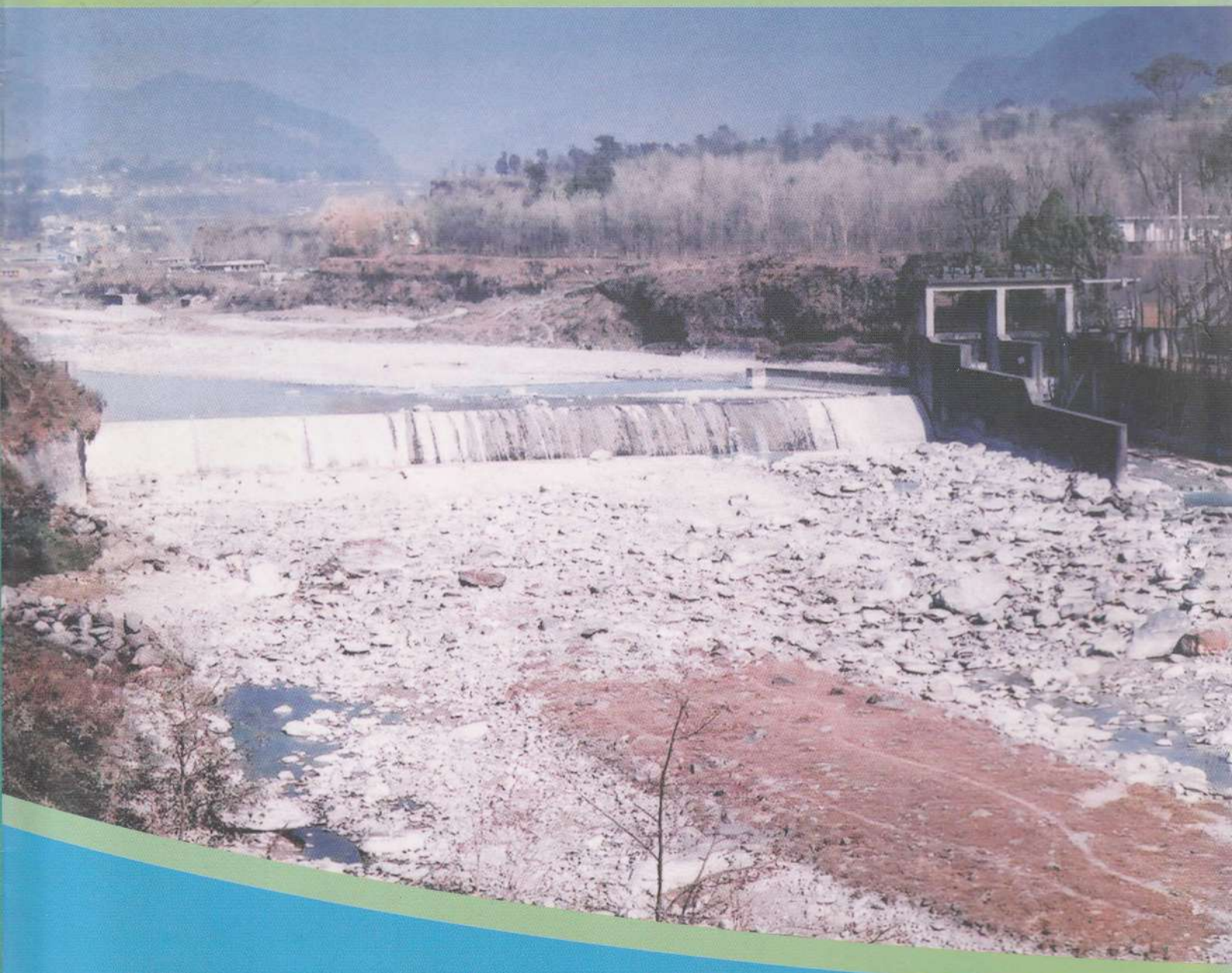
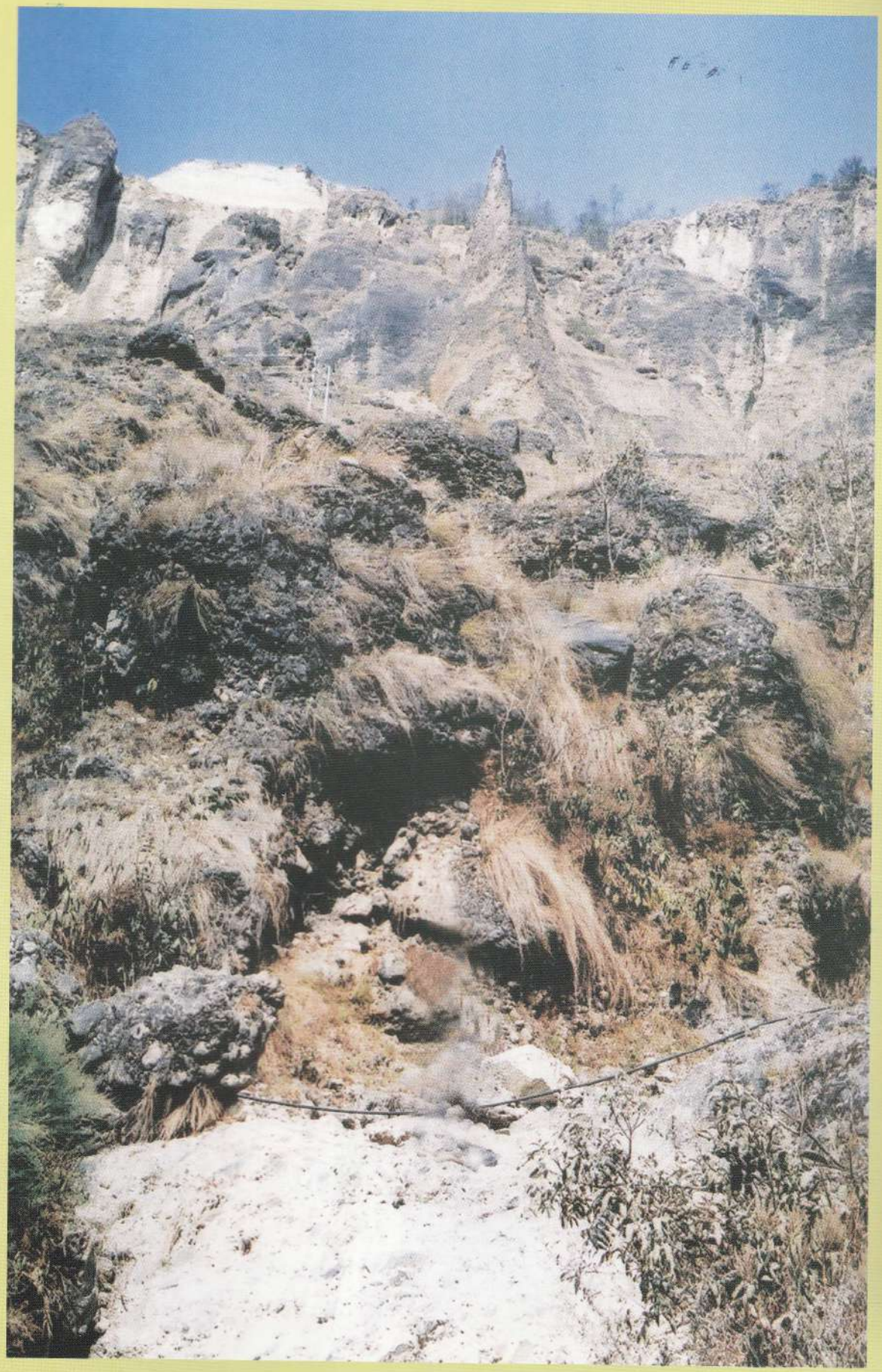
A GUIDE BOOK ON GEOLOGICAL SECTION OF BHUPI SHERCHAN MARG (POKHARA-BENI HIGHWAY), WESTERN NEPAL



Government of Nepal
Ministry of Industry, Commerce and Supplies
Department of Mines and Geology
Lainchaur, Kathmandu, Nepal



Pinnacle formed by the erosion of glacio-fluvial deposit

A GUIDE BOOK ON
GEOLOGICAL SECTION OF BHUPI SHERCHAN MARG
(POKHARA – BENI HIGHWAY), WESTERN NEPAL

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July, 2008

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PREFACE

This guide book is intended for the use of geo-scientists, engineers and students. At the same time this guide book will be beneficial to tourists, trekkers and people of different walk of life, who would like to enjoy exploring nature including geology, while trekking. One can enjoy the science, natural beauty and at the same time keep himself aware of his location along the road by the locality name and distance peg in every 5 km of the road in the map. This guide book is expected to guide the road to any body with some knowledge on geology or geography. It is the programme of the Department of Mines and Geology to provide geological, geomorphological, natural hazard and development infrastructure information of major highways of Nepal. As a part of the annual program for the fiscal year 2064-65, DMG is publishing this guide book on Bhupi Sherchan Rajmarg (Pokhara-Beni Highway. The department had already published two such guide books, namely 1. Geological Section along Arniko Highway (Kathmandu-Kodari road), Central Nepal in June 2006 and 2.Geological Section of Siddhartha Highway (Butwal-Pokhara road), Wstern Nepal in June 2007

The geological section and the guide book have been prepared on the basis of field study and existing topographic maps, geological maps and reports of the area. This guide book contains general geological information about Nepal Himalaya and geology, geomorphology and natural hazards along the road section. Typical outcrops of geological formation, geological structures and natural hazards like landslides, flood effects as well as other spots of general interest are described with photographs. Other information of socio-cultural aspects like location of hotel facilities, hospitals, petrol pumps etc are shown in the geological section.

Pokhara-Beni Highway, which is known as Bhupi Sherchan Marg is a very important route used by trekkers, tourists and general people, as the road leads to Jomsom, Muktinath, upper Mustang and to Tibet. Main bottleneck of this important trekking route was the lack of motorable bridge over Kaligandaki River at Beni. The bridge, which was in the process of construction for many years, has been completed and is serving for single lane vehicular traffic. Further construction of the road from Beni to Jomsom is continuing

The road section lies in Indian topo-sheet nos. 62P/16, 62P/15, 62P/12, and 62P/11 (1" = 1mile) and sheet numbers: 2883 16B, 2883 15B, 2883 12C, 2883 12D, 2883 11D, and 2883 11C of 1:25000 scale topographic maps published by Survey Department, Government of Nepal. The coordinates of zero km. area in Pokhara is 28° 12' 46"N 83°58' 38"E and that of Galeshwar of Myagdi district is 28° 22' 30"N and 83° 34' 13" E. The road section covers parts of Kaski, Parbat, Baglung and Myagdi districts.

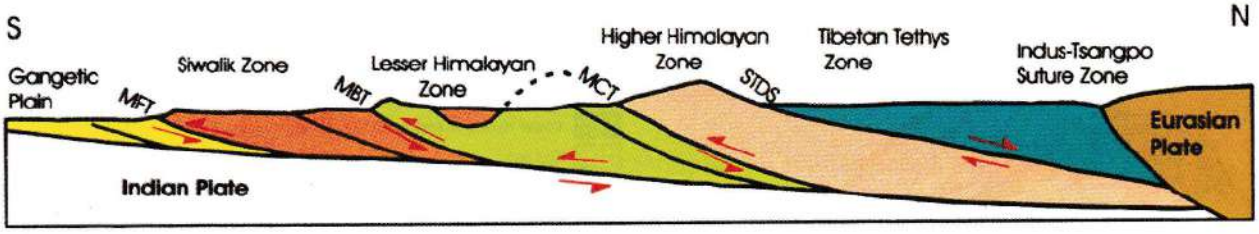
In this road section mainly glacio-fluvial deposits and rocks of Kunchha Formation and Kushma Quartzites are present. Three week long field study was carried out along this road section. During the field work, detailed studies of selected spots were carried out which are described along with photographs in this book. These spots include different type of geological formation, geological structure, geomorphological features, major development structure and flood hazard etc.

Two caves are present in this road section. Sheetal Gupha (cave) is present at 40km from Pokhara and Gupteshwar Gupha is present at 58.5km from Pokhara. In this road section hotel facilities are available at Pokhara, Phedi, Kade, Kushma, Baglung and Beni area. The road from Pokhara to Maldhunga, which is 68 km long is metalled but the road from Maldhunga to Galeshwar is gravelled. Major development structures in this road section are: Modi Hydro Power Plant at Dimuwa 46.5 km, Modi Hydro Power Intake Site at 43.5km, and Seti Canal Intake Site at 5.0 km from Pokhara. The authors believe that the book will be very much useful and beneficial in further engineering development activities along the road corridor and adjacent areas. It will also help in the tourism development of the area.

1. GENERAL GEOLOGY OF NEPAL

The South Tibetan Detachment Fault System (STDFS), the Main Central Thrust (MCT), the Main Boundary Thrust (MBT) and the Main Frontal Thrust (MFT) from north to south are the major tectonic structures that control the basic frame work of the Himalaya. All these structures dip toward north. The Main Central Thrust (MCT), the Main Boundary Thrust (MBT) and the Main Frontal Thrust (MFT) are thrust faults but the South Tibetan Detachment Fault System (STDFS) is a normal fault. At present MFT is the most active structure of the Himalaya. MCT was initiated around 25 million years ago and was active until 15 million years ago. (Harrison and others 1998).

These structures divide the Himalaya into five major geological zones. From south to north they are: 1. Terai or Indo-Gangetic plain, 2. Siwalik (Sub Himalaya), 3. Lesser Himalaya, 4. Higher Himalaya and 5. Tibetan Tethys Zone.



STDS: South Tibetan Detachment System
MBT: Main Boundary Thrust
MCT: Main Central Thrust
MFT: Main Frontal Thrust

A schematic geological cross section of the Himalaya (Upreti and others 2005).

The Terai (Indo-Gangetic Plain)

It is the northern fringe of Indo-Gangetic plain, which lies to the south of the Siwalik foot hills. It is composed of Quaternary alluvial deposits consisted of gravel, sand, silt and clay. It is believed that the Terai is slightly tilted (2^0-5^0) towards south and south west. Total thickness of the sediments varies from 500 to 2500m.

Siwalik (Sub-Himalaya)

Siwalik range forms the southern most mountain range of the Himalaya. It is bounded to the south by Main Frontal Thrust and to the north by Main Boundary Thrust. It is consisted of Neogene to Quaternary fluvial sedimentary rocks such as shale, claystone, mudstone, sandstone and conglomerate. In general, coarsening upward sequence is the characteristic of the rocks of the Siwalik Group. It is divided into three units: Lower, Middle and Upper Siwalik Formation.

Lesser Himalaya

The Lesser Himalaya is bounded to the south by Main Boundary Thrust (MBT) and to the north by Main Central Thrust. In contrast to unmetamorphosed Siwalik rocks in south and high grade metamorphic rocks in the north, the Lesser Himalaya is composed mainly of low grade metamorphic rocks such as limestones, dolomites, slates, phyllites and quartzites. Stromatolites are the only known fossil evidences in the rocks of the Lesser Himalaya and age of these rocks is assumed to be Pre-Cambrian to Early Paleozoic. But at some places, Tansen area and Phulchauki area, these Lesser Himalayan rocks are unconformably overlain by fossiliferous younger rocks of Permo-Carboniferous to Miocene age.

The Higher Himalaya

The Higher Himalaya lies between the Main Central Thrust to the south and South Tibetan Detachment Fault System to the north. The Higher Himalaya is

composed of high grade metamorphic rocks, which include various kinds of gneisses, schists, migmatites, quartzites and marbles. Rocks of the Higher Himalaya form the basement of the Tibetan –Tethys Sedimentary Sequence.

The Tethys Zone (The Inner Himalaya)

This zone is bounded by the South Tibetan Detachment Fault System (STDFS) to the south and the Indus-Tsangpo Suture Zone (ITSZ) to the north which is exposed beyond the Nepal border in Tibetan Plateau. The ITSZ marks the boundary between the Indian and Eurasian Plates. This zone is consisted of weakly metamorphosed to non metamorphosed sedimentary rocks such as limestone, sandstone and shales. Fossil evidences show that their age ranges from Cambrian to Middle Cretaceous (Colchen and others 1986). The rocks are considered to have been deposited in the Tethys Sea on a part of the north Indian Continental Margin (Liu and Einsele, 1994).

2. GEOLOGY, GEOMORPHOLOGY AND NATURAL HAZARDS OF THE AREA

2.1 Geology

Pokhara-Beni Road starts from Pokhara, with fluvial deposits. Rocks of Kunchha Formation of Lower Nuwakot Group is the dominant rock type present in this road section. Rocks of the Kunchha Formation cover about 80% of the hard rock area around this road section. Kushma Quartzite and Dandagaon Phyllite, each covers about 10% of the hard rock exposure in the area around the road section. Hard rock occurs in the hilly part of the road section and in the hill surrounding the road in the valley. The valleys of Seti River, Modi Khola, and Kaligandaki River have glacio-fluvial and fluvial deposit. Kunchha Formation is consisted of greenish grey, dark grey to yellowish grey phyllite with gritty phyllite and quartzite beds. Kushma Quartzite consists of white, fine grained platy quartzite with dykes of basic rocks. Similarly Dandagaon Phyllite consists of greenish grey to silver grey phyllite with bands of meta-sandstone and at places lenses of dolomites. Fluvial deposits consist of gravel, pebble, sand, silt and clay.

2.2 Geomorphology

Pokhara – Beni Road starts from Pokhara valley with an altitude of 800m. It is the lowest area, through which the road passes. The road has roughly E-W trend in middle part, but in eastern part in Pokhara area and in Kushma area, the road is stretched toward south. Similarly, in western part in Beni area, it is stretched toward North. From Pokhara in south-east to Phedi in north-west, the road passes along the flat terrace deposit of Seti and Yandi khola. In this area, the road climbs 300m height in a distance of 16km. West of Phedi, the road passes through the hilly part, the road climbs up from 1100m at Phedi to 1730m at Kade, in a distance of 15 km. Kade is the highest area in this road section. West of Kade, the road descends following Dhoti khola till it reaches confluence of Dhoti khola with Modi khola. From the confluence, the road follows the left bank of Modi khola up to Dimuwa. From Dimuwa, the road follows the right bank of Modi khola up to Kushma, headquarter of Parbat district. North-west of Kushma, the road follows the left bank of Kaligandaki River up to Beni. At Beni, the road crosses the Kaligandaki River and follows the right bank of Kaligandaki River up to Galeshwar, the northwestern end point of the study area.

Banks of Kaligandaki River and Seti River, consisted of glacio-fluvial deposits, are generally steep due to toppling failures of the banks. Wide flood plain, with fertile alluvial deposits, is created by Seti River and Yandi Khola around Hemja area. Similarly Kushma area is the flood plain, with fertile alluvial deposits, created by Kaligandaki River and Modi Khola. Smaller alluvial flood plains are common along the bank of Kaligandaki River and Modi Khola, especially at the confluences of their tributaries. Kaligandaki River flowing from N-NW at Galeshwar to S-SE and Modi Khola flowing from NE at Birethati to SW joins at Majhbeni south of Kushma Bazar. The valleys of Modi Khola and Kaligandaki River are broad and wide and hill slopes are gentler in southward. In northward, especially the valley of Kaligandaki River north of Beni is narrower and hill slopes are also steeper.

2.3 Natural Hazards

When the stream coming down from hilly area with confined river channel reaches the flat alluvial land, it releases its force, by moving forcefully and haphazardly away from its normal course, as it has easily erodable bed. This is the case of Yangdi Khola. (spot no.3). In this area, a small stream of few meter width in normal period, makes hundreds of meter wide flood plain during rainy season. Highly jointed quartzite exposure area, along the road is another source of hazard for the road. The impact of rock fall and its rolling along the road has caused the damages of the road. (Spot no.9). Extraction of sand below the water level of the river has caused the flow of water of the river into the depression created by sand extraction, resulting the flooding of the mining area and shifting of river course towards the road alignment, eventually creating a potential danger to the road. Erosion of thick glacio fluvial-deposit causes detachment of big blocks of the deposit. These detached blocks roll down to the toe of the slope damaging the slope and road on its course. Road constructed on the hilly terrain, either passes through slope with hard rock or through toe part of the slope with soft sediment. The road alignment along the slope with hard rock, will be expensive, so generally, the road alignment will be taken along the toe part. Most parts of the toe part of the slope are made of either of the following: landslide deposit, fan deposit, fluvial deposit or scree deposit. These loose, incoherent deposits will not be stable when considered for longer period. Toppling failures and debris falls are common along the bank of Seti River and Kaligandaki River. Steep banks, toe under cutting by water and dissolution of calcareous cement of the debris sediments are the main reasons behind the failures along the bank of Seti River and Kaligandaki River.

3. GEOLOGY ALONG THE HIGHWAY

Pokhara–Beni Road section has been divided into four sectors; they are 1.Pokhara – Phedi Sector, 2. Phedi – Biruwa sector, 3. Biruwa – Maldhunga sector and 4. Maldhunga – Galeshwar sector.

Pokhara – Phedi Sector

This sector extends from Pokhara valley in SE to Phedi in NW. This sector covers 16 km in distance. In this sector, the road passes mainly over the fluvial deposits of Seti River and Yandi Khola. The fluvial deposit is consisted of clay, sand and gravel. Fluvial deposits occur in the valley of Seti River and Yandi Khola. Rocks of Kunchha Formation occur in the surrounding hills and hill spurs reaching the valley. Since the road follows the river valley, the gradient of the road is gentle in this sector.

Phedi – Biruwa Sector

This sector extends from Phedi in east to Biruwa in west and covers a distance of 20km. This sector lies in the hilly parts and mainly rocks of the Kunchha Formation occur along the road in this sector. Kunchha Formation is consisted of light greenish grey to dark grey sericitic chloritic phyllite and phyllitic quartzite interbedded with yellowish green gritty phyllite with quartzite bands. About 2km north of the road, from around Kade area, a band of Ulleri Gneiss occurs within the Kunchha Formation. Ulleri Gneiss consists of grey, light grey augen gneiss and quartzites.

Biruwa – Maldhunga Sector

This sector extends from Biruwa (36km) in east to Maldhunga (67.5km) in west covering a distance of 21.5km. In this sector, mainly rocks of Kushma Quartzite and glacio-fluvial deposits are present along the road section. Kushma Quartzite is consisted of thin bedded to thick bedded, white grey to greenish grey, very fine to fine grained sericitic quartzites. It is composed mainly of quartz grains. The quarzites contain thin intercalation to thick bands of green phyllite. Both the quartzites and phyllites are non calcareous. Ripple marks are present in the quartzites. At places, dykes of basic rocks are noted in the quartzites. The quartzite exposures are present from Biruwa in NE to Sundare Khola in SW for a distance of 13km. From Sundare Khola toward west, the road passes over the glacio fluvial deposit of Modi Khola and Kaligandaki River for a distance of about 12 km, except for few km NW of Kushma, where rocks of Kushma Quartzites are exposed. The glacio fluvial deposit is consisted of gravels, pebbles, cobbles and boulders in sandy matrix. The gravels, pebbles are made up of white grey, greenish grey quartzite, fine grained biotite schist, gneiss, calc-gneiss, marble and limestone with some phyllite and slate. These conglomerates are cemented by calcareous cement. The gravels pebbles are sub angular to rounded, eighty percent of them are sub-rounded. Maximum thickness of the glacio-fluvial deposit exposed in the area is 240m. At places top part of the deposit has been deeply weathered into lateritic soil.

Maldhunga – Galeshwar Sector

This sector extends from Maldhunga in south to Galeshwar in north for a distance of 18km. In this sector mainly glacio-fluvial deposit of Kaligandaki River occurs along the road section except at few places, where the road touches the hill spurs. The road follows the Valley of Kaligandaki River in this section. In the surrounding hills and hill spurs, rocks of Kunchha Formation occur from Maldhunga to Lamabagar in north. North of Lamabagar, rocks of Dandagaon Phyllite occur. Dandagaon Phyllite is thrusted over by Kunchha Formation in this sector.

4. OUTCROP (SPOT) DESCRIPTION

For the purpose of outcrop description, right side of the road indicates right side, while driving from Pokhara to Beni. Many interesting geological formations, geological structures like folds, faults, geomorphological features like landslides, creeps, caves and different development structures can be seen while driving from Pokhara to Beni. Some of them are described below with photographs.

Spot No.1, (4.00Km): Kunchha Formation, Pokhara, (Left side of the road).

Thinly banded (1cm to 4cm thick), fine grained bluish grey to greenish grey (silicious to argillaceous) phyllites of Kunchha Formation are exposed in the area. The rocks are exposed as the area has been excavated to prepare the site for the construction of a new house (photo-1). The attitude of the bed is N30^{0}W and dip 20^0 SW. A local fault plane exposed in the area has trend of N65^{0}W and dip 65^0 toward south.

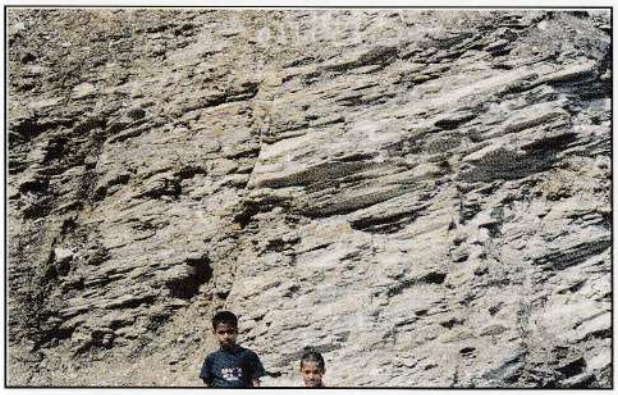


Photo 1: Fine grained greenish grey phyllite of Kunchha Formation exposed in the excavated area(Feb.2007)

A small house constructed in front of the outcrop (Feb.2008).

Spot No. 2, (5.00km): Intake site of Seti canal, Yandi, Kaski, (Right side of the road).

At about 5km from Pokhara, shows the intake site of the Seti canal (photo 2). The intake for the canal is located on left bank of the Seti River. The canal fulfills the cleaning water demand of the local people in the northern part of the Pokhara Valley. In south eastern part; the water is used for irrigation of the wide agricultural land of Pokhara Valley.

Photo 2: Seti dam and intake of Seti canal on left bank of Seti River.

Spot No. 3, (15.25km): Flood Hazard of Yandi Khola, Phedi, Kaski, (Left side of the road).

Yandi Khola flowing from west to east, in its meandering process, often hits north toward the road. The river bed, at this area, is in flat alluvial terrace deposit. As the stream is coming down from the hilly area, the kinetic force of water during rainy season will be high and the water flow deviates quite a long distance from its normal course. During the field study period (month of Feb/March) the water course in the stream is about 150m south from the embankment wall. During the rainy season, the flow course reaches the side hill, hundreds of meters away from its normal course. It is observed that only due to the embankment wall, the road is protected from the flood. The flood plain is about 350m wide though the stream channel itself at present is only few meters (2-4m) wide.

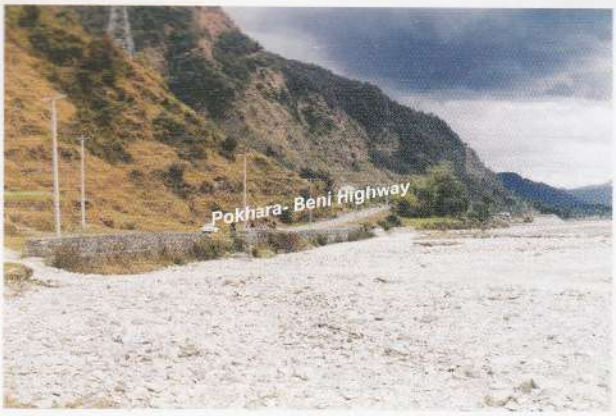


Photo 3: Debris of Yandi Khola affecting the road alignment.

Spot No. 4, (15.50km): Soil Creep, Phedi, Kaski, (Right side of the road).

A soil creep of about 60m wide and 40m high is present at Phedi on the right side of the road (photo-4) The road has been protected from the creep by erecting a gabion wall at the base of the creep (on right side of the road). If the creep activates, there is potential danger to the road.

Photo 4: Creeping soil mass affecting the road.

Spot No. 5, (40.00km): Sheetal Gupha, Dada, Kaski, (Left side of the road).

A small cave is present on the left side of the road at a distance of 40km from Pokhara (photo-5). The cave exposed on a small stream and is situated about 50m uphill from the road. The cave seems to be formed by breaking and leaching of calcareous glacio-fluvial deposit. Numerous boulders of 15 to 20m diameter are present on the kholsa by the side of the cave. Calcite leaching is common inside the cave. The mouth of the cave has the shape of triangle. It is 3m wide at base and 3m high at the centre.

Photo 5: A cave in glacio-fluvial deposit at Dada.

Spot No. 6, (43.40km): Intake Site of Modi Khola Hydropower Plant, Dhaba, Kaski, (Right side of the road).

The intake site of the Modi Khola Hydro Power Plant is located on the right bank of khola. From the intake site, about 500m long tunnel brings the water to settlement reservoir located also on the right bank of the khola. The reservoir is about 300m long. The water from the reservoir is carried through the tunnel to the power house located at Dimuwa.

Photo 6: Water of the Modi Khola diverted to the tunnel on right side of the river in Intake site of Modi Khola power house

Spot No.7, (46.50km): Kushma Quartzite at Dimuwa, (Right side of the road).

Thick bedded to massive, very fine to fine grained, white grey to greenish grey quartzite of Kushma

Quartzite is exposed in this area. The quartzite has dominance of quartz grains with few flakes of sericites. Poorly developed ripple marks are present. A wedge shaped medium bedded and fractured quartzite band of about 5m wide has pushed into the quartzite as a result of local faults. Upper contact of the wedge has sharp contact but the lower contact has brecciated rock fragments and about half meter thick soil has been developed in the contact area.

Photo 7: Medium bedded and fractured quartzite band in thick bedded quartzite of Kushma Quartzite.

Spot No.8, (49.20km): Destruction of the road by rock fall, Ambot, (Left side of the road).

White quartzites of the Kushma Quartzite are highly fractured and jointed causing easy disintegration of the rock exposures. As a result rock falls and consequent road damages are quite common in this Biruwa-Maldhunga sector of the Pokhara- Beni Road passing through the quartzite area. A white quartzite block of about 1.25m diameter has fallen from the hill slope on right side of the road. The rock fall has damaged 1.5m wide part of the road for a distance of about 4m (photo-8). The quartzite has ripple marks.

Photo 8: Fall of the ripple marked quartzite, which has damaged the road.

Spot No. 9, (50.10km): Reverse Fault between Quartzite and shale at Ambot, Parbat (Right side of the road).

A local reverse fault is present between the overlying white grey, fine grained crystalline quartzite and underlying very fine to massive greenish shale. Underlying shales are pulverized and edges of the overlying quartzites are bent down and fractured as the quartzite bands move upward in relation to the underlying shales along the fault plane. Though the shales, exposed few meters away from the fault contact, are massive in nature, the shales at the fault contact are phyllitic in nature. The quartzite bands have attitude of N55°E and dip55° toward north and the shales have attitude of N60°W and dip 35° toward north.

Photo 9: Downward bent quartzite of the hanging wall lying over the shale of the foot wall at Ambot.

Spot No. 10, (58.50km): Gupteshwar Gupha (Cave), Kushma, (Left side of the road).

A cave is present 50m below the road level near the confluence of two streamlets at Kushma. There are lot of stalactites and stalagmites inside the cave. The cave is about 1km long and sloping up inside. About half meter wide RCC pavement is provided up to a distance of 700m inside the cave. In this area a small temple of Lord Shiva is present and electric light is provided up to this area. Beyond the distance of 700m, the cave gets steeper and narrower. A beautiful gate is made at the entrance of the cave. The cave can be approached from two sides, one from the northern part of the Kushma Bazar and another from the road near the district police station at Kushma. The cave is

developed in glacio-fluvial deposit.

Photo 10: Steps and Entrance leading to Gupteshwar Cave.

Spot No. 11, (59.50km): Scree Deposit NW of Kushma, (Right side of the road).

Scree Deposit of gravels, pebbles and boulders of white grey, fine grained quartzite and some phyllites of Kushma Quartzite occur on the right side hill slope, NW of Kushma. The scree in the form of slope debris consists of pebbles about 25%, cobbles about 30%, boulders about 25% and sand / silt about 20%. As the fragments are not cemented, rock fall to the road is quite common in this area and needs frequent maintenance work.

Photo 11: Colluvial deposits of quartzite.

Spot No. 12, (61.40km): Fault Plane exposed at Armadi, Parbat, (Right side of the road).

A fault plane with fault scarp of about 20meter long is present about 1 km north-east of Armadi on right side of the road. Vegetation including trees is grown on fault zone between the underlying green phyllite and overlying quartzite. Green to dark green phyllite with 10-30 cm thick green sandstone bands is in faulted contact with thick bedded white quartzite. The fault plane has trend of N65°E and dip 50° toward S. The fault zone is 1.5 to 2m wide and consists of breccias of green sandstone and phyllite. Thick vegetation including trees has grown along the fault zone (photo-12).

Photo 12: Vegetation including trees grown along the fault contact between Phyllite and Quartzite at Armadi.

Spot No.13, (63.00km): Landslide pushing out the road, west of Bayerbot, (Right side of the road).

About 50m long creeping landslide from the hill slope on right side of the road near Bayerbot has damaged the road. The landslide has covered the existing road and a temporary road was built about 15m away (SW-W) from its original position. The landslide has occurred in glacio- fluvial deposit of Kaligandaki River.

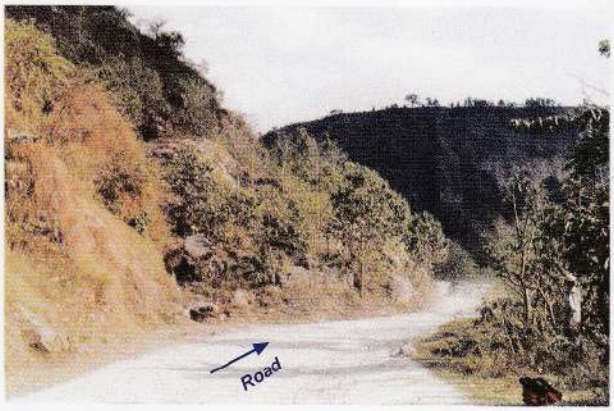


Photo 13: Landslide debris occupying the road at Bayerbot.

Spot No.14, (63.00km): Sand quarry on the flood plain of Kaligandaki River, SE of Nayapul, Left bank of the Kaligandaki River.

Sand along with gravels is quarried on flood plain of Kali Gandaki River on its left bank. The sand is quarried to fulfill the demand of sand in the new construction activities going on in Beni Bazar and Baglung Bazar. As the sand has been quarried quite below the water level of nearby Kaligandaki River, the water from the river is seeping into the quarried area creating a temporary pond. If uncontrolled quarrying of sand in the flood plain continued, the river may change its flow course and may damage the road on its left bank.

Photo 14: Creation of badland topography by haphazard extraction of sand on the flood plain.

Spot No. 15, (68.00km): Glacio-fluvial Deposit unconformably overlying bed rock (quartzite), W of Nuwara, (Right side of the road).

Glacio-fluvial deposit overlies the quartzite unconformably. The quartzites are exposed about 25m above the Kaligandaki River on the left bank hill slope. The quartzite consists of thin to thick bedded light grey, fine grained quartzite. The contact is angular unconformity. The quartzite beds, having a trend of N25°W and dipping at 30° toward E, are overlain by horizontal glacio-fluvial deposit of Kaligandaki River. Lower part of the fluvial deposit is consisted of about 15m thick coarse sand with some gravels and pebbles and few boulders. The coarse sand layer is overlain by more than 30m thick conglomerate layer, consisting of gravels, pebbles, cobbles, boulders and some quartzite blocks of up to 3m wide. The pebbles and gravels are generally sub-rounded but the quartzite blocks are angular. These quartzite blocks should have come from near by quartzite outcrops.

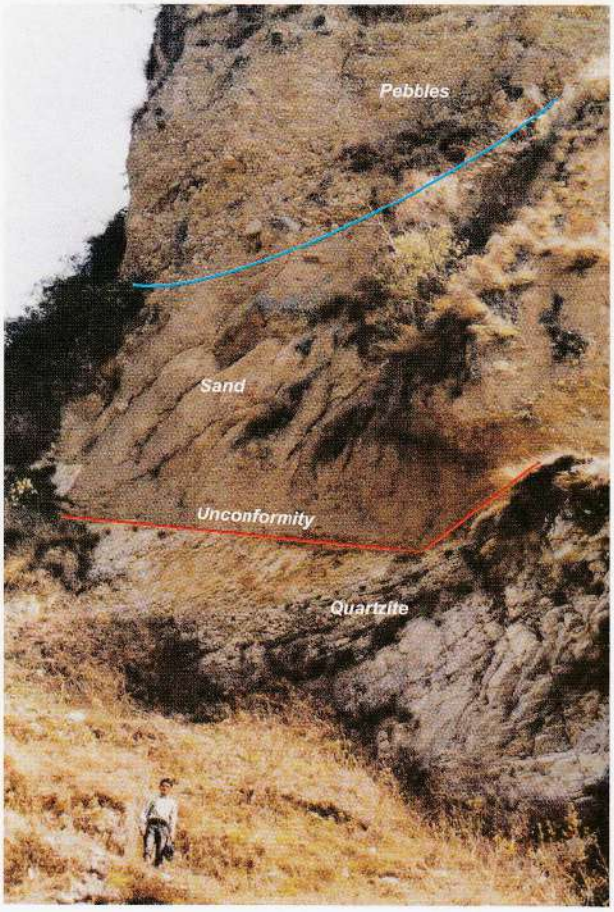


Photo 15: Angular unconformity between east dipping quartzite and horizontal glacio-fluvial deposit.

Spot No. 16, (71.00km): Anticlinal Fold exposed north of Nagliban Khola. (Right side of the road).

10 to 40 cm thick, light grey to white grey, fine grained quartzite interbedded with very fine grained light greenish grey sericitic, chloritic phyllite of Kunchha Formation are forming an anticlinal fold structure. Further to the right limb of the anticlinal fold, a complimentary synclinal fold occurs. The axis of the syncline is faulted forming a reverse fault (photo-16).

Photo 16: Folding in thinly bedded quartzite and phyllite, exposed in left bank of Kaligandaki River.

Spot No.17, (72.00km): Glacio- fluvial deposit exposed on terrace of Baglung Bazar, (Left side of the road).

A thick exposure of glacio-fluvial deposit is present on right bank of the Kaligandaki River. The exposure is more than 80m thick and is exposed on east scarp of the Baglung terrace deposit. The deposit consists of sand and silt with gravels 30%, pebbles 50%, and cobbles and boulders 20%. The gravels, pebbles are moderately sorted and consist of white grey, greenish grey quartzite, fine grained biotite schist, gneiss, calc-gneiss, marbles, phyllites, limestone, calc-schist and some dark grey slate. Generally the cementing material is calcareous. The gravel, pebbles are 80% sub-angular to sub-rounded and about 10% are angular to sub-angular. Top of the fluvial deposit is 230m above the river bed. Red lateritic soil has been developed on top of the fluvial deposit. The exposure lies on the hill slope, one kilometer west of the road.

Photo 17: Gravels, pebbles and boulders of glacio-fluvial deposit on right bank of Kaligandaki River.

Spot No. 18, (73.25km): Sand Quarry on flood plain of Kaligandaki River, South of Lasti, (Left side of the road).

Sand is quarried on the left bank of Kaligandaki River about 1km south of Lasti. The quarrying has taken place 2-3m below the surface. At places, river water has entered into the excavated area. The sand deposit in the area is about 200m long and up to 100m wide. Upper part of the sand deposit is fine grained sand with silt but the lower part consists fine to medium grained sand. The sand mining has caused the formation of artificial low land in the flood plain of Kaligandaki River.

Photo 18: Artificial ponds on flood plain of Kaligandaki River created by extraction of sands below the water level of the river.

Spot No.19, (73.75km): Huge Conglomerate Boulder on middle of Kaligandaki River, Lasti, Parbat, (Left side of the road).

Very huge conglomerate boulder derived from the glacio-fluvial deposit is lying on the middle of the Kaligandaki river channel causing water to divert on both sides of the boulder. The boulder is about 15m long and 5m high above the water surface and occupies about 50% of the river channel in that location. The boulder is consisted of pebbles, cobbles to boulder. Pebbles and cobbles are sub-rounded to rounded, while big boulder and rock fragments are sub-angular to sub rounded. The conglomerate has calcareous cementing material with matrix of coarse sand. This boulder seems to have rolled down from the side hill consisting of glacio-fluvial deposit.

Photo 19: Compact and tough conglomerate boulder of glacio-fluvial deposit, bifurcating the water of Kaligandaki River.

Spot No.20, (74.00km): Recumbent Fold on quartzite of Kunchha Formation at Lasti area, Parbat, (Left side of the road).

A recumbent fold occurs on white grey to greenish grey fine to medium grained, medium bedded quartzite of Kunchha Formation. The fold is exposed on the left bank of Kaligandaki River near Lasti. Numbers of tensional cracks are developed on the limbs of the fold. Quartz veins at right angle to axial plane are common. The fold axis has trend of S70°E.

Photo 20: Core of the recumbent fold exposed on left bank of Kaligandaki River, just below the road at Lasti, Parbat.

Spot No. 21, (78.00km): Slide on glacio-fluvial deposit, south of Beni, (Left side of the road).

Landslide in glacio-fluvial deposit consisting of sub-rounded to rounded gravels, cobbles and boulders with some angular rock fragments is present in the area. Rocks are quartzite, gneiss and phyllites. Presence of some big boulders is retarding the sliding process at some places. Stepped gabion protection wall is provided at the toe of the slide to protect the road from the slide.

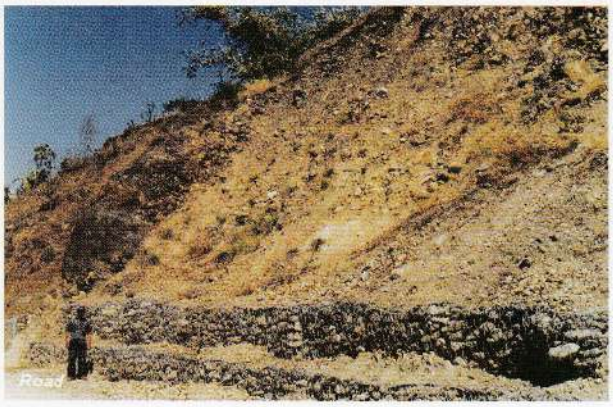


Photo 21: Landslide affecting the road south of Beni.

Spot No.22, (79.00km): Erosion Feature in glacio-fluvial deposit, south of Beni, (Right side of the road).

Big blocks of glacio-fluvial deposits are toppling down the slope. The blocks range in size from a meter to 10 meter in diameter. The deposit is exposed up to 240m high from the current river bed, which indicates that the deposit is more than 240 m thick. A deep vertical erosion of the deposit has created a pointed pinnacle/ earth pillar of about 30m high (photo-22). In these fluvial deposits, small streams are found to erode down ward vertically creating deep and narrow gorges. Another important feature of the fluvial deposit in the area is that the ensuing erosion has created topography with steep scarp on the upper part, relatively gentle slope in the middle part and deposition of toppled blocks on the toe part.

Photo 22: Badland topography created by erosion of glacio-fluvial deposit, south of Pari Beni.

Spot No. 23, (79.90km): Bridge over Kaligandaki River, Beni, Myagdi.

Bridge over Kaligandaki River at Beni was under construction in February 2007 (Photo-23A). Right and left side parts of the bridge had been completed and only central part needed to be constructed. Supporting structures needed to construct the middle part, had been readied, as seen in photo in right part of the bridge. The bridge was completed in June 2007(Photo-23B). Now the vehicle coming along the bank of Kaligandaki River can reach Beni. Previously, only the vehicles coming through Baglung Bazar can reach Beni by crossing bridge over Myagdi Khola, a tributary to Kaligandaki River near Beni Bazar.

Photo 23A: Bridge over Kaligandaki River under construction.

Photo-23B Newly built bridge over Kali Gandaki River.

Spot No. 24, (82.40km): Dandagaon Phyllite exposed at south of Galeshwar, (Left bank of the road).

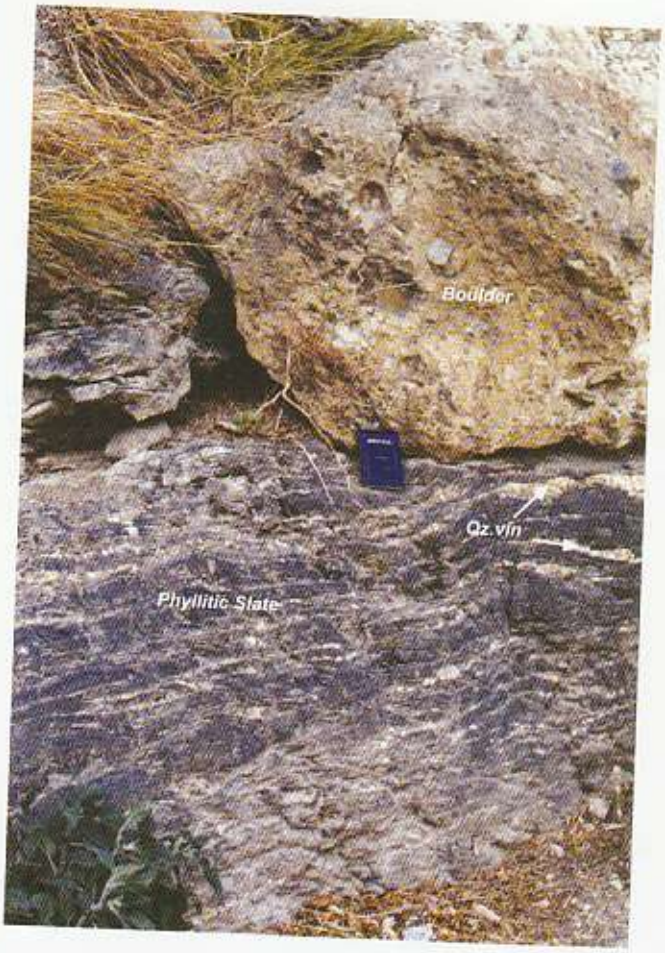


Photo 24: Dark bluish grey slate and phyllite with quartz veins along the foliation planes.

Thinly bedded dark bluish grey to black slate and phyllite of Dandagaon Phyllite with quartz veins are exposed in this area. The quartz veins are 1cm to 8cm thick and are intruded along the foliation plane of the phyllitic slate. A depression has been created on top of the outcrop by the current of the river. Boulders of glacio-fluvial deposit are deposited on the depression. The boulder is consisted of sub-angular to sub-rounded gravels, pebbles of quartzite and limestone

Acknowledgement

The authors wish to express their sincere gratitude to Director General Mr. Pranab Lal Shrestha for providing facilities required for the publication of this guidebook. We are grateful to Deputy Director General Dr. Rajendra Bahadur Shrestha for editing the manuscript, map and his valuable guidance and suggestion in the publication of this guidebook. The authors also wish to thank Geologist Mrs. Shova Singh and Geologist Mr. Kusal Nandan Pokharel for their help in GIS data processing of the map.

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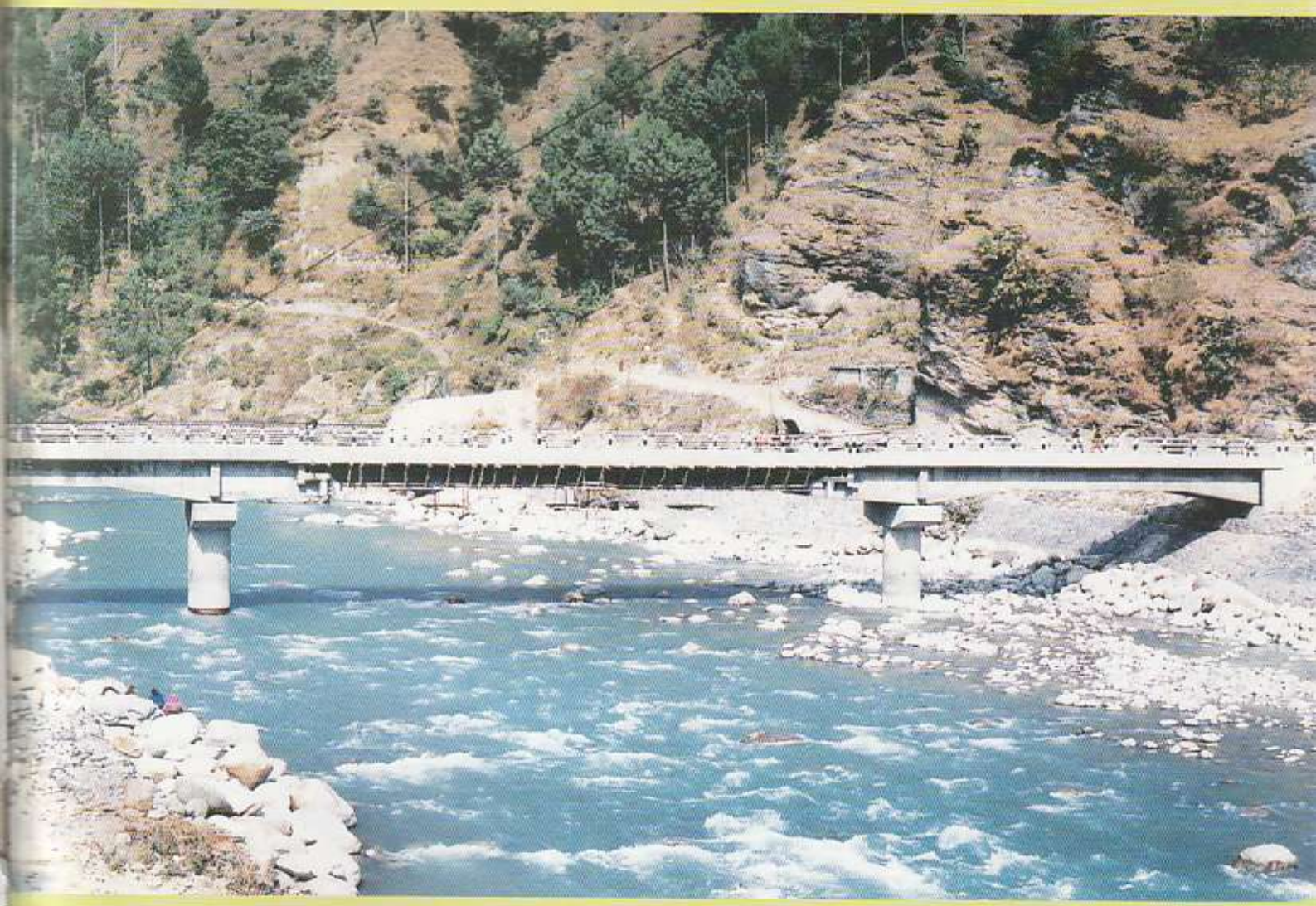
GEOLOGICAL SECTION OF POKHARA-BENI HIGHWAY (BHUPI SHERCHAN MARG)



Bridge over Kali Gandaki River at Beni

Huge conglomerate boulder in the middle of Kali Gandaki River at Lasti