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Triassic Radiolarian Biostratigraphy of the Semanggol Formation, south Kedah, Peninsular Malaysia

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Abstract: Twenty-seven taxa of the Triassic radiolarian faunas have been identified from seven chert samples collected from an outcrop exposed at a construction site 4.5km east of Kuala Ketil, south Kedah. The faunas were divided into four assemblage zones: *Entactinosphaera chiakensis* Zone, late Spathian, *Triassocampe coronata* Zone, middle Anisian, *Triassocampe deweveri* Zone, late Anisian and *Oertlispongus inaequispinosus* Zone, early Ladinian. The radiolarian assemblages indicate an age ranging from late Spathian to early Ladinian, Triassic.

Abstrak: Dua puluh tujuh taksa radiolaria Trias telah dikenal pasti daripada tujuh sampel rijang diambil daripada satu singkapan yang terdedah pada tapah binaan 4.5 km di timur Kuala Ketil, selatan Kedah. Fauna dibahagikan kepada empat zon himpunan; Zon *Entactinosphaera chiakensis*, Spathian akhir, Zon *Triassocampe coronata*, Anisian tengah, Zon *Triassocampe deweveri*, Anisian akhir dan Zon *Oerlispongus inaequispinosus*, Ladinian awal. Himpunan radiolaria menunjukkan julat usia dari spathian akhir hingga Ladinian awal, Trias.

INTRODUCTION.

Triassic siliceous rocks have been recorded from the Semanggol Formation, and the Kodiang Limestone in northwest Peninsular Malaysia. Triassic radiolarians have been discovered from the chert unit of the formations. The chert unit of the Semanggol Formation yielded Middle Triassic radiolarian assemblage, representing *Triassocampe deweveri Assemblage* Zone (Basir Jasin, 1994,1997; Spiller and Metcalfe, 1995). Basir Jasin (1994) discovered Triassic radiolarians from two localities of Bukit Tembaga and Pokok Pauh in north Kedah and at a locality in Merbau Pulas, south Kedah. Spiller (2002) recorded two assemblage zones; *Triassocampe coronata* Zone from the Kuala Nerang area and *Triassocampe deweveri* Zones from Bukit Tembaga, which indicate an age of middle Anisian to late Ladinian respectively.

Two assemblages of radiolarians were recorded from the Kodiang Limestone. The late Early Triassic radiolarian assemblage has been recovered from the lower part of the Kodiang Limestone exposed at Bukit Kechil (Basir Jasin and Zaiton Harun, 2001). The other assemblage recovered from the cherty packstone unit at Bukit Kodiang indicates an age of Carnian-Norian, Late Triassic (Basir Jasin *et al.* 1995).

Recently, we have collected some chert samples from an outcrop of the Semanggol Formation in south Kedah approximately 4.5 km east of Kuala Ketil town. The chert yielded plenty of moderately well preserved radiolarians.

GEOLOGICAL SETTING

Courtier (1974) recorded four sedimentary formations in the area i.e. Mahang Formation, Sungai Petani Formation, Tawar Formation and Semanggol Formation. However, Burton (1988) considered that the Sungai Petani Formation is equivalent to the Mahang Formation, while the Tawar Formation constitutes one facies of the Semanggol Formation. Burton (1988) recognized two formations in the area, i.e. the Mahang Formation (Ordovician to Early Devonian) and the Semanggol Formation (Early Permian to Late Triassic). Burton (1988) considered the Semanggol Formation unconformably overlying the Mahang Formation. There is no stratigraphic contact observed between the two formations. The boundary between the two formations is a fault contact. Both formations were deposited in a deep-water environment and apparently there was no record of tectonic uplifting during the Late Devonian to Early Permian in the area. No Late Devonian- Early Permian rocks have been discovered to date. A detailed study must be carried out to solve the stratigraphic problems of the area.

The Semanggol Formation comprises three units i.e. the chert unit, interbedded sandstone and mudstone unit (rhythmite) and conglomerate unit. The three units are widespread in north Kedah. The formation consists of the chert and the interbedded sandstone and mudstone units (rhythmite) in south Kedah. In north Perak, only the conglomerate and the interbedded sandstone and mudstone units (rhythmite) are exposed. The Semanggol Formation is folded and faulted.The conglomerate forms prominent hills in north Kedah and north Perak. The chert unit forms a low undulating strike ridge in north and south Kedah.

Burton (1973) noted that the chert unit (member) contains chert, black carbonaceous shale or mudstone and greywacke. Earth quarrying and excavating activities in north and south Kedah exposed extensive outcrops of the Semanggol Foramtion. More rock types are observed especially in the chert unit. The chert unit is composed of chert, black mudstone, tuff, tuffaceous sandstone, interbedded sandstone and mudstone. Tuff is widespread in the chert unit in north and south Kedah.

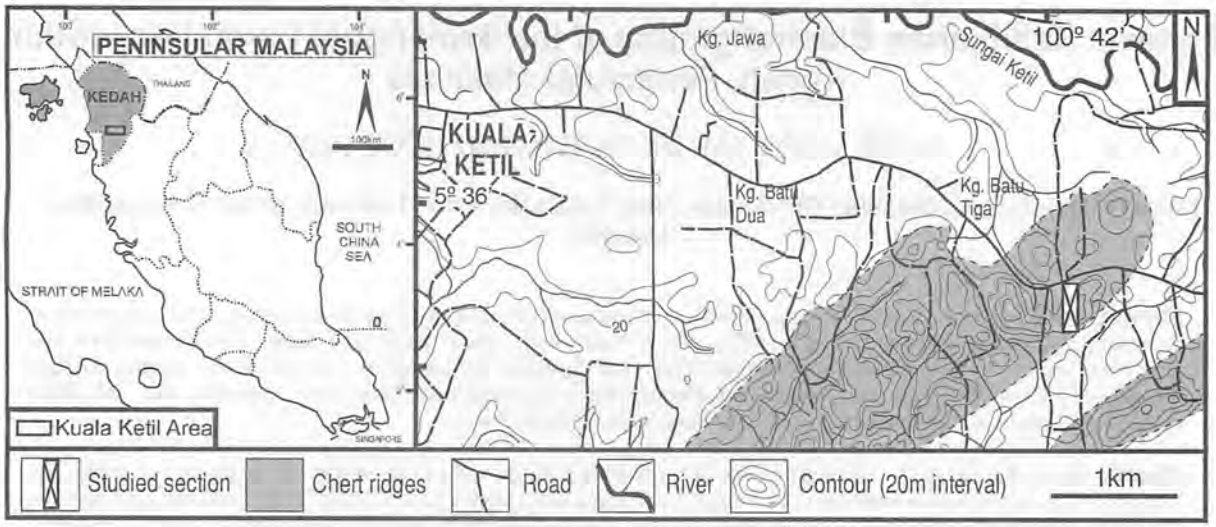

Fig. 1. Map showing the chert unit and the studied section in the Kuala Ketil area, south Kedah.

DESCRIPTION OF THE OUTCROP

Seven lithofacies were recognized at an extensive outcrop exposed at a construction site, approximately 4.5 km east of the Kuala Ketil town. The section is oriented north–south (Fig.2). The outcrop was cut by several strike-slip and thrust faults. The rocks strike generally in east-west direction and dip southwards. The rock sequence at this locality may represent the chert unit (which is equivalent to member as used by Burton, 1973). Seven lithofacies were recognized (in ascending order) i.e. laminated black mudstone, interbedded mudstone and sandstone, thinly bedded to massive tuff, interbedded siliceous shale, chert and tuffaceous sandstone, thinly bedded chert, gray mudstone and thinly bedded chert.

Twenty meters thick of mylonite occurs between thinly bedded chert and gray mudstone. The mylonite represents a shear zone which is related to a major fault movement. The thinly bedded chert of the topmost of the section is cut by a thrust fault, which brought the younger chert sequence up (Fig. 2). The younger chert sequence contains Triassic radiolarians.

TRIASSIC RADIOLARIAN BIOSTRATIGRAPHY

Twenty-seven taxa were identified and their stratigraphic distribution is shown in Figure 3. The radiolarians are divided into four assemblages based on their stratigraphic occurrences.

Entactinosphaera chiakensis Assemblage Zone

The assemblage is represented by low diversity spherical spumellarians of "Paleozoic type" (Sugiyama, 1992). The zone is characterized by the occurrence of:-

Entactinosphaera chiakensis Sashida and Igo, (Pl. 1, figs. 4, 5)
Cenosphaera andoi Sugiyama (Pl. 1, fig. 1)
Archaeosemantis cristianensis Dumitrica (Pl. 1, fig. 2)
Archaeosemantis sp. (Pl.1, fig. 3)
Entactinia sp (Pl. 1, fig. 6, 9)
Entactinosphaera sp. (Pl. 1, fig. 7)
Thaisphaera cf. *minuta* Sashida and Igo (Pl. 1, fig. 8)
Thaisphaera sp. (Pl. 1, fig. 10)
Parentactinia sp. (Pl. 1, fig. 11)

Most of the specimens are fairly well preserved and the assemblage was retrieved from sample KKb 3. Sample KKb2 yielded very poorly preserved *Entactinosphaera* sp. and *Thaisphaera* sp., and could belong to the same assemblage zone. *Entactinosphaera chiakensis* has a very short stratigraphic distribution from latest Spathian to earliest Anisian (Sashida and Igo, 1992). *Cenosphaera andoi* was recorded from the *Parentactinia nakatsugawaensis* Assemblage Zone, Spathian of central Japan (Sugiyama, 1992). Kamata (1999) recorded the occurrence of *Entactinosphaera chiakensis* occurred together with *Parentactinia nakatsugawaensis* in the *Parentactinia nakatsugawaensis* assemblage zone from the Kuzu area, central Japan.

It is evident that the *Entactinosphaera chiakensis* Assemblage Zone of the present study is equivalent to the *Parentactinia nakatsugawaensis* (Pn) of Sugiyama (1992). In spite of careful examination, the zonal marker *Parentactinia nakatsugawaensis* is not observed in the present material. In Peninsular Malaysia, a similar radiolarian assemblage zone has been reported from the Kodiang Limestone (Basir Jasin and Zaiton Harun, 2001). This is the first record of the Early Triassic radiolarian zone from the Semanggol Formation.

Triassocampe coronata Assemblage Zone

This zone is characterized by the occurrence of *Triassocampe coronata* Bragin (Pl. 1, fig. 12). Other species consist of *Pseudostylosphaera japonica* (Nakaseko and Nishimura) (Pl. 1, fig. 13), *Eptingium manfredi* Dumitrica (Pl. 1, fig. 14), *Acanthosphaera awaensis*

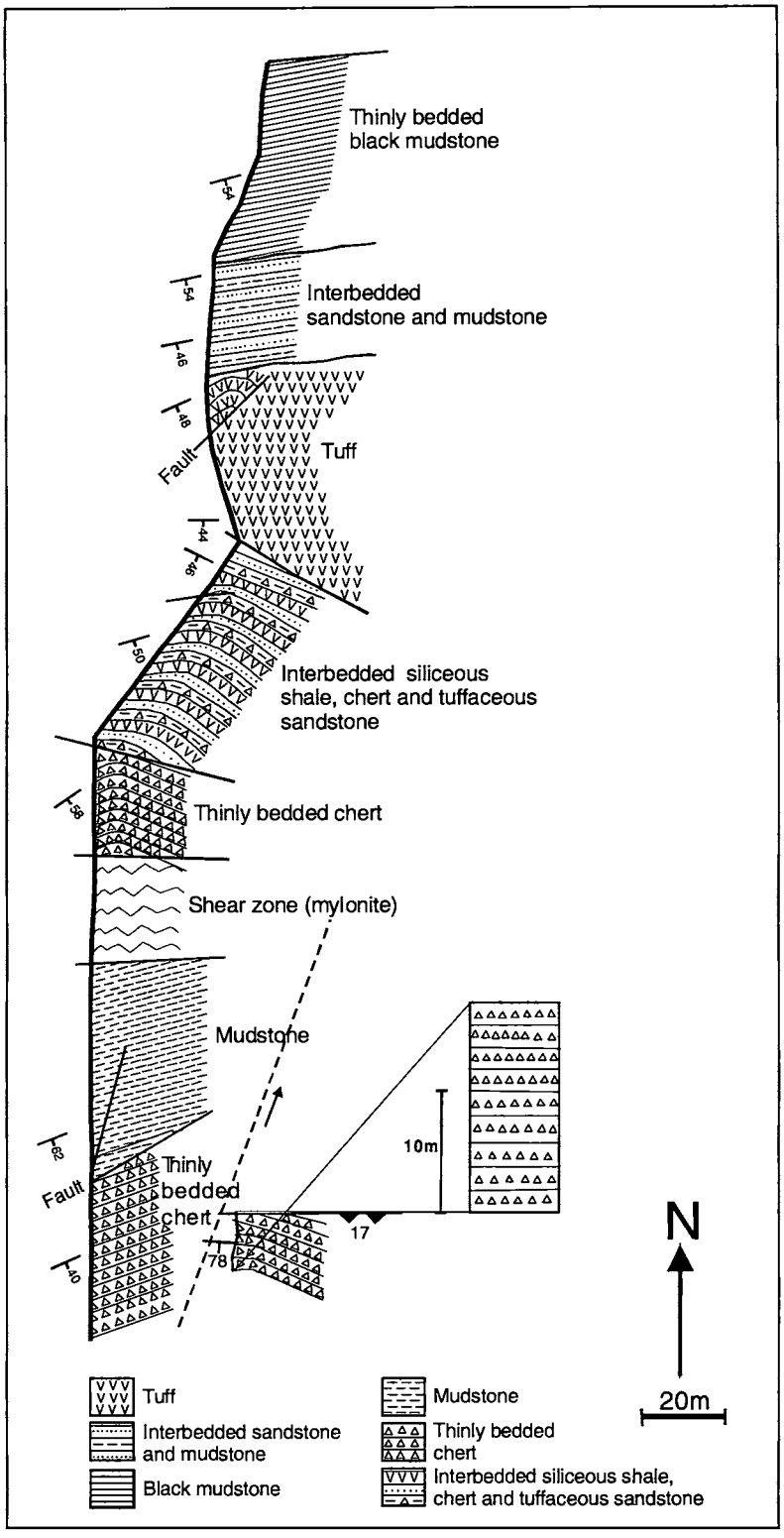

Fig. 2. Lithofacies and lithologic log of the rock sequence exposed at the studied section.

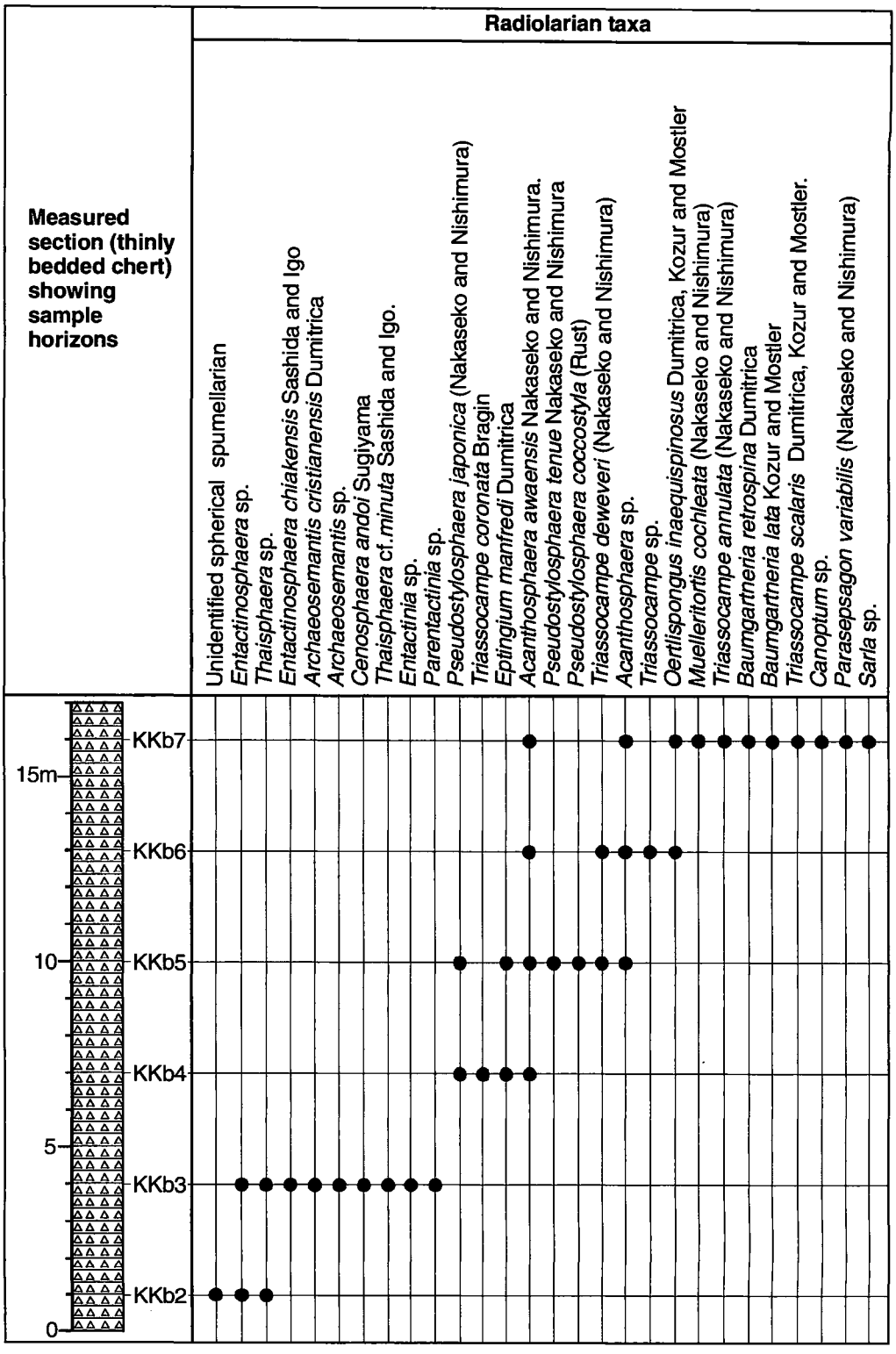

Fig. 3. Stratigraphic distribution of Triassic radiolarians in the section.

Nakaseko and Nishimura (Pl. 1, fig. 15) and *Acanthosphaera* sp. (Pl. 1, fig. 16). The assemblage is recovered from sample KKb4. Sugiyama (1992) recorded that the stratigraphic range of *Triassocampe coronata* is restricted to the *Triassocampe coronata* Zone, middle Anisian, Middle Triassic. Spiller (2002) noted the occurrence of the zone based only on the occurrence of poorly preserved specimens of *Triassocampe coronata* from the chert sample of the Semanggol Formation near Kuala Nerang, north Kedah.

Triassocampe deweveri Assemblage Zone

The zone is characterized by the presence of :-

Eptingium manfredi Dumitrica (Pl. 2, fig. 1)
Triassocampe deweveri (Nakaseko and Nishimura) (Pl. 2, figs. 3, 4)
Pseudostylosphaera japonica (Nakaseko and Nishimura) (Pl. 2, fig. 11)
P*seudostylosphaera tenue* (Nakaseko and Nishimura) (Pl. 2, fig. 13)
Pseudostylosphaera coccostyla (Rηst) (Pl. 2, fig. 12)
Acanthosphaera awaensis Nakaseko and Nishimura (Pl. 2, fig. 18)
Triassocampe sp. (Pl. 2, fig. 7)
Oertlispongus inaequispinosus Dumitrica, Kozur and Mostler (Pl. 2, figs. 14, 15)
Acanthosphaera sp. (Pl. 2, fig. Fig. 19)
This assemblage was retrieved from sample KKb5 and sample KKb6.

Yao (1982) assigned the *Triassocampe deweveri* Zone to Ladinian. Sugiyama (1997) revised the zone and placed it in the middle Anisian. Feng *et al.*, (2001) considered it to be late Anisian. In the present study, we placed it in the middle to late Anisian. *Triassocampe deweveri* has a long stratigraphic range. It first appeared in late Anisian (Mizutani and Koike, 1982) and became extinct in Carnian, Late Triassic (Yeh, 1990). The zone is determined based on the radiolarian assemblage of Yao (1982) and Sugiyama (1997).

The *Triassocampe deweveri* Zone has been identified from the Semanggol Formation in Kedah, exposed at Bukit Tembaga (Basir Jasin, 1994, 1997; Spiller and

<table>
<tr><th colspan="2" rowspan="2">AGE</th><th colspan="4">RADIOLARIAN BIOSTRATIGRAPHY</th></tr>
<tr><th colspan="2">Circum Pacific</th><th colspan="2">Palaeotethys</th></tr>
<tr><th colspan="2"></th><th>Sugiyama (1997)</th><th>Yao (1982)
Sugiyama (1992)</th><th>Kozur and Mostler (1994)</th><th>This paper</th></tr>
<tr><td rowspan="7">Middle Triassic</td><td rowspan="2">Ladinian</td><td>Muelleritorlis cochleata</td><td></td><td>Muelleritorlis cochleata</td><td rowspan="2"></td></tr>
<tr><td rowspan="2">Yeharaia elegans</td><td rowspan="4">Triassocampe deweveri</td><td>Ladinocampe multiperforata</td></tr>
<tr><td>Oertlispongus inaequispinosus</td><td>Oertlispongus inaequispinosus</td></tr>
<tr><td rowspan="4">Anisian</td><td>Spine A2</td><td>Oertlispongus primitivus</td><td rowspan="3">Triassocampe deweveri</td></tr>
<tr><td>Triassocampe deweveri</td><td rowspan="2">Spongosilicarmiger italicus transitus</td></tr>
<tr><td>Triassocampe coronata</td><td>Triassocampe coronata</td><td>Tetraspinocyrtis laevis</td><td>Triassocampe coronata</td></tr>
<tr><td>Eptingium nakasekoi</td><td>Hozmadia gifuenses</td><td>Parasepsagon robustus</td><td></td></tr>
<tr><td rowspan="2">Early Triassic</td><td rowspan="2">Spathian</td><td>Parentactinia nakatsugawaensis</td><td rowspan="2">Parentactinia nakatsugawaensis</td><td rowspan="2"></td><td>Entactinosphaera chiakensis</td></tr>
<tr><td>Fullicucullus</td><td></td></tr>
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Fig. 4.Radiolarian biozonation for the Triassic radiolarians of the Semanggol Formation.

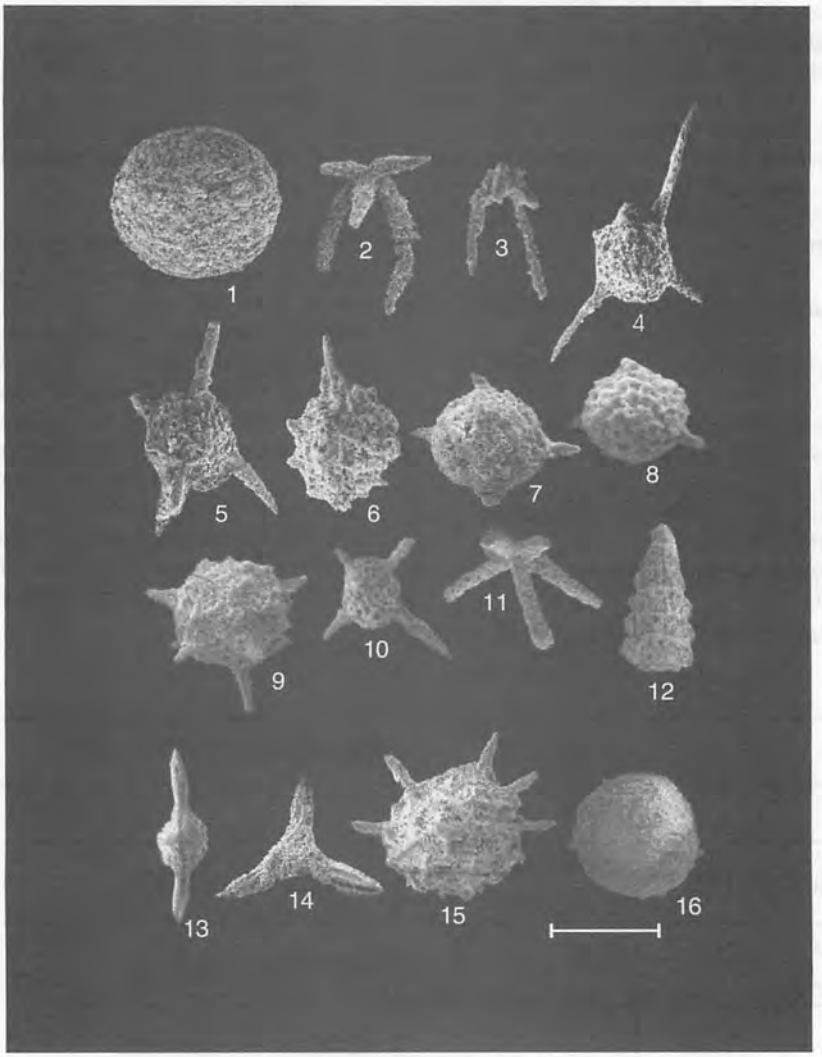

Plate 1 (Scale bar in μm is indicated in parenthesis)

1. *Cenosphaera andoi* Sugiyama (100μm)
2. *Archaeosemantis cristianensis* Dumitrica (100μm)
3. *Archaeosemantis* sp. (100μm)
4. *Entactinosphaera chiakensis* Sashida and Igo (100μm)
5. *Entactinosphaera chiakensis* Sashida and Igo (100μm)
6. *Entactinia* sp A. (100μm)
7. *Entactinosphaera* sp. (100μm)
8. *Thaisphaera* cf. *minuta* Sashida and Igo (100μm)
9. *Entactinia* sp B. (100μm)
10. *Thaisphaera* sp. (100μm)
11. *Parentactinia* sp. (100μm)
12. *Triassocampe coronata* Bragin (100μm)
13. *Pseudostylosphaera japonica* (Nakaseko and Nishimura) (200μm)
14. *Eptingium manfredi* Dumitrica (100μm)
15. *Acanthosphaera awaensis* Nakaseko and Nishimura (115μm)
16. *Acanthosphaera* sp. (200μm)

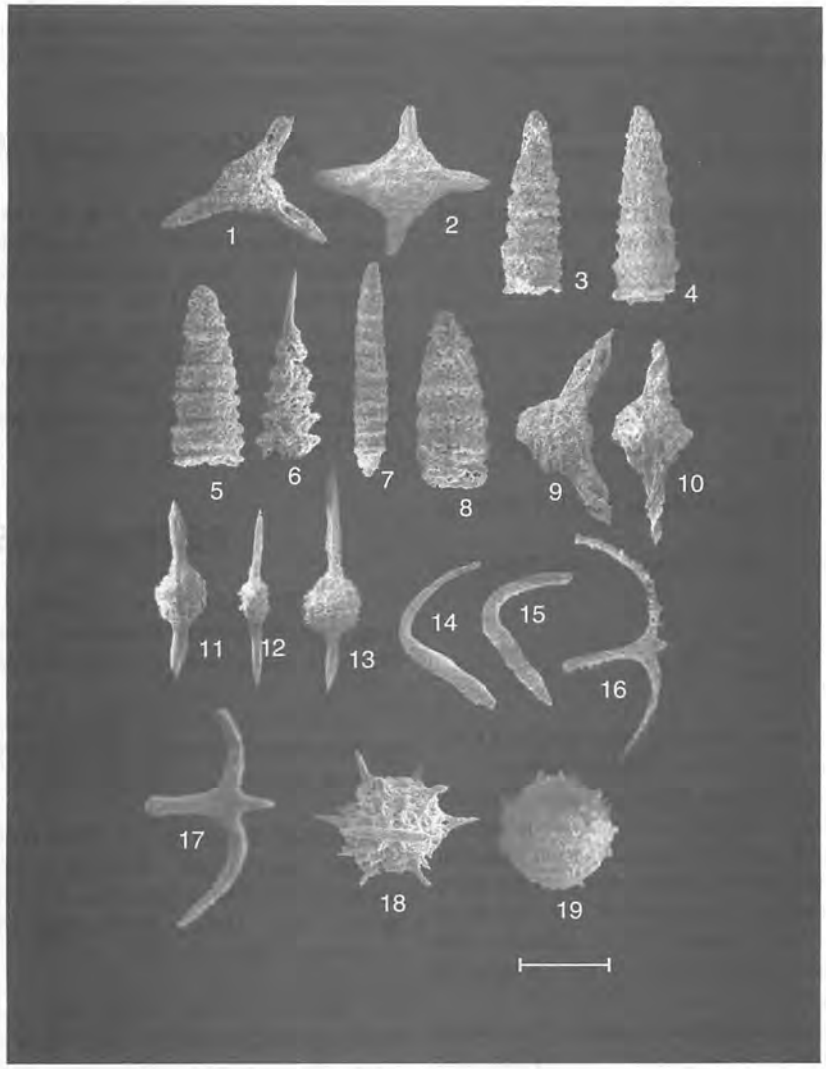

Plate 2. (Scale bar in μm is indicated in parenthesis)

1. *Eptingium manfredi* Dumitrica (130μm)
2. *Parasepsagon variabilis* (Nakaseko and Nishimura) (100μm)
3. *Triassocampe deweveri* (Nakaseko and Nishimura) (100μm)
4. *Triassocampe deweveri* (Nakaseko and Nishimura) (100μm)
5. *Triassocampe scalaris* Dumitrica, Kozur and Mostler (100μm)
6. *Triassocampe annulata* (Nakaseko and Nishimura) (100μm)
7. *Triassocampe* sp. (120μm)
8. *Canoptum* sp.(80μm)
9. *Sarla* sp. (100μm)
10. *Muelleritortis cochleata* (Nakaseko and Nishimura) (120μm)
11. *Pseudostylosphaera japonica* (Nakaseko and Nishimura) (120μm)
12. *Pseudostylosphaera coccostyla* (Rηst) (200μm)
13. *Pseudostylosphaera tenue* (Nakaseko and Nishimura) (120μm)
14. *Oertlispongus inaequispinosus* Dumitrica, Kozur and Mostler. (100μm)
15. *Oertlispongus inaequispinosus* Dumitrica, Kozur and Mostler. (100μm)
16. *Baumgartneria retrospina* Dumitrica (90μm)
17. *Baumgartneria lata* Kozur and Mostler. (90μm)
18. *Acanthosphaera awaensis* Nakaseko and Nishimura (100μm)
19. *Acanthosphaera* sp. (100μm).

Metcalfe, 1995; Spiller, 2002), Pokok Pauh (Basir Jasin, 1994, 1997) and Merbau Pulas (Basir Jasin, 1994).

Oertlispongos inaequispinosus Assemblage Zone

The zone is characterized by the occurrences of:-

Oertlispongus inaequispinosus Dumitrica, Kozur and Mostler (Pl. 2, figs. 14, 15)
Muelleritortis cochleata (Nakaseko and Nishimura) (Pl. 2, fig. 10)
Triassocampe annulata (Nakaseko and Nishimura) (Pl. 2, fig. 6)
Baumgartneria retrospina Dumitrica (Pl. 2, fig. 16)
Baumgartneria lata Kozur and Mostler (Pl. 2, fig. 17)
Triassocampe scalaris Dumitrica, Kozur and Mostler (Pl. 2, fig. 5)
Parasepsagon variabilis (Nakaseko and Nishimura) (Pl. 2, fig. 2)
Acanthosphaera awaensis (Nakaseko and Nishimura) (Pl. 2, fig. 18)
Canoptum sp. (Pl. 2, fig. 8)
Acanthosphaera sp. (Pl. 2, fig. 19)
Sarla sp. (Pl. 2, fig. 9)

The assemblage was recovered from sample KKb7. The assemblage represents Ladinian, Middle Triassic.

The zone was established based on high diversity radiolarian assemblage in the European Paleothethys region by Kozur and Mostler (1994). Radiolarian faunas in the present material are low in specific diversity but there are some species that are common in the European Paleothethys. Feng and Liang (2003) recorded the *Oertlispongus inaequispinosus* zone from the Ladinian of West Sichuan, China.

A proper Triassic radiolarian zonation (Sugiyama, 1997; Kozur and Mostler, 1994) cannot be applied here because the present material exhibits low specific diversity and continuous stratigraphic distribution of the species cannot be determined. Four biozones were recognized (Figure 4).

The occurrence of Triassic radiolarians in the chert offers some clues to the stratigraphy of the siliceous deposits. Previously, Burton (1973, 1988) considered that the chert unit (member) as the oldest unit in the Semanggol Formation. The discovery of Triassic radiolarians suggests that the chert unit is partly of the same age as the rhythmite and conglomerate units. To date, Late Triassic radiolarians have not yet been discovered from the Semanggol Formation.

CONCLUSION

Seven samples collected from the thinly bedded chert from the topmost part of the section exposed at a construction site approximately 4.5 km east of the Kuala Ketil town, yielded 27 taxa of Triassic radiolarians. The radiolarians can be divided into four assemblages, representing an age ranging from late Early Triassic to Middle Triassic i.e. *Entactinosphaera chiakensis* Zone representing late Spathian, *Triassocampe coronata* Zone, middle Anisian, *Triassocampe deweveri* Zone, late Anisian and *Oertlispongus inaequispinosus* Zone, early Ladinian. The occurrence of some radiolarians in the *Entactinosphaera chiakensis* Zone indicates the earliest development of radiolarian faunas in Malaysia after the late Permian catastrophic event.

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