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Umur, Lingkungan Pengendapan, dan Karakteristik Fosil Palinomorf Formasi Batuasih, Sukabumi, Jawa Barat

Age, Depositional Environment, and Characteristics of Palynomorph Fossil in the Batuasih Formation, Sukabumi, West Java

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INTISARI

Palinomorf merupakan sisa material organik dari makhluk hidup yang berukuran debu dengan sifat tahan terhadap zat asam kuat yang dapat mencerminkan bagaimana kondisi umur dan lingkungan saat suatu batuan terbentuk. Formasi Batuasih merupakan salah satu formasi batuan di Cekungan Bogor berumur tua yang masih sangat sedikit diinterpretasikan terutama dari aspek palinomorfnya. Penelitian ini bertujuan untuk melihat karakteristik palinomorf, umur relatif, dan lingkungan dari batuan di Formasi Batuasih. Metode penelitian meliputi kegiatan lapangan dengan melakukan pengukuran penampang stratigrafi terukur dan sampling batuan dengan interval 5 meter atau setiap perubahan litologi, kegiatan laboratorium meliputi kegiatan preparasi sampel dengan metode asam treatment, identifikasi dilakukan menggunakan mikroskop binocular CX-22, dan analisis umur dan lingkungan pengendapan ditarik berdasarkan asosiasi palinomorf yang hadir pada batuan. Hasilnya, Palinomorf hadir pada 8 dari 10 sampel diantaranya (B.1, B.2, B.4, B.6 – B.10). 169 individu palinomorf teridentifikasi terdiri dari 19 spesies yang berbeda. *Proxapertites* merupakan genus yang mendominasi baik itu *Proxapertites operculatus*, *Proxapertites cursus*, dan *Proxapertites psilatus*. Sedangkan spora didominasi datang species *Verrucatosporites usmensis*. Selain polen dan spora, ditemukan juga palinomorf berupa dinoflagellata dan foraminifera test lining. Analisis palinomorf mencerminkan Formasi Batuasih memiliki umur Eosen akhir – Oligosen awal (41,2 – 27,8 jtl) dengan lingkungan pengendapan transisi.

Kata kunci: *Palinomorf, Formasi Batuasih, Karakteristik, Umur, Lingkungan*

ABSTRACT

Palinomorphs are the remains of organic material from living things that are dust-sized with properties that are resistant to strong acids, which can reflect how the age and environmental conditions were when a rock was formed. Batuasih Formation is one of the oldest rock formations in Bogor Basin which is rarely interpreted, especially from its palynological aspect. This study aims to see palynomorph characteristics, relative age, and environmental conditions in Batuasih Formation. There are several steps in conducting the research. Field activities by measured stratigraphic sections and sampling every 5-meter intervals or each lithological changes, laboratory activities by sample preparation using acid treatment method, identification were carried out using CX-22 binocular microscope, and laboratory analysis of age and depositional environment is drawn based on palynomorph associations that are present in rocks. The result found that palynomorphs were present in 8 of 10 samples (B.1, B.2, B.4, B.6 - B.10). 169

palynomorphs identified to consist of 19 different species. Dominant pollen came from genus *Proxapertites*, both *Proxapertites operculatus*, *Proxapertites cursus*, and *Proxapertites psilatus*. While dominant spores came from *Verrucatosporites usmensis*. Apart from pollen and spores, Palynomorphs in the form of dinoflagellates and foraminifera test lining are also present in this formation. Palynomorph analysis shows that Batuasih Formation has Late Eocene - Early Oligocene age (41.2 - 27.8 Ma) with transitional depositional environment.

Keywords: Palynomorph, Batuasih Formation, Characteristics, Age, Environment

INTRODUCTION

Java Island is part of Indonesia which is located in the primary Indo-Pacific environment and has very high rainfall and tropical climate (Dubois *et al.,* 2014). Its existence in the tropical region makes Java Island has a very high diversity of flora called mega-biodiversity. This diversity has continued to change, especially since the last ice age occurred in Indonesia (Kaars & Dam, 1995; Kaars & Dam, 1997; Kaars *et al.,* 2001; Wibowo *et al.,* 2016). Flora always has a desire to reproduce, one method of plant reproduction is through pollination of pollen and spores (Ritchie & Lichti-Federovich, 1967; Di-Giovanni & Kevan, 1991).

Palynomorph is a dust-sized material that resistant to strong acids (Riding & Kyffin-Hughes, 2004; Traverse, 2007; Dutta *et al.,* 2013). Pollen and spores are the main components of palynomorphs in addition to other materials such as algae, acritarch, and foraminifera lining test (Miller *et al.,* 1982; Baioumi *et al.,* 2012). During the reproduction process, pollen and spores can fall to the surface and preserved to become fossils in the rock (Slater and Wellman, 2015; Xu *et al.*, 2016). The presence of palynomorphs in these rocks can reflect the age and environmental conditions when these rocks formed (Hope *et al.,* 2004; Winantris *et al.,* 2006; Setijadi *et al.,* 2015). Seeing palynomorphs have wide distribution and complete evolution, they are suitable for determining relative age and environmental conditions of rocks, especially in terrestrial and transitional environments (Hillen, 1986; Larsson *et al.,* 2006; Macphail & Cantrill, 2006).

Research using palynomorphs to determine age and environment sediment has been widely carried out in Java region, but most of these studies have focused on Holocene age (Kaars & Dam, 1995; Kaars & Dam, 1997; Kaars *et al.,* 2001). Batuasih Formation is one of the oldest formations in Bogor Basin (Figure 1d) with Early Oligocene - Late Oligocene age interval (33.9 - 23.03 Ma) which interpreted to be deposited in the transitional environment - shallow seas from previous studies (Baumann, 1972; Effendi *et al.,* 1998; Martodjodjo, 2003; Clements, 2007; Hendrizan, 2012; Wibowo & Kapid, 2014). Research on fossils in Batuasih Formation has been very few, especially when viewed from the palynological aspect. The research location is in Batuasih Formation which exposed in Cibatu River area, Sukadamai Village, Sukabumi Regency, West Java with coordinates $06^{o}56'29.64''$ South Latitude - $106^{o}50'30.18''$ East Longitude to $06^{o}56'37.47''$ South Latitude - $106^{o}50'32.95''$ East Longitude (Figure 1). From this explanation, it becomes interesting to see how palynomorph content, relative age, and environmental conditions of Batuasih Formation rocks if interpreted through its Palynological aspect.

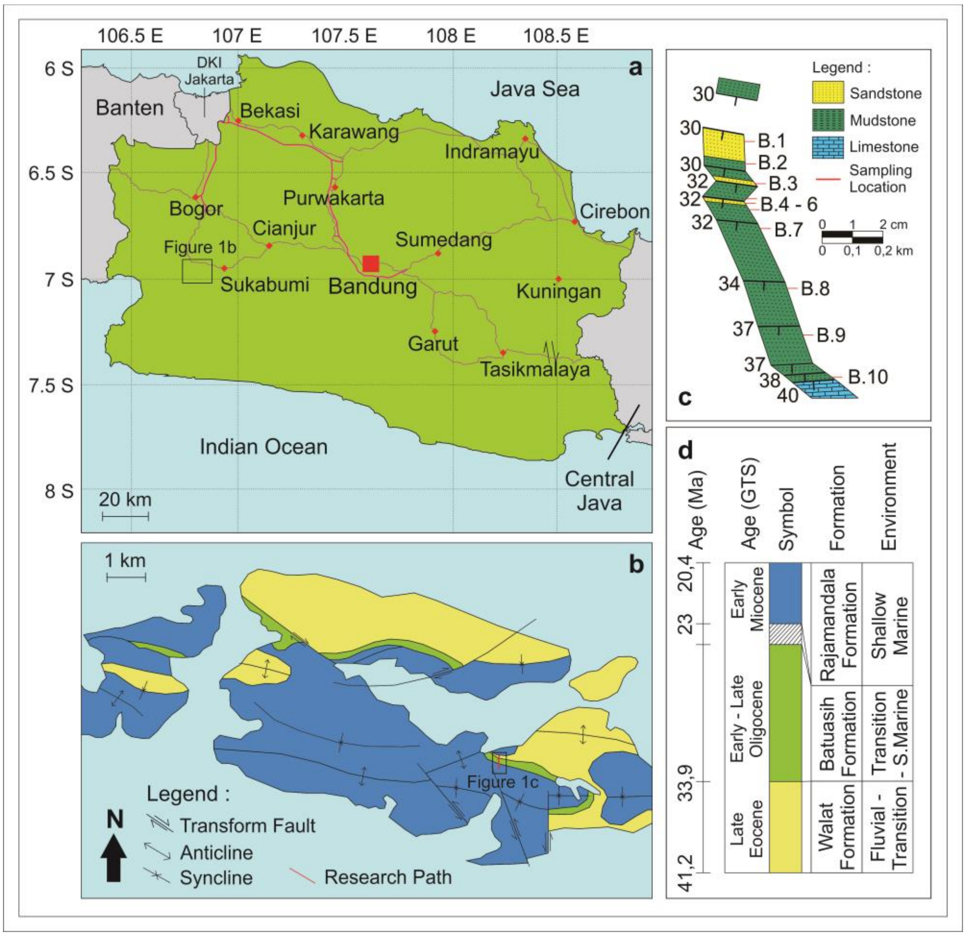

Figure 1. Research area; a. Research location is related to West Java; b. Research location is related to the Walat, Batuasih, and Rajamandala Formations (Effendi *et al.*, 1998); c. Sampling and measured stratigraphic section results; d. Stratigraphy of study area

MATERIALS AND METHODS

The research method is divided into several steps. These steps include field activity, laboratory activity in the form of sample preparation, and laboratory analysis in the form of palynomorph characteristics identification, age, and depositional environment analysis.

Field activity was carried out by measured stratigraphic sections of Batuasih Formation rocks which exposed in Cibatu River (Siregar, 2005; Fauzi, 2017; Subagja *et al.*, 2019). Sampling mainly focuses on any lithological changes, but if thickness of the rock layer exceeds 5 meters, rock sampling takes at 5-meter intervals. The sample then prepared in the laboratory. Laboratory preparation was conducted by acid treatment to separate palynomorph material from other materials using certain chemicals (Grey, 1999; Azizah *et al.*, 2016; Fajrina *et al.*, 2016; Yulianto *et al.*, 2019). Preparation results then identified using CX-22 binocular microscope to see the characteristics of pollen and spores present in Batuasih formation (Winantris *et al.*, 2012; Marcos *et al.*, 2015).

In this study, the age and depositional environment of Batuasih Formation were identified by looking at palynomorph content in these rocks. Age and depositional environment are drawn based on palynomorph associations present in rocks which represent the relative age and environmental conditions at the time Batuasih Formation was formed (McGlone *et al.*, 1978; KSSI, 1996; Polhaupessy, 2009; Yulianto *et al.*, 2019).

Table 1. Palinomorph Content of Batuasih Formation

Fossil Name	Sample											Environment
	B.1	B.2	B.3	B.4	B.5	B.6	B.7	B.8	B.9	B.10	T	
Acrostichum sp.				2		1	1				4	Fluvial-lacustrine, Back mangrove
Chepalomappa malloticarpa				3		2	2				7	Freshwater swamp
Clavifera triplex						1					1	Transitional
Crassoretitriletes vanraadshoveni	1					1					2	Freshwater swamp
Dicolpopollis sp.		1		1		1			1		4	Freshwater swamp
Distaeverrusporites simplex									1		1	Tidak Signifikan
Foraminifera Test Lining							2				2	Marine
Laevigatosporites						2	1		4		7	Fluvial-deltaic, Lacustrine, Freshwater
Lycopodium cernuum							1				1	Fluvial-lacustrine
Palmaepollenites kutchensis						1	1	1			3	Mangrove, Back-mangrove
Podocarpidites marwickii		1								1	2	Montane-forest
Proxapertites cursus						1	2		2		5	Fluvial-deltaic
Proxapertites operculatus		1		18		24	27	9	22	1	102	Fluvial-deltaic
Proxapertites psilatus				1		6	4		2		13	Fluvial-deltaic
Spiniferites pseudofurcatus							1				1	Marine-Lagoon
Spiniferites ramosus				1							1	Marine-deltaic
Trichotomosulcites subgranulatus							1				1	Fluvial
Tricolpites confessus				1			1				2	Fluvial
Verrucatosporites usmensis				1		3	5		1		10	Freshwater swamp
Total	1	3	0	28	0	43	49	10	33	2	169	

RESULTS

Research area has a lithology which is dominated by mudstone which in some places alternates with sandstone and limestone. The thickness of rock outcrop that was found reached 74 meters on the edge of Cibatu River. The characteristics of mudstone are massive, dark gray color with pyrite content in this rock. Sandstone has a massive light gray color with fine sand grain size. Meanwhile, limestone has white and hard characteristics. From this rock outcrop samples were taken for palynomorph analysis (Figure 1c).

Palynomorphs found in Batuasih Formation are very diverse. From 10 samples (B.1 - B.10), palynomorphs were present in 8 samples (B.1, B.2, B.4, B.6 - B.10). The number of palynomorphs observed reached up to 169 individuals which identified into 19 different species. The most dominant pollen palynomorphs come from the genus *Proxapertites*, both *Proxapertites operculatus*, *Proxapertites cursus*, and *Proxapertites psilatus*. While spores in Batuasih Formation are dominated by *Verrucatosporites usmensis*. Apart from pollen and spores, palynomorphs in Batuasih Formation sample also found other palynomorphs, and this palynomorph is in the form of dinoflagellates and foraminifera test lining (Table 1).

Palynomorph Characteristics

The characteristics of pollen and spores (palynomorphs) in Batuasih Formation are very numerous in terms of size, shape, aperture/laesure, and ornamentation. The following describes each palynomorph found in the Batuasih Formation.

Fossil Name : *Acrostichum* sp.
Botanical Affinity : *Acrostichum*
Description (Figure 2e) :
Spores with size 30 – 50 µ (Medium); Figure 50 x 47 µ; Unity monad, Brownish yellow color, Polarity polar, Distal axis rounded; Proximal axis slightly pointed; Shape Amb triagular;

Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Laesure trilete L = 12 µ; W = thin < 1 µ; Laesura extends 2/3 center to surface, Ornamentation psilate – locally scabrate < 1 µ, Intectate, and Heteropolar.

Fossil Name : *Chepalomappa malloticarpa*
Botanical Affinity : *Chepalomappa malloticarpa*
Description :
Pollen with size 30 – 60 µ (Medium - Large); Figure 61 x 43 µ, Unity monad, Brownish yellow color, Polarity oblique, Shape Amb circular / rounded; Ekuatorial peroblate - oblate (P/E = < 4/8 – 6/8), Aperture inaperture difficult to observe, Ornamentation reticulate; Muri > 1 µ; Lumen > 2 µ; Brochi not uniform circular - polygonal, Intectate, and Isopolar.

Fossil Name: *Clavifera triplex*
Botanical Affinity : Gleicheniaceae
Description :
Spores with size 25 – 40 µ (Medium); Figure 32 x 25 µ, Unity monad; Brownish yellow color, Polarity polar, Shape Amb triangular concave; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Laesure trilete L = 5 µ; W = thin < 1 µ; Wavy extending from the center to the surface; There was thickening of columella on surface and center, Ornamentation psilate, Tectate, and Heteropolar.

Fossil Name : *Crassoretitriletes vanraadshooveni*
Botanical Affinity : *Lygodium microphyllum*
Description (Figure 2f) :
Spores with size 58 – 101 µ (Large – Very large); Figure 58 x 54 µ, Unity monad, Brown color, Polarity oblique, Distal axis rounded; Proximal axis slightly pointed; Shape Amb triagular convex – sub-circular; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Laesure trilete L = 15 µ; W = thin; laesure covered in ornamentation, Ornamentation reticulate; Muri 2 µ; Lumen > 2 µ; Brochi uniform circular - polygonal, Tectate, and Heteropolar.

Fossil Name : *Dicolpopollis* sp.
Botanical Affinity : Palmae
Description (Figure 2a) :
Pollen with size 24 – 50 µ (Medium); Figure 50 x 27 µ, Unity monad, Brownish yellow color, Polarity polar, Shape Amb elliptical; Ekuatorial oblate (P/E = 4/8 – 6/8), Aperture disulcate (2-Sulcate) L = 15 µ; W = 3 µ; thinning towards center; Longicolpate until merge, Ornamentation reticulate; Muri 1 µ; Lumen 1 µ; Brochi uniform rectangular - polygonal, Tectate, and Isopolar.

Fossil Name : *Distaeverrusporites simplex*
Botanical Affinity : Unknown
Description :
Spores with size 30 – 40 µ (Medium); Figure 37 x 37 µ, Unity monad, Orange color, Polarity oblique, Shape Amb circular / rounded; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Laesure alete difficult to observe covered in ornamentation, Ornamentation reticulate; Muri > 1 µ; Lumen > 1 µ; Brochi uniform circular - polygonal, Intectate, and Isopolar.

Fossil Name : *Foraminifera Test Lining*
Botanical Affinity : *Foraminifera*
Description (Figure 2j) :
Foraminifera with size 50 – 70 µ (Large); Figure 69 x 58 µ, Unity monad, Brown color, Polarity oblique; Shape Amb sub-circular; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Divided into chamber; Planispiral, Chamber L = 21 µ and W = 20 µ; Suture 4 µ, Ornamentation psilate, Intectate, and Isopolar.

Fossil Name : *Laevigatosporites*
Botanical Affinity : Polypodiaceae
Description (Figure 2g) :
Spores with size 30 – 60 µ (Medium - Large); Figure 60 x 38 µ, Unity monad, Brownish yellow color, Polarity ekuatorial, Shape Amb peanut / sub-circular; Ekuatorial peroblate - oblate (P/E = < 4/8 – 6/8), Laesure monolete L = 31 µ; W = 3 µ; Laesure is thickened in the middle and extends but not to the surface of spores, Ornamentation psilate, Intectate, and Heteropolar.

Fossil Name : *Lycopodium cernuum*
Botanical Affinity : *Lycopodium cernuum*
Description :
Spores with size 30 – 60 µ (Medium - Large); Figure 38 x 32 µ, Unity monad, Brownish yellow

color, Polarity polar, Shape Amb triagular; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Laesure trilete L = 15 µ; W = thin thickened to the center until 2 µ; Laesure extends 1/2 center to surface, Ornamentation fine-rugulate; Thickening at edge of the spores, Intectate, and Heteropolar.

Fossil Name : *Palmaepollenites kutchensis*
Botanical Affinity : *Palmae*
Description :
Spores with size 27 – 152 µ (Medium – Very large); Figure 38 x 37 µ, Unity monad, Brownish yellow color, Polarity polar, Shape Amb peanut / sub-circular; Ekuatorial oblate - subspheroidal (P/E = 4/8 – 8/6), Laesure monolete L = 35 µ (Half Individual); W = 11 µ; Laesura is thickened in middle and extends to the surface of the spores, Ornamentation psilate, Intectate, and Heteropolar.

Fossil Name : *Podocarpidites marwickii*
Botanical Affinity : *Podocarpus*
Description (Figure 2b) :
Pollen with size corpus 37 – 51 µ (Medium - Large) and saccate 17 – 30 µ (Medium); Figure 49 x 40 µ, Unity monad, Yellow color, Polarity polar, Shape Amb circular / bisaccate; Ekuatorial peroblate - oblate (P/E = < 4/8 – 6/8), Inaperture bisaccate (2-Saccate); Corpus L = 37 µ; W = 26 µ; Saccate L = 33 µ; W = 24 µ; Surface to saccate = 3 µ; Between saccate = 1 µ, Ornamentation reticulate - psilate; Saccate reticulate; Muri < 1 µ; Lumen 1 µ; Brochi uniform polygonal; Corpus granulate or scabrate; Ornamentation uniform, Tectate, and Heteropolar.

Fossil Name : *Proxapertites cursus*
Botanical Affinity : Araceae or Arecaceae
Description :
Pollen with size 40 – 60 µ (Medium - Large); Figure 55 x 35 µ, Unity monad, Brownish yellow color, Polarity oblique, Flat on equatorial view; Shape Amb circular / rounded; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Aperture monosulcate difficult to observe; Irregular; Aperture extends along surface of the pollen in equatorial part, Ornamentation reticulate; Muri > 1 µ; Lumen 1 µ; Brochi uniform polygonal increase irregular approaching the sulcus, Tectate, and Heteropolar.

Fossil Name : *Proxapertites operculatus*
Botanical Affinity : Araceae or Arecaceae
Description (Figure 2c):
Pollen with size 40 – 60 µ (Medium - Large); Figure 52 x 37 µ, Unity monad, Brownish yellow color, Polarity oblique, Flat on equatorial view; Shape Amb circular / rounded; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Aperture monosulcate L = 42 µ; W = 7 µ; Irregular; Aperture extends along surface of the pollen in equatorial part, Ornamentation fine-reticulate; Muri < 1 µ, Lumen < 1 µ; Brochi uniform circular - polygonal, Tectate, and Heteropolar.
Fossil Name : *Proxapertites psilatus*
Botanical Affinity : Araceae or Arecaceae
Description (Figure 2d):
Pollen with size 40 – 60 µ (Medium - Large); Figure 60 x 38 µ, Unity monad, Brownish yellow color, Polarity oblique, Flat on equatorial view; Shape Amb circular / rounded; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Aperture monosulcate difficult to observe; Irregular; Aperture extends along surface of the pollen in equatorial part, Ornamentation psilate, Intectate, and Heteropolar.

Fossil Name : *Spiniferites pseudofurcatus*
Botanical Affinity : *Spiniferites pseudofurcatus*
Description (Figure 2i):
Dinoflagellates with size 30 – 60 µ (Medium - Large); Figure 43 x 36 µ, Unity monad, Yellow color, Polarity oblique, Shape Amb circular / rounded; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Ornamentation in the form of arms L = 5-9 µ and W = thin < 1 µ; The arms is split into 2 parts to form “v” at the ends, Ornamentation psilate, Intectate, and Isopolar.

Fossil Name : *Spiniferites ramosus*
Botanical Affinity : *Spiniferites ramosus*
Description :
Dinoflagellates with size 70 – 90 µ (Medium - Large); Figure 88 x 75 µ, Unity monad, Brownish yellow color, Polarity oblique, Shape Amb circular / rounded; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Ornamentation

in the form of arms L = 16 µ and W = 1-2 µ; The arms is split in 2 parts at the end to form an elbow, Ornamentation psilate, Intectate, and Isopolar.

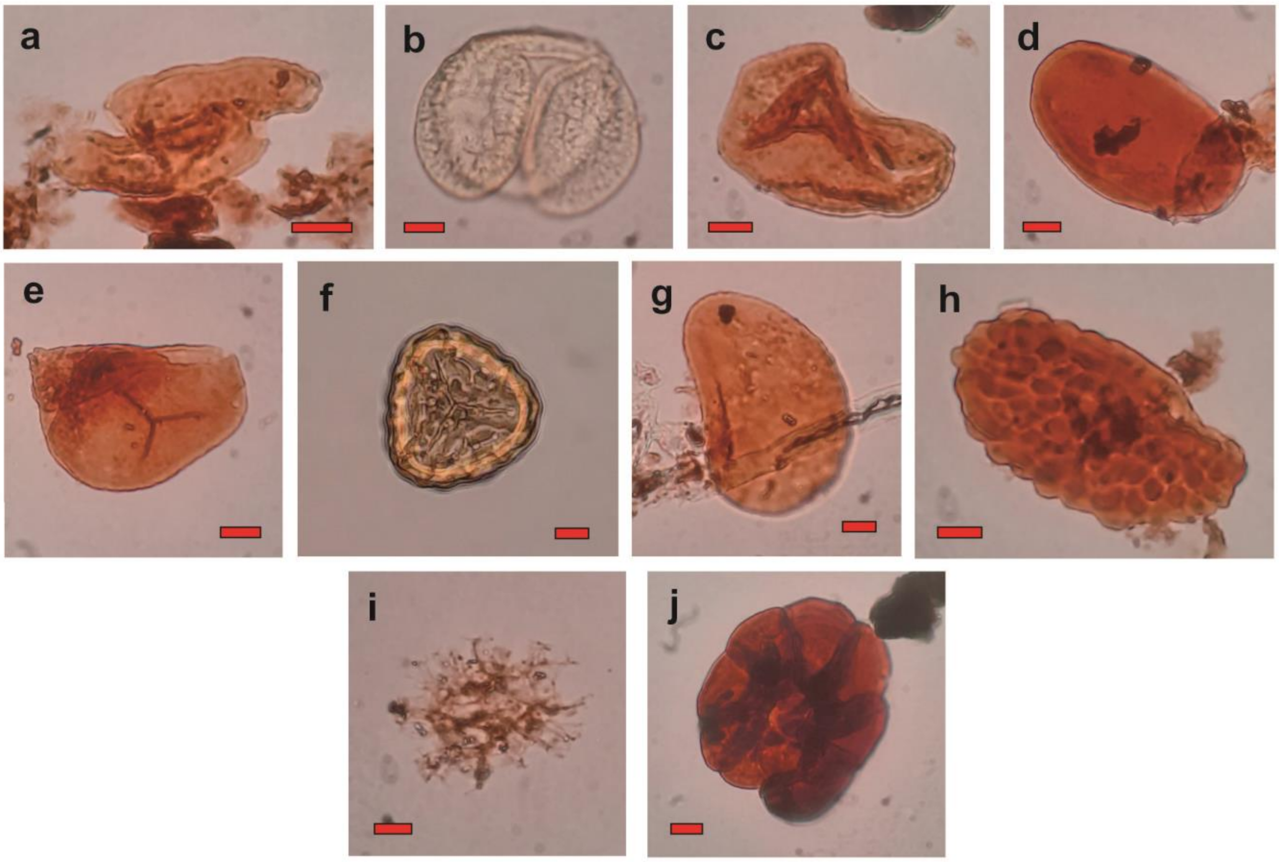

Figure 2. Palynomorph Batuasih Formation; a-d. Pollen; a. *Dicolpopollis* sp.; b. *Podocarpidites marwickii*; c. *Proxapertites operculatus*; d. *Proxapertites psilatus*; e-h. Spores; e. *Acrostichum* sp.; f. *Crassoretitriletes vanraadshoveni*; g. *Laevigatosporites*; h. *Verrucatosporites usmensis*; i. Dinoflagellates; i. *Spiniferites pseudofurcatus*; j. Foraminifera Test Lining; Scale Bar = 10 µ

Fossil Name : *Trichotomosulcites subgranulatus*
Botanical Affinity : Dicotyledonae
Description :
Pollen with size 31 – 47 µ (Medium); Figure 36 x 32 µ, Unity monad, Brownish yellow color, Polarity oblique, Shape Amb triangular - sub-circular; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Inaperture Saccate L (Surface to triangle) = 11 µ; W (Triangle) = 10 µ; Saccate forms triangle at the center of the pollen, Ornamentation psilate - microgranulate – microreticulate; Muri 1 µ; Lumen 1 µ; Brochi uniform circular – polygonal, Intectate, and Isopolar.

Fossil Name : *Tricolpites confessus*
Botanical Affinity : *Tricolpites confessus*
Description :
Pollen with size 25 – 50 µ (Medium); Figure 47 x 44 µ, Unity monad, Brownish yellow color, Polarity polar, Shape Amb circular / rounded / lobate convex; Ekuatorial subspheroidal (P/E = 6/8 – 8/6), Aperture tricolpate (3-Colpate) L = 9 µ; W = 14 µ; Longicolpate extends from the surface to center < ½ body, Ornamentation fine-reticulate; Muri < 1 µ; Lumen < 1 µ; Brochi uniform polygonal, Punctectate, and Isopolar.

Fossil Name : *Verrucatosporites usmensis*
Botanical Affinity : *Stenochlaena palustris*
Description (Figure 2h) :
Spores with size 39 – 61 µ (Medium - Large); Figure 57 x 33 µ, Unity monad, Brown color,

Polarity ekuatorial, Bilateral symmetry; Distal axis convex; Proximal axis straight until slightly concave; Shape Amb peanut / sub-circular; Ekuatorial peroblate - oblate (P/E = < 4/8 – 6/8), Laesure monolete covered in ornamentation, Oenamentation gemmate L & W = 3-10 µ; Size and shape of ornamentation is not uniform and decreasing towards the laesura, Tectate, and Heteropolar.

Age and Depositional Environment Batuasih Formation

In this study, Batuasih Formation has Late Eocene to Early Oligocene age range (41.2 - 27.8 Ma). The age range is drawn based on biostratigraphic interval zone between the presence of *Proxapertites* group which became extinct in Late Eocene and *Crassoretitriletes vanraadshooveni* that only emerged at Early Oligocene age (Figure 3a). Additionally, the presence of genus *Podocarpus* (*Podocarpidites*) indicates that the relative age of Batuasih Formation is in Eocene - Oligocene boundary (Morley, 2010; Morley, 1991).

Depositional environment of Batuasih Formation in this study is in a transitional environment, defined by the presence of large numbers of transitional palynomorphs such as *Acrostichum* and *Palmaepollenites kutchensis*. The dominance of *Proxapertites* group can also be a key indicator of transitional depositional environment. This *Proxapertites* group can be present along rivers (Fluvial) to transitional parts, either deltas or lagoons (Germeraad *et al.*, 1968). Some samples found marine palynomorphs such as dinoflagellates and foraminifera test lining. It indicates that Batuasih Formation is no longer in a terrestrial environment but is more vital towards the transitional environment (Vernal *et al.*, 1993; Sawada *et al.*, 1999; Raine & Askin, 2001).

The depositional environment interpreted by palynomorphs cannot be directly drawn based on the dominance of palynomorphs. Instead, an interpretation must be drawn based on the presence and association of plants reflected by the presence of palynomorphs in a rock sample. Besides, palynomorphs from terrestrial can become numerous in the transition region because these palynomorphs are transported and deposited in different environments (downstream direction). Therefore, the depositional environment interpretation was carried out by looking at the presence of palynomorphs and their associations (Haseldonckx, 1974; Haseldonckx, 1977).

It can be seen from the diagram that as moving towards the younger sample, the terrestrial palynomorphs are getting more replaced by the transitional palynomorphs. It indicates a more substantial transition effect towards Batuasih Formation sample (Figures 3b - 3c). In some samples, it appears that palynomorph terrestrial (Fluvial) are dominant due to differences in the number of individuals of each sample. However, if seen from the total percentage of each environment, it can be seen that the effect of the transition palynomorph is very high, reaching up into 43% (Figure 3d).

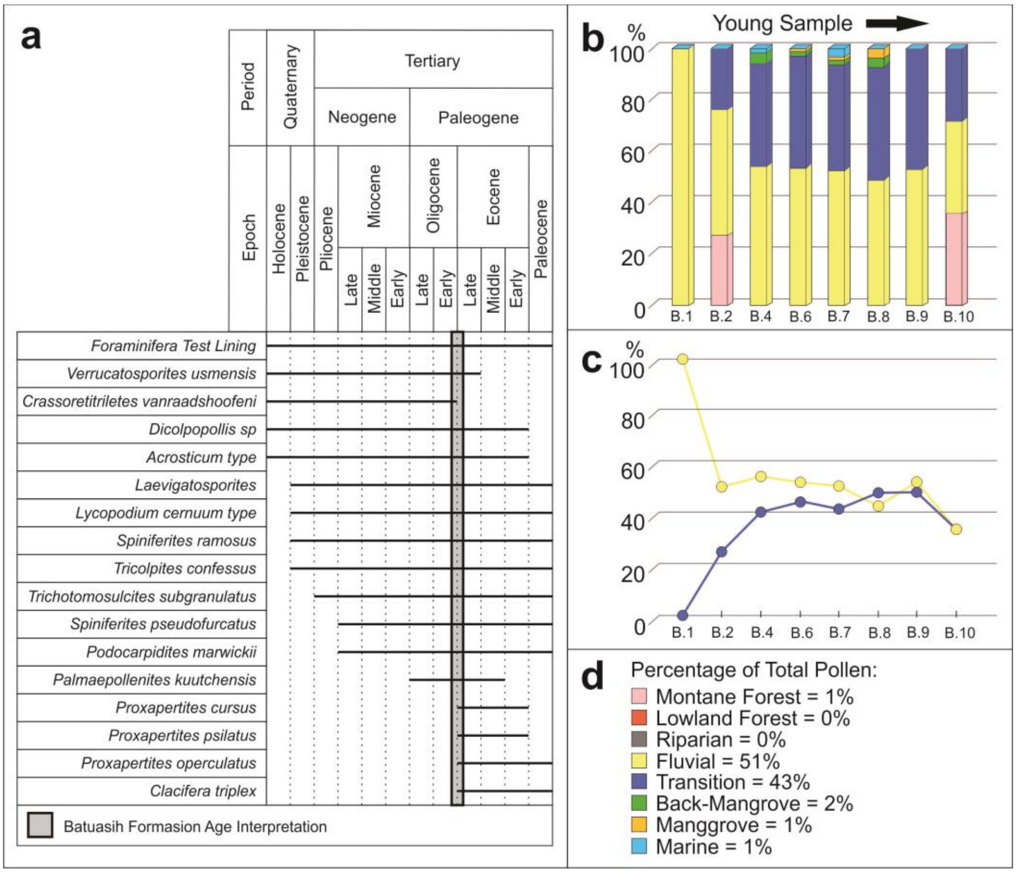

Figure 3. Age and deposition environment of the Batuasih Formation; a. Age range from interval zone of Batuasih Formation; b. Palynomorph distribution in each depositional environment; c. Comparison of fluvial and transition palynomorphs of study samples; d. Legend and percentage of palynomorphs for each environment

DISCUSSION

Previous research states that Batuasih Formation was formed at Early Oligocene - Late Oligocene age (33.9 - 23.03 Ma) which interpreted through other objects such as foraminifera and nannoplankton. (Baumann, 1972; Effendi *et al.*, 1998; Martodjodjo, 2003; Clements, 2007; Hendrizan, 2012; Wibowo & Kapid, 2014). From this, it can be seen that the age of Batuasih Formation has an older age (Late Eocene). This Late Eocene age cannot be neglected because key palynomorphs of Late Eocene age in Batuasih Formation are the dominant palynomorphs. This dominant palynomorph is *Proxapertites* group (*Proxapertites cursus, Proxapertites operculatus*, and *Proxapertites psilatus*). While the last age of Batuasih Formation found in this study was limited to Early Oligocene. It happened because *Proxapertites* group became extinct at this age (Morley, 1991). Moreover, the presence of *Podocarpidites* indicates that Batuasih Formation has relative age not far from Eocene - Oligocene boundary (33.9 Ma). It happened because *Podocarpidites* appeared in Indonesia in the Late Eocene. *Podocarpidites* came to Indonesia after spreading from India and Ninety East Ridge at the Paleocene age (Morley, 2010; Morley, 1991). Another source states that coniferous groups in Indonesia were present after Late Eocene age. It occurred in association with Late Eocene collision between the Indian plate and the Eurasian plate (Dupont-Nivet *et al.*, 2013). Therefore, the presence of *Podocarpidites* indicates that the age of Batuasih Formation is not far from the Eocene - Oligocene boundary. Other studies that extend the age of Batuasih Formation to Late Oligocene can occur. It happened because Batuasih Formation was exposed in other areas. Therefore, there is the possibility of finding Batuasih Formation, which has Late Oligocene age in that region.

From this interpretation, the depositional environment of this research is consistent with results of previous studies. Previous research has interpreted Batuasih Formation to form in the transitional environment to shallow seas (Baumann, 1972; Effendi *et al.*, 1998; Martodjodjo, 2003; Clements, 2007; Hendrizan, 2012; Wibowo & Kapid, 2014). As for this study, Batuasih Formation is interpreted to form in a transitional environment characterized by the presence of marine palynomorphs and the strong influence of transition palynomorphs in the study sample.

CONCLUSION

Batuasih Formation is one of the rock formations in Bogor Basin that shows the presence of palynomorphs. As a result, 169 individuals palynomorph from 19 species were identified. Dominant pollen came from genus *Proxapertites*, both *Proxapertites operculatus*, *Proxapertites cursus*, and *Proxapertites psilatus*. While dominant spores come from *Verrucatosporites usmensis*. Palynomorphs in form of dinoflagellates and foraminifera test lining are also present in this formation. From palynomorph analysis, Batuasih Formation has Late Eocene - Early Oligocene age (41.2 - 27.8 ma) with the transitional depositional environment.

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