# CHAPTER VI

## CONCLUSIONS

The petrography of the Ordovician carbonate sediments generally reveals that they are essentially biomicrite, fossiliferous micrite, dismicrite, pelmicrite, biosparite, oosparite, oolitic pelsparite, and intraclastic pelsparite. These rocks have been partially to completely dolomitized in almost all cases.

The first measured section extending along the Dewatering Drift to Huai Chanee represents the Ordovician carbonate sediments above the mineralization zone. The 850-metre thick of this section is characterized by the interbedding of dolomitic dismicrite, dolomitic fossiliferous micrite, dolomitic biomicrite, dolomitic pelmicrite, dolomitic biosparite, dolomitic oosparite, dolomitic oolitic pelsparite, and medium crystalline dolomite of varying thickness. The allochemical components are mainly of crinoids, pellets, ostracods, oolites, algae-like, and molluscs in decreasing order of their abundances. For orthochemical components, there are micrite, microsparite, and sparry calcite cement of approximately equal proportion. In addition to the carbonate constituents, it is noted that minor amount of acid insoluble residue of totally less than 45 per cent by weight has been recognized throughout the section. Quartz can be divided into three types, namely, silt- to sand-sized detrital quartz, subhedral authigenic quartz, and mosaic authigenic quartz. For clay,it is identified as muscovite natural 3T.

The second measured section is the drill-hole number 68 of totally 190 metres thick above the mineralization zone. This section is characterized by the interbedding of dolomitic fossiliferous micrite, dolomitic biomicrite, dolomitic dismicrite, dolomitic biosparite, and medium crystalline dolomite of varying thickness. The allochemical components are mainly of crinoids, molluscs, ostracods, algae like, and pellets in decreasing order of their abundances. For orthochemical components, there are micrite, microsparite, and sparry calcite cement of approximately equal proportion. In addition to the carbonate constituents, it is noted that minor amount of acid insoluble residue of totally less than 35 per cent by weight has been recognized throughout the section. Quartz can be divided into three types, namely, silt- to sand-sized detrital quartz, subhedral authigenic quartz, and mosaic authigenic quartz. For clay, it is identified as muscovite natural 3T.

The third measured section is the drill-hole number 67 of totally 235 metres thick from the 575-ramp. It is relatively above the mineralization zone except for the lower part. The section is characterized by the interbedding of dolomitic fossiliferous micrite, dolomitic biomicrite, dolomitic dismicrite, and medium crystalline dolomite of varying thickness. The allochemical components are mainly of crinoids, molluscs, and algae-like in decreasing order of their abundances. For orthochemical components, there are micrite, microsparite, and sparry calcite cement in descending order of their abundances. In addition to the carbonate constituents, it is noted that minor amount of acid insoluble residue of totally less than 40 per cent by weight has been recognized throughout the section. Quartz can be divided into three types, namely, silt- to sand-sized detrital quartz, subhedral authigenic quartz, and mosaic authigenic quartz. For clay, it is identified as muscovite natural 3T.

For the surface exposures, the carbonate rock samples collected from the natural outcrops in the study area, at least five lithofacies units, namely, dolomitic biosparite, dolomitic oolitic pelsparite, dolomitic biomicrite, dolomitic fossiliferous micrite, and medium crystalline dolomite have been recognized. The lead-zinc mineralization zone is associated within the dolomitic biosparite unit. The dolomitic oolitic pelsparite unit, it is believed to be a lens-shaped geometry intercalated in the dolomitic biosparite unit. The dolomitic biomicrite unit is generally exposed in/or adjacent to the dolomitic biosparite unit as small zones. The dolomitic fossiliferous micrite unit is believed to be intercalated in the dolomitic biosparite unit. The last unit is the medium crystalline dolomite exposed around the study area particularly on both sides of the major fault in the eastern direction of the mine camp.

Upon comparing the microfacies characteristics of the Ordovician carbonate sediments under the present investigation with the microfacies models of carbonate sediments of Reeckmann and Friedman (1982), and Flügel (1978), the depositional environments are regarded to be mainly shallow marine carbonate and some intertidal of the marginal marine carbonate.

It is interesting to note that the intertidal facies of marginal marine carbonate facies have been recognized to be intercalated only in the upper part of the measured section along the

Dewatering Drift to Huai Chanee, whereas the rest of the sections are essentially subtidal shallow marine carbonate facies. Oolites are mainly formed under the hydrographical regime of agitated marine water with depth not more than 6 feet, or between intertidal zone (Newell, et al., 1960; and Monaghan, et al., 1956). The indication of the subtidal zone of shallow marine carbonate is the presences of pellets, crinoids, and brachiopods. Besides, the presence of algal fragments is the good indication of marginal and shallow marine environments of the carbonate shelf (James, 1983).

The presences of small amount of detrital quartz and clay in the carbonate sediments under the present study indicates some influences of the terrigenous influx from the coastline. Therefore, in addition to the paleontological features which indicate the coastal proximity, the detrital quartz and clay in carbonate sediments can provide an indication for the marginal and shallow marine carbonate environments.

Therefore, it is concluded that the three measured sections of the Ordovician carbonate sediments in the vicinity of the Song Toh Mine area represent the inner to middle carbonate shelf facies deposited mainly in the subtidal zone of the shallow marine environments and some intertidal zones of the marginal marine environments. The 850-metre thick of the carbonate sequence might represent the carbonate sedimentation in slow subsiding basin where the rate of sedimentation is almost balance with the rate of subsidence. This would explain the thick sequence of the carbonate sediments which were deposited in the more or less stable environments.

This reconstruction of the depositional environment is, however, limited by the complexity of post-depositional changes of both diagenesis and structural deformation. Despite such a limitation, the overall interpretation regarding this matter is reliable except for some additional details which can not be exactly pointed out. With respect to authigenesis, the most common authigenesis minerals found in carbonate rocks of the present study are quartz, pyritohedral pyrite and dolomite.

In addition to microfacies analysis, an attempt has been made to determine the geochemical facies characteristics of the following parameters, namely, calcium, magnesium, iron, strontium, lead, zinc, barium, manganese, cobalt, and acid insoluble residue. Altogether 97 samples of the carbonate sediments have been obtained from the non-mineralized zone of the three measured sections, and 25 samples of the ore-bearing carbonate sediments. The geochemical results reveal that the strontium, barium, and acid insoluble residue contents of the ore-bearing samples are relatively higher than the rock samples, whereas the iron and cobalt contents are relatively lower than the rock samples. The manganese content of both rock and ore-bearing samples show only slight different.

Regarding to petrographic characteristics of the carbonate rocks in the mineralized zone, it is generally slightly different from those of the non-mineralized zone. However, the most distinctive carbonate rock type which are only present in the mineralized zone are dolomitic intraclastic pelsparite. Besides, the finely crystalline rocks in the mineralized zone usually exhibit the flaser structure of micrite or microsparite which show micro-layer alternation with medium-grained dolomite lenses, and the veinlets of secondary coarsely calcite with associated dolomite rhombs, and authigenic medium to coarsely crystalline quartz mosaic are quite common.

For geochemical characteristics of the ore-bearing samples, it is apparent that the very strong positive geochemical correlation exists between the lead and barium, zinc and acid insoluble residue. Besides, there is the strong positive geochemical correlation between lead and zinc, iron and manganese, lead and acid insoluble residue, and barium and strontium. For calcium and acid insoluble residue, there is a strong negative geochemical correlation.

The sulphide ores of the Song Toh Mine are characterized by galena and sphalerite, whereas pyrite, barite, quartz, dolomite, calcite, and clay are associated gangues. Besides, secondary ores which are mainly associated with the exposed primary ore zones or as oxidized minerals are cerussite, smithsonite, hemimorphite, and hydrozincite.

The mineralization of galena and sphalerite is entirely confined in the Ordovician carbonate sequence, and at least three different main types have been recognized, namely, layered or banded galena/sphalerite ores, massive sulphides ores, and disseminated sulphides ores.

Microscopically, galena which is the most abundant ore can be recognized in two types in the layered or banded galena/sphalerite ores. The galena type I occurs as fine-grained or irregular inclusions in detached dolomite rhombs and/or mosaic calcite, and closely associated with the framboidal to pyritohedral pyrite, sphalerite type I and/or clay, whereas the galena type II associated with the layered or banded galena/sphalerite ores and/or disseminated sulphides ores particularly in the massive sulphide ores as fine to coarsely patches to a massive aggregate or irregular mass wrapping around detached dolomite rhombs and/or framboidal to pyritohedral pyrite. It also occurs as intergrowth with authigenic quartz and sphalerite type II. The galena type II probably represents the recrystallization and/or remobilization of the primary or early-formed galena type I. For sphalerite, in layered or banded galena/sphalerite ores, shows a diversity in grain size and morphology. Texturally, there are at least two genetic types of sphalerite. The most common and widely distributed is the fine-grained sphalerite type I ranges from irregularly polycrystalline aggregates or cluster to semi-linear bands to finely laminated bands, anhedral crystals in barite, and carbonate matrix. It commonly mixed with oriented clay laminae, galena type I, and framboidal to pyritohedral pyrite. The less common sphalerite type II is characterized by a clear, medium to coarse crystals or aggregates, and commonly associated with coarsely crystalline sparry calcite cement and occasionally with remobilized galena type II.

The lead-zinc mineralized zone is characterized by the sharp contact with carbonate-host rock without any evidence of hydrothermal wall-rock alteration (Permthong, 1982), sharp and abrupt contact without any transitional zone of the geochemical profiles of lead and zinc across the mineralized zone, the similar diagnostic fabrics of the Ordovician carbonate sediments within and outside the mineralized zone. It is noted that underlying the lead-zinc mineralized zones is a thick Cambro-Ordovician fine-grained clastic rocks (Koch, 1973; Hagen and Kemper, 1976; and Diehl and Kern, 1981); and tuffaceous layers and volcanic breccia in the vicinity of the Song Toh Mine which can be related to the mineralization (Diehl and Kern, 1981).

Based on the data and information on microfacies and geochemical facies characteristics, paragenesis, regional geological setting of the study area, and the theoretical framework of the carbonate-hosted sulphide deposits, it is proposed that the ore-bearing fluid is believed to be either squeezed out of the underlying fine-grained clastic rocks of possibly Cambro-Ordovician Epoch during compaction and/or tectonic dewatering processes or metal-rich brine which might be derived from exhalative processes to be generated and migrated to the edge of epicontinental basin floor. This ore-bearing fluid will eventually be precipitated penecontemporaneously with the Ordovician carbonate sediments at the seawater/carbonate sediment interface which was the active site of the Ordovician carbonate sedimentation in the shallow marine environment under low temperature of syn- and early diagenetic conditions. Besides, the reducing condition probably caused by the discharge of $H_2S$ in high concentration produced by organic-rich sediments and/or sulphide-reducing bacterial action of connate water can react with the lead/zinc-bearing fluid to precipitated galena and sphalerite.

After the diagenetic mineralization of lead-zinc sulphides in the Ordovician carbonate sediments, subsequent tectonic deformation during Late Carboniferous to Permo-Triassic Epoch (Permthong, 1982) is believed to play an important role in the crystallization and/or remobilization of the most of the original sulphide ores.

In conclusion, the lead-zinc mineralization in the Ordovician carbonate sediments of the Song Toh Mine area is of sedimentary origin. However, evidences from the present study is inadequate to pin point exactly to the source of the metal-fluid.