IMPACT-GENERATED DYKES FROM THE HAUGHTON IMPACT STRUCTURE, CANADA.

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Introduction: Many aspects of the well-preserved Haughton impact structure on Devon Island in the Canadian High Arctic have been previously investigated. These aspects include its overall geology, impactites, hydrothermal activity, and geophysical properties (see [1] for overview). This study examines the occurrence of impact-generated dykes within the Haughton impact structure and their components.

Breccia dykes have been mentioned in prior investigations of Haughton [2,3]; however, features of these breccias were not explored in detail. Impact dykes are found within exposed target rock and differ from the pale grey crater-fill impact melt rock preserved within the central uplift region or ejecta megablocks from the rim region of the impact structure described by [1,4].

Target rocks in the impact structure include limestone, dolostone, evaporites, and sandstone of Cambrian to Silurian age and fragments of pre-Cambrian granite are found as clasts in the crater-fill impact melt rock [1]. Dykes in this study are located around the edge of the central uplift and out towards the rim.

Samples and Methods: Fifteen samples were collected along the Haughton River Valley and 8 from various locations within the impact structure (Fig. 1).

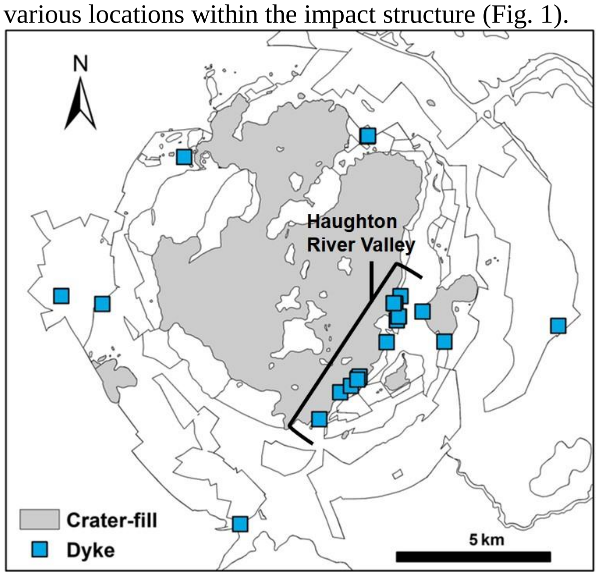

Figure 1. Sites of dykes in the Haughton impact structure examined in this study. See [1] for a detailed geologic map and unit descriptions of the impact structure.

Thin sections were characterized using a petrographic microscope and a JEOL JXA-8503F microprobe equipped with energy and wavelength dispersive spectrometers at the Earth and Planetary Materials Analysis Laboratory at Western.

Results and Discussion: Dykes from the Haughton impact structure are broadly divided into two groups based on the presence or absence of melt; melt in the dykes examined from Haughton is more likely to occur closer to the central uplift of the impact structure. Mechanical twinning is observed in calcite grains but is absent from dolomite. Sulfides are sparse and are typically up to a few 10s of µm in diameter when present.

Lithic impact breccia dykes. Lithic dykes are located toward the rim of the structure with several found in the Haughton River Valley (Fig. 1). Lithic breccia dykes are melt-free and are typically monomict, clast-rich, and range in colour from grey, brown, to yellow depending on the host rock formation and degree of weathering. The fine-grained matrix is often too fine to resolve petrographically and the angular to sub-rounded clasts range in size from fine to coarse. Dykes within the Thumb Mountain Formation are easily recognized by their abundance of microfossils.

Clast-rich impact melt rock dykes. Dykes in this group are exposed along the Haughton River Valley in the Eleanor River Formation (ERF). Impact melt rock dykes are pale grey to beige in colour and reflect the chert-bearing limestone composition of the ERF. These dykes differ from the crater-fill impact melt rock as the crater-fill contains clasts from all target lithologies [4]. Small vesicles and cavities visible at hand sample-scale are common and range from angular to rounded up to several cm in diameter. The shape of the larger cavities or "ghost clasts" resemble that of clasts that seem to have weathered out of the groundmass (Fig. 2).

Figure 2. Clast-rich impact melt rock containing "ghost clasts" or clast-like cavities in the Eleanor River Formation.

In thin section, these so-called "ghost clasts" often have a thin interior rim of orange-brown devitrified silicate glass. The groundmass in the melt rock dykes consists of microcrystalline calcite. Wavelength dispersive spectroscopy (WDS) analyses detected several wt% of SiO_2 and Al_2O_3 present in groundmass calcite.

Silicate glass. Small fragments of silicate glass have been identified in the groundmass of some impact melt rock dykes. Remnants of silicate glass has also been identified along the inner edge of "ghost clasts" in the same melt rock dykes. Most of the glass observed is devitrified and orange-red to brown in colour under plane-polarized light (PPL). Silicate glass compositions are similar to type C4 glass [4] or have a high MgO content (21 to 29 wt%), no Al or K, and variable analytical totals (~70 to 88 wt%); electron dispersive spectroscopy (EDS) detected an average content of 12 wt% carbon in the high MgO glasses.

Toasted chert. Another feature associated with the chert-bearing limestone of the ERF within the impact structure is potential evidence of shock in chert manifested as toasting in thin section. In PPL, this toasted chert appears orange-brown in colour compared to near colourless untoasted microcrystalline chert. In hand sample, unshocked ERF samples contain white-coloured chert nodules while chert in the ERF from the impact structure may be white or black in colour. Toasted chert corresponds to the black coloured chert suggesting that the colour change is a result of an increased exposure to shock. Chert grains are typically either completely toasted or untoasted but in rare occurrences both may occur in the same grain (Fig. 3).

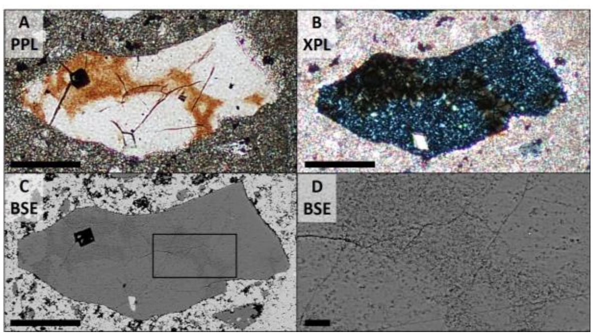

Figure 3. Partially toasted clast of chert present from a clast-rich impact melt rock dyke in the Haughton River Valley. In part A, the toasted chert area corresponds with the brown central area of the pale-coloured chert clast. Scale bars in part A to C are 100 µm and is 10 µm in part D.

When viewed in BSE, the toasted area appears rougher with more pitting, contrasting with the smoother adjacent untoasted chert (Fig. 3D). There is no detectable difference in composition between the toasted and untoasted areas of chert based on quantitative WDS analyses. The differences between the two areas of the chert grain are visual and textural in nature (Fig. 3) and parallel observations made between quartz and toasted quartz from other impact structures [5,6].

Quartz-cemented carbonate breccia. The dyke located near the northwest edge of the structure has an unusual composition compared to the rest of the dykes examined. This dyke consists primarily of angular to sub-rounded dolomite clasts, rounded to sub-rounded calcite clasts, and sub-angular chert clasts cemented together by quartz (Fig. 4). WDS analyses of the cement reveal a composition close to 100% SiO_2, with <2, <1, and <0.5 wt% of CaO, MgO, and Al_2O_3, respectively. Dolomite clast compositions do not deviate from expected values while calcite contains <0.4 wt% SiO_2 and Al_2O_3. The slight anomaly in calcite composition [7] suggests that the rounded "clasts" are actually melted calcite globules that had limited mixing with the surrounding silicate cement.

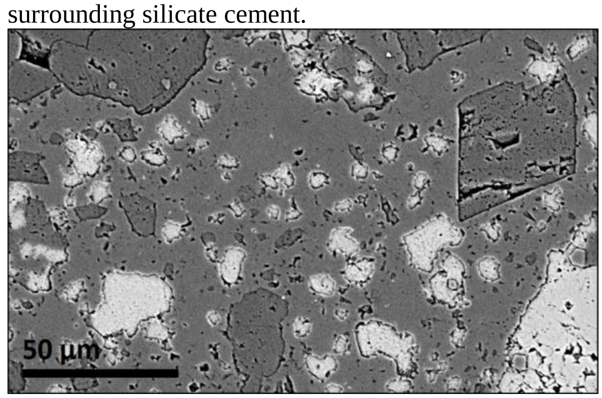

Figure 4. Backscattered electron image of quartz-cemented carbonate breccia; calcite is white, dolomite is darker grey clasts, and grey cement filling space between clasts is quartz.

Conclusions: The diversity within the suite of impact-generated dykes examined in this study highlights the complexity of dyke formation in the cratering process. Examining previously uncharacterized dykes has not only expanded the knowledge and range of impactites at the Haughton impact structure but identified new impact related products associated with this impact site including toasted chert. These impactites and products provide further insights into temperature and pressure conditions generated during the impact event.

Acknowledgements: This work was funded by NSERC, the Canadian Space Agency, and the Northern Scientific Training Program. The Polar Continental Shelf Project is gratefully acknowledged for logistical support. S. Wood and M. Beauchamp are thanked for their assistance with sample preparation and analysis.

References: [1] Osinski G. R. et al. (2005) *Meteoritics & Planetary Science*, 40, 1759-1776. [2] Bischoff L. and Oskierski W. (1988) *Meteoritics*, 23, 209-220. [3] Osinski G. R. and Spray J. (2005) *Meteoritics & Planetary Science*, 40, 1813-1834. [4] Osinski G. R. et al. (2005) *Meteoritics & Planetary Science*, 40, 1789-1812. [5] Short N. M. and Gold D. P. (1996) *Geological Society of America Special Paper 302*, 245-265. [6] Whitehead J. et al. (2002) *Geology*, 30, 431-434. [7] Osinski G. R. et al. (2008) *Geological Society of America Special Publication*, 437, 1-18.