Spatial and geochemical relationships between footwall granophyre and sulfide Ni-Cu-PGE veins, Sudbury impact structure, Canada

LE Debono[1], GR Osinski[1, 2]

[1]Centre for Planetary Science and Exploration/Dept. of Earth Sciences, University of Western Ontario, London, Ontario; [2]Dept. of Physics and Astronomy, University of Western Ontario, London, Ontario;

The 1.85 Ga Sudbury Igneous Complex (SIC) has been the strategic exploration target behind the production of world-class Ni-Cu-PGE deposits at Sudbury. This is testament to the genetic relationship between the SIC impact melt sheet, and the mobilization and formation of ore deposits. The superheated impact melt sheet caused partial melting and mixing at the footwall-melt sheet interface, yielding "footwall granophyre" (FWGR) veins that penetrate the footwall. Contemporaneous circulation of high temperature and -salinity magmatic sulfides resulted in sulfide lixiviation and remobilization via veins systems throughout structurally weak areas. Field work was conducted in the South and Southwest Zones of the Broken Hammer region (field access permitted by Wallbridge Mining Co. Ltd.). Occurrences of FWGR veins (<3 m thick) were observed penetrating the country rock (Levack Gneiss, LG), within 5 m of massive sulfide Ni-Cu-PGE veins (~12 cm thick). FWGR veins were commonly seen penetrating fractures in the surrounding LG, and Sudbury Breccia matrix. Grid mapping and strike measurements revealed a common trend range of 285-330° (n=42) for both Ni-Cu-PGE and FWGR veins. Petrography and electron dispersive spectrometry analyses were conducted on sampled FWGR veins situated 5 m from massive sulfide Ni-Cu-PGE veins. In the FWGR samples, grains of 50-550 μm magnetite hosts linear ilmenite-titanite mineralization, and sparse occurrences of pyrite inclusions 1 μm in size. No other occurrences of sulfide mineralization were observed in the FWGR veins. Thus, it is interpreted that the sulfides mobilized by the SIC hydrothermal system preferentially replaced thick (~12 cm) rather than thin (<3 cm) FWGR veins. Thin FWGR veins cool at a relatively faster rate as they migrate through fractures, thereby losing heat through conduction over a brief time period and limiting brine convection. Due to greater volume and ability to retain heat, thicker FWGR partial melt veins conduct more heat into the surrounding rock over a longer duration of time as they migrate through fractures. The higher temperatures would facilitate hydrothermal activity and increase brine salinity, resulting in easier mobilization of sulfides. The specific mechanism/s by which hydrothermal sulfides preferentially replace FWGR veins is uncertain. However, based on the structural, spatial, geochemical, and microscopic evidence in this study, it is confirmed that FWGR veins and associated Cu-Ni-PGE veins are closely related. Results in this study suggest that the emplacement of FWGR veins and Cu-Ni-PGE veins is cogenetic, and therefore is likely governed by the same geologic processes.