PALYNOLOGICAL EVENTS OF THE TALANG AKAR FORMATION IN THE ON-SHORE AREA OF THE SOUTH SUMATRA BASIN

by
Eko Budi Lelono

I. INTRODUCTION

South Sumatra has been well known as the one of the largest hydrocarbon producers in Indonesia. Due to its potentiality, South Sumatra has been explored since the Dutch era. Million barrels of oil have been pumped out from this area and many unpublished reports and papers have been made regarding the remaining reserve of this area. This study focuses on Talang Akar Formation which is considered as the main reservoir in South Sumatra. Talang Akar Formation is interpreted to be formed in a deltaic environment (De Coster, 1974). The deltaic sediment must have contained excellent palynomorph assemblage as demonstrated by the previous authors (Hasjim, 1993, Morley, 1995 and LEMIGAS 2001a, b and c). On the other hand, marine microfossils show poor recovery including foraminifers and nannoplankton. This condition is understandable as marine microfossils are difficult to develop in the transition environment. For this reason, palynology is intensively studied as a powerful tool to comprehend the stratigraphy of the Talang Akar Formation.

The deposition of Talang Akar Formation was influenced by the tectonic event during Late Cretaceous to Early Tertiary which caused the occurrence of Semangko Dextral Fault (Suwidiyanto, 2003). This fault resulted in the formation of horst and graben which allowed sedimentation of Lahat Formation and the Lower Talang Akar Formation in the low topography. Subsequently, sea level increased rapidly drowning up the deposition center which resulted in the sedimentation of the Upper Talang Akar Formation and limestone Baturaja Formation (Suwidiyanto, 2003). Based on lithological character, Talang Akar Formation is separated into Great Sand Member (GRM) occupying lower part of this formation and Transition Member (TRM) situating in the upper formation. GRM was formed in the fluvial to delta plain environment, whilst TRM was deposited in delta plain to pro-delta environment (De Coster, 1974). The environmental change from fluvial-delta plain of GRM (non-marine) to delta plain-prodelta of TRM (non-marine to transition) suggests the occurrence of transgressive phase. Palynologically, this change must be reflected in the palynological assemblage. In fact, TRM yields more brackish palynomorphs than those of GRM. In contrary, GRM especially those of river channel deposits are characterised by regular occurrence of riparian (freshwater) pollen such as *Marginipollis concinus* and *Pandaniidites* sp. (LEMIGAS, 2001a, b and c).

Although palynological investigations were frequently conducted within the Talang Akar Formation, the results of these investigations were restricted on age interpretation and paleoenvironment analysis. There are more information can be obtained from the palynological data. Therefore, it is required extra efforts to elaborate data becoming useful information such as palynological event, sea level changes and paleoclimate. This study intends to explore the stratigraphy of the Talang Akar Formation based on its palynological and other micro-fossil content which focuses on palynological characteristic of the Talang Akar Formation, palynological event and other biostratigraphic information (zones, age and depositional environment).

II. DATA AVAILABILITY

The area of study is located in the on-shore South Sumatra (Figure 1). Data used in this study derives from subsurface samples collected by our clients. Palynological data extracted from these samples was used by LEMIGAS to provide technical services for commercial works. Therefore, it is considered to be confidential and should not be public domain. This situation discourages the author to disclose the complete data as this will break the commitment between LEMIGAS and its client.

Having condition as mentioned above, this paper will not reveal detailed information of the wells which are used in this study. The wells are named using alphabetic codes such as E, K and O. In addition, only relevant information is shown in this paper due to space limitation. In this case, pollen diagrams only show selected palynomorphs which affect analysis and interpretation.

III. METHODOLOGY

The material used in this research is cutting samples which were collected from the selected intervals of three studied wells, so called Wells E, K and O. These samples were processed in the LEMIGAS Stratigraphy Laboratory using the standard methods 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 a statistically viable population (=count number) of palynomorphs in every sample.

Chart analysis is focused on finding significant abundance of selected taxa which is believed to represent certain geological events such as the existence of marine influence (or transgression), non-marine domination during deposition and climatic changes. Age interpretation is based on palynological zonations which were proposed by Rahardjo et al. in 1994. On the other hand, palaeoenvironmental analysis refers to deltaic classification based on vegetational changes by Morley (1977).

IV. PROPOSED PALYNOLOGICAL EVENTS

Based on the appearance of selected palynomorphs, the Talang Akar Formation can be divided into three distinct events which are as follows (from older to younger events):

A. *Top Regular Abundance of* Marginipollis Concinus

Marginipollis concinus is known to derive from vegetation which grows along the river side, so called riparian (Morley, 1990). Therefore, this species is abundantly found in the river deposit such as channel deposit. In the Talang Akar Formation, this type of deposit is represented by the appearance of distributary channel sands of the GRM. In the Gamma ray log, the occurrence of this sand deposit is usually characterised by certain log shape i.e. cylinder shape (Figures 2 and 4). However, in some cases, it is also marked by other log shapes such as funnel and bell shapes (Figure 3).

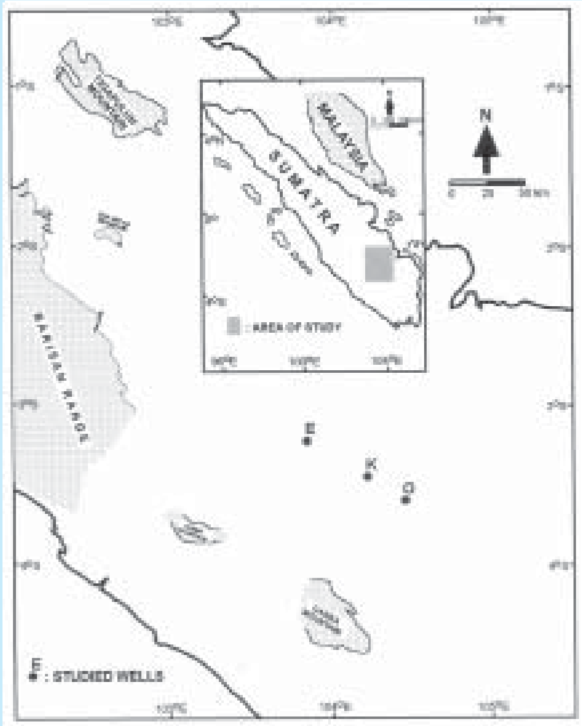

Figure 1
The area of study which shows the location of the studied wells

Palynological investigation shows that a riparian pollen of *Marginipollis concinus* appears in moderate abundance along the sand deposits of the GRM. In Well E, it ranges from depth of 2360m-2940m (Figure 2), whilst in Well K, it occupies depth interval of 1876 m - 2310 m (Figure 3). Meanwhile, in Well O, *M. concinus* appears significantly along the depth of 1596m-1970m (Figure 4). This species gradually decreases toward the top of this member. *M. concinus* continues to appear irregularly exceeding through GRM into transition sediment of TRM with poor occurrences (Figures 3 and 4). It is inferred that moderate and regular abundance of *M. concinus* marks the existence of GRM. In addition,

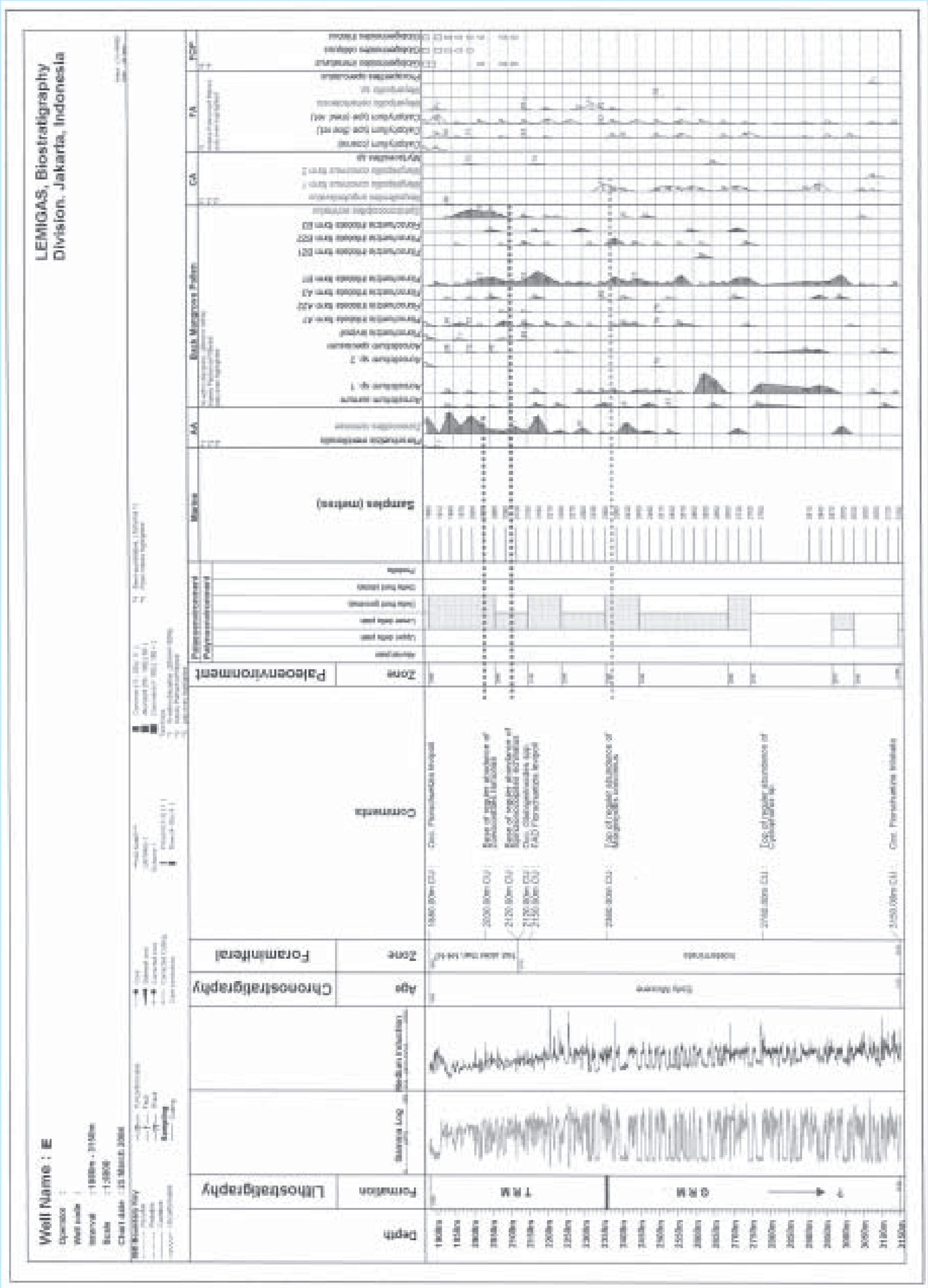

Figure 2
Quatitative palynology distribution chart of Well E

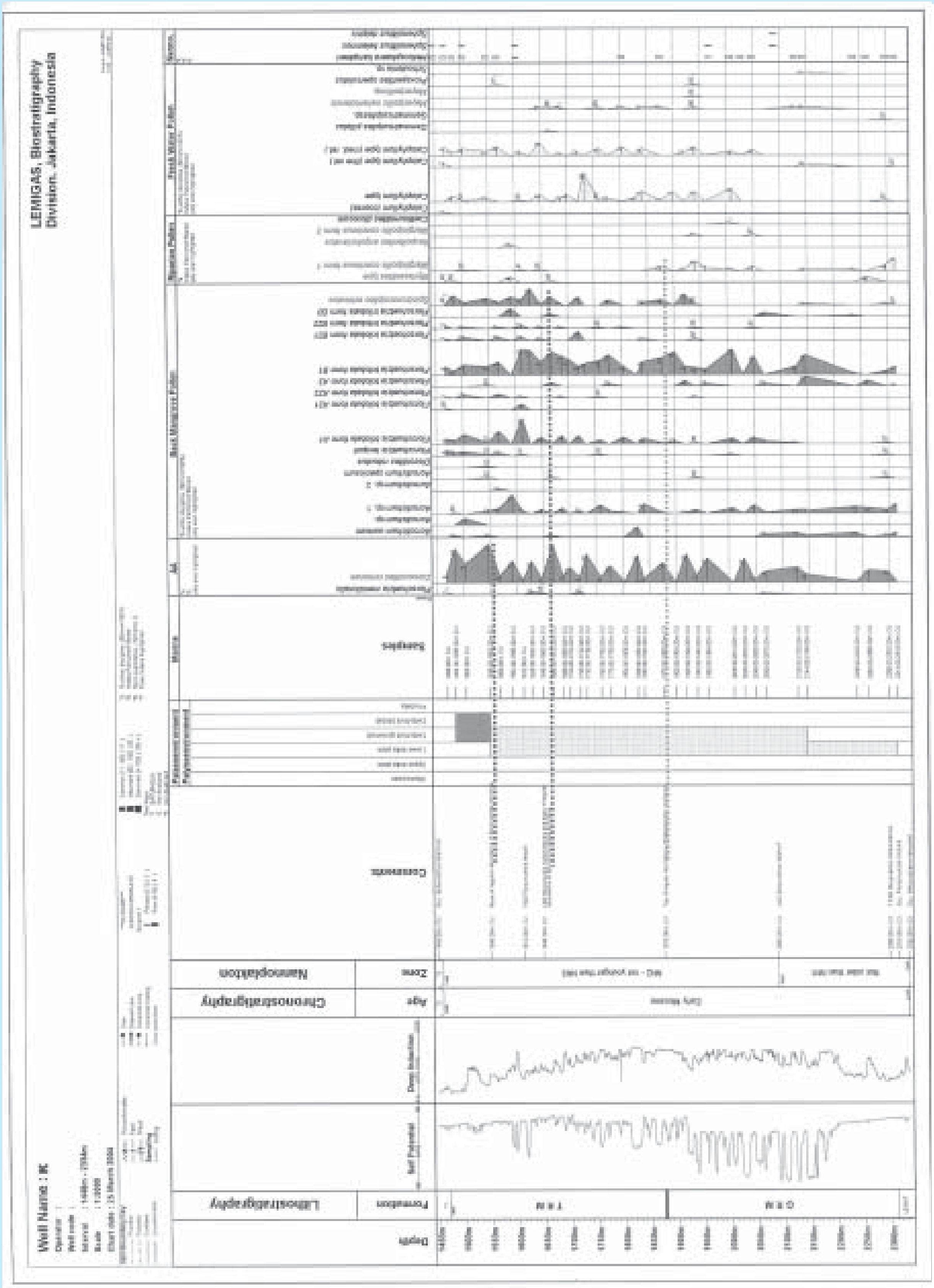

Figure 3
Quatitative palynology distribution chart of Well K

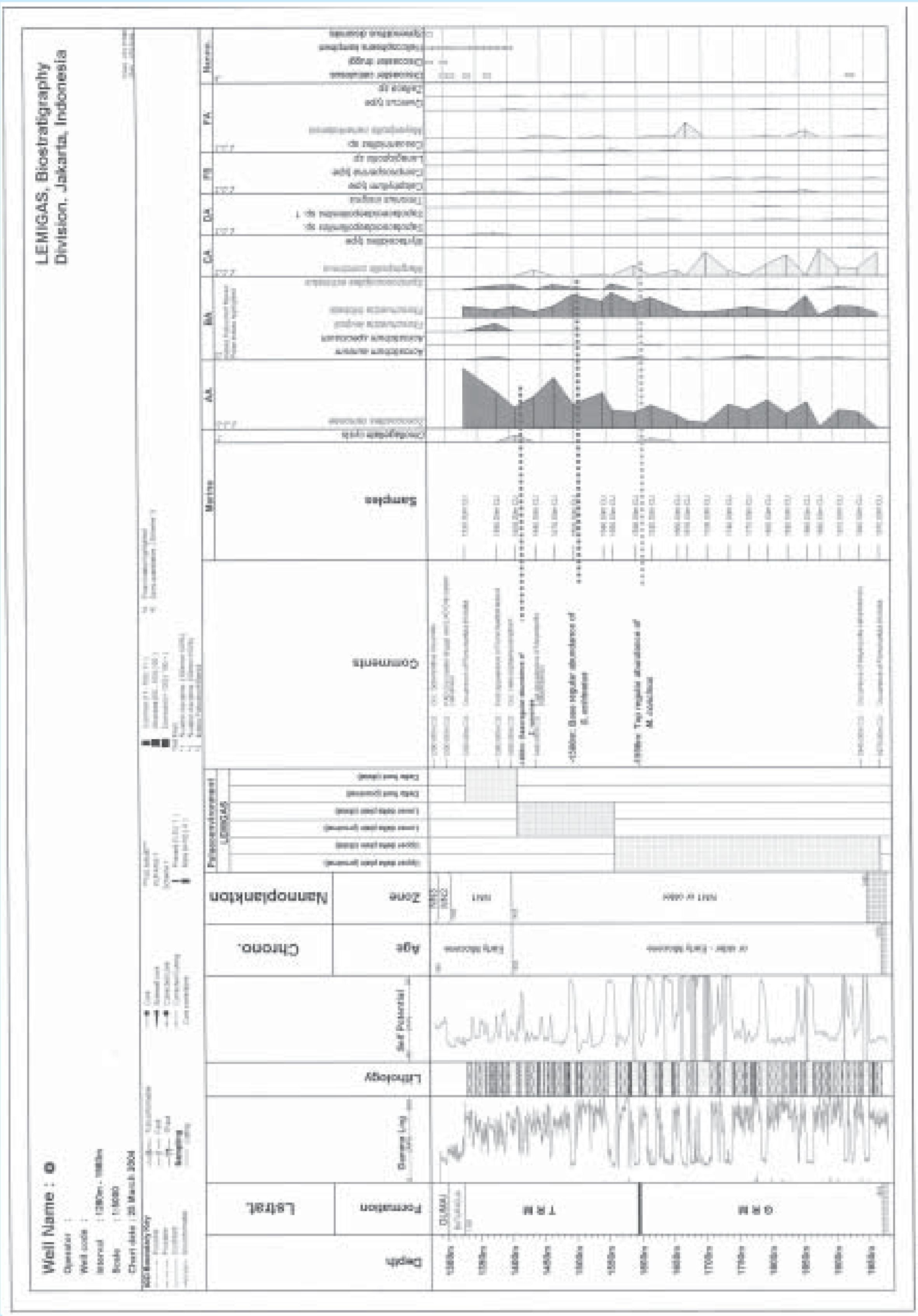

Figure 4
Quatitative palynology distribution chart of Well O

the top GRM is assumed to coincide with the top regular abundance of *M. concinus* (2360m in Well E, 1876m in Well K and 1596m in Well O; see Figures 2, 3 and 4).

As GRM was mostly deposited in the non-marine environment (fluvial to delta plain), foraminifer was hardly found along this member. However, marine incursions happened regularly during the deposition of GRM as indicated by the appearance of mangrove and back-mangrove palynomorphs in calcareous lithologies such as *Zonocostites ramonae*, *Florschuetzia trilobata* forms and *Acrostichum* sp. (Figures 2, 3 and 4). In fact, marine incursions provide a chance to extract marine nannoplankton from these types of lithology. Although nannoplankton relatively less develops than palynomorps, it helps palynologist to compare pollen result with nannofossil interpretation. In Well K, this event is located within nannozone of NN2 to not younger than NN3 (interval 1442m-2060m) or equivalent to Early Miocene base on the occurrence of *Sphenolithus delphix* in 2060m and *S. belemnos* in 1442m (Martini, 1971; Figure 3). On the other hand, in Well O, top regular abundance of *M. concinus* is situated within nannozone of NN1 or older (interval 1400m-1940m) which equals to the age of Early Miocene or older base on the presence of *Helicosphaera kampneri* in 1400m (Martini, 1971). The base of this nannozone is unknown as index nannofossil disappears from the lower zone (Figure 4).

Having these comparisons, it can be inferred that the occurrence of top regular abundance of *M. concinus* ranges from NN1 or older to not younger than NN3 or Early Miocene age or older.

B. *Base Regular Abudance of* Spinizonocolpites Echinatus

The base regular abundance of *S. echinatus* appears above the previous event suggesting the increase of marine activity. It occurs in 2120m of Well E (Figure 2), in 1642m of Well K (Figure 3) and in 1500m of Well O (Figure 4). The plant producing this pollen is called *Nypa* which lives under marine influence (Muller, 1964). *Nypa* is known as an element of back-mangrove vegetation which grows behind mangrove forest (Morley, 1990). The dynamics of this vegetation corresponds to sea level activities. *Nypa* pollen increases significantly during high sea level. Meanwhile, it declines or even absent when sea level drops.

The event of base regular abundance of *S. echinatus* occurs within TRM which is inferred to represent transition-marine succession. The depositional environment of TRM varies from delta plain to pro-delta (De Coster, 1974). However, TRM was generally deposited in the delta front environment (Beicip, 1985 in Suwidiyanto, 2003). In the gamma log, TRM is identified by the alternation of funnel and bell shapes (Figures 2 and 4). In addition, cylinder shape occasionally occurs in gamma log of TRM (Figure 4). Palynological study confirms the previous interpretation by De Coster (1974) regarding depositional environment of TRM as proved by moderate abundance of back-mangrove pollen of *Spinizonocolpites echinatus* and high abundance of mangrove pollen of *Zonocostites ramonae* along this member (Figures 2, 3 and 4).

Nannoplankton study indicates that in Well K, base regular abundance of *S. echinatus* occupies nannozone of NN2 to not younger than NN3 (interval 1442m-2060m; Figure 3), whilst in Well O, it lies in nannozone of NN1 or older (interval 1400m-1940m; Figure 4). In Well E, this event is situated in foramzone of not older than N4 to N7 (interval 1880m-2120m), base on the occurrence of planktonic foraminifer of *Globigerinoides* spp. in 2120m (Blow, 1969). The upper boundary of this foramzone is unknown (Figure 2). After all, it can be concluded that the event of base regular abundance of *S. echinatus* occurs in Early Miocene or older.

C. *Base Regular Abudance of* Zonocostites Ramonae

The youngest event appearing in Talang Akar Formation of the on-shore South Sumatra is the base regular abundance of *Z. ramonae*. This pollen has modern relative which is confined to the mangrove habitat (Tomlinson, 1986). *Z. ramonae* is similar to modern *Rhizophora* type from Borneo described by Muller (1964). Similar to *Nypa*, the development of *Rhizophora* is affected by marine activity. Therefore, this pollen is the best marker for analysing sea level changes. In addition, its appearance in the sediment indicates the presence of marine influence during deposition. Pollen study demonstrates high abundance of *Z. ramonae* in the upper part of TRM which is traditionally assigned to represent major transgressive period within the Talang Akar Formation. In fact, this situation is supported by the significant increase of abundance and diversity of marine microfossils such as foraminifer and nannoplankton as shown in interval 1880m-2030m of Well E (Figure 2) and interval 1330m-1400m of Well O (Figure 4).

Lithologically, the upper TRM is marked by the occurrence of more calcareous lithology than that of the

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lower part. It consists of the alternation of thin sandstone, shale and siltstone with coal alteration occasionally. In the gamma log, upper TRM usually shows the funnel and bell shapes (Figures 2 and 4). The increase of calcareous content coupled with highest abundance of *Zonocostites ramonae* may suggest flooding surface within upper TRM. This flooding surface may occur in 1940m of Well E (Figure 2), in 1542m of Well K (Figure 3) and in 1330m of Well O (Figure 4).

Base on nannoplankton investigation, in Well K, the base regular abundance of *Z. ramonae* coincides with nannozone of NN2 to not younger than NN3 (interval 1442m-2060m; Figure 3) whilst in Well O, it is situated in nannozone of NN1 or older (interval 1400m-1940m; Figure 4). Meanwhile, foraminiferal analysis of Well E shows that this event is located in foramzone of not older than N4 to N7 (interval 1880m-2120m; Figure 2). It is inferred that the event of base regular abundance of *Z. ramonae* appears in Early Miocene or older.

V. AGE DISAGREEMENT OF PALYNOLOGICAL EVENTS

The application of nannoplankton discipline reveals the occurrence of inconsistent age within palynological events (Figures 3 and 4). It will be impossible to use these events for correlation as the age of each event varies from one well to another. Well correlation using these events must be unreliable as this against stratigraphic concept which correlates points with the same age.

On the other hand, nannoplankton analysis provides low fossil recovery, especially in the lower Talang Akar Formation (GRM). Many age-restricted taxa disappear from the studied wells. In addition, some index taxa occur irregularly along these wells (LEMIGAS, 2001a and b). The above situations result in the difficulty in interpreting the definitive age (nannozone). Meanwhile, foraminiferal analysis of Well E shows that sediment of GRM is barren (LEMIGAS, 2001c). Apparently, this analysis does not help refining nannoplankton results. The poor occurrence of nannoplankton and foraminifer is partly caused by unfavorable condition of deltaic environment which prevents these marine microfossils from developing. This could be the major aspect that causes uncertainty in defining zonal boundary within the studied wells. Here, the boundary of nannozone and foramzone is subject to change depending on incoming new reliable data. Therefore, zonal determination of palynological events base on nannoplankton and foraminifer is unconfident. However, there is one thing certain regarding the age of these events that all events occur during Early Miocene time as the fossil records are dominated by Early Miocene taxa.

Another data supporting the similarity of the stratigraphic level of these events is the fact that well correlation using palynological events agrees with that based on well logs (gamma log and self potential) as seen in Figure 5. This is strengthened by Suwidiyanto in his unpublished thesis (2003) which established the stratigraphy of Talang Akar Formation based on palynology. He demonstrated the application of these events for correlation of other wells drilled in on-shore South Sumatra. He discovered that event correlation actually agreed with well log correlation.

However, as palynological events very much depend on depositional environment, it is possible that they may not be recognised in some wells, especially those penetrated deeper deltaic setting such as pro-delta. For example, the base of regular abundance of riparian pollen of *M. concinus* indicating the presence of GRM is hardly found within pro-deltaic sediment as GRM is most likely absent from this sediment. In this case, the use of palynological events for well correlation is insufficient. It is suggested to apply pollen zone (qualitative palynology) which occurs in the Talang Akar Formation. Generally, Talang Akar Formation ranges from pollen zones of *Florschuetzia trilobata* to *F. levipoli* (LEMIGAS, 2001a, b and c).

VI. CONCLUSION

This study shows that palynology is the best tool for stratigraphic analysis of the deltaic deposit. Palynology enables separating Talang Akar Formation into GRM and TRM base on the significant occurrence of the selected environmental markers. The moderate abundance of riparian pollen of *Marginipollis concinus* indicates the presence of GRM (non-marine deposit), whilst the moderate and high abundances of brackish pollen of *Spinizonocolpites echinatus* and *Zonocostites ramonae* suggests the existence of TRM (transition-shallow marine deposit).

This study proposes three distinct events within the Talang Akar Formation of the on-shore South Sumatra based on the appearance of selected palynomorphs. These events are (from older to younger): (1) top reguler abundance of *M. concinus* marking top boundary of GRM, (2) base regular abundance of *S. echinatus* indicating lower TRM and (3) base regular abundance of *Z. ramonae* suggesting the upper TRM.

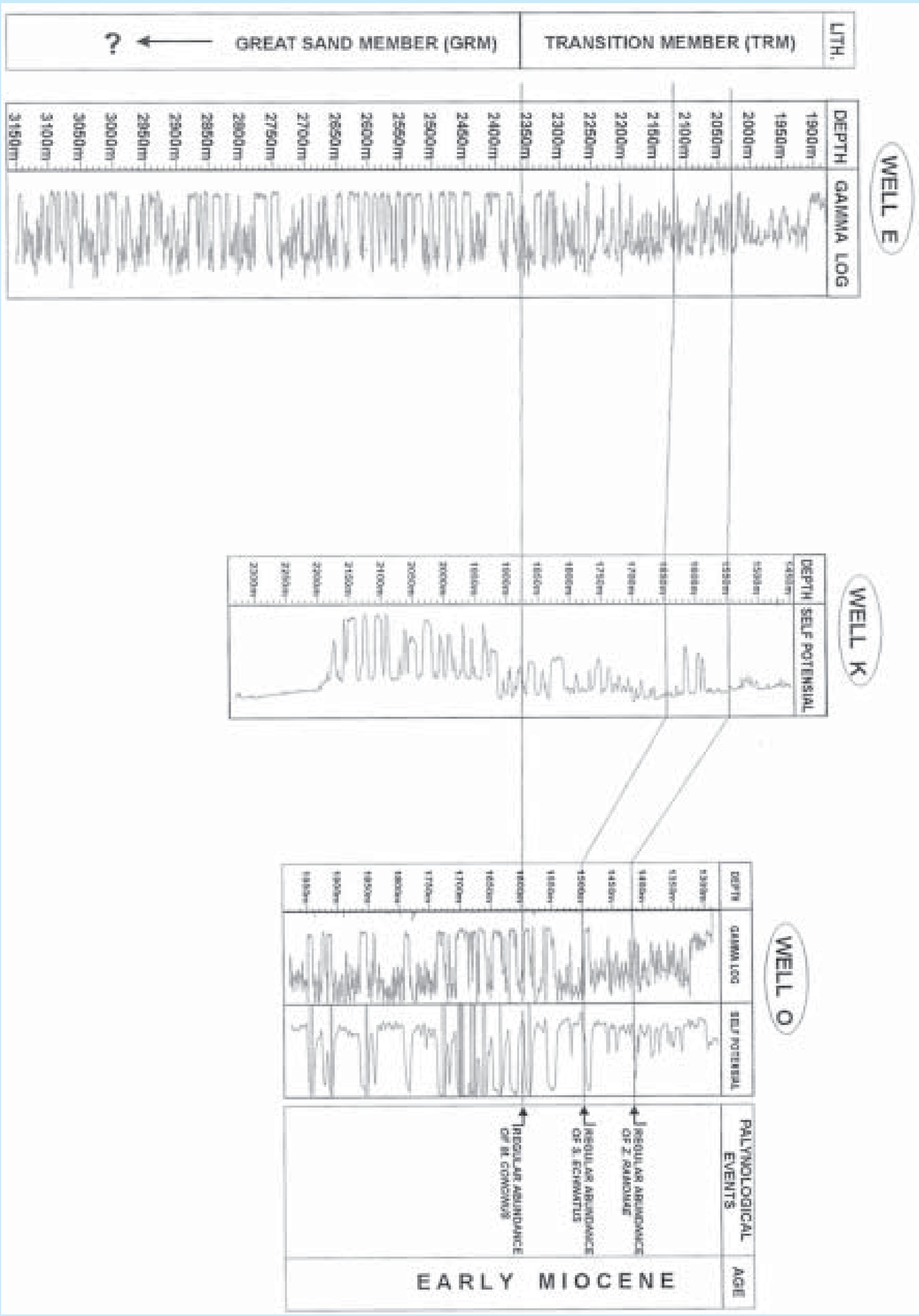

Figure 5
Well correlation bases on palynological events. Datum line is the base of regular abundance of riparian pollen of *Marginipollis consinus* which presumably coincides with top GRM

VII. ACKNOWLEDGEMENT

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