The chief goal of the present study is to constrain the metamorphic evolution of the granulite facies rocks of Patharkhang, a part of the Gneissic Complex of the Shillong Plateau, Assam-Meghalaya. In view of this, the discussion based on the present investigation relates to several critical issues on the origin of these granulites from the area. But, before discussing these aspects, it is important to mention that the present study is only scientific investigation for the granulite facies rocks of the area. As a matter of fact, it shows that there are many problems yet to be resolved in the Shillong Plateau, where detailed studies are only just beginning and hence this work is also considered to build up a database on a subject where information is inadequate.

Mainly the present discussion relates to four important and general issues of granulite metamorphism. They are centered on the question of (a) tectonothermal episode, (b) pressure - temperature conditions and P-T path, (c) geochemical affinity of granulite facies rocks and (d) selective chemical depletion in granulites.

SEQUENCES OF METAMORPHIC EVENTS

The area is recognised as well defined volcano - sedimentary terrain consisting of basic granulites and metapelites. The intrusion of mafic magma probably pre-to syn-_, which accompanied high grade metamorphism and melting of the pre-existing metapelitic assemblages. The formation of granulite facies fabric is likely to be the product of re-crystallisation which started and outlasted before commencement of D_anno-deformation (F_1 folding episode), the earliest compressional deformation so far.
known in the area. This is evident from compositional layering, which is defined by
the alternation of leucocratic and melanocratic layers of granulite facies mineral
assemblages and melts layers. In Patharkhang area, the syn-S₁ melt layers contain
garnet in metapelitic rocks, while coarse orthopyroxene grains are prominent within
mafic granulites. The granulite facies fabric in basic granulites and high temperature
melting with the development of garnet leucosome in metapelites record the
metamorphic peak (M₁, Syn-S₁).

Following the attainment of peak temperature the rocks throughout the area
had undergone a prolonged episode of annealing recrystallisation. This had resulted
the granoblastic fabric which superimposed on the gneissic foliation of the basic
granulites while melting in the metapelites was continued with the removal of partial
melt to produce cordierite garnet sillimanite bearing restites in the area and in further
to north in Sonapahar (Lal et al., 1978).

The post M₁ metamorphic episode is marked by widespread retrogression of
the rocks throughout the area. Textural features show that, two distinct sets of
reactions: the first set producing coronitic cordierite (M₂) at the expense of garnet
and sillimanite + quartz in metapelites and second set producing hydrous minerals
during fluid enhanced retrogression. Development of cordierite corona assumes
special importance and it implies a near isothermal decompression (ITD path, Harley,
1989). The preservation of corona texture requires a dominantly static environment,
therefore implying little deformation subsequent to M₂. M₂ might have started during
D₂ because in local areas of strong D₂ strain partitioning some M₂ reaction coronas
are erased. However, M₂ continued after D₂ and it is possible that some of the M₂
coronas formed during the crystallisation of the partial melt at much lower
temperatures. D₃ is the last folding event in the Patharkhang area. A late stage thermal event (M₃), which is again possibly associated, second set of retrogression reaction that involved fluid induced transformation of garnet into biotite. This reaction is seen to be prevalent in the metapelites, the source of fluid may be post-kinematic blastoporphyritic granite into the Gneissic Complex of the Assam Meghalaya Plateau (Ghose et al., 1991).

PRESSURE - TEMPERATURE CONDITIONS AND P-T PATH

The geothermobarometric data on the earliest metamorphic (M₁) mineral assemblages show a temperature range 730°C - 780°C (Table 6.1) while a comparison of relevant experimental data indicate that the peak metamorphic temperature condition of Patharkhang granulites > 800°C (Spear, 1981). However the M₁ pressure is not well constrained. Lai et al. (1978) considered that Sonapahar and surrounding region as low – pressure (< 4.5 kb) metamorphic terrain. Although the present study lacks the direct estimation of pressure value for M₁, textural evidences (Chapter3) indicate that this assumption for a low-pressure is not unrealistic. The last metamorphic event (M₂) prevailed in the entire region (Lal et al., 1978, Chatterjee et al., 2005). The present study reveals that the M₂ event was related to the stabilisation of coronitic growth of cordierites at the expense of M₁ garnet and sillimanite + quartz has gentle dP/dT slope with cordierite on low-pressure side. The reaction has been widely adopted to indicate decompression. Thermobarometric study has shown that decompression at the rate of nearly 1.4 - 1.8 kb/60°C. The intruding porphyritic granites (Ghosh et al., 2005) provided the heat supply during on-going deformation. This is consistent with the view of Chatterjee et al. (2005) that heating induced by the felsic emplacements during on-going deformation was responsible for the Cambrian (500 Ma, Monazite
age) orogeny that formed cordierite at the expense of garnet + sillimanite + quartz. It is noted that the retrograde P-T path for the Patharkhang granulites is characterised by isothermal decompression although the prograde P-T trajectory is not known.

GEOCHEMICAL IMPLICATION.

The systematic geochemical studies implies that the ancestor of basic granulites represents highly differentiated basaltic magma displaying a distinct tholeiitic trend and was little crustally contaminated liquid derived from mantle source resembling MORB volcanisms. The trace element systematics of the rocks indicate an involvement of enriched mantle source in the genesis of the rocks while the unique compositional feature of the cordierite bearing metapelites indicate that these can hardly be expected to be analogues of any type of pelites or greywacke – even allowing for the expected changes caused by metamorphic differentiation. Thus, it is inferred that the precursors of cordierite bearing metapelites were shales with some volcanic intercalations whose compositions have been possibly modified by partial melting and metamorphic differentiation. The high average K/Rb ratios of the rocks (> 500) also suggest their restitic origin after the removal of partial melts.

GEOTECTONICAL MODEL FOR PATHARKHANG GRAULITES

Finally, from the geological characteristics discussed above it is difficult to constrain any geotectonic model for the granulite facies rocks in the study area. One of the important aspect is that basic granulites, do not reflect any evidence of prograde or retrograde P-T trajectory which only metapelites indicate isothermal decompression following peak M1 metamorphism. Retrograde cooling can occur from a variety of tectonic conditions and processes (Bohlen 1987, Ellis 1987, Harley 1989, Sandiford
and Powell 1986). Harley (1989), in a compilation for the retrograde path of several granulite terrains of the world, stipulated the more common P-T paths as isobaric cooling (IBC) and isothermal decompression (ITD) of the granulites. Bohlen (1987) proposes that anticlockwise-IBC paths in granulites are caused by magmatic underplating beneath the continental crust and intrusion and crystallization of substantial volumes of igneous materials within the crust. A continental magmatic environment was as a likely tectonic regime in which such processes could take place; but, hot spots or incipient rift environments (Sandiford and Powell 1986) under certain circumstances might also yield IBC - type anti-clockwise paths. In accord with Harley (1989), ITD granulites are formed in crust thickened by collision, with magmatic additions as an important source of heat. The prograde portion of the trajectories is rarely preserved in many granulite terrains, but this part is essential for understanding the metamorphism. The absence of evidence for the prograde trajectory in the basic granulites in the area makes it difficult to choose any existing model of origin of the granulites of this area. On the basis of the observed clockwise P-T path as demonstrated by metapelites in neighboring area (Sonapahar, Chatterjee et al 2005) it may assume the continental collisional model (Thompson and England 1984) as likely phenomenon to explain these granulite terrains. However, at the assumed pressure of < 5 kb, the temperatures are too high for the granulites to have formed during isostatic uplift of a portion of lower crust thickened by continental collision. In addition, the basic granulites do not have the chemical character of a deep-seated magma chamber related to a calc-alkaline arc, but they have strong affinity to continental tholeiites. Moreover, textural evidences from rarely preserved earliest assemblage in metapelites (Chapter 3) indicate that the Patharkhang and neighbouring Sonapahar (Chatterjee et al 2005) did not suffer an early high-pressure history. The
low-pressure conditions recorded in the Patharkhang and other adjacent granulite areas of the Shillong Plateau implies that a thin continental crust might have existed already in these areas when the granulites were formed. It is seen that granulite facies conditions were attained in the crust of near normal thickness in many IBC granulites — cooling from high T, occurred at nearly constant pressure (Ellis 1980, Bohlen 1987). Further, the several models for the generation of high grade rocks, as for example, those of Bird and Baum-gardner (1981) and Looseveld and Etheridge (1990) which involve regional heating during compression of the terrain are consistent with the low pressure granulite. However; although these models are relevant to low-pressure metamorphism during thickening approximately on broad scale, they cannot be directly applicable to Patharkhang area, where metamorphism is relatively local and occur in shallow crustal level.

In summing up, it is clear from this study that any process that involves high temperature, low pressure metamorphism and also magmatism will likely to be satisfactory model to explain the mechanism for the generation of Patharkhang granulites. The continental extension could be only possibility where the upwelling of hot asthenosphere can alter the geothermal gradient of the near normal crust and provide the source of under plating intrusions, these intrusions will be directly involve high temperature metamorphism or facilitate the transfer of heat from the mantle to the crust. At the end of cooling, decompression coincides with the uplift, which brought the granulites near to the surface.