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PALYNOLOGICAL STUDY OF THE JAMBI SUB-BASIN, SOUTH SUMATRA

STUDI PALINOLOGI SUB-CEKUNGAN JAMBI, SUMATRA SELATAN

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ABSTRAK

Studi palinologi di Sub-cekungan Jambi, Sumatera Selatan dilakukan untuk menyusun biostratigrafi formasi batuan terpilih yang telah diidentifikasi. Analisis palinologi ini memberikan hasil berupa umur batuan sedimen serta interpretasi lingkungan pengendapan. Penelitian dilakukan pada percontoh permukaan (*outcrops*) yang tersingkap di Sungai Merangin, daerah Muara Jernih dan Mengupeh. Umur sedimen daerah penelitian berkisar antara Miosen Awal sampai Miosen Tengah. Batas atas umur Miosen Tengah ditandai oleh kemunculan polen *Florschuetzia levipoli* dan *Florschuetzia meridionalis*, sementara batas bawah umur Miosen Awal dicirikan oleh kemunculan nanoplangton *Sphenolithus compactust*. Batuan sedimen di Sungai Merangin dan daerah Muara Jernih yang diperkirakan sebagai Formasi Talang Akar, diendapkan di lingkungan *lower delta plain* sampai *delta front* selama umur Miosen Awal. Di daerah Mengupeh, lingkungan pengendapan Formasi Talang Akar ini bergeser ke arah darat menjadi *upper delta plain* sampai *lower delta plain* pada umur Miosen Tengah.
Kata Kunci: sub-cekungan Jambi, formasi Talang Akar, palinologi

ABSTRACT

The palynological study of the Jambi Sub-basin, South Sumatera is carried out to construct biostratigraphy of the identified formation. The palynological analysis provides an age interpretation as well as environment of depositional interpretation. The study uses outcrop samples which were collected from Merangin River, Muara Jernih and Mengupeh areas. The age of the studied sediment ranges from Early to Middle Miocene. The top Middle Miocene age is identified by the occurrence of pollen Florschuetzia levipoli and Florschuetzia meridionalis, whilst the base of Early Miocene is marked by the appearance of nannoplankton Sphenolithus compactust. The studied sediment cropping out at the Merangin River and Muara Jernih area interpreted as Talang Akar Formation was deposited in a lower delta plain to delta front during Early Miocene. In the Mengupeh area, this sediment shifted landward into upper delta plain to lower delta plain environment during Middle Miocene.
Keywords: *Jambi sub-basin, Talang Akar Formation, Palynology*

I. INTRODUCTION

It has been known that most hydrocarbons trapped into the Tertiary reservoir rocks in the South Sumatera Basin were mainly expelled from terrestrial to fluvio-deltaic shales and coals of Talang Akar Formation, where the sandstones of this formation are acting as reservoir rocks. On the other hand, in some areas, based on geochemical and geological data, shales of Miocene Gumai Formation also display characteristics and capability of both potential and generating source rocks.

Geological survey of hydrocarbon potential in the Jambi Sub-basin has been done by LEMIGAS Stratigraphy Group to collect the sedimentary outcropped samples which are predicted as potential source rock for generating hydrocarbon, for determining age and depositional environment of sedimentary rock series of the selected rocks. Meanwhile, the occurrence of older formation in this basin such as shales and coals of the Permian Mengkarang Formation can be considered as other possible source rock.

The study area is located at the Muara Bungo – Bangko which is administratively situated in Bungo and Merangin Regency, Jambi Province (Figure 1). This area is geologically included into Jambi sub-Basin which is located in the northern part of South Sumatera Basin.

This study has been undertaken to understand the stratigraphy of the Muara Bungo – Bangko area of the Jambi Sub-basin, South Sumatra. The purpose of this study is to determine biostratigraphy of the identified formations especially those which are predicted as potential source rocks. The palynological analysis will provide a zonal subdivision to determine age of the sediment and also the depositional of environment interpretation. The result of this analysis is cross-checked by the foraminiferal and calcareous nannoplankton analyses and integrated with the previous works done by LEMIGAS with the target of Talang Akar Formation.

Target locations are located in the northern and southern parts of the studied area. Muara Bungo area is a southern target, whilst Merangin/Mengkarang River and Muara Jernih area are the northern targets. The type of analysed sample is outcrop sample. All

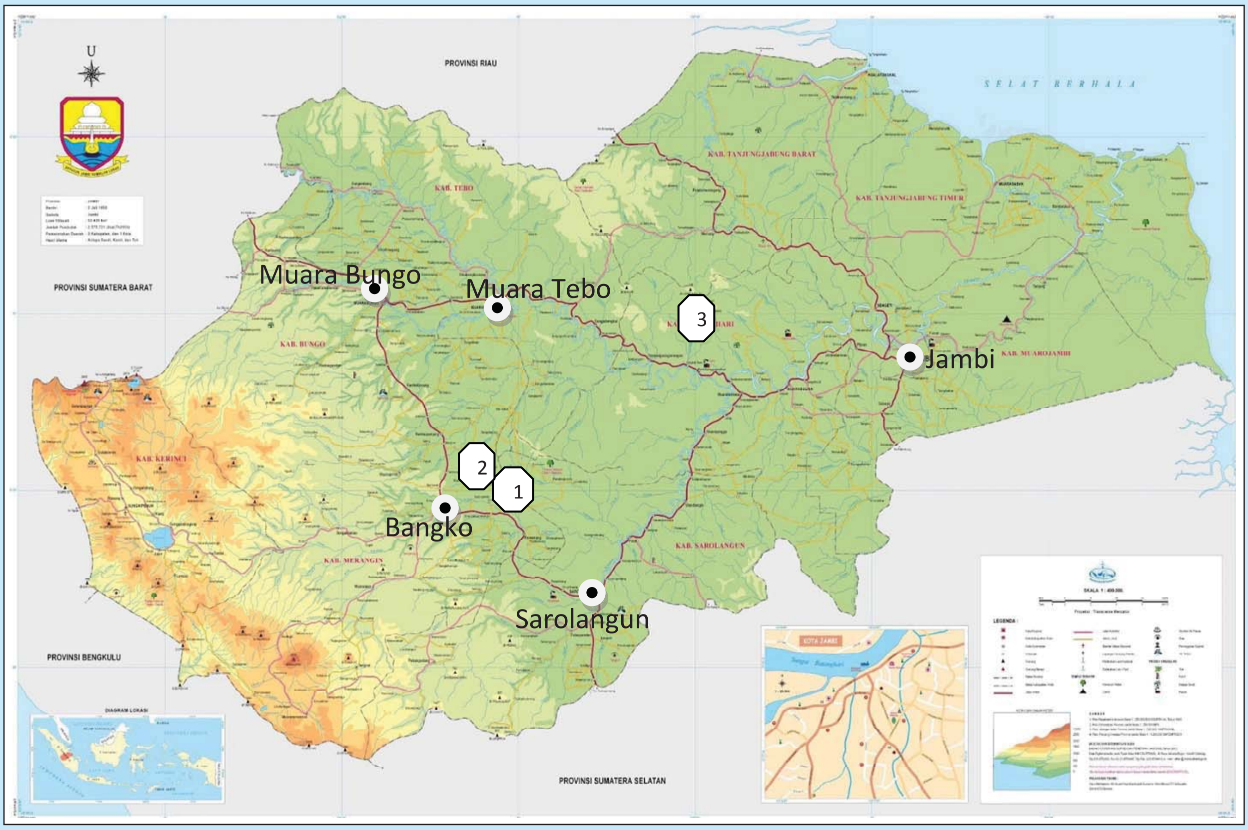

Figure 1
The study area is spanning from Muara Bungo to Bangko
(Number 1 represents sample location of MJ and MRG sections.
Number 2 shows sample location of MGP and BT sections.
Number 3 indicates sample location of Mengupeh-Bukit Kerendo section
(secondary data obtained from LEMIGAS Stratigraphy Group during the period 1993-1995).

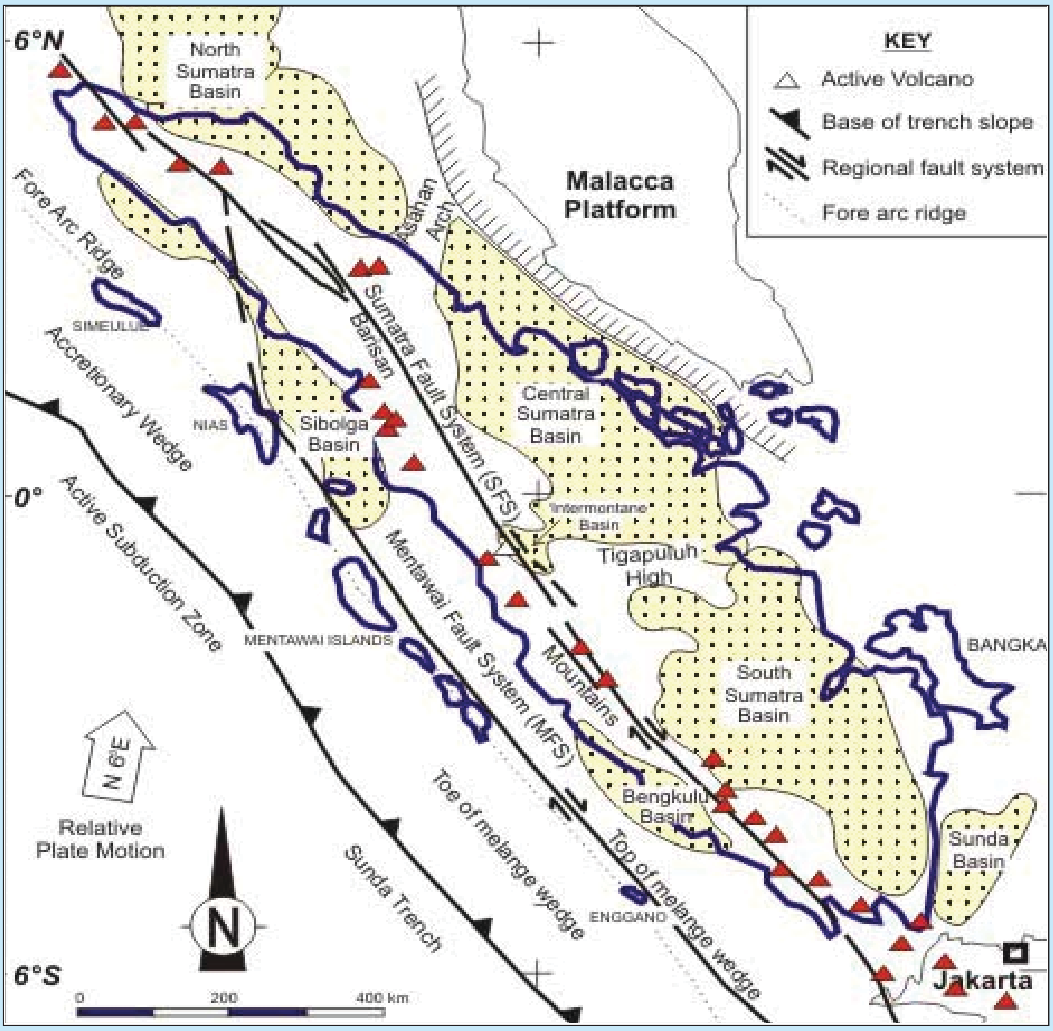

Figure 2
Locality map of the South Sumatra Basin (de Coster 1974).

samples were processed using standard palynological preparation technique applied in the Stratigraphy Laboratory of LEMIGAS, Jakarta.

Geology of the Jambi Sub-basin

The South Sumatra basin is located in the southern part of Sumatra Island, which is regarded as a back-arc basin bounded by the Barisan Mountains in the southwest and by the Pre-Tertiary Sunda Shelf to the northeast (de Coster 1974).

The South Sumatra Basin is separated from the Central Sumatra Basin by the Tigapuluh High. To the east the Lampung High separates it from the Sunda Basin at the Java Sea (Figure 2). The basin was formed by the extension of "pre-Tertiary basement" rocks on "pre-existing faults" and the subsiding graben in the Late Eocene to Early Oligocene (Barber and Crow 2003). In Williams *et al.* (1995), the South Sumatra Basin has been divided into five sub-basins as follows: Jambi, North Palembang, Central Palembang, South Palembang and Bandar Jaya. In contrast, Clure (1991) divided South Sumatera Basin into two sub-basins including Palembang and the Jambi. Three tectonic events have formed the South Sumatra Basin. Firstly, the Paleocene to Early Miocene extension grabens, which trend in a north direction and were later filled with sediments of Eocene to early Miocene. Secondly, the inactive Late Miocene to Early Pliocene normal fault. Thirdly, the Pliocene to Present compression of the basement rocks with the inversion of basin and reverse normal faults that formed anticline related oil traps.

Generally, the South Sumatra Basin consists of "semi-connected NNW-SSE trending synrift basins" (i.e. the Jambi Sub-basin and the Palembang Sub-basin). Figure 3 shows the Jambi Sub-basin and the Palembang Sub-basin with the basement faults and anticlines. This region has also being divided according to the stacking patterns "tectonostratigraphy" (the pre-rift, the horst and graben stage and the transgression and regression stage) of the Tertiary sediment that filled the basins (Barber 2000).

The Jambi Sub-basin is oriented in a NE – SW direction. It is smaller and more proximal to the source than the Palembang Sub-basin (Doust and Noble 2008). It has an area of many faults that are closely spaced (fault zones) called the Tembesi Fault (Figure 3). The Tembesi fault trends in a southwest to northeast direction and also forms the northwest edge of the Jambi Trough (Hutchison 1996).

Stratigraphy

The general stratigraphy of the South Sumatera Basin is shown in Figure 4. basement of the South Sumatra Basin is pre-Tertiary rocks, comprising various igneous and low grade meta-sediments. It is overlain unconformably by the Eocene-Oligocene

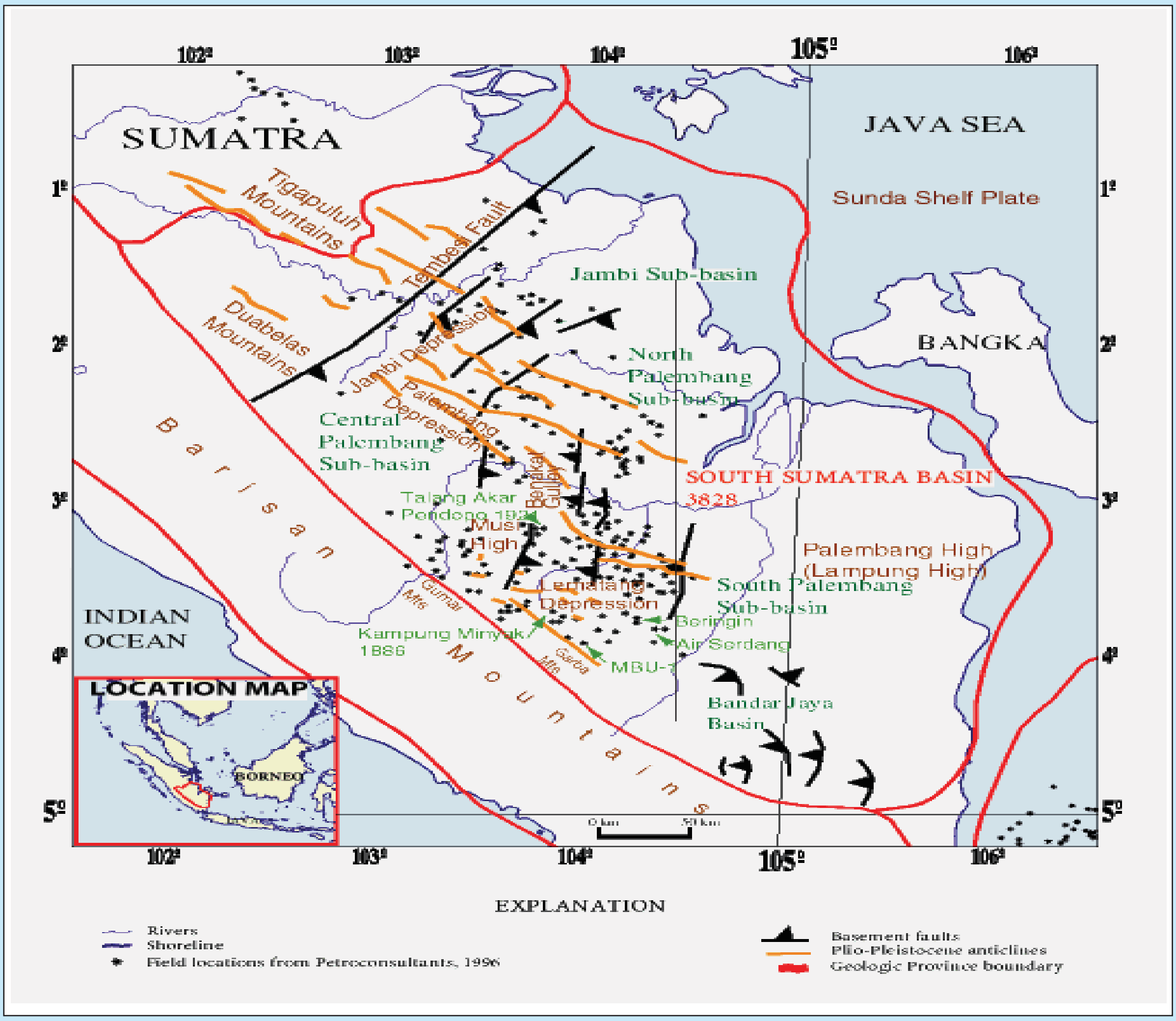

Figure 3
The structural features of the South Sumatra Basin: the Jambi Sub-basin, the Palembang Sub-basins and the Tembesi Fault. (Hutchison 1996).

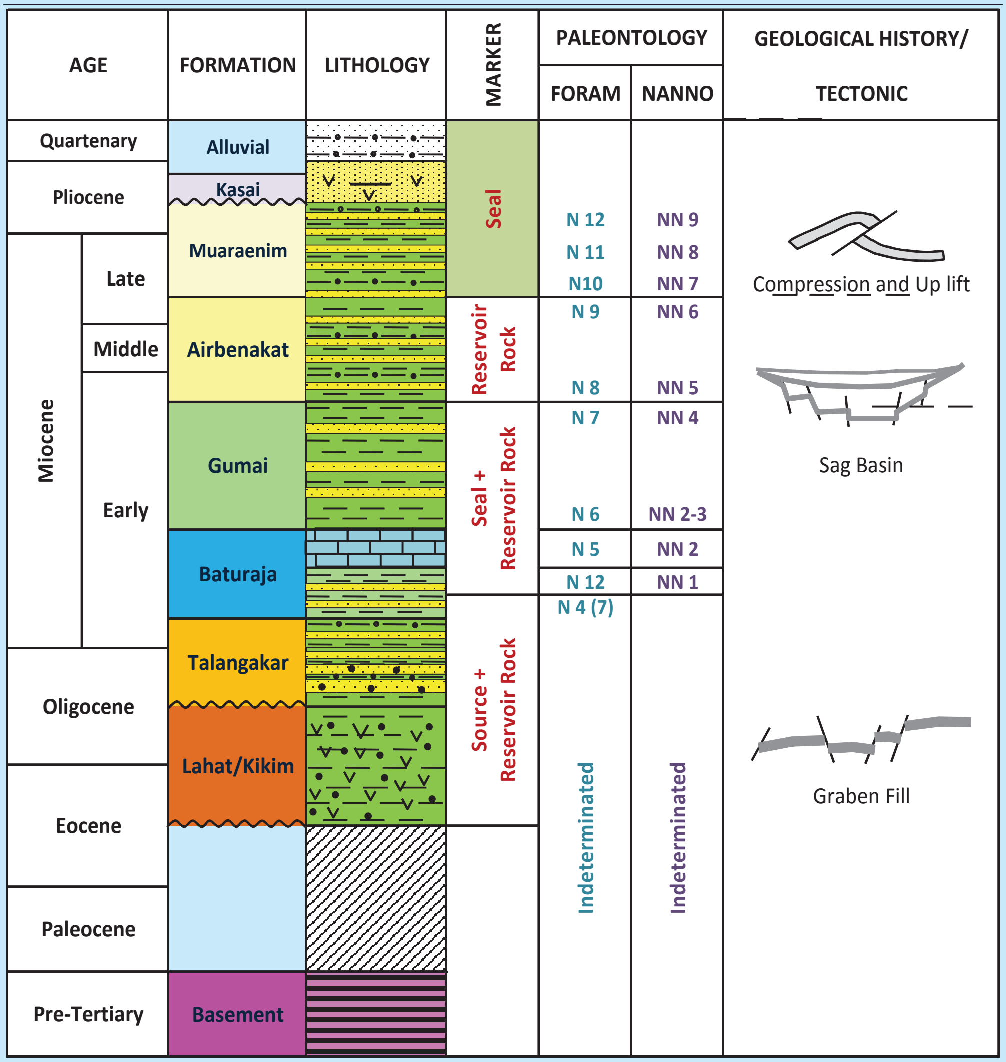

Figure 4
The stratigraphy of rock successions in the South Sumatra Basin (taken from Tarazona et al.1999 in Hermiyanto et al. 2009).

Lahat (Kikim) Formation consisting of purple green and red brown tuff, tuffaceous clays, andesite, breccia and conglomerate.

In turn, the Lahat Formation is unconformably overlain by the Oligocene-Miocene Talang Akar Formation, composed of medium to coarse grained sandstones and coal seams in the lower part; and calcareous grey shale and sandstone with coal seams in the upper part. Thickness of the Talang Akar Formation is approximately (up to) 900 m. Locally, the Talang Akar Formation was deposited in a terrestrial to paralic environment, resting unconformably on top of the pre-Tertiary basement. The Talang Akar Formation is conformably overlain by the shallow marine calcareous shale and limestone of the Baturaja Formation. Moreover, the Baturaja Formation is conformably underlain by the Gumai Formation composed of marl, claystone, shale, and silty shale, with occasionally thin limestone and sandstone intercalations. The Gumai sediments were deposited in a deeper open marine environment. In turn, the Gumai Formation is conformably overlain by the littoral to shallow marine Air Benakat Formation comprising sandy and marly claystone, with intercalations of glauconitic sometimes calcareous sandstone. The deposition of Talang Akar Formation up to Air Benakat Formation occurred during Oligo-Miocene time.

Subsequently, the Late Miocene-Pliocene Muaraenim Formation conformably overlying the Air Benakat Formation which is divided into Member a (interstratified sandstone and brownish claystone with principal coal seams) and Member b (greenish blue claystone with numerous ligniteous coal seams) deposited in a brackish environment (Suwarna 2006).

The youngest unit is the Kasai Formation, consisting of gravel, tuffaceous sands and clays, volcanic concretion, pumice, and tuff. This formation conformably to unconformably overlies the Mio-Pliocene Muaraenim Formation. The deposition of the Kasai Formation coincided with volcanic and magmatic activity occurring in the area. This activity formed some igneous intrusives intruding the coal layers such as found in the Bukit Asam coal mine.

II. METHODOLOGY

The study area is situated within the Geological Maps of Muara Bungo Sheet (Suwarna et al. 1992) and Sarolangun Sheet (Simanjuntak *et al.* 1994). These maps are used for basic reference in knowing the distribution of the Permian Mengkarang Formation, Talang Akar Formation, Gumai Formation, Air Benakat Formation, and Muaraenim Formation. The study focuses on the sedimentary rocks series which represent the target formations including Mengkarang and Talang Akar Formations. These formations are predicted to be potential source rocks. However, a view sample was collected from the younger sequences of the Air Benakat Formation in order to validate the palynological analysis of the target formations. Eventually, each formation was selected for a representative section, which was followed by collecting rock samples for laboratory analysis purposes. Systematic sampling was performed to obtain reliable analysis. For palynological analysis, it is preferable to have a fine grain sample with dark colour such as shale and coal.

A total of 21 samples were collected for this study consisting of 7 samples from Mengkarang Formation, 11 samples of Talang Akar Formation and 3 samples representing Air Benakat Formation. All samples were processed using standard palynological preparation technique in the Stratigraphy Laboratory of LEMIGAS including HCl, HF and HNO_3 macerations, which were employed to get sufficient recovery of plant micro-fossils for palynological analysis. These acid treatments were followed by the alkali treatment using 10% KOH to clear up the residue. Sieving using 5 microns sieve was conducted to collect more palynomorphs by separating them from debris materials. Finally, residue was mounted on the slides using polyvinyl alcohol and canada balsam. The fossil examination was taken under the transmitted light microscope with an oil immersion objective and X 12. 5 eye piece. The result of examination is recorded in the determination sheets and used for the analyses. As this study applies quantitative analysis, it is required to count 250 palynomorphs in each sample. The percentage abundance of palynomorphs from every sample was plotted onto a chart to illustrate temporal abundance fluctuations of each palynomorph type, using astatistically viable population (=count number) of palynomorphs in every sample. All analysed samples are integrated into a chart according to their stratigraphic position defined on the basis of field observation. Age interpretation is based on palynological zonations which were proposed by Rahardjo *et al.* in 1994. On the other hand, the environmental classification used in this paper refers to the deltaic environment modified by Winantris *et al.* (2014).

III. RESULTS AND DISCUSSION

In general, the studied sections provide low to moderate pollen assemblages with moderate preservation. Palynomorphs occurring in these sections derived from various vegetations including mangrove, backmangrove, riparian, peat swamp, and freshwater. Some selected palynomorphs which significantly appear in these sections are *Zonocostites ramonae* (mangrove pollen), *Florschuetzia trilobata* (back-mangrove pollen), *Marginipollis concinus* (riparian pollen), *Sapotaceoidaepollenites* type (peatswamp pollen) and *Callophyllum* type (freshwater pollen) (Figure 5). The significant occurrence of fresh water pollen indicates the development of freshwater vegetation under wet climate condition. In addition, considerable appearance of peatswamp pollen strongly supports wet climate indication.

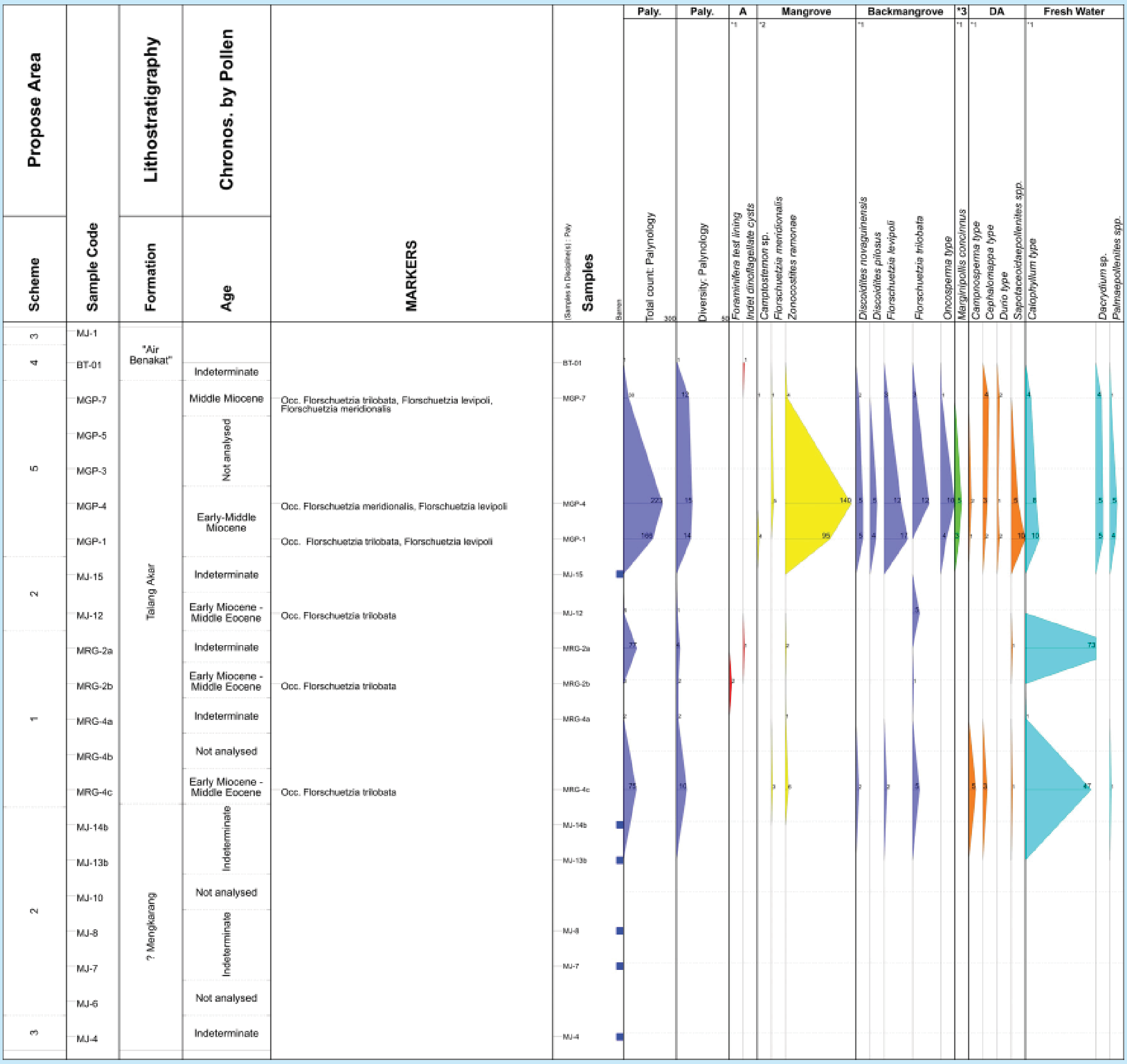

Figure 5
Quantitative palynological distribution chart occurring in the studied area.

A. Age Interpretation

Palynological zonation of the studied area is assigned to Early to Middle Miocene age. The sedimentary rocks taken from the Merangin River and the Muara Jernih area can be dated as not younger than Early Miocene as indicated by the appearance of biomarker *Florschuetzia trilobata* along the samples MRG-4c, MRG-2b, MRG-2a and MJ-12 and MJ-15 (see Figure 1 for sample location). Moreover, the sediment crouping out in the Mengupeh area also represents Early to Middle Miocene age as marked by the presence of index pollen *Florschuetzia trilobata, F. levipoli* and *F. Meridionalis* in samples MGP-1, MGP-4 and MGP-7 (see Figure 1 for sample location).

Most studied samples show lack of nannoplankton assemblage. However, some index nannoplankton occur to indicate the age of the analised samples. Basically, nannoplankton analysis confirms the age interpretation based on palynomorphs as suggested by the occurrence of *Sphenolithus compactus* in sample MJ-15 of the Muara Jernih area. It is supported by the existence of *Sphenolithus moriformis* at sample MGP-3 of the Mengupeh area suggesting zone NN9 to zone NN12 which equals to Early Miocene age (Bown 2012).

The foraminiferal assemblage yields poor recovery along the analysed sections. However, the presence of *Globigerinoides subquadratus* in the Mengupeh area indicates the top Early Miocene (BouDagher-Fadel 2012).

In light of the above discussion, it is concluded that the sediment situated in the studied intervals is assigned to Early to Middle Miocene.

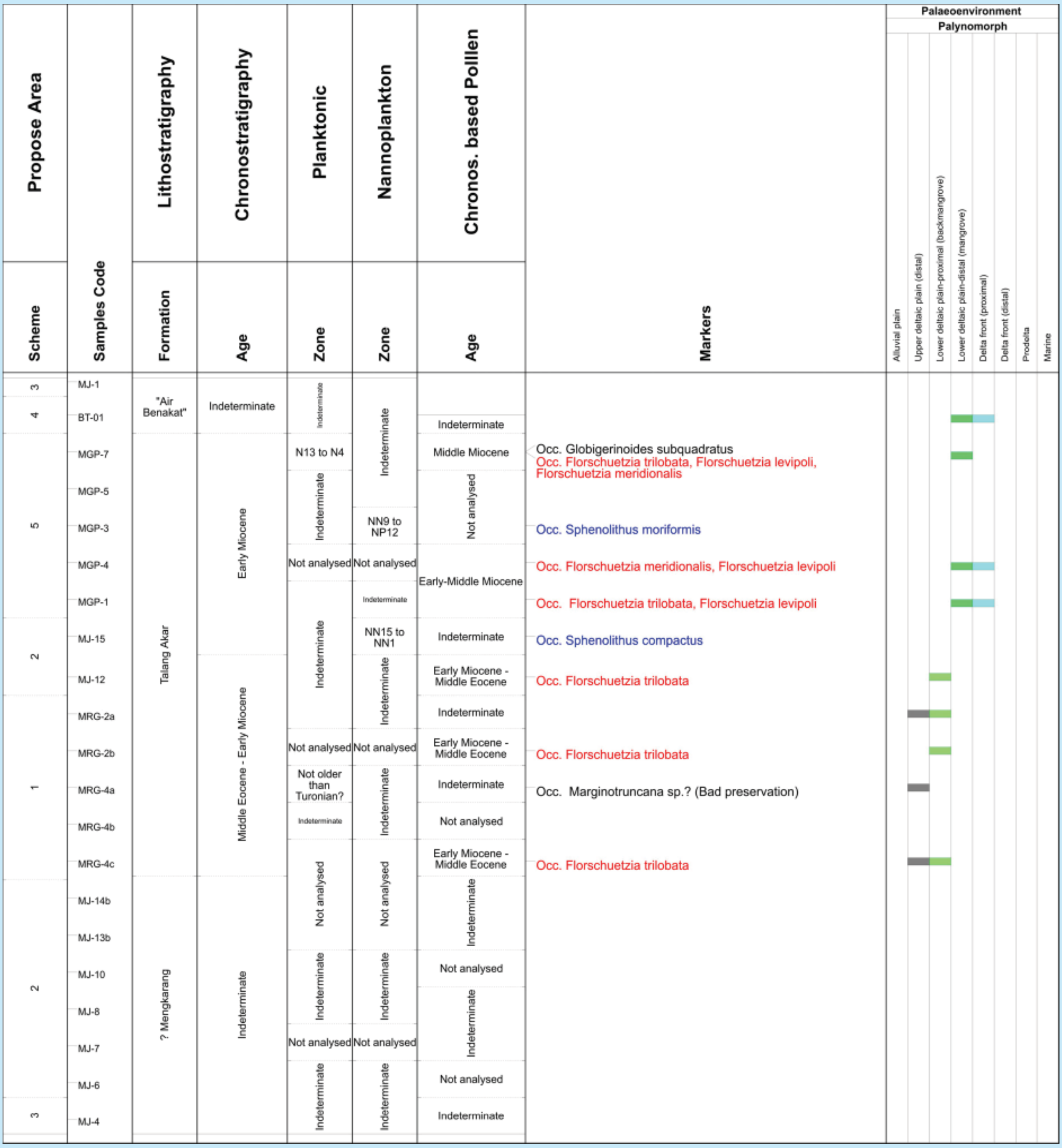

Figure 6
Biostratigraphic data summary log of the studied area.

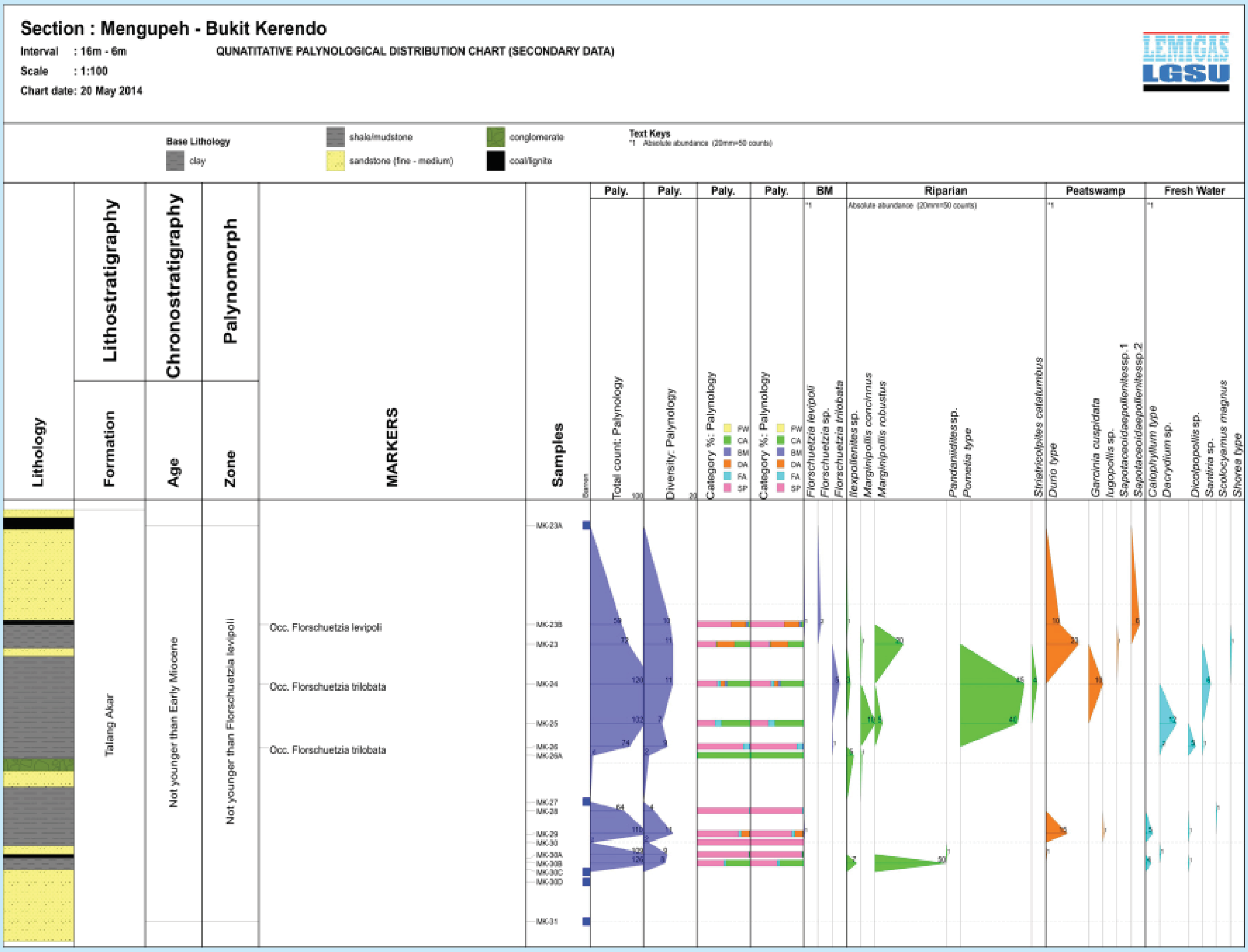

Figure 7
Quantitative palynological distribution chart of the Mengupeh – Bukit Kerendo section (see Figure 1 for sample location).

B. Paleoenvironment Analysis

The study shows that the analysed sediment was formed in various deltaic environments ranging from upper delta plain to delta front (Figure 6). The sequences found in the Merangin River and the Muara Jernih area considered as Talang Akar Formation were possibly deposited in upper delta plain to lower delta plain (littoral). Meanwhile, the sediment of the Talang Akar Formation in the Mengupeh area was formed in lower delta plain to delta front (littoral-inner neritic).

High abundance of brackish pollen *Zonocostites ramonae* appears in Early Miocene indicating the influence of marine environment during sedimentation (Figure 5). The studied sections are marked by significant occurrence of some freshwater pollen produced by peatswamp and freshwater swamp vegetation such as *Cephalomappa* type, *Campnospermae* type and *Sapotaceoidaepollenites* spp. Riparian elements regularly appear as shown by *Marginipollis concinus* and *Myrtaecidites* spp.

Review Of Previous Works

The secondary data used in this study is part of the result of South Sumatra Basin research, which was done by LEMIGAS Stratigraphy Group, Exploration Division in 1993–1995. The data was generated mainly from the field samples along some measure sections in the Mengupeh – Bukit Kerendo area, Jambi which are close to the study area (see Figure 1 for location).

The palynological analysis of the Talang Akar Formation obtained from the Mengupeh – Bukit Kerendo sections exhibits low to moderate pollen

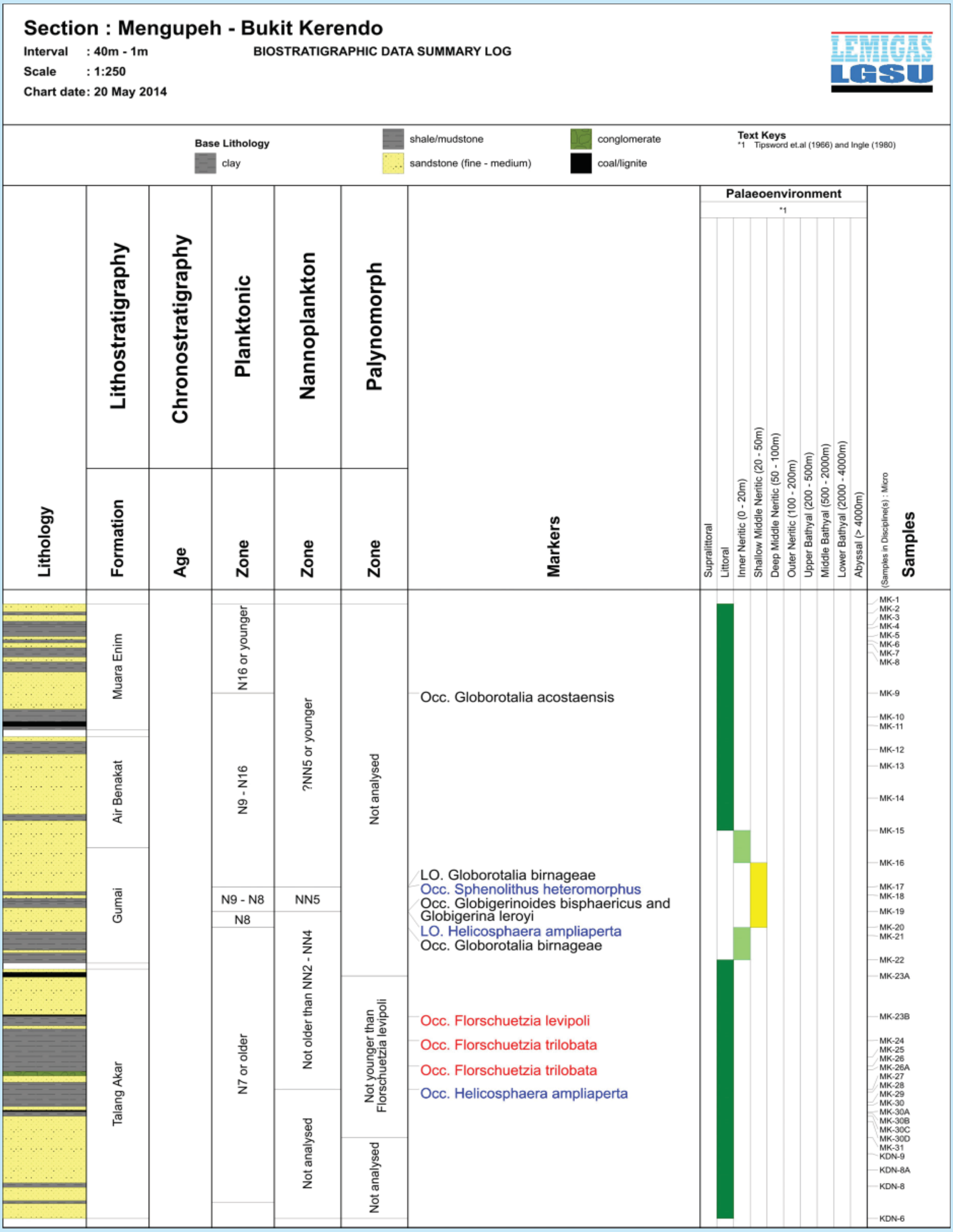

Figure 8
Biostratigraphic data summary log of the Mengupeh – Bukit Kerendo section (see Figure 1 for sample location).

assemblage. It is dominated by fresh water pollen including *Pometia* sp., *Marginipollis robustus* (riparian), *Durio* type and *Garcinia cuspidata* (peatswamp) (Figure 7). In this area, the Talang Akar formation is predicted to have an age of not younger than Early Miocene. This is based on the occurrence of pollen index *Florschuetzia trilobata* along the sample MK24 to sample MK26.

Foraminiferal investigation shows that most of the analysed samples are barren. Referring to the appearance of some index of planktonic foraminifer, the sediment of the Mengupeh-Bukit Kerendo sections possesses the age ranging from Early to Late Miocene as indicated by the occurrence of *Globorotalia birnageae*, *Globigerinoides bispaericus*, *Globigerina leroyi* and *Globorotalia acostaensis*. The Early to Middle Miocene sediment is marked by the last occurrence of *Globorotalia birnageae* at the top suggesting the existence of the Gumai Formation. In addition, the presence of *Globorotalia acostaensis* in the upper section suggests that the sediment within the upper section is attributed to the Late Miocene age (Figure 8).

Similar to foraminiferal analysis, most studied sediment is barren of nannoplankton assemblage. Calcareous nannoplankton mostly distributed within the lower part of the studied section. The last occurrence of *Helicosphaera ampliaperta* and the occurrence of *Sphenolithus heteromorphus* indicate zone NN5 which is equivalent to Middle Miocene age. Meanwhile, the occurrence of *Helicosphaera ampliaperta* at the lower part of this section defines the age of not older than zone NN2 (Early Miocene) as seen in Figure 8.

By using data integration of their benthonic foraminiferal and palynological assemblages, paleoenvironment of the studied sediment is reconstructed. In addition, this reconstruction also considers the presence of planktonic foraminifera, calcareous nannoplankton, other fossils and the existing lithology (inferred from cutting). Paleoenvironment of the studied area occurs in littoral which gradually shifts seaward into inner neritic and continuing to shallow middle neritic. Littoral environment is characterised by barren foraminifer. Litologically, it contains sandstones, clay with intercalations lignit and coal, and sediments structure of laminations and cross bedding. Inner neritic environment is represented by benthic forms of *Haplopragmoides* and *Bolivina* (Adisaputra *et al.* 2010). Meanwhile, the shallow middle neritic environment is indicated by the appearance of *Bolivina, Planulina, Pseudorotalia, Ammonia* and *Cancris* sp. supported by common foraminifer and calcareous nannoplankton.

After all, it can be concluded that the previous works conducted by LEMIGAS Stratigraphy Group suggest the age of Early Miocene for the Talang Akar Formation. This formation shows transgressive sucession as indicated by gradual change from transition (littoral) into shallow marine (inner neritic to shallow middle neritic). Due to the locations being close to the study area, this result is useful for reference of the current study.

IV. CONCLUSIONS

This study shows that the studied sediment mostly provides low to moderate pollen assemblages with moderate preservation. Palynomorphs are assumed to derive from various vegetations including mangrove, backmangrove, riparian, peat swamp and freshwater. The studied sediment has an age of Early to Middle Miocene which may be attributed to the Talang Akar Formation. Top Early Miocene is defined by the first occurrence of pollen *Florschuetzia levipoli* and the occurrence of *F. trilobata* supported by the occurrence of planktonic foraminiferal species *Globigerinoides subquadratus*. Meanwhile, the Middle Miocene age is indicated by the occurrence of pollen *F. levipoli* and *F. meridionalis*.

Paleoenvironment of the studied sediment initially occur in upper delta plain to lower delta plain (littoral) during Early Miocene at the Merangin River and Muara Jernih area. It subsequently shifts into lower delta plain to delta front (littoral to inner neritic) at the Mengupeh area during Middle Miocene. This interpretation is supported by the previous study done by LEMIGAS Stratigraphy Group during 1993 to 1995.

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