Middle and Late Permian radiolarians from the Semanggol Formation, Northwest Peninsular Malaysia

KATSUO SASHIDA¹, SHUKO ADACHI¹, HISAYOSHI IGO¹, TOSHIO KOIKE², and IBRAHIM B. AMNAN³

¹Institute of Geoscience, University of Tsukuba, Ibaraki, 305 Japan
²Geological Institute, Faculty of Education, Yokohama National University, Yokohama, 240 Japan
³Geological Survey of Malaysia, Ipoh, Malaysia

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Abstract. The Semanggol Formation exposed in the northwestern part of Peninsular Malaysia is subdivided into the lower Chert, middle Rhytmite, and upper Conglomerate Members. Previous to the present study, this formation was regarded as Triassic because of the occurrence of Daonella and Halobia in the middle Rhytmite Member. We newly recovered late Middle Permian radiolarians, including Folliculculus monacanthus, from an allochthonous siliceous limestone block contained in the upper part of the lower Chert Member exposed at Bukit Barak, 25 km northeast of Alor Setar. Furthermore, moderately well preserved Late Permian radiolarians belonging to the Neoalbaillella optima and N. ornithiformis Assemblages were discovered in chert beds of the same member exposed at Bukit Nyan, 20 km east of Alor Setar. These Permian radiolarian faunas are very similar to those reported from Japan, the Philippines, and southern China. We interpret the significance of this occurrence in the paleobiogeography of Peninsular Malaysia during Late Paleozoic to Early Mesozoic times. Eight species and five unidentified species belonging to 10 genera of Radiolaria are systematically described in this paper.

Key words: Neoalbaillella, Peninsular Malaysia, Permian, Radiolaria, Semanggol Formation, Triassic.

Introduction

Peninsular Malaysia is geologically subdivided into two continental blocks, the western Sibumasu and eastern East Malaya blocks. As shown in Figure 1, these two blocks are in contact with the Bentong-Raub Suture, which is continued from the Uttradit-Nan Suture of Thailand and extends into Sumatra as the Lalong Line (Metcalfe, 1988; Hutchison, 1989). Concerning the timing of the collision or amalgamation of these continental blocks, there are diverse opinions such as Carboniferous-Permian (Helmke, 1988); Triassic (Sengor et al., 1988; Metcalfe, 1988; Mitchell, 1989); and Jurassic-Cretaceous (Audley-Charles, 1988).

Sashida, Igo, Hisada et al. (1993) pointed out that establishment of detailed geochronology in siliceous and associated fine-grained clastic rocks based on microfossils provides one of the keys to solve the above-mentioned problem. We, however, did not have any sufficient micropaleontological data in Peninsular Malaysia for this purpose except for conodont age assignment determined in chert beds exposed at Tawar, Kedah (Koike, 1973). In November and December of 1991, we made a field survey in northwest Peninsular Malaysia to clarify the geologic age of the Semanggol (or Semanggul) Formation. We were fortunate to discover Late Permian radiolarians from the lower Chert Member and late Middle Permian radiolarians from an allochthonous block probably contained in the upper part of the lower Chert Member. The lower and middle members were assigned to Early to Middle Triassic by previous workers (e.g., Tamura et al., 1975; Teoh, 1992). This discovery was preliminarily reported by Sashida, Igo, Adachi et al. (1993) and is the first report of Permian radiolarians in Peninsular Malaysia. These faunas are very similar to those reported from Japan, the Philippines, and southern China, and the occurrence in Malaysia is of interesting geologic significance as discussed below.

The first author (K.S.) systematically describes the species of radiolarians belonging to the characteristic genera including Albaillella, Neoalbaillella, and Folliculculus herein.

Acknowledgments

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field survey was funded by a grant under the Monbusho (Government of Japan) International Scientific Research Program (No. 02140210 to H. Igo) and also supported by the Geological Survey of Malaysia. We thank Messrs. Yin Ee Heng (former Director-General), Khoo Hang Peng, and Shu Yooh Khoon of Geological Survey of Malaysia, who gave permission and facilities for our field survey.

Geologic setting

Jones (1978) first established a geologic framework for the extensive area of northwest Peninsular Malaysia (Perlis and Kedah States), including the Langkawi Islands. He divided Paleozoic and Mesozoic sedimentary rocks into four lithostratigraphic units: the Machinchang Formation (Late Cambrian), Setul Formation (Ordovician to Devonian), Kubang Pasu and Singa Formations (Late Devonian to Early Permian), and Chuping Formation (Middle Permian to Triassic).

Recently, Teoh (1992) has mapped the Sungai Tiang area of central Kedah and divided the Paleozoic and Mesozoic rocks into the following three lithostratigraphic units: the Mahang Formation (Early Silurian), Kubang Pasu (Carboniferous), and Semanggol Formations (Middle to Late Triassic). In Kedah and Perlis, Permian and Triassic limestones occur outside of this mapped area and have been known as the Chuping and Kodiang Limestones. These limestones mostly constitute isolated spectacular tower karst hills in the Quaternary plain. They conformably overlie the Kubang Pasu Formation (e. g., Foo, 1983). Conodonts in the Chuping and Kodiang Limestones were repeatedly studied by Koike (1973, 1982) and Metcalfe (1981, 1990a, 1992), and these authors clarified the detailed geologic age of these limestones.

The name “Semanggol (or Semanggul) Formation” has been informally used by several writers for the large tracts of flysch-type sedimentary rocks of the Middle to Late Triassic distributed in Kedah and Perlis (Khoo, 1983; Foo, 1990; Teoh, 1992). This formation occurs in a wide area east of the Chuping and Kodiang Limestones with an almost NS orientation (Figure 2). The stratigraphic relationship, however, between the Semanggol and both overlying and underlying formations is unclear. Burton (1973) subdivided this formation into three members, the lower Chert Member, the middle Rhythmite Member, and

Figure 1. Index map showing the study area and the tectonostratigraphic terranes which constitute the continental mainland of Southeast Asia. The base map is slightly modified from Metcalfe (1988, 1991).

Figure 2. Map showing the distribution of the Chuping Limestone (1), Kodiang Limestone (2) and Semanggol Formation (3) and locations of two radiolarian localities, Bukit Nyan and Bukit Barak. The base map is after Metcalfe (1990a).
the upper Conglomerate Member, but this subdivision is now thought to be oversimplified by Malaysian geologists (e.g., Ahmad et al., 1987). The detailed stratigraphy and exact thickness of the Semanggol cannot be ascertained due to the tightly folded structure and the absence of marker beds. Foo (1990) and Teoh (1992), however, estimated that the thickness of this formation is no less than 760 to 800 m. Under this circumstance, we compiled an idealized geologic columnar section with the geochronological scale of the Semanggol Formation as shown in Figure 3.

The lower Chert Member consists mainly of chert, forms echelon ridges trending almost NS, and crops out well in the western part of the area mapped as the Semanggol. Good outcrops of this member can be traced along the roadcut from Pokok Sena to Kuala Nerang and in operating and abandoned quarries east of Pokok Sena in central Kedah. The cherts are commonly black to gray, thinly bedded, tightly folded, and grade upward into siliceous shales or mudstones.

Calcareous chert or cherty limestone beds and limestone lenses are intercalated in siliceous shale that represents the upper part of the Chert Member, and one of the field occurrences of these intercalations at an active earth quarry of Bukit Barak was described in detail by Ahmed et al. (1987). They considered that these limestone lenses are pelagic in origin, and confirmed the occurrence of Triassic conodonts in the lensoid-shaped limestone bodies. Furthermore, in their interpretation these bodies were not slumped-in but were contemporaneous in-situ deposits. Subsequently, Metcalfe (1990a) reported the occurrence of Carnian conodonts, such as *Neogondolella polygonathiformis* (Budrow and Stefanov) in these limestone lenses.

The middle Rhythmite Member conformably overlies the lower member, and consists of rhythmically alternating beds of sandstone and shale. Each bed is commonly less than 10 cm thick. Sandstone beds are interpreted as turbidites, and commonly exhibit numerous syngenetic structures and sedimentary features that are typical of “flysch-type” deposits. Shale beds of this member yield well known Triassic pelycopod fossils such as *Posidonina kedahensis* Kobayashi, *Halobia taluana* Wannier, *Halobia paralia* Kobayashi, *Halobia comata* Bittner and others, indicating an interval of Ladinian to Norian (Kobayashi, 1963).

The upper Conglomerate Member conformably overlies the middle member and is prevalent in eastern Kedah. This member is predominantly irregularly interbedded sandstone and shale with intercalations of numerous conglomerate lenses or bands. Clasts of conglomerate are commonly well-rounded pebble- to cobble-size chert, metamorphosed crystalline quartz, and argillaceous rocks. Some chert clasts contain radiolarian fossils.

The stratigraphic relationship among these three members is not entirely one of superposition, rather they seem to be partly intertonguing each other (Figure 3). The depositional environment of the Semanggol Formation was analyzed by Burton (1973), Metcalfe (1990a, etc.), Teoh (1992), and others. According to them, the Kodiang Limestone and some parts of the Chuping Limestone are heterofacies of the Semanggol Formation, and were deposited in the shelf which was continued to the foreland toward the west. The lower Chert and middle Rhythmite Members of the Semanggol were deposited in the deeper part to the east. The latter member is apparently of turbidite origin. The characteristic sedimentary facies in the upper Conglomerate Member suggests a transition to a shallower water environment.

**Permian radiolarians in the Semanggol Formation**

**Localities**

**Bukit Barak**: Middle Permian radiolarians were recovered from a siliceous limestone block embedded in siliceous shale of the upper part of the lower Chert Member exposed at a quarry of Bukit Barak (Figures 2, 4).
A geologic sketch of this quarry was given by Ahmad et al. (1987). They showed a 27-m-thick columnar section and pointed out the occurrence of conodonts in lensoid-shaped limestone bodies embedded in the siliceous shale situated at the top of the column. These authors stressed that the lensoid limestone bodies were not slumped-in but were contemporaneous in-situ deposits. Subsequently, Metcalfe (1980a) studied these conodonts and identified *Metapolygnathus (= Neogondolella) polygnathiformis* (Budurov and Stefanov), which is an excellent indicator of the lower Carnian (lower Upper Triassic).

During our field survey in 1991, we tried to restudy the section shown by Ahmad et al. (1987), but quarry operation was much progressed, and the outcrop measured by them was already quarried out. We, however, could observe a similar sequence and confirmed the intercalation of lensoid limestone bodies in siliceous shales. Several samples of siliceous shales and limestones were collected from various stratigraphic levels (Figure 4). These samples were treated with HF (hydrofluoric acid) at our laboratory with the same technique mentioned by Sashida (1959). As a result, we encountered poorly preserved but apparent Permian radiolarian specimens in residue obtained from the lensoid siliceous limestone (sample BT-1). The only identified species among discrete specimens is *Folliculculus monacanthus* Ishiga and Imoto. Under the microscope, this limestone is almost completely silicified, and primary microfacies has been obliterated by microcrystalline silica. Calcite crystals are rare, but euahedral crystals of dolomite are commonly scattered. Minute dark brown iron minerals are concentrated in some parts. Minute spheres and spines of radiolarians are also commonly visible.

We could not recover any Triassic conodonts from the limestones as reported by Metcalfe (1990a), but we made several thin sections and discovered some other fossils. Furthermore, there we recognized two types of limestones containing Triassic fossils. Under the microscope, one type is a micritic limestone including abundant peloids and algal clasts, subordinate foraminifers, bryozoans, and fragments of Echinodermata. Preliminarily identified foraminifers are *Aulotortus* spp., *Arenovitallina indosinica* Lám., *Endothyra*? sp., *Glomospira* sp., and *Dentalina* sp. The two first mentioned forms are known to occur in the Middle to Upper Triassic. The other type is also micritic limestone including abundant thin-shelled pelecypods and radiolarian tests. These pelecypod-bearing radiolarian limestones are common in the Middle to Upper Triassic pelagic calcareous facies elsewhere in the world. These paleontological facts indicate that the siliceous shales intercalate both Permian and Triassic lenticular limestones of which depositional environments are different. Our principal new finding, mentioned above, is demonstration that the lensoid limestones intercalated in almost the same level are of three different types, Middle Permian radiolarian-bearing siliceous limestone, Triassic foraminifer-algal shallow water limestone, and pelagic pelecypod-bearing limestone. Therefore, we concluded that these limestone bodies are allochthonous blocks instead of contemporaneous in-situ deposits as advocated by the previous authors.

**Bukit Nyan**: We made a geological survey at an abandoned manganese quarry of Bukit Nyan (also spelled Nyah or Nayan) located about 8 km south of Pokok Sena (Figure 2). Bedded cherts about 100 m thick that apparently belong to the lower Chert Member of the Semanggol are exposed at the quarry. Cherts are mostly thin-bedded and show a wide range of color, but are commonly brown, maroon, and pale gray. They strike N10°-30°E and dip almost vertical (Figure 5). Under the microscope these cherts contain abundant minute spherules (0.2 mm in average diameter) filled with spherulitic calcedony or microcrystalline quartz. We collected more than 10 samples at this quarry of which four samples (CHU-41, 42, 43, and 44) yield moderately well preserved Late Permian radiolarians. They are the species of the genera *Neoalbillella*, *Albillella*, *Entactinosphaera*, *Nazarovella*, *Trilanospongos*, and others.

**Radiolarian fauna and age**

As mentioned above, we newly recovered radiolarians from a siliceous limestone block at the quarry of Bukit Barak. These radiolarians are poorly preserved, and *Folliculculus monacanthus* Ishiga and Imoto, which is an apparent indicator of the upper part of the Middle Permian, is the only identified species. Other radiolarians...
of Late Permian radiolarians (Table 1). These radiolarians can be grouped into two assemblages. One assemblage occurs in two samples (CHU-41, 42 in Figure 5) and is characterized by the presence of *Albaillella triangularis* Ishiga, Kito and Imoto, but lacks *Neocalullia cf. ornithoformis* Takemura and Nakaseko. The other one is confirmed in chert samples (CHU-43, 44 in Figure 5) and characterized by the assemblage of *N. cf. ornithoformis* and spumellarians including *Entactinosphaera pseudocinclis* Sashida and Tonishi, *Nazarovella gracilis* De Wever and Caridroit, *N. inflata* Sashida and Tonishi, and *Triplanospogon musashiensis* Sashida and Tonishi.

*Albaillella triangularis*, *A. levis*, and *A. excelsa* were first described by Ishiga *et al.* (1982b) from the Yono area of the Tamba district, west of Kyoto and the Nabejiri-yama area of Shiga Prefecture, Japan. *Neocalullia ornithoformis* was also introduced from the Tamba district (Takemura and Nakaseko, 1981). Associated spumellarians with *N. cf. ornithoformis* in CHU-43 and CHU-44, such as *Nazarovella gracilis* and *Triplanospogon musashiensis* were described from the Late Permian chert exposed in Itsukaichi, Tokyo (e.g., Sashida and Tonishi, 1985).

Ishiga *et al.* (1982a) and Ishiga (1986) established assemblage-zones based on the stratigraphic occurrence of the species of *Neocalullia* in the Upper Permian chert facies of Southwest Japan. They set up two zones, the older *Neocalullia optima* Assemblage-zone and younger *Neocalullia ornithoformis* Assemblage-zone in the Upper Permian. The former zone is characterized by the joint occurrence of *Albaillella triangularis* and *Neocalullia optima*. The latter one is defined by the occurrence of *Neocalullia ornithoformis*. *Albaillella excelsa* and *A. levis* have a short range and first appear near the boundary between the two *Neocalullia* zones. Concerning the detailed geologic age of these zones, Ishiga (1986) and others placed it in the Dzhulfian and Dorashamian (Late Permian) based on the co-occurrence of conodonts.

Two newly recovered radiolarian assemblages from chert beds exposed at Bukit Nyan are correlated with the *Neocalullia optima* Assemblage-zone and *Neocalullia ornithoformis* Assemblage zone established in Japan; their geologic ages are considered to be Late Permian (Dzhulfian to Dorashamian).

**Appraisal of the occurrence of Permian radiolarians in the Semanggol Formation**

In this paper, we apprise the above-mentioned newly obtained micropaleontological data and further discuss paleogeography related to the geologic evolution of Peninsular Malaysia and its neighboring regions in Permian to Triassic times.

Our present discovery shows that the geologic age of the Semanggol Formation is not confined within the Triassic as concluded by previous studies but extends down into at least the Middle Permian. The presence of lensoid limestones of two different ages (late Middle Permian and early Late Triassic) in almost the same stratigraphic level of siliceous shale suggests that the
Table 1. List of Permian radiolarians from Bukit Nyan. Locality numbers are shown in Figure 5.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Localities</th>
<th>CHU-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>Neoalbaillella cfr. ornithoformis Takamura and Nakaseko</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albailllea excelsa Ishiga, Kito and Imoto</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Albailllea levis Ishiga, Kito and Imoto</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Entactinosphaera pseudocimelia Sashida and Tonishi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entactinosphaera sp.</td>
<td></td>
<td></td>
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<tr>
<td>Octatormentum? sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nazarovella gracilis De Wever and Caridroit</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nazarovella inflata Sashida and Tonishi</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Praedeflandrella sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudotormentus sp.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ishigaum? sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triplanospongos musashiensis Sashida and Tonishi</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

X, taxon present; –, taxon not found.

Limestones are allochthonous and the sedimentary environments of the Semanggol as analyzed by previous authors should be revised.

In Permian time, two different and contrasting lithofacies, the western shallower limestone facies (Chuping and Kodiang Limestones) and eastern deeper-sea siliceous sedimentary rock facies (lower part of the Semanggol Formation) were already present in northwest Peninsular Malaysia as shown in Figure 6. The deposition of these formations was continued in Triassic time, but the depositional site of the Semanggol became shallower as indicated by its sedimentary features. Furthermore, the accretion of the Sibumasu block to the East Malaya block became active in the Late Triassic and provided a different sedimentary setting than that of the Permian as shown in Figure 7. The following lines briefly summarize interpretation of these two diagrammatic figures.

![Middle to Late Permian](image)

**Figure 6.** Schematic reconstruction of the sedimentary setting of the Chuping and Kodiang Limestones and Semanggol Formation.
Carbonate facies is prevalent in the west and represented by almost continuous deposition of the Chuping and Kodiang Limestones. Previously, these limestones were thought to be two distinct lithogenetic units of the Permian and Triassic, respectively. Subsequent studies, however, concluded that the geologic age of these limestone units is Middle (?) Permian to Late Triassic (e.g., Metcalfe, 1981, 1984, 1990a, 1992; Fontaine et al., 1988). Similar limestones are also exposed in Peninsular Thailand and have been called the Permian Ratburi Limestone. Recently, Triassic fossils have been discovered from the Ratburi Limestone in Peninsular Thailand (e.g., Igo et al., 1988; Sashida and Igo, 1992), and the Chaiburi Formation was introduced for the Triassic limestone (Ampornmaha, 1993 MS; Adachi et al., 1993). These carbonate facies are also known in north Sumatra and form an elongate Permian and Triassic limestone complex in Sibumasu (Metcalfe, 1989, 1990a).

The boundary between the Permian and Triassic in this limestone complex is roughly settled at Gunong Keriang and Bukit Harlu in Kedah by conodont studies (Metcalfe, 1981, 1984). The boundary is also presumed in the limestone complex of the Phatthalung area of southern Thailand (Ampornmaha, 1993MS). The boundary between the Permian and Triassic in these limestone sections is said to be conformable, but the exact boundary has never been reported because carbonate rocks near the boundary are completely dolomitized and do not successively yield any reliable uppermost Permian (Dora-

shanian) and lowermost Triassic (Griesbachian) fossils. The limestone that yields Smithian, Spathian, and Anisian conodonts and radiolarians in northwest Peninsular Malaysia and southern Peninsular Thailand are mostly thin-bedded micrite limestone with intercalations of thin chert layers and nodules (e.g., Metcalfe, 1984; Sashida and Igo, 1992). These limestones are considered to have been deposited in off-shore, deeper, and low-energy environments. The upper part of the carbonate complex was represented mainly by thickly bedded algal-foraminifer limestone with interbeds of coral-sponge buildups in places. It was deposited in a shallow sea of high-energy conditions (Ampornmaha, 1993 MS; Adachi et al., 1993). The age of this part of the limestone is Late Triassic (Carnian and Norian).

As already mentioned, the lower and middle parts of the Semanggol Formation were deposited in the deeper and off-shore pelagic environments which spread in the eastern part of the Permian-Triassic carbonate complex. The present discovery of Upper Permian radiolarians from Bukit Nyan suggests that the boundary between the Permian and Triassic will be settled within the lower Chert Member of the Semanggol in the future. Furthermore, our other discovery of Middle Permian radiolarians from a siliceous limestone block and Carnian algal-foraminifer limestone blocks at Bukit Barak supports our contention that the upper part of the Chert Member is contemporaneous but is a heterofacies with both the middle Rhythmite and upper Conglomerate Members. Allocthonous
blocks of Permian siliceous limestone and Triassic limestone were derived from the paleoslope of the carbonate complex in the west and slumped in the siliceous shale sequence of the upper part of the Chert Member.

The middle Rhyolite Member that yields Middle and Late Triassic pelecypods is characterized by thinly bedded alternations of sandstone and shale. Various sedimentary structures observed in these alternations have been interpreted as turbidites (e.g., Teoh, 1992). The source area of these turbidites was located in the east where accretionary wedges were formed associated with the collision of Sibumasu. The absence of carbonate rocks as clastics in these turbidites also supports an eastern sediment source.

Toward the east the accretionary wedges are further continued to the Semantan Basin formed in the East Malaya block. The Semantan Formation (Jaafar, 1976) was deposited in this basin. This formation is a flysch sequence of alternating carbonaceous shale, siltstone, and rhyolitic tuff with very few lenses of crystalline limestone. It locally yields *Danoella*, *Posidonia*, and other Middle Triassic pelecypods (e.g., Kobayashi, 1963, Metcalfe et al., 1982). Provenance of volcanic materials was interpreted as acidic volcanic islands or an island chain (e.g., Metcalfe et al., 1982) aligned along the eastern margin of the Semantan Basin (Figure 7). This model accords well with the scenario of tectonic evolution of Peninsular Malaysia explained by collision of the Sibumasu block with the East Malaya block in Early Triassic time.

Sashida, Igo, Adachi et al. (1993) and Sashida, Igo, Hisada et al. (1993) pointed out the occurrence of Permian to Middle Triassic radiolarians in cherts exposed in the Fang area of northwestern Thailand and also in the Sra Kaeo-Chanthaburi areas of eastern Thailand. These radiolarian faunas are similar to those of Japan, the Philippines, and southern China. This paleontological evidence shows that the radiolarian cherts in these regions were deposited on the same ocean floor "Paleotethys" in the interval of Middle Permian to Middle Triassic times (Figure 8). The Fang area is situated in the western mountains of the Sukhothai Fold Belt (Bunopas, 1981) or the ophiolitic areas of the Plateau Belt in the Shan Thai Block (Mitchell, 1992). The Sra Kaeo-Chanthaburi areas also rest in the ophiolitic areas of the Loei and Sukhothai Fold Belts. These areas are characterized by a complicated geologic structure that consists of various kinds of sedimentary rocks, ultra mafic and mafic rocks, and volcanic and plutonic rocks of Late Paleozoic to Middle Triassic age. This complex has been regarded as a mobile belt or accretionary wedges formed as a result of collision of the Sibumasu (Suan-Thai) and Indochina blocks. As mentioned above, the youngest age of the deeper marine sedimentary rocks (radiolarian cherts) that constitute these folded belts is the Middle Triassic, hence the timing of collision of these two continental blocks in Thailand is considered to be not prior to the Middle Triassic. Moreover, it is well known that the thick nonmarine strata, the Khorat Group (late Triassic to Cretaceous) unconformably and extensively rests on the Indochina block. Our present study shows that the timing of collision of the Sibumasu and East Malaya continental blocks was slightly earlier than in Thailand (Figure 8).

**Systematic paleontology**

All specimens described in this paper are deposited in the Institute of Geoscience, University of Tsukuba with the prefix IGUT.

- **Order** Polycystida Ehrenberg, 1838, emend. Riedel, 1967
- **Suborder** Albeillellaria Deflandre, 1952, emend. Holdsworth, 1969
- **Superfamily** Follicucullacea Cheng, 1986
- **Family** Neoalbaillellidae Takemura and Nakaseko, 1981
- **Genus** Neoalbaillella Takemura and Nakaseko, 1981
- **Neoalbaillella cfr. ornithoformis** Takemura and Nakaseko

Figures 10-1-4

Compare:

*Neoalbaillella ornithoformis* Takemura and Nakaseko, 1981, p. 211-213, pl. 33, figs. 1-6; Ishiga et al., 1982b, p. 15-16, pl. 1, figs. 6-8, pl. 2, fig. 1; Nishizono et al., 1982, pl. 2, fig. 7; Sashida and Tonishi, 1985, pl. 7, figs. 8-9; Ishiga, 1990, pl. 1, fig. 5; Tumanda et al., 1990, pl. 2, fig. 21; Ishida et al., 1992, pl. 1, fig. 2.

*Neoalbaillella sp.*, Kojima, 1982, pl. 2, figs. 8-9, pl. 3, fig. 1.
Neolabillella sp. cfr. N. ornithoformis, Kojima, 1982, pl. 2, fig. 10.

Remarks.—Although preservation of our present specimen is very poor, the shape of the apical cone and the dorsal wing are identical with that of the type species of Neolabillella ornithoformis. Our specimens differ from N. optima in lacking ladder-shaped extension of rods. Occurrence.—CHU-43, 44.

Alabillella triangularis Ishiga, Kito and Imoto

Figures 10–18—20

Alabillella triangularis Ishiga, Kito and Imoto, 1982b, p. 2, figs. 8–11; Wakita, 1983, pl. 6, fig. 8; Caridroit et al., 1985, pl. 1, fig. 1; Ishiga, 1985, p. 13, pl. 2, figs. 13–19; Yoshida and Murata, 1985, pl. 2, figs. 9, 10; Caridroit and De Wever, 1966, p. 58–59, pl. 1, figs. 1–5; Wu and Li, 1989, pl. 1, fig. 14; Tumanda et al., 1990, pl. 2, fig. 18; Kuwahara et al., 1991, figs. 4–1–2; Ando et al., 1991, pl. 9, fig. 9; Kuwahara and Sakamoto, 1992, pl. 3, figs. 5–6; Yao et al., 1993, pl. 1, fig. 3.

Alabillella sp. cf. A. triangularis, Cheng, 1989, p. 138, pl. 5, figs. 6–9, 11–12.

Remarks.—This species is characterized by having a triangular shell with a ridged H-frame. Owing to ill-preservation, our specimens lack the H-frame but other characters such as a triangular shell with horizontal bands on the shell surface are quite identical with the type species and the above-listed reports of this species. Occurrence.—CHU-41, 42.

Alabillella levius Ishiga, Kito and Imoto

Figures 10–16—17, 21

Alabillellidae gen. et sp. indet., Takemura and Nakaseko, 1961, pl. 34, fig. 10.
Alabillella levius Ishiga, Kito and Imoto, 1982b, p. 17, pl. 3, figs. 1–4; Kojima, 1982, pl. 3, figs. 5–6; Wakita, 1983, pl. 6, figs. 5–6; Sashida and Tonishi, 1985, pl. 5, figs. 5–6; Tumanda, 1985, pl. 2, figs. 11–12; Noble and Renne, 1990, pl. 1, figs. 12–15; Tumanda et al., 1990, pl. 2, fig. 24; Ishida et al., 1992, pl. 1, fig. 4; Kuwahara and Sakamoto, 1992, pl. 40, pl. 3, figs. 8–9, 12; Yao et al., 1993, pl. 1, figs. 6, 8.

Alabillella sp. cfr. A. levius, Cheng, 1989, p. 138, pl. 1, figs. 5–7, pl. 2, figs. 1–4; Ando et al., 1991, pl. 9, fig. 10.

Alabillella levius, Wu and Li, 1989, pl. 1, fig. 10.
Remarks.—Our specimens assignable to the present species lack an H-frame but the general shell shape with a ventral rod is similar to that of the original specimens.

Occurrence.—CHU-41, 42, 43, 44.

*Albaillella excelsa* Ishiga, Kito and Imoto

Figures 10-5-11

*Albaillella excelsa* Ishiga, Kito and Imoto, 1982b, p. 17-18, pl. 3, figs. 5-8; Wu and Li, 1989, pl. 1, figs. 8-9; Kuwahara and Sakamoto, 1962, pl. 39, pl. 1, fig. 8, pl. 3, figs. 1-3; Yao et al., pl. 1, figs. 2, 7.


Remarks.—Our specimens are similar to the original

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**Figure 10.** Permian radiolarians from Bukit Barak and Bukit Nyan. 1-4. *Neoalbaillella* cfr. *ornithoformis* Takemura and Nakaseko, 1; IGUT-KS0580, CHU-43, x 200, 2; IGUT-KS0517, CHU-44, x 170, 3; IGUT-KS0579, CHU-43, x 200, 4; IGUT-KS0531, CHU-44, x 150. 5-11. *Albaillella excelsa* Ishiga, Kito and Imoto, 5; IGUT-KS0536, CHU-41, x 150, 6; IGUT-KS0555, CHU-41, x 150, 7; IGUT-KS0542, CHU-42, x 150, 8; IGUT-KS0547, CHU-42, x 150, 9; IGUT-KS0575, CHU-41, x 150, 10; IGUT-KS0545, CHU-42, x 150, 11; IGUT-KS0537, CHU-42, x 150. 12-15. *Folicucillus monacanthus* Ishiga and Imoto, 12; IGUT-KS0591, BT-1, x 100, 13; IGUT-KS0578, BT-1, x 100, 14; IGUT-KS0588, BT-1, x 100, 15; IGUT-KS0589, BT-1, x 100. 16-17, 21. *Albaillella levis* Ishiga, Kito and Imoto, 16; IGUT-KS0518, CHU-44, x 150, 17; IGUT-KS0571, CHU-41, x 150, 21; IGUT-KS0560, CHU-41, x 150. 18-20. *Albaillella triangularis* Ishiga, Kito and Imoto, 18; IGUT-KS0573, CHU-42, x 150, 19; IGUT-KS0533, CHU-42, x 150, 20; IGUT-KS0539, CHU-42, x 150.
984. Permian Radiolaria from Peninsular Malaysia

and other above-listed specimens. The present species is similar to Albalillella lauta Kuwahara, but length between the proximal part of wing and aperture in A. levus is longer than in A. lauta. Albalillella flexa Kuwahara is distinguished from A. excelsa in having a diagnostic bending in the apical portion.

Occurrence.—CHU-41, 42, 43, 44.

Genus Follicucillus Ormiston and Babcock, 1979
Follicucillus monacanthus Ishiga and Imoto

Figures 10-12-15

Follicucillus sp. A, Ishiga and Imoto, 1980, p. 340, pl. 4, figs. 11-15; Ishiga et al., 1982a, pl. 2, figs. 5-6; Ishiga et al., 1982b, pl. 2, figs. 5-7.

Follicucillus monacanthus Ishiga and Imoto, in Ishiga et al., 1982c, p. 276-277, pl. 4, figs. 15-17; Suzuki et al., 1983, pl. 4, figs. 1, 2; Isokzaki, 1984, pl. 31, figs. 2-7-8; Tazawa et al., 1984, fig. 2-3; Ishiga, 1984, pl. 431, pl. 1, figs. 9-12; Naka and Ishiga, 1985, pl. 1, figs. 8-11; Yoshida and Murata, 1985, pl. 2, figs. 3-4; Ishiga et al., 1986, p. 128, pl. 2, figs. 4-11; Kojima, 1986, fig. 3-12; Uchiyama et al., 1986, pl. 8, fig. 14; Nishimura and Ishiga, 1987, pl. 1, figs. 7-10; Ishiga and Suzuki, 1988, pl. 1, fig. 1; Ishiga et al., 1988, figs. 5, 13; Wang, 1991, pl. 3, fig. 4; Ando et al., 1991, pl. 9, fig. 4; Blome and Reed, 1992, p. 364, figs. 9, 14-15; Ishiga et al., 1992, pl. 2, fig. 2

Follicucillus sp. B, Ishiga and Imoto, in Ishiga et al., 1982c, pl. 4, figs. 18-20.

Remarks.—Follicucillus monacanthus is similar to F. scholasticus morphotype II Ishiga in general shell shape. The former species, however, is discriminated from the latter in having a short hook-like spine (or wing) on the dorsal side of the apical cone. Although our specimens are poorly preserved, shell shape with a strongly segmented pseudoabdomen in the dorsal side and a hook-like spine are identical with F. monacanthus.

Occurrence.—BT-1.

Suborder Spumellaria Ehrenberg, 1875
Superfamily Entactinioidea Riedel, 1967
Family Entactinioidea Riedel, 1967

Remarks.—Sugiyama (1992) included this family in the order Entactinaria which was proposed by Kozur and Mostler (1982). He pointed out that the family is characterized by the spherical shell and internal spicule that suggest phylogenetically much closer to nassellarians than to typical spumellarians. Nazarov and Ormiston (1985) systematically listed and classified this radiolarian group. Kozur and Mostler (1989) described many genera and species attributable to the suborder Entactinaria. There are, however, diverse opinions in taxonomy of this kind of radiolarians (e.g., Blome and Reed, 1992). We tentatively classified these radiolarians as the suborder Spumellaria.

Genus Entactinosphaera Foreman, 1963
Entactinosphaera pseudocimelia Sashida and Tonishi

Figures 11-1-3

Entactinosphaera pseudocimelia Sashida and Tonishi, 1988, p. 528-529, figs. 7-1-3, 6-8.

Remarks.—The present materials have longer major spines compared with those of the original species described by Sashida and Tonishi (1988). As already pointed out by them, Entactinosphaera pseudocimelia is distinguished from E. cimelia Nazarov and Ormiston in the nature of major spines. The latter species has thin-bladed and long major spines which are triangular in cross section.

Occurrence.—CHU-43, 44.

Entactinosphaera sp.

Figures 11-4-6

Remarks.—This unidentified species is characterized in having three sturdy major spines, which are triradiate in cross section. The length and width of these major spines are variable.

Occurrence.—CHU-43, 44.

Superfamily Latentifistulidae Nazarov and Ormiston, 1983
Family Ruzenc евисpongidae Kozur, 1980
Genus Octatormentum Nazarov and Ormiston, 1985
Octatormentum ? sp.

Figure 11-20

Remarks.—The present specimens lack terminal spines. An internal sphere cannot be observed. This unidentified species is referred to the genus Octatormentum, which has a spongy shell of double pyramidal form.

Occurrence.—CHU-44.

Family Ormistonellidae De Wever and Cardroit, 1984

Remarks.—This family diagnostically has four rays in a tetrahedral pattern without any surrounding external shell. Two genera, Nazarovella De Wever and Cardroit and Ormistonella De Wever and Cardroit are grouped in this family. Previously, Sashida and Tonishi (1986) placed these genera in the family Latentifistulidae, but we include these genera in the family Ormistonellidae in this study.

Genus Nazarovellla De Wever and Cardroit, 1984
Nazarovellla gracilis De Wever and Cardroit

Figures 11-17, 19

Nazarovellla gracilis De Wever and Cardroit, 1984, p. 101, pl. 1, figs. 14-15, 17; Ishiga, 1985, pl. 2, figs. 22-23; Naka and

Ishiga, 1985, pl. 1, figs. 14-15; Yamakita, 1986, pl. 1, figs. 12-13; Ishiga and Miyamoto, 1986, pl. 64, fig. 16; Sashida and Tonishi, 1986, p. 10, pl. 3, figs. 10-12, pl. 4, fig. 7; Caridroit and De Wever, 1986, p. 82-83, pl. 4, figs. 9-15; Tumanda et al., 1990, pl. 1, fig. 27; Blome and Reed, 1992, p. 375, figs. 13, 9-10. Nazarovella sp., Cheng, 1989, pl. 2, fig. 12. Nazarovella sp., Ishiga et al., 1986, pl. 3, figs. 11-13.

Remarks.—Although all of our specimens are incompletely preserved, they may be identified with N. gracilis in having diagnostic features of four arms, one of which, the fourth arm, is perpendicular to the plane of the other three.

Occurrence.—CHU-43, 44.

*Nazarovella inflata* Sashida and Tonishi

Figures 11-15—16

*Nazarovella inflata* Sashida and Tonishi, 1986, p. 10-11, pl. 4, figs. 1-6, 10-12; Tumanda et al., 1990, pl. 1, fig. 20; Wang, 1991, pl. 4, fig. 2.

*Nazarovella* spp., Cheng, 1989, pl. 2, figs. 10-11.

unidentified ? latentifistulid, Blome and Reed, 1992, fig. 13. 21.

Remarks.—An inflated tetrahedral shell with long cylindrical rays is a distinctive feature of this species. Expansion of the tetrahedral shell is fairly variable in specimens. Some specimens (e.g., Figure 10-15) have a less expanded shell compared with other ones (e.g., Figure 10-16). This species is easily distinguished from *N. gracilis* in having a tetrahedral shell and cylindrical rays.

Occurrence.—CHU-44.

Genus *Praedeflandrella* Kozur and Mostler, 1989

*Praedeflandrella* sp.

Figure 11-14

Remarks.—Several poorly preserved specimens were obtained. This unidentified species differs from other species of the genus *Deflandrella* De Wever and Caridroit in having chambered arms.

Occurrence.—CHU-41.

Family Ishigidae Kozur and Mostler, 1989

Genus *Pseudotortentus* De Wever and Caridroit, 1984

*Pseudotortentus* sp.

Figure 11-18

Remarks.—This unidentified species slightly resembles *Pseudotortentus kamigoriensis* De Wever and Caridroit from southwest Japan. The shell of the latter species, however, has a bulbous central portion. This unnamed species is also similar to *Latentifistula* sp. described by Sashida and Tonishi (1986) from Itsukachi, Tokyo, but we refrain from a detailed comparison because of the restricted number of specimens.

Occurrence.—CHU-41.

Genus *Ishigaum* De Wever and Caridroit, 1984

*Ishigaum* ? sp.

Figures 11-7–11

Remarks.—Completely preserved specimens are rare in our collection. This unidentified species characteristically has a large shell composed of three rays, the length of which attains more than 500 μm. Rays with coarse spongy club-like tips are composed of a bundle of three thin rods and have weak torsion. A conical terminal spine protrudes from the spongy club-like tips. The generic position of this unidentified species is tentative.

Occurrence.—CHU-43, 44.

Genus *Spumellaria Incertae sedis* Triplanospongios Sashida and Tonishi, 1988

Remarks.—This genus has almost the same shell structure as that of *Triplanospongus* Noble and Renne, 1990. Blome and Reed (1992) considered that *Triplanospongus* is a junior synonym of the present genus.

*Triplanospongios musashiensis* Sashida and Tonishi, 1988

Figures 11-12—13

*Paronaela* sp. A, Waki, 1983, pl. 7, fig. 7.

Angulobracchia ? sp., Yoshida and Murata, 1985, pl. 2, fig. 18.

*Triplanospongios musashiensis* Sashida and Tonishi, 1988, p. 536–539; Tumanda et al., 1990, pl. 2, fig. 14.


*Trifidiospongus angustus* Noble and Renne, 1990, p. 389, pl. 1, figs. 4-6.

Remarks.—This species shows broad variation in ray morphology as shown by Sashida and Tonishi (1988). The above–listed species placements may reflect different degrees of preservation.

Occurrence.—CHU-42, 43, 44.

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