TEXTURAL INVESTIGATION OF IMPACT MELT ALONG A VERTICAL TRANSECT AT DISCOVERY HILL, MISTASTIN LAKE IMPACT STRUCTURE, CANADA.

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Introduction: Kamestastin (Mistastin) Lake impact structure in northern Labrador, Canada (55˚53' N; 63˚ 18' W), is a complex crater that formed in crystalline target rocks. The crater has a diameter of ~28 km and the impact event has been dated at 37.83 Ma by [1].

Mistastin offers a rare opportunity to study the field relationships of impact lithologies through well preserved outcrops of impactites and target rocks. Target rocks of Mistastin Lake impact consist of intrusive bodies including anorthosite and mangerite that are part of the Mistastin Batholith, making the Mistastin impact structure a unique lunar analogue site. The impactite stratigraphy, from bottom to top, consists of fractured target rocks, monomict breccia, polymict melt free to melt poor breccia, polymict impact melt-bearing breccia and impact melt rock [2]. Impact melt rock units at Mistastin occur within various outcrops in the crater interior and range from centimeter sized dikes, predominantly in the crater rim region, to ~80 m at the thickest at Discovery Hill [2] (Fig. 1).

A ~2-week field expedition to Mistastin Lake was conducted in September 2021 for field mapping and sample collection of impact melt rock. Our focus for this work is Discovery Hill, a roche moutonnée primarily consisting of columnar jointed impact melt rock that exhibits a sharp contact with underlying impact breccia. Here we present preliminary observations from a detailed vertical transect of the impact melt unit at Discovery Hill.

Discovery Hill Transect: A vertical transect, about 70 m in height, for sample collection was carried out by Dr. Osinski by rappelling down the south face of Discovery Hill, from the top of the hill up to the contact with the breccia unit below (Fig. 1). A total of 25 samples of impact melt were collected along the transect and polished thin sections were prepared for each sample. Following is a systematic description of the samples to document the petrographic characteristics of the impact melt along the transect.

Microtextures: The impact melt rocks at Discovery Hill exhibit porphyritic to aphanitic textures in hand samples. Optical microscopy was used for qualitative investigation of matrix and clast content of each impact melt rock. Texturally, the impact melt varies in grain size and clast content from the top to the base. In the upper portion of the transect, near the top of the hill, as seen in Fig. 2, the melt is medium to fine grained, crystalline, with micro-porphyritic textures.

Figure 1: Drone image of Discovery Hill with red line representing the line of transect along the south cliff face.

This part of the melt is almost free of clasts. The mineralogy is dominated by euhedral to subhedral micro-phenocrysts of plagioclase followed by lesser abundant anhedral pyroxenes (Figure 2). The melt exhibits a range of microtextures from ophitic/subophitic, where larger grains of pyroxenes include smaller plagioclase laths, to intergranular where pyroxenes are enclosed within networks of plagioclase crystals. Radiating arrangements of plagioclase laths were noted in some of the samples. One plagioclase grain containing kink-band-like features was identified in the melt matrix (Fig. 2). Iron oxide phases are common, and occur in blocky forms, and can be identified by their opaque nature under transmitted light.

Moving downwards, the unit grades into melt with very fine-grained matrix. Mineralogically, the matrix composition does not critically differ from the melt above, with plagioclase and pyroxenes still comprising the bulk. However, there are rare domains of glassy matrix which varies in colour from pale brown to dark brown and no significant flow textures were found.

Clast content increases downwards, and clast composition is mainly subhedral to anhedral plagioclase, quartz, and lithic fragments. Highest concentration of clasts is seen near the base of the transect where the melt becomes clast rich with very fine-grained matrix. The mineralogical composition of the melt matrix at the base is similar to the top, but here

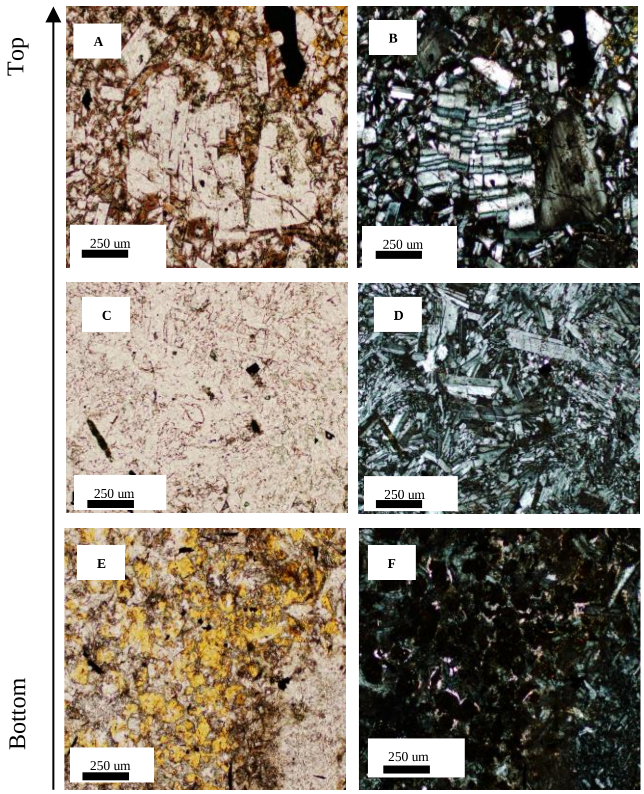

Figure 2: Photomicrographs of impact melt at Discovery Hill. Left column shows images in plane polarized light, right column under crossed polars. (A-B): Clast poor, fine to medium grained melt with micro-porphyritic texture and a kink banded plagioclase phenocryst. (C-D): Clast poor melt with fine grained matrix. (E-F): Clast rich melt with fine grained to glassy (pale brown) matrix.

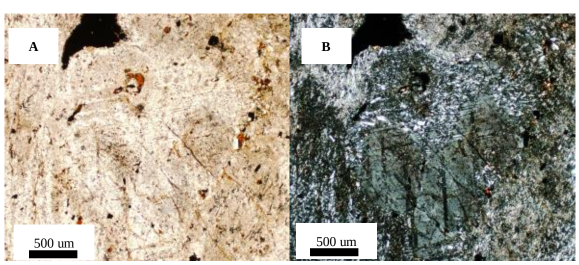

Figure 3: Plagioclase clast with planar fractures in the clast rich melt embedded in a fine-grained matrix (A: plane polarized light, B: under crossed polars). Note the preferred alignment of microlites around the clast.

the matrix contains more of the pale brown glass, and preferential orientation of plagioclase microlites around clasts is seen in some samples (Fig. 3). Shock metamorphic features like planar fractures and undulose extinction are evident in some of the mineral clasts.

Discussion: Discovery Hill comprises the thickest unit of impact melt rock at the Mistastin Lake impact structure [3,4]. Similar to endogenic igneous rocks, textures of impact melt rocks also inform us about the cooling and crystallization history of the rocks [5]. However, in the case of impact melt rocks, the added component of clasts complicates the melt cooling process. From fieldwork and optical microscopy results, it is seen that the base of the Discovery Hill impact melt is clast rich. The melt shows gradational variation in texture along the vertical transect, with clast abundance decreasing upwards with a corresponding increase in grain size of the matrix. Glass content of the impact melt matrix, in this case, appears to vary with clast content, and diminishes towards the upper end of the transect. This trend of textures indicates that cooling rates were highest at the base of the unit, where a greater degree of undercooling would have caused the melt to rapidly quench and form more glass (especially around boundaries of clasts) and a fine-grained texture, as well as to preserve clasts that were trapped within the hot melt. As we move up along the unit, the cooling rate would have been sufficiently low to allow the digestion of the suspended clasts by the melt, and the melt would have enough time to form more microlites, and even larger crystals further up in the unit.

To better understand the cooling and crystallization processes within the melt sheet, and to determine the extent of the influence of clasts on the thermal evolution of the melt, a detailed geochemical analysis with an electron microprobe will be performed on the transect samples. Further study of the samples will also include examination of textures at the micrometer scale with the help of Backscattered Electron (BSE) imaging.

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