American Mineralogist, Volume 107, pages 1065–1073, 2022

Etching of fission tracks in monazite: Further evidence from optical and focused ion beam scanning electron microscopy

Sean Jones[1,*], Barry Kohn[1], and Andy Gleadow[1,†]

[1]School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Victoria 3010, Australia

Abstract

A series of experiments on monazites from Victoria, Australia, is presented to further understand their fission track etching properties. Using a 6 M HCl etchant at 90 °C, SEM images on crystal (100) pinacoid faces reveal well-etched rhombic spontaneous fission track openings. Average rhombic etch pit diameters Dpc and Dpb, parallel to the crystallographic *c*- and *b*-axes are 0.81 ± 0.20 μm and 0.73 ± 0.26 μm, respectively. An angular distribution experiment on (100) faces found that spontaneous fission tracks initially etch anisotropically, being preferentially revealed at an azimuth of 90° to the crystallographic *c*-axis up to ~60 min of etching. As etching continues, however, the distribution becomes progressively more uniform and is essentially isotropic by 90 min. Two experimental methods determined the rate at which the etchant penetrated along the lengths of implanted ^{252}Cf fission tracks. This involved the application of a focused ion beam scanning electron microscope (FIB-SEM) to mill progressively into slightly etched monazite crystals followed by an etch-anneal-etch approach. Results indicate that at least the greater part of the etchable ranges of the latent fission tracks were penetrated by the 6 M HCl etchant within the first few minutes. Continued etching to 5 min indicates that track etching slows down toward the ends of the tracks, but the maximum ranges are estimated to be reached after 5–15 min, which represents the longest time the latent segments of the tracks are exposed to potential annealing at the etchant temperature. Taking into account that implanted ^{252}Cf fission tracks in monazite anneal on average ~4% of their length at 90 °C after 1 h (Jones et al. 2019), suggests that a much shorter duration for exposure to this temperature causes less than ~1% of fission track length reduction during etching.

Keywords: Monazite, fission tracks, etching, FIB-SEM, etch-anneal-etch