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TRACE ELEMENT GEOCHEMISTRY AND PETROGENESIS OF FELSIC VOLCANIC ROCKS ASSOCIATED WITH VOLCANOGENIC MASSIVE Cu-Zn-Pb SULFIDE DEPOSITS

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Abstract

Volcanogenic massive Cu-Zn-(Pb) sulfide (VMS) deposits occur primarily in subaqueous rift-related environments (e.g., oceanic, fore-arc, arc, back-arc, continental margin, or continental), are hosted primarily by bimodal, mafic-felsic volcanic successions, and are typically associated with felsic volcanic rocks with specific geochemical characteristics. FI alkalic dacites and rhyodacites, despite being abundant in the rock record, are typically barren. Some FII calc-alkalic rhyodacites and rhyolites host VMS deposits, but most are barren. FIII tholeiitic and FIV depleted rhyolites and high silica rhyolites are much less abundant in the rock record but commonly host VMS deposits, regardless of age, and FIII rhyolites appear to host the largest deposits.

Most petrogenetic models proposed for the formation of FII and FIII-FIV felsic volcanic rocks link felsic magma genesis to fractionation processes in high-level magma chambers now represented by associated subvolcanic intrusions, where the magma is also interpreted to have supplied the heat and/or metals required to generate and sustain the VMS-forming convective hydrothermal system. However, the relatively constant compositions of FII and FIII-FIV felsic volcanic rocks within individual areas, the high eruptive temperatures (at or above liquidus) of FIII rhyolites, and the bimodality of VMS-hosting volcanic successions indicate that fractional crystallization within subvolcanic intrusions could not have generated or significantly modified the compositions of FII and FIII-FIV magmas. This, coupled with detailed geological, geochemical, and geochronological studies indicates that many of these subvolcanic intrusions were emplaced in multiple phases and that the later, most voluminous phases often cut ore-associated, hydrothermally altered rocks.

A reassessment of the physical conditions responsible for producing the geochemistry of ore-associated FII and FIII-FIV felsic volcanic rocks and a review of the compositions of felsic volcanic rocks associated with VMS deposits that range in age from Mesoarchean to Cenozoic provide important constraints on models for VMS-associated felsic volcanic rocks and their relationship to mineralization. The compositions of felsic volcanic rocks may be explained by low to moderate degrees of partial melting of mafic sources at a range of depths within rift environments where the mineralogy and composition of the source regions, modes, and degrees of partial melting, pressure and temperature of melting, and, to a lesser extent, subsequent fractionation processes, account for the compositional variations from FI through FII to FIII-FIV. Long-lived, enhanced heat flow and structural permeability of rift environments that allows partial melting to form some FII rhyolites at midcrustal levels (10–15 km) and FIII-FIV rhyolites at shallow crustal levels (<10 km), both within the zone of brittle fracture permeability, are essential to sustain the high-temperature convective hydrothermal systems that are required to form large VMS deposits and camps. Rift environments contain long-lived, thermal, magmatic, and structural corridors that focus magma ascent, heat flow, high-temperature convective hydrothermal systems, and emplacement of subvolcanic intrusions that are favorable environments for the formation of VMS deposits and FII and FIII-FIV felsic volcanic rocks.

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