CHAPTER - III

SCOPE OF PRESENT STUDY

GENERAL

The geological picture of the Ambamata and its neighbourhood, as visualised by Heron & Ghosh (1938) remained rather intact for the last four decades, and almost all the subsequent workers have more or less accepted the stratigraphy, structure and igneous history put forth by the two workers. Of course, Sharma (1953) did express some doubts about the actual age of the granitic rocks of this area, and he considered in the Ambamata-Danta area granites of at least two different ages - one Post-Aravalli (Pre-Delhi) and the other,

Post-Delhi (Erinpura). Moreover, the exact nature of the so called 'Schistose-quartz-porphyry' of Ambamata was also never fully understood. But in a general way, the need for reinvestigating the geology of this area was not much realised.

Some very recent studies, however, on the neighbouring areas to the west and east of Ambamata, have provided a wealth of new data on the Delhi metasediments and associated granitic and mafic rocks in this part of north Gujarat. The studies of Desai et al. (1978) and Sychanthavong (Unpublished Ph.D. Thesis, 1978) have brought to light a number of structural and metamorphic complexities which were not visualised by the previous workers.

About the crystalline rocks of Balaram-Abu Road area (immediately to the west of the study area) new and interesting facts have been reported. Located at the southwest extremity of the Delhi Synclinorium, the area was described by Coulson (1933) and Heron & Ghosh (1938) as comprising rocks of Delhi System- both Alwars and Ajabgarhs, intruded by Erinpura granite and younger olivine and hypersthene bearing dolerites and gabbros. Desai et al. (1978) however, on a reinvestigation, have recently reported that part of the metasedimentaries (supposed to be Delhis) could be much older, constituting a metamorphically high grade granulitic assemblage. According to these workers, the olivine and

hypersthene bearing rocks did not represent any Post-Erinpura basic activity, but instead formed metamorphic rocks of charnockitic affinity of Pre-Delhi age on a large scale.

Similarly, the recent mapping by Sychanthavong (1978) around Posina-Kherod area to the east of Ambamata, has thrown new light on the stratigraphy and structure of the Ajabgarh series. Sychanthavong has observed that

1. the structural pattern of these Delhi rocks within the narrow NNE plunging synclinorium, shows three fold episodes- the first two being co-axial and trending NNE-SSW, and the third having a WNW-ESE trend, and

2. the Ajabgarhs are resting directly over the oceanic crust and this mafic basement, involved in the various Delhi foldings, is now exposed as narrow linear outcrops of amphibolites within the metasedimentaries, at most places wrongly considered as sills or dykes by other workers.

Obviously, the geological framework of the Ambamata area, lying between the two areas to the west and east, thus provided a vital clue for the scrutiny and veracity of the revised set up visualised by Desai et al (1978) and Sychanthavong (*op.* cit.)

In order to fully appreciate the scope and nature of the author's investigations, and his conclusions, it is most necessary that a brief account of the new facts available from the two neighbouring areas, are made available to the reader.

POLYMETAMORPHITES OF BALARAM - ABU ROAD AREA

Earlier workers (Coulson, 1933; Heron & Ghosh, 1938) gave the following stratigraphy for the rocks of Balaram - Abu Road area :

Post-Erinpura granite	-	Olivine dolerites and gabbros
Erinpura granite	-	Granitic rocks
Pre-Erinpura granite	-	Epidiorites
Delhi System	-	Calc-schists, Calc-gneisses, Biotite-schists & Quartzites.

The above set up has been revised by Desai et al. (1978), and these authors have suggested the age sequence as under :

Post-Erinpura granite	-	Basaltic dykes
Erinpura granite	-	Granitic rocks
Delhi Group	-	Calc-schists and calc-gneisses with amphibolite layers.
Pre-Delhi Group (Aravalli or? older)	-	Charnockitic rocks with associated pelitic and calc-granulitic layers

According to these authors,

(i) The calc-schists and calc-gneisses of Delhi Group are confined to the eastern extremity of the area only and these overlie unconformably a high-grade granulitic terrain;

(ii) The Erinpura granites have extensively intruded these older metamorphics;

(iii) The outcrops of narrow lensoid quartzite extending along the NE-SW fault zone, shown by Heron & Ghosh (1938) as belonging to the Alwar Series are cherty fault breccia, in no way connected with the Delhi deposition;

(iv) The Pre-Delhi granulites which are possibly older basement rocks exposed between the Erinpura granite to the west and south and the Delhis to the east consist of the following main rocks types :

(a) Hyperstone- bearing charnockitic rocks with associated relicts of peridotite, troctolite and olivine-norite,

(b) Calc-granulites,

(c) Pelitic granulites;

(v) The sporadic basaltic dykes, which represent the youngest E-W trending narrow dykelets are composed of a fine grained alkali basalt showing variolitic texture.

The Balaram-Abu Road area is also interesting from the structural view point. The Pre-Delhi granulites show evidences of repeated foldings. Cross-folding is well exhibited by numerous eyed folds, refolded folds and crenulation cleavage. The granulitic rocks form a fairly tight NNE-SSW trending fold that has been much distorted by a set of NW-SE trending late folds. Both these fold events, according to Desai et al. (1978) appear to be associated with Delhi orogeny.

The above authors are not sure whether these higher grade rocks comprised Aravallis or they were still older. They have stated (p. 389), "The Aravalli Group in southern and central Rajasthan and northern Gujarat consist of low grade, green-schist facies quartzites, dolomites, phyllites and graywacke phyllites. They nowhere carry such high-grade granulitic rocks of charnockite-khondalite affinity. So these rocks appear to be older than the Pre-Aravalli-Bhilwara group of Raja Rao (1967) of eastern Rajasthan. They are perhaps extensions of the charnockitic rocks from the Western ghats of Kerala and South Mysore, now constituting basement rocks for the Aravallis and Delhis".

AJABGARHS OF KHEROD - POSINA AREA

This area, lying immediately to the east of the Ambamata has provided a wealth of information which has direct

relevance to the present investigation. According to Sychanthavong (1978) the geology and structure of the Kherod-Posina area which comprises the SSW extremity of the Delhi synclinorium, fundamentally differ from those of Heron & Ghosh (1938), as these earlier workers did not comprehend the structural complexity. Sychanthavong (op. cit.) has very clearly established that the Delhi Orogeny comprised three fold episodes. The first two folds F_1 and F_2 were co-axial, trending NNE-SSW, and their axes originally plunging NNE. It was on account of a third folding F_3 along WNW-ESE axial planes, that the variation in the direction and amount of the axes of F_1 and F_2 has been brought about. A proper understanding of F_1 and F_2 interference enabled him to work out the following stratigraphy and sequence :

9.	Andesites and aplites	
8.	Erinpura granites	Intrusive rocks
7.	Epidiorites, dolerites and gabbros	
6.	Slates, phyllites, schists and impure limestones	
5.	Crystalline impure and slaty limestones	
4.	Crinkled biotite-garnet schists	
3.	Calc-gneisses	Ajabgarh metasediments
2.	Calc-schists, staurolite-schists and thin bands of para-amphibolites and calc-granulites	
1.	Biotite gneisses and pelitic granulites	

--------- Non-depositional unconformity ---------

0. Ortho-amphibolites and associated high grade mafic rocks } Basement (Oceanic crust)

According to Sychanthavong (1978)

1) The Ajabgarh series comprises a succession of pelagic sediments deposited directly over the oceanic crust, and it shows imprints of three metamorphic events, each connected with the successive deformational episodes.

2) The Delhi orogeny comprised three fold episodes. The first two folds F_1 and F_2 were co-axial, trending NNE-SSW, their axes originally plunging NNE. It was on account of a third folding F_3 along WNW-ESE axial plane, that the variation in the direction and amount of the axes of F_1 and F_2 has been brought about.

3) The Erinpura granites supposed to comprise a single igneous event closely following the Delhi folding, on the other hand, point to granitic rocks of more than one generation. The older granitic rocks are well foliated and involved in F_1, F_2 and sometimes F_3. These have been found to be metasomatic, having been derived by the granitisation

of ortho-amphibolites, pelitic and calcareous rocks. The younger intrusive granitic bodies, are undoubtedly post F_1, deformed sometimes by F_2 but always by F_3. The intrusive type is supposed to represent mobilised and emplaced earlier granitised 'migmatitic material.

Synchanthavong has suggested an altogether new model for the evolution of the Delhi System and he has invoked the mechanism of proto-plate tectonics to explain the various complexities. A summary of the model envisaged by him, is given below, in his own words :

"It is now generally agreed that during Pre-cambrian time, there existed three Indian proto-continents, viz. Aravalli, Singbhum and Dharwar (Naqvi et al., 1974), the Narmada suture marking the joining line of the Aravalli proto-continent with Singbhum and Dharwar proto-continents. The palaeomagnetic data (Athavale et al., 1970; Bhimasankaram & Pal, 1970) from different parts of Indian shield, reveal that the three proto-continents have behaved as one unit since 1600 m.y. But prior to this, evidence exists of the southward drift of the Aravalli proto-continent.

Considering the various geological and geochronological evidences, it could be surmised that prior to 2100 m.y., the Aravalli proto-continent must have been a part of a much

larger northwestern proto-continent which broke down and started drifting southeastward towards the Dharwar and Singbhum proto-continents. This process of drifting, initiated near about 2100 m.y. continued upto 1600 m.y. and it was during this interval that the Delhi rocks were deposited. At 1600 m.y. the subduction of the oceanic plate beneath the Aravalli proto-continent along the trailing edge started, underthrusting and squeezing the Delhi sediments against the Aravalli proto-continental margin. The orogenic upheaval that folded and lifted up the Delhi system, thus appears to have taken place during 1600 to 600 m.y. This is evidenced by the age of granites and other intrusive rocks associated with Delhis.

It is envisaged that with the southeastward movement of the Aravalli proto-continent, the Delhi deposition started. The Ajabgarhs were deposited in a lepto-geosyncline over the oceanic plate, while the Alwars were simultaneously deposited over the continental shelf of the Aravalli proto-continent, characterising a miogeosyncline, the two being deposited at the same time.

The subduction of the oceanic plate began when the Aravalli proto-continent collided with the Dharwar and Singbhum proto-continents, the line of contact marked by the Narmada suture. It is not possible to exactly date this event, but it was certainly prior to the beginning of Delhi

orogeny. This subduction was obviously due to the continued sea floor spreading, while the Aravalli protocontinent was blocked against the two southern proto-continents. The present junction line between the Alwars and Ajabgarhs (Idar - Deogarh - Ajmer fault zone) thus represents the trench and the margin of the trailing edge of the Aravalli proto-continent. It was the continued movement of the oceanic plate and its subduction beneath the Aravalli B.G.C. continental margin, that controlled the folding of the Delhi sediments. The progressively increasing squeeze was accompanied by the development of a number of low-angled thrusts in the Ajabgarh sequence.

The folded Ajabgarhs are intruded by granites, mafics and ultramafics, and the author has visualised the intrusion of these igneous rocks along the thrusts that developed on account of plate movements. The mafic and ultramafic intrusive bodies in the Ajabgarhs obviously represent molten and differentiated fractions of the oceanic crust. The granitic rocks (a fair proportion of which is hornblendic) are supposed to comprise the acidic and granitised fraction of the basic oceanic crust together with granitised pelitic sediments immediately overlying it.

The ortho-amphibolites of the fold cores represent metamorphosed oceanic crust which are scrapped off during

earlier phase of subduction and squeezing. The fault-zone ortho-amphibolites, as well as the hypersthenic granulites and the intrusive bodies of olivine dolerites etc. on the other hand, comprise metamorphosed and partially melted products of subducted oceanic crust, subsequently uplifted along the longitudinal dislocations during F_2 folding. The last major event was that of F_3 during which the push came from SSW, arching up and folded the pre-existing structures. This must have happened 600 m.y. ago, during the formation of the Pangean continent (Burke, Dewey & Kidd, 1970; Deway, 1976)."

PRESENT AUTHOR'S MAIN FINDINGS

The investigations carried out by the present author, have provided interesting results. A painstaking mapping of all the individual outcrops and their petrological evaluation has led him to arrive at conclusions which not only ideally explain the various unexplained complexities but also fit in very well with the geological set up of the adjoining areas. Some of the salient features of the author's findings, on which this thesis dwells, have been summarised below :

1. The structural sequence of Delhi metasediments is not as straightforward as visualised by earlier workers. In fact, the area has undergone repeated

foldings, as a result of which the actual sequence is quite different from the regional stratigraphy of the Ajabgarhs.

2. The grade of metamorphism of the pelitic, calcareous and basic rocks is higher than that visualised previously.

3. There are two distinct phases of Erinpura granite activity at 950 and 750 m.y. Some of the hornblendic and foliated varieties could be still older.

4. The mafic rocks of the area belong to three age groups-the oldest ortho-amphibolites, followed by a group of intrusive meta-dolerites, and the last event represented by Post-Erinpura basaltic dykes.

Considering all aspects of his own investigations and the geology of the adjoining areas as worked out by Desai et al. (1978) and Sychanthavong, (1978) the present author has worked out the following age sequence for the rocks of the Ambamata area :

Basaltic dykes	Intrusives	Post Erinpura Granite
Granites		Erinpura Granite
Meta dolerites		Post-Delhi-Pre-Erinpura Granite

Calc schists and Calc silicate gneisses with marble lenses	Ajabgarh Series	Delhi System
Pelitic schists		
Biotite gneisses		
Hornblend gneisses		
Ortho-amphibolites		Basement
Granulitic rocks		??