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Mafic inputs into the rhyolitic magmatic system of the 2.08 Ma Huckleberry Ridge eruption, Yellowstone

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Abstract

The silicic (broadly dacitic to rhyolitic) magmatic systems that feed supereruptions show great diversity, but have in common a role for mafic (broadly basaltic to andesitic) magmas as drivers of the systems. Here we document the mafic component in the rhyolitic magmatic system of the 2.08 Ma Huckleberry Ridge Tuff (HRT), Yellowstone, and compare it to mafic materials erupted prior to and following the HRT eruption in the area within and immediately around its associated caldera. The HRT eruption generated initial fall deposits, then three ignimbrite members A, B, and C, with further fall deposits locally separating B and C. A "scoria" component was previously known from the upper B ignimbrite, but we additionally recognize juvenile mafic material as a sparse component in early A, locally abundant in upper A and sparsely in lower B. It has not been found in the C ignimbrite. In upper B the mafic material is vesicular, black to oxidized red-brown scoria, but at other sites is overwhelmingly non-vesicular, and sparsely porphyritic to aphyric. Despite their contrasting appearances and occurrences, the mafic components form a coherent compositional suite from 49.3–63.3 wt% SiO_2, with high alkalis (Na_2O+K_2O = 4.5–7.3 wt%), high P_2O_5 (0.52–1.80 wt%), and notably high concentrations of both high field strength and large-ion lithophile elements (e.g., Zr = 790–1830 ppm; Ba = 2650–3800 ppm). Coupled with the trace-element data, Sr-Nd-Pb isotopic systematics show influences from Archean age lower crust and lithospheric mantle modified by metasomatism during the late Cretaceous to Eocene, as previously proposed for extensive Eocene magmatism/volcanism around the Yellowstone area. The HRT mafic compositions contrast markedly with the Snake River Plain olivine tholeiites erupted before and after the HRT eruption, but are broadly similar in several respects to the generally small-volume Craters of the Moon-type mafic to intermediate lavas erupted recently just west of the HRT caldera, as well as farther west in their type area. The combination of trace element and isotopic data on the HRT mafics are only consistent with an origin for their parental magma as melts from mantle enriched by high temperature and pressure melts, most likely from the underlying Farallon slab. Subsequent interaction of the HRT mafic magmas occurred with the Archean lower crust and lithospheric mantle, but not the highly radiogenic upper crust in this area. The close temporal and spatial relationships of the HRT mafic compositions and the preceding Snake River Plain olivine tholeiite eruptives suggest a high degree of spatial heterogeneity in the mantle beneath the Yellowstone area during the early (and subsequent) development of its modern magmatic system.

Keywords: Yellowstone, Huckleberry Ridge Tuff, Craters of the Moon, mafic magmas, magma genesis, mantle metasomatism