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PETROLOGY AND PETROGENESIS OF METAMORPHIC ROCKS IN ZA YAT KWIN AREA, THABEIKKYIN TOWNSHIP, MANDALAY REGION

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Abstract

The study area is situated in southern part of Thabeikkyin Township, Mandalay Regions. The study area is located in UTM map No 2296 01. The study area falls within the Mogok Metamorphic Belt, mainly composed of metamorphic rocks and igneous rock. The study area comprises gneiss, marble and garnet – diopside - calc – silicate rock. In gneiss unit includes biotite - gneiss and marble units includes graphite marble, phlogopite – diopside marble and grossularite - diopside marble. Garnet – diopside - calc – silicate rock is composed of calcite, quartz, feldspar (orthoclase, plagioclase), diopside, sphene, garnet, zircon and opaque minerals. Most of the calcite twin bands are giving tapering twin and its showing first order to upper higher order. These calcite twins are gradationally change small to large twins and change the colour because of due to the effect of deformation. According to the mineral assemblages, regional metamorphism (amphibolites facies) is recognized in the study area. The grade of the metamorphism in the study area is medium to high grade metamorphism.

Keywords: Mogok Metamorphic Belt, tapering twin, amphibolites facies

Introduction

The study area is located in the eastern part of Thabeikkyin Township and the northern part of Singu Township in Mandalay Region. It is situated between latitude 22˚ 25' to 22˚ 30' and longitude 96˚ 99' to 96˚ 04' and in UTM map number 2296 01. Transport and communication to the study area is easily accessible. This area is readily accessible as the car road connecting Mandalay- Mogok and Mandalay – Thabeikkyin passes through it. Location map of the study area is shown in Figure. 1. Topographically, the eastern part of the study area is mountainous terrain and western marginal area is flat – lying topography and they are trending nearly N – S in direction. In the research area, the main stream flows from east to west. They are locally named as Kyet Saung Taung Chaung and On Zon Chaung. The drainage pattern of the study area is coarse dendritic pattern. Drainage pattern of the study area is shown in Figure. 2.

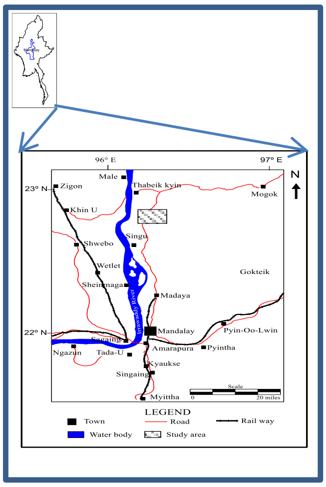

Figure 1 Location map of the study area

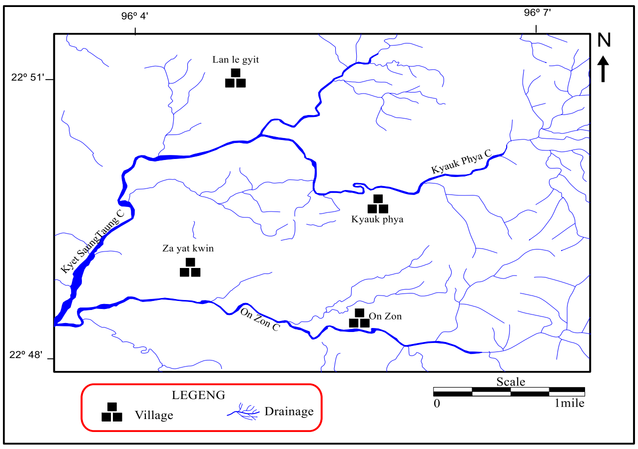

Figure 2 Drainage pattern of the study area

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Regional Geologic Setting

The present area lies in the Mogok Belt of Searle and Haq (1964), and occupies a part of the western margin of eastern highlands. The Mogok Belt is a narrow zone (about 10 – 15 miles wide) of regionally metamorphosed rocks, extending southwest from Mogok through Kyaukse to Thazi and Yamethin. The regional geologic setting of the study area is shown in Figure.3. The study area is located about 91.2 km to the SW of the well known Mogok stone track and the same structural trends passing through both areas can readily be seen on landsat images. The mineralogy and rock type of the present area are rather similar to those of the Mogok area. The western margin of the study area is the Cenozoic rocks of the Central Burma Belt separated from the rocks of the Mogok series by the well known Sagaing fault.

The outpouring of basaltic lava through this fault has resulted in the formation of the Singu lava plateau in the south – western part of near the study area. The metamorphic rocks of the area extend father north and brought in contact with the rocks of the Upper Irrawaddy Province (of Bender, 1991) along the Momeik fault. Father east beyond the study area marble, gneiss, calc – silicate and granitic igneous rocks are exposed (One million scale, Geological Map of Burma, 1977).

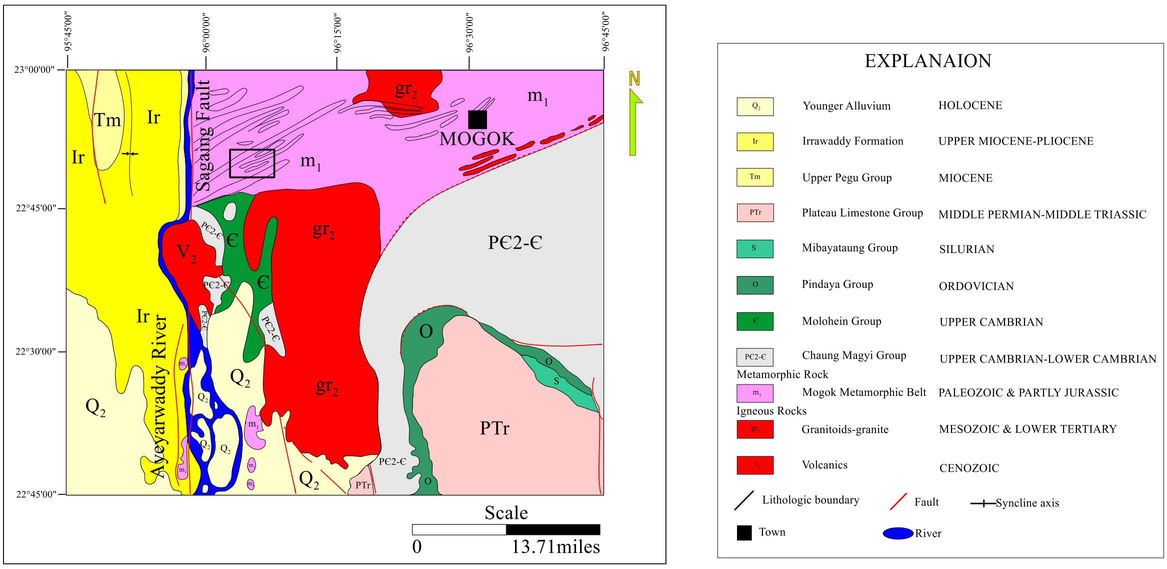


Figure 3 Regional Geological Map of the study area (from One million scale, Geological Map of Burma, 1977)

Metamorphic Rocks of the Study Area

This area is mainly composed of high – grade metamorphic rocks of the Mogok Metamorphic Belt. Exposures can be found in the Kyet Saung Taung in phlogopite - diopside marble and graphite marble. Phlogopite – diopside marble can occur in the On Zon Chaung. In the eastern part of the study area occur as grossularite - diopside marble. The biotite - gneiss unit occurs in near the Za Yat Kwin village and this unit is highly weathered. The garnet – diopside - calc - silicate rocks mostly occurs in the north eastern part of the study area and a few occurs in the Kyet Saung Taung and at the end of the Za Yat Kwin Village.

Rock Unit	Possible Age
Alluvium	Quaternary
Unconformity	~~~~~~~~~

Metamorphic rocks

Biotite - gneiss Garnet – diopside - calc - silicate rocks Graphite marble Phlogopite – diopside marble Grossularite - diopside marble	Late Paleozoic to Mesozoic

Petrography

The research area is mainly composed of the medium to high grade metamorphic rocks. Especially, types of marble, biotite - gneiss and garnet – diopside - calc – silicate rocks are well exposed in the study area.

Biotite gneiss

Megascopic studies

This unit is occur in the between Za Yat Kwin village and Kyet Saung Taung. It is highly weathered and red colour on weathered surface and grey colour on fresh surface, Figure. (4). It is medium – grained, gneissose texture and banded of felsic (quartz, feldspar) and mafic (biotite) minerals.

Microscopic studies

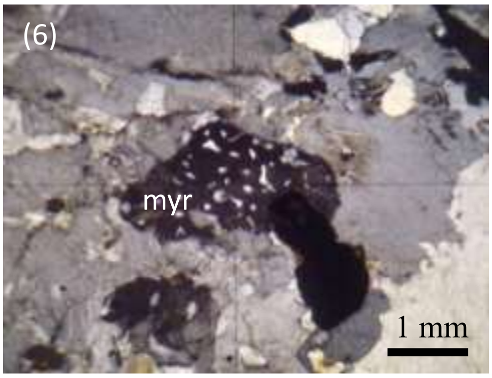
Biotite - gneiss shows medium - grained and gneissose texture, figure. (5). It is composed of the alkali feldspar, plagioclase, quartz, biotite, muscovite and apatite, sphene, zircon and opaque are accessories minerals.

Alkali feldspars are orthoclase, string perthite and myrmekite. Orthoclase occurs as subhedral form of simple twin. String perthite and myrmekite are also occurs in the biotite gneiss, figure. (6). Plagioclase feldspar is also found in this unit. Plagioclase feldspar occurs as polysynthetic twinning.

Quartz usually occurs as anhedral grains with suture boundaries and shows undulose extinction, figure. (7). Biotite is found as subhedral form. Muscovite is also occur subhedral prismatic crystals. Euhedral form of sphene and it shows very high relief. Zircon and apatite are displays subhedral to euhedral form and opaque are accessories minerals in this unit.

Figure 4 Jointed nature of biotite gneiss in near the Za Yat Kwin village (Loc; N 22˚49' 47.79", E 96˚5'11.61", Facing - 80˚)

Figure 5 Gneissose texture of the biotite - gneiss (Bet.XN, 4X)



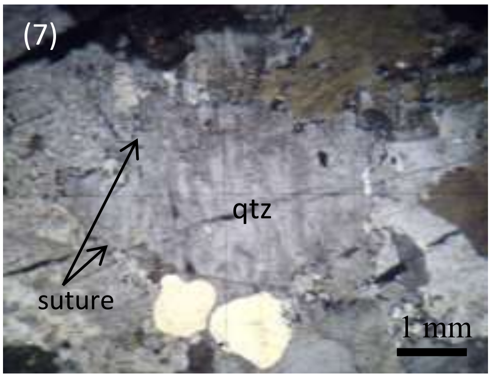


Figure 6 Myrmekite occur in the biotite – gneiss (Bet.XN, 4X)

Figure 7 Suture contacts of quartz grains in the biotite - gneiss (Bet.XN, 4X)

Garnet – diopside - calc - silicate rock

Megascopic Studies

Garnet – diopside - calc – silicate rocks is well exposed in Za Yat Kwin village and northeastern part of the study area. It is dark green colour on weathered surface and fresh surface is gray, figure. (8).

Microscopic Studies

It has coarse – grained, granoblastic texture, figure. (9). It is comprises calcite, quartz, feldspar (orthoclase and plagioclase), diopside, sphene, garnet (grossularite), zircon and opaque minerals. Calcite shows anhedral form and rhombohedral cleavages. This calcite twin bands are bent and sometimes showing tapering twins because due to the effect of strain, figure. (10, 11, 12). Quartz usually occurs as anhedral grains and undulose extinction.

Feldspars are found as orthoclase and plagioclase. Anhedral orthoclase is showing untwined nature. Plagioclase displays polysynthetic twinning. Diopside form as anhedral and short prismatic cryatal. The size of the diopside is 0.2 mm to 1.5 mm in diameter. Garnet (grossularite) occurs as anhedral grains with crack, figure. (13). Sphene display subhedral to euhedral forms. Euhedral zircon occurs in garnet – diopside - calc – silicate rock and opaque minerals are occurred in this unit.

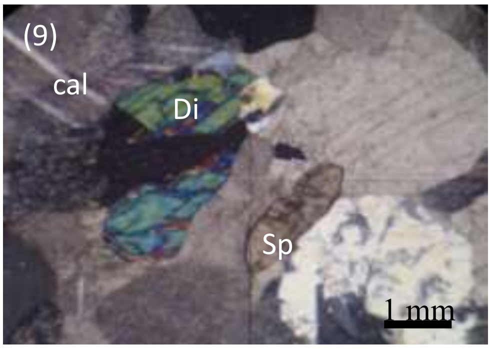
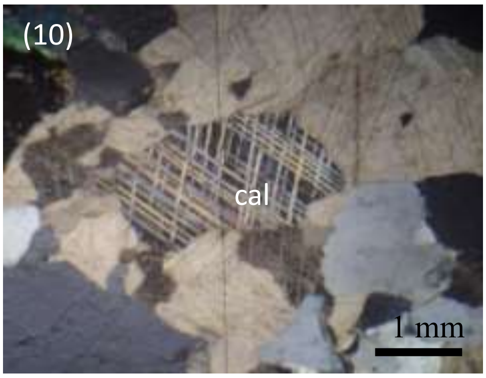


Figure 8 Drag Fold in garnet – diopside - calc – silicate rock at Za Yat Kwin village (Loc; N 22˚ 49' 38.36", E 96˚ 4' 53.29", Facing – 260˚)

Figure 9 Granoblastic texture of garnet – diopside - calc – silicate rock (Bet.XN, 4X)



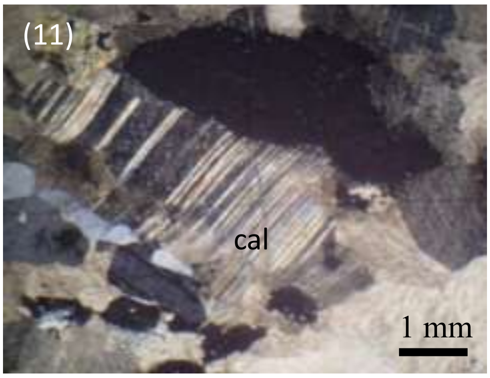
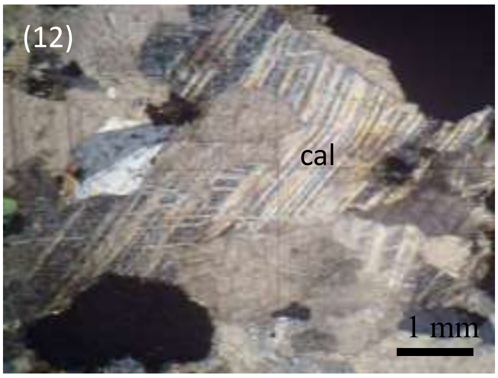


Figure 10 Thick patchy twin calcite in garnet – diopside - calc – silicate rock (Bet. XN, 4X)

Figure 11 Thick twins calcite in garnet – diopside - calc - silicate rock (Bet. XN, 4X)



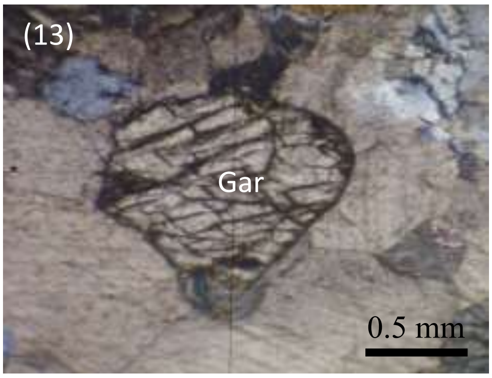


Figure 12 Curve deformation of calcite twins in garnet–diopside -calc- ilicate rock (Bet. XN, 4X)

Figure 13 Rounded garnet (grossularite) in garnet – diopside - calc - silicate rock (Bet.XN, 10X)

Graphite marble

Megascopic studies

Graphite marble occurs in the Kyet Saung Taung near the Za Yat Kwin village, figure. (14). Graphite marble is commonly grey colour on weathered surface and whitish colour on fresh surface. This unit is medium to coarse grained and it fairly hard and compact.

Microscopic studies

Graphite marble is coarse – grained and granoblastic texture, figure. (15). It is mainly composed of calcite and some graphite. Accessories minerals are diopside, apatite, zircon and opaque minerals. Calcite displays anhedral grains and distinct rhombohedral cleavages, figure. (16). Graphite occurs as dark and opaque. Diopside shows subhedral short prismatic form. Apatite is found as six – sided form, figure. (17). Euhedral zircon and opaque are occurs in graphite marble.

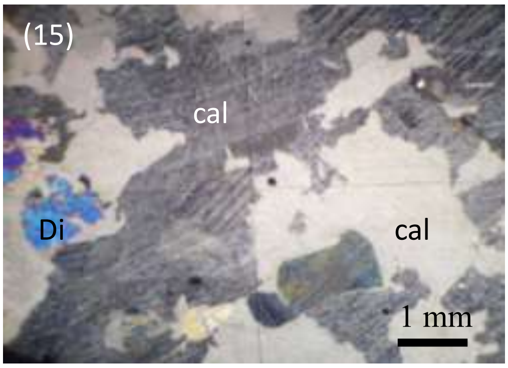
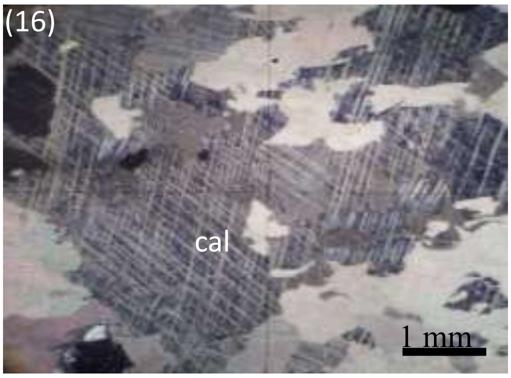


Figure 14 Exposures nature of graphite marble at Kyat Saung Taung near the Za Yat Kwin village (Loc; N 22˚ 50' 05.30", E 96˚ 4' 34.81", Facing – 300˚)
Figure 15 Granoblastic texture of graphite marble (Bet.XN, 4X)



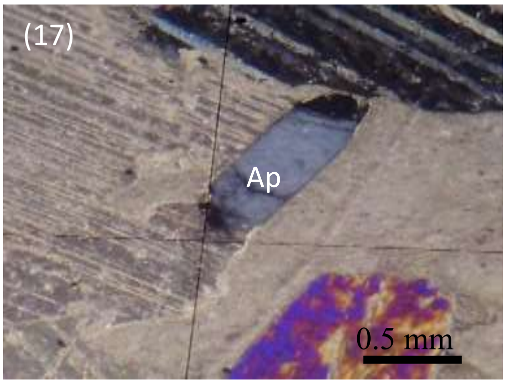


Figure 16 Thin twin rhombohedral cleavages of calcite in graphite marble (Bet.XN, 4X)

Figure 17 Subhedral to euhedral form apatite in graphite marble (Bet.XN, 10X)

Phlogopite – diopside marble

Megascopic studies

Phlogopite – diopside marble are occurs in the Kyet Saung Taung near the Za Yat Kwin village and the On Zon Chaung, figure. (18). This unit is medium to coarse – grained, massive nature. Dark green colour on weather surface and whitish colour on fresh surface.

Microscopic studies

It is coarse – grained, granoblastic texture and mainly composed of calcite, diopside, forsterite, phlogopite, quartz, garnet (grossularite) and accessory minerals are apatite, opaque, zircon, spinel and sphene. Calcite is found as coarse – grained, anhedral crystals. The size varies from 1mm to greater than 4 mm in diameter. Calcite shows rhombohedral cleavages and some calcite twin bands are bent because of deformation, figure. (19, 20, 21, 22).

Diopside shows subhedral form and it sometime distinct two sets of cleavages. Some diopside show polysynthetic twin. The size of diopside is 0.5mm to greater than 4 mm in diameter. Forsterite shows subhedral crystals, figure. (23). It is giving parallel extinction. Phlogopite shows subhedral or tabular form, figure. (24) and grain size varies from 0.5 mm to 2.5 mm in diameter. Phlogopite display one set of cleavage and parallel extinction. Garnet (grossularite) display subhedral grains with fractures and cracks.

Sphene shows spindle – shaped and subhedral form. Euhedral zircon occurs in phlogopite - diopside marble, Figure. (25). Quartz usually occurs as anhedral grains. But subhedral form of quartz can occur in this unit. It is showing wavy extinction. Subhedral form apatite and opaque are common in phlogopite - diopside marble. Spinel occurs as euhedral three to four sided and it shows isotropic between cross nicols.

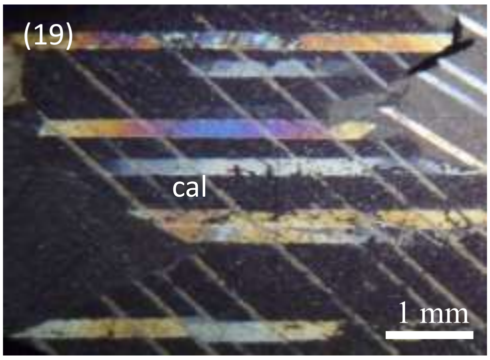
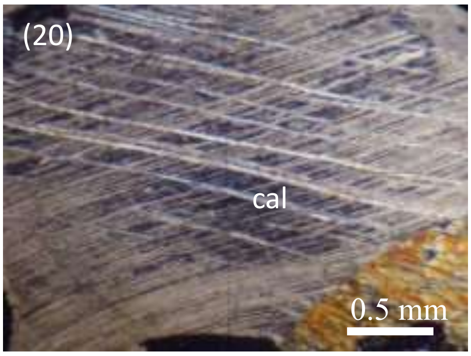


Figure 18 Good exposures of phlogopite – diopside marble at On Zon Chaung (Loc; N 22˚ 48' 44.68", E 96˚ 5' 50.21", Facing - 270˚)

Figure19 Thick twins of calcite in phlogopite – diopside marble (Bet.XN, 4X)



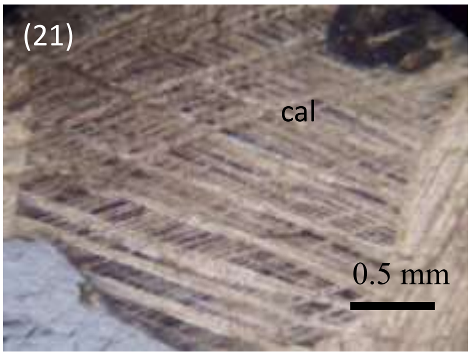
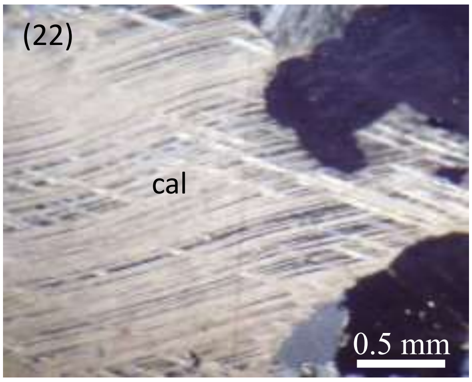


Figure 20 Thin twins and tapering of calcite in phlogopite – diopside marble (Bet.XN, 10X)

Figure 21 Thin to thick twins calcite in phlogopite – diopside marble (Bet.XN, 10X)



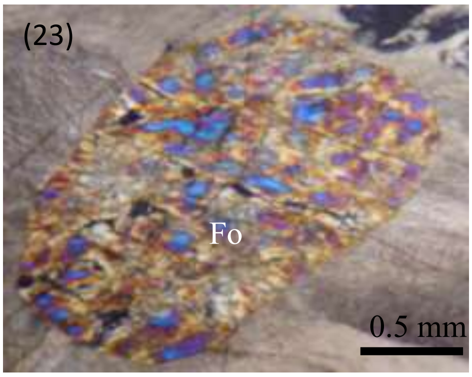


Figure 22 Curve deformation calcite twins in phlogopite – diopside marble (Bet.XN, 10X)

Figure 23 Forsterite in phlogopite - diopside marble (Bet.XN, 10X)

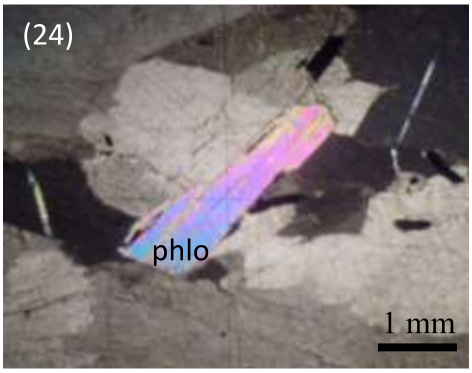


Figure 24 Sheets form of phlogopite in phlogopite – diopside marble (Bet.XN, 4X)

Figure 25 Euhedral form zircon in phlogopite – diopside marble (Bet.XN, 10X)

Grossularite - diopside marble

Megascopic studies

Near the Kyauk Phya village occurs grossularite - diopside marble figure. (26). This unit is occurs in the southeastern part of the study area near the Kyauk Phya village. It is gray colour on weather surface and whitish colour on fresh surface. Grossular - diopside marble and pure white marble are closely related.

Microscopic studies

Grossularite - diopside marble is coarse – grained, granoblastic texture. It is mainly composed of calcite, garnet (grossularite), diopside, phlogopite, forsterite, muscovite and opaque are accessories minerals.

Calcite has two sets of rhombohedral cleavages and occur tapering twin in the calcite. Most of the calcite twins bands are show first order to upper higher order. And then, most of the twin bands are strain of the deformation, figure. (27, 28). Garnet (grossularite) show subhedral to euhedral (six sided) form. All of the garnet (grossularite) minerals are show anomalous extinction because due to the deformation, figure. (29). Muscovite is occurs in the garnet diopside marble. Phlogopite show subhedral form and the size of phlogopite is 0.5 mm to 1.5 mm in diameter. Forstrtite show subhedral crystals. Forsterite is showing parallel extinction. Diopside show subhedral form and it alteration occur in the garnet diopside marble. Opaque is occurs in the accessory mineral in this unit.

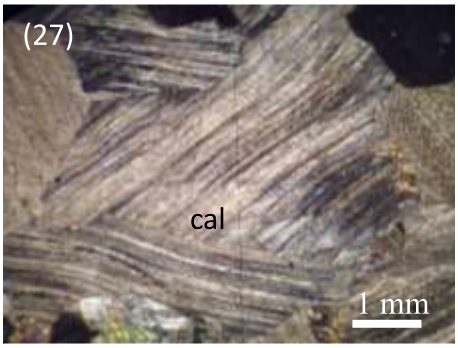
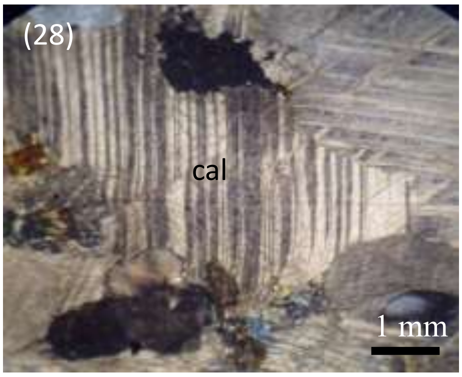


Figure 26 Outcrop nature of grossularite - diopside marble near the Kyauk Phya village (Loc; N 22˚ 49' 31.62", E 96˚ 5' 47.15", Facing – 290˚)

Figure 27 Due to the deformation of calcite twin bands are curved in the grossularite – diopside marble (Bet.X.N, 4X)



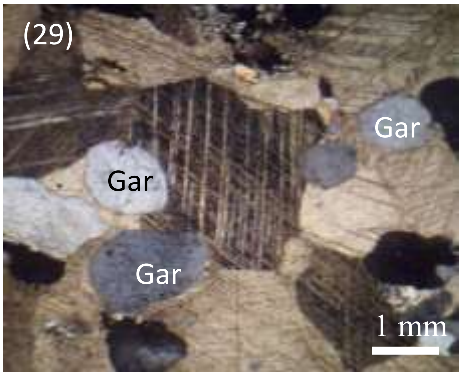


Figure 28 Tapering twin in grossularite - diopside marble (Bet.X.N, 4X)

Figure 29 Garnet is showing anomalous extinction in the grossularite - diopside marble (Bet.X.N, 4X)

Petrogenesis

Mineral Assemblages and Metamorphic Facies

For the classification, nomenclature and defining mineral assemblages, thin section cut from various metamorphic rock types were studied for the mineral association. The mineral assemblages recognized in facies and rock types indicate that the metamorphic rocks of the area belong to the amphibolites facies. The following mineral assemblages are recognized in the study area.

Mineral assemblage recognized in biotite - gneiss is;

1. Orthoclase + quartz + plagioclase + biotite

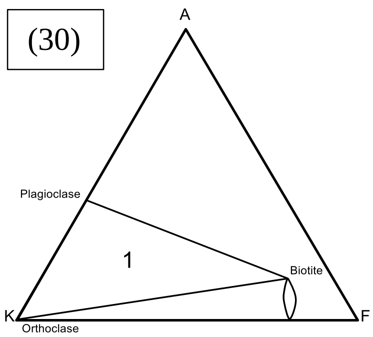
Mineral assemblage recognized in garnet – diopside - calc – silicate rock is;

2. Calcite + quartz + orthoclase + plagioclase + diopside + garnet (grossularite)

Mineral assemblages recognized in marbles are;

3. Calcite + graphite + diopside
4. Calcite + diopside + phlogopite + forsterite + quartz + garnet (grossularite)
5. Calcite + diopside
6. Calcite + diopside + phlogopite + forsterite + garnet (grossularite) + muscovite

The above mineral assemblages were plotted on ACF and AKF diagrams are shown in figure.30, 31, 32 and 33.



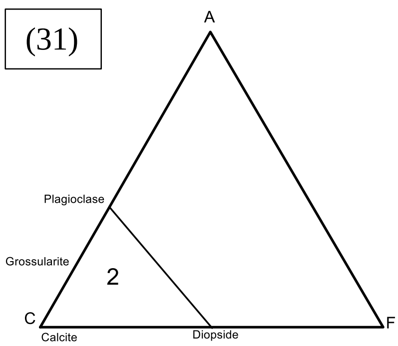
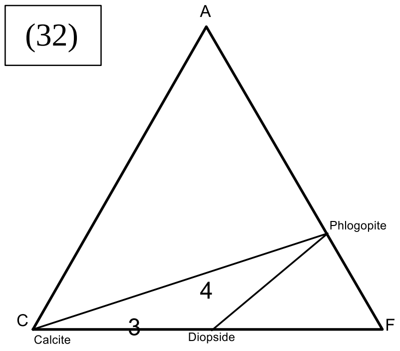


Figure 30 AKF diagram showing the mineral assemblages of Amphibolite Facies (after Turner and Verhoogen, 1960)

Figure 31 ACF diagram showing the mineral assemblages of Amphibolite Facies (after Turner, 1981)



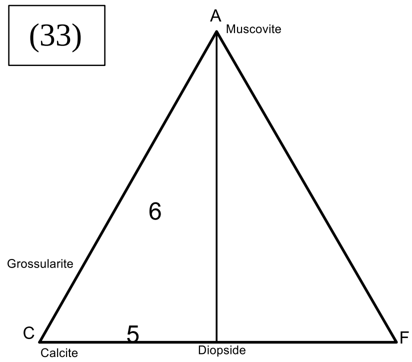


Figure 32 ACF diagram showing the mineral assemblages of Amphibolite Facies (after Turner and Verhoogen, 1960)

Figure 33 ACF diagram showing the mineral assemblages of Amphibolite Facies (after Askola, 1939)

Types of Metamorphism

The mineral assemblages are found in the area indicate that the study area had been subjected to regional metamorphism. Regional metamorphism is the most wide spread and the grade of metamorphic facies is Amphibolite Facies. The index minerals of amphibolite facies such as diopside and forsterite are occurred in the study area. Therefore, it can be indicated that the rocks of the study area belong to the upper amphibolites facies.

According to the modern classification of the facies series (Miyashiro, 1980) the medium to high grade regional metamorphism of this area belong to the medium pressure. The occurrence of diopside from at about 600˚C and P_f = 5 kbars (Winkler, 1979). In the study area, the occurrence of grossularite from 600˚C at 2 kbars (Winkler, 1979). The formation of forsterite takes place at 700˚C and P_f = 5 kbars (Winkler, 1979).

Metamorphic Grade

Twin morphology in calcite appears to be strongly temperature dependant and has been proposed as a geothermometer (Burkhard, 1993). The number and volume of twins in calcite has been proposed as a microgauge for different stress (Jamison and Spang, 1976, Laurent et. al 1990). According to the petrographic analysis of the calcite twins in marble units, metamorphic grade of the study area increase to the south, Figure. 34.

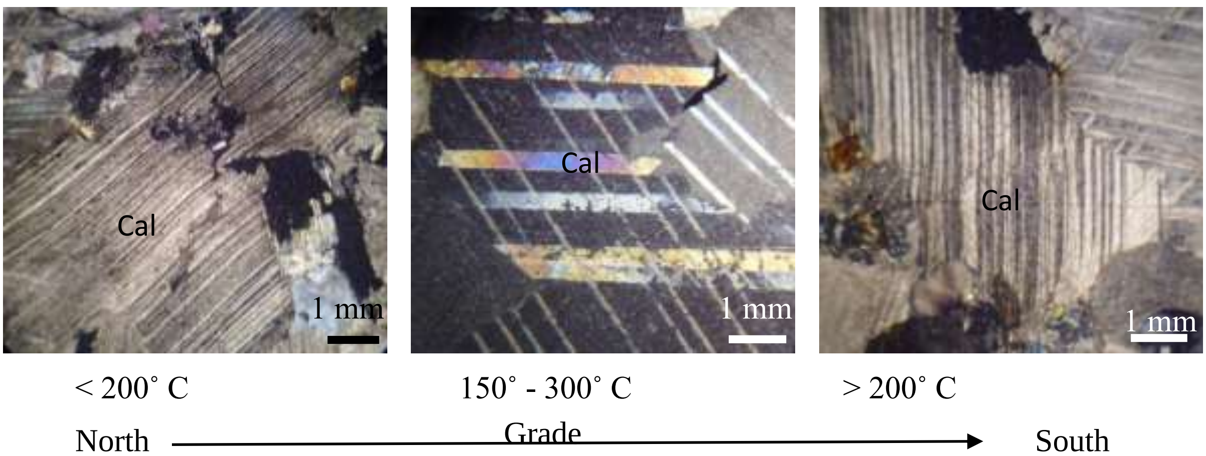


Figure 34 Appearance of calcite twins with increasing temperature reproduced (Burkhard, 1993)

Regional Metamorphism

According to the mineral assemblages the regional metamorphism of the study area had taken place in the "Amphibolite Facies" (Turner and Verhoogen, 1960 and Askola, 1939). The following mineral reactions are significant in the formation and paragenesis of some minerals.

1. Diopside is found in types of marble. Diopside can be formed from the following equation, (Winkler, 1979).

   Tremolite + 3 Calcite + 2 Quartz $\longrightarrow$ 5Diopside + 3CO_2 + H_2O

   Dolomite + 2 Quartz $\longrightarrow$ Diopside + 2CO_2

   3 Dolomite + 5 Calcite $\longrightarrow$ 11 Diopside + 2 Forsterite + 5 CO_2 + 3H_2O

2. Phlogopite is found in types of marble. Phlogopite can be obtained from the following equation, (Winkler, 1979).

   3Dolomite + K – Feldspar + H_2O $\longrightarrow$ Phlogopite + 3Calcite + 3CO_2

3. K – Feldspar can be obtained from the following equation;

   Muscovite + Calcite +2Quartz $\longrightarrow$ K – Feldspar + Anorthite + CO_2 + H_2O

4. The equation for garnet (grossularite) is the following equation;

   Anorthite + 2Calcite + Quartz $\longrightarrow$ Grossularite + 2 CO_2

5. The presence of forsterite may have been due to the following reaction

   (Winkler, 1979)

   1 Diopside + 3 Dolomite $\longrightarrow$ 2 Forsterite + 4 Calcite +2 CO_2

Origin of Metamorphic Rock

Biotite - gneiss has been derived from pelitic rocks. Calc – silicate rock and types of marble are have been derived from the siliceous dolomitic limestone and calcareous rocks.

Summary and conclusion

The study area is falls within the UTM map number 2296 01 and located in the eastern part of Thabeikkyin Township and the northern part of Singu Township in Mandalay Region. The present study area lies within the Mogok Metamorphic Belt, lying between Sagaing Fault and Shan Scarp Fault. The metamorphic rocks such as biotite - gneiss, grossularite - diopside marble, phlogopite – diopside marble, graphite marble and garnet – diopside - calc – silicate rocks. Biotite - gneiss is well exposed in the central part of the study area near the Za Yat Kwin village.

Marbles are widely distributed in the study area. Especially, marbles are can be found in the Kyet Saung Taung. Garnet – diopside - calc – silicate rocks is well exposed in the Za Yat Kwin village and northeastern part of the study area. Regional metamorphism (amphibolites facies) is recognized in the study area. The grade of the metamorphism in the study area is medium to high grade metamorphism.

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