First evidence Jurassic-Cretaceous radiolaria in Menanga Formation, Lampung, Sumatra, Indonesia

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Abstract. Research on Menanga Formation in Lampung and surrounding areas is still limited, especially research on paleontology. The purpose of this study was to identify the presence of radiolarian fossils in the Menanga Formation. Field observations were carried out at two site in Way Sabu, Pesawaran and Gunungkasih, Tanggamus, Lampung. Twelve samples were extracted from interbedded siltstone and claystone for radiolaria fossils. There were four samples that had radiolarian fossils. Radiolaria from genus *Tetraditryma* sp., *Paronaella* sp., *Pantanellium* sp., *Holocryptocanium* sp., *Archaeocenosphaera* sp., *Napora* sp., *Sethocapsa* sp., and *Orbiculiforma* sp. were found in the Menanga Formation indicate Jurassic to Cretaceous age. Based on radiolaria assemblage, Menanga Formation was probably positioned within a warm water current system in the low latitude Mesotethys. The exposed Menanga Formation caused by a collision between Woyla terrane and West Sumatra terrane that occurred in the Late Cretaceous.

1 Introduction

The Sumatra island formed from the collision of various terranees and exposed Paleozoic and Mesozoic age rocks [1,2]. The rocks of the island of Sumatra can be divided into three large groups based on their geological age [1] namely the Tapanuli Group of Carboniferous-Permian age, the Peusangan Group of Permian-Triassic age, and the Woyla group of Jurassic-Cretaceous age (Fig 1). Collision between Sibumasu and eastern Malaya terrane closed the Paleotethys sea in the Permian age. The collision of the West Sumatran terrane and the Woyla terrane closed the Mesotethys sea in the Late Cretaceous [3, 4, 5].

Geological map of the Lampung region mapped and described by Mangga et al. [6] and Amin et al. [7] shown the pre-Tertiary rock groups that make up Sumatra Island, namely the Woyla Group which is grouped into the Menanga Formation. The exposed Menanga Formation spreads over the Lampung and surrounding areas in a limited dimension (Fig 2). The relative age of pre-Tertiary sedimentary rocks in Lampung has been subject to much debate due to the lack of paleontological research. The presence of pre-Tertiary rocks is always associated with the base rocks of the Gunungkasih Complex [6,7]. Research on Menanga Formation in Lampung areas is still limited, especially research on paleontology. The purpose of this study was to identify the presence of radiolarian fossils in the Menanga Formation, relative age, and paleogeography of the Menanga Formation.

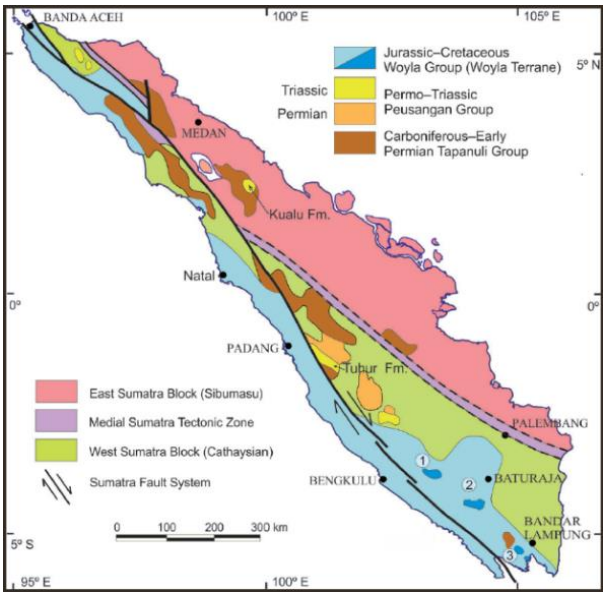

Fig. 1. Tectonic terrane of Sumatra [2]

2 Literature review

Radiolaria are widely used to identify tectonic setting that uplifts oceanic crustal rocks and paleogeographic-paleoceanographic reconstruction [8, 9, 10, 11]. Southern Sumatra area exposed Woyla terrane member in three locations; 1.) Gumai, 2.) Garba, and 3.) Gunungkasih [6, 7, 8]. The Menanga Formation is Mesozoic in age, tectonically in contact with the schists of the Gunungkasih Complex and has a variety of lithologies including interbedded calcareous shale,

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claystone and sandstone interbedded with chert [6, 7]. Part of the Menanga Formation is marine deposits characterized by coral and chert reefs containing radiolaria fossils and remains of foraminifera contained in calcareous shale. Based on the fossils found by *Orbitulina* sp. The Menanga formation is estimated to be Cretaceous in age [6,7]. Menanga Formation equivalent with the Late Jurassic-Early Cretaceous volcanic arc member of Garba Formation [12].

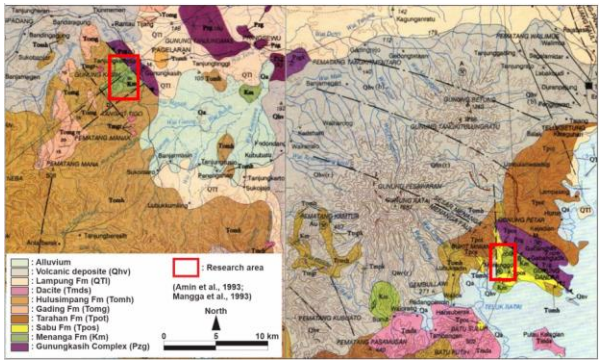

Fig. 2. Geological map of the Lampung area [6,7]

There are quite little research on radiolaria in Indonesia, there have been at least only nine studies in Indonesia, including Okamato [13], Wakita et al. [14], Jasin and Haile [15], Sashida [16], McCarthy [17], Pessagno dan Hull [18], Munasri [19], Munasri [20], and Munasri [21]. On the island of Sumatra there are only five radiolaria report including McCharthy [17] and Munasri [20]; while the three authors are Alditian [22], Sagitariyanti [23]; and Yanti [24] reported indications of radiolaria in the field mapping area in Lampung but was not described clearly. In the research of Mangga et al. [7] there are indications of the existence of radiolaria fossils in the Menanga Formation, but the description of the type, genus and age of the radiolaria has not yet reached the stage.

3 Methodology

Field observations were carried out at two site in Way Sabu-Pesawaran and Gunungkasih-Tanggamus, Lampung. Twelve samples were extracted from interbedded siltstone and claystone for radiolaria fossils. Radiolarian specimens were separated from calcareous shale using the dilute hydrofluoric acid (HF) method mentioned by Sashida [25] carried out at Paleontology Laboratorium, ITERA. Radiolaria identification using Catalogue of Mesozoic radiolarian genera [26].

4 Results and Discussion

4.1 Litology

Outcrops of the Menanga Formation shown there are five facies, including laminated red mudstone (F1), layered gray mudstone (F2), massive siltstone (F3), laminated siltstone (F4), and laminated sandstone (F5) (Fig.3). At the Gunungkasih Pesawaran observation location, the Menanga Formation shows alternation between laminated red mudstone (F1) and monotonous, parallel-bedded gray siltstone (F2) while at the Sabu River observation location, the Menanga Formation are interbedded with massive siltstone (F3), laminated siltstone (F4), and laminated sandstone (F5) shows dip more than 80° caused by geological structures. These facies characteristics are interpreted to have been deposited in a submarine fan environment. Based on the facies model of Walker [27].

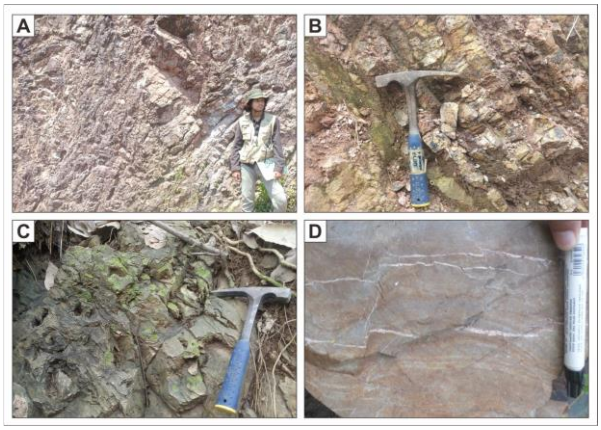

Fig. 3. Outcrop of Menanga Formation; (A, B) Red siltstone in Gunungkasih (C) Greenish siltstone in Gunungkasih (D) Interbedded of siltstone and fine sandstone in Way Sabu

4.2 Radiolaria

There are eight genera of radiolaria found in the Menanga Formation (Table 1), namely *Tetratrabs* sp., *Paronaella* sp., *Pantanellium* sp., *Holocryptocanium* sp., *Archaeocenosphaera* sp., *Napora* sp., *Sethocapsa* sp. and *Orbiculiforma* sp. (Fig. 4). Menanga Formation shown Jurassic to Cretaceous age

Table 1. Radiolaria assemblage

No	Nama Radiolaria	Gunungkasih 1			Tanjungagung	
		1A	1B	1C	2A	2B
1	*Tetratrabs* sp.	-	+	-	-	-
2	*Paronaella* sp.	-	+	-	+	-
3	*Holocryptocanium* sp.	++++	++++	+++	++++	++
4	*Archaeocenosphaera* sp.	+++	++++	+++	+++	++++
5	*Pantanellium* sp.	-	-	-	+	-
6	*Napora* sp.	-	-	+	-	-
7	*Hiscocapsa* sp.	+	+	++	+	++
8	*Orbiculiforma* sp. (?)	+	+	-	-	-
9	*Orbiculiforma* sp.	++	+++	+++	+	+++

Abundant	++++	>10
Common	+++	5-10
Few	++	3-5
Rare	+	1-2
None	-	0

4.3 Taxonomic List

Order SPUMELLARIDA [28]
Family Hagiastridae [29], emend. [30]
Genus *Tetraditryma* [31]
Figure: 4a
Range: Jurassic Cretaceous.
Occurrence: World-wide in Tethyan.

Genus *Paronaella* Pessagno [30]; emend. [31]
Figure: 4b
Range: ?Paleozoic; Triassic to Upper Cretaceous.
Occurrence: Worldwide in Tethyan and Boreal Realms.

Family Pantanelliidae [32]
Genus: *Pantanellium* [32] sensu [33]
Figure: 4f and 4g
Range: Upper Triassic (Karnian) to Lower Cretaceous (upper Aptian; ?lower Albian).
Occurrence: Tethyan Realm: Central Tethyan Province and Northern Tethyan Province (Jurassic). Boreal Realm: Southern Boreal Province (Jurassic). Also reported from Tethyan deposits in Southern Hemisphere.

Family Actinommidae [34], emend. [29]
Genus *Archaeocenosphaera* [35]
Figure: 4e
Range: Cretaceous.
Occurrence: Worldwide in Tethyan Realms

Family ORBICULIFORMIDAE [36]
Type genus: *Orbiculiforma* [36]
Figure: 4j and 4h
Range: Upper Triassic to Upper Cretaceous
Occurrence: Northern and Southern Hemispheres.

NASSELLARIA [28]
Family Williriedellidae [37]
Genus *Holocryptocanium* [37]
Fig: 4c and 4d
Range: Cretaceous.
Occurrence: World-wide in Tethyan.

Family Ultranaporidae [38] emend. [36]
Genus *Napora* [38] emend. [36]
Figure: 4h
Range: Lower Jurassic: ?upper Sinemurian; lower Pliensbachian to Upper Cretaceous.
Occurrence: World-wide in Tethyan, Austral, and Boreal Realms.

Family Carpocaniidae [40]
Genus *Sethocapsa* [40]
Figure: 4i
Range: Cretaceous.
Occurrence: World-wide in Tethyan

4.4 Paleoclimate and paleogeography implication

Based on the characteristics of their genera, the eight radiolaria genera found in the Menanga Formation are warm water current environment radiolarian assemblages [20, 40, 41] which are interpreted Menanga Formation deposited in the part of Mesotethys Ocean. This can be seen from the similarity of the radiolarian assemblages of the Menanga Formation with those found in Outher Banda Arc [16, 20, 40], Italy [41], and Turkiye [42].

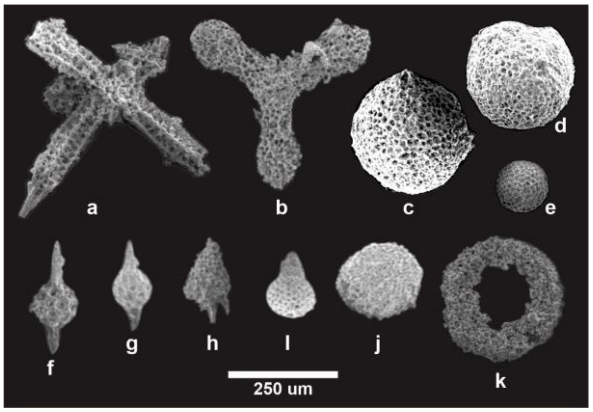

Fig. 4. Radiolaria in Menanga Formation: a. *Tetraditryma* sp., b. *Paronaella* sp., c-d. *Holocryptocanium* sp., e. *Archaeocenosphaera* sp., f-g. *Pantanellium* sp., h. *Napora* sp., i. *Sethocapsa* sp., j. *Orbiculiforma* sp. (?), h. *Orbiculiforma* sp.

The Woyla Terrane is a volcanic arc [1, 2, 43] which, during the Cretaceous age, moved towards the West Sumatra terrane, causing the closure of the Meso-Tethys Ocean [44, 45]. The closure of the Mesotethys ocean caused changes in paleogeography, from a sea basin turning into a mountain belt. Barber and Crow call the exposure of the Woyla groupas as Woyla nappe, which indicates that the collision between the West Sumatra continental plate and the Woyla volcanic arc plate caused the lifting of some of the Woyla rocks to the surface [1, 2]. The most complete uplift of oceanic rock sequences can be found in Aceh and surroundings are [44]. The exposure of the Menanga Formation in Lampung is interpreted to be part of the accreted Woyla terrane assemblage which is supported by the Mesotethys ocean radiolaria association.

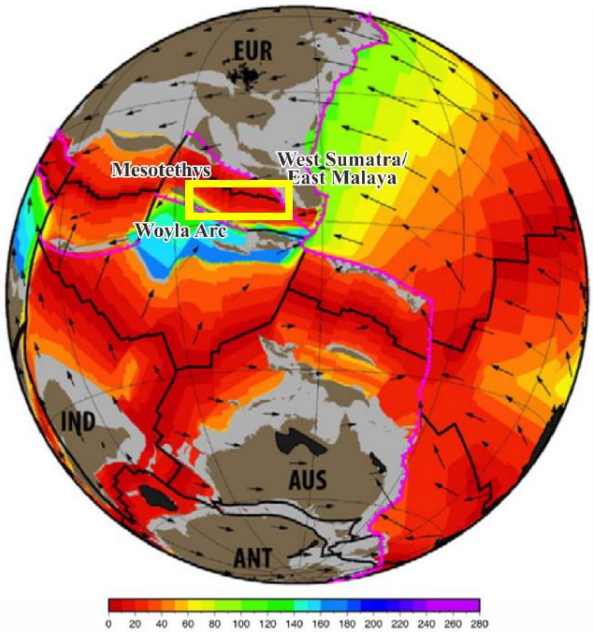

Fig. 5. Model of plate tectonic in Mesozoic age (Early Cretaceous/105 Ma.) shows Mesotethys formed between Woyla terrane and West Sumatra terrane [44], later its called Ngalau plate by Advokaat et al. [45].

5 Conclusion

There are eight radiolaria genus in Menanga Formation: *Tetraditryma* sp., *Paronaella* sp., *Pantanellium* sp., *Holocryptocanium* sp., *Archaeocenosphaera* sp., *Napora* sp., *Sethocapsa* sp., and *Orbiculiforma* sp.. Radiolarian-bearing claystone of the Menanga Formation interpreted to be deposited in the warm current Tethyan realm or low paleolatitudinal belt, as a part of the Woyla Terrane in Jurassic-Cretaceous age.

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