GEOCHEMICAL FEATURES AND ECONOMIC ASPECTS OF ORDOVICIAN LIMESTONES EXPOSED AROUND THE MYOGYI AREA, YWANGAN TOWNSHIP, SOUTHERN SHAN STATE

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Abstract

The study area lies in the Myogyi village, Ywangan Township, southern Shan State. It is located about 48 miles west of Ywangan Township and situated along the Kyaukse-Ywangan Motor car road. It is bounded by latitudes 21° 26′ N to 21° 30′ N and longitudes 96° 15′ E to 96° 25′ E in one inch topographic map 93 C/7. The age of the Lokepyin Formation can be assigned as Early Ordovician. The Wunbye Formation is well exposed at the southeast of Bodawgyi Taung. The age of the Wunbye Formation can be assigned as middle Ordovician. According to XRF data, limestone samples of Wunbye Formation, showed a reasonably high composition of CaO compounds, about 35.0% - 83.6%. Two limestone samples were classified as good quality (CaO content >49%). Metagreywacke, schist and slate of the Chaung Magyi Group and limestones of the Wunbye Formation can be used as decorative stones and construction materials. The dark blue of limestones especially from those of the Wunbye Formation used a road material.

Keywords: Lokepyin Formation, Wunbye Formation, Ordovician

Introduction

The study area lies in the Myogyi village, Ywangan Township, southern Shan State. It is located about 48 miles west of Ywangan Township and situated along the Kyaukse-Ywangan Motor car road. It is bounded by latitudes 21° 26′ N to 21° 30′ N and longitudes 96° 15′ E to 96° 25′ E in one inch topographic map 93 C/7. During 10th June to 15th June 2025, field studies had been made in the study area.

Geochemistry

Ordovician limestones of Lokepyin Formation and Wunbye Formation occurred in the study area. The aim of this study is to examine the petrographic and geochemical features of the carbonates in the Lokepyin Formation and Wunbye Formation. Mineralogy and geochemical components, such as the major oxide compounds (SiO_2, $Al2O_3$, CaO, MgO, and Na_2O) present in the Ordovician limestones of Lokepyin Formation and Wunbye Formation, will be used to determine the characteristics of the limestone of the Lokepyin Formation and Wunbye Formation.

According to XRF data, limestone samples of Wunbye Formation, showed a reasonably high composition of CaO compounds, about 35.0% - 83.6%. Two limestone samples were classified as good quality (CaO content >49%) (Qodri et al., 2023). One limestone sample of Wunbye Formation showed low composition of CaO compounds, about 35.0 %and two limestone samples of Lokepyin Formation, showed a low composition of CaO compounds, about 29.4 % and 38.2 %,poor quality limestones.

Geological Condition

The name "Lokepyin Formation" is named after the Lokepyin village situated about four miles northeast of Myaing in Ywangan Township. Myint Lwin Thein (1973) first named the Lokepyin Formation. It is well exposed at Ywathit village and

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Yethayauk village car road. The unit has general trend of NNW-SSE and dips to the west with angles ranging from 30° to 60°. The Lokepyin Formation consists of medium bedded, yellowish brown argillaceous limestone, thin to medium bedded grey to pinkish limestone, dolomitic limestone and ferrugineous siltstones, where it was deposited above the Wunbye Formation (Figure 1 a, b). The Lokepyin Formation is Early Ordovician in age (Myint Lwin Thein, 1973). The depositional environment is a shallow marine, open shelf environment (Win Naing, 1991).

The name "Wunbye Formation" is named by Myint Lwin Thein (1973) after the Wunbye Hill, located about two miles southwest of Linwe village in Ywangan Township. It is well exposed at Pa Dauk Tat village, Pyaukseikpin village and at the southeast of Bodawgyi Taung. It consists of medium to thick bedded, bluish grey limestone with irregular silt parting and silt patches. The weathered surface is yellowish grey and grey on the fresh surface (Figure 2 a, b). The Wunbye Formation is Middle Ordovician in age (Myint Lwin Thein, 1973). The depositional environments are supratidal, intertidal and subtidal (Win Naing, 1991). The extremely shallow marine environment was suggested by the presence of receptaculitid algae *(Fisherites burmensis)* (Aye Ko Aung, 2006).

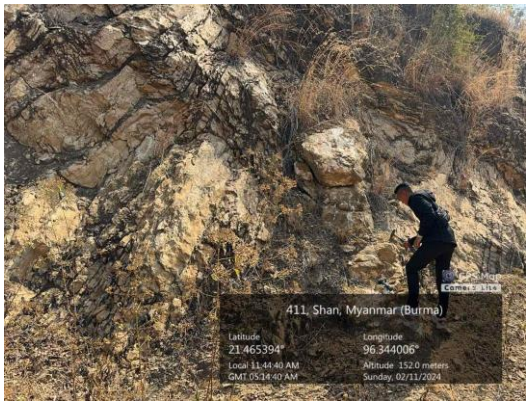

Figure 1 (a) Thin to medium-bedded grey to pinkish limestone of Lokepyin Formation at (N 21° 46', E 96° 34')

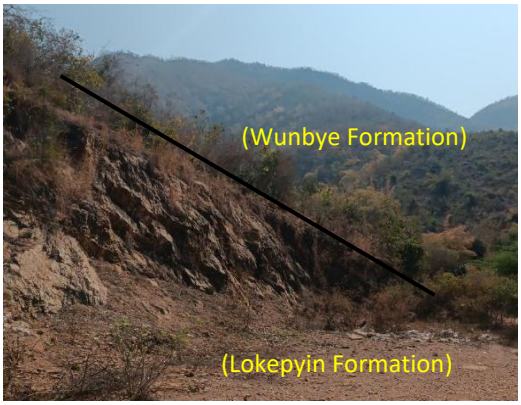

Figure 1 (b) Contact of Lokepyin Formation and Wunbye Formation occurred at (N 21° 46', E 96° 34')

Figure 2 (a) Medium to thick bedded limestone of Wunbye Formation at N 21° 28' 10", E 96° 20' 4"

Figure 2 (b) Bluish grey limestone of Wunbye Formation at N 21° 28' 9", E 96° 19' 58"

Analytical Methods

Petrographic and geochemical analyses were carried out for the data analysis stage. Petrographic analysis was carried out to determine the mineralogy and then geochemical analysis to determine the chemical content and its percentage. The outcrop sampling was based on the colour and texture differences of the limestone.

In the laboratory analysis, rock thin section was observed using a polarizing microscope to identify the existing limestone. Chemical content analysis was carried out using the X-ray Fluorescence method. The X-Ray Fluorescence method was chosen because this method is easy, fast, inexpensive, and has sufficient precision to determine the chemical content of the rock under study. Petrography and geochemical sampling was carried out on two limestone samples of Lokepyin Formation and three limestone samples of Wunbye Formation at the study area.

The major oxide data in figure (3) and table (1) show that Ordovician limestones of Lokepyin Formation and Wunbye Formation in the study area. Limestones of Lokepyin Formation contain CaO concentration that ranges from 29.4 and38.2 wt.%, SiO_2 39.2and41.5 wt.%, MgO 0.873 and 1.37 wt.%, Al_2O_3 9.6 and 10.1 wt.%, TiO_2 0.904 and 0.981 wt.%, P_2O_5 0.749 and 0.779 wt.%, K_2O 3.23 and 3.46 wt.%, MnO 0.121 and0.147 wt.%. Yellowish brown color limestones of Lokepyin Formation are high Fe_2O_3 6.29 and 9.36 wt. %. One limestone sample contains Na_2O 3.64 wt. %. Na_2O value is depleted in one limestone sample of Lokepyin Formation.

Limestones of Wunbye Formation contain CaO concentration that ranges from 54.4 - 83.6 wt.%, SiO_2 8.33 - 54.4 wt.%, MgO 0.61–2.42 wt.%, Al_2O_3 2.15–2.66 wt.%, Fe_2O_3 3.23–3.76 wt.%, TiO_2 0.166 - 0.206 wt.%, P_2O_5 0.507 - 0.74 wt.%, K_2O .677 - .84 wt. %, MnO 0.11 - 0.173 wt.%.Na_2O values are depleted in limestones of Wunbye Formation.

Plotting of major oxide variation (x-axis) versus major oxide concentration of the sample on y-axis uses normalization from PAAS (Post Archean Australian Shale) (Qodriet al., 2023). The plotting shows that CaO concentration of Limestones of Wunbye Formation is the highest concentration of two limestone samples (Figure 3). Two limestone samples of Wunbye Formation at the study area were classified as good quality limestone because they had CaO content >49% as a raw material for making cement.

CaO concentration in limestone is derived from limestone grains made up of organism pieces (foraminifera, algae, molluscs, corals, and so on). The presence or lack of clay minerals and other minerals that constitute the matrix in the limestone influences the levels of MgO, SiO_2, Al_2O_3, Fe_2O_3 and K_2O (Qodriet al.,2023). The geochemistry results also demonstrate that the limestones of Lokepyin Formation have low CaO content and high MgO content. In contrast, limestones of Wunbye Formation have high CaO and low MgO content. This is because the limestones of Lokepyin Formation contain fewer bioclastic and calcite minerals.

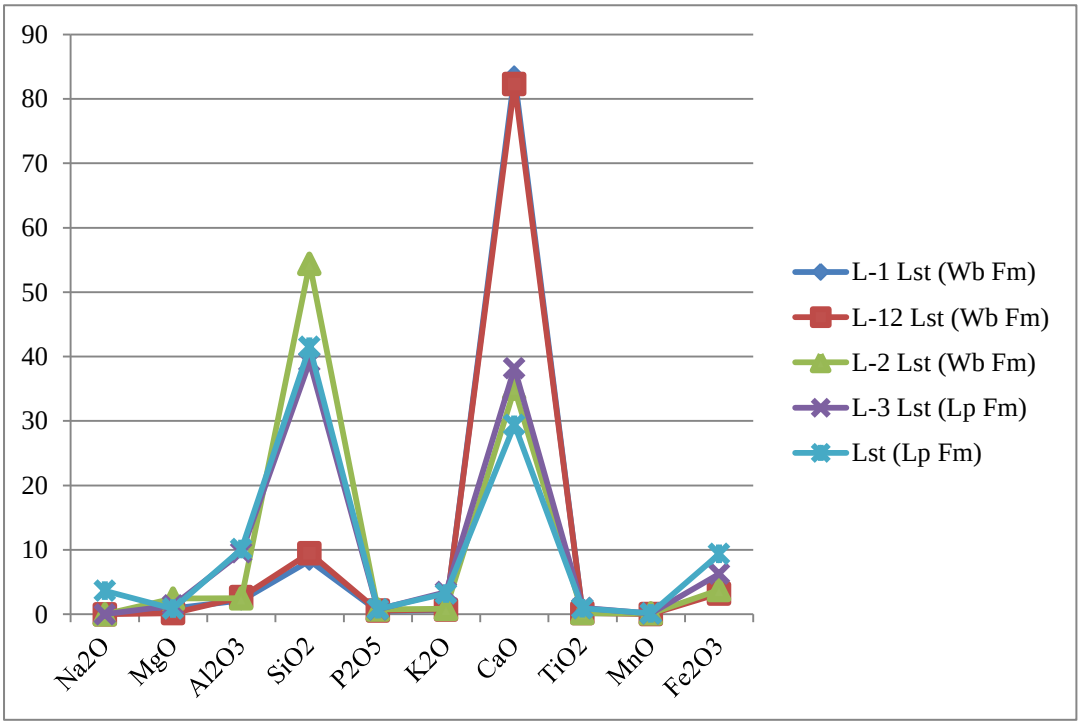

Figure 3 Normalized major oxide diagram for Ordovician limestone samples of the study area (Sources; Qodriet al., 2023)

Table 1 Major oxides composition of the Ordovician limestones in the study area

Major Oxide	L-1 Lst (Wunbye Formation)	L-12 Lst (Wunbye Formation)	L-2 Lst (Wunbye Formation)	L-3 Lst (Lokepyin Formation)	Lst (Lokepyin Formation)
Na_2O	-	-	-	-	3.64
MgO	0.889	0.173	2.42	1.37	0.873
Al_2O_3	2.15	2.66	2.49	9.6	10.1
SiO_2	8.33	9.48	54.4	39.2	41.5
P_2O_5	0.507	0.565	0.74	0.749	0.779
K2O	0.677	0.741	0.84	3.46	3.23
CaO	83.6	82.3	35.0	38.2	29.4
TiO_2	0.17	0.206	0.166	0.981	0.904
MnO	0.136	0.025	0.11	0.121	0.147
Fe_2O_3	3.56	3.23	3.76	6.29	9.36

Petrography and Dolomitization of Ordovician Limestones

In the chemical analyzes, seven samples were also determined MgO-CaO ratio. Many of the dolomites ($CaMg[CO_3]_2$) are secondary origin and formed by geochemical and tectonic factors and replacement calcite ($CaCO_3$).There are two types of carbonate by chemical data; limestone, dolomitic limestone. The rate of dolomitization is very variable and at the fracture regions, the Mg ratio increases, indicating that tectonism is the cause of dolomitization. Furthermore, the liquid which causes the dolomitization reactions interact with the lime deposits or pre-formed limestone(Yetiş et.al.,2023). Depending on the replacement process, dolomitic limestone and limestone are commonly present. Minor quantities are non-carbonated components; these are generally siliceous, iron-oxide and aluminum components. There are two types of dolomitization stages in the majority of carbonate platforms:(1) early stage (syn-sedimentary) and (2) post depositional stage. The contacts between dolomite, calcitic dolomite, dolomitic limestone and limestone are the correlations between the mineral calcite and dolomite via % MgO values (Yetiş et al. 2023). According to (Yetiş et al. 2023), there are classified into three groups of dolomite (100% - 90% dolomite crystal), calcitic dolomite (90% - 50% dolomite crystal) and dolomitic limestone (50% - 10% dolomite crystal). The dolomite crystals which are usually rombohedral-shaped in dolomitic limestone of the Wunbye Formation (Figure 4 a, b).

The Lokepyin Formation and the Wunbye Formation are deposited in a shallow marine environment (Win Naing, 1991). The Wunbye Formation consists of medium to thick bedded and massive bluish grey limestone with irregular silt parting and silt patches and dolomitic limestone. Cracks which are formed as a result of deformations are widely observed in the Wunbye Formation that is locally shown dolomitization.

Some samples were taken from the Wunbye Formation and have tectonic micro-fractures. Cracks are filled with calcite vein in dolomitic limestoneand the high amplitude stylolites found in some samples are cut tectonic fractures (Figure 5 a, b) and (Figure 6 a, b).Tectonic micro-fractures, cracks, late diagenetic stylolites are present at dolomitic limestone and limestonesin the study area (Figure 7 a, b).

Carbonate rocks are divided on the basis of dolomite content into: limestone, dolomitic limestone, calcitic limestone and dolomite (Tucker, 2001). The carbonates in the study area were primarily precipitated as limestone ($CaCO_3$) and then replaced to dolomite ($CaCO_3$,$MgCO_3$) by burial diagenesis. Dolomitization occurred with late diagenetic stages but all limestone sequence did not replace to dolomite in the Lokepyin Formation and the Wunbye Formation. Dolomitization was more intense in regions where Ca in the limestone was replaced by Mg in the direction.

The CaO-MgO graphs of the samples are given in figure (8). According to the graphs, the CaO ratio is 34.39% - 53.95% in calcitic dolomites and has low values and CaO values in the limestones can reach up to 55.21. The ratio of MgO value to calcite dolomite is 17.83%, while that value of limestone is between 0% - 1.20%.

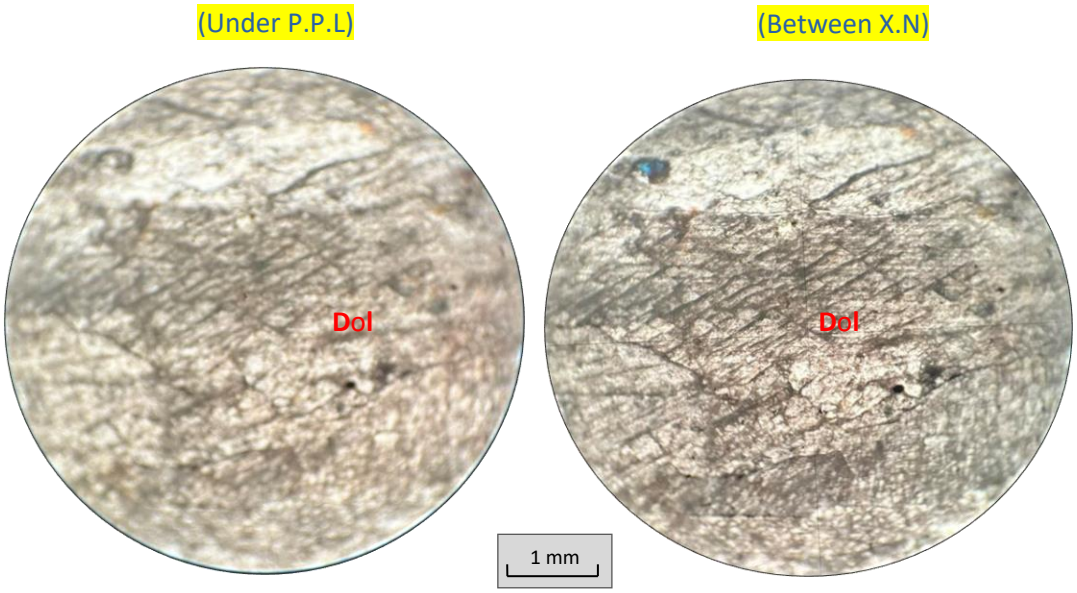

Figure 4 (a) Dolomite crystal (Dol) in the dolomitic limestone of Wunbye Formation (under P.P.L, 40X)

Figure 4 (b) Dolomite crystal (Dol) in the dolomitic limestone of Wunbye Formation (between X.N, 40X)

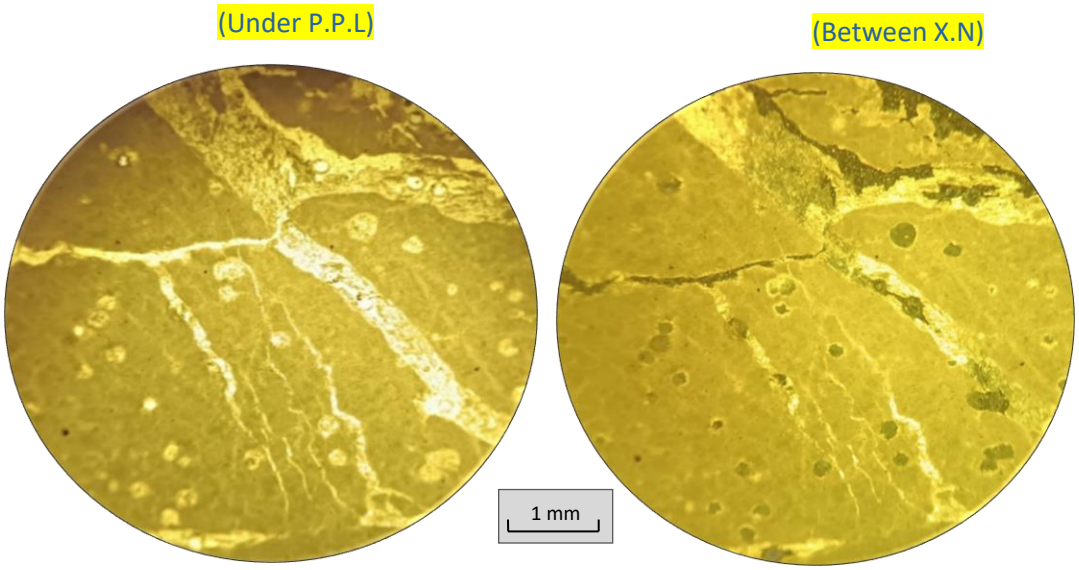

Figure 5 (a) Cracks are filled with calcite vein in dolomitic limestone of the Wunbye Formation (under P.P.L, 40X)

Figure 5 (b) Cracks are filled with calcite vein in dolomitic limestone of the Wunbye Formation (between X.N, 40X)

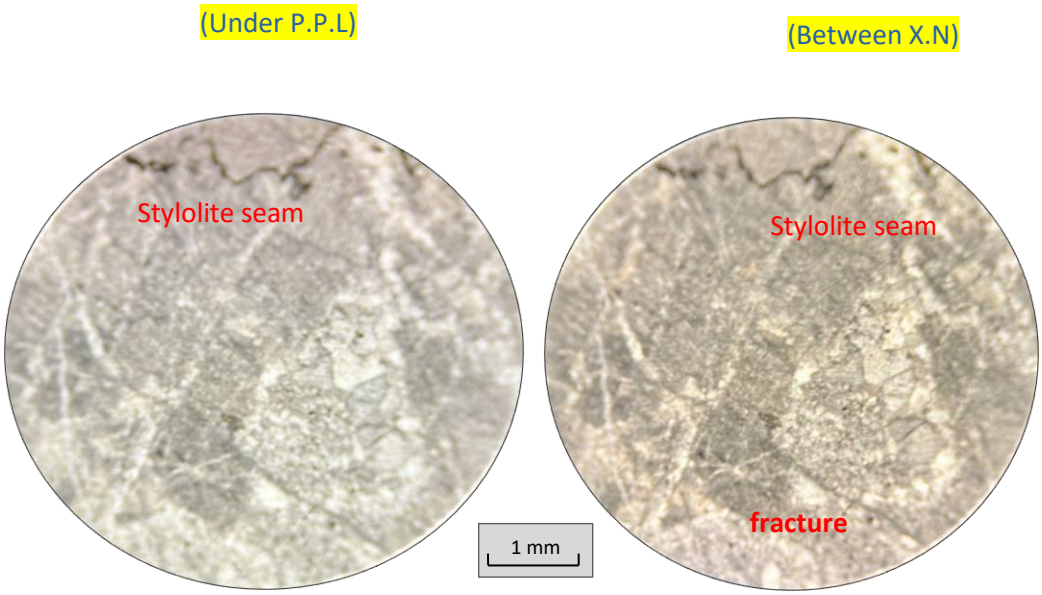

Figure 6 (a) Stylolite seam found in the dolomitic limestone of Wunbye Formation (under P.P.L, 40X)

Figure 6 (b) Stylolite seam found in the dolomitic limestone of Wunbye Formation (between X.N, 40X)

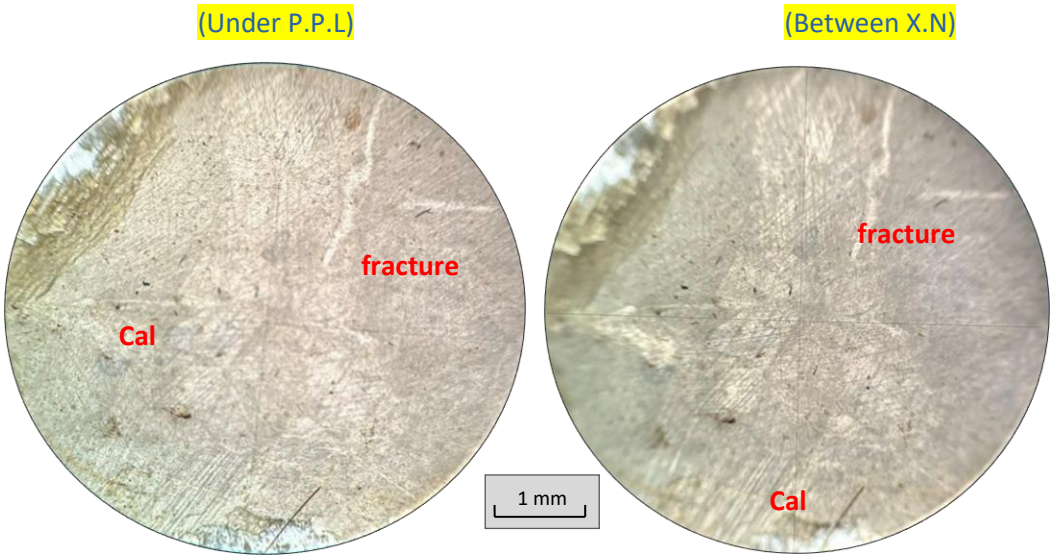

Figure 7 (a) Sparry calcite (cal) and tectonic micro-fractures occurred in the limestone of Wunbye Formation (under P.P.L, 40X)

Figure 7 (b) Sparry calcite (cal) and tectonic micro-fractures occurred in the limestone of Wunbye Formation (between X.N, 40X)

Results

The Lokepyin Formation and the Wunbye Formation are shallow marine environments. The CaO-MgO graphs of two samples of the Lokepyin Formation and the one sample of the Wunbye Formation are dolomitic limestones. However, the existence of stylolites after the sedimentation reveals the burial dolomitization (Yetiş et al. 2023). Dolomitization stages can be examined in two groups as early diagenetic and late diagenetic (subsurface burial dolomitization). The dolomites formed in the early diagenetic stage were dolomitized immediately after sedimentation by limestone replacement. The late diagenetic dolomites were formed by the replacement of limestone of Mg-rich waters after sedimentation. According to Yetiş et al. (2023),other two samples of the Wunbye Formation are limestones because of CaO values can reach up to 55.21%, (82.3% and 83.6%) and MgO values between 0% - 1.20% (0.173 % and 0.889 %).

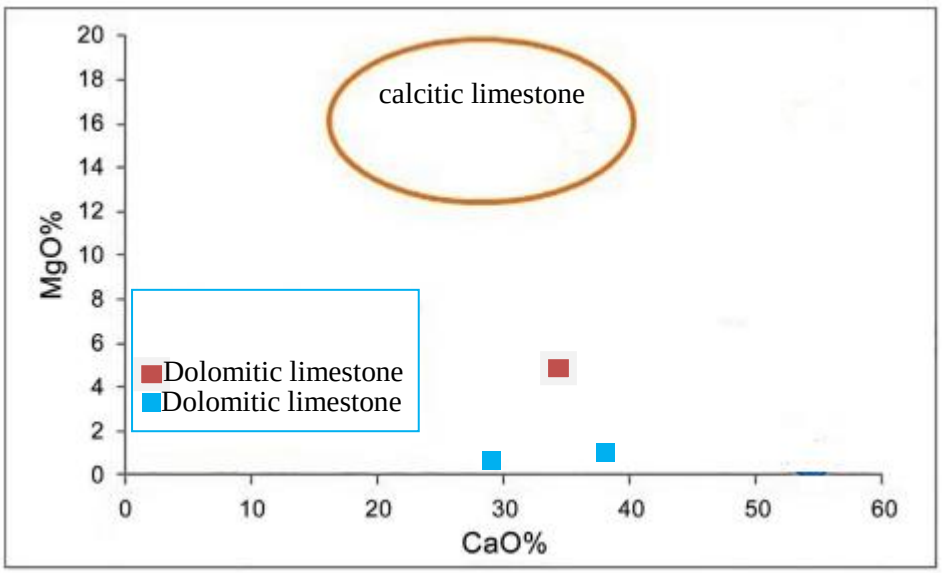

Figure 8 CaO-MgO plots of the samples limestone-dolomitic limestone and calcitic dolomite chart (Sources; Yetiş et al. 2023)

Economic Aspects

Economically, the present area is of little importance because of metasediments of the Chaung Magyi Group and limestones of the Wunbye Formation. Industrial raw materials, such as limestones are present extensively in the area. These limestones have high content of CaO.

Industrial Minerals

In the present area, limestone containing CaO more than 49% and MgO less than 2% is used to produce lime especially for cement factory and constructional works. According to above constitution, the limestones of Wunbye Formation can be used for lime baking purposed. Quartzite of the Chaung Magyi group can be used as industrial raw materials in the Hanlin Taung of the study area.

Decorative Stones and Construction Materials

Greenish metagreywacke, schist and slate of the Chaung Magyi Group can be used as decorative stones and construction materials. The dark blue of limestones especially from those of the Wunbye Formation used a road material (Figure.9 a, b).

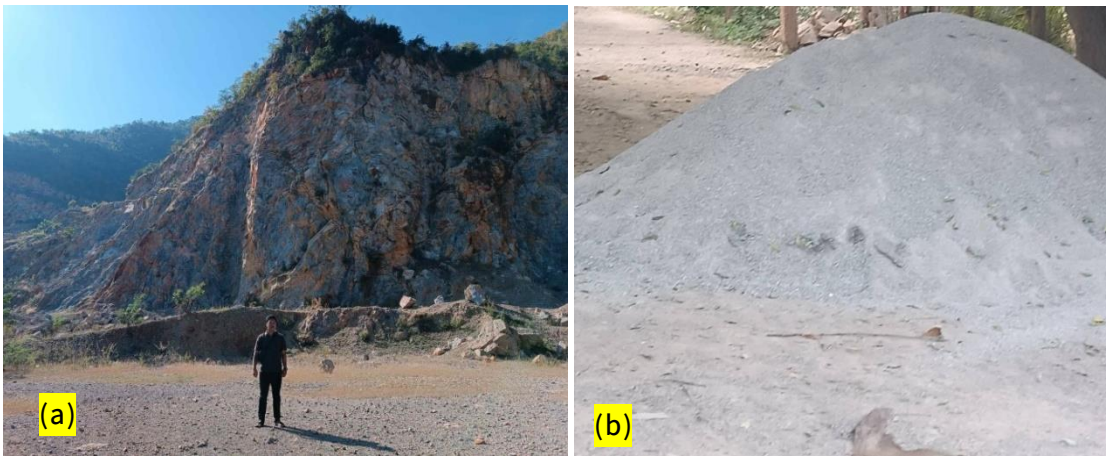

Figure 9 (a) The dark blue limestones of the Wunbye Formation **(b)** dark blue of limestones are crushed and used as road materials

Summary and Conclusion

According to XRF data, limestone samples of Wunbye Formation, showed a reasonably high composition of CaO compounds, about 35.0% - 83.6%. Two limestone samples were classified as good quality (CaO content >49%) (Qodri et al.,2023). One limestone sample of Wunbye Formation showed low composition of CaO compounds, about 35.0 %and two limestone samples of Lokepyin Formation, showed a low composition of CaO compounds, about 29.4 % and 38.2 %,poor quality limestones. The Lokepyin Formation and the Wunbye Formationare are shallow marine environments. The CaO-MgO graphs of two samples of the Lokepyin Formation and the one sample of the Wunbye Formation are dolomitic limestones. However, the existence of stylolites after the sedimentation reveals the burial dolomitization (Yetiş et al. 2023). According to Yetiş et al. (2023), other two samples

of the Wunbye Formation are limestones because of CaO values can reach up to 55.21%, (82.3% and 83.6%) and MgO values between 0% - 1.20% (0.173 % and 0.889 %).

The small occurrences of base metals ore, however, have been observed in metasediments of the Chaung Magyi Group and limestones of the Wunbye Formation. Industrial raw materials, such as limestones are present extensively in the area. These limestones have high content of CaO. Greenish metagreywacke, schist and slate of the Chaung Magyi Group can be used as decorative stones and construction materials. The dark blue of limestones especially from those of the Wunbye Formation used a road material.

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