GFF volume 122 (2000), pp. 11–12. "Early Paleogene Warm Climates and Biosphere Dynamics"

Spanish and Tunisian Cretaceous/Tertiary boundary sections: A planktic foraminiferal biostratigraphic comparison and evolutionary events

IGNACIO ARENILLAS, JOSÉ ANTONIO ARZ, and EUSTOQUIO MOLINA

We performed a planktic foraminiferal biostratigraphic study of the most expanded and continuous sections of the Cretaceous/Tertiary (K/T) boundary located in Spain and Tunisia in order to evaluate the continuity and thickness of the K/T boundary sections and establish the correlation among biozones and sections. It was important to test the extinction patterns of Maastrichtian planktic foraminifera and the evolution of Tertiary species in order to determine the thickness of the different planktic foraminiferal biozones.

We considered the four classical biozones: *Abathomphalus mayaroensis* Biozone (Cretaceous), *Guembelitria cretacea* Biozone, *Parvularugoglobigerina eugubina* Biozone, and *Parasubbotina pseudobulloides* Biozone (Tertiary). The bases of these biozones are placed at the first appearance of the eponymous species, except for the base of *G. cretacea* Biozone which is situated at the last appearance datum of *A. mayaroensis*, precisely at the K/T boundary. We distinguished *Pv. eugubina* (low-arched aperture) from *Pv. longiapertura* (high-arched aperture) and we realised the earlier appearance of the latter species. Since these morphospecies are considered synonyms by some authors, the *Pv. longiapertura* FAD has frequently been used to establish the base of the P0, which is not exactly equivalent to the *Pv. eugubina* Biozone of Molina et al. (1998).

In a comparative study of the sections, we established four quantitative stages in the planktic foraminiferal population in the lowermost part of the Danian. Initially, the planktic foraminiferal assemblages are dominated by *Guembelitria*. The lower part of the *G. cretacea* Biozone (= P0) is characterised by a major increase of *Guembelitria* with a maximum peak in abundance. *Parvularugoglobigerina* and *Globoconusa*? proliferated across the boundary between the *G. cretacea* and *Pv. eugubina* Biozones. Later, *Chiloguembelina* and *Woodringina* were the most abundant. Finally, they were replaced in abundance by *Eoglobigerina*, *Parasubbotina*, *Praemurica*, and *Globanomalina* in the lower Danian. These quantitative stages were initially observed and proposed for several Pyrenean sections (Zumaya, Osinaga, and Músquiz) by Arenillas et al. (1998). Furthermore, the partial or complete identification of these stages allows us to recognize and quantify the hiatus span across the K/T boundary, since these stages do not depend on problematic taxonomic assignments of species.

Here we summarize the best eight sections from Spain and Tunisia. The El Kef section-stratotype is probably the most expanded and continuous marine section yet known. The Elles section is comparable to the El Kef stratotype, except that Elles presents a short hiatus between the *Pv. eugubina* and *P. pseudobulloides* Biozones (Arz et al. 1999). In both sections, P0 is 50 cm thick and the *Pv. eugubina* Biozone is more than 200 cm thick. The Aïn Settara section is a good reference-section for the K/T boundary and is probably the best exposed in Tunisia. The best studied Spanish sections are Agost and Caravaca in the Betic Cordillera (Canudo et al. 1991; Molina et al. 1996). In these sections, P0 is 4–5 cm thick and the *Pv. eugubina* Biozone is 14–16 cm thick. Other important Spanish K/T boundary sections are located in the Pyrenees. The best known is Zumaya, which is similar in thickness to the Betic sections. In Zumaya and other Pyrenean sections such as San Sebastián and Sopelana, P0 is 2–5 cm thick and the *Pv. eugubina* Biozone is 10–15 cm thick. All these Spanish sections are continuous although less expanded than the Tunisian sections (Fig. 1).

The K/T boundary is generally marked by dark grey clay with a rust-red layer at the base. This red layer contains the Ir anomaly and other impact evidence such as the Ni-rich spinels, shocked quartz and microspherules, which have been described as altered microtektites (Smit 1982). The K/T boundary clay shows a drop in $CaCO_3$ and a negative excursion in $\delta^{13}C$. These evidences suggest the impact of an asteroid.

The absolute abundance of planktic foraminifera was decimated just at the K/T boundary. The planktic foraminiferal extinction occurred over a short period, with approximately 70% of the species going extinct in coincidence with the K/T boundary (Fig. 1). Most of these species were large, complex, tropical-subtropical and deep-intermediate dwelling forms. All species of *Globotruncana*, *Globotruncanita*, *Contusotruncana*, *Abathomphalus*, *Rugoglobigerina*, *Plummerita*, *Schackoina*, *Pseudotextularia*, *Gublerina*, *Planoglobulina*, and *Racemiguembelina* became extinct at the K/T boundary. The few species that disappeared in the late Maastrichtian did so probably as a result of the normal process of background extinction or the remaining Signor-Lipps effect (Keller et al. 1995). Very few specimens of these genera can be found in the lowermost part of the Danian and almost all of them present some evidence of reworking. This extinction event is clearly the most important catastrophic mass extinction recorded in the history of planktic foraminifera and is very consistent with the effect of the impact of a large asteroid.

Some small cosmopolitan surface dwellers with simple morphologies appear to have survived and the last of them gradually disappeared in the early Danian. These Maastrichtian species (25% of population) belong to *Guembelitria*, *Hedbergella*, *Heterohelix*, *Pseudoguembelina*, and *Globigerinelloides* and could be considered possible Cretaceous survivors since most of the specimens show almost no evidence of reworking. However, there is no clear evidence that all of them are survivors and, therefore, must only be considered as possible Maastrichtian survivors. The only certain survivors are guembelitrids because their abundance seems to increase into the lowermost Danian and they play a clear role in the phylogeny of new Danian taxa. The controversial extinction of these species in the early Danian could be related to the long-term effect of the asteroid impact. Guembelitriids species were disaster species that bloomed immediately after the K/T boundary in the *G. cretacea* Zone. Hedbergellids, heterohelicids, and globigerinellids may have been opportunistic pre-adapted survivors and ecological generalists.

After the K/T catastrophic mass extinction, two evolutionary

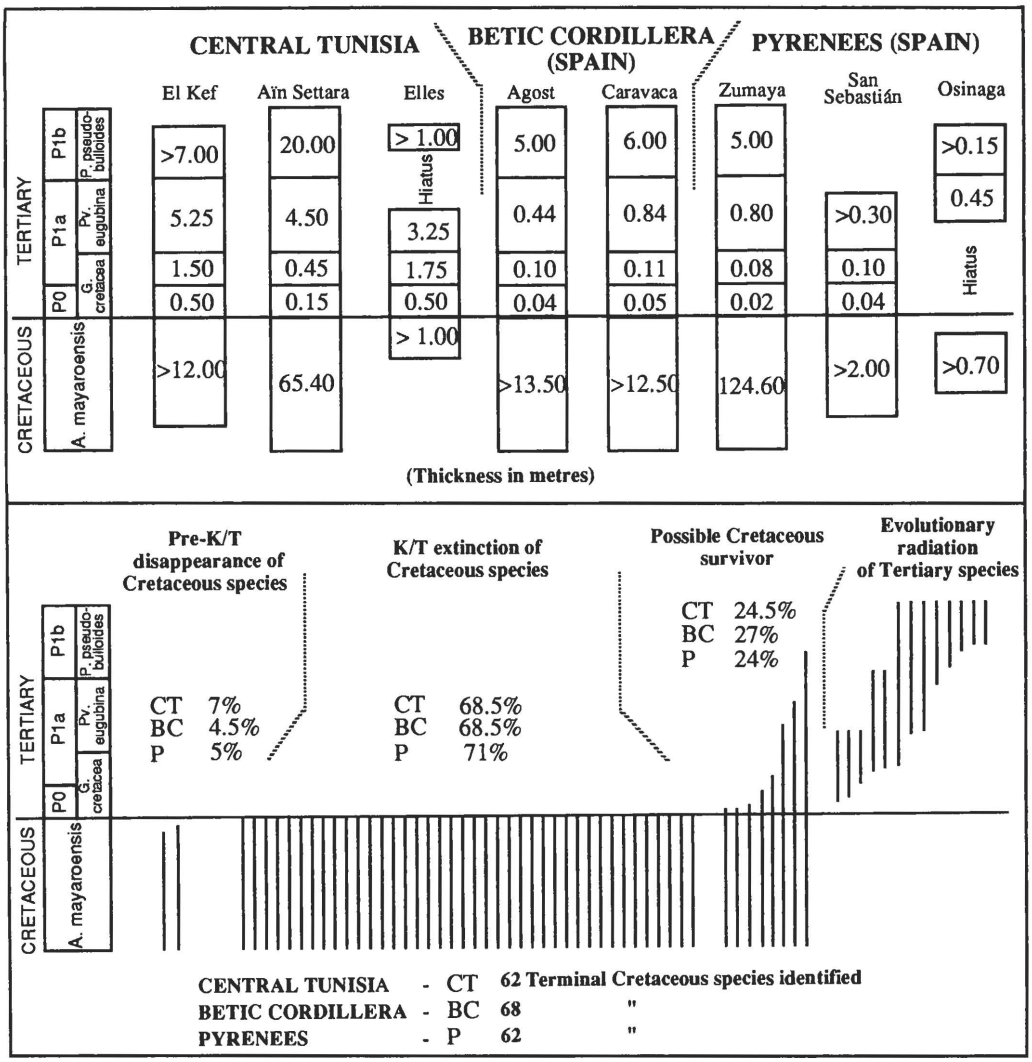

Fig. 1. Thickness of biozones and extinction rates of planktic foraminifera across the K/T boundary.

radiations of new Paleocene species are recognizable just above the K/T boundary. The first radiation of new opportunistic species occurred across the boundary between the *G. cretacea* and *Pv. eugubina* Biozones, with the first appearance of small species of *Parvularugoglobigerina*, *Globoconusa*?, *Woodringina*, and *Chiloguembelina*. These new species were also opportunistic and some of them proliferated, but most of them can be considered failed crisis progenitors since they soon became extinct in the *Pv. eugubina* Biozone. The second radiation of new Tertiary species occurred across the boundary between the *Pv. eugubina* and *P. pseudobulloides* Biozones, with the first appearance of species with perforate cancellate wall texture. In this interval, the planktic foraminifera became larger once again and $CaCO_3$ and $\delta^{13}C$ returned to similar values as those recorded in the Maastrichtian.

Acknowledgement. – This research was funded by DGES project PB97-1016.

References

Arenillas, I., Arz, J.A. & Molina, E., 1998: El límite Cretácico/Terciario de Zumaya, Osinaga y Músquiz (Pirineos): control bioestratigráfico y cuantitativo de hiatos con foraminíferos planctónicos. *Revista de la Sociedad Geológica de España 11*, 127–138.

Arz, J.A., Arenillas, I., Molina, E. & Dupuis, C., 1999: La extinción en masa de foraminíferos planctónicos en el límite Cretácico/Terciario (K/T) de Elles (Túnez): Los efectos tafonómico y "Signor-Lipps". *Revista de la Sociedad Geológica de España 12*, 251–268.

Canudo, J.I., Keller, G. & Molina, E., 1991: Cretaceous/Tertiary boundary extinction pattern and faunal turnover at Agost and Caravaca, SE Spain. *Marine Micropaleontology 17*, 319–341.

Keller, G., Li, L. & MacLeod, N., 1995: The Cretaceous/Tertiary boundary stratotype sections at El Kef, Tunisia: How catastrophic was the mass extinction? *Palaeogeography, Palaeoclimatology, Palaeoecology 119*, 221–254.

Molina, E., Arenillas, I. & Arz, J.A., 1996: The Cretaceous/Tertiary boundary mass extinction in planktic foraminifera at Agost (Spain). *Revue de Micropaléontologie 39*, 225–243.

Molina, E., Arenillas, I. & Arz, J.A., 1998: Mass extinction in planktic foraminifera at the Cretaceous/Tertiary boundary in subtropical and temperate latitudes. *Bulletin de la Société Géologique de France 169*, 351–363.

Smit, J., 1982: Extinction and evolution of planktonic foraminifera after a major impact at the Cretaceous/Tertiary boundary. *Geological Society of America, Special Paper 190*, 329–352.

I. Arenillas & E. Molina (emolina@posta.unizar.es), Departamento de Ciencias de la Tierra, Universidad de Zaragoza, ES-50009 Zaragoza, Spain, fax +34-76-761088

J.A. Arz, Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León, MEX-67700 Linares, N.L., Mexico, fax +52-821-24326