Oxygen isotope and U-Pb insights into dynamics and longevity of large silicic magma systems

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Microscale (laser fluorination and SIMS) studies of oxygen isotopes in phenocrysts from large silicic magma systems are combined with studies of gradients of trace element concentrations in phenocrysts, crystal size distributions, and in situ U-Pb dating of zircons by SHRIMP. We present and review data from 3 young and large silicic magma systems: Yellowstone; Long Valley, California; and Timber Mountain, Nevada. A variety of timescales and mechanisms result from these studies. Crystal zoning with respect to trace elements and $\delta^{18}O$, and CSD of quartz and zircons extracted from individual pumice clasts of stratigraphically-controlled Bishop Tuff, Lava Creek Tuff, Timber Mountain Tuffs and intracaldera lavas are consistent with short residence (10^3 -10^4 years). Remarkable (±0.1‰) oxygen isotope homogeneity in >650 km^3 Bishop Tuff and several other large-volume magma systems require long (10^5-10^6 years) magma residence and is in accord with published Rb-Sr data on system longevity. Sidewall crystallization and long residence of crystal mush, that is periodically reactivated and reset by new influx of hotter more mafic magmas from below, is favored as a mechanism to reconcile the dichotonomy of timescales in large silicic magma chambers. Sidewall residence of a three-phase mixture (phenocrysts+gas+fluid) explains variable $\delta^{18}O$ and $^{87}Sr/^{86}Sr(i)$ values of phenocrysts due to exchange with wallrocks of variable lithology. Inheritance of precaldera zircons and quartz characterized smaller low-$\delta^{18}O$ intracaldera magma bodies of Yellowstone, and voluminous (>1000 km^3), compositionally zoned low-$\delta^{18}O$ Ammonia Tanks Tuff and smaller volume lavas of Timber Mountain caldera complex. Short generation times (10^2-10^4 years) are required and the mechanism includes rapid bulk melting of precaldera volcanic rocks. In all studied low-$\delta^{18}O$ units most crystals are xenocrysts, zircons and quartz preserve $\delta^{18}O$ zoning, and most zircons contain 0.1 to 2.1 My older inherited cores. We review the relative role of volcanic recycling in caldera complexes and how this process can be reconciled with magma production rates and heat balance.

Molybdenite Re-Os dating of biotite dehydration melting: the Rogaland granulites, S Norway

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The ability of the Re–Os system in molybdenite to record and preserve the age of granulite-facies metamorphism is tested using the small Ørsdalen W-Mo deposit, Rogaland, S Norway. A HT to UHT granulite-facies domain is exposed around the 931 ± 2 Ma Rogaland anorthosite complex. A contact metamorphism overprinted a 1025–970 Ma regional metamorphism. The Ørsdalen deposit consists of several prospects distributed along two layers of biotite gneiss and amphibolite. The Mjåvassknuten prospect is specifically linked to a lens of dark Bt-rich, Grt-granulite (Mg# = 0.4) containing Mag, Ilm and Po. Molybdenite occurs in and around deformed Opx ± Grt leucocratic veins, interpreted as migmatic leucosomes formed by fluid-absent melting of biotite, based on partial melting experiments by Patiño Douce and Beard (1996) at $f(O_2) \leq$ QFM. Molybdenum, likely hosted in Bt, Mag and Ilm in the protolith, probably precipitated as residual molybdenite coeval with residual Opx and Grt. Three molybdenite samples collected at the Mjåvassknuten and Stopulen prospects were dated using Re–Os (Stein et al. 2001). Four model ages overlap at the 2 sigma level of uncertainty. The four data points provide a Model 3 isochron age of 973 ± 4 Ma including the zero point. The isochroneity of the results indicates that the data record widespread precipitation of molybdenite during biotite fluid-absent melting at 973 ± 4 Ma. It demonstrates regional granulite-facies metamorphism before intrusion of the anorthosites, and also the robustness of the Re-Os system in molybdenite through the HT thermal overprint (which corresponds to development of Grt coronas in the deposit).

Patiño Douce A. E. and Beard J. S. (1996). *Journal of Petrology* **37**, 999–1024.

Stein H. J., Markey R. J., Morgan J. W., Hannah J. L., and Scherstén A. (2001) *Terra Nova* **13**, 479–486.