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Oxygen isotope geochemistry of the Sierra Nevada batholith, CA, USA

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The Mesozoic Sierra Nevada batholith (SNB), California, USA, formed during the subduction of oceanic crust beneath western North America and is a classic example of a continental convergent margin batholith. Tracking the spatial and temporal variation in geochemistry of the SNB allows an understanding of crustal growth and recycling, as these changes record diverse interactions of crust and mantle reservoirs.

Oxygen isotopes are particularly useful for identifying input of supracrustal rocks into arc magmas. Ongoing research in the SNB has focused on mapping the temporal and 3-D spatial distribution of $\delta^{18}O$[1-3]. To avoid alteration effects, $\delta^{18}O$ of zircon (Zc) is analyzed, which provides the most reliable record of magmatic $\delta^{18}O$[4]. Over the life of the SNB, the volume of successive magmatic pulses increased as did the range of $\delta^{18}O$(Zc) values: Triassic (5.5–8‰, n=13 samples), Jurassic (4.8–8.0‰ n=27); Cretaceous (4.7–9.5‰, n=285). Equivalent whole rock $\delta^{18}O$ values are 6.5–10‰, 5.8–10.0‰, 5.7–11.5‰, respectively. "S-type" $\delta^{18}O$(Zc) values (>8‰) are only found in Cretaceous rocks (11% of samples) and indicate greater input of supracrustal rocks.

Many high-$\delta^{18}O$(Zc) values (>7.0‰) are found in western SNB gabbros, diorites, quartz diorites and tonalites. The western SNB is underlain by Paleozoic-Mesozoic accreted oceanic crust (initial $^{87}Sr/^{86}Sr$ (Sr_i) < 0.706), and previous studies considered Western SNB plutons to be mostly mantle derived and primitive. However, high $\delta^{18}O$(Zc) values indicate that mantle-derived rocks, which were previously hydrothermally altered at or near Earth's surface (e.g., subducted ocean crust, volcanic arc sediments), were a major component of western SNB magmas. Lower $\delta^{18}O$ values (5–7‰) in the eastern SNB (including Sierra Crest plutons), with Sr_i values >0.706, are consistent with magma generation from Proterozoic lithospheric mantle, e.g., [5], with limited input of high-$\delta^{18}O$ metasediments. The highest $\delta^{18}O$(Zc) values in the SNB (7-9.5‰) occur in middle and lower crust rocks in the southern SNB, which indicate the batholith is zoned vertically, as well as laterally, in $\delta^{18}O$.

While metamorphic wallrocks are abundant in the middle and upper crust of the SNB, incorporation of these rocks into SNB magmas was limited; instead, $\delta^{18}O$(Zc) reveals complex magma interaction with heterogeneous reservoirs in the lower crust and lithospheric mantle.

References

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Oxygen isotopes in garnets from pelitic migmatites

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Oxygen isotopes (^{16}O and ^{18}O) in garnet were analysed with a spatial resolution of 15 micron using a Cameca 1270 ion probe at the NORDSIM facility in Stockholm, Sweden and double Faraday cup collection. External reproducibility of the UWG-2 garnet [1] varied between 0.5 and 1 per mil (2σ) for the different analytical sessions.

The analysed garnets are situated in the mesosome, melanosome and leucosome of the same psammopelitic, stromatic migmatite sample from the Turku granulite facies area in SW Finland. They enclose quartz, biotite and cordierite + accessories. The garnets have grown during near isobaric heating from ca. 700-800 °C at 6-7 kbar [2].

Slabs of garnet were cut and mounted in epoxy. Preliminary results show $\delta^{18}O$ SMOW variations of up to 7 per mil (2σ ~0.5 to 1.4‰) between core and rim regions of the garnets. The largest variations can be seen in the mesosome and leucosome garnets and the smallest in the melanosome garnet. Generally $\delta^{18}O$ SMOW decreases towards the garnet rims, opposite to what would be expected during prograde garnet growth by dehydration reactions in a closed system [3]. Decreasing trends in a closed system can occur in garnets growing during cooling [4]. However, the change in our samples appears too large for a closed system. Jumps in the trends suggest that the garnets may consist of aggregates and have not uniformly grown from one centre. Local compositions deviating from the general trends may be due to small inclusions and by minor retrogression at the garnet rims.

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