Tourmaline: A Fertility Assessment and Vectoring Tool for Magmatic-Hydrothermal Systems

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Tourmaline's occurrence in a wide variety of ore-forming systems makes it a powerful tool for recording the temporal and spatial evolution of hydrothermal fluid compositions. It can provide key information regarding metal fertility and exploration vectoring within a system. We sampled tourmaline-bearing rocks from a diversity of magmatic-hydrothermal systems, including porphyry Cu-Mo and Cu-Au deposits and prospects, tourmaline-rich breccias, granite-related Sn mineralization, Archean Au lodes, metamorphic terrain, pegmatite, and granite batholiths. Analyses of >2,200 individual LA-ICP-MS spots revealed that tourmaline chemistry can discriminate different types of hydrothermal systems and geologic environments. Pegmatite-related tourmaline has extremely high Al, Li, and Pb and low Fe, Mg, and Ti contents, whereas metamorphic tourmaline is characterized by high Mn and Zn and low Y and Ba. High Sr, Ni, and Cr and low Ga and Mn/Zn characterize tourmaline from the Red Lake Archean gold deposit. Tourmaline from granite-related tin systems is characterized by high Al, Fe/Mg, and Sn and low Sr. Tourmalines from porphyry deposits and associated breccias typically have low Fe/Mg and high As, Sb, Sc, V, and Sr. Tourmaline's compositions vary systematically from deep to shallow regions in porphyry-related alteration zones and breccia pipes. Most transition elements in tourmaline commonly increase in concentration with increasing distance from mineralization centers. Arsenic, Sb, Pb, and Sr in tourmaline have their highest concentrations between 1 and 1.5 km from the deposit center, and define geochemical shoulders to the mineralization zones. Several trace elements in tourmaline can be used for fertility assessment to discriminate porphyry deposits from barren batholiths and to distinguish large porphyry deposits from smaller systems. Tourmaline is a new exploration tool that records hypogene low-level geochemical anomalies that assist in vectoring and fertility assessments for magmatic-hydrothermal systems, particularly those associated with porphyry Cu-Mo-Au mineralization.