IMPACTITES OF THE MISTASTIN LAKE IMPACT STRUCTURE, CANADA: INSIGHTS INTO IMPACT EJECTA EMPLACEMENT. M. M. Mader[1,2] and G. R. Osinski[2], [1]Royal Ontario Museum, Centre for Earth & Space, 100 Queen's Park, Toronto, ON Canada M5S 2C6 (mmader@rom.on.ca), [2]Centre for Planetary Science and Exploration, Dept. of Earth Sciences, University of Western Ontario, 1151 Richmond Street, London, ON, Canada, N6A 5B7 (gosinski@uwo.ca).

Introduction: Impact craters are the dominant geological landform on rocky planetary surfaces; however, with limited planetary samples, scientists look to terrestrial craters as analogues to understand the formation of impactites. Many terrestrial impact structures have been eroded to such a degree that only the underlying autochthonous target rocks are preserved or the crater structure has been infilled by later sedimentary units and thus impactites can only be accessed through drilling. In both cases, it is difficult to have a clear understanding of the spatial occurrence of impactities with respect to the crater structure and their formation mechanisms, especially allochthonous ejecta units. The Mistastin Lake impact structure offers a unique opportunity to study an almost complete suite of impactites in which their geological context (i.e., contact relationships) can be observed in the field, including unequivocal evidence of impact melt-bearing ejecta overlying melt-free lithic breccia ejecta within the terraced rim region.

Mistastin Lake impact structure: The Mistastin Lake impact structure is located in northern Labrador, Canada (55°53'N; 63°18'W) has an apparent crater rim diameter of ~28 km and was formed ~36 Ma [1]. The original crater has been differentially eroded; however, a subdued rim and distinct central uplift are still observed [2]. The inner portion of the structure is covered by the Mistastin Lake and the surrounding area is locally covered by soil/glacial deposits and vegetation. The target rocks at Mistastin are dominated by granodiorite, quartz monzonite, and anorthosite. It is notable that this structure has only previously been mapped in reconnaissance fashion [3].

Methodology: Field mapping was conducted over three field seasons. Samples of all major impactities units were collected and contacts between various impactites were studied in detail. Follow-up petrographic, backscattered electron microscopy, and electron microprobe analysis were conducted with a focus on textural features.

Results: Key exposures of impactites at Mistastin describe a radial transect outwards from the central uplift across the apparent crater rim. Figure 1 shows a sectional view across the Mistastin Lake impact structure, highlighting the stratigraphy within different parts of the crater structure. A general stratigraphy, from bottom to top includes:

A) Unshocked target rocks;
B) Autochothonous/parautochthonous shocked and fractured target rocks;
C) Parautochthonous monomict lithic breccias;
D) Allochthonous polymict lithic breccias (melt-poor and melt-bearing);
E) Allochthonous impact melt rocks (grading from clast-rich to clast-poor from bottom to top).

Unshocked target rocks underlie all impactite units. Although the original crystalline stratigraphy of the batholith is unknown, the high concentration of anorthosite fragments within allochthonous breccias and as the main component of impact melt rocks, suggests that the anorthosite body was at least the width and depth of the transient cavity. Autochothonous, fractured target rocks are found in the terraced rim region of the Mistastin impact crater and make up the raised ring of hills that define the apparent crater rim.

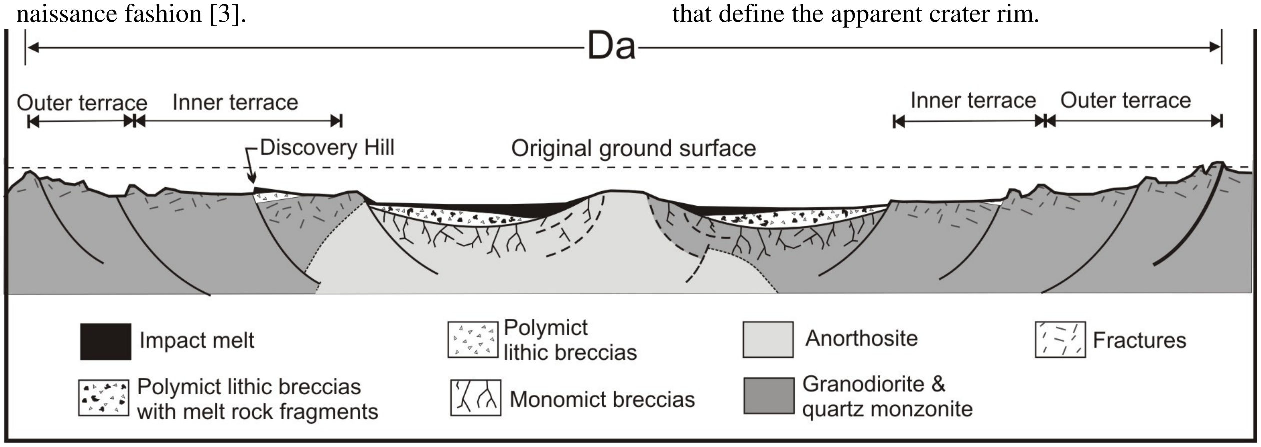

Fig. 1 Schematic cross-section of the Mistatin Lake impact structure showing present-day surface after erosion and glaciation; Da = diameter of apparent crater rim.

Allochthonous polymict impact breccias overlying allochthonous impact melt rocks were observed within the inner terrace and lie stratigraphically above nearby fractured mangerite target rocks. Locally, a curved trough of impact melt rocks with vertically dipping sides define a flow channel (Fig 2). The melt rocks overlie polymict breccia characterized by unsorted, cm-size fragments of anorthosite and plagioclase of mixed shock level with less than 2% of melt fragments. The boundary between the impact melt rock and polymict breccia is sharp along the vertical sides of the trough. In comparison, at the base of the trough, a transitional zone in which the melt unit is intermixed with the underlying polymict breccias, suggests that the melt flowed rapidly through the channel. Within this transitional zone, the amount of melt fragments increases as proximity to the overlying melt rock contact increases (Fig. 2). In addition, chilled, ropey textures within the melt unit at the boundary with the underlying polymict breccias and crystalline groundmass phases display quench textures, both indicating rapid crystallization from a melt.

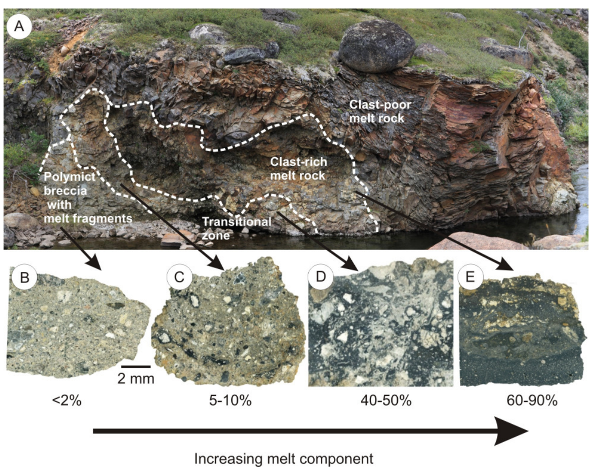

Fig. 2 a) Channel of impact melt rock overlying ballistically emplaced polymict impact breccias. b) – e) At the base of the channel the melt unit mixes with the polymict breccias forming melt-bearing polymict breccias of differing concentrations of melt fragments (also termed 'suevite').

Discovery Hill, a 120 m thick unit of melt rock, lies within the terraced rim of the impact craters, situated above the current lake level (Fig. 1). Its wedge shape is the result of glaciation. Locally, a sharp contact with underlying melt-poor, polymict breccia was observed. The lack of mixing between the overlying melt and the breccia, indicates that the melt pooled on top of the breccia or moved slowly overtop without disrupting the unconsolidated polymict breccia.

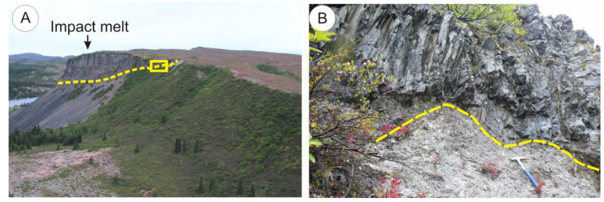

Fig. 3 a) Wedged shaped Discovery Hill. b) Detail of area outlined in a). Sharp contact of impact melt rock overlying polymict breccia.

Interpretations and Discussion: Impact ejecta is defined here as any target material, regardless of its physical state, that is transported beyond the rim of the transient cavity [4]. Thus, the localities shown in Figures 2 and 3 are impact ejecta. Isolated outcrops of impact melt rocks overlying polymict breccia within the terraced rim, are not interpreted as being continuous with the original melt sheet as concluded by previous studies [2]. Instead they are interpreted as discontinuous melt that flowed along channels or units emplaced as melt ponds over ballistically emplaced polymict breccia.

A multi-stage model for the origin and emplacement of impact melt rocks and the formation of impact ejecta is proposed for the Mistastin Lake impact structure based on a synthesis of the field and petrographic observations. This model involves the generation of a continuous ejecta blanket during the excavation stage of cratering, via the conventional ballistic sedimentation and radial flow model as originally proposed by [6], followed by the emplacement of more melt-rich, ground-hugging flows during the terminal stages of crater excavation and the modification stage of crater formation (cf. [4]).

The stratigraphy seen at Mistastin is identical to that at the similarly-sized Ries impact structure, Germany, and the Haughton impact structure, Canada, which lends further support to hypothesis that impact ejecta is emplaced in a multi-stage process [4].

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