GEOCHEMICAL AND PETROGRAPHIC CHARACTERIZATION OF THE SUEVITE SEQUENCE WITHIN THE IODP-ICDP EXP. 364 CORE OF THE CHICXULUB PEAK RING.

P. Kaskes1,2, S. J. de Graaff1,2, T. Déhais1,2, S. Goderis1, J.-G. Feignnon3, L. Ferrière4, C. Koeberl3,4, J. Smit5, and Ph. Claeys1, 1Analytical-, Environmental- and Geo-Chemistry, Vrije Universiteit Brussel, B-1050 Brussels, Belgium (pim.kaskes@vub.be), 2G-Time, Université Libre de Bruxelles, B-1050 Brussels, Belgium, 3Department of Lithospheric Research, University of Vienna, A-1090 Vienna, Austria, 4Natural History Museum, A-1010 Vienna, Austria, 5Faculty of Sciences, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, the Netherlands.

Introduction: In May 2016, the IODP-ICDP Expedition 364 drilled the peak ring of the buried Chicxulub impact structure in Mexico and obtained a 104 m thick continuous sequence of suevite between core 40.1 and 87.2 (617.33 – 721.62 mbsf, defined as unit 2A-2C by [1]). This succession provides vital information on the different target lithologies affected by the impact and gives a snapshot into the sequence of dynamic processes that occurred in the peak ring zone in the first minutes to hours after the impact [2].

Suevite is defined as an impact melt-bearing polymict breccia with a particulate matrix [3]. However, the emplacement mechanisms of suevite are still under debate, as these are highly dependent on the characteristics of the target stratigraphy and the presence or absence of (sea)water. For Chicxulub, the target was a shallow marine environment with a carbonate-evaporite platform on top of a crystalline and metamorphic basement [4]. Over the last decades, several formational scenarios have been suggested for the suevite in the Chicxulub crater, varying from ground surging-density currents [5], fallback due to the collapse of the ejecta plume [5], tsunami resurge [6] and phreatomagmatic (molten fuel coolant) interaction [7].

The IODP-ICDP Exp. 364 core sheds a new light on the Chicxulub suevite conundrum, because it shows a continuous succession with intact contacts with the lower lying impact melt rock sequence (unit 3A-B) and the transitional unit (unit 1G) above. Here, we present a detailed petrographic, mineralogic, and geochemical dataset, both bulk and clast-specific, covering the entire suevite sequence to characterize and interpret this unit.

Samples & methodology: 65 suevite thin sections and corresponding polished thick sections, between cores 40.1 and 87.2, were analyzed petrographically and geochemically. Optical microscopy was combined with micro X-ray fluorescence (μXRF) scanning [8], which produced semi-quantitative major and trace element maps at a high resolution of 25 μm. μXRF maps of thick sections were quantified by means of the fundamental parameter method and this data was compared with bulk powder ICP-OES and bulk ICP-MS data [9] from homogenized powders of 10 selected suevite samples. The bulk powder XRF and X-ray diffraction (XRD) dataset collected by the Exp. 364 team [1] also served as a comparison. In addition, μXRF spot analysis on 80 melt particles was performed and quantified using 25 standards of glasses and igneous rocks.

Results: Throughout the 104 m of stratigraphy, a polymict breccia with a particulate, fine-grained matrix was detected with abundant more or less altered glass fragments (in general >50%). This suevite and in particular the glass shards, now mostly replaced by phyllosilicate minerals, show varying degrees of alteration throughout the core. The Exp. 364 suevite is characterized by a fining and increasingly well-sorted upward trend. Based on our petrographic observations and μXRF maps, the suevite is subdivided in at least four general intervals (Fig. 1).

Interval 1 (core 40 to core 49): a relatively well sorted, fine-grained (<5mm), matrix supported suevite with isolated foraminifera, small carbonate and chert clasts and a brown micritic matrix. Abundant angular brown glass fragments altered to phyllosilicate minerals are present, and no basement clasts are found.

Interval 2 (core 49 to core 59): a poorly sorted, medium to coarse grained (~5-10 mm), matrix-supported suevite with abundant green-yellowish, vesicular melt particles and few angular chert fragments. No isolated microfossils are found in the matrix, only within limestone clasts, together with fragments of large macrofossils such as corals.

Interval 3 (core 59 to core 80): a poorly sorted, coarse-grained unit (~5-20 mm) with the first clear basement clasts, which are dominated by granitoids with some rare gneisses. This unit appears to be often clast-supported and displays pervasive hydrothermal alteration, clearly visible in the alteration rings of vesicular melt particles.

Interval 4 (core 80 to core 87): a very poorly sorted, matrix-supported suevite, which is intersected by dark impact melt bodies. The matrix of the suevite is not micritic, but clastic and Ca rich (Fig. 1). Many vesicular, equant melt shards are present together with large basement clasts and recrystallized carbonate clasts.

In contrast to these petrographic observations, the suevite displays a rather homogeneous major elemental composition, with a slight increase in CaO content towards the top (Fig. 1). The observed variations downcore are mostly related to increasing clast size. The bulk trace elemental composition of the suevite is
similar to that of the upper and lower impact melt, although the suevites show an enrichment in Sr [9].

Based on bulk µXRF trace element data, the suevite sequence is characterized by a very low S content (<0.7 wt%), the only outliers occurring close to the transitional unit and in an interval rich in large carbonate clasts (Fig. 1). The S-rich minerals in these intervals were characterized using µXRF have petrographically been identified as being pyrites (FeS₂), and not as anhydrite (CaSO₄), gypsum (CaSO₄ * H₂O), or other types of iron sulfides (e.g., marcasite). Most melt particles analyzed using µXRF spot analysis show a basaltic to andesitic composition, with little variation with depth. This will be verified and refined with Electron Microprobe Analysis and Laser Ablation ICP-MS measurement campaigns, following a strategy carried out on Yaxcopoil-1 melt particles [10].

Discussion and conclusions: The characteristics described above show an influence of fragments from the carbonatic platform (limestone & chert) within the entire suevite unit in contrast to the felsic basement, which seems not to have affected the deposition of intervals 1 and 2. The well-sorted uppermost ~ 30 m of the suevite (core 40 to 49), which is characterized by isolated foraminifera and higher CaO content, suggests that ocean water resurge in the crater caused settling and sorting of the clasts. The emplacement of the middle and lower part of the suevite is more difficult to interpret due to pervasive hydrothermal alteration.

Therefore, analytical image methods are planned to be carried out on scans and µXRF maps of polished thin and thick sections. The aim is to quantify the petrographic observations in terms of e.g. clast size, sorting, roundness, and modal distribution of clast types and matrix. Together with core line logging [6] and CT scans [1], this will allow us to integrate geochemical and physical data to further unravel the emplacement history of the Chicxulub suevite and to quantify the proportions of the different target lithologies within the core.

The absence of S and lack of anhydrite clasts observed in the entire Exp. 364 suevite is not something that was witnessed to that extent in other Yucatán boreholes. For example, the suevite from the Yucatán-6 core shows some large anhydrite clasts in the lower interval, but the evaporite-carbonate ratio does not exceed 20% [4]. Bulk µXRF S-values of samples from Yucatán-6 range from 0.2-3.7 wt%. In addition, impact breccias from the lower part of core UNAM-5, ~ 20 km outside of the crater, are rich in anhydrite clasts [11] and show S-values between 16-23 wt%. These differences in S and amount of anhydrite clasts might be explained by the location of the Exp. 364 core on the Chicxulub peak ring. It is interpreted that in the peak ring zone, massive shock-vaporization of the pre-impact evaporite platform could have occurred or a particle size effect removed large parts of this cover [2].


Fig. 1. Subdivision of the Exp. 364 suevite showing S-content, major elemental composition, µXRF maps and petrographic results.