CHAPTER III

GEOLOGICAL SETTING

INTRODUCTION

The area around Almora, comprising the crystalline rocks of the Almora nappe, is situated almost on the hinge of the Almora nappe synform, the axial trace of which passes through the north-eastern corner. Auden (1937) considered these rocks as equivalent to the Garhwal nappe, belonging to the Chandpurs (? Mid-Palaeozoic). According to Heim & Gansser (1939), these rocks constitute the 'Crystalline Zone of Almora'. The rocks of the study area consist of metamorphosed and granitised sediments, now represented mainly by garnet mica-schists, gneisses, gneissic granites and quartzites. These major groups show variation within themselves, thus giving rise to a number of lithological types recognisable in the field. Thin layers of graphitic schists and calc-silicate rocks add more variety. The intermixing of the coarse and fine components in all proportions, has very often produced an imperceptible gradation from the most micaceous to the most quartzitic type. Inspite of the transition, several fairly distinct rock types have been recognised. Apart from the variations due to the original nature of the sediments, the effects of varying metamorphism and deformation have influenced the appearance of the quartzites, quartzose mica-schists and garnet mica-schists in the field, producing distinct varieties. The various rock types show difference in colour, grain-size, structure and mineral content, and are easily recognisable in the field. The calc-silicate bands and graphitic schists indicate the presence of calcareous and carbonaceous matter in the original sediments. Granitisation of the mica-schists has given rise to a group of rocks which show gradation from felspathic schist to gneissic granite.

The geological map (Fig.III.1) of the area prepared by the author, clearly brings out the broad structural pattern exhibited by the crystalline rocks. A perusal of the foliation trends (Fig.III.2) reveals a large NNE-SSW antiform in the western half of the area, which has folded numerous macroscopic isoclinally folded quartzite layers. In the NE, is seen a synformal structure whose axial trace runs ENE-WSW. The rocks of the eastern portion show development of a pair of E-W antiform and synform.

The various synforms and antiforms, together with the isoclinally folded quartzite layers, have been found to be related to three distinct fold episodes which affected the rocks of the area in succession. The details of the structural pattern have been discussed in Chapter IV.

ROCK TYPES

The main rock types recognised in the field have been classified as under:

1. Mica-schists:
   (a) Garnet mica-schists
   (b) Graphitic schists
   (c) Quartzose mica-schists

2. <u>Granitised rocks</u>:
   - (a) Felspathic schist
   - (b) Augen gneiss
   - (c) Porphyroblastic gneiss
   - (d) Gneissic granite
3. <u>Flaggy quartzites</u>
4. <u>Calc-silicate rocks</u>
5. <u>Quartz veins</u>

Mica-schists

These rocks essentially contain muscovite, biotite and quartz. Garnet is almost always present. Depending on the relative abundance of micas and quartz, the schists have been divided into two main varieties: (i) Garnet mica-schists (ii) Quartzose mica-schists. Generally the muscovite is the main mica. In some localities biotite is much less while in others the proportion of biotite is relatively higher. Schists belonging to any of the above variety containing graphite, have been identified and referred to as graphitic schists. Further classification of these schistose rocks has been given in the chapter on petrography, wherein the various mineral assemblages have been taken into account to sub-divide the schists. The schistosity is seen to show axial-plane relationship with the isoclinally folded quartzite layers and the quartz veins, and thus very clearly suggests that they originated during the time of the early isoclinal folding (referred to as F_1 in this thesis). Superimposition of later folds (F_2 and F_3) has resulted into extensive crinkling of the schists, and the axes of the microfolds and crinkles (puckers) provide valuable clues in deciphering the structural pattern.

The mica-schists of different varieties are well foliated and show a varying garnet content. The garnets are idiomorphic and occur in good proportion as, well-formed porphyroblasts. The minerals visible in hand-specimens are quartz, muscovite, biotite and pink garnets. Weathering has imparted a characteristic bronze colour to these rocks.

The graphite bearing mica-schists occur as discrete lenses in mica-schists, never exceeding 100 meters in thickness, and extending for about as much as 1000 meters at the most. The graphitic schists appear to be confined to a few horizons only, occurring in association with calc-silicate bands and their abundance is obviously due to the repeated folding.

These graphitic rocks are easily recognised by their dark grey colour and soapy touch. These comprise a medium to fine grained friable rock showing a distinct schistosity. On the variation in quartz content depends the hardness of these rocks.

Quartzose mica-schists contain more quartz than the schists, and comprise a light grey compact and fairly hard rock showing distinct foliation. The schistosity is marked by the parallel flakes of micas. In this variety garnet is not always present. The colour of the rock varies according to the biotite content. These are in fact transitional rocks between the garnet mica-schists and the flaggy quartzites.

<u>Granitised rocks</u>

These are felspathic rocks derived by the granitisation of mica-schists. In the field, they form outcrops of coarse to medium grained rocks and show considerable textural and mineralogical variation. Based on the field study alone, this gneissic group has been classified into four types:-

(a) <u>Felspathic schist</u> : are more or less schistose, highly micaceous rocks containing small felspar grains. As compared to schists these rocks contain more felspars. They also contain all the structures exhibited by the neighbouring schists. They are found on the borders of the gneissic rocks as thin discontinuous bands.

(b) Augen gneiss: indicate increasing felspar content and show a gneissic structure with felspars as small lenticular grains along the foliation. In the coarser variety the felspars occur as full grown augens which are uniformly scattered along the foliation and are seen wrapped round by the selveges of mica. These augens appear to have grown as eye-shaped grains by pushing apart micaceous foliae.

(c) Porphyroblastic gneiss: indicate an advanced stage of granitisation. These gneisses are coarsely foliated greyish white, with abundant porphyroblasts of felspars. The felspars are seen to grow across the foliation, and due to such development of the porphyroblasts the foliation is much disturbed (Plate III.1).

(d) Gneissic granites: are coarse to medium grained granitoid rocks with an indistinct foliation. Many undigested patches of mica schists occur in these rocks.

PLATE III.1

Porphyroblastic gneiss (Loc. Chaunsali)

Flaggy quartzites

Flaggy quartzites occur extensively all throughout the area in the form of narrow elongated lensoid bands intercalated in schists. The outcrop pattern of the quartzite bands suggest that their repetitious occurrence is mainly due to repeated isoclinal folding of a limited number of quartzite horizons in schists. Stretching and boudinaging have at several places obliterated these folds.

The quartzites are yellowish and greyish brown in colour. The flaggy nature is due to the presence of mica concentrated along films and layers which tend to impart a strong fissility to the rocks. These micaceous layers indicate the original bedding. The quartzites show prominent linear structures like fold axes, grooves, striping and mineral orientation. Mesoscopic folds and refolded folds, quite common in these rocks have proved very useful in structural studies.

Calc-silicate rocks

Thin layers of calc-silicate rocks ranging from 3 to 5 cm in thickness are frequently recorded within the mica-schists and quartzose mica-schists. These are easily recognized by their characteristic light-grey colour, and the presence of amphibole needles and cinnamon coloured garnets.

Quartz veins

Quartz veins occur in almost all parts of the area in varying abundance. They show rather sharp contacts with the country rocks and are quite often seen involved in folding (Plate III.2.). These veins usually contain quartz and sometimes felspars.

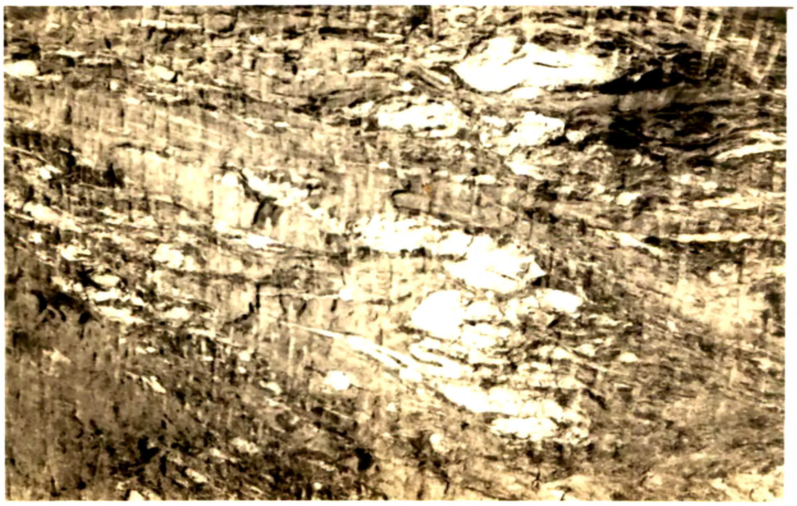
DISTRIBUTION

The various lithological types described above are seen in the field to form recognisable outcrops. On account of repeated isoclinal folding that synchronised with the regional metamorphism, the original sedimentary sequence can nowhere be now established. The folding on a regional scale has perhaps caused the repetition of a single group more than once, when traced from one end of the area to the other. The author, therefore has been unable to work out a succession - stratigraphic or structural, in the field.

Mica-schists

As stated above, this group constitutes the dominant rock types in the area, and is encountered all over. On account of the absence of sharp contacts between the different varieties of mica schists, and

PLATE III.2



Folded quartz veins (Loc. Chitai)

also due to considerable lithological variation even along the strike, the individual variety cannot be traced continuously for long distances. The transition from one variety to other is rather gradual.

At most places, the muscovite rich variety is encountered. It is a coarse-grained and light to grey shining, highly garnetiferous rock. The garnets, are big (2 mm to 5 mm) and numerous. Typically pink, they are almandine type and are seen in abundance at places released due to weathering. These schists are exposed in almost all parts of the area. Ideal outcrops are seen at many places, especially in the W, NW and NE near the villages Naugaon, Jyoli and Kasardevi. Mica-schists with an appreciable biotite content are also quite common, and are frequently recorded in association with the muscovitic type. With increasing biotite content, the rock assumes a characteristic bronze-yellow colour. These are more common in the eastern and south-eastern part of the area around villages Pokhri, Guna, Aincholi and Bandanidevi.

The graphitic schists occur as narrow (about 100 m thick) lenses in the mica-schists. They extend for several hundred meters but finally pinch out. The author has observed that these graphitic rocks, form a distinct horizon in the entire metasedimentary sequence, and their present distribution is mainly due to the effects of more than one fold episode. In all, eight occurrences of graphitic schists are recorded. The localities where these rocks occur are Guna, Anryakot, Phalsimi, Kalimat and Mat.

With the increase in quartz content, the garnet mica-schists tend to change over to the hard compact quartzose mica-schists. These quartz-rich variety occur in intimate association with garnet mica-schists, and it is not possible to demarcate them as they show very gradual transition to mica-schists on one hand, and to the flaggy quartzites on the other. While it is not difficult to distinguish between micaceous schists and quartzose schists, the actual demarcation between the latter and the flaggy quartzites is rather not very easy and clear-cut. Thus, this quartzose variety of schists not only is met with all over the mica-schists terrain, but even in the areas occupied by flaggy quartzites, some portions are more like quartzose schists.

A variety almost devoid of biotite is seen to occur in the Dyolidanda hill, forming a thin band within the gneissic granite. These schists typically show a crenulation cleavage - which has been found to be quite different from the similar cleavage elsewhere. The author believes that this cleavage is related to the isoclinal folding and not to the late synformal folding (Plate III.3).

Granitised rocks

These include felspathic schist, augen gneiss, porphyroblastic gneiss and gneissic granite - in order of increasing granitisation. Of the above varieties, the most predominent ones are the last three.

The WNW-ESE running gneissic band (Chaunsali band) in the SW part consists entirely of augen bearing and porphyroblastic gneisses. This band of augen and porphyroblastic gneiss is an extensive one, and enters the area from the SE and extends WNW for several kilometers right upto Siahidevi and Ranikhet. Ideal exposures of this band are recorded at Chaunsali, Tat and south of Dal village. This gneissic band has narrow rims of felspathic schists. The main rock is augen gneiss, but in the median portion, development of porphyroblasts are not uncommon.

PLATE III.3

Relict F_1 fold in quartzose mica-schist
(Loc. near Dyolidanda hill)

Augen gneiss is also exposed in number of narrow lensoid bands - never exceeding 100 to 200 meters in thickness and extending for 300 to 400 meters, recorded at Phalsimi, Bintola, Gajaul, Kasaun, Sheora in the NE and at Sainar in the central part. Porphyroblastic variety is generally not seen in these smaller bands.

The Dyolidanda hill of granitic rocks, comprises a core of gneissic granite and porphyroblastic gneiss with a border of augen gneiss. This hill of granitic rocks has attracted attention of most previous workers, and its mode of occurrence suggests an apparent intrusive origin. A careful mapping by the author has revealed that though the rock is coarse-grained and almost granitic, it still preserves a crude foliation and the apparent massive look is on account of the crowding of haphazardly-grown felspar porphyroblasts. This coarse gneissic variety gradually merges outward with the augen gneiss.

All exposures of the augen gneiss show distinct crinkling of micas at many places, suggestive of their involvement in the synformal folding of the nappe rocks (Plate IV:1).

The felspathic schists, which indicate the beginning of the granitisation, form narrow discontinous fringe all along the Dyolidanda gneissic granite. These also border the gneissic band of Chaunsali. This variety is however not well defined in the smaller gneissic bands.

Flaggy quartzites

The quartzites occur as huge lensoid masses within the schists. Also smaller layers ranging in size from a few cm to a metre or two are not uncommon in schists. The bigger layers of this rock form ridges and hills. Their occurrence typically illustrates repeated folding, stretching and boudinaging of a limited number of quartzite layers, resulting into their lensoid shapes and prolific occurrence. The quartzite layers and lenses, show folding at all scales - from macroscopic to mesoscopic (Plate III.4). Sedimentary structures are generally not recorded and the bedding planes are characterised by the thin micaceous layers which have made them flaggy. An idea of the distribution of these quartzites can be had from the geological map (Fig.III.1). The rugged topography around the town of Almora is mainly due to the concentration of quartzite ridges in that area.

PLATE III.4

Mesoscopic F_1 reclined fold in flaggy quartzite
(Loc. Khatiari)

Calc-silicate rocks

Calc-silicate rocks occur in small patches and lenses throughout the area. Generally, these never exceed a few cm in thickness and in length vary between 2 to 5 meters. Obviously, the calc-silicate rock represents calcareous impurities in the original sediments. This rock is mostly associated with the garnet and biotite rich schists and its occurrences are quite frequent in the S and SE. Good outcrops are recorded at Guna, Aincholi and Lat villages.

Quartz veins

Quartz veins occur in almost all parts of the area in varying abundance. They show rather sharp contacts with the country rocks. At many places they are seen folded and boudinaged, giving rise to quartz rods. The minor structures such as lineations, boudinages and rodding shown by these quartz veins are very useful in determining the structural history of the area.