Radiolarian Research in Some Mesozoic Provinces in Indonesia

Munasri (Puslitbang Geoteknologi – LIPI)

Introduction

The single-celled radiolarians average between 20-200 mm in diameter. These planktonic animals range from Cambrian to Holocene. The name Radiolaria was first proposed by Muller (1858) for marine Sarcodina with radial symmetry to distinguish them from foraminifera. Ehrenberg (1838) proposed the name of Polysystina for fossil skeletons consisting of solid opaline processes. This group includes the two taxa Spumellaria (spherical) and Nassellaria (bell shaped).

Although Radiolaria has been known since 19th Century, but their fossils were only comprehensively treated for stratigraphic purpose within the last three decades. The new way of extraction of radiolarian-bearing rocks by using hydrofluoric acid solution; and the use of scanning electron microscope have also rapidly enhanced the development of radiolarian research.

Recent studies of Radiolaria mostly emphasize their value to biostratigraphic correlation of marine sediments, as almost any initial report of the Deep-Sea Drilling Project has demonstrated. Radiolarians are particularly useful where other microfossils have suffered dissolution. They have also been used to indicate paleogeographic and tectonic change in ocean basin. For examples, radiolarians stratigraphy gave early support to the hypothesis of sea-floor spreading (Riedel, 1967); and paleogeographically distinct low- and high-paleolatitude faunas were described by Baumgartner (1993).

Research on fossil Radiolaria in Indonesia

Radiolarian research in Indonesia was actually begun by Hinde (1890) from the investigation of rock from Central Kalimantan. This work was the first investigation of early Cretaceous radiolarians in the circum-Pacific. In 1928, Tan Sin Hok published the description of radiolarian from Rotti Island. The taxonomy of some Jurassic to Cretaceous radiolarians now used worldwide was derived from Tan's description.

In the recent research of this field, Mesozoic radiolarians have been studied in several areas of Indonesia (figure 1). Some radiolarian

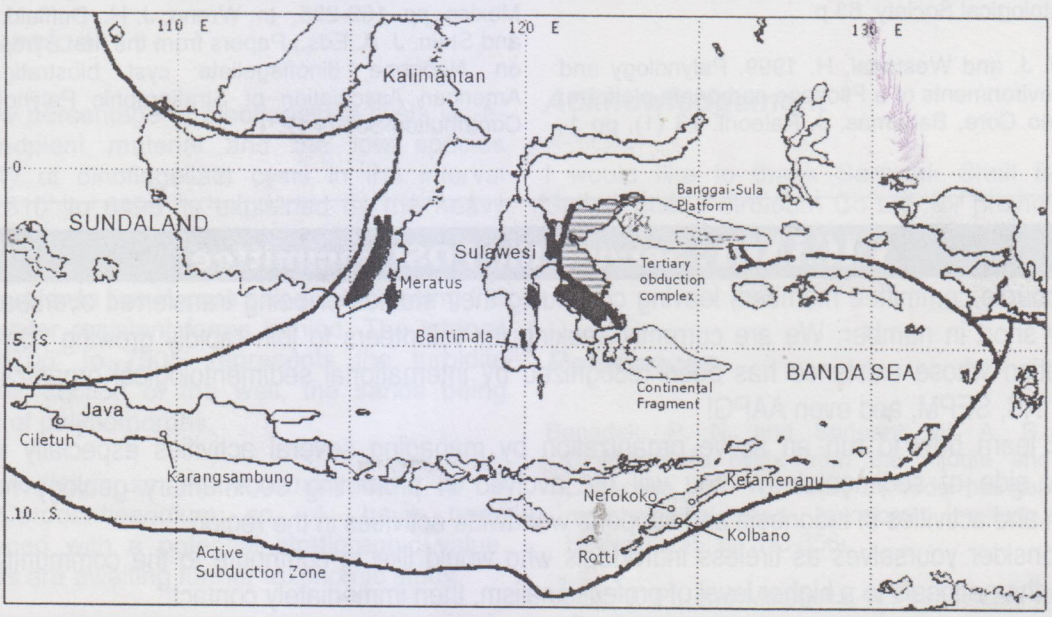


Figure 1: Geographical distribution of radiolarian research over Indonesia. The background map is taken from Hamilton (1979).

research, especially in the west and central Indonesian region (Jawa, Sulawesi and Kalimantan) were conducted within 1990 to 1998 by the join cooperation among Indonesian Institute of Sciences (LIPI), Geological Survey of Japan (GSJ), and Geolgogical Research and Development Centre (GRDC=P3G, see Wakita et al., 1994a, 1994b, 1996, Munasri, 1995 and Wakita et al., 1998). In the period of 1995 to 1997, the University of Tsukuba, Japan together with LIPI underwent research on Mesozoic radiolarians in Timor and Rotti Islands (Sashida et al., 1996, 1999a, 1999b; Munasri, 1998, Munasri and Sashida 1998). Summary of age distribution of Mesozoic radiolarian-bearing sequences is shown in Figure 2 and some typical radiolarains are shown in Figure 3. Followings are the summary of Mesozoic radiolarian research in certain several area in Indonesia:

Early to latest Creataceous radiolarians from Karangsambung, Central Java

Chaotic rocks of Lok Ulo melange complex in the Karangsambung area are composed of shale, pebbly shale, limestone, chert, sandstone, schist, basic to ultra basic rocks, rhyolite, marble, phyllite, and conglomerate. Chert is often interbedded with limestone, while sandstone usually alternates with shale. Radiolarians were mostly extracted from shale and chert. They are grouped into five assemblages (Wakita et al., 1994a).

Assemblage I is characterized by the present of *Pseudodictyomitra carpatica* and *P. leptoconica*. The age of this assemblage is Early Cretaceous (up to Barremian).

Assemblage II is derived from rocks containing *Archaeodictyomitra* sp. cf. *A. apiarium*, *A.* sp. cf. *A. pseudoschalaris*, *A.* sp. cf. *A. vulgaris* and *A. simplex*. Age: Middle Cretaceous.

Assemblage III is characterized by the present of *Dictyomitra formosa* and lacking *D. koslovae*. Age: early Late Cretaceous.

Assemblage IV includes *D. formosa, Theocampe urna, T. salillum, Praeconocaryomma universa* and *Pseudoaulophacus* sp. cf. *P. parageraensis*. Age: Late Cretaceous (Coniacian to Campanian).

Assemblage V contains species of *Acaeonityle* sp. aff. *A. umbilicata, Dictyomitra multicostata, Stichomitra communisl* and *T. urna*. Age: Latest Cretaceous (late Campanian to Maastrichian).

From radiolarian data, siliceous and argillaceous rocks of the Lok Ulo Melange complex are considered to have deposited in Early to Late Cretaceous time, and accreted at a subduction trench during middle to latest Cretaceous or earliest Paleocene.

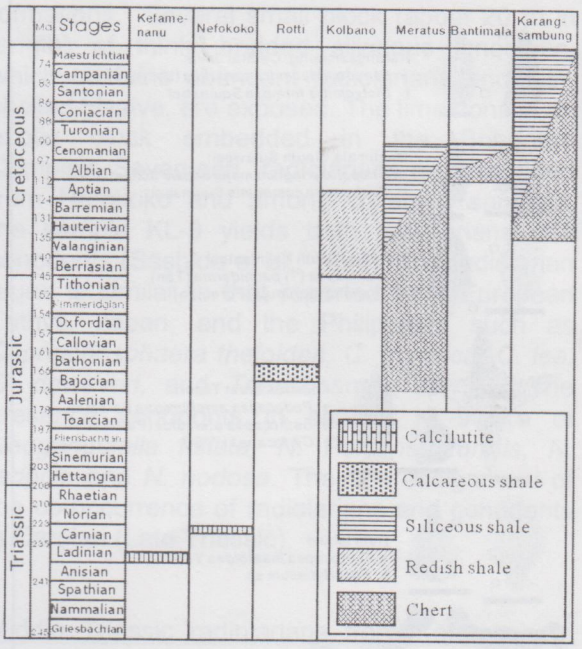


Figure 2: Summary of age distribution of radiolarian-bearing sequences in the study area.

Middle Cretaceous radiolarians from Bantimala area, South Sulawesi

The Bantimala mélange complex of South Sulawesi consists mainly of chert, siliceous shale, basalt, schist and include clasts and blocks of sandstone, in a sheared shale matrix. Well-preserved radiolarians were obtained respectively from chert and siliceous shale (Wakita et al, 1994b; Wakita et al, 1996). Among the obtained radiolarians, several species are known for age determination. They are of *Acaeniotyle umbilicata, Archaeodictyomitra vulgaris, Holocryptocanium barbui, Rhophalosyringium majuroensis, Stichomitra communis, Thanarla conica* and *Xitus spicularius*. The range age of these taxa is middle Cretaceous (late Albian – early Cenomanian) or about 105-95 Ma.

Wakita et al (1994b) also dated the K-Ar age for the schist fragment from the base of chert in Paring River. The K-Ar age dating of this metamorphic rock range from 132 to 114 Ma. The time lag of these two kinds of age data from chert and underlying schist suggest short-time tectonic, immediately followed by a fast waning

tectonism during the Albian-Cenomanian transgression. The radiolarian sedimentation started just after the sedimentation of clastic rocks derived from schist.

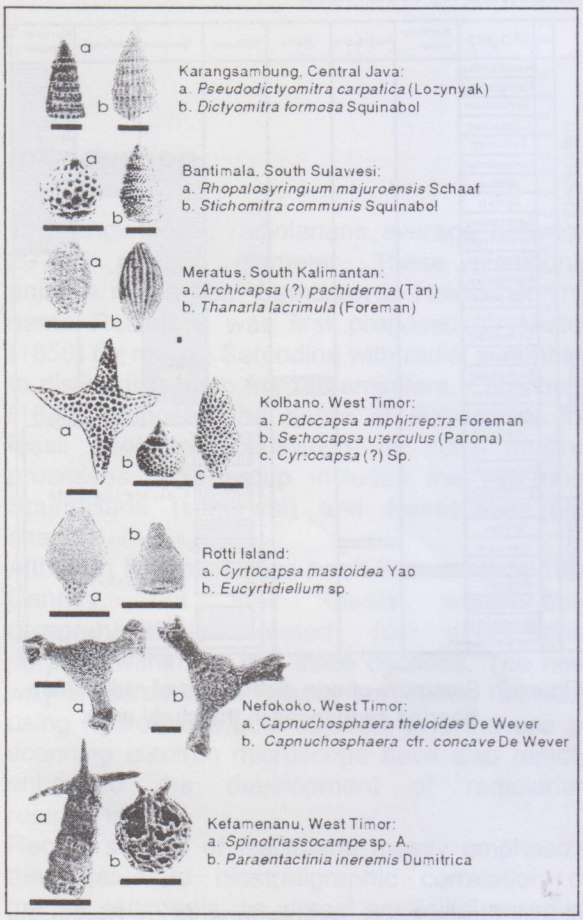


Figure 3: Some typical Triassic to Cretaceous radiolarians from the study area.

Jurassic to Cretaceous radiolarians from Meratus area, South Kalimantan

The Meratus Mountains and Laut Island (Meratus area) in South Kalimantan composed of Cretaceous formations, ultramafic and plutonic rocks, schist and phylite, and mélange. Radiolarians were extracted from chert and siliceous shale in the mélange at Sekoyang, Laut Island and from the Pitap and Haruyan formations. Radiolarian associations from chert and siliceous shale in mélange at Sekoyang range in age from early Middle Jurassic (Bajocian) to late Early Cretaceous (Aptian). They are from following six samples:

1. Sample SK47C (Bedded chert): *Transhuum hisyikyoense* and *Archicapsa* (?) *pachiderma*.
Age: Bajocian.
2. Sample SK52B (chert clast in breccia): *Protunum turbo* and *Stichocapsa himedarma*.
Age: Bajocian – Bathonian.
3. Sample SK41X (chert block in mélange): *Eucyrtidiellum ptycum*, *Emiluvia prenyogii* and *Titrabs rhododactylus*.
Age: Bathonian-Oxfordian.
4. Sample SK52A (chert breccia): *Eucyrtidiellum pyramis, Parvicingula mashitaensis,* and *Protunuma japonicus*.
Age: Tithonian.
5. Sample SK50A (tuffaceous bedded chert): Pseudodictyomitra carpatica, Sethocapsa uterculus, and *Xitus gifuensis*.
Age: Tithonian – Valanginian.
6. Sample SK60A (siliceous shale): *Sethocapsa uterculus, Thanarla pacifica, Pantanelium lanceola.*
Age: Valanginian – Aptian.

Radiolarians from Haruyan Formation contain *Stichomitra communis* and *Tananrla brouweri* of Cenomanian age (early Late Cretaceous).
The radiolarian data suggests that the oceanic plate covered by these cherts was at least older than early Middle Jurassic and finally subducted in middle Cretaceous.

Early Cretaceous radiolarians from Kolbano area, West Timor

The Permian to Pliocene sedimentary rocks of the Kolbano area, southern West Timor, are an accretionary complex stacked at the leading edge of the Timor arc-continent collision zone between Australian continental margin and the Banda island arc. The Cretaceous Nakfunu Formation is one of the elements of this accretionary complex. The formation is mainly made up of gray, pink and reddish shale and abundantly contains radiolarian skeletons. More than 150 radiolarian species were collected from the Nakfunu Formation. Among them, several species are useful for age determination. These taxa which contain Tethyan and non-Tethyan fauna have a range age of Berriasian-Aptian (Early Cretaceous) can be discriminated into four radiolarian assemblages:
Assemblage 1 is dominated by non-Tethyan fauna with several well-known Tethyan index species *Acaeniotyle dentata, Hsuum foliformis, Emiluvia chica decuccata, Podocapsa amphitreptra* and *Pantanellium squinaboli.* Age: Berriasian-early Valanginian.

Assemblage 2 is dominated by Tethyan fauna with less (5%) of non-Tethyan fauna. Characterized species (of Tethyan fauna) *Archaeodictyomitra apiarium, A. lacrimula, Cecrops septrmporatus, Eucirtis columbaria* and

Pseudodictyomitra carpatica show the age of late Valanginian-Barremian.

Assemblage 3 contains characterized species as well as in the Assemblage 2 with lack of non-Tethyan fauna. Age: late Valanginian-Barremian.

Assemblage 4 is mostly of Tethyan species such as *Dicroa periosa, Dictyomitra pseudoscalaris, Sethocapsa simplex* and *Stichomitra asymbatos*. Age: Aptian.

The non-Tethyan radiolarians have been reported from the ODP site 765 and 766, Argo Abyssal Plain, northwestern Australian margin (Baumgartner, 1993). The presence of non-Tethyan fauna in the older strata of the Nakfunu Formation indicate that sedimentation process of the Nakfunu Formation is started in the area of higher paleo-latitude and/or be influenced by cold oceanic circum-Antarctic current system (Munasri, 1998).

Middle Jurassic radiolarians from Baa, Rotti Island

Rotti Island is located about 15 km southwest of Timor Island. According to the 1: 250.000 geologic map of Rosidi et al. (1981) the geologic setting of the island is composed of the Triassic Aitutu Formation, the Middle Miocene to Pliocene Bobonaro Complex, the Plioi-Pliestocene Noele Formation, and the Quaternary coralline limestone. A well-preserved Middle Jurassic radiolarians were discriminated from calcareous shale of the unit previously mapped as Bobonaro Complex (Sashida et al., 1999b). Radiolarians obtained from sample RT-1 are indicative of late Bajocian-early Bathonian (Middle Jurassic age) such as *Tricolocapsa plicarum, T.? fusiformis, Stichocapsa convexa*, and *Protunuma turbo*. Two species *Tricolocapsa multispinosa Sashida* and *Tricolocapsa matsuokai* Sashida are described as new.

Mesozoic formations in Timor Island consist of the Triassic Aitutu Formation, the Jurassic Wai Luli Formation and the Cretaceous Nakfunu Formation. Radiolarian-bearing calcareous shale in Rotti Island is suspected belong to the Jurassic Wai Luli Formation. This shale is believed to have been deposited in the deep ocean remote from land areas as opposed to the Bajocian belemnite-bearing Wai Luli Formation.

Late Triassic radiolarians from Nefokoko, West Timor

Nefokoko is a small village situated about 15 km west of Kapan, west Timor. The most part of Nefokoko is occupied by massive and bedded limestone and clastic rocks which may be attributed to the Permian and Triassic formations. Several small block (about 20 m in length) of thinly bedded siliceous limestone, which contains abundant radiolarians and thin-shelled bivalve, are exposed. The limestone is an exotic block embedded in the Bobonaro Complex. Seventeen radiolarians are described from Nefokoko and among collected samples, the sample KL-9 yields both radiolarians and conodonts (Sashida et al., 1996). The radiolarian fauna is similar to that reported from European Tethys, Japan, and the Philippines such as *Capnuchosphaera theloides, C. triassica, C. lea, C. deweveri,* and *Triassocampe* sp. A. The presence conodonts in sample KL-9 are of *Neogondolella foliata, N. Polygnathiformis, N. tadpole* and *N. nodosa*. The age assignment of the co-occurrence of radiolarians and conodonts is Carnian (Late Triassic).

Middle Triassic radiolarians from Kefamenanu, West Timor

Kefamenanu is located in the central west Timor, about 197 km east of Kupang. Most of the area is covered by the Bobonaro Complex. Radiolarian-bearing rocks are derived from calcilutite exposed along the road about 3 km west Kefamenanu. From 5 calcilutite samples, radiolarians are discriminated into 59 species belonging to 35 genera. Among them, the following species are useful for age assignment and regional correlation, namely: *Pseudostylosphaera coccostyla coccostyla, P. postjaponica, P. spinulosa, Spongostylus tricostatus, Katorella bifurcata, Oertlispongus inaequispinosus, Spongostephanedium japonicum, Tetraspinocyrtis anisica*, and *Hozmadia spinosa.*

The radiolarian fauna from Kefamenanu is identical to that of early Ladinian (middle Triassic) of European Tethys and other related faunas reported from the Philippines, Russia Far East and Japan. In contrast, this radiolarian fauna fairly different with those of faunas reported from New Zealand and Siberia (Aita, 1994 and Bragin, 1994; in Sashida, 1999). These radiolarian data suggest that roughly two distinct realms can be recognized in Middle Triassic time; the low latitude Tethyan and high latitude non-Tethyan Realms.

Conclusions

Radiolarians have proven useful for age determination or as stratigraphic tool. They also have a value to biostratigraphic correlation of oceanic sediments. Radiolarian data revealed a new insight in tectonic of (i.e. Karangsambung, Bantimala and Meratus) and paleogeography of (i.e. Timor: Kolbano, Nefokoko and Kefamenanu; and Rotti Island).

References

Baumgartner, P.O., 1993, Early Cretaceous radiolarians of the Northern Indian Ocean (Leg 123: Sites 765, 766 and DSDP Site 261): The Antarctic-Tethys connection. In: D Lazarus and P. De Wever (Eds), Interrad VI, Marine Micropaleontology, 21, pp. 329-352, pls. 1-2.

Ehrenberg, C.G., 1838, Uber die Bildungder Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. Konigliche Akademie der Wissenschaften zu Berlin, Abhandlungen, pp. 59-147, pls. 1-4.

Hamilton, W., 1979, Tectonics of the Indonesian region, US Geological Survey, Professional Paper, 1078.

Hinde, G. J., 1900, Description of fossil Radiolaria from the rocks of Of Central Borneo. In: Borneo-Expeditie: Geologische verkenningstochten in Central Borneo (1893-94), ed. G. A. F. Molengraaf, E. J. Brill, Leiden and H. Gerlings, Amsterdam, pp. 1-51, 54-6.

Muller, J., 1858, Uber die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres, Abhandlungen der Preussichen Academie der Wissenschaften, Jahrgang, pp. 1-62, pls. 1-11.

Munasri, 1995, Cretaceous radiolarian biostratigraphy in the Bantimala and Barru areas, South Sulawesi, Indonesia, MS Thesis, Univ. Tsukuba, Japan, unpublished.

Munasri, 1998, Early Cretaceous radiolarian biostratigraphy of the Nakfunu Formation, the Kolbano area, West Timor, Ph. D. Thesis, Univ. Tsukuba, Japan, unpublished.

Munasri, Permana, H. dan Siregar, S., 1999, Pulau Seram adalah cerminan Pulau Timor?, Prosiding PIT XXVIII IAGI, Jakarta 30 November - 1Desember.

Riedel, W. R., 1967, Subclass Radiolaria. In: The Fossil record, ed. W. B. Harland et al., Geological Society of London, pp. 291-8.

Sashida, K., Adachi, S., and Ueno, K., and Munasri, 1996, Late Triassic radiolarians from Nefokoko, West Timor, Indonesia, In: Noda, H. and Sashida, K., eds., Prof. H. Igo Commem. Vol., p. 225-234, Gakujyutsu Tosho Insastsu Co.

Sashida, K., Munasri, Adachi, S. and Kamata, Y., 1999a, Middle Jurassic radiolarian fauna from Rotti Island, Indonesia, Journal of Asian Earth Sciences, p. 561-672.

Sashida, K., Kamata, Y., Adachi, S. and Munasri, 1999b, Middle Triassic radiolarians from West Timor, Indonesia, J. Paleont., v. 75, no. 5, p. 765-786.

Tan Sin Hok, 1927, Over de samenstelling en het onstaan van krijt-en mergel gesteenten van de Molukken, in: Brouwer, H. A. (ed): Jaarboek van hetmijnwezen in Nederlandsch Oost-Indie, jaargang 55, 1926, p. 5-165.

Wakita, K., Munasri, and Widoyoko, B., 1994a, Cretaceous radiolarians from the Lok Ulo Melange Complex in the Karangsambung area, central Java, Indonesia, Jour. Southeast Asia Earth Sci., v. 9, no. 1-2, p. 5-23.

Wakita, K., Munasri, Sopaheluawkan, J., Zulkarnain, I., and Miyazaki, K., 1994b, Early Cretaceous tectonic events implied in the time-lag between the age of radiolarian chert and its metamorphic basement in the Bantimala area South Sulawesi, Indonesia, The Island Arc, 3, p. 90-102.

Wakita, K., Sopaheluawkan, J., Miyazaki, K., Zulkarnain, I., and Munasri, 1996, Tectonic evolution of the Bantimala Complex, South Sulawesi, Indonesia, In: Hall, R. and Blundell, D. (Eds), Tectonic Evolution of Southeast Asia, Geological Society Spec. Publ. No. 106, p. 353-364.

Wakita, K., Miyazaki, K., Zulkarnain, I., Sopaheluwakan, J., and Sanjoto, P., 1998, Tectonic implications of new age data for the Meratus Complex of south Kalimantan, Indonesia, The Island Arc, 7, p. 202-222.

