CHAPTER V

S T R U C T U R E O F T H E A R E A

The structural studies of the rocks of Ankola-Gokarn, were found somewhat difficult on account of the following three main reasons:

(1) Metamorphism and granitisation have obliterated the various minor structures - planar and linear, at most places. Systematic study of these minor structures was very vital in interpreting the regional structural pattern.

(2) The granitisation in all its stages, appears to have made the rocks in different parts somewhat soft and plastic, and this has considerably modified the orientation of the structural elements related to the successive fold episodes.

(3) Vast lateritic cappings have rendered the outcrops disconnected and fragmentary, thus obscuring some vitally important exposures.

The structural geology of the area looks quite simple at first glance, but on a detailed mapping of all the exposures, and a critical analysis of the structural data preserved, a rather complicated structural pattern has emerged. The study has revealed that the existing shape of the area comprises a big Z shaped band of amphibolitic rocks forming a pair of early isoclinal folds (F_1) on which late NW-SE or E-W folds (F_2) have been superimposed (Fig. 4B). Almost in all parts of the area, effects of two major fold episodes are recorded, each having given rise to a number of planar and linear structures. In their present state however, these minor structures are considerably obliterated, and are noted in such small numbers that their systematic statistical analysis could not be undertaken. Minor folds related to the various fold episodes are sporadically recorded and just furnish a general idea of the behaviour of cross-folding pattern in different parts of the ground.

The structural interpretation has therefore, been made, taking into account the following criteria:-

(1) Trends of the foliation in different parts of the area.

(2) Trends of the axial planes and fold axes of the various minor folds, especially the refolded folds.

Accordingly, the geometry of the early (F_1) and the late (F_2) folds in different parts of the area, was worked out. For this, the area was divided into 7 sub-areas, and the foliation poles of each sub-area, were plotted on Schmidt's Equal Area Net. The π -diagrams, thus obtained were contoured to bring out clearly the fold trends in the various sub-areas (Fig. 4A, B and C). The fold axes (and related lineation if any) were not plotted, as their readings were too few (and sometimes erratic) and inadequate for statistical purposes. However, the various minor folds, though small in number, proved quite useful in working out the structure, and it was found that in a broad way the π-diagrams revealed the same orientation of the folding as exhibited by the related minor folds recorded in the respective sub-areas.

STRUCTURAL CHARACTERS OF THE VARIOUS SUB-AREAS

Sub-area (i): This sub-area includes exposures on the coast around Honnebail and Vadibogri. The rocks mostly amphibolitic, show foliation trend striking generally WNW-ESE, though fluctuations to as much as NW-SE and E-W, are quite frequent. The dips are either vertical or dipping very steeply to N or S. Early tight folds (F_1) are frequently recorded. These isoclinal structures run parallel to the foliation, and their axes are seen plunging moderately either due SW, WSW, NW or even N, depending on the directions of the dip and strike of the foliation. The variation in the trend of the foliation from E-W to NW-SE is seen to be due to a late flexuring. A few minor folds-fairly open, and related to this late folding are seen plunging due S in Manjuguni area. A late schistose cleavage, obviously related to F_2 developed in hornblendic portion, has a SSE trend and dips steeply due SW. (At this stage, it is worth pointing out that at a number of places, evidences of a third folding (F_3) are clearly recognised, but so little is revealed by them that it appears that this last deformation was rather feeble and sporadic).

Sub-area (2): To this sub-area, belong the granitic outcrops of the extreme north, along the road to Hubli. The author is inclined to join the hornblendic rocks of Honnebail-Vadibogri to the rocks of this sub-area, such that the rocks of the former take a swing, join up with those N of Ankola, and thus form a big fold, closing immediately to the N of Vadibogri. Definite geometry of this closure cannot be obtained on account of the lack of exposures. The rocks of the sub-area (2) are in an advanced stage of granitisation, and the pre-existing foliation and other structures are considerably obliterated. But enough are preserved to give an approximate idea of the structure of this part. The foliation shows variation in trend on account of frequent folding on an axial plane roughly E-W and almost vertical. This folding has affected the rocks on all scales. Abundant E-W folds ranging in size from a few cm to several metres, are recorded. These folds are undoubtedly late folds (F_2) as they are seen folding earlier tight folds (F_1).

Sub-area (3): This sub-area includes the exposures around Ankola and Hosgadde, and are made up of partly granitised amphibolitic rocks. Obviously, these rocks are the southern continuation of those of the sub-area (2). Tight early folds (F_1) obliterated but quite recognisable, are abundantly seen both, in granitic rocks as well as in amphibolites. These are seen refolded by minor folds (F_2) striking ENE-WSW. The axial planes of these F_2 folds are inclined to the N and the axes plunge due NE. Generally measuring of axial plunge is not very easy. This structural feature, however, can be ideally seen in the stereogram of the foliations (Fig. 4C). It shows two girdles, one somewhat better developed and showing identical orientation as that of the previous sub-area (2), and another a broken and fragmentary.

Sub-area (4): This sub-area includes outcrops of Belse-Shirur, further south of Hosgadde. Partial granitisation, nearness of the Gangavali fault, and widespread lateritisation, have rendered these exposures somewhat obscure, and unsuitable for study. There is considerable structural confusion. As usual, early folds (F_1) follow the foliation trends, while the late (F_2) folds show two orientations.

Some are seen striking due NW-SE to NNW-SSE; while others show NE-SW trend, the axes plunging rather steeply due SE or NE respectively. The stereogram (Fig. 4C) obtained from the π -diagram, though not very illustrative shows two partly developed girdles, related to these two (F_2) fold directions. It is seen that the NE trending folds become more conspicuous towards north, while the SE fold become more prominent southwards. In Shirur area, the axial plane of F_2 changes its strike (from NW-SE, WNW-ESE) to almost NE-SW.

Sub-area (5): Within the limits of this sub-area, lie the two groups of exposures to the south of Gangavali river; one along the ridge - almost NE-SW from Ulvari across Devigadde to as far as Kadme, and the other comprising the outcrops NW of Chevatgiri. The rocks are partly granitised amphibolites and banded haematite-quartzites. The rocks of this sub-area show considerable structural complexity, and superimposition of several folds are recognised. It is seen that the foliation trend in Ulvari-Kadme is NE-SW, and this swings to almost NW-SE at Chevatgeri. This change in the strike characterises the late folding (F_2). Associated minor folds (F_2) are seen developed in abundance, with upright axial planes and the axes plunging ESE to SE. These typically late folds are seen folding an earlier set of tight isoclinal folds (F_1). The axes of these early folds are difficult to measure.

In this part, impress of a third fold episode (F_3) are also noted, and at a few places, this folding has given rise to clear chevron type folds striking NNE-SSW (F_3). The stereogram (Fig. 4C) of the foliation poles, indicates a rather imperfect girdle of late folding (F_2).

Sub-area (6): The exposures included within this sub-area, constitute the southwestern extension of the Chevatgeri rocks, and occupy the coast line at Gokarn. Here the granitisation is at its minimum, the rocks being mainly different varieties of amphibolites. The stereogram (Fig. 4C) of the foliations, does not reveal much, on account of the reason that at most places here, the foliation trend is generally E-W and vertical. If it is not vertical, then shows very steep dips. Small tight folds (F_1) abound in number, their axes mostly plunging at various angles due WNW to NW. The abundance of tight folds (M shaped) suggests the existence of the fold core (hinge portion) of F_1 in the Gokarn area. Structural confusion, especially the variation in the orientation of the F_1 fold axes, appears to be due to the presence of numerous late (F_2) folds, whose axial planes strike almost NW-SE, are upright, and whose axes plunge due SE. It is this folding that has given rise to frequent NS strike of foliation in the Gokarn area.

Sub-area (7): This sub-area includes the southern extension of the Gokarn rocks, and comprises the out-crops along the coastline from Kudle, Kuchni to as far as Tadri. Structurally, this part shows maximum complication, and it is obvious that this structural complexity is on account of the following reasons:

(1) This part of the area, together with Gokarn, possibly comprises the hinge area (crest) of the earliest isoclinal fold (F_1) and is made up of a large number of 'M' shaped folds.

(2) During the later folding (F_2), along NW-SE axial plane, it appears that the various F_1 folds in the crestal portion, got distorted and opened up in a somewhat fan shaped manner.

(3) Superimposition of a number of F_2 folds, have given rise to a complex assemblage of minor folds and axes related to them.

The net result is an utter confusion and mixing up of structural elements. The π -diagram of this region (Fig. 4C) is also not very helpful and the only feature that stands out is a broken but conspicuous girdle, whose pole roughly coincides with the trend of the fold axes of the various minor structures related to the early folding (F_1). These minor folds, at many places in this area, are not very tight, obviously being on the crest of the fold. The fold axes always plunge in the NW sector. In a broad way, in Gokarn area, the plunge is generally due WNW, but on coming south to Kudle-Kuchni, the direction of plunge gradually swings to as much as NNW.

Some late folds (F_2) with vertical axial planes striking NW-SE are occasionally recorded. Axial plunge of these folds is however quite variable.

Sub-area (8): To this sub-area belong the three groups of outcrops in the south-east: (i) on the Aghnashini coast (opposite Tadri), (ii) a few isolated hills to the

SW of Bargi (west of the road) and (iii) group of low hills E and NW of Bargi. Mapping shows that the rocks of Tadri continue in Aghnashini. The foliation trend from W to E takes a systematic turn, and at Aghnashini it is WNW-ESE (dipping due N). On going east, it gradually swings to ENE-WSW and then to NE-SW. The dips suddenly become due SE. Further NE near Bargi, the dips are due ESE (strike being NNE-SSW). This swing in the foliation is due to a big fold (rather reclined) whose axial plane strikes somewhere between NW-SE and NNW-SSE, and is inclined to the NE. The fold axis, accordingly is seen plunging due NE (Fig. 4C). This fold (F_2) is the late structure superimposed on the SE limb of the early isoclinal fold (F_1). [The effect of this fold on the other limb (NW) is already discussed in the account of the sub-area (5) of Chevatgeri and Devigadde area]

Small microfolds and related striping lineation (due to F_2) are ideally seen in the amphibolitic rocks of the Aghnashini. At Bargi, the granitisation has obliterated these structures.

<u>Sub-area (9)</u>: Rocks of Bargi continue northward and form good exposures to the east and north of Hiregutti. This sub-area includes the outcrops around Hiregutti. Here the

foliation has a tendency to swing from NNE-SSW to as far as NW-SE, the dips all the time being easterly and steep. The rocks form an open flexure, whose axial plane is almost upright and striking due WNW-ESE, with axial plunge due ESE (Fig. 4C). A number of minor folds conforming to this geometry are seen. These are late (F_2) folds whose axes plunge due ESE to SE. Evidently the axial plane of F_2 here is upright (and not inclined as in the previous sub-area), and accordingly, the plunge of the related fold axes has also changed.

FOLD PATTERN

On bringing together the various evidences, discussed above, the pattern that has emerged out, is found to be quite complex and interesting. The author has attempted to reconstruct the structure of the area, which is shown in the accompanying sketches (Figs. 3 and 4B).

It is evident that the rocks of the area comprise a band of amphibolitic rocks, affected at least by three foldings. The first two fold episodes were quite prominent while the third one was not so intense. The early folding (F_1) gave rise to a pair of big isoclinal structures. The shape of the folded rocks was somewhat like a big 'Z', such that one closure or hinge lies in the area between Vadibogri and Ankola in the north, while the hinge area of the complementary fold in the south lies in the Gokarn-Kudle coast. It is this folding that has resulted into three somewhat parallel groups of exposures, broadly running NS. On this folded amphibolite band (partly granitised) was superimposed another fold (F_2). This late fold is very distinctly seen in the Devigadde-Kadme-Chevatgeri and Aghnashini-Bargi areas, each showing superimposition of F_2 on two separate limbs of F_1.

It is significant to note that the geometry of the F_2 fold is variable in different parts of the area. It is roughly NW-SE in the southern part, but towards north, its axial plane tends to become almost E-W. The fold axis also shows much variation. These variations are on account of two main reasons: (1) Superimposition of an yet younger (F_3) fold, the effects of which have only sporadically developed. This folding has occasionally given rise to a few NS or NNE-SSW folds, and it appears that this deformation was not very intense. (2) Extreme plastic nature of the rocks due to granitisation.

FAULTS

Fracturing and faulting is quite widespread and is noticed in all parts of the area, on all scales. The author has recorded one conspicuous and big fault, running along the Gangavali river. It is quite possible that there are other faults also, but on account of the fragmentary nature of exposures, they are difficult to recognise.

The dislocation which follows the Gangavali river is a major (E-W) strike-slip fault, showing sinistral movement. The net slip however, is comparatively small and of the order of a few hundred metres or so. Considerable brecciation is encountered along this fault zone. Thin sections of the rocks, affected by this fault, show evidence of shearing and related mineralogical changes.

The slipping along the Gangavali fault is identical to that seen along the axial planes of F_2 folds to the north, and this clearly points out that two are genetically related. It can be concluded that the faulting along Gangavali river was caused by the same deforming stresses which gave rise to F_2 folds. Thus, this fault might have developed immediately after the F_2 folding.

This fault along the Gangavali river, originally a straight E-W or ESE-WNW dislocation, appears to have been affected by the late F_3 folding, and as such shows its present wavy trend.

There is the likelihood of existence of another fault, along Andle, striking almost NE-SW and cutting the Gangavali fault, and extending SW for about 4 km, as far as upto the mouth of the river Aghnashini.

Small faults showing displacement of a few centimetres, are frequently recorded all over the area, both in amphibolitic and granitic rocks. In fact, slipping and shearing is so common, and in varied directions, that only very general statements can be made about this phenomenon. In a broad way, it can be stated that lateral slipping has taken place in the axial plane direction of the second folding F_2 and is always sinistral. The slip direction varies from NNW-SSE to WNW-ESE in the region to the south of Gangavali river. To its north, the common slip direction is E-W or ENE-WSW almost coinciding with the Gangavali faulting.