Zirconium Mobility and Constraints on Partial Melting and Melt Segregation within the Contact Metamorphic Aureole of the 1.85 Ga Sudbury Igneous Complex, Ontario, Canada

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Abstract

The geochemistry and microscopic textures of pyroxene hornfels rocks within the southern contact metamorphic aureole of the 1.85 Ga Sudbury Igneous Complex (SIC) record Zr-loss related to partial melting. Fe-rich tholeiitic rocks of the 2.45 Ga Elsie Mountain Formation (EMF) comprise the dominant lithology in the southern footwall of the SIC, and include a ≥ 725m (true thickness) two-pyroxene zone that can be traced for over 1.5 km along strike. Within *ca*. 500m of the SIC the two-pyroxene zone is dominantly composed of hornfelses with only minor amphibole present. Based on geochemistry the hornfelses can be subdivided into two subzones: 1) a *ca*. 250m-thick outer zone characterized by higher Cs-Rb-K and Ba, higher Th-U-LREE and W, and less pronounced negative Zr-Hf anomalies (Zr/Zr* >0.68), and 2) a *ca*. 250m-thick inner zone characterized by lower Cs-Rb-K and Ba, lower Th-U-LREE and W, and more pronounced negative Zr-Hf anomalies (Zr/Zr* <0.68). Petrographic examination of the samples within the inner zone reveals the presence of semi-continuous *ca.* 10 um wide films of zircon at silicate-silicate, silicate-oxide and oxide-oxide interfaces with low dihedral angles against the surrounding phases (approaching 0°). These textures are interpreted to reflect liberation of Zr either via exsolution from or melting of Zr repository phases during high temperature metamorphism. While some Zr was mobilized and lost in partial melts, the rest crystallized as zircon films when melts became Zr-saturated. In combination with geochemistry, this suggests that the thickness of the zone that records melting and melt segregation on the South Range (at least 250m) is much greater than that reported on the North Range (~25m), consistent with the greater thickness of the Main Mass of the SIC on the South Range (~3 km) than that on the North Range (~2 km), and the significantly greater thickness of the pyroxene hornfels zone on the South Range (~500m) than reported on the North Range (~200m). Sharp-walled Cu-Ni-PPGE-rich veins in the North Range footwall rocks appear to be restricted to within 200-300m of the SIC contact, reflecting the maximum depths that molten sulfides could penetrate. Because footwall Cu-Ni-PPGE-rich veins appear to be much less common in the South Range footwall rocks, their emplacement may have been inhibited more by the rheology of the footwall mafic and sedimentary rocks on the South Range than by the thickness of the high-temperature part of the contact metamorphic aureole.