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Tracing Magmatic and Metamorphic Events using Accessory Mineral REE Contents

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The rare earth element (REE) contents of accessory minerals can provide unique insights into magmatic and metamorphic events, however, interpreting the REE patterns and deciphering the petrogenetic histories that they record can be challenging. We have parameterised the shape of accessory mineral REE patterns in terms of three independent parameters: average abundance, slope and curvature. Quantifying REE pattern shape in this manner minimises the amount of data to be handled, from 14 REE abundances to three shape parameters, while maximising the amount of information contained by each datum. By constructing quantitative models of REE partitioning during processes such as crystal fractionation and partial melting we are able to interpret changes in REE pattern shape in terms of the processes they record. We applied this modelling to the accessory minerals of Archean terranes (including the Napier Complex, Antarctica and the Lewisian Gneiss Complex, Scotland) and igneous intrusions (Boggy Plain Supersuite, Australia and the Ilimaussaq alkaline complex, Greenland). In the case of the Lewisian Gneiss Complex we are able show that a certain zircon population crystallised synchronously with garnet, thus dating a specific period of metamorphism. For the Boggy Plain the REE patterns of apatite record fractional crystallisation and density driven melt separation. Such diverse geological settings have been chosen to demonstrate the broad applicability of our modelling. We show that by parameterising REE patterns in terms of their shape, and applying quantitative modelling, we are able to clearly decipher the processes that accessory minerals record and construct accurate petrogenetic histories of their host rocks.