Chapter- 1

INTRODUCTION
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1.1.0 INTRODUCTION

Shillong plateau is a prominent Precambrian Gneissic Complex, occurs in Northeast India. The plateau is bounded and dissected by several E-W and N-S trending faults formed by the Kerguelen plume-related domal up-arching during the Mesozoic (Gupta and Sen, 1988) and uplift related to collision of the Indian and Tibetan plates during the Cenozoic (Johnson and Alam, 1991; Bilham and England, 2001). Towards south, the plateau is bounded by Dauki Fault, towards north by Brahmaputra Fault and towards east the plateau is bounded by Jamuna Fault (Evans, 1964; Nandy, 1980).

The Shillong Plateau covers an area of about 33000 km² within 25°20'N - 26°30'N latitude and 90°E - 93°50'E longitude (Fig. 1.1). The plateau consists predominantly of Precambrian Gneissic Complex forming the basement, the Proterozoic Shillong Group of metasedimentary rocks overlying the basement and the granitic plutons (ca. 881 to 479 Ma old) intrusive into both the gneissic basement and the Shillong group of rocks (Desikachar, 1974; Mazumder, 1976). Sylhet traps which are flows of basalts form small outcrops over the basement in the southern part of the plateau. Deep drilling and geophysical data shows that Precambrian rocks of the Shillong plateau extend for many tens of kilometers Northeast of the plateau, beneath the Brahmaputra alluvium, and also Westward to the Chotanagpur area (Evans, 1964; Desikachar, 1974).

Geological understandings on the gneisses and granulites belonging amphibolite to granulite facies forming the basement of Shillong plateau are very poor. Not much works have been carried out on the basement rocks of the Shillong plateau with modern understandings on geochemistry. Most of the previous studies were confined mainly to the facies analysis and mineral paragenesis. Detailed investigations on the basement gneisses and granulites have not been carried out to elucidate the geodynamic setting and crustal evolution of Shillong plateau. Recent studies envisaged a Pan-African Suture, the Prydz Bay-Denman Glacier Suture, passing through Shillong plateau with the implication that the different Precambrian crustal blocks of the Eastern Gondwana including that of Shillong plateau assembled
Figure 1.1: Terrain Map of Shillong Plateau showing the location of the study area. (Source: http://maps.google.co.in/maps?hl=en&tab=wl.)
at ca. 500 Ma (Zhao et al., 1995; Fitzsimons, 2003; Harley, 2003). The Proterozoic granulites gneiss Complexes of the Indian Subcontinent including the Eastern Ghats Belt (EGB); the Chotanagpur Gneissic Complex (CGC) and the central Indian Tectonic Zone (CITZ) occur in Sigmoidal Zone (Fermor, 1936). The available chronological data from the high grade rocks of CITZ (Bhowmik et al., 2005) and CGC (Pandey et al., 1986; Saha, 1987; Harris, 1993; Ray Barman et al., 1994) and the granulites of the EGB (Shaw et al., 1997; Mezger and Cosca 1999; Dobmeier and Raith, 2003) suggest that the domains are largely Proterozoic in age with relict or reworked Archaean components (Ricker et al., 2001; Ramachandra and Roy, 2001) and interspersed Grenvillian domains. Only the EGB exhibits strong Pan-African imprints (Clark and Subbarao, 1971; Shaw et al., 1997; Mezger and Cosca, 1999) at the Cratonic fringe, but it is unclear if the prograde re-heating was an effect of crustal suturing or reactivation at the craton-mobile belt boundary (Mahato and Bhattacharya, 2006).

The SMGC is separated from the main mass of the Indian Peninsular shield by the Tertiary Ganges-Brahmaputra Alluvium, and the Cretaceous Rajmahal volcanics. The Shillong plateau has been described as a detached part of the Indian shield (Evans, 1964) or an extension of the CGC (Desikachar, 1974) or the EGB (Crawford, 1974).

1.2 PHYSIOGRAPHY

The whole of Meghalaya is a plateau (150-1960 m MSL) having western, central and eastern parts, commonly known as Garo, Khasi, and Jaintia Hills. The plateau is marked by great diversities in relief features. It has highly dissected and irregular topography in the northern and western part and steep and regular slopes in the southern part. In the north, the boundary of the plateau is not well defined due to the presence of broken hill ranges (Fig. 1.2).

Garo Hills, which is conglomerate of three districts viz., East Garo Hills, West Garo Hills and South Garo Hills stretches out between 25°08’ N to 26°1’N latitude and 89°50’ E to 90°59’ E longitude. The total area of the three districts is 8167 Sq. Kms. It is bounded in south by Mymensing district and a part of Rangpur district of Bangladesh, by a district of Assam on the North and the West and by the West Khasi Hills District of Meghalaya in the east. The Garo Hills is a highly dissected region
with an average elevation of about 600 m. An interesting feature of Garo Hills is the
presence of Tura and Arabella Ranges running parallel in east-west direction. The
Tura range (about 50 km long) runs from Siju to Tura and its highest peak is Nokrek
(altitude of 1412 m). The Arabella Range runs parallel to the Tura Range on its north.
It gradually increases in height and join Tura to the South. The remaining parts of the
Garo Hills consist of hill ranges running from north to south with highest points
varying in height from 450 to 600 m.

The area is predominantly hilly except for some plain areas in the southern
and western parts. The elevation of the hills starts sharply from the southern plain
areas and after attaining their highest elevation at Tura and Arbella Ranges, slope
downs and merges with the plains of the Brahmaputra in the North. The Tura Range
occupies the southern portion stretching across from west to east. Another parallel
range is Arbella which runs from West to central part of Garo Hills. A good number
of high peaks in the Garo Hills are part of Tura Range. The physical features of Garo
Hills are grouped into three regions: (a) The Northern Sub-montane regions (b) The
Central Plateau region and (c) The Southern Hills slope region.

To the east of the Garo Hills lie the higher Khasi Hills and the easternmost
part of the Meghalaya Plateau is the Jaintia Hills. The Khasi and Jaintia Hills have the
following three parts based on their physiographic characteristics:

i) Northern undulating hills,

ii) Central upland zone and

iii) Southern plateau.

The Northern hills (elevation ranging from 170 to 820 m) generally slope
towards the Brahmaputra Valley. Above 490 m elevation, most of the hills are flat-
topped in appearance. The central upland zone runs from west to east and occupies
more than one-third of the central and eastern Meghalaya. The Shillong Peak (1961
m) is its highest point. The southern point of the central and eastern Meghalaya
plateau is characterized by steep slopes. The deeply cut valleys divide this section into
three parts – the Cherapunjee Platform, the Mawsynram Platform, and the Lynkyrdem
Platform. On the Cherapunjee platform there are many small rounded hills made of
limestone. These hills have caves with narrow underground tunnels and characteristic
karst features. Towards the plains of Bangladesh, the face of the plateau at many places is characterized by deep precipices caused by abrupt slope and heavy rainfall.

Figure 1.2: Physiographic Divisions of Meghalaya.

The Jaintia Hills (eastern plateau) is a contiguous part of the central Meghalaya Plateau but it is relatively lower with an average height of a little more than 1200 m. The Marangksih peak on the Eastern plateau of Jaintia Hills stands majestically at the elevation of 163 m above mean sea level and is the highest peak in the entire district. The main elevation of the district ranges between 1050 m to 1350 m. The three parts of the plateau viz. northern hills, the central upland (Jowai upland) and the southern escarpment coincide with three parts of the Central Meghalaya. The central upland (1500 m) extending from east to west acts as a watershed between the Surma Valley in Bangladesh and the Brahmaputra Valley in Assam. The Jaintia Hills have more low and level lands than the Khasi Hills (Fig. 1.2). In general, the whole district is full of rugged and undulating terrain with the exception of the deep gorges and narrow valley carved out by Umngot, Myntdu, Lukha rivers.

1.3 DRAINAGE SYSTEM

The drainage system of Meghalaya is greatly determined by its geological structure and the physiographic features. The Tura range in Garo Hills and the central uplands in Khasi and Jaintia Hills form watersheds, and from these watersheds the rivers flow down towards the plains of Bangladesh in the south and the Brahmaputra
The important rivers in the Garo Hills (of the northern group from west to east) are the Kalu, Ringgi, Didak, Didram, Krishnai and Dudhnai. Sanda, Bandra, Bhogai, Dareng, Nitai and Simsang are the important rivers of the southern group.

The rivers in Khasi and Jaintia Hills also flow in two reverse directions. The main rivers of the northern groups (Khri, Digaru, Umtrew, Umiew and Myngot) form the boundary of the plateau very irregular. The south bound rivers give rise to deep valleys on the faulted surface of the hills as they leave Meghalaya to enter Bangladesh plains (Fig. 1.3).

1.4 CLIMATE

The climatic conditions of Meghalaya vary according to the altitudinal changes occurring over the north-western part of India and the Bay of Bengal (formation of high pressure) and the warm and moist wind coming from the south or the south-west. Meghalaya receives most of its rainfall from the south-west monsoon winds. Khasi and Jaintia Hills is uniquely pleasant while in Garo Hills the summer is humid and warm, and winter is pleasant. During winters, ground frost is common in the table land of Khasi and Jaintia hills. The monsoon winds from the Bay of Bengal strike against the hill ranges in the southern part of the state experiencing heavy rainfall. The Mawsynram-Sohra belt in this region has the highest rainfall record in the world (1392 cm). More rainfall is at windward slopes and less on the leeward side.

The average annual rainfall in the south-west is about 400 cm, in the central part between 300 - 400 cm and in the north it ranges from 250 to 300 cm. More than 75% of the rainfall is received within 6 months from April to September. Winter months with only 6 cm rainfall are almost dry.

The climate of this region is directly influenced by the Southwest monsoon and the Northeast winds. There are four distinct seasons: (1) Spring from March and April; (2) Summer (Monsoon) May to September; (3) Autumn – October to November and (4) Winter – December to February. Rainfall starts by the 3rd week of May and continue right up to the end of September and sometime well into the middle of October.
1.5 PREVIOUS WORK

Oldham (1858) had carried out the pioneering geological work on part of Khasi Hills of the region. The systematic geological mapping of the region was subsequently carried out in details by Medlicott (1869), Godwin Austin (1869), La Touche (1883, 1887) and Mallet (1876). Their contribution gave impetus in the further systematic of different parts of the region by later workers viz. Palmer (1923), Fox (1934-35), Mukerjee (1939), Ghosh (1936-39), Talukdar (1967), Bhattacharya and Barman (2000). Medlicott (1869) reported the occurrence of granitoid massives in the Meghalaya plateau. The Archaean and Precambrian rocks of the plateau have been mapped systematically by Gogoi (1961-73), Munshi (1964-65) and Mazumder (1965-68). Their works led to the delineation of the individual rock units of the Archaean and Precambrian (Shillong group) but also revealed their inter-relationship and also brought interesting structural features of the region. Geological Survey of India (GSI, 1974, 1989) gave the stratigraphic sequence, geology and mineral resources of the region. Since inception of the Assam circle (later Assam-Meghalaya circle/Regional Geology divisions of Meghalaya and Assam) of Geological Survey of India at Shillong in 1961, a programme of systematic geological mapping of Meghalaya Plateau was undertaken this is still continuing. Mazumder (1968, 1976) gave a detail account on the region geology and field relationships of felsic magmatism and

The geology and geodynamics of the Shillong plateau are reported by Nandy and Das Gupta (1986); Nandy (2001); Srinivasan (2005) and Selvan et al., (1995). Chatterjee et al., (2007) reported electron microprobe (EPMA) monazite dates and mineral paragenesis of granulite facies metapelites of Shillong Plateau. Based on the age they reconstructed a Neoproterozoic-Cambrian assembly of the Rodinia supercontinent where in the Shillong plateau was presumed at the leading edge during an oblique collision of India with Australo-Antarctica. Lal et al., (1978) discussed the phase petrology of the sapphirine-bearing granulites of the proposed area. While working on the exhumation and uplift of the Shillong plateau, Biswas et al., (2007) opined that the exhumation of the plateau began at least 9–15 Ma ago, its surface uplift was chronologically decoupled from its exhumation and started after 3–4 Ma at rates of 0.4–0.53 mm/a, and the long-term horizontal shortening rate accommodated by the plateau is 0.65–2.3 mm/a, which represents only 10–15% of the India-Asia convergence rate. Several works on Seismotectonics of Shillong plateau are carried out, including focal mechanism solutions of earthquake in Shillong plateau (Angelier and Baruah, 2009; Kayal and De Reena 1991; Kayal 2001), the role of major lineaments in the area (Evans, 1964; Mukhopadhyay, 1984; Kayal, 1987), the estimation of b-values (Bhattacharya et al., 2002; Bhattacharya and Kayal, 2003; Khan, 2005) and the delineation of crustal as well as upper mantle heterogeneities on the basis of seismic tomography (Kayal and Zhao, 1998).

Although significant progress has been made in the knowledge of this Precambrian Gneissic Complex, yet many of the questions concerning the evolution of the rocks and source characteristics etc. still remains a question. Petrological and geochemical study of these Precambrian rocks had been sporadic and adequate summaries of the results achieved are still meager. In addition, a detailed geochemical
study and a data base on the basement rocks of Shillong plateau are still much warranted. Towards the solution of this problem, the region needs more data for a better understanding of the geodynamic evolution of the Shillong plateau as these rocks represent middle to lower continental crustal rocks of the earth.

1.6 SCOPE OF THE WORK

The principal aim of the work is to generate petrographical and geochemical characteristics of the mafic and felsic granulites of Sonapahar area forming the basement of Shillong plateau and to elucidate the petrogenetic evolution of these basement rocks. Granulites are believed to constitute a major portion of the lower to middle continental crust and thus a better understanding of the petrogenesis of these rocks will enhance our knowledge of geodynamic evolution of deep continental crust. The geochemical study of the Precambrian basement of granulite facies assemblages of Shillong plateau will open further scopes for correlation with other granulite belts found elsewhere in India particularly in Eastern Granulite belt and Southern Granulite terrain. Granulite-facies terranes and granulite xenoliths carried up by volcanic rocks provide windows into the middle and lower crust and have received considerable attention in elucidating crustal evolution history and tectonic processes. The formation mechanisms and exhumation history of granulite facies assemblages from various parts of the world have been topics of many recent investigations (Bingen and Stein., 2003; Blein et al., 2003; Garcia et al., 2003; Owen et al., 2003; Santosh and Tsunogae., 2003; Santosh et al., 2003a, b; Seth et al., 2003; Tsunogae et al., 2003; Yu et al., 2003). Thus, study of granulites of the Sonapahar area has important significance for further study of formation and tectonics of deeper crust of the Shillong Plateau. Whole-rock geochemical data are implemented to define compositionally distinct rock types and constrain their possible petrogenetic relations. They also provide important background information for comparison of rock types showing contrasting petrological history of their protolith. The rocks even when metamorphosed to high pressures of the granulite facies retain their geochemical signatures inherited from the source rocks (Cox et al., 1995). Thus analysis of major oxides and trace elements including REE could be one of the efficient tools to interpret the composition of the protoliths because the elements with high ionic potential (Ti, Zr, Y, V, Cr, Ni.) and REE are interpreted to have been effectively
immobile during high grade metamorphism (Rollinson and Windley, 1980; Condie 1981; Sheraton, 1980).

The main objective of this research work constitutes:

i) To carry out detailed geological field work and to collect rock samples for laboratory studies.

ii) To carry out detailed petrographic studies of the basement rocks of the Sonapahar area, Shillong Plateau.

iii) To carry out whole rock geochemical analysis of the basement rocks for major, trace including REE and to interpret the data.

(iv) To understand and elucidate the petrogenetic evolution of basement rocks of the Shillong plateau.