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Oxygen isotope thermometry reveals high magmatic temperatures and short residence times in Yellowstone and other hot-dry rhyolites compared to cold-wet systems

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Abstract

The eruption and storage temperatures of rhyolitic magmas are critical factors for understanding the mechanisms of their eruption and petrogenesis. Temperatures are particularly important when comparing the magmatic histories of hot-dry rhyolites from the Yellowstone-Snake River Plain (YSRP) and Iceland to cold-wet rhyolites such as the Bishop Tuff. Here we employ mineral pair oxygen isotope fractionations for estimating rhyolite temperatures independent of pressure and other compositional factors. We report high precision oxygen isotope analyses of quartz, pyroxene, magnetite, and zircon that we use to estimate crystallization and storage temperatures. Temperatures for YSRP and Icelandic rhyolites are highest for quartz-magnetite and quartz-clinopyroxene (~950 °C), with lower quartz-zircon (850 °C) temperatures that are similar to estimates of zircon saturation. The magnitude and pattern of these temperatures is consistent with crystallization from near-liquidus rhyolites. In contrast, oxygen isotope temperatures calculated for the Bishop and other "cold-wet" type tuffs define low ~760 °C temperatures for all three mineral pairs consistent with prolonged mineral residence at near-solidus conditions. Preservation of a down-temperature crystallization sequence of hot magnetite and clinopyroxene with colder zircon in hot-dry YSRP and Icelandic rhyolites suggest <1000 yr magma residence, where magnetite does not have sufficient time to diffusively equilibrate oxygen in a lower temperature melt. This is consistent with recently determined high precision U-Pb crystallization ages zircons from the same units indicating magma generation shortly before eruption.

Keywords: Oxygen isotopes, thermometery, magma storage timescales, rhyolites, Yellowstone, Snake River Plain