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Chert blocks in Bentong-Raub Suture Zone: A heritage of Palaeo-Tethys

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Abstract: Bentong-Raub Suture Zone is considered as a collision zone between the Sibumasu and East Malaya (Indochina) terranes. Sibumasu was a part of the Cimmerian plate, which was attached to Gondwana during the Carboniferous. East Malaya was attached to the Indochina plate. From the Devonian to the Permian the Sibumasu and East Malaya blocks were separated by an ocean called Palaeo-Tethys. The closure of Palaeo-Tethys was completed during the Triassic. The major part of the history of the Palaeo-Tethys was destroyed and only a small portion is still preserved in blocks of oceanic sedimentary rocks such as cherts. The chert blocks are exposed in several localities along the Bentong-Raub road (3°35'N, 101°54'E), Gua Musang-Cameron Highland road (4°45'N, 101°45'E) and at a road-cut in Langkap (2°38'N, 102°21'E). The chert blocks consist of thinly bedded chert interbeded with mudstone. Some chert layers contain radiolarians. The oldest chert block found at Bentong-Raub road-cut yielded an assemblage of radiolarians belonging to the *Trilonche minax* Zone of early Frasnian, (early Late Devonian) age. A chert block from Langkap, Negeri Sembilan yielded radiolarians belonging to the *Albaillella deflandrei* Assemblage Zone, Tournaisian, (Early Carboniferous) age. Permian radiolarians were retrieved from several chert blocks in the vicinity of Pos Blau, Ulu Kelantan. The youngest radiolarian assemblage in the area is from the *Follicucullus monacanthus* Assemblage Zone indicating Wordian, (Middle Permian) age. The occurrence of radiolarian chert suggests high plankton productivity during the Late Devonian, Early Carboniferous and Permian. These chert blocks are the natural heritage of the Paleo-Tethys which needed to be conserved as National Heritage sites.

Keywords: chert block; Benton-Raub Suture Zone; radiolarians, Palaeo-Tethys, heritage

Abstrak: Zon Sutura Bentong-Raub dianggap sebagai satu zon pelanggaran antara teran Sibumasu dan teran Malaya Timur (Indochina). Sibumasu merupakan sebahagian daripada kepingan Cimmeria yang masih bercantum dengan Gondwana semasa Karbon. Teran Malaya Timur pula bercantum dengan Kepingan Indochina. Dari Devon hingga Perm Sibumasu dan Malaya Timur dipisahkan oleh lautan yang dikenali sebagai Palaeo-Tethys. Penutupan Palaeo-Tethys tamat pada masa Trias. Sebahagian besar sejarah Palaeo-Tethys telah termusnah, hanya sebahagian kecil yang masih terawet dalam batuan enapan kelautan seperti rijang. Bongkah rijang tersingkap di beberapa lokaliti di sepanjang jalan Bentong-Raub (3°35'U, 101°54'T), Gua Musang - Cameron Highland (4°45'U, 101°45'T) dan singkapan jalan dekat Langkap (2°38'U, 102°21'T). Bongkah terdiri daripada lapisan nipis rijang berselang lapis dengan batu lumpur. Beberapa lapisan rijang mengandungi radiolarian. Bongkah rijang yang paling tua ditemui dekat singkapan jalan Bentong-Raub yang menghasilkan himpunan radiolarian daripada Zon Himpunan *Trilonche minax* berusia Frasnian awal, awal Devon Akhir. Bongkah rijang dari Langkap, Negeri Sembilan menghasilkan radiolaria daripada Zon Himpunan *Albaillella deflandrei*, Tournaisian, Karbon Awal. Radiolaria Perm ditemui dalam beberapa bungkah rijang dekat Pos Blau, Ulu Kelantan. Himpunan radiolaria yang termuda di kawasan ini ialah daripada Zon Himpunan *Follicucullus monacanthus* menunjukkan usia Wordian, Perm Tengah. Kewujudan rijang berradiolaria mencadangkan berlaku produktiviti plankton yang tinggi semasa Devon Akhir, Karbon Awal dan Perm. Bongkah-bongkah rijang ini merupakaan warisan tabii Palaeo-Tethys yang perlu di pulihara sebagai tapak Warisan Kebangsaan.

INTRODUCTION

The Bentong–Raub Suture Zone (Metcalfe, 2000) extends from Tomo, southern Thailand southwards through Bentong and Raub to Melaka (Tjia, 1989) (Figure 1). It is an extension of the Nan-Uttaradit suture of Thailand. The Bentong-Raub line was proposed by Hutchison (1973) as the major tectonic boundary between the Western and Central belts of Peninsular Malaysia. Hutchison (1975) named it the Bentong-Raub ophiolite line. Tjia (1989) extended to the suture further south to Bengkalis, Sumatra and named it the Bentong-Bengkalis suture. The suture zone extends northwards to Lancangjian, Changning–Menglian, Yunnan Province Southwest China and Chiangmai, north Thailand (Metcalfe, 2000). The Lancangjian, Changning–Menglian, Chiangmai and Bentong-Raub suture Zones represent the main Palaeo-Tethys ocean.

The Bentong-Raub suture Zone in Peninsular Malaysia is located between the Sibumasu Terrane and the East Malaya (Indochina) Terrane. The Sibumasu terrane was attached to the Cimmerian plate and the East Malaya terrane attached to the Indochina and the South China plate. The Sibumasu and East Malaya blocks were separated by an ocean called Paleo-Tethys. The opening of the Palaeo-Tethys was initiated when the sliver of North and South China, Indochina and Tarim plate rifted from Gondwanaland during Devonian. The Palaeo-Tethys was diminished when the Sibumasu terrane

collided with East Malaya (Indochina) terrane during the Triassic. The remnant of Palaeo-Tethys was only preserved in the chert blocks in the Bentong-Raub Suture Zone.

GEOLOGY OF BENTONG-RAUB SUTURE ZONE.

The Bentong-Raub Suture Zone is well-exposed at road-cuts along the Gua Musang-Cameron Highland road, Karak Highway and Bentong- Raub road. The suture is an approximately13 km wide zone of deformed rocks consists of schist, phyllite, meta-sedimentary rocks, sandstone, cherts, olistostrome and mélange (Tjia & Almashoor, 1996). Metcalfe (2000) estimated the suture to be approximately 20 km wide. Small serpentinite bodies are also found in the suture zone at Pos Mering, Sungai Cheroh, Durian Tipus and Bukit Rokan (Metcalfe, 2000). But there is little evidence to support the presence of true ophiolites along the Bentong–Raub Suture Zone.

The Bentong-Raub Suture Zone is marked by a belt of mélange and olistotrome which comprise blocks or clasts of cherts, sandstone, limestone, conglomerate, interbedded sandstone and mudstone and tuffaceous mudstone embedded in a sheared matrix of mudstone. The sizes of clasts vary from a few cm to hundreds of meters. The most important clasts/ blocks are cherts which are considered to represent the oceanic sedimentary rocks.

WHAT IS RADIOLARIAN CHERT

Radiolarian chert (radiolarite) is a microcrystalline or cryptocrystalline biogenic sedimentary rock composed of siliceous skeletons of radiolarians (Figure 2). The chert comprises chalcedony or opaline silica, usually as thinly bedded ribbon chert. Radiolarians occur almost exclusively in the open ocean as part of the plankton community. Their skeletons occur abundantly in oceanic sediments. Development of radiolarian chert is related to the planktic productivity of the ocean at a distance from the continental margin. The plankton productivity is controlled by the amount of nutrients. High productivity is related to the upwelling of nutrient-rich bottom water which brings the material to the surface. The deposition of chert is usually episodic. The radiolarian cherts are well-developed in an oceanic realm where the supply of clastic material is lacking. The chert can be used as an indicator of oceanic sediment. The occurrence of radiolarian chert blocks in the Bentong-Raub Suture Zone represents the remnant of the Palaeo-Tethys sediments.

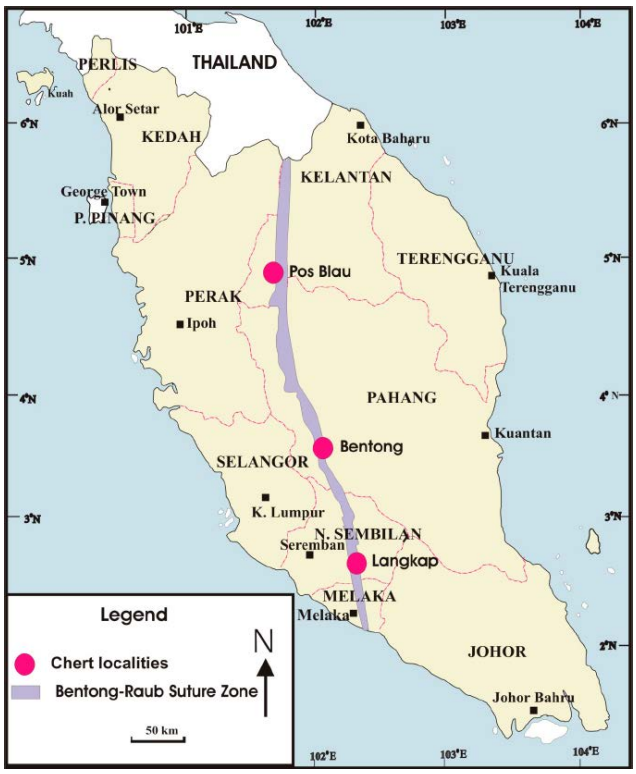

Figure 1: Bentong-Raub Suture Zone and the radiolarian chert blocks localities.

THE OCCURRENCE OF CHERT BLOCKS

The chert blocks in the Bentong-Raub Suture Zone are mainly associated with clastic sediments such as mudstone and sandstone, which were metamorphosed in places to form schist or/and phyllite. This rock association is considered as a continental margin chert association (Jones & Murchey, 1986). Although blocks of serpentinite were reported in Sungai Rokan, Negeri Sembilan, Sungai Cheroh, Pahang, and Sungai Cherderoh, Kelantan (Metcalfe, 2000) there was no apparent ophiolitic-chert association observed in the zone. Spiller & Metcalfe (1995) reported that Cerium anomaly values indicate the chert was deposited in an ocean basin. The absence of carbonate rock in the chert sequence suggests that the chert was deposited in a deep marine environment below the calcite compensation depth.

Chert blocks have been recorded in many localities in the suture zone at Langkap, Negeri Sembilan; Genting Sempah, Selangor; Karak and Bentong, Pahang; and Pos Blau, Kelantan (Spiller, 2002; Basir & Che Aziz, 1997a,1997b, Basir *et al*., 2004). Three of these chert blocks yielded significant radiolarian faunas and are hereby proposed to be considered for conservation as heritage of the Malaysian Palaeo-Tethys (Figure 1).

- Chert block from Bentong, Pahang.
- Chert block from Langkap, Negeri Sembilan
- Chert block from Pos Blau, Kelantan.

The chert blocks yielded three different radiolarian assemblages belong to three different ages.

Chert Block from Bentong, Pahang

The chert block is exposed at a road-cut of Bentong-Raub road (3°35'N, 101°54'E). The outcrop consists of mélange containing blocks of ribbon chert, siliceous mudstone and massive dark gray sandstone. The width of the chert block is approximately 30m. The chert layers are strongly faulted (Figure 3).

Basir *et al*. (2004) identified ten taxa of radiolarians and wrongly assigned it to Femennian age. The occurrence of *Trilonche minax* (Hinde), *Trilonche davidi* (Hinde),

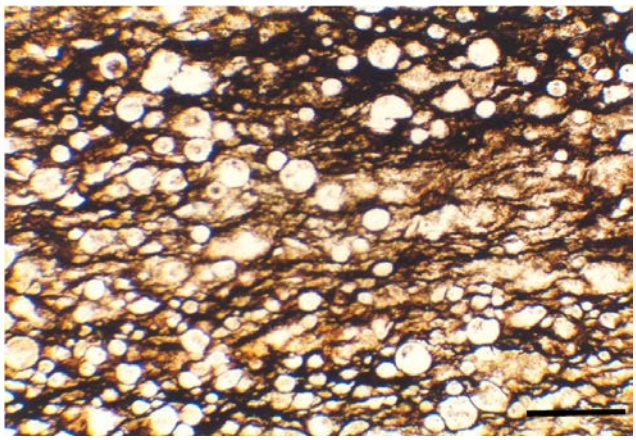

Figure 2: Photographs of radiolarian chert in thin section (Scale bar = 0.3mm).

Figure 3: Chert block exposed at Bentong-Raub road (3°35'N, 101°54'E).

Figure 4: A small part of the chert block exposed at Langkap, Negeri Sembilan. The outcrop is covered by thick vegetations (2°38'N, 102°21'E).

Figure 5: Ribbon chert exposed at Pos Blau Ulu Kelantan. (4°45'N, 101°45'E) (Scale bar = 1m).

Trilonche vestusa Hinde, *Trilonche tretactinia* (Foreman), and *Stigmosphaerostylus herculean* (Foreman) (Plate 1, figs. 1-5) represent the *Trilonche minax* assemblage zone of Aitchison *et al*., (1999) indicating early Frasnian (early Late Devonian) age. This is the oldest radiolarian chert in Bentong-Raub Suture Zone. Spiller (2002) reported *Holoeciscus* Assemblage Zone, middle and upper Famennian (late Devonian) from radiolarian chert blocks in Karak, Pahang.

Chert Block from Langkap, Negeri Sembilan

The Langkap chert is exposed at a road-cut near Langkap, Negeri Sembilan (2°38'N, 102°21'E), The chert block is located within the Bentong-Raub Suture Zone. It is faulted and folded. The chert layers strikes 060° and dips 50° (Figure 4). The chert block is approximately 105 m long. The lower part comprises chert layers interbedded with thinly bedded mudstone. The top part consists of black laminated mudstones which contain well-preserved radiolarians.

The chert sequence in Langkap yielded 34 radiolarians (Basir & Che Aziz, 1997a). The occurrence of *Albaillella deflandrei* Gourmelon, *Albaillella paradoxa* Deflandre, *Albaillella undulata* Deflandre, *Albaillella indensis ambigua* Braun, *Ceratoikiscum avimexpectans* Deflandre, *Ceratoikiscum berggreni* Gourmelon, and *Ceratoikiscum umbriculum* Won (Plate 1, figs. 6-12) indicates a Tournaisian (Early Carboniferous) age. Spiller & Metcalfe (1995), and Spiller, (2002) reported the occurrence of Late Devonian and Early Carboniferous radiolarians from the same locality.

Chert Blocks from Pos Blau, Kelantan

Several chert blocks are exposed at the Gua Musang-Cameron Highland road. The sizes of the chert blocks range from 30 m to several hundred metres. The largest block is located at Pos Blau (4°45'N, 101°45'E). The block has red coloured ribbon-chert (Figure 5).

Twenty two species of radiolarians were identified from the chert block (Basir & Che Aziz, 1997b). The zone is characterized by the occurrence of the zonal marker *Pseudoalbaillella lomentaria* Ishiga and Imoto, *Pseudoalbaillella ornata* Ishiga and Imoto, *Pseudoalbaillella sakmarensis* Kozur, *Pseudoalbaillella scalprata scalprata* Ishiga and *Pseudoalbaillella scalprata postscalprata* Ishiga (Plate 2, figs.1-5). The assemblage is indicative of a late Asselian-early Sakmarian (Early Permian) age.

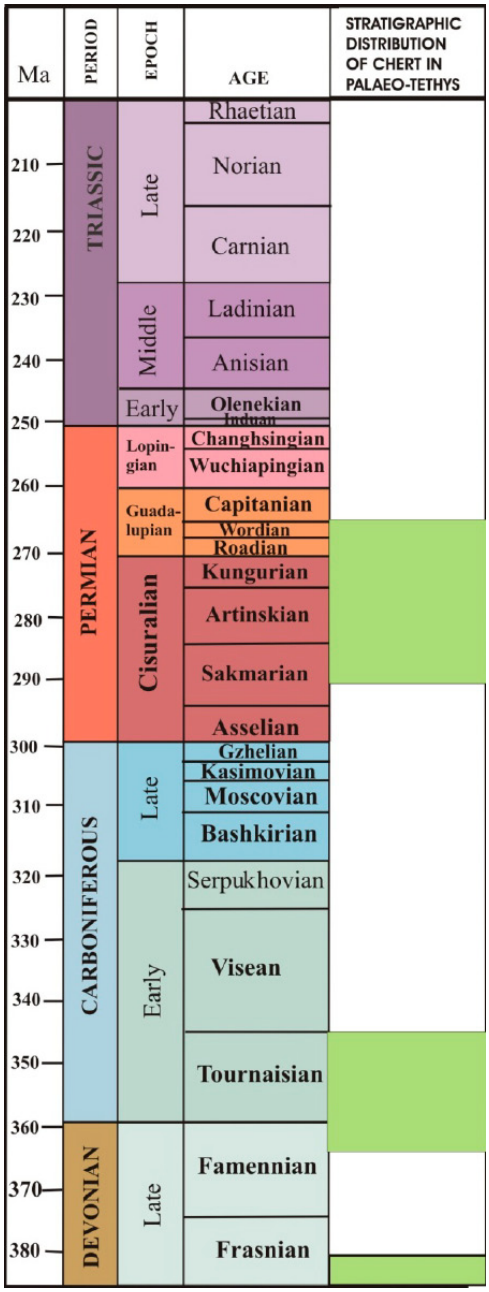

Figure 6: Stratigraphic distribution of radiolarian cherts in the Bentong-Raub Suture Zone.

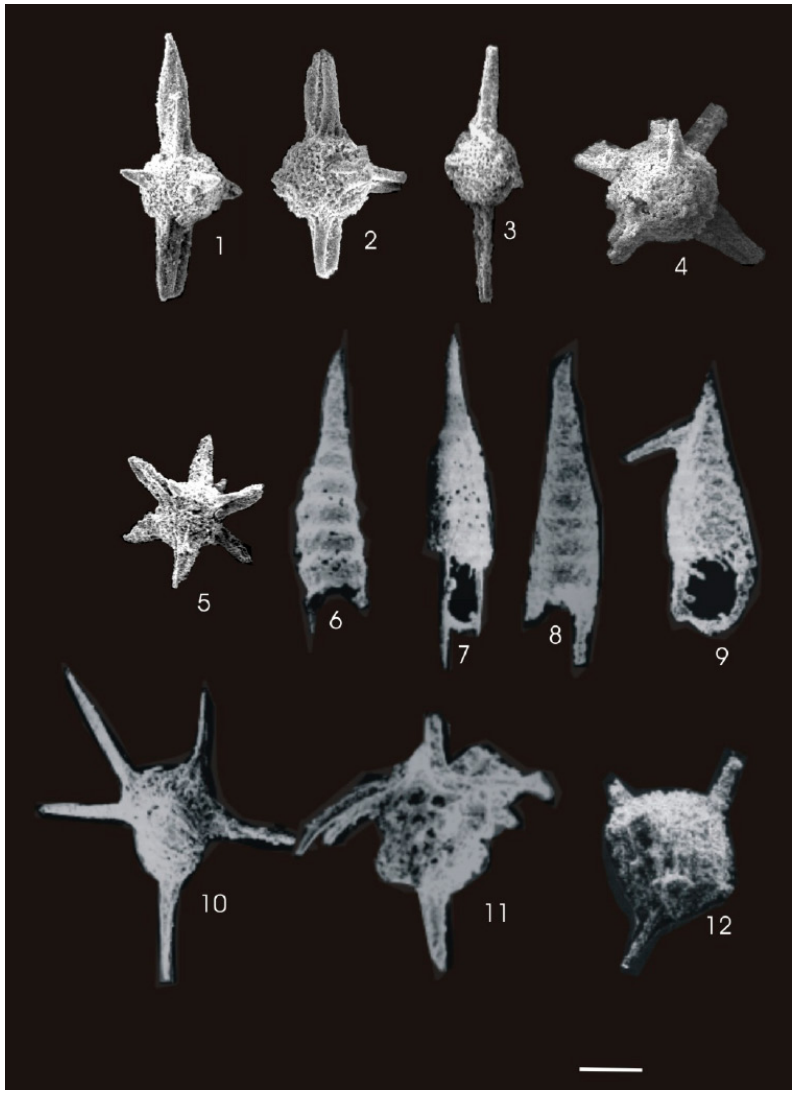

Plate 1: Late Devonian and Early Carboniferous radiolarians from Bentong-Raub Suture Zone. (Scale bar is indicated in the parentheses). 1. *Trilonche minax* (Hinde) (100µm), 2. *Trilonche davidi* (Hinde)(75µm), 3. *Trilonche vitusta* (Hinde) (100µm), 4. *Trilonche tretactinia* (Foreman) (100µm), 5. *Stigmosphaerostylus herculean* (Foreman) (75µm), 6. *Albaillella deflandrei* Gourmelon (100µm), 7. *Albaillella paradoxa* Deflandre (200µm), 8. *Albaillella undulata* Deflandre (133µm), 9. *Albaillella indensis ambigua* Braun (100µm), 10. *Ceratoikiscum avimexpectans* Deflandre (133µm), 11. *Ceratoikiscum berggreni* Gourmelon (100µm), 12. *Ceratoikiscum umbraculum* Won (133µm).

Recently, more radiolarian species have been recovered from a chert block near Sungai Berok (4°44'49''N 101°45'05''E). The chert yielded at least two assemblages of radiolarians. The first assemblage contains *Pseudoalbaillella longtanensis* Sheng & Wang, *Pseudoalbaillella nanjingensis* Sheng & Wang, *Pseudoalbaillella globosa* Ishiga & Imoto, *Pseudoalbaillella* cf. *longicornis* Ishiga & Imoto, *Albaillella asymmetrica* Ishiga and Imoto, *Pseudoalbaillella fusiformis* Holdsworth & Jones (Plate 2, figs. 6-11). This assemblage belongs to *Pseudoalbaillella globosa* Assemblage Zone (Ishiga, 1990). Another assemblage contains *Follicucullus scholasticus* Ormiston & Babcock, *Follicucullus monacanthus* Ishiga & Imoto, and *Hagleria mammilla* (Sheng and Wang) (Plate 2, figs. 12-15) that represent the *Follicucullus monacanthus* Assemblage Zone of Wordian (Middle Permian) age (Ishiga, 1990). This *Follicucullus monacanthus* zone is the youngest zone obtained from the chert blocks in the Bentong-Raub Suture Zone to date.

HISTORICAL SIGNIFICANCE OF CHERTS

The radiolarian cherts in the Bentong-Raub Suture Zone indicate that radiolarian productivities were very high at times during the Late Devonian, Early Carboniferous, and late Early Permian to Middle Permian (Figure 6). The Early Carboniferous and Middle Permian radiolarian cherts were deposited during the global hypersiliceous period (Racki & Cordey, 2000).

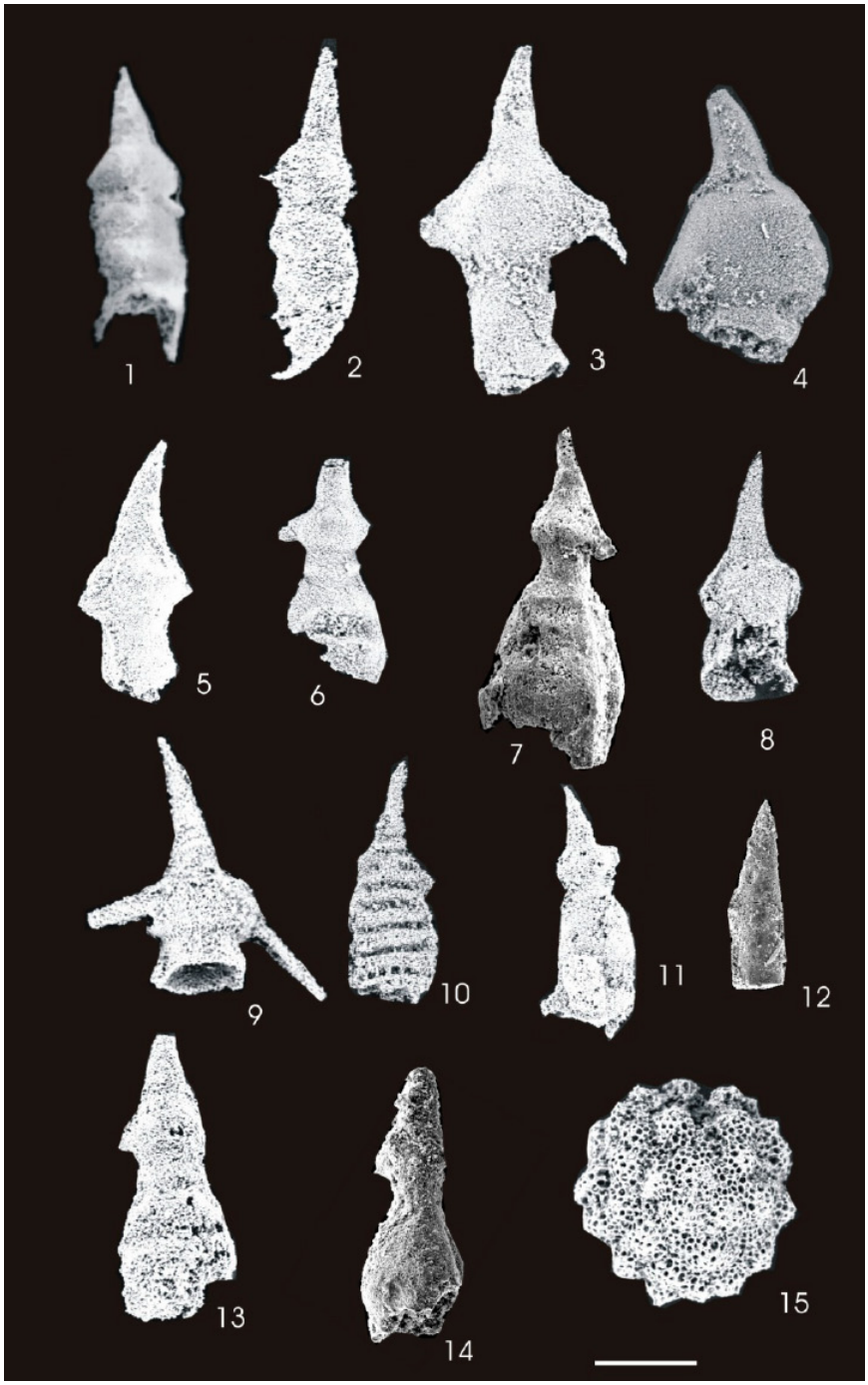

Plate 2: Permian Radiolarians from Chert Block Pos Blau, Ulu Kelantan. (Scale bar= 100µm).
1. *Pseudoalbaillella lomentaria* Ishiga & Imoto,
2. *Pseudoalbaillella sakmarensis* (Kozur),
3. *Pseudoalbaillella scalprata* m. *rhombothoracata* Ishiga and Imoto,
4. *Pseudoalbaillella scalprata* m. *scalprata* Holdsworth & Jones,
5. *Pseudoalbaillella scalprata* m. *postscalprata* Ishiga,
6. *Pseudoalbaillella longtanensis* Sheng & Wang,
7. *Pseudoalbaillella nanjingensis* Sheng & Wang,
8. *Pseudoalbaillella globosa* Ishiga & Imoto,
9. *Pseudoalbaillella* cf. *longicornis* Ishiga & Imoto,
10. *Albaillella asymmetrica* Ishiga & Imoto,
11. *Pseudoalbaillella fusiformis* Holdsworth & Jones,
12. *Follicucullus scholasticus* Ormiston & Babcock,
13, 14. *Follicucullus monacanthus* Ishiga & Imoto,
15. *Hagleria mammilla* (Sheng & Wang).

Radiolarian chert blocks in the Bentong-Raub Suture Zone are the remnants of oceanic sediments deposited in Palaeo-Tethys Ocean. The Palaeo-Tethys was developed during the Early or Middle Devonian. During the early Frasnian (Late Devonian), the Palaeo-Tethys was an ocean where the oldest radiolarian chert was deposited. The Palaeo-Tethys became wider during the Carboniferous. The Palaeo-Tethys oceanic crust collided and subducted eastwards under the East Malaya terrane during Late Permian (Mitchell, 1977). The Palaeo-Tethys became a shallow sea during Early Triassic and was dominated by scattered fossiliferous limestone (Fontaine *et al.*, 1995). The closure of Palaeo-Tethys was completed during Triassic and to form the Bentong-Raub Suture Zone (Figure 7). More than 120 million years history of sedimentation of the Palaeo-Tethys has been destroyed by the collision and only small fractions of the palaeo-ocean are preserved in the chert blocks within the mélange of the Bentong-Raub Suture.

CHERTS AS NATURAL HERITAGE

The operational guideline for implementation of the World Heritage Convention (UNESCO, 1995) has set up a list of criteria for natural heritage sites. The sites nominated should be *outstanding examples* representing *major stages*

of earth's history, including the record of life, *significant* on-going geological processes in the development of land forms, or significant geomorphic or physiographic features.

The chert blocks of the Bentong-Raub Suture Zone represent a very important history of the Palaeo-Tethys and should be conserved as a National heritage. It is recommended that these three sites of the chert blocks from Langkap. Negeri Sembilan; Bentong, Pahang; and Pos Blau, Kelantan to be proposed at least as National Heritage sites and perhaps even as a regional heritage sites.

CONCLUSION

Radiolarian cherts are oceanic sedimentary rocks usually deposited in deep-ocean basins. The cherts are thinly bedded and known as ribbon cherts. The absence of calcareous fossils in the cherts indicates that the cherts were deposited below the Calcite Compensation Depth. Radiolarian chert blocks in the Bentong-Raub Suture Zone are remnant of the Palaeo-Tethys ocean. They are very important for age determination and paleobiogeographic studies. The occurrence of Frasnian radiolarian chert suggests that the Palaeo-Tethys already existed during the early Late Devonian and continued through to the Carboniferous and Permian. The youngest chert in the Bentong-Raub Suture Zone is Wordian (Middle Permian). The deposition of chert was diminished in the Late Permian and the Palaeo-Tethys became a narrow shallow sea during Triassic. The 120 million years history of Palaeo-Tethys was partially recorded in the radiolarian cherts blocks. The oceanic sedimentary rocks were deformed and destroyed during the collision of Sibumasu terrane and East Malaya Terrane. Only chert blocks are left as remnants of the Palaeo-Tethys. The chert blocks could be conserved as National Heritage sites.

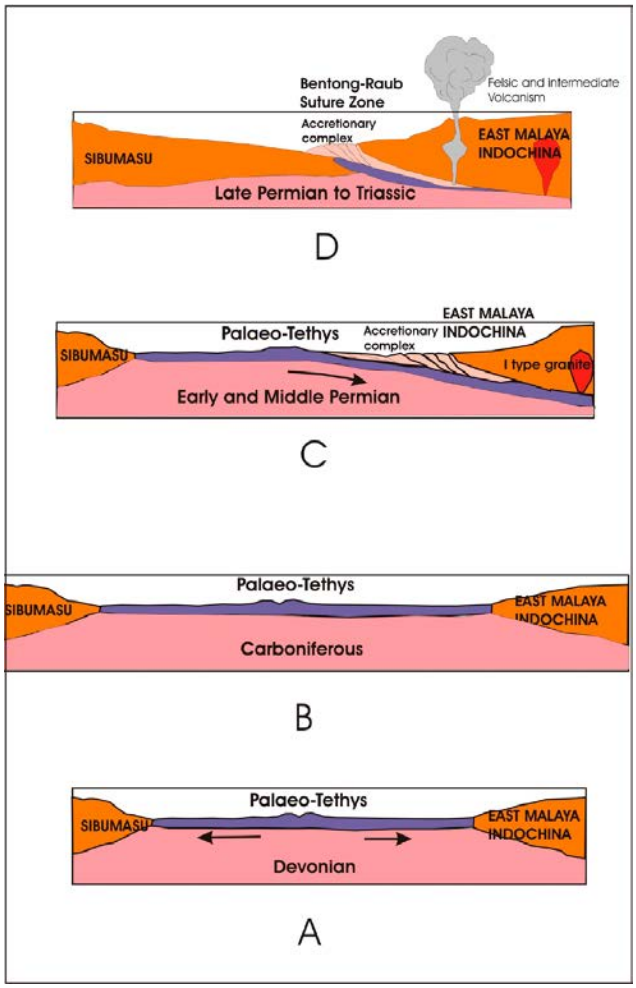

Figure 7: Evolution of the Palaeo-Tethys based on radiolarian cherts (modified after Metcalfe, 2000). A. Opening of Palaeo-Tethys during Devonian, B. Palaeo-Tethys became wider ocean during Carboniferous, C. The Palaeo-Tethys subducted under the East Malaya / Indochina Terrane, D. Collision between Sibumasu and East Malaya / Indochina terranes during Late Permian- Triassic.

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