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PETROGRAPHY AND PETROGENESIS OF METAMORPHIC ROCKS EXPOSED AT MOGAUNGGYI AREA, SINGU TOWNSHIP, MANDALAY REGION

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Abstract

The Mogaunggyi area is situated in Singu Township, Mandalay Region and forms the southern continuation of highly deformed Mogok Metamorphic Belt. Based on the petrological, mineralogical and field criteria, metamorphic rocks in the study area comprise metapelites (garnet - biotite gneiss), metacarbonate (varieties of marbles and calc-silicates) and skarn. There are two main types of metamorphism affecting in this area; regional metamorphism and contact metamorphism. The metamorphic mineral such as sillimanite, garnet, diopside and forsterite, phlogopite and spinel are the evidence of regional metamorphism and belongs to the almandine-amphibolite facies with 0.4-0.8GPa and 550°C to 750°C estimated pressure and temperature respectively. The regional metamorphism was later superimposed by contact metamorphism by the intrusions of granite, biotitemicrogranite and pegmatite. Hence, the skarn rocks occurred at the marginal part. They belong to the pyroxene-hornfelsfacies and estimated pressure and temperature are between 0.1-0.2GPa and 600°C - 700°C respectively. The protolith age of the metamorphic rocks in the study area may range from Precambrian to Late Paleozoic, and the time of metamorphism of the study area is suggested to be from Oligocene to Middle Miocene.

***Keywords*;** Mogok Metamorphic Belt, metapelite, metacarbonate, skarn, facies, protolith

Introduction

The Mogaunggyi area lies in Singu Township, Mandalay Region, approximately 68 km to the north of Mandalay. It falls in one inch topographic map no. 93 B/2 and B/3.The location map of the study area is shown in Figure (1).

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Purposes of study

This research will contribute the petrological characteristics, types of metamorphism, metamorphic facies and probable P-T condition, and age of metamorphic rock in the study area.

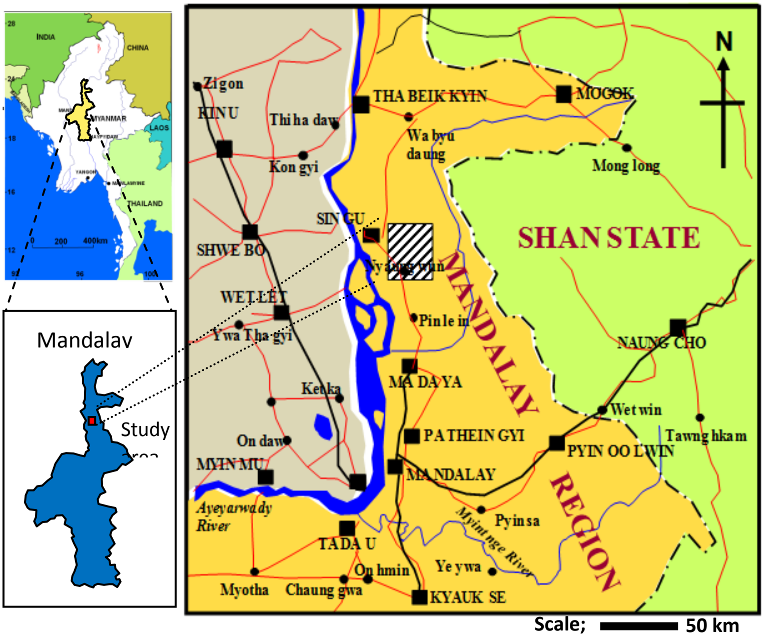


Figure 1: Location Map of the Study Area.

Methods of study

Before the field study, previous works, satellite images, and aerial photos were studied. Fieldstudy includes the systematic sampling of various metamorphic rocksand minerals to investigate the petrological characteristics and metamorphic grades.The nature of lithologic contacts, dips and strikes, foliations, joints, folds and faults were studied and measured systematically by using compass and GPS.

Detailed petrographic studies were made by using a standard binocular polarizing microscope. Type and grade of metamorphism were determined on the basis of the field studies and microscopic studies. Metamorphic facies diagrams were constructed on the basis of the characteristic mineral assemblages.

Regional Geology

Mogaunggyi area is a segment of the Mogok Metamorphic Belt and it is a southern continuation of the Himalayan Orogenic Belt and extends from north of Putao through Mogok towards Martaban in the south (Searle and Haq, 1964). The study area is situated between the Shan Plateau in the east and Central Low Land in the west and also located in the Central Granitoid Belt.Lithologically, the present investigated area is essentially made up of igneous rocks and metamorphic rocks that formed at different geological episode. Metamorphic rocks comprise metapelites (garnet-biotitegneiss), metacarbonate (various kinds of marble units andcalc-silicate rocks) and skarn rocks. Igneous rocks are biotitemicrogranite, tourmaline granite, leucogranite and pegmatite.

Regionally, the Mogok Metamorphic Belt is bounded as well as overthrusted by the Chaungmagyi Group in the east.Sagaingfault, 700 km long N-S aligned right lateral strike-slip fault that connects south to the active spreading centers in the Andaman Sea in the west. Eruptions of basaltic lava occurred around the Singu area.The regional geologic setting of the study area is shown in Figure (2).

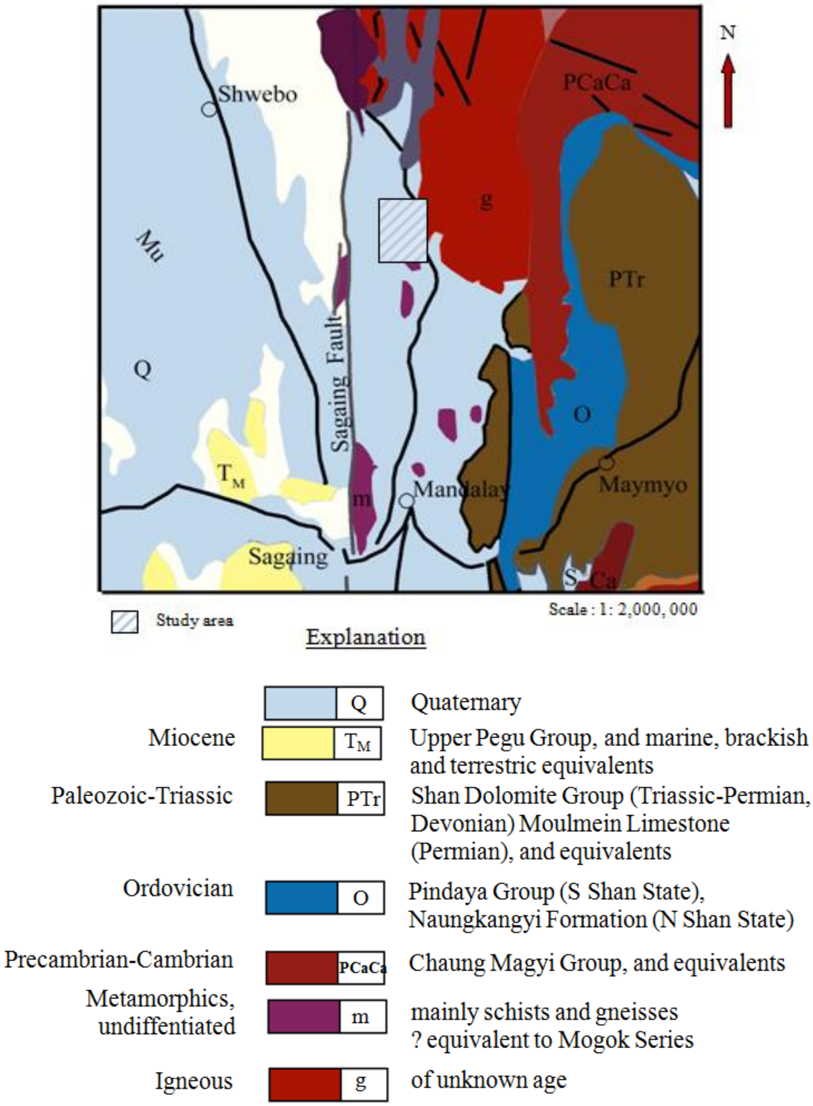


Figure 2: Regional geologic setting of the study area

Petrography

Gneiss

This unit is well exposed at the eastern part and can be subdivided into three types, viz:garnet-biotite gneiss (Figure 3A), banded biotite gneissand minor sillimanite-biotite gneiss.These rocks are well foliated, moderately banded and frequently contorted. It is the basement unit of the area.Microscopically, it is medium to coarse–grained, gneissose texture and mainly composed of orthoclase, quartz, plagioclase and biotite. Almandine occurs as important accessory mineral (Figure 4A). The minor accessory minerals are sphene and iron ores. Sillimanite occurs as tiny or minute fibres (Figure 4B).

DiopsideCalc-Silicate Rocks

Calc–silicate rock unit overlies the gneiss unit and underlies the marble unit. It is intruded by biotitemicrogranite. Differential weathering features (ridge and furrow structures) (Figure 3B), concentric folds, drag folds and boudinage have been noted in this unit. Alternating bands of dark color diopside and light color mineral such as quartz and feldspar are distinguishing feature of this unit due to metamorphic differentiation. Microscopically, it shows medium to coarse-grained, granoblastic texture and mainly composed of diopside, calcite, quartz, feldspar and other accessories. Sphene, apatite and graphite occur as minor accessory minerals.

Marble

Marble in this area has diverse mineralogy. Depending on the mineral assemblages, this unit can be subdivided into four subunits; (1) White marble, (2) Diopside marble (Figure 3C), (3) Graphite-phlogopite marble, and (4) Spinel bearing marble (Figure 3D). These are well exposed at western part of the study area. The grain size varies from medium to coarse-grained and contains diopside, spinel, phlogopite (Figure 3E), forsterite and chondrodite. Someoutcrops show hard, compact, massive nature and milky white in color.

Microscopically, it shows medium to coarse–grained, idioblastic texture. Disseminated graphite, scapolite and phlogopite can be observed in the calcite matrix.Diopside occurs as separate grains and as aggregate of small crystals (Figure 4C).

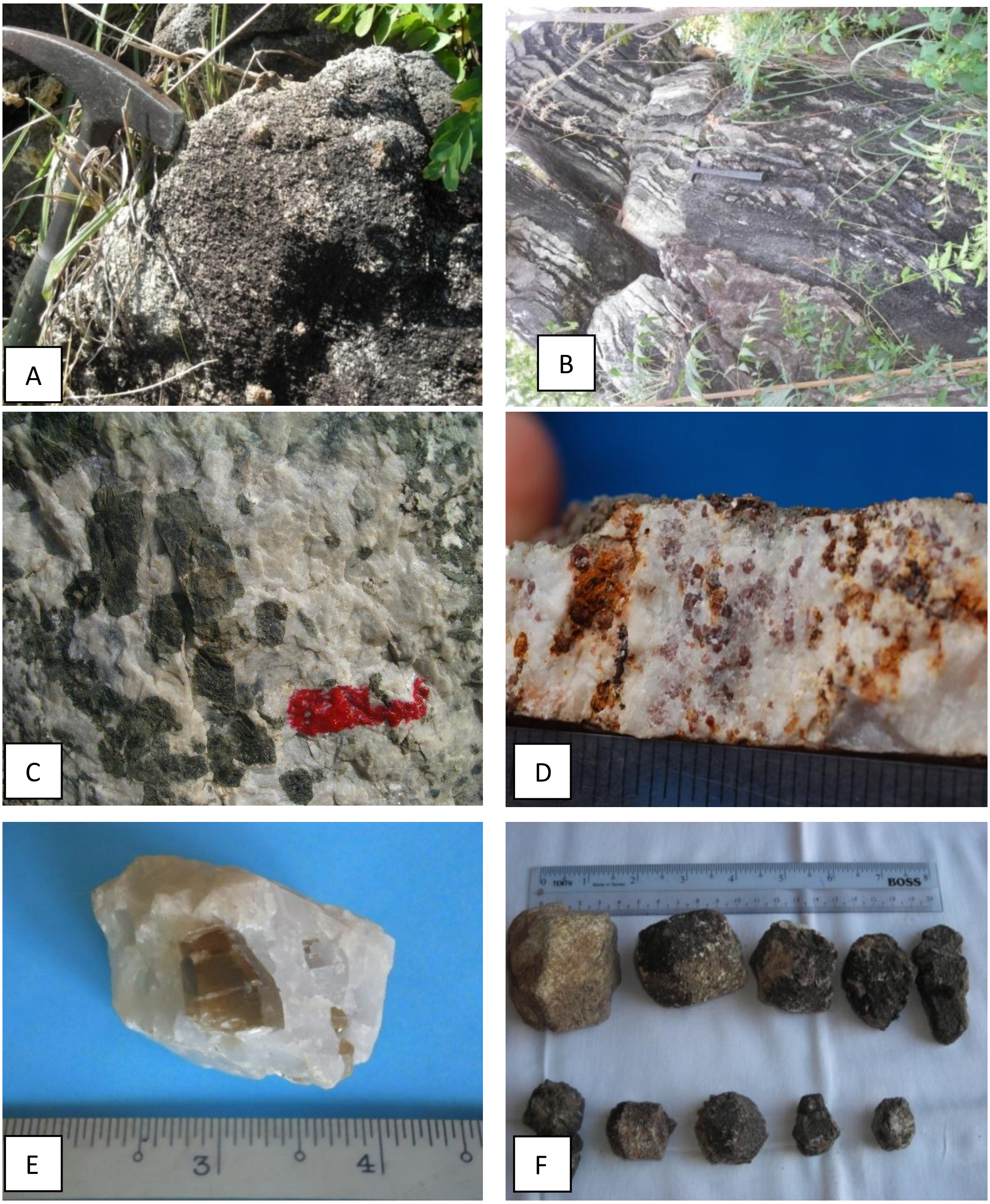


Figure 3: A. Garnet porphyroblasts in garnet-biotite gneiss B.Diopsidecalc-silicate unit is marked by banded nature as a result of compositional layering C. Diopside minerals aggregateson the fresh surface of diopside marble unit D. Spinel, phlogopite, forsterite minerals embedded in spinel bearing marble E. Phlogopite mineral embedded in the marble F.Grossular garnet crystals in skarn zone

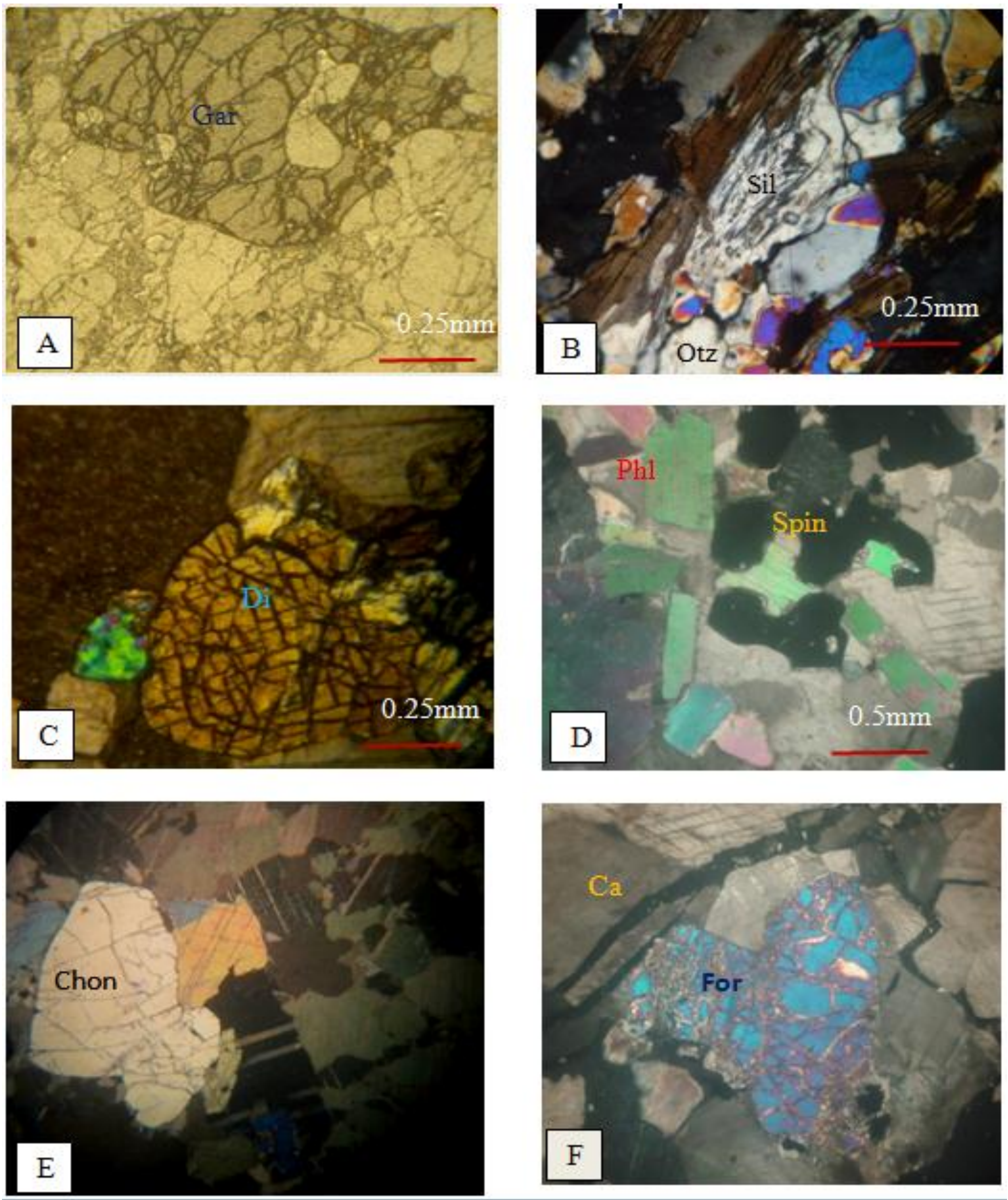


Figure 4: A. Inclusion of small quartz grains embeded in garnet crystal (Gar) resulting poikiloblastic texture, under PPLB. Small sillimanite (Sil) fibres show preferred orientation in garnet-biotitegneiss, XNC. Euhedraldiopside crystal with prominent cleavages in diopsidemarble, XN D. Mineral assemblages of spinel (Spin), phlogopite (Phl), and calcite in spinel bearing marble, XN E.Chondrodite(Chon) in spinel bearing marble, XN F.Subhedral to rounded forsterite grains with irregular fractures in spinel bearing marble, XN

Some diopside grains exhibit simple contact twin and some show polysynthetic twinning in longitudinal section. Spinels are found as octahedral idioblastic to subidioblastic crystals in the calcite matrix and irregular fractures are common (Figure 4D). The average grain size is 0.2 mm to 1.5 mm in diameter. Subhedral to rounded forsterite grains are 0.25mm to 1mm in size andirregular fractures are common. Anhedral rounded grains of chondrodite are 0.1mm to 1mm in diameterFig.4E. Partial serpentinization of forsterite is found along the cleavage plane, showing yellowish coloured serpentine and bluish green colouredforsterite (Figure 4F).

Skarn

In the study area, biotitemicrogranite bodies intrude the metacarbonate rocks. The outstanding skarn zones are (1) Diopside-tremolite bearingskarnand (2) Garnet-diopside-wollastonite bearing skarn.

This zone is essentially composed of dark green diopside, tremolite, garnet, wollastonite and calcite. Microscopically, subroundeddiopside shows colourless to pale green and partially altered to chloride.Grossular garnet occurs as subrounded grains to aggregate, pale brown in colour and commonly with irregular fractures.Radial aggregates of wollastonite show high relief and parallel extinction.

Petrogenesis

Mineral Assemblages and Metamorphic Facies

Facies classification and graphical representation used in the study area are based on Winkler (1979), Bucher & Frey (1994) and Winter (2001).

The mineral assemblages in the study area are listed in Table 1 and graphically represented by ACF and AKF diagrams in Figure (5, 6, 7 and 8). According to the petrographic studies, (23) mineral assemblages are recorded in the study area.

Table 1: Mineral Assemblages and Metamorphic facies of Mogaunggyi Area

I. Almandine – amphibolite facies

(a) Quartzofeldspathic mineral assemblages

1. Quartz + orthoclase + biotite + almandine + plagioclase
2. Quartz + orthoclase + plagioclase +biotite
3. Quartz + plagioclase + biotite + almandine + sphene
4. Orthoclase + quartz + sillimanite + plagioclase + biotite

(b) Calcareous mineral assemblages

5. Diopside + orthoclase + scapolite + plagioclase + calcite
6. Calcite + diopside + scapolite + quartz + plagioclase
7. Calcite + diopside + quartz + plagioclase + sphene
8. Calcite + diopside + quartz + orthoclase
9. Calcite + diopside + scapolite + graphite
10. Calcite + spinel + scapolite
11. Calcite + diopside + phlogopite + sphene
12. Calcite + phlogopite + graphite
13. Calcite + chondrodite + spinel
14. Calcite + diopside
15. Calcite + spinel + phlogopite
16. Calcite + phlogopite + chondrodite + spinel
17. Calcite + forsterite + chondrodite + spinel

II. Pyroxene-hornfelsfacies

(a) Skarn assemblages

18. Plagioclase + diopside + tremolite + calcite
19. Diopside + grossularite + wollastonite + quartz + calcite

20. Plagioclase + diopside + grossularite + calcite
21. Diopside + quartz + tremolite + calcite
22. Diopside + grossularite + calcite
23. Diopside + quartz + tremolite + scapolite

Types of metamorphism

The observed textural, structural, petrological and mineralogical studies indicate the present study area has subjected to two main types of metamorphism; (a) regional metamorphism and (b) contact metamorphism.

Regional Metamorphism

The indicator minerals are diopside, forsterite, phlogopite in marble and sillimanite and almandine in gneiss. Plagioclase in gneiss and calc-silicate rocks is in the range of oligoclase and andesine.

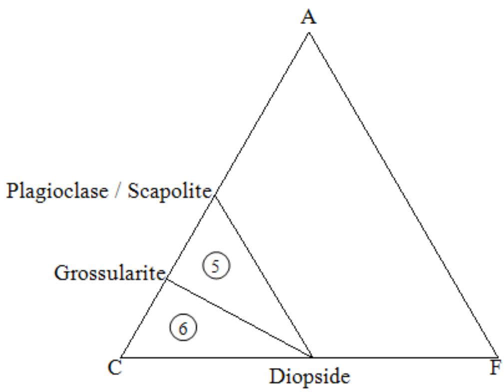
The mineral association of calcite-diopside-forsterite and calcite-diopside-phlogopite are seen in marble units. These mineral assemblages correspond to the almandine-amphibolite facies. Moreover, small amounts of sillimanite occur with orthoclase without muscovite. Hence, the mineral assemblages indicate that the study area had reached the sillimanite-almandine-orthoclase subfacies ofWinter (2001). The metamorphism took place at a temperature range between 550°C to 720°C and pressure between 0.4 to 0.8GPa.In the Mogaunggyi area, small amount of tremolite minerals occur at the northeastern part in contact with diopside marble. Diopside marble is abundant in the central part. In addition, diopside-forsterite marble is present in the southwestern part of the study area. It is inferred that the metamorphic grade in the study area increases towards the southwest.

Contact Metamorphism

The contact effects at the vicinity of granite intrusive bodies are indicative of the presence of skarn rocks. The assemblages, forsterite + spinel + phlogopite and diopside + forsterite are found in marble near the contact of biotitemicrogranite intrusive body.

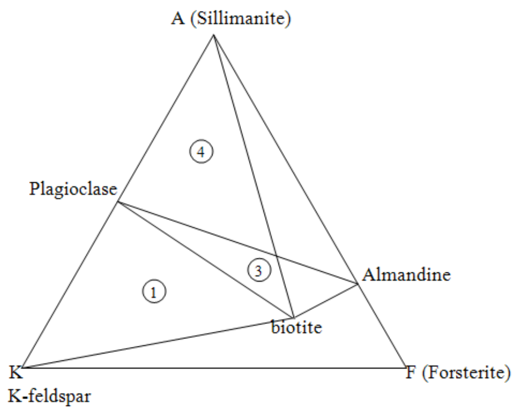
Wollastonite in the skarn rocks is associated with diopside and grossularite. The association of calcite + grossularite + diopsideskarn is also found at the vicinity of biotitemicrogranite intrusion. Forsterite commonly shows partial replacement by serpentine. The above mineral assemblages confirm that contact metamorphic grade belongs to pyroxene-hornfelsfacies. The pyroxene-hornfelsfacies is represented by the appearance of diopside with forsterite in calcareous rocks. According to this diagram, established by Winter(2001) inFig.6.The depth of metamorphism in the study area is estimated as below 2 km with the temperature of about 650°C - 700°C and pressure 0.1-0.2GPa.

A.



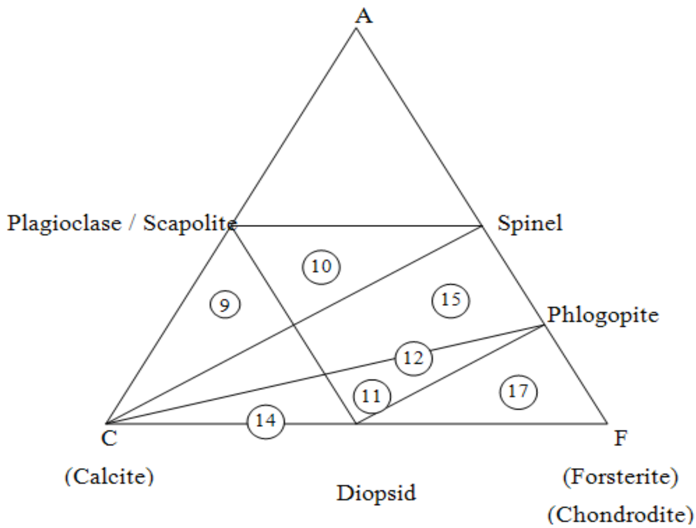
Amphibolite facies (Qtz ē)

B.



Amphibolite facies (Qtz ē)

Figure 5: ACF diagram (A), AKF diagram (B) for quartzofeldspathic and calcareous mineral assemblages of Amphibolite facies recognized in Mogaunggyi area.



Amphibolite facies (Qtzēout)

Figure 6: ACF diagram for calcareous mineral assemblages of Amphibolite faciesrecognized in Mogaunggyi area.

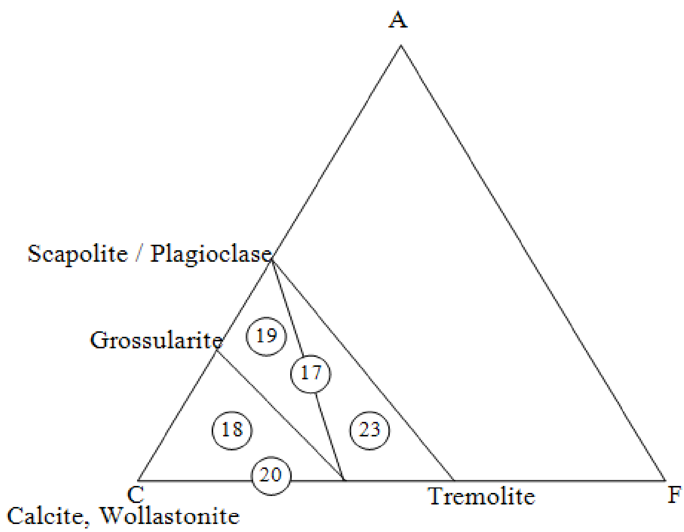


Figure 7: ACF diagram showing the mineral assemblages of Pyroxene-hornfelsfacies.

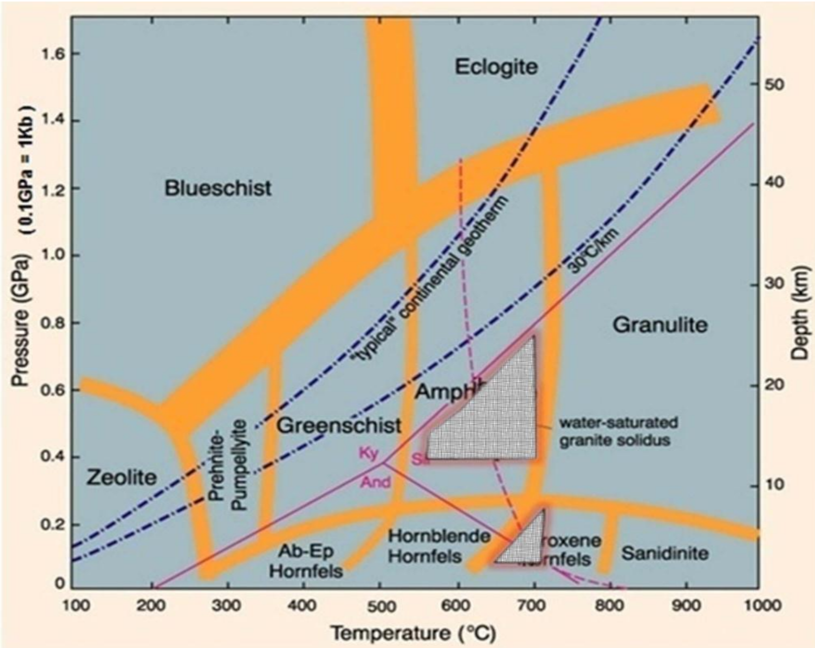


Figure 8: Temperature-Pressure diagram of the study area

(**Source:** Winter, 2001)

Time of Metamorphism

The study area is considered as the southern continuation of Mogok Metamorphic Belt and the age of metamorphic rocks in this area may be contemporaneous with the Mogok Group. Radiometric dating of a phlogopite sample from the Mogok area gives about 40 Ma. This means that the metamorphism could be the consequent event of the early Himalayas Orogeny that took place during Late Eocene (Maung Thein and Ba Than Haq, 1964).

Radiometric age determination on the MMB include an early U/Pb age on pegmatite (Searle and Ba Than Haq, 1964), K/Ar ages on augen gneiss, Rb/Srisochron ages on granite (Cobbing et al., 1992) and Ar/Ar and K/Ar ages on granitic and metamorphic rocks (Bertrand et al., 2001). All these data provide the evidence for a Lower to Middle Tertiary major thermal event.

Maung Thein (2000) suggested that the regional metamorphism of the Mogok Belt might have occurred during Late Oligocene in relation to the middle phase of Himalayan Orogeny. Win Naing (2008) proposed that the uplifting and exhumation of MMB, a consequence of India-Asia collision have taken place at Eocene to Middle Miocene.

In the study area, leucogranite sample from the Mogaunggyi area was analyzed by U-Pb zircon dating method. The age of 26.14 ± 0.37 Ma (Late Oligocene), this may interpret the crystallization age of leucogranite. In addition, sample of biotitemicrogranite from the study area were radiometrically analyzed and gives the age of 17.1 ± 0.2 Ma (Middle Miocene).

Based on the above factors, the time of metamorphism of the study area is suggested to be from 26.14 to 17.1 Ma (Oligocene to Middle Miocene).

Summary and Conclusion

The study area comprise metapelites (garnet - biotite gneiss), metacarbonate (varieties of marbles and calc-silicates) and skarn. According to the field observations, petrological studies and geochronological datas, two main types of metamorphism are recognizedviz; regional and contact. The metamorphic mineral assemblages; sillimanite, garnet, diopside and forsterite belongs to the almandine-amphibolite facies with 0.4-0.8GPa and 550°C to 720°C estimated pressure and temperature respectively. Moreover, small amount of sillimanite occur with orthoclase pointed out that the study area had reached the sillimanite-almandine-orthoclase subfacies. The metamorphic grade in the study area increases towards the southwest. The regional metamorphism was later superimposed by contact metamorphism by thegranitoids intrusion. They belong to the pyroxene-hornfelsfacies and estimated pressure and temperature are between 0.1-0.2GPa and 650°C - 700°C respectively. The age of premetamorphic rocks of the study area is probably Precambrian to Late Paleozoic, and the time of metamorphism may have taken place during Oligocene to Middle Miocene.

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