



A melt inclusion study of the Sudbury Igneous Complex (Ontario, Canada): preliminary results

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The 1.85 Ga Sudbury Igneous Complex (SIC), Ontario, Canada, is an intrusive complex representing the crystallized melt sheet that formed within a large impact crater. The SIC has been extensively studied due to its rich endowment in magmatic sulfide ores (Ni-Cu-PGEs). The nature and origin of the SIC melt sheet and its subsequent evolution still remain controversial. In this study, analyses of primary melt inclusions hosted in cumulus apatite within three mafic units of the SIC (gabbro, norite and sublayer quartz diorite) are used to decipher the thermometric and chemical characteristics of the evolving melt sheet as it crystallized.

Apatite-hosted melt inclusions commonly display a negative crystal shape, occur parallel to the c-axis, and often occur within a central growth zone, which suggest a primary origin. The compositions of coeval (co-entrapped) melt inclusions are distinct and may represent either the products of immiscibility (low or high temperature field; *c.f.* the Skaergaard Intrusion: Jakobsen et al., Geology, 2005), or a product of early, high-temperature, impact-generated emulsification (prior to and independent of crystallization of the melt sheet). The compositions of homogenized (1100–1200°C for 3 hrs) melt inclusions, determined by SEM-EDS and EMP analyses of opened, homogenized melt inclusions, equate to two distinct compositions: (1) Type-I are SiO₂-rich, ranging from tonalitic to granodioritic in composition (60–70 wt% SiO₂, up to 11 wt% FeO); and (2) Type-II are Fe-rich with syenogabbroic to essexitic to alkali gabbroic compositions (27–49 wt% SiO₂, 16–44 wt% FeO). Trace element data, obtained by LA-ICPMS analyses of single inclusions and surrounding host apatite, are used to infer D values between apatite and the two melt types, and between the coexisting melt types. Apparent D^{ap/melt} values for both Type-I and Type-II inclusions show that the REE, Sr, and Y are compatible in apatite, and As is weakly compatible or incompatible in apatite, whereas the following elements behaved incomparably (in increasing order of incompatibility: Cr, Ni, Cu, Zr, Co, Cs, Ag, Nb, Hf, Ta, Rb). Apparent D values between the two coexisting melt phases (D^{Fe-rich/Si-rich}) show that most trace elements were weakly compatible or incompatible in each melt phase, with the exception of V, Co, Rb, Sr and Cs that show consistent enrichment in the Fe-rich melt phase. Preliminary melt inclusion analyses suggest that the earliest (and quenched?) melt phase of the SIC, as represented by sublayer quartz diorite, was enriched in Ni and Cu, up to an order of magnitude higher than those liquids trapped in the units stratigraphically higher in the SIC, and may reflect loss of these metals to early sulfide liquids.

The results of this study have implications for our understanding of layered intrusions world-wide and may lead to the development of parameters that enhance exploration success in mafic-ultramafic systems where post-magmatic processes have severely limited the application of bulk rock chemistry in understanding their petrogenesis. This study provides the first in-situ determination of actual ore-metal concentrations and partitioning behavior of ore metals and other trace elements in a differentiated, mafic-ultramafic intrusion.