Hf isotopes in zircon: Implications for magma evolution at Long Valley

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Hf isotope measurements of zircon and whole rocks for 2 pre-caldera rhyolites, 3 pumice fragments from the Bishop Tuff (BT), and 3 post-caldera rhyolites help us better address magma processes at Long Valley, a large caldera complex. The Hf isotope record coupled with an improved Ar/Ar geochronology provides direct evidence about the isotopic signatures of magmas from which the rhyolites originated and the tempo of the source evolution leading up to and immediately after caldera collapse. High precision (±0.2 epsilon) Hf isotopic analyses of 8 single (~10 μg) and 40 groups (n=2 to 20) of size-sorted smaller (≤4.0 to ~0.3 μg) zircons were measured by MC-ICPMS along with their respective whole rocks. All studied rhyolites contain zircons with variable $^{176}Hf/^{177}Hf$ values (~1 to 3 ε_{Hf} unit variations). Yet, most zircons in the rhyolites record Hf isotopic compositions that imply a secular increase in ε_{Hf} over time mirroring the change exhibited by their respective whole rocks (a shift in $^{176}Hf/^{177}Hf$ from 0.28276 to 0.28284). The exception is the BT, which has more radiogenic Hf (i.e. a greater mantle component) than the pre- and post-dating rhyolites. The oldest post-caldera rhyolite (~702 ka) and pre-caldera rhyolite OD (~1712 ka) have zircons with $^{176}Hf/^{177}Hf$ values equal to or lower than their inferred melts (i.e. whole rocks) by up to ~3 ε_{Hf} units. Whereas younger post-caldera rhyolites (~570 ka and ~333 ka) contain zircons with more primitive compositions (i.e. higher ε_{Hf}) than their respective whole rocks. Most zircon from the ~780 ka BT have $^{176}Hf/^{177}Hf$ values equal to or lower than the host pumice. Several zircons from the late erupted BT exhibit values up to ~1 ε_{Hf} unit higher than the pumice. The BT also contains rare xenocrystic zircon ($^{176}Hf/^{177}Hf$ = 0.28256) originating from its Mesozoic host rock. The >2.5 epsilon increase in $^{176}Hf/^{177}Hf$ between pre-caldera and younger rhyolites is consistent with shifts seen in whole rock Nd isotopes. In contrast to pre-caldera rhyolites, the secular increases in ε_{Hf} and ε_{Nd} of post-caldera rhyolites appear uncorrelated with eruption size and imply a new generation of rhyolitic magmas with significantly less crustal assimilation. The decreasing crustal signature recorded by zircon and whole rock Hf isotopes may result from prior rhyolite melt generation that would have preferentially depleted, low melting temperature, silica-rich regions of the crust.

Relationship between water and hydrogen isotopes in mantle end-members

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Characterizing the relationship between volatile dehydration and stable isotopic fraction during subduction is critical to understanding the generation of mantle heterogeneity through recycling of subducted lithosphere into the deep mantle.

Previous work shows systematic correlations between volatile concentrations and radiogenic isotopic tracers of enriched mantle sources. For example, 'damp' EM-type sources have been shown to be drier (lower concentrations of H_2O and lower H_2O/Ce) relative to 'wet' HIMU/FOZO-type sources, consistent with the hypothesis that EM-type sources are more dehydrated than HIMU/FOZO-type sources. Existing δD data for submarine glasses also correlate systematically with trace element ratios and radiogenic isotopes implying systematic differences between HIMU, EM and DMM mantle components (Fig. 1). Enriched 'wet' HIMU/FOZO end-members have δD values (-30 to -40‰) significantly heavier than MORB. EM 'damp' end-members have δD values (~-65‰) lighter than HIMU/FOZO end-members, but still heavier than MORB (-80 ± 10‰). We will present new δD on FAZAR (MAR 33° to 41°N) glasses to test this proposed variation of δD values in oceanic basalts, and to investigate how these differences relate to recycling of volatiles.