The Trace Element Composition of Detrital Apatite

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Apatite is a near-ubiquitous phase in crystalline rocks due to the inability of the major rock-forming minerals to incorporate significant P, consequently, apatite trace-element composition is inherently diverse.

Due to this chemical diversity, we have assembled a database of published apatite trace element compositions from the literature. These LA-ICPMS data comprise over 500 separate bedrock samples (several thousand separate spot analyses) and span the complete range of common lithologies present on the Earth's surface. When this database is plotted on biplot using principal component analysis it is possible to reliably separate individual apatite analyses by lithology, and accordingly, to assign rock-type to detrital apatite grains of unknown provenance. This permits the extraction of much more provenance information from detrital apatite than can be achieved using U-Pb age data alone.

We demonstrate the efficacy of the combined U-Pb and trace element analysis approach for detrital apatite provenance using examples from ancient c. 1 Ga detritus in NW Scotland [1] and modern detritus from the river Tarn in the Massif Central of France [2]. In individual samples there is strong correlation between U-Pb age and source lithology, and this provenance information can be exploited to give greater insight into the orogenic histories of the sediment source areas. This approach also permits the deconvolution of broad apatite U-Pb age-peaks on kernel density estimate (KDE) plots into more effective source-diagnostic lithology-specific U-Pb KDEs. Combined with previously published zircon U-Pb data from the same samples [1], it is possible to constrain complex multistage geological histories, demonstrating the usefulness of multi-proxy provenance strategies.

[1] Kenny et al., 2019. On the track of a Scottish impact structure: a detrital zircon and apatite provenance study of the Stac Fada Member and wider Stoer Group, NW Scotland. Geological Magazine https://doi.org/10.1017/S0016756819000220

[2] O'Sullivan et al., 2018. An integrated apatite geochronology and geochemistry tool for sedimentary provenance analysis. G-Cubed. https://doi.org/10.1002/2017GC007343