Heavy-ion induced defects in phlogopite imaged by scanning force microscopy

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A new geological dating method uses alpha-recoil tracks (ART) created by the natural α-decay of U, Th, and their daughter products. When visualizing ART by optical microscopy, the age range is restricted to the last 10^6 a. Recording of etched ART by scanning force microscopy (SFM) enables the access to track densities beyond 10^8 cm^{-2} and thus extends ART dating to ages $>10^6$ a. In the present work, natural radiation damage induced by ions was simulated by irradiating phlogopite samples, originating from Quaternary and Tertiary volcanic rocks of the Eifel (Germany) and Kerguelen Islands (Indian Ocean), with U, Ni (11.4 MeV/*u*), Xe, Cr, Ne (1.4 MeV/*u)*, and Bi (200 keV) ions. Before and after irradiation and etching with HF, the phlogopite surfaces were imaged by SFM. On freshly cleaved natural phlogopite, latent ART, located near to the cleavage plane, form small hillocks. In addition, numerous similar hillocks develop in air, not related to ART since they do not transform to etch pits. Due to these hillocks, whose origin is still unknown, it is presently not possible to study latent ART with SFM. A further kind of hillock arises after irradiation with energetic heavy ions. The damage trails created by these ions are etchable, providing hexagonal etch pits in the case of U, Xe and Cr ions, whereas the pits of Ni, Ne and Bi ion tracks are triangular. The transition from triangular to hexagonal shape occurs between the electronic energy loss values 5.4 and 8.1 keV/nm for Ni and Cr ions, respectively, coinciding with a sharp increase of the track etch velocity.