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SPECIAL COLLECTION: APATITE: A COMMON MINERAL, UNCOMMONLY VERSATILE

Apatite trace element and isotope applications to petrogenesis and provenance

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Abstract

Apatite is an excellent tracer of petrogenetic processes as it can incorporate a large range of elements that are sensitive to melt evolution (LREE-MREE, Sr, Pb, Mn, halogens, Nd isotopes). Recent advances in the understanding of trace element concentrations and isotope ratios in apatite provide a novel tool to investigate magmatic petrogenesis and sediment provenance. Recent experimental work has better characterized trace element partition coefficients for apatite, which are sensitive to changes in magma composition (e.g., SiO_2 and the aluminum saturation index value). The chemistry of apatites from granitoids has been suggested to reflect the composition of the host magma and yield information about petrogenetic processes that are invisible at the whole-rock scale (mixing, in situ crystal fractionation, metasomatism). Nd isotopes in apatite can now be analyzed by LA-MC-ICP-MS to constrain mantle and crustal contributions to the source(s) of the studied magma. These recent advances highlight exciting new horizons to understand igneous processes using accessory minerals. In this contribution, we use a compilation of recent data to show that apatite in the matrix and as inclusions within zircon and titanite is useful for providing insights into the nature and petrogenesis of the parental magma. Trace element modeling from in situ analyses of apatite and titanite can reliably estimate the original magma composition, using appropriate partition coefficients and careful imaging. This provides a new way to look at magmatic petrogenesis that have been overprinted by metamorphic processes. It also provides the rationale for new investigations of sedimentary provenance using detrital accessory minerals, and could provide a powerful new window into early Earth processes if applied to Archean or Hadean samples.

Keywords: Apatite, petrogenesis, inclusions in accessory minerals, crustal evolution, provenance