CHAPTER - IX

SYNTHESIS AND DISCUSSION

GENERAL CONSIDERATIONS

In the foregoing pages, the author has presented a geological picture of the area, which is at considerable variance with the one visualised by most of the earlier workers. In fact, the various details of the Ambamata geology that were observed by Sharma (1931) and Heron & Ghosh (1938), are more appropriately explained by the present author's reinterpretation. Of course, in arriving at the various conclusions, the author always kept in mind the excellent field account of Heron & Ghosh (op. cit.). The most recent findings of Desai et al. (1978) and Sychanthavong (1978) provided the much needed data from the neighbouring areas. A synthesis of all available facts has enabled the author to arrive at certain important conclusions that are of vital importance to the Precambrian geology of Western India as a whole.

Metamorphically, the Ambamata rocks show a fairly high metamorphic grade. It is not correct to consider these rocks to belong to greenschist facies. The mineral assemblages in the calcareous rocks and the amphibolites typically indicate medium grade amphibolite facies metamorphism. No doubt the pelitic rocks are scarce in garnet and the biotite quite often shows chloritisation, but these facts respectively could best be explained by invoking the (1) relative dominance of quartzo-felspathic constituents in comparison to the argillaceous material in original sediments, and (2) change over of biotite to chlorite due to the hydrothermal effects of the Erinpura granite. Also, the extensive exposures of biotite gneisses, do not have any direct genetic relationship with the intrusive masses of Erinpura granite. The former represent deepseated granitised pelitic metasediments. Structurally too, the area though looking simple, has revealed a more complicated fold pattern, the folding being an integral part of the Delhi orogeny. The various aspects of the geology of the area, as worked out by the author have been critically discussed.

STRUCTURAL PATTERN

The outcrop pattern of the area is due to the superimposition of late WNW-ESE flexures on an earlier set of very tight folds (which must have been originally NNE-SSW or so). Stratigraphic considerations have enabled to identify and correlate these fold events with those worked out by Sychanthavong (1978) further east. The two better represented folds of the study area are the F_1 and F_3 of Sychanthavong. The presence of F_2 is visualised only on a regional scale (Fig. V.2).

The large basin like synclinal structure in the area, which most workers have recognised has been found to be a combination of F_2 and F_3.

The F_1 folds are difficult to recognise as they are tight and somewhat fragmentary. To a certain extent the tight F_1 anticlines and synclines have been inferred from the nature of occurrence of calcareous and amphibolitic rocks. The F_1 syncline extends right across the calcareous rocks, while a complementary anticline is observed in the amphibolitic terrain. Of course, both have been affected by F_3 synform and antiform respectively. It is not unlikely that the numerous amphibolitic bands in the southeastern part might be comprising obliterated F_1 fold cores. It is also interesting to observe that the pink finegrained granite of Minagarh (Δ 921) appears to have arisen along the F_1 syncline.

Though the structural history of the Ambamata is almost identical with that of the Kherod-Posina area (Sychanthavong, 1978), the outcrop patterns of the two areas are quite different. This is due to the difference in the relationship between the F_{1-2} and F_3 stress fields in the two areas. In the Kherod-Posina area, the stress relationship was as under :

σ_1^3 - NNE-SSW subhorizontal coinciding with σ_2^1 and σ_2^2. (= B_1 and B_2 fold axes)

σ_2^3 - Subvertical

σ_3^3 - WNW-ESE subhorizontal and coinciding with σ_1^2.

The deformation during F_3, had therefore following effects on earlier stress axes.

1. No effect on σ_1^1 and σ_1^2.
2. Rotation of σ_2^1 and σ_3^1, σ_2^2 and σ_3^2 in a plane normal to σ_3^3 (= fold axis B_3).

But in Ambamata area, the relationship was different. The trend of σ_1^3 axis coincided with the trend of σ_2^1 and σ_2^2, but was inclined in a F_3 stress field. Obviously σ_2^3 and σ_3^3 were not respectively subvertical and subhorizontal. Furthermore, during F_3 folding, σ_2^1 and σ_2^2 were twisted obliquely and this relationship gave rise to the tortuous outcrop pattern in contrasts to that further east.

STRATIGRAPHY

The metasediments of the study area belong to the Ajabgarh Series, and have been found to consist of mainly two horizons - a lower pelitic and the upper calcareous. The basement is ortho-amphibolite. The two groups of sediments, within them also show considerable compositional variation. The pelitic sediments must have comprised beds of graywackes (sometimes pebbly), subgraywackes and argillaceous sandstone. Within this group, a small horizon of calc-magnesian sediments also occurred. The existing diversity of those metapelites reflects partly the original nature of sediments and partly their response to varying metamorphic conditions.

The stratigraphic sequence established by Heron & Ghosh (1938), so far as the Ajabgarhs are concerned, appears to be quite valid. The most interesting part of the author's findings comprises the correct unravelling of the structure and identification of tight folding. In the absence of this understanding, the local succession shown by the calcareous and argillaceous rocks pointed almost to the contrary, and quite a few geologists were erroneously led to believe calcareous rocks to be older than the pelitic rocks (Fig. V.1b). Earlier, Sharma (1931) who included these rocks under doubtful Aravallis, also put calcareous rocks beneath the quartzites, phyllites and biotite-schists. The correct depositional sequence as interpreted by the author, keeping in mind the work of Sychanthavong (1978) works out as under :

Calcareous sediments	Calc-schist, Calc-silicate gneiss with lenses of pure marble.	Ajabgarh Series (Delhi System)
Pelitic sediments	Biotite schist, quartz - mica schist, micaceous quartzite	
----- Unconformity -----		
Basement	Ortho-amphibolite	Oceanic plate

TRUE NATURE OF BASIC ROCKS

Considerable confusion has prevailed in respect of the basic rocks - metamorphosed and unmetamorphosed, of this region. Sharma & Nandy (1936) have invoked three phases of basic intrusions. The earliest intrusives, somewhat metamorphosed, were referred to as epidiorites, hornblende schists and pyroxene granulites. The second phase of basic intrusion, according to these two workers, comprised the various bodies of metagabbro and metadolerite, far less metamorphosed than the older intrusives. The third group of youngest igneous intrusives (of Post Erinpura age), obsolutely free from all signs of metamorphism, include the dykes or sills of olivine dolerite and olivine basalt.

Heron & Ghosh (1938) have followed more or less the classification suggested by Coulson (1933) for the basic intrusives of the adjoining Sirohi area, and they have grouped the similar rocks from Ambamata area accordingly, though with some uncertainty. According to these workers, the epidiorites and hornblende schists are Pre-Erinpura granite, while the dolerites, gabbros and basalts represent intrusions later than the granite.

Merh (1950) also recognised two groups of basic rocks - Pre and Post-Erinpura granite, but he classified the former group into epidorites and amphibolites, depending on whether the rocks exhibited ophitic or granoblastic texture. He however, did not realise that the amphibolites could after all be much older than the epidiorites.

An altogether new classification has emerged from the present study. None of the earlier workers realised the true nature of amphibolitic rocks. They show a fairly high metamorphism-almost of the same grade as the metasediments, and also show their involvement in the various foldings. Structurally, they have been found to comprise the oldest rocks of the area. The present author has every reason to agree with Sychanthavong (1978) who has considered these amphibolites and hornblende schists to be the basement rocks involved in F_1 and F_2 and simultaneously metamorphosed. These Ortho-amphibolites are quite distinct from the intrusive sills which typically show relict ophitic textures and have been designated as epidiorites. The present author, has deliberately omitted the name 'epidiorite' and has included these rocks with the much less altered dolerites (= metadolerites of earlier workers).

According to the present study, the basic rocks belong to the following three age groups :

Pre-Delhi

1. Ortho-amphibolites - metamorphosed and folded oceanic (basaltic) basement - showing amphibolite facies mineral assemblages and granoblastic to granulitic textures.

2. Post-Delhi but Pre-Erinpura Metadolerites - To this category belong the so called 'epidiorites' and some of the metadolerites and metagabbros. These are seen as distinct and well defined sills and plugs within the metasediments. The overall

metamorphism is very low. Original textures are preserved. The saussuritisation of plagioclase and chloritisation - uralitisation of pyroxene, is related to the hydrothermal effects of Erinpura Granite. These appear to have been intruded after F_2 and before F_3 folding.

3. Post-Erinpura basaltic dykes - These are only sporadically recorded, and have been found to be finegrained variolitic oligoclase basalts. Coulson (1933) thought that this dyke rock referred to in Sirohi as albitised basalt. Heron & Ghosh (1938) called these as oligoclase dolerite, but they were not certain whether these were Post-Malani. Desai et al. (1978) have also come across narrow dykes of similar rocks, called by them as a finegrained alkali basalts. Sychanthavong (1978) has referred to these rocks as andesites and has mentioned that these occupy the axial plane fractures of F_3.

GRANITIC ROCKS

The various foliated as well as unfoliated varieties of granitic rocks of the Ambamata and its surrounding areas have been taken as Erinpura Granite by Heron & Ghosh (1938). The main bulk of the Erinpura granite, according to these workers, comprises a coarse biotitic variety, unfoliated and moderately porphyritic forming bare knobs of rock. These workers considered the fine and mediumgrained (with scanty ferromagnesians) pink granite (felsite like) to represent the first manifestation of the igneous activity, and it was this early phase which is supposed to have given rise to the gneissic types by interfoliar injection of this felsitic material. The biotite gneisses are supposed to have originated by a process of lit par lit injections in biotite schists, while the hornblende gneisses have been described as composite gneisses consisting of sheets of pink granite interbanded with older amphibolites.

Merh (1950) has more or less followed Heron & Ghosh (1938) in respect of the nature of gneissic rocks, having considered these foliated varieties to be due to lit par lit injection of the Erinpura granite in the older schists. However, like Sharma (1931), he considered the 'microgranite' i.e. "finegrained pink flesh coloured rock, almost devoid of mafic minerals, to represent an acidic differentiate of large original magma which gave rise to Erinpura granite, and consequently they may be slightly younger in age".

The present study has however shown that the nature and age relationship of the various granitic types, is quite different, and the findings of the author have far-reaching regional significance. The main conclusions pertaining to the granitic rocks, arrived at by the present author could be summarised as under :

1. The finegrained pink granite which forms a number of big hills (Δ 921; Minagarh) as also sheets interfoliated with metasediments, represent an early phase of granite activity. The maps of the area (Figs. IV.1 & V.2) very clearly show the involvement of this granite in F_2 and F_3. In fact this granite has obviously arisen along the axial plane fractures of the F_1 syncline, the core of which this granite occupies.

2. The coarsegrained unfoliated biotite granite (Erinpura Granite porper) which forms conspicuous hills and ridges, has been intruded at a later date i.e. after F_3.

3. The gneissic variety (biotite gneiss) represents the product of 'in Situ' granitisation of pelitic sediments during F_1. Admixture of this granitic material with the underlying amphibolitic rock, have given rise to the hornblende gneiss. Thus, the granites and genisses of Erinpura granite supposed to comprise a single igneous event following Delhi folding, point to granitic rocks of more than one generation and of different origin. Older foliated varieties have been found to be metamorphically and metasomatically formed and involved in F_1, F_2 and F_3, while the instrusive

granitic bodies are of two generations - ome finegrained (pink) Pre-F_2 and the other (coarse biotitic) Post-F_3.

One very interesting point that the author would like to mention here is the significance of the recent geochronological data (Crawford, 1975; Gopalan et al., 1978; Merh, 1978). It has been now conclusively established that quite a few intrusive masses of Erinpura Granite in Idar and Ambamata show isochron age almost with that of the Abu granites and Jalor-Siwana granites. All have been formed to range between 735 $\pm$ 15 m.y. to 745 $\pm$ 15 m.y. But in Ambamata, there are difinitely older granites - Pre-F_3 or Pre-F_2. Unfortunately no age data is available on them. Future geochronological studies on the granites of Ambamata will therefore be of great help in dating the various fold events.

MINERALISATION

The base metal sulphide mineralisation is restricted to the pelitic schists, the entire mineralised zone being about 2 km. long in WNW direction and about 0.7 km. wide in the central portion. The mineralisation occurs in the calc-magnesian rocks and the associated biotite schists. The main host rock is the talc tremolite schist. The primary sulphide minerals - chalcopyrite, sphalerite and galena, exhibit interesting associational and segregational tendencies, as also preferential lithological affinities. The predominantly Pb-Zn mineralisation shows a preference to the calc-magnesian rocks, the Cu mineralisation to the more arenaceous rocks, and the trimetal ores to the intermediate types (Murthy & Shekar, 1975). Several well defined WNW-ESE trending mineralised zones have been delineated by the officers of G.S.I. and M.E.C. The individual ore bodies appear as stout or elongated lenses. According to Murthy & Shekar (op. cit.), these base metal deposits are stratiform, associated with near-shore sediments. The problem of the genesis of these ore bodies has not been studied in detail, but the available data according to them, point to their syngenetic, pre-tectonic and pre-metamorphic origin.

The present author has not been able to take up the study of the mineralised zone in detail, and as such he is not in a position to rally adequate evidences to come to appropriate conclusions. But, he has considered some broarder facts of basemetal mineralisation in relation to tectonism and has come to some tentative conclusions which need further scrutiny.

In an area of repeated folding, two of which were tight and co-axial, the parallelism between foliation and ore bodies need not necessarily indicate a stratiform syngenetic deposit. On the other hand, there is a better likelihood of syntectonic mineralisation along F_1 axial plane fractures during the Delhi deformation. In this connection, the concepts developed by Sychanthavong (personal communication) are not only interesting but appear to be quite valid. He has invoked a mechanism of oceanic plate subduction to explain the Delhi folding, and according to him the ortho-amphibolites that comprised the oceanic plate, on subduction underwent considerable dehydration. The hydrothermal solutions formed due to dehydration, rich in base metals rose upward during F_1 along the various longitudinal fault zones and got fixed up in appropriate host metasediments. Later on these were subjected to F_2 and F_3, and to-day give an erroneously stratiform syngenetic appearance. Of course, these ideas of Sychanthavong require exhaustive and further scrutiny. The scope of the present study does not allow that.