CHAPTER III

PALYNOLOGY

The palynology can determine climate changes and vegetation from past to present. The pollen deposit in each layer of sediment could be considered the climatic fluctuation.

Thailand is diverse vegetation of 15,000 plant species. The forest can be classified into two types: evergreen and deciduous forests (Santisuk, 2546, in Thai). The evergreen forest is divides into four main categories: tropical evergreen, hill evergreen, pine and mangrove forests. Deciduous forest is divided into four main categories: deciduous, mixed deciduous, savannah and bamboo forests (Rugsat, 2544, in Thai)

1. Evergreen forest

1.1 Tropical evergreen forest occupies all past of the country which dominates in eastern and southern parts. It is always in the vallay and river (Rugsat, 2544, in Thai), and confines at 0-100 meters of elevation (UNEP/EAP.AP, 2006). Dipterocarpaceae (Rugsat, 2544, in Thai) and Leguminocsae are commonly found in this forest type. Many genera in the family Dipterocarpaceae are found such as *Anisoptera*, *Neobalanocarpus*, *Dipterocarpus*, *Hopea*, *Shorea* and *Vatica*. While the distinct leguminous plants are *Butea monosperma* (Lam.) Taub., *Derris dalbergioides* Baker, *Millettia* and *Parkia* (Singhawisai, 1996).

1.2 Hill evergreen forest confines to a higher elevation from 200-1,600 meters from the mean sea level. It scatters in wet zone of the country (UNEP/EAP.AP, 2006). The dominant families are Fagaceae (*Castanopsis*, *Lithocarpus* and *Quercus*) (Rugsat, 2544, in Thai), Magnoliaceae (*Magnolia*, *Manglietia* and *Michelia*), Ericaceae (*Rhododendron*),and Rosaceae (*Docynia* and *Prunus*) (Singhawisai, 1996).

1.3 **Pine forest** covers from upward 700 meters in northern and northeastern region(Rugsat, 2544, in Thai). *Pinus merkusii* Jungh. & de Vriese and *P. kesiya* Royle ex Gordon are dominant species in a forest. An other species are *Vaccinium* spp., *Craibiodendron stellatum* (W.W.Sm.), *Helicia* spp., *Sterculia villosa* Roxb., *Cycas* spp., *Ochna integerrima* Merr. and *Rhododendron* spp (Singhawisai, 1996).

1.4 **Mangrove forest** covers along the estuary of the rivers and shore line. The dominant species in this forest type are in *Bruguiera*, *Ceriops*, *Kandelia*, *Rhizophora*, *Acanthus australasiae* A. Rich., *Cerbera manghas* L., *Sonneratia griffithii* Kurz, and *Hibiscus tiliaceus* L. (Singhawisai, 1996).

2. Deciduous forest

2.1 **Mixed deciduous forest** normally shed the leaves in dry season. It occurrs widely in drier parts of the north, northeast and central (Rugsat, 2544, in Thai), and limits an elevation at 50-600 meters (UNEP/EAP.AP, 2006). The dominant species are *Lagerstroemia macrocarpa* Wall., *L. speciosa* (L.) Pers., *Pterocarpus macrocarpus* Kurz, *Tectona grandis* L.f., *Xylia xylocarpa* (Roxb.) Taub (Singhawisai, 1996).

2.2 **Deciduous dipterocarp forest** almost shed all the leaves in dry season. The vegetation covers at 100-600 meters (UNEP/EAP.AP, 2006). This forest distributes in Myanmar, Laos, Cambodia, and frequently in northeastern Thailand. The common plants are *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb., *D.* spp., *Shorea obtusa* Wall. ex Blume, *S. roxburghii* G. Don, *S. siamensis* Miq. (Rugsat, 2544, in Thai).

2.3 **Savanna forest** in tropical zone characterizes by tall grasses with occasional trees. The limitation of tree is effeced by agricultural practices. Moveover human activities, grassland-burning and cutting the trees in order to cultivate, extend the savanna. The dominant family is only Gramineae (Rugsat, 2544, in Thai).

2.4 **Bamboo forest** resumes the mixed deciduous forest after its having destruction. However it is always a small patch to other forests (Rugsat, 2544, in Thai).

The plant observation by Bunchalee (2004) along the Mun River, carried out between June and August 2004. The survey area covered two kilometers wide along both sides of the river at geographical coordinates of 15° 00' - 15° 03' N latitude and 102° 15' – 102° 19' E longitude. It belongs to Chaloem Phra Kiat and Non Sung Districts. A total number was 212 species in 167 genera, belong to 76 families. They can be classified by 43 spicies of tree, 24 species of climber, 75 species of herb, 55 species of shrub and 17 species of exotic plants. They demonstrated the degenerate forest by abundance of herb which affected by extending of village and villager, agriculture and land management.

Palynology study structure and the formation of pollen grains which are produced by angiosperms and gymnosperms, and spores which are produce by pteridophytes, bryophytes, algae and fungi (Moore, Webb & Collinson, 1991). The most important diagnostic morphological features of spores and pollen grains are size, shape, surface, exine sculpture and aperture (shape, number and position). Pollen are small which are easily transported and highly resistant. They tend to represent the more regional vegetation which not represented in macroflora (Culver & Rawson, 2000). Many pollen grains are carried by insects but they are not transported far by wind and water. 99 % tend to be deposited within one kilometer from the source (Brasier, 1981),

3.1 Previous study of palynology

Ratanasthien (1984) dated some Tertiary coal and oil deposits in Northern Thailand by using spore and pollen. *Appendicisporites triconitatus*, *Cicatricososporites drumhellerensis*, *Plicatella* sp., *Verrumonoletes* sp., *Laevigatosporites* sp. and *Lophotriletes* sp. are present in the oil bearing formation for Fang, as well as the coal bearing formation of Mae Teep and Mae Tun. Lower Tertiary of Senonian or Paleogene age given. The presence of *Spinozonocolpites* cf. *echinatus* and *Rugubivesiculites* sp.

in the Fang shales is interpreted to indicate a nearshore-deltaic facies and marine incursions as the deposition environment.

Sangsuwan, Jongkanjanasoontorn & Hillen (1986) devided the Bangkok Clay which is exposed in the Senanivate pit, Bangkok metropolis into five pollen zones (from the bottom to the uppermost respectively). Zone I: rarely preserved pollen because of oxidation under terrestrial condition, during sediment deposition. Zone II: abundant Gramineae pollen, and *Ceratopteris* spores which indicate to freshwater conditions. Zone III: 90 percent mangrove species, the abundance of Rhizophoraceae is related to intertidal conditions. Zone IV: no plant macrofossils and vegetation in situ as well as fine-grained sediment, mangrove species are indicate to subtidal conditions, due to transportation. Zone V: appear the weathered sandy clay and absence of pollen.

Ratanasthien and Haraluck (1988) studied the palynology of several oil-exploration core samples in the Fang Basin. They found two palynological zones, 1. *Verrucatosporites usmensis* (Pantropical Zones), it was widespread in the Upper Eocene (45-38 Ma). 2. *Magnastriatites howardi* (Pantropical Zones), is found in fresh-water lakes of tropical climates and was widespread in the Oligocene to Lower Miocene (38-22 Ma).

Watanasak, Songtham & Mildenhall (1995) determined the age of two coal-bearing terrestrial sequences at Susan Hoi and Krabi Coal Mine in the Krabi basin, Southern Thailand using pollen. They found *Polypodiisporites usmensis* which is Oligocene or younger, *Echiperiporites* cf. *E. estelae* which is Miocene or younger, *Pandanniidites texus* which is Miocene or younger and *Florschuetzia trilobata* which was the dominant of mangrove pollen type.

Ampaiwan (2000) studied the Tertiary palynology of a coal-bearing unit in Mae Ramat basin, Tak Province. He is found one biozone composed of two subzones; *Laevigatisporites* Biozone is dominated by *Lavigatisporites* sp. and *Trilites verrucatus-Graminidites* Subzone, which is the assemblage zone of *Graminidites* sp., *Liquidambarpollenites* sp., *Momipites coryloides*. *Pinuspollenites* sp., *Polydiisporites usmensis*, *Polypodiaceoisporites* sp. and *Trilites verrucatus* and *Magnastriatites*

grandiosus Subzone, the dominated spore is *Magnastriatites grandiosus*, from the lower to the upper respectively. Palynological indicator comparative with lithological result can estimate the occurrence of the site. A deposition of sediment occur in fresh-water lake of tropical rain forest and tropical humid climate of Early Miocene.

Sun, Luo, Huang, Tian & Wang (2003) observed pollen from the deep-sea of the South China Sea. They were interpreted to be Pleistocene epoch of East Asian Monsoon. Pinus-dominant pollen zones was related to the lighter δ^{18}o values with correspond to interglacial periods, and herb-dominant pollen zones was related to the heavier δ^{18}o values with correspond to glacial periods. The winter monsoon was interpreted by tree pollen which began from 600 ka, the summer monsoon can be assigned by the fern spore abundance which was related to high humid conditions before 600 ka.

Wannakoaw (2004) investigated palaeo-vegetation and climatic changes in the Holocene period using pollen analysis and radiocarbon dating at Thung Salang Luang National Park, Pitsanulok Province. The results showed that the dominant of both palaeo-ecological system were sub-tropical forest (common microfloras were *Pinus* sp., Liliaceae and Iridaceae) and Tropical forest (common microfloras were Dipterocarpaceae, Polygonaceae and Compositae), however they were similar to the plant community of forest types in the site at present. Furthermore the data from radiocarbon dating of carbon sample at the depth of 97 cm. (SLL728) was 1,150 ± 40 BP and predicted the age by using Linear extrapotation at the depth of 74 cm was 877 ± 40 BP. The pollen of Gramineae appear increasing since 877 ± 40 BP may remind to forest which having fire occurrence.

3.2 Methodology of palynology

3.2.1 Sample collection

Sampling depended on the grain size of the sediments. They were generally taken from fine-grained layers, the mud to fine sand sediments in the profile. Cut off the outer surface of the sample by knife to prevented contamination with modern-pollen

and spores. The sample was colleted in a plastic bag, and labeling. Fourtty-two samples were collected from the profile (Fig. 7 and Table 1).

3.2.2 Palynological extraction

Fourthty-two samples have been palynologically prepared according to preparation method of the Laboratory for Palaeobotany and Palynology (LPP), Utrecht, the Netherland. The procedure is as follows.

1. Clean all surfaces of samples by razor blade. Use 50 g and transfer it into mortar for gentle crush. Removed sample into polypropylene bottle.

2. Add 150 ml of 30 percentage with hydrochloric acid (HCl) into bottle for removing calcium carbonate, and leave over night until particles settled and decant the water out. Washing the sample by distilled water and leave over night for three times.

3. Add 150 ml of 40 percentages of hydrofluoric acid (HF) into bottle to removed silica, by slowly and carefully for the reaction, and leave over night until particles settled and decant the water out. Washing the sample by distilled water and leave over night for three times.

4. Removing silicates waste by adds 38 percentage of hydrochloric acid into bottle. Washing the sample by distilled water and leave over night for two times.

5. Sieve and wash the sediment through the metal mesh (100 µm aperture diameter) and the lower mesh is support by bowl, then drain the sediment through the metal mesh (14 µm), Put the sediment that is larger than 100 µm into vial tube (10 ml volume).

6. Separated the palynomorph from sediment used by added zinc chloride solution ($ZnCl_2$ density 2 + water) into vial tube. Centrifuge the tube at 2,500 rpm. for 10 minutes.

7. Drain the upper part of liquid in vial tube to metal mesh (14 µm) and wash by distilled water. Keep the sample into vial bottle (7.5 ml volume) and add 2 ml of glycerin water, stir, label. Put vial in 60° oven overnight to remove water.

8. Mounting residues by heat slide on gentle warm plate, and add one drop of sample. When the sample completely dry, add a piece of glycerin jelly mixed to sample. While the slide still warm, cover with coverslip.

*Note: the instruments are acid resistant and easier to clean.

3.2.3 Palynological identification and counting

A convenient to identify and count palynomorph under a light microscope is x400, with the oil immersion lens at x1000 to identify difficult grains. 300 spores and pollen was counted per slide. Their percentage calculated the proportion of each plant. Each percentage of plant was categorized, which based on its own forest type of habitat. Pollen diagram was drawn for paleovegetational and palaeoclimatic interpretations.

3.3 Result of palynological study

From 42 samples that were collected and palynological extraction for palynological slides. Two duplicate slide sets were made per one palynological sample. Fifthteen sediment samples considered to palynomorph analysis. Three hundred recognizable palynomorphs grains were counted for each palynological sample. The pre-survey of palynomorphs in slides, it show in a table 1.

Table 1.1 Sample collection.

Sediment samples no.	Depth (m)	Sediment samples component	Palynomorphs survey in slides
S01	0.05	Dark gray clay with reddish brown mottles and rootlets.	Rare
S02	0.35	Dark gray clay with reddish brown mottles and rootlets.	Rare
S03	0.75	Dark gray clay with reddish brown mottles and rootlets.	Rare
S04	1.10	Dark gray clay with reddish brown mottles and rootlets.	Rare
S05	1.50	Dark gray clay with reddish brown mottles and rootlets.	Rare
S06	1.85	Dark gray clay with reddish brown mottles and rootlets.	Rare
S07	2.25	Dark gray clay with reddish brown mottles and rootlets.	Rare
S08	2.60	Dark gray clay with reddish brown mottles and rootlets.	Abundant
S09	3.00	Dark gray clay with reddish brown mottles and rootlets.	Rare
S10	3.35	Dark gray clay with reddish brown mottles and rootlets.	Rare
S11	4.05	Dark gray clay with reddish brown mottles and rootlets.	Abundant
S12	4.30	Dark gray clay with reddish brown mottles and rootlets.	Abundant
S13	4.65	Dark gray clay with reddish brown mottles and rootlets.	Abundant
S14	5.00	Dark gray clay with reddish brown mottles and rootlets.	Abundant
S15	5.35	Dark gray clay with reddish brown mottles and rootlets.	Abundant
S16	5.90	Dark gray silty clay.	Abundant
S17	10.75	Dark clay, sand and pebble.	Abundant
S18	11.50	Black clay.	Abundant
S19	11.60	Gray very fine sand.	Rare
S20	12.00	Gray very fine sand.	Rare
S21	12.40	Gray very fine sand.	Rare

Table 1.2 Sample collection (cont.)

Sediment samples no.	Depth (m)	Sediment samples component	Palynomorphs survey in slides
S22	12.90	Gray very fine sand.	Medium
S23	14.10	Gray clayey silt with abundant of bamboo fragment.	Medium
S24	14.60	Gray clayey silt with abundant of bamboo fragment.	Abundant
S25	15.05	Gray clayey silt with abundant of bamboo fragment.	rare
S26	15.50	Gray clayey silt with abundant of bamboo fragment.	Abundant
S27	15.95	Gray clayey silt with abundant of bamboo fragment.	Abundant
S28	16.40	Gray clayey silt with abundant of bamboo fragment.	Abundant
S29	17.05	Black clay.	Medium
S30	17.50	Very coarse sand to granule.	Rare
S31	19.15	White fine sand.	Rare
S32	19.60	Gray very fine sand.	No preservation
S33	20.45	Gray very fine sand with rootlets & small plant fragments.	Abundant
S34	22.55	Black clay with pebble embedded inside.	Medium
S35	23.20	Light gray silt to very fine sand with gray clay nodules.	Abundant
S36	23.50	Light gray silt to very fine sand with gray clay nodules.	Medium
S37	23.75	Light gray silt to very fine sand with gray clay nodules.	Medium
S38	24.05	Light gray silt to very fine sand with gray clay nodules.	Abundant
S39	24.20	Light gray silt to very fine sand with gray clay nodules.	No preservation
S40	24.55	Light gray silt to very fine sand with gray clay nodules.	No preservation
S41	24.95	Light gray silt to very fine sand with gray clay nodules.	No preservation
S42	25.35	Light gray silt to very fine sand with gray clay nodules.	Rare

According to the present study of fifthteen sediment samples, 59 palynomorphs taxa could be recognized. 54 taxa are described in this study. They are arranged alphabetically and higher taxa to lower taxa under bold capital titles of pteridophytic spores, gymnospermic pollen, angiospermic pollen. The terminology used in to describe shape, size, sculpture on the exine, structure of the exine, and aperture characterristics is based on the work of Erdtman (1952) as followed.

Group 1. Fungal spores, 5 taxa were recognized: Fungal spore type, *Foveodiporites* type, *Fusiformisporites* type A, *Fusiformisporites* type B, and *Pluricellaesporites* type.

Group 2. Pteridophytic spores, 29 taxa were recognized into two sub-groups. 2.1 Sub-group monolete spores: Aspleniaceae type, *Asplenium* type, Dryopteridaceae type A, Dryopteridaceae type B, *Dryopteris* type A, *Dryopteris* type B, Filicopsida type, Polypodiaceae type, *Polypodium* type A, *Polypodium* type B, *Polypodium* type C and *Polypodium* type D. 2.2 Sub-group trilete spores: *Ceratopteris* type A, *Ceratopteris* type B, *Ceratopteris* type C, Cyatheaceae type A, Cyatheaceae type B, Cyatheaceae type C, *Cyathea* type A, *Cyathea* type B, Cyathea type C, Dicksoniaceae type A, Dicksoniaceae type B, *Lycopodium* type, *Osmunda* type, Pteridophyta type A, Pteridophyta type B, *Selaginella* type A, and *Selaginella* type B.

Group 3. Gymnospermic pollens, 4 taxa were recognized: *Darcrycarpus* type, Pinaceaea type, *Pinus* type A and *Pinus* type B.

Group 4. Angiospermic pollens, 21 taxa were recognized into two sub-groups. Sub-group 4.1 Monocotyledonous pollen: *Borassus* type, Cyperaceae type A, Cyperaceae type B, Cyperaceae type C, Cyperaceae type D, Poaceae type A, Poaceae type B, Poaceae type C and *Sagittaria* type. 4.2 Dicotyledonous pollen: *Altingia* type, Asteraceae type A, Asteraceae type B, Asteraceae type C, Caesalpinioideae type, *Castanopsis* type, *Croton* type, *Lemna* type, Mimosoideae type A, Mimosoideae type B, *Mimosa* type and *Tribulus* type.

Group 1. Fungal spores

Fungal spore type

Not described. Plate 21 (S42), i-ii.

Foveodiporites type (Fungal spore)

Not described. Plate 18 (S36), iv-vi.

Fusiformisporites type A (fungal spore)

Not described. Plate 12 (S28), xxxvi-xxxvii.

Fusiformisporites type B (fungal spore)

Not described. Plate 16 (S34), iv-v.

Pluricellaesporites type (fungal spore)

Not described. Plate 12 (S28), xxxiv-xxxv.

Group 2. Pteridophytic spores

Aspleniaceae type

Spore monolete, heteropolar, bilaterally symmetric; sclerine 4 micron thick, apparently reticulate; perine present, membraneous; amb elliptic (proximal view), concave-convex in lateral view; spores 60x40 micron (lateral view). Plate 8 (S18), i-iii.

Asplenium type (Aspleniaceae)

Spore monolete, heteropolar, bilaterally symmetric; sclerine 0.8 micron thick, apparently psilate; perine present with undulating membraneous ridges; sculpture

scabrate; amb elliptic to circular (proximal view); spores 33x35 micron (distal view). Plate 8 (S18), iv-vi and Plate 17 (S35), i-ii.

Dryopteridaceae type A

Spore monolete, heteropolar, bilaterally symmetric; sclerine 3-5 micron thick (including ornamentation); apparently reticulate; perine 2-4 micron thick, membraneous, curving and twisting ridges; amb circular (proximal view); spores 20-24 micron (proximal view). Plate 5 (S16), i-iii.

Dryopteridaceae type B

Spore monolete, heteropolar, bilaterally symmetric; sclerine 8-10 micron thick (including ornamentation); perine 7-8 micron thick, membraneous, curving and twisting ridges; amb circular to elliptic, plano-convex in lateral view; spores 49x38 micron (lateral view). Plate 5 (S16), iv-vi.

Dryopteris type A (Dryopteridaceae)

Spore monolete, heteropolar, bilaterally symmetric; sclerine 11-14 micron thick (including ornamentation); perine 10-13 micron, curving and twisting ridges; sacci intersect and anastomose; amb elliptic to circular (proximal view), elliptic-biconvex in lateral view; spores 78x60 micron (lateral view). Plate 3 (S15), i-v.

Dryopteris type B

Spore monolete, heteropolar, bilaterally symmetric; sclerine 2-3 micron thick (including ornamentation); perine 1-2 micron curving and twisting ridges; amb elliptic (proximal view), concave-convex in lateral view; spores 49x30 micron (lateral view). Plate 3 (S15), vi-ix.

Filicopsida type

Spore monolete, heteropolar, bilaterally symmetric; sclerine 0.7 micron thick; sculture psilate to scabrate; laesurae ¾ length of spore; margo inconspicuous;

amb broad elliptic (proximal view); spores 28x22 micron (proximal view). Plate 17 (S35), iii-iv.

Polypodiaceae type

Spore monolete, heteropolar, asymmetric; sclerine 1 micron thick (including ornamentation), psilate; laesurae narrow, sinuous, as long as of spores; margo inconspicuous; amb elliptic-biconvex (proximal veiw); spores 36x22 (proximal view) micron. Plate 8 (S18), vii-x.

Polypodium type A (Polypodiaceae)

Spore monolete, heteropolar, bilaterally symmetric; sclerine (0.8-) 1-2 micron thick (ornamentation excluded), verrucate; amb elliptic (proximal view), plano-convex in lateral view; spores (45-) 57-58x23-25 (-30) micron (proximal view). Plate 1 (S08), i-iv; Plate 3 (S15), x-xii; Plate 5 (S16), vii-ix; Plate 11 (S28), i-iii; Plate 13 (S29), i-ii and Plate 14 (S33), i-iv.

Polypodium type B

Spores monolete, heteropolar, bilaterally symmetric; sclerine 1 micron (ornamentation excluded), finely verrucate; amb elliptic to circular (proximal veiw), plano-convex in lateral view; spore 60x35 micron (lateral view). Plate 5 (S16), x-xii.

Polypodium type C

Spores monolete, heteropolar, bilaterally symmetric; sclerine 1 micron (including ornamentation), scabrate; laesurae narrow, sinuous, ¾ length of spore; margo inconspicuous; amb oblong (proximal view); spore 30x18 micron (proximal view). Plate 17 (S35), v-vi.

Polypodium type D

Spore monolete, heteropolar, bilaterally symmetric; sclerine 0.8 micron (ornamentation excluded), verrucate; verrucae protruding, 0.8 micron height; amb elliptic to circular; spores 30 micron (lateral view). Plate 20 (S38), i-ii.

Ceratopteris type A (Parkeriaceae)

Spore trilete, heteropolar, radially symmetric; sclerine striate; laesurae straight; concave-convex in lateral view; spores (110-) 80x74 micron (lateral view). Plate 1 (S08), v-vi and Plate 5 (S16), xiii-xv.

Ceratopteris type B

Spore trilete, heteropolar, radially symmetric; sclerine striate; laesurae narrow, straight, covering ¾ of the proximal face; margo inconspicuous; amb subtriangular-convex; spores 92-98x48-53 micron (distal view). Plate 10 (S21), i-ix; Plate 13 (S29), iii-vii and Plate 14 (S33), v-viii.

Ceratopteris type C

Spore trilete, heteropolar, radially symmetric; sclerine striate; laesurae narrow, straight, covering ¾ of the proximal face; margo inconspicuous; amb subtriangular-convex (proximal view); plano-convex in lateral view; spore 45 micron (lateral view). Plate 16 (S34), i-iii; Plate 17 (S35), vii-x and Plate 19 (S37), i-iii.

Cyatheaceae type A

Spore trilete, heteropolar, radially symmetric; sclerine 0.8-1 micron thick (including ornamentation), psilate; laesurae narrow, straight, as long as radius; thin margo present; amb subtriangular (proximal view); spores 35-37 (40) micron (proximal view). Plate 1 (S08), vii-xi; Plate 3 (S15), xiii-xiv; Plate 7 (S17), i-ii and Plate 8 (S18), xiv-xvii.

Cyatheaceae type B

Spore trilete, heteropolar, radially symmetric; sclerine 1 micron thick (including ornamentation), slightly scabrate; laesurae narrow, straight, as long as radius; apparently thick margo present; amb trilobate (proximal view); spores 34-35 micron (proximal view). Plate 1 (S08), xii-xiv.

Cyatheaceae type C

Spore trilete, heteropolar, radially symmetric; sclerine 1 micron thick, regulate, laesurae covering ¾ of the proximal face; amb subtriangular (proximal view), spores 22 micron, 23x16 micron in lateral view. Plate 8 (S18), xi-xiii and Plate 11 (S28), iv-v.

Cyathea type A (Cyatheaceae)

Spore trilete, heteropolar, radially symmetric; sclerine 5-6 micron thick (including ornamentation), verrucae protruding; laesurae wide, covering ¾ of the proximal face; thick margo present; amb subtriangular-semiconcave (proximal view); spores 43-45 micron (proximal view). Plate 1 (S08), xv-xxi.

Cyathea type B

Spore trilete, heteropolar, radially symmetric; sclerine 1.5-2 micron thick (including ornamentation), psilate; laesurae narrow, sinuous, as long as radius; margo inconspicuous; amb subtriangular (proximal view); spores 29-30 (-40) micron (proximal view). Plate 3 (S15), xv-xvi and Plate 5 (S16), xvi-xviii.

Cyathea type C

Spore trilete,heteropolar, radially symmetric; sclerine slightly gemmate-psilate (proximal view), reticulate and gemmate in lumen; laesurae narrow, straight, as long as radius; margo conspicuous, and thick at center of trilete; amb subtriangular (proximal view); spores 38-45 micron (proximal view). Plate 8 (S18), xviii-xxi and Plate 11 (S28), vi-ix.

Dicksoniaceae type A

Spore trilete, heteropolar, radially symmetric; sclerine 3-6 micron thick (including ornamentation), thickening at angles; psilate in proximal view, striate in distal view; laesurae stright, as long as radius; margo conspicuous, thicker at center of trilete; amb subtriangular (proximal view), plano-convex in lateral view; spores (42-) 45-53 micron (proximal view), 50x36 micron in lateral view. Plate 1 (S08), xxii-xxv; Plate 3

(S15), xvii-xix; Plate 11 (S28), x-xiii; Plate 13 (S29), viii-ix; Plate 14 (S33), ix-xii and Plate 20 (S38), iii-v.

Dicksoniaceae type B

Spore trilete, heteropolar, radially symmetric; sclerine 4 micron thick (ornamentation included) with thickening at angles; spores psilate; laesurae slightly sinuous, as long as radius; margo thicker at the base of each radius; amb subtriangular (proximal view); spores 52-55 micron (proximal view). Plate 8 (S18), xxiv-xxvi.

Lycopodium type (Lycopodiaceae)

Spore trilete, heteropolar, radially symmetric; sclerine 5 micron thick (including ornamentation), reticulate; laesurae acute, ¾ length of radius; amb subtriangular (proximal view); spores 65-76 micron (proximal view). Plate 1 (S08), xxvi-xxviii; Plate 2 (S08), xxix and Plate 5 (S16), xix-xxiii.

Osmunda type (Osmundaceae)

Spore trilete, heteropolar, radially symmetric; sclerine 3 micron thick, rugulate sometime joning sideways to form a reticulate, laesurae narrow, straight, covering ¾ of radius; amb subtriangular-convex (proximal view); spores 37 micron (proximal view). Plate 3 (S15), xx-xxii.

Pteridophyta type A

Spores trilete, heteropolar, radially symmetric; sclerine 2 micron thick, scabrate; laesurae straight, narrow, as long as radius; thin margo present; amb subtriangular to circular (proximal view); spores 43 micron (proximal view). Plate 5 (S16), xxiv-xxv.

Pteridophyta type B

Spore trilete, heteropolar, radially symmetric; sclerine 1.5 micron thick, scabrate; laesurae narrow, straight, as long as radius; margo thin; amb subtriangular-concave (proximal view); spore 23-35 micron (proximal view). Plate 8 (S18), xxiv-xxvi.

Selaginella type A (Selaginellaceae)

Spore trilete, heteropolar, radially symmetric; sclerine thin 1 micron thick, pattern apprently slightly scabrate; laesurae narrow, as long as spore; amb subtriangular (proximal view); spores 30 micron (proximal view). Plate 3 (S15), xxiii-xxv.

Selaginella type B

Spore trilete, heteropolar, radially symmetric; sclerine thin 1 micron thick, pattern apprently apparently reticulete; laesurae inconspicuous; amb subtriangular (proximal view); spores 83x58 micron (lateral view). Plate 10 (S21), x-xii.

Group 3. Gymnospermic pollens

Darcrycarpus type (Podocarpaceae)

Grain bisaccate, diploxylonoid; bilaterally symmetric, heteropolar; exine 4 micron (includidng ornamentation); sexine rugulate; corpus rounded; sacci frill; total length of corpus and sacci 40 micron. Plate 2 (S08), xxx-xxxii.

Pinaceae type

Grain bisaccate, diploxylonoid, bilaterally symmetric, heteropolar; exine 1 micron; corpus hemisherical psilate, 40x23 micron; sacci hemispherical, finely reticulate, 30x15 micron. Plate 14 (S33), xiii-xiv.

Pinus type A (Pinaceae)

Grain bisaccate, diploxylonoid; bilaterally symmetric, heteropolar; exine 2 micron thick; corpus rounded, scabrate; sacci hemisherical, reticulate; total length and wide of corpus and sacci (63-) 57-53x32-35 (-43) micron. Plate 2 (S08), xxxiii-xxxv; Plate 3 (S15), xxvi-xxviii; Plate 5 (S16), xxvi-xxviii; Plate 7 (S17), iii-v; Plate 8 (S18), xxvii-xxviii and Plate 9 (S18), xxix.

Pinus type B

Grain bisaccate, diploxylonoid; bilaterally symmetric, heteropolar; exine 2 micron thick; corpus rounded, scabrate, cappa 2 micron thick, cappa thicker than cappula; sacci globose, reticulate; total length and wide of corpus and sacci 77x50 micron. Plate 7 (S17), vi-xiii.

Group 4. Angiospermic pollens

Borassus type (Palme)

Grain monad, heteropolar, bilaterally symmetric; monosulcate; exine 1 micron thick (ornamentation excluded); sexine echinate-psilate; spine scarcely scattered, conical, ca. 2 micron height; amb elliptic; grains suboblate (distal view), 28x25 micron. Plate 7 (S17), xvi-xx.

Cyperaceae type A

Grain monad, heteropolar, bilaterally symmetric; pseudopores (4-aperturate); exine 1 micron thick; sexine scabrate; amb circuar; grains 26-30 micron, pare sharp. Plate 2 (S08), xxxvi-xxxvii. Plate 4 (S15), xxxiv-xxxvi and Plate 18 (S36), i-iii.

Cyperaceae type B

Grain monad, heteropolar, bilaterally symmetric; pseudopores present; exine 1 micron thick; sexine psilate; amb circuar; grains ovoid (lateral view), 34-36 micron. Plate 2 (S08), xxxviii-xxxix.

Cyperaceae type C

Grain monad, apolar, radially symmetric; pore inconspicuous; exine 1 micron thick; sexine scabrate; grains spheroidal, 23-25 micron. Plate 6 (S16), xxix-xxx.

Cyperaceae type D

Grain monad, heteropolar, bilaterally symmetric; triporate; exine 1 micron thick; sexine scabrate; pores appearing as pseudoapertures; grains pare sharp, amb irregularly rounded; grains 27x20 micron. Plate 11 (S28), xiv-xv.

Poaceae type A

Grain monad, heteropolar, bilaterally symmetric; monoporate; exine 1-2 micron thick; sexine psilate to slightly scabrate; pore circular, protruding, 2-3 micron diameter, annulate; amb circular; grains 25-33 micron. Plate 4 (S15), xxix-xxx; Plate 6 (S16), xxx-xxxiii; Plate 7 (S17), xiv-xv; Plate 9 (S18), xxxi-xxxii; Plate 10 (S21), xiii; Plate 11 (S28), xvi-xix and Plate 14 (S33), xv-xx.

Poaceae type B

Grain monad, heteropolar, bilaterally symmetric; monoporate; exine 2 micron thick; sexine psilate; pore circular, protruding, 2 micron diameter, annulate; amb circular; grains 21-22 micron. Plate 4 (S15), xxxi-xxxiii and Plate 6 (S16), xxxiv-xxxv.

Poaceae type C

Grain monad, heteropolar, bilaterally symmetric; monoporate, wrinkle; exine 0.8 micron thick; sexine psilate-slightly scabrate; pore circular, protruding, 2 micron diameter, annulate; amb circular; grains 34 micron. Plate 20 (S38), vi-viii.

Sagittaria type (Alismataceae)

Grain monad, apolar, radially symmetric; periporate; exine 1.8 micron thick (ornamentation excluded); sexine echinate, spine conical, sharp, 4 micron length; grian spheroidal, 22-25 micron (ornametation included). Aquatic herb. Plate 4 (S15), xxxvii-xl.

Altingia type (Hamamelidaceae)

Grain monad, apolar, asymmetric; pores circular, periporate (14-porate), 4-5 micron diameter; exine 0.8-1 micron thick; sexine reticulate; pores circular, 5 micron

diameter; grains spheroidal, 26-32 micron. Plate 2 (S08), xl-xlvi; Plate 6 (S16), xxxvi-xxxix; Plate 11 (S28), xx-xxii and Plate 14 (S33), xxi-xxv.

Asteraceae type A

Grain monad, isopolar, radially symmetric; tricoporate; exine 5 micron thick (ornamentation excluded); sexine strongly separated from nexine; sexine echinate, spine conical, wide base, slightly curve, ca. 6 micron height; amb trilobate; grains spheroidal, 27-30 micron (including ornamentation). Plate 11 (S28), xxiii-xxv.

Asteraceae type B

Grain monad, isopolar, radially symmetric; tricoporate; exine 2 micron thick (ornamentation excluded); sexine strongly separated from nexine; sexine echinate, spine conical, wide base, 2-3 micron height; amb circular-trilobate; grains spheroidal, 17-23 micron (including ornamentation). Plate 11 (S28), xxvi-xxvii; Plate 14 (S33), xxvi-xxviii and Plate 15 (S33), xxix.

Asteraceae type C

Grain monad, isopolar, radially symmetric; tricolporate; exine 3 micron thick (ornamentation excluded), sexine echinate; spine sharp, conical, wide base, with scabrate process between them; amb circular; grains prolate-spheroidal, 27-28x25-26 micron (including ornamentation). Plate 4 (S15), xli-xliv and Plate 6 (S16), xl-xlii.

Caesalpinioideae type

Grain monad, isopolar, radially symmetric; tricolporate; exine 1 micron thick; sexine striate; colpi as long as grain; amb trilobate; grains prolate, 25-28x18-20 micron. Plate 4 (S15), xlv-xlvii and Plate 6 (S16), xliii-xlvii.

Castanopsis type A (Fagaceae)

Grain monad, isopolar, radially symmetric; tricolporate; exine 1 micron thick; sexine psilate to slighly scabrate; amb circular-trilobate; grains prolate to subprolate, 30-32x15-18 micron. Plate 4 (S15), xlviii-l and Plate 9 (S18), xxxiii-xxxiv.

Croton type (Euphorbiaceae)

Grain monad, apolar, asymmetric; inaperturate; exine 2-3 micron thick; sexine clavate; grains spheroidal, 37-45 micron. Plate 4 (S15), li-liii; Plate 6 (S16), xlviii-l; Plate 11 (S28), xxviii-xxix and Plate 15 (S33), xxx-xxxiii.

Lemna type (Lemnaceae)

Grain monad heteropolar, bilaterally symmetric; monoporate; exine 1 micron thick (ornamentation excluded); sexine echinate-scabrate; spine scarcely scattered, conical, 2 micron length; pore circular, 3 micron diameter; amb circular; grains spheroidal, 37 micron (including ornamentation). Plate 6 (S16), li-liv.

Mimosoideae type A

Polyad, oblique, 10 to 12 grains asymmetrically arranged, exine 0.5 micron thick; sexine psilate. Individual grains apolar, asymmetric; apeture inconspicuous; grains suboblate, 30 micron. Plate 12 (S28), xxx-xxxi.

Mimosoideae type B

Polyad, oblique, 4 grains asymmetrically arranged, exine 0.5 micron thick; sexine psilate. Individual grains apolar, asymmetric; apeture inconspicuous; grains suboblate, 15-17 micron. Plate 20 (S38), xii-xiii.

Mimosa type (Mimosoideae)

Polyad, oblique, 8-18 grains, heteropolar, asymmetric; apparently periporate; exine < 1 micron thick; sexine psilate; pores inconspicuous; grains suboblate. Plate 10 (S21), xiv; Plate 12 (S28), xxxii-xxxiii and Plate 15 (S33), xxxiv-xxxvi.

Tribulus type (Zygophyllaceae)

Grain monad, apolar, radially symmetric; periporate; exine 3-4 micron thick; sexine eureticulate (columellae in a reticulate pattern under the muri); grains spheroidal, 35-43 micron. Plate 6 (S16), lv-lvi and Plate 17 (S35), xi-xiv.

Table 2.1 Palynomorphs data.

Sample no.	Depth (m)	Palynomorphs groups																																			
		Fungal spores					Pteridophytic spores																																
							Monolete spores											Trilete spores																					
		Fungal spore type	*Foveodiporites* type	*Fusiformisporites* type A	*Fusiformisporites* type B	*Pluricellaesporites* type	Aspleniaceae type	*Asplenium* type	Dryopteridaceae type A	Dryopteridaceae type B	*Dryopteris* type A	*Dryopteris* type B	Filicopsida type	Polypodiaceae type	*Polypodium* type A	*Polypodium* type B	*Polypodium* type C	*Polypodium* type D	*Ceratopteris* type A	*Ceratopteris* type B	*Ceratopteris* type C	Cyatheaceae type A	Cyatheaceae type B	Cyatheaceae type C	*Cyathea* type A	*Cyathea* type B	*Cyathea* type C	Dicksoniaceae type A	Dicksoniaceae-type B	*Lycopodium* type	*Osmunda* type	Pteridophyta type A	Pteridophyta type B	*Selaginella* type A	*Selaginella* type B
S08	2.60	-	-	-	-	-	-	-	-	-	-	-	-	-	24	-	-	-	3	-	-	6	3	-	15	-	-	27	-	6	-	-	-	-	-	-
S15	5.35	-	-	-	-	-	-	-			17	3	-	-	7	-	-	-	-	-	-	3	-	-	-	9	-	1	-	-	2	-	-	2	-	-
S16	5.90	-	-	-	-	-	-	-	3	1	-	-	-	-	1	5	-	-	1	-	-	-	-	-	-	4	-	-	-	5	-	1	-	-	-	-
S17	10.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S18	11.50	-	-	-	-	-	2	2						18	-	-	-	-	-	-	-	24	-	2	-	-	2	-	4	-	-	-	6	-	-	-	-
S21	12.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33
S28	16.40	-	1	4	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-
S29	17.05	-	-	-	-	-	-	-	-		-	-	-	-	18	-	-	-	-	30	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
S30	17.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S33	20.45	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	45	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
S34	22.55	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S35	23.20	-	-	-	-	-	-	6	-	-	-	-	6	-	-	-	-	3	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S36	23.50	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S37	23.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S38	24.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
S42	25.35	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2.2 Palynomorphs data (cont.).

Sample no.	Depth (m)	Palynomorphs groups																											Palynomorph sum
		Gymnosperm pollens				Angiosperm pollen																							
						Monocotyledonous pollen									Dicotyledonous pollen														Indetermination groups
		Darcrycarpus type	Pinaceae type	*Pinus* type A	*Pinus* type B	*Borassus* type	Cyperaceae type A	Cyperaceae type B	Cyperaceae type C	Cyperaceae type D	Poaceae type A	Poaceae type B	Poaceae type C	*Sagittaria* type	*Altingia* type	Asteraceae type A	Asteraceae type B	Asteraceae type C	Caesalpinioideae type	*Castanopsis* type	*Croton* type	*Lemna* type	Mimosoideae type A	Mimosoideae type B	*Mimosa* type	*Tribulus* type		
S08	2.60	3	-	9	-	-	30	6	-	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	147	300
S15	5.35	-	-	8	-	-	22	-	-	-	93	10	-	11	-	-	-	4	5	2	6	-	-	-	-	-	95	300
S16	5.90	-	-	10	-	-	-	-	66	-	6	45	-	-	5	-	-	4	5	-	5	1	-	-	-	3	129	300
S17	10.75	-	-	111	9	3	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	116	300
S18	11.50	-	-	36	-	-	-	-	-	-	24	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	178	300
S21	12.40	-	-	-	-	-	-	-	-	-	33	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	85	200
S28	16.40	-	-	-	-	-	-	-	-	3	135	-	-	-	4	3	1	-	-	-	1	-	1	-	8	-	121	300
S29	17.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48	100
S30	17.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	100
S33	20.45	-	13	-	-	-	-	-	-	-	108	-	-	-	6	-	18	-	-	-	8	-	-	-	12	-	80	300
S34	22.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85	100
S35	23.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	258	300
S36	23.50	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74	100
S37	23.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99	100
S38	24.05	-	-	-	-	-	-	-	-	-	-	-	36	-	-	-	-	-	-	-	-	-	3	-	-	256	300
S42	25.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	10

Table 3.1 Percentage of palynomorphs data.

Sample no.	Depth (m)	Palynomorphs groups																																				
		Fungal spores					Pteridophytic spores																																	
							Monolete spores															Trilete spores																		
		Fungal spore type	*Fusiformisporites* type A	*Fusiformisporites* type B	*Foveodiporites* type	*Pluricellaesporites* type	Aspleniaceae type	*Asplenium* type	Dryopteridaceae type A	Dryoptendaceae type B	*Dryopteris* type A	*Dryopteris* type B	Filicopsida type	Polypodiaceae type	*Polypodium* type A	*Polypodium* type B	*Polypodium* type C	*Polypodium* type D	*Ceratopteris* type A	*Ceratopteris* type B	*Ceratopteris* type C	Cyatheaceae type A	Cyatheaceae type B	Cyatheaceae type C	*Cyathea* type A	*Cyathea* type B	*Cyathea* type C	Dicksoniaceae type A	Dicksoniaceae-type B	*Lycopodium* type	*Osmunda* type	Pteridophyta type A	Pteridophyta type B	*Selaginella* type A	*Selaginella* type B
S08	2.60	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	1	-	-	2	1	-	5	-	-	9	-	2	-	-	-	-	-	-
S15	5.35	-	-	-	-	-	-	-	-	-	5.7	1	-	-	2.3	-	-	-	-	-	-	1	-	-	-	3	-	0.3	-	-	0.7	-	-	0.7	-
S16	5.90	-	-	-	-	-	-	-	1	0.3	-	-	-	-	0.3	1.7	-	-	0.3	-	-	-	-	-	-	1.3	-	-	-	1.7	-	0.3	-	-	-
S17	10.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
S18	11.50	-	-	-	-	-	0.7	0.7	-	-	-	-	-	6	-	-	-	-	-	-	-	8	-	0.7	-	-	0.7	-	1.3	-	-	-	2	-	-
S21	12.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
S28	16.40	-	1.3	-	-	0.3	-	-	-	-	-	-	-	-	3.7	-	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-	-
S29	17.05	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	10	-	-	-	-	-	-	-	1.3	-	-	-	-	-	-	-
S30	17.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S33	20.45	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	15	-	-	-	-	-	-	-	1.3	-	-	-	-	-	-	-
S34	22.55	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S35	23.20	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S36	23.50	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S37	23.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S38	24.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-
S42	25.35	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.2 Percentage of palynomorphs data.

Sample no	Depth (m)	Palynomorphs groups																											Palynomorph sum
		Gymnosperm pollens				Angiosperm pollens																							
						Monocotyledonous pollen									Dicotyledonous pollen														
		Darcrycarpus type	Pinaceae type	*Pinus* type A	*Pinus* type B	*Borassus* type	Cyperaceae type A	Cyperaceae type B	Cyperaceae type C	Cyperaceae type D	Poaceae type A	Poaceae type B	Poaceae type C	*Sagittaria* type	*Alfingia* type	Asteraceae type A	Asteraceae type B	Asteraceae type C	Caesalpinioideae type	*Castanopsis* type	*Croton* type	*Lemna* type	Mimosoideae type A	Mimosoideae type B	*Mimosa* type	*Tribulus* type	Indetermination groups	
S08	2.60	1	-	3	-	-	10	2	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	49	100
S15	5.35	-	-	2.7	-	-	7.3	-	-	-	31	3.3	-	3.7	-	-	-	1.3	1.7	0.7	2	-	-	-	-	31.6	100
S16	5.90	-	-	3.3	-	-	-	-	22	-	2	15	-	-	1.7	-	-	1.3	1.7	-	1.7	0.3	-	-	1	43.1	100
S17	10.75	-	-	37	3	1	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.7	100
S18	11.50	-	-	12	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	0.7	-	-	-	-	-	59.2	100
S21	12.40	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	5.3	-	61.7	100
S28	16.40	-	-	-	-	-	-	-	-	1	45	-	-	-	1.3	1	0.3	-	-	-	0.3	-	0.3	-	2.7	-	40.5	100
S29	17.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82.7	100
S30	17.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	100
S33	20.45	-	4.3	-	-	-	-	-	-	-	36	-	-	-	2	-	6	-	-	-	2.7	-	-	4	-	26.7	100
S34	22.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	67	100
S35	23.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	86	100
S36	23.50	-	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	91.3	100
S37	23.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99.7	100
S38	24.05	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	1	-	-	85.4	100
S42	25.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99.7	100

3.4 Conclusion and discussion of palynology

The section of Mong Korn sand pit can be devided into two zones using palynomorphs which are contain in each layer of sediments. The palynological zone were recognized of the first appearance and absence of each dominant taxa in each zone (fig. 10).

Pinus Zone overlays the *Ceratopteris* Zone. Rang from 2.6 to 11.5 m depth.This zone defined by the occurrence of *Pinus* type A. The dominant taxa in this zone are Poaceae type A and B, *Pinus* type A, Cyperaceae type A and Cyperaceae type C, respectively. This unit consists of Aspleniaceae type, *Asplenium* type, Dryopteridaceae type A, Dryopteridaceae type B, *Dryopteris* type A, *Dryopteris* type B, Polypodiaceae type, *Polypodium* type A, *Polypodium* type B, *Polypodium* type D, *Ceratopteris* type A, Cyatheaceae type A, Cyatheaceae type B, Cyatheaceae type C, *Cyathea* type A, *Cyathea* type B, Cyathea type C, Dicksoniaceae type A, Dicksoniaceae type B, *Lycopodium* type, *Osmunda* type, Pteridophyta type A, Pteridophyta type B, *Selaginella* type A, *Darcrycarpus* type, *Pinus* type A and *Pinus* type B, *Borassus* type, Cyperaceae type A, Cyperaceae type B, Cyperaceae type C, Poaceae type A, Poaceae type B, *Sagittaria* type, *Altingia* type, Asteraceae type C, Caesalpinioideae type, *Castanopsis* type, *Croton* type, *Lemna* type and *Tribulus* type. The presence of temperate taxa, *Pinus* type A and B and *Castanopsis* type are indicators for a temperate flora, and grass family is common in pine forest.

The *Ceratopteris* Zone is the lowest zone, and overlays the barren Zone A. Rang from 11.6 to 24.05 m depth. This zone is charactered by the occurrence of *Ceratopteris* type B and C, that were found rather abundantly throughout the assemblage. The dominant taxa are Poaceae type A, *Polypodium* type A, *Ceratopteris* type A and B, *Mimosa* type and Dicksoniaceae type A. This unit consist of *Foveodiporites* type, *Fusiformisporites* type A, *Fusiformisporites* type B, Filicopsida type, *Polypodium* type A, *Polypodium* type D, *Ceratopteris* type A, *Ceratopteris* type B, *Ceratopteris* type C, Cyatheaceae type C, Dicksoniaceae type A, *Selaginella* type B, *Darcrycarpus* type, Pinaceaea type, Cyperaceae type A, Cyperaceae type C, Cyperaceae type D, Poaceae

type A, *Altingia* type, Asteraceae type A, Asteraceae type B, *Croton* type, Mimosoideae type A, *Mimosa* type and *Tribulus* type. Abundance of *Ceratopteris* spp., *Polypodium* and Dicksoniaceae is typical for tropical to warm temperate climate (Walters & Keil, 1996) and they also indicate a humid environment. The *Ceratopteris* is an aquatic plant which grows in fresh-water. This area might have been swamp or lake.

The presence of Poaceae type A, *Polypodium* type A, *Ceratopteris* type A and B, *Mimosa* type and Dicksoniaceae type A in the *Ceratopteris* Zone, which were indicate a typical for tropical to warm temperate climate, humid environment. *Ceratopteris* is point a sedimentation in fluvial deposits. *Pinus* type A and B and *Castanopsis* type in *Pinus* Zone, which were indicate a temperate climate. Such an interpretation The palynological data suggest the temperate flora assemblage in the *Ceratopteris* Zone is warmer than the Pinus Zone. When suggest to the occurrence of *Polypodium* type A, *Cyathea* type B, Dicksoniaceae type A and *Lycopodium* type. The number of spores are inclease in a upper part of *Pinus* Zone. It point to a temperater is change from temperate climatetropical climate (Fig. 11).

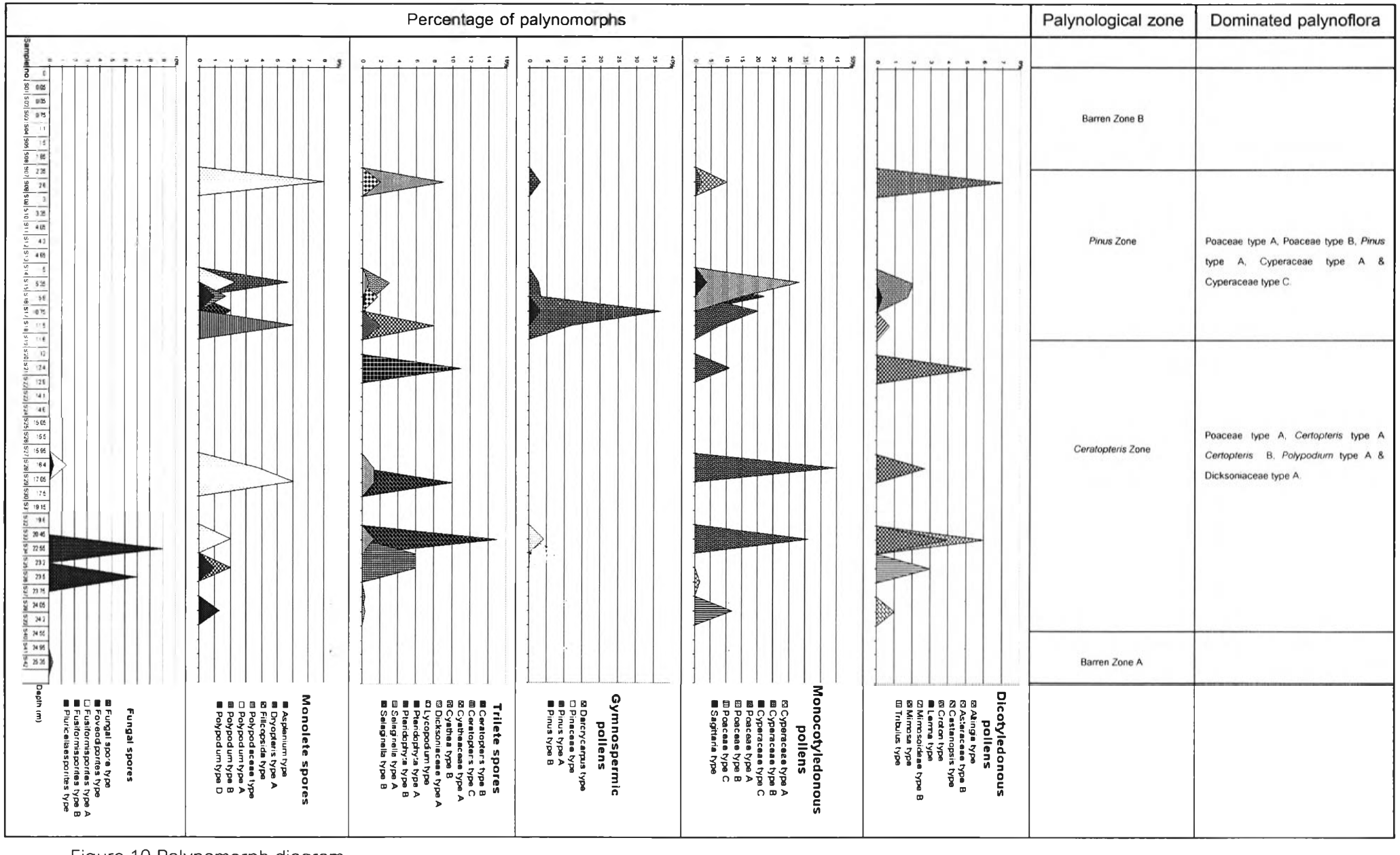

Figure 10 Palynomorph diagram.

Depth (m)	Lithostraticgraphic column	Palynological zone	Palaeoclimate
0		Barren Zone B	
5		*Pinus* Zone	Temperate climate
10			
15		*Ceratopteris* Zone	Tropical climate
20			
25		Barren Zone A	

Figure 11 Palynostraticgraphic section of Mong Korn sand pit.