Characterization of magma from inclusions in zircon: Apatite and biotite work well, feldspar less so

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Detrital zircon grains are frequently employed to decipher sediment provenances and crustal evolution throughout Earth history, and they provide unique evidence of Hadean crust-mantle differentiation. However, interpretation of detrital zircon is hampered by the remarkably restricted range of geochemical characteristics of zircon derived from a range of igneous source rocks. Mineral inclusions in zircon are an underexploited resource and provide valuable additional petrologic information on the condition under which zircon crystallised. Zircon grains from a range of plutonic rocks (diorite-monzonite-granite sequence) contain inclusions of apatite and mafic phases (biotite, amphibole, pyroxenes) which accurately reflect the chemical compositions of the equivalent phases in the matrix of the host rocks. Chemical characteristics of the inclusions, such as Mg/Fe ratios of mafic phases, and Sr abundances in apatite, correlate well with the compositions of the whole rocks. High concentrations of Y_2O_3 (>0.4 wt%) and low concentrations of SrO (<0.02 wt%) in apatite inclusions in zircon are diagnostic of evolved, felsic granitoid host rocks. In strong contrast, the relative abundances and compositions of plagioclase and alkali feldspar inclusions in zircon are decoupled from the composition of the whole rock, and are generally indicative of chemically evolved, granitic melts, regardless of the bulk rock composition. This is best explained by the late crystallization of zircon relative to the bulk of the feldspars.

We conclude that inclusions of apatite and mafic phases in zircon constrain the potential source rocks of detrital zircon, whereas feldspar inclusions do not. This ability to differentiate between grains from primitive and evolved sources has important applications to the interpretation of Hadean zircons.

Secular trends in granite zircon εHf–δ^{18}O, Australian Tasmanides

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The possible role of arc/back-arc accretionary processes in generating continental crust has recently been highlighted [1]. In this context, it has been argued that the Phanerozoic Tasmanides (~3000 x 6000 km) comprising the eastern third of the Australian continent formed during repeated opening and closing of sediment-filled back-arc basins triggered by alternating slab rollback and advances in a long-lived Cambrian to Triassic subduction system [2]. Kemp *et al.* [3] attempted to correlate additions of newly formed juvenile crust to the Tasmanide igneous rocks with the pattern of deformational/tectonic events during three orogenies (Delamerian, Lachlan, New England) using isotope signatures (whole rock Nd, zircon U/Pb, Hf and O). They proposed S-type granite emplacement in thickened crust followed by increasing juvenile contributions during back-arc rifting. The limited data set did not fully define the long-term Tasmanide isotopic trend, however, and few data represented the key Carboniferous event between the main crust forming episodes in the Lachlan (LFB) and New England (NEO) orogens.

New zircon U-Pb, Hf and O isotopic data from Carboniferous-Early Triassic granites in the LFB and NEO have been used to test the Kemp *et al.* [3] tectonic model. The I-type LFB Carboniferous granites show a trend from juvenile to more crustal (higher) $\delta^{18}O_{Zrn}$ with time, but a step from strongly to weakly positive εHf (t). Permian S-type granites of the NEO have very high, crustal $\delta^{18}O_{Zrn}$, but uniformally moderately positive εHf (t). Most analysed NEO I-type granites have moderate $\delta^{18}O_{Zrn}$, except for the oldest, in which the range of $\delta^{18}O_{Zrn}$ is similar to that in the LFB S-types. All have moderately to strongly positive εHf (t).

The zircon Hf and O isotopic compositions in the post-Devonian granites of the LFB and NEO are decoupled. Further, emplacement of the NEO S-type granites did not coincide with any recognised deformation episode. These features are not consistent with current models of arc/back-arc accretion.

[1] Cawood & Buchan (2007) *Earth Sci. Rev.* **82**, 217–256.
[2] Collins & Richards (2008) *Geology* **36**, 559–562.
[3] Kemp *et al.* (2009) *EPSL*, **284**, 455–466.