Different Structural Styles of Deformational Evidences on the Momeik Metamorphics, Northern Shan State Based on Field and Petrographic Criteria

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Abstract

The study area is situated within the northern adjacent part of the Momeik Town, Northern Shan State. This area is mainly composed of metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. This research work deals to describe the field criteria and petrographic criteria of different structural styles of deformation, and to deduce some of the tectonic reviews of the Momeik area. The investigations of numerous deformational criteria observed in various units of the study area point out that the research area might have been encountered four different styles of deformation during Tertiary period. These are (i) E-W compressional deformation (Eocene to Oligocene), (ii) NNW-SSE ductile-extensional deformation (Oligocene to Early Miocene), (iii) brittle-ductile deformation (Early to Middle Miocene), and (iv) brittle-extensional deformation (Middle Miocene). The investigation of the deformational criteria might be revealed that the metamorphic rocks of the study area might have been exhumed by the extensional tectonics accompanied with E-W compressional deformation during Middle Miocene.

Key words: field criteria, petrographic criteria, deformation, extensional tectonics

Introduction

The study area, the northern continuation of Mogok Metamorphic Belt, is situated within the northern adjacent part of the Momeik Town. The area is bounded by latitude 23°9' N to 23°19'N and longitude 96°32' to 96°43'E in one inch to one mile scale topographic maps of 93-A/11 and 93-A/12. It covers approximately about 285 square km with 18 km in length and 16 km in width of rugged and mountainous terrains (Fig.1-A & B).

The Mogok Metamorphic Belt containing the study area is mainly composed of metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. The main objective of this work is to describe the field and petrographic criteria of different structural styles of deformation, and to deduce some of the tectonic reviews of the present area. To attain the petrographic criteria of structural deformation, more than twenty thin sections were cut from various representative rock samples.

Distribution of the Petrographic Units

The most abundant metamorphic rocks occupied in this area is metapelites (garnet-biotite gneiss, biotite gneiss, silliminite schist and biotite schist) which are well exposed at the southern and western parts of the study area. Metacarbonate units (forsterite-graphite marble, phlogopite marble, diopside marble, white marble and diopside calc-silicate rock) are found in the central and northeastern part of the study area. Metaigneous rocks (Orthogneiss) are commonly observed along the Momeik fault zone in the southern part of the area. The igneous units are found at central and northern parts of the area. The geological map of the study area is as shown in figure (2).

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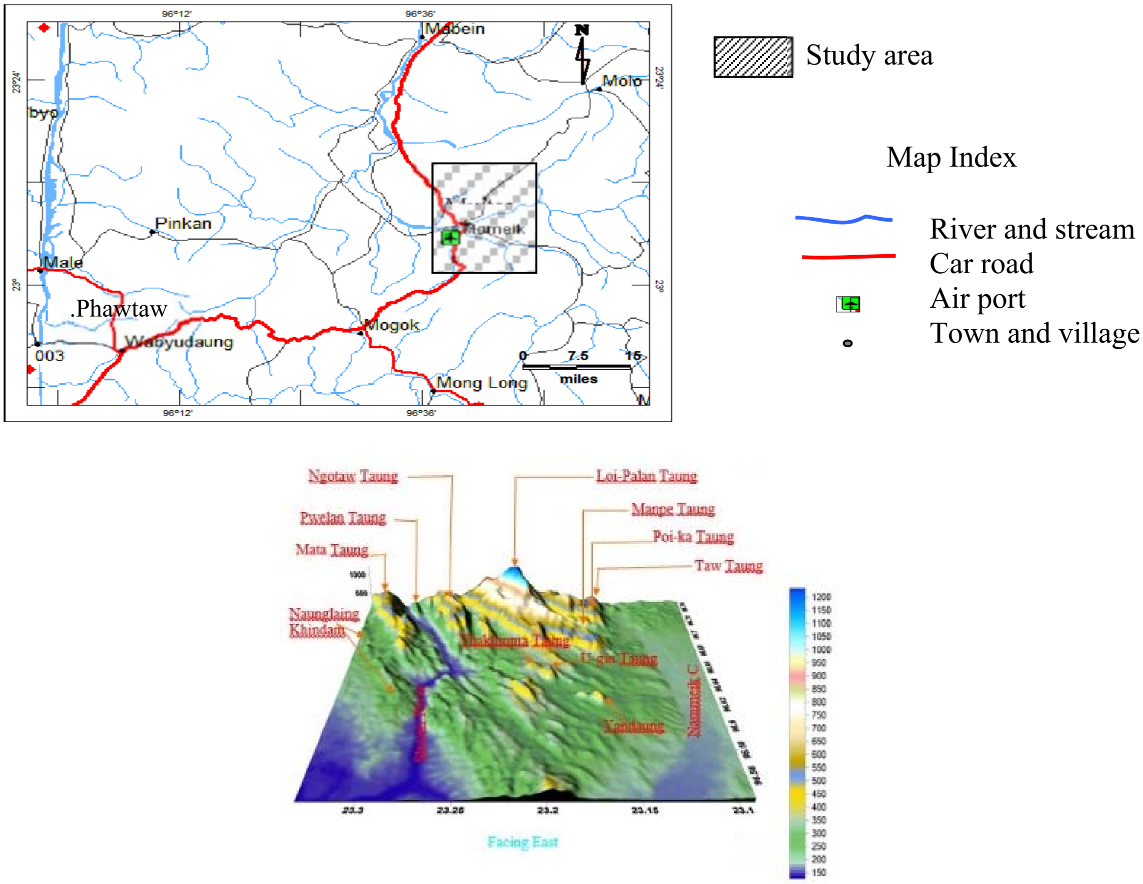

Figure (1-A & B). Location and three dimensional satellite image of the Momeik-Myitson area

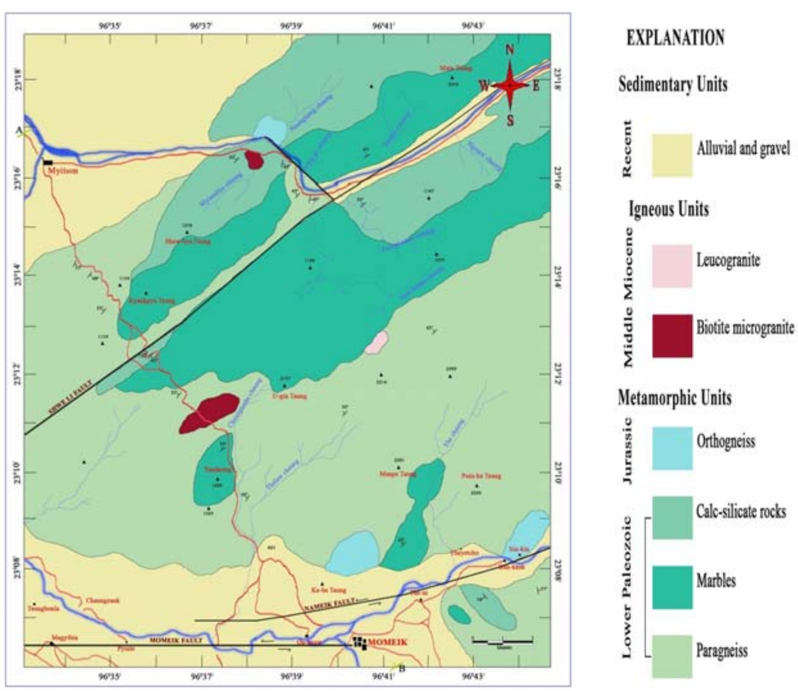

Figure (2). Geological map of the Momeik-Myitson area.

Petrographic Criteria for Structural Deformation

On the basis of field evidences and microscopic examination, four different types of structural deformation can be recognized in the Mommeik-Myitson area. These are (i) compressional deformation, (ii) ductile-extensional deformation, (iii) brittle-ductile deformation, and (iv) brittle-extensional deformation.

The criteria of compressional deformation is scarcely observed as drag folding in calc-silicate rock which is intruded by leucogranite bodies at the downstream of Myintabye Chaung section (Fig.3). The axial plane of this drag fold runs nearly NE-SW and plunges to southwest. This minor structure also indicates that the major recumbent similar folding may exist regionally (Myint Lwin Thein et. al.,1990).

The metapelites in the lower part of the study area are highly foliated and the foliation generally trends NW-SE with a low-dipping (Fig.4-A). This foliation planes often bear NNW-SSE trending stretching lineation that indicate ductile, extensional deformation. Boudinage and pinch- and -swell structures are observed in biotite gneiss (Fig.4-B). They are developed in such a way that an originally continuous rigid band or layer existing between relatively plastic layers is stretched and thinned until rupture occurs. These structures are field evidences of ductile, extensional deformation. Deformation twins with tapered termination in calcite grains are also observed in diopside calc-silicate rock (Fig.5-A). These facts indicate that these rocks have suffered from some degree of ductile deformation. Figure 5-B shows the nature of stretched garnet porphyroblast with stretching orientation 1600 in garnet-biotite gneiss. Porphyroblasts are among the most useful tools for interpreting metamorphic deformational histories because they are mechanically more resistant to deformation, and can thus become porphyroblasts during later shearing (in Winter, 2010). So, stretched garnet is the microscopic evidence of ductile, extensional deformation.

Field evidences of brittle-ductile deformation are observed at some paragneiss exposures in which biotite-rich layers indicate ductile deformation, whereas more quartzo-feldsapathic layers are characterized by both ductile and brittle deformation (Fig.6-A&B). In graphite marble, graphite flakes are characterized by shape-fabric orientation that indicates the ductile deformation in first phase, while dolomite crystals show brittle fragmentation that indicates brittle deformation in second phase (Fig.7-A). In phlogopite marble, cleavages of calcite crystals show slightly curved nature of ductile deformation in the first phase, while subhedral forsterite grains exhibit highly cleavable nature of brittle deformation in the second phase (Fig.7-B). These structures are the criteria for two-phase style of brittle-ductile deformation.

Figure (3). Dragfold found in calc-silicate rocks near the intrusion of leucogranitic bodies showing the field evidence of compressional deformation (Loc: N 23° 16' 20'' & E 96° 38' 15'').

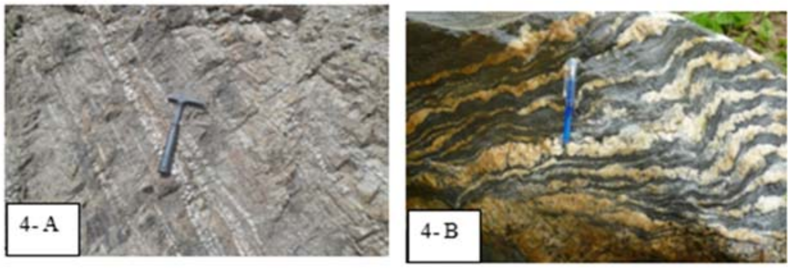

Figure (4). Field evidences of ductile deformation in Momeik-Myitson area. (A) NW-SE trending foliation planes in biotite gneiss (Loc: N 23o 08' 10''& E 96o 38' 30''). (B) Highly contorted and pinch-and-swell structure in biotite gneiss (Loc: N 23o 08' 45'' & E 96o 43' 35'').

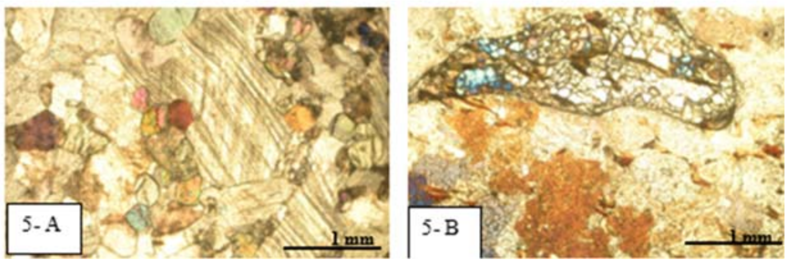

Figure (5). Microscopic evidences of ductile deformation in Momeik-Myitson area. (A)Deformation twins with tapered termination of calcite grains in diopside calc-silicate rock (B)Stretched nature of garnet porphyroblast in garnet-biotite gneiss.

Field evidences of brittle, extensional deformation indicate steeply inclined planes observed in banded calc-silicate rocks along the Shweli fault plane (Fig.8-A) and scarp faces of snistral fault observed in garnet biotite gneiss along the Mommeik fault plane (Fig.8-B).

For microscopic evidences, figure 9-A shows well-defined, cleavable nature of diopside grains in diopside marble, and sometimes in basal section these two cleavage sets intersect one another at nearly right angles. Figure 9-B shows highly fractured, xenoblastic grain of plagioclase crystal that cuts across along the foliation plane with sense of motion either NNW or SSE in biotite gneiss. The above-mentioned criteria point out that these rocks have suffered from brittle, extensional deformation.

Some facts on tectonic reviews inferred from petrological criteria

The field relationship, petrographic and petrogenetic criteria and facies series observed from metamorphic rocks of the study area help to deduce some of the tectonic reviews of the present area.

The criteria achieved from the metamorphic sequences are described below.

(1) The metamorphism which prevailed in the present area is considered as prograde regional metamorphism.

(2) Metacarbonates and metapelites occurred in close association in the field were metamorphosed to medium to high grade condition.

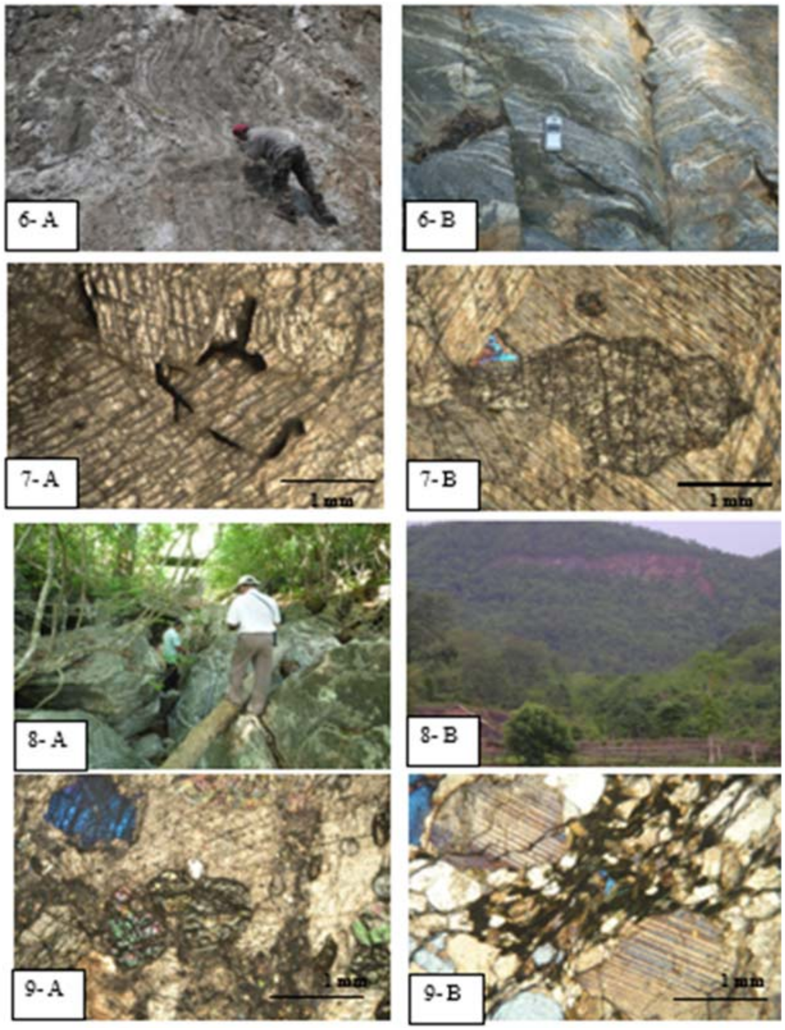

Figure (6). Field evidences showing two-phase style of brittle-ductile deformation in Momeik-Myitson area. (A) Biotite rich layer showing first phase and quartzofeldspathic layer indicating second phase in biotite gneiss (Loc: N 23^{o} 13’ 20’’ & E 96^{o} 35’ 50’’). (B) Biotite rich layer showing first phase and quartzofeldspathic layer indicating second phase in garnet-biotite gneiss(Loc: N 23^{o} 16’ 15’’ & E 96^{o} 37’ 51’’).

Fig. (7) Microscopic evidences of brittle-ductile deformation in Momeik-Myitson area. (A) Shape-fabric orientation of graphite flakes in first phase and fragmentation of dolomite crystals in second phase. Graphite marble,XN (B) Curved twin planes of calcite grain in first phase and highly cleavable nature of forsterite grain in second phase. Phlogopite marble,XN.

Fig. (8) Field evidences of brittle extensional deformation in Momeik-Myitson area. (A)Steeply inclined planes of banded calc-silicate rocks along the normal fault (Loc: N 23o 12’ 10’’ & E 96o 36’ 55’’). (B) Scarp face about half mile SE of Thayetcho village (Loc: N 23o 12’ 10’’ & E 96o 36’ 55’’).

Fig. (9) Microscopic evidences of brittle-extensional deformation in Momeik-Myitson area.(A) Well-defined, cleavable nature of diopside grains in diopside marble, XN.(B) Highly fractured, xenoblastic grain of plagioclase crystal that cuts across along the foliation plane with sense of motion either NNW or SSE in biotite gneiss,XN.

(3) Equilibrium mineral assemblages of the metamorphic rocks belong to pyroxene hornfel facies of contact metamorphism and upper amphibolite facies of regional metamorphism.

(4) Facies transitions in both metacarbonates and metapelites are similar to Buchan / Barrovian Facies series.

(5) Diagnostic mineral assemblages for the metamorphic represent the estimated temperature range between 450oC to 750oC and pressure between 3.5 to 5 kbars.

(6) Pressure – Temperature relationship in these facies series corresponds to collision tectonic zone (Bucher and Frey, 1994).

(7) Northern part is cut-off by brittle normal fault (Shweli Fault) and southern edge is cut-off by continental scale left lateral strike slip fault (Momeik Fault).

These facts collectively suggest that the protoliths were formed on sea floor first, and driven to subduction zone. After subduction had ceased and subduction suture had closed, protolith mixture encountered collision related metamorphism. Later, these metamorphics were exhumed from the lower crustal level by compressional deformation and then at near surface by brittle, extensional deformation.

The summarized table of structural and petrological criteria for the tectonic events of the study area is given in table (1).

Table (1). Summarized table of structure and petrological criteria for tectonic events of the study area.

Age		Stages of Deformation	Depth	Metamorphic Condition			Igneous Intrusion	Estimate T & P		Relationship to Plate Tectonics
				Facies	Grade	Type				
Miocene	Late	Tranpressional deformation	0-5 km	Upper Amphibolite	Medium to High	Prograde regional Metamorphism	Pegmatite&Aplite	450°C to 750°C	3.5kb To 5kb	COLLISION
	Middle	brittle extensional deformation brittle ductile deformation	5-10 km 10-15 km				Leucogranite Kabaing Granite			
	Early	ductile extensional deformation	15-30 km				possible			
Oligocene	Late									
	Early	E-W compressional deformation	>30km							
Eocene	Late									
	Middle									
	Early									

Conclusion

The research area was dominated by metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. From the field and petrographic observations, the metamorphic rocks of the study area can be encountered in four different styles of deformation: E-W compressional deformation (> 30 km depth), ductile-extensional deformation (15-30 km depth), brittle-ductile deformation (10-15 km depth), brittle-extensional deformation (5-10 km depth). The investigation of the deformational criteria might be revealed that the metamorphic rocks of the study area might have been exhumed by the extensional tectonics accompanied with E-W compressional deformation during Middle Miocene.

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