12. PLANKTONIC FORAMINIFERS FROM THE CRETACEOUS/TERTIARY BOUNDARY AT DEEP SEA DRILLING PROJECT SITE 605, NORTH ATLANTIC[1]

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ABSTRACT

Analysis of planktonic foraminifers from Section 605-66-1 established the Cretaceous/Tertiary (K/T) boundary between 68 and 73 cm. Comparison with the detailed zonation established at El Kef, Tunisia, indicates that some of the section may be missing, probably because of drilling disturbance. The preservation of the planktonic foraminifers is generally good, particularly in the basal Paleocene section. However, extensive dissolution and the many broken specimens render quantitative estimates unreliable. There were no microtektite-like spherules to suggest a layer rich in extraterrestrial components, as have been found in most complete pelagic K/T boundary sections. The better preservation of Paleocene foraminiferal test in this core and in many other DSDP cores from other basins is probably due to a change in oceanic carbonate chemistry exactly at the K/T boundary. This may have been caused by a temporary and almost complete disappearance of carbonate-fixing organisms at the boundary.

INTRODUCTION

Site 605 (38°44.5′N, 72°36.6′W) is located on the upper continental rise at 2194 m water depth (Fig. 1). Eight samples from Section 605-1 were analyzed for planktonic foraminifers to test the completeness of the K/T boundary section in Core 66 and to determine whether the foraminiferal patterns of this core are comparable with the faunal patterns of other DSDP sites where a sudden mass extinction is observed at the boundary.

METHODS AND RESULTS

The samples were allowed to disaggregate in 5% H_2O_2 solution and were wet-sieved on a 90-μm nylon screen. The sediments appeared relatively lithified and ultrasound cleaning of washed residues was necessary. The residues were strewn on a counting tray and the first 200 recognizable >50% whole specimens were counted (Fig. 2, Table 1).

The faunas are moderately well preserved, particularly in the Paleocene section. Sample 605-66-1, 73–74 cm shows a significant drop in abundance and diversity of planktonic foraminifers and an increase in the benthic-planktonic (B-P) foraminifer ratio. Microscopic examination of the untreated sample shows that especially larger planktonic foraminifers were almost all dissolved; they do not show up in washed residues. However, examination of rock fragments under a binocular microscope showed that globotruncanids and rugoglobigerinids are roughly of the same abundance as in samples from the intervals at 75–79 cm, 92–95 cm, and 136–140 cm. We consider this sample still Cretaceous in age. Thus the K/T boundary, unfortunately, occurs in the broken core section between 44 and 72 cm (Fig. 3).

BIOSTRATIGRAPHY

Planktonic foraminifers were zoned according to the zonation of Smit (1982) and Smit and Romein (1985) (Fig. 4). All their zones are based on first appearances of marker species (FAD), except the *Guembelitria cretacea* (P0) Zone. This zone is defined as the interval between the mass extinction level of *Globotruncana* and *Rugoglobigerina* and the first appearance of *"Globigerina" minutula*. Within this zone, *Guembelitria cretacea* is usually abundant to even monospecific (Smit, 1982). This zonation follows van Hinte (1976) for the uppermost Cretaceous, and Hardenbol and Berggren (1978) for the lowermost Paleocene, although additional datums are defined in the basal Paleocene. This detailed zonation was possible because the sedimentation rate was unusually high (6 cm/10^3 yr.) in the Upper Cretaceous and Paleocene El Haria shales of the El Kef section, Tunisia.

Hole 605 was drilled on the continental rise in a thick sedimentary sequence; thus a high (hemipelagic) sedimentation rate was expected in the K/T boundary section, promising high biostratigraphic resolution. If a biozonation like that at El Kef could be found in Hole 605, it would indicate that this zonal scheme has more than a regional value. However, specimens referable to *"Globigerina" eugubina* (Luterbacher and Premoli Silva), *"Globigerina" minutula* (Luterbacher and Premoli Silva) or *"Globigerina" fringa* (Subbotina) were not found, although they are present in the basal Paleocene of DSDP Hole 390A on the Blake Nose (Smit and Romein, 1985). This indicates a hiatus in Hole 605 which ranges from the *Abathomphalus mayaroensis* Zone to the lower part of the *Globigerina pseudobulloides* Zone and which probably encompasses most of P0, P1a, P1b, and the lower part of P1c. This hiatus is largely due to drilling disturbance (Fig. 4) (34.7 cm of the core was not recovered), although nondeposition or erosion cannot be excluded. Drilling disturbance would not be surprising however. Generally in the thick, hemipelagic, lithified K/T boundary sections in Europe, such as near Gubbio, Caravaca, Bidart, Zumaya, Stevns Klint, Nye Kløv (Smit and Romein, 1985), the so-called boundary clay stands out as a soft, nonlithified clay layer, 1–10 cm thick. Drilling disturbance from rotary drilling will preferentially attack

[1] van Hinte, J. E., Wise, S. W., Jr., et al., *Init. Repts. DSDP*, 93: Washington (U. S. Govt. Printing Office).

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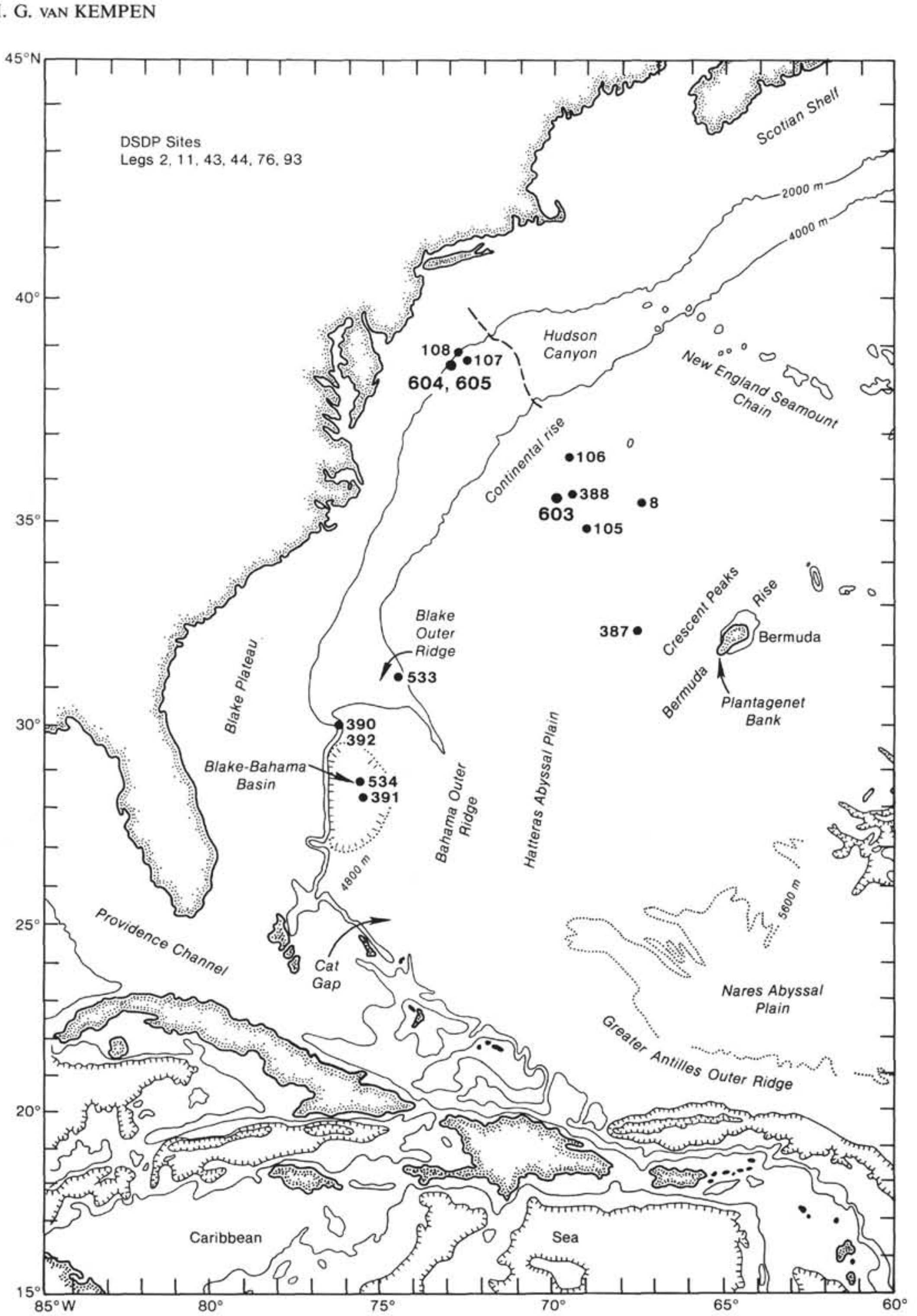

Figure 1. Location map for DSDP Leg 93 sites.

the soft clay. In view of the rather high clay content (Klaver, this volume) of Hole 605 pelagic sediments in the K/T boundary interval, a similar soft clay layer may have been present.

PRESERVATION CHANGES ACROSS THE K/T BOUNDARY

Several authors (Boersma, 1982; Thierstein, 1982; Hsü et al., 1982; Smit, 1982; Smit and Romein, 1985) have recognized that the preservation of planktonic foraminifers differs markedly between the uppermost Cretaceous and the lower Paleocene. Worsley (1974) postulated a rise of the CCD into the photic zone and extrapolated this rise as being the cause of the terminal Cretaceous extinction of calcareous plankton.

We have studied the preservation of planktonic foraminifers not only from Hole 605, but also from many boreholes from other ocean basins (DSDP Holes 47.2,

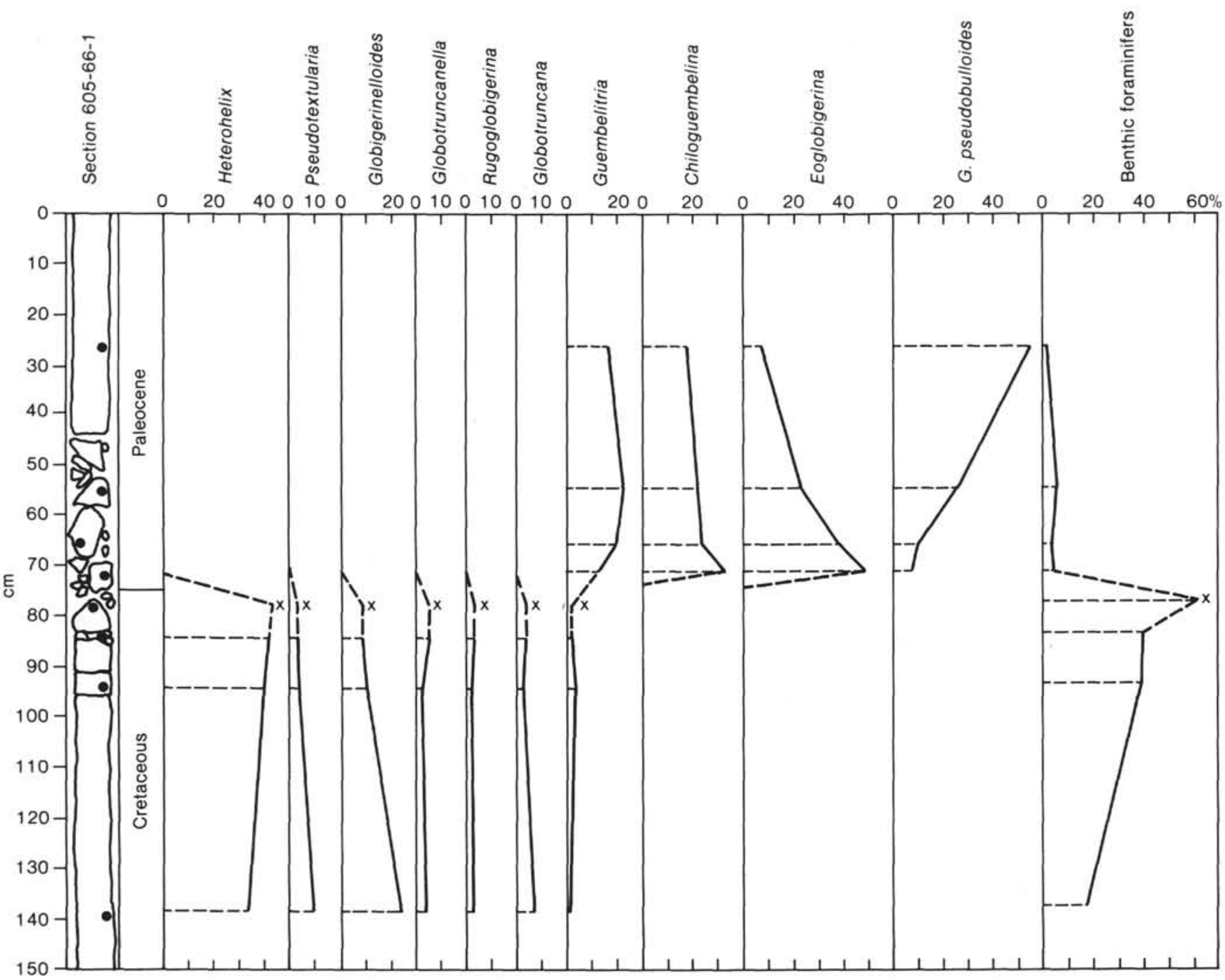

Figure 2. Relative abundances of planktonic foraminifers in Section 605-66-1. x = Sample 605-66-1, 73–74 cm (see text discussion). Horizontal lines mark sample levels.

Table 1. Distribution of planktonic foraminifers in Section 605-66-1.

Interval (cm)	*Globotruncana* sp.	*Globotruncana arca*	*G. elevata*	*G. fornicata*	*G. contusa*	*G. stuarti*	*G. falsostuarti*	*Rugoglobigerina* sp.	*R. rugosa*	*Trinitella scotti*	*Globotruncanella caravacaensis*	*G. havanensis*	*G. monmouthensis*	*G. petaloidea*	*Globigerinelloides aspera*	*G. messinae*	*Planoglobulina* sp.	*Racemiguembelina fructicosa*	*Pseudotextularia* spp.	*Heterohelix* spp.	*Abathomphalus intermedia*	*A. mayaroensis*	*Guembelitria cretacea*	*Chiloguembelina midwayensis*	*Chiloguembelina* sp.	*Eoglobigerina edita*	*E.* spp.	*Globigerina pseudobulloides*	*G. triloculinoides*	*Planorotalites compressus*	*Globoconusa daubjergensis*
24–26																							C	C	C	C	C	C	C	P	P
53–55																							C	C	C	C	C	C	C		
64–66																							C	C	C	C	C	C	C		P
67–68												P				P							C	P	C	C	C	C	P	P	P
73–74	D	D	?	?	D	D	?	D	D			D			P	C		D	C	C			C								
75–79	C	P	?		P	C		C	P	P	P	C	P		C	C			C	C	P	P	P								
92–95	C					?		P	P			P			P	C	P		C	C			P								
136–140	C	P	P	P	P	P	P	P	C		P	C	P	P	C	C	P	P	C	C			P								

Note: D = dissolved, P = present, C = common, ? = questionable.

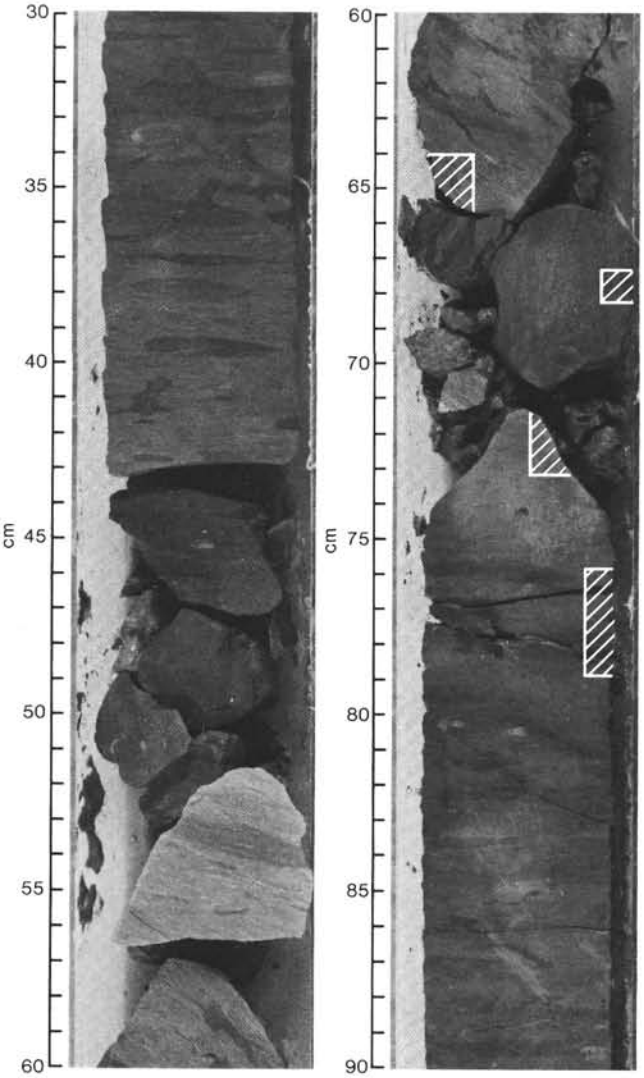

Figure 3. Cretaceous/Tertiary boundary interval in Section 605-66-1. Foraminifers from the intervals at 73–74 and 75–79 cm are of Late Cretaceous age (UC17), those from intervals at 67–68 and 64–66 cm are of early Paleocene (P1c) age.

190, 199, 217, 305, 365, 384, 390A, 416, 465A, 524, 527, 577), as well as from sections at El Kef (Tunisia), Gredero and other locations in southern Spain, Bidart section (France), and Nye Kløv (Denmark) (Smit and Romein, 1985). Preservation of foraminiferal tests varies from excellent to poor. A characteristic feature at these sites is the marked difference in preservation across the K/T boundary: foraminiferal tests in the uppermost Cretaceous strata are dissolved or recrystallized, whereas they appear well preserved in basal Paleocene strata. One cannot fail to observe the close connection with the terminal Cretaceous extinction event, for the change coincides precisely with the mass-extinction/mass-mortality event, which is marked by a layer with maximum extraterrestrial components (iridium anomaly and altered microtektites in most DSDP cores [Smit and Romein, 1985] and also by shocked feldspar and quartz grains at Caravaca, Stevns Klint, and Gubbio [Bruce M. Bohor, personal communication]). In none of these sections has there been found any indication that these changes started at some point in the Late Cretaceous, increased in magnitude, and then climaxed at the mass extinction level.

Studies of washed residues and thin sections from Upper Cretaceous strata in the sections of El Kef, Caravaca, Bidart, and Nye Kløv have failed to reveal signs of increasing dissolution of carbonate tests toward the K/T boundary. A rise in CCD or lysocline into the photic zone in the Late Cretaceous, as hypothesized by Worsley (1974), thus seems unlikely.

The most spectacular changes have been found at DSDP Sites 47.2, 305, 465, and 577 in the Pacific Ocean and Sites 142, 365, and 524 in the Atlantic. In these cores, uppermost Cretaceous planktonic forms are rare to extremely rare, whereas remaining tests show signs of severe dissolution. This is in great contrast with the often excellent preservation of the fragile, minute tests of the foraminifers from the very base of the Paleocene, as well as from the *Globigerina eugubina* and the lower part of the *Globigerina pseudobulloides* zones.

The coincidence of a marked carbonate preservational signal with the K/T boundary hints to a direct relation with the terminal Cretaceous mass-extinction event itself, whether it was the result of an impact or not (Smit and Romein, 1985). The simplest explanation is possibly a sudden drop of the lysocline/CCD under the influence of the aftereffects of the sudden mass mortality at the K/T boundary. Hsü et al. (1983) hypothesize a "Strangelove ocean" in the earliest Tertiary, in which for several thousands of years oceanic life was almost nonexistent, at least in ocean surface waters. This "barren ocean" would be indicated by the collapse of the $\delta^{13}C$ gradient in this ocean; the $\delta^{13}C$ values of benthic foraminifers became almost the same as those for of planktonic foraminifers.

CONCLUSIONS

The K/T boundary is identified in DSDP Section 605-66-1, between 68 and 74 cm. However, this interval has been severely disturbed by drilling, and part of the planktonic foraminiferal zonation is missing (P0, the *Guembelitria cretacea* Zone to base of P1c, the *Globigerina pseudobulloides* Zone). Also, typical lithologies known from other K/T boundary sections, such as a "boundary clay," microtektite-like spherules, or an iridium anomaly, seem to be missing. In Site 605, but even more prominently in many other DSDP sites, there is an improvement in preservation of foraminiferal tests from Cretaceous to Paleocene. The exact coincidence with the mass-mortality horizon suggests that this change is due to the terminal Cretaceous event(s).

ACKNOWLEDGMENTS

We express our gratitude to J. E. van Hinte for providing the samples. Reviews by J. E. van Hinte, D. A. Dunn, W. E. Sliter, R. M. Leckie, and M. A. Kaminski are greatly appreciated. This work was supported by NSF Grants OCE-82-08197 and OCE-84-10177 to J.S. at UCLA.

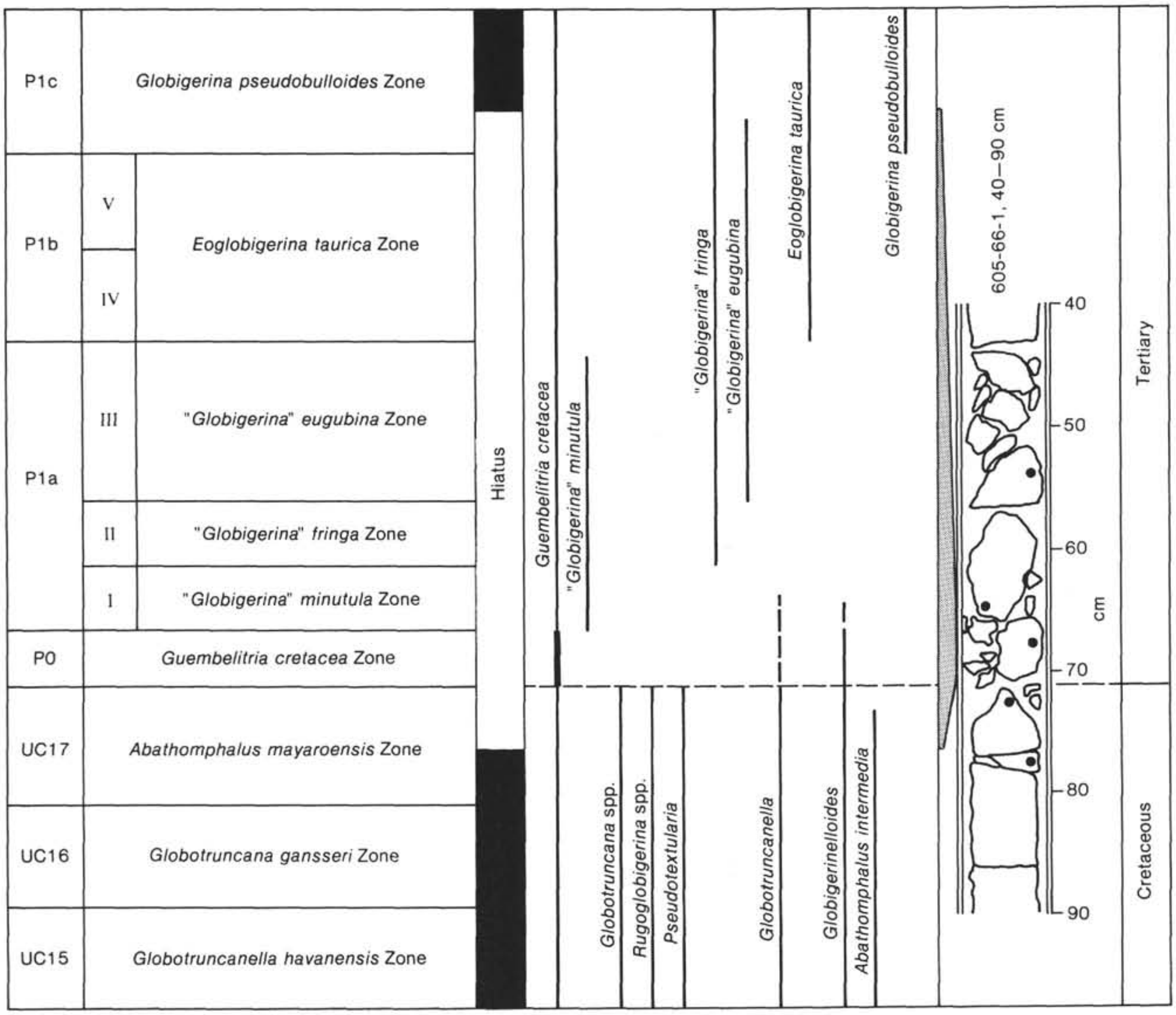

Figure 4. Planktonic foraminiferal biostratigraphic zonation of the K/T boundary interval based on the high-resolution stratigraphy of the El Kef section in northern Tunisia (after Smit, 1982). Ranges of important index species are indicated. Part of the zonation is missing, at 605-66-1, 68–73 cm (noted at right). Dots indicate sample locations. Heavier portion of *G. cretacea* line indicates higher relative abundance.

REFERENCES

Boersma, A., 1982. Cretaceous and early Tertiary foraminifers from DSDP Leg 62 sites in the central Pacific. *In* Thiede, J., Vallier, T. J., et al., *Init. Repts. DSDP*, 62: Washington (U.S. Govt. Printing Office), 377–396.

Hsü, K. J., He, Q., McKenzie, J. A., Weissert, H., Perch-Nielsen, K., Oberhänsli, H. et al., 1982. Mass mortality and its environmental and evolutionary consequences. *Science*, 216:249–256.

Hsü, K. J., and McKenzie, J. A., 1983. The Strangelove effect—carbon isotopic perturbation—as indication of mass-mortality. *Terra Cognita*, 3:222. (Abstract)

Hardenbol, J., and Berggren W. A., 1978. A new Paleogene numerical time scale. *In* Cohee, G. V., Glaessner, M. F., and Hedberg, H. D. (Eds.), *Contributions to the Geologic Time Scale.* Am. Assoc. Pet. Geol. Stud. Geol., 6:213–234.

Hinte, J. E., van, 1976. A Cretaceous time scale. *Am. Assoc. Pet. Geol. Bull.*, 60:498–516.

Smit, J., 1982. Extinction and evolution of planktonic Foraminifera after a major impact at the Cretaceous/Tertiary boundary. *Geol. Soc. Am. Spec. Pap.*, 190:329–352.

Smit, J., and Romein, A. J. T., 1985. A sequence of events across the Cretaceous Tertiary boundary. *Earth Planet. Sci. Lett.*, 74:155–170.

Thierstein, H. R., 1982. Terminal Cretaceous plankton extinctions: A critical assessment. *Geol. Soc. Am. Spec. Pap.*, 190:385–400.

Worsley, T. R., 1974. The Cretaceous/Tertiary boundary in the ocean. *Soc. Econ. Paleontol. Mineral. Spec. Publ.*, 20:94–125.

Date of Initial Receipt: 29 April 1985
Date of Acceptance: 3 March 1986