Petrography of the Metamorphic Rocks in the Taungnyo Area, Sagaing Township, Sagaing Region

Eisan Mon

Abstract

The Taungnyo area is located in the Central Cenozoic Belt, closed to the western margin of Eastern Highlands. The Sagaing Metamorphics (Precambrian-Early Paleozoic), the Minwun Metamorphics (Early-Middle Triassic) and Cenozoic sediments are widely distributed in the study area. The present work aims to describe the petrography of the metamorphic rocks of the Taungnyo area, Sagaing Region. The Sagaing metamorphics consists of Marbles which are subdivided into (i) Diopside-phlogopite-forsterite marble, (ii) Spinel-bearing-phlogopite-forsterite-marble, and (iii) White marble; Calc-silicate rocks; and Gneisses which are also subdivided into (i) Hornblende-biotite gneiss, (ii) Biotite gneiss, and (iii) Leucogneiss. The Minwun metamorphics include Garnet-mica schist and Actinolite schist. The petrographic characteristics of rock forming minerals such as quartz, feldspar, mica, hornblende, and calcite and the metamorphic minerals such as garnet, diopside, forsterite, actinolite are described in detailed in the present research.

Keywords: Taungnyo area, Sagaing Region, Petrography, Metamorphic rocks

Introduction

The Taungnyo area is located in the Central Cenozoic Belt, closed to the western margin of Eastern Highlands. The Sagaing Metamorphics (Precambrian-Early Paleozoic), the Minwun Metamorphics (Early-Middle Triassic) and Cenozoic sediments are widely distributed in the study area. A few previous authors studied the geology, structural geology and regional geology in this area (La Touche, 1913; Chhibber, 1934; Kan Saw, 1976; Myint Thein et al., 1979; Maung Maung, 1987; Maw Maw Myint, 1993). The present work aims to describe the petrography of the various rock units of the Taungnyo area, Sagaing Township, Sagaing Region.

Location

The study area is located in the northern part of the Sagaing Township, Sagaing Region. It is bounded by the Ayeyarwady River in the east, the Kaunghmudaw Inn in the west, the Sagaing Township in the south, and the Yega area in the north. The area lies on the topographic map no. 84 O/13, 93 C/1 (Figure 1). The present area is situated between 21° 53’ N to 21° 58' N and 95° 56' E to 96° 02' E. The length is 8 km along the N-S and the width is 9 km along the E-W, so the total areal coverage is approximately 72 square kilometers.

Aim and Objectives

The present research aims to describe the systematic petrographic studies of the rock units exposed in the Taungnyo area, Sagaing Township. The objectives of the present research are to present the geology and to describe the lithologic characteristics of the various rock units in the Taungnyo area, Sagaing Township, Sagaing Region.

Demonstrator, Department of Geology, Hinthada University

Method of Study

Before the reconnaissance survey, the study of the aerial photographs of 1:24,000 scale was made and these data were accurately transferred on the base map to demarcate the occurrence of outcrop structural trends, lithologic contacts of rock units, possible fold and fault traces within the study area.

The representative samples were collected for detailed study in the laboratory. 20 thin sections of the representative rock specimens from the various rock types were prepaired for the petrological study. Detailed petrological characteristics were studied under the petrological microscope.

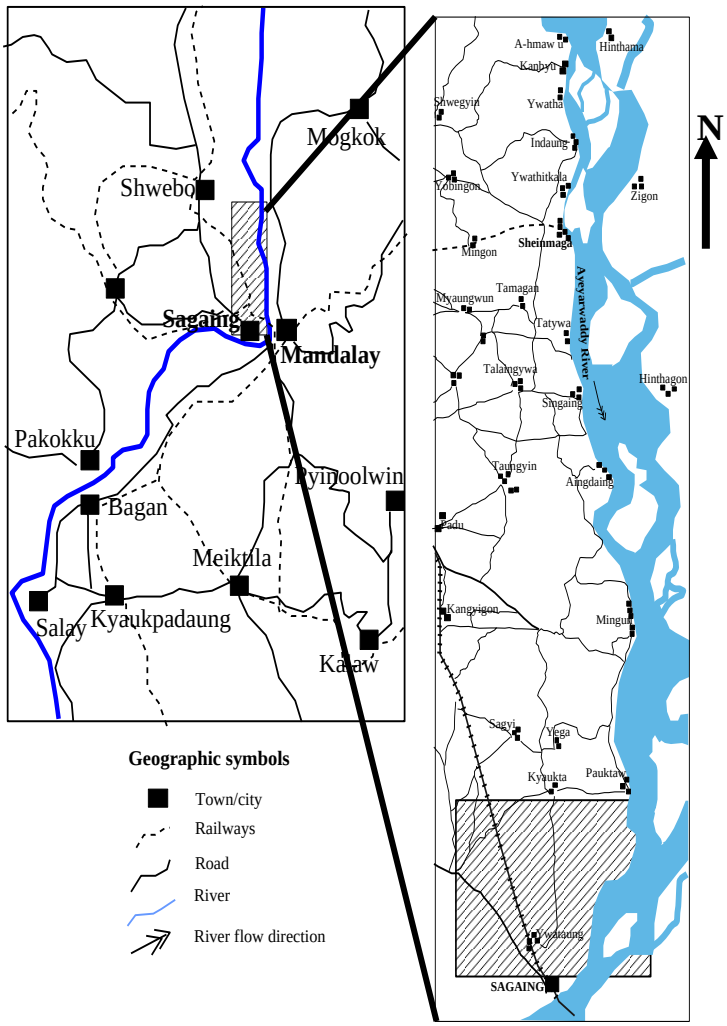

Figure (1) Location map of the study area.

General Geology

The study area is located in Central Cenozoic Belt, closed to the western margin of Eastern Highlands. It is occur as a north-south narrow linear strip, along the western part of Ayeyarwady River, N-S trending. There are various rock units exposed as a narrow linear belt, NW-SE trend. The Sagaing ridge and Minwun ridge are separated by Sagaing Fault. The metamorphic rocks are exposed on Sagaing ridge are Sagaing metamorphics and the

metamorphic rocks are exposed on Minwun ridge are Minwun metamorphics (La Touche, 1913). Sedimentary rocks are exposed on not only Minwun ridge but also Sagaing ridge.

Sagaing metamorphics (Precambrian to Early Paleozoic), Minwun metamorphics (Middle to Late Triassic (?)), Male Sandstone (Early to Middle Eocene) and Irrawaddy Formation (Late Miocene to Pliocene) are exposed in the study area (Figure 2). The rock sequence of the study area is shown in Table (1).

Table (1) Rock units of the study area.

Rock Units	Lithology	Age
Recent Alluvium	Alluvium	Holocen
⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒	Unconformity	⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒
Irrawaddy Formation	Gritty sandstone Silty sandstone Fanglomerate	Pontian to Villafranchian
⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒	unconformity	⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒
Male Formation	Interbedded fine-grained sandstone and medium to coarse-grained sandstone Gritty sandstone interbedded with fine-grained sandstone	Lower to Middle Eocene
⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒	unconformity	⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒
Minwun metamorphics	Garnet – muscovite / biotite schist Actinolite schist	Middle to Upper Triassic (?)
⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒	unconformity	⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒⌒
Sagaing metamorphics	Diopside-phlogopite –forsterite marble, Phlogopite - forsterite marble, White marble Calc-silicate rocks Banded hornblende biotite-gneiss, Biotite gneiss, Leucogneiss	Precambrian to Lower Paleozoic

Metamorphic Rocks

Sagaing metamorphics

Sagaing metamorphics are exposed along the Sagaing ridge, and it is mainly composed of marbles, calc-silicate rocks and gneisses. Sagaing metamorphics are found two third of the study area (Figure 2).

Marble can be divided into three units such as diopside-phlogopite-forsterite marble (Figure 3), phlogopite-forsterite marble (Figure 4) and white marble (Figure 5). Marbles are widely exposed on the western flank of the Sagaing ridge. They are found as massive, hard and compact in outcrop nature.

Calc-silicate rocks contact with eastern boundary of white marble unit. They are well exposed in the northern part of the study area. They show pale green in fresh surface and dull colour in weathered surface. They show generally NE-SW strike with east dipping (Figure 6).

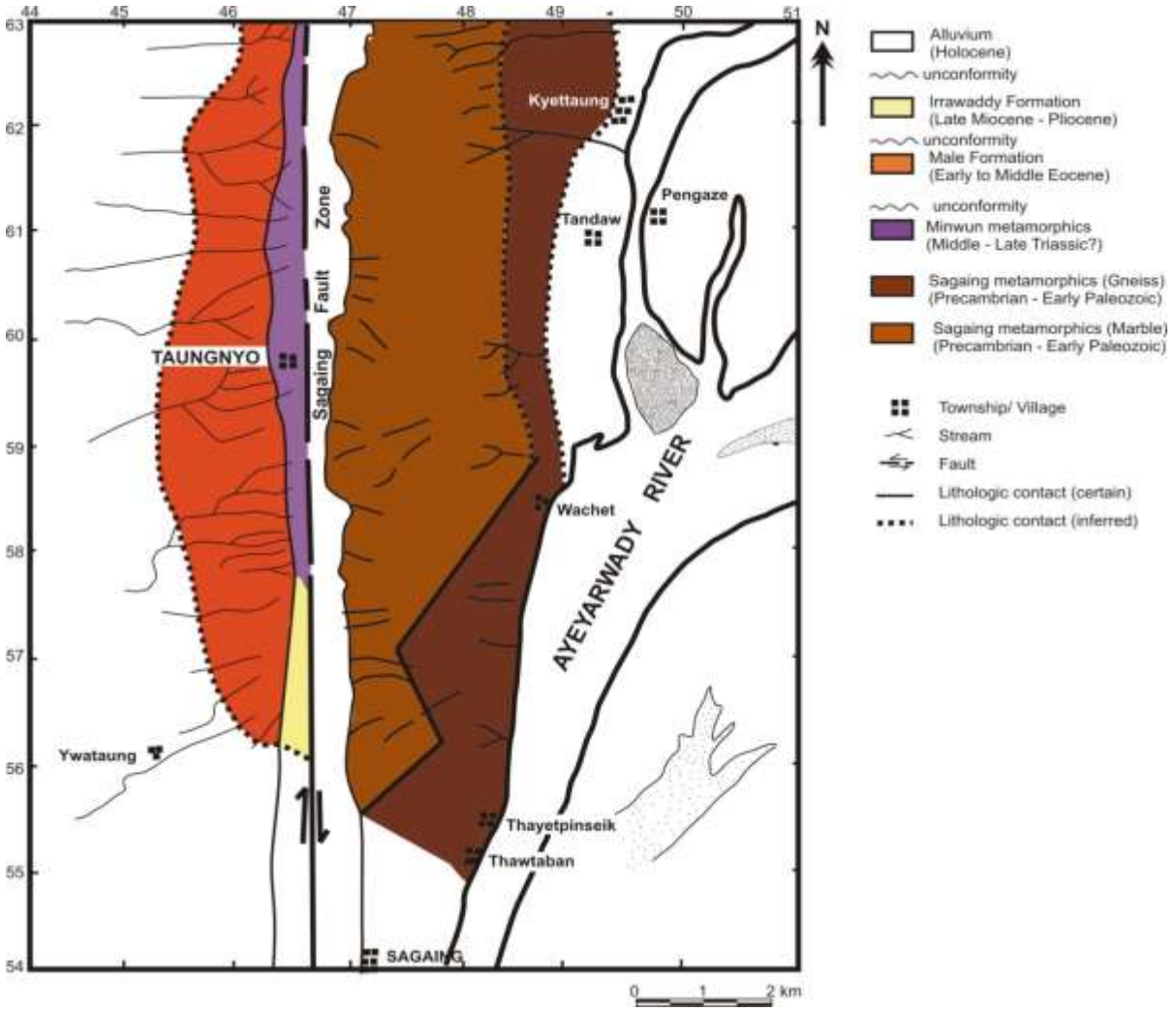

Figure (2) Geological map of the Taungnyo area, Sagaing Township

Gneiss can also be divided into three units such as hornblende-biotite gneiss, biotite gneiss and leucogneiss. It is widely exposed along the eastern flank of the Sagaing ridge, especially along the side of Yega-Wachet-Sagaing car road. They are thin to medium bedded, hard and compact. They show well banded nature due to alternative arrangement of quartz-feldspar rich (Felsic) layers and hornblende biotite rich (Mafic) layers. Sometime pegmatite veins are intruded in this rock (Figure 7). Quartzo-feldspathic veins are common throughout this unit. It is mainly composed of quartz, and feldspar. Biotite occurs as minor amount (Figure 8). Their foliation is NW-SE direction.

Figure (3) Outcrop nature of diopside-phlogopite-forsterite marble (W of the Kyettaung Villgae) N 21˚ 56′ 59.2″; E 96˚ 00′ 10.5″

Figure (4) Outcrop nature of phlogopite-forsterite marble (W of Wachet villge) N 21˚ 55′ 16.5″ E 95˚ 59′ 22.6″

Figure (5) White marble in the quarry (W of Tandaw Village) N 21˚ 56′ 18.7″ E 95˚ 59′ 45.5″

Figure (6) Outcrop nature of calc-silicate rocks (W of Pangaze Village) N 21˚ 56′ 34.5″ E 96˚ 00′ 07.5″

Figure (7) Quartzo-feldspathic vein intruding in banded hornblende-biotite gneiss (around Thayetpinseik) N 21˚ 53′ 45.7″ E 95˚ 59′ 30.7″

Figure (8) Outcrop nature of biotite-gneiss (around Wachet Village) N 21˚ 54′ 42.1″ E 96˚ 00′ 04.5″

Age and correlation

The Sagaing metamorphics are the most western outcrop of the Mogok Series in Precambrian age (Chhibber, 1934). This metamorphic rocks correlate to the Mayathein metamorphics of the Katha-Meza area and regarded as Early Mesozoic age. Sagaing metamorphics were possibly metamorphosed in Early Paleozoic.

3.2.2 Minwun Metamorphics

Minwun metamorphics are exposed along the Minwun ridge and generally east dipping. They are mainly composed of schists: garnet-muscovite/biotite schist (Figure 9) and Actinolite schist which are probably sedimentary derivatives. Minwun metamorphics were possibly metamorphosed Mesozoic (Triassic?) (Maung Maung, 1987). These metamorphic rocks have been metamorphosed from Ngapyawdaw Chaung Formation of middle to Upper Triassic? (Myint Thein, et al., 1983).

Sedimentary Rocks

Male Formation

Male sandstones are well exposed in the western part of Minwun ridge and underlain by Minwun metamorphics. They are found as bedded nature and dark grey on weathered surface, buff colour in fresh surface.

In the lower member of Male Formation, gritty sandstone is interbedded with fine grained sandstone. Sandstone and shale are found to be intercalated with these sandstones. They are highly jointed and fine grained sandstones are thin bedded. The upper member of the Male Formation consists of interbedded fine grained sandstone and medium to coarse grained sandstone. Gritty sandstone bands are intercalated with these sandstones. Small scale cross laminations, horizontal laminations are common (Figure 10).

This formation was regarded as a part of Upper Pegu (Kan Saw, 1976). Lithologically, it can be correlated with Moza Formation (Late Miocene) of Shwetaung-Taungtalon area. Therefore this formation may possibly be Late Miocene in age (Maung Maung, 1980). This unit is overlain by Irrawaddy Formation (Late Miocene to Pliocene) and underlain by Minwun metamorphics (Middle to Late Triassic). So this formation may be assigned to the Early to Middle Eocene age.

Figure (9) Outcrop nature of garnet-mica schist (N of Taungnyo Village) N 21˚ 56′ 16.2″, E 95˚ 59′ 07.1″

Figure (10) Crossed bedded nature of Male sandstone (N Taungnyo Village) N 21˚ 56′ 38.9″,E 95˚ 58′ 33.8″

Irrawaddy Formation

The rocks rrawaddy Formation are exposed between Male Formation and alluvial, in the western part of study area. It is mainly composed of fanglomerate, silty sandstone and gritty sandstone.

Fanglomerate is mainly composed of fine- to coarse-grained sandstone layers. The silty sandstone is massive-thick bedded, and it is intercalated within the gritty sandstones.

Gritty sandstone is composed of gritty to pebbly sandstone and medium- to coarse-grained sandstone. They are massive to thick-bedded and whitish to yellowish brown in colour. Large scale cross stratifications and concretions are common. The age of this formation is Late Miocene to Pliocene (Kan Saw, 1976; Myint Thein et al., 1979).

Petrography of the Metamorphic Rocks

In the study area, the metamorphics rocks are marbles (diopside-phlogopite-forsterite marble, phlogopite-forsterite marble and white marble), gneisses (hornblende-biotite gneiss, biotite gneiss and leucogneiss), calc-silicate rocks and schists (garnet mica schist and actinolite schist).

Sagaing Metamorphics

Marbles

(i) Diopside-phlogopite-forsterite marble

Megascopically, it is a coarse-grained granoblastic texture. It gives dark grey in weathered surface and white with black and brown spot in fresh surface. They are found as massive, hard and compact.

Microscopically, it is medium grained granoblastic texture. It is mainly composed of calcite, forsterite, phlogopite, diopside. Sphene and opapue minerals occur as accessory minerals (Figure 11 a, b).

Calcite is most abundant (80%), occurring as anhedral crystal. It is colourless in a thin section. It shows two sets of cleavage. Twinkling effects are also noticed.

Most forsterites are shown in advance stage of alteration mostly antigorite and magnetite. It is colourless in thin section. It shows high relief. It gives second order interference colour and parallel extinction.

Phlogopite shows distinct pleochroism from pale brown to colourless. It occurs as prismatic crystals. It has one set of cleavage and parallel extinction.

Diopside shows pale green colour, subhedral crystal. It gives two sets of cleavage. Some diopside shows a certain stage of alteration especially along the cleavage and fracture.

Sphene is pale brown in thin section. It occurs as an euhedral crystal that has an acute rhombic cross section in irregular grains. It gives a very high relief and higher order interference colour. It gives a symmetrical extinction.

(ii) Spinel-bearing-phlogopite-forsterite-marble

Megascopically, it is medium to coarse grained granoblastic texture. It shows brown colour in weathered surface and grey colour in fresh surface. It occurs as massive, hard and compact.

Microscopically, it is medium- to coarse-grained granoblastic texture. It is mainly composed of calcite, forsterie, phlogopite and other accessory minerals (Figure 12 a, b).

Calcite is colourless in thin section and two sets of cleavage with rhombohedral form. It shows twinkling effect. It has high relief.

Forsterite is colourless in thin section and anhedral crystal with polygonal outline. It has one set of cleavage and irregular fractures. The maximum interference colour is second order and extinction is parallel. Olivine is altered to antigorite and magnetite which give high relief and mesh texture.

Phlogopite gives distinct pleochroism from colourless to pale brown, subhedral form. It show one set of cleavage and second order interference colour. It gives parallel extinction.

Spinel is colourless in thin section and euhedral crystal. It shows imperfect cleavage and high relief. It is an isotropic mineral in XN.

Figure (11, a) Photomicrograph showing diopside-phlogopite-forsterite marble with medium to coarse-grained granoblastic texture (P.P.L)

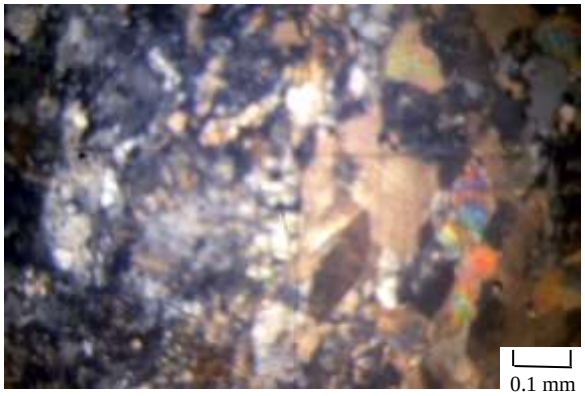

Figure (11, b) Photomicrograph showing diopside-phlogopite-forsterite marble with medium to coarse-grained granoblastic texture (XN)

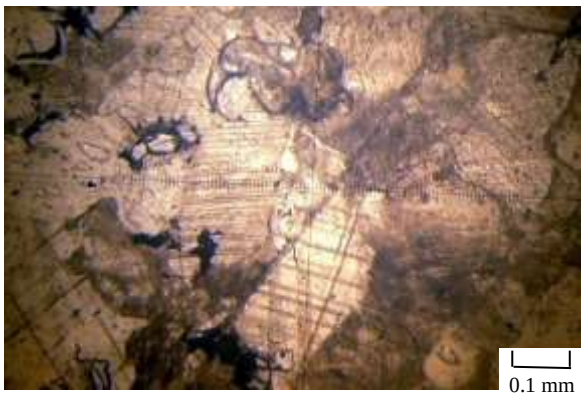

Figure (12, a) Photomicrograph showing spinel-bearing phlogopite-forsterite marble with medium to coarse grained granoblastic texture (P.P.L)

Figure (12, b) Photomicrograph showing spinel-bearing phlogopite-forsterite marble with medium to coarse grained granoblastic texture (XN)

(iii) White marble

Megascopically, it is medium grained granoblastic texture. It gives light colour in both weathered and fresh surface. It is occur as massive, hard and compact.

Microscopically, it is fine to medium grained grano-blastic texture. It is mainly composed of calcite (90 %), phlogopite (7 %) and other accessory minerals (3 %) such as opafue minerals (Figure 13 a, b).

Calcite gives colourless in thin section with anhedral form. It has two sets of cleavage, rhombohedral form. Its relief varies with the direction and it gives twinkling effects. Frequently observed curved twin lamellae in calcite grains indicate the rock had suffered to some degree of deformation.

Phlogopite is present as minor amount. It is pale brown colour of thick tabular. It has one set of cleavage and parallel extinction. The maximum interference colour is second order. Mica flakes are bent due to the deformation effect.

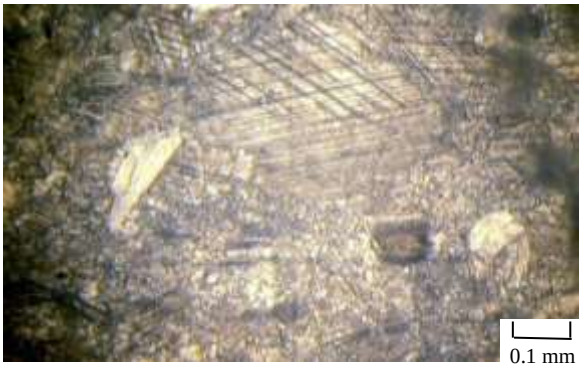

Figure (13, a) Photomicrograph showing white marble with accessory mineral, phlogopite (P.P.L)

Figure (13, b) Photomicrograph showing white marble with accessory mineral, phlogopite (XN)

Calc-silicate rocks

Megascopically, it is medium- to coarse-grained granoblastic texture. Its weather colour is brown with iron stained and fresh colour in green. By the differential weathering ridge and furrow structure are also observed in weathered surface.

Microscopically, it gives medium to coarse grained granoblastic texture. It is mainly composed of calcite, hornblende, quartz, feldspar, diopside, sphene and other accessory minerals (Figure 14 a, b). Calcite is colourless in thin section, coarse-grained anhedral form. It give grey or white of the higher order interference colour, polysynthetic twining.

Hornblende show strong pleochroism from yellowish green to green colour. It gives prismatic form and two sets of basal cleavage intersecting cut about 56° and 124°. It show second order interference colour and partly altered to chlorite. Diopside are pale green to bright green colour, occur as subhedral forms. It has two sets of cleavage intersecting out 87° and 93°. It gives 2^{nd} order interference colour. Feldspar occurs as subhedral to archedral grains. Quartz, sphene and other accessory minerals are also present.

Figure (14, a) Photomicrograph showing calc-silicate rock with medium to coarse-grained granoblastic texture (P.P.L)

Figure (14, b) Photomicrograph showing calc-silicate rock with medium to coarse-grained granoblastic texture (XN)

Gneisses

(i) Hornblende-biotite gneiss

Megascopically, it is medium-grained foliated gneissose texture. It shows greenish grey colour in fresh surface and grey colour in weathered surface. It is thin to medium bedded nature, hard and compact and show banded nature.

Microscopically, it is medium to coarse grained gneissose texture. Prismatic hornblendes are preferred orientations which show nematoblastic texture. It is mainly composed of quartz, feldspar, biotite, hornblende and other accessory minerals. Nematoblasts are hornblende. Foliations are fairly distinct. Many grains are fairly crushed (Figure 15 a, b).

Biotite shows strong pleochroism from yellow to dark brown in PPL, and fair relief. It is occur as subhedral to anhedral crystal. Sometime it shows as lamellar aggregates. It has one set of cleavage. It gives parallel extinction and second order interference colour.

Hornblendes are distinct pleochroism from colourless to pale green in thin section and have rather high relief. It is occur as prismatic form. It have two sets of cleavage, cut at 56° and 124°, give indeed extinction. It show middle second order interference colour. Alteration is not common in hornblende.

Plagioclases occur as porphyroblasts and have slightly bent of polysynthetic twin lamellar. It shows white to grey colour in thin section. Quartz is recognised by lack of colour, absence of cleavage and alteration.

Figure (15, a) Photomicrograph showing hornblende-biotite gneiss with distinct foliation (P.P.L)

Figure (15, b) Photomicrograph showing hornblende-biotite gneiss with distinct foliation (XN)

(ii) Biotite-gneiss

Megascopically, it is medium-grained gneissose texture. It is pale brown colour in weathered surface and grey colour in fresh surface. Foliation is well marked

by platy brown biotite layers in quartzo-feldspathic groundmass. In some places, they show mylonitic nature.

Microscopically, it is medium grained gneissose texture. It is mainly composed of quartz, feldspar, biotite, muscovite and other accessory minerals. It has banded nature (Figure 16 a, b).

Biotite is yellowish brown colour in thin section. It is occur as anhedral crystal. It has one set of cleavage and parallel extinction. It gives fair relief and second order interference colour.

Plagioclase is mainly found as equidimensional grains. Feldspar is colourless in thin section and gives distinct polysynthetic twin. Plagioclase feldspar occurs as anhedral to subhedral form. It gives marginal granulation, bent and broken twin lamellar.

Quartz are also abundant. It is colourless in thin section. It has absent of cleavage. It shows wavy extinction and very low relief.

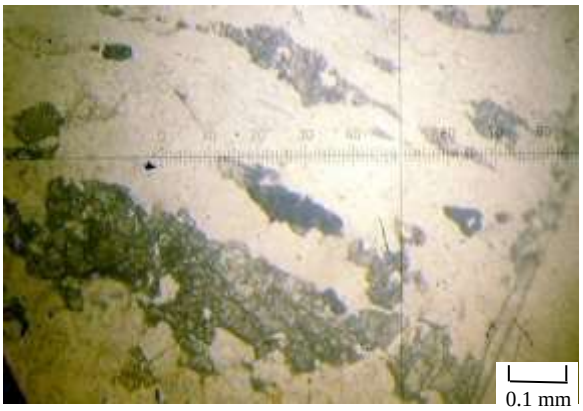

Figure (16, a) Photomicrograph showing biotite gneiss with medium-grained gneissose texture in biotite gneiss (P.P.L)

Figure (16, b) Photomicrograph showing biotite gneiss with medium-grained gneissose texture in biotite gneiss (XN)

(iii) Leucogneiss

Megascopically, it is medium to coarse grained gneissose texture. It is white colour in both fresh and weathered surface. It is medium bedded nature. It is slightly foliated and highly jointed.

Microscopically, it is medium to very coarse grained prophyroblastic granoblastic gneissose texture. It is mainly composed of quartz, feldspar and other accessory minerals (Figure 17 a, b). In some leucogneiss show myrmekitic intergrowth of quartz and feldspar. Foliated grains of quartz and feldspar are lie along the foliation plane.

Quartzs are also present in some leucogneiss. Quartz grains are closely interlocked. Quartz is characterised by colourless and anhedral form. It is strongly deformed and gives wavy extinction.

Feldspar, are mostly orthoclase, plagioclase feldspars occur as subordinate amount. Orthoclase occurs as a porphyroblast, it is subhedral form. It shows partly wavy extinction fairly cloudy. It shows simple twin and low relief. It gives first order interference colour. Alteration is not common.

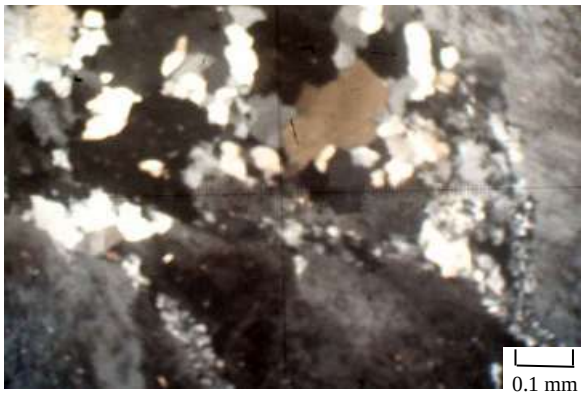

Figure (17, a) Photomicrograph showing leuco gneiss with medium to coarse-grained porphyroblastic granoblastic gneissose texture (XN)

Figure (17, b) Photomicrograph showing myrmekitic intergrowths of quartz and feldspar in leucogneiss (XN)

4.2 Minwun metamorphics

4.2.1 Schists

(i) Garnet mica schist

Megascopically, it is medium to coarse grained schistose granoblastic texture. It is pale brown in weathered surface, and light grey in fresh surface. Foliation is shown by mineral lamination of thin layers of mica and quartz + feldspar. It gives generally east dipping.

Microscopically, it is medium to coarse grained, lepidoblastic, porphyroblastic, gneissose texture, partly show schistose texture in part of medium grained. It is mainly composed of quartz, feldspar, biotite, muscovite, garnet and other accessory minerals. Micas show distinct foliation (Figure 18 a, b).

Muscovite shows colourless in thin section. It less occurs than the biotite. Its forms occur as thin tabular crystal. It has one set cleavage and parallel extinction.

Quartz and feldspar contains as nearly equal amount in this rocks. Quartz is colourless in thin section. It is intergrowth with feldspar. It has absent cleavage and very low relief. It gives wavy extinction and first order white interference colour.

Feldspar occurs as mostly porphyroblast. Most feldspars show cloudy appearance due to sericitization. Alkali feldspars are more common. Relict parthetic in the growth can be found in alkalifeldspar. Garnet occurs as porphyroblast. It shows colourless, tint colour, high relief, enhedral six-sided form in PPL. Between cross-nicol, it is isotropic.

Figure (18, a) Photomicrograph showing garnet-mica schist with medium to coarse grained lepidoblastic, porphyroblastic schistose texture (P.P.L)

Figure (18, b) Photomicrograph showing garnet-mica schist with medium to coarse grained lepidoblastic, porphyroblastic schistose texture (XN)

(ii) Actinolite schist

Meagascopically, actinolite schists are fine- to medium-grained schistose texture. In the hand specimen, it is generally dark bluish green colour.

Microscopically, it is fine- to medium-grained granoblastic schistose texture. It is mainly composed of quartz, feldspar, actinolite chlorite, epidote and minor amount of other accessory minerals (Figure 19 a, b).

Actinolite occurs as long prismatic crystals and columnar to fibrous aggregates. It shows faint pleochroism. It has two sets of cleavage intersecting at 56° and 124°. It have fairly high relief and middle second order interference colour.

The plagioclase feldspar occurs as porphyroblast enclosing parallel strings of actinolite needles are common. It show simple twin. Quartz commonly occurs in this rock. Epidote and chlorite are present as accessory minerals.

Figure (19, a) Photomicrograph showing actinolite schist with fine to medium grained schistose texture (P.P.L)

Figure (19, b) Photomicrograph showing actinolite schist with fine to medium grained schistose texture (XN)

Conclusion

The Taungnyo area is located in the Central Cenozoic Belt, closed to the western margin of Eastern Highlands. The Sagaing Metamorphics (Precambrian-Early Paleozoic), the

Minwun Metamorphics (Early-Middle Triassic) and Cenozoic sediments are widely distributed in the study area. The present work aims to describe the petrography of the metamorphic rocks of the Taungnyo area, Sagaing Township, Sagaing Region. The metamorphic rocks are exposed on Sagaing ridge are Sagaing metamorphics and the metamorphic rocks exposed on Minwun ridge are Minwun metamorphics. Sagaing metamorphics (Precambrian to Early Paleozoic), Minwun metamorphics (Middle to Late Triassic (?)), Male Sandstone (Early to Middle Eocene) and Irrawaddy Formation (Late Miocene to Pliocene) are exposed in the study area.

The Sagaing and Minwun metamorphics are petrographically described in this research. The Sagaing metamorphics consists of Marbles which are subdivided into (i) Diopside-phlogopite-forsterite marble, (ii) Spinel-bearing-phlogopite-forsterite-marble, and (iii) White marble; Calc-silicate rocks; and Gneisses which are also subdivided into (i) Hornblende-biotite gneiss, (ii) Biotite gneiss, and (iii) Leucogneiss. The Minwun metamorphics include Garnet-mica schist and Actinolite schist.

The petrographic characteristics of rock forming minerals such as quartz, feldspar, mica, hornblende, and calcite and the metamorphic minerals such as garnet, diopside, forsterite, actinolite are systematically described in the present study.

Acknowledgements

I would like to express my sincere gratitude to Dr. Aung Win, Action Rector of Hinthada University, and Dr. Theingi Shwe, Pro-Rector of Hinthada University, for their encouragement to carry out this paper. I am grateful to Dr. Theingi Kyaw (Professor and Head of the Department of Geology, Hinthada University) for a critical reading the manuscript. Thanks are also due to my colleagues of the Department of Geology, Hinthada University, for their help throughout in the preparation work.

References

Chhibber, H.L., 1934. *The Geology of Burma*, 558 pp, London, Mac Mallan.

Kan Saw, 1976. *Geology of the Northern Mingun-Kabwet Area*, Unpublished, MSc Thesis, Department of Geology, University of Mandalay.

La Touche, 1913. Geology of the Northern Shan States. – Mem. Geol. Surv. India, 39, 2: 1-379, 28 pls., 3 maps, 11 figs.

Maung Thein and Soe Win, 1969. The metamorphic petrology, structures and mineral resources of the Shantaung-U-Thandawmywet Range, Kyaukse District. *Journal of Science and Technology, Union of Burma*, Vol. **3**, p. 487-514.

Maung Maung, 1980. *Geology of the Kyaukta-Yega Area*: Univ. of Mandalay, report.

Maw Maw Myint, 1993. *Geology of the Sheinmaga-Htonbo Area*, Unpublished, MSc Thesis, Department of Geology, University of Mandalay.

Myint Thein, Kyaw Tint, and Kan Saw, 1979. Geology of the Easterm Margin of the Central Burma Belt between Sagaing and Tagaung. Unpublished Report, Department of Geology, University of Mandalay.