Combined chronometry and geochemistry of apatite for very high resolution provenance analysis

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We present detrital apatite U-Pb and trace element data from the Tarn river, which drains the Cévennes sub-range of the southern Massif Central in France. In this provenance case study, we demonstrate that detrital apatite provides a high-resolution record of orogenesis in the Cévennes over the past 400 Ma.

Detrital apatite U-Pb data from the Tarn records peak Variscan regional metamorphism (related to nappe-stacking), subsequent pluton-emplacement during Variscan extensional collapse, and Miocene to recent basic intraplate volcanism. In addition, detrital apatite trace-element analysis is able to reliably ascertain the source lithology of each individual apatite grain (e.g. felsic or basic, igneous or metamorphic) using published apatite trace element datasets from the literature as a reference database. Combined, these methods allow for the categorization of almost every analysed grain, and demonstrate the power of this provenance approach.

A complicating factor in our detrital trace element study was an inability to discriminate between apatite preserving igneous emplacement ages and igneous trace-element compositions, from apatite with igneous trace-element compositions but which yielded younger ages recording Barrovian metamorphism (due to Pb-diffusion in the 375-550°C temperature window causing age resetting).

To examine whether it is possible to distinguish "diffusively age-reset" igneous apatite from primary igneous apatite using only trace element data, we have analysed the trace element composition of variably age-reset apatite from metagranitoids in the Tauern Window, Austria, by in-situ LA-ICPMS mapping. Our results indicate that at temperatures approaching 500°C, Mn and Sr are mobile in the apatite lattice, with decreasing Mn and increasing Sr contents in age-reset apatite. These results indicate that at least some age-reset igneous apatite in sedimentary systems that sample low- to medium-grade metamorphic belts may be distinguished from primary igneous apatite.