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Element Fluxes During Alteration in High-sulfidation Epithermal Systems

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The processes involved in the alteration of rocks associated with high-sulfidation epithermal ore deposits, which host significant quantities of gold and silver, cause a large-scale and complex migration of chemical elements. Elements can either be added into the system by magmatic-hydrothermal fluids or mobilized from one alteration facies to another due to the hydrothermal dissolution of minerals in the precursor rock and subsequent re-precipitation as new minerals elsewhere.

In this study, we present an elemental mass transfer analysis of alteration associated with the Pueblo Viejo Au-Ag(-Cu) high-sulfidation deposit, Dominican Republic. The whole-rock chemistry of precursor and variably altered andesite was used to determine the behavior of 64 elements during quartz-alunite, quartz-pyrophyllite, and chlorite-carbonate-kaolinite facies alteration. For high-sulfidation systems, relatively few mass transfer analyses have previously been successfully undertaken due to the difficulty in accurately identifying elements that remain immobile during alteration. This is necessary to remove the effects of significant bulk mass change on whole-rock element concentrations. Elements typically considered to be immobile in other settings where hydrothermal alteration occurs are unsuitable in the high-sulfidation environment, due to the highly acidic fluids responsible for alteration. We show that LREEs are immobile during high-sulfidation-related alteration because of the low stability of LREE complexes in the fluids (lower ionic potential) relative to HREE complexes, and the resultant formation of alteration minerals, such as woodhouseite, which preferentially retain LREEs on a local scale.

The calculated changes in elements during alteration were integrated with changes in mineralogy and mineral chemistry, determined using electron microprobe and laser ablation ICP-MS, to identify the minerals in which elements are hosted in both precursor and altered andesite. Understanding chemical and mineralogical changes that occur during alteration and mineralization provides an insight into the nature of ore-forming fluids and the changes in their physicochemical properties during intense fluid-rock interaction.