Preservation of chemical and isotopic inheritance in allanite during protracted Alpine melting

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The response of allanite to incipient melting was investigated in a systematic study of migmatites from the Tertiary Barrovian-type sequence of the Central Alps.

Inheritance and new metamorphic growth were recorded in complex allanite grains sampled from country rocks and leucosomes. Ion microprobe dating of high La/Lu and Th/U allanite cores exclusive to country rocks yielded pre-Alpine ages consistent with magmatic crystallisation dating protolith intrusion. In contrast, Alpine ages ranging between ~30 and 23 Ma, were measured from overgrowths and new grains in country rocks and leucosomes; these date allanite formation during the Barrovian event.

The common inheritance of Permian allanite cores attests to minimal Pb diffusion in this mineral for the duration of Alpine melting at upper amphibolite facies conditions, i.e. ~7 million years above 650°C. In migmatite samples where zircon had rare or limited metamorphic overgrowths, allanite recorded the Alpine event more readily than zircon. This indicates that even in the presence of melt, allanite and zircon may respond differently. The U-Th-Pb system in allanite therefore presents a robust and complementary approach to zircon for dating low-temperature melt processes, where the preservation of allanite is aided by low LREE solubility in the anatectic melts [1].

The new ages obtained from allanite formed in leucosome indicate that the Alpine melting regime was protracted over several million years and later than previously accepted. Combined with previous data, the prolonged high-T evolution down to ~23 Ma requires a subsequent period of fast cooling on the order of 100°C/Ma for the southernmost part of the Central Alps.

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Hydrosphere-crust interactions: Constraints from stable ssotopes, tectonics and the rock cycle

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The oxygen and hydrogen isotope composition of the oceans anchors the meteoric water cycle, the key to semi-quantatively intepreting paleoclimate. The competition between subaerial chemical weathering and hydrothermal interactions on the seafloor control the oxygen and strontium isotopic composition of the oceans. The existence of water and near surface igneous activity insures that the long term carbon cycle prevents an atmosphere dominated by CO_2 due to the retrograde solubility of carbonate minerals moderating the atmospheric greenhouse [1]. The existence of submarine pillow lavas deposited on Early Archean continental crust (e.g. the Pilbara) is direct evidence of the stability of liquid water on the surface and the existence of oceans. The predominance of continental marine sediments formed in the epicontinental seas as recorded stratigraphically for all eons [e.g 2], including the clastic-starved sediments common in Archean greenstone belts (chert association), suggests that spreading rates are currently near geologic minima. The time constants [3] (100's million years) for the buffering of seawater $^{18}O/^{16}O$ ratios suggest that the oceans were fully formed prior to the Archean. The predominance of ^{18}O-enriched greenstones relative to primary MORB all through Earth history [4] require that the ridge flux dominate the oxygen isotope composition of the oceans for most of Earth history. For the ridge flux to buffer the oceans in a water world with suppressed subaerial weathering, complementary high temperature and low temperature exchanged reservoirs must balance over times short compared to the characteristic oxygen isotope exchange times of ~100 Myr for the oceanic crust. Because the thickness of oceanic crust (plagioclase-bearing rocks) is robust against spreading rates that vary over an order of magnitude, this ^{18}O-buffering of the oceans requires modern-style plate tectonics very early in Earth history.

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