CHAPTER 5

PALYNOLOGY

5.1 INTRODUCTION

The Tertiary intermontane basins of Thailand (including the Fang Basin) and the associated sedimentary fill have always been potential targets for hydrocarbon exploration and exploitation. Inspite of the high demand for regional Tertiary biostratigraphic and age studies, the age of the sediments is not well known (Watasanak, 1989). In the Fang Basin, only few palynologic studies have been undertaken and the strata are dated as Eocene to Pleiostocene (refer to section 1.7). The present study is also thought to add upto the knowledge of the stratigraphy of the basin.

In general, palynological techniques have been developed for the study of pollen and spores - the dispersed, usually microscopic, reproductive structures of plants. Individual species are loosely referred to as palynomorphs. Palynologic studies are mainly concerned with the dispersal and spatial relationship of palynolomorphs, and their applications thereof. The ubiquity and abundance of palynomorphs in sedimentary rocks provides a source material that has enormous potential in documenting the geologic record of plants. The technique has far reaching applications, particularity in the oil industries, in the correlation and determination of the relative ages of strata. Paleoenvironmental and ecological factors may also be reflected by changes in the flora of successive layers. Hence, the microfloral assemblages identified in this study may provide information required for the correlation of strata and paleoenvironmental inferrences.

For this study, various intervals from the Mae Sot Formation of IF 30 03S were sampled for palynological investigations (Table 5.1). A number of

Table 5.1 Samples for Palynological study.

Samples No.	Sample type	Depth (in feet)
2	Cutting	1735-1770
5.2	Core	1934
12	Cutting	2800-2840
16	Cutting	3200-3250
22	Core	3597
28	Cutting	3705-3755
31	Cutting	4005-4075
41	Cutting	4500-4524

N.B. CUTTING SAMPLES ARE MIXED FOR THE DEPTH OF INTERVAL INDICATED fossil spores, pollens and fungal remains alltogether amounting to 114 were recovered. Much of the yield came from the upper part of the succession (Unit 3). Recovery from the lower part (Units 1 and 2) was relatively poor and yet few key fossils were recorded. Of the total, 71 fossils were photographed, the morphology of selected palynomorphs described, and the probable botanic affinities of some spores and pollens were given. The palynomorphs were evaluated in the light of their stratigraphic/age, and paleoenvironmental significances.

5.2 SAMPLE PREPARATION

Sample preparation and extraction were made following the techniques outlined by Gray (1965) and Brown (1960). About 10-15 grams of each sample were used for palynological processing.

Rock/cutting samples were crushed to a particle size of about 1-2 mm. diameter using porcelain mortar and pestle. Following this, the broken samples were placed in a plastic beaker and tested for the presence of carbonates. All the samples were carbonate free. These were then directly treated with hydrofluoric acid in order to disintegrate and partially dissolve the inorganic matrix. The thoroughly washed and centrifugated residue was treated with Schulze's solution (HNO_3 + $NaCO_3$). The latter oxidizes and partially dissolves the humic matrix. The residue is again washed free of acid and treated with a basic solution such as NaOH (1 %) until the humic material is thoroughly dispersed. Following every other step, the residue was thoroughly washed using distilled water, centrifugated, and the water decanted repeatedly. After the complete maceration of the sedimentary matrix, complete separation is often attained by differential floatation using either heavy liquid separation or ultrasonic vibration, allowing the organic remains to float and the mineral fractions to settle. This is followed by vaccum drying method.

The palynomorphs are then mounted on glass slides permanently. Permanent slides are prepared using silcon oil as a mounting medium. The dried palynomorphs were mixed and dispersed evenly over the glass slide. Finally the glass slide was covered with cover glass and let to dry at room temperature.

In this study, three sets of slides were examined for the presence of genera or species following a series of traverses. For identification, the specimen were examined under x 1000 magnification using x 100 oil immersion objective. Published materials were used for comparisons to facilitate identification.

5.3 SELECTED PALYNOMORPHS

Plates 1-5 illustrate the photomicrographed fossil spores and pollen grains together with other plant microfossils found in this study. The photomicrographs were taken with a Zeiss photomicroscope, in bright field, using x 100 oil immersion objective. All the specimens were figured at a magnification of x 1000 (if not otherwise stated) using untouched negatives.

Plate 1

Angiospermae

Figure 1 *Nyssapollenites pseudolaesus* (potonie') Thiergart (RLCPBS, 1989) [Research on Late Cenozoic palynology of the Bohai sea].

Figure 2 *Nyssapollenites microregulatus* Zheng sp. nov. (RLCPBS, 1989).

Figure 3 *Betulaepollenites claripites* (Wodeh) Sung and Tsao (RCPLSA, 1985) [A Research on Cenozoic Palynology of the Longjing Structural Area].

Figure 4 *Symplocospollenites latiporus* (Pflug et Thomson) song comb. nov. (ETSPADR, 1989) [Early Tertiary Spore and Pollen Assemblages from the Dougu Region].

Figure 5 *Tiliaepollenites instructus* Potonie', 1951 (RLCPBS, 1980).

Figure 6 *Lonicerapollis minus* Song et G.X. Li sp. nov. (ETSPADR, 1989).

Figure 7 *Margocolporites* cf. *cribellatus Srivestava* (ETSPADR, 1989).

Figure 8 *Caryapollenites latiporous* (Pflug) Krutzsch (x 400) (RTRQB, 1985) [Research on Tertiary Palynology from the Quaidam Basin, Qinghai province].

Figure 9 *Quericoidites henrici* (Potonie) Potonie', Thomson & Thiergart (RLCPBS, 1989).

Figure 10 *Florschuetzia trilobata* (Germeraad and others, 1968).

Pteridophyta

Figure 11 *Osmundacites* sp. C. (Meesuk, 1986).

Figure 12 *Polypodiaceasporites haarditi* (Pot et Ven) Thiergart 1938 [*Laevigatosporites haarditi* (Pot & Ven) Thiergart] (ETSPADR, 1989).

Figure 13 *Deltoidospora regularis* (Pflug) Sung et. Zheng (ETSPADR, 1989).

Gymnospermae

Figure 14 *Pinus labdacus* f. minor potonie (RCPLS, 1985).

Fungal Spores

Figure 15 *Monoporisporites* sp. (ETSPADR, 1989).

Figure 16 *Exessisporites* sp. GLASS AND ELSIK (Glass and Elsik, 1986).

Figure 17 *Dicellaesporites lenghuensis* Song (RTPQB, 1985).

Plate 1

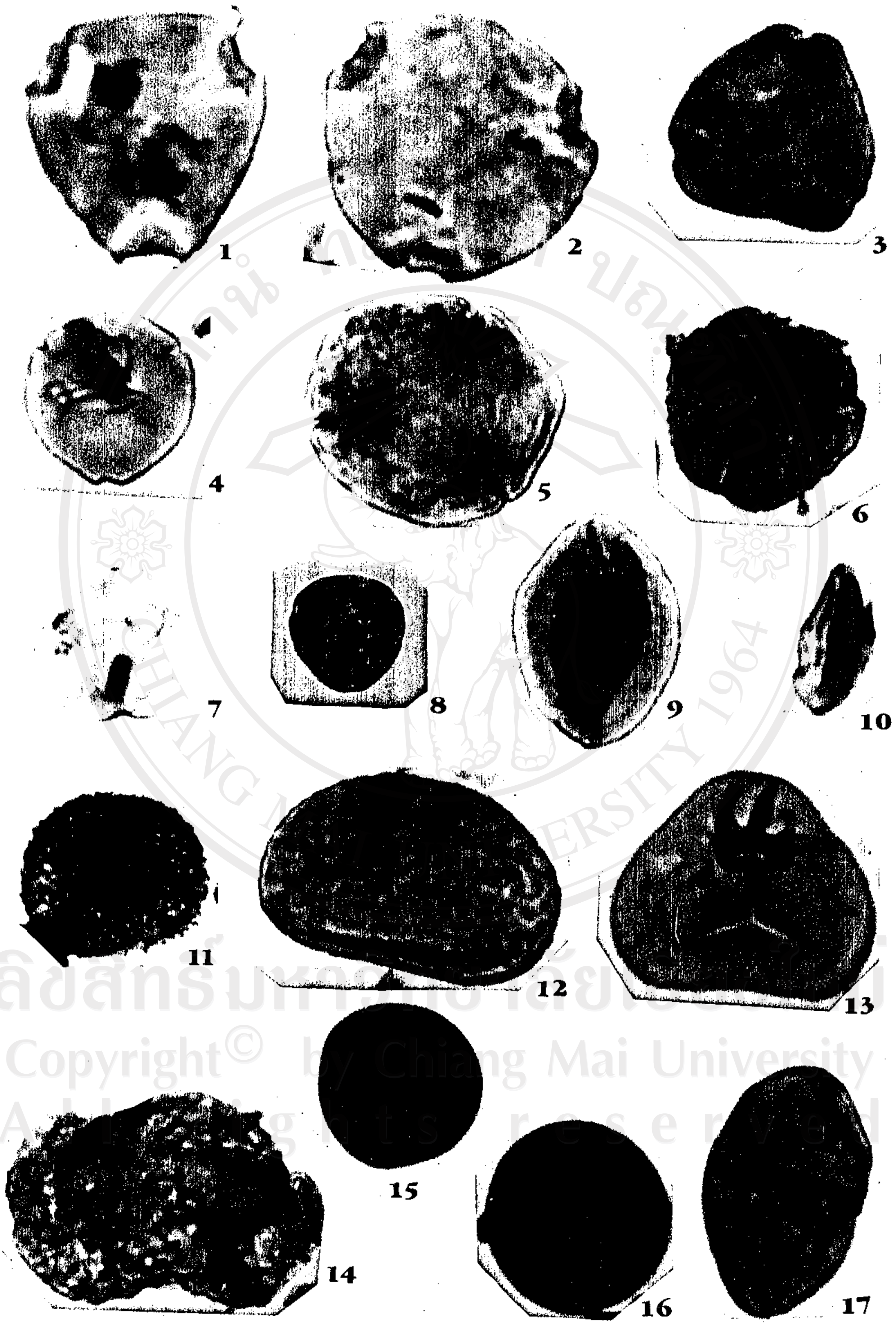


Plate 2

Angiospermae

Figure 1 *Sallixipollenites* cf. major Ke et Shi (RCPLSA, 1985).

Figure 2 *Faguspollenites mediocus* Zheng, 1985 (RCPLSA, 1985) [A Research on Cenozoic palynology of the Longjing structural area in Shelf Basin of the East China Sea (Donghai)].

Figure 3 *Margocolporites* Vanwijhei (Germeraad and Others, 1968).

Figure 4 *Labitricolpites* Ke et Shi (ETSPADR, 1989).

Figure 5 *Fraxinopollenites microregulatus* Ke et Shi (RCPLSA, 1985).

Figure 6 *Cruciferaeipites minor* Zheng gen et sp. nov. (RLCPBS, 2989).

Figure 7 *Cyrillaceaepollenites miniporus* Zheng sp. nov. (RLCPBS, 1989).

Figure 8 *Symplocoipollenites vestibulum* (Potonie) Potonie' (RCPLSA, 1985).

Figure 9 *Betulaepollenites lenghuensis* Song et Zhu sp. nov. (RTPQB, 1985) [Research on Tertiary Palynology from the Qaidam Basin, Qinghai Province].

Figure 10 *Abutilonacidites bohainesis* Guan et Zheng gen. et. sp. nov. (RLCPBS, 1989).

Figure 11 *Rhoipites bradeleyi*, Wodehouse (ETSPADR, 1989).

Figure 12 *Polypodiaceoisporites regularis* Zhang 1981 (RCPLSA, 1985).

Figure 13 *Foveoinaperturites* sp.4 (RLCPBS, 1989).

Gymnospermae

Figure 14 *Pinuspollenites labdcus* maximus (Pot.) Potonie (RTPQB, 1985).

Figure 15 *Foveotriletes* sp. G.X. Li sp. nov. (ETSPADR, 1989) (x 400).

Figure 16 *Cynathidites minor* Couper (RTDQB, 1985).

Fungal Spore

Figure 17 *Fusiformis rugosus* (Sheffy and Dilcher, 1971).

Plate 2

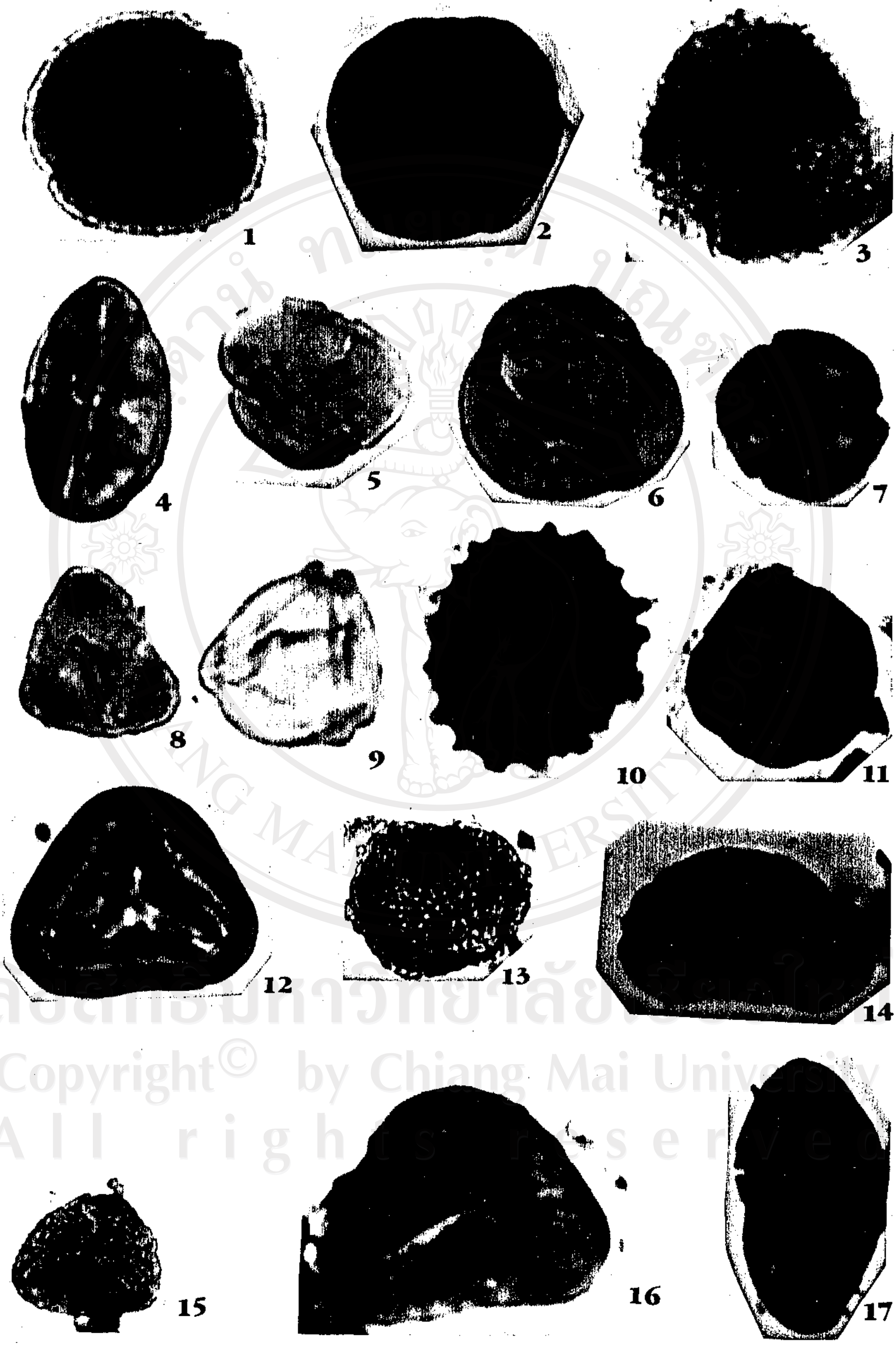


Plate 3

Angiospermae

Figure 1 *Sparagniaceaepollenites sparganoides* (Meyer) Krutzsch (RTPQB, 1985) (A Research on Tertiary Palynology from Qaidam Basin).

Figure 2 *Pericariopollis lusticus* Krutzsch (ETSPADR, 1989) [Early Tertiary spore and pollen assemblages from the Dongu Region].

Figure 3 *Ranunculacidites versus* Song et G.X. Li sp. nov. (ETSPADR, 1989).

Figure 4 *Tricolpite baculatus* (Kar and Kumar, 1986).

Figure 5 *Rutaceoipollis paraviporus* Zheng sp. nov. (RCPLSA, 1985).

Figure 6 *Cupuliferoipollenites pusillus* (Pot) potonie [Synonym : *Tricolporopollenites cingulum pusillus* (Pot.) Thomson et Pflug (ETSPADR, 1989)].

Figure 7 *Florschuetzia trilobata* (Germeraad and others, 1968).

Figure 8 *Florschuetzia semilobata* (Germeraad and others, 1968).

Figure 9 *Zonocostites ramamoe* (Germeraad and others, 1968).

Figure 10 *Momipites coryloides*, wodehouse (ETSPADR, 1989).

Gymnospermae

Figure 11 *Piceaepollenites sacculiferoides* (Krutzsch) Zhu et Wu comb. nov. (RTPQB, 1985) [A Research on Tertiary Palynology from the Qaidam Basin, Qinghai Province].

Pteridophyta

Figure 12 *Verrucatosporites* cf. *V. favus* (Potonie) Thomson & Pflug (Synonym : Polypodiisporites favus Potenie) [RCPLSA, 1985).

Figure 13 *Verrucatosporites inanghuensis* (Couper) Krutzsch, 1959 (Meesuk, 1986).

<u>Fungal Spores</u>

Figure 14 *Hypoxylonites sulekii* (Elsik, 1990).

Figure 15 *Multicellaesporites ellipticus* (ETSPADR, 1989).

Figure 16 *Hypoxylonites ramanujamii* (Elsik, 1990).

Figure 17 *Hypoxylonites gulfensis* (Elsik, 1990).

Plate 3

Plate 4

Angiospermae

Figure 1 *Tricolporopoll. cingulum fusus* (Potonie') Thomson & Pflug, 1953 (Meesuk, 1986).

Figure 2 *Zonocostites ramanoe* (Germeraad, 1968).

Figure 3 *Alnipollenites versus* (Potonie) Potonie (Germeraad & others, 1968).

Figure 4 *Echiperiporites estelae* (Germeraad and others, 1968).

Figure 5 *Psilatricolporites operculatus* Van der Hammen & Wystra 1964 (Germeraad & others, 1968).

Figure 6 *Spinozonocolpites echinatus* (Germeraad & others, 1968).

Gymnospermae

Figure 7 *Inaperturopollenites hiatus* (Potonie) Thomson & Pflug, 1953 (Meesuk, 1986; ETSPADR, 1989).

Figure 8 *Pinuspollenites strobiformis* (Zalk) Song comb. nov. (ETSPADR, 1986).

Figure 9 *Pityosporites* cf. *P. labdacus* (Potenie) Thomson & Pflug, 1953 (Meesuk, 1986).

Pteridophyta

Figure 10 *Verrucatosporites usmensis* (Van der Hammen) [Germeraad and others, 1968].

Figure 11 *Magnastriatites granulastriatus* Li sp. nov. (RCPLA, 1985) [A Research on Cenozoic Palynology of the Longjing structural area].

Figure 12 *Magnastriatites howardi* (Germeraad & others, 1968).

Plate 4

Plate 5

Microthyriaceous fungi

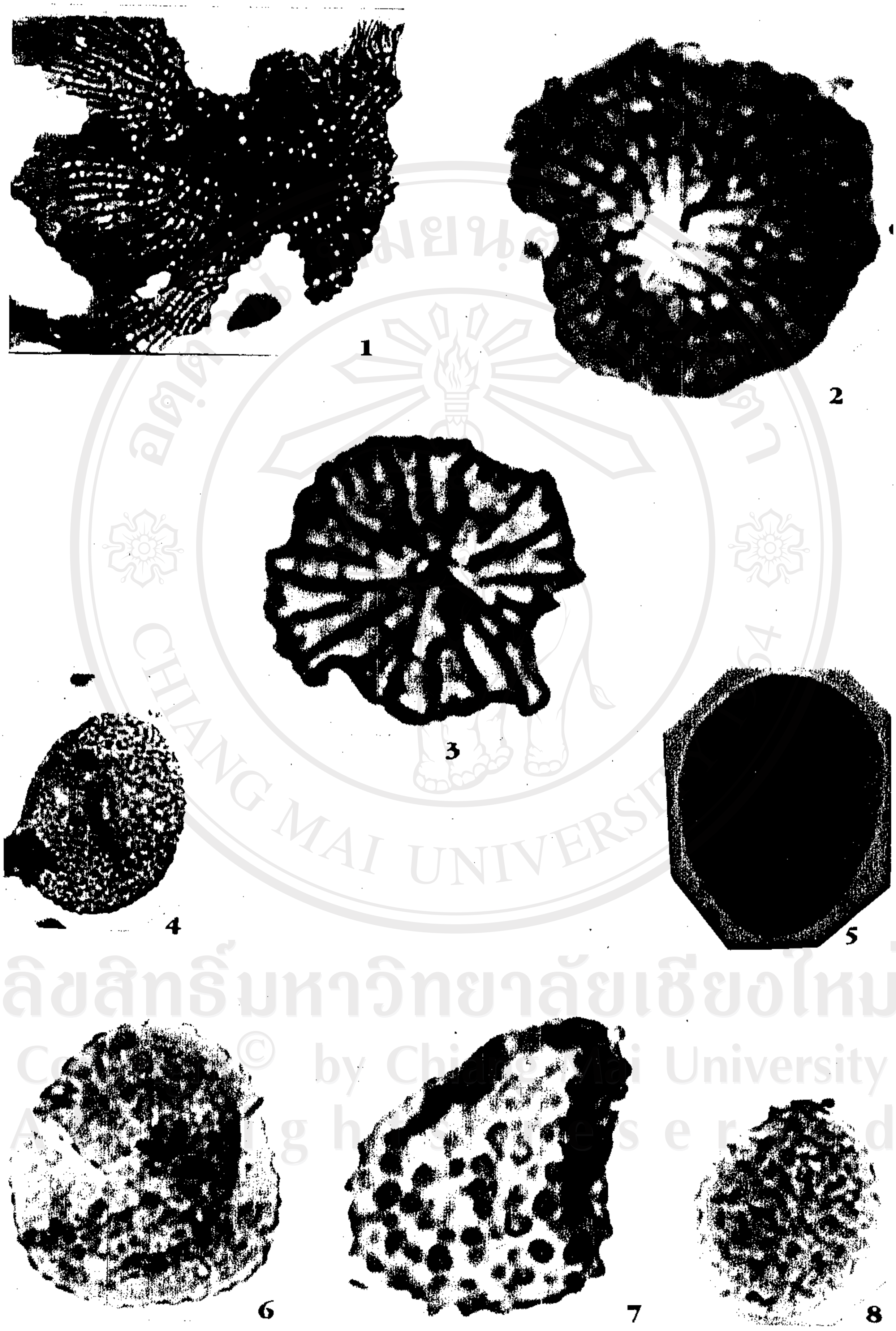
Figure 1 *Callimothallus pertusus* Dilcher, 1965 (Elsik, 1978).

Figure 2 *Microthallites lutosus* Dilcher, 1965 (Elsik, 1978).

Figure 3 *Asterothyrites minutus* Cookson, 1947a (Elsik, 1978).

Figure 4-8 Undentified fossils.

Plate 5



5.4 SYSTEMATIC PALYNOLOGY

Palynomorphs occurring most abundantly or which are given special emphasis for their age, paleoenvironmental or ecological significances are systematically described below :

Genus Hypoxylonites.

Type species : *Hypoxylonites Sulekii* Elsik (Plate 3, Figure 14).

Diagnosis : Aseptate, psilate fungal spore ca. 10-14 x 34-44 um overall. Spore outline in top view is narrowly elliptical, with the rounded to narrowly rounded ends slightly or markedly protruded. The longitudinal furrow is a narrow slit or can be gapping with rounded ends. Outline in side view reinform or boat shaped, assymetrical, ends of the spore to the furrow are convex, then become straight to concave along the furrow.

Age Lower and/or middle Miocene.

Genus Magnastratites nov.

Type species : *Magnastratites howardi* (Plate 4, Figure 12).

Diagnosis : Single grain, radially symmetrical, anisopolar, with rounded distal pole, and more pointed proximal pole, in polar view nearly circular; shape suboblate to spherical. Contact area of proximal face psilate, surrounded by a circular ridge, which makes contact with the striated ridge pattern at the points of the laesura.

Taxonomic affinity : Virtually identical with the spores of the tropical-subtropical fresh-water fern genus *Ceratopteris*.

Age Upper Eocene-Recent.

Genus Floreschuetzia nov. gen.

Type species : *Floreschuetzia semilobata* (Plate 3, Figure 8).

Diagnosis : Single grain, radially symetrical, isopolar; prolate; in polar view lobate. Triporate, interlobate, endexinous (in less well preserved grains appearing as endexine + ectexine). Total wall thiness 1-2 u on poles and meridional ridges, probably < 1 u on porate fields; endexine < 1/2 u thick, columella generally indistinct, tectum ± 1 u thick, areolate-verrucate, coarser on meridional ridges.

Taxonomic affinity : aperture and sculptural type clearly point to affinity with the pollen of *Sonneratiaceae*.

Age Lower Miocene.

Genus CALLIMOTHALLUS DILCHER, 1965

Type species : *Callimothallus pertusus* (Plate 5, Figure 1).

Diagnosis : Individual cells may possess a signle pore, although normally not every cell in a single specimen may be porate; the porate condition is required for at least a number of cells.

Affinity : *Microthyriaceous fungi*

Age Early Eocene to Lower Oligocene (Elsik, 1978).

Genus

Type species : *Tricolporopollenites cingulum* subsp. *Pusillus* (Pot.) Thomson et Pflug, Thomson et Pflug (Plate 3, Figure 6).

Diagnosis : Pollen grains free, isopolar, prolate, Tricolporate, 1.5-2 um thick, very fine and faintly intrarugulate structure, surface sculpture laevigate to faintly psilate.

Affinity : probably related to the genus *Castanea* or *Castanopsis*.

Age Oligocene-Miocene.

Genus

Type species : *Verrucatosporites* cf. *V. favus* (Potonie') Thomson & Pflug 1953 (Plate 3, Figure 12).

Diagnosis : Monolete spores, bean-shaped with straight proximal outline in equatorial view, bilateral symmetry, laesura straight and simple. Densly verrucate, verrucae densly packed but mainly inconspicous, about 2-2.5 um in diameter.

Affinity : *Polypodiaceae* (Thomson & Pflug, 1953).

Age Middle Oligocene-Lower Miocene

Genus *Zonocostites* nov. gen.

Type species : Single grain, radially symmetrical, isopolar, spherical, Tricolporate, colpi ectexinous, medium long, straight with pointed ends, slightly costate often almost psilate on equator, or thicker at poles due to longer columalae.

Age Oligocene to Recent.

Genus Exessisporites

Type species : *Exessisporites* sp. Glass and Elsik (Plate 1, Figure 16).

Diagnosis : Fungal spore, aseptate, outline circular, porate, single pore central, often subrounded by slightly thickened area (annulus); margin (equator ?) slightly thickened and occassionally with slit or separation; surface psilate to finely granulate, color dark brown to black.

Age Early to Middle Miocene.

Genus Spinozonocolpites Muller, 1968.

Type species : *Spinozonocolpites echinatus* (Plate 4, Figure 6).

Diagnosis : Single grain, radially symmetrical, slightly anisopolar; sublobate-spherical. Spines scattered on tectum, 5-13 u long, 10-12 apart, echinate with a rather blunt to pointed apex, with the lower part slightly expanded, straight or slightly curved.

Taxonomic affinity : indentical with pollen of Nypa fruticans (Arecaceae or Palmae).

Age Upper Cretaceous to Recent.

Genus OSMUNDACIDITES COUPER, 1953.

Type species : *Osmundacites* sp. C (Plate 1, Figure 10).

Diagnosis : Spores radial, trilete, sub-circular to circular in polar view. Laesurae straight, extent about 2/3 to 3/4 of spore. Sculpture rugulate. Exine thickness 2.5-2 um, generally obscured by ornaments.

Age Middle Oligocene-Middle Miocene.

5.5 PALYNOLOGIC ASSEMBLAGES AND PALEOENVIRONMENTAL INTERPRETATION

Based on the distribution and abundance of the palynomorphs, a local subdivision of the sequence into two distinct palynomorphic assemblages has been estabilished. Paleoenvironmental and to a lesser extent ecological inferrences have been attempted by comparison with the available sedimentological and stratigraphic data. In order to facilitate the interpretation, the botanical affinities of some spores and pollens is given in Table 5.1.

Table 5.2 Possible botanical affinities of Tertiary Palynomorphs from IF 30 03S.

Extant taxon		Fossil Taxon
Family	Genus	
<u>PTERIDOPHYTES</u>		
OSMUNDACEAE	Osmunda	*Osmundaciditessp.* c.
PARKERIACEAE	Ceratopteris	*Magnastriatites howardi*
POLYPODIACEAE	Asplenium type	*Laevigatosporites haardti*
	Polypodium type	*Verrucatosporites inangahuensis* *V.* cf. *favus*
	Stenochlaena	*Verrucatosporites usmensis*
TAXODIACEAE	Taxodium	*Inaperturopollenites hiatus*
PINACEAE	Pinus	*Pityosporites* cf. *P. labdacus* *Pinuspollenites labdcus maximus* *Pinuspollenites strobiformis*
<u>ANGIOSPERMS</u>	Alnus	*Alnipollenites versus*
BETULACEAE	Betula	*Betulaepollenites claripites* *Betulaepollenites lenghuensis*
	Castanea/Castanopsis	*Tricolporopollenites cingulum oviformis* *Tricolporopollenites pusillus* *Graminidites gracilis*
NYSSACEAE	Nyssa	*Nyssapollenites puedolaesus* *Nyssapollenites microregulatus*
FAGACEAE	Quercus Fagus	*Quericoidites henrici* *Faguspollenites mediocus*
SONNERATIACEAE	Sonnertia	*Florschuetzia trilobata* *Florschuetzia semilobata*
LEGUMINOSAE	Caesalpinia	*Margocolporites* cf. *cribellatus srivastava* *Margocolporites minor*

Table 5.2 Cont.

Extant taxon		Fossil Taxon
Family	Genus	
SYMPLOCACEAE	Symplcoipollenites	*Symplocoipollenites vestibulum*
	Symplcopollenites	*Symplocospollenites latiporous*
JUNGLANDACEAE	Carya	*Caryapollenites triangulus* *Platycaryapollenites*
RUTACEAE	Ptelea	*Tricolporopollenites cingulum fusus*
TILIACEAE	Tilia	*Tiliaepollenites instructus*
RHIZOPHORACEAE	Rhizophora	*Zonocostites ramonae*
<u>PTERDOPHYTES</u> POLYPODIACEAE	Polypodiaceae-sporites	*Polypodiaceasporites gracilis*
	Polypodiisporites	*Polypodiisporites* cf. *aliens*
	Polypodiaceoi-sporites	*Polypodiaceoisporites regularis*
<u>MICROTHYRIACEOUS FUNGI</u>	Callimothallus	*Callimothallus pertusus*
	Microthallites	*Microthallites lutosus*
	Asterothyrites	*Asterothyrites minutus*

5.5.1 Palyno-assemblage 1

This microfloral assemblage represents the lower lacustrine facies in the sedimentary succession. Framework components comprise predominantly of angiosperms, quite few species of pteridophytes and relatively scarce gymnosperm pollens and spores. Typical association diagonising this assemblage includes rare *Magnastriatites*, common to abundant *Polypodiaceae (Polypodium* type, *Stenochlaena)*, rare *Pinaceae (Pinuspollenites)* and *Piceapollenites*, fairly abundant *Quericoidites* and *Nypa (Spinozonocolpite* sp). The *Pinaceae* and *Piceae* varities are fairly common but are not as abundant as they are in palyno-assemblage 2, whereas, *Betulaceae, Tilaceae, Nyssaceae* are exlusively missing. The *Sonneratiaceae-Florschuetzia trilobata* and *Florschuetzia* semilobata decline drastically as compared to palyno-assemblage 2 and are restricted to the upper part of the lacustrine facies. This assemblage is further characterised by a large number of *Ephiphyllous* and *Microthyriaceous* fungal spores (*Callimothallus pertusus, Dicellaesporites, Pluricellaesporites* and *Multicellaesporites, Hypoxylonites*). On the species level also rare elements such as *Psilatricolporites operculatus, Microfoveolatosporites psuedodentatus, Alnipollenite versus, Punctatosporites* and *Echiperiporites estalae* were also noted. Mangrove pollens are relatively sparse and are represented by the *Rhizophora-Zonocostites ramonae* and *Nypa* species (*Spinozonocolpites echinatus*).

Palynomorphs of special paleo-environmental or - of climatic significance include *Magnastriatites howardi*, and *Callimuthallus pertusus*. *Magnastriatites howardi* is said to have a strong taxonomic affinity to the fern genus *Ceratopteris*. The parent plant of this species grows as small aquatic fern in shallow and fresh-water habitats bordering lakes or river banks (Germeraad and others, 1968). The *Microthyriaceae* fungi including *Callmothallus pertusus* are ecoparasites dwelling on tropical and sub-tropical vegetation (Elsik, 1978). At the generic level also forms such as *Quericodites, Polypodiaceae* and *Tricolporopollenites*, and *Ephiphylous* fungal spores clearly indicate a tropical to sub-tropical climate. Further, *Polypodiaceae* are indicative of humid climate. The assemblage also includes quantitatively insignificant amounts of mangrove elements (*Florschuetzia trilobata, Florschuetizia semilobata*, the *Rhizophora-Zonocostites ramonae*). For mangroves which are known to be prolific producers of pollens, the amount preserved here is quite insignificant. Hence, the possibility of an insitu supply by direct shedding from the parent plant can be ruled out. Instead, the mangrove pollens could have been supplied by various means including erosion from adjacent brackish and fresh-water environments. It is probable that a mangrove environment existed in close proximity to the depositional site. *Spinozoncolpites echinatus* is taxonomically identical with *Nypa* fructicans. The latter is at present restricted to the mangrove environments of the humid Indo-Malesian tropics, from the Ganges delta to North Australia (Germeraad and others, 1968). The *Rhizophora-Zonocostites ramonae* is reported from a variety of environmental conditions including coastal and marine strata of the tropics.

In short, the microfloral assemblage is predominantly characteristics of a humid tropical and subtropical type climate and apparently typical of a pre-Neogene aspect.

5.5.2 **Palyno-assemblage 2**

This microfloral assemblage represents the fluvio-lacustrine and the upper lacustrine facies. It is further subdivided into two distinct sub-assemblages, referred to as palyno-assemblage 2.1 and palyno-assemblage 2.2.

A. Palyno-assemblage 2.1

This association is characteristics of the fluvio-lacustrine facies and is represented by the presence of *Florschuetzia trilobata, Florschuetzia semilobata,* fairly abundant *Quericodites, Polypodiacea,* rare forms such as *Tricolporopollenites, Trilobapolis, Retitricolpites, Tricolpites, Tricolporites. Ephiphyllous* fungal spores are ubiquitous throughout much of the section, of which, *Hypoxylonites sulekii* and *Hypoxylonites gulfensis* are the most prominent ones. *Microthyriaceous* fungi are also present but are not as such abundant. Here, there is a perceptible increase in *Quericoidites* and *Polypodiaceae* as compared to palyno-assemblage 1.

Core and back-mangrove pollens such as *Rhizophora (Zonocostites ramonae)* and *Nypa,* respectively, are scarce, although well preserved. They rather form a minor component of the lowermost part of the succession.

The microfloral assemblage shows a Middle Tertiary aspect. The climate under which such an assemblage could have sustained is assumably one of a tropical to sub-tropical type. The core as well as back mangrove taxa could represent authocthonus pollens belonging to a hinterland vegetation such as a mangrove swamp but were ultimately transported into the lake sediments by some means.

B. Palyno-assemblage 2.2

The association represents the upper part of the Mae Sot Formation, mainly a continental clastics comprising of lake sediments. Angiosperms, Gymnosperms and Pteridophytes are the main source materials contributing to this assemblage. Species and/or families characterising this assemblage include *Quericoidites* and *Polypodiaceae* (abundant *Polypodiaceasporites*, few *Polypodiaceoisporites) Pinaceae (Pinuspollenites)* and *Betulaceae (Deltoidospores, Betulaceapollenites*). The *Quericoidites-Polypodiaceae* assemblage is the most abundant in the upper part of the succession but distinctly decreases in the lower part. A noteworthy feature of the lowermost part is a distinct increase in *Pinaceae* and *Betulaceae* and the introduction of rare species such as *Tilaceae, Nyssaceae, Junglandaceae, Faguceae, Osmundacea, Taxodiaceae* (*Inaperturopollents hiatus*). Under rare circumstances species such as *Tricolporopollenites, Tricolpites, Margocolporites, Compositae* (*Echiperiporites estelae* and *Echitrocolporites spinosus*) were encountered. Core and back-mangrove pollens form a minor component of the lowermost part of the succession. These include the *Rhizophora* type (*Zonocostites ramonae*) and *Nypa* respectively. The relatively low amount of these pollens is indicative that they were not part of the pollen site but were probably carried to the lake sediments by some means. A mangrove swamp or environment in the vicinity of the depositional site could have been the source.

Few of these elements may have some significance in paleo-environmental interpretation and climatic indication. For instance, a warm climatic condition is well represented by *Taxodiaceae* and *Betulaceae* and that of cool temperate climate by species such as *Pinus*. Furthermore, damp and humid conditions are represented by the occurrence of *Polypodiaceae* and *Osmundaceae* (Wilkinson and Boutler, 1980) which as well are indicative of cool/warm temperate and tropical/sub-tropical climates (Stuchilik, 1964). On the generic level, forms such as *Castanea/Castanopsis* and *Leguminosea* (Table 5.2) are indicative of a sub-tropical climate. In addition, peat swamp forest or open swamp and shallow lake conditions could be reflected by species such as *Osmundaceae, Faguceae (Castanea/Castanopsis), Polypodiacea (Asplenium* type) and Rutacea (Ptelea) [Table 5.2]. These could possibly suggest the existence of extensive swamp forest bordering the lake.

In general, microfloral assemblage (2) includes a wide assortment of various elements including warm and/or cool temperate and tropical/sub-tropical varieties. Such a mixture, at first, appears to be out of order. However, the temperate varieties are most likely to have been transported into the basin from a coeval upland vegetation. Considered overall, the major source material (paleo-vegetation) may be inferred as to have included swamp forests with Taxodium and Nyssa; shrubs of *Polypodiaceae* ferns; hardwood forest of *Fagaceae (Quericodites, Tricolporopollenites)*; and conifer forests of Betula and *Pinaceae* etc.

The microfloral successions (Palyno-assemblages 1 and 2) described above appear to show a unique trend, where dominantly tropical/sub-tropical taxa at the bottom pass gradually into one of a mixed assemblage (temperate and tropical to sub-tropical type). The situation might probably be similar to the general cooling trend for continental climates previously reported by some workers and cited by Elsik (1969) since Eocene.

5.6 AGE APPROXIMATION

Summary of the stratigraphic occurrences of selected palynomorphs is illustrated in Figure 5.1. A few of these palynomorphs are known to span through relatively short periods in the stratigraphic record, hence, proved to be sufficiently adequate in making a preliminary age assessment. The interpretation was also enhanced or substantiated by several others which are either abundant or widely distributed throughout the section.

The age diagnostic palynomorphs include *Florschuetzia trilobata, Florschuetzia semilobata, Magnastriatites howardi, Verrucatosporites usmensis, Zonocostites ramonae, Verrucatosporites* cf. *V. favus, Tricolporopollenites, Alnipollenites versus, Psilatricolporites operculatus, Echtricolporites spinosus, Echiperiporites Estelae, Hypoxylonites sulekii, Hypoxylonites gulfensis*, etc. The overall palynomorphic assemblage is suggestive of an Oligocene to lower Miocene age.

The lower lacustrine and the fluvio-lacustrine facies, higher in the succession, are mainly characterised by the dominance of *Florschuetzia trilobata, Florschuetzia semilobata, Zoncostites ramanoe, Echtricolporites spinosus, Echiperiporites estelae, Hypoxylonites sulekii* and *Hypoxylonites guifensis*. Individual species such as *Florschuetzia trilobata* and of the Oligocene to Lower Miocene sediments in southeast Asia (Germeraad, and

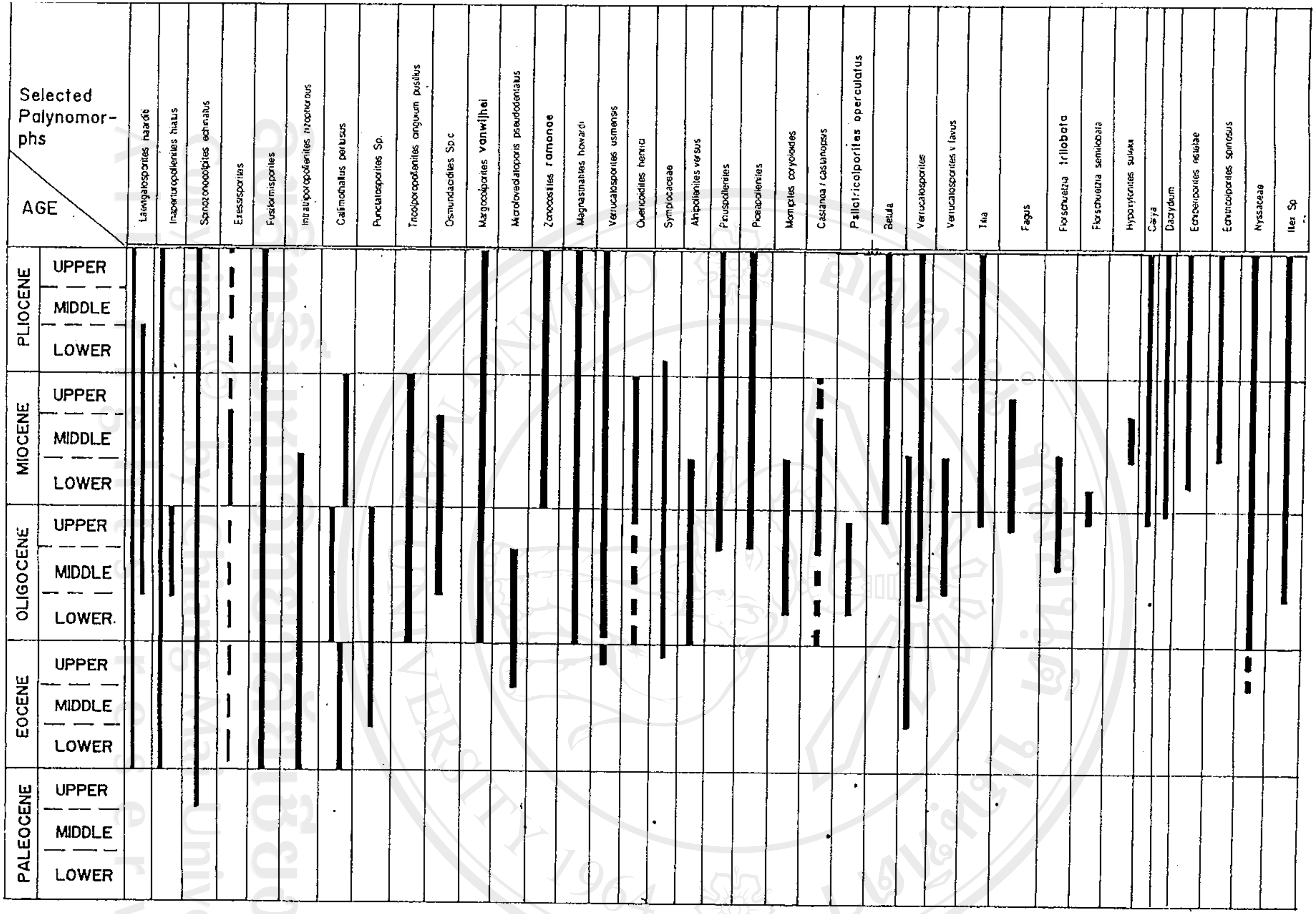


Figure 5.1 Known stratigraphic ranges of selected palynomorphs of Oil Well IF 30 03S

others, 1968). In particular, *Florschuetzia semilobata* is supposed to have entered into the stratigraphic record during Lower Miocene and was extinct shortly afterwards. The assemblage also lacks *Florschuetzia levipoli* and *Florschuetzia meridionalis* which are younger forms of Sonnertia, and appeared in south-east Asia during late Miocene. The *Rhizophora* type - *Zonocostites ramonae* reached its maxima in Miocene; hence is considered to be characteristics of Neogene sediments. The *Ephiphyllous* fungal spores - *Hypoxylonites sulekii* and *Hypoxylonites gulfensis* were reported from the Lower Miocene sediments of the Gulf coast area and from the Middle Miocene strata of Venuzuela (Elsik, 1990). Taking all these facts into consideration, a late Oligocene - Lower Miocene age appears to be quite a reasonable approximation for this part of the succession.

The basal lacustrine facies is characterised by the occurrence of *Magnastriatites howardi, Verrucatosporites usmensis, Callimothallus perfusus, Tricolporopollenites, Alnipollenites versus, Psilatricolporites operculatus, Echiperiporites estelae, Quericoidites, Piceapollenites, Pinacea* and several others listed in palyno-assemblage 1. In the virtual absence of age indicating fossils, as is the case here, a group of fossils are as equally valuable as index fossils do in age diagnosis. The group of fossils included in this partial list are common place elements of Oligocene strata. For instance, in the complete absence of index fossils of Oligocene age, an age range of Middle/Late Eocene - to Early Oligocene, is considered to be reasonable for *Verrucatosporites usmensis* (Germeraad, 1968). *Verrucatosporites* cf. *V. Favus* has been reported from the Middle

Oligocene to Lower Miocene of Germany (Krutzsch, 1967). *Alnipollenites versus*, *Piceapollenites, Pinacea, Quericoidites, Polypodiaceae* (RTPQB, 1985); *Tricolporopollenites, Intratriporopollenites* cf. *I. rizophorous* (Wilkinson and Boutler, 1953; Ziembinska - Twozdlo, 1974); *Callimothallus pertusus* (Elsik, 1978) were reported from sedimentary sequences Oligocene age. Palynologically, the deposit can be possibly correlated with some deposits in the Li Basin (eg. Ban Pa Kha) which are of Oligocene - lower Miocene and its upper could possibly match with the Wiang Haeng deposit (lower Miocene).

As reported by Asnachinda (1978), most of the Tertiary intermontane basins including the Fang Basin are said to have originated as a result of a Late Cretaceous or Early Tertiary extensional rifting. From such a data and the palynological evidence stated here, it is possible to deduce tentatively that Tertiary strata of IF 30 03S could be of Oligocene - Lower Miocene age. The possibility of extending the lower limit to a pre-Oligocene age, at least for this borehole which did not reach the basement and, partly for the lack of fossil evidence of an older age is restricted.

A similar palynological assemblage has been reported from the Mae Soon and Pong Nok Basins (Ratanasthien and Haraluck, 1987). According to these workers, an upper Eocene sedimentation at Mae Soon, and a possibility of younging of the sediments and expansion of the basin to the east was postulated. The strata, both at these basins and IF 30 03S match well with respect to their palynological as well as sedimentological characters. Based on these data, it is probable that the basin might have as well extended to the NW sometimes during the Oligocene.

Palynomorphs recorded in the preliminary palynomorphic population but not illustrated in the plates are listed below. The distribution of palynomorphs and the corresponding facies of IF 30 03S is summarised in Table 5.3.

Angiospermae

Echitricolporites spinosus Van der Hammen

Graminidites gracilis Krutzsch, 1970

Quericoidites microhenrici (Potonie') Potonie'

Sallixpollenites pseudoporites Sung et Tsao, 1976

Margocolporites sp.

Echitricolporites minor Song et Zhe sp. nov.

Tricolporites paenstriatus Stov and Part, 1973

Tricolporopollenites margaritatus (Potonie') Thomson and Pflug

Artemisiaepollenites selluris Nagy, 1969

Aceripollenites communicus Zheng sp. nov.

Pericariopollis minor (Meusli) Krutzsch, 1962

Quericoidites asper (Thomson and Pfug) Song and Zheng

Echitricolporites microechinatus (Trevisan) Zheng comb. nov.

Rhoipites cf. *isoreticulatus* Kemp, 1970

Echitricolporites sp. 1

Illex sp. (Fair Child and Elsik, 1969)

Margocolporite minor Zheng sp. nov.

Lonicerapollis gallwitzii Krutzsch

Rhoipites pseudocingulum (Potonie') Potonie'

Retitricolpites matauraensis (Couper) Song and Zheng

Cyrillaceaepollenites megaexactus (Potonie') Potonie'

Rutaceoipollis ovatus Sung and Tsao

Intratriporopollenites cf. *I. rizophorous* (Pot). Subsp. geiselaensis

Gymnospermae

Piceapollenites alatus Potonie, 1931

Pinuspollenites pachydermis Ke et Shi

Dacrydiumites florinii Cookson and Pike

Taxodiaceaepollenites elongatus Ke et Shi

Abietineaepollenites microalatus f. minor Potonie'

Podocarpidites nageiaformis (Zalk) Krutzsch

Podocarpidites biformis Rouse, 1959

Piceaepollenites planoides (Krutzsch) X.J. Sun and Li

Pteridophytes

Verrucatosporites secundus Potonie

Verrucatosporites cf. *V. megabaltics* Krutzsch, 1967

Polypodiisporites aliensis Potonie' emend. Khan and Martin, 1971

Polypodiidites Vesicoverus Song et Zheng

Extrapunctatosporis gracilis Zhang sp. nov.

Extrapunctatosporis ovatus Zhang

Microfoveolatosporis pseudodentatus Krutzsch, 1973

Punctatosporites Ibrahim, 1933

Ephiphyllous fungi and Others

Diporisporites oblongatus Ke et Shi

Pluricellaesporites sp. Van der Hammen

Inapertisporites sp. Van der Hammen

Lacrimasporonites sp. Sheffy and Dilcher

Table 5.3 Distribution of palynomorphs and the corresponding sedimentary facies of Oil Well IF 30 03S

AGE	Litho-strat i-graphy	Litho-logy	Unit	Facies	Palynomorphic assemblages and sub - assemblages		
Late Micoene - Holocene*	MAE FANG		Unit 4 - 6	Fluviatile			*Quericus* sp.,* *ulmus*,* *Combretaceae*
Late Oligocene-Lower Miocene	MAE SOD		Unit 3	Upper Lacustrine	Palyno - assemblage 2	Palyno - assemblage 2.2	*Quericoidites, Tiliaceae, Polypodiaceae (Polypodiaceae-sporites, Polypodiaceoisporites), Pinaceae, Betulaceae, Jungladaceae,* (*Carya*), *Faguceae Osmundaceae, Compositae, Nypa*
			Unit 2	Fluvio - lacustrine		Palyno - assemblage 2.1	*Florschuetzia trilobata* *Florschuetzia semilobata* *Zonocostites ramanoe* *Polypodiaceae* *Quericoidites* *Ephiphyllous fungi*
Oligocene			Unit 1	Lower Lacustrine	Palyno - assemblage 1		*Magnastriatites, Quericoidites, Pinaceae, Piceae, Polypodiaceae (Polypodium* types, *Stenochlaena). Tricolporopollenites, Ephiphyllous* and *Microthyriaceous fungi* and other Angiosperms

N.B. Asterix (*) = Previous work Pradidtan, (1989)