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Electron-microprobe dating as a tool for determining the closure of Th-U-Pb systems in migmatitic monazites

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Abstract

High spatial resolution dating of monazite by the electron-probe microanalyzer (EPMA) enables systematic and detailed studies of small minerals. Like zircon, monazite records the complex history undergone by the host rocks. Recent improvements in the statistical treatment of many in situ data now make it possible to decipher the related thermal events and so obtain reliable and precise ages. Our work shows that a significant number of individual spot analyses is required to reach such precise information (i.e., more than 30–40 data). Using the examples of monazites from three migmatites and one granite, we show how to select the most efficient method of age calculation according to the U and Th geochemistry of the grains, or grain domains, that we are trying to date. Three situations may be met: (1) monazites exhibiting significant Th/U ratio variation, (2) monazites exhibiting a fairly constant Th/U ratio, but significant U + Th heterogeneity, and (3) monazites of constant U and Th concentrations. For the first case, a precise mean age can be calculated using a method of data reduction in the Th/Pb = *f*(U/Pb) diagram, whereby a precision of ±5–10 Ma (2σ) is commonly achieved. For the second case, an isochron age can be calculated according to the Pb = *f*(Th*) method, with a common precision of around 20 Ma (2σ), whereas for the third case, a simple weighted average age can be calculated. Using these approaches, coupled with a back-scattered electron image study, we demonstrate that inheritance is probably as common for monazite as for zircon. In addition, the combination of high spatial resolution and precise age determination show the limited extent of Pb diffusion in monazite.

Finally, an example from a migmatite from southern French Guiana demonstrates the especially robust behavior of the Th-U-Pb system in monazite. This system remains closed during late migmatization and during the subsequent zircon crystallization and zircon overgrowth of protolith zircons. The monazite yielded exactly the same age as the protolith zircons.