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Isotopic composition of zircon during high-grade metamorphism: An example from South Greenland

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The O-Hf-U-Pb isotopic composition of zircon is integral to our understanding of crustal growth over Earth history. An essential assumption in such studies is that the isotopic compositions are pristine and undisturbed by later metamorphic events and alteration. The Southern Domain of the Ketilidian Orogen in South Greenland is interpreted to represent fore-arc sediments derived from uplift and erosion of the continental arc rocks of the 1.80 to 1.85 Ga Julianehåb Igneous Complex. Following deposition, these fore-arc sediments were metamorphosed at conditions increasing from amphibolite facies in the North to granulite facies in the South. Metamorphism culminated with the intrusion of rapakivi granites and related rocks of the Ilua Suite at 1.75 Ga. Zircons from the Julianehåb Igneous Complex have predominantly suprachondritic Hf isotope compositions and mantle-like O isotope compositions indicative of sources dominated by mantle-derived components and mafic lower crust. Detrital zircons from the Southern Domain metasediments are dominated by 1.80-1.85 Ga ages, consistent with derivation from the Julianehåb Igneous Complex. Some older ages are also present indicating input from other erosional sources. Hf isotope compositions of the Southern Domain zircons are also consistent with a dominant Julianehåb provenance. However, O isotope compositions of Southern Domain zircons are distinctly heavier than those of the Julianehåb Igneous Complex. This could be interpreted to indicate that the metasediments were derived by erosion of a distinct (and unrecognized) terrane with similar ages and Hf isotope compositions to the Julianehåb Igneous Complex, but with a significant input from supracrustal materials. Alternatively, we interpret the heavy O isotope signatures in the zircons to indicate that their O isotope compositions have equilibrated with the sediments during metamorphism. Simple modelling using experimentally-derived diffusion coefficients indicates that the O isotope compositions of typical zircon crystals can equilibrate over relatively short timeframes at upper amphibolite to granulite facies temperatures, whereas U-Pb age data, Hf isotope compositions and compositional variations that define back-scattered electron image zoning remain unaffected. These results indicate that O isotope compositions of detrital zircons in high-grade metasedimentary rocks may not be pristine and should be interpreted with care.