CHAPTER I

INTRODUCTION

The Laitkor-Mawkyndur area is situated at the eastern part of East Khasi Hills and the western part of Jaintia Hills districts of Meghalaya state (Fig.1). The plateau region of north-eastern India, popularly known as Shillong plateau is comprised of the entire Meghalaya state and parts of Assam (Fig. 1.1 inset). The Shillong plateau (shield area) is regarded geologically as the north-eastern extension of the Indian Peninsular Shield (Pascoe, 1950). The two shield areas are separated from each other by the Garo-Rajmahal trough fault (Fig. 1.2 inset, after Eremenko et al., 1969). The Precambrian rocks of the Shillong plateau display a NE-SW strike similar to that of the tectonic trend of the Eastern-Ghats orogeny (Krishnan, 1953).

The rocks of the area under investigation to a large extent belong to the Proterozoic age and comprise of the metasediments of the Shillong Group, intruded first by the metadolerites (Khasi Greenstones) and then by the porphyritic granite (Mylliem Pluton). A hornblendic rock (hornblendite?) bearing concordant and discordant relationship with the Shillong Group of rocks also occurs in the area. This hornblendic rocks is later cut by basic dikes, supposed to be related to the Sung Valley Alkaline Carbonatite Complex (Cretaceous : Chattopadhyay & Hashimi,1984), hence much younger in age. The presence of a highly altered tuffaceous rock (supposed to be equivalent of the Jurassic? Sylhet Trap) covering a small area near Laitkor adds complexity to the geology of this region.

1.1 Location of the area

The area under investigation lies between Shillong, the capital of Meghalaya state and Jowai, the district headquarter of Jaintia Hills district. The area is covered by Toposheet Number $78^{0}/_{14}$ and $83^{c}/_{2}$ published by the Survey of India in 1:50,000 scale. The area under investigation is bounded by longitudes 91°52'E and 92°8'E and latitudes 25°30'N and 25°34'N, covering an area of approximately 130 sq. km.

1.2 Communication and accessibility

The area is communicable by roads from Shillong. The National Highway 44 connects Shillong with Jowai, and runs through the northern limit of the study area. Bus and taxi services are available from Shillong to Jowai and vice versa.

The southern part of the area is situated far away from the National Highway 44 and are approachable partly by narrow metalled roads, but mostly by narrow gravelled roads and footpaths. The villages connected by metalled roads are approachable any time of the year. The footpaths at the foothills and those across the hills help in carrying out the survey works during dry season. During monsoons, these paths and approaches become muddy and slippery.

1.3 Topography and drainage

The Khasi and Jaintia Hills, which form the central and eastern parts of Meghalaya is an imposing plateau with rolling grasslands, hills and river valleys. The study area, which falls more or less in the central part of the plateau, has an undulating topography with chains of hills sloping generally to the south towards the plains of Bangladesh. The Shillong Peak (1960m.), the highest point in the Shillong Plateau, is just beyond the north-western corner of the study area.

The drainage of the area is excellent.It is traversed by a number of small rivers and streams, which originate in the hills and flow down the slopes. A few of them are seasonal becoming almost dry in winter, but most are perennial in nature. They flow towards the south, entwinning with one another, ultimately becoming the major streams Um Iew or Um Iam, Um Dih, Um Dzothodang and the Um Ngot. Fewer streams flow towards the north; they ultimately join the Um Khen, which meets the mighty Brahmaputra river in the plains of Assam. (see Chapter III).

1.4 Climate and vegetation

The climate is largely controlled and influenced by the seasonal winds, viz. the South-west monsoon and the North-east monsoon. The South-west monsoon brings considerable amount of rainfall during summer, the average rainfall being 56 cms. per annum. Winters are dry and sunny. The rainly season is from April till October and winter season is from November till February. The average summer temperature is around 28^0C and the average winter temperature is around 12^0C.

The vegetation in the study area is fairly uniform comprising of thick forests of tropical evergreen moist deciduous and sub-tropical pine trees. Agro-horticultural products are potato, maize, rice and a variety of vegetables. Azaleas and rhododendrons grow wild in the forests alongwith many beautiful orchids.

1.5 Weathering and soil

Intensive weathering is a conspicous phenomenon seen in the area. The diurnal variation in temperature, running water, moist air, wind, rainfall, etc., are the various weathering agents.

The area, including the hills and valleys, are covered by thin and thick soil cover and vegetation. Exposed rocks are so highly weathered that, at places, they have turned into soft and friable rocks. In some hills weathered and rounded boulders are found, exhibiting the typical spheroidal type of weathering.

Weatering agents, such as water, acting along the joint planes of the quartzite country rock, ultimately dislodge the rocks from its original position in rectangular slabs or blocks.

The dark colored basic rocks are less resistant to weathering than the quartzites. At places, the weathering agents, generally water, act along the joint planes and break them easily. Exfoliation (Pl. 4.19) of thin sheets from the surface is a typical feature that is usually observed.

Spheroidal weathering (Pl. 4.20) is a typical feature seen in the granitic terrain.

The pelitic rocks are weathered easily. The weathered rocks become friable and break easily when struck lightly by hammer.

The soils of the area are variable, but they can be classified into two - a red colored fine textured soil produced due to weathering of basic rocks, the red color being due to the iron liberated through chemical alteration of ferro-magnesian minerals of those rocks and its subsequent oxidation to Fe_2O_3; and a light-colored soil with tints of pink or brown formed due to the weathering of the quartzitic rocks.

1.6 Nature of exposures

The area, consisting of rolling hills separated by small valleys, is covered by soil and vegetation. Soil and vegetation cover even the hill-tops and slopes, making the area very scanty of rock outcrops.

However, artificial excavations in the form of highway/road cuts afford good rocks exposures. Rock quarries are few, but, wherever present, show excellent rock exposures and provide very good scope for carrying out structural studies of the rocks. Steep slopes, at places, show some good rock sections.

1.7 Economic importance of the rocks

The granites, quartzites and greenstones are quarried for use in the construction of buildings, roads, bridges, retaining walls, etc. Good propects for making of tiles and slabs out of the granites are reported. The quartzites too can be used for the same purpose and also as decorative panels in builidings at a commercially viable cost (Paul, 1996).

1.8 Scope and purpose of the present work

No detailed geological work so far has been done in the present area of investigation. The present study is intended to give an account of the Precambrian rocks between Laitkor in East Khasi Hills and Mawkyndur in Jaintia Hills. Besides the geomorphology of the area, structure, mineralogy and petrography of the rocks are studied. The intrusive relationships of the basic rocks and the granite with the country rocks, the thermal and regional metamorphism are the other lines of investigation.

Besides petrology and structure, geochemical studies of rocks are also done. On the basis of all these studies, the origin of the various rock units are put forward.

1.9 Method of investigation

The investigation has been carried out broadly in two stages - 1. field and 2. laboratory.

1.9.1 Field investigation

A topographic map, with all roads, footpaths and important elevations, is prepared from the original Toposheet No. $78^{o}/_{14}$ and $83^{c}/_{2}$ of 1:50,000 scale. This map is enlarged to double its size and then used as a base map of scale 1:50,000 in the field for geological mapping and sampling.

The field work was carried out from 1996 onwards mainly during the winter season. The distribution of various rock types and their field relationship were studied and plotted in the map. Various structural features like folds, faults, joints, foliation, lineation, shear zones and current bedding were studied. To show the lithological dispositions and structural pattern field sketches were drawn and field photographs taken. The contacts between the different rock types were observed and plotted. Descriptions of the rock types were noted down.

A good number of fresh representative rock samples, were collected from different localities and systematically numbered.

With the help of a Brunton compass measurement of bearings, extension, strike and dip, foliation, flow lines, flow layers, joints, lineation, pitch and plunge of various linear features were made. Such measurements were recorded carefully and plotted in the base map with proper symbols. Rock outcrops were measured by closed traverses and sometimes by tape measure.

1.9.2 Laboratory techniques

To study the geomorphology of the area satellite imageries alongwith toposheets were studied, compared and correlated to understand the various geomorphologic parameters and their inter-relationship with the tectonic lineaments.

Structural data that were collected in the field were tried to be interpreted by plotting the data on maps, drawing of cross sections, calculating the paleocurrent direction and plotting the attitudes of foliations and joints on Schmidts equal area projection net to prepare contour diagrams.

Altogether 114 thin sections were prepared from the various rock units for microscopic studies. The mineralogy was noted and their inter-relations studied. Microstructures observed were carefully drawn or photographed just as important mineralogical relations like grain contacts, intergrowth, zoning, etc., were noted or photographed. Textural aspects of genetic significance were carefully recorded.

Modal analysis of all the major rock units were done with the help of Swift's point counter, as suggested by Chayes (1956).

The rock samples collected in the field were examined and minute details noted down. Representative rock samples of each litho-unit were drawn to bring attention to their specialites.

Altogether 32 representative rock samples belonging to various litho-units were grinded, sieved at 100 mesh and chemically analyzed for their major element oxides only. From the chemical data various petrological parameters like CIPW Norm, Niggli values, ACF, felsic index, mafic index, differentiation index and variation diagram parameters were calculated. Such calculated parameters were used to prepare various petrochemical variation diagrams to evaluate the rocks' chemical characters and petrogenesis.

From the porphyritic granite the zircon crystals were separated out by crushing and treating it with bromoform and finally mounted on glass slides with canada balsam. The zircons were then studied under the microscope.

For the determination of the triclinicity of feldspars of the porphyritic granite, large phenocrysts of potash feldspar were extracted from the rock mass, crushed and grinded to 150 mesh and triclinicity values determined in X-ray diffractometer.

1.10 Previous literature

The Precambrian geology of the Shillong plateau was first initiated by Oldham (1858), followed by Medlicott (1869), Bose (1901), Palmer (1924), Dasgupta (1934), Chatterjee (1937), Fox (1938) (1949), Pasoe (1950) and others. However, a summary of the available literature on the rocks of the plateau, relevant to the present area, is discussed here.

Oldham (1858) was the pioneer worker who studied the rocks of the Shillong plateau. He discovered two types of metamorphic rocks in the Khasi Hills. The older, and more altered group, is represented by alternating bands of gneiss, quartzite and schist, greatly traversed by viens of fine crystalline granite. The younger group of rocks is "essentially slaty" consisting of blue and gray flaky schists with some micaceous and quartzose layers.

Medlicott (1869) really laid down the foundation of the geology of the Khasi Hills. His lucid accounts were prepared before petrographic microscope were in use. He mapped a portion of the Shillong Plateau and stated that the Shillong Series consists of a considerable thickness of quartzite, locally largely conglomeratic. He also noted compact, sharply bedded varieties and also coarse forms, in which, false bedding is closely seen. About the Khasi greenstones, he said, "it is undoubtedly an igneous

A panoramic view of the study area.

rock, a dense basic trap in which the feldspathic element is subordinate". About the porphyritic granites, he was of the opinion that "there can be little doubt these granitic masses are truely intruded" and he assigned to it a younger age than the Khasi greenstone.

Bose (1901) found xenoliths of quartzite of the Shillong Series in the granites, which was observed to be cut obliquely across the strike of the rocks of the Shillong Series.

Palmer (1924) dealt with the main structural features of the Shillong plateau and indicated that the plateau is an ancient mass of gneiss. He mapped the southern contact of a granitic pluton and stated that "the granite is a structureless aggregation of large porphyritic pink orthoclase, quartz and biotite. Sometimes by a reduction in the amount of quartz the rock approaches a syenite. The gray granite seems merely a variety of the pink".

Bradshaw (1925) confirmed the earlier reports of Palmer and observed that the porphyritic granite is to some extent foliated to the south which he believed to be a primary structure induced at the time of intrusion when the rock was in a semi-molten condition.

Dasgupta (1934) agreed with the views expressed by the earliar workers and stated that the presence of xenoliths of quartzites in the Mylliem granite, the cross-cutting relationship of granite with the quartzite and the very coarse granitic structure of the rocks point to the intrusive nature of the granite. It was further confirmed by the changes the granite had produced in the older rocks, where they have been affected by the intrusive granite. He also noted that "the general lie of the granite is fairly parallel to the tectonic axis of the Khasi Hills". He also stated that the granite intrusion took place in early Precambrain.

Chatterjee (1937-38) also supported the view that the Mylliem Granite is intrusive into the quartzites of the Shillong Group. He stated that "there are typical tension fractures in the granite filled up in many cases by aplites, pegmatites and quartz viens and later shifting of these viens suggest displacements in the granite". Chatterjee observed that the flow of the feldspar phenocrysts to be mostly along N-S with varying angles of pitch, generally towards north.

Fox (1949) described that the terrain is made up of largely of a complex in which an older series of banded gneissic hornblendic rocks and other foliated types were intruded by a younger pink granite.

Pascoe (1950) in his discussion about the Mylliem granite stated that "the dip and strike of the Shillong quartzites along the granite boundary are quite independent of the granite, and the contortions of the quartzites must have been effected before the granite was intruded."

Choudhury and Rahman (1959) observed that the emplacement of the Mylliem granite might have taken place in a synclinal basin running in a E-W direction. It was suggested that the flow of the granitic magma pushed apart the country rocks, throwing them into open, gently plunging folds, trending roughly parallel to the trend of the pluton. They considered the Mylliem granite to be a high level pluton. The elongation of the xenoliths of earlier rocks parallel to that of the feldspar phenocrysts indicate that the emplacement of the granite took place while the magma was still mobile.

Choudhury (1962) stated that "the Khasi Greenstones are derived from basic igneous rocks and had undergone regional metamorphism alongwith the quartzites of the Shillong Series prior to the intrusion of the Mylliem Granite. The mineralogy indicated that the Khasi greenstone belong to the almandine - amphibolite facies.

Gannser (1964) reported that the greenschist facies of most of the Shillong rocks contrasted with the high grade metamorphics reported to be influenced by granite contacts." He subdivided the Archean Shillong rocks into the Shillong Group and an older gneisses and granites.

Choudhury and Rahman (1968) studied the effects of granite in the surrounding quartzites, which were collected from different distances of the contact zone of the granite and noted the conversion of sericite to muscovite and recrystallization of quartz and the total obliteration of the original clastic nature of the metasediments.

Bhattacharjee (1968) stated that during the Precambrian, the Shillong Plateau experienced altenate period of igneous activity and sedimentaion till all the depositional activitites ceased after the intrusion of the granite (Mylliem granite).

Sarkar (1968), stated that in Assam, the Precambrian schist and gneisses and granites have a general NE-SW trend with local variation to E-W. From his K-Ar dating, Sarkar concluded that the granite of the Shillong Plateau is about 795 million years old.

Mazumdar (1971) reported that the porphyritic granite of the Khasi Hills were late tectonic plutons, intrusive as diapirs with contact aureole in some parts. The Khasi greenstones were intrusive into the Shillong Group and metamorphosed together with the latter; their emplacement seemed to be related to a tensional field. About the Shillong Group be stated that they lie unconformably over the Gneissic complex with migmatitic granitoids and that they were laid down in a molasse setting.

Barooah (1971) marked at least three phases of deformation in the rocks of the Shillong Group.

Barooah and Goswami (1972) divided the Shillong Group of rocks of the Khasi and Jaintia Hills into two divisions - the older and more metamorphosed as Tyrssad formation and the younger and less metamorphosed as Shillong formation, separated from each other by a sheared conglomerate.

Geological Survery of India (1974) commented that "the kernal of the plateau is the exposed Archean gneisses and schists covered in the central and eastern part by Precambrian quartzite and phyllite intruded by younger granite and basic/ ultrabasic suites."

Mazumdar (1976) stated that a number of discordant granitic plutons intrude the basement gneissic complex and the overlying Proterozoic metasediments of the Shillong Group in the Meghalaya plateau.

Rahman (1981) stated that the average composition of the Khasi greenstone (metadolerite) of Shillong area corresponds to the common tholeiitic basalt and dolerite. He observed skeletal structures of pyroxene, complex twin in plagioclase and relict ophitic structure in the greenstone.

Rahman and Borah (1982) studied the morphology and growth trends of the zircons from the porphyritic granites (Mylliem and South Khasi plutons) and the quartzo-feldspathic gneiss and stated that the zircon in the former were of igneous origin while in the lattar they were derived through sedimentary processes.

Bhattacharjee and Rahman (1985) on the basis of lithological and structural evidences separated the Shillong Group into two divisions - a lower argillaceous (Manai Formation) and an upper areanceous division (Mawphlang Formation).

Mazumdar (1986) was of the opinion that plutons of the Meghalaya Plateau (viz., Mylliem, Nongpoh, South Khasi) were late to post-tectonic fracture controlled diapers resulting from major thermal event subsequent to the evolution and metamorphism of the Shillong Group of metasediments.

Rahman (1987) stated that the Mylliem Granite is a normal two-feldspar biotite granite. The granitic magma was believed to have been intruded along the trough of the tectonically controlled synclinal basin and exerted lateral pressure on the wall rocks, which in turn warped around the granite body. All evidences clearly suggested that the pink color of the Mylliem granite was due to dominance of pink colored microcline which contained higher proportions of ferric oxide impurities than the gray granite. Besides, the enrichment of Sr and alkalis and improverishment of CaO and MgO contents in the pink granite compared with the gray granites suggests that the former was the late fraction of crystallization of the former.

Chimote et al. (1988) have noted that the dating of the Mylliem granite by Rb-Sr whole rock isochron method yielded an age of 607 t13.14 Ma.

Rahman and Borah (1990) studied the Khasi greenstone occuring as intrusives within the metasediments of the Shillong Group and stated that the meta-dolerite had initially a mineral assemblage of clino-pyroxene-calcic plagioclase-iron ore (+ilmenite) of a basic igneous rock. The low grade metamorphosed greenstones have the composition actinolite-chlorite-albite-epidote, equivalent to low greenschist facies, preserving some of the original igneous textures.

Rahman (1991) studied the emplacement of some Precambrian granite plutons in the Shillong Plateau and observed that the general lie of the granite body to be E-W to NE-SW and thereby followed the tectonic axis or the major lineament ENE-WSW of the Shillong plateau. The thermal aureoles around the granite plutons were very narrow (maximum of 400 m.) He was of the opinion that low temperature granitic magma was emplaced at comparitively higher level of the crust as post-tectonic high level pluton.

Ghosh et al. (1991) were of the opinion that a protracted thermal event during the Proterozoic and early Paleozoic (500-700 Ma), possibly related to mantle upwelling, might have triggered the generation of grantoids of the Meghalaya plateau.

Rahman (1996) stated that the Mylliem granite is a funnel-shaped pluton emplaced in a synformal basin formed by the downwarping in the metasediments of the Shillong Group. The granite was post-tectonic in origin.

Sikdar and Rahman (1998) observed the triclinicity (Δ) values of the K-feldspar to be higher or near unit for the samples in the inner zones of the Kyrdem granite pluton while the (Δ) values gradually decreased for the samples of the outer of the pluton indicating magnatic origin of the granite. Besides, the petrochemistry of the granite also supported a magmatic origin.

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Fig.1 Map of Khasi Hills andJaintia Hills districts of Meghalaya, showing the location of the present area (shaded)
Fig.1.1 Map of NE India showing Meghalaya (shaded)
Fig.1.2 Tectonic map of India (ONGC)
Fig.1.3 Lineaments around Shillong(GSI)

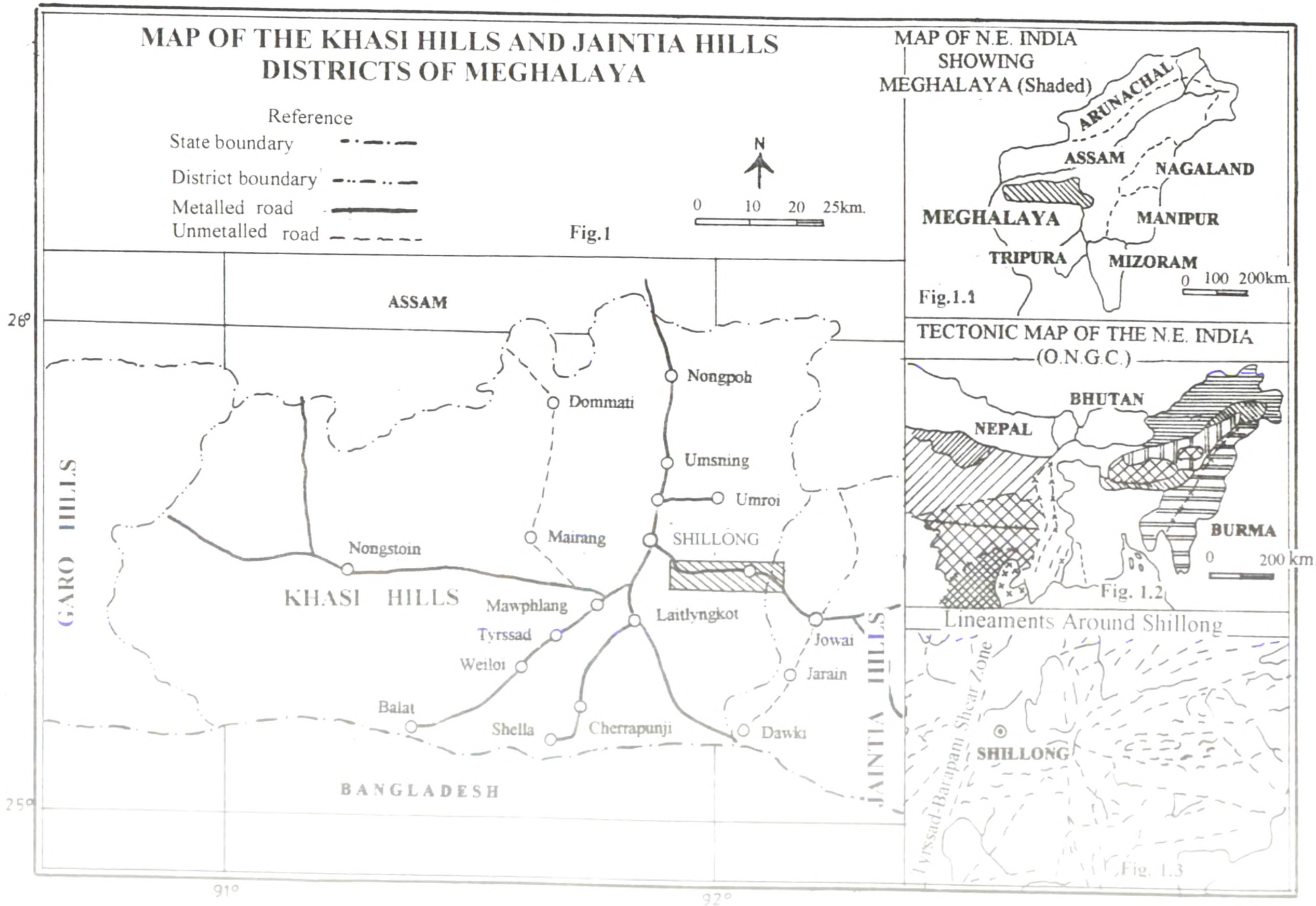

Fig.1

Fig.1.1

Fig. 1.2

Fig. 1.3