Palynomorphs from non-marine deposits in the Malay basin

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Malay Basin is a northwest-southeast trending, elongate, pull-apart basin, which began to subside during the latest Eocene or early Oligocene, following the collision of the Indian Plate with Asia, and the subsequent eastward extrusion of a major part of southeast Asian plate toward the Pacific (Tapponnier *et al.*, 1986). The basin contains sediments in excess of 10,000 m, and is bounded to the southwest by the Tenggol Arch, and to the northeast by the Khorat Swell. To the northwest, the Malay basin is connected to the Pattani Trough, and at its southern end, it is connected to the Penyu and West Natuna Basins. The initial phase of sediment accumulation involved the deposition of lacustrine and fluvial sediments during the Oligocene rift phase of basin development. Subsequently in the Early Miocene, the non-marine condition phased out during which evidence of a first marine incursion has been detected in the southern part of the Malay Basin (Azmi *et al.*, 1994).

The non-marine deposits so far penetrated in the Malay basin are mostly equivalent to the Seligi and Ledang formations which comprised of an upper shaly and a lower sandy units. The shale is believed to have been deposited in a lacustrine environment. The lithology and palynomorphs assemblage within these units are correlatable to the West Natuna Basin which is thought to be Oligocene (Morley, personal communication).

This paper discusses the morphotypes, stratigraphy, distribution and source rock potential of palynomorphs from the lacustrine sediments, with emphasis on the freshwater algal palynomorphs. The materials used in this study were ditch-cuttings from wells Ledang-1, Kaca-1 and Angsi-1. These wells are located in the south part of the Malay Basin. The lacustrine sediments in Ledang-1 and Kaca-1 are preserved at relatively shallow depths. Consequently, the morphology of the palynomorphs are easily understood and the knowledge was used to identify poorly preserved specimens from the deeply buried section of the Angsi-1 Well. The results from this study were tested against data from previous study in order to determine their stratigraphic significance.

Freshwater algae dominate the palynomorph assemblage and sometimes constitute up to 80 percent of

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the total palynomorph observed in the sediments. They can mostly be referred to the genera *Bosedinia, Granodiscus, Pediastrum* and *Botryococcus*. The former two were well preserved and occur in abundance, whereas the latter two were otherwise. Ten morphotypes of *Bosedinia* and *Granodiscus* were recognised and they can be classified as 'thin' and 'thick'-walled forms. The thin-walled forms comprised the *B. infragranulata* and *B. granulata* and, the thick-walled consisted of the *G. staplinii, B. kuantanensis* and *B. whelkaris*. A new morphotype was identified and named as *Bosedinia gemmata* Azmi (1994). This type is characterised by gemmate ornamentation, sphaerical to subsphaerical cysts with single layered wall typically 1 m in thickness and possessed a distinct omphalos, thickened relative to the cyst wall.

In the Malay Basin, four palynological zones had been recognised within the Ledang and Seligi formations using abundance changes within the thin and thick-walled algal assemblages. The top of PR1 is marked by a decrease in the abundance of algal cysts and is associated with fluvial deposition. The overlying PR2 zone is characterised by high abundance of the algal cysts and is believed to represent a widespread lacustrine unit. PR3 is characterised by reduced abundance of the algal cysts and is thought to be associated with fluvial plain. The low abundance of freshwater algal cysts persisted in PR4 during which the basin was already under marine influence. Further reduction of algal cysts marked the top of PR4 zone. The thick-walled algal cysts are restricted to the wells from the southeast corner of the Malay Basin where the Ledang and Seligi formations had been penetrated, whereas the thin-walled cysts are more widely distributed.

The lacustrine sediments in the south Malay basin, in particular the Ledang and Seligi shale are organically rich and form the major petroleum source rock. The lake that developed, in particular during the Ledang shale time, must be sufficiently deep that permanent water stratification could have formed. This could have caused the organic matter to be preserved. The main source of organic matter in the lacustrine shale is believed to have been the algal palynomorphs and inwashed detritus from terrestrial vegetation. The algal cysts are easily recognised under the microscope by their high fluorescence characteristics.

This study has demonstrated that the occurrence of freshwater algal palynomorphs in the Oligocene sediments of the Malay Basin are important not only as the major source of organic matter in the shale but also as stratigraphic indicator. Therefore, understanding of their morphology and distribution are essential.