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Middle Permian Radiolarians from the siliceous mudstone block near Pos Blau, Ulu Kelantan and their significance

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Abstract: A large siliceous sedimentary block was exposed in the vicinity Pos Blau, Ulu Kelantan. The block is a part of mélange in the Bentong-Raub Suture Zone. The lower part of the block is composed of ribbon chert and the upper part consists of interbedded siliceous mudstone and tuffaceous mudstone. Five samples from the siliceous mudstone yielded very low number of individuals but fairly high number of species. Fourteen radiolarians taxa were identified. The radiolarians are divided into two assemblage zones namely *Pseudoalbaillella fusiformis* Zone and *Follicucullus monacanthus* Zone indicating Middle Permian age. The occurrence of tuffaceous material in Middle Permian siliceous rock in Peninsular Malaysia was related to volcanic activities as a result of collision between Palaeo-Tethys oceanic crust and the East Malaya terrane. The source of the tuffaceous material was from the East Malaya terrane. The tuffaceous sediments became widespread in Late Permian and Triassic. This indicates the early stage of closing the Palaeo-Tethys.

Abstrak: Satu blok batuan sedimen bersilika yang besar terdedah pada kawasan berhampiran dengan Pos Blau, Ulu Kelantan. Blok ini sebahagian daripada *mélange* dalam Zon Sutura Bentong-Raub. Bahagian bawah blok terdiri daripada rijang ribbon dan bahagian atas terdiri daripada selang-lapis batu lumpur bersilika dan batu lumpur bertuf. Lima sampel daripada batu lumpur bersilika menghasilkan bilangan individu yang sedikit tetapi bilangan spesies agak tinggi. Empat belas taksa radiolarian telah dikenal pasti. Radiolaria dibahagikan kepada dua zon himpunan iaitu Zon Pseudoalbaillella fusiformis dan Zon Follicucullus monacanthus yang menunjukkan usia Perm Tengah. Kewujudan bahan bertuf dalam batuan bersilika Perm Tengah di Semenanjung Malaysia berkait dengan kegiatan volkano hasil daripada pelanggaran antara kerak lautan Palaeo-Tethys dan teran Malaya Timur. Punca bahan bertuf itu daripada teran Malaya Timur. Sedimen bertuf tersebar luas pada Perm Akhir dan Trias. Ini menunjukkan tahap awal penutupan Palaeo-Tethys.

Keywords: Radiolaria, siliceous mudstone, tuffaceous mudstone, Middle Permian, Palaeo-Tethys

INTRODUCTION

Chert and siliceous mudstone occur as blocks in the mélange of Bentong-Raub Suture Zone. The siliceous rocks yielded Late Devonian, Early Carboniferous and Permian radiolarians. The late Devonian radiolarians were reported from Bentong area (Spiller & Metcalfe, 1995; Spiller, 2002; Basir *et al*., 2004). Early Carboniferous radiolarians were recorded from Langkap (Spiller & Metcalfe, 1995; Spiller, 2002; Basir & Che Aziz, 1997a). In Pos Blau area, the siliceous sedimentary sequence comprises ribbon chert at the lower part and interbedded siliceous mudstone and tuffaceous mudstone in the upper part. The ribbon chert block yielded well-preserved and high diversity Early Permian radiolarian assemblages belonging to *Pseudoalbaillella lomentaria* and *Pseudoalbaillella scalprata* m. *rhombothoracata* Zones (Spiller & Metcalfe, 1995, Basir & Che Aziz, 1997b; Spiller, 2002). The siliceous and tuffaceous mudstone yielded an early Middle Permian radiolarian assemblage indicating the uppermost part *Pseudoalbaillella longtanensis* – lowermost part of *Pseudoalbaillella globosa* Zones (Spiller & Metcalfe, 1995; Spiller, 2002). Chert and siliceous mudstone represent oceanic sediments. These rocks were folded, faulted and highly deformed. The chert blocks represent the remnant of Palaeo-Tethys.

Recently, twenty two samples of siliceous mudstone were collected from an outcrop of abandoned timber track (Figure 1). The rocks comprise thinly bedded siliceous mudstone interbeds with tuffaceous mudstone and steeply dipping towards southeast. Five samples yielded very low number of individuals but fairly well preserved specimens.

GEOLOGICAL SETTING

The Bentong-Raub suture zone is a belt of mélange consisting of olistromal blocks of oceanic sediments such as chert, siliceous mudstone, tuffaceous mudstone, sandstone, limestone, with minor serpentinite bodies. Some of these rocks are sheared, faulted and embedded in the sheared matrix of mudstone. Tjia & Almashoor (1996) had conducted a detailed mapping of the Bentong-Raub Suture Zone in Southwest Kelantan. The rocks generally strike in a north-south direction and they recorded at least seven tectonic units representing imbricate thrust slices which formed a compressed accretionary prism. They estimated the width of this accretionary prism is at least 18 km. This rock assemblage could be classified as a lithodemic called complex and the most appropriate term is Bentong Complex.

The biggest siliceous sediment block is located at the eastern part of the Bentong-Raub Suture Zone in the

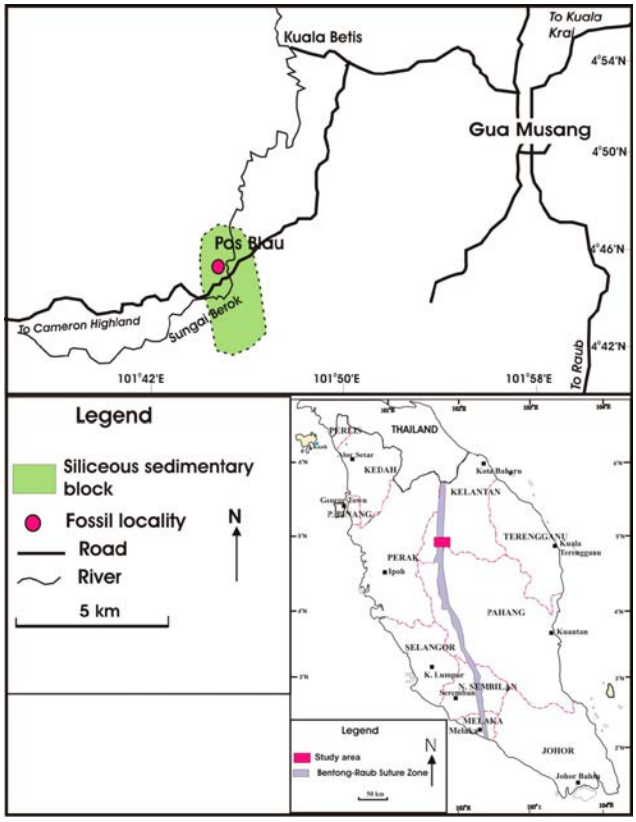

Figure 1: Map showing study area and fossil locality.

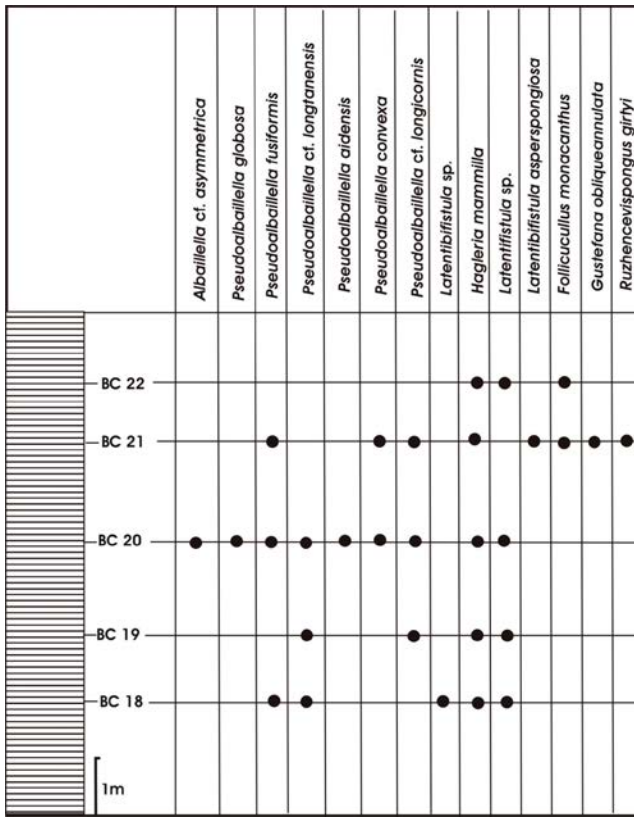

Figure 3: Stratigraphic distribution of radiolarians in the study section.

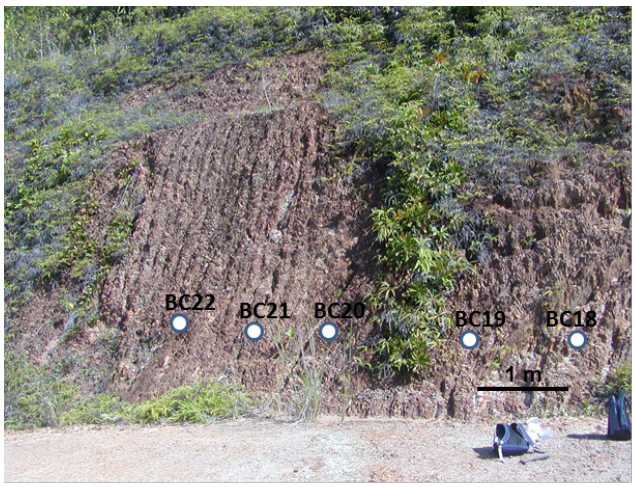

Figure 2: Outcrop of the interbedded siliceous mudstone and tuffaceous mudstone showing sampling sites.

vicinity of Pos Blau. The block extend further south into the oil palm plantation. The size of the block cannot be properly estimated because lacking of outcrop. The chert block exhibits thinly bedded chert interbeds with siliceous mudstone and tuffaceous mudstone. Well bedded ribbon chert is exposed at km 38 Gua Musang-Cameron Highland road.

DESCRIPTION OF OUTCROP

The outcrop is located at an abandoned timber track near Pos Blau (4°45'13"N, 101°45'3"E) (Figure 1). The outcrop is approximately 10 m wide consisting of thinly bedded siliceous mudstone interbeds with tuffaceous mudstone. The rocks are highly weathered and steeply dipping towards southeast (Figure 2).

RESULTS AND DISCUSSION

Radiolarians and Age

Twenty two samples of siliceous mudstone were collected and only 5 samples yielded quite well-preserved radiolarians. The radiolarians exhibit relatively high specific diversity but low number of individuals. A total of fourteen species radiolarians were identified (Plate 1). Stratigraphic distribution of the species is listed in Figure 3. The radiolarians can be grouped into two assemblage zones i.e. *Pseudoalbaillella fusiformis* Zone and *Follicucullus monacanthus* Zone.

Pseudoalbaillella fusiformis Zone

The zone is characterized by the occurrence of *Pseudoalbaillella fusiformis* (Holdsworth and Jones) (Pl. 1, figs. 1,2,3), *Pseudoalbaillella globosa* Ishiga and Imoto (Pl. 1, figs. 4,5,6), *Albaillella* cf. *asymmetrica* Ishiga and Imoto (Pl.1, fig 7), *Pseudoalbaillella* cf. *longtanensis* (Sheng and Wang) (Pl.1, fig. 8), *Pseudoalbaillella convexa* Rudenko and Panasenko (Pl. 1, fig. 9), *Pseudoalbaillella* cf. *longicornis* Ishiga and Imoto (Pl. 1, fig. 10), and *Pseudoalbaillella aidensis* Nishimura and Ishiga (Pl. 1, fig. 11). This zone was proposed by Zhang Ning *et al*. (2010). The lower

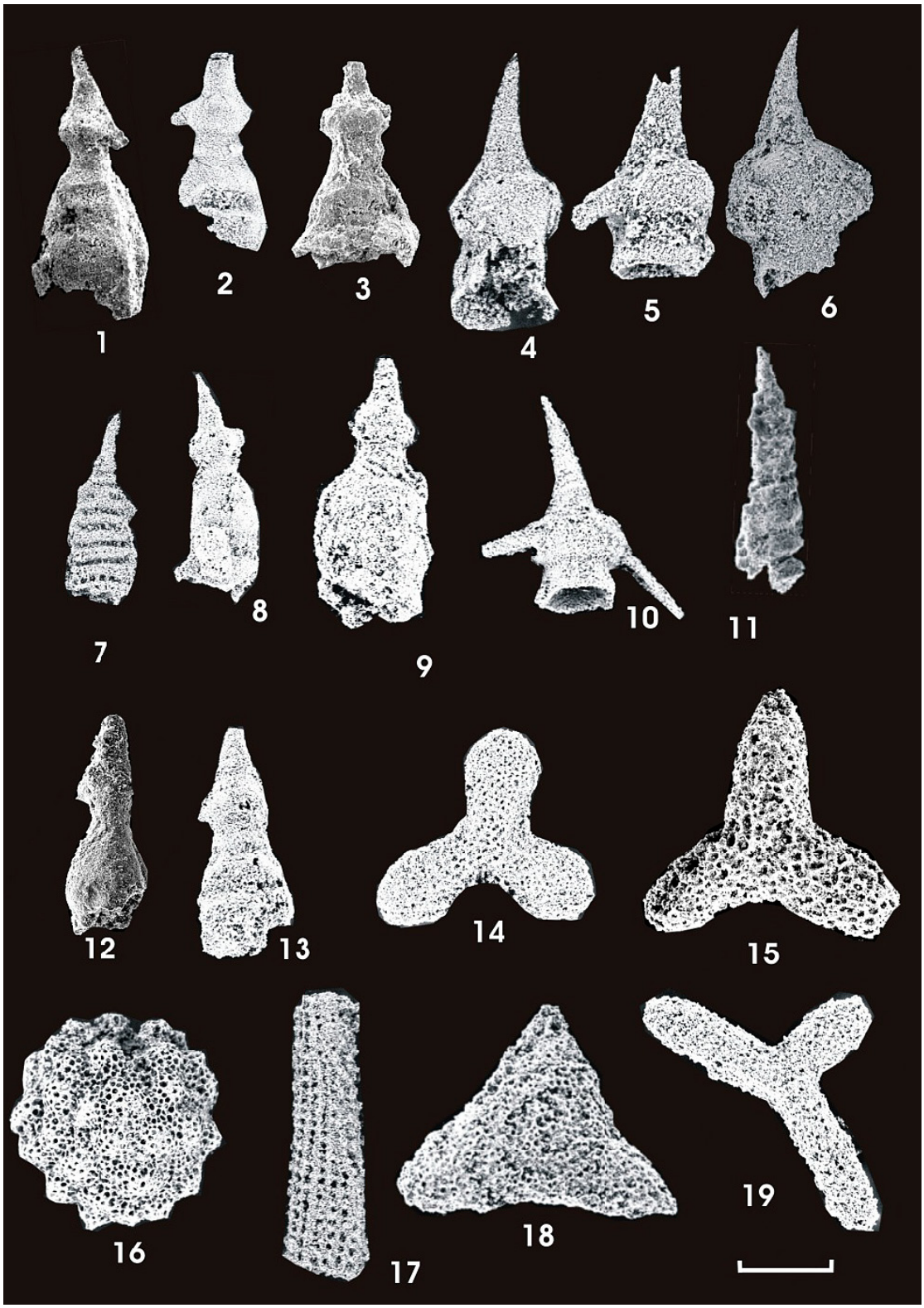

Plate 1: Middle Permian radiolarians from Pos Blau, Kelantan. Scale bar is indicated in the parenthesis. 1, 2. 3. *Pseudoalbaillella fusiformis* (Holdsworth and Jones) (100µm). 4, 5, 6. *Pseudoalbaillella globosa* Ishiga and Imoto (100µm). 7. *Albaillella* cf. *asymmetrica* Ishiga and Imoto (100µm). 8. *Pseudoalbaillella* cf. *longtanensis* (Sheng and Wang)(100µm). 9. *Pseudoalbaillella convexa* Rudenko and Panasenko (135 µm). 10. *Pseudoalbaillella* cf. *longicornis* Ishiga and Imoto (100 µm). 11. *Pseudoalbaillella aidensis* Nishimura and Ishiga (100 µm). 12, 13. *Follicucullus monacanthus* Ishiga and Imoto(100 µm). 14. *Latentibifistula asperspongiosa* Sashida and Tonishi (176 µm). 15. *Latentibifistula* sp. (120 µm). 16. *Hegleria mammilla* Sheng and Wang (138 µm). 17. *Gustefana obliqueannulata* Kozur (120 µm). 18. *Ruzhencevispongus girtyi* Nazarov and Ormiston(100 µm). 19. *Latentifistula* sp. (137 µm).

boundary of the zone is based on the first occurrence of *Pseudoalbaillella fusiformis*. This zone is equivalent to the top part of the *Pseudoalbaillella globosa* Zone (Ishiga, 1991) indicative an age of late Raordian, early Middle Permian. The assemblage is recorded from samples BC 18 to BC 20.

Follicucullus monacanthus Zone

The zone is marked by the occurrence of zonal marker *Follicucullus monacanthus* (Pl. 1, figs. 12, 13) which restricted to the zone. Other species found are *Latentibifistula asperspongiosa* Sashida and Tonishi (Pl. 1 fig. 14), *Latentibifistula* sp. (Pl. 1. Fig.15), *Hegleria mammilla* Sheng and Wang (Pl. 1, fig. 16), *Gustefana obliqueannulata* Kozur (Pl. 1, fig. 17), *Ruzhencevispongus girtyi* Nazarov and Ormiston (Pl. 1, fig. 18) and *Latentifistula* sp. (Pl. 1, fig 19). The assemblage is obtained from samples BC21 and BC22. This assemblage suggests Wordian age, middle Middle Permian.

Pseudoalbaillella fusiformis, Pseudoalbaillella convexa, Pseudoalbaillella cf. *longicornis*, *Hegleria mammilla,* and *Latentifistula* sp. occur in both zones.

Spiller & Metcalfe (1995) and Spiller (2002) were also discovered *Pseudoalbaillella* cf. l*ongicornis, Pseudoalbaillella fusiformis, pseudoalbaillella longtanensis* and *Albaillella asymmetrica* from the tuffaceous argillite and chert near Pos Blau, Kelantan. They assigned the assemblage to the uppermost part *Pseudoalbaillella longtanensis* – lowermost part of *Pseudoalbaillella globosa* Zones. The zone is older than the present material.

Occurrence of Middle Permian Radiolarians in Peninsular Malaysia

Middle Permian radiolarians were also reported from the siliceous sediment from Jengka area, Central Pahang (Basir *et al*., 1995), Kuala Ketil and Pokok Sena, Kedah (Sashida *et al*., 1995; Basir *et al*., 2005; Basir, 2008)(Figure 4). Nine species radiolarians were identified i.e. *Entactinia itsukaichiensis*, *Entactinia* sp., *Hegleria mammilla*, *Hegleria* sp., *Copycyntra* sp., *Copiellintra* sp., *Follicucullus monacanthus*, *Follicucullus japonicus* and *Pseudoalbaillella globosa*. This assemblge was previously assigned to the *Follicucullus japonicus* Zone of Ishiga (1991). *Follicucullus japonicus* Ishiga (1991) is a junior synonomy of *Follicucullus porrectus* Rudenko (1984). The assemblage is now included in the *Follicucullus monacanthus* Zone.

In the Western Belt of Peninsular Malaysia, Middle Permian Radiolarians were reported mainly from the Semanggol Formation at Bukit Yoi, Pokok Sena, Kedah (Basir, 2008) and from Bukit Kukus, Kuala Ketil area, south Kedah (Basir *et al*., 2005). Middle Permian Radiolarians from Bukit Yoi comprise *Pseudoalbaillella globosa* together with *Pseudoalbaillella yanaharensis*, *Pseudoalbaillella fusiformis*, *Pseudoalbaillella* cf. *longicornis*, *Latentifistula texana, Raciditor inflata*, *Pseudoalbaillella* sp. and *Ishigaum* sp. This assemblage is indicating Roardian in age. Middle Permian *Follicucullus monacanthus* Zone was also reported from Bukit Barak, near Pokok Sena, Kedah (Sashida *et al*., 1995). In Kuala Ketil area, south Kedah two Middle Permian radiolarian zones were recognized namely *Follicucullus monacanthus* and *Follicucullus porrectus* Zones (Basir *et al*., 2005). The zones contain very low number of species.

The most common feature shared by the Middle Permian siliceous sediments from the three areas namely Jengka, Pahang; Pos Blau, Kelantan; Bukit Yoi, and Bukit Kukus, Kedah is the occurrence of tuffaceous sediments interbedded with siliceous mudstone. The tuffaceous mudstone was reported from Jengka (Basir *et al*., 1995), Bukit Kukus (Basir *et al*., 2005), Bukit Yoi (Basir, 2008) and Pos Blau (Spiller & Metcalfe, 1995; Spiller, 2002). Middle Permian tuffaceous material was also recorded from Northern Johor (Sone *et al*., 2003) and Bera, south Pahang (Sone & Leman, 2005). This suggests that tuffaceous material was quite widespread in the Middle Permian of Peninsular Malaysia. At Bukit Kukus, Kedah the tuffaceous material was found below the *Pseudoalbaillella scalprata rhombothoracata* Zone in Early Permian (Basir *et al*., 2005). The tuffaceous material had diluted the siliceous sediments and prevented the formation of radiolarians chert during Middle Permian.

Tectonics implications

Paleozoic-Lower Mesozoic sedimentary sequences in Langkawi and Perlis consist of shallow marine environment namely the Machinchang, Setul, Singa, Kubang Pasu and Chuping Formations. The whole sequences were deposited in continental shelf environment. In Kedah, the sedimentary sequences of the Mahang, Kubang Pasu and Semanggol Formations were deposited in deeper water ranging from deep-sea fan (continental rise) to basin environment (Basir, 1999). These formations represent the passive continental margin of the Sibumasu terrane.

Since the Sibumasu terrane was a passive margin, the source of the tuffaceous material was originated from the volcanism in the East Malaya/Indochina terrane. This volcanism was related to an early phase of closing the Palaeo-Tethys where the oceanic plate of the Palaeo-Tethys subducted under the East Malaya/Indochina terrane during Middle Permian. Azman (2009) reported the oldest acid volcanic rock from Pulau Sibu, Johor which indicate an age of 297 Ma, Early Permian. This was probably the source of tuffaceous material in the Permian sediments. The collision took place at Bentong-Raub Suture Zone where the accretionary complex developed (Tjia & Almashoor, 1996).

The occurrence of Middle Permian oceanic sediments (radiolarian bearing siliceous sediments) indicate the Palaeo-Tethys was divided into two depositional basins namely the Semanggol basin in the Western Belt and Semantan/ Gua Musang/Aring basin in Central Belt (Sashida *et al*., 1995). These basins were separated by Bentong-Raub Suture Zone (Figure 5). The Palaeo-Tethys became narrow and shallow during Triassic where patchy of limestone beds were deposited (Fontaine *et al*., 1995) and the volcanic activities became more intense in the Central Belt. At the end of Triassic there was an uplifting episode caused by

the emplacement of granite and finally the Palaeo-Tethys diminished.

CONCLUSION

Middle Permian radiolarians from Pos Blau were recovered from the siliceous mudstone interbeds with tuffaceous mudstone. Two radiolarian assemblages were identified namely, *Pseudoalbaillella fusiformis* and *Follicucullus monacanthus* Zones, which represent late Roardian and Wordian age respectively. Similar radiolarian assemblages were also reported in siliceous mudstone associated with tuffaceous sediments from the Semanggol Formation in the Western Belt and in Jengka area Central Belt. Widespread occurrence of tuffaceous material in Western and Central Belts was related to volcanism as a result of collision between Palaeo-Tethys oceanic crust and the East Malaya terrane. The Palaeo-Tethys subducted under the East Malaya terrane, the convergence processes continued and the Palaeo-Tethys became narrower and shallower in Triassic. Finally, Palaeo-Tethys disappeared in Late Triassic by an uplifting episode caused by granite intrusion.

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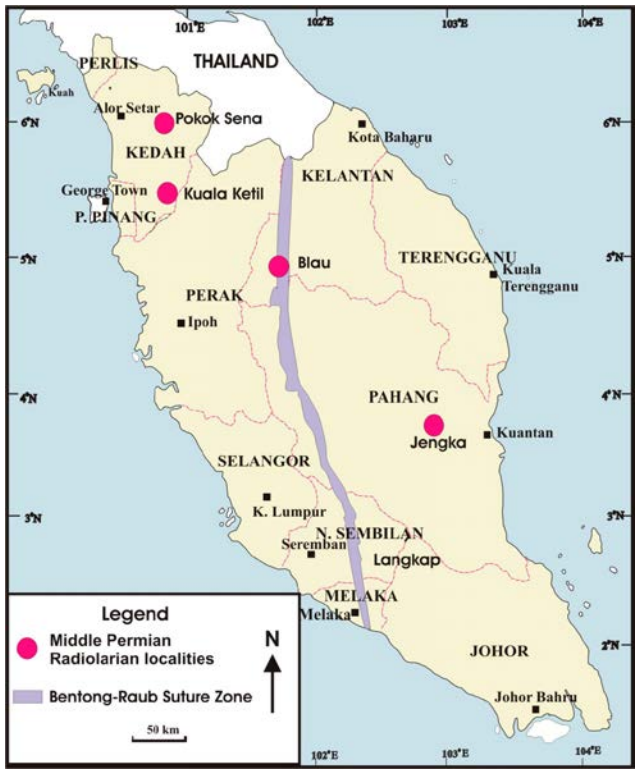

Figure4: Geographical distribution of Middle Permian radiolarian siliceous sediments associated with tuffaceous mudstone.

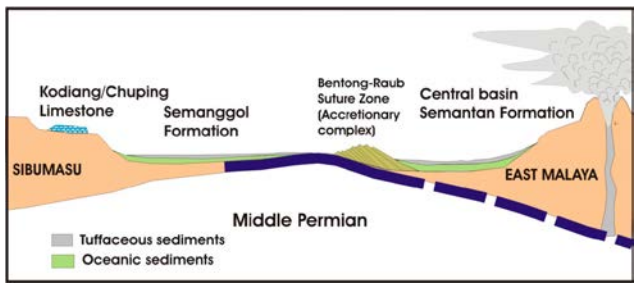

Figure 5: Tectonic setting of the Palaeo-Tethys basin during Middle Permian of Peninsular Malaysia (modified after Metcalfe, 2000).

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