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The Cretaceous-Paleogene (K-Pg) transition in ODP Leg 207, Western Atlantic: From the Chicxulub impact to the first Paleocene hyperthermal events

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The ODP Leg 207 from the Demerara Rise, tropical western North Atlantic, has recovered an expanded and stratigraphically complete Cretaceous-Paleogene (K-Pg) sedimentary record including latest Maastrichtian and Danian clayey chalks, separated by the Chicxulub ejecta-bearing event deposit at the K-Pg boundary (MacLeod et al., 2007, GSA Bulletin). Our combination of high-resolution mineralogical and isotope geochemical analysis with shipboard geophysical data revealed (i) a remarkable complex Chicxulub ejecta deposit and (ii) severe paleoceanographic changes following the K-Pg boundary with possible evidence for two early Danian hyperthermal events.

(i) The graded, 2-3 cm thick Chicxulub ejecta deposit consists of $\sim$0.3-1mm-sized spherules. They are generally altered to dioctahedral smectite. Some, however, show internal Fe-Mg-enriched globules and microkrystites indicative of silicate-silicate "liquid immiscibility" and quenching from a melt, suggesting a primary origin. Similar Fe-Mg-enrichment has been observed in Chicxulub spherules from Mexico and Texas. In the upper part of the K-Pg ejecta deposit, spherule composition becomes enriched in Fe-Mg – reflecting a more mafic progenitor– and shocked quartz and feldspars, as well as abundant carbonate and dolomite spherules are present. The similarity of the sponge-like porous texture of carbonate and dolomite spherules to textures observed in carbonate shock experiments suggests degassing of CO_2 during the impact

event. In addition, carbonates and dolomites enveloped by silicates melts provide evidence for thermal alteration. The microstratigraphy of the K-P ejecta deposit at ODP Leg 207 is unlike most other distal K-Pg spherule deposits recovered in the Atlantic or Pacific that are mostly affected by turbidity currents. However, it strongly resembles the terrestrial dual-layer K-Pg deposit in the Western Interior, though the acidic swamp environments in the Western Interior precluded preservation of carbonates. Therefore, the ODP Leg 207 K-P record provides the first evidence for dispersal of shocked carbonates and dolomites by the Chicxulub impact possibly associated with degassing of CO_2.

(ii) The K-Pg boundary in ODP Leg 207 Site 1259C is characterized by a sharp –2.5 per mille δ^{13}C anomaly, followed by an immediate positive 1 per mille shift during Zone P0. Concomitantly, calcite contents drops from $>$80 % to less than 20 % followed by rapid recovery to about 35 %. During Zone Pα, however, δ^{13}C values decrease again (–0.3 per mille). At the onset of Zone P1a, about 200 ky post K-Pg, two rapid –0.5 per mille δ^{13}C shifts occur that both are associated with a 1 per mille lowering of δ^{18}O values and a 50 % reduction of the carbonate content. Rietveld refinement of XRD data revealed improved calcite crystallinity during both intervals that may result from the preferential removal of weakly crystallized carbonate phases during dissolution episodes associated with shallowing of the lysocline. The onset of several dm-m-thick, iron oxide and hydroxide-rich red stained intervals about 20-40 cm above the K-Pg in all early Danian ODP Leg 207 cores, is probably related to additional oceanographic changes in the Atlantic (e.g., influx of oxygen-rich deep-water) during the early Danian. Subsequently, during Zone P1b/ P1c, the absence of red staining and the significant increase of pyrite indicates more reducing depositional conditions possibly associated with the warming of surficial waters as indicated by generally lighter δ^{18}O values during this interval. In conclusion, our results correlate well with stable isotope data from other South Atlantic DSDP (527, 528) and North Atlantic ODP (171) Sites (Quillévéré et al., 2007, EPSL), suggesting significant oceanographic changes following the K-Pg boundary as well as the presence of two short periods – named “Dan-C2 event” – of transient greenhouse gas-driven warming and dissolution of carbonates on the seafloor analogous to the PETM in the early Paleocene.