CHAPTER - IX

UPLIFTMENT HISTORY OF GRANULITE PROVINCE

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IX.1 Petrographic Evidences

The symplectitic textures preserved in the pelitic granulites are represented by :

1. Quartz-cordierite symplectites,
2. perthite-quartz symplectites,
3. Garnet breakdown symplectites,
4. Osumilite break down symplectites and
5. Sapphirine bearing symplectites

The calc granulites contain diopside-scapolite symplectites.

Symplectites are generally suggestive of very high pressure-temperature mineral assemblage which have experienced sudden decrease in P-T conditions. While decrease in pressure leads to depression of the melting point of the minerals resulting in melt formation due to breakdown of high P minerals, the decrease in the temperature helps in preservation of the partially molten breakdown products. Such partially molten breakdown products are seen as plumose and vermicular symplectites.

The granulite facies mineral assemblages are suggestive of P-T conditions appropriate of lower to middle crustal levels (approximating 10-30 km depth). Assemblages such as sapphirine-garnet-spinel-Orthopyroxene-sillimanite-cordierite etc indicate 8-10 k bars pressure and 825-900°C temperatures which represent the peak metamorphic conditions (Table-IX.1). The textures showing the breakdown of the minerals garnet, cordierite, osumilite and perthite etc. indicate decrease in pressure. It has already been demonstrated (Chapter-VIII) that the granulite terrain of the study area is a tectonic wedge/sliver/slice which is bounded on the west by Kui-Chitrasani fault and Surpagla tectonic junction to its east. As such the allochthonous nature of this granulite wedge, as it occurs at near surface level, is undisputed. The symplectitc textures, clearly indicating breakdown of high pressure minerals, suggest decompression and thus confirm the upliftment of this deep crustal segment to shallow level. This upliftment and the resultant decompression may have lead to retrogression of granulite facies assemblages to amphibolite facies further east of the study area (Limaye and Desai, op cit).

The upliftment must have been a rapid phenomenon which may have facilitated a process of decompression followed by immediate cooling akin to "quenching" and thus preservation of symplectites. A slow upliftment would have destroyed such textures. Geothermobarometry supports near isothermal decompression experienced by these rocks. (Chapter-VII Tectonometamorphic evolution).

Table-IX.1

Geothermometry estimates for the study area

Grt-Crd (symplectite free)

T°C	700	800	900
Thompson (1976)			———
Holdaway & Le (1977)			———
Wells (1979)		———	
Lavrent'Eva & Perchuk (1981)			———
Bhattacharya et al. (1988)		———	
Fonarev (1991)		———	

Grt-Crd(Symplectite bearing)

T°C	700	800	900
Thompson (1976)			———
Holdaway & Le (1977)			———
Wells (1979)		———	
Lavrent'Eva & Perchuk (1981)			———
Bhattacharya et al. (1988)		———	
Fonarev (1991)		———	

IX.2 Mechanism of upliftment

The westerly dipping nature of the tectonic slice/wedge of the granulite terrain and its abutment against the Erinpura granites along the Kui-Chitrasani lineament as also the presence of ~50m thick westerly dipping quartz- breccia, suggest this tectonic wedge to be an obducted slice/sliver. It has been suggested that the Pre-Delhi oceanic plate moved towards west and subducted along PDZ (Phulad Dislocation Zone) which is the northeastern extension of Kui-Chitrasani lineament (Chapter-VIII). In the late stage of Delhi orogeny, upliftment brought up the segments of lower-middle crust.

The symplectitic intergrowths of cordierite, k-feldspar and quartz owe their origin to retrogressive garnet breakdown reactions following decompression during uplift,

Sivasubrahmanian et al (1991, 1992) reported such symplectites after garnet during rapid decompression from Perumalmalai area in the Palni hills of Kodaikanal massif. Of late Ravindra Kumar and Chacko (1994) described orthopyroxene + plagioclase symplectites after garnet break down from mafic granulites of Palghat gap region, Tamil Nadu. thereby suggesting rapid decompression for this terrain.

Thus the occurrence of these symplectites in pelitic granulites are limited to regional granulite facies metamorphism. In the study area symplectites are perhaps due to breakdown of osumilite which is otherwise a high temperature index mineral. Similar cordierite - k-feldspar - quartz +_ hypersthene symplectite has been reported from Chimakurti, India. This osumilite may have developed during granulite facies metamorphism (Pre-Delhi) and breakdown of osumilite took place during rapid upliftment of these rocks. Further this uplift also caused strong decompression leading to such reaction textures. Because of this decompression, the osumilite of the granulite facies broke down to form plumose symplectite in pelitic granulites of Balaram area. Grew (1982) has also suggested that such symplectites result from the breakdown of osumilite and also they are strikingly similar to the symplectites derived from osumilite breakdown in granulite facies rocks of Enderby Land, Antarctica (Ellis et al, 1980, Grew, 1982 and Babu, 1996).

Further osumilite is an important constituent of metapelitic rocks of relatively high temperature and very low water pressures in the granulite facies. Such metamorphic conditions indicated for osumilite formation overlap the estimated physical conditions for metamorphism in the granulite facies. Breakdown of osumilite to quartz-cordierite symplectites suggests isothermal decompression which is suggested to have taken place due to obduction of the granulite facies rocks such as tectonic slices/slivers (Srikarni et al, op cit).

IX.3 Time of upliftment

In the absence of any radiometric dates it is difficult to precisely arrive at the time of upliftment. However, the following points may be viewed

1. Along the Kui-Chitrasani fault the granulite facies terrain is abutted against Aravallis and granitoids. Hence the final stage of obduction must have been post Aravallis.
2. Contrasting styles of deformation i.e. (a) complex deformation in Pre-Delhi rocks and (b) rather simple style of deformation in Delhis confirms the possible Pre-Delhi age of upliftment. The variation in the trend of ductile shear zone (Or-Surpagla tectonic junction) leads one to infer that this junction developed at the time of obduction and has to be Pre-Delhi.

The author is of opinion that these plumose symplectites in pelitic granulites of Balaram area of N. Gujarat could be due to breakdown of Osumilite resulted by rapid uplift during Pre-Delhi obduction.

IX.4 Conclusions

On the basis of geophysical data, it has been postulated by Srikarni et al (op cit) that there is a possibility of sub-surface continuity of a regional tectonic feature - in this case - an obducted slab of the basement from Balaram (North of Palanpur) to Sandmata complex through Bhim-Karera-Bandanwara of probably pre-Aravalli (? Archaean).

If the surmise that Balaram - Abu Road area represents subsurface continuity of Sandmata area is logical, then the granulite facies rocks of Sandmata & Balaram Abu Road area through Bhinai-Bandanwara (Bhim-Karera) define a polymetamorphic terrain that shows two contrasting but overlapping PT paths. Sandmata-Bhinai-Bandanwara (SinhaRoy op cit, Sharma, op cit, Gyani et al, op cit, Dasgupta et al, op cit) indicate that the first metamorphism had an "anticlockwise PT path" with time and was terminated by isobaric cooling to a stable crustal geotherm. In contrast the metamorphic episodes (M1-M2) in Balaram-Abu Road area define a "reworking" Goscombe et al (op cit) and followed a "clockwise PT path" (i.e. decreasing PT with time) terminated by Isothermal decompression and cooling (6-7 kb) on a stable crustal geotherm.

Balaram Abu Road area being a low pressure granulite province (Desai et al, op cit) is bound to show decompression (clockwise P-T path) during minimal cooling (Young et al op cit) and their subsurface continuity, the higher pressure granulite of Sandmata-Bhinai of central Rajasthan is bound to exhibit evidences for isobaric cooling paths. (anticlockwise PT trajectory, Bohlen, op cit, Young et al, op cit).

Thus the granulite facies metamorphic terrain is correlatable with that of Sandmata area & is thus Pre-Delhi. Although the reworking of granulite facies rocks has to be related to

(i) Pre-Delhi deformation - collisional tectonics which facilitated deep burial of the protoliths of granulites by subduction along a convergent plate margin, and

(ii) a temporally & tectonically unrelated tectono-thermal cycle attributable to Delhi orogeny.

With the help of geophysical (gravity) data Srikarni et al (1996) had shown that the present granulite province is the southwestern continuity of Sandmata complex, Bhinai, Bhim-Karera areas of Rajasthan (Chapter-VIII). The age of the Sandmata granulites, has been debated by different workers. These are stratigraphically positioned

in the Banded Gneissic Complex (Bhilwara Supergroup) (Gupta et al, 1992, 1997, Sinha-Roy et al, 1998). These have been considered to be Proterozoic (Roy, 1996). The upper age limit is constrained by the enderbite plutons intrusive into the granulites in Sandmata Complex at 1730 Ma (Sarkar et al, 1989). So all the granulites are certainly older than 1730 Ma. As the geophysical studies suggest that the study area is the southern continuation of Sandmata Complex, these granulites too, can be safely considered to be older than 1730 Ma.

Another mute question in the area is the relationship between the granulite facies complex (Pre-Delhi ?) and adjoining amphibolite facies terrain (Delhi). There is a sharp difference in the PT conditions of metamorphism and also in the tectonic styles in the two terrains This boundary is marked by the development of a ductile shear zone.

Thus the amphibolite-granulite facies contact in the study area (similar to one in Sandmata area, Dasgupta et al, op cit) does not indicate a zone of progressive or retrogressive metamorphism. Instead one is looking at two crustal sections juxtaposed against each other probably due to differential uplift. What one encounters today is the total causative factors related to Pre-Delhi and Delhi deformations.

As is the case the present area, many granulite terrains are associated with zones of large scale faulting and mylonitic rocks. Such features are noted in different areas, Cooray (1960) in Ceylon; Rama Rao (1945) in Mysore, India; Watson (1949) in Scotland; Wilson (1969) in Australia, in East Kimberly Block, in the Broken Hill Block and the Fraser Ranges; Sinha-Roy et al. (1992, 1995, 1998) in South-Central Rajasthan.