OLIGOCENE PALYNOLOGICAL ZONATION SCHEME FROM EAST JAVA SEA

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ABSTRACT

Systematic biostratigraphic analyses have been undertaken on the Oligocene clastic and carbonate Kujung Formation from the East Java Sea, North of Madura. The succession has been examined mainly using cutting samples in two wells, using a combination of foraminiferal, nannofossil and palynological analyses at regular spacing. Nannofossil analysis indicates that the Late Oligocene to basal Early Miocene succession is more or less complete, with zones NP24, NP25 and NN1 are all being well developed. In addition, the Early Oligocene is indentified by larger foraminifera indicating the Tc/ Td Letter Stage. Because the traditional palynological zonation of Morley (1978) does not work well in this area, the succession has been divided into broad assemblage zones, which appear to be controlled mainly by climate. These zones are OL-1, OL-2, OL-3, OL-4 and OL-5. Zone OL-1 is based essentially on the absence of seasonal climate and riparian elements, whilst zone OL-2 is characterized by the regular occurrence of seasonal climate elements, especially of Malvacipollis diversus. Zone OL-3 is indicated by common to abundant Dacrydium and Casuarina pollen, with a strong acme of dinoflagellate cysts dominated by Operculodinium spp. and Spiniferites spp., whereas zone OL-4 is marked by abundant Dacrydium and regular Casuarina pollen, but low representation of riparian elements. Finally, the youngest zone is OL-5 which is characterized by reduced Dacrydium and Casuarina pollen, and increased riparian elements. The above palynological zonation suggests climate change, which closely parallels the climate succession from West Java Sea (but with changes less pronounced). Therefore, this study provides a well dated Oligocene palynological zonation which can be applied across Java.

Keywords: *Oligocene, Palynological zonation, East Java Sea.*

I. INTRODUCTION

The Oligocene of East Java Sea area (here known as Kujung Formation) is usually subdivided biostratigraphically using a combination of nannofossils and foraminifera. It is indeed one of the mainstay areas for larger foraminifera, with many classic papers from the onshore region (van der Vlerk and Umgrove, 1927 and Leupold and van der Vlerk, 1931). This is understandable as most Oligocene succession is dominated by marine sediment. In this situation, palynology concerning non-marine micro-flora received less attention. However, in the area of study which is NW of Madura (Figure 1), the Kujung Formation often contains interbedded clastics. In one hand, this introduces additional correlation problems, whilst in another hand, this offers possibility for palynology to study the Oligocene section to clarify correlations of this area.

Palynological analysis has revealed the presence of rich pollen and spore assemblages throughout the Oligocene succession. This is the first time that a well-dated marine Oligocene succession has yielded a good quality palynological record. The traditional palynological zonation (Morley 1978) does not work

SCIENTIFIC CONTRIBUTIONS OIL & GAS
VOL. 34. NO. 2, SEPTEMBER 2011 : 95 - 104

well in this area, and so the succession has been divided into broad assemblage zones, which appear to be controlled mainly by climate. Some pollen types found to be stratigraphically useful in the Sunda Basin have also been recorded, and can be used in this area to help define the zones. The palynological zones appear to provide the best criteria for correlation of the observed succession. The age of the assemblage zones, however, is best determined on nannofossils, with support from larger foraminifera. Providing one of the first instances where an Oligocene palynological succession from the SE Asian region can be independently dated using marine fossils.

The palynological succession is characterised by the assemblages that are very similar to those from the Sunda Basin, in the West Java Sea, which has never been satisfactorily dated using marine fossils. The palynological succession also suggests climate change, which closely parallels the climate succession from West Java Sea, but with changes less pronounced (Morley, 2000). This study provides a well dated Oligocene palynological zonation which can be applied across Java.

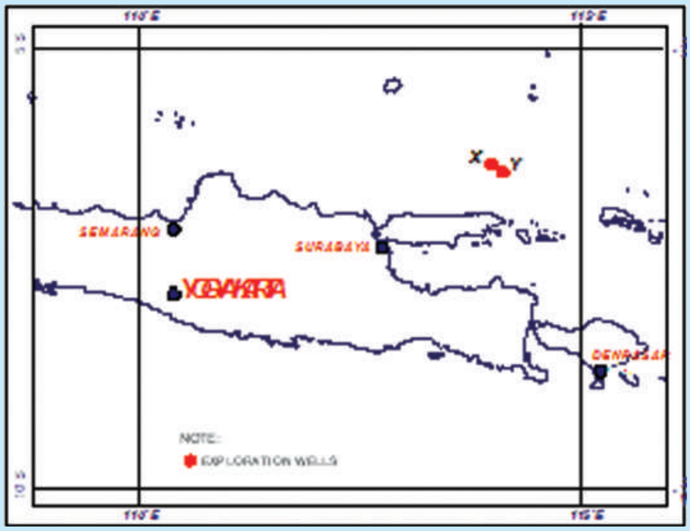

Figure 1
Location of the studied wells

II. MATERIAL AND METHOD

The data used in this study are derived from well samples supplied by the oil companies for the purpose of the provision of the technical services. Having this fact, data produced during this study are considered to be confidential. Regarding data confidentiality, well names are therefore hidden and alternated by using alphabetical codes. Two wells are selected to cover Oligocene sediment including X and Y. In addition, only relevant information is exhibited in this paper due to space limitation. In this case, the biostratigraphic diagrams only show selected taxa which determine interpretation.

The materials used in this research are cutting samples which were collected from the selected intervals of the studied wells. 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 a quantitative analysis, it is required to count 250 palynomorphs in each sample. Meanwhile, 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. The percentage abundance of micro-fossils from every sample was plotted onto a chart to illustrate temporal abundance fluctuations of each fossil type, using a statistically viable population (=count number) of fossils in every sample.

The Age interpretation is mainly based on marine fossils including planktonic foraminifera (Blow, 1969), larger foraminifera (Berggren, 1973; Haak and Postuma, 1975 and Billman et al., 1980) and nannoplankton (Martini, 1971). In addition, palynological assemblage allows detail subdivision of Oligocene age which is applied across Java area.

III. STRATIGRAPHY OF THE STUDY AREA

A regional stratigraphy of East Java basin is shown in Figure 2. It is commenced by the occurrence of Ngimbang Formation which was unconformably deposited over pre-Tertiary basement during Eocene to Oligocene. This formation is considered as a synrift deposit consisting of thin sand, shale and coal alternation. It is characterized by the

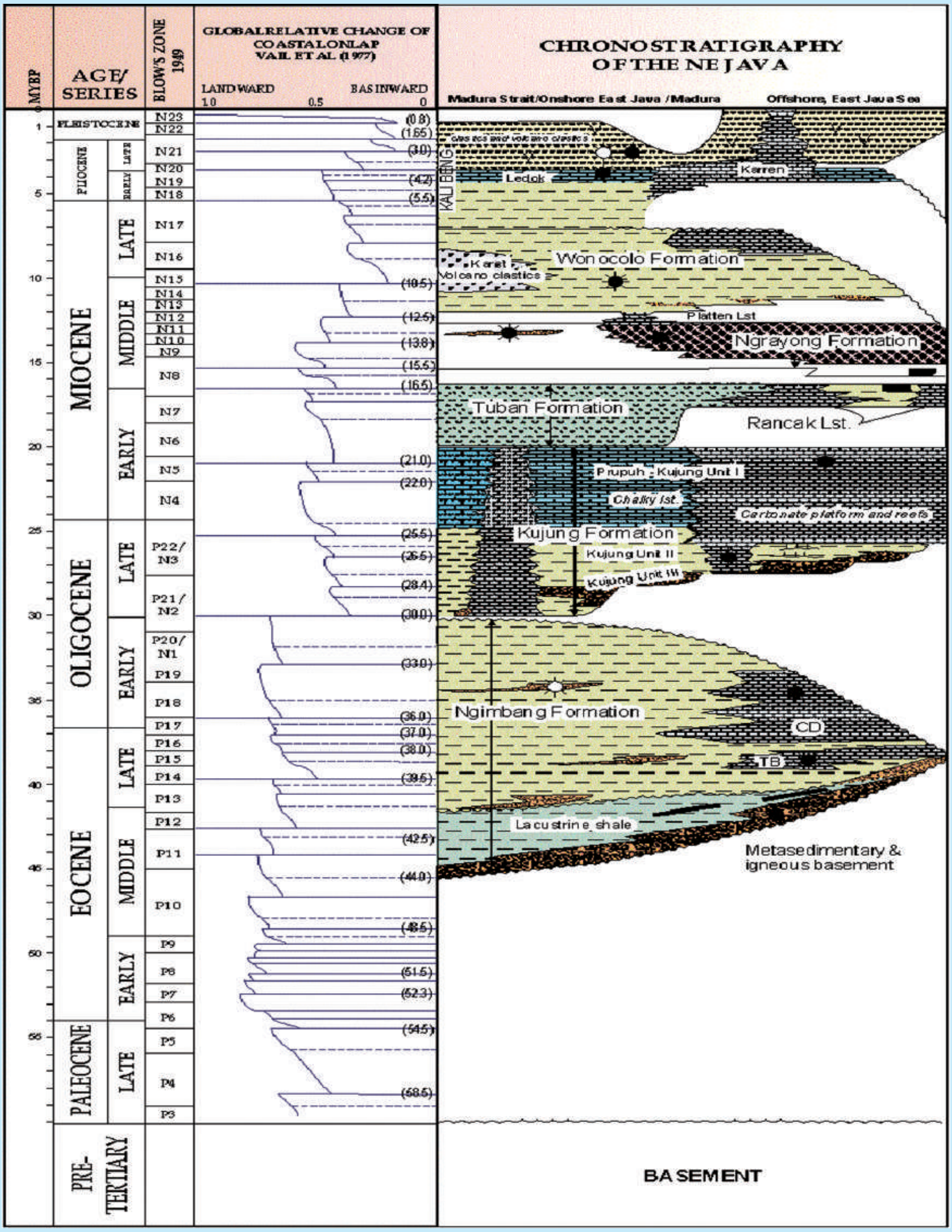

Figure 2
Regional stratigraphy of the NE Java Sea.

SCIENTIFIC CONTRIBUTIONS OIL & GAS
VOL. 34. NO. 2, SEPTEMBER 2011 : 95 - 104

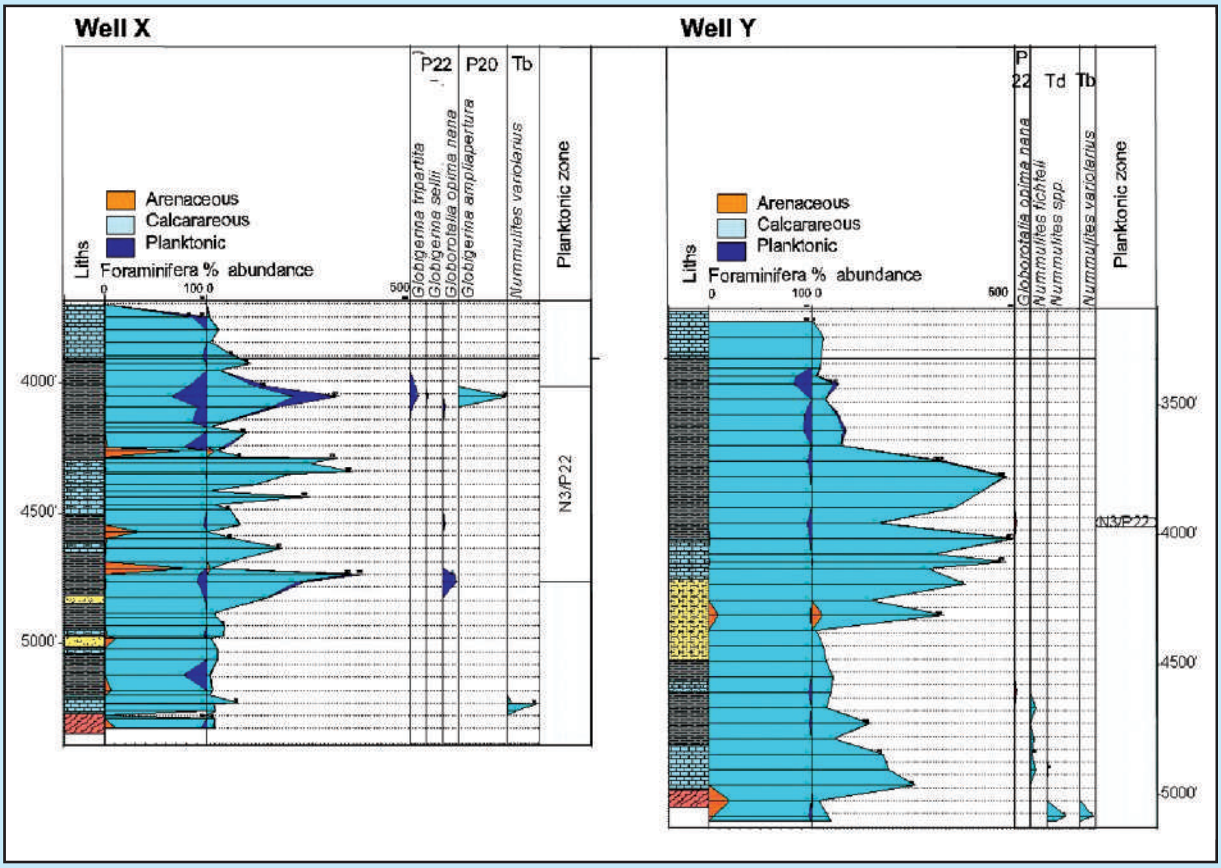

Figure 3
Foraminifera from Well X and Well Y.

transgressive sediment as indicated by the occurrence of carbonate deposit in the upper formation as a result of sea level rise. However, it was reported the presence of deeper sedimentary unit grouped as pre-Ngimbang Formation in the Kangean area. This unit is unconformably overlain by Ngimbang Formation which is subsequently followed by post-rift tectonic quiescence with the deposition of a thick and extensive carbonate platform sequence during Late Oligocene-Early Miocene (Johansen, 2003). This is usually referred to as Kujung Formation which was unconformably deposited above Ngimbang Formation during transgressive phase. In addition, the deposition of Late Oligocene-Early Miocene shallow marine carbonate is widespread along the Java Sea area, from the Sunda Basin in the West to the North East Java Basin in the East. The Kujung Formation is divided into three units including Kujung Units III, II and I. Kujung unit III is the oldest (Late Oligocene) comprising of the alternation of shale, sand and limestone. Meanwhile, Kujung unit II is characterized by siliciclastic-carbonates such as basal sandstone (lower unit) and carbonates (upper unit) which was formed during Late Oligocene-Early Miocene, whilst Kujung unit I is represented by Early Miocene carbonate build ups widespread over an extensive carbonate platform of Kujung unit II.

The Kujung Formation is conformably overlain by the Neogene sequences comprising of Tuban, Ngrayong, Wonocolo, Ledok and Mundu Formations. Tuban Formation is dominated by claystone with the intercalation of foraminiferal rich-marls which was formed during Early Miocene in outer neritic (Firdaus et al., 2004). However, sandy limestone dominantly appears in the upper Tuban formation. Following the deposition of Tuban Formation, Ngrayong Sand (Formation) conformably occurred over the previous formation during Middle Miocene composing quartz sandstone, shale and claystone. This formation is then conformably overlain by Wonocolo Formation which is characterized by fine to medium grain sediment such as calcareous claystone, sandy marl and volcanic clastic deposit. This formation was deposited during Middle to Late Miocene. Ledok Formation conformably overlies Wonocolo Formation consisting of glauconitic limestone with marl intercalation which was formed during Pliocene. Finally, the youngest sequences of Mundu Formation end the East Java succession. This formation is indicated by fine grain-volcanic clastic with thin marl intercalation.

IV. RESULT AND DISCUSSION

A. Foraminiferal Analysis

The succession yields variable recovery of foraminifera, consisting mainly of calcareous benthonics (Figure 3), with larger foraminifera featuring prominently. Planktonics, however, are poorly represented.

With respect to planktonics, the presence of Globigerina tripartita and Globorotalia opima nana in Well X indicates reference to the Late Oligocene planktonic zone P22, but correlation to Well Y cannot be achieved as planktonics in that well are very rare indeed.

Larger foraminifera provides a better basis for correlation (Figure 3), since Lower Te foraminifera (Spiroclypeus spp. without Miogypsina spp.) are well represented in both wells. The Early Oligocene Tc letter stage is represented in Well Y from the regular presence of Nummulites fitchelii, but not in Well X. However, the occurrence of Tb marker Nummulites variolensis near the base of the well, although present in both sections, may be due to reworking (see below).

B. Nannofossil Analysis

Nannofossil recovery from both sections was good in the upper part, and zone NP25 can be interpreted from the interval between top Sphenolithus ciperoensis and top Sphenolithus distentus (Figure 4). The base of NP24 is marked by the base of Sphenolithus ciperoensis, but this species appears much lower stratigraphically in Well Y, where it is likely to be present closer to its true base. Its base in Well X is likely to be controlled by environmental restraints.

There are no nannofossils to date the Early Oligocene, although the topmost Eocene nannofossil Discoaster saipanensis (top in NP20) occurs at the base of both wells, for which reworking is suspected. Eocene foraminifera and nannofossils are associated with a basal lag over basement in both Well X and Well Y. Foraminifers include Globorotaloides carsoseleensis (tops in P16) and Morozovella lehneri (tops in P14) and Cribrohantkenina inflata (range P16/17) together with the Tb larger foram Nummulites variolensis. The Eocene assemblage is thus from a variety of different stratigraphic intervals, with the ranges of the taxa that do not overlap. The likelihood is that the basal lag contains a mixture of reworked Eocene fossils and may be of Early Oligocene age. The rarity of palynomorph markers for top Eocene would also support the idea that Eocene sediments are missing form these sections.

C. Palynological Zonation Scheme

Rich pollen and spore assemblages were found more or less throughout the succession, and dinoflagellates cysts and other marine palynomorphs were also well represented. Pollen/spore assemblages can be divided into three groups, mangroves, hinterland pollen and spores. The hinterland pollen group shows the most interesting succession, with elements suggesting on the one hand everwet climates, and seasonal elements on the other, characterising the succession (Figure 5).

Based on the assemblage changes, five palynological zones are proposed as follows (Figure 6):

Zone OL-1

This zone is difficult to define, and is based essentially on the rarity of seasonal climate and riparian elements.

Zone OL-2

This zone is characterized by the regular occurrence of seasonal climate elements, especially of Malvacipollis diversus, with the top continuous occurrence of this species parking the top of the zone. Other seasonal climate elements are

SCIENTIFIC CONTRIBUTIONS OIL & GAS
VOL. 34. NO. 2, SEPTEMBER 2011 : 95 - 104

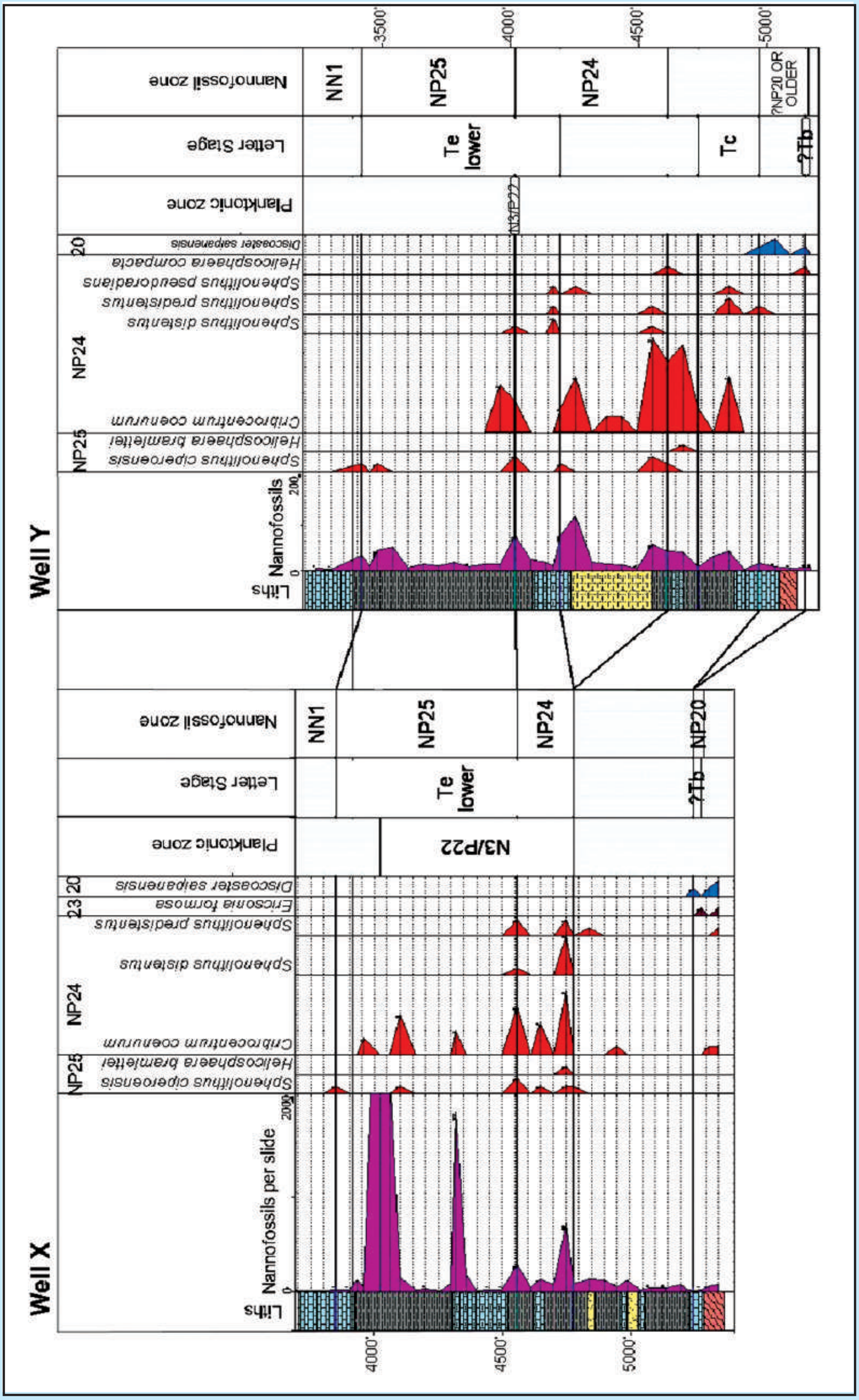

Figure 4
Nannofossils from Well X and Well Y

SCIENTIFIC CONTRIBUTIONS OIL & GAS
VOL. 34. NO. 2, SEPTEMBER 2011 : 95 - 104

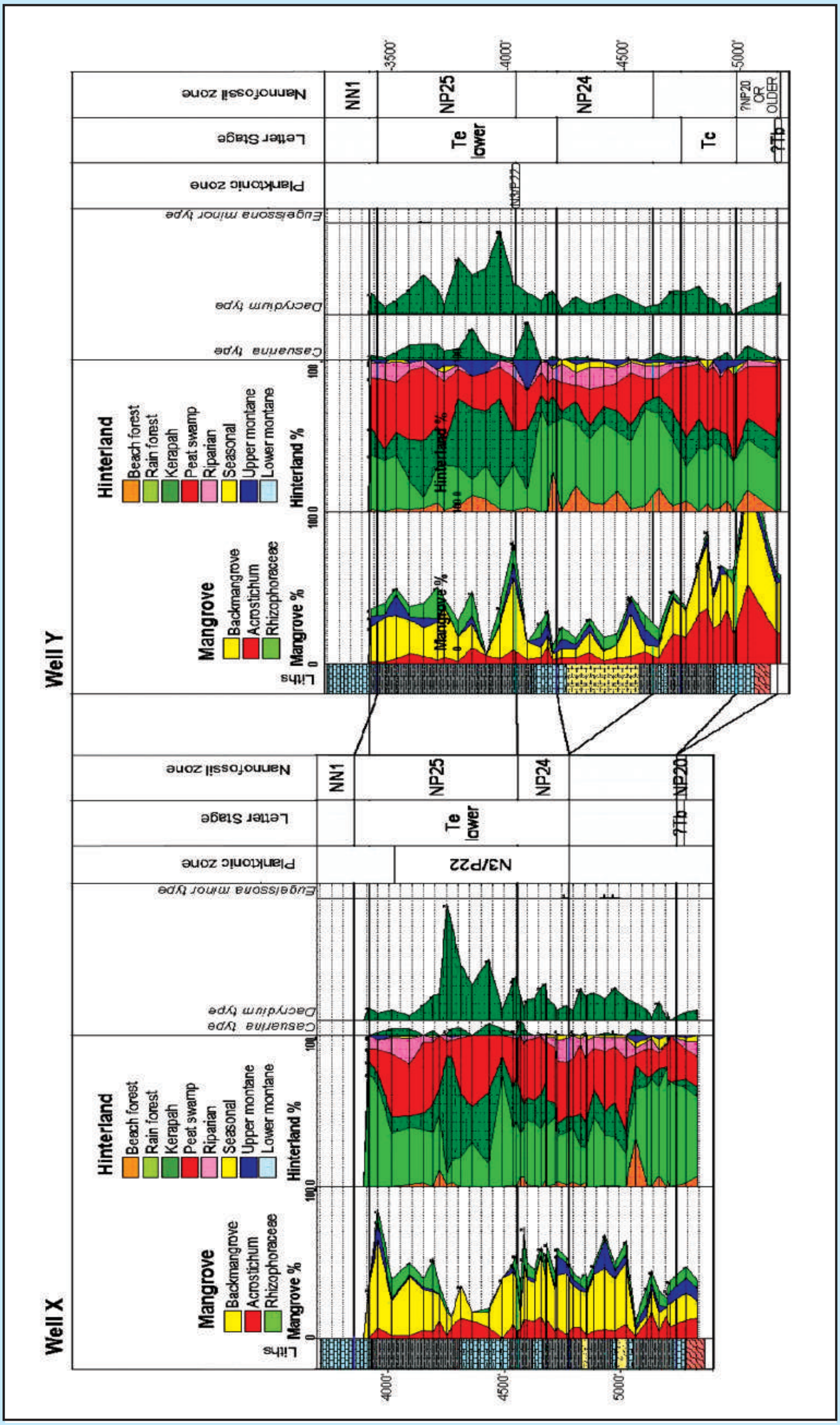

Figure 5
Mangrove, hinterland pollen and *Dacrydium*/*Casuarina* from Well X and Well Y

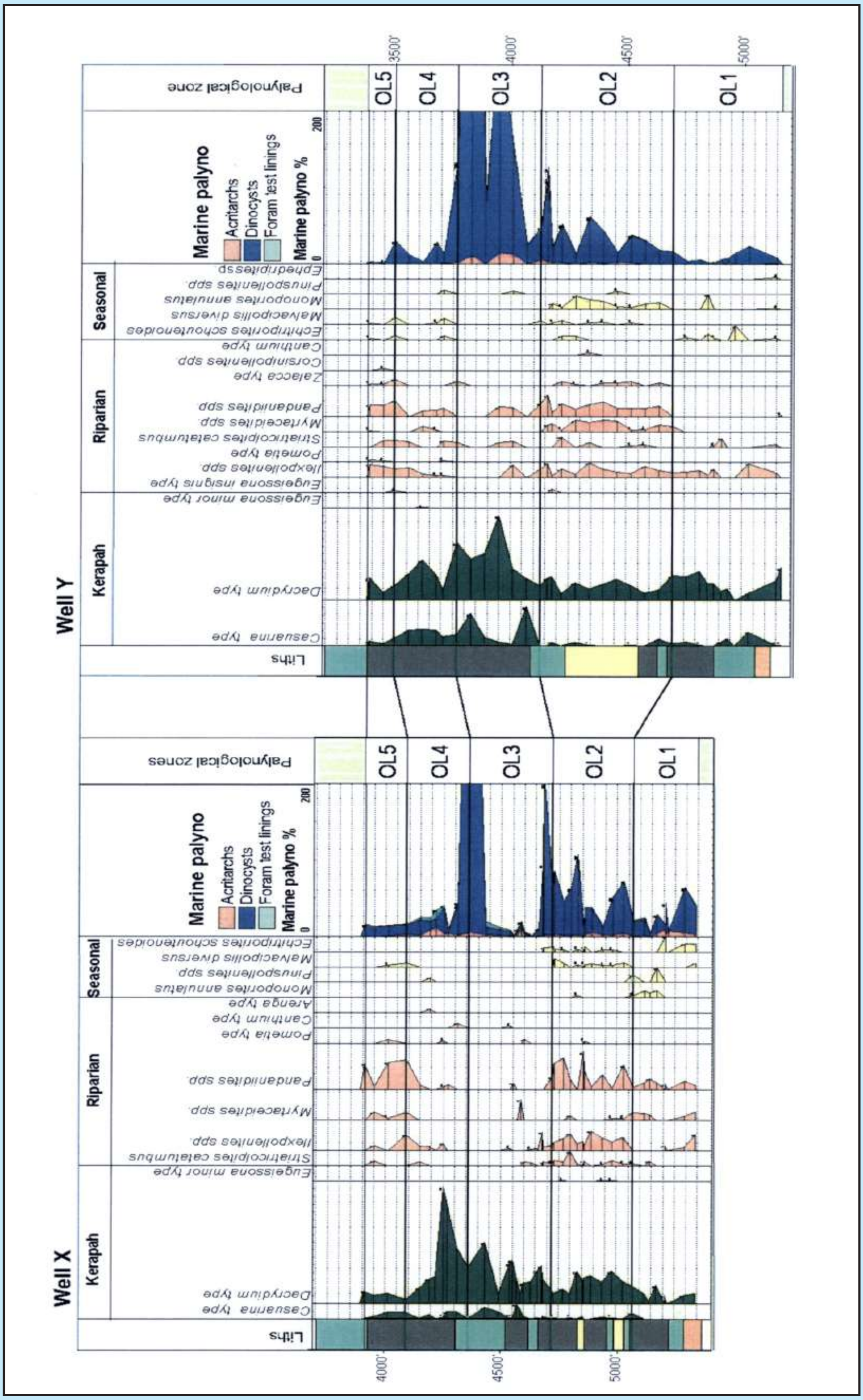

Figure 6
Algal palynomorphs from Well X and Well Y and proposed palynological zonation

Gramineae pollen and Echiperiporites schoutenioides (Schoutenia pollen). Riparian elements are also well represented in this interval.

Zone OL-3

Zone OL-3 is characterized by common to abundant Dacrydium and Casuarina pollen, with a strong acme of dinoflagellate cysts dominated by Operculodinium spp. and Spiniferites spp. marking the top of the zone but the low representation of Pandanus, Ilex and other riparian elements.

Zone OL-4

Zone OL-4 is characterized by abundant Dacrydium and regular Casuarina pollen, but the low representation of Pandanus, Ilex and other riparian elements and dinoflagellate cysts.

Zone OL-5

Zone OL-5 is characterized by reduced Dacrydium and Casuarina pollen, and increased riparian elements such as Ilex and Pandanus.

V. CONCLUSION

Based on the occurrence of age-restricted nannoplankton supported by larger benthonic foraminifera, the studied successions (here are the Kujung Formation) occurring in two well sections are assigned to Oligocene age. The appearance of interbedded clastics provide opportunity to study palynology which is hoped clarifying the stratigraphic correlation of this area. In fact, these sections contain rich pollen and spore assemblages. This is the first time that a well-dated marine Oligocene succession has yielded a good quality palynological record.

The traditional palynological zonation (Morley 1978) is less applicable in this area, therefore the successions have been divided into broad assemblage zones, which appear to be controlled mainly by climate. These zones, from older to younger are OL-1, OL-2, OL-3, OL-4 and OL-5. Zone OL-1 is based essentially on the absence of seasonal climate and riparian elements, whilst zone OL-2 is characterized by the regular occurrence of seasonal climate elements, especially of Malvacipollis diversus. Zone OL-3 is indicated by common to abundant Dacrydium and Casuarina pollen, with a strong acme of dinoflagellate cysts dominated by Operculodinium spp. and Spiniferites spp., whereas zone OL-4 is marked by abundant Dacrydium and regular Casuarina pollen, but low representation of riparian elements. Finally, zone OL-5 is characterized by reduced Dacrydium and Casuarina pollen, and increased riparian elements.

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SCIENTIFIC CONTRIBUTIONS OIL & GAS
VOL. 34. NO. 2, SEPTEMBER 2011 : 95 - 104

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