

CHAPTER III
S T R A T I G R A P H Y

GENERAL

The Garampani area comprises a part of the southeastern extremity of the Krol belt, lying to the north of Naini Tal and its rocks compare fairly well with those of the type area described by Auden (1934).

No one has worked out the stratigraphy of this area in the past, and it appears that this part of Naini Tal district remained neglected because of its inaccessibility and rugged topography. Perhaps, the structural complexity of the area might also have prevented workers

from going into the details of its lithology and stratigraphy. As will be evident from this chapter, it is for the first time that a detailed and convincing stratigraphy of the terrain north of Naini Tal has been worked out. The author had the opportunity to collect adequate data including that on structure, based on which he has built the structural and stratigraphic picture of the area (Fig. 3.1 and 3.2).

For the purpose of nomenclature and correlation, the author has relied mainly on the classic work of Auden (1934). He has also based his study on the work of Heim and Gansser (1939) especially on the Naini Tal region. But in matters of detailed interpretation his conclusions are at some variance with these two authors. The most important aspect of stratigraphy on which the author has differed from Heim and Gansser (1939) is that of the age of lowermost quartzitic rocks that overlie the foliated traps (= Bhowali Traps). According to Heim and Gansser, they are Nagthats, while the author has considered them as equivalent to the Blainis. There are ample evidences to suggest that these bouldery quartzites with overlying slates and limestone, comprise the Blaini sequence.

In working out the stratigraphy, the author has taken into account an important structural consideration that the area shows three episodes of folding. The major anticlinal structure of the area viz. Garampani-Bardau Malla anticline which is the north-western extension of the Bhowali anticline represents an early fold episode; and on it two later folds have been superimposed. This fact has been ideally brought out by Devendra Pal (personal communication) in his studies on the rocks of Naini Tal to the south. Devendra Pal has established that the synclinal structure of Naini Tal belongs to the second fold episode superimposed on a pair of tight anticline and syncline which is of the same generation as Bhowali anticline. Devendra Pal has brought out this fact for the first time. O.K. Shah in the neighbouring Bhowali-Bhimtal area has also recognised E-W folds (related to Naini Tal synclinal folding) distorting the Bhowali anticline. The slaty cleavage developed during the first folding and was affected by these second folds (Fig. 3.3).

The various structural details of the area have been discussed in Chapter V, and here, the author has confined himself only to the stratigraphic and lithologic details of the various formations.

As the north eastern limb of the regional anticlinal structure is truncated by the Ramgarh thrust, the actual succession on two limbs of the anticline are rather different. The north-eastern limb, shows the following succession:

Quartzites and slaty phyllites
 Limestone with slates
 Slates interbedded with quartzites
 Sheared granites and granophyres
 - - - - - Ramgarh Thrust - - - - -
 Pebbly and bouldery quartzites
 Foliated Trap

In this succession, the rocks that come above the thrust, are older to the pebbly and bouldery quartzites, and obviously the succession is not stratigraphical. On the other hand, the succession on the south-western limb is normal and uninterrupted as under:

Grey slates, silty slates and quartzites(interbedded)
 Purple and carbonaceous slates with limestone
 Grey slates and quartzites (interbedded)
 Pebbly quartzites, sub-graywackes with thin slaty layers
 Bouldery quartzites
 Foliated Traps

The above sequences on synthesis have provided the following stratigraphic succession:

Carbonaceous and purple slates, silty slates and pebbly quartzites	0 0 0	Infra-Krol
Purple and carbonaceous slate with limestone	0 0 0 0 0	
Gray slates and quartzites (interbedded)	0 0 0 0 0	
Pebbly quartzites, sub-graywackes with thin slaty layers	0 0 0 0 0	Blaini
Bouldery quartzites	0 0 0 0 0	
Foliated Traps	0 0 0 0 0	
- - - - - ? Unconformity - - - - -		
Quartzites and slaty phyllites	0 0 0 0 0	
Limestones with slates	0 0 0 0 0	
Slates interbedded with quartzites	0 0 0 0 0	? Nagthat
Sheared granites and granophyres	0 0 0 0 0	

The Blaini-Infra-Krol sedimentary sequence rests over the foliated traps, while Nagthat sequence is considered older to the traps. It is not clear whether the trappean rocks form a part of the Nagthat sequence or they represent a post-Nagthat volcanic igneous activity. O.K. Shah has found these rocks in the Bhowali-Bhim Tal area to be of spillitic nature, comprising submarine lava flows and tuffaceous beds associated with graywackes. It is not

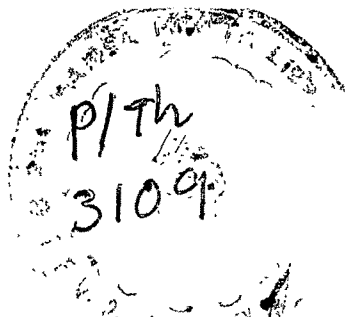
unlikely that these typically represent geosynclinal volcanism heralding and preceding the deposition of the Krol group (Blaini-Infra-Krol-Tal sequence). The boulder beds that overlies these traps are no doubt discontinuous, but neither the author in the present area, nor O.K.Shah in Bhowali-Bhim Tal area has come across any distinct unconformity between the two.

Keeping this in mind the author has provisionally kept the traps in between the two groups of geosynclinal sequences, with a likelihood of these representing the earliest event of the miogeosyncline (with a floor of Nagthat) which was the site of the deposition for Krol group sequence.

LITHOLOGY

Nagthat Formation

To this formation, have been assigned the rocks that come above the Ramgarh thrust, to its north and northeast. The rocks comprise a fairly prominent sequence extending right upto the South Almora thrust. As this formation is bounded by two thrusts above and below, it is obvious that only a part of its complete succession is represented here. The trappean rocks that underlie



Blainis are perhaps younger to this formation. Allowing for the effects of Ramgarh thrust (and South Almora thrust), the Nagthat formation as represented in the area has been given the following sequence.

Folited traps (with intercalations
of quartzites)
-----? Unconformity -----
(Top not seen)
Quartzites interbedded with slaty
phyllites
Limestone with slaty phyllites
Quartzites interbedded with slaty
phyllites
Sheared granites and granophyres
(Base not seen)
----- Ramgarh thrust -----

The author has designated this Infra-Blaini sequence as Nagthat formation, following recent correlation of the rocks by Tewari and Mehdi (1964) and Mehdi et al. (1972). These workers have included this entire sequence under the name of Nagthat formation to represent early Paleozoic (Infra-Blaini) metasediments. The various members of the formations have been briefly described below.

Sheared granites and granophyres resting over the Ramgarh thrust, are an interesting group of green foliated "porphyry" looking rocks. In the study area, only a small portion of these is encountered, and ideal exposures are seen on the roads to Almora and Ranikhet near the Khairna bridge and the village Bhujan (Plate 3.1). These sheared and mylonitised granitic and granophyric rocks form extensive exposures in the Ramgarh area in the SE, and J.P. Patel (1971) has studied them in much detail. In Ramgarh area, these sheared rocks contain numerous phyllitic and quartzitic layers, but the author did not encounter them in the present area. J.P. Patel (1971) has not mentioned granophyric rocks, but a scrutiny of thin sections of rocks from his area as well as those of the present area, does show that prior to shearing, in addition to the granite, some "porphyries" also existed. S.G. Patel (personal communication) has come across extensive granophyric rocks occurring in association with granites in the Amritpur (Fig. 3.3) and perhaps it is the same granophyre-granite association that has been sheared by the Ramgarh thrust.

The intensity of shearing decreases on going away from the Ramgarh thrust. The rock, in hand specimen, is

PLATE 3.1

Sheared granites and granophyres
(Loc. Bhujan)

seen to be of light green colour, highly foliated and containing augen shaped "porphyroclasts" of quartz and felspar. Thin sections reveal drawn out streaks of quartz and sericite-quartz in a highly foliated chlorite-sericite groundmass. The former indicate the stretching, granulation and destruction of coarser quartz and felspar grains. Some samples show considerable microfolding and development of a crenulation cleavage (Plate 3.2). Biotite is seen to have changed over to chlorite. Away from the thrust, partly broken augen-shaped "porphyroclasts" superficially resemble metasomatically grown porphyroblasts, and in the past quite a few workers have mistaken this rock to be a product of progressive migmatization (Pande 1956, Kashyap, 1972).

The author believes that this sheared and mylonitised rock represents the granophyres and granites intruded into the sedimentary sequence, sometime before the Rangarh thrust, and perhaps these are acidic differentiates genetically related to the effusive mafic igneous activity widespread during the Nagthat period.

Quartzites, slaty phyllites and limestones: Just above the chloritic and sericitic sheared granitic-granophyric rocks, there is a 900 meter thick sequence

PLATE 3.2A

Sheared granitic rock showing granulation and alteration of feldspars. (Photomicrograph: cross nicols, X45).

PLATE 3.2B

Sheared granitic rock showing crenulation cleavage. (Photomicrograph: cross nicols, X45).

of interbedded quartzites and slaty phyllites. The beds of constituent rocks, viz. quartzites and phyllites are not very thick, and usually the individual layers never exceed 50 meters in thickness. The quartzites are of cream white, grey and greenish colour, gritty and distinctly flaggy. In thin section, these show a medium-grained mosaic of sutured quartz and streaks of tiny biotite flakes. Occasional grains of oligoclase are also seen. Biotite streaks mark the foliation. Tourmaline occurs as accessory mineral (Plate 3.4A). Sedimentary structures other than bedding are not seen. The phyllites are nearer to slate, and show greenish grey colour.

Overlying this quartzite phyllite sequence is a conspicuous limestone horizon having a thickness of 225 m (Plate 3.3⁸⁺⁹). The rock consists of thickly bedded siliceous limestone of grey and greyish-black colour with interbedded thin grey carbonaceous slates. Original sedimentary bedding is distinctly preserved.

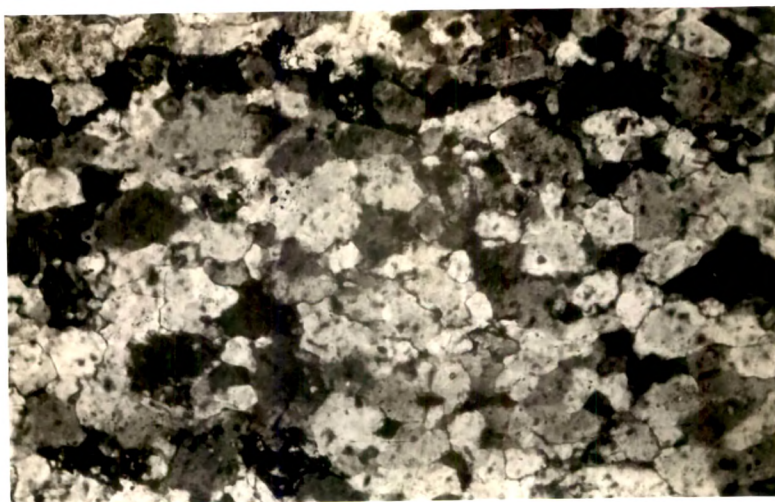
Thin sections of this limestone show an almost exclusive content of calcite and quartz, the calcite always predominating. The texture is crystalline granulitic, the calcite grain showing somewhat flattened shape, quartz grains are tiny, flattened and arranged in streaks (Plate 3.4B).

PLATE 3.3A

Nagthar limestone showing drag folds
(Loc. Between Patli Talla & Patli Malla).

PLATE 3.3B

Nagthar limestone showing drag folds
(Loc. Near Tripola)

PLATE 3.4A

Texture of flaggy quartzites (Nagthat)
(Photomicrograph: cross nicols, X45).

PLATE 3.4B

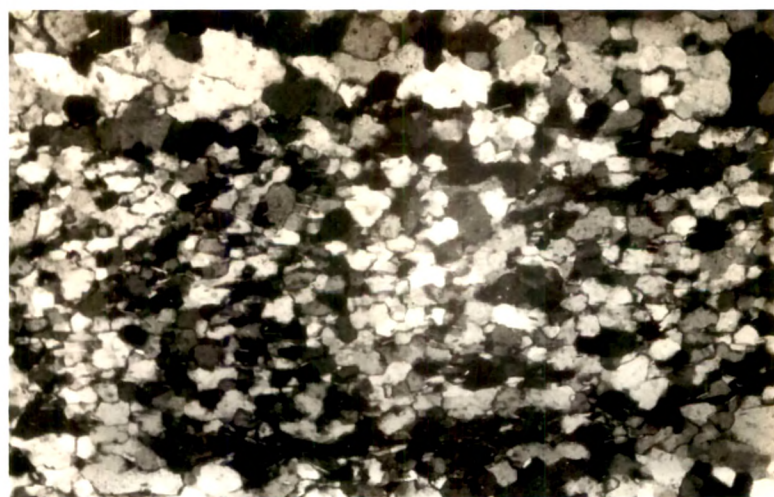
Texture of crystalline limestones.
(Photomicrograph: Cross nicols, X45).

Above this limestone, comes another sequence of quartzite-phyllite. The quartzites dominate over phyllites. Quartzites are white, pink, yellow and buff coloured, both massive and flaggy. The slaty phyllites are of greenish grey colour. The quartzites beds vary in thickness from a few cm to as much as several meters, but the phyllite layers never exceed 10 meters. Intermediate varieties with considerable mica content are quite common, and those could be considered as quartzose phyllites. It is a very thick sequence, its upper portion cut by South Almora thrust.

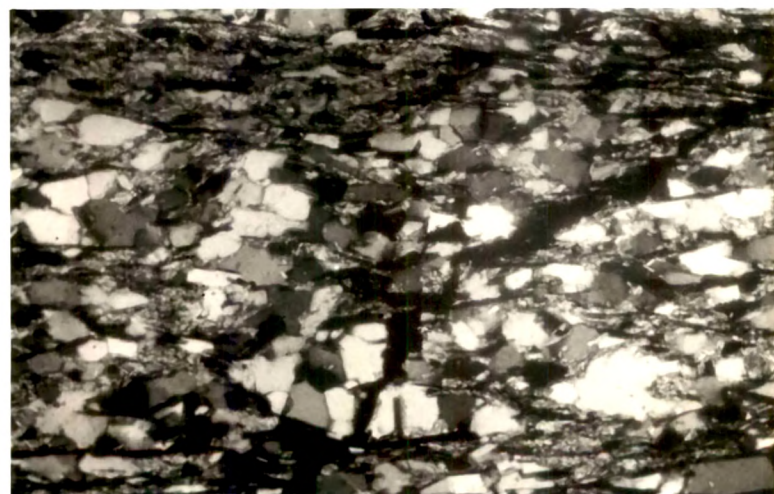
The quartzites in thin section reveal an equigranular mosaic of partly interlocking equidimensional quartz grains. Biotite flakes are confined to discrete streaks, the parallelism of which characterises the foliation. At most places the biotite is seen changed over to green chlorite (Plate 3.5A). More biotitic and flaggy varieties (= quartzose phyllites) show in thin section, a strongly foliated mass of biotite and muscovite flakes interspersed with lensoid aggregates of quartz grains (Plate 3.5B).

Foliated Traps

The traps that underlie the bouldery quartzites, have been considered by the author to be younger than the Nagthat formation. These mafic rocks represent

PLATE 3.5A

Texture of Nagthat quartzite above limestone.
(Photomicrograph: cross nicols, X45).

PLATE 3.5B

Texture of quartzose phyllites (Nagthat)
(Photomicrograph: cross nicols, X45).

volcanic activity at the close of the Nagthat deposition, and comprise penecontemporaneous sub-marine lava flows, tuffs and ash beds. The author has not made any detailed study of these trappean rocks, but O.K. Shah (personal communication) has established that these igneous rocks are typically of spil~~l~~itic affinity and form an integral part of the beginning of the deposition of the overlying Blaini-Infra-Krol sequence.

In the study area, the author has recorded only two main varieties of traps. One is a fine grained aphanitic greyish green rock, showing a well defined foliation in hand specimen (Plate 3.6). These could be easily mistaken for chloritic slates. Frequent presence of deformed amygdules and vesicles is not uncommon. In thin section however the foliation is not recognised so well. Texturally, the rock is typically basaltic, showing small laths of plagioclase in an illdefined chloritic groundmass. The amygdules are of calcite, chlorite, chalcedony and epidote (Plate 3.7A). Some samples have been found to be rather coarse grained - almost a diabase. Relicts of ophitic texture are clearly observed. The feldspar is oligoclase (An_{15-20}) much altered. The pyroxene

PLATE 3.6

Trap showing well defined foliation
(Loc. Near Majhera).

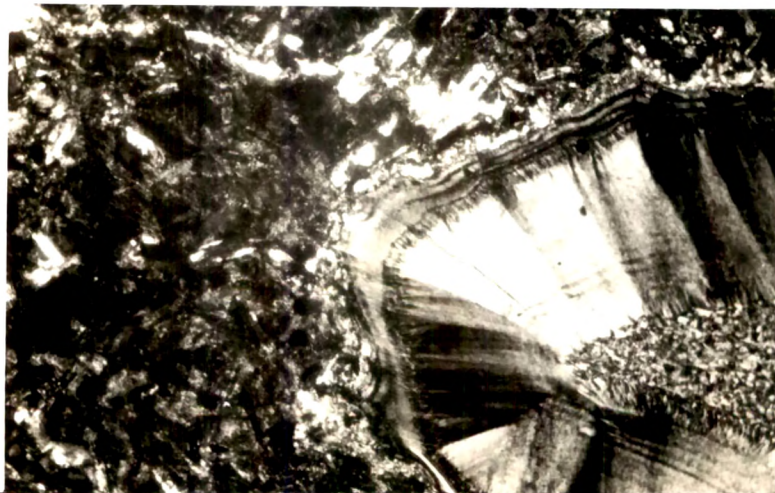
originally an augite is now seen partly altered to uralite, chlorite and epidote etc. Finely granular leucoxenised illminite is a characteristic accessory (Plate 3.7B).

The submarine character of these rocks is shown in the granulation effect, G. Meska and F. ^{Fiala}~~Pollia~~ (1966, pp. 23,25) introduced this term for disintegration of hot thin lava, occasionally containing some gases and flowing violently into water. In contact with water, the lava, frothy due to sudden drop of pressure, cooled quickly and disintegrated into minute granules. At times these granules form lumps by a process similar to that of furnace slag granulation. The author has collected a few samples of this trap that show the granulation effect. These resemble a furnace slag in hand specimens (Plate 3.8A) but under microscope, revealed their basaltic nature (Plate 3.8B).

According to the above mentioned authors, this granulation phenomenon is a process characteristic of shallow marine volcanism and somewhat identical to the pillow structure. Pillow structure is supposed to develop at greater depth with strong pressure of water column on the lava effusion. Thus, the absence of typical pillow structure suggests that the depth of water must not have been great, at the time of the volcanism in the study area.

PLATE 3.7A

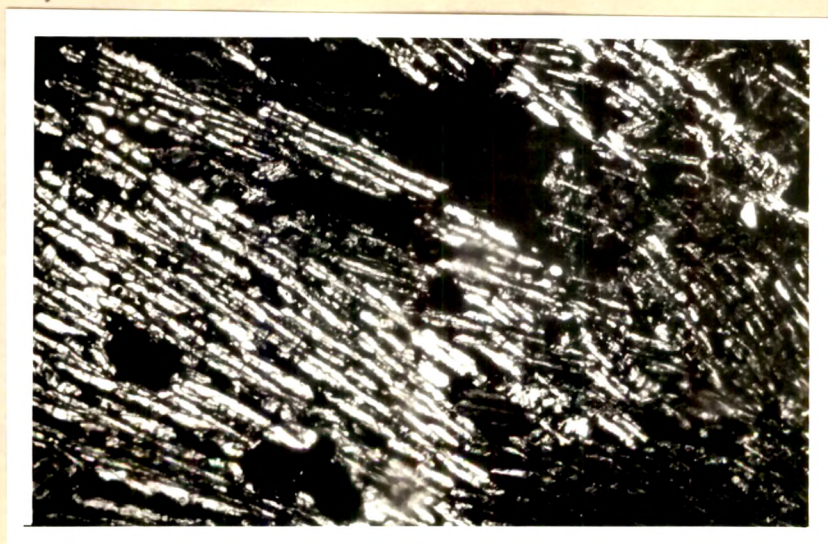
Coarse basaltic texture of traps
(Photomicrograph: cross nicols, X45)

PLATE 3.7B

Fine basaltic texture with amygdules of
chlorite (Photomicrograph: cross nicols, X45)

PLATE 3.8A

Handspecimen of granulated trap
resembling slag.

PLATE 3.8B

Texture of granulated trap
(Photomicrograph: cross nicols, X45)

As only a very small and uppermost portion of the traps, is exposed in the study area, it was not possible to investigate these rocks in detail, nor were any inter-bedded quartzites encountered. But further south, frequent bouldery beds and quartzitic layers have been mapped by O.K. Shah and S.G. Patel (Fig. 3.3).

It is difficult to conclusively state whether an unconformity exists between the Nagthats and the Traps. Nowhere this contact is encountered. But as these traps have been taken as the earliest representatives of the geosyncline in which the Krol group was deposited, unconformity below the formation comprising beds of lava flows tuff and associated sediments, cannot be ruled out.

Blaini Formation

The sequence of bouldery and pebbly quartzites, carbonaceous slates and limestones that come over the traps have been taken as Blainis by the author. None in the past, has recorded the limestone in this area and the entire terrain of the study area was taken to be of quartzites of Nagthat age (Heim and Gansser, 1939). The author has joined-up his map with that of the area to the south prepared by Devendra Pal (personal communication) and both fully agree about these being Blainis.

The Blaini succession in the study area is almost complete, consisting of the following members:

Purple and carbonaceous slates (with limestone).

Pebbly quartzites and sub-graywackes with thin slaty layers.

Bouldery quartzites.

The lowermost member, the Bouldery quartzites (Boulder beds) come over traps, and are ideally exposed along the Garampani scrap at Khairna bridge and in the Kosi valley on way to Bardau Malla along its northern bank (Plate 3.9A and B). The rocks contain sub-rounded to sub-angular boulders, cobbles, pebbles and gravels of quartzite, greywacke, silt stone, slate, trap, chert, or vein quartz. The megacrasts are embedded in a gritty matrix consisting of quartz and felspar (both microcline and plagioclase), cemented by argillaceous material or resembles green volcanic tuffaceous material. Due to recrystallisation the cement is now seen to consist of sericite (Plate 3.10A and B).

These bouldery beds grade upward into pebbly quartzites and sub-graywackes. Pebbles are of quartzite and quartz (Plate 3.11). The matrix is predominantly gritty quartzose but sometimes consist of angular fragments



PLATE 3.9A

Bouldary quartzite (Blaini)
(Loc. Near Khairna)

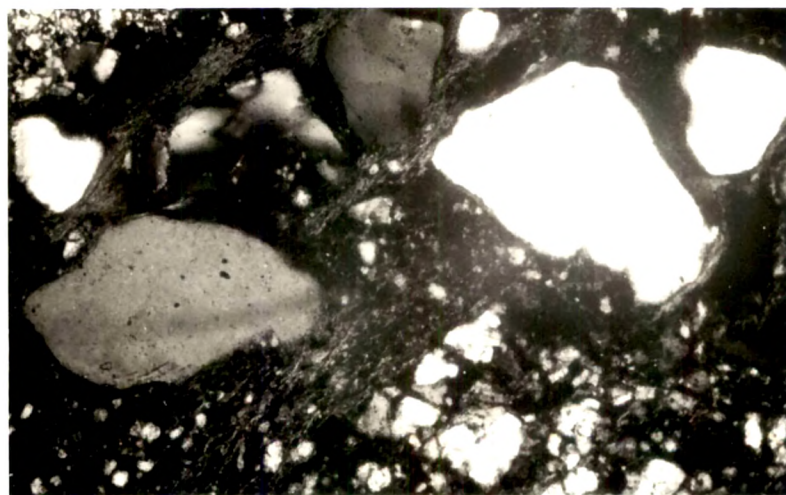
PLATE 3.9B



Bedding and jointing in Blaini quartzites.
(Loc. Near Chapar)

PLATE 3.10A

Heterogeneous coarse matrix (sub-greywacke) of Blaini bouldary beds (Photomicrograph: cross nicols, X45).

PLATE 3.10B

Argillaceous slaty matrix of bouldary beds (Photomicrograph: cross nicols, X45).

PLATE 3.11

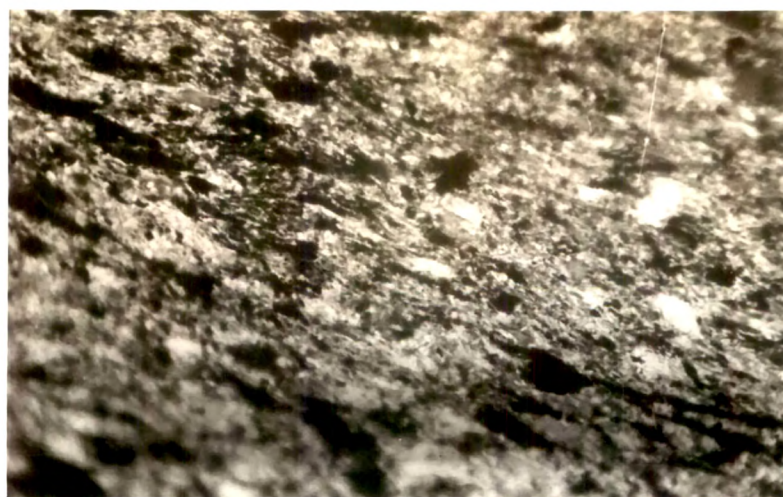


Pebbly quartzites (Blaini)
(Loc. West of Bhujan).

of diverse rocks. These quartzites are sometimes flaggy and contain thin grey slaty layers.

The limestone overlies the quartzites, intervened by a thin distinct unit of carbonaceous slate. These slates in thin section reveal a foliated mass of sericite and carbonaceous dusty streaks within which small granules of quartz are interspersed (Plate 3.12A). The limestone is pink and grey and contain thin layers of grey slates. Thin sections reveal a finegrained aggregate of calcite with stray granules of quartz, slaty layers are seen as consisting of calcite and quartz with streaks of a dusty opaque material (Plate 3.12B). The purple slates under microscope, are seen to consist of almost colourless material with very low grey polarisation colours (? devitrified glass) in which are interspersed flakes and needles of sericite and laths of plagioclase. The entire mass contains bands of dusty opaque matter. The author suspects that these purple slates are of volcanic tuff or mud (Plate 3.13).

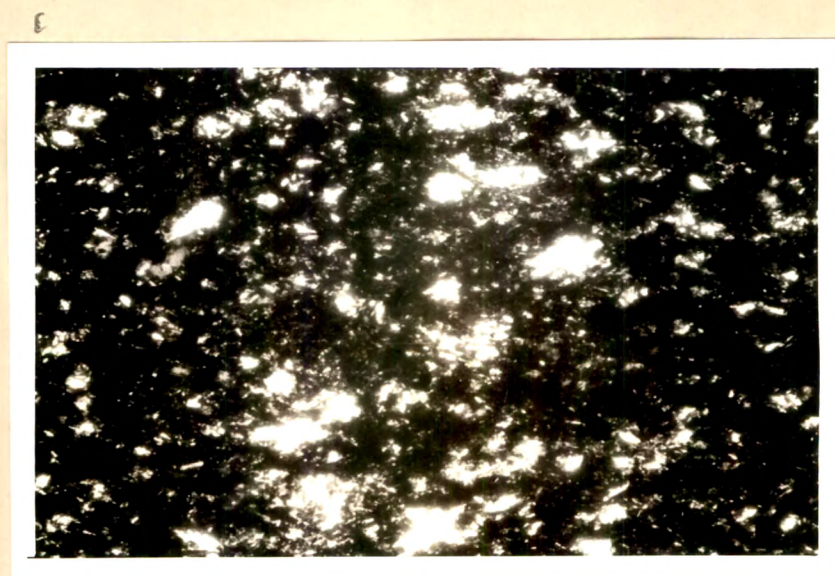
The Blaini limestone forms a very conspicuous and almost continuous band, typically bringing out the shape of the major anticline of the area. It forms one limb of the fold from Bardau Malla eastward upto Chapar where it perhaps punches out, after getting faulted by a NW-SE

PLATE 3.12A

Texture of carbonaceous slates (Blaini)
(Photomicrograph: Polarised light, X45)

PLATE 3.12B

Texture of Blaini limestone
(Photomicrograph: polarised light, X45)

PLATE 3.13

Texture of purple slate.
(Photomicrograph: cross nicols, X45).

fault. The other limb of the anticline extends SE from Bardau Malla for 10 km passing through Basgaon, Sakdena, Baskot, Bharar upto Dolkot, where it gets dislocated by a NE-SW fault and finally pinches out near Bajeri. Upward, this limestone is seen overlain by purple and red slates, and with these the Blainis gradually merge into the overlying Infra-Krols.

Infra-Krol Formation

In this part of Naini Tal district, according to Devendra Pal, the Infra-Krol sequence comprises three members as under:

Pebbly quartzites and grey slates.

Carbonaceous slates, silty slates and quartzites.

Purple and Carbonaceous slates.

These members are well exposed in the area north of Naini Tal lake. In the study area, however, only the lower two members are encountered. The third and the upper one lies beyond the limit to the west and in the north is cut on account of the Ramgarh thrust.

The lowermost member of the Infra-Krol consists of purple and carbonaceous slates which conformably overlies

the limestone of Blaini (Plate 3.14). In fact, these slates are in no way different from those that occur below the limestones. Devendra Pal has reported that in south, toward Naini Tal, where the limestone has pinched out, the demarcation between Blaini and Infra-Krol could not be made. This depositional feature is of great significance and has been utilised in working out the depositional history of the Blaini-Infra-Krol sequence.

The next overlying member is that consisting of silty slates and quartzites. A few carbonaceous slaty layers are confined to its lower part. These carbonaceous rocks are grey and sheeny and alternate with quartzite layers. They are identified by their property of soiling the fingers and yellowish limonitic encrustations on the surface.

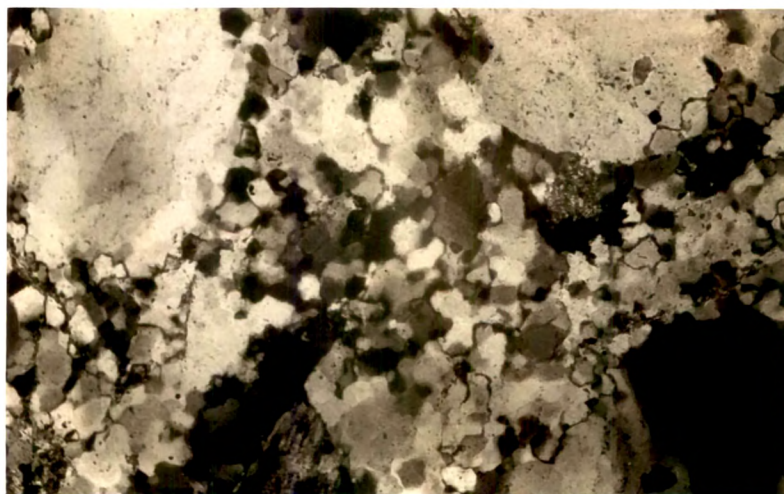
Upward, the rock becomes more arenaceous and beds of quartzite dominate. These quartzites are of light, pink, light green and light grey colour, and show frequent cross bedding and ripple marks. These quartzites quite often contain fragments of slates (Plate 3.15). Under the microscope, these quartzites reveal gritty to pebbly nature, composing a mediumgrained mosaic of highly sutured quartz with bigger quartz grains interbedded in it (Plate 3.16A).

PLATE 3.14

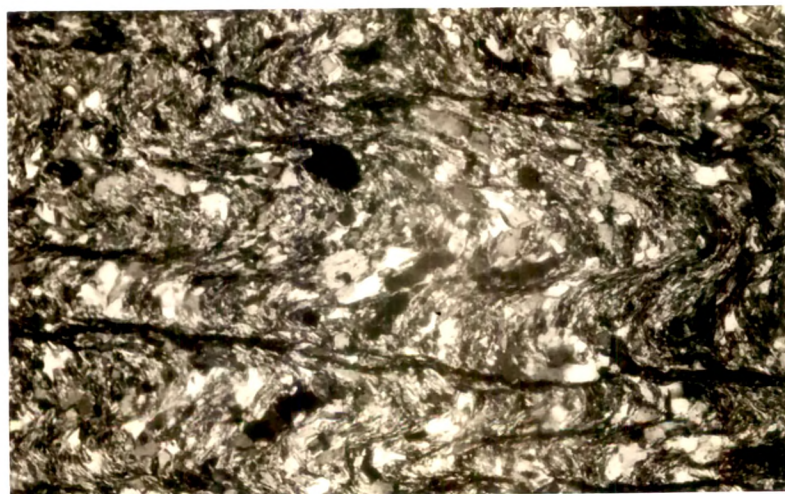
NE dipping Infra Krol slates in Kosi valley.

PLATE 3.15

Infra Krol quartzites showing sedimentary bedding and containing slaty fragments. (Loc. NW of Koran).

PLATE 3.16A

Texture of Infra Krol pebbly quartzite
(Photomicrograph: cross nicols, X45).

PLATE 3.16B

Silty slates of Infra Krol showing crenulation
cleavage (Photomicrograph: cross nicols, x45)

The slaty layers are grey and greenish grey and mostly reveal a slaty nature. Silty slates are recognised by their hardness and colour. They are slightly coarser-grained than the slates and show relative increase of quartz content. A sample of silty slates from the top of Lodiakhan ridge, in the immediate vicinity of Ramgarh thrust, shows a good development of crenulation cleavage in micaceous portions (Plate 3.16B).

The uppermost member of the Infra-Krol does not lie within the area. But stated above, toward Naini Tal, these Infra-Krols are overlain by a full Krol succession.

DEPOSITIONAL HISTORY

The various rock formations of the area represent two major depositional sequences, viz. the Nagthats and the Blaini-Infra-Krol. The Nagthat formation, comprising the older group of sediments, indicate a geosynclinal sedimentation prior to the volcanic activity which is now represented by the foliated trap rocks. Only a small portion of this sequence is encountered in the study area, and it was not possible to investigate these rocks in detail.

The author, on the other hand, has paid more attention to the post-Nagthat depositional history,

because the problems connected with the deposition of the Krol belt rocks right from Simla to Naini Tal, have yet to be finally solved, and in this context the present area throws some light on them.

It is not possible to find out how the traps of Garampani-Bhowali-Bhim Tal rest over the Naghats. But an unconformity is most likely. The author has reasons to believe that the spillitic traps form an integral part of the overlying Krol group depositional sequence, and if this contention is valid, then the trap flows, tuff beds and the associated bouldery and pebbly heterogeneous sedimentary beds of graywacke affinity, all comprise a 'flysch' type of deposit. Upward, these gradually change over to sub-graywackes. The entire sequence of Blaini to Krol in Naini Tal area has been found to be a single lithostratigraphic group. In the type area of Krol belt near Simla, Bhattacharya and Niyogi (1971) have rightly included Blaini, Infra-Krols and Krols into one group, and found that the entire succession shows close stratigraphic association, absence of marked unconformities, somewhat related environments of deposition and continuity of depositional history.

A significant feature of the Krol group deposition is the relative shallowness of the basin right from the beginning. The entire sequence typically represents deposition in a marginal basin, basement of which was perhaps of Nagthat. The trappean rocks and the overlying sedimentary formations - all show shallow water deposition. Even the phenomenon of "granulation" (see page 43) shown by trap flows indicates volcanic effusive activity in shallow marine condition. Absence of pillow lavas and typical graywacke, also points to a shallow water environment. Of course, from Blaini upward, the depositional history is quite clearly understood.

So far as the Blainis are concerned, they do not appear to be glacial, or fluvioglacial. The bouldery and pebbly beds of Blaini, in all probability, represent slump deposits involving shallow water sediments. The angularity of pebbles and lack of sorting, do not represent glacial origin, but they indicate frequent submarine slides when portions of partly consolidated Blaini sediments together with a few extraneous pebbles contributed towards the formation of the pebbly mudstones. The presence of lensoid limestone also goes against the glacial origin; carbonate beds indicate warm shallow waters. Bhattacharya and

Niyogi (op cit. p.117) have, for the Blainis of Simla area, visualised "a shallow delta-front environment near the shore line where in local secluded clear-water pools, the carbonate lenses were formed." Rupke (1968) and Valdiya (1970) have also considered Blainis as shallow water turbidites.

Bhargava (1969, 1972) has however, maintained that the Blainis are glacio-marine deposits. According to him, the end of Nagthat period coincided with movement which brought about the Talchir glaciation in the Peninsula. These glaciers towards north descended in the Krol basins to form the Blaini Boulder Beds.

The red and carbonaceous slates associated with the Blaini limestone are quite identical with those of the Infra-Krols, and it has been found difficult to demarcate Infra-Krol from Blainis in such areas where the limestone does not occur. It was on this basis, that in type area, Bhattacharya and Niyogi (op cit., p.188-189) have questioned the justification of separating Infra-Krols from Blainis.

The slate sequence in the lower part of the Infra-Krols, suggests a comparative deepening of the basin during this period. On the other hand, the upper part

of the Infra-Krols, which shows increasing number of intercalated quartzites, tending to be pebbly, indicates shallowing of the basin again. This upper part of the Infra-Krol formation is also marked by cross-bedding and and ripple marks. Perhaps the upliftment of the underlying sequence in the north provided the provenance for the upper Infra-Krol. Bhattacharya and Niyogi (1971, p. 192) have suggested that Infra-Krol of Simla area, were deposited in a transitional deltaic environment.

Devendra Pal, who has mapped the overlying Krol rocks to the south, has suggested that the Krols indicated a gradual deepening during the Lower Krol deposition. The environment of deposition of the Krol members is indicated to be of stable tectonic set up - an environment of mixed clastic and carbonate deposition. The oolitic nature of the uppermost Krol member speaks of a shallow, near shore environment. Oolites indicate extreme shallowness of basin, nearness of shore line and a wave-and current-agitated environment. It is obvious that the basin became very shallow, sub-aerially exposed during late Krol deposition, and perhaps the area became positive soon after. It is due to this non-deposition, that the Tal formation is absent in Kumaon.