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# Lower Carboniferous (Tournaisian) radiolarians from Peninsular Malaysia and their significance

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**Abstract:** Lower Carboniferous (Tournaisian) radiolarians are widespread in Peninsular Malaysia especially in the Western Belt. The radiolarians were recorded in the Kubang Pasu Formation of Kedah and Perlis, Kenny Hill Formation, Selangor, Upper Paleozoic rocks from Nenering, north Perak and the chert block in Langkap, Negeri Sembilan. The radiolarians retrieved from the Kubang Pasu and Kenny Hill Formations exhibit very low specific diversity. The chert from Nenering and Langkap yielded moderate diversity (20 species) and high specific diversity (30 species), respectively. The lithologic association of the Kubang Pasu and Kenny Hill Formations comprises chert overlain by turbiditic sandstone and shale, which indicates the depositional environment was in a basin close to a continental margin. The lithologic association of chert from Langkap consists of interbedded chert and shale, which is indicative of basinal environment. The widespread distribution of chert is related to high radiolarian productivity during the Tournaisian. The Tournaisian is also known as a hypersiliceous age. The high productivity of radiolarians was related to upwelling cold dense bottom water that was very rich in siliceous material, oxygen, and nutrients. This bottom current was developed at a glacial north-Gondwanan area and flowed southwards. The chert also can be used as a marker bed for Tournaisian age and is a very important rock unit to define the base of the Kubang Pasu Formation.

**Abstrak:** Radiolaria berusia Karbon Awal (Tournaisian) tertabur secara meluas di Semenanjung Malaysia terutama di Jalur Barat. Radiolaria dilaporkan daripada Formasi Kubang Pasu, Kedah dan Perlis, Formasi Kenny Hill, Selangor, batuan Paleozoic Atas dari Nenering, Perak utara dan dari blok rijang di Langkap, Negeri Sembilan. Radiolaria yang diperolehi dari Formasi Kubang Pasu dan Kenny Hill menunjukkan kepelbagaian spesies yang terlalu rendah. Rijang dari Nenering menghasilkan kepelbagaian menengah (20 spesies) dan rijang dari Langkap menghasilkan kepelbagaian tinggi (30 spesies). Sekutuan litologi dalam Formasi Kubang Pasu dan Kenny Hill terdiri daripada rijang yang ditindih oleh batu pasir turbidit dan syal mencadangkan sekitaran pengendapan dalam lembangan berhampiran dengan pinggir benua. Sekutuan litologi rijang dari Langkap terdiri daripada selang lapis rijang dan syal yang menunjukkan sekitaran lembangan. Taburan rijang yang meluas berkait dengan produktiviti radiolaria pada masa Tournaisian. Tournaisian dikenali sebagai zaman *hypersiliceous*. Produktiviti radiolaria yang tinggi mempunyai hubungkait dengan arus timbul air bawah laut yang sejuk dan padat yang kaya dengan bahan silika, oksigen dan bahan nutrien. Arus bawah laut terbentuk di kawasan glasier utara Gondwana dan mengalir kearah selatan. Rijang ini boleh juga digunakan sebagai lapisan penanda masa Tournaisian dan sebagai unit batuan rijang sangat penting dalam menentukan sempadan bawah Formasi Kubang Pasu.

**Keywords:** Radiolarian chert, Tournaisian, chert association, assemblage, paleogeography, paleooceanography

## INTRODUCTION

Lower Carboniferous radiolarians are widely distributed. They are reported from Germany (Won, 1983, 1990; Braun, 1990, Braun & Schmidt-Effing, 1993), France (Gourmelon, 1986, 1987), Spain (O'Dogherty *et al.*, 2000), Turkey (Holdsworth, 1973, Noble *et al.*, 2008), China (Wang & Kuang, 1993, Wu *et al.*, 1994; Feng *et al.*,1997, Wang *et al.*, 1998), Thailand (Sashida *et al.*, 2002, Feng *et al.*, 2004, Wonganan *et al.*, 2007), Australia (Aitchison 1988, Aitchison & Flood, 1990) and Peninsular Malaysia (Basir 1995, Basir & Che Aziz, 1997, Basir & Zaiton 2001, Zaiton & Basir 2003, Basir & Zaiton 2006). Tournaisian radiolarians reported from China, Thailand, Malaysia, Turkey and Australia have been recovered mostly from siliceous shale and chert. Radiolarians from Western Europe are reported mainly from siliceous shale facies which contain phosphatic nodules with well-preserved radiolarians.

Studies of Lower Carboniferous radiolarians in Peninsular Malaysia have been carried out especially from the Kubang Pasu Formation (Basir, 1995; Basir & Zaiton, 2001), Kenny Hill Formation (Zaiton & Basir 2003), Upper Paleozoic rocks of Nenering, north Perak (Basir & Zaiton, 2006) and the chert block from Langkap, Negeri Sembilan (Basir & Che Aziz, 1997). The results show that the species diversity of radiolarians retrieved from the Kubang Pasu and the Kenny Hill Formations is very low compared to those of Nenering and Langkap. Despite extensive sampling of chert in the Kubang Pasu Formation, the number of species is still very low. In this paper, we explain the probable relationship among radiolarians from the three different assemblages and their implications for paleoenvironment, paleogeography and paleooceanography.

## GEOLOGICAL SETTING

The Kubang Pasu Formation is widely distributed in Kedah and Perlis. Chert occurs in Bukit Kamelong, Bukit Telaga Jatoh, Guar Kepayang, Pinang Tunggal, Bukit Inas, Bukit Pinang, Bukit Binjal, Bukit Kelubi, and Pokok Sena, Kedah. In Perlis, chert is exposed at the northern part of Guar Sanai and Bukit Tuntung, Ulu Pauh (Figure 1). The lower boundary of the formation has not been properly determined. The age of the formation ranges from Late Devonian to Early Permian. However, there are no reliable index fossils indicative of a Late Devonian age. Basir (1995) and Basir & Zaiton (2001) considered the chert as a lowermost unit of the Kubang Pasu Formation. The fossiliferous red beds which are considered to be Late Devonian-Earliest Carboniferous by Meor & Lee (2005) are in fact located above the chert.

Depositional environments of the Kubang Pasu Formation can be divided into two types: shallow-marine and deep-marine environments. The shallow marine sequence occurs in Perlis where it is underlain by the Setul Limestone and is overlain by the Chuping Limestone. The Kubang Pasu Formation in Perlis is composed of a chert sequence at the bottom, interbedded sandstone and shale, and more dominant sandstone in the upper part, representing a shallowing upward sequence and finally passing into the shallow marine Chuping Limestone. The Kubang Pasu Formation in Kedah is underlain by the Mahang Formation and is overlain by the Kodiang and the Semanggol formations. The Kubang Pasu Formation in Kedah consists of chert and interbedded turbiditic sandstone and mudstone which represent deep-marine environments. Generally, the whole rock sequence in Kedah, was deposited in deep-marine environments, except the Kodiang Limestone. The Kati Formation is located around Kuala Kangsar, Perak and consists of metamorphosed reddish brown carbonaceous shale, silt, sandstone with minor conglomerate and chert (Foo, 1990). The formation is highly folded and no fossils were found.

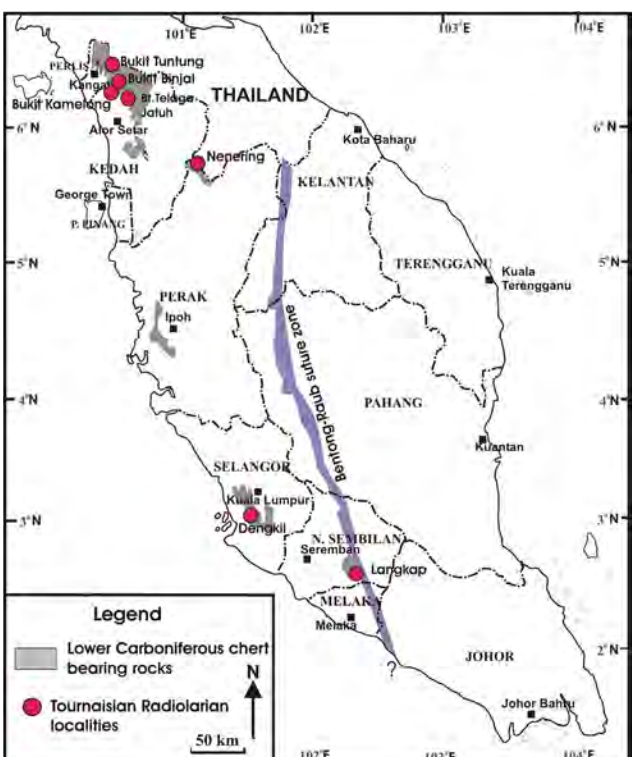


**Figure1:** Distribution of Early Carboniferous cherts in Peninsular Malaysia.

The north Perak Upper Paleozoic sequence is exposed in the Nenering area close to the Thailand border. This unnamed sequence is comparable to the Kubang Pasu Formation. It is underlain by Lower Paleozoic Keroh Formation. The sequence comprises chert at a lower part and is overlain by interbedded turbiditic sandstone and shale. The chert is highly folded.

Lower Carboniferous chert also was discovered at Langkap, Negeri Sembilan. The chert sequence comprises thinly bedded chert interbeded with shale. The chert forms a block in the Bentong-Raub Suture Zone (Figure 1).

Most Tournaisian cherts are ribbon cherts and are black in colour. The cherts from the Kubang Pasu Formation contains high organic carbon (Basir *et al.,* 2003).

## CHERT ASSOCIATION

All Lower Carboniferous cherts are associated with clastic rocks, particularly shale. This rock association is known as chert/shale association (Karl, 1989) or continental-margin chert association (Jones & Murchey, 1986). This rock association is very widespread and represents deep-marine environment along the continental margin (Karl, 1989). The vertical change of lithology from the chert/shale association to tubiditic sandstone and shale sequences in the Kubang Pasu Formation, the Kenny Hill Formation and the Lower Paleozoic rocks of Nenering, north Perak suggests that the depositional environment was located close to a continental margin from which an occasional influx of sand was derived by turbidity currents. These turbiditic sandstones typically are deposited at the continental rise of a passive margin. The chert/shale association of the chert block at Langkap is indicative of a basinal environment. The shale was deposited from pelagic to hemiplegic material, as it does not contain any carbonate material. This suggests that the depositional environment was below the Calcite Compensation Depth.

## RADIOLARIAN ASSEMBLAGES AND ENVIRONMENT

Petrushevkaya (1966) reported that the recent radiolarians low species diversity occurs in shallow water zones and very high diversity occurs in deeper zones. The distribution of plankton is controlled by salinity and distance from the continent. They are abundant in normal marine salinity, 30-35 parts per thousand (Kling, 1978; Anderson, 1983). Polycystine radiolarians are abundant at depths between 50 m to 400 m of the water column (Afanasieva & Amon, 2006). Recent study of the modern radiolarian fauna from the South China Sea shows that the species diversity of radiolarians increases from the shallow surface water to the deep water regions (Chen *et al.,* 2008). Radiolarian assemblages, species diversity and lithologic association were used to estimate the probable depositional environment of the Tournaisian cherts in Peninsular Malaysia.

Three radiolarian assemblages, *Stigmosphaerostylus*, *Archocyrtium* and *Albailella* assemblages are recognized based on the faunal composition and diversity. The assemblages discussed below are used together with lithologic association to interpret depositional environments.

### *Stigmosphaerostylus* Assemblage

This assemblage is characterized by the occurrence of *Stigmosphaerostylus variospina* (Won) and spherical Entactinaria. The specific diversity is very low. Most of the chert samples from the Kubang Pasu Formation yielded only two species, *Stigmosphaerostylus variospina* (Won) and *Callela hexactinia* Won, except for one sample from Bukit Binjal, Kedah which yielded nine species of radiolarians namely *Stigmosphaerostylus variospina* (Won), *Entactinia unispina* Won, *Entactinia inaquoporosa* Won, *Callela hexatinia* Won, *Callela* cf *parvispinosa*, *Trianosphaera hebes* Won, *Cubaxonium? octaedrospongiosum* Won, *Duplexia foremanae* Won, and *Duplexia parviperporata* Won (Basir & Zaiton, 2001). Some of the important species are shown in Plate 1. All species occurrences are listed in Table 1.

This assemblage is comparable to the one reported from the Malaguide Complex, Southern Spain (O'Dogherty *et al*., 2000). *Stigmosphaerostylus variospina* is common in the Tournaisian (Braun, 1990, Sashida *et al*., 2002). The

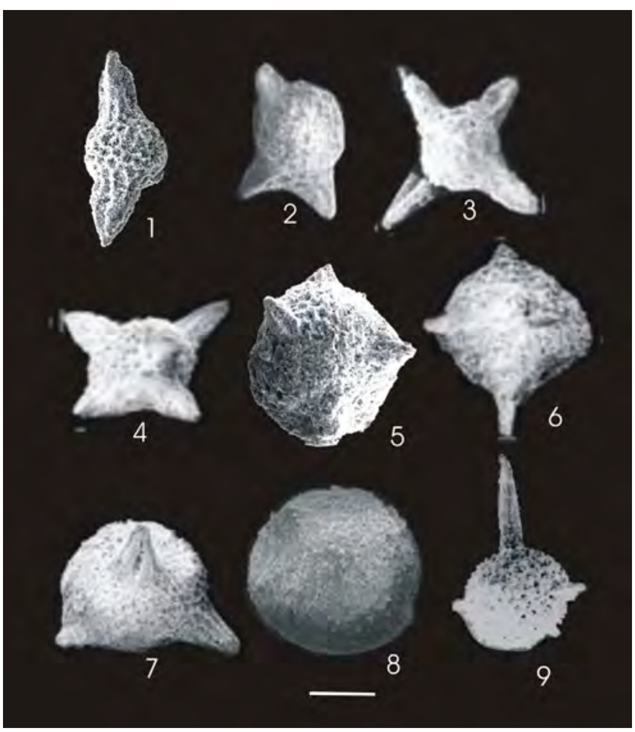


**Plate 1:** *Stigmosphaerostylus* Assemblage from the Kubang Pasu and Kenny Hill formations. (Scale bar is indicated in the parentheses)
1.,2. *Stigmostylosphaera variospina* (Won) with two spines (100µm)
3. *Stigmostylosphaera variospina* (Won) with three spines (100µm)
4. *Stigmostylosphaera variospina* (Won) with four spines (80µm)
5. *Stigmostylosphaera variospina* (Won) with five spines (100µm)
6. *Callella hexactinia* Won (100µm)
7. *Cubaxonium*? *octaedrospongiosum* Won (100µm)
8. *Duplexia? parviperforata* Won (100µm)
9. *Trilonche palimbola* (Foreman) (100µm).

**Table 1:** List of radiolarian taxa in cherts of the Kubang Pasu and Kenny Hill formations, the Upper Paleozoic rocks of Nenering, north Perak, and the chert block in Langkap, Negeri Sembilan.

| No. | Radiolarian species | Kubang Pasu and Kenny Hill formations | Chert of Nenering, North Perak | Chert block from Langkap |
|---|---|---|---|---|
| 1 | *Stigmosphaerostylus variospina* (Won) | X | | |
| 2 | *Callela hexatinia* Won | X | | |
| 3 | *Entactinia inaquoporosa* Won, | X | | |
| 4 | *Callela* cf *parvispinosa* Won | X | | |
| 5 | *Trianosphaera hebes* Won | X | | |
| 6 | *Cubaxonium? octaedrospongiosum* Won | X | | |
| 7 | *Duplexia foremanae* Won | X | | |
| 8 | *Duplexia parviperporata* Won | X | | |
| 9 | *Entactinosphaera palimbola* Foreman | X | | X |
| 10 | *Albaillella* cf. *perforata* s.l. Won | | X | |
| 11 | *Archocyrtium lagabriellei* Gourmelon | | X | X |
| 12 | *Archocyrtium pulchrum* Braun, | | X | X |
| 13 | *Archocyrtium venustum* Cheng | | X | |
| 14 | *Astroentactinia biaciculata* Nazarov | | X | X |
| 15 | *Astroentactinia digitosa* Braun | | X | |
| 16 | *Astroentactinia mirousi* Gourmelon | | X | |
| 17 | *Astroentactinia multispinosa* Won | | X | X |
| 18 | *Astroentactinia stellaesimilis* Won | | X | |
| 19 | *Belowea hexaculeata* Won | | X | |
| 20 | *Belowea variabilis* Ormiston & Lane | | X | |
| 21 | *Ceratoikiscum berggreni* Gourmelon | | X | X |
| 22 | *Palaeoscenidium cladophorum* Deflandre | | X | |
| 23 | *Pylentonema antiqua* Deflandre | | X | |
| 24 | *Stigmosphaerostylus brilonensis* (Won) | | X | |
| 25 | *Stigmosphaerostylus tortispina* (Ormiston & Lane) | | X | |
| 26 | *Stigmosphaerostylus vulgaris* (Won) | | X | |
| 27 | *Trilonche altasulcata* (Won) | | X | |
| 28 | *Triaenosphaera* sp. | | X | |
| 29 | *Albaillella cornuta* Deflandre | | | X |
| 30 | *Albaillella deflandrei* Gourmelon | | | X |
| 31 | *Albaillella paradoxa* Deflandre | | | X |
| 32 | *Albaillella undulata* Deflandre | | | X |
| 33 | *Archocyrtium clinoceros* Deflandre | | | X |
| 34 | *Archocyrtium ludicrum* Deflandre | | | X |
| 35 | *Archocyrtium strictum* Deflandre | | | X |
| 36 | *Archocyrtium tinnulum* ( Deflandre) | | | X |
| 37 | *Archocyrtium* sp. | | | X |
| 38 | *Belowea* sp. | | | X |
| 39 | *Callella* cf. *conispinosa* Won | | | X |
| 40 | *Calella parvispinosa* Won | | | X |
| 41 | *Ceratoikiscum avimexpectans* Deflandre | | | X |
| 42 | *Ceratoiciskum umbraculum* Won | | | X |
| 43 | *Ceratoiciskum* sp. | | | X |
| 44 | *Cerarchocyrtium singularum* Cheng | | | X |
| 45 | *Cystisphaeractinium mendax* Deflandre | | | X |
| 46 | *Cystisphaeractinium* spp. | | | X |
| 47 | *Entactinia digitosa* Braun | | | X |
| 48 | *Huasha* sp. | | | X |
| 49 | *Polyentactinia polygonia* Foreman | | | X |
| 50 | *Pylentonema* sp. | | | X |
| 51 | *Robotium* sp. | | | X |
| 52 | *Triaenosphaera sicarius* Deflandre | | | X |
| 52 | *Archocyrtium cf. babini* Gourmelon | | | X |

chert from the Kenny Hill Formation yielded *Trilonche palimbola* (Foreman), *Duplexia parviperporata* Won and some unidentified spherical entactinarians. This assemblage was assigned to Early Carboniferous (Zaiton & Basir, 2003). This assemblage lacks in *Albaillella*, *Archocyrtium* and *Pylentonema*. This absence was also reported from France (O'Dogherty *et al*., 2000) and Germany (Braun, 1990). O'Dogherty *et al*. (2000) interpreted the absence as a consequence of strong diagenesis and selective dissolution. We think that the absence of *Albaillella*, *Archocyrtium* and *Pylentonema* in the Kubang Pasu and the Kenny Hill formations is due to the shallow water environment where the spherical forms were more common.

### *Archocyrtium* Assemblage

This assemblage is characterized by moderate diversity and is dominated by cone-shaped archocyrtids such as *Archocyrtium* (Table 1). Radiolarian chert from the Upper Paleozoic rock sequence of Nenering, north Perak yielded 20 radiolarian taxa (Basir & Zaiton, 2006), namely *Albaillella* cf. *perforata* s.l. Won, *Archocyrtium lagabriellei* Gourmelon, *Archocyrtium pulchrum* Braun, *Archocyrtium venustum* Cheng, *Astroentactinia biaciculata* Nazarov, *Astroentactinia digitosa* Braun, *Astroentactinia mirousi* Gourmelon, *Astroentactinia multispinosa* Won, *Astroentactinia stellaesimilis* Won, *Belowea hexaculeata* Won, *Belowea variabilis* Ormiston & Lane, *Ceratoikiscum berggreni* Gourmelon, *Palaeoscenidium cladophorum* Deflandre, *Pylentonema antiqua* Deflandre, *Stigmosphaerostylus brilonensis* (Won), *Stigmosphaerostylus tortispina* (Ormiston & Lane), *Stigmosphaerostylus variospina* (Won), *Stigmosphaerostylus vulgaris* (Won), *Trilonche altasulcata* (Won), and *Triaenosphaera* sp. (Plate 2). The occurrence of *Albaillella* cf. *perforata* s.l. Won, *Archocyrtium lagabriellei* Gourmelon, *Archocyrtium pulchrum* Braun, *Archocyrtium venustum* Cheng, and a moderately high species diversity of radiolarians in the Nenering chert suggest the chert was deposited in a deeper environment than the *Stigmosphaerostylus* assemblage.

### *Albaillella* Assemblage

This assemblage is characterized by the common occurrence of *Albaillella* and very high species diversity. Basir & Che Aziz (1997) identified more than 34 radiolarian taxa from the chert block in Langkap (Table 1). Selected species are portrayed in Plate 3. The high specific diversity and the presence of *Albaillella* suggest an open deep-sea marine environment.

## PALEOOCEANOGRAPHY AND PALAOEGEOGRAPHY

The Tournaisian is considered as a hypersiliceous period where the concentration of silica in the ocean was about 60 mg/L (Racki & Cordey, 2000). Chert deposits were common throughout the Palaeo-Tethys Ocean (Sashida *et al*., 2002). During Carboniferous and Permian times, the climate was cool and the ocean was very rich in nutrients (Martin, 1995). During the cool period the ocean was stratified with cold-water located in the deeper part and warm water occupied the shallower parts of the ocean, comparable to the present day ocean. The bottom water was very rich in siliceous material, oxygen, and nutrients. The upwelling of the bottom water enriched the surface water which triggered the high plankton productivity. This led to deposition of thick radiolarite. The high productivity of Tournaisian radiolarians was also indicated by the occurrence of black chert which contains high organic carbon (Basir *et al*., 2003).

This major radiolarian event can be seen as an element of the Palaeozoic revolution (Vermeij, 1995). A cold water upwelling model is commonly applied to ancient biosiliceous blooms (Hein & Parrish, 1987). During Early Carboniferous, siliceous deposition related to cold deep water current circulation originated from a glacial north-Gondwanan area, and was flowing southwards to the tropical regions (Raymond & Lethiers, 1990). The deep water mass was upwelling at the northern continental margin of Gondwana.

The three Tournaisian radiolarian assemblages occupied the environment close to a continental margin during development of the Palaeo-Tethys (Figure 2). The *Stigmosphaerostylus* and the *Archocyrtium* assemblages are discovered in the chert sequences overlain by turbiditic sands and shales. These assemblages probably occupied a continental rise. The *Stigmosphaerostylus* assemblage probably was deposited on the upper continental rise and the *Archocyrtium* assemblage was deposited on the lower continental rise; they occasionally were subjected to turbidity currents that brought the sand to the environment. The *Albaillella-Archocyrtium* assemblage was deposited in a basinal environment far from the supply of coarse clastic material (Figure 3).

## STRATIGRAPHIC IMPLICATION

Although some radiolarians in the Kubang Pasu Formation, the Kenny Hill Formation, and the Upper Paleozoic sequence of Nenering, north Perak are not age diagnostic, the current age assignment to the Tournaisian is based on the occurrence of *Stigmosphaerostylus variospina*, which also was reported from Tournaisian chert in southern Thailand (Sashida *et al*., 2002) and in Spain (O'Dogherty *et al*., 2000). Chert from Langkap contains age-diagnostic radiolarians such as *Albaillella paradoxa*, *Albaillella deflandrei*, *Albaillella paradoxa*, and *Albaillella indensis ambigua*. These cherts from the Kubang Pasu Formation, the Kenny Hill Formation, Nenering and Langkap were deposited during the hypersiliceous time and are considered to be Tournaisian in age.

The Tournaisian cherts are widespread in northwest Peninsular Malaysia. The chert in the Kubang Pasu Formation is considered as a marker bed, representing the lower part of the Kubang Pasu Formation (Basir & Zaiton, 2001). The occurrence of Tournaisian cherts in Kedah and Perlis defines the lower boundary between the Kubang Pasu

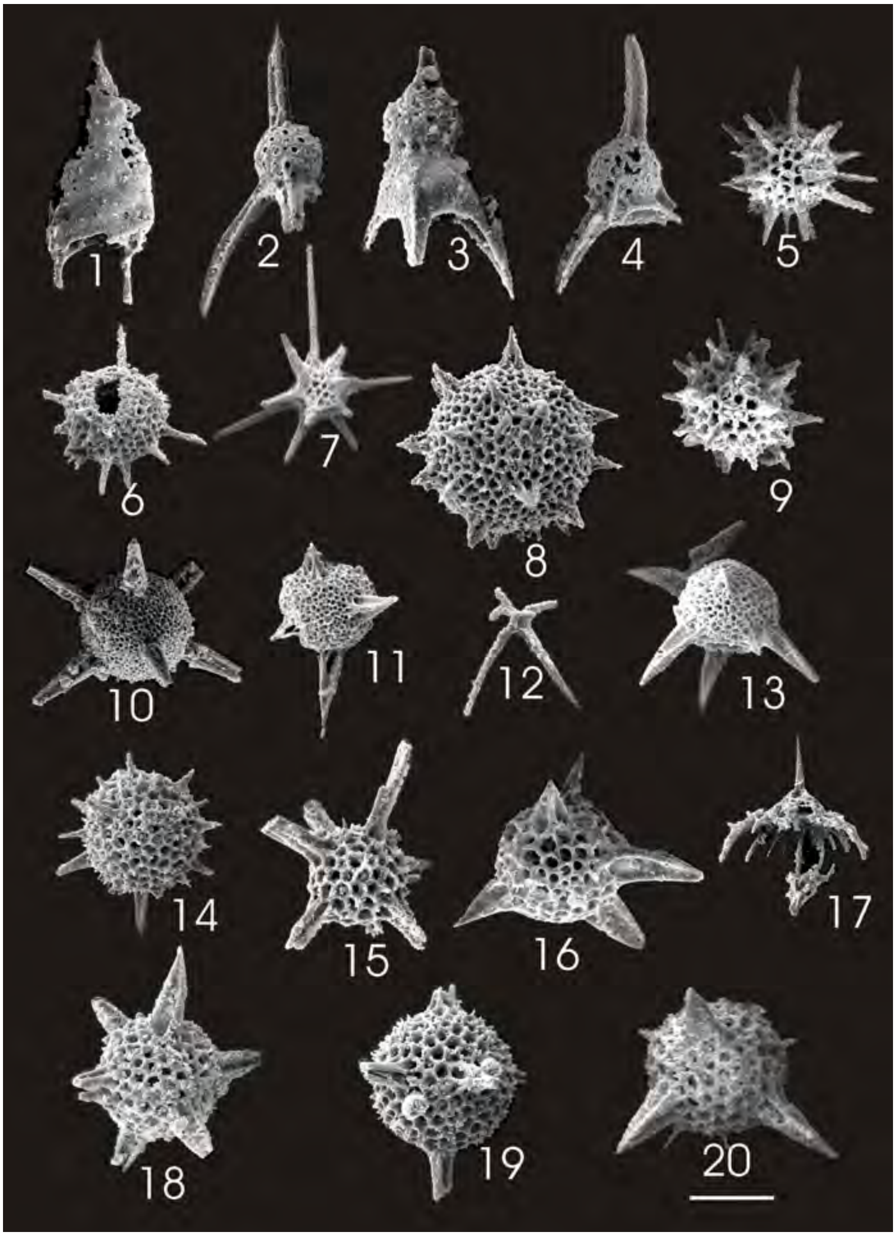


**Plate 2:** *Archocyrtium* Assemblage from Nenering, north Perak. (Scale bar is indicated in the parentheses)

1. *Albaillella* cf. *perforata* s.l. Won (100 μm)
2. *Archocyrtium lagabriellei* Gourmelon (100 μm)
3. *Archocyrtium pulchrum* Braun (50 μm)
4. *Archocyrtium venustum* Cheng (100 μm)
5. *Astroentactinia biaciculata* Nazarov (100 μm)
6. *Astroentactinia digitosa* Braun (100 μm)
7. *Astroentactinia mirousi* Gourmelon (100 μm)
8. *Astroentactinia multispinosa* Won (75μm)
9. *Astroentactinia stellaesimilis* Won (75 μm)
10. *Belowea hexaculeata* Won (125 μm)
11. *Belowea variabilis* Ormiston & Lane (100 μm)
12. *Palaeoscenidium cladophorum* Deflandre (50 μm)
13. *Pylentonema antiqua* Deflandre (100 μm)
14. *Stigmosphaerostylus brilonensis* (Won) (100 μm)
15. *Stigmosphaerostylus tortispina* (Ormiston & Lane) (75 μm)
16. *Stigmosphaerostylus variospina* (Won) (75 μm)
17. *Ceratoikiscum berggreni* Gourmelon (100 μm)
18. *Stigmosphaerostylus vulgaris* (Won) (75 μm).
19. *Triloncheh altasulcata* (Won) (100 μm)
20. *Triaenosphaera* sp. (75 μm)

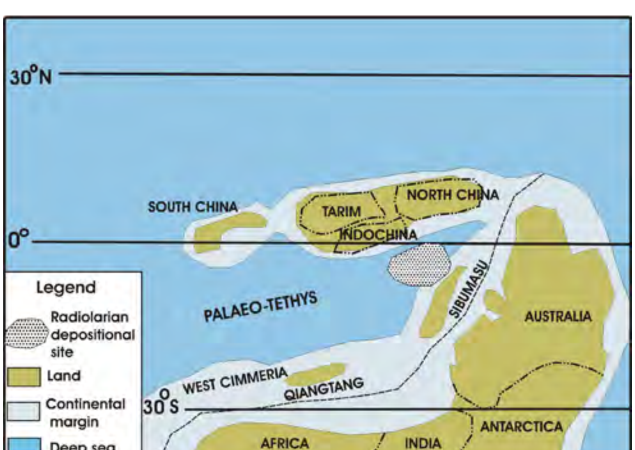


**Figure 2:** Late Devonian-Early Carboniferous paleogeographic map (modified after Metcalfe, 2006) showing a depositional site of the radiolarian assemblages.

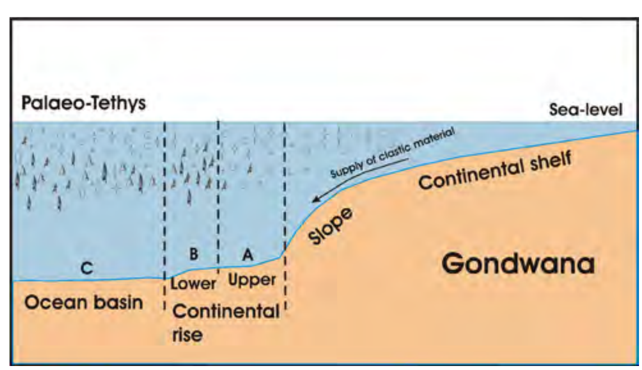


**Figure 3:** Diagram showing the three possible depositional environments of the radiolarian assemblages.
A- *Stigmosphaerostylus* Assemblage, B- *Archocyrtium* Assemblage, and C- *Albaillella* Assemblage.

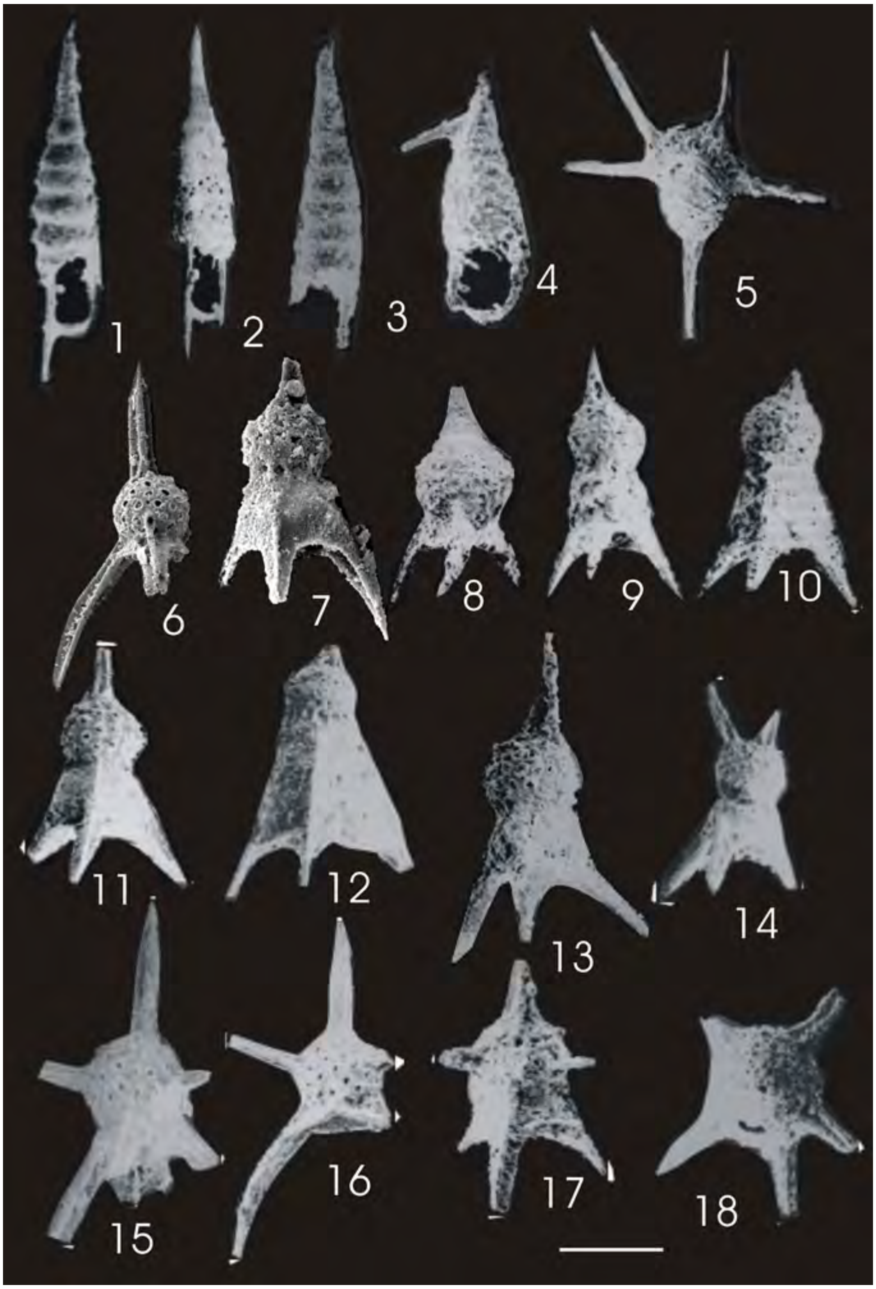


**Plate 3:** Some selected taxa from *Albaillella* Assemblage from Langkap, Negeri Sembilan. (Scale bar is indicated in the parentheses)
1. *Albaillella deflandrei* Gourmelon (100µm)
2. *Albaillella paradoxa* Deflandre (200µm)
3. *Albaillella undulata* Deflandre (133µm)
4. *Albaillella indensis ambigua* Braun (133µm)
5. *Ceratoikiscum avimexpectans* Deflandre (133µm)
6. *Archocyrtium lagabriellei* Gourmelon (100µm)
7. *Archocyrtium pulchrum* Braun (50µm)
8. *Archocyrtium ludicrum* Deflandre (70 µm)
9. *Archocyrtium strictum* Deflandre (100 µm)
10. *Archocyrtium tinnulum* ( Deflandre) (100 µm)
11. *Archocyrtium* sp.(100 µm)
12. *Archocyrtium* cf. *babini* Gourmelon) (100 µm)
13. Archocyrtium clinoceros Deflandre (100 µm)
14. *Cerarchocyrtium singularum* Cheng (100 µm)
14. *Cystisphaeractinium mendax* Deflandre (100 µm)
15. *Cystisphaeractinium* sp A. (100 µm)
16. *Cystisphaeractinium* sp B. (100 µm)
17. *Robotium* sp.(100 µm).

Formation and the Setul/Mahang formations (Figure 4). We suggest that the Kubang Pasu Formation includes the chert as its lowermost unit. At Hill B and Hill C of Guar Sanai, the fossiliferous red beds containing *Posidonomya* (*Posidonia*) spp., *Cyrtosymbole* (*Waribole) perlisiensis* Kobayashi and Hamada, cephalopods, ambocoeliids brachiopods are stratigraphically younger than the cherts. Therefore, the redbeds are younger than Tournaisian. The fossils from the red beds are endemic and their age cannot properly be determined. Large *Posidonomya* (*Posidonia)* bivalves are common in the Lower Carboniferous of the Kulm Facies in central Europe and they were used as zonal markers in the Visean (Amler, 2004). The occurrence of *Posidonia* in the red beds suggests the Visean age. Meor and Lee (2005) included the red beds in the Middle -Late Devonian Chepor Formation which is older than the Tournaisian cherts (Telaga Jatoh Formation of Meor & Lee, 2005) but the stratigraphic sections exposed at Hill B and Hill C of the Guar Sanai area and Bukit Tuntung, Pauh, Perlis prove the cherts are older than the red beds (Figure 4).

Meor & Lee (2005) included the Tournaisian chert in a new formation called Telaga Jatoh Formation. However, Lee (2009) has revised the lithostratigraphy of Guar Jentik, Perlis and included the Tournaisian chert in the Lower Devonian Lalang Member of the Timah Tasoh Formation. It is an error to place the Tournaisian chert in the Timah Tasoh Formation. The lithostratigraphy of the Guar Sanai area becomes more complicated and needs further revision. A research is being carried out to solve the lithostratigraphic problems especially in Kedah and Perlis.

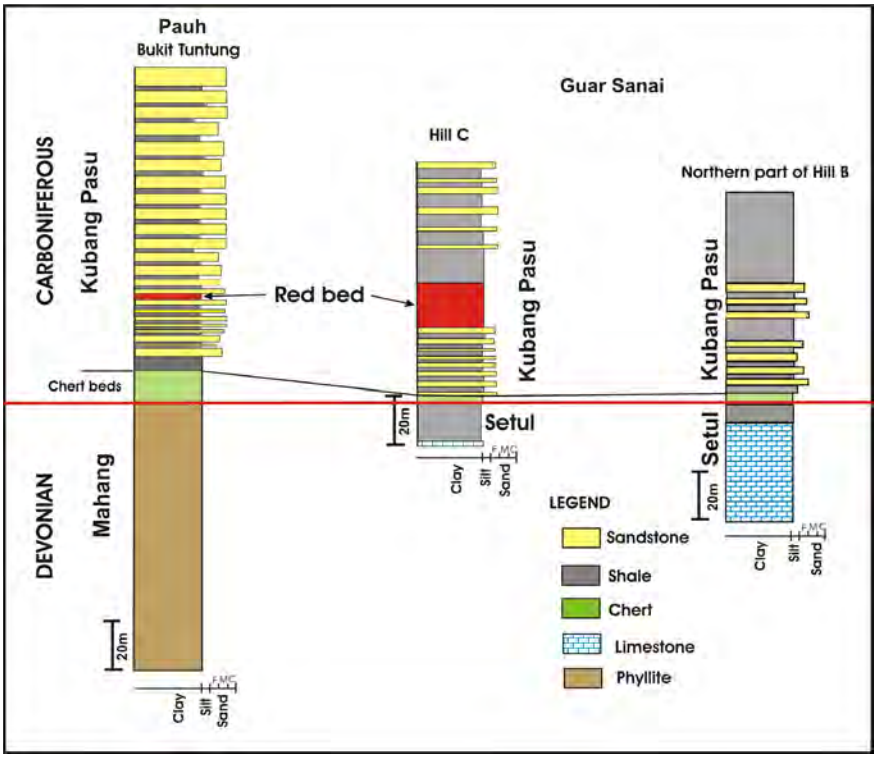


**Figure 4:** The correlation chart of bedded cherts at Ulu Pauh and Guar Sanai, Perlis.

## CONCLUSION

Tournaisian chert was deposited under hypersiliceous conditions where the concentration of silica in the oceanic water was approximately 60 mg/L (Racki & Cordey, 2000). Three radiolarian assemblages were recognized based on the specific diversity and faunal composition. Lithologic associations and radiolarian assemblages are used to determine depositional environments. The *Stigmosphaerostylus* assemblage represents upper continental rise, *Archocyrtium* assemblage located at the lower continental rise and the *Albaillella* assemblage represents a basinal environment. The radiolarian assemblages occupied the margin of the Palaeo-Tethys Ocean.

The chert was developed during the Carboniferous-Permian cool interval (Martin, 1995). The high productivity of radiolarians was related to the upwelling cold dense bottom currents which was very rich in silica, oxygen and nutrients. The cold bottom mass was developed in the north Gondwana glacial area and flow southwards. This resulted in the formation of radiolarian chert. The chert can be used as a marker bed for Tournaisian. It also can be used to define the lowermost part of the Kubang Pasu Formation.

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