SEG 100 Conference: Celebrating a Century of Discovery

D1

Crustal Architecture of a World-Class Mineral District: Transcrustal Upflow Zones and Metal Endowment

Taus R. Jørgensen[1], Harold L. Gibson[1], Eric Roots[1], Rajesh Vayavur[1], Graham Hill[2], David Snyder[3], Mostafa Naghizadeh[1]
1. Mineral Exploration Research Centre, Harquail School of Earth Sciences, Laurentian University, Sudbury, ON, Canada, 2. Institute of Geophysics of the Czech Academy of Sciences, Prague, Czech Republic, 3. Geological Survey of Canada, Ottawa, ON, Canada

Lithospheric-scale crustal growth processes are first-order controls on metal source, transport, and concentration. However, the crustal architecture and geologic features that characterize mineral districts and the processes responsible for district-scale metal endowment are poorly understood. Here we present a whole-of-crust analysis that provides insights into belt- and district-scale features and processes, which influenced the metal endowment of the Neoarchean Noranda District (Abitibi greenstone belt, Canada) as documented by its ~20 volcanogenic massive sulfide deposits (VMS), ~19 orogenic Au deposits, and minor synvolcanic intrusion-hosted Cu-Mo ± Au ± Ag mineralization. Much of the metal budget (17 of 20 VMS deposits; 104 Mt of 130 Mt of VMS ore) is confined to a smaller area characterized by a magmatic center with the greatest combined surface area of synvolcanic plutons and felsic volcanic rocks and the highest density of major synvolcanic structures. Crustal-scale integration of seismic, gravity, and magnetotelluric imaging with surface geology shows that the more endowed area is marked by increased felsic plutonism at depth and located above subvertical pipe-like corridors that connect to relatively low resistivity middle-lower crust. The largest and most Au-rich VMS deposits are situated where three major synvolcanic faults correspond to one of the most predominant structural corridors at the locus of the magmatic center. This new crustal reconstruction explains the clustering of ore deposits on both belt and district scales by ancestral transcrustal structures that are interpreted to have localized, optimized, and sustained magmatic and ore-forming processes. The results highlight a strong magmatic control on metal and in particular Au endowment in VMS systems and indicate that the VMS hydrothermal system was not restricted to a near-surface (~<5 km) convective subseafloor seawater system but is part of a larger vertically extensive but areally localized, deep crustal to mantle magmatic system. Overprinting by ca. 30 m.y. younger orogenic Au deposits suggests that VMS Au enrichment may be a proxy for SCLM Au and base metal enrichment.