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A brief account of lead mineralization at Phaungdaw Prospect, Pyawbwe Township, Mandalay Division, Burma

KHIN ZAW[1] AND P.J. GOOSSENS[2]

[1] Geology Department,
University of Tasmania,
GPO Box 252C, Hobart,
Tasmania 7001 , Australia.

[2] Bugeco, C/O Dept. of Geology and Mineralogy,
Royal Museum of Central Africa,
B-1980 Turvuren, Belgium.

Abstract: The Phaungdaw Lead Prospect is situated at North Latitude 20° 39' and East Longitude 96° 19' in Pyawbwe Township, Mandalay Division, Burma. Lead mineralization occurs in the metasedimentary rocks of Phaungdaw Formation (Paleozoic). The ore minerals are strictly confined to the coarsely crystalline, white to bluish grey, thick-bedded marble unit of the Phaungdaw Formation and formed as parallel groups of stratiform lenses or layers of 1 to 2 meters across either conformable to the bedding of the host rock or along the crests of the minor folds. The ore assemblages are predominantly of galena with very little sphalerite, pyrite, chalcopyrite and tetrahedrite-tennantite. The gangues are mainly of quartz and calcite. Petrologic and mineralogic investigation of host rocks, ores and gangues indicates that the Phaungdaw area has suffered by a regional metamorphism. The ore assemblages were observed to have been affected by later metamorphism and deformation. In many respects, the Phaungdaw Lead Prospect is comparable to the Theingon deposit in the nearby Southern Shan State, Burma which have many similarities to the Mississippi Valley type deposits, but the Theingon deposit shows no sign of metamorphic effect and contains more Zn and Ag ore minerals.

INTRODUCTION

Phaungdaw Lead Prospect lies about 28.8 km (18 miles) northeast of Phawbwe Township, Mandalay Division, Burma at North Latitude 20° 39' and East Longitude 96° 19' (Fig. 1).

History And Production

Available informations indicated that the development of the Phaungdaw Lead Prospect was made first by the German Mt. Pyinma Mining Company in March, 1904. During 1904-1914, the Phaungdaw lead deposit was operated with

an annual production of 2200 metric tons and the lead ores were hauled by narrow gauge from the mine-site to crusher at Pyawbwe. The production ceased at the start of World War I as the British Governer did not allow the Germans to continue their mining operation.

The next recorded mining activity was during 1950-1960. Henzada U Mya,

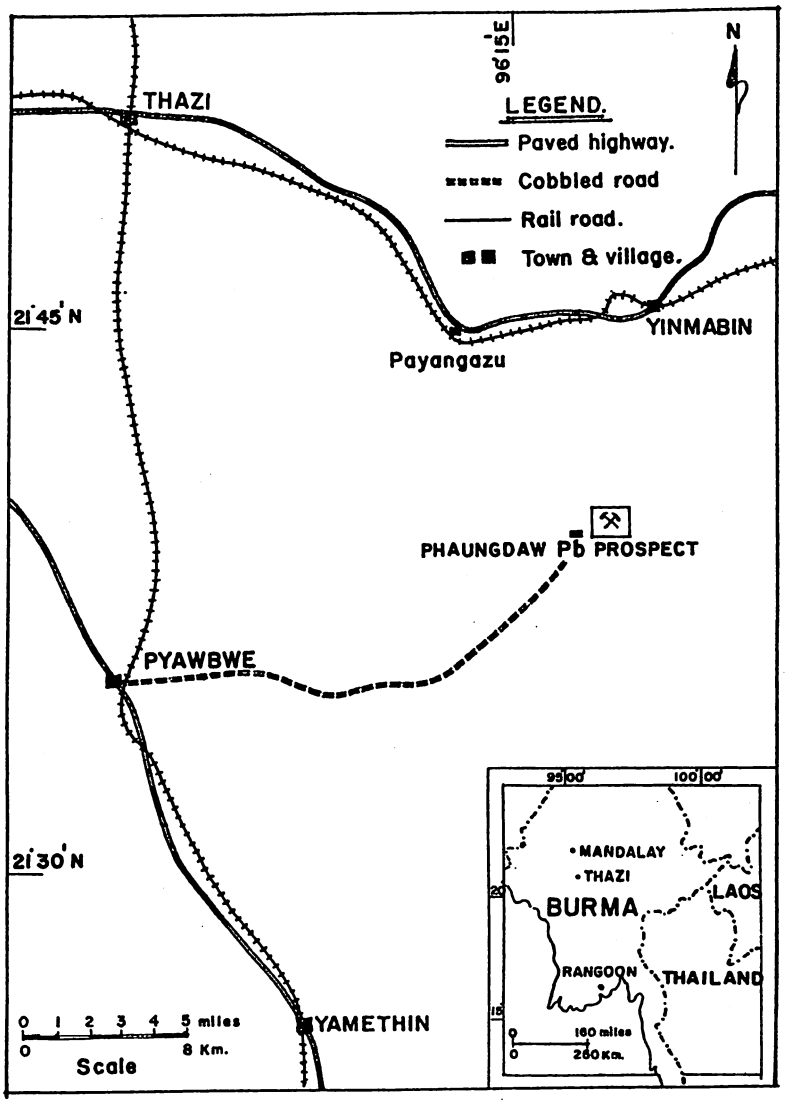


Figure 1 : Location map of Phaungdaw Lead Prospect area, Pyawbwe Township, Mandalay, Division, Burma.

a local miner, extracted 90 metric tons of lead ore monthly by a tribute mining system. The mining activity was again started in 1965 and ceased in 1975. Since then, no production has ever been recorded. Thus, a total of 43600 metric tons of ore would have been extracted by the previous mining activities. The grade of the ore for the previous mine products is not known.

Previous Studies

The Mt. Pyinma Mining Company was the first to survey the Phaungdaw Lead Prospect in March 1904. However, a systematic geological investigation was begun in 1965 by U Zaw Pe of D.G.S.E (Directorate of Geological Survey and Exploration) formerly called Mineral Development Corporation. Self-potential geophysical survey around Phaungdaw Lead Prospect was done by D.G.S.E over an areal extent of 1.6 sq. km. In 1971-1973, a regional geological mapping in the Phaungdaw area on a scale of 1 inch to one mile was made by Faculty members and students of Geology Department, Rangoon University, Burma (Ohn Myint, 1971; Aung Myint Thein *et al.*, 1971; Aung Myint Thein and Myo Min, 1973).

During 1974-1977, this area was a mineral exploration training site for the Postgraduate trainees from Applied Geology Department, Rangoon University, Burma. Detailed outcrop geological mapping, and geochemical and geophysical surveys were conducted (Aung Myint Thein *et al.*, 1979). Recently Goossens (1978) reported the geological setting of the Phaungdaw Lead Prospect in his contribution to the Metallogeny of Burma.

REGIONAL GEOLOGY

The regional geological setting of the Phaungdaw area is shown in Fig. 2. The Phaungdaw mine area is characterised by a series of metasedimentary rocks which were intruded by granitoid rocks. Chaungmagyi Group (Precambrian) is the oldest rock unit in the area and mainly made up of calc-silicates, gneisses, schists and quartzites. Phaungdaw Formation conformably rests on the Chaungmagyi rocks and occurs as a host rock for the Pb mineralization. The Phaungdaw Formation essentially consists of calc-silicates and marbles.

The metasedimentary rocks of the Phaungdaw Formation is believed to be metamorphosed equivalent of Wunbye Formation (Lower Middle Ordovician) of the Southern Shan State. The Wunbye Formation is also known to be major host rock for the localisation of Pb-Zn occurrences in the Southern Shan States, and essentially composed of limestones, dolomitic limestones, minor dolomites and siltstones. The Phaungdaw Formation is unconformably overlain by Lebyin Formation (Carboniferous ?) which principally consists of slates.

The granitoid rocks in the Phaungdaw area are leucogranites, biotite granites and metadiorites which form as small bodies of less than (0.8) km across. Since these granitoid plutons lie along the W-Sn related granitoid belt in Burma, they are thought to have been emplaced contemporaneously with W-Sn

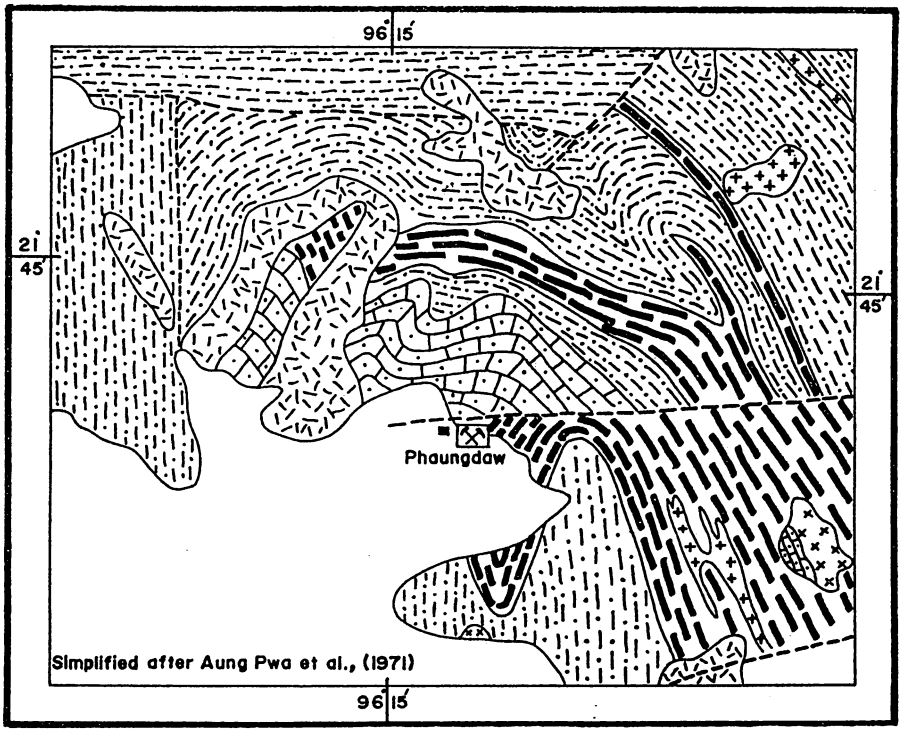
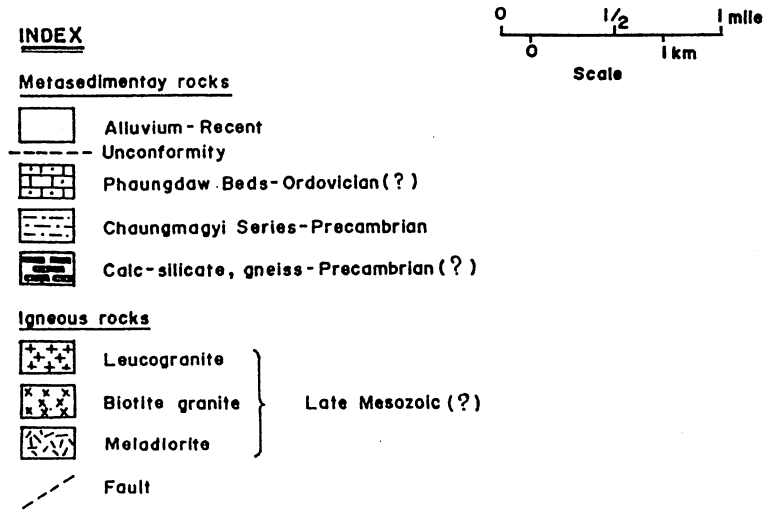


Figure 2 : Regional geological map of Phaungdaw area, Burma.



bearing granitoids. Recent stratigraphic and radiometric evidences indicate that the W-Sn related granitoid in Burma were emplaced above a shallow-dipping, eastward subduction zone during Late Cretaceous to Eocene interval (Mitchell and Garson, 1972; Mitchell, 1973) but Khin Zaw (1985 in preparation) recently interpreted that these granitoids were emplaced during collision of older magmatic-volcanic arc with continental foreland to the east.

The metasedimentary rocks in the Phaungdaw area were folded into large anticlines and synclines, later intruded by granitoids and then faulted. Structurally, the mine workings of the Phaungdaw Lead Prospect lie in a trough of a large south-plunging syncline (see Fig. 2), but it is not known whether it is overturned. Numerous south-plunging undulations are also superimposed on this major structure. The general strike of the area is N 30° W dipping 15° - 25° to the south.

DETAILED OUTCROP GEOLOGY

The detailed outcrop geological map of the Phaungdaw mine area is shown in Fig. 3. The major lithologic units are calc-silicates interbedded with phyllites (unit CP) and marbles (unit M of the Phaungdaw Formation with granitoid intrusion, unit G). As was described before, the age of the Phaungdaw Formation is suggested to be Ordovician (Paleozoic).

The unit CP is well exposed as erosional remnants at the elevated ground in the northeast and southeast of the mine area. They also show well preserved outcrops in the stream section. This unit is characterised by drag-folded, finely crystalline, calc-silicates and minor phyllites with ribbon pattern of alternate light and dark green coloured bands. Dark bands contain more siliceous minerals whereas the light ones are more calcareous. Thickness of these bands are irregular from 0.5 cm to 5-6 cm. So far no lead mineralization has been reported in this unit CP.

The unit M conformably lies on the unit CP and the contact is gradational. The unit M is composed entirely of marbles which are generally medium- to coarse-grained, crystalline, white, grey or blue, massive, and thick-bedded. Although the unit M is easily weathered and leached, it is widely exposed as scattered outcrops all over the mine area. Garnets are sometimes observed with naked eyes in this unit M. The original bedding of the unit M is represented by bands of silty and siliceous materials. Quartz veinlets of various sizes are seen cutting the unit M throughout the area. Quartz blocks and sometimes granite blocks of several centimeters across with certain alignment are also noted in the unit M. The origin of these blocks is not known but it is possible that these are either remnants of once quartz veins or dykes broken into pieces during deformation or metamorphosed chert nodules. Galena dissemination is also noted in these quartz blocks. The unit M is the host rock for the galena-bearing quartz veins in the mine area.

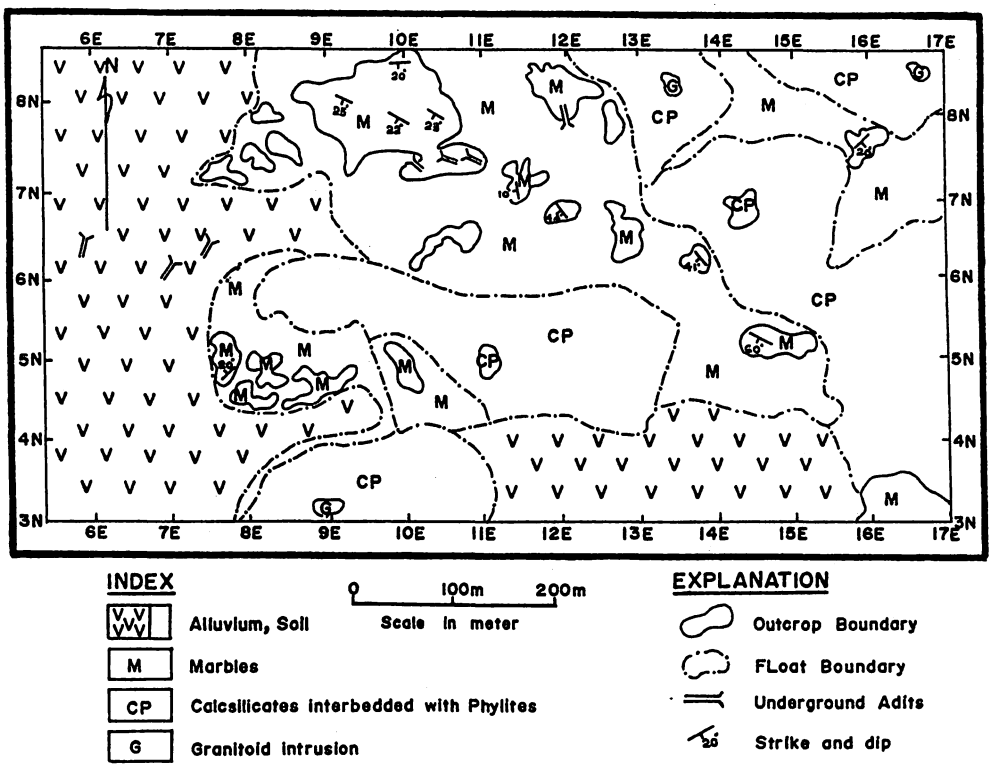


Figure 3 : Detailed outcrop geological map of Phaungdaw Lead Prospect, Pyawbwe Township, Yemethin District, Burma

The granitoid rocks (unit G) are locally exposed as dyke-like bodies with an average length of 15 meters. The granitoids are fine- to medium-grained, buff to grey granite of uniform mineral composition and texture, and locally foliated. No skarn zone occurs at the contact between the granitoid dykes and the country rocks. No galena mineralization is encountered in this granitoid (unit G). The age of the granitoid emplacement is presumed to be Late Mesozoic since these Phaungdaw granitoid bodies lie along the W-Sn belt with granitoids of predominantly Late Mesozoic age.

As described earlier, the mine area is regionally formed as a part of the south-plunging syncline trending N 30° W with southerly dip of 15°- 25° Many south-plunging minor folds with similar attitude of the major fold was observed. It is noteworthy that rich lead mineralization is related to those minor folds or undulations.

Only minor faults which do not upset the general structure are observed in the Phaungdaw area. These minor faults are generally trending north-south and this small-scale faulting is thought to be related to the axial tension of the large

syncline. Mineralization is not recorded along any fault structure, but is cut and displaced by faults. Four major set of joints in the Phaungdaw area can be recognised : J_1 N 70° W/ vertical, J_2 N 60° E/ vertical, J_3 N 48° E/ 75° SE, and J_4 N 60° W/ 86° NE. The stereographic projection of the joints in the mine area is shown in Fig. 4. J_3 and J_4 are thought to be shear joints with respect to the fold axis and J_1 and J_2 are tensional joints, one perpendicular and the other parallel to the fold axis.

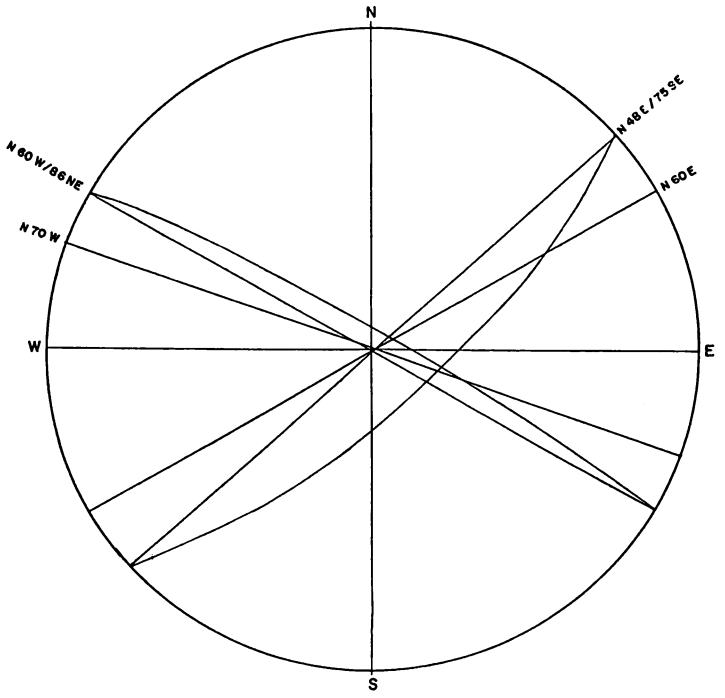


Figure 4 : Stereographic projection of joints of beds at Phaungdaw Lead Prospect area, Pyawbwe Township, Mandalay Division, Burma.

MINERALIZATION

The galena mineralization occurs as disseminated grains or stringers in the quartz veins which conformably lies within the marble (unit M). The quartz veins are generally 1-2 meter thick with 2 to 3 individual layers. As was described before, galena is noted in quartz blocks in the marble, which are thought to be broken pieces of deformed quartz vein. The mineralized quartz veins are stratiform to the bedding of the host marble unit (Fig. 5), but sometimes cross-cutting relations are also seen (Fig. 6). Lead mineralization is preferrably localised along the crests of the fold structures (see Fig. 7). No significant wall rock alteration was noted and no greisenization nor chloritization was also observed near the ore layers.

As the major host rocks for the Phaungdaw lead mineralization are marble associated with calc-silicates, about 25 host rock samples were collected and studied under the microscope. The calc-silicates essentially consist of quartz and calcite with minor chlorite, epidote, biotite, tremolite and diopside. No galena mineralization was observed in the calc-silicates. The marbles contain predominantly of coarsely crystalline calcites with plagioclase feldspar, quartz, epidote, tremolite, garnet, and also fine-grained calcite. Thus, the metamorphic assemblages of the Phaungdaw Formation appear to be Upper Greenschists to Lower Amphibolite Facies. Using the data of Turner (1968) the metamorphism took place under the temperature range 300°- 500° C and the pressure of 3-5 kb.

ORE MINERALOGY

Several ore samples were collected from old workings in the Phaungdaw Lead Prospect area for ore microscopic examination. The ore mineralogy of the Phaungdaw lead Prospect is rather simple and can be comparable with that of the Mississippi Valley type deposits. The principal ore mineral is galena with very little sphalerite, pyrite, chalcopyrite, and tetrahedrite-tennantite. The gangue minerals are quartz and calcite.

Galena is the most abundant mineral in the Phaungdaw old workings. Galena makes up about 30 per cent of the ore specimens. In all samples, galena is smeared along fractures and interstices of gangue minerals. The galena is in places coarse-grained, subhedral to anhedral and up to 5 mm across and

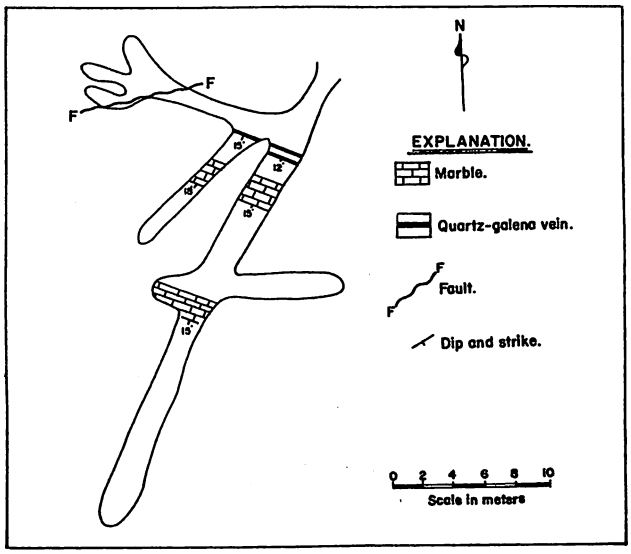


Figure 5 : Underground geological map of mine working No 2, Phaungdaw Lead Prospect, Pyawbwe Township, Mandalay Division, Burma.

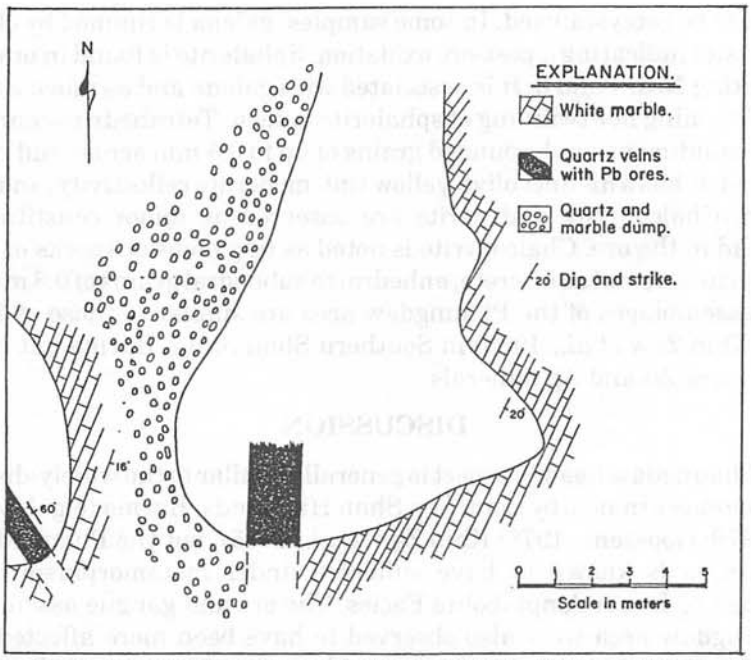


Figure 6 : Underground geological map of mine working No. 7, Phaungdaw Lead Prospect, Pyawbwe Township, Mandalay Division, Burma

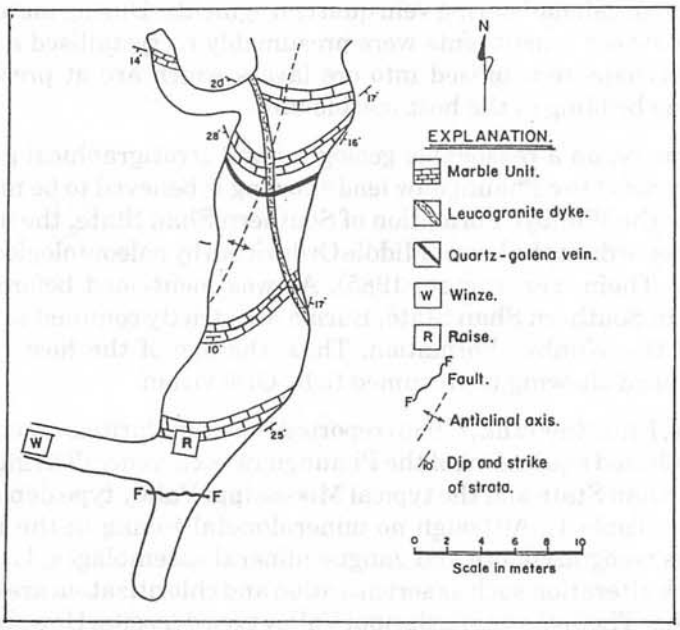


Figure 7 : Underground geological map of mine working No. 1, Phaungdaw Lead Prospect, Pyawbwe Township, Mandalay Division, Burma

appeared to be recrystallised. In some samples, galena is rimmed by clusters of tiny cerussite indicating a post-ore oxidation. Sphalerite is found in ore samples from working Nos. 4 and 6. It is associated with galena and as much as 0.4 mm across. No zoning nor twinning of sphalerite is seen. Tetrahedrite-tennantite is found as equidimensional, rounded grains of up to 0.5 mm across and randomly distributed. It has a distinct olive-yellow tint, moderate reflectivity, and internal reflection. Chalcopyrite and pyrite are observed as minor constituents but widespread in the ore. Chalcopyrite is noted as tiny blebs or specks of 0.25 mm across. Pyrite is found as discrete, anhedral to subhedral grains of 0.3 mm across. The ore assemblages of the Phaungdaw area are similar to those of Theingon deposit (Khin Zaw *et al.,* 1985) in Southern Shan State, Burma but the latter contains more Zn and Ag minerals.

DISCUSSION

The Phaungdaw Lead Prospect is generally similar to the widely-distributed lead occurrences in nearby Southern Shan Highlands, Burma (e.g. Myint Lwin Thein, 1979; Goossens, 1978; Khin Zaw *et al.,* 1985), but the Phaungdaw Lead Prospect area is known to have sufferred under metamorphism of Upper Greenschist to Lower Amphibolite Facies. The ore and gangue assemblages of the Phaungdaw area were also observed to have been more affected and deformed by the tectonic movements as evidenced by the recrystallised coarse-grained texture and wavy, triangular cleavage pits of galena and broken pieces of disseminated, galena-bearing vein quartz fragments. During metamorphism, the Phaungdaw ore constituents were presumably recrystallised and reconstituted, and perhaps remobilised into ore layers which are at present strictly parallel to the bedding of the host marble unit.

Furthermore, on a reasonable geological and stratigraphical grounds, the major host rocks of the Phaungdaw lead showing is believed to be metamorphic equivalent of the Wunbye Formation of Southern Shan State, the age of which is presently regarded to be Lower Middle Ordovician by paleontological evidences (Myint Lwin Thein, per. comm., 1985). As was mentioned before, all Pb-Zn occurrences in Southern Shan State, Burma are strictly confined to the carbonate rocks of the Wunbye Formation. Thus, the age of the host rocks of the Phaungdaw lead showing is presumed to be Ordovician.

Recently, Khin Zaw *et al.*, (1985) reported some similarities among one of the unmetamorphosed equivalent of the Phaungdaw occurrence (Theingon deposit) in Southern Shan State and the typical Mississippi Valley type deposits of Heyl *et al.*, (1974) (Table 1). Although no mineral/metal zoning in the Phaungdaw Prospect was recognised, ore and gangue mineral assemblages, lack of significant wall rock alteration such as sericitization and chloritization are comparable to that of either Theingon or Mississippi Valley type deposits. However, it should be born in mind that the geological and mineralogical characteristics of the

Phaungdaw Lead showing can be duplicated in contact metasomatic vein and replacement deposits associated with granitoid intrusion, but any geological evidence of the relationship between lead mineralization and granitoid intrusion was not observed in the Phaungdaw area. Although tremolite and diopside skarn was locally developed along the granitoid and carbonate rocks contact in the Phaungdaw area, no visible ore mineralization was observed in these skarn rocks.

The source or sources of the Phaungdaw ore solution cannot be ascertained in this research. Thus, the hydrothermal solutions responsible for the emplacement of the Phaungdaw lead showing can be magmatic (juvenile) water or meteoric water circulated through the granitoid and adjacent metasedimentary rocks, and/or mixing of those waters. Similarly, the source of the metals is not known.

Table 1: Some comparisons between the Theingon Deposit (unmetamorphosed equivalent of Phaungdaw Lead Deposit) and Mississippi Valley Type Deposit (after Khin Zaw *et el.*, 1985).

	Mississippi Valley type deposit	**Theingon deposit**
Type of host rock	Mostly in carbonate rocks (commonly dolomitic).	Carbonate rocks (oolitic and dolomitic)
Age of host rock	Paleozoic (Cambrian to Pennsylvanian).	Paleozoic (Lower Middle Ordovician).
Structural Setting	Most deposits are epigenetic, structurally controlled open-space fillings, which in places, occur in the crests or lobes of fractured major domes or gentle anticlinal uplifts	Epigenetic, structurally controlled open-space fillings localised in a limb of east-dipping small overturned anticline.
Ore mineralogy	Principally galena, sphalerite, barite, and fluorite.	Mostly galena and sphalerite with minor tetrahedrite-tennantite, covellite, chalcopyrite, digenite, and argentite.
Gangue mineralogy	Mainly calcite, dolomite and cryptocrystalline quartz.	Mainly calcite and quartz.
Zonation of ore	Mineralization is distinctive and districtwide; vertical mineral zonation is present in places but much less widespread.	Overlapping ore metal zoning, mainly within the orebody.

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