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PERMO-TRIASSIC PALYNOLOGY OF THE WEST TIMOR

PALINOLOGI UMUR PERM-TRIAS DI TIMOR BARAT

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ABSTRAK

Analisis palinologi telah dilakukan terhadap 15 percontoh permukaan Formasi Bisana berumur Perm - Trias yang tersingkap di Timor Barat (NTT). Formasi Bisane merupakan sedimen tertua di daerah ini yang berasal dari Kontinen Australia akibat bertumbukan dengan Busur Vulkanik Banda di utara. Secara umum Formasi Bisane tersusun oleh batubasir gampingan tebal (0,3-5 m) dengan sisipan serpih dan kaya kandungan fosil laut krinoid yang menunjukan umur Perm dan lingkungan laut. Selain itu, ternyata Formasi Bisane memiliki ciri litologi lain yaitu perselingan antara serpih abu-abu gelap-hitam dan lanau, non-gampingan, memperlihatkan struktur lembar kertas dan kaya kandungan sulfur. Palinomorf yang ditemukan di daerah penelitian umumnya dicirikan oleh kumpulan taxa penciri umur Perm-Trias seperti polen striate-bissactes: Protohaploxypinus samoilovichii, P. fuscus, P. goraiensis, Striatopodocarpidites phaleratus, Pinuspollenites globosaccus *dan* Lunatisporites pellucidus. *Namun demikian, pada percontoh serpih non-gampingan ditemukan spora trilete-monosaccate:* Plicatipollenites malabarensis *dan* Cannanoropollis janakii *yang menunjukan bahwa percontoh tersebut berumur Perm atau lebih tua. Penelitian ini menemukan keberadaan dinoflagelata pada percontoh gampingan yang menguatkan fakta adanya pengaruh lingkungan laut saat pembentukannya. Dinoflagelata menghilang pada percontoh non-gampingan mengindikasikan lingkungan pengendapan air tawar. Dengan mengintegrasikan hasil analisis palinologi dan pembentukan rift pada umur Perm, dapat disimpulkan bahwa percontoh non-gampingan terbentuk awal* syn-rift *yang ditandai dengan kehadiran endapan air tawar (mungkin endapan danau). Selanjutnya saat muka laut naik pada periode* post-rift*, lingkungan pengendapan bergeser ke lingkungan laut, yang ditandai dengan munculnya percontoh gampingan berumur Perm-Trias. Jika memang demikian, keberadaan sedimen berumur Perm-Trias membuka peluang adanya sistem petroleum baru pada sedimen Paleozoik di Timor Barat. Dalam hal ini, serpih hitam dapat berperan sebagai batuan sumber, sedangkan batupasir tebal dapat bertindak sebagai reservoir.*

Kata Kunci: *Palinologi, Perm, Trias, Timor Barat.*

ABSTRACT

Fifteen surface samples were examined to analyze palynology of the Permo-Triassic sediments of West Timor. The studied samples were collected from the clastic sediment of Bisane Formation which is considered to be the oldest formation. It derives from the Australian continent (Gondwana) following the collision with the Banda volcanic arc. The Bisane Formation generally comprises thick calcareous sandstone (0.3-5 meters) with shale alternation and abundant marine microfossil of Chrinoid. The appearance of Chrinoid may indicate Permian age and shallow marine environment. Meanwhile, other Bisane sediment shows different lithology in which it is composed of the intercalation of non-calacreous, dark gray to black shale and siltstone showing papery structure and rich in sulphur. Generally, palynological assemblage of the studied samples characterises Permo-Triassic age as indicated by the existence of common striate-bisaccate pollen including *Protohaploxypinus samoilovichii*, *P. fuscus*, *P. goraiensis*, *Striatopodocarpidites phaleratus*, *Pinuspollenites globosaccus* and *Lunatisporites pellucidus*. However, the appearance of trilete-monosaccate spores of *Plicatipollenites malabarensis* and *Cannanoropollis janakii* within the non-calcareous shale samples defines the age as Permian or older for these samples. Interestingly, marine dinoflagellates appear to mark calcareous samples suggesting the influence of a marine environment. They disappear from the non-calcareous samples indicating a freshwater environment. By integrating this palynological analysis and Permian tectonic event which is marked by rifting, it can be interpreted that the non-calcareous samples were formed during early syn-rift as evidenced by the occurrence of freshwater deposit (may be lacustrine). Subsequently, following sea level rises during post rift, the depositional environment shifted to shallow marine as indicated by the existence of calcareous Permo-Triassic samples. If this is the case, the appearance of Permo-Triassic sediments provides an opportunity to find a new petroleum system in the Paleozoic series of West Timor. Source rock is represented by black shale, whereas reservoir is represented by thick sandstone.

Keywords: Palynology, Permian, Triassic, West Timor

I. INTRODUCTION

Timor Island is geologicaly situated within the Banda arc-Australian continental collision zone. It is known as the youngest tectonic collision product in the world which created a high complexity of geology. Timor is interpreted by many geoscientists to have various tectonic situations such as an overthrust (Harris 2011), rebound (Chamalaun and Grady 1978), imbricated (Hamilton 1979), duplex (Harris 1991), over-thrust margin (Sawyer et al. 1993), and basement involved thrust (Charlton and Gandara 2012). These tectonic situations resulted in the wide exposured zone of Paleozoic-Mesozoic and Tertiary sequences. In addition, major publications agree that Timor Island is a distal part of Australian continental plate which consists of distal marine sediment from Paleozoic to Quaternary ages.

The study area is located in Nusa Tenggara Timur Province of West Timor (Figure 1). It is adjacent to the east of the Republic of Democratic Timor Leste, which has successfuly produced oil from some wells located near the Indonesian and Timor Leste border. This study is a part of geological and geophysical surveys in West Timor to evaluate hydrocarbon potential of this area. Data provided for this publication was generated from the surface samples which were collected during the surveys.

West Timor has been well known as an area for marine biostratigraphic research of the Late Paleozoic era. This is understandable because

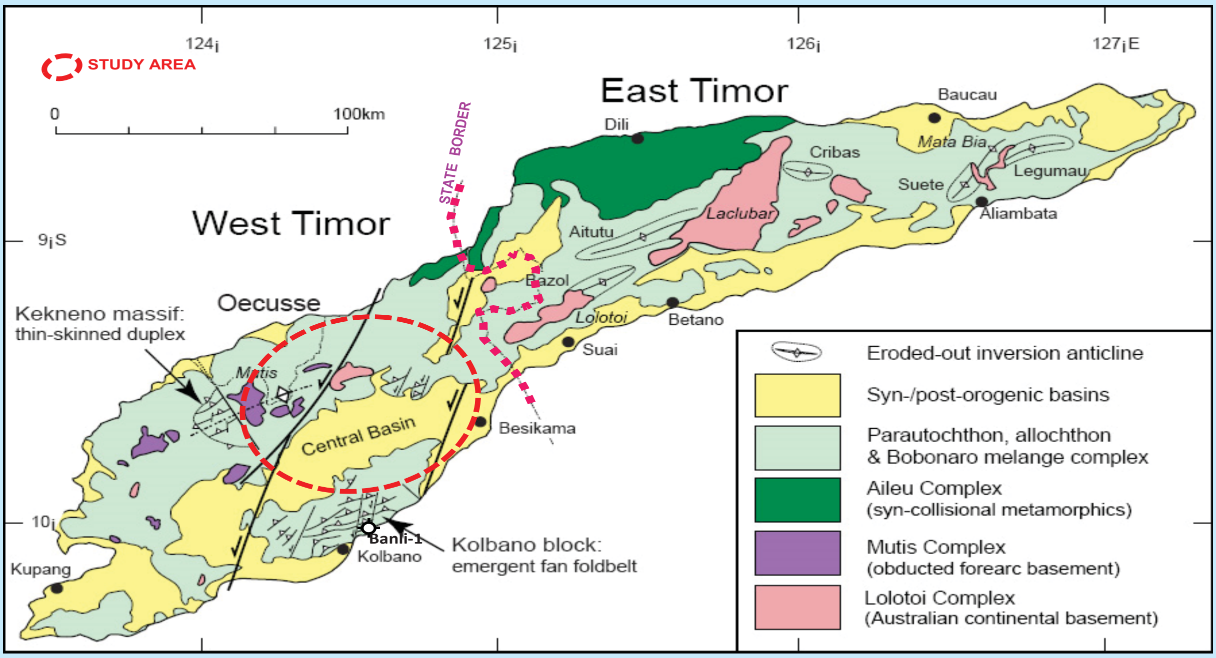

Figure 1
Geological map of the Timor island and the study area.

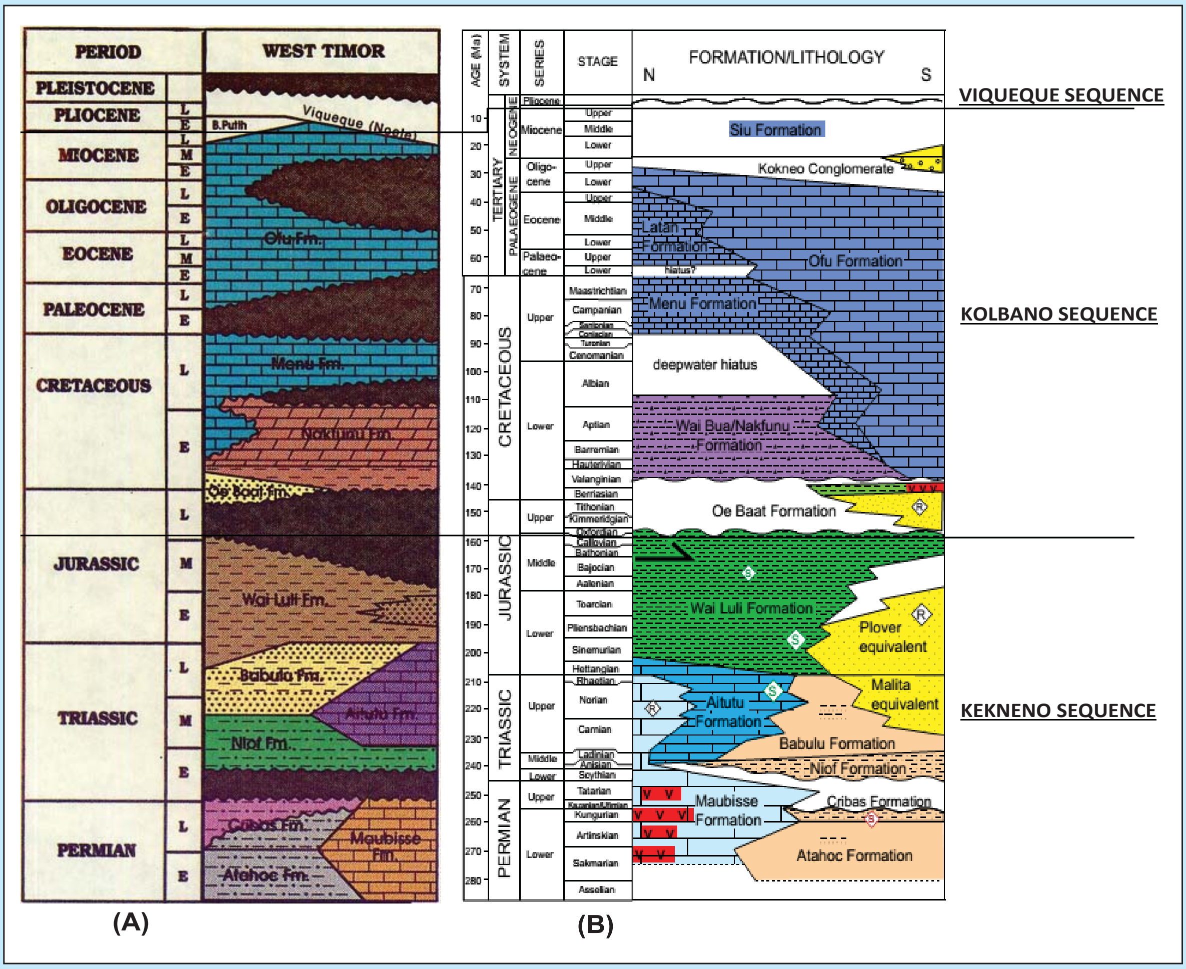

Figure 2
Regional stratigraphy of West Timor: (A) Sawyer et. al., 1993 and (B) Charlton, 2002.

most of the Paleozoic sediments are in marine facies (van Gorsel 2014). Having this situation, palynological work of the Late Paleozoic sediment is rarely performed on West Timor as indicated by limited publications regarding this subject. There is difficulty in accessing the data, especially those provided by the oil companies (both well and surface data). In addition, there is only one well which was drilled in this area. This results in unsuitable material for palynological analysis. Therefore, in responding to this situation, a field survey was undertaken to obtain suitable samples for proper palynological examination. This paper is intended to study palynology of the Permo-Triassic sediments which will contribute to an understanding of the pre-Tertiary palynology in West Timor.

Based on research by Rosidi et al. (1979), Sawyer et al. (1993), Charlton (2001) and Harris (2011), stratigraphy of West Timor generally can be divided into three sequences - Kekneno, Kolbano and Viqueque sequences (Figure 2). The oldest sequence is Kekneno which unconformably overlays pre-Permian basement. It ranges from Early Perm to Middle Jura consisting of Bisane, Maubise, Niof, Aitutu, Babulu and Wailuli Formations. Subsequently, the Kolbano sequence is composed of Late Jura to Early Pliocene formations including Oebaat, Nakfunu, Menu and Ofu Formations. Finally, the Viqueque sequence represents Plio-Pleistocene syn-orogenic sediments including Viqueque Formation and melange. The Viqupue Formation comprises Batu Putih and Nole Members, while melange consists of Bobonaro and Sonnebait Formations. The Viqueque Formation is unconformably overlain by the Quarternary sediment comprising of coral, conglomerate, gravel and alluvial.

Palynological work shown in this paper was conducted on the Permian Bisane Formation which is divided into calcareous and non-calcareous sediments. The calcareous Bisane Formation is characterised by thick sandstone (0.3-5 meters), yellowish grey, fine to medium sand with angular to sub-angular grain, fining upward, cross bedding and hummocky (Elnusa, 2015). It contains abundant mica and some marine macrofossil of Chrinoid. In addition, it is marked by the occurrence of black shale with a maximum thickness of 5 meters. On the other hand, the non-calcareous sediment within this formation shows the intercalation of shale and siltstone, dark grey to black, rich of sulphur and characterised by papery sedimentary structure.

The Paleozoic palynomorphs are assumed to have Australian affinity as the floras grew in this continent. Previous study on Permian fresh water sediments proved the appearance of this affinity such as *Protohaploxypinus samoilovichii*, *P. fuscus*, *P. goraiensis*, *Striatopodocarpidites phaleratus*, *Pinuspollenites globosaccus* and *Lunatisporites*

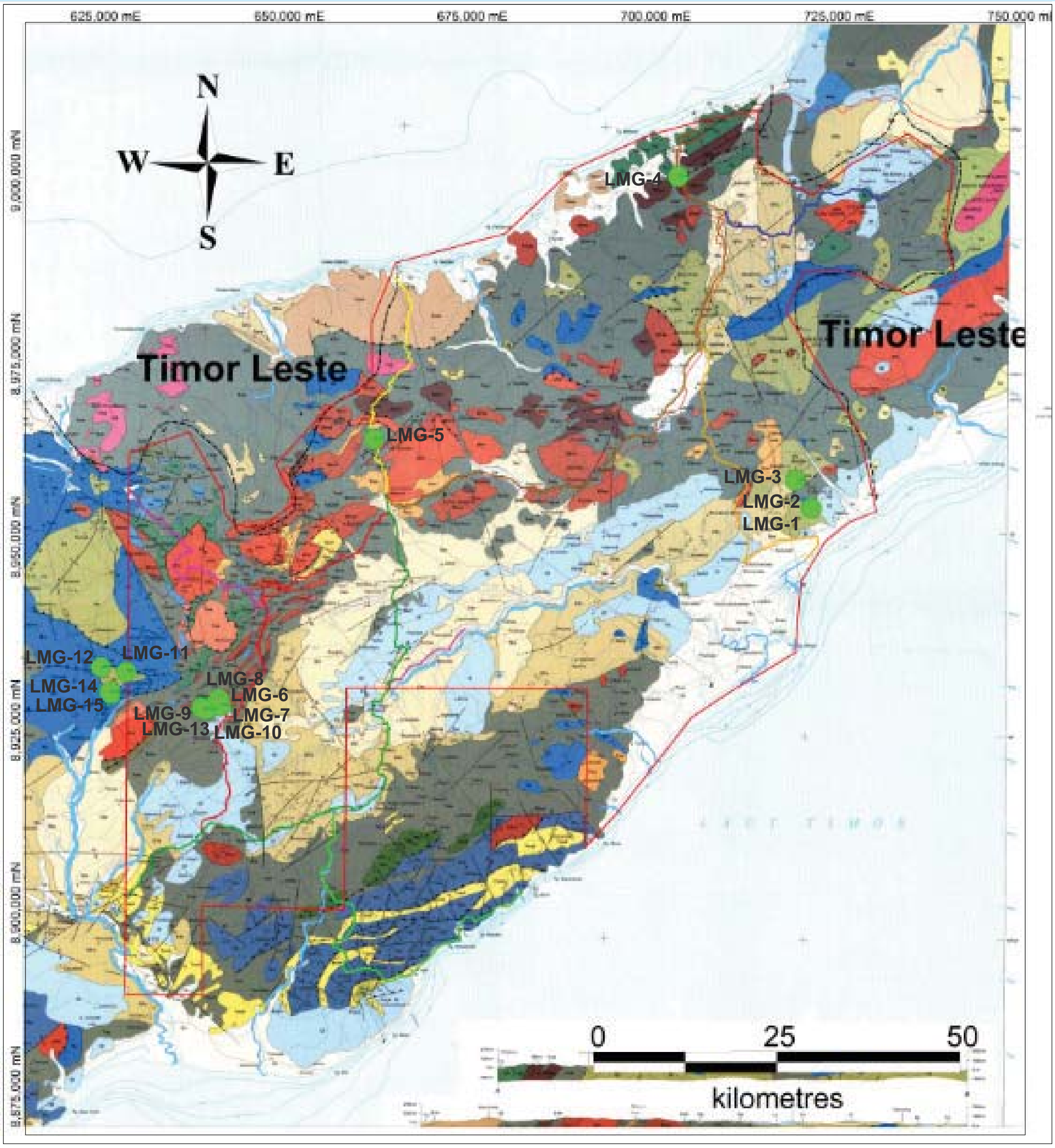

Figure 3
Sampling locations, indicated by green spots (●).

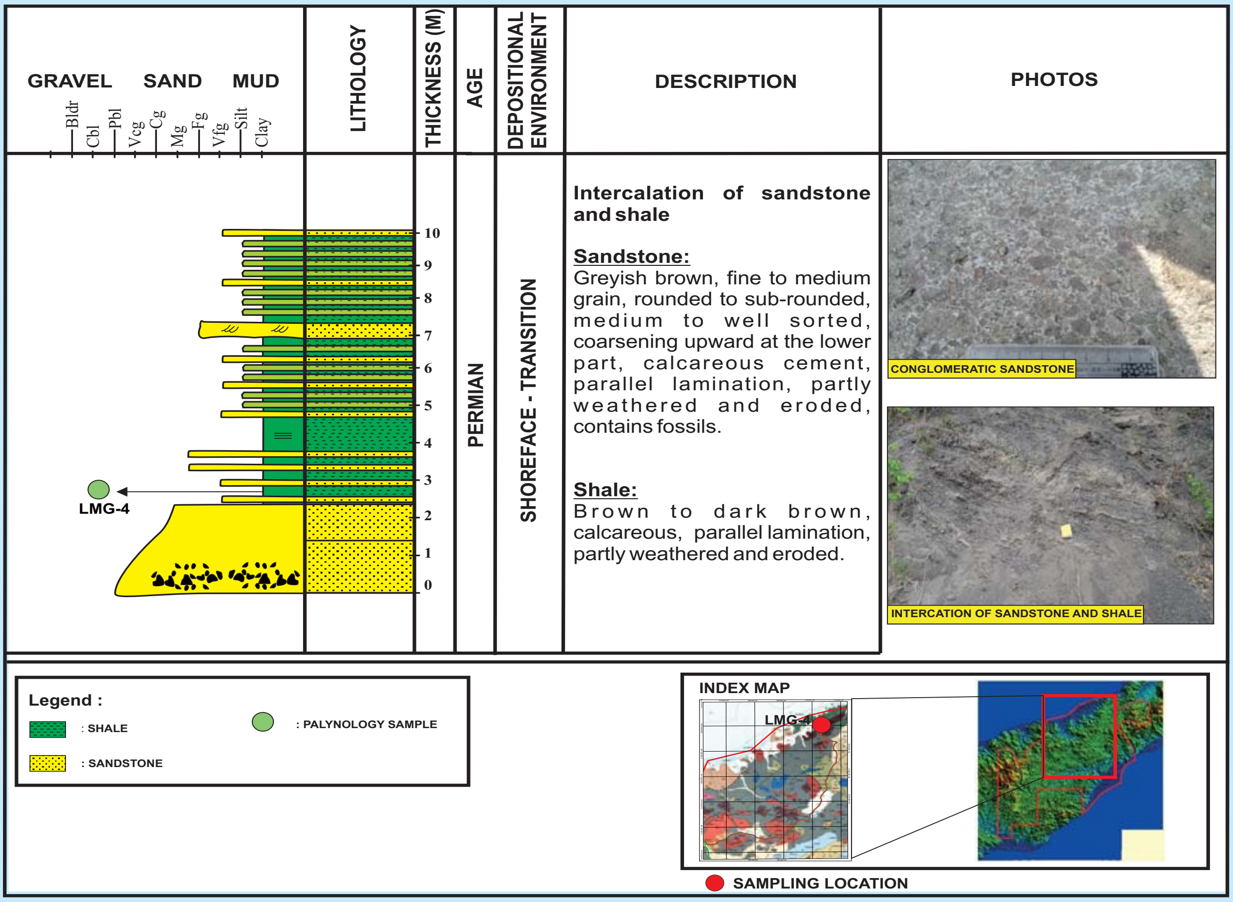

Figure 4
Lithology column and outcrop of the calcareous sample.

pellucidus (Lelono et al. 2016). Van Gorsel (2014) reported some palynomorphs from Timor such as *Glossopteris* (the tree-like seed fern, typical of Gondwana: Austalia, India) and *Gigantopteris* (flora characteristic of low latitude chataysian terranes: South China, Indochina). *Glossopteris* was producing striate *Protohaploxypinus* pollen which is an indication of Late Carboniferous-Permian (Traverse 1988). In addition, miospore was abundant and well preserved to characterise Late Carboniferous to Early Permian (Feng et al. 2008 and Jan 2014). Meanwhile, the domination of saccate forms (monosaccates and bisaccates) marks Late Permian palynofloras, especially those of striate bisaccates indicating well developed trees of conifer or conifer-like gymnosperm (Jha et al. 2014). These striate bisaccate pollen persisted up to Middle Triassic.

II. METHODOLOGY

Materials used in this study are surface samples which were collected during field activities. Figure 3 shows some locations where samples were collected. Fifteen samples were selected for palynological analysis. Lithologically, the studied samples are divided into two types. Firstly, calcareous lithology which consists of eight samples including LMG-3, -4, -5, -6, -8, -10, -11 and -12 (Figure 4). Secondly, non-calcareous lithology which are composed of seven samples such as LMG-1, -2, -7, -9, -13, -14 and -15 (Figure 5). Sampling was focused on the sediments consisting of fine grain lithology and yielding high organic content as indicated by its dark colour (Lelono 2000). In addition, due to outcrop limitation, the studied samples were selected randomly as spot samples.

Approximately 5 grams of samples were cleaned up and then crushed to reduce the surface sample and hence, speed up the sample maceration using HCl, HF and HNO_3. The important step within the maceration was heating the sample while reacting with nitric acid (HNO_3). Following this maceration, the sample was treated in alkali solution using 10% KOH in order to clear up the residue. The proper

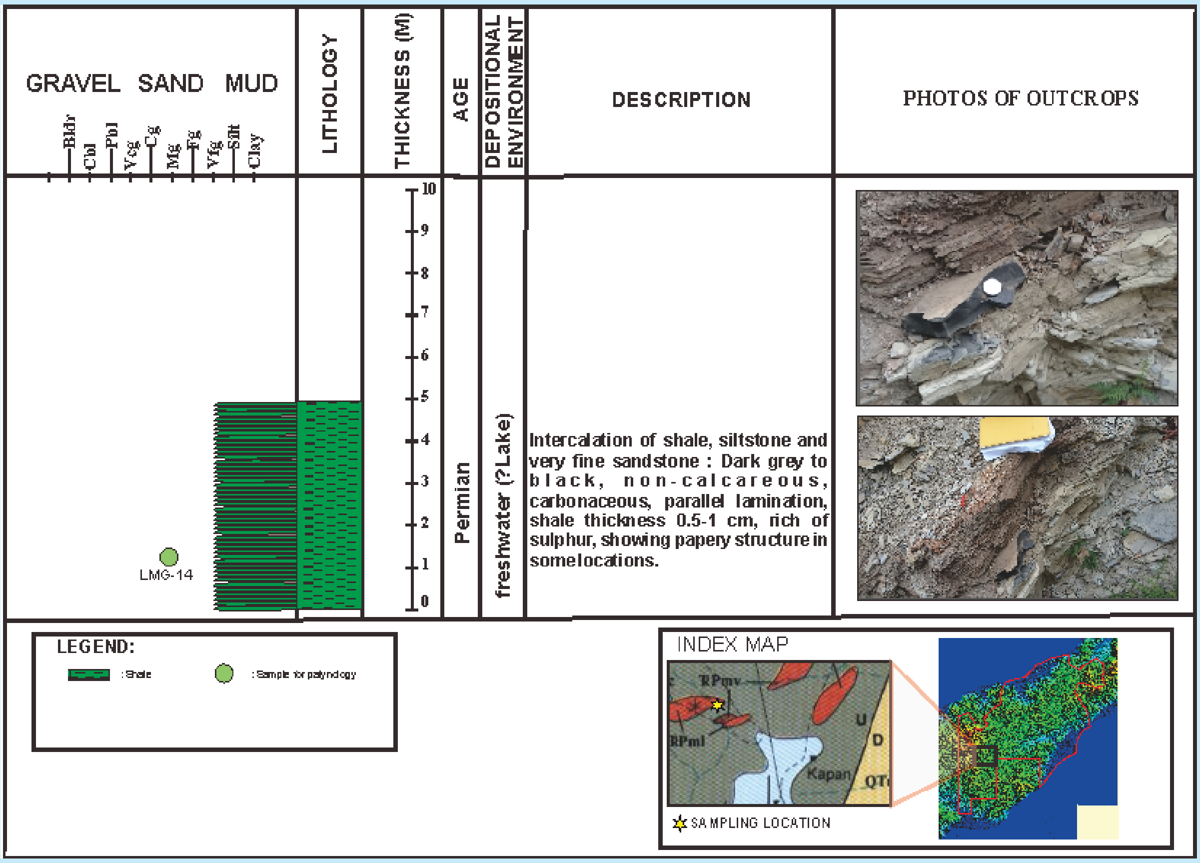

Figure 5
Lithology column and outcrop of the non-calcareous sample.

duration time of alkali treatment determined the number of palynomorphs turning up in the residue. It was necessary to sieve residue using a 5 microns sieve to collect more palynomorphs by separating them from debris materials. Finally, residue was mounted on the slides using polyvinyl alcohol (p. v. a) and canada balsam (Lelono 2001).

Palynomorph identification was conducted using a transmitted light microscope with an oil immersion objective and a X 12. 5 eye piece. The identification results were recorded in the identification sheets and used for the analyses. In addition, selected palynomorphs appearing within the studied samples were photographed for collection. Age interpretation and palaeoenvironmental analysis refers to the classic book of Traverse (1988) combined with those of Brugman et al. (1985) and Burger (1996) as well as recent publications introduced by several authors including Feng et al. (2008), Jan (2014) and Jha et al. (2014).

III. RESULTS AND DISCUSSION

The studied samples exhibit low to moderate abundance and diversity of palynomorph. Seventy seven distinct palynomorphs were sucessfuly extracted from the studied samples. They are mostly miospores and bisaccate pollen as listed in Table 1. Palynomorphs occurring in this study were also recorded in Australia, Africa and India as reported by the previous authors. In addition, key palynomorphs for zonal construction and age analysis appear in these samples. Key palynomorphs of striate bisaccates appear in the whole samples, both calcareous and non-calcareous lithologies. Meanwhile, index palynomorphs of trilete monosaccates only occur in the non-calcareous samples. In addition, marine dinoflagellates are only recorded in calcareous samples. They disappear from non-calcareous samples.

A. Palynological Assemblage

Good preservation of palynomorphs can be observed in nearly all samples. Three out of fifteen samples are barren. Palynomorph assemblages are characterised by the domination of bisaccate forms and spores (Table 1). The bisaccates are divided into striate and non striate forms. The striate bisaccate pollen are represented by common *Protohaploxypinus samoilovichi*, *P fuscus*, *Lunatisporites pellucidus*, *Staurosaccites quadrifidus*. Meanwhile, the non striate bisaccates include common *Falcisporites australis*, *Samaropollenites speciosus* and *Minutosaccus crenulatus*. These bisaccates appear within all samples. The domination of bisaccate pollen especially those of *Protohaploxypinus samoilovichi* and *Falcisporites australis* may indicate Late Paleozoic (Brugman et al. 1985).

Spores regularly present throughout the studied samples as shown by *Osmundacidites senectus*, *Microbaculispora* sp., *Dictyophyllidites mortonii*, *Cicatricosisporites australis* and *Semiretisporites denmeadi*. In addition, trilete spores with monosaccate including *P malabarensis* and *Cannanoropollis janakii* appear to designate Late Carbonaceous to Early Permian (Brugman et al. 1985). In fact, these two index spores mostly occur within non-calcareous samples such as samples LMG-7, -12, -14 and -15. Selected spore and pollen mentioned above are the key elements to determine the age of the studied samples.

This work also reveals the appearance of non-saccate pollen and spore as well as non-striate bisaccates which are specifically recorded in the Permo-Triassic age. These palynomorphs present in low abundance. The non saccate pollen are represented by *Vittatina simplex*, *Cycadopites stonei* and *Ashmoripollis reducta*. On the other hand, the non-saccate spores are including *Ceratosporites helidonensis*, *Dictyophyllidites mortonii*, *Cadagarsporites senectus* and *Polycingulatisporites crenulatus*. The non-striate bissaccates are *Samaropollenites speciosus*, *Alisporites* spp., *Ruqubiversiculites* sp., *Sulcatisporites institatus* and *Minutosaccus crenulatus*.

Some marine dinoflagellates appear to indicate the occurrence of marine influence. They include *Dapsilidnium langii*, *Eschaeisphaeridia* sp., *Heirbergella balmei*, *H. kandelbachia*, *Pareodinia ceratophora*, *Systematophora* sp. *Phallocysta*

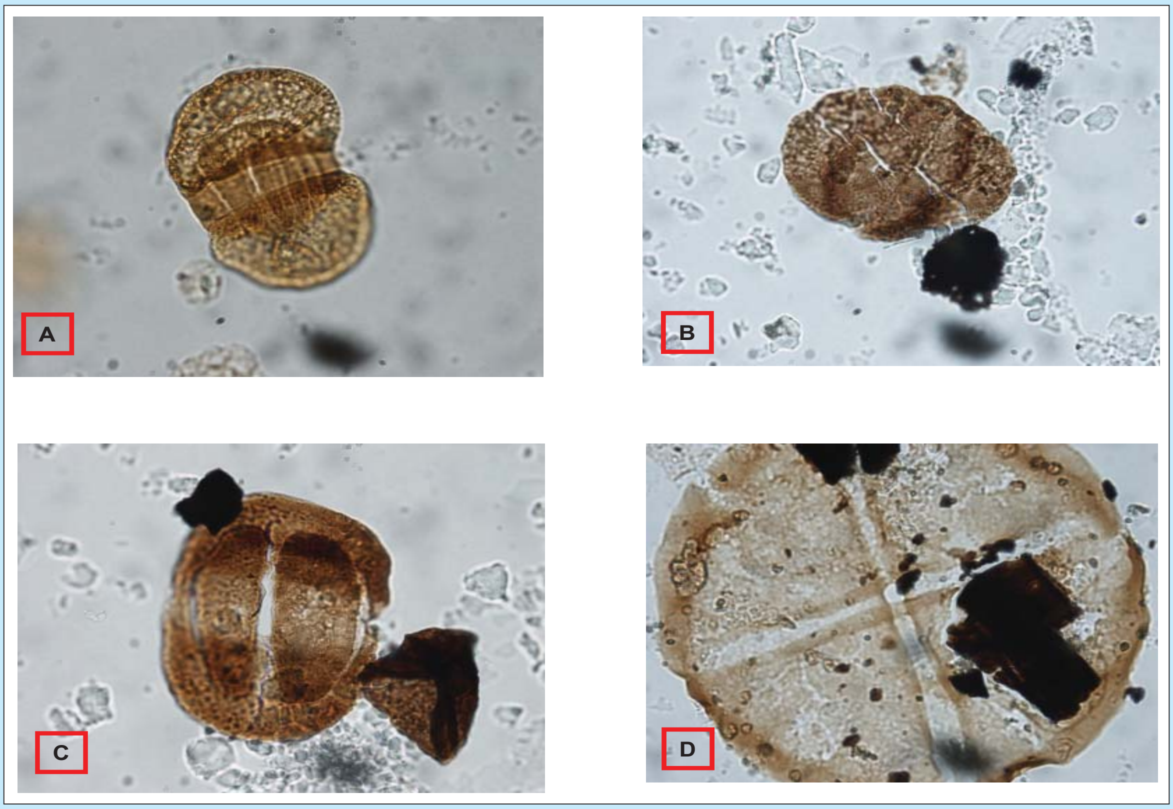

Figure 6
Typical Permian-Triassic palynomorphs from West Timor.
(A) *Protohaploxypinus samoilovichii* (Jansonius, 1962) Hart, 1964.
(B) *Falcisporites australis* (Gould, 1975). (C) *Lunatisporites pellucidus* Goubin. (D) *Staurosaccites quadrifidus* (Dolby and Balme, 1976). All specimens are X 1000.

erregulensis and *Dingodinium jurassicum*. Interestingly, these dinoflagellates are only found within the calcareous samples. They disappear from the non-calcareous samples. The occurrence of dinoflagellates are signatures for the marine influences.

B. Age Analysis

Generally, all samples are characterised by common appearance of bisaccates marking Permo-Triassic age including *Protohaploxypinus samoilovichi*, *P fuscus*, *Falcisporites australis*, *Lunatisporites pellucidus*, *Staurosaccites quadrifidus* and *Cycadophytes stonei* as shown in Table 1. Referring to Mesozoic zones proposed by Helby et al. (1987), the appearance of these palynomorphs indicates Falcisporites superzone which ranges from Late Permian to Late Triassic age. Although these bisaccates appear in all samples, it is hard to define pollen zone within the Falcisporites superzone. This is because the studied samples were collected from separated sections or even from spot samples which resulted in the difficulty in defining the vertical distribution of each index pollen. In addition, pollen of *Cycadophytes stonei* is stratigraphically distributed up to Late Triassic (Burger, 1996). Therefore, based on the appearance of *Protohaploxypinus samoilovichi*, *P fuscus*, *Falcisporites australis*, *Lunatisporites pellucidus* and *Staurosaccites quadrifidus*, the studied samples are designated to Permian – Triassic age (Figure 6).

On the contrary, moderate trilete spores with monosaccate appear to mark the Carboniferous-Permian age. These miospores are represented by *Plicatipollenites malabarensis* and *Cannanoropollis janakii* (Figure 7). They are only found in the non-calcareous samples and disappear from the calcareous samples. On the basis of the occurrence of these spores, it is inferred that the non-calcareous samples were formed during Carboniferous - Permian age (Brugman et al. 1985). However, some non-calcareous samples (samples LMG-1 and -9) lack these index spores which are presumably caused by minimum palynomorph assemblages. In addition, sample LMG-2 with moderate pollen abundance shows the disappearance of these spores which may suggest a younger age than those of other non-calcareous samples. Interestingly, one calcareous sample (LMG-11) contains trilete monosaccate of *Cannanoropollis janakii* which possibly indicates Permian or older age. This data suggest that marine influence might occur during syn-rift period. Meanwhile, several samples, both calcareous (LMG-4 and -5) and non calcareous (LMG-13) are unable to be designated due to their barren condition. Sample LMG-3 is also indeterminate due to the absence of age-restricted taxa as this sample has very low pollen occurrence.

In light of the above discussion, it can be inferred that the age of the studied samples can be divided as follows: The non-calcareous samples (samples LMG-7, -12, -14 and -15) are assigned to Permian age or older, whilst the calcareous samples (samples LMG-6, -8, -10 and -12) are atributed to Permo-Triassic age.

C. Paleoenvironmental Analysis

Bisaccate pollen and spores are the dominant element within the palynomorph assemblages occurring in the studied samples. This study

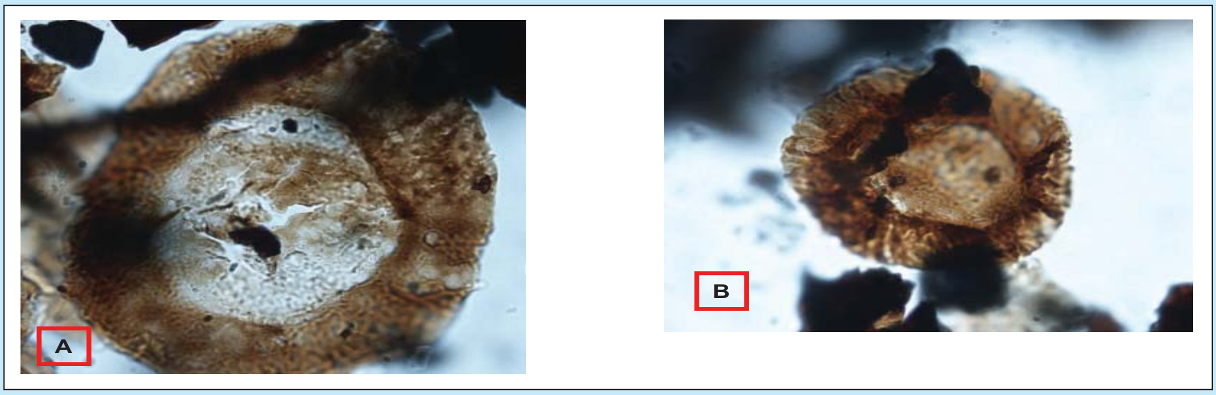

Figure 7
Late Carboniferous-Permian palynomorphs from West Timor.
(A) *Plicatipollenites malabarensis* (Potonie and Sah, 1958) Foster, 1975.
(B) *Cannanoropollis janakii* (Potonie and Sah, 1958). All specimens are X 1000.

Table 1
The abundance and diversity of palynomorphs appear in the studied samples

PALYNOMORPHS	SAMPLES														
	LMG-1	LMG-2	LMG-3	LMG-4	LMG-5	LMG-6	LMG-7	LMG-8	LMG-9	LMG-10	LMG-11	LMG-12	LMG-13	LMG-14	LMG-15
				B	B								B		
STRIATE BISACCATES															
Protohaploxypinus samoilovichi						8	?3	8	5	2		1		6	6
Protohaploxypinus fuscus															3
Taeniaesporites obex						1		1							
Lunatisporites noviaulensis							1			2				2	1
Lunatisporites pellucidus		1													3
Lunatisporites sp.		2													
Distriatites insculptus							1								
Distriatiles insolitus							1			1				1	1
Strotersporites indicus															2
NON-STRIATE BISSACTES															
Vitreisporites pallidus		5				1								2	
Ashmoripollis reducta										2				1	2
Pinuspollentis globasaccus		15				1			1						5
Pityosporites spp.						2			4						1
Falcisporites australis	5	20				1	11		3		1	13		1	2
Limitisporites elongatus						2		4							2
Triadispora plicata														1	
Triadispora crassa														1	
Sulcatisporites instilatus														1	2
Alisporites spp.		10													1
Callialasporites pallidus															2
Staurosaccites quadrifidus		6					2			?4					5
Corisaccites alutas															1
Ruqubiversiculites sp.		11													
Samaropollenites speciosus		4													
Platysaccus spp.		3													
Sulcatisporites institatus		7													
Triadisporites plicata		3													
Callialasporites spp.							1				?1				
Minutosaccus crenulatus										2					
Limitisporites diversus										1					
bisaccate pollen indeterminate	4		4							1					
MONOSACCATE															
Cannanoropollis janakii							1				1	3		14	2
Plicatipollenites malabarensis															3
OTHER POLLEN															
Vittatina simplex						1								1	2
Inaperturopollenites sp.						2									2
Cycadophytes stonei		4				1			1					2	3
Araucariates fissus														7	

Table 1
The abundance and diversity of palynomorphs appear in the studied samples (Continued)

PALYNOMORPHS	SAMPLES														
	LMG-1	LMG-2	LMG-3	LMG-4	LMG-5	LMG-6	LMG-7	LMG-8	LMG-9	LMG-10	LMG-11	LMG-12	LMG-13	LMG-14	LMG-15
SPORES															
Osmundacidites senectus	1					4	4	3	1	4	7	3		1	
Osmundacidites wellmani											2			1	
Cadargasporites senectus								3							1
Cyathidites sp.								1							
Aequitriradiates sp.						1									
Microbaculispora tentula						1									
Dictyophyllidites mortonii		3												8	1
Zebrasporites sp.														3	
Baculatisporites comaumensis														2	
Staplinisporites telatus														9	
Ceratosporites helidonensis														2	
Semiretisporis denmeadi														2	
Antulsporites saeuus														4	
Laevigatosporites belfordii							1							2	
Polycingulatisporites crenulatus														5	1
Apiculatisporites carnarvonensis														1	
Aratisporites parvispinosus														1	
Aratisporites sp.										1					
Lundbladispora willmotii		2													
Contignisporites sp.											2	2			
Gleicheniidites sp.											2				
Concavissimisporites variverrucatus							1			1					
Retitriletes facetus												1			
Cicatricosisporites australis															1
Microbaculisporites trisina		2													
Ceratosporites equalis											4				
Ceratosporites sp.							1								
DYNOFLAGELLATES AND ACRITARCH															
Dapsilidnium langii						25		20							
Eschaeisphaeridia sp.								2							
Heirbergella balmei						1									
Heirbergella kendelbachia						1									
Pareodinia ceratophora						1									
Phallocysta erregulensis						2									
Dingodinium jurassicum						1									
Systematophora sp.											15				
Systematophora palcula										1					
Veryhachium sp. (Acritarch)						1									

recorded some important bisaccates of both striate and non-striate forms which might relate to Glossopterid. These pollen might have been produced by the plant that lived in the hinterland. They include *Protohaploxypinus samoilovichi*, *P fuscus*, *Lunatisporites pellucidus*, *Staurosaccites quadrifidus* (striate forms), *Falcisporites australis* and *Samaropollenites speciosus* (non-striate form). On the other hand, common occurrence of spores may be an indication of a wet environment. Some important spores are *Osmundacidites senectus*, *Dictyophyllidites mortonii*, *Polycingulatisporites crenulatus*, *Apiculatisporites carnarvonensis* and *Aratisporites parvispinosus*. It can be interpreted that these spores might have grown as herbaceous understorey plants in the flooding environment (Jha et al. 2014).

Lithologically, the studied samples are divided into calcareous and non-calcareous. The calcareous samples are characterised by the presence of marine dinoflagellates suggesting the influence of a marine environment (Figure 8). In contrast, the non-calcareous samples are indicated by the absence of marine dinoflagellates suggesting the occurrence of a non-marine environment. The non-calcareous samples are black shale indicating high organic materials. It can be assumed that the depositional environment of the non-calcareous samples may relate to the peat formation. The domination of gymnosperm (bisaccate pollen) may indicate the existence of cool climate during the deposition of the studied samples. Moreover, common occurrence of spore may suggest that the depositional setting is in a wet condition.

Accordingly, it can be concluded that the depositional environment of the study area was initially freshwater environments, especially those of forest swamp environment during the Permian or older age. The depositional environment subsequently shifted into more marine environment during the Permo-Triassic age.

IV. CONCLUSION

Fifteen surface samples were collected from West Timor to study Permo-Triassic palynology. These samples were processed to extract palynomorph content. This study recorded seventy seven different palynomorphs which were dominated by spores and bisaccate forms. Based on the appearance of index pollen of *Protohaploxypinus samoilovichi*, *Falcisporites australis* and *Lunatisporites pellucidus*, it can be inferred that thirteen calcareous samples were formed during the Permian-Triassic age. Meanwhile, referring to these index pollen combined with index spores of *Plicatipollenites malabarensis and Cannanoropollis janakii*, two non-calcareous samples may be designated to the Permian age or older.

Paleoenvironment of the study area initially occurred in a forest swamp environment (peat swamp) based on common appearance of striate and non-striate bisaccates (glossopterid) and miospores in the absence of marine dinoflagellates, combined

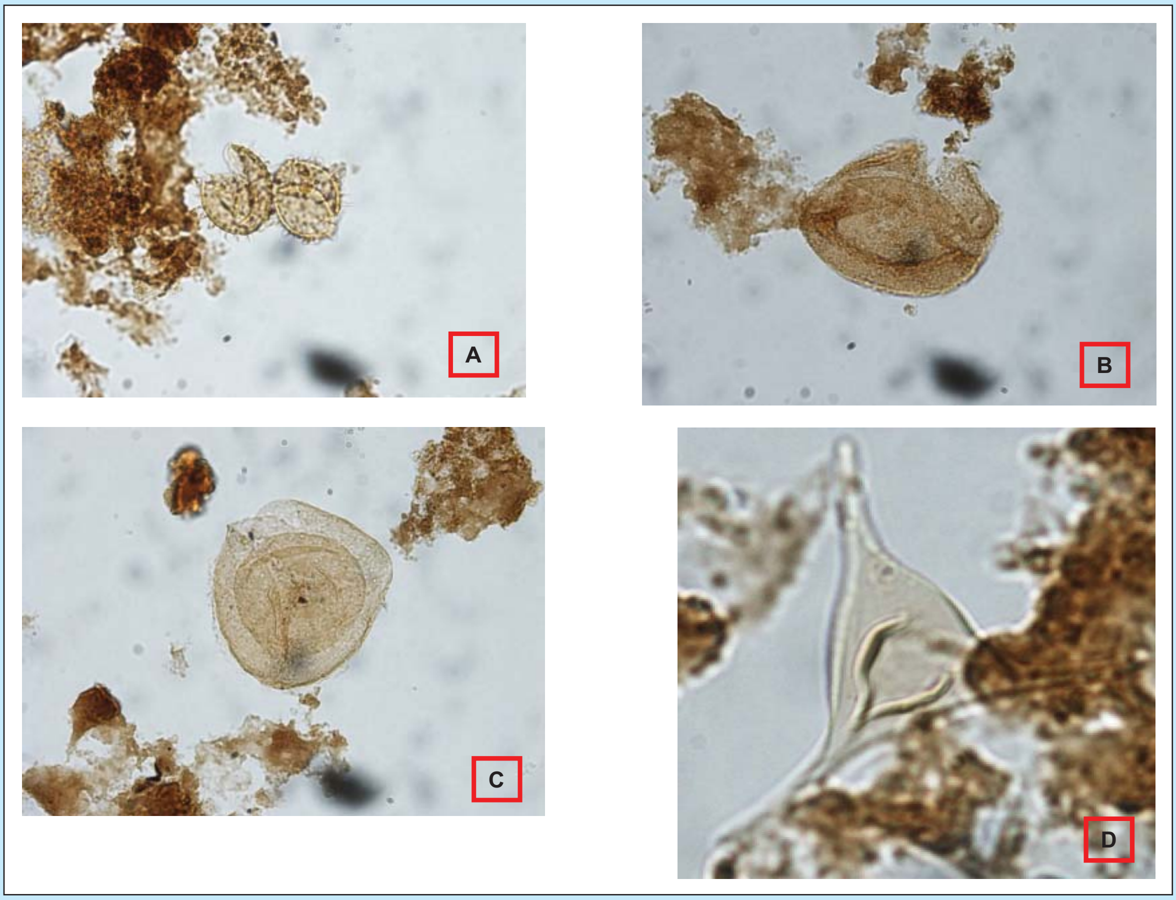

Figure 8
Representative dinoflagellates and acritarch from West Timor.
(A) *Dapsilidinium langii.* (B) *Heibergella kandelbachia*. (C) Phallocysta erregulensis.
(D) *Veryhachium* sp. All specimens are X 1000.

with non-calcareous black shale. Paleoenvironment then shifted into a more marine environment as indicated by common appearance of marine dinoflagellates. In addition, paleoclimate occurring during the deposition of the samples is assumed to be cool and in wet condition.

Considering a tectonic event during Permo-Triassic which is characterised by rifting, this study indicates that the non-calcareous samples were formed during early syn-rift as proved by the occurrence of freshwater deposit (Permian or older). Subsequently, following a sea level rise during post rift, the depositional environment shifted to a more marine environment, as indicated by the existence of calcareous Permo-Triassic samples.

The finding of Permian freshwater black shale indicates the petroleum system of West Timor. It provides an opportunity to find a new petroleum system in the Paleozoic sequences. The black shale is considered to be source rock, whereas thick sandstone is assumed to act as reservoir.

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