5. CRETACEOUS FORAMINIFERS FROM DEEP SEA DRILLING PROJECT SITE 612, NORTWEST ATLANTIC OCEAN

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ABSTRACT

Site 612, located some 100 km southeast of Atlantic City in the northwest Atlantic Ocean, was cored to a total depth of 675.3 m below sea floor. The final 114.96 m recovered an Upper Cretaceous succession that can be assigned to the late Campanian and early Maestrichtian. The dark mudstones of Campanian age contain an impoverished fauna of planktonic foraminifers, while the paler, nannofossil chalks of Maestrichtian age contain a typically diverse planktonic fauna. The environment represented by the Campanian fauna indicates the presence of slightly anoxic water in the vicinity of the New Jersey Slope at that time.

INTRODUCTION

Site 612, drilled during DSDP Leg 95, is located on the middle part of the New Jersey Slope, some 100 km southeast of Atlantic City (Fig. 1). This site and the others on Leg 95 were designed to complement Sites 603, 604, and 605 (drilled during Leg 93) of the "New Jersey Transect" (Poag, 1985). The area has been intensively surveyed by the United States Geological Survey (U.S.G.S.) and the Bundesanstalt für Geowissenschaften und Rohstoffe (BRG), together with several other oceanographic institutions. Site 612 was located approximately on U.S.G.S. Line 25 in order for the sediments recovered to calibrate this important seismic data set. Site 612 was not intended to core any great distance into the Cretaceous sedimentary pile, but the short succession recovered has proven to be of great value.

The Cretaceous succession is divisible into two distinct lithologic units, with a marked erosional hiatus (Fig. 2) between them. The lowest part of the succession, of late Campanian age, comprises 27.8 m of black to gray, foraminifer or nannofossil chalks, mudstones, and shales. The dark color is attributed to the abundance of organic matter; the highest total organic carbon (TOC) value is 2.68%. In the slide preparations for the dinoflagellate investigation (Tocher, this volume) large, matted clumps of dinoflagellates were seen in the majority of samples from this level.

The overlying 79.26 m of sediment is a gray, marly, intensely bioturbated foraminifer–nannofossil chalk. This unit is assigned to the Maestrichtian, but the foraminifers do not define any more than the lowest part of that stage.

METHODOLOGY

The samples were prepared using standard foraminiferal preparation methods. Samples were disaggregated gently using very dilute hydrogen peroxide and wet sieved on 75-µm mesh. When dried, the samples were inspected in the following size fractions; > 500 µm, 500-250 µm, 250-125µm and 125-75µm. Faunal counts were made on the 500-250µm size fractions, as this normally includes the greatest number of adult individuals and has the advantage of ease of study (see Poag and Low, this volume for an analysis of the finer size fractions). Full species lists were compiled but only taxa occurring in a number of samples have been included in this account. The only exceptions to this rule are those species known to have a proven stratigraphic value. Some typical examples of the fauna (and its preservation) are shown in Plate 1.

PLANKTONIC FORAMINIFERS

A total of 29 species of planktonic foraminifers were recorded (Table 1), many of which are long-ranging taxa of limited stratigraphic value. Preservation is poor to quite bad, and the specimens from the interval assigned to the Campanian are fragmented and badly corroded. The overlying Maestrichtian material is generally better preserved and some samples are in an exceptionally good condition. Identifications were largely based on the work...
Figure 2. The Campanian/Maestrichtian boundary in Sample 612-69-3, 8 cm. This level is intensely bioturbated, as is the whole of the Maestrichtian succession.

of Robaszynski et al. (1984), Smith and Pessagno (1973), and Pessagno (1967). The planktonic foraminifers cannot be used to identify precisely the interval represented by the hiatus (but see nannofossil information in Site 612, chapter, this volume) seen at the Campanian/Maestrichtian boundary, nor have I found any specimens of Gansserina gansseri (Bolli), the presence of which would indicate a middle Maestrichtian age for the succession. However, Poag and Low (this volume), who also examined the finer size fractions, report the presence of (probably juvenile) G. gansseri in Sample 612-69-3, 4-7 cm. Only a few specimens of the early Maestrichtian zonal indicator, Globotruncanita falsostuartii Sigal, were found, while in the late Campanian only one broken specimen Globotruncanita cf. calcara (Cushman) was recorded. Typical late Campanian species such as Globotruncanita bulloides Vogler, Globotruncanita linneiana (d’Orbigny), Globotruncanita arca (Cushman), and Rosita fornicata (Plummer) also range through into the early Maestrichtian. The more distinctively Maestrichtian species such as Globotruncanita havanensis (Voorwijk), Planoglobulina multicamerata de Klasz, Globotruncanita aegyptiaca Nakkady, and Rugoglobigerina milamensis Smith and Pessagno appear gradually in the higher levels of the Site 612 succession. One or two of the ranges recorded here are at variance with the information provided by Robaszynski et al. (1984). The most dramatic of these discrepancies appear to be the very distinctive planoconvex specimens referable to Globotruncanita cf. angulata Tilev, which have been recorded throughout the Cretaceous succession at Site 612 but for which Robaszynski et al. would only claim a middle and late Maestrichtian...
Table 1. The distribution of planktonic foraminifers in the Cretaceous succession of Site 612.

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<tr>
<th>Sample (interval in cm)</th>
<th>Globotruncanita contusa</th>
<th>Globotruncana bulioides</th>
<th>Heterohelix striata</th>
<th>Rugoglobigerina rugosa</th>
<th>Archaeoglobigerina cretacea</th>
<th>Osangularia varians</th>
<th>Parvulaubulina pontiacea</th>
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Range. The full list of species recorded in Table 1 is as follows:

Archaoglobigerina cretacea (d'Orbigny) = Globigerina cretacea d'Orbigny, 1840, p. 34, pl. 3, figs. 12-14.
Globigerinelloides aspera (Ehrenberg) = Phanerostomum asperum Ehrenberg, 1854, p. 23, pl. 30, fig. 26.
Globigerinelloides prateri (Ehrenberg) = Globigerina prateri Pessagno, 1967, pp. 277-278, pl. 60, figs. 2-3, pl. 83, fig. 1, pl. 90, figs. 1-2, pl. 97, figs. 3, 4.
Globigerinelloides multispinata (Lalicker) = Biglobigerinella multispinata Lalicker, 1948, p. 5, pl. 92, figs. 1-3.
Globotruncana aegyptiaca Nakkady, 1950, p. 690, pl. 80, fig. 20.
Globotruncana arenicola (Cushman) = Pulvinulina arenicola Cushman, 1926, p. 39, pl. 3, fig. 1.
Globotruncana bulioides Vogler, 1941, p. 287, pl. 23, figs. 32-39.
Globotruncana falsostuarti Sigal, 1952, p. 43, t. fig. 46.
Globotruncana insignis Gandolfi, 1955, p. 67, pl. 6, fig. 2a-c.
Globotruncana lineata (d'Orbigny) = Rosalina lineata d'Orbigny, 1839, p. 101, pl. 5, figs. 10-12.
Globotruncana marielli Banner and Blow, 1960, type figure is Globotruncana cretacea Cushman, 1938, pl. 11, fig. 6a-c.
Globotruncana orientalis El Naggar, 1966, p. 125, pl. 12, fig. 4a-d.
Globotruncana rossetta (Carsey) = Rosalina rossetta Carsey, 1926, p. 44, pl. 5, fig. 3a-b.
Globotruncana ventricosa White, 1928, p. 284, pl. 38, fig. 5a-c.
Globotruncana arenicola (Voorwijk) = Globotruncana havanaensis Voorwijk, 1937, p. 195, pl. 1, figs. 25, 26, 29.
Globotruncana patelliformis Gandolfi subsp. patelliformis Gandolfi, 1955, p. 52, pl. 3, fig. 13a-c.
Globotruncana cf. angulata (Tiley) = Globotruncana angulata Tiley var. angulata Tiley, 1951, p. 46, pl. 3, fig. 1a-c, fig. 13a-c.
Globotruncana cf. calcarea (Cushman) = Globotruncana calcarea Cushman, 1927, p. 115, pl. 23, fig. 10a-b.
Globotruncana stuartiformis (Dalbiez) = Globotruncana (Globotruncana) stuartiformis (Dalbiez), 1955, p. 169, t. fig. 10a-c.
Globotruncana subspinosus (Pessagno) = Globotruncana (Globotruncana) subspinosus Pessagno, 1960, p. 101, pl. 1, figs. 4-6.
Hedbergella holmdensisolsson, 1964, p. 160, pl. 10, fig. 2a-c.
Heterohelix striata (Ehrenberg) = Textularia striata Ehrenberg, 1840, p. 135, pl. 4, figs. 1-3, not 9.
Planoglobulina multicamerata de Klasz, 1953, p. 230, pl. 5, fig. 1a-b.
Pseudotextularia elegans (Kozluk) = Cuneolina elegans Kozluk, 1891, p. 4.
Rosita fornicata (Plummer) = Globotruncana fornicata Plummer, 1931, p. 130, pl. 13, fig. 4a-c.
Rosita patelliformis (Gandolfi) = Globotruncana (Globotruncana) contusa (Cushman) subsp. patelliformis Gandolfi, 1955, p. 54, pl. 4, fig. 2a-c.
Rugoglobigerina milaniensis Smith and Pessagno, 1973, p. 56, pl. 24, figs. 4-7.
Rugoglobigerina pennyi Brönnimann, 1952, p. 34, pl. 4, figs. 1-3.
Rugoglobigerina rugosa (Plummer) = Globigerina rugosa Plummer, 1926, p. 38, pl. 2, fig. 10a.

BENTHIC FORAMINIFERS

The benthic foraminifers are well represented, especially in the late Campanian sediments. In the overlying Maestrichtian strata, ranges become difficult to establish as the small sample size, coupled with the reduced benthic faunas, provides a few individuals for study. There is an extensive literature on Cretaceous benthic foraminifers but the following provided all of the required information: Olsson and Nyong (1984), Nyong and Olsson (1984), Sliter (1968), Hart et al. (1981), Bailey (1978), and Swiecicki (1980). There are some significant differences in taxonomic usage between American and European workers, except for certain groups (e.g., Bolivinoides) of proven stratigraphic value. It is clear from this investigation that European names can, in many cases, be applied to the fauna under discussion, but in this limited study there has not been sufficient time for a full European vs. American comparison. Nearly all the recorded species (Table 2) are well known in northwest Europe, with clearly defined stratigraphic ranges (see Hart et al., 1981). It is probable, however, that such ranges may have been slightly different in the Baltimore Canyon Trough (allowing for migration times), although in some cases there appears to be no difference. The species of Neofabellina, Bolivinoides, Stensioina, Eponides, and Osangularia all seem to be in agreement with their known ranges in the U.K., although some genera (e.g., Globorotaliidae) appear to have a slightly different range. Gavelinella montenerlensis (Marie) still appears to

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be a distinctive late Campanian species while *Bolivinoides laevisgatus* Marie, *B. decoratus* (Jones) and *B. miliaris* Hilttermann and Koch are again recorded from lower Maestrichtian strata.

In northwest Europe the Maestrichtian Stage is subdivided into lower and upper substages and the distribution of key benthic taxa against this standard has been described by Świecicki (1980). Unfortunately, the comparison of this bipartite division with the tripartite scheme adopted by workers on Tethyan planktonic foraminifers (Robaszyński et al., 1984) is not known in detail at the present time and this has caused some difficulties in the present investigation. As indicated earlier no “middle Maestrichtian” planktonic assemblage has been recorded by the author at Site 612, and there are no benthic taxa that are characteristic of the upper half of the northwest European early Maestrichtian. Thus, although no definitive statements can be made, it seems that from both these lines of evidence the mid-Maestrichtian (based on foraminifers) is not represented in the Site 612 succession. The species used in Table 2 are now listed as follows:

### Table 2. The distribution of benthic foraminifers in the Cretaceous succession of Site 612.

REGIONAL IMPLICATIONS

Recently Nyong and Olsson (1984) and Olsson and Nyong (1984) have documented the late Cretaceous palaeoenvironments of the New Jersey Coastal Plain and the adjacent offshore areas. From their palaeoslope model, they concluded that there was a transgressive event during the late Campanian, followed by a slight regression in the early Maestrichtian. They also describe the occurrence of a localized oxygen deficient zone within the late Campanian sediments of the New Jersey Slope.

As a part of the present investigation, faunal counts have been made on samples from Site 612 and calculated as percentages of keeled planktonic foraminifers, non-keeled planktonic foraminifers, calcareous benthic foraminifers, and arenaceous benthic foraminifers. The graph so produced (see Fig. 3) shows a quite distinctive change at the Campanian/Maestrichtian boundary as described earlier. The late Campanian assemblage contains a rich assemblage of arenaceous and calcareous benthic foraminifers, whereas above the hiatus the total benthic component of the fauna rarely climbs as far as 20% of the total.

Hart and Ball (1986) have recently documented the Upper Cretaceous succession (Fig. 4) at DSDP Site 551 (Goban Spur, northeast Atlantic Ocean). That succession again shows this reduced planktonic fauna in the late Campanian, with the benthic fauna in this example running as high as 95% of the total. Literature on Cretaceous transgressions/regressions (Hancock and Kauffman, 1979) indicate that over most of the globe there is a transgressive peak in the late Campanian. This would indicate that planktonic faunas should extend more widely at that time, and the lack of a diverse planktonic fauna at Sites 612 and 551 must clearly indicate some alternative environmental interpretation and possible restriction. Hart and Ball (1986) have interpreted the data from Sites 612 and 551 as indicating the presence of an oxygen-depleted zone in the water column during a period of eustatic highstand. Although such “oceanic anoxic events (OAEs)” are well documented in the Aptian/Albian, late Cenomanian and Santonian, this record in the late Campanian is quite interesting as it probably indicates that during the greater part of the late Cretaceous a layer of oxygen-depleted water existed in a good part of the North Atlantic Ocean.

Previously described OAEs are only the intervals where the depleted zone expanded in the water column to the point where it could be detected by the limited number of sites that have penetrated this stratigraphic interval. Whenever this has occurred (e.g., the late Cenomanian event in northwest Europe) it is expressed by the widespread distribution of a grey-black mudstone, rich in dinoflagellates and with a significantly reduced fauna of planktonic foraminifers.

SUMMARY

The late Campanian and early Maestrichtian succession at Site 612 provides benthic faunas directly comparable with those in northwest Europe and serves to demonstrate how cosmopolitan the late Cretaceous fauna had

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Figure 3. The Cretaceous succession at Site 612 is a mudstone-dominated late Campanian sequence overlain by a nannofossil chalk sequence of early Maestrichtian age. No data are presented for the overlying Cenozoic succession. The percentages plot of the foraminifers is based on counts of the 500–250 µm size fraction and is subdivided into the following categories: (a) keeled planktonic foraminifers, (b) non-keeled planktonic foraminifers, (c) calcareous benthic foraminifers, and (d) arenaceous benthic foraminifers.
Figure 4. The Cretaceous succession at Site 551. The geological succession is complicated by the major hiatus between the early Turonian and the late Campanian. No data are presented for the overlying Cenozoic succession. The graph is based on the same categories as given in Figure 3. At Site 551, middle Maestrichtian is definitely proven but the boundary between the zones is yet to be established; this explains the use of the terms “lower” and “middle” instead of species names. 

R. cush. = Rotalipora cushmani,
W. arch. = Whiteinella archaocretacea.

ACKNOWLEDGMENTS

The author wishes to acknowledge the financial assistance given by the Natural Environment Research Council for participation on this leg. The other shipboard scientists are thanked for their assistance in the formulation of the ideas expressed in this chapter.

REFERENCES


The presence of a localized anoxic “event” at Site 612 confirms the palaeoslope model of Nyong and Olsson (1984) and the predictions made by Hart and Ball (in press) in their study of the material from DSDP Leg 80.


