CHAPTER IV

G E O L O G I C A L S E T T I N G

As has been already stated, the main bulk of the rocks belong to the Pre-Cambrian period and consists of partly granitised hornblendic rocks. These are seen cut up by a large number of basic dykes. A considerable portion of these Pre-Cambrian formations is overlain by laterites, thus rendering their exposures somewhat fragmentary (Fig. 2).

The rocks of the area can be arranged in the following sequence:

	Formations		Age
4.	Soils	...	Recent and Sub-Recent
3.	Laterites	...	Tertiary
2.	Dolerite dykes	...	? Lower Cuddapah
1.	Amphibolites and Granites with their derivatives	...	Dharwar and Post-Dharwar of Archaean age.

Investigations have revealed that the amphibolitic rocks comprise a single broad band folded into a large 'Z' shaped structure. The granitic rocks have originated at the expense of these amphibolites, and the degree and intensity of granitisation has been found to be quite variable.

In a broad way it can be stated that the amphibolitic rocks are exposed along the coastal track while the granitic rocks occupy major portion of the eastern part of the area. A major E-W fault, along which the Gangavali river flows, cuts across the area.

In the following pages a detailed field description and distribution of the various rock types has been given.

AMPHIBOLITIC ROCKS

These amphibolites, perhaps represent metamorphosed and differentiated basic rocks and constitute a group of

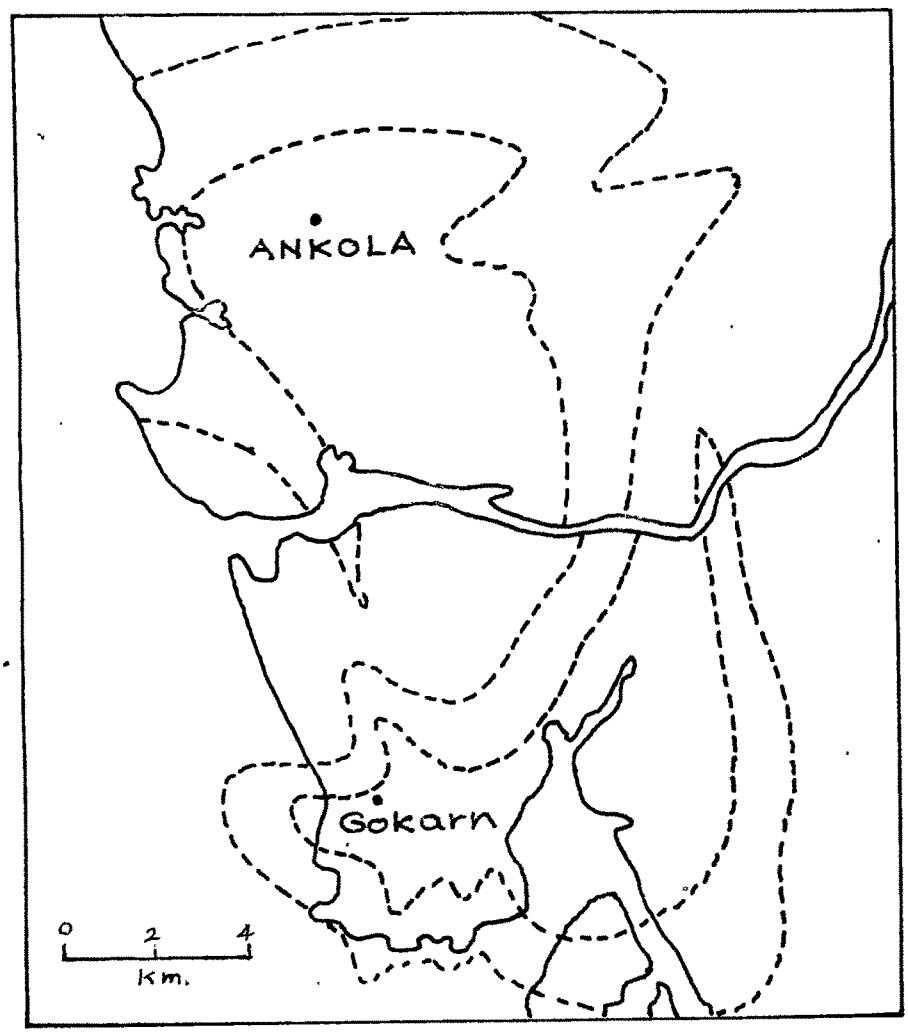
hornblendic rocks. As has been already discussed in the previous chapter the variation in the amount of hornblende in different bands has given rise to various types, and depending upon the mineral content, structures and textures the three types - foliated, massive and streaky, can be recognised in the field. Petrographic details of these have been already given.

Most of these varieties occur in cloase association and sometimes it is very difficult to demarcate and describe their characters. At most places, the different varieties form a banded assemblage, and have been described in the field as banded amphibolites.

The amphibolitic rocks, in general occur in three regional bands. As already stated above, these bands form three limbs of a pair of big refolded folds (Figs. 2 and 3). The western band occupies the coastal areas between Manjaguni and Vadibogri. The central band, considerably granitised, extends from Ankola to Gokarn-Kudle through Hosgadde, Belse, Shrirur, Devigadde, Kadme and Chivatgeri. The western band and the central band perhaps meet in the area W of Ankola (N and NE of Vadibogri, forming a fold). Similarly, the central band in Gokarn-Kudle

FIG.3

SKETCH MAP SHOWING FOLD PATTERN
OF AMPHIBOLITIC ROCKS



area turns round and forms another fold hinge and extends due E as far as Bargi and then NNE upto Hiregutti. The exposures at Bargi, Hiregutti and Andle constitute the eastern band.

(1) Manjaguni, Honnebail and Vadibogri area

At Manjaguni ferry a small patch of streaky and foliated amphibolites is exposed. The regional foliation, marked by the lighter bands in hornblendic rocks, is more or less vertical or steeply dipping due N and strikes almost due WNW-ESE. This banded variety appears to be much distorted by folding. Early tight folds of silicious bands enclose hornblendic matter. Shearing along NNW-SSE direction has given rise to bands of chlorite schist. The strike of these is roughly NW-SE. From its association with the hornblendic matter it is clear that the chlorite is derived from hornblende.

Further north and northwest in the Honnebail and Vadibogri areas, rather extensive exposures of the streaky amphibolitic rocks are met with. The strike of these rocks is more or less persistent being WNW-ESE with vertical or steep dips either due N or S.

(2) Ankola area

A few outcrops of hornblendic rocks occur 1 km east of Ankola, behind the college building. The rocks are foliated as well as massive, and medium-grained. The foliation trends are WNW-ESE with very steep dips due NE. These rocks very often contain white bands of quartzo-felspathic matter varying in width from 2 to 10 cm. Joints are seen running along 140° with a dip of about 70° due NE. The rocks show some conspicuous folding.

A little towards east (100 metres) we get the massive variety, rather bouldery, without any orientation in minerals.

A late dolerite dyke cuts through these rocks.

To the east and northeast of Ankola, it is seen that the amphibolites have progressively changed over to granites, and in these parts, these rocks occur as scattered and partly preserved fragments only. North of Ankola (2 km) near the 18/7 milestone, the hornblendic rock shows a somewhat banded character, and these bands follow a ENE strike and dip 40° NW. However sudden variations in strikes are common and very often foliation trends are seen to be as much as SE-NW to NNW-SSE dipping 70° to NE.

(3) Hosgadde area

The amphibolitic rocks in the Hosgadde area are considerably granitised. In a broad way, the western portions of the hills (▲ 510') are almost granitic, while the eastern ones are still amphibolitic - streaky, gneissic and conspicuously banded.

(4) Belse area

South of Hosgadde, in the vicinity of Belse village (east of 23 milestone), outcrops of amphibolites showing considerable granitisation are met with.

Just north of Belse, the amphibolites are foliated and schistose and show a SE strike with a dip of about 70° due NE. In the surrounding area, this hornblendic rock is partly granitised with considerable addition of quartzo-felspathic matter and partial alteration of hornblende to biotite (Plate 13). In a broad way, the foliation strike is N-S but it fluctuates between SSE to SSW or SW and dips about 50°-60° due E. In the adjoining hills just towards NE, banded and streaky amphibolitic rocks are encountered. A few late doleritic dykes are seen cutting these rocks.

(5) Shirur area

The rocks at the village Shirur are foliated and streaky amphibolites with little granitisation except a

PLATE 13

A leucocratic folded vein containing relicts of amphibolite. The metasomatic origin is clearly seen. Loc: Hosgadde.

few stringers and thin bands of quartzo-felspathic matter. Along the bank of the river Gangavali near the 26/5 milestone, the rock shows well developed foliated character. It is a medium grained rock with dark lustrous hornblende. The general trend of foliation is ENE with gentle dips due NNW..

Here, considerable 'in situ' lateritization of these rocks is seen at higher levels (Plate 14). Immediately in the neighbourhood of the river, the rock is so much disturbed that a clear picture of the foliation trends is not obtained. This is due to the existence of a fault along the Gangavali river.

A few dolerite dykes are recorded here.

(6) Madangeri-Devigadde-Kadme area

Across the Gangavali river, the amphibolites are exposed conspicuously in the Madangeri-Devigadde and Kadme area. Obviously these outcrops are the continuation of the Shirur rocks.

The bulk of the rock types is banded and streaky amphibolites with frequent patches of massive and foliated varieties. The general trend of the banding and streakiness

PLATE 14

'In Situ' lateritization seen on the road cutting. Loc: Shirur near Gangavali river.

is NE-SW with dips varying between 40° to 60° due SE, though steep and vertical dips are not uncommon. Considerable structural complication is seen here on account of the interference of two fold systems. Partly obscured tight folds are amply recorded by the less mafic bands of the rocks. These folds mostly run along the banding and their axes are difficult to measure. Some of them doubtfully plunge due S. The effects of late folding are more conspicuous. Apart from a few distinct folds striking NW-SE, the late deformation has given rise to a marked schistosity in hornblendic rocks due to orientation of hornblendic crystals. This axial plane cleavage strikes 150° and makes a distinct angle with the early banding. It is not possible to measure the axes of the folds. It is interesting to note that the southern portion of this hornblendic exposure is considerably granitised, and all stages of transformation from unaltered hornblendic rock to almost unfoliated granitic rocks are met with.

The second folding, affected the partly granitised mass and resulted into numerous folds, shown so well by the light coloured bands. Considerable slipping along

the axial plane appears to have taken place during the folding. It is also evident that the whole mass was quite plastic as, at many places, this late folding has completely obliterated the pre-existing structures (Plate 23).

In the northern part, amongst the streaky amphibolites, on the hill near the village Devigadde, is seen a peculiar lensoid outcrop of talc-chlorite-schist. It is evidently a retrograde crushed rock derived due to the shearing of a highly mafic segregation.

The amphibolitic rocks when traced north of Madangeri, tend to become lateritic and form a conspicuous NS ridge, extending right upto Gangavali river. The ridge ideally shows the lateritization of the amphibolitic rocks. An interesting rock type of the nature of magnetite schist is met with, all along the length of the hill and it is likely that in this part the differentiation of the pre-existing amphibolites, gave rise to segregated masses of iron-ores which, later on became lateritic.

The strikes are quite conspicuous, are N-S, the dip of the foliation being almost vertical. In this

hill, are recorded two coarse grained dolerite dykes one running almost parallel to the foliation, and the other cutting across in a E-W direction.

(7) Chivatgeri area

Obviously the outcrops at Chivatgeri are the south-western continuation of those of Kadme-Devigadde, but here the strike of the foliation takes a sudden swing to NW-SE, and this change is on account of the effect of a folding (late) so conspicuously seen in this area.

The foliated and the massive varieties occur in very close association, and are prominently seen on the western side of the road on a small hillock ($\triangle$ 152'). The two varieties merge imperceptibly into one another. Here the foliation trend is NW-SE and it dips rather steeply (60°-70°) due NE. A late coarse dolerite dyke measuring about 25 metres in thickness cuts through these hornblendic rocks and runs NNW-SSE.

East of the road, are met with banded as well as streaky hornblendic rocks which are seen continuing further for at least 2 km along the hills. The trend of

these rocks is generally NW-SE, but it quite often fluctuates to as much as E-W. Dips are vertical or about 85° due south. The amount of hornblende here is somewhat less and the rocks are streaky on account of the presence of numerous light coloured bands. Due to the development of epidote on a large scale, the rocks are a little greenish. These rocks show considerable structural complexity and reveal evidences of at least three fold episodes. Light coloured (rather siliceous) layers show delicate and obscure tight folds, running parallel to the general banding. In fact the streakiness and repeated banding in these amphibolitic rocks is due to the isoclinal folding. These are the earliest folds and are seen refolded on an NW-SE to NNW-SSE axial planes. These late folds are quite conspicuous, rather angular with upright axial planes, and their axes plunge moderately due SE. This folding has given rise to a distinct shearing in hornblendic patches at several spots and it is interesting to note that the shear cleavage makes an angle of about 40° with the banding. This shearing and slipping is noted along the axial plane direction of the folding. Yet another superimposed folding is recorded sporadically, mainly in some schistose or foliated variety. The third folding has

given rise to the development of clear chevron type microfolds along NNE-SSW direction.

At the eastern end, the siliceous layers in the hornblendic rocks vary from 1/2 cm to 5 cm in width and show folds of numerous generations.

Along the southern slope, just by the side of 25/3 milestone along Bankikodla road, in a small area measuring about 100 sq. metres are met with banded haematite-hornblende-quartzites. These show chevron folds of small sizes, measuring about 1/2 to 1 metre in size, their axial plane runs along 110° and dips 75° SW. The fold axis plunges 30° due W. Perhaps these are earliest folds.

(8) Gokarn area

The amphibolitic rocks, further southwest at Gokarn beach, are somewhat similar to those seen at Chivatgeri, but they show considerable structural complexity. Small scale folding, faulting and displacement have taken place extensively. Banded and streaky amphibolites predominate in this part. Generally the rocks show almost an E-W strike with steep northerly

dips. Vertical dips or steep southerly dips are not uncommon, but frequent change in the trends due to a late folding is seen. Therefore, two different trends of strikes, one due N-S, and other due E-W to WNW-ESE are recorded (Plate 15A).

Numerous folds belonging to this late (second) generation are present all over the Gokarn beach. They are open or tight rather angular folds, 1 to 2 metres in size. Axial planes trend roughly due ESE-WNW, or SE-NW, steeply dipping due SW or are vertical. The axes of these folds plunge moderately (30°) due SE. However, considerable variation in the amount of plunge is recorded and as high as 80° is noted in some folds. In many cases lateral slipping has taken place in the axial plane direction.

An early generation of folds is recorded in tight obscure and rather isoclinal structures whose axes point due WNW with a plunge of 30° to 40°. The related ribbon type lineation is well developed which also plunges moderately due WNW.

Detailed and careful analyses of the various structural elements have revealed that the Gokarn area

PLATE 15

A

A. Banded and streaky amphibolites showing two sets of folds. Loc: Gokarn coast.

B

B. Streaky amphibolites with veins, bands and pods of quartzo-felspathic matter. Loc: Gokarn coast.

perhaps represents the core portion of an early isoclinal fold. The tight minor folds, described above are related to this folding only. The isoclinal structure has been later on refolded along NW-SE, and the late folds are related to the superimposed structure.

The hornblendic rocks of Gokarn contain numerous veins, pods and bands of quartzo-felspathic matter of migmatitic nature (Plate 15B). In the outcrops on the beach just near the Mahabaleshwar Temple, are seen narrow zones of chlorite schist amongst the hornblendic rocks. These finely foliated chloritic rocks are a product of intense crushing along a few shear planes and are undoubtedly retrograde rocks after the amphibolites.

In this area, in addition to the pods, patches and veins of quartz-felspar, a typical growth of metasomatic augens of felspar is seen. Porphyroblasts of felspar (plagioclase) are seen growing into the hornblendic matrix and at places the rock looks almost like an augen bearing hornblendic gneiss.

A few basic dykes are also noted in this part. A distinct basaltic dyke of about 2 metre width, runs

along 50° trend just near Rameshwar temple.

(9) Kudle area

The amphibolitic rocks at Kudle, south of Gokarn along the coast are almost identical. But here, they show considerable variation in their foliation trend. At Kudle beach, at its southern end, occur foliated, massive as well as streaky varieties (Plate 16A). The foliated amphibolites show oriented needles of hornblende. The rocks in this area follow a NE-SW trend with dips of about 50°-60° due NW.

In these amphibolites, the streaks of white quartzo-felspathic matter have given rise to a ribbon type lineation which shows a plunge of 35°-40° due NW. This lineation is obviously a very early one, representing the axes of the tight isoclinal microfolds.

The foliation in the northern part of the Kudle beach changes to almost E-W and dips about 70°-80° due N.

It is clear that this area also has been affected by two folds, but minor folds related to both the episodes, as seen at the Gokarn coast, are not recorded here. Streaky varieties show frequent tight folds, related to the earliest folding, and their axes plunge due NW with angles of about 30°-40° (Plate 16B).

PLATE 16

A

A. Streaky amphibolites with quartzo-felspathic dykes. Loc: Kudle coast.

B

B. Leucocratic matter in streaky amphibolites showing folding on F_1.

Loc: Kudle coast.

(10) Kuchani area

Further east along the coast at Kuchani, both streaky as well as the foliated types of amphibolitic rocks are present. But the foliation trend changes from NW-SE to almost N-S. Dips are more or less steep, generally due W.

These rocks show sudden changes not only in their trend but also in the mineral assemblage. Some portions may show schistose structure while some would show streakiness depending upon the amount of hornblende in various bands.

Two sets of folds are clearly recognised. The early folds, tight isoclinal, run parallel to the foliation. Their axes plunge due NW to NNW at angles of about 30°-40°. The late folds, seen forming distinct, fairly open structures have upright axial planes striking NW-SE. The axes of these folds plunge at angles of about 50°. Strong lineation of the nature of streakiness, ribbons and mineral orientation parallel to the early fold axes are seen developed all over the area.

(11) Tadri area

To the east of Kuchani on the northern bank of the Aghnashini river near Tadri, good exposures of amphibolitic

rocks are encountered. These rocks outcrop at low level on the beach and form a small strip along the coast. Obviously these are eastern extension of the Kuchani exposures. On the whole, the foliated (schistose) type is scarce, and the rocks are finely banded and streaky. The individual bands with varying hornblende content are themselves massive, hard and fine grained.

The banding or foliation strikes generally due NNW-SSE and dips steeply either due E or W; or is almost vertical. Considerable variation in the dip and strike is noted, and occasionally the strike becomes as much as N-S with dips due W. The light coloured quartzo-felspathic streaks show numerous small tight folds. The present structure and appearance of the rocks is due to repeated folding and shearing along the axial planes. The possibility of metamorphic segregation along the shear planes also appears to have aided in imparting the streakiness to the rocks.

These tight folds suggest an early isoclinal folding. The cores of these minor folds, seen as rods of leucocratic matter indicate the axes of early folding and mark the

dominant lineation in the rocks. This fold axis lineation generally plunges due NW or WNW with moderate angles. At some places, folding and slipping in white bands is nicely seen.

These streaky hornblendic rocks are traversed by a few quartz and pegmatitic veins, most of which follow the foliation trend. A few of them show pinch and swell as well as lenticular structures. Laterite has covered these rocks to the north.

(12) Aghnashini area

Opposite to Tadri, on the southern bank of the Aghnashini river, amphibolitic rocks of various types are ideally exposed (Plate 17). These rocks form an east-west outcrop fringing the bank and go below the laterites when traced inland.

In a broad way, the foliated or schistose variety dominates. The massive variety lies to the east while the streaky and banded hornblendic rocks are common towards the west.

The foliated amphibolites are rather fine grained. Hornblende needles, well arranged in rows impart a strong

PLATE 17

Foliated amphibolites. Loc: Aghnashini coast.

lineation. The foliation strikes WNW-ESE with a dip due N, but on account of structural disturbances and flexures its trend is found to be varying considerably even within a few metres. A careful mapping of about 500 sq. metre area has revealed the following:

(i) The foliation trend fluctuates from E-W to as much as NW-SE and the amount of dip varies between 50° to 85° due N to NE.

(ii) These rocks show rather open to angular rapid folds which have given rise to a rodding which plunges by about 55° to 60° due NE.

(iii) Some quartzo-felspathic matter occurs as small lenses and masses, and has obviously formed after folding.

This area also shows some minor faulting and in many cases the fault plane strikes due 140° with a dextral displacement of few cm only. Most of the fault planes are filled with epidotic matter.

To the east, the amphibolites tend to become massive. They do not show any foliation or orientation of minerals.

A late dolerite dyke is found cutting these rocks and runs almost N-S.

(13) Bargi, Hirregutti and Andle area

The rocks exposed along the Kuchani, Tadri and Aghnashini coastal areas, when traced to the east, gradually swing through NE to NS, and then to almost NNW-SSE, and extend northward forming a more or less continuous chain of exposures. Good outcrops from Bargi, on the south, to as far north as Andle, are encountered.

From the quarries around Bargi, amphibolitic rocks extend NNW upto Andle, through Hiregutti. These occur along low lying areas comprising the different varieties of hornblendic rocks which, at a few places are granitised.

Near Bargi the amphibolites are streaky and much granitised. Dark bands - somewhat hornblendic (and biotitic) represent the relict of the pre-existing amphibolitic rocks.

Foliation approximately strikes due NNE-SSW to NE-SW, with steep dips to either side or vertical. The

most striking phenomenon here is the development of numerous quartzo-felspathic veins running in all directions. On a careful scrutiny these are seen to have grown in place (metasomatically) without disturbing or oblitering the pre-existing foliation (Plate 18). Small but conspicuous N-S reverse faulting, dipping steeply due E, show shearing and development of epidote along them.

A little north of Bargi near 30/4 milestone, small flexures are noticed in banded hornblendic and granitised rocks. In the surrounding areas also, hornblendic rocks are granitised to a considerable extent and these exposures are underlain by laterite.

On going north about 2 km a few outcrops of ungranitised foliated amphibolites are encountered. These amphibolites show similarity to those of Aghnashini and Kudle area. Surprisingly, very little granitisation is seen here.

The foliation trends show considerable fluctuation when traced from south to north. There is a tendency in foliation to swing from NNE-SSW to as much as NW-SE; the dips all the time being easterly. Local variations

PLATE 18

Quartzo-felspathic matter showing a gradual metasomatic growth, without obliterating the earlier foliation.

also confirm these changes. Small folds are quite common and it is seen that their axes plunge 25°-30° due ESE. These folds are quite open and perhaps related to the late regional flexures causing the foliation swing in this part. A conspicuous ribbon type of lineation in hornblendic rocks has developed which coincides with the axes of the above mentioned folds (Plate 19).

A little to the north (i.e. east of Hiregutti village), the hornblendic rocks show intensive contortions and fairly tight overturned folds are numerous. Further north near Andle, the foliation trend is WNW-ESE to NW-SE and dip about 45° due NE.

These amphibolitic rocks do not extend beyond the Gangavali river, and it is not clear what happens to them in the north; perhaps they pinch out.

GRANITIC ROCKS

Granitic rocks broadly occupy the eastern and northern parts of the area.

These rocks show interesting structural, textural and mineralogical variations, and these changes can be

seen within short distances. Both foliated and non-foliated varieties, occur in intimate association; the various minerals also occur in varying proportions. It is very obvious that these granitic rocks have formed at the expense of hornblendic rocks, the latter having played a major role in imparting mineralogical diversity to the granitic rocks.

Textural and mineraφlogical characters of the various granitic rocks have been described in the previous chapter on petrography.

It is seen that the granitic rocks consist of several varieties with varying mafic mineral contents and include fine to coarse grained massive granitic rocks of various shades of grey (obviously due to the presence of hornblende and biotite) - foliated as well as massive, and light coloured bands and patches of quartz and felspar.

All the varieties are seen occurring together, quite often intimately mixed up. Transitions from one variety to another, can be sharp as well as gradual. In most of the outcrops, the biotite and biotite-hornblende content is variable to a considerable

extent, and a single exposure may change over from dark grey variety to white variety, very poor in the above mentioned minerals. It is very often seen that biotite and hornblende, together or individually, from segregated selvages around quartzo-felspathic veins and lenses. The reverse is also quite true (Plate 11). The main bulk of the granites showing such gradational varieties in mafic contents is in turn, seen traversed by pegmatitic and aplitic veins and dykes in all directions showing very sharp contacts with the enclosing rocks. These give an impression as if they are late intrusive bodies. Some of these veins are involved in folding, while others cut across all structures (Plate 8).

The various foliated and non-foliated varieties occur together in most of the areas. Hence the field characters and the description of both the foliated and the nonfoliated granites, is given together. All possible field relations and distinct characters of the different varieties have, however, been pointed out.

The following account is based on the observations of the author in a large number of fresh exposures in quarries opened all over the granitic terrain.

(1) N and NE of Ankola

Granitic rocks occur in force, in the hills N and NE of Ankola. A number of quarries opened in these areas, afford good opportunity of studying these rocks in fair detail.

About 6 km NNE of Ankola, in the numerous quarries one comes across granitic rocks, highly dissected by numerous white quartzo-felspathic bands and veins. The main rock is grey, medium to fine grained, and for all practical purposes massive and nonfoliated. In mineral composition, these are seen to contain quartz, plagioclase, microcline, biotite and hornblende. On the whole, microcline content is subordinate. The main mafic mineral is biotite, but hornblende is almost always present in small proportions. Considering the overall mineralogy, these rocks can better be described as similar to trondjhemites and granodorites. Only on a very careful observation a streakiness in the rocks is discerned. The proportion of the mafic mineral is quite variable, and on account of this, the rock shows various shades of grey within a single outcrop. The faint foliation, wherever recognised shows much variation,

but broadly it is seen to be varying between N-S and NW-SE; with dips either almost vertical or as much as 50° due E or NE. The quartzo-felspathic veins traverse in all possible directions, and in most cases their contacts with the granites are very sharp. A few ill defined, rather moderately open folds, are recognised in these granites, the axial planes of these folds are roughly E-W. Some of the light coloured veins are seen involved in the folding, while others cut across the folds. One most characteristic feature of some of the coarser grained veins is the development of numerous greasy oval shaped or rounded crystals of microcline near the margins. As a result, these veins are coarser along the two margins and finer in the medium parts (Plate 9).

Further east, the same types of rocks with very little variation in their structural and mineral character are seen to continue. In general, the rocks are massive, fine grained and can be grouped under nonfoliated category. The biotite poor light coloured variety is "spotted" with small rounded patches (1 to 3 cm diam) and elongated lenses of biotitic variety still preserving the original trend of the foliation. Such examples very clearly illustrate two points -

(i) the biotite rich and biotite poor varieties are derived by metasomatic action;

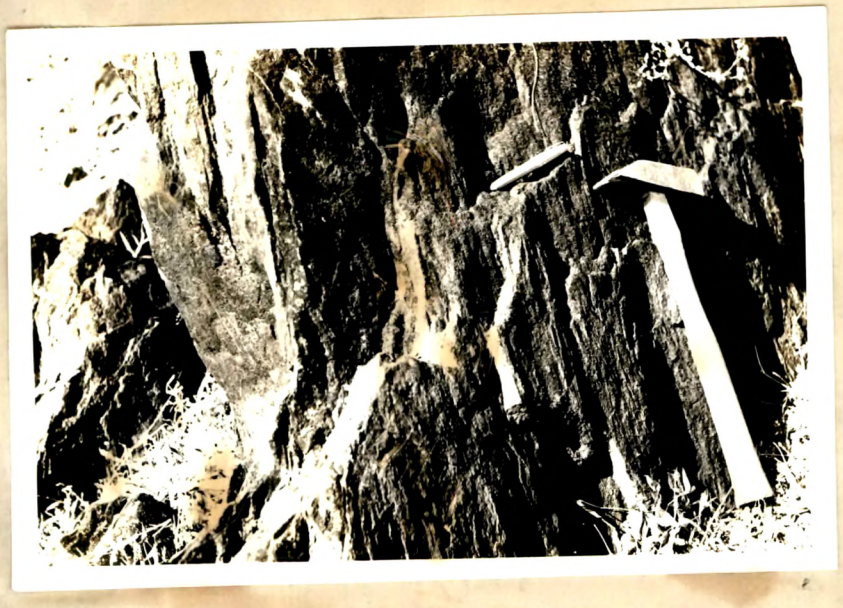
(ii) the obliteration of foliation has given rise to nonfoliated varieties.

In the quarries just a few metres towards east, the granitic rocks are seen to be both foliated and nonfoliated. The nonfoliated type is rather massive and fine grained, with little mafic content. The gneissic variety is typically streaky with biotite and a little hornblende. As usual, the quartzo-felspathic bands cut across in all possible directions. A few of them contain ovoids of microcline. The trend of some of the pegmatites is roughly NE-SW, while a few fine grained veins run along N-S direction. A number of minor faults are noted at some places. It is obvious that fracturing facilitated metasomatic growth of the quartzo-felspathic veins and dykes.

The strikes are almost SSE-NNW with a dip varying from 80°-90° on both sides.

In another quarry just near the junction of the Karwar-Hubli-Ankola roads, medium to coarse grained, faintly foliated biotite granites are seen. The

PLATE 19



Ribbon type of lineation seen in amphibolites.
Loc: East of Hiregutti.

foliation is roughly WNW-ESE with dips of about 70° to the NNE. Of course, the foliation at many places is obscured. Pegmatites are common with quartz, felspar (both oligoclase and microcline) and flakes of biotite (about 2 cm long). The trends of these pegmatites is E-W with dips of 45° due N. Compared to the previous outcrops this area shows less effects of deformation. Major joints are along WNW-ESE dipping steeply to the N.

In the adjacent area also the rocks are of the same character. They are finegrained biotitic granodiorites. Foliation is almost absent but can be recognised in faint streakiness which runs almost NNE-SSW. There is a network of pegmatites and aplites and quite a few of them run along NNW-SSE.

In the extreme E and SE parts of this group of exposures, the proportion of hornblende is seen to be rather comparatively high.

About 2 km N of Ankola in the quarries near the 19th milestone both, foliated as well as nonfoliated varieties are encountered.

In this exposure, a complex assemblage of a number of types is seen. The main bulk is the usual fine to

medium grained gneissic biotite granite, with numerous light coloured veins and bands of quartz-felspar (Plate 20 A). Though at most places the foliation is of the nature of streakiness, alternate banding of light and dark constituents, is also a factor to impart a gneissic appearance. The foliation trend though vary variable, is broadly fluctuating between ENE-WSW to ESE-WNW dipping steeply to the north. Of course, gentler dips are not uncommon.

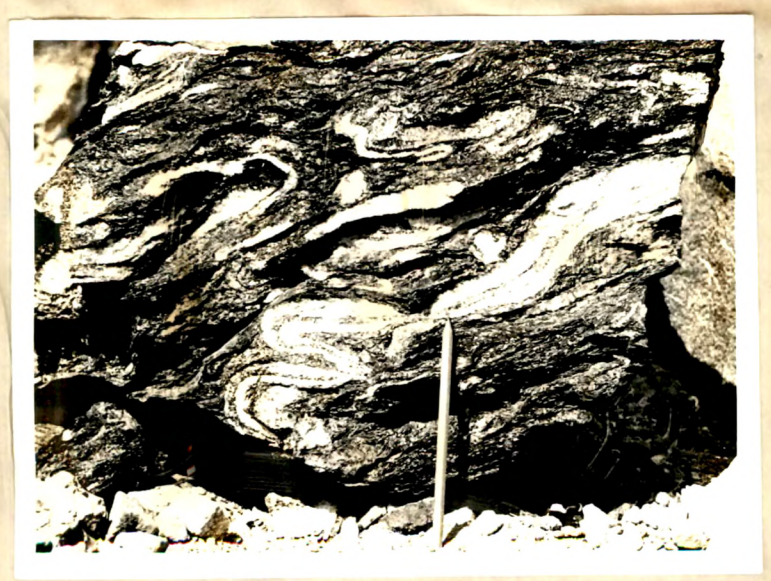
The microcline content in this part is quite high. But the rocks here show a wide mineralogical variation, and granitic rocks containing (1) Quartz, plagioclase and hornblende, (2) quartz, plagioclase, hornblende, biotite, (3) quartz, plagioclase, microcline, hornblende, biotite and (4) quartz, microcline, biotite $\pm$ hornblende, are recorded.

The most striking feature here, is the frequent occurrence of patches and pods of highly biotitic segregations. Such micaceous patches show very strong schistosity. These biotitic concentrations themselves contain numerous strings and veins of quartz-felspar, running mostly along the foliation. The true nature of

PLATE 20

A

A. Grey gneissic granite with leucocratic veins and patches. Loc: Near 19th milestone N of Ankola.



B

B. Leucocratic bands showing two sets of folding. Loc: Near 19th milestone N of Ankola.

these highly micaceous masses is very interesting and is ideally revealed in a number of elliptical, lensoid and spindle shaped biotitic patches occurring in the granites. On a careful scrutiny these elongate patches are seen to be obliterated tight fold cores, and these almost invariably contain a white rim of quartz-felspar, thus indicating a process of differentiation (metasomatic) during the intense folding responsible for their formation. Bigger biotitic masses show numerous contortions and tight folds, and the quartzo-felspathic matter occurring in them ideally show refolded folds. (Plate 20B). These schistose patches also show two foliations - earlier one is seen folded,and the later one developing along the axial planes of the folds. In an exposure to the E of the quarry near the road side, hornblende bearing granites are recorded. It is very obvious even in the field, that the hornblende gave rise to biotite, the segregation having taken place during the foldings.

The most striking feature of these granitic rocks is the abundance of streaks, veins, dykes and patches of white quartzo-felspathic material. These occur in all directions, thus rendering the whole mass a confused assemblage of the rocks of various shades, which could

best be described as resembling to 'agmatites'. Some of the leucocratic veins are involved in both the folding - early as well as late, while some are seen folded by the late deformations only. While there are others which are post folding. In a general way, it is seen that the early veins are richer in plagioclase, while the late ones dominate in microcline. These veins of quartz-felspar are of all dimensions ranging in size from tiny streaks to bands of several centimeters thickness. Generally these pegmatitic and aplitic veins show fairly sharp contacts with the surrounding rocks. It is significant that in most of the veins which run across or oblique to the foliation, faint traces of the foliation are still preserved within them. Thus the main foliation is seen extending across the vein material undisturbed. Such veins appear to have grown gradually along fracture planes by metasomatic replacement. Another criteria which supports metasomatic growth is the courseness of vein material along the margins, the middle portion being finer grained.

A close relationship is seen to exist between folding and the segregation and growth of quartzofelspathic patches and bands. As is already mentioned,

the exposures show evidence of at least two fold episodes, and during both the deformations, the quartzo-felspathic segregations have grown. Some of these are seen involved in the early folding. Quite a few however, appear to have grown along joint planes and ruptures, almost synchronous with the late folding. Such veins show very good late folds and the development of axial plane foliation which merges with the main foliation in the enclosing rock. Greasy 'voids' of microcline (1 to 2 cm in diam) are seen crowded along the margins. Some veins have grown after the late folding, and these are seen cutting the folds (Plate 21).

The foliated rocks have a regional ENE trend with rather moderate dips due N. It shows some 'Z' shaped anomalous folds with axial plane along ENE direction, dipping 70° towards NW. These are late folds varying in size from 1/2 to 2 metres.

(2) <u>East of Ankola around Hosgadde area</u>

About 2 km to the east of Ankola, along the southern slopes of the east-west ridge, granitic rocks are ideally exposed. These rocks are seen in a number of quarries opened up recently. The constituent rock

PLATE 21

Leucocratic vein developed after the late folding. Loc: Near 19th milestone N of Ankola.

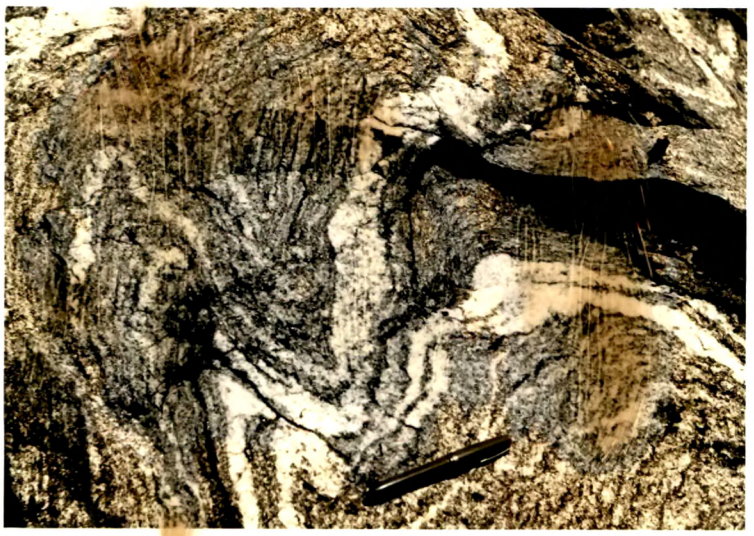
is dominantly a medium grained, rather dark grey streaky and foliated gneissic granite, traversed by numerous clear cut bands and veins of quartz and felspar. The foliation is, on the whole seen running ENE-WSW with gentle dips due N but is highly folded and crumpled at most places. The relative abundance of the quartzo-felspathic bands and streaks is variable. While at some places they are scarce, at other places these dominate and appear to be intimately mixed up with the grey gneissic variety. Considerable mineralogical diversity is noted in these outcrops. In the main bulk of the greyish granites, both the felspars-microcline and plagioclase, are present but in variable proportions. Some are richer in plagioclase while in others microcline dominates. The mafic minerals are seen to be both biotite and hornblende, and even in the hand specimen, it is clearly seen that biotite is developed at the expense of hornblende.

Two generations of quartz-felspar veins are recorded. Those which originated prior to or during early folding, are more or less rich in plagioclase. Later dykes and veins are dominantly made up of quartz and microcline.

In a broad way, in Hosgadde area these gneissic granites dominate the western part of the ridge while to the east, these gradually merge through hornblende gneisses into amphibolites. Structurally, these rocks are quite interesting and show at least two generations of minor folds. As it has already been alluded to, the various light coloured quartz-felspar segregations that form distinct streaks, veins and bands, are products of metasomatic differentiation. A number of such bands are seen to be tightly folded and it is thus obvious that the tight folding followed or at least synchronised with the early granitisation. These tight folds follow the foliation trend, and are in turn, refolded (Plate 22A). The late folds have given rise to widespread crumpling, chevron type structures and a distinct crinkling with a strain-slip in the axial plane direction (Plate 22B). This late folding has an axial plane roughly trending ENE-WSW with steep (about 70°) dip to the N. The fold axes are difficult to measure, but at few places they are seen plunging to the NE.

Interesting relationship is seen to exist between the successive fold episodes and the formation of quartz-felspar segregations. These segregations at least of

PLATE 22



A

A. Leucocratic veins in gneissic granite showing refolded folds. Loc: N of Hosgadde.

B

B. Development of 'strain slip' folds in gneisses. Loc: N of Hosgadde.

three generations, are recognised:-

(1) Very early veins and streaks (sometimes illdefined), which are seen involved in both the folding, and show refolded structures.

(2) Rather distinct bands, parallel to, as well as cutting obliquely the early banding and foliation, and involved in the late folding only.

(3) Sharp and straight bands, cutting the foliation, and all the folded structures, and obviously grown after second folding.

(3) NE, E and SE of Hosgadde

When traced further to the northeast, east and southeast, the granitic rocks tend to become somewhat more hornblendic. In the hill △ 1164' (△ 385 m) to the east of Hosgadde, the constituent rocks are seen to be more of the nature of a banded hornblende-biotite gneiss. In a general way, the microcline and plagioclase are present in equal proportions, but individual spots might contain rocks richer in either felspar. Occasionally, the banding becomes very faint and inconspicuous and this renders the rock to look massive and unfoliated. On the whole, the foliation trend is due NW-SE with a moderate dip due NE, though steeper dips are not uncommon. To

the south near the village Talgadde, the strike of the foliation swings to almost NNW-SSE, and N-S. A fine dolerite dyke is seen cutting the granites here.

The eastern extension of these rocks, which form very conspicuous hills in the NE of the area, are found to be somewhat less granitised and represent an intermediate stage. The rock type occupying this part, can best be described as a group of hornblende-biotite gneiss, banded and streaky, comprising of partly granitised dark coloured bands of hornblendic rock traversed by numerous quartz-felspar veins and streaks. The foliation is quite distinct and is seen to be NW-SE in the north and almost NS in the south with moderately high dips due NE and E. A number of late doleritic dykes are intruded into these rocks.

In the quarries immediately to the south of the village Hosgadde, the granitic rocks again show a fine streaky gneissic foliation. The microcline content also increases. The trend of the foliation is NW-SE, but fluctuates to as much as N-S. The dips are seen to be due NE or E. Frequent quartz-felspar bands show tight early folding. Late flexures on ENE-WSW axial

plane are also recorded. A number of pegmatites cut these rocks in an ENE-WSW direction, perhaps following the axial planes of the late folds.

In the southern quarries, the mafic content increases. A considerable differentiation is suggested by the presence (of pods, patches and veins) of mafic minerals - biotite and hornblende.

There are some tight folds also and many of them are partly obliterated. In these outcrops, again a number of irregular pegmatitic veins showing rather sharp contacts, are present. These pegmatites show greasy ovoids of microcline concentrated along the outer mrgins - again substantiating a metasomatic mode of origin.

South of Hosagadde these granitic rocks continue to outcrop as scattered exposures. The foliation as usual fluctuates between NW-SE to N-S. At many places contortions and flexures, roughly ENE-WSW to NE-SW, are recorded. Near the Belse village, the granitic rocks contain considerable amount of hornblende, and a distinct ungranitised amphibolite patch is present.

(4) Near Shirur

To the south, it is seen that the granitic rocks tend to become scarce, and near Shirur, the group of hills immediately to the north of Gangavali river, contain only a few patches of granitic rocks. Even otherwise, at this place the rocks - granitic as well as hornblendic, have been considerably lateritised. The hornblendic and granitic rocks are exposed at lower levels in the road cuttings only.

The rocks, transitional from hornblendic to biotitic, are rather finely gneissic, more of the nature of hornblende-biotite-gneiss. The quartz-felspar bands and veins are conspicuously more frequent in the biotite gneiss. The plagioclase dominates over microcline, and the quartz-felspar veins, though containing both the felspars, are conspicuous by the absence of microcline 'ovoids', so common in the north.

The foliation is seen striking due NNE to NE, with rather variable dips due SE. On the whole the dips are steeper but on going toward the river the values become rather less.

Here again, two sets of minor folds are met with. The light coloured quartz-felspar bands show tight isoclinal folds, and these in turn, have been refolded on an axial plane trending almost NE and dipping 60° to the NW. The axes of these late folds are seen plunging in the same direction. This folding has imparted a fine crinkling in the biotitic portions.

(5) Around Kadme

To the S and SW of Shirur, around Kadme, the granitic rocks occur in a restricted manner in close association with amphibolites. Here, some portions of the amphibolites show complete granitisation and abundance of microcline. Exposures in this part are very valuable and important from the point of view of the granitisation history of the rocks. In fact, it becomes very clear that the process of granitisation was, for the most part, synkinematic, and synchronised with the various major fold episodes. A large number of tightly folded quartzo-felspathic (migmatitic) bands indicate the advent of granitisation prior to the isoclinal folding. Tight fold cores occurring as spindle shaped masses of quartz-felspar (1 metre long and 15 cm wide) with a selvage of 8 to 10 cm thick

hornblendic rock (mainly crystals of hornblende), ideally reveal the process of 'filtering off' or metasomatic differentiation and segregation leading to granitisation initiated during the early isoclinal folding (Plate 11A). Similarly lensoid patches of hornblendic rock with light coloured rims of quartzo-felspathic matter are also present (Plate 11B). Outcrops here amply show that the early deformation aided the granitisation process in differentiating and transforming (?) the hornblendic rock into banded assemblage of rocks of varying mafic and felsic contents(Plate 23).

(6) Around Hiregutti and Bargi

Near the villages Hiregutti and Bargi, the granitic rocks are recorded in intimate association with the amphibolitic rocks. In fact, in Bargi area it is very difficult to demarcate and distinguish between the two types. While describing the hornblendic rocks of this area, considerable details of the associated granitic derivatives have been given.

Granitic rocks of Bargi, though looking quite similar to those of the northern part of the area, are

PLATE 23

Granitic rocks with a typical agmatitic appearance - a confused assemblage of different types, leucocratic portions showing effect of folding.
Loc: Kadme.

such that plagioclase dominates over microcline. The potash felspar shows variable distribution. The change of biotite from hornblende is very conspicuous.

(7) Near Andle village

The granitic rocks are again met with near the village Andle, but here they form a few outcrop only. The surrounding rocks, though at present almost lateritised, clearly reveal the original dominance of hornblendic rocks. This indicates that the granitisation is somewhat discontinuous.

Granitic rocks here are fine grained, compact and streaky. Banding is less conspicuous. Along with quartz, felspar and biotite a little muscovite is seen in these rocks. The foliation trend varies from NNE to NE and dips from 60° to 70° due SE. These rocks show less distortions as compared to the area in the neighbourhood. However, pegmatitic segregations and quartz veins are quite common. Two dykes of dolerites cut these rocks.