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POLLEN RECORD OF THE PERMIAN MARINE SEDIMENTS FROM WEST TIMOR

REKAMAN POLEN SEDIMEN LAUT UMUR PEREM DI TIMOR BARAT

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ABSTRAK

Makalah ini merupakan publikasi pertama yang mengungkap hasil studi palinologi pada sedimen laut berumur Perem di Timor Barat. Studi ini bertujuan untuk menganalisis kandungan fosil palinomorfnya. Sebelumnya studi palinologi pernah juga dilakukan pada sedimen Perem, tetapi khusus untuk sedimen non-marin. Sebanyak 16 perconto dipilih dari batuan yang tersingkap di sungai Lilana. Singkapan batuan ini merupakan bagian dari Formasi Bisane yang tersusun oleh perselingan serpih dan batupasir gampingan. Untuk mendapatkan kandungan fosil palinomorf, perconto diproses di laboratorium menggunakan teknik preparasi standar seperti acid maceration dan oksidasi. Studi ini menerapkan metode kuantitatif yaitu menghitung fosil palinomorf yang muncul pada setiap perconto. Studi palinologi memperlihatkan kandungan polen rendah sampai sedang yang umumnya terdiri atas striate dan non-striate bisaccates serta trilete monosaccates. Fosil index penentu umur berhasil ditemukan antara lain Protohaploxypinus samoilovichi, Lunatisporites pellucidus, Falcisporites australis, Plicatipollenites malabarensis and Cannanoropollis janakii. Berdasarkan kehadiran fosil index ini yang juga ditemukan pada sedimen non-marin, disimpulkan bahwa umur perconto batuan adalah Perem. Di sisi lain, kemunculan dinoflagelata laut Dapsilidium langii dan Veryhachim reductum ditunjang melimpahnya fosil makro chrinoids menunjukan lingkungan pengendapan laut dangkal. Hasil riset yang menarik adalah ditemukannya alga hijau Tasmanites sp. dalam jumlah cukup yang merupakan bukti kuat bahwa sedimen laut dangkal Formasi Bisane yang berumur Perem merupakan batuan induk hidrokarbon di Timor Barat.

Kata Kunci: *rekaman polen, perem, sedimen laut, Timor Barat.*

ABSTRACT

This is the first publication to present palynological study on the Permian marine sediments of West Timor. This is aimed to evaluate its palynomorph content. Similar studies have been performed on the Permian sediments which mostly focus on non-marine sediments. 15 surface samples were collected from Lilana river outcrop which comprises the alternation of calcareous shale and sandstone. This outcrop is assumed to represent some parts of Bisane Formation. Standard preparation methods were employed to extract palynomorphs including acid maceration and oxidation. This study applies quantitative method which requires counting of palynomorphs in each sample. This study provides low to moderate pollen recovery which mostly consists of striate and non-striate bisaccates as well as trilete monosaccates. The age restricted taxa appearing in the non-marine sediments also present in the studied samples to mark Permian age such as *Protohaploxypinus samoilovichi*, *Lunatisporites pellucidus*, *Falcisporites australis*, *Plicatipollenites malabarensis* and *Cannanoropollis janakii.* On the other hand, common occurrence of marine dinoflagellates of *Dapsilidium langii* and *Veryhachim reductum* combined with abundant macrofossil of chrinoids confirm a shallow marine paleoenvironment. Common green algae of *Tasmanites* sp. is a firmed evidence for the appearance of potential source rock of hydrocarbon within the Permian shallow marine sediments of West Timor.

Keywords: pollen record, permian, marine sediment, West Timor.

I. INTRODUCTION

As a distal part of Australian continental plate, Timor is dominated by shallow to deep marine sediments from Paleozoic to Cenozoic (Charlton and Gandara 2012). In addition, Perm is well known to deposit marine sequence which able to preserve marine fossils such as crinoids, molluscs, brachiopods, corals and trilobits (van Gorsel 2014). However, latest works by Lelono et al. (2016a) prove that Permian formation exposed on West Timor is compossed of non-marine (lacustrine) and marine sediments. While the non-marine sediments receive major attention due to its potentiality as a source of hydrocarbon, the marine sediments have never been properly explored. Mean while, in other areas where Perm is non-marine successions, palynomorphs were proved to occur considerably. The flora of almost all Permian Gondwanan continents between 40^{o} to 90^{o} paleolatitude is dominated by glossopterids (Mc Loughlin 2001). Although Gondwana was a large supercontinent which was presumably supported by homogenous vegetation, some intra-Gondwanan floristic provinces can be recognised as indicated by distinct regional palynomorph compositions. Recent study by Barbolini et al. (2016) on the Permian sediments from Australia and South Africa shows that index pollen appear diachronously in the two countries or they are absent in one of the countries. On the other hand, palynological study on the Late Permian coal of the Bowen Basin, Australia defines pollen zone of Protohaploxypinus sp. as partly indicated by the presence of *Protohaploxypinus* sp., *Plicatipollenites densus*, *Falcisporites australis*, *Striatopodocarpites fusus* (van de Wetering, 2013). The Late Permian sediments from Godavari Graben, India is characterised by abundant striate bisaccates which derived from Glossopterids. The paleovegetation studies depict the dominance of arborescent vegetation along with the low percentage of algal and pteridophytic spores which support the occurrence of warm, humid tropical forests. However, the occasional bloom in algal and pteridophytic spores represents the flooding environment (Mishra et al. 2015).

The area of study is located in Nusa Tenggara Timur of West Timor (Figure 1). The island of Timor is interpreted as a young product of the collision between Banda volcanic arc and Australian continent which has occurred since late Neogene (Chamalaun and Grady 1978; Hamilton 1979 and Harris 1991). Regional stratigraphy of West Timor proposed by Rosidi et al. (1979) and combined with Sawyer et al. (1993); Charlton (2001) and Harris (2011) covers pre-Permian to Quaternary successions representing tectonic events during this.

Ages (Figure 2). The research provided in this paper is a palynological study on the Permian marine sediment which is a part of Bisane Formation. In the regional stratigraphy of Timor, the Bisane Formation is assumed to equal to Atahoc Formation or Cribas Formation. The result of this study combined with the previous research on lacustrine sediment by Lelono et al. (2017) will complete inventarisation of palynomorphs from Permian West Timor. Having the above situation, this study is aimed to access palynological content of the Permian shallow marine sediments for understanding the Late Paleozoic stratigraphy and its possibility to be the source rock.

II. METHODOLOGY

For sampling purpose, it is selected a section along the Lilana river which provides sufficient outcrops for sample collection. It is employed a method of measured section to build a lithology coloumn allowing systematic sampling (Figures 1 and 3). 15 samples with fine grain lithology (such as shale, clay, silt) were selected from about 50 meters thick of outcrop, namely LIL-0A to LIL-13. This outcrop is lithologically characterised by the alternation of calcareous sandstone and shale. Sandstones range from 0.3 to 5 meters, light grey colour, calcareous, fine to medium with angular to sub-angular grains, fining upward, cross bedding and hummocky. They contain abundant mica and some marine macrofossil of chrinoid. Mean while, shales show dark grey and calcareous.

All samples were processed in the LEMIGAS Stratigraphy laboratory using standard preparation techniques such as HCl, HF and HNO_3 macerations which were followed by the alkali treatment using 10% KOH to clear up the residue. Sieving with 5 microns sieve was performed to collect more palynomorphs by separating them from debris materials. Finally, residue was mounted on the slides using polyvinyl alcohol and canada balsam (Lelono 2001).

Pollen identification heavily refers to the publications of Permian palynology especially those concerning Timor as written by Lelono et al. (2016b and 2017). Accurate identification determines reliable age and paleoenvironmental interpretations.

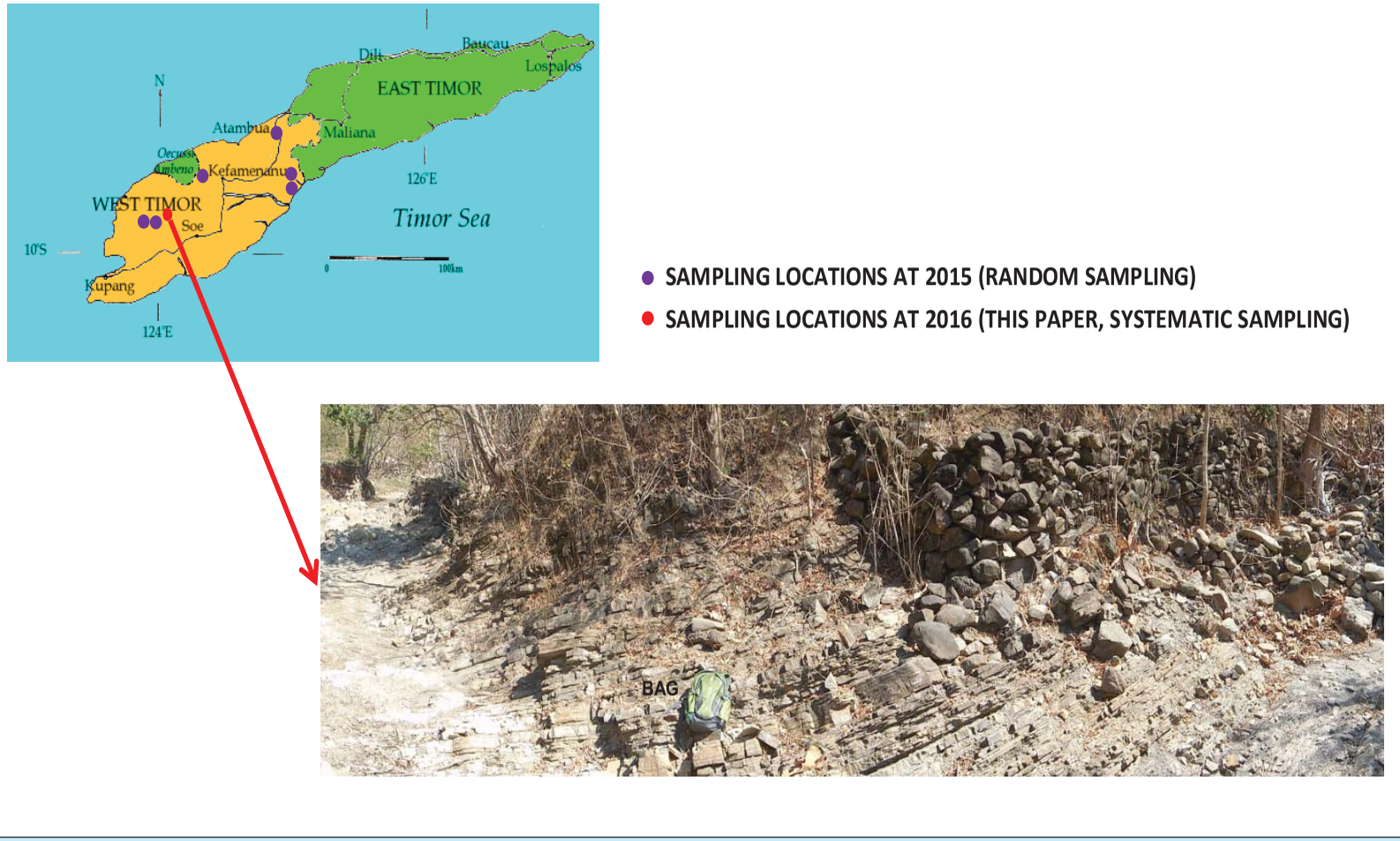

Figure 1
Map shows the area of study ● and the outcrop of Permian marine succession.

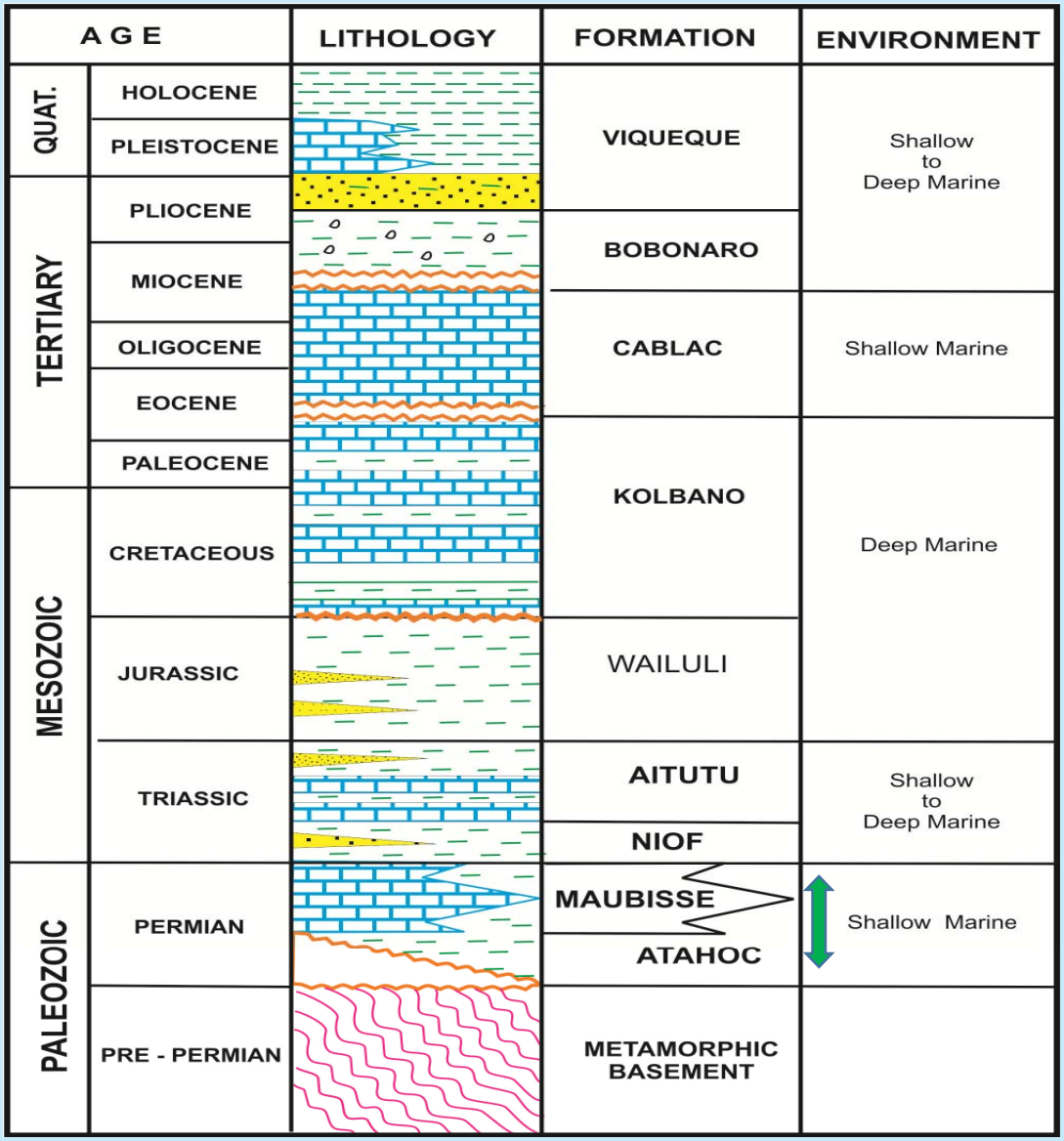

Figure 2
Regional stratigraphy of Timor Island as proposed by de Smet et al. (1996 in Lelono et al. 2015) shows studied interval ( ).

More over, the author refers to other publications which relate to the Permian palynology for analysing age and paleoenvironment such as Traverse (1988), Brugman et al. (1985), Feng et al. (2008), Jan (2014) and Jha et al. (2014).

III. RESULT AND DISCUSSION

All samples generally show low to moderate pollen recovery (Figure 4). Only twenty nine species are recorded which mostly consist of miospore and bisaccate pollen. Most species are also found in the Permian non-marine (lacustrine) sediments of West Timor such as *Protohaploxypinus samoilovichi*, *Lunatisporites pellucidus* (striate bissacate), *Falcisporites australis*, *Pinuspollentis globasaccus*, *Staurosaccites quadratus*, *Platysaccus* spp. (non striate bissacate), *Plicatipollenites malabarensis*, *Cannanoropollis janakii* (monosaccate), *Osmundacidites senectus* and *Ceratosporites helidonensis* (miospore) (Lelono et al. 2016b and

2017). Although, palynomorphs are rare, some key taxa appear to allow zonal reconstruction and age analysis including striate bisaccates and trilete monosaccates (Figure 5). In addition, this research provides the evidence for dinoflagellate occurrence which supports marine paleoenvironment. In fact, some palynomorphs from studied area are reported to appear in Australia (Kemp et al. 1977), Africa (Ruckwied et al. 2014), India (Tewari et al. 2015) and South America (Beri et al. 2010 and Boardman et al. 2012). Further more, this study discovers significant appearance of green algae *Tasmanites* sp. in the lower section (Figures 4 and 5). *Tasmanites* sp. is a major element in the Permian lacustrine sediments of West Timor which dominates more than 80% of pollen assemblages. In addition, it is proved to be the source of hydrocarbon (Lelono et al. 2017).

The age restricted taxa of bisaccate pollen appearing in the measured section characterises

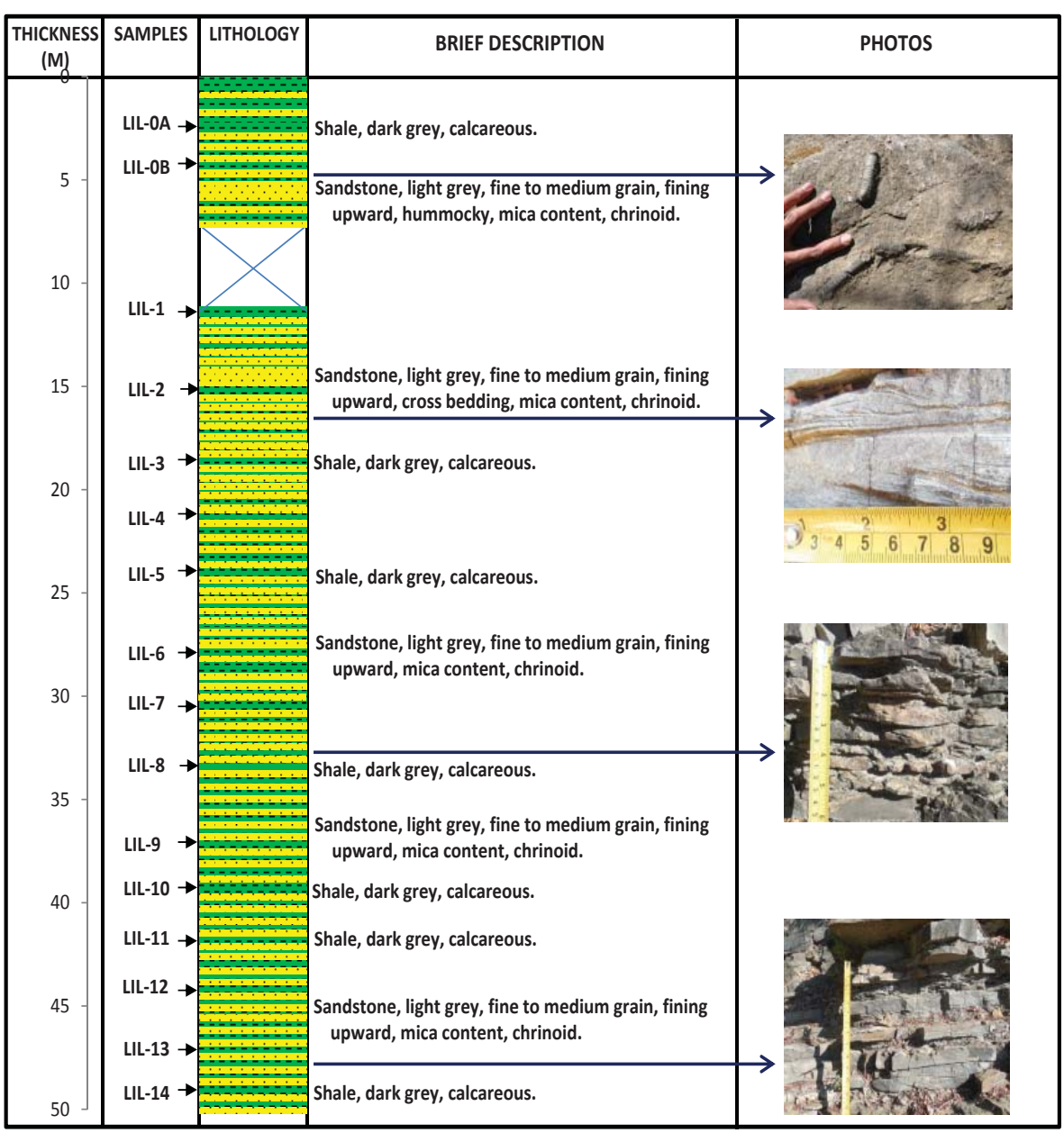

Figure 3
Lithology coloumn is obtained from measured section of the lilana river.

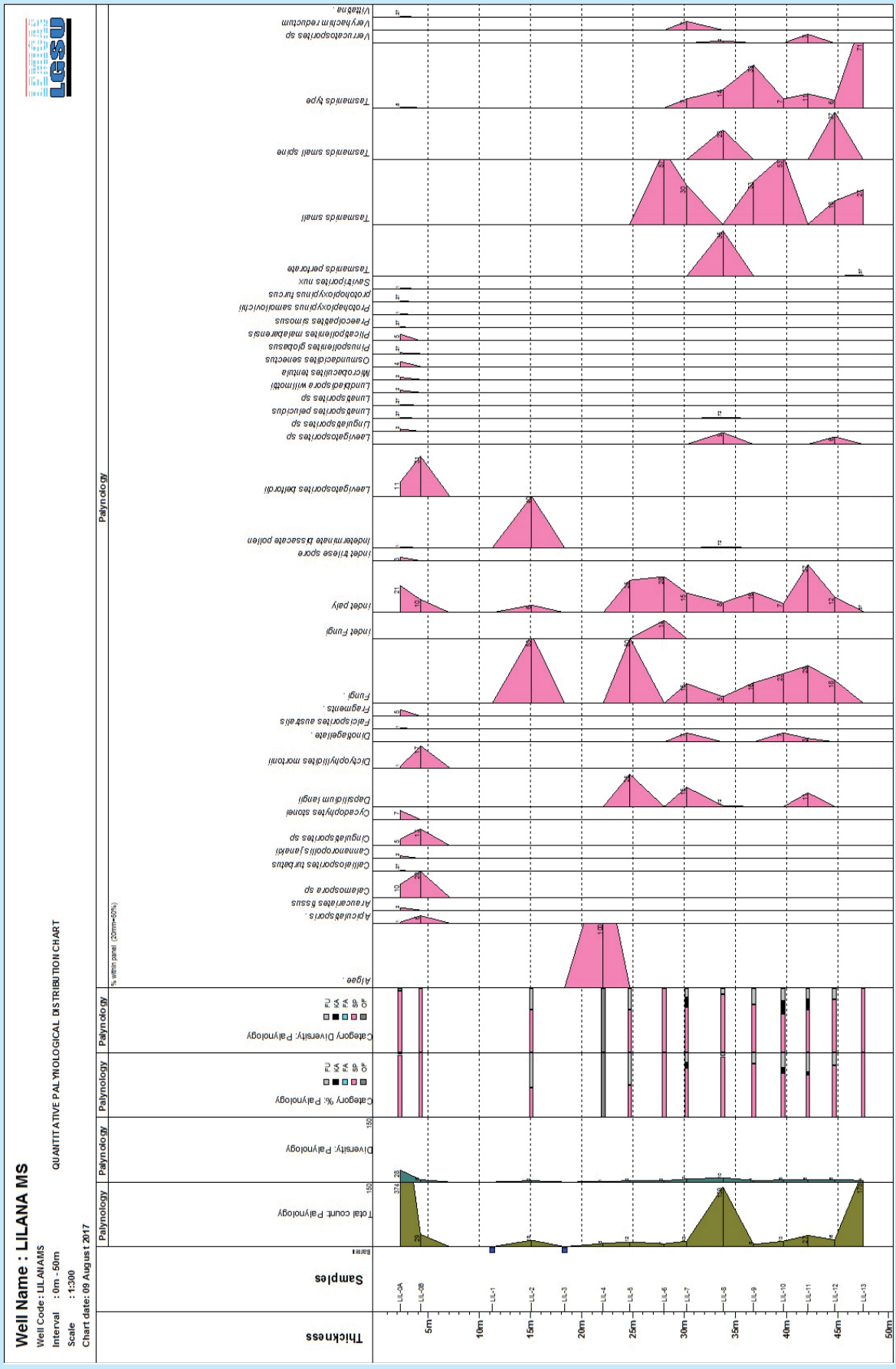

Figure 4
Pollen diagram of the Permian shallow marine samples (Lilana river of West Timor).

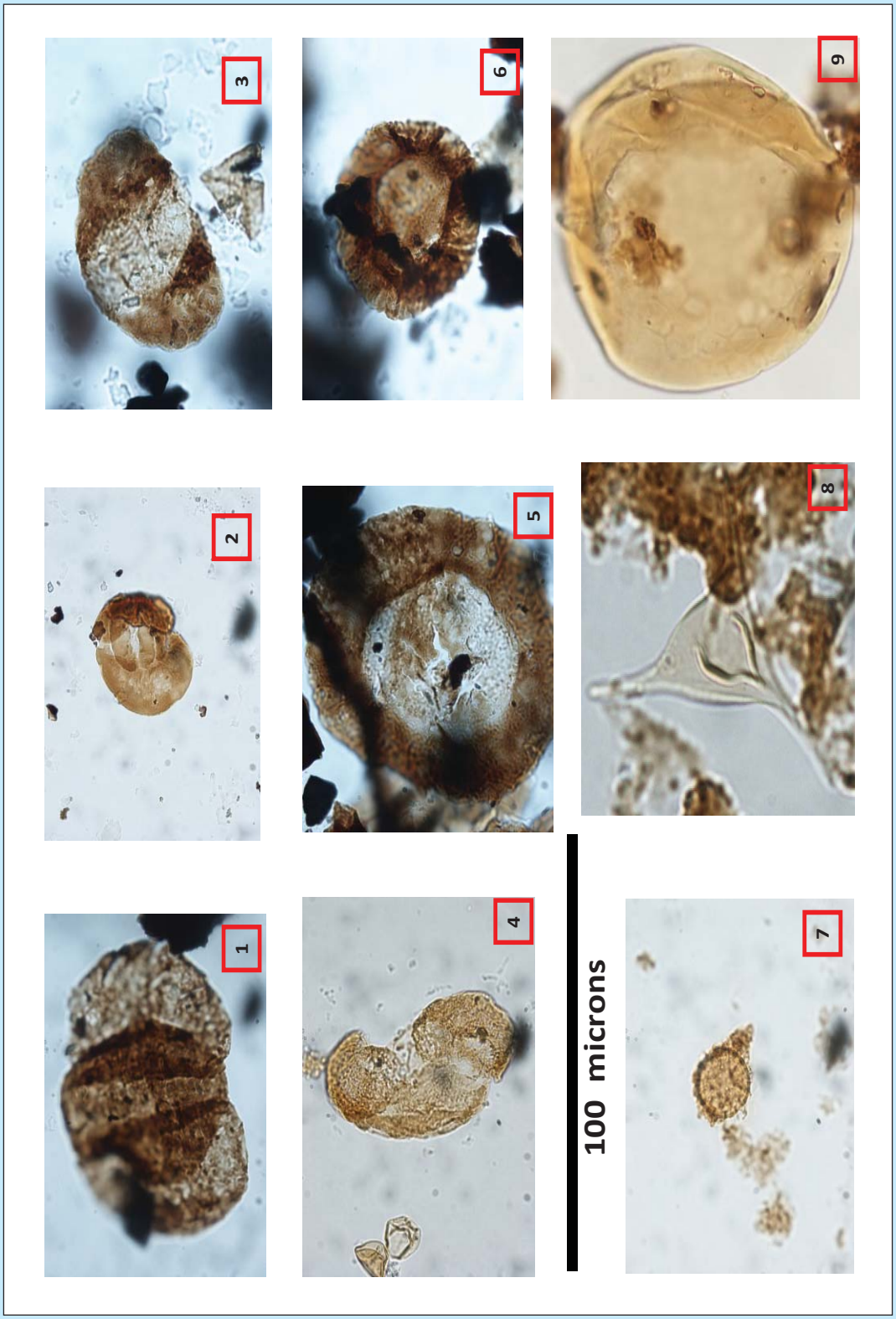

Figure 5
Key palynomorphs to interprete age and depositional environment: (1) Protohaploxypinus moilovichii, (2) Lunatisporites pellucidus, (3) Falcisporites australis, (4) Pinuspollenites globosaccus, (5) Plicatipollenites malabarensis, (6) Cannanoropollis janakii, (7) Dapsilidinium langii, (8) Veryhachim reductum and (9) green algae Tasmanites sp.

Permo-Triassic age including *Protohaploxypinus samoilovichi*, *Lunatisporites pellucidus* (striate bissacates), *Falcisporites australis* (non striate bissacate). Referring to Mesozoic pollen zonation of Australia, these palynomorphs indicate Falcisporites superzone which ranges from Late Permian to Late Triassic (Helby et al. 1987). The presence of index spore of trilete monosaccates of *Plicatipollenites malabarensis* and *Cannanoropollis janakii* suggests the age of Carboniferous-Permian age (Brugman et al. 1985). Meanwhile, the appearance of chrinoid within the calcareous sandstones may indicate Permian age (Lelono, 2016b). After all, it can be inferred that the studied sediments are assigned to Permian age.

Pollen assemblage of the studied section is characterized by significant occurrence of marine dinoflagellates including *Dapsilidium langii* and *Veryhachim reductum*. This indicates the appearance of marine environment. In addition, the calcareous sandstone with rich of chrinoids defining shallow marine environment.

Having this data, it is interpreted that the studied sediments must have been deposited in the shallow marine environment. The occurrence of green algae *Tasmanites* sp. is an interesting part of this study as this algae is found abundantly in the Permian lacustrine black shale of West Timor. It is proved to be the source of hydrocarbon by the discovery of tricyclic terpenoids compound which is the major element of hydrocarbon (Lelono et al. 2017). The enrichment of *Tasmanites* in Palaeozoic deposits from Gondwana have been interpreted as reflecting algal blooms in areas supplied with meltwater from surrounding glaciers (Revill et al. 1994). In this case, significant occurrence of *Tasmanites* sp. may indicate that Timor Island was geographically situated far south in the temperate region during Permian. Meanwhile, the presence of *Tasmanites* sp. in the marine deposits proves that this green algae may live in both marine and non-marine environments as stated by Traverese (1988). On the other hand, land condition is reflected by the presence of various bisaccates of both striate and non-striate forms which are asigned to Glossopterid representting forest development in the hinterland (van Gorsel, 2014). The occurrence of some spores (i.e: *Osmundacidites senectus*, *Ceratosporites helidonensis*, *Calamospora* sp., *Dictyophilidites mortonii* and *Laevigatosporites belfordii*) and occasional bloom in green algae (*Tasmanites* sp.) shows the growth of herbaceous understorey plants in the flooding environment (Jha et al. 2014 and Mishra et al. 2015). These facts are evidences for the presence of warmer climate.

IV. CONCLUSION

Palynological analysis on the marine samples shows the presence of age restricted taxa asigning to Permian such as *Protohaploxypinus samoilovichi*, *Lunatisporites pellucidus* (striate bissacates), *Falcisporites australis* (non striate bissacate), *Plicatipollenites malabarensis* and *Cannanoropollis janakii* (trilete monosaccates). This is supported by the high occurrence of macrofossil of chrinoids. On the other hand, significant appearance of marine dinoflagellates of *Dapsilidium langii* and *Veryhachim reductum* doubled with calcareous sandstones with rich in macrofossil of chrinoids concludes that the studied sediments were formed in the shallow marine environment.

Common occurrence of green algae of *Tasmanites* sp. demonstrates the potentiality of the Permian marine sediment as a major source for hydrocarbon which is proved by the presence of tryciclic terpenoid compound. As the enrichment of this algae relates to algal blooms in areas supplied with meltwater from surrounding glaciers, it is inferred that Timor Island was geographically situated far south in the temperate region during Permian.

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