# Metamorphic Condition of Metamorphic Rocks Exposed at the Hngetmi Taung Area, Pyawbwe Township, Mandalay Region

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**Abstract**

The research area, Hngetmi Taung is located about 11 miles southeast of Pyawbwe, so it is easily accessible by any vehicle throughout the year. The area under investigation falls within Mogok metamorphic Belt and lies between the Shan Highland and Central Cenozoic Belt .The area is a rather rugged terrain with high relief. Metamorphosed pelitic rocks and igneous rocks mainly occupy the study area. These rocks, for the whole area are found as a long narrow strip along the western margin of the Shan massif. The major rock units exposed in the study area are marble, calc-silicate rocks, gneiss, schists, biotite granite, diorite and rhyolite porphyry. Due to the similarity of Litholgic attributies and Lateral continuity of outcrops it is concluded that the original age of the metasedimentary rocks of the present area is possibly Paleozoic. The mineral assemblages of rock units indicate that the metamorphic rocks of the study area belong to the amphibolite facies and pyrixene hornfel facies. The age of metamorphism in this area is tentatively assigned to during Tertiary period,i.e Late Eocene to Early Miocene. The marbles and related rocks may have been metamorphosed mainly from the Plateau limestone, and perhaps partly from the Cretaceous limestones. Due to the appearance of lithologic continuity and index minerals pointed out that the metamorphic grade in the investigated area increase towards the west.

Key words: amphibolite facies, pyroxene hornfel facies, Tertiary period, Cretaceous Limestone

## Introduction

The research area, situated about 14 miles southeast of Pyawbwe, is bounded by vertical grids 770 to 810 and horizontal grids 001 to 050 in one-inch topographic map 93 D/6. Figures (1) and (2) are the location map and Location on satellite image of the study area. It covers about 30 square kilometer of fairly rugged terrain. It extends about 5 km from north to south, and 6 km from east to west. Kyauk Oo and Hngetmi villages, located at the western margin of present area, are easily accessible by tractor in all seasons from Pyawbwe.

## Regional Geologic Setting

This area lies in the western marginal zone of the Shan Plateau. This zone probably became a stable block since late Mesozoic. It occupies a part of Mogok Metamorphic Belt (Searle and Haq, 1964). The Lebyin Gruoup (Carboniferous) is exposed in a NNW-SSE trending belt extending from the Pyinnyaung area to the east of Pyinmana. This belt is bounded by the Kalaw Basin on the east and by a granitic belt (Mesozoic) on the west. The igneous rocks predominantly granitic in composition and exposed in the western part, may have intruded during Late Mesozoic, and this caused contact metamorphism superimposed upon the regionally metamorphosed metasedimentary rocks. Interbedded reddish conglomerates, siltstones and sandstones of the Kalaw Red Beds are exposed along the Myittha Chaung and locally in the eastern part. This unit unconformably overlies the Lebyin Group. Fig. (3) shows the generalized regional geology of part of Thazi, Pyawbwe and Yamethin townships

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according to the one million scale geological map of Bruma (1977 in IGCP, 1975) and Fig 4 shows the physiographic nature of the study area.

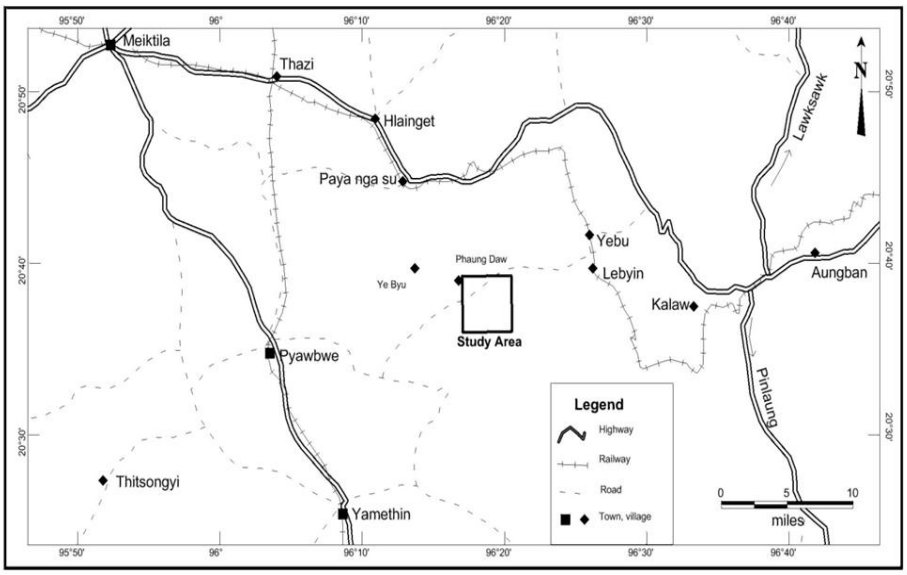


Fig (1) Location map of the research area.

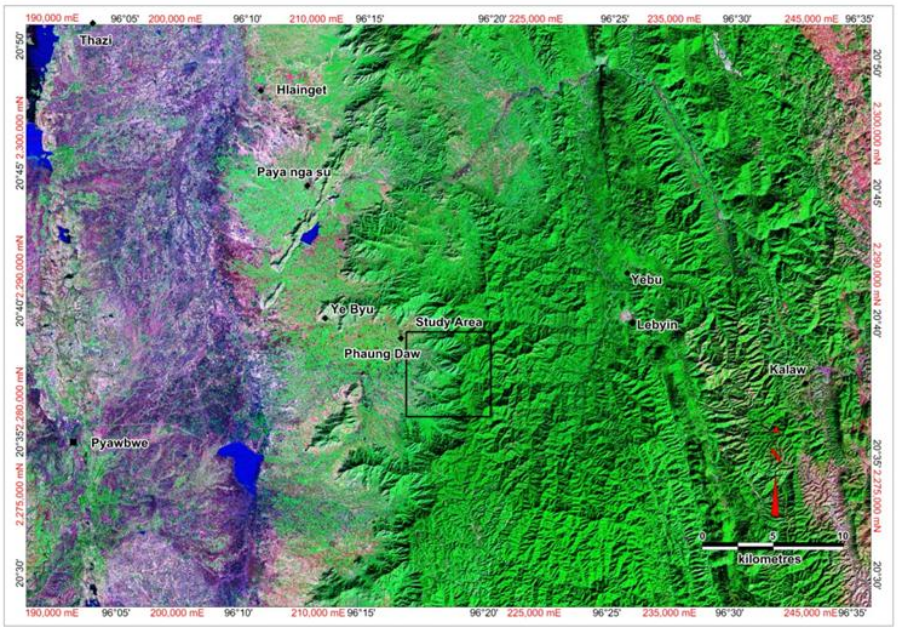


Fig (2) Location on satellite image of the research area.

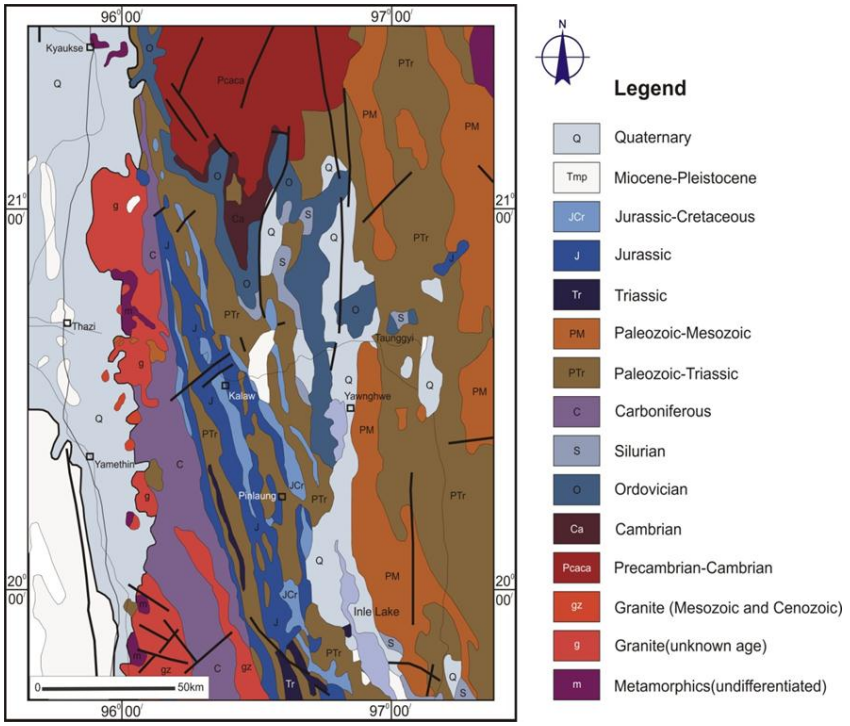


Fig (3) Regional geologic setting of the research area (Source : one million scale geological map of Bruma (1977)

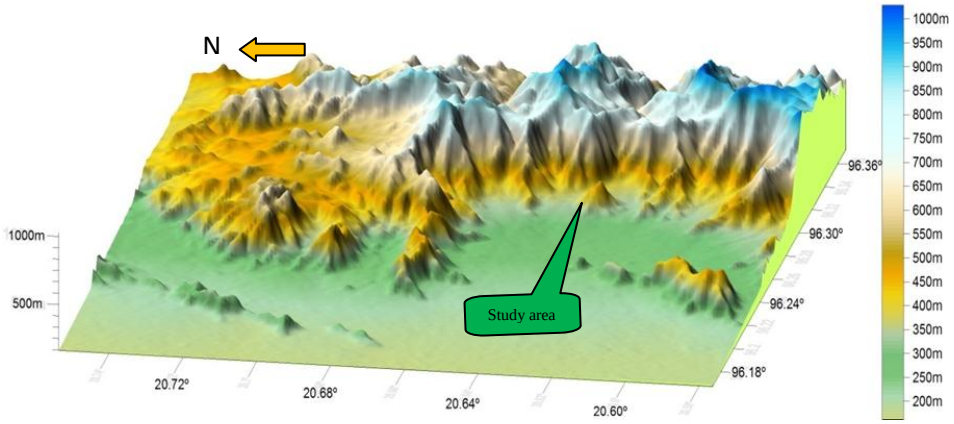


Fig (4) Physiographic nature of the research area.

## Rock Sequence

Metamorphosed calcareous rocks and igneous rocks mainly occupy the study area. These rocks, for the whole area are found as a long narrow strip along the western margin of the Shan massif where a variety of calcareous units belonging to the Plateau Limestone of La Touche (1913) are predominant. Metamorphosed calcareous observed in the study area mainly consist of a blue gray marble, calc phyllite, calc silicate rocks. These rock units have general trend of NNE-SSW direction and dips towards ESE to SSE at the angle of 25º to 45º. Geological map of the study area is shown in Fig (5) and rock sequence and age of the study are is shown in Table ( 1 ).

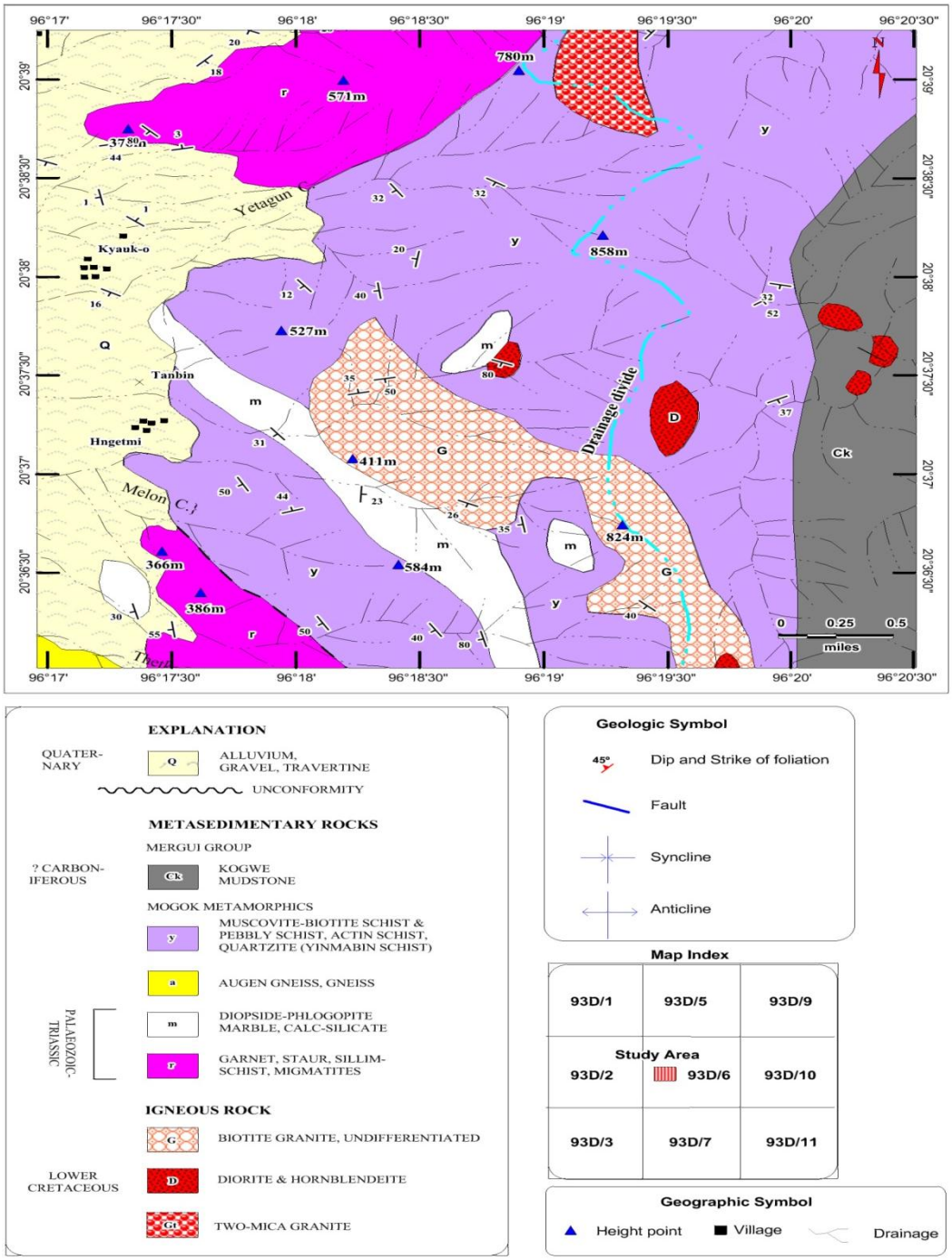


Fig (5) Geological map of the research area. ( Adopted after data of Ivanhole Myanmar Co. Ltd )

Table (1) Sequence of rock units in the research area

| Stratigrapic unit | Age |
|---|---|
| **Metasedimentary Units** | |
| Alluvium | Quaternary |
| Slate Belt: Mudstones, Sandstones, Slate | Upper Paleozoic (Carboniferous?) |
| Gneiss, Schist, and Quartzite, Calc-silicate and marble | Upper Paleozoic |
| **Igneous and Metaigneous Rocks** | |
| Vein and Dykes<br>Pegmatite and Aplite | Late Miocene (12 Ma) |
| Leucogranite<br>Tourmaline granite<br>Biotite microgranite<br>Garnet biotite granite | Oligocene to Middle Miocene (23 to 15 Ma) |
| Porphyritic- biotite granite | Eocene to Oligocene (33 to 22 Ma) |
| Biotite granite | Paleocene (59.5 ± 0.9 Ma) |
| Augen Gneiss | Cretaceous |

* Note that age data is based on the dating presented by Mitchell et al., 2007

The present research only focuses on the petrogenesis of metamorphic rocks.

Calc-silicate Rocks interbedded with Marbles unit is exposed mainly at the hills around Hnget mi village, at the western foothills of Net Taung, at the upper reach of Kogwe Chaung, east of Kyauk-O and in some parts of Kyauk me taung. This unit consists mainly of green to grey calc-silicate rocks and white bluish marble with skarn rocks, phyllite, schists and fine-grained quartzite as minor rock types. Calc-silicate Rocks are characterized by thinly bedded character (individual bands are 2-8 inches in thickness) and showing typical rib and furrow structure Fig (6). Marbles units are classified into blue banded marble and gray marble. They are exposed at the northwestern part of Nat Taung Fig (7). Gray marbles, show karst nature on the surface due to differential weathering Fig (8). The gneisses subunit are composed of quartzitic gneiss, banded gneiss and intercalated mica schist. Quratzitic gneiss, the most abundant lithology in this subunit, is easily recognizable in the field as whitish, hard, compact and poorly foliated gneiss. Fig (9). The mica schist subunit is composed of biotite schist, andalusite mica schist, sillimanite schist with minor banded botite gneiss Fig (10). Fine to medium-grained, hard and compact quartzite can be seen in the stream section of Melon, Thetke Taung and upper Kogwe Chaungs Fig (11).

Fig 6 Calc silicate rocks showing rib and furrow structure on weathered surface, 2km southeast from Hnget mi village, Loc: N20° 60′ .59″ and E 96°


Fig 7 Blue marble showing the relict of calcite veins on its weathered surface, 1km east of Kyauk- O village, Loc: N20° 63′ 00″ and E 96° 30′ 001″

Fig 8 Gray marble showing karst structure on weathered surface, 2 km southeast from Kyauk-O village, Loc: N20° 64′ .58″ and E 96° 29′.065″


Fig 9 Buff colour weathered surface of granitic biotite gneiss with parallel orientation of mafic minerals and felsic minerals, 0.5 km east of Hmget mi village, Loc: N20° 64′ .326″ and E 96° 29′.065″

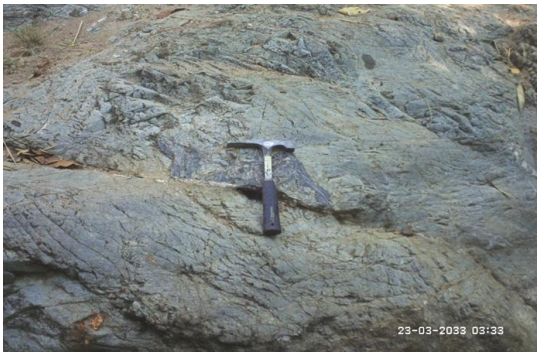


Fig 10 The phyllite at southern part of Nat Taung showing more pronounced schistosity, 0.5 km east of Hmget mi village, Loc: N20° 64′ .326″ and E 96° 29′.065″


Fig 11 Indurated quartzite showing greenish to dark colour on weathered surface, 0.5 km east of Hmget mi village, Loc: N20° 64′ .326″ and E 96° 29′.065″

## Metamorphic Condition

More than 30 thin sections were cut from various representative rock samples collected from the study area in order to make for the petrographic studies. Petrogenesis of these rock units are described on the bases of lithology, mineral chemistry, field relationships and correlation to those of other areas. The field occurrence and microscopic studies suggest that at least two processes; regional metamorphism consisting of high-grade and low-grade and contact metamorphism. The regional metamorphism is characterized by the occurrence of the foliations, lineation, recrystallization, neomineralization and recrystallization texture. It is further distinguished by the formation of such high grade minerals as sillimanite, andalusite, almandite, diopside, etc. Rrepresentative mineral assemblages are shown in table (2) and Fig (12,13, 14,15). The study of metamorphic rocks under microscope reveals the presence of strong preferred orientation of mica flakes in gneiss, bending and breaking of twin lamellae calcitic crystals in marbles, broken twin plane in plagioclase in calc- silicate rock and contortion in augen gneiss suggesting that the intense deformation might have been prevailing probably due to an upward rising of younger granitic intrusion and tectonisim. In general, the grade of metamorphism increases toward the west.

Table 2 ) Mineral assemblages and metamorphic facies of the research area (Bucher & Frey, 1994 is used as a reference book)

| **(a) For regional metamorphism** | | | |
|---|---|---|---|
| **Rock Group** | **Rock Type** | **Mineral Assemblages** | **Facies** |
| Pelitic rock (MMB) | Sillimanite- biotite gneiss<br>Biotite gneiss<br>Andalusite-muscovite schist | 1. Sillimanite-Quartz-Biotite-Plagioclase<br>2. Quartz-Biotite- Plagioclase<br>3. Andalusite-Muscovite-Quartz-Plagioclase | **Amphibolite facies** |
| Calcareous rock | ***(i) Calc-silicate Rocks***<br>Diopside calc-silicate rock<br>***(ii) Marbles***<br>Grey marble | 1.Diopside- Calcite- Quartz<br>2.Diopside- Calcite- Phlogopite-Graphite | |
| **(b) For contact metamorphism** | | | |
| Contact rock | Grossularite Skarn<br>Diopside Skarn<br>Wollastonite Skarn | 1.Diopside-Grossularite-Quartz<br>2.Diopside - Calcite<br>2.Wollastonite-Diopside- Calcite - Quartz | **Pyroxene – hornfel fcies** |

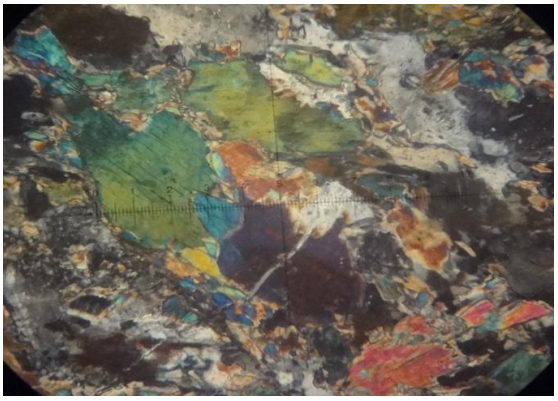

Fig (3.10) Carbonaceous phyllite showing mica flakes which are aligned along the foliation plane .( Under XN, x40 )

Fig (3.10)Adalusite mica schist showing mica flakes which are aligned along the foliation plane .( Under XN, x25 )

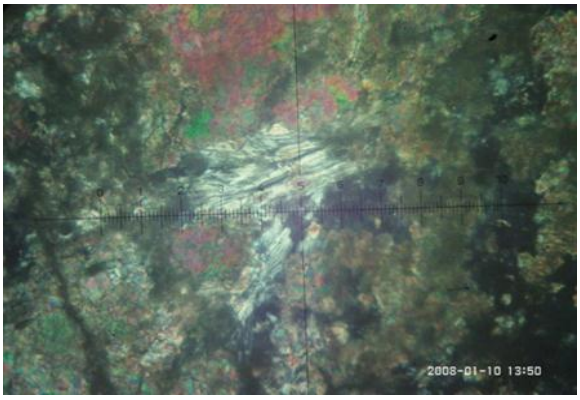


Fig (3.12) Turbit, white radiating fibrous form of wollastonite in wollastonite- diopside skarn.( Under XN, x40 )

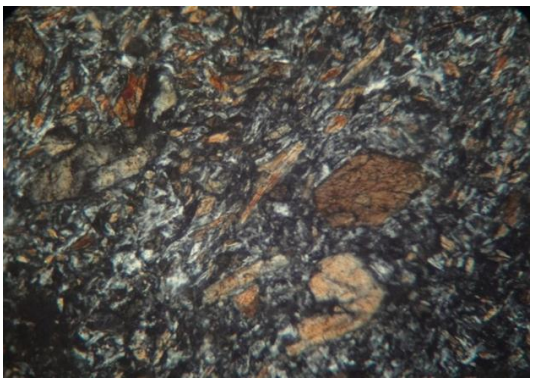

Fig (3.13) Aggregates of andalusites and hornblende in hornblende hornfels.( Under XN, x30 )

**Origin of Metasedimentary Rocks (Protolith)**

The metamorphic rocks of the present area are namely quartzites, marbles, calc-silicates and gneisses. All rocks are originated from sedimentary rocks of pelitic and calcareous composition. Grey marble were metamorphosed from pure limestone and impure dolomitic limestone. Quartzite, calc-silicate rocks were metamorphosed from arenaceous and argillaceous rocks with thin beds of impure dolomitic limestone.

The biotite gneisses, probably the oldest rocks of the Mogok Metamorphic Belt, are overlain by the marbles and the related rocks. The absence of unconformity between these two was party obliterated by later igneous activity and metamorphism.

There are several assumptions on the original rock sequences. These are as follows.

Noetling (in Baucer, 1896 in Ali Akbar Khan, 1985) mentioned that the Mogok crystalline limestone of La Touche (1913) might have been metamorphosed from the Plateau Limestone.

1. Maung Thein and Soe Win (1969) found relict fossil remains of Carboniferous age in the marbles which lies in the Mogok Belt of Myanmar.
2. Nodules composed of wollastonite and diopside in the skarn rocks might be originally chert nodules which were later metamorphosed mainly by the intrusion of the Kabaing granite (Ali Akbar Khan, 1985).
3. Clegg (1941) contended that the Mogok crystalline limestones are metamorphosed from Cretaceous limestone whose extensions can be followed to the Second Defile of the Irrawaddy River.
4. Moreover the bedding nature of marble is more or less similar in character of Wunbye Limestone Formation of Ordovician age (Myint Lwin Thein *et. al.*, 1990).
5. Mitchell *et. al*., (2007) proposed that the strong compositional layering in marbles with calc-schist laminations supports correlation with fosiliferous Ordovician to early Devonian carbonates of the Shan Plateau sequence.

Comparison of lithologic sequence of the research area with the established lithostratigraphic units in Myanmar shows that the succession of the present area is in well agreement with the Ordovician units of both northern and southern Shan State.

**Age of Metamorphic Rocks**

Being situated in the southern continuation of Mogok Metamorphic Belt (MMB), the gneisses, marbles and calc- silicate rocks of the research area are typical representation of the Mogok Metamorphic Belt. Hence, based on the regional framework, lateral continuity and lithologic similarities, the age of the metamorphic rocks of the research area is presumed to be the contemporaneous with the Mogok Metamorphic Belt (MMB).

Age of Mogok Metamorphic Belt is considered diversely from Precambrian to Cretaceous by various authors as Searl and Haq (1964),

Searl and Haq (1964) believed the Mogok Metamorphic Belt to be of Pre-Paleozoic age based on the fact that the host rocks in the migmatite zone are representative of the Chaung Magyi Series.

Myint Lwin Thein *et. al*., (1990) contended that the metamorphic rocks exposed in study area are correlated with Sagaing Ridge, Mandalay Hill, Yankin Taung, Sagyin Hill and the original rock sequence of this area are regarded as Paleozoic in age.

Femor, Iyer, La Touche and Coggin Brown considered that Mogok Series and intrusive rocks are Precambrian in age (in Tun Soe 1985).

Although the age of the rocks of the study area is controversial, The Paleozoic age for the research area can be agreeable by the following factors.

1. The Paleozoic rock sequences are situated in the east of the present area and the metamorphic rocks in the study area might be derived from these sequences.
2. At the NNE of the present area, the Precambrian rock units are basement unit.

3. The occurrence of same lithology and metamorphic grade of Sagaing Hill possibly metamorphosed Paleozoic age by Myint Thein *et al*., 1983, in Maung Maung (, 2002) which are also same structural trend and same belt of the Mogok Metamorphic Belt can be correlated with the Pyinbya area.
4. Besides, as previously stated the protolith of the metamorphics in the present area is considered to be Ordovician units.

Therefore, on the basis of all available lines of evidence, the age of the metasedimentary rocks of the study area is of Late Paleozoic or Ordovician.

**Time of Metamorphism**

The rocks of the research area might be compared with those of the Mogok Metamorphic Belt in Mogok area. The time of metamorphism of the research area is suggested on the bases of the following points.

1. If the statement of Clegg (1944) is true, then the metamorphism of the Mogok Metamorphic Belt will be of post- Cretaceous.
2. The radiometric dating on a phlogopite sample from the Mogok area gives 40 m.y.(Maung Thein and Ba Than Haq, 1969)
3. Searl and Haq (1964) suggested that the time of metamorphism might be Post- Paleozoic and almost certainly related to the Himalayan orogeny.
4. Maung Thein (1983) stated that the regional metamorphism of the Mogok Metamorphic Belt might have occurred during Late Eocene in relation to the early phase of Himalayan Orogeny.
5. Time and spatial occupation of the metamorphics in the present area is well correlable with the established Mogok metamorphics in terms of lithology and original sequence.
6. In 1999, radiometric dating by GIAC project indicated that the latest regional metamorphism of the area was formed during Late Oligocene to Early Miocene, about 20-25 Ma age.

Therefore, it can be concluded that the time of metamorphism of the metamorphics in the study area is probably Late Oligocene to Early Miocene in age.

**Origin of Meta-igneous Rocks**

The following points suggest that orthogneiss derived from pre- existing igneous rocks as a result of later metamorphism.

1. The rocks are gneissose, but in places, they are only faintly gneissose which looks like migmatite in nature although the mineral composition generally is homogeneous throughout the rock body.
2. In some places, especially, there is gradational from less gneissose rocks (granitoid–looking) to well gneissose rocks (banded gneiss).
3. Relict features such as micrographic texture and euhedral crystals of minor accessory minerals are sometimes preserved in the less altered portion of the gneiss body.
4. There is predominance of plagioclase in this rock, indicating an original igneous rock.
5. Isolated and irregular outcrops of these gneisses suggested that their derivation from discrete igneous bodies.

6. The age of augen- gneiss (orthogneiss) in the area is 170 Ma based on radio metric dating (see also Barley *et al.*, 2003, Mitchell *et al.*, 2007)

## Conclusion

Petrogenesis of these rock units are described on the bases of lithology, mineral chemistry, field relationships and correlation to those of other areas. The field occurrence and microscopic studies suggest that metamorphism of the present area was regional metamorphism and contact metamorphism. The metamorphic rocks of the present area are originated from sedimentary rocks of pelitic and calcareous composition. lithologic sequence of the research area well agreement with the Ordovician units of both northern and southern Shan State and age of metasedimentary rocks may be Late Paleozoic or Ordovician. The rocks of the Pyinbya area might be compared with those of the Mogok Metamorphic Belt in Mogok area. Therefore, the time of metamorphism of the metamorphics in the study area is probably Late Oligocene to Early Miocene in age. The mineral assemblages of rock units indicate that the metamorphic rocks of the study area belong to the amphibolite facies and pyrixene hornfel facies.

## Acknowledgements

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### References

Ali Akbar Khan (1985), Geology of the Wapyutaung–Ondan Area, Mogok and Thabeikyin Township; Univ. Mandalay, unpublished Master´s Thesis.

Barley. M. E and Pickard , Khin Zaw ,P. Rak and M. G. Doyle (2003), *Jurassic to Miocene magmatism and metamorphism in the Mogok metamorphic belt and the India-Eurasia collision in Myanmar*, Tectonic, Vol. 22, No. 3, University of Western Austrila, Crawley, Western Austrila, Austrila.

Bucher,K., and Frey,M.,1994. *Petrogenesis of Metamorphic Rocks*, 6th ed., Springer Verlag.

Clegg, E. L. G. (1941), *The Cretaceous and Associated Rocks of Burma*: Mem. Gol. Surv. India.

GIAC., 1999. *The tectonics of Myanmar*; Final Report of GIAC Project 1996-1999. Graw- Hill, New York.

Iyer, L. A. N. (1953), *The Geology of the Northern Part of Tha Khin Ma Taung*: unpub. field report of M.A.S.U.

La Touche, T. H. D. (1913), *Geology of the Northern Shan State*: Mem. Geol. Surv. India, v. 39.

Maung Maung, 2002. *Brief geological reports on Sagaing Minwun area*. Dept. of Geol., Yadanabon University. (Unpublished)

Maung Thein, 1983. *The geology evolution of Burma.* Unpublished Paper. 26p.

Maung Thein and Ba Than Haq (1959), *The Pre-Paleozoic and Paleozoic stratigraphy of Burma*. A brief review. Union of Burma Jour. Sci. Tech, V. 2, N0. 2, p. 275-287.

Maung Thein, (2005), *Mode of Occurrence and Origin of Precious Gemstone Deposits of the Mogok Stone Tract*. Yangon University.

Maung Thein and Soe Win (1970), *The metamorphic petrology, structures and mineral resources of Shantaung-U – Thabdawmyet Range, Kyaukse District*: Union of Burma Jour. Sci. Tech.

Mitchell, A.H.G., Myint Thein Htay, Kyaw Min Htun, Myint Naing Win, Thura Oo and Tin Hlaing, 2007. Rock relationships in the Mogok metamorphic belt, Tatkon to Mandalay, central Myanmar. *Journal of Asian Earth Sciences*, Vol. 29, pp. 891–910.

Myint Lwin Thein, et. al.,1990. *Geology and stratigraphy of the Thabeikkyin-Mogok Area*, (A.G.D. staff Report. No 98).

Searle, D. L. and Ba Than Haq (1964), *The Mogok Belt of Burma and its Relationship to the Himalayan Orogeny*: Proc. 22nd Intern. Geol. Congr., II, p. 132-161.

Tun Soe, 1985. Geology and Mineral Resources of the Paungdaw-Hngetmi area. Pyawbwe Township, Unpublished M Sc. Thesis, Department of Geology, University of Mandalay.