PLEISTOCENE PALYNOLOGY OF EAST JAVA

by
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I. INTRODUCTION

This study is a part of geological investigation on Pleistocene sediment in East Java in order to evaluate hydrocarbon potential within this sediment of this area. The area of study is located in the on-shore East Java (Figure 1). 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 hided in this paper. Data used in this study derives from three wells namely R, S and T. 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.

The area of study is in East Java Basin which can be classified as a classical back-arc basin. During Pleistocene, the area of study was marked by regional uplift and the cessation of open marine sedimentation (LEMIGAS, 2005). Therefore Pleistocene age was dominated by non-marine deposition. Generally, this type of sediment is separated from the underlying layer by an unconformity (LEMIGAS, 2005). Most Pleistocene sediment consists of volcanoclastic as a result of volcanic activity which related to uplifting period. It is possible that volcanic activity was responsible for the burning of grass as indicated by the occurrence of charred Gramineae cuticles.

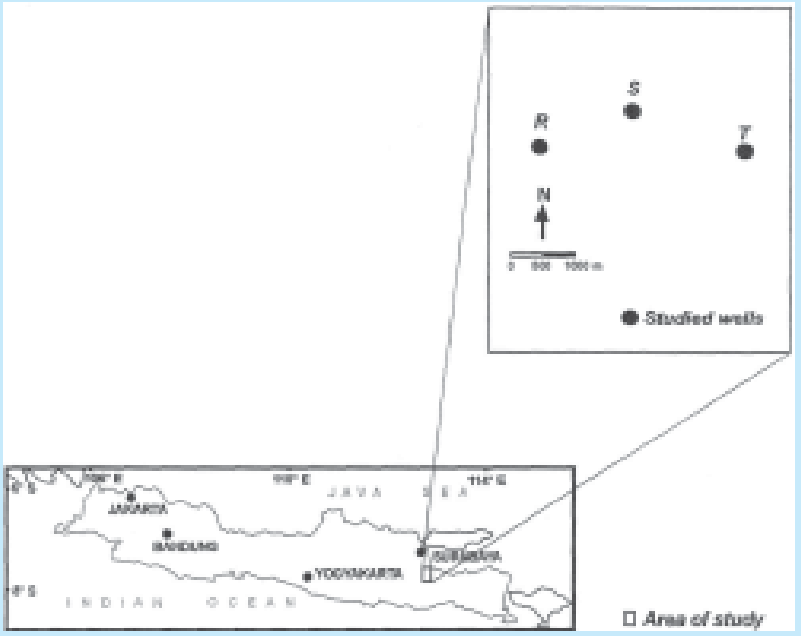

Figure 1
Location of the study area

The previous investigations on Pleistocene sediment showed the domination of grass pollen of *Monoporites annulatus* which suggested the expansion of dry climate during Pleistocene glacial maxima. The pollen diagram from Lombok Ridge produced by van der Kaas (1991a) proves the domination of Gramineae pollen during Pleistocene (Figure 2). The period of dry climate (glacial climate) is characterised by abundant Gramineae pollen, whilst the period of wetter climate (interglacial climate) is indicated by

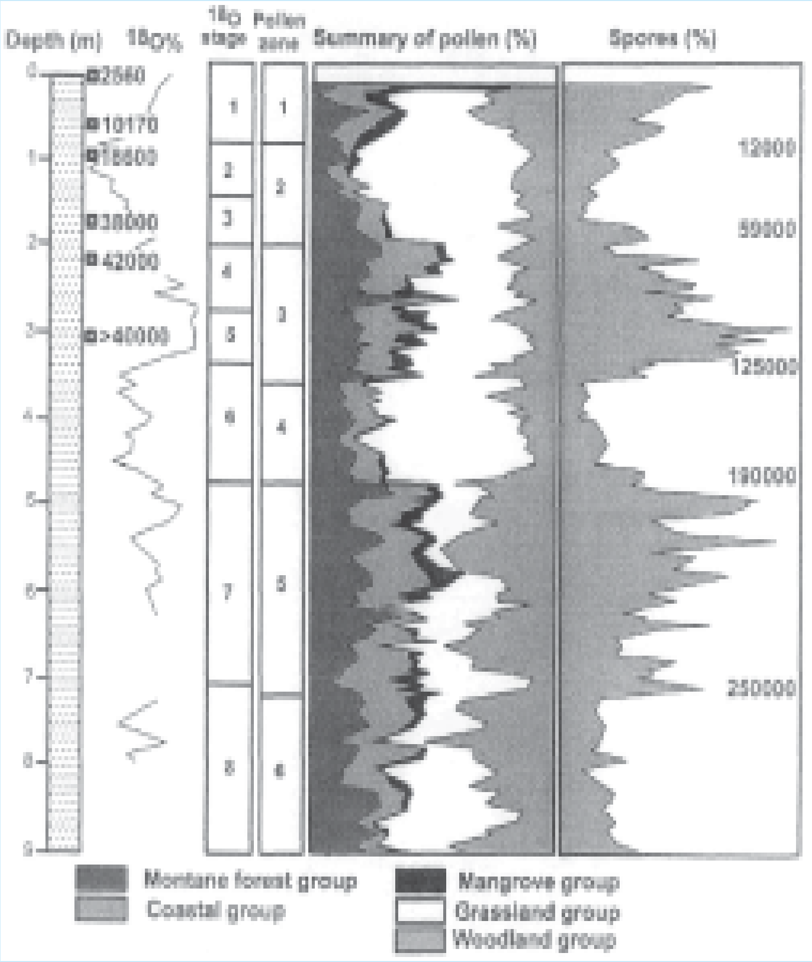

Figure 2

Summary of pollen diagram from a deep marine core of Lombok Ridge, South of Sumbawa, modified from van der Kaas (1991). 'Glacial' climates, coinciding with oxygen isotope stages 2+3, 6 and 8 are characterised by abundant Gramineae pollen, but low representation of pollen of coastal plants, mangroves and fern spores, reflecting periods of widespread savanna vegetation. 'Interglacial' climates coinciding with oxygen isotope stages 4+5 and 7 are characterised by abundant pteridophyte spores, and increased pollen of coastal plants, and mangroves, but greatly reduced frequencies of Gramineae pollen, reflecting periods of forest and mangrove swamp expansion during periods of wetter climates. Dates to left of diagram are radiocarbon dates, whereas those to the right refer to oxygen isotope stage boundaries; note older radiocarbon datesare likely to be significantly underestimated (taken from Morley *et al.*, 2003)

an increase of coastal and mangrove palynomorphs, but greatly reduced frequencies of Graminaae pollen (Morley, 2000). In addition, Rahardjo *et al*. (1994) referred to the high abundance of *Monoporites annulatus* to propose Pleistocene pollen zone of *M. annulatus* (Figure 3).

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

Three main laboratory analyses are employed in this study including palynology, foraminifer and calcareous nannoplankton.

The biostratigraphic analyses apply the quantitative method which involves logging and counting of the existing micro-fossils. For foraminiferal analysis, this method means weighing 100 grs of wet samples. For nannoplankton analysis, the quantitative method is counting the absolute occurrence of micro-fossil which occurs in 200 fields of view for each sample. On the other hand, palynological analysis requires 250 specimens per sample allowing quantitative application. Subsequently, the biostratigraphic data obtained from microscopic work was inputted into the computer using certain software called StrataBug.

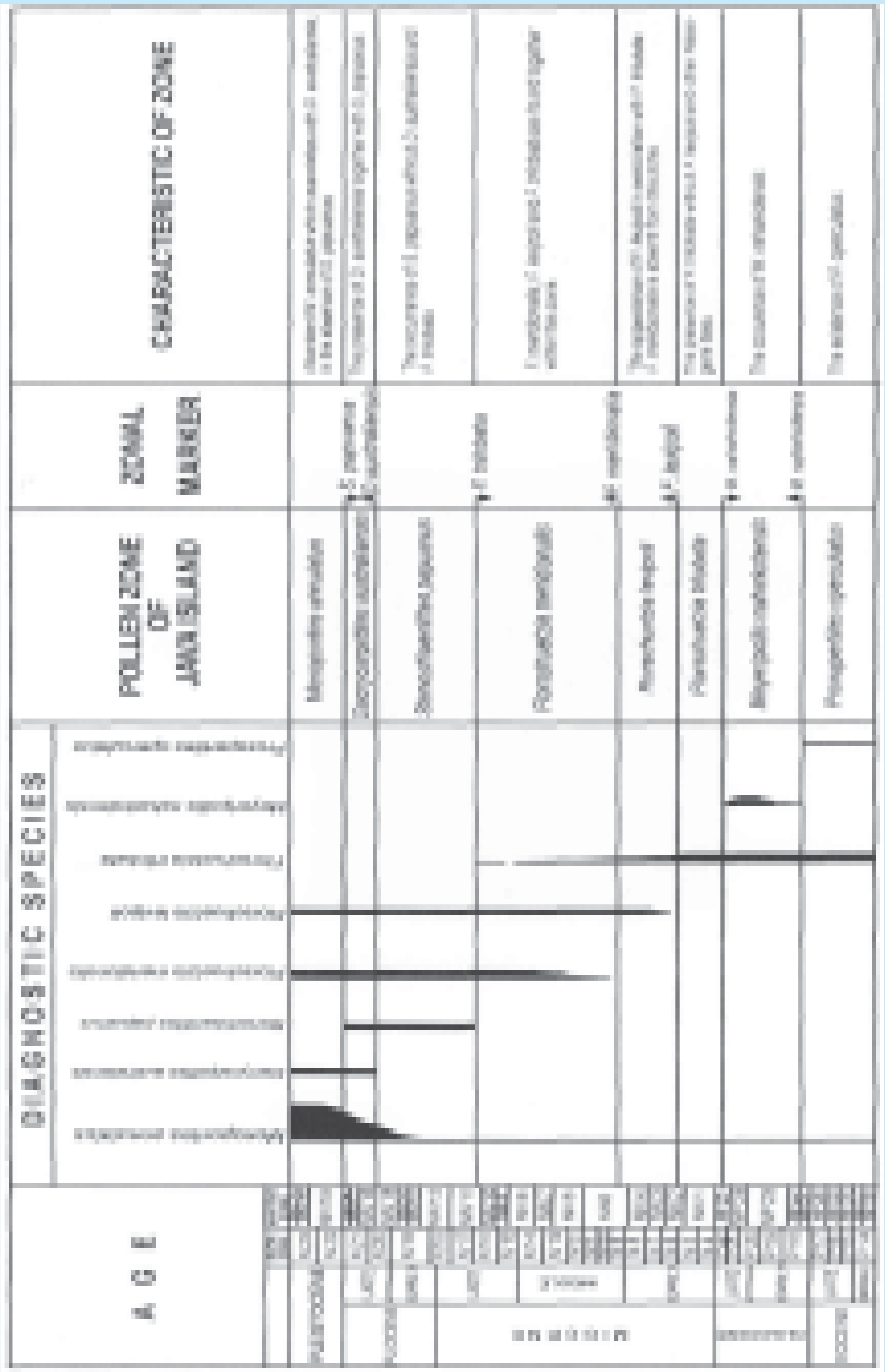

Figure 3
Palynological zonation of Java Island (Rahardjo *et al*., 1994)

The composition and the abundance of each micro-fossil are plotted into biostratigraphic quantitative chart for identifying biostratigraphic zone and age of the sediment as well as interpreting depositional environment of the studied sediment. Foraminiferal and palynological quantitative charts include the interpretation of age and depositional environment, where as nannoplankton quantitative chart provides the age interpretation.

Zonal and age interpretations refer to distinct zonations depending on the type of analysis. For foraminiferal analysis, zonal subdivision and age interpretation are based on foram-zone proposed by Blow (1969) with some modification. In case of the absence of index planktonic taxa, the zonal and age determination rely on benthonic zonation proposed by Billman *et al*. (1980). For nannoplankton analysis, these interpretations refer to nanno-zone of Martini (1971) with some modification. In addition, the pollen-zone proposed by Rahardjo *et. al*. (1994) is used to infer zonal subdivision as well as age interpretation (Figure 2). Meanwhile, two different classifications are applied in this study for paleoenvironmental analysis. Firstly, paleoenvironment based on foraminifers refers to that classified by Tipword *et. al*. (1966) and Ingle (1980). Secondly, paleoenvironmental analysis based on pollen assemblage uses the deltaic classification which was introduced by Morley (1997).

The biostratigraphic assessment using three different disciplines provides independent results which allow biostratigrapher to gain accurate interpretation. The result of palynological analysis can be easily tested with other analyses (foraminifer and nannoplankton) to get reliable picture of the Pleistocene palynology in East Java area.

IV. POLLEN ASSEMBLAGE

Compared to Late Neogene, Pleistocene relatively yields low pollen diversity. About 60 distinct palynomorphs are recorded within this study. The palynomorph assemblage existing in the studied sections is demonstrated in Figures 4, 5 and 6. Palynomorph occurring in wells R, S and T is predicted to derive from the following vegetations: mangrove, back-mangrove, riparian, peat swamp, freshwater swamp, undifferentiated fresh water and montane. Some selected palynomorphs which significantly appear in these wells are *Zonocostites ramonae* (mangrove pollen), *Spinizonocolpites echinatus* (back-mangrove), *Casuarina* and *Monoporites annulatus* (freshwater pollen). Another palynomorph showing moderate abundance is burning grass, so called charred Gramineae cuticle. Although montane pollen is not abundant, it is quite diverse as shown by the existence of *Dacrycarpidites australiensis*, *Dacrycarpidites* sp., *Podocarpus polystachyus* and *Podocarpus* sp.

V. AGE INTERPRETATION

Palynological analysis indicates the appearance of pollen *Monoporites annulatus* together with *Podocarpidites australiensis* along the studied wells (Figures 4, 5 and 6). In addition, *M. annulatus* shows high abundance to mark the studied section. Based on the occurrence of these pollen in the absence of spore of *Stenochlaenidites papuanus*, it can be inferred that the sediment situated in the studied section is attributed to pollen zone of *M. annulatus* (Rahardjo *et al*., 1994). This pollen zone is equivalent to Pleistocene (Figure 3).

In addition, nannoplankton analysis proves the occurrence of *Gephyrocapsa eocenica* almost in the whole part of the studied sections, except in the small part of the top sections (Figures 7, 8 and 9). It is concluded that sections with *G. eocenica* are assigned to nanno zone of NN19c, whilst section without *G. eocenica* is attributed to nanno zone of NN19d (Martini, 1971). However, both NN19c and NN19d represent Pleistocene age (Martini, 1971).

The presence of planktonic foraminifer is unable to define the age of the sediment situated in the studied wells. Therefore, the age interpretation refers to benthic foraminifer (Figures 7, 8 and 9). Based on the existence of *Asterorotalia gaimardii* and *Pseudorotalia schroeteriana* in the absence of *Asterorotalia gaimardii inermis*, *Pseudorotalia schroeteriana angusta*, *P. alveiformis*, *Asanoina globosa* and *Ammonia ikebei* thought out wells R, S and T, it is inferred that the sediment in these wells has benthic zone of lower NB1/ *Calcarina* (Billman *et al.*, 1980) which is equivalent to planktonic zone of N22 (Early Pleistocene).

Having these interpretations, it is concluded that the sediment situated in the studied intervals represents Pleistocene age (possible Early Pleistocene).

VI. PALEOENVIRONMENT

Apparently, all sections contain mangrove and back-mangrove palynomorphs indicating transitional

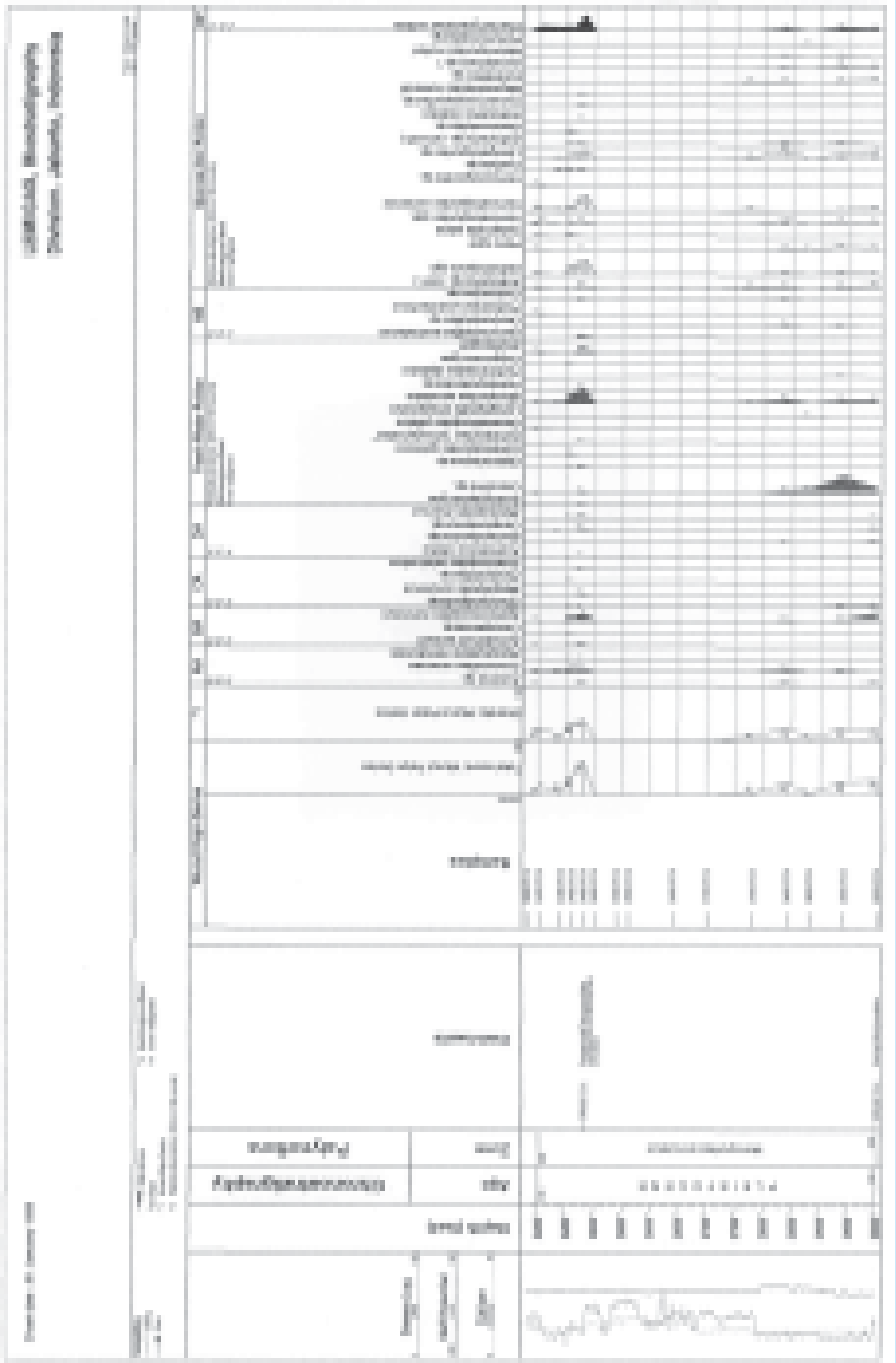

Figure 4
Palynological record of Well R interval 2300.00'-3000.00'k

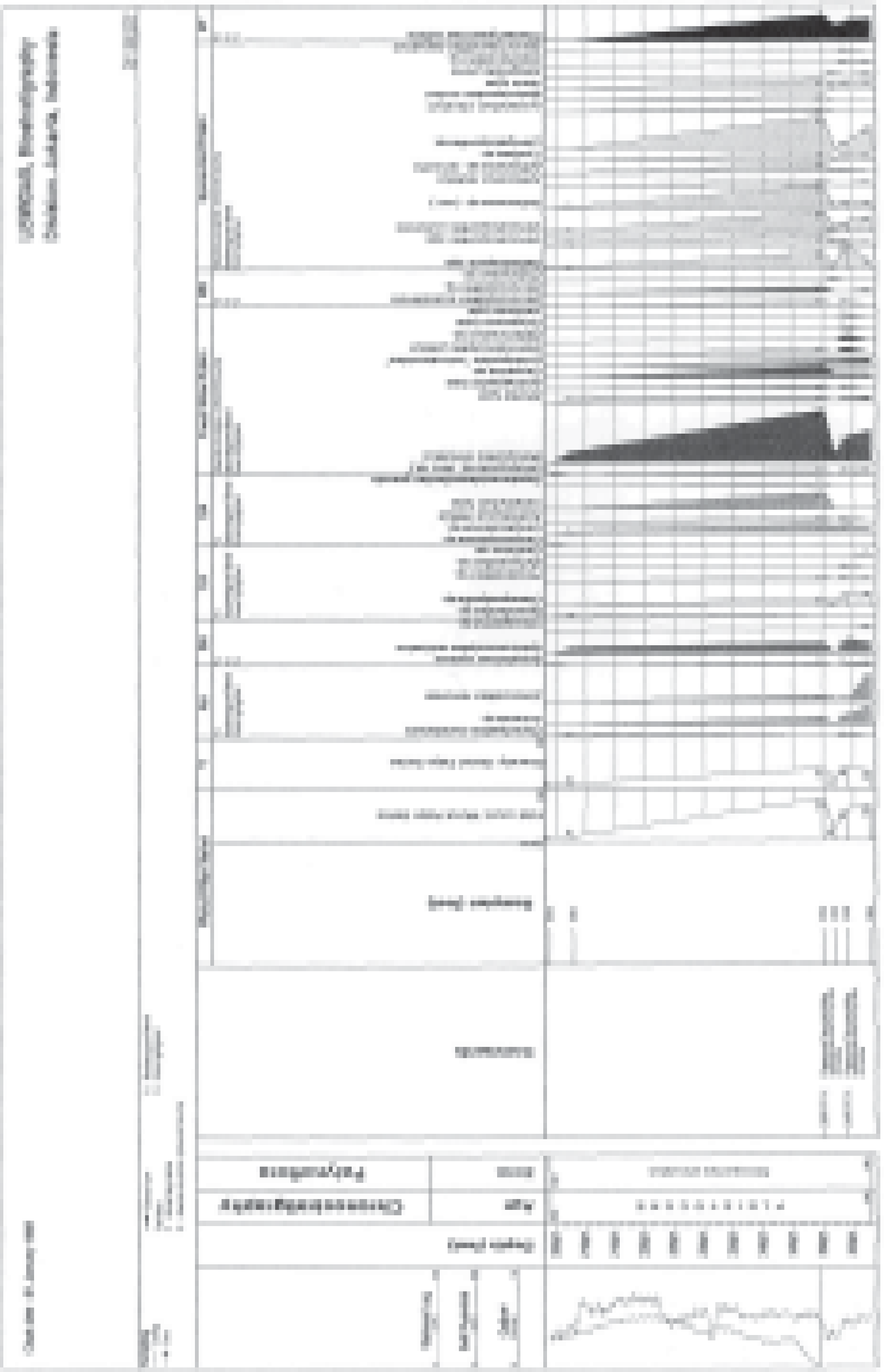

Figure 5
Palynological record of Well S interval 2000.00'-2600.00'

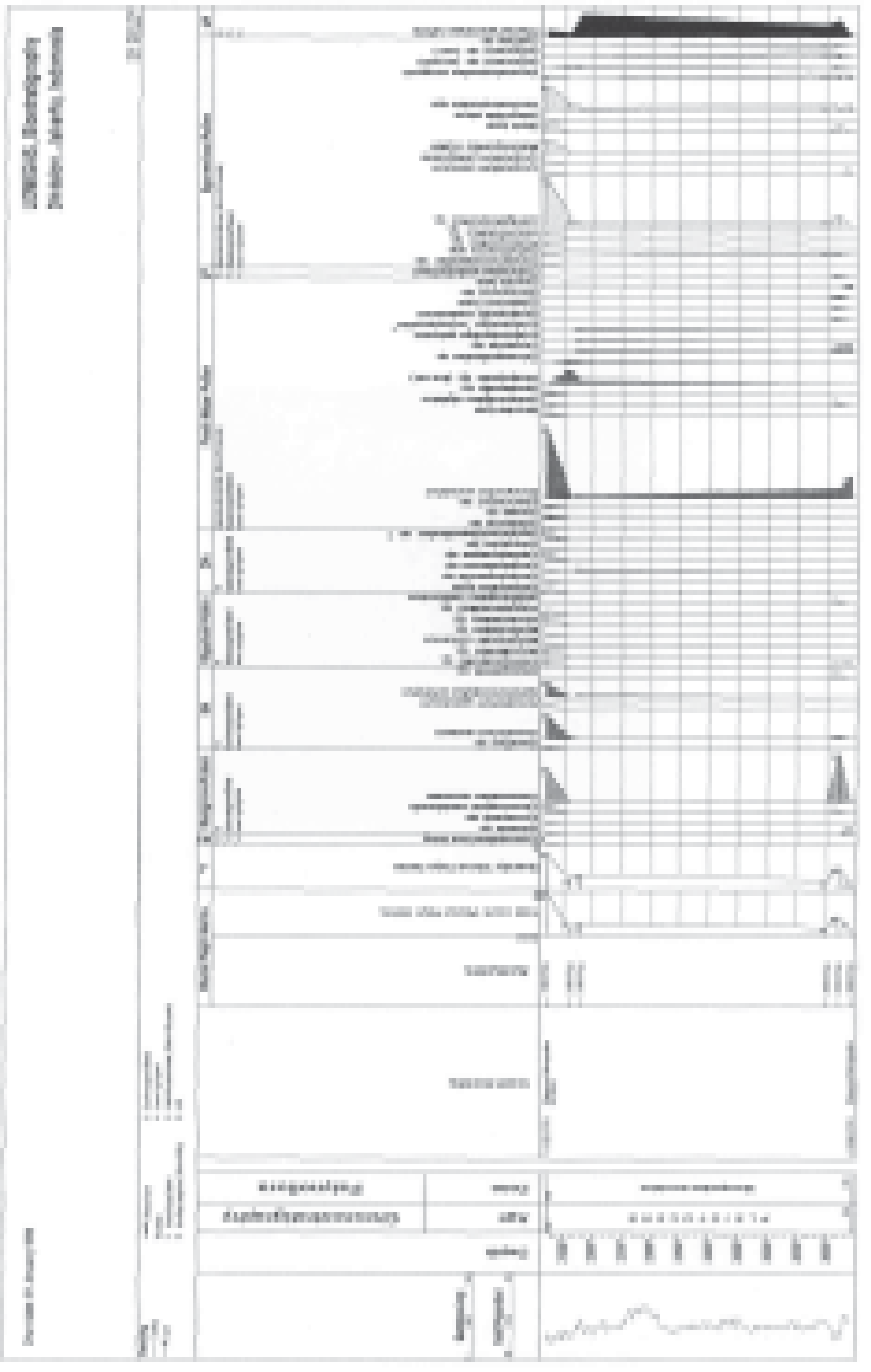

Figure 6
Palynological record of Well T interval 2100.00'-2650.00'

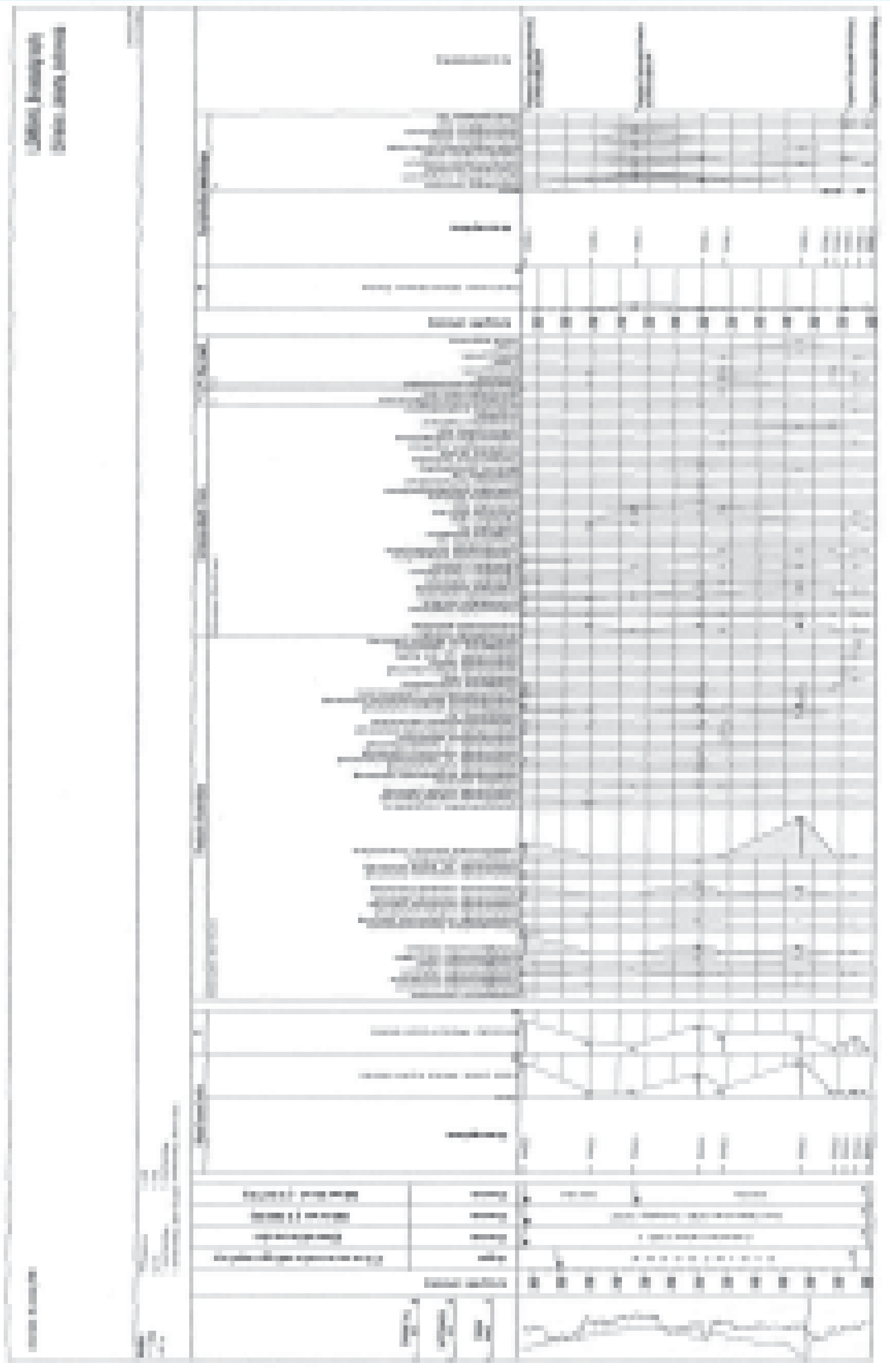

Figure 7
Micropaleontological and nannoplankton record of Well R interval 2300.00'-2800.00'

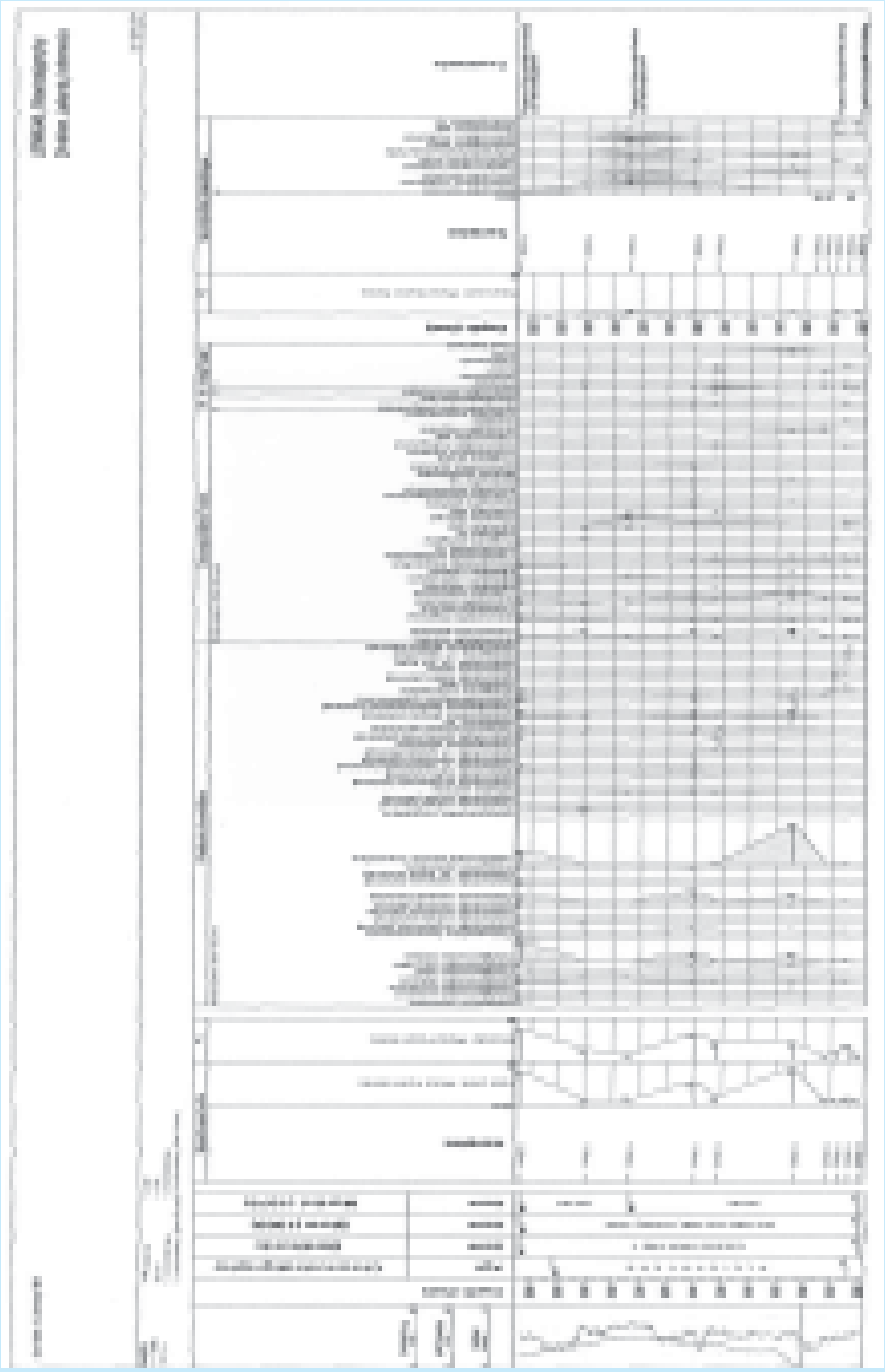

Figure 8
Micropaleontological and nannoplankton record of Well S interval 1950.00'-2600.00'

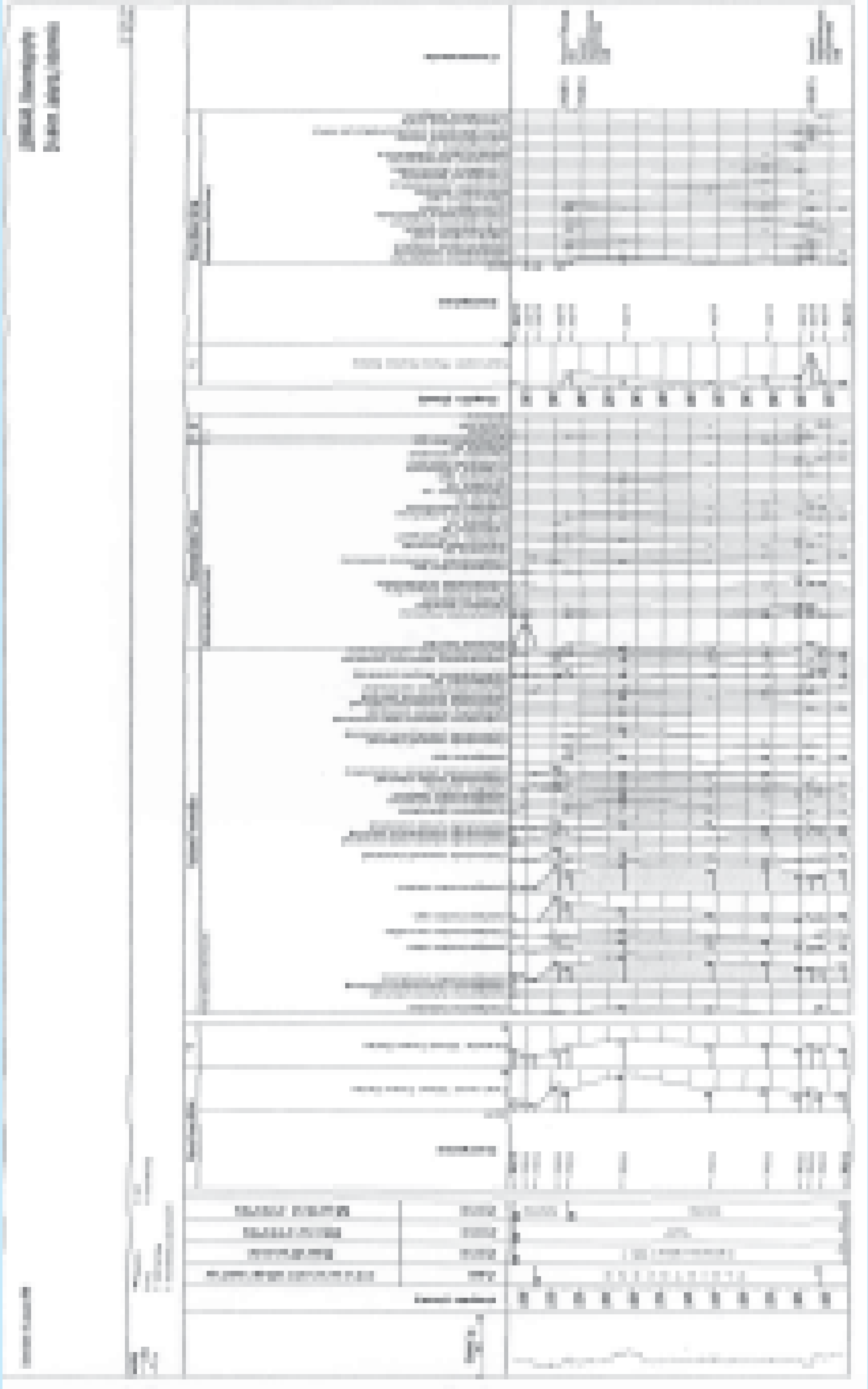

Figure 9
Micropaleontological and nannoplankton record of Well T interval 2050.00'-2700.00'

environment, such as *Zonocostites ramonae*, *Avicenia* type, *Camptostemon*, *Spinizonocolpites echinatus* and *Acrostichum aureum* (Figures 4, 5 and 6). Except for well R, *Z. ramonae* shows high abundance along the studied wells which concludes the phase of sea level rise. In addition, foraminiferal analysis provides low foraminiferal assemblage (Figures 7, 8 and 9). In well R, it shows the domination of benthonic form over the planktonic form (Figure 7). The benthonic form is mostly represented by shallow water forms such as *Ammonia beccarii*, *Asterorotalia gaimardii*, *Pseudorotalia schroeteriana* and *Elphidium* spp. marking inner neritic environment (0-20 m). Based on palynological data combined with foraminiferal data, it can be inferred that the sediment situated in the studied interval was deposited in back-mangrove/ mangrove to inner neritic environment.

Some freshwater pollen produced by peatswamp and freshwater swamp vegetation appear in significant abundance including *Cephalomappa*, *Calophyllum* type, *Monoporites annulatus* and *Casuarina* (Figures 4, 5 and 6). Their appearances could indicate the development of low land forest during sea level rise. This might have happened under wetter climate condition. On the other hand, abundant grass pollen of *M. annulatus* clearly suggests well development of savanna during dry climate phase. It is well known that Pleistocene is characterised by expansion of dry climate as proved by the establishment of dry savanna vegetation especially in the region of Java (Morley, 2000). In this case, the occurrence of moist climate within the area of study provides an evidence for the existence of moist climate during Pleistocene dry climate as seen in Kalimantan in which moist climate drove the development of low land forest (Morley, 2000).

The charred Gramineae cuticles deriving from burning grass might have been caused by extreme heat which could relate to the volcanic activities existed in East Java. Apparently, the occurrence of volcanic activities is indicated by high percentage of volcanic materials found in the studied sediment (LEMIGAS, 2005).

VII. CONCLUSION

The result of this study enriches the understanding of the Pleistocene palynology in western Indonesia, especially in East Java. It allows the recognition of moist climates during the expansion of dry climate. From the palynological point of view, the appearance of Pleistocene in the studied wells is characterised by the occurrence of index pollen of *Dacrycarpidites australiensis* and abundant grass pollen of *Monoporites annulatus* in the absence of spore of *Stenochlaenidites papuanus*. This interpretation is supported by the occurrence of nannoplankton of *Gephyrocapsa eocenica* suggesting nanno zone of NN19 which equals to Pleistocene. In addition, foraminiferal analysis concludes benthic zone of lower NB1 which is equivalent to planktonic zone of N22 (Early Pleistocene) based on the appearance of *Asterorotalia gaimardii* and *Pseudorotalia schroeteriana* in the absence of *Asterorotalia gaimardii inermis*, *Pseudorotalia schroeteriana angusta*, *P. alveiformis*, *Asanoina globosa* and *Ammonia ikebei*.

Based on abundant *Zonocostites ramonae* and *Spinizonocolpites echinatus* combined with the domination of shallow water benthonic such as *Ammonia beccarii*, *Asterorotalia gaimardii*, *Pseudorotalia schroeteriana* and *Elphidium* spp. over the planktonic form, it is inferred that the sediment in the studied sections was formed in mangrove/ back-mangrove to inner neritic environment.

VIII. ACKNOWLEDGMENT

This study is a part of the technical services provided by LEMIGAS Exploration Department for its client in order to conduct hydrocarbon evaluation in the Pleistocene East Java. The author is grateful to the management of the project for 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.

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