CHAPTER 7
DISCUSSION AND CONCLUSION

7.1. INTRODUCTION

The present study devotes towards an understanding of metamorphic evolution of metapelites of the Umpyrtha–Patharkhammah area in specific and the Gneissic Complex of the Shillong Plateau in general. It is pertinent to mention that the main contribution of the present thermo–chronological study is building a data base in the subject where no adequate information is available. In fact, the present thermo-chronological data on large expanses of high grade rocks in the central part of the Gneissic Complex of the Shilling Plateau provide us an opportunity for correlation with other high grade terrains and since the study area is frontal edge of the Indian plate, it put constraints on global scale reconstruction of the Gondwanaland. In this context, the present discussion is centered on the following important issues to achieve the overt goal of this study. These issues are mainly (i) sequence of metamorphic/chronologic events, (ii) metamorphic P-T path (iii) regional implication and (v) Pan Gondwanic correlation.

7.2. SEQUENCE OF METAMORPHIC / CHRONOLOGIC EVENTS

The mineralogical and textural features of the metapelites clearly indicate four distinct metamorphic events, \( M_1 \), \( M_2 \), \( M_3 \) and \( M_4 \) while metabasic rocks (clinopyroxene bearing amphibolites) show the evidence of prograde P-T path towards peak metamorphic event (\( M_2 \)). This is evident from the significant textural feature such as elimination of opaque granules along the border of green brown hornblende (Sen and Ray, 1971) and growth of pyroxenes along the border of hornblende. Interestingly, the metabasic rocks are free from any sign of retrogression and preserved only mineral paragenesis belongs to peak metamorphic event. Thus, the peak metamorphic event (\( M_2 \)) involved: (i) the generation of cordierite + garnet bearing leucosomes from an initially a low temperature, sillimanite + biotite + quartz assemblage (\( M_1 \)) by heating and loading, and, (ii) the stabilization of clinopyroxene in already existing hornblende-plagioclase bearing amphibolites. The minor inclusion of biotite + sillimanite + quartz within the porphyroblasts of garnet and cordierite (\( M_2 \)) indicate
the earliest metamorphic assemblage (M₁) representing syn-S₁ assemblage of prograde evolutionary P-T path. In Umpyrtha- Patharkhammah area, the melt escaped leaving behind the garnet + cordierite bearing restite. However in some instances, existence of melt is indicated by inclusions of granitoids and pegmatites within metapelites. Further, relics of cordierite, sillimanite, garnet within granitoid rocks (Petrography, in Chapter 4) indicate that the upward movement of the partial melts.

The next metamorphic event (M₃) involved the formation of a solid-state fabric defined by biotite + sillimanite + quartz belongs to amphibolite facies condition during D₁ – D₂ regime (syn-S₂). These minerals were largely stabilized through fluid induced (hydration) reaction involving consumption of garnet and cordierite in metapelites in presence of k-feldspar. Since, biotite occurs in low temperature side of the reactions, the transformations were promoted by decreasing temperature.

The last metamorphic event marked by development of cordierite corona (M₄) at the expense of garnet (M₂) and sillimanite + quartz (M₃) in metapelites postdating fabric forming event (syn-S₂). Since most of the corona was preserved in metapelites, the development of cordierite corona took place certainly in a static environment possibly during post- D₃ deformation. The development of cordierite corona at the expense of garnet (+ sillimanite + quartz) assumes special interest as this implies a period of decompression of the high grade rocks of the area. Although the different metamorphic events are characterized by distinct mineral assemblages and reactions, it is not possible to differentiate M₁, M₂, M₃ and M₄ on the basis of present EPMA dating. In this context, it is observed that most of the monazite grains are homogenous and yield a well constrained age of 532 ± 3 Ma (n=162, MSWD = 0.79; probability = 0.98) irrespective of their textural setting from four different samples of different locations of the study area. In addition to monazite, xenotime yield a well constraint ages dated at 498 ± 13 Ma (n = 24, MSWD = 0.60, probability = 0.93) which indicate the overwhelming a pan African age in large expanse of high grade rocks in the central part of the Shillong Plateau.
7.3. METAMORPHIC P-T PATH

Textural evidences in metapelites show prograde path and high temperature anatexis of the rocks before attaining peak P-T condition (M₂) . The clinopyroxene-bearing amphibolites strongly associated with metapelites in the area not only indicate a prograde path but also quantify the peak metamorphic condition (\(706^0\text{C} - 785^0\text{C}\), average = \(741^0\text{C}\) and pressure 4.6 kbar- 6.6 kbar, average = 5.80 kbar ). The retrograde P-T path is well documented in the rocks of the area. The spectacular event is related to the development of cordierite corona (M₄) at the expense of garnet (M₂) and sillimanite + quartz (M₃) indicates decompression. The thermobarometric studies on cordierite corona in metapelites quantify a near- isothermal decompression (ITD) through a decrease of pressure from 5.8 kbar to 3.0 kbar for a minimal decrease of \(\sim 70^0\text{C}\) (Fig.5.6). Thus, the present study indicates a near ITD path from peak P-T condition determined in metapelites, on the basis of thermobarometric computations (Table 5.7) and a comparison between experimental reaction curves (Holdaway, 1971; Spear 1981; Spear et al., 1999; Nichols et al., 2007 in Fig.5.6 ) with mineral reactions in the rocks ( Petrography, in Chapter 4) identified on the basis of critical textures.

7.4. REGIONAL IMPLICATION

The Pan African age of the present metapelites with well defined retrograde ITD path resembles to several amphibolites-granulite facies areas along the hilly tracts of the central and western part of the Gneissic Complex of the Shillong Plateau. Recent studies by several workers (Lal et al., 1978; Chatterjee et al., 2007; Mazumdar, 2016) reveal that these high grade terrains chiefly consist of \(\sim 500\) Ma, old garnet- cordierite ± spinel bearing anatectic metapelites identified as low pressure granulites. As for example, Sonapahar metapelites with peak \(T=750^0\text{C}\) and \(P = 4.5\text{kbar}\) (Lal et al., 1978) is definitely low pressure granulite area. Large expanse of low pressure granulite in this area in the Shillong Plateau excluding Garo-Goalpara Hills (Chatterjee et al., 2007) are characterized by isothermal decompression (ITD) path as reflected from several mineral reactions in these rocks. The origin of many ITD granulites is formed in crust thickened by collision, with magmatic additions as an important source of heat. According to Yin et al., 2010, the three
episodes of igneous activity (1600 Ma, 1100 Ma and 520-500 Ma) as inferred from their U-Pb zircon dating are reasonably consistent with the three metamorphic events detected by chemical dating of monazite from the metamorphic basement of the Shillong Plateau by Chatterjee et al., 2007. This will suggest that magmatism is coeval with metamorphism in the region. Therefore, a continent-continent collision followed by a late-kinematic granitoid intrusion during Pan-African Orogeny was likely to be a phenomenon to explain for the evolution of high grade terrains in the Shillong Plateau.

7.5. PAN-GONDWANIC CORRELATION

Finally, the most important issue to be addressed here is to correlate different high grade domains in this region in order to identify whether these high grade domains were formed within a single coherent continent or they desperately evolved crustal fragments formed at different geological periods finally amalgamated to form the Gneissic Complex of the Shillong Plateau. The present study reveals that the central part of the plateau covers a large area consisting of Palaeozoic high grade rocks which is a spectacular feature in context of Pan Gondwanic reconstruction. Chatterjee et al., 2007, reported an Early Palaeozoic age (500 ± 14 Ma) for metapelitic granulites from Sonapahar and a Early Mesoproterozoic age (1596 ± 15 Ma) of similar rocks from Garo-Goalpara Hills located at extreme western part of the Shillong Plateau. While the P-T path of the Early Paleozoic metamorphism in Sonapahar is unknown, granulites from the Garo-Goalpara Hills are seen to exhibit an anticlockwise P-T path with distinct isobaric cooling (IBC) history indicating different tectonic setting with respect to the present area. The recent geochronological data (Bidyananda and Deomurari 2007; Yin et al. 2010; Chatterjee et al., 2007) clarified the continuity of high grade rocks between Mesoproterozoic granulites of the Garo Goalpara Hills and Palaeo-Mesoproterozoic granulites of several areas in Chhotanagpur Gneissic Complex (Pandey et al., 1986; Chatterjee et al., 2008, 2010; Maji et al. 2008).

On the other hand, the retrograde P-T path of Early Paleozoic metamorphism in the Gneissic Complex of the Shillong Plateau including the Umpyrtha –Patharkhammah metapelites are comparable with those from the Prydz Bay area which show decompression history from 7 to 3 kbar with cooling from 750°C - 800°C.
Based on similarity in ~500Ma geological history between the Prydz Bay area and the Shillong Plateau and predominance of Cambro-Ordovician ages and post-tectonic granitoids emplacement in central part and towards eastern part, Chatterjee et al., 2007 demonstrated that the Pan-African suture passing through Prydz Bay in Antarctica, possibly continued northward into India through the Shillong Plateau with the western margin of the suture between the Sonapahar and the Garo-Goalpara Hills regions. It is noteworthy that the Pan-African overprinting on Mesoproterozoic granulites in the Garo-Goalpara Hills is totally absent and therefore location of the proposed suture possibly passed through more towards the central part of the Gneissic Complex of the Shillong Plateau, where the Umpyrtha-Patharkhammah area took a leading role in Pan-African final amalgamation of the Indian plate with the Australo-Antarctic plate.

In conclusion, the compelling evidences such as high temperature melting and metamorphism followed by intense compressive deformations and NNE directed sinistral shearing, polymetamorphic history with ITD path of the metapelites and predominance of late tectonic granitoids undoubtedly have placed the Umpyrtha-Patharkhammah region as one of the most strategic areas during Pan-Gondwanic amalgamation.