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Palynology as a tool in delineating tropical lowland depositional environments of Late Quaternary age

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Abstract: As part of a Quaternary geological research project about 170 samples from several lowland depositional environments in Lower Perak and Kelantan (Peninsular Malaysia) were investigated for their pollen content. The results indicate that palynology is a reliable method for reconstructing tropical lowland sedimentary environments of Late Quaternary age.

Samples from the following environments were studied: shallow offshore, deltaic/estuarine, mangrove, transition between salt and fresh water environments, fresh water swamp and peat swamp. The various environments are characterized palynologically. Some pollen diagrams from different environments are presented.

Differentiation between salt/brackish and fresh water environments can be readily achieved for each individual sample, even with only limited knowledge of pollen types. For a more detailed interpretation a vertical sequence of samples is required.

INTRODUCTION

In the past few years, palynology (the study of modern and fossil pollen and spores) has become established as one of the common laboratory techniques at the Quaternary Geology Division of the Geological Survey of Malaysia. In Indonesia, palynological studies are also in use to support the Quaternary mapping programme (e.g. Polhaupessy, 1981) and a pollen unit in Thailand is being developed. This growing interest in palynology results from the fact that Quaternary geologists, in their tasks of mapping coastal and alluvial areas, are often confronted with the problem of interpreting deposits in terms of depositional environments. Palynology is one of the micro-palaeontological techniques that can provide clues for this kind of interpretations (Muller, 1959; Haseldonckx, 1974; Birks and Birks, 1980).

In 1982, the Quaternary Division of the Geological Survey of Malaysia launched a project aimed at establishing field and laboratory criteria to characterize various sedimentary environments (Bosch, in press). Field studies were undertaken in Lower Perak (west coast Peninsular Malaysia) and Kelantan (east coast). The location of the study areas is indicated in figure 1. Within the framework of this project, the pollen content of about 170 samples was investigated. Following is a discussion of some selected pollen diagrams. These diagrams are presented here as examples of the usefulness of palynology in delineating tropical lowland depositional environments of Late Quaternary age.

POLLEN ANALYSIS

Pollen are single-celled (occasionally few-celled) bodies produced by higher plants as a means of propagating a new individual. Pollen from various plant species can be differentiated on the basis of morphological characteristics, shape and size. Plants produce pollen in huge quantities and upon ripening in the anthers of the flowers they are scattered over the surrounding area. If pollen (and spores) are not exposed to intensive oxidation they might be preserved once they become incorporated in the sediment. This may happen, for example, in peats or clastic deposits formed under water. When these sediments are later sampled, the pollen can subsequently be extracted in the laboratory (for procedures see e.g. Faegri and Iversen, 1975) and microscopic study may reveal the pollen content. Then, the pollen and spores in the samples are counted and a reconstruction of the vegetation during the time of deposition of the sediments can be made. For a proper interpretation a sound knowledge of the ecology of the various taxa is required. Interpretation of fossil pollen assemblages relies heavily on comparison with recent vegetational successions and ecological conditions. Once a reconstruction of the former vegetation has been made, an idea can be formed about the environment of deposition. Geological data are also considered, such as the setting of the area, the lithology of the sediment and the results of relevant laboratory tests.

PRESENTATION OF RESULTS

The results of palynological investigations are most conveniently recorded in the form of pollen diagrams. In the diagrams presented here (figures 2–5) the first column shows the lithology of the sampling spot. The depth is recorded in metres below the surface. Next come the sample number, the pollensum and the "pollen class". The pollensum includes all pollen that were counted in the particular sample. Pollen frequencies of the various taxa are expressed as percentages of the pollensum. The "pollen class" should be considered an indication of the amount of pollen in a sample. Five pollen classes were distinguished:

0—barren	: no pollen
1—very poor	: 0–15 pollen grains per slide
2—poor	: 16–50 pollen grains per slide
3—moderately rich	: 51–150 pollen grains per slide
4—rich	: > 150 pollen grains per slide

Next on the diagrams are the composite diagrams in which four groups of pollen are distinguished:

— MANGROVE species, i.e. species that are more or less tolerant to salt water: Rhizophoraceae, *Sonneratia*, *Avicennia*, *Brownlowia*.

— TRANSITION species, i.e. species with a limited tolerance to salt or brackish water: Palmae, *Pometia*, *Barringtonia*. These species are common along rivermouths and in the back-mangrove zone.

— FRESH WATER species. This group in fact comprises all other identified pollen.

— UNIDENTIFIED pollen.

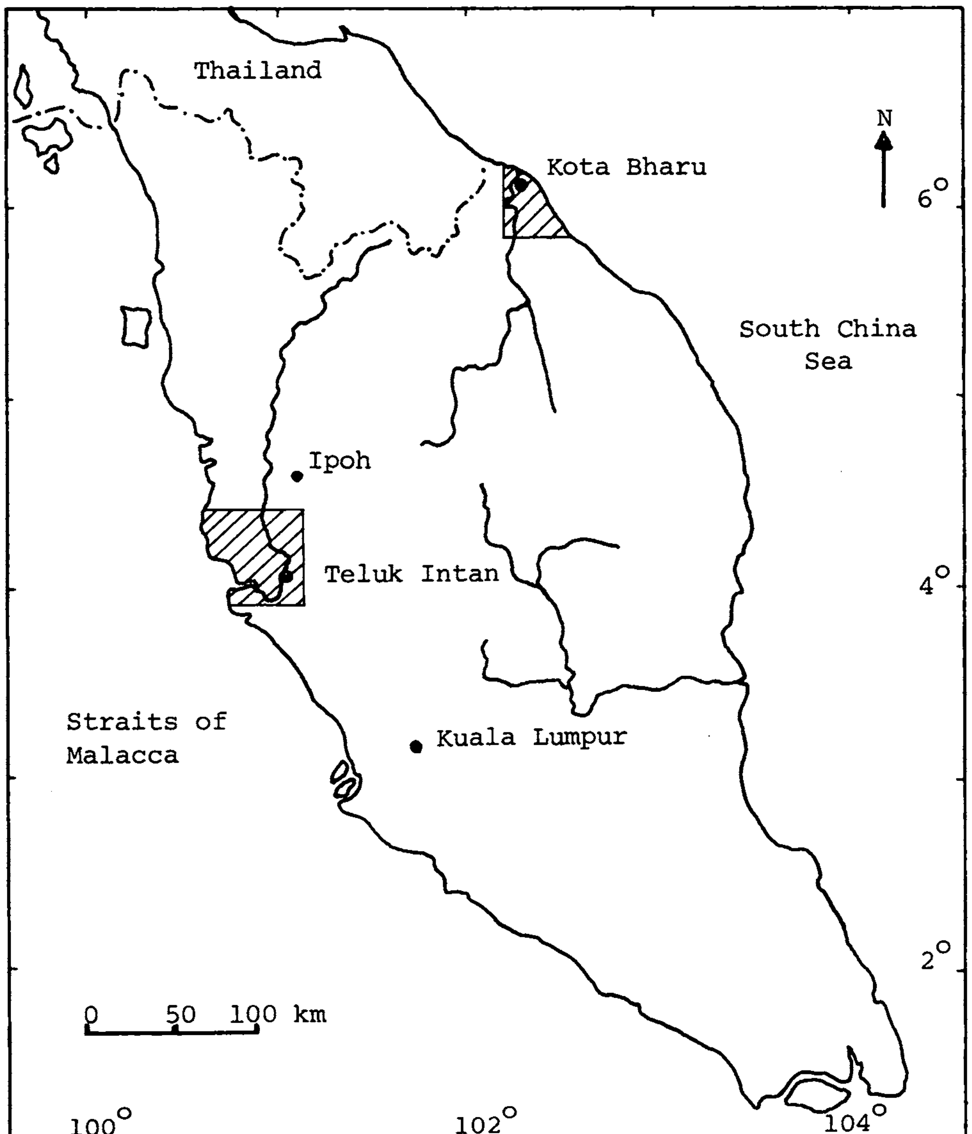


Fig. 1 Location of study areas

The composite diagrams are especially useful to display environmental transitions, notably changes in salinity.

In all diagrams a selection of individual curves of relevant species is given, expressed as a percentage of the pollensum. The last curve concerns the sum of all spores, again expressed as a percentage of the pollensum.

DISCUSSION OF POLLEN DIAGRAMS

Four selected pollen diagrams from Lower Perak and Kelantan are discussed below. More results from the same study areas will be published shortly (Hillen, in press) or are reported internally (Hillen, 1984).

DIAGRAM A (figure 2) is from a drill hole South of Teluk Intan in Lower Perak (see figure 1 for topographic names). The lithology is a greenish grey silty clay with plant remains, overlain by an ombrogenous peat layer. The samples in diagram A are rich in pollen. The diagram can be divided into three parts:

- The lower part (samples P21–26) is characterized by appr. 90% mangrove taxa, almost exclusively *Rhizophora*. Palmae and fresh water species only form a few percent of the pollensum. The amount of species is very limited; spores percentages are very low. Samples from mangrove environments collected throughout Peninsular Malaysia have similar characteristics. Pollen studies from the northern coast of South America are in agreement with these results (Van der Hammen, 1963; Roeleveld, 1969).

- The middle part (samples P19B and 20) forms the transition from a salt water environment to a fresh water environment. High values (> 50%) for transition species, especially the palm *Oncosperma* (Nibong, in Malay language), are recorded. The sharp decline in mangrove species comes together with an increase in spores and unidentified pollen.

- In the upper part of the diagram (samples P17–19) fresh water species dominate and the variety in terms of species present is very high. First peaks for common fresh water species of the Rubiaceae and Euphorbiaceae families are recorded, indicating that the nutrient rich groundwater is still within reach of the vegetation. Later taxa like *Ilex*, *Campnosperma* and *Stemonurus* attain high values. Now the peat swamp phase is reached; the peat grew beyond the influence of the groundwater and a peat dome is developing.

The succession mangrove—transition—peat swamp is related to the outbuilding of the coast during a marine regression. The sharp drop in Rhizophoraceae values at 3.5 metres below surface (appr. 3.2 metres above present mean sea-level) probably corresponds with a drop in sea-level after the sea-level high as recorded from Peninsular Malaysian shorelines in the middle of the Holocene (Geyh, *et al.*, 1979).

DIAGRAM B (figure 3) is from a drill hole approximately 30 km South of Kota Bharu, Kelantan. The samples are from a rather compact peat layer which is under-

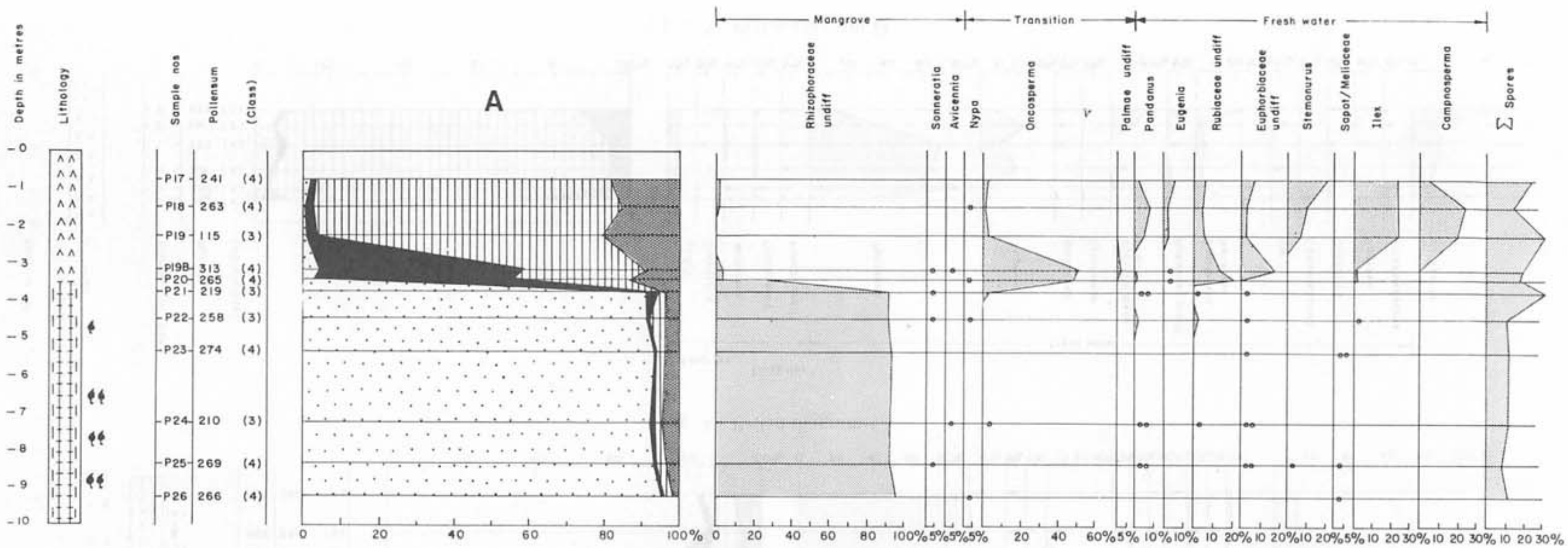


Fig. 2 Pollen diagram A

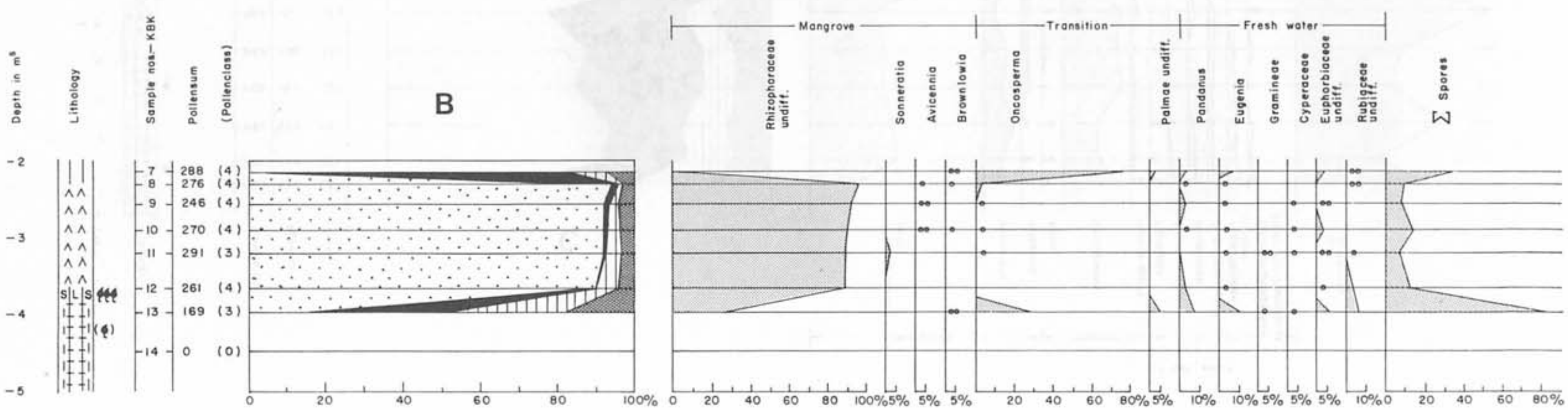


Fig. 3 Pollen diagram B

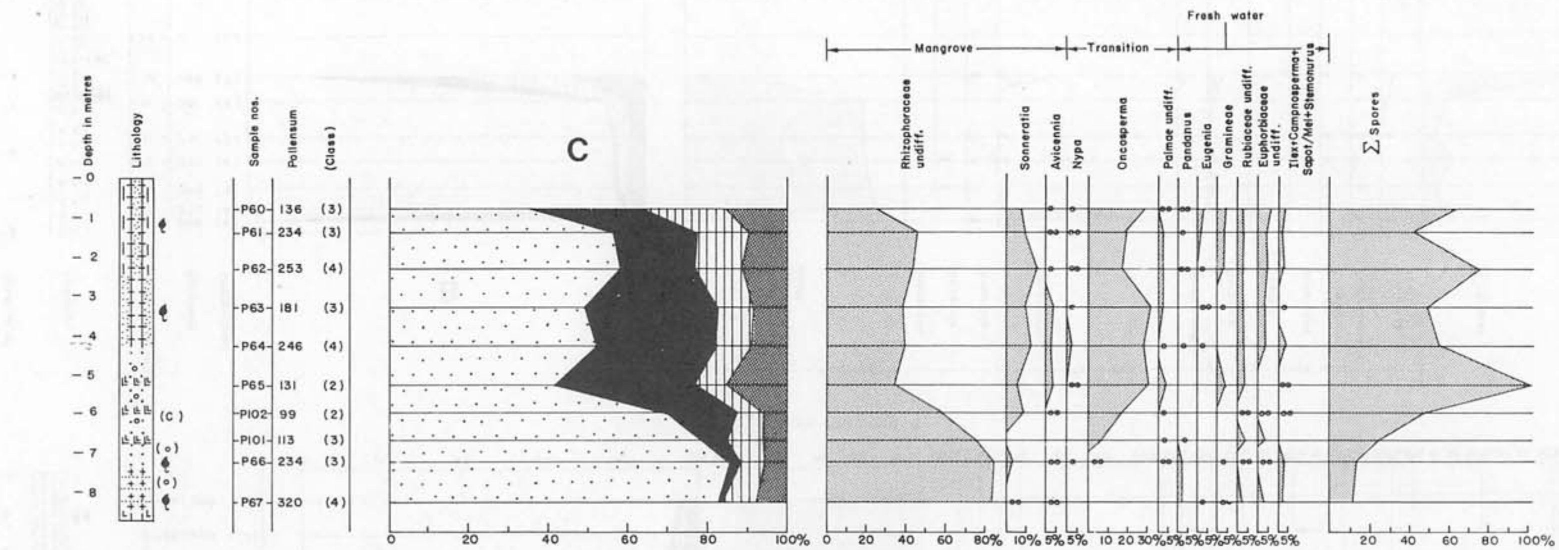


Fig. 4 Pollen diagram C

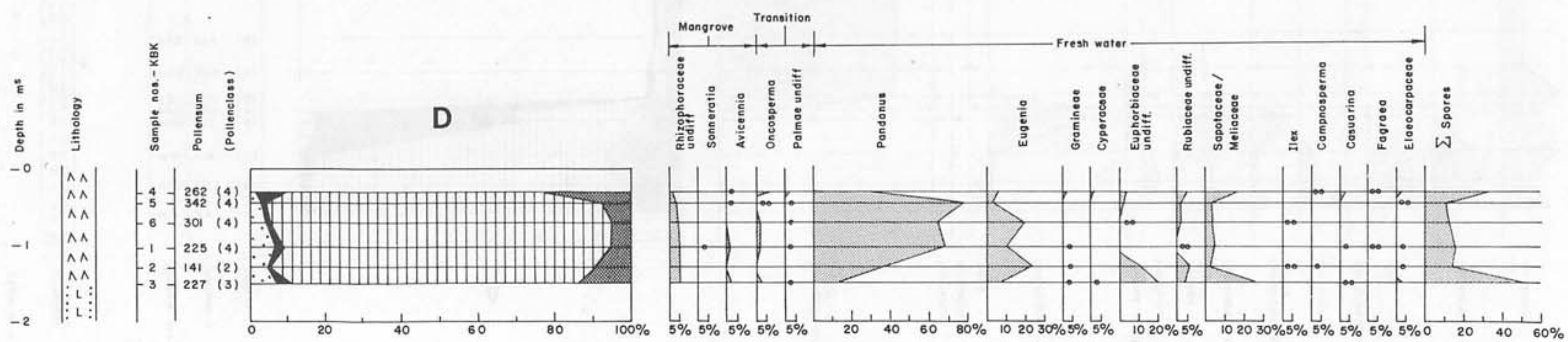
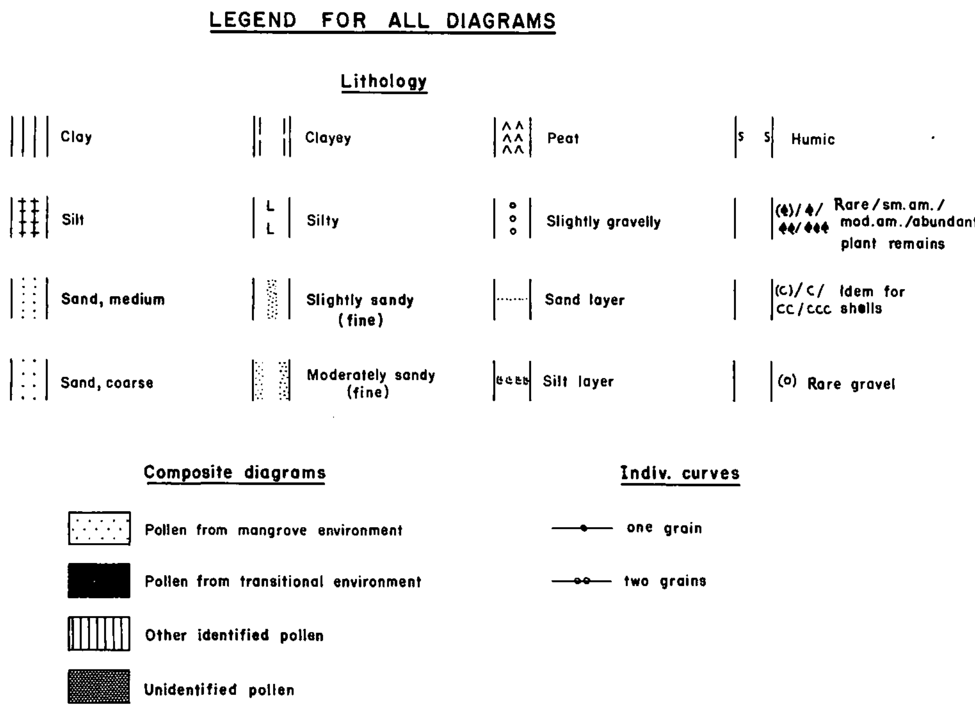


Fig. 5 Pollen diagram D



and overlain by fluviatile deposits. Pollen analysis revealed that the peat was formed in a mangrove environment: > 90% mangrove species, rich in pollen (mainly pollen class 4), the variety of species is low and only few spores are present. Samples KBK 13 and 7 of diagram B reflect the onset and retreat of the salt water and are characterized by (very) high values for transition species (notably *Oncosperma*), limited percentages of mangrove pollen, and higher values for fresh water species and spores. Unfortunately, sample KBK 14, derived from fluviatile clayey silt, is barren of pollen.

During the fieldwork the salt water character of the peat was not recognized. The palynological interpretation was later supported by results from x-ray diffraction analysis (presence of montmorillonite, an indication for a marine environment; Bosch, in press).

DIAGRAM C (figure 4) is from the Trans Perak area, west of Teluk Intan. The lithology shows silt and sand layers, occasionally with shell fragments. From the field evidence it was concluded that the deposits were formed in an estuarine environment.

The samples are moderately rich in pollen; except for samples P65 and P102 which were derived from sandy intervals. Two pollen zones can be distinguished in diagram C. The lower zone (samples P66, 67, 101) is characterized by high values for Rhizophoraceae and low percentages for all other taxa and spores. This part of the diagram is comparable with the lower zone of diagram A and is interpreted as a mangrove environment. The upper part of the diagram (P60–65, 102) shows a rather heterogeneous pollen assemblage with about 50% mangrove elements, 25% Palmae and fair quantities for pollen of fresh water species. Spores percentages are relatively high.

As for diagram C, the palynological results support the field evidence. The upper part of the diagram is best explained by suggesting mixing of pollen. This mixing is likely to occur in a deltaic or estuarine environment with both fluvial (a former course of the Perak River; Koopmans, 1964) and marine influences. The high percentages of *Oncosperma* reflect the presence of this palm tree in riparian vegetation. The high values for *Sonneratia* (percentages of 10% are very high for a poor pollen producer like *Sonneratia*, here mainly the pioneer species *S. alba*) indicate this this species was present in the estuary or delta.

The samples of DIAGRAM D (figure 5) were collected in a swale in the older beachridge (permatang) series in Kelantan. In the drill hole a 1.5 m thick peat layer was encountered overlying sands and silts. Six samples from the peat were analysed for pollen. The top four samples are (very) rich in pollen, the lowest two belong to lower pollen classes. Fresh water species are clearly dominant, mangrove and transition species amount to about 5 and 2% respectively.

From the individual curves it appears that *Pandanus* (Mengkuang in Malay) is the dominant species. Other important taxa are *Eugenia* (including a considerable percentage of *Melaleuca*, Gelam), Euphorbiaceae (among others *Macaranga*) and Sapotaceae/Meliaceae. From the pollen assemblage it is concluded that the peat was produced by a *Pandanus* marsh (at present extensive *Pandanus* marshes are found in Pahang state on the East coast of Peninsular Malaysia). Influence of salt and brackish water was virtually absent during the peat formation.

CONCLUSIONS

In the course of the Lower Perak and Kelantan fieldwork many more samples for palynological analysis were collected. On several occasions the field interpretation had to be revised once the palynological results became available. The results from pollen analysis are in agreement with the outcome of the x-ray diffraction analysis of the fraction finer than 2 microns.

Differentiation between salt/brackish water environments and fresh water environments can be readily achieved for each individual sample. For a more detailed interpretation, a vertical sequence of samples is generally required. Table I summarizes the major palynological characteristics of six lowland environments.

The percentage of unidentified pollen is dependent in the first place on the number of species present. Both mangrove and transition environments are relatively poor in species and the group of unidentified pollen is subsequently low. Fresh water environments are (very) rich in species and the percentage of unidentified pollen is generally considerably higher.

Generally, fluviatile deposits are not very suitable for palynological investigation

TABLE I

MAJOR PALYNOLOGICAL CHARACTERISTICS OF SIX LOWLAND ENVIRONMENTS

depositional environment		main palynological characteristics
salt/brackish water	shallow offshore	• poor in pollen • 60–80% mangrove species • 5–15% Palmae • moderate spores—values
salt/brackish water	mixed environment (e.g. deltaic, estuarine)	• moderately rich in pollen • 40–60% mangrove species • 15–35% Palmae • moderately rich in species • high spores—values
salt/brackish water	mangrove	• rich in pollen • $\pm$ 90% mangrove species • very low Palmae—values • poor in species/low % unidentified • low spores—values
salt/brackish water / fresh water	transition	• rich in pollen • Palmae dominant (esp. *Oncosperma*) • poor in species/low % unidentified • moderate spores—values
fresh water	fresh water swamp	• (moderately) rich in pollen • rich in species/high % unidentified • mangrove spp./Palmae virtually absent • common species: Rubiaceae, Euphorbiaceae, *Pandanus*, *Eugenia*, Gramineae • varying spores—values
fresh water	peat swamp	• rich in pollen • rich in species/high % unidentified • mangrove spp./Palmae virtually absent • common species: *Ilex*, *Stemonurus*, *Campnosperma*

(except for the organic-rich top-strata in back-swamp deposits) because of the amount of sand and coarse silt in the sediments and the fact that the deposits have commonly been exposed to oxidation during and shortly after their formation.

The flora of Malaysia (and neighbouring countries) is known to be one of the richest of the world. However, when dealing with lowland samples, knowledge of a fairly limited amount of pollen types is sufficient to arrive at reliable interpretations (N.B. for this study around 60 different pollen types were identified).

In conclusion, the results from Lower Perak and Kelantan demonstrate the usefulness of palynology in delineating sedimentary environments. Intensifying pollen studies seems worthwhile and it is desirable that palynology becomes further incorporated in the study of Quaternary deposits from Southeast Asia.

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