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SPECIAL COLLECTION: PERSPECTIVES ON ORIGINS AND EVOLUTION OF CRUSTAL MAGMAS

Hafnium, oxygen, neodymium, strontium, and lead isotopic constraints on magmatic evolution of the supereruptive southern Black Mountains volcanic center, Arizona, U.S.A.: A combined LASS zircon–whole-rock study

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Abstract

The >700 km^3 Peach Spring Tuff (PST), erupted at 18.8 Ma from the Silver Creek caldera in the southern Black Mountains volcanic center (SBMVC) of western Arizona, is the only supereruption-scale ignimbrite in the northern Colorado River Extensional Corridor. The SBMVC contains pre- and post-caldera volcanic rocks and caldera-related intrusions (~19–17 Ma) that provide a detailed petrologic record of ignimbrite antecedence and aftermath.

Whole-rock Sr-Nd-Pb-Hf isotopic data combined with complementary zircon O and Hf isotopic data from a suite of pre- through post-PST samples provide robust constraints on (1) how the SBMVC evolved with respect to magmatic sources and processes throughout its ~2 Ma history and (2) the petrogenetic relationships between the PST and slightly younger intracaldera plutons. Both pre- and post-PST units have isotopic ranges (ε_{Nd} = –8.3 to –11.6, ε_{Hf} = –8.2 to –14.0, $^{87}Sr/^{86}Sr_i$ = 0.709–0.712; $^{206}Pb/^{204}Pb$ = 18.19–18.49, $^{207}Pb/^{204}Pb$ = 15.60–15.62, $^{208}Pb/^{204}Pb$ = 38.95–39.29) that fall within the spectrum of Miocene Colorado River Extensional Corridor rocks and are consistent with mixing of substantial fractions of Proterozoic (Mojave) crust and juvenile material derived from regional enriched mantle. Compared to the PST, which has relatively uniform isotopic ratios (ε_{Nd} = –11.4 to –11.7, ε_{Hf} = –13.8 to –14.3, $^{87}Sr/^{86}Sr_i$ = 0.709–0.712; $^{206}Pb/^{204}Pb$ = 18.20–18.29, $^{207}Pb/^{204}Pb$ = 15.60–15.62, $^{208}Pb/^{204}Pb$ = 39.02–39.33), individual pre- and post-PST units are isotopically more variable and generally more primitive.

Consistent with whole-rock isotopes, zircon ε_{Hf} (–8 to –14) and oxygen $\delta^{18}O$ (+4.5 to +7.2‰) for most pre- and post-PST units also have wider ranges and more mantle-like values than those of the PST (–12 to –15, +6.1 to +7.1‰). Moreover, zircon isotopic compositions decrease in post-PST samples. A few zircons from post-PST intrusions have $\delta^{18}O$ values lower than mantle values (<+5‰), suggesting incorporation of hydrothermally altered rock.

Whole-rock and zircon elemental and isotopic analyses indicate that (1) most pre- and post-PST units are less evolved and less homogenized than the PST itself; (2) intrusions in the Silver Creek caldera are petrogenetically distinct from the PST and therefore represent discrete magmatic pulses, not unerupted PST mush; (3) enriched mantle input increased in the SBMVC following the paroxysmal PST eruption; (4) post-PST history of the SBMVC was characterized by periodic influx of magmas with varying juvenile fractions into pre-existing mushy or solidified intrusions, resulting in variable and incomplete hybridization; and (5) melting and assimilation of hydrothermally altered crust played a relatively minor role in the generation and evolution of magmas in the SBMVC.

Keywords: Volcanic center, petrogenesis, zircon, oxygen isotopes, Sr isotopes, Hf isotopes, Nd isotopes, Pb isotopes, supereruption