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# Compositional effects on the etching of fossil confined fission tracks in apatite

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## Abstract

Fission track analysis is a thermochronologic method for dating rocks and reconstructing their low-temperature thermal histories. We investigate the influence of the apatite composition on the etching of fossil confined fission tracks and its consequences for the fission track method. We conducted step-etch experiments with 5.5 M $HNO_3$ at 21 °C on samples with etch pit diameters (*Dpar*) spanning most of the range for natural apatites (Panasqueira: 1.60 µm; Slyudyanka: 2.44 µm; Brazil: 3.92 µm; and Bamble: 4.60 µm) to determine their apatite etch rates $v_R$ (the rate at which each lattice plane is displaced parallel to itself) as a function of crystallographic orientation ($\phi'$). Our measurements revealed significant differences between the four samples. We fitted three-parameter functions, $v_R = a(Dpar)\phi' e^{b(Dpar)\phi'} + c$, describing $v_R$ as a function of the angle to the apatite ***c***-axis for our hexagonal samples (excluding Bamble) and Durango apatite. Both parameters *a* and *b* exhibit a linear correlation with *Dpar*, whereas the constant *c* is small (~0.1 µm/min) and its between-sample variation is negligible at the resolution of our measurements. Bamble exhibits a different, bimodal relationship between $v_R$ and $\phi'$, which we fitted with a sum of two sine functions. In all cases, including Bamble, there is a striking correlation between the angular frequencies of horizontal confined tracks and the magnitude of the apatite etch rate $v_R$ perpendicular to the track axes. This result shows that the sample of confined tracks selected for measurement and modeling is to a much greater degree determined by the etching properties of the apatite sample than by geometric or subjective biases. The track etch rate $v_T$ is constant along most of the track length but varies from track to track. The mean $v_T$ correlates with *Dpar*, so that tracks etch to their full lengths in a shorter time in faster etching apatites. The mean rate of length increase between etch steps, $v_L$, also correlates with *Dpar*. The length increments of individual tracks are however irregular. This points to an intermittent structure at the ends of the tracks.

**Keywords:** Apatite, fission track, confined track, track revelation, apatite etch rate, track etch rate; Isotopes, Minerals, and Petrology: Honoring John Valley