IMPACT MELT VEINS IN THE CENTRAL UPLIFT OF THE WEST CLEARWATER LAKE IMPACT STRUCTURE, NORTHERN QUEBEC, CANADA. R. P. A. Wilks[1], and G. R. Osinski[1,2], [1]Centre for Planetary Science and Exploration and Department of Earth Science, University of Western Ontario, London, Ontario, Canada, N6A 5B7(rwilks@uwo.ca), [2]Department of Physics and Astronomy, University of Western Ontario, London, Ontario, Canada, N6A 5B7 .

Introduction: Impact cratering is one of the most common geological processes in our Solar System and can be studied in order to understand the geological history of Earth and other planetary bodies. Impact cratering is a process that is still not fully understood, particularly with respect to how the uplift of underlying rocks occurs in the centre of large complex impact structures. This research aims to investigate central uplifts; specifically impact melt veins and dykes found within uplifted target rocks, in order to better understand their formation processes. It has been hypothesized by other researchers that impact-generated melt may play a major role in the weakening of rocks which make up the crater floor and allow for the central uplift process to occur [1–3]. Impact melt is thought to lubricate faults making blocks more susceptible to displacement, but whether this melt is a product of the initial shock or due to frictional melting caused by wide scale movement between large rock units is unknown. This research focuses on the investigation of impact melt observed as vein structures within the central uplift of large complex impact structures using petrography and geochemistry in order to determine the process by which they formed. This will result in a better understanding of the role of melt on central uplift formation on Earth and other planetary bodies.

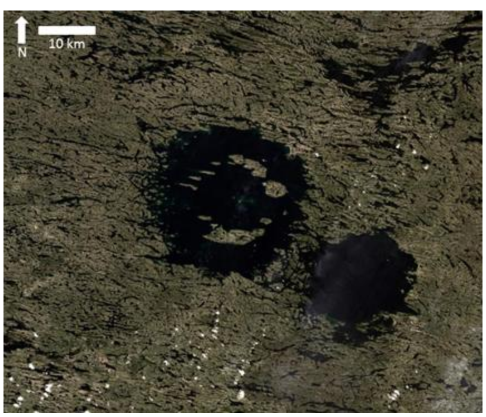

Figure 1. Satellite image of the West Clearwater Lake impact structure (left with ring of islands).

Study Site: The ~290 Ma West Clearwater Lake impact structure (WCIS) [4] is located in northern Quebec at 56°08′N 74°18′W ~125 km east of Hudson Bay (Fig. 1). The impact occurred into coarse-grained plutonic target rocks of the Superior Province which had granodiorite, quartz monzonite and amphibolite lithologies. This structure is ~30 km in diameter and has a series of central islands (Figure 1).

Methods and Samples: Fieldwork was conducted in August and September 2014 as part of a Canadian-US-UK expedition (see [5] for an overview of this expedition and other ongoing studies). Approximately 300 samples were collected. This study focused on the analysis of three WCIS samples from the central islands in West Clearwater Lake where melt veins were observed (Fig. 2). In this study we have used optical microscopy and electron dispersive spectroscopy (EDS) techniques to analyze mineral structure, petrography, and chemical composition.

Figure 2. ~2cm thick red impact melt vein in basement rock on the central islands.

Results:

WCIS-14-AR-016. WCIS-14-AR-016 is a red melt vein in country rock retrieved from a basement outcrop located on the central islands. The host rock is feldspathic with shock induced deformation twinning evident in the plagioclase grains. The host rock also has grains of diopside, anorthoclase, magnetite, apatite, biotite, ilmenite and hematite. The iron oxides appear to increase in frequency as the vein is approached. The vein was shown using EDS to consist of hematite, ilmenite, and plagioclase and includes plagioclase clasts (Fig. 3) which similarly to the host rock plagioclase show undulatory extinction. Pieces of the plagioclase wall are seen to be breaking off and are being incorporated into the melt (Fig. 4).

Figure 3. A plagioclase clast within the melt vein of WCIS-14-AR-016 with evident flow textures in plane polarized light.

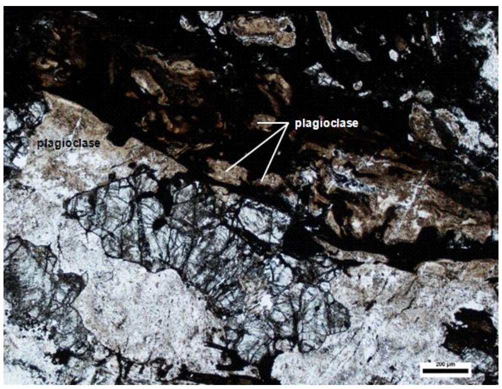

Figure 4. The wall (light) and melt vein (dark) of WCIS-14-AR-016 in plane polarized light, showing pieces of the wall (plagioclase) being incorporated into the melt vein.

WCIS-14-RW-011. This sample exhibits a red melt vein contact with a large diorite clast. Mineral abundances of both plagioclase and amphibole in the basement clast are approximately 50%; the amphibole is titanium bearing and is possibly kaersutite, as identified by EDS. The melt is identified using EDS as anorthoclase with enstatite grains.

WCIS-14-RW-013. The red melt vein in this sample is coating granitic basement clasts. The mineralogical composition of the basement clast is predominately orthoclase and quartz whereas the melt has small grains of iron oxides including ilmenite and hematite in addition to anorthoclase, orthoclase and quarts inclusions. This melt is predominantly gray in colour but has some linear features, which are red (Figure 5). The EDS data retrieved from these red areas showed an increased wt% of iron when compared to the gray coloured areas of the melt; however, this was not observed in every comparison. The quartz inclusions, which are incorporated into the matrix, exhibit a rim of pyroxene, likely diopside as identified with EDS.

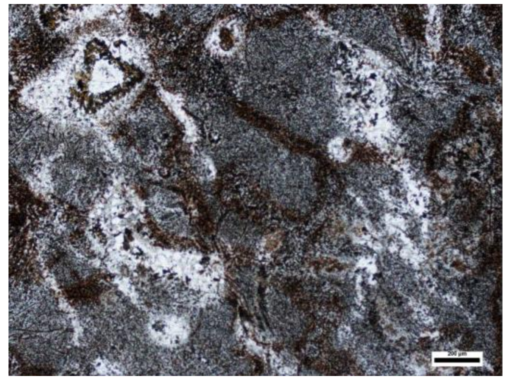

Figure 5. WCIS-14-RW-013 in plane polarized light showing colour differential within melt vein, note the red worm like pattern.

Discussion: Both WCIS-14-RW-011 and WCIS-14-RW-013 have melt veins that comprise a different mineralogy to that of the host rock and specific minerals in the melt vein that are not seen in the host rock. Chemical data is needed to confirm but these melt veins could, therefore, represent intruded shock melt. WCIS-14-AR-016 is the only sample that shows evidence of the wall being incorporated into the melt vein, which was seen through flow textures in optical analysis and the chemical compositions of the clasts. This sample was also the only occurrence when all the identified mineralogical compositions of the basement are evident in the melt vein through EDS analysis. Not only were the plagioclase clasts included in the vein the same composition of the host rock but they also exhibit the undulatory extinction and shock deformation twinning seen in the plagioclase that comprise the host rock. Of the three samples analyzed WCIS-14-AR-016 appears to be the most likely candidate for *in situ* melt; however, further chemical data must be acquired before concluding formation through frictional melting.

Future work will investigate the origin of these impact melt veins and the role, if any, that they could have played in the formation of the central uplift at the West Clearwater Lake impact structure. The distribution of these veins in 3D will also be investigated through the continued analysis of field samples and through the study of drill cores taken in the 1960s.

References: [1] Spray J. G., & Thompson, L. M. (1995) *Nature*, 373: 130-132. [2] Lana C. et al. (2003). *Meteoritics & Planetary Science, 38*, 1093-1107. [3] Senft L. E., & Stewart S. T. (2009) *Earth and Planetary Science Letters, 287*, 471-482 [4] Wanless R.K. et al. (1964). Geological Survey of Canada Paper, 64: 17. [5] Osinski et al. (2015) LPS XLVI, this conference.