Geochemical Characteristics and Petrogenesis of the Marbles in the Momeik-Myitson Area, Momeik Township, Northern Shan State

Naing Lin*, Nu Nu Hlaing, Soe Myint***, Aye Aye Mar******

Abstract

The research area is situated in the northern adjacent part of the Momeik Town, Momeik Township, northern Shan State. It is constituted chiefly of metamorphic (metapelite, metacarbonate and metaigneous) and associated with igneous rocks. The aim of this study is to describe the petrography and investigate the geochemical characteristics of the marble units by using XRF analysis in the research area. Petrographic investigation on the mineral assemblages of the marble units in the study area indicates that the variety of marble can be classified into four types: forsterite-graphite marble, phlogopite marble, diopside marble and white marble. Geochemical characteristics of the marbles of the research area point out that they are calcitic marbles containing dolomite minerals in varying proportions and the pre-metarmorphic limestone body may be deposited in the shallow, highly saline environment prior to the metamorphism of carbonates.

Key words: Marble, Mineral assemblages, Geochemical characteristics

Introduction

The study area is situated in the northern adjacent part of the Momeik Town, Momeik Township, northern Shan State. 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 288 square kilometer with 18 km in length and 16 kilometer in width of rugged and mountainous terrains (Fig.1).

The aim of this study is to describe the petrography and investigate the geochemical characteristics of the marble units by using XRF analysis in the research area.

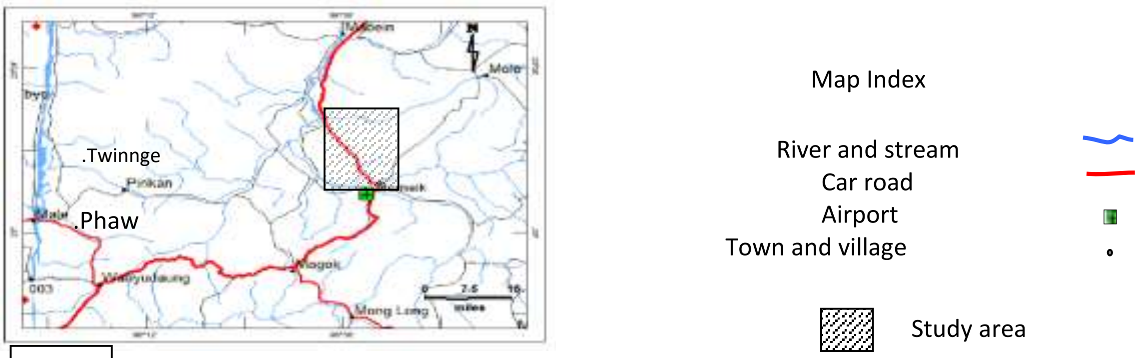


Fig-1

Fig. (1) Location map of the Momeik-Myitson area

Materials & Methods

* Professor, Dr, Department of Geology, Yadanabon University

** Demonstrator, Department of Geology, Yadanabon University

*** Lecturer, Department of Geology, Yadanabon University

**** Associate Professor, Department of Geology, Yadanabon University

A detailed geological field investigation of lithologic contacts, structural trends, foliation and fault criteria was recorded with the aid of GPS and compass, and plotted on the base map. In the field, fresh representative samples were systematically collected from various rock units. Detailed mineralogical characters, textural features and other petrological criteria of representative rock samples were systematically studied under a petrographic microscope. Petrochemical analyses of representative rock types were determined by X-ray fluorescence spectrometry (XRF) method.

Distributions of the Petrographic Units

The most abundant metamorphic rocks occupied in this area are 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 in central and northern parts of the area.

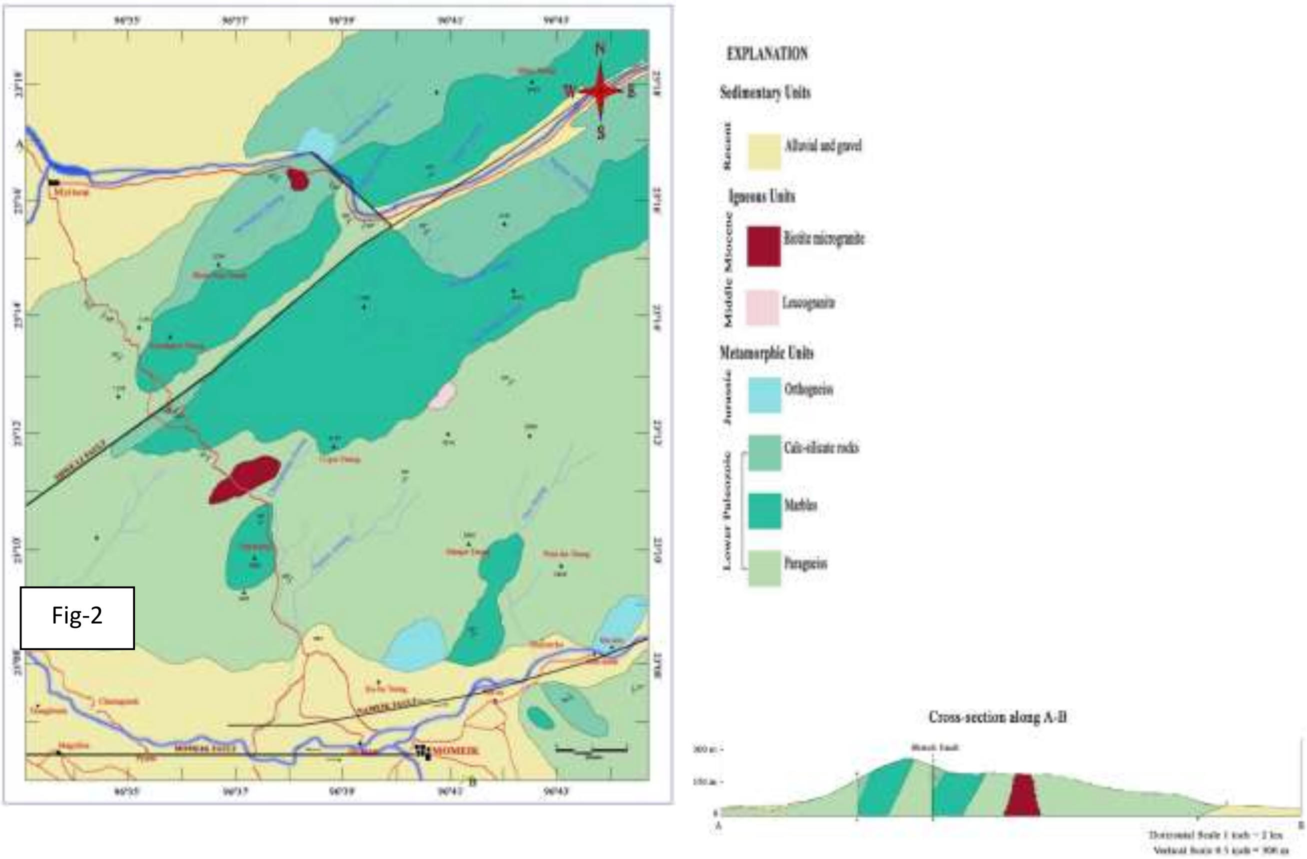


Fig. (2) Geological map of the Momeik-Myitson area

Depending upon the available field relationship, structural and stratigraphic evidences, the rock sequence arranged in descending order in age is shown in Table (1) and their distributions are shown in geological map of the study area in Figure (2).

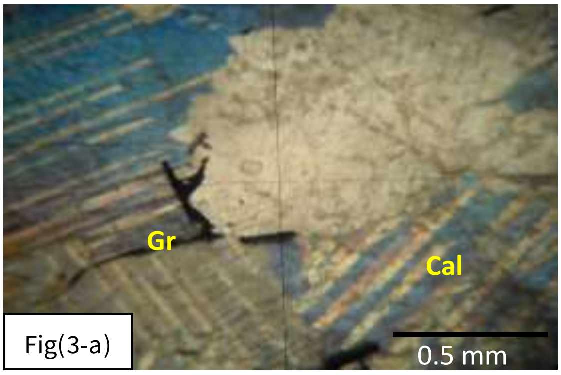
Table (1) Rock sequence of the Momeik-Myitson area

	Lithologic Units		**Age**
	Sedimentary Unit		
	Alluvium and gravely soil		Recent
	Igneous Unit		
	Biotite microgranite		Miocene
	Leucogranite		
	Tourmaline granite		
	Metamorphic Unit		
Metagranitoid	Biotite Gneiss	Unconformity	Late Jurassic-Early Cretaceous
	Skarn rock		Early Paleozoic
Metapsammite and metapelite	Quartzite		
	Biotite Schist		
	Silliminite Schist		
Metacarbonat	White Marble		
	Diopside Marble		
	Diopside calc-silicate rocks		
	Phlogopite Marble		
	Forsterite-graphite Marble		
Paragneiss	Biotite gneiss		
	Garnet-biotite gneiss		

Results

Petrography of forsterite-graphite marble

Under the microscope, the constituent minerals are calcite, graphite, forsterite, corundum and scapolite. Graphite flakes are randomly impregnated in excellent twin lamellae of calcite grains which usually display bright interference colors (Fig.3a). Six-sided form of pink colour corundum crystal has no cleavage but has rhombohedral partings and very high relief. Forsterite occurs as subhedral crystal with irregular fractures and cleavage planes that suggest these might have occurred during deformation (Fig.3b).



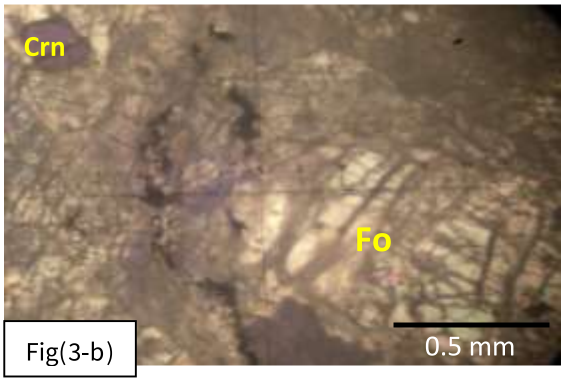
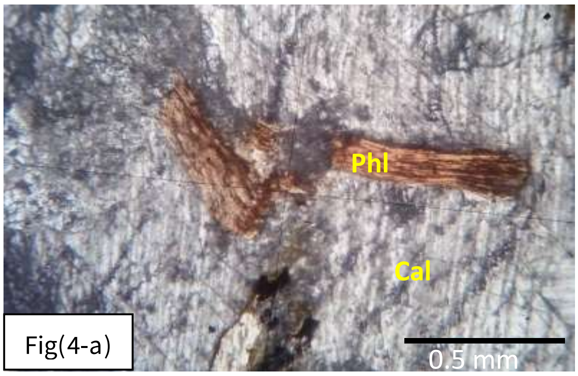


Fig. (3a) Randomly impregnated graphite rods and twin lamellae of calcite showing bright interference colour in forsterite-graphite marble. (XN)

Fig. (3b) Six-sided corundum crystal and subhedral forsterite crystal recognized by its cleavage planes and irregular fracture in forsterite-graphite marble. (XN)

Petrography of Phlogopite marble

Microscopically, the major constituents of this marble are calcite, phlogopite, forsterite and graphite. Phlogopite mineral shows bent and fractured flake due to latter effect caused by additional stress during metamorphism (Fig.4-a). Moreover, calcite crystals show slightly curved nature and subhedral forsterite grains exhibit highly cleavable nature (Fig.4-b). These characters indicate that this rock has suffered from different styles of deformations during metamorphism.



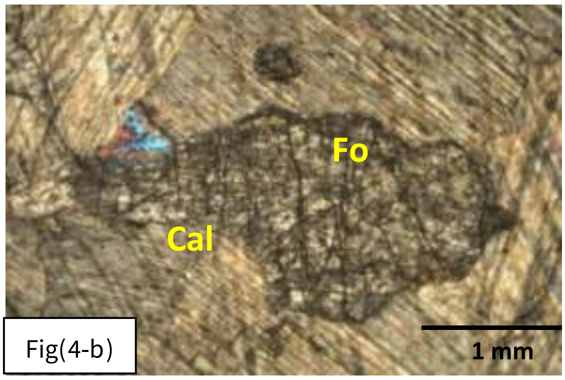
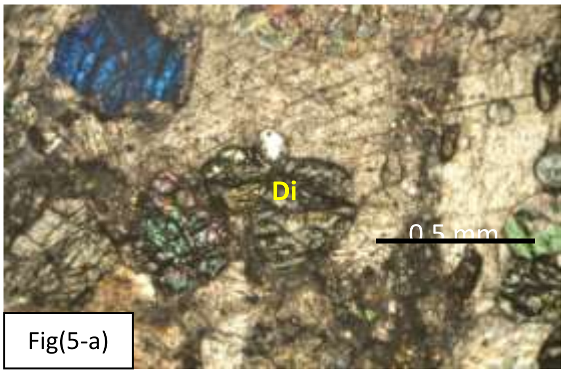


Fig. (4-a) Long prismatic form of phlogopite crystal showing bent cleavage and fracturing in phlogopite marble. (PPL)

Fig. (4-b) Photomicrograph showing curved twin planes of calcite grain and highly cleavable nature of forsterite grain in phlogopite marble. (XN)

Petrography of Diopside marble

Microscopically, the chief constituent minerals are calcite and diopside. There is a minor amount of graphite, scapolite and sphene. The rock shows granoblastic texture. Diopside grains occur as rounded and idioblastic to xenoblastic grains in most thin sections. They are also observed as well-defined, cleavable nature, disseminated and randomly oriented grains (Fig.5-a). In certain specimens, the transformation of tremolite to diopside can be recognized (Fig.5-b).



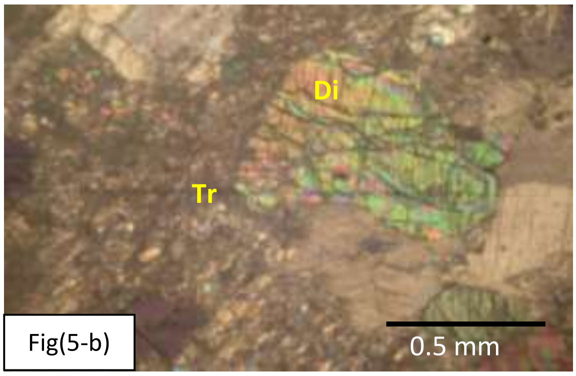
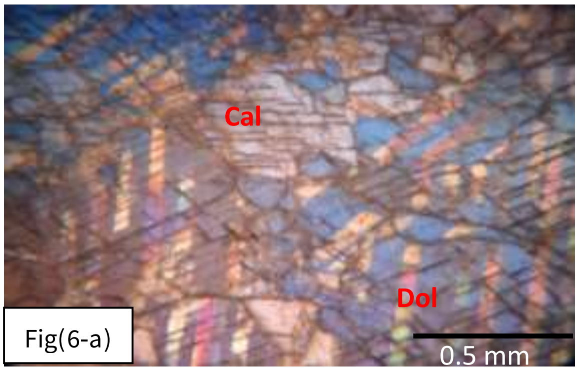


Fig. (5-a) Photomicrograph showing well-defined, cleavable nature, disseminated and randomly oriented diopside grains in diopside marble. (XN)

Fig. (5-b) Photomicrograph showing the transformation of tremolite to diopside in diopside marble. (XN)

Petrography of White marble

Under the microscope, white marble is mainly composed of calcite with very few amounts of dolomite, graphite, apatite and corundum. Most of these grains are fractured, stretched, and the distinct rhombohedral cleavage can be well-observed. Dolomite crystals whose twin lamellae are parallel to short diagonal of rhombohedral cleavage are fairly found in this rock (Fig.6-a). The frequent deformation on the traces of polysynthetic twining are indicative of some metamorphic stress. The mosaic of anhedral to subhedral grains of calcite gives granoblastic texture with abundant triple points of straight boundaries, indicating a close approach to textural equilibrium (Fig.6-b).



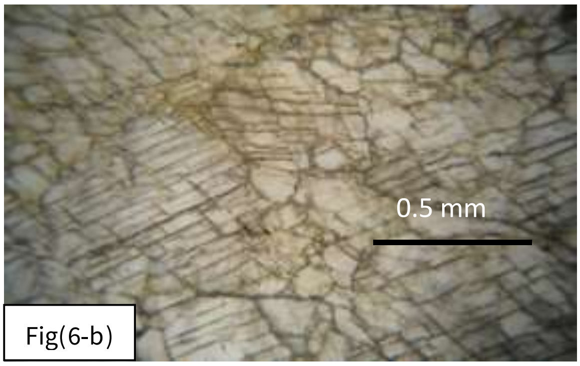


Fig. (6-a) Photomicrograph showing dolomite crystal recognized by the parallelism of twin lamellae to the short diagonal rhombohedral cleavage in white marble. (XN)

Fig. (6-b) Photomicrograph showing granoblastic texture with abundant triple points of straight boundaries observed in white marble. (XN)

Geochemistry of Marbles

In order to determine the major elements composition of the marble, X-Ray Fluorescence (XRF) Spectrometric analysis of marble samples was carried out. Major element oxides determined include SiO_2, CaO, MgO, Al_2O_3, Na_2O, K_2O and total Fe as Fe_2O_3. Loss on ignition (LOI) of the marble samples was determined before XRF analysis. The chemical data of the major elements oxides determined from the XRF analysis of the marble are presented in Table 2.

Table 2. Major elements compositions of marbles of the Momeik-Myitson Area (Results from XRF)

	Marble Samples			
Major element oxides (%)	**Nl-1**	**Nl-2**	**Nl-3**	Average values
SiO_2	7.24	3.02	2.02	4.09
TiO_2	0.02	0	0	0.01
Al_2O_3	0.13	0.29	0.35	0.26
FeO	1.12	0.36	0.12	0.53
MnO	0.03	0	0	0.01
MgO	10.78	2.04	17.45	10.09
CaO	45.65	52.03	40.83	46.17
Na_2O	0.14	0.03	0.07	0.08
K_2O	0.75	0.01	0	0.25
P_2O_5	0.01	0	0	0
LOI	33.5	41.65	38.39	37.85
Total	99.37	99.43	99.23	99.34

A. CaO/ MgO Content

CaO and MgO are the most important elemental oxides in most carbonates of metamorphic terrain. In calcitic type marble, CaO is usually in the order 50 – 54 % while MgO is < 15 %. Dolomitic or Magnesium type marble on the other hand have CaO values generally in the range of 28-31% and MgO values in the range of 15-21% [Goldschmidt *et. al*,]. A value of MgO greater than 1% in limestone suggests that the mineral dolomite is present [Brownflow]. The marble samples from the study area have a higher CaO content ranging from 40.83 % - 52.03 %. These samples also have a relatively high MgO content (Table-2). The MgO content in the marble bodies ranges from 2.04 % - 17.45 %. The average ratio of CaO to MgO in the marble bodies is 5:1 respectively. The mean contents of CaO and MgO for the marbles are in the range 46 % to 10 %. Thus, the marbles from the present area are calcitic marbles containing dolomite crystals in varying proportions.

B. Silica Content

Silica in carbonate rocks is contributed from both silicate minerals and chert nodules resulting from the influx of near shore materials into the basin of deposition of the original limestone body prior to metamorphism [Brownflow]. The silica content in the marble samples varies widely. It ranges from 2.02 % to 7.24 % (average value = 4.09 %) in Table 2. The relatively higher content of silica in marbles can be attributed to the relatively shallower depth of deposition of the pre-metamorphic limestone body.

C. Alkali (Na_2O + K_2O) Content

The alkali elements, such as Na and K, which are indicative of salinity level have been very useful in interpreting depositional and lithification conditions prior to metamorphism of carbonates (Land and Hopp). The concentration of the total alkalis (Na_2O + K_2O) in the marbles of the Momeik-Myitson area is very low, generally less than 1% (Table 2). According to Clarke (1924), Na and K concentrations in marbles tend to decrease with increase in salinity. The low values of total alkali content in the marbles of the Momeik-Myitson area indicate that the environment of deposition of the original carbonate materials that were metamorphosed to marbles in the Momeik-Myitson area must have been a shallow, highly saline environment.

D. Other oxides (Al_2O_3 and FeO)

The other oxides (Al_2O_3 and FeO) are generally low and less than 1%, and it may be an indication of the absence of aluminosilicates in the marbles.

E. Loss on Ignition (LOI)

L.O.I. reflects the content of volatiles (CO_2, H_2O) present in the marble bodies. The average values of L.O.I of the marbles in the Momeik area are 33.5% to 41.65%. In general, L.O.I values are high. This indicates high volatile content and by implication high carbonate content since it is synonymous with the evolvement of carbon dioxide after heating at 900^0C [Olatunji]. Higher L.O.I value has higher carbonate content than lower L.O.I value.

F. Trace Element Geochemistry

Since some sedimentary rocks have unique assemblages of trace elements, a study of these elements in metamorphic rocks provides a unique way to guess the nature of the premetamorphic material. Immobile trace elements such as the Rare-Earth Elements (REE) and the High Field Strength elements (HFS) are important for provenance determination of pelitic rocks [Taylor and

McLennan] because their concentrations often reflect those of their source rock. Most of the rare elements are more abundant in shales than in sandstones and limestones [Konrad et al]. The major exceptions are strontium and manganese, which are markedly enriched in carbonate sediments. The enrichment of strontium in limestone is accounted for by the fact that Sr^{2+} substitutes readily for the very similar ion Ca^{2+}. The smaller but appreciable concentration of zinc in carbonates is probably also attributable to similarity in ionic size.

A comparism of the trace elements (Ni, Cr, Zn and Sr) content in the Momeik marbles with that in sedimentary carbonates (the protolith of marbles), is shown in Table 3.

Table 3. A comparism of some trace elements of Momeik marbles with those of carbonate rocks

Trace elements (ppm)	Marbles				Carbonates rocks (Turekian and Wedepohl,1961)	
	Nl-1	Nl-2	Nl-3	Average values	Shallow Sea	Deep Sea
Ni	0.00	2.01	0.00	0.67	20	30
Cr	0.00	0.00	0.00	0.00	11	11
Zn	0.02	0.01	0.00	0.01	20	35
Sr	258.01	213.00	126.00	199.00	610	2000

The Sr content in the marbles of the research area ranges from 126 to 258 ppm with an average value of 199 ppm (Table-3). The Sr content in the marbles is lower than that of carbonates. The Zn content is also much lower than those in carbonates. The low content of Sr and Zn in the marbles of the research area is related to the substitution of Sr and Zn by Ca during the recrystallization of the mineral grains at higher temperatures. The concentration of the immobile elements (Ni and Cr) in the marbles of the research area is relatively low compared to that in carbonates (Table-3). The concentrations of Ni and Cr in the marble therefore reflect those of their source rocks.

G. Variation Diagrams

A series of major element oxide plots for the Momeik marbles is presented in Figs. 7-11. Plots of Na_2O+K_2O, CaO, MgO, FeO vs. SiO_2 were carried out for the Momeik marbles. SiO_2 was used as abscissa in these plots because it shows substantial variations among the marbles.

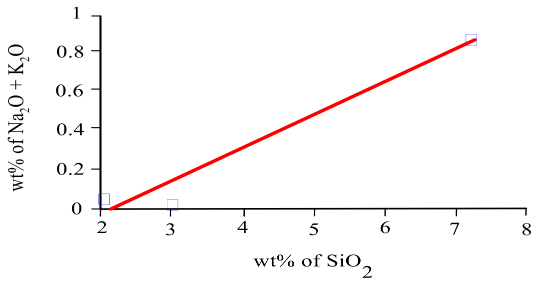


Fig. (7) SiO_2 Vs. Na_2O+K_2O variation diagram showing positive trend for Momeik marbles

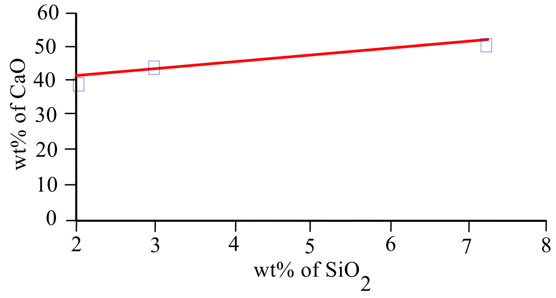


Fig. (8) SiO_2 Vs. CaO variation diagram showing positive trend for Momeik marbles

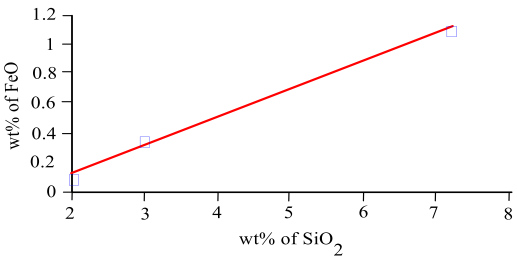


Fig. (9) SiO_2 Vs. FeO variation diagram showing positive trend for Momeik marbles

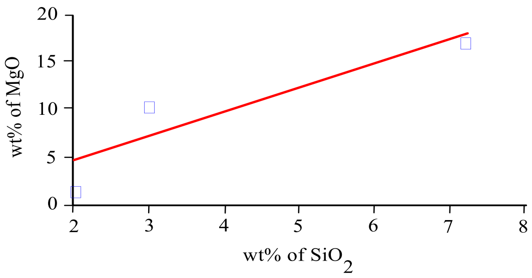


Fig. (10) SiO_2 Vs. MgO variation diagram showing positive trend for Momeik

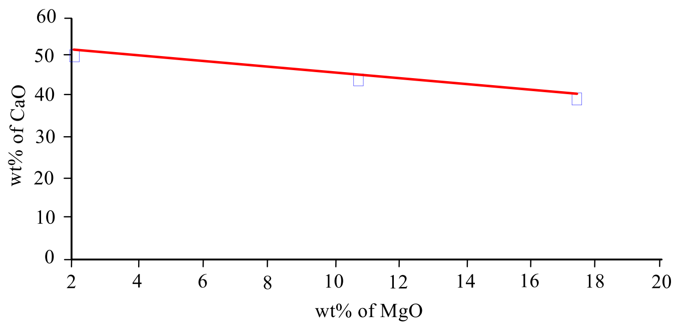


Fig. (11) CaO Vs. MgO variation diagram showing negative trend for Momeik

These variation diagram plots for the marble units show similar positive trends with SiO_2 (Figs.7-10), and these reflect the introduction of chert during the deposition of the protolith (limestone) of the marble body. The variation plot of CaO vs. MgO (Fig.11) shows negative relationship. This is reflected in the inverse relationship in the proportion of calcite to dolomite in the marble.

Discussion

Petrographic investigation on the mineral assemblages of the marble units in the study area indicates that the variety of marble contain more calcitic minerals than dolomitic minerals. This observation is in line with geochemical results in Momeik marbles. Geochemical data observed in marble units of the research area indicate that they are calcitic marbles containing dolomite minerals in varying proportions and the pre-metarmorphic limestone body may be deposited in the shallow, highly saline environment prior to the metamorphism of carbonates.

Conclusion

The study area which forms part of the northern continuation of the Mogok Metamorphic Belt occupies the northern part of Momeik Town in Momeik Township, northern Shan State. The research area is mainly composed of metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. Based on microscopic examination, various types of marbles can be classified into four types: forsterite-graphite marble, phlogopite marble, diopside marble and white marble. Based on geochemical data, CaO and MgO contents for the marbles indicate that they are calcitic marbles containing dolomite crystals in varying proportions. The low values of total alkali content and high contents of SiO2 point out that the depositional environment of the protolith of the marble units of the study area must have been a shallow, highly saline environment. The low content of Sr and Zn in the marbles of the research area is related to the substitution of Sr and Zn by Ca during the recrystallization of the mineral grains at higher temperatures.

Acknoledgements

I would like to thank to Rector Dr Tint Moe Thuzar, Yadanabon University for allowing me to contribute this research paper. I would also like to express my gratitude to Professor Dr Hnin Hnin Htay, Head of Geology Department in Yadanabon University for her kind permission to carry out this work.

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