PALEOGENE PALYNOLOGY OF THE CENTRAL SUMATERA BASIN

PALINOLOGI UMUR PALEOGEN DI CEKUNGAN SUMATERA TENGAH

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ABSTRAK

Dibandingkan dengan kandungan polen pada sedimen Paleogen di Kawasan Barat Indonesia yang umumnya melimpah (seperti pada Formasi Nanggulan di Jawa Tengah, Formasi Tanjung di Kalimantan Selatan dan Formasi Malawa di Sulawesi Selatan), kumpulan polen pada sedimen Paleogen di Cekungan Sumatera Tengah relatif sedikit. Berdasarkan kemunculan spora indeks Oligosen *Cicatricosisporites dorogensis* dan didukung oleh keberadaan polen *Palmaepollenites kutchensis* dan *Meyeripollis naharkotensis,* disimpulkan bahwa percontoh sedimen yang dianalisis berumur Oligosen. Kesimpulan ini turut diperkuat oleh ketidak hadiran palinomorf asal India yang tiba di *Sundaland* pada umur Eosen. Studi ini juga menunjukan perbedaan kandungan palinomorf antara Brown Shale dan Upper Red Bed. Brown Shale didominasi oleh polen air tawar tanpa kehadiran polen air payau, menunjukan lingkungan non-marin. Diperkirakan Brown Shale terbentuk pada fase *syn-rift*. Anehnya, sedimen Brown Shale tidak mengandung alge air tawar penciri lingkungan danau seperti *Botriococcus* dan *Pediastrum* (sebagaimana dijumpai pada endapan danau Formasi Talang Akar di Cekungan Sunda-Asri). Sementara itu, *Upper Red Bed* ditandai oleh keberadaan palinomorf air payau secara signifikan, menunjukan pengaruh lingkungan marin pada periode *post-rift*. Secara keseluruhan penelitian ini membuktikan terjadinya sedimentasi transgresif yang dimulai dengan lingkungan air tawar tempat pembentukan sedimen *Brown Shale,* kemudian berpindah ke lingkungan transisi (laut dangkal) tempat terbentuknya endapan *Upper Red Bed*.

Kata Kunci: Palinologi, Paleogen, Cekungan Sumatera Tengah

ABSTRACT

Unlike rich pollen assemblage of other Paleogene sediments in western Indonesia (as seen in Nanggulan Formation of Central Java, Tanjung Formation of South Kalimantan and Malawa Formation of South Sulawesi), pollen assemblage of Paleogene sediments in the Central Sumatera Basin is considerably low. Referring to the occurrence of Oligocene spore Cicatricosisporites dorogensis supported by pollen Palmaepollenites kutchensis and Meyeripollis naharkotensis, it is inferred that the studied sediment is assigned to Oligocene age. This is strengthened by the disappearance of many key Indian affinities which arrived in the Sundaland during Eocene. Palynologically, this study separates the Brown Shale from the Upper Red Bed. The Brown Shale is dominated by fresh water pollen without brackish element suggesting non-marine environment. This sequence might have been formed in syn-rift setting. Surprisingly, lacustrine indicators of fresh water algae Botriococcus and Pediastrum (as found in the lacustrine sediment of Talang Akar Formation of Sunda-Asri Basin) are absent. Mean while, the Upper Red Bed is marked by significant occurrence of brackish palynomorphs suggesting the influence of marine environment during post-rift period. This condition proves the existence of the transgressive phase where sedimentation started in freshwater environment during the Brown Shale deposition which gradually shifted into transition (shallow marine) environment during the Upper Red Bed sedimentation.

Keywords: *Palynology, Paleogene, Central Sumatera Basin*

I. INTRODUCTION

Background

The Central Sumatera Basin is well known as a bigest oil producing basin in Indonesia. It had been produced since the Dutch colonisation and still producing today. This basin is clasified as a mature basin in which the basin is well explored providing sufficient data for research. Therefore, many papers have been published covering various aspects of geoscience. However, palynological research performed on this basin is minimum as indicated by limited publication regarding this research, especially that of Paleogene age. This condition may relate to the difficulty in accessing sufficient data which was mostly obtained during exploration drilling by the oil companies. This data is then considered to be confidential and non public domain. Although, palynological publication may be absent for more than a decade, palynological works are continously and sporadically conducted to support exploration activities. The result of these works can be viewed in the company reports and publications concerning the Central Sumatera Basin. In addition, recent publication was writen by Setyaningsih in 2013 who proposed palynological events of the Pematang Formation occurring in the Aman Trough. On the other hand, previous works on neighbouring basin indicated excellent palynological assemblages obtaining from Paleogene sediment (Batram & Nugrahaningsih, 1990). The iguanurinoid palm pollen type *Palmaepolenites kutchensis* was found in coal lithology of the Sangkarewang Formation of the Ombilin Basin to define the Eocene age. High pollen assemblages combined with coal appearances indicate that the Central Sumatera Basin experienced wet climate condition during Eocene.

Refering to the above condition, this paper is intended to evaluate palynological content extracted from the Paleogene sediments to better understand the stratigraphy of Central Sumatera Basin. It is different from the previous study performed on this basin in term of data sources and the results of the study including the interpretations of age, depositional environment and sea level changes. The study area is located in the on-shore Central Sumatera (Figure 1). This study is conducted by Lemigas Stratigraphy Group in order to investigate the geology of Paleogene sediment in Central Sumatera. It is aimed to evaluate the hydrocarbon potential within this sediment of this area. Data used in this study is biostratigraphic data which is generated from subsurface samples deriving from wells L, M and G. It includes palynology, micropaleontology and nannoplankton data. This independent analysis allows biostratigraphers to gains accurate interpretation by crosschecking available data.

The Eocene/Oligocene palynology of western Indonesia is influenced by the tectonic activities as indicated by rapid rifting and subsidence which result in the initiation of some basins including the central Sumatera basin (Morley, 2000). These basins were firstly filled by the sediment which was deposited in the non-marine environment (such as river, lake, swamp, etc.), known as syn-rift deposit. It is reported that during this age, vegetation well developed under wet climate condition. It seems that low land forest dominates this environment. Palynologically, the syn-rift sediment is dominated by fresh water pollen especially those derive from vegetations growing around the river, lake or swamp. *Sapotaceoidaepollenites* sp., *Calophyllum* type, *Dicolpopollis* spp., *Meyeripollis naharkotensis* and *Palmaepollenites* spp. usually appear to indicate

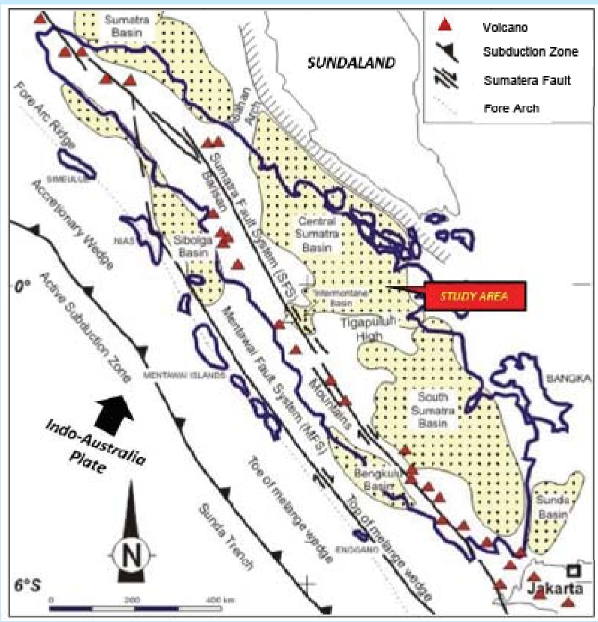

Figure 1
Location of study area and the tectonic setting of the Sumatra Island (Pertamina-BPPKA, 1996 in Indranadi et al, 2011)

this sediment. In addition, lacustrine sediment of Oligocene Talang Akar Formation in Asri Basin is marked by high occurrence of fresh water algae of *Botriococcus* and *Pediastrum* (Lelono, 2006). Mean while, Eocene Sangkarewang Formation of Ombilin Basin shows high pollen assemblages to suggest well development of low land forest under the influence of wet climate. Subsidence continues to shift depositional environment into transition or shallow marine environment forming post-rift deposit. This is proved by the occurrence of bracksih pollen such as *Zonocostites ramonae* and *Spinizonocolpites echinatus*.

Regional Geology

The Central Sumatera Basin is a part of back arch basin situated on the southwest edge of the Sunda Craton (Utomo et al, 2011). It is located on the center of Sumatera Island which is limited by Asahan Arch at the northwest, Sunda Craton pre-Tertiery outcrops from the east to the northeast, Tigapuluh Mountain at the south, intermontane basin at the southwest and Barisan Mountain at the west (Figure 1). The Central Sumatera Basin is generally shallow which is less than 2000m depth (Indranadi et al, 2011). This basin consists of several sub-basins which are oriented into two different patterns including the older pattern of N-S trends and the younger pattern of NW-SE trends. The N-S trending grabens are usually deeper than the NW-SE trending grabens. These grabens are represented by Baruman, Baram-Kiri, Aman and Bengkalis. Mean while, the NW-SE trending grabens include Mandian, Tesso, Kiliran and Binio. The tectonic events occurring in western Indonesia very much influence the geological history of the basin. The tectonic episode during Eocene-Oligocene as indicated by the arrival of Indian continent on Asian Continent has resulted in the formation of half-graben along Southeast Asian Region including the Central Sumatera Basin (Hendrick & Aulia, 1993 in Utomo et al, 2011). This event is characterised by the occurrence of syn-rift deposit so called Pematang Formation which is actually the subject of this study. It was deposited in the fluvial to lacustrine environment (Yustiawan et al, 2013). The opening of South China Sea during Late Oligocene has caused slow movement of the Australian Oceanic Plate which retreated subduction zone triggering basin subsidence in the upper plate. Therefore, this event is marked by subsidence and transgression sequences due to extentional tectonic regime during Late Oligocene to Middle Miocene as shown by Sihapas Group (Lakat, Tualang & Telisa Formations). These formations were deposited in the transtional to shallow marine environment. Finally, the activation of subduction zone due to oceanic crust spreading in the Andaman Sea during Middle Miocene caused mega faults along Sumatera Island (well known as Sumatera Fault System) and up-lifted the Barisan Mountain. This compressional tectonic regime formed regional inverted within the Sumateran basins which is represented by the appearance of regression sequences as shown by Binio and Korinci Formations of the Petani Group (Indranadi et al, 2011). Regional stratigraphy of the Central Sumatera Basin is shown in Figure 2.

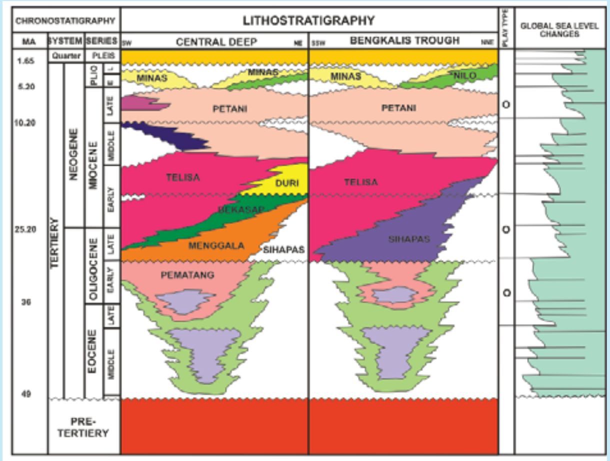

Figure 2
General stratigraphy of the Central Sumatra Basin
(Hadipandoyo et al, 2006)

This study is focused on the Paleogene succession which was presumably formed within syn-rift period consisting of Lower Red Beds, Brown Shale and Upper Red Beds Formations. These formations are equivalent to the Pematang Formation (Simanjuntak et al, 1991 & 1994 in Harahap et al, 2003) which was formally named Kelesa Formation by de Coster (1979). Mean while, Yustiawan et al, (2013) separate syn-rift deposits of the Pematang Formation into two main facies based on the lithological character including Pematang Sandstone and Pematang Brown Shale. Refering to the occurrence of index palynomorphs of *Meyeripollis naharkotensis*, *Florschuetzia trilobata* and *Proxapertites operculatus*, the age of this formation is assigned to Late Eocene to Oligocene (Utomo et al, 2011). The Lower Red Bed sequence representing the first succession of the Pematang Formation unconformably overlies the pre-Tertiery basement. It is lithologically characterised by conglomerate, arcosic sandstone, siltstone, mudstone and shale. The Lower Red Bed was deposited in the alluvial plain along the hinge border of graben faults. The appearance of fanglomerates and conglomerates with basement fragments indicates an early deposition in the Central Sumatera Basin (early syn-rift). Due to lack of age diagnostic fossil, the age of this deposit is unknown. However, on the basis of its stratigraphic position, the Lower Red Bed is assumed to have an age of older than Oligocene or possibly Eocene (Indranadi *et. al*., 2011). The Brown Shale conformably overlies the Lower Red Bed consisting of sand, shale and coal. It is interpreted to be formed in the fluvial overbanks or shallow lacustrine environment during Late Eocene to Early Oligocene (Yustiawan et al, 2013). The Pematang Brown Shale is proven as a source rock in the Central Sumatera Basin. Finally, the Upper Red Bed is situated above the Brown Shale which is characterised by the occurrence of paleosol suggesting basin uplifting and erosion during Late Oligocene (Indranadi et al, 2011).

II. MATERIALS AND METHODS

The samples used in this study are ditch cuttings which were obtained from three exploration wells namely L, M and G. Although this study focusses on palynological analysis, it is also employed other biostratigraphic analyses including foraminifer and calcareous nannoplankton. The biostratigraphic assessment using three different analyses provides independent results which allow biostratigraphers to cross-check each analysis. In order to get accurate interpretation, this study applies quantitative method which involves logging and counting of every single micro-flora or fauna. Palynological analysis requires 250 specimens per sample to perform quantitative method. Mean while, foraminiferal analysis needs to weigh 100 grs of wet samples. Nannoplankton analysis counts the absolute occurrence of micro-fossil which occurs in 200 fields of view for each sample. Subsequently, the biostratigraphic data obtained from microscopic work was inputted into the computer using selected software so called StrataBug.

The diversity and the abundance of each micro-fossil are plotted into biostratigraphic quantitative charts to define the age and the depositional environment of the studied samples. Foraminiferal and palynological quantitative charts provide the interpretation of age and depositional environment, whilst nannoplankton quantitative chart presents the age interpretation. The determination of biozonation and age of the studied samples is based on various standard zonations published by various authors. For foraminiferal analysis, zonal subdivision and age interpretation are based on planktonic zonation proposed by BouDagher-Fadel (2012) with some modification. In case of the absence of index planktonic taxa, the zonal and age determination rely on benthonic zonation proposed by Kholiq (2007). For nannoplankton analysis, these interpretations refer to nannoplankton zonation of Bown (2012) with some modification. In addition, the pollen zonation proposed by Rahardjo et al, (1994) is used to define zonal subdivision and age interpretation (Figure 3). Mean while, the reconstruction of the depositional environment of the studied samples applies two different classifications including deltaic classification modified by Winantris et al, (2014) and marine classification proposed by Adisaputra et al, (2010).

III. RESULTS AND DISCUSSIONS

A. Pollen Assemblages

The Paleogene sediment observed in this study consists of Brown Shale and Upper Red Bed of the Pematang Formation. The result of palynological analysis surprisingly shows low pollen assemblages. This is different compared to those occurring in the Eocene-Oligocene sediments which were collected from other locations in western Indonesian. The Middle to Late Eocene Nanggulan Formation crouped out in Yogyakarta (Central Java) provides high abundance and diversity of palynomorph. In fact, many of them came from India following the collision between Indian Micro-continent and Asian Continent at about Middle Eocene such as *Palmaepollenites kutchensis*, *Proxapertites* group, *Lakiapollis ovatus* and *Retistephanocolpites williamsi* (Lelono, 2007). Eocene Malawa Formation of South Sulawesi yields

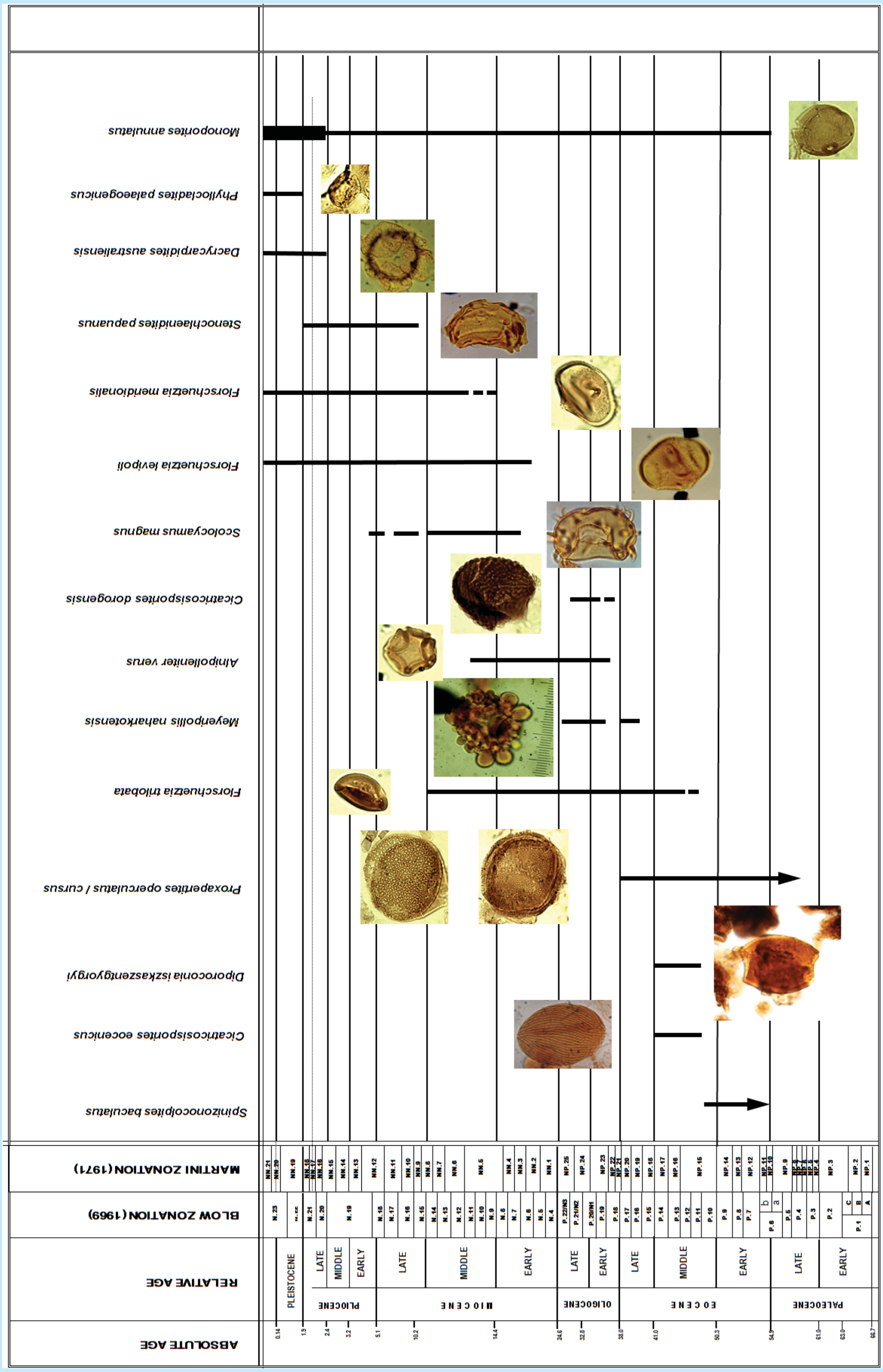

Figure 3
Palynological zonation of western Indonesia (Rahardjo et al, 1994 with small modification)

simillar pollen assemblages as those found in the Nanggulan Formation in Central Java (Lelono, 2000). Mean while, Oligocene Talang Akar Formation from Sunda-Asri Basin (Off-shore Northwest Java Basin) demonstrates high abundance of fresh water algae *Pediatrum* and *Botriococcus* to indicate lacustrine environment (Lelono, 2006).

In general, there are two diferent features that can be observed along the studied well sections. Firstly, the Brown Shale sequence (lower sections) shows low abundance of palynomorphs, whilst the Upper Red Bed (upper sections) exhibits moderate to high abundance of palynomorphs. Secondly, the Brown Shale lacks of brackish pollen, whereas the Upper Red Bed contains significant brackish pollen including *Zonocostites ramonae* and *Spinizonocolpites echinatus* (Figures 4 and 5). These differentiations may be used to separate the Brown Shale from the Upper Red Bed which occur in the study area.

Palynomorphs recorded from the studied wells are typically representing Asian affinity. They derive from various sources including brackish water (mangrove and back-mangrove), river side, peat swamp and freshwater swamp, as well as undifferentiated fresh water and montane. The pollen assemblages existing in the studied sections are demonstrated in Figure 6. The brackish palynomorphs appear in the upper sections indicating the influence of marine environment which include *Zonocostites ramonae* (mangrove pollen) and *Spinizonocolpites echinatus* (back-mangrove pollen). On the other hand, river side pollen are represented by *Illexpollenites* sp. and *Pandanidites* sp. Other fresh water palynomorphs are *Cephalomappa* type, *Durio* type and *Sapotaceoidaepollenites* spp. (peat swamp), *Calophyllum* type, *Casuarina* sp., *Dacrydium* sp., and *Palamepollenites kutchensis* (fresh water).

B. Age Interpretation

Some Paleogene markers are consistently found across the studied wells. They are *Palmaepollenites kutchensis*, *Meyeripollis naharkotensis* and *Cicatricosisporites dorogensis* (Figure 6). Pollen *P. kutchensis* derived from India and appeared in Western Indonesia at Middle Eocene. This pollen was abundantly found in the Eocene Nanggulan Formation of Central Java (Lelono, 2000). It stratigraphically appears up to Early Oligocene (Morley, 2000). Mean while, another Indian pollen of *M. naharkotensis* firstly arrived at Sundaland in Late Eocene and continued to occur up to Late Oligocene (Morley, 1991). However, its appearance is influenced by the occurrence of peat layers. This pollen is motsly common in the area where peats or coals are well developed suggesting wet climate condition (Lelono, 2001). The spore *C. dorogensis* is widely used to define Oligocene age. Therefore, the apprearance of spore *C. dorogensis* within the studied samples indicates that they are attributed to Oligocene (Morley, 1991).

Considering the occurrence of pollen *Palmaepollenites kutchensis* and *Meyeripollis naharkotensis*, one may assume the existence of Late Eocene to Oligocene age. However, referring to the pollen assemblages of the Eocene Nanggulan and Malawa Formations where planty of key Indian affinities disappear from the studied wells, it is possible that the studied samples are somewhat younger than those formations. In addition, the appearance of Oligocene marker of spore *Cicatricosisporites dorogensis* through out the well sections most likely suggests the Oligocene age. This spore shows peak abundance in the upper section (Upper Red Bed) as seen in well L (Figure 6). Having said that, it can be inferred that the sediment situated in the studied sections is attributed to the Oligocene age.

Unfortunately this interpretation is unable to be cross-checked using other biostratigraphic tools including foraminifer and nannoplankton as these marine micro-fossils are extremely low. This situation is understandable because most samples is non-marine sediment as proved by non-calcareous lithology. Only samples collected from the Upper Red Bed were analysed for foraminifer and nannoplankton as they contained brackish palynomorphs (*Zonocostites ramonae*, *Spinizonocolpites echinatus* and foraminiferal test linnings) indicating the existence of marine influence (Figure 4). Based on the occurrence of the index planktonic foraminifer *Globigerinoides primordius* at the top sample (Figure 7/B), it is interpreted that the top part of this formation belongs to Early Miocene (BouDagher-Fadel, 2012). This is supported by the appearance of nannoplankton *Cyclicargolithus abisectus* which defines the age of not younger than lower part of Early Miocene (Bown, 2012).

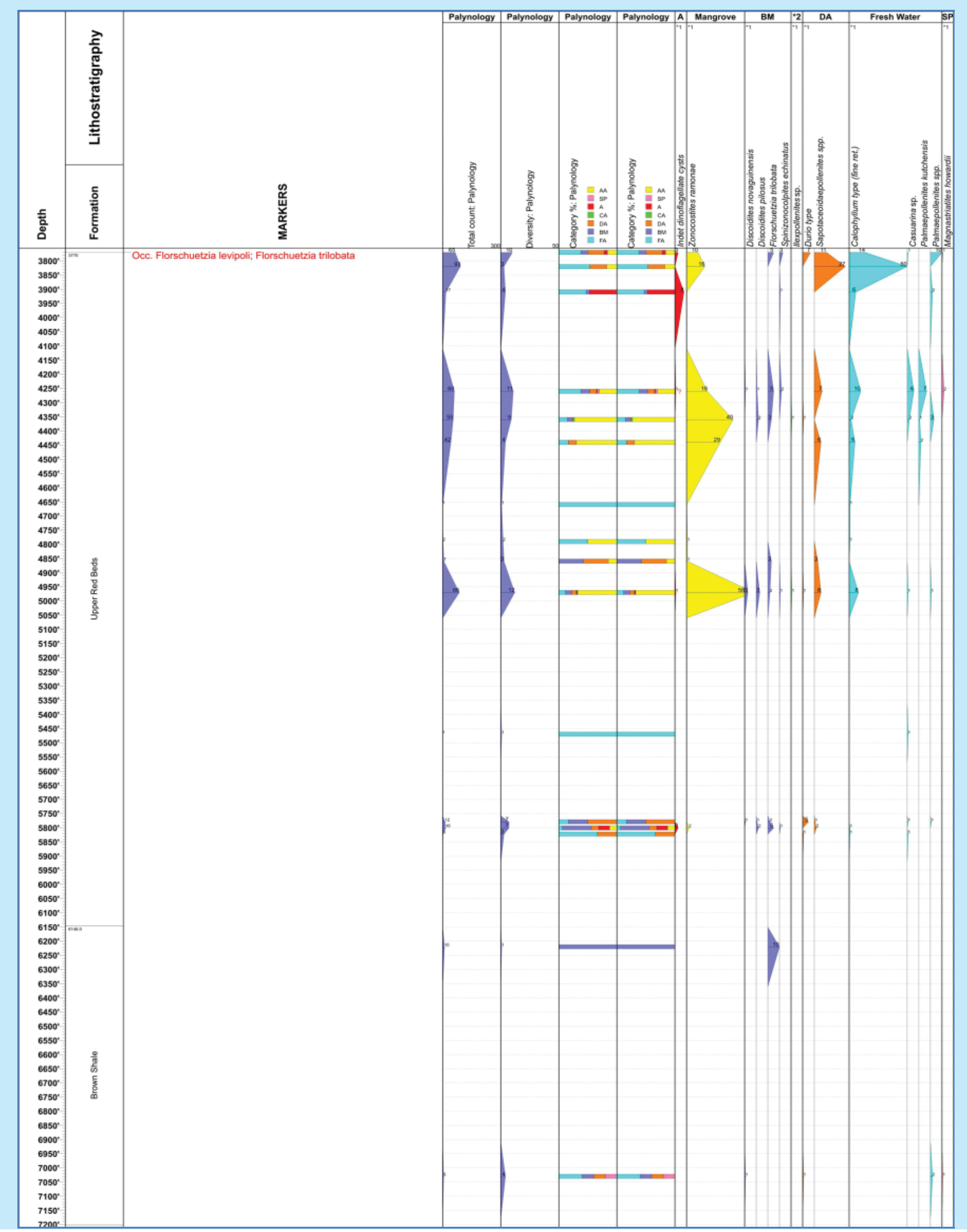

Figure 4
The appearance of brackish palynomorphs (mangrove and back-mangrove (BM) within the Upper Red Bed in well M.

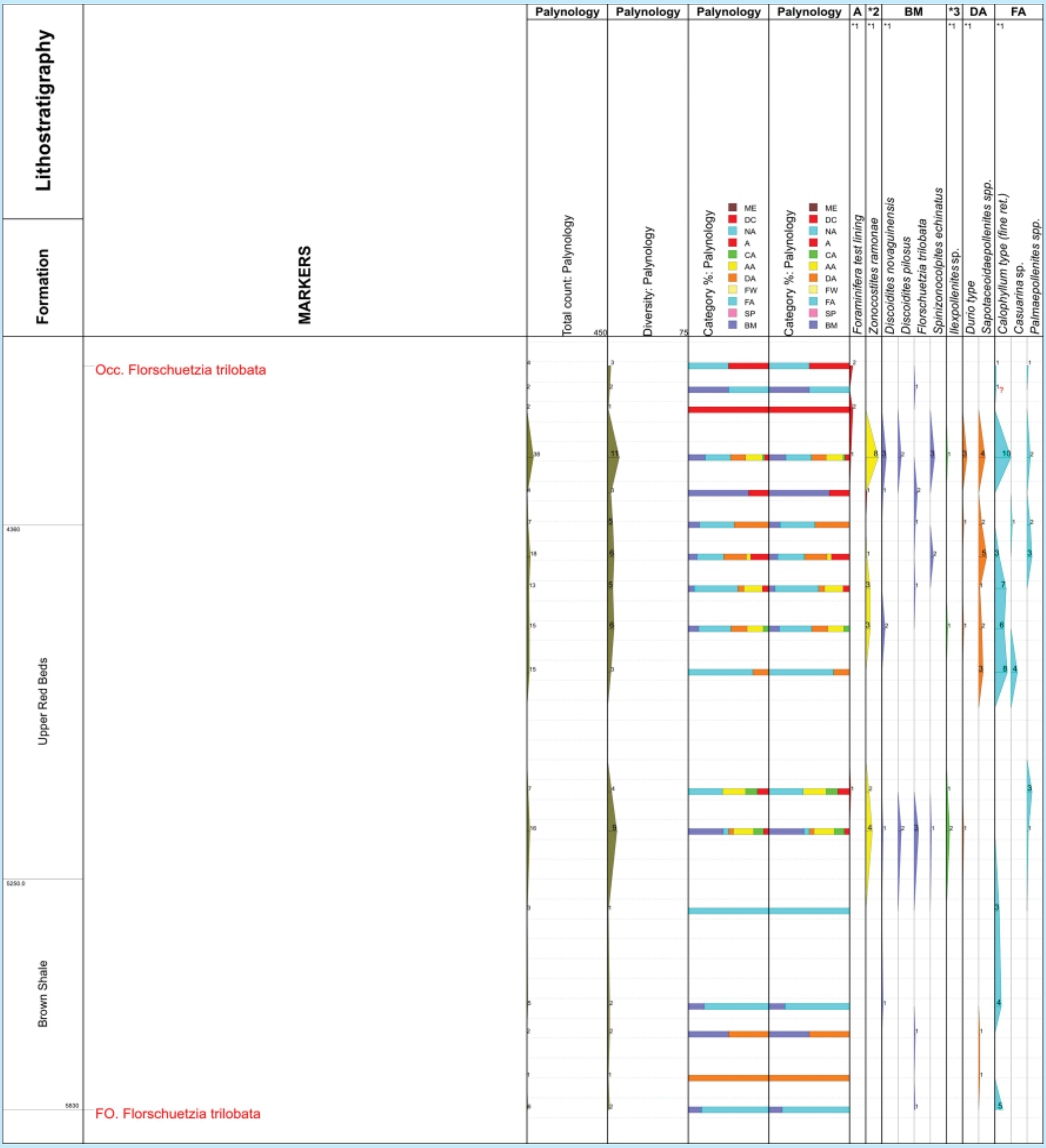

Figure 5
The Upper Red Bed occuring in well G is indicated by the appearance of brackish pollen, whilst the Brown Shale is marked by the lack of this pollen (*2 and BM).

Having these interpretations, it is concluded that the sediment situated in the studied intervals represents Oligocene age.

C. Paleoenvironment

Generally, the studied sediment can be separated into two types based on the occurrence of palynomorphs. The first type is the sediment without (or with rare) brackish element which is situated in the lower sections (older). This type is assigned to the Brown Shale. The second type is the sediment showing the appearance of brackish palynonmorphs which locates in the upper sections (younger). This type includes the Upper Red Bed (Figure 4). Referring to this fact, it can be interpreted that the studied sediment was formed during transgression phase. Sedimentation initially occurred in the fresh water environment as proved by the existance of Brown Shale which hardly contained brackish palynomorph. It then gradually changed into transition environment as suggested by the appearance of Upper Red Bed which yields brackish palynomorphs and marine micro-fossil of foraminifers and nannoplankton.

The Brown Shale sequence is characterised by the domination of low occurrence of fresh water pollen including *Ilexpollenites* sp. (riparian), *Sapotaceoidaepollenites* spp. (peatswamp), *calophyllum* types, *Casuarina* sp., *Meyeripollis naharkotensis* and *Shore* type (fresh water). The limited appearance of brackish palynomorphs in Well L is considered to be caving forms as shown by *Discoidites* spp. and *Florschuetzia trilobata* (Figure 6). The lacustrine indicators of fresh water algae *Pediatrum* and *Bosedenia* disappear from this sequence. On the contrary, the Oligocene Talang Akar Formation of the Sunda Sub-basin is marked by abundant *Pediastrum* and *Bosedinia* indicating the occurrence of lacustrine sediment. The question is that where have they gone? Although this is unlikely, the absence of these algae may indicate the disappearance of the lacustrine sediment. In fact, all studied wells lack of these fresh water

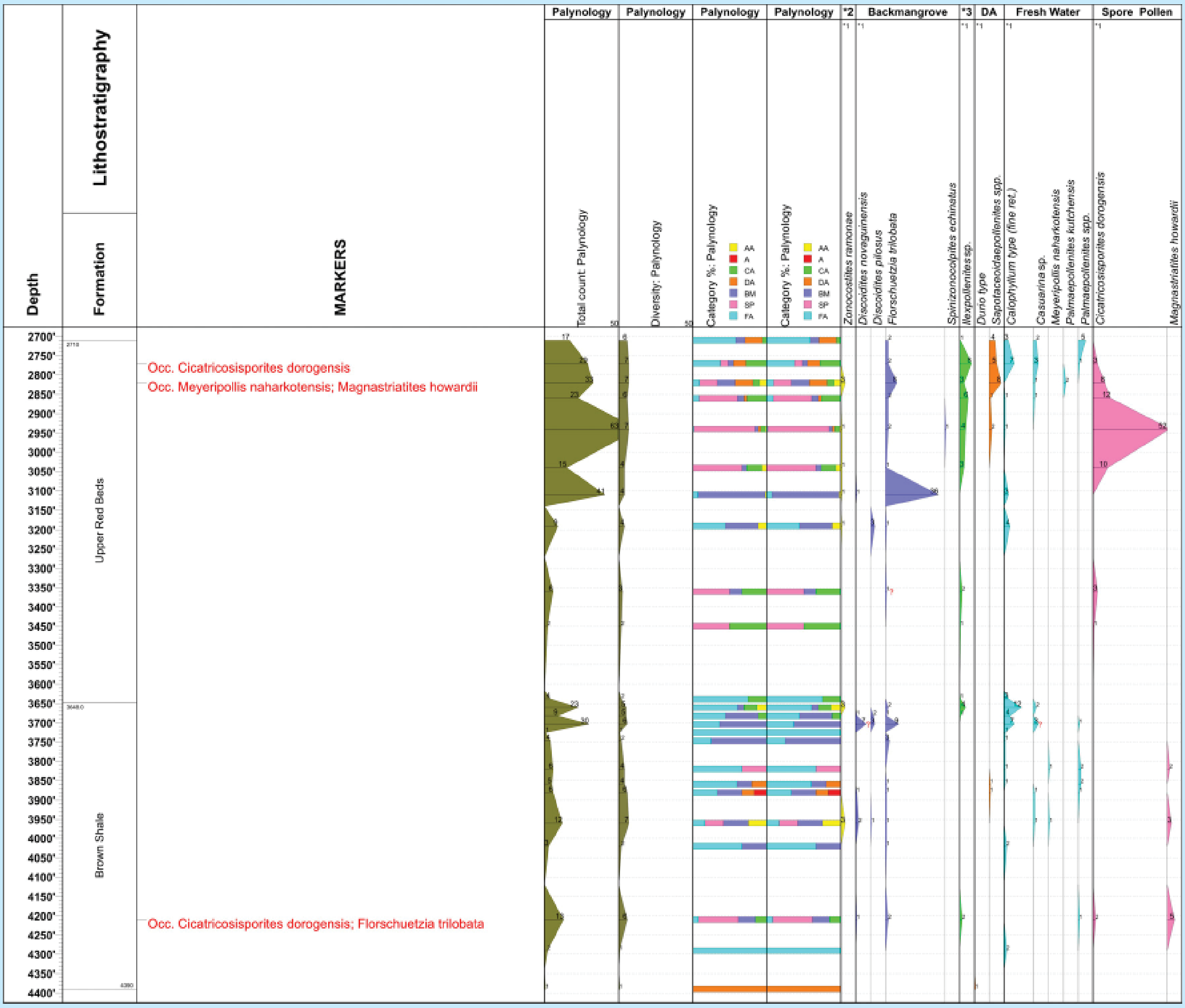

Figure 6
Pollen distribution of well L showing the occurrence of age-restricted taxa including Palmae-pollenites kutchensis, Meyeripollis naharkotensis and Cicatricosisporites dorogensis

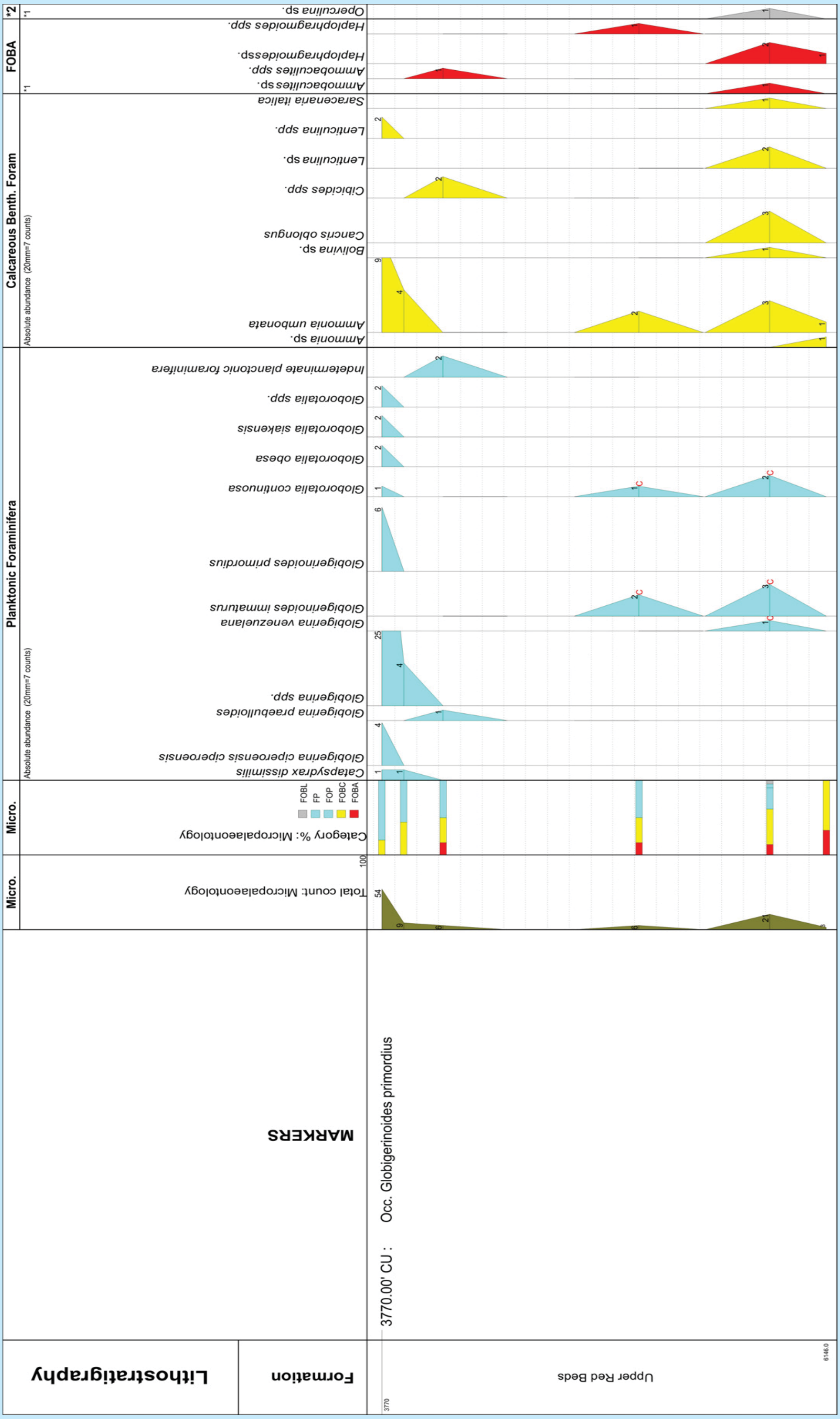

Figure 7
The distribution of marine micro-fossils of foraminifer within the Upper Red Bed occuring in well M.

algae. Apparently, this evidence does not support the appearance of lacustrine sediment of Brown Shale as proposed by the previous authors. Therefore, this needs more works to find palynological evidence for defining lacustrine sediment.

The opposite situation is shown in the Upper Red Bed in which the pollen assemblages increase significantly. More over, brackish palynomorphs gradualy increase suggesting the influence of marine environment. The brackish palynomorphs are represented by *Zonocostites ramonae*, *Acrostichum aureum*, *Discoidites* group, *Spinizonocolpites echinatus*, foraminiferal test linning and indeterminate dinoflagellate cysts. This is in line with the existence of marine micro-fossils of foraminifers along the Upper Red Bed as demonstrated in Well M (Figure 7). Generally, foraminiferal assemblages are low consisting of planktonic and benthonic forms. Planktonic foraminifers are concentrated on the top section compossing of *Globigerina ciperoensis ciperoensis*, *Globigerina* spp., *Globigerinoides primordius* and *Globorotalia siakensis*. Mean while, benthonic foraminifers are dominated by shallow marine forms including *Ammonia umbonata*, *Bolivina* sp., *Lenticulina* sp., *Ammobaculites* sp. and *Haplophragmoides* sp. Another shallow marine indicator is larger benthonic foraminifer of *Operculina* sp. These shallow water markers indicate depositional environment within bathimetry up to 20 m or classified as lithoral to inner neritic (Adisaputra *et. al.*, 2010). The benthonic foraminifers are concentrated at the lower section which considerably decrease toward the upper section. Both planktonic and benthonic foraminiferal assemblages suggest that depositional environment changes from shallower setting at the lower sections to deeper and more open environment at the upper sections. Therefore, it can be assumed that sedimentation of the Upper Red Bed was presumably under the transgressive phase where depositional environment initially took place at the shallower marine setting (lower sections) gradually shifted into deeper marine environment (upper sections).

Regarding climate condition, the studied area might experience dry situation as indicated by low abundance and diversity of palynomorphs suggesting low rain forest development. Some climate indicators appearing in the studied sections are *Cephalomappa* type, *Sapotaceoidaepollenites* spp., *Calophyllum* type, *Palmaepollenites kutchensis* (wet climate), *Monoporites annulatus* and *Magnastriatites howardii* (dry climate). The wet indicators show low assemblage in the lower sections (Brown Shale). They significantly increase in the upper sections (Upper Red Bed). Considering above evidence, it is possible that the climate might have changed from dry (Brown Shale) to slightly wetter (Upper Red Bed).

After all, it is infered that sedimentation initially occurred in the freshwater environment to form Brown Shale Sequence. It gradually shifts in to fresh water – transition (shallow marine) during the deposition of Upper Red Bed Sequence.

IV. CONCLUSION

This study investigates palynological content of the Paleogene samples obtained from three exploration wells which are located in the Central Sumatra Basin. Most samples show low pollen assemblages deriving from various environments including mangrove, back-mangrove, riparian, peat swamp and fresh water. The studied sediment is equivalent to the Pematang Formation which consists of Brown Shale and Upper Red Bed. Based on the occurrence of Paleogene pollen of *Meyeripollis naharkotensis* and *Palmaepollenites kutchensis* it is assumed that the age of the studied sediment is Late Eocene to Oligocene. However, the disappearance of many Indian affinities as abundantly found in other Eocene formations in western Indonesia (Nanggulan Formation in Central Java, Tanjung Formation in South Kalimantan and Malawa Formation in South Sulawesi) tends to indicate Oligocene age. This is strengthened by the occurrence of Oligocene spore of *Cicatricosisporites dorogensis*. Unfortunately, this interpretation is unable to be confirmed using other biostratigraphic tools such as planktonic foraminifer or calcareous nannoplankton as they are barren.

The Brown Shale samples are identified by the disappearance of brackish palynomorphs. They are represented by fresh water pollen. On the other hand, the Upper Red Bed samples are marked by significant occurrence of brackish elements suggesting marine influence. This is in line with the facts that marine micro-fossil of foraminifers are only concentrated in the Upper Red Bed lithogy. They are disappearing within the Brown Shale sequence. Surprisingly, the lacustrine indicators of fresh water algae *Pediatrum* and *Bosedenia* are not found along the studied sections. These evidences suggest that the studied sediment was deposited under transgressive regim. The sedimentation commenced in the freshwater environment during the Brown Shale deposition. It gradually shifted in to transition (shallow marine) environment during the Upper Red Bed sedimentation. It is possible that the studied area might experience dry climate as indicated by low abundance and diversity of palynomorphs suggesting low rain forest development.

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