CHAPTER IV

DEPOSITIONAL ENVIRONMENT AND ECONOMIC POTENTIAL OF DIATOMITE

A depositional environment is considered as being defined by a set of values of physical, chemical, and biological variable that correspond to a particular geomorphological unit. The philosophy of the present approach to environmental analysis is basically traditional in the sense that modern depositional environments provide the "key to the past" in examining stratigraphic successions preserved in the geological record. There is clearly a close connection between the environment of deposition and the nature of the sediment deposited. It is this records of past environmental conditions preserved in the sediments that provides the basic criteria for recognizing sedimentary environments in the stratigraphic column.

A sedimentary environment may be a site of erosion, non-deposition, or deposition. As a broad generalization, sub-aerial environments are typically erosional while sub-aqueous environments are mostly depositional areas. Some environments alternate through time between phases of erosion, equilibrium, and deposition. Among these, depositional environment is most important because there is a sedimentary products which can be used as record for environmental analysis.

"Sedimentary facies" is defined as any areally restricted part of a designated stratigraphic unit which exhibits characters significantly different from those of other parts of the unit. The rock record of any sedimentary environment, including both physical and organic characters, is designated by the term "lithofacies" (Moore, 1949). Facies are important because their recognition and analysis provide the basis for an environmental interpretation of stratigraphic units.

In order to recognize sedimentary facies in the geological record it is necessary to use multiple recognition criteria including

a) sedimentary structure

b) lithology

c) geometric relationships of rock units

d) character of biological content

Therefore, a facies should ideally be distinctive rock that forms under certain conditions of sedimentation, reflecting a particular process or environment. Facies may be subdivided into sub-facies or grouped into facies associations or assemblages.

For environmental reconstruction, there is a need of features that were produced at the time of deposition. However, diagenesis is also important for the study of rock history but it tends to obliterate the primary features, which can be helpful in reconstruction of the environment of deposition of a given rock. In environmental reconstruction the approach should be pluralistic. Several independent parameters should be studied before many final picture of the depositional environment is made. Environmental reconstruction is more certain if several in dependent parameters point to the same conclusion.

Facies analysis is partly controlled by depositional environment and partly dependent on tectonics. The relative importance of these controlling factors varies between different environments. In this study, an attempt has been made to reconstruct the depositional history of sedimentary sequences within the Mae Tha Sub-basin in the right of depositional environment and tectonics concerned.

4.1 Lithofacies Analysis

4.1.1 Lithofacies Analysis of Mae Sot formation

In this study the sequence of "Mae Sot" formation is best represented in drill-hole No. D 10. Approximately 280 m. thick of the uppermost part of Mae Sot formation in the study area is employed in the facies analysis and depositional environment reconstruction.

The general characteristics of lithofacies of the Mae Sot formation is mainly repeated cycles of greenish grey, laminated fine-grained clastic sediments associated with thin bands of coal and oil shale. At least 3 cycles of these repeated sequence have been recognized. It is noted that some part of the greenish grey laminated fine-grained clastic sediment is interbedded with thin layer of medium-grained clastic sediment. Some fish fossils are found associated in this lithofacies, notably scales and fragments of operculum of Cypriniforms , and serrated spine of Siluriforms . The overall geometry of the lithofacies is tabular. The lithofacies analysis of the Mae Sot formation is illustrated in Fig. 4.1.1.

4.1.2 Lithofacies Analysis of Ko Kha formation

The sequence of "Ko Kha" formation is generally characterized by the interbedding of diatomaceous clay of varying clay content and diatomite. They are found in three separated areas of various thickness ranging from 15-35 m. The boundary between Mae Sot formation and "Ko Kha" formation is transitional without any unconformity.

The diatomaceous sequence is mainly composed of frustules of *Melosira granulata* (EHR.) RALFS, and rarely *Navicula spp.* and *Fragilaria spp.* It is inferred that the deposit was accumulated under the particular condition favorable for *Melosira granulata* (EHR.) RALFS.

The diatomaceous claystone in this lithofacies frequently shows lamination (Fig. 4.1.2a). It is believed that the three separated diatomite deposits in the area under the present investigation were continuous during the time of deposition. The original geometry of this lithofacies is therefore concluded to be lentiform. The lithofacies analysis of the "Ko Kha" formation is illustrated in Fig. 4.1.2b.

4.1.3 Lithofacies Analysis of Mae Taeng formation

The general characteristics of the Mae Taeng Formation is mainly a sequence unconsolidated sediments i.e. gravel, sand, silt, clay with some limestone fragments. The sequence shows maximum thickness of approximately 170 m. in the central part of the area and thinning out on both eastern and western parts. The sedimentary succession shows a series of fining upward sequences from sand to clay in the lower part

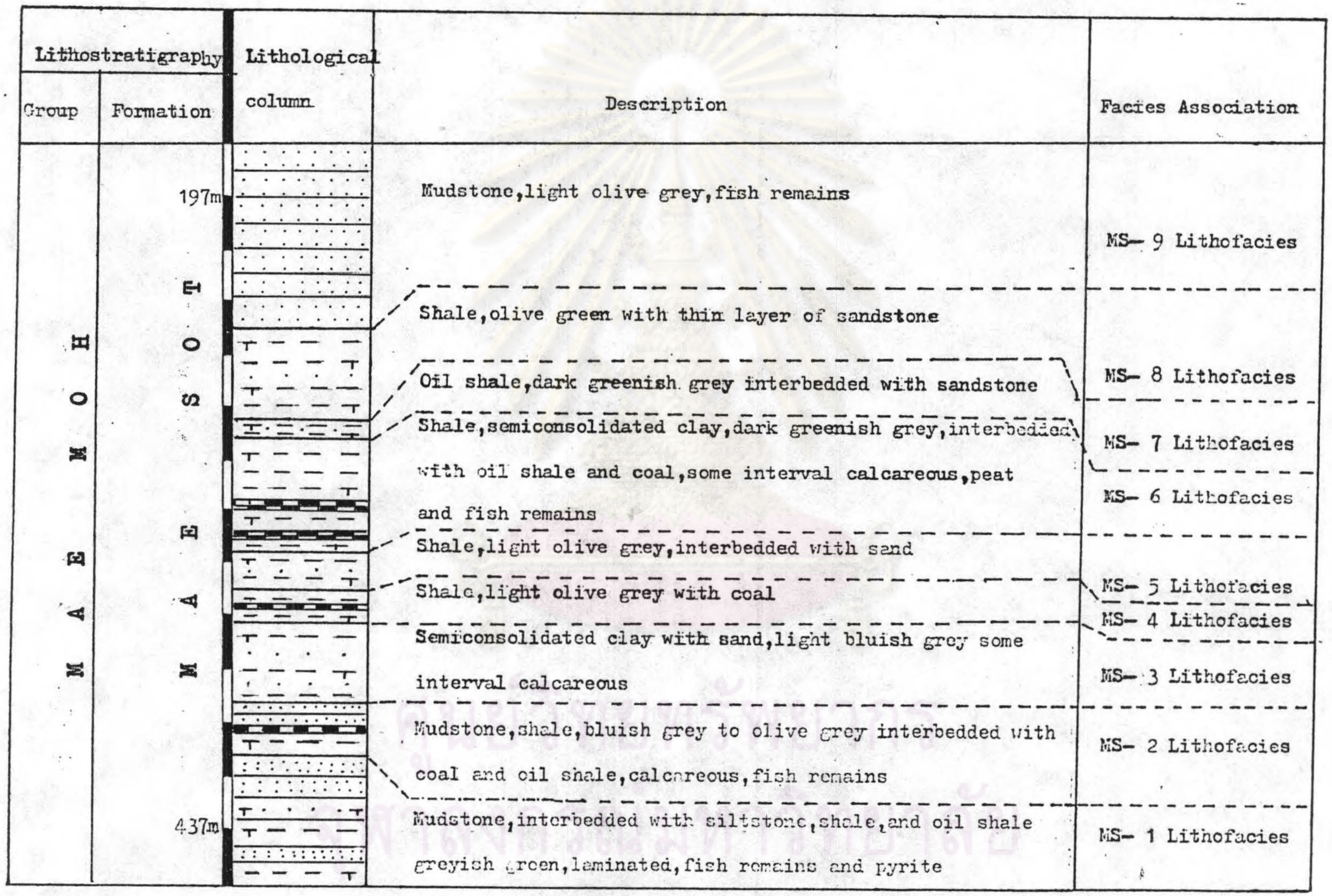


Fig. 4.1.1 Lithofacies analysis of the Mae Sot formation

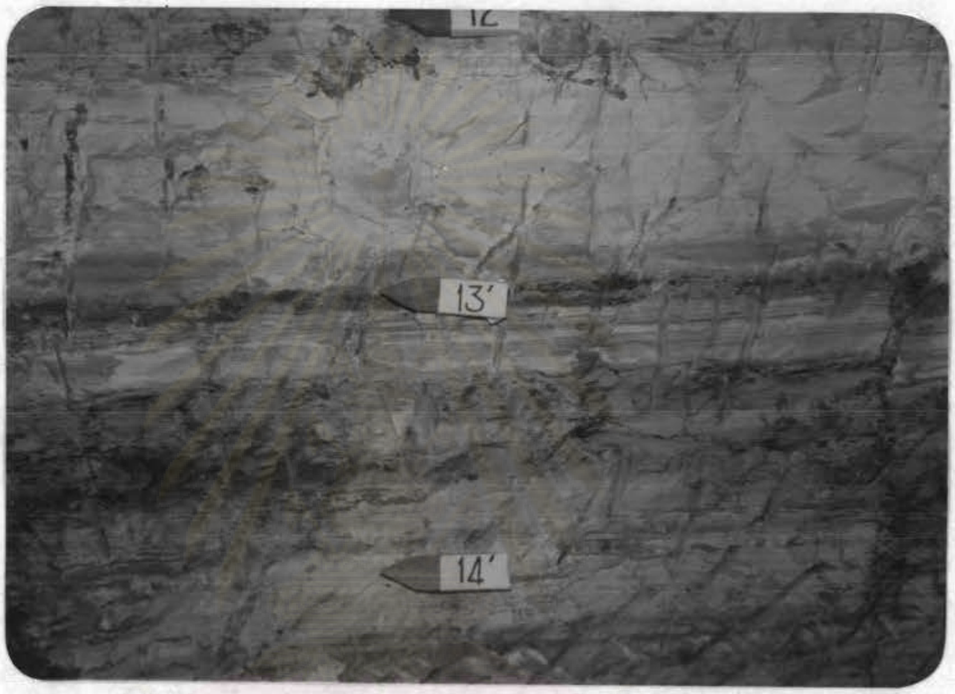


Fig. 4.1.2a Showing the lamination of diatomaceous claystone in prospecting shaft no. 2 (S.2)

Lithostratigrapy		Lithologic column	Description	Lithofacies
Group	Formation			
M A E M O H	K O K H A 15 m 25 m 35 m		Diatomite and diatomaceous clay with Fe. oxide, semi to consolidated, massive to laminated, dip 0-5° colour varied from white, very pale orange, moderate yellowish brown to greyish orang pink	K O K H A LITHOFACIES

Fig.4.1.2b Lithofacies analysis of the Ko Kha formation

and gravel to clay in the upper part. The lithology of the gravel is mainly quartzite and limestone. The overall geometry of this lithofacies is lens -shaped. The lithofacies analysis of the Mae Taeng formation is illustrated in Fig. 4.1.3.

4.1.4 Lithofacies Analysis of "Top Soil" formation

The sediments are characterized by mixtures of lateritic, sandy, some quartz pebbly, limestone pebbly, clayey materials of 1-5 m. thick. This lithofacies covers extensively throughout the study area. The area of Mae Tha Sub-basin has eventually been covered by the thin veneer of this lithofacies of varying thickness. The lithofacies analysis of the "Top Soil" formation is illustrated in Fig. 4.1.4.

4.2 Reconstruction of Depositional Environment

The facies association of the upper 280 m. of Mae Sot Formation is consisting of 9 lithofacies. With regards to the depositional environment of these lithofacies, it is proposed that the laminated fine-grained clastic association with or without thin sand layer represent the lacustrine sediments of mainly central lake sub-facies and some marginal lake sub-facies of clastic lake deposits (Kukal, 1971; Picard and Hight, 1972; Reeineck and Singh, 1973; Selley, 1982; Davis, 1983). The association of thin band of coal and oil shale is believed to represent the coal swamp deposits associated with lacustrine environment (Francis, 1961; Landis and Averitt, 1978; Tucker, 1981).

It is significant to note that each cycles of lake and coal swamp deposits of approximately 40 m. thick was deposited in the subsiding basin presumably reactivated by block-faulting. Therefore, the uppermost 280 m. thick of Mae Sot formation was deposited in the alternate environments of in-land fresh-water lake and coal swamp controlled by intermittent subsidence under the influence of block-faulting. The environmental interpretation of facies association of Mae Sot formation are summarized and presented in Fig. 4.2.1

With respect to the depositional environment of Ko Kha lithofacies, the interpretation is essentially based on the paleoecological

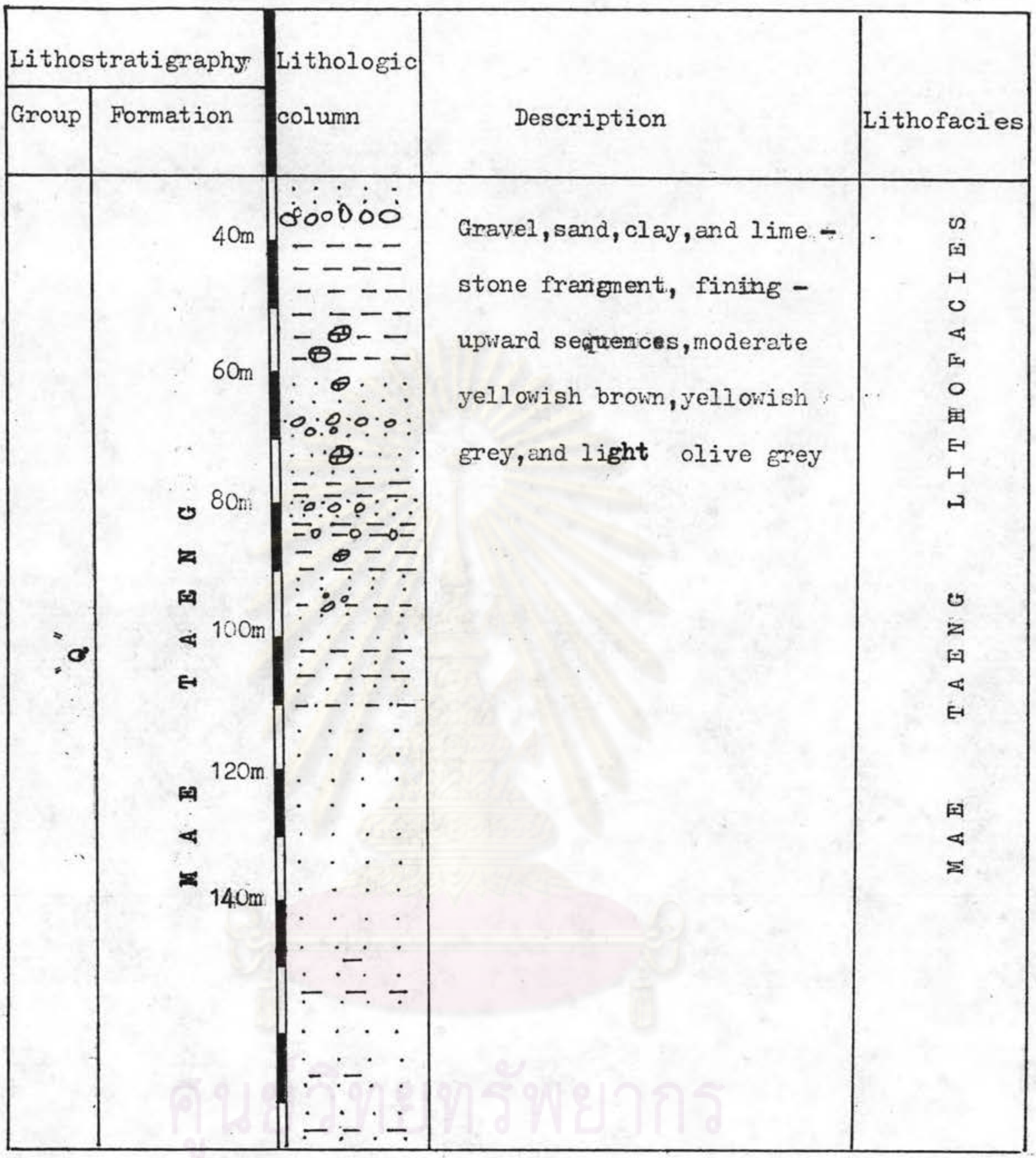


Fig. 4.1.3 Lithofacies analysis of the Mae Taeng formation

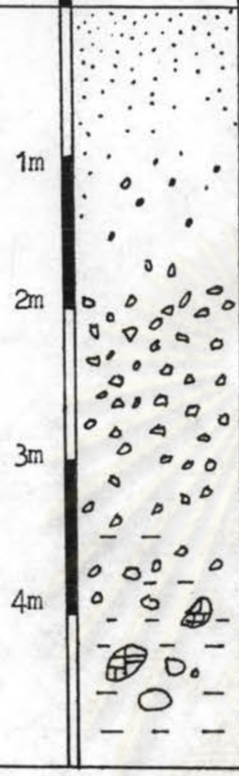
Lithostratigrapy		Lithologic column	Description	Lithofacies
Group	Formation			
"Q"	"TOP SOIL"		Top soil, laterite, quartz grains Fe oxide grains, (size: coarse sand to gravel, shape: angular to subangular) and clay with limestone fragments in some area colour varied from moderate yellowish brown, pale orang to dark yellowish orange	TOP SOIL LITHOFACIES

Fig.4.1.4 Lithofacies analysis of the Top Soil formation

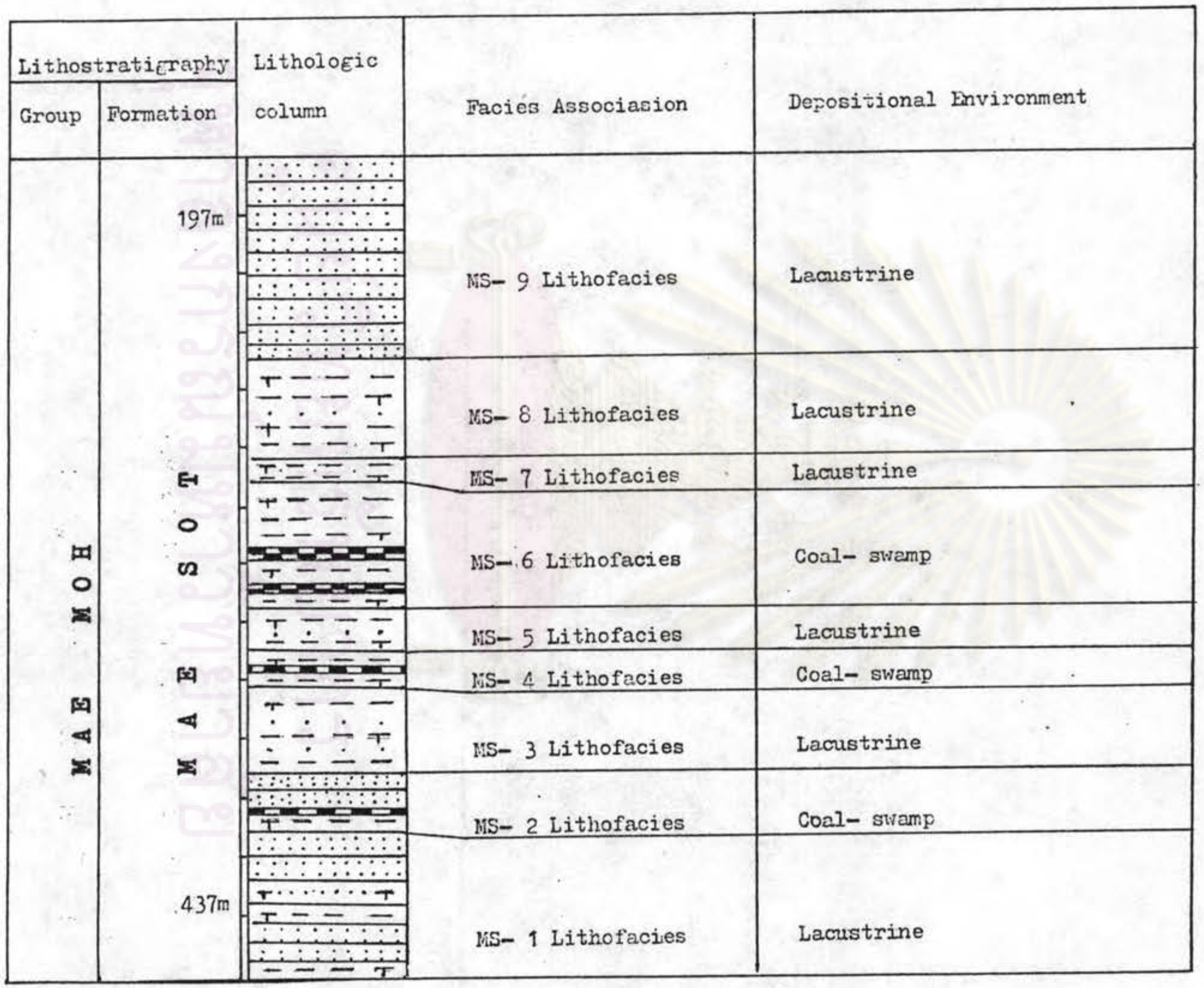


Fig. 4.2.1 The depositional environment of facies association of Mae Sot formation

condition of diatoms found supplemented by the lithofacies analysis. Although diatom is found in a wide range of climates, the very thick-wall form with very coarse pore appear to be the characteristics of warm climate especially sub-tropical to tropical (Bunopas, 1981, p.355). It is a fresh-water planktonic species, and prefers eutrophic, stagnant lake deposit, warm-water, often found in cool temperate regions during the summer months(Hutchinson, et sl., 1956; Akutsu, 1972). Besides, this planktonic diatoms live in the zone below the surface of lake water down to the depth of 35 m. in order to utilize the sunlight for photosynthesis (Kadey, 1975, p.609). The chemistry of lake water which is most favorable for the organic production of diatoms is as follows; dissolved silica content of 5-25 mg./l.,which is a high concentrate (Kilham, 1971 in Bunopas, 1981, p. 355) alkalinity 1-10 meq./l., which is relatively dilute (Richardson, 1978 in Bunopas, p. 355) the presence of SO_2 in suitable content, abundant nutrients, i.e. phosphate, nitrates, etc., free of toxic substance (Kukal, 1971). Besides, the lake must be of large shallow basins (preferrably 35 m. or less in depth) and low clastic sediments input (Kadey, 1975).

The lake in the southeastern part of Lampang Basin was eutrophic in late Tertiary. The lake had a high production of plankton and their waters were rich in organic matter. The regime of lakes was influenced by the bed-rock in the bottom and the vicinity of the lake. In the southeastern part of Lampang Basin, lake was developed on porous sediments rich in organic matter or on soils of Lampang, Volcanic and Ratburi Groups, which were easily leached and enriched the lake water with organic matter. Limnic diatomaceous sediments are, on the whole, confined to a minor part of lake, but occur in a great abundance in them. The deposition of diatomaceous sediments in lake requires the following condition to be fulfilled:

a) Suitable conditions for the growth of diatoms.

b) Absence of disturbing and masking components

A low temperature of water complies with the first requirement, because it supports the production of diatoms and restrains the growth of bacteria. Therefore, lake with diatomaceous sediment occurs mainly in higher geographical latitude or higher altitudes above sea level. Mountain lake with cool clear water furnishes an ideal environment for the growth and deposition of diatoms. Diatoms can originate already at the presence of 1-5 ppm. of dissolved SiO_2 and their maximum development occurs at 5-20 ppm. of SiO_2 in water (Fig. 4.2.2). Provided that all the above mentioned conditions are fullfilled, a continuous carpet of diatom test is formed on the surface of some lake during summer. After attaining thickness of a few millimetres the carpet sinks. In this way layer of diatomaceous sediments up to 35 m. thick can originate.

The very common association of deposits of siliceous organisms, particularly diatoms, with volcanic ash has been noted by many authors (Bramlette, 1946, p.39). This association has led Taliaferro (1933, p.54) and Bramlette(1946, p. 41) among others to suggest that much of the silica and perhaps much of the other nutrients utilized by the organisms may have been released by the weathering of volcanic ash. Trask (1932, p. 237) emphasized the necessity of adequate nitrate for high organic acitivity, as in areas of turbulence or upwelling (Harvey, 1955, p. 99-101). Much of nitrate and phosphate must thus be available through the cycle of renewal and upwelling, but unusual supplies of silica from the volcanics might be critical for long-continued extraction of silica that is being permanently removed as the opaline tests of diatoms (Cressman, 1962, p. 17). In addition to extracting soluble silica from water, some diatoms are capable of obtaining silica directly from aluminosilicate mineral (Murray and Irvine, 1889, Hutchinson, 1957, p.790).

The major source of dissolved silica in the paleolake is believed to be contributed from the weathering of Permo-Triassic rhyolite, tuff, agglomerate in the eastern part of Lampang Basin. The X-ray diffractograms show the pattern of montmorillonite, kaolinite and illite occurring as impurities. These clay minerals mingle throughout the entire thickness of diatomite beds during the deposition. Ion-exchange reactions are most important after initial weathering has formed clay minerals. Berner (1971, p.173) has emphasized the

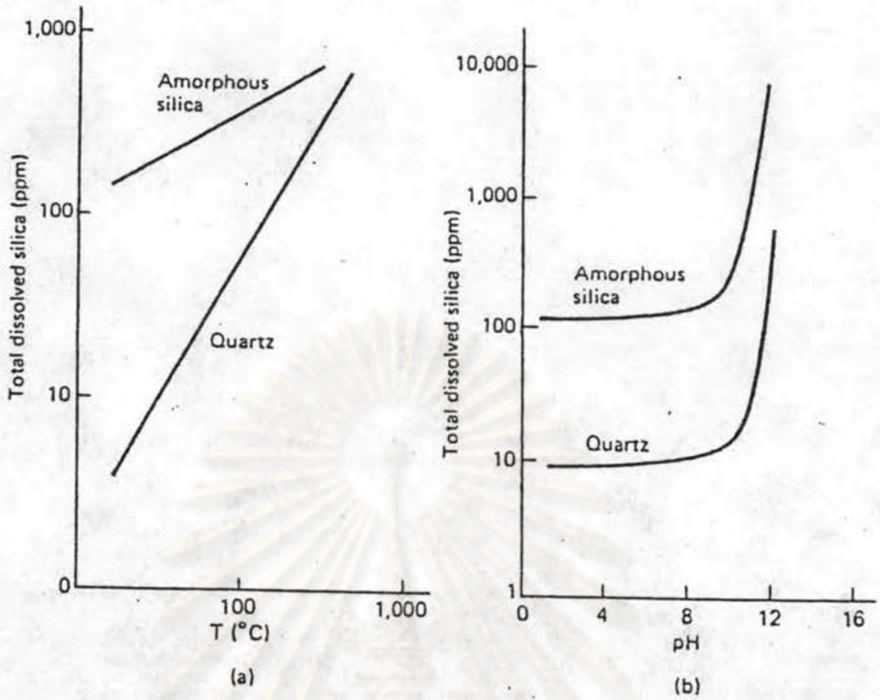


Figure 4.2.2 Solubility of silica as a function of temperature and pH: (a) solubility as a function of temperature at pH < 7; (b) solubility as a function of pH at 25°C. [(a) After Siever. © 1962 by the University of Chicago. All rights reserved. (b) After *Evolution of Sedimentary Rocks* by Garrels and Mackenzie, p. 149. Used by permission of W. W. Norton & Company. Copyright © 1971 by W. W. Norton & Company, Inc. From Krauskopf, K., 1967, *Introduction to Geochemistry*, New York: McGraw-Hill, Inc.]

importance of water flow as a controlling factor in weathering. At moderate flow rates, albite is changed to kaolinite. When flow rates are very slow, material is removed very slowly from the weathering pile and, provided Mg^{2+} is available, the product is montmorillonite. Berner (1971) pointed out that, in addition to water flow rate, the other two major factors determining the nature of the clays found in a particular area are the mineralogy of the rock being weathered and the chemical composition of the weathering solution. Feldspars tend to change to kaolinite, whereas ferromagnesium minerals provide magnesium for the formation of montmorillonite. Biotite and muscovite often weather to illite. With increasing activity (concentration) of dissolved silica, kaolinite is more stable than gibbsite, and montmorillonite is more stable than kaolinite. At high silica activities amorphous SiO_2 precipitates. Increasing activities for Na^+, Ca^{2+}, and K^+ along with decreasing hydrogen ion activity (higher pH) make montmorillonite, illite and the feldspar stable relative to kaolinite. These general relationships agree with those found in nature.

Lacustrine diatomaceous sediments in the study area show the following composition: diatom test, plant remains, available amount of coarse (sand and silty) terrigenous detritus and clay minerals. Some uppermost parts of diatomaceous sediments of Ko Kha formation which lie unconformable under the unconsolidated sediment of Mae Taeng formation also contain gypsum crystals (selenite), which originated by the oxidation of pyrite and do not indicate an increased salinity, as could be erroneously interpreted. The depositional environment of Ko Kha lithofacies is presented in Fig. 4.2.3.

After the deposition of diatomite and diatomaceous clay, it is believed that the Mae Tha paleolake was eventually uplifted during Pleistocene tectonism. The diatomaceous deposits in Mae Tha Sub-basin was accordingly exposed sub-aerially and was subjected to partial erosion particularly in the central part by fluvial process and followed by the deposition of Quaternary deposits of "Mae Taeng" and "Top Soil" formations. The characteristics of Mae Taeng formation which is mainly composed of

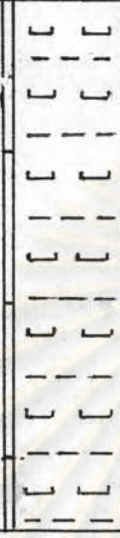
Lithostratigraphy		Litho-logic column	Litho-facies	Depositional Environment
Group	Formation			
MAE MOH	KO KHA	15m 25m 35m 	KO KHA LITHOFACIES	Lacustrine, fresh- water, cool clear water, large basin, high dissolved silica ,and stagnant water

Fig.4.2.3 The depositional environment of Ko Kha lithofacies

gravel, sand, and clay of varying proportion arranged in a series of fining upward cycles. The lithofacies of Mae Taeng formation strongly suggest the deposition under the fluvial environment. This lithofacies shows the thickest zone in the central part of the study area elongated approximately N/S direction. This indicates the maximum fluvial processes in the central part of the study area which had a tendency to erode the friable diatomite deposits of the underlying Ko Kha formation. At present, the diatomite deposits which were continuous during the time of deposition are separated by the unconsolidated fluvial sediments of Mae Taeng formation. The top part of the Quaternary deposits is the thin veneer of sediments of the "Top Soil" formation characterized by laterite, lateritic soil, angular to subangular grains of quartz and iron oxide, coarse sand to gravel. The depositional environment of Quaternary facies association is presented in Fig. 4.2.4.

In conclusion, the history of deposition of sediments in the Mae Tha Sub-basin including related tectonic activity is presented as depositional model in the light of lithofacies analysis and tectonism in Table 4.2.1 and Fig. 4.2.5.

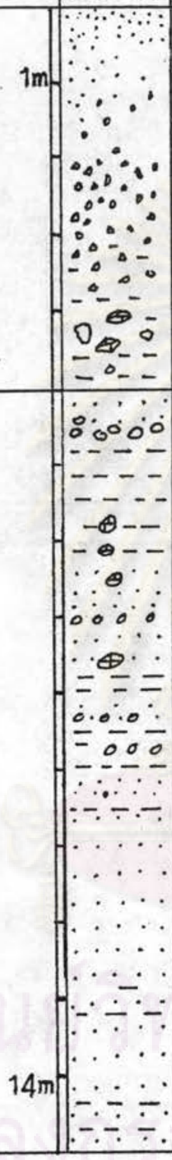
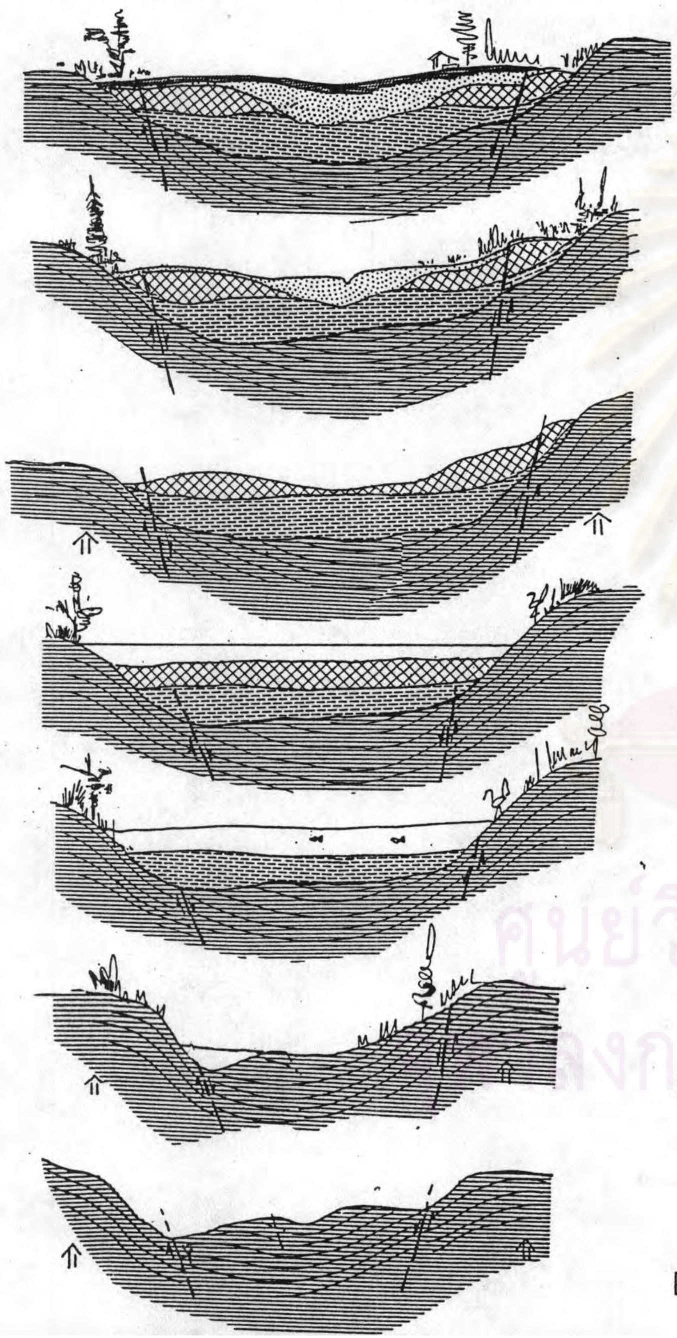
Lithostratigraphy		Litho-logic-column	Facies associ-ation	Depositional Environment
Group	Formation			
"Q"	"TOP SOIL"		TOP SOIL LITHOFACIES	Fluvial environment , weathering, erosion, and deposition in Holocene Epoch
	MAE TAENG		MAE TAENG LITHOFACIES	Fluvial environment

Fig.4.2.4 The deposional environment of Quaternary facies association

Facies Association					Environmental Interpretation	Tectonism
Lithofacies	Lithology	Geometry	Sed.Structure	Fossils		
Quaternary Facies Association	Top soil, laterite, gravel,sand,clay	Lense-shaped	Fining upward sequences	-	weathering, erosion,and deposition Fluvial	Uplift, bending of N/S faults
Ko Kha Lithofacies	Diatomite interbedded with diatomaceous clay	Lentiform	Massive to lamination dip 0 -5	*Melosira granurata*, *Navicula* spp, *Fragilaria* spp.	Freshwater, eutrophic, stagnant lake deposit.	
Mae Sot Facies Association: MS- 9 MS- 8 MS- 7 MS- 6 MS- 5 MS- 4 MS- 3 MS- 2 MS- 1	Mudstone, claystone ,shale, oilshale, coal ,and some sandstone,siltstone interbedded,some calcareous, pyrite	Tabular-shaped	Lamination, graded-bedding massive, many slip cleavage	Fish remains Cypriniforms, Siluriforms, and plant remains	Coal swamp deposits associated with lacustrine environment at least 3 cycles	Extensional faults horsts & grabens, little uplift

Table 4.2.1 Summary of depositional environment,lithofacies,and tectonism in the study area

Fig 4.2.5 Showing the history of deposition model



7 (Holocene) The area of Mae Tha Sub-basin had been covered by "Top Soil" formation

6 Later, Ko Kha formation was subject to partial erosion by fluvial action and subsequencely infilled with fluvial sediment of Mae Taeng Formation

5 (Pleistocene) Faulting and uplift, Ko Kha formation exposed sub-aerially

4 (Upper Tertiary to Lower Pleistocene) Lacustrine environment continuous and Ko Kha formation deposited

3 (Middle to Upper Tertiary) Lacustrine developed and Mae Sot formation deposited

2 (Lower to Middle Tertiary) Tectonic uplifting, Extensional faults, horsts and grabens

1 (Late Cretaceous to Lower Tertiary) Tectonic uplifting and developed N/S trending normal fault

4.3 Palaeontology and Ecology of Diatoms in the Study Area

4.3.1 Scanning Electron Microscopic Study of the Surface Structure of Diatoms

The scanning electron microscopy is a technique of X-ray analysis. The beam of electrons from a source, a tungsten filament in a high voltage field, is swept on to the sample surface by a scanning coil similar to the television scene. A sample holder was painted with the conductive silver glue as a thin layer and a dry crushed sample was strewed on the glue. After it was dried in the air, the sample holder was placed in the fine-coat machine. The coating chamber was evacuated and the voltage of 5 kilovolts was applied. The gold particles from the coil in the coating chamber was then dispersed to coat the sample surface on the holder as a thin film. The instrument was turned off and the air was automatically released into the chamber. The coated sample holder was inserted into the sample position of the scanning electron microscope. The chamber was evacuated and the high voltage of 20 kv was applied. The coarse and fine buttons of the electron microscope were adjusted until the clear-cut image on the oscilloscope was achieved at the required magnification. The general structure of diatom is presented in Fig. 4.3.1 .

4.3.2 Palaeontology

By means of electron microscope scanning a frustules of diatoms is mainly composed of *Melosira granulata* (EHR.)RALFS. and rarely *Navicula spp.* and *Fragilaria spp.*

Description of Species

Genus Melosira AGARDH, 1824

Melosira granulata (EHR.)RALFS, 1861

Melosira granulata (EHR.)RALFS.

Hustedt, 1930, p.248-252, fig. 104.

Size range of measured specimens: Height of valves 10 to 20µ, diameter of valves 6 to 30 µ.Ratio of height to diameter, 0.4 to 2.3.

Remarks: - Hustedt's description and illustrations of

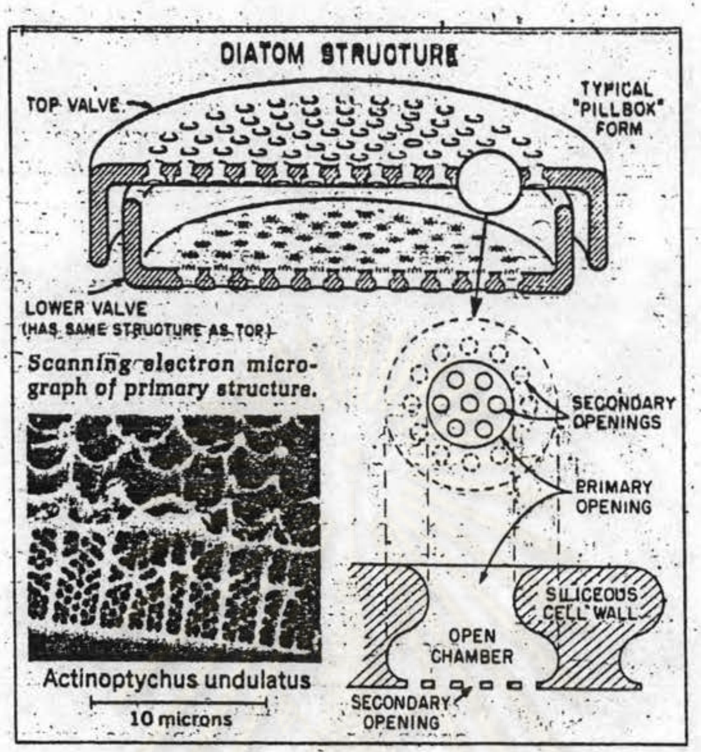
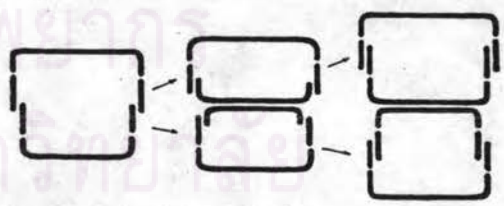


Fig.4.3.1 The general structure of diatom

. Diagrammatic section of a typical diatom frustule.

V_1, V_2 = Valves
B_1, B_2 = Connecting bands
$V_1 + B_1$ = Epitheca
$V_2 + B_2$ = Hypotheca
$B_1 + B_2$ = Girdle
R = Raphe



. Diagram indicating the mode of division of a diatom cell showing the formation of new silica valves.

Melosira granulata (EHR.) RALFS. indicate that this species has 8-9 pore-lines in 10 μ on the valve mantle which run obliquely or parallel to pervalvar axis, and the species has long·spines (Borsten) on the valve margin.

Most of the specimens studied are separated to valves or fragments and have not formed filaments of valves. Valve mantle covered with pore -lines 6-7 in 10 μ, pore 6 in 10 μ , and pore-line run parallel to pervalvar axis, and some valves have prominent spines.

In the specimens studied, the number of pore-lines and pores in 10 μ are less than the description, but prominent spines characterize this species.

The ratio of height to diameter of valves varies from 15 μ: 30 μ = 0.5 to 19 μ : 8 μ = 2.3, namely, drum shaped valves to cylindrical valves, but there are no distinct relations between height and diameter or ratio of height to diameter. Then, the specimens are all identified to the species.

The examination by electron microscope (Superscope, Japan Electron Co., resolution 4 A°) shows that sieve membranes are not preserved except for its trace barely left along the edge of pores (Akutsu, 1972). From the scanning electron microscope , the surface feature of diatoms in the study area are illustrated in Figs.4.3.2a,b.c.d

4.3.3 Ecology

From the abundant occurrences of *Melosira granulata* (EHR.) RALFS. It is inferred that the deposit was accumulated under the particular condition favorable for *Melosira granulata* (EHR.) RALFS.

Melosira granulata (EHR.) RALFS. is a freshwater planktonic species, and prefer eutrophic, warm water; often found in cool temperate regions during the summer months (Hutchinson, et al., 1956).

Foged (1954), on the basis of studies made for those species in lakes of Denmark, gave the ecological preference of *Melosira granulata* as follows: in halobion spectra it is indifferent meaning freshwater proper; in pH spectra alkaliphilous forms, appearing at a

Fig. 4.3.2a Showing cylindrical shape of diatoms *(Melosira granulata)* from quarry near prospecting shaft no. 1.

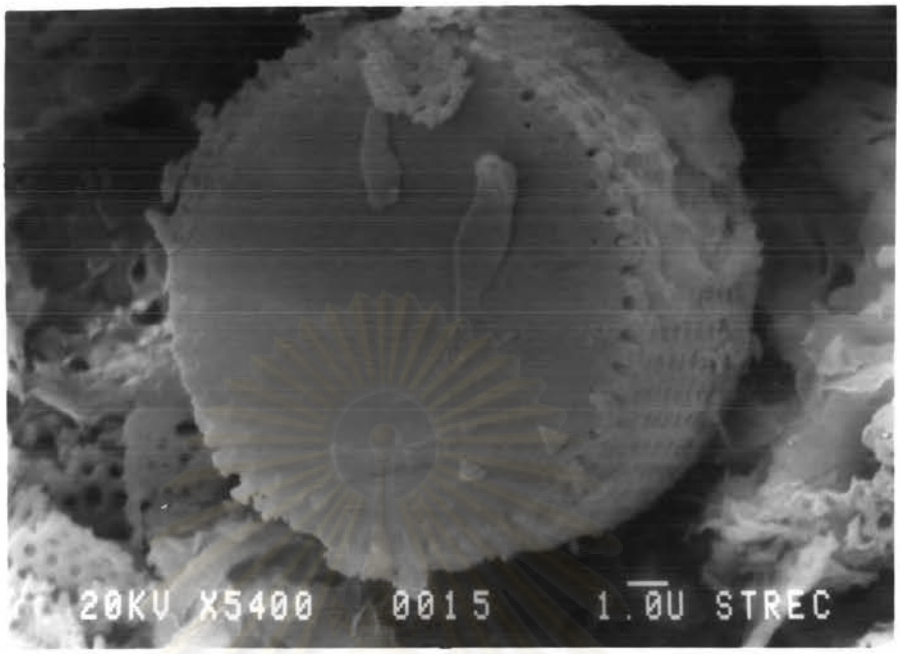


Fig. 4.3.2b Showing drum shape of *Melosira granulata* from prospecting shaft no. 2 at level 10'.

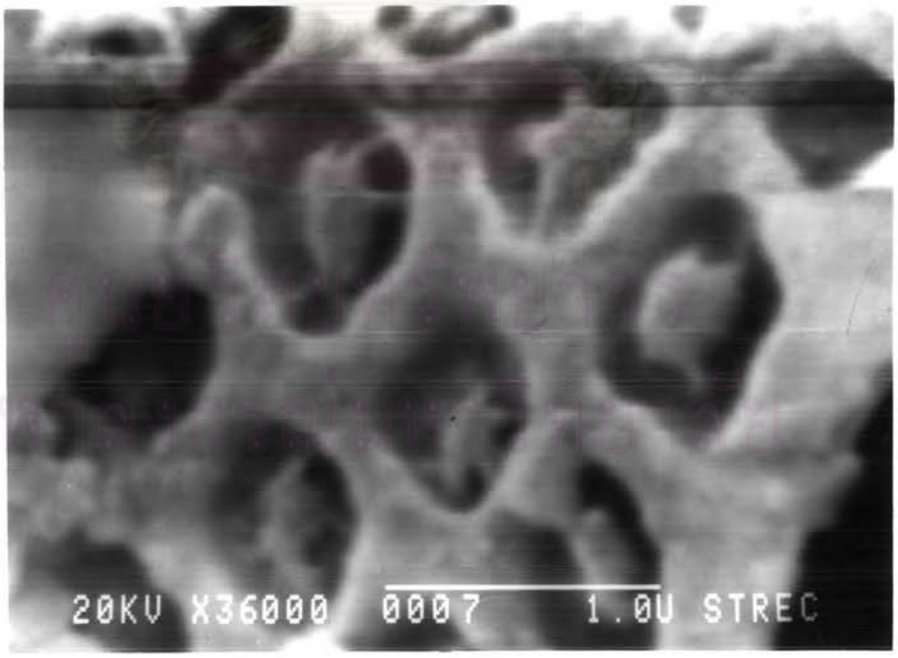


Fig. 4.3.2c Showing surface structure of *Melosira granulata*.

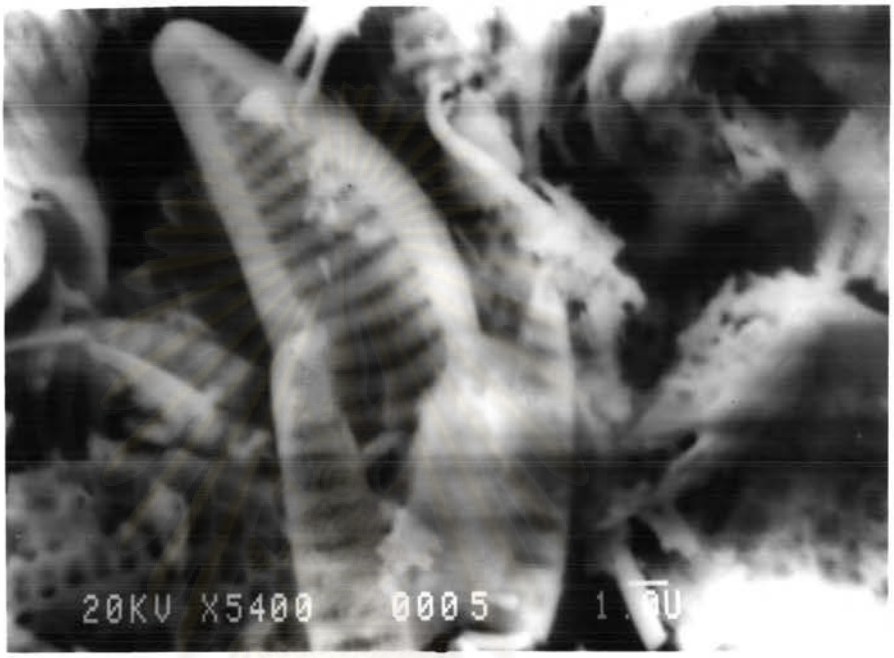


Fig. 4.3.2d Showing surface structure of *Fragilaria* *spp*. (?) from quarry near prospecting shaft no. 1.

pH about 7, with their optimum above pH 7; in current spectra, it belongs to limnophilous having their optimum of development in stagnant water.

Okuno (1958) reported *Melosira granulata* (EHR.) RALFS. from the Setana Formation (Miocene), Hokkaido, Japan. The Setana assemblage is known to consist almost exclusively of this species. It is the earliest geologic occurrence so far reported from the diatomite of fresh-water origin, in Japan. The species occurs also in younger formations in Japan and is still living in Japanese lakes.

Van Landingham (1964) studied the Miocene non-marine diatoms from Yakima region in south central Washington, and reported the species associated with *Melosira canadensis* HUSTEDT which may be a good marker fossil.

Van Landingham (1967) described the Miocene diatom flora of the diatomite from the Otis Basin-Juntura region of Harney and Malheur Countries, Oregon, and found *Melosira granulata* abundantly in some samples.

As to *Melosira granulata*, he (1967) stated that "The stratigraphic range is from Oligocene (?) or Miocene to Recent. This diatom is very common in marine, brackish and freshwater. This species is probably the most abundant of non-marine North American Miocene diatoms." It is of interest to note that, Okuno's studies of Japanese diatomites, absolute dominance of this species (coarse structure type) have been recorded only in those fresh-water diatomites in Miocene age. Further studies are needed, however, to validate the observation. The fact that the structure of the specimens here presented is more coarse than that of their living representatives (Hustedt, 1930) as well as of Pleistocene age (Akutsu, 1964), may bear stratigraphic importance to be studied in the future.

The conclusion regarding the palaeontological aspect of diatoms, it is significant to note that:

a.) The *Melosira granulata* under the present study appears to have less pores and pore lines than the specimen identified by Hustedt (1930,p.248-252, fig. 104.)

b.) This species under the present study shows prominent spines.

c.) The ratio of height to diameter of valves is variable with drum shaped to cylindrical valves.

d.) The *Melosira granulata* specimen shows no seive membranes preserved, however, trace barely left along the edge of pores.

With respect to ecological condition of diatoms, the following conclusions are reached:

a.) Abundance occurrence of *Melosira granulata* requires special environmental condition.

b.) The species is fresh-water plankton of warm, eutrophic zone with optimum development in stagnant water.

c.) The favorable pH of the water is about 7 or slightly higher.

d.) The age of this species ranges from Miocene to Holocene.

4.4 Economic Potential of Diatomite Deposits

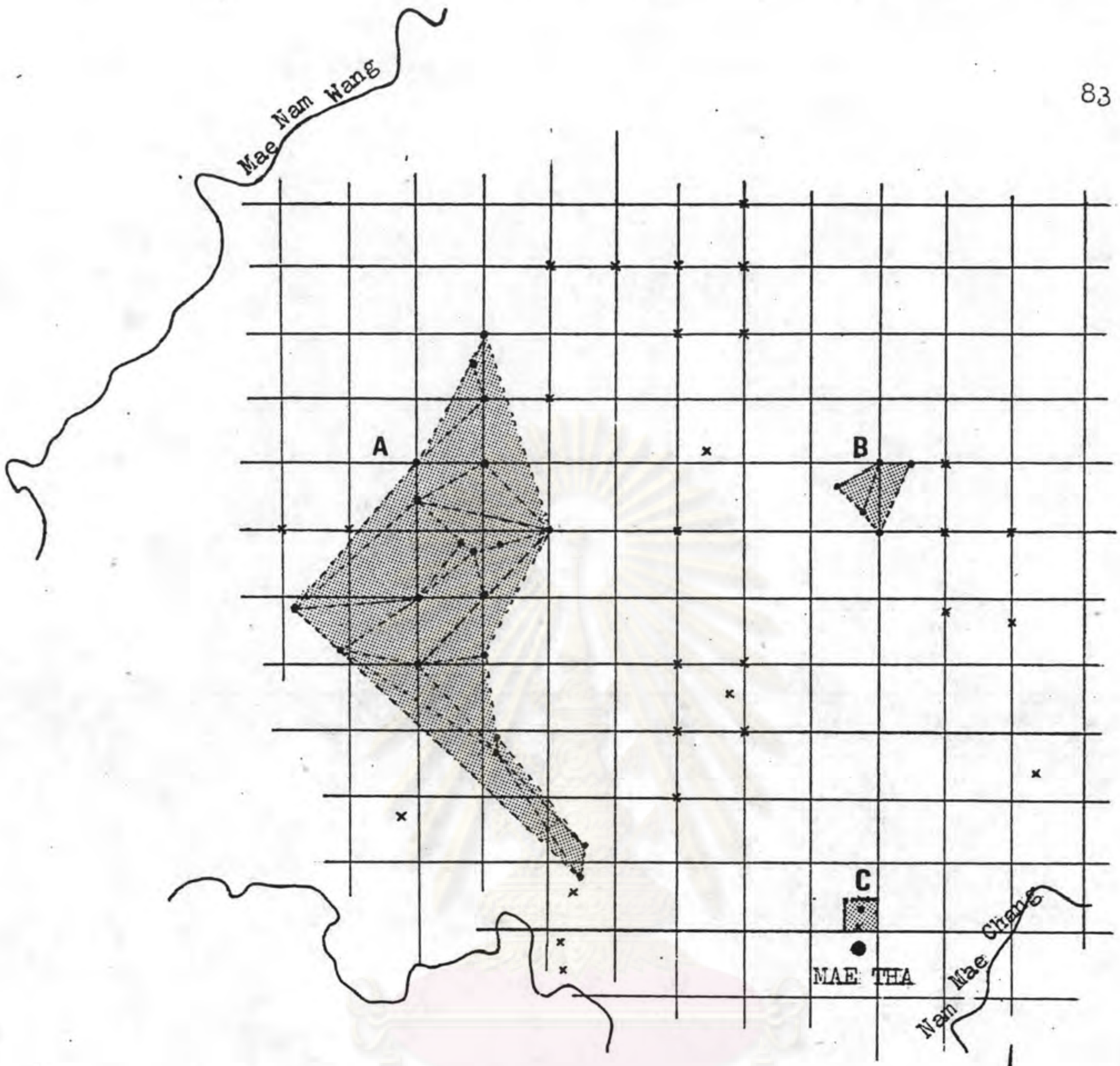
4.4.1 Ore Reserves

At present, the diatomite deposits in the study area are found in three separate areas (Fig. 4.4.1). From irregular spaced drill-holes, the result of ore reserves from calculation are probable (semiproven) or indicated reserves according to Leith (1933, pp. 47-48) definitions of probable reserves as follows: " Probable or semiproven ore covers extensions near at hand, where the conditions are such that ore will probably be found but where the extent and limiting conditions cannot be so precisely defined as for proved ore. Semiproven may also mean ore that has been cut by scattered drill holes too widely spaces to assure contunuity. " Besides, the use of the classification adopted by the U.S. Geol. Surv. and Bureau of Mines, definition of indicated reserves as follows: " Indicated reserves are those for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout. "

Calculation of ore reserves is computed using triangular method of 3 drill holes (Areegul. S., 1977, p. 15) as shown in Fig. 1.5.2. Firstly, compute the volume of each triangle by multiplication the area of the triangle with average thickness of 3 holes. Secondly, the sum of the volume of each triangle is the total volume of the deposit. Thirdly, tonnage of each area equals the multiplication of the total volume by average bulk density of diatomite in each area. The calculation concerned is shown as follws:

a.) Area "A"

Total volume	=	308.22×10^6 m^3.
Average bulk density at 105°C	=	0.71 gm./cc.
Probable dry ore reserve of area "A"	=	218.83×10^6 metric tons



EXPLANATION

× Drill hole without diatomaceous clay

• Drill hole or exploratory shaft with diatomaceous clay

Fig 4.4.1 Showing areas of diatomaceous clay reserves in study area

Lithostratigraphy and Depositional Environment of Diatomite Deposits in the Southeastern Part of Lampang Basin, Changwat Lampang
PONGSAK SRIPONGPHUN GEOLOGY DEPARTMENT GRADUATE SCHOOL CHULALONGKORN UNIVERSITY 1985

b.) Area "B"

Total volume	=	$10.88x10^6$ m^3.
Average bulk density at 105°C	=	0.80 gm./cc.
Probable dry ore reserve of area "B"	=	$8.71x10^6$ metric tons

c.) Area "C"

Approximate total volume	=	$3.43x10^6$ m^3.
Average bulk density at 105°C	=	0.52 gm./cc.
Probable dry ore reserve of area "C"	=	$1.78x10^6$ metric tons

Hence probable dry ore reserve in the study area totally

= $229.32x10^6$ metric tons

4.4.2 Quality of Diatomite Deposits in the Study Area

The chemical analyses of diatomite from some parts at the study area (Appendix 1) indicate that the C-deposit has the highest silica content which is used as a measure of diatom quantity. However, the iron content and alumina content which are used as 2 measures of the clay quantity are also high. Therefore, the potential utilization of this diatomite deposit is lower than it should be. If these undesirable minerals are removed, the diatomite in the study area will be more useful, e.g. as filtering media, adsorbent and solid support for chromatography. The results of the chemical analyses of diatomaceous clay in 3 exploratory shafts are extremely varied. The chemical analysis of diatomite at various depths of the same shaft as shown in the Appendix A-1 shows the fluctuation of SiO_2 and Al_2O_3 contents in diatomite at various depths. Therefore, the purity of diatomite might not depend on the depth at which diatomite were deposited (Fig. 4.4.2a, 4.4.2b, 4.4.2c). The contents of alkali and alkali-earth oxides in diatomite at different levels are similar except the content of Na_2O at the upper level which is mostly higher than that of the lower level. This might be due to the different impurity of the diatomaceous clay.

The content of Al_2O_3 indicates the presence of high content of clay mineral. Assuming that all of alumina content was the composition of clay and clay was generally composed of 40% Al_2O_3 (Van O phen, 1963),

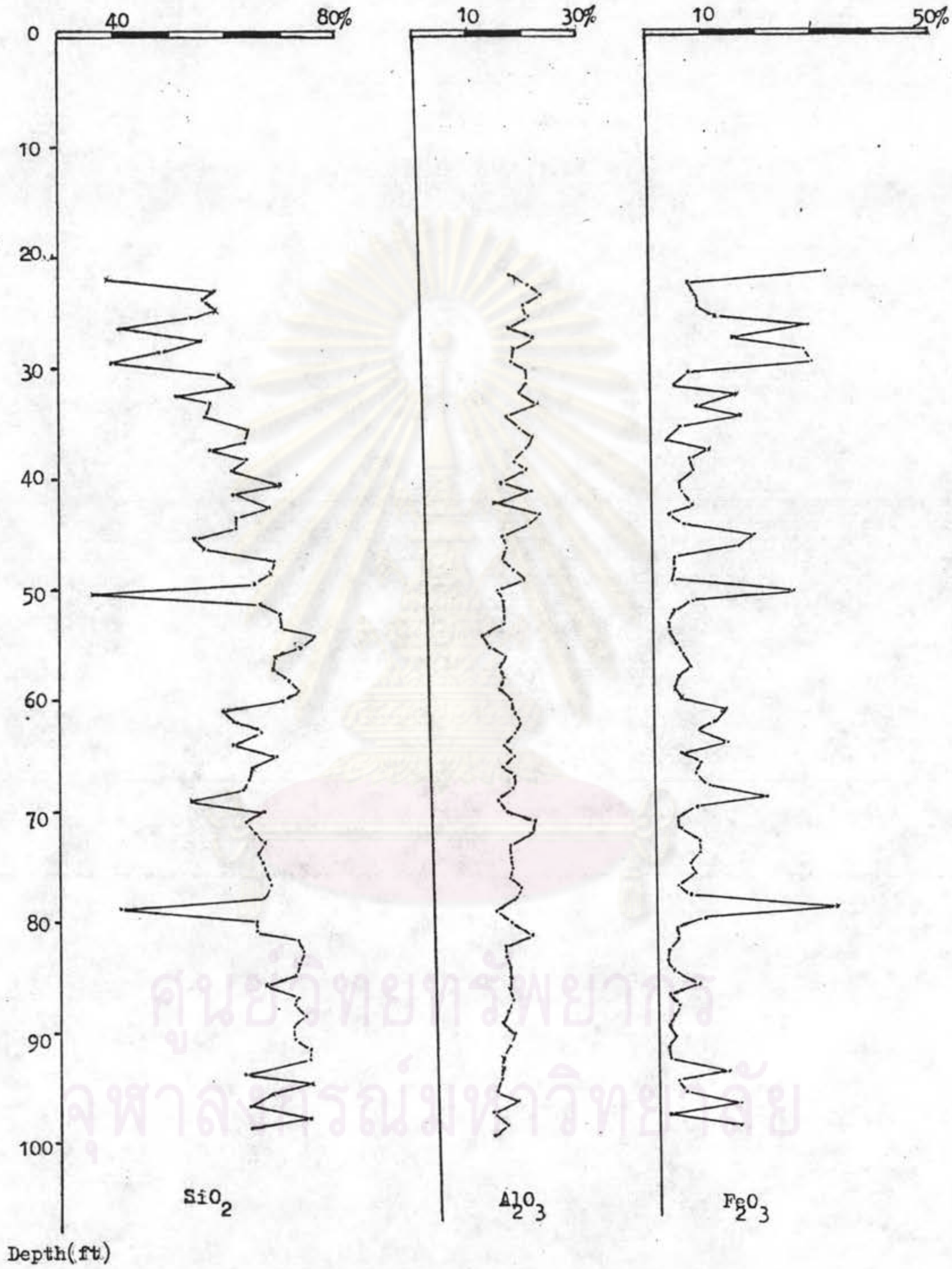


FIG. 4.4.2a The relationship between depth and the chemical composition of Ko Kha formation in shaft 1.

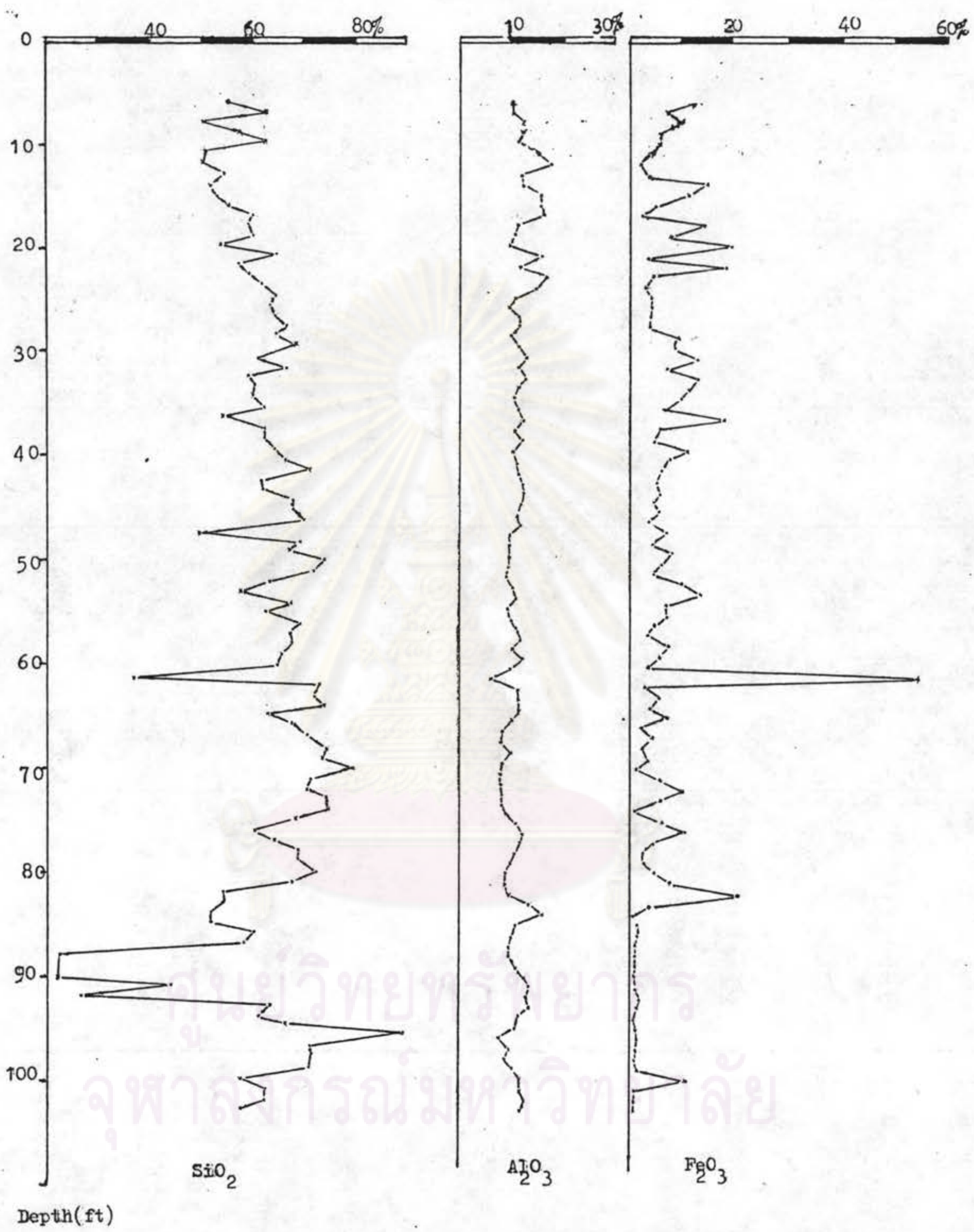


FIG.4.4.2b The relationship between depth and the chemical composition of Ko Kha formation in shaft 2.

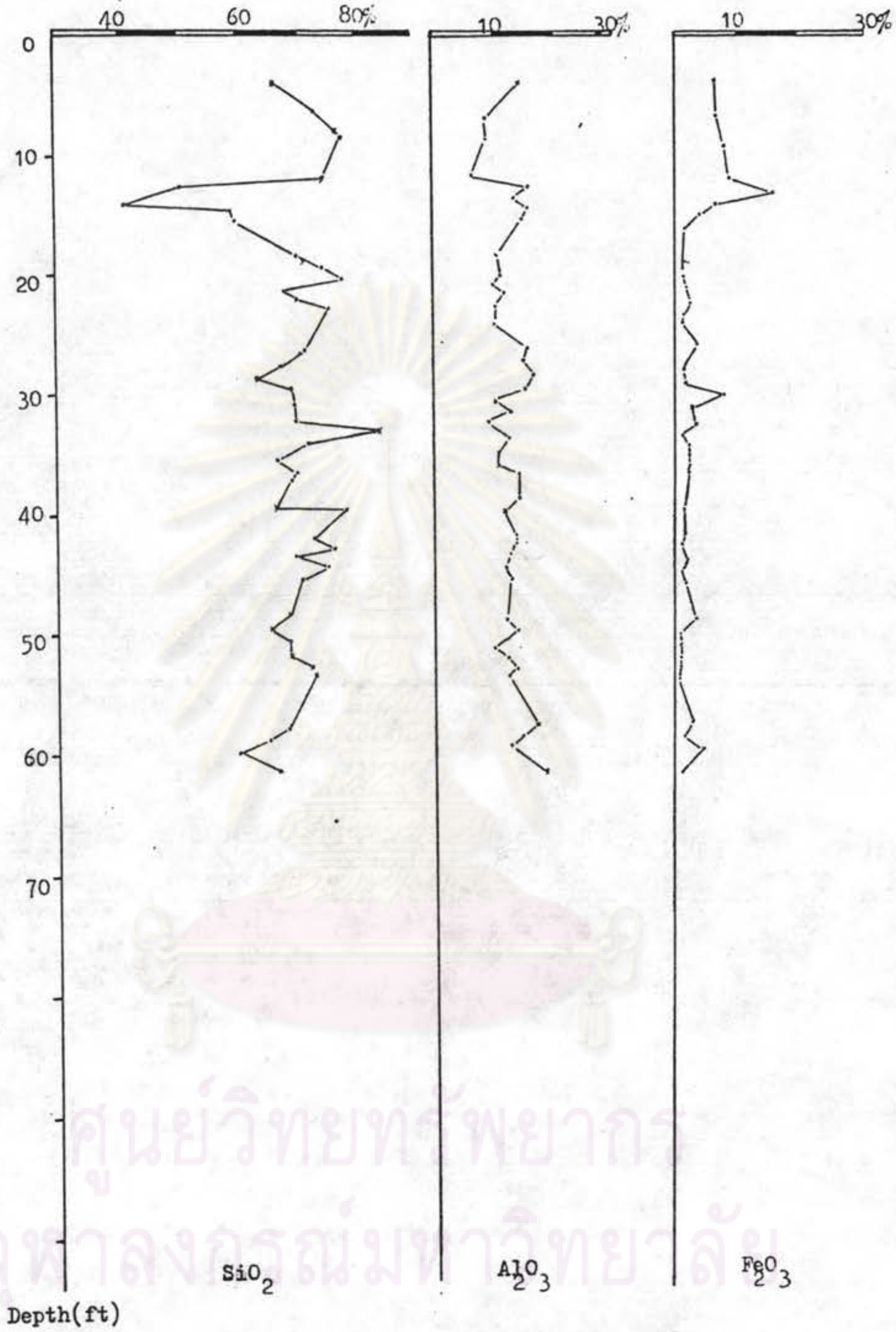


FIG. 4.4.2c The relationship between depth and the chemical composition of Ko Kha formation in shaft 3.

thus the calculated amount of clay in the diatomaceous clay as shown in the Appendix 1 and Fig. 4.4.2d. X-ray diffractograms show the patterns of montmorillonite, kaolinite and illite occurring as impurities in diatomite specimens. These clay minerals mingle throughout the entire thickness of diatomite beds during the deposition. It is known that the clay particles are very small ($<2\mu m$), this reduces the surface area of diatomite because they covered the pores of diatomite structure. In addition, the surface of clay itself has an adsorptive property due to the presence of some cations.

Considering the iron content, they are quite high and could interfere the process of the flux calcination of diatomite, e.g., the excess content of iron caused the product colored. Fe_2O_3 acts as a fluxing agent, this causes the difficulty of controlling the partial fusion of diatomite. To remove the impurities from diatomite, several steps of water washing, settling, and acid treatment are required.

The higher percentage of SiO_2 and the lower percentage of Al_2O_3 can be obtained from the decantation technique. All of soluble salts which caused the clay particles flocculated and iron can be removed from the diatomite by water washing and coarse-mineral settling. The clean diatomite obtained from the mechanical separation is treated with HCl to remove the remained iron. The presence of iron in diatomite could affect to the hardness, color and surface area of the flux-calcined diatomite. If the content of iron is too high, the diatomite would be more fused than that required and might be colored of pink to brown.

4.4.3 Utilization of Diatomite

4.4.3.1 General Utilization

Diatomite deposit is usually selectively mined by open pit method. The freshly excavated material is stockpiled for initial drying in the open air. Then, three different processes are used depending upon the end product desired: natural, non-flux(straight) calcined or flux-calcined grade.

Natural Product: The crude ore is milled, dried at relatively

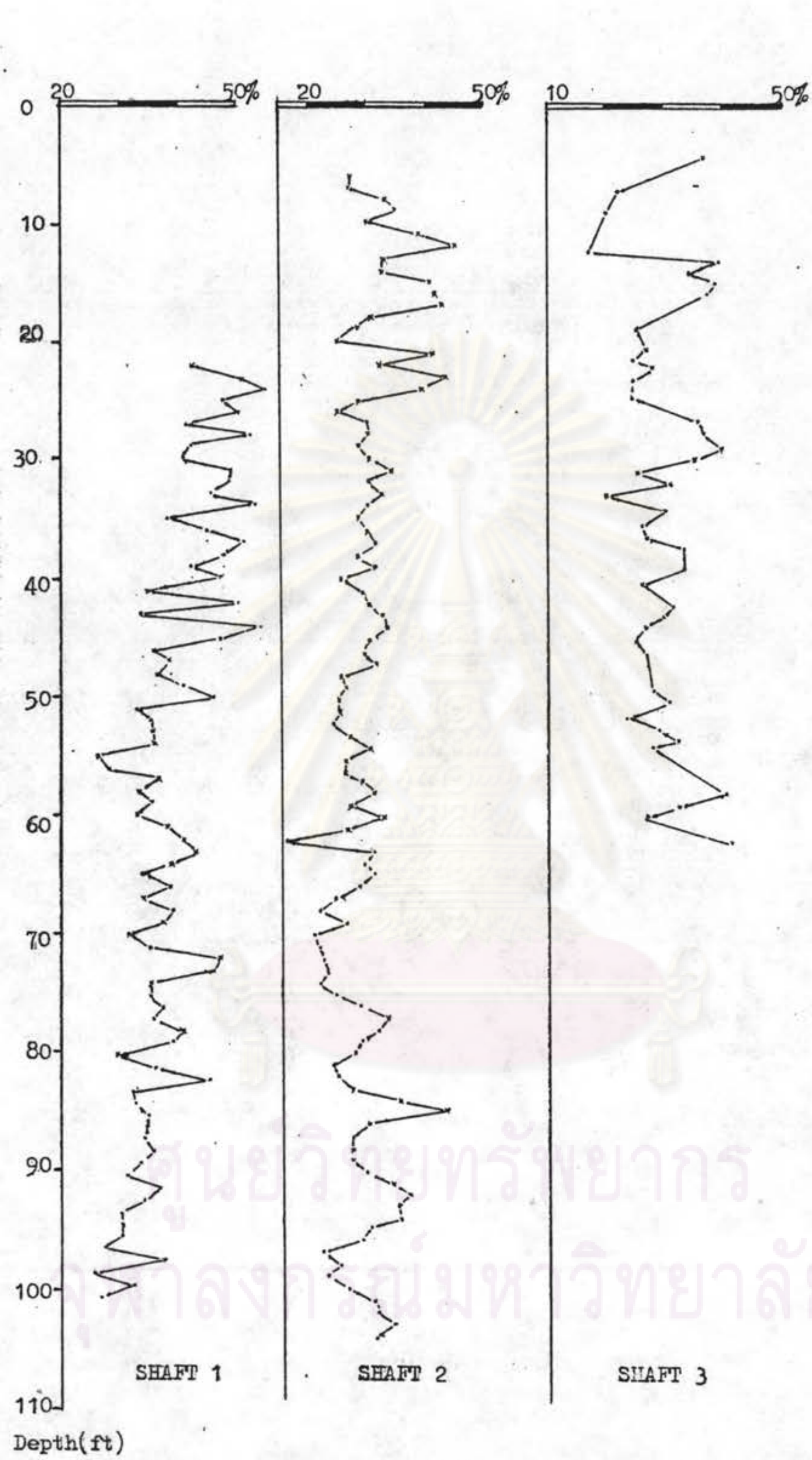


FIG.4.4.2d The relationship between depth and estimated clay contents of the "Ko Kha" formation.

low temperatures and classified to remove extraneous matter and to produce a variety of particle size grades. These natural powders are generally off-white in color, and may contain small percentages (usually less than 5%) of quartz.

Non-flux Calcined Product: This product is produced from the natural material by calcination at high temperatures (1,500°-1,800°F) in a rotary kiln. Depending upon the application it may be again milled and classified into different grades with selected particle size range. During calcination the organics and volatiles are removed, the color typically changes from off white to tan or pink and some of the amorphous silica is converted to crystalline silica, mainly cristobalite.

Flux-calcined Product: This product is made from the natural grade by calcining in a rotary kiln at high temperatures in the presence of a flux, generally soda ash. During flux calcination, the diatoms fuse together, considerably increasing the particle size, become white in color, and again some of the amorphous silica is converted to crystalline silica. Further milling and air separation control particle size distribution.

Recent studies by the U.S. Bureau of Mines, the U.S. Geological Survey (Schroeder, 1970; Durham, 1973) and the California Division of Mines and Geology have indicated that there are at least 350 different uses of diatomite, and possibly there could be as many as 500 different products. The uses of diatomite fall into 10 main categories viz., filters, mineral fillers, insulating materials, mild abrasives, absorbents, catalyst carriers, reactive-silica source structural materials, additive or pozzolan for concretes, and conditioners or anticaking agents.

The most important use falls into the filtering agents or filter aids. In this application, diatomite is added to a liquid for the purpose of removing suspended solids at commercially required flow rates and producing brilliant clarity. Typical uses include the filtration of sugar juices (beet, cane, corn), fruit juices, edible oils and fats, other foods and beverages, pharmaceuticals, enzymes, potable water, lubrication oil additives, beer and wines, metallurgical solution, swimming pool water, waste water, dry cleaning solvents and industrial chemicals. In these instance, diatomite functions only as a processing aid to remove undesirable solid substances from valuable liquid products and, as such , is not a food component or additive. One type of filtration using filter aids is two-step operation. First, a thin protective layer of filter aid (the precoat) is built up on the filter septum by recirculating a filter aid slurry. After precoating, small amounts of filter aid (body feed) are regularly added to the liquid to be filtered. As filtering progresses, the filter aid,mixed with the suspended solids from the unfiltered liquid, is deposited on the precoat. Thus, a new filtering surface is continuously formed; the minute filter aid particles provide countless microscopic channels which entrap suspended impurities but allow clear liquid to pass through, without clogging (Fig. 4.4.3). An efficient, economical filter aid must:

a.) have rigid, intricately shaped, porous, individual particles;

b.) form a highly permeable, stable, incompressible filter cake;

c.) remove even the finest solids at high rates of flow;

d.) be as chemically inert and insoluble as practicable to the liquid being filtered.

The second important uses are as mineral fillers. The unique physical properties of diatomite make an excellent mineral filler and formulation agent. Typical uses are as a filler in paints, rubber, plastics, paper, cardboard, insulation, concrete and asphalt; as a coating agent in fertilizers; as a carrier for catalysts, herbicides, pesticides and fungicides; as an active ingredient in polishes and cleansers.

The other uses of diatomaceous earth aggregates are as industrial absorbents, catalyst supports and as carriers for herbicides pesticides and fungicides.

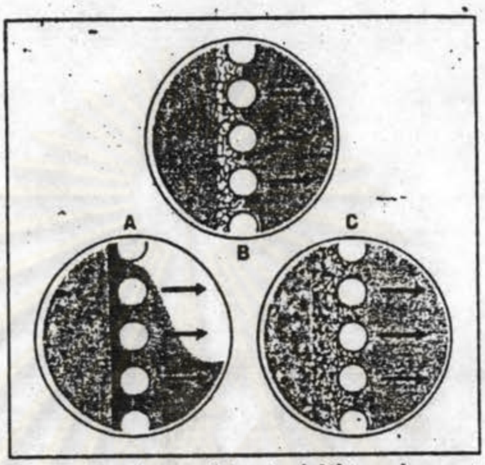


Fig.4.4.3 *Cross-Sections of typical filter element show why Celite filter aids improve filtration.*

A *If Celite is not used, fine solids form a seal over the filter surface and stop the flow of liquids.*

B *The first step in the use of Celite is to build up a "precoat" of Celite filter aid on the filter medium.*

C *During filtration, additional small amounts of Celite are added to keep forming a fresh filter surface.*

Celite is a registered Johns-Manville trade-mark for its diatomaceous silica products. Celite powders have an exceptionally high silica content-as 94 percent. Three to four percent of combined water and an average of four percent free moisture are present in the uncalcined grades. "Natural" powders are light grey-tan, calcined material is pink while flux-calcined Celite is a high brightness white. Because it is essentially silica, Celite is inert to most chemical reactions and is resistant to extreamly high temperatures with, a softening point of about 2,600°F. The remarkable physical structure of the individual diatom skeleton is the characteristic upon which almost all of the applications of Celite functional fillers are based. It has been determined that ninety-three percent of the apparent volume of Celite consists of a myriad of tiny interconnected pores or voids. This explains the very high absorptive capacity of Celite- about $2\frac{1}{2}$ times its own weight. However, in spite of their exceptionally high absorptive capacity, Celite mineral fillers do not absorb any appreciable amount of moisture from the air. Celite has a high surface area. Only 210 gms. of Celite ($< \frac{1}{2}$ lb.) has a surface area equal to the area of a football field (45,000 ft^2.)

Micro-Cel is a registered Johns-Manville trademark for its synthetic hydrous calcium silicate, produced by the hydrothermal reaction of diatomaceous silica, hydrated lime, and water. Some physical characteristics peculiar to Micro-Cel are very high liquid absorption, high surface area, excellent flowability, low bulk density and a unique particle structure. Micro-Cel grades are developed to meet specific industrial needs.

Johns-Manville have been mining and processing Celite diatomite for over 48 years. When Johns-Manville acquired the Celite Company in 1928, little was known about diatomite

Generally, the uses of Celite diatomite fall into two categories. One, as a mineral filler that is added to a process to extend a more expensive ingredient. And two as a mineral filler that is added to a process because of the effect it will have on the finished product. Both uses take adventage of Celite's unique physical properties is one way or another.

Table 4.4.3.1a

Celite Mineral Filters — Average Chemical Properties

Grade	% Chemical Analysis*								
	Ignition Loss %	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	TiO_2	CaO	MgO	$Na_2O + K_2O$
Uncalcined (Natural)	3.6	85.8	3.8	1.2	0.2	0.2	0.5	0.6	1.1
Calcined	0.5	91.1	4.0	1.3	0.2	0.2	0.5	0.6	1.1
Flux Calcined	0.2	89.6	4.0	1.5	0.2	0.2	0.5	0.6	3.3

*The soluble portion of Celite filter aids is extremely low. For example Hyflo Super-Cel has a total acid solubility of less than 1%.

Table 4.4.3.1b

Celite Mineral Fillers
Average Physical Properties*

Celite Grade	Color	Screen Analysis		Absorption % Wt. Average		Sp Gr True	Av. % H_2O as Shipped	pH		Density lbs/ft³		Refractive Index	Porosity	Surface Area m²/gm	Brightness (Av. Tappi T-452-m-45)	Free Alk. Na_2CO_3	Paint Bulking Value	
		Av. % 150 Mesh	Av. % 325 Mesh	Water	Oil Gardner Coleman			Max.	Min.	Loose Av.	Wet Max.						lbs/gal	gal/lb
Uncalcined (Natural)																		
FC, 289, 292, 321A, 400	Lt. Gray	0.5	5.0	229	210	2.10	4.0	7.0	–	7.0	17.0 20.0 (321A)	All Grades Range From 1.40 to 1.46	All Grades Range From 65% to 85%	All Grades Range From 10 to 20	†60	None	17.5	0.057
379	Lt. Gray	0.5	4.5	195	185	2.10	–	7.0	–	8.0	–				57	None	–	–
Snow Floss	Lt. Gray	0.05	0.3	185	175	2.10	4.0	7.0	5.0	7.5	(av.) 22.0				69	None	–	–
209, 322	Lt. Gray	TRC	0.5	185	175	2.10	4.0	7.0	5.0	8.0	(av.) 24.0				64	None	–	–
266	Lt. Gray	TRC	0.5	185	175	2.10	4.0	7.0	5.0	8.0	(av.) 24.0				66	None	17.5	0.057
305	Lt. Grey	TRC	0.5	185	175	2.10	4.0	7.0	5.0	8.0	(av.) 24.0				66	None	–	–
Calcined																		
SSC, 235	Lt. Pink	4.5	13.0	220	200	2.15	0.5	7.0	–	8.0	19.6	All Grades Range From 1.41 to 1.48	All Grades Range From 65% to 85%	All Grades Range From 4 to 6	52	None	–	–
246, 202	Lt. Pink	6.8	15.0	220	200	2.15	0.5	7.0	–	8.0	17.6				–	None	–	–
315	Lt. Pink	TRC	0.3	170	150	2.15	0.5	7.0	–	8.0	27.0				–	None	–	–
270	Lt. Pink	–	0.5	170	160	2.15	0.5	7.0	–	8.0	26.0				–	None	–	–
Flux Calcined																		
HSC	White	5.0	18.0	220	190	2.30	0.5	10.0	8.5	9.0	17.6	All Grades Range From 1.45 to 1.49	All Grades Range From 65% to 85%	All Grades Range From 1 to 3.5	87.5	**	–	–
255	White	7.5	30.0	220	190	2.30	0.5	10.0	8.5	9.5	18.4				–	**	–	–
273	White	9.0	30.0	220	190	2.30	0.5	10.0	8.5	9.5	18.4				–	**	–	–
269	White	10.0	45.0	220	190	2.30	0.5	10.0	8.5	12.0	18.9				–	**	–	–
319	White	12.0	50.0	220	190	2.30	0.5	10.0	8.5	12.0	18.9				–	**	–	–
Super Floss	White	–	0.1	150	125	2.30	0.5	10.0	8.5	8.5	30.0				92	**	19.2	0.052
165-S	White	–	–	–	105	2.30	0.5	–	–	17.3	–				–	**	19.2	0.052
110	White	3.0	11.0	185	175	2.30	0.5	10.0	8.5	9.0	21.0				91	**	19.2	0.052
263	White	TRC	0.5	150	130	2.30	0.5	10.0	8.5	8.5	32.0				89	**	–	–
281, 388	White	0.1	1.0	160	140	2.30	0.5	10.0	8.5	8.5	24.0				89	**	19.2	0.052
320	White	50.0	90.0	210	170	2.30	0.5	10.0	8.5	(av.) 19.5	(av.) 20.0				–	**	–	–
Super-Fine Super Floss	White	–	0.05	140	120	2.30	0.5	10.0	8.5	8.5	27 min.				90	**	19.2	0.052
499	White	–	TRC	180	160	2.30	0.5	10.0	8.5	8.5	22				90	**	19.2	0.052
219	White	0	TR	210	160	2.30	0.1	9.5	–	7.2	19.0				89	**	19.2	0.053
White Mist	White	0	TR	215	160	2.30	0.1	9.8	–	6.8	20.8				90	**	19.2	0.053
Silver Frost K-5	White	0	TR	150	115	2.30	0.1	9.8	–	7.1	29.0				88.5	**	19.2	0.053

*Not to be used for specifications. **Alkaline reaction in water suspension but no free Na_2CO_3 present. †321A same as 321 but with average 65 brightness.

Table 4.4.3.1c
Applications of J-M Celite Mineral Fillers

Product	Celite Grade	Amount Suggested	Celite Properties	Product Benefits	Remarks
Acetylene Tank Filler	Celite FC	Same weight as lime	Porosity, source of reactive silica, high absorption, fine powder	Reduce explosion hazard, high porosity, no shrinkage	Clinker composed of cement, asbestos, diatomite, lime and carbon
Adhesives	Snow Floss/ Super Floss	1-5%	High absorption, fineness	Thickens adhesive, faster solvent release	Pyrogenic silica principally used
Aerosol Rug Cleaner	Celite 219	15% by weight	Absorption, abrasion	Improves scrubbing action, holds dirt for easy removal	Used in foam type cleaner sprays
Asbestos Friction Papers	Celite 319	25-40% based on asbestos pulp	Diatom structure	Faster pulp drainage, improved friction	Used for clutch facings
Asphalt	Celite 292	5-10%	Diatom structure, absorption	Raises melting point, high bulk, fast solvent release	Slate dust, cheap fillers used
Asphalt Crack Filler	Celite 292	10%	High absorption, diatom structure, inert, fine powder	Improves resiliency and weathering, decreased cracking	Texas usage
Battery Box Separators (Latex-Fiber Glass)	Celite HSC	20-25%	Inert, absorption, diatom structure, bulk	Lightweight and permeability	Few present producers
Catalyst Carrier (Vanadium Oxide)	Super Floss		Inert, absorption, fineness	Active material tabletted. Used for H_2SO_4 production	Only several major producers
Catalyst Carrier (Nickel Hydrogenation)	Celite FC		Inert, absorptive, easily filtered	Powder catalyst for hydrogenation of vegetable oils	Few present producers; some captive
Catalyst Carrier (Phosphoric Acid)	Celite FC		Inert, absorption, easy pelleting	Extended pellets for cracking catalyst	Only several producers
Ceramic Tile	Celite FC	5%	Diatom structure, silica filler	Dimensional stability, improved vitrification and firing	
Ceramic Glaze	Super Floss	Up to 50% of glaze compound	Diatomaceous silica source	Lowers maturing temperature, extends temperature range, improves surface	Little used
Chemical Coating	White Mist	Various	Diatom structure	High Hegman, efficient sheen control	For use vs. talc and silicas in industrial finishes
Chromatography	All Chromosorb grades		Column support material		All various technical bulletins
Cleansers (Household)	Celite HSC	2-10%	High bulk, abrasive absorption	Reduce "outage" conditioning effect, mild abrasive effect	Cheaper fillers generally used
Concrete	Celite for Concrete	2-5 lbs/sack of cement	Diatom structure, absorption, inert	Improved workability, more impermeable concrete	

Product	Celite Grade	Amount Suggested	Celite Properties	Product Benefits	Remarks
Crayons	Celite 281 Snow Floss	10-25%	Bulk, mild abrasiveness	Provides good "bite", wears uniformly	Small volume
Dental Mold Compounds	Celite 224	25-35%	Bulk, diatom structure	Improved mold strength, easier release, reduced shrinkage, low heat conductivity	Several principal mfrs.
Dry Fish Solubles	Celite 211 (FC) and Micro-Cel E	Dry liquids	Absorption	All "DLC" values, easy to handle, mix, ship, etc.	Combination of Celite and Micro-Cel for lower cost "DLC"
Dental Impressions	Celite 427 (HSC)	50-60% by weight	Fluffiness, absorption	Uniform impression	Used to make impressions of teeth by dentists. Dries in 2 minutes or less. Water is added to dry powder.
Embalming Compound	Celite FC	75%	Bulk absorption	Replace viscera removed by autopsy	3-4 lbs/remains, primarily cremation. Leaves powder residue
Tempera Poster Paints	Celite 499	½-¾ lbs/gal	Fineness, oil absorption, flatting	Hiding and opacity, full dead flat, impart thickening	Provides very flat poster paint
Fertilizer	Celite 379	1-3%	Absorption, fineness, fine particle size, inert, high surface area	Maintains free flow, absorbs deliquescent moisture	Also Kaolin Clay, widely used
Filter Paper	Celite 388	Probably 10-30%	Wet density, diatom structure	Drainage, clarity	No details known—one customer uses 400 tons/yr.
Friction Papers	Celite 388	22-27%	Abrasive, wet density	Drainage and bulking	Transmission friction disc made from sulphite and asbestos pulp
Gunite	Celite for Concrete	2-4 lbs/sack of cement	Absorption, fine particle size	Permits use of wet sand, reduces rebound, improves finishing properties	Good swim pool potential
Ink (Silk Screen)	White Mist	Small quantities	Diatom structure	Lowers gloss, more uniform appearance	
Insecticide (Wettable Powders & Dusts)	Celite 209, 400	1-25%	Absorption, fine particle size, high surface area	Anti-caking, carrier, fluffs up finished dusts	Clays, talcs, synthetic silicas
Insulating Block (High Temperature)	Celite 202	20-30%	Diatom structure bulk, low heat conductivity	Produces lightweight block with minimum shrinkage	Usual composition is asbestos, magnesia, clay and diatomite
Insulation (Lime Silica)	Celite 300	25-50%	Bulk, silica source	Source of reactive silica	

Product	Celite Grade	Amount Suggested	Celite Properties	Product Benefits	Remarks
Lost Wax Castings	Super Floss 219	Gypsum 35% Silica Flour 40% Clay 10% Talc 10% Celite 5%	Fine powder diatom structure	Prevents voids, reduces shrinkage, improves gas permeability	
Match Heads	Celite FC	10-20%	Porosity, absorption, inert	Porosity to match head, absorbs liquid ingredients, greater bulk	
Mold Release	Super Floss	10-15%	Diatom structure inert	Good release properties, insulation effect, uniform surface on finished product	Our only use today is in centrifugal casting
Paint, Flat Wall	Celite 281, 499	¼-½ lb/gal	Diatom structure, absorption, inert	Reduce gloss, controls side sheen, covers wall imperfections	See paint bulletins. Contact J-M representative.
Paint, House	Celite 281	½ lb/gal	Gloss and sheen control, diatom structure	Low lustre finish, more permeability, reduced blistering	
Paint, Semi-Gloss	Celite 499 White Mist	¼-¾ lb/gal	499 provides 5 Hegman, SFSF 6 Hegman by disc dispersion	Celite flatting at lower cost than talc	
Paint, Traffic	Celite 110, 281	½ lb/gal	Diatom structure, inert	Better night visibility, more durable, faster dry	
Paper, Book	Celite 305	3-6%	Absorption, bulk, inert, structure	Provides added bulk, opacity, ink receptivity	
Paper, Boxboard	Celite 321, 388	2-6%	Absorption, bulk, inert, structure	Faster machine speed, better drainage, pitch control and bulk	
Paper, Mimeo	Celite 305, 263	3-7% for 305 2-4% for 263	Absorption, bulk, inert, structure	Greater bulk and opacity	
Paper, Laminating	263	5-30%	Bulk, absorption	Improves printing, absorption of resin, provides opacity	Highly absorbent paper impregnated
Paper, Bond	Celite 263	2%	Absorption, bulk, inert, structure	Brightness, opacity and greater bulk	
Pastel Chalk	Celite 281, 110	10-30% by weight	Diatom structure	Provides matte finish and "bite", sharp outlines, fine color graduations, improves forming	Pastel chalk used for drawing on paper — artist use
Phosphoric Acid	Celite 300, 448	100%	Source of reactive silica, used as reactant	Combines with fluorides in phosphoric acid production	Used to produce higher purity acid, used in making di-calcium phosphate

Product	Celite Grade	Amount Suggested	Celite Properties	Product Benefits	Remarks
Plastics, Molded (Phenol-formaldehyde)	Celite 270	10-15%	Diatom structure, inert	Conditioning effect, low moisture absorption of molded product, improved surface finish	Many other lower cost fillers are used
Plastic, Sheet and Film	Super Floss Celite 219 White Mist Silver Frost K5	Less than ¼ %	Diatom structure, low refractive index	Diatom particles protrude through surface reducing effective surface contact area	Extensively used as anti-block agent in polyethylene
Polish	Snow Floss Super Floss Celite 315	10-90%	Diatom structure, inert, absorption, delicate abrasion	Easy removal, non-scratching abrasive, absorbs dirt and grime	Universally used in fine silver and auto polishes
Pomanders	Celite 410	"As is"	Pellet shape absorption	Used to absorb perfume	Impregnated pellets placed in sachet to scent closets
Rubber (Latex Molded)	Snow Floss	½-1 lb/gal water and/or alcohol slurry	Diatom structure, bulk, inert	Parting agent to facilitate stripping molded product from form	Talc
Rubber, Silicone	Super Floss Celite 350, 270	Varies according to formulation	Diatom structure, inert	Semi-reinforcing filler, improved oil resistance	
Rubber, Sponge	Celite 292, 270	25% replacement of whiting and/or talc	Oil absorption and low specific gravity	Enables addition of more extender oil lowering amount of polymer needed — total lower cost	Although Celite is more costly, greater volume of final product and less polymer justifies use
Stone Stencils	Celite 219	75 lbs 435 lb batch	Diatom structure	Probably semi-reinforcing filler-toughen sheet, make easier to cut clean	Urethane sheet used to make stencils to cut designs into monument stone by sand blasting
Rubber Reclaiming	Celite 322	1%	Low density oil absorption	Faster production, soaks up oil, more workable mix	Several reclaimers of old tires
Safe Insulation	Celite 202	About 30% of Vermiculite weight	Low bulk density, low K factor	Lighter weight, safe insulation, good fire protection	Composition is Vermiculite, Celite Cement and water to fill, safe as a slurry
Seed Coating	Celite FC	20-70% Celite FC	Fine particle size, high bulk	Coat seeds for single seed planting	
Stucco	Celite 281 FC	3 lbs/sack of cement		Fluffy, workable slippery mix for easy application, reduces gunite rebound, reduced cracking	
Tempera Poster Paints	Celite 499	⅓-¾ lb/gal	Fineness, oil absorption, flatting	Hiding and opacity, full dead flat, impart thickening	Provides very flat poster paint

Product.	Celite Grade	Amount Suggested	Celite Properties	Product Benefits	Remarks
Tomato Dust	Celite 209	20 lbs/100 gal water	High surface area, fine particle size	White wash to prevent sunscald	Applied at 150 gals/acre. One qt "Spreader Sticker" used per 100 gals to provide adherence
Toothpaste	White Mist	Approx 5%	Absorption, delicate abrasion	Good tooth cleaning	Specialty toothpaste only
Typing Correction Fluid	Celite 281	4% Celite 281, 499 on total	Flatting	Low gloss correction fluid	Used to coat typing mistakes – composed of TiO_2 and fast drying binder
Ultamarine Blue	Celite FC	5-10%	Reactive silica source, bulk	Desirable blue color, keeps mass porous so reaction proceeds rapidly	Single U.S. supplier uses Celite
Varnish	Celite 232-S White Mist	Varies	Diatomite structure	Good flatting efficiency at lower cost	Synthetic silicas principally used
Welding Rod Coatings	Snow Floss	15-20% on weight of coating	Diatom structure silica	Imparts fluidity to coating and porosity to flux after welding, good uniformity of coating, reduced shrinkage and cracking	Not a large use

Table 4.4.3.1d Typical properties of diatomite filter aids

TYPICAL PROPERTIES

	Grade	Color	Density Lbs. Cu. Ft.		Screen Analysis % Retained	pH	Specific Gravity	Water Absorption %	Relative Flow Rate	Equivalent Fibra-Flo Grade	% Chemical Analysis[2]								
			Dry	Wet	150 Mesh						Ignition Loss %	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	T_1O_2	CaO	MgO	NaO + K_2O
Natural	Filter Cel	Gray	7.0	15.9	3.0	7.0	2.10	235	100	1	3.6	85.8	3.8	1.2	0.2	0.2	0.5	0.6	1.1
Calcined	505	Pink	8.0	21.0	—	7.0	2.15	170	135	3	0.4	92.8	3.3	1.3	0.2	0.2	0.4	0.5	0.8
Calcined	Standard Super-Cel	Pink	8.0	17.2	7.0	7.0	2.15	255	200	5	0.5	91.1	4.0	1.3	0.2	0.2	0.5	0.6	1.1
Calcined	512	Pink	8.0	17.9	9.5	7.0	2.15	250	300	6	0.5	91.1	4.0	1.3	0.2	0.2	0.5	0.6	1.1
Flux Calcined	Hyflo Super-Cel	White	9.0	17.2	9.5	10.0	2.30	245	500	7	0.2	89.6	4.0	1.5	0.2	0.2	0.5	0.6	3.3
Flux Calcined	501	White	9.5	16.9	15.0	10.0	2.30	250	750	8	0.2	89.6	4.0	1.3	0.2	0.2	0.5	0.6	3.3
Flux Calcined	503	White	9.5	17.2	15.0	10.0	2.30	240	900	9	0.2	89.6	4.0	1.3	0.2	0.2	0.5	0.6	3.3
Flux Calcined	535	White	12.0	17.6	20.0	10.0	2.30	245	1350	10	0.2	89.6	4.0	1.3	0.2	0.2	0.5	0.6	3.3
Flux Calcined	545	White	12.0	18.0	20.0	10.0	2.30	240	2160	11	0.2	89.6	4.0	1.3	0.2	0.2	0.5	0.6	3.3
Flux Calcined	550[1]	White	18.1	21.0	25.0	8.0	2.30	220	2380	12	0.2	89.6	4.0	1.3	0.2	0.2	0.5	0.6	3.3
Flux Calcined	560	White	19.5	20.0	60.0	10.0	2.30	220	7500	13	0.2	89.6	4.0	1.3	0.2	0.2	0.5	0.6	3.3

NOTE (1): Celite 550 is a flux calcined grade with a unique property of hardness. Typical uses for this grade is in systems requiring a high flow rate filter aid but where filter aid breakdown may occur. Filtration of viscose liquids at pressures above 40 to 50 psi is another application.

NOTE (2): The soluble portion of Celite filter aids is extremely low. For example Hyflo Super-Cel has a total acid solubility of less than 1%.

4.5.3.2 Utilization of Diatomite in the Study Area

The diatomite from the study area is suggested to be used as solid support in gas chromatography for Chromatographic Columns (Borvornwattananont, 1984). The microstructure of diatomite from the study area was found as *Melosira granulata* (EHR.)RALFS which was the same as that of Gas Chrom Q. The method of benefication of diatomite from the study area by machanical means was 4-stage washing with H_2O (at a solid:liquid ratio of 1:5 w/v), isolating coarse minerals and clay by decantation. The clean diatomite was 1-stage extracted with 10% v/v HCl (at a solid: liquid ratio of 1:5 w/v). The acid-treated diatomite was flux-calcined with 8.55% Na_2CO_3 at 1,000°C for 3 hours. The flux-calcined product was crushed into the required particle and silanized with 5% v/v DMCS (dimethyl dichlorosilane) in toluene solution. The prepared support showed more surface area and more adsorptive effect on the coating of 5% OV-101 than those of Gas Chrom Q. The chromatographic characteristics for separation of non-polar compound were the same. However, for the separation of intermediately polar and polar compounds, it provided better column efficiency than Gas Chrom Q. Therefore, this prepared support was proposed as an excellent solid support for gas chromatography and it was named as " Diatochrom L ".

In addition, the diatomite in this area can be used as composite raw materials for insulating bricks (DMR., 1980). It is further suggested that it can also be used as filler materials for petrochemical products, fertilizer, etc., and as silicate and alumina additives. However, it is recommended that additional benefication techniques are required prior to the maximum utilization of Lampang diatomite.