GRANULOMETRIC AND LITHOLOGIC LINE-LOGGING OF GRADED SUEVITE IN THE IODP-ICDP EXPEDITION 364 CHICXULUB M0077 CORE: EVIDENCE FOR A RAPID SEAWATER RESURGE.

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Introduction: The 200km diameter Chicxulub impact crater formed ~66Ma in a shallow marine epicontinental setting [see review by 1], and is one of the best preserved large impact structures on Earth. Improved understanding of the processes of multi-ring crater formation was a main objective of the 2016 joint ICDP/IODP Expedition 364 [2]. At Site M0077 (21.45°N, 89.95°W), core between 505.70 and 1334.73mbsf (meters below sea floor) was recovered from the peak ring WNW of crater center. The project also studies formation and modification of a relatively large crater in an aquatic environment as well as the effects on the extinction/recovery of biota in the area. Core from Hole M0077A shows, from top down, a sequence that begins with ~110m of post-impact hemipelagic and pelagic Paleogene sediments that are followed downwards by ~130m (617 to 747mbsf) of impact-related polymict suevite [2]. These, in turn, overlie clast-poor impact melt rock and felsic basement rocks with pre-impact igneous dikes (both mafic and felsic), as well as impact-generated melt and suevitic dikes (747 to 1334.73mbsf) [2].

Aim of study: Previous studies of marine-target craters show that the marine environment influences both the cratering and modification processes to varying degrees depending on the relative target water depth [e.g., 3], especially with regard to marine resurge. Based on previous core drillings at Chicxulub, Goto et al. [4] presented evidence for resurge of water into the newly formed crater. Here, we try to estimate the magnitude and timing of this resurge, as well as the provenance of the material carried by the the flow to the location of Site M0077.

Methodology: Line-logging of drill cores is useful in the analysis of relative changes through the infill of im-pact craters, including slump and resurge deposits due to a marine target environment. This technique has been successfully applied to the Lockne, Tvären and Chesapeake Bay impact structures [5, 6, 7]. In this method, every clast with a length axis larger than a certain cut-off size (here 5mm) that touches a line drawn along the core is assessed for size, roundness and lithology. Instead of using actual drill core, for the first time, this technique was applied to high-resolution core photos with the use of the image analysis software jMicrovision (version 1.2.7). In the suevite (M0077 core's unit 2), 2376 clasts were analysed between depths 672.01mbsf and 715.93mbsf and note was also made of matrix/clast support. The use of computer tomography (CTA) images aided the lithological determinations. The lithologies were (preliminarily) classified into 17 categories that include a) melt rocks of different colors and textures, b) upper target (sedimentary rock, mainly carbonates), and c) lower target (crystalline rock and quartzite). The granulometric data were treated statistically as variations per meter, which allowed plots of clast frequency per meter and size sorting. Owing to the large amount of data, clast vs. matrix support was plotted as a ratio per meter. For core meters with core losses >46% the whole meter is omitted. For losses 10-32% the data point for 'clasts per meter' is put in brackets. The loss of 8% at 713.5mbsf is considered insignificant. Losses <32% are not significantly affecting the other graphs as they are relative values.

Results and discussion: Figure 1 shows that the number of clasts increase linearly upwards until the effect of the 5mm cut off becomes noticeable as a drop above 679mbsf. In reality, the clasts continue to increase in numbers above that level as the sediment becomes finer-grained. Below 706mbsf, the clast size and sorting, as well as matrix/clast support varies strongly. Above 706mbsf, there is a general fining-up trend, and gradual increase in sorting from moderately to well sorted. At 697mbsf, there is a second noticeable shift in several of the parameters, especially a break in the otherwise upwards increase in roundness where it reverts to a level of high angularity that continues to the top of the logged section. The interval between 697mbsf and 706mbsf is also characterized by a near absence in the otherwise rather common brown carbonate ("upper target II") clasts and green melt. Instead the interval is dominated by grey melt fragments, and the amount of tan carbonate ("upper target I") and other target rocks remain essentially unchanged over the 697-706mbsf interval, followed by a relative decrease towards the top of the logged section. We find the variation in the occurrence of the grey and the green impact melt fragments, as well as the tan and brown carbonates ("upper target I and II") of special interest in the analysis of the source for the transported material. Below 706mbsf, the green melt occurs as matrix and clusters of clasts with good fitting (i.e., short transport) whereas higher up in the core it forms isolated, small clasts in a muddy matrix (i.e., long transport). This difference may indicate a source as both fall-back of melt into the seawater surrounding the crater, as well as subsequent rip-up of melt fragments from rapidly quenched impact melt in slump and avalanche breccias at the peak ring inside the crater. The high angularity of especially the melt clasts above 697mbsf in the logged section (Fig. 1) suggest explosive disruption of melt in contact with the water, and insignificant abrasion during strong, but short duration, aquatic transport. This interpretation is supported by the presence of angular green vecicular melt fragments weathered to clay in carbonate ejecta units exposed in northern Belize (Albion Island, ~400 km from crater center) [8]. Field observations in the area of Belize-Guatemala-Mexico suggest that tan carbonates likely come from the upper part of the Yucatan Group (equivalent of Barton Creek formation in Belize and Campur Formation of Guatemala) and that brown carbonates likely come from the lower Yucatan Group (equivalent of Yalbac formation of Belize and Coban Formation of Guatemala). Our current interpretation is that below 706mbsf depth to the end of the logged interval the breccia is dominated by outwards slumping during peak ring formation. Experience from previous logging of similar sequences at other marine-target craters show that slump deposits are indicated by a strong change in the sorting [5, 6, 7]. Above the 706mbsf level, marine resurge has caused a general fining-up with good sorting (i.e., indicating a suspension flow). Given the previously noted upwards transition into marine secular sediments by a generally fining-up, nearly 55m thick, section of uniform beds [9], and > 30m thick single fining-up section of the logged interval, and in comparison with other marine-target impact craters [cf., 5, 6, 7], deposition most likely occurred in a forceful water resurge. If assuming a maximum sediment load of a hyperconcentrated suspension flow of 20 vol %, which seems reasonable from the diagrams in Figure 1, the flow must have been at least 5*30 m, or 150 m deep. We believe that an initial stage of slumping from the newly formed peak ring is followed (at 706mbsf) by a resurge flow that carries mainly grey melt fragments, and uppermost target material (e.g., tan carbonate) and some lower target material. The flow then shifts (at 697mbsf) to carry mostly green melt fragments and lower parts of the upper target (e.g., brown carbonates) as well as some lower target material. The resurge was then followed by oscillating water movements analogous with Lockne [5].

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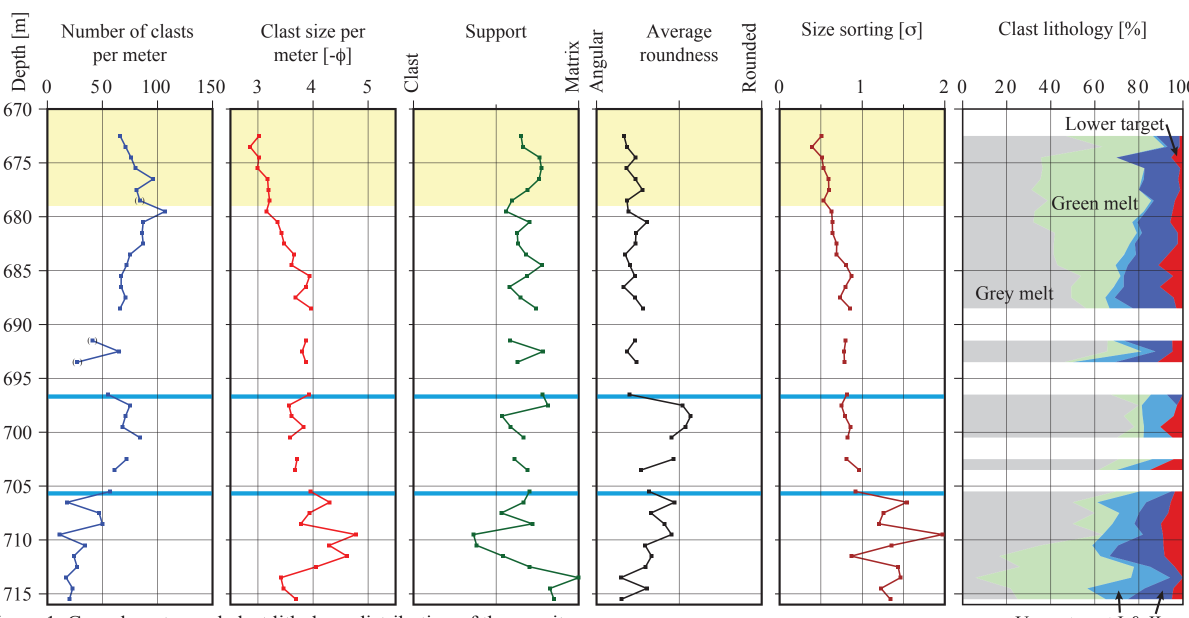

Figure 1. Granulometry and clast lithology distribution of the suevite.