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IMPACT AND EXTINCTION SIGNATURES IN COMPLETE CRETACEOUS TERTIARY (KT) BOUNDARY SECTIONS.

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The Zumaya, Caravaca and Agost sections in Spain, the El Kef section in Tunisia and the Negev (Nahal Avdat) sections in Israel are among the most continuous, expanded and complete KT boundary sections. We analysed quantitatively the distribution patterns of the planktic faunas in closely spaced samples across the KT boundary in these sections, in conjunction with the geochemistry, stable isotopes, mineralogy and magnetostratigraphy. 300 foraminiferal specimens were randomly selected and determined. Reliable estimates for the foraminiferal productivity changes across the KT boundary and for the 1-2 Ma interval preceding the KT boundary were made from the numbers of individuals/gram of sediment corrected for the sedimentation rates (calculated from magnetic reversals and lithology).

No significant progressive changes were observed in either faunal composition or in productivity of surface and bottom dwelling foraminifera in the 1-2 Ma interval preceding the KT boundary, which here is determined by a major iridium peak, shocked quartz and/or microtektite-like spherules. P/B ratios remain high (90-99%) and stable throughout the pre-KT interval, and thus contradict any major sealevel changes below the KT boundary, as often suggested. Among others, Keller (1) proposed a stepwise plankton extinction, starting a few dm below the boundary. However, this is not confirmed by us. At El Kef we found species, which Keller reported as disappearing below the KT boundary, to be present to within the last cm of the Cretaceous.

The Negev sections Nahal Avdat and HorHaHar are highly bioturbated. Burrows abound and many carapace remains were found of crustaceans, notorious burrowers. This has led to smearing of geochemical spikes and first and last appearances of foraminifera. In outcrop the KT boundary is almost invisible, but is indicated by a color change and a carbonate low, which coincides with the first appearance of Paleocene forams and a dramatic drop in abundance of individuals of Cretaceous species.

The new Agost section is identical to the Caravaca section in lithology, geochemistry, and abundance and composition of planktic faunas. Sedimentation rates are somewhat lower than at Caravaca. The KT interval, however, appears to be better preserved because it is not disturbed by any tectonic movements and surface weathering is considerably less. As at Caravaca the ejecta layer is about 2 mm thick, and well-preserved due to reduced bioturbation in the KT interval following the ejecta layer. The ejecta layer is composed of pure smectite with embedded smectite, goetite and K-feldspar spherules as well as grains of shocked quartz up to 0.1 mm in size. Most spherules have retained their original quenched texture and have the same median (0.4 mm) grainsize as the Caravaca spherules. Some smectite spherules contain small magnesioferrite skeletal crystals. The quenched textures are remarkably similar to textures recently found in microtektite-like spherules from DSDP site 577 which are composed of dendritic clinopyroxene (cpx) crystals, which were partially altered to smectite and which also contain dendritic crystals of K-spar.

Peak iridium values at Agost are similar to those at Caravaca (up to 24.5 ng/g), and anomalously high levels of Co, Ni As, Sb, Cr and U were also found. As at Caravaca and Stevns Klint the ejecta layer shows anomalously low REE abundances. Both the low REE and the cpx within the spherules indicate strongly an oceanic impact site for (one of) the impactor(s).

As at Caravaca, high Ir values were found in the basal part of the carbonate poor layer immediately overlying the ejecta layer, but without concurrent anomalous concentrations of the other above-mentioned elements or spherules. This indicates that most of this excess Ir came in with hemipelagic detritus eroded from other Ir-enriched areas, since bioturbation should have moved the other elements as well. The 6.5 cm clay-rich layer on top of the ejecta layer lacks most of the Cretaceous foraminifera and does not contain a single Paleocene species. G. cretacea is the abundant form, but Globotruncanella and Globigerinelloides still occur commonly. Although faunal composition and carbonate content are constant throughout most of the clay layer, both the $\partial 13C$ and $\partial 018$ profiles show a strong 2 per mil decrease in the basal cm's of the clay layer, identical to the profiles of the Caravaca section. This indicates that these signals are apparently real, and presumably indicate a 10° warming of surface waters, with a concurrent primary (nannofossil) production crisis just following deposition of the ejecta layer. If we assume constant supply of hemipelagic detritus (clay) across the KT boundary (an estimate which will presumably not be off by more than a factor of two) these stable isotope shifts lasted for a few hundred to a few thousand years. Only when isotope values returned to the same or slightly higher values than in the uppermost Cretaceous do we see the origin (or the immigration) of new Paleocene planktic species in the Spanish sections.

Greenhouse warming due to the CO_2 release by mass-mortality and subsequent blocking of the CO_2 recycling due to the global collapse of primary productivity appear to be the most attractive scenario. This warming may not have caused the initial mass-mortality, which was likely caused by the immediate effects of an impact such as sunlight blocking, but it certainly prohibited a return of the old planktic faunas, and thus may have caused the final extinction of Cretaceous species. CO_2 release due to volcanic outgassing of e.g., the Deccan traps is unlikely as this should have lasted for a much longer period than the duration of the peaks observed in these sections.

In summary:

1) We see no gradual or stepwise extinction below the KT boundary nor any productivity decrease.

2) Stable isotope analyses show a warming just after deposition of the ejecta layer, not cooling as predicted by "nuclear winter " scenarios, although the duration of such cooling may have been too short to be observed even in these complete sections.

3) Low REE values and cpx spherules with quench textures identical to quench-textures in diagenetically altered spherules, strongly indicate an oceanic site of (one of) the impactor(s)

REFERENCE

(1) Keller, G. *et. al.* I.A.S. Tunis (abstract), 1987.