A STUDY OF HYDROTHERMAL ACTIVITY ASSOCIATED WITH THE STEEN RIVER IMPACT STRUCTURE, NW ALBERTA, CANADA

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Introduction: Hydrothermal activity, induced by the interaction of shock-melted and / or heated target rocks and fluids, is widely recognized as a fundamental process associated with hypervelocity impact events [e.g., 1]. The resultant rock-water circulatory system can dissolve, transport and precipitate new mineral species. Study of the mineralogy and occurrence of these products yield information on the temperature, timing and chemistry of the post-impact hydrothermal system. Hydrothermal systems associated with impact structures are significant not only because of their potential to produce economically viable mineralization, but for their potential to provide habitable environments on Earth and possibly other planets [2]. Here, we present the first detailed characterization of the hydrothermal system associated with the Steen River impact event, which produced a 25-km diameter crater in mixed target rocks of the central uplift type in the Western Canada Sedimentary Basin.

Crater Overview, Samples and Methods: The Steen River impact structure (SRIS) is found in NW Alberta. The timing of impact is widely cited to be ~91 ± 7 Ma [3] but may be significantly older. The crater, now buried beneath ~200 m of post-impact Cretaceous marine shale and sandstone, is accessible through several diamond drill core penetrating the crater-fill deposits. Detailed sampling of one core, ST003, ~4 km from the crater center, was conducted. The length of the core (381 m) comprises 11 m of crystalline basement from the central uplift, overlain by 164 m of impact melt-bearing polymict breccia. The contact between the crater-fill breccias and the post-impact sedimentary stratra occurs at 206 m; these upper units (<206 m) were not sampled. A total of 72 thin sections were prepared. Sample numbers in the text refer to the depth in meters (e.g., S209.8 = ST003 core sampled at 209.8 meters depth). Study of these thin sections, employing optical microscopy, a FESEM and EMP at the University of Alberta, and a Raman spectrometer at MacEwan University, have allowed for characterization of the SRIS hydrothermal system in terms of the minerals produced, their composition and occurrence.

Results: The entire sequence of impactites intersected by ST003 show evidence of alteration. Within the crater-fill polymict breccias hydrothermal alteration is pervasive, in contrast with the bottom 11 m of core sampling shock-veined crystalline basement rocks where alteration is localized.

Petrography and mineralogy of alteration products 381–370 m: Within crystalline basement rocks, mineralization associated with hydrothermal activity is concentrated within, and along the margins of, shock veins and breccia veinlets injected into the central uplift. Alteration products include epidote, chlorite, chamosite and clay minerals. Along shock vein margins igneous quartz and feldspar are partially isotropic. These shock-produced diaplectic glasses exhibit an extensive degree of alteration and replacement by Fe-rich clay minerals.

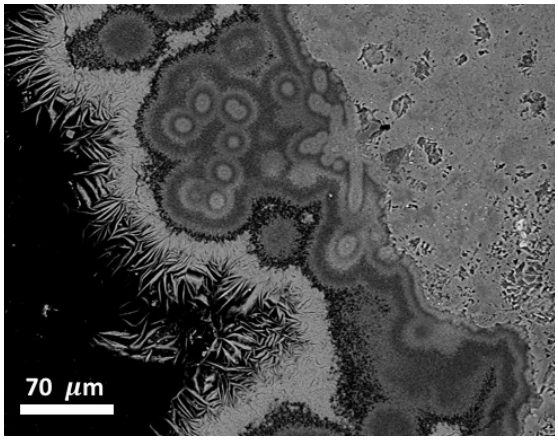

Fig 1. BSE image, vug-filling clay minerals (S364.5)

Petrography and mineralogy of alteration products 370–206 m: Within the overlying breccia unit, alteration products are found within open spaces (vugs / vesicles / fractures) as linings or fillings, and as pervasive alteration of matrix phases and impact melt clasts. Secondary K-feldspar (adularia) in S251.4 occurs as vesicle-lining euhedral crystals in impact melt. Major element composition, as well as physical and optical characteristics, suggest the presence of at least three zeolite minerals: analcime, epistilbite and laumontite. Clays are predominantly smectite group minerals (nontronite-saponite-montmorillonite) (Fig. 1). Calcite is abundant in the upper units of the core (e.g., S239.5–S209.8). Texture and composition support an origin for calcite as clasts inherited from target rocks, impact melt and secondary calcite (the latter as a vug-filling product associated with zeolites).

Discussion: Alteration associated with a post-impact hydrothermal system is an important component of the impactites at the SRIS. The heat source was likely the melt-bearing breccias themselves, coupled with elevated thermal gradients associated with 1–2 km of structural uplift. This study also demonstrates that shock-induced veinlets provide pathways for migration of fluids within the central uplift of complex craters.

References: [1] Naumov M. (2005) *Geofluids* 5, 165–184. [2] Cockell C. and Lee P. (2002) *Biological Reviews* 77, 279–310. [3] Winzer S. (1972) *24th International Geological Congress* 15, 148–156.