Advancing petrochronology: linking zircon and monazite to garnet

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Linking accessory minerals to garnet growth using the relative and absolute concentrations of rare earth elements (REE) is a key method in petrochronology. Experimental data show the great potential of this approach in dating petrological processes. However, in natural samples this approach is often not without complexity; garnet dates are either not available or they differ from what is expected based on accessory mineral age and REE systematics. Systematic studies combining accessory mineral REE and U-Pb analysis with garnet chronology are necessary to establish this link. In this study, we performed such comparative analysis on high-grade samples from different orogens and of different age.

Ultrahigh-pressure migmatites from the Western Gneiss Region, Norway, and felsic granulite xenoliths from the Pamir, Tajikistan, were subjected to in-situ zircon and monazite U-(Th-)Pb dating and REE analysis by LA-ICPMS, and Lu-Hf garnet chronology. The REE systematics and textural record of accessory minerals from the Pamir xenoliths were used to suggest that garnet in these samples grew between 42-37 Ma [1]. Lu-Hf garnet ages of 41-38 Ma confirm this inference, indicating that equilibrium with respect to REE may have occurred on a rock scale for these samples. In contrast, zircon from the Norwegian migmatite shows a more complex pattern, with strongly scattering Gd/Yb across the age range. The upper envelope of the Gd/Yb-age data peaks at 430-420 Ma, which agrees with the Lu-Hf garnet age. The data indicate that in this particular sample the scale of REE equilibrium was limited. Many accessory minerals were cogenetic with garnet, yet recorded local REE compositions that were unaffected by petrological processes occurring elsewhere in the rock.

This study illustrates the reliability of accessory mineral petrochronology in certain systems, yet also shows that caution is warranted for rocks that are not properly chemically equilibriated. In the latter case, positive diagnosis of the probable age of garnet growth may require a large quantity of data for accessory phases in different textural settings to best constrain the extremes of Gd/Yb with time.

[1] Kooijman *et al.* (2017) *EPSL* **465**, 59–69.