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Making sense of destruction: A geochemical investigation into the impact generated melt rocks of the Chicxulub impact structure, Yucatán, recovered during IODP-ICDP Expedition 364.

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In 2016 the International Ocean Discovery Program (IODP) and International Continental Scientific Drilling Program (ICDP) Expedition 364 sampled the peak-ring of the Chicxulub impact structure, Yucatán (Morgan et al., 2016). This impact structure is famously linked to the Cretaceous-Palaeogene event, which lead to the extinction of the non-avian dinosaurs (Alvarez et al., 1980, Smit and Hertogen, 1980, Schulte et al. 2010). The IODP-ICDP 364 Expedition cored the peak ring of the crater, recovering ±110 m of Paleogene sediments, ±130 m of breccia containing impact melt fragments (suevite) and clast poor impact melt rocks, and ±590 m of granitoid basement material, containing impact melt rocks (Morgan et al., 2016). The impact melt rocks can be subdivided in the upper (between ± 721 - 747 meters below seafloor (mbsf)) and lower melt rocks (between ± 1209 – 1316 mbsf). This study focused on the recovered impact melt rocks. Impact generated melt rocks essentially represent the molten, quenched state of the target rock (Belza et al., 2014) and their geochemical and isotopic signatures provide a unique fingerprint that characterizes the impact site (Premo and Izett, 1992). Thus, impact melts hold the key to understanding the formation of an impact crater.

The dynamic collapse model is the currently accepted model to have formed the Chicxulub impact structure (Morgan et al., 2016; Fig.1). Visually this model suggests the formation of a uniform, single impact melt sheet formed from the different target lithologies (Fig. 1). However, geochemical variations of the impact melt rocks do not agree with this observation. The upper melts sheet shows higher Al₂O₃ (up to 18 wt%) and CaO (up to 20 wt%) and generally lower Fe₂O₃ and MgO (around 5 and 2 wt% respectively) when compared to the lower melt rocks. Moreover, the lower melt rocks show trace elemental compositions more comparable to crustal basement target rocks with notable enrichment in Sr isotopic composition (⁸⁷Sr/⁸⁶Sr up to 0.7083, compared to ± 0.7077 of the basement). This shows the upper melt rocks to be more comparable to the carbonate target rock, while the lower melt rocks are more similar to the crustal target rocks. This suggests that the formation of the upper and lower melt rocks was to some extent decoupled. Whether this implies discrete melt formation or the immiscibility of carbonaceous (upper) and more siliceous (lower) melts is yet to be determined.
Figure 1: Chicxulub crater formation according to the dynamic collapse model showing the formation of a peak ring and the emplacement of mid-crustal basement at shallow depths. Box 2 displays the impact zone at time of impact (T = 0 min), Box 6 displays the impact zone at 10 minutes after impact (T = 10 min) when no suevite sequence and sedimentary cover was deposited yet (redrawn by R. Vandijck after Morgan, et al., 2016).

References


