Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36318

Geochemistry of subalkaline volcanic rocks of the Abitibi Greenstone Belt: classification, petrogenetic modelling and implications for VMS fertility

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A critical challenge for geochemical studies of volcanic rocks from greenstone belts is the variable extent to which their primary signatures can be overprinted by hydrothermal alteration (particularly near metal deposits) and metamorphism. The Abitibi Greenstone Belt (Superior Province, Canada) has a relatively high proportion of supracrustal rocks and rich mineral endowment (such as volcanogenic massive sulphides, VMS). The classification of a dataset of 12,554 volcanic rock samples from all seven of the ~2795 to 2695 Ma subalkaline volcanic assemblages of the Abitibi Greenstone Belt into 3 komatiitic types and 12 mafic to felsic geochemical groups provides a significant opportunity to gain insights into Archean petrogenesis and VMS fertility. These geochemical groups exhibit within-group coherency of trace element patterns and systematic changes in trace element characteristics between groups. Petrologic modelling using the Magma Chamber Simulator demonstrates how various differentiation processes produce the geochemical diversity of the mafic to felsic geochemical groups. The compositional diversity can be explained with two types of mantle-derived parental magmas (tholeiitic and HREE-enriched basalt groups) and different combinations of fractional crystallisation and interaction with crustal components. Crystallisation of basalt magmas at 2-4 kbar and ΔFMQ = 0-2 with 0-1 wt% initial H_2O contents produce compositions from basalts to rhyolites. The basaltic magmas could potentially interact at different pressures with low-Y tonalites (similar to the average of SE Superior Province TTGs), high-Y tonalites or pre-existing tholeiitic basalts via either assimilation fractional crystallisation or simple mixing, resulting in different trajectories through the geochemical groups. Except for the two earliest assemblages, each assemblage has a wide geochemical diversity, with variable proportions of almost all geochemical groups. Nevertheless, relative to the whole Abitibi, the three assemblages most fertile in VMS contain fewer Tholeiitic basalts, HREE-enriched basalts, and HREE-depleted intermediates, and are particularly abundant in Tholeiitic and Transitional dacites and rhyolites and Calc-alkaline rhyolites. Given the petrogenetic modelling, magmatic systems that undergo extensive differentiation are more favourable for VMS formation, but no single geochemical signature or magmatic affinity is an indicator of VMS fertility.