Insights into crustal anatexis from zircon-garnet REE behaviour

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Studies of the REE behaviour of zircon and garnet during high-grade metamorphism and anatexis have shown that the compositions of these minerals are sensitive to fluctuations in coexisting melt compositions and therefore to the timing of individual mineral growth relative to melt evolution. Zircon-garnet REE distribution behaviour is therefore critical to not only dating partial melting, but also to the assessment of the effects of melt generation, migration, drainage and recharge in migmatites within the deep crust.

A detailed study has been carried out on superbly exposed pelitic migmatites from the Brattstrand Bluffs, Prydz Bay, east Antarctica. The pelites underwent biotite-controlled vapour-absent partial melting at metamorphic conditions of ~6 kbar and ~860°C. Melting resulted in production of semi-restitic to restitic Sil-Spl-Grt melanosome and segregation of quartzofeldspathic leucosome with variable abundances of entrained residue. Transport of partial melts occurred on a range of scales, from a few centimetres to beyond 100m. Field observations suggest that some melt was still mobile during deformation assocated with post-peak decompression.

Zircon, which is concentrated both within restitic melansome and along contacts between leucosome and melansome, was analysed in-situ along with garnet for REE and other key trace and major element data. Zircon and garnet REE patterns and partitioning data suggest that growth of new zircon on corroded detrital grains occurred in equilibrium with peritectic garnet in the melanosome. Similar REE evidence indicates that zircon present in larger melt accumulations and veins most likely grew at the site of melting before being extracted, to variable degrees, along with the melt. Integration of our field and thin section observations with mineral REE data leads to the general conclusion that zircon growth in migmatitic granulites predominantly occurs early in the progression of partial melting, at close to peak conditions. In contrast late zircon growth during post-peak decompression and cooling is limited.

Tracing the lost arcs: Granitic zircon as a geodynamic indicator?

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Subduction-related magmatism has long been acribed a central role in the generation of Earth's continental crust, based in part on modern arc analogues. Yet, radiogenic isotope evidence implies that much of the present-day continental mass formed early in Earth history, and attempts to understand the geodynamic drivers are hampered by fragmentary preservation of ancient geological terranes. Recent studies have exploited the detrital zircon archive to chart the growth of crustal segments and even to infer Hadean subduction [1], but whether zircon-derived isotope information can reliably diagnose tectonic setting remains unknown.

We address this issue with reference to two case studies of areas formed in subduction-related settings, the Paleozoic Tasman Orogenic Belt of Eastern Australia, and the Cenozoic Hidaka Metamorphic Belt of Hokkaido, Japan. The Tasmanides preserve the record of 300 Myrs of accretionary tectonic processes outboard of the eastern Gondwana cratonic margin. Geological evidence argues that the voluminous and diverse granites of the Tasmanides formed behind a long-lived, retreating subduction system that was punctuated by episodic contraction. Isotopic data confirms the involvement of multiple source materials in granite genesis, the nature and proportion of which changed with time. The Hidaka belt comprises a remarkably complete arc sequence that encompasses upper mantle to shallow crustal depths. Formed in a trench-proximal position adjacent to the Eurasian margin, the Hidaka belt evolved from a continental arc to oceanic back arc realm with the opening of the Japan Sea at 25 Ma, prior to exhumation during collision between the Japan and Kuril arcs. Granitic rocks are abundant at all crustal levels.

We examine the micro-isotopic (U-Th-Pb, $^{18}O/^{16}O$, Lu-Hf) systematics of granite-hosted zircon from both areas to deconvolve the magma sources as a function of tectonic evolution, and for the Hidaka, crustal depth. The goal is to capture the 'signature' of crustal growth and reworking in these arc settings from a zircon perspective, and thus to place the zircon record into a geodynamic context. We will explore the extent to which this signature manifests in isotope arrays generated from old zircons, and discuss the implications for the tectonic mode of crustal growth in ancient orogens.

References

[1] Harrison T.M. *et al.* (2005) *Science* **310**, 1947-1950.