CHAPTER - IV

GEOLOGICAL SETTING

GENERAL

As mentioned earlier, the study area occupies a part of the southern nose of the Delhi Synclinorium, and consists of mostly the rocks of the Ajabgarh Series of the Delhi System. The present study has enabled the author to obtain an altogether new and revised geological picture of the area in particular and the Ajabgarh Series in general. In this chapter, he has briefly summarised the distribution, lithology and field characters of the various rocks encountered, and has worked out the geological framework. The systematic and detailed mapping by the present author

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		
Hornblende gneisses		
Ortho-amphibolites		Basement
Granulitic rocks		??

ORTHO-AMPHIBOLITES

The Ajabgarh Series of the Delhi System is supposed to be resting directly over the oceanic crust (plate), comprising the basement. Due to the subsequent involvement of this crust (= basaltic) late into the Delhi folding and the related metamorphism of the constituent rocks, the basement is now exposed as narrow linear outcrops of amphibolitic rocks within the metasedimentaries. Obviously, the older pelitic sediments that were resting over the basement, have been subsequently metamorphosed and granitised, and on account of tight folding and some intermixing, the amphibolites are now seen to occur as fragmentary linear outcrops in the vicinity of Jetwas and Ghikla. It is

significant to observe that the ortho-amphibolites are exclusively restricted to pelitic rocks, and are nowhere seen to occur in calcareous and other higher up sediments.

These ortho-amphibolites are quite distinct from the younger meta-dolerites (which occur as sills very often), and have been confused by the previous workers to belong to the same igneous phase. Metamorphically, the meta-dolerites are quite distinct, typically comprise 'metabasites' and are seen intruding all the Ajabgarh sediments as also the ortho-amphibolites. Obviously, these younger mafic bodies, intruded after the Delhi folding, are typically free from effects of deformation, while the ortho-amphibolites show clear evidences of their involvement in foldings.

Somewhat diffused contact of these basement ortho-amphibolites with the overlying hornblende gneisses, it appears, is due to the mixing of the anatectically derived granitic melts from the overlying pelitic sediments.

AJABGARH SERIES

These Delhi rocks obviously comprise a lower pelitic and an upper calcareous horizon. The uppermost pelitic layers do not occur in the area. Due to tight folding, the lower pelitic portion which is supposed to have been deposited directly over the oceanic (basic) crust, is seen to occupy

the areas both to the SW and NE of the calcareous rocks. In the northwest extremity of the study area (near Parli Chhapri), the pelitic rocks are observed to comprise almandine with cordierite and fibrolite and closely resemble the gneissic granulite of Desai et al. (1978). A proper perspective of the regional distribution of these rocks in relation to the older amphibolitic as well as the younger calcareous rocks, can be obtained from fig. IV.1.

The present author has, on the basis of his field and laboratory studies, further subdivided the pelitic and calcareous horizons. The former comprises from bottom to top a gradational sequence of hornblende gneiss, biotite gneiss and pelitic schist and associated rocks while the latter has been classified into marble and calc-schist & calc-silicate gneiss, depending on their original composition from place to place.

Hornblende gneisses

Partial melting of the basement rocks along with that of the overlying pelitic metasediments, has resulted into the development of hornblende gneisses. The author envisages a transformation of pelitic sediments into migmatitic gneiss by deepseated plutonic processes, and their subsequent mixing up with the basement amphibolites. Obviously, the hornblendic gneisses that occur in between the amphibolites

and the overlying biotite gneisses represent a rock, in which the granitic constituents have been intimately mixed with the hornblendic material from below. No wholesale granitisation of the amphibolites is envisaged and the hornblende bearing gneiss is taken as indicative of the assimilative contact. No doubt, a considerable portion of the biotite in the biotite rich gneiss, is seen to have developed at the expense of hornblende.

The hornblende gneisses show restricted occurrence in the vicinity of Chikla and Jetwas villages, and have been found to occupy a refolded anticlinal fold core. The basement ortho-amphibolites occur within these gneisses as narrow fragmentary bands. The entire valley to the south of Kumbharia temples, abounds in exposures showing lit-par-lit injection of granitic material into amphibolites, giving rise to what Heron & Ghosh (1938, p. 388) called composite gneisses. Of course, these authors considered the granitic layers to belong to the Erinpura granite, while in fact, the quartzo-felspathic material, according to the present author, represents anatectic melt derived from the pelitic rocks at deeper levels.

Biotite gneisses

These gneissic rocks were taken as 'granitoid gneisses' by Sharma (1931) older than the Erinpura Granite, while

Heron & Ghosh (1938) took them as a variety of Erinpura granite, a product of the granitisation of pelitic metasediments due to introduction of quartzo-felspathic material during the Erinpura granite emplacement.

The present author has also found these rocks to be granitised equivalents of pelitic sediments, but his interpretation however, is quite different from that of the early workers. These biotite gneisses, as will be seen from the structural map of the area, comprise fairly deepseated rocks involved in folding and metamorphic changes. Their transformation did not involve introduction of granitic constituents from outside, but according to the present author, those felspathic rocks are derived by a metamorphic reconstitution of pelitic sediments by multiple transformative processes, into granitic assemblage. These gneisses are extensively exposed in the southeastern part of the study area, as well as to the east around the villages Songarh, Khedru, Mamma Pipla etc. In the study area proper, these biotitic gneisses show occasional layers and patches of fairly high grade mineral assemblages, for example, south of the village Rinchhri, garnet (almandine) bearing rocks are recorded.

Pelitic schists and associated rocks

These rocks comprise the upper part of the pelitic metasediments, free from granitisation. Ideal exposures

of the various constituent rocks are recorded extensively in the area north and northwest of the Ambamata temple. These rocks, typically comprise an almost saucer shaped basin, a product of cross-folding. On account of the structural complexity, the actual sequence in this part appears as inverted, and the lack of appreciation of this fact misled the various previous workers in correctly interpreting the stratigraphy.

It is interesting to observe that the metamorphism is quite pronounced almost of amphibolite facies, but as the rocks do not contain substantial percentage of micaceous minerals, they give an erroneous impression of a low metamorphic grade. In fact, these rocks with increasing metamorphism have changed over to gneisses.

The constituent rocks comprising this group, can be listed as under :

1. Quartzites and micaceous quartzites
2. Schists containing variable proportion of micas, quartz and felspars.

These schists and quartzites occur in narrow bands quite often with transitional boundaries and it is not easy to delineate them on the map. These rocks occupy the low lying hilly terrain containing the villages of Mala, Amlimal, Ghoda Tankni, Parli Chhapri, Deri etc.

In the upper part of this group, at some places (e.g. around Ghoda Tankni) the rock could best he described as quartzo-felspathic schist - a metamorphic equivalent to subgraywacke to graywacke rock. In the field, this rock shows dark grey colour, is quite tough and without any foliation or bedding. The presence of slightly bigger grains of bluish quartz is typical and misleading. Due to such quartz grains and the absence of a distinct foliation, this variety resembles an igneous rock and previous workers gave it a name as 'schistose quartz porphyry'

It is in this group, near its upper contact with the calcareous horizon that extensive base metal mineralisation (Pb, Zn & Cu) has taken place. The Ambamata Pb-Zn-Cu mineralised zone extends for a length of 2 km in a northwesterly direction from the outskirts of Ambamata village. This multimetal mineralisation is intimately associated with a well-defined zone of calc-magnesian rocks and their pelitic variants occurring within the pelitic schist of the Ajabgarh Series. The main host rock for mineralisation is talc-tremolite-biotile-chlorite schist and its variants. Other rock type containing mineralisation is the biotite-quartz schist.

Second workable base metal deposit is located at Deri which is about 3 km north of Ambamata. Mineralisation is

in the same group of rocks. Here the associated rocks consist of micaceous quartzites and quartz biotite sericite schists, intruded by granite and basic rocks. Details about mineralisation are discussed in chapter-IX.

Calcareous rocks

Calcareous rocks, that comprise the upper part of the Ajabgarh sequence in the area, represent pure and impure carbonate sediments. Based on the mineral composition, these have been divided into two types :

1. Marble
2. Calc schist and Calc silicate gneiss

Obviously the pure calcareous sediments have given rise to marbles, while the impure calcareous sediments have produced the other two. In marble, calcite is the predominant mineral and in calc-schists, the minerals present are calcite and various calc-silicates like diopside, grossularite, clinozoisite, plagiocalse etc. The calc-schists show a distinct mineral orientation and segregation banding. With increase in grain size, these pass into calc silicate gneisses. The gneisses are typically characterised by a banding, the limestone bands are rich in calcite and the silicate bands are predominantly made up of diopside, felspars, quartz and amphiboles.

In the field, while marble exposures can be easily demarcated, the Calc schists and Calc silicate gneisses are somewhat difficult to separate. Obviously, these rocks reflect variation in the original composition and the effect of metamorphic differentiation. As such, it is difficult to sort the two varieties out.

It is worthwhile mentioning that though the calcareous rocks of this area were shown as calc-schists by Heron & Ghosh on their map (Fig. II-1), they were described in the text as Calc-gneisses (1938, p. 382-383-390). The present author has therefore included both the varieties together on the map.

In a general way, the Calcareous rocks are extensively developed in northern half, form a horse-shoe shaped outcrop and occupy large areas around the villages of Jhari-Vav, Khokribil, Ghoda Tankni, Indi and southeast of Surpagla near the confluence of two streams. Southward, these are found to extend as narrow discontinuous bands (? tight synformal fold cores). The most striking occurrence is that of marble which forms the conspicuous ridges northeast of Ambamata forming a number of discontinuous NNW-SSE ridges. The exposure extends for about 4 km from Jhari Vav in the south to the village Indi in the north. The width is not uniform throughout, being maximum near Jhari Vav. The marbles show various colours

like white, green pink and grey. The texture of the marbles varies from coarse grained sachharoidal to fine grained. Being fairly massive, the minor folds are not developed as they lack banding. These marble outcrops have been extensively quarried for the last thousand years or more and have provided the building material for the famous Delwada temples of Mount Abu.

INTRUSIVE ROCKS

Meta-dolerites

These mafic intrusive rocks, occur as sills within the metasediments, and are quite distinct from the amphibolitic bands. While the latter are typically fragmentary and show a high metamorphic grade and total absence of igneous texture, the partly altered dolerites and gabbros, from very conspicuous and continuous well defined outcrops of fresh rocks. It is interesting to observe that these mafic bodies are younger than the early folding (NNE-SSW) but have been involved in the late (WNW-ESE) folding. This is ideally seen in their trend of outcrops. A large number of sills of these rocks are encountered all over the area, and only a few major ones have been shown on the map. In a general way, they are more abundant in the pelitic metasediments.

Petrographic studies (chapter-VI) have clearly shown that these rocks are only feebly metamorphosed and totally

free from the intense deformational stresses. Whatever mineralogical changes are observed, are mostly hydrothermal and related to the Erinpura granite activity.

These rocks were referred to as 'epidiorites' by Heron & Ghosh (1938) and evidently these authors also included some of the ortho-amphibolite in their epidiorite group. The present author has preferred to call them meta-dolerites because they still show considerable igneous mineralogy and texture.

Erinpura Granite

These Post-Delhi granitic rocks are extensively developed in the study area, and occupy large tracts in the southwest, where the constituent rocks are mostly coarse to fine grained biotite granites. Another interesting outcrop of these granites is seen in the northeast, where a prominent ridge (~~Menagir~~ Minagarh 921 m. 3027') runs parallel to the calcareous rocks. This granite is rather fine grained, flesh coloured and devoid of ferromagnesian minerals. Sharma (1931) called this variety as microgranite, and so did Merh (1950). Heron & Ghosh (1938) however, have included them in Erinpura granite and have avoided the term microgranite.

The present author, so far as the study area is concerned, has included only the non-foliated granites into

Erinpura granite. Most of the so-called foliated varieties referred to by Heron & Ghosh (1938) and Merh (1950) have been found to belong to the older pelitic gneisses. Erinpura granite intrudes these gneisses at many places, and quite often one gets an impression as if they are one and the same.

The unfoliated biotite granite forms a number of bold peaks, and the entire terrain to the west and south of the study area is accordingly rugged and hilly. This granite forms too big and conspicuous outcrops. West of Ambamata it is coarse, biotite rich and moderately porphyritic. (A good example of this is the striking hill of Gabbar (Δ 1959' = 597 m.), 3 km. west of Ambamata. South of Ambamata is the Rasanio (Δ 2420' = 737 m.) hill composed of fine and medium grained pink granite. The hills southeast of Rasanio show the solid granite masses containing coarse grained pinkish variety. The hilly terrain in the southwest of the study area shows two varieties of granite - one is of pink coarse grained graphic granite with practically no ferromagnesian minerals and the other fine pink granite with biotite. Near Dharara village the granite is very coarse grained and big felspar crystals (pink as well as grey) are seen in it. Very fine grained and pinkish variety of granite is exposed on the hill (Δ 2301 = 701 m.) which is just 5 km. east of Ambamata and lies adjacent to the

eastern border of the study area. No evidence is recorded to prove that the unfoliated granite was involved in any folding, but looking to the trend of the Menagir (Minagarh) ridge consisting of fine grained granite, it appears to have been affected by WNW-ESE flexures.

Wherever the granites have come in contact with the calcareous rocks, they have given rise to considerable epidote. Pegmatites are, on the whole, scarce and are only occasionally recorded. When present, the pegmatite is fairly coarse and consists of quartz, felspar, mica and tourmaline. Quartz veins are more common in the metapelites in the northern part. Some of the larger veins consisting exclusively of quartz extend for a kilometre or so.

Post-Erinpura basic rocks

Basaltic dykes cutting the Erinpura granite have been reported by almost all previous workers from all parts of N. Gujarat (Coulson, 1933; Heron & Ghosh, 1938; Patel, 1971; Desai et al., 1978). The present author has recorded only a few sporadic occurrences from the eastern ~~middle~~ and southern part of the area. Near the village Chikla, ~~Here~~ these comprise narrow 1 m thick dykes extending WNW-ESE for a few meters only. Petrographically these have been found to be fine grained basalt. Coulson (1933) described similar rocks from Sirohi area, as albitised basalts, Patel (1971)

described these rocks as 'trachy andesites' in Bhatana and Kapasia area of Sirohi-Palanpur districts, while more recently Desai et al., (1978) have referred to these dyke rocks as 'fine grained alkali basalts'. Sychanthovong (1978) has referred to similar rocks from Posina-Kherod area as comprising andesites and dolerites. Almost all workers have considered these to be of the same age as Pre-Malani but Post-Erinpura.