Journal of Scientific Research
Banaras Hindu University, Varanasi
Vol. 63, 2019:25-37
ISSN: 0447-9483

GEOLOGY AND PETROGRAPHIC STUDIES OF MYLLIEM GRANITE, EAST KHASI HILLS, MEGHALAYA, NORTHEAST INDIA

***Santosh K. Singh and Lanuinla Aier**
Department of Geology, Nagaland University, Kohima Campus Meriema, Kohima-797004
*santosh632002@yahoo.co.in

Abstract:

Field observations and petrographic studies reveal that Mylliem Granite is a grey to pink coloured, medium to coarse grained porphyritic granite with abundant K-feldspar. The phenocrysts are mainly composed of prismatic grains of microcline and lath-shaped plagioclase. At some places, perthitic and myrmekitic textures are also observed in the Mylliem Granite samples. The main mineral constituents are quartz, K-feldspar, plagioclase and biotite. Muscovite, hornblende, epidote, allanite, sphene, apatite, zircon, ilmenite and magnetite are present as accessory minerals. The modal minerals constituents of the Mylliem granite occupy the field of granite in the Q-A-P diagram. At places, Mylliem Graniteshows cumulus phases (plagioclase-K-feldspar-biotite) with intercumulus quartz exhibiting together cumulate like texture. Presence of minor hydrothermal pegmatite within the Mylliem granite reveals that the melt was water saturated at the end of its crystallization (near solidus). Aplite and quartz veins are also the late magmatic products of the Mylliem Granitic

Keywords: Mylliem granite; petrography; porphyritic; East Khasi Hills; Northeast India.

Introduction

The Meghalaya plateau comprises the Garo, Khasi and Jaintia hills and forms the northeastern extension of the Indian Peninsular Shield. It is an E-W trending oblong horst block elevated about 600 to 1800 m above the mean sea level in the south and separated from Peninsular India by Rajmahal-Garo gap. The Proterozoic metasedimentary Shillong Group and the Basement Gneissic Complex constitute most of the Meghalaya Plateau. They have been intruded by a number of discordant granitic plutons. The Kyrdem and Mylliem plutons are intrusives into the Shillong Group of rocks whereas the Nongpoh and South Khasi batholiths intrude both the Shillong Group as well as the Basement Gneissic Complex.

Previous Works

Medlicott [1] carried out first systematic geological mapping of the region and laid the geological foundation of Meghalaya Plateau and reported the presence of granites within the Shillong Group of rocks. Dasgupta [2] reported the occurrence of enclaves from Mylliem granite. GSI [3] published the geology and mineral resources of Meghalaya and other states of northeast India. Mazumder [4, 5] described in detail the regional geology and relation of felsic magmatism and associated litho-units of

Mylliem, Nongpoh, Kyrdem and South Khasi plutons. Rahman [6, 7] studied the petrology and geochemistry of Mylliem pluton. Chimote et al. [8] determined the age of Mylliem pluton based on Rb-Sr isotopic data and gave the age of 607±13 Ma. Chimote et al. [8] presented the statistical and mineralogical studies as petrogenetic indicator for Mylliem Granites. Hazra et al. [9] and Lanuinla[10] studied geology and geochemistry of Mylliem granites with reference to the metallogenic potential. This paper aims to present a detailed picture of field observations and petrographic studies of the Mylliem pluton and their bearing on the origin of Mylliem Granites.

Geological Setting

The Meghalaya plateau erstwhile considered a detached Precambrian block of Indian Peninsula in the north-east India has been uplifted since Jurassic times to its present height of about 610-1554 m above mean sea level. Its tectonic history begins with the effusion of Plateau basalt (Sylhet Trap) through fractures and faults in the basement and uplift and subsidence of adjacent basement blocks. These were followed by Upper Cretaceous-Tertiary sedimentation into the relatively down thrown portion along faults. The Meghalaya plateau (Fig.1) is bounded to the north by E-W trending Brahmaputra depression or fault system [11, 12] and to the south by E-W trending Dauki fault. The western and eastern sides are bordered by the N–Strending Jamuna fault system and the NW–SE trending Kopili Fault System respectively, the latter separating the Meghalaya Plateau from the Mikir Hills [11-16].

Geology of the Study Area

The study area comprises of Shillong Group of rocks, which in turn intruded by the felsic magmatism, referred to as Mylliem Granite and various vein litho-units, *viz*, aplites, pegmatites and quartz veins (Fig. 2). The different litho-units exposed in the study area are broadly presented as follow:

Aplites, pegmatites, quartz veins	---------------	Vein rocks
Medium to coarse-grained porphyritic granitoids in association with enclaves	---------------	Mylliem Granite
Epidiorite, dolerite dykes and sills	---------------	Khasi Greenstone
Quartzites, phyllites and Conglomerates	---------------	Shillong Group

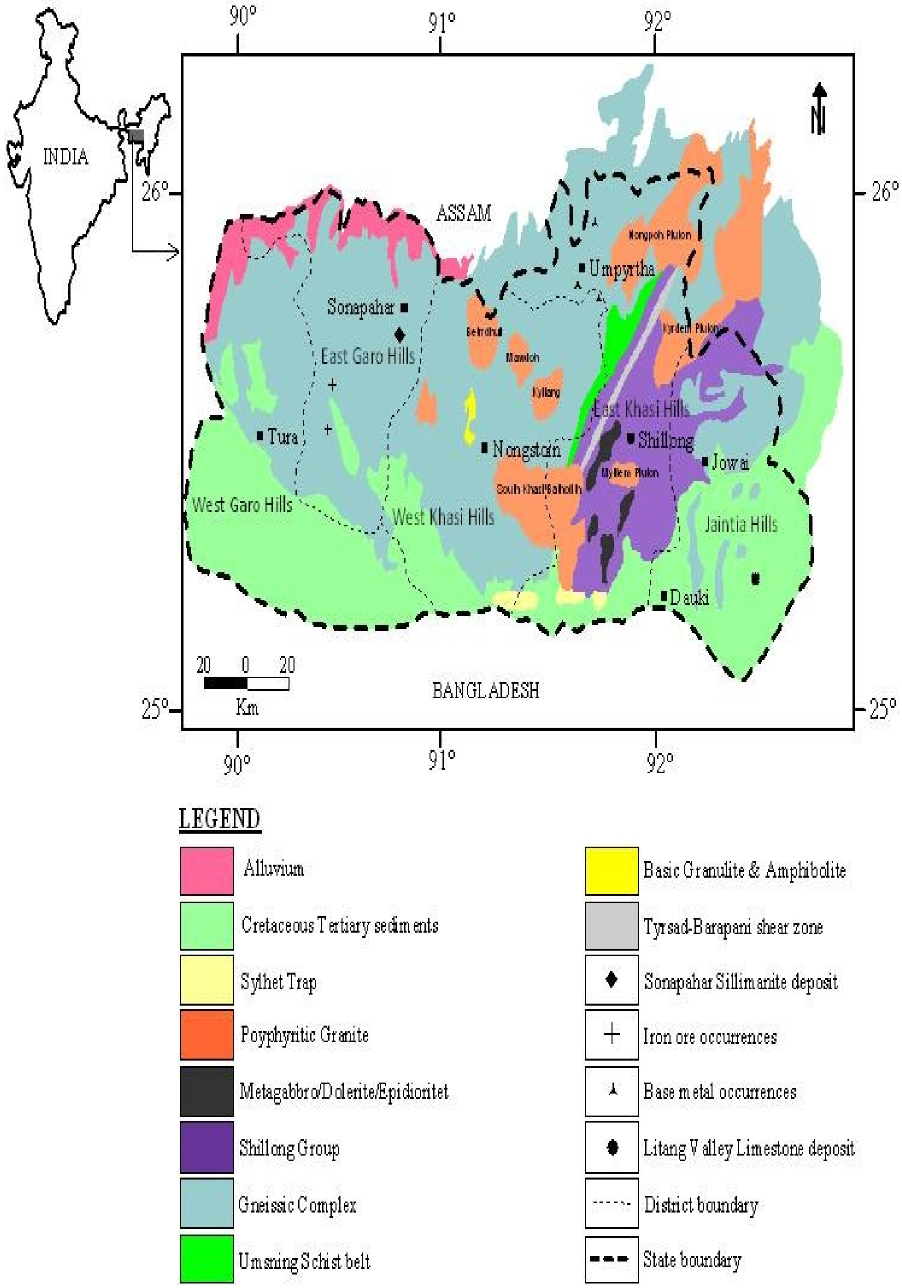


Fig. 1: Geological map of Meghalaya (after Mazumdar, [4])

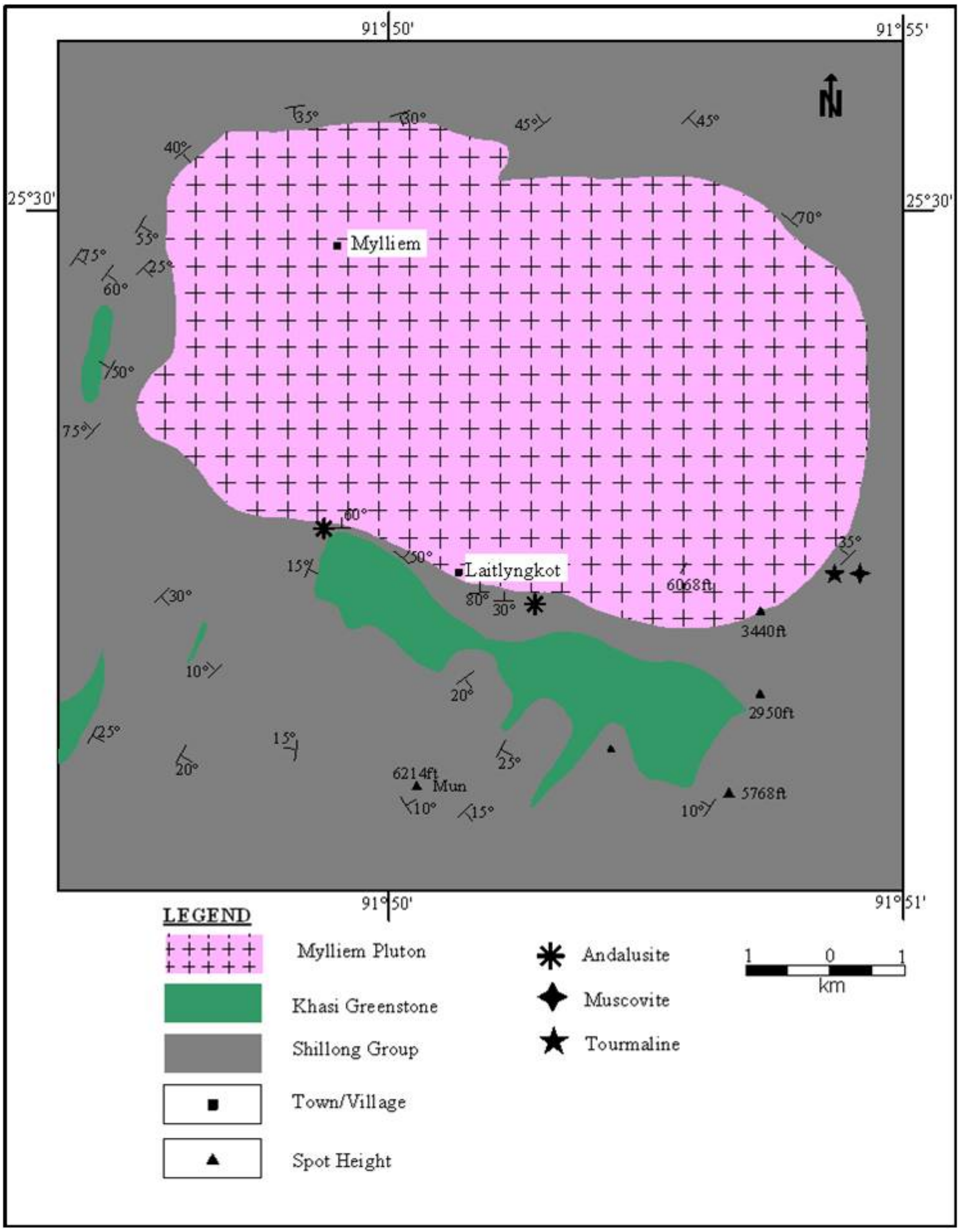


Fig. 2: Geological map of the study area (after Mazumdar, [5])

Field Observations

Mylliem Granite has been the earliest described pluton from the Meghalaya Plateau and is named after the same village Mylliem [12]. It is emplaced into the metasediments and quartzites of the Shillong Group and is represented by dominant coarse porphyritic granitoids and subordinate medium-grained granitoids. The Mylliem pluton is exposed in a roughly elliptical outcrop, the longer axis of the pluton being approximately E-W and 8.4 km in length (Fig. 2) and the E-W elongation is oblique to the prevailing NE-SW strike of the enclosing Shillong Group of rocks. Mylliem Granite shows sharp boundaries along the contact of Shillong Group of metasediments. Tongues and apophyses of the Mylliem Granite into the country rocks are quite common. Further, Mylliem Granite also contains the discrete xenoliths of Shillong Group of metasediments and older metabasic rocks.

Mylliem Granite is mostly characterized by gray to pink coloured coarse grained porphyritic texture with abundant K-feldspar megacrysts ranging in size from few mm to 4 cm. They are structurally characterized by primary foliations developed mainly along the margin of the pluton whereas the dip of the primary foliation is towards the central portion of the pluton and roughly parallel to the trend of the margin indicating a funnel-shaped intrusion.

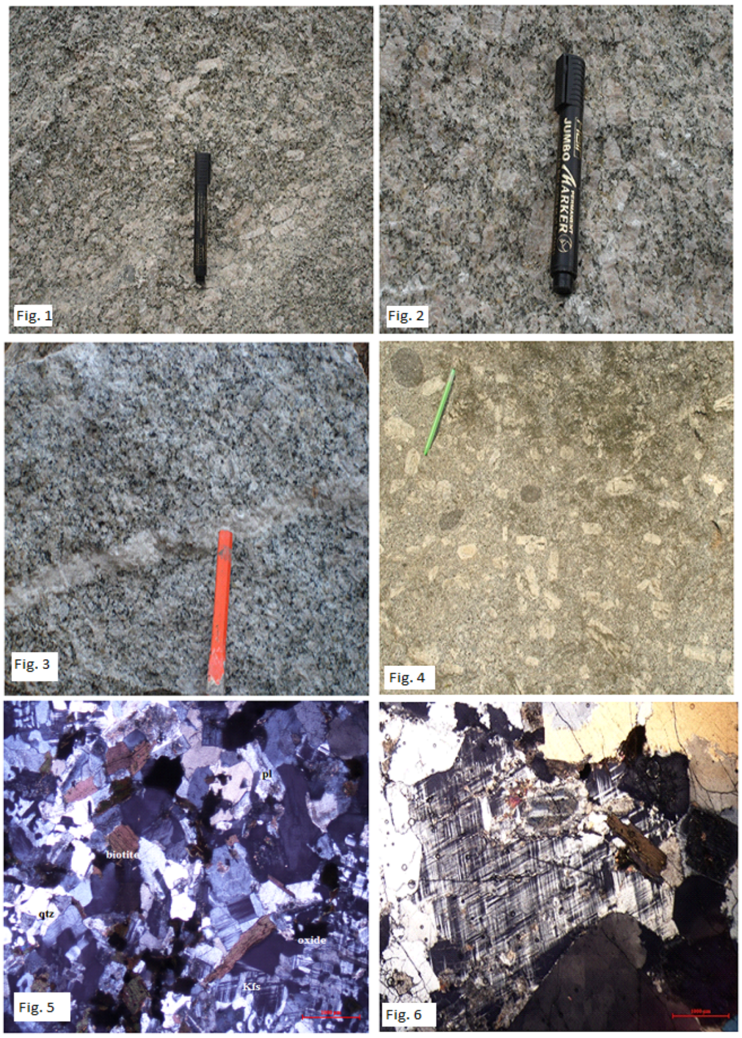
Grey granite: The rock is mainly grey in colour with random orientation of K-feldspar megacrysts (Plate I, Fig.1). The grey colour groundmass is composed of quartz, plagioclase, K-feldspar and fine flakes of biotite. The K-feldspar megacrysts vary in size from 3 cm x 1.5 cm to 1 cm x 0.5 cm.

Pink granite: This type of granite is only found near Dawki gate on Cherrapunji road. The main difference of this type of granite with the other is its concentration of K-feldspar and biotites and its crushed nature. The large phenocrysts of K-feldspar are pink in colour (Plate I, Fig.2). This type of granite dominates the area with various sizes of phenocrysts of K-feldspar usually of perthitic microcline. The size of the K-feldspar phenocrysts varies from 4 cm x 2.5 cm to 1cm x 0.5 cm. The groundmass is the aggregation of quartz, plagioclase, K-feldspar and biotite.

Vein Rocks: The vein rocks of the present study area are mostly represented by aplite, pegmatite and quartz veins. Though there are many small pegmatite veins in the study area, but no significant vein of mapable dimension is observed. Many thin quartz veins are noticed in the study area (Plate 1, Fig.3). They generally occupy the fractures produced after solidification of the Mylliem Granite and show the regional trends of schistosity of the metasediments.

Enclaves: Enclaves of different shape, size and composition are noted in Mylliem Granite. These enclaves are ovoidal to circular in shape and vary in size from a few cm to nearly about 16 cm (Plate I, Fig.4). They show more or less a sharp irregular contact with the enveloping granite. Different types of enclaves noted megascopically are: (a) dark coloured microgranular enclave, (b) medium-grained, light gray enclaves of porphyritic composition, and (c) biotite rich schilerens and clots.

PLATE – I



Figs.1. Field photograph showing the porphyritic grey Mylliem Granite with laths of prismatic megacrysts of K-feldspars, 2.Field photograph showing the pink MylliemGranite due to high abundance of K-feldspar megacrysts, 3. Field photograph showing quartz vein in grey Mylliem Granite, 4. Field photograph showing rounded and semi-rounded microgranular enclaves within host Mylliem Granite, 5. Photomicrograph of the Mylliem Granite showing hypidiomorphic texture, (40x, Crossed Polars), 6. Photomicrograph showing perthitic nature of feldspar (soda feldspar enclosed within potash feldspar) within Mylliem Granite. (40x, Crossed Polars).

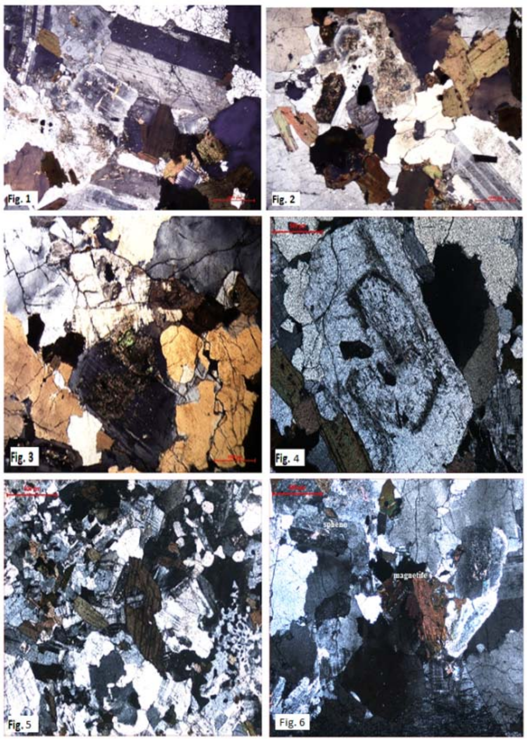
Petrography ofMylliemGranite

Megascopic characters: Megascopically, the Mylliem granite are leucocratic, coarse grained, phanerocrystalline, inequigranular and porphyritic in nature. Mylliemgranitoids are distinctly characterized by the development of pink to white coloured phenocrysts of feldspar giving rise to dominant porphyritic texture. At some places, the K-feldspar grains are altered to kaolin giving rise to a chalky appearance. The groundmass is essentially composed of a roughly equigranular mosaic of quartz, microcline, plagioclase, biotite and muscovite.

Microscopic characters: The Mylliem Granite show porphyritic texture where the phenocrysts are mainly composed of prismatic grains of microcline and lath-shaped plagioclase. It is medium to coarse-grained inequigranular rock showing hypidiomorphic texture (Plate I, Fig.5). At some places perthitic and other places myrmekitic textures are also observed in Mylliem Granite. The main mineral constituents are quartz, K-feldspar, plagioclase and biotite.

Muscovite, hornblende, epidote, allanite, sphene, apatite, zircon, ilmenite and magnetite are the main accessories present in Mylliem Granite.

PLATE II



Figs. (40x, Crossed Polars), 1. Photomicrograph showing albite twinning in Plagioclase Feldspar. 2. Photomicrograph showing alteration of plagioclase into sericite (sericitization), 3. Photomicrograph showing alteration of plagioclase into epidote (saussuritization), 4. Photomicrograph showing zoning in plagioclase grain of Mylliem Granite, 5. Photomicrograph showing the presence of hornblende in Mylliem Granite. Myrmekitic texture can also be seen at the bottom corner of the right side, 6. Photomicrograph showing the presence of magnetite and sphene in Mylliem Granite.

Quartz grains are anhedral, coarse- to medium-grained and usually occur as interstitial grains as well as small inclusions within quartz phenocrysts and other minerals. Quartz crystals show first order grey interference colour and undulose extinction low refractive index.

K-feldspar occurs as megacrysts, phenocrysts, microphenocrysts as well as in interstitial groundmass in the form of microcline. The microcline shows characteristic cross-hatched twinning and is subhedral to euhedral in nature. Perthitic nature of microcline (soda plagioclase enclosed within potash feldspar) is also observed in Mylliem Granite (Plate I, Fig.6). At places, they show poikilitic texture, enclosing fine grains of plagioclase and biotite. K-feldspars in the groundmass are mostly anhedral with irregular boundaries and shows replacement relations towards plagioclase and biotite. At places, K-feldspar grains show kaolinisation.

Plagioclase occurs as subhedral to euhedral crystals and frequently showing Carlsbad, albite and polysynthetic twinning (Plate II, Fig.1). At places, plagioclase grains are moderately sericitised (Plate II, Fig.2). Alteration of plagioclase into epidote (saussuritization) is also observed (Plate II, Fig.3). Poikilitic habit of plagioclase is also noticed, which randomly encloses biotite, quartz and apatite. Zoning in plagioclase grains is also observed at places (Plate II, Fig.4).

Biotite occurs as pleochroic flakes with good cleavage and subhedral to anhedral grains. They are yellowish to dark brown in colour and are the most abundant mafic mineral in the groundmass. Biotite occurs in close association with plagioclase, hornblende, epidote and magnetite. It is also found replacing the hornblende, which suggests biotitisation of hornblende with release of secondary iron oxides. At places, alteration of biotite into chlorite is also observed.

Muscovite occurs in two forms. One type is flaky muscovite with idiomorphic outlines closely associated with biotite, while another type occurs as irregular tiny flakes within altered plagioclases. It is found as an accessory mineral in Mylliem Granite.

Epidote shows green colour and occurs in granular to columnar aggregates as an accessory mineral in Mylliem Granite. It is characterised by high relief, perfect cleavage, strong birefringence and parallel extinction.

Allanite is observed as a metamict mineral (as a result of **“**self –irradiation” by radioactive constituents in the original mineral.

Hornblende occurs as prismatic and elongated crystals (Plate II, Fig.5) in accessory amount. Primary hornblende shows distinct cleavage. Some hornblendes also occur assmall platy grains with irregular margins. At places, alteration of hornblende into biotite has also been observed as a result of biotitisation.

Other accessory minerals observed are sphene, apatite, magnetite and ilmenite. They occur in association with biotite and hornblende and also as inclusions in other major rock-forming minerals (Plate II, Fig.6).

Modal Mineralogy and IUGS classification

Modal analyses (volume percentage of the mineral constituents) of 8 representative samples of Mylliem Granite were carried out. The results are presented in Table 1. Recalculated Q (quartz) - A (alkali feldspar) - P (plagioclase) modal volume percentages were then plotted in International Union of Geological Sciences (IUGS) recommended triangular diagram [17]. According to IUGS system of classification [18], the representative samples of Mylliem Granite, on the basis of its modal mineral constituents, occupy the field of granite in the Q-A-P diagram (Fig. 3).

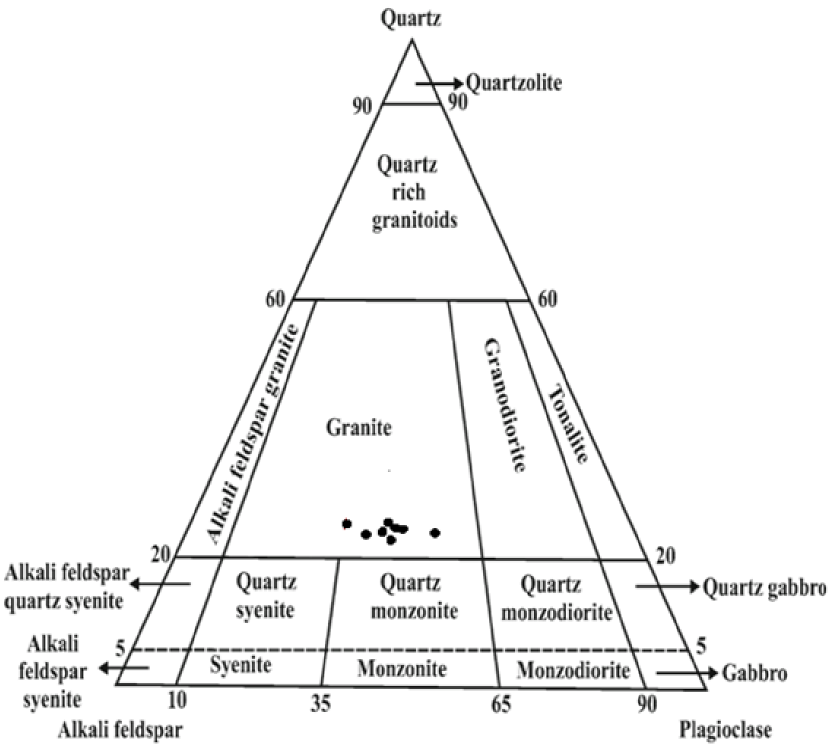


Fig.3. Modal mineral constituents of Mylliem Granite in the Q-A-P diagram (Streckeisen, [17]).

Table 1: Modal mineral constituents of representative samples Mylliem Granites

Sr. No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Sample No.	**OG-03**	**OG-09**	**OG-12**	**OG-16**	**OG-19**	**OG-25**	**OG-42**	**OG-46**
Quartz	21.36	18.97	22.86	20.82	21.14	22.46	23.18	21.40
K-feldspar	40.32	33.72	42.10	30.22	41.10	36.08	36.46	34.16
Plagioclase	33.14	25.36	23.02	36.08	27.26	30.52	28.92	30.82
Biotite	4.56	20.08	10.76	12.14	10.08	09.45	10.60	12.70
Accessories*	0.62	1.88	1.28	0.74	0.42	1.52	0.86	0.92
Total	100.00	100.01	100.02	100.00	100.00	100.03	100.02	100.00

* Muscovite, epidote, allanite, hornblende, sphene, apatite, chlorite and opaques

Discussion and Conclusions

MylliemGranite is structurally characterized by primary foliations developed mainly along the margin of the pluton. Occurrence of discrete xenoliths of Shillong Group of metasediments within the Mylliem granitic pluton as well as apophyses and tongues of the granite extending in to the Shillong Group of rocks reflect the intrusive nature of the Mylliem Granite. The dip of primary foliation is towards the central portion of the pluton and roughly parallel to the trend of the margin indicating a funnel-shaped intrusion of the parent magma. The roughly elliptical shape outcrop (Fig. 2.2) of the pluton clearly indicates that the MylliemGranite formsadomalup-arch within the surrounding Shillong Group of rocks. This would imply a domal intrusion of the pluton into the Shillong Group of rocks.

Xenoliths of quartzites and mafic rocks are found hosted in Mylliem Granite. Gneissic xenoliths retain original sedimentary fabric but are slightly folded and banded because of its ductile nature probably developed due to thermal rejuvenation by Mylliem Granite melt. Quartzite xenoliths hosted in Mylliem Granite are mostly represented by Shillong Group of rocks, and therefore should have been incorporated into Mylliem Granite melt at emplacement level. Four processes such as (1) solid-liquid inter-diffusion at the felsic melt-xenolith with or without a fluid phase, (2) inter-diffusion between felsic host and anatectic melts (extracted from xenolith melting), (3) mechanical mixing of these two felsic melts, and (4) uncommon, more rarely vapour phase transport, have commonly been considered operative during xenolith-felsic melt assimilation simultaneous with fractional crystallization or magma mixing processes [19]. Xenoliths in Mylliem Granite occur near the margin and shallow part of the intrusion, which have not been suffered intense thermal metamorphism and therefore could not lead to partial melting process.

The origin of K-feldspar megacrysts in granitoids was believed to have formed by metasomatism (felspathization) because of its extreme large size [20]. Mazumder [5] opined that much of the ferromagnesian minerals in South Khasi Granites were derived by progressive dissolution of mafic rocks by K-rich felsic melt. In the present study, K-feldspar megacrysts in the microgranular enclaves are found identical (twin plane, size and distribution of poikilitic inclusions) to that observed in the Mylliem Granite, which suggest that K-feldspar megacrysts in the granite are phenocrysts (not the porphyroblast) whereas in microgranular enclaves they are xenocrysts [21-24]. Supporting the phenocrystic origin of K-feldspar in Mylliem Granite, Sikdar and Rahman [25] have shown that triclinicity of K-feldspar in the core of the Kyrdem Granitoid pluton is higher than those observed near the margin of pluton, and therefore core of the pluton cooled at relatively slower rate than the margin. This might be the reason for K-feldspar megacrysts in Mylliem Granite that near the margin of the pluton, they could not attain large size. Xenocrystic origin of K-feldspar megacrysts in microgranular enclaves can be very well established provided their structural states are similar to that of granitoids.

Mylliem Granites commonly show medium - to coarse-grained, equigranular to porphyritic textures containing varying proportions of felsic and mafic phases. Occasionally Mylliem Granite have shown cumulus phases (plagioclase-K-feldspar-biotite) with intercumulus quartz exhibiting together cumulate like texture, as similarly described in other granitic plutons [26]. Sometimes, hornblende grains in Mylliem Granite cluster closely forming mafic aggregates are partially being replaced by biotite suggesting that biotite formed at the expense of amphiboles as a result of biotitization. Effect of post-magmatic hydrothermal solution on mafic phases forming chlorites in Mylliem Granite can be observed particularly when intruded by micropegmatite system. The Mylliem Granite melt was therefore water-saturated at the end of its crystallization (near solidus), which was capable to generate minor hydrothermal pegmatite system. Aplite and quartz veins are also late magmatic products of the Mylliem Granite melt.

Acknowledgement

The present work has been carried out at the Department of Geology, Nagaland University, Kohima Campus Meriema.

References

[1] H. B. Medlicott, “Geological sketch of the Shillong Plateau in N.E. Bengal,” Mem. Geol. Surv. Ind., vol. 7, pt. 1, pp. 151-207, 1869.

[2] H. C. Dasgupta, “On the Mylliem granite, Khasi Hills”, Q. lour. Geol. Min. Met. Soc. Ind., VI (1-4), 1934.

[3] Geological Survey of India, “Geology and mineral resources of the states of India”, Misc. Publ. No. 30, pt. IV, pp. 72-78, 1974.

[4] S. K. Mazumder, “A summary of the Precambrian geology of the Khasi Hills, Meghalaya”, Geol. Surv. India, Misc. Publ. No. 23, pp. 311-324., 1976.

[5] S. K. Mazumder, “The Precambrian framework of part of the Khasi Hills, Meghalaya”, Rec. Geol. Surv. Ind., vol. 117 (2), pp. 1-59, 1986.

[6] S. Rahman, “Petro chemistry of the Mylliem granite, Khasi Hills, Meghalaya”, Jour. Geol. Soc. India, vol. 26, pp. 356-359, 1985.

[7] S. Rahman, “Origin and emplacement of the Mylliem granite, Khasi Hills, Meghalaya”, India. Revista Brasileira de Geosciencias, vol. 17, pp. 660-662, 1987.

[8] J. S. Chimote, B.K. Pandey, A.K. Bagchi, A. N. Basu, J. N. Gupta, and A.C. Saraswat, Rb-Sr whole-rock isochron age for the Mylliem granite, Khasi hills, Meghalaya. Four. Nat. Symp. Mass Spect., Bangalore, pp. EPS-9/1-9/4, 1988.

[9] S. Hazra, P. Saha, Jyotisankar Ray, and A. Podder, “Simple statistical and mineralogical studies as petrogenetic indicator for Neoproterozoic Mylliem porphyritic granites of East Khasi Hills, Meghalaya, Northeastern India”, Jour. Geol. Soc. India, vol.75**,** pp.760–68, 2010.

[10] Lanuinla Aier, “Geology and geochemistry of Mylliem granites, East Khasi Hills, Meghalaya with reference to its metallogenic potential”, Unpublished Ph.D. Thesis, Nagaland University, 79 p, 2014.

[11] D. R. Nandy, and S. Das Gupta, “Application of remote sensing in regional geological studies - A case study in north-eastern part of India”, Proc. Int. sem. on photogrammetry and remote sensing for developing countries, vol. 1, pp. T.4. P/6.1- P/6.4, 1986.

[12] D.R. Nandy, “Geodynamics of North-Eastern India and the adjoining region”, Abc Publ., Calcutta, 209p, 2001.

[13] P. Evans, “The tectonic framework of Assam”, Jour. Geol. Soc. India”, vol.5, pp. 80–96, 1964.

[14] S.V. Desikachar, “A review of the tectonic and geological history of eastern India in terms of plate tectonic theory”, Jour. Geol. Soc. India, vol.15, pp.37–149, 1974.

[15] S. K. Acharya, N. D. Mitra, and D. R. Nandy, “Regional geology and tectonic setting of North-East India and adjoining region”, Geol. Surv. India Memoir119, pp. 6–12, 1986.

[16] R. P. Gupta, and A. K. Sen, “Imprints of the Ninety-East Ridge in the Shillong Plateau, Indian Shield”, Tectonophysics, vol.154,pp.335–341, 1988.

[17] A. Streckeisen, “To each plutonic rock its proper name”, Earth Sci. Review, vol. 12, pp. 1-33, 1976.

[18] R.W. Le Maitre, “Igneous rocks: a classification and glossary of terms”, Recommendations of the International Union of Geological Sciences, Sub

commission on the Systematic of Igneous rocks, 2nd Edition, Cambridge University Press, Cambridge, 236p, 2002.

[19] R. E. Maury, and J. Didier, “Xenoliths and the role of assimilation”, In: Didier, J. and Barbarin, B. (Eds.) Enclaves and granite petrology. Elsevier, Amsterdam, pp. 529- 542, 1991.

[20] H. H. Read, “The granite controversy”, Thomas Murby and Co., London, 430p. 1957.

[21] R. H. Vernon, “K-feldspar megacrysts in granites - phenocrysts, not porphyroblasts”, Earth Sci. Rev., vol. 23, pp. 1-63, 1986.

[22] J. Didier, “Contribution of enclaves studies to the understanding of origin and evolution of granitic magmas”, Geol. Rundsh., vol. 76, pp. 41-50, 1987.

[23] M. A. Elburg, and I. A. Nicholls, “Origin of microgranitoid enclaves in the S-type Wilson’s Promontory Batholith, Victoria: Evidence for magma mingling”, Aust. Jour. Earth Sci., vol. 52, pp. 423-435, 1995.

[24] Santosh Kumar, T., Pieru, V. Rino, and B. C. Lyngdoh, “Micro granular enclaves in Neoproterozoicgranitoids of south Khasi Hills Meghalaya Plateau, northeast India: field evidence of interacting coeval mafic and felsic magmas”, Jour. Geol. Soc. India, vol. 65, pp. 629-633, 2005.

[25] D. Sikdar, and S. Rahman, “Triclinicity of the potash feldspar and the petro chemistry of the Kyrdem granite, Khasi hills, Meghalaya. Proc. Reg. Sem. Dev. Geol. Res., NE India, Guwahati, pp. 45-55, 1998.

[26] B.W. Chappell, and D. Wyborn, “Cumulate and cumulative granites and associated rocks”, Resource Geol., vol. 54, pp. 227-240, 2004.