Carbonate rocks-hosted Lead Mineralization in Mogyo Taung – Thapanbin Area, Ywangan Township, Shan State (South), Myanmar

Thein Min Swe[1], May Thwe Aye[2], Han Sein[3], Than Htay[4]

Abstract

Mogyo Taung-Thapanbin area lies in Ywangan Township, Taunggyi District, Shan State (South). Regionally, the Precambrian rocks of Chaungmagyi Group are surrounded by Early Paleozoic rocks. The study area is located in the northwestern part of Pindaya Range that lies in the southwestern part of the Shan Plateau. Sedimentary rocks of the Lokepyin Formation, Wunbye Formation, Nan-on Formation of Pindaya Group (Ordovician age) and Linwe Formation, Wabya Formation of Mibayataung Group (Silurian age) cropped out in the study area. The lead mineralization is confined to the carbonate rocks of Wunbye Formation of Middle Ordovician age. Absence of igneous rocks is conspicuous. Two types of wallrock alteration are dolomitization as the main alteration, and silicification as subordinate, which predate the ore mineralization. The ore mineralogy is relatively simple. The major ore minerals are galena and barite, and its associated minerals are sphalerite, pyrite, chalcopyrite, covellite and anglesite. The gangue minerals are calcite, dolomite and quartz. Lead mineralizations are localized by both structural and lithostratigraphical controls. Based on the geological, geochemical and mineralogical characteristics, the lead mineralizations in the study area are carbonate rocks-hosted, stratabound deposits, and epigenetic in origin and may be regarded as one of the sub-types of the Mississippi Valley-Type (MVT) deposits.

Keywords: Lead mineralization, Structural and Lithostratigraphical controls, carbonated-hosted stratabond, Epigenetic, Mississippi Valley Type (MVT)

Introduction

Geological studies and mineral exploration have been conducted near Ywangan and its surrounding area since 1932. In the past, there was no systematic exploration. The first systematic investigation on the lead mineralization of Ywangan area was conducted by Professor Ba Than Haq *et al.*, in 1969. In 1970, geologists from the Institute of Geological Sciences (I.G.S) investigated for four months to evaluate the potential mineral resource of the Ywangan area.

The study area is located about 20 kilometres northeast of Ywangan, Ywangan Township in Shan State (South) (Fig. 1). It covers about 25 square kilometres in Universal Traverse Mercator map sheet no. 2196 11 (Topographic map sheet no. 93C/11). It lies within the vertical grids 47Q 243000E to 47Q 248000E and horizontal grids 47Q 2352000N to 47Q 2357000N in Universal Traverse Mercator sheet no. 2196 11. It also lies within north latitude 21°15´43´´ to 21°17´52´´and east longitude 96°32´12´´ to 96°34´17´´. This paper presents mineralization as well as ore mineralogy, wallrock alteration, and geochemical characteristics of lead mineralization.

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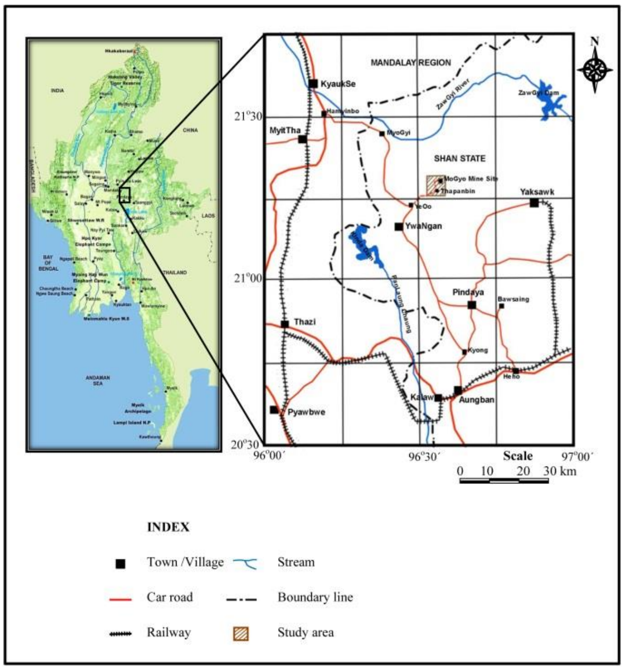


Figure (1). Location map of Mogyo Taung-Thapanbin area

Geology

Regional Geology

In regional view, the area has various formations, ranging in age from Precambrian to Tertiary. The regional stratigraphy of around the study area was defined by Myint Lwin Thein (1973) who recognized a series of Lower Paleozoic rocks. The Precambrian rock unit, Chaungmagyi Group is exposed in the north of study area. In the areas of central and northern part of the Pindaya range, Molohein Group is extensively developed, the flank and southern portions occupied by the rocks of Pindaya Group, Mibayataung Group, limestones and dolomites of Plateau Limestone Group**.** Further southern part, the lower Paleozoic rocks and the Mesozoic rocks of Kalaw Red Bed are exposed. Irrawaddian Formation (Miocene to Pliocene) has exposed in the western part of the study area.

Geology of the Study Area

The study area is located in the northwestern part of Pindaya range. The study area comprises the Pindaya Group (Ordovician age) and Mibayataung Group (Silurian age). The stratigraphic classification of the study area is adopted from Myint Lwin Thein (1973) for Lower Paleozoic rocks. In the study area, Lokepyin Formation, Wunbye Formation, Nan-on Formation of Pindaya Group, and Linwe Formation, Wabya Formation of Mibayataung Group have been observed. Most of trends are N-S and NNE-SSW with dipping toward the E. Major lineament, Karani fault, trends N-S and some lineaments trend NNW-SSE and SSW-NNE that oblique this major lineament. The present work deals with the rocks of Wunbye Formation of the Middle Ordovicain age. Geological map of the study area is shown in figure (2) and stratigraphic succession of the present study area is shown in table (1).

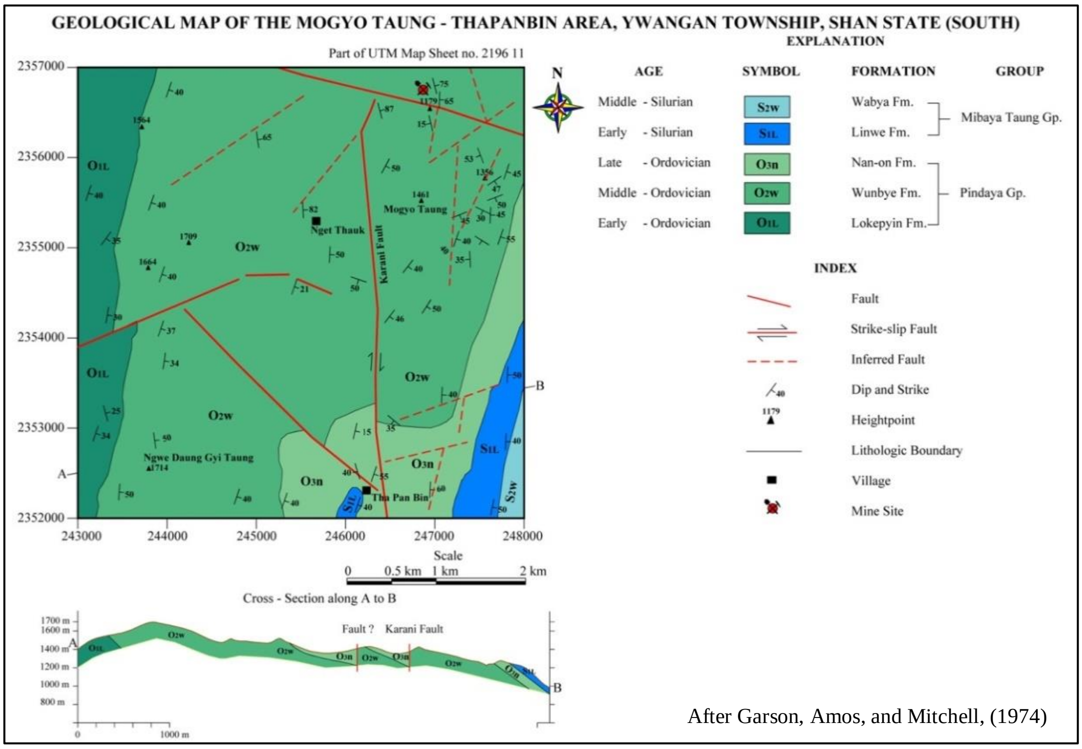


Figure (2). Geological Map of the Mogyo Taung – Thapanbin Area

Table (1). Stratigraphic succession of the study area (After Myint Lwin Thein, 1973)

Group	Formation	Age	Lithology
Mibaya Taung	Wabya	Middle Silurian	Light grey coloured silty shale
	Linwe	Early Silurian	Pinkish grey and reddish brown coloured phacoidal limestone
Pindaya	Nan-on	Late Ordovician	Yellow to buff coloured, liminated silt stone and mudstone
	Wunbye	Middle Ordovician	Grey to dark grey coloured, fine-grained to micritic, silt parting and burrow nature limestone
	Lokepyin	Early Ordovician	Grey to buff colour (fresh) or brightly yellow colour (weathered), medium to thick bedded, fine-grained silt stone and silty mudstone

Mineralization

In the study area, lead mineralization is generally found as veins, veinlets, and disseminations in limestone and dolomitic limestone, and irregular patches to massive aggregates in barite. It is commonly found with deposits of other minerals, such as sphalerite, pyrite, chalcopyrite and barite. The gangue minerals are calcite, dolomite and quartz.

Nature of Lead Mineralization

In the study area, lead ore occurs as types of fracture fillings, disseminations and open-space fillings, and found in limestones of Wunbye Formation (Ordovician age). Galena (lead sulphide) is hosted mostly in oolitic limestone and dolomitic limestone, and also occurred in barite veins in the study area. Lead mineralization occurs as; 1) dissemination, 2) fracture-filling or open space filling, and 3) replacement as shown in figure (3).

There are three occurrences of lead mineralization in the study area; 1) Mogyo Taung lead deposits 2) Ingyinyay Taung lead mineralization and 3) Thabanpin lead mineralization as shown in figure (4).

In the present study area, the major linearments are predominantly N-S and the trend of lead bearing ore veins are NNW-SSE and NNE-SSW. The ore bearing brecciated dolomitized zones and barite veins occur generally as sills intruded conformably along the bedding planes of host limestones. So these deposits occur under both structural and lithostratigraphical controls (Myint Lwin Thein, 1979 and Ohn Myint, 1980).

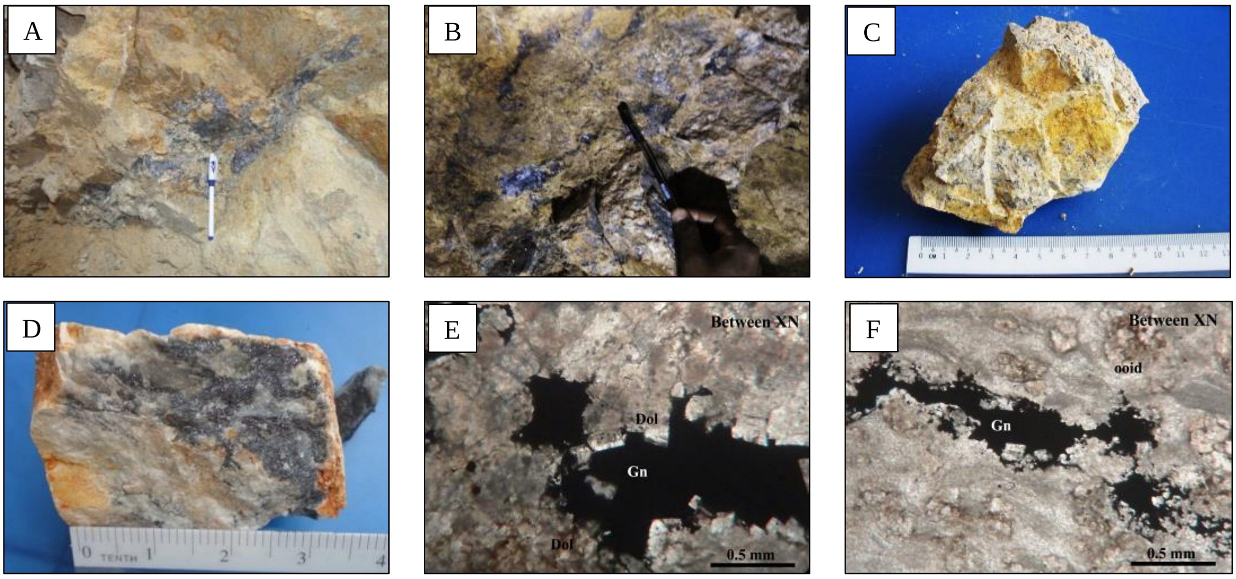


Figure (3). (A) Fracture filling type, (B&C) patches and disseminated type, (D) replacement type, (E) galena occurs in dolomitic limestone (Thin-section), (F) galena occurs in oolitic limestone (Thin-section)

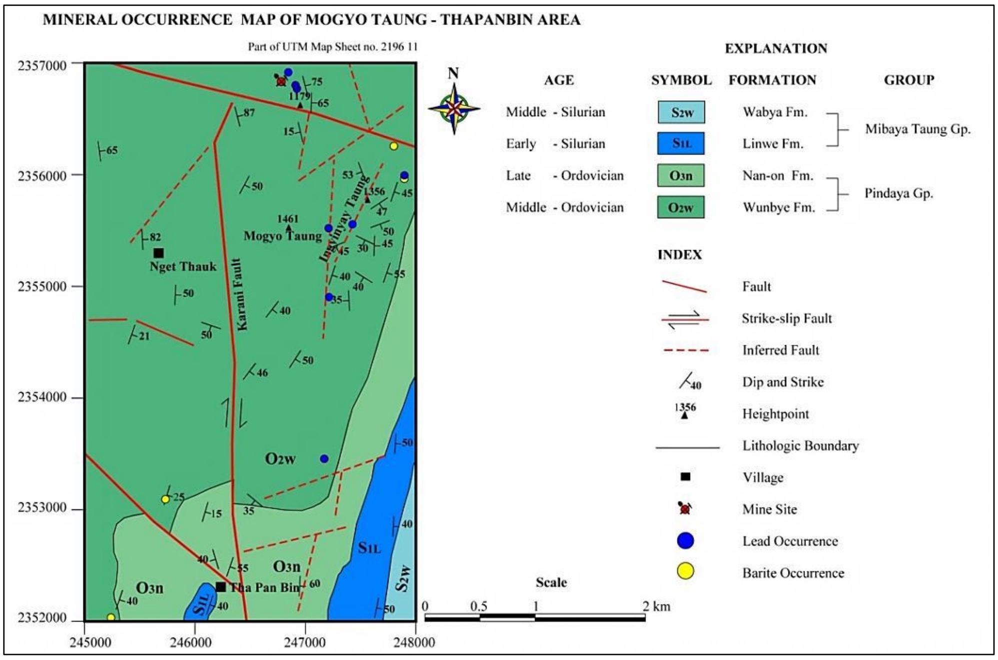


Figure (4). Mineral Occurrences Map of the Mogyo Taung – Thapanbin Area

Ore Mineralogy

The ore mineralogy of the study area is relatively simple, and the major constituents being galena and barite with minor amount of sphalerite. Fluorite is conspicuously absent. The associated minerals are pyrite, chalcopyrite, covellite and anglesite. The gangue minerals are calcite, dolomite and quartz. The primary lead ore as galena can be observed in the Wunbye Formation. It is constantly associated with sphalerite and barite. According to Craige *et al*., and Marshall *et al*., the following ore minerals are identified;

[1] ***Galena*** is the most common lead ore mineral. Galena in polished section under ore microscope is characterized by light or light-grey colour and high reflectivity (Fig. 5A).

[2] ***Sphalerite*** is characterized by its gray colour with brown tint and yellowish brown to reddish brown internal reflection under the microscope. Sphalerite has higher relief than galena grain in polish sections (Fig. 5B). It suggests that sphalerite bearing ore fluid early deposited than galena.

[3] ***Pyrite*** occurs in the main mineralized zone as tiny isolated crystals in galena and sphalerite (Fig. 5C).

[4] ***Chalcopyrite*** occurs as rare, isolated yellowish coloured patches in some polished sections (Fig. 5C).

[5] ***Covellite*** is altered from chalcopyrite as a result of decomposition of chalcopyrite (Fig. 5D).

[6] ***Anglesite*** is occasionally found, in place, as a result of oxidation of lead sulphides occurred to form lead oxide, and then galena has been replaced by anglesite with curving inward texture (Fig. 5E).

[7] ***Barite*** is also a very common mineral which occur in association with sphalerite, galena and calcite. In thin sections, barite is found as pale yellow, tabular aggregates with many cleavage planes (Fig. 5F).

Ore Texture

In the study, the most common textures revealed are; open-space filling, vugs and cavities texture, and replacement texture.

Wallrock Alteration

The alteration zone is narrow in the study area. The dolomitization alteration is most commonly recognized and also silicification alteration is subordinated.

Dolomitization

Dolomitization is a common accompaniment of low to medium temperature ore deposition in limestones, and dolomite is probably the commonest of carbonates formed by hydrothermal activity (Evan, 1993). It is associated most commonly with low temperature lead-zinc deposits. Dolomitization generally appears to have preceded sulphide mineralization, to have increased the permeability of the host limestones, to have gave rise to a higher porosity and thus to have prepared them for mineralization (Fig. 6). As the result of dolomitization there was an increase in the porosity of the host rocks facilitating the flow of the ore fluids. At the time of mineralization, the ore bearing fluids may have gained entrance and migrated through the porous dolomitized carbonates rocks and deposited at a favourable fissure-type solution channel (Soe Win, 2016).

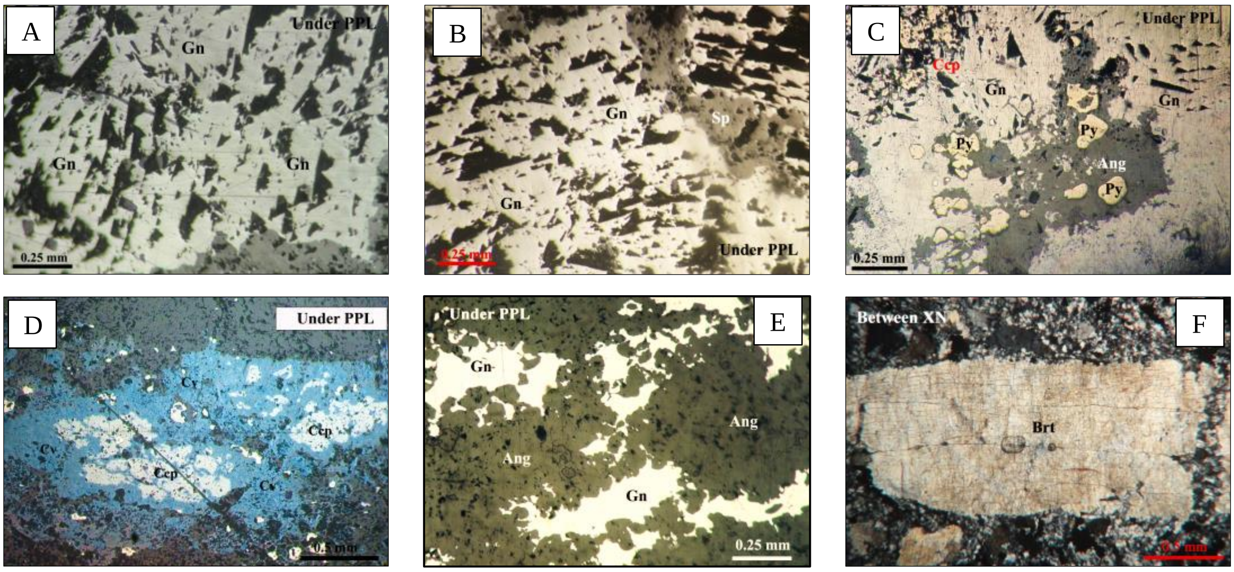


Figure (5). (A) galena (Gn), (B) sphalerite (Sp) with galena, (C) pyrite (Py) and chalcopyrite (Ccp), (D) covellite (Cv), (E) anglesite (Ang) are observed Under reflected light, (F) barite (Brt) observed in thin-section

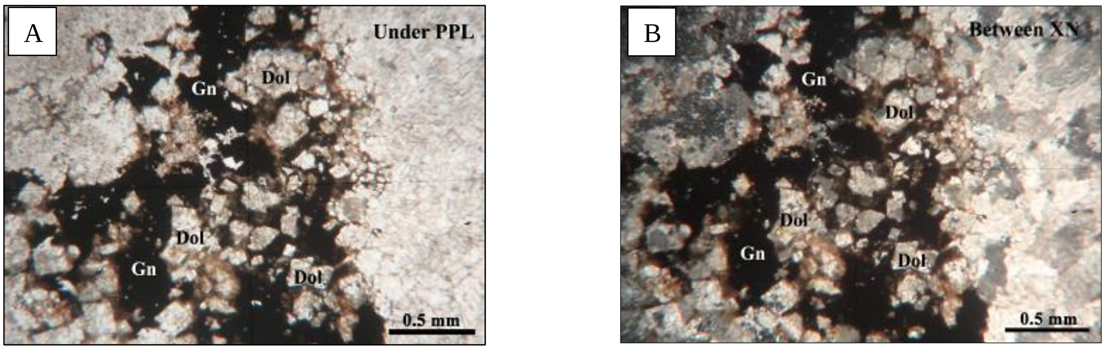


Figure (6). Dolomitization with Pb mineralization (Thin-section)

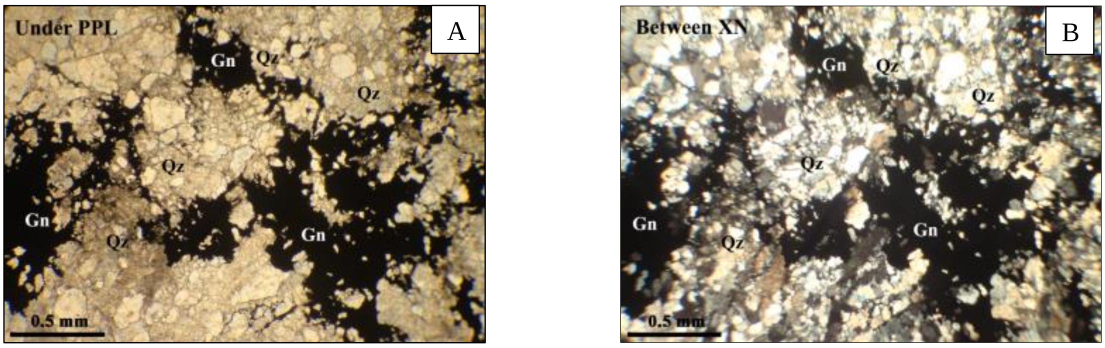


Figure (7). Silicification with Pb mineralization (Thin-section)

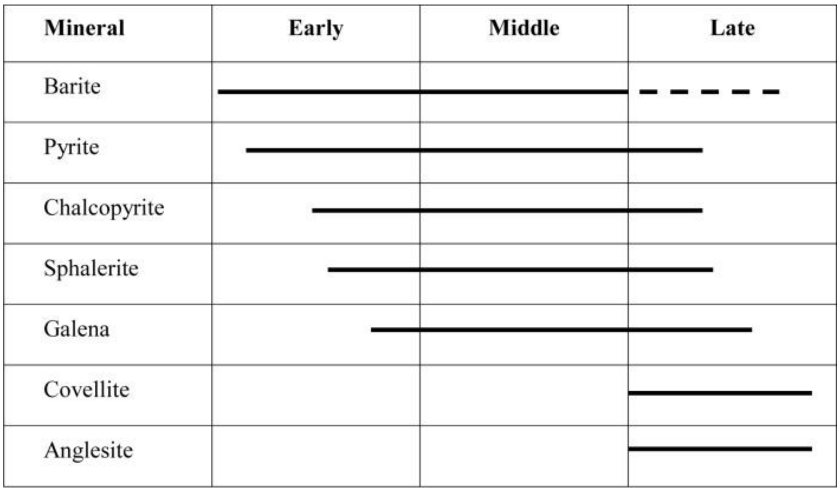
Silicification

Silicification is another wallrock alteration of the carbonate host rocks in the study area. Silicification involves an increase in the proportion of quartz or crypto-crystalline silica in the altered rocks (Fig. 7). The silica may be introduced from the hydrothermal solutions, as in the case of chertified limestones associated with lead-zinc-fluorite-barite deposits. The silica is believed to have derived from wallrock alteration and by leaching of hydrothermal fluids that were saturated with silica (Soe Win, 2016).

Paragenetic Sequence

The paragenetic sequence of ore minerals of the study area is based upon the ore microscopic study. Under reflected light, barite and other gangue minerals such as dolomite and calcite are found to have formed first. And then the early stage mineralization of sulphide minerals such as pyrite, chalcopyrite, sphalerite, and galena are formed as infilled or disseminated along the fracture and interstices of gangue minerals. Finally, the late stage of secondary minerals such as covellite and anglesite are formed by the alteration or decomposition of sulphides. Barite was deposited throughout the entire period of the mineralization. The paragenetic sequence of ore minerals in the study area is shown in the table (2).

Table (2). Paragenetic sequence of ore minerals



Mineral Content

In the study area, Pb values range from 3.485% to 66.17% in Mogyo Taung, 0.162% to 14.57% in Ingyinyay Taung, and up to 5.264% in Thapanbin. The content of Zn is up to 2.617%, Cu is up to 0.8838%, and Ba ranges is up to 51.59%.The XRF results of some ore minerals in the study are as shown in table (3).

Table (3). XRF results (%) of some ore minerals in the study area

No	Sample No	Location E	Location N	Pb %	Zn %	Cu %	Fe %	Ba %
1	MGT 002	246820	2356763	60.6	0.0231	0.0895	0.464	0
2	MGT 004	246820	2356763	3.485	0.0202	0.671	0.453	46.18
3	MGT 006	246906	2356796	61.21	0.112	0.207	1.14	0
4	MGT 007	246906	2356796	18.78	0.01	0.0152	1.404	0.408
5	MGT 009	246906	2356796	66.02	0	0.0891	0.155	0
6	MGT 011	246818	2356947	66.17	0.015	0.0893	0.123	0
7	MGT 014	247159	2354905	5.546	2.055	0.0279	0.256	19.38
8	MGT 015 A	247210	2355523	3.598	0.0432	0.8838	1.425	0.129
9	MGT 015 B	247210	2355523	0.162	0.0249	0.158	0.376	41.41
10	MGT 016	247432	2355563	14.57	2.617	0.0913	0.154	11.42
11	MGT 017	247790	2356257	0.035	0	0	0.0386	50.94
12	MGT 025	246818	2356947	24.31	0.019	0.022	1.17	1.5
13	MGT 026	246818	2356947	9.6	0.007	0	1.432	2.12
14	MGT 027	246883	2356866	55.34	0.023	0.021	1.16	0
15	MGT 028	246883	2356866	51.36	0.0407	0.02	0.744	0
16	IGY 005	247894	2355990	0.858	0.0239	0.215	0.116	47.02
17	IGY 006	247894	2355990	3.878	0.024	0.043	0.0885	48.57
18	TPB 007	245730	2353093	0.948	0	0.0427	0.05	51.59
19	MGT 032 A	247201	2353427	5.264	0.019	0.522	0.552	44.83

Comparison of Ore Characteristics between the Lead Mineralizations of the Study Area and Bawsaing Lead Deposits

The comparison of ore deposit characteristics between the lead mineralization of the study area and Bawsaing lead deposits, Shan State (South) (Hnin Min Soe, 2008) is shown in table (4).

Geochemical Investigation

The XRF results from geochemical analysis were treated by statistical method using geostatistical software by calculating the values of Mean ($\bar{X}$) and Standard Deviation (S) that shown in table (5) and regression diagrams showing the relationship between lead and associated minerals are shown in figure (8) respectively.

Table (4). Comparison of Ore Deposit Characteristics between the Lead Mineralizations of the Study Area and Bawsaing Lead Deposits

Description	**Mogyo Taung – Thapanbin Area**	**Bawsaing Area**
Host Rock	Burrowed Limestone Wunbye Formation Middle Ordovician	Burrowed Limestone Wunbye Formation Middle Ordovician
Structure	Concordant Nearly east dipping 30^o to 60^o	Cross-cutting Nearly vertical dipping
Regional Strike	Nearly N-S (~ 350^o)	NE
Deposit Type	Sub-type of MVT	Sub-type of MVT
Alteration	Dolomitization Silicification	Dolomitization Silicification Pyritization
Dominant Ore Minerals	Galena & barite	Galena
Associated Ore Minerals	Sphalerite, chalcopyrite, pyrite, covellite, anglesite	Sphalerite, pyrite, barite
Gangue Minerals	Calcite, dolomite, quartz	Calcite, dolomite, quartz, clays
Silver	Rare	Argentiferous
Sphalerite	Rare	Rare
Sulphide Content	Low	High
Oxidation	Weak	Strong
Ore Fluids	Connate water	Connate water
Ore Control Factors	Structure & lithostratigraphy	Structure & lithostratigraphy
Igneous Rocks	Absent	Absent
Classification	Stratabound, Epigenetic Carbonate-hosted Ba-Pb	Stratabound, Epigenetic Carbonate-hosted Pb&Ba
Economic Aspect	Small-scale mining	Potential large-scale mining

Table (5). Mean ($\bar{X}$), Standard deviation (S) and Threshold ($\bar{X}$+2S) values of Elements from Mogyo Taung Lead Deposits (%)

No	**Element**	**Mean ($\bar{X}$) Value**	**Standard deviation (S) value**	**Threshold ($\bar{X}$+2S) value**	**Range**	
					Minimum	**Maximum**
1	Pb	41.688	24.779	91.266	3.485	66.17
2	Zn	0.027	0.032	0.091	0	0.112
3	Cu	0.122	0.202	0.527	0	0.671
4	Fe	0.825	0.500	1.825	0.123	1.432
5	Ca	9.570	10.258	30.087	0.031	22.24
6	S	3.910	3.864	11.638	0.318	11.99
7	Si	0.942	0.520	1.981	0.16	1.76
8	Al	0.445	0.247	0.938	0.076	0.844
9	Mg	3.266	3.405	10.076	0.034	10.32
10	Ba	5.021	14.481	33.984	0	46.18

Regression Diagram

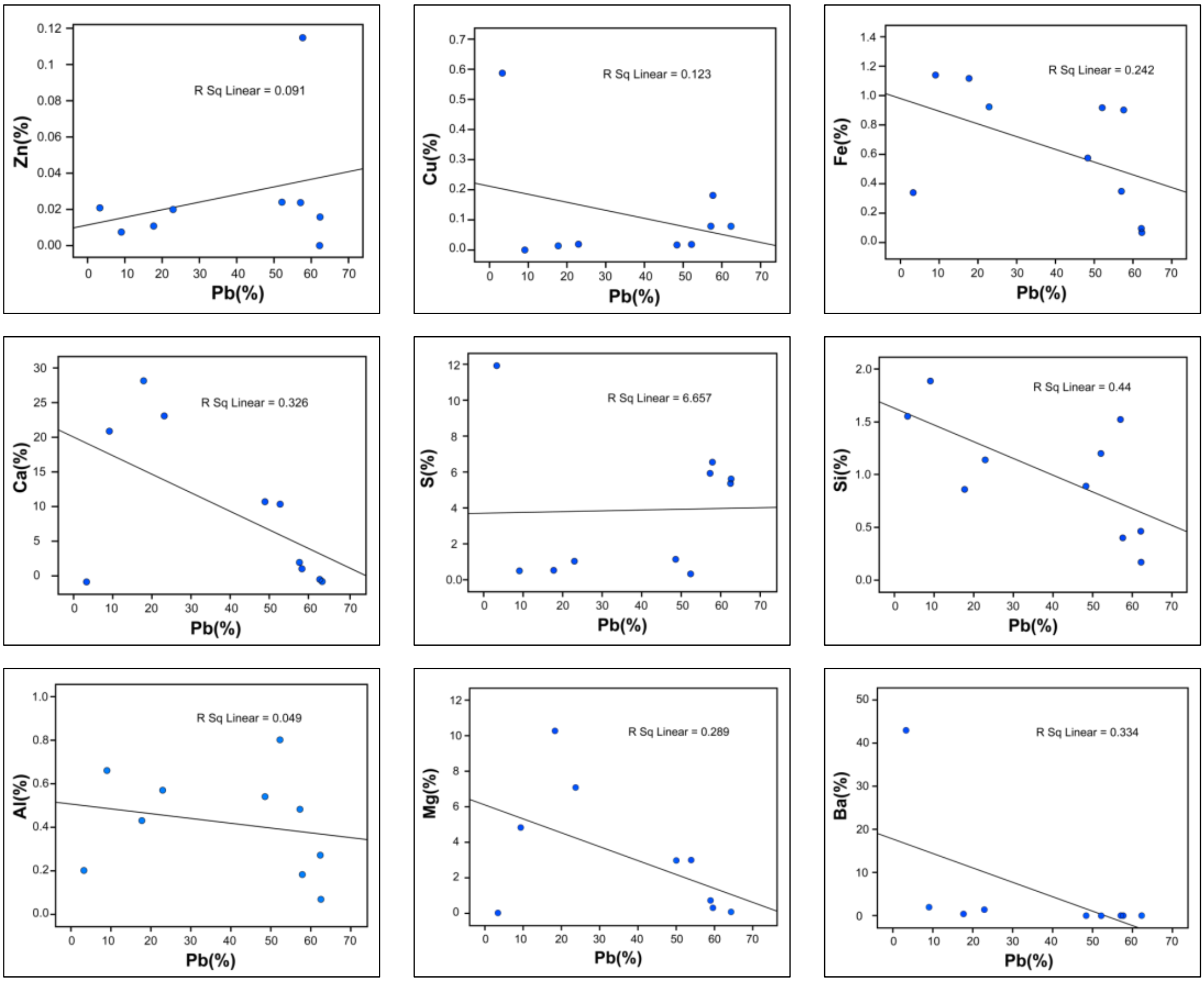


Figure (8). Regression diagrams showing the relationship between lead and respectively associated minerals

According to the geochemical analysis, Zn is positively correlated with Pb and Cu, Fe, Ca, S, Si, Al, Mg and Ba are negatively correlated with Pb in Mogyo Taung deposits.

Cluster Analysis of Mogyo Taung Lead Deposits

Cluster analysis of elements in ore samples is performed by the weighted pair group method. This investigation is based on ten ore samples assay results of X.R.F analysis from Mogyo Taung lead deposit, as shown in table (6).

According to the cluster analysises of Mogyo Taung lead deposits, Zn is more closely associated with Pb than other elements in lead mineralization of the study area. The constructed dendrogram is shown in figure (9).

Table (6). Proximity Matrix of Correlation Coefficient of Elements

	Pb	Zn	Cu	Fe	Ca	S	Si	Al	Mg	Ba
Pb	1									
Zn	0.301	1								
Cu	-0.35	0.152	1							
Fe	-0.492	0.213	-0.347	1						
Ca	-0.571	-0.272	-0.519	0.807	1					
S	0.026	0.204	0.883	-0.64	-0.786	1				
Si	-0.663	-0.321	0.161	0.377	0.336	-0.088	1			
Al	-0.221	-0.249	-0.522	0.618	0.613	-0.75	0.615	1		
Mg	-0.537	-0.273	-0.468	0.746	0.975	-0.72	0.226	0.505	1	
Ba	-0.578	-0.092	0.943	-0.232	-0.293	0.717	0.373	-0.309	-0.264	1

Dendrogram

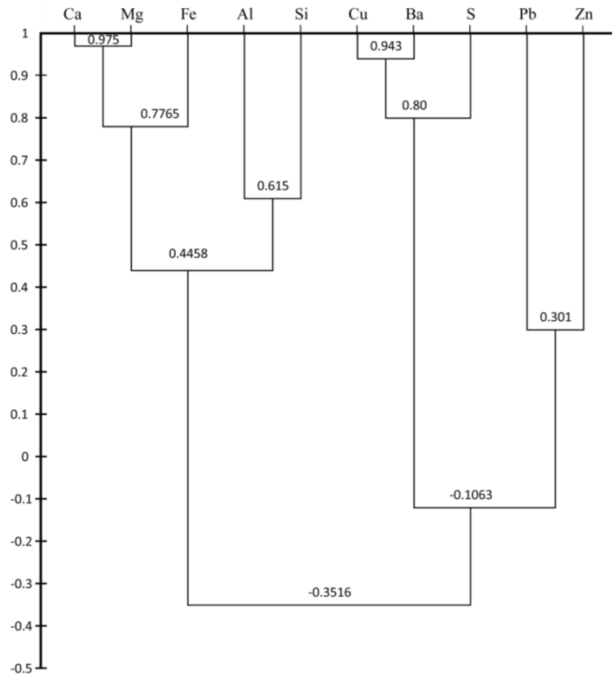


Figure (9). Dendrogram constructed by weighted pair group method of Mogyo Taung Lead Deposit

Discussion and Conclusion

The present research work involves the carbonate rocks of the Wunbye Formation (Middle Ordovicain age) which hosts the lead ore mineralization. Lead mineralization extensively occurred in Mogyo Taung range, Ingyinyay Taung and near Thapanbin village, in three distinct styles, namely, disseminations, fracture fillings (veinlets) or open space fillings and replacement ores (irregular patches to massive aggregates). The pre-indicating wallrock alteration zone is usefully narrow where dolomitization alteration forms the main alteration predating the lead sulphide mineralization and silicification is subordinate. Most of the lead ore mineralized host rocks are dolomitic limestone as well as oolitic limestone. The ore mineralogy is relatively simple, and the major constituents being galena and barite and its associated minerals are sphalerite, pyrite, chalcopyrite, covellite and anglesite with minor amount of argentite. Calcite, dolomite and quartz are gangue minerals. Both structural and lithographical controls are important parameters for lead mineralization in the study area.

The following possible findings on the genesis of lead mineralization can be observed;

1. The ore mineralizations have simple mineral assemblages that consist of galena, barite, sphalerite, pyrite and chalcopyrite with minor amount of argentite. The gaugue minerals are dolomite, quartz and calcite.
2. Ore mineralization is spatially associated with oolitic limestone and dolomitic limestone. So, the ore deposits are stratigraphically confined to Wunbye Formation (Middle Ordovician age) of carbonate rocks.
3. Wallrock alreations are mainly dolomitization and subordinately silicification. Lack of a prominent wallrock alteration halo around the mineralization and absence of outcrops of intrusive rocks within the several kilometres of mineralization are characteristics of carbonate rocks-hosted lead deposits.
4. Textures of sulphide minerals are mostly related to open-space filling of breccias, fractures, and vugs. Replacement of carbonate host rocks and internal sediments and sulphide dissemination are also observed.
5. Deposits range from massive replacement zones to open-space fillings of crystals that occupy intergranular pore spaces.
6. The ore deposits occurred in the zones of highly brecciated dolomite, bedding plane, faults and fractures and these zones are arranged in linear patterns suggesting a distnict structural control.
7. The ore deposits are localized by both regionally and locally structural and lithostratigraphical controls.
8. As no igneous rocks occur in the study area of mineral deposits, the mineralization cannot be attributed mainly magmatic ore forming processes.
9. Therefore, the ore deposits are carbonate rocks-hosted, stratabound deposits and are of epigenetic origin.

Although the study is incomplete, lacking data on fluid inclusions, temperature and salinity of the fluids prevailing, and isotopic study of ore deposits, above the mentioned findings are relatively same the characteristics of Mississippi Valley Type (MVT) deposits (Anderson, *et al*., 1982), (Sangster, *et al*., 1996) and (David, *et al*., 2010).

So, all the above deposit features strongly indicate that the ore deposits of Mogyo Taung - Thapanbin area are carbonate rocks-hosted, stratabound deposits and epigenetic origin, and most probably belong to one of the sub-types of the Mississippi Valley-Type (MVT) deposits.

Acknowledgement

We would like to express our heartfelt thanks to Prof. Dr Day Wa Aung (Professor and Head, Department of Geology, University of Yangon), the late Dr Han Sein (Associate Professor, Applied Geology Department, University of Yangon) for his valuable advice and suggestions, close supervision and constant guidance throughout research work. We would like to acknowledge U Than Htay (Retired Deputy Director General, Department of Geological Survey and Mineral Exploration, Ministry of Mine) with deep gratitude for his critical reading of our manuscript and immensely improving it both in English and geological contexts. Last but not least, we would like to very sincerely thank all of the villagers from Thapanbin village, and responsible persons from Harbor Star Mining Co. Ltd. for their kind helps, full logistics and facilities, and warm hospitality during my field work.

References

Anderson, G.M. and Macqueen, R.W., (1982). “Ore Deposit Models-6, Mississippi Valley-Type Lead-Zinc Deposits”. Geoscience Canada, Vol.9, No.2, pp. 108-117

Craig, J.R. & Vaughan, D.J., (1981). *Ore Microscopy and Ore Petrography*. John Willey and Sons. 406 p

Dan Marshall, C.D. Anglin & Hamid Mumin, (2004). *Ore Mineral Atlas*, Geological Association of Canada, Mineral Deposits Division. 122p

David L. Leach, Ryan D. Taylor, David L. Fey, Sharon F. Diehl & Richard W. Saltus, (2010). “A Deposit Model for Mississippi Valley-Type Lead-Zinc Ores”, Scientific Investigation Report 2010-5070-A, U.S.G.S, U.S. Department of the Interior. 52p

Evans, A. M. (1993). *Ore Geology and Industrial Mineral, An Introduction*, Geoscience Texts, (3rd Edit), Blackwell Science, Australia, pp. 40-51

Garson, M.S. Amos, B.J. and Mitchell, A.H.G., (1974), “Geology of the area around Neyaungga and Ywangan, Shan State (South), Burma”. 1:63360 scale geological map, inst: Geol: Sci., London.

Hnin Min Soe, (2008). *Economic Geology of North Ywangan Township, Taunggyi District, Shan State (South), Myanmar*, PhD Dissertation, Department of Geology, University of Yangon. (Unpublished) 168p

Myint Lwin Thein, (1973). “The Lower Paleozoic Stratigraphy of Western part of the Southern Shan State, Burma”: Geol. Soc. Malaysia, Bulletin No. 6, pp. 143-163

Myint Lwin Thein, (1979). “Barite and Galena Occurrences in the Ordovician Rocks of the Western part of the Shan Plateau”, A paper read at Burma Research Congress.

Ohn Myint, (1980). *Detailed Stratigraphic and Structural Analysis of Lithostratigraphic Units in Relationship to Mineralization at Bawsaing Area, Southern Shan State*. MSc Thesis, Rangoon Art and Science University. (Unpublished) 127p

Sangster, D.F. (1996). “Mississippi Valley-Type Lead-Zinc”, in Geology of Canadian Mineral Deposit Types, (ed.) O.R. Eckstrand, W.D. Sinclair, and R.I. Thorpe; Geological Survey of Canada, Geology of Canada, No.8, p. 253-261.

Soe Win, (2016). *Economic Geology of the Carbonate-Hosted Lead-Zinc Deposits of the Loi Hseng Trend, Naungcho Township, Shan State*, PhD. Dissertation, Department of Geology, University of Mandalay. (Unpublished) 200p