Primitive Source Revealed in the Sudbury Impact Structure: Implications for Cratering and Metal Sources.

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Introduction: The Sudbury Structure is the eroded remnant of a large 150-200 km multi-ring impact crater and uniquely reveals on present-day surface the crustal impact structures in the crater floor below the igneous complex [1,2]. Large terrestrial impact structures had transient craters that penetrated 30-40 km depth and collapsed to form ~200 km impact craters with perturbations of the Moho [2,3]. The footwall environment to the Sudbury Igneous Complex contains permeable pseudotachylite zones that act as conduits for magmas, fluids and gases.

An extensive array of concentric and radial structures below the interpreted melt sheet crosscut the earlier pseudotachylite zones and may be filled with mafic igneous melt as at the Copper Cliff and Worthington offset dykes or partial melts of the footwall (meta/footwall breccia), discontinuous igneous pods and breccias (ie. Whistle, Trill). Recently unearthed concentric offset structures in the NW quadrant now extend over 45 km subparallel to and ~12 km below the base of the melt sheet.

North Range isotopic results: The Broken Hammer deposit is a Paleoproterozoic zone of Cu-Ni-PGE mineralization within brecciated Neoarchean gneiss and granites in the northern footwall of the Sudbury Igneous Complex. It is hosted, by impact-induced pseudotachylitic breccias 1 to 1.5 km below the crater floor. The Joe Lake mafic intrusion that extends 1.5 km from Broken Hammer to the SIC and over 10 km along the SIC contact was previously thought to be part of a Paleoproterozoic suite of mafic intrusions [2].

U-Pb geochronology. Preliminary zircon U-Pb geochronology and field observations of a penetrative fabric compatible with that of adjacent Levack gneisses indicate it must be older. Our initial results suggest the Joe Lake gabbro was metamorphosed at 2657±9 Ma, based on near concordant metamorphic zircons, and was intruded by relatively undeformed late Archean pegmatite dykes shortly after.

These mafic rocks in the impact target rocks have been proposed as a source of arsenic incorporated early into the impact melt during initial impact [5].

Low sulphide-PGE zone. An unusual hydrothermal occurrence of low-sulphide, silicate-rich, PGE-rich high-grade zone with a Pt: Pd ratio of 2:1 is situated in epidote-quartz extensional veins and pods on the edge of the Broken Hammer open pit. This spectacular high-grade PGE zone is dominated by coarse epidote, quartz and sperrylite ($PtAs_2$) crystals up to 13 mm (Fig 1).

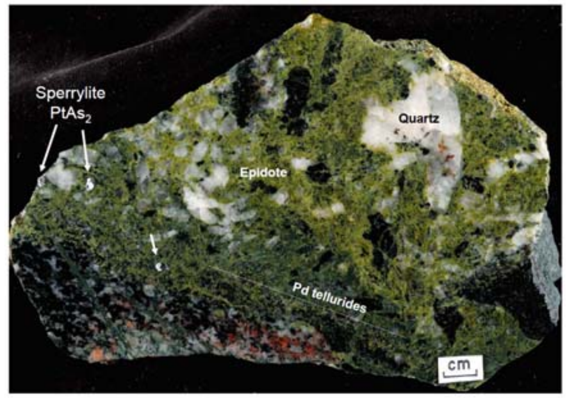

Figure 1. Polished rock slab of coarse epidote-quartz-sperrylite, minor merenskyite and Ni chlorite hydrothermal assemblage in contact with gabbro.

The dominant palladium mineral is merenskyite ($PdTe_2$) and not michenerite that formed in most North Range sulphide dominated ore systems. Isolated sperrylite grains in quartz-epidote have inclusions of gold, Au-Ag tellurides whereas complex intergrowths of Pd-, Bi- and Ag-tellurdes are associated with specular hematite and cassiterite reflecting oxidizing conditions.

Sr isotopes. Early formed epidote that hosts coarse sperrylite was analyzed by TIMS yielding a narrow range of low age-corrected $^{86}Sr/^{86}Sr$ ratios from 0.705948 to 0.706457 with a primitive non-radiogenic source. This reveals a source not recognized previously in the crustally dominated radiogenic Sr in the SIC, carbonates and other epidote in the SIC and Onaping Formation [6].

Implications and future work: In-situ LA-MC-ICP-MS Sr isotope analysis of epidote and calcite in a variety of paragenetic suites in the structures below the melt sheet will be used to identify potential sources and trace the evolution of fluids in the Sudbury crater.

References: [1] Milkereit et al. (2010), Large Meteorite Impacts and Planetary Evolution IV: GSA Special Paper 465, 115-131. [2] Ames et al. (2008), Econ. Geol. 103, 1057-1077. [3] Christenson et al. (2009), EPSL 284, 249-257. [4] Pentek et al. (2008), Econ. Geol. 103, 1005-1028. [5] Ames et al. (2010), SEG Keystone. [6] Hanley and Ames (2012) *PACROFI-XI,* **11**, 39-40.