
- Channel logging in 1:500 scales.

RESULT AND FINDINGS

Presently, three promising cement grade limestone prospects are identified within Baitadi Carbonate Formation in Baitadi district. Out of these identified limestone prospects, Diyari Gad and Bhumeshwor are promising prospect, where as Chauraha is smaller one (Figure 1).

Diyari Gad Limestone: This is the northernmost limestone band with considerable thickness of 150-275 meters exposed between Singodi Gad and Bisal Gad, all along northern slope of Raulushaves ridge. The general trends of main limestone band are east west and dip varies from 40° to 60° towards north. Its strike extension is 10-12 km with variable thickness.

Figure. I



GEOLOGICAL MAP OF RAULESHWAR AREA
BAITADI DISTRICT.
29°36'
80°30'
29°36'
80°35'
LEGEND
Phyllite, Quartzite & amphibolite.
Dolomite & Slate with sst.
Dolomite with magnesite
Black slate.
Quartzite.
Grey slate & Quartzite.
Dolomite & slate.
Limestone.
Dolomite
Dolomite with Quartzite
Calcarious slate.
Purple slate.
Green slate.
Thrust
Fault
Dip and Strike.
Motorable road
To Darchula
Dhig Gad
Singdi Gad
Diya Gad
Rauledhua Dada
8337
Surnaya Gad
Liskita
Chaurha
To Baitadi
To Dadeldhura
29°30'
80°35'
29°30'
80°35'
GEOLOGICAL SECTION ALONG A-B
S
N
8000'
6000'
4000'
2000'
0'
A
B
0
1
2 Km.

The limestone is light gray to dark grey, bluish grey, brownish and thin to medium thick bedded. The limestone contains thin intercalations of argillaceous materials. Approximate potential reserve is 150 - 175 million tons. Average CaO content is 47.1% and MgO 2.34%. This limestone deposit has no overburden.

Bhumeshwor Limestone: This limestone deposit lies in the southern part of the investigation area. The general trend of the limestone band is east west and dip varies from 40°– 60° dipping towards north. It is exposed at southern slope of Bhumeshwor ridge, south of Chillepani village and Dhilidhar area. Strike extension of main limestone band is 8-10 km. out of which 2-3 km section east of Bhumeshwor temple to Surnaya Gad has low overburden. Thickness of this limestone is 70-75 meters.

The limestone is gray to dark grey occasionally grayish brown colored. fine grained and thin to medium thick bedded. The limestone contains thin intercalations of argillaceous materials. Approximate potential reserve is 40-50 million tons. Average CaO content is 46.75% and MgO is 3.17%.

Chauraha Limestone: This is a small limestone band exposed 300 meters north of Satbaj Chauraha along the Dadeldhura – Baitadi – Darchula road. Thickness of main limestone band in 60-65 meters and strike extension in 800 meters. This limestone prospect has no overburden.

The limestone is grey to dark grey colored, fine grained, and thin to thick bedded. Approximate potential reserve is 3-4 million tons. Average CaO contant is 47.25% and MgO content in 2.75%.

CONCLUSION AND RECOMMENDATIONS

Among the three limestone prospects in the investigated area, Diyari Gad and Bhumeshwor limestone prospects are large prospects were as Chauraha limestone is smaller one. Diyari Gad limestone and Chauraha limestone have no overburden where as Bhumeshwor limestone prospects has very low overburden. Chemical analysis result of the channel samples and continuous chip samples are encouraging. All the three limestone prospects are accessible with motorable road. Detailed follow-up exploration work is recommended for the coming fiscal year.

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Exploration of Polished Stone in Parts of Makawanpur District

Uttam Bol Shrestha, * Mining Engineer, Natural Gas and Coal Section

INTRODUCTION

An investigation for polished stones within 50 sq. km. area of Makawanpur district covered in HMG Survey Department. Topo-Sheet no. 2785 05C, 2785 09A, (Scale 1: 25000) has been carried out in fiscal year 057/58. Area bounded by Sikrikot in the north, Mandu Khola and Okhardanda in the east, Shyauli bazaar and Suparitar in the south and Yanrang village in the west within Latitude of 27^0 27' 30" to 27^0 37' 30" N and Longitude of 85^0 00' 00' to 85^0 07' 30"E has been covered. The investigated site has been chosen based upon the geological reports showing existence of marble, granite, amphibolite, quartzite suitable for polished stone. Moreover, the investigated site has facilities of electricity and good road networks (Tribhuvan Rajpath, feeder roads to Hetaunda Cement Industry, Kulekhani Hydropower Project, Bhimphedi, Chisapanigadhi, Jhurikhet and Namtar). The people of the area are cultured and acquainted with mining and related industries. Furthermore, if such type of industry could be established, the major market places such as Kathmandu, Hetaunda, Birgunj etc. are not far from the project area.

OBJECTIVE

The objectives of the investigation are to explore polishing grade rocks for decorative purposes, identify the resources, examine the rocks for its durability and suitability and prepare a map delineating the important deposits of such rocks in the scale of 1:25000.

METHODOLOGY

Technical report on geology of Kathmandu area and Central Mahabharat Range had established the stratigraphic subdivision of the area (UNDP, 1981). Several authors had produced the geological maps of the area (Stocklin and Bhattarai, 1995; Joshi, 1971).

Several organizations such as American Society for Testing Materials (ASTM), European Committee for Standardization (CEN) and International Standard Organization (ISO) though lay standardization for dimension stone, the standardization of ASTM has been used. According to ASTMC 10 natural stone that has been selected, trimmed, or cut to specified or indicated shapes or sizes, with or without one or more mechanically dressed surface has been defined as the "Dimension Stone" (ASTM,1996). When such stones are polished to use in flooring, wall cladding, mausoleum crypt fronts, custom specialties are called polished stone. Its use for different purposes depends upon suitability, durability and color. (Sadmond, 1993; UNDP 1977, Baker and Austin, 1994, Power, 1994)

The different processes adopted in the study are

- geological traverse along rivers, roads, and ridges for suitable rock types,
- study the appearance, texture, and luster for suitability,
- estimate intact rock strength and hardness for durability,
- estimate the rock mass properties and measure the discontinuities,
- collect samples for different tests, and
- prepare a Polished Stone Exploration Map of 1:25, 000 scale.

Chemical analysis, petrographic study and ASTM specified tests for durability such as Density, Absorption by weight, Abrasion Resistance, Compressive Strength, Modulus of Elasticity are carried out. Rock samples are polished for

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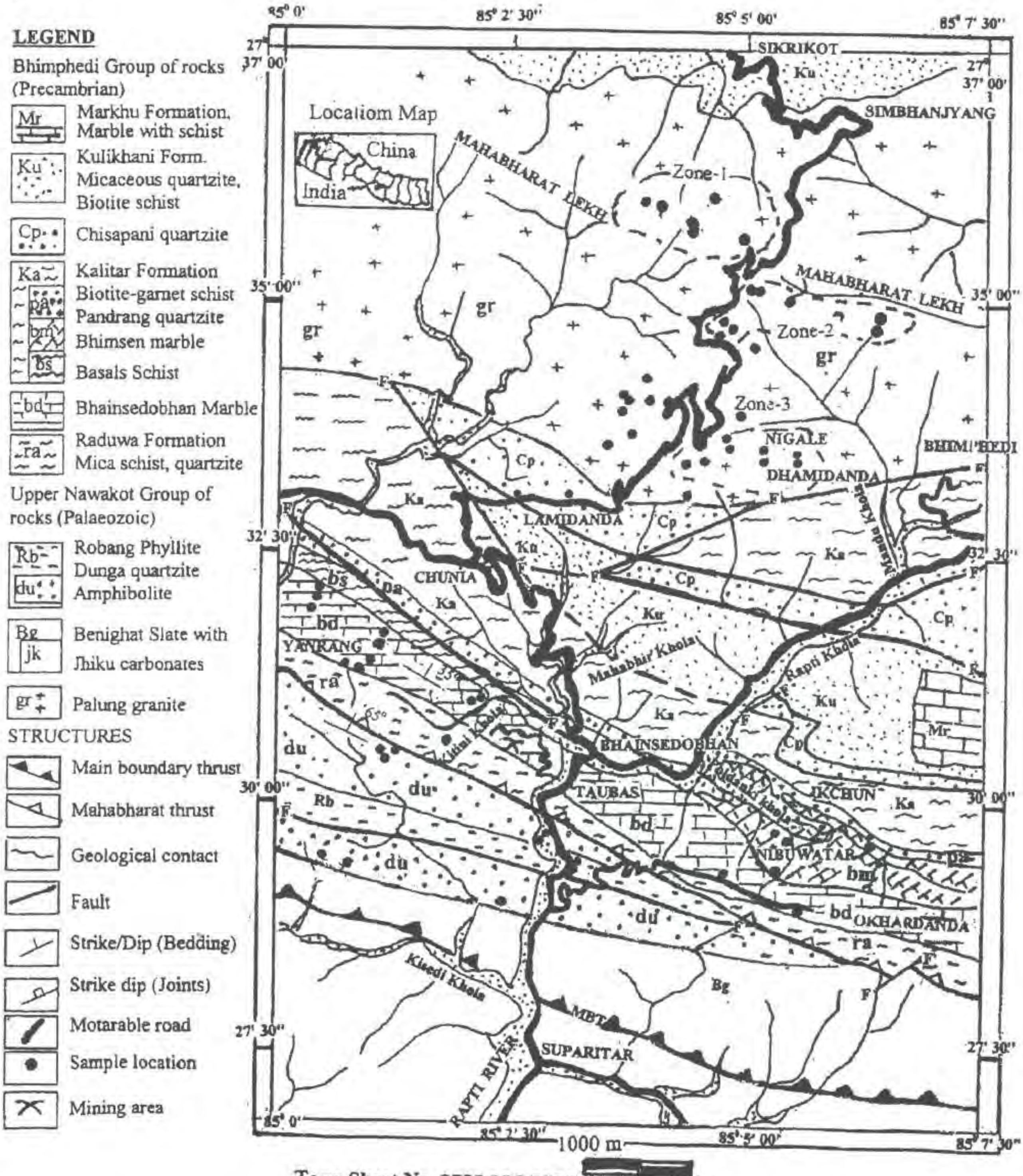
checking its appearance and suitability. The results are compared with the ASTM specifications. Discontinuity analysis to confirm the major joint sets and estimates of possible block sizes is also carried out.

RESULT AND FINDINGS

The project area comprises of the rocks of Bhimphedi group of Kathmandu Complex and Upper Nawakot group of Nawakot Complex and granites of Palung Massif. Based on the results of investigation, Polished Stone Exploration Map of 1:25000 scale (Fig.1) has been prepared. The important resources found are briefly described below:

Fig. 1



Topo Sheet No. 2785 05C/2785 09 A 1000 m

Palung Granite: Slightly weathered to fresh granites of Palung Massif is found suitable for polished stone. Based on estimated intact rock strength, rock mass properties and mining possibilities, granites within the study area are delineated into four specific zones. Zone-1 and 2 cover the area of Mahabharat Lekh extending towards west and east respectively from Simbhanjyang. These resources are easily accessible and within a distance of half a kilometer from Simbhanjyang. Fresh to slightly weathered granite is within few meters from the surface. There are three major joint sets. The possible blocks of 1-3m in lateral dimension are estimated. Zone-3 covers the area within the ridge of Nigale to Dhamidanda. The granite, at the ridge show variable weathering profile from fresh to slightly weathered to completely decomposed granites. The fresh to slightly weathered granite situated nearby Tribhuvan Rajpath could be of economic value. Rest of the granites within study area that are either far from the highway or with thick overburden is not marked.

Marbles: Bhaisedobhan Marbles and Bhimsen Marble (of Kalitar Formation) within Bhimphedi Groups of Kathmandu Complex are found very suitable for polished stone. Most of the area covered by Bhainsedobhan Marble falls under the mining licensed area of Hetaunda Cement Industry. However, the resources situated in the west of Kitini Khola, and the one situated on the north sloping terrains of Bhainse to Okhardanda are promising. The Bhimsen marbles occurring aside the Polanki Khola near by Ikchun, Paribas and Chilaune villages are also of economic value.

Quartzite and Amphibolite: Milky white Dunga Quartzite and Green Amphibolite within Robang Formation of Upper Nawakot Group of Nawakot Complex are suitable for the excellent polished stone. The quartzite near or in contact with the Mahabharat Thrust is thinly bedded and highly fractured. Its thickness and competency increases and fracture diminishes away from the thrust. Bedding thickness varies from 0.6m to 1.3m. The resources located nearly 1.5 km downstream of Taubas village, that of Nayagau, Kitinigau and north of Kisedi Khola, are highly promising. Similarly, amphibolite is seen along Tribhuvan Rajpath nearly 2 km downstream from Taubas.

Petrography Study: Thin sections from samples of granite (coarse and applitic), amphibolite, marbles and Dunga quartzite are carried out and results are shown in Table 1.

Table 1: Results of Thin Section

Rock Type	Color	Texture	Min. Constitutions (%)						
			Quartz	Ortho-clase	Biotite/ Musc vite	Hornblend	Pyroxene	Cal-cite	Fe – Oxide
Coarse Granite	Smoky white to milky white with irregular black spots	Inequigranular, Porphiritic, fine to coarse grained 0.1 – 2.1 mm, phenocrysts of quartz and orthoclase	50 to 55	35 to 40	5 to 7				< 1
Aplitic Granite	Light with regular black flakes	Fine grained 0.1 – 0.5 mm	45 to 50	45 to 48	1 to 2	-			
Bhainse. Marble	White	Fine grained, 0.1-0.5 mm, weak planar foliation	3 to 5		<0.5			92 to 95	<1
Bhimsen Marble	Bluish gray	Fine grained 0.1-1.2 mm, granoblastic	5 to 7		<0.5			91 to 93	<0.5
Amphi bolite	Greenish	Fine grained, 0.1- 0.5 mm				90 to 92	3 to 5	1 to 3	

Chemical Analysis: Chemical Analysis of representative samples of Bhimsen Marble, Bhainsedobhan Marble and Dunga Quartzite are carried out and the results are given in Table 2.

Table 2: Result of Chemical Analysis

Rock Type	Sample No.	LOI %	SiO2 %	R2O3 %	Fe2O3%	Al2O3 %	CaO %	MgO %
Bhainsedobhan Marble	L4-S3	33.99	16.86	5.32	0.50	4.82	40.65	2.52
	L5-S2	40.65	5.02	3.72	0.55	3.17	46.82	3.72
	L9-S2	42.43	2.68	2.96	0.47	2.49	46.82	5.04
Bhimsen Marble	L28-S1	40.18	5.99	3.58	0.79	2.79	48.22	2.01
	L29-S1	34.33	17.15	4.74	0.90	3.84	42.20	1.20
	L29-S2	36.30	13.31	5.14	0.90	4.24	43.18	1.91
Dunga Quartzite	L14-S2	6.64	77.68	6.62	0.62	6.00	7.40	0.70
	L14-S3	2.97	86.22	6.64	0.42	6.22	2.94	0.70
	L33-S1	5.59	84.05	3.42	0.34	3.08	6.16	0.70

Durability Tests: ASTM specified tests for durability of dimension stone are determined and the results are compared with the ASTM specifications as given in Table 3.

Table 3: Results of Physico-Mechanical Tests for Durability of Dimension Stone

Rock Type	Bulk Density, D (Kg/m3), ASTM C 97		Absorption by Weight Abs. (%,) ASTM C 97		Compressive Strength, Cu (MPa), ASTM C170		Abrasion by weight Abr. ASTM C 241	
	Required by ASTM	Value Obtaine d	Required by ASTM	Value Obtained	Required by ASTM	Value Obtained	Required by ASTM	Value Obtained
Course Granite	2560 min.	2620–2800	0.4 max	0.49–0.50	131 min.	87–134	10.3 min	17–41
Aplitic Granite	2560 min.	2670	0.4 max	0.60	131 min.	119–230	10.3 min	31-56
Bhimsen Marble	2595 min., I 2800 min., II 2690 min., III 2305 min., IV	2710	0.7 max	0.16-0.30	52 min.	116–229	10 min	32
Bhainse. Marble	I Calcite, II Dolomite III Serpentine IV Travertine	2712-2820	0.7 max	0.09-0.17	52 min.	72–96	10 min	32
Quartzite	2560 min.	2710	1 max	0.28	137.9 min.	135-225	8 min	71
Amphibolite	2560 min	3050-3100	1 max	< 0.11	137.9 min.	195-345	8 min	45-11

Discontinuity Analysis: Discontinuities in granite rock mass are measured and analyzed by plotting in Stereographic Projections (ISRM, 1976) and are given in Fig 2 and 3 for Zone 1 and Zone 2 respectively.

The combined effort of field investigation, laboratory tests and analysis resulted with following findings.

- Slightly weathered to fresh granite of Palung Massif satisfies all the requirements specified by ASTM standards (ASTM, 1996) for durability of dimension stone. Coarse grained as well as fine textured granites have very attractive appearance after polishing and suitable for interior as well as exterior decoration (Fig.4) (Osterhuis, 1999)

- Light colored Bhainsedobhan Marbles, and bluish gray Bhimsen Marbles have very attractive appearance on polishing and suitable for interior use. Both of them excellently meet all the specifications required by ASTM standards for dimension stone (Fig.5)

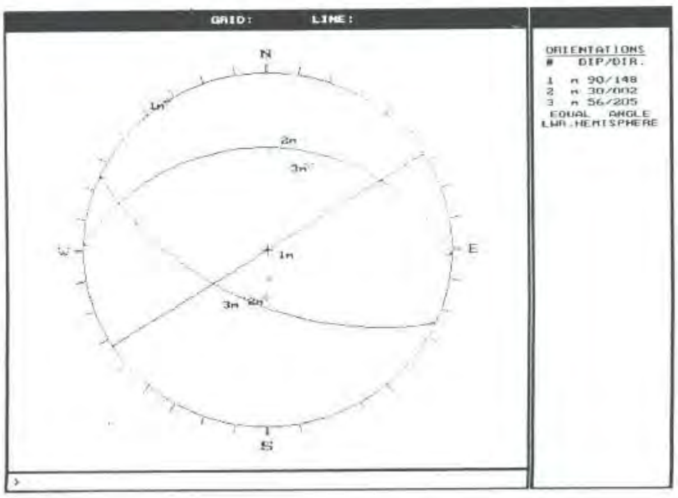


Fig. 2 Steriographic Presentation of Average Attitude of Major Joints from nearly 75 joints in Palung granite of Zone-1

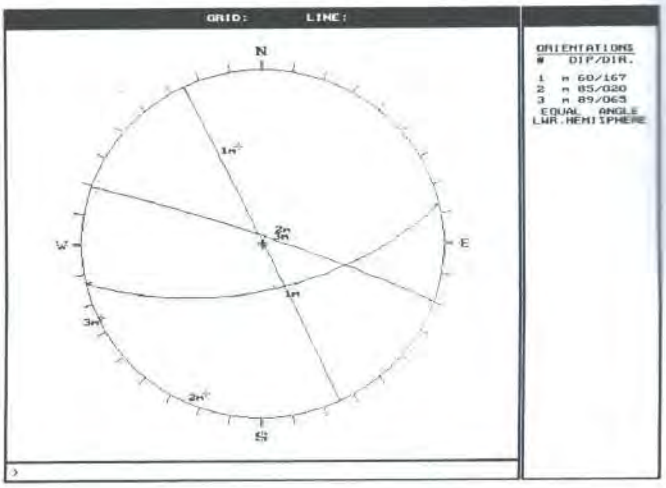


Fig. 3 Steriographic Presentation of Average Attitude of Major Joints

Similarly, milky white Dunga Quartzite and Green Amphibolite excellently satisfy all the requirements specified by ASTM standards. Quartzite contains 77- 84% of SiO2 and 3-7% CaO with other constituents. It is easier to cut and polish than the granite. The polished surfaces have very attractive appearance, luster and colorfast. As they are not to be deteriorated by acid rain, both of them are marvelous for exterior as well as interior use (Fig. 5).

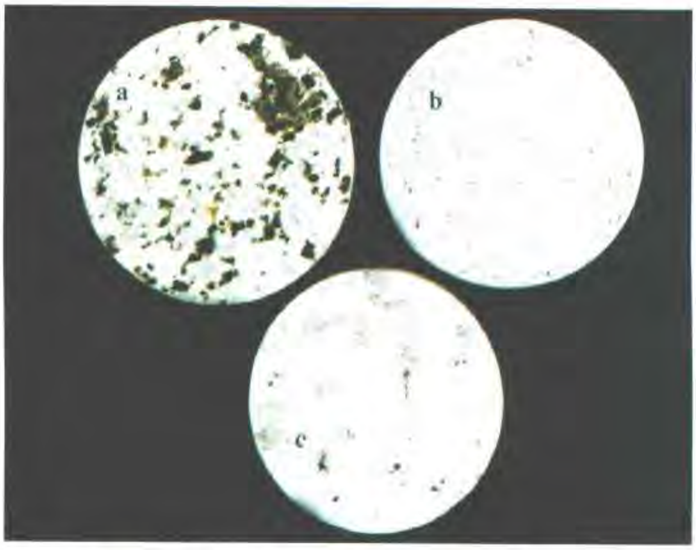


Fig. 4 Polished Granite Samples from Zone-1 (a) Coarse grained granite with biotite and tourmaline (b) Aplitic granite and (c) Coarse grained granite with little biotite

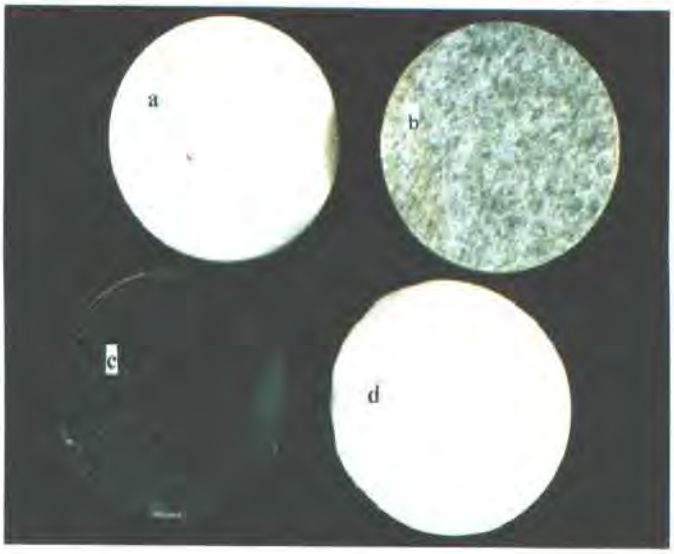


Fig. 5 Polished Samples of (a) Bhainsedobhan Marble (b) Bhimsen Marble (c) Amphibolite and (d) Dunga Quartizite

CONCLUSION AND RECOMMENDATIONS

Conclusion:

- Palung Granite at places, Bhainsedobhan Marble, Bhimsen Marble, Dunga Quartzite and Amphibolite found within the study area are suitable for polished stones from durability and suitability aspects.
- Out of the three zones delineated in Palung Granite, a huge mineable resource exists in Zone-1. Similarly, Zone-2 comprises of possible huge deposit along with several small mineable deposits. There are several small mineable deposits in Zone-3 also.
- Bhimsen Marbles, aside Poldanki Khola near Ikchun village, could be easily mined and possess a considerable mining deposit. Beside that, the deposits occurring at Chilaune, Nibuwatar and Paribas villages are also of economic interest.
- Bhainsedobhan Marbles occurring at northern slopes from Bhainse to Okhardanda could be separated into several small mineable deposits. Similarly, the deposits that lie west of Kitini Khola also may be economically feasible and studied in detail.
- A huge deposit of Dunga Quartzite occurs nearly 1.5 km down stream of Taubas. Several deposits of quartzite exist at south of Nayagau, Kitinigau and north of Kisedi Khola. They are all promising, deposits and should be studied in detail.
- Amphibolite of the area is though suitable for polished stone; no mineable deposits are noticed.
- M/S Hetaunda Lime Industry is producing polished as well as unpolished slabs from boulders of Rapti River. It is a great contribution of the private entrepreneurs to the mining industry and shall be highly appreciated.

Recommendations:

- At least one of the zones delineated in the Palung Granite, one deposit of Dunga Quartzite and one deposit of Bhimsen and Bhainsedobhan Marbles shall be studied in detail with drilling and discontinuity mapping. Weathering profile, possible block size and rock properties shall be fully established.
- These deposits shall be studied for other test specified by ASTM, which could not be performed at present in the laboratory of Department of Mines and Geology.
- All the information and study results shall be published and made available to the private entrepreneurs so that they will be prompted to exploitation of these deposits for the benefit of the country.
- Field investigations as well as laboratory studies for dimension stone shall be carried out for these rock units at other places too.

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Construction Stone in Jhapa and Ilam district

Sarbjit Prasad Mahato, Senior Divisional Mining Engineer, Mine Lease Section

INTRODUCTION

Stone is one of the major construction materials for Civil Engineering Work. Construction materials are used in roads, airfields, railways, dams, coastal protection structures, building and other structures. The stone is required in the development of civil engineering projects in our country. It is exported to India in great quantity. Bangladesh is also interested to import construction stone from Nepal. Hence, it is necessary to identify stone and gravel resources in different districts of Nepal. The current market study shows the demand of construction materials is rapidly increasing every year in our country.

Previously, Mr. Chakra Das Rajbhandari had studied for establishment of gravel based industries in the Terai region (year 1973) and indicated eight different localities for the stone industries. Neither the private companies nor the Government sector invested in such industries.

Department of Mines and Geology (DMG) realized the need of detail study. The study was started from 1981 and completed in 1988. Sharma, 1988 mentioned that Bangladesh need about 140,000 m^3 of construction stone annually for the initial three to four years to construct a project. After that, at least 50, 000 m^3 is required annually for their maintenance. The construction stone could be exported from Ninda, Temai and Telpani rivers to fullfill the continuous demand of Bangladesh. It was necessary to open a stone quarry near the Krishna Thumki at the north of Bahundangi. No further initiative was taken to export the construction stone. Again, the DMG realized to re-evaluate the river gravel deposit, terrace gravel deposit and stone quarries as a lapse of long time from previous studies and the depleting nature of gravel/stone deposits. A fieldwork to access the potentialities of construction material in Jhapa and Illam districts has been proposed.

The study of river courses is covered between Mechi river to Mawa river and terrace gravel deposit at the north side of the Mahendra Raj Marga in Jhapa District of eastern Nepal. The stone quarries are in Illam District, which are located at Godak in Mechi Highway and Shidhi River. The area lies in between latitude 26^0 30' 00" to 26^0 55' 00" N and longitude 87^0 37' 30" to 88^0 12' 30" E in topo-sheet No. 2688 05A and 2688 01C of 1:25,000 scale.

The available river and terrace gravel deposits are generally 10 km to 16 km towards North from Mahendra Raj Marga. The stone quarry of Shidhi river is at 26 km and another stone quarry at 60 km (in Godak of Mechi highway) from Mahendra Raj Marga to the north. For the export purpose to Bangladesh, the total road transport from the source of gravel does not exceed 80 km and for the stone does not exceed 120 km. For India, transport system is only 8 km from Kakarvitta and then railway facilities are available.

OBJECTIVES

The main objectives of the study are

- To study the present situation of the boulders, gravels and sand along the river courses in Jhapa District.
- To study the terrace deposit and stone quarry for the construction stone.
- To estimate the quantity and quality of deposits.
- To collect the samples for determining the Engineering properties. (i.e.strength, durability, Los Angeles Abrasion etc.)
- To prepare a "Resource Map of Construction Stone, Gravels and Sand" in the scale 1:25,000 for the studied area.

METHODOLOGY

Following methodology was performed in the evaluation of riverbed, terrace deposit and stone quarry.

(A) Riverbed courses:

- Pitting - to estimate the reserve.

- Shorting- to determine the quantity of the boulders and cobbles.
- Sieving - to determine the quantity of the pebbles and granules.
- Tentative reserve has been estimated of the construction stone at different river.
- All the examined area has been located in the map.

(B) Terrace deposit:

Detailed study was carried out in the terrace deposit for the evaluation of construction stones.

- Detailed cross-section at few exposed places.
- Trenching/Pitting - to estimate the reserve.
- Shorting- to determine the quantity of the boulders and cobbles.
- Sieving - to determine the quantity of the pebbles and granules.
- Tentative reserve has been estimated of the construction stone at different location area.
- Terrace deposit is located in the map.

(C) Stone quarry:

- Physical exploration (trenching) to expose the bed rock.
- Few samples were collected for determining the engineering properties (strength, durability and Los Angeles Abrasion etc).
- Tentative reserve has been estimated of the construction stone.
- The stone quarry area is located in the map.

(D) Market study:

Data and information collection from District Development Committees (DDC), Village Development Committees (VDC), contractors, government organizations, local consumers and the consumers in adjoining boarder areas.

RESULT AND FINDINGS

A "Resource Map of Construction Stone" with the location of riverbed courses, terrace deposit and stone quarry area has been prepared in the scale of 1: 25,000 (Fig.1).

The total reserve of boulders and cobbles is $3{,}790\text{x}10^3$ m^3 in the river courses, $87.44\text{x}10^6$ m^3 in the terrace and the total reserve of stone is $9.3\text{x}10^6$ m^3 in the two stone quarries. The local consumption of construction materials is 79,500 m^3 per year and increasing 15 to 20 % every year. The riverbed gravel is capable of fulfilling the local demand for another 15 years. The terrace deposits under the forest and cultivated area are not suitable for the mining at present. The stone quarry should be developed for export and future local demand (Tables 1-4).

CONCLUSION AND RECOMMENDATIONS

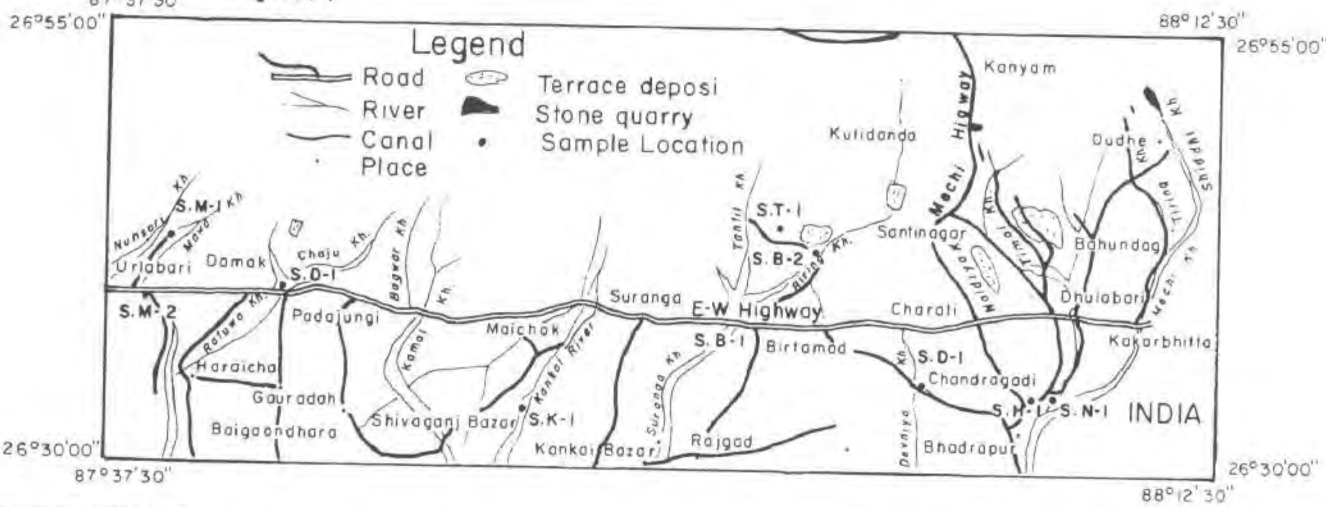
Conclusion:

- The total reserve of gravel along the river courses from Mechi to Mawa river has been estimated $19281\text{x}10^3$ m^3 but the boulders and cobbles reserve is $3{,}790\text{x}10^3$, which is generally used for the construction purposes.
- The total gravel reserve has been estimated $164.36\text{x}10^6$ m^3 but the boulders and cobbles reserve is $87.44\text{x}10^6$, which is generally used for the construction purposes.
- The tentative reserve of stone quarry deposit has been estimated $9.3\text{x}10^6$ m^3 and rock types are generally medium to coarse grained gneiss, quartzite and quartzitic schist.
- The local consumption of construction materials is 79,500 m^3 per year and it increases at the rate of 15 to 20 % per year.

CONSTRUCTION MATERIAL RESOURCES MAP OF JHAPA DISTRICT

(Not to the Scale)

Figure. I



Recommendations:

- DMG is directly/indirectly related with the mines administration and the tax generation from the construction materials, which imparts a good amount of royalty for the Government. Hence, the Department must explore and evaluate the recent position of the construction materials.
- DMG has limited old data on gravel deposit along the river courses, so, it must have latest data of the construction materials in different district.
- The detailed study of Terai and Churiya regions for the construction materials is very necessary to fulfill the national as well as international demand. Therefore, the market study and the resource survey in other districts for the stone quarry is recommended for the detailed study in future.

Table-1. Tentative Reserve of the River

S.No	Name of the river	Quantity of Boulders x 1000 (m^3)	Quantity of Cobbles x 1000 (m^3)	Quantity of Pebbles x 1000 (m^3)	Quantity of Granule, silt, sand, clay etc x 1000 (m^3)	Quantity of Gravels x 1000 (m^3)	Rock type	Remarks
1.	Siddhi	156.90	113.83	112.25	82.03	465.01	Mostly gneiss, quartzite and quartzitic schist, etc.	CL-3km fro dovan of Mechi
2.	Mechi	192.73	260.80	550.88	638.29	1642.70	"	SD-7km CL-8.5km
3.	Ninda	104.81	263.73	927.72	1514.36	2810.62	Mostly gneiss, quartzitic Schist, quartzite etc.	SD-0km CL-15.5km
4.	Sukeninda	49.19	72.52	142.63	123.16	387.50	"	CL-5km
5.	Telpani	9.93	9.87	15.98	20.72	56.50	"	CL-3km
6.	Timai	81.90	258.62	388.21	491.27	1220.00	"	CL-10km
7.	Hadiya	20.83	27.84	213.79	391.87	654.33	"	SD-15.5km CL-9 km
8.	Biring	51.66	258.28	1016.75	2075.81	3402.50	"	SD-19 km CL-19 km
9.	Tantin	41.77	479.48	1091.93	966.09	2579.27	"	16.5 km fro dovan of Biring
10.	Kankai	35.66	120.63	777.33	666.38	1600.00	Mostly gneiss, quartzitic Schist, sst. etc.	CL-3km
11.	Ratuwa	46.66	506.22	896.15	1038.47	2487.5	Mostly gneiss, quartzitic Schist, quartzite, sst. etc.	SD-2.5km CL-10.5km
12.	Mawa	46.05	579.60	856.52	692.84	2175.01	"	SD-5km CL-8.5km
	Total	838.09	2951.48	6790.14	8701.29	19281.00		

Note: SD- Starting distance from Mahendra Raj Marg.
CL- Total covered length of the river course.

Table-2. Reserve of The Terrace Deposit

S.No.	Terrace No.	Total Avg. Area (m^2)	Avg. mineable thickness (m)	Avg. O/B (top-soil (m)	Quantity of gravels (m^3) (70%recovery)	Rock type	Remarks
1.	TA	$6.34x10^6$	5.00	1.50	$22.19x10^6$	Mostly gneiss, quartzitic schist, quartzite etc.	2km. from MRM
2.	TB	$8.25x10^6$	10.00	2.00	$57.75x10^6$	,,	5km from MRM
3	TC	$2.00x10^6$	20.00	2.00	$28.00x10^6$	,,	7km from MRM
4	TD	$10.00x10^6$	8.00	2.00	$56.00x10^6$	Mostly gneiss, quartzitic schist, quartzite, sst. etc.	8km from MRM
5	TE	$0.20x10^6$	3.00	1.50	$0.42x10^6$	,,	6km from MRM

Total reserve = $164.36x10^6$ m^3

Table-3. Tentative Reserve of the stone quarry:

QA :- Stone quarry at Shidhi river, Strike length = 600 m, thickness = 100 m, dip length = 120 m, The total volume = $7.2x10^6$ m^3.

QB :- Stone quarry at Godar 60 km from Mahendra Raj Marg, Strike length = 500 m, thickness = 60 m, dip length = 70 m, The total volume = $2.1x10^6$ m^3.

Table-4. Local Consumption of Stone (2056/57)

S. No.	Project	Boulder (m^3)	Cobble (m^3)	Chips and Single (m^3)	Total (m^3)
1	Road	1450	12470	10280	24200
2	Irrigation	9750	7520	7520	24790
3	River training	8600	6540	-	15140
4	Building	3230	9830	2310	15370
	Total	23030	36360	20110	79500

The local consumption of construction materials is 79500 m^3 per year and its increased with 15 to 20 % yearly.

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Coal Occurrences in Harthok-Mujhun Area of Western Palpa

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INTRODUCTION

Department of Mines & Geology (DMG) has planned to evaluate the coal resources of Nepal during the ninth five-year plan. Consequently, the program of systematic geological mapping and evaluation of the coal-bearing horizon in the Lesser Himalayan region of Nepal has been included in its annual program since the fiscal year 1996. Until now, the potentialities of the coal have been accessed in Tosh, Seuza and Tulsipur – Kapurkot area of Dang, Sallyan, Rolpa and Piuthan districts. Similarly, during the fiscal year 1999/2000, the area lying east of Tansen of Palpa district was mapped and coal occurrences at Simaldi and Chirtung Danda are reported to be highly promising. During fiscal year 2000/01, area around Harthok and Mujhun lying to the west of Tansen of Palpa district, has been explored for coal and is briefly presented here.

The investigation was carried for 40 days. It covers an area of 100-sq. km. bounded by Harthok, in the east and Chhahara in the west. Harthok and Chhahara are connected by earth road from Tansen and respectively lie at 12 km and 30 km west of it. The investigated area falls in the Survey of India Topo - sheet No. 61 M/9 (Scale 1: 63, 360) and JICA Sheet No. 098-08 (Scale 1: 25, 000).

OBJECTIVES

It is aimed to develop a complete scenario of available coal resources of Nepal. Hence, geological mapping for locating the coal occurrences, stratigraphic and litho-stratigraphic study for understanding the behavior of host rock and geo-mining study for confirming the coal seams extent within the area were to be carried out.

METHODOLOGY

Regional geological maps and reports of the areas are reviewed (Tater, 1973; Kayastha and Aryal, 1982; Hirayama et. al., 1982; Adhikary, 1982; and. Shrestha, 1985). A broad scenario on regional geological settings of the area has been already published (DMG, 2000). A stratigraphic and litho-stratigraphic sequence of the region has also been already established (Sakai, 1983).

The field investigation work comprised of detailed geological mapping of the area (100-sq. km.) in the scale: 1:25, 000 with section measurement of the coal seams detected during mapping. Limited excavations necessary to detect the extension of concealed coal seam was also carried out. In addition to it, study of the existing exploratory adits and trenches and old workings on coal by private entrepreneurs were also studied.

RESULT AND FINDINGS:

The area constitutes a broad belt of Lesser Himalayas and has very rugged topographical expression with high hilltops towards south and north with gentle to moderate hill slopes towards east and middle part of the map area. Ridi Khola in the north and Chakaldi Khola in the south are the major rivers of the area

Tansen area of western Nepal consists of a thick sequence of sedimentary rock, ranging from Precambrian to Tertiary in age. Precambrian rocks are represented by Benighat Formation (gray to dark – gray banded shale) and Nourpul Formation (purple shale and silicified dolomite and limestone). These formations occur as a nappe in the area. On the other hand, the Tertiary groups of rocks are represented by Taltung Formation (Lower Gondawana within glacial bed), Amile Formation (the Upper Gondawana beds), Bhainsekatti Formation (Eocene beds) and Dumri Formation of non-marine green quartzite and red shale (Oligocene to Early Miocene). These rocks are found repeatedly thrusted over in the area in the form of a thin slice or either in a thin continuous bed. Regionally, the boundaries between each formation, except that of Amile and the Bhainskatti Formations are disconformable. Table-1 and Fig. 1 provide the detailed litho- stratigraphic superposition of rock types of the area.

Table 1: Litho – stratigraphic Sequence of the Area

Rock type	Symbol	Lithological Description	Correlation of Formations			Age
			DMG	Sakai	Indian Himalayas	
Green quartzitic sandstone and red shale		Greenish gray to reddish brown, fine to coarse grained green quartzitic sandstone and red shale	Suntar	-	Kasuali	Oligocene To Lower Miocene
Gray splintery shale and fossileferous limestone		Gray, whitish gray, highly splintery shale with bands of Numulitic limestone. Pelecypods and Gastropods are common	Swat	Bhainse-katti	Subathu	Eocene
Orthoquartzite, highly ferruginous with interbands of carbonaceous shale and coal beds.		Gray to brown coarse grained, ferruginous orthoquartzite with carbonaceous shale and 0.75 m to 1.00-m thick coal bed. Cong. at the base of quartzite	Melpani	Amile	Tal	Cretaceous
		UNCONFORMITY				
Gray shale, siltstone and conglomerate		Gray shale, olive green shale and sandstone, conglomerate with invertebrate fossils	Taltung	Taltung		Late Jurassic to Early Cretaceous
		UNCONFORMITY				
Black shale, clay - stone and diamictite		Gray to black shale, claystone and diamictite with Fenestellid bryozoan fossils	Sisne	Sisne	Krol	Late Carboniferous to Permian
		UNCONFORMITY				
Limestone and shale		Grey to cream colored, massive bedded dolomite and limestone with interbands of gray shale	Lakharpata	Kerabari		Late Paleozoic to Triassic
Green and purple shale with thin bands of limestone		Alternate bands of purple and green shale with bands of pinkish limestone	Khara	-	-	-

Out of these formations, the Amile Formation represents a typical deltaic sedimentary facies. It consists mostly of thick-bedded massive white quartzite occasionally pebbly at the base. It is mottled with ferruginous matter and is found to contain interbands of black shale and coal beds in them. The orthoquartzite beds are found to occur in the west, south as well as in the north along both limbs of the regional Tansen Synclinorium. This synclinorium closes around Mangal area toward west. As a consequence, the orthoquartzite bed in Mangal area is reasonably swelled up and is covering wide portion of the map area.

As the coal bearing ferruginous orthoquartzite are intensively folded and faulted, coal seams appear to be in the forms of lenses and small stringers at Bokhar village, Dabka and Kaule area. The thickness of the coal bed in all these areas ranges from 0.75m to 1.5 m in general. The general strike of the host rock in the area varies from NW-SE to E-W with a 20° - 50° dip towards NE/N. The intimate associations of coal with orthoquartzite bed of the region indicate that the carbonaceous materials were essentially deposited in an isolated basin in the fluvial flood plain environment. The available information on the nature of coal mineralisation and the present state of conditions are presented in Table – 2.

Table – 2: Coal occurrences in the investigated area

S. No.	Location of coal seams	Rock type	Thickness	Strike Extension	Coal type	Remarks
1.	Kurung Khola below Ghekul danda	Purple shale of Khara Formation	3 m	Covered by colluviam ~5m	Carbonaceous shale	New Finding
2.	Rep Khola below Malmul village	Ferruginous orthoquartzite	0.5m	3m	Sub-Bituminous	New Finding
3.	Tribeni Khola near Tahari village	Black carbonaceous shale within ferruginous orthoquartzite	1.00m	20m	Sub-Bituminous	New Finding
4.	Adheri Khola near Kaule village	Purple shale of Khara Formation	0.75m	>5m	Lignite	New Finding
5.	Ghat Khola below Dabaka village	Ferruginous orthoquartzite	1 m	Covered by colluviam ~5m	Sub-Bituminous	New Ffinding
6.	Phek village, along road cut	Ferruginous orthoquartzite	0.75m	Covered by colluviam ~3m	Sub-Bituminous	New Finding
7.	Lumbas khola near Lumbas village	Ferruginous orthoquartzite	1.2 m	Covered by colluviam ~3m	Sub-Bituminous	New Ffinding
8.	Bokhara gau	Ferruginous orthoquartzite	1.2 m	Covered by colluviam ~9m	Sub-Bituminous	New Finding
9.	Ripdikotdanda within reserved forest	Along the contact of purple shale of Khara Formation and ferruginous orthoquartzite	1.5m and 2 m	Covered by colluviam ~ 10 m	Sub-Bituminous	New Finding Two layers
10.	Bamsran Khola, west of Porkani village	Eocene shale, top of ferruginous orthoquartzite	1 m	Covered by colluviam ~8m	Sub-Bituminous	New Finding

Apart from this, digging trenches and pits at several places also exposed the other minor occurrences at Chhahara, Dhikichaur and Kusum Khola. These coal occurrences in the area were in the form of small lenses.

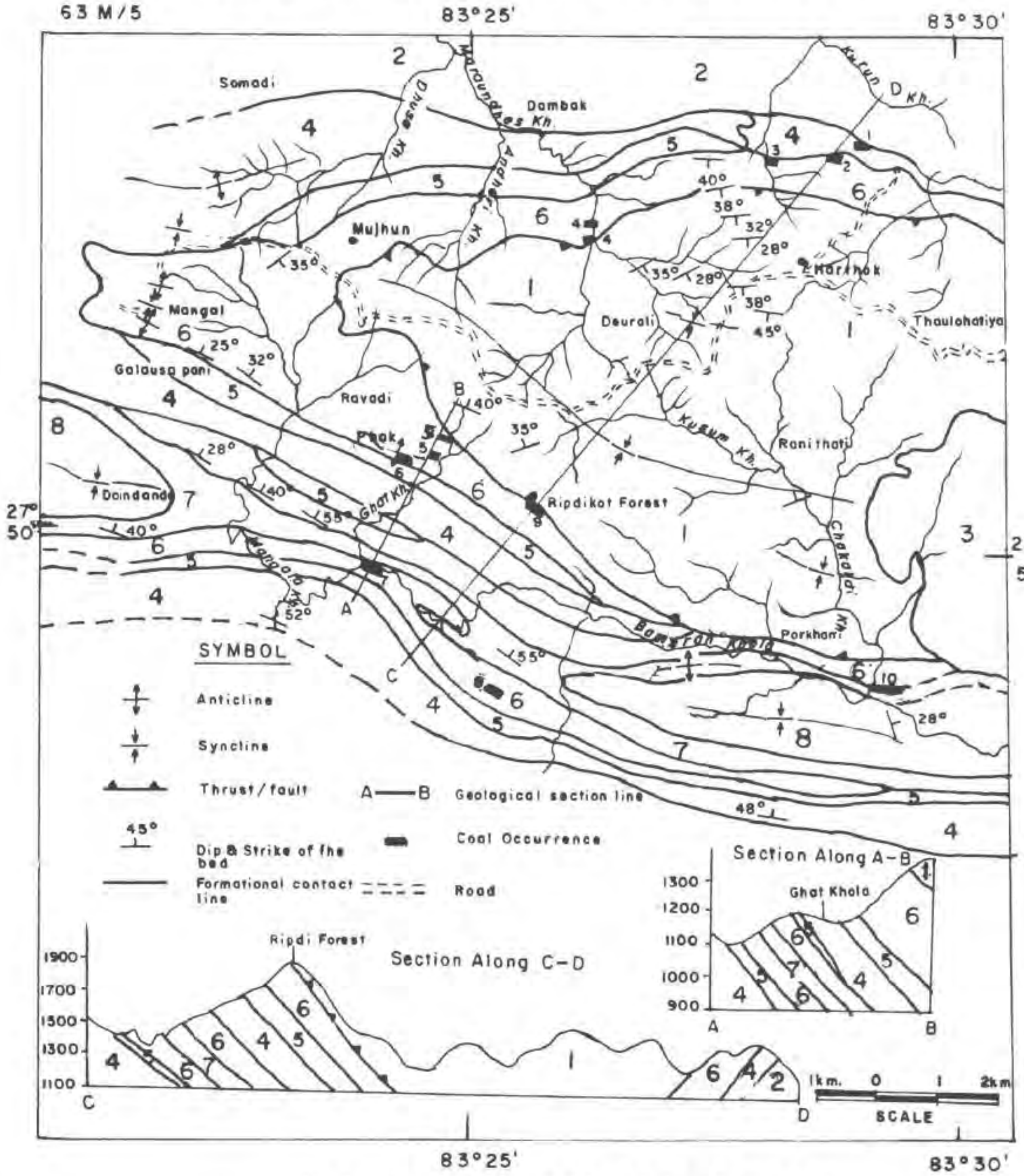
The major occurrences of coal within the area are briefly described:

- **Ripdikotdanda reserved forest area:** Two seams of sub-bituminous coal occur within the orthoquartzite near the thrust plane separating the purple and green shale of Khara Formation with orthoquartzite of Melpani formation. The upper coal seam is 2 m thick while the lower seam is about 1.5 m thick and lies about 3 m underneath. The host rock strikes NE - SW dipping due N by an amount of 40 degrees. It is exposed only to a length of 10 m along strike direction.

- **Near Phek village along road cut:** Carbonaceous shale of about 2 m thickness is found exposed within the ferruginous orthoquartzite along the road cut below Phek village. The shale with coal layer within the orthoquartzite is highly squeezed. It is striking almost in E – W direction and dips 20 degrees due N. The coal layer is exposed to a length of 5 m. The nature of this sub-bituminous coal mineralisation is very much similar to that of Tosh area, hence it deserves for further attention.

- **Below Palung village near the junction of Ghat Khola and Lumbas Khola:** About 1.75 m thick coal bed is exposed near the junction of Ghat Khola and Lumbas Khola. The coal within the ferruginous orthoquartzite bed exposed at khola is striking NW-SE direction and dips more than 30 degree due NE. It is exposed to a length of 5 m along strike and then covered by colluvium. It is anticipated to extend to a appreciable length. The exposed coal is of sub–bituminous grade.

Fig.1.
GEOLOGICAL MAP WITH COAL OCCURRENCE BETWEEN
HARTHOK AND MUJHUN AREA, PALPA



JICA SHEET NO.098-08(2783-020).

Legend:

8 Suntar Formation: Green quartzite, sandstone and red shale

7 Swat Formation: Gray splintery shale and fossileferous limestone

6 Amile Formation: Orthoquartzite, highly ferruginous with interbands of carbonaceous shale and coal beds.

5 Taltung Formation: Gray shale, siltstone and conglomerate

4 Sisne Formation: Black shale, claystone and diamicite

3 Benighat Slate: Gray to dark gray banded shale

2 Lakharpata Formation: Limestone and shale

1 Khara Formation: Green and purple shale with bands of limestone

CONCLUSION AND RECOMMENDATIONS

Conclusion:

- On the basis of field observations, coal occurrences at Ripdikotdanda, Phek and Palung area are found to be encouraging.
- As found-elsewhere in Nepal (Tosh and Seuza area), the coal in the region is also found occurring in association with ferruginous orthoquartzite.
- In Tosh – Seuza area, the green quartzitic sandstone is found to contain coal mineralisation at many places, however, in Palpa region the green quartzitic sandstone is not found mineralized with coal
- Maximum concentration of coal mineralisation is found along the closure portion of the Tansen Synclinorium, i.e. in the east along Devinagar side and in the west along Mangal and Ripdikot danda

Recommendations:

- As the orthoquartzite beds are still extending to the west of present investigated area, the exploration work for coal should be further extended towards west in Arghakanchi, Piuthan and western part of Dang district. This will help in ascertaining the nature of coal mineralisation in the Lesser Himalayas of Nepal in general and correlation to Dang coal.
- The coal mineralisation at Ripdikotdanda, Phek and Palung areas deserves further attention.

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Semi-detailed Follow-up Gold Exploration in Gorang, Bangabagar-Baggot and Lali Gad Area of Baitadi and Darchula districts, Far Western Nepal

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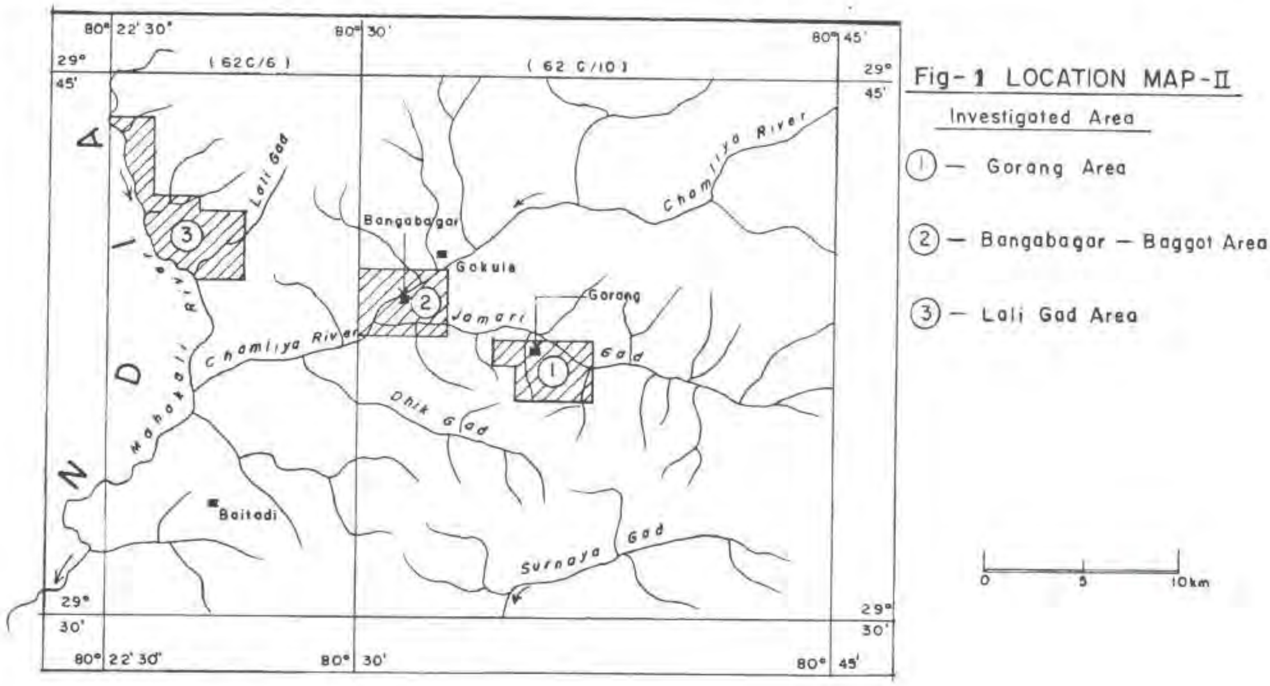
INTRODUCTION

According to the annual field programme of Department of Mines and Geology (DMG) for the fiscal year 2000/01, a "Semi-detailed Follow-up Gold Exploration" field was conducted in Gorang, Bangabagar-Baggot and Lali Gad areas of Baitadi and Darchula districts, Far Western Nepal. All the three investigated areas lie within the Longitude 80° 22' 30" to 80°40' E and the Latitude 29°35' to 29°45' N covering more than 100 sq. km. area (Fig. 1). A motorable road from Attaria (Mahendra Highway)-Dadeldhura–Patan–Satbagar to Gokuleshwar is the only road, which connects the Bangabagar–Baggot area. Gorang area can be approached by one-day walk from Bangabagar towards east. Likewise Lali Gad area can also be approached by one-day walk from Bangabagar towards west.



OBJECTIVES OF THE STUDY

The main objectives of the study are:

- to trace the primary gold mineralisation which could occur in the sulphide bearing high radioactive quartzite body,
- to find out the extension and thickness of mineralized body and primary gold content in them, and
- to collect channel, chip and bulk sample for gold analysis.

Previous works

Bashyal (1981), Kaphle and Khan (1992,1993) prepared regional geological maps of the area. Jnawali and Jha (1992) prepared geological map along Mahakali River of the area. They reported alluvial gold from Mahakali River. Kaphle and Khan (1994) did preliminary follow up exploration for alluvial gold and uranium in 10 sq. km area around the confluence of Jamari Gad and

Chamaliya Rivers. They reported poorly sulphide bearing high radioactive auriferous quartzite float in Jamari Gad containing 5.06 ppm gold and 1617 ppm uranium and some irregular radioactive quartzite bands/lenses with 1.56 ppm gold and 132 ppm uranium within Banku quartizite unit. Khan and Khadka (1999) carried out a preliminary follow - up investigation for gold in the area lying between Mahakali River and Jamari Gad covering more than 150 sq. km. area. They traced poorly sulphide bearing high radioactive quartzite band (showing up to 10,000 cps total counts) in Gorang area and low to medium radioactive quartzite band (showing up to 1500 cps total counts) in Bangabar-Baggotanea, which extended over 1.0 km in strike length. Likewise few irregular bands of ferruginous quartzite (containing hematite, magnetite and pyrite), copper bearing quartzite (containing few malachite and chalcopyrite) were traced in Lali Gad area. Previous work in the same area has confirmed the association of primary gold with radioactive minerals. Therefore, a semi detailed follow – up gold exploration was proposed in Gorang, Bangabagar – Baggot and Lali Gad areas.

METHODOLOGY

Field investigation consists of:

- preparation of detail geological maps,
- tracing mineralized bands,
- visual checking of gold content in the ore,
- heavy mineral concentrate sampling, and
- trenching/pitting.

RESULT AND FINDINGS

Accordingly, the major works carried out are

- Detailed geological maps of Gorang, Bangabagar–Baggot and Lali Gad area were prepared.
- Extension and thickness of radioactive quartzite bands of Gorang and Bangabagar- Baggot areas and iron ore band of Lali Gad area were traced.
- Trenching/pitting was carried out (more than 200 cubic meters) to expose the mineralized bodies and take the fresh rock samples.
- 112 rock chip/channel samples were collected from mineralized bands for petrographical study and chemical analysis for gold, copper, uranium, arsenic and iron. Results of gold, uranium and arsenic are awaited.
- 32 heavy mineral concentrate samples were collected from the riverbeds and old river terraces. Some gold colors up to 1. 0 mm size were recorded in Jamari Gad, Chamliya River, Mahakali River and Lali Gad.
- Old river terraces along Mahakali River also consist of few gold colors.
- 38 ore samples from different mineralized bodies were crushed, sieved and panned in the field to check the gold content in them. Few fine gold colors were observed in three samples collected from Gorang and Bagabagar – Baggot area.
- An updated semi-detailed geological map of a part of Mahakali River – Jamari Gad area was also prepared (Fig. 2).

The exploration work was mostly confined within Banku quartzite unit. This unit consists essentially of quartzite with green to dark green amphibolite and massive basic rock bodies. Intercalation of green chloritic phyllites is seen at places. Two bands of black carbonaceous phyllite are also recorded in Lali Gad section. The quartzites are fine to medium grained, poorly to well foliated, generally white colored and sericitic. Intraformational pebbles to boulder conglomerate bands are also observed within this unit in the western part of the area. All the mineralized bodies are encountered within Banku quartzite unit. Short descriptions of the mineralisation are given below.

Medium to high radioactive quartzite band of Gorang area: A medium to high radioactive quartzite band is recorded near Gorang village. Its strike length is about 160 m and thickness ranges from 3 m to 8 m. Radioactive intensity (R.I) value is recorded up to 10,000 (count per second) in total counts (Uranium, Thorium and Potassium). This band shows swelling and pinching nature. Mineralisation consists mainly of radioactive minerals with some pyrite and chalcopyrite. Generally two types of radioactive minerals are seen. The yellow colored mineral could be Autonite while the black one could be Uraninite/ Pitchblende. Some samples (5 to 6 kg each) from this radioactive quartzite band were crushed, sieved and panned. Few fine gold colors were observed in two samples. This indicates the presence of gold within this band that is associated with sulphide and radioactive minerals. Analytical results of the samples show up to 802 ppm copper.

Low to medium radioactive Quartzite band of Bangabagar-Baggot area: A low to medium radioactive quartzite band is traced in Bangabagar-Baggot area. Strike length of this band is about 1.5 km and thickness ranges from 1.5 to 6.0 m. R.I value is recorded up to 3500 cps total counts. It seems that the nature of this band is also swelling and pinching. Mineralisation consists mainly of radioactive minerals with few pyrite and rarely chalcopyrite. Some samples from this band were also crushed, sieved and panned. Few very fine colors were recorded in one sample. This also reveals the association of gold with radioactive minerals. Analytical results of the samples show up to 104 ppm copper.

Iron ore band of Lali Gad: Two bands of iron ore are traced in Lali gad. But towards western side, only one band is recorded. This band runs along the thrust contact between Banku quartzite unit and Malekhu limestone unit. Strike length of this band is about 1.5 km and average thickness is 2.5 m. The band consists mainly of hematite and magnetite with some pyrite and chalcopyrite. The host rock is medium to coarse grained, massive to slightly foliated, brown coloured quartzite with intrusion of small quartz veins. Analytical results of the samples show up to 30 % iron and 438.4 ppm copper. Result of gold is awaited.

Besides the above mentioned bands, a low radioactive quartzite band (showing up to 1200 cps total counts) and radioactive phyllite lenses (showing up to 400 cps total counts) are recorded in Gorang area. Likewise a 5.0 m thick and 500 m long band of magnesite (up to 42.33% MgO and 0.63% CaO) within Malekhu limestone unit is traced near Panjunaya in Bangbagar-Boggot area. Few radioactive quartzite lenses are also encountered in Bangabagar-Baggot area. Two bands of ferruginous quartzite (up to 7.35% iron and 130 ppm copper), one band of radioactive conglomerate (up to 800 cps total count), one band of malachite bearing quartzite (up to 402.4 ppm copper), two bands of carbonaceous phyllite consisting of pyrite bearing quartz veins (up to 422.0 ppm copper) are recorded in Lali Gad area.

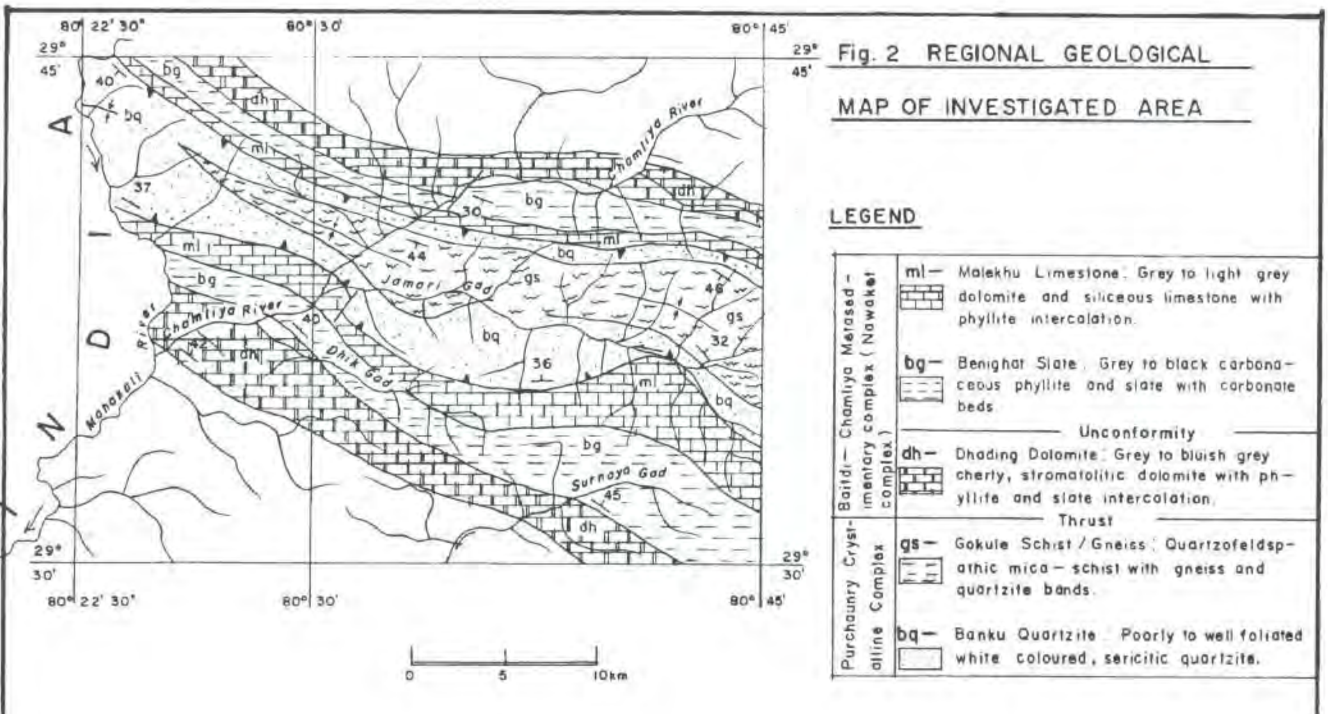


Fig. 2 REGIONAL GEOLOGICAL MAP OF INVESTIGATED AREA

CONCLUSION AND RECOMMENDATIONS

- Presence of gold colors in the crushed samples collected from the radioactive quartzite bands of Gorang and Bangabagar–Baggt area shows the association of primary gold with radioactive minerals. These radioactive bands could be one of the primary sources of alluvial gold in Jamari Gad and Chamaliya River.

- Presence of gold colors in heavy mineral concentrate samples of Jamari Gad and Lali Gad also indicates the existence of gold mineralisation in the investigated areas.

- Heavy mineral concentrate samples collected from old river traces of Lali and Banku along Mahakali River also consist of some gold colors. Evaluation of these terraces could be of economic interest.

- Chemical analysis result of samples could give the clear vision of gold mineralisation in the investigated areas. Further exploration work in the area could be recommended only after getting the chemical analysis results of various types of samples.

- Water of Gorang khola is used for drinking by the people of Gorang village. This water is not hygienic for drinking because of the presence of high radioactive body/ floats in the catchment area of Gorang khola.

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Geochemical Prospecting of base metals and gold in parts of Dailekh and Achham districts, mid-western Nepal

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INTRODUCTION

A reconnaissance geochemical stream sediment survey for base metals (Cu, Pb, Zn) and gold was undertaken over 650 km^2. area, topo-sheet no. 62 H/9, according to the annual field program of Department of Mines and Geology (DMG) for the fiscal year 2001. This activity is the continuation of the regional geochemical works carried out with a view to cover the whole Lesser Himalaya of Nepal to identify the targets for follow-up exploration. The investigated area lies between latitude 28^0 45' 00" to 29^0 00' 00" N and longitude 81^0 30' 00" to 81^0 45' 00" E. It covers the part of Dailekh and Achham districts of Midwestern and Far western Development regions.

Previous works

The area had been investigated with different objectives by many investigators: -

D. P. Dhoundial (1958) carried out an investigation with a view to make a preliminary examination of the inflammable gas seepages at Siristhan, Nabhisthan and Padukasthan in Dailekh District. He made four traverses and gave a fair account of the geology of the area.

C.K. Sharma (1962) made some geological traverses to Dailekh and investigated the thrusted pile of metamorphic sequences above the Eocene formation.

Y.L. Singh (1963 and 1965) worked on oil show of Padukasthan.

K.D. Bhattarai (1973) prepared a regional geological map of the area and desribed the metamorphism, structure, petrography and igneous activity.

T. Sharma (1984) prepared a geological map of the eastern sector of the area and presented the tectonostragraphy and structural evolution.

OBJECTIVE

The main objectives of the work are

- to carryout reconnaissance geochemical survey for base metals (Cu, Pb, Zn) and gold in order to delineate the anomalous areas and targets for further follow up exploration.
- to update the existing geological map.

METHODOLOGY

Fieldwork was carried out with the help of a base map with 1:63360 scale. Traverses were made all along the main and tributary streams and foot trails. Lithological rock units and structural discontinuities were identified and updated.

Heavy concentrate samples were collected only from the main tributary streams. About 40 kg. gravel mixed sediments were collected and sieved through 10 mesh sieve. Only minus 10 mesh fraction were washed and panned for heavy mineral concentrate. All samples were dried on the spot and packed in the labeled plastic bags.

Ore float samples were collected from the riverbeds and rock chip samples were collected from the outcrops.

The rock samples were studied under the petrographic microscope to determine mineralogical composition, texture and rock type. A geological map and cross sections were prepared. An outcrop location map, stream sediment and heavy concentrate sampling map, Cu, Pb, Zn anomaly maps and photographic documentation has been prepared.

Atomic Absorption System (AAS) was used for stream sediment sample analysis. All the geochemical results were interpreted statistically. While interpreting the geochemical data, geology of the area was also considered.

Heavy concentrate samples were separated into magnetic, feebly magnetic and nonmagnetic fraction and studied under the binocular microscope in the laboratory and various heavy minerals were identified.

RESULT AND FINDINGS

Six lithological units are identified in the investigated area which consists of sedimentary as well as low to medium grade metamorphic rocks such as shale, sandstone, phyllite, schist, quartzite and granitic gneiss. Stream sediment survey was conducted to identify the anomalous areas for Cu, Pb, and Zn. A total of 544 stream sediment samples with an average sample density of 0.836 samples per square km. area were collected and analyzed for Cu, Pb, Zn using AAS method. Lithology of the area is divided into two groups and the statistical parameters for Cu, Pb, Zn of groups A and B are as follow:

Table - 1a

Group A: Mainly schist with quartzite

Element	Background (ppm)	Standard Deviation (ppm)	Anomalous Value (ppm)
Cu	24.16	8.5	>41.16
Pb	21.2	10.6	>42.4
Zn	71.5	22.41	>116.3

Table – 1b

Group B: Mainly phyllite with quartzite and some schist

Element	Background (ppm)	Standard Deviation (ppm)	Anomalous Value (ppm)
Cu	23.2	9.93	>43.06
Pb	15.04	7.06	>29.18
Zn	49.41	21.22	>91.85

A few small anomalous areas of Cu, Pb and Zn were identified. Among them Sot Khola area falls in the anomalous category $2^{1/2}$ for Pb. Forty-four heavy mineral concentrate samples were collected from the present river/stream beds. Heavy mineral concentrate samples show a few flakes/colours of gold upto 1mm. only in 5 samples of Karnali river. It revealed that the primary source of gold is lying further upstream beyond the present study area.

Anomalous area for Cu: Three anomalous areas for Cu have been identified in the investigated area. The anomalous category obtained for Cu in this area is 4 for all areas (Table-2). This indicates that the area have least priority for the follow up investigation.

Table-2: Anomalous area for Cu

S. N.	Location	Area KM^2	Value ppm	No. of anomalous streams (X+3SD)	Category	Lithology
1	NW Tributary of Dabada	<1.0	53	1	4	Phyllite
2	Tore area	1.0	55-59	2	4	Phyllite and quartzite
3	Karnali River area	1.0	54	2	4	Phyllite and quartzite
4	Katuwalgaon	1.0	56	1	4	Phyllite and quartzite

Anomalous area for Pb: Six anomalous areas for Pb have been identified. The anomalous categories range from 2.5 to 4 (Table-3). Priority can be given to the areas with categories 2.5 to 3 for further follow up exploration.

Table-3: Anomalous area for Pb

S. N.	Location	Area KM^2	Value ppm	No. of anomalous streams (X+3SD)	Category	Lithology
1	Utiseni Khola area	<1.0	58	1	4	Schist and quartzite
2	Paduka Khola area	1.0	98	1	3	Phyllite and quartzite
3	Bhurti area	1.0	70	1	4	Phyllite and quartzite
4	Rati Khola area	2.0	42-46	2	4	Phyllite and quartzite, Granitic gneiss
5	Sot Khola area	2.0	64	2	$2^{1/2}$	Phyllite and quartzite
6	Katuwalgaon area	1.0	38	1	4	Phyllite and quartzite

Anomalous area for Zn: Two anomalous areas for Zn have been identified in the investigated area. The anomalous categories found in the area are 4 for all areas (Table-4).

Table-4: Anomalous area for Zn

S. N.	Location	Area M^2	Value ppm	No. of anomalous streams (X+3SD)	Category	Lithology
1	Kure Khola area	7.0	122-124	2	4	Phyllite and quartzite
2	Bansi area	10	124-174	2	4	Phyllite and quartzite

Heavy Mineral Concentrate Survey

Altogether 44 heavy concentrate samples were collected from the present beds of main streams.

Gold: Alluvial gold colours as very fine dust were detected in most of the samples collected from Karnali River. The gold content in the samples varied from 0.01mm to 1mm in size and 10 to over 30 flakes. Visible gold colours are recorded in sample no. 12,13,15,16 from Karnali River. No single flake of gold could be traced from other tributaries. This indicates that the source of the alluvial gold in Karnali River lies outside the present study area. It could be further north in the Higher Himalayan region.

Other heavy minerals: Garnet, magnetite, ilmenite, rutile are common in all samples. In some samples, tourmaline, zircon, pyrite occur as main constituents. None of them have economic values.

CONCLUSION AND RECOMMENDATIONS

The investigated area is very poor in metallic minerals. Results of reconnaissance geochemical stream sediment survey indicate a few geochemical anomalies for Cu, Pb, and Zn in the area (Table no. 2, 3 and 4). Categories of these anomalies range from $2^{1/2}$ to 4. The anomalies which have category $2^{1/2}$ is recommended for further follow-up investigation.

One anomalous area for Pb of category $2^{1/2}$ nas been identified in Sot Khola. A preliminary follow up exploration is recommended for this area.

Other few anomalous areas for Cu, Pb and Zn have been identified but all of them fall in anomaly category 3 and 4. (Tables 2,3 and 4). Therefore, further follow up investigation is not recommended.

Alluvial gold flakes/ colours of very fine dust <1 mm size are recorded only from the Karnali River. This indicates that the primary source of gold must be lying further upstream beyond the present investigated area.

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Geology of a Part of Doti - Achham - Surkhet - Kailali Districts, Far Western Nepal

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Petroleum Exploration Promotion Project (PEPP)

INTRODUCTION

The fieldwork was conducted in accordance with the program of Petroleum Exploration Promotion Project, Department of Mines and Geology (DMG) for the fiscal year 2057-58. The study area lies in the Doti, Achham, Surkhet and Kailali Districts of Far Western Nepal bounded in between Latitudes 28° 35'N and 29° 05' N and Longitudes 81° 00' E and 81° 15' E of Indian Toposheet Nos. 62 H/1, 62H/2, and 62 G/4 of 1:63,360 scale.

OBJECTIVE

The main objective of the fieldwork was to carry out the detail geological section measurement in order to establish the Stratigraphy of the area and collect the petrogeochemical samples for source rock analysis.

BACKGROUND AND PREVIOUS WORK

Different Nepalese geologists in connection with regional geological mapping purpose have studied the area. Vaidya, Y.L. (1971) carried out the regional geological mapping of the area. Thapa, G.S. (1974) has done regional geological mapping of a portion of Surkhet, Dailekh, Achham and Doti area. Kaphle, K. P. (1979) conducted the geological mapping along the Main Boundary Thrust (MBT). Pradhan, U.M.S (1983) carried out the geological mapping around the Seti and Karnali area. Shrestha, S.B (1989) prepared the geological map of a part of Achham and Doti area. Khan, H.R (1998) carried out the geological map of a part of Doti and Achham area.

RESULT AND FINDINGS

The study area consists of sedimentary, meta sedimentary and metamorphic rocks belonging to Dadeldhura Group, Dailekh Group, Lakharpata Group, Gondwana Group, Surkhet Group and Siwalik Group. The geological map of Petroleum Exploration Block 2 (Karnali) was published on 2003 by PEPP/DMG (Figure 1). The petrogeochemical samples from Surkhet Group are collected for the source rock analysis. Selected samples were sent to U.S.A for geochemical analysis and the results are awaited.

General geology: The rocks of Dadeldhura Group in the study area are exposed in northwestern corner of the mapped area. Dadeldhura Group consists of mica schist, feldspathic quartz mica schist, biotite schist, gneiss and granite.

The Dubbidanda Formation of Dailekh Group covers the northern part of the study area and it consists of phyllites, quartzites with amphibolites. The Lakharpata Group is further subdivided into five formations namely Sangram, Ramkot, Gawar, Khara and Katwa Formations. These formations of the Lakharpata Group comprises of dolomites, limestones, variegated shales and slates. Charchare Formation of the Gondwana Group is mainly composed of shale and diamictite with conglomerate beds.

The Surkhet Group is composed of variegated shales, sandstones, orthoquartzite and limestones and has been classified into three formations, namely Melpani, Swat and Suntar Formations. The Swat Formation has yielded different faunas such as Nummulities, Lamellibranches and Gastropods.

The Siwalik Group has been classified into Lower Siwalik, Middle Siwalik and Upper Siwalik. Further Middle Siwalik is subdivided into two units, Upper Middle Siwalik (MS2) and Lower Middle Siwalik (MS1). Upper Siwalik is also subdivided into two units Upper Upper Siwalik (US2) and Lower Upper Siwalik (US1). Siwalik Group is dominantly composed of sandstones, shales, clays, siltstones and conglomerates.

Structure: In the investigated area, there are numerous major and minor folds and faults. Based on the structure, the area can be divided into three tectonic units:

- the autochthon Siwalik Group exposing the Upper Tertiary sediment in the southern foot hills;
- the para-autochthon comprising of sedimentary and metasedimentary rocks of the Lakharpata Group and Surkhet Group overthrusted along the Main Boundary Thrust (MBT);
- the allochthon comprising of metamorphic rocks of Dubbidanda Formation of Dailekh Group thrust over the para-autochthon by the Ranimatta Thrust; and
- rocks of Dadeldhura Group have been brought over Dailekh Group by a thrust fault, which is known as Dadeldhura Thrust.

CONCLUSION

Detail geological sections measurement were done to identify the thickness of the sedimentary and metasedimentary rocks and to trace the lateral extension of sandstone channels. The petrogeochemical sampling were done to evaluate the potential of source, seal and reservoir rocks. The rocks of Surkhet Group, especially, Swat Formation (Sw. F) for source and seal rock and Melpani Formation (Mp. F) for source and reservoir rocks and Siwalik Group (Middle Siwalik) for probable reservoir are of high interest from petroleum exploration point of view.

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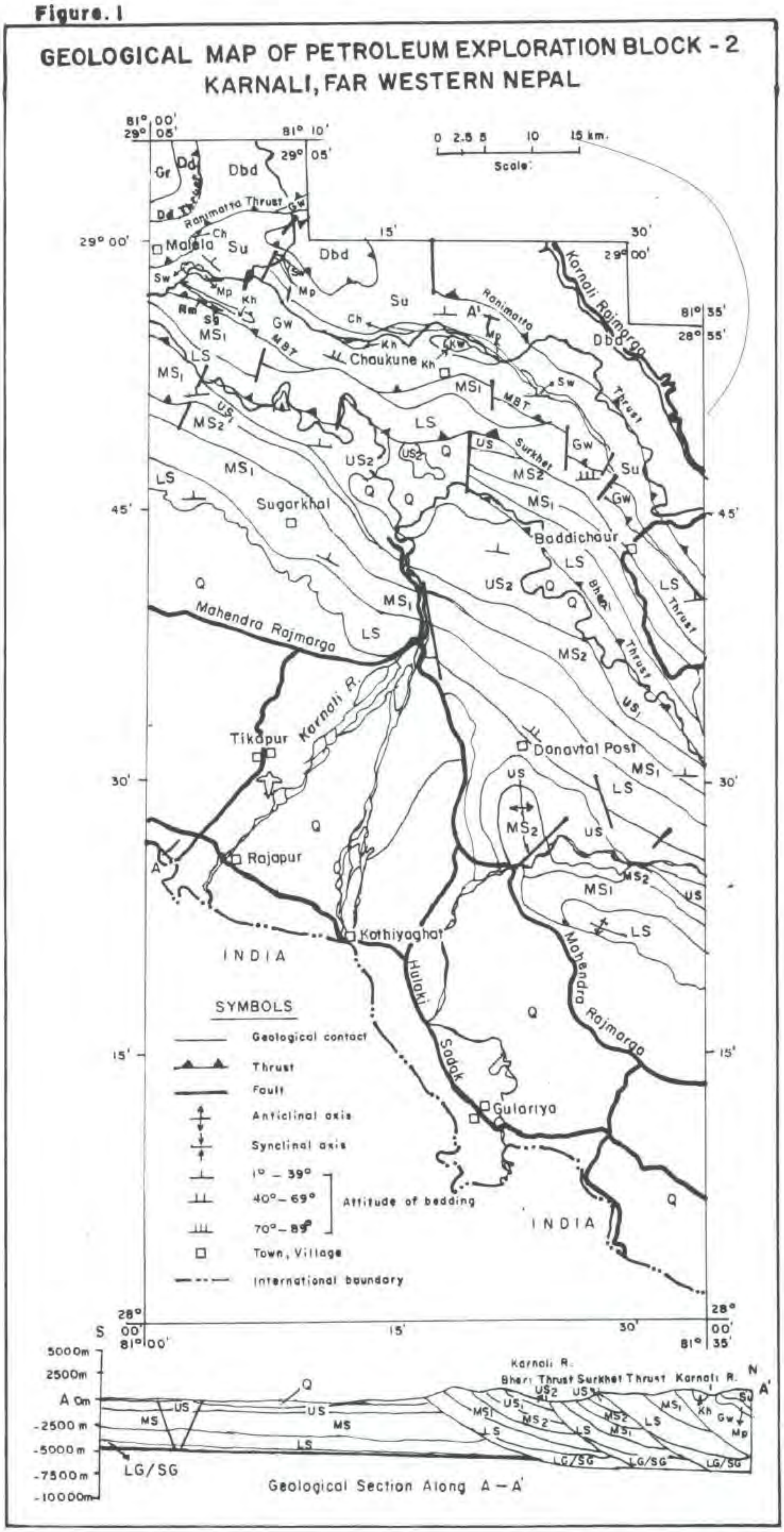
Figure. I



GEOLOGICAL MAP OF PETROLEUM EXPLORATION BLOCK - 2
KARNALI, FAR WESTERN NEPAL
Scale
Ranimatta Thrust
Malala
Chaukune
MBT
Surkhet
Sugarkhal
Baddichaur
Karnali Rajmarga
Thrust
Bheri
Mahendra Rajmarga
Karnali R.
Tikapur
Donavtal Post
Rajapur
Kothiyaghat
INDIA
Hulaki
Sadak
Gulariya
SYMBOLS
Geological contact
Thrust
Fault
Anticlinal axis
Synclinal axis
1° – 39°
40° – 69°
70° – 89°
Attitude of bedding
Town, Village
International boundary
Karnali R.
Bheri Thrust Surkhet Thrust Karnali R.
LG/SG
Geological Section Along A – A'

LEGEND

SURFICIAL DEPOSITS (Quaternary –Recent)

Q — Alluvium, boulder, gravel, sand and clay.

SIWALIK GROUP (Middle Miocene – Lower Pleistocene)

US_2 — **Upper Upper Siwalik:** Boulder cobble conglomerates with minor yellow, grey mud and silt. Sand bands and lenses in the conglomerates.

US — **Upper siwalik:** Undifferentiated.

US_1 — **Lower Upper Siwalik:** Pebbly conglomerates, yellow and grey mud with minor grey sand.

MS_2 — **Upper Middle Siwalik:** Medium to coarse-grained sandstone, pebbly sandstone with siltstone and mudstone with relicts of hard sandstone. Turtle limb is present in the sandstone.

MS — **Middle Siwalik:** Undifferentiated.

MS_1 — **Lower Middle Siwalik:** Medium, fine to medium grained sandstone with interbeds of siltstone and mudstone. Coaly materials and plant fossils are present.

LS — **Lower Siwalik:** Fine grained sandstone with interbeds of purple or red coloured mudstone, shale siltstone and occasional marl.

SURKHET GROUP (Upper Cretaceous – Lower Miocene)

Su — **Suntar Formation:** Green and greenish grey sandstone and purple shale with occasional marl.

Sw — **Swat Formation:** Grey to dark grey shale with foraminiferal limestone (Nummulites beaumonti, Assilina papillata) and coquina.

Mp — **Melpani Formation:** White, grey, ferruginous quartzitic sandstone and grey to dark grey shale with basal conglomerate. Coaly materials, bivalves are present.

GONDWANA GROUP (Carboniferous – Lower Cretaceous)

Ch — **Charchare Formation:** Grey, dark grey shale, calcareous shale and diamictite with conglomerate beds.

LAKHARPATA GROUP (Precambrian – Early Palaeozoic)

Kw — **Katuwa Formation:** Grey to dark grey shale with limestone dominant in the upper part.

Kh — **Khara Formation:** Green, grey and purple shale and limestone.

Gw — **Gawar Formation:** Grey stromatolitic dolomite, limestone with white grey subordinate sandstone and shale.

Rm — **Ramkot Formation:** Pink sandstone with ripple marks and purple, grey shale. **Mud cracks are present.**

Sg — **Sangram Formation:** Greenish grey to grey carbonaceous shale.

DAILEKH GROUP (Precambrian)

Dbd — **Dubbidanda Formation:** grey, green grey chloritic phyllite, gritty phyllite and white grey quartzites with amphibolites.

DADELDHURA GROUP (Precambrian)

Dd — **Dadeldhura Group:** Undifferentiated.

Gr — Granites.

Mines Rules and Administration Sub-Division

Babu Raja Aryal, Superintendent Mining Engineer
Mines Rules and Administration Sub-Division

1. INTRODUCTION

Mines Rules and Administration sub-division comprises of two sections, namely, i) License Section, and ii) Monitoring and Conflict Resolution Section. The main functions of this sub-division are:

- Issue/renew prospecting and mining license.
- Collect the mineral production data and royalties.
- Formulate and update Mining Act, Rules and Regulation.
- Inspect and monitor mines.
- Resolve the conflicts on mining operation.
- Provide technical approval for the licensing of Ordinary Construction Materials. (stone, gravel, soil, sand and slate).

Prospecting license (PL) is necessary in order to obtain a mining license except in the case of ordinary construction material and special mineral. Special Minerals refers to the mineral deposit explored by DMG itself. District Development Committee (DDC) deals with mining license of ordinary construction material. In case of special minerals, DMG invites for the proposal and grants Mining License after evaluation of the proposal. Licensing process and mining operation are governed by the following acts and rules;

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

2. PROCESS TO OBTAIN A PROSPECTING LICENSE

The application should be submitted as specified in Schedule-3 of Mines and Mineral Regulation with the followings;

- Nepalese stamps worth Rs. 5/-
- If the applicant is a company, he/she should submit an attested copy of registration including PAN number. The applicant, if individual, should submit an attested copy of Nepalese Citizenship certificates.
- Document showing technical and financial capability.
- Proposed plan of prospecting.

The prospecting area applied should not be less than 0.25 sq.km and not more than 250 sq.km in rectangular shape. The length should not exceed more than four times the breadth.

On approval, the applicant should pay the fees as per schedule-4 and annual Land Rent as per schedule-14.

The application may be disapproved in one of the following cases:

- The area applied is overlapped partially or fully with an area already awarded to other parties or to an area under the exploration activities of the DMG.
- Not a qualified applicant
- Incomplete or unclear document.

Qualifications of Applicant for Mining License

Mineral Type	Experience (Technical Capability)	Financial Capability
Very Important Minerals	Two years of experience or Capacity to employ an expert	Rs.3, 000,000/-per Sq.km
Important and valuable Minerals	Two years of experience or Capacity to employ an expert	Rs.2, 000,000/-per Sq.km
Ordinary minerals	One year of experience or Capacity to employ an expert	Rs.1,000,000/-per Sq.km

License may be canceled if prospecting operations do not start within 90 days from the date the license is issued. The license holder shall have the facilities to take abroad the samples of minerals found during prospecting for testing/analyzing.

3. PROCESS TO OBTAIN A MINING LICENSE (ML)

Any individual or company having PL should apply in the form as per Schedule 7 enclosing a detailed prospecting report and proposed Mining Scheme. The area applied should not be less than 0.25 sq.km and not more than 25 sq.km.

Qualifications of Applicant for Mining License

Mineral Type	Experience (Technical Capability)	Financial Capability
Very Important Minerals	Two years of experience or Capacity to employ an expert	Rs.3, 000,000/-per Sq.km
Important and valuable Minerals	Two years of experience or Capacity to employ an expert	Rs.2, 000,000/-per Sq.km
Ordinary minerals	One year of experience or Capacity to employ an expert	Rs.1,000,000/-per Sq.km

The mining scheme is approved on the basis of the field visit report and technical comments. On approval of the Mining Scheme, the applicant has to submit the Terms of Reference (TOR) for IEE/EIA Report of the mining area. EIA is necessary for medium or large scale mining, whereas IEE is necessary for small scale mining.

The scale of mining is decided on the basis of mineral type and daily production as shown in the following tables:

Scale for Metallic and Industrial non-metallic minerals

	Very small Scale	Small Scale	Medium Scale	Large Scale
Underground Mining	Up to 10 ton	Up to 100 ton	Up to 500 ton	Over 500 ton
Surface Mining	Up to 25 ton	Up to 250 ton	Up to 1000 ton	Over 1000 ton

Scale for Fuel minerals

	Very small Scale	Small Scale	Medium Scale	Large Scale
Underground	Up to 10 ton	Up to 100 t	Up to 500 ton	Over 500 ton
Surface Mining	Up to 20 ton	Up to 200 t	Up to 1000 ton	Over 1000 ton
Natural Gas	Up to 1000 Cum.	Upto 10000Cum.	Upto 50000 Cum	Over 50000Cum.

Scale for Construction Minerals

Minerals	Very small Scale	Small Scale	Medium Scale	Large Scale
Decorative Stones	Up to 3 Sq.m.	Up to 15 Sq.m	Up to 60 Sq.m.	Over 60 Sq.m.
Limestone for cement	Up to 30 tons	Up to 200 ton	Up to 1000 tons	Over 1000 tons
Limestone for lime	Up to 10 tons	Up to 100 ton	Up to 500 tons	Over 500 tons
Soil	Up to 25 Cum.	Up to 100 Cum.	Up to 400 Cum.	Over 400 Cum.
Ordinary Stone	Up to 25 Cum.	Up to 150 Cum.	Up to 500 Cum.	Over 500 Cum.
Block Stone	Up to 5 Cum.	Up to 25 Cum.	Up to 125 Cum.	Over 125 Cum.
Slab Stone	Up to 50 Cu.m	Up to 600 Cu.m.	Up to 2400 Cum.	Over 2400 Cum
Aggregates (Gravel)	Up to 20 Cu.m.	Up to 100 Cu.m	Up to 400 Cum.	Over 400 Cu.m
Sand and gravel	Up to 50 Cu.m.	Up to 200 Cum	Up to 800 Cum	Over 800 Cum.

The TOR should be presented as per Environment Protection Act 2053 and Environment Protection Rules 2054. After the approval of TOR, the applicant has to submit the IEE/EIA Report. Environment Committee of DMG approves the TOR/IEE, whereas TOR/EIA is approved by Ministry of Populatation and Environment.

On the approval of IEE/EIA report, the applicant shall receive the Mining License after paying the security deposits and fees as per the schedule-4 and annual Land Rent as per the schedule-14.

The Period for ML is 10 - 30 years depending upon the scale of mining. The license holder has to renew the license every fiscal year. Failing to renew the license by the end of Aswin , the license may be cancelled.

The leaseholder should commence mining activities within 6 months after getting the license. The leaseholder is allowed to sell and export extracted minerals and import machinery equipments for mining operations.

4. PROCESS TO OBTAIN A MINING LICENSE FOR SPECIAL MINERALS

Special Provisions of Minses and Mineral Act (Section 5) and Regulations (Section 24-30) applies in order to obtain a ML on the mineral deposit explored by DMG itself. DMG offers the data package that provides information on geology and detail exploration of the deposit, in addition, with the infrastructure details. DMG then invites to submit proposals from interested national and international investors.

The applicant should submit the Technical and Financial proposals. The proposal shall include the details including:

- Proof of having capital, machinery and equipments and specialized managerial capability necessary for mining.
- Method of explorative development, feasibility study and method of implementing mining scheme and time frame.
- Minimum phase wise program to be carried out during the mining period.
- A commitment to reimburse the exploration cost to DMG

DMG shall evaluate the proposals on the basis of, technical and financial capability, qualifications as per Rule 5, experience of the applicant and proposed minimum works/expenses during the period of explorative development/feasibility study.

After evaluation of the proposal, DMG may negotiate with the applicants and accept the proposal, enter in a contract and grant mining license as per Schedule 11. The contract will cover mining period, duty and liabilities, budget, exploration operations, environmental protection, protection of mineral, protection of life and property, sale and domestic supply, employee, and training etc.

5. MINING LICENSE FOR ORDINARY CONSTRUCTION MATERIALS

Sand, gravel, clay, slate and construction stones are defined as Ordinary Construction Minerals. Chapter-7 (Rules 34 to 38) states provisions to obtain ML for such minerals.

Application in the form prescribed in Schedule 12 should be submitted to DDC, and is then refered to the Mines Development Committee. The Mines Development Committee comprises of representative members from various governmental district organizations including Forest Office, Road Office and Soil Conservation Office. After the recommendation from this Committee, DDC shall forward to DMG for technical approval. On approval of Mining Scheme, TOR and IEE/EIA, DDC will issue the mining license.

6. MONITORING

The Monitoring section of DMG will visit and monitor active mines 2 - 3 times a year, as per approved annual program of DMG. The monitoring area is divided into 6 corridors:

Corridor No.1 -	Kavre, Sindhupalchok and Dolakha.
Corridor No.2 -	Dhading, Chitawan, Makawanpur, Tanahu, Palpa, Kaski, Arghakhanchi.
Corridor No.3 -	Sindhuli, Udayapur, Taplejung, Sankuuwasabha
Corridor No.4 -	Salyan, Rolpa, Dang, Jajarkot.
Corridor No.5 -	Rasuwa, Nuwakot, Dhading (North), Mustang.
Corridor No.6 -	Kathmandu Valley and nearby area

The monitoring team will inspect the mines with mining and environment point of view, whether the license holder is working as per approved mining scheme and as per conditions set forth by DMG at the time of issuing of license. Further more, the following details are inspected and checked:

- Bench width and height, dimensions of tunnels and other excavation and evaluate their standard size with safety point of view.
- The record books to verify the monthly production/royalties figures declared by the miners.
- Mining out side of the permitted area.
- Mining in an environment friendly manner as approved by DMG.
- Explosive uses and the blasting pattern, the blasting records to verify the monthly/annual consumption figures of blasting materials declared by the miners.
- Any complains made against the miners by other concern parties.
- Recommend closing down illegal mining, if any.

7. ACTIVE PROSPECTING LICENSE

Several prospecting licenses have been issued so far. In total 87 prospecting licenses have been issued in the past 3 fiscal years (17 in 2057/58, 22 in 2058/59 and 37 in 2059/60). The prospectors have abandoned many of them, some of them have been cancelled by DMG and some of them have obtained Mining License. The followings are the currently active prospecting licenses:

	Mineral	Numbers	Locations
1	Limestone	13	Chitawan,Makawanpur,Dhading, Udayapur
2	Calcite	1	Makawanpur
3	Talc	9	Kaski,Bajhang,Tanahu,Dhading
4	Marble	8	Makawanpur, Gorkha, Ilam
5	Gold	1	Panchthar
6	Zinc	1	Dhading
7	Lead	2	Dhading, Dang
8	Coal	10	Dang, Rolpa, Pyuthan,Dhankuta
9	Tourmaline	9	Jajarkot,Dailekh,Surkhet,Taplejung
10	Kyenite	5	Jajarkot
11	Quartz	1	Surkhet, Dailekh
12	Corrundum	2	Dhading, Taplejung
13	Garnet	2	Sankhuwasabha
14	Dolomite	2	Makawanpur, Chitawan
15	Acquimarine	1	Taplejung
	TOTAL	67	

8. ACTIVE MINING LICENSE

Several Mining Licenses have been issued so far. In total 5 Mining Licenses have been issued in the past 3 fiscal years (4 in 2057/58 and 1 in 2059/60). The miners have abandoned some of them. Some of them have been cancelled by DMG for various reasons. The followings are the currently active Mining Licenses:

		Mineral	Numbers Locations
1	Limestone	11	Makawanpur,Dhading,Udayapur,Arghakhanchi, Kavre,Sindhuli,Kathmandu
2	Red Clay	3	Udayapur, Kavre, Arghakanchi
3	Talc	7	Tanahu,Dolakha,Chitawan,Kaski, Sindhupalchok
4	Marble	2	Lalitpur,Kavre
5	Silver	1	Rasuwa
6	Zinc	1	Rasuwa
7	Lead	1	Rasuwa
8	Coal	19	Dang, Rolpa, Salyan, Palpa
9	Tourmaline	2	Jajarkot, Sankhuwasabha
10	Kyanite	1	Jajarkot
11	Quartz	2	Taplejung, Nuwakot
12	Salt	1	Mustang
13	Lignite	2	Lalitpur
TOTAL		53	

9. ROYALTY

After 31 Bhadra 2056, the royalty is collected on the basis of production as per schedule-10 of Mines and Minerals Regulations, 2056. DMG collected Rs. 41,87,484/-, Rs. 85,65,137/- and 1,01,55,010/- in the fiscal years 2057/58, 2058/59 and 2059/60 respectively. Marble has been the highest royalty paying commodity so far.

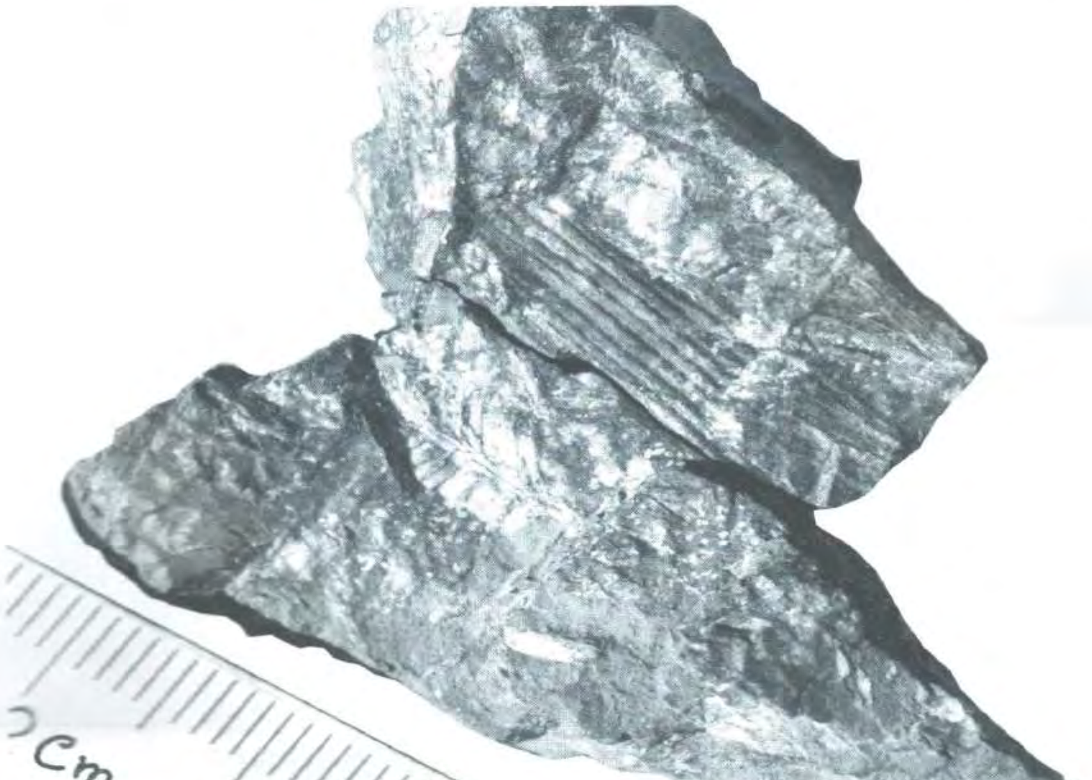
Royalty Rate

S. No	Mineral	Royalty Rs.	S.No	Mineral	Royalty Rs.
1	Gold	7.00/gram metal	2	Silver metal	100.00/Kg.
3	Copper	1.00/ Kg. metal	4	Lead	0.20/Kg metal
5	Zinc	0.60/Kg metal	6	Iron	8.00/ton
7	Limestone/calcite	12.00/ton	8	Talc	20.00/ton
9	Salt	01.00/ton	10	Ochres	05.00/cu.m
11	Quartz(Gems Quality)	20.00/Kg.	12	Quartz (Industrial)	20.00/ton
13	Silica Sand	10.00/ton	14	Magnesite	15.00/ton
15	Dolomite	10.00/ton	16	Corundum/Beryl/ Tourmaline (Industrial)	300.00/ton
17	Corundum/Beryl/Tourmalin (Gems Quality) 1. Ruby 2. Sapphire/Emerald / Aquamarine	 5000.00/Kg. 3000.00/Kg	18	Garnet/Kynite (Gems)	3.00/Kg
19	Garnet/Kyanite (Industrial)	50.00/ton	20	Fossils	10.00/Kg
21	Coal	35.00/ton	22	Lignite	04.00/ton
23	Natural Gas	00.20/Cu.m.	24	Marble/Decorative stone (Dressed block)	428.00/Cu.m
25	Marble/Decorative stone (Chips)	50.00/ton	26	Clay (Industrial)	07.00/Cu.m
27	Clay (Ordinary)	05.00/Cu.m	28	Raw Stone	05.00/Cu.m
29	Slab Stone	04.00/Sq.m	30	Slate Stone	01.00/Sq.m
31	Aggraegate	12.00/Cu.m	32	Sand	04.00/Cu.m
33	Gravel	03.00/Cu.m			

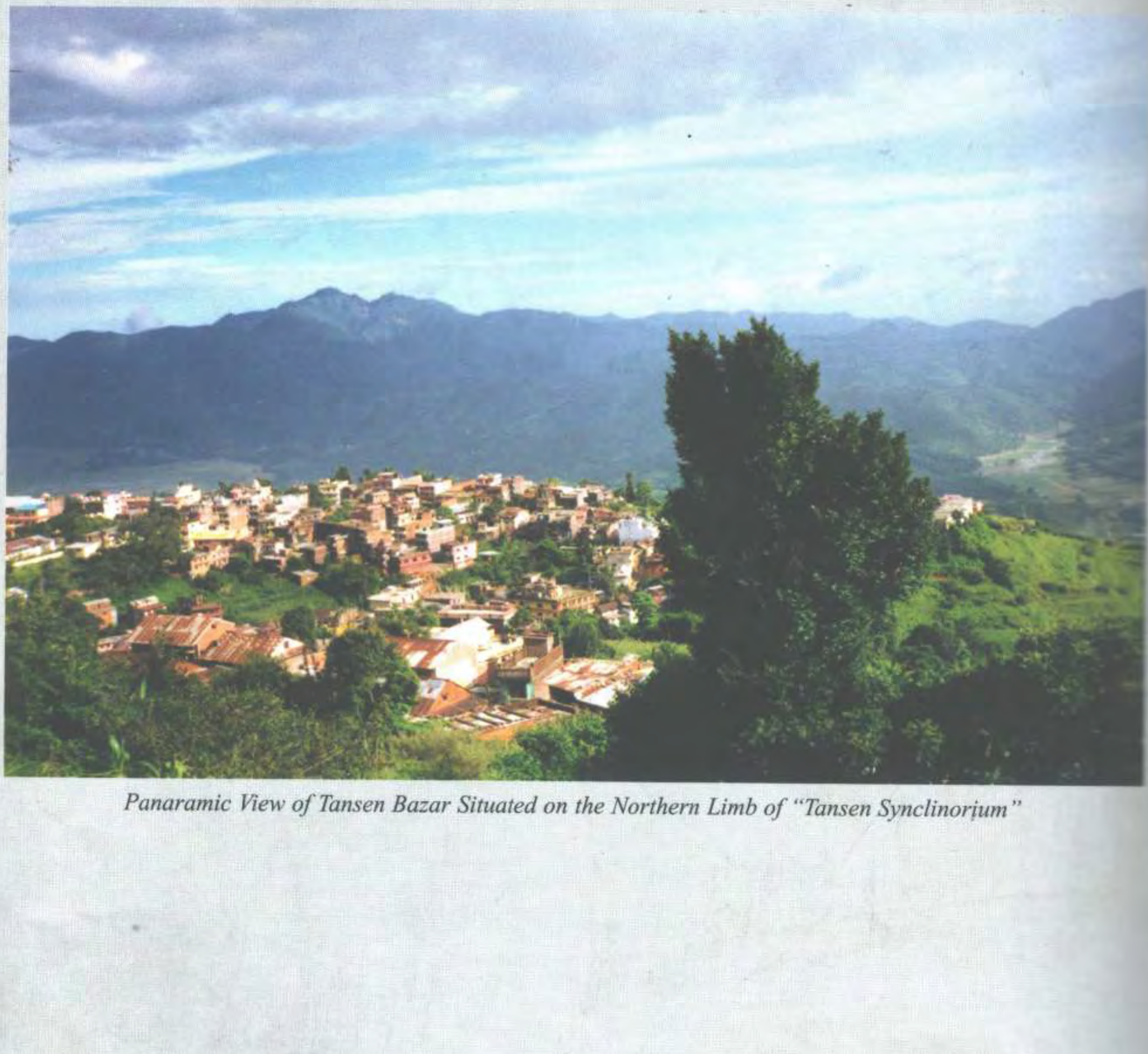
10. MINERAL PRODUCTION (for last three fiscal years):

Mineral	Unit	2057/58	2058/59	2059/60
Limestone (Chemical grade)	tons	15587	20000	15773.509
Limestone (Cement grade)	tons	287810	356218	283816.971
Red Clay	tons	36953	28036	21977.38
Talc	tons	3923	2621	7075.4
Marble (slab)	sq.m	54834	46156	46197.72
Marble (Chips)	ton	6065	537	395.025
Crazy Marble	sq.m	1333	2279	681.97
Coal	tons	16589	9612	11987.861
Kyanite (Industrial)	tons	1	9.4	3.79
Kyanite (Gems)	Kg	100	1040	420
Quartz (Industrial)	tons	123	172	172.5
Quartz (Gems)	Kg	1135	1720	1725
Salt	ton	5	5	3.5
Tourmaline (Industrial)	ton	-	-	11.5

Badlands Development due to Gully Erosion along Eastern Bank of Sardu Khola below Raitol Area.



"Schizonera gondwanesis Feistm" Plant Fossil found in the Black Shale of Barahakshetra Formation at Takure Khola, Dharan.



Panaramic View of Tansen Bazar Situated on the Northern Limb of "Tansen Synclinorium"

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