A coupled Lu-Hf and O isotope in zircon approach to granite genesis

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Metaluminous granitic rocks are typically the most voluminous constituents of plutonic belts, irrespective of age or tectonic setting. It is virtually axiomatic that these derive from unweathered 'infracrustal' sources, such an accreted mafic underplate, in contrast to peraluminous granites that are assigned metasedimentary or 'supracrustal' protoliths. This notion has given rise to the I- and S-type paradigm that pervades the literature and forms the cornerstone for petrogenetic models involving granites. Yet, several lines of evidence point to the involvement of both sedimentary materials *and* juvenile mantle-derived liquids in hornblende granite genesis, degrading the I-type status. Quantification of these components is essential for understanding the processes of magmatic differentiation, and formulating realistic models for the thermal and compositional evolution of the continental crust. This aim is greatly hampered by the ambiguities with interpreting whole-rock isotope data, which registers the final state of the magmatic system but gives no information on the pathways by which this state was attained.

One way to resolve this problem is by unravelling the isotopic information encoded within the fine-scale growth zoning of minerals such as zircon, which potentially tracks the processes operative during crystallisation. A radiogenic-stable isotope pair is most advantageous, since this approach is uniquely capable of diagnosing a sedimentary source component. To this end we report a laser-ablation ICP-MS and SIMS study into the Hf and O isotope stratigraphy of magmatic and inherited zircons hosted by the classic I-type granites of the Lachlan Fold Belt (SE Australia). All grains were previously dated by U-Pb SIMS analysis. The Hf-O isotope systematics suggest that current ideas on the formation of these granites require revision. Many plutons derive from protoliths that had experienced a prior low temperature history and/or incorporated a sedimentary ingredient. Furthermore, covariation between εHf and $\delta^{18}O$ and certain trace elements can only be reconciled by open system behaviour during crystallisation, although in detail this differed between suites. Models for the generation of the Lachlan I-types based on these data shall be presented, together with implications for crustal differentiation processes along the palaeo-Gondwana margin.

'Restitic' quartz and its melt inclusions: A record of assimilation/melting processes

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Assimilation/melting is a major differentiation mechanism in magmas. However, it is often difficult to determine the assimilated or melted end-members from whole rock compositions because the characteristics of the end-members are diluted. For the 26.5 ka Oruanui eruption at Taupo volcano, New Zealand, we have discovered evidence for 'restitic' quartz with melt inclusions. The inclusion compositions help constrain the nature of some end-members.

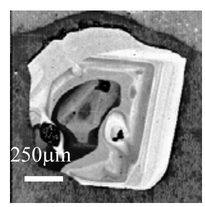

Fig. 1. CL image of restitic quartz.

The Oruanui eruption released ~530 km^3 of rhyolitic magma. Cathodoluminescence (CL) images of quartz reveal jagged 'restitic' cores with moderate CL intensity and oscillatory zoning mantled by dark CL zones (Fig. 1). The oscillatory zoning is a common feature in igneous quartz [2]. The 'restitic' quartz grains were plausibly formed by resorption/partial melting of xenocrysts/antecrysts (rather than fragmentation of quartz phenocrysts) because of their jagged shapes and because the dark CL zone suggests lower temperatures of formation [3]. Melt inclusions in the 'restitic' quartz show a negative correlation of Ba with Rb, suggesting the presence of Ba-rich minerals (particularly sanidine) in the associated assemblage. However, sanidine is absent from the <60 ka eruptives at Taupo and only common in ignimbrites erupted from an overlapping center at 320-340 ka. The contrast between the inferred mineral assemblage and that of Oraunui suggests that the jagged quartz cores are indeed restitic.

References

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