PRELIMINARY CHARACTERIZATION OF HYDROTHERMAL ALTERATION IN THE PEAK-RING OF THE CHICXULUB IMPACT STRUCTURE, MEXICO. S. L. Simpson[1], G. R. Osinski[1,2], D. A. Kring[3], C. S. Cockell[4], and the IODP-ICDP Expedition 364 Science Party. [1]Centre for Planetary Science and Exploration, University of Western Ontario, London, ON, Canada (ssimps56@uwo.ca). [2]Dept. Earth Sciences / Dept. Physics and Astronomy, University of Western Ontario, London, ON, Canada. [3]USRA-Lunar and Planetary Institute, Houston TX 77058. [4]School of Physics and Astronomy, The University of Edinburgh, Edinburgh, UK.

Introduction: Impact cratering is the most ubiquitous process affecting solid bodies in our Solar System. Although notoriously destructive, cratering also has the potential to generate transient hydrothermal environments that may be conducive to the development of microbial communities [1,2], making them attractive features in the search for life on the surface of other terrestrial planets and satellites.

The immense amount of heat deposited by an impact may sustain hydrothermal activity for several million years [3]. The fracture network created by a large impact event may extend several kilometres below and outwards into the target of large structures; hydrothermal fluids are often concentrated within these fracture systems, making these environments favourable for colonization by thermophilic microbes, particularly in large craters which generate a long-lasting thermal anomaly [e.g., 4–6]. Multi-ring basins and peak-ring structures are commonplace on the surface of other large solid bodies in the inner Solar System, but are not well preserved on Earth.

Chicxulub: Here we document the types and distribution of hydrothermal products preserved within the peak-ring of the 200km-diameter Chicxulub impact structure, Mexico [7-10] In 2016, the joint International Ocean Discovery Program (IODP)-International Continental Scientific Drilling Program (ICDP) Expedition 364 recovered core between ~506 and 1335 metres below the seafloor (mbsf) at site M0077A, located at 21.45°N, 89.95°W [11]. The uppermost part of the sequence contains a layer of impact melt-bearing breccia overlying clast-poor impact melt rock, followed by fractured and faulted crystalline basement locally with intervals of impact melt-bearing breccia and impact melt rock, as well as pre-impact dikes [11].

Preliminary results: Hydrothermal alteration is a common feature of the peak-ring and appears to have affected the entire drill core to some degree. Impact melt-bearing breccias in both the upper (i.e., immediately below Cenozoic sedimentary units, from 618 to 748 mbsf) and lower sequences (i.e., melt-bearing impact breccias within felsic basement) are largely dominated by argillic alteration; glass clasts within the can be completely altered to dark green and grey Fe-Mg-clays and smectites (Fig. 1). Melt-bearing impact breccias contain localized veins, vugs and fracture-coatings contain euhedral quartz, calcite and zeolites within the groundmass and lithic clasts (Figs. 1 and 2). Very minor amounts of euhedral iron sulfide mineralization, likely pyrite, and slightly more abundant quartz is found crystallized within fractures of lithic clasts in cores 291 (1294-1297 mbsf) and 295 (1306-1309 mbsf); because of their context, it is unknown whether these represent post- or pre-impact hydrothermal alteration. The felsic crystalline basement contains much more localized hydrothermal veins and fractures of quartz, sericite, epidote and minor iron sulfides.

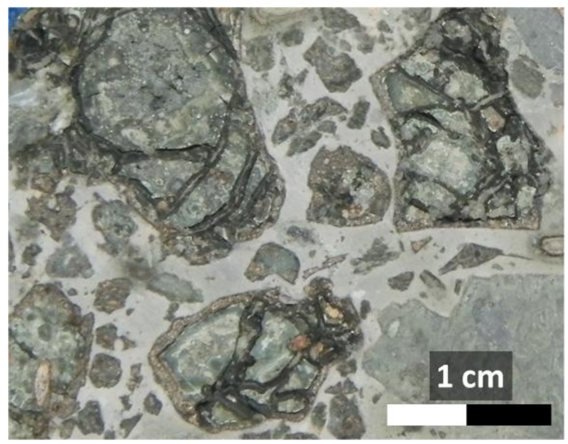

Figure 1: Dark-green and grey smectitic clays presumably replacing impact glass clasts in the melt-bearing impact breccia, ~675 mbsf (sample 59-2-67-68.5.)

Discussion: The distribution of hydrothermal alteration in the peak-ring of Chicxulub varies greatly between the impact melt-bearing breccias, impact melt rocks, and the felsic crystalline basement. The reason(s) for this is currently unknown, but likely reflects a combination of factors, including differences in porosity and permeability, mineral stability, and intensity and duration of heat source (i.e., melt and glass-rich vs. melt-poor) amongst lithologies, as well as the evolution of fluid chemistry as the system cools and fO_2.

It should be noted that without further constraints, it is unclear at this point as to whether all the alteration products are impact-generated, particularly those within the coherent felsic crystalline basement. The overprinting of multiple fluid events (i.e., pre-impact vs. post-impact vs. diagenesis) within terrestrial craters has been documented at other craters; therefore, caution must be taken when assigning a provenance to secondary assemblages. This is particularly the case for alteration products hosted within lithic clasts and basement material as their origin is more ambiguous (versus those which are hosted purely within impact products, such as melt).

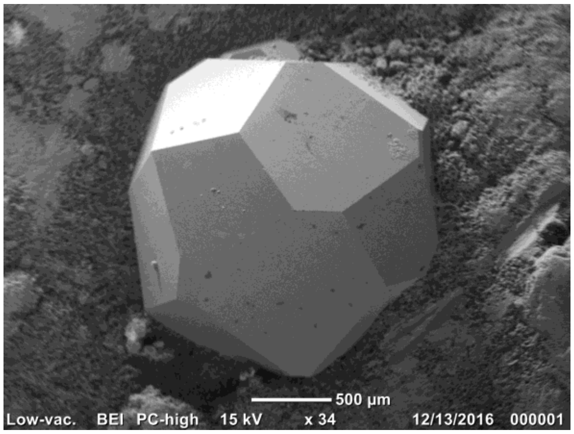

Figure 2: SEM image of euhedral analcime crystallized on the fracture surface of an impact melt-bearing breccia located ~1300 mbsf (sample 293-1-8-10.) Scale bar is 500µm wide.

Conclusion and forthcoming work: Hydrothermal alteration within the peak-ring appears to be more localized within the fractured and faulted crystalline basement, while melt-bearing lithologies are more pervasively altered, as evidenced by the alteration of what are presumably impact glass clasts. Alteration within the melt-bearing breccias appears to be dominated by argillic-zeolite assemblages with very minor sulfide mineralization, while the felsic basement has been affected predominantly by a K-metasomatic regime.

Thorough classification of alteration within the peak-ring using scanning electron microscopy (SEM), X-ray diffraction (XRD) and Raman spectroscopy will further reveal and confirm secondary mineralogy as well as cross-cutting relationships. Results will then be compared to those found within the Yaxcopoil-1 drill core [7-10], which recovered material from the annular trough of Chicxulub, to compare hydrothermal regimes.

Subsequently, secondary minerals and fluid inclusions which are suitably preserved throughout all intervals in the drill core will be utilized for forthcoming $\delta^{2}H$, $\delta^{18}O$, $\delta^{13}C$ and $\delta^{34}S$ stable isotope work, in order to constrain peak hydrothermal temperatures and fluid sources. Additionally, a thorough comparison of $\delta^{34}S$ variations in pre- and post-impact sulphides and sulphates, if sufficiently preserved, may reveal evidence of ancient thermophilic sulphate-reducing bacteria, which have been found previously in other terrestrial craters [4, 5]

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