Geophysical Research Abstracts
Vol. 19, EGU2017-1175-2, 2017
EGU General Assembly 2017

Titanite petrochronology of ultrahigh-temperature (UHT) calc-silicates from southern Madagascar: laser-ablation split-stream ICP-MS spot analyses, depth profiles, and quantified trace-element x-ray maps

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Calc-silicate rocks are often overlooked as sources of pressure-temperature-time data in granulite-UHT metamorphic terranes due to the strong dependence of calc-silicate mineral assemblages on complex fluid compositions, as well as a lack of thermodynamic data on common high-temperature calc-silicate minerals such as scapolite. In the Ediacaran–Cambrian UHT rocks of southern Madagascar, clinopyroxene–scapolite–feldspar–quartz–titanite calc-silicate rocks are wide-spread. U-Pb dates of c. 540-520 Ma from unaltered portions of titanite correspond to cooling of the rocks through upper-amphibolite facies and indicate UHT metamorphism occurred before 540 Ma. Zr concentrations in these domains preserve growth temperatures of 900–950 C, consistent with peak temperatures calculated by pseudosection modeling of nearby pelitic rocks. Younger U-Pb dates (c. 510-490 Ma) correspond to fluid-mediated Pb loss from titanite grains, which occurred below their diffusive Pb-closure temperature, along fractures. The extent of fluid alteration is seen clearly in back-scattered electron images as well as Zr-, Al-, Fe-, Ce-, and Nb-concentration maps. Laser-ablation depth profiling of idioblastic titanite grains shows preserved Pb diffusion profiles at grain rims, but there is no evidence for Zr diffusion, indicating that it was effectively immobile even at UHT.