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The Chicxulub ejecta layer – new analytical data create new ideas

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1. The K-Pg event bed

The impact event at the K-Pg boundary ~65.5 million years ago, led to worldwide deposition of materials that originated from vaporized projectile (e.g., platinum group elements - PGE) and from target lithologies, shocked to various degrees [1]. Depending on the distance to the Chicxulub crater site and mode of deposition, the K-Pg event deposit may be strongly diluted by material from more local sources [2]. Open questions include (i) the time-frame for the formation of this deposit reaching a thickness of several tens of meters close to the crater yet only some mm at the most distal sites, and (ii) the fate of the >3-km-thick carbonate (and anhydrite) sediments that have covered the Chicxulub target area. About 25 000 km³ of this material were deformed, melted or vaporized and should occur in the K-Pg ejecta deposits.

2. ODP 207 Site 1259

The ~2-cm-thick Chicxulub ejecta deposit at ODP 207 Site 1259C (Demerara Rise, W Altlantic) is exceptional due to total absence of bioturbation, lack of evidence for traction transport or post-depositional reworking. The normally graded deposit consists of 0.1- to 1-mm-sized spherules [2, 3] displaying delicate internal textures ranging from vesicles over chemically distinct melt globules to whisker crystals. Most of the glass spherules are altered to smectite; phyllosilicates form also the matrix of the layer.

Using a LA-ICP-MS Element2, equipped with a 193 nm ArF excimer laser (WWU Münster) as analytical tool (spot size 235 µm) we detected projectile matter only in the uppermost 1000 µm of the layer that carry also the shocked quartz and carbonate clasts [3]. Distribution patterns (Fig. 1) of rare earth elements show that upper crustal materials, the Chicxulub ejecta, form the major part of the layer. Very low Zr/Hf and Nb/Ta ratios indicate that – contemporaneous to ejecta deposition – highly fractionated supracrustal material off the Guiana craton reached the sea floor in the Atlantic. Settling of the ballistically ejected spherules constrain the onset of deposition at 2km water depth to a few days after the impact. The sub-µm-small particles carrying PGE and trace elements like Pb, however, can only reach the sea floor when attached to larger particles. We estimate that sedimentation of the PGE-carrying particles was finished in less than a year. This transport mechanism explains also the abrupt decrease of PGE contents exactly at the top of the event bed, and the rapid return to depositional conditions quite similar to the pre-impact situation.

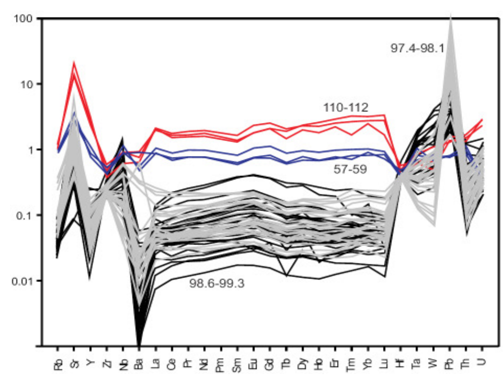


Fig. 1: Distribution of trace elements in the K-Pg event bed at Site 1259C 98.6-99.3 cm (light grey: upper; dark grey: lower part), and the Maastrichtian 110-112 cm (red) and Danian 57-59 cm (blue) reference samples, normalized to abundances in the upper continental crust [4].

3. Carbonate spherules

So far, carbonate impact melt was rarely discerned [5], and the frequent carbonate spherules in K-Pg boundary layers in the Gulf of Mexico region [3] were always interpreted to be of secondary origin, i.e., alteration products. Yet our new observations suggest that considerable amounts of carbonate melt were ejected by the Chicxulub impact, and deposited together with silicic melt spherules [1]; actually, the amount of carbonate ejecta frequently exceeds that one of silicic melt lithologies in K-Pg event beds. Carbonate and silicic melts were dispersed concurrent but as distinct melt batches that, in part, were mixed as evidenced by emulsion-like bubbly textures and Cc spherules with thin shells of silicic melt (Fig. 2).

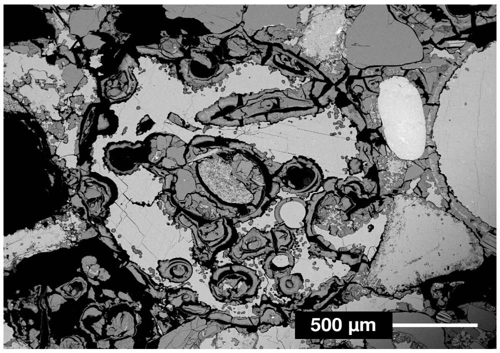
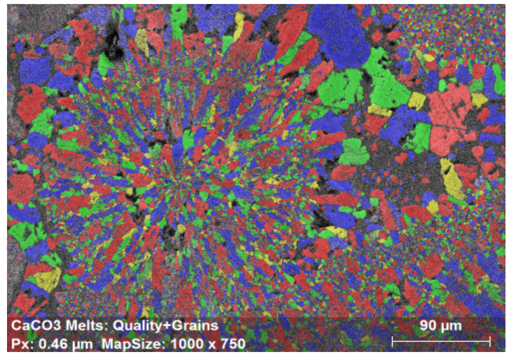


Fig. 2: Complex impact spherule, K-Pg layer, Shell Creek, Alabama, with an accretionary lapilli (*center*) surrounded by in part flattened silicic glass spherules (now smectite) and smectite-lined voids, embedded in a carbonate spherule that is lined by silicic glass (smectite). Note Ti-rich seams in the outer shell of the spherule (*right*), documenting dissolution – precipitation during alteration of silicic glass to smectite. Back scatter SEM.

Currently we are evaluating the criteria necessary to distinguish primary textures from those grown during alteration and diagenesis using microchemical, cathodoluminescence, and electron back-scatter diffractions techniques (Fig. 3).

Fig. 3 (opposite column): EBSB micrograph of a carbonate spherule from El Guayal, S. Mexico with radially grown Cc crystals. SEM: ZEISS Supra 55, beam current ~11 nA, acceleration voltage 15kV.



3. Outlook

Undisturbed K-Pg layers like that one at ODP 207 Site 1259C document that deposition and return to depositional conditions quite similar to the pre-impact situation occurred most probably within a year after the impact. The composition of these layers is very complex due to the input of material from more local sources, yet so-called alteration products like carbonates are clearly of primary origin (even if some re-crystallization may have occurred.

Acknowledgements

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