CHAPTER III

GEOLOGICAL SETTING

GENERAL

The rocks of the study area belong to the Nawakot nappe No.3 of Hagen (1969), Chail nappe and Tansing Unit of Fuchs (1967) and the Dhorpatan phyllite zone and Baglung schuppen zone (Midland metasediment group) of Sako et al. (in Ohta & Akiba, 1973).

Structurally, the area is divided into two tectonic units, separated by a thrust running NW-SE in the north-eastern part of the area, passing through the villages of Phalebas and Lame Deorali. This dislocation, designated as

the Phalebas Thrust by the present author, dips due NE and separates the less metamorphosed southern unit from the comparatively more metamorphosed unit in the north. This thrust is comparable with the Chail Thrust of Fuchs (1967) and Lame Deorali Thrust of Nadgir & Nanda (1966).

For the sake of descriptive convenience, the northern unit is named here as Kusma Unit, following the name of one of the important villages to the north of the area. The southern unit is designated as Sirkang Unit after the village of Sirkang (Fig. III.1).

The rock types that are referred to in this chapter are recognised and precisely named on the basis of the field study as well as the microscopic characters. Their detailed petrographic descriptions are given in Chapter IV.

The Kusma Unit mainly comprises a rock assemblage of quartzites, quartz-sericite-phyllite, gritty quartzose phyllites and argillaceous phyllites (Fig. III.2A). To this Unit are confined some lenses of metavolcanics, mostly interbedded with the quartzites. The Sirkang Unit, on the other hand, is essentially composed of slates, slaty phyllites, sandstones, stromatolitic dolomites and carbonaceous slates. The rocks of these two units are easily distinguished

FIG. III.1

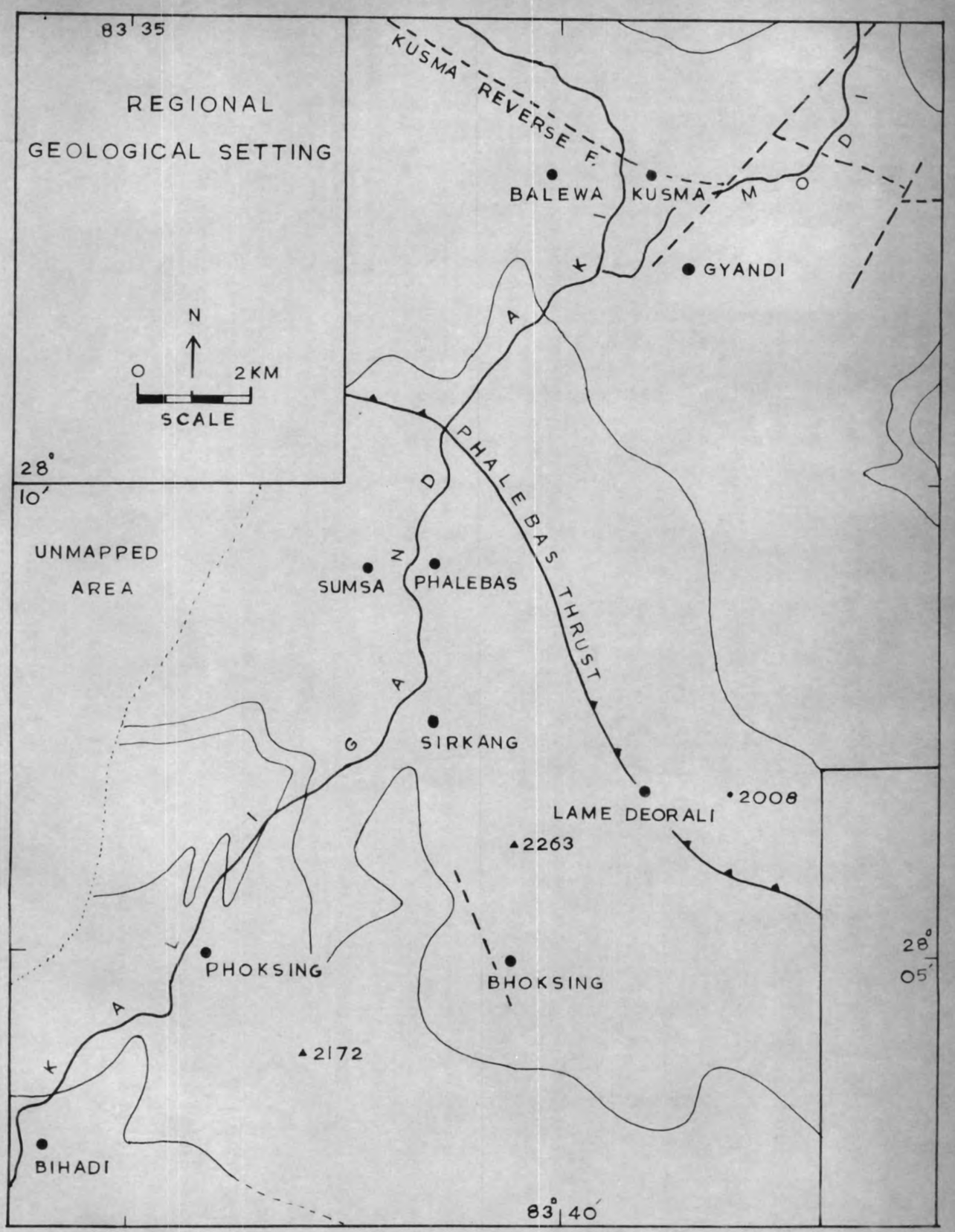
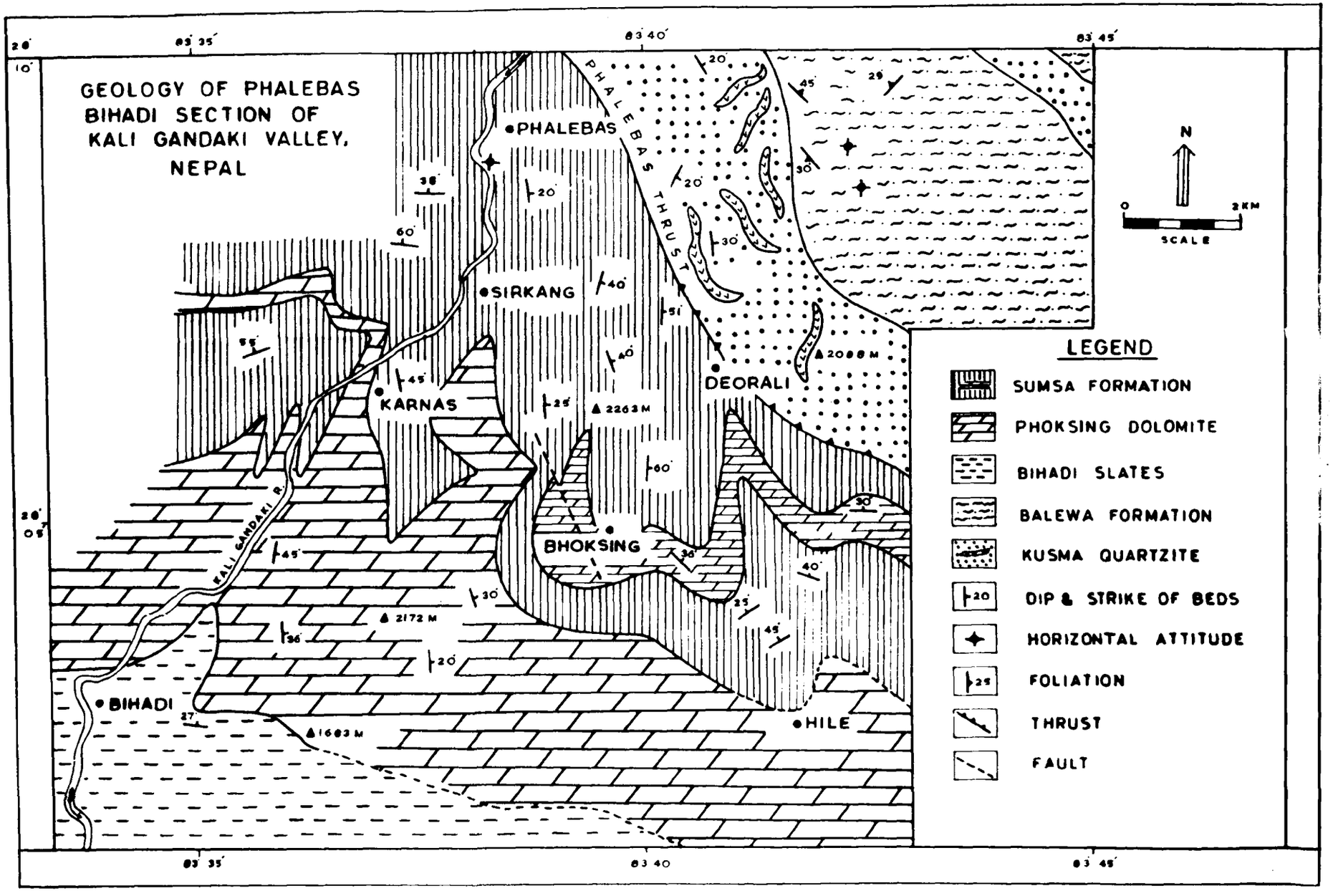

83° 35
REGIONAL
GEOLOGICAL SETTING
N
0
2KM
SCALE
28° 10'
KUSMA REVERSE F.
BALEWA
KUSMA
GYANDI
KHOLA
PHALEBAS THRUST
UNMAPPED
AREA
SUMSA
PHALEBAS
GANDAKI
SIRKANG
LAME DEORALI
2008
2263
PHOKSING
BHOKSING
2172
BIHADI
28° 05'
83° 40'

FIG. III.2


GEOLOGY OF PHALEBAS
BIHADI SECTION OF
KALI GANDAKI VALLEY,
NEPAL
83 35'
83 40'
83 45'
28 10'
28 05'
PHALEBAS
PHALEBAS THRUST
SIRKANG
KARNAS
DEORALI
BHOKSING
BIHADI
HILE
KALI GANDAKI R.
2088 M
2263 M
2172 M
1683 M
N
0
2KM
SCALE
LEGEND
SUMSA FORMATION
PHOKSING DOLOMITE
BIHADI SLATES
BALEWA FORMATION
KUSMA QUARTZITE
DIP & STRIKE OF BEDS
HORIZONTAL ATTITUDE
FOLIATION
THRUST
FAULT

in the field on the basis of their lithology and metamorphism. The Kusma Unit is metamorphosed upto the grade of chlorite-sericite schist facies of the epigrade zone of Barrovian type, while the Sirkang Unit shows only an incipient metamorphism, even preserving the original sedimentary structures to some extent. There is a conspicuous change in the grade of metamorphism when one crosses the Phalebas Thrust.

From north to south, the rocks show the field sequence as shown in table III.1.

The sequence above and north of Phalebas Thrust is repeated twice due to the Kusma Reverse Fault. The rocks below the Phalebas Thrust which show considerably reduced metamorphism is supposed to comprise a group of younger rocks.

The correlation of lithotectonic subdivisions in Lesser Himalaya of Central West Nepal as proposed by various authors is shown in table III.2.

THE KUSMA UNIT

The rocks of this unit have been designated as the Chail Formation by Fuchs & Frank (1970), 'Series de Kuncha' by Bordet et al. (1964a), Suparitar Series by Nadgir & Nanda (1966), Okharbot suite by Talalov (1972) and Middle

Table III.1 Field Succession

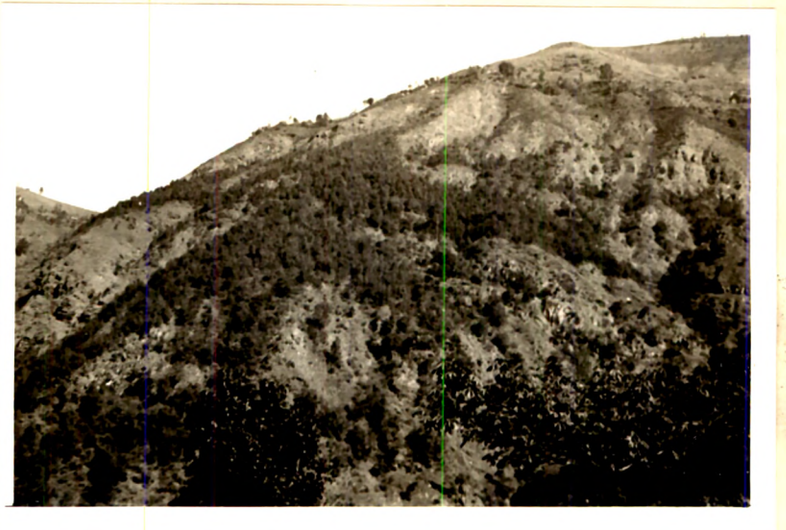
Kusma Unit (Northern Unit)	Balewa Formation	Quartz-sericite-phyllites, gritty quartzose phyllites and flaggy quartzites.
	Kusma Quartzite	White to brownish coloured quartzites with frequent lensoid intercalations of spilites.
	----------Kusma Reverse Fault ----------	
	Balewa Formation	Quartz-sericite phyllites, gritty quartzose phyllites and flaggy quartzites.
	Kusma Quartzite	White to brownish coloured quartzites with frequent lensoid intercalations of spilites.
---------- Phalebas Thrust ----------		
Sirkang Unit (Southern Unit)	Sumsa Formation	Purple, greenish and gray slates, slaty phyllites intercalated with sandstones and thin layers of siliceous dolomite.
	Phoksing Dolomite	Bluish-gray to dark gray stromatolitic dolomite with minor intercalations of carbonaceous slates and intraclastic dolomite.
	Bihadi Slates	Carbonaceous slates and shales with occasional layers of sandstones and dolomites.

argillo-arenaceous subgroup of Midland metasediments of Ohta & Akiba (1973). This rock sequence has been assigned to different ages by different authors and the strong controversy on the age of these rocks exists, till today. Fuchs (1967) and Fuchs & Frank (1970) have shown that the rocks of this unit continue all throughout the Himalaya having an independent tectonic set up and named it as Chail nappe. In Hiunchulli zone, further west, they have split this nappe into three slices as Chail nappes 1, 2 and 3. Hagen (1969) also divides his Nawakot nappe into 1, 2, 3 and 4, but the present study area lies only within his Nawakot nappe 3. Hagen and Fuchs are the two main propounders of nappe concept in this part of Nepal Himalaya. But, Bordet (1964_{λ}^{a}), Nadgir & Nanda (1966), Talalov (1972), Ohta & Akiba (1973) and Remy (1975) etc. do not subscribe to the Nappe Theory, at least in this sector of Nepal Himalaya. According to them, this area constitutes a single wide autochthonous zone which has been intensely folded, faulted and thrusted.

KUSMA QUARTZITE

This quartzitic sequence lying just above the Phalebas Thrust and marking the base of the Kusma Unit constitutes a major lithological unit of the area (Plate III.1). It extends in a belt of about 2.5 km width and runs in the NW-SE direction for nearly 13 km. These rocks are ideally exposed

Plate III.1 A view of Kusma Quartzite.
On the top is seen the village
Thana. Viewed north from Lame.



around Dhunwakot-Thana, Lamai Khola section, and near Jyamireghat bridge. In most of these places, this rock forms very high cliffs. The total thickness varies between 1,000 - 1,200 m but since they are involved in isoclinal folding, the actual thickness could be much less. This quartzitic band suddenly pinches out to the west of Jyamireghat bridge just outside the study area. A little to the north of Kusma village, similar quartzitic rocks form another band of 2.5 to 3 km width that trends WNW-ESE to E-W direction. Here,the Kusma Reverse Fault marks the southern boundary of these quartzites and to the north, upward these pass into quartzose phyllites. Between these two quartzite bands there is a wide belt of Balewa Formation of huge thickness. The outcrops of these quartzites in the Kusma area, have been studied by Toran Sharma (personal communication). The present author also took a number of traverses in the neighbouring areas to fully understand the true nature of these quartzites.

Nadgir & Nanda (1966) and Nanda (1973) in their geological map of Western Nepal have shown three bands of quartzites. The southernmost band, to a little north of their Lame Deorali Thrust, corresponds to the quartzites of the study area. Their next quartzite band northward passes through the village of Nawakot (about 16 air km SW of Pokhara) and it is shown extending for 40 km in the E-W to WNW-ESE direction. This Nawakot quartzite band in all probability

is the same as the one seen north of Kusma. Further north, the third one, an essentially E-W running band lies about 7 km north of Pokhara and these authors have traced it for more than 50 km. According to them, the second and the third quartzite bands are one and the same formation and are repeated due to anticlinal folding, exposing the older grits in the core in Pokhara area. Since, the Syanjya Fault of Nanda (1973) marks the base of Nawakot quartzite, it is quite logical to extend it westward to join the Kusma Reverse Fault. From this, it is obvious that Kusma Reverse Fault is quite an important tectonic dislocation which appears to run for atleast 60-70 km in the E-W direction. The huge cliff-like exposure of quartzites near Nagdanda is also the continuation of the quartzites of Kusma.

It is interesting to note that these quartzitic rocks form distinct bands of considerable thicknesses that persistently run for long distances. Such formations are of great value as a stratigraphic marker horizon. These quartzites will be much useful in sorting out the confused stratigraphy of the Lesser Himalayan metasediments of Western Nepal.

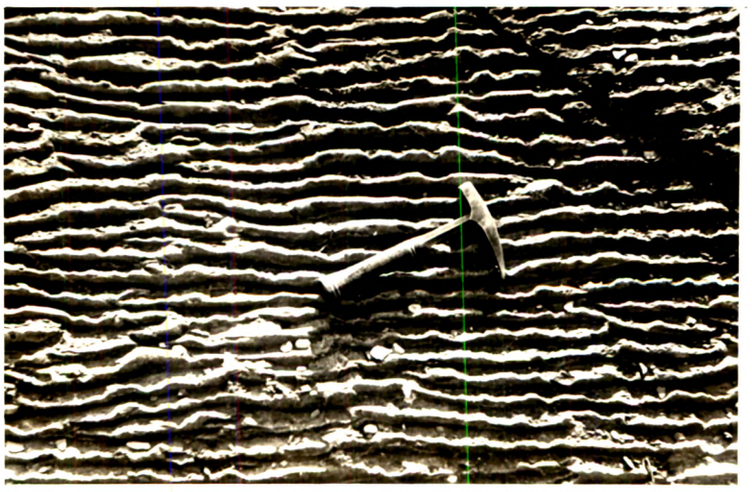
Both the quartzite bands that are exposed in Dhunwakot and Kusma area are very much similar in character.

They are hard, compact and conspicuously bedded. They vary in colour from brownish white, greenish white to white. The primary sedimentary structures like cross beddings and ripple marks (Plate III.2) are widely developed. The attitude of these rocks vary considerably. Near Phalebas village and in Thana area they are almost horizontal, but in the Lamai Khola section near Khalti village, they show almost vertical disposition.

These quartzites contain numerous lenses of basic rocks. These follow the strike of the host rock and seem to be penecontemporaneous lava flows. They form small lenses having concordant relation with the host rock (Fig. III.2). They measure a few meters to several meters in thickness and similarly vary in length. They are dark green in colour when fresh, coarsely crystalline at the core but nearer the margins they form green chloritic phyllites with good development of foliations parallel to the attitude of the country rock. With a few exceptions, most of the basics are highly weathered at the surface. Even some of the fresh-looking rocks show much alteration under the microscope. The basics show interbedded relationship and occasionally inter-mixing with quartzitic material, indicating their penecontemporaneous deposition. A detailed account of these rocks is given separately in Chapter VIII.

Plate III.2 Ripple marks in Kusma Quartzite.

Location: Near Thana (x 1/12).



Apart from the basics, these quartzites are very often intercalated with phyllites and quartz-sericite-phyllites of a few centimeters to a few meters thickness. Near the Gahate village and in Dhunwakot area the quartzites show good exposures of intercalations of quartzose phyllites and argillaceous phyllites.

BALEWA FORMATION

This rock sequence which comes above Kusma Quartzite and exposed north of Dhunwakot (△ 2088), is a major litho-unit of the Western Nepal Himalaya. This is designated as 'Series de Kuncha' of Jurassic-Cretaceous age by Bordet et al. (1964a), as grits belonging to Suparitar Series of Precambrian age by Nadgir & Nanda (1966) and Chail Series of Devonian age by Fuchs (1967). Talalov (1972) includes this rock unit into his Okharwot suite of Cambrian age while Ohta & Akiba (1973) consider it to belong to their mica schist of Eocambrian age belonging to the Baglung schuppen zone. Nadgir & Nanda (1966) and Nanda (1973) have shown this rock unit to extend in the E-W direction for more than 100 km from Kuncha in the east to Dhorpatan in the west, with an average width of about 20 km along the Pokhara section, lying between the two bands of previously described quartzite. They consider this rock to be oldest of the Suparitar series. Fuchs (1967) has shown

this rock lying to the north of his Chail Thrust to extend continuously westward right upto the Simla area and beyond in the Indian Himalaya.

The main bulk of this thick, monotonous formation comprises of quartz-sericite-phyllites, gritty quartzose phyllites, argillaceous phyllites and frequently interbedded flaggy quartzites. Very rarely, some smaller basic lenses are also associated with this rock unit. In the upper reaches of Lamai Khola, pebbly quartzites of 1 to 2 m thickness are encountered in this formation. The attitude of foliation varies considerably from nearly horizontal to almost vertical in various directions. This is obviously due to the complicated fold patterns resulted on account of superimposed deformational episodes. Original bedding planes are somewhat obscured, except in the quartzitic layers, and they are difficult to be recognised in the quartz-sericite-phyllites and gritty quartzose phyllites.

Quartz-sericite-phyllite is the dominant rock type, and makes up a major proportion of this rock unit. They are medium to finegrained, light gray to greenish gray in colour with a silky lustre. They are mainly composed of quartz, sericite and chlorite with sporadic development of muscovite in some cases.

The gritty quartzose phyllite is essentially composed of large augen-shaped (megascopically identifiable) grains of quartz (1 - 2 mm) along with a few similar grains of felspars embedded in a matrix of fine quartz, sericite mica and chlorite. Chlorite and sericite are easily identified in hand specimens and due to the presence of these minerals along with the flattened quartz grains, the rock has been imparted a well developed cleavage.

Argillaceous phyllite is another rock type that is usually interbedded with quartz-sericite phyllite. It comprises thin layers of few centimeters to several meters in thickness. Highly flaggy quartzites of variable thickness are also commonly intercalated with quartz-sericite-phyllite. Such intercalations are best observed in the Khalti Khola section to the north of Dhunwakot (2088 m). Discontinuous bands of 1-2 m thick crystalline carbonate rocks (dolomitic) occur at a few localities.

The various phyllites and quartzites of this formation have faithfully preserved lineations related to different fold events, and almost all exposures exhibit at least two sets of pucker lineations related tc two successive fold generations. The interference of folds particularly of the last two

generations has given rise to a large number of shallow basins and low domal structures.

THE SIRKANG UNIT

This unit lying to the south of Phalebas Thrust has been variously interpreted by different authors. Fuchs & Frank (1970) called this as Tansing Unit (= parautochthonous Krol Unit of Fuchs, 1967). Talalov (1972) in his geological map has shown this unit to comprise partly his Hilang suite of Proterozoic age and Tara Suite of Cambrian age. Nadgir & Nanda (1966) have shown the area to belong to the Suparitar Series of Precambrian age. This unit also lies within the Dhorpatan phyllite zone of Midland metasediments of Sako et al. (In Ohta & Akiba, 1973).

An important feature of this unit is the occurrence of stromatolitic dolomites. The algal structures are the only record of life that existed in these metasedimentaries of Lesser Himalaya and these organosedimentary structures are of some help in fixing the age and stratigraphy of the rocks in absence of any other criteria. The Japanese authors, Ohta & Akiba (1973) have taken the dolomite of this unit as a marker horizon for arriving at their lithostratigraphic subdivisions.

A major portion of the study area falls within this unit, which consists of the low grade metamorphic rocks - slates, slaty phyllites, sandstones and stromatolitic dolomites. By and large, the rocks show an almost N-S strike with variable easterly dips. In the north-western and south-eastern corners of the area, however, the attitude of the rocks varies considerably and instead of the general N-S trend, it tends to fluctuate to almost E-W dipping due N.

This unit has been further sub-divided into three formations as under (Fig. III.2):

Sumsa Formation,

Phoksing Dolomite,

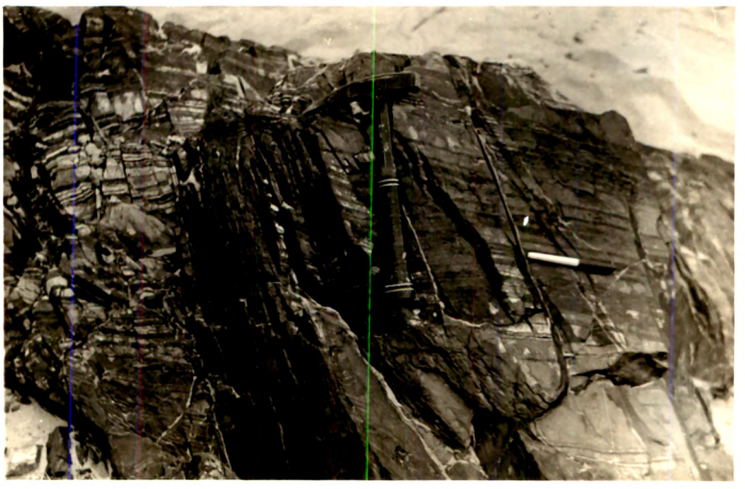
Bihadi Slates.

BIHADI SLATES

These slaty rocks are encountered in the southern extremity of the area and physically lie below the Phoksing Dolomite (Plate III.3A). They however, extend in force southward beyond the limits of the study area. In the previous literature, these rocks have been named as carbonaceous shale of Silurian age by Bordet et al. (1964a), carbonaceous shale by Nadgir & Nanda (1966) and Fuchs (1967) identified these rocks as Infra Krols. Comprising a group of dark gray to

Plate III.3A Field photograph showing the sharp contact between the Bihadi Slates and the overlying Phoksing Dolomite. The contrast in vegetation marks the boundary. Viewed north from Namnadi.

Plate III.3B An outcrop showing the relation between cleavage and bedding in Bihadi Slates. The surface over which pen lies marks the cleavage plane.
Location: About 1.5 km N of Purtighat, on the west side of Kali Gandaki river.



grayish black carbonaceous slates, these are conspicuously exposed in the relatively low altitude terrain. On the hill slopes, the exposures of these black slates show partial bleaching and a blotchy appearance. Good exposures of these rocks are encountered in the Bihadi and Purtighat areas. At places, the slates are highly ferruginous, though these have quite restricted occurrence as thin narrow layers of red coloured slates within the carbonaceous slates. The slates reveal traces of isoclinal folds, such that the cleavage marks the axial plane. At most places, the bedding is difficult to observe, but a careful scrutiny of a large number of outcrops ideally shows mesoscopic tight folding. Quite often the alternation of their layers of grayish black and light gray color conspicuously reveal the cleavage bedding relationship (Plate III 3B). The axes of these folds as also the lineations due to cleavage-bedding intersection, are related to this fold episode and show fairly diverse orientation.

PHOKSING DOLOMITE

Dolomites constitute the important rock unit of the present study area, and roughly occupy about one third of the mapped terrain. This formation mainly comprises the high and rugged portion in the southern half of the area, physically lying below the Sumsa Formation to the north. The dolomites show a typical outcrop pattern forming tongue-like

exposures in a N-S direction indicating their folded nature. In Bhoksing-Gorlang danda section, they are very well exposed and a complete section from the base of the Kali Gandaki river (610 m) to the Gorlang Khoria (2172 m) is seen. This formation is several hundred meters thick, though the isoclinal folding has rendered its true thickness difficult to measure. These dolomites are massive to thickly bedded,with numerous joints. The massive nature of the rock and scarcity of the startification laminae render it difficult to recognise the bedding plane surfaces. However, the algal laminae which are parallel to the bedding planes are good indicators of the bedding.The constituent rocks are dominantly massive, fine grained, bluish gray to dark gray dolomite with spcradic intercalation of black carbonaceous slate. A fairly large lens of carbonaceous slate is found intercalated with dolomite near Gorlang danda (2172 m).

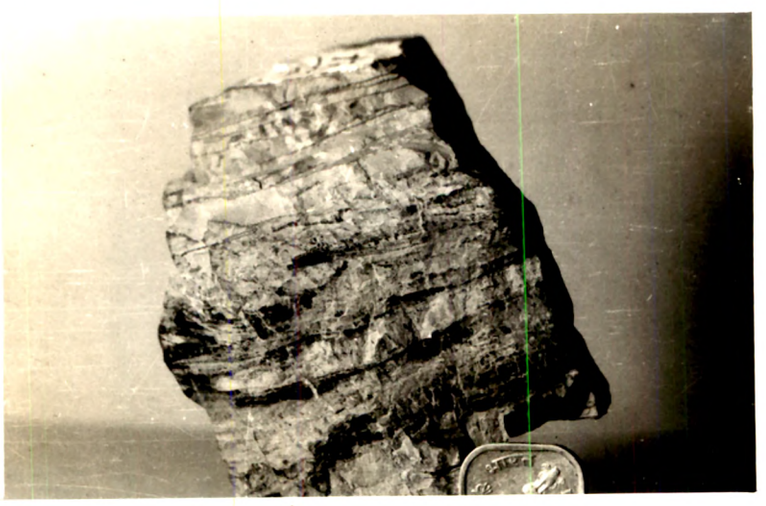
The dolomite rock is on the whole, very fine grained and its thin sections do not reveal much except the patches of crystalline dolomite and quartz grains. An interesting feature of this formation is the occurrence of layers of <u>intraclastic dolomite</u> (Plate III.4A). They are typically recognised in hand specimen by the presence of rounded to subrounded fragments of dolomite (0.2 to 1 m) cemented by crystalline dolomite. But sometimes they are composed of very angular

Plate III.4A Field photograph of intraclastic dolomite.

Location: About 1.5 km NE of Sakuni village, exposed on the main route along Kali Gandaki valley (x 1/7).

Plate III.4B A dolomite specimen showing layers of black chert.

Location: About 2 km E of Sakuni along the Khahare Khola section (Approx. natural size).



fragments of dolomite of larger dimensions. Oolites are commonly associated with these intraclasts. Such intraclastic rocks are encountered around Karnas bridge, Gebtan and Sakuni villages.

The boundaries between the dolomite and overlying as well as underlying rock sequences are generally sharp. Southwest of Bhoksing village, along the upper reaches of Bachha Khola, however, the contact is gradational. The overlying phyllites, dolomitic sandstones and slates are found to contain intercalations of dolomite near their lower contact. Near Bagmara village, the bluish gray dolomite grades into pinkish dolomite upwards. Bedded black cherts are sometimes associated with dolomite (Plate III.4B).

Development of stromatolite is observed in almost all parts of this formation, and these algal structures have been found very useful in obtaining detailed information on the environment of deposition and age of these rocks. The most abundant forms of stromatolites found in this area are similar to the structures generally described as the genus Collenia and Conophytons. A critical evaluation of these stromatolitic carbonate rocks is given in Chapter VII (Carbonate Rocks).

SUMSA FORMATION

This formation lies above the Phoksing Dolomite and its northern extension is truncated by the NW-SE running Phalebas Thrust. It was named as Purple formation by Nadgir & Nanda (1966), whereas Fuchs (1967) considered this rock to be partly as Jaunsars. The formation is dominantly composed of slaty and phyllitic rocks with intercalations of sandy and dolomitic layers. The lower part of the sequence is characterised by the presence of fine grained pinkish siliceous dolomite, dolomitic sandstones and purple slates intimately intercalated, and variegated slates with layers of sandstones of variable thickness. These are best developed in the Luwa Khola and Bachha Khola sections. The upper section of this sequence, on the other hand, is almost exclusively composed of argillaceous rocks. Here, the slates are usually dark gray, grayish black and greenish in colour. Typical exposures are seen in the lower reaches of Chirdi Khola section, Kurgha, Sumsa and Chokhya village area.

The slates and slaty phyllites are the dominant rocks and make up the main bulk. These are intercalated with pink coloured dolomitic sandstones and layers of graywacke. The former are quite intimately intercalated and are typically seen as distinct bands of a few millimeters to as much as a meter or so. They are even seen to form lenses within each other. (Plate III.5A).

Plate III.5A A specimen showing the alternate layers of purple slate and siliceous dolomite in Sumsa Formation.
Location: About 0.4 km W of Karnas bridge.

Plate III.5B An exposure of the alternate layers of purple slate and siliceous dolomite in Sumsa Formation.
Location: Near Bagmara.


0 1cm

The pink siliceous dolomites and dolomitic sandstones are very characteristic. Usually, they are fine grained and intimately intercalated with purple slates and occasionally with green and gray slates (Plate III.5B). When the carbonate minerals are leached out due to weathering, the dolomitic sandstones become highly friable. The thickness of the individual band is rarely more than a meter. The proportion of the slates and these dolomite rocks varies very much in different sections. The rock is best exposed in the lower section of Luwa Khola, Bachha Khola, Lunwa Khola and Cahur Khola. These siliceous dolomites readily give effervescence with dilute HCl. The mineral dolomite occuring in these rocks are identified in thin sections by staining method. Desiccation rocks are widely developed in these rocks (Plate III.6).

The sandy layers (sublitharenite, felspathic graywacke, lithic graywacke) are found at different horizons of this formation. The thickness of the individual layers varies from less than a meter to more than 100 m. These rocks are medium to coarse grained, fresh, hard and compact. The rocks are generally darker in colour especially when the chloritic content is high. Occasionally, they also contain pyrite crystals. They show distinct bedding planes and a good development of joints. Ripple marks are very common. The petrography of these sandstones are dealt with in Chapter IV.

Plate III.6 Desiccation cracks in purple slate and siliceous dolomite of Sumsa Formation. The cracks reveal the underlying dolomite.

Location: 1.2 km SSE of Bhoksing (x 1/6).