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Role of impact devolatilization in the genesis of Ni-Cu-PGE mineralization in the Sudbury Impact Structure

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Summary

Most models for the genesis of the Ni-Cu-PGE mineralization in the Sudbury Impact Structure involve exsolution of immiscible sulfides during cooling of the impact melt, gravitational settling to the basal contact, and sweeping into topographic embayments by convection currents or as gravity flows followed by local injection into radial and concentric “offset” dikes and footwall rocks. Variations in the S-Os-Pb isotopic compositions of the ores around the SIC have been explained by incomplete mixing or local “interaction” with underlying rocks, but this cannot explain the magnitudes of the variations, the insignificant variations in Hf isotopic compositions of overlying silicate rocks, or the mismatch between observed ore tenors and metal depletion trends in overlying norites. The wide variations in Pb isotopic variations have been attributed to volatilization of Pb from the impact melt followed by incorporation of significant Pb from underlying rocks during post-impact thermomechanical erosion, but S is as volatile as Pb, so it should have been also devolatilized. This leads to an alternative model for ore genesis involving 1) syn-impact devolatilization of significant amounts of Hg-Tl-Cd-S-Se-Sn-Te-Zn-Pb-Bi and lesser amounts of Sb-Ag-Cu-Au-As from the impact melt, 2) mechanical and convective homogenization of all chalcophile (S-Fe-Ni-Cu-Pt-Os-Pb) and lithophile (Sr-Nd-Hf) isotopic systems during formation of the impact melt sheet, and 3) significant local thermomechanical erosion and incorporation of barren Fe sulfides (Huronian basalts/sediments), subeconomic Fe-Cu-Ni-(PGE) sulfides (most Nipissing and/or East Bull Lake Intrusive Suites), or economic Fe-Ni-Cu-(PGE) sulfides (Shakespeare-type Nipissing intrusives), forming sulfide xenomelts that reacted with overlying impact melt. These interactions can be mathematically modelled to produce the observed variations in Ni-Cu-PGE tenors and S-Os-Pb and Sr-Nd-Hf isotopic compositions. Publication number MERC-2020-003.