# *In situ* observation of alpha-particle induced annealing of radiation damage in Durango apatite

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Radiation damage created by α-recoil nuclei affects the diffusion, or even the loss, of Pb, He and other noble gases, in solids, and therefore, should be considered in the interpretation of thermochronologic results. The effect of thermal events has been considered as the sole cause of the recovery of radiation damage, although there has been some evidence that α-particle irradiation may cause the recovery of α-recoil damage [1]. In this study, we have simulated the α-particle induced recovery of radiation damage by *in situ* transmission electron microscopy (TEM) observation of consecutive ion-irradiations: *i*.) 1 MeV $Kr^{2+}$ (simulating the radiation damage by 70 keV α-recoils), *ii*.) followed by 400 keV $He^{+}$ (simulating radiation-induced annealing by 4.5 MeV α-particles). The two-step irradiations were monitored by observing the gradual change in both the morphology and diffraction pattern of electron-transparent slices, which were prepared by the diamond microtome method [2]. This method ensures uniform sample thickness (~70 nm) and irradiation in the same crystallographic orientation, that is the [0001] of Durango apatite. At room temperature, the originally crystalline apatite became fully amorphous at 1 dpa (displacement per atom), much higher than the widely cited value (~0.3 dpa), which was measured without controlling for sample thickness and orientation [3]. Partial recrystallization of the originally, fully-amorphous apatite pre-damaged by 1 MeV $Kr^{2+}$ was evidenced by the gradual appearance of new diffraction maxima, appearing at the lowest dose of $1.25\times10^{15}$ He/cm$^2$, up to the highest dose at $2.00\times10^{16}$ He/cm$^2$. In addition to the well-established effects of thermal annealing, the α-annealing effects must also be considered when evaluating the loss of He from radiation-damaged apatite.

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