THE IMPACT MELT SHEET AT WEST CLEARWATER IMPACT STRUCTURE: A PETROGRAPHIC AND GEOCHEMICAL ANALYSIS. G. D. Tolometti[1], G. R. Osinski[1,2], C. D. Neish[1]. [1]Department of Earth Sciences / Centre for Planetary Science and Exploration, University of Western Ontario, London, ON; [2]Dept. of Physics and Astronomy, University of Western Ontario, London, ON (gtolomet@uwo.ca)

Introduction: The West Clearwater Lake impact structure is classified as a complex crater with a diameter of 36 km with a ring of islands in the center interpreted to be its central uplift, and a 34 km^3 impact melt sheet [1,2], located in northern Quebec (56°10 N, 74°20 W). Work conducted by [3] determined the age of West Clearwater to be ~286 Ma based off ^{40}Ar-^{39}Ar analysis on the melts. The impact melt sheet is made up of three melt units: a clast-rich and clast-poor fine-grained melt, and a clast-poor coarse-grained melt. Previous research has reported the textures and compositions of the impact melt rocks [4]; however, little work has been done to revisit the impact melt rocks since the early 1980's or discussed changes in composition and textures in the impactite stratigraphy [4]. Impact melt composition informs us which target rocks melted during the formation of the impact crater, and the textures describe the cooling conditions of the impact melt sheet. In this study, using petrographic analysis, electron micro-probe analysis (EMPA), and X-ray Fluorescence (XRF), we evaluate the textures and composition to provide descriptions of the impact melts (Figure 1), and explain the changes observed in the impactite stratigraphy.

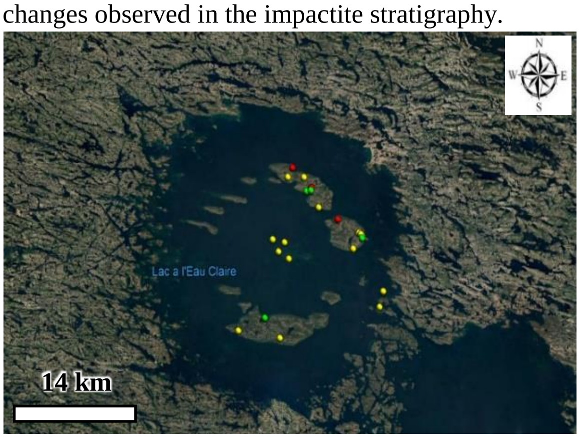

Figure 1. Google Earth image of the West Clearwater Lake impact structure. Points mark the locations of samples used for petrographic and geochemical analysis. Green - fine grained melt rocks, Red - coarse grained melt rocks, Yellow – target rocks (granite, mafic, diabase, and diorite).

West Clearwater impact melt rocks: Based off the previous work conducted by [4-6], the impactite stratigraphy at West Clearwater comprises the following units starting from the base: fragmented basement rocks - monomict lithic breccias – impact melt-bearing breccia – clast-rich fine-grained melt – clast-poor fine-grained melt – clast-poor coarse-grained melt. The focus of this research is the clast-rich and -poor fine-grained melt and clast-poor coarse-grained melt.

Clast-rich fine-grained melt. Overlying the impact-bearing breccia is a clast-rich fine-grained melt. Osinski et al. [6] describe the contact to be gradual, ranging from several 10s cm to several 10s of m. The clast-rich melt contains >25% clasts, >1 mm. The clasts comprise lithic and mineral clasts of the target rocks. The melt matrix is red and aphanitic.

Clast-poor fine-grained melt. The clast-poor fine-grained samples contain <15% of clasts, >1mm. The melt matrix is aphanitic and has not experienced as much oxidation, leaving patches of red markings. The fine-grained melt, clast-rich and poor, has a maximum known thickness of 35 m [5].

Clast-poor coarse-grained melt. The melt matrix is coarse-grained (>2 mm), and comprises <5% of clasts and very few quartz and feldspar mineral fragments. The low abundance of clasts and mineral fragments implies that the melt had more time to assimilate the material and/or the clasts settled towards the base of the impact melt sheet before it solidified.

Geochemical analysis: Laboratory XRF and electron microprobe analysis (EMPA) was used to observe changes in the impact melt compositions moving up the impactite stratigraphy. Volcanic TAS diagrams identify the impact melts as a trachyandesite, with a couple of outliers as andesite. Major element data shows the impact melts are similar in composition. Small variations are present in the fine-grained melt rocks. These variations could have developed from the incomplete assimilation of the clasts present in the clast-rich melt rocks. Failed assimilation however, can only be considered if clast settling did not occur during the formation of the impact melt sheet.

Impact melt textures: Optical microscopy was used to estimate the clast abundance and matrix size, and identify shock metamorphism and minerals in the melt matrix and clasts. The textures transition from an aphanitic to ophitic texture (Figure 2). The matrix in all three melts is composed primarily of subhedral quartz, plagioclase, orthoclase, and clinopyroxene (Cpx). Hematite, magnetite, apatite, and ilmenite are found in both clast-rich and clast-poor melt rock samples. However, fine-grained melt rocks are more abundant in these minerals than the coarse-grained melt rocks. Cpx and quartz-feldspar intergrowth textures are found growing around the margins of quartz clasts. Toasting and mosaic textures in quartz, and undulose extinction and complex twinning of feldspar clasts are found within the fine-grained melts. The clasts in the coarse-grained melts exhibit the same shock features except for toasting's in quartz.

Impact melt sheet: Impact melt rock textures provide context for the cooling rates of the impact melt sheet, and composition informs us about the efficiency of melt mixing and what target rocks melted during the impact event. The coarsening up sequence implies the coarse melt had lower cooling rates than the finer melt in contact with the crater floor [7]. Clasts suspended in the melt would have accelerated cooling, which is observed comparing the clast-rich and clast-poor fine-grained melt textures; aphanitic to sub-ophitic. Slower cooling rates in the clast-poor fine and coarse-grained melts provided the time to assimilate most of the clasts before solidification. Alternatively, settling of the clasts would have concentrated a majority closer to the base of the impact melt sheet, which would be the clast-rich fine grained melt rock unit [8].

The impact melt sheet appears relatively homogenous based on the major element results. A homogenous impact melt sheet requires a well-mixed model to allow enough time for the melted material to be evenly distributed. Small geochemical differences in the impact melt rocks could have originated either from the incomplete assimilation of clasts, or the settling of clasts within proximity to the base of the impact melt sheet. Regarding incomplete assimilation, the clast-poor melts that may have assimilated more clasts could have incorporated more constituents from the target rocks such as SiO_2 and CaO. If settling of clasts played a larger role, the melt would not have had the time to assimilate the clasts before melt solidification. The lack of adsorbed clast margins in the clast-rich samples found close to the base of the impact melt sheet supports settling as a plausible process. However, no crystals are found reoriented around the clasts, a sign of physical interaction between the clasts and crystals in the melt from settling. Further petrographic analysis can investigate whether the distribution of clasts is a result of settling or failed assimilation. Despite the clast abundance varying in the fine and coarse-grained melt rocks, the impact melt sheet can be regarded as one homogenous melt sheet as XRF geochemical data identifies the fine and coarse-grained melts rocks as trachyandesite.

Conclusion: Analysis of clast-rich and poor fine-grained melt, and clast-poor coarse-grained melt samples show changes in textures from aphanitic to ophitic, and a relatively homogenous trachyandesite composition throughout the melt sheet. Decreasing cooling rates moving up the impactite stratigraphy produced the aphanitic to ophitic texture transition. The base of the melt sheet rapidly cooled due to the heat exchange between the crater floor and walls and the target rock clasts. The mixing and homogenization of the impact melt at the West Clearwater impact structure produced a large trachyandesitic melt sheet.

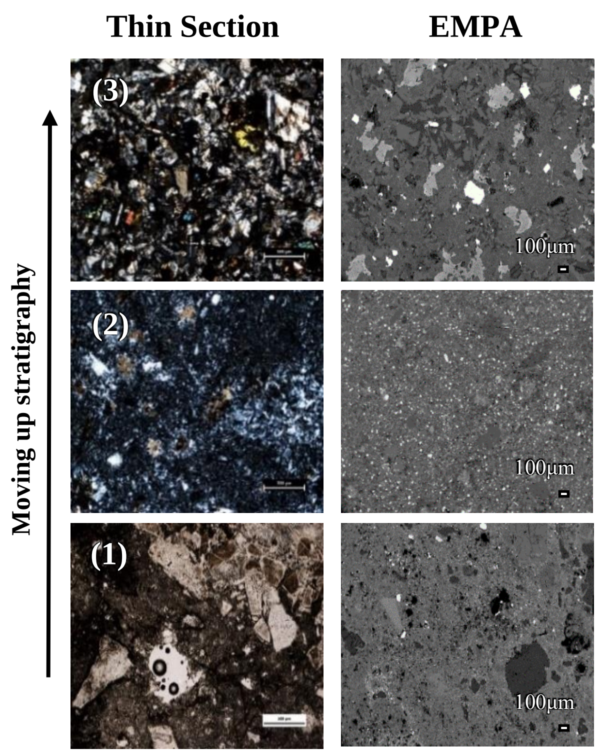

Figure 2. Images from thin sections and EMPA analysis arranged in the same stratigraphic order visible at West Clearwater. The grain size and clast abundance changes moving up stratigraphy. (1) a clast-rich fine-grained melt. (2) a clast-poor fine-grained melt. (3) a clast-poor coarse-grained melt.

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