PETROLOGICAL STUDY OF METAMORPHIC ROCKS EXPOSED IN CHAUNGZON AREA, CHAUNGZON TOWNSHIP, MON STATE

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Abstract

The study area occupies the Chaungzon Township, Mon State. It is situated between Latitude 16˚ 15′ 00″ to 16˚ 30′ 00″ N and Longitude 97˚ 30′ 00″ to 97˚ 35′ 00″ E, one-inch topographic map No.94H/11. It covers approximately 6.56 km^2. It is located in the western part of Shan-Tanintharyi block. The area was composed of low to medium grade metamorphic rocks which were intruded by igneous rocks. The metamorphic rocks are garnet-biotite gneiss, graphite-sillimanite-mica schist and calc-silicate rock, quartz-sericite schist and quartzite, banded quartzite and mica schist, micaceous quartzite and quartzite and slate, phyllite and quartzite interbedded. Slaty, phyllitic, schistose, gneissose and granoblastic texture are observed in the area. Mineralogical and textural features indicate that all metamorphic rocks had undergone regional and contact metamorphisms. In general, the grade of metamorphism increases from east to west. On the basis of the mineral assemblages, the metamorphic rocks are greenschist facies, amphibolite facies and hornblende hornfels facies. The relative age of metamorphic rocks was probably Post Carboniferous.

Keywords: regional and contact metamorphism, greenschist facies, amphibolite facies, hornblende hornfels facies and Post Carboniferous

Introduction

Location and Size

The study area situated Chaungzon area, Chaungzon Township, Mon State. It is bounded by Latitude 16 ˚ 17′ 00″ – 16˚ 23′ 30″ N and Longitude 97 ˚ 30′ 00″ – 97 ˚ 34′ 00″ E, and vertical grid 08 to 16 and horizontal grid 74 to 96 in one-inch topographic map index of 94 H/11 (Figure 1). This area is about 10.4 km long in north-south direction and 6.4 km wide in east-west direction. It covers about 66.56 km^2.

Methods of Study

Rock samples from each rock unit were collected at all locations where the lithology of rock units changed. Under the microscope, 50 thin sections of different rock units were examined to interpret petrography and petrogenesis of rock units.

Purposes of study

The purposes of this study area are as follows:

1. To describe detailed geological map of the area
2. To study the petrography of the rock units
3. To interpret types of metamorphism and petrogenesis of rock units

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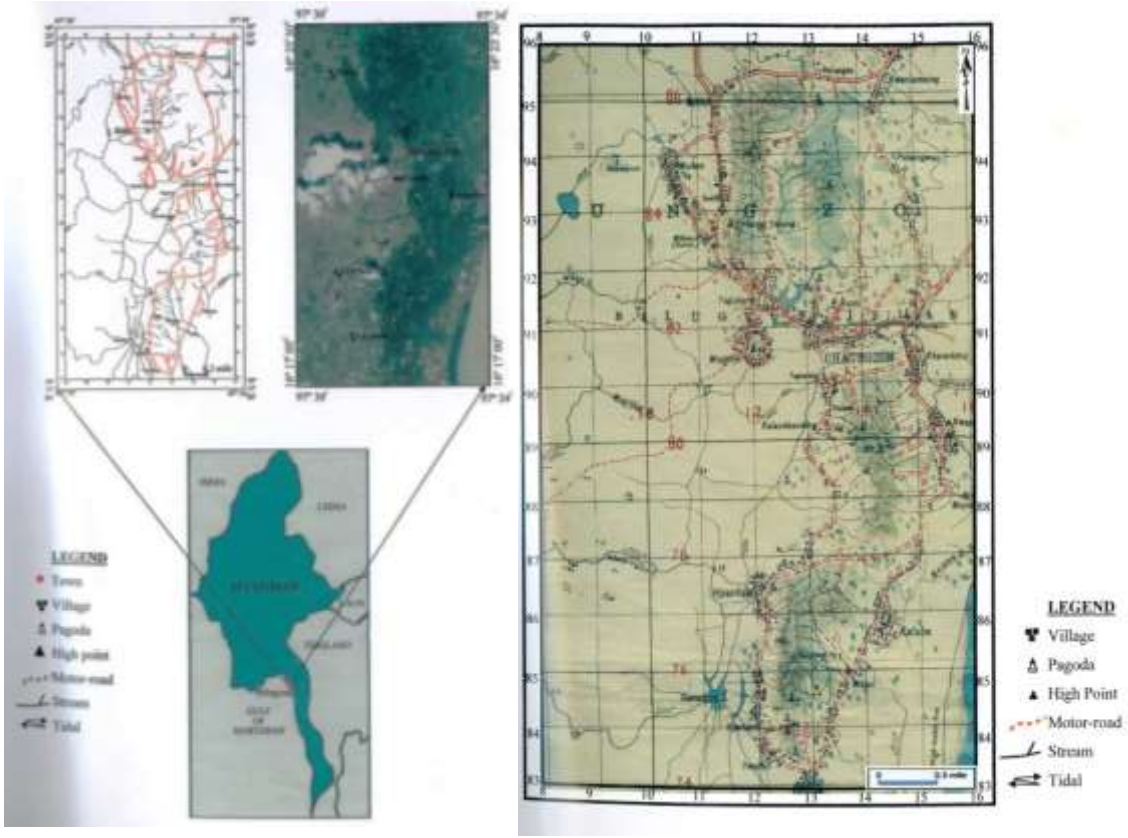


Figure 1 Location and Topographic maps of the study area

Rock Sequence

The rock sequence of the area has six major metamorphic rocks, (Table 1). Most of the rock units exposed along the stream sections, ranges, at the hills and foot-paths. These rocks are mapped in the geological map (Figure 2).

Table (1) Rock sequence of the study area

Alluvium -Holocene	
Laterite and lateritic soil	-Pleistocene
Metamorphic Rocks	
(6) Slate, phyllite and quartzite interbedded	Probably Silurian to Carboniferous
(5) Micaceous quartzite and quartzite	
(4) Banded quartzite and mica schist	
(3) Quartz-sericite schist and quartzite	
(2) Graphite-sillimanite-mica schist and calc-silicate rock	
(1) Garnet-biotite gneiss	

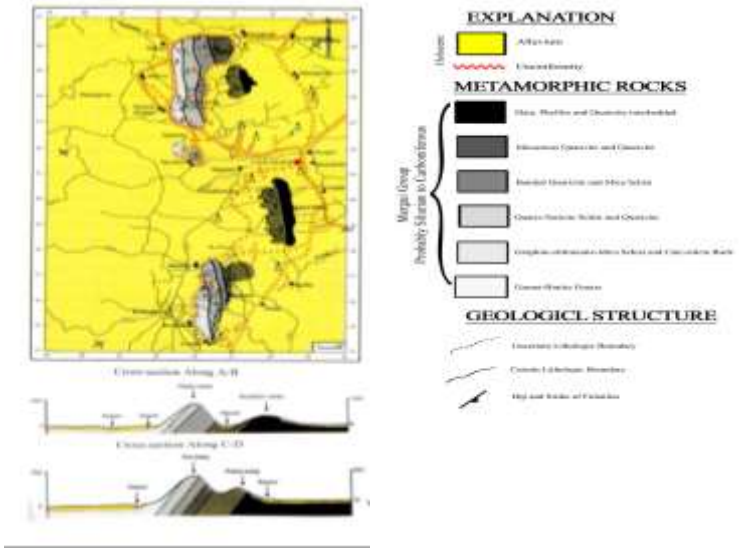


Figure 2 Geological map of the study area

Petrography of Metamorphic rocks

The area is mainly composed of metamorphic rocks. Metamorphic rocks are divided into six units. The classification is mainly based on textural structural criteria and laboratory work including petrographic analysis for precise determination of mineral assemblages.

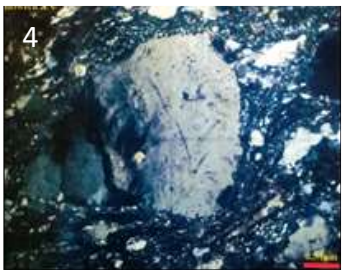
(1) Garnet-biotite gneiss

Megascopic Nature

Garnet-biotite gneiss exposed at the western part of Nat taung, especially Kadon village (Loc. 116764) (Figure 3). This rock is well foliated, hard and compact. It shows medium to coarse-grained and gneissose texture. Both banded and augen textures are observed in the outcrop.

Microscopic Nature

These rocks show gneissose, banded texture under the microscope. It is mainly composed of quartz, orthoclase, biotite and minute flakes of muscovite and almandine. Orthoclase is subhedral form. Inclusions of small quartz, biotite and apatite are present in orthoclase (Figure 4). String perthites are found in this rock (Figure 5). Microcline occurs as porphyroblasts which are cloudy and grey in color (Figure 6) and almandine garnet (Figure 7 and 8).



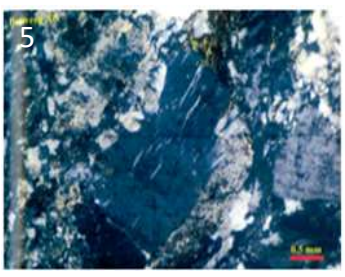
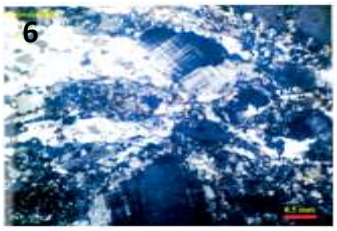
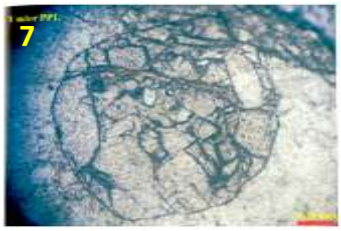


Figure 3 West dipping outcrop nature of garnet-biotite gneiss at the gneiss quarry in Kadon village (Loc. 116764)

Figure 4 Inclusions of small quartz, biotite and apatite in orthoclase of garnet-biotite gneiss (Loc. 116764, between X.N)

Figure 5 String perthite in garnet-biotitegneiss (Loc. 116764, between X.N)





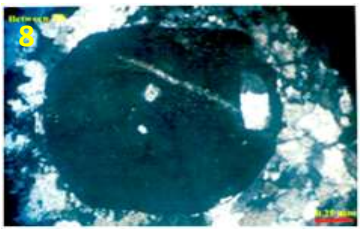


Figure 6 Microcline with cross-hatched twinning in garnet-biotite gneiss (Loc. 116764, between X.N)

Figure 7 Subhedral almandine garnet in garnet-biotite gneiss (Loc. 129753, under PPL)

Figure 8 Almandine garnet crystal in garnet-biotite gneiss (Loc. 129753, between X.N)

(2) Graphite-sillimanite-mica schist and calc-silicate rock

Megascopic Nature

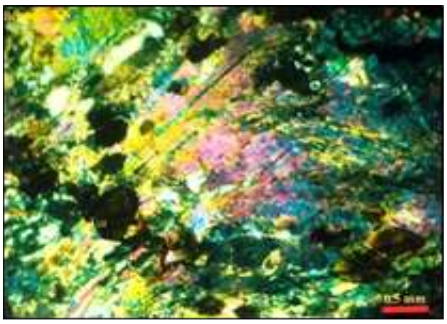
Graphite-sillimanite-mica schist occurred along the Nat taung and Gin Eit Monastery (Loc. 124749) (Figure 9). Calc-silicate rock exposed at the stream sections of Nat taung (Loc. 125761). Ridges and furrows are occurred in this rock (Figure 10).

Figure 9 Outcrop nature of graphite-sillimanite-mica schist, Gin Eit Monastery (Loc. 124749)

Figure 10 Ridge and furrow features of calc-silicate rock along the stream sections near the Nat taung (Loc. 125761)

Microscopic Nature

Graphite-sillimanite-mica schist is medium to coarse-grained and schistose texture. The chief minerals are biotite, muscovite, graphite, sillimanite and tourmaline. Mica appears as elongated alignment of flaky minerals (Figure 11). Sillimanites are found as pale yellow color, acicular form and fibrous form. Calc-silicate rock shows medium-grained, granoblastic texture. Diopsite and tremolite minerals occur as in this rock (Figure 12). Basal section of diopside show distinct pyroxene cleavage under the microscope.



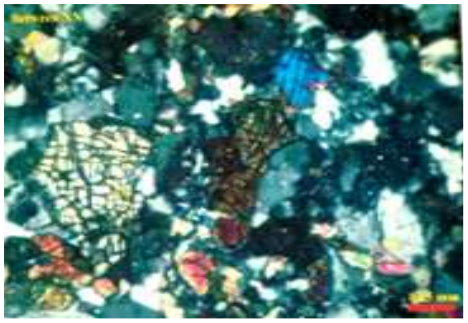


Figure 11 Muscovite (Mus), tourmaline (Tur) and accicular sillimanite (Sil) in graphite-sillimanite-mica schist (Loc. 124749, between X.N)

Figure 12 Anhedral basal section of diopside (Di) and subhedral tremolite (Tr) in calc-silicate rock (Loc. 125761, between X.N)

(3) Quartz-sericite schist and quartzite

Megascopic Nature

The exposures of quartz-sericite schist are found near the Paingkada village (Loc. 121863), Thetke taung (Loc. 116835) and at the middle part of Nat taung (Loc. 126760) (Figure 13). Light grey color on fresh surfaces and yellowish color on weathered surfaces. Quartzite is alternately occurred within quartz-sericite schist. It is found as massive exposures but in some places it occurs as thick bedded and highly jointed nature (Loc. 125761). It is whitish grey color on fresh surfaces and grey color on weathered surfaces (Figure 14).

Microscopic Nature

Quartz-sericite schist is mainly composed of quartz, sericite and mica under the microscope. Some muscovite flakes and sericite streaks are showing parallel alignment along the foliation planes. Some muscovite is altered to sericite (Figure 15). Quartzite is fine to medium-grained and mainly composed of granular quartz grains. Quartz shows anhedral grains, flattened grain boundaries and suture contact. Muscovite patches are observed between the quartz grains. Crystal aggregates of zircon are found in this unit (Figure 16).

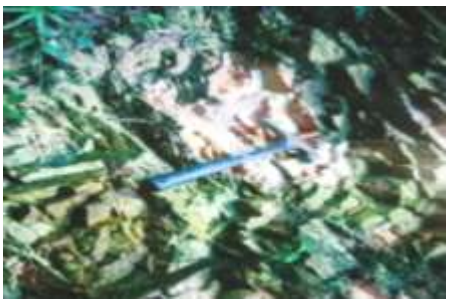
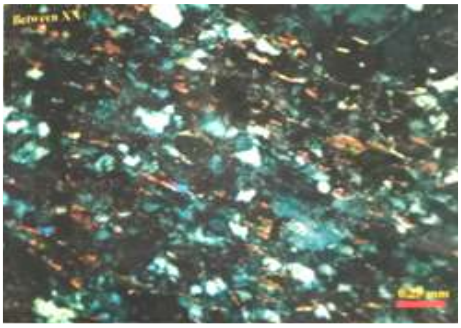


Figure 13 Highly weathered and moderately jointed outcrop nature of quartz-sericite schist of at the middle part of Nat taung (Loc. 126760)

Figure 14 Highly jointed outcrop nature of quartzite at the middle part of Nat tuang (Loc. 125761)



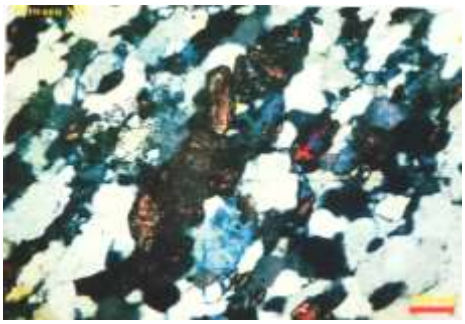


Figure 15 Parallel alignments of sericite and muscovite in quartz-sericite schist (Loc. 126760, between X.N)

Figure 16 Zircon crystal (Zrn) aggregates in quartzite (Loc. 125761, between X.N)

(4) Banded quartzite and mica schist

Megascopic Nature

Banded quartzite exposed at the eastern part of Nattaung (Loc. 128757). It shows light grey color on fresh surfaces and grey color to weathered surfaces. It is fine to medium-grained, hard and compact with distinct banding character. The characteristic features of banding are well developed. Sometimes quartzofeldspathic veins are intruded in this banded quartzite (Figure 17). Mica-schist is found along the Nattaung range (Loc. 129768). Quartz veins are found in this unit. It is medium-grained and schistose texture. Light grey color on fresh surfaces and yellowish to grey color on weathered surfaces **(**figure 18).

Microscopic Nature

Banded quartzite is fine to medium-grained and mainly composed of quartz 95% and other accessories about 5%. It shows granoblastic texture and slightly foliated texture due to the elongation of quartz grains which show wavy extinction (Figure 19).

Under the microscopic, mica schist is mainly composed of quartz, feldspar, biotite, muscovite and sericite minerals. Quartz grains are elongated and parallel alignments which showed ribbon-shaped. Biotite appears as parallel orientation and lies along the foliation (Figure 20).

Figure 17 Quartzofeldspathic vein intruded in banded quartzite at the eastern part of Nat taung (Loc. 128757)

Figure 18 Quartz vein intruded into the foliation planes of mica schist, C_1t^4 unit along the Nat taung range (Loc. 129768)

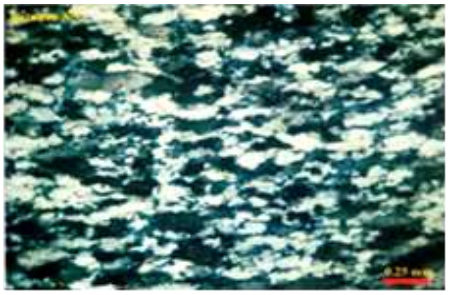
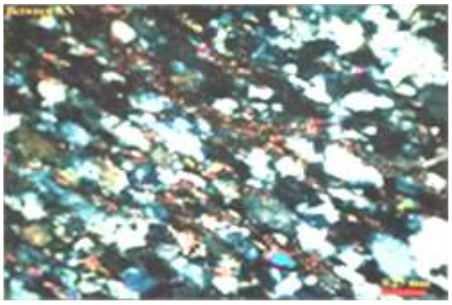



Figure 19 Slightly foliated texture due to the elongation of quartz grains in banded quartzite (Loc. 128757, between X.N)

Figure 20 Parallel orientation of flattened mica flakes in schist (Loc. 129768 between X.N)

(5) Micaceous quartzite and quartzite

Megascopic Nature

Exposures of micaceous quartzite occur at the middle part of Kyaikkwe taung Pagoda (Loc. 141794) and its vicinity. It is mainly composed of quartz. The outcrop natures are brecciated and highly jointed (Figure 21). It also shows faintly foliation. Quartzite can be seen at the slope of Kyaikke taung (Loc. 143794). It is more hard and compact than micaceous quartzite. Brownish grey on weathered surfaces and light grey on fresh surfaces can be seen. It is mainly composed of quartz (Figure 22).

Microscopic Nature

Micaceous quartzite shows fine to medium-grained, granoblastic texture. It contains quartz and minor biotite, muscovite and chlorite. Quartz occurs as subhedral, granular and some are elongated crystals. They are sub-parallel to each other in orientation. Flatten and elongated quartz crystals exhibit foliation (Figure 23). Most of the quartz showing undulatory extinction indicates that it had structural strain effect. Quartzite is fine to medium-grained and mainly composed of granoblastic quartz grains. Quartz occurs as anhedral grains interlocking and also shows suture contact. Some quartz crystal show wavy extinction. Small amount of plagioclase and muscovite, epidote and sericite patches are observed between quartz grains (Figure 24).


Figure 21 Highly weathered and faintly foliated outcrop nature of micaceous quartzite at the middle part of Kyaikkwe taung Pagoda (Loc. 141794)

Figure 22 Outcrop of quartzite at the slope of the Kyaikkaw taung (Loc. 143794)

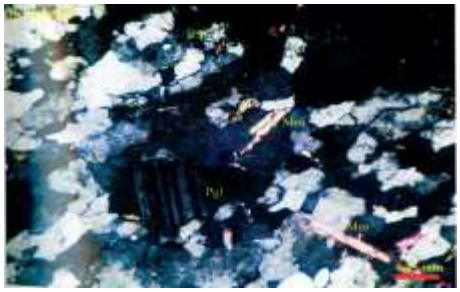



Figure 23 Sub-parallel oritneation of stretched and flattened quartz grain boundaries in micaceous guartzite (Loc. 141794 between X.N)

Figure 24 Plagioclase (Pgl), muscovite (Mus) and epidote (Ep) in quartzite (Loc. 143794, between X.N)

(6) Slate, phyllite and quartzite interbedded

Megascopic Nature

Exposure of slate can be seen at the eastern part of Kyaikkwe taung (Loc. 143796). Slate is fine-grained, dark grey color on fresh surfaces and brownish grey color on weathered surfaces. It is an indurated and argillaceous rock. It is highly weathered and moderately jointed. Carbonaceous minerals also contain in this slate. It is fairly hard and smooth and compact (Figure 25). Phyllite occurred at the Mayan Monastery near the Kyaikkwe taung (Loc. 145790). Phyllite is a fine-grained rock. The phyllitic texture and sheen is well observed on the surface. Some phyllites are more compact and indistinct foliation (Figure 26). It is brownish grey color on fresh surfaces and yellowish grey color on weathered surfaces. Exposure of quartzite can be seen along the eastern part of Kyaikkwe taung (Loc. 140785). The weathered surface color is buff to grey and light grey on the fresh surface (Figure 27).



Figure 25 Exposure nature of slate at the earstern part of Kyaikkwe taung (Loc. 143796)

Figure 26 Outcrop nature of phyllite at the Mayan Monastery near the Kyaikkwe taung (Loc. 145790)

Figure 27 Outcrop nature of quartzite along the eastern part of Kyaikkwe taung (Loc. 140785)

Microscopic Nature

Under polarizing microscopic, the slate always shows the parallel orientation of both mica and quartz mineral (Figure 28). The major mineral assemblages observed quartz (while patches), biotite (dark brown patches), and muscovite (milky gray patches) with occasional chlorite. The accessory constituents are iron ore and other opaque mineral. Phyllite shows fine-grained phyllitic texture with parallel orientation of mica flakes and quart grains as shown (Figure 29). It is mainly composed of quartz, biotite, muscovite and chlorite. Minor constituents are opaque minerals. Muscovite occurs as scaly aggregated crystals. Elongated quartz grains sandwiched between mica

bands and quartz showed wavy extension. Microscopic nature of quartzite shows fine to medium-grained, granoblastic texture. Quartz shows wavy extinction and little amount of feldspar is present. Alternate banding of fine-grained and coarse-grained quartz crystals can be seen (Figure 30).

Figure 28 Parallel orientation of quartz and mica flasks in slate (Loc. 143796, between X.N)

Figure 29 Elongated quartz grains sandwiched between mica bands in phyllite (Loc. 145790, between X.N)

Figure 30 Wavy extinction and suture contact of quartz grains in quartzite (Loc. 140785, between X.N)

Types of Metamorphism

In general, grade of metamorphism increases gradually from east to west. Slate, phyllite, quartzite, schist, graphite-sillimanite-mica schist, garnet-biotite gneiss and quartzite are the product of regional metamorphism. Some graphite-sillimanite-mica schist suffered local contact metamorphism.

Metamorphic Facies

The metamorphic facies classification, nomenclature and defining mineral assemblages used in this study are mainly based on Winter (2010). Based on the mineral asssemblages, the metamorphic rocks of the study area were formed under the greenschist facies, amphibolite facies to hornblende hornfels facies. The mineral assemblages are graphically represented by ACF and AKF diagrams (Figure 31-a, b, c, d).

Table 2 Mineral assemblages of greenschist facies

1.Greenschist facies	
Mineral assemblages	**Pelitic and Psammatic rocks**
1.Quartz+muscovite+biotite+chlorite	Slate, Phyllite
2.Quartz+plagioclase+sericite+epidote	Quartzite
3. Quartz+muscovite+biotite+chlorite	Banded quaratzite
4.Quartz+orthoclase+biotite+epidote	Micaceous quartzite

Table 3 Mineral assemblages of amphibolite facies

2.Amphibolite facies	
Mineral assemblages	**Pelitic and Psammatic rocks**
1. Quartz+muscovite+biotite+sercite+ orthoclase	Quartz-sericite schist
2. Muscovite+biotite+tourmaline+plagioclase +quartz+almandine garnet	Mica schist
3. Biotite+muscovite+microcline+orthoclase +quartz	Garnet-biotite gneiss
4. Orthoclase+plagioclase+biotite+ quartz+almandine garnet	Garnet-biotite gneiss
5 .Biotite+muscovite+sillimanite+ tourmaline+ quartz	Graphite-sillimanite-mica schist
6. Muscovite+quartz+orthoclase+graphite +tourmaline	Graphite-sillimanite-mica schist
	Calcareous rocks
7. Quartz+tremolite+diopside+muscovite	Calc-sillicate rocks
8. Quartz+diopside+plagioclase+calcite	Calc-sillicate rocks

Table 4 Mineral assemblages of hornblende hornfels facies

Hornblende hornfels facies	
Mineral assemblages	**Pelitic rock**
1. Muscovite+sillimanite+graphite+orthoclase +almandine garnet+ tourmaline	Graphite-sillimanite-mica schist
2. Quartz+muscovite+almandine garnet +orthoclase	Graphite-sillimanite-mica schist

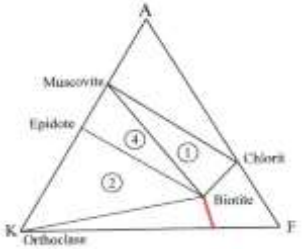


Figure (31-a) AKF diagram showing the mineral assemblages of greenschist facies

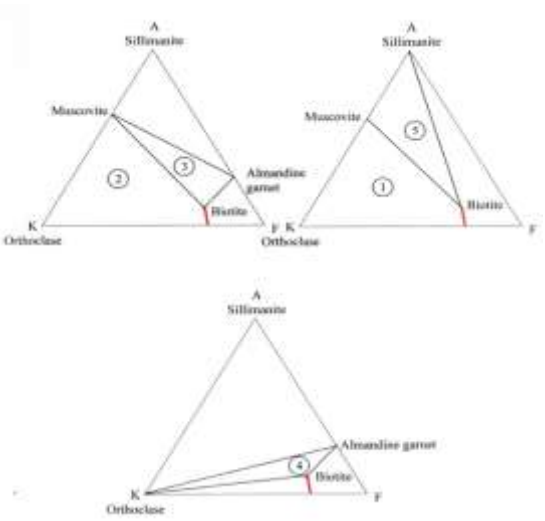


Figure (31-b) AFK diagrams showing the mineral assemblages of amphibolite facies.

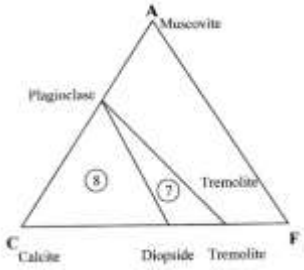


Figure (31-c) ACF diagram showing the mineral assemblages of amphibolite facies

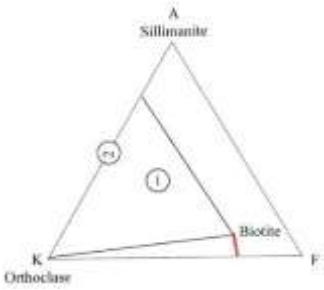


Figure (31-d) AKF diagram showing the mineral assemblages of hornblende hornfels facies

Estimation of P-T condition

According to (Winter, 2010), the estimate P-T condition of metamorphism in the area may be between 250˚C to 680˚C and pressure about 2 kb to 5 kb. The probable P-T condition of metamorphic rocks (figure 32).

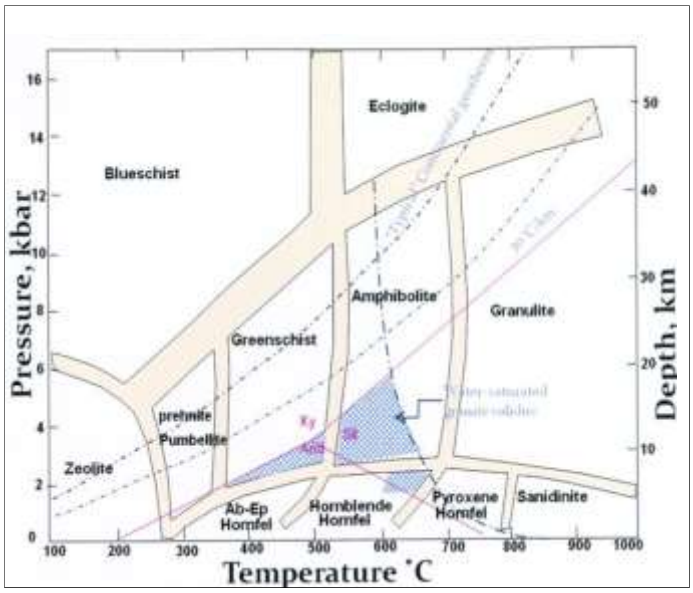


Figure 32 P-T range of greenschist facies, amphibolite facies and hornblende hornfels facies (after Winter, 2010)

Time of metamorphism

Mergui Group, Taungnyo Formation and Martaban beds are in the same composite seires, which is assigned Silurian to Carboniferous based on the fossil evidence. Moulmein Limestone

(Premian age) overlying unconformably Taungnyo Formation was not metamorphosed. As mentioned earlier, the metamorphic rocks of this area most probably belong to the Mergui Series. Thus the main phase of regional metamorphism in the area was probably Post Carboniferous.

Conclusion

The research area is situated in Chaungzon Township, Mon State and covers about 66.56 km^2. The metamorphic rocks are gneiss, schist, calc-silicate rock, quartzite, phyllite and slate in the area. The area has been subjected to regional metamorphism. The grade of metamorphism increases from east to west. Regional metamorphism is most widespread in garnet-biotite gneiss, mica schist, calc-silicate rock, quartz-sericite schist, quartzite, phyllite and slate. According to the mineral assemblages, greenschist facies and amphibolite facies are noted in the area. Overprinting of contact metamorphism also took place. The effect of contact metamorphism is found in graphite-sillimanite mica schist where minerals belonging to hornblende hornfels facies. The estimate of P-T condition of metamorphism may be between 250˚C to 680˚C and pressure about 2kb to 5kb.The rocks of this area most probably belong to the Mergui Group. Thus, the main phase of regional metamorphism in the area was probably Post Carboniferous.

Acknowledgement

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