



Research paper

Size variations of coccoliths in Cretaceous oceans – A result of preservation, genetics and ecology?

Nathalie Lübke^{a,*}, Jörg Mutterlose^a, Cinzia Bottini^b^a Institute for Geology, Mineralogy and Geophysics, Ruhr-Universität Bochum, Universitätsstr. 150, 44801 Bochum, Germany^b University of Milano, via Mangiagalli 34, 20133 Milano, Italy

ARTICLE INFO

Article history:

Received 10 January 2014

Received in revised form 11 March 2015

Accepted 29 March 2015

Available online 4 April 2015

Keywords:

Biometry

Calcareous nannofossils

Cretaceous

Preservation

Sea-surface temperature

Light availability

ABSTRACT

Biometric studies of coccoliths, the remains of coccolithophores, offer the opportunity to survey single species instead of entire assemblages. We obtained and analyzed size data of three common species (*Biscutum constans*, *Zeughrabdodus erectus* and *Watznaueria barnesiae*) in a stratigraphically very well-defined interval of early Aptian age (~126 Ma; Cretaceous). Material is derived from four sites (Lower Saxony Basin, North Sea, western Tethys, Mid-Pacific) covering nearshore to open-oceanic paleosettings.

Length and width measurements of 1986 specimens were evaluated. The recorded size patterns show a larger data spread for *B. constans* and *W. barnesiae* in the western Tethys and the Mid-Pacific than in the North Sea and the Lower Saxony Basin. The latter two sites are dominated by small coccoliths of *B. constans* while coccoliths of *W. barnesiae* show similar sizes at all four sites. Solely small specimens of *Z. erectus* characterize the samples from the North Sea and the Lower Saxony Basin while only large ones are present in the samples of the western Tethys and Mid-Pacific.

For explaining the recorded size patterns, three theories are discussed in detail; these include (1) preservation of nannofossils, (2) genetics and (3) paleoecology. (1) Intense dissolution or overgrowth of the nannofossils may have altered the original coccolith sizes particularly when biometric data from different sites with potentially varying states of preservation are compared. Due to its delicate morphology, *Z. erectus* appears most prone to dissolution, probably explaining its size pattern. (2) If the recorded size data of the remaining two species represent original patterns, these can be interpreted by new findings in recent coccolithophore genetics. It has been shown that size variations within a single cryptic species are only minor. Shifts of coccolith sizes, both in recent and fossil taxa, can be related to genotypic variation. The varying size ranges recorded for *B. constans* and *W. barnesiae* may therefore reflect diversity changes of cryptic species at the different sites. (3) These cryptic species may have preferred different depth habitats depending on geographically-controlled factors such as sea-surface temperatures, light availability or trophic load.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

The first appearance of calcareous nannofossils, including remains of marine coccolith-bearing, haptophyte algae, dates back to the Late Triassic (Janofske, 1992; Bown, 1998). Since then, these unicellular organisms have inhabited the photic zone and are among the main primary and carbonate producers of the oceans (e.g., Bown and Young, 1998; Bown et al., 2004; de Vargas et al., 2007; Jordan, 2012). Changes in coccolithophore assemblage composition may indicate and record changes in the physical, chemical and trophic conditions of the ocean due to the environmental sensitivity of various species. *Coccolithus pelagicus* for example prefers cold waters and high nutrient concentrations (Roth, 1994). The morphology of nannoplankton and its

cell cover may indicate adaptations to specific environmental conditions. The three modern taxa *Florisphaera profunda*, *Gladiolithus flabellatus* and *Algirosphaera robusta* are heavily calcified species with asymmetrically arranged coccosphears (Young, 1994). They are associated with the deep photic zone in the low to mid-latitudes (Young, 1994). Several studies of fossil species suggested a link between coccolith size and morphology (e.g., Mattioli et al., 2004; Linnert and Mutterlose, 2009; Mattioli et al., 2009; Linnert and Mutterlose, 2013).

Biometric studies can help to better understand relationships between coccolithophores and their environment. The role of coccoliths and of the entire coccosphere is still under discussion, but they possibly served more than one function. The wide range of coccoliths and coccosphere morphologies supports this concept of a multi-functional cell cover (Young, 1994).

In the fossil record, *Biscutum constans*, represented by small-to medium-sized elliptical placoliths, had its first appearance in the early Bathonian (~168 Ma) and became extinct in the late Maastrichtian

* Corresponding author at: Institute for Geology, Mineralogy and Geophysics, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum, Germany.

E-mail address: nathalie.luebke@rub.de (N. Lübke).

(~66 Ma) (Bown and Cooper, 1998; Burnett, 1998). *Zeugrhabdotus erectus* includes small elliptical loxolith muroliths and ranges from the early Pliensbachian (~191 Ma) to the late Maastrichtian (~66 Ma) (Bown and Cooper, 1998; Burnett, 1998). Both species have been described as high-fertility indicators by Roth (1981). The ecological relationship between these species is not yet fully understood (Lees et al., 2005). The third studied species, *Watznaueria barnesiae*, consists of broad elliptical placoliths. It has a wide size range and is abundant to dominant in sediments of early Bajocian (~170 Ma) to late Maastrichtian (~66 Ma) age (Bown and Cooper, 1998; Burnett, 1998). It is an ecologically robust species which is able to occupy new and extreme biotopes (e.g., Lees et al., 2004, 2005; Mutterlose et al., 2005 and references therein). It is considered as the Mesozoic analogue of the recent taxon *Emiliania huxleyi* (Lees et al., 2004).

Biometric studies of *B. constans* suggest a wide range of possible size-controlling factors. Bornemann and Mutterlose (2006) reported that a coccolith size decrease of *B. constans* is most likely related to a cooling trend during the late Albian. A positive correlation between the coccolith size of *Biscutum* spp. and nutrient availability was proposed by Linnert and Mutterlose (2013). Erba et al. (2010) recorded an abrupt coccolith size reduction of *B. constans* and *Z. erectus* associated with Oceanic Anoxic Event 1a. Conversely, several studies on the size of *W. barnesiae* revealed that a stable mean coccolith size was retained with respect to changes in temperature, nutrient concentration and seawater chemistry (e.g., Bornemann and Mutterlose, 2006; Erba et al., 2010; Linnert and Mutterlose, 2013). Apart from these studies of Cretaceous taxa, biometric analyses on coccoliths were also conducted for a number of species throughout the Mesozoic and Cenozoic. In Jurassic sediments, Giraud et al. (2006, 2009) described several morphotypes of *Watznaueria britannica*. The smallest-sized representatives were assigned to turbulent, unstable and/or eutrophic conditions. Fraguas and Young (2011) observed a drastic size decrease of the coccolith genus *Lotharingius* during

the early Toarcian probably related to unfavorable paleoenvironmental conditions for biomineralization.

In the present study, we compare biometric measurements of the three most common mid-Cretaceous calcareous nannofossil species (*B. constans*, *Z. erectus*, *W. barnesiae*) from four sections of early Aptian age. The three species account for more than half of the total nannofossil abundance in each sample. The objective of this study was to detect size variations in coccolith species at four different settings, from 40°N to 20°S paleolatitude. The results allow us to evaluate the factors that might have affected the size distribution of coccoliths.

2. Material and stratigraphy

2.1. North Sea (40°N paleolatitude)

The material analyzed in this study is derived from two cores (North Jens-1, Adda-2), which were drilled by Mærsk Oil. Two samples from North Jens-1 and one sample from Adda-2 were studied (Table 1). Both sites are located in the center of the Central Graben of the North Sea. Situated about 15 km apart, the cores lie ~200 km west of Denmark (North Jens-1: 55°50'N, 04°33'E; Adda-2: 55°48'N, 04°50'E; Fig. 1). The encountered sediments of early Aptian age (Fig. 2) are mainly laminated nannofossil-bearing claystone. The studied samples, which can be classified as marls (Pettijohn, 1975) according to their carbonate content, are typical of pelagic to hemipelagic settings (Kühnau and Michelsen, 1994; Mutterlose and Bottini, 2013). During the Cretaceous, the North Sea formed the southern extension of the Boreal-Arctic Realm. Temporary connections to the Tethys Ocean in the south allowed for floral and faunal exchange (e.g., Mutterlose, 1992). The age assignment is based on Mutterlose and Bottini (2013), who used calcareous nannofossils and stable carbon isotopes. Nannofossil assemblage data were compiled by Bottini and Mutterlose (2012).

Table 1
Details of studied samples. Lithology according to carbonate content is based on the classification by Pettijohn (1975).

Samples	Location	Age	Number of measured specimens	Lithology according to literature	Lithology according to carbonate content	Paleolatitude	References
2253.5 m	North Sea North Jens-1	BC 18	205	Laminated claystone	Limey marl (stone)	~40°N	Age, lithology, paleolatitude: Mutterlose and Bottini (2013)
2254.2 m	North Sea North Jens-1	BC 18	205	Laminated claystone	Marl (stone)		
2370.6 m	North Sea Adda-2	BC 18	209	Laminated claystone	Marl (stone)		
3.53 m	NW-Germany Alstätte 1	BC 18	205	Claystone/mudstone	Pure clay (stone)	~40°N	Age, lithology, paleolatitude: Bottini and Mutterlose (2012)
3.33 m	NW-Germany Alstätte 1	BC 18	203	Claystone/mudstone	Pure clay (stone)		
3.15 m	NW-Germany Alstätte 1	BC 18	201	Claystone/mudstone	Pure clay (stone)		
24.13 m	Italy Cismon	NC 6	80	Carbonaceous limestone	Marl (stone)	~20°N	Age, lithology, paleolatitude: Erba et al. (2010)
26.16 m	Italy Cismon	NC 6	110	Carbonaceous limestone	Marl to limestone		
30.08 m	Italy Cismon	NC 6	80	Carbonaceous limestone	Marl to limestone		
625.5 m	Mid-Pacific DSDP Site 463	NC 6	110	Carbonaceous limestone	Marl-to clay (stone)	~13–20°S	Age, lithology: Erba et al. (2010)
626.96 m	Mid-Pacific DSDP Site 463	NC 6	110	Limestone	Marl (stone)		Paleolatitude: Tarduno et al. (1995); Schouten et al. (2003)
634.98 m	Mid-Pacific DSDP Site 463	NC 6	110	Carbonaceous limestone	Marl (stone)		
625.535 m	Mid-Pacific DSDP Site 463	NC 6	52	Carbonaceous limestone	Marl-to clay (stone)		
626.98 m	Mid-Pacific DSDP Site 463	NC 6	53	Limestone	Marl (stone)		
634.995 m	Mid-Pacific DSDP Site 463	NC 6	53	Carbonaceous limestone	Marl (stone)		
		SUM:	1986				

Download English Version:

<https://daneshyari.com/en/article/6448547>

Download Persian Version:

<https://daneshyari.com/article/6448547>

[Daneshyari.com](https://daneshyari.com)