Palynofacies analysis of the Eocene Bayah Formation in Bayah High, Banten Block, SW Java

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ABSTRACT

The objective of this study is to characterize the palynofacies of the Bayah Formation from cores of wells DDH-1 (242m) and DDH-2 (315m).The wells were systematically sampled at 5m intervals. There were 47 samples from the DDH-1 and 62 samples from the DDH-2 wells. Sediment preparation was done in the Palynology Laboratory, Geological Engineering of ITB Laboratory. The examination of the processed samples was carried out with a light microscope at 400X magnification. The results of palynofacies investigation are presented in the form of palynodebris diagrams, which were then used for the basic interpretation. The palynodebris character of the Bayah Formation at DDH-1 core can be grouped into 6 palynofacies units, DDH-2 core into 7 palynofacies units. Palynofacies units 1 to 4 showed similar successions and can be correlated. The datum of the palynofacies correlation was the acme zone of Proxapertites operculatus, which is present in both wells.

INTRODUCTION

The Bayah Formation is composed of thick Eocene fluvial-deltaic sediments at the Bayah High in the southwest Java forearc Basin. The thickness of Bayah Formation is 1500 meters or more. This research aims to subdivide the Bayah Formation into distinct units based on the palynofacies analysis.

Palynofacies analysis is characterization of sediments based on palynomorph assemblages and palynodebris. Sediment samples are chemically processed with hydrochloric and hydrofluoric acids and the resultant organic matter is mounted on glass slides and are studied by microscope.

Studies of Eocene palynofacies in the Java are rare. This is probably related to the limited outcrops of Eocene age in Java. The other outcrops of Java Eocene sediments are at Ciletuh Bay (near Pelabuhan Ratu, West Java), Karangsambung (Kebumen, Central Java), Nanggulan (west of Yogyakarta) and Bayat (east of Yogyakarta). Rahardjo *et.al.* (2009) analyzed the palynofacies at Weleran river, Karangsambung, Central Java. The palynofacies assemblages of their study are characterized by the abundance of amorphous organic matter and also common microforaminiferal linings, indicating a marine environment. Meanwhile, the palynofacies assemblages at the Bayah High are characterized by abundant phytoclasts, characteristic of fluvio-deltaic environments.

Until this work, there has not been a systematic sampling of the Bayah Formation for palynofacies. The results of this research should be useful in recognizing the character of palynofacies assemblages and the changes of palynofacies pattern in the fluvio-deltaic area.

REGIONAL STRATIGRAPHY

The name Bayah Formation was proposed by Koolhoven (1933), based on the name of sub district at South Banten Area. The lithology of this formation consists of coarse sand and conglomerate intercalations with clay and coal. Based on the presence of foraminifera fossils, such as: *Globorotaliacentralis* sp., *Globigerapsis* sp., *Chiloguembelina* sp. and *Globorotalia* sp., in clays at the Cimandiri River, the age of this formation is Middle to Late Eocene.

West Java can be divided into three main sedimentary provinces, namely the continental shelf in the north, the Bogor basin in the south and the Banten province in the west. The Banten sedimentary province consists of three cycles of sedimentation. The lowermost interval is dominated by volcanic and igneous rocks equivalent to the Jatibarang Formation of the north province. It is unconformably overlain by shallow marine to terrestrial deposits of the Bayah Formation. The lower part of Bayah Formation is a prodelta deposit, characterized by black shale with some limestone lenses, rich in Eocene larger forams. The upper part of Bayah Formation contains quartz sandstones to

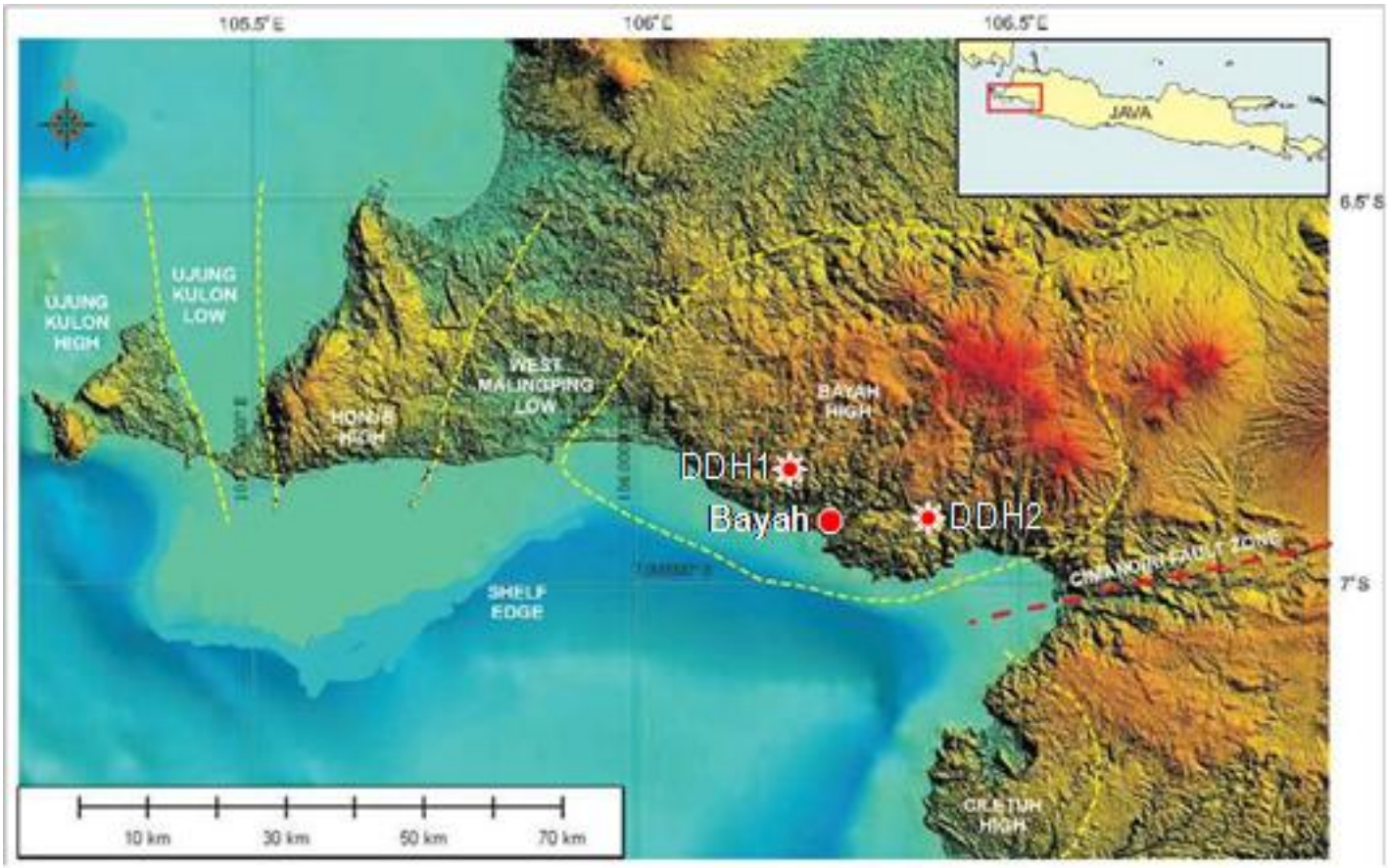


Figure 1. *Location map showing where DDH-1 and DDH-1 wells were drilled. Modified from Yulianto et.al. (2007) and Keetley et.al. (1997).*

pebbly sandstones with coal lenses up to 100 cm thick. The second cycle unconformably overlies the Bayah Formation and consists of volcanic breccias and sandstones with some clays of the Cicarucup Formation. These are followed by limestones of the Cijengkol Formation, a 1500 m thick section of volcanic influx, composed of gravity flows of tuffs and breccias of the Cimapag Formation, sourced from the area south to the Bayah region. The third cycle consists of 1000m of shallow to transitional marine deposits belonging to Saraweh and the Badui Formations. These are overlain by young, marine influenced sediments of the Bojongmanik Formation, consisting of clays, sands with some lignite lenses of the Middle Miocene age (Martodjojo, 2003).

The Bayah Formation in the Bayah Area is divided into two facies, a north facies and a south facies, by Koolhoven (1933), the relationship between these facies remains concealed, since they are mostly in fault contact. The northern facies is dominated by black claystone, with conchoidal fractures and with some lenses of limestone. Meanwhile, the Southern Bayah facies is dominated by coarse grained sediments (Martodjojo, 2003). The northern Bayah facies is now referred to as the Ciletuh and Cijengkol Formations (Martodjojo, 2003).

The Bayah Formation or the equivalent is not only present at the Bayah High, but also at the Cimandiri, Sukabumi and Jampang Highs. The location of Bayah High and wells DDH-1 and DDH-2 are shown in Figure 1.

DATA AND METHODS

Palynofacies preparation was performed by using standard palynological techniques, using hydrochloric and hydrofluoric acids to isolate the organic matter from the sediment matrix. The organic matter residues were then prepared as microscopic slides. Organic matter identifications were performed using a transmitted light microscope, using the classification of Tyson (1995). Choosing the organic classification used in palynofacies analysis is the first steps before identification, followed by relative proportion measurements and determination of other palynofacies parameters (Steffen and Gorin, 1993). The choice of palynofacies parameters ultimately depends upon the objectives of the study and upon the kerogen and palynomorphs classifications used to collect data (Tyson, 1995).

This study analyzes cores from the Bayah Formation. The cores are from the DDH-1 Well (242m) and DDH-2 well (315m), which are located in the Bayah area, Banten province (see figure 1). The DDH-1 and DDH-2 well was drilled by Amoco and ITB lab worked on the cores as a material for practical sedimentology instruction.



Figure 2. *Classification of palynofacies categories based on morphological character by Tyson (1995).*

CLASSIFICATION OF SEDIMENTARY ORGANIC MATTER

Many terminologies have been proposed to classify organic materials in palynofacies studies, including Staplin (1969), Burges (1974), Combaz (1980), Parry *et.al.* (1981), Whitaker (1984), Bryant *et.al.* (1988) and Tyson (1995). Differences among the classifications were triggered by various and different analysis techniques and the purposes of their studies. This research will use the classification of Tyson (1995) which relies on the morphology identified under transmitted light microscope (Figure 2).

This morphology-based classification recognizes three palynofacies groups: phytoclasts, amorphous organic material and palynomorphs. Phytoclasts include two sub units: translucent and opaque. Resembling phytoclasts, the amorphous group also has two sub units: amorphous and resin. Palynomorphs are split into 2 major groups: marine and terrestrial palynomorphs. Marine palynomorphs include microforaminifera test linings and dinoflagellates, while the terrestrial component includes *Pediastrum* fresh-water algae, pollen and spores.

According to Tyson (1995), highly detailed palynofacies analysis requires a classification that contains at least, 10 categories. This study used the classification from Tyson (1995), distinguishing 16 categories (Figure 2).

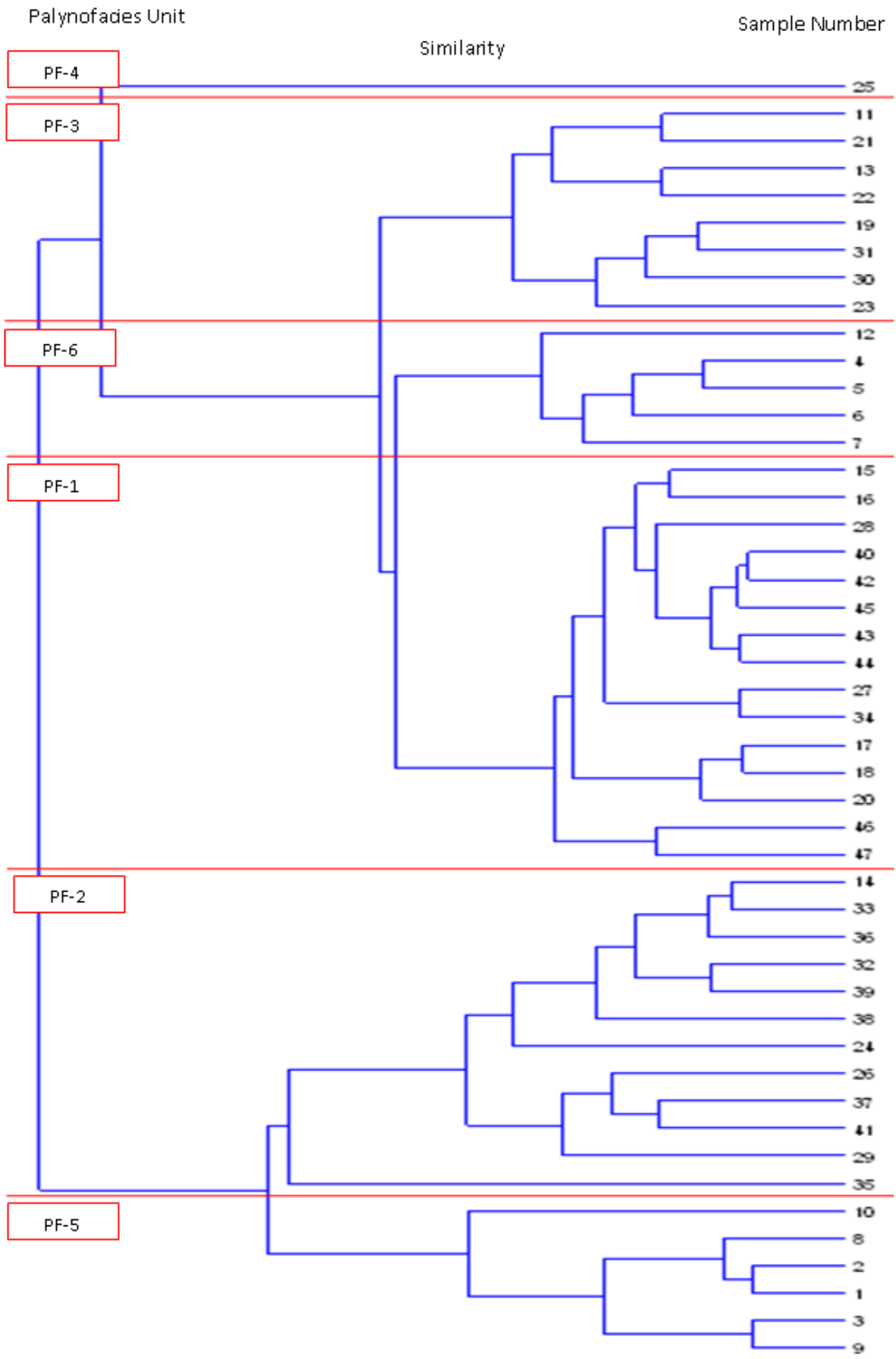


Figure 3. *Cluster analysis with organic distribution in DDH-1 well. Palynofacies units are sorted based on similarities of organic material in each sample, using Euclidean Distance method.*

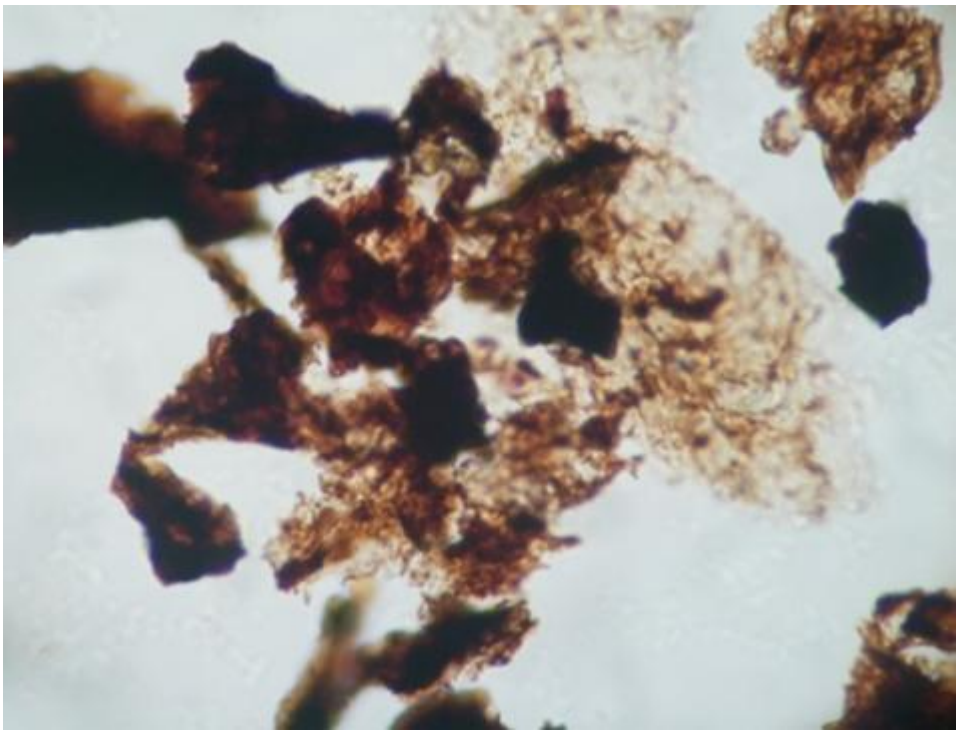


Figure 4. *Palynofacies-1/PF-1 from DDH-1 well. Marked by high phytoclast translucent dominance.*

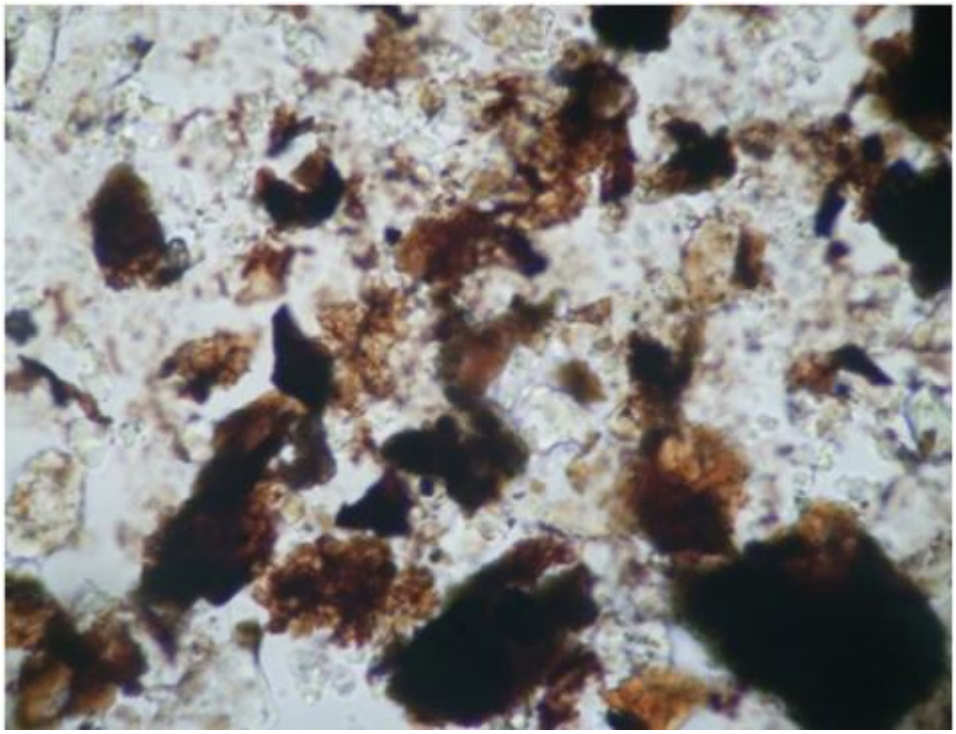


Figure 5. *Palynofacies-2/PF-2 from DDH-1 well. Marked by amorphous and phytoclast translucent dominance.*

SEDIMENT CHARACTERIZATION

Palynofacies studies for sediment characterizations should be performed systematically on the entire sedimentary section to seize any dynamic changes of the organic facies (Chandra, 2010). According to Tyson (1995) it is essential for in-depth information that the changes are tied to other characteristics of the rocks, because sometimes quantitative changes in palynofacies can be connected to those arising from changes in lithology, sedimentology, ecology and geochemistry, eventhough many changes in palynofacies characteristics could occur without any changes in those factors. Hence, it is essential to perform palynofacies studies in a systematic way, covering all lithology varieties and facies examined.

PALYNOFACIES

The palynofacies units are based on grouping samples with close similarities of organic maceral types and abundances. We used cluster analysis available in a free statistical program called PAST program (Paleontological Statistics v.1.29), to group the samples into the palynofacies units. This helped to reduce inaccuracies in manually grouping the

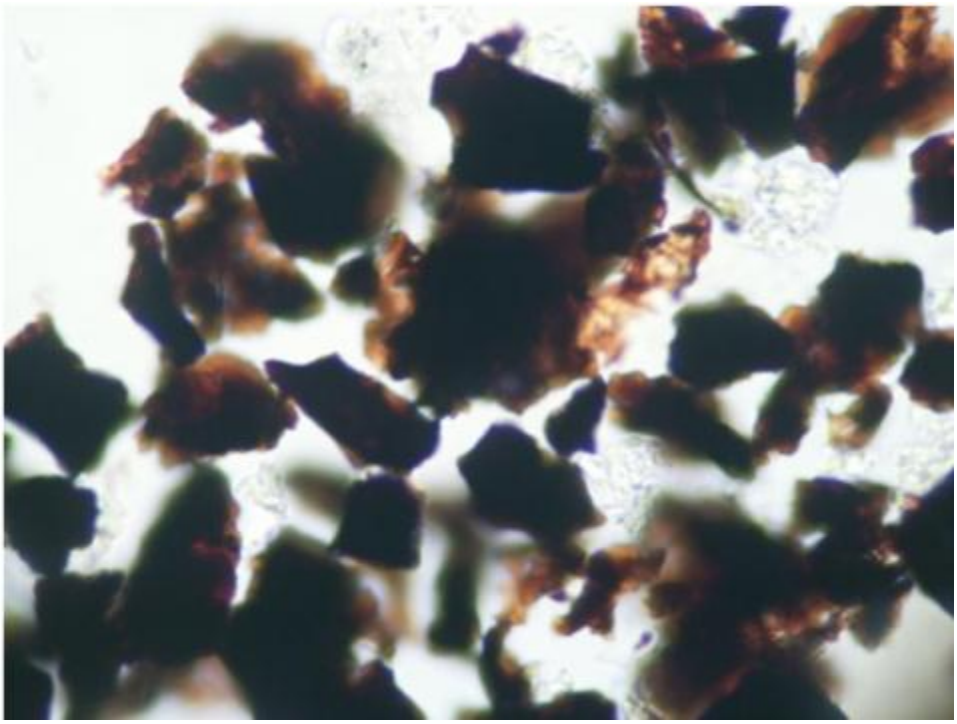


Figure 6. *Palynofacies-3/PF-3 from DDH-1 well. Marked by high phytoclast opaque dominance.*

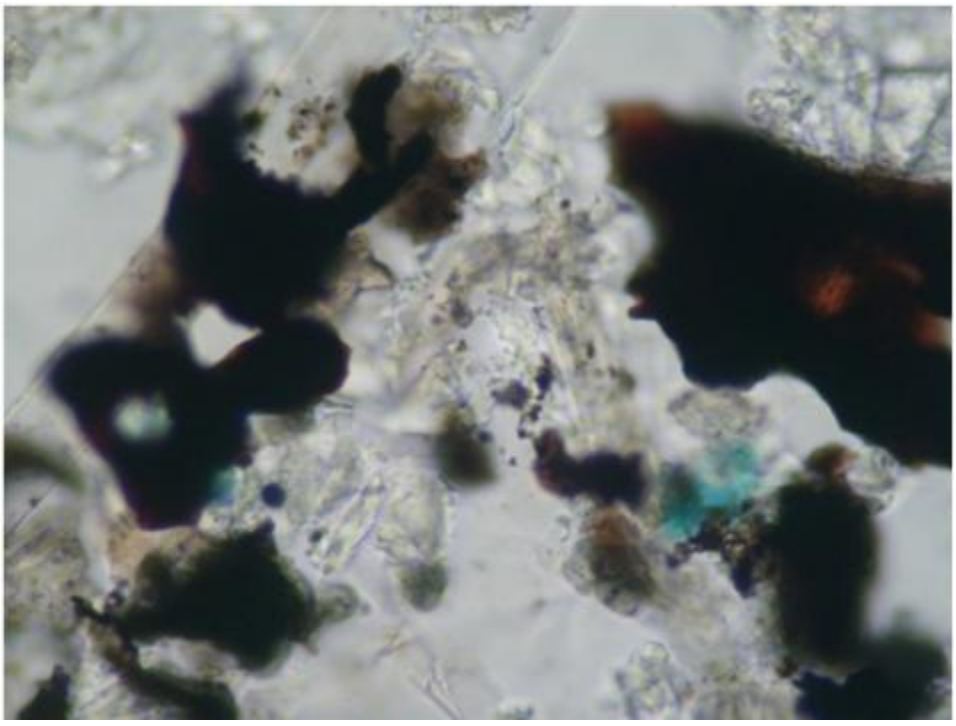


Figure 7. *Palynofacies-4/PF-4 from DDH-1 well. Marked by phytoclast opaque, dominantly equidimensional.*

data. We used an unweighted pair-group average (UPGMA) method that groups clusters by their average distance between each sample into 2 groups and used 14 matrices of different distances/lengths to identify similarities. In this research, we employed a Euclidean method that state changing the distance for similarity. The measurement method assesses the distance between rows in the matrix or, in this case the distance/similarity between rock samples. Results were displayed as 'dendrograms' which shows groups of samples with similar palynofacies characteristics (Figures 3, 11).

Palynofacies of DDH-1 well

Based on the relative frequency of *palynomorphs*, *phytoclasts-translucen*t, phytoclasts-*opaque*, and *amorphous* materials we could distinguish six categories of palynofacies (***PF-1*** to ***PF-6***). These categories came from groupings within cluster analyses (see Figure 3). Below are the descriptions of the palynofacies categories in the DDH-1 well:

PF-1 Dominated by *phytoclasts-translucent* (49%-73%) with quite equal amounts between non-cuticle material, *highly gelified woody cuticle* and membrane (Figure 4).

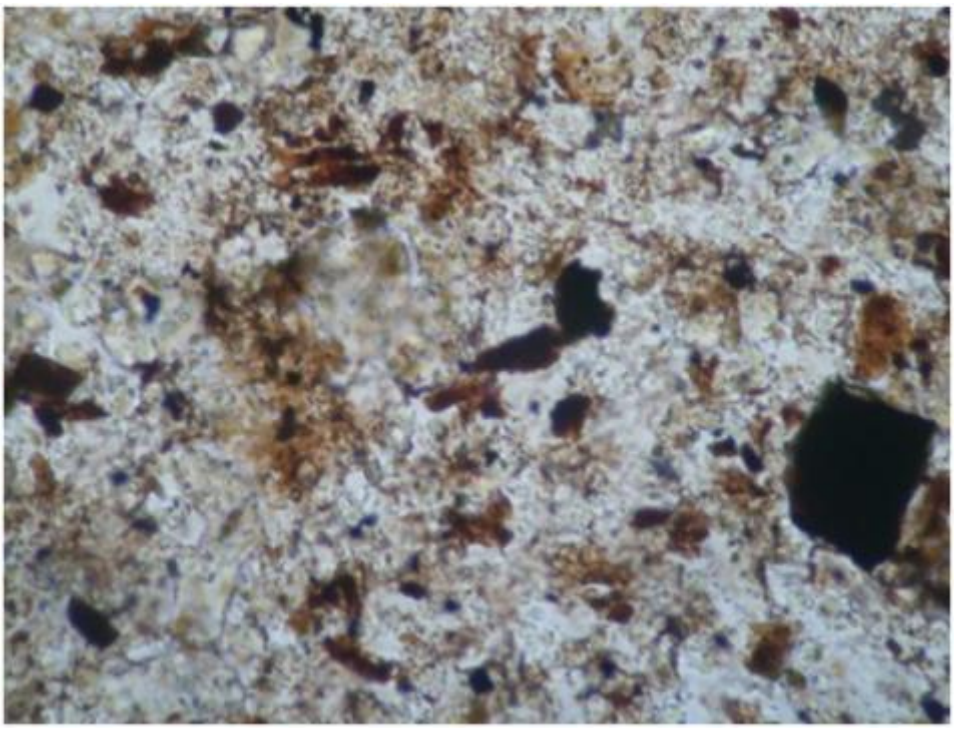


Figure 8. *Palynofacies-5/PF-5 from DDH-1 well. Marked by high presence of amorphous.*

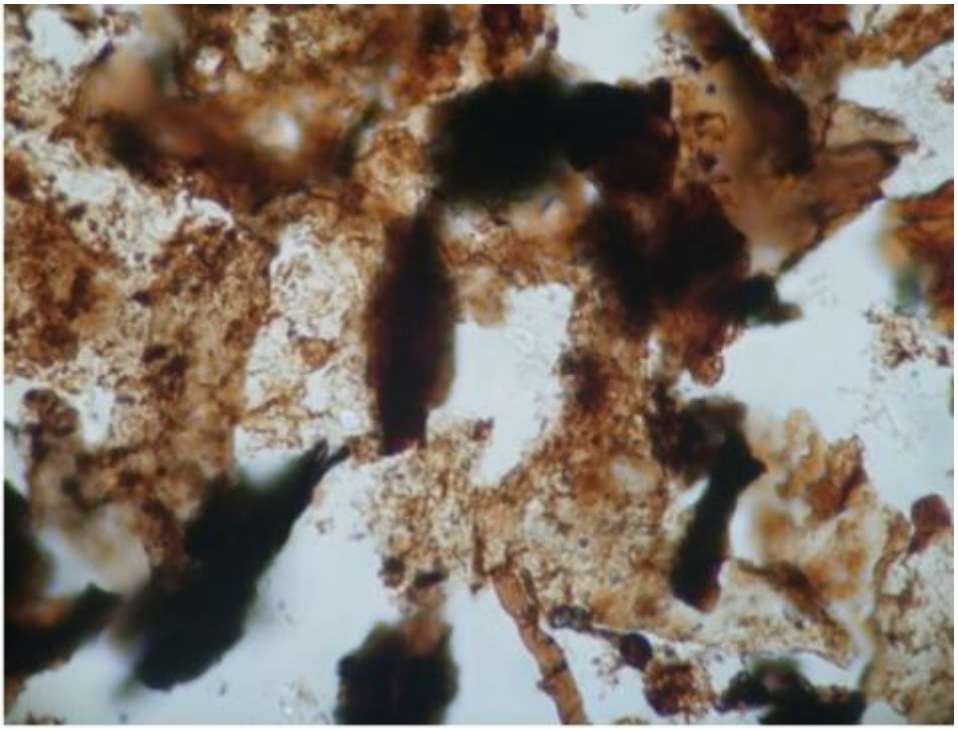


Figure 9. *Palynofacies-6/PF-6 from DDH-1 well. Marked by high dominanceof highly gelified wood and membrane.*

PF-2 Marked by the presence of moderate to high amorphous material (18%-65%), *phytoclast-translucent* between 22% to 54% and also *phytoclasts-opaque* from 10% to 50% (Figure 5).

PF-3 *Phytoclasts- opaque* dominates (about 45%-70%), while amorphous appears very low (3%- 5%), or even does not exist in samples from 60 m depth (Figure 6).

PF-4 Palynofacies is dominated by *phytoclasts-opaque* in equidimensional shape (Figure 7). This facies appears in only one sample from 130 m.

PF-5 Amorphous material is dominant (55% - 75%), while *phytoclasts-opaque* are rare (5% -20%) (Figure 8).

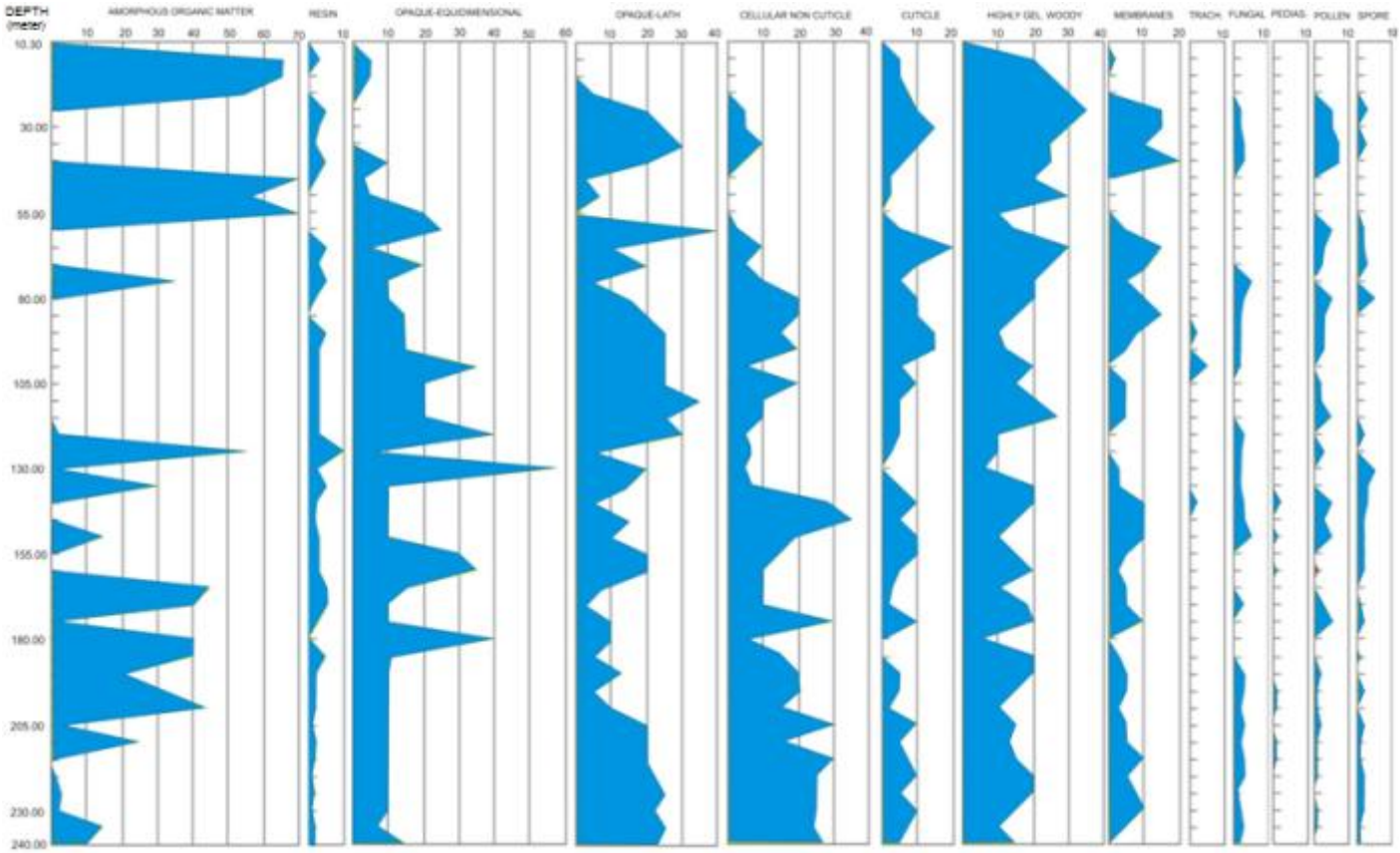


Figure 10. *Diagram of palynofacies analysis of DDH-1 well.*

PF-6 This facies shows high percentages of *phytoclasts-translucent* (58%- 75%), with the remarkable appearance of *highly gelified wood* and membrane. Amorphous material appears as resin at low quantities (2%-5%) (Figure 9).

Figure 10 shows the result of palynofacies analysis at DDH-1 well.

Palynofacies of DDH-2 well

Based on the relative frequency of *palynomorphs*, *phytoclasts-translucent, phytoclasts-opaque*, and *amorphous* materials, we could distinguish seven types of palynofacies (***PF-1*** to ***PF-7***). All facies came from groupings by cluster analysis (see Figure 11). Below are the descriptions of each of the palynofacies in the DDH-2 well:
PF-1 Dominated by *phytoclasts-translucent* (59%-82%) while *phytoclasts-opaque* appears relatively rare (15% - 35%) (Figure 12).

PF-2 Marked by the presence of *phytoclasts-translucent* which vary from moderate to high stage (35% - 59%) and *phytoclasts-opaque* at 35% - 50%. Amorphous with or without resin also appear inconsiderable amounts in a few samples (Figure13).

PF-3 Only present in samples 8 and 9, with high presence of *phytoclasts-opaque* at 80% from 80m and 67% from 45.5m depth. Other characteristics of this facies is the absence of amorphous and palynomorphs (Figure14).

PF-4 This palynofacies is marked by high dominance of *phytoclast opaque equidimensional* at 45% - 60% (Figure 15).

PF-5 Amorphous is present at high percentage (50% and 55%) but only present at 145m and 160m depth (Figure 16).

PF-6 Dominated by *phytoclasts-opaque* at 45%-70% and *phytoclasts-translucent* present in moderate to high amounts (22% - 45%) (Figure 17).

PF-7 Amorphous appears reasonably high at 11%-23% and palynomorphs terrestrial at 4% - 12%. *Phytoclasts-translucent* (30%-46%) and *opaque* (28%-35%) appear in similar amounts (Figure 18).

A complete report of palynofacies analysis from DDH-2 well is presented on Figure 19.

Palynofacies Correlation between DDH-1 and DDH-2 well

Based primarily on the acme zone of *Proxapertites operculatus* pollen, which is present consistently both at the DDH-1 well and DDH-2 wells, palynofacies correlation of the Bayah Formation on DDH-1 and DDH-2 well could be established (Figure 20). The result shows that the palynofacies units at the lowest zone of DDH-1 (240m) to the upper zone (125m depth) can be correlated with the interval 130m to 10m depth in DDH-2.

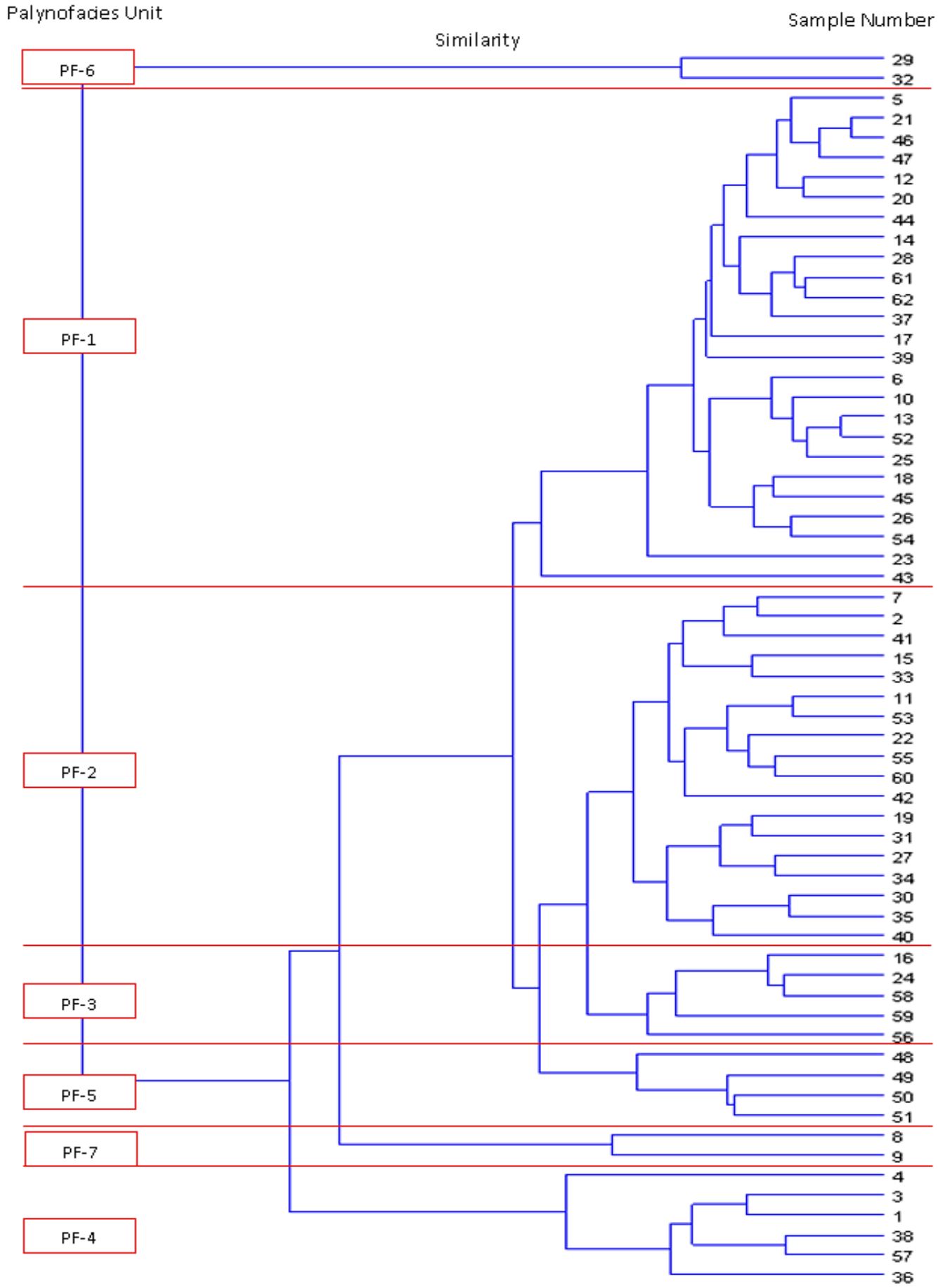


Figure 11. *Cluster analyze with organic distribution on DDH-2 well. Palynofacies units are sorted based on the similarities of organic material in each sample carry using Euclidean Distance method.*

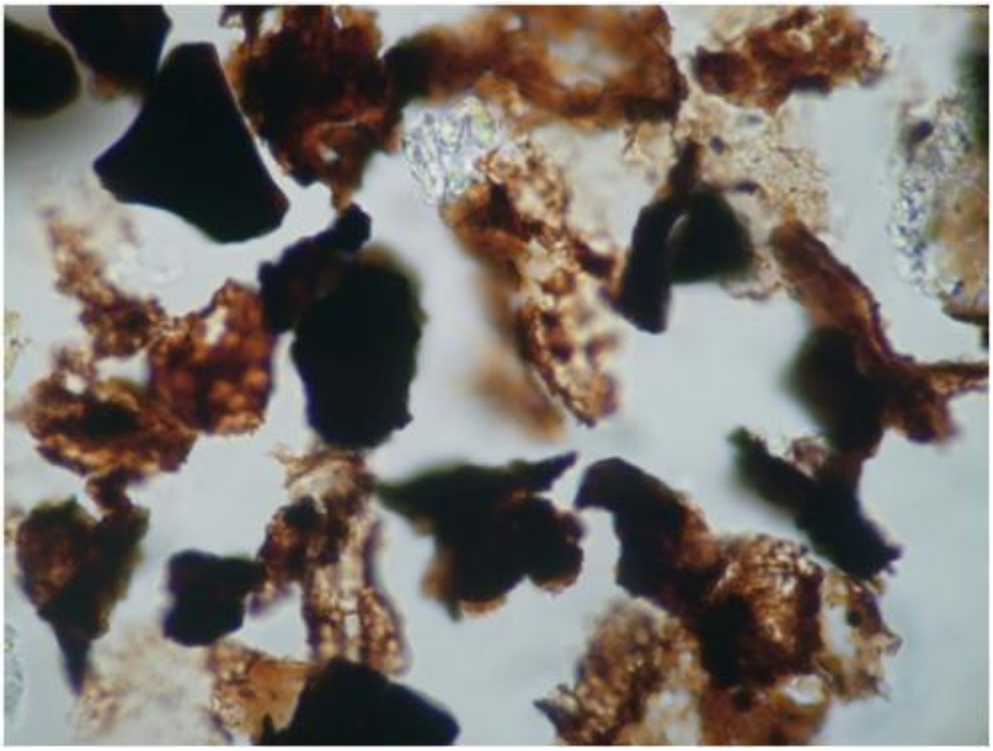


Figure 12. *Palynofacies-1/PF-1 from DDH-2 well is dominated by phytoclasts-translucent.*

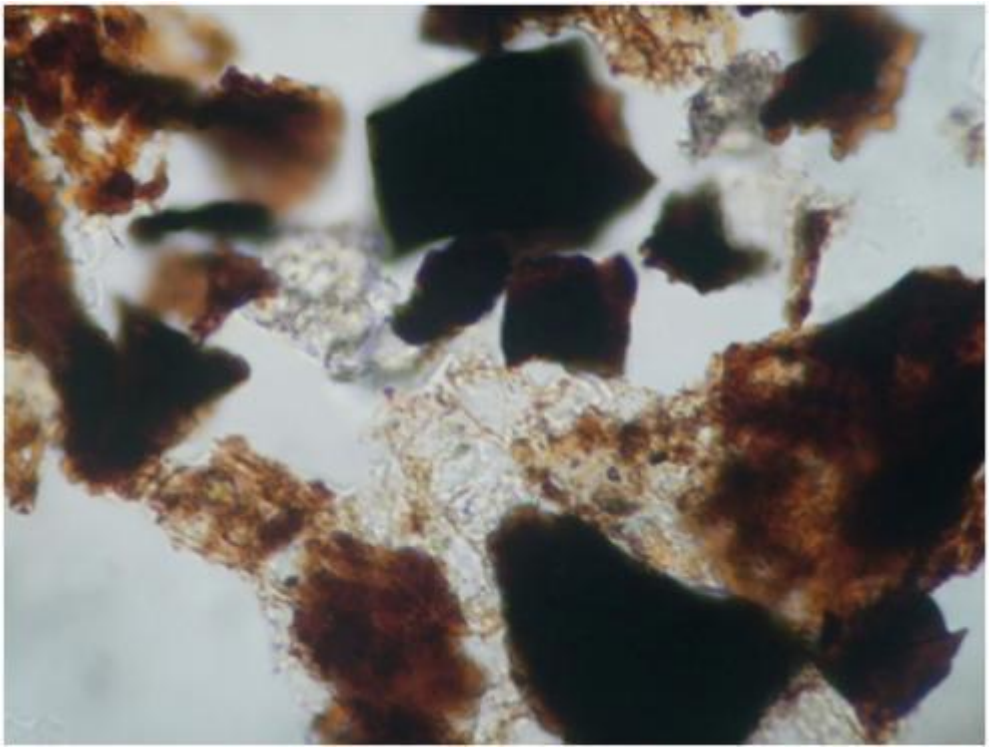


Figure 13. *Palynofacies-2/PF-2 from DDH-2 well is marked by phytoclasts-translucent, phytoclasts-opaque and amorphous material.*

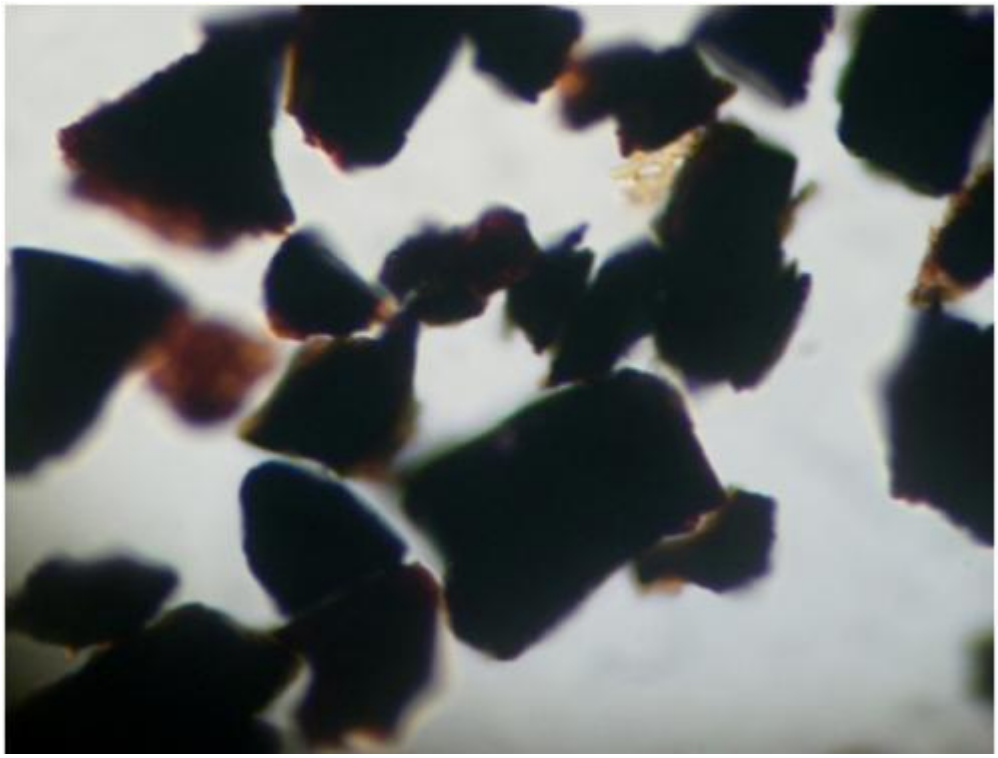


Figure 14. *Palynofacies-3/PF-3 from DDH-2 well is marked by dominat phytoclasts-opaque.*

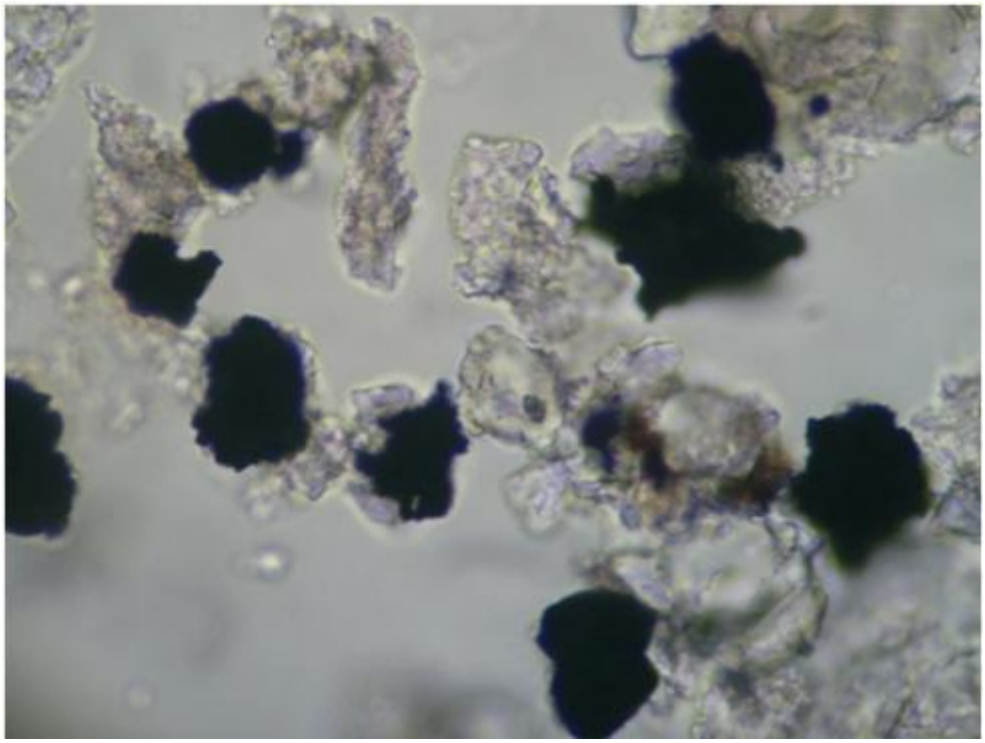


Figure 15. *Palynofacies-4/PF-4 from DDH-2 well is marked by high dominance of phytoclasts-opaque equidimensional.*

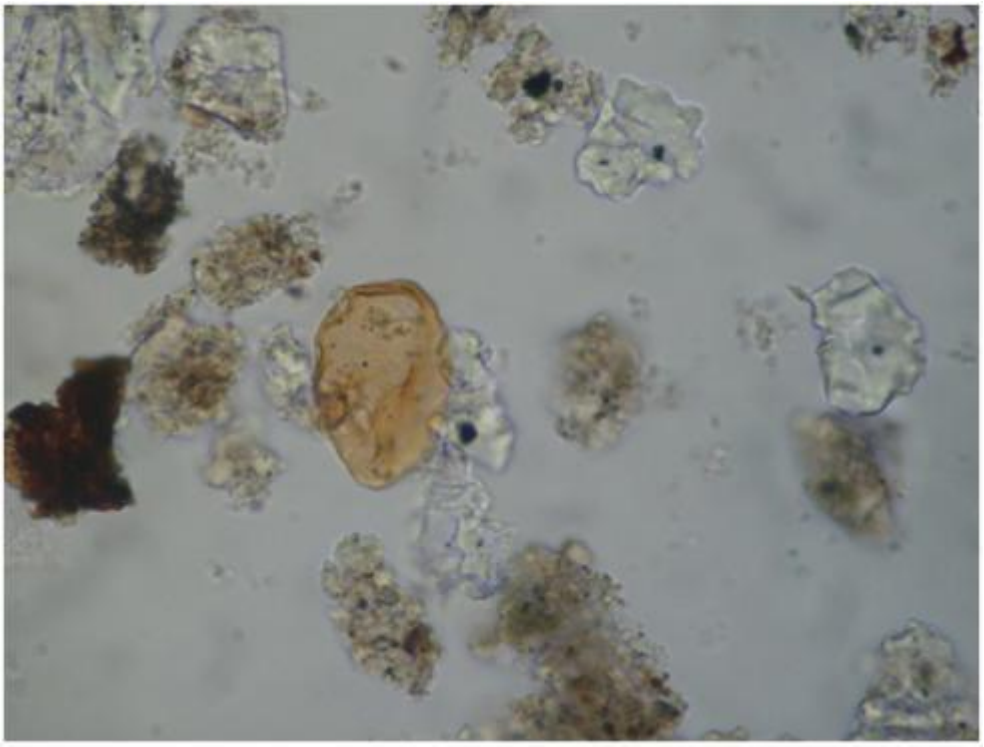


Figure 16. *Palynofacies-5/PF-5 from DDH-2 well. Amorphous dominates this unit.*

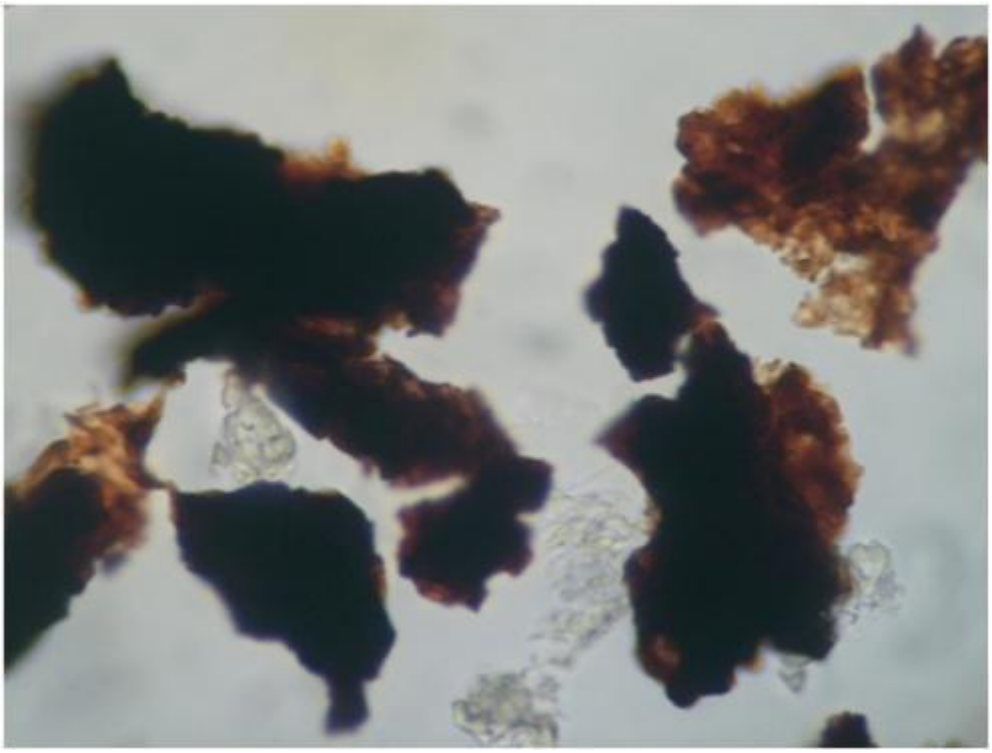


Figure 17. *Palynofacies-6/PF-6 from DDH-2 well is marked by high number of phytoclasts-opaque and moderate to high phytoclasts-translucent.*

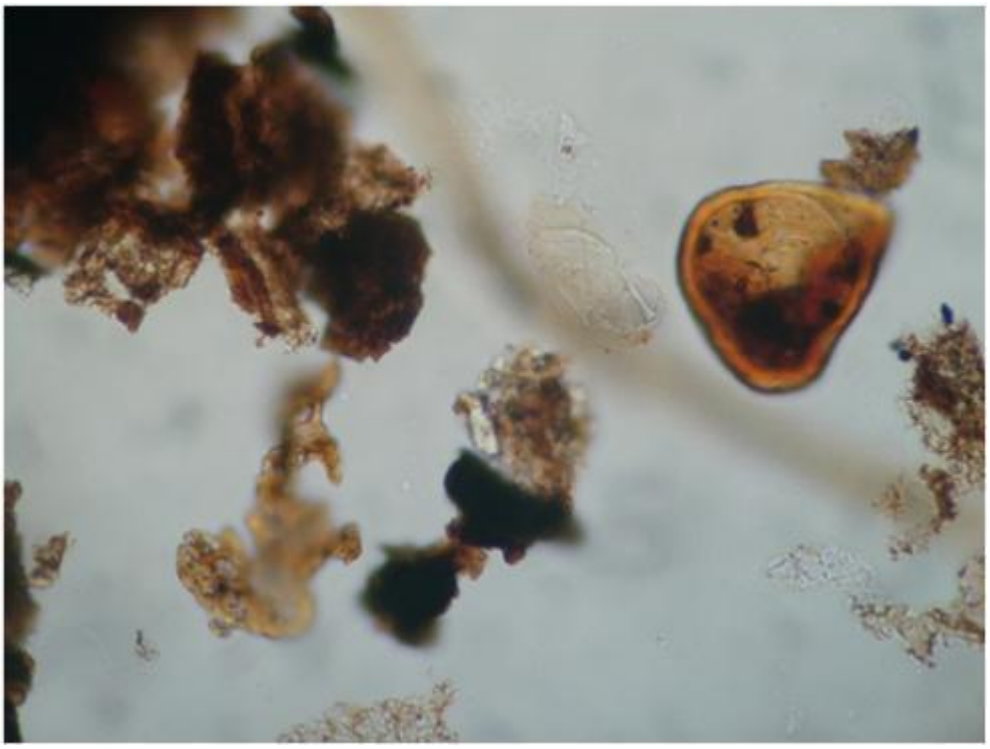


Figure 18. *Palynofacies-7/PF-7 from DDH-2 well is marked by similar levels of phytoclasts-opaque and translucent, with reasonable presence of both terrestrial palynomorphs and amorphous material.*

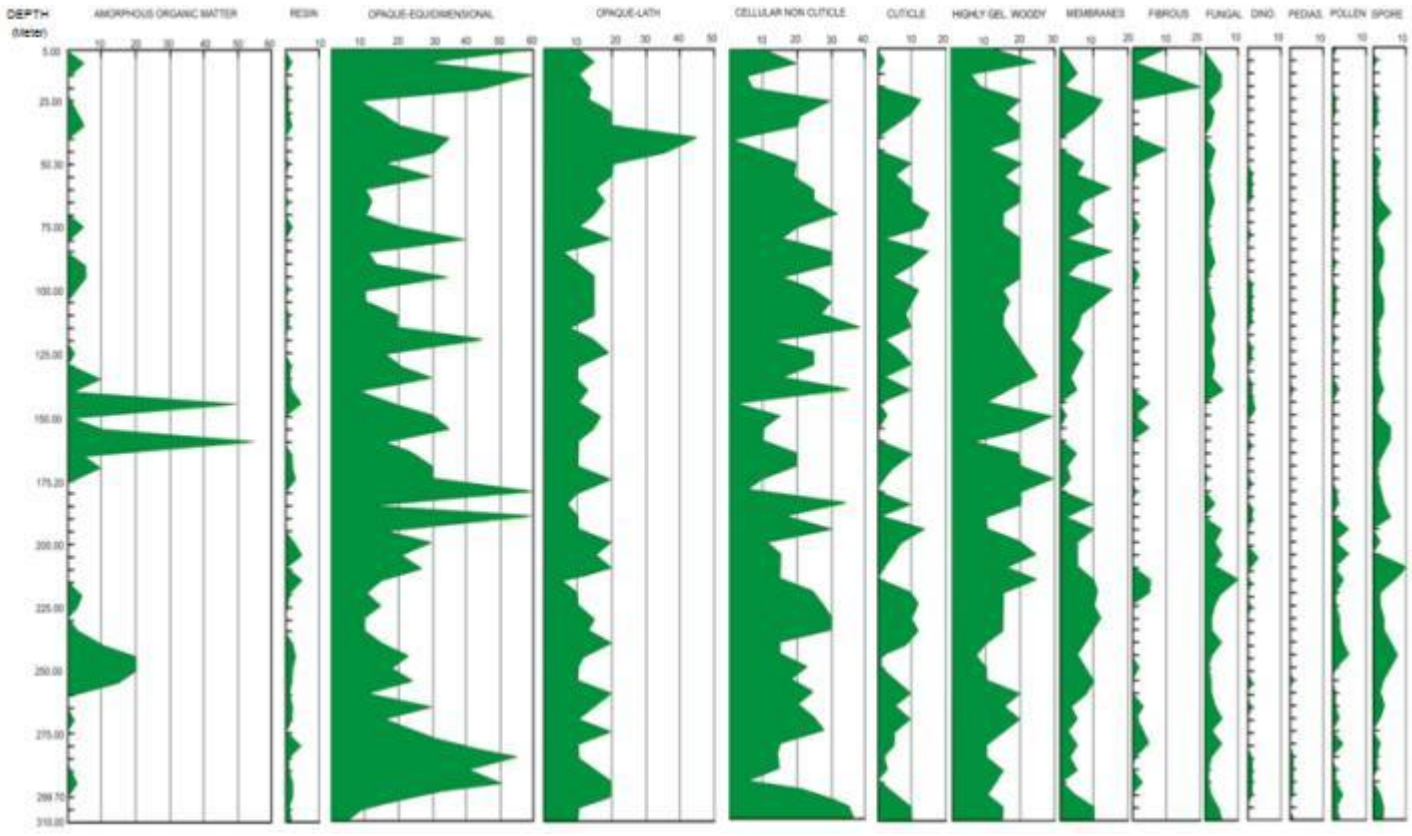


Figure 19. *Diagram of palynofacies analysis of DDH-2 well.*

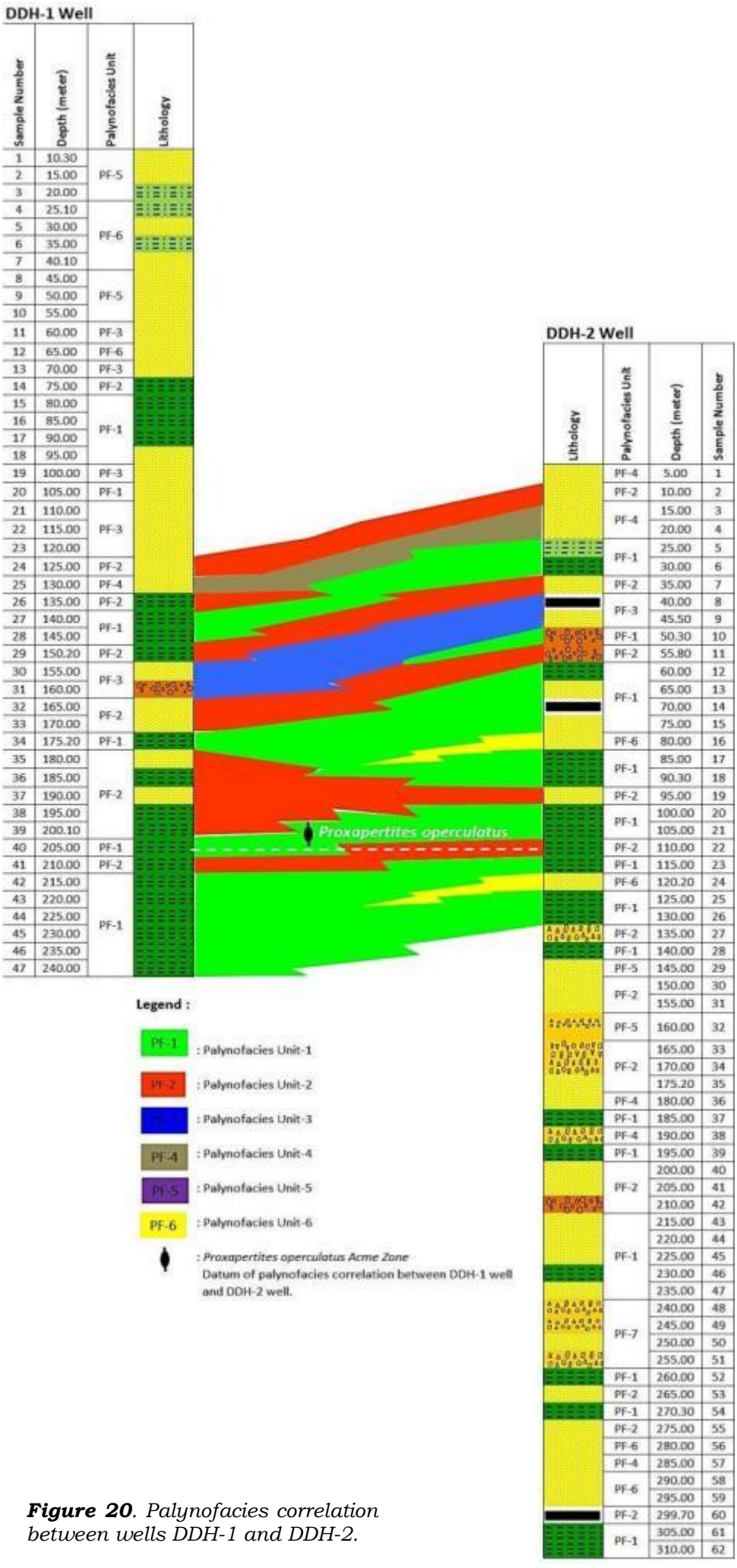


***Figure 20**. Palynofacies correlation between wells DDH-1 and DDH-2.*

CONCLUSIONS

Palynofacies analysis at DDH-1 and DDH-2 well allowed subdivision of the Bayah Formation into seven palynofacies units. Palynofacies-1 to palynofacies-6 occur in both wells, whereas palynofacies-7 occurs only in DDH-2 well. Based on the acme zone of *Proxapertites operculatus*, the DDH-1 and DDH-2 wells correlate at the Eocene level in the palynofacies-1 to palynofacies-4.

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