SEEKING EVIDENCE OF LIFE IN SULPHIDES FROM THE BOLTYSH IMPACT STRUCTURE

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Introduction: Hypervelocity impact cratering is a significant process in the development of terrestrial planetary surfaces and is considered to have played a profound role in the origin of life [1–5] by providing a heat source on otherwise cold planetary surfaces, and creating habitable environments [3]. However, finding direct evidence for microbial colonization within impact structures has proven to be challenging and contentious [e.g., 6–9]. Recent work on sulphides in the Chicxulub and Rochechouart impact structures [e.g., 10,11] has demonstrated that sulphur in secondary sulphides was fractionated in a manner consistent with biological sulphur isotope fractionation, suggesting that biological mediation of these isotopes occurred after the impact, most likely while the post-impact hydrothermal system was active. The presence of hydrothermal alteration in the central uplift and crater fill impactites of the Boltysh impact structure, Ukraine [1,12,13] has motivated us to investigate whether the sulphides have an isotopic signature consistent with biological fractionation. Here we present preliminary results of a study examining the sulphide minerals in impact-melt bearing breccias of the 25 km diameter, ~65.5 Ma Boltysh impact structure.

Methods: Preliminary investigation has been conducted using scanning electron microscopy back-scatter electron imaging and electron dispersive spectroscopy at the University of Glasgow. These analyses will be followed by electron backscatter diffraction, and secondary ion mass spectrometry.

Results: Four thin sections of impact melt-bearing breccia from different depths (589.7, 590.7, 591.3, 593.6 m) in core 42-11 [14] were mapped using BSE and EDS to identify and locate sulphide minerals.

BLT-589.7 samples the contact between a clast of impact melt and the lithic fraction of the breccia. Sulphides are concentrated in the lithic portion. They range in size from 20-80 μm and are found infilling pore space and filling fractures. Most are anhedral, following the shape of the pores or fractures they fill, but some are rhomboid or cross sections through pyritohedra.

BLT-590.7 is mainly lithic breccia, with small clasts of impact melt. Sulphides range in size from 10 μm to 1 mm, the majority being ~60 μm. They are found infilling pore space and replacing other minerals. Most are aggregates following the shape of the pores they fill, but some are distinct pyritohedra.

BLT-591.3 samples the contact between a clast of impact melt and the lithic portion of the breccia. Sulphides are concentrated in pore space near the impact-melt/lithic contact. They range in size from <5-300 μm and are found filling pore space and replacing other minerals. Most are aggregates following the shape of the pores, but some are pyritohedra, rhomboid, or octahedra.

BLT-593.6 is mainly lithic breccia with a small component of impact melt clasts. It has fewer sulphides than the other three samples, and they are mainly concentrated in the lithic portions. The sulphides range in size from 10-200 μm and are found filling pore space, replacing other minerals, and as euhedral crystals in cavities. Most follow the shape of the pores they fill, but some are euhedral and rhomboid.

Discussion: Our initial observations of sulphide mineralization in the Boltysh impact-melt-bearing breccia match the descriptions of Gurov et al. [15], and we will expand upon this work by determining sulphur isotope ratios and investigating microstructure in more detail via EBSD. Similar sulphide morphologies and relationships to surrounding minerals were observed at the Chicxulub impact structure [11]. Those sulphides yielded negative $\delta^{34}S$ and $\Delta S_{sulphate\text{-}sulphide}$ values indicative of biological fractionation. Upcoming sulphur isotope measurements on the Boltysh samples described here will provide another data point for our understanding of sulphide minerals in post-impact hydrothermal systems, and their possibilities for preserving signs of past life.

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