Insights into lower crustal evolution from Hf isotope and Zr thermometry data for rutile

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Chemical and isotopic analysis of minerals previously resident deep in the crust provides critical information towards understanding the formation, evolution and differentiation of the continental crust. Rutile is an accessory mineral in many lower crustal metapelites and is an appealing target for such studies, but its full potential has not yet been exploited. While the ability to measure Hf isotopes in rutile has been demonstrated [1], an understanding of the behaviour of this system in rutile at high temperatures is lacking. Hf isotope information for this mineral can be combined with temperatures determined by Zr-in-rutile thermometry.

In this study, the classic lower crustal section of the Ivrea-Verbano Zone (IVZ), Italy, was used as a natural laboratory in which to explore the behaviour of the Hf isotope and Zr thermometry systems in rutile at high temperatures. Zr-in-rutile thermometry for a suite of granulite facies metapelites from the IVZ records high temperatures related to peak metamorphic conditions, as well as resetting of the Zr-in-rutile thermometer in some grains. Rutile from metapelite slivers incorporated into the underplating Mafic Complex record heating to temperatures in excess of 1000 ºC during emplacement of the gabbro. Zr-in-rutile is the only thermometer to record this extreme thermal overprint, which is not recorded by Ti-in-zircon or Fe-Mg thermometry.

Hf isotope data for the same suite of metapelites demonstrate that rutile preserves a robust record of Hf isotope composition, even under conditions of high temperature metamorphism and partial melting. The results also demonstrate that in metapelites that have experienced the highest temperatures, zircon dissolution plays an important role in determining the Hf isotope composition of subsequently-formed phases. This observation has profound implications for the interpretation of Hf isotope data for all minerals in both metamorphic and magmatic systems. When complete dissolution of zircon occurs, rutile is shown to become the main host of Zr and Hf in these samples, and controls the Zr/Hf of residue and melt.

The new results demonstrate the valuable contribution that chemical and isotopic analysis of rutile can make to constraining the evolution of the lower crust.

[1] Ewing *et al*. (2011) *Chem. Geol*. **281**, 72-82.