New insights into granite genesis from isotopic and REE micro-analyses of zircons: the Scottish Caledonian Granites

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Granitic rocks provide an important window into the nature and evolution of the Earth's crust and upper mantle. Most granites involve more than one source. Thus, geochemical and isotopic studies of whole-rocks and mineral separates average or lose information, potentially leading to incorrect interpretations of granite sources and evolution.

Zircon is ubiquitous in granitic rocks, and preserves a robust record of the ages, sources, magmatic evolution and crustal interaction of granitic magmas. This record can be accessed at the intra- and inter-grain scale by integrating SEM imaging with SIMS (U-Pb dating, $\delta^{18}O$, REE), LA-ICP-MS (Hf isotopes) and EPMA. SIMS analyses can be made on the same ~20µm analysis spot in different components (growth zones, inherited cores) of single zircon crystals. Integrating these micro-analytical techniques provides unique new insights into the genesis and evolution of granitic rocks.

This study applies these techniques to selected I- (igneous precursor) and S- (sedimentary precursor) type granites of the Scottish Grampian Highlands, a classic suite of syn- and post-orogenic (Caledonian) granites. The main focus is on two I-type granites, Lochnagar and Etive, which show contrasting whole-rock isotope and geochemical characteristics that point to sources of significantly different age and/or composition.
Crystallisation ages, crustal residence ages, tectonic setting, magma sources, and relative mantle and crustal contributions are being examined by combined U-Pb geochronology, REE/trace element analysis, and O and Hf isotope analysis of zircon from the sampled plutons. First results show that neither the I-type nor the S-type granite zircons have a dominantly mantle-like ($\delta^{18}O$ (Zrc)=5.3‰) composition; in each case more than one magma source is indicated. Zircons in S-type granites have $\delta^{18}O$ (4.5-13.5‰), requiring a large mantle-derived component, and U-Pb ages of inherited cores that match those of detrital zircon in local (Neoproterozoic) metasediments.