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RISET
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EARLY CRETACEOUS RADIOLARIANS IN MANGANESE CARBONATE NODULE FROM THE BARRU AREA, SOUTH SULAWESI, INDONESIA.

Radiolaria Kapur Awal pada Nodul Mangan Karbonat dari Daerah Barru Sulawesi Selatan, Indonesia

Munasri

ABSTRACT The Mesozoic basement complex in South Sulawesi, Indonesia, is exposed in two areas near Bantimala and Barru, known as the Bantimala Complex and the Barru Complex. The complexes consist of metamorphic, ultramafic and sedimentary rocks. Part of these rocks was chaotically mixed to form a mélange. Early Cretaceous (Valanginian to Barremian) radiolarians were extracted from manganese carbonate nodule embeded in dark reddish shale of the Barru Complex. Previously middle Cretaceous (late Albian to early Cenomanian) radiolarian assemblage was reported found in chert and siliceous shale of the Bantimala Complex.The hemipelagic dark reddish shale with manganese carbonate nodule of the Barru Complex are considered to have been deposited in Early Cretaceous time (Valanginian to Barremian) and accreted at the subduction trench during late Early Cretaceous (Aptian) time.Based on radiolarian data, it is considered that the Barru and Bantimala Complexes were not derived from single accretionary complex as previously regarded.

Keywords: Radiolaria, Manganese Carbonate, Early Cretaceous, Barru Complex, South Sulawesi.

ABSTRAK *Komplek batuan dasar berumur Mesozoikum di Sulawesi Selatan tersingkap di dua wilayah dekat Barru dan Bantimala, dan dikenal sebagai Komplek Barru dan Komplek Bantimala. Komplek ini mengandung komponen yang terdiri atas batuan-batuan metamorf, ultramafik, sedimen; dan sebagian dari batuan ini tercampur-aduk sebagai mélange. Fosil radiolaria berumur Kapur Awal (Valanginian – Barremian) telah diekstraksi dari batuan nodul mangan karbonat yang terbenam pada batuserpih merah dari Komplek Barru. Sebelumnya dilaporkan kumpulan fosil radiolaria berumur Kapur tengah (Albian – Cenomanian) terdapat pada batu rijang dan serpih di Komplek Bantimala. Endapan hemipelagik serpih merah dengan nodul mangan karbonat di Komplek Barru dianggap diendapkan pada zaman Kapur Awal dan terakresi pada parit subduksi selama masa akhir Kapur Awal (Aptian). Berdasarkan data radiolaria, Komplek Barru dan Komplek Bantimala bukan komplek batuan dasar yang berasal dari satu sistem komplek akresi yang sama, seperti anggapan sebelumnya.*

Kata kunci: *Radiolaria, nodul mangan karbonat, Kapur Awal, Komplek Barru, Sulawesi Selatan.*

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INTRODUCTION

Since the discovery of Mesozoic radiolarians in Rote Island, West Nusatenggara, was reported by Tan Sin Hok (1927), modern radiolarian research - using SEM tools - in Indonesia was just started in the 1990s. Radiolarian occurrences were reported mainly from Mesozoic strata (Okamoto *et al*., 1994; Wakita *et al*., 1994a, 1994b, 1998; Sashida *et al*., 1996, 1999a, 1999b; and Jasin and Haile, 1996). All of these radiolarians were extracted from chert, siliceous shale or siliceous mudstone. These rocks are suggested to represent pelagic and hemipelagic sedimentary rocks of the Indian Ocean floor that has been subducted and accreted to Southeast Asia/Sundaland continent. Besides in chert and siliceous shale, radiolarians are naturally deposited within the manganese carbonate rocks. However, up to now, there has been no published report of radiolarians in manganese carbonate rocks in Indonesia.

In Japan, the occurrences of radiolarians in manganese nodules - mostly of Jurassic in age - have been reported by several workers since the 1970s (e.g. Yao. 1972, 1979; Hattori, 1988; Arakawa, 1998; Hori and Wakita, 2006). Most of manganese nodules from the inland section in Japan contain abundant, diversified and well preserved radiolarians. These radiolarians were examined for the use of taxonomy, age determination, biochronology and their paleogeographic deposition.

This paper presents the first discovery of Early Cretaceous radiolarians in manganese carbonate nodule located near Barru, South Sulawesi. Fairly well-preserved radiolarians in manganese carbonate nodule from the Barru area are not as abundant and diverse as those in manganese nodules samples from Japan. However, some certain species of radiolarians from the Barru area enable to set the age of the assemblage.

GEOLOGIC SETTING

The Mesozoic basement complex in the South Arm of Sulawesi is exposed in two areas, near Bantimala and Barru, known as the Bantimala Complex and the Barru Complex respectively and separated each other within 30 km. The complexes consist of metamorphic, ultramafic and sedimentary rocks, which part of these rocks are chaotically mixed as mélange (Figure 1). Mélange of the Bantimala Complex includes clasts and blocks of chert, sandstone, basalt, limestone and schist, embedded within a sheared shale matrix; and no such typical mélange is observed in the Barru Complex. Of the two exposures, the larger (Bantimala Complex) is the better known. The detailed geology of the Bantimala Complex has been investigated by Sukamto (1975, 1978, 1982, 1986), Hasan (1991) and Wakita *et al*. (1994b, 1996). Sukamto (1982) established that the older rocks, which unconformably overlain by Late Cretaceous Balangbaru Formation - flysch type sedimentary rocks, as a mass named the Bantimala Tectonic Complex. These older rocks are referred to which including the set of rocks in the Barru Complex and the Bantimala Complex. The complexes are surrounded with Tertiary and Quarternary sedimentary and volcanic rocks.

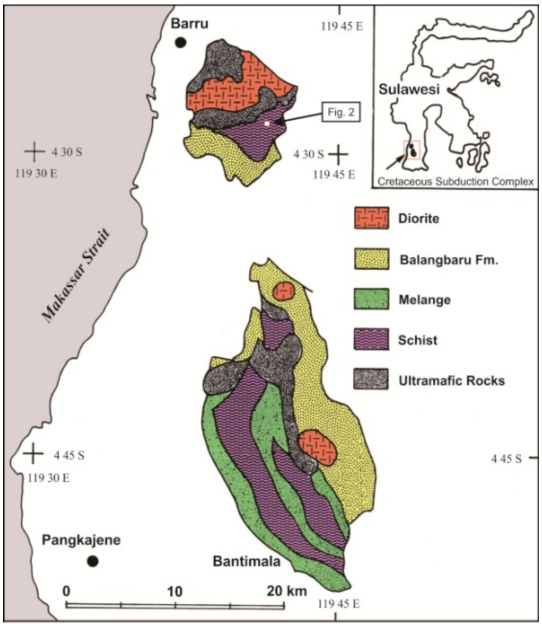


Figure 1. Geologic map of Cretaceous Subduction Complex in South Sulawesi (simplified after Sukamto, 1982 and Wakita *et al*., 1994b).

Wakita *et al*. (1994b) reported that the age of chert and shale in the Bantimala Complex is middle Cretaceous (late Albian to early Cenomanian). The age is determined by the presence of certain species of radiolarians including *Holocryptocanium barbui*, *Thanarla conica*, *Archaeodictyomitra vulgaris*, *Rhopalosyringium majuroensis, Pseudodictyomitra pseudomacrocephala* and *Stichomitra communis.*

In the Barru Complex, radiolarian-bearing manganese carbonate nodule was found near the junction of Dengenge River with its tributary, Lagala River (Figure 2). This locality is about 15 km southeast of Barru, South Sulawesi.

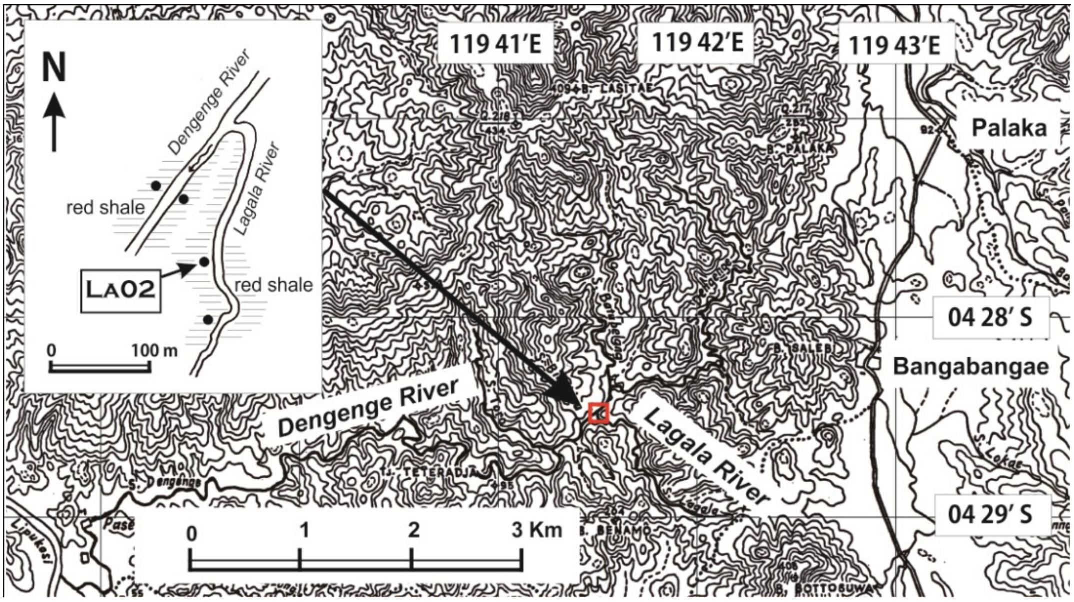


Figure 2. Locality map of manganese carbonate nodule.

The sample locality can be approached by car from Barru to Bangabangae through Palaka. To reach the sample site from Bangabangae was done by traversing from upstream and along the tributary Lagala River. Manganese carbonate nodules are scattered and embedded in weathered dark reddish shale (Figure 3). The nodules range from 10– 20 cm in size. The outer surface is brownish-black in color, while the fresh inside part is gray. According to Hattori (1993), manganese nodules are originally rhodochrosite concretions (Figure 4) and the outer black parts are composed of opaque manganese such as manganite and manganese hydroxides. Within the geologic map of Sukamto (1982), the sample site is laid on the geologic unit of metamorphic rock.

Figure 3. Outcrop of manganese carbonate nodule (a) embedded in weathered reddish shale (b).

The contact boundary of manganese carbonate nodules-bearing shale with underlying metamorphic rocks is not observed. No radiolarian is obtained in shale. Of four sample

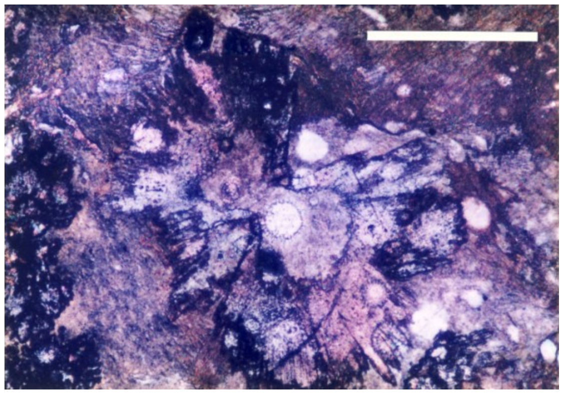


Figure 4. Microscopic feature of single rhodochrosite 'micronodule' in sample LA02 with radiate structure containing radiolarian skeleton. Scale bar = 500 µm.

points of manganese carbonate nodule, only sample LA02 contains radiolarians (see the procedure of extracting below).

MATERIAL AND METHODS

Radiolarians are extracted from the manganese nodule using the following procedure that modified from a technique developed by Pessagno and Newport (1972):

1. Manganese carbonate nodule is crushed into 2-3 cm in size and placed into 200 ml polyetylen beaker.
2. The sample then is soaked with 10-15 % hydrochloric acid (HCl) for 12-24 hours to dissolve manganese carbonate.
3. After acid in solution is removed, the residues are washed gently over a 250 mesh sieve with a spray of running water and dried in the oven.
4. Radiolarians then are observed under the scanning electron microscope.

Radiolarian species obtained from sample LA02 are listed in Table 1 with their abundance. These radiolarian pictures are illustrated in Figures 5 and 6.

Table 1. List of radiolarians from sample LA02. Abundance codes are as follows, Rare: 1-2, Few: 3-5.

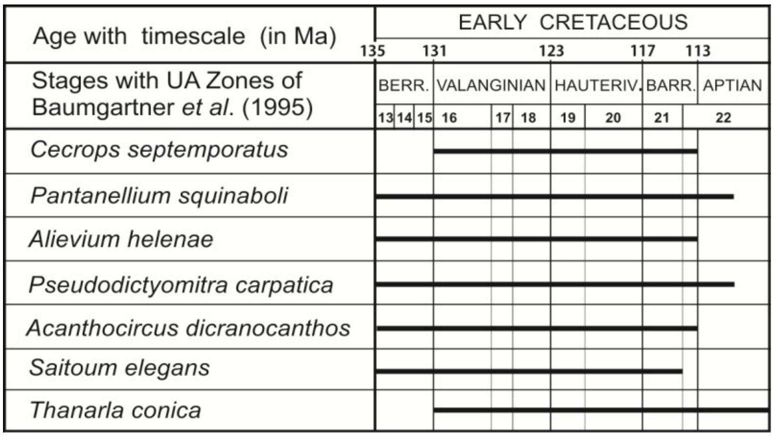
Radiolarian species	**Abun-dance**	**Figure**
Pantanellium squinaboli (Tan Sin Hok)	Few	5. 1, 2
Cecrops septmporatus (Parona)	Few	5. 3
Patulibrachium sp?	Rare	5. 4
Emiluvia sp.	Rare	5. 5
Alieveum sp.	Few	5. 6
Acaeniotyle sp.	Rare	5. 7
Patelula sp.	Rare	5. 8
Acanthocircus dicranocanthos (Squinabol)	Few	5. 9, 10
Praeconocaryomma sp.	Rare	5. 11
Saitoum elegans (De Wever)	Few	5. 12, 13
Napora sp.	Rare	5. 14
Katroma sp.	Rare	5. 15
Theocoeys sp.	Rare	6. 1
Eucyrtidium parviporum Tan Sin Hok	Few	6. 2
Theocapsa laevis Tan Sin Hok	Few	6. 3
Podobursa sp	Rare	6. 4
Stichomitra doliolum Aita	Few	6. 5. 6
Stichocapsa pseudodecora Tan Sin Hok	Few	6. 7
Pseudodictyomitra lilyae (Tan Sin Hok)	Rare	6. 8
Pseudodictyomitra carpatica (Lozyniak)	Rare	6. 9
Gongylothorax verbeeki (Tan Sin Hok)	Few	6. 10, 11
Eucirtidium broweri Tan Sin Hok	Few	6. 12
Thanarla conica (Aliev)	Few	6. 13
Nassellaria gen. et sp. Indet.	Few	6. 14-16

RADIOLARIAN AGE ASSIGNMENT

The radiolarian assemblage obtained from manganese carbonate nodule of the Barru Complex includes some age diagnostic species for Early Cretaceous. The age of the radiolarian assemblage described here (Table 2) refers to radiolarian biostratigraphic study of Baumgartner *et al*. (1995), Tumanda (1989), Aita and Okada (1986), Sanfilippo & Riedel (1985) and Pessagno (1977). Based on Unitary Associtiion (UA) Zones of Baumgartner *et al*. (1995) the biostratigraphic range of diagnostic species from this study is included within UAZ 17 and UAZ 21 (late Valanginian to early Barremian). Tumanda (1989) established four Createaceous radiolarian assemblage zones for the Esashi Mountain area, Northern Hokkaido, Japan on the basis of the association of several characteristic species. One of them, the *Staurosphaera septemporata-Parvicingula usotanensis* Assemblage Zone is define by the occurrence of characterisitic species of *Staurosphaera septemporata* = ***Cecrops septemporatus***, *Parvicingula boesii, P. usotanensis, Sethocapsa trachystraca, S. uterculus, Mirifusus mediodilatatus,* ***Alievium helenae***, *Acaeniotyle diaphorogona, A. umbilicata,* ***Acanthocircus dicranocanthos***, *Hemicriptocapsa capita, Orbiculiforma satoi, O. coronata, Archaeodictyomitra apiara, A. excellens,* ***Pseudodictyomitra carpatica***, *P. puga,* ***Thanarla conica***, *T. Pulchela, Xitus spicularius, Sphaerostylus lanceola* = ***Pantanellium squinaboli***, *Podobursa triacantha* and *Holocriptocanium barbui.* Six diagnostic species in bold are species also obtained from sample LA02 in this study. Tumanda (1989) determined this zone within the Valanginian to Barremian.

Aita and Okada (1986) placed 18 diagnostic species obtained from the section along Breggia River near Balerna, Switzerland into their new *Ditrabs sansalvadorensis* Zone and *Sphaerostylus septemporatus* Zone. Four species of them which also found in sample LA02 in the Barru Complex are *Alievium helenae*, *Cecrops septemporatus, Stichomitra doliolum* and *Acanthocircus dicranocanthos.* They assigned this assemblage within Berriasian to Barremian.

Table 2. Biostratigraphic range of certain radiolarians compiled from Baumgartner *et al*. (1995), Tumanda (1989), Aita and Okada (1986), Sanfilippo & Riedel (1985) and Pessagno (1977). The range-chart is based on Baumgartner *et al*. (1995).



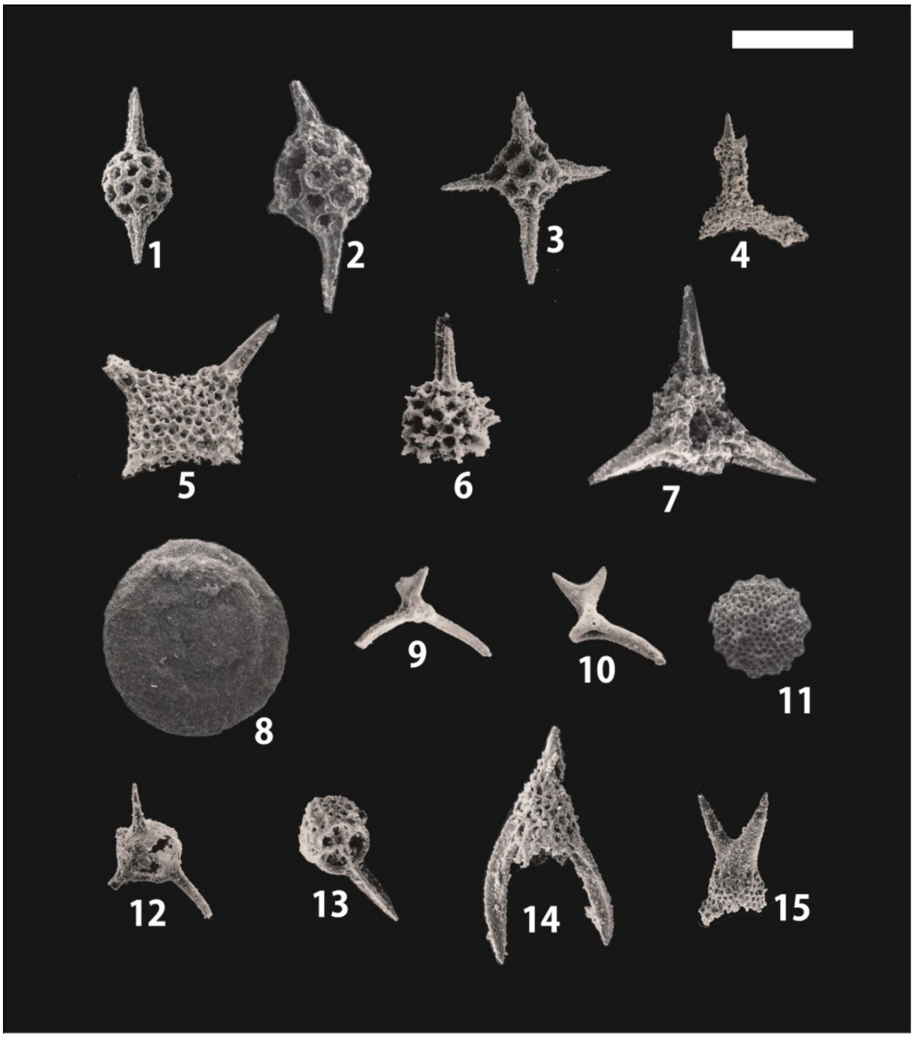


Figure 5. Scanning electron photomicrograph of Valanginian-Barremian radiolarians from manganese carbonate nodule of the Barru Complex, South Sulawesi. Bar scale indicates 100 µm. 1, 2. *Pantanellium squinaboli* (Tan Sin Hok), 3. *Cecrops septemporatus* (Parona), 4. *Patulibrachium* sp?, 5. *Emiluvia* sp., 6. *Alieveum* sp., 7. *Acaeniotyle* sp., 8. *Patelula* sp., 9, 10. *Acanthocircus dicranocanthos* (Squinabol), 11. *Praeconocaryomma* sp., 12, 13. *Saitoum elegans* (De Wever), 14. *Napora* sp., 15. *Katroma* sp.

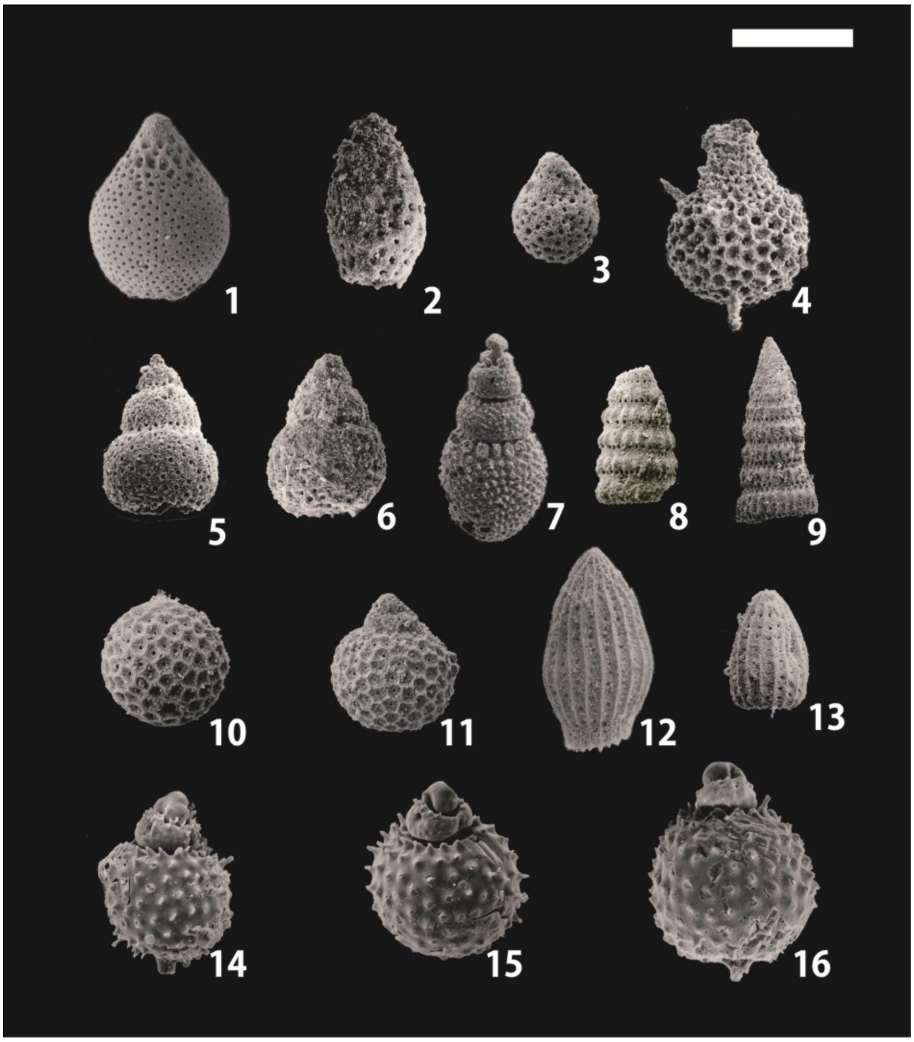


Figure 6. Scanning electron photomicrograph of Valanginian - Barremian radiolarians from manganese carbonate nodule of the Barru Complex, South Sulawesi. Bar scale indicates 100 µm. 1. *Theocoeys* sp., 2. *Eucyrtidium parviporum* Tan Sin Hok, 3. *Theocapsa laevis* Tan Sin Hok, 4. *Podobursa* sp., 5, 6. *Stichomitra doliolum* Aita, 7. *Stichocapsa pseudodecora* Tan Sin Hok, 8. *Pseudodictyomitra lilyae* (Tan Sin Hok), 9. *Pseudodictyomitra carpatica* (Lozyniak), 10, 11. *Gongylothorax verbeeki* (Tan Sin Hok), 12. *Eucirtidium broweri* Tan Sin Hok, 13. *Thanarla conica* (Aliev), 14 – 16. Nassellaria gen. et sp. indet.

In Sanfilippo and Riedel (1985) range-chart of Cretaceous radiolarians, three similar species from sample LA02, *Sphaerostylus* (= *Cecrops*) *septemporatus*, *Sphaerostylus lanceola* = *Pantanellium squinaboli* and *Acanthocircus dicranocanthos* have been placed within *Sphaeorostylus* (= *Cecrops*) *septemporatus* Zone to *Dibolachrastytthopora* Zone or within Valanginian to Hauterivian.

Pessagno (1977) defined the *Cecrops septemporatus* Subzone primarily by the first occurrence of *Thanarla conica* and *Cecrops septemporatus*; and by the last occurrence of *Acanthocircus dicranocanthos.* The range of this subzone is upper Valanginian.

Based on the evidence and age assignment mentioned above, it is indicated that the age of radiolarian assemblage from sample LA02 is not younger than Barremian. The most probable geologic age of radiolarians in manganese rock of the Barru Complex, South Sulawesi is Valanginian to Barremian.

DISCUSSION

The basement complex in South Sulawesi exposed in two areas, the Bantimala Complex and the Barru Complex, separated within 30 km. The complex is believed to be equivalent and has been named the Bantimala Tectonic Complex (Sukamto, 1982).

Manganese carbonate nodule containing radiolarians for the first time are discovered in the Barru Complex. The age of the radiolarian assemblage extracted from manganese carbonate nodule embedded in dark reddish shale of the Barru Complex is Valanginian to Barremian. The depth of depositional site of this manganese carbonate nodule was above the paleo carbonate compensation depth (CCD), and may occur on top of mid oceanic ridge or within hemipelagic environment near the subduction zone. It is thought more likely that manganese carbonate nodule was deposited in hemipelagic environment and within the same formation with dark reddish shale, which has the material comes from terrigenous source. Hence, dark reddish shale and manganese carbonate nodule of the Barru Complex are considered to have been deposited in Early Cretaceous time (Valanginian to Barremian = 131 – 115 Ma).

Previously, Wakita *et al*. (1994b, 1996) reported middle Cretaceous (Albian to Cenomanian = 108 – 92 Ma) radiolarians extracted from chert and siliceous shale of the Bantimala Complex. The two differences that related on radiolarian occurrence in the Barru Complex and the Bantimala Complex are radiolarians age and radiolarian-bearing rocks. The age of radiolarian assemblage from the Barru Complex is older than that found in the Bantimala Complex. Furthermore, radiolarians-bearing rock in the Barru Complex is manganese carbonate nodule embedded in dark reddish shale, unlike in the Bantimala Complex, which is chert and siliceous shale. It showed that the timing of precipitation of radiolarians and sedimentation environment of the radiolarians-bearing rocks of that in the Barru Complex and the Bantimala Complex are different. These differences lead to whether the Barru Complex and the Bantimala Complex represent two distinct complexes, as considered based on data of metamorphic rock (Maulana *et al.,* 2010). The Bantimala Complex contains blueschist and eclogite (Maulana *et al*., 2010, Soesilo *et al*., 2010; see also Wakita *et al*., 1996), which have undergone metamorphism at high pressure and low to moderate temperatures. In contrast, the Barru Complex has no blueschist or eclogite exposed, but show predominantly of some higher temperature amphibolite-facies metamorphic rocks (Maulana *et al.,* 2010).

Physiographically, the distinct feature of the complexes was described on the geologic map of Sukamto (1982). The trend of tectonic slices of the Bantimala Complex is elongated and strike NW-SE with the dip of strata ranges from 20-80^{o} (Wakita *et al*., 1996) towards the northeast, in the same direction with the plane of thrust fault boundaries. While the main structural trends of the Barru Complex show the strike of E-W, almost perpendicular to that in the Bantimala Complex, the dip of strata is towards to the south and in opposite position with the plane of thrust fault boundary. The complex was widely covered by volcanic rock.

In addition to revealing the radiolarian age of the Bantimala Complex, Wakita *et al.* (1994b) also showed the age dating results from schist in the Bantimala Complex (132 to 114 Ma), and schist in the Barru Complex (106 Ma). From radiolarian data and a summary of some distinct features between the Bantimala Complex and the Barru Complex (see Table 3), can be interpreted that the Barru Complex and the Bantimala Complex are two different entities and not derived from single accretionary complex. It is considered that the reddish shale with manganese carbonate nodule of the Barru Complex was accreted in the subduction trench during Aptian (115 – 108 Ma). In this stages, subduction of oceanic plate resulting continental uplift which caused the exhumation of schist in the Bantimala Complex. This event as mentioned by Wakita *et al.* (1994b) was followed by transgression and deposition of bedded chert of the Bantimala Complex within the Albian - Cenomanian (108 - 92 Ma).

Table 3. Distinctive features of the Barru Complex and the Bantimala Complex. References code are as follow, 1). Sukamto (1982), 2). Maulana *et al*. (2010), 3). Sopaheluwakan (1979), 4). Soesilo *et al*. (2010), 5). Wakita *et al*. (1996), 6). Wakita *et al*. (1994b), 7). Munasri (this study).

Features	Barru Complex	Bantimala Complex
Dimension and ditribution.	Resembles a circular shape with a diameter of 10 km length; tectonic slices, strike E-W.[1)]	1) Elongated shape with an area of approximately 10 km x 30 km; tectonic slices, strike NW-SE.[1)]
Metamorphic rocks.	Amphibolite, greenschist, gneiss [2)] Greenschist, pelitic schist. [3)]	Eclogites, blueschist, greenschist (quartz-mica schist, actinolite schist).[2, 4), 5)]
Ultramafic rocks.	Spinel lherzolite, harzburgite.[2)] Peridotite, harzburgite, dunite. [3)]	Harzburgite, dunite.[2)] Serpentizied peridotite.[5)]
Chert.	No chert and melange as that in the Bantimala Complex is observed.[7)]	Widely distributed in melange.[1, 6)]
Age of radiolarians.	Early Cretaceous (Valanginian – Barremian = 131 – 113 Ma).[7)]	middle Cretaceous (Albian – early Cenomanian = 108 – 92 Ma).[6)]
Age of schist.	106 Ma.[6)]	132 – 114 Ma.[6)]
Radiolarians-bearing rocks.	Manganese carbonate nodule.[7)]	Chert, siliceous shale.[6)]

Radiolarian assemblage of the similar age to that in Barru Complex is also occur in Laut Island, Meratus Complex in South Kalimantan (Wakita *et al*., 1998). Radiolarians in Laut Island were extracted from chert and siliceous shale in the melange. However, most of species member within these assemblage are different with those in the Barru Complex, except for *Pseudodic tyomitra carpatica* and *Pantanellium squinaboli*. Wakita *et al*. (1998) also found manganese carbonate nodule in melange of Laut Island, but lack of radiolarian or very poorly preserved. This difference may be influenced by sedimentation environment and/or paleo-current that bring nutrient for radiolarians life.

For the future discussion, the present of radiolarian assemblage in the manganese carbonate nodule can provide data to evaluate the origin, paleogeographic and tectonic evolution of the Barru complex.

CONCLUSION

Fairly well preserved radiolarians obtained from manganese carbonate nodule of the Barru Complex, South Sulawesi indicates Early Cretaceous (Valanginian to Barremian) age. Previously Middle Cretaceous (late Albian to early Cenomanian) radiolarians were reported from chert and siliceous shale of the Bantimala Complex. From radiolarians data and supported with some other distinct features between the Bantimala Complex and the Barru Complex, it is considered the two complexes are not a single accretionary complex. Future investigations needed to clarify the relationship with origin, paleogeographic and tectonic evolution of the Barru Complex.

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