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Petrogenetic Interpretation Based on Petrographic Characters of Pelitic Metamorphic Rocks exposed in Pinwe-Mawlu Area, Indaw Township, Sagaing Region

Aung Khin Soe

Abstract

The study area lies in Indaw Township, northeastern part of Sagaing Region. It is situated between Latitude 24° 20′ to 24° 35′ N and Longitude 96° 10′ to 96° 20′ E. The present study area is made up chiefly of metamorphic rocks and minor sedimentary rocks. They occupy the entire bulk of the Katha-Gangaw Range. Metamorphic rocks are low to medium grade and mainly exposed in the central and eastern part of the area. Because of the thick soil cover and dense growth of plants, rock units are poorly exposed. Good exposures can be seen along the stream sections and some topmost parts of the hills.

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On the basic of petrographic analysis, eight representative mineral assemblages are recognized. Petrographic investigation on this rock assemblage reveals that the metamorphic grade of these rocks range from low grade of lower greenschist facies to higher grade of upper amphibolite facies.

The sequence of metamorphic facies encountered in the study area could be compared to the medium P/T (intermediate pressure and intermediate temperature) facies series of Barrovian Type.

Key wards: Katha-Gangaw Range, greenschist facies, amphibolite facies, Barrovian Type

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Introduction

The investigated area, Pinwe-Mawlu area, is situated in Indaw Township, northeastern part of the Sagaing Region. It lies between Latitude 24° 20′ to 24° 35′ N and Longitude 96° 10′ to 96° 20′ E. The area is bounded by vertical grids 140 to 280 and horizontal grids 940 to 150 in UTM maps of sheet No. 2496 02, sheet No. 2496 03, sheet No. 2496 06 and sheet N0.2496 07.The present area is about 21 km long in the N-S direction and 14 km wide in an E-W direction. It covers about 294 square km. The location map, satellite image and DEM image of the study area are shown in (Figs. 1,2 and 3).

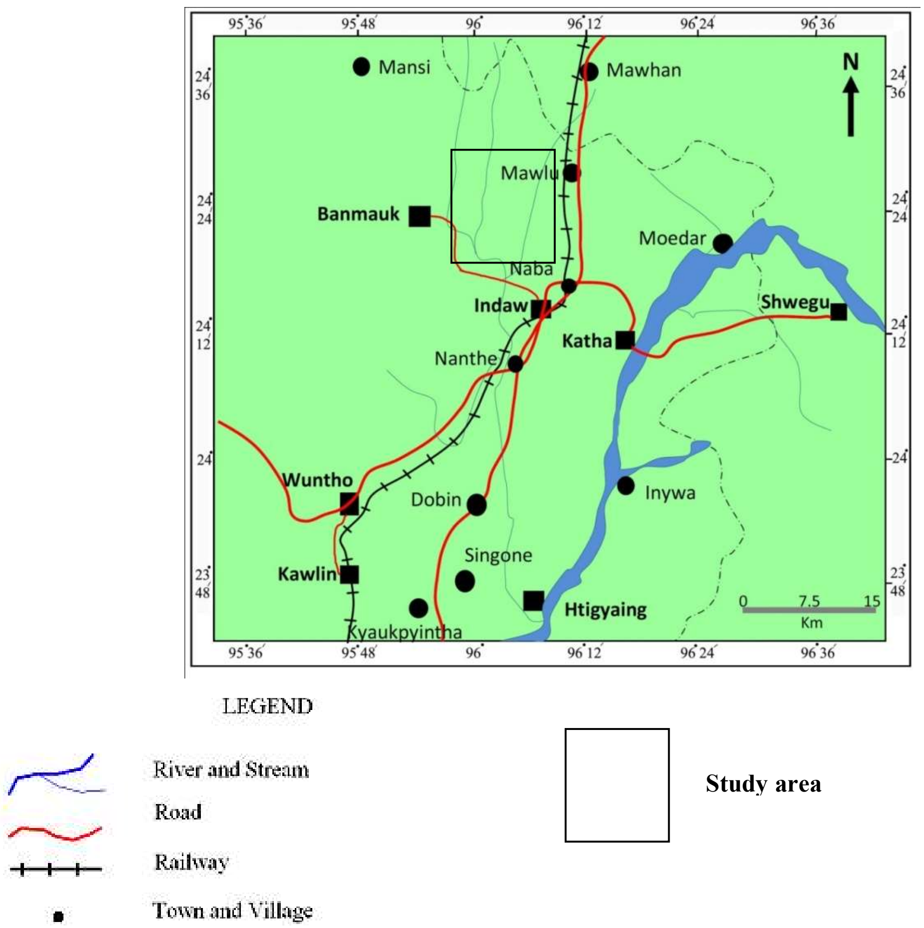


Fig.(1) Location map of the study area

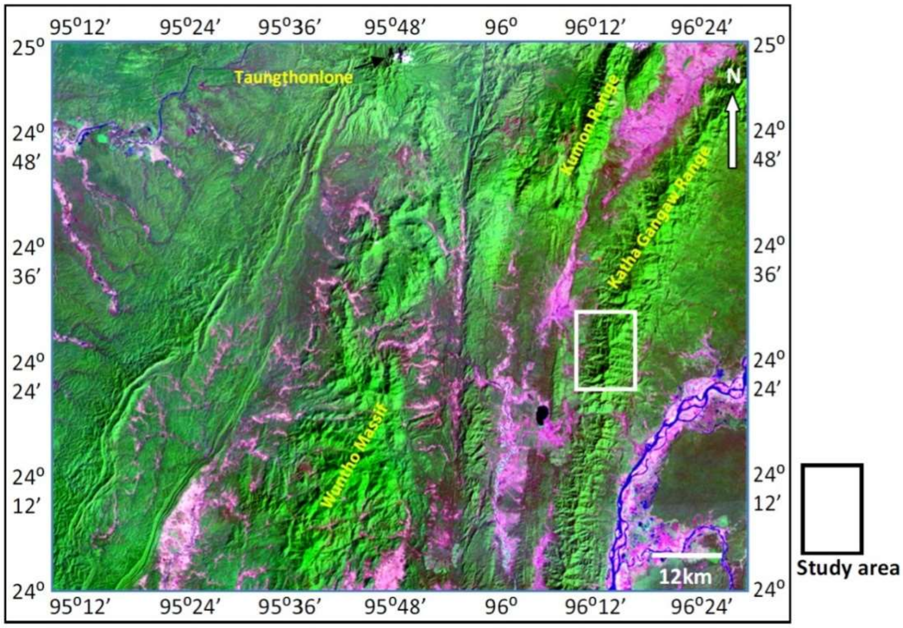


Fig. (2) Satellite image of the study area and its environs

(Source: Suntec, 2000)

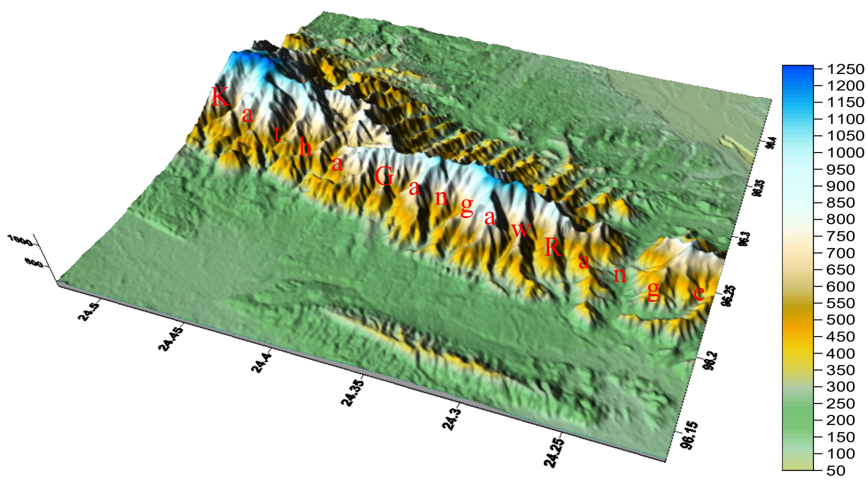


Fig. (3) DEM (Digital Elevation Model) image showing the physiography of the study area

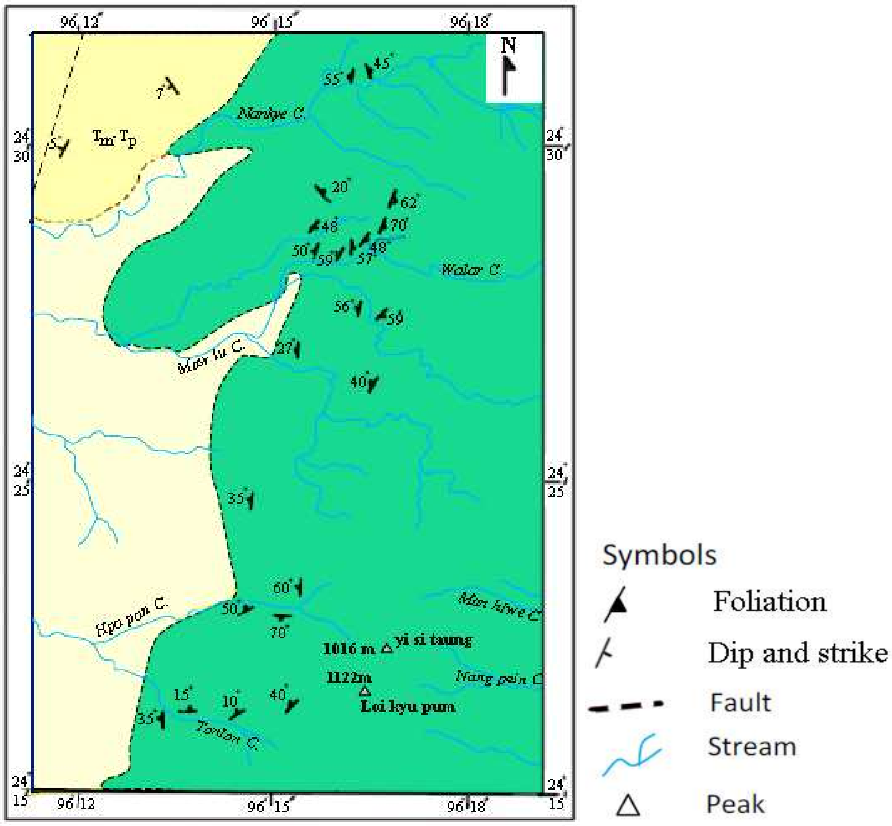
Distribution of Rock Units

The present study area is made up chiefly of metamorphic rocks with minor sediments. The metamorphic rocks are of Late Jurassic-Early Cretaceous Katha Metamorphic rock units and Miocene to Plio-Pleistocene Irrawaddy Formation. They occupy the entire bulk of the Katha-Gangaw Range and the metamorphic rocks arelow to medium grade.It is noteworthy that the metamorphic units pass into one another in a gradational manner. The Katha metamorphic rock units cover two-third of the study area.

Based on the field observation,lithologic trends and mineral variation, the possible rock sequence and schist series of the present investigated area can be described in Table (1) and proposed geological map of the study area is also shown in Fig. (4).

Table (1) Stratigraphic succession of the study area

STRATIGRAPHIC UNIT		AGE
Sedimentary Unit		
Alluvium		Recent
-unconformity		
Irrawaddy Formation		Miocene to Plio-Pleistocene
-unconformity		
Metamorphic Unit		
Chlorite schist	Katha Metamorphics	Late Jurassic-Early Cretaceous
Biotite schist		
Muscovite schist		
Garnet biotite schist		
Garnet muscovite schist		
Garnet paragonite schist		
Garnet staurolite schist		
Garnet kyanite muscovite schist		
Garnet actinolite schist		
Quartzite		
Micaceous quartzite		



Explanation

	Alluvium	Recent	
	Irrawaddy Formation Buff to whitish, medium to coarse grained, friable and massive sandstone	Miocene to Plio-Pleistocene	
	Katha Metamorphics Chlorite schist, quartzite, biotite schist, muscovite schist, garnet actinolite schist, garnet biotite schist, garnet muscovite schist, micaceous quartzite, garnet paragonite schist, garent staurolite schist, garnet kyanite muscovite schist	Late Jurassic-Early Cretaceous	

Fig.(4) Geological Map of the Pinwe-Mawlu Area, Indaw Township, Sagaing Region

PETROGRAPGY

Chlorite schist

The rock is characterized by fine to medium-grained texture and chiefly composed of quartz, chlorite, actinolite, muscovite, chloritoid and minor epidote. Quartz grains in this rock are commonly elongated fine-grained granular aggregates. The orientation of these aggregates is parallel to schistosity. Chlorite is concentrated as fibrous aggregates and sometimes contains small opaque inclusions. Actinolite occurs as acicular hypidioblastic to idioblastic crystals up to 0.5 mm in length and as clusters of smaller crystals. It is partly transformed into chlorite. Muscovite is present as platy xenoblastic crystals up to 0.3 mm in length and concentrated in certain layers. Xenoblastic greenish blue chloritoid grains and xenoblastic to hypidioblastic epidote crystals <0.3 mm in size are found with chlorite in this rock. The resulting foliation in chlorite schist is one of the most prominent features of regionally metamorphosed rocks, especially those of pelitic composition (Fig.5 A&B).

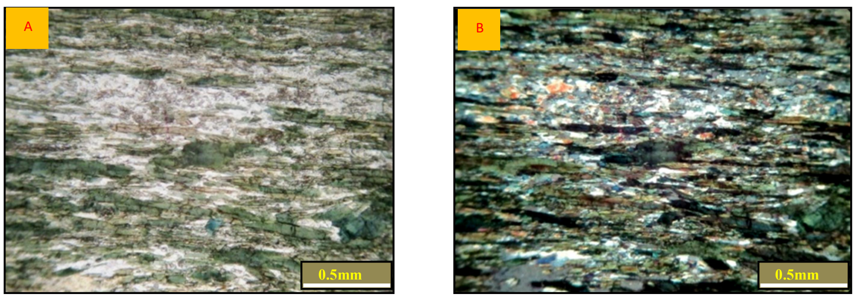


Fig.(5) Crystallization and parallelism of platy, fibrous and acicular minerals of chlorite, actinolite and muscovite in chlorite schist. (A) under PPL, (B) between XN, 40X

Biotite schist

The rock is fine to medium-grained texture and chiefly composed of quartz, biotite, muscovite, chlorite, K-feldspar and minor opaque minerals. Quartz is commonly occurred as xenoblastic grains. They are well developed suture contact and exhibit a weak grain flattening fabric. Biotite and muscovite are aligned to form a strong pervasive schistosity (Fig.6 A&B) (may be the reaction as $3Chl+8Kfs=5Bt+3Ms+9Qtz+4H_2O$) and weakly developed crenulation fabric. Most of biotite crystals are range from 0.5 to 1 mm in length. Anhedral to subhedral K-feldspar is found with chlorite in this rock.

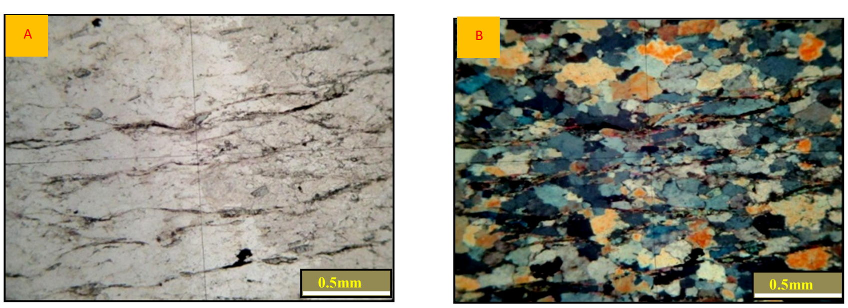


Fig.(6) Muscovite and biotite are oriented parallel to the foliation in biotite schist.(A) under PPL, (B) between XN, 40X

Muscovite schist

This rock is fine- to medium-grained, a strongly foliated metamorphic rock dominated by quartz, muscovite, biotite with minor chlorite and opaque minerals. Xenoblastic quartz grains are slightly flat and orientation of these grains produce crude foliation. Mica crystals are weakly aligned in the quartz rich layers to form a planar fabric, but, many of the thin platy muscovite crystals are aligned along the quartz grains boundaries (Fig.7 A&B). Biotite is present as platy hypidioblastic crystals up to 0.5 mm in length and is concentrated in certain layers. Chlorite occurs as irregular flakes and laths and as clusters of smaller crystals.

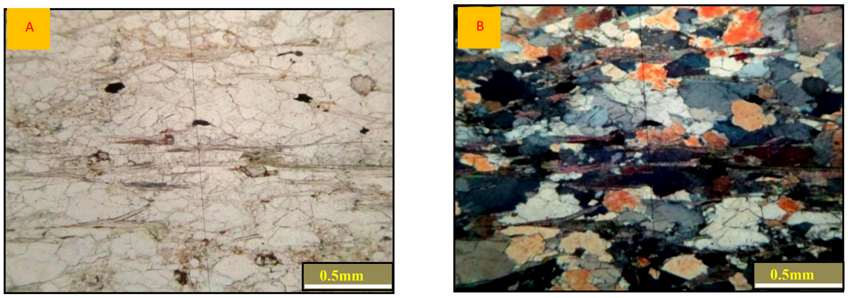


Fig.(7) The schistosity in muscovite schist is defined by the alignment of muscovite and quartz. (A) under PPL, (B) between XN, 40X

Garnet biotite schist

Garnet biotite schist is a fine- to coarse-grained porphyroblastic metamorphic rock with a well-developed schistose fabric and is dominated by garnet, biotite, muscovite and quartz with accessory opaque minerals.

Garnet is present hypidioblastic to idioblastic poikiloblast up to 2 mm in size and has extensive coronas of biotite (garnet may be formed by the reaction as $1Ms+1Bt+3Qtz=1Alm+2Kfs+2H_2O$). Quartz inclusions within the garnets are flattened and sinuous.The foliation plane of quartz layers in the garnet are at an angle of considerable amount to the foliation in the surrounding host rock. This indicates that the garnet crystal has rotated clockwise by this amount since it formed (Fig.8A&B). Post tectonic rim growth, syntectonic porphyroblast phase and reaction rim occurred in some garnet porphyroblasts (Fig.9 A&B, Fig.10 A&B and Fig.11 A&B). Reaction is pointed out disequilibrium texture with matrix conditions.

Sinuous biotite flakes are occurred in this rock and seem to be caused by the development of garnet porphyroblasts. Most biotite crystals are not larger than 0.5 mm in their length.

The matrix of this rock is dominated by biotite, muscovite and quartz and has a strong pervasive fabric formed by muscovite and flattening grains of quartz. Quartz is more abundant at the hinges of crenulations and do not exceed 0.2 mm in length.

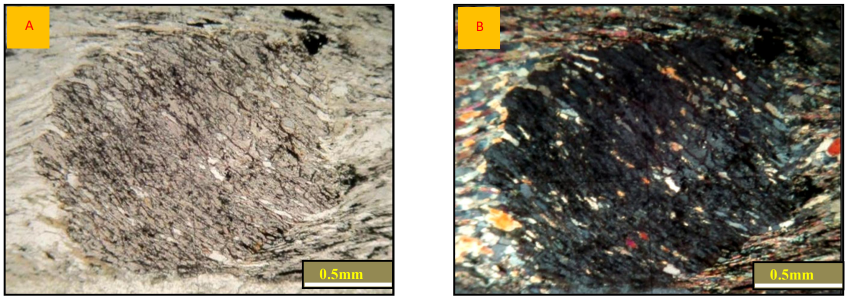


Fig.(8) Hypidioblastic porphyroblast of garnet with enclosing quartz layers developed in garnet biotite schist and that the garnet crystal has rotated clockwise direction. (A) under PPL, (B) between XN, 40X

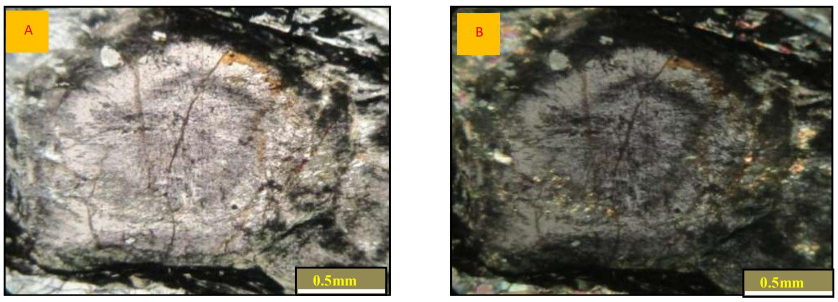


Fig. (9) Idioblastic porphyroblast of garnet developed post tectonic rim growth (A) under PPL, (B) between XN, 40X

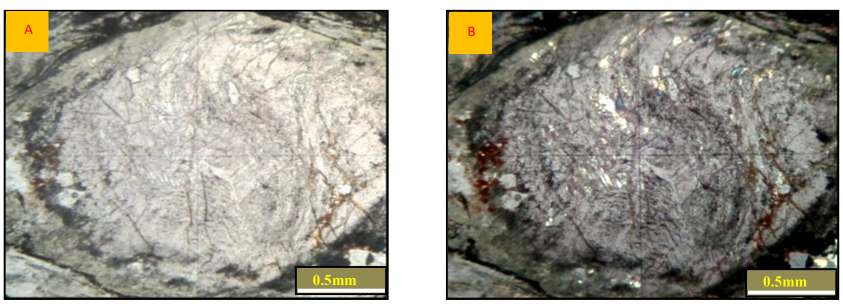


Fig. (10) Xenoblasticporphyroblast of garnet developed syntectonic phase of S-shape quartz inclusion. (A) under PPL, (B) between XN, 40X

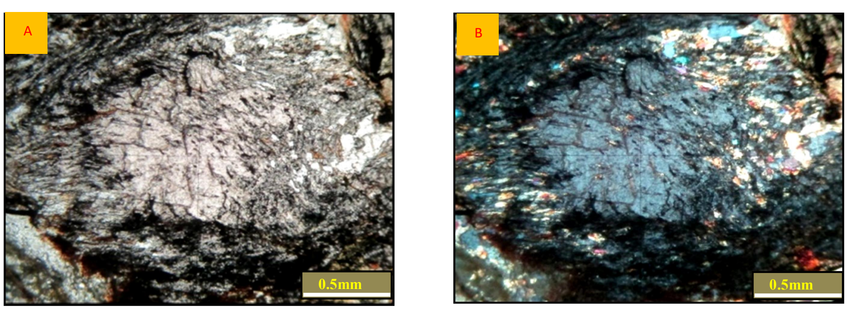


Fig. (11) Reaction rim (garnet $\rightleftharpoons$ biotite) developed in garnet porphyroblast. It is the best recognized around porphyroblasts that is in disequilibrium with matrix conditions (A) under PPL, (B) between XN, 40X

Garnet muscovite schist

This rock is strongly foliated, fine- to coarse-grained, porphyroblastic metamorphic rock dominated by garnet and quartz poikiloblasts in a fine-grained, banded, matrix of quartz, muscovite, biotite and chlorite.

It is composed of quartz- rich layers and mica-rich layers which also contain porphyroblasts. Quartz crystals exhibit a weak grain flattening fabric and mica crystals are aligned in the quartz-rich layers to form a planar fabric. Muscovite and biotite are aligned to form a strong pervasive schistosity but also have a superimposed, weakly developed crenulation fabric.

Garnet porphyroblasts are hypidioblastic to idioblastic and up to 2 mm in size. They contain abundant inclusions of matrix phases including quartz, that tract the external pervasive and crenulation fabric (Fig.12 A&B and Fig.13 A&B) (garnet may be formed by the reaction as $1Ms+3Chl+3Qtz=4Alm+1Bt+12H_2O$). The development of euhedral porphyroblasts is most favoured by conditions of unimpeded slow growth in an anisotropic medium. In peliticschists, garnet typically formed euhedral porphyroblasts.

The boundaries between the quartz-rich and mica-rich layers are gradational on one side. Some microfolds are also occurred in thin section of this rock.

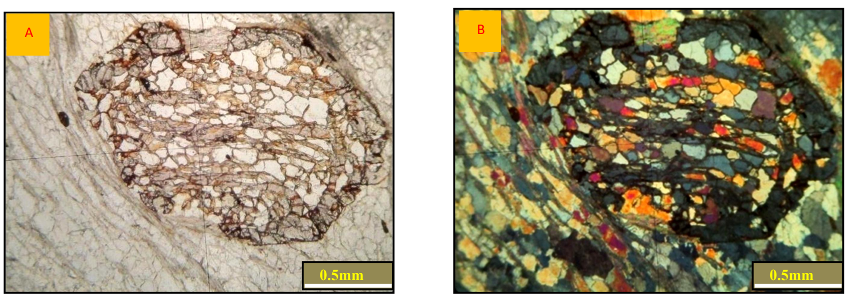


Fig. (12) Idioblasticporphyroblast of garnet developed in garnet muscovite schist. (A)under PPL,(B) between XN, 40X

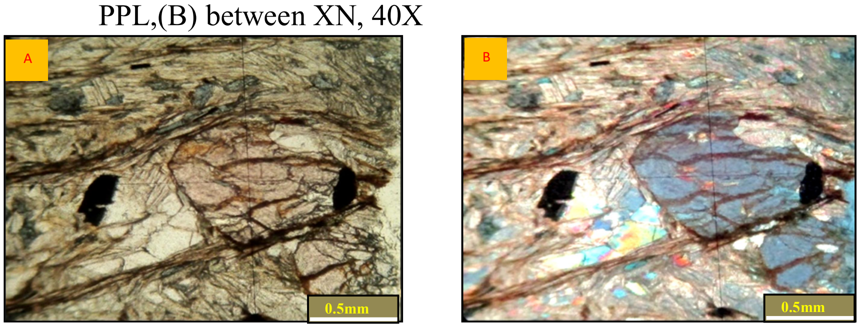
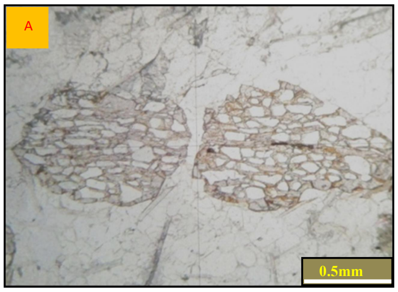


Fig.(13) Hypidioblastic porphyroblasts of garnet enveloped by a schistose fabric comprised of Chl + Ms + Bt + Qtz in garnet muscovite schist (A)under PPL, (B) between XN, 40X

Garnet paragonite schist

This rock is fine- to medium-grained porphyroblastic metamorphic rock. It is essentially composed of garnet, paragonite and quartz with minor chlorite and accessory opaque minerals.

Garnet is present as embayed poikiloblasts up to 1 mm in size (garnet may be formed by the reaction as 2Pg+3Chl+6Qtz=5Alm+2Ab+14H_2O). Quartz inclusions within the garnets are flattened and sinuous (Fig.14). The paragonite crystals have no preferred orientation. Poorly developed pressure shadows containing granoblastic quartz are presented adjacent to some porphyroblasts. The matrix of this rock is dominated by paragonite, muscovite and quartz, and has a strong pervasive fabric formed by muscovite crystals and grain flattening of quartz.



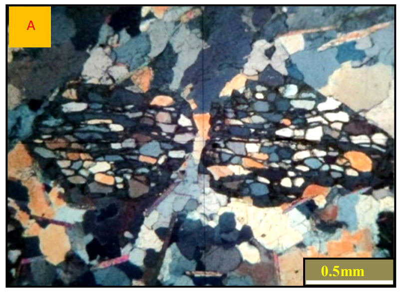


Fig.(14) The skeletal porphyroblasts of garnet formed by the growth between quartz grain boundaries in garnet paragonite schist (A)under PPL, (B) between XN, 40X

Garnet-staurolite-sillimanite schist

This rock is a fine-to coarse-grained, strongly foliated, porphyroblastic metamorphic rock dominated by porphyroblasts of staurolite and garnet in a matrix composed of sillimanite, muscovite, quartz and minor opaques.

Staurolite porphyroblasts are present as yellow, hypidioblastic grains up to 1mm in size and contain inclusions of quartz (Fig.15).Staurolite is partly decomposed into fine needle-like sillimanite (fibrolite) and it abundantly found in this rock (staurolite decomposed into sillimanite is the reaction as St=Grt+Bt+Sil). This decomposition pointed out that sillimanite is the product of breakdown of staurolite at higher grade metamorphic condition.

Garnet porphyroblasts are idioblastic grains and up to 3 mm in size. They contain abundant inclusions of quartz and some muscovite. It is intergrown with staurolite in places.

Sillimanite is not occurred large single crystal at all and occurs as fine, needle-like aggregate. The occurrence of sillimanites in this rock is contact with quartz and muscovite. They are produced from the stauroliteporphyroblastand pointed out that they are resulted from the breakdown of staurolite (Fig.16).

Fine-grained aggregates of quartz and muscovite present along the margin of staurolite and garnet porphyroblasts.

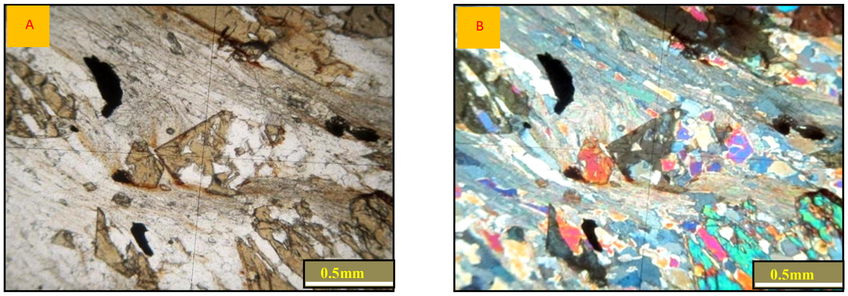


Fig. (15) Xenoblastic to hypidioblasticporphyroblasts of staurolite formed in garnet-staurolite-sillimanite schist. The schistisity in this rock is defined by the rough alignment of elongated staurolite crystals (A)under PPL, (B) between XN, 40X

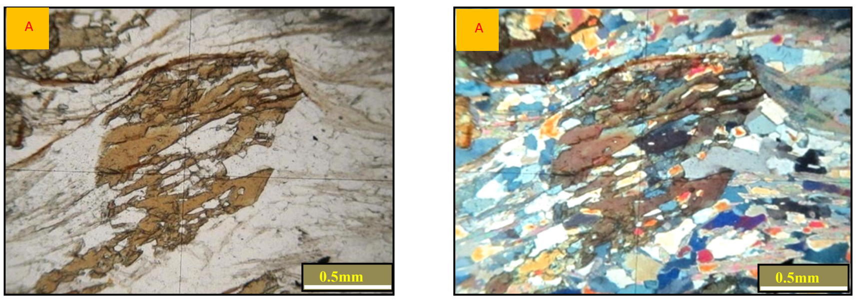


Fig. (16) The development of sillimanite (fibrolite) from the breakdown of staurolite in garnet-staurolite-sillimanite schist (A)under PPL, (B) between XN, 40X

Garnet-kyanite-sillimanite-muscovite schist

This rock is fine- to coarse-grained, foliated metamorphic rock dominated by garnet, kyanite, muscovite and quartz with minor sillimanite and opaque minerals.

Garnet is present as hypidioblastic rounded porphyroblasts up to 2mm in size surrounded by a matrix of platy muscovite with irregular quartz grains. They contain abundant inclusions of quartz and some muscovite.

Kyanite is occurred as hypidioblastic prismatic grains. Embayed porphyroblasts are up to 3 mm in size and partly transformed into sillimanite (fibrolite) (Fig.17 and Fig.18). Some kyanite contains abundant inclusions of quartz. Muscovite occurs as elongated laths and they are found along the margin of kyanite porphyroblasts. A well-developed crenulation cleavage is occurred in some places. Opaque minerals are present within the crenulation cleavage.

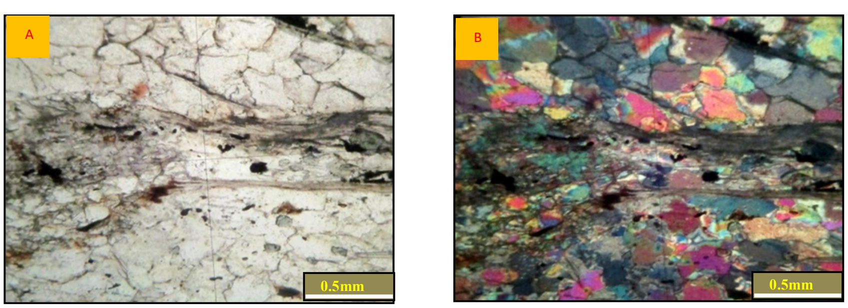


Fig.(17)Fibrolitic sillimanite formed by the breakdown of kyanite in garnet-kyanite-sillimanite-muscovite schist (A) under PPL, (B) between XN, 40X

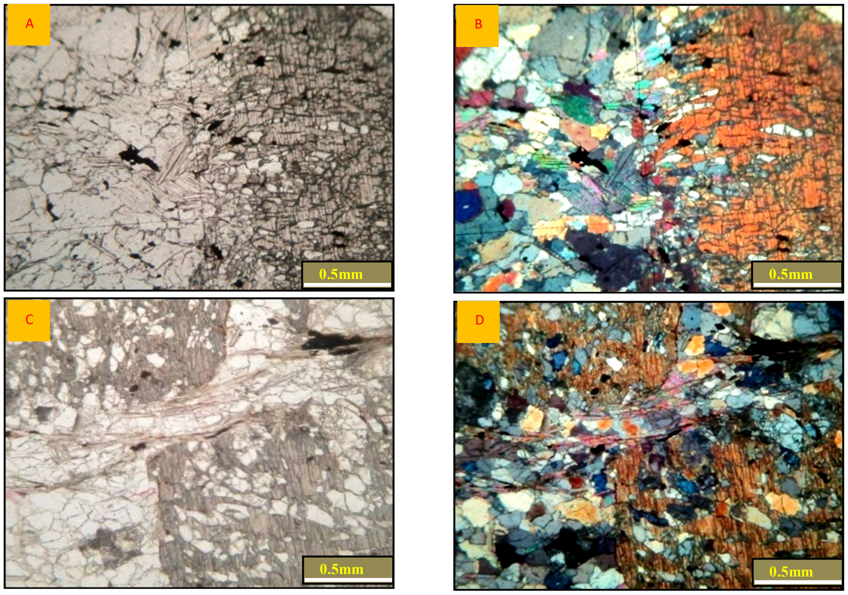


Fig.(18) The prograde breakdown of kyanite to coarse muscovite relating to the upper amphibolite facies transformation Ky→Sil (A)&(C) under PPL and (B)&(D) between XN,40X

MINERAL ASSEMBLAGES AND METAMORPHIC FACIES

On the basis of petrographic analysis, the metamorphic rocks of the study area are mainly interpreted as greenschistfacies to amphibolitesfacies in politic schist. The following mineral assemblages are distinctive in various types of schists occurred in the study area. The mineral assemblages of metapelite are,

1. chlorite, muscovite,quartz,actinolite,chloritoid, epidote
2. biotite, muscovite, chlorite, K-feldspar,quartz,
3. biotite, muscovite, chlorite,quartz,
4. garnet, biotite, muscovite, quartz
5. garnet, biotite, muscovite,quartz, chlorite
6. garnet, paragonite,quartz
7. garnet, staurolite, sillimanite, muscovite, quartz
8. garnet, kyanite, sillimanite, muscovite, quartz

The facies classification, nomenclature and representative mineral assemblages used in this research work was mainly based on Turner (1968), Yardley (1989), Bucher and Frey (1994) and Winter (2010).

The mineral assemblage of Chl-Ms-Qtz is typical assemblage of chlorite schist. The occurrence of this mineral assemblage in chlorite schist clearly indicates that the rock develops in chlorite zone of lower greenschist facies.

The Bt-Ms-Chl-Kfs-Qtz assemblage is developed in the biotite schist and Bt-Ms-Chl-Qtz in muscovite schist. These assemblages are the characteristic of biotite zone of upper greenschist facies.

Grt-Bt-Ms-Chl-Qtz assemblage is common in garnet biotite schist and garnet muscovite schist. This assemblage is typically developed in the metapelite of garnet zone of lower amphibolite facies.

The Grt-St-Sil-Ms-Qtz assemblage is developed in garnet staurolite sillimanite schist and the Grt-Ky-Sil-Ms-Qtz assemblage in garnet kyanite muscovite sillimanite schist. These mineral assemblages develop commonly fall within the sillimanite zone. Base on occurrence of these mineral assemblages that the metamorphic condition of these rocks reached up to upper amphibolites facies.

CONCLUSION

(1)The occurrence of chlorite, garnet, staurolite, kyanite and sillimanite pointed out the original rocks probably pelitic rocks.

(2) The occurrence of idioblastic garnet porphyroblast pointed out pelitic composition.

(3) The resulting foliation is one of the most prominent of regional metamorphism and pelitic composition.

(4) The occurrence of skeletal garnet porphyroblast pointed out quartz rich protolith.

(5) The occurrence of syn-tectonic and post-tectonic garnet porphyroblast pointed out more than one time of deformation.

(6) According to Bucher and Frey (1994) the sequence of metamorphic facies encountered in the study area could be compared to the medium P/T facies series of Barrovian Type.

Acknowledgements

I would like to express my thanks to Dr Win Naing, Rector of Monywa University, Dr Sein Sein Aung and Dr Thet Naing Oo, Pro-rectors of Monywa University and Dr Zaw Myint Ni, Professor and Head of Geology Department, Monywa University for their encouragement. Thanks are also due to all local people of the Pinwe and Mawlu villages for their valuable helps through the field trip. Finally, all teaching staff members from Geology Department, Monywa University are highly thanked for their cooperation.

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