CHAPTER III

MICROFACIES ANALYSIS OF THE ORDOVICIAN CARBONATE SEDIMENTS

Every depositional facies usually shows well-defined petrographical, geological and paleontological properties which can be clearly differentiated from the properties of other facies in the same geological period. Generally, in facies analysis, paleontological, sedimentological, geological, and geochemical data provide the basic information about the sedimentary environment, the lithogenesis, and the biotopes of organisms preserved as fossils (Flügel, 1978). However, the depositional data has been altered during the complex diagenetic changes. These alteration processes have therefore further complicated the reconstruction of the depositional environment.

The term "microfacies" was first suggested by Brown (1943): "In thin-section, the rock is seen to be composed of ... microfacies". Therefore, microfacies refers to the criteria appearing in thin-sections under microscope. By definition, microfacies is the total of all the paleontological and sedimentological criteria which can be classified in thin-sections, peels, and polished slabs (Flügel, 1978).

In this study, an attempt has been made to conduct the preliminary microfacies analysis of carbonate rocks which had been partially mineralized by the lead-zinc ores. Emphases have been given to the sedimentological and geochemical aspects of the carbonate

rocks. It is anticipated that, the relationships between the microfacies data and the mineralized zone might be established in order to fully understand the mineralization.

For microfacies analysis employed in the present investigation, two aspects are considered, namely, physical and geochemical. In the physical study, the carbonate grain components (allochems and orthochems), and mineralogical components (authigenic, carbonate, detrital quartz, and ore/gangue minerals) are semiquantitatively and quantitatively determined. With respect to geochemical aspects, various trace elements are quantitatively determined. The overall microfacies characteristics will be employed in the formulation of facies models concerned.

The following discussion will be focussing upon the physical and geochemical aspects of microfacies of some Ordovician carbonate sediments in the vicinity of Song Toh Mine area, as well as the interpretation of facies models.

3.1 Physical aspect.

The physical aspects of carbonate sediments referred to in this study include the petrographic, mineralogical parameters. For petrographic parameters (types and relative degree of abundance of various kinds of allochems, namely, skeletal fragments, pellets, and oolites; orthochems, namely, micrite, microsparite, and sparry calcite cement) are determined using visual comparison method. With respect to the mineralogical aspect, an emphasis has been given on the calcite/dolomite ratio and the mineralogy and total content of acid insoluble residue.

Altogether, approximately 450 standard thin-sections from three measured sections of totally about 2,000 metres long are being employed in this study. In addition, approximately 90 standard thin-sections of carbonate sediments collected from the surface exposures covering the area of approximately 2.0 square kilometres are examined petrographically.

3.1.1 Petrography of the carbonate sediments.

Petrographic examinations of standard thin-sections of the Ordovician carbonate sediments of totally 540 samples obtained from measured sections and surface sampling (Figures 3.1.1a, b,and c) generally reveal that they are essentially biomicrite, fossiliferous micrite, dismicrite, biosparite, biopelsparite, pelsparite, and oosparite. These rocks have been partially to completely dolomitized in almost all cases.

In addition to carbonate components, the Ordovician carbonate sediments in the study area contain considerable amount of terrigenous materials, notably, detrital quartz of mainly silt- to medium sand-size, and clay (muscovite natural 3T; Appendix C, Figure C-1).

The major allochemical constituents of the Ordovician carbonate sediments are oolites, pellets, and skeletal fragments of ostracod, algae-like, mollusc, brachiopod and crinoid. These allochems, particularly the skeletal fragments, have been strongly altered by diagenetic changes. With respect to the orthochemical components, they are micrite, microsparite, and sparry calcite cement in decreasing order of their abundances.

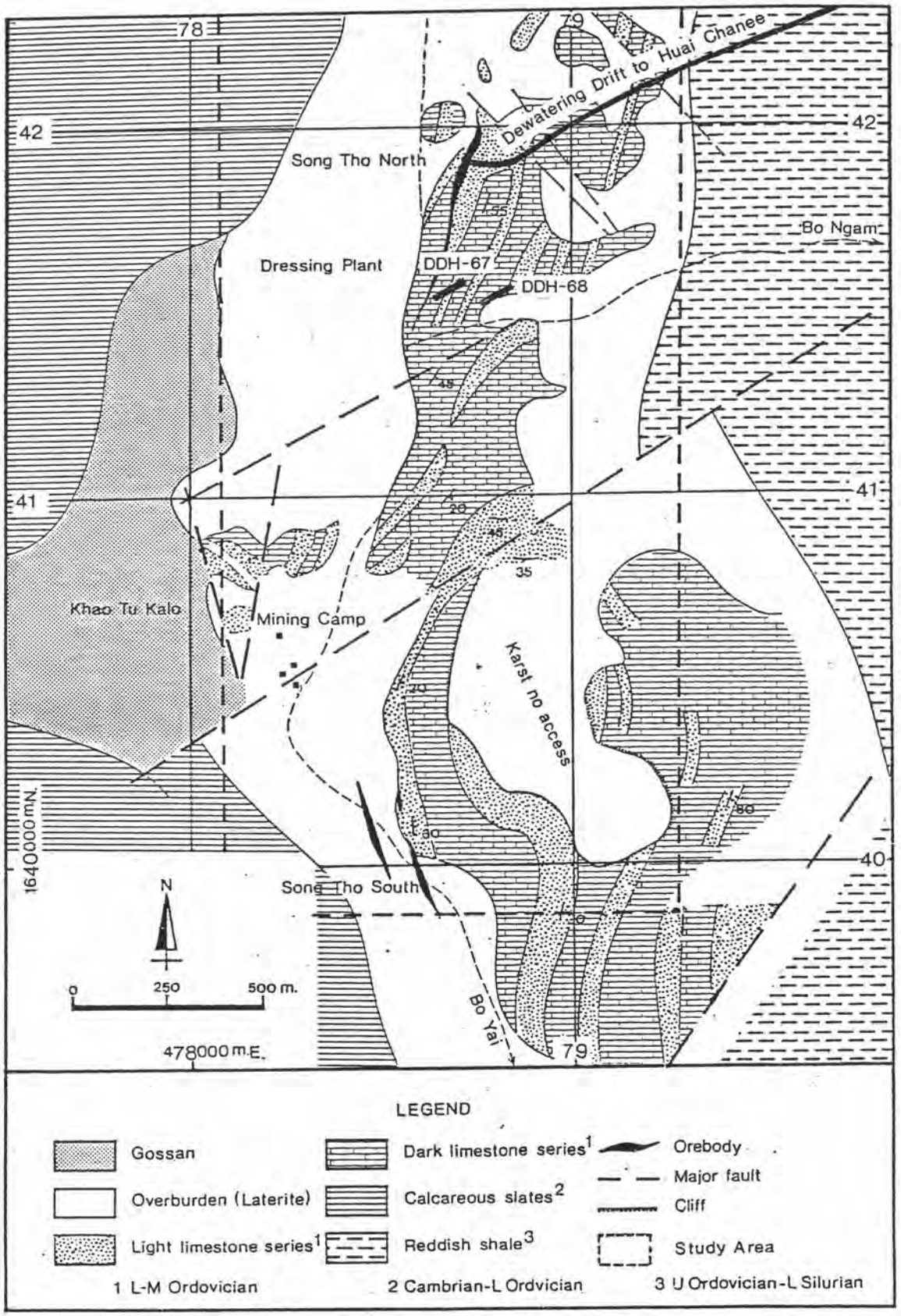


Figure 3.1.1a Location of the measured sections (the Dewatering Drift to Huai Chanee, the DDH-67, and DDH-68).

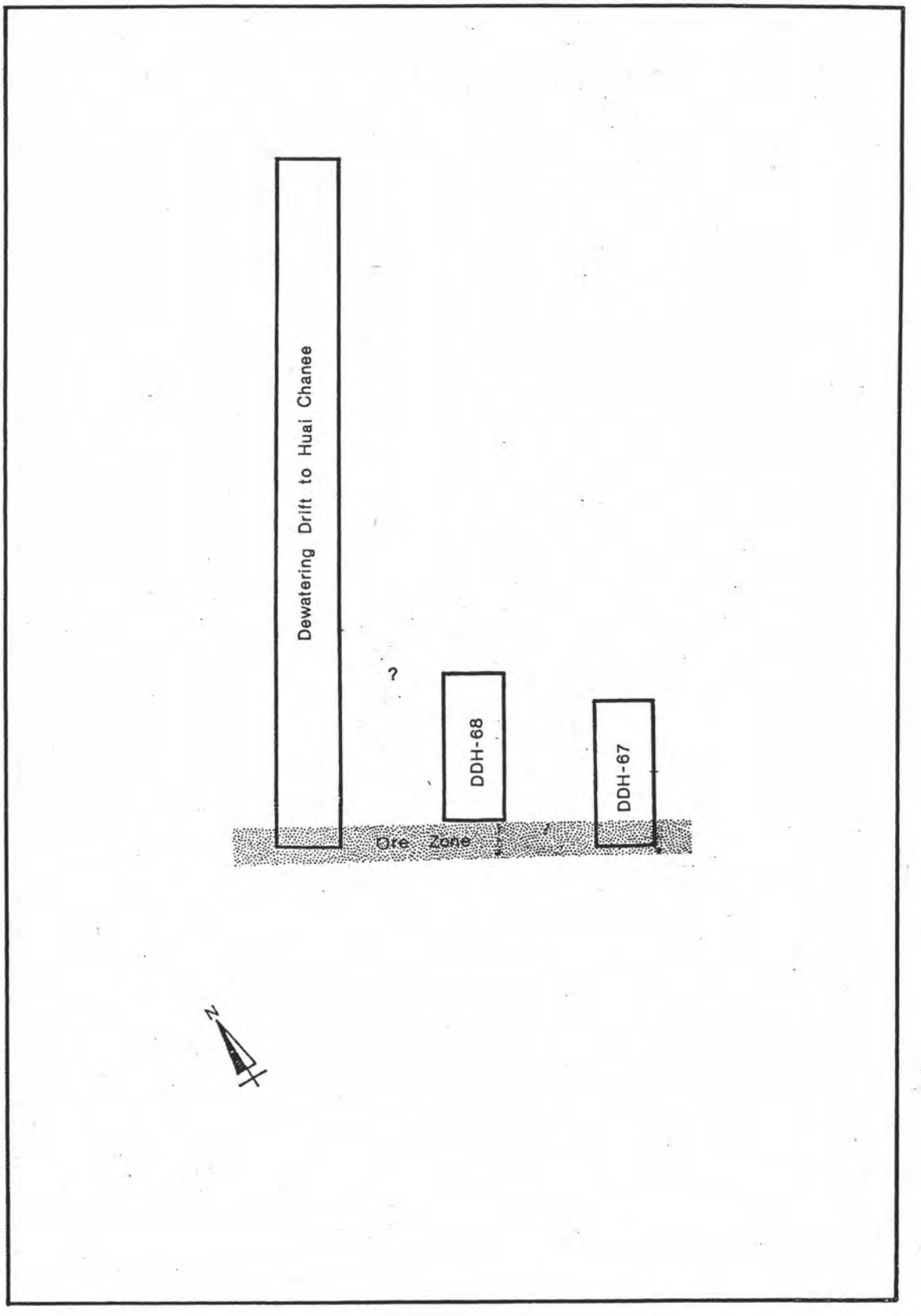


Figure 3.1.1b The relative stratigraphic position of the measured sections in the Song Toh North Mine area (not to scale).

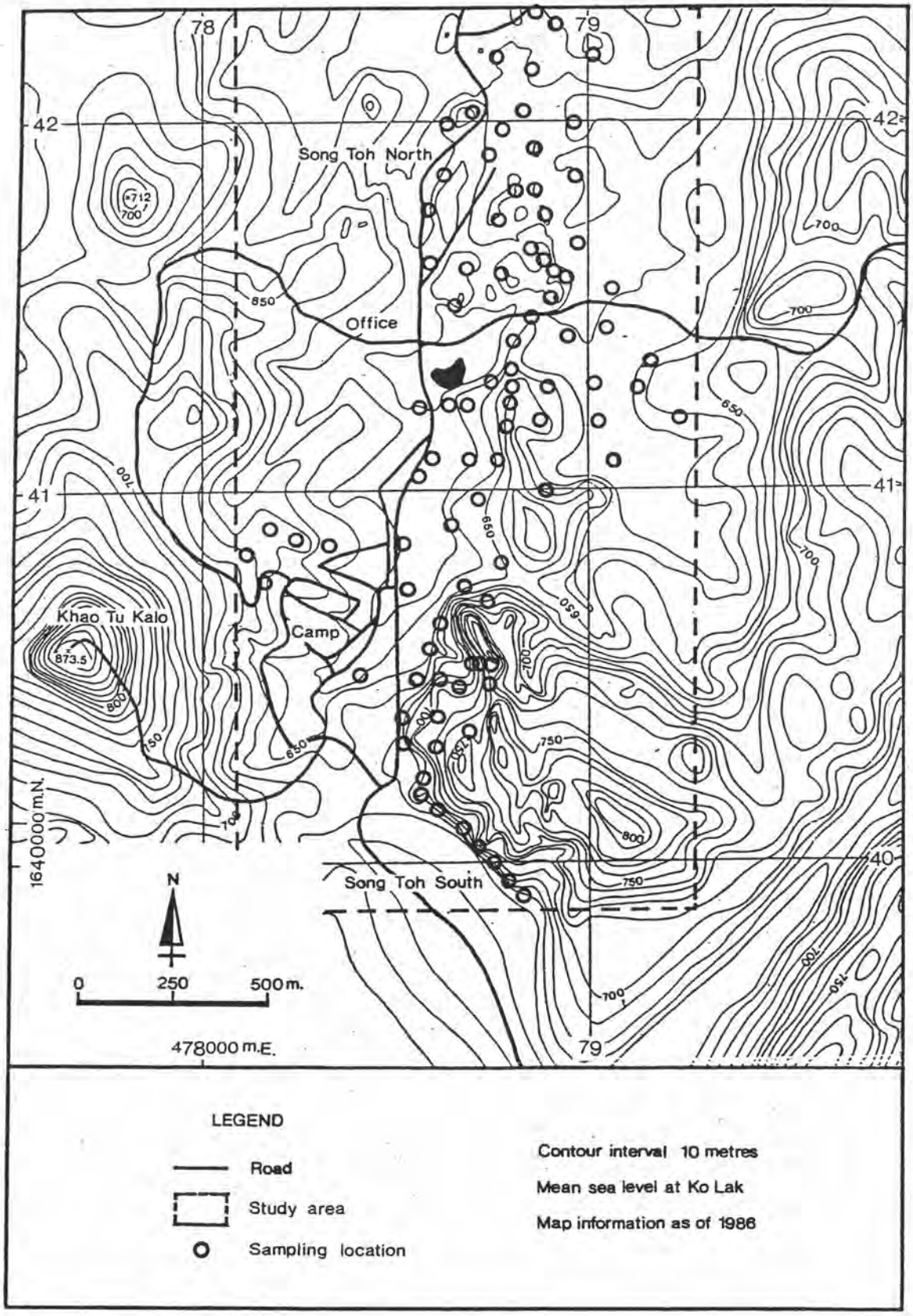


Figure 3.1.1c Sampling location in the study area.

The classification and nomenclature of the Ordovician carbonate sediments employed in this study is essentially based on Folk (1968).

a) Measured section along the Dewatering Drift to Huai Chanee:

The measured section along the Dewatering Drift to Huai Chanee has been chosen for the microfacies study primarily because the continuity of the lithological sequences of Upper Ordovician to Silurian/Devonian (Diehl and Kern, 1981) can be best observed in the direction approximately perpendicular to the regional strike. The total length of the section is approximately 1,500 metres covering about 500 metres of Silurian/Devonian fine-grained clastic/carbonate sediments, and about 1,000 metres of the Ordovician carbonate sediments. Altogether 360 samples of the Ordovician carbonate sediments have been obtained from the 1,000-metre long of upper Ordovician carbonate sequence. The boundary between upper part of the Ordovician carbonate sequence and Silurian/Devonian fine-grained clastics is a fault contact (Geology and Survey Department of Song Toh Mine, 1983). The petrographic characteristics of this section is described unit by unit in descending order as follows:

X-1 Unit.: The uppermost unit of the Ordovician carbonate sediments is the dolomitic biomicrite of approximately 10 metres thick. The allochems are crinoids, ostracods, and unidentified skeletal fragments. Other terrigenous materials associated within this unit are detrital quartz of less than 7.5 per cent by volume, and clay content is very low (Plate 3-1: X-1).

X-2 Unit.: This unit is the dolomitic biosparite of approximately 14 metres thick. The allochemical components are unidentified skeletal fragments and pellets. Most of the quartz grains associated with this unit are authigenic quartz which mainly show subhedral to euhedral crystal habits (Plate 3-1: X-2).

X-3 Unit.: This unit is the fine-grained carbonate sediments, namely, dolomitic biomicrite, dolomitic fossiliferous micrite and dolomitic dismicrite of about 9, 9.5, and 23 metres, respectively in descending order which have been partially dolomitized. The thickness of this unit is approximately 41.5 metres. The skeletal constituents are unidentified skeletal fragments. The terrigenous materials associated within this unit are detrital quartz and clay. The content of these terrigenous are relatively higher than the upper unit with detrital quartz content of up to 10 per cent by volume, and clay is low (Plate 3-1: X-3a, b, and c).

X-4 Unit.: This unit is the medium crystalline dolomite of 14.5 metres thick. It is interesting to note that there are abundant detrital quartz of sand-size of approximately 50 per cent by volume associated with this unit. The texture of dolomite is mostly medium-grained mosaic (Plate 3-1: X-4).

X-5 Unit.: This unit is the 85 metres thick of dolomitic biopelsparite with thin layer of dolomitic fossiliferous micrite intercalation. The detailed succession of this unit are dolomitic oolitic pelsparite, dolomitic fossiliferous micrite, dolomitic oosparite, dolomitic oolitic pelsparite, and dolomitic biosparite of approximately 15.5, 9.5, 10, 33.5, and 16.5 metres, respectively in

Plate 3-1 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

X-1: Dolomitic biomicrite showing ostracods (Os) and unidentified skeletal fragments (U) embedded in micrite matrix (under transmitted light; uncrossed nicols).

X-2: Dolomitic biosparite showing pellets (Pl), unidentified skeletal fragments (U), and authigenic and detrital quartzs with sparry calcite cement (under transmitted light; crossed nicols).

X-3a: Dolomitic biomicrite showing unidentified skeletal fragments (U), detrital quartz (Qz) embedded in micrite matrix (under transmitted light; crossed nicols).

X-3b: Dolomitic biomicrite showing ostracods (Os), and unidentified skeletal fragments (U), and quartz (Qz) embedded in micrite matrix (under transmitted light; crossed nicols).

X-3c: Dolomitic dismicrite bisected by calcite veinlets, and detrital quartz (Qz) (under transmitted light; crossed nicols).

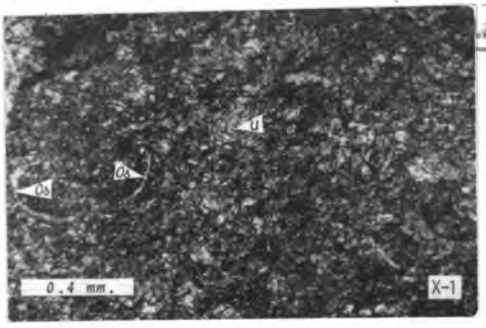
X-4: Dolomite with medium-grained, showing both of dolomite rhombs and mosaic fabrics, detrital quartz (Qz) (under transmitted light; crossed nicols).

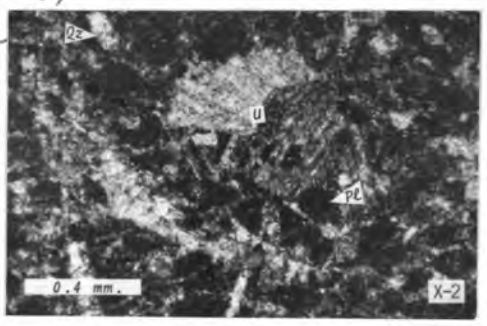
X-5a: Dolomitic pelsparite with some oolites, calcite veinlet, some dolomite rhombs partially replaced pellets (under transmitted light; uncrossed nicols).

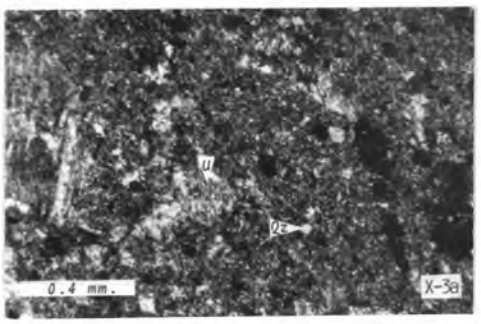
X-5b: Dolomitic fossiliferous micrite showing ostracods (Os) (under transmitted light; crossed nicols).

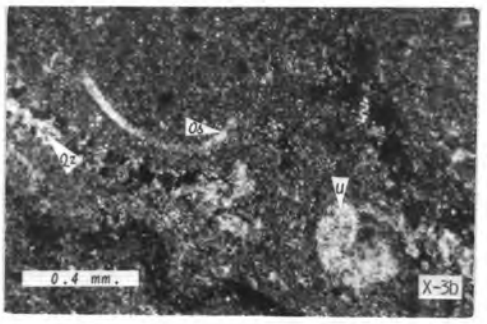
X-5c: Dolomitic oosparite with some pellets (Pl) and some oolites (Oo; under transmitted light; uncrossed nicols).

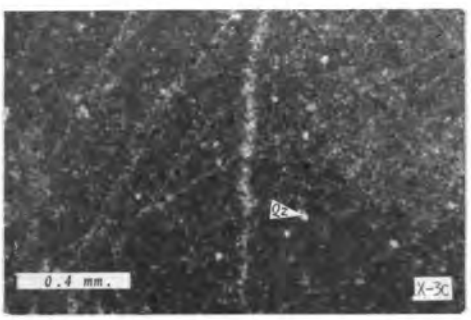
X-5d: Dolomitic biosparite showing unidentified skeletal fragments (U; brachiopods ?) dolomite rhombs, detrital quartz (Qz) (under transmitted light; crossed nicols).

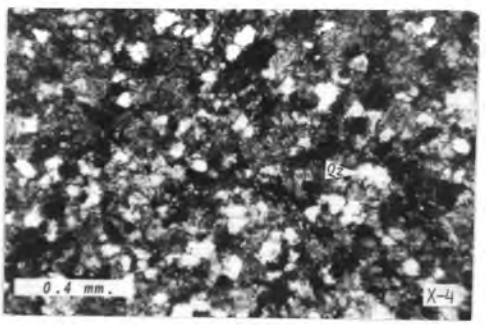


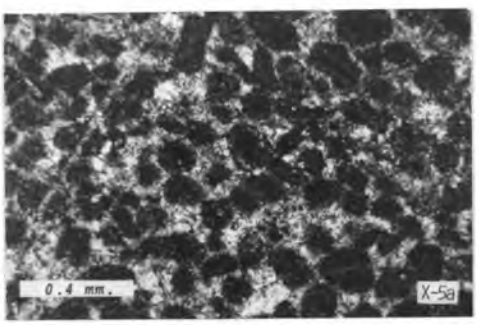


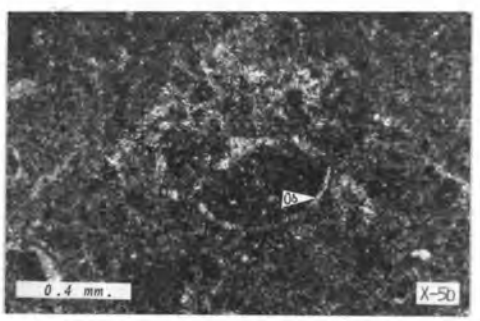


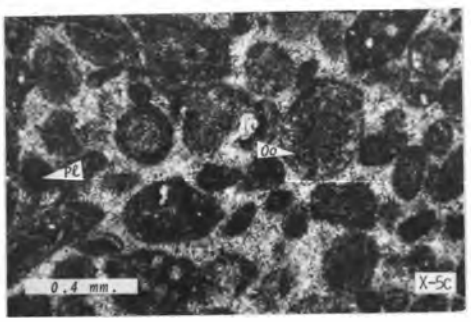


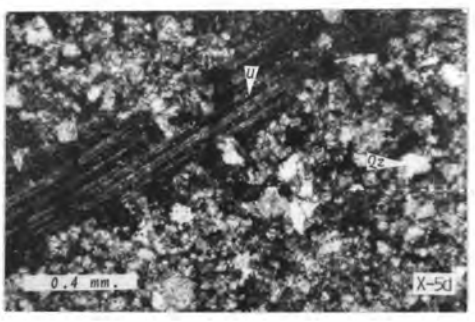












descending order. The allochemical components are pellets, oolites, ostracods, mollusc shell fragments, and other unidentified skeletal fragments. The content of terrigenous materials, both detrital quartz and acid insoluble residue are extremely low. This rock unit is only slightly dolomitized (Plate 3-1: X-5a, b, c,and d).

X-6 Unit.: This unit is the medium crystalline dolomite of about 18 metres thick. The overall characteristics of this unit is similar to the upper dolomite unit (X-4 Unit) earlier described except the dolomite grains exhibit both mosaic and rhomb textural characteristics (Plate 3-2: X-6).

X-7 Unit.: This unit is the dolomitic pelsparite of 16.5 metres thick. Other associated allochems are some unidentified shell fragments. Quartz grains in this unit are both detrital and authigenic origins of totally 5 per cent by volume. This unit is slightly dolomitized (Plate 3-2: X-7).

X-8 Unit.: This unit is the dolomitic fossiliferous micrite of about 12 metres thick with abundant crinoids. The total amounts of quartz both of detrital and authigenic origins as well as dolomite are lower than the overlying unit (Plate 3-2: X-8).

X-9 Unit.: The dolomitic pelsparite unit is about 17.5 metres thick, and slightly dolomitized. The allochems are pellets, and unidentified skeletal fragments. The authigenic quartz content is approximately 2.5 per cent by volume and, shows subhedral and euhedral crystals (Plate 3-2: X-9).

X-10 Unit.: This unit is the dolomitic fossiliferous micrite of approximately 37.5 metres thick. The allochemical components are unidentified skeletal fragments with relatively less abundant than the upper one. In addition, detrital and authigenic quartz of up to 7.5 per cent by volume is associated with this unit. The clay content is very low (Plate 3-2: X-10).

X-11 Unit.: This unit is the dolomite of totally 9 metres thick. The characteristics of this unit is similar to the upper dolomite unit except the quartz content of this unit is authigenic origin of about 2.5 per cent by volume (Plate 3-2: X-11).

X-12 Unit.: This unit is the 16 metres thick of dolomitic fossiliferous micrite with moderately dolomitized and medium dolomite crystals show both mosaic and rhomb habits. The authigenic quartz is approximately 5 per cent by volume, whereas the clay content is extremely low. The allochems are unidentified skeletal fragments (Plate 3-2: X-12).

X-13 Unit.: This unit is the dolomitic biosparite of about 9.5 metres thick with abundant unidentified skeletal fragments. Other components are authigenic quartz of approximately 2.5 per cent by volume and very low content of clay (Plate 3-2: X-13).

X-14 Unit.: This unit is the dolomitic fossiliferous micrite of totally 11 metres thick. The overall characteristics are the same as the upper dolomitic fossiliferous micrite unit (X-12 Unit; Plate 3-2: X-14).

Plate 3-2 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

X-6: Medium crystalline dolomite showing detrital quartz (Qz) (under transmitted light; crossed nicols).

X-7: Dolomitic pelsparite showing pellets, and both of detrital and authigenic quartzs (Qz) (under transmitted light; uncrossed nicols).

X-8: Dolomitic fossiliferous micrite with unidentified skeletal fragments (U) and detrital quartz in micrite matrix (under transmitted light; crossed nicols).

X-9: Dolomitic pelsparite showing pellets and, calcite veinlet, and detrital quartz (under transmitted light; uncrossed nicols).

X-10: Dolomitic fossiliferous micrite showing unidentified skeletal fragments (U), and both of detrital quartz and authigenic quartz (white colour; under transmitted light;crossed nicols).

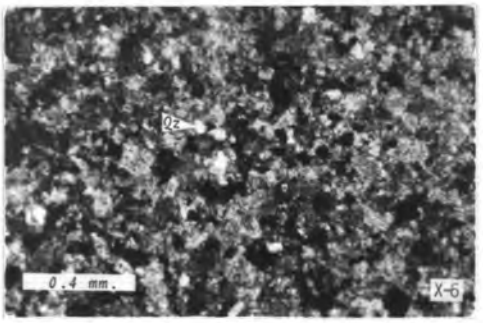
X-11: Medium crystalline dolomite with quartz (Qz) (under transmitted light; crossed nicols).

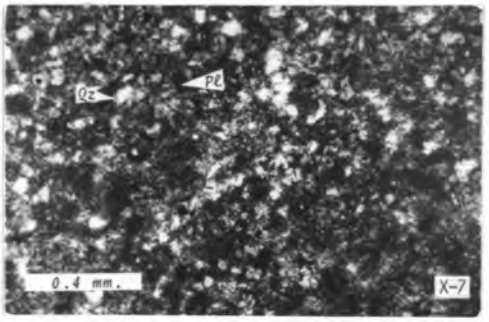
X-12: Dolomitic fossiliferous micrite showing authigenic quartz (Qz) (under transmitted light; crossed nicols).

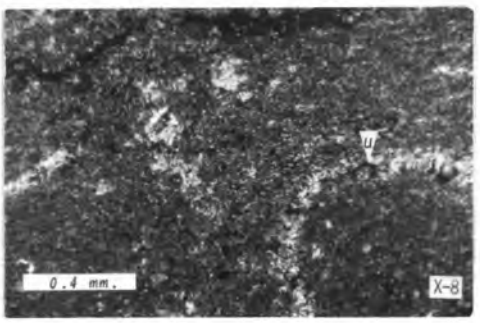
X-13: Dolomitic biosparite showing crinoid (C) unidentified skeletal fragments (U), and authigenic quartz (white colour; under transmitted light; crossed nicols).

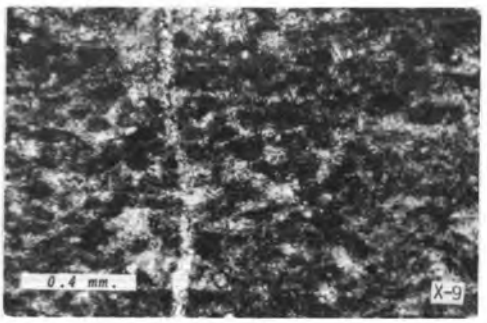
X-14: Dolomitic fossiliferous micrite with authigenic quartz (Qz) in micrite matrix (under transmitted light; crossed nicols).

X-15: Medium crystalline dolomite showing both of rhombs and mosaic fabrics, authigenic quartz (Qz) (under transmitted light; crossed nicols).


Qz
0.4 mm.
X-6


Qz
Pl
0.4 mm.
X-7


U
0.4 mm.
X-8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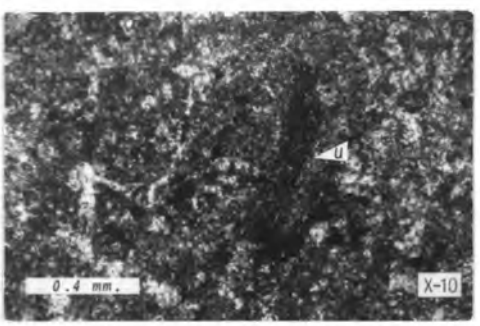
X-9


U
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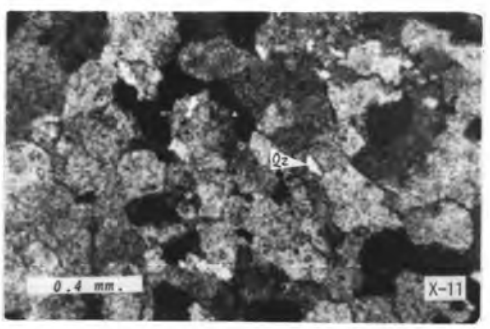
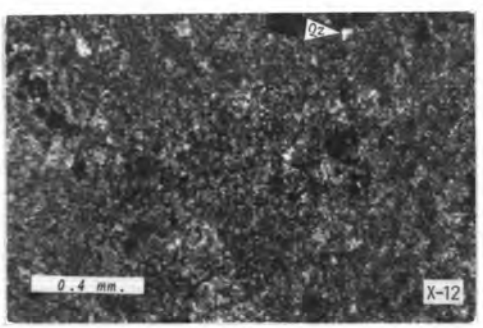
X-10


Qz
0.4 mm.
X-11


Qz
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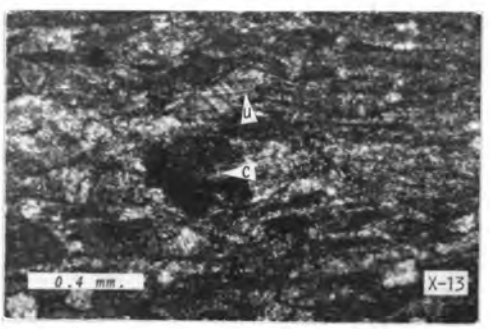
X-12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C
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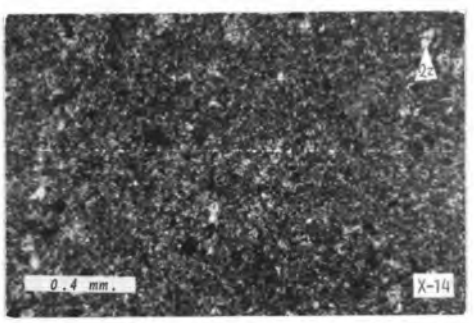
X-13


Zr
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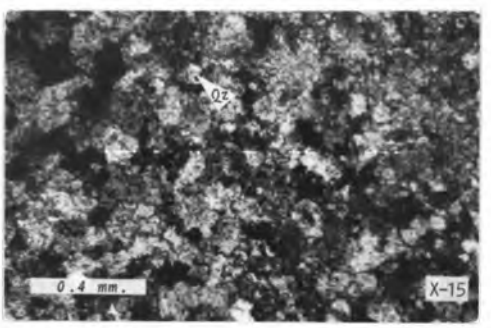
X-14


Qz
0.4 mm.
X-15

X-15 Unit.: This unit is the medium crystalline dolomite of about 10 metres thick. This unit is characterized by mosaic and rhomb of medium-sized dolomite, and relatively rare unidentified skeletal fragments. Other characteristics are similar to the upper dolomite units (Plate 3-2: X-15).

X-16 Unit.: This unit is approximately 15.5 metres thick of fine-grained carbonates. The detailed succession of the unit is 8-metre thick of dolomitic pelmicrite in the upper part, and 7.5-metre thick of dolomitic fossiliferous micrite in the lower part with unidentified skeletal fragments. Most of quartz grains are of authigenic origin ranging in content from 2.5 to 5 per cent by volume (Plate 3-3: X-16a, and b).

X-17 Unit.: This unit is medium crystalline dolomite of about 10 metres thick with 2.5 per cent of authigenic quartz. The dolomite crystals show both mosaic and rhombs habits (Plate 3-3: X-17).

X-18 Unit.: This unit is the dolomitic biopelsparite of totally 17.5 metres thick. The allochemical components are pellets, unidentified skeletal fragments, and mollusc shell fragments (?). Quartz grains are of authigenic origin of ranging in content from 2.5 to 5 per cent by volume. In addition, clay content is extremely low (Plate 3-3: X-18).

X-19 Unit.: This unit is the dolomitic oolitic biomicrite of approximately 21 metres thick. The succession of the unit are 11.5-metre thick of dolomitic oomicrite with crinoids, and 9.5-metre thick of dolomitic biomicrite, respectively in descending order. The upper part is highly dolomitized while the authigenic quartz content

of this unit is very low of approximately 2.5 per cent by volume (Plate 3-3: X-19a, and b).

X-20 Unit.: The biosparite/micrite unit is of about 85 metres thick. The characteristics of this unit are interbedding of dolomitic biosparite and dolomitic fossiliferous micrite with relatively low content of allochems in the middle part. The quartz content of both of authigenic and detrital origins is ranging from 1 to 2.5 per cent by volume, while the clay content is very low (Plate 3-3: X-20a, and b).

X-21 Unit.: The medium crystalline dolomite unit is totally 16 metres thick. The characteristics of this unit are the dolomite crystals showing both of mosaic and rhomb textures. The amount of sand-sized authigenic quartz is about 7.5 per cent by volume (Plate 3-3: X-21).

X-22 Unit.: The fine-grained carbonate unit is of approximately 40 metres thick. The detailed succession within this unit is the 10-metre thick of dolomitic fossiliferous micrite in the upper part, the 10-metre thick of pelmicrite in the middle part, and the 20-metre thick of dolomitic dismicrite in the lower part. The allochems in the upper part are crinoids and unidentified skeletal fragments, pellets in the middle part, whereas the amounts of both of quartz (authigenic and detrital origins), and clay are extremely low (Plate 3-4: X-22a, and b).

X-23 Unit.: The medium crystalline dolomite unit is about 12 metres thick. This unit is characterized by the same characteristics as the upper dolomite unit (X-21 Unit) except quartz

Plate 3-3 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

X-16a: Dolomitic pelmicrite showing dolomite rhombs (Do), authigenic quartz (Qz) and pellets (Pl) (under transmitted light; crossed nicols).

X-16b: Dolomitic fossiliferous micrite showing euhedral authigenic quartz crystals (Qz) in micrite matrix (under transmitted light; crossed nicols).

X-17: Medium crystalline dolomite with authigenic quartz crystals (Qz), showing both of rhombs and mosaic fabrics (under transmitted light; crossed nicols).

X-18: Dolomitic biosparite showing authigenic quartz(Qz), pellets(Pl) and dolomite rhombs (under transmitted light; crossed nicols).

X-19a: Dolomitic oomicrite showing oolite (Oo) and authigenic quartz (Qz) (under transmitted light; crossed nicols).

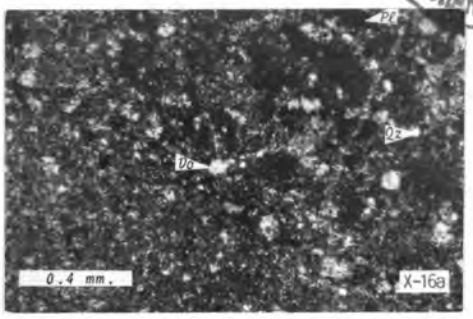
X-19b: Dolomitic biomicrite with dolomite rhombs and showing unidentified skeletal fragments (U) (under transmitted light; crossed nicols).

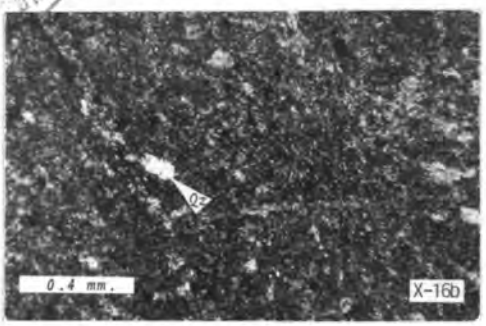
X-20a: Dolomitic biosparite showing authigenic quartz crystals (Qz) and algae (?) (under transmitted light; crossed nicols).

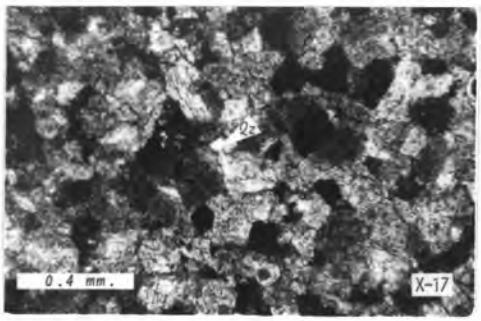
X-20b: Dolomitic fossiliferous micrite showing unidentified skeletal fragments (U), and both of authigenic and detrital quartzs (Qz) (under transmitted light; crossed nicols).

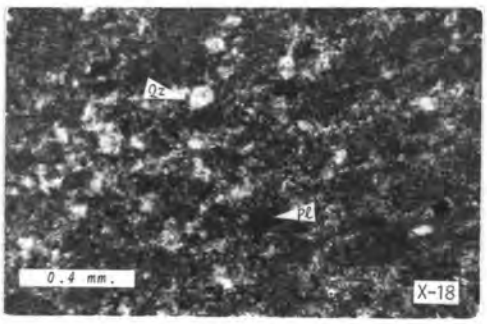
X-20c: Dolomitic biosparite with very large unidentified skeletal fragments (U) and authigenic quartz crystal (Qz) (under transmitted light; crossed nicols).

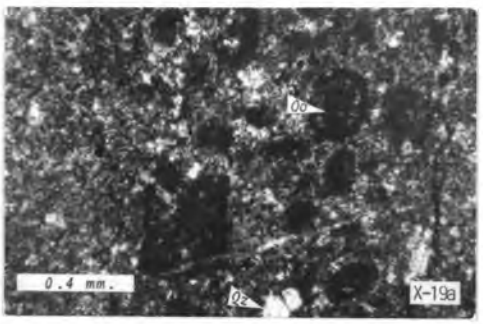
X-21: Medium crystalline dolomite showing very large authigenic quartz (Qz) and dolomite rhombs (under transmitted light; crossed nicols).

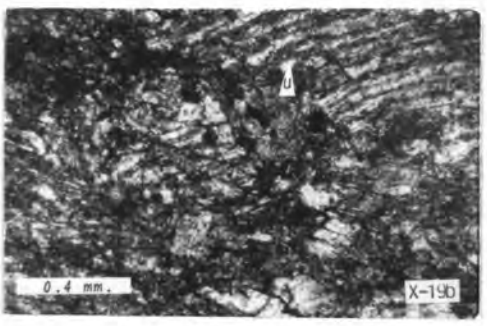


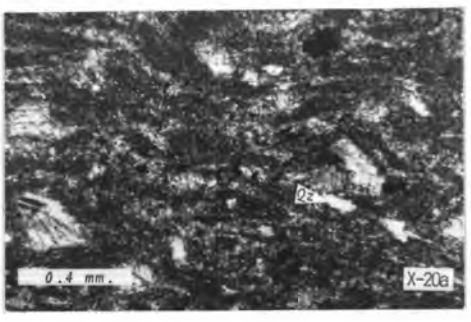


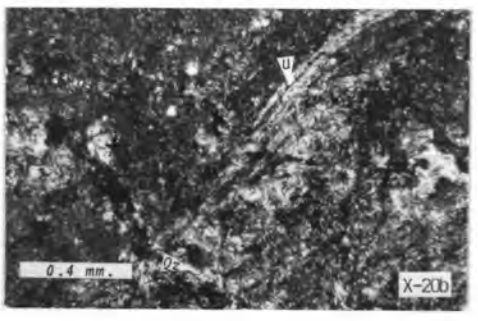


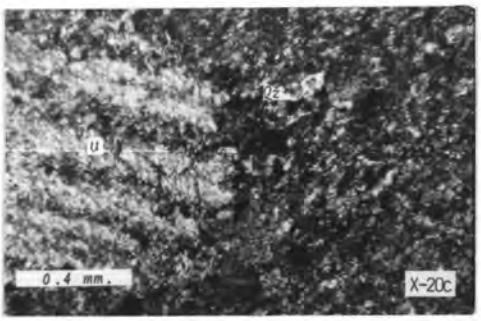


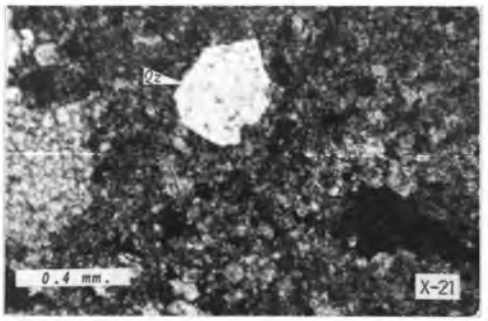












is entirely absent (Plate 3-4: X-23).

X-24 Unit.: The dolomitic biosparite unit is totally 8 metres thick. The allochemical constituent is mainly of unidentified skeletal fragments, while the sand-sized authigenic quartz is about 2.5 per cent by volume. This unit is strongly dolomitized (Plate 3-4: X-24).

X-25 Unit.: The medium crystalline dolomite unit is approximately 39 metres thick with extremely low quartz content. The dolomite crystals show the mosaic texture (Plate 3-4: X-25).

X-26 Unit.: The dolomitic biosparite unit is of about 10.5 metres thick. The characteristics of this unit are the abundance of algae-like, authigenic quartz of 2.5 per cent by volume, and moderately dolomitized. The dolomite crystals in this unit exhibit rhombohedral habit (Plate 3-4: X-26).

X-27 Unit.: The dolomitic fossiliferous micrite unit is approximately 48 metres thick with moderately dolomitized in the upper part, whereas the lower part is slightly dolomitized. The allochems are crinoid and unidentified skeletal fragments, while the amount of quartz grains of both authigenic and detrital origins is between 2.5 to 5 per cent by volume (Plate 3-4: X-27).

X-28 Unit.: This unit is 9 metres thick of dolomitic biosparite. The allochemical components are mollusc shell fragments (?), and unidentified skeletal fragments. The authigenic quartz is approximately 1 per cent by volume, and the clay is entirely absent (Plate 3-4: X-28).

Plate 3-4 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

X-22a: Dolomitic fossiliferous micrite showing the abundance of unidentified skeletal fragments (U), and some authigenic and detrital quartzs (under transmitted light; crossed nicols).

X-22b: Dolomitic dismicrite showing both of detrital and authigenic quartzs (Qz) in micrite matrix (under transmitted light; crossed nicols).

X-23: Medium crystalline dolomite showing both of rhomb and mosaic fabrics (under transmitted light; crossed nicols).

X-24: Dolomitic biosparite with dolomite rhombs and unidentified skeletal fragments (under transmitted light; crossed nicols).

X-25: Medium crystalline dolomite showing authigenic quartz crystals (Qz), dolomite show both of rhomb and mosaic fabrics (under transmitted light; crossed nicols).

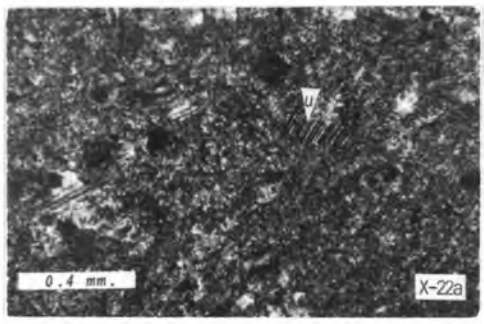
X-26: Dolomitic biosparite showing algae (?) (A) and authigenic quartz (Qz) (under transmitted light; crossed nicols).

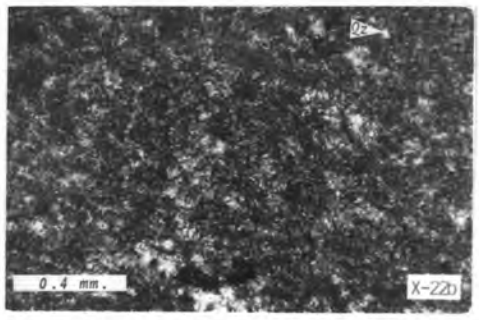
X-27: Dolomitic fossiliferous micrite showing crinoid (C), both of detrital and authigenic quartzs (Qz), and unidentified skeletal fragments (U) (under transmitted light; crossed nicols).

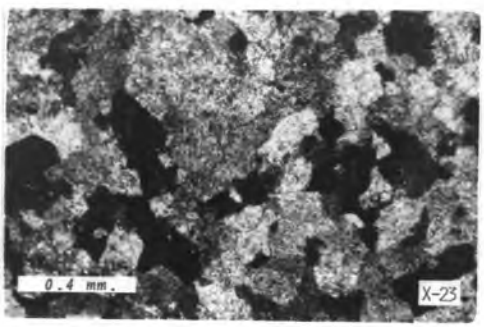
X-28: Dolomitic biosparite showing mollusc shell fragments (?) (Mu), authigenic quartz (Qz) and dolomite rhombs (under transmitted light; crossed nicols).

X-29: Medium crystalline dolomite showing both of dolomite rhomb and mosaic fabrics, and euhedral authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

X-30: Dolomitic fossiliferous micrite showing dolomite rhombs (Do) and authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).


U
0.4 mm.
X-22a


Qz
0.4 mm.
X-22b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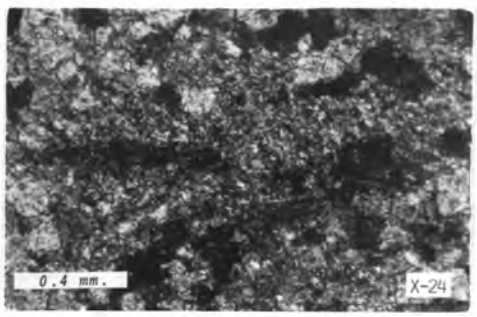
X-23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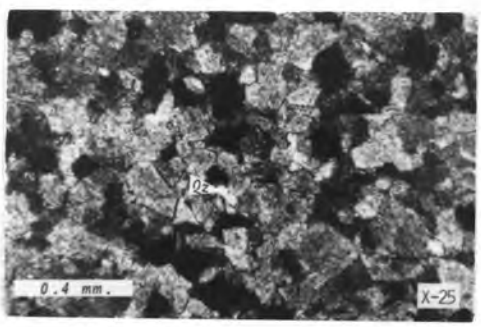
X-24


Qz
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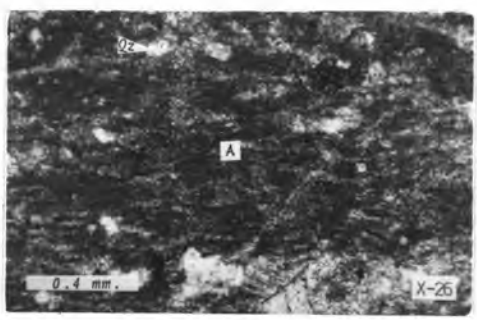
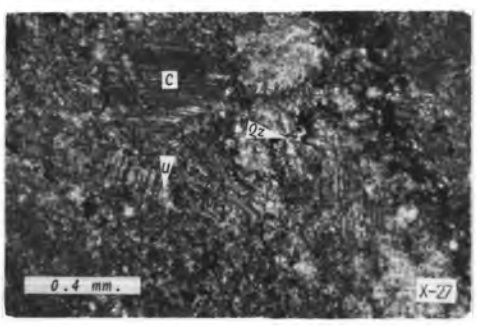
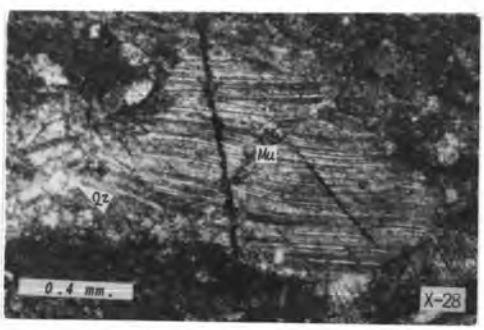
X-25


Qz
A
0.4 mm.
X-26


C
Qz
U
0.4 mm.
X-27


Mu
Qz
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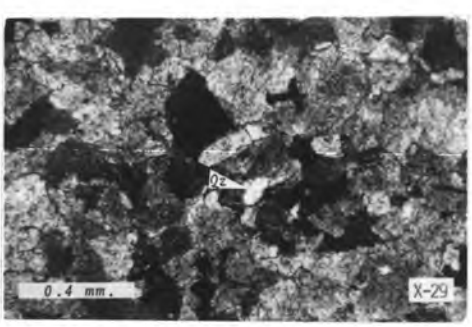
X-28


Qz
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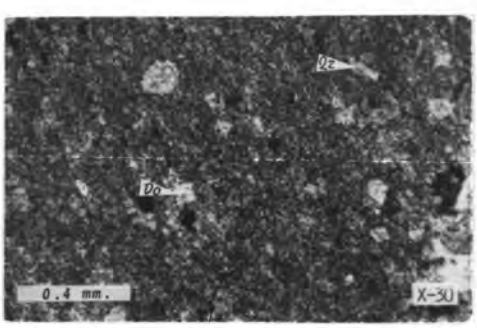
X-29


Qz
Do
0.4 mm.
X-30

X-29 Unit.: The medium crystalline dolomite unit is of about 10 metres thick. The amount of authigenic quartz content is about 2.5 per cent by volume showing subhedral and euhedral crystals (Plate 3-4: X-29).

X-30 Unit.: The dolomitic fossiliferous micrite unit is of totally 6.5 metres thick and strongly dolomitized and dolomite shows rhombohedral habit. The allochems are brachiopod and other unidentified skeletal fragments. The amount of authigenic quartz crystals of both subhedral and euhedral crystals, is approximately 1 per cent by volume (Plate 3-4: X-30).

X-31 Unit.: The medium crystalline dolomite unit is of approximately 17 metres thick. Other characteristics of this unit are very low content of authigenic quartz and detrital quartz, and clay (Plate 3-5: X-31).

X-32 Unit.: The biosparite/micrite unit is of totally 65 metres thick. The detailed successions of this unit are dolomitic fossiliferous micrite, dolomitic biosparite, dolomitic fossiliferous micrite, and dolomitic biosparite of about 6, 6, 12, and 41 metres thick, respectively in descending order. The allochemical constituents are mainly algae-like, and crinoid and unidentified skeletal fragments. The dolomite content within this unit varies considerably from a few per cent to as high as 80 per cent by volume. The degree of dolomitization in different layers in this succession is also highly fluctuated. In addition, detrital quartz, authigenic quartz, and clay are extremely low in content (Plate 3-5: X-32a, and b).

X-33 Unit.: The medium crystalline dolomite unit is of about 6 metres thick with very low content of authigenic quartz. The dolomite show mosaic texture, and some skeletal fragments are still preserved (Plate 3-5: X-33).

X-34 Unit.: The dolomitic biosparite unit is of approximately 5 metres thick. The allochems are algae-like, crinoid, and unidentified skeletal fragments. The terrigenous materials, notably, detrital quartz of about 5 per cent by volume and low clay content are recognized (Plate 3-5: X-34).

X-35 Unit.: The medium crystalline dolomite unit is of about 10 metres thick. The texture of this unit is characterized by rhomb and mosaic habits of dolomite, and very low content of sand-sized authigenic quartz (Plate 3-5: X-35).

X-36 Unit.: The fine-grained carbonate unit is of totally 50 metres thick. The detailed successions of this unit which is slightly dolomitized are dismicrite, fossiliferous micrite, and dismicrite, of approximately 14, 18, and 18 metres thick, respectively in descending order. The quartz content of both of detrital and authigenic origins is between 1 to 5 per cent by volume, while the allochems are algae-like, pellets, crinoid, and unidentified skeletal fragments (Plate 3-5: X-36a, and b).

The petrographic characteristics of this measured section are summarized and graphically presented in Figure 3.1.1d.

Plate 3-5 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

X-31: Medium crystalline dolomite showing both of rhomb and mosaic fabrics, euhedral authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

X-32a: Dolomitic fossiliferous micrite showing euhedral authigenic quartz crystals (Qz) and unidentified skeletal fragment (U) (under transmitted light; crossed nicols).

X-32b: Dolomitic biosparite showing algae (?) (A) and euhedral authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

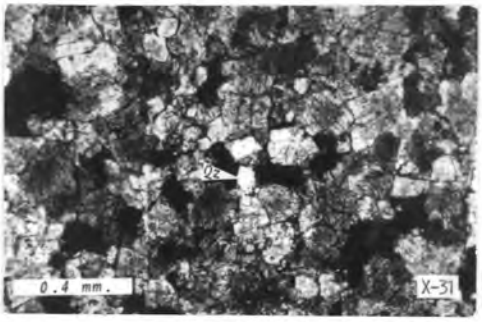
X-33: Medium crystalline dolomite with very fine-grained authigenic quartz crystals (under transmitted light; crossed nicols).

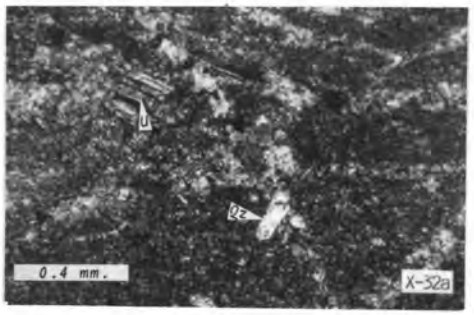
X-34: Dolomitic biosparite showing authigenic quartz crystals (Qz), and dolomite show both of rhomb and mosaic fabrics (under transmitted light; crossed nicols).

X-35: Medium crystalline dolomite showing both of rhomb and mosaic fabrics (under transmitted light; crossed nicols).

X-36a: Dolomitic dismicrite showing both of very fine-grained authigenic quartz and detrital quartz (Qz) (under transmitted light; crossed nicols).

X-36b: Dolomitic fossiliferous micrite showing crinoids (C), authigenic quartz crystals (Qz), and unidentified skeletal fragment (U) (under transmitted light; crossed nicols).


Qz
0.4 mm.
X-31


U
Qz
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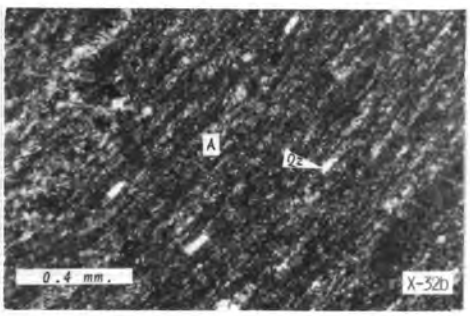
X-32a


A
Qz
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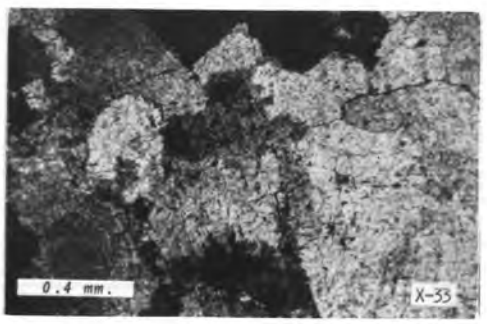
X-32b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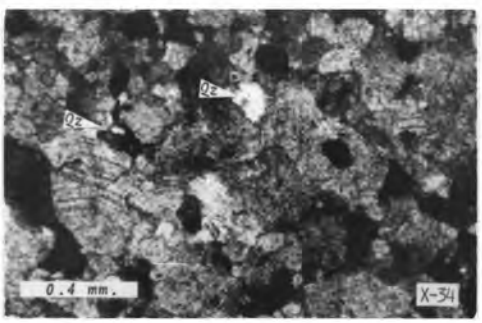
X-33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Qz
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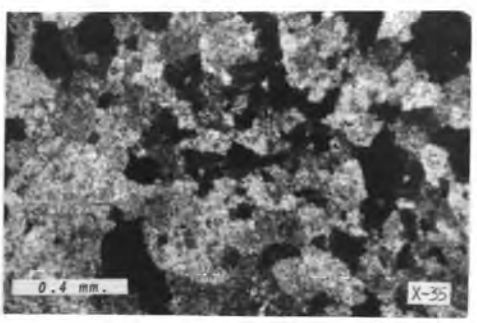
X-34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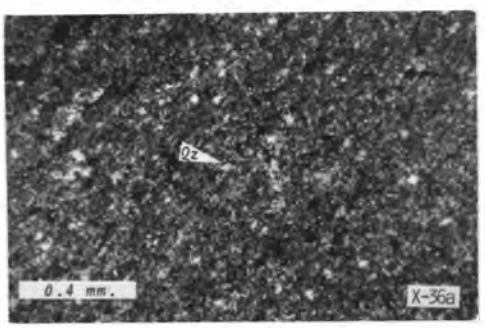
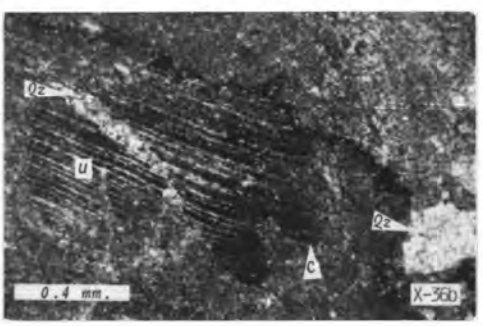
X-35


Qz
0.4 mm.
X-36a


Qz
U
Qz
C
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X-36b

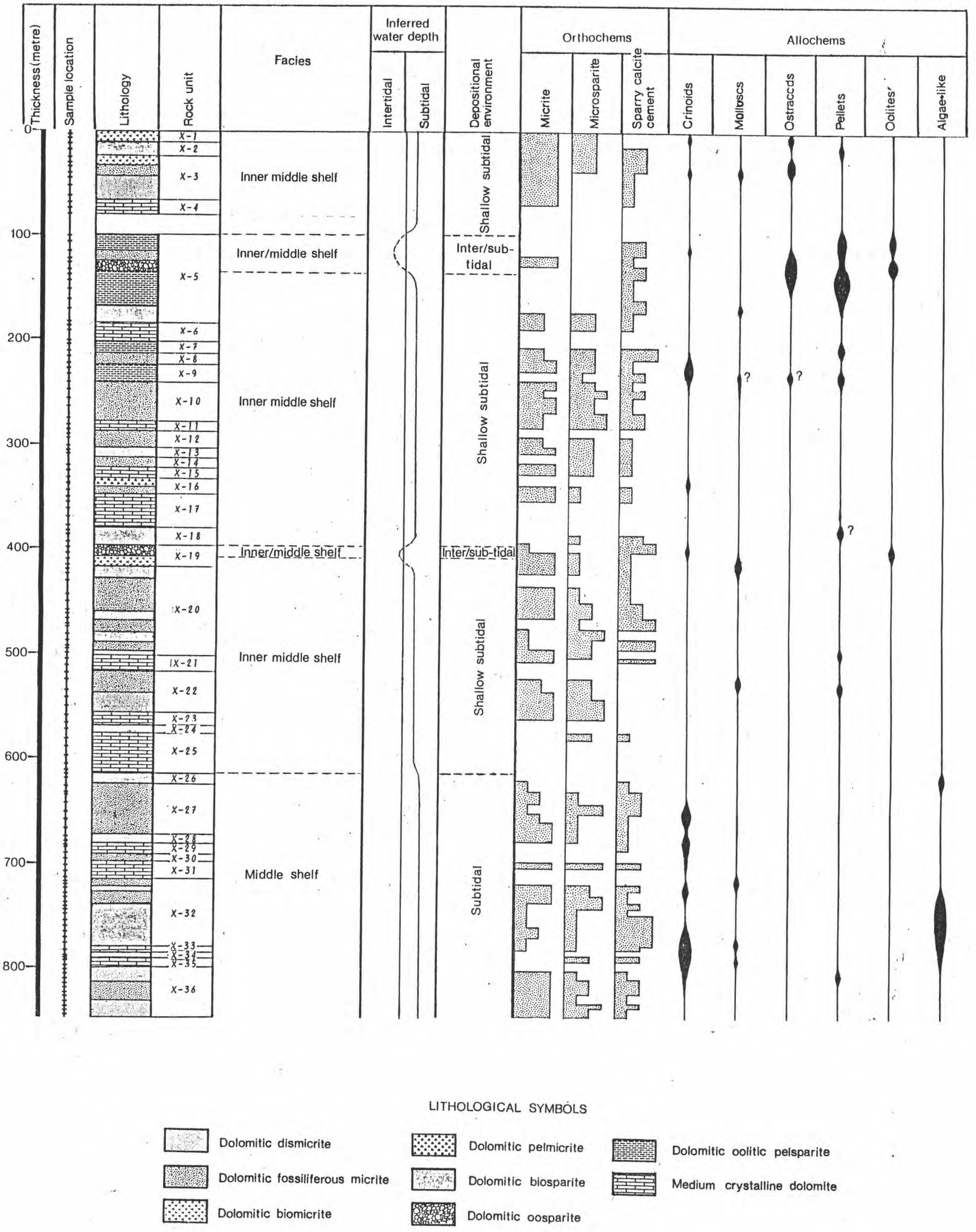


Figure 3.1.1d The petrographic characteristics of the Dewatering Drift to Huai Chanee section.

b) Measured section of the drill-hole number 68:

This lithological sequence is obtained from the fully-cored exploratory drill-hole of totally 190 metres in length from the ground surface in the direction approximately perpendicular to both strike and bedding plane. The collar elevation of the drill-hole is approximately 625 metres above the mean sea level. Altogether 40 samples are obtained from the splitting of the core-samples at various intervals of the entire length of the drill-hole. The sampling method is the stratified sampling type, that is the sampling is undertaken whenever there is a change in lithological characteristics. For each unit, at least two samples are obtained in order to observe the variation in lithological characteristics. The entire section is in the Ordovician carbonate succession above the 5 to 10-metre thick of lead-zinc mineralized zone. The petrography of this sequence is characterized unit by unit in descending order as follows:

Y-1 Unit.: The medium crystalline dolomite unit is of about 22 metres thick and dolomite showing both of mosaic and rhomb habits. The amount of sand-sized quartz content of both authigenic and detrital origins is up to 5 per cent by volume, and clay is extremely low (Plate 3-6: Y-1).

Y-2 Unit.: The dolomitic fossiliferous micrite unit is of about 5 metres thick. The allochems are unidentified skeletal fragments. The sand-sized, detrital quartz content is about 2.5 per cent by volume. This unit is moderately dolomitized, and the content of clay is low (Plate 3-6: Y-2).

Y-3 Unit.: The medium crystalline dolomite is of 10 metres thick with scattered flaky clay. The sand-sized quartz content is relatively less abundant than the uppermost dolomite unit while the other characteristics are also similar to the uppermost dolomite unit (Plate 3-6: Y-3).

Y-4 Unit.: The biosparite/micrite unit is of approximately 16 metres thick with moderately dolomitized. The detailed succession within the unit are biosparite, dismicrite, and fossiliferous micrite of about 5, 6, and 5 metres, respectively in descending order. The allochems are unidentified skeletal fragments. The clay content is very low. In addition, the silt- to sand-sized detrital and authigenic quartz content is between 2.5 to 7.5 per cent by volume (Plate 3-6: Y-4).

Y-5 Unit.: The medium crystalline dolomite unit is about 10 metres thick. The other characteristics of this unit are the absence of clay, and low content of both detrital and authigenic quartz. Mostly of dolomite exhibit the mosaic texture (Plate 3-6: Y-5).

Y-6 Unit.: The fine-grained carbonates unit of totally 20 metres thick is characterized by the increasing of allochems from top to bottom. The sequence is composed of 3 subunits of dolomitic dismicrite, dolomitic fossiliferous micrite, and dolomitic biomicrite of about 5, 10, and 5 metres thick, respectively in descending order. The allochemical constituents are very large brachiopod shell fragments and unidentified skeletal fragments. This sequence is moderately dolomitized and dolomite shows rhomb and mosaic habits. In addition, the silt- to sand-sized quartz, both of authigenic and

Plate 3-6 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

Y-1: Medium crystalline dolomite showing detrital quartz and euhedral quartzs crystals (Qz) (under transmitted light; crossed nicols).

Y-2: Dolomitic fossiliferous micrite showing detrital quartz (Qz), unidentified skeletal fragment (U), and dolomite show rhombohedral shape (under transmitted light; crossed nicols).

Y-3: Medium crystalline dolomite showing euhedral authigenic quartz crystals (Qz), dolomite show both of rhomb and mosaic fabrics (under transmitted light; crossed nicols).

Y-4a: Dolomitic biosparite showing algae (?), euhedral authigenic quartz crystals (Qz), and dolomite rhombs (under transmitted light; crossed nicols).

Y-4b: Dolomitic dismicrite showing both of authigenic and detrital quartzs (Qz; under transmitted light; crossed nicols).

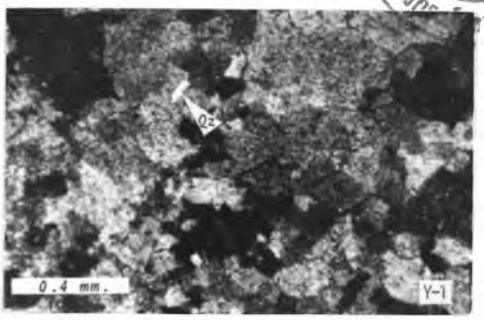
Y-4c: Dolomitic fossiliferous micrite showing detrital quartz (Qz) and unidentified skletal fragments (U; under transmitted light; crossed nicols).

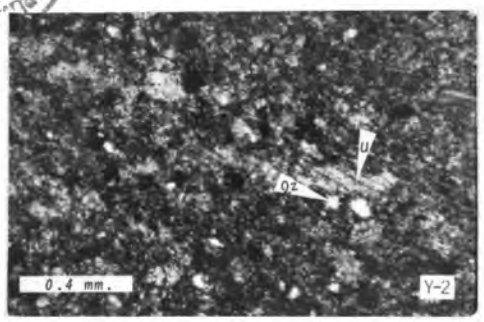
Y-5: Medium crystalline dolomite showing both of rhombs and mosaic fabrics, authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

Y-6a: Dolomitic dismicrite showing unidentified skeletal fragment (U), and both of authigenic and detrital quartzs (Qz) (under transmitted light; crossed nicols).

Y-6b: Dolomitic fossiliferous micrite showing unidentified skeletal fragment (U), and authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

Y-6c: Dolomitic biomicrite showing mollusc shell fragment (Mu) and detrital quartz (Qz) (under transmitted light; crossed nicols).


Qz
0.4 mm.
Y-1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Qz
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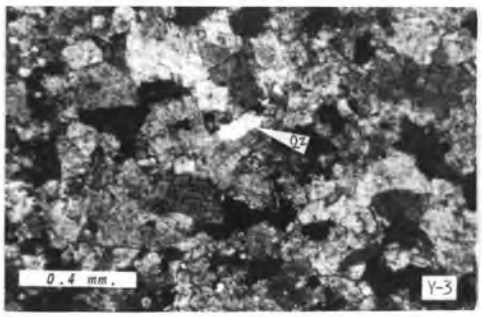
Y-2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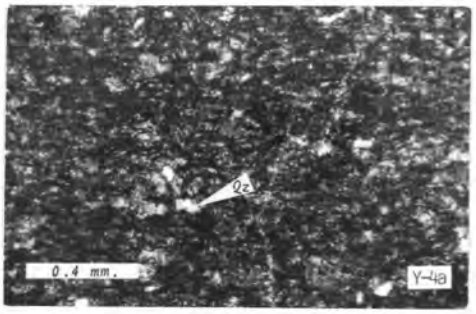
Y-3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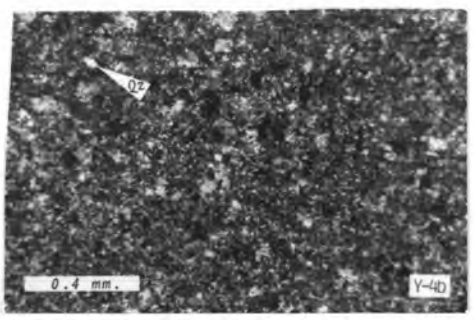
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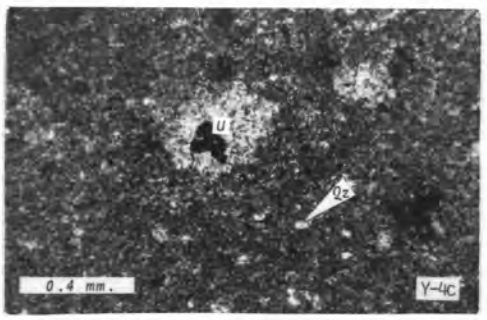
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Qz
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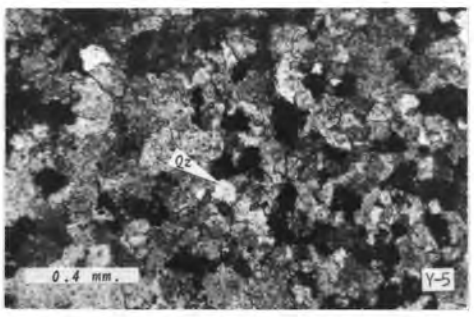
Y-4c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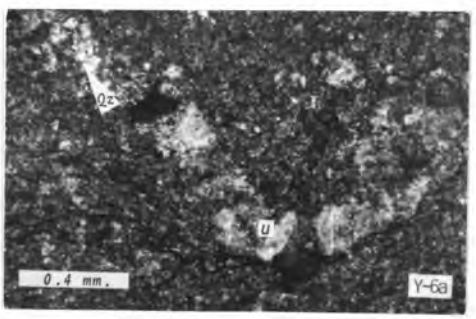
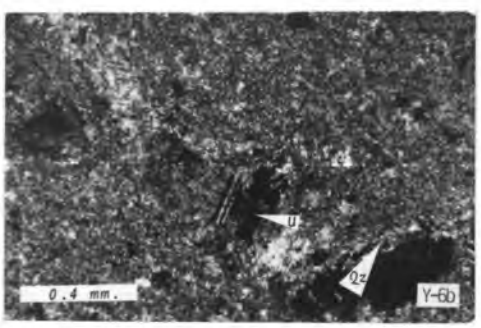
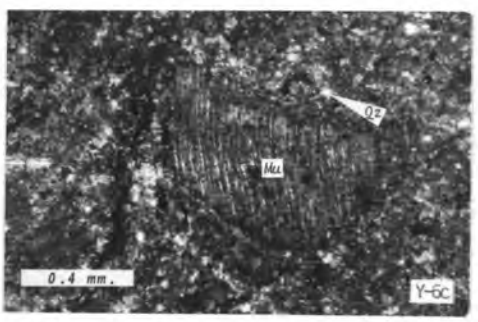
Y-5


Qz
U
0.4 mm.
Y-6a


U
Qz
0.4 mm.
Y-6b


Qz
Mu
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Y-6c

detrital origins is between 2.5 to 7.5 per cent by volume and the clay content is extremely low (Plate 3-6: Y-6a, b, and c).

Y-7 Unit.: The dolomitic biosparite unit is of approximately 5 metres thick. The allochems are unidentified skeletal fragments. This unit is moderately dolomitized and dolomite exhibit mosaic and rhomb textures The authigenic quartz and detrital quartz as well as clay contents are very low (Plate 3-7: Y-7).

Y-8 Unit.: The medium crystalline dolomite unit is 5 metres thick with sand-sized quartz of both authigenic and detrital origins of about 2.5 per cent by volume (Plate 3-7: Y-8).

Y-9 Unit.: The dolomitic biomicrite unit is of about 6 metres thick with moderately dolomitized and extremely low content of flaky clay. The allochemical constituents are unidentified skeletal fragments, and sand-sized quartz content of both authigenic and detrital origins is up to 1 per cent by volume (Plate 3-7: Y-9).

Y-10 Unit.: The dolomitic biosparite unit is of approximately 20 metres thick. This unit is slightly dolomitized. The quartz content of both authigenic and detrital origins is about 2.5 per cent by volume. The allochems are mollusc shell fragments and unidentified skeletal fragments (Plate 3-7: Y-10).

Y-11 Unit.: The dolomitic micrite unit is of totally 20 metres thick. The characteristics of this unit are low content of allochems in the upper part and no allochem in the lower part. The detailed successions of the unit are 10-metre thick of dolomitic fossiliferous micrite and 10-metre thick of dolomitic dismicrite in descending order. The quartz content of both of detrital and authigenic origins is between 1 to 5 per cent by volume while the clay is extremely low. This unit is slightly dolomitized, and dolomite shows both of mosaic and rhomb habits (Plate 3-7: Y-11a, and b).

Y-12 Unit.: The medium crystalline dolomite unit is of about 5 metres thick with very low content of banded clay. The quartz content of both authigenic and detrital origins is about 5 per cent by volume (Plate 3-7: Y-12).

Y-13 Unit.: The fine-grained carbonate unit is of totally 48 metres thick. The succession of the unit are dolomitic dismicrite, dolomitic fossiliferous micrite, and dolomitic dismicrite of about 25, and 23 metres, respectively in descending order. The characteristics of this sequence is slightly dolomitized and allochems are relatively abundant in the middle part. The terrigenous materials content of silt- to sand-sized quartz and flaky clay of up to 5 per cent by volume and extremely low, respectively. In addition, the banded clay is associated with unidentified opaque mineral (Plate 3-7 ; Y-13a, and b).

The petrographic characteristics of this measured section are summarized and graphically presented in Figure 3.1.1e.

Plate 3-7 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

Y-7: Dolomitic biosparite showing aggregated authigenic quartz crystals (Qz) and unidentified skeletal fragment (U) (under transmitted light; crossed nicols).

Y-8: Medium crystalline dolomite showing both of rhomb and mosaic fabrics, and authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

Y-9: Dolomitic biomicrite showing very large unidentified skeletal fragment (U), and both of authigenic quartz crystals and detrital quartz (Qz) (under transmitted light; crossed nicols).

Y-10: Dolomitic fossiliferous micrite showing unidentified skeletal fragment(U), both of authigenic and detrital quartzs (Qz), and calcite veinlets (under transmitted light; crossed nicols).

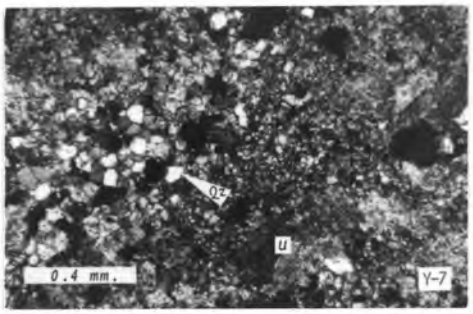
Y-11a: Dolomitic fossiliferous micrite showing unidentified skeletal fragment (U), both of authigenic quartz crystals and detrital quartz (Qz), calcite veinlets (under transmitted light; crossed nicols).

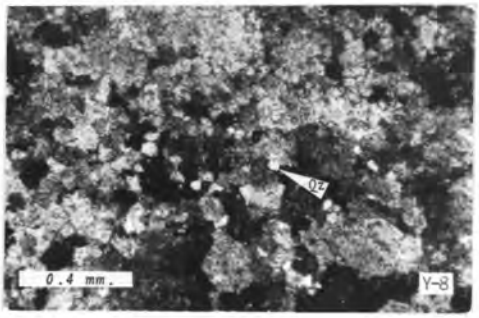
Y-11b: Dolomitic dismicrite showing euhedral authigenic quartz crystals (Qz) and calcite veinlets (under transmitted light; crossed nicols).

Y-12: Medium crystalline dolomite with abundance of both authigenic quartz crystals and detrital quartz (Qz), dolomite show both of rhomb and mosaic fabrics, and calcite veinlets (under transmitted light; crossed nicols).

Y-13a: Dolomitic dismicrite showing authigenic quartz crystals (Qz) and unidentified skeletal fragments (U) (under transmitted light; crossed nicols).

Y-13b: Dolomitic fossiliferous micrite showing unidentified skeletal fragment (U), authigenic quartz (Qz), and dolomite shows rhombohedral crystals (under transmitted light; crossed nicols).


Qz
u
0.4 mm.
Y-7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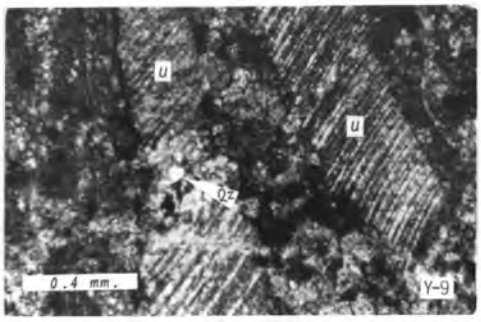
Y-8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u
Qz
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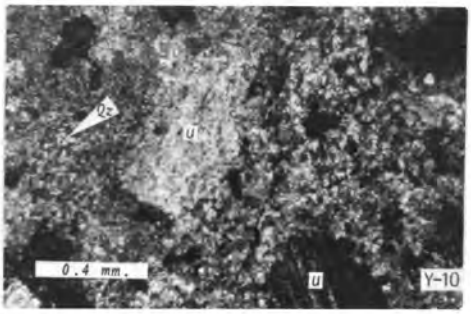
Y-9


Qz
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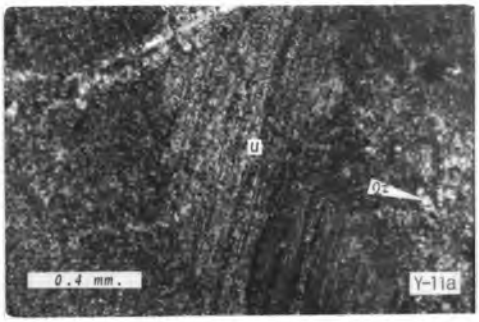
u
Y-10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Qz
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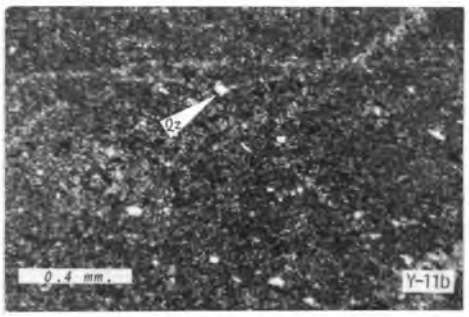
Y-11a


Qz
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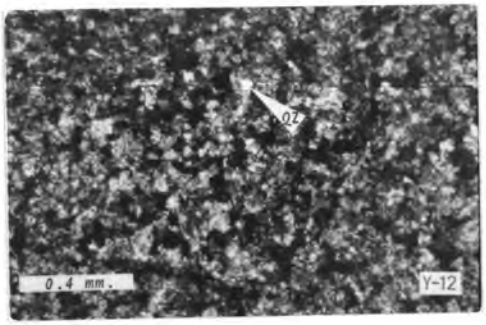
Y-11b


Qz
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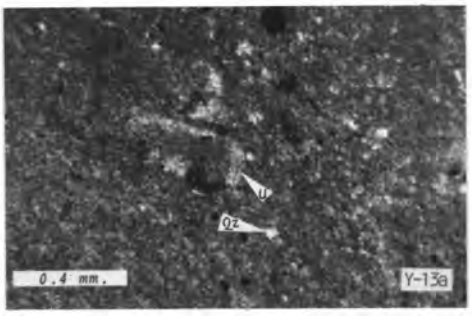
Y-12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Qz
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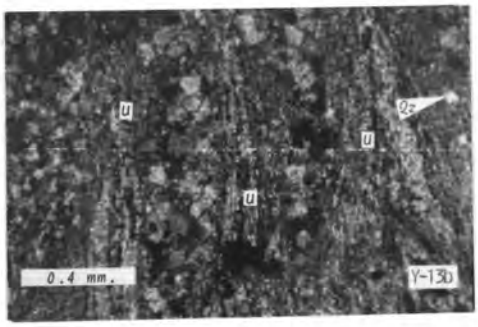
Y-13a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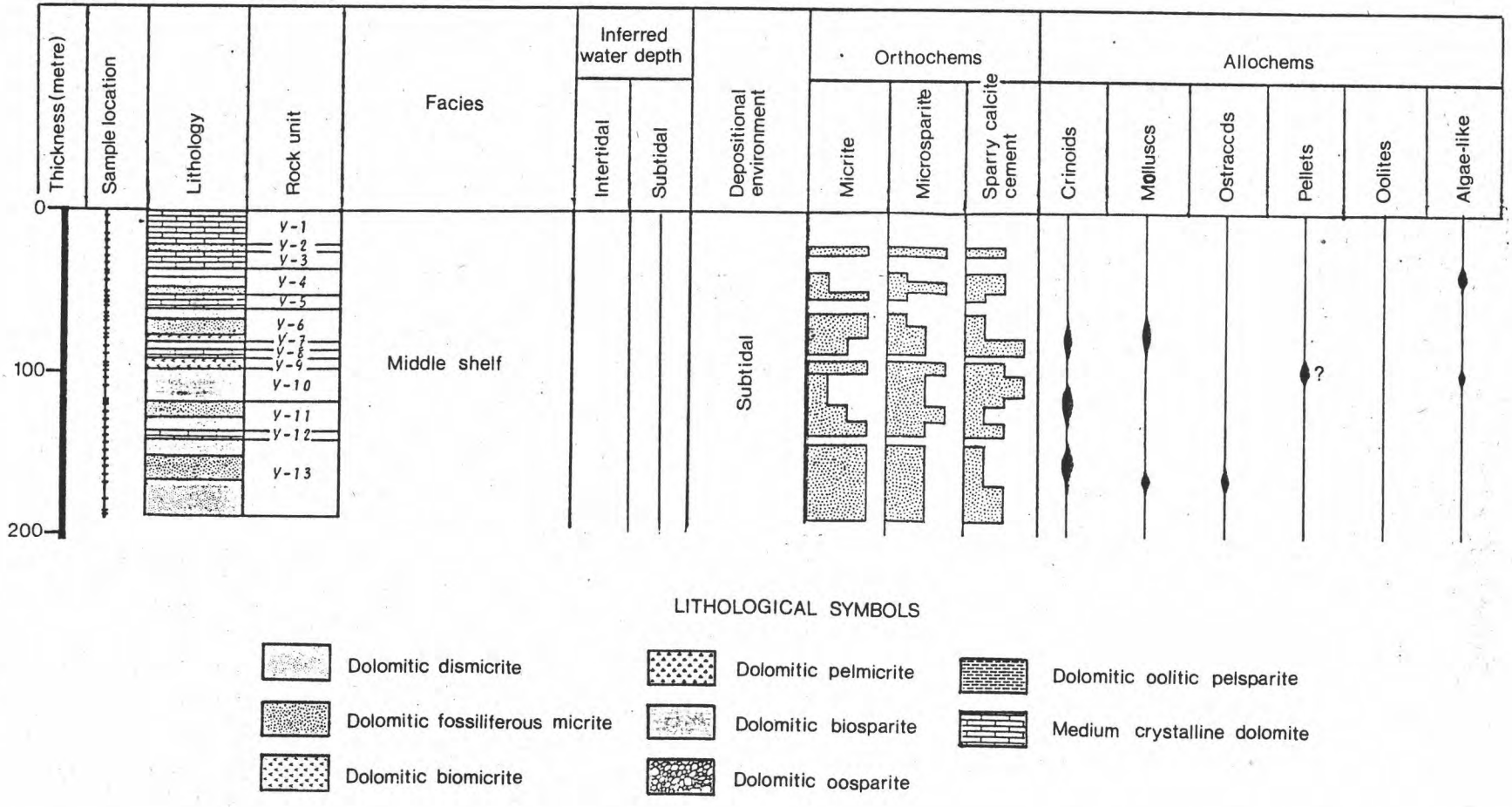


Figure 3.1.1e The petrographic characteristics of the drill-hole number 68 section.

c) Measured section of the drill-hole number 67:

This sequence is obtained from the fully-cored exploratory drill-hole of totally 235 metres in length from the ramp. The collar elevation of the drill-hole is 575.71 metres above the mean sea level and the direction of the drill-hole is approximately perpendicular to both strike and bedding plane. Altogether 43 samples are obtained from the splitting of the core-samples at various intervals of the entire length of the drill-hole. The sampling is undertaken whenever there is a change in lithological characteristics or stratified sampling. For each unit, at least two samples are obtained in order to observe the variation in lithological characteristics. The entire section is in the Ordovician carbonate succession and being slightly penetrated the lead-zinc ore zone. The petrographic characteristics of this sequence are described unit by unit in descending order as follows:

Z-1 Unit.: The dolomitic fossiliferous micrite unit is of approximately 13 metres thick. The quartz content of both of authigenic and detrital origins is about 5 per cent by volume. The authigenic quartz exhibits subhedral and euhedral crystals. This rock unit is slightly to moderately dolomitized (Plate 3-8: Z-1).

Z-2 Unit.: The dolomitic biosparite unit is of about 5 metres thick. The allochemical constituents are mollusc shell fragments, crinoid, and unidentified skeletal fragments. The content of quartz of both detrital and authigenic origins is approximately 2.5 per cent by volume (Plate 3-8: Z-2).

Z-3 Unit.: The dolomitic dismicrite unit with intercalation of thin layers of dolomitic biosparite is of approximately 40 metres thick with slightly to moderately dolomitized. The quartz content of both of silt to sand-sized authigenic and detrital origins is between 1 to 5 per cent by volume. In addition, the clay with scattered and banded habits are present to about 1 to 2 per cent by volume (Plate 3-8: Z-3a, and b).

Z-4 Unit.: The fine-grained carbonates unit is of about 55 metres thick. The characteristics of this unit are the interbedding of fossiliferous micrite with some pellets, and dismicrite. The detailed successions are fossiliferous micrite, dolomitic dismicrite, fossiliferous micrite, and dismicrite of about 10, 10, 10, and 15 metres thick, respectively in descending order. The degree of dolomitization appears to be increasing downward. The detrital and authigenic quartz is between 1 to 7.5 per cent by volume. Clay content is extremely low (Plate 3-8: Z-4a, b, c.1, and c.2).

Z-5 Unit.: The biosparite/micrite unit is of totally 54 metres thick. This unit is characterized by the interbedding of dolomitic biosparite and dolomitic fossiliferous micrite. The allochems are crinoids, mollusc shell fragments and unidentified skeletal fragments. The quartz content of both detrital and authigenic origins is between 2 to 5 per cent by volume. This thick succession is moderately dolomitized in the middle part, while other parts are slightly dolomitized. The clay content is very low (Plate 3-8: Z-5a, and b).

Plate 3-8 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

Z-1: Dolomitic fossiliferous micrite showing unidentified skeletal fragment (U), and very fine-grained detrital and authigenic quartz crystals (under transmitted light; crossed nicols).

Z-2: Dolomitic biosparite showing crinoids (C) and unidentified skeletal fragment (U) (under transmitted light; crossed nicols).

Z-3a: Dolomitic dismicrite showing algae (?), and both of detrital and authigenic quartzs (Qz) (under transmitted light; crossed nicols).

Z-3b: Dolomitic dismicrite showing sparry calcite cement patch (Sp), and very fine-grained detrital quartz (under transmitted light; crossed nicols).

Z-4a: Dolomitic fossiliferous micrite showing unidentified skeletal fragment (U), and detrital quartz (Qz) (under transmitted light; crossed nicols).

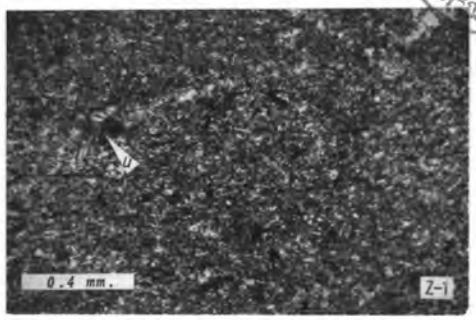
Z-4b: Dolomitic dismicrite with detrital quartz (Qz),and banded clay (under transmitted light; crossed nicols).

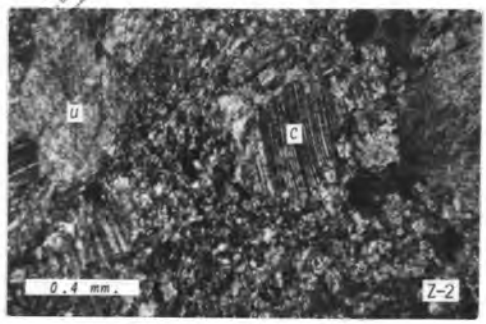
Z-4c.1:Dolomitic fossiliferous micrite showing authigenic quartz crystals (Qz), crinoid(C), and calcite veinlets (under transmitted light; crossed nicols).

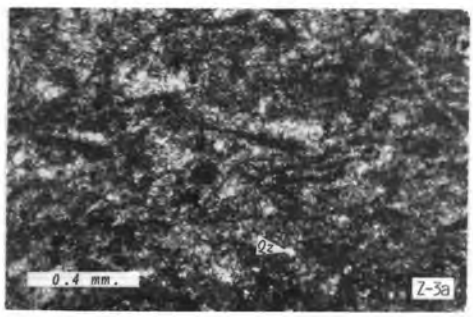
Z-4c.2:Dolomitic fossiliferous micrite showing very large unidentified skeletal fragment (U), and some pellets (under transmitted light; crossed nicols).

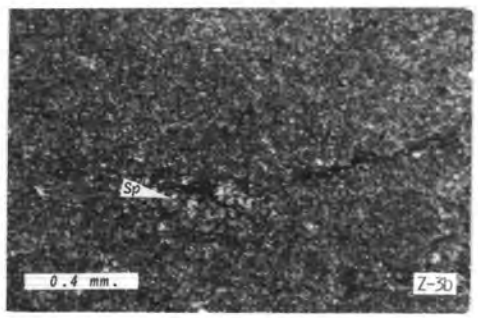
Z-5a: Dolomitic biosparite showing unidentified skeletal fragment (U), authigenic quartz crystals(Qz), and dolomite show rhombohedral crystals (under transmitted light; crossed nicols).

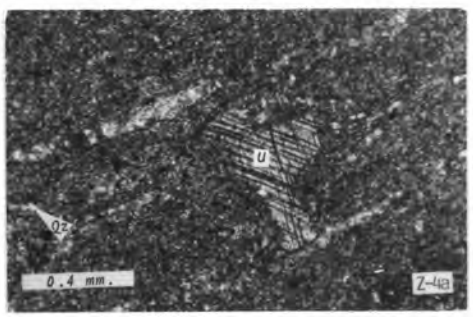
Z-5b: Dolomitic fossiliferous micrite showing crinoid (C), detrital quartz (Qz), and unidentified skeletal fragment (U) (under transmitted light; crossed nicols).

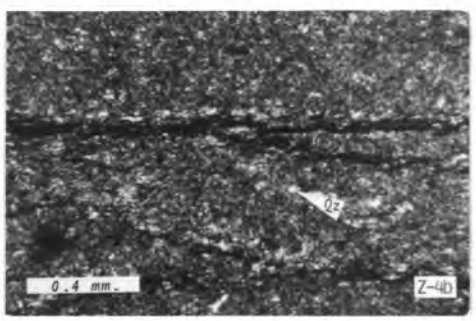


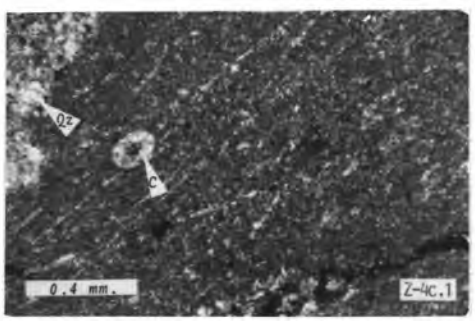


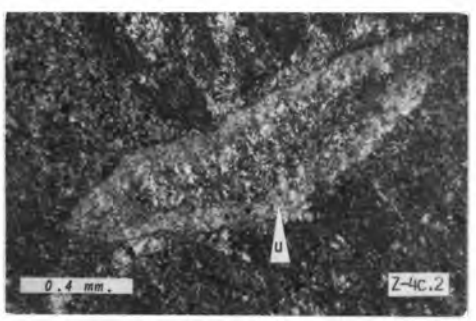


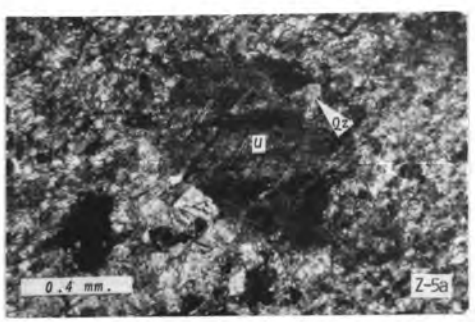


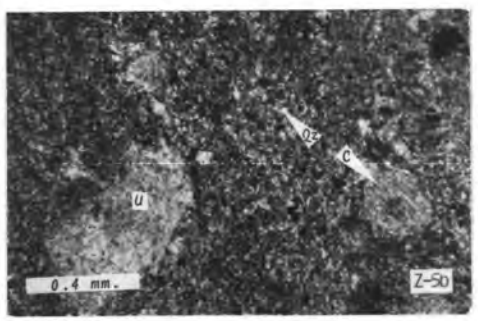












Z-6 Unit.: The fine-grained carbonate unit is of 62 metres thick. The succession of this unit are biomicrite, dismicrite, fossiliferous micrite, dismicrite, and fossiliferous micrite, respectively in descending order. This unit is characterized by the interbedding of relatively high and low allochemical contents. The allochems are mollusc, crinoid, and unidentified skeletal fragments. The dolomitization is dominant in the biomicrite subunit, whereas the others are slightly dolomitized. In addition, authigenic and detrital quartz is between 2.0 to 7.5 per cent by volume, while the clay content is very low (Plate 3-9: Z-6a, b, and c).

The petrographic characteristics of this measured section are summarized and graphically presented in Figure 3.1.1f.

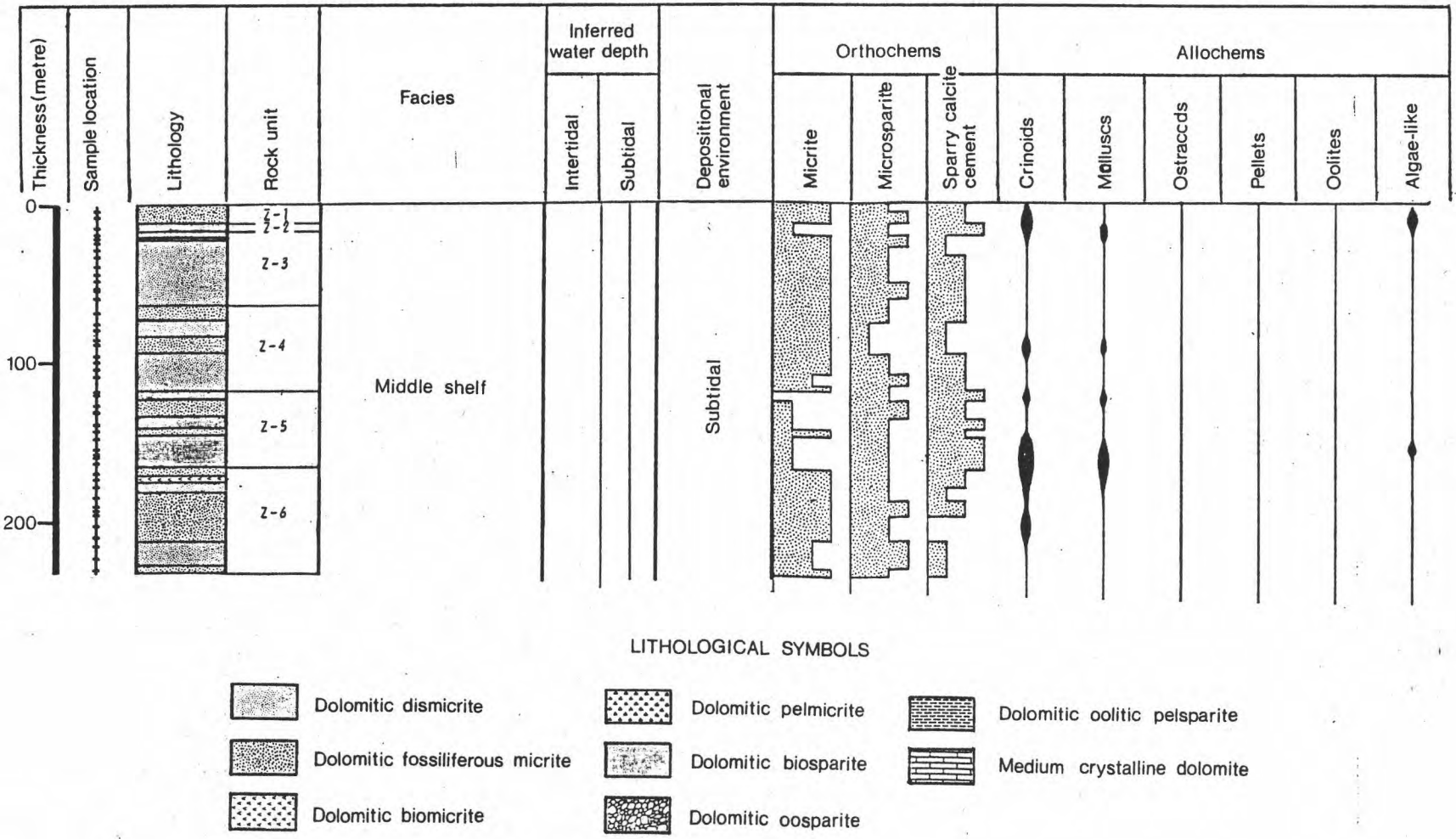


Figure 3.1.1f The petrographic characteristics of the drill-hole number 67 section.

d) Carbonate lithofacies map.

Petrographic examinations of approximately 90 samples of carbonate rocks collected from outcrops in the vicinity of the Song Toh North and Song Toh South Mines covering an area of about 2.0 square kilometres have been able to differentiate carbonate rocks into different lithofacies units. At least five lithofacies units, notably, dolomitic biosparite, dolomitic pelsparite, dolomitic fossiliferous micrite, dolomitic biomicrite, and medium crystalline dolomite have been recognized. These units have been formerly classified as light limestone series, and dark limestone series (Diehl and Kern, 1981); and as light gray, gray, and dark gray limestones (Permthong, 1982).

The carbonate lithofacies map of the study area is presented in Figure 3.1.1g.

The dolomitic biosparite lithofacies unit is characterized by crinoid, mollusc, and algae-like fragments in descending order of their abundances. On the basis of the present investigation this lithofacies unit is the major unit and widely distributed in the northern part of the study area adjacent to the Song Toh North Mine. Besides, two additional small zones of dolomitic biosparite lithofacies unit are exposed in the northwestern and southeastern parts about 200 metres away from the mine camp. Diagnostic characteristics of the unit are dark to light gray colour and well stratified. The lead-zinc mineralization zone of the Song Toh North Mine is associated with this dolomitic biosparite lithofacies unit and the attitude of the ore zone is conformable with that of the

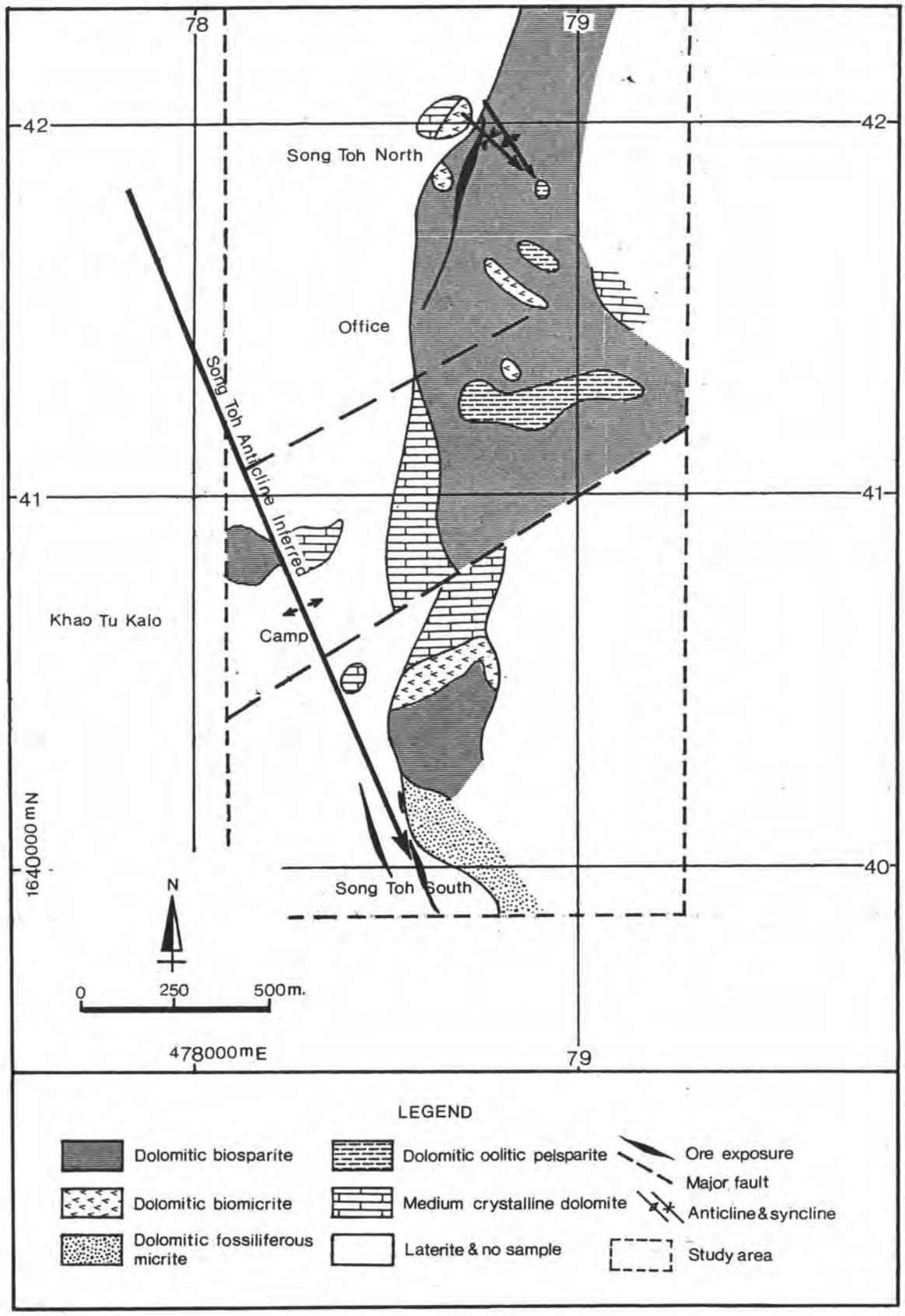


Figure 3.1.1g The carbonate lithofacies map of the study area.

carbonate-host rock (Plate 3-9: BS-1, 2, and 3).

Within the large area in the north which is essentially underlain by the dolomitic biosparite lithofacies unit, there are at least three small zones of dolomitic oolitic pelsparite lithofacies unit. The allochemical constituents of this unit are characterized by pellets, oolites, and the skeletal fragments of particularly crinoids, molluscs, algae-like materials, in descending order of their abundances. This unit is believed to have a lens-shaped geometry intercalated with the dolomitic biosparite lithofacies unit (Plate 3-9: PS-1, 2, and 3).

The dolomitic biomicrite lithofacies unit is generally exposed in or adjacent to the dolomitic biosparite lithofacies unit as small zones. The allochemical constituents are mainly crinoid, mollusc, and other unidentified skeletal fragments. The geometry of this unit is lens-shaped associated with dolomitic biosparite lithofacies unit. At least four small and elongated zones of dolomitic biomicrite lithofacies have been recognized, among these three zones are intercalated in the large dolomitic biosparite lithofacies unit in the vicinity of the Song Toh North Mine area and another is associated with dolomitic biosparite lithofacies unit of the Song Toh South Mine area (Plate 3-10: BM-1, and 2).

The dolomitic fossiliferous micrite lithofacies unit is mainly exposed as elongated zone in the vicinity of the Song Toh South Mine area, and as a small lens in the vicinity of the Song Toh North Mine area. The allochemical constituents of this unit are mainly of crinoid and unidentified skeletal fragments. This unit is

Plate 3-9 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

Z-6a: Dolomitic dismicrite showing unidentified skeletal fragment (U), and both of authigenic and detrital quartzs (Qz) (under transmitted light; crossed nicols).

Z-6b: Dolomitic fossiliferous micrite showing crinoid (C), unidentified skeletal fragment (U), and rhombohedral dolomite crystals (Do) (under transmitted light; crossed nicols).

Z-6c: Dolomitic dismicrite showing detrital quartz (Qz) (under transmitted light; crossed nicols).

BS-1: Dolomitic biosparite showing mollusc shell fragment (Mu) and euhedral authigenic quartz crystals (Qz) (under transmitted light; crossed nicols).

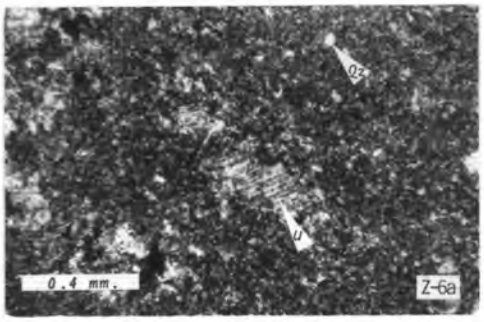
BS-2: Dolomitic biosparite showing unidentified skeletal fragment (U), authigenic quartz crystals(Qz), and dolomite show rhombohedral crystals (under transmitted light; crossed nicols).

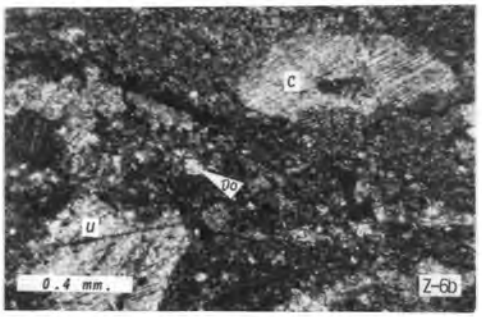
BS-3: Dolomitic biosparite showing algae (?) with very fine-grained detrital quartz (under transmitted light; crossed nicols).

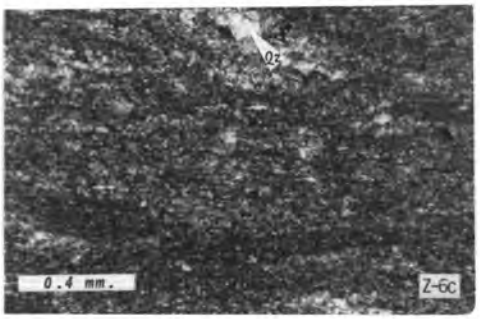
PS-1: Dolomitic pelsparite showing pellets (Pl) in sparry calcite cement, and detrital quartz (under transmitted light; crossed nicols).

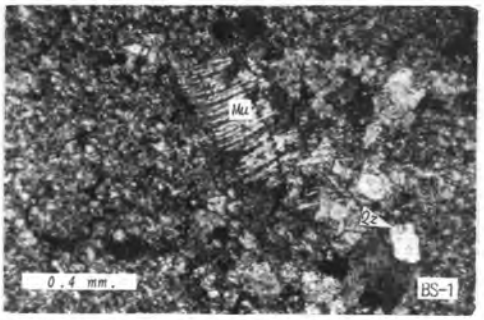
PS-2: Dolomitic oo-pelsparite showing oolites (Oo), and pellets in sparry calcite cement (under transmitted light; crossed nicols).

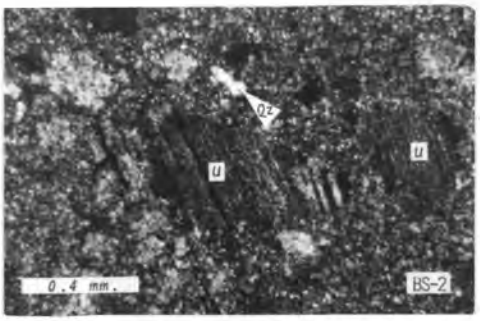
PS-3: Dolomitic pelsparite showing pellets(Pl)and authigenic quartz crystals (Qz) in sparry calcite cement (under transmitted light; crossed nicols).

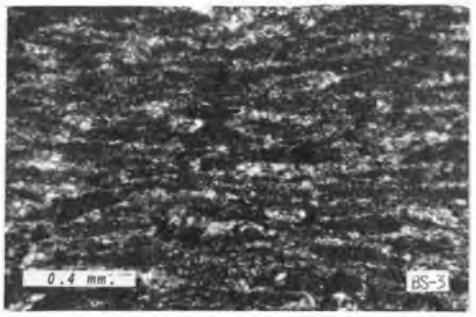


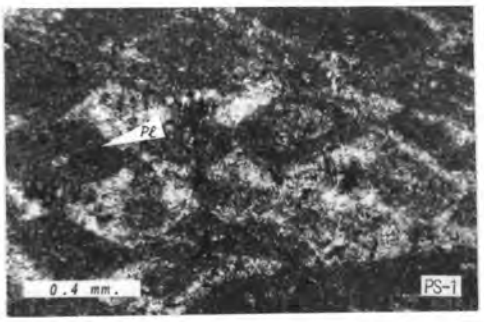


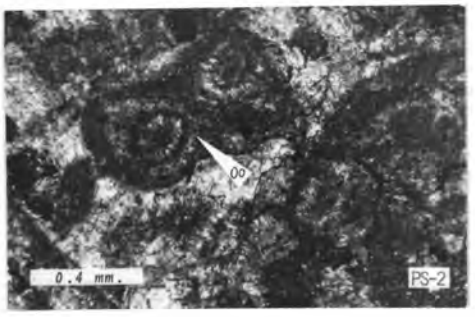


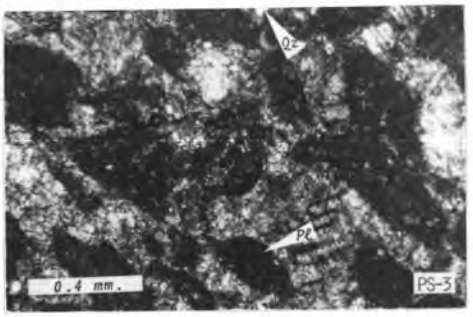












believed to be intercalated in the dolomitic biosparite lithofacies unit (Plate 3-10: FM-1, and 2).

The last unit is the medium crystalline dolomite lithofacies unit. This unit is exposed around the mine area particularly on both sides of the major fault in the mountain range east of the mine camp. The lithology of the unit is characterized by medium-grained dolomite mosaic with some rhombs. The mineralogical composition is almost entirely dolomite (Plate 3-10: DM-1, and 2).

It is significant to note that, the silt- to fine sand-sized detrital quartz and authigenic quartz are widely distributed in all lithofacies units. However, the amount of the quartz is relatively small.

3.1.2 Mineralogical aspect.

The carbonate mineralogy of the Ordovician carbonate sediments of the three measured sections has been investigated by using the X-ray diffractometric method and petrographic technique. The carbonate minerals present are entirely calcite and/or dolomite of various proportions. The calcite is mainly in the form of allochemical, orthochemical, and calcite veinlets, whereas the dolomite is associated with the orthochemical components, or partially replaced the allochemical components, or entirely replaced the rock mass. The presences of these two minerals in the three measured sections are expressed in terms of calcite/dolomite ratio (Figures 3.1.2a, b, and c).

Plate 3-10 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

BM-1: Dolomitic biomocrite showing unidentified skeletal fragment (U), dolomite rhombs, and very fine-grained authigenic quartz crystals (under transmitted light; crossed nicols).

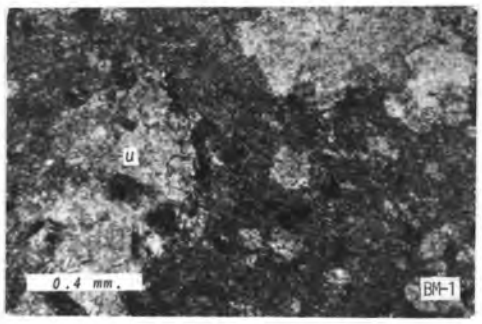
BM-2: Dolomitic biomicrite showing unidentified skeletal fragment (U) in micrite matrix with very fine-grained both of authigenic and detrital quartzs (under transmitted light; crossed nicols).

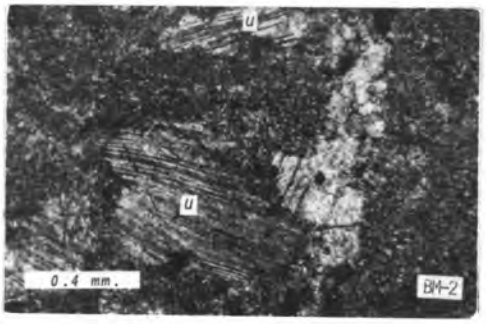
FM-1: Dolomitic fossiliferous micrite showing unidentified skeletal fragment(U) and detrital quartz(Qz) (under transmitted light; crossed nicols).

FM-2: Dolomitic fossiliferous micrite showing unidentified skeletal fragment (U) and detrital quartz (under transmitted light; crossed nicols).

DM-1: Medium crystalline dolomite showing both of mosaic and rhomb fabrics and detrital quartz (Qz) (under transmitted light; crossed nicols).

DM-2: Medium crystalline dolomite showing both of mosaic and rhomb fabrics and detrital quartz (Qz) (under transmitted light; crossed nicols).


u
0.4 mm.
BM-1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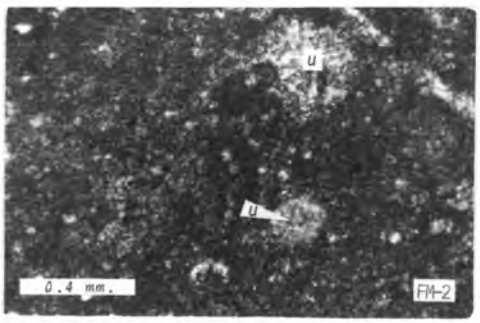
BM-2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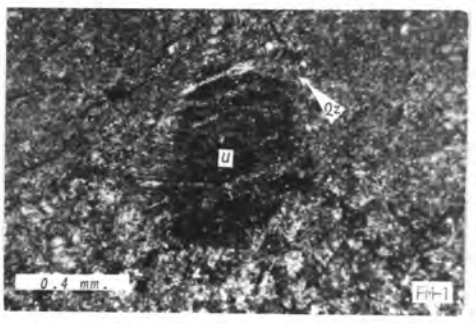
FM-2


Qz
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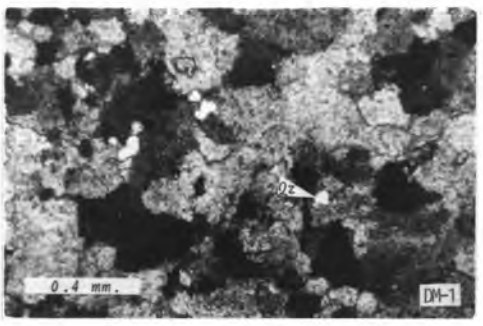
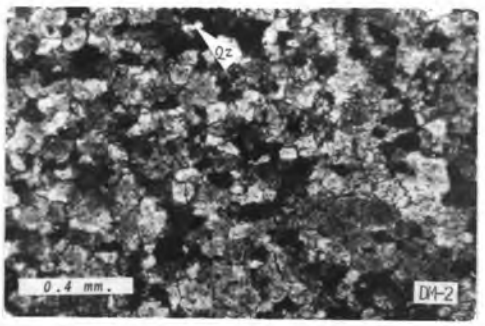
0.4 mm.
FM-1


Qz
0.4 mm.
DM-1


Qz
0.4 mm.
DM-2

In addition to the major carbonate composition of the Ordovician carbonate sequence of the three measured sections, quartz of both detrital and authigenic origins has been semiquantitatively estimated from the visual comparison technique of the thin-sections. Almost all of the quartz grains are silt- to fine sand-sized, widely distributed throughout the rock mass in variable content of less than 10 per cent by volume. The detrital quartz is characterized by fine grain-sized, subrounded, high sphericity. For authigenic quartz, the grain is characterized by subhedral to euhedral crystal forms and crystal aggregates,commonly pseudomorphed after carbonate particles. The total amount of detrital quartz and authigenic quartz of the three measured sections is presented in Figures 3.1.2a, b, and c.

All non-carbonate minerals or rock fragments which have been brought into the depositional environment are called terrigenous particles. The most important ones are clay, and quartz. These particles including authigenically formed minerals are collectively determined as acid insoluble residue. It is noted that, the total amount of acid insoluble residue varies considerably with maximum value of approximately 30 per cent by weight. The clay is mainly of muscovite natural 3T. The analytical results of the acid insoluble residue of the three measured sections is presented in Figures 3.1.2a, b, and c.

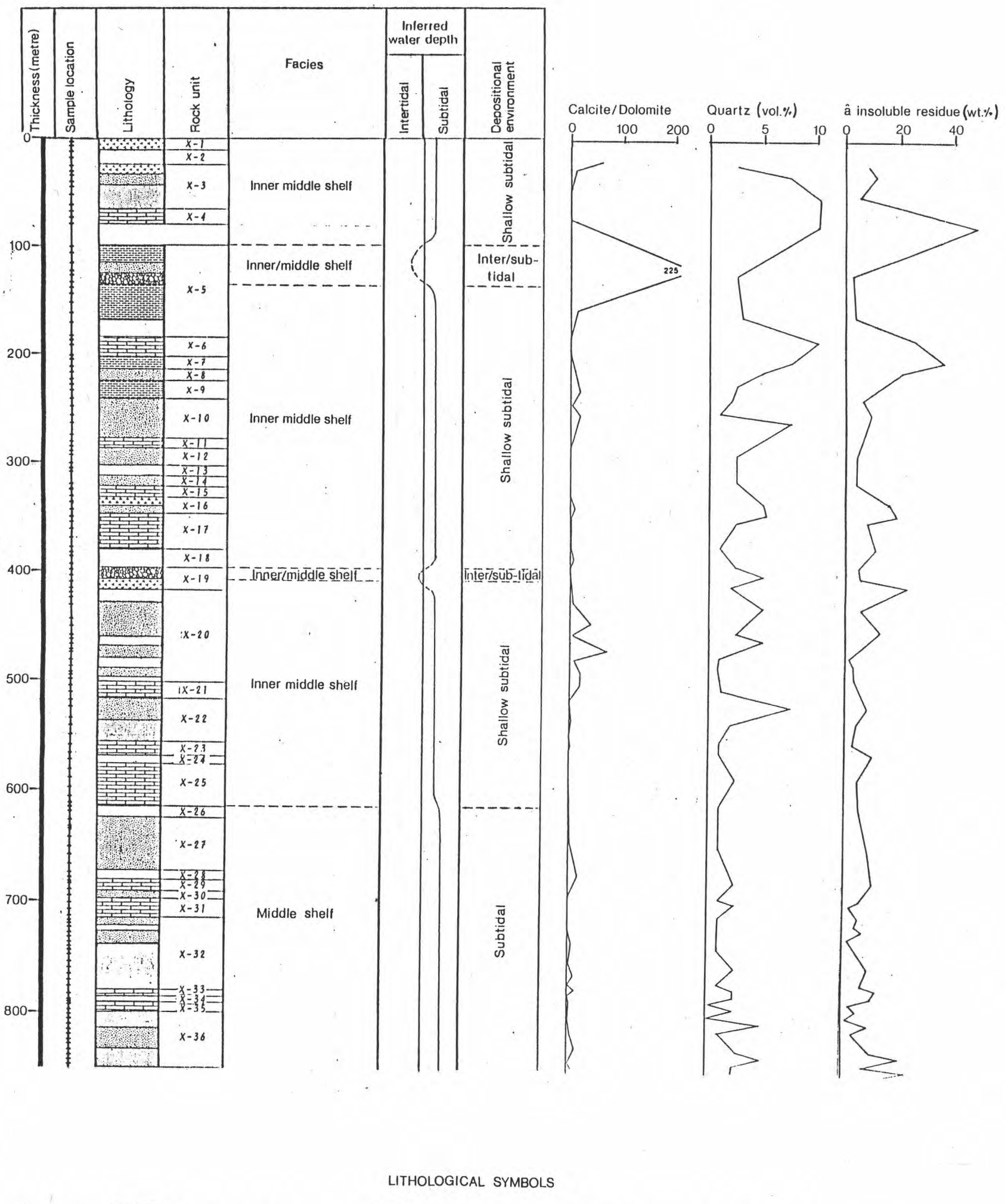


Figure 3.1.2a The graphic presentation of the mineralogical aspect of the Dewatering Drift to Huai Chanee section.

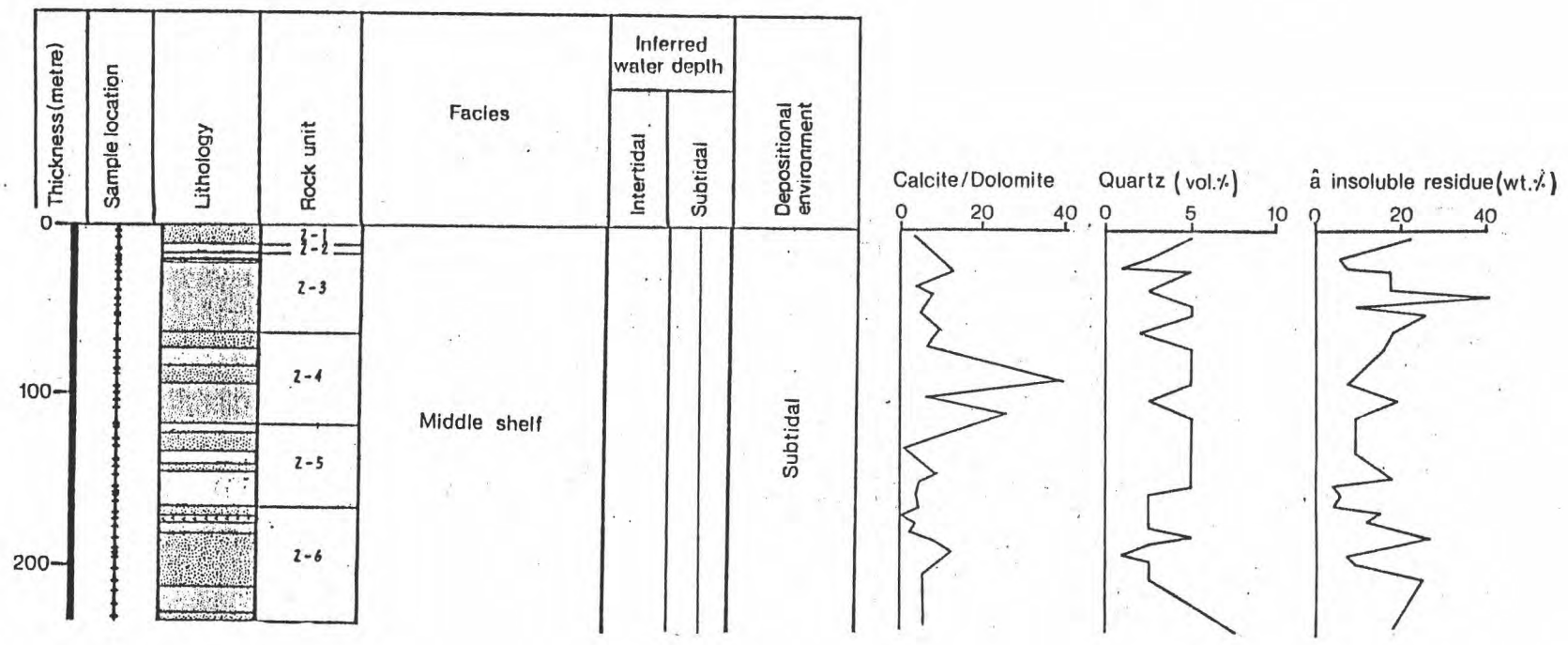
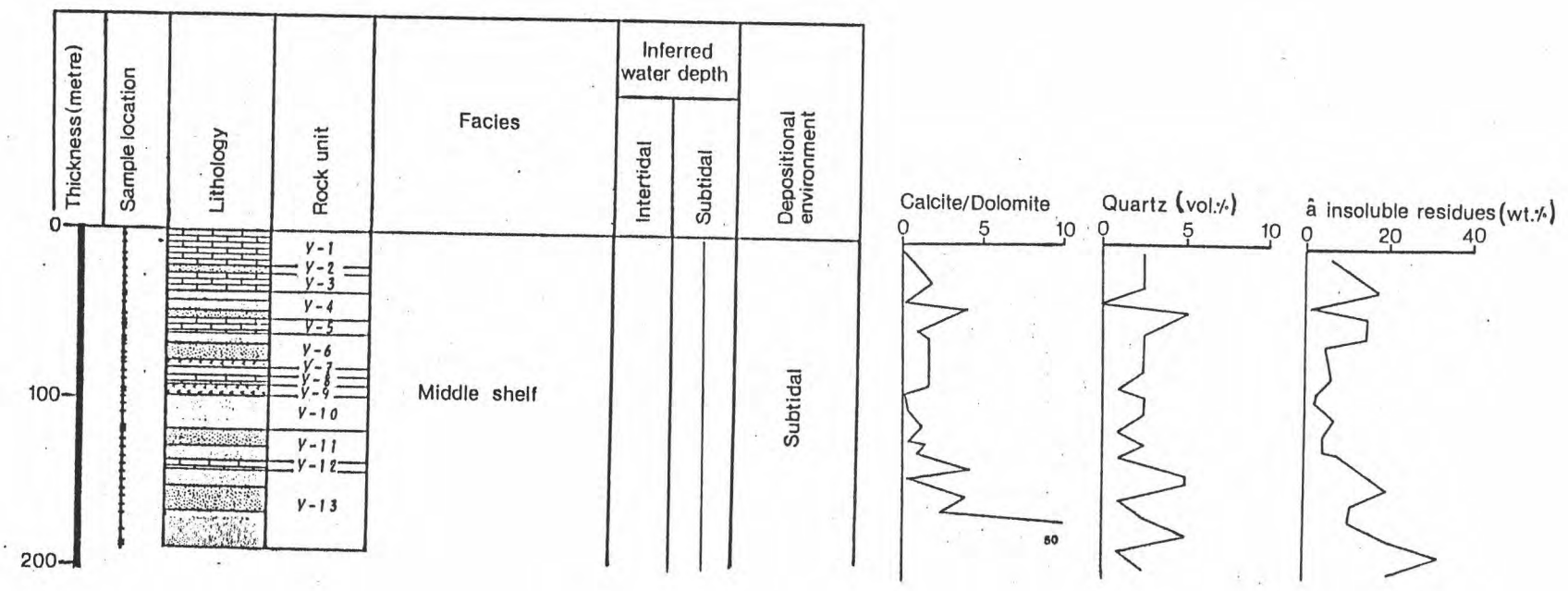


Figure 3.1.2b The graphic presentation of the mineralogical aspect of the drill-hole number 68 section.



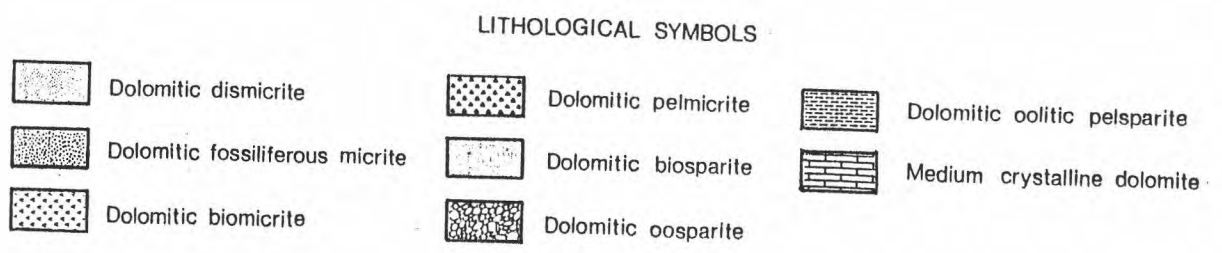


Figure 3.1.2c The graphic presentation of the mineralogical aspect of the drill-hole number 67 section.

3.2 Interpretation of microfacies.

3.2.1 Depositional environments.

Depositional environments are natural geographic entities in which sediment accumulates. They are characterized by sets of biological, physical, and chemical parameters. The interaction of these parameters produces different sediment types or facies representative of different environmental conditions. A study of sedimentary facies in the rock record allows some interpretations of the condition present in ancient depositional setting. In places, sets of environmental parameters are represented in the rock record only by a surface, for example, a bedding plane or disconformity surface. In most sequences these parameters correspond to a body or volume of sedimentary rocks.

Many parameters characterized depositional environments, and these can be recognized through their effect on accumulating sediments. Environmental reconstruction is based on a knowledge of environmental processes and their products, which build up the sedimentary sequence. Facies models are used as a basis for understanding depositional environments and are constructed from real and theoretical studies, both of the rock record and of modern environments.

The basis for the study of sedimentary rocks and the best starting point for paleoenvironmental interpretation is a knowledge of modern environmental models. Certain biological factors have changed with time, such as extinction and domination of certain genera and the environmental niche inhabited by certain genera; many

factors have remained unchanged, however. The development of "ancient" models based on the rock record takes into account these factors and help greatly in understanding the sedimentology of carbonates. The recognition of the various depositional environments is based on a number of observations (Reeckmann and Friedman, 1982) as follows:

a) Observation of macroscopic and microscopic features of the sediments. These include sedimentary structures, lithologies, mineralogical composition, and other aspects (Appendix E, Table E-1).

b) Recognition of biological characteristics of the environment. These include the kind of fauna and flora present, the interaction between organisms and sediments, such as bioturbation, trapping binding, and contribution of aragonite needles (Appendix E, Table E-2).

c) Observation of physical and chemical conditions within the depositional environment, including salinity, dynamics, and climate (Appendix E, Table E-3).

Although water depth is not an ecological boundary and the sedimentological differences observed at various water depths can usually be explained by the level of water energy and the sedimentary process itself, a great deal of the scientific literature is concerned with search for and determination of paleobathymetric criteria. When interpreting the depth of formation of carbonate sediments, "shallow marine" and "deeper marine" carbonates are usually differentiated, with "shallow marine" commonly referring to

the area bordered by the lower tidal zone and the edge of the continental shelf. Because the shelf edge in many regions now lies at about 200 metres deep, and this depth coincides with the lower boundary of the euphotic or disphotic zone, the range of the shallow marine zone just overlying the continental shelf can also be defined by biological factors. It must not be forgotten, however, that the lower boundary of marine plants dependent on light is often deeper (Flügel, 1978).

Based on the criteria of water depth it is possible to distinguish the following environmental areas (Flügel, 1978):

a) Marginal marine areas without continuous inundation: i) supratidal zone (above the normal tidal zone corresponds to the splash zone; intermittently moistened or flooded), and ii) intertidal zone (tidal area between extreme high-water spring tides and extreme low-water spring tides; intermittently flooded and exposed).

b) Shallow marine environment (subtidal) below the tidal zone. Sometimes directly adjoining the supratidal area. The lower boundary limit is not clearly defined, often drawn around 200 metres. It can be subdivided according to the significance of the phytal: i) shallower subtidal zone, characterized by an abundance of algae and by invertebrates which are adapted to the phytal, such as foraminifera, sponges, hydroids, bryozoans, and polycheates. Epizoans and epiphytes are common. Important criteria for determining shallow subtidal environments are a high diversity of dasycladaceans and coralline algae as well as frequently observed associations of algae and encrusting organisms (foraminifera, bryozoans, serpulids). The

lower boundary of this zone, after comparison with Recent zonations, can be drawn at about 30 metres. Often, however, much shallower depths are observed, and ii) deeper subtidal environment characterized by communities of organisms with various diversities. Calcareous algae still occur in addition to invertebrates; dasycladaceans, however, are absent.

Detailed examinations on the petrographic characteristics and mineralogical composition of the three measured sections are served as a basis for the reconstruction of depositional environment. Emphasis has been given to the type and degree of abundant of all important allochemical constituents of the carbonate sediments. Besides, the presences of detrital quartz and clay have also been taken into consideration for the environmental reconstruction.

Upon comparing the petrographic and mineralogical microfacies of the three measured sections with the microfacies models for carbonate sediments of Reeckmann and Friedman (1982) ,and Flügel (1978) (Appendix E), the whole sections can be regarded as mainly shallow marine carbonate facies and some intertidal facies of the carbonate shelf. It is noted that, the intertidal facies of marginal marine carbonate have been recognized to be intercalated only in the upper part of the measured section of 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 subtidal zone of shallow marine carbonate are 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).

Generally, it is very difficult to prove that there is a terrigenous control of marine carbonate sedimentation, solely by means of microfacies criteria (Flügel, 1978). However, the presences of small amount of detrital quartz and clay 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.

In conclusion, the three measured sections of the Ordovician carbonate sediments in the vicinity of Song Toh Mine area under the present investigation represent the subtidal shallow marine carbonate facies with some intercalations of the intertidal marginal marine carbonate facies. Therefore, the Ordovician carbonate sediments in this area are regarded to be deposited mainly in the subtidal zone of the shallow marine environments and some intertidal zone of the marginal marine environments. The total thickness of the three measured sections is approximately 850 metres and might represent the carbonate sedimentation in a slow subsiding basin where the rate of sedimentation is almost balanced with the rate of subsidence. This would explained the thick sequence of carbonate sediments which were deposited in the more or less stable environments.

The reconstruction of depositional environment of the Ordovician carbonate sequence under the present investigation is limited by the complexity of post-depositional changes both diagenesis and structural deformation. Many original characteristics of the sediments, which might have been used as depositional criteria have been partially or wholly in some cases obliterated. Despite such a limitation, the overall interpretation regarding to this matter is reliable except some additional details can not be extractively pointed out.

3.2.2 Authigenesis.

Minerals generated in places subsequent to the formation of the sediments are called authigenic minerals. The following characteristics (Teodorovich, 1961) indicate an authigenic origin of minerals:- euhedral crystal form, pseudomorphs after carbonate particles (e.g., oolites) and fossils, inclusions which correspond mineralogically to the matrix of the rock (e.g., carbonate inclusions within authigenic quartz crystals), zones of inclusions arranged parallel to idiomorphic faces of euhedral crystals, cross-cutting relationships between crystal boundaries and host-rock fabrics, crystal aggregates such as spherulites and radiated clusters, differences in the optical properties in comparison to detrital grains, and abundant occurrence of minerals, which can not be interpreted by a sorting effect during transport.

Among the most common authigenic minerals found in carbonate rocks of the present study are quartz, dolomite and pyritohedral pyrite. Authigenic quartz in the Ordovician carbonate sediments is mainly found in idiomorphic or irregular grains in calcite and/or dolomite matrix (Plate 3-11: 1, 2, 3, 4, and 5). The authigenic quartz in carbonates is believed to be formed during late diagenesis and during epigenesis (Teodorovich, 1961).

Petrographic evidences of the Ordovician carbonate sediments in the present study show relatively high percentages of authigenic quartz. It is suggested that the silica building up the tiny authigenic quartz crystals is derived from dissolved amorphous silica of organic siliceous skeletons and detrital quartz grains. The amount delivered by dissolution of detrital quartz grains can be very high, as the grains are extremely corroded (Plate 3-11: 1, and 5). However, no relics of sponge spicules or radiolaria tests, was observed. The siliceous skeleton might be dissolved entirely, probably due to slightly changes in pH because of decaying organic material. This solution produced silica-rich interstitial water, which, due to compaction and diffusion migrated into overlying horizon where silica was precipitated as authigenic quartz. This quartz partly grew in the pore spaces and partly replaced the calcite matrix to form crystal of the size up to 40 micrometres. It is also noted that, relics of extremely fine-grained dolomite rhombs are observed to be enclosed in some authigenic quartz grains. This is probably due to the silica-rich interstitial waters had replaced the calcite of the carbonate matrix but did not replaced the tiny dolomite rhombs (Plate 3-11: 6).

The iron-bearing minerals in the carbonate rocks, pyrite, is also believed to be formed during syn- or early diagenesis. In marine environment, reducing conditions generally occur a short distance below the depositional interface and the sulphur is available from dissolved sulphate and organic matters. The result is the reduction of pre-existing iron minerals, first to monosulphides and then to pyrite. Finally disseminated pyrite may give the carbonate rocks a gray colour (Berner, 1970).

Plate 3-11 Photomicrographs of the Ordovician carbonate sediments from the Song Toh Mine area.

1 Idiomorphic authigenic quartz crystals (Qz) with extremely corroded by calcite and/or dolomite (Do) in dolomitic fossiliferous micrite (under transmitted light; crossed nicols).

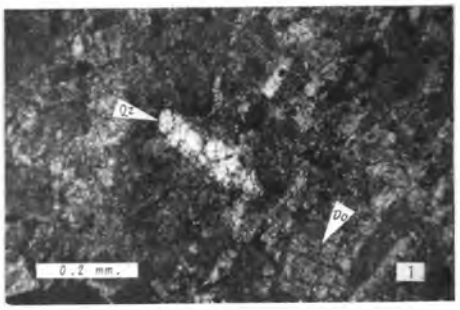
2 Idiomorphic and irregular crystals of authigenic quartz (Qz) with slightly corroded by calcite and/or dolomite in dolomitic biosparite (under transmitted light; crossed nicols).

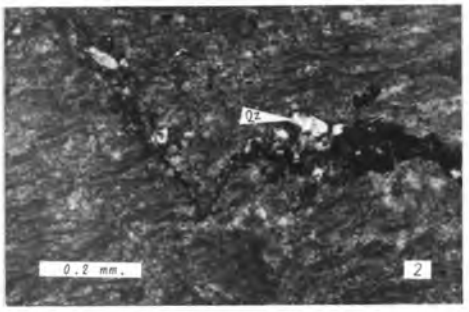
3 Irregular crystals of authigenic quartz (Qz), and dolomite rhombs (Do) in dolomitic fossiliferous micrite (under transmitted light; crossed nicols).

4 Irregular crystals of authigenic quartz(Qz) in medium crystalline dolomite (Do; under transmitted light; crossed nicols).

5 Dolomite rhombs enclosed in euhedral authigenic quartz crystals (Qz) and quartz corroded by dolomite (Do) and/or calcite (under transmitted light; crossed nicols).

6 Dolomite rhomb (Do) in authigenic quartz crystals (Qz) in dolomitic biosparite and quartz corroded by calcite and/or dolomite (under transmitted light; crossed nicols).


Qz
Qz
0.2 mm.
1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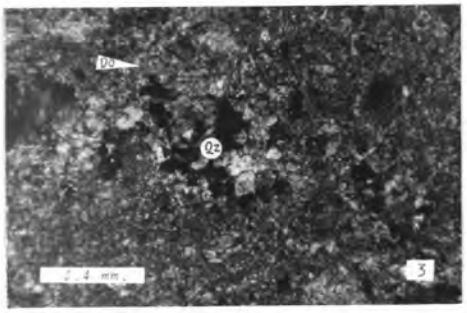
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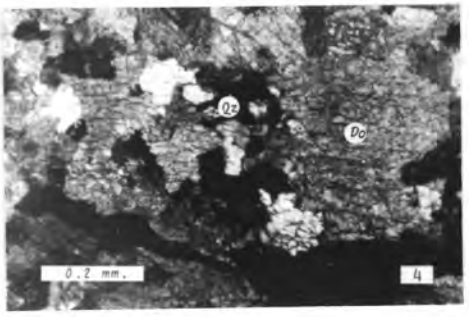
3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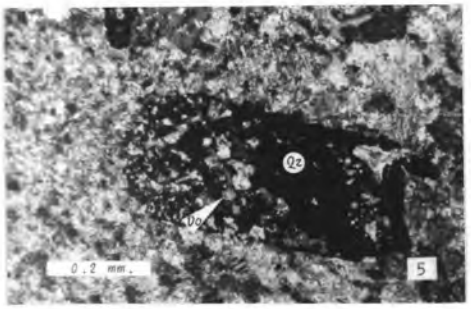
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Qz
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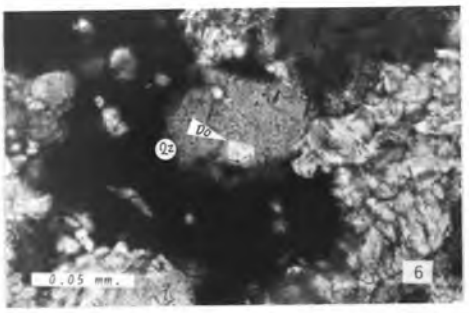
5


Qz
Qz
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6