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TEXTURAL EVIDENCE FOR IMPACT MELT IN DRILL CORE AT THE HAUGHTON IMPACT STRUCTURE, NUNAVUT, CANADA.

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Introduction: Although it has been established through numerical modeling, experimental analysis and physical observations that impact melting occurs in sedimentary rocks as readily as crystalline rocks, there are further complications due to porosity, volatile content and stratigraphy [1 and references therein]. Evidence for carbonate and evaporite melts are heavily scrutinized as they are the least well understood.

Recognizing the products of impact melting in sedimentary target rocks can be problematic as they are often texturally and chemically different than their well-studied counterparts in crystalline targets. The latter demonstrate classic igenous textures and silicate geochemistry [2]. A recent review of impact melting in sedimentary rocks [1], describes the melt products of carbonates in particular. They typically occur as 1) trapped immiscible silicate and carbonate melts; 2) euhedral calcite crystals within impact glass clasts; 3) carbonates intergrown with CaO-MgO-rich silicates; 4) CaO-MgO-CO_2-rich glasses; 5) quench textures in the form of feathery or globular calcite intermingled with silicate glass; and 6) carbonate spherules. These deposits occur dominantly within proximal and distal ejecta deposits as well as melt-bearing crater-fill breccias. There is the added challenge of discriminating between diagenetic and hydrothermal carbonate as well. However, this can be addressed using petrographic relationships and geochemistry.

The objective of this study is to characterize newly discovered textures within the drill cores from the impactite deposits at the Haughton impact structure.

Haughton*:* The 23-km diameter Haughton impact structure is located on Devon Island, Nunavut in the Canadian High Arctic. The impact occured into an ~1880 m thick sedimentary sequence of Lower Paleozoic sediments of the Arctic Platform, which consists primarily of limestones, dolostones and interbedded gypsum, with minor shales and sandstones which overly a Precambrian basement [3].

The crater fill impactites at Haughton consist of grey clast-supported lithic breccias pasing upwards into pale grey clast-rich impact melt rocks with a microscopic groundmass consisting of calcite, anhydrite and silicate glass with clasts from all target lithologies [4].

Field Work: Quesnel et al. [5] conducted surveys to explain the unique coupled negative gravity anomaly and positive magnetic anomaly at Haughton. They concluded that a km-sized body with enhanced magnetization is the result of hydrothermal alteration in the porous crater-fill deposits. The body is located close to the well-known site, Anomaly Hill. To follow-on with the study, shallow drilling was completed to sample within the anomaly's isolated volumes near the surface. Two cores were successfully collected; F2 within the anomaly and F3 just outside of it. Preliminary macro-scale petrography and magnetometry of the cores were conducted [6]. To date, these are the only cores of impactites at Haughton.

Analytical Methods: Multiple polished thin sections were made of both F2 and F3 cores. Petrography was completed with a Nikon petrographic microscope. Imaging, geochemical and micro-textural analysis were completed on a JEOL JXA-8530F field-emission electron microprobe at Western University.

Results: The F3 core consists of several fragments of core collected between depths of -2.9 m to -4.9 m; whereas, the F2 core consists of nearly continous core from a depth of -8.6 m to -12.8 m [6]. Remarkable differences in colour, groundmass and clast textures are immediately apparent between the cores.

F3 Core. It is a grey, clast-rich polymict impactite and is a good representation of the surficial clast-rich impactites previously described at Haughton by [4]. It has a fragmental groundmass and is possibly melt-bearing. It is very poorly sorted with a groundmass consisting of fine-grained fragments of calcite, anhydrite, and dolomite. Clast population consists of altered and unaltered, angular to sub-rounded fragments of all target lithologies. Clast size varies from <5 µm to > 1 mm.

F2 Core. The F2 core is a white to pale green clast-rich polymict impactite, with a lower density and higher natural remanent magnetization (NRM) than F3 [6]. The groundmass is heterogeneous but is dominated by fine-grained calcite (Fig. 1A). The groundmass proportion varies widely from 20 to 80% [6], and the majority of the clasts are >300 µm, rounded, zoned and/or intensely altered. Clasts consist of altered limestone, gneiss, and mafic fragments but no observable dolomite. Centimeter-scale hydrothermal selenite veins also occur in F2, and F2 shows evidence of more intense alteration than F3.

Igneous Texture in F2. BSE imaging confirms there are notable differences both in the groundmass and clasts in the two core samples. A series of igneous textures within the groundmass of F2 were observed, including acicular calcite with silicate alteration (Fig. 1B); altered dendritic silicate hosted in calcite; calcite - Mg-rich silicate needle intergrowth textures (Fig. 1C) that appear to be acicular calcite in plane light; skeletal Mg-rich silicate (Fig. 1D); and a series of clast coronas. Silicate coronas surrounding clasts (Fg. 1A) or relict clasts now replaced are common in F2, as well as calcite mantles surrounding silicate clasts. In a more intensly altered section of the F2 core, a coarse-grained anhydrite forms the groundmass (Fig. 1D), here the calcite mantles and skeletal silicate are more common. None of the above are found in F3. Note that microprobe analyses show that almost all the silicates in F2 have been altered to a talc-like clay.

Implications: The cores reveal a new impactite lithology showing multiple igneous textures. These are typical of rapid cooling or quenching [7], in this case of a silicate-carbonate melt. In particular, the intergrowth textures indicate co-existing carbonate-silicate melts; the coronas may be the result of disequilibrium reactions between melt and clasts; and the lack of clasts smaller than 300 μm may suggest clast assimilation by the melt. The lack of dolomite clasts suggests it may have been incorporated into the silicate melt to later form the now altered Mg-rich silicate.

Given the recent geophysical results, this core potentially represents a much larger unexposed body of impactites on the order of 1 km, which we suggest represents an isolated carbonate-rich melt lens within the impactites at Haughton.

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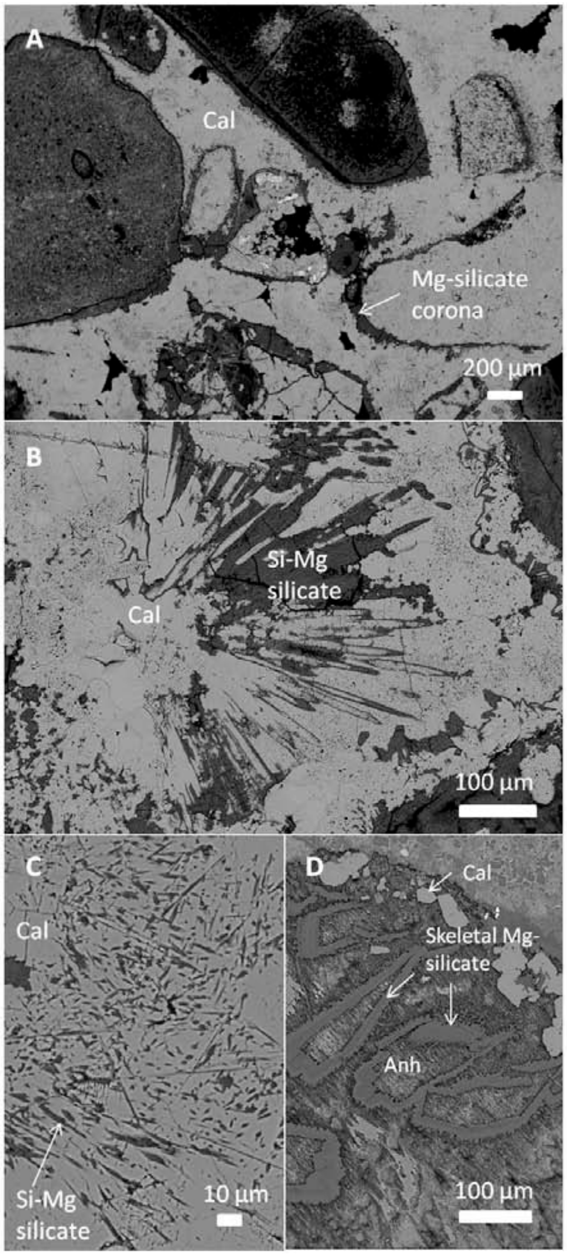

Figure 1. Backscatter electron images of the F2 drill core. A) Context image showing fine-grained groundmass of calcite intergrown with very-fine acicular silicate. Note the silicate coronas around relict clasts and intensely altered clasts; B) Acicular calcite with mantles of Mg-rich silicate, hosted in calcite groundmass; C) Section of groundmass from lower right of Fig. 1A. Fine-grained intergrowth of acicular Mg silicate and calcite resembling granophyre; and D) Skeletal Mg silicate, hosted by a coarse-grained anhydrite and gypsum groundmass. Skeletal grains are filled with anhydrite. Fine-grained calcite is also common in the groundmass, as isolated grains and mantling silicate clasts (not shown).