GEOLOGY OF THE TERTIARY COAL BASINS OF THAILAND

by

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SUMMARY

Non-marine Cenozoic deposits are found in many small intermontane basins and larger regional basins in Thailand. These basins are fault-bounded grabens and half grabens. Coal seams of up to 35m thick are commonly found interbedded with mudstone, shale, sandstone, and minor oil shale, carbonate, diatomite, gypsum, and conglomerate of Tertiary age. Quaternary fluvial deposits are generally found lying unconformably over the coal-bearing strata. The rank of the coal ranges from lignite B to high-volatile C bituminous (A.S.T.M. classification). Coal of higher rank (low volatile bituminous) is also found associated with carbonaceous shale, carbonaceous sandstone and conglomerate of Carboniferous age. A few small deposits are found in narrow stream valleys in the northeastern part of the country.

One hundred coal samples from the Cenozoic : Mae Teep, Mae Mo, Li (Ban Pu), Mae Tun, and Krabi (Bang Pu Dam) basins and Carboniferous Na Duang deposit are palynologically studied. The method using Schulze reagent is employed for sample extraction. Permanent slides are made using Cellosize (hydroxyl cellulose) as the dispersing and mounting medium together with Histomount.

At least 155 species of Cenozoic spores and pollen grains, 14 other plant microfossils (mainly fungal remains), and 4 Carboniferous spores are listed. A total of 74 species were identified, described and discussed in terms of other records. This comparative analysis shows that the Cenozoic deposits are of Lower Eocene to Upper Pliocene age and the Carboniferous deposit is of Westphalian A age. The assemblages indicated warm temperature, subhumid, upland flood plain conditions for the Li (Ban Pu) deposit; the same but drier for the Mae Tun deposit; temperate, damp, humid, peat swamp forests for the Mae Teep deposit; warm temperature to subtropical, subaquatic for Mae Mo; and tropical, coastal swamp forests for the Krabi (Bang Pu Dam) deposit.

Some petrological and organic geochemical observations of Mae Mo samples show the high proportions of the maceral densinite and a high angiosperms input (as indicated by the high proportion of Triterpenoids in the sample).

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CHAPTER 1

INTRODUCTION

1.1 General

Coal deposits in Thailand are mainly found within Cenozoic basins associated with sedimentary rocks of Tertiary age. About 60 basins are scattered around the country both inland and offshore. In this study, the coal samples were collected from 5 Cenozoic deposits known as Mae Teep, Mae Mo, Li (Ban Pu), Mae Tun (located in the North) and Krabi (Bang Pu Dam) deposits (from the South). High-grade coals were also collected from Carboniferous deposit of the Northeast, namely Na Duang deposit.

The geology and stratigraphy of the basins were discussed for both Tertiary and Carboniferous deposits. A total 100 samples of coal were analysed palynologically in order to study the morphology of the fossil spores and pollen grains found within the samples. The specimens were described systematically using the existing artificial systems. The distribution and relative frequency of each species were determined.

The stratigraphic significance of the identified species were summarized and the palaeoecology of the basin were discussed on the basis of their microfloral assemblage.

The chemical properties of the samples were described and summarized. Some samples were examined for their petrological and organic geochemical characteristics and were briefly discussed.

1.2 Previous Work

The geology of the Tertiary basins in Thailand was studied and previously discussed by various investigators (see detail in Chapter 2). However nearly all the work has been on stratigraphy and sedimentology. There have been few palynological studies in Thailand and the available data are mainly unpublished and confidential. This study will be the first detailed palynological research ever carried out in Thailand.

1.3 Field Work

Field work was carried out between March and May 1983. The work included sample collection and stratigraphic section measurements within the area of study.

1.3.1 Sample Collection

To maintain the samples in good condition for further study, the samples were kept under water in the air-tight glass jars after sampling. They were collected stratigraphically through the seam thickness. Only coal and/or lignite samples were collected. The sampling points were chosen mainly from clean-cut quarry faces to obtain the fresh and precisely located samples. In some areas, due to the difficulty caused by high and steep slopes, the stratigraphic sections were made from various sampling points. In the area where the quarry was obscured, samples were collected from avaiable surfaces and hence only a few samples were collected.

The sampling procedures were carried out as follows:

1. Well-exposed quarry surfaces were chosen, where most of the stratigraphic units could be examined from top to bottom of the coal seams.

2. An area of about 3 metres wide was cleaned of the dust and loose debris.

3. In the middle, a channel of about 1 metre wide was cut through the section at the depth of at least 5 centimetres to removed the weathered surfaces.

4. Inside the channel, a groove of 10-15 centimetres wide was cut in the middle with the depth of about 5 centimetres for hard coals and 10-15 centimetres for lignites to collect the samples at the appropriate intervals.

5. Lumps of sample (3-5 cm. in diameter) were kept under water in the air-tighted glass jar of 2.5 litres capacity.

6. All sample jars were clearly labelled and stored in the foam-cushioned crate ready to be transported.

1.3.2 Stratigraphic Section Measurement

The measurement of stratigraphic units was made by means of measuring tape and Brunton compass. Detailed descriptions were made from top to bottom of the seam while brief descriptions were given for the units which overlie and underlie the seam.

When compiling, general geological terms have been employed. Geological units were based on the geological map of Thailand, 1 : 250,000 scale.

CHAPTER 2

GEOLOGY AND STRATIGRAPHY

2.1 Introduction

Coal deposits in Thailand are mostly found in Cenozoic basins associated with sedimentary rocks of Tertiary age. Only a few deposits are found within the older rocks. The coals are mainly of low quality, ranking from lignite to high-volatile bituminous coals. They are scattered in the North, South and West of the country (Fig. 1). They are also reported to be offshore, both in the Gulf of Thailand and the Andaman Sea (Natasilapa and Suconthanikorn, 1979; Achalabhuti, 1979; Ratanasthien, 1980; Gibling and Ratanasthien, 1980; Bunopas and Vella, 1983).

Small deposits of higher rank coals have also been found scattered near the northeastern border, associated with the Jurassic or older formations (Wongpornpukdee, 1980; Ratanasthien and Gibling, 1981; Kuentug, 1981; Ukkakimaphan and Meesuk, 1983).

2.2 Geology

The Cenozoic basins in Thailand are found throughout the country (Fig. 2). The basins are mainly fault-bounded grabens and half grabens, formed by reactivation of basement structures (Gibling and Ratanasthien, 1980).

Geological data (mainly brief discussions of surface outcrops) have been given for some basins. The history of research has been summarized by Nutalaya (1975).

Tertiary sedimentary rocks were previously reviewed by Bunopas (1976), Gibling and Ratanasthien (1980), Snansieng and Chaodumrong (1981), Sae Leow (1982), and Chaodumrong *et al*. (1983). A summary of coal activities in Thailand has been provided by the Coal Working Group (1984) of the Department of Mineral Resources, Thailand.

Natasilapa and Suconthanikorn (1979) listed 43 basins in northern Thailand which contain known Cenozoic deposits. Present day surface areas of the basin range from 30 to 1400 km^2, averaging 295 km^2. They form flat-lying alluvium deposits between the mountain ranges and follow the orientation of the regional basement rocks. Some large basins, i.e. Chiang Mai and Lampang basins, consist of a connected set of sub-basins.

In central Thailand, the Chao Phraya basin forms as a huge regional depression. It covers an area of about 60,200 km^2 (Gibling and Ratanasthien, 1980) and extends into the Gulf of Thailand.

In the South, eight basins have been discussed by Brown _et al_. (1951); and Chaodumrong _et_ _al_. (1983) have discussed two basins in the Northeast and one in the West.

2.3 Stratigraphy

Because of the problems associated with the isolated nature of the basins, the differences in age and rock types, as well as differences in regional nomenclature, the term "Cenozoic" has been used for the rocks and sediments of both Tertiary and Quaternary age. Many local classifications were established by various workers.

Brown _et_ _al_. (1951) used the terms Mae Sot Series and Krabi Series for Tertiary rocks in northern and southern Thailand respectively. Mae Mo Formation has been named by Gardner (1967) for the Cenozoic rocks from outcrops and boreholes in the vicinity of the Mae Mo mine. This term was later used by various investigators in many adjacent basins, i.e. Mae Mo Group of Piyasin (1972, 1975).

Javanaphet (1969) used Krabi Group for older Cenozoic sediments in Thailand. The terms Mae Sot Formation and Mae Fang Formation have also been used for the sediments in several northern basins (Piyasin, 1979). More superficial alluvial sediments has been grouped as the Mae Taeng Formation (Piyasin, 1972).

Other occasionally used terms include the Nam Pat and Li Formations for older Cenozoic (Buravas, 1973); the Chao Phraya Formation for alluvium deposits (Buravas, 1969); the Ko Kha Formation for younger Cenozoic (Defense Energy Department, 1977); and the Maha Sarakham and Phu Tok Formations for the lower Tertiary units in the Northeast (Chonglakmani et al., 1979). A summary of some of these classifications is shown in Table 1.

In the North, the Cenozoic strata lie unconformably over Mesozoic and older rocks. The stratigraphic sequence is more or less similar in most of the large basins. Normally, the lowermost unit (e.g. Mae Sot Fm.) consists of dark mudstone, coal, oil shale, sandstone and conglomerate. The overlying unit (e.g. Mae Fang Fm.) consists mainly of sandstone, paler mudstone, conglomerate and red beds with or without gypsum. The third unit (e.g. Mae Taeng Fm.) consists of semi-consolidated to unconsolidated conglomerates and sandstones, including alluvium of modern river systems, with an unconformable basal contact.

Age determinations have been made for some deposits by using plant remains, insects, gastropods, fishes, land vertebrates and pollen and spores. Endo (1964, 1966) studied plant remains at Ban Pa Kha coal deposit and suggested a Paleogene age (possibly Upper Eocene) for the lower mudstone-coal unit. Buravas (1975) reported the age (from the pollen and spores assemblages) for the sediments at 1860 ft. depth in the Fang basin to be of Oligo-Miocene age. Von Koenigswald (1959) suggested Lower to Middle Pliocene age for the fossil assemblages from the Mae Mo deposit. Strata of rather different facies in the Mae Sot basin were dated as ?Miocene, Pliocene-Pleistocene (Brown et al., 1951; Endo and Fujiyama, 1965; and Mineral Fuels Division, 1978).

In the Gulf of Thailand, age determinations from palynological assemblages indicate drilled sedimentary sequences to range from Oligocene to Holocene in age (Achalabhuti, 1975). A notably unconformity occurs at 1000-4500 ft. depth (Achalabhuti, 1975; Hamilton, 1979). It is overlain by strata of late Miocene age.

In the South, the Cenozoic strata also rest unconformably on Mesozoic and older rocks. At Krabi, the Krabi Formation comprises a sequence of strata which vary from in-land lacustrine to littoral sediments with coalified plant remains of palm trees, similar to those found in the Recent coastal swamps (Ratanasthien, 1983).

2.4 Sedimentation

Gibling and Ratanasathien (1980), divided sedimentation into three groups : a coarse terrigeneous association; a fine terrigeneous assoication; and a fine terrigeneous-carbonate assoication. The environment of deposition varies from fluviatile to shallow lacustrine to moderate depth lacustrine, respectively. Economic reserves of coal are found within the second type of deposition namely the fine terrigeneous association of the shallow lacustrine environment.

2.5 Tectonics

The tectonic history of Thailand has been briefly summarized by Suensilpong et al. (1978). The Cenozoic basins orginated as the result of uplifting during Cretaceous to early Tertiary times. Graben development took place from Oligocene to Quaternary. Asanachinda (1978) suggested that, by the end of Mesozoic, back-arc extensional tectonics lead to updoming and formation of Tertiary basing in the Gulf of Thailand as well as the northern part of the country.

These fault-originated basins were eventually filled with sediments including organic matter which is the source of coal, oil shale, and natural gas (Ratanasthien, 1983). In the Fang basin (Piyasin, 1979), a major fault system delineates the western margin of the basin, with strata dipping westwards and thickening to the West (half graben structure). A similar situation may occurred in the Mae Mo basin where Cenozoic strata are faulted to the West but are believed to lie unconformably on older rocks on the eastern margin (Gardner, 1967).

C H A P T E R 3

CENOZOIC COAL DEPOSITS

3.1 Introduction

The coals are mainly banded, consisting of finely-interlayered vitrain and attrital coal (Gardner, 1967). They rank from lignite to high-volatile bituminous coal, according to their heating value which ranged from 4,523 to 15,309 Btu/lb (Gibling and Ratanasthien, 1980).

Ratanasthien (1983) divided the Tertiary coal-bearing basins into three groups based on their environment of deposition: lacustrine environment represented by the Mae Mo deposit; intermontane forest swamps represented by the Mae Tun deposit; and littoral environment represented by the Krabi deposit.

In the present study, samples from five Cenozoic deposits were collected as follows : Mae Teep, Mae Mo, Li, Mae Tun, and Krabi deposits.

3.2 Mae Teep Deposit

3.2.1 Location

Mae Teep basin is located near to Mae Teep village, Ngao district, about 80km. East of Lampang province (1:50,000 topographic map sheet 5046 III) between the larger Ngao and Phrae basins (Fig. 3).

3.2.2 Geography

The Mae Teep basin is a fault-bounded basin, about 3km wide and 10km long. The elevation of the valley floor is 220-280m above mean sea level whilst the surrounding hills rise up to nearly 1,200m. Along the axis of the basin, the stream Nam Mae Teep runs northeastwards with numerous tributaries in the hills to east and west, and flows into Mae Nam Ngao river at the northern edge of the basin (Fig. 4).

3.2.3 Geology and Stratigraphy

The bed rock surrounding the basin consists of a Permo-Triassic Volcanic Group; and shale, sandstone, and limestone of the Triassic Lampang Group (Meesuk and

Pitchayakul, 1982). Coal-bearing (Tertiary) formations consist of pale mudstone, oil shale and coal beds underlied thick sequences of oil shale and mudstone. Superficial deposits of Quaternary gravels, sands, silts, and clays are the youngest deposits in the area (Fig. 5). A detailed stratigraphic sequence and sampling section is shown on Fig. 6.

3.2.4 Environment of Deposition

Gibling *et al*. (1981) studied facies changes of the sediments within the basin and stated the environment of deposition to be lacustrine, which later changed into narrow peat swamps, where coals and other organic materials accumulated, and which finally turned into shallow lake conditions.

3.3 Mae Mo Deposit

3.3.1 Location

Mae Mo basin covers an area of about 150km^2 in the vicinity of Mae Mo sub-district, about 30km East of Lampang province (1:50,000 topographic map sheet 4945 IV).

3.3.2 Geography

The Mae Mo basin orginated in a faulted graben which resulted from the Cretaceous/Tertiary orogeny (Ratanasthien, 1983). The basin lies in a north-south trend surrounded by mountains formed by older rocks. The elevations range from 300-400m at the basin floor to 800-900m along the mountain ranges. The main stream Nam Mae Mo runs along the axis of the basin.

3.3.3 Geology and Stratigraphy

The country rocks which formed the surrounding mountains and the basement of the basin are the Permo-Triassic Volcanic Group and shale, sandstone, limestone of Triassic Lampang Group. The Tertiary Group is partly covered by younger sediments and basalts of Quaternary age (Fig. 7).

The Tertiary Group consists mainly of freshwater mudstones with two lignite seams overlain by a thick sequence of interbedded claystone, lignite, oil shale and laminated mudstone, and is itself covered with sand, silt, clay, and gravel beds of Quaternary age (Fig. 8). Twenty-seven samples were collected from the upper "K" seam. Detailed stratigraphic section is given in Fig. 9.

3.3.4 Environment of Deposition

The Mae Mo basin was initially formed as a large basin which was subjected to repeated subsidence. Both the water level and the supply of sediments also changed during the sedimentation.

The stratigraphic succession shows that during early deposition, the basin contains a large expense of open water with sediment input which varied according to the changing rate of subsidence of the basin. This gave rise to cyclic graded bedding and mainly subangular sediments ranging in size from conglmerate, sandstone, to shale and mudstone. This sequence is up to 450m thick.

Later the basin was undisturbed and the abundance of living creatures accumulated resulting in fossiliferous beds; lignites of humic gel origin were also deposited (Ratanasthien and Ruengwatanasirikul, 1984). The basin then shallowed and the accumulation of diatomites took place.

After that at least 10 cycles of graded sediments from fine-sand to clay accumulated resulting from changing in water level, however, the water level was remained shallow. During this period, the lignite "K" seam accumulated. Because of changes in water level, the lignite was frequently interbedded with other sediments. Then there was a long period of deep water where sediments of mudstone, siltstone, and shale accumulated, to the thickness of about 150m.

A yet later period was dominated by shallow water in which thin lignite beds formed alternately with claystone and shale. The sedimentation was short-lived for the sediments are only 10-30m thick. Then they grade into claystone and siltstone associated with gypsum and calcareous nodules suggesting an origin in a shallow water environment.

Finally the sequence were covered with Quaternary sediments which are mainly of fluviatile origin.

This suggests that the environment of deposition has changed with time, from a large body of open water to a swamp and then to peat bogs and finally to a fluviatile one.

3.4 Li (Ban Pu) Deposit

3.4.1 Location

Ban Pu basin is a small intermontane basin located in the vicinity of Ban Pu village, about 7km East of Li district, Lamphun province. Strata are well exposed along the Mae nam Li river which runs across the basin (1:50,000 topographic map sheet 4844 IV).

3.4.2 Geography

The basin forms a flat-lying area of about $10km^2$ at 470m above mean sea level, surrounded on three sides by mountains up to 700m high (Fig. 10). The Mae Nam Li river runs across the basin southwards with east and west tributaries.

3.4.3 Geology and Stratigraphy

The geology of Ban Pu basin has been briefly discussed by Chaodumrong et al. (1982, 1983) and Ratanasthien and Ruengwatanasirikul (1984). Limestone of Ordivician age is found forming the northern margin as well as the basin basement while the east and west sides of the basin are bounded by black shale and cherts of Silurian-Devonian age (Fig. 11). A Cenozoic sequence of at least 90m thick (Chaodumrong et al., 1982), includes sandstone, shale, gray claystone, mudstone, and coal. A stratigraphic section measured at the mine quarry is shown in Fig. 12.

3.3.4 Environment of Deposition

Ban Pu basin was formed by an east-west trending fault which cut into the former north-south trending fault of the Li basin margin, resulting in the steep slope of the basin (Ratanasthien and Ruengwatanasirikul, 1984). Sediments and organic materials including wood logs and stumps found at the bottom of the basin indicate in situ deposition of the coal bed with a high energy current environment (Ratanasthien and Ruengwatanasirikul, 1984). Non-organic clastic components are less important than organic materials which formed as thick beds of coal with thin shale and claystone partings. The environment of deposition suggested by Ratanasthien and Ruengwatanasirikul (1984) for the Ban Pu deposit was that of an intermontane forest swamps.

3.5 Mae Tun Deposit

3.5.1 Location

Mae Tun basin is a small elongate intermontane basin located in the Ban Ko Lo Hae village, Mae Ramat district, Tak province. Outcrops of coal are found along the Nam Mae Tun river at grid reference 616932 on 1:50000 topographic map sheet 4747 III.

3.5.2 Geography

The basin forms a small elongate flood plain alongside the stream Nam Mae Tun which runs southeastwards. Elevation ranges from about 280m above mean sea level for the basin floor up to 900m in the high mountains around the basin (Fig. **13**). The basin covers an area of about $5km^2$.

3.5.3 Geology and Stratigraphy

The bed rock surrounding the basin consists of sandstone and quartzite of Cambrian age and the metamorphic rocks of Pre-Cambrian age (Fig. **14**). The basement beneath the Cenozoic sequence is the Ordovician limestone. Within the basin the Cenozoic sequence can be divided into two units : the lower unit and the upper unit (Ukkakimaphan and Supertipanish, 1979).

The lower unit consists of layers of grey mudstone/shale interbedded with brown to light grey siltstone and sandstone. The unit strikes N 40^{o}W and dips at about 10-15^{o} westwards (Ukkakimaphan and Supertipanish, 1979).

The upper unit consists of coarse to very coarse-grained sandstone, conglomeratic sandstone and conglomerate. The unit strikes N 50^{o}E and dips westwards at about 25^{o} (Ukkakimaphan and Supertipanish, 1979).

Coal is found within the lower unit interbedded with thin beds of pale to dark gray claystone and oil shale partings (Ratanasthien, 1983). A stratigraphic section obtained from borehole drilling data (Ukkakimaphan and Supertipanish, 1979) is given in Fig. **15**.

3.5.4 Environment of Deposition

Ratanasthien and Ruengwatanasirikul (1984) suggested the environment of desposition of Mae Tun deposit to be of an intermontance forest swamps type.

3.5 Krabi (Bang Pu Dam) Deposit

3.6.1 Location

The Krabi basin is located in the southern part of Thailand. It covers an area of about 250km^2 in the vicinity of Muang and Khlong Thom districts, Krabi province. The Bang Pu Dam deposit occurs in the middle of the basin at grid reference 050837 on 1:50,000 topographic map sheet 4824 IV, about 15km East of Krabi province.

3.6.2 Geography

The deposit lies near or at the surface in a low coastal plain which fringes the Andaman sea. Its surface elevation ranges from about 30m above mean sea level at the basin floor to about 200m on the surrounding hills. The stream Khlong Khanan, Khlong Phela, and Khlong Thom run through to coastal mangrove swamps (Fig. **16**).

3.6.3 Geology and Stratigraphy

Poothai and Chana (1969), Garson *et al*. (1975), Sae Leow (1982), Thongvilat (1982), Chaodumrong *et al*. (1983), and Ratanasthien (1983) have briefly discussed the geology of the Krabi basin. A Cenozoic sequence lies unconformably on the Khorat (Jurassic) Group and Ratburi (Permian) limestone (Poothai and Chana, 1969; Garson *et al*, 1975) (Fig. **17**). The sequence consists mainly of dark gray to greenish gray claystone interbedded with lignite seams (15-30m thick) and minor sandstone/shale beds (Thongvilat, 1982; Ratanasthien, 1983). The sequence is partly fossiliferous with fragments (1 to 3cm. in diameter) of gastropods and bivalves (Thongvilat, 1982). The sequence strikes N 36^{o}-46^{o} W along the basin axis and dips 10^{o}-22^{o} southwestwards (Thongvilat, 1982). The stratigraphy of the sequence at the sampling point is shown in Fig. **18**.

3.6.4 Environment of deposition

Chaodumrong *et al*. (1983) suggested three cycles of deposition from a marine transitional environment at the bottom of the sequence to brackish mangrove swamps where coals were deposited and then to a fluviatile environment at the top of the sequence where sands, silts and clays were deposited. Ratanasthein (1983) proposed a littoral environment where the strata showed the effects of marine transgressions and regressions.

CHAPTER 4

PRE-CENOZOIC COAL DEPOSITS

4.1 Introduction

Apart from the more abundant low-grade coal deposits associated with rocks of Cenozoic age, small deposits of higher rank coals have been recently discovered. Most of them grade up to anthracite but contain a high graphitic content (Ratanasthien, 1983). Wongpornpakdee (1980) and Kuentug (1981) reported the occurence of high grade coals in rocks of Jurassic age or older. Ukkakimaphan and Meesuk (1983) investigated the coal deposit at the Na Duang district, Loei province and reported it to be of Lower Carboniferous age. Only one report has shown the presence of a thin bed (less than 10cm) of anthracite in the strata of Hong Hoi Fm. Lampang (Triassic) Group at Huai Wang Woa, 15-20km South of Mae Teep basin (Ukkakimaphan et al., 1982). In this study, six coal samples were collected from Na Duang deposit.

4.2 Na Duang Deposit

4.2.1 Location

The deposit was found in the areas between latitude 17° 31' 30" to 17° 35' N and longitude 102° 02' 30" to 102° 05' E on the 1:50,000 topographic map sheet 5444 III. The area occupies the vicinity of Na Duang sub-district, about 50km Northeast of Loei province.

4.2.2 Geography

The deposits are found in the long narrow stream valleys which run in the north-south trend. The elevation ranges from 380-430m above mean sea level on the valley floor to over 500m on the adjacent hills. The main stream Huai Lin Kwai runs southeast wards from the Phu Yai hill and Huai Mong runs southwards from the Phu Mong hill (Fig. 19).

4.2.3 Geology and Stratigraphy

Satayarak and Sutheethorn (1982) mapped the rocks of the area as Carboniferous and Silurian-Devonian in age. The Carboniferous Group consists of three formations : the Upper, Middle and Lower Formations. The Lower Formation which is the coal-bearing formation consists of carbonaceous sandstones and shales, interbedded with coal beds and minor conglomerate beds. The Middle Formation contains sedimentary rocks of volcaniclastic origin, comprising tuffaceous sandstone, shale and agglomerate. The two formations were deposited conformably. The Upper Formation lies uncomformably on the first two formations and consists of massive conglomerate bed. The Silurian-Devovian Group is found as a fault contact at the eastern margin of the area (Fig. 20).

Coals are found within two sites, at Phu Yai, and Phu Mong areas. At Phu Mong, coals are found in the sheared zone which are crushed together with an enclosing sequence of sandstone and shale. Coals are found as fragments in the sheared zone and formed as the outer crust of the rock fragments. The sheared zone is about 10m thick and stikes N 22^{o}-45^{o}W with a 80^{o}-85^{o} westwards dip (Ukkakimaphan and Meesuk, 1983). The coal itself is shiny black, with a metallic luster, sugary texture, and has low-volatile bituminous rank.

At Phu Yai, where a mine is operating, coals are found within the sequence of olive green sandstone and shale (some are fossiliferous) along the stream Huai Lin Kwai. The contact between coals and host rocks is a fault contact. In this area, coals are also found fractured and sheared together with parts of host rocks but the impurities are less than those at Phu Mong. The seams are about 5m thick. The simplified stratigraphic sequence at the mine is shown in Fig. 21.

4.2.4 Environment of Deposition

Coals in this area are believed to be deposited under a reducing environment in shallow water and sediments accumulated together with wood fragments and leaves (Ukkakimaphan and Meesuk, 1983). After the deposition of the coal-bearing formation, volcanic activity took place where the sediments are of volcaniclastic origin. Eruption continued and increased in energy occasionally until the end of Middle Carboniferous period. The activity resulted in the basin being uplifted and finally deposition of red beds took place.

After red beds deposition, the area was completely uplifted and weathering and erosion dominated together with a period of faulting and shearing, this resulted in the Lower and Middle Formations being deformed, sheared, faulted, and eroded. Subsequently the area was resubmerged and the deposition of conglomerates of the Upper Formation took place.

During the period of volcanic activity and eruption coals were deformed together with the host rocks and also upgraded. With the effect of later igneous intrusion the coals finally upgraded to low volatile bituminous.

CHAPTER 5

PALYNOLOGY

5.1 Introduction

The coal samples were studied palynologically in order to determine the morphology of fossil spores and pollen grains and their stratigraphic and palaeoecological significances. The quantitative analysis was carried out in order to determine the detailed distributions of the microfossils within each deposit.

5.2 Review of Literatures

The palynological studies in Thailand are mainly unpublished. The available data were very brief and not directly in the field of palynology. Endo (1964, 1966) identified fossil plant remains, mainly leaves, from the Eocene lignite and oil shale deposits at the Li district as: *Alnus thaiensis*, *Alnus thaiensis*(?), *Carpinus*(?) sp., *Fagus feroniae*, *Ficus eowightiana*, *Glyptostrobus europaeus*, *Quercus lanceaefolia*, *Quercus* cf. *Q. protoglauca*, *Sequoia langsdorfii*, *Taxodium thaiensis*, and *Salix* sp. Fossil plants identified as *Bauhinia* sp. were reported together with fossil insect remains from the Miocene oil shale deposit at the Mae Sot district (Endo and Fujiyama, 1965). Gardner (1967) mentioned the plant remains, mostly herbs and grasses, from the lignite beds of the Mae Mo deposit.

Six species of pollen remains embedded in shale core from the Mae Soon oil field, Fang district were reported by Buravas (1973). They were identified as _Pollenites coryphaeus_, _Pollenites fallax_, _Pollenties henrici_, _Pollenites microhenrici_, _Salix_ sp., and _Pinus haploxylon_ type of Oligocene age (Buravas, 1973). Achalabhuti (1975) described five floral zones as : _Podocarpus_, _Dacrydium_, _Florschuetzia meridionalis_, _F. levipoli_, _F. trilobata_, and _Alnipollenites verus_ zones, associated with sedimentary sequences ranging in age from Holocene of Oligocene, in the Gulf of Thailand. More recently Ratanasthien (1984) dated some Tertiary deposits in the northern part of Thailand using the assemblages of fossil spores and pollen grains. The results indicated that the age of the sediments ranged from Senonian to Miocene.

Apart from Thailand, Potonie' (1960) reported palynological studies of an Eocene coal of Burma. In the Indo-Malaysian region, the Tertiary palynology has been intensively studied by Muller (1964, 1966, 1968, 1972), Germeraad _et al_. (1968), Anderson and Muller (1975), and Kemp and Harris (1977). The Quaternary palynology was described by Muller (1965), Anderson and Muller (1975), Haseldonckx (1977), and

Flenley (1979). The Tertiary and Quaternary palynology in Southeast Asia was summarized by Morley (1977). The works of Anderson (1958, 1964), Aston (1972), Flenley (1972) and Steenis (1962) dealt with the ecology of the plant communities in the Indo-Malaysian region. Haseldonckx (1974) summarized the palynological interpretation of palaeo-environment in Southeast Asia. The catalogue of all recorded species of flowering plants, ferns and fern allies from the peat swamp forests of Sarawak and Brunei was listed by Anderson (1963).

Elsewhere, the Cenozoic palynology of equatorial Latin America has been described by Van der Hammen, 1956; Van der Hammen and Wymstra, 1964; Van der Hammen and Garcia de Mutis, 1966; and Wymstra and Van der Hammen, 1967; etc., and the Upper Cretaceous-Cenozoic palynology of equatorial Africa by Van Hoeken-Klinkenberg, 1964, 1966; Saad, 1965; Salard-Cheboldaeff, 1975, 1978, 1979; etc. The palynology of all these areas was comparable. The Cenozoic palynology of Australia studied by Cookson, 1956; Cookson and Pike, 1954; Hekel, 1972; Stover and Partridge, 1972; Playford, 1982; etc., and New Zealand (Couper 1953, 1958) were similar to some extent. The floral assemblages reported from the Cenozoic deposits of India (Baksi, 1962; Ramanujam, 1966, etc.) were somewhat less comparable.

5.3 Sampling and Sample Preparation

The samples were collected from the surface of mine quarries. The procedures have already been described in the field work section. After the samples arrived at the laboratory at Aston University, they were prepared for palynological studies as follows :

1. About 5-10gm of each sample were drawn from the sample jar, dried of excess water with tissue paper and then left to air-dry at room temperature for 1-2 days.

2. The dried samples were gently crushed to a particle size of about 1-2mm diameter with a porcelain mortar and pestle or alternatively by carefully wrapping the samples in dry, clean tissue paper and then gently pounding on the hard surface with a pestle (the latter procedure reduced the time for cleaning the equipment between each preparation).

3. The crushed or pounded samples were then collected and kept in a dry, clean plastic bag and clearly labelled (the dusty particles were discarded).

5.4 Sample Extraction

Various methods of sample extraction are described by Brown

(1960) and Gray (1965) for both rock and coal samples. The methods particularly for coal samples, mainly unweathered and of high rank are summarized by Smith and Butterworth (1967). In this study, various methods described by various authors cited above were experimented with and the following methods were proved to be successful.

5.4.1 Method Using Nitric Acid

Nitric acid is an efficient and powerful oxidizing reagent particularly for organic compounds (Gray, 1965). In this study, Low rank coals (lignite to subbituminous) are easily dissolved (either using concentrated or fuming nitric acid) and the reaction is sufficient with or without the completion by alkaline treatment. The time required for the reaction ranges from a few minutes up to half an hour depending on rank and freshness of the samples, and the concentration of the acid. However, for the higher rank coal samples (the Carboniferous low-volatile bituminous of Na Duang deposit), this method is useless even after soaking the samples with fuming nitric acid for up to two weeks.

The most satisfactory results were obtained by treating about 0.5gm of sample with 3-5ml of fuming HNO_3 in 12.5ml centrifuge tube. Concentrated HNO_3 was immediately added to fill the tube, and centrifuged. This was then decanted and H_2O added and again centrifuged. This procedure was repeated until the solution was cleared. About 2ml of 0.1N KOH was added to the residues, stirred, left about 1 min., H_2O added and centrifuged. This was decanted, H_2O added and again centrifuged. This was repeated until the solution was cleared. The final residues were transferred and kept in a small sample vial.

Remarks :

1. If the reaction is too vigorous, concentrated HNO_3 was used instead of fuming HNO_3.

2. By covering the sample with 2-3ml H_2O before acid is added, vigorous reaction can be prevented and the completion of the reaction can be observed as the solution will change from colourless to yellow with gas bubbles and finally turn to a dark brown colour.

3. Centrifuging at approximately 5000rpm for 1 min is sufficient and necessary when the solution is at the first stage (either adding acid or alkaline solution) in order to prevent over oxidation. After that the centrifuging at 3000 rpm for 3 mins is useful as the lighter suspension is separated from the specimens.

5.4.2 Method Using Schulze Reagent

The standard method using Schulze reagent is widely used by present palynologists. The solution is the combination of HNO_3 and $KClO_3$ ($NaClO_3$ may be used), and can be used as an oxidant for almost any matrix (Gray, 1965). In this study, when using the so-called dry method, the high rank coals were dissolved immediately and the reaction can be completed within 24 hours. For lower rank coals, the normal method as described below is sufficient and can be completed within 5 mins for any sample. This technique was used for all samples studied.

In this study, for lower rank coals, the samples of about 0.5gm were covered with 2-3ml saturated aqueous solution of $KClO_3$ in a 12.5ml centrifuge tube. Equal to double amounts of concentrated HNO_3 were added (the amount of HNO_3 added depends on the rank of samples, lignite needs a less amount than subbituminous coal). The solution changes from colourless to yellowish brown within 5 minutes, hot H_2O added and centrifuged. The procedures are repeated as described for HNO_3 treatment except using hot H_2O instead of normal cold H_2O.

For the higher rank coals 0.5gm of sample and 0.5gm of $KClO_3$ were thoroughly mixed together. About 5ml of fuming HNO_3 were slowly and carefully added, left for 24 hours, then the same procedures followed as for low rank coals.

Remarks :

1. When the dry method is used, extreme caution must be employed as the reaction can cause spontaneous explosion at concentration above 30 percent (Gray, 1965).

2. The standard solution is usually prepared by mixing one part saturated aqueous $KClO_3$ and two to three parts NHO_3 (Gray, 1965). In this study, one part $KClO_3$ per one to two parts HNO_3 is sufficient for samples ranked from lignite to subbituminous coal.

3. Hot H_2O used in the procedure produced more satisfactory results compared to normal cold H_2O. The final residue is clean and clear when examined under the microscope.

5.5 Slide Preparation

Permanent slides can be prepared using solid media such as hydroxyethyl cellulose-"Cellosize" (Jeffords and Jones, 1959), polyvinal alcohol (Funkhouser and Evitt 1959), and canada balsam (Schopf, 1960). In this study 1% aqueous solution of Cellosize is used. One part of the final residue is mixed thoroughly with one part Cellosize. A few drops of the mixture are placed on the cover glass, the mixture evenly dispersed over the surface, and the film is set aside to dry at room temperature. When dry the cover glass is sealed to the slide by one or two drops of Histomount (Histological mounting medium) and allowed to dry at room temperature.

5.6 Counting Techniques

Smith and Butterworth (1965) discussed various methods concerning the number of spores or pollen grains, that should be counted in order to represent the assemblage. More details of this aspect were presented by Moore and Webb (1978).

In this study, 250 specimens were counted for each sample. Two duplicate sets of slide were scanned for the presence of the genera and species which were not recorded during the count. A series of traverse was made under x 100 magnification. For identification the specimen was examined under x 1000 magnification using x 100 oil immersion objective. The dimensions were measured by inserting the graduated micrometer in one of the eyepieces (in this study, one section read equals 0.66um for x 1000 magnification and 1.64um when using x 400 magnification). Partly broken specimens which can be identified were included.

5.7 Morphology and Descriptive Terminology

The terms used for the description of fossil spores and pollen grains mainly followed the work of Thomson and Pflug (1953), Kremp (1965), Erdtman (1966), Tschudy (1969), and Moore and Webb (1978).

5.7.1 Apertures

The first features necessary for the identification of fossil spores and pollen grains are those of the apertures. Pteridophyte spore normally posses either single (monolete) or multiple (trilete) apertures which are the remains of the scar. In some case the tetrad scar is absent (alete). The monolete spores are the common type and occur in rocks from the Paleozoic to the present. They may occur as simple monolete, such as *Laevigatosporites*; with a cingulum such as *Pericutosporites*; or with a perisporium, such as the modern *Asplenium* spores (Tschudy, 1969).

The trilete spores are more developed morphologically both in structure and sculpture. For the various morphologic types of trilete spores, reference should be made to the work of Tschudy (1969, Figures 2-3, 2-4 and 2-5).

Fossil pollen grains of the gymnosperm encountered in this study include inaperturate, monosaccate, and disaccate pollen. The descriptive terms used here follow the work of Kremp (1965).

For the angiosperm pollen grains, two basic aperture types, namely pori (pores) and colpi (furrows) are the most common features. The variations of their shape and arrangement are clearly described and illustrated by Kremp (1965, plates 3 and 4) and Moore and Webb (1978, figure 4.4). The features associated with pori and colpi can be found in Kremp (1965, plates 18 and 19) and Moore and Webb (1978, figure 4.6).

5.7.2 Shape

The shape of the fossil spores and pollen grains vary even in one grain type. The choice of extraction methods and embedding media (Moore and Webb, 1978) as well as the orientation of the grains when compressed can cause the variation in shape. When examining the specimens, the shapes were recorded as grain outline in polar view and/or equatorial view. In this study, simple terms, such as circular, bean-shaped, prolate, etc., were used. Various types of shape both in polar view and equatorial view are summarized in Kremp (1965, plate 9, figures 162-183), and Moore and Webb (1978, figure 4-7).

5.7.3 Exine Sculpture and Structure

Sculpturing types for both spores and pollen grains are not differentiated here. The terms used in this study are a combination of the terms described by Tschudy (1969), and Moore and Webb (1978). The exine structures follow the work of Thomson and Pflug (1953). More detailed descriptions can be found in Kremp (1965).

5.7.4 Size

The specimens with similar aperture type, shape, exine sculpture, structure and size can be used as the criteria for distinguishing between species (Smith and Butterworth, 1967). In this study sizes are measured as a mean with extreme limits and mostly taken from at least 10 specimens from various horizons.

5.8 Systematic Descriptions

The main problem in the systematic part is that there are too many systems. They can roughly be divided into 3 categories : morphological or artifical system, natural system, and the combination between the first two systems. The first system is based entirely on the morphology of the specimens, the second is based on extant genera, and the third falls in between.

For tropical Tertiary sequences, the artificial system created by Van der Hammen (1956) is widely used (e.g. Leidelmeyer, 1966; Van Hoeken-Klinkenberg 1964, 1966; Gonzalez, 1967, and others). In the Indo-Malaysian region, a simplified artificial system is used by Muller (1968), Germeraad et al (1968), and Kemp and Harris (1977). However, the natural system is somewhat more widely used in this area (e.g. Muller, 1964, 1966; Anderson and Muller, 1975; Haseldonckx, 1977, and others).

In this study the artificial system, based mainly on Thomson and Pflug (1953) and Van der Hammen (1956) is used. The possible botanical affinity is given where applicable. Full detailed descriptions and photographs are given for all identified species. Those which can not be identified are photographed, briefly described, and possible names suggested. No new taxa are created.

SYSTEMATIC DESCRIPTIONS

Anteterma SPORITES H. Potonie', 1893

Turma MONOLETES Ibrahim, 1933

Genus LAEVIGATOSPORITES Ibrahim, 1933

Laevigatosporites haardti (Pot. & Ven.)

Thomson & Pflug, 1953

(Plate 4, fig. 1)

1934 Sporites haardti Potonie' & Venitz, p.13, pl.1, fig.13

1964 Laevigato-sporites ovatus Wilson & Webster. p.273, fig.5

1953 Laevigatosporites haardti (Pot. & Ven.) Thomson & Pflug. p.59, pl.3, figs. 27-38

1977 Laevigatosporites ovatus Wilson & Webster in Kemp & Harris, p.24, pl.3, fig.4.

Designated : M1a

Description : Spores monolete, bean-shaped, bilateral symmetry. Laesura straight, simple, extent about 2/3 of spore length. Exine thin, less than 0.5um, laevigate.

Dimensions : Length 25(38)49um, width 16(27)38um (50 specimens from various horizons).

Remarks : Since the name L. haardti was proposed before L. ovatus and there is no distinguishing difference between them, they should be regarded as synonyms and L. haardti then should be used according to priority as indicated by Krutzsch (1967).

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Affinity : This spore is typical of Polypodiaceae (Manum, 1962) and possibly produced by various fern genera e.g. Asplenium, Athyrium, Blechnum, Dryopteris, etc. (Kemp and Harris, 1977).

Distribution : Widespread and very common in every deposit. This form is widely distributed throughout the world in Mesozoic and Cenozoic strata.

Laevigatosporites adiscordatus Krutzsch, 1959

(Plate 4, fig.2)

1959 Laevigatosporites adiscordatus Krutzsch, p.196, pl.39, fig.431

1967 L. adiscordatus Krutzsch in Krutzsch, p.152, pl.54, figs.6-7

1971 L. adiscordatus Krutzsch in Srivastava, p.253, pl.1, fig.1

Mountains of Hungary (Kedves, 1973).

Genus MICROFOVEOLATOSPORIS Krutzsch, 1959

(Plate 4, figs.3-4)

Microfoveolatosporis pseudodentatus Krutzsch, 1959

1959 Microfoveolatosporis pseudodentatus Krutzsch, p.212, pl.41, figs.463-465

1968 M. pseudodentatus Krutzsch in Elsik p.290. pl.7, fig.5

1973 M. pseudodentatus Krutzsch in Kedves, p.65, pl.22, figs. 9-10

1982 Microfoveolatosporis sp. Playford, p.39, pl.3, figs.4-11

Designated : M2

Description : Spores monolete, elongate bean-shaped, bilateral symmetry. Laesura straight, simple, long, slightly opened, extent about 3/4 of spore length. Exine thickness distinct, 2-2.5um thick. Foveolate; foveolae circular, 1-1.5um in diameter, 1-1.5um apart, regularly distributed.

Dimensions : Length 56(67)79um, width 25(41)52um (10 specimens from various horizons).

Remarks : The specimens are similar to M. pseudodentatus described and photographed by Krutzsch (1959). M. pseudodentatus Krutzsch photographed but briefly described by Elsik (1968) and Kedves (1973) are comparable. Microfoveolatosporis sp. photographed by Playford (1982) is also more or less similar to the specimens.

Affinity : Krutzsch (1959) suggested the genus Schizaea whilst Playford (1982) mentioned the family Schizaeceae as well as Psilotaceae. Kedves (1973) also mentioned the family Psilotaceae. The specimens can be compared closely with the species Psilotum nadum shown in Tschudy (1969, pl.2-2, fig.1).

Distribution : Specimens are absent in the Li and Mae Tun samples and rare in the others. The same species was found in the Middle Eocene brown coal from Geiseltales (Krutzsch, 1959), the Middle Eocene Brown-Coal formation of Hungary (Kedves, 1973), the Oligocene of the British Isles (Wilkinson and Boulter, 1980), and the Neogene sediments of Papua New Guinea (Playford, 1982).

Genus PUNCTATOSPORTIES Ibrahim, 1933

Punctatosporites sp.

(Plate 4, fig.5)

1977 Punctatosporites sp. Kemp & Harris, p.22, pl.2, figs.1-2

1980 Form-genus Punctatosporites Wilkinson & Boulter, p.41.

Designated : M3

Description : Spores monolete, bean-shaped, bilateral symmetry. Laesura straight, simple, extent about 2/3 of spore length. Exine thin, less than 0.5um. Granulate to scabrate; elements up to 0.5um in both height and basal diameter which sometimes coalesce to form short discrete ridges but not a complete reticulate pattern.

Dimensions : Length 25(31)36um, width 16(23)36um (50 specimens from various horizons).

Remarks : This form is very similar to those described and photographed by Kemp & Harris (1977) and described in Wilkinson & Boulter (1980) both in dimensions and ornamentation. The older form Marattisporites scabratus Couper (1958) recorded from the British Mesozoic is comparable (Kemp and Harris, 1977; Wilkinson and Boulter, 1980). As this form is almost restricted to the Mae Mo deposit which is surrounded by mainly Mesozoic sedimentary rocks, it could possibly be derived from these older formations.

Affinity : Possibly genus Marattia of the family Marattiaceae (Couper, 1958).

Distribution : Almost restricted to the Mae Mo deposit. Occasionally found in the Mae Teep deposit and absent elsewhere. This form is also found within the Early Tertiary sediments of the Ninetyeast Ridge, Indian Ocean (Kemp and Harris, 1977) and is rarely found in the Oligocene of the British Isles (Wilkinson and Boulter, 1980). An older form M. scabratus was recorded in the British Mesozoic (Couper, 1958).

Genus RETICULOIDOSPORITES Thomson & Pflug, 1953

Reticuloidosporites secondus (Potonie') Thomson & Pflug, 1953

(Plate 4, figs.6-7)

1934 Sporites secondus Potonie' p.39 pl.6, fig.7

1953 Reticuloidosporites secondus (Potonie') Thomson & Pflug, p.60-61, pl.4, figs.9-10

Designated : M4

Description : Spores monolete, bean-shaped with slightly convex promixal surface, bilateral symmetry. Laesura straight, simple, slightly opened, extent about 2/3 of spore length. Exine thickness distinct, 2-3um, with faint verrucate; verrucae irregularly rounded to polygonal, diameter 1-1.5um, less than 0.5um high, separated by a fine negative reticulum (0.5-1um wide).

Dimensions : Length 46(57)74um, width 30(42)56um (50 specimens from various horizons)

Remarks : This form varies in thickness of exine and coarseness of verrucate elements. Krutzsch (1967) recombined and emended R. secondus (Potonie') Thomson & Pflug and designated plate 4 figure 10 of Thomson & Pflug (1953) as the holotype of Verrucatosporites favus pseudosecundus.

Affinity : Polypodiaceae (Thomson & Pflug, 1953)

Distribution : Sparsely distributed in every deposit. This form was recorded from the Miocene of Central Europe (Thomson & Pflug, 1953; Krutzsch, 1967).

<u>Verrucatosporites</u> cf. <u>V</u>. <u>megabalticus</u> Krutzsch, 1967

(Plate 4, figs.8-9)

1967 <u>Verrucatosporites</u> <u>megabalticus</u> Krutzsch, p.180, pl.66, Figs.1-13

1974 <u>V.</u> <u>megabalticus</u> Krutzsch in Ziembinska-Tworzydlo, p.341, pl.7, figs.5a-b

Designated : M5a

Description : Spores monolete, bean-shaped with slightly convex proximal outline in equatorial view, bilateral symmetry. Laesura straight, simple, slightly opened, extent about 3/4 of spore length. Exine thickness distinct, 1.5-2um (not including muri). Surface sculpture verrucate with irregularly rounded verrucae, 1.5-2um in basal diameter, 1-1.5um high on proximal surface and coalesce to form broad discrete ridges 3-5um high, 5-10um long, and 1-1.5um high on distal surface. Elements are separated by 1-1.5um wide negative reticulum.

Dimensions : Length 34(47)62um, width 18(33)44um (50 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by Krutzsch (1967) and Ziembinska-Tworzydlo (1974) but differ slightly in their grain sizes.

Affinity : Polypodiaceae (Ziembinska-Tworzydlo, 1974).

Distribution : Found in most samples in every deposits at relatively low percentages. Similar form was found in the Middle Oligocene to the Lower Miocene of East Germany (Krutzsch, 1967), the Middle Oligocene of the Great Poland Lowlands (Ziembinska-Tworzydlo, 1974), and was reported from the Oligocene Lough Neagh Clays boreholes of the British Isles as the Form-gneus Polypodiidites (Wilkinson & Boulter, 1980).

Verrucatosporites inangahuensis (Couper) Krutzsch, 1959

(Plate 4, figs.10-11)

1953 Polypodiidites inangahuensis Couper, p.29, pl.2, fig. 16

1959 Verrucatosporites inangahuensis (Couper) Krutzsch, p.205

1960 Polypodiidites inangahuensis Couper in Couper, p.39, pl.1, fig 7

1967 Verrucatosporites inangahuensis (Couper) Krutzsch in Krutzsch, p.196, pl.74, fig 1

Designated : M5b

Description : Spores monolete, bean-shaped, proximal outline straight to slightly concave in equatorial view, bilateral symmetry. Laesura straight, simple, relatively short, extent about 1/2 of spore length. Exine thickness fairly distinct, often obscured by the sculpture, 2.5-3um (including muri). Sculpture verrucate; verrucae flat, coalesce to form irregular discrete ridges on distal surface and less distinct on proximal surface, 1-1.5um in basal diameter, up to 0.5um in height, and separated by irregular grooves about 1.5-2um wide.

Dimensions : Length 54(68)82um, width 34(49)66um (15 specimens from various horizons).

Remarks : The specimens are comparable to Polypodiidites inangahuensis Couper described and figured by Couper (1953, 1960). P. inangahuensis was transferred to the genus Verrucatosporites Thomson & Pflug by Krutzsch (1959). In order to keep the classification simple and avoid using more generic name as well as the specimens were distinguished by their verrucate sculpture, the name Verrucatosporites inangahuensis Krutzsch is used here.

Affinity : ?Polypodiaceae and probably related to Microsorium aff. diversifolium (Willd.) Copel (Couper, 1953,1960).

Distribution : Rare in Li, Mae Teep, and Mae Mo deposits. Absent in Mae Tun and Krabi deposits. P. inangahuensis was reported from the Waitakian (Middle Oligocene) to the Lower Nukumaruan (Lower Pleistocene) of New Zealand (Couper, 1960).

Verrucatosporites cf. V. Favus (Potonie')
Thomson & Pflug,1953
(Plate 4, figs.12-13)

1931c Polypodii (?) -sporonites favus Potonie', p.556,fig.3

1953 Verrucatosporites favus (Potonie') Thomson & Pflug, p.60, pl.3, figs.52-55; pl.4, figs.1-4

1962 Verrucatosporites cf. favus Potonie' Type B Manum, p.21, pl.1, figs.5-7

1967 V. favus (Potonie') Thomson & Pflug subsp. favus Krutzsch p.184, pl.68, figs.1-8

Designated : M5c

Description : Spores monolete, bean-shaped with straight proximal outline in equatorial view, bilateral symmetry. Laesura straight, simple, extent about 1/2 to 2/3 of spore length. Exine thickness distinct, 2.5-3um (including muri). Densely verrucate with scattered baculae. Verrucae densely packed but mainly inconspicuous, about 2-2.5um in diameter, 0.5um in height, irregular in shape and separated by an irregular negative reticulum. Baculae 1-1.5um in diameter, 2.5-3um high, occur scattered around the distal surface.

Dimensions : Length 73um, width 54um (2 specimens from samples MTu 1 and MTe 14).

Remarks : Only 3 specimens were found in this study. They are comparable to P. favus Potonie' figured by Penny, 1960 (in Tschudy & Scott, 1960, text figure 10, pl.16-3, p.348), V. cf. favus Potonie' Type B described and photographed by Manum (1960), V. favus (Potonie') Thomson & Pflug (Thomson & Pflug, 1953) and V. favus Thomson & Pflug subsp. favus Krutzsch (Krutzsch, 1967). However, the sparsely distributed baculate elements of the specimens are distinctive and may be used in distinguishing them from the original V. favus.

Affinity : Polypodiaceae (Thomson & Pflug, 1953).

Ditribution : Very rare, only 3 specimens were found within samples MTe 14, MM7 and MTu 1. Verrucatosporites cf. V. favus Potonie' Type B was recorded from the Tertiary deposit of Spitsbergen (Manum, 1960). V. favus favus was reported from the Middle Oligocene to Lower Miocene Of

Germany (Krutzsch, 1967).

Verrucatosporites usmensis (Van der Hammen)

Germeraad, Hopping & Muller, 1968

(Plate 5, fig.1)

1956 Verrumonoletes usmensis Van der Hammen, p.116, fig.7

1968 Verrucatosporites usmensis (Van der Hammen) Germeraad, Hopping & Muller, p.280, pl.2, fig.3

1972 Polypodiidites usmensis (Van der Hammen) Hekel, p.6, pl.1, figs.8-9

1982 P. usmensis (Van der Hammen) Hekel in Playford, p.42, pl.5, figs.4-7

Designated : M5d

Description : Spores monolete, bean-shaped with straight to slightly concave proximal outline in equatorial view, bilateral symmetry. Laesura straight, simple and opened up to 7um wide in some specimens. Exine thickness distinct, 1-1.5um. Sculpture verrucate, with cone-like verrucae, 1.5-2.5um in both basal diameter and height, randomly dispersed on both distal and proximal surfaces, separated by lumina of variable width.

Dimensions : Length 34(45)54um, width 23(30)49um (30 specimens from various horizons).

Remarks : The randomly dispersed cone-like verrucate sculpture is the most distinctive features of this species. The specimens sre similar to those described and photographed by various authors cited above. Cookson (1956) described and photographed monolete spores with similar features from Papua New Guinea and designated them as Schizaea papuana. This species may be represented more than one species; one with practically complete ridges and the other with an almost verrucose exospore (Cookson, 1956). The latter is more or less similar to the specimens.

Affinity : Germeraad et al. (1968) related this species to an Indo-Malesian climbing fern species Stenochlaena palustris.

Distribution : Occasionally found in Mae Teep, Mae Mo, Li, and Krabi samples, absent in Mae Tun samples. The same species was reported from the Eocene to Holocene of northern South America, Nigeria, and Borneo (Germeraad et al., 1968) and the Neogene of Queensland (Hekel, 1972).

Verrucatosporites sp

(Plate 5, fig.2)

Designated : M5e

Description : Spores monolete, bean-shaped with straight to slightly convex proximal outline in equatorial view, bilateral symmetry. Laesura straight, simple, extent about 2/3 of spore length. Exine thickness distinct, 1.5-1.8um. Sculpture laevigate with scattered verrucae, cone-like shape, 1.5-3um in basal diameter, 1-1.5um high, loosely scattered on the spore wall.

Dimensions : Length 52(61)72um, width 39(48)54um (10 specimens from various horizons).

Remarks : The specimens differ from V. usmensis (Van der Hammen) Germeraad et al. (1968) in their loosely scattered verrucae and larger grain size.

Affinity : Most probably related to Cyclophorus lingira (Jan Wilschut, 1985 : pers. comm.).

Distribution : Occasionally found in Li, Mae Teep, and Mae Mo samples, absent elsewhere.

Turma TRILETES (Reinsch) Dettmann, 1963

Genus TODISPORITES Couper, 1958

Todisporites cf. T. minor Couper, 1958

(PLate 5, fig.3)

1958 Todisporites minor Couper, p.135,pl.16, figs.9-10

Designated : T1

Description : Spores trilete, circular in polar view, radial symmetry. Laesurae straight, distinct, accompanied by slightly undulating margo (2-3um wide), extent about 1/2-2/3 of spore radius. Exine thickness distinct, 1-1.5um, laevigate to finely granulate.

Dimensions : Equatorial diameter 33(44)49um (20 specimens from various horizons).

Remarks : Specimens differ slightly from T. minor Couper described and photographed by Couper (1958) in their relatively shorter laesurae and, especially in their distinctive margo. T. rotundiformis (Mal.) Pocock described and photographed by Varma & Ramanujam (1984) shows no significant difference from T. minor Couper.

Affinity : Couper (1958) compared his T. minor with Todites princeps of the family Osmandaceae.

Distribution : Mostly found at low percentages in Mae Teep samples and sparsely occured in Mae Mo and Li samples. T. minor was reported from the Jurassic of Great Britain (Couper, 1958). T. rotundiformis was recorded from the Jurassic sediments of Western Canada and from the Upper Gondwana deposits of India (Varma & Ramanujam, 1984).

Genus LEIOTRILETES (Naumova) Potonie' & Kremp, 1954

Leiotriletes apheles (Hunger) Krutzsch, 1959

(PLate 5, fig.4)

1952 Sporites apheles Hunger, p.193, pl.1, fig.4

1959 Leiotriletes apheles (Hunger) Krutzsch, p.58

1962 Leiotriletes apheles (Hunger) Krutzsch in Krutzsch, p.22, pl.4, figs.8-10

Designated : T2a

Description : Spores trilete, circular in polar view, radial symmetry. Laesurae straight to slightly curved (possibly due to folding of spores), slightly opened, extent about 4/5 of spore radius. Exine thickness distinct, 1.5-2.5um, laevigate.

Dimensions : Equatorial diameter 39(50)57um (20 specimens from various horizons).

Remarks : The specimens are closely comparable to L. apheles (Hunger) Krutzsch described and photographed by Krutzsch (1959,1962). L. aphleles distinctively differs from T. minor Couper described above in their distinct exine thickness, longer laesurae without margo, and completely laevigate sculpture.

Affinity : Hunger (1952) referred this species to Ophioglossum culgatum.

Distribution : Mostly found at low percentages in Mae Teep samples, rarer in Mae Mo and absent elsewhere. Hunger (1952) reported this species from the Upper Oligocene brown coal from Seidewitz in Tummlitzer Wald. Krutzsch (1962) recorded this species from the Miocene deposit of East Germany.

Leiotriletes sp

(Plate 5, Fig.5)

Designated : T2b

Description : Spores trilete, rounded elliptical shape. Laesurae straight, simple, extent about 1/2 to 2/3 of spore radius, somewhat unequal. Exine thickness distinct, 2-2.5um thick, laevigate.

Dimensions : Equatorial diameter 20(23)25um (5 specimens from various horizons).

Remarks : The specimens are tentatively placed in the genus Leiotriletes.

Affinity : Unknown.

Distribution : The specimens were found sporadically within the samples from Li, Mae Teep, Mae Mo, and Mae Tun deposits.

Genus LAEVIGATISPORITES (Bennie & Kidston) Ibrahim, 1933

Laevigatisporites pseudomaximus Pflug & Thomson, 1953

(PLate 5, fig.6)

1953 Laevigatisporites pseudomaximus Pflug & Thomson in Thomson & Pflug, p.54, pl.2, figs.18-23

Designated : T3a

Description : Spores trilete, triangular with straight to slightly convex sides and rounded angles, radial symmetry. Laesurae straight, simple, distinct, extent about 2/3 to

3/4 of spore radius. Exine 1.2 to 1.5um thick, laevigate.

Dimensions : Equatorial diameter 54(59)64um (30 specimens from various horizons).

Remarks : The specimens are similar to those described by Thomson & Pflug (1953). Krutzsch (1959) combined and designated plate 2, fig.20 of Thomson & Pflug (1953) as the holotype of Leiotrletes adriennis (Potonie' & Gelletich) subsp. pseudomaximus (Thomson & Pflug). Cyathidites australis Couper (1953) differs from the specimens in its concave sides. Biretsporites huensis Playford (1982) differs from the specimens in its typically unequal laesurae that are, moreover, narrowly lipped.

Affinity : Genus Lygodium (Thompson & Pflug, 1953).

Distribution : Common to abundant within the samples from Mae Mo deposit, rare to absent elsewhere. The same species was reported to be commonly found in Paleocene and Oligo-Miocene deposits of Central Europe (Thompson & Pflug, 1953). Leiotriletes adriennis pseudomaximus was recorded from the Middle Eocene browncoal deposit of East Germany (Krutzsch, 1959)

Laevigatisporites sp

(Plate 5, fig.7)

Designated : T3b

Description : Similar to Laevigatisporites pseudomaximus, differs only in its smaller size.

Dimensions : Equatorial diameter 25(39)52um (20 specimens from various horizons).

Remarks : The specimens could represent a smaller form of L. pseudomaximus described above. Leiotriletes microadriennis Krutzsch (1959), which tended to represent the smaller form of L. adriennis pseudomaximus (Krutzsch, 1959), somewhat differs in its more rounded shape.

Affinity : Possibly the same as L. pseudomaximus

Distribution : Occasionally found in the samples from Li, Mae Teep, Mae Mo, and Krabi deposits.

Genus CONCAVISPORITES Pflug, 1953

Concavisporites (Obtusisporis) minimus Krutzsch, 1962

(Plate 5, Figs.8-9)

1962 Concavisporites (Obtusisporis) minimus Krutzsch, p.106, pl.46, figs.1-14

Designated : T4

Description : Spores trilete, triangular with straight to undulating concave sides and slightly pointed angles in polar view. Laesurae long, reaching equator, undulating and partially obscured. Exine thin, spore wall slightly undulose. Sculpture laevigate to faintly psilate.

Dimensions : Equatorial diameter 28(29)30um (5 specimens from various horizons).

Remarks : The specimens are closely comparable to <u>Concavisporites</u> <u>(Obtusisporis)</u> <u>minirous</u> described and photographed by Krutsch (1962) but relatively larger (specimens described by Krutzsch were about 15-22um in diametre). Similar form <u>Concavisporites</u> <u>juriensis</u> Balme and <u>Cibotiumsporites</u> <u>juriensis</u> (Balme) photographed by McLachlan & Pieterse (1978) and Harris (1978), respectively are comparable but have no detailed description.

Affinity : Gleicheniaceae (Thomson & Pflug, 1953 in Krutzsch, 1962).

Distribution : Very rare, found in Mae Mo samples only, Krutzsch (1962) recorded this species sparsely occurred in the Oligocene and Miocene, and very rare in the Pliocene of

East Germany. Similar form, C. juriensis, was found in the Cenomanian sediments from site 361, Deep Sea Drilling Project (McLanchlan & Pieterse, 1978). Another similar form, Cibotiumsporites juriensis (Balme), was recorded from site 330 (Harris, 1976).

Genus FOVEOTRILETES (Van der Hammen) Potonie', 1956

Foveotriletes cf. F. crassifovearis Krutzsch, 1962

(Plate 5, Fig.10)

1962 Foveotriletes crassifovearis Krutzsch, p.56, pl.21, Figs.1-12.

Designated : T5a

Description : Spores trilete, subtriangular with straight to slighly convex sides and rounded angles, radial symmetry. Laesurae long, indistinct, generally reach the equator. Exine thickness distinct, 2-3um. Sculpture foveolate; foveolae oval-shaped in outline, diameter about 1.5-2.0um, 2-2.5um apart, regularly distributed, tend to be less concentrated around the contact area.

Dimensions : Equatorial diameter 21(37)44um (15 specimens from various horizons).

Remarks : The specimens are closely related to those described and photographed by Krutzsch (1962) but differ in the leasurae pattern where Krutzsch's specimens seem to have more distinct and slightly opened laesurae.

Affinity : Possibly Lycopodium (Wilschut, 1985 : personal communication).

Distribution : Sparsely distributed within Mae Mo samples only. Similar form was recorded from the Oligo-Miocene of East Germany (Krutzsch, 1962)

Foveotriletes balteus Partridge, 1973

(Plate 5, figs.11-12)

1973 Foveotriletes balteus Partridge in Stover & Partridge, p.247, pl.14, fig.7.

Designated : T5b

Description : Spores trilete, subtriangular with straight to slightly convex sides and rounded angles. Laesurae long, distinct, extent about 4/5 of spore radius, straight. Exine thickness distinct, 1-1.5um. Sculpture foveolate; foveolae small, sub-circular, about 1um in diameter, 1-1.5um apart, regularly distributed. Proximal surface shows tori between the trilete rays.

Dimensions : Equatorial diameter 34(37)43um (5 specimens from various horizons).

Remarks : Specimens resemble Foveotriletes balteus Partridge, described and photographed by Stover & Partridge (1973). The distinctive feature is the occurrence of tori or kyrtomes (Stover & Partridge, 1973) between the trilete rays.

Affinity : ?. Gleichenidites. According to Thomson & Pflug (1953), the tori structure is the characteristic feature of spores belonged to this genus.

Distribution : Sparsely occurred in Mae Mo and Mae Teep samples. The same species was first recorded from the Middle Eocene to Miocene sediments of the Gippsland Basin, southeastern Australia (Stover & Partridge, 1973).

Foveotriletes cf. F. crassifovearis subsp. crassoides Krutzsch, 1967
(Plate 5, Figs.13-14)

1967 Foveotriletes crassifovearis subsp. crassoides Krutzsch, p.44, pl.4, figs.7-8.

Description : Spores trilete, subtriangular with straight sides and rounded angles, radial symmetry. Laesurae straight, slightly opened, extent about 2/3 of spores radius. Exine thickness distinct, 2.5-3um. Sculpture foveolate; foveolae small, circular in outline, about 1um in diameter, 3-5um apart, sparsely distributed.

Dimensions : Equatorial diameter 28um (1 specimen from sample No.MM 16 only).

Remarks : The specimen differs slightly from Foveotriletes crassifovearis crassoides described and photographed by Krutzsch (1967) in its slightly shorter laesurae and smaller size. However, more specimens are needed for comparison. Filtrotriletes nigeriensis described and photographed by Hoeken-Klinkenberg (1966) is also comparable.

Affinity : Unknown.

Distribution : Only one specimen was found is sample MM 16. Similar forms were recorded from the Miocene of East Germany (Krutzsch, 1967). Filtrotriletes nigeriensis was reported from the Maastrichtian of Nigeria (Hoeken-Klinkenberg, 1966).

Genus OSMUNDACIDITES Couper, 1953

Remarks : Couper (1953) made it quite clear that the genus Osmundacidites was intended for the reception of spores of Osmundaceous affinity which could be included the genera Baculatisporites and Rugulatisporites proposed by Thomson & Pflug (1953). Krutzsch (1967) studied the spores from the Recent Osmunda and included the genera Osmundacidites, Baculatisporites, and Rugulatusporites within the genus Baculatisporites which then compared to the Recent Osmunda. Therefore, in this study, the genus Osmundacidites will be used, and the different forms will be designated as sp.A,B, etc.

Osmundacidites sp.A
(Plate 5, Figs.15-18)

Designated : T6a

Description : Spores trilete, sub-triangular to sub circular with rounded angles and convex sides in polar view. Laesurae straight accompanied by conspicuous margo (3-5um across), extent about 4/5-5.5 of spore radius. Exine thickness 1.5-2um, generally obscured by ornaments. Sculpture densely packed baculate - clavate, fairly regularly distributed. Elements 1.5-2um in basal diameter, 3-5um high, slightly bent.

Dimensions : Equatorial diameter 31(45)49um (50 specimens from various horizons).

Remarks : This form is comparable to Baculatisporites nanus nanus described and photographed by Krutzsch (1967) and Ziembinska-Tworzydlo (1974).

Affinity : According to Krutzsch (1967) this form can be related to Osmunda claytonia L.

Distribution : Occurred in every sample from Mae Teep deposit, scattered in Mae Mo and rare in Li samples. Similar form Baculatisporites nanus nanus Krutzsch, was common in the Pliocene of East Germany (Krutzsch 1967) and in the Lower to Upper Miocene of Western Poland (Ziembinska-Tworzydlo, 1974).

Osmundacidites sp. B

(Plate 6, Figs.1-3)

Designated : T6b

Description : Spores trilete, circular in polar view but always folded, radial symmetry. Laesurae straight, simple, slightly opened, normally obscured by the ornamentation, extent about 4/5 of spore radius. Exine thickness 1.5-2um, generally obscured by ornaments. Sculpture baculate/ clavate. Elements closely packed, regularly distributed, 1-1.5um in basal diameter, 2-3um high, slightly bent.

Dimensions : Equatorial diameter 52(65)85um (50 specimens from various horizons).

Remarks : This form generally differs from Osmundacidites sp. A in its circular outline in polar view, larger size, and does not have the conspicuous margo. The specimen is comparable to Baculatisporites primarius crassiprimarius Krutzsch, described and photographed by Krutzsch (1967). Similar forms B. cf. gemmatus Krutzsch (Manum; 1962) and B. comaumensis (Cookson) Potonie' (Harris, 1965) are also comparable.

Affinity : Krutzsch (1967) compared his specimen with Osmunda banksiafolia, O. interrupta, and O. javanica. In this study the specimens are closely comparable to O. javanica.

Distribution : Similar to sp.A in the areas of study. B. primarius crassiprimarius was reported from the Upper Eocene to Upper Pliocene of East Germany (Krutzsch, 1967), and B. cf. gemmatus was found in the Tertiary basin of Spitsbergen (Manum, 1962). B. comaumensis was recorded in the basal Tertiary from the Princetown area, Victoria, Australia (Harris, 1965).

Osmundacidites sp.C

(Plate 6, Figs.4-6)

Designated : T6c

Description : Spores radial, trilete, sub-circular to circular in polar view. Laesurae straight, extent about 2/3 to 3/4 of spore radius, accompanied by more or less conspicuous margo (3.5um across). Exine thickness 1.5-2um, generally obscured by ornaments. Sculpture rugulate, rugulae 1.5-2um wide, 3-5um long, 1-1.5um high, closely packed and more or less coalescing to form irregular ridges and grooves pattern.

Dimensions : Equatorial diameter 54(68)90um (50 specimens from various horizons).

Remarks : Specimens resemble the spores of Baculatisporites quintus quintus described and photographed by Krutzsch (1967) and Ziembinska-Tworzydlo (1974), Osmunda regalites by Martin & Rouse (1965), and Rugulatisporites cf. quintus Thomson & Pflug by Manum (1962).

Affinity : Most probably O. regalis as indicated by Martin & Rouse (1965) and Krutzsch (1967).

Distribution : Similar to sp.A and B in the area of study. Rugulatisporites cf. quintus Thomson & Pflug was recorded in the Tertiary of Spitsbergen (Manum, 1962). Osmunda regalites was found within the Tertiary of Queen Charlotte Islands, British Columbia (Martin & Rouse, 1965), and B. quintus quintus was reported from the Upper Miocene to Pliocene of East Germany (Krutzsch, 1967), and the Middle Oigocene to Middle Miocene of Western Poland (Ziembinska-Tworzydlo, 1974).

Osmundacidites sp.D
(Plate 6, Figs.7-8)

Designated : T6d

Description : Spores radial, trilete, circular in polar view. Laesurae straight, extent about 2/3 of spore radius, slightly opened, accompanied by distinct margo (3-5um across). Exine thickness distinct, 3-5um. Sculpture rugulate; rugulae 1.5-2um wide, 3-5um long, less than lum high, closely packed and coalescing to form the irregular ridges and grooves pattern.

Dimensions : Equatorial diameter 30(40)50um (50 specimens from various horizons).

Remarks : This form differs from sp.C in its smaller size, thicker exine, rugulate elements are shorter but more regularly distributed, and more clearly distinguished ridges and grooves pattern. The specimens closely resemble the species Baculatisporites quintus regulatoides described and photographed by Krutzsch (1967).

Affinity : Family Osmundaceae.

Distribution : Same as sp.A,B, and C. B. quintus regulatoids was found in the Pleistocene of East Germany (Krutzsch, 1967).

Genus POLYPODIACEOISPORITES Potonie', 1951

Polypodiaceoisporites brevisculptatus Kedves, 1973

(Plate 6, Figs.9-16)

1973 Polypodiaceoisporites brevisculptatus Kedves, p.45-46, pl.14, figs.12-14.

Designated : T7

Description : Spores radial, trilete, triangular to subtriangular with straight to slightly convex sides (occasionally undulating) and rounded apices in polar view. Laesurae straight, simple, extent 4/5 to 5/5 of spore radius, slightly opened. Cingulum 3-5um wide, laevigate, more or less uniform in width on given specimen. Sculpture rugulate; rugulae irregularly developed, smooth, rounded, 1.5-2.0um wide, up to 8um long (mainly 3-5um), less than

0.5um high, 1-1.5um apart, denser and coarser on the distal surface than the proximal surface.

Dimensions : Equatorial diameter 25(32)39um (60 specimens from various horizons).

Remarks : Specimens are very similar to P. brevisculptatus described and photographed by Kedves (1973) from the Lower to Middle Eocene formations of the Bakony Mountains. Various species described and photographed by Krutzsch (1967) are closely related but more or less differ from the specimens studied by virtue or ornamentation and size. For example, P. lusaticus, P. tanndorfensis, and P. seidewitzensis are similar in size but have granulate to verrucate ornament on the proximal surface rather than rugulate. P. microconcavus is similar in ornamentation but the size is smaller and having more or less concave sides. P. schoenewaldensis is also similar in ornamentation but differs by its larger size.

Affinity : Pteridaceae (Kedves, 1973) and most probably Pteris cf. pellucida (Jan Wilschut, 1985 : personal communication).

Distribution : Common in Li samples, fairly common in Mae Teep, and rare in Mae Mo samples. Kedves (1973) reported the occurrence of this species from the Lower to Middle Eocene formations of the Bakony Mountains, Hungary.

Genus MAGNASTRIATITES Germeraad, Hopping, & Muller, 1968

Magnastriatites grandiosus (Kedves & Sole' de Porta) Duenas, 1980

(Plate 7, figs.8-9)

1963 Cicatricosisporites grandiosus Kedves & Sole' de Porta, p.59, pl.7, figs.2-3.

1968 Magnastriatites howardii Germeraad, Hopping & Muller, p.288-289, pl.3, fig.1.

1980b Magnastriatites grandiosus (Kedves & Sole' de Porta) Dueñas, p.331, pl.1, figs.1-3.

Designated : T8

Description : Spores radial, trilete, anisopolar with rounded distal pole and slightly pointed proximal pole, sub circular in polar view. Laesurae straight. Contact area surrounded by a circular ridge, which makes contact with the straite ridge pattern at the points of the laesurae. Striate; striae 1.5-3u wide, 1-1.5um high, continuous, grooves 1.5-3um wide.

Dimensions : Equatorial diameter 61(77)90um (25 specimens from sample MM 6).

Remarks : Specimens closely resemble the species *M. grandiosus* described and photographed by Dueñas (1980b). The species is restricted within the sample MM 6 from Mae Mo deposit only.

Affinity : Virtually identical with the fresh-water fern genus *Ceratopteris* (Germeraad *et al*, 1968).

distribution : Abundant but restricted to the sample MM 6 from Mae Mo deposit only. The same species was recorded from the Eocene to Recent of the Caribbean, Nigeria and Borneo areas (Germeraad *et al*., 1968). Medus (1975) reported its occurrence in the Tertiary sediments from the Senegal Meridional. Salard-Cheboldaeff (1975, 1976, 1979) described and photographed this species from the Tertiary (Oligocene?) sediments of Cameroun.

Genus CRASSORETITRILETES Germeraad, Hopping & Muller, 1968

Crassoretitriletes vanraadshooveni Germeraad, Hopping & Muller, 1968

(Plate 7, fig.11)

1968 *Crassoretitriletes vanraadshooveni* Germeraad *et al*., p.286-287, pl.1, fig.3.

Designated : T9

Description : Spores radial, trilete, subtriangular with straight to slightly convex sides and rounded apices in polar view, rounded distal pole and slightly pointed proximal pole in equatorial view. Laesurae straight, normally inconspicuous, accompanied by faintly margo (5-7um across). Exine thickness indistinct, 1.5-3um. Reticulate, undulating muri 3-5um wide, 2um high, lumina 2-4um wide, 4-6um long.

Dimensions : Equatorial diameter 62(73)90um (25 specimens from various horizons).

Remarks : The specimens vary in size and coarseness of sculpture.

Affinity : Produced by the fern genus Lygodium (Germeraad et al., 1968).

Distribution : Occurred at low percentages within the Mae Teep and Mae Mo samples, absent elsewhere. Germeraad et al, (1968) recorded this species from the Lower Miocene to Recent sediments of the Columbia, Nigeria, and Borneo areas.

INDETERMINATE TRILETES SPORES

Designated : T10

(Plate 7, Figs.12-14)

Description : Spores radial, trilete, subcircular with undulating outline in polar view, surrounded by thin, narrow zone appearing as wavy line in equatorial view, subprolate in equatorial view, rigid. Laesurae distinct, irregular, extent toward the equatorial margin, accompanied by solid margo (3-5um across). Sculpture psilate on the entire surface including the zonal area. Spores commonly preserved in the equatorial compression.

Dimensions : In equatorial compression : long axis 18(25)31um, short axis 10(16)21um (45 specimens from various horizons).

Remarks : Undulatisporites takutensis described and photographed by Van Der Hammen & Burger (1966) is the most closely related to the specimens but differs in its fossulate sculpture which does not appear in the specimens studied. The distinctive features of the specimens is that they mostly occur in equatorial compression with irregular prolate outline consisting of an undulating equatorial line which may resemble a zonal structure, and the spore looks very rigid.

Affinity : Unknown.

Distribution : Very common in Mae Teep samples, fairly common in Mae Mo, only one specimen found in Li samples and absent in Krabi and Mae Tun samples. Similar form U. takutuensis is recorded from the Takuta Formation, Guyana (Van Der Hammen & Burger, 1966).

The tests of the indeterminate trilete spores are found in small numbers. They are listed as follows :

Designated : T11a (Plate 5, fig.19) Only one specimen was found within sample MM 1. The species Trilites sinuatus described and figured by Couper, 1953 is similar in general but different in sculptural details.

Designated : T11b (Plate 5, fig.20-21) One specimen was recognised from sample MM 4. Similar to T11a, this form could be compared with T. sinuatus but differs in sculptural details.

Designated : T12 (Plate 5, fig.22) A few specimens are found in Mae Teep and Mae Mo samples. Specimens are mainly poorly preserved and could be derived from older deposits. The most closely related is the spore of Cingulatisporites scabratus described and photographed by Couper, 1958 from the Mesozoic of Britain.

Designated : T13 (Plate 5, fig.23) Only one specimen was found in the sample MM 18. The specimen is similar to

Concavisporites (Appendicisporites) complicatus Pflug described and photographed by Thomson & Pflug (1953).

Designated : T14a (Plate 7, fig.1) : Only one specimen was found in sample MM 25. The specimen is tentatively placed within the genus Corrugatisporites (Thomson & Pel. 1953 non Ibr. 1933) Weyland & Greifield (1953).

Designated : T14b (Plate 7, figs.2,3,5) : Only three specimens were found within samples Mm 22 and MM 25. The specimens are more or less similar to Corrugatisporites toratus Weyland & Greifeld described and photographed by Weyland & Greifeld (1953) from the Upper Cretaceous clay deposit near Quedlinburg, Harz, Germany.

Designated : T14c (Plate 7, fig.4) : Only a few specimens were found within Mae Mo samples. The specimens are more or less similar to Corrugatisporites arcuatus Weyland & Greifeld described and photographed by Weyland & Greifeld (1953) from the Upper Cretacous clay of Germany.

Designated : T15 (Plate 7, figs.6) : Only one specimen was found in sample MTe 1. The specimen is tentatively placed in the genus Cicatricosisporites Potonie' & Gelletich (1933).

Designated : T16 (Plate 7, figs.7) : Two specimens were found in samples MM 14 and MM 27. The specimens were more or less similar to Lycopodiumsporites gristhorpensis Couper described and photographed by Couper (1958) from the British Mesozoic deposit.

Designated : T17 (Plate 7, fig.8) : Only one specimen was found in sample MM 2. The specimen is tentatively placed in the genus Echinatisporis Krutzsch (1959).

Anteturma POLLENITES Potonie', 1931

Turma SACCITES Erdtman, 1947

Subturma DISACCITES Cookson, 1947

Genus PITYOSPORITES (Seward) Potonie' & Klaus, 1954

Pityosporites cf. P. labdacus (Potonie')
Thomson & Pflug, 1953
(Plate 8, figs.1-11)

1931b Pollenites labdacus Potonie', p.5, fig.32

1953 Pityosporites labdacus (Potonie') Thomson & Pflug, p.66, pl.5, figs.60-62.

1964 Pityosporites labdacus (Potonie') Thomson & Pflug in Stichlik, p.26, pl.9, figs.4-9.

Designated : DS1

Description : Pollen grains free, anispolar, disaccate, bilateral symmetry. Corpus sub-circular in polar view. Proximal cap indistinct with faintly tuberculate sculpture 1.5-2um thick. Dorsal outline even to slightly undulate, body outline slightly undulate only in the region of sac attachment. Sacci are fairly broadly attached to the corpus and not constricted at the attachmen points. Sculpture of the sacci loosely reticulate.

Dimensions : Lateral longitudinal view : corpus height 20(36)52um, breadth 30(46)66um; sacci height 15(25)49um, depth 16(36)48um (50 specimens from various horizons).

Remarks : The specimens are placed in the genus Pityospites (Seward) Potonie' & Klaus (1954) in the sense that they have doubtful affiliation to the living species of the genus Pinus as suggested by Rouse (1959). The specimens are more or less similar to Pityosporites labdacus (Potonie') Thomson & Pflug (1953) which they referred to the Pinus Group diploxylon (Sylvestris-Type). This assignment by Thomson & Pflug (1953) is thought to correspond with the original Pinus diploxylon proposed by Rudolph (1935) for fossil pollen grains resembling the modern genus Pinus of uncertain affinity as indicated by Boulter (1971) and Wilkinson & Boulter (1980). Boulter (1971) also pointed out that such comparative implication could be misleading as Pinus sylvestris is the only living species indigenous to the British Isles.

Affinity : Genus <u>Pinus</u> (Thomson & Pflug, 1953).

Distribution : Occurred at relatively low percentages in all deposite except the anomalous one, sample MTu 1, in which it reached 46%. This species was found in many strata world wide under various names such as : <u>Pityosporites labdacus</u> (Thomson & Pflug, 1953; Stuchlik, 1964); <u>Pollenites labdacus</u> (Potonie' 1931b,1934; Potonie' & Venitz, 1934); <u>Pinus sylvestris</u> Type (Traverse, 1952; Boulter, 1971); and <u>Pinus diploxylon</u> Type (Rudolph, 1935).

INDETERMINATE DISACCATE POLLEN GRAINS

Designated : DS 2a (Plate 9, figs.1-3 and 7-10) : A few specimens were found in samples LI3 and MTul. The specimens are tentatively placed in the genus <u>Podocarpidites</u> Cookson ex Couper, 1953, and more or less similar to <u>Podocarpidites biformis</u> Rouse, (1959).

Designated : DS 2b (Plate 9, figs.4-6) : A few specimens were found in samples MTe14, MM18, and LI3. The specimens are tentatively placed in the genus <u>Podocarpidites</u> Cookson ex Couper, 1953, and more or less similar to <u>Podocarpidites ellipticus</u> Cookson, 1947.

Designated : DS 2c (Plate 9, fig.11) : Only one specimen was found in the MM 26 sample. The specimen is tentatively placed in the genus Podocarpidites Cookson ex Couper, 1953.

Designated : DS 3 (Plate 9, figs.12-13) : Two specimens were found in the samples MM 2 and LI3. The specimens are tentatiely placed in the genus Dacrydiumites Cookson, 1947.

Designated : DS 4 (Plate 9, Fig.14) : Only a few specimens were found in the MTul sample. Based on their disaccate appearance, the specimens are roughly placed in the Subturma Disaccites Cookson, 1947.

Genus ZONALAPOLLENITES Pflug, 1953

Zonalapollenites igniculus (Potonie') Thomson & Pflug, 1953

(Plate 10, figs.1-3)

1931c Sporonites igniculus Potonie', p.556, fig.2.

1953 Zonalapollenites igniculus (Potonie') Thomson & Pflug, p.66-67, pl.4, figs. 75-79

1974 Zonalapollenites igniculus (Potonie') Thomson & Pflug in Ziembinska-Tworzydlo, p.352, pl.13, fig.1.

Designated : Zla

Description : Pollen grains free, monosaccate, circular in polar view, with distinct undulate equatorial fringe of about 10-15um wide. Faintly verrucate sculpture with minute spinules.

Dimensions : Equatorial diameter 45(62)80um (10 specimens from various horizons).

Remarks : The specimens are similar to those described by various authors cited above. The species resembled Tsuga diversifolia type (Thomson & Pflug, 1953; Stuchlik, 1964; Boulter, 1971).

Affinity : Genus Tsuga (Thomson & Pflug, 1053).

Distribution : Very occasionally found within the Li, Mae Teep, and Mae Mo samples, absent elsewhere. The same species were reported from the Oligocene/Miocene lignite of Germany (Potonie', 1931c), the Middle to Upper Tertiary deposits of Central Europe (Thomson & Pflug, 1953), the Miocene deposits at Rypin, N.W. of Warsaw (Stuchlik, 1964); the Neogene plant beds in Derbyshire (Boulter, 1971), and the Miocene deposits of western Poland (Ziembinska-Tworzydlo, 1974).

Zonalapollenites (Tsuga) viridifluminipites (Wodehouse) Thomson & Pflug, 1953

(Plate 10, figs.4-6)

1933 Tsuga viridi-fluminipites Wodehouse, p.491, fig.14

1953 Zonalapollenites (Tsuga) viridifluminipites (Wodehouse) Thomson & Pflug, p.67, pl.4, figs. 80-82

1962 Tsugaepollenites viridifluminipites (Wodehouse) Potonie' in Manum, p.45, pl.10, figs.1-4.

Designated : Z1b

Description : Pollen grains free, monosaccate, circular in polar view, with indistinct undulate equatorial finge of about 10um wide. Distinct verrucate sculpture.

Dimensions : Equatorial diameter 60(72)80um (10 specimens from various horizons).

Remarks : The specimens resembled Tsuga canadensis type (Wodehouse, 1933; Thomson & Pflug, 1953). The specimens differ from Z1a in having narrower equatorial fringe and more distinctive verrucate sculpture.

Affinity : Genus Tsuga (Wodehouse, 1933; Thomson & Pflug, 1953).

Distribution : Found within the samples from Mae Tun deposit only. The same species were recorded in the Eocene Green River Formation (Wodehouse, 1933), the Middle to Upper Tertiary desposits of Central Europe (Thomson & Pflug, 1953), the Tertiary deposits of Spitsbergen (Manum, 1962), the Miocene deposits at Rypin, N.W. of Warsaw (Stuchlik, 1964), and the Neogene plant beds in Derbyshire (Boulter, 1971).

Turma INAPERTURES Pflug & Thomson, 1953

Genus INAPERTUROPOLLENITES Pflug & Thomson, 1953

Remarks : As proposed by Thomson & Pflug (1953) the genus <u>Inaperturopollenites</u> will be used for all inaperturate pollen grains both with or without the spliting of the exine along the radial line.

<u>Inaperturopollenites</u> sp.1 (cf. <u>Araucariacites</u> <u>australis</u>)

(Plate 11, figs.7-9)

Designated : I1

Description : Pollen grains free, inaperturate, subcircular to circular in outline, grain always folded and crumpled. Exine 1-1.5um thick. Sculpture laevigate to finely granulate.

Dimensions : Diameter 28(45)72um (50 specimens from various horizons).

Remarks : The specimens with finely granulate sculpture are more or less similar to Granulonapites (Araucariacites) australis Cookson described and photographed by Cookson (1947), Van der Hammen & Burger (1966), Muller (1968), and Varma & Ramanujam (1984). The others were similar to Inaperturopollenites magnus (Potonie') Thomson & Pflug (1953) as well as Form-genus Inaperturopollenites Group B Wilkinson & Boulter (1980). In this study the specimens are preferably compared to Granulonapites (Araucariacites) australis Cookson which resembled the family Araucariaceae (Cookson, 1947). None of Thomson & Pflug's inaperturate pollen grains related to this family.

Affinity : According to Cookson (1947) the specimens resembled the pollen grains of the family Araucariaceae.

Distribution : Common to abundant in the samples from Li, Mae Mo, and Mae Tun deposits, rare elsewhere. Granulonapites (Araucariacites) australis Cookson were reported from the Tertiary lignite and carbonaceous sandstone of Kerguelen Archipelago (Cookson, 1947), the Lower Cretaceous formation of Guyana (Van der Hammen & Burger, 1966), the Cretaceous-Eocene formation of Sarawak, Malaysia (Muller, 1968), and the Upper Gondwana Deposit of

India (Varma & Ramanujam, 1984).

Inaperturopollenites sp.2(cf. Sequoia langsdorfii)

(Plate 11, fig.10)

Designated : I2

Description : Pollen grains free, inaperturate, pear-shaped, grains always folded and crumpled. Exine less than 0.5um thick. Sculpture laevigate to finely granulate.

Dimensions : Polar axis 39(45)59um, equatorial axis 26(35)41um (20 specimens from various horizons).

Remarks : The specimens are very similar to I1 when folded and crumpled. The specimens showed some similarity with the grains of modern genus Sequoia illustrated by Erdtman (1957, p.41, fig.66). Endo (1964, 1966) identified the fossil plant remains, mainly leaves, from Li deposit as Sequoia langsdorfii.

Affinity : Most probably related to the genus Sequoia of the family Taxodiaceae.

Distribution : Occasionally found within the samples from Li and Mae Mo deposits.

? Inaperturopollenites sp.3

(Plate 11, fig.11)

Designated : I3

Description : Pollen grains free, inaperturate, circular in outline. Exine 1.5-3.0um thick sometimes appears as two layers with the outer 1.5-2.5um and inner 0.5-1.0um thick but always conspicuous. Sculpture laevigate.

Dimensions : Diameter 20(28)39um (15 specimens from various horizons).

Remarks : The specimen is somewhat similar to Classopollis klausi Boltenhagen photographed by Morgan (1978), which he grouped within the Inaperturate Forms, without any description. However, according to Couper (1958), the type species for his emended genus Classopollis has, although not always clearly shown, a distal pore (monoporate) which is absent in the specimens. The specimen, therefore, is tentatively placed within the genus Inaperturopoll. In addition, the specimen may be fungal spore rather than pollen grain.

Affinity : Unknown.

Distribution : Occurred very sparsely in every deposit. C. klausi was reported from the Deep Sea Drilling Project Site 364, Angola basin by Morgan (1978).

Inaperturopollenites hiatus (Potonie')
Thomson & Pflug, 1953
(Plate 11, figs.12-13)

1931d Pollenites hiatus Potonie, p.5, fig.27

1953 Inaperturopollenites hiatus (Potonie') Thomson & Pflug. p.65, pl.5, fig.14-20

1980 Form-genus Inaperturopollenites Group C Wilkinson & Boulter, p.45, pl.1, figs.18-22; pl.2, figs.1-10

Remarks : The species comprises all inaperturate pollen grains which split along the symmetry plane. They can be divided into two groups by means of their size, shape, degree of splitting and sculpture. They are, in this study, never found within the same deposit.

Designated : I4a (Plate 11, fig.12); I4b (Plate 11, fig.13).

Description : Pollen grains elongate (I4a) to circular (I4b), exine 0.5-1um, laevigate (I4a) to scabrate (I4b).

Degree of splitting ranges from nearly full diameter (I4a) to about half diameter (I4b).

Dimensions : Measured as the diameter along the line of splitting; I4a 25(40)59um (15 specimens from various horizons); I4b 26(32)39um (20 specimens from various horizons).

Affinity : Taxodium (Thomson & Pflug, 1953).

Distribution : I4a were occasionally found within Mae Teep and Mae Mo samples whilst I4b were commonly found within Mae Tun and Li samples. They were both absent from Krabi samples.

INDETERMINATE INAPERURATE POLLEN GRAINS

Designated : I5 (Plate 11, fig.14) : Pollen grains inaperturate, thin exine (1-1.5um) with loosely scattered gemmate sculpture. The specimens are more or less comparable to the pollen of I. incertus fossulatus Pflug & Thomson described and photographed by Thomson & Pflug (1953). The specimens occurred within samples LI15 and LI33, and only five specimens were found. Average diameter 53um.

Designated : I6 (Plate 11, figs.15-16) : Pollen grains inaperturate, circular, thin exine (less than 1um) with negative irregular reticulum. Small grains, average diameter 17um. A few specimens were found within samples KB4 and MM15.

Designated : I7 (Plate 11, fig.17) : Pollen grains inaperturate, circular, thin exine (less than 1um). Sculpture very faintly verrucate, normally inconspicuous. Some grains showed signs of a tetrad scar. Size ranges 15-25um, average 19um. Common to abundant in the samples from Krabi deposit, absent elsewhere.

Designated : I8 (Plate 11, figs.18-19) : Pollen grains inaperturate, circular, thin exine (about 1um). Sculpture granulate; granules about 1um in diameter and 2.5-3um apart. Grains small, 25(35)43um (15 grains from various horizons). The specimens are more or less comparable to the pollen of the modern genus Typha as record by Couper (1960) as Typha sp. from the Middle Oligocene to Recent of New Zealand.

Designated : I9 (Plate 11, figs.20,21) : Pollen grains inaperturate, oval-shaped. Exine inconspicuous covered with fine reticulate sculpture. Only two specimens were found within MTu1 and MM12 samples. The specimens are closely similar to Clavainaperturites clavatus described and photographed by Van der Hammen & Wymstra (1964) but the size is smaller.

Turma PLICATES Naumova, 1939

Subturma MONOCOLPATES Iversen & Troels-Smith, 1950

Genus PROXAPERTITES Van der Hammen, 1956

Proxapertites operculatus (Van der Hammen)

Germeraad, Hopping & Muller, 1968

(Plate 11, figs. 1-2)

1954 Monocolpites operculatus Van der Hammen, p.89, pl.5, figs.2-3

1956 Proxapertites operculatus Van der Hammen, p.105, pl.1, fig.3

1966 Proxapertites operculatus Van der Hammen in Hoeken-Klinkenberg, p.43, pl.1, fig.10

1968 Proxapertites operculatus Van der Hammen in Muller, p.12, pl.3, fig.4

1968 Proxapertites operculatus (Van der Hammen) Germeraad, Hopping & Muller, p.296, pl.5, fig.2

1976 Proxapertites operculatus Van der Hammen in Salard-Cheboldaeff p.239, pl.1, fig.12

1980a Proxapertites minutus Dueñas, p.317, pl.1, figs.2-4

Designated : MC1

Description : Pollen grains free, slightly anisopolar as they are normally separated by a continuous equatorial colpus into two unequal parts, circular to oblate in polar view, radial symmetry. Exine 1-1.5um thick with psilate to scabrate sculpture.

Dimensions : Diameter 25(35)56um (50 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by various authors cited above and the diagnosis by Germeraad *et al*. (1968), that they are monad rather than dyads as in the original diagnosis by Van der Hammen (1956), seemed to be clearly shown within the specimens studied. The new species *P. minutus*, described by Duenas (1980a) which differed from *P. operculate* only by the smaller size, is thought to be included in this species as they were always found together and there is no other evidence to support that they were produced by different species.

Affinity : Derived from an extinct group of palms related to *Nypa* (Muller, 1968).

Distribution : Occurred sparsely within the Mae Teep and Mae Mo samples with the anomaly of 16.8% in sample MM21, and found only in sample LI3 from Li deposit, absent elsewhere. This species was reported from the Eocene of Colombia (Van der Hammen, 1954, 1956); the Paleocene of Nigeria (Hoeken-Klinkenburg, 1966); the Paleocene of Sarawak, Malaysia (Muller, 1968); the Paleocene of Borneo, the Paleocene-Eocene of Nigeria and the Senonian up to Pliocene of the Caribbean (Germeraad *et al.*, 1968); the Paleocene to Eocene of Cameroun (Salard-Cheboldaeff, 1976, 1979); and the minor form *P. minutus* was recorded from the Oligocene-Miocene strata of Northern Colombia (Dueñas, 1980a).

Genus *Ovoidites* (Potonie') Krutzsch, 1959

***Ovoidites elongatus* (Hunger) Krutzsch, 1959 subsp.**

***elongatus* Krutzsch, 1959**

(Plate 14, Fig.1)

1952 *Sporites elongatus* Hunger, p.193, pl.1, fig.12 (only)

1959 *Ovidites elongatus* (Hunger) Krutzsch subsp. *elongatus* Krutzsch, p.252.

Designated : MC2a

Description : Pollen grains free, isopolar, ellipsoidal shaped with rounded poles, bilateral symmetry. Exine 1.5-2um thick, laevigate to faintly psilate, translucent. Grains bisected by elongated colpus toward the long axis but never split.

Dimensions : Equatorial diameter; long axis 35(56)80um, short axis 26(36)46um (45 specimens from various horizons).

Remarks : The specimens are similar to those described by Krutzsch (1959). However, they differ slightly in their smaller size (Krutzsch's specimens were 75-100um in the long axis), Ovidites laeviligneolus Krutzsch (1959) is also comparable but differs in its typically split aperture.

Affinity : Uncertain, probably related to the Recent genus Magnolia or Liriodendron of the family Maynoliaceae.

Distribution : Abundant within Mae Mo samples, common in Mae Teep and very rare in the others. The same species was first recorded from the Upper Olgocene brown coal deposit of Tummlitzer Waldes, northwestern Saxony (Hunger, 1952 in Krutzsch, 1959). Krutzsch (1959) also reported the occurrence of this species to be common within the Upper Oligocene brown coal deposit of East Germany but rare within the Miocene deposit of the same area.

<u>Ovoidites</u> <u>microligneolus</u> Krutzsch, 1959

(Plate 14, fig.2)

1959 <u>Ovoidites</u> <u>microligneolus</u> Krutzsch, p.254, pl.41, figs.635-637

Designated : MC2b

Description : Pollen grains free, isopolar, ellipsoidal in shape. Exine thickness distinct, 2.5-3.5um thick (including muri). Sculpture rugulate-reticulate pattern with muri' 1.5-2um wide, 1-1.5um high, and divided by 1.5-2um wide lumina. Grains always bisected into two equal parts by an elongate colpus along the long axis, slightly split in some grains.

Dimensions : Equatorial diameter; long axis 62(66)74um, short axis 38(43)48um (15 specimens from sample no. MM27 only).

Remarks : The specimens are similar to those described and illustrated by Krutzsch (1959).

Affinity : The same as MC2a.

Distribution : Abundant within sample MM27 only. Krutzsch (1959) reported this species in the Eocene of E. Germany.

INDETERMINATE MONOCOLPATE POLLEN GRAINS

Designated : MC3 (Plate 11, figs.22-23) : Pollen grains monocolpate, exine 1.5-2um thick, sculpture echinate. The specimens is similar to Nupharipollis minor Krutzsch described and photographed by Krutzsch (1970). Only one specimen was found in sample MM18.

Designated : MC4 (Plate 11, figs.24-26) : Pollen grains circular in equatorial view and subtriangular in polar view, the furrow could be monosulcate or monocolpate. Exine 1-1.5um thick (including muri) with microreticulate sculpture. The specimens more or less resemble the genus Arecipites, for example, A. pseudoconvexus (Thiergart) Krutzsch and A. oligocaenicus Krutzsch, described and photographed by Krutzsch (1970). A few specimens were found in Mae Mo and Li samples.

Designated : MC5 (Plate 11, figs.27-30) : Pollen grains free, oval-shaped in both equatorial and polar views, the furrow is doubtfully monosulate or monocolpate. Exine 1.5-2um thick (including muri), microreticulate sculpture. A few specimens were found within Krabi and Mae Mo samples.

Designated : MC6 (Plate 11, figs.31-32) : Pollen grains free, isopolar, elliptical outline in equatorial view.

Furrow is doubtfully monosulcate or monocolpate with thickened lips (may be compressed tricolpate or tricolporate pollen grains). Exine 1.5-2um thick, psilate to microreticulate sculpture. Grain size 16-33um. The specimens are more or less comparable to Ephedripites (Distachyapites) claricristatus (Shakmundes) Krutzsch described and photographed by krutzsch (1970).

Subturma TRIPTYCHES Naumova, 1939

Genus DISCOIDITES Muller, 1968

Discoidites borneensis Muller, 1968

(Plate 14, figs. 5-10)

1964 Brownlovia-type Pollen Muller, p.37, pl.1, fig.4

1968 Discoidites borneensis Muller, p.20, pl.4, fig.16

Designated : TC1

Description : Pollen grains single, tricolpate, disc-shaped, circular to subcircular in polar view. Colpi fairly short, reaching 1/3 to 1/2 of the distance to the pole, endexinous margins often slightly thickened. Endexine thin, less than 0.5um thick, ectexine about 2um thick composes of 1-1.5um long, less than 1um in diameter, slender, straight, regularly distributed columella and covered by finely granulate tectum.

Dimensions : Equatorial diameter 19(25)34um (30 specimens from various horizons).

Remarks : The specimens are similar to Discoidites borneensis Muller described and photographed by Muller (1968). The genus differs from Tiliaepollenites (Potonie') ex Potonie' & Venitz (1934) in the presence of short colpi and the absence of any indication of vestibulate pores. The exine structure is similar (Muller, 1968).

Affinity : The appearance of this species is similar to that of the Recent pollen of Brownlowia and Pentace of the Tiliaceae (Muller, 1964, 1968).

Distribution : Occurred at relatively low percentages in Krabi, Mae Mo and Mae Teep samples. Rarely found in Li samples and absent in Mae Tun samples. The same species was reported to be rarely found throughout the whole Tertiary of Sarawak, Malaysia (Muller, 1964, 1968).

INDETERMINATE TRICOLPATE POLLEN GRAINS

Designated : TC2 (Plate 14, figs.15-19) : Pollen grains tricolpate, circular in polar view. Colpi short, slightly split. Exine 2-3um thick, microreticulate sculpture. The specimens are more or less similar to Discoidites novaguineensis Khan (1976). Two specimens were found in samples KB8 and MM5.

Designated : TC3 (Plate 14, figs.3-4) : Pollen grain tricolpate, circular in polar view. Copli long, nearly reaching the pole. Exine with reticulate sculpture. The specimen is tentatively placed in the genus Retitricolpites Pierce (1961). Only one specimen was found in sample MM10.

Designated : TC4 (Plate 14, fig.12) : Pollen grain tricolpate, circular in polar view. Copli long, nearly reaching the pole. Exine about lum thick, psilate scultpure. The specimen is more or less similar to Tricolpites confessus Stover (1973). Only one specimen was found in sample MM7.

Designated : TC5 (Plate 14, Fig.13) : Pollen grain tricolpate, subcircular in polar view. Colpi short, with irregular margins. Exine about lum thick, psilate with scattered finely granulate sculpture. The specimen is similar to Tricolpites gillii Cookson (1957). Only one specimen was found in sample MM4.

Designated : TC6 (Plate 14, fig.14) : Pollen grains tricolpate, circular in polar view. Colpi long and split. Exine about lum thick, scabrate to finely granulate sculpture. The specimens are more or less similar to Tricolpites fissillis Couper (1960). The specimens were occassionally found in the samples from Mae Mo, Mae Tun, and Li desposit.

Designated : TC7 (Plate 20, figs.1-5) : Pollen grains tricolpate, prolate in equatorial view, subtriangular in polar view. Colpi short, straight. Exine 2-2.5um thick, finely echinate sculpture. The specimens are more or less similar to Lonicerapollis gallwitzii Krutzsch (1962). A few specimens were found in Mae Teep and Li samples.

Designated : TC8 (Plate 19, figs.10-12) : ?Tricolpate pollen grain, large, perforate sculpture. Perfortricolpites digitatus Gonzalez (1967) is more or less similar to the specimen. Only one specimen was found in sample No.MM14.

Subturma PTYCHOTRIPORINES Naumova, 1939

Genus TRICOLPOROPOLLENITES Pflug & Thomson, 1953

Tricolporopollenites cingulum subsp. oviformis (Potonie') Thomson & Pflug, 1953

(Plate 14, figs.20-21)

1931a Pollenites oviformis Potonie', p.328, pl.1, fig.20

1934 Pollenites oviformis Potonie', in Potonie', p.95, pl.5, figs.23-27.

1953 <u>Tricolporopollenites</u> <u>cingulum</u> <u>oviformis</u> (Potonie') Thomson & Pflug, p.100, pl.12, figs.42-49.

1974 <u>Tricolporopollenites</u> <u>cingulum</u> <u>oviformis</u> (Potonie') Thomson & Pflug in Ziembinska-Tworzydlo, p.388, pl.20, figs.3-5.

Designated : TCP1a

Description : Pollen grains free, isoplar, prolate , sides convex, polar view not seen (according to this study only). Tricolporate, colpi long, almost reaching to poles, bordered by prominent margo which is clearly seen in equatorial view. Distinct transverse furrow, slightly costate, present on each colpus at the equator. Exine thickness distinct, 0.5-1um thick, composed of two layers, the inner layer is much thinner than the outer one. Laevigate to faintly psilate sculpture.

Dimensions : Equatorial diameters, long axis 10(16)21um short axis 7(11)16um (50 specimens from various horizons).

Remarks : The specimens are very similar to those described and illustrated by Potonie' (1931a, 1934) and Thomson & Pflug (1953) but differ slightly from that described and photographed by Ziembinska-Tworzydlo (1974) in their distinct transverse furrows compared to the rounded pores described by Ziembinska-Tworzydlo (1974).

The specimens are also more or less similar to Castanoidites exactus Potonie' (Potonie', Thomson & Thiergart, 1950), Castanea sleyana Traverse (Traverse, 1955), Tricolporites traversei Anderson (Anderson, 1960), Castanea mullensis Simpson (Simpson, 1961), Cupuliferoipollenites pusillus Potonie' (Drugg, 1967), Tricolporites (C_3P_3) type 12 (Van der Hammen et al., 1973), Castanea (Rachele, 1976), Castanea sp. (Koreneva et al., 1976; Koreneva & Kartashova, 1978) and Tricolporopollenites Group A Wilkinson & Boulter (Wilkinson & Boulter, 1980). Psilatricolporites prolatus Pierce (Muller, 1968), and various species of the genus Cupuliferoidaepollenites Potonie', Thomson & Thiergart (Potonie', Thomson, & Thiergart, 1950; Potonie', 1960) differ from the specimens in having indistinct pores or being without pores.

Affinity : According to the authors cited above, the specimens are related to the modern genus Castanea. However they could be referred to as the Lithocarpus, Pasania and most probably Castanopsis of the same family (Fagaceae).

Distribution : Common to abundant in all deposits. The same species was recorded from the Eocene lignite of Mine Cecilie, Geiseltal, Germany (Potonie', 1931a); Miocene browncoal of Beisselsgruble, Geiseltal, Germany (Potonie', 1934); the Pliocene of Central Europe (Thomson & Pflug, 1953); the Olig-Miocene lignite deposits near Midlovary, South Bohemia (Pacltova, 1960); the Neogene of Western Poland (Ziembinska-Tworzydlo, 1974); and the Oligocene deposits of the British Isles (Wilkinson & Boulter, 1980).

Tricolporopollenites cingulum subsp. pusillus (Potonie') Thomson & Pflug, 1953
(Plate 14, figs.25-28)

1934 Pollenites quisqualis pusillus Potonie', p.72, pl.3, fig.21

1953 Tricolporopollenites cingulum pusillus Thomson & Pflug, p.100, pl.12, figs.28-41

1958 Tricolporopollenites cingulum pusillus (Potonie') Thomson & Pflug in Weyland, Pflug & Pantic' pl.14 figs.31-32

1974 Tricolporopollenites cingulum pusillus (Potonie') Thomson & Pflug in Ziembinska-Tworzydlo, p.387-388, pl.20, figs.9a-c.

Designated : TCP 1b

Description : Pollen grains free, isopolar, prolate. Tricolporate, colpi long almost reaching to poles, bordered by prominent margo which is clearly seen in equatorial view. Faint transverse furrows, slightly costate, present on each colpus at the equator. Exine thickness distinct, 1.5-2um thick, very fine and faintly intrarugulate structure. Surface sculpture laevigate to faintly psilate.

Dimensions : Equatorial diameters, long axis 23(24)25um, short axis 13(17)20um (50 specimens from various horizons).

Remarks : The specimens are similar to those described and illustrated by various authors cited above. The specimens differ from the subsp. oviformis by their thicker exine, larger grain size, and less distinct transverse furrows.

Affinity : Most probably related to the genus Castanea (Thomson & Pflug, 1953) or Castanopsis (Ziembinska-Tworzydlo, 1974).

Distribution : Similar to TCP la. The same species was reported from the Pliocene of Central Europe (Thomson & Pflug, 1953), the Tertiary browncoal of Yugoslavia (Weyland et al., 1958), and from the Oligo-Miocene of Western Poland (Ziembinska-Tworzydlo, 1974).

Tricolporopollenites cingulum sub.sp fusus (Potonie')

Thomson & Pflug, 1953

(Plate 14, figs.22-24, 29-31)

1934 Pollenites fusus Potonie', p.82, pl.4, fig.20.

1952 Tricolporopollenites cingulum fusus (Potonie') Thomson & Pflug, p.100, pl.12, figs.15-27.

1964 Tricolporopollenites cingulum fusus (Potonie') Thomson & Pflug in Stuchlik, p.55, pl.16, fig.26-30

1974 Tricolporopollenites cingulum fusus (Potonie') Thomson & Pflug in Ziembinska-Tworzydlo p.387, pl.20, figs. 10a-b, 13a-c, 14a-b.

Designated : TCP 1c

Description : Similar to TCP 1b except having larger grain size and psilate to finely granulate sculpture.

Dimensions : Equatorial diameters, long axis 21(28)36um, short axis 13(20)29um (50 specimens from various horizons).

Remarks : The specimens are similar to those described and illustrated by the authors listed above. The species Psilatricolporites colpiconstriatus Hoeken-Klink. and Euphorbia sp. illustrated but not described by Zaklinskaja (1977, pl.2, figs.5-9) are strikingly similar to some specimens (e.g. figures 29-31). However, because of lack of description, certain comparisons can not be made.

Affinity : The species was tentatively related to the family Rutaceae and probably genus Ptelea (Stuchlik, 1964; Ziembinska-Tworzydlo, 1974). According to Zaklinskaja (1977) it could be related to the Family Euphorbiaceae (Euphorbia sp.).

Distribution : Similar to TCP 1a and TCP 1b. The same species was reported from the Lower to Middle Tertiary of Central Europe (Thomson & Pflug, 1953), the Miocene deposit at Rypin, NW of Warsaw (Stuchlik, 1964) and the Middle Oligocene deposit of Western Poland (Ziembinska-Tworzydlo, 1974).

Tricolporopollenites cf. T. pacatus Pflug, 1953

(Plate 14, figs.33-34; pl.15, figs.3-4)

1953 Tricolporopollenites pacatus Pflug (1953) in Thomson & Pflug, p.99, pl.12, figs.118-121

Designated : TCP2

Description : Pollen grains free, isopolar, broad elliptical to subcircular in equatorial view. Tricolporate, colpi distinct, extent parallel to the meridional outline with thickening lips in some grains. Transverse furrows, distinct, extent nearly reaching each other, present on each colpus at the equator, slightly costate. Exine thickness distinct, 1.5-2.0um thick. Exine structure composed of faintly intrabaculate and semitectate structures, stratification indistinct. Surface sculpture psilate to finely granulate.

Dimensions : Equatorial diameters; long axis 27(35)43um, short axis 18(23)36um (30 specimens from various horizons).

Remarks : The specimens are comparable to T. pacatus described and photographed by Thomson & Pflug (1953) but differ in their larger grain size and the somewhat more simple germinal apertures.

Affinity : Simarubaceae genus Ailanthus (Thomson & Pflug, 1953).

Distribution : Common within the samples from Mae Mo and Krabi deposits. Rare to absent elsewhere. T. pacatus was reported from the Tertiary sediments of Central Europe (Thomson & Pflug, 1953).

Tricolporopollenites cf. T. rhomboidaliformis
McIntyre, 1968
(Plate 15, figs.15-17)

1968 Tricolporopollenites rhomboidaliformis McIntyre, p.190-191, figs.42-45.

Designed : TCP 3

Description : Pollen grains free, isopolar, prolate to spheroidal, radial symmetry. Tricolporate, colpi short, narrow, indistinct. Distinct long transverse furrows present on each colpus at equator. Exine thickness distinct, 1.5-2.0um thick. Exine structure very fine intrabaculate structure. Surface sculpture very fine reticulate composed of less than 0.5um wide muri and about 0.5um wide lumina, regularly distributed over the entire surface.

Dimensions : Equatorial diameters 29(36)44um (50 specimens from various horizons).

Remarks : The specimens are very similar to those described and photographed by McIntyre (1968) but differ slightly in their more or less regular exine thickness and larger grain size. <u>Tricolporopollenites</u> <u>donatus</u> Pflug described and illustrated by Thomson & Pflug (1953) is also comparable but having larger grain size and less distinct transverse furrows. The fossil pollen grains of <u>Calophyllum</u> photographed but briefly described by Anderson & Muller (1975) appear strikingly similar to the specimens. However, more detailed description is needed for certain comparison.

Affinity : McIntyre (1968) mentioned that the species of the family Araliaceae and Umbrelliferae produced grains of this type but none of the present New Zealand members of these family have grains exactly like T. rhomboidaliformis. Anderson & Muller (1975) referred their specimens to the genus Calophyllum of the family Guttiferae. In this study, the specimens are preferably related to Calophyllum.

Distribution : Occurred at low percentages within the Mae Teep and Mae Mo deposits, absent elsewhere T. rhomboidaliformis was reported from the Paleocene to Miocene deposits from New Zealand (McIntyre, 1968). Calophyllum was found in the Miocene coal and Holocene peat deposits of NW Borne (Anderson & Muller, 1975) and from the Holocene peat swamp in Johore, Malaysia (Haseldonckx, 1977).

Tricolporopollenites euphorii (Potonie')
Thomson & Pflug, 1953
(Plate 15, figs.5-12)

1931a Pollenites euphorii Potonie', p.328, pl.1, figs.12, 28

1934 Pollenites euphorii Potonie' (1931) in Potonie' p.64; pl.2, figs.33, 39; pl.3, fig.19

1953 Tricolporopollenites euphorii (Potonie') Thomson & Pflug, p.102, pl.12, figs.133-140

Designated : TCP 4

Description : Pollen grains free, isopolar, rhombic shape with convex sides and rounded angles in equatorial view. Tricolporate, colpi distinct, long, reaching to poles, with distinct thickened rims Distinct long, thin, transverse furrows present on each colpus at equator, reaching each other, slightly costate. Exine thickness distinct, 2-2.5um thick, somewhat thicker around the polar area. Fine baculate structure, baculae about 0.5um wide, 2um high, regularly distributed and coalescing to form a fine reticulate surface sculpture.

Dimensions : Equatorial diameters; long axis 20(29)44um, short axis 11(22)31um (50 specimens from various horizons).

Remarks : The specimens are very similar to those described and photographed by the authors cited above. The rhombic shape is more or less the characteristic of this species. T. edmundi (Potonie') Thomson & Pflug (1953) differs from the specimens in its larger size.

Affinity : Araliaceae (Thomson & Pflug, 1953).

Distribution : The same as TCP 3. The same species was reported from the Eocene brown coal deposit at Geiseltal, Germany (Potonie', 1931a and 1934) and from the Tertiary sediments of Central Europe (Thomson & Pflug, 1953).

<u>Tricolporopollenites</u> <u>margaritatus</u> (Potonie')
Thomson & Pflug, 1953
(Plate 16, figs.1-12; pl.18, figs.13-18)

1931a <u>Pollenites</u> <u>margaritatus</u> Potonie', p.328, pl.1, fig.33

1934 <u>Pollenites</u> <u>margaritatus</u> Potonie' in Potonie', p.73, pl.3, fig.25

1953 <u>Tricolporopollenites</u> <u>margaritatus</u> (Potonie') Thomson & Pflug, p.107, pl.14, figs.67-80

Designated : TCP 5

Description : Pollen grains free, isopolar, radial symmetry, subspheroidal to prolate shape in equatorial view, circular to subtrilobate shape in polar view. Fossaperturate, tricolporate, colpi long, margins generally obscured by sculpture elements. Pori indistinct, very small, present on each colpus at equator, generally obscured by sculpture elements. Exine thickness distinct, 2-3um (including muri). Exine sculpture baculate to clavate, 2.5-3um high, 1-1.5um wide at base and swollen to about 1.5-2um wide at the top, fairly regularly distributed but always bent, becoming slightly smaller near colpus margin.

Dimensions : Equatorial diameters; long axis 20(25)31um, short axis 11(18)25um (25 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by Thomson & Pflug (1953). They have divided this species into three subspecies by means of grain size. The specimens fall in between subspecies <u>medius</u> (25-40um) and <u>minor</u> (15-25um). Various species of fossil <u>Ilex</u> pollen grains described and photographed by Traverse (1955) are also comparable to the specimens studied but differ in their larger grain size and they were described as tricolpate pollen grains. However, by ignoring the difference stated above they can be compared to the specimens as follows : <u>Ilex inaequaliclayata</u> is similar to the specimens shown in plate 18, figures 1-2; <u>Ilex densiclavata</u> is similar to the specimens shown in plate 20, figures 13-15 and 18; <u>Ilex longipollenata</u> is comparable to the specimen shown in plate 18, figs.6-8; and <u>Ilex obscuricostata</u> is similar to the specimens shown in plate 18, figures 3-5 and 8-12.

Affinity : Aquifoliaceae and most probably the genus <u>Ilex</u> (Thomson & Pflug, 1953).

Distribution : Occurred at low percentages within most of the samples from Li and Mae Teep deposits, rare to absent elsewhere. The same species was reported from the Eocene brown coal deposit at Geiseltal, Germany (Potonie', 1931a and 1934); the Tertiary sediments from Central Europe (Thomson & Pflug, 1953), the Miocene deposits at Rypin, northwest of Warsaw (Stuchlik, 1964) and the Neogene plant beds in Derbyshire, England (Boulter, 1971). Various species of fossil Ilex pollen grains were reported by Traverse (1955) from the Brandon Lignite of Vermont.

Genus RETITRICOLPORITES (Van der Hammen)

Van der Hammen & Wymstra, 1964

Retitricolporites annulatus Salard-Cheboldaeff, 1978

(Plate 15, figs.18,19; pl.17, figs.28-32)

1978 Retitricolporites annulatus Salard-Cheboldaeff, p.236-237, pl.4, figs.7-9

Designated : Pollen grains free, isopolar, sub-spherical to spherical. Tricolporate, colpi long reaching to poles, wide, accompanied by prominent margo. Pores large, circular, with distinct annulus, placed at the middle of each colpus. Exine thickness indistinct, 0.5-1um thick, indistinct exine structure and stratification. Reticulate exine sculpture composed of regular width muri of about 0.5um wide and irregular polygonal lumina of about 0.5-1um in diameter. Reticulum mesh size slightly reduced in the area near colpi.

Dimensions : Equatorial diameter 15(19)21um (40 specimens from various horizons).

Remarks : The specimens are comparable to those described and photographed by Salard-Cheboldaeff (1978).

Affinity : Possibly the genus Mitragyna Korth of the family Rubiaceae (Salard-Cheboldaeff, 1978). Anderson & Muller (1975) recorded the presence of the genus Canthium and Jackia of the family Rubiaceae from the Miocene brown coal deposits of NW Borneo.

Distribution : Common in all deposits except Mae Tun. The same species was recorded from the Oligo-Miocene sedimentary basin in Cameroon (Salard-Cheboldaeff, 1978).

Genus RHOIPITES Wodehouse, 1933

Rhoipites cf. R. isoreticulatus Kemp 1977

(Plate 15, figs.20-25)

1974 Tricolpites sp. Kemp, p.816, pl.1, figs.6-8.

1977 Rhoipites isoreticulatus Kemp in Kemp & Harris, p.38-39, pl.6, figs.7-9, 17.

Designated : TCP7

Description : Pollen grains free, isopolar, prolate in equatorial view, polar view not seen. Tricolporate, colpi short, about 2/3 of the long axis, accompanied by prominent margo clearly seen in equatorial view. Pores large with margin forming an incomplete circle, present at the equator of each colpus. Exine thickness distinct, 2.0-2.5um thick, exine structure intrabaculate or finely pilate in which the distal ends of the columellae unite to form a regular reticulate pattern. Reticulum composed of muri about 0.5um wide and regular polygonal lumina of about 0.5-1um in diameter.

Dimensions : Equatorial diameter, long axis 21(26)31um, short axis 16(19)21um, (20 specimens from various horizons).

Remarks : The specimens are similar to <u>Rhoipites isoreticulatus</u> described and photographed by Kemp (Kemp & Harris, 1977). However the fossaperturate aperture feature is not observed in the specimens. <u>Tricolporopollenites villensis</u> (Potonie') Thomson & Pflug described and photographed by Thomson & Pflug (1953), and Ziembinska-Tworzydlo (1974) is comparable but differs in the exine and aperture pattern. Pocknall & Crobie (1982) have revised some of the Tertiary tricolporate and tricolpate pollen grains from New Zealand. They regarded <u>Rhoipites</u>

isoreticulatus Kemp as the junior synonym of Rhoipites alveolatus (Couper), their new combination, by personal communication (Pocknall & Crosbie, 1982). However, it should be noted that, the person they mentioned (J.I. Raine) is not one of the authors of Rhoipites isoreticulatus (i.e. Kemp & Harris).

Affinity : Verbinaceae probably the genus Avicennia (Kemp & Harris, 1977). Avicennia sp. described and photographed by Muller (1959, 1964) and Van der Hammen (1963) is very similar to the specimens in this study.

Distribution : Fairly common within the samples from Mae Mo and Krabi deposits, occasionally found within Li samples and absent elsewhere. The same species was reported by Kemp & Harris (1977) from the ? Oligocene sediments of the Ninetyeast Ridge, Indean Ocean. Rhoipites alveolatus (Couper) Pocknall & Crosbie was recorded from the Middle Eocene to Late Pliocene of New Zealand (Pocknall & Crosbie, 1982), the Upper Pliocene to Early Pleistocene of Australia (Martin 1973 in Pocknall & Crosbie, 1982), the Middle Miocene of Kerguelen Archipelago and the Pliocene of New Guinea (Cookson & Pike, 1954 in Pocknall & Crosbie, 1982) and the Upper Oligocene to Miocene of Queensland (Hekel, 1972 in Pocknall & Crosbie, 1982).

Rhoipites sp.

(Plate 15, figs.26-30)

Designated : TCP 8

Description : Pollen grains free, isopolar, radial symmetry, prolate with convex sides in equatorial view. Tricolporate, colpi long, reaching to poles, with distinct thickened margins. Transverse furrows, distinct, present on each colpus at equator but generally obscured by exine sculpture particularly in the smaller grains. Exine thickness distinct, 1.5-2um thick (including muri). Reticulate sculpture, muri about 0.5-1um wide, divided by fairly regular lumina of about 1-1.5um in diameter and supported by short (about 1um) columella. The reticulate pattern is fairly regular in both shape and size over the entire surface.

Dimensions : Equatorial diameters, long axis 23(30)39um, short axis 16(21)33um (20 specimens from various horizons).

Remarks : Rhoipites waimuensis (Couper) described and photographed by Pocknall & Crosbie (1982) is similar in shape and germinal operature but differs in its larger grain size and the irregular pattern of reticulate sculpture. Horniella clavaticosta Traverse described and photographed by Traverse (1955) is also similar but differs in its thicker exine and higher muri of the reticulate sculpture. <u>Salix</u> <u>acmophylla</u> Boissier photographed by Srivastava (1972, pl.22, figs.11-13) is very similar to the smaller form of the specimens (pl.15, figs.26-28) but has tricolpate apertures.

Affinity : Unknown.

Distribution : Common within Mae Teep and Mae Mo samples. Very rare to absent elsewhere.

Genus MARGOCOLPORITES Ramanujam, 1966

<u>Margocolporites</u> <u>vanwijhei</u> Germeraad,

Hopping & Muller, 1968

(Plate 18, figs.4-6)

1968 <u>Margocolporites</u> <u>vanwijhei</u> Germeraad, Hopping & Muller, p.342, pl.18, fig.3

1978 <u>Margocolporites</u> <u>vanwijhei</u> Germerrad, Hopping & Muller in Partridge, pl.2, figs.6

Designated : TCP 9

Description : Pollen grains free, rounded subtriangular to subrounded in polar view, equatorial view not seen, radial symmetry. Tricolporate, colpi wide, gradually tapering toward poles, well defined margin, costate, with very distinct margo. Pori distinct, circular, about 3um in diameter. Exine thickness distinct, about 1.5um thick (including muri). Surface sculpture composed of very fine, about 1.3um high, densely packed baculae in the colpus region and coarser, less packed, about 1.3um high baculae which coalesce to form a reticulate pattern in the area between each colpus. Reticulum composed of muri less than 0.5um in both width and height, divided by irregular polygonal lumina of about 0.5-1um in diameter.

Dimensions : Polar diameter 31-33um (2 specimens from sample MTe 14).

Remarks : The specimens are indentical with _M. vanwijhei_ Germeraad, Hopping & Muller described and photographed by Germeraad _et al_. (1968) and Partridge (1978), although only two specimens have been found.

Affinity : According to Germeraad _et al_. (1968), the species can be related with various genera of the Fabaceae (Leguminosae), especially the pollen of _Caesalpinia bondac_ and _C. coriaria_.

Distribution : Only two specimens were found from sample MTe 14. The same species was recorded from the Upper Eocene to Pleistocene in the Caribbean, the Upper Eocene to Oligocene in Nigeria and the late Upper Eocene to Pleistocene in Borneo (Germeraad _et al_., 1968). Partridge

(1978) also reported the presence of this species from the Upper Tertiary sequence at Site 365, Deep Sea Drilling Project, off the West Coast of Africa.

Margocolporites sp.
(Plate 18, figs.1-3)

Designated : TCP 10

Description : Mainly similar to TCP 9 described above. The difference is that of the exine sculpture. The specimen has sparsely distributed, rounded gemmate sculpture in the colpus area and more prominent and coarser baculate-reticulate sculpture in the area between colpi. It also differs in its spheroidal shape and larger size.

Dimensions : 45um (one specimen from sample MTe 10).

Remarks : Only one specimen was found from sample MTe 10. It differs from TCP 9 in the size, shape, and sculpture as stated above. *M. tsukadai* Ramanujam, described and photographed by Ramanujam (1966) differs in its microreticulate sculpture in the colpus area.

Affinity : The same as TCP 9.

Distribution : One grain was found in sample MTe 10.

Genus BOMBACACIDITES Couper, 1960

Bombacacidites cf. B. annae (Van der Hammen)

Leidelmeyer, 1966

(Plate 18, figs.33-36)

1954 Tricolporites annae Van der Hammen, p.96, pl.9

1966 Bombacacidites annae (Van der Hammen) Leidelmeyer, p.55

1968 Bombacacidites annae (Van der Hammen) Leidelmeyer in Germeraad *et al.*, p.340, pl.17, fig.10).

Designated : TCP 11

Description : Pollen grains free, rounded triangular in polar view, equatorial view not seen, radial symmetry. Tricolporate, colpi distinct, short, costate (costae about 1.5um wide), situated at the midpoint of the sides, pori indistinct. Exine thickness distinct, 1.5-2um thick (including muri). Surface sculpture reticulate, muri less than 0.5um wide, lumina irregularly polygonal in shape, about 1.5um in diameter in the polar area and reduced to perforate in the intercolpate areas.

Dimensions : Polar diameter 34(35)36um (8 specimens from various horizons).

Remarks : The specimens differ slightly from Bombacacidites annae Leidelmeyer described and photographed by Germeraad et al. (1968) in its more triangular shape in polar view and smaller size.

Affinty Bombax (Bombacaceae) (Leidelmeyer, 1966).

Distribution: Occasionally found within the Mae Teep and Mae Mo samples. B. annae was reported from the Paleocene of Guyana (Leidelmeyer, 1966) and the Paleocene of the Caribbean (Germeraad et al., 1968).

Genus PALEOCAESALPINIACEAEPITES Biswas, 1962

Paleocaesalpiniaceaepites sp.

(Plate 16, figs.35-36; pl.18, figs.19-20)

Designated : TCP 12

Description : Pollen grains free, isopolar, prolate to oblate in equatorial view, rounded subtriangular in polar view, radial symmetry. Tricolporate, colpi long, reaching to poles, showing constriction in some grains, slightly costate, with prominent margo. Pori indistinct. Exine thickness distinct, 1.5-2um thick (including muri). Sculpture reticulate formed by individual pilate elements fused together. Pilate elements about 1.5um high, rounded heads about 0.8um in diameter, supported by 1um high, 0.5um wide columellae, 1-1.5um apart. Lumina 2-3um in diameter, irregular polygonal shape.

Dimensions : Equatorial diameters; long axis 21(26)30um, short axis 13(19)25um (20 specimens from various horizons).

Remarks : Palecocaesalpiniaceaepites ratnami Ramanujam described and photographed by Ramanujam (1966) has identical exine sculpture but differs in the greater size (45 x 32um) and the gaping of colpi at equator. P. eocenica Biswas (1962) has different exine sculpture. Retitricolporites irregularis and R. guianesis Van der Hammen & Wymstra (1964) have some similarity but differ in the stronger reticulate sculpture and more distinct pori respectively.

Affinity : Caesalpiniaceae (Biswas, 1962).

Distribution : Occurred fairly commonly within the samples from Li deposit only. P. ratnami was reported from the Miocene lignite of South Arcot District, Madras, India (Ramanujam, 1966). P. eocenica was reported from the Tertiary of Assam, India (Biswas, 1962; Baksi, 1962).

Genus LANAGIOPOLLIS Morley, 1982

Lanagiopollis cf. L. microrugulatus Morley, 1982

(Plate 19, figs.1-6)

1982 <u>Lanagiopollis</u> <u>microrugulatus</u> Morley, p.71, pl.1, figs.1-2

Designated : Pollen grains free, isopolar, oblate (?) in equatorial view, rounded subtriangular in polar view, radial symmetry. Tricolporate, colpi distinct, costate, costae about 2um wide, 4.5um thick. Pori distinct composed of transverse furrows about 3.5um wide and 13um long (? exoporus) and subcircular endoporus about 4um in diameter, present on each colpus at equator. Exine thickness distinct, 2.5-3um thick, composed of two layers of approximately equal thickness which are clearly seen in polar view. Exine structure tectate with very small, densely packed columellae, tectum thickness about 1/3 of columellae height and fused to form a fine, irregular straite-rugulate sculpture.

Dimensions : Equatorial diameter 60um, polar diameter 54-58um (2 specimens only, from samples MTe 5 and MTe 15).

Remarks : <u>Lanagiopollis</u> <u>microrugulatus</u> described and photographed by Morley (1982) closely resembles the specimens but differs slightly in its larger grain size (68-73um), thicker exine (ca.5um) and the heavy costae (ca.10um wide, 5um thick) around the less distinct pori.

Affinity : Probably <u>Alangium</u> <u>ebanaceum</u> type (Morley, 1982).

Distribution : Only three specimens were found within the Mae Teep samples. L. microrugulatus Morley was recorded from the Upper Eocene sediments (not older than Middle Eocene) from Central Java, Malaysia (Morley, 1982).

INDETERMINATE TRICOLPORATE POLLEN GRAINS

Designated : TCP 14 (Plate 14, fig.32) : Pollen grains free, isopolar, radial symmetry, subspheroidal shape. Tricolporate, colpi short, narrow. Transverse furrows narrow, slightly costate. Exine thickness distinct, about 1.5um thick. Psilate surface sculpture. Equatorial diameter about 21-26um. Only a few specimens were found within the Krabi samples. Psilatricolporites transversalis described and photographed by Dueñas (1980a) is very similar to the specimens.

Designated : TCP 15 (Plate 15, fig.35-37) : Pollen grains free, isopolar, radially symmetrical, spheroidal shape. Tricolporate with indistinct short, narrow, colpi and slit-liked transverse furrows. Exine thickness distinct, 1.5-2um thick. Psilate to finely granulate sculpture. Average equatorial diameter 21um (20 specimens from various horizons). Pollenites pseudocruciatus designated by Potonie' (1931a) is similar to the specimens but the later emendation (Potonie', 1934) made the species differs from the specimens in the character of its germinal apertures.

Designated : TCP 16 (Plate 14, figs.39-40) : Pollen grains, free isopolar, radial symmetry, broad elliptical shape. Tricolporate, colpi long, reaching to poles, with distinct thickened lips. Pori small, present on each colpus at equator. Exine thickness distinct, 1.5-2um thick. Psilate to finely granulate surface sculpture. Equatorial diameters about 20-25um by 15-20um (a few specimens measured). A few specimens were found within the Mae Teep, Mae Mo and Mae Tun samples. The specimens are more or less similar to the pollen grains of <u>Nyssa</u> type.

Designated : TCP 17 (Plate 17, figs.16-19) : Pollen grains free, preserved in polar compression, subtriangular shape, tricolporate, diameter about 15-20um. Only a few specimens were found within the samples from Mae Teep, Mae Mo, and Krabi deposits. Possibly more than one species is represented. The specimens resemble pollen grains of <u>Nyssa</u> type.

Designated : TCP 18 (Plate 15, figs.1-2) : Pollen grains free, isopolar, radial symmetry, prolate shape. Tricolporate, colpi long, reaching to pole with distinct margo. Pori small, present on each colpus at equator. Exine thin, about 1um thick, laevigate sculpture. Grain size 28um by 21um. Only one grain was found from sample no. MM24. Tricolporopollenites eschweilerensis Pflug & Thomson described and photographed by Thomson & Pflug (1953) is very similar to this specimen.

Designated : TCP 19 (Plate 15, figs.13-14) : Pollen grains free, isopolar, radial symmetry, spheroidal shape. Tricolporate with long, narrow colpi and equatorial furrows. Exine 1-1.5um thick, fine reticulate scultpure. Grain size about 21um in equatorial diameter. Only a few grains were found within the Mae Mo samples. The specimens may possibly be placed in the genus Retitricolporites Van der Hammen & Wymstra (1964) based on their reticulate sculpture and tricolporate apertures.

Designated : TCP 20 (Plate 17, figs.24-27) : Pollen grains very similar to the above TCP 19 excepting their larger grain size (about 35-45um). A few grains were found within the Mae Teep and Mae Mo samples. The specimens may be a larger form of TCP 19 described above.

Designated : TCP 21 (Plate 15, figs.35-36) : Pollen grains free, isopolar, radial symmetry, subspheroidal shape. Tricolporate with indistinct colpi and transverse furrows. Exine 1-1.5um thick, finely reticulate sculpture. Grain size about 25um in equatorial diameter. Only one specimen was found from sample KB 14. Based on its reticulate scultpure, the specimen may be placed in the genus Retitricolporites Van der Hammen & Wymstra (1964).

Designated : TCP 22 (Plate 15, figs.31-32; plate 17, figs.45-46) : Pollen grains free, isopolar, radial symmetry, spheroidal shape. Tricolporate, colpi short, narrow, indistinct. Transverse furrows, indistinct, slightly costate, present on each colpus at equator. Exine thickness distinct, 1.5-2um thick. Reticulate with muri about 1.5um high, 0.5-1um wide and lumina about 1.5-2um in diameter. Mesh size of the reticulate somewhat slightly smaller near poles. Equatorial diameter 28(34)43um (20 specimens from various horizons). Occurred at low percentages within the samples from Mae Teep, Mae Mo, and Krabi deposits, absent elsewhere. The specimens are tentatively placed in the genus Retitricolporites Van der Hammen & Wymstra (1964) based on their reticulate sculpture.

Designated : TCP 23 (Plate 15, figs.33-34; plate 17, figs.39-40) : Pollen grains free, isopolar, radial symmetry, subcircular in both equatorial and polar views. Tricolporate, colpi short, with very distinct margo clearly seen in equatorial view. Pores circular, small, present at equator on each colpus. Exine thickness distinct, 2-2.5um thick, with intrabaculate structure and finely reticulate surface sculpture. Equatorial diameter 30-50um, polar diameter about 23-42um (4 specimens measured). Only a few specimens were found within the samples from Mae Teep, Mae Mo, and Krabi deposits. Tricolporopollenites sustamanni Pflug & Thomson described by Thomson & Pflug (1953) is more or less similar to the specimens.

Designated : TCP 24 (Plate 16, figs.13-15) : Pollen grains free, isopolar, radial symmetry, prolate shape. Tricolporate (?), colpi indistinct. Equatorial furrows distinct, slightly costate, present on each colpus at equator. Exine thickness distinct, 1.5-2um thick, intrabaculate structure which is arranged to form a faintly striate surface sculpture. Equatorial diameters about 32-36um by 20-25um (a few grains measured). Occurred sporadically within the samples from Mae Teep and Mae Mo deposits. Fossil pollen grain of Polygalaceae photographed by Koreneva & Kartashova (1978) is very similar to the specimens.

Designated : TCP 25 (Plate 16, figs.19-22) : Pollen grains similar to TCP 24 but are larger in size and have well-defined tricolporate apertures. A few specimens were found within the Mae Teep samples. The fossil pollen grains of Leguminosae photographed by Koreneva & Kartashova (1978) are more or less comparable to the specimens.

Designated : TCP 26 (Plate 16, figs.16-18, 23-27) : Pollen grains free, isopolar, radial symmetry, prolate shape. Tricolporate, colpi long, reaching to poles, with prominent margo. Pori indistinct, small, present on each colpus at equator. Exine thickness indistinct, thin, with intrabaculate (?) structure and faintly striate surface sculpture. Equatorial diameters about 25-30um by 20-25um (a few specimens measured). The specimens were occasionally found within the Mae Teep and Mae Mo sample. The specimens are more or less similar to Striatricolporites minor Muller described and photographed by Muller (1968).

Designated : TCP 27 (Plate 16, figs.28-30) : Pollen grains free, isopolar, radial symmetry, prolate shape. Tricolporate, colpi long, with prominent margo. Transverse furrows, distinct, present on each colpus at equator. Exine thickness 1-1.5um thick, intrabaculate structure and faintly striate surface sculpture. Equatorial diameters about 25-30um by 18-22um (a few specimens measured). Very rarely found within the Mae Mo samples. Tricolporites paenestriatus described and photographed by Stover & Partridge (1973) is more or less similar to the specimens.

Designated : TCP 28 (Plate 18, figs.21-26) : Pollen grains, tricolporate, polar compression, subtriangular to circular shape. Distinct colpi and transverse furrows. Exine 1-1.5um thick, finely striate sculpture. Polar diameter 20-25um (a few specimens measured). Only a few specimens were encountered within the Mae Mo samples. The specimens may be placed in the genus Striatricolporites Van der Hammen (1956) based on the striate surface sculpture.

Designated : TCP 29 (Plate 16, figs.31-34) : Pollen grains free, isopolar, radial symmetry, prolate shape. Tricolporate (?) with indistinct apertures which is obscured by the surface sculpture. Exine thickness indistinct. Strong striate surface, striae 0-5.1um wide, 1-1.5um high, divided by grooves 0.5-1um wide. Equatorial diameter 34-40um by 16-25um (3 specimens only). Only 3 specimens were found within the samples MM7 and MM8. Fossil pollen grain of Crudia type described and photographed by Anderson & Muller (1975) is very similar to the specimens.

Designated : TCP 30 (Plate 17, figs.1-3) : Pollen grains tricolporate, subtriangular to subcircular in polar view, radial symmetry. Colpi long with distinct margo, pori indistinct. Exine thickness distinct, 2-2.5um thick, psilate to finely granulate sculpture. Polar diameter 18-25um (a few specimens measured). Occasionally found within the Mae Teep, Mae Mo, and Li samples. The modern grains Cyrilla racemifora illustrated by Erdtman (1966, p.143, fig.79A) is very similar to the specimens.

Designated : TCP 31 (Plate 17, figs.4-5) : Pollen grains tricolporate, fossaperturate, subcircular in polar view, radial symmetry. Colpi long with distinct margo, pori indistinct. Exine thickness distinct, 2-2.5um thick, psilate sculpture. Polar diameter 15-20um (a few specimens measured). Occasionally found within the Mae Teep and Mae

Mo samples. The specimens differ from TCP 30 described above in their distinct trilobate shape. Pollen grains described and illustrated as Capparaceae (Medus, 1975, p.576, pl.11, figs.8-9) are more or less similar to the specimens.

Designated : TCP 32 (Plate 17, figs.6-15) : Pollen grains tricolporate, circular in polar view, radial symmetry. Colpi long, well defined with thin slender operculi, pori indistinct. Exine thickness 1-1.5um thick, psilate to finely granulate sculpture. Polar diameter 15-25um (a few specimens measured). Occurred sporadically within the Mae Teep and Mae Mo samples. The specimens resemble <u>Psilatricolporites</u> <u>operculatus</u> Van der Hammen & Wymstra (1964) described and photographed by various authors, such as Germeraad <u>et</u> <u>al</u>,. (1968), Medus (1975) and Salard-Cheboldaeff (1978).

Designated : TCP 33 (Plate 17, figs.20-23) : Pollen grains, tricolporate, circular in polar view, radial symmetry. Colpi distinct, narrow, long, reaching to poles with indistinct transverse furrows, slightly costate. Exine thickness distinct, 2-2.5um thick, faintly intrabaculate (?) structure and finely granulate surface sculpture. Polar diameter 25-35um (a few specimens measured). Found sparsely within in Mae Mo samples. The specimens may possibly be placed in the genus <u>Psilatricolporites</u> Van der Hammen (1956) on account of the psilate surface sculpture.

Designated : TCP 34 (Plate 17, figs.33-36) : Pollen grains tricolporate (? tricolpate), circular in polar view, radial symmetry. Colpi wide, provided with operculum, pori (?) indistinct. Exine thickness distinct, 1.5-2um thick, intrabaculate structure and fine reticulate sculpture. Polar diameter about 20um (a few grains measured). Found very occasionally within the Mae Mo samples. Schizocolpus marlinensis Stover described and photographed by Stover & Partride (1973) differs from the specimens in having two pores present on each colpus. Psilatricolporites operculatus Van der Hammen & Wymstra (1964) differs from the specimens in its psilate sculpture. The specimens are tentatively placed in the genus Retitricolporites Van der Hammen & Wymstra (1964).

Designated : TCP 35 (Plate 17, figs.37-38) : Pollen grain tricolporate (? tricolpate), circular in polar view, radial symmetry. Colpi distinct, pori indistinct. Exine thickness distinct, about 1.5um thick, reticulate sculpture. Polar diameter about 28um, one specimen was found in sample MM22. On the basis of its reticulate sculpture, the specimen is tentatively placed in the genus Retitricolporites Van der Hammen & Wymstra (1964).

Designated : TCP 36 (Plate 17, figs.41-42) : Pollen grains tricolporate (? tricolpate), subcircular in polar view, radial symmetry. Colpi with distinct margo, pori indistinct. Exine thickness 1-1.5um, baculate, baculae densely packed and partly coalesce to form a finely reticulate pattern. Polar diameter 15-20um (a few specimens measured). Occasionally found in the Mae Mo samples. The specimens are tentatively placed in the genus <u>Retitricolporites</u> Van der Hammen & Wymstra (1964) on the basis of their reticulate sculpture.

Designated : TCP 37 (Plate 17, figs.43-44) : Pollen grain tricolporate, subcircular in polar view, radial symmetry. Colpi wide with prominent margo and very thin, narrow operculum, pori indistinct. Exine thickness distinct, 2-2.5um thick. Intrabaculate structure, baculae long, slender and tapered at the distal end to form a well-defined reticulate sculpture. Diameter about 30um. Only one specimen was found in sample MM18. Based on its reticulate sculpture, the specimen is placed in the genus <u>Retitricolporites</u> Van der Hammen & Wymstra (1964).

Designated : TCP 38 (Plate 18, figs.7-8) : Pollen grain, tricolporate (? tricolpate), subtriangular in polar view, radial symmetry. Colpi long, indistinct. Exine 1.5um thick with coarsely reticulate sculpture. Diameter about 15um. Only one specimen was found in sample MM27. The specimen is tentatively placed in the genus <u>Retitricolporites</u> Van der Hammen & Wymstra (1964).

Designated : TCP 39 (Plate 18, figs.9-12) : Pollen grain tricolporate (? tricolpate), triangular in polar view, radial symmetry. Colpi long, narrow, with distinct thickened rims, pori indistinct. Exine thickness obscured by the reticulate sculpture which is smaller in mesh size near the margin of the grain. Diameter about 18um. Only one specimen was found in sample MTe 11. The specimen is placed in the genus <u>Retitricolporites</u> Van der Hammen & Wymstra (1964).

Designated : TCP 40 (Plate 19, figs.7-9) : Pollen grain tricolporate, subtriangular in polar view, radial symmetry. Colpi narrow with thickened rims, pori rounded (?), slightly thickened rims. Exine thickness about 1.5um with very densely packed, long, slender baculae which formed a perforate sculpture. Polar diameter 50um (one specimen only). Only one specimen was found in sample MTe 14. The specimen may be placed within the genus <u>Foveotricolporites</u> Pierce (1961).

Designated : TCP 41 (Plate 20, fig.8) : Pollen grain tricolporate, subtriangular in polar view. Indistinct colpi, distinct pori with thickened rims. Thin exine with faintly psilate sculpture. Size about 40um (only one specimen was found in sample KB 7). The specimen is tentatively placed in the genus <u>Psilatricolporites</u> Van der Hammen (1956).

Designated : TCP 42 (Plate 20, fig.9) : Pollen grain tricolporate, spheroidal shape. Distinct colpi and pori. Exine thickness distinct, about 2um thick, psilate. Diameter about 40um (only one specimen was found in sample MM 14). The specimen is tentatively placed in the genus Psilatricolporites Van der Hammen (1956).

Genus MYRTACEIDITES Cookson & Pike, 1954

Myrtaceidites parvus Cookson & Pike, 1954

(Plate 11, figs.3-4)

1954 Myrtaceidites parvus Cookson & Pike, p.206, pl.1, figs.27-31

1972 Myrtaceidites parvus Cookson & Pike in Hekel, p.15, pl.4, fig.9

1973 Myrtaceidites parvus Cookson & Pike in Martin, p.23-24, figs.94-95

Designated : SCP 1

Description : Pollen grains free, isopolar, subtriangular with convex sides and rounded angles in polar view, radial symmetry. Syncolporate, arci distinct with or without polar islands. Exine thickness distinct, about 0.5um thick, slightly thickened around the apertures, psilate sculpture.

Dimensions : Polar diameter 9(13)20um (25 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by various authors cited above. Two subspecies may be differentiated by the presence or absence of the polar island, subsp. nesus Cookson & Pike and anesus Cookson & Pike respectively (Cookson & Pike, 1954; Martin, 1973). The two subspecies always occur together.

Affinity : Family Myrtaceae (Cookson & Pike, 1954).

Distribution : Occasionally found within the samples from Mae Teep and Mae Mo deposits. Anomalously reached the maximum percentage of about 13.5% in sample MTe11. Absent elsewhere. The same species was reported from the Eocene to Pliocene deposits of various Australian regions (Cookson & Pike, 1954), Queensland Tertiary (Hekel, 1972), and the Lachland and Cowra Formations from New South Wales (Martin, 1973).

Genus CUPANIEIDITES Cookson & Pike, 1954

Cupanieidites major Cookson & Pike, 1954

(Plate 11, figs. 5-6)

1954 Cupanieidites major Cookson & Pike, p.213-214, pl.2, figs.83-85

1967 Cupanieidites major Cookson & Pike in Drugg, p.52, pl.8, fig.5

Designated : SCP 2

Description : Pollen grains free, isopolar, triangular shape with slightly convex sides in polar view, radial symmetry. Syncolporate with very small polar islands. Exine thickness about 0.5um thick, very fine reticulate sculpture.

Dimensions : Polar diameter 20(25)33um (15 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by Cookson & Pike (1954) and Drugg (1967).

Affinity : Cupaniopsis wadsworthii (F. Muell.) Radlk. (Cookson & Pike, 1954).

Distribution : Sparsely found within the samples from Li, Mae Mo and Krabi deposits, absent elsewhere. The same species was reported from the Eocene deposit from Victoria, Australia (Cookson & Pike, 1954) and from the Maastrichtian, Danian sediments of Escarpado Canyon, California (Drugg, 1967).

Subturma PTYCHOPOLYPORINES Naumova emend. Potonie', 1960

Genus PSILASTEPHANOCOLPORITES Leidelmeyer, 1966

Remarks : The specimens placed in this genus include all polycolporate pollen grains which have laevigate, psilate and finely punctate sculpture. Two species are classified as species A and B according to their grain size.

<u>Psilastephanocolporites</u> sp.A

(Plate 16, figs.37-38)

Designated : PCP 1a

Description : Pollen grains free, isopolar, broad elliptical shape with rounded poles in equatorial view, polar view not observed. Stephanocolporate, 4-6 colporate (mostly shown as 4 colporate); colpi distinct, long, with prominent margo; pori distinct, circular, 0.5-1.5um in diameter, present on each colpus at equator. Exine thickness, 1-1.5um thick, laevigate to faintly psilate sculpture.

Dimensions : Equatorial diameter; long axis 15(19)23um; short axis 9(14)18um (25 specimens from various horizons).

Remarks : Tetracolporopollenites abditus Pflug described and photographed by Thomson & Pflug (1953) is similar in shape and size but differs in the tapering of colpus (caverna) at the pole. T. biconus Pflug and T. folliformis Pflug in Thomson & Pflug (1953) both have a different shape and equatorially elongated pori. T. microrhombus Pflug described and photographed by Thomson & Pflug (1953) also has different pori.

Affinity : Most probably related to Sapotaceae.

Distribution : Found in the samples from Mae Teep, Mae Mo, and Krabi deposits at low percentages. Thomson & Pflug (1953) described various species of the similar pollen type from the Eocene to Upper Miocene of Central Europe. Salard-Cheboldaeff (1979) also reported various species of Psilastephanocolporites from the Middle Paleocene to the Miocene of Cameroon.

Psilastephanocolporites sp.B

(Plate 16, figs.39-42; pl.18, figs.28-32)

Designated : PCP 1b

Description : Pollen grains free, isopolar, broad elliptical to subcircular shape in equatorial view, circular shape in polar view, radial symmetry. Stephanocolporate, 4-5-(6) colporate, colpi distinct, moderate length, narrow, slightly costate (shown in some specimens, e.g. pl.16, fig.39), pori distinct, rounded to equatorially elongated elliptical shape, 3-5um in the longest diameter, some trace of equatorial furrows in some grains (pl.16, figs.41-42), present on each colpus at equator. Exine thickness distinct, 1.5um thick, psilate to faintly punctate sculpture.

Dimensions : Equatorial diameters; long axis 23(28)39um; short axis 15(21)31um (60 specimens from various horizons).

Remarks : It is possible that the specimens belong to more than one species, one with a broad eliptical shape, colpi with prominent margo, and with faintly punctate sculpture (plate 16, fig.39) and the other with a more or less spheroidal shape, narrow colpi without margo, laevigate to psilate exine sculpture. The specimens show some resemblance to Tetracolporopollenites obscurus Pflug & Thomson and Tetracolporopollenites sapotoides Pflug &

Thomson (in Thomson & Pflug, 1953) as well as Psilastephanocolporites laevigatus Salard-Cheboldaeff and P. perforatus Salard-Cheboldaeff described and photographed by Salard-Cheboldaeff (1978, 1979).

Affinity : Sapotaceae.

Distribution : Abundant within Krabi samples and rare to common in the others. Various similar species described by Thomson & Pflug (1953) and Salard-Cheboldaeff (1979) were reported from the Lower to Middle Tertiary sequences of Central Europe and Cameroon, respectively.

Turma POROSES Naumova emend. Potonie', 1960

Subturma MONOPORINES Naumova, 1939

Genus GRAMINIDITES Cookson, 1947

Graminidites gracilis Krutzsch, 1970

(Plate 11, figs.34-35)

1970 Graminidites gracilis Krutzsch, p.58, pl.4, figs.12-20

Designated : MP 1a

Description : Pollen grains free, spheroidal shape, monoporate. Porus distinct, circular, 1-2um in diameter, with distinct circular annulus of about 0.5-1.2um wide.

Exine thin, less that 0.5um to about 0.8um thick. Exine sculpture finely punctate, punctae faint to distinct, irregularly distributed over the surface. Intrapunctate structure can be observed in some well-preserved grains. Grains always folded.

Dimensions : Diameter 16(24)31um (40 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by Krutzsch (1970). G. micropunctatus Krutzsch (1970) differs in having a more or less regular punctate sculpture and showing no sign of intrapunctate sculpture.

Affinity : Family Gramineae (Krutzsch, 1970).

Distribution : Common in all samples from Mae Mo desposit, rare to absent elsewhere. The same species was recorded from the Miocene desposits of Central Europe (Krutzsch, 1970). The similar species described as Monoporites annulatus Van der Hammen were reported from the Lower Eocene to Middle Oligocene profile of Cameroon (Salard-Cheboldaeff, 1979); and from the Eocene to Pleistocene strata of the Caribbian and Nigerian regions, and from the Upper Eocene to the Pleistocene deposits in the Borneo area (Germeraad et al., 1968).

Graminidites subtiliglobosus (Trevisan) Krutzsch, 1970

(Plate 11, fig.33)

1967 Monoporopollenites subtiliglobosus Trevisan, p.49, 63, pl.33, figs.6a-f.

1970 Graminidites subtiliglobosus (Trevisan) Krutzsch, p.54, pl.2, figs.1-14.

1974 Graminidites subtiliglobosus (Trevisan) Krutzsch in Ziembinska-Tworzyldo, p.365, pl.16, fig.3.

Designated : MP 1b

Description : Pollen grains free, subspheroidal to spheroidal, monoporate. Porus distinct, circular, about 4um in diameter, with distinct circular annulus 2-2.5um wide. Exine thin, less than 0.5um thick. Exine sculpture very fine punctate to laevigate. Grains always folded.

Dimensions : Diameter 34(37)44um (15 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by various authors cited above. They differ slightly from MP 1a in having a larger grain size and smoother exine.

Affinity : Family Gramineae (Krutzsch, 1970; Ziembinska-Tworzydlo, 1974).

Distribution : Occurred sporadically within the samples from Li, Mae Mo and Mae Teep deposits, absent elsewhere. The same species was reported from the Miocene deposit near Tripoli, Italy (Trevisan, 1967), the Miocene deposit of Central Europe (Krutzsch, 1970) and the Upper Miocene deposit of Western Poland (Ziembinska-Tworzydlo, 1974).

INDETERMINATE MONOPORATE POLLEN GRAINS

Designated : MP 2 (Plate 11, fig.34) : Pollen grains free, spheroidal but always folded, monoporate. Porus indistinct, about 5um in diameter with trace of annulus of about 1.2um wide. Exine thickness distinct, 0.7um thick, psilate sculpture, pale dark brown colour. Grain size about 45-50um (6 specimens measured). Six grains were found within sample no. MM 1,2, and 3. The specimens are more or less comparable to Graminidites sp.B (type 2 Stuchlik) described and photographed by Krutzsch (1970).

Designated : MP 3 (Plate 11, fig.37-38) : ? Monoporate pollen grains with thick exine, with clavae forming reticulate sculpture. Only one grain was found in sample MTe 14. The specimen is tentatively grouped in the monoporate pollen type.

Designated : MP 4 (Plate 11, fig.39) : Monoporate (?) pollen grains, small size (about 15um), with fine echinate sculpture. Two specimens were found in samples MM10 and MM12. The specimens are tentatively placed in the genus Monoporites Van der Hammen (1954).

Subturma DIPORINES Naumova, 1939

Genus DIPORITES Van der Hammen, 1954

Diporites sp.

(Plate 12, figs.1-2)

Designated : DP1

Description : Pollen grains free, isopolar, broad elliptical shape, diporate. Pori distinct, circular about 2.5um in diameter with about 1.5um wide annulus around each porus, costate. Pori situated along the short axis of the grain in polar view, spaced opposite each other. Exine thin, less than 0.5um thick, laevigate.

Dimensions : Polar diameters; long axis 16(22)31um; short axis 10(17)26um (25 specimens from various horizons).

Remarks : The specimens are placed in the genus Diporites Van der Hammen (1954) based on their bearing two pores. The specimens differ from Psilodiporites Varma & Rawat, 1963 (the spelling "Psiladiporites" was adopted by subsequent authors, e.g. Van der Hammen & Wymstra, 1964) in having completely smooth exine (laevigate) sculpture.

Affinity : Unknown.

Distribution : Found within the samples from Krabi deposit at low percentages only.

INDETERMINATE DIPORATE POLLEN GRAINS

Designated : DP2 (Plate 12, figs.4-7) : Diporate pollen grains, broad elliptical shape in polar view, pore situated along the long axis and spaced opposite each other, slightly costate. Finely punctate exine sculpture. A few specimens were found within the sample MTe 14 only. The specimens are tentatively placed in the genus Punctodiporites Varma & Rawat (1963).

Subturma TRIPORINES Naumova, 1939

Genus SUBTRIPOROPOLLENITES Pflug & Thomson, 1953

Subtriporopollenites simplex subsp. simplex

(Potonie' & Venitz) Pflug & Thomson, 1953

(Plate 12, figs.18-19)

1931b Pollenites simplex Potonie', p.3, fig.4.

1934 Carya (?) - pollenites simplex Potonie' (1931) in Potonie & Venitz, p.21, pl.2, figs.28-30.

1953 Subtriporopollenites simplex simplex (Potonie' & Venitz) Pflug & Thomson in Thomson & Pflug, P.86, pl.9, figs.64-73.

Designated : TP1

Description : Pollen grains free, slightly anisopolar, rounded subtriangular to subrounded in polar view, radial symmetry. Triporate, pori distinct, circular, about 2-3um in diameter, subequatorially and angularly arranged. Exine thickness distinct, 2-2.5um thick, psilate to finely granulate sculpture.

Dimensions : Polar diameter 28(38)56um (30 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by Thomson & Pflug (1953). The species was originally designated as Pollenites simplex Potonie' (1931b) and subsequently was redesignated as Caryapollenites simplex (Potonie' 1931) Potonie' (1960).

Affinity : Carya (Thomson & Pflug, 1953).

Distribution : Found at low percentages in all Krabi samples, rare to absent elsewhere. The same species was reported from the Tertiary of Central Europe (Thomson & Pflug, 1953).

Subtriporopollenites cf. S. annulatus subsp. nanus
Pflug & Thomson, 1953
(Plate 12, figs.8-9)

1953 Subtriporopollenites annulatus nanus Pflug & Thomson in Thomson & Pflug, p.86, pl.9, figs.54-55.

Designated : TP2

Description : Pollen grains free, slightly anisopolar, sub-circular to circular in polar view, radial symmetry. Triporate, pori distinct, circular, 1-1.5um in diameter, subequatorially arranged. Exine thin, indistinct, less than 0.5um thick, with psilate to finely granulate sculpture.

Dimensions : Polar diameter 15(20)28um (50 specimens from various horizons).

Remarks : The specimens differ slightly from those described and photographed by Thomson & Pflug (1953) in having a thinner exine.

Affinity : Family Junglandaceae (Thomson & Pflug, 1953).

Distribution : Common to abundant in Mae Mo and Krabi deposits, rare to absent elsewhere. _S._ _annulatus_ _nanus_ Pflug & Thomson was reported from the Upper Paleocene sequence of Central Europe (Thomson & Pflug, 1953).

Genus TRIPOROPOLLENITES Pflug & Thomson, 1953

Triporopollenites cf. _T._ _coryloides_ Pflug, 1953

(Plate 12, figs.10-11)

1953 _Triporopollenites_ _coryloides_ Pflug in Thomson & Pflug, p.84, pl.9, figs.20-24.

1974 _Triporopollenites_ _coryloides_ Pflug in Ziembinska-Tworzydlo, p.371-372, pl.17, fig.12

Designated : TP3

Description : Pollen grains free, slightly anisopolar, rounded subtriangular with convex sides in polar view, radial symmetry. Triporate, pori distinct, subcircular, about 1.5-2.5um in diameter, slightly subequatorially and angularly arranged. Exine thickness distinct, 1-1.5um thick, very slightly thickened around pori, with psilate sculpture.

Dimensions : Polar diameter 16(23)28um (50 specimens from various horizons).

Remarks : The specimens differ slightly from those described and photographed by Thomson & Pflug (1953) and Ziembinska-Tworzydlo (1974) in their relatively smaller grain size.

Affinity : Genus Corylus (Thomson & Pflug, 1953) and comparable with pollen grains of the Recent American species Corylus rostata (Ziembinska-Tworzydlo, 1974).

Distribution : Abundant to common within the samples from Li and Krabi deposits, rare elsewhere. Triporopollenites coryloides Pflug was reported from the Middle to Upper Tertiary deposits of Central Europe (Thomson & Pflug, 1953) and the Upper Miocene profiles of Western Poland (Ziembinska-Tworzydlo, 1974).

Genus TRIVESTIBULOPOLLENITES Pflug, 1953

Trivestibulopollenites betuloides Pflug, 1953

(Plate 12, figs.12-15)

1953 Trivestibulopollenites betuloides Pflug in Thomson & Pflug, p.85, pl.9, figs.25-34.

1974 _Trivestibulopollenites_ _betuloides_ Pflug in Ziembinska-Tworzydlo, p.376, pl.17, figs.8a-b, 10a-b.

Designated : TP4

Description : Pollen grains free, isopolar, subtriangular with straight to slightly convex sides in polar view, radial symmetry. Triporate, pori distinct, small, circular, about 1-1.5um in diameter, with distinct annulus and vestibulum, angularly and equatorially arranged. Exine thickness distinct, 1.5-2um thick, with psilate sculpture.

Dimensions : Polar diameter 13(20)26um (15 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by the authors stated above.

Affinity : Most probably related to the genus _Betula_ (Thomson & Pflug,1953; Ziembinska-Tworzydlo, 1974).

Distribution : Occasionally found within Mae Mo and Krabi samples, absent elsewhere. The same species were reported from the Middle Eocene to the Pliocene deposits of Central Europe (Thomson & Pflug, 1953), and from the Middle and Upper Miocene sequences of Western Poland (Ziembinska-Tworzydlo, 1974).

Genus STRIATRIPORITES Hoeken-Klinkenberg, 1966

Striatriporites nigeriensis Hoeken-Klinkenberg, 1966

(Plate 12, figs.35-36)

1966 Striatriporites nigeriensis Hoeken-Klinkenberg, p.40, pl.1, fig.1.

Designated : TP 5

Description : Pollen grains free, isopolar, triangular with convex sides in polar view, radial symmetry. Triporate, pori distinct, 2-4um in diameter with prominent annulus and vestibulum. Exine thickness indistinct, always obscured by the prominent striate sculpture.

Dimensions : Polar diameter 21(22)23um (5 specimens from sample MM 5-9).

Remarks : Very distinct striate sculpture. The specimens are identicial with those described and photographed by Hoeken-Klinkenberg (1966).

Affinity : Unknown (Hoeken-Klinkenberg, 1966). Anderson & Muller (1975) stated that some species of the triporate grains of the genus Casuarina (i.e. C. nobile) have striate-rugulate sculpture.

Distribution : Found with relatively low percentages and restricted within the samples MM 5 to MM 9 only. The same species was first recognised by Hoeken-Klinkenberg (1966) in the Maastrichtian sediments from borehole Owan-1, Nigeria.

Genus INTRATRIPOROPOLLENITES Pflug & Thomson, 1953

Intratriporopollenites cf. I. rizophorus (Potonie') Thomson & Pflug, 1953

(Plate 12, figs.41-43)

1934 Pollenites rizophorus Potonie', p.94; pl.6, fig.32; pl.5, figs.25-26.

1953 Intratriporopollenites rizophorus (Potonie') Thomson & Pflug, p.88, pl.9, figs.1-6.

Designated : TP6

Description : Pollen grains free, isopolar, spheroidal shape, radial symmetry. Triporate, pori distinct, circular, 3-5um in diameter, with distinct annulus of about 2um wide, slightly subequatorially arranged. Exine thin,0.5-1um thick, finely granulate and echinate sculpture. Echinae small, less than 1um in the basal diameter, about 1.5 to 4um high.

Dimensions : Polar diameter 21(32)46um (20 specimens from various horizons).

Remarks : The specimens differ from T. rizophorus (Potonie') Thomson & Pflug (1953) in their thinner exine, finer echinate elements, and having a finely granulate background to the echinate sculpture. Triporites (Echitriporites) argutus Van der Hammen (1956) is also similar to the specimens but the species was based on the Recent Campanula rotundifolia L. It is possible that more than one species is represented : one with a larger grain size, long echinae and prominent finely granulate background, the others with a smaller size, short echinae and somewhat psilate background to the echinate sculpture.

Affinity : Unknown.

Distribution : Occasionally found within the Mae Teep, Mae Mo, and Krabi deposits, absent elsewhere. T. rizophorus was recorded from the Lower Eocene to Middle Miocene of Central Europe (Thomson & Pflug, 1953).

INDETERMINATE TRIPORATE POLLEN GRAINS

Designated : TP7 (Plate 12, figs.28-31) : Triporate pollen grains with distinct protruded pores, sub-triangular with convex sides in polar views. Exine thickness obscured by reticulate sculpture. Grain size about 20-40um in polar diameter (10 specimens measured). Occasionally found within the Mae Teep, Mae Mo, and Krabi samples. The specimens are tentatively placed within the genus Proteacidites Cookson (1950).

Designated : TP8 (Plate 12, figs.25-27) : Triporate pollen grains with distinct protruded pores, subrounded in polar view. Exine thickness about 1.5um thick with very fine reticulate sculpture. Grain size about 23-25um in polar diameter (a few specimens measured). Very occasionally found within the samples from Mae Mo and Krabi deposits. The specimens are tentatively placed within the genus Proteacidites Cookson (1950).

Designated : TP 9 (Plate 12, fig.32) : Triporate pollen grain, pores with distinct annulus but not protruded, subcircular in polar view, reticulate sculpture. Size about 30um (one grain from samples MM4 only). The specimen is tentatively placed within the genus Proteacidites Cookson (1950).

Designated : TP10 (Plate 12, fig.33-34) : Triporate pollen grain, rounded pores without annulus, thick exine with faintly reticulate sculpture. Size about 32um (one specimen from sample MTe 11 only). The specimen is tentatively placed in the subgenus Retitriporites Van der Hammen (1956).

Designated : TP11 (Plate 12, fig.33) : Triporate (?) pollen grain with fine reticulate sculpture. Elliptical shape in polar view. Size about 20um in the long axis (one specimen from sample KB7 only). The specimen is tentatively placed in the subgenus Retitriporites Van der Hammen (1956).

Designated : TP12 (Plate 12, figs.16-17) : Pollen grains triporate with slightly protruded pores and distinct vestibula, subtriangular with convex sides in polar view. Exine thin, with psilate sculpture. Grain size averages about 25um (3 specimens were found in samples MTe14, MM12, and MM16). The specimens are more or less similar to Trivestibulopollenites prominus Pflug in Thomson & Pflug (1953).

Designated : TP13 (Plate 12, figs.37-38) : Pollen grain triporate, subcircular in polar view, pores distinct with prominent annulus but not protruded. Exine thickness distinct, 1.5um thick with finely granulate sculpture. Grain size 25um in polar diameter (only one specimen from sample MTe 14). The specimen is similar to Intratriporopollenites indubitablis (Potonie') Thomson & Pflug (1953) and more or less resembles the Recent genus Tilia.

Designated : TP14 (Plate 12, figs.39-40) : Triporate pollen grains : pores distinct, elliptical shape; thick exine with sparsely distributed baculate sculpture. Grain size 26(28)30um (5 specimens measured). Only five specimens were found in samples MM18 and MM19. The specimens are tentatively placed in the genus Intratriporopollenites Pflug & Thomson and probably Intratriporopollenites pilosus Pflug (in Thomson & Pflug, 1953).

Designated : TP15 (Plate 12, figs.20-24) : Small triporate pollen grains, subtriangular in polar view. Pori distinct with prominent annulus but not protruded. Exine about 1um thick with perforate to reticulate sculpture. Grain size about 15um (2 specimens from samples MM2 and MM16). The specimens are tentatively placed within the genus Triporopollenites Pflug & Thomson (1953).

Subturma POLYPORINES Naumova 1939

Genus PERIPOROPOLLENITES Pflug & Thomson, 1953

Periporopollenites cf. P. vesicus Partridge, 1973

(Plate 13, figs.4-7)

1973 Periporopollenites vesicus Partridge in Stover & Partridge, p.273, pl.26, fig.12.

Designated : PP1

Description : Pollen grains free, circular in outline but always folded. Periporate, number of pores more than 10, elliptical shape, about 5 x 3 to 6 x 4.5um in diameter, well-defined. Exine fairly thin, indistinct, less than 1um thick, always obscured by reticulate sculpture. Exine structure intrabaculate, elements about 0.5um high, 0.5um apart, coalesced to form a fine reticulate sculpture; lumina about 0.5um in diameter. Also short baculae present within the pore areas.

Dimensions : Polar diameter 26(32)39um (15 specimens from various horizons).

Remarks : The specimens differ slightly from P. vesicus Partridge (1973) in having elliptical pori and a thinner exine. P. stigmosus (Potonie') Pflug (1953) has a somewhat larger size and a more circular pori. This genus was also designated as Liquidambarpollenites Raatz (1937) which in fact has priority. However, in order to keep the classification in the same system as much as possible (which mainly follows Thomson & Pflug's system) and the fact that the genus Periporopollenites is widely used, the genus Periporopollenites is employed here. It is also noteworthy that the species L. stigmosus (Potonie') Raatz, 1937 (which is also based on Pollenites stigmosus Potonie', 1931) described and photographed by Ziembinska-Tworzydlo (1974) appears to be very similar to the specimens studied.

Affinity : Genus Liquidambar.

Distribution : Occured at relatively low percentages in the samples from Li deposit only. P. vesicus Partridge was recorded from the Middle Eocene through Oligocene sediments of the Gippsband Basin, southeastern Australia (Stover & Partridge, 1973). The similar species L. stigmosus (Stover & Partridge, 1973). The similar species L. stigmosus (Potonie') Raatz was reported from the Oligocene and Miocene deposits of Western Poland (Ziembinska-Tworzydlo, 1974).

Genus POLYVESTIBULOPOLLENITES Pflug, 1953

Polyvestibulopollenites (Alnipollenites) verus (Potonie') Thomson & Pflug, 1953

(Plate 13, figs.35-37)

1931a Pollenites verus Potonie', p.332, pl.2, fig.40

1934 Alni-pollenites verus (Potonie') Potonie', p.58, pl.2, figs.13,17,18,25,26.

1934 Alni-pollenites verus (Potonie') in Potonie' & Venitz, p.25, pl.2, fig.51.

1953 Polyvestibulopollenites (Alnipollenites) verus (Potonie') Thomson & Pflug, p.90, pl.10, figs.62-76.

1968 Polyvestibulopollenites verus (Potonie') Thomson & Pflug in Nakoman, pl.5, figs.3-5.

1974 Alnipollenites verus Potonie' in Ziembinska-Tworzydlo, p.379, pl.18, figs.1-2.

Designated : PP2

Description : Pollen grain free, isopolar, angular with 4-5- or 6-gonal shape in polar view, radial symmetry. Stephanoporate with 4-6 pori (generally 5), distinct arci and vestibuli. Exine thin, laevigate to faintly psilate sculpture.

Dimensions : Polar diameter 21(24)28um (40 specimens from various horizons).

Remarks : The specimens are similar to those described and illustrated by various authors cited above. The genus Polyvestibulopollenites Pflug is used here in order to keep within the same system.

Affinity : Genus Alnus.

Distribution : Abundant within the samples from Li deposit, occasionally found within Mae Teep and Krabi samples, absent elsewhere. The same species was recorded from the Eocene to Pliocene browncoal deposits of Germany (Potonie', 1931a, 1934; Potonie' & Venitz, 1934), throughout the Tertiary (actually known from Paleocene to Pliocene) but less common in the Older Tertiary from Central Europe (Thomson & Pflug, 1953), the Tertiary lignites of Seyitomer, Turkey (Nakoman, 1968), and abundant within the Miocene profile of Western Poland (Ziembinska-Tworzydlo, 1974).

Genus POLYPOROPOLLENITES Pflug, 1953

<u>Polyporopollenites</u> <u>carpinoides</u> Pflug, 1953

(Plate 13, figs.33-34, 38)

1953 <u>Polyporopollenites</u> <u>carpinoides</u> Pflug in Thomson & Pflug, p.92, pl.10, figs.79-84

1960 <u>Polyporopollenites</u> <u>carpinoides</u> Pflug in Nakoman, pl.5, figs.13-14

1974 <u>Carpinuspollenites</u> <u>carpinoides</u> (Pflug) Nagy (1959) in Ziembinska-Tworzydlo, p.378, pl.18, figs.9.

Designated : PP3

Description : Pollen grains free, isopolar to slightly anisopolar, rounded polygonal with slightly convex sides in polar view, radial symmetry. Stephanoporate with five or six pores, angularly and equatorially to subequatorially arranged, without annulus. Exine thin, with psilate sculpture.

Dimensions : Polar diameter 20(27)33um (10 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by various authors cited above. Carpinuspollenites carpinoides (Pflug) Nagy described and photographed by Ziembinska-Tworzydlo (1974) was based on P. carpinoides Pflug and is regarded as a synonym here. However it should be noted that the genus Carpinuspollenites was designated by Thiergard (1938) and actually has priority. In order to follow the same system, the genus Polyporopollenites was chosen here.

Affinity : According to the authors cited above, the specimens resemble the genus Carpinus of the family Betulaceae.

Distribution : Occasionally found within the Li, Mae Mo, and Krabi samples absent elsewhere. The same species were reported to be regularly distributed within the Middle to Upper Tertiary deposits from Central Europe (Thomson & Pflug, 1953) and in the Tertiary lignite deposits from Seyitomer, Turkey (Nakoman, 1968). Ziembinska-Tworzydlo (1974) also reported the occurrence of Carpinuspollenites carpinoides (Pflug) Nagy from the Upper Miocene strata of

Western Poland.

Genus PERSICARIOPOLLIS Krutzsch, 1962

Persicariopollis meuseli Krutzsch, 1962

(Plate 20, figs.10-15)

1962 Persicariopollis meuseli Krutzsch, p.282, pl.8, figs.9-16.

1963 Polygonum persicaria-type in Van der Hammen, pl.7, figs.1-3.

1974 Persicariopollis meuseli Krutzsch in Ziembinska-Tworzydlo, p.407, pl.26, figs.6a-c.

1978 Polygonum cf. persicaria in Koreneva & Kartashova, pl.10, fig.10.

Designated : PP4

Description : Pollen grains free, isopolar, spheroidal shape, radial symmetry. Periporate with more than 20 pores which occur in the lumina areas of the heavy reticulate sculpture, circular, 2-3um in diameter. Exine thickness distinct, 3-5um thick (including muri) with baculate elements forming the coarsely reticulate sculpture. Reticulate sculpture consists of muri about lum wide parted by irregularly polygonal lumina about 4-5um in diameter, and supported by columellae 0.5um wide, 3-4um high.

Dimensions : Polar diameter 23(40)49um (30 specimens from various horizons).

Remarks : The specimens are similar to those described and photographed by various authors cited above, particularly Polygonum persicaria-type (Van der Hammen, 1963). The species P. meuseli Krutzsch designated by Krutzsch (1962) was intended to resemble the modern species Polygonum persicaria. Reticulataepollis intergranulatus Krutzsch described and photographed by Krutzsch (1959) is similar in exine structure and sculpture but has three meridional elongated pores. Guettardidites ivirensis Khan described and photographed by Khan (1976) is also similar in its exine feature but has a triaperturate aperture.

Affinity : The specimens resemble the modern grains of Polygonum persicaria.

Distribution : Found at relatively low percentages within the Mae Teep and Mae Mo samples only. The same species was recorded as a rare element from the Miocene and Pliocene of East Germany (Krutzsch, 1962) and from the Upper Miocene of Gierlachowo, Western Poland (Ziembinska-Tworzydlo, 1973). Polygonum persicaria-type was recorded from the Quaternary of British Guinea (Van der Hammen, 1963) and P. cf.

persicaria was found within the Pliocene samples from Hole 380A, Deep Sea Drilling Project of the Black Sea region (Koreneva & Kartashova, 1978).

INDETERMINATE POLYPORATE POLLEN GRAINS

Designated : PP5 (Plate 13, figs.24-29) : Pollen grains free, isopolar, spheoridal shape, radial symmetry. Periporate, four to eight pores (generally six), pores circular to oval shape, distinct, 2-3um in diameter, with a faint annulus about 1um wide. Exine thickness distinct, 2-3um with psilate to finely granulate sculpture. Light brown colour. Polar diameter 21(27)31um (15 specimens from various horizons). Occasionally found within the Li, Mae Teep, Mae Mo, and Krabi samples. The specimens are tentatively placed within the genus Miocenipollis Krutzsch (1966).

Designated : PP6 (Plate 13, figs.17-23) : Pollen grains free, subisopolar, spheroidal shape, radial symmetry. Periporate, four to eight pores, distinct, circular to elliptical shape, about 2um in diameter, with distinct annulus about 0.5-1um wide. Exine thickness distinct, 0.5-1um, with finely granulate sculpture. Polar diameter 16(24)30um (10 specimens from various horizons). Rare in every deposit. The specimens are tentatively placed in the genus Miocenipollis Krutzsch (1966). They differ from PP4 described above in having more distinct annuli and a thinner exine.

Designated : PP7 (Plate 13, figs.8-10) : Small periporate pollen grains, with more than ten pores and very fine reticulate sculpture. Grain size about 20-25um (a few grains measured). Found sporadically within the Li, Mae Teep, Mae Mo, and Krabi samples. The specimens are tentatively placed within the genus Periporopollenites Pflug & Thomson (1953).

Designated : PP8 (Plate 13, figs.13-18) : Pollen grain circular in outline. Periporate, more than 20 pores, distinct. Psilate exine sculpture. Grain size about 15um in diameter. Only one specimen was found in sample MM16. The specimen is similar to Periporopollenites microprolatus Nakoman (1968).

Designated : PP9 (Plate 13, figs.11-12) : Pollen grain circular in outline. Periporate, pores distinct, more than 10, oval shape. Thick exine with psilate sculpture. Grain size about 20um in diameter. Only one specimen was found within the sample MTe8. The specimen shows some resemblance to Periporopollenites halifani Nakoman (1967).

Designated : PP10 (Plate 13, figs.1-3) : Pollen grain free, circular in outline. Periporate, about 8 pores, distinct, oval shape. Thick exine with finely granulate sculpture and baculate-echinate projecting elements. Grain size 54um. Only one specimen found in sample MTe 14. The specimen is more or less similar to Echiperiporites estalae Germeraad, Hopping & Muller (1968).

Designated : PP11 (Plate 13, fig.16) : Small (15um) tetraporate pollen grain, circular in outline. Stephanoporate, pores small, equatorially arranged. Thin exine with finely granulate sculpture. Only one specimen was found in sample MM7. The specimen is tentatively placed within the genus Polyporopollenites Pflug (in Thomson & Pflug, 1953).

Designated : PP12 (Plate 13, figs.30-32) : Pollen grains free, circular in outline. Stephanoporate, 4-6 pores, distinct. Thin exine with faintly rugulate sculpture. Grain size 20-30um (a few specimens from various horizons). Sporadically found in every deposits except Mae Tun. The specimens are tentatively placed within the genus Polyporopollenites Pflug (1953).

Designated : PP13 (Plate 13, fig.39) : Pollen grains similar to Polyporopollenites undulosus (Wolff) Thomson & Pflug (1953). One specimen was found in sample MTe 15.

INDETERMINATE POLLEN GRAINS OF UNKNOWN TYPE

Designated : U1 (Plate 20, figs.6-7) : Large broad elliptical shape pollen grain without any distinguishable aperture. Thick exine with very coarse reticulate sculpture, muri about 1.2um wide, 3um high, divided by distinct polygonal lumina of about 10um in diameter. Only one corroded grain was found in sample MM4.

Designated : U2 (Plate 20, figs.18-20) : Pollen grains hexagonal in outline, covered with pentagonal lumina of regular diameter of about 10um and muri 1.5um wide, 0.5um high. Three pore-like indentations equatorially arranged on the grain outline with a vestibulate structure. Brownish colour. Only two specimens were found in samples MM 4 and MM 20. The specimen shows some similarity with the genus Fenestrites designated by Van der Hammen (1956).

OTHER INDETERMINATE PLANT MICROFOSSILS

Designated : PR1 (Plate 21, fig.1) : Plant remains, probably walls of the teacheids, with circular bordered pits which are arranged in one, two or three rows. Similar plant remains were described by Miner (1956, pl.24, figs.17-20).

Designated : PR2 (Plate 21, fig.2) : Similar to PR1 except smaller bordered pits which are arranged in one row only.

Designated : PR3 (Plate 21, fig.3) : Plant remains, probably woody fragments.

Designated : FR1 (Plate 21, fig.4) : Fungal remains, elongated elliptical shape with rounded ends, consist of 2-6 cells (mostly 5), constricted between cells. The specimens are more or less similar to fungal remains type 324 described and photographed by Van Geel et al. (1981, pl.6, figs.324a-c).

Designated : FR2 (Plate 21, fig.5) : Fungal remains, rounded elliptical shape, consist of 2-4 cells (mostly 3), with mycelium attachment. The specimens are more or less similar to fungal remains type 359 described and photographed by Van Geel et al. (1981, pl.10, figs.359a-e).

Designated : FR3 (Plate 21, fig.6) : Fungal remains, small elongated elliptical shape, consist of 2 cells, with dense longitudinal ridged ornament. The specimens are more or less of fungal remains type 85 (ascospore) described and photographed by Van Geel (1977, pl.16, figs.85a-b).

Designated : FR4 (Plate 21, figs.7,8) : Fungal remains, dark colour, spheroidal to ellipsoidal in shape, with a minutes single pore. The specimens are more or less similar to fungal remains type 351 (spores) described and photographed by Van Geel _et_ _al_ (1981, pl.9, figs.351a-c).

Designated : FR5a (Plate 21, figs.9,10) : Fungal remains similar to fungal type 89, conidium of _Tetraploa_ _aristata_ Berk. & Br., described and photographed by Van Geel (1977, pl.17, fig.89).

Designated : FR5b (Plate 22, fig.2) : Fungal remains similar to FR5a probably the polar view.

Designated : FR6 (Plate 21, fig.11) : Fungal remains similar to fungal type 13, cf. _Entophlyctis_ _lobata_ Willoughby & Townky (Chytridiales), described and photographed by Van Geel (1977, pl.6, figs.13a-b).

Designated : FR7a (Plate 21, fig.12) : Fungal remains similar to fingal type 8b, fungal fruit-bodies, described and photographed by Van Geel (1977, pl.2, figs.8B.e).

Designated : FR7b (Plate 22, fig.1) : Fungal remains probably fungal fruit-bodies, differ from FR7a in having a smooth outline.

Designated : FR8 (Plate 21, fig.13) : Fungal remains similar to fungal spores described as _Fusiformis_ _crabbii_ Rouse described and photographed by Rouse (1962, pl4, figs.27-29).

Designated : PM (Plate 21, fig.14) : Plant microfossils similar to those described as plant microfossil type 354 and may represent spores of Bryophyta sp. but not of Sphagnum (Van Geel et al., 1981, pl.9, figs.354b).

Remarks : These plant microfossils are commonly found in every deposit at relatively low percentages but may be locally abundant. No details have been studied.

FOSSIL SPORES FROM CARBONIFEROUS COAL

Genus LYCOSPORA (Schopf, Wilson & Bentall)

Potonie' & Kremp, 1954

Lycospora pellucida (Wicher) Schopf, Wilson & Bentall, 1944

(Plate 22, figs.6-7)

1934 Sporites pellucida Wicher, p.186, pl.8, figs.29

1944 Lycospora pellucida (Wicher) Schopf, Wilson & Bentall, p.54

1967 Lycospora pellicida (Wicher) Schopf, Wilson & Bentall in Smith & Butterworth, p.250-1, pl.20, figs.7-9.

Designated : L

Description : Spores radial, trilete, rounded triangular in polar view, proximal surface slightly pointed and distal surface convex in equatorial view. Laesurae straight, extent to the outer margin of the inner zone of cingulum, with ridges of about 1um high. Cingulum comprises two zones, the darker inner zone and the lighter outer zone. Total width of cingulum 3-6um. Granulate sculpture.

Dimensions : Equatorial diameters 26(31)37um (40 specimens from sample ND4).

Remark : The specimens are similar to those described and photographed by Smith & Butterworth (1967). The specimens were found within the sample ND4 of the Na Duang deposit only.

Genus DENSOSPORITES (Berry) Butterworth, Jansonius, Smith, and Staplin, 1964

Densosporites annulatus (Loose) Smith & Butterworth, 1967

(Plate 22, fig.3)

1932 Sporonites annulatus Loose in Potonie', Ibrahim, & Loose, p.451, pl.18, fig.44

1967 Densosporites annulatus (Loose) Smith & Butterworth, p.239, pl.19, figs.5-6.

Designated : D

Description : Spores radial, trilete, rounded sub-triangular in polar view. Laesurae straight, simple, extent to the inner margin of cingulum, mostly indistinct. Cingulum, mostly indistinct. Cingulum distinct, much darker than polar area, relatively uniform and smooth, 5-10um wide. Sculpture psilate.

Dimensions : Equatorial diameter 30(35)40 (15 specimens from sample ND4).

Remarks : The specimens are similar to those described and photographed by Smith & Butterworth (1967). Specimens were found within sample ND4 only.

INDERMINATE CARBONIFEROUS SPORES

Designated : G (Plate 22, fig.4) : Trilete spores, triangular shape with one lobe folded (?). Sculpture conical shaped, verrucate to gemmate. The specimens are tentatively placed in the genus Granulatisporites (Ibrahim) Potonie' & Kremp (1954). Specimens were found in sample ND4 only.

Designated : AP (Plate 22, fig.5) : The specimen is tentatively placed in the genus Apiculatisporis Potonie' & Kremp (1956) based on its sculpture and displaying few distinctive features. Only one specimen was found in sample ND4.

Remarks : In addition, there are a few poorly preserved grains of Lycospora sp. (similar to L described above but having a larger grain size, slightly pointed angles in polar view and finely granulate sculpture); ?Punctatosporites minutus (a small monolete spores, bean-shaped, laevigate sculpture); and ?Schulzospora spp. (cavate spore with circular intexine surrounded by oval exoexine, short trilete laesurae not exceeding intexine, scabrate sculpture).

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Introduction

At least 155 species of fossil spores and pollen grains together with 14 other plant microfossils, mainly fungal remains, were found in the Cenozoic coal samples. In addition at least 4 species of fossil spores were found in the Carboniferous samples. Among the fossil spores and pollen grains, 74 species were described systematically, photographed, and given a possible botanical affinity. The rest were grouped as indeterminate under each morphological type (i.e. indeterminate trilete spores, indeterminate tricolporate pollen grains, etc), briefly described, photographed, and tentatively named where possible.

The distributions and frequencies of all Cenozoic species are summarized in Diagram 1. Known stratigraphic ranges of some Cenozoic species from other regions, for examples; tropical zones, Europe, and others, are compiled in Diagram 2. Table 2 presents the possible botanical affinity of identified species.

6.2 Stratigraphic Significance

The known stratigraphic ranges of some Cenozoic spores and pollen grains from other Cenozoic deposits are summarized in Diagram 2. In this study, the proposed age of each deposit will be given on the basis of floral assemblages compared with these known ranges. The major criteria is based on the species which occurred abundantly and are restricted or fairly restricted within each deposit. This will be supported by the species which, although they occur in relatively low percentages, are widely distributed throughout the section. The previous age determination by other fossils is given for comparison.

In general, the microfloral assemblages found in all deposits are similar. The species which are widely distributed include :

M1a Laevigatosporites haardti

M1b Laevigatosporites adiscordatus

M5b Verrucatosporites inangahuensis

DS1 Pityosporites cf. P. Labdacus

I1 Inaperturopollenites sp.1

TCP1a Tricolporopollenites cingulum oviformis

TCP1b Tricolporopollenites cingulum pusillus

TCP1c Tricolporopollenites cingulum fusus

TCP2 Tricolporopollenites cf. T. pacatus

TCP6 Retitricolporites annulatus

PCP1b Psilastephanocolporites sp.B

TP3 Triporopollenites cf. T. coryloides

From the known stratigraphic ranges of these species, the age of all deposits could range from Senonian to Pliocene and most probably from Middle Eocene to Upper Miocene (see Diagram 2). However, by considering some other significant species, the individual age determinations for each deposit could be as follows :

6.2.1 Li (Ban Pu) Deposits

Endo (1964, 1966) previously described fossil plant remains from lignite and oil shale at Li (Ban Pa Kha) deposit, another subbasin of the Li basin (about 10km South of the Ban Pu deposits), to be of Upper Eocene age. Recently, Ratanasthien (1984) reported the palynological study of the coal and clay samples from both Ban Pu and Ban Pa Kha deposits (top of the coal seam and underclay samples for Ban Pu, and top of the upper coal seam sample for Ban Pa Kha) and concluded that the accumulation started in the Senonian or Paleogene and ended in the Oligocene to Lower Miocene.

In this study, apart from the widespread assemblage described above, the presence of T7 (Polypodiaceoisporites brevisculptatus), I4b (Inaperturopollenites hiatus group B), TCP12 (Palaeocaesalpiniaceaepites sp.), PP1

(Periporopollenites cf. vesicus), and PP2 (Polyvestiburopollenites (Alnipollenites) verus) confirms the age of this deposit to be from Middle Eocene to Upper Miocene.

6.2.2 Mae Teep Deposit

Ukkakimaphan et al. (1982) reported the occurrence of a gastropod bed (thickness up to 50um) which is confined to this deposit, but no age determination has been made. Ratanasthien (1984) investigated shale and clay samples (2 underclays, 1 upperclay, and 1 upper shale samples) and reported the occurrence of Appendicisporites tricornitatus (Weyland & Griefeld) Couper, Cicatricosisporites drumhellerensis Srivastava, Plicatella sp., Verrumonoletes sp., Laevigatosporites sp., and Lophotriletes sp. in the underclay sample and the Plicatella sp. and Verrumonoletes sp. in the upperpart of the coal seam samples. From this assemblage Ratanasthien (1984) concluded that the coal-bearing formations started their accumulations in the Senonian or Paleogene and ended in the Paleogene period.

In this study, apart from the widespread assemblage, the occurrence of M2 (Microfoveolatosporis pseudodentatus), T6a-c (Osmundacidites sp.A-C), T9 (Crassoretitriletes vanraadshooveni), SCP1 (Myrtaceidites parvus), TP1 (Subtriporopollenites simplex simplex), TP2

(Subtriporopollenites cf. S. annulatus manus), and PP4 (Persicariopollis meuseli) indicates the deposit to range in age between Oligocene to Upper Miocene (possibly up to Pliocene).

6.2.3 Mae Mo Deposits

Various records of fossil found within the Mae Mo deposit indicate the age of the deposit to range from Miocene to Pliocene (Chaodumrong et al., 1983). The classic fossil record found in the deposit is that of the mastodont teeth collected from the upper part of the K seam (the same as this study) by Van Koenigswald (1959). This was later identified as Stegolophodon praelatidens and indicated Lower to Middle Pliocene age (Von Koenigswald, 1959). Ingavat (1981) also identified various fossil remains, mainly gastropods and bivalves, as Paludina sp., Viviparus sp., Physa sp., Melanoides sp., Planorbis sp., and others and suggested a Miocene age.

In this study, the microfloral assemblage indicates the deposit to range in age from Upper Oligocene to Upper Pliocene. The assemblage includes M3 (Punctatosporites sp.), M5d (Verrucatosporites usmensis), T3a (Laevigatisporites pseudomaximus), T8 (Magnastriatites grandiosus), T9 (Crassoretitriletes vanraadshooveni), MC1a (Ovoidites elongatus elongatus), MP1a (Graminidites gracilis), and PP4 (Persicariopollis meuseli).

6.2.4 Mae Tun Deposit

Ratanasthien (1984) suggested that the coal-bearing formation in the Mae Tun deposit could possibly have started accumulating in the Senonian or Paleogene and finished in the Paleogene, on the evidence of Plicatella sp. and Verrumonoletes sp. in the clay and shale samples (top carbonaceous shale and the intercalation clay).

In this study, the possible range of microfloral assemblages is from Lower Eocene to Middle Miocene. The assemblage (apart from the background) also includes Z1b (Zonalapollenites (Tsuga) Viridifluminipites), 14b (Inaperturopollenites hiatus group B) and PP2 (Polyvestiburopollenites) (Alnipollenites) verus).

6.2.5 Krabi (Bang Pu Dam) Deposit

Achalabhuti (1975) briefly reviewed the stratigraphy of the Tertiary deposit in the Krabi area and noted the age of the deposit to be of Palecene to Eocene based on the result of palynological analysis (Hedlund 1972 in Achalabhuti, 1975). Ingawat (1982) also reported the age of the fossil collected from Khlong Wai Lek deposit (about 5km NE of Bang

Pu Dam deposit) to be of Miocene age.

In this study, the age of the coal samples collected from the upper part of the main coal seam at Bang Pu Dam deposit ranges probably from Upper Eocene to Upper Miocene. The floral assemblage includes TP1 (Subtriporopollenites simplex simplex) and TP2 (Subtriporopollenites cf. S. annulatus nanus).

6.2.6 Na Duang Deposit

Ukkakimaphan & Meesuk (1983) reported the occurence of fossil plant remains together with fossil coral associated with the coal-bearing strata. The fossil coral was previously identified as Palaeosmilia sp. (Fontain & Ingavat, 1981) and indicated the upper part of Lower Carboniferous (Upper Visean).

According to this study, the microfloral assemblages could be of Upper Carboniferous (Westphalian A) age as indicated by the presence of ?Punctatosporites minutus which is first occurred at the base of the Westphalian A age and ?Schulzospora spp. which is disappeared at the top of the Westphalian A age (Dr. M.A. Butterworth : written personal communication).

6.3 Palaeoecology

6.3.1 Introduction

Since only coal samples of one section from each deposit have been studied, the palaeoecology as reflected by floral assemblage could not be representative of the whole deposits. To date, the environment of deposition for each deposit has only been described in terms of sedimentology and stratigraphy. Ecological interpretations on the basis of palynology either for modern or ancient deposits has never been done in Thailand before. Therefore, in this study, the interpretation will be based on palynological records given elsewhere compared with sedimentological and stratigraphical data available from Thailand (see Chapter 2). Table 2 shows the possible botanical affinity of the identified Cenozoic spores and pollen grains found in this study. The distribution and frequency of each species are given in Diagram 1.

In general, each deposit contains a similar microfossils assemblege. The majority of these microfossils are characterized as tropical to warm temperate lowland vegetation occuring in either inland or coastal peat swamp areas. Some pollen types however, indicate upland vegetation and are locally abundant. The palaeoecology based on the palynological data is somewhat similar to those previously described by other means (e.g.

Ratanasthien, 1983).

6.3.2 Li (Ban Pu) Deposit

Li (Ban Pu) deposit contains assemblages of spores and pollen grains,? tracheids walls,? woody fragments, and fungal remains. The spores and pollen grains, which although are the main components, are somewhat less abundant and more poorly preserved than in the other deposits. They are also extremely rare in samples LI 1,2,16,22, and 31, where there is an abundance of ? woody fragments. Fungal remains are found sporadically throughout the section and are somewhat abundant at the lower part (samples no.LI 31-34). However, no detailed studies for the other plant microfossils have been made.

On the basis of spores and pollen grains, the angiosperms dominate the section with minor gymnosperms and locally abundant pteridophytes spores. The assemblage consists mainly of the spores of the Polypodiaceae (Asplenium type: M1a), Pteridaceae (Pteris : T7); and the pollen grains of the Araucariaceae (Araucacia/Agathis : I1), Taxodiaceae (Taxodium : I4b), Fagaceae (Castanea/Castanopsis : TCP 1a, TCP 1b), Rutacaeae (Ptelea : TCP 1c) and Betulaceae (Alnus: PP2, Corylus : TP 3) with minor Pinaceae (Pinus : DS1), Rubiaceae (Canthium/Jackia : TCP 6), Leguminosae (Caesalpinia : TCP 12), and Hamamelidaceae (Liquidambar :

PP1).

The warm temperate climate is well represent by the abundance of Araucariaceae (Martin, 1973), Taxodiaceae (Rachele, 1975; Jarzen, 1975) and Corylus (Stuchlik, 1964). However, the presence of the cold temperate species i.e. Alnus and Pinus (Stuchlik, 1964) could suggested an upland habitat (Muller, 1966). An upland habitat is also evidenced by the presence of the Pteris spores which, as indicated by Muller (1959), is tree-fern growing in montane rain forest above 2500 feet. Together with the other peat swamps forest elements i.e. Polypodiaceae spores (Asplenium type), Fagaceae (Castanea/Castanopsis), Rutaceae (Ptelea) and Leguminosae (Caesalpinia) pollen grains, the coal in Li (Ban Pu) basin could be deposited in the warm swampy environment at the upland slope. The locally abundant ? woody fragments instead of spores and pollen grains, together with the occurence of other plant remains observed in the samples (leaves, petrified woods, stumps) may indicated the deposit was located in a region of flooding (e.g. flood plain, oxbow lakes, etc.).

6.3.3 Mae Teep Deposit

The microfossils assemblage of the Mae Teep deposit consists mainly of pteridophytes spores, angiosperms pollen grains and, common to locally abundant, fungal remains.

The spores and pollen assemblage are composed mainly of spores of Polypodiaceae (Asplenium type : M1a), Osmandaceae (Osmanda: T 6a-d), and pollen grains of Fagaceae (Castanea/Castanopsis : TCP 1a, TCP 1b), Rutaceae (Ptelea : TCP 1c), Simarubaceae (Ailanthus : TCP 2), and Rubiaceae (Canthium/Jackia : TCP 6).

The assemblage contains peat swamp forest elements similar to those described by Anderson & Muller (1975) from the Holocene Peat and Miocene coal of NW Borneo. Damp and humid conditions are represented by the occurrence of Polypodiaceae and Osmunda spores (Stuchlik, 1964; Wilkinson & Boulter, 1980) which, as well, are the indicative of temperate to cool temperate climate (Stuchlik, 1964). Together with the plants of drier habitat such as Castanea/Castanopsis (Jarzen, 1978), Ptelea (Stuchlik, 1964; Ziembinska-Tworzydlo, 1974) the assemblage suggests that the Mae Teep coal could be accumulated in temperate peat swamp forests with high humidity perhaps surrounded by drier land.

6.3.4. Mae Mo Deposit

The deposit contains large numbers of fossil spores and pollen grains. Other plant remains as well as fungal remains are rarer. The assemblage consists of the spores of Polypodiaceae (Asplenium type), Marattiaceae (Marattia :

M 3), Schizaeaceae (Lygodium : T3a); and the pollen grains of Araucariaceae, ? Magnoliaceae (Magnolia/Liriodendron : MC 2a), Fagaceae (Castanea/Castanopsis), Rubiaceae (Canthium/Jackia), Gramineae (MP la), and Betulaceae (Betula : TP 2).

A warm temperate to subtropical climate is represented by the abundance of both warm temperate elements i.e. Araucariceae (Martin 1973), ? Magnoliaceae and Gramineae (Stuchlik, 1964) and subtropical elements such as Lygodium (Pacltova, 1960), Castanea/Castanopsis (Jarzen, 1978), etc. The abundance of Polypodiaceae, Lygodium, ? Magnoliaceae, and Gramineae with minor Ceratopteris (T8) and Palmae (Nypa: MC la) could be indicative of an open water swamp to shallow lake condition whilst the Betula pollen grains are most probably derived from the surrounded hills. The overall environment of deposition for the Mae Mo deposit could be warm temperate to subtropical open water swamps surrounded by higher land.

6.3.5 Mae Tun Deposit

Although only 3 coal samples have been analysed, the abundance of Pinus (DS 1) and Alnus together with other gymnosperms i.e. Tsuga (Z lb), Araucariaceae and Taxodium could represent a temperate climate in an upland area. The lack of pteridophytes spores and lesser abundance of other angiosperms pollen may indicate dry condition. The deposit therefore could have accumulated in a dry, temperate, upland basin and most probably in an old river channel.

6.3.6 Krabi (Bang Pu Dam) Deposit

The deposit contains a notably high percentage of angiosperms pollen. The assemblage consists mainly of tropical elements such as Castanea/Castanopsis, Ptelea, and Sapotaceae (PCP 1b). Minor mangrove elements, i.e. Brownlowia/Pentace (TC 1), Avicennia (TCP 7), as indicated by Muller (1968), Anderson & Muller (1975) and Haseldonckx (1977) as well as montane elements, i.e. Corylus, are also presented. Coastal peat swamps may be represented by the presence of Rubiaceae (TCP 6) and Sapotaceae (Haseldonckx, 1977). The Krabi (Bang Pu Dam) deposit thus probably accumulated in the tropical coastal swamp forests adjacent to both mangrove forests and higher lands.

APPENDIX A : TABLES

Table 1 Some classifications of Cenozoic rocks (after Chaodumrong *et al*, 1983)

	Palaeogene			Neogene	
	Paleocene	Eocene	Oligocene	Miocene	Pliocene
Brown *et al.*, 1951					Krabi Series (South) Mae Sot Series (North)
Javanaphet, 1969	Krabi Group				
	Li Formation			Mae Mo Formation	
Gardner, 1969					Mae Mo Formation
Piyasin, 1972 1975	Mae Mo Group				
Buravas, 1973	Nam Pat Fm.		Li Fm.	Mae Mo Fm.	Mae Sot Fm.
Suensilpong *et al.*, 1978	Krabi Group				
	Li Fm.				Mae Mo Fm.
Others	Tertiary Group or local geographic name				

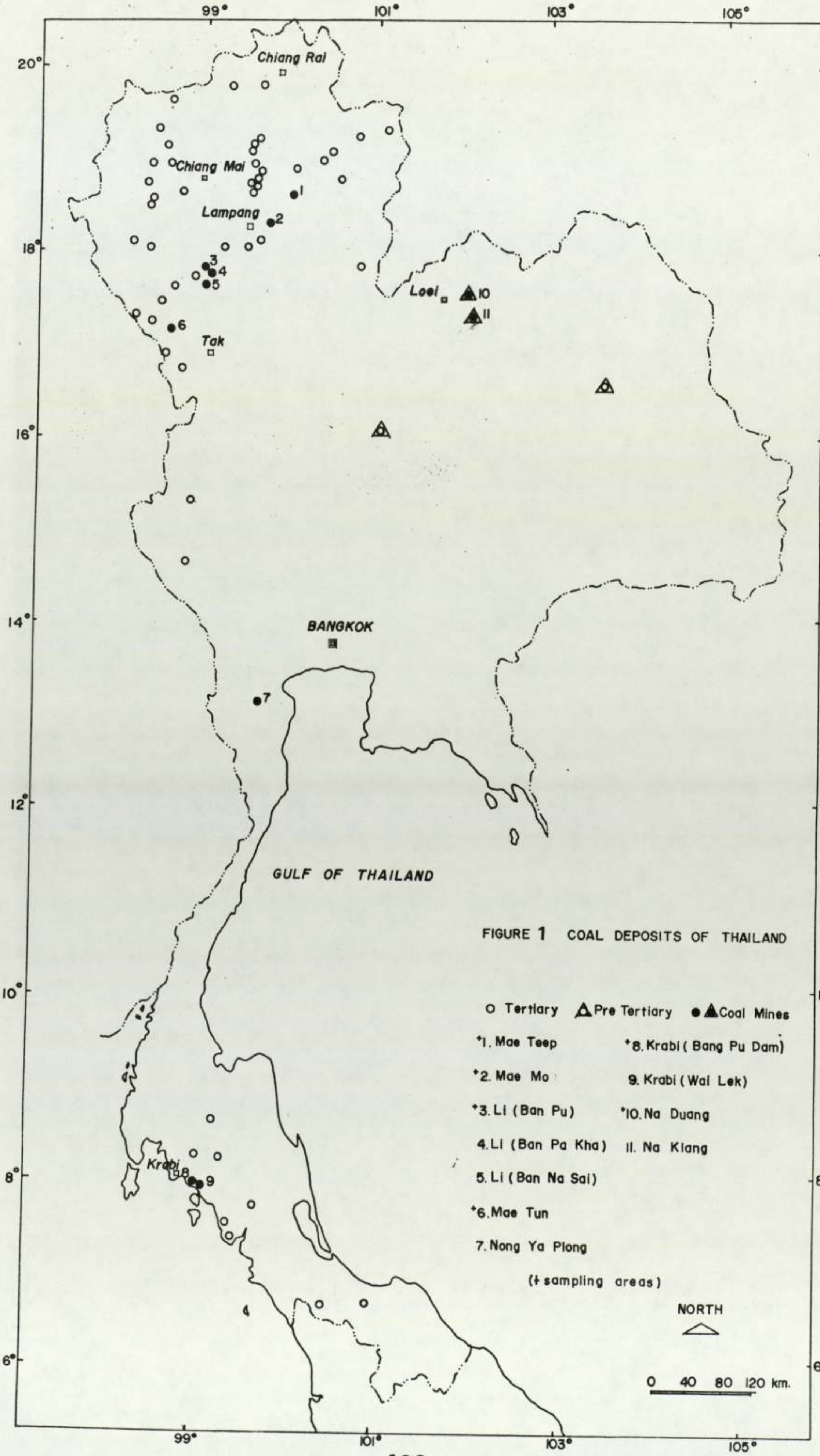
Table 2 Possible botanical affinity of identified Cenozoic spores and pollen grains from Thailand.

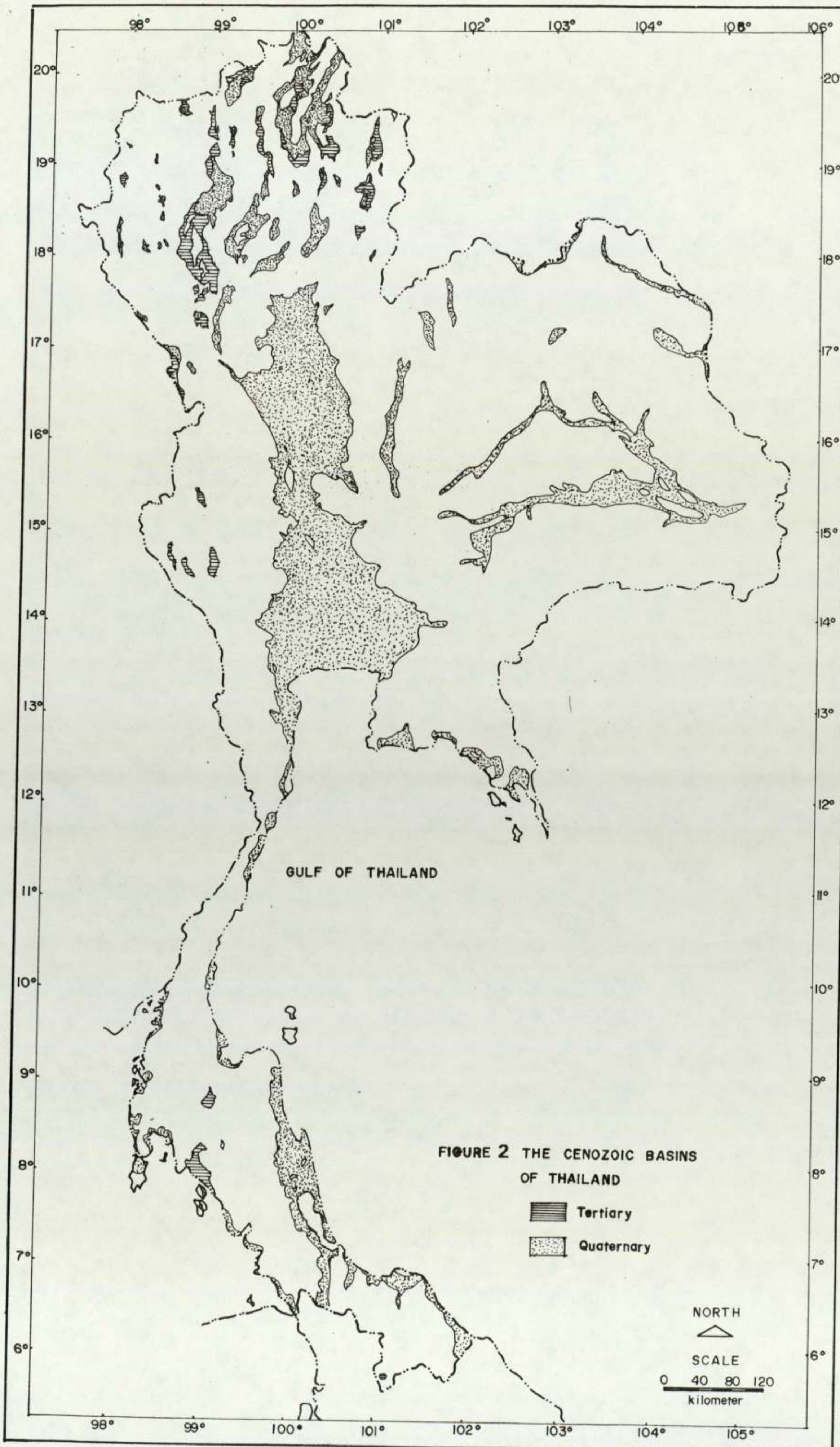
Extant Taxon		Desig-nated	Fossil Taxon
Family	Genus		
PTERIDOPHYTES			
GLEICHENIACEAE		T 4	*Concavisporites (Obtusisporites) minimus*
LYCOPODIACEAE	*Lycopodium*	T 5a	*Foveotriletes* cf. *F. crassifovearis*
		T 5c	*F.* cf. *F. crassifovearis crassoids*
MARATTIACEAE	*Marattia*	M 3	*Punctatosporites* sp.
OPHIOGLOSSACEAE	*Ophioglossum*	T 2a	*Leiotriletes apheles*
OSMUNDACEAE	*Todites*	T 1	*Todisporites* cf. *T. minor*
	Osmunda	T 6a	*Osmundacidites* sp. A
		T 6b	*Osmundacidites* sp. B
		T 6c	*Osmundacidites* sp. C
		T 6d	*Osmundacidites* sp. D
PARKERIACEAE	*Ceratopteris*	T 8	*Magnastriatites grandiosus*
POLYPODIACEAE	*Asplenium* type	M 1a	*Laevigatosporites haardti*
		M 1b	*L. adiscordatus*
	Polypodium type	M 4	*Reticuloidosporites secondus*
		M 5a	*Verrucatosporites* cf. *V. megabalticus*
		M 5b	*V. inangahuensis*
		M 5c	*V.* cf. *V. favus*
	Stenochlaena	M 5d	*V. usmensis*
	Cyclophorus	M 5e	*Verrucatosporites* sp.
PSILOTACEAE	*Psilotum*	M 2	*Microfoveolatosporis pseudosecondus*
PTERIDACEAE	*Pteris*	T 7	*Polypodiaceosporites brevisculptatus*
SCHIZAEACEAE	*Lygodium*	T 3a	*Laevigatisporites pseudomaximus*
		T 3b	*Laevigatisporites* sp.
		T 9	*Crassoretitriletes vanraadshooveni*
GYMNOSPERMS			
ARAUCARIACEAE	*Araucacia/ Agathis*	I 1	*Inaperturopollenites* sp. 1
TAXODIACEAE	*Sequoia*	I 2	*Inaperturopollenites* sp. 2
	Taxodium	I 4	*Inaperturopollenites hiatus*
PINACEAE	*Pinus*	DS 1	*Pityosporites* cf. *P. labdacus*
	Tsuga	Z 1a	*Zonalapollenites igniculus*
		Z 1b	*Z. viridifluminipites*
ANGIOSPERMS			
ALANGIACEAE	*Alangium*	TCP13	*Lanagiopollis* cf. *L. microrugulatus*
AQUIFOLIACEAE	*Ilex*	TCP5	*Tricolporopollenites margaritatus*
ARALIACEAE		TCP4	*T. euphorii*
BETULACEAE	*Alnus*	PP 2	*Polyvestibulopoll. (Alnipollenites) verus*
	Betula	TP4	*Trivestibulopollenites betuloides*
	Carpinus	PP 3	*Polyporopollenites carpinoides*
	Corylus	TP3	*Triporopollenites* cf. *T. coryloides*
BOMBACACEAE	*Bombax*	TCP 11	*Bombacidites* cf. *B. nanus*
FAGACEAE	*Castanea/ Castanopsis*	TCP1a	*Tricolporopollenites cingulum oviformis*
		TCP1b	*T. cingulum pusillus*
GRAMINEAE		MP 1a	*Graminidites gracillus*
		MP 1b	*G. subtiliglobosus*
GUTTIFERAE	*Calophyllum*	TCP3	*Tricolporopollenites* cf. *T. rhomboidaliformis*
HAMAMELIDACEAE	*Liquidambar*	PP 1	*Periporopollenites* cf. *P. vesicus*

Table 2 Possible botanical affinity of identified Cenozoic spores and pollen grains from Thailand(cont.).

Extant Taxon		Desig-nated	Fossil Taxon
Family	Genus		
JUNGLANDACEAE		TP2	*Subtriporopollenites* cf. *S. annulatus nanus*
	Carya	TP1	*S. simplex simplex*
LEGUMINOCEAE	*Caesalpinia*	TCP9	*Margocolporites vanwijhei*
		TCP10	*Margocolporites* sp.
		TCP12	*Palaeocaesalpiniaceaepites* sp.
MAGNOLIACEAE	*Magnolia* / *Liriodendron*	MC2a	*Ovoidites elongatus elongatus*
		MC2b	*O. microligneolus*
MYRTACEAE		SCP1	*Myrtaceidites parvus*
PALMAE	*Nypa*	MC1	*Proxapertites operculatus*
POLYGONACEAE	*Polygonum*	PP4	*Persicaliopollis meuseli*
RUBIACEAE	*Canthium* / *Jackia*	TCP6	*Retitricolporites annulatus*
RUTACEAE	*Ptlea*	TCP1c	*Tricolporopollenites cingulum fusus*
SAPINDACEAE	*Cupaniopsis*	SCP2	*Cupanieidites major*
SAPOTACEAE		PCP1a	*Psilastephanocolporites* sp. A
		PCP1b	*Psilastephanocolporites* sp. B
SIMARUBACEAE	*Ailanthus*	TCP2	*Tricolporopollenites* cf. *T. pacatus*
TILIACEAE	*Brownlowia* / *Pentace*	TC1	*Discoidites borneensis*
VERBINACEAE	*Avicennia*	TCP7	*Rhoipites* cf. *R. isoreticulatus*

APPENDIX B : FIGURES


99°
101°
103°
105°
20°
18°
16°
14°
12°
10°
8°
6°
Chiang Rai
Chiang Mai
Lampang
Tak
Loei
BANGKOK
GULF OF THAILAND
Krabi
FIGURE 1 COAL DEPOSITS OF THAILAND
o Tertiary
Pre Tertiary
Coal Mines
*1. Mae Teep
*2. Mae Mo
*3. Li (Ban Pu)
4. Li (Ban Pa Kha)
5. Li (Ban Na Sai)
*6. Mae Tun
7. Nong Ya Plong
*8. Krabi (Bang Pu Dam)
9. Krabi (Wai Lek)
*10. Na Duang
11. Na Klang
(* sampling areas)
NORTH
0 40 80 120 km.


GULF OF THAILAND
FIGURE 2 THE CENOZOIC BASINS OF THAILAND
Tertiary
Quaternary
NORTH
SCALE
0 40 80 120
kilometer

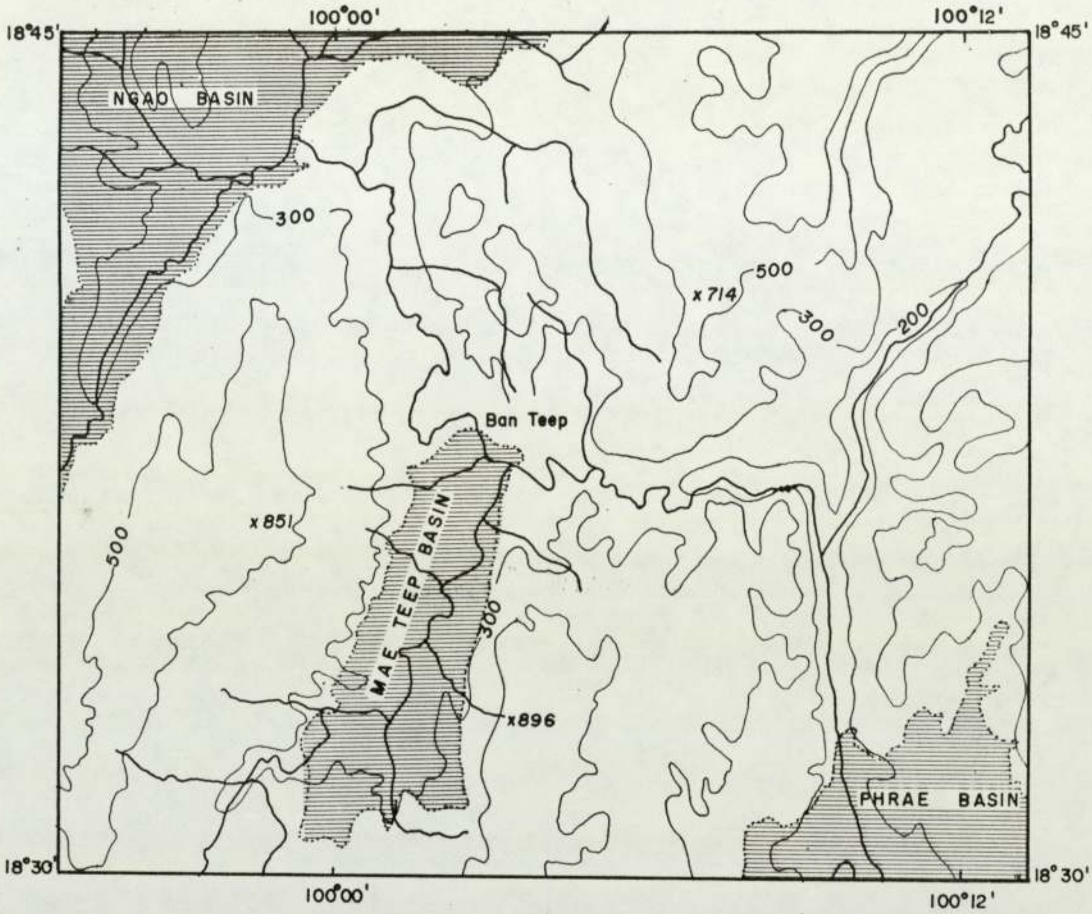


FIGURE 3 TOPOGRAPHIC MAP OF MAE TEEP BASIN.
(From 1:250,000 sheet NE 47-7)

0 5 10 km
Scale 1:250,000

north

	contours
x 896	spot height
	mining area
	approximate basin boundaries
	stream lines

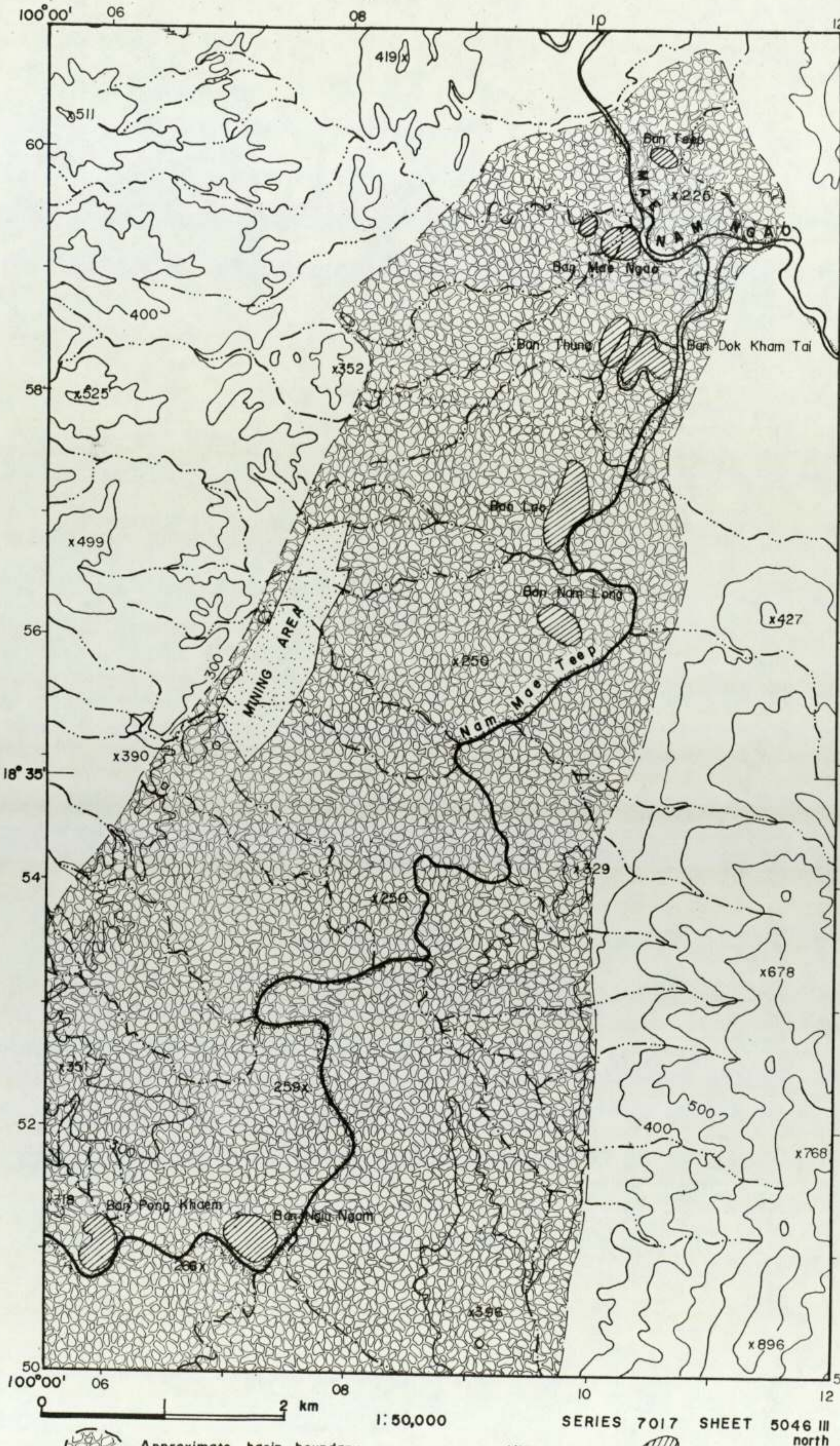


FIGURE 4 TOPOGRAPHIC MAP OF MAE TEEP BASIN.

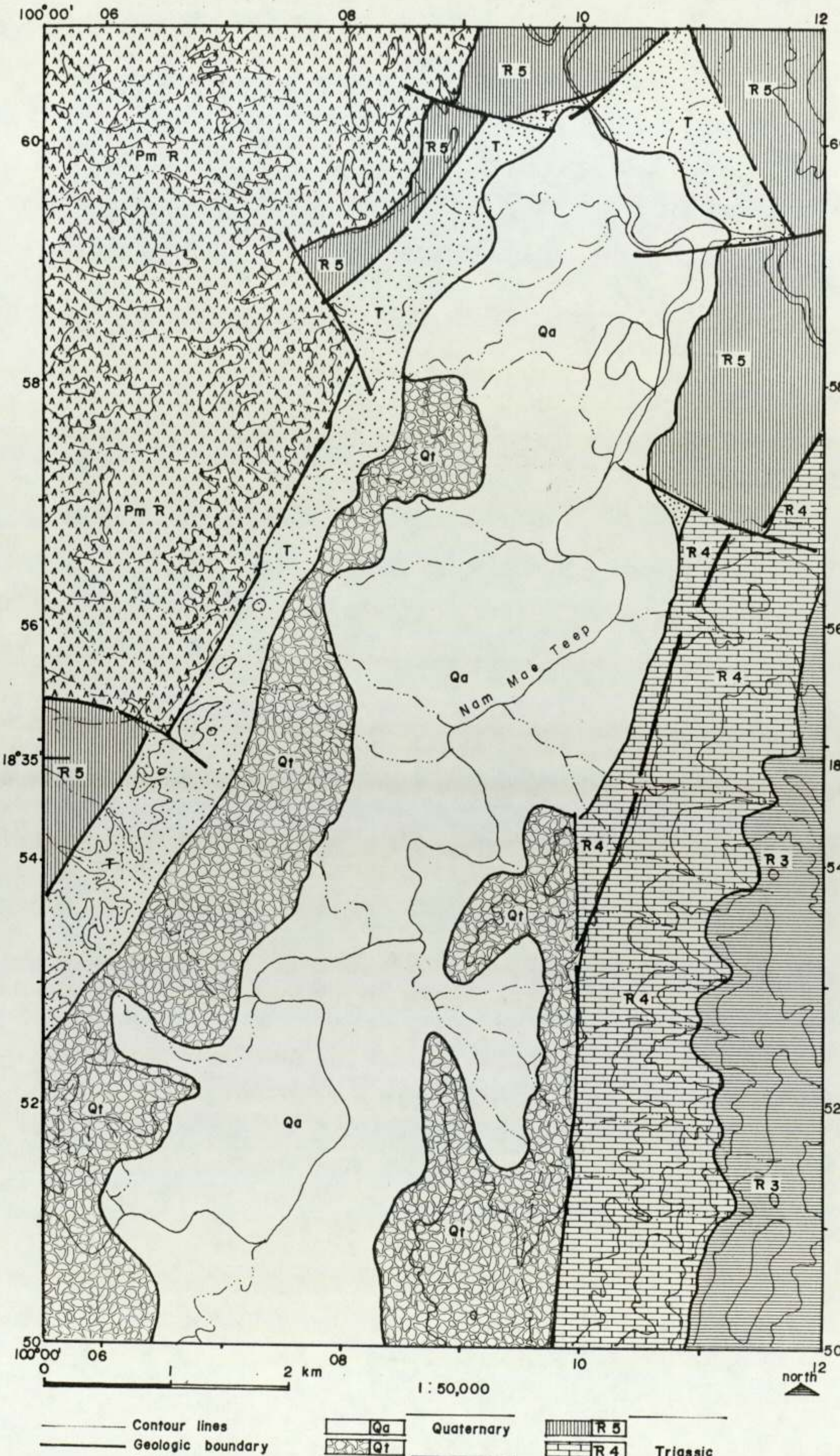
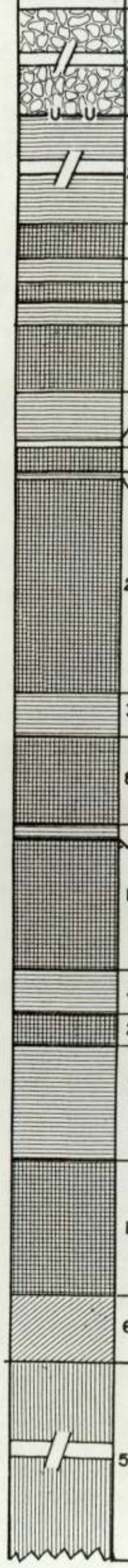


FIGURE 5 GEOLOGIC MAP OF MAE TEEP BASIN. (After Meesuk and Pithchayakul, 1982)

FIGURE 6 STRATIGRAPHIC SECTION OF MAE TEEP DEPOSIT.



STRATI-GRAPHIC COLUMN	THICKNESS (cm.)	DESCRIPTION	AGE
	200+	ALLUVIUM : gravel, sand, silt and clay	QUATER-NARY
		UNCONFORMITY	
	2200+	OIL SHALE : brownish gray to gray, with insect remains	TERTIARY
	33	COAL : dark brownish gray to black, earthy to resinous luster, subconcoidal fracture : sampling MTe 1	
	26	OIL SHALE : dark greenish gray to dull black, with fossil insect parts	
	18	COAL : as above : sampling MTe 2	
	21	OIL SHALE : as above	
	62	COAL : jet black, resinous luster, subconcoidal fracture : sampling MTe 3	
	46	COAL : as above with thin (2-3 cm.) oil shale partings : sampling MTe 4	
	6	MARLSTONE : light gray (fresh) to yellowish brown (weathered)	
	21	COAL : as MTe 3 : sampling MTe 5	
	7	OIL SHALE : as above	
	200	COAL : as MTe 4 : sampling MTe 6-9 at 50 cm. intervals	
	38	OIL SHALE (brownish gray) / CARBONACEOUS SHALE (gray)	
	82	COAL : as above : MTe 10	
	15	OIL SHALE : as above	
	120	COAL : jet black interbedded with brownish gray oil shale and ligneous clay : sampling MTe 11 – 13 at 60 cm. intervals	
	40	OIL SHALE : as above	
	28	COAL : as above : sampling MTe 13	
	110	OIL SHALE : as above with a 5 cm. coal parting	
	130	COAL : dark gray to jet black interbedded with gray oil shale and dusky gray ligneous clay : sampling MTe 14-15 at 65 cm. intervals	
	60	LIGNEOUS CLAY : dark gray to dusky black, poorly cemented	
	500+	UNDER CLAY : creamy white, dense	

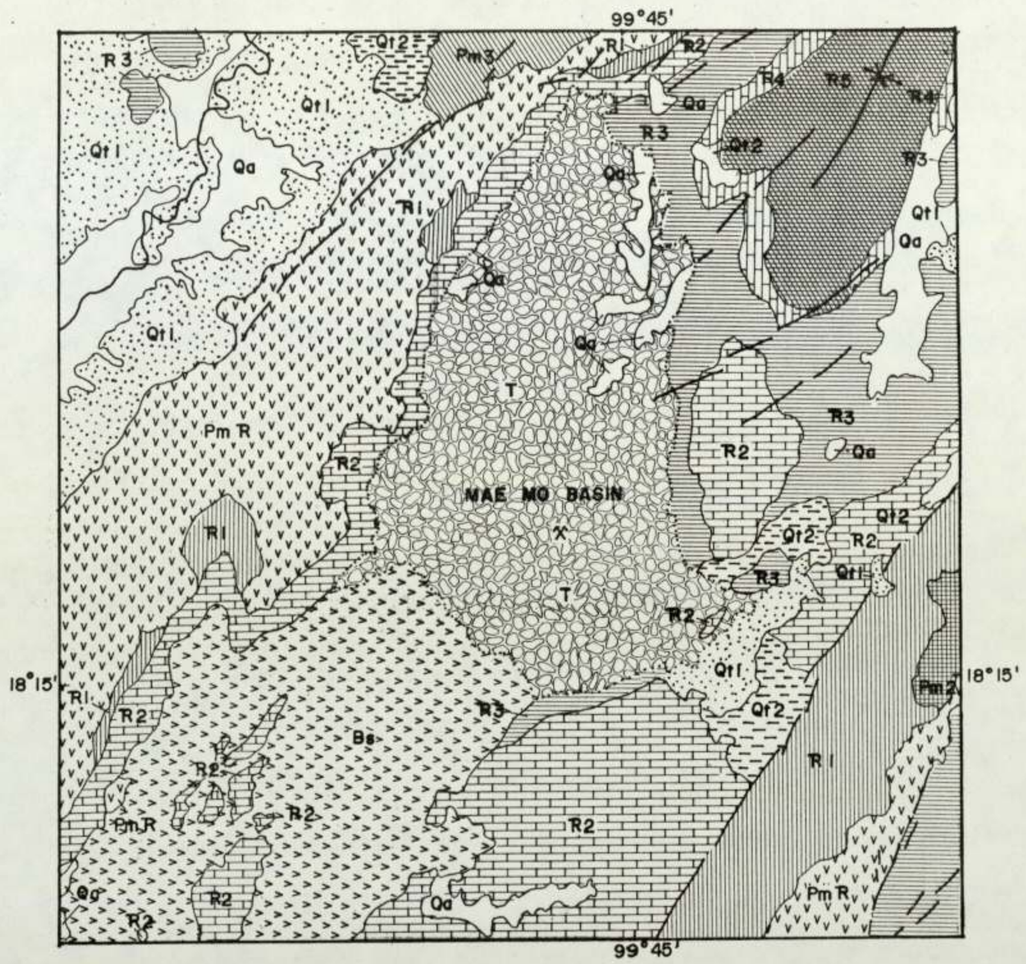


FIGURE 7 GEOLOGIC MAP OF MAE MO BASIN.
(From Piyasin, 1971)

Scale 1: 250,000
0 5 10
kilometers

north

- Geologic boundary
- Approximate basin boundary
- Fault
- Syncline
- Mining area

Qa.	Recent
Qt 1	Quaternary
Qt2	Quaternary
T	Tertiary
R 5	Triassic
R 4	Triassic
R 3	Triassic
R 2	Triassic
R 1	Triassic
Pm R	Permo-Triassic
Pm 3	Permian
Pm 2	Permian
BS	Quaternary basalt

FIGURE 8 STRATIGRAPHIC SECTION OF MAE MO DEPOSIT (After Supertipanish et al., 1983)

THICK-NESS (M.)	STRATIGRAPHIC COLUMN	DESCRIPTION	AGE
75		clay, sandy clay, clayey sand : brownish yellow to brownish red; stiff, high plasticity, slightly calcareous	TERTIARY
100		shale : brownish gray, laminated to bedded, moderately fissiled, highly calcareous, contains some thin conglomerate partings, with insect remains and coaly fragments	
40		coal seam: with some thin partings of lignitic shale and brown shale (K-seam)	
35		claystone : pale to grayish brown, slightly to highly calcareous with some insect remains	
30		coal seam : black, dully to shiny lustre, with some thin lignitic clay partings (Q-seam)	
3.5	total depth 283.65	fossiliferous claystone : brown to grayish brown, dense, consists mainly of gastropod remains	

FIGURE 9 STRATIGRAPHIC SECTION OF MAE MO DEPOSIT (K-SEAM)

STRATI-GRAPHIC COLUMN	THICKNESS (CM.)	DESCRIPTION	AGE
	200 +	OVERBURDEN : shale : light brown to light greenish gray, fine-grained, well-sorted, moderately cemented, at least 200 cm. thick	TERTIARY
	135	COAL : dusky brown to black, earthy luster, uneven to subconchoidal fracture, stiff (fresh) to brittle (weathered) : sampling MM 1-2 at 60 cm. intervals	
	15	SHALE/SANDSTONE : fossiliferous with minor lignitic layers	
	200	COAL : as above : sampling MM 3-6 at 50 cm. intervals	
	50	SANDSTONE/SHALE : as above	
	408	COAL : similar to the above with creamy white spots probably derived from weathed and eroded fossil remains (bivalves, gastropods, etc.) : sampling MM 7-11 at 80 cm. intervals	
	70	SANDSTONE : light yellowish brown to brown, medium- to coarse-grained, poor-sorted, moderately cemented, with thin black carbonaceous lens	
	75	COAL : as above : sampling MM 12	
	65	SANDSTONE : as above	
	240	COAL : as above : sampling MM 13-15 at 75 cm. intervals	
	40	SANDSTONE : as above with thin coal bands	
	190	COAL : as above : sampling MM 16-18 at 65 cm. intervals	
	214	COAL/SANDSTONE/SHALE : interbedded; coal, 3-10 cm., spotted, sandstone/shale, 5-15 cm., fossiliferous	
	305	COAL : as above, sampling MM 19-22 at 75 cm. intervals	
	120	COAL : dusky gray, spotted, interbedded with 3-5 cm. fossiliferous beds	
	90	COAL : as MM 1-6, sampling MM 23	
	188	COAL : spotted, interbedded with fossiliferous and white clayey beds, sampling MM 24	
	200	CLAYSTONE/SANDSTONE : dusky gray, spotted, interbedded with thin (3-5 cm.) coal beds, partly fossiliferous	
	105	COAL : as above, partly mottled, intercalated with sand lens (common) of about 150 cm. wide and 50 cm. thick, sampling MM 24	
	285	COAL : as MM 1-6, sampling MM 26-27	
	33	CLAYSTONE : gray to dark gray, ligneous, stiff	
	144	OIL SHALE : moderate greenish gray, with some thin coal partings	
	67 +	CLAYSTONE : creamy white, poor-cemented, more than 500 cm. thick	

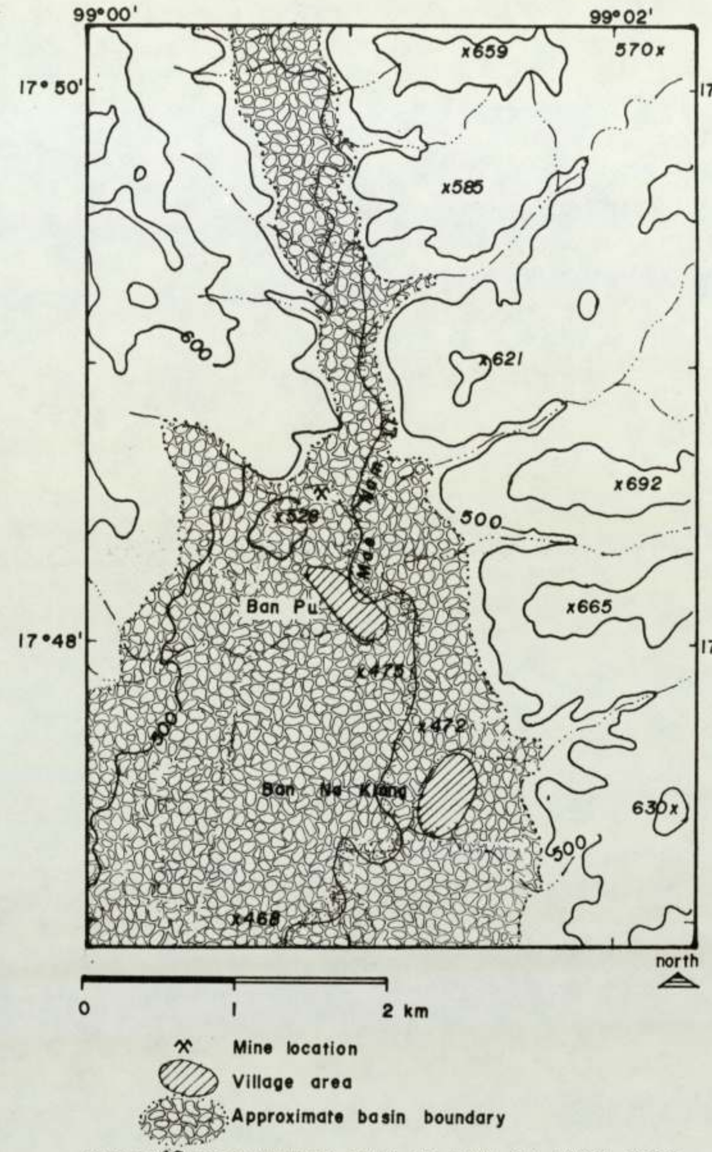


FIGURE 10 TOPOGRAPHIC MAP OF BAN PU BASIN FROM 1:50,000 MAP SHEET 4844 IV.

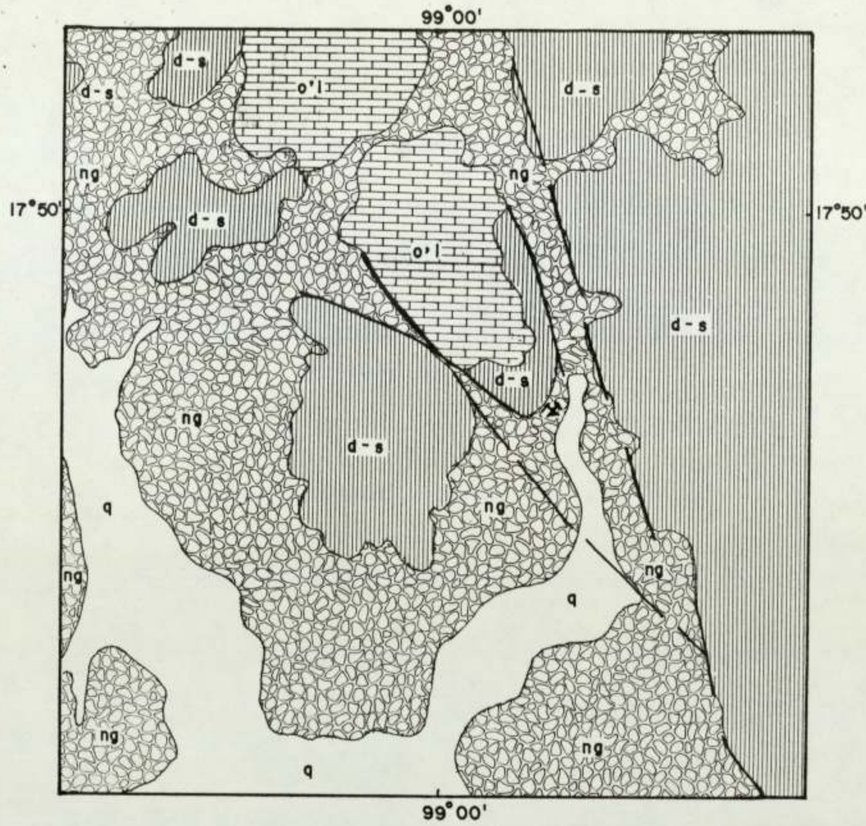


FIGURE 11 GEOLOGIC MAP OF LI (BAN PU) DEPOSIT.
(Modified after Braun *et al.*, 1981)

FIGURE 12 STRATIGRAPHIC SECTION OF LI (BAN PU) DEPOSIT.

STRATIGRAPHIC COLUMN	THICKNESS (CM.)	DESCRIPTION	AGE
	500 +	OVERBURDEN : at least 500 cm. thick, consists of gravel, sand, silt and clay, reddish brown on the top and creamy white near contact	QUATERNARY
		UNCONFORMITY	
	180	CLAY : creamy white, poor layer developed	TERTIARY
	732	COAL SEAM : consists of brown coal, peat, and ligneous clay interbedded COAL : dark tan to dusky gray, subconchoidal fracture, earthy luster, dull/bright bands are common : sampling LI 1-7 at 100 cm. intervals	
	78	CLAY : creamy white, contain numerous fossil plants remains (mainly leaves)	
	884	COAL : as above, sampling LI 8-16 at 100 cm. intervals	
	17	CLAY : light to whitish gray	
	32	COAL : as above, sampling LI 17	
	9	CLAY : gray with fossil plant remains	
	36	COAL : as above, sampling LI 18	
	103	CLAY : creamy white	
	372	COAL : as above, sampling LI 19–22 at 100 cm. intervals	
	34	CLAY : as above	
	48	COAL : as above, sampling LI 23	
	57	CLAY : as above	
	197	COAL : as above, sampling LI 24–25 at 100 cm. intervals	
	295	CLAY/SANDSTONE : white, fine- to medium-grained, moderately sorted and cemented, interbedded with 5-15 cm. coal beds	
	678	COAL : as above, sampling LI 26–32 at 100 cm. intervals	
	38	CLAY/SANDSTONE : as above	
	200 +	COAL : as above, sampling LI 33-34 at 100 cm. intervals, thickness up to 15 metres	

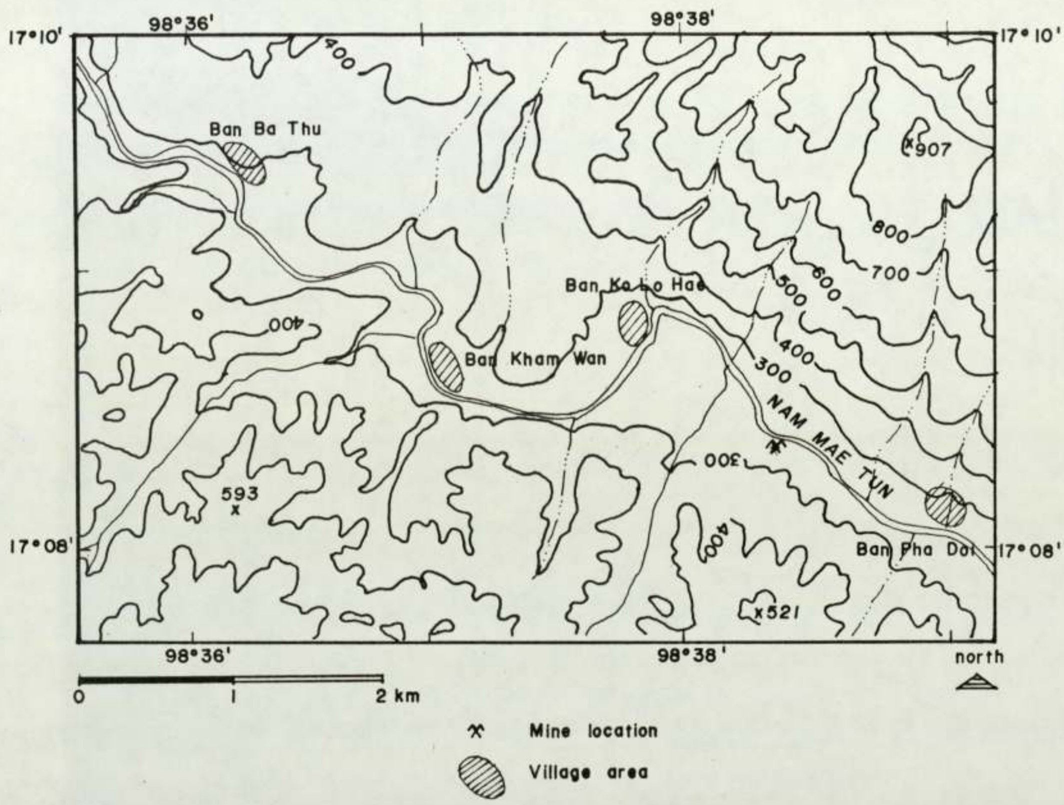


FIGURE 13 TOPOGRAPHIC MAP OF MAE TUN BASIN FROM 1:50,000 MAP SHEET 4747 III.

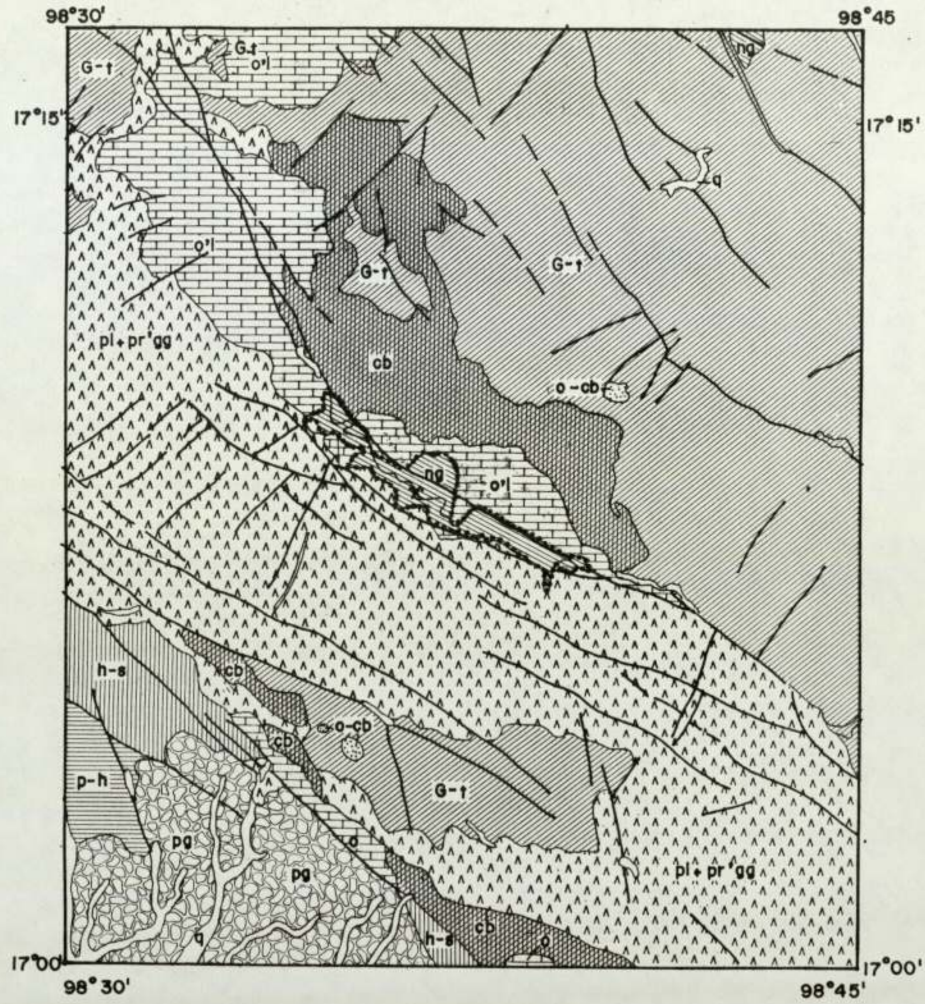


FIGURE 14 GEOLOGIC MAP OF MAE TUN BASIN.

(From Braun et al., 1981)

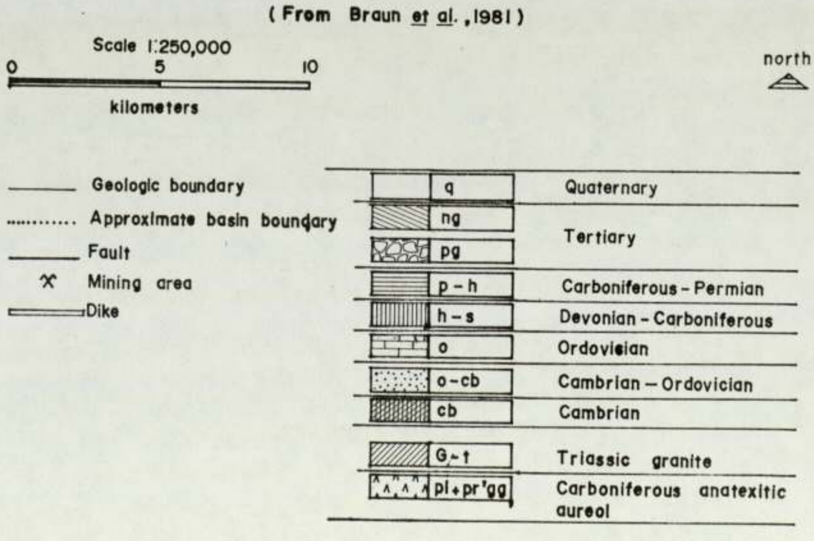


FIGURE 15 STRATIGRAPHIC SECTION OF MAE TUN DEPOSIT (After Supertipanish et al. 1983)

THICK-NESS(M.)	STRATIGRAPHIC COLUMN	DESCRIPTION	AGE
6		shale, mudstone; gray-dark gray, interbedded with light gray-white sandstone	TERTIARY
15-25		sandstone, feldspathic, light gray to white, fine-to coarse-grained	
18-30		shale, oil shale, coal ligneous clay; gray to dark gray to dusky brown, with some thin bedded sandstone	
25		sandstone, conglomeratic sandstone, conglomerate; greenish gray	
6		siltstone, shale, clay, coal (3 m.); gray to dark gray	
7.5		feldspathic sandstone; fine-to coarse-grained	
3		conglomerate, framework consists of quartz and quartzite, interbedded with thin bed of fine-to coarse-grained sandstone	
		UNCONFORMITY	
?		dark gray limestone	ORDOVICIAN

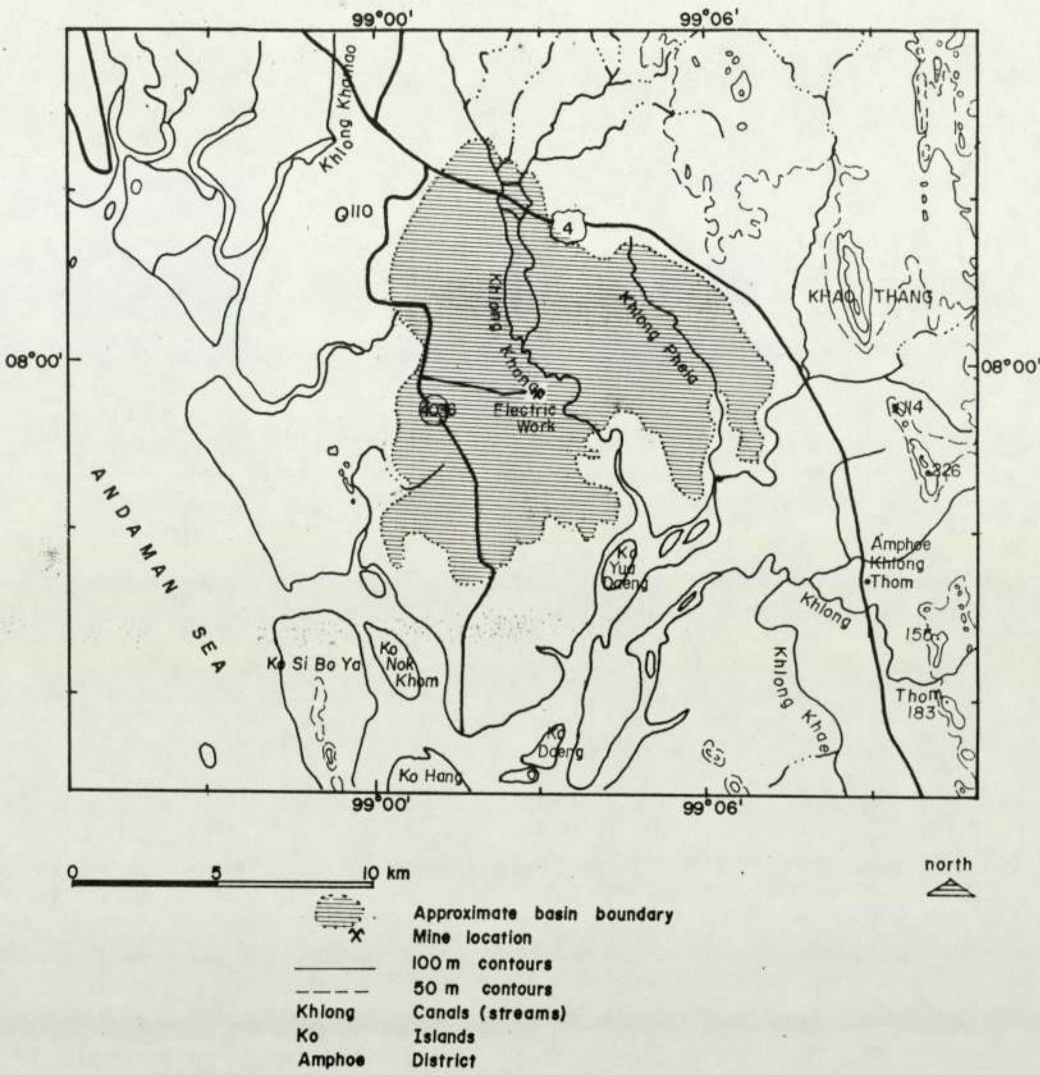


FIGURE 16 TOPOGRAPHIC MAP OF KRABI BASIN. (From 1:250,000 map sheets NB 47-2, NC 47-14, and NC 47-15)

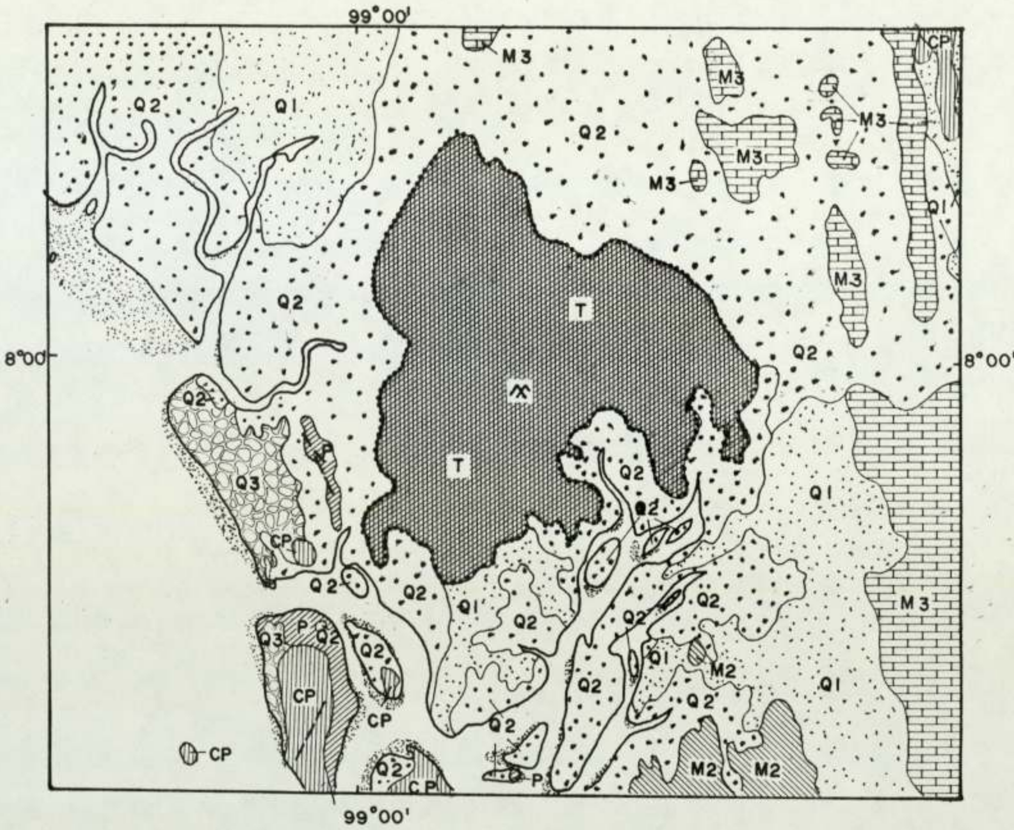


FIGURE 17 GEOLOGIC MAP OF KRABI BASIN.
(From 1:250,000 Geologic Map Sheets NB 47-2, NC 47-14, and NC 47-15 - Draft)

Scale 1:250,000
0 5 10
kilometers

north

Geologic boundary
Approximate basin boundary
Fault
Mining area

Q 3	Quaternary
Q 2	Quaternary
Q 1	Quaternary
T	Tertiary
M 3	Jurassic - Cretaceous
M 2	Jurassic - Cretaceous
P	Permian
CP	Carboniferous - Permian

FIGURE 18 STRATIGRAPHIC SECTION OF KRABI (BANG PU DAM) DEPOSIT.

STRATI-GRAPHIC COLUMN	THICK-NESS (CM.)	DESCRIPTION	AGE
	230	SHALE : gray to brownish gray, fossiliferous (Melanoids, Viviparus)	TERTIARY
	85	SHALE : brownish to greenish gray, partly fossiliferous (as above)	
	142	SHALE : dark gray, well-fissiled, poorly cemented, with thin coal partings	
	975	SHALE : brownish to greenish gray	
	30	COAL : dark tan to black, earthy to subresinous luster, subconchoidal fracture, stiff (fresh)	
	14	SANDY SHALE : fine- to medium-grained, poorly sorted, moderately cemented, reddish brown	
	18	COAL : as above	
	67	SHALE : as above (dark gray)	
	1105	SHALE : brownish to greenish gray	
	2500	COAL : dark tan to black, earthy to subresinous luster, subconchoidal fracture, with creamy white spots, sampling KB 1-15 at 50 cm. intervals from the top of the seam, also brownish gray sandy shale occurred as small lens to thin beds	
	500+	UNDERCLAY : creamy white to light gray, well-sorted, moderately cemented	

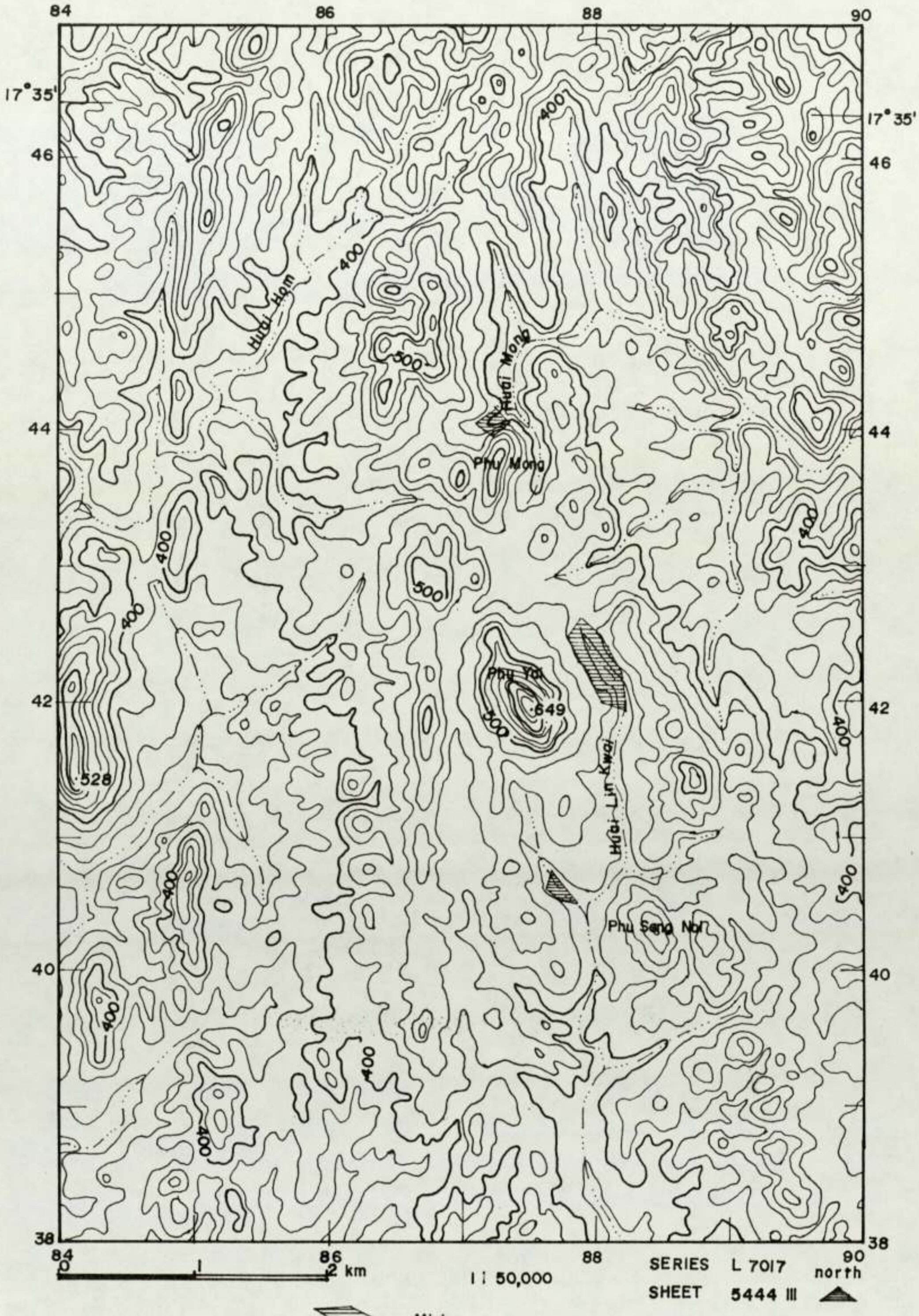


FIGURE 19 TOPOGRAPHIC MAP OF NA DUANG COAL DEPOSIT.

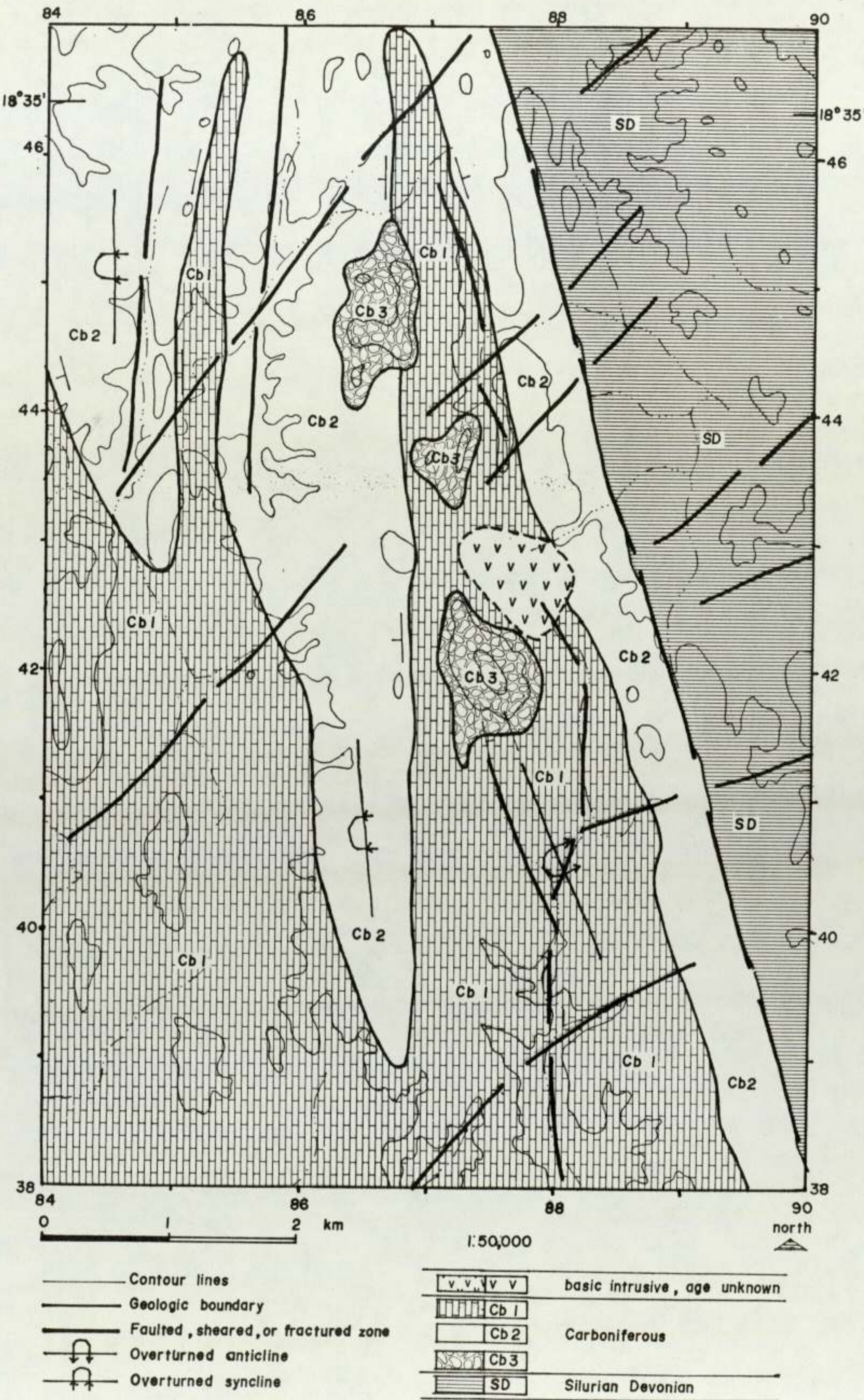


FIGURE 20 GEOLOGIC MAP OF NA DUANG COAL DEPOSIT. (After Ukkakimaphan and Meesuk, 1983)

FIGURE 21 SIMPLIFIED STRATIGRAPHIC SECTION OF NA DUANG DEPOSIT

STRATI-GRAPHIC COLUMN	THICK-NESS (CM.)	DESCRIPTION	AGE
	200 +	SANDSTONE : gray to light gray, well sorted, poorly cemented, with black carbonaceous shale occurred as intercalated thin layers	
	50	SANDSTONE : light to dark gray, laminated (0.1-0.5 cm. black carbonaceous sandstone/shale lamination), medium-grained, well sorted, moderately cemented	
	120	SANDSTONE : gray to dark gray, laminated (0.3 cm. lamination with 4 cm. dark gray sandstone partings), fine-grained, well sorted, moderately cemented	
	80	SHALE : greenish gray to gray, laminated	
	200	SHALE : dark gray to black, carbonaceous, highly sheared, with carbonaceous sandstone partings, sulfides are common	
	100	CONTACT (FAULT ?) BETWEEN ORES AND HOSTS	
	100	ND 1 : COAL : jet black, metallic luster, brittle, composed of small aggregated grains (ave. 0.3 cm. in diameter), even fracture along sheared planes, light weight	LOWER CARBONIFEROUS (?)
	100	ND 2 : COAL : similar to ND 1, with sulfide and white clay(?) minerals	
	100	ND 3 : COAL : similar to ND 2, with less minerals contents and heavier weight	
	100	ND 4 : COAL : similar to ND 2 & 3, with some rock fragments	
	150	ND 5 : COAL : similar to ND 1, with coarser aggregated grains	
	150	ND 6 : COAL : similar to ND 5, with white clay (?) minerals	
		FAULT?	
	400 +	SANDSTONE/SHALE : dark gray to black, carbonaceous	

APPENDIX C : PLATES

Plates 4-22 illustrate the photomicrographed of fossil spores and pollen grains together with the other plant microfossils found in this study. The photomicrographes were taken with a Zeiss Photomicroscope II, in bright field, using x 100 oil immersion objective and 35mm panchromatic film. All the specimens are figured at a magnification of x 1000 from unretouched negative. The location on microslide indicated by slide number followed by the co-ordinate reading from the built-in mechanical stage on Vickers Microscope (Inst. No.722715, Pat. No.877813). All preparations, strew residues, and original samples are deposited at the Department of Geological Sciences, University of Aston in Birmingham, Gosta Green, Birmingham B4 7ET, England.

PLATE 1

Fig. 1 Northwestwards view of the mine quarry at Mae Teep deposit.

Fig. 2 Southwestwards view of the mine quarry at Mae Mo deposit.

PLATE 2

Fig. 1 Northwestwards view of the mine quarry at Li (Ban Pu) deposit.

Fig. 2 Southeastwards view of the mine quarry at Mae Tun deposit.

PLATE 3

Fig. 1 Southeastwards view of the mine quarry at Krabi (Bang Pu Dam) deposit.

Fig. 2 Southeastwards view of the mine quarry at Na Duang deposit.

PLATE 4

Fig. 1 Designated M1a : Laevigatosporites haardti (Potonie') Thomson & Pflug, 1953
Slide MTe8, coordinate 124.0/59.5

Fig. 2 Designated M1b : Laevigatosporites adiscordatus Krutzsch, 1959
Slide MM3/1, coordinate 119.3/55.6

Figs. 3,4 Designated M2 : Microfoveolatosporis pseudodentatus Krutzsch, 1959
Slide MTe6/1, coordinate 118.4/58.0 (two different focus)

Fig. 5 Designated M3 : Punctatosporites sp.
Slide MM13/1, coordinate 119.4/54.0

Figs. 6,7 Designated M4 : Reticuloidosporites secondus (Potonie') Thomson & Pflug, 1953
Slide MM22/1, coordinate 121.5/56.5 (two different focus)

Figs. 8,9 Designated M5a : Verrucatosporites cf. megabalticus Krutzsch, 1967
Slide LI 9, coordinate 136.0/51.5 (two different focus)

Figs. 10,11 Designated M5b : Verrucatosporites inangahuensis (Couper) Krutzsch, 1959
Slide MM19, coordinate 129.8/42.4 (two different focus)

Figs. 12,13 Designated M5c : Verrucatosporites cf. V. favus (Potonie') Thomson & Pflug, 1953
Slide MM7/1, coordinate 122.7/26.5 (two different focus)

PLATE 5

Fig. 1 Designated M5d : Verrucatosporites usmensis (Van der Hammen) Germeraad et al., 1968
Slide MM1, coordinate 123.1/27.7

Fig. 2 Designated M5e : Verrucatosporites sp.
Slide MM9, coordinate 128.7/55.4

Fig. 3 Designated T1 : Todisporites cf. T. minor Couper, 1958
Slide MTe13/1, coordinate 122.2/35.8

Fig. 4 Designated T2a : Leiotriletes apheles (Hunger) Krutzsch, 1959
Slide MTe10, coordinate 129.8/60.6

Fig. 5 Designated T2b : Leiotriletes sp.
Slide MM10/1, coordinate 117.5/40.1

Fig. 6 Designated T3a : Laevigatisporites pseudomaximus Pflug & Thomson, 1953
Slide MM18/1, coordinate 135.9/43.6

Fig. 7 Designated T3b : Laevigatisporites sp.
Slide KB11, coordinate 124.0/53.7

Figs. 8,9 Designated T4 : Concavisporites (Obtusisporis) minimus Krutzsch, 1962
Slide MM27/1, coordinate 124.7/39.0 (two different focus)

Fig. 10 Designated T5a : Foveotriletes cf. crassifovearis Krutzsch 1962
Slide MTe 14, coordinate 129.6/51.9

Figs. 11,12 Designated T5b : Foveotriletes balteus Partridge, 1973

Slide MM19, coordinate 135.5/44.6 (two different focus)

Figs. 13,14 Designated T5c : <u>Foveotriletes</u> cf. <u>F. crassifovearis</u> subsp. <u>crassoides</u> Krutzsch, 1967
Slide MM16/1, coordinate 125.4/40.5 (two different focus)

Figs. 15-18 Designated T6a : <u>Osmundacidites</u> sp.A
Fig. 15 Slide MTe1, coordinate 118.2/60.9
Figs.16-18 Slide MTe13/1, coordinate 124.6/38.7 (three different focus)

Fig. 19 Designated T11a : Indeterminate (cf. <u>Trilites sinuatus</u> Couper, 1953 : Group A)
Slide MM1/1, coordinate 117.3/44.5

Figs. 20,21 Designated T11b : Indeterminate (cf. <u>Trilites sinuatus</u> Couper, 1953 : Group B)
Slide MM4a, coordinate 125.7/50.0 (two different focus)

Fig. 22 Designated T12 : Indeterminate (cf. <u>Cingulatisporites</u> <u>scabratus</u> Couper, 1958)
Slide MM1, coordinate 119.3/29.0

Fig. 23 Designated T13 : Indeterminate (cf. <u>Concavisporites</u> (<u>Appendicisporites</u>) <u>complicatus</u> Pflug, 1953

Slide MM18, coordinate 122.4/58.2

PLATE 6

Figs. 1-3 Designated T6b : <u>Osmundacidites</u> sp.B

Figs.1,2 Slide MTe7, coordinate 135.0/52.0 (two different focus)

Fig. 3 Slide MTe14, coordinate 136.9/53.0

Figs. 4-6 Designated T6c : <u>Osmundacidites</u> sp.C

Figs.4,5 Slide MTe8/1, coordinate 131.2/43.9 (two different focus)

Fig. 6 Slide MTe5, coordinate 123.6/36.4

Figs. 7-8 Designated T6d : <u>Osmundacidites</u> sp.D

Slide MTe15/2, coordinate 129.6/52.3 (two different focus)

Figs. 9-16 Designated T7 : <u>Polypodiaceoisporites brevisculptatus</u> Kedves, 1973

Figs.9-10 Slide MTe10, coordinate 130.0/ 47.0 (two different focus)

Fig. 11 Slide MTe5, coordinate 119.4/61.9 (distal pole)

Figs.12-14 Slide LI5, coordinate 128.8/61.9 (three different focus)

Figs.15-16 Slide MTe5, coordinate 132.0/36.6 (equatorial view)

PLATE 7

Fig. 1	Designated T14a : Indeterminate (cf. Corrugatisporites sp.) Slide MM25/1, coordinate 117.7/26.4
Figs. 2-3	Designated T14b : Indeterminate (cf. Corrugatisporites toratus Weyland & Greifeld, 1953) Slide MM25/1, coordinate 125.4/53.6 (two different focus)
Fig. 4	Designated T14c : Indeterminate (cf. Corrugatisporites arcuatus Weyland & Greifeld, 1953) Slide MM4C, coordinate 124.0/34.5
Fig. 5	Designated T14b : Indeterminate (cf. Corrugatisporites toratus Weyland & Greifeld, 1953) Slide MM22/1, coordinate 136.5/29.0
Fig. 6	Designated T15 : Indeterminate (cf. Cicatricosisporites sp.) Slide MTel, coordinate 120.3/39.2
Fig. 7	Designated T16 : Indeterminate (cf. Lycopodiumsporites gristhorpensis Couper, 1958) Slide MM14/1, coordinate 129.4/46.9

Fig. 8 Designated T17 : Indeterminate (cf. Echinatisporis sp.)
Slide MM2, coordinate 117.5/49.6

Figs. 9-10 Designated T8 : Magnastriatites grandiosus (Kedves & Sole' de Porta) Dueñas, 1980b
Slide MM6/1, coordinate 117.0/36.8 (two different focus)

Fig. 11 Designated T9 : Crassoretitriletes vanraadshooveni Germeraad, Hopping & Muller, 1968
Slide MTe13/1, coordinate 130.9/31.8

Figs. 12-14 Designated T10 : Indeterminate (cf. Undulatisporites takutuensis Van der Hammen & Burger, 1966)
Figs.12-13 Slide MTe14, coordinate 129.5/ 46.5 (two different focus, polar view)
Fig.14 Slide MTe14, coordinate 125.0/39.6 (Equatorial view).

PLATE 8

Figs. 1-11 Designated DS1 : Pityosporites cf. P. Labdacus (Potonie') Thomson & Pflug, 1953
Fig. 1 Slide MTe14, coordinate 130.3/60.9
Fig. 2 Slide MTu1/1, coordinate 121.3/56.7
Fig. 3 Slide MTu1/1, coordinate 118.0/50.9

Fig. 4 Slide MTu1/1, coordinate 123.2/29.0

Fig. 5 Slide KB3, coordinate 117.8/39.0

Fig. 6 Slide MM13/1, coordinate 119.5/54.0

Fig. 7 Slide MTe14, coordinate 123.1/58.4

Fig. 8 Slide MM6/1, coordinate 123.0/53.9

Fig. 9 Slide MTu1/1, coordinate 122.0/34.0

Fig.10 Slide MTe14/1, coordinate 130.9/54.0

Fig.11 Slide MTe4/1, coordinate 121.9/41.2

PLATE 9

Figs.1-3, 7-10 Designated DS2a : Indeterminate (cf. Podocarpidites biformis Rouse, 1959)

Figs.1 Slide MTu1/1, coordinate 127.2/55.7

Figs.2,3 Slide LI3, coordinate 122.5/48.6 (two different focus)

Figs.7,8 Slide MTu1/1, coordinate 137.1/51.0 (two different focus)

Figs.9,10 Slide MTu1/1, coordinate 134.2/53.3 (two different focus)

Figs.4-6 Designated DS2b : Indeterminate (cf. Podocarpidites ellipticus Cookson, 1947)

Fig.4 Slide LI3, coordinate 123.2/51.3

Fig.5 Slide MTe14/1, coordinate 126.7/47.9

Fig.6 Slide MM18/1, coordinate 133.7/37.9

Fig.11 Designated DS2c : Indeterminate (cf. Podocarpidites sp.)

Slide MM26/1, coordinate 119.0/47.3

Figs.12,13 Designated DS3 : Indeterminate (cf. Dycrydiumites sp.)

Fig.12 Slide LI3, coordinate 117.0/22.0

Fig.13 Slide MM2, coordinate 131.5/55.2

Fig.14 Designated DS4 : Indeterminate (cf. Disaccate pollen grain)

Slide MTul, coordinate 121.5/50.0

PLATE 10

Figs.1-3 Designated Zla : Zonalapollenites igniculus (Potonie') Thomson & Pflug, 1953

Fig.1 Slide MM18, coordinate 123.9/43.0

Fig.2 Slide LI9, coordinate 117.5/50.0

Fig.3 Slide LI3, coordinate 134.0/53.7

Figs.4-6 Designated Zlb : Zonalapoll. (Tsuga) viridifluminipites (Wodhouse) Thomson & Pflug, 1953.

Fig.4 Slide MTul/1, coordinate 130.0/30.0

Fig.5 Slide MTul/1, coordinate 131.0/53.9

Fig.6 Slide MTul/1, coordinate 123.5/56.3

PLATE 11

Figs.1-2 Designated MCl : Proxapertites operculatus

(Van der Hammen) Germeraad _et_ _al_., 1968
Fig.1 Slide LI3, coordinate 116.5/41.0
Fig.2 Slide MM13/1, coordinate 135.0/50.7

Figs.3-4 Designated SCP1 : _Myrtaceidites_ _parvus_ Cookson & Pike, 1954
Fig.3 Slide MTe11/2, coordinate 133.9/34.5
Fig.4 Slide MM6/1, coordinate 121.6/25.0

Figs.5,6 Designated SCP2 : _Cupanieidites_ _major_ Cookson & Pike, 1954
Slide MM7/1, coordinate 131.4/52.0

Figs.7-9 Designated I1 : _Inaperturopollenites_ sp.1 (cf. _Araucariacite_ _australis_)
Fig.7 Slide MM18/1, coordinate 120.9/55.0
Fig.8 Slide MM3/1, coordinate 130.5/48.7
Fig.9 Slide MM1, coordinate 127.6/58.3

Fig.10 Designated I2 : _Inaperturopollenites_ sp.2 (cf. Sequoia langsdorfii)
Slide MM1, coordinate 122.5/45.6

Fig.11 Designated I3 : ? _Inaperturopollenites_ sp.3
Slide KB1, coordinate 117.9/48.0

Fig.12 Designated I4a : _Inaperturopollenites_ _hiatus_ (Potonie') Thomson & Pflug, 1953 : Group A
Slide MTe14, coordinate 130.2/50.8

Fig.13 Designated I4b : Inaperturopollenites hiatus (Potonie') Thomson & pflug, 1953 : Group B
Slide LI11, coordinate 120.0/26.7

Fig.14 Designated I5 : Indeterminate (cf. Inaperturopoll. incertus fossulatus Thomson & Pflug, 1953
Slide LI15, coordinate 127.7/31.0

Figs.15,16 Designated I6 : Indeterminate (?)
Slide MM14, coordinate 128.4/47.0 (two different focus)

Fig.17 Designated I7 : Indeterminate (?)
Slide KB4, coordinate 128.0/54.0

Figs.18,19 Designated I8 : Indeterminate (cf. Typha-type)
Fig.18 Slide MTe14/1, coordinate 129.0/44.0
Fig.19 Slide MM14, coordinate 134.0/53.5

Figs.20,21 Designated I9 : Indeterminate (cf. Clavaniaperturites clavatus Van der Hammen & Wymstra, 1964
Slide MM12/1, coordinate 131.6/34.5 (two different focus)

Figs.22,23 Designated MC3 : Indeterminate (cf. Nupharipollis minor Krutzsch, 1970)
Slide MM18/1, coordinate 136.0/43.5 (two

different focus)

Figs.24-26 Designated MC4 : Indeterminate

Figs.24-25 Slide MM20/1, coordinate 123.0/45.0 (two different focus)

Fig. 26 Slide LI3, coordinate 127.8/49.5

Figs.27-30 Designated MC5 : Indeterminate

Figs.27-28 Slide KB4, coordinate 130.7/50.5 (two different focus)

Figs.29-30 Slide MM8/1, coordinate 124.0/59.3 (two different focus)

Figs.31,32 Designated MC6 : Indeterminate (cf. Ephedripites claricristatus (Shak.) Krutzsch, 1970)

Fig.31 Slide MM14/1, coordinate 128.6/38.7

Fig.32 Slide MM14/1, coordinate 134.2/55.7

Fig.33 Designated MP1b : Graminidites subtiliglobosus (Trevisan) Krutzsch, 1970 119.9/43.8

Figs.34,35 Designated MP1a : Graminidites gracilis Krutzsch, 1970

Fig.34 Slide MM2/1, coordinate 120.7/53.3

Fig.35 Slide MM3/1, coordinate 120.2/60.0

Fig.36 Designated MP2 : Indeterminate (cf. Graminidites sp.)
Slide MM2/1, coordinate 122.6/26.0

Figs.37,38 Designated MP3 : Indeterminate
Slide MTe 14/1, coordinate 124.0/57.2

Fig.39 Designated MP4 : Indeterminate (cf. Monoporites sp.)
Slide MM12/1, coordinate 136.9/56.2

PLATE 12

Figs.1,2 Designated DP1 : Diporites sp.
Fig.1 Slide KB11, coordinate 123.0/47.5
Fig.2 Slide KB11, coordinate 131.5/50.9

Fig.3 Designated TP11 : Indeterminate (cf. Retitriporites sp.)
Slide KB7, coordinate 131.0/36.2

Figs.4-7 Designated DP2 : Indeterminate (cf. Punctodiporites sp.)
Fig.4 Slide MTe14/1, coordinate 124.0/58.5
Fig.5 Slide MTe14/1, coordinate 128.7/42.8
Figs.6,7 Slide MTe14, coordinate 127.0/54.5
(two different focus)

Figs.8,9 Designated TP2 : Subtriporopoll. cf. S. annulatus nanus Pflug & Thomson, 1953

Fig.8 Slide MM8/1, coordinate 119.2/45.5

Fig.9 Slide KB8, coordinate 128.1/56.1

Figs.10,11 Designated TP3 : Triporopoll. cf. T. coryloides Pflug, 1953

Fig.10 Slide MM4/1, coordinate 128.0/36.6

Fig.11 Slide MM9, coordinate 134.0/50.5

Figs.12-15 Designated TP4 : Trivestibulopoll. betuloides Pflug, 1953

Fig.12 Slide MM16/1, coordinate 125.0/29.0

Fig.13 Slide MM9/1, coordinate 136.8/58.5

Fig.14 Slide LI20, coordinate 119.0/52.5

Fig.15 Slide MM7, coordinate 127.1/25.6

Figs.16,17 Designated TP12 : Indeterminate (cf. Trivestibulopoll. prominus Pflug, 1953)

Fig.16 Slide MTe14, coordinate 120.8/52.5

Fig.17 Slide MM12/1, coordinate 131.1/25.0

Figs.18,19 Designated TP1 : Subtriporopoll. simplex simplex (Pot. & Ven.) Pflug & Thomson, 1953

Fig.18 Slide KB4, coordinate 132.2/24.0

Fig.19 Slide MTe12/1, coordinate 120.2/59.0

Figs.20-24 Designated TP15 : Indeterminate (cf. Triporopollenites sp.)

Figs.20,21 Slide MM16/1, coordinate 130.5/53.3 (two different focus)

Figs.22-24 Slide MM2, coordinate 123.6/32.5 (three different focus)

Figs.25-27 Designated TP8 : Indeterminate (cf. Proteacidites sp.)

Fig. 25 Slide MM20/1, coordinate 118.0/49.0

Figs.26,27 Slide MM 5/1, coordinate 124.9/40.5 (two different focus)

Figs.28-31 Designated TP7 : Indeterminate (cf. Proteacidites sp.)

Figs.28-29 Slide MM14/1, coordinate 129.2/49.9 (two different focus)

Figs.30-31 Slide MM13/1, coordinate 123.2/38.9 (two different focus)

Fig.32 Designated TP9 : Indeterminate (cf. Proteacidites sp.)

Slide MM4a, coordinate 128.5/47.3

Figs.33,34 Designated TP10 : Indeterminate (cf. Retitriporites sp.)

Slide MTell/2, coordinate 118.5/53.5 (two different focus)

Figs.35,36 Designated TP5 : Striatriporites nigeriensis Hoeken-Klinkenburg, 1966

Slide MM7, coordinate 125.3/61.8 (two different focus)

Figs.37,38 Designated TP13 : Indeterminate (cf. Intratriporopoll. indubitablis (Pot.) Thomson & Pflug, 1953

Slide MTe14/1, coordinate 128.5/58.5 (two different focus)

Figs.39,40 Designated TP14 : Indeterminate (cf. Intratriporopoll. pilosus Pflug, 1953)

Slide MM18/1, coordinate 127.4/57.5 (two different focus)

Figs.41-43 Designated TP6 : Intratriporopoll. cf. I. rizophorus (Pot.) Thomson & Pflug, 1953

Fig.41 Slide MTe7, coordinate 130.5/44.2

Figs.42,43 Slide MM16, coordinate 129.0/37.8 (two different focus)

PLATE 13

Figs.1-3 Designated PP10 : Indeterminate (cf. Polyporopollenites sp.)

Slide MTe14/2, coordinate 120.8/56.9 (two different focus)

Figs.4-7 Designated PP1 : Periporopoll. cf. P. vesicus Partridge, 1973

Figs.4,5 Slide LI3, coordinate 132.5/45.5 (two different focus)

Figs.6,7 Slide LI3, coordinate 121.5/49.5 (two different focus)

Figs.8-10 Designated PP7 : Indeterminate (cf. Periporopollenites sp.)

Fig. 8 Slide LI20, coordinate 127.0/58.6

Fig. 9 Slide MM4, coordinate 133.2/54.3

Fig.10 Slide MM6, coordinate 127.1/40.9

Figs.11,12 Designated PP9 : Indeterminate (cf. Periporopoll. halifani Nakoman, 1967)

Slide MTe8/2, coordinate 124.9/46.8 (two different focus)

Figs.13-15 Designated PP8 : Indeterminate (cf. Periporopoll. microprolatus Nakoman, 1968)

Slide MM16/1, coordinate 120.2/47.4 (three different focus)

Fig.16 Designated PP11 : Indeterminate (cf. Polyporopollenites sp.)

Slide MM7/1, coordinate 126.0/42.0

Figs.17-23 Designated PP6 : Indeterminate (cf. Miocenipollis sp.)

Figs.17,18 Slide MM26/1, coordinate 133.5/41.6 (two different focus)

Fig. 19 Slide KB13, coordinate 123.2/31.0

Fig. 20 Slide MM20/1, coordinate 127.0/45.7

Fig. 21 Slide MM17/1, coordinate 131.4/40.3

Fig. 22 Slide MTe15/1, coordinate 131.0/45.7

Fig. 23 Slide MTe14, coordinate 118.0/56.9

Figs.24-29 Designated PP5 : Indeterminate (cf. Miocenipollis sp.)

Figs.24-26 Slide MM12, coordinate 129.0/29.7 (three different focus)

Fig. 27 Slide MTe14, coordinate 133.0/36.6

Fig. 28 Slide MTe14, coordinate 121.5/36.6

Fig. 29 Slide LI10, coordinate 131.6/58.3

Figs.30-32 Designated PP12 : Indeterminate (cf. Polyporopollenites sp.)

Fig.30 Slide MM4, coordinate 135.3/58.7

Fig.31 Slide MM2, coordinate 128.2/54.8

Fig.32 Slide MM20/1, coordinate 132.6/40.4

Figs.33, 34,38 Designated PP3 : Polyporopoll. carpinoides Pflug, 1953

Fig.33 Slide MTe14, coordinate 121.0/34.5

Fig.34 Slide LI3, coordinate 127.6/46.5

Fig.38 Slide LI20, coordinate 130.0/29.5

Figs.35-37 Designated PP2 : Polyvestibulopoll. (Alnipoll) verus (Pot.) Thomson & Pflug, 1953

Fig.35 Slide MTe9/1, coordinate 135.4/41.6

Fig.36 Slide LI3, coordinate 136.8/56.6

Fig.37 Slide LI9, coordinate 133.0/33.8

Fig.39 Designated PP13 : Indeterminate (cf. Polyporopoll. undulosus (Wolff) Thomson & Pflug, 1953)

Slide MTe5/2, coordinate 125.7/44.5

PLATE 14

Fig.1 Designated MC2a : Ovoidites elongatus (Hunger) subsp. elongatus Krutzsch, 1959

Slide MM14/1, coordinate 120.5/51.5

Fig.2 Designated MC2b : Ovoidites microligneolus Krutzsch, 1959

Slide MM27/1, coordinate 118.5/46.5

Figs.3,4 Designated TC3 : Indeterminate (cf. Retitricolpites sp.)

Slide MM10, coordinate 131.5/62.6

Figs.5-10 Designated TC1 : Discoidites borneensis Muller, 1968

Fig.5 Slide MM6, coordinate 134.6/55.6

Fig.6 Slide MM4, coordinate 123.5/54.0

Figs.7-10 Slide MM4/1, coordinate 126.0/58.6 (two different focus)

Fig.12 Designated TC4 : Indeterminate (cf. <u>Tricolpites</u> <u>confessus</u> Stover, 1973)
Slide MM7/1, coordinate 128.0/39.5

Fig.13 Designated TC5 : Indeterminate (cf. <u>Tricolpites</u> <u>gillii</u> Cookson, 1957)
Slide MM4a, coordinate 131.1/35.0

Fig.14 Designated TC6 : Indeterminate (cf. <u>Tricolpites</u> <u>fissillis</u> Couper, 1960)
Slide MTe11/2, coordinate 136.4/45.3

Figs.15-19 Designated TC2 : Indeterminate (cf. <u>Discoidites</u> <u>novaguineensis</u> Khan, 1976)
Figs.15-16 Slide KB8, coordinate 128.1/56.1 (two different focus)
Figs.17-19 Slide MM5/1, coordinate 118.7/45.6 (three different focus)

Figs.20,21 Designated TCP1a : <u>Tricolporopoll</u>. <u>cingulum</u> <u>oviformis</u> (Potonie') Thomson & Pflug, 1953
Fig.20 Slide MM3, coordinate 131.4/34.0
Fig.21 Slide MTe9/1, coordinate 135.5/31.0

Figs.22-24 29-31 Designated TCP1c : <u>Tricolporopoll</u>. <u>cingulum</u> fusus (Potonie') Thomson & Pflug, 1953
Fig. 22 Slide KB1, coordinate 135.5/25.8
Figs.23-24 Slide MTe, coordinate 135.4/45.0
(two different focus)

Fig. 29 Slide MTel2/1, coordinate 134.0/62.8

Figs.30-31 Slide MM18/1, coordinate 125.6/52.8 (two different focus)

Figs.25-28 Designated TCP1b : Tricolporopoll. cingulum pusillus (Potonie') Thomson & Pflug, 1953

Figs.25-26 Slide MM12/1, coordinate 118.0/37.5 (two different focus)

Figs.27-28 Slide MM20/1, coordinate 134.6/45.7 (two different focus)

Fig.32 Designated TCP14 : Indeterminate (cf. Psilatricolporites transversalis Duenas, 1980a)

Slide KB5, coordinate 129.5/45.0

Figs.33-34 Designated TCP2 : Tricolporopoll. cf. T. pacatus Pflug, 1953

Slide KB10, coordinate 118.0/42.2 (two different focus)

Figs.35-38 Designated TCP15 : Indeterminate (cf. Pollenites pseudocruciatus Potonie', 1931)

Fig.35 Slide MM 9/1, coordinate 118.5/51.5

Fig.36 Slide MM20/1, coordinate 120.5/51.0

Fig.37 Slide MM14/1, coordinate 122.0/38.7

Fig.38 Slide MM15/1, coordinate 131.5/24.6

Figs.39-40 Designated TCP16 : Indeterminate (cf. Nyssa-type)

Fig.39 Slide MM6/1, coordinate 126.0/58.9

Fig.40 Slide MTe1/2, coordinate 119.2/30.7

PLATE 15

Figs.1,2 Designated TCP18 : Indeterminate (cf. Tricolporopoll. eschweilerensis Pflug & Thomson 1953)

Slide MM24/1, coordinate 136.0/34.0 (two different focus)

Figs.3,4 Designated TCP2 : Tricolporopoll. cf. T. pacatus Pflug, 1953

Fig.3 Slide MM8/1, coordinate 121.8/54.6

Fig.4 Slide MTe14, coordinate 127.9/55.0

Figs.5-12 Designated TCP4 : Tricolporopoll. euphorii (Potonie') Thomson & Pflug, 1953

Fig.5 Slide MTe15, coordinate 123.3/45.2

Figs.6-8 Slide MM23, coordinate 121.2/57.8 (three different focus)

Figs.9-12 Slide MM4, coordinate 123.3/30.0 (four different focus)

Figs.13-14 Designated TCP19 : Indeterminate (cf. Retitricolporites sp.)

Slide MM10/1, coordinate 131.1/56.6 (two different focus)

Figs.15-17 Designated TCP3 : Tricolporopoll. cf. T. rhomboidaliformis McIntyre, 1968

Slide MM5/1, coordinate 119.4/48.8

Figs.18-19 Designated TCP6 : Retitricolporites annulatus Salard-Cheboldaeff, 1978

Slide KB1, cooordinate 118.0/53.3 (two different focus)

Figs.20-25 Designated TCP7 : Rhoipites cf. R. isoreticulatus Kemp, 1977

Figs.20-23 Slide MM7/1, coordinate 126.4/33.9 (three different focus)

Figs.23-25 Slide MM13/1, coordinate 128.5/59.5 (three different focus)

Figs.36-30 Designated TCP8 : Rhoipites sp.

Figs.26-28 Slide MTe15, coordinate 124.6/44.6 (three different focus)

Figs.29-30 Slide MTe14, coordinate 118.4/51.0 (two different focus)

Figs.31,32 Designated TCP22 : Indeterminate (cf. Retitricolporites sp.)

Slide MM11/1, coordinate 133.4/30.5 (two different focus)

Figs.33,34 Designated TCP23 : Indeterminate (cf. Tricolporopoll. sustamanni Pflug & Thomson, 1953)

Slide MM18/1, coordinate 117.5/28.8 (two different focus)

Figs.35,36 Designated TCP21 : Indeterminate (cf. Retitricolporites sp.)

Slide KB14, coordinate 125.0/43.5 (two different focus)

PLATE 16

Figs.1-12 Designated TCP5 : Tricolporopollenites margaritatus (Potonie') Thomson & Pflug, 1953

Figs.1-2 Slide LI8, coordinate 127.7/48.9 (two different focus)

Figs.3-5 Slide MTe7, coordinate 137.8/46.4 (three different focus)

Figs.6-8 Slide MM15/1, coordinate 135.9/55.9 (three different focus)

Figs.9-12 Slide KB4, coordinate 134.9/53.6 (four different focus)

Figs.13-18 Designated TCP24 : Indeterminate (cf. Polygalaceae-type)

Figs.13-15 Slide MM7/1, coordinate 127.9/30.8 (three different focus)

Figs.16-18 Slide MTe15/2, coordinate 135.4/57.6 (three different focus)

Figs.19-22 Designated TCP25 : Indeterminate (cf. Leguminosae-type)
Slide MTe14, coordinate 132.3/58.0 (four different focus)

Figs.23-27 Designated TCP26 : Indeterminate (cf. Striatricolporites minor Muller, 1968)
Figs.23-24 Slide MM11/1, coordinate 127.5/56.5 (two different focus)
Figs.25-27 Slide MM7/1, coordinate 133.6/54.5 (three different focus)

Figs.28-30 Designated TCP27 : Indeterminate (cf. Tricolporites paenestriatus Stov.& Part., 1973)
Slide MM26/1, coordinate 134.6/23.0 (three different focus)

Figs.31-34 Designated TCP29 : Indeterminate (cf. Striatricolporites sp.)
Figs.31-32 Slide MM15/1, coordinate 136.0/47.4 (two different focus)
Figs.33-34 Slide MM20/1, coordinate 131.5/49.5 (two different focus)

Figs.35-36 Designated TCP12 : Palaeocaesalpiniaceaepites sp.
Slide LI6, coordinate 117.6/27.5 (two different focus)

Figs.37,38 Designated PCP1a : Psilastephanocolporites sp.A

Fig.37 Slide MM2/1, coordinate 135.2/52.4

Fig.38 Slide MM17/1, coordinate 118.8/52.4

Figs.39-42 Designated PCP1b : Psilastephanocolporites sp.B

Fig.39 Slide MM17/1, coordinate 129.6/25.6

Fig.40 Slide KB10, coordinate 132.5/36.0

Fig.41 Slide KB5, coordinate 131.9/28.6

Fig.42 Slide MTe5, coordinate 133.3/45.7

PLATE 17

Figs.1-3 Designated TCP30 : Indeterminate (cf. Cyrilla racemifora-type)

Fig.1 Slide MTe14, coordinate 130.3/50.4

Fig.2 Slide MTe10, coordinate 128.0/47.6

Fig.3 Slide LI3, coordinate 127.9.56.8

Figs.4-5 Designated TCP31 : Indeterminate (cf. Capparaceae-type)

Slide MM20/1, coordinate 137.0/44.2 (two different focus)

Figs.6-15 Designated TCP32 : Indeterminate (cf. Psilatricolporites operculatus Van der Hammen & Wymstra, 1964)

Figs.6,7 Slide MM14/1, coordinate 128.0/23.8

(two different focus)

Fig. 8 Slide MM7/1, coordinate 132.5/45.6

Fig. 9 Slide MM8, coordinate 135.0/48.7

Fig. 10 Slide MTel4, coordinate 126.5/55.5

Figs.11-12 Slide MM17/1, coordinate 132.0/28.5

(two different focus)

Fig. 13 Slide MM18/1, coordinate 128.0/57.5

Fig. 14 Slide MM20/1, coordinate 126.2/34.0

Fig. 15 Slide MM18/1, coordinate 123.9/32.0

Figs.16-19 Designated TCP17 : Indeterminate (cf. Nyssa-type)

Fig.16 Slide MM14/1, coordinate 136.1/25.3

Fig.17 Slide MM16/1, coordinate 121.3/55.5

Fig.18 Slide MTel4, coordinate 120.5/49.0

Fig.19 Slide MM27/1, coordinate 131.1/26.0

Figs.20-23 Designated TCP33 : Indeterminate (cf. Psilatricolporite sp.)

Figs.20,21 Slide MM7/1, coordinate 124.0/27.0

(two different focus)

Figs.22,23 Slide MM10/1, coordinate 123.5/35.3

(two different focus)

Figs.24-27 Designated TCP20 : Indeterminate (cf. Retitricolporites sp.)

Figs.24,25 Slide MTel4, coordinate 117.5/39.3

(two different focus)

Figs.26,27 Slide MTel4, coordinate 131.5/42.5

(two different focus)

Figs.28-32 Designated TCP6 : Retitricolporites annulatus Salard-Cheboldaeff, 1978

Fig. 28 Slide MM20/1, coordinate 130.0/48.5

Figs.29,30 Slide MTe14/1, coordinate 129.0/59.5 (two different focus)

Figs.31,32 Slide MTe10/1, coordinate 132.6/51.8 (two different focus)

Figs.33-36 Designated TCP34 : (cf. Retitricolporites sp.)

Figs.33,34 Slide MM8/1, coordinate 134.0/32.8 (two different focus)

Figs.35,36 Slide MM26/1, coordinate 123.0/45.0 (two different focus)

Figs.37-38 Designated TCP35 : Indeterminate (cf. Retitricolporites sp.)

Slide MM22/1, coordinate 130.1/26.8 (two different focus)

Figs.39,40 Designated TCP23 : Indeterminate (cf. Tricolporopoll. sustamanni Pflug & Thomson, 1953)

Slide MM8/1, coordinate 131.6/30.1 (two different focus)

Figs.41,42 Designated TCP36 : Indeterminate (cf. Retitricolporites sp.)

Slide MM19/1, coordinate 125.4/29.6 (two different focus)

Figs.43,44 Designated TCP37 : Indeterminate (cf. Retitricolporites sp.)
Slide MM18, coordinate 135.5/50.8 (two different focus)

Figs.45,46 Designated TCP22 : Indeterminate (cf. Retitricolporites sp.)
Slide MM8, coordinate 118.6/36.4 (two different focus)

PLATE 18

Figs.1-3 Designated TCP10 : Margocolporites sp.
Slide MTe10/1, coordinate 120.5/48.5 (three different focus)

Figs.4-6 Designated TCP9 : Margocolporites vanwijhei Germeraad et al., 1968
Figs.4,5 Slide MTe14/1, coordinate 128.4/42.9 (two different focus)
Fig. 6 Slide MTe14, coordinate 131.8/50.5

Figs.7,8 Designated TCP38 : Indeterminate (cf. Retitricolporites sp.)
Slide MM27/1, coordinate 120.5/42.8 (two different focus)

Figs.9-12 Designated TCP39 : Indeterminate (cf. Retitricolporites sp.)

Slide MTe11/2, coordinate 126.4/48.8 (four different focus)

Figs.13-18 Designated TCP5 : Tricolporopoll. margaritatus (Potonie') Thomson & Pflug, 1953

Figs.13-15 Slide MTe15/2, coordinate 129.0/55.9 (three different focus)

Figs.16-17 Slide MTe14, coordinate 130.0/46.5 (two different focus)

Fig. 18 Slide MTe12/1, coordinate 123.7/27.4

Figs.19-20 Designated TCP12 : Palaeocaesalpiniaceaepites sp.

Slide LI21, coordinate 118.1/26.2 (two different focus)

Figs.21-26 Designated TCP28 : Indeterminate (cf. Striatricolporites sp.)

Figs.21-23 Slide MM7/1, coordinate 133.3/49.9 (three different focus)

Figs.24-26 Slide MM7/1, coordinate 130.0/26.0 (three different focus)

Fig.27 Designated PCP1a : Psilastephanocolporites sp.A

Slide MM4/1, coordinate 132.7/23.8

Figs.28-32 Designated PCP1b : Psilastephanocolporites sp.B

Fig.28 Slide MTe5, coordinate 132.8/44.6

Fig.29 Slide KB12, coordinate 136.0/53.9

Fig.30 Slide MTe5, coordinate 132.8/33.3

Fig.31 Slide KB5, coordinate 118.9/31.6

Fig.32 Slide KB13, coordinate 128.5/45.0

Figs.33-36 Designated TCP11 : Bombacacidites cf. B. annae (Van der Hammen) Germeraad et al., 1968

Slide MTe9/2, coordinate 125.9/56.2 (four different focus)

PLATE 19

Figs.1-6 Designated TCP13 : Lanagispollis cf. L. microrugulatus Morley, 1982

Figs.1-3 Slide MTe5/1, coordinate 128.4/53.0 (three different focus)

Figs.4-6 Slide MTe15/1, coordinate 126.9/56.5 (three different focus)

Figs.7-9 Designated TCP40 : Indeterminate (cf. Foveotricolporites sp.)

Slide MTe14, coordinate 136.0/53.9 (three different focus)

Figs.10-12 Designated TC8 : Indeterminate (cf. Perfortricolpites digitatus Gonzalez, 1967)

Slide MM14/1, coordinate 118.9/59.0 (three different focus)

PLATE 20

Figs.1-5 Designated TC7 : Indeterminate (cf. Lonicerapollis gallwitzii Krutzsch, 1962)
Figs.1,2 Slide LI8, coordinate 123.0/52.6 (two different focus)
Fig. 3 Slide LI15, coordinate 123.8/24.5
Figs.4,5 Slide MTe15/2, coordinate 123.7/55.5 (two different focus)

Figs.6,7 Designated U1 : Indeterminate (?)
Slide MM4, coordinate 118.5/50.9 (two different focus)

Fig.8 Desginated TCP41 : Indeterminate (cf. Psilatricolporites sp.)
Slide KB7, coordinate 117.6/28.0

Fig.9 Designated TCP42 : Indeterminate (cf. Psilatricolporites sp.)
Slide MM4/1, coordinate 126.2/53.8

Figs.10-17 Designated PP4 : Persicariopollis meuseli Krutzsch, 1962
Figs.10-13 Slide MM12, coordinate 132.5/58.2 (four different focus)

Figs.14-17 Slide MM15/1, coordinate 117.0/45.9 (four different focus)

Figs.18-20 Designated U2 : Indeterminate (cf. Fenestrites sp.)
Slide MM20/1, coordinate 130.5/38.3 (three different focus)

PLATE 21

Fig.1 Designated PR1 : Indeterminate (Plant remains probably walls of the tracheids)
Slide LI11, coordinate 128.0/36.5

Fig.2 Designated PR2 : Indeterminate (Plant remains probably walls of the tracheids)
Slide LI11, coordinate 123.5/38.8

Fig.3 Designated PR3 : Indeterminate (Plate remains probably woody fragments)
Slide LI11, coordinate 124.4/39.0

Fig.4 Designated FRI : Indeterminate (Fungal remains cf. type 324 Van Geel et al., 1981)
Slide MTe12, coordinate 121.2/55.3

Fig.5 Designated FR2 : Indeterminate (Fungal remains cf. type 359 Van Geel et al., 1981)
Slide MTe5, coordinate 136.5/40.8

Fig.6 Designated FR3 : Indeterminate (Fungal remains cf. type 85 Van Geel, 1977)
Slide MTel4, coordinate 127.5/36.5

Figs.7,8 Designated FR4 : Indeterminate (Fungal remains cf. type 351 Van Geel *et al*., 1981)
Fig.7 Slide MTel5, coordinate 135.7/45.5
Fig.8 Slide MTel5, coordinate 137.5/50.5

Figs.9,10 Designated FR5a : Indeterminate (Fungal remains cf. type 89 Van Geel, 1977)
Slide MM23/1, coordinate 118.3/55.0 (two different scales, Fig.10 = x 1000)

Fig.11 Designated FR6 : Indeterminate (Fungal remains cf. type 13 Van Geel, 1977)
Slide MTe5, coordinate 135.0/50.7

Fig.12 Designated FR7a : Indeterminate (Fungal remains cf. type 8B Van Geel, 1977)
Slide MTe5, coordinate 131.5/62.0

Fig.13 Designated FR8 : Indeterminate (cf. *Fusiformis crabbii* Rouse, 1962)
Slide MTel2, coordinate 125.3/54.5

Fig.14 Designated PM : Indeterminate (cf. spores of *Bryophyta* sp.)
Slide MTel4, coordinate 127.3/36.5

PLATE 22

Fig.1 Designated FR7b : Indeterminate (? Fungal fruit-bodies)
Slide MM12, coordinate 126.8/28.8

Fig.2 Designated FR5b : Indeterminate (? Fungal conidium)
Slide MTe5, coordinate 130.0/38.2

Fig.3 Designated D : Densosporites annulatus (Loose) Smith & Butterworth, 1967
Slide ND4/1, coordinate 129.9/36.0

Fig.4 Designated G : Indeterminate (cf. Granulatisporites sp.)
Slide ND4/2, coordinate 128.1/38.5

Fig.5 Designated AP : Indeterminate (cf. Apiculatisporis sp.)
Slide ND4/1, coordinate 118.0/52.6

Figs.6,7 Designated L : Lycospora pellucida (Wicher) Schopf, Wilson & Bentall, 1944
Fig.6 Slide ND4, coordinate 136.0/51.5 (polar view)
Fig.7 Slide ND4, coordinate 128.3/58.8 (equatorial view)

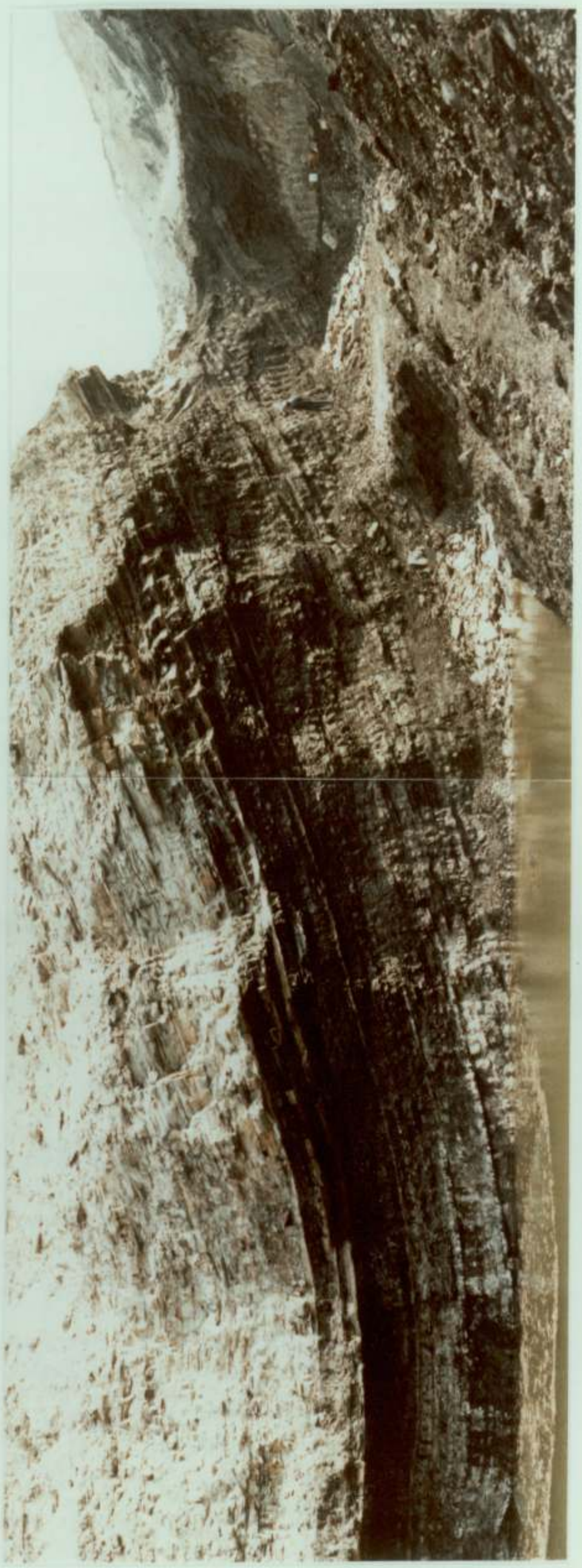


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Figure 2

PLATE 2

Figure 1

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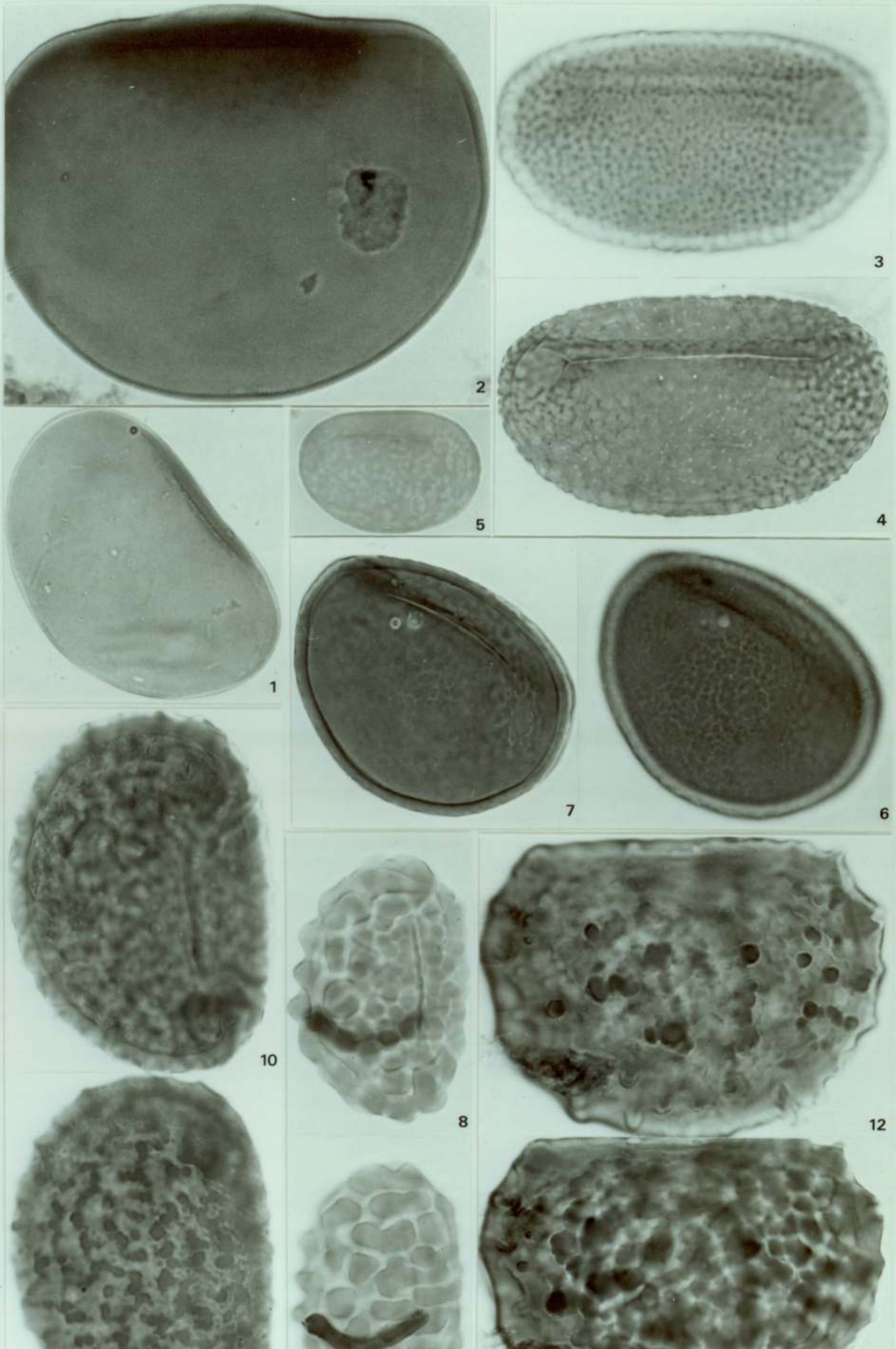
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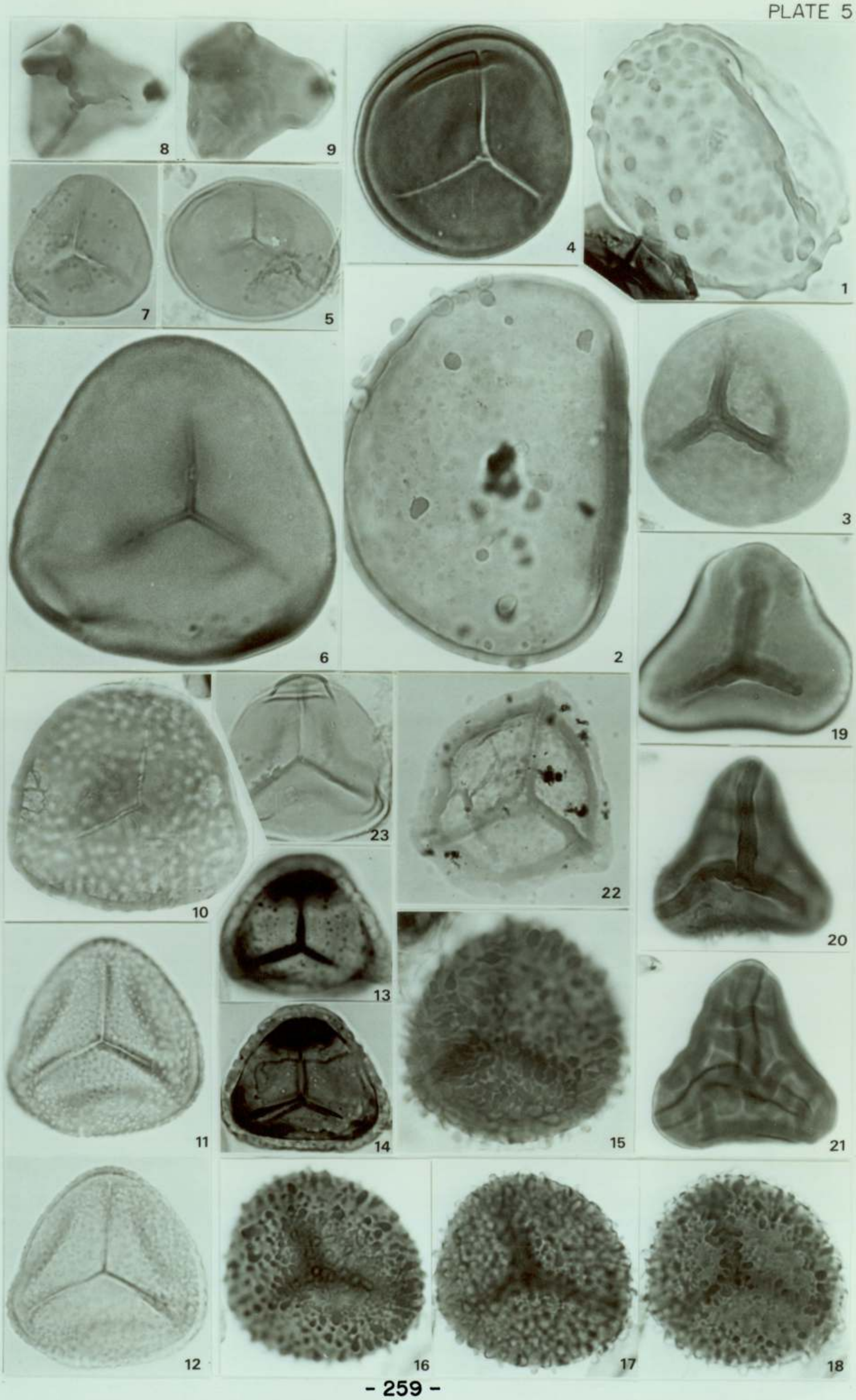

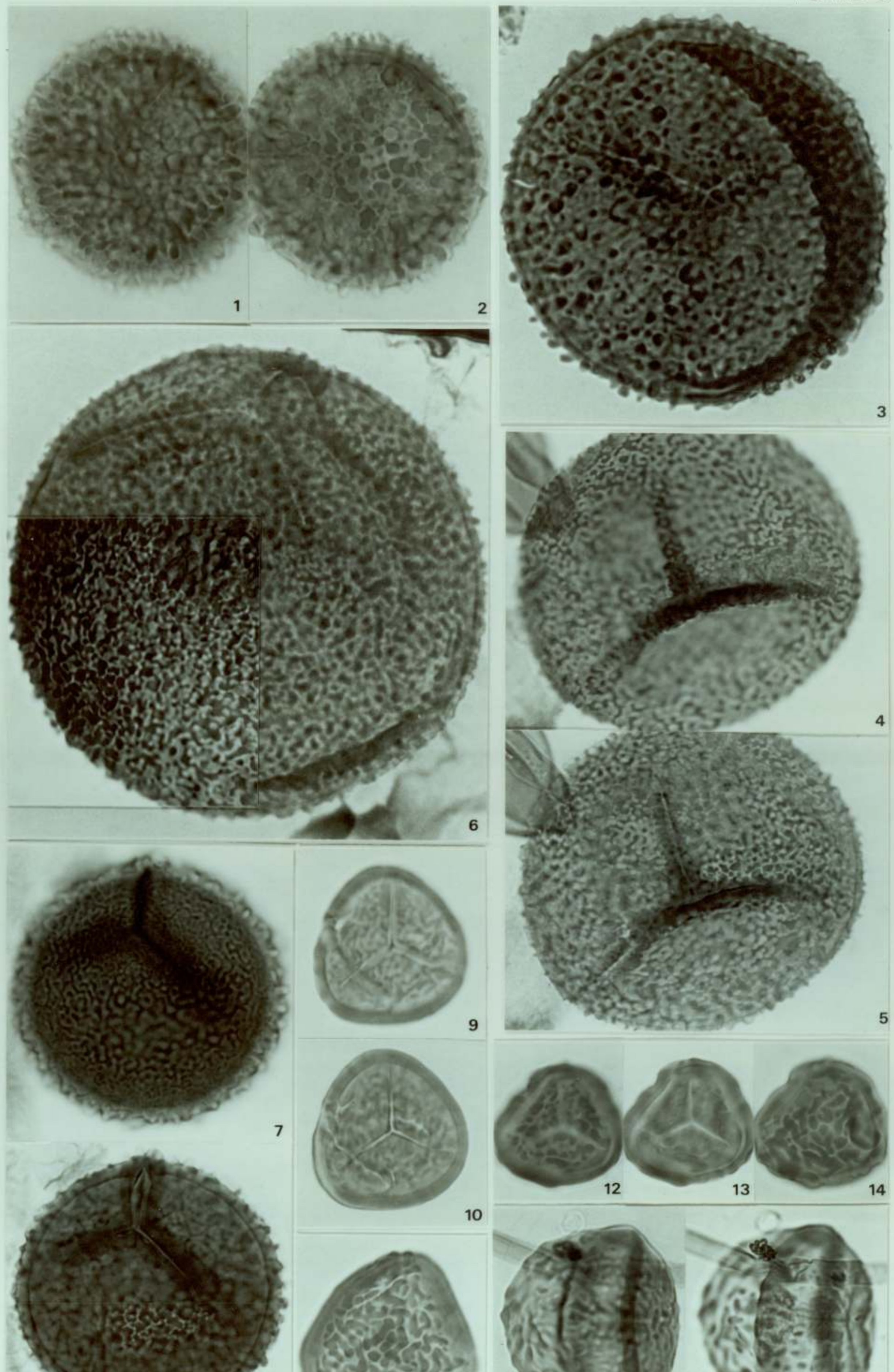
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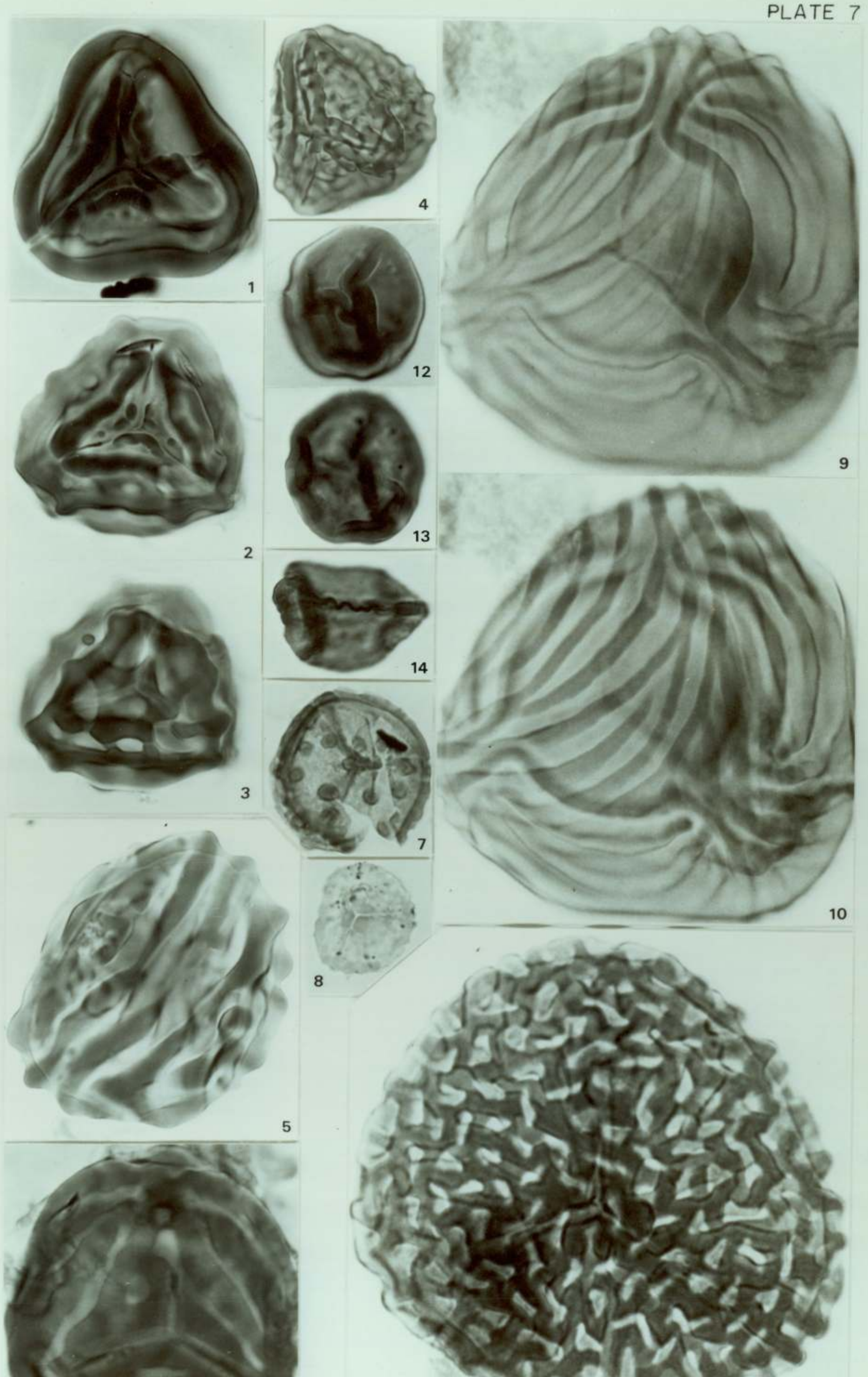

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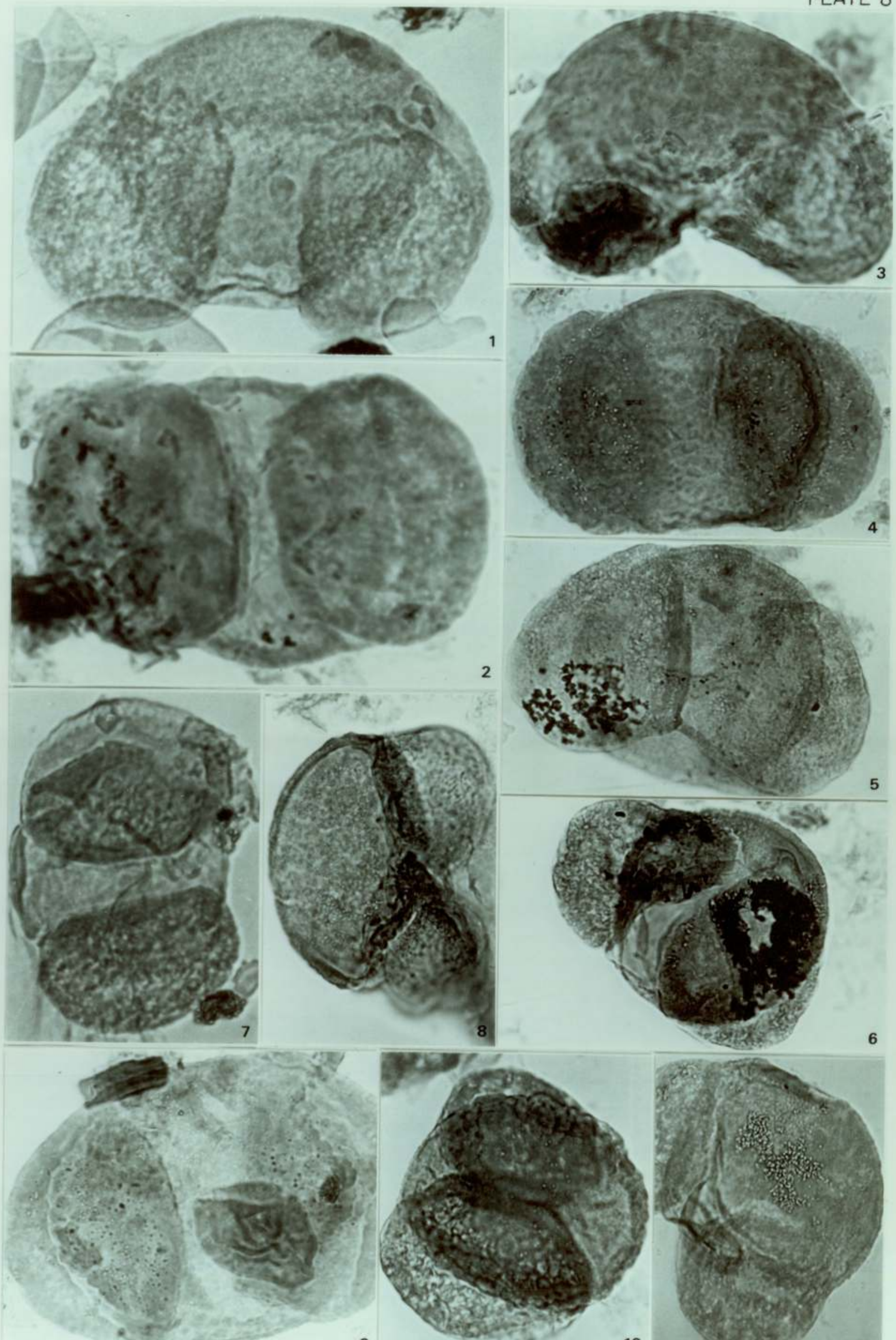

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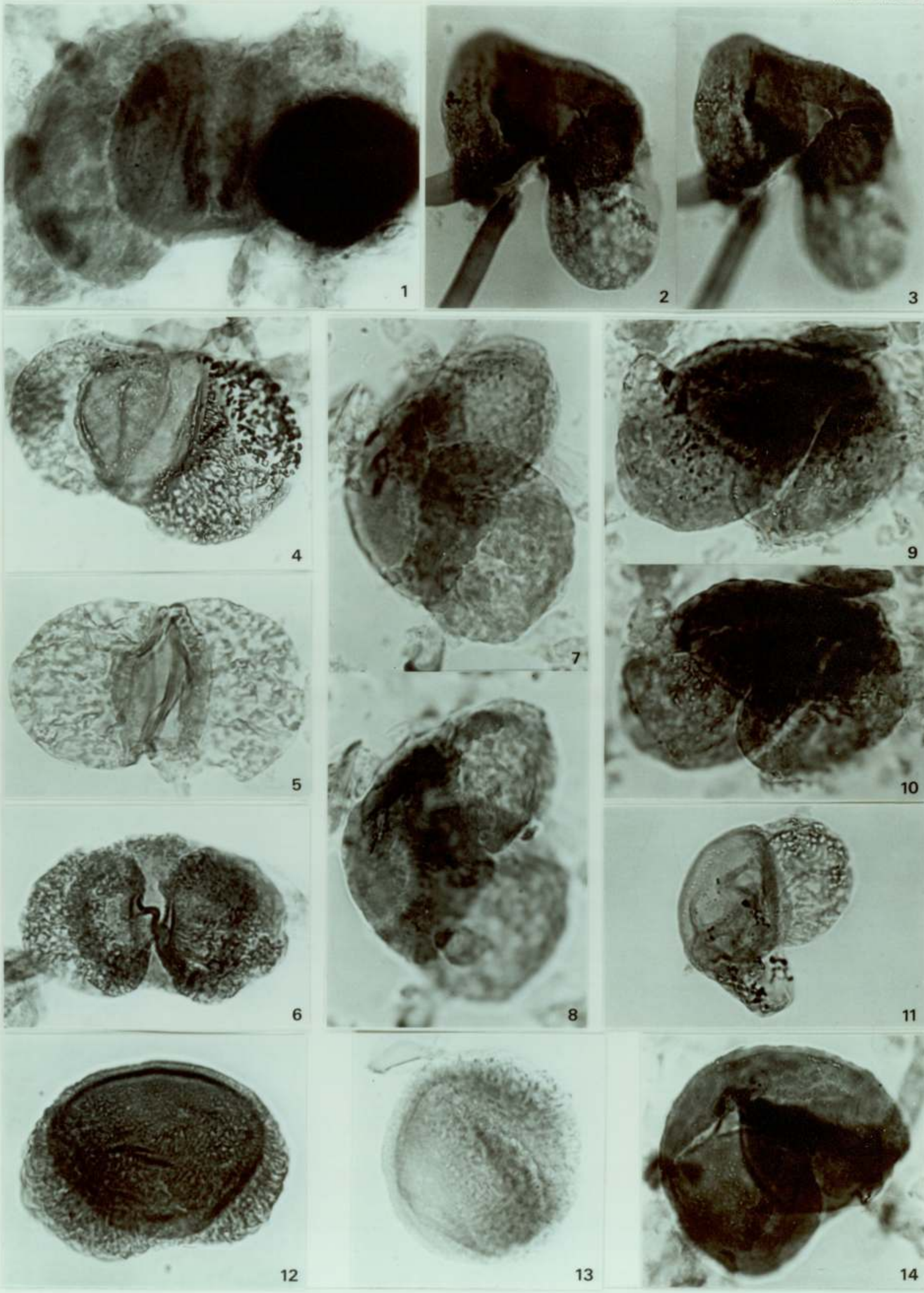

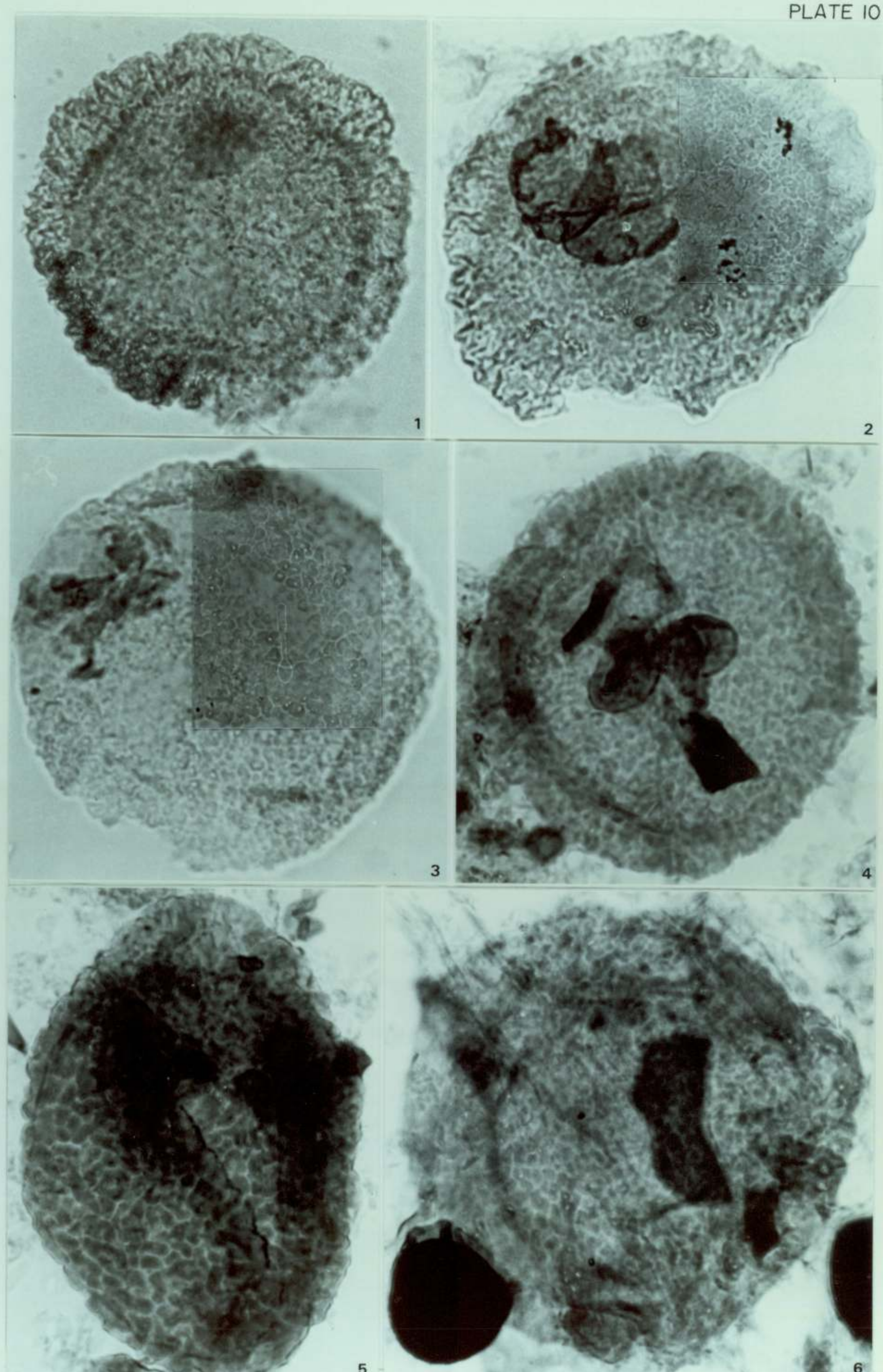
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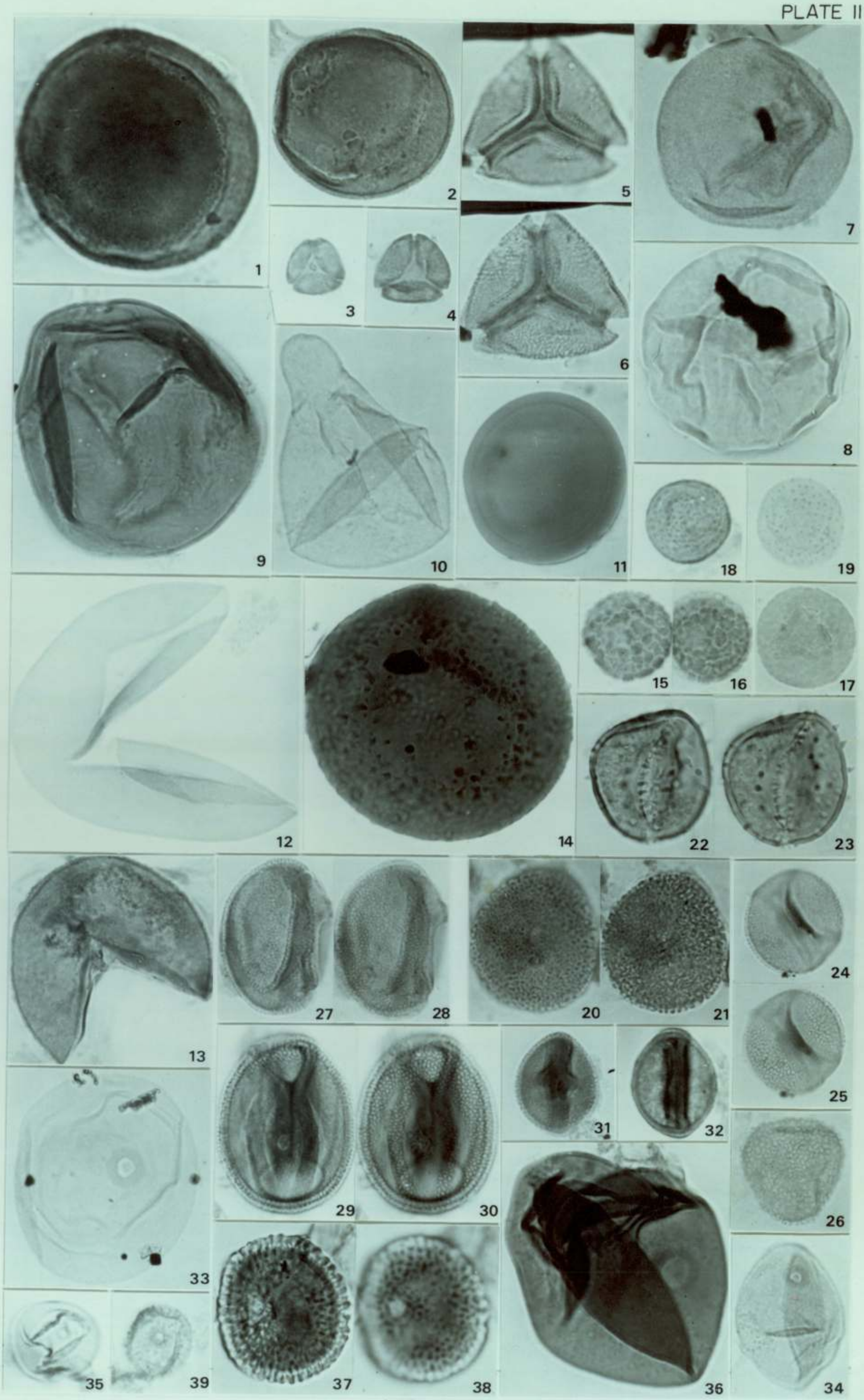
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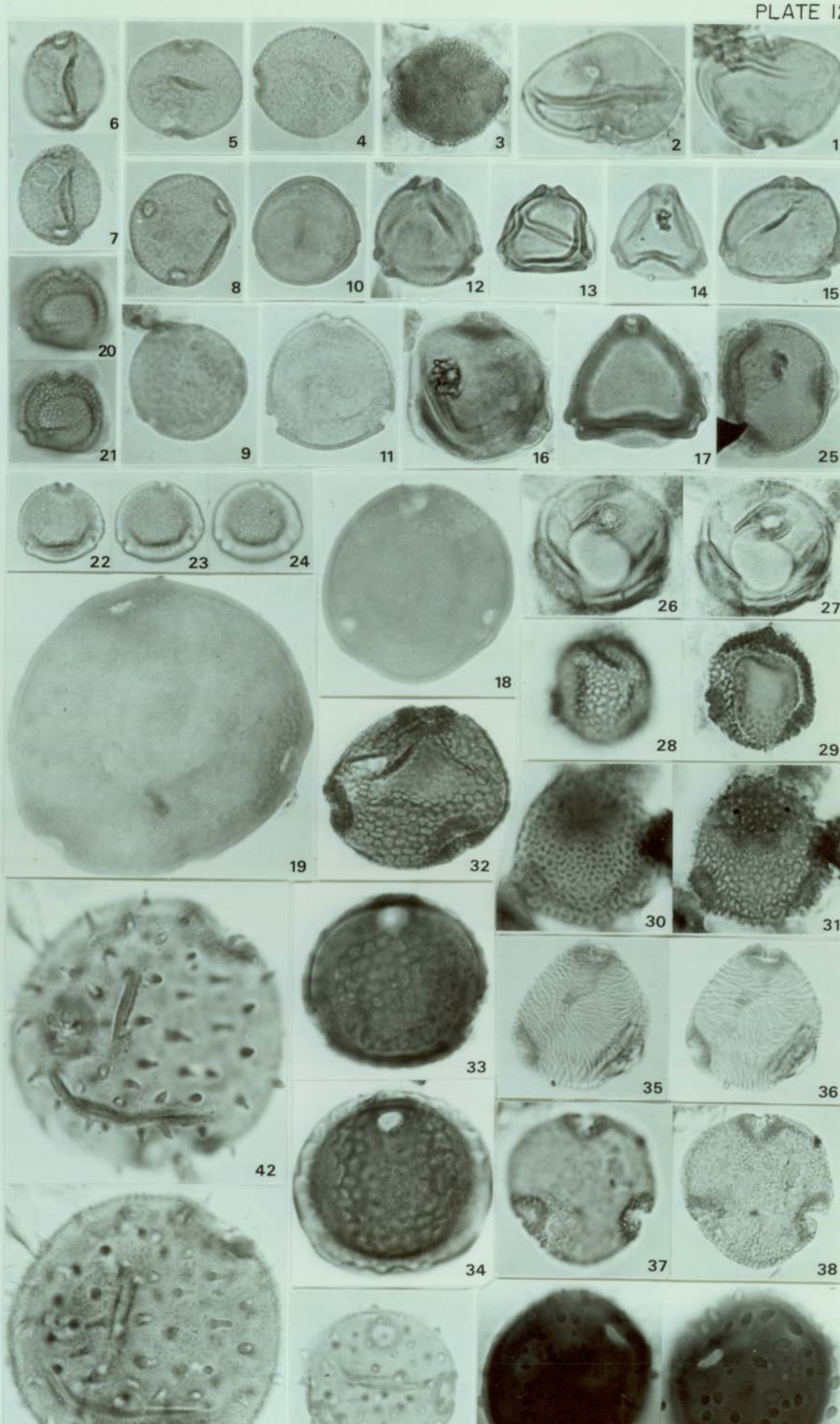
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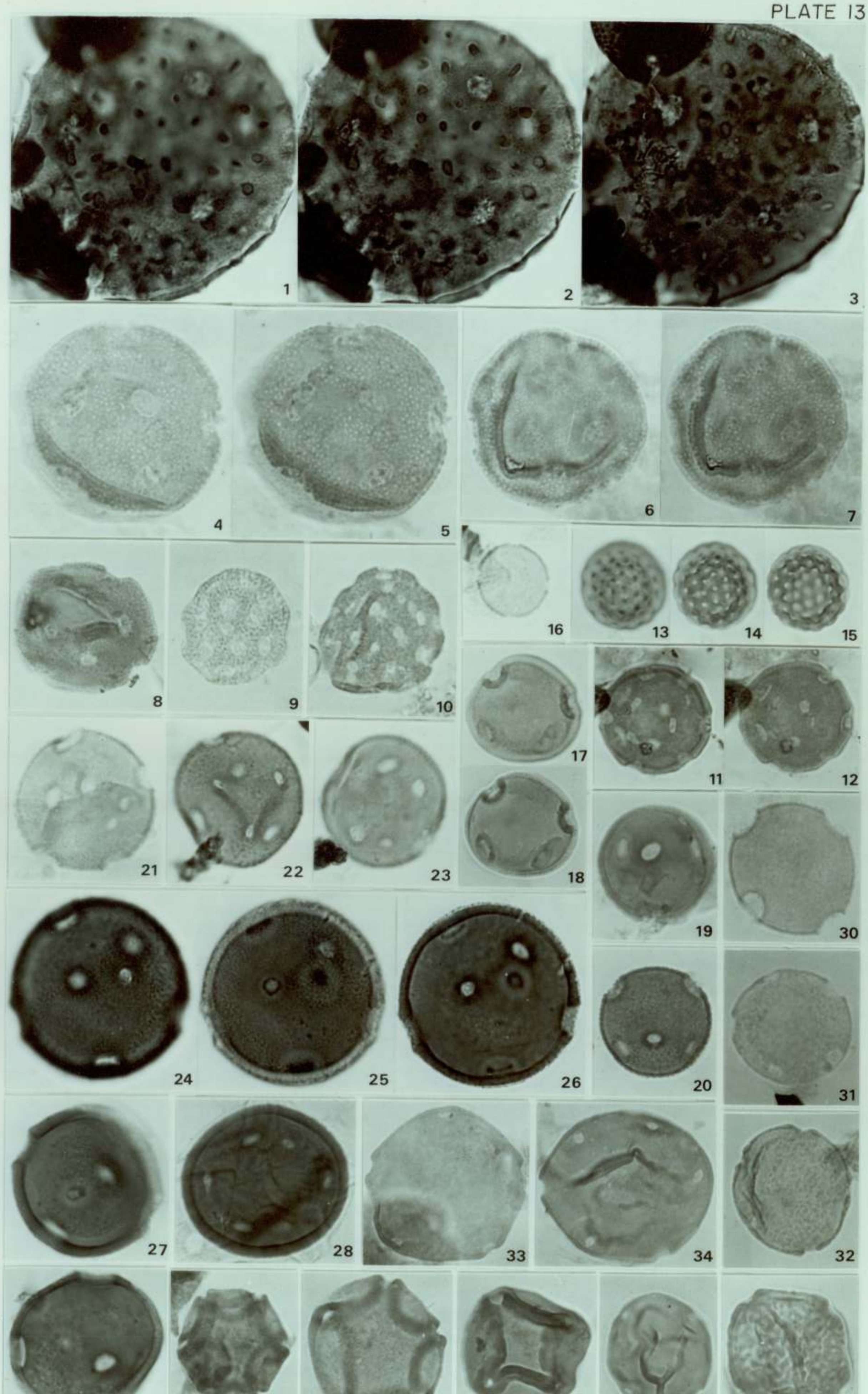
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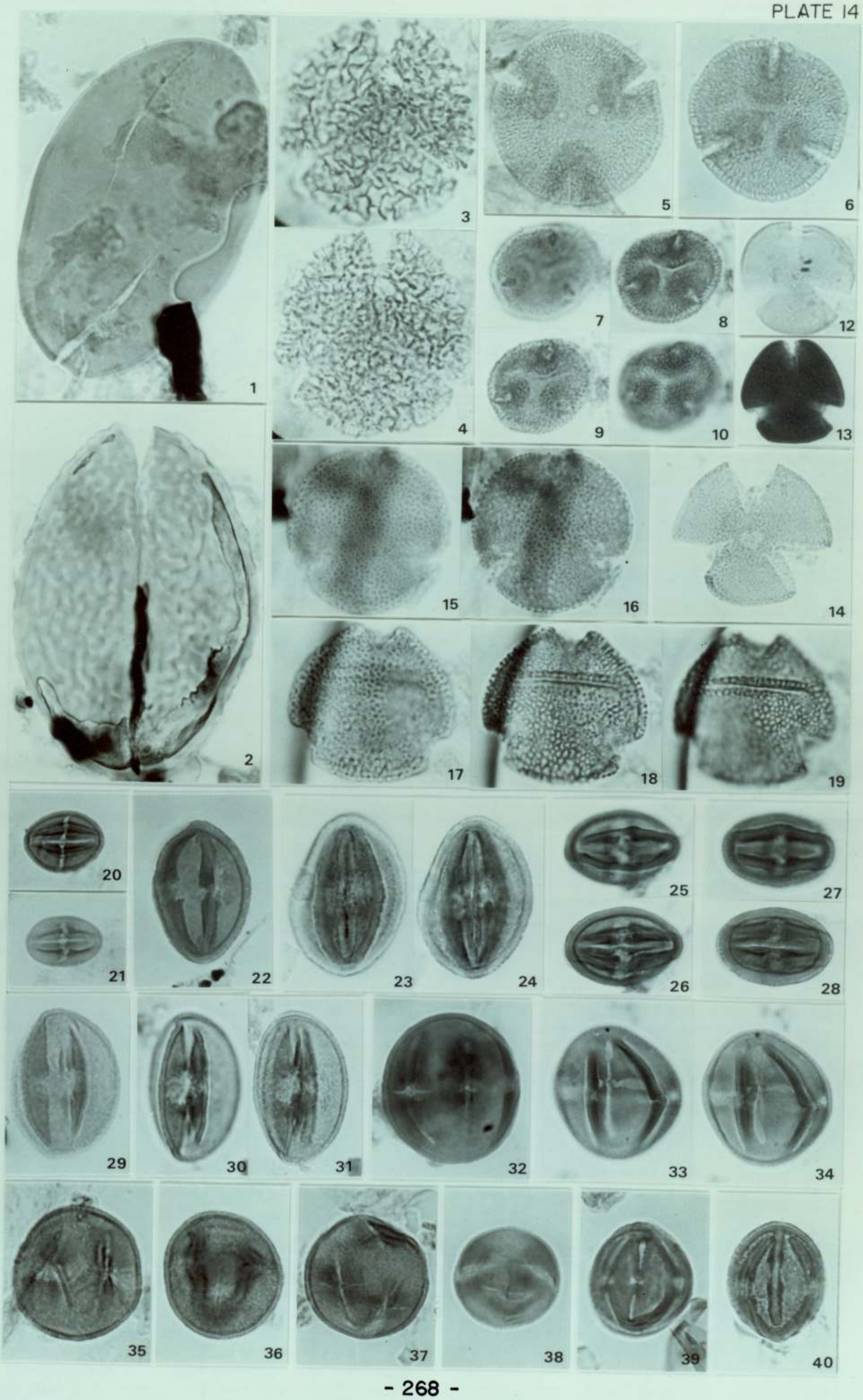
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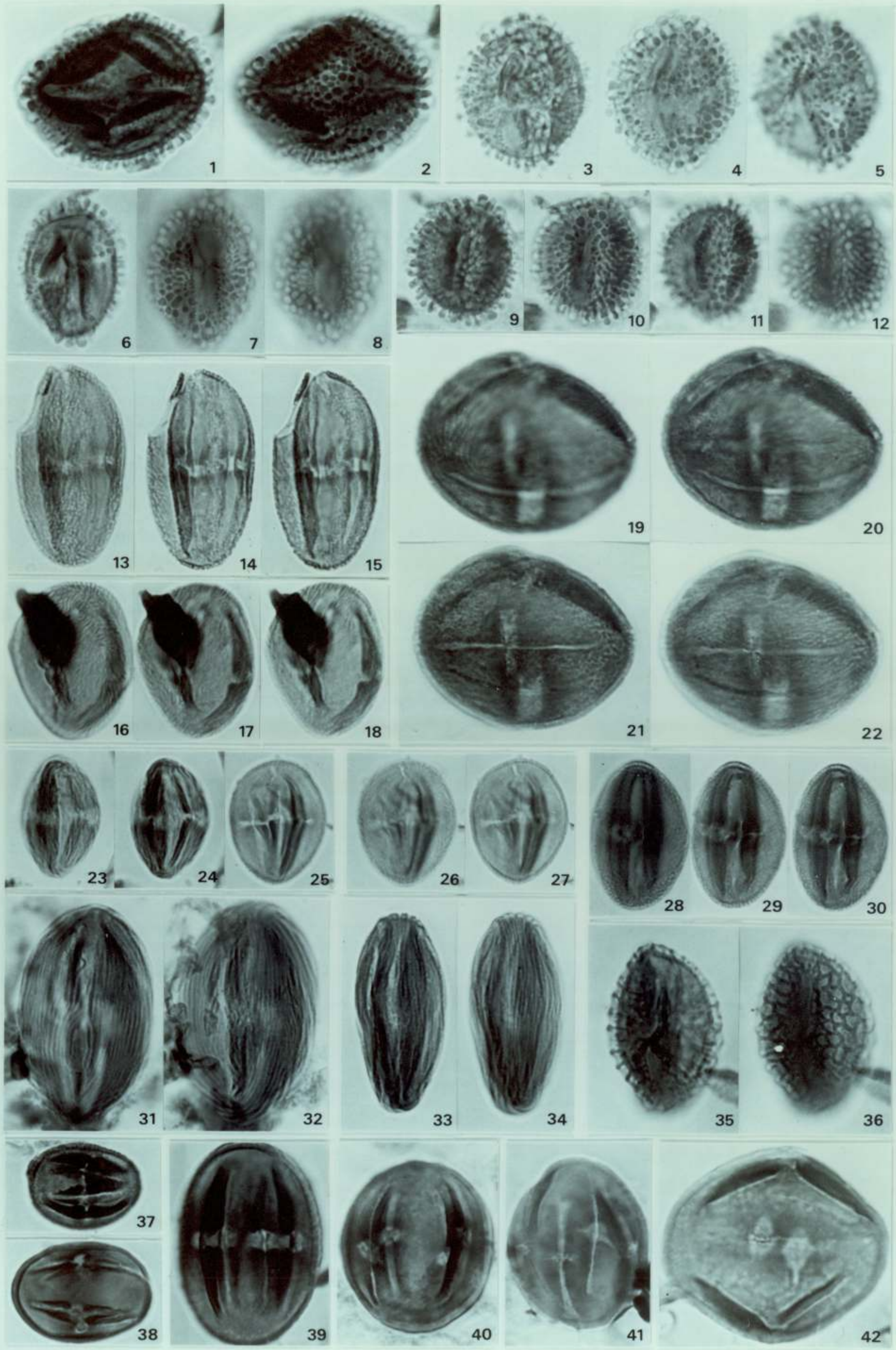
PLATE 16



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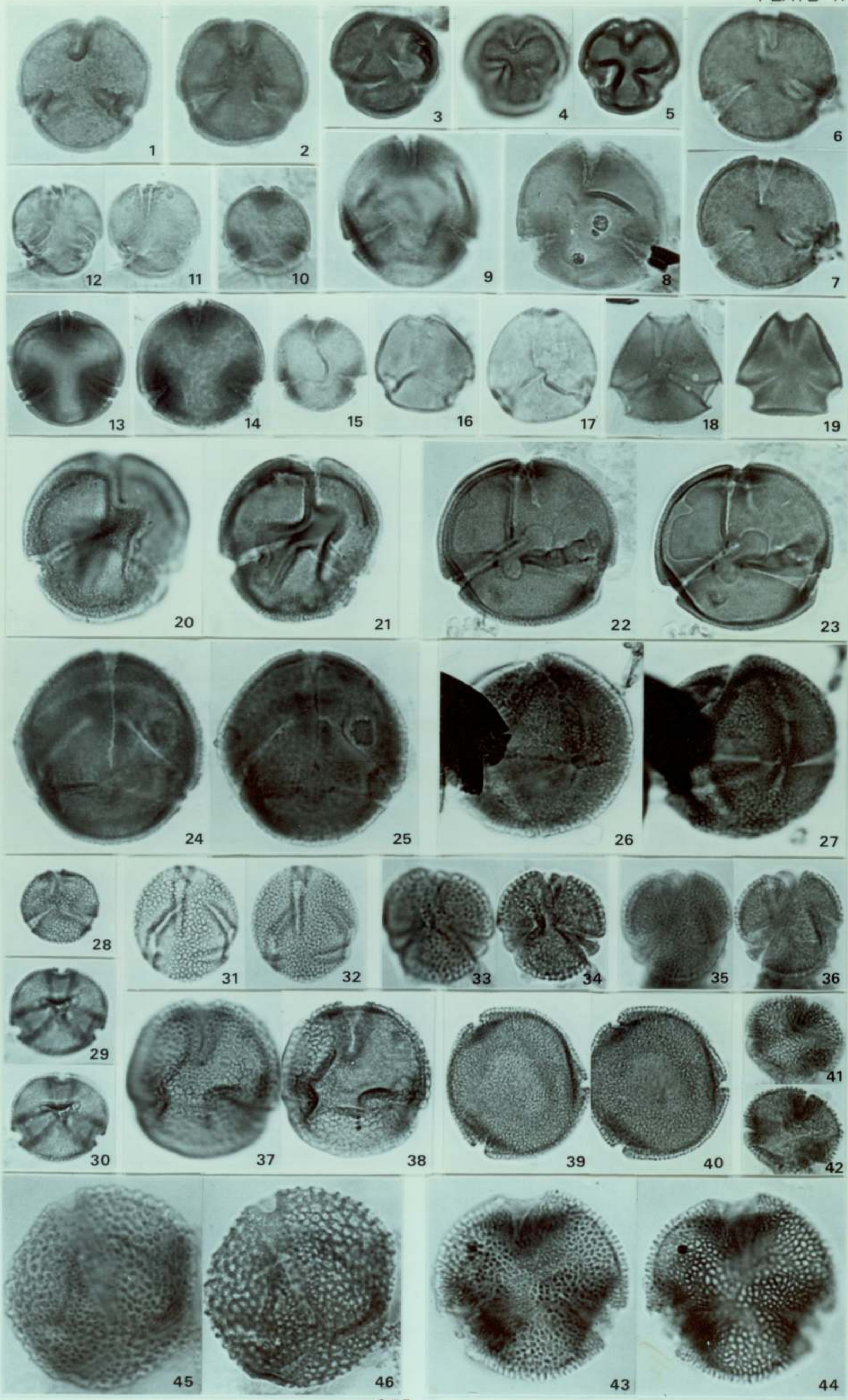
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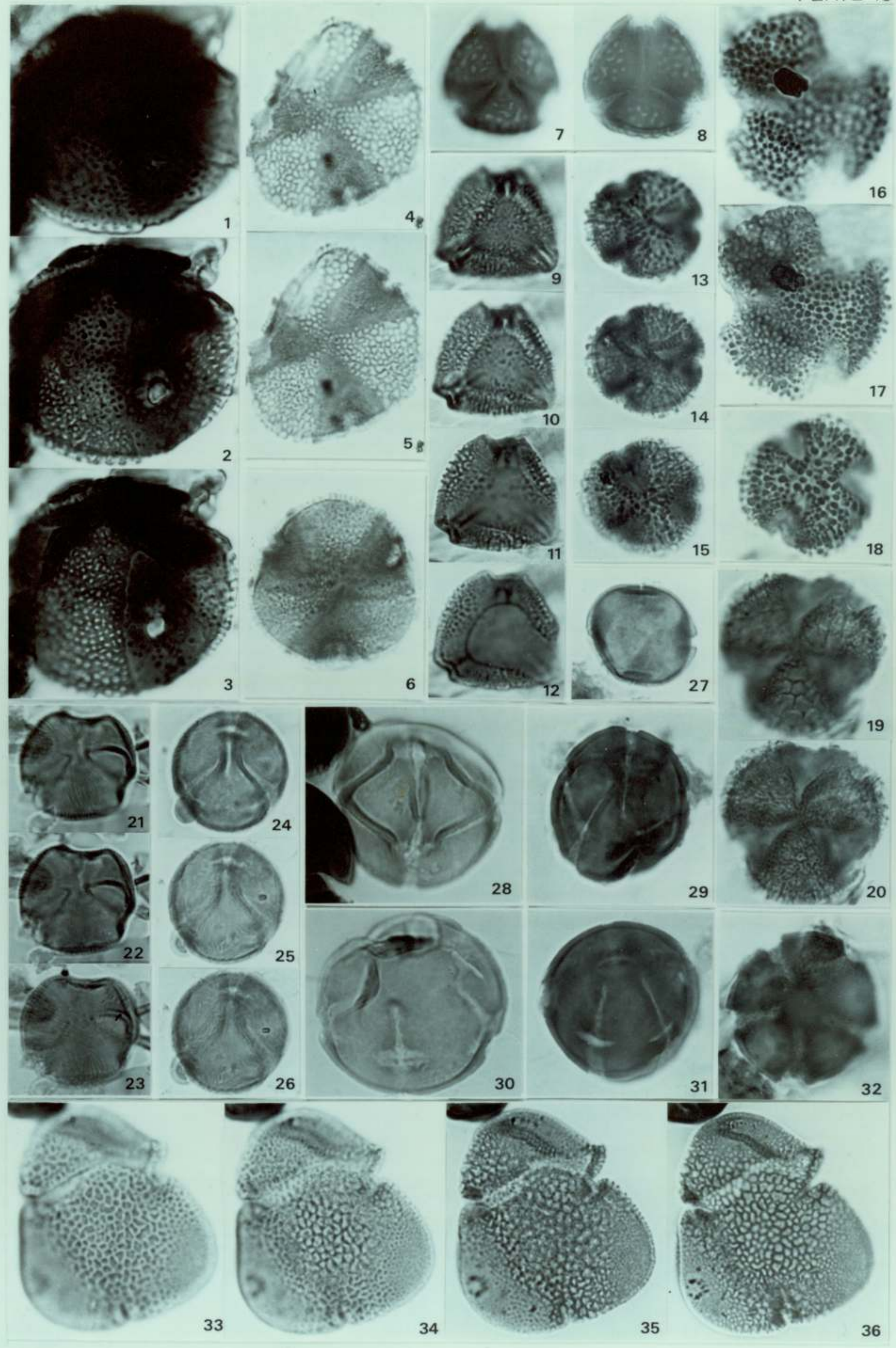
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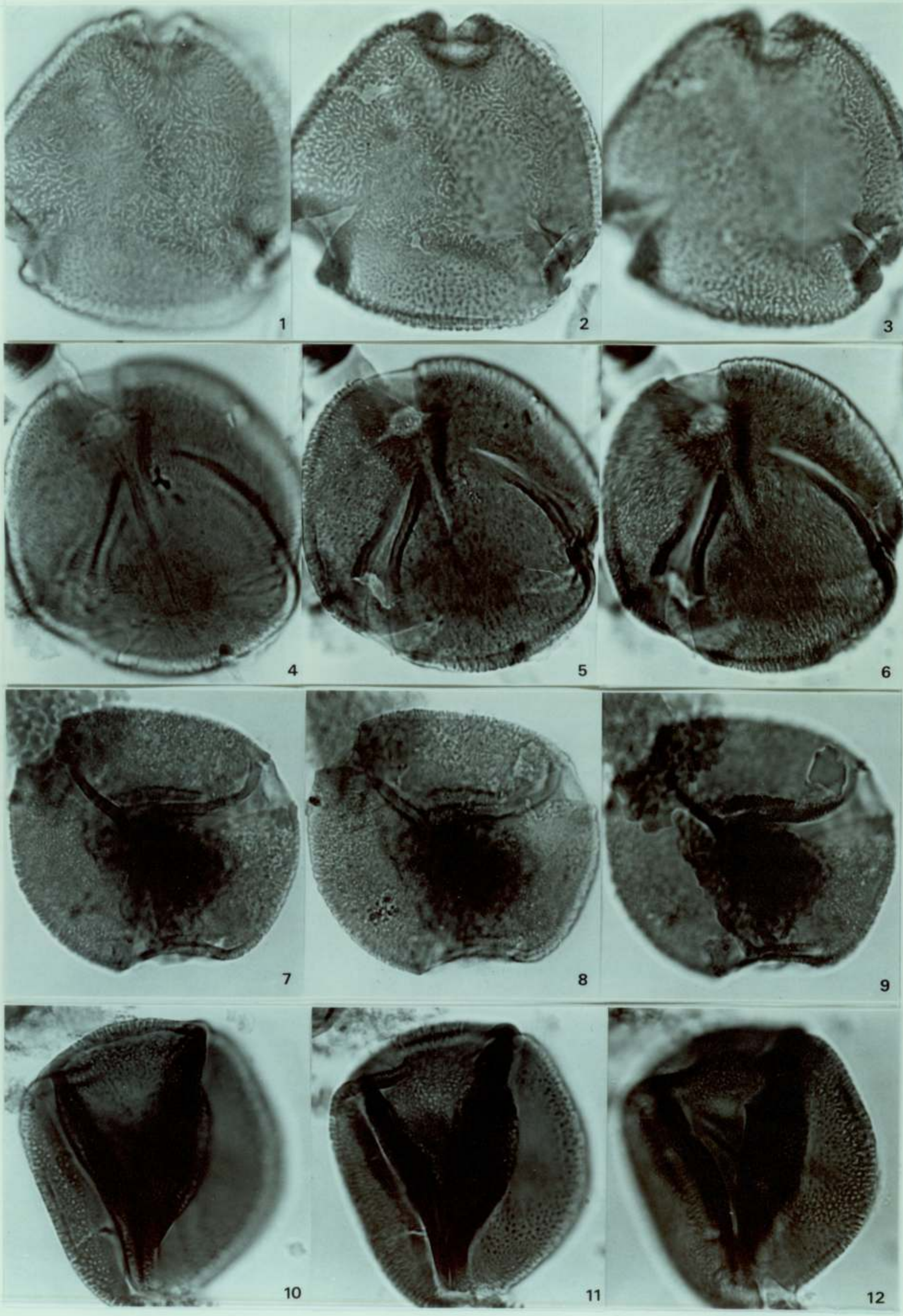
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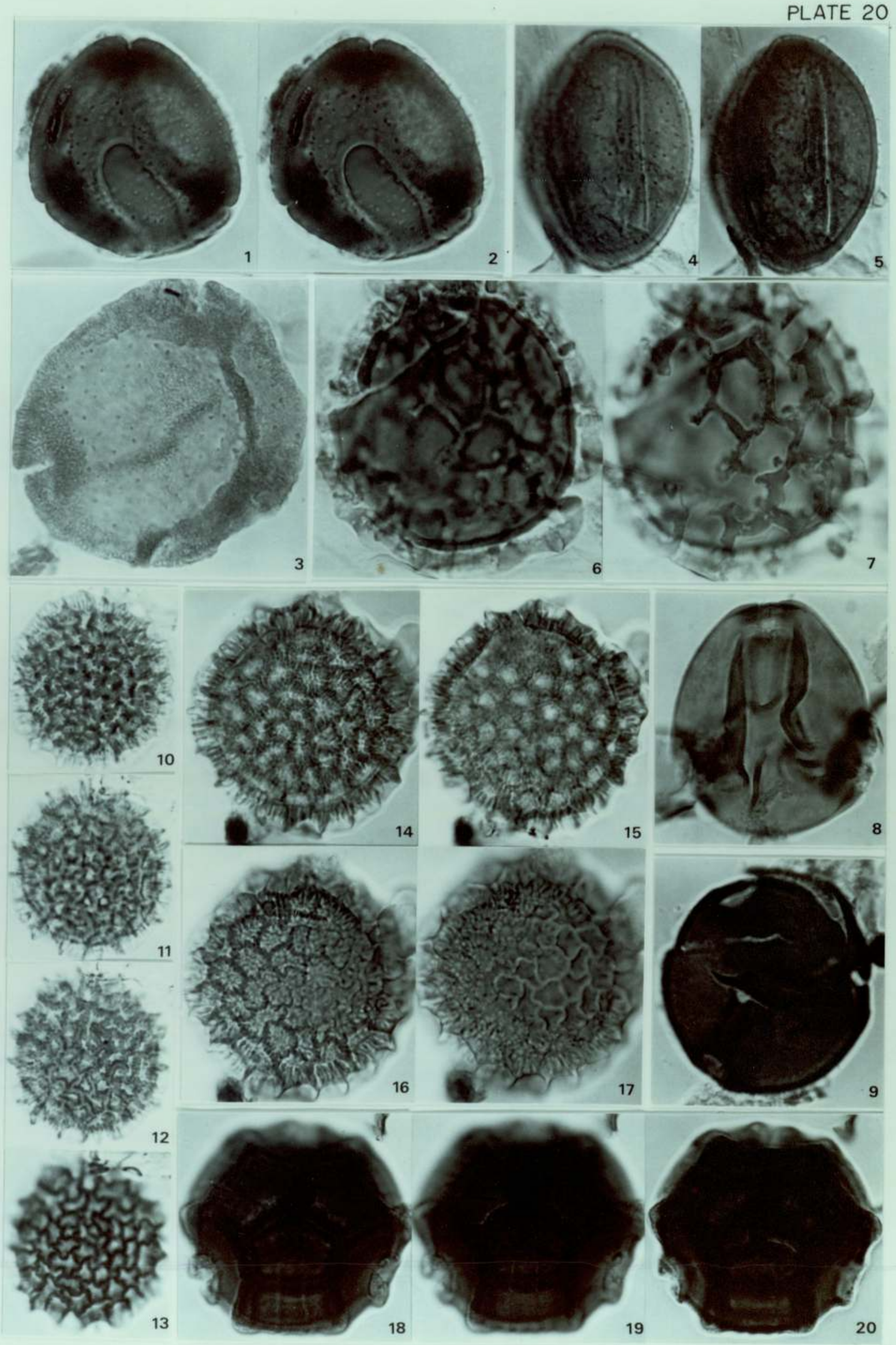

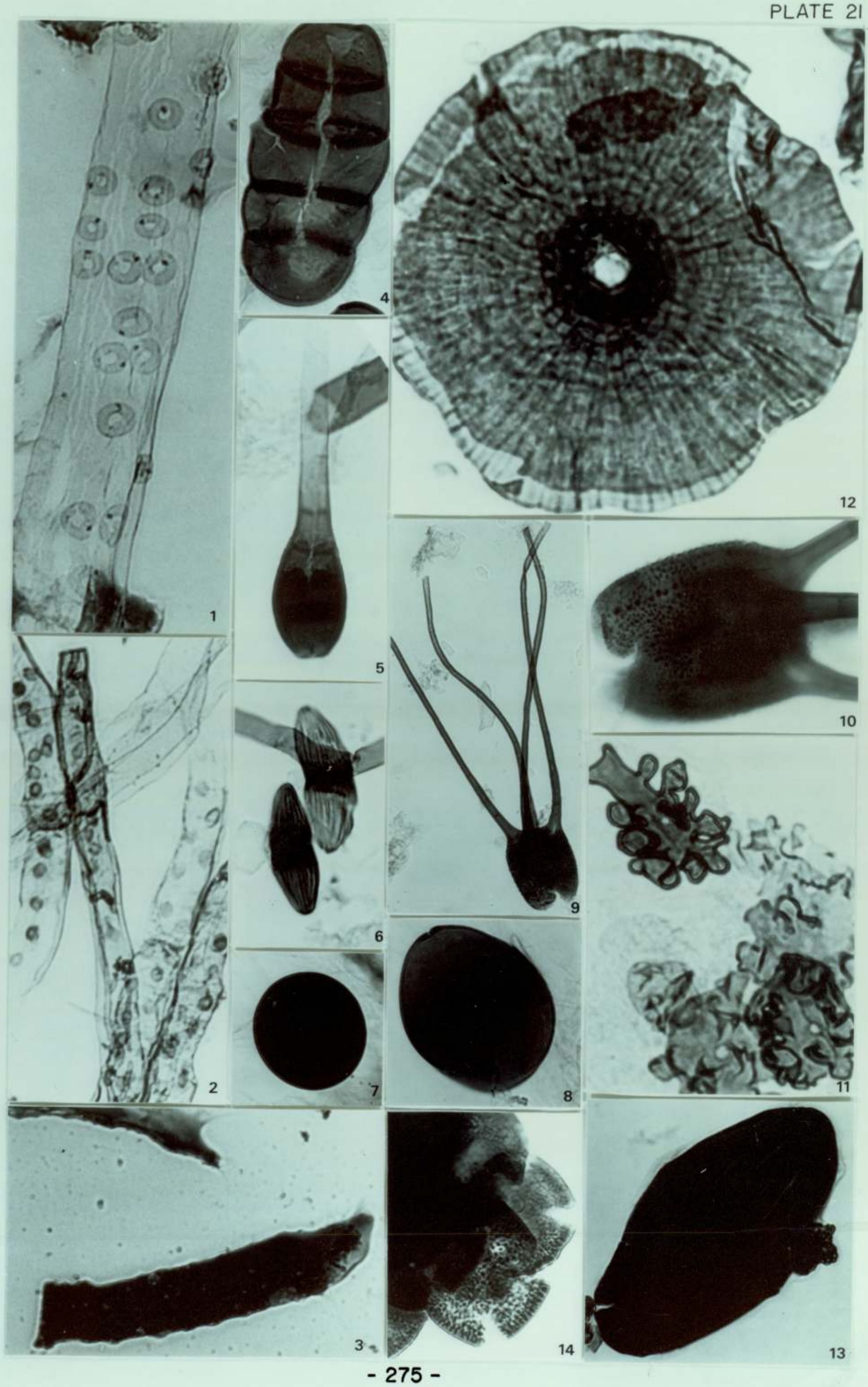
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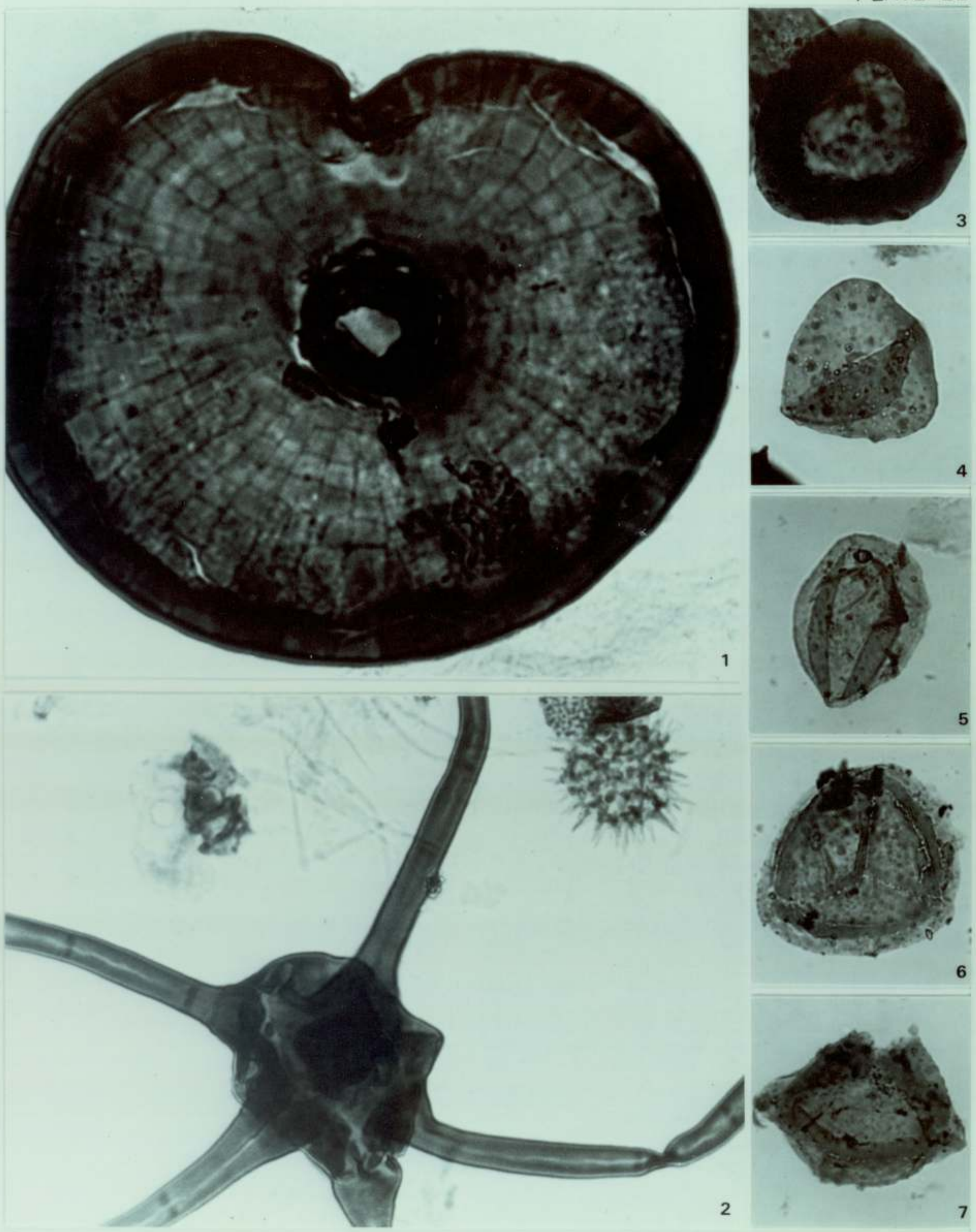
PLATE 22



APPENDIX D : DIAGRAMS

DIAGRAM 1 Distribution and relative frequency of Cenozoic spores and pollen grains in the studied areas. Frequencies based on counts of 250 grains per sample except for the samples LI11 (210 grains), LI18 (94 grains), and LI26 (236 grains); + denotes observed in sample but not in count.

DIAGRAM 2 Simplified stratigraphic ranges of some Cenozoic spores and pollen grains from various known deposits. Number in bracket indicated sources of references as follows : **(1)** Cookson & Pike, 1954 **(2)** Couper, 1958 **(3)** Drugg, 1967 **(4)** Dueñas, 1980a **(5)** Germeraad et al., 1968; 5.1 Caribbean area, 5.2 Nigeria, 5.3 Borneo **(6)** Harris, 1965 **(7)** Hekel, 1972 **(8)** Hoeken-Klinkenberg, 1966 **(9)** Hunger, 1952 **(10)** Kedves, 1973 **(11)** Kemp & Harris, 1977 **(12)** Koreneva & Kartashova, 1978 **(13)** Krutzsch, 1959 **(14)** Krutzsch, 1962 **(15)** Krutzsch, 1967 **(16)** Martin, 1973 **(17)** Morley, 1982 **(18)** Muller, 1964 **(19)** Muller, 1966 **(20)** Muller, 1968 **(21)** Pocknall & Crosbie, 1982 **(22)** Salard-Cheboldaeff, 1979 **(23)** Stover & Partridge, 1973 **(24)** Thomson & Pflug, 1953 **(25)** Trevisan, 1967 **(26)** Wilkinson & Boulter, 1980 **(27)** Ziembinska-Tworzydlo, 1974 and **(28)** Ramanujam, 1966.

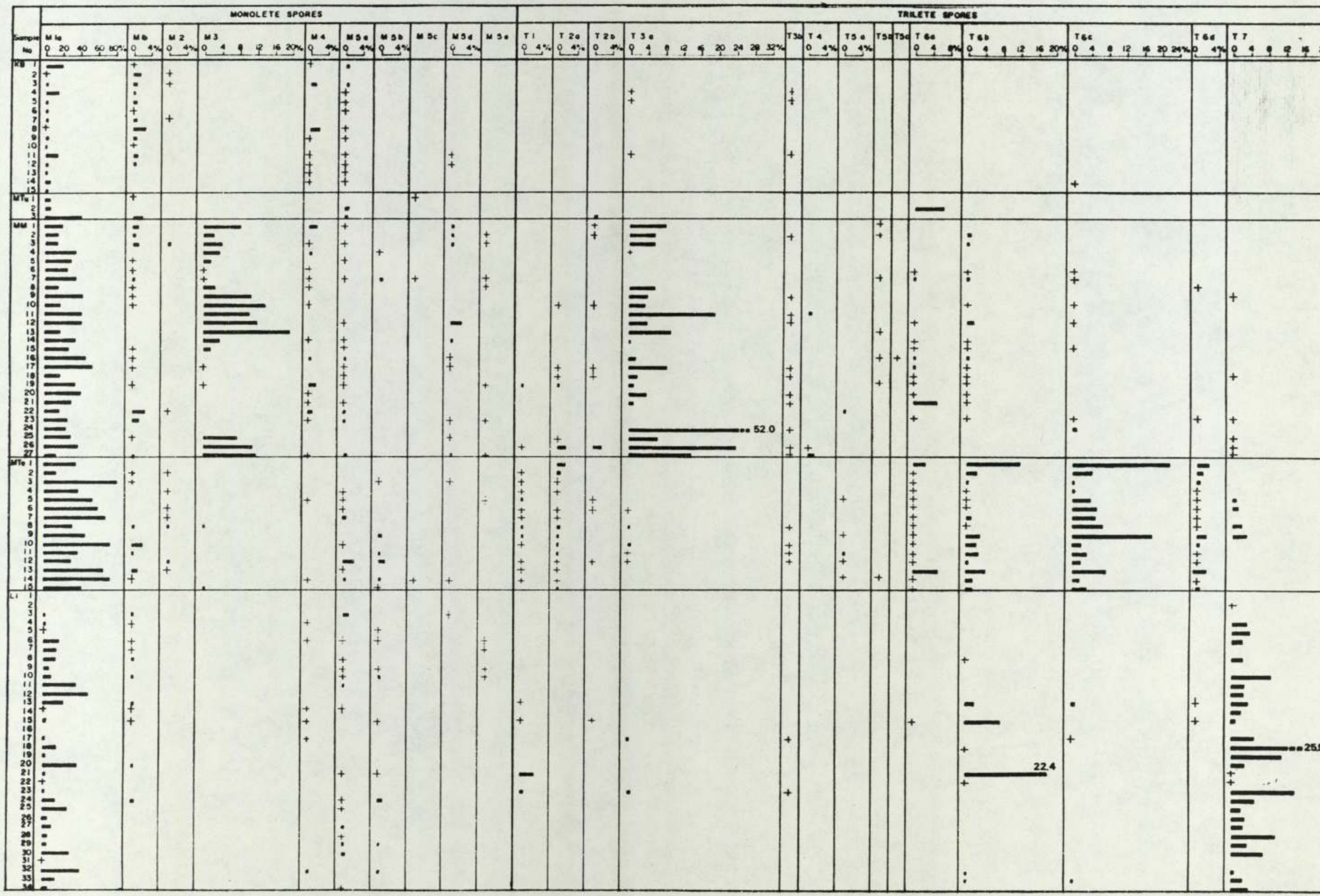

MONOLETE SPORES
TRILETE SPORES
Sample No
M 1a
M 1b
M 2
M 3
M 4
M 5a
M 5b
M 5c
M 5d
M 5e
T 1
T 2a
T 2b
T 3a
T 3b
T 4
T 5a
T 5b
T 5c
T 6a
T 6b
T 6c
T 6d
T 7
KB
MM
52.0
25.5
22.4

DIAGRAM I

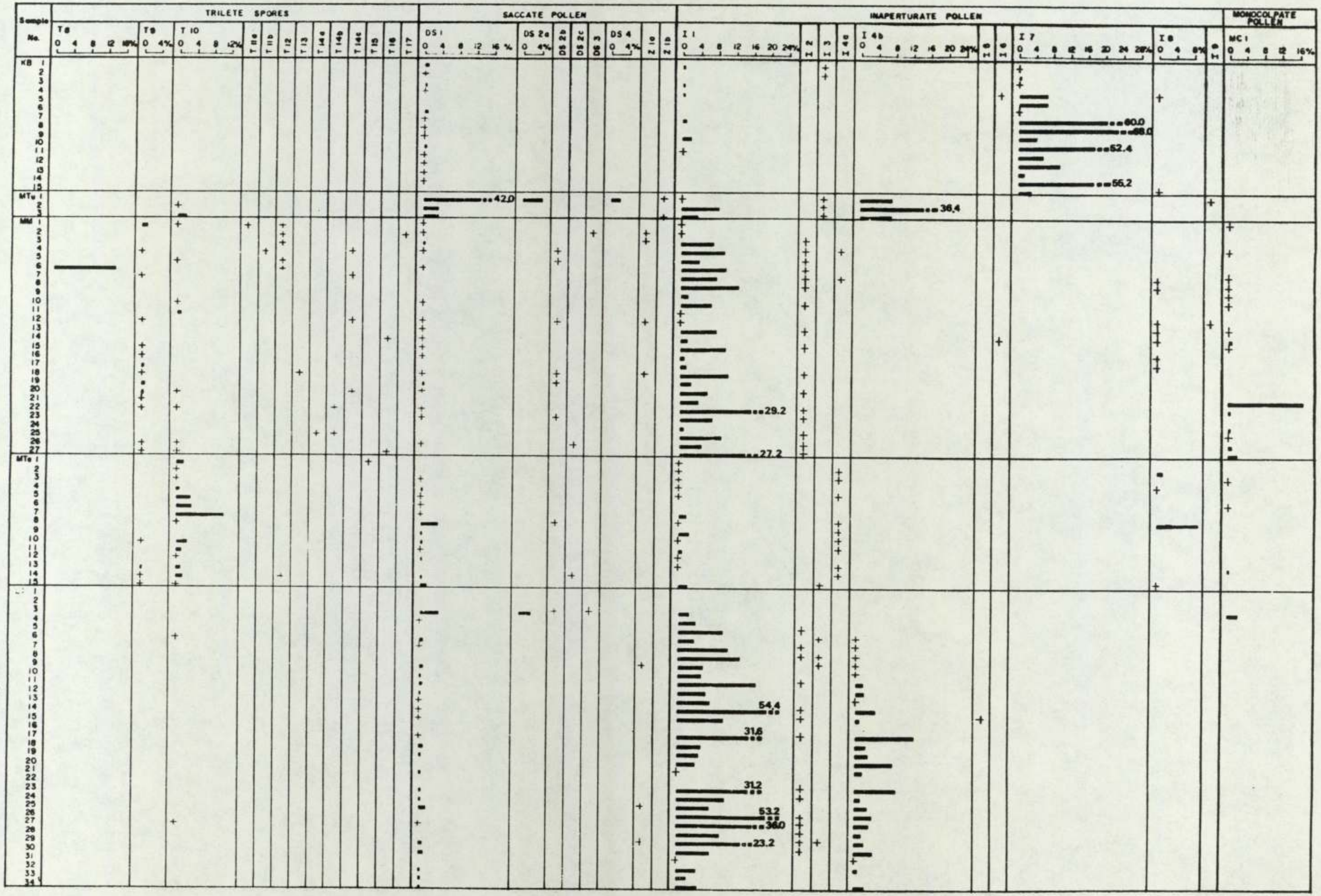


DIAGRAM I (cont)

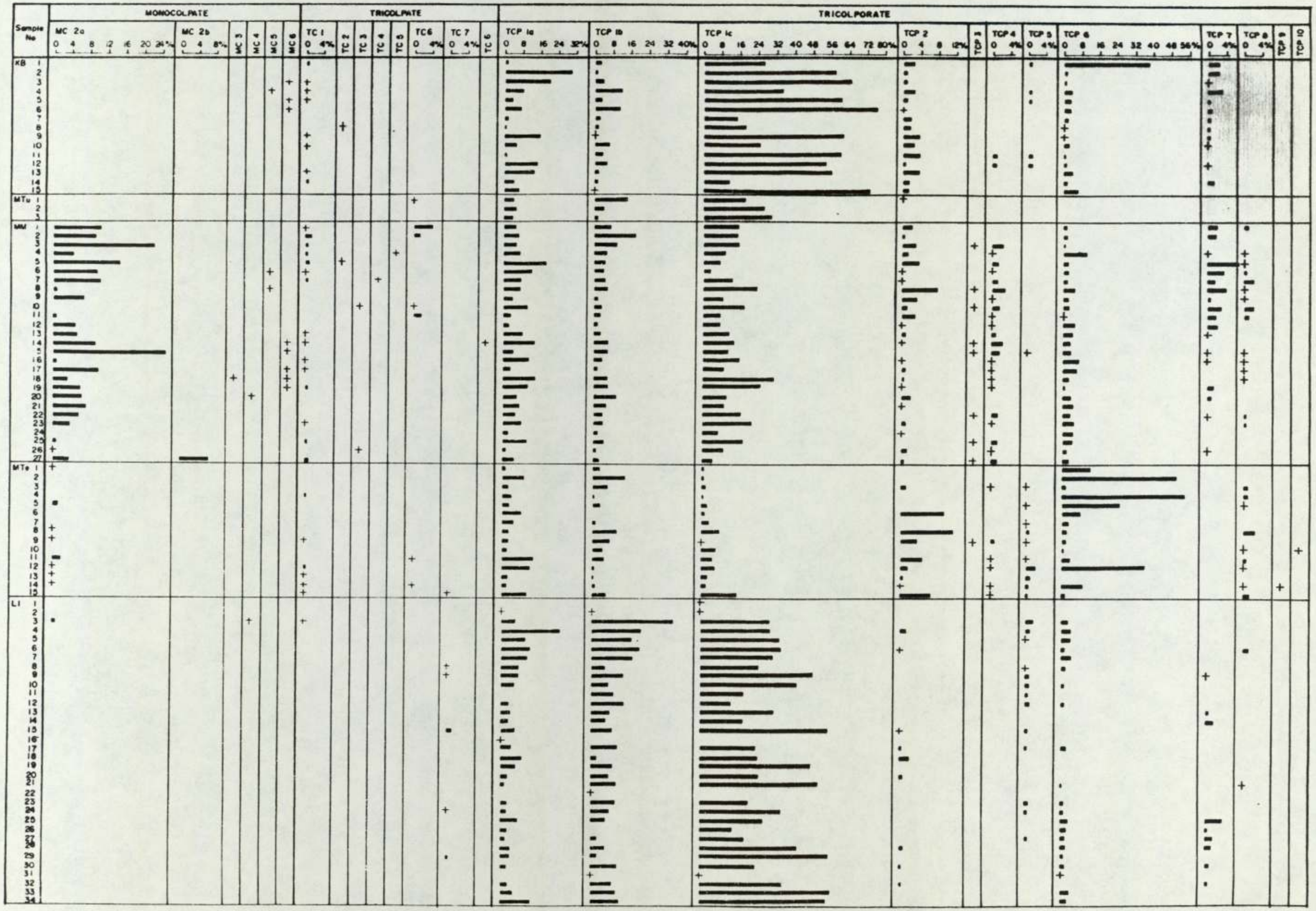


DIAGRAM I (cont.)

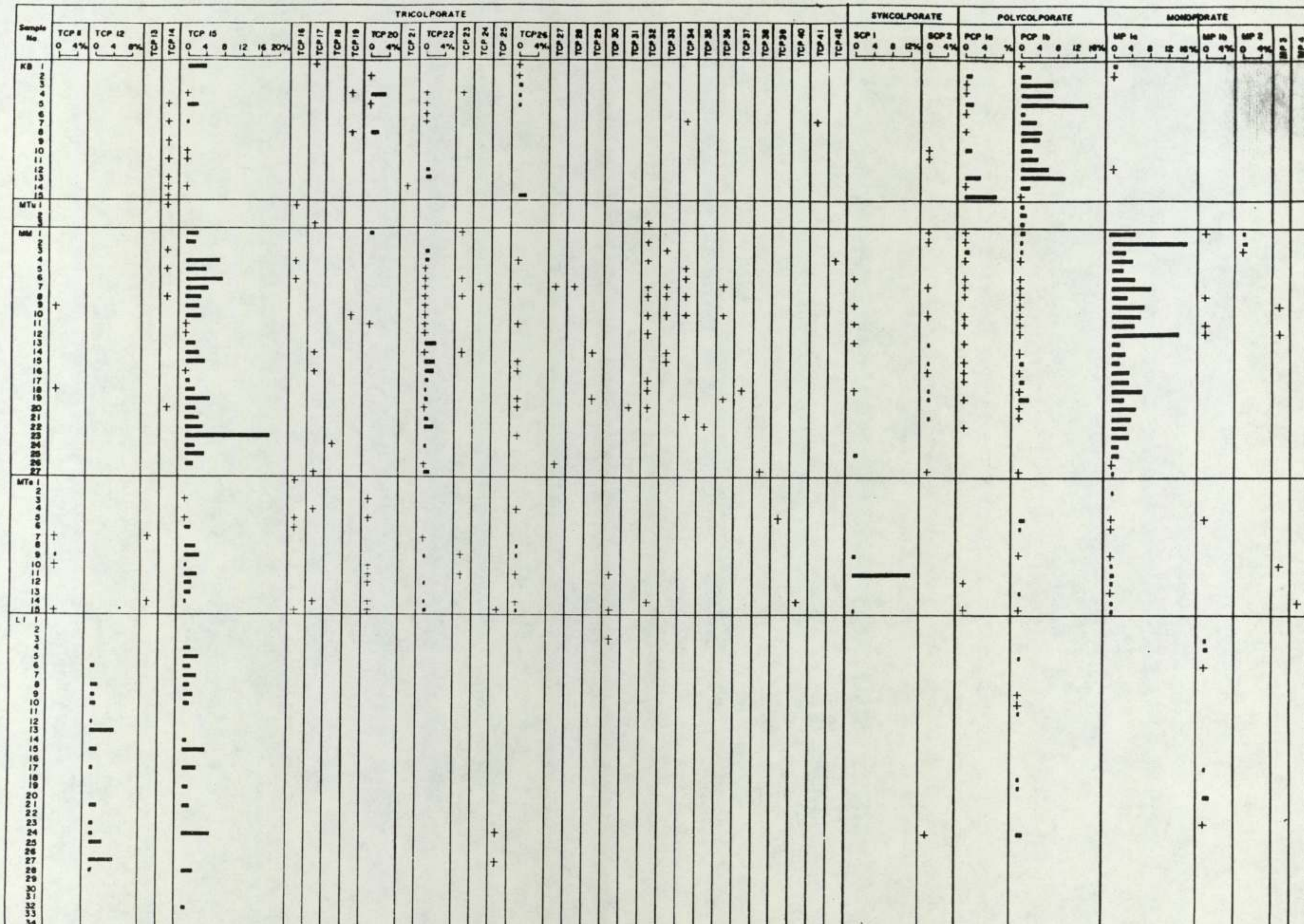


DIAGRAM I (cont.)

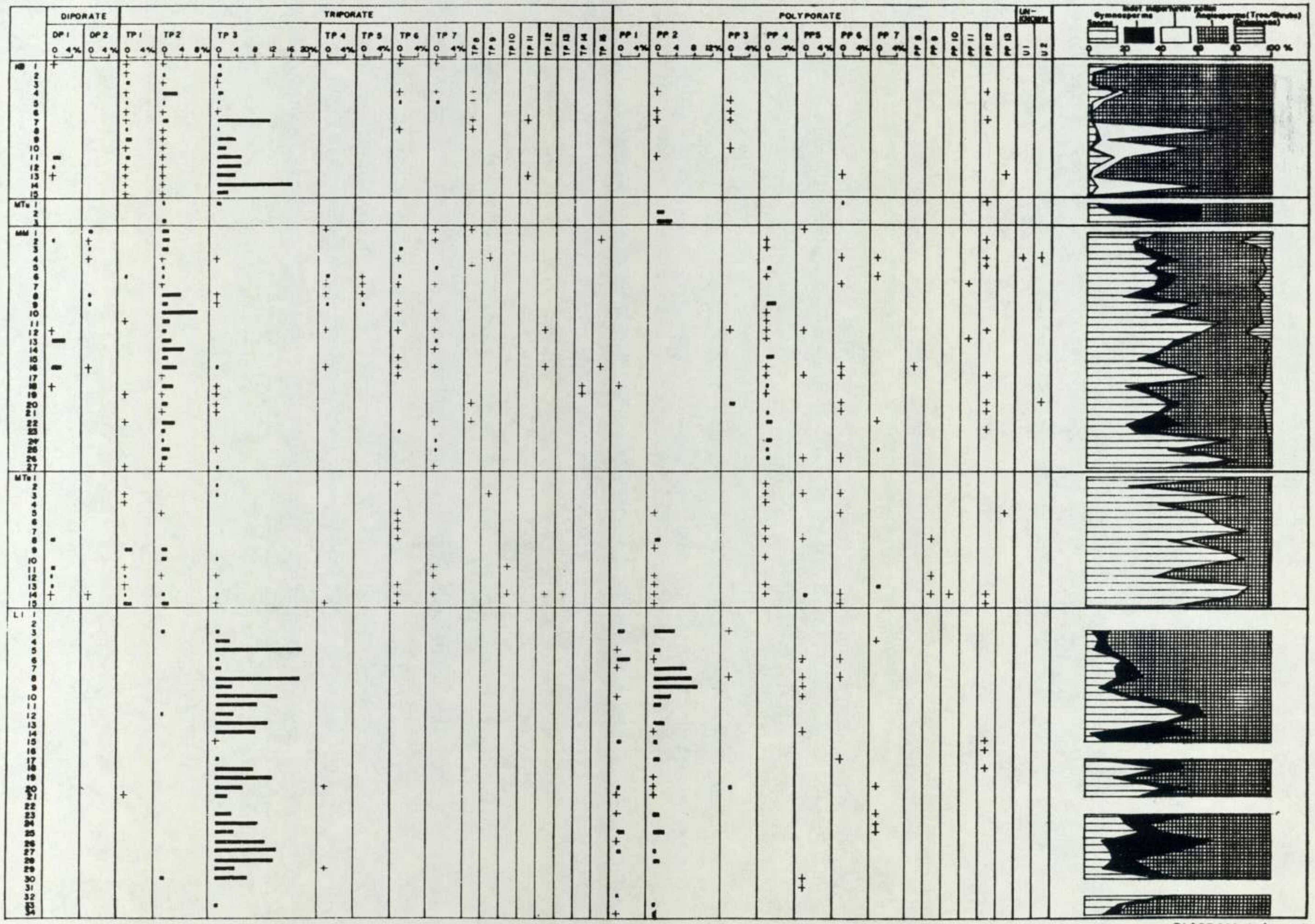


DIAGRAM I (cont.)

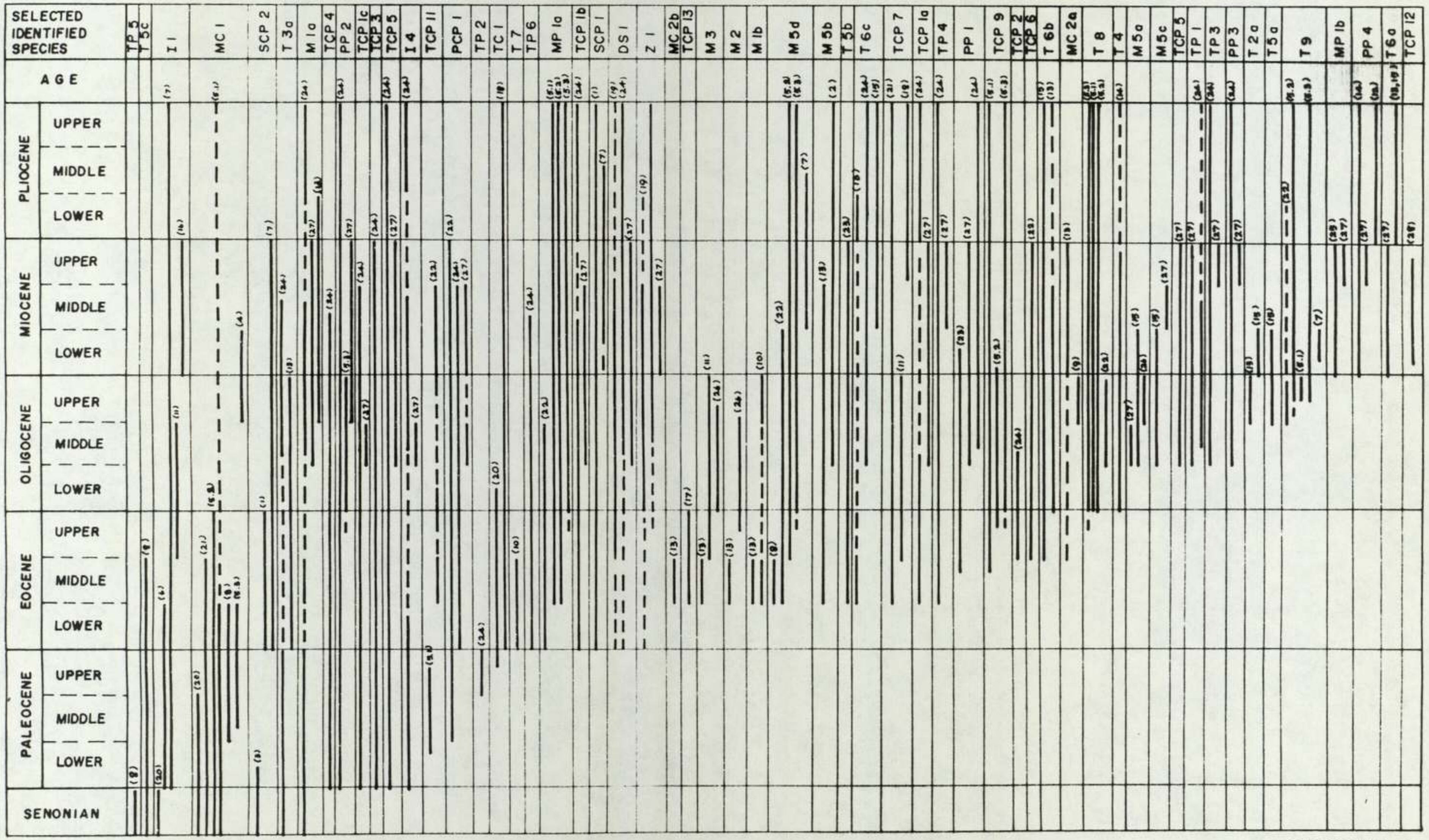

SELECTED IDENTIFIED SPECIES
AGE
TP 5
T 5c
I 1
MC 1
SCP 2
T 3a
M 1a
TCP 4
PP 2
TCP 1c
TCP 3
TCP 5
I 4
TCP 11
PCP 1
TP 2
TC 1
T 7
TP 6
MP 1a
TCP 1b
SCP 1
DS 1
Z 1
MC 2b
TCP 13
M 3
M 2
M 1b
M 5d
M 5b
T 5b
T 6c
TCP 7
TCP 1a
TP 4
PP 1
TCP 9
TCP 2
TCP 6
T 6b
MC 2a
T 8
T 4
M 5a
M 5c
TCP 5
TP 1
TP 3
PP 3
T 2a
T 5a
T 9
MP 1b
PP 4
T 6a
TCP 12
PLIOCENE
UPPER
MIDDLE
LOWER
MIOCENE
UPPER
MIDDLE
LOWER
OLIGOCENE
UPPER
MIDDLE
LOWER
EOCENE
UPPER
MIDDLE
LOWER
PALEOCENE
UPPER
MIDDLE
LOWER
SENONIAN

DIAGRAM 2

APPENDIX E INDEX OF FOSSIL SPORES AND POLLEN GRAINS FOUND IN THE COAL DEPOSITS OF THAILAND

M5c	Verrucatosporites cf. V. favus (Potonie') Thomson & Pflug, 1953	4	12,13	53
M5d	Verrucatosporites usmensis (Van der Hammen) Germeraad et al. 1968	5	1	55
M5e	Verrucatosporites sp.	5	2	57

TRILETE SPORES

T1	Todisporites cf. T. minor Couper, 1958	5	3	58
T2a	Leiotriletes apheles (Hunger) Krutzsch, 1959	5	4	59
T2b	Leiotriletes sp.	5	5	60
T3a	Laevigatisporites pseudomaximus Pflug & Thomson, 1953	5	6	61
T3b	Laevigatisporites sp.	5	7	63
T4	Concavisporites (Obtusisporis) minimus Krutzsch, 1962	5	8,9	63

T5a	<u>Foveotriletes</u> cf. <u>F. crassifovearis</u> Krutzsch, 1962	5	10	65
T5b	<u>Foveotriletes</u> <u>balteus</u> Partridge, 1973	5	11,12	66
T5c	<u>Foveotriletes</u> cf. <u>F. crassifovearis</u> <u>crassoides</u> Krutzsch, 1967	5	13,14	67
T6a	<u>Osmundacidites</u> sp.A	5	15-18	69
T6b	<u>Osmundacidites</u> sp.B	6	1-3	70
T6c	<u>Osmundacidites</u> sp.C	6	4-6	72
T6d	<u>Osmundacidites</u> sp.D	6	7-8	73
T7	<u>Polypodiaceoisporites</u> <u>brevisculptatus</u> Kedves, 1973	6	9-16	74
T8	<u>Magnastriatites</u> <u>grandiosus</u> (Kedves & Sole' de Porta) Dueñas, 1980b	7	9-10	76
T9	<u>Crassoretitriletes</u> <u>vanraadshooveni</u> Germeraad <u>et</u> <u>al</u>., 1968	6	11	77

T10	Indeterminate (cf. *Undulatisporites takutuensis* V.d. Ham. & Burg., 1966)	7	12-14	79
T11a	Indeterminate (cf. *Trilites sinuatus* Couper, 1953 : Group A)	5	19	80
T11b	Indeterminate (cf. *Trilites sinuatus* Couper, 1953 : Group B)	5	20,21	80
T12	Indeterminate (cf. *Cingulatisporites scabratus* Couper, 1958)	5	22	80
T13	Indeterminate (cf. *Concavisporites* (*Appendicisporites*) *complicatus* Pflug, 1953)	5	23	80
T14a	Indeterminate (cf. *Corrugatisporites* sp.)	7	1	81
T14b	Indeterminate (cf. *Corrugatisporites toratus* Weyland & Greifeld, 1953)	7	2,3,5	81
T14c	Indeterminate (cf. *Corrugatisporites arcuatus* Weyland & Greifeld, 1953)	7	4	81

T15	Indeterminate (cf. *Cicatricosisporites* sp.)	7	6	81
T16	Indeterminate (cf. *Lycopodiumsporites gristhorpensis* Couper, 1958)	7	7	81
T17	Indeterminate (cf. *Echinatisporis* sp.)	7	8	82

SACCATE POLLEN GRAINS

DS1	*Pityosporites* cf. *P. labdacus* (Potonie') Thomson & Pflug, 1953	8	1-11	82
DS2a	Indeterminate (cf. *Podocarpidites biformis* Rouse, 1959)	9	1-3, 7-10	84
DS2b	Indeterminate (cf. *Podocarpidites ellipticus* Cookson, 1947)	9	4-6	84
DS2c	Indeterminate (cf. *Podocarpidites* sp.)	9	11	84
DS3	Indeterminate (cf. *Dycrydiumites* sp.)	9	12-13	85

DS4	Indeterminate (cf. Disaccate pollen grains)	9	14	85
Z1a	Zonalapollenites igniculus (Potonie') Thomson & Pflug, 1953	10	1-3	85
Z1b	Zonalapollenites (Tsuga) viridifluminipites (Wodehouse) Thomson & Pflug, 1953	10	4-6	87

INAPERTURATE POLLEN GRAINS

I1	Inaperturopollenites sp.1 (cf. Araucariacities australis	11	7-9	88
I2	Inaperturopollenites sp.2 (cf. Sequoia langsdorfii	11	10	90
I3	? Inaperturopollenites sp.3	11	11	91
I4a	Inaperturopollenites hiatus (Potonie') Thomson & Pflug, 1953 Group A	11	12	92
I4b	Inaperturopollenites hiatus (Potonie') Thomson & Pflug, 1953 Group B	11	13	92

I5	Indeterminate (cf. _Inaperturopoll._ _incertus_ _fossulatus_ Thomson & Pflug, 1953)	11	14	93
I6	Indeterminate (?)	11	15,16	94
I7	Indeterminate (?)	11	17	94
I8	Indeterminate (cf. _Typha_-type)	11	18,19	94
I9	Indeterminate (cf. _Clavin-aperturites_ _clavatus_ V.d. Hammen & Wymstra, 1964	11	20,21	94

MONOCOLPATE POLLEN GRAINS

MC1	_Proxapertites_ _operculatus_ (V.d. Hammen) Germeraad _et_ _al_, 1968	11	1,2	95
MC2a	_Ovoidites_ _elongatus_ (Hunger) _elongatus_ Krutzsch, 1959	14	1	97
MC2b	_Ovoidites_ _microligneolus_ Krutzsch, 1959	14	2	99

MC3	Indeterminate (cf. Nupharipollis minor Krutzsch, 1970)	11	22,23	100
MC4	Indeterminate	11	24-26	100
MC5	Indeterminate	11	27-30	100
MC6	Indeterminate (cf. Ephedripites (Distachyapites) claricristatus (Shakmundes) Krutzsch, 1970)	11	31,32	100

TRICOLPATE POLLEN GRAINS

TC1	Discoidites borneensis Muller, 1968	14	5-10	101
TC2	Indeterminate (cf. Discoidites novaguineensis Khan, 1976)	14	15-19	102
TC3	Indeterminate (cf. Retitricolpites sp.)	14	3-4	103
TC4	Indeterminate (cf. Tricolpites confessus Stover, 1973)	14	12	103
TC5	Indeterminate (cf. Tricolpites gillii Cookson, 1957)	14	13	103

TC6	Indeterminate (cf. *Tricolpites fissillis* Couper, 1960)	14	14	103
TC7	Indeterminate (cf. *Lonicerapollis gallwitzii* Krutzsch, 1962)	20	1-5	104
TC8	Indeterminate (cf. *Perfortricolpites digitatus* Gonzalez, 1967)	19	10-12	104

TRICOLPORATE POLLEN GRAINS

TCP1a	*Tricolporopoll*. *cingulum oviformis* (Potonie') Thomson & Pflug, 1953	14	20,21	104
TCP1b	*Tricolporopoll*. *cingulum pusillus* (Potonie') Thomson & Pflug, 1953	14	25-28	107
TCP1c	*Tricolporopoll*. *cingulum fusus* (Potonie') Thomson & Pflug, 1953	14	22-24, 29-31	108
TCP2	*Tricolporopoll*. cf. *T. pacatus* Pflug, 1953	14	33,34	110
		15	3,4	110
TCP3	*Tricolporopoll*. cf. *T. rhomboidaliformis* McIntyre, 1968	15	15-17	111

TCP4	<u>Tricolporopoll</u>. <u>euphorii</u> (Potonie')			
	Thomson & Pflug, 1953	15	5-12	113
TCP5	<u>Tricolporopoll</u>. <u>margaritatus</u>			
	(Potonie') Thomson & Pflug, 1953	16	1-2	115
		18	13-18	115
TCP6	<u>Retitricolporites</u> <u>annulatus</u>			
	Salard-Cheboldaeff, 1978	15	18,19	117
		17	28-32	117
TCP7	<u>Rhoipites</u> cf. <u>R.</u> <u>isoreticulatus</u>			
	Kemp, 1977	15	20-25	118
TCP8	<u>Rhoipites</u> sp.	15	26-30	121
TCP9	<u>Margocolporites</u> <u>vanwijhei</u>			
	Germeraad <u>et</u> <u>al</u>., 1968	16	4-6	122
TCP10	<u>Margocolporites</u> sp.	16	1-3	124
TCP11	<u>Bombacacidites</u> cf. <u>B.</u> <u>annae</u>			
	(V.d. Hammen) Leidelmeyer, 1966	18	33-36	125
TCP12	<u>Palaeocaesalpiniaceaepites</u> sp.	16	35,36	126
		18	19,20	126
TCP13	<u>Lanagiopollis</u> cf. <u>L.</u>			
	<u>microrugulatus</u> Morley, 1982	19	1-6	127

TCP14	Indeterminate (cf. <u>Psilatricolporites</u> <u>transversalis</u> Duenas, 1980)	14	32	129
TCP15	Indeterminate (cf. <u>Pollenites</u> <u>pseudocruciatus</u> Potonie', 1931)	14	35-38	129
TCP16	Indeterminate (cf. <u>Nyssa</u>-type)	14	39,40	130
TCP17	Indeterminate (cf. <u>Nyssa</u>-type)	17	16-19	130
TCP18	Indeterminate (cf. <u>Tricolporopoll</u>. <u>eschweilerensis</u> Pflug & Thomson, 1953)	15	1-2	130
TCP19	Indeterminate (cf. <u>Retitricolporites</u> sp.)	15	13,14	131
TCP20	Indeterminate (cf. <u>Retitricolporites</u> sp.)	17	24,27	131
TCP21	Indeterminate (cf. <u>Retitricolporites</u> sp.)	15	35,36	131
TCP22	Indeterminate (cf. <u>Retitricolporites</u> sp.)	15	31,32	132
		17	45,46	132

TCP23	Indeterminate (cf. _Tricolporopoll._ _sustamanni_ Pflug & Thomson, 1953)	15	33,34	132
		17	39,40	132
TCP24	Indeterminate (cf. Polygalaceae-type)	16	13-15	133
TCP25	Indeterminate (cf. Leguminosae-type)	16	19-22	133
TCP26	Indeterminate (cf. _Striatricolporites_ _minor_ Muller, 1968)	16	16-18	133
		16	23-27	133
TCP27	Indeterminate (cf. _Tricolporites_ _paenestriatus_ Stover & Partridge, 1973)	16	28-30	134
TCP28	Indeterminate (cf. _Striatricolporites_ sp.)	18	21-26	134
TCP29	Indeterminate (cf. _Crudia_-type Anderson & Muller, 1975)	16	31-34	135
TCP30	Indeterminate (cf. _Cyrilla_ _racemifora_-type)	17	1-3	135

TCP31	Indeterminate (cf. Capparaceae-type)	17	4,5	135
TCP32	Indeterminate (cf. *Psilatricolporites operculatus* V.d. Hammen & Wymstra, 1964)	17	6-15	136
TCP33	Indeterminate (cf. *Psilatricolporites* sp.)	17	20-23	136
TCP34	Indeterminate (cf. *Retitricolporites* sp.)	17	33-36	137
TCP35	Indeterminate (cf. *Retitricolporites* sp.)	17	37,38	137
TCP36	Indeterminate (cf. *Retitricolporites* sp.)	17	41,42	137
TCP37	Indeterminate (cf. *Retitricolporites* sp.)	17	43,44	138
TCP38	Indeterminate (cf. *Retitricolporites* sp.)	18	7,8	138
TCP39	Indeterminate (cf. *Retitricolporites* sp.)	18	9-12	139

TCP40	Indeterminate (cf. *Foveotricolporites* sp.)	19	7-9	139
TCP41	Indeterminate (cf. *Psilatricolporites* sp.)	20	8	139
TCP42	Indeterminate (cf. *Psilatricolporites* sp.)	20	9	140

SYNCOLPORATE POLLEN GRAINS

SCP1	*Myrtaceidites parvus* Cookson & Pike, 1954	11	3,4	140
SCP2	*Cupanieidites major* Cookson & Pike, 1954	11	5,6	142

POLYCOLPORATE POLLEN GRAINS

PCP1a	*Psilastephanocolporites* sp.A	16	37,38	143
		18	27	143
PCP1b	*Psilastephanocolporites* sp.B	16	39-42	145
		18	28-32	145

MONOPORATE POLLEN GRAINS

MP1a	Graminidites gracilis Krutzsch, 1970	11	34,35	146
MP1b	Graminidites subtiliglobosus (Trevisan) Krutzsch, 1970	11	33	148
MP2	Indeterminate (cf. Graminidites sp.)	11	36	149
MP3	Indeterminate	11	37,38	149
MP4	Indeterminate (cf. Monoporites sp.)	11	39	150

DIPORATE POLLEN GRAINS

DP1	Diporites sp.	12	1,2	150
DP2	Indeterminate (cf. Punctodiporites sp.)	12	4-7	151

TRIPORATE POLLEN GRAINS

TP1	Subtriporopoll. simplex simplex (Potonie' & Venitz) Pflug & Thomson, 1953	12	18,19	151
TP2	Subtriporopoll. cf. S. annulatus nanus Pflug & Thomson, 1953	12	8,9	153
TP3	Triporopoll. cf. T. coryloides Pflug, 1953	12	10,11	154
TP4	Trivestibulopoll. betuloides Pflug, 1953	12	12-15	155
TP5	Striatriporites nigeriensis Hoeken-Klinkenberg, 1966	12	35-36	157
TP6	Intratriporopoll. cf. I. rizophorus (Potonie') Thomson & Pflug, 1953	12	41-43	158
TP7	Indeterminate (cf. Proteacidites sp.)	12	28-31	159
TP8	Indeterminate (cf. Proteacidites sp.)	12	25-27	160

TP9	Indeterminate (cf. <u>Proteacidites</u> sp.)	12	32	160
TP10	Indeterminate (cf. <u>Retitriporites</u> sp.)	12	33,34	160
TP11	Indeterminate (cf. <u>Retitriporites</u> sp.)	12	3	161
TP12	Indeterminate (cf. <u>Trivestibulopoll</u>. prominus Pflug. 1953)	12	16,17	161
TP13	Indeterminate (cf. <u>Intratriporopoll</u>. <u>indubitablis</u> (Potonie') Thomson & Pflug, 1953)	12	37,38	161
TP14	Indeterminate (cf. <u>Intratriporopoll</u>. <u>pilosus</u> Pflug, 1953)	12	39,40	161
TP15	Indeterminate (cf. <u>Triporopollenites</u> sp.)	12	20-24	162

POLYPORATE POLLEN GRAINS

PP1	<u>Periporopoll</u> cf. <u>P.</u> <u>vesicus</u> Partridge, 1973	13	4-7	162

PP2	<u>Polyvestibulopoll</u>. (<u>Alnipoll</u>.) <u>verus</u> (Potonie') Thomson & Pflug, 1953	13	35-37	164
PP3	<u>Polyporopoll</u>. <u>carpinoides</u> Pflug, 1953	13	33,34,38	166
PP4	<u>Persicariopollis</u> <u>meuseli</u> Krutzsch, 1962	20	10-15	168
PP5	Indeterminate (cf. <u>Miocenipollis</u> sp.)	13	24-29	170
PP6	Indeterminate (cf. <u>Miocenipollis</u> sp.)	13	17-23	170
PP7	Indeterminate (cf. <u>Periporopollenites</u> sp.)	13	8-10	171
PP8	Indeterminate (cf. <u>Periporopoll</u>. <u>microprolatus</u> Nakoman, 1968	13	13-15	171
PP9	Indeterminate (cf. <u>Periporopoll</u>. <u>halifani</u> Nakoman, 1967	13	11-12	171
PP10	Indeterminate (cf. <u>Echiperiporites</u> <u>estalae</u> Germeraad <u>et</u> <u>al</u>., 1968	13	1-3	171

PP11	Indeterminate (cf. <u>Polyporopollenites</u> sp.)	13	16	172
PP12	Indeterminate (cf. <u>Polyporopollenites</u> sp.)	13	30-32	172
PP13	Indeterminate (cf. <u>Polyporopoll.</u> <u>undulosus</u> (Wolff) Thomson & Pflug, 1953)	13	39	172

UNKNOWN POLLEN GRAINS

U1	Indeterminate (?)	20	6,7	173
U2	Indeterminate (cf. <u>Fenestrites</u> sp.)	20	18-20	173

OTHERS PLANT MICROFOSSILS

PR1	Indeterminate (? walls of the tracheids)	21	1	173
PR2	Indeterminate (? walls of the tracheids)	21	2	174
PR3	Indeterminate (? woody fragments)	21	3	174

FR1	Indeterminate (cf. type 324 Van Geel et al., 1981)	21	4	174
FR2	Indeterminate (cf. type 359 Van Geel et al., 1981)	21	5	174
FR3	Indeterminate (cf. type 85 Van Geel, 1977)	21	6	174
FR4	Indeterminate (cf. type 351 Van Geel et al., 1981)	21	7,8	174
FR5a	Indeterminate (cf. type 89 Van Geel, 1977)	21	9,10	175
FR5b	Indeterminate (? fungal conidium)	22	2	175
FR6	Indeterminate (cf. type 13 Van Geel, 1977)	21	11	175
FR7a	Indeterminate (cf. type 8B Van Geel, 1977)	21	12	175
FR7b	Indeterminte (? fungal fruit-bodies)	22	2	175
FR8	Indeterminate (cf. *Fusiformis crabbii* Rouse, 1962)	21	13	175

PM	Indeterminate (cf. spores of Bryophyta sp.)	21	14	176

CARBONIFEROUS SPORES

L	*Lycospora pellucida* (Wicher) Schopf, Wilson & Bentall, 1944	22	6,7	177
D	*Densosporites annulatus* (Loose) Smith & Butterworth, 1967	22	3	178
G	Indeterminate (cf. *Granulatisporites* sp.)	22	4	179
AP	Indeterminate (cf. *Apiculatisporites* sp.)	22	5	179

APPENDIX F : CHEMICAL PROPERTIES AND SOME OBSERVATIONS ON PETROLOGY AND ORGANIC GEOCHEMISTRY

Chemical Properties

Chemical properties of coals are generally characterized by their proximate and ultimate analyses. Proximate analysis consists of moisture, volatile matter and ash determinations whilst ultimate analysis give the percentages of the various elements present. In addition the calorific value of coal is a valuable technological parameter.

Ranks of the samples (A.S.T.M. Classification) determined using proximate analytical data (Table F1) are as follows : Sub-bituminous C coal to High-volatile C bituminous coal for Mae Teep samples; Lignite A for Mae Mo samples; Lignite A to Sub-bituminous A coal for Li (Ban Pu) samples; Lignite B to High-volatile A bituminous coal for Mae Tun samples; Lignite A to Sub-bituminous C coal for Krabi (Bang Pu Dam) samples; and Low-volatile bituminous coal for Na Duang samples. It should be noted that the analytical data are compiled from previous investigations by various workers not from the samples collected for this study (e.g. Gibling & Ratanasthien, 1980; Chaodumrong *et al*., 1982; and others).

Petrology

The organic constituents of coal are microscopically recognized as macerals. Three main groups are vitrinite (or huminite for brown coal), exinite (or liptinite for brown coal), and inertinite. They are generally identified by their relative reflectance, colour, and morphology using reflected light microscopy (either normal or fluorescence light). Rank of a given coal can be determined from the reflectivity of the maceral group, vitrinite.

In order to obtain experience of the techniques, ten samples from Mae Mo deposit were studied. The work included maceral analysis and rank determination using reflectivity measurement method.

The particulate blocks of samples were examined using the reflected light microscope and the automatic point counter was used for maceral analysis. The 500 point count was carried out twice on the same polished block for each sample. Rank was also determined by measuring random reflectance of the macerals ulminite and humocollinite. Standard conditions and procedures are followed the outlines described in the International Handbook of Coal Petrography (ICCP, 1971).

The result of maceral analysis is as follows :

<u>Maceral Group Huminite</u>

This group consists of the humotellinite, humodetrinite, and humocollinite subgroups. The maceral ulminite (variety A was found more than B) is the main component of the humotellinite subgroup. The amount of ulminite found in the samples is ranging from 4.1 to 57.6%.

Of the second subgroup, the maceral densinite is predominated. It was found ranging from 26.3 to 80.0%. Densinite is the main constituent in nearly all samples except sample no.85474.

The humocollinite subgroup ranges from 8.7 to 28.3%. No maceral can be clearly identified for this subgroup.

Maceral Group Liptinite

The macerals found in this group consists of sporinite, cutinite, resinite, suberinite and ?liptodetrinite. In this study, the maceral alginite is never found in any sample and the maceral suberinite can be detected under fluorescene light only. Sporinite is the most common maceral of this group. Range of liptinite group is between 2.4 to 6.5%.

Maceral Group Inertinite

This group is composed of the macerals fusinite, semifusinite, macrinite, sclerotinite and inertodetrinite. The maceral sclerotinite is frequently found in all samples at relatively low percentages. The others are occasionally found. The range of the inertinite group is between 0.8 to 3.1%.

Minerals

In this study, pyrite is the most common mineral and easily recognizable. The others are doubtful clay minerals and probably carbonate minerals which are occasionally found. Pyrite is always found as framboids. The individual crystal is observed in some samples. The amounts of minerals (pyrite) range from 0.5 to 1.1%.

Summary of the result of maceral analysis is shown in Table F2.

Reflectance Measurement

Rank was determined by measuring random reflectance of the ulminite and humocollinite of the huminite maceral subgroup (vitrinite for hard coal). Values reported here are the mean of 100 measurements per sample. Procedures for the measurement are clearly described in the International Handbook of Coal Petrography (ICCP, 1971).

The reflectance obtained from ulminite ranges from 0.334 to 0.432% Rm whilst from the humocollnite ranges from 0.383 to 0.463% Rm. Mean reflectances of 100 measurements falls between 0.360 to 0.449% Rm. Using mean reflectance data the bright brown coal rank was obtained for any sample. The result of reflectance measurement is shown in Table F3.

Organic Geochemistry

The organic components of coal are usually soluble in the organic solvent. The solution extracted from the coals always contains three fraction : the non-hydrocarbon, the aromatic hydrocarbon, and the aliphatic hydrocarbon (alkane fraction). These fractions can be separated using column chromatography techniques.

The analytical data obtained from aromatic fraction can be used for the the determination of degree of maturation and age of diagenesis. In addition, the gas chromatogram of the aliphatic (alklane) fraction is useful for the interpretation of the amount and type of the plant input of the samples. In general, the peaks between C_{14} and C_{15} spectra (Sesquiterpenoids) indicated algal input, between C_{19} and C_{20} (Diterpenoids) indicated gymnosperms input, and in the region between C_{22} and C_{33} (Triterpenoids) represented the angiosperms input (see Diagram F1).

In this study, four samples from Mae Mo deposit were extracted using dichloromethane. The extracts then subjected to column chromatograph separated for aliphatic hydrocarbon (alkane) fraction using n-hexane as the separator (aromatic hydrocarbon fraction can be obtained using dichloromethane and non-hydrocarbon by methanol). The alkane fraction was analysed using capillary gas chromatographic techniques. One sample was subjected to gas chromatography-mass spectrometry for Triterpenoids indentification.

Gas chromatograms of all four samples are very similar but the intensity of the spectra is somewhat variable. They are consisted of weak spectra between C_{16} and C_{24} and stronger between C_{25} and C_{33}. The results indicate that the samples were composed mainly of the organic matter derived from the angiosperms plant rather than gymnosperms or algae. The compound identified by mass-spectrometry is probably be $C_{30}\,\Delta^{17\,(21)}$ Hopane (see Diagrams F2 and F3).

DEPOSIT NAME / ANALYSIS	MAE TEEP				MAE MO				(LI (BAN PU)				MAE TUN				KRABI (BANG PU DAM)		NA DUANG
REF.	1	2	3	4	1	5	3	4	6	7	3	4	8	1	3	4	9	4	10
Moisture (%)	18.3	16.6	19.2	19.0	17.7	24.0	17.5	32.5	18.6	23.2	26.5	26.2	20.1	4.8	9.1	7.8	19.8	30.0	6.0
Ash (%)	6.2	24.6	22.2	6.2	14.7	22.5	20.9	19.0	3.4	8.9	12.4	7.5	19.7	12.8	19.2	1.1	6.9	21.0	24.6
Vol. Mat. (1) (%)	46.4	50.8	52.1	42.4	57.0	57.9	49.5	43.4	48.4	67.9	51.9	53.4	51.9	45.1	44.0	45.6	53.2	85.5	17.9
Fixed Carbon (1) (%)	53.6	49.2	47.9	57.6	43.0	42.1	50.5	56.6	51.6	32.1	48.1	46.6	48.1	54.9	56.0	54.4	46.8	14.5	82.1
Cal. Value (2) B.t.u/lb	11,938	9,675	9,306	11,067	7,688	7,292	7,902	6,298	9,419	11,226	7,975	8,446	6,080	14,417	9,440	12,026	9,383	6,908	11,658
MJ/Kg	27.8	22.5	21.6	25.7	17.9	17.0	18.4	14.6	21.9	26.1	18.5	19.6	14.1	33.5	22.0	28.0	22.0	16.0	27.1
Sulphur (%)	6.5	1.5	1.2	6.5	3.0	3.0	1.3	1.6	1.1	2.6	1.9	1.5	0.6	0.6	1.0	0.7	3.1	2.0	0.5

Table F1 Summary of Chemical Analysis of the coal samples from **Thailand**.

(1): dry, mineral matter-free basis Vol. Mat. : Volatile Matter
(2): moist, mineral matter-free basis Cal. Value : Calorific Value

References :
1. Gibling & Rattanasthien (1980)
2. Gibling et al. (1981)
3. Ratanasthien & Ruengwatanasirikul (1984)
4. Coal Working Group (1984)
5. Ratanasthien (1983)
6. Sriroong-rueng (1981)
7. Chaodumrong et al. (1982)
8. Ukkakimaphan & Supertipanish (1975)
9. Poothai & Chana (1969)
10. Ukkakimaphan & Meesuk (1983)

Sample No. \ Random Reflectance (%)	Ulminite				Humocollinite				Average Huminite			
	Mean	S	SE	N	Mean	S	SE	N	Mean	S	SE	N
85465 (MM 1)	.360	.034	.005	49	.405	.034	.005	51	.383	.041	.004	100
85466 (MM 4)	.336	.028	.004	49	.383	.037	.005	51	.360	.040	.004	100
85467 (MM 9)	.432	.046	.007	46	.463	.053	.007	54	.449	.052	.005	100
85468 (MM 12)	.378	.028	.004	55	.403	.028	.004	45	.389	.031	.003	100
85469 (MM 14)	.388	.034	.006	38	.408	.048	.006	62	.400	.044	.004	100
85470 (MM 17)	.387	.031	.004	50	.404	.033	.005	50	.394	.033	.003	100
85471 (MM 20)	.377	.035	.005	56	.394	.026	.004	44	.384	.032	.003	100
85472 (MM 23)	.340	.036	.005	53	.399	.045	.007	47	.368	.050	.005	100
85473 (MM 24)	.334	.038	.006	40	.384	.029	.004	60	.384	.041	.004	100
85474 (MM 26)	.396	.021	.003	66	.417	.024	.004	34	.403	.024	.002	100

Table F2 Summary of Random Reflectance measurements of the coal. samples from Mae Mo deposit, Thailand (S = standard diviation, SE=standard error of the means, N = number of measurements).

Macerals / Sample No.	HUMINITE				LIPTINITE						INERTINITE						
	Humotellinite (Ulminite)	Humodetrinite (Densinite)	Humocollinite	Total	Sporinite	Cutinite	Resinite	Suberinite	Liptodetrinite	Total	Fusinite	Semifusinite	Macrinite	Sclerotinite	Inertodetrinite	Total	Minerals (Pyrites)
85465 (MM 1)	14.2	48.5	28.3	91.0	1.2	1.9	2.9	X	X	6.0	0.9	0.1	X	0.6	0.5	2.1	0.9
85466 (MM 4)	15.1	48.3	23.2	86.6	2.4	1.0	3.1	X	X	6.5	X	X	X	0.8	X	0.8	6.1
85467 (MM 9)	15.0	53.4	23.8	92.2	1.9	1.0	1.1	X	X	4.0	X	0.2	X	2.2	0.2	2.6	1.2
85468 (MM12)	19.5	54.1	19.3	92.9	1.4	0.6	1.5	X	X	3.5	X	0.4	X	1.5	X	1.9	1.7
85469 (MM14)	4.1	80.0	11.7	95.8	1.7	0.8	0.4	X	X	2.9	0.3	X	X	X	0.5	0.8	0.5
85470 (MM17)	9.9	71.5	14.1	95.5	0.6	0.3	1.5	X	X	2.4	X	0.3	0.1	0.8	0.2	1.4	0.7
85471 (MM20)	23.7	56.8	8.7	89.2	2.4	1.5	2.0	X	X	5.9	0.3	1.0	X	1.5	0.3	3.1	1.8
85472 (MM23)	11.8	69.2	12.0	93.0	3.1	1.1	0.4	X	X	4.6	X	0.1	X	0.8	0.4	1.3	1.1
85473 (MM24)	25.7	48.1	17.7	91.5	2.5	1.5	2.1	X	X	6.1	X	0.3	X	1.4	0.2	1.9	0.5
85474 (MM26)	57.6	26.3	10.4	94.3	1.3	1.2	0.7	X	X	3.2	X	0.4	X	1.5	X	1.9	0.6

Table F3 Summary of the Maceral Analysis of the coal samples from Mae Mo deposit, Thailand. The figures represented an average percentages calculated from two analyses by the same worker, using the same instruments, and working on the same polished surface; based on 500 counts per sample; X denotes occurrence in sample but not in count.

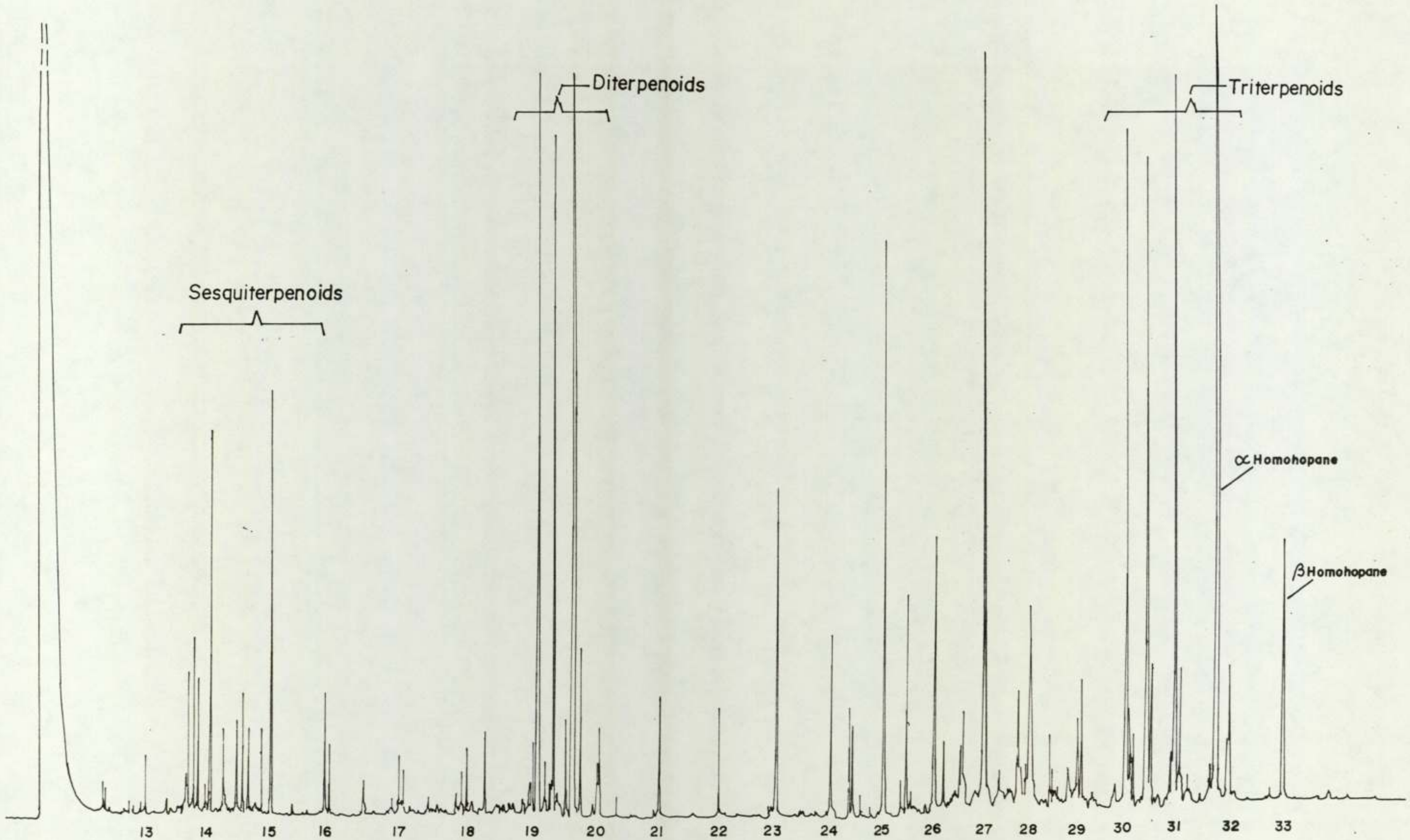


Diagram F1 Example of alkane fraction from Rheinish brown coal (data obtain from Dr. W. Puttman, Lehrstuhl für Erdöl und Kohle, Aachen, W. Germany).

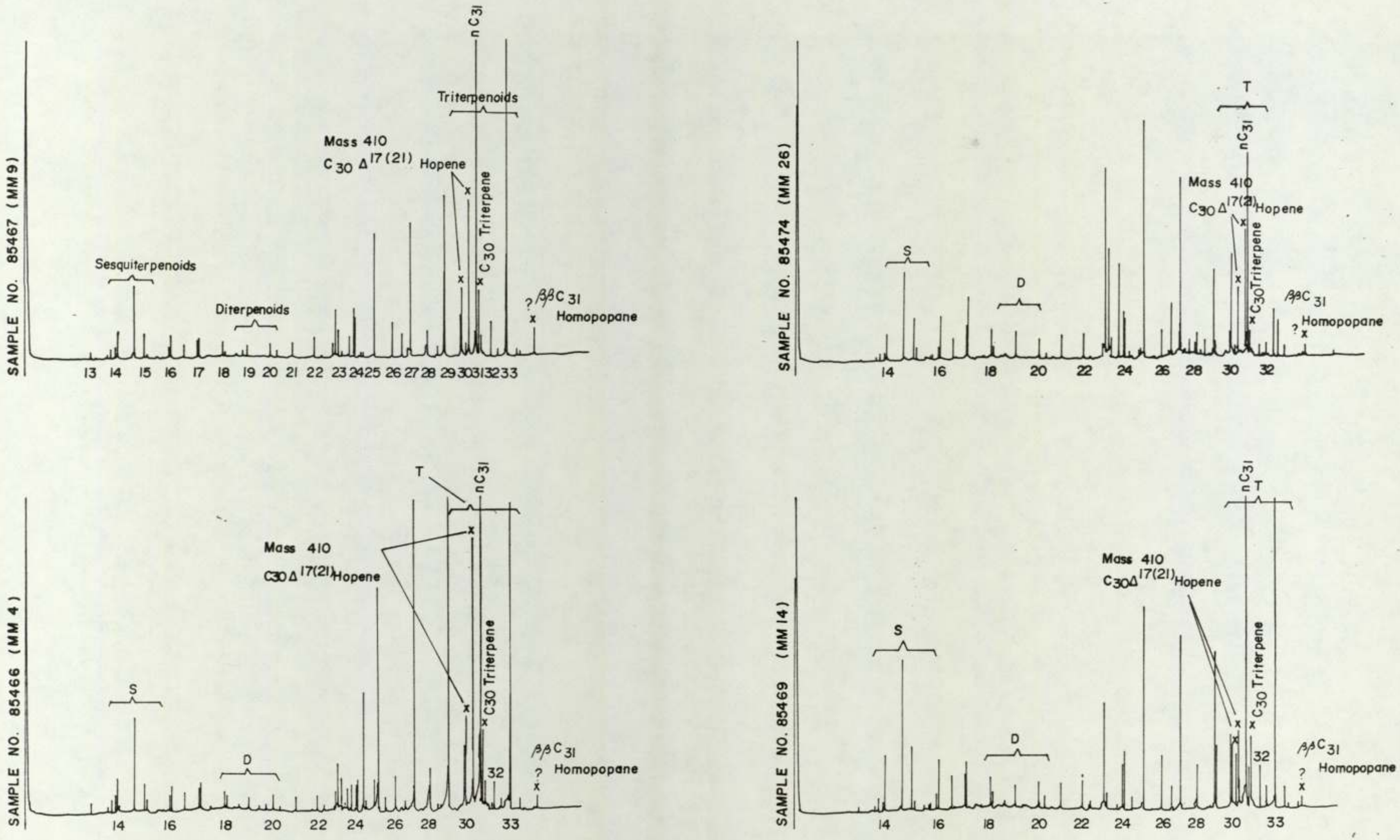


Diagram F 2 Gas chromatograms of alkane fraction from Mae Mo brown coals, Mae Mo Mine, Thailand.
(Data interpreted by Dr.W. Puttman and J. Taylor, Lehrstul für Erdöl und Kohle, Aachen, W. Germany.)

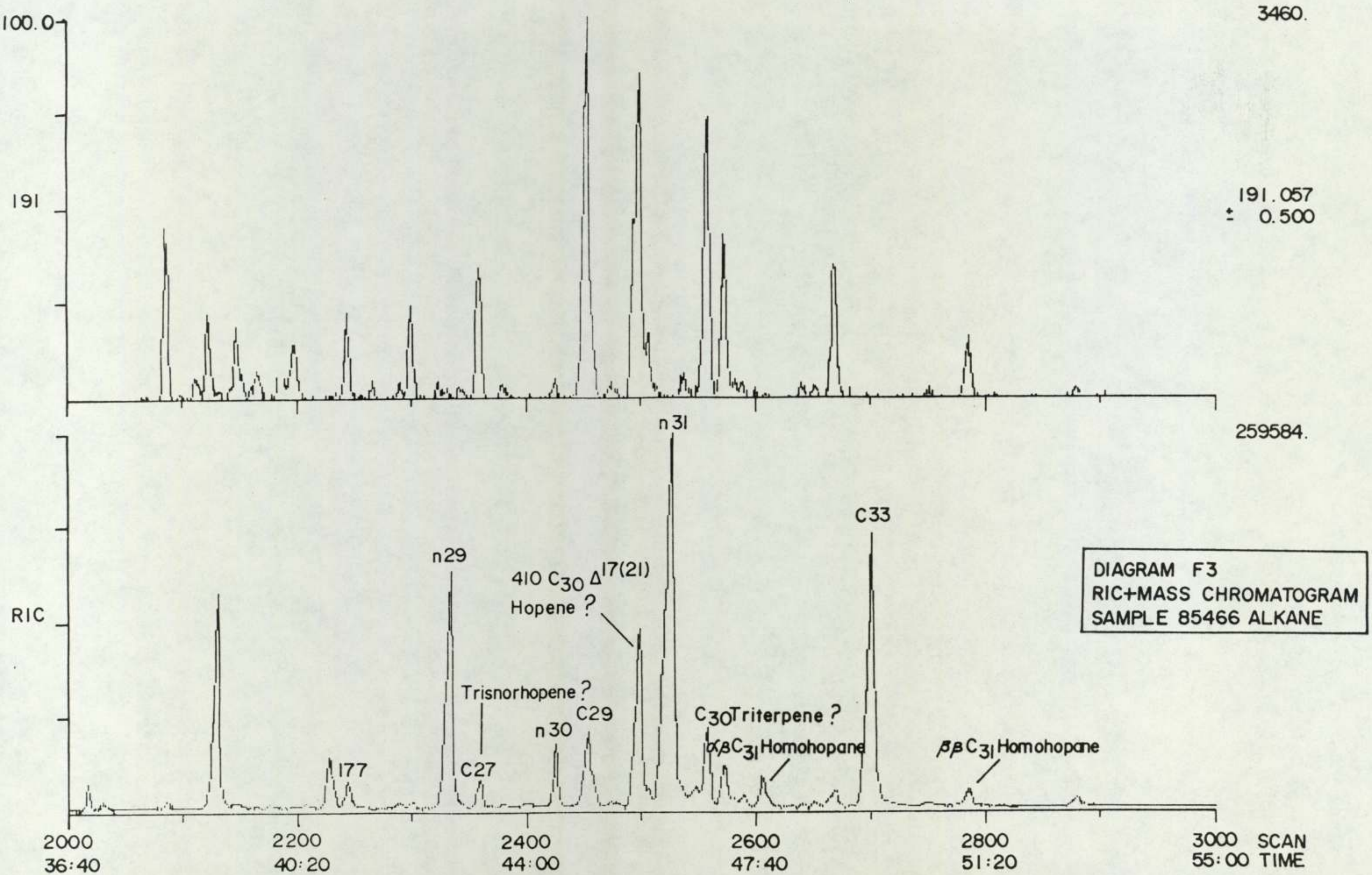


DIAGRAM F3
RIC+MASS CHROMATOGRAM
SAMPLE 85466 ALKANE

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