Mineral-scale magma generation: Insights from rhyolite lavas prior to last Yellowstone supereruption

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The Island Park-Mount Jackson (IPMJ) series represents a suite of rhyolitic lavas erupted effusively between Yellowstone's last explosive eruptions, the Mesa Falls Tuff at ~1.2 Ma and the Lava Creek Tuff (LCT) at ~0.6 Ma. These lavas are still insufficiently studied and provide a unique window into processes acting on the magmatic reservoir prior to the subsequent super eruption. This study reports whole rock and mineral compositional analyses, $\delta^{18}O$ for quartz and sanidine and Pb isotopes for sanidine coupled with Ar/Ar-dating on sanidine and U-Pb dating on zircon.

The studied lavas are high-silica rhyolites containing abundant sanidine and quartz with lesser amounts of plagioclase, Fe-Ti oxides and mafic minerals such as augite ± orthopyroxene and fayalite. Ar/Ar ages suggest that both rhyolite series overlap by ~66 ka and that volcanism occurs in unevenly distributed clusters over the entire area of the volcanic field. Mildly depleted $\delta^{18}O$ values ($\delta^{18}O_{melt}$ +4.8 to +5.5‰) for early postcaldera units suggest minor involvement of hydrothermally altered materials compared to the post-LCT record. Depletions in $\delta^{18}O$ are accompanied by increased mineral variability and the occurrence of hydrous minerals such as amphibole and biotite, indicating an increased recycling component. The common occurrence of non-eruption Ar/Ar-ages in sanidines as well as the inter-crystal O isotopic variability require crystal entrainment on a timescale of months to years prior to eruption.

Mafic minerals and plagioclase are rare as free phenocrysts but occur concentrated in glomerocrysts lacking sanidine and quartz. Compared to bulk compositions the lack of silicic components such as sanidine, quartz and melt results in more mafic "bulk" compositions of the glomerocrysts. These crystal-rich aggregates are interpreted as cumulates remaining after late-stage extraction of liquid from a crystal-rich mush. Following extraction, quartz grew over timescales of ~10,000 years which are in agreement with zircon geochronology studies. Combined our data suggests complex open system magma generation in a long-lived upper crustal mush zone with localized remelting during the IPMJ period.