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Barium mobility in a geothermal environment, Yellowstone National Park

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Abstract

Ba-rich minerals are frequently observed in epithermal environments and include characteristic phases such as barite and alunite supergroup minerals. At Yellowstone, electron microprobe analysis shows that Ba in the unaltered third-cycle Tuff of Sulphur Creek is largely contained within sanidine phenocrysts (mean 1.60 wt% BaO) with lesser concentrations in plagioclase (mean 0.22 wt% BaO) and volcanic glass (mean 0.05 wt% BaO). Whole-rock XRD analyses of rocks hydrothermally altered by alkaline-chloride fluids at Ridge 7741 in Seven Mile Hole, Yellowstone National Park, show they are dominated by illite + quartz ± hydrothermal feldspar, primarily adularia. In this alteration zone, adularia is the principal phase that contains significant Ba (mean 0.43 wt% BaO). In shallower alteration, dominated by acid-sulfate assemblages, such as kaolinite + opaline silica ± alunite supergroup minerals (alunite, walthierite, huangite) ± barite, Ba is sequestered in the sulfate minerals. Alunite supergroup minerals (mean 1.12 wt% BaO) are more prevalent than barite and are largely found from the modern valley rim to about 60 m below the modern surface, especially around the South Fork of Sulphur Creek. However, nearly 80 m below the modern rim of the Grand Canyon of the Yellowstone River, in areas previously altered by alkaline-chloride fluids, adularia altered to alunite supergroup minerals may contain similar to slightly elevated Ba concentrations relative to the replaced grain. Barite is primarily found sporadically in altered rocks along the valley rim of the South Fork of Sulphur Creek, with rare occurrences along the rim of the Grand Canyon. Despite the hydrothermal alteration, whole-rock XRF and ICP-MS analyses show similar mean concentrations between unaltered (0.11 wt% BaO) and altered (0.09 wt% BaO) Tuff of Sulphur Creek samples. Hydrothermally altered rocks are important sources of Yellowstone low-$\delta^{18}O$ rhyolites, like the Tuff of Sulphur Creek, which inherits their low $\delta^{18}O$ signal from them. Cenozoic rhyolites throughout the North American Cordillera tend to exhibit high Ba concentrations, including the low-$\delta^{18}O$ Yellowstone rhyolites. This work shows that hydrothermal alteration mobilizes Ba in volcanic units with minimal dispersion of Ba out of that unit. The genesis of similar silicic volcanic rocks with elevated Ba, relative to mean upper crustal concentrations, may be the result of partial melting of hydrothermally altered rock.

Keywords: Epithermal, Yellowstone, barium, hydrothermal, alkaline-chloride, acid-sulfate, rhyolite