COCCOLITHS AS TEST-BUILDING MATERIAL FOR FORAMINIFERA ('COCCOLITHOFERA')

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Abstract: Very little is known about the functions of coccoliths, or the reasons for the different morphologies of various species (Young, 1994). It is a matter of course that a coccolithophore forms coccoliths of a (or several) specific shape(s) as a cell-covering. Here, we report that coccolithophores are not the only organisms using coccoliths of a specific morphology as cell-cover. Calcareous nannofossils are also known to sometimes be used as test-building material by foraminifera (Brönniman & Whittaker, 1988). We present three different examples of such 'coccolithofera'.

'Coccolithophera'

Recently, a new species of agglutinated foraminifera, *Gaudryina cribrosphaerellifera* (Plate 1, Figure 1a), was reported by Widmark & Henriksson (1995). They named the foraminifera after the generic name of the species prime agglutinant, the nannofossil *Cribrosphaerella ehrenbergii* (i.e. *cribrosphaerella*-'fera' = *cribrosphaerella*-'bearing' or -'carrying'). The Upper Cretaceous benthic foraminifera used this nannofossil species as its prime test-building material (Plate 1, Figures 1a-d). Widmark & Henriksson (1995) suggested that these coccoliths may have been the most advantageous particles available for use by the foraminifera forming these 'coccolithofera': *C. ehrenbergii* has a sieve-like central-area plate which may have been an important feature for the foraminifera (Plate 1, Figure 1d). The sediment in which *G. cribrosphaerellifera* lived was a nannofossil ooze composed of approximately 50 different nannofossil species and dominated by *Watznaueria barnesae* (30-45%), whereas *C. ehrenbergii* only represents 3-8% of the assemblage (Henriksson, 1996). This suggested that *C. ehrenbergii* was actively chosen by the foraminifera, which utilised this particular coccolith species to develop a well-oriented, smooth 'pavement' covering the test surface (Plate 1, Figure 1b). *C. ehrenbergii* first appeared in the Late Albian (Thierstein, 1973) and became extinct at the K/T boundary (Bramlette & Martini, 1964; Percival & Fisher, 1977; Perch-Nielsen, 1985). Widmark & Henriksson (1995) found that the upper limit of the stratigraphical distribution of *C. ehrenbergii* controlled the range of *G. cribrosphaerellifera*: when coccoliths of *C. ehrenbergii* were no longer available, *G. cribrosphaerellifera* became extinct as well.

Holbourn & Kaminski (1997) documented the agglutinated benthic foraminifera *Spiroplectinella* sp. (Plate 2, Figure 1a). This species selectively used the coccolith species *W. barnesae* for test-building. As in the case of *G. cribrosphaerellifera*, it used a similar technique to construct its test. The coccoliths are found in a preferred orientation with the convex, distal side of the coccoliths directed outwards on the surface of the test (Plate 2, Figure 1b). The sediment in which *Spiroplectinella* sp. lived was composed of a variety of different coccolith species, with *W. barnesae* again being the most abundant (Moran, 1992). A Recent foraminifera, *Eggerelloides* sp., also utilises coccoliths as test-building material (Plate 3, Figure 1a). This specimen used several different species of coccoliths (e.g. *Calcidiscus leptoporus*, *Helicosphaera* sp., *Gephyrocapsa* sp.) to build its test (Plate 3, Figure 1b). However, another specimen of *Eggerelloides* sp. shows that it can also use clay particles to build its test (Plate 3, Figures 2a, b).

Material

G. cribrosphaerellifera was found by Widmark & Malmgren (1992) during a study of a 3m-long section across the K/T boundary at the Pacific DSDP Site 465 (34°N, 179°E). *Spiroplectinella* sp. was encountered by Holbourn & Kaminski (1997) in Upper Albian sediments of ODP Site 766 (20°S, 110°E) in the Indian Ocean. *Eggerelloides* sp. lives in an oxygen-minimum zone in the NE Arabian Sea (Indian Ocean) on the continental margin off western India and Pakistan. It was collected at station 42KG of the R/V Sonne 90 cruise (24°S, 66°E).

Discussion

The functional hypothesis of Widmark & Henriksson (1995) was that *C. ehrenbergii* was actively chosen by *G. cribrosphaerellifera*, and that the central-areas of the coccoliths of *C. ehrenbergii* may have acted as sieve-plates to protect the pore entrances of the test. An alternative view to this hypothesis could be that the foraminifera utilised the most abundant particles available on the sea-floor at a specific time and that they built their tests during seasonal nannoplankton blooms (the sediment subsequently having been mixed so that these discrete horizons are now indistinct and homogenised within the sequence).

The Recent form, *Eggerelloides* sp., was found in an oxygen-minimum zone under an area of high surface-water productivity. This foraminifera represents opportunistic, fast-growing taxa which reproduce quickly in response to fluctuating seasonal phytodetritus inputs. It appears that *Eggerelloides* sp. may simply use what is available on the sea-floor as test material (Plate 3, Figures 1, 2). Experiments on Recent benthic foraminifera suggest that foraminifera are not selective of particles used for test-building, and that they almost indiscriminately use a variety of grains to build their tests (Bender, 1989). Another example of non-selectivity is from the South China Sea, where agglutinated foraminifera which survived the eruption of Mount Pinatubo in 1993 were found to have tests built with different types of grains. Before the eruption, the foraminifera used sand grains to build the early chambers of the test. The last chambers of the test, which were built after the eruption, comprised only ash grains (Hess & Kuhnt, 1996).

It is thus likely that when certain species of coccolithophore bloom, they become the most common, or even the totally dominant, particles available for use by foraminifera. In the cases of *G. cribrosphaerellifera* and *Spiroplectinella* sp., it is thus possible that they built their tests during blooms of *C. ehrenbergii* and *W. barnesae*, respectively, at times when these coccolith species may have been the only particles on the sea-floor.

Acknowledgements

Support from the Swedish STINT Foundation (to ASH) is gratefully acknowledged.

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Plate 1

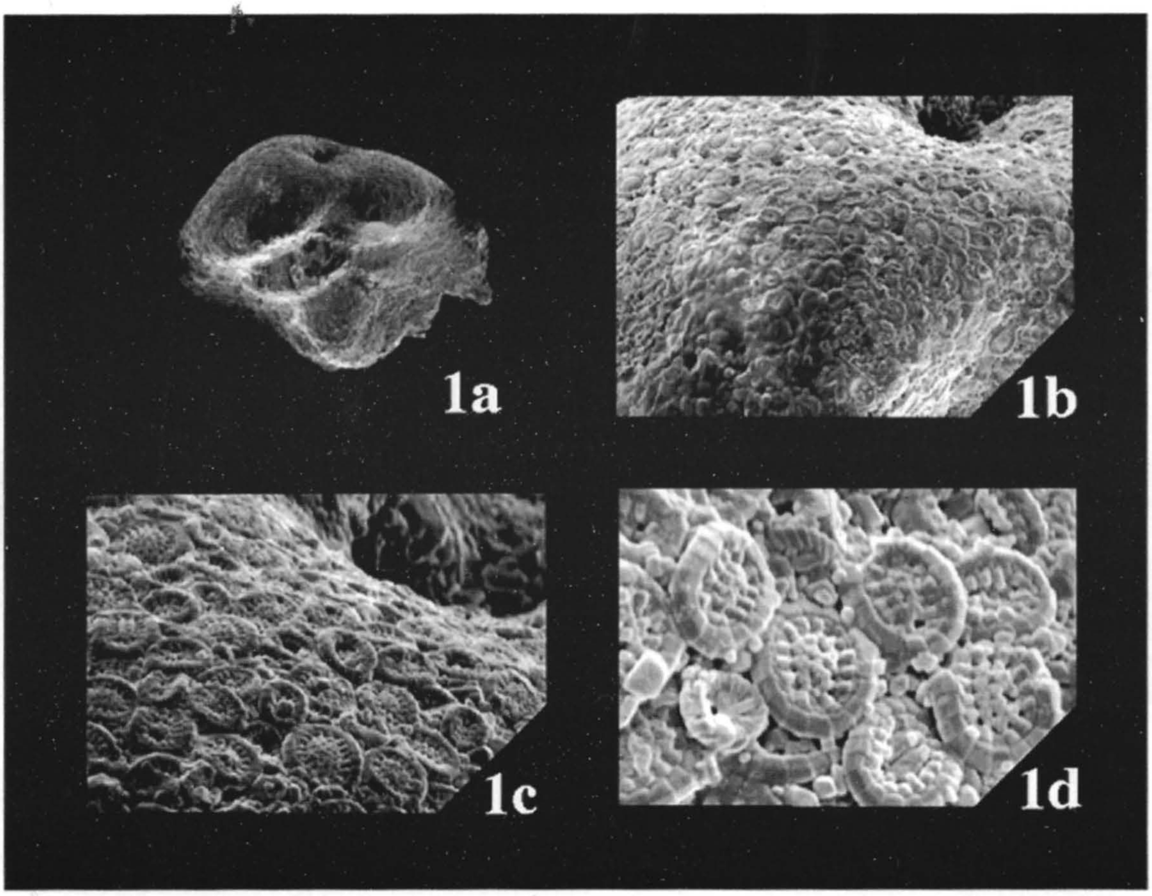

PLATE 1: ***Gaudryina cribrosphaerellifera.*** **Fig.1a**: Sample 465A-3-4, 30-31cm; size of specimen ~250μm. **Fig.1b**: Detail on the ultimate chamber, showing the high degree of selection of *C. ehrenbergii* as test-building material; x1500. **Fig.1c**: Detail; x3500. **Fig.1d**: Close-up of specimens of *C. ehrenbergii* from the surface of the ultimate chamber shown in Figs 1a-1c; note the sieve-like central area of *C. ehrenbergii*; x7500.

Plate 2

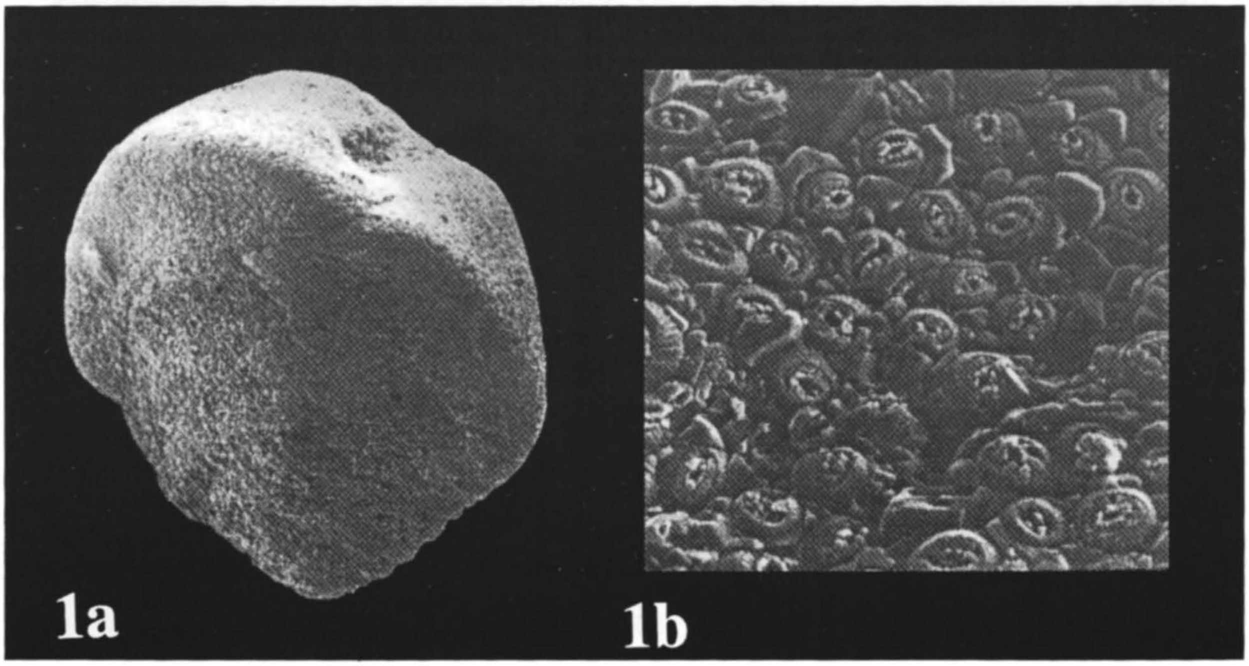

PLATE 2: ***Spiroplectinella* sp. Fig.1a**: Sample 766-16R-3, 32-36cm; x210. **Fig.1b**: Detail of test wall; x1900.

Plate 3

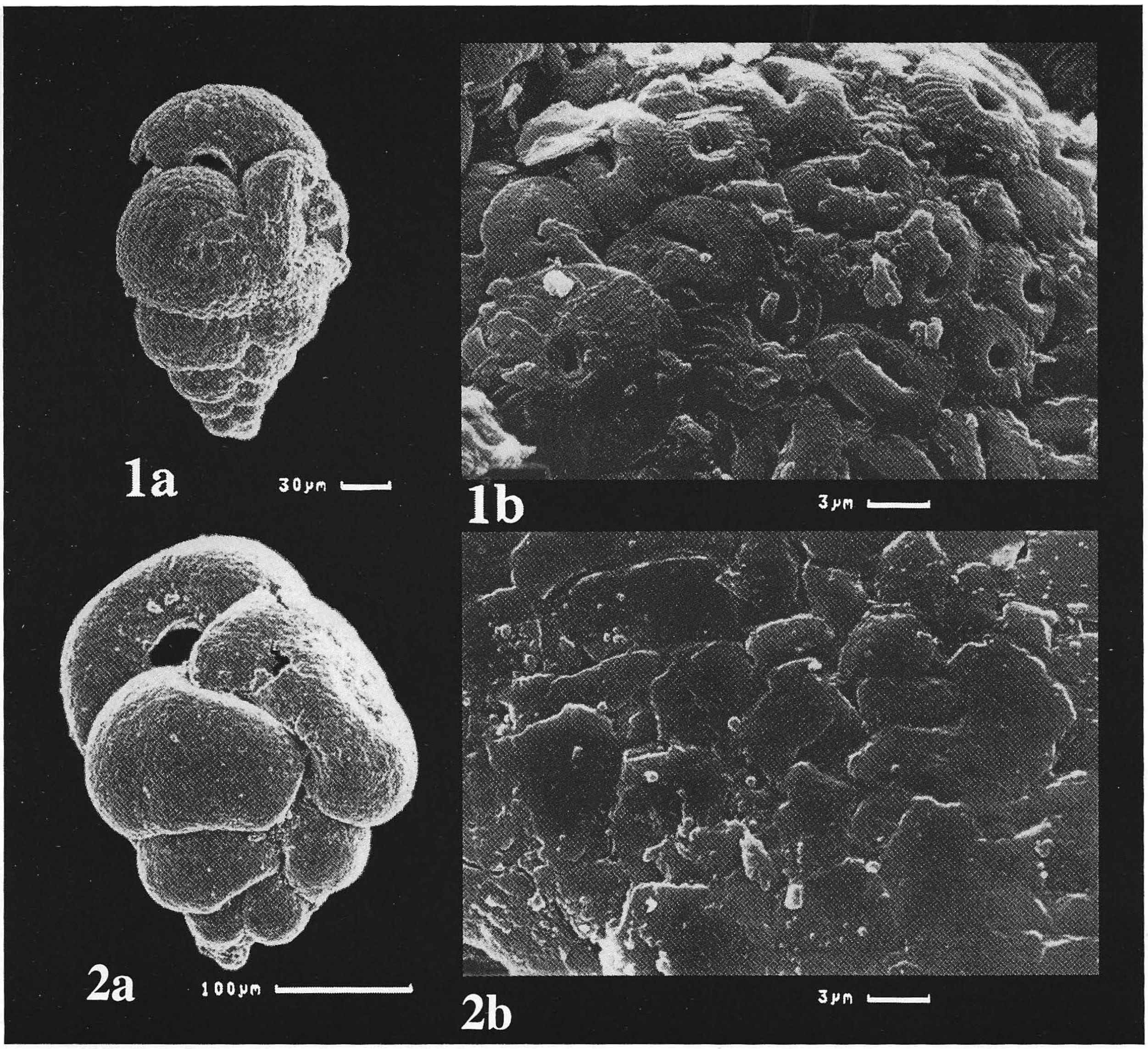

PLATE 3: ***Eggerelloides* sp. Fig.1a**: Surface sample, Station 42KG of the R/V Sonne 90 cruise. **Fig.1b**: Detail of test wall composed of coccoliths. **Fig.2a**: Surface sample, Station 42KG of the R/V Sonne 90 cruise. **Fig.2b**: Detail of test wall composed of clay particles.