# Evidence for alpha self-healing in monazite by double beam in-situ TEM experiments: the reason why natural monazite never becomes amorphous.

A.-M. SEYDOUX-GUILLAUME[1,2*], X. DESCHANELS[3], C. BAUMIER[4], W. WEBER[5], AND S. PEUGET[6]

[1]CNRS, Univ. Lyon, UCBL, ENSL, LGL-TPE, F-69622 Villeurbanne, France.

[2]Univ.Lyon, UJM, Laboratoire de Geologie, F-42023, Saint-Etienne, France

[3]Institut de Chimie Séparative de Marcoule, UMR 5257, F-30207, Bagnols-sur-Ceze, France

[4]CSNSM, JANNuS-Orsay/SCALP, Univ Paris-Sud, CNRS/IN2P3, Orsay, France

[5]Department of Materials Science and Engineering, University of Tennessee, Knoxville, TN 37996, USA

[6]CEA, DEN, DE2D, SEVT, LMPA BP 17171, 30207 Bagnols-sur-Ceze Cedex, France.

*anne.magali.seydoux@univ-st-etienne.fr

Monazite is a common accessory rare-earth orthophosphate mineral in the continental crust widely used in U-Pb geochronology, and also a promising candidate for the conditioning of Pu and minor actinides (MA) coming from spent nuclear fuel reprocessing. However, an old paradox remains unsolved: why do natural monazites, independent of their geological history, remain crystalline even when they did not experience any thermal event that could heal the defects? In the present work we have studied the radiation resistance of this mineral to double beam irradiations so as to evaluate the potential coupling effects between the nuclear and electronic energy losses arising from the recoil nuclei and alpha particles of an alpha decay. Synthetic polycrystals of $LaPO_4$-monazite were irradiated sequentially or simultaneously with alpha particles (He @ 160keV IRMA) and gold (Au @ 1.5MeV, ARAMIS) ions. I*n situ* irradiation experiments were performed at room temperature conditions on the JANNuS-Orsay/SCALP platform, which allows the coupling of these two accelerators in the JANNuS Transmission Electron Microscope.

The results experimentally demonstrate the existence of a defect recovery mechanism, called alpha-healing, acting in the monazite structure due to electronic energy loss of alpha particles, which explains the absence of amorphization in natural monazite samples. This mechanism is critically important to design and predictively model the long-term behavior of ceramic matrices for nuclear waste conditioning and for monazite thermochronology.

Seydoux-Guillaume A.-M., et al. (2018). American Mineralogist, 103(5), 824-827.