Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16352

In-situ triple dating (Rb-Sr, Lu-Hf, U-Pb) of carbonate-hosted glauconite and bioapatite from the Middle Cambrian Georgina Basin, Australia

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In-situ laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS and MS/MS) techniques are useful for directly dating authigenic minerals and fossils, providing valuable insights into depositional ages and stratigraphic correlation, as well as diagenetic and isotopic overprinting within sedimentary basins. The feasibility of in-situ Rb-Sr, Lu-Hf and U-Pb dating techniques are tested here using carbonate-hosted glauconite and bioapatite from the Thorntonia and overlying Currant Bush Formations of the Mid-Cambrian Georgina Basin (expected depositional age of 505 ± 2 Ma).

A U-Pb age of 501 ± 22 Ma was obtained for fine-crystalline dolomite from the Thorntonia Formation, interpreted to record 'primary' carbonate precipitation or an early marine dolomitization event. In contrast, a medium to coarsely crystallized dolomite yielded a younger age of 459 ± 22 Ma, suggesting a diagenetic origin. In addition, U-Pb dating of dolo-micrite from the Currant Bush Formation produced an age of 506 ± 25 Ma, within uncertainties of the U-Pb fine-crystalline dolomite and the Lu-Hf bioapatite ages. For the latter, in-situ Lu-Hf dating of bioapatite produced dates ranging from 499 ± 98 Ma to 473 ± 157 Ma, which overlap with the depositional age, but with significant uncertainties. The large uncertainties are due to low Lu concentrations (0.5-2 ppm with 120μm spot size) within the studied fossils.

Finally, in-situ Rb-Sr dating of glauconite yielded younger dates ranging from 439 ± 16 Ma to 402 ± 13 Ma, which are interpreted to record the later post-depositional events. The glauconite Rb-Sr system is readily reset, but the dates appear geologically meaningful and likely reflect isotopic disturbances during the Rodingan orogenic event (~450 to 430 Ma). Secondary coarsely crystallized dolomite U-Pb ages also appear to record the same event.

Overall, our triple dating approaches (in-situ Rb-Sr, Lu-Hf and U-Pb) demonstrate different behaviours of these geochronometers during the post-depositional histories, linked to complex factors such as mineralogy, porosity/recrystallisation, and ambient diagenetic conditions.

Encouragingly, the Lu-Hf dates for fossil bioapatite, U-Pb dates of dolo-micrite, and early finely crystalline dolomite overlap with the expected depositional age, suggesting these methods can potentially yield stratigraphic age constraints provided sufficient parent isotope concentrations.