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Etching mechanism of monazite fission tracks: A promising low temperature thermochronometer

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The sensitivity of fission tracks in monazite to thermal events occurring at low temperature range (25 - 55°C) makes it be an important candidate to constrain the thermal history of rocks where subtle thermal changes are unable to be detected by other widely-used minerals, such as apatite (60 - 120 °C) and zircon (210 - 330 °C). There are few studies reported in monazite[1,2], since track etching mechanism and possible track recovery during etching remain unknown for previous track-etching methods by which heating the etchant is a must (e.g., up to 90 °C for 45 min). Here we report a room temperature (RT) etching method, and show track etching mechanism by comparing the RT results with those conducted at different conditions of etching and heat treatment. The etched lengths as obtained by the RT method and the heating method are similar. The etching rate at an earlier stage is significantly faster than that obtained by conventional method: After etching for only 1 min at 90 °C, an abrupt advance of etchants along the tracks is evidenced by the increase of the mean length to 9.07 μm, which accounts for 86% of the fully-etched length for 45 min; the track widths are enlarged to 50~150 nm (as observed by transmission electron microscopy) after 0.5 min etching. Thus, track-etching in monazite begins with a rapid advance of the etchant penetrating the majority of its full etchable length in a short time, followed by a much lower etching along the track until the track-width steadily increases to a value above ~200 nm so that the tracks can be seen by optical microscopy. These results have important implications for improving our understanding of nanoscale or even atomic scale mechanism of track etching in zircon and apatite and for discovering low temperature events by monazite fission tracks.

[1] Jones, S., Gleadow, A., Kohn, B. & Reddy, S. M. Etching of Fission Tracks in Monazite: An Experimental Study. *Terra Nova*, 179-188 (2019).

[2] Jones, S., Gleadow, A. & Kohn, B. Thermal annealing of implanted ^{252}Cf fission tracks in monazite. *Geochronology* **3**, 89-102 (2021).