CHAPTER III

PETROGRAPHY AND MICROFACIES ANALYSIS

Problems concerning the interpretation of the depositional environments of the carbonate successions in study area can commonly be carried out by subdividing them into constituent facies and combining observations, which are made on their spatial relations, and internal characteristics (lithology and sedimentary structures), with comparative information from other well-studied stratigraphic units and modern sedimentary environments.

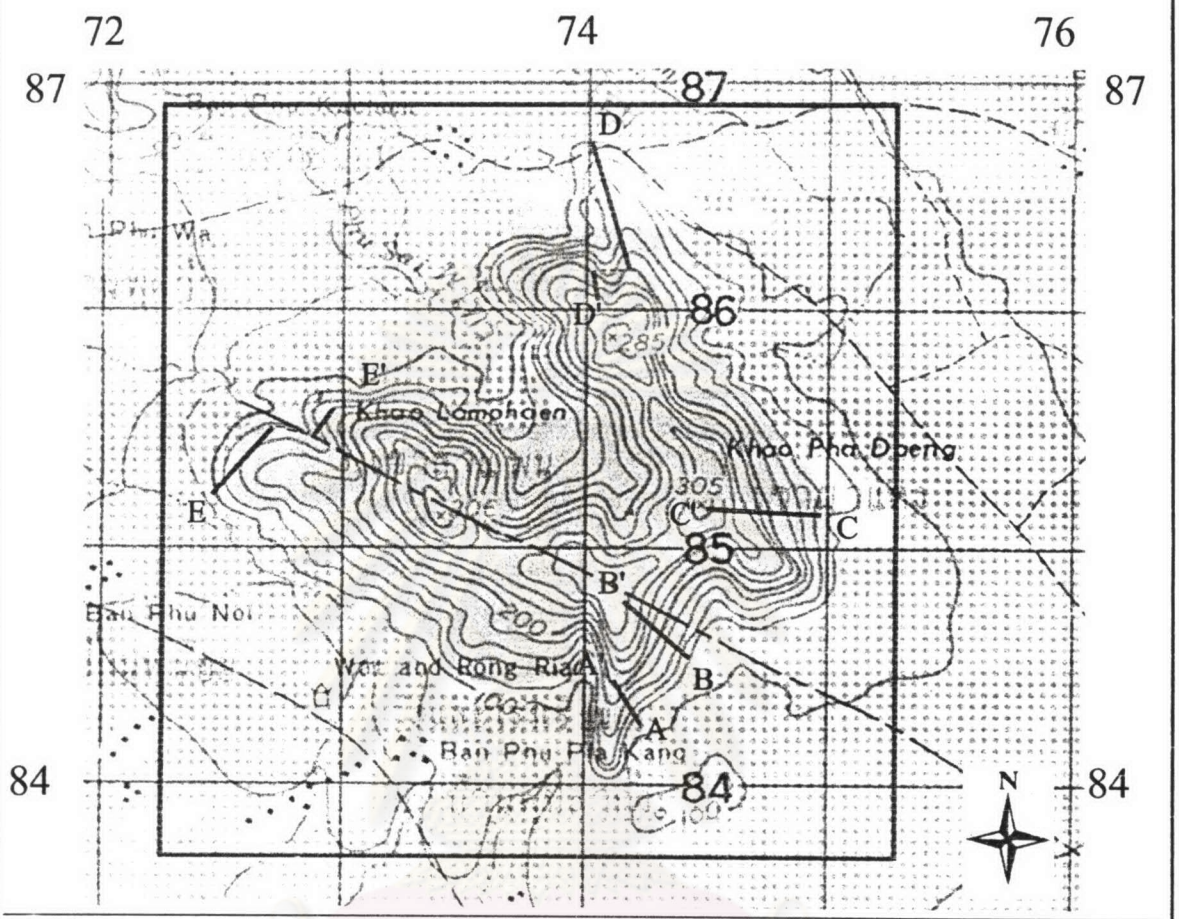
Thus, the following discussions are focusing upon a semi-detailed systematic collecting rock samples from 5 measured sections and subsequent petrographic descriptions of them which can be referred to an analysis of microfacies and their depositional environments.

3.1 Measured sections

Since, the regional strike of the carbonate rock orientates in NNW direction, the measuring sections were oriented in ENE-WSW direction located in 5 areas arranging alphabetically as sections A, B, C, D and E, respectively (Figure 3.1).

Based on the field investigation, the stratigraphic positions of these rock-sections could be recognized. The section E (Panorama view as shown in Figure 3.2) is, 52.5 meters thick, located in the western part of the hill (at Ban Phu Noi), probably the youngest succession in the study area. The section C of 89.5 meters thick, and D of 171 meters thick, (Panorama view as shown in Figure 3.3), located in the eastern part of the hill (at Wat Khao Lamphean) are probably the oldest sequences.

In addition, the section A of 65.5 meters thick, and B of 175 meters thick, (Panorama view as shown in Figure 3.4) located in the southern part of the hill (at Ban Chon Muang) appear to be in the intermediate positions among those previously described sections.



PRELIMINARY MICROFACIES AND LITHOSTRATIGRAPHY OF PERMIAN CARBONATE SEDIMENTS IN THE VICINITY OF KHAO LAMPHEAN, AMPHOE NONG MUANG, CHANGWAT LOPBURI.

Figure 3.1 A topographic map showing 5 measuring sections arranged alphabetically as Section A (A-A'), Section B (B-B'), Section C (C-C'), Section D (D-D') and Section E (E-E')

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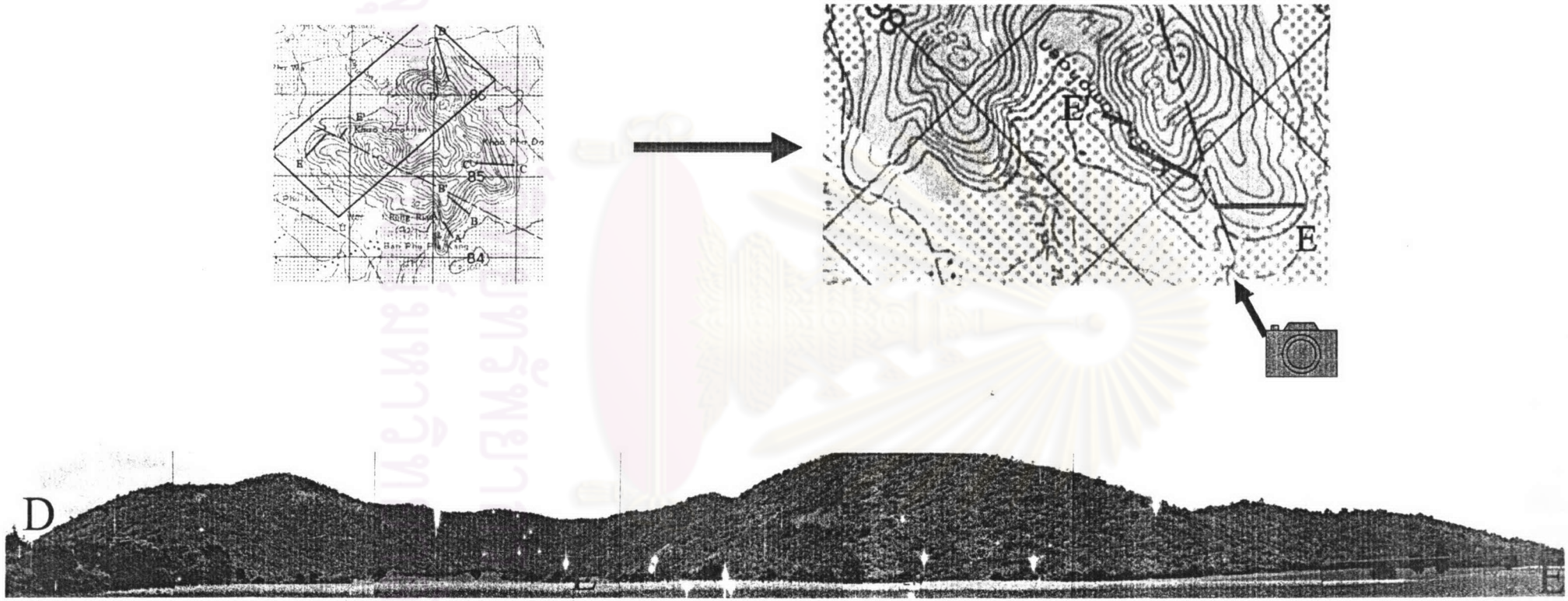


Figure 3.2 A panorama view (looking west) showing the investigation lines of the section E (E-E') located in western part of the study area.

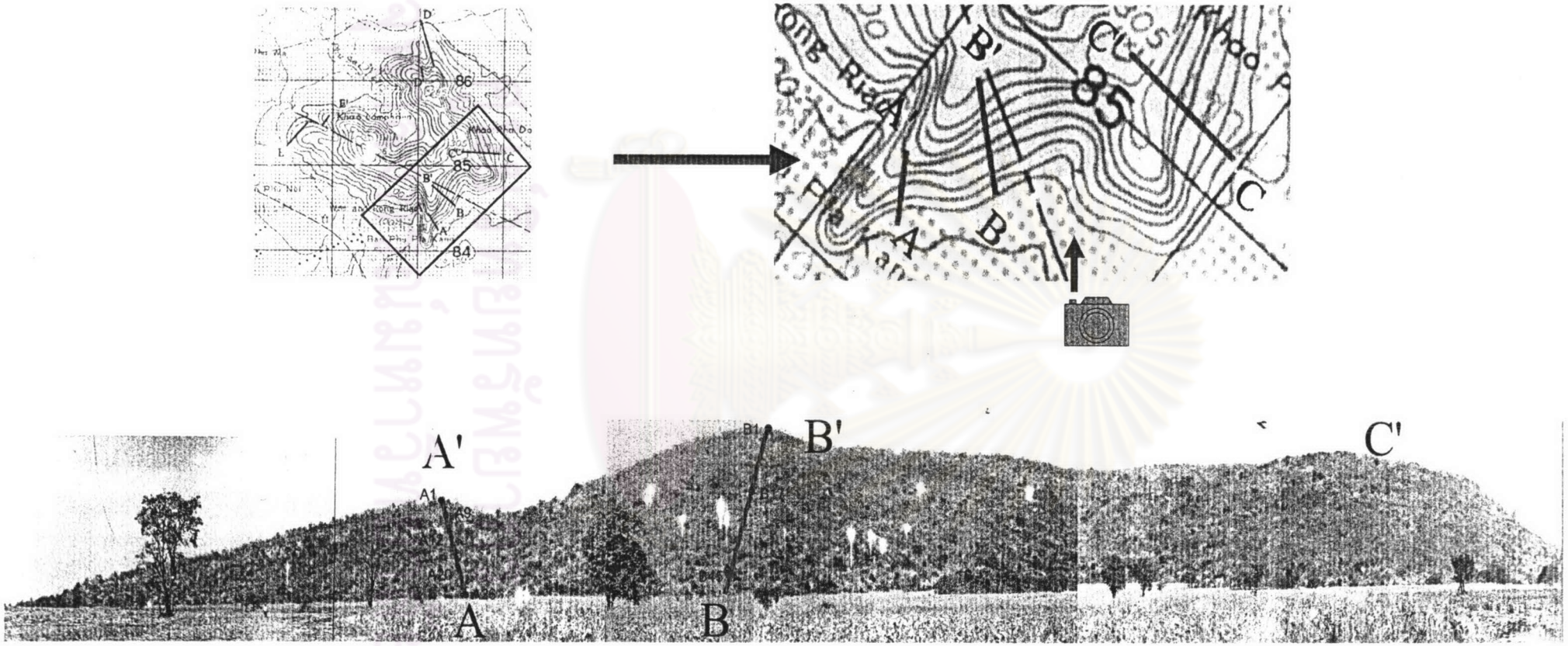


Figure 3.3 A panorama view (looking NW.) showing the investigation lines of section A (A-A') and section B (B-B') located in southern part of the study area.

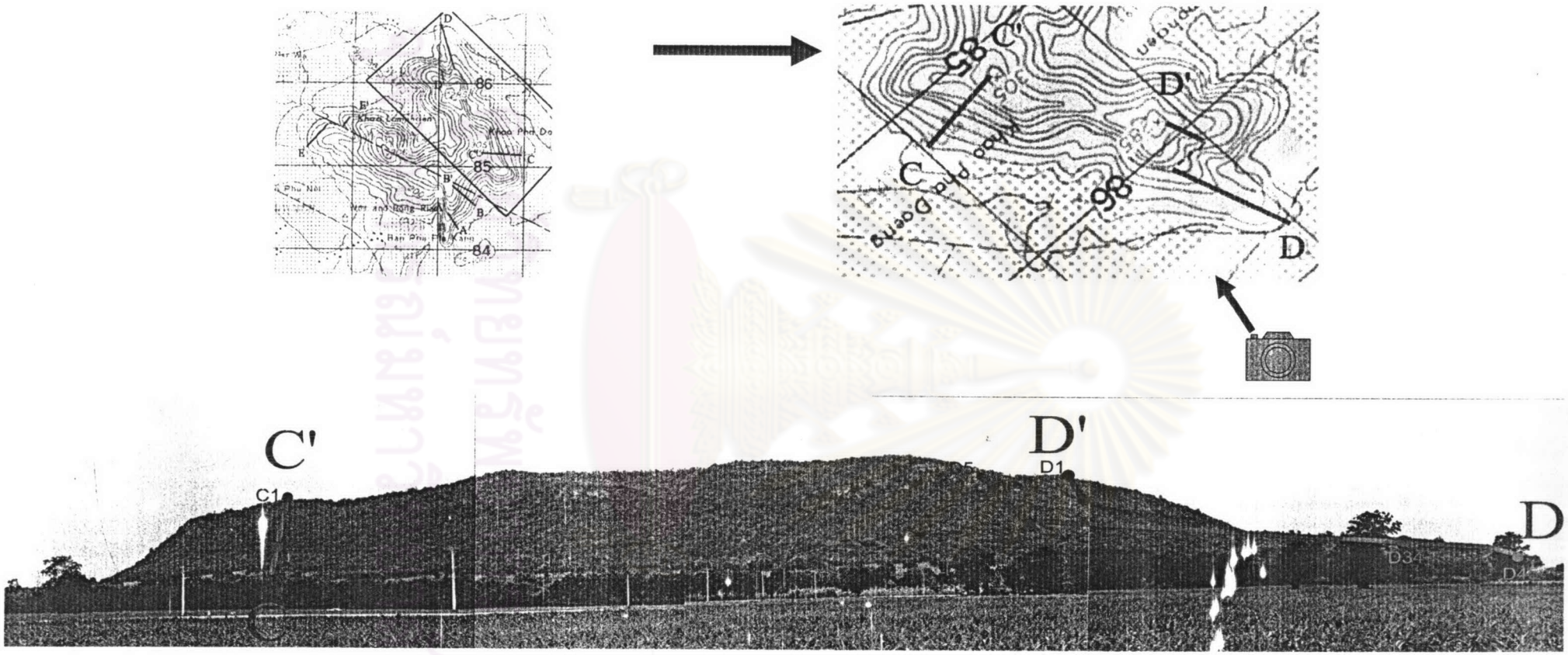


Figure 3.4 A panorama view (looking south) showing the investigation lines of section C (C-C') and section D (D-D') located in eastern part of the study area.

The stratified sampling method (Flugel, 1982) was applied in this investigation. Samples were systematically collected either from a limestone bed or from a group of beds that with characteristics. In the latter case, the sample vertical interval is commonly 3 meters apart. This vertical distance may be sufficient, in preliminary study, to unravel the main depositional variations (Carozzi, 1978).

The total thickness of the composite sequence, from 5 measured sections are 553.5 meters. Accordingly, 310 samples were collected for subsequent petrographic study and fossil identification.

3.2 Petrographic Methodology

Studies of microfacies of ancient carbonate rocks can commonly be carried out by means of microscopic petrography, since there is a remarkable correlation between the interpretation of their principal components together with their and sedimentary textures and their depositional environments.

Accordingly, 158 thin-sections were prepared from selective samples for the petrographic investigation under the polarized light-microscopes. In addition, some thin-sections were stained, using technique that was developed by Hutchison (1974).

The petrographic descriptions of the carbonate are based on "Carbonate Rock Classifications" proposed by Folk (1959 and, 1962). This classification places primary emphasis on the relative proportions of the grain constituents (allochems), the matrix (orthochems) and sparry calcite cement.

The grain constituents or allochems were described in terms of four categories, namely Ooids, Peloids, Intraclasts and Bioclasts. The matrix consists of microcrystalline calcite of two categories namely micrite (less than 4 μm) and microspar (5-30 μm in diameter, Folk 1965). In addition, the diagenetic constituents such as sparry calcite cement and replaced dolomites will be considered. The quantities of these constituents were estimated by "comparison chart method" (Flugel,1982). There are four degrees for the abundance of allochems, namely, none (not present), rare (present to less than 5% of the bulk), common (5%-30% of the bulk), and abundant (more than 30% of the bulk).

The grain-size was described using terms introduced by Grabau (1903) as calcilutite (silt and clay size), calcareanite (sand size), and calcirudite (larger sand size). However, the calcirudite used herein one millimeter as its lower limit (Folk, 1968).

Besides, some interesting samples were investigated in the greater detail by scanning electron microscope (SEM) to define characters of the microcrystalline components. Some samples were also analyzed by X-ray diffractrometry technique (XRD) to identify mineral compositions.

The details of petrographic methodology and their results will be represented in appendix A.

3.3 Microfacies Analysis

The term "microfacies" was first suggested by Brown (1943) as "In the thin-section, the rock is seen to be composed of microfacies". Therefore, the microfacies is commonly referred to criteria of facies appearing in the observation of thin- section under microscope. Anderton (1985) described the requirements of a facies classification as "to establish a set of definitions that will subdivide all the rock under study". Thus, the microfacies must be referred to the set of unique microscopic properties that can be set up to subdivide the thin-section of the rock under microscope.

In this study, the microfacies are defined by three important aspects of microscopic properties, notably, (1) characteristics of the sedimentary components (allochems, matrix and cement); (2) textures or fabrics; and (3) mineral compositions. In other words, a microfacies is the microscopic geometry and relationships of all components of a rock including such things as primary sediments, diagenetic features and pore spaces.

Accordingly, 9 microfacies were recognized in the Khao Lamphean carbonate rocks as shown in Table 3.1.

Table 3.1 Summary the microfacies types identified in the study area.

Microfacies	Lithological characteristic	Deg
I Algal and a mixture of skeletal fragments, packed biomicrite	Micrite matrix with rare to common microsparite; Algal is common to abundant occurring with a mixture of skeletal fragments of bryozoa, ostracods, crinoids and mollusk shells; grain supported, packstone to grainstone textures; grain sizes: medium calcarenite to fine calcirudite	A
II Shell fragments biomicrudite	Micrite matrix with rare microsparite; mollusk shells are abundant and associated with ostracods, mud or grain supported; grain sizes fine to coarse calcirudite	R
III Encrenite	Micrite matrix with rare microsparite; crinoid stems are very abundant with rarity of other skeletal fragments; grain supported with grain interactions; grain sizes: fine to medium calcirudite	R
IV Argillaceous sparse biomicrite	Micrite matrix with rare microsparite; a mixture of algae, crinoids, smaller forams and ostracods; detrital quartz and ferroan calcite are presented, matrix supported; grain sizes: calcilutite to medium calcarenite	R
V Foraminiferal packed biomicrudite	Micrite matrix with rare microsparite; fusulinids and smaller forams are abundant with rarity of other skeletal fragments; grain supported with occasionally grain interact; grain sizes: normally fine calcirudite	A
VI Sparse biomicrite and fossiliferous micrite	Micrite matrix with rare to common microsparite; a mixture of algae, crinoids, smaller forams and ostracods; mud supported; grain sizes calcilutite to fine calcirudite	C

Deg=degree of abundance of the microfacies A=abundant C=common R=rare

Table 3.1 (cont.) Summary the microfacies types identified in the study area.

Microfacies	Lithological characteristic	Deg
VII Biosparite	Sparry calcite cements with rare micrite; algal fragments and forams are abundant; grain supported; grain sizes: medium to coarse calcarenite	R
VIII Biopelsparite	Sparry calcite cements with rare micrite, peloids are abundant, and associated with forams and algal fragments; normally grain supported; grain sizes: medium to coarse calcarenite	R
IX Biopelmicrite	Micrite matrix with rare microsparite; a mixture of small faecal peloids and bioclasts (normally forams and algal fragments); mud to grain supported; grain sizes: medium to coarse calcarenite	C

Deg=degree of abundance of the microfacies A=abundant C=common R=rare

3.3.1 Microfacies I Algal and a mixture of skeletal fragments packed biomicrite

The Microfacies I, Algal and a mixture of skeletal fragments packed biomicrite, is composed of bioclasts as major allochems with dominant micrite or microcrystalline calcite matrix. The important character of this microfacies is its allochems consisting of algae and a mixture of various skeletal fragments including smaller forams, fusulinids, bryozoa, ostracods, crinoids and mollusk shells as the bioclastic components.

The microfacies I is commonly medium bedded (bed thickness 20-30 centimeters) to very thickly bedded (bed thickness 2-3 meters). Its color varies from gray to dark gray color. It usually does not show any remarkably internal sedimentary structure.

This microfacies is most predominant in the study area. It is widely discovered in the measuring section E and also alternates with other microfacies in the sections A, B, C and D. The distribution of the microfacies I is shown in Figure 3.14.

Under microscope, It commonly shows grain supported textures grading from packstone to occasionally grainstone with abundant micritic mud matrix. The micrite usually invert to the larger crystalline microsparite (by 10-50% of the orthochems).

The allochems are almost bioclasts including fragments of various faunas. Their grain sizes range from medium to coarse calcarenite (normally 0.2-1 millimeters in diameter) but in some horizons which contain large fusuline, the grain sizes will increase to fine calcirudite (normally 1-5 mm.). The clasts are generally not rounded and could be identified by comparison with categories of faunas. However, some grains are so well rounded as spheroclast (Flugel, 1982) that they could not be identified. The grains are commonly well sorted to moderately sorted, except in some horizons, where they contain macro faunas and large fusuline, their sorting become poor.

The eminent bioclasts, algal remains, are most common to abundant (usually more than 10% up to 70% estimated by volumetric comparison chart). The algal remains

appeared both as unidentified algal clasts and fragmented thallus of dasycladacean algae which almost indicate allochthonous origins or can be compared to rudstone and floatstone (Wilson, 1975 and James, 1983). But in the section D (D4, D38 and D45) and section E (E9, E12 and E16) the algae show life positioned autochthonous origin as bafflestone which appear to be the massive and branch coral colonies.

Fusulinids and smaller forams are the second-most abundant faunas found with the algae fragments in common (5%-30%) except in the measuring section E where the foraminifera become rare (less than 5%). Though bryozoa are usually rare (less than 5%), they are occasionally found in every sections.

Ostracods and mollusk shells are quit n common (10%-20%) in some parts of the measuring section E and also in the lower part of the measuring section D but they are usually rare (less than 5%) in other measuring sections. Similarly, crinoid fragments are commonly rare (usually 1-3 grains in a thin section) except in the horizons E12 and B41 where they are commonly found (20-30%).

A selective of examples of the Microfacies I, showing some variation in their bioclasts and textures are shown in Figure 3.5.

Interpretation : The presence of abundant micrite and the domination of embedded, unbroken algal fragments with mixed bioclasts indicate the low energy depositional environment of subtidal and subwavebase zone. Grain-supported texture and some of fragmented clasts and spheroclasts indicate shallow water close to wave-base or irregularly effected by storm wave base.

3.3.2 Microfacies II Shell fragments biomicrudite.

This microfacies composed of bioclasts as major allochems and contain of micrite or microcrystalline calcite matrix. The distinctive character of this microfacies is its major bioclastic grains consisting mainly of fragments of mollusk or ostracod shells.

Figure 3.5 Photomicrographs of the microfacies I, Algal and a mixture of skeletal packed biomicrite

(All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 7-11-1AB] showing general petrography of the microfacies I.

(b) Unstained thin-section [Sample No. 3-6-5L] showing general micrographic petrography of the microfacies I, Major grain component are algal fragments [A] and some of shell fragments [SH] in among of the micritic mud matrix [MI] as in grain supported.

(c) Unstained thin-section [Sample No. 6-17-1F], close up of the major grain components; fusulinid [F], algal fragment [A] and some crinoid stem fragment [CS].

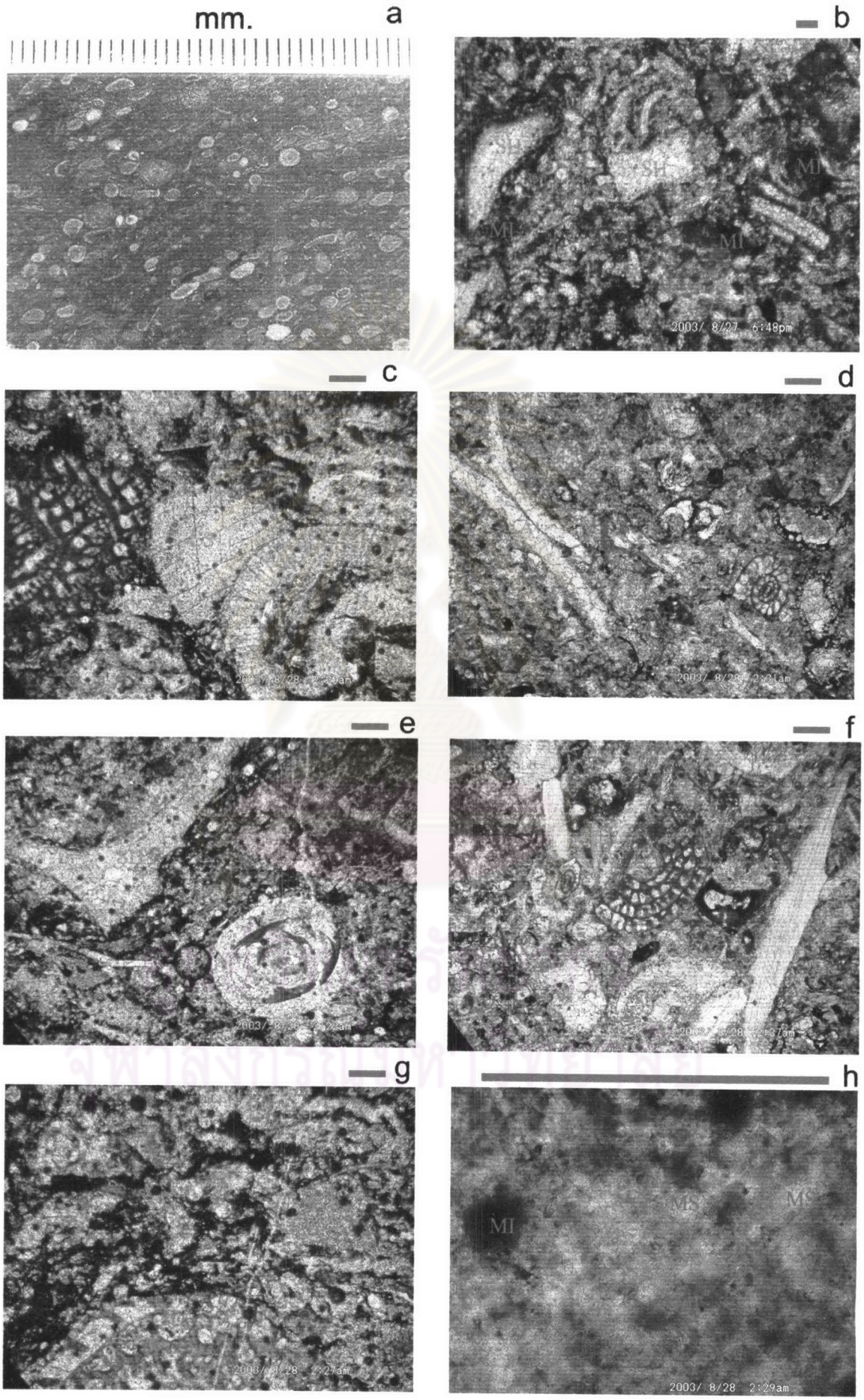
(d) Unstained thin section [Sample No. 8-1-1L], showing some of minor grain components; smaller forams [SF] and algal fragments [A].

(e) Unstained thin-section [Sample No. 6-17-1F] showing the grain components; shell fragments [SH], and encrusted foraminifera [A].

(f) Stained thin-section [Sample No. 6-15-1F] showing all grain components and matrix are red stained by alizarin red-s solution and indicate the calcite character.

(g) Unstained thin-section [Sample No. 8-1-1L] showing the micrite mud matrix with wrinkle lamination of stylolitic texture.

(h) Unstained thin section [Sample No. 3-6-5F] in high resolution micrograph showing almost microsparite [MS] matrix and some relics of micrite mud matrix [MI].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This microfacies is quite rare. It could be discovered only in the horizons E2, B5/1, B24/1, B29, A12/1, A15/1, C9/1, C14, D7, D15 and D36 (See figure 3.14).

The microfacies II are usually medium to thickly bedded (bed thickness 20-50 centimeters). Its color is usually dark gray, darker than others.

Under microscope, Its textures range from mud supported with abundant of micritic mud matrix, namely, sparse biomicrite to grain supported, namely, packed biomicrite. However, microsparite matrix are relatively less common and locally replaced by fine grained dolomite.

The allochems are almost bioclasts of mollusk shell. In the horizon E2 and D15, the shell fragments consist only of unidentified fragments of brachiopods and bivalves. Their grain sizes range from coarse calcarenite to fine-medium calcirudite (normally 0.5-2 centimeter). Most bioclasts are aligned parallel to the bedding.

However, in the horizons B5/1, B24/1, B29, A12/1, A15/1, C9/1, C14, D7 and D36, the abundant bioclasts are composed of giant Alatoconchid bivalves (Family Alatoconchidae) with other, less abundant, shell fragments. Ostracods are varying from rare to common (usually not more than 10%). The sizes of fragments are coarse calcirudite (normally ranging between 5-30 centimeters in length).

Some selective textures, showing their variation in grain constituents and textures of the Microfacies II are shown in Figure 3.6.

Interpretation : The presence of abundant micrite indicates the low energy depositional environment of subtidal and subwavebase zone. The mulluscan and other infaunal biota point to soft substrate condition and restricted environments but the influence of moderate circulation might cause fragmentation of bioclasts. Moreover, the majority of grain-supported texture of fragmented clasts and spheroclasts may indicate either shallow water close to wave-base or being irregularly affected by the storm wave base.

Figure 3.6 Photomicrographs of the microfacies II, Shell fragments biomicruite (All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 7-11-1AB] showing general petrography of the microfacies II.

(b) Unstained thin-section [Sample No. 3-6-5L] showing the general micrographic petrography of microfacies II, the major grain components are the shell fragments [SH] in the micritic mud matrix [MI].

(c) Unstained thin-section [Sample No. 6-17-1F] close up the grain components; shell fragments [SH], Giant bivalve shell [ALA], algal fragments [A], and the fragments of crinoid stems [CS].

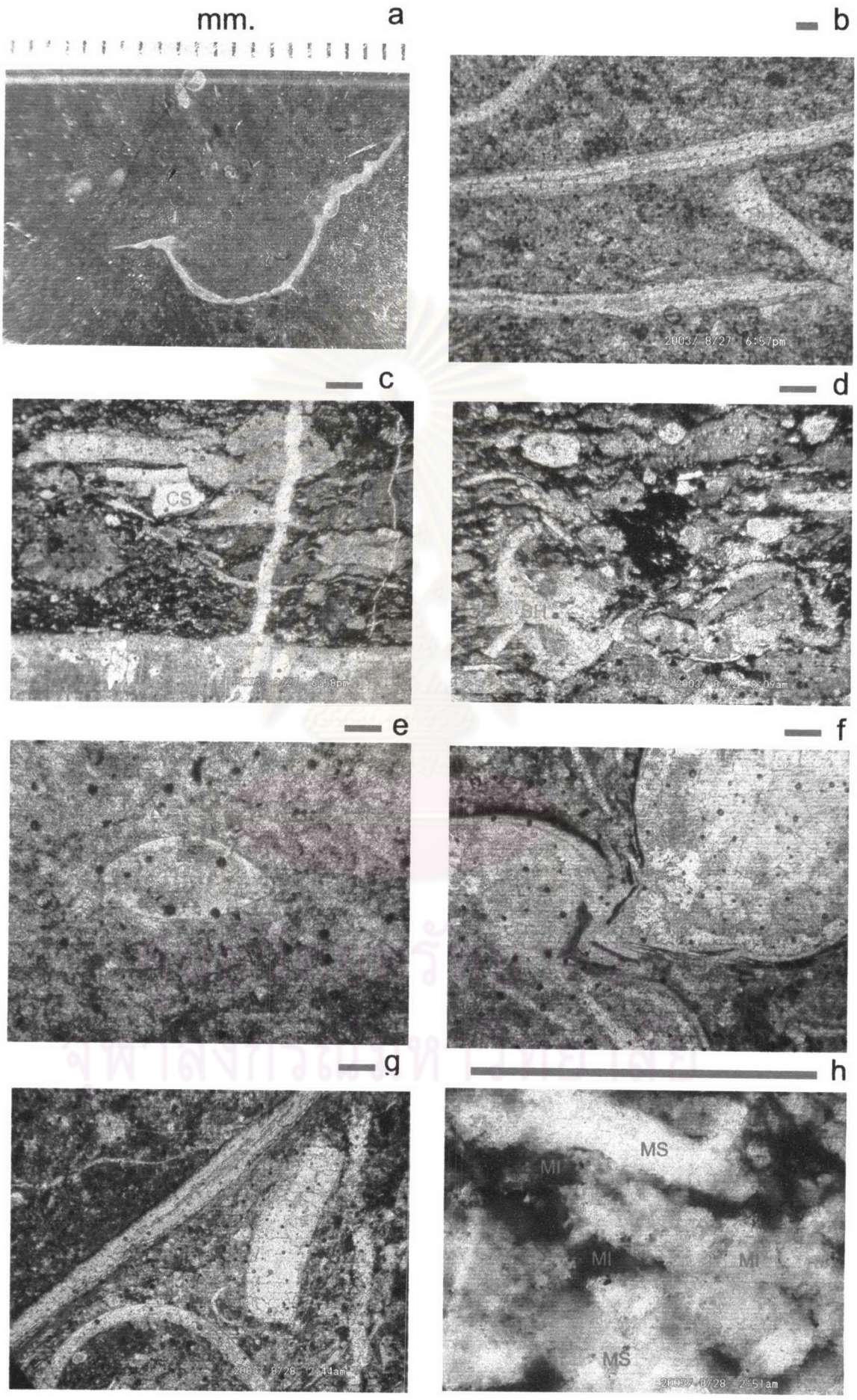
(d) Unstained thin section [Sample No. 8-1-1L] showing the grain components; shell fragments [SH] and algal fragments [A], and the locally occurred stylolitic texture.

(e) Unstained thin-section [Sample No. 6-17-1F] showing the grain components; ostracods shell [OS] in the mud-supported texture.

(f) Stained thin section [Sample No. 6-15-1F] showing all grain components and matrix are red stained by alizarin red-s solution indicate the calcite character.

(g) Stained thin-section [Sample No. 8-1-1L] showing some shell fragment were dolomitized and unstained by alizarin red-s solution.

(h) Unstained thin section [Sample No. 3-6-5F] in high resolution micrograph showing almost microsparite [MS] matrix and some relics of micrite mud matrix [MI].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3.3.3 Microfacies III Encrenite

The Microfacies III, Encrenite, is the specific name which is defined for the limestone that contain crinoidal fragments more than 50% of the bulk (Bissell and Chilinger, 1967). It is equivalent to crinoidal packed biomicrite.

This microfacies is commonly rare. It could be only discovered in horizon B12 and C2 (see Figure 3.14). It is usually , gray, thickly-bedded average bed thickness is 1 meter, and does not display internal sedimentary structure.

Under microscope, It commonly shows grain supported textures including obviously grain interact with minor micritic mud matrix or microspar matrix.

Crinoids stems are most abundant bioclastic fragments (60-80% of bulk), and frequently well rounded. Other associated faunas are, usually smaller forams, rare to common (not more than 10% of bulk). In addition, they are usually poor to moderately sorted.

There are a member of several horizons display microfacies that almost resemble the encrenite. For example, the horizon A5, B14 and B 41 commonly consist of crinoidal fragments (20-30% of the bulk), but the other associated faunas, such as smaller forams, fusulinids and algal fragments are also similar abundant. Thus, they are put in the microfacies I, Algal and mixture of skeletal packed biomicrite.

In addition, the horizon B1 and C8 are also composed of crinoidal fragments (20-30% of the bulk) being embedded in mud supported and they could be referred to as encrenitic limestone (Bissell and Chilinger, 1967). Accordingly, they will be more appropriate to the microfacies VI, sparse biomicrite and fossiliferous micrite.

Some selective textures showing their variation in grain constituents and textures of the Microfacies III are shown in Figure 3.7.

Figure 3.7 Photomicrographs of the microfacies III, Encrenite
(All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 5-11-1L] showing general characteristics of the microfacies III.

(b) Unstained thin-section [Sample No. 5-11-1L] showing the general micrographic characteristics of microfacies III, the major grain components; Crinoid stems [CS].

(c) Unstained thin-section [Sample No. 5-11-1L] showing the grain components; the fragments of crinoid stems [CS].

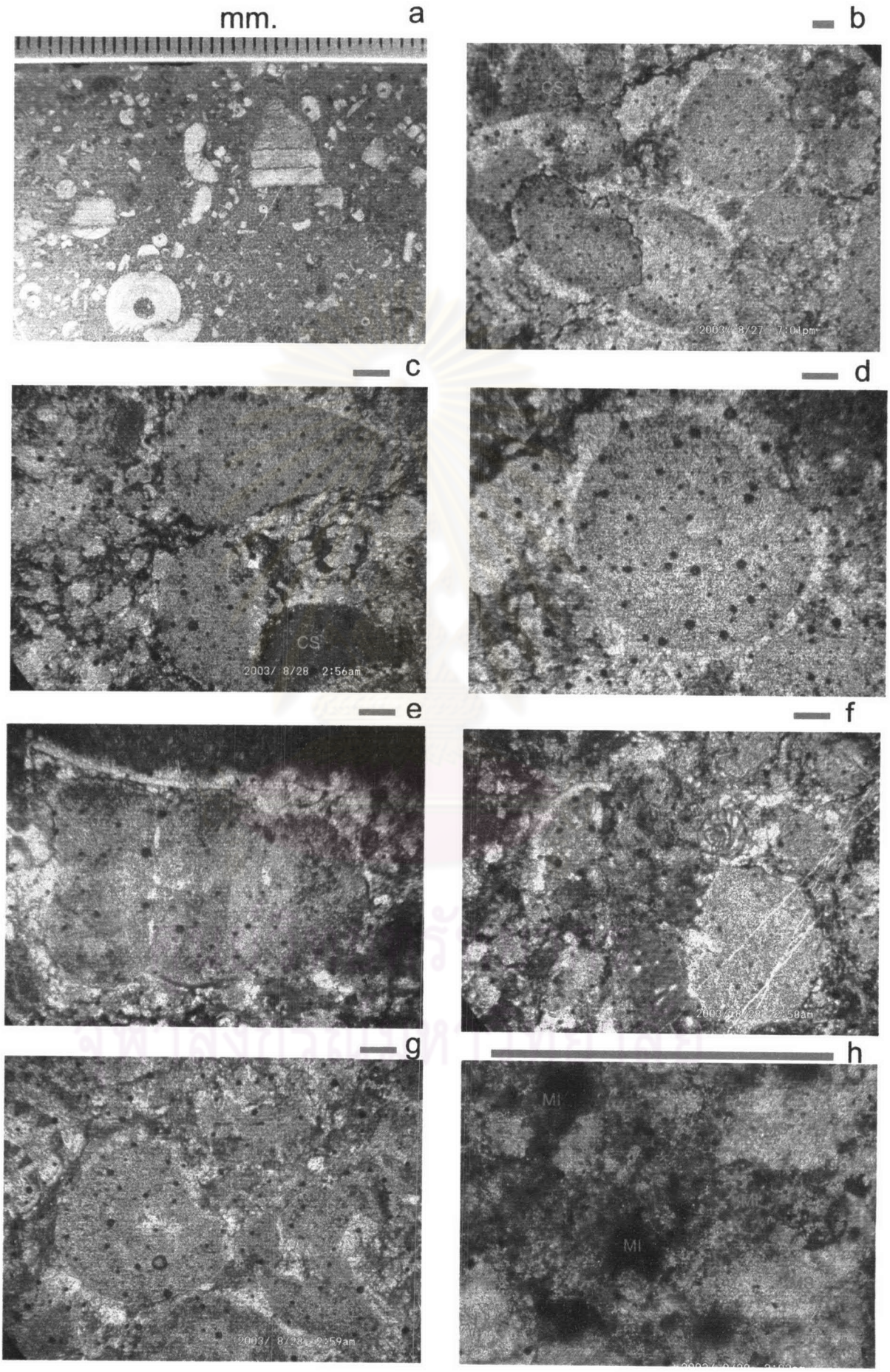
(d) Unstained thin section [Sample No. 5-11-1L] showing the grain components; crinoid stem in cross-section.

(e) Unstained thin-section [Sample No. 5-11-1L] showing the grain components; crinoid stem in longitudinal section.

(f) Unstained thin section [Sample No. 5-11-1L] showing the grain component; crinoid stems [CS] and the associated forams [F].

(g) Stained thin-section [Sample No. 5-11-1L] all grain components and matrix are red stained.

(h) Unstained thin section [Sample No. 5-11-1L] in high resolution micrograph showing the micrite mud matrix [MI], and the microsparite [MS].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Interpretation : The presence of abundant micrite indicate the low energy depositional environment of subtidal and subwavebase zone. Grain-supported texture i.e., almost grainstone consisting of fragmented crinoid stems and some spheroclasts also indicate either shallow water close to wave-base or irregularly being affected by storm wave base.

3.3.4 Microfacies IV Argillaceous sparse biomicrite

The argillaceous sparse biomicrite is the rarest microfacies found in the study area. Only one horizon E3 (see Figure 3.14e), at most 2 meters thick, belong to this microfacies.

This microfacies is characterized by bioclasts as its major allochems and micritic mud supported texture. The sedimentary structure obviously shows internal laminations.

In the field, the rocks are medium bedded (bed thickness 20-30 centimeters), yellowish gray calcilutite. Their argillaceous components are easily recognized on their weathered surfaces.

Under microscope, The rocks are commonly composed of a mixture of bioclastic components (about 40 % of the bulk), namely smaller forams, mollusk shell fragments, algal fragments, rare fragments of crinoids, bryozoa and ostracods being embedded in abundant micrite matrix or microsparite matrix (about 50%). In places, numerous thin seams of clay and iron minerals are frequently observed indicating stylolitization in the rocks.

Another distinctive characteristic of this microfacies is the presence of detrital quartz grains. The quartz grain, well rounded, fine sand to silt sizes, are found in common (nearly 10% of the bulk).

Furthermore, in stained thin-section (using combination of potassium ferricyanide and alizarin red-S solution), quartz grains show colorless but some components such as the

microspar in cavities, and algal fragments turn mauve, which is the characteristic of ferroan calcite (Hutchison, 1974).

Some selective textures showing their variation in grain constituents and textures are shown in Figure 3.8.

Interpretation : The presence of abundant micrite indicates the low energy depositional environment of subtidal and subwavebase zone. The terrigenous sediments and mud-supported texture might also indicate near shore and restricted depositional environment which probably rise in peritidal zone due to the presence of mud laminations.

3.3.5 Microfacies V Foraminifera packed biomicrudite

This microfacies is composed of the bioclasts as dominant allochems and some micrite matrix. The most distinctive character of this microfacies is the remarkable abundant foraminifera as the bioclastic components.

It is dominant microfacies found in the study area. It occurs in almost measuring sections except the section E. It is particularly discovered in the middle of the section A, B and D and at the lower part of the section C.

It is commonly medium bedded (bed thickness 20-30 centimeters) to very thickly bedded (bed thickness 1-2 meters), gray to dark gray and sometime shows internal lamination and graded bedding.

It is usually intercalated with the Microfacies I and Microfacies VI. The distribution of the microfacies V is shown in figure 3.14.

Under microscope, it clearly shows grain supported fabric with grain interaction, and their intergranular spaces were filled by micrite or microspar calcite. In places,

Figure 3.8 Photomicrographs of the microfacies IV, Argillaceous sparse biomicrite (All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 8-3-1L] showing general characteristics of the microfacies IV.

(b) Unstained thin-section [Sample No. 8-3-1L] shows the general micrographic characters of the microfacies IV.

(c) Unstained thin-section [Sample No. 8-3-1L] shows the stylonodular texture; Detrital quartz grain [Q] and micrite mud matrix in wrinkle lamination of stylolite [MI].

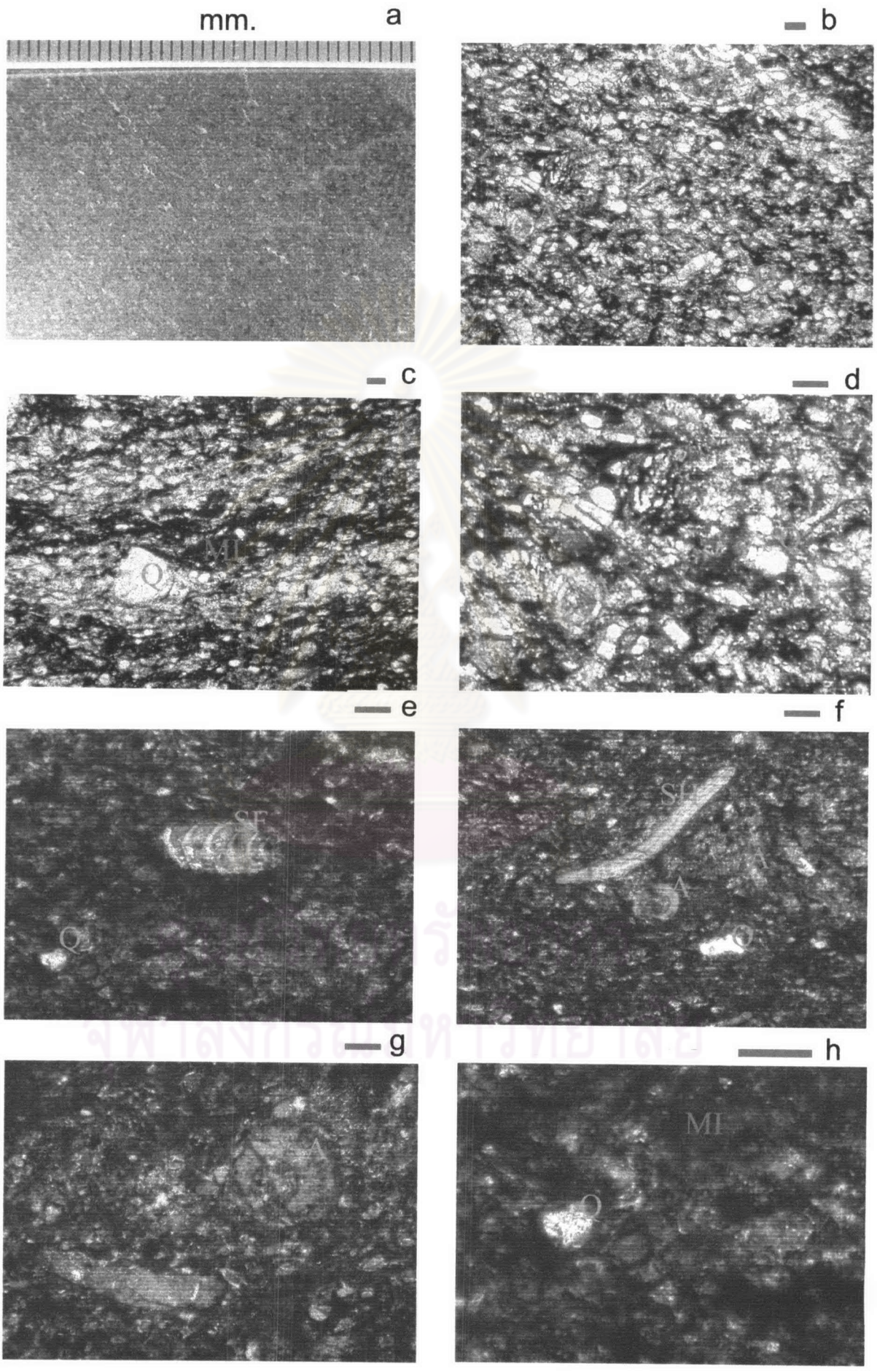
(d) Unstained thin-section [Sample No. 8-3-1L] shows the general micrographic characters of the microfacies IV and the major grain components; Algal fragments [A] and detrital quartz grain [Q].

(e) Stained thin section [Sample No. 8-3-1L] shows the grain components. Smaller forams with different stained colored (red stained of calcite and violet stained of ferron calcite) [SF] and detritral quartz grain [Q].

(f) Stained thin section [Sample No. 8-3-1L] shows the grain components. Detrital quartz grain (not stained) [Q], Algae (both red stained of calcite and violet stained of ferron calcite) [A] and shell fragments (red stained of calcite) [SH].

(g) Stained thin section [Sample No. 8-3-1L] shows the grain components. Algal fragments (top is its cross section and red stained of calcite, bottom is its longitudinal section with half red stained and violet stained) [A].

(h) Unstained thin-section [Sample No. 8-3-1L] in high resolution micrograph shows the major grain components and the matrix. Algal fragments [A], detrital quartz grain [Q], microsparite matrix [microcrystalline calcite in white color area] and the micrite mud matrix [MI] (black color area)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numerous thin seams of clay and iron minerals are frequently observed indicating stylolitization.

The allochems are almost tests of both smaller foraminifera and larger fusulines. The former is commonly 0.2-1 millimeters in length consisting of various species, however at least 5 species of them can be recognized. Contrarily, the latter is usually 1-5 millimeter in length and consisting of Neoschwagerinids and Verbeekinids. Furthermore, some fragments (0.2-1 millimeter. in length) of ostracods and other shells are occasionally seen.

Some selective textures showing the variation in grain constituents are shown in Figure 3.9.

Interpretation : The presence of abundant micrite and the domination of embedded the foraminiferal tests indicate the low energy depositional environment of subtidal and subwavebase zone. Grain-supported texture with some fragmented clasts and corroded tests indicate either shallow water close to wave-base or being irregularly affected by storm wave base.

3.3.6 Microfacies VI Sparse biomicrite and fossiliferous micrite

This microfacies is rather common in the study area. It occurs in every measured rock-sections. It is usually alternated with the Microfacies I and Microfacies V. The distribution of the microfacies VI is showing in Figure 3.14.

In the field, it is usually medium bedded (20-30 centimeters thick) to very thickly bedded (0.50-2 metes thick), dark to dark gray, and does not show internal sedimentary structures.

Under microscope, It shows various bioclasts scattered by embedded in abundant micritic matrix. This distinctive feature, mud supported texture, can fall into two categories;

Figure 3.9 Photomicrographs of the microfacies V, Foraminiferal packed biomicruite (All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 7-11-1AB] showing general characteristics of the microfacies V.

(b) Unstained thin-section [Sample No. 3-6-5L] showing the general micrographic characteristics of microfacies V.

(c) Unstained thin-section [Sample No. 6-17-1F] showing the grain-supported texture with interactions of the grain components (grainstone texture).

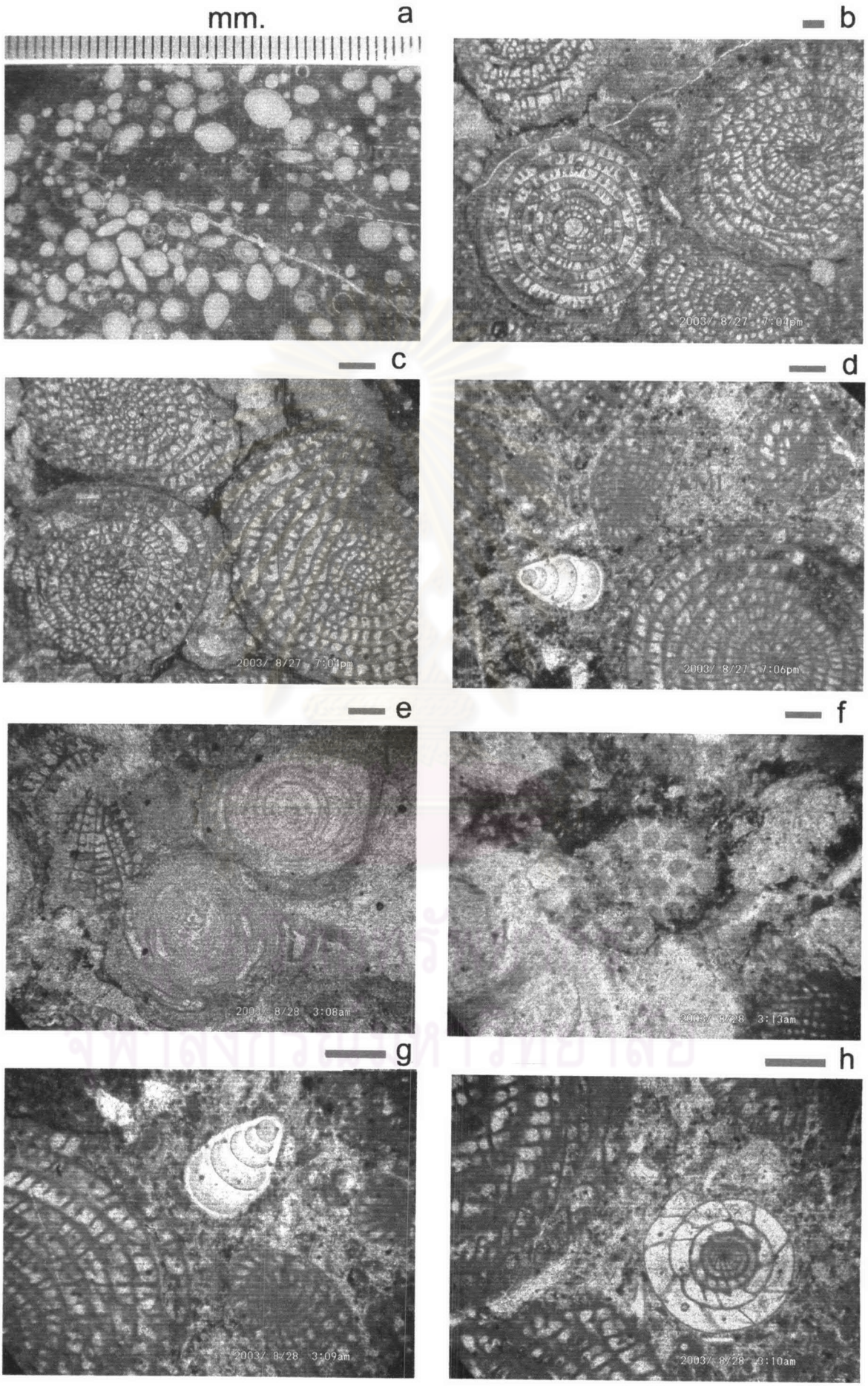
(d) Unstained thin section [Sample No. 8-1-1L] showing the grain components; fusulinids tests [F] and smaller forams [SM].

(e) Unstained thin-section [Sample No. 6-17-1F] showing the micrite matrix [MI] and the grain components; fusulinids [F] and encrusted forams [A].

(f) Unstained thin section [Sample No. 6-15-1F] showing the grain components; bryozoa.

(g) Stained thin-section [Sample No. 11-10-1F] showing all grain components and matrix are red stained.

(h) Stained thin-section [Sample No. 11-10-1F] showing all grain components and matrix are red stained.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namely sparse biomicrite (10%-50% of the bioclasts) and the fossiliferous micrite (1%-10% of the bioclasts).

The sparse biomicrite is widespread and composed of various combinations of skeletal fragments such as fusulinids dominant (B42, D10, E6 and C18), algae dominant (D16, B18, B20 and B43), crinoids dominant (B1 and C8), ostracods dominant (B31) and shell fragments (C13 and D25).

The fossiliferous micrite are less found. It appears only in the top of the measured rock-section B and the lower part of the measured rock-section D. It obviously shows lower diversity of bioclasts. Few fragments of algae and ostracods are occasionally seen. However some appearance of bioturbations were discovered (B2 and B9).

Regarding to its grain size, the rocks are commonly equivalent to calcilutite, and some bioclasts are usually smaller than medium calcarenite (about 0.2 millimeter in length), except in some horizons which contain large fusulines, their grain-size range from 1 millimeter up to 5 millimeters in length.

Some selective ,textures showing their variation in grain constituents, are shown in Figure 3.10.

Interpretation : The presence of abundant micrite indicates the low energy depositional environment of subtidal and subwavebase zone. The faunas are rare and found only fragmented bioclasts which indicate allochthonous origin far from their sources. The bioturbations indicate calm, low energy and slightly deep condition with conducting for the soft substrate infaunas. Majority of mud-supported texture with some fragmented clasts indicate deeper water and rarely affected by the storm wave base.

3.3.7 Microfacies VII Biosparite

This microfacies is considerably rare. It is locally found only in the top of the measured rock-section B namely the horizon B3, B4, B5, B7 and B17. The distribution of the microfacies VII is shown in Figure 3.14.

Figure 3.10 Photomicrographs of the microfacies VI, Sparse biomicrite and fossiliferous micrite

(All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 11-8-1L] showing general characteristics of the microfacies VI.

(b) Unstained thin-section [Sample No. 12-8-1L] showing the general micrographic characteristics of microfacies VI.

(c) Unstained thin-section [Sample No. 2-0-2L] showing the mud-supported texture.

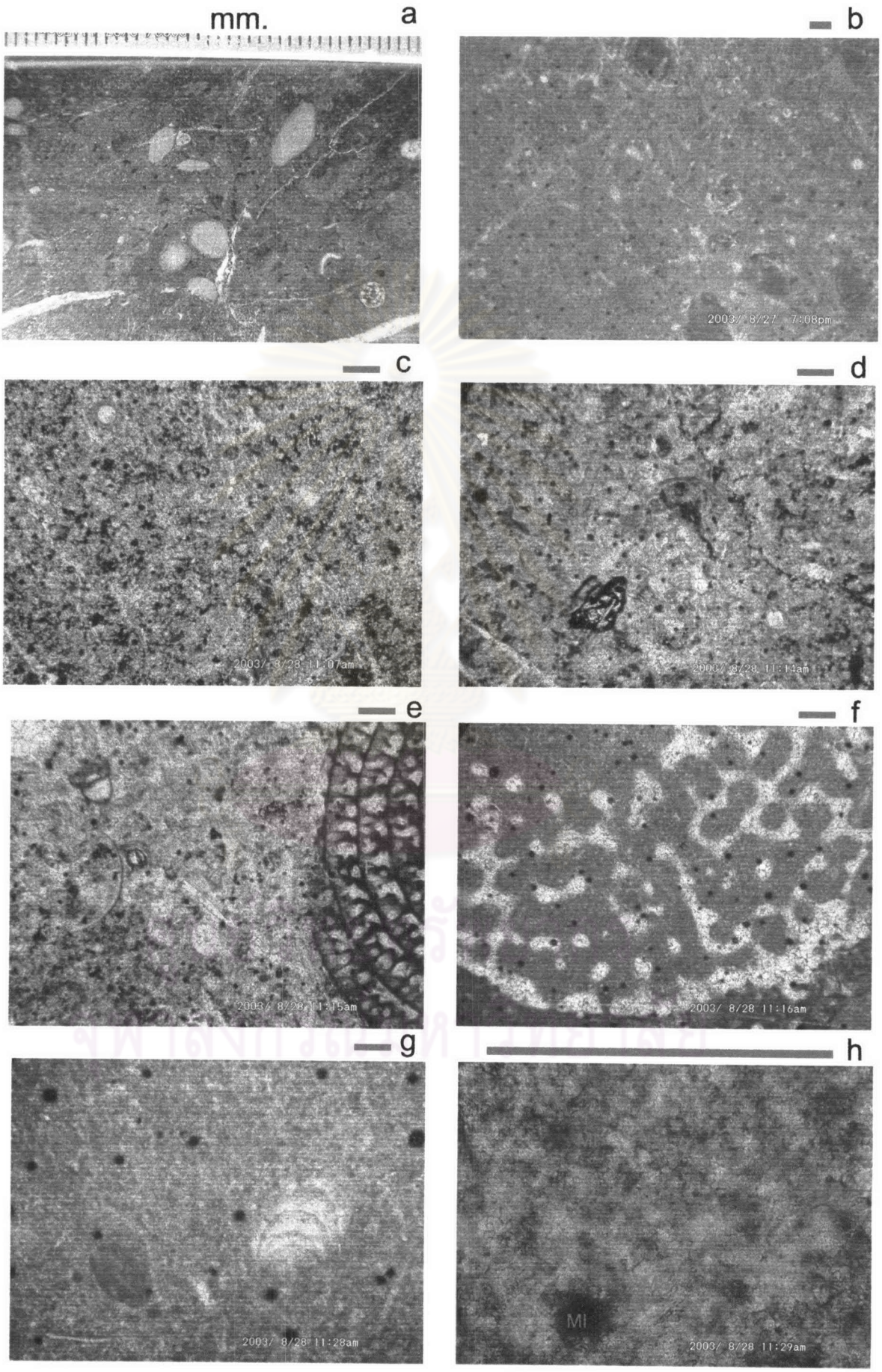
(d) Unstained thin section [Sample No. 12-8-1L] showing the micritic mud matrix and the grain components; algal fragments [A].

(e) Unstained thin-section [Sample No. 5-0-2L] showing the grain components; fusulinids [F], ostracods tests [OS], and algal fragments [A].

(f) Unstained thin section [Sample No. 5-11-1L] showing the bioturbations.

(g) Stained thin-section [Sample No. 1-8-11-F] all grain components and matrix are red stained.

(h) Unstained thin section [Sample No. 11-8-1L] in high resolution micrograph showing the micrite mud matrix [MI], and the microsparite [MS].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In the field, the rocks is medium bedded (bed thickness 20-30 cm) to very thickly bedded (bed thickness 1-2 centimeters), gray to dark gray, and does not show internal structures.

Under microscope, texturally, it is distinctly grain-supported with intergranular, sparry calcite cements (20-50 microns in diameter). Furthermore, this microfacies could be subdivided into two categories, namely, rounded biosparite and unsorted biosparite.

The rounded biosparite is rarely found only in horizons B3. The micrite matrix appearance in rare (less than 10% of the matrix). The allochems are abundant and consist mostly of abundant algal fragments (about 50% of the bulk) with minor amount of fusulinids and bryozoa was found in common (less than 10% of the bulk). The fragments are medium calcarenite (0.3-0.5 millimeters in length), generally well rounded to sub-round.

The unsorted biosparite is more common than the round biosparite. It is found in horizon B4, B5, B7 and B17. The micrite matrix is quite common (10%-30% of the matrix). Its bioclastic content is more diverse and commonly consists of fusulinids (5-20%) with subordinate amount of algal fragments and smaller forams. The clasts are sub-angular and poorly sorted. Their grain sizes range from fine calcarenite to coarse calcarenite (0.1-1 millimeter) and up to fine calcirudite (1-5 millimeters) of fusulinid grain sizes.

Some selective textures, showing their variation in grain constituents, are shown in Figure 3.11.

Interpretation : The presence of abundant sparry calcite as the intergranular cements indicate the high energy depositional environment in subtidal and wave agitated zone where almost muddy constituents were washed out. Grain-supported texture and the domination of almost rounded fragments also indicate shallow water being regularly affected by normal wave agitation.

Figure 3.11 Photomicrographs of the microfacies VII, Biosparite
(All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 5-4-1F] showing general characteristics of the microfacies VII.

(b) Unstained thin-section [Sample No. 5-7-2F] showing the general micrographic characteristics of microfacies VII.

(c) Unstained thin-section [Sample No. 5-15-2F] showing the grain components; algal fragments [A].

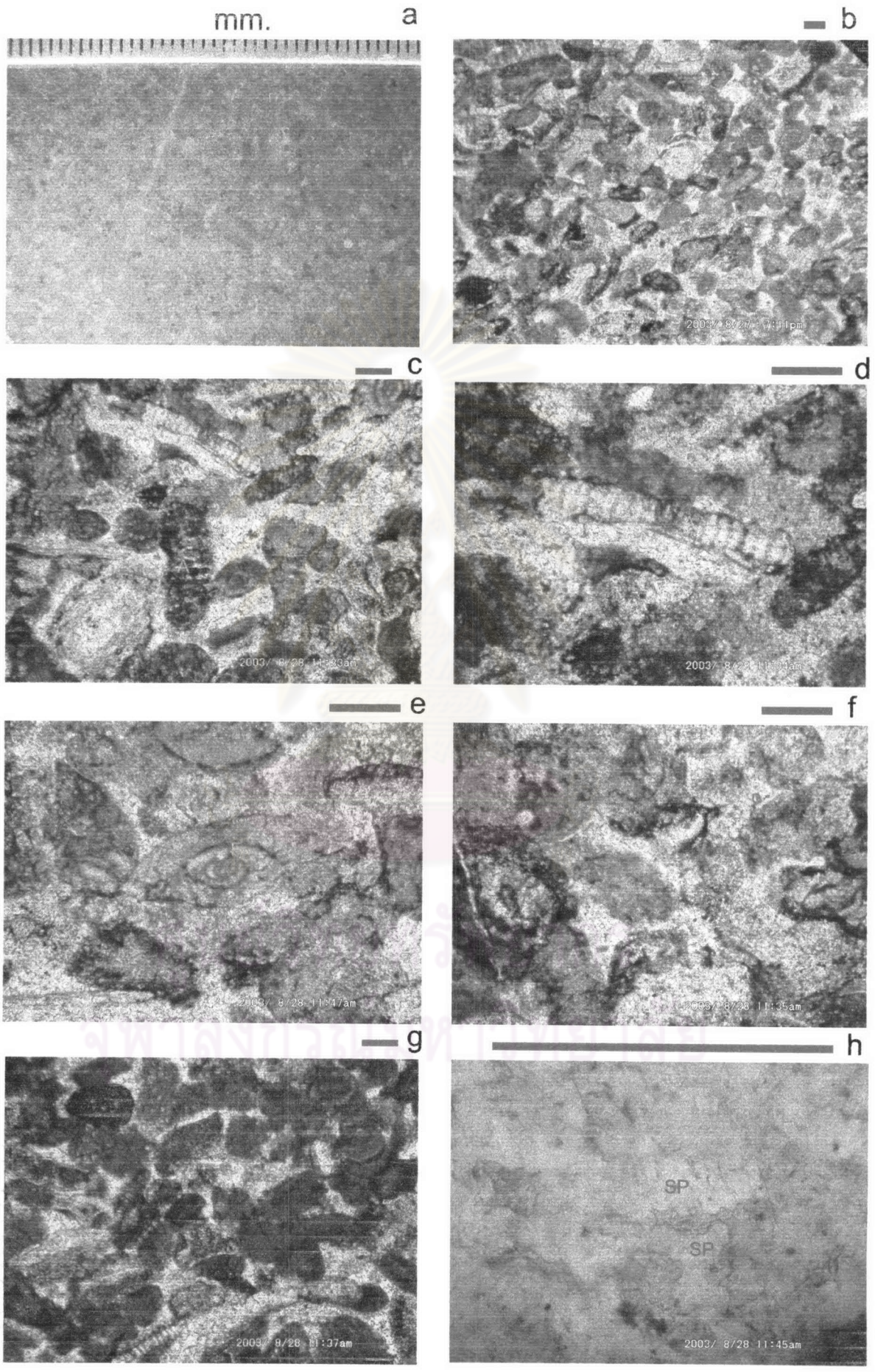
(d) Unstained thin section [Sample No. 5-15-2F] showing the sparry calcite cement and the grain components; algal fragments [A].

(e) Unstained thin-section [Sample No. 5-11-1L] showing the grain components; fusulinids [F].

(f) Unstained thin section [Sample No. 5-4-1F] showing the sparry calcite cement and the grain components; algal fragments [A].

(g) Stained thin-section [Sample No. 5-7-2F] all grain components and cement are red stained.

(h) Unstained thin section [Sample No. 5-4-1F] in high resolution micrograph showing the sparry calcite [SP].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3.3.8 Microfacies VIII Biopelsparite

This microfacies is widespread. It occurs in the top of the measure section A (horizon A2, A3, A4 and A16.), in the measured section B (horizon B8, B15 and B16) in the measured section C (horizon C5) and also in the lower part of the measures section E (horizon E15) as shown in Figure 3.14.

In the field, the rocks are usually thickly bedded (bed thickness 0.5-1 meter) to very thickly bedded (bed thickness 1-2 centimeters), gray to dark gray, and does not show internal structures.

Under microscope, it consists predominantly of peloids (20-60% of the bulk) and subordinate bioclastic grains. Texturally, it is grain-supported with intergranular, sparry calcite cement (20-50 microns in diameter) as shown in Figure 3.12h.

The peloidal grains seem to be faecal peloids because of their characteristic of dark, fine-grained (50-100 microns), elliptical or ovoid shaped, and structureless. The pellets are particularly abundant (50-60% of the bulk) in the horizons A2, A3 and C5, lesser abundant (30-50%) in the horizons A4, B15, B16, and being just common (20-30%) in the horizons B8 and E16.

The bioclasts are also common to abundant (20-50%) in some horizons. The major grains are algal fragments (often in abundant) with some of fusulinids and smaller forams (often in common). The clasts are well sorted and their grain-sizes commonly range from medium calcarenite to coarse calcarenite (0.3-1 millimeter) and up to fine calcirudite (1-5 millimeters) especially with fusulinid grains.

The ratio of bioclasts by pellets to usually ranging from 1/3 (in the horizons which very abundant pellet) to 1/1 (in the horizons of equal abundant), except the horizons B8 and E16 where pellet and algal fragments are roughly equal, thus it is about 1/2.

Some selective textures, showing their variation in grain constituents, are shown in Figure 3.12.

Interpretation : The presence of abundant sparry calcite as the intergranular cements indicate the high energy depositional environment of subtidal and wave agitated zone where almost muddy constituents were washed out. Grain-supported texture and the domination of almost rounded bioclastic grains indicate shallow water regularly being affected by normal wave agitation. However, more association of micrite and presence of faecal pellets indicate less effects of wave due to some protections but moderate circulation.

3.3.9 Microfacies IX Biopelmicrite

This microfacies is found in most measured rock-sections except the measured rock-section E. namely in the middle of the measured section A (the horizon A8, A9, A10 and A15.), in the measured section B (the horizon B13 and B19) , in the measured section C (C3, C4, C6, C7, C9, C12 and C15), and in the section D (D4, D17, D26, D29, D30, D32 and D33) as shown in Figure 3.14.

In the field, the rocks is thickly bedded (bed thickness 0.3-1 meters) to very thickly bedded (bed thickness 1-2 centimeters), gray to dark gray and occasionally shows internal laminations.

Under microscope, it is composed mainly of peloids ranging from common to abundant (10-40% of the bulk) and some bioclasts embedded in micrites or, sometimes, microsparite matrix. Texturally, mud supported is predominantly observed as shown in the Figure 3.14.

The peloidal grains seem to be faecal peloids being indicated by their characteristic of dark, ellipsoidal shape, fine-grained (50-100 microns) and structureless grains. The pellets were usually found in common (5-30% of the bulk).

Figure 3.12 Photomicrographs of the microfacies VIII, Biopelsparite
(All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 1-2-1A] showing general characteristics of the microfacies VIII.

(b) Unstained thin-section [Sample No. 1-1-2F] showing the general micrographic characteristics of microfacies VIII.

(c) Unstained thin-section [Sample No. 5-14-1L] showing the grain components; smaller forams [SM] and peloids [P] .

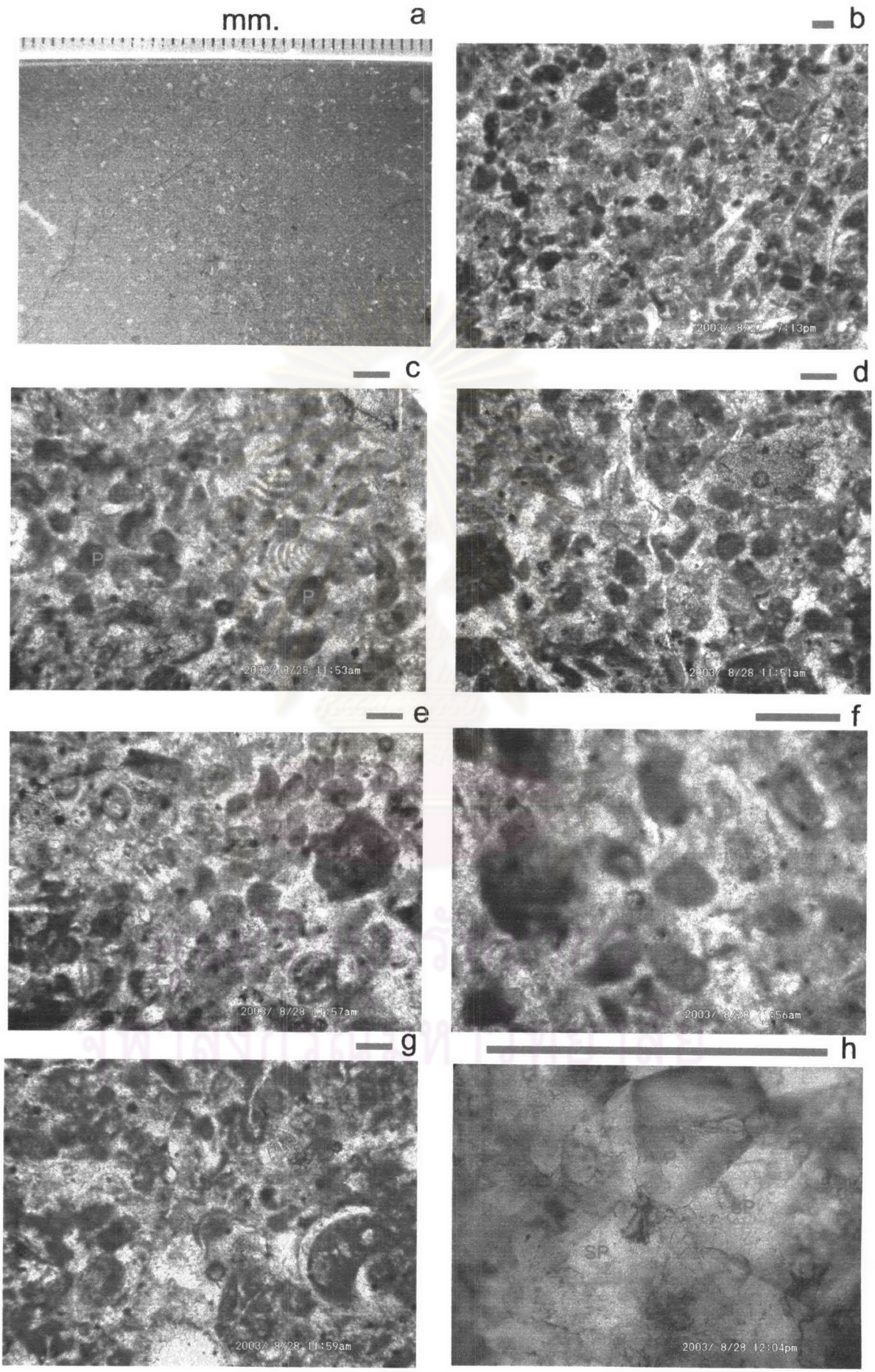
(d) Unstained thin section [Sample No. 5-14-1L] showing the sparry calcite cement and the grain components.

(e) Unstained thin-section [Sample No. 1-1-2F] showing character of peloids in different size.

(f) Unstained thin section [Sample No. 1-1-2F] the feacial peloids.

(g) Stained thin-section [Sample No. 1-2-1A] all grain components and cement are red stained.

(h) Unstained thin section [Sample No. 1-1-2F] in high resolution micrograph showing the sparry calcite [SP].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Some bioclasts are common to abundant (5-50% of the bulk) consisting of various of types. Algal fragments and forams are mostly found. Ostracods fragments and other shell-fragments are sometimes found in places. The clasts are commonly poorly sorted, and their grain-sizes range from fine calcarenite to coarse calcarenite (0.1-1 millimeter), and occasionally up to fine calcirudite (1-5 millimeters) with the fusulinid grains.

The proportions of the bioclasts to pellets usually range from 1/2 to 1/3 in the horizons which grain supported, and sometimes it becomes 1/1 in the mud supported horizon.

Some selective textures, showing their variation in grain constituents, are shown in Figure 3.13.

Interpretation : The presence of abundant micrite and the domination of embedded, unbroken algal fragments with mixed bioclasts indicate the low energy depositional environment of subtidal and subwavebase zone. Moreover, mud-supported texture with the presence of faecal pellets indicate rare affects of wave due to some protections but moderate circulation.

3.3.10 Distribution of the microfacies

The distribution in the Section A

In this section, the microfacies I, V, VIII and IX are distinctly observed. The lower part of the section is an alternation of microfacies I and V. The middle part obviously encounter peloidal microfacies such as the microfacies VIII and IX.

The distribution of the microfacies in the section A is shown in the Figure 3.14a.

The distribution in the Section B

In this section, the microfacies I, V, VI, VII, VIII and IX are distinctly observed. The lower part of the section is an alternation of microfacies I and V. Its middle part peloidal

Figure 3.13 Photomicrographs of the microfacies IX, Biopelmicrite
(All scale bar=0.25 millimeter)

(a) Polished slab [Sample No. 1-6-3L] showing general characteristics of the microfacies IX.

(b) Unstained thin-section [Sample No. 1-5-2F] showing the general micrographic characteristics of microfacies IX.

(c) Unstained thin-section [Sample No. 1-12-1F] showing the micritic mud matrix and the grain components; smaller forams [SM], crinoid stem [CS] and peloids [P] .

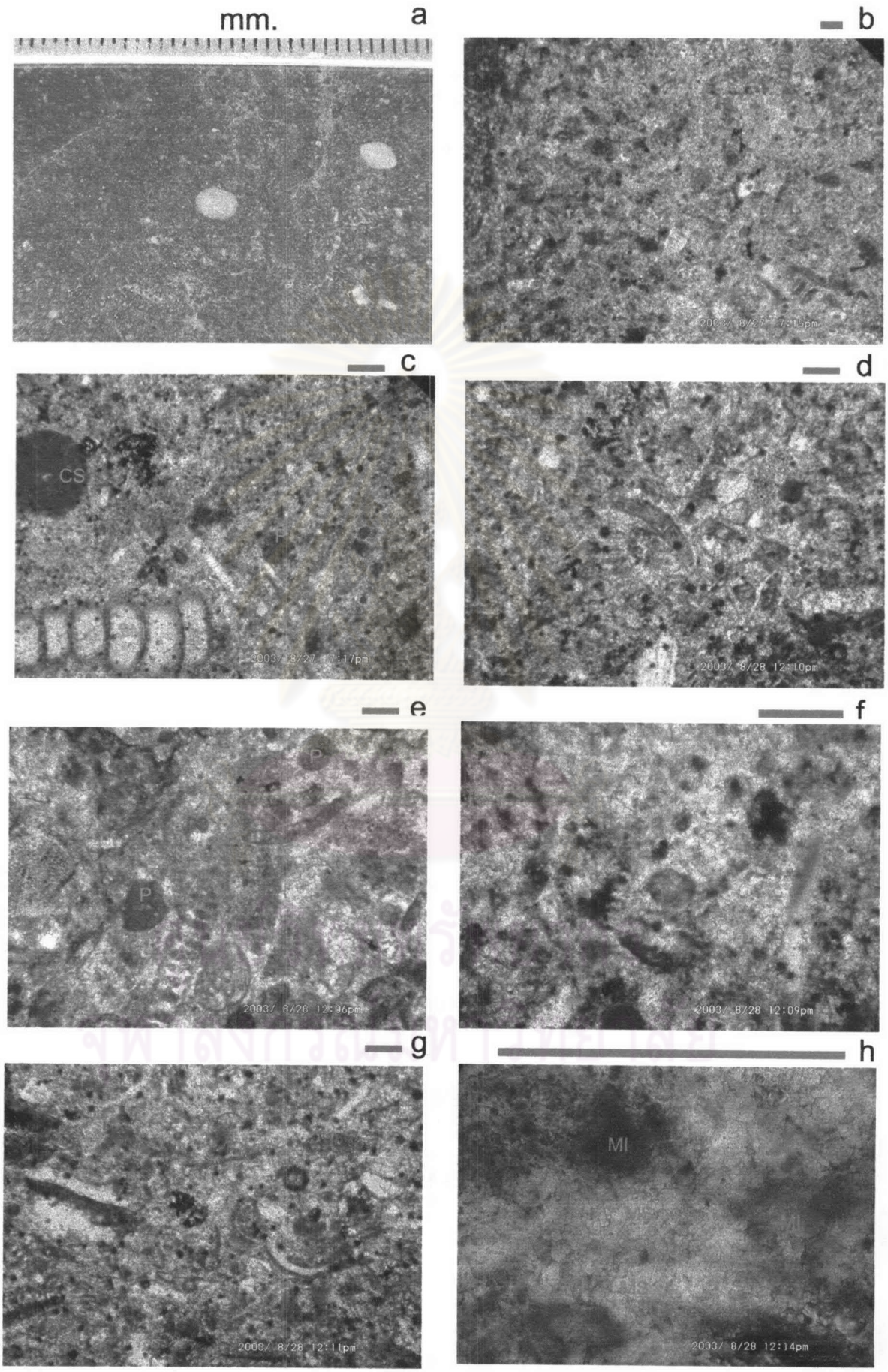
(d) Unstained thin section [Sample No. 1-6-3L] showing the micritic mud matrix and the grain components.

(e) Unstained thin-section [Sample No. 6-2-2L] showing the micritic mud matrix and the grain components; smaller forams [SM], algal fragments [A] and peloids [P]

(f) Unstained thin section [Sample No. 1-6-3L] the faecal pellets.

(g) Stained thin-section [Sample No. 2-2-1AL] all grain components and cement are red stained.

(h) Unstained thin section [Sample No. 1-12-1F] in high resolution micrograph showing the micrite mud matrix [MI], and the microsparite [MS].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microfacies such as the microfacies VIII and IX accompany with other microfacies such as the microfacies I, V, VI and VII. The upper part of the section is obviously a distribution of the microfacies VII.

The distribution of the microfacies in the section B is shown in the Figure 3.14b.

The distribution in the Section C

In this section, the microfacies I, V, VI, VIII and IX were studded out. The lower part of the section is an alternation of microfacies I and V. The middle part obviously encounter peloidal microfacies such as the microfacies VII and IX. It is well correlated with the section A.

The distribution of the microfacies in the section C is shown in the Figure 3.14c.

The distribution in the Section D

In this section, the microfacies I, V, VI and IX were studded out. The lower part of the section is an alternation of microfacies I, V, VI and IX. The middle part the muddy microfacies VI is distinctly observed. The upper part of the section also accompany the microfacies I, V, VI and IX like its lower part.

The distribution of the microfacies in the section D is shown in the Figure 3.14d.

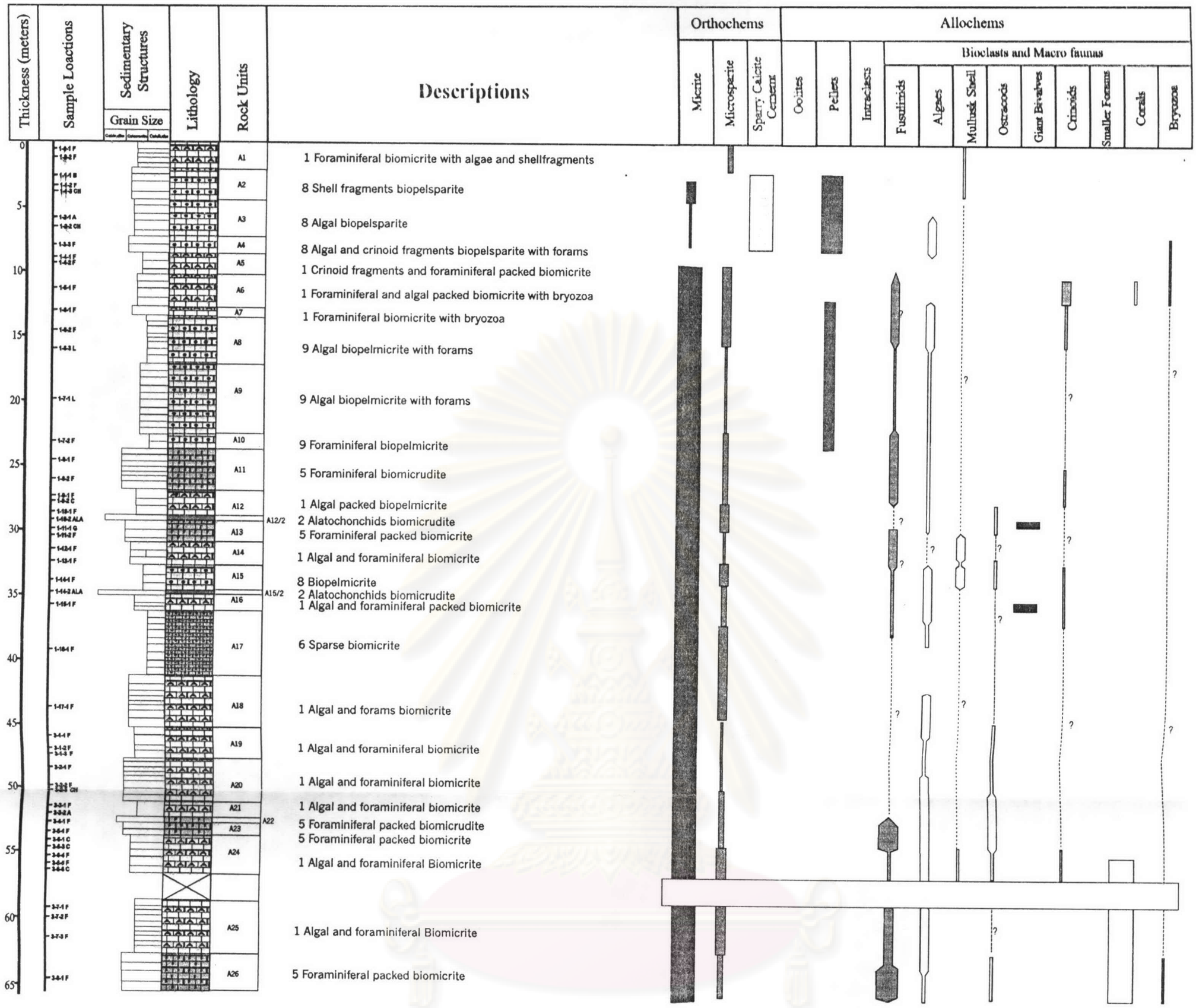
The distribution in the Section E

The microfacies I is distinctly observed throughout the section E with an insertion of the microfacies VIII in the lower part, and the microfacies II, IV and VI in the upper part.

The distribution of the microfacies in the section E is shown in the Figure 3.14e.

3.4 Fossils identification

A particular attempt has been made to identify some distinguishing fossils which may provide important stratigraphic or paleoenvironmental information in the carbonate rocks found in the study area.



MICROFACIES SYMBOLS

- **Microfacies I** Algal and a mixture of skeletal packed biomicrite
- **Microfacies II** Shell fragments biomicrudite
- **Microfacies III** Encrenite
- **Microfacies IV** Argillaceous sparse biomicrite
- **Microfacies V** Foraminiferal packed biomicrudite
- **Microfacies VI** Sparse biomicrite and fossiliferous micrite
- **Microfacies VII** Biosparite
- **Microfacies VIII** Biopelsparite
- **Microfacies IX** Biopelmicrite

DEGREE OF ABUNDANCE

RARE	Present to less than 5%
COMMON	5% to 30%
ABUNDANT	More than 30%

Figure 3.14(a) The petrographic characteristics of the section A at Ban Chon Muang in the southern part of the study area.

Thickness (meters) | Sample Loactions | Sedimentary Structures | Grain Size | Lithology | Rock Units | Descriptions

Orthochems: Micrite | Microsparite | Sparry Calcite Cement

Allochems: Oolites | Pellets | Intraclasts | Bioclasts and Macro faunas: Fusulinids | Smaller Forams | Mullusk Shell | Ostracods | Giant Bivalves | Crinoids | Algaes | Corals | Bryozoa

Rock Units	Descriptions
B1	6 Sparse biomicrite with crinoids
B2	6 Fossiliferous micrite with bioturbation
B3	7 Algal rounded biosparite with fusulinids and bryozoa
B4	7 Algal unsorted biosparite with fusulinids
B5	7 Unsorted biosparite with algal and fusulinids
B5/1	Alatoconcha shell fragment packed biomicrite
B6	1 Mixed skeletal packed biomicrite
B7	7 Unsorted biosparite with algal and fusulinids
B8	7 Algal biopelsparite with fusulinids
B9	6 Fossiliferous micrite with bioturbation
B10	1 Algal and foraminiferal packed biomicrite with dolomite replaced
B11	1 Locally dolomitic replaced algal packed biomicrite with fusulinids
B12	3 Crinoidal packed biomicrudite
B13	9 Biopelmicrite with algae and forams
B14	5 Foraminiferal packed biomicrudite
B15	8 Algal biopelsparrite
B16	8 Biopelsparrite with algae
B17	7 Foraminiferal unsorted biosparite
B18	6 Sparse biomicrite with algae
B19	9 Alagal biopelmicrite with smaller forams
B20	6 Sparse biomicrite with algae
B21	1 Algal and foraminiferal packed biomicrite
B22	1 Mixed skeletal packed biomicrite
B23	1 Algal packed biomicrite
B24	5 Foraminiferal packed biomicrudite with shell fragments
B24/1	2 Alatoconchid packed biomicrudite
B25	6 Mixed skeletal sparse biomicrite
B26	1 Algal packed biomicrudite with smaller forams
B27	5 Foraminiferal packed biomicrite
B28	5 Foraminiferal packed biomicrite
B29	2 Alatoconchids packed biomicrudite
B30	1 Algal packed biomicrite withfusulinids
B31	6 Sparse biomicrite with ostracods
B32	1 Foraminiferal and algal packed biomicrite
B33	6 Foraminiferal packed biomicrite
B34	6 Foraminiferal packed biomicrite
B35	1 Foraminiferal and algal packed biomicrite
B36	1 Algal packed biomicrite with forams and shell fragments
B37	1 Foraminiferal and algal packed biomicrudite
B38	1 Foraminiferal and algal packed biomicrite with rugose corals
B39	5 Foraminiferal packed biomicrudite with rugose corals
B40	5 Foraminiferal packed biomicrite with rugose corals
B41	1 Crinoidal and foraminiferal packed biomicrite
B42	6 Spase biomicrite with fusulinids and rugose corals
B43	6 Sparse biomicrite with algae
B44	5 Foraminiferal packed biomicrudite with abudant rugose corals
B45	5 Foraminiferal packed biomicrite

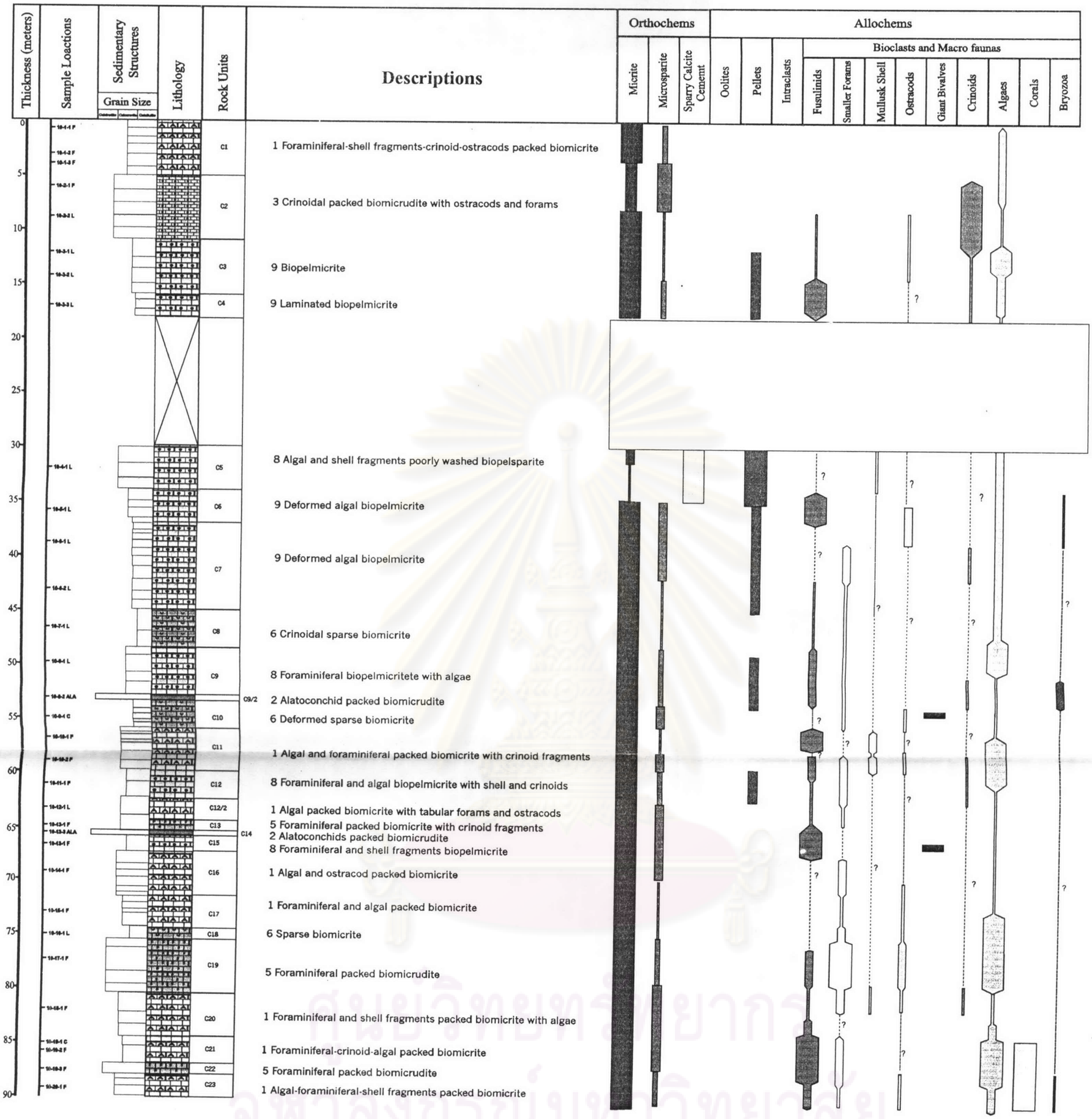
MICROFACIES SYMBOLS

- **Microfacies I** Algal and a mixture of skeletal packed biomicrite
- **Microfacies II** Shell fragments biomicrudite
- **Microfacies III** Encrenite
- **Microfacies IV** Argillaceous sparse biomicrite
- **Microfacies V** Foraminiferal packed biomicrudite
- **Microfacies VI** Sparse biomicrite and fossiliferous micrite
- **Microfacies VII** Biosparite
- **Microfacies VIII** Biopelsparite
- **Microfacies IX** Biopelmicrite

DEGREE OF ABUNDANCE

RARE	Present to less than 5%
COMMON	5% to 30%
ABUNDANT	More than 30%

Figure 3.14(b) The petrographic characteristics of the section B at Ban Chon Muang in the southern part of the study area.



MICROFACIES SYMBOLS

- **Microfacies I** Algal and a mixture of skeletal packed biomicrite
- **Microfacies II** Shell fragments biomicrudite
- **Microfacies III** Encrenite
- **Microfacies IV** Argillaceous sparse biomicrite
- **Microfacies V** Foraminiferal packed biomicrudite
- **Microfacies VI** Sparse biomicrite and fossiliferous micrite
- **Microfacies VII** Biosparite
- **Microfacies VIII** Biopelsparite
- **Microfacies IX** Biopelmicrite

DEGREE OF ABUNDANCE

RARE	Present to less than 5%
COMMON	5% to 30%
ABUNDANT	More than 30%

Figure 3.14(c) The petrographic characteristics of the section C in the eastern part of the study area.

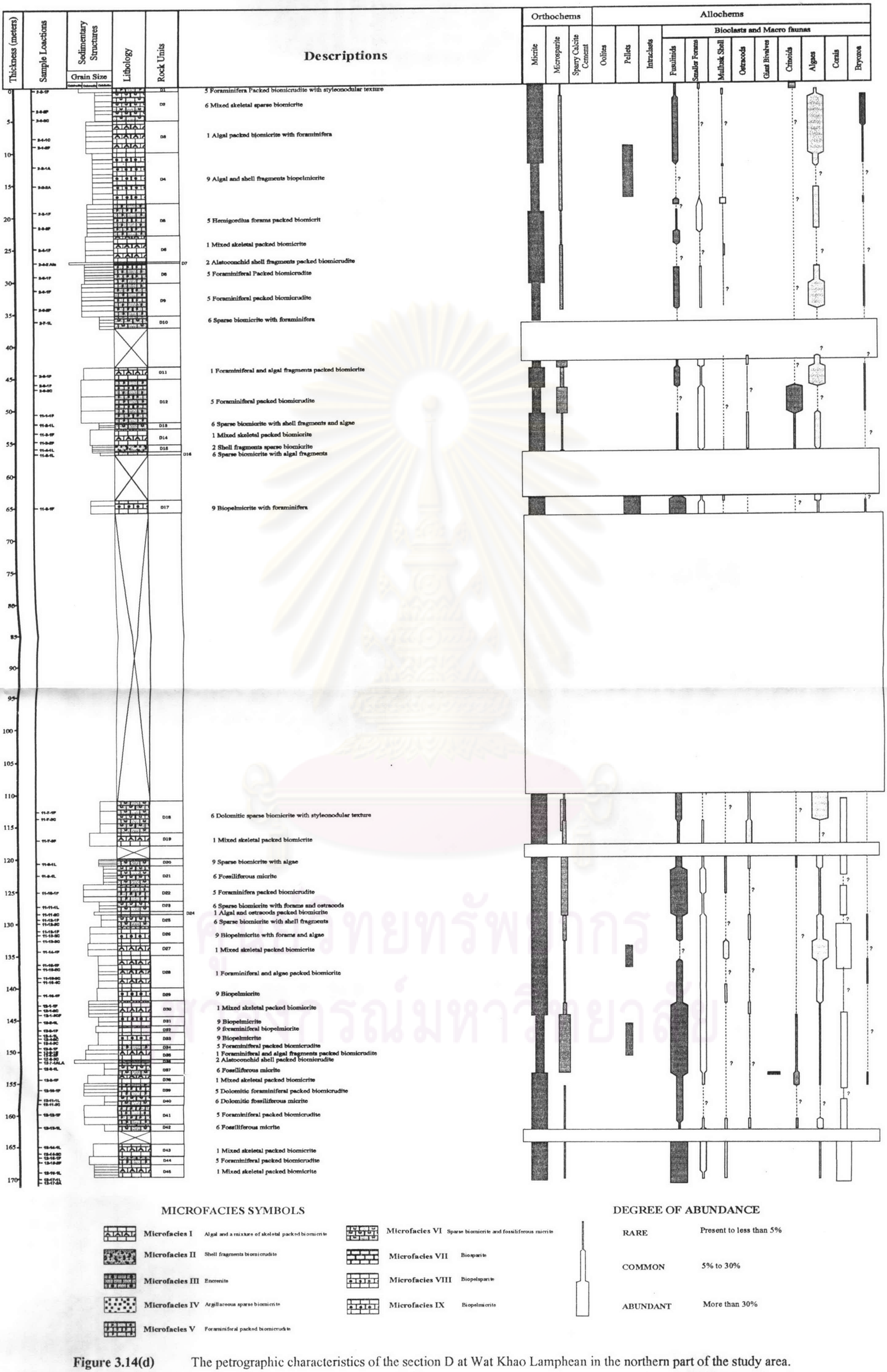
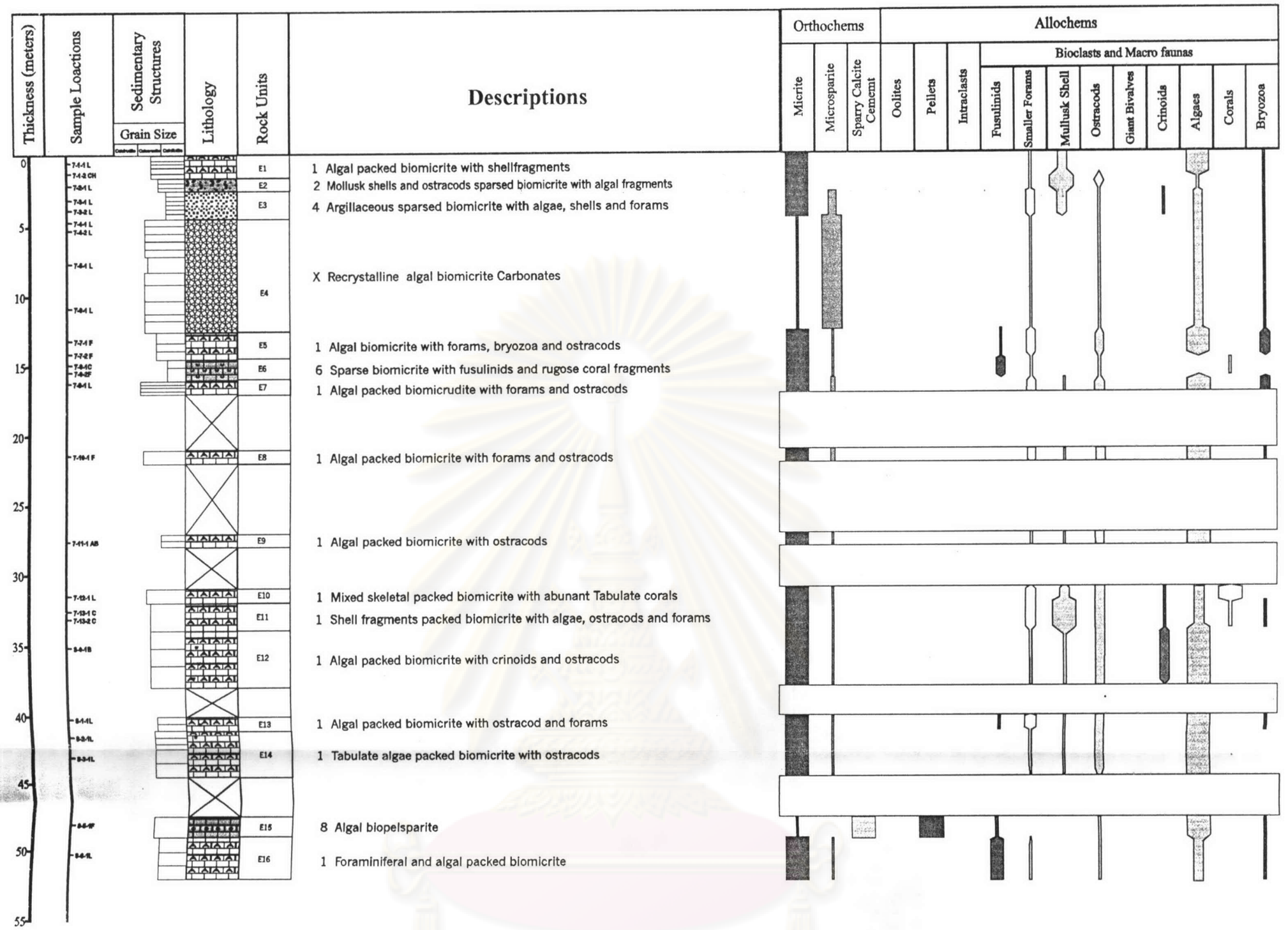


Figure 3.14(d) The petrographic characteristics of the section D at Wat Khao Lamphean in the northern part of the study area.



MICROFACIES SYMBOLS

- **Microfacies I** Algal and a mixture of skeletal packed biomicrite
- **Microfacies II** Shell fragments biomicrudite
- **Microfacies III** Encrenite
- **Microfacies IV** Argillaceous sparse biomicrite
- **Microfacies V** Foraminiferal packed biomicrudite
- **Microfacies VI** Sparse biomicrite and fossiliferous micrite
- **Microfacies VII** Biosparite
- **Microfacies VIII** Biopelsparite
- **Microfacies IX** Biopelmicrite
- **Microfacies X** Recrystalline limestone

DEGREE OF ABUNDANCE

NONE	None
RARE	Present to less than 5%
COMMON	5% to 30%
ABUNDANT	More than 30%

Figure 3.14(e) The petrographic characteristics of the section E at Ban Phu Noi in the western part of the study area.

Corals and fusulinids are, among other fossils, the most important index faunas for studying the Permian stratigraphy. They have been studied by many paleontologists in many countries for a long time not only because of their widespread distribution around the world, but also they developed many phylogenetic lineages with rapid evolution.

In Thailand, since, many paleontological works have conducted for the identification of the corals and fusulinids as well as their distribution in the Permian stratigraphy of Thailand, their well correlated biostratigraphic zonations have been remarkably established.

Thus, the present study also gives emphasis to corals and fusulinids because of their abundant occurrences in the study area and their biostratigraphic importance. Their characters and distribution will be presented in this chapter.

3.4.1 Fusulinids

Fusulinids are the single-cell invertebrate fossils. Their tests or shells are commonly fusiform or subcylindrical shapes coiling around an axis called axis of coiling, and are ranging from 1 mm. to 100 mm. in length. They belong to phylum Protozoa, Class Sarcodina, Order Foraminiferida. The fusulinaceans are commonly referred to as a superfamily of suborder Fusulinina which contains many hundreds species.

The fusulinids are extraordinarily profuse in many rock formations in Thailand and other countries. They are an exclusively late Paleozoic group of fossils beginning in late Mississippian Period and extinct at the end of Permian Period (Thompson, 1964).

The studying of fusulinids in Thailand started at 1939. Dunbar (in Heim and Hirschi, 1939) reported the occurrence of middle Permian fusulinids (*Neoschwagerinids* and *Schwagerinids*) in the limestone collected by Heim and Hirschi from Changwat Uttaradit, central-north Thailand.

Subsequently, fusulinids have been focused on by many researchers, which important studies particularly in the Central Thailand, namely, Toriyama and Suki (1959), Borax and Stewart (1963), Pitakpaivan (1966), Toriyama and Kanmera (1968), Toriyama et al. (1969), Ozawa (1970), Toriyama and Pitakpaivan (1973), Toriyama et al. (1974, 1975),

Titirananda (1976), Toriyama (1976), Toriyama and Kanmera (1977), Toriyama (1978), Toriyama and Kanmera (1979), Wielchosky and Young (1985), Altermann (1989), Chonglakmani and Fontaine (1992), Dawson and Racey (1993), Fontaine et al. (2000), Jaiboon (2001), and Fontaine et al. (2002).

From the investigation, the distinct Middle Permian fusuline belong to Family Neoschwagerinidae, Verbeekinidae and Schubertellidae were discovered in the study area.

Accordingly, five species of the fusulinids of five genera in four families are described in this work. The following are identified species.

Order FORAMINIFERIDA Eichwald, 1830

Suborder FUSULININA Wedekind, 1937

Superfamily FUSULINACEA von Moller, 1878

Family Neoschwagerinidae Dunbar and Condra, 1927.

Subfamily Neoschwagerininae Dunbar and Condra, 1927.

Genus *Colania* Lee, 1934.

- *Colania* sp. .....pl.1, figs.1-6.

Subfamily Sumatrininae Silvestri, 1933.

Genus *Sumatrina* Volz, 1904.

- *Sumatrina* sp. cf. *S. longissima* Deprat, ...pl.2, figs.1-4.

Family Schwagerinidae Dunbar and Henbest, 1930.

Subfamily Chusenellininae F.Kahler and G. Kahler, 1966.

Genus *Chusenella* Hsu, 1942

- *Chusenella* sp. .....pl.2, figs.5-7.

Family Verbeekinidae Staff and Wedekind, 1910.

Subfamily Verbeekininae, 1909.

Genus *Verbeekina* Staff, 1909.

- *Verbeekina* sp. .....pl.3, figs.1-3.

Family Schubertellidae Skiner, 1931.

Subfamily Boultoninae Skiner and Wilde, 1953.

Genus *Codonofusiella* Dunbar and Skiner 1937.

- *Codonofusiella* sp. .....pl.3, figs.4-7.

Therefore, the fusulinids in Khao Lamphean area which is characterized by abundant *Colania* sp. occurs together with *Sumatrina* sp. and *Verbeekina* sp. This fusulinids coteries are widely distributed in Central Thailand such as in Khoa I-mot (Ozawa, 1970), and Khao Wong (Jaiboon, 2001).

The age of *Colania* sp. is Capitanian (Ozawa, 1970), while *Sumatrina* cf. *longissima* Deprat is lower to upper Capitanian (Ozawa, 1970 and Jaiboon, 2001) and *Verbeekina* sp. yields long occurrence in Guadalupian.

Thus, the age of the carbonate rocks in the study area will be assigned in the Lower to Upper Capitanian according to the age range of the *Sumatrina* cf. *longissima*.

3.4.2 Corals

According to the characteristics of their mid-body cavities, coral have been classified in Phylum Coelenterata, subphylum Cnidaria, class Anthozoa, which have been found from Precambrian to present day.

The most abundant anthozoan in the Paleozoic were assigned to subclass Rugosa (rugose corals) and subclass Tabulata (tabulate corals). They construct their calcium carbonate exoskeletons, which called corallite, for supporting their bodies and are usually preserved as fossils. The rugose and tabulate corals are widely discovered in the Permian and Carboniferous rock formations in Thailand.

In Thailand, the coral fossils have been less interested than fusulinids. Minato (1944) reported the first discovery of coral fossils, namely, *Wentzellella subtimorica* in the Northern Thailand.

Sugiyama (1982) studied corals collected from Khao Khao, Changwat Saraburi, Central Thailand. They comprise *Chihsiaphullum kanmerai* Sugiyama, *Psuedohuangia* aff. *Aberrans* Fontaine, *Ipciphyllum saraburiense* Sugiyama, *Paraipciphyllum* aff. *hudsoni* Minato and Kato, and *Tetraporinus* aff. *huishuiensis* Yang.

After that, almost studies of coral fossils in Thailand particularly in the Permian Saraburi Group in Central Thailand were carried out by Dr. Henri Fontaine with his co-worker including the senior projects on his advised at the Department of Geology Chulalongkorn university.

Chonglakmani and Fontaine (1992) studied coral fossils and paleoenvironments of Carboniferous to Permian aged platform in Lam Narai – Phetchabun area. They concluded that the depositional environments were shallow marine and warm sea water and yield proliferation of coral and algal reef in some place. The coral are most favored in Murghabian (*Ipciphyllum, Wentzelloides, Psudohuangia* and *Sinopora*) with large fusulinids (*Verbeekina, Sumatrina,* and *Neoschwagerina*) and marine fossils belonging to Dzhulfian and Dorashamian have never been found, but plant fossils have been discovered that indicate the place of continental environment in Late Permian in this area.

Fontaine, Sattayarak and Suteethorn (1994) studied the assemblage and distribution of the Permian corals of Thailand and suggested 5 concepts about Permian corals in Thailand as follows:

(1) Faunas including *Kepingophyllidae*, indicate Asselian-Sakmarian

(2) Limestone rich in *Protomichelinia* commonly belonging to Yatashian-Bolorian, at least in the Leoi-Wang Saphung region.

(3) The *Chihsiaphyllum-Crassiparietiphyllum* assemblage corresponding to Kubergandian may be the base of Murghabian.

(4) The *Ipcipphyllum-Multimurinus* assemblage is common in Murghabian.

(5) *Waagenophyllum* was still present in Dzhulfian strata, but coral not on wane. Their decline was more obvious in Dorashamian limestone where Rugosa was represented only by rare small solitary corals without dissepiments. The coral records has showed that the number of species dropped more than during Midian and Dzhulfian.

Fontaine, Salayaponges, Tien and Vachard (2002) study fossil corals, forams and algae at Khao Tham Yai, Nam Nao area, Changwat Phetchabun. They reported various eight horizons containing different fossil assemblages of Murghabian to Upper Midian.

Jirawanwasana (1995) studied Permian corals and fusulinids from the eastern area of Changwat Leoi. The assemblages consist of corals, *Protomichelinia* (Yabe and Hayasaka), and fusulinids, *Schwagerina* sp. indicated the age of Lower Permian.

Madee (1997) studied fossils of coral collected from 3 localities in Changwat Nakhon Ratcha Sima, Lop Buri and Loei. At Ban Hua Krok, Amphoe Pakchong, Changwat Nakhon Ratcha Sima, he identified two species of Genus *Yatsengia.* At Khao Wong Chan Daeng, Amphoe Chi Badan, Changwat Lop Buri, he described a fossil assemblage consisting corals, namely, *Pseudozaphentoides mapingense* and *Caninophyllum* sp., and the fusulinids, namely, *Pseudoschwagerina* sp. and *Parafusulina* sp., indicating Sakmarian - lower Guadalupian age.

In additional, at Pha Doen, Changwat Loei, he reported the corals, namely, *Pseudozaphentoides mapingense* associated with fusulinids, namely, *Pseudoschwagerina* sp. and *Pseudofusulina* sp. which indicating Asselian to Sakmarian age.

Noipow (1999) studied corals found in limestone lens belonging to Pang Asok Formation (Saraburi Group) located in Muak Lek area, Central Thailand. The fossil

assemblage comprises *Multimurinus regularis* (Fontaine), *Yatsengia* sp., *Calophyllum* sp., *Lophophyllidium* sp. indicating the Roadian (lower of Middle Permian) age.

The massive rugose coral belong to the family Waagenophyllidae and family Wentzelellidae are most widely distributed in the study area.

In addition, the fasciculate Waagenophyllid and branching tabulate corals are scatter found in the section D and E.

Accordingly, the fossil corals of four genera in three families are studied and described in this work. The following are identified species.

Phylum COELENTERATA Frey et Leuckart, 1842

Subphylum CNIDARIA Hatschek,1888

Class ANTROZOA Ehrenberg,1834

Subclass RUGOSA Milne-Edwards et Haime, 1850

Order STAURIIDA Verrill, 1865

Suborder Lonsdaleiina Spasskiy, 1974

Family Waagenophyllidae Wang, 1950

Genus *Waagenophyllum* Hayasaka, 1924.

- *Waagenophyllum* sp. .....pl.4, figs.4-6.

Genus *Ipciphyllum* Hudson, 1958.

- *Ipciphyllum* sp..... pl.5, figs.1-4.

Family Wentzelellidae Hudson, 1958

Genus *Multimurinus* Fontaine, 1967.

- *Multimurinus* sp. .....pl.5, figs.5-8.

Subclass TABULATA Milne-Edwards et Haime, 1850

Order Auloporida, Sokolov, 1947

Superfamily Auloporicae Milne-Edwards et Haime, 1851

Family Sinoporidae Sololov, 1955

Genus *Sinopora* Sololov, 1955.

- *Sinopora* sp. ..... pl.4, figs.1-3.

Therefore, the corals in Khao Lamphean area are characterized by abundant of *Ipcipphyllum* sp. and *Multimurinus* sp. The *Ipcipphyllum- Multimurinus* assemblage is common in the Murghabian (Fontaine et al., 1994) which very widely discovered in the Central Thailand especially in Saraburi – Lop Buri area. But in the study area they are abundantly restricted only in the lower part of the section A, B, C and D. The *Sinopora* sp. commonly occurred in Permian age (Fontaine et al., 1994) and *Waagenophyllum* sp. are also discover in the Murghabian and they was still presented higher in Dzhulfian.

This coterie of corals is very resembled to the coral which was reported in Khao Tabong Nak (Fontaine et al., 1994), Khao Som Phot (Fontaine et al., 1999), Khao Tham Yai (Fontaine et al., 2002) and many localities in Lam Narai area (Chonglakmani and Fontaine, 1992) which is referred to the age of Late Murghabian (Upper Wordian).

3.4.3 Other associated faunas

Unless the fusulinid and corals, there are a lot of other faunas discovered in the study area, namely, algae, brachiopods, crinoids, and bryozoa, ostracods, gastropods and bivalves. It is interesting to study these faunas in the paleontological issue but the studying require a really experience including a lot reference.

Accordingly attempts is identifying some faunas which eminently occurred in the study area such as the algae and giant bivalves.

3.4.3.1 Algae

The algae were extraordinary discovered in the recent study area. It is quite be interesting because the algae is well indicating a paleoenvironments especially in the green algae.

In Thailand, the fossil algae are less studied than other faunas and very few Upper Paleozoic algae were reported.

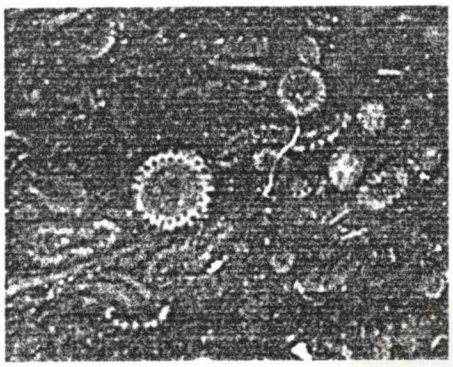
Endo (1969) describe 64 species in 33 genera of Permian algae associated with fusulinids from Khao Phlong Phrab, Changwat Saraburi, Central Thailand. The assemblage consists of coralline algae and dasycladacean.

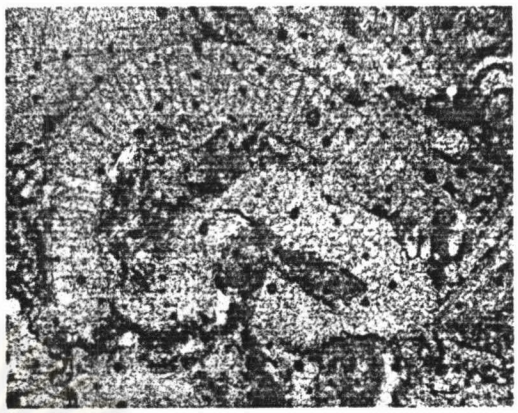
Fontaine et al., (2002a) summarized the Permian fossils collected from limestones of Nan area, northern Thailand and described the associated dasycladacean algae, i.e., *Anthracoporella spectabilis* Pia and *Mizzia velebitana* Schubert, which were found in many localities.

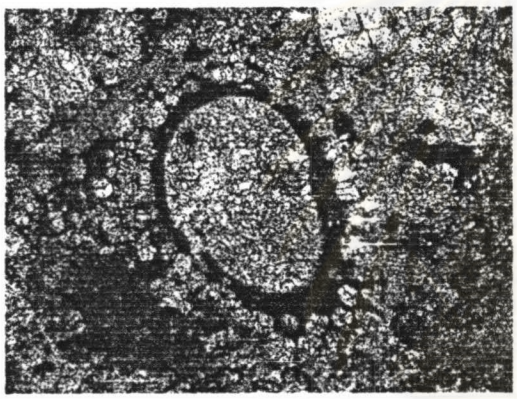
Fontaine et al., (2002b) study the Permian faunas of Khao Tham Yai area, Changwat Petchabun, northeastern Thailand. He found the associated dasycladacean algae, *Anthracoporella spectabilis* Pia in the lower horizon ,and *Mizzia* sp. in the upper horizon.

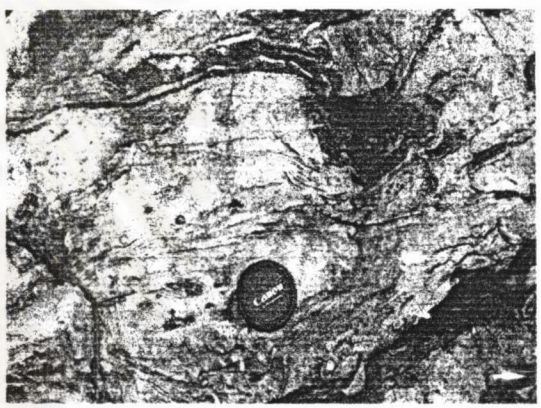
In the present study area, very abundant algal occurred especially in the section E and the upper part of section B, but they are almost fragmented and hard to identified. They seems to be the dasycladacean algae belong genus *Anthracoporella*? due to their round shaped in the cross section and numerous pores (see Figure 3.15) comparing with Genus *Mizzia*, common algae in Middle Permian of Thailand, which seems to be not discovered in the study area.

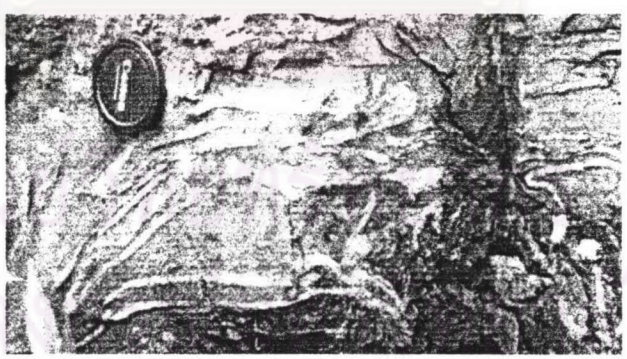
The algae in the Khao Lamphean are well correlated with the algae found in the lower horizons of Khao Tham Yai (Fontaine et al., 2002)











INITIAL MICROFACIES AND LITHOSTRATIGRAPHY OF PERMIAN CARBONATE SEDIMENTS IN THE VICINITY OF KHAO LAMPHEAN, AMPHOE NONG MUANG, CHANGWAT LOPBURI.

Figure 3.15 Other associated fossils. **1-3.** Dasycladacean algae, *Antracoporella?* sp. **4-5.** Giant bivalves Family Alatoconchidae.

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