Journal of Micropalaeontology, **14**: 159–164.

Unusual twin specimens of *Nannoconus abundans* (Calcareous Nannofossil, *Incertae Sedis*)

BRIGITTA VAN NIEL
Institute of Oceanographic Sciences, Deacon Laboratory, Brook Road, Wormley, Surrey, GU8 5UB, UK.

ABSTRACT - Monospecific laminae of the species *Nannoconus abundans* (calcareous nannofossil, *incertae sedis*) were studied from the Munk Marl of North Jens-1, Danish Central Trough. These laminae contained unusual twin specimens which are considered to represent natural associations, rather than preservation artefacts. *J. Micropalaeontol.* **14**(2): 159–164, October 1995.

INTRODUCTION

During a recent investigation into the taxonomy and distribution of *Nannoconus* in the North Sea (van Niel, 1992*a*, *b*) some unusual twin specimens of *N. abundans* were discovered. These appear to be natural associations and so are of interest for attempts to constrain the biological affinities and ecology of this biostratigraphically valuable and ecologically significant nannofossil. This paper describes the new twin associations, reviews the other known associations, and summarizes the biological inferences that can be made from such associations.

Study on the genus *Nannoconus* (calcareous nannofossil, *Incertae Sedis*) has mostly been restricted to the observation of individual specimens for stratigraphic and palaeoceanographic studies. The distribution pattern worldwide has shown the genus to be tethyan-derived with a preference for continental margins, shallow plateaux and epicontinental seas, with a low terrigenous input (Erba, 1989). The actual controls on the occurrence of nannoconids in rock-building quantities in the Tethys has been related to carbonate productivity and possibly to the onset of upwelling, but nannoconids were found to be rare at palaeo-upwelling sites (Roth & Krumbach, 1986).

Very little is known about the biological nature of the nannoconid organism and its life-cycle. Studies on the taxonomic affinities of this genus have been hindered by the scarcity of associations and sometimes of individuals, notably in the boreal realm. The individual nannoconid fossils were probably originally parts of a composite structure, but preservation of entire skeleton structures would have required rapid transport of the organism through the water column and absence of subsequent bioturbation. By comparison, assemblages with abundant coccospheres have been interpreted as due to rapid sedimentation from blooms into anoxic bottom conditions (Cepek & Kemper, 1981; Mutterlose & Harding, 1987; Thomsen, 1989*a*, *b*; Young & Bown, 1991).

Associations of nannoconid individuals were described by Noël (1958) as rosette associations of *Nannoconus colomii* (syn. *Nannoconus steinmannii steinmannii*). Trejo (1960) illustrated the first unambiguous rosette associations of this species from Mexico. The cone-shaped bodies are arranged with the long axis of the individuals radiating from a small common central opening. He illustrated his observations with a light micrograph of an association (Trejo, 1960, pl. 3). Sketches of these rosettes from the Neocomian of Tampico, Mexico were later illustrated by Colom (1965). Figure 1 shows some of the sketches of rosettes.

Since then only Lambert (1987) has documented similar associations in a different species, *Nannoconus* aff. *fragilis* (syn. *Nannoconus regularis*) from Cameroon. However, his micrographs of a sphere of this species (Lambert, 1987, pl. 15, figs 3, 4 & pl. 16, figs 1, 2) are unclear. The scanning electron micrograph image (pl. 15, fig. 3) shows an incomplete 'sphere' which could also be interpreted as a depositional feature. The second electron micrograph (pl. 16, fig. 1) is here thought to show specimens of another genus. The individuals within the sphere lack the characteristic overlapping plate structure which is present in all taxa of the genus *Nannoconus*. The light micrographs of the spherical structures (pl. 15, fig. 5; pl. 16, fig. 2) are difficult to illustrate, focusing being essential to observe the individuals within the associations. It is also interesting to note that the monospecific lamina illustrated of *N.* aff. *fragilis* (Lambert, 1987, pl. 16, fig. 3) does not show evidence of spherical or twinning associations.

The most recent record of a rosette of *Nannoconus* sp. has been from the Maiolica limestone of Italy (Erba & Quadrio, 1987, pl. 6, fig. 10). This structure is similar to those described by Trejo (1960).

No associations of other nannoconid species have been recorded and therefore the observation of *N. abundans* twins are of interest, especially in such well preserved material. When interpreting these structures the question needs to be asked: are these structures a post-mortem phenomenon or have they been produced by the living cell? The problem is addressed by interpretation of the facies, the structure of the individual specimens and the nature of the twin-structure morphology.

MATERIAL

The material studied from the Munk Marl in North Jens-1, located in the Danish Central Trough (Fig. 2), was dated as early Late Barremian by the presence of the marker species *Nannoconus abundans* (Jakubowski, 1987; Crux, 1989). This facies is characterized by a thin unit of <1 m of black, finely laminated, pyritic marlstone containing 50% calcium

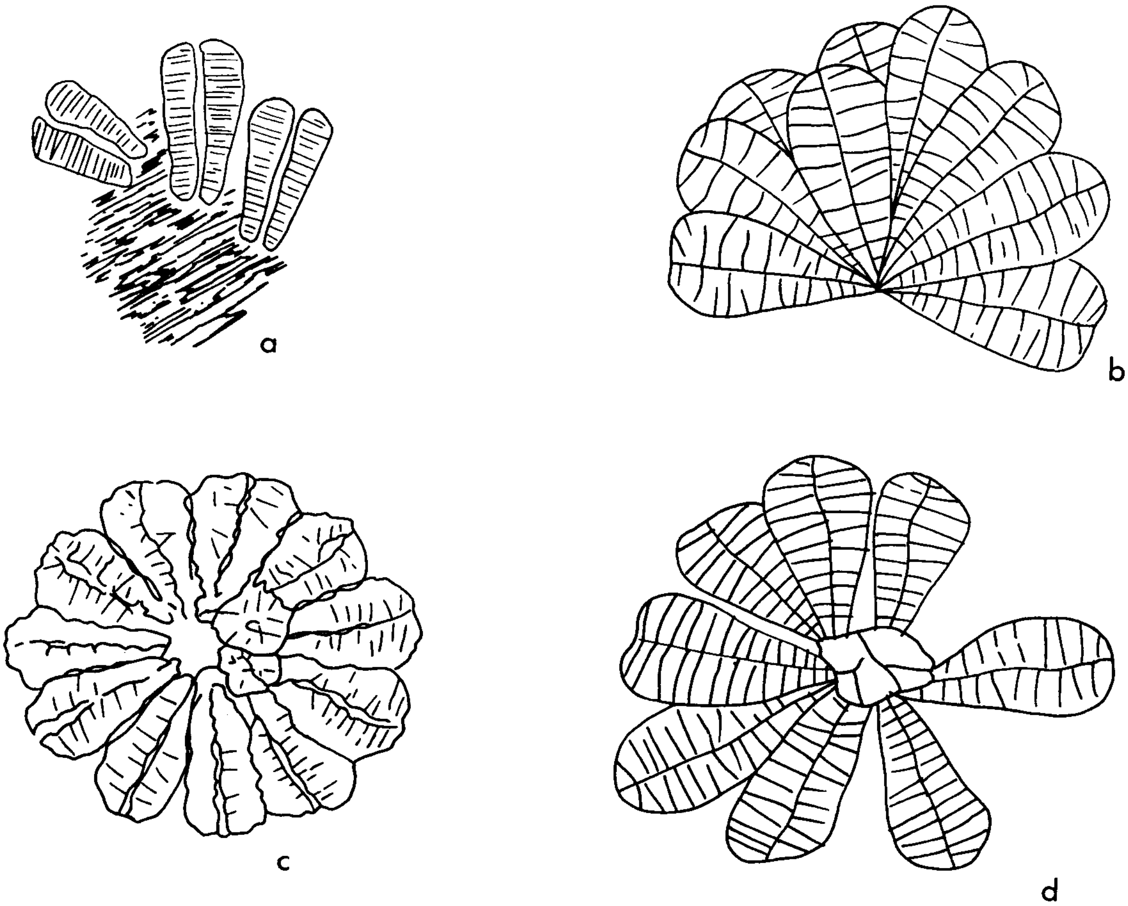

Fig. 1. Early sketches of rosette associations of *N. steinmannii steinmannii*. a. Noël (1958, pl. 4, fig. 29) ×800. b. Trejo (1960, pl.1, fig c) ×600. c. Colom (1965, drawn from Trejo 1960, pl. 3, fig. 2) ×600. d. Trejo (1960, pl. 1, fig d) ×600.

carbonate and 8–14% organic carbon (Jensen & Buchardt, 1987). The laminae consist of alternating layers of coccolith or nannolith species and thin organic-rich clay layers, visible in hand-specimen as faint, pale streaks.

Similar laminated facies have been observed across NW Europe: the Hauptblätterton of the Lower Saxony Basin, Barremian Blätterton facies of Helgoland and the upper part of the Lower B beds of Speeton, North Yorkshire (Mutterlose, 1991). Only slight lithological changes have been observed between the facies and all of the beds have been assigned to the *rude-fissicostatum* ammonite zone (Rawson & Mutterlose, 1983; Mutterlose & Harding, 1987).

METHODS

A small sample from the core was broken and carefully split across the laminae using a scalpel. The orientation of the sample was recorded using an arrow drawn on the surface. The sample was mounted onto a stub using colloidal silver and sputter coated with gold in preparation for scanning electron microscopy in a JEOL T200.

PRESERVATION

The preservation of the calcareous nannofossils was excellent with little indication of dissolution or secondary overgrowth. As in the material studied by Thomsen (1989*a*, *b*), physical crushing by the overlying sediment is absent and the minor damage to very delicate species appears to have occurred shortly before or after deposition. The nannofossil laminae also contain numerous intact coccospheres and clusters of coccoliths from disaggregated spheres. This has been taken to indicate minimal disturbance during the settling of the spheres and particles through the water column and negligible pre-sedimentation disturbance by current winnowing and movement (Thomsen, 1989*a*, *b*).

A single mono-specific lamina of *Nannoconus abundans* was observed in the sample material. This lamina appeared to be continuous and uniform with no indication of faecal pellet deposition and minimal bioturbation and disruption. A similar monospecific lamina of this species has been illustrated by Cepek & Kemper (1981, pl. 2, fig. 2), however, their lamina appears slightly damaged and some specimens removed, possibly during sample preparation. Nannoconids were observed in other laminae but only as rare individuals within assemblages of other nannofossils.

INDIVIDUAL MORPHOLOGY

The *Nannoconus abundans* individuals found in the lamina are characterized by a central body and a single, large,

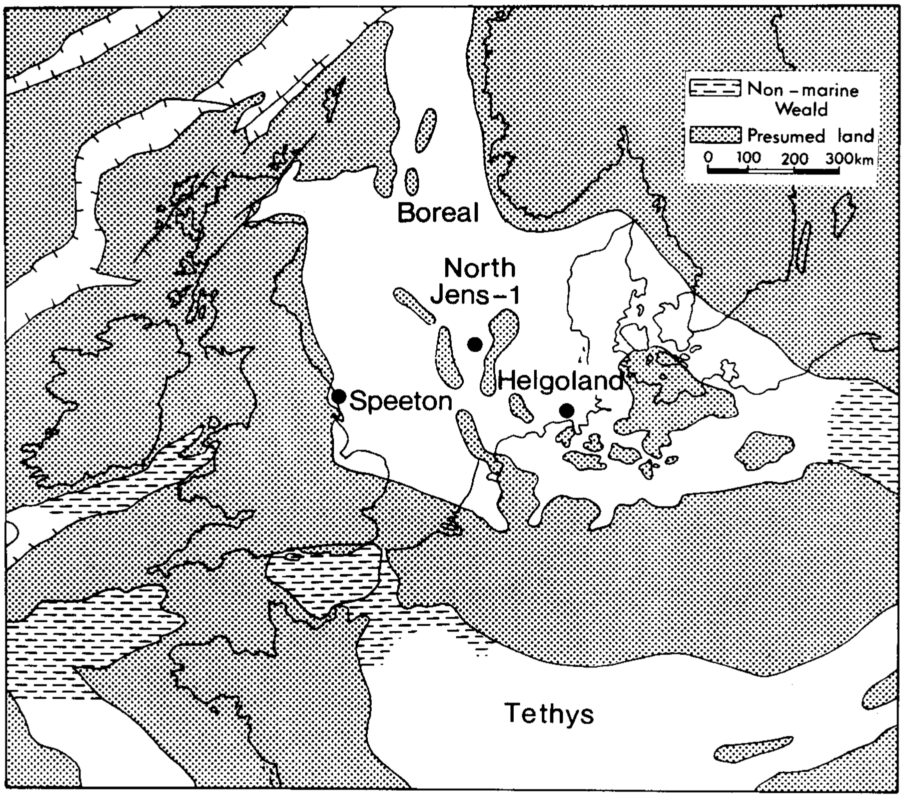

Fig. 2. Palaeogeographical map showing the position of North Jens-1. Interpretation from Mutterlose (1991).

symmetrical flange. A narrow central canal is present which opens at both poles, although the aperture in the flange shows a greater degree of restriction. The plates change in length and breadth, but not width, between the central body and flange.

The diameter of the flange/s at both poles can vary to a great extent within this taxon. Specimens may have a single symmetrical flange (Stradner & Grün, 1973, pl. 1 fig. 1) or show the presence of two symmetrical flanges (Mutterlose & Harding, 1987, pl. 2, figs 10, 11). Asymmetrical flanges have also been observed in the North Sea (van Niel, 1992*b*; Rutledge, 1993 pers. comm.). The terms used to describe the flanges are outlined in a nannoconid terminology document (van Niel, in press). The individuals within the sample only showed the presence of a single, symmetrical flange.

N. abundans has recently been assigned to Morphogroup 1.1 ($\beta < 20°$ and Cycle A width $<0.5\ \mu$m), based upon wall structure characteristics (van Niel, 1992*a*, *b*). The external surface of *N. abundans* individuals, observed in the SEM, shows a pronounced ridge and groove pattern, as also noted by Stradner & Grün (1973). These are not always observed but are thought to be formed by the overlap of the long axis of the rhomboidal plates in Cycle A. The absence of this feature in some specimens may be due to poor preservation or changes in the plate shape.

TWIN MORPHOLOGY

Each twin structure is constructed of two individual *N. abundans* specimens lying adjacent to each other along the well-developed symmetrical flange with only a very narrow common opening. The ridge and groove patterns can be traced across the boundary between the two individuals with no apparent deviation in inclination (Pl. 1). Also the flanges of the two individuals within the twin are perfectly aligned which would be unlikely to occur as a result of post-mortem processes.

The nature of plate construction and of the mechanism forming them within the nannoconid wall is unclear. The simple spiral model proposed by Brönimann (1955) appears oversimplified in light of new wall structure observations (van Niel, 1992*a*, *b*). Further study of the inter-relationships of the cycles is needed before we can determine whether there is continuity of ultrastructure between the twins, as well as of external morphology.

DISCUSSION

Despite the early recognition that nannoconid individuals are parts of composite structures (Lapparent, 1925; Kamptner, 1931), the problem of their systematic position has not been solved. The observation of a rosette of *N. steinmannii steinmannii* (Trejo, 1960) confirmed the hypothesis of Colom (1956) that individuals formed a

<table>
<tr><th colspan="4">Protozoa</th></tr>
<tr><th colspan="2">Foraminifera</th><th colspan="2">Incertae Sedis</th></tr>
<tr><td colspan="2">Lapparent (1925, 1931)
Lombard (1938, 1945)
Colom (1945, 1952)
Trejo (1960)
Aubry (1974)</td><td colspan="2">Baldi-Beke (1962)</td></tr>
<tr><th colspan="4">Unicellular Algae</th></tr>
<tr><th>Pyrophyta</th><th>Chlorophyta</th><th>Charophyta</th><th>Haptophyta</th></tr>
<tr><td>Busson & Noël (1991)</td><td>Cadisch (1934)</td><td>Peck (1934)
Brönnimann (1955)</td><td>Colom (1956)
Deflandre (1959)
Noël (1965)
Stradner & Grün (1973)</td></tr>
</table>

Fig. 3. Authors' concepts as to the biological affinity of *Nannoconus*.

spherical structure, comparable to many coccolithophorids. However, no perfect sphere of nannoconid individuals has been illustrated convincingly in the scanning electron microscope to date. Stradner & Grün (1973) compared the plate structure of nannoconids to similar calcite growth patterns, in vivo or post mortem, within the genus *Watznaueria*. This led them to conclude a phylogenetic relationship between the coccolithophorids and nannoconids. However, the presence of two cycles of plates with the c-axis deviating by <90° suggests that the nucleation/growth patterns differ significantly from those of coccolithophorids (Young, 1992) . Further study is needed to understand fully the nucleation/growth patterns of nannoconid taxa.

Other workers have suggested other biological origins for *Nannoconus* as summarized in Fig. 3. Early taxonomic assignments (to the unicellular algae) were based mainly on observations of the structure of the individuals in the light microscope (Peck, 1934; Brönnimann, 1955). The occurrence and distribution of nannoconids has also led to speculation as to their biological affinity (Lapparent, 1925, 1931; Busson & Noël, 1991).

CONCLUSIONS

The scarcity of the monospecific laminae of *Nannoconus abundans* and their relation to changes in the marine environment is unclear. In fact little is known about this extinct species apart from its morphology and distribution. Biologically inferences can only be made from the sediments and palaeo-associations. The Munk Marl is renowned for providing an exceptionally well preserved facies which contains other nannofossil assemblages indicating minimal disturbance during settling, deposition and diagenesis of the sediment. The lamination shows seasonal and annual variations which have been observed in modern oceanic nannoplankton (Okada & McIntyre, 1979). The fossil record, however, differs in containing a bewildering range of dominant species in comparison to the relatively oligotrophic successions of modern assemblages (Thomsen, 1989*a*). The scarcity of monospecific nannoconid laminae within the Munk Marl may suggest their dominance in unusual water mass conditions. Further detailed study of the Munk Marl and equivalent laminated facies in NW Europe might clarify some of these queries.

No firm conclusions as to the biological significance of these twins can be drawn at this stage. Further study of undisturbed laminae or beds containing high concentrations of different nannoconid taxa are needed before we can fully comprehend some of the biological controls on their distribution. The observation of twin structures of *N. abundans*, however, are significant as it is the first time that associations have been illustrated in another species within the genus *Nannoconus*.

ACKNOWLEDGEMENTS

The material was gratefully received from Maersk Olie & Gas and the author wishes to acknowledge the support and guidance of Professor A. R. Lord, technical support by Toby Stiles (University College London) and Paulette Williamson (IOSDL). The helpful comments and suggestions of the editor, Dr E. Erba, Dr P. Roth and Dr R. Jordan are greatly appreciated. This research was undertaken at University

---

Explanation of Plate 1

N. abundans, detail of twin structures. Locality: North Jens-1, 7560.11 m, Barremian. Scale bar 1 μm. **Figs 1, 2.** Enlargement of twin structures. **Fig. 3.** Plan view of lamina surface showing 4 twin structures, indicated by arrows.

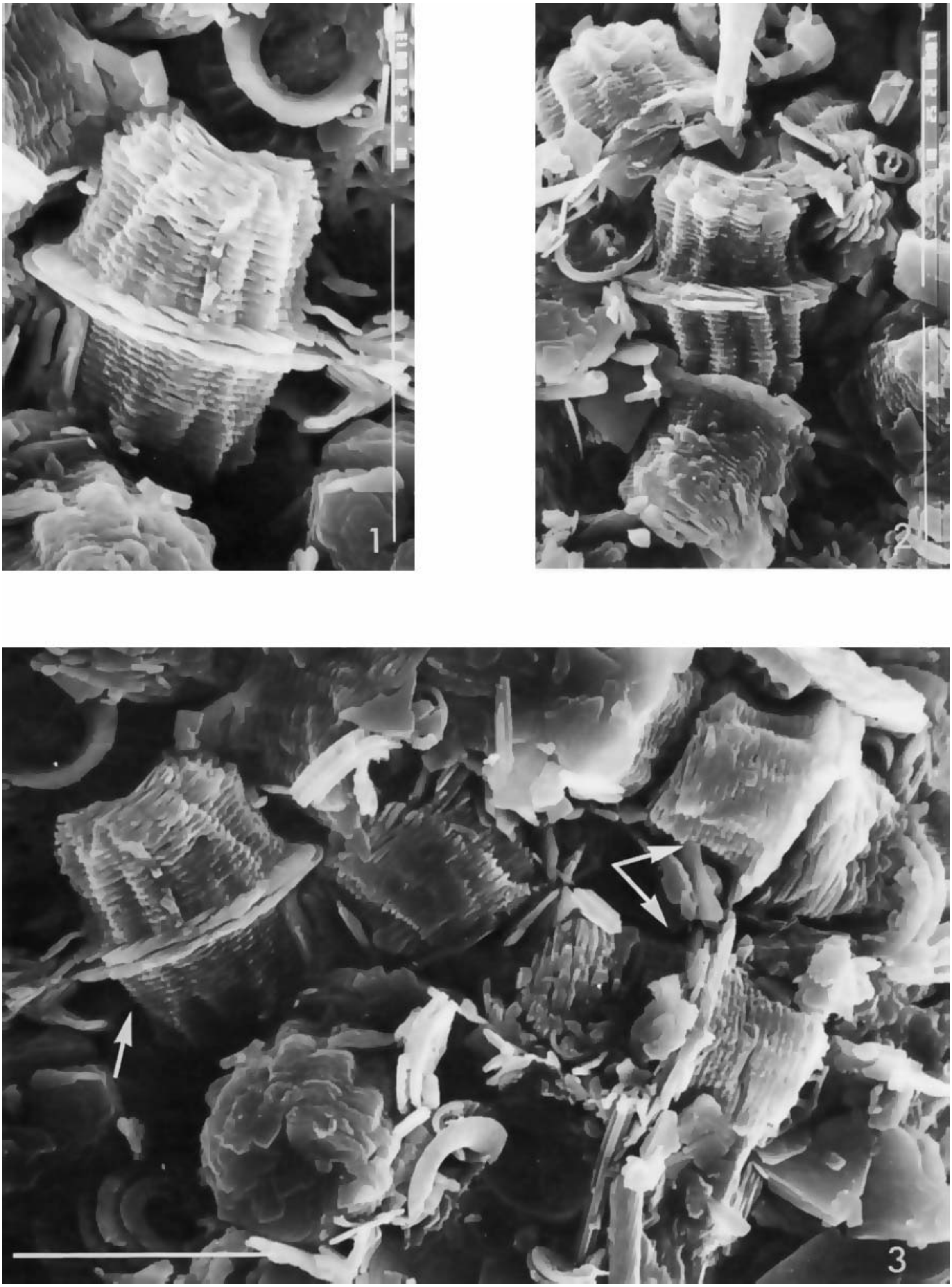

Plate 1

College London whilst in receipt of a NERC/Case studentship with Shell.

Manuscript received August 1993
Manuscript accepted May 1994

REFERENCES

Aubry, M. P. 1974. Remarques sur la systématique des *Nannoconus* de la Craie. *Cahiers de Micropaléontologie*, **4:** 3–22.

Baldi-Beke, M. 1962.The genus *Nannoconus* (Protozoa, *inc. sedis*) in Hungary. *Geologica Hungarica ser. Palaeontologica*, **29–32:** 118–179.

Brönnimann, P. 1955. Microfossils *incertae sedis* from the Upper Jurassic and Lower Cretaceous of Cuba. *Micropaleontology*, **1:** 28–51.

Busson, G. & Noël, D. 1991. Les nannoconidés, indicateurs environmentaux des océans et mers épicontinentales du Jurassique terminal et du Crétacé inférieur. *Oceanologica Acta*, **4:** 333–356.

Cadisch, J. 1934. *Geologie der Schweizeralpen*. 1–371. Zürich.

Cepek, P. & Kemper, E. 1981. Der Blättertonstein des nordwestdeutschen Barrême und die Bedeutung des Nannoplanktons für die fein laminierten, anoxisch enstandenen Gesteine. *Geologisches Jahrbuch*, **A58:** 3–13.

Colom, G. 1945. *Nannoconus steinmanni* Kamptner y *Lagena colomi* Lapparent. *Publicaciones del Instituto geológico*, **7:** 123–132.

Colom, G. 1952. On the distribution and implications of *Nannoconus* limestones in the bathyal facies of the Lower Cretaceous of the Western Mediterranean. *International Geological Congress, 18th (London, 1948) Report 10, Faunal and Floral Facies and Correlation*, 83–91.

Colom, G. 1956. Lithofacies y micropaleontologica de las formaciones Jurasico neocomienses de la Sierra de Ricotte (Murcia). *Boletín del Instituto geología y Minero de España*, **67:** 1–51.

Colom, G. 1965. Essais sur la biologie, la distribution géographique et stratigraphique des Tintinnodiens fossiles. *Eclogae geologicae Helvetiae*, **58:** 319–334.

Crux, J. 1989. Biostratigraphy and palaeogeographical applications of Lower Cretaceous nannofossils from north-western Europe. *In* Heck, S. & Crux, J. (Eds), *Nannofossils and their applications*, 143–211, Ellis Horwood Ltd., Chichester.

Deflandre, G. 1959. Sur les nannofossiles calcaires et leur systématique. *Revue de Micropaléontologie*, **2:** 127–152.

Erba, E. 1989. Upper Jurassic to Lower Cretaceous *Nannoconus* distribution in some sections from Northern and Central Italy. *Memoire di Scienze Geologiche*, **41:** 255–161.

Erba, E. & Quadrio, B. 1987. Biostratigrafia a Nannofossili calcarei, Calpionellidi e Foraminiferi planctonici della Maiolica (Titoniano superiore-Aptiano) affiorante nelle Prealpi Bresciane (Italia Settenrionale). *Rivista Italiana di Palaeontologia e Stratigrafia*, **93:** 3–108.

Jakubowski, M. 1987. A proposed Lower Cretaceous calcareous nannofossil zonation scheme for the Moray Firth area of the North Sea. *Abhandlungen der Geologischen Bundesanstalt*, **39:** 99–119.

Jensen, T. & Buchardt, B. 1987. Sedimentology and geochemistry of the organic carbon-rich Lower Cretaceous Sola Formation (Barremian-Albian), Danish North Sea. *In* Brooks, J. & Glennie, K. (Eds), *Petroleum Geology of North West Europe*, 441–452. Graham & Trotman.

Kamptner, E. 1931. *Nannoconus steinmanni* nov. gen., nov. spec., ein merkwürdiges gesteinbildendes Mikrofossil aus dem jungeren Mesozoikum der Alpen. *Paläontologische Zeitschrift*, **13:** 288–297.

Lambert, B. 1987. Nannofossiles calcaires de l'Albien supérieur et du Vraconnien du Cameroun méridional. *Cahiers de Micropaléontologie*, **2:** 33–60.

Lapparent, J. de, 1925. Sur une variété de calcaire à grain fin. *Comptes rendus sommaire des séances de la Societé géologique de France*, **7:** 104–106.

Lapparent, J. de, 1931. Sur les pretendus 'embryons de *Lagena*. *Comptes rendus sommaire des séances de la Societé géologique de France*, **14–15:** 222–223.

Lombard, A. 1938. Microfossiles du Jurassique supérieur alpin. *Eclogae geologicae Helvetiae*, **30:** 320–331.

Lombard, A. 1945. Attribution de microfossiles du Jurassique Supérieur alpin a des Chlorophycées (Proto et Pleurococcacées). *Eclogae geologicae Helvetiae*, **38:** 163–173.

Mutterlose, J. 1991. The distribution and migration patterns of calcareous nannofossils in the Lower Cretaceous (Valanginian-Apt) NW-Deutschlands. *Palaeontographica B*, **221:** 27–152.

Mutterlose, J. & Harding, I. 1987. The Barremian Blätterton: an Anoxic Warm Water sediment of the Lower Saxony Basin. *In* Kemper, E. (Ed.), Das Klima der Kreide-Zeit. *Geologisches Jahrbuch*, **A96:** 187–207.

Noël, D. 1958. Etude de Coccolithés du Jurassique et du Crétacé Inférieur. *Publications du Service de la Carte Géologique de l' Algérie*, **20:** 157–196.

Noël, D. 1965. Famille des nannoconidae. *In Sur les coccolithés du Jurassique european et d'Afrique du nord*. Editions du Centre National de la Recherche Scientifique, 156–171.

Okada, H. & McIntyre, A. 1979. Seasonal distribution of modern coccolithophores in the western North Atlantic Ocean. *Marine Biology*, **54:** 319–328.

Peck, R. E. 1934. The North American trochiliscids, Palaeozoic Charophyta. *Journal of Paleontology*, **8:** 83–119.

Rawson, P. & Mutterlose, J. 1983. Stratigraphy of the Lower B and basal Cement Beds (Barremian) of the Speeton Clay, Yorkshire, England. *Proceedings of the Geological Association*, **94:** 133–146.

Roth, P. & Krumbach, K. 1986. Middle Cretaceous calcareous nannofossil biogeography and preservation in the Atlantic and Indian Oceans: Implications for paleoceanography. *Marine Micropaleontology*, **10:** 235–266.

Stradner, H. & Grün, W. 1973. On *Nannoconus abundans* nov. spec. and on laminated calcite growth in Lower Cretaceous Nannofossils. *Verhandlungen der Geologischen Bundesanstalt*, **2:** 267–283.

Thomsen, E. 1989*a*. Seasonal variation in Boreal Early Cretaceous calcareous nannofossils. *Marine Micropaleontology*, **15:** 123–152.

Thomsen, E. 1989*b*. Seasonal variability in the production of Lower Cretaceous calcareous nannoplankton. *Geology*, **17:** 715–717.

Trejo, M. 1960. La familia Nannoconidae y su Alcance Estratigrafico en America. (Protozoa, Incertae Sedis). *Bolletin Asociacion Mexicana de Geologos Petroleros*, **12:** 259–314.

van Niel, B. E. 1992*a*. New observations on the morphology of *Nannoconus*. *In* Hamrsmid, B. & Young, J. R. (Eds), *Nannoplankton Research Volume* 1: *General Topics*; *Mesozoic Biostratigraphy*. Proceedings of the Fourth INA Conference, Prague 1991, Moravské Naftové Doly, Hodonín, Czech Republic, 73–85.

van Niel, B. E. 1992*b*. Early Cretaceous *Nannoconus* (calcareous nannofossil, *incertae sedis*) in NW Europe. PhD Thesis, University College, London.

van Niel, B. E. in press. A review of nannoconid terminology. *Cahiers de Micropaléontologie*.

Young, J. R. 1992. The description and analysis of coccolith structure. *In* Hamrsmid, B & Young, J. R. (Eds), *Nannoplankton Research Volume* 1: *General Topics*; *Mesozoic Biostratigraphy*. Proceedings of the Fourth INA Conference, Prague 1991 Moravské Naftové Doly, Hodonín, Czech Republic, 35–73.

Young, J. R. & Bown, P. R. 1991. An ontogenetic sequence of coccoliths from the Late Jurassic Kimmeridge Clay of England. *Palaeontology*, **34:** 843–850.