



A magma reservoir prior to a Yellowstone supereruption: Constraints from the Mount Jackson Rhyolite and the Island Park dome series (Wyoming, USA)

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The Yellowstone volcanic field is one of the largest and best-studied centers of rhyolitic volcanism on Earth. The Mount Jackson rhyolite (MJR) and the Island Park dome (IPD) series represent a less extensively studied collection of rhyolitic lavas which were erupted in the 600,000 years following the second caldera-forming eruption of Yellowstone, the 280 km³ Mesa Falls Tuff (MFT, ~1.29 Ma). We present here an approach of detailed major and trace element compositional analyses of bulk and mineral chemistry coupled with high-resolution ⁴⁰Ar/³⁹Ar-dating to examine the evolution within the magmatic system that culminated in Yellowstone's last 'super' eruption, the 1,000 km³ Lava Creek Tuff (~0.64 Ma).

The studied lavas are high-silica rhyolites and contain sanidine (~15‰), quartz (~10‰) and minor plagioclase, plus variable amounts of mafic minerals (<4‰) such as augite, orthopyroxene and abundant Fe-Ti-oxides (magnetite and minor ilmenite). In some units amphibole and fayalitic olivine make up a considerable fraction of the mafic mineral assemblage (~60‰ for amphibole, ~25‰ for olivine) and even occur in the same units. Biotite, allanite, chevkinite and zircon are present as accessory phases. Plagioclase is rare as single crystals but occurs together with pyroxene and Fe-Ti-oxides in crystal-rich aggregates lacking sanidine and quartz.

CL imaging of quartz crystals and associated measurements of Ti-in-Qtz via LA-ICP-MS and EPM show variable CL brightness distributions and Ti contents (35-193 ppm). Ti-in-Qtz thermometry paired with Zr-saturation and Cpx-Opx geothermometry reveal high temperatures and a complex thermal history within each unit (~800-900°C) but without major resolvable differences between them, suggesting that crystals are derived from multiple sources. Pb-isotopes in sanidine (²⁰⁸Pb/²⁰⁶Pb 2.216-2.231, ²⁰⁷Pb/²⁰⁶Pb 0.899-0.904) and δ¹⁸O-analyses on both quartz (δ¹⁸O 4.52-6.54‰) and sanidine crystals (δ¹⁸O 4.85-6.43‰) reveal only slight differences between MJR and IPD and moderately low δ¹⁸O-values show only minor assimilation of hydrothermally altered material, consistent with previous models. However, the diversity of δ¹⁸O-values, the disequilibrium assemblage of mafic minerals and the complex temperature record imply substantial crystal recycling. A suspicious scarcity of mafic minerals and plagioclase as free phenocrysts in some units and their occurrence in crystal aggregates with cumulate characteristics suggest efficient melt removal and accumulation in pockets within an upper crustal mush zone. This is supported by REE patterns in bulk rock and glass compositions indicating significant plagioclase fractionation. The similarities between units suggest that the process of melt extraction and crystal recycling from cumulate walls following periodic recharge occurs recurrently in the Yellowstone area.