6

METAMORPHIC HISTORY

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From the foregoing account it will be revealed that these rocks exhibit a great petrographic diversity which reflects their complex evolutionary history. The rocks portray the presence of several igneous events, and various mineralogical and textural changes developed in response to successive periods of deformation and metamorphism. Thus the rocks of the study area as seen today are those of typical polymetamorphic terrains and conglomeration of mineralogical constituents point to an interesting metamorphic history . On the basis of a careful scrutiny of metamorphic and structural episodes, the author has worked out the following picture of their metamorphic evolution.

1. The formation of granulite facies (pyroxene - granulite and hornblende - granulite subfacies) of regional metamorphism of pelitic, semipelitic and calcareous sediments with associated basic rocks, in response to deformation which could be Pre- Delhi. In a broad way these correspond to "supracrustal rocks" of (Parras, 1958).

   This metamorphic event might have synchronised with Bhilwara orogenic cycle, 3.2 to 2.5 Ga (Gandhi et al., 1984).

2. Superimposition of almandine amphibolite facies metamorphism on granulite facies rocks. This retrogressive phase simulates the process of "reworking" of (Watson,1973, Windley,1973, Nambiar et al., 1992).

   This regional metamorphism and related migmatization has developed in response to the Delhi deformation. This regional metamorphism of amphibolite facies is responsible for giving rise to overall gneissic appearance of rocks.

3. Superimposition of thermal metamorphism on above rocks.

   This event is related to the intrusion of Erinpura granites which were emplaced during the late and post kinematic stages of Delhi orogenic cycle.

The processes connected with the Delhi upheaval not only developed refolded folds and resultant variation in the attitudes of early planar and linear structures but also brought about concomitant metamorphic changes. Therefore, the regional metamorphism shown by these rocks is quite complex. This had to be fully delineated and studied after identifying and sorting out the metamorphic and metasomatic effects, (1) of later metamorphism (accompanied by granitisation) and (2) of later granites. The various mineral assemblages of different lithological types showing imprints of both the original high grade regional metamorphism and the subsequent events are already discussed in the (Chapter IV).

TIME RELATIONSHIP OF ASSEMBLAGES ASSIGNED TO GRANULITE FACIES

From the mineral assemblages and textures alluded to above, it is obvious that these rocks show the effects of both early and late metamorphism. The earlier (granulite facies) metamorphism appears to be connected with a Pre-Delhi (Bhilwara orogeny) and the later (amphibolite facies) is connected with Delhi orogeny. However, the rocks of the two facies are seen interbanded in a number of localities e.g. Danta, Harivav, Kanbiavas, Pipodara, Kuavrsi, where pelitic granulites and pelitic gneisses occur together. South of

Danta near Vajapur, Nedardi, calc granulites and calc gneisses closely occur together.

It is characteristic to note that wherever such transitions occur, granites are invariably found in the field. There is a conspicuous variation in colour from dark grey to grey and greyish pink in pelitic rocks. Likewise the quantity of quartzofelspathic constituents also shows conspicuous increase. Such colour changes are common in calc granulites (virtually devoid of quartzofelspathic bands) and calc gneisses where migmatitic components dominate. The author is of opinion that most rocks of amphibolite facies are retrogressed granulites because amphibolite facies minerals are seen in section to replace earlier minerals, their development is associated with formation of new structures (fold and foliation) and this predominates near young granite rocks. Elsewhere, rocks of one or other facies predominate, but it is possible that earlier metamorphic assemblages need not have been of granulitic facies everywhere, the possibilities of such variation in early metamorphism will be discussed later. Interbanding of similar types has been described from many granulitic terrains, e.g. SriLanka (Cooray, 1960), Finland (Eskola, 1952), Scotland (Sutton and Watson, 1951), Canada (Wynne-Edwards,1967), Northern Kerela (Nambiar et al., 1992). In SriLanka, Cooray (1960, p.353) has shown an interdigitation of biotite gneisses and charnockitic rocks in a transitional zone of Polonaruwa sheet area. Eskola (1952, p.166) has also mentioned that granulite and amphibolite facies rocks usually alternate.

MINERAL ASSEMBLAGES

Pelitic Members

<u>Cordierite-garnet -sillimanite gneissic granulites</u>

Quartz- cordierite - garnet (almandine) - sillimanite - biotite - k-felspar (perthite) - zircon - monazite.

<u>Cordierite - biotite gneisses</u>

Cordierite - quartz - biotite - k-felspar (microcline - perthite).

<u>Biotite gneisses</u>

Quartz - biotite - k-felspar (microcline) - pagioclase (albite + oligoclase) - ilmenite.

Calcareous Members

<u>Calc granulites</u>

Calcite - diopside - plagioclase (anorthite) - scapolite - wollastonite - sphene - forsterite (olivine).

<u>Calc gneisses</u>

Calcite - diopside - k-felspar (microcline) - -plagioclase (anorthite) - quartz - sphene.

Basic Rocks

Meta Gabbros

Augite - diopside - hypersthene - plagioclase (labradorite) - hornblende - biotite - epidote.

Hornblende Granulites

Hornblende - quartz - plagioclase (oligoclase - andesine) - k-felspar (perthite) - zircon - apatite - rutile - graphite.

Amphibolites

Hornblende - quartz - sphene - plagioclase (andesine - oligoclase) - biotite - epidote.

Based on the presence of distinctive mineral associations in various rock types described above, the author feels that early metamorphism took place in a pyroxene - granulite subfacies and hornblende-granulite subfacies, of Turner (1968) and low pressure facies series of Miyashiro (1973). The presence of diverse textures indicated by pelitic members has led the author to discuss at length the metamorphic facies of pelitic rocks in particular and this is as follows.

As early as (1939), Eskola gave a concept of granulite facies to cover regionally metamorphosed rocks in which the hydrous mineral biotite and hornblende are unstable and are replaced by the anhydrous minerals such as almandine, orthopyroxene and clinopyroxene. Dewaard

(1965) suggested that completely anhydrous assemblages are relatively rare. However it has become apparent that there is an extensive zone of transition between regions of the almandine - amphibolite and granulite facies which bears characteristic of both but by definition does not belongs to either. This transitional zone is characterised by two phenomena (1) predominance of "mixed" but apparently stable assemblages containing orthopyroxene, which is distinctive of the granulite facies, but also biotite and/or hornblende or both clearly suggesting affiliation with the almandite - amphibolite facies (2) close association and intermingling in the field of these mixed assemblages with anhydrous assemblages of the granulite facies and with typical assemblages of almandite - amphibolite facies. Because of regional extent for which "mixed" and intermingled assemblages commonly occur, Turner, (1968), Young et al., (1989), Hapuarachchi (1967), proposed the term "hornblende - granulite subfacies" for an association of hornblende, biotite and cordierite bearing rocks. Further the cordierite is also considered as a stable and widespread mineral in granulite facies terrain. The mineral parageneses and the assemblages of cordierite bearing granulite in the present area demonstrate the following reaction.

$$3(Fe, Mg)_2 Al_4 Si_5 O_{18} \rightleftharpoons 2(Fe, Mg)_3 Al_2 Si_3 O_{12} + 4Al_2 SiO_5 + 5SiO_2$$

cordierite ⇌ almandine + sillimanite + quartz

Almandine (garnet) and sillimanite are coexisting phases in the orthopyroxene - plagioclase subfacies which is represented by right hand side of the reaction. Although becoming unstable towards left in the presence of sillimanite and quartz, almandine otherwise remains characteristically a stable phase in cordierite bearing granulites. The coexistence of cordierite and almandine is therefore considered typomorphic for the subfacies represented by the left hand side of the equation for which the name cordierite - almandite subfacies is proposed. The considerable reduction in molar volume towards the right in the reaction indicates that the cordierite - almandine subfacies occupy the relatively low load pressure region of granulite facies environments. DeWaard (1964,1965) has proposed the term "cordierite - almandite subfacies" that occupies relatively low load pressure region of granulite facies environment. He suggests that the cordierite - almandite subfacies is transitional between the orthopyroxene - plagioclase subfacies and the pyroxene - hornfels facies. Completely anhydrous rocks characteristic of cordierite - almandite subfacies are apparently quite common. Biotite is reported to be normally present in cordierite - garnet gneisses. The biotite - cordierite -

almandite subfacies of granulite facies is characterised by the presence of biotite in k-felspar bearing rocks which have a cordierite, garnet - cordierite or sillimanite -cordierite assemblages. Rocks of the biotite cordierite - almandite subfacies are extensively and regionally developed in certain granulite and charnockite terranes e.g. Lapland (Eskola, 1952), Southern Finland (Hietanen, 1947, Parras, 1958), the Granulitegebirge in Saxony (Scheumann and Hackenholz, 1961), Western Australia (Prider, 1945) and in Southeastern Ontario (Wynne - Edwards and Hay, 1963).

So far as the study area is concerned, the author is of the opinion that the cordierite - sillimanite garnet bearing qneisses granulites are perhaps product of the Pre-Delhi metamorphism and belong to low pressure granulites of Miyashiro(1973), Green and Ringwood (1967) Young et al.,(1989). Further the assemblage cordierite - hypersthene - garnet is unusual one and is also reported from Danta area (Deshpande et al., 1971). Similar assemblage has been reported by Desai et al., (1978, 1985, 1992) from Balaram - Abu Road area, north of Danta. Devaraju and Sadashivaiah (1975) has also reported such unusual assemblage in metapelites of Sathnur - Halguru area of Karnataka state. Wynne - Edwards (op.cit.) has reported identical mineral assemblage in Westport map area of Canada. All these assemblages as also those of the study area pointedly represent a typical low pressure assemblage and similar view has been upheld by Harris et al., (1982). Thus the author is of opinion that this assemblage need not be considered as what DeWaard (1965) and Deshpande et al., (op.cit.) considered transitional to hornfels facies but should be considered to belong to granulite facies only. This is substantiated by the presence of rutile needles in cordierite, quartz, hypersthene, k-felspar. The presence of perthite, quartz - cordierite symplectite in these rocks is also indicative of their formation under granulite facies conditions.

According to DeWaard (1965) the close association and intermingling in the field of these mixed assemblages with anhydrous assemblages of the granulite facies and with typical assemblages of the almandite - amphibolite facies can be explained by considering the following reactions.

$$\underset{\text{orthopyroxene}}{15(Fe,Mg)SiO_3} + \underset{\text{orthoclase}}{4KAlSi_3O_8} + NaAlSi_3O_8 +$$

$$\underset{\text{plagioclase}}{2CaAlSi_2O_8} + 5H_2O \rightleftharpoons \underset{\text{hornblende}}{NaCa_2(Fe,Mg)_4Al_3Si_6O_{22}(OH)_2}$$

$$+ \underset{\text{biotite}}{2K_2(Fe,Mg)_{5\frac{1}{2}}Al_3Si_{5\frac{1}{2}}O_{20}(OH)_4} + \underset{\text{quartz}}{17SiO_2}$$

$$\underset{\text{orthopyroxene}}{7(Fe,Mg)_4Al_3Si_6O_{22}(OH)_2} + NaAlSi_3O_8 + \underset{\text{plagioclase}}{2CaAl_2Si_2O_8} + H_2O$$

$$\rightleftharpoons \underset{\text{hornblende}}{NaCa_2(Fe,Mg)_4Al_3Si_6O_{22}(OH)_2} + \underset{\text{almandine}}{(Fe,Mg)_3Al_2}$$

$$Si_3O_{12} + 5SiO_2$$

Minerals on the left hand side of the reactions are typical of pyroxene - granulite subfacies, while those on the right hand side represent almandite - amphibolite subfacies. The hornblende -granulite subfacies with mixed assemblages is thus characterised by coexistence of reactants and products and presumably represents univariant equilibrium for boundary reactions. Intermingling can be explained by differences in Pw-T conditions between the various boundary reactions. This includes variation in cation ratios in rocks which affect the Pw-T conditions of each reaction, and by the variations in Pw from layer to layer as a result of initial differences in H_2O content which remained proportionally dissimilar during progressive metamorphism and decreasing rock permeability.

The abundance of biotite and/or microcline potash felspar is related to later deformation which will be discussed at a later stage of this chapter. Similarly, the development of andalusite in these group of rocks is related to thermal imprint.

In the study area, garnet sillimanite rocks showing abundance of cordierite may correspond either to the kinzigites or kinzigitic gneisses (metasomatically produced garnet - cordierite gneisses) of Waldmann (1929), Wager (1938), Kranck (1931) and Hietanen (1943,

1947) or to lutogenites of Parras (1946, 1958). Parras (op. cit.) has suggested that these rocks in all possibility have not been produced in a metasomatic manner from one or many other rocks, but are highly metamorphic representatives of sediments of a clay composition and proposes the name Lutogenite' (argillaceous, the roof in latin Lutum - clay). The total composition is most nearly that of a mixture of sand with clay i.e. these rocks represent arenaceous - argillaceous or residual hydrolyzatic sediments. Similar rocks of the study area are, therefore, regarded as derivatives of undoubted sediments but the possibility of some metasomatism also cannot be ruled out.

The mineral assemblages in calc-granulites and calc gneisses are also distinct. The calc granulites containing diopside, plagioclase and scapolites are usually green coloured. Those containing exclusively calcite and forsterite are white coloured marbles. Obviously, the calc granulites represent high grade metamorphic assemblages derived from original calcareous as well as calc magnesian sediments as is commonly observed in high grade terrains of South India. Like cordierite, scapolite is indicative of low pressure and is unstable at higher pressures. The association of scapolite with plagioclase has led the author to indicate that whether it is primary or it has developed at the expense of plagioclase. Obviously the scapolite could be the result of metasomatic processes involving such fugitive constituents as Cl, CO_2 , SO_3 released during earliest regional metamorphism. Thus crystallization of scapolite was dependent not only on the presence of high CO_2 pressure, but also on a deficiencey of (Al+Na+K) with respect to Ca. It is possible that the various fugitive constituents that gave rise to scapolite might have been liberated during metamorphism itself, CO_2 having been freed during reactions between carbonate rocks and silicates. The occasional presence of wollastonite and sphene suggests conditions transitional to amphibolite facies.

Comparison with other areas to the northwest and southeast of Danta suggests that on a wider scale such variations can be seen and this should be consistent with a metamorphism of a low pressure facies series at other lower grade than that discussed above. Cooray (1960,P.315) originally considered that the appearance of these mineral assemblages indicates their formation under conditions of granulite facies. In his subsequent publications (1962, Table 1,P.252) he had shown that wollastonite and sphene occur in the transitional rocks only and sphene is carried to much further stages, thereby indicating its stability throughout the amphibolite facies rocks (Vijayan series). According to

Sherbakov (1992) wollastonite is encountered in zones transitional to amphibolite facies. Based on the sporadic occurrence of wollastonite and sphene, the author is inclined to believe that the calcareous rocks of the study area suggest metamorphic conditions transitional to amphibolite facies. Moreover, the presence of scapolite, diopside and plagioclase indicates that they may have once belonged to granulite facies.

Basic Rocks

The isolated body of basic rocks near Nedardi, south of Danta within calc gneisses show cryptic or rhythmic layering. The mineralogical characters of these layered igneous rocks suggest that they are either due to mineralogical layering and fabrics due to metamorphic effects or they represent isolated fragments of larger igneous complexes tectonically emplaced into the present positions. The presence of mineral assemblages such as augite (clinopyroxene) and labradorite (calcic plagioclase) forming mafic units and calcium rich labradorite forming anorthosite unit is noteworthy. It is quite common to see alternate mafic and anorthosite units in these layered rocks. However structures and textures reminescent of primary igneous minerals may be identified. The pyroxenes show granoblastic texture and have straight boundaries meeting in 120° triple point.

Windley (1973) has mentioned that cryptic trends of individual minerals such as plagioclase, olivine, orthopyroxene and hornblende can be well represented despite subsequent granulite and amphibolite facies metamorphism. The study area, representing the low pressure granulite region, can be closely compared with low pressure granulite regions of Western Australia (Prider,1945) and Lapland (Eskola,1952). The presence of layered igneous series as also the granoblastic texture in pyroxene and labradorite having straight boundaries meeting in 120° triple points indicate granulite facies metamorphism. In almost all these rocks, the large primary crystals partly or completely replaced by polygonal mosaic of plagioclase and pyroxenes have been noticed. Sutton and Watson (1951) and Davis (1974) have attributed the formation of such minerals to early granulite facies metamorphism. In the area, the tectonite fabrics are poorly developed and minerals indicate metamorphic assemblage of granulite facies. The metabasics belonging to pyroxene -granulite, and hornblende - granulite to amphibolite transitional facies conditions has been reported also from TamilNadu area (Krishna Rao, 1992). The basic rocks indicating hornblende - granulite subfacies metamorphism are found within biotite gneisses near Tarsulighati, north of Danta.

Available literature on granulite rocks have shown that there are discripencies both in experimentally determined and naturally occurring mineral assemblages, e.g. close association of low pressure and intermediate pressure granulite (of Green and Ringwood,1967) in Lapland, SriLanka, Karnataka etc. Most of the Pre Cambrian terrains have polymetamorphic history, the mineral assemblages shown by them are more often transitional rather than indicating well defined limits of metamorphic facies. Similarly the structural history of such terrains is quite complex and superimposition of one deformation above the other is recognizable.

In polymetamorphic belts of Pre-Cambrian terrains such an intermingling of rock types is not uncommon and may be due to either different periods of metamorphism (Sutton and Watson, 1951) or to the variation in P load temperature and P H_2O conditions during the formation of rocks.

In the present case, the first metamorphism corresponding with the Pre-Delhi deformation produced metasedimentary rocks of pyroxene -granulite subfacies. The successive metamorphism corresponding to the second deformation (Delhi deformation ?) gave rise to the conditions of the hornblende - granulite subfacies (low temperature, increase P H_2O). Some of the earlier formed rocks survived the second metamorphism and are thus found to be associated in places with the hornblende granulite subfacies rocks.

The amphibolite facies rocks have distinctly developed in response to the Delhi deformation and related metamorphic alteration. At this juncture, it is rather difficult to suggest the exact time of formation of hornblende - granulite subfacies rocks. It is possible that they also might have developed during Pre-Delhi metamorphism, where the existence of local gradients in temperature or P H_2O during the same metamorphism. It is obvious that juxtaposition of mineral assemblages which is characteristic of two subfacies of the granulite facies within compartively small areas has already been reported by Hapuarachchi (1967) and Cooray (1972) in SriLanka

Biotite + Sillimanite + Quartz
Cordierite and/or Almandine + K- felspar + H_2O

Cordierite ----> Almandine + Sillimanite + Quartz + H_2O

In the study area, some of the important minor assemblages that follow the cessation of granulite facies conditions are the intergrowth textures such as perthites and symplectites in pelitic granulites. The k-felspar shows a range and indefinite cross hatched twinning which is generally unevenly distributed over crystals. Eskola (1952) has called this effect "microlinization" of orthoclase and this feature is reported from granulites of many parts of the world. The plagioclase crystals also show wedge shaped lamellae and infrequent fracturing of the crystals.

MAJOR CHANGES ASSOCIATED WITH LATER METAMORPHISM

The conspicuous changes associated with the later metamorphic phase are recorded in respect of the rock types, the mineral assemblages, the styles of folding and amount of migmatization. These changes are due to the introduction of hydroxyl radical. That these differences can be related to the types of later metamorphism which have affected the rocks and to the of the study area have been described in the following pages.

The rocks are dominantly migmatitic and granitic and the granulitic rocks are gradually replaced by cordierite - garnet - biotite - qneisses, cordierite - biotite qneisses, biotite - gneisses and by granitization in amphibolites. All these indicates transition to amphibolite facies of regional metamorphism. Most conspicuous change is the development of k-felspar and microcline and mafic mineral such as hornblende and biotite and wollastonite and tremolite in the calc gneisses.

In the pelitic granulites, development of biotite and or chlorite at the expense of garnet is associated with the addition of hydroxyl radical. Similarly the formation of biotite and/or hornblende at the expense of hypersthene may have aided by the introduced water (Sen,1959). In the amphibolites, the hornblende assumes bluish green colour with addition of soda. Watson (1949) suggests that the transformation of hornblende to biotite is due to the arrival of potash which makes the formation of biotite possible and results into the development of biotite qneisses and this also is a case of migmatization (retrogression).

In addition to hornblende and biotite, the migmatitic gneisses rocks are characterised by microcline as main k-felspar. Microcline shows distinct cross hatching extending uniformly over the crystals and this twinning is clearly different from the vague ill defined cross hatched twinning in the k-felspars of the granulite rocks. The perthitic and myrmekitic inclusions together with rounded bodies of quartz are often seen in the microcline crystals. Myrmekite developed at the contact of plagioclase and k-felspars is invariably present. In some sections even myrmekitic biotite is also present. The myrmekitic biotite has also been reported by Desai (1974) and Dempster et al., (1991).

All these evidences strongly suggest that K, Na, Si bearing emanations have passed through this stage.

Comparable mineralogical changes in the associated rock types are as follows

(a) Formation of biotite and chlorite after garnet in pelitic rocks.

(b) Alteration of cordierite to biotite and pinite in cordierite bearing rocks.

(c) Formation of tremolite after diopside in calcareous rocks.

Further the transformation of pyroxenes to hornblende or biotie in metagabbros and amphibolites, and of pyroxenes to hornblende and biotite in pelitic rocks is an indication of retrogression, such that hornblende biotite containing rocks might represent metamorphic conditions of almandine -amphibolite subfacies. The author is of opinion that these changes are connected to this superimposition of metamorphism (accompanied by granitisation). The cordierite biotite gneisses and biotite gneisses are obviously the granitised derivatives of the pelitic granulites. The author believes that this granitization was a forerunner to the Erinpura granite activity. The formation of migmatitic and biotite gneisses which often surround pelitic granulites took place in the higher amphibolite facies conditions and really mark final stages in the retrogressive metamorphism of the granulite facies rocks.

Similarly the transformation of garnet and cordierite to biotite and or chlorite, pinite and of diopside to tremolite is associated with the later metamorphism. Eskola (1952) also considered that cordierite and biotite belonged to a facies stable at next lower temperature. The presence of tremolite and sphene in calcareous rocks also indicates amphibolite facies and this is also borne out by Cooray (1960) in SriLanka.

Thus the diapthoretic changes and transformations in the granulite facies rocks seem to have taken place on a failing temperature scale (Watson, 1949,P.49) and are carried to a much further stages in the migmatitic rocks, where the facies conditions may have been high almandine amphibolite facies and this resulted into the formation of minerals of a lower grade than those originally present. Much greater changes of metamorphic conditions are evident in the area and this is reflected in more complex transformations in all rock types. The last of these changes is the complete retrogression of granulites and associated rocks to the migmatitic gneisses and is shown as under.

(i) Cordierite - garnet - sillimanite gneissic granulites ---> Cordierite - biotite gneisses --> Biotite gneisses.

(ii) Calc granulites --> Calc gneisses.

The important fact that emerges from the above cases is the addition of hydroxyl radical that causes these retrogressive changes. As Watson (1949,P.48) has suggested, "the rarity of hornblende and biotite" in granulites and their abundance in retrogressed rock indicate "dryness" of the complex due to the high temperature at which metamorphism took place or to an actual scarcity of water during the period. The formation of migmatitic gneisses or development of alteration minerals like hornblende and biotite was in part due to the addition of water to the complex. This might have been the case in the present area during the amphibolite facies metamorphism in which the high grade minerals were gradually replaced by those minerals stable in the prevailing conditions.

RELATIONSHIP OF METAMORPHIC CHANGES WITH GRANITIC FORMATION

The metamorphic changes associated with granite formation are of two types

(A) Hydrothermal changes

(B) Superimposition of contact metamorphism over high grade rocks (cordierite gneissic granulites)

(A) The hydrothermal changes are :

(i) The formation of chlorite from garnet and biotite in pelitic granulites.

(ii) The transformation of cordierite to pinite in cordierite bearing rocks.

(iii) Alteration of plagioclase to epidote in calcareous rocks, amphibolites and metagabbros.

(B) The formation of andalusite in the pelitic gneissic granulites and of epidotes in calc gneisses and metagabbros is due to contact metamorphic effect.

As a case of superimposition of contact metamorphism over regional metamorphism, the striking change is the development of andalusite as typical contact metamorphic mineral. As the pelitic granulites and cordierite garnet gneisses are intermingled, it is difficult to precisely sort out changes caused by amphibolite facies of regional metamorphism and the granitic activity. However, a careful gleaning of the thin sections has prompted the author to suggest that the development of andalusite in pelitic gneissic granulites is indicative of pyroxene - hornfels facies and the presence of andalusite with muscovite in cordierite biotite gneisses is suggestive of hornblende - hornfels facies of thermal metamorphism of Turner (1968) and Miyashiro (1973). The development of corresponding mineral assemblages in calcareous components is also suggestive of both these facies of regional as wellas thermal metamorphism in the rocks of the study area.

POSSIBLE GEOLOGICAL SIGNIFICANCE OF METAMORPHIC HISTORY

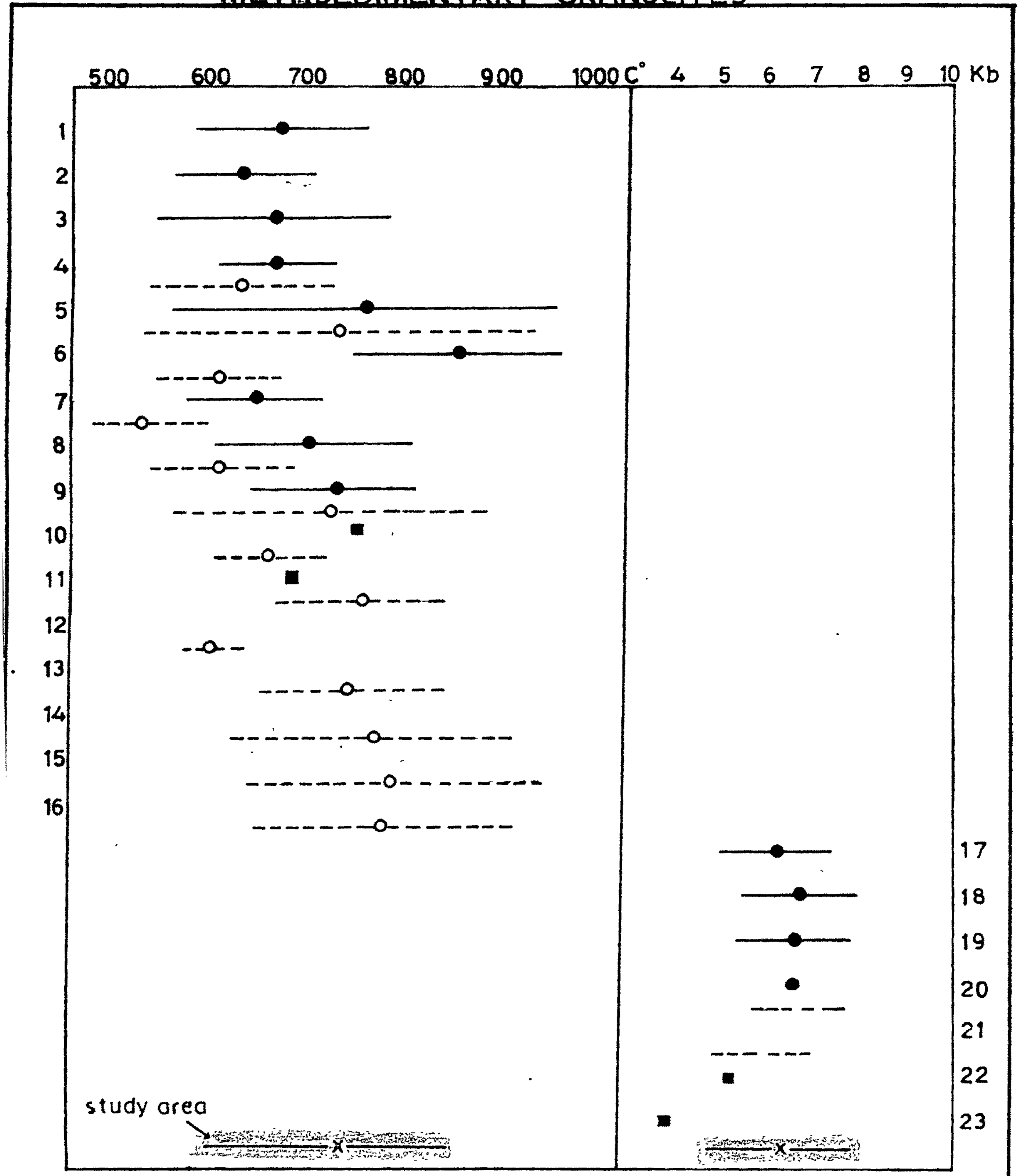
Based on above observations the author thinks that the cordierite biotite gneisses, biotite gneisses and the calc gneisses have formed at a later date than the pelitic and calc granulites. Taking into consideration the presence of numerous folds and the abundance of hydroxyl minerals, it is surmized that the retrogressive changes that led to the development of migmatitic rocks are related to the Delhi deformation and associated with Erinpura' granite activity. It is not exactly known howlong before this the granulite facies metamorphism took place, but it is possible that this metamorphism could belong to Pre - Delhi stage.

The metamorphic history of the study area could thus be said to begin with the formation of high grade granulite rocks and develops as several stages of polymetamorphism under the relatively water rich conditions of the amphibolite facies carrying pseudomorphs after hypersthene or other high grade minerals. These are linked by transitional types with biotite gneisses lacking identifiable alteration products of high grade minerals and in inturn are closely linked with granitic gneisses. The waning phase of granite activity has left its imprints on these high grade rocks. The static partial recrystallisation and mechanical reworking (Krupicka, 1973; Watson 1973) accelerated the process of granitisation and formed microcline rich granite gneisses. The dynamic reworking accelerates adaptation to new equillibrium conditions and promotes a general tendencey to granitisation. The increase in amount of k-felspar and the decrease in anorthite content are especially pronounced in intensely reworked rocks. Thus in the present area too, the migmatitic rocks showing abundance of microcline may indicate that they are reworked high grade rocks. Therefore, it can be assumed that in the study area, there exists continuous retrogressive metamorphic series from granulites to granitic gneisses and that the rocks of lower metamorphic grade than the granulites represent polymetamorphic products of original granulites.

Although the author has not carried out mineral chemical analysis of rock types in the study area, but taking into consideration the mineral assemblages like cordierite, garnet, biotite, orthopyroxene, clinopyroxene, physical variables namely P-T have been

Fig.VI-1

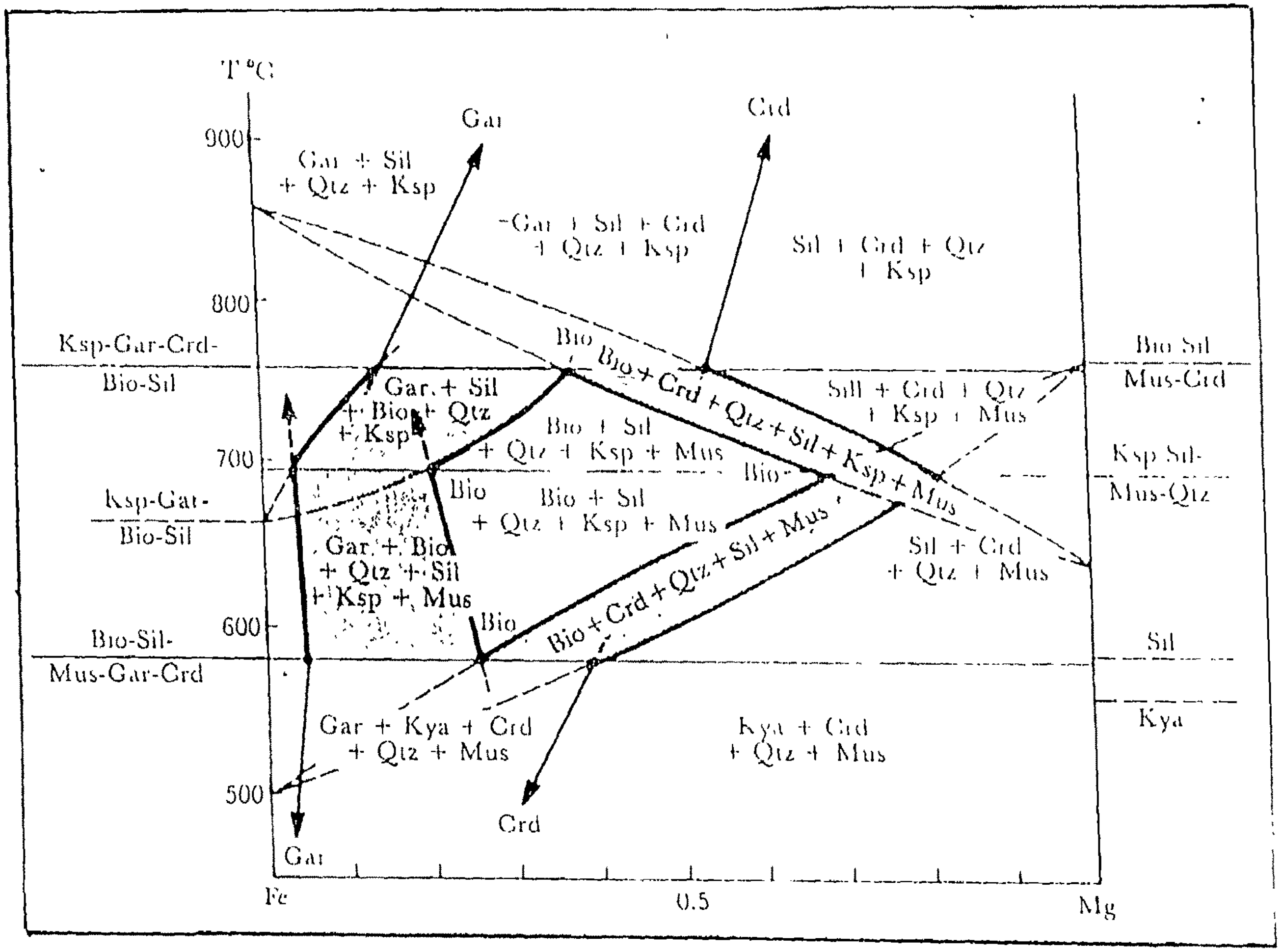
SUMMARY OF PT ESTIMATES FOR THE METASEDIMENTARY GRANULITES



(After Devaraju & Others, 1992)

Fig. VI-2

CALCULATED TEMPERATURE COMPOSITION FOR CONTINUOUS AND DISCONTINUOUS REACTIONS



(After A B.Thompson, 1976 b)

suggested. The P-T estimation (Fig.VI.1) indicate that temperatures from 600° to 850° C and pressures from 5 to 8 kb, corresponding to 20-25 km crustal thickness existed at the time of granulite facies metamorphism. This is also substantiated by Thompson's diagram (Fig.VI.2). The later diapothersis on account of migmatization, upliftment and exposures to lower P-T conditions (amphibolite facies) is attributed to later addition of water.