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A Review of Tertiary Palynomorph Assemblage in Cuu Long Basin: Case Study of Palynomorphs in Miocene – Oligocene Sediments

Nguyen Hoai Chung[a*], Chu Duc Quang[b], Nguyen Thi Tham[c]

[a,b,c]*Biostratigraphy laboratory, Analysis Laboratory Center, Vietnam Petroleum Institute (VPI).*
Block G1 Thanh Da Hotel, Binh Thanh District, HoChiMinh City, Vietnam
[a]*Email: Chungnh@vpi.pvn.vn*

Abstract

Tertiary deposits in Cuu Long Basin are very important because they contain fossil fuels such as oil and gas. More than 50% of oil and gas has been produced in Vietnam from Cuu Long Basin. Palynology is used as a valuable tool to support for depositional and age interpretation as well as well correlation. In this study, a Palynological study has been carried out on ditch cutting samples from a well which was drilled in Cuu Long Basin where situated in the southern Vietnam. Palynological result has revealed the palynomorph assemblages were dominated by typical tertiary palynomorphs such as *Stenochlaena palustris, Acrostichum aureum, Polypodiisporites perverrucatus, Polypodiaceaesporites undiff, Osmundacidites, Crassoretitriletes vanraadshoveni, Magnastriatites howardii* etc., and others fresh water to brackish algal, i.e. *Pediastrum, Bosedinia and Botryococcus* groups. The age of the rock succession is probably Late Miocene to Early Oligocene based on the presence of certain stratigraphically significant and age restricted taxa such as *Florschuetzia trilobata, Florschuetzia meridionalis, Stenochlaenidites papuanus (Stenochlaenanidites laurifolia), Jussiena spp. Verutricolporites pachydermus, Gothanipollis basensis. Cicatricosisporites dorogensis, Lycopodiumsporites neogenicus, Meyeripolis nahankotensis.*

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* Corresponding author.

E-mail address: chungnh@vpi.pvn.vn

This paper aims to introduce the VPI Palynological zonation which is using to clarify the palynological characteristics in the southern shelf of Vietnam.

Keywords: Tertiary; Palynology; Cuu Long Basin; VPI; Palynozonation

1. Introduction

Tertiary deposits in Cuu Long Basin are very important because they contain fossil fuels such as oil and gas. More than 50% of oil and gas has been produced in Vietnam from Cuu Long Basin [1]. Palynology analysis is used to support for depositional interpretation especially for terrestrial and transitional deposit as well as age correlation [2]. Well correlation is based on biostratigraphy along with age and depositional environments have been a subject of many discussions and arguments. From the southern continental shelf of the South Vietnam to Borneo, Java and Indonesia, Palynomorphs are generally abundant, more than 30,000 floral species recorded in this region [3]. The principle of biostratigraphy mainly based on Palynological assemblages.

Cuu Long Basin is a rift basin of southern Vietnam, which is trending an area of more than 25,000km^2, typically, in which underlain by fractured and weathered Mesozoic basement [4]. The rich-organic sediments mainly deposit in lacustrine and fluvial conditions with a minor brackish water influence over Oligocene, which is the main source rocks in this basin.

Palynology has been studying at Vietnam Petroleum Institute (VPI) since 1984s with thousands well have been analysed in Cuu Long Basin. This paper aims to compare and summarize the distribution of Palynology in Cuu Long Basin based on both palynology analyses and previous studies. Totally there were 200 cuttings samples and sidewall cores were collected from well A (figure 1) over the interval 520-4,316m which mainly consists of shale with thin lamina of sandstone in Cuu Long Basin were used and analysed at Biostratigraphy laboratory, Analysis Laboratory Center, Vietnam Petroleum Institute, Vietnam.

2. Materials and Methods

2.1. Sample preparation

The samples from a well which was drilled in Cuu Long basin were chosen for analyses. The selected samples were processed consistent with the standard Palynological preparation modified from authors in [5], [6] and [7] 10% hydrochloric and 47% hydrofluoric acids were used to dissolve and remove carbonates and silicates. Heavy minerals and palynomorphs can be separated by using the heavy liquid solution of zinc bromide (specific gravity about 2.2). The remaining filtrates were neutralized, centrifuged and fixed on glass slides with Canada balsam. The palynology slides were observed by using an Axio Imager A2, biological transmitted light microscope at magnification varying from 20x to 100x. The palynomorphs were identified by comparing to the existing floral community and other published data by previous researchers such as authors in [8], [9], [10], [11], [12], [13] and [14]. The quantitative method was applied in this study with at least 50-100 palynomorphs counted in each sample. The palynomorphs were found then grouped based on flora vegetation such as fresh water, mangrove, montane and marine palynomorphs. The results were arranged on excel spreadsheets and plotted on biostratigraphic distribution chart by using StrataBugs v2.1.

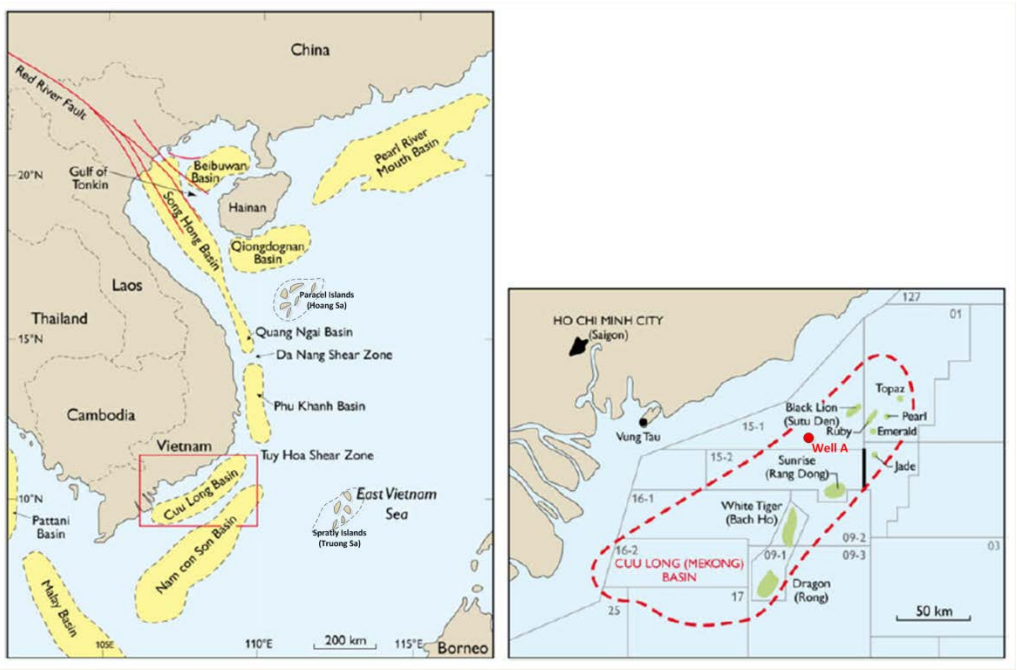

Figure 1: The location of sample plot in well A in Cuu Long Basin [4]

2.2. Age and depositional environments determinations

Age determination

Based on palynological studies from many wells relevant to Cuu Long Basin which have been analysed since 1984s, comparing to the published zonation and palynomorph assemblages particularly within south-east Asia such as authors in [9], [10], [11], [12], [15], and [16] as well as case studies were published by author in [17].

VPI palynological zonation has suggested that the Oligocene to Miocene in Cuu Long Basin can be divided into three floral zones, as follows: i) The *Florschuetzia trilobata* zone (Oligocene to Early Miocene). This zone is subdivided into *Verrutricolporites pachydermus* subzone which is a good indicator for late Oligocene in Cuu Long basin, due to the abundant occurrence of this species throughout this period, ii) The *Florschuetzia levipoli* zone (early Miocene to middle Middle Miocene) in which *F. levipoli* occurs for the first time within the early Miocene, iii) The *Florschuetzia meridionalis* zone is indicated by the occurrence of both *F. meridionalis* and *F. levipoli* [10], [11]. *Florschuetzia semilobata* subzone in which characterized by the appearance of *F. semilobata* (Oligocene to Middle Miocene). This species occurs since the Oligocene and disappeared within early-middle Middle Miocene. First appearance downhole (FAD) and last downhole appearance downhole (LAD) of associated fossils are marked as Marker events which have been explained in figure 2

Oligocene period has been defined which is based on the assemblages such as *Gothanipollis basensis. Cicadorogensis neogenicus, Meyeri nahankotensis, Jussiena spp*, especially, *Verrutricolporites pachydermus* subzone (frequently abundance in Late Oligocene) in which the common occurrence of *Verrutricolporites pachydermus*. This facie is a morphologically distinct taxon that has been found previously in Late Eocene-Middle Miocene deposits in the Caribbean region and Nigeria [9]. In Cuu Long Basin, it has been encountered

in Oligocene deposits, especially abundant in Late Oligocene; similarly with the previous study in the northern continental shelf of the South China Sea [18].

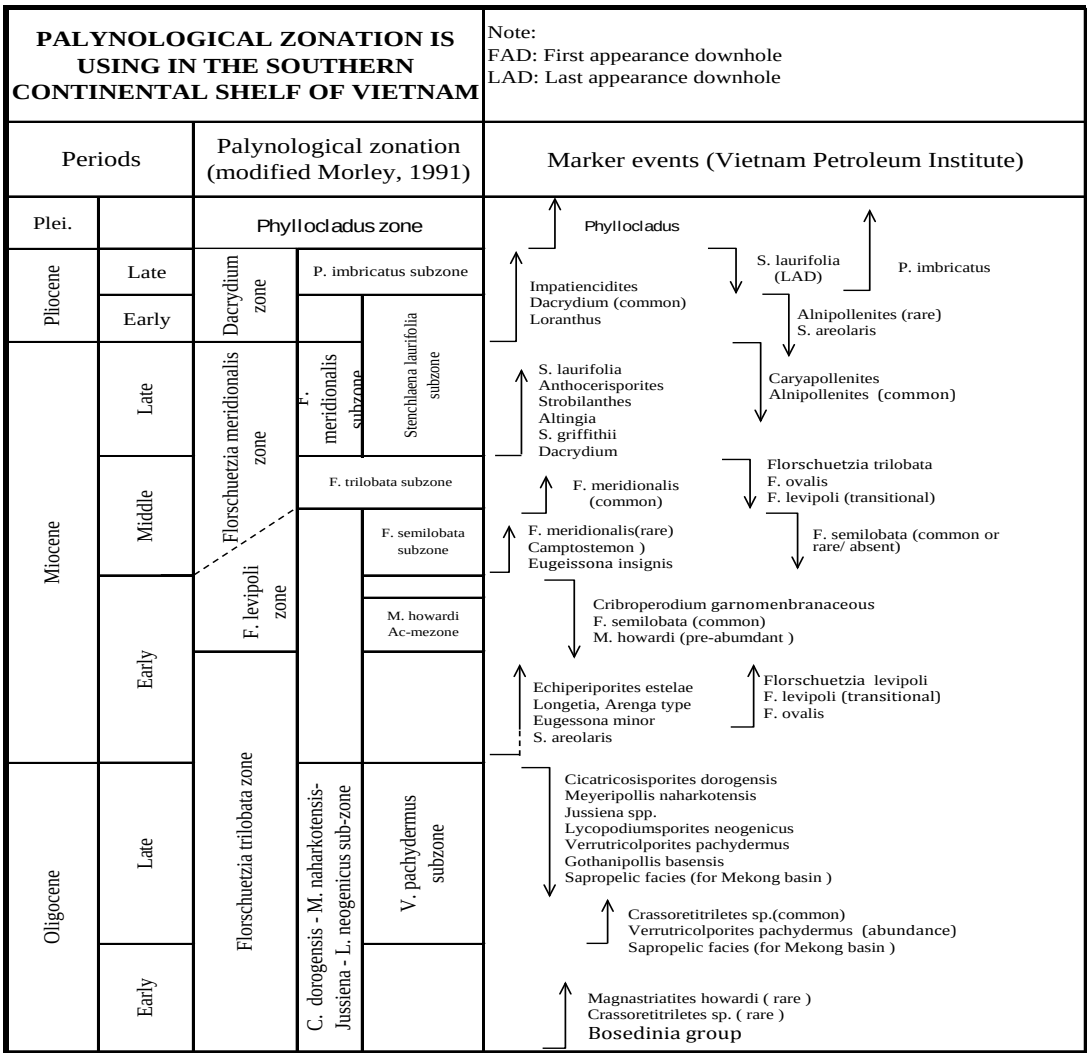

Figure 2: VPI Palynological zonation is applied in the southern continental shelf of Vietnam

Depositional environments

In considering the palaeoecology in SE Asia, depositional environment is suggested to five types according to the views of authors in [9], [23], [11], [10], [12], [17] and [19].

In Cuu Long Basin, it is possible to distinguish in the present study four palaeoenvironments following the framework of Palynoflora depositional distribution has shown in figure 3: i) The palynomorph Freshwater algae species such as *Pediastrum, Botryococcus* and *Bosedinia* groups which characterized the lacustrine environment, ii) The occurrence of riparian plant communities such as *Stenochlaena* group, *Ilexpollenites spp., Alnipollenites spp*., may demonstrate the ephemeral peat swamp, iii) Mangrove environment can be demonstrated based on the occurrence of *Florchuetzia* flora, which is produced by *Sonneratia* mangrove plants (*Florschuetzia levipoli and Florschuetzia meridionalis*), *Nypa, Barringtonia, Acrostichum, Brownlowia,*

Rhizophora [20], iv) the inner neritic is defined based on the occurrence of marine dinocysts taxa which is occupied with montane taxa.

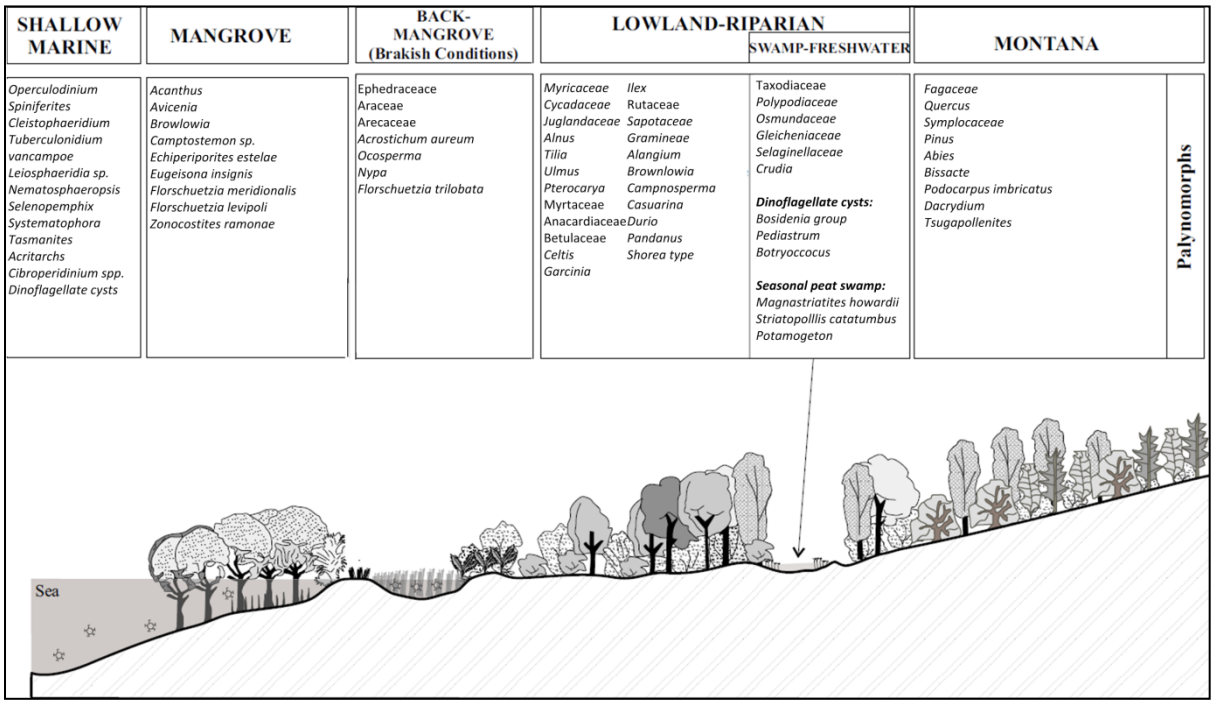

Figure 3: Palynoflora depositional distributions (modified from authors in [17] and [19])

3. Results and discussions

A well from Cuu Long Basin was analysed and interpreted. Total 200 samples were analysed. The summary of palynological result for well A has been shown in figure 4 and figure 5 as following comments:

The presences of *Florschuetzia levipoli* and *Florschuetzia meridionalis* are datable within the Middle – Late Miocene age from interval 520m to 1,790m. This assemblage can also be employed palynologically as *Florschuetzia meridionalis* zone due to the common occurrence of *F. meridionalis.* The Middle Miocene age was assigned by the first downhole occurrence of *Florschuetzia trilobata.*

The occurrence of *Cibroperidinium spp* and the absence of *F. meridionalis* indicated the Early Miocene age within the interval 1,970-2,590m.

The frequent occurrences of *Verrutricolporties pachydermus, Jussiena spp, Lycopodiumsporites neogenicus, Cicatricosisporites dorogensis, Crassoretitriletes vanraadshoveni* and *Magnastriatites howardii* can be used as the pointer for Oligocene age. The Early Oligocene age is defined by decreasing of palynomorphs as well as the absence of *Verrutricolporites pachydermus* from interval 3,524.6m to 4,310m

In view of the depositional environment of study area, the interval 520-1,520m and 1,960-2,120m probably accumulated in inner neritic. This is suggested by the occurrence of palynomorphs such as *Florschuetzia*

meridionalis, and Dinoflagellate cysts. The often high frequencies of *Florschuetzia meridionalis* relative to other mangroves suggest the lower part of the lower delta plain [10]. The abundance of *Pinaceae* counts, principally *Pinus* pollen, which is strong, over-represented the influence on the marine sediments [21] supports this environment.

The interval 1,520-1,960m and 2,120-2,590m probably reflect a brackish lagoon which is covering areas of riverine peat swamps forest, riparian vegetation, back mangrove with the influence of marine. This is signalled by greater frequency of large fresh water algae (*Botryococcus* group) which is bloomed in brackish condition, relatively saline lakes [22]. In addition, the percentage diagram over this interval shows a very "spiky" character and palynomorphs recovery is low, relatively high energy, suggesting predominantly littoral (beach) depositional setting.

The interval 2,590-3,824.6m probably reflects the sediments were deposited in fresh water lacustrine due to the abundance of freshwater dinocysts such as *Bosedinia* group which normally develops in large and long-lived lakes [12].

Sediments from the interval 3,824.6-4,310m were deposited in fresh water riverine peat swamp. The palynomorphs recovery is poor, suggesting predominantly high energy conditions.

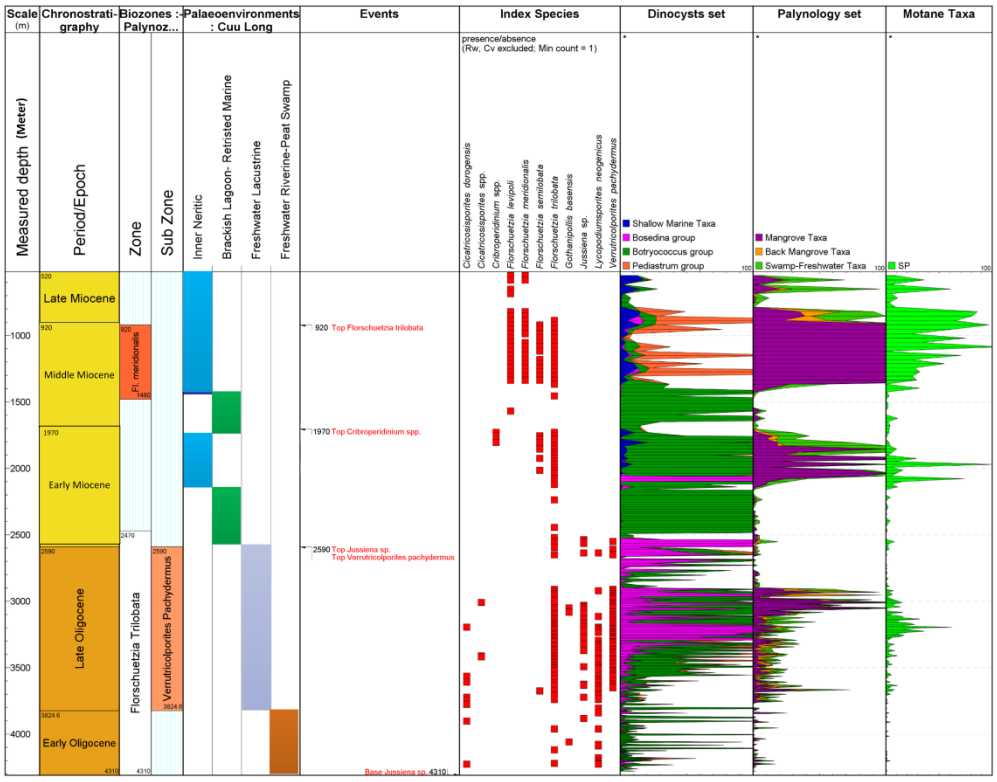

Figure 4: Main Pollen and spores graph and representative abundance of using ecological taxa in well A

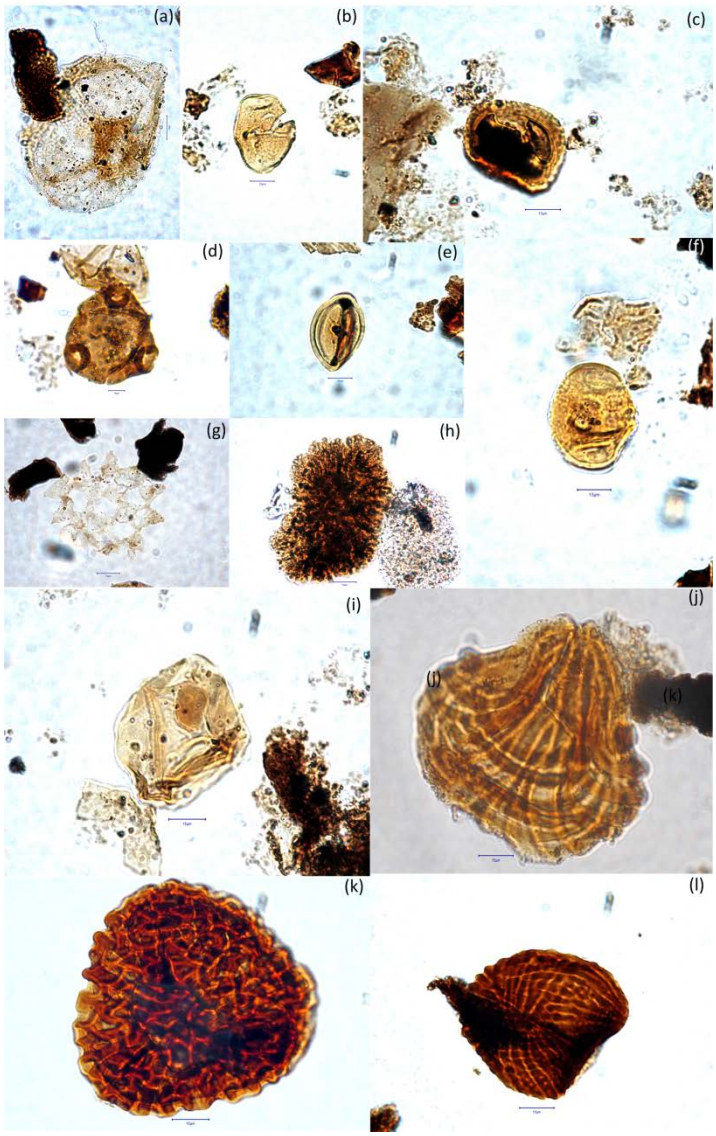

Figure 5: Photomicrographs of index palynomorphs extracted from well A – Cuu Long Basin: (a) *Cibroperidinium sp.*, (b) *Florschuetzia levipoli*, (c) *Verrutricolporites pachydermus*, (d) *Jussiena sp.*, (e) *Florschuetzia trilobata*, (f) *Florschuetzia meridionalis, (g) Pediastrum, (h) Botryococcus braunii, (i) Bosedinia, (j) Magnastriatites howardii, (k) Crassoretitriletes vanraadshoveni, (l) Cicatricosiporites dorogensis*

Scale bar: 15µm

4. Conclusion

The Palynological study of the selected cutting samples from Cuu Long Basin has discovered that the palynomorph assemblage resembles that of Tertiary palynomorphs. These terrestrial palynomorphs in well A were commonly transported to the basin via submarine fans, Alluvial plain, mangrove and lower plain delta to inner neritic. The assemblage is dominated by swamp and mangrove plant communities which reflect the changing of the environment from Miocene to Oligocene in this area. *Bosedinia* group swamp was quite well developed in Late Oligocene. This is the good evidence to derive the peat freshwater swamps (lacustrine

environment) were spreading over this area throughout Late Oligocene. VPI palynological zonation is useful to interpret the age based on the palynomorphs assemblages. *Verrutricolporites pachydermus* is a good indicator for late Oligocene due to the abundant assemblage of this specie in this area. However, other new markers in this area should be more investigated in order to improve the palynological analytical result

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