

OLIGOCENE PALYNOLOGY OF ON-SHORE WEST JAVA

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ABSTRAK

Dibandingkan dengan sedimen umur Oligosen di lepas pantai (*off-shore*) Jawa Barat Utara (juga lepas pantai Jawa Timur Utara), sedimen Oligosen di daratan (*on-shore*) Jawa Barat Utara mengandung palinomorf dengan kelimpahan rendah. Palinomorf penunjuk iklim superwet yang banyak dijumpai di lepas pantai tersebut, jarang ditemukan di daratan. Meskipun demikian, diyakini bahwa area daratan dipengaruhi iklim basah (*wet*) sebagaimana dibuktikan dengan banyaknya polen rotan *Dicolpopollis* sp. yang menunjukkan lebatnya hutan rawa (*swamp forest*). Selain itu, pada sedimen Oligosen di daratan Jawa Barat Utara jarang dijumpai palinomorf danau (*lacustrine*) sebagaimana banyak ditemukan pada sedimen Oligosen di lepas pantai Jawa Barat Utara. Kemungkinan hal ini menandai tidak berkembangnya sedimen danau pada umur Oligosen di daratan Jawa barat Utara. Penentuan umur Oligosen berdasarkan pada kemunculan polen penunjuk umur Oligosen, yaitu *Meyeripollis naharkotensis*. Kemunculan akhir polen ini menandai puncak umur Oligosen. Kenyataannya, kehadiran polen *Meyeripollis naharkotensis* biasa digunakan untuk memisahkan umur Oligosen dan Miosen di area lepas pantai. Pada penelitian ini, penentuan umur Oligosen ditunjang oleh hasil analisis foraminifera dan nanoplankton yang mengkonfirmasi kehadiran umur ini. Studi ini juga membuktikan bahwa percontoh batuan yang dianalisis terbentuk di lingkungan transisi sampai laut dangkal yang dibuktikan dengan kehadiran fosil laut dengan kelimpahan rendah. Kehadiran lingkungan transisi (*mangrove/ back-mangrove*) ditandai dengan kelimpahan sedang polen *Zonocostites ramonae* (Rizophora) dan *Spinizonocolpites echinatus* (Nypa). Sementara itu, keberadaan lingkungan laut dangkal dicirikan oleh dominasi foraminifera bentonik laut dangkal atas foraminifera planktonik.

Kata kunci: Palinologi, Oligosen, Daratan Jawa Barat

ABSTRACT

Compared to its counterpart in the off-shore area (including Northwest Java and Northeast Java), the Oligocene sediment of on-shore West Java provides low pollen assemblages. In addition, superwet elements of *Dacrydium* and *Casuarina* commonly occurred in off-shore area are less represented in the on-shore area. However, it is believed that the study area still experienced wet climate condition as proved by common occurrence of rattan pollen *Dicolpopollis* spp. indicating a thick growth of swamp forest under moist climate. Unlike its counterpart in the off-shore North West Java, the studied sediment rarely yields lacustrine elements suggesting the disappearance of lake deposit. The Oligocene sediment of on-shore West Java is defined by the regular appearance of Oligocene marker of pollen *Meyeripollis naharkotensis*. The last occurrence of this pollen marks the top Oligocene age. In fact, the appearance of pollen *M. Naharkotensis* is obviously used to separate Oligocene age from Miocene age in the off-shore area. Moreover, marine micropaleontology analysis on foraminifers and calcareous nannoplankton confirms this age. The studied sediment was deposited in the transition to shallow marine environment as indicated by rare occurrence of marine microfossils. The common brackish pollen of *Zonocostites ramonae* (Rizophora) and *Spinizonocolpites echinatus* (Nypa) indicates mangrove/ back-mangrove environment. Moreover, the domination of shallow water benthonic over the planktonic forms suggests shallow marine setting.

Keywords: Palynology, Oligocene, On-shore West Java

I. INTRODUCTION

This paper is published to complete the information of Oligocene palynology occurring in Java Island. This is important to understand a whole picture of palynological aspect during Oligocene throughout this island. The area of study is situated in the Ciputat Sub-basin which is an on-shore part of North West Java Basin (Figure 1). This basin is regionally a back-arc system, located between the Sunda micro plate and the India Australia subduction zone and it occurred during Tertiary (Adnan *et al.*, 1991). The tectonic activity in the back-arc area caused the formation of several major normal faults with a mainly north-south direction. These major faults generated several sub-basins with horst and graben pattern in the basinal area, including the existence of the Ciputat Sub-basin.

Generally, during Early Oligocene the pattern of rifting and subsidence, which began in the Late Eocene, continued with the opening of pull-apart basins in the region of the South Cina Sea, Sumatra and the West Java Sea. Uplift was mainly restricted to the Indoburman Ranges and the Andaman/ Nicobar Ridge. Pull-apart basins assumed N-S lineaments in the case of the Sumatran, West java Sea and Gulf of Thailand rifts, NW-SE lineaments for the Malay Basin and WSW-ENE lineaments for the Natuna Sea and Vietnamese rifts. Most of the rifts contained large, often deep, fresh-water lakes, which gradually filled with often organic-rich muds (which following “cooking” by subsequent burial, produced most of the hydrocarbons of SE Asia), or with fluvial sands, during periods of low lake levels. By the beginning of Early Miocene (25-16 Ma), most of these rifts were filled, but subsidence continued over the wider area,

further reducing the land area and, coupled with a sudden sea level rise at the beginning of Miocene, a huge part of the Sunda region, from Vietnam to Natuna, became submerged by a very shallow, brackish water sea (Morley, 2000).

Early Oligocene pollen records from the West Natuna Basin and off-shore Vietnam indicate that the sediment is mostly lacustrine in origin (Figure 2). Palynomorph assemblages reflect the character of fringing freshwater swamp communities. In addition, grass pollen significantly appears to suggest either savana vegetation or grass-dominated freshwater swamps. It seemed that the lake was bordered by a fringe of such swamp forest (Morley, 2000). In Sunda Sub-basin, the Early Oligocene sections are indicated by high abundance of fresh-water lake algae of *Pediastrum* suggesting lacustrine environment (Figure 3). The dry climate indicators moderately appear together with this algae including *Monoporites annulatus* (Graminae) and Cyperaceae. Mean while, *Pediastrum*, *M. annulatus* and Cyperaceae gradually disappear toward Late Oligocene successions. These palynomorphs were absence during middle to upper parts of Late Oligocene age. On the other hand, wet climate markers significantly occur during Late Oligocene such as *Campanosperma*, *Calophyllum* type, *Sapotaceoidapollenites* spp. and *Striatricolpites catatumbus*. These evidences suggest wetter climate than that of Early Oligocene age. This interpretation is supported by the increase of marine and brackish indicators such as Dinoflagellates, *Zonocostites ramonae* and *Discoidites borneensis* marking the occurrence of marine influence (Lelono, 2006).



Figure 1
The location of well samples which are used for the study

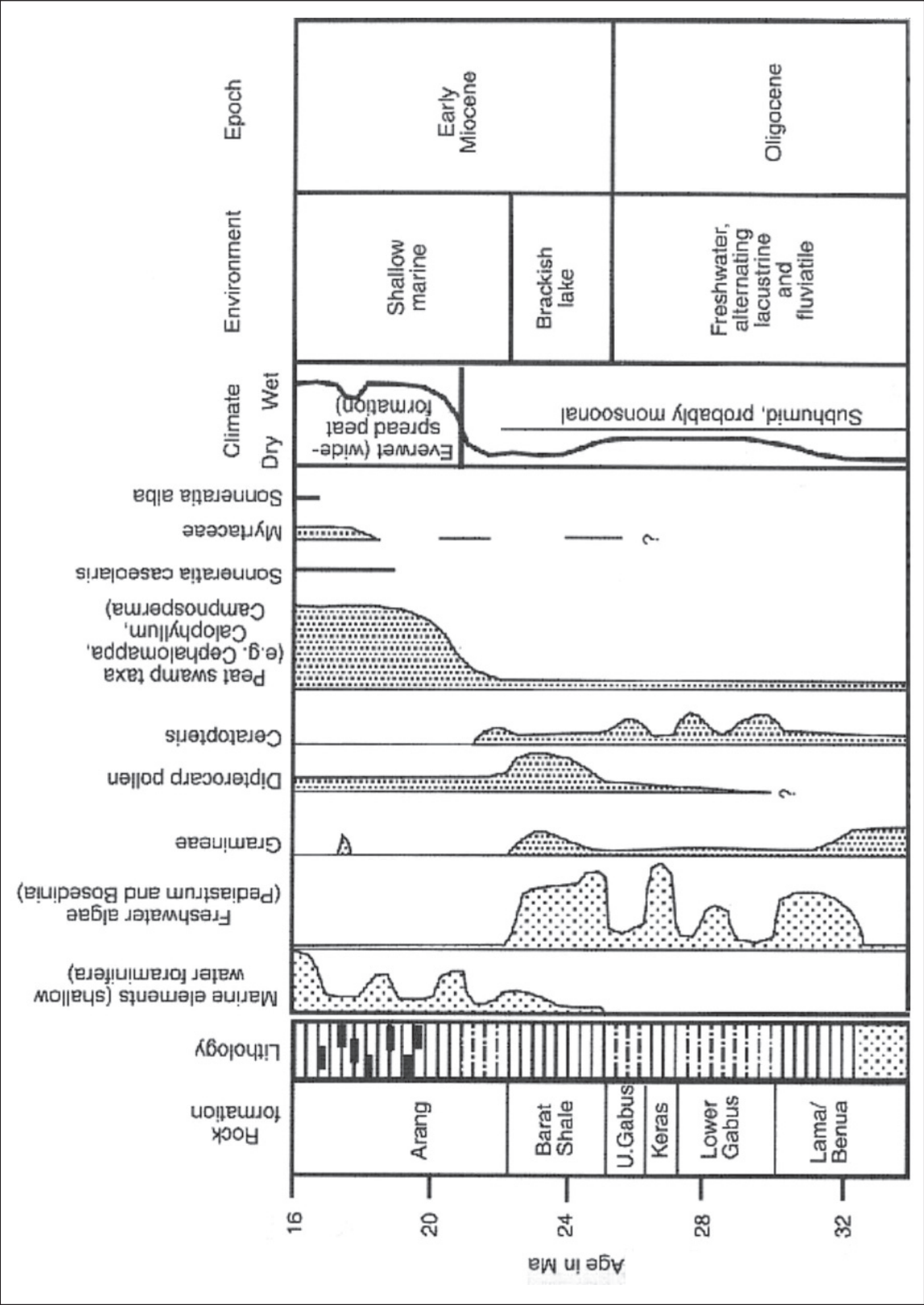


Figure 2
The summary of the palynological record of the West Natuna Basin (taken from Morley, 2000)

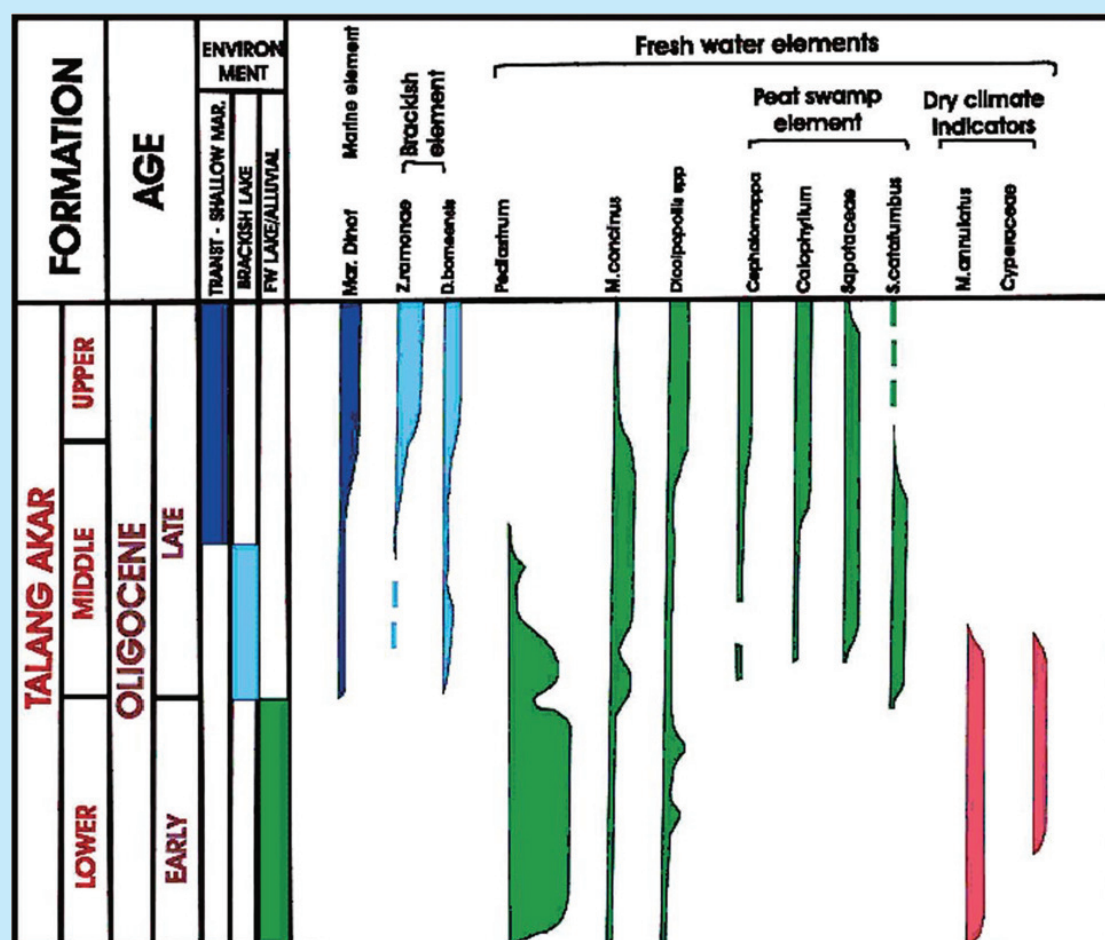


Figure 3
The summary of the palynological record of the Sunda Sub-basin

The Late Oligocene sediments of West Java, Malay Basin and West Natuna Basin consist of the alternation of lacustrine shale and fluvial sand-prone facies. The fluvial sediment is characterised by low diversity of freshwater marsh and swamp pollen. Very shallow ponds and lakes possibly appear during Late Oligocene as indicated by high abundance of spores of the rooted aquatic fern *Ceratopteris*. In addition, the occurrence of swamp thickets are reflected by maxima of calamoid (*Dicolpopollis*) pollen and fern spores (Morley, 2000). Meanwhile, other Late Oligocene records from Northwest Java Basin show the domination of fresh water and brackish palynomorphs, but poor lacustrine marker of *Pediastrum*. This may indicate the occurrence of

marine influence during transgressive period towards the end of Oligocene. In addition, wet climate indicators are more abundant and diverse than the dry climate elements (Figure 3). It is interpreted that the Late Oligocene sediment of Northwest Java Basin was formed under wet climate condition (Lelono, 2006).

Unlike previous records from the various basins above, the Oligocene records from off-shore East Java provide different trend, in which brackish palynomorphs regularly appear through out the Oligocene sediment suggesting fully marine section. This is strengthened by the fact that marine microfossils develop very well across this section (Lelono *et. al.*, 2011). On the other hand, freshwater algae

of *Pediastrum* and *Bosedinia* indicating lacustrine environment almost disappears. It is most likely that Oligocene sediment of this area had never been deposited in the lake. The lacustrine sediment might occur in the older age, i.e. Eocene. However, the Oligocene climate of off-shore East Java shows similar trend to that of the previous areas, in which being more seasonal in the Early Oligocene changing into wetter climate in the Late Oligocene.

Basically, this paper is taken from a study which performs geological investigation on Oligocene sediment of on-shore West Java in order to evaluate hydrocarbon potential of this sediment. It is financially supported by the oil company as this is commercial work done by LEMIGAS Exploration Department. Therefore, data used in this paper will be incompletely presented as they are confidential. The name of the studied wells and their precise locations are hidden in this paper. Data used in this study derives from three wells namely O, P and Q. Three different disciplines are applied in this study including palynology, micropaleontology and nannoplankton analyses which are useful for crosschecking purposes. Apparently, the integration of these analyses gains accurate interpretation of stratigraphy and depositional environment.

II. DATA AVAILABILITY

Data used in this study was generated from subsurface samples provided by LEMIGAS clients. Palynological and other biostratigraphic data extracted from these samples were used by LEMIGAS to conduct technical services for commercial works. Therefore, they are considered to be confidential and should not be public domain. Another data used in this work is well log including Gamma Ray, Self Potential and Resistivity logs which are applied to support stratigraphic correlation. Due to space limitation, only pollen diagrams with selected palynomorphs are shown in this paper. This paper also exhibits foraminiferal and nannoplankton diagrams to support palynological analysis.

III. METHODOLOGY

Samples used in this study are cuttings which were collected from the selected intervals of three studied wells (O, P and Q). These samples were processed in the LEMIGAS Stratigraphy Laboratory using the standard methods including HCl, HF

and HNO₃ 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 a statistically viable population (=count number) of palynomorphs in every sample.

Age interpretation is based on palynological zonations which were proposed by Rahardjo *et al.* in 1994 (Figure 4). On the other hand, palaeoenvironmental analysis refers to deltaic classification based on vegetational changes by Morley (1977).

This study applies other micropaleontology assessments including foraminifera and calcareous nannoplankton. This allows the author to test the result of palynological analysis by cross-checking it with other disciplines to gain reliable interpretation.

IV. POLLEN ASSEMBLAGE

Generally, the studied sections yield low to moderate pollen assemblages with good preservation. Palynomorphs occurring in these sections derive from various vegetations including mangrove, back-mangrove, riparian, peat swamp, freshwater swamp, undifferentiated fresh water and montane. Some selected palynomorphs which significantly appear in these sections are *Zonocostites ramonae* (mangrove pollen), *Florschuetzia trilobata* (back-mangrove), *Marginipollis concinus* (riparian), *Cephalomappa* type (peatswamp) and *Dicolpopollis* spp. (freshwater pollen). Mangrove taxa continuously occur all the way through the studied sections indicating strong marine influence. Interestingly, unlike those in off-shore West Java, West Natuna and Malay Basin, lacustrine elements of freshwater algae of *Pediastrum* and

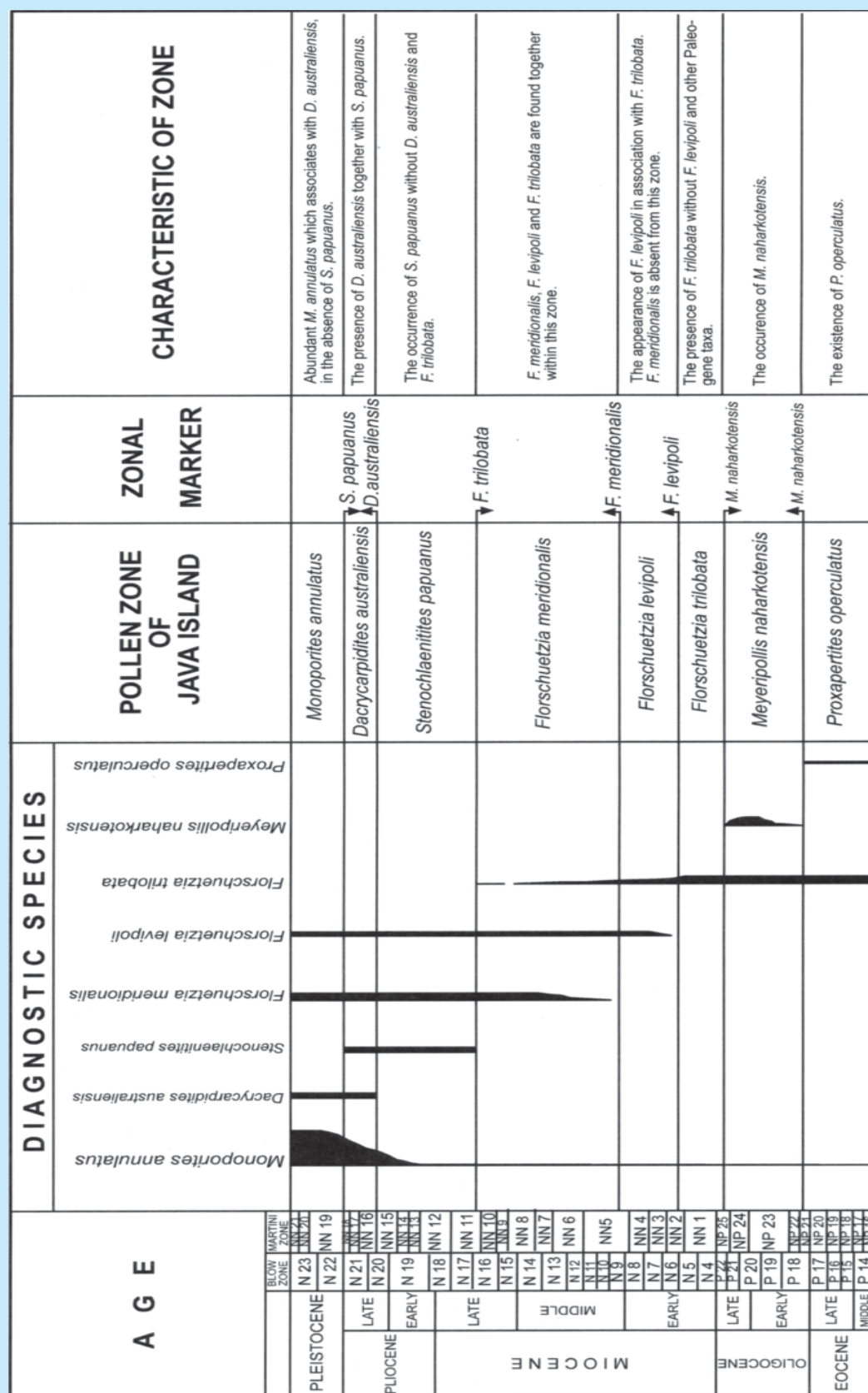


Figure 4
Palynological zonation of Java island (Rahardjo et al., 1994).

Bosedinia rarely appear suggesting the disappearance of lacustrine environment in the studied area. This data confirms that the deposition occurred under marine influence during Oligocene. It is possible that lacustrine facies might occur in the older sediment (possibly Eocene sediment). This situation resembles that of Oligocene East Java Sea, where lacustrine elements disappear from pollen records.

Another important observation is low occurrence of superwet elements of *Dacrydium* and *Casuarina*. These two pollen significantly appear in Oligocene off-shore West and East Java sections to indicate everwet climate. In fact, they are increasing in number during the latest Late Oligocene as the climate getting wetter (Lelono *et al.*, 2011). However, the significant occurrence of rattan pollen *Dicolpopollis* marks well development of swamp forest under wet climate condition. In addition, considerable appearance of peatswamp pollen *Cephalomappa* strongly supports wet climate indication.

V. AGE INTERPRETATION

Rahardjo *et al.* (1994) defines the Oligocene age based on the common occurrence of pollen *Meyeripollis naharkotensis*. Top Oligocene age is identified by the last occurrence of this pollen. However, the base of Oligocene age may not be correlable with the first occurrence of *M. naharkotensis* as this pollen continuously appears down to Late Eocene age. In fact, this pollen is found in the Late Eocene sediment of East Kalimantan and Mangkalihat Peninsula (Morley, 1991). In addition, Oligocene age can be separated from Eocene age by the absence of many Indian taxa. These taxa significantly occur to characterise the Eocene section (Lelono, 2001).

The studied sections consistently show the occurrence of *M. naharkotensis* (Figure 5). Referring to the pollen zone of Rahardjo *et al.* (1994), the studied section can be assigned to the *Meyeripollis naharkotensis* zone which equals to Oligocene age. The last occurrence of this pollen defines the top Oligocene age. On the other hand, the studied sections are characterised by the absence of many Indian affinity such as *Proxapertites operculatus*, *Proxapertites cursus*, *aff. Beaupreadites matsuoake*, *Cupanieidites cf. C. flaccidiformis*, *Ixonanthes type*, *Quillonipollenites sp.*, *Retistephanocolpites williamsi*, *Polygalacidites clarus*, *Lakiapollis ovatus*, *Restioniidites punctulosus*, (*Restionaceae*),

Diporoconia iszkaszentgyorgyi, *Ruellia type*, *Dandotiospora laevigata* and *Cicatricosisporites eocenicus*. In addition, pollen *Palmaepollenites kutchensis* rarely appears through out the studied sections. This pollen is usually abundant to mark Eocene age (Lelono, 2000).

Calcareous nannoplankton occurs regularly to allow biostratigrapher constructing nanno zones and their equivalent ages. Basically, nannoplankton analysis confirms the age interpretation based on palynomorphs as suggested by the last occurrence of *Helicosphaera kamptneri* at the top of Oligocene age (Figure 6). It is also supported by the occurrence of *Sphenolithus ciperoensis* and *Cyclicargolithus abisectus* in the upper sections to indicate zone NP 24 – NP25 or Late oligocene (Martini, 1971). The lower sections are difficult to date due to the disappearance of the age-restricted taxa.

Foraminiferal assemblage is sufficient within the upper sections allowing zonal reconstruction and age interpretation. This assemblage is decreasing toward the lower sections which results in the disappearance of most index taxa preventing from having accurate interpretation. The lowest occurrence of planktonic foraminifer *Globigerinoides* identifies the top of Oligocene as shown in Figure 7 (Blow, 1969). Moreover, the last occurrence of large benthonic foraminifer of *Spiroclypeous* spp. identifies the upper part of Oligocene age (Adam, 1970). This is supported by the occurrence of other Oligocene-Miocene species including *Austrotrilina striata* and *Lepidocyclina (N) parva*.

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

VII. PALEOENVIRONMENT

This study demonstrates that mangrove and back-mangrove taxa commonly appear across the studied sections indicating the influence of marine environment during sedimentation (Figure 8). These taxa are represented by *Zonocostites ramonae* (mangrove), *Discooidites* spp., *Spinizonocolpites echinatus*, *Acrostichum aureum* and *Acrostichum speciosum* (back-mangrove). Unlike the lower sections, the upper sections are characterised by moderate abundance of mangrove pollen *Z. ramonae* combined with marine dinoflagellates. It is possible

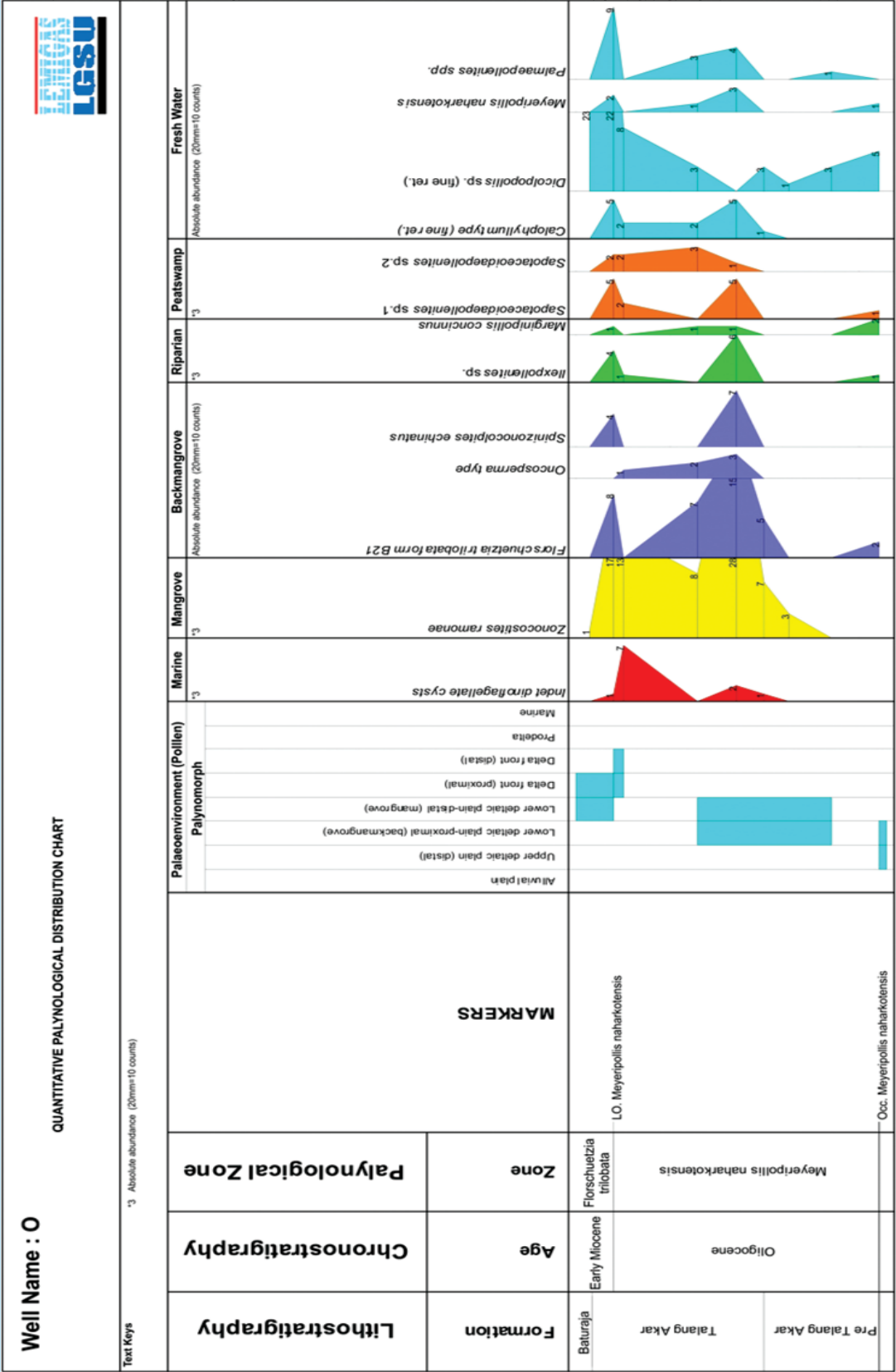
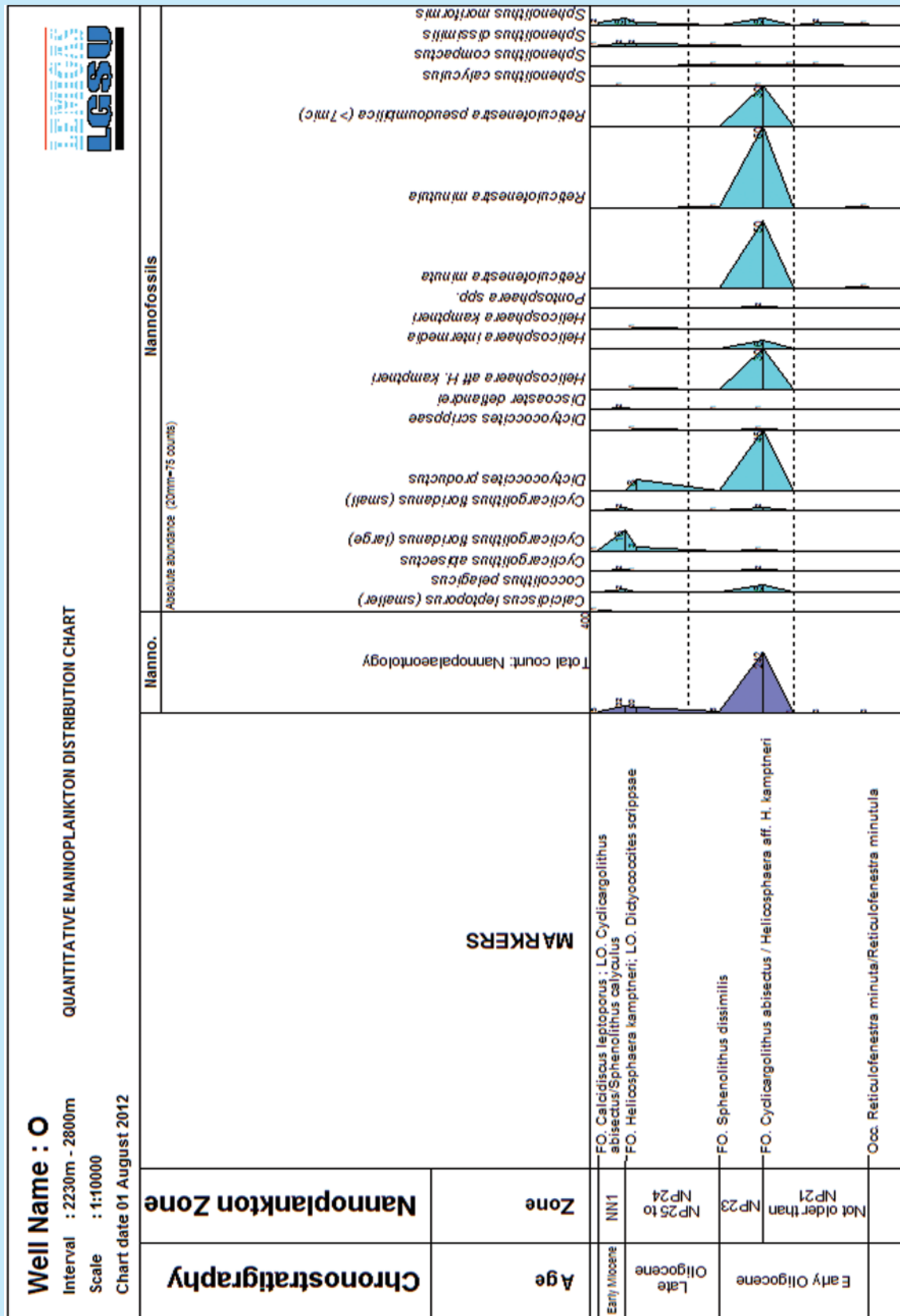


Figure 5
Regular occurrence of index pollen Meyeripollis naharkotensis throughout Well O indicating Oligocene succession.
This is supported by the absence of many Indian palynomorphs marking Eocene sediment of Western Indonesia



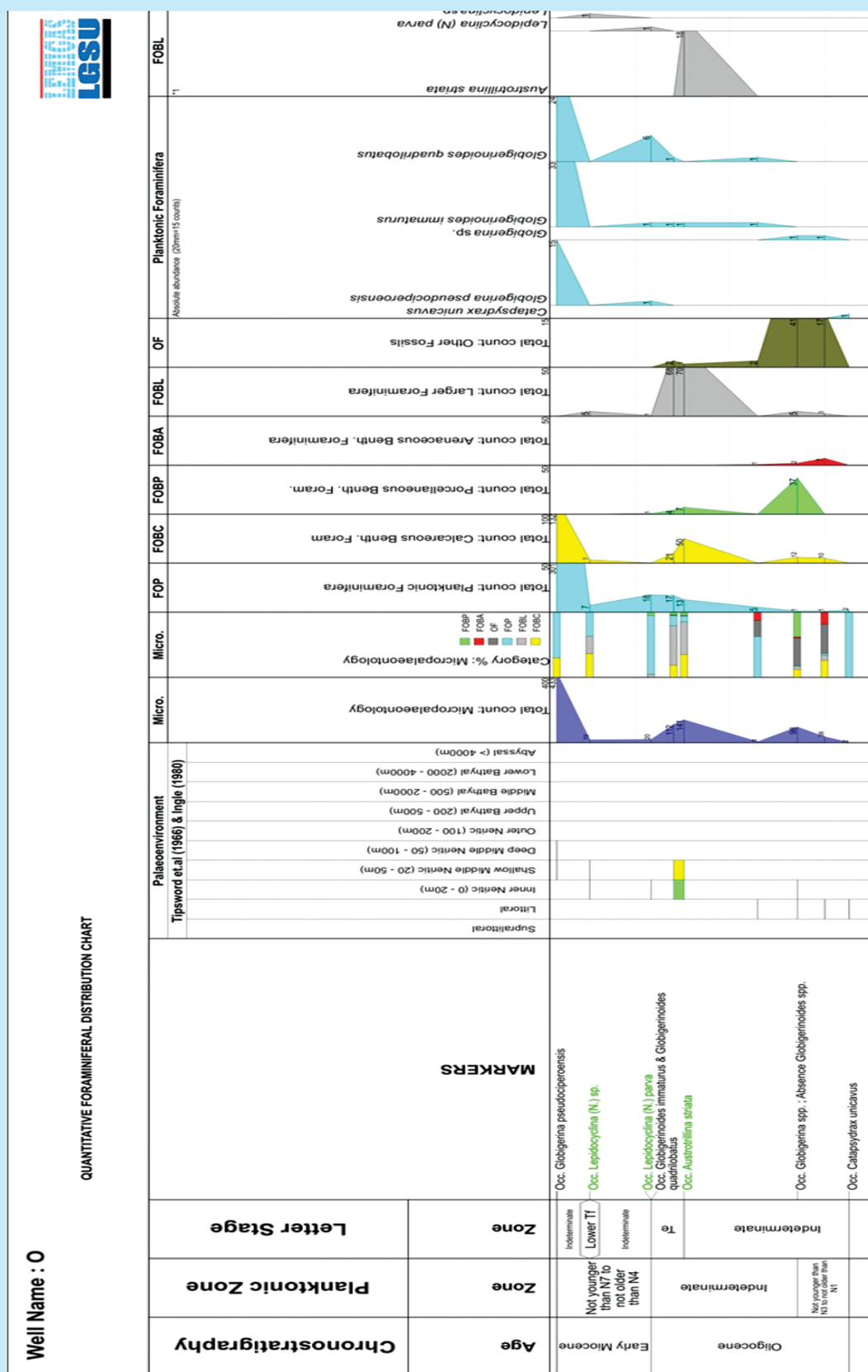


Figure 7
The occurrence of foraminifers within Well O suggests the possible presence of Oligocene section.

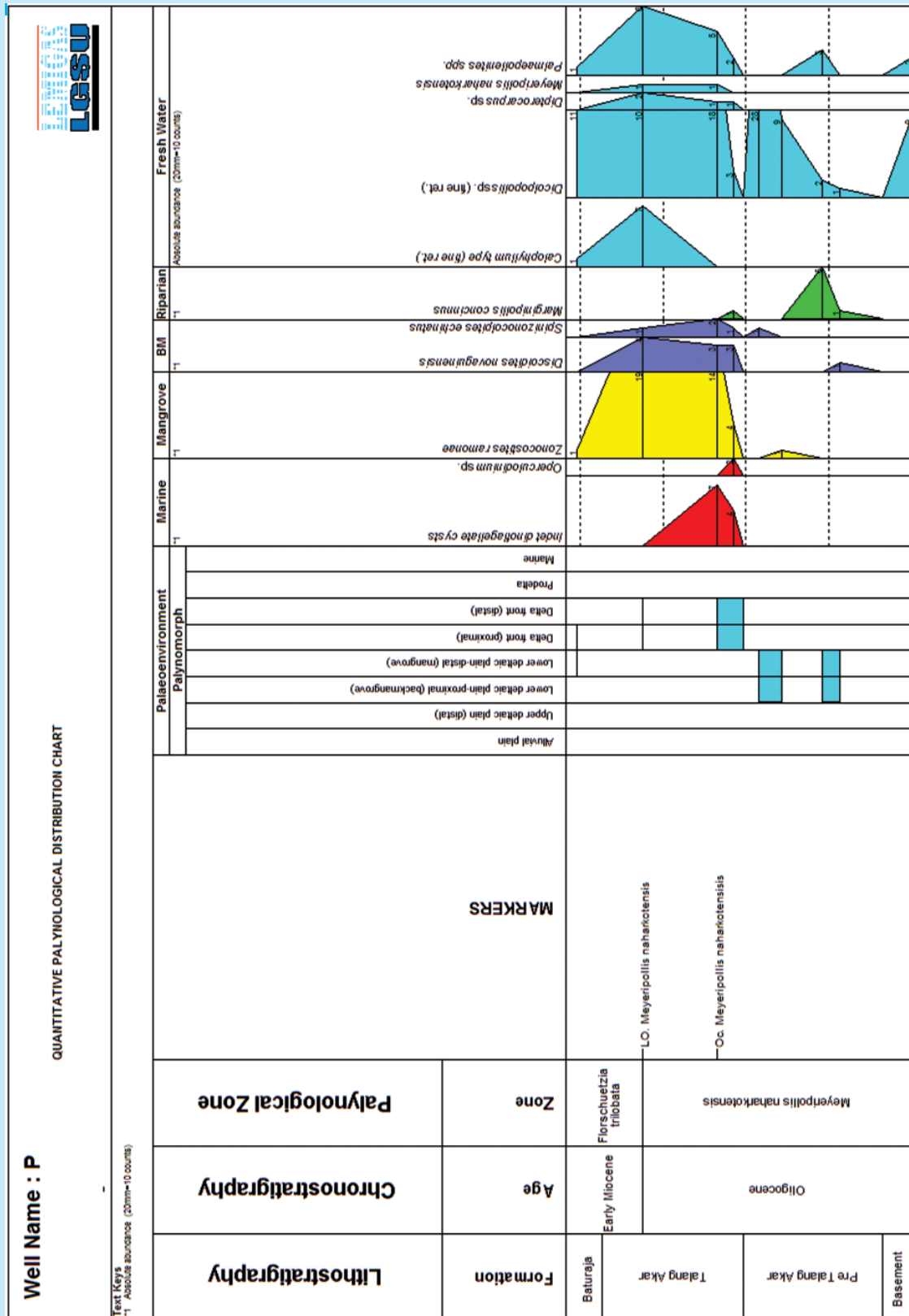


Figure 8
 Significant occurrence of mangrove and back-mangrove pollen doubled with marine dinoflagellates in Well P indicates the influence of marine environment

that the marine influence is getting stronger towards the upper section. In fact, foraminiferal and calcareous nannoplankton assemblages are increasing towards the upper sections (Figures 9). Foraminiferal content is characterised by the domination of benthonic form over the planktonic form. The benthonic form is mostly represented by shallow water forms especially those of large forms such as *Amphistegina radiata* and *Operculina ammonoides*. Other shallow water species are represented by arenaceous forms including *Ammonia beccarii*, *Cibicides* spp. and *Pseudorotalia schroeteriana* spp. After all, it can be inferred that the sediment situated in the studied interval was deposited in littoral to inner neritic environment (0-20 m). In addition, the sedimentation is commenced in shallower water in littoral environment (lower sections) and ended in deeper water in inner neritic environment (upper sections).

The studied sections are also marked by significant occurrence of some freshwater pollen produced by peat swamp and freshwater swamp vegetation such as *Cephalomappa* type, *Dicolpopollis* spp. and *Palmaepollenites* spp. Riparian elements regularly appear in low abundance as shown by *Marginipollis concinus* and *Pandaniidites* spp. (Figures 8). Unlike its counterpart in the off-shore, palynomorph assemblage of on-shore West Java lacks of freshwater algae of *Pediastrum* and *Bosedini*. In the West Java Sea, high abundance of these algae indicates the existence of lacustrine environment. Therefore, it is assumed that the studied sediments are less likely to have correlation with lake deposit as these two important markers for lacustrine environment are less represented. However, this situation resembles that of the Oligocene East Java Sea which is dominated by shallow marine facies. This is indicated by moderate to high abundance of marine algae with moderate diversity. In addition, brackish palynomorphs consistently occur through out the sections. On the other hand, lacustrine markers of freshwater algae *Pediastrum* and *Bosedini* disappear from the Oligocene sediments of the East Java Sea (Lelono *et al.*, 2011). The similarities between on-shore West Java and off-shore East Java suggest that the Oligocene sediments of both areas were formed under marine influence (mostly shallow marine). The lacustrine facies might have been occurred earlier in the Eocene age.

VII. PALEOCLIMATE

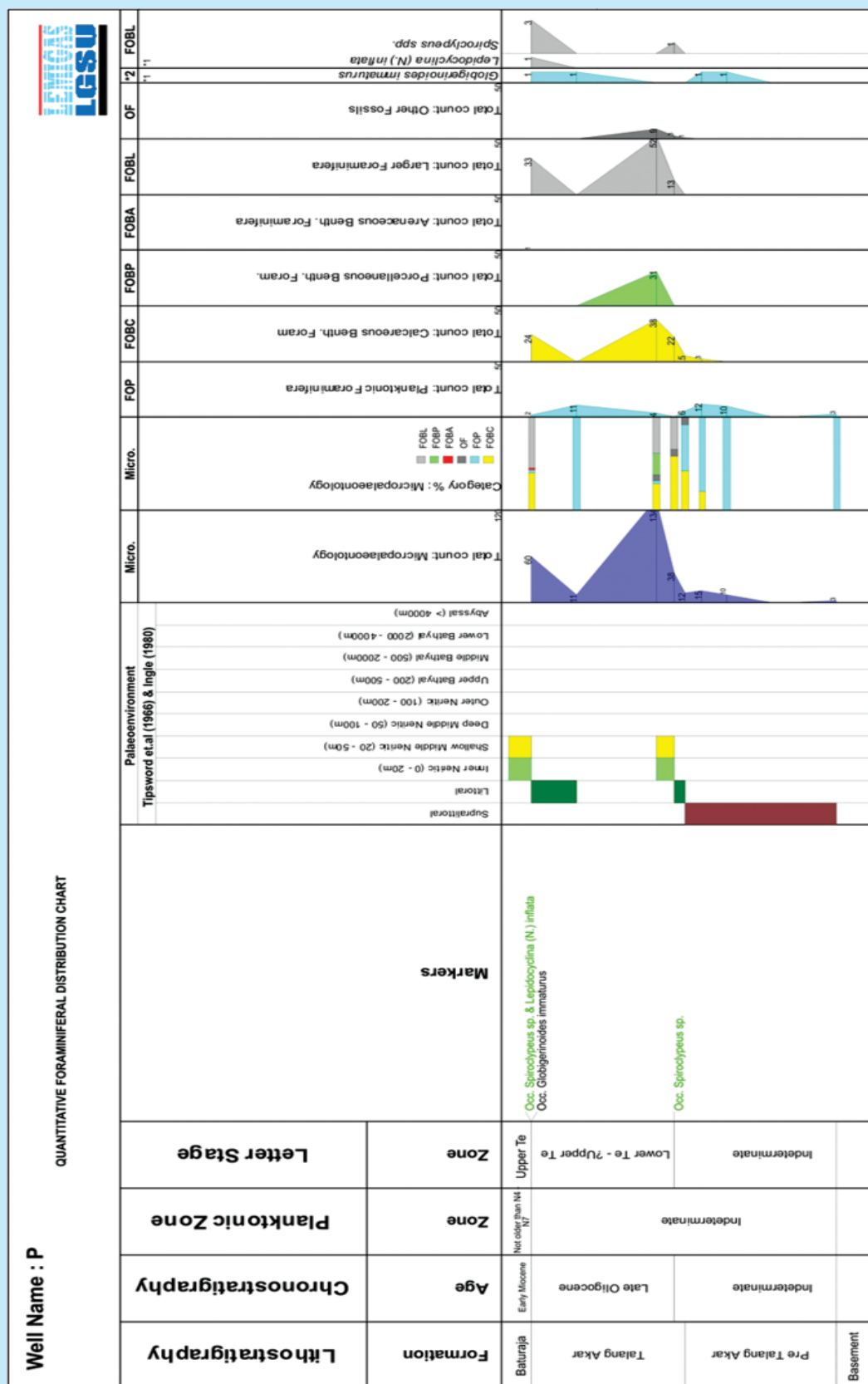
The superwet elements of *Casuarina* and *Dacrydium* rarely occur in the studied sections. On the contrary, these elements significantly occur in the Oligocene sections of North West and North East Java Seas (especially in the upper part) marking the existence of wettest climate during this age. Based on this event, the “coaly” Talang Akar Formation of North West Java Sea is able to be correlated with zone OL3-OL4 of Kujung Formation in East Java Sea as shown in Figure 10 (Lelono *et al.*, 2011). The studied sections are characterised by considerable occurrence of rattan pollen of *Dicolpopollis* spp. (especially in the upper sections; see Figure 11) indicating a thick growth of swamp forest. Moreover, this coincides with common *Cephalomappa* type (peat swamp element) and *Palmaepollenites* spp. (freshwater swamp). This data informs well development of swamp thickets under wet climate condition. The upper sections with common *Dicolpopollis* spp. combined with regular occurrence of *Cephalomappa* type and *Palmaepollenites* spp. is assumed to experience the wettest climate which can be correlated to zone OL3-OL4 of East Java Sea.

Using pollen records generated from the studied wells, it is interpreted that the Oligocene age is generally characterised by moist climate. However, seasonal/ dry climate episodically appears to alternate wet climate.

VIII. CONCLUSION

This study exhibits low to moderate pollen assemblage within the Oligocene sediment of the on-shore West Java. Unlike its counterpart in the off-shore North West Java, the studied sediment rarely yields lacustrine elements suggesting the disappearance of lake deposit. In addition, it differs from that of off-shore North West and North East Java in the low occurrence of superwet elements of *Dacrydium* and *Casuarina*. However, paleoclimate of those areas is about the same as proved by common occurrence of rattan pollen *Dicolpopollis* spp. in the area of study which indicates a thick growth of swamp forest under moist climate.

The studied sediment observed from three wells is assigned to Oligocene age based on the occurrence of pollen *Meyeripollis naharkotensis*. The top Oligocene is limited by the last occurrence



of this pollen, whilst the base Oligocene is uncertain. The absence of Eocene markers deriving from Indian micro-continent confirms that the studied sediment is Oligocene in age. This is also supported by the occurrence of calcareous nannoplankton *Sphenolithus ciproensis* and *Cyclicargolithus abisectus* in the upper sections to indicate zone NP 24 – NP25 or Late oligocene.

Mangrove pollen *Zonocostites ramonae* is regularly found through out the studied sections suggesting marine influence during deposition. This is supported by significant occurrence of marine

dinoflagellates. In addition, the domination of shallow water benthonic over the planktonic forms suggests shallow marine setting. It is interpreted that the studied sediment was deposited in mangrove/back-mangrove to inner neritic.

IX. ACKNOWLEDGMENT

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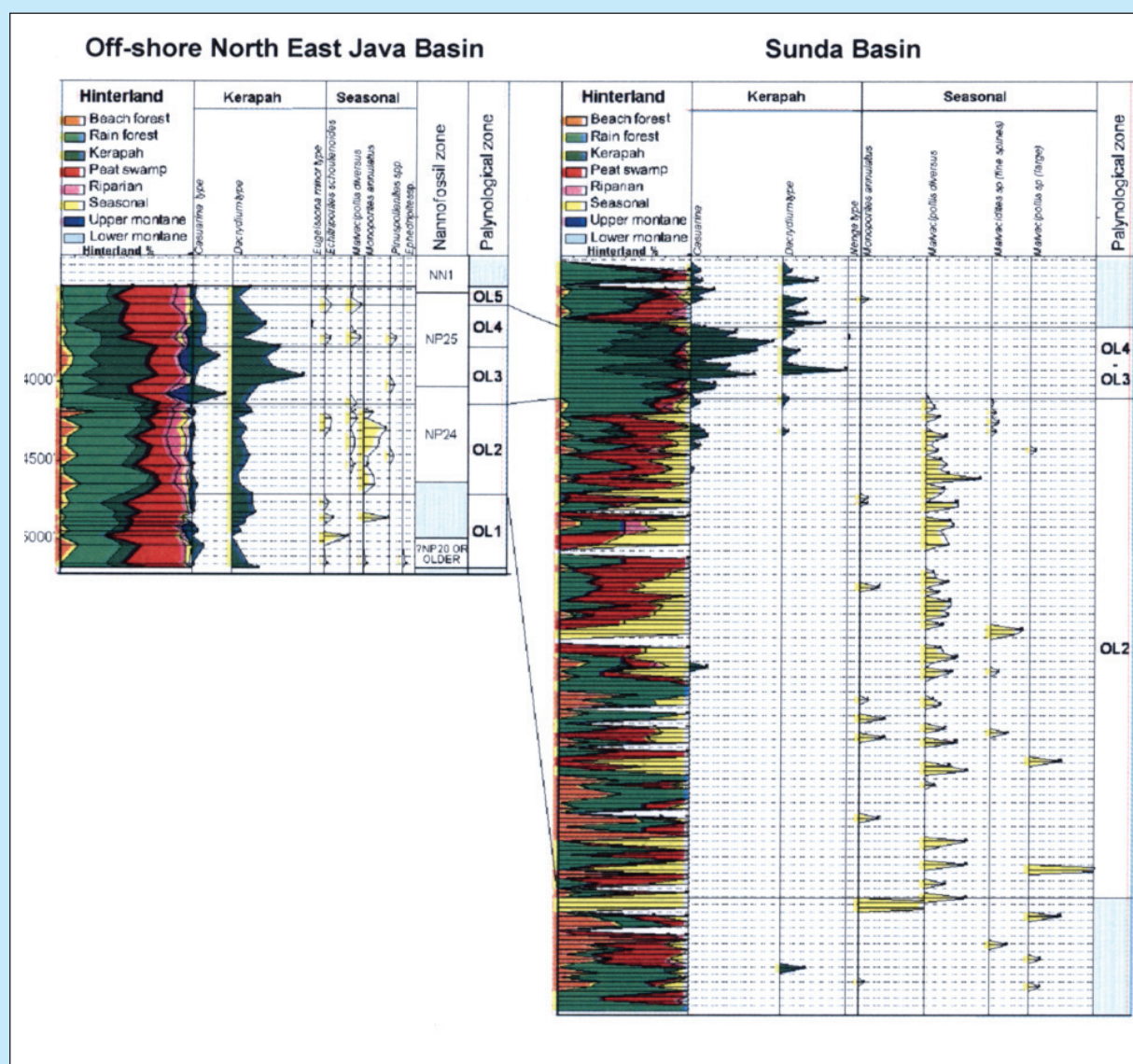


Figure 10
Correlation of Off-shore Northeast Java Basin and Sunda Basin

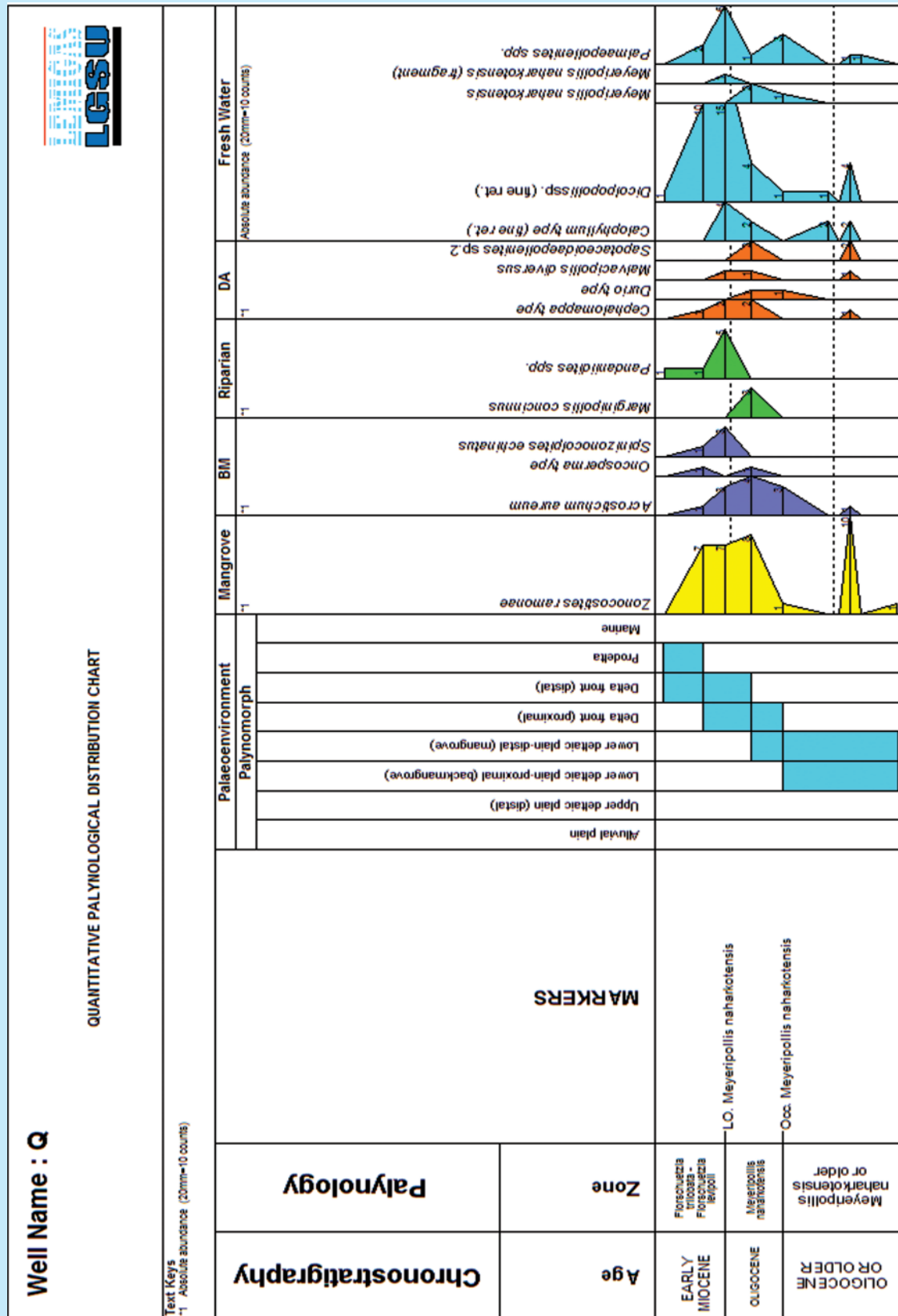


Figure 11

Significant occurrence of rattan pollen of *Dicolpopollis* sp. in the Late Oligocene combined with other freshwater elements suggests the wettest climate.

providing the permission to publish some part of this work. The author wishes to thank colleagues in LEMIGAS Stratigraphy Group for their effort in doing biostratigraphic analyses of the studied area. The author also thanks to M Taufik of the LEMIGAS Stratigraphy Group who helps producing biostratigraphic diagrams.

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