THE ORIGINAL PUBLISHED DESCRIPTION OF AN EMBRYONIC APPARATUS FROM THE ORBITOLINIDAE (FORAMINIFERA) (LOWER CRETACEOUS OF BORNEO) WITH A BRIEF COMMENTARY ON THE AGE OF ORBITOLINID OCCURRENCES IN BORNEO

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Abstract The family Orbitolinidae originates with Martin (1890), who described the external and internal test features of orbitolinids from what can now be regarded as the Lower Cretaceous of western Borneo. Overlooked in subsequent literature, this description includes the illustration of a transverse section passing through a megalospheric embryo of a specimen assigned to Orbitolina concava Lamarck and regarded as being Cenomanian in age. However, the illustration, description, and dimensions refer this specimen to Palorbitolina lenticularis (Blumenbach, 1805) comprising a relatively large, subdivided chamber (= periembryonic chambers) surrounding a large 'Centralkammer'. It is worth mentioning that the original illustration by Blumenbach (1805) from the Lower Cretaceous of southeastern France as Madreporites lenticularis did not show this taxonomically important feature in the modern classification of the Orbitolinidae and with special respect to the subfamily Orbitolininae. The re-interpretation of Martin’s illustrations and a literature review challenge Cenomanian ages ascribed to orbitolinid occurrences in Borneo.

Keywords: Orbitolinidae, Embryonic apparatus, Cretaceous, Borneo.

INTRODUCTION

The family Orbitolinidae originates with Martin (1890) who described an orbitolinid assemblage from what can now be regarded as the Lower Cretaceous of Borneo. Given the vintage of this paper, this work can be considered as highly advanced in the treatment of external and internal features, including the first illustration of embryonic chambers of a specimen assigned to Orbitolina concava Lamarck, and regarded as being of Cenomanian age. It appears that This is the first (or at least one of the first) descriptions of this feature that in the modern taxonomy of the Orbitolinidae, and in particular, the subfamily Orbitolininae, is of paramount importance, allowing the discrimination of genera and species (Schroeder, 1962, 1963, 1975). This brief note therefore pays credit to the scientific work of the German geologist and palaeontologist Karl Martin (1851-1942). A brief review of the published literature is included, that suggests that despite some historical and modern reports to the contrary, there are no confirmed Cenomanian occurrences of orbitolinids in Borneo, all determinable records being demonstrably older.

DESCRIPTION OF MARTIN (1890)

The orbitolinids studied by Martin (1890) were from the Seberoearc Cretaceous System (lithostratigraphy varies between authors) of the Kalimantan Province in western Borneo (Hashimoto et al., 1975). In his report about Lower Cretaceous Orbitolinidae from Borneo, Martin (1890) included two plates (pl. XXIV and XXV) with drawings of the outer morphology, and pointing to structural details such as in plate XXIV, figure 11 ‘Scheidewände erster Ordnung’ (= septa) or ‘dritter Ordnung’ (= rafters) that has since become standard practice in modern foraminiferal works (Hottinger, 2006). Martin (1890, p. 212) stressed the similarity of the internal structure of ‘O. lenticularis’ and ‘O. concava’. Since the work of Martin (1890), orbitolinid taxonomy has been revolutionised, and it is now understood that these two species as per modern concepts belong to two distinct genera with very different embryonic apparatus structure (Schroeder, 1962, 1963). Martin (1890) noted that in sections cutting the cone apex, usually a large spheroidal chamber measuring 0.18 mm to 0.19 mm (including the wall) can be observed. Within this chamber, one section of a ‘favorable preserved preparation’, thereby referring to plate XXV, fig. 18 (re-illustrated herein Fig. 1a-b), yielded the cross section of a ‘second, rounded cavity, that possibly can be interpreted as initial chamber. In this case, the Orbitolina would comprise a central chamber and a larger chamber surrounding the former’. This concentric outer ring ‘is subdivided by numerous, radial oriented secondary partitions into chamberlets’ (p. 213).

INTERPRETATION

Douglass (1960, p. 14) remarked that the ‘illustrations of the internal structures of specimens from Borneo (Martin 1889 [sic], pl. 24, 25) are probably the most detailed

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available. However, Douglass did not provide further comments on these illustrations and their taxonomic status or interpretation.

The transverse section illustrated and described by Martin (1890) is herein interpreted as passing through the central protoconch (‘Centralkammer’ or ‘embryonic chamber’, Martin, 1890, p. 222) and the surrounding peri-embryonic zone subdivided by radial partitions (‘Scheidewände’) into several chamberlets (‘Kämmerchen’). The illustration and description of Martin (1890) therefore appears to be one of the first (if not the first) remarks upon the embryonic structure in Orbitolinidae and identifies the specimen as Palorbitolina lenticularis (Blumenbach), a well-known species from the late Barremian – early Aptian of Neotethys (Schroeder, 1963; Schroeder et al., 2010), thus supporting the synonymy suggestion of Matsumaru et al., (2005).

The chamberlets of the periembryonic zone or ring may be, depending on the section plane, distinctly wider than high, shown for example in the transverse section of P. lenticularis provided by Schroeder (1963, pl. 24, fig. 4) (Fig. 1c). Such an observation excludes the material of Martin (1890) from belonging to O. concava. Surprisingly, the Martin (1890) record was not included within the authoritative synonymy list of Schroeder (1963) for Palorbitolina lenticularis, although Schroeder (1962) recognised that the Martin (1890) specimens were not O. concava (“Als Orbitolina concava wurden von Martin (1890) Orbitolinien vom Seberuang (Borneo) beschrieben.

**DISCUSSION**

The Orbitolininae are a group of larger benthic foraminifera that proliferated on the Early-mid Cretaceous shallow marine shelves of Neo-Tethys, with extension into the central America and palaeo-Pacific realms. Their biostratigraphic utility (ability to determine stage/substage) was established by the pioneering studies of Rolf Schroeder (e.g., Schroeder, 1962, 1963, 1975; Schroeder et al., 2010).

Although somewhat on the margins of the paleogeographic distribution of the Orbitolininae, reports of their occurrence in Borneo dates back to the geological expeditions of the late 19th century. During an expedition in 1856-1857, Everwijn (as reported in 1879) discovered sediments in the Seberoeang region of western Borneo.
(modern-day Kalimantan), containing what he thought to be Eocene *Nummulites* Lamarck. Von Fritsch (1879) also examined material from this locality and considered the foraminifera to be *Patellina* Williamson, introducing, with some uncertainty, two new species *Patellina trochos* and *Patellina scutum*. As discussed herein, it was Martin (1890) who, using material provided by van Schelle (1880), recognised that these occurrences were of orbitolinids, and compared them to *O. concava*, first described from the Cenomanian of France (Lamarck, 1815). By doing so, Martin (1890) established that the orbitolinid-bearing sediments in the Seberoaang and neighbouring Bajau region were not Eocene but Cretaceous, and moreover, in his view, Cenomanian ("Wahrscheinlich ist es auf Grund des Vorkommens von *O. concava*, dass die biorefined Ablagerungen vom Seberoaang und vom Bajau dem Cenoman angehören").

The notion that the orbitolinids of Borneo are *O. concava* and/or are Cenomanian in age was subsequently debated in the research literature of the 20th century. Yabe & Hanzawa (1926, 1931) considered that the Borneo material to be distinct from *O. concava*, and better described as *Orbitolina scutum* (von Fritsch) and probably upper Aptian. This was strongly disputed by Zeylman van Emmichoven (1936, 1939) who regarded the occurrences as "upper Gault [i.e., no older than late Albian] to Cenomanian". Meanwhile, orbitolinid occurrences were reported from other parts of Borneo including the Penrissen area of west Sarawak (Molengaagra, 1902; Haile, 1957; Wilford & Kho, 1965) and the Meratus Mountains region of southern Kalimantan (Koolhoven, 1933, 1935). Such records were either assigned to *O. concava* and/or regarded as indicating an at least in part Cenomanian age. This notion persists in even quite modern records: Williams et al. (1988) "limestones with *Orbitolina of Cenomanian age*" or Tate (2001) "The limestones consist of algal and coralline micrites with *Orbitolina species of Cenomanian age*" (see also Hutchison, 2005).

Key papers challenging the presence of *O. concava* and of Cenomanian orbitolinids in Borneo are those of Hashimoto & Matsumuru (1974, 1977). Drawing on observations made by Jan Hofker jr., and using his terminology (Hofker, 1963) that regards Orbitolininae as belonging to only one species (*O. lenticularis*) with evolutionary "form-groups", they found that only form-group I was present in Sarawak material and form groups I-II and II-III in western Kalimantan material, indicating Aptian – Albian ages. In modern terminology *P. lenticularis* (Hashimoto & Matsumuru, 1977 pl. VI, fig. 1; Hashimoto & Matsumuru, 1974 pl. XII, figs. 30, 35), *Mesorbitolina parva* (Douglass) (Hashimoto & Matsumuru, 1974, pl. XI, figs. 29, 31; pl. XII, fig. 28) and *M. cf. texana* (Romer) (Hashimoto & Matsumuru, 1974, pl. XI, figs. 30, 32) are present in their material. The approach of Hofker (1963) was rapidly rejected (Schroeder, 1964), but nonetheless, its key to note that no Cenomanian forms were found by Hashimoto & Matsumuru (1974, 1977) in their studies.

In summary, no convincing species of *O. concava* in its modern concept (Schroeder, 1962; Schroeder in Schroeder & Neumann, 1985) have ever been illustrated from Borneo material, nor other Cenomanian species of Orbitolininae. Sikumbang (1986) illustrated *Mesorbitolina parva* (early late Aptian), whilst material illustrated by BouDagher-Fadel & Price (2019) is mostly *Palorbitolinaeides hedini* Cherchi & Schroeder (Schlagintweit et al., 2022), a typical early – middle Albian species (Schlagintweit et al., 2022).

In this context, the recognition herein of the material illustrated by Martin (1890) as *P. lenticularis*, a late Barremian – early Aptian species (Schroeder et al., 2010), not *O. concava*, an early Cenomanian species (Schroeder in Schroeder & Neumann, 1985), provides further confirmation that *O. concava* is not present in the Cretaceous sediments of Borneo, and that suggestions of the presence of Cenomanian orbitolinid limestones cannot be substantiated. This has implications for studies of Cretaceous palaeogeography in south-east Asia, and for understanding the dispersal and evolution of the Orbitolininae.

CONCLUSIONS

Modern taxonomy of orbitolinid foraminifera (Orbitolininae) relies on an understanding of internal structure, especially the embryonic apparatus. Although overlooked in the literature, most likely the first description and illustration of such was provided by Martin (1890) for specimens assigned to *Orbitolina concava* (Lamarck) from the supposed “Cenomanian” of Borneo. However, the features described and illustrated are compatible with the material being of the Lower Cretaceous species *Palorbitolina lenticularis*. This species is known to occur in the region, and records of *O. concava* and of Cenomanian orbitolinids cannot be proven from a literature review.

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