COMPOSITIONAL VARIABILITY IN INTER-MINGLED IMPACT MELTS AT KAMESTASTIN (MISTASTIN) CRATER, LABRADOR.

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Introduction: The Kamestastin (*aka* Mistastin) Lake impact structure in Labrador, Canada (55.89°W, 63.30°W) is a 36 ± 4 million-year-old [1] complex crater with a suite of impactites exposed by erosion, including ponded impact melt rock, polymict and monomict impact breccias, impact glass, and fractured target rock [2, 3] (**Fig. 1**).

This contribution focuses on the location known as "West Point," where a complex outcrop of impact melt rock and impact melt-bearing polymict breccia is well-exposed along the shore of Kamestastin Lake.

The target rocks of the crater are the Mesoproterozoic Mistastin batholith of the Nain plutonic suite. Geologic mapping by [4] recorded granitic rocks with a generally quartz-monzonite-to-granodiorite composition, with localized regions of anorthosites. The quartz monzonites are coarse-grained-to-porphyritic with 20-60% ovoid alkali feldspars rimmed by plagioclase. A wide range of feldspathic compositions have been recorded in the country rocks of the crater [5].

Hypervelocity impacts apply a sudden and very large shock pressure to a volume of target rocks; impact melt is generated when this pressure is released and the target rocks decompress adiabatically; this initially creates a relatively homogenized body of melt [6]. The melt body can then evolve in composition due to factors such as differential cooling rates, turbulent mixing, and/or interactions with entrained clasts [7]. At West Point, two co-existing textures of impact melt are observed: vesicle-poor and vesicle-rich. Colour variations are also seen in these melt rocks. Due to the vesicular textures in these rocks, the West Point outcrop has previously been interpreted to represent a point stratigraphically high in the original melt sheet, chilled quickly by proximity to the surface [8].

Understanding the process behind the formation of these co-existing melts is crucial to understanding melt-sheet evolution at Kamestastin. In addition, impact melt-bearing breccias occur in contact to the melt rocks. Termed "suevite" by many authors at other impact structures, the genesis of this type of impactite remains debated.

Methods: Samples were collected from West Point during the 2021 and 2023 field seasons (**Fig. 2**). Polished slabs and thin-sections were prepared for 6 of the collected hand samples. Element maps were obtained from polished slabs using a Bruker M4 Tornado micro-X-ray-fluorescence (XRF) instrument. Energy-dispersive spectroscopy (EDS) was used to collect element maps of thin sections with an accelerating voltage of 15 kV/150nA using a JEOL JXA-8530F field-emission electron microprobe.

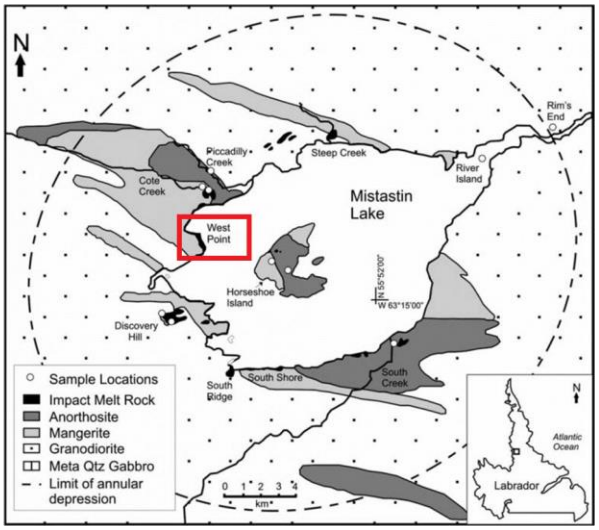

Figure 1: Geological map of the Kamestastin (Mistastin) Lake impact structure (adapted from [9]).

Results:

Petrography: three texturally distinct melt units are observed in the polished samples: a clast-rich, vesicle-*poor* impact melt (**VPM**), a clast-rich, vesicle-*rich* impact melt (**VRM**), and an impact melt breccia containing both. These two melt units may each include bodies of the other. The melt bodies range in size from comprising most of a hand sample to being cm-scale bodies within an impact melt breccia. Blebs of the VRM are distinctly more elongate and sinuous than those of the VPM, though at cm-scale the VPM melt units show curving and smearing at their margins. Colour varies in both melts from dark blue-grey to red. The VRM has the most prominent examples of red colour, whereas the VPM is mostly dark blue-grey. Lithic clasts are predominantly subangular and crystalline, with white-to-yellow colour. Some clasts are vesicular and show degrees of assimilation by the surrounding melt.

Geochemistry: Micro-XRF analysis of the polished samples revealed relative compositional variation between the melt units (**Fig. 2**) The VRM units show a relatively lower signal in K, Fe, and Si than does the VPM in the same sample. Lithic clasts show enhancements in the elements of the feldspars but Fe- and Ti-bearing clasts are sometimes observed.

Elemental mapping of thin sections via EDS confirmed the sharply-bounded compositional variations at the microscopic scale—where the K, Fe, and Si signal is lower in the VRM, the VPM shows the reverse.

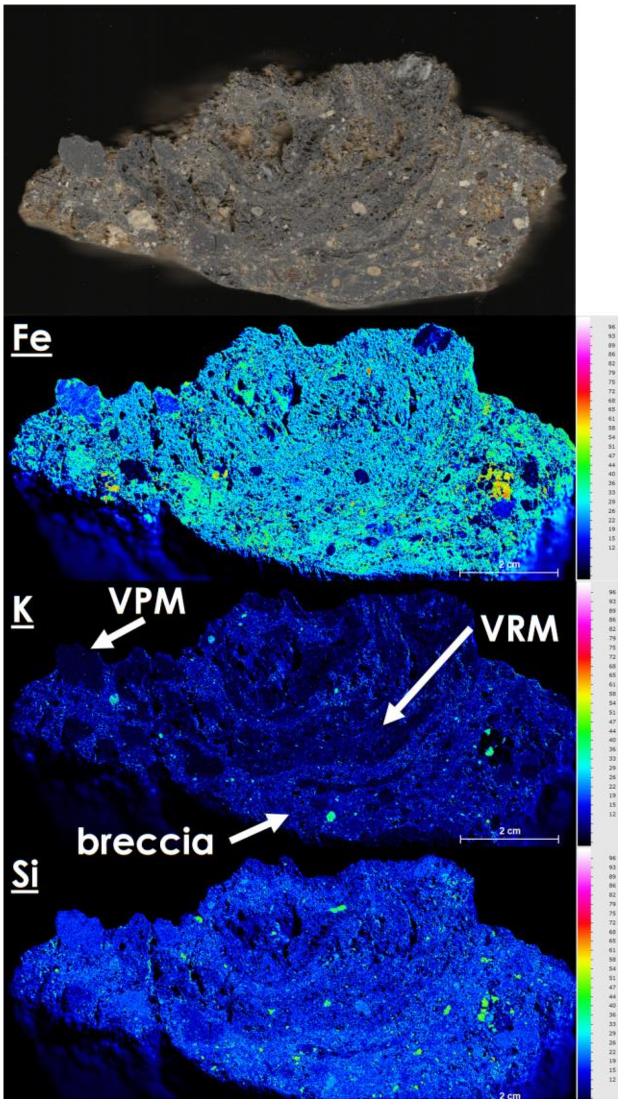

Figure 2: Sample WP21_3364 is a clast-rich impact melt-rock, 12 cm in length, which demonstrates the vesicle-rich and -poor texture and the breccia unit.

Discussion:

The VPM units appear either in contiguous lenses (ranging in size up to the majority of a ~10cm hand sample), in small blebs which tend to be subangular, or rounded-blocky shapes. VRM material, by contrast, appears usually as ropey stringers or rounded blobs. From this textural evidence, it can be hypothesized that, at the time of emplacement, the VPM was to some degree cooler and more viscous at the time the VRM.

Vesicularity in Kamestastin impact melts from around the crater is discussed by [10], who suggest that the melt sheet may have been thinner and more heterogeneously distributed than the “classic” uniform melt sheet model. Rapid cooling of thinner parts of the melt sheet is presented as a mechanism to prevent exsolution of supersaturated volatiles, resulting in less-vesicular melt rock retaining more volatile elements.

Whether the West Point outcrops represent a stratigraphically high position in a more traditional melt sheet or a localized, thinner flow is not known. In either case, a near-surface process in the melt sheet of two-phase interactions between a cooler, vesicle-poor melt (which retains more volatile elements) and a hotter, vesicle-rich melt (which has lost some of the same to vapour phases) may provide an environment whereby melts with differing compositions can coexist, as is seen in these samples.

Further work: Further study of these rocks will expand upon these preliminary petrographic analyses and supplement compositional observations with quantitative geochemistry via the methods above and wave-dispersive spectroscopy. Shock effects may be quantified using Raman spectroscopy and X-ray diffraction or rock-forming minerals (e.g. plagioclase, pyroxene).

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