Radiation Damage in Nuclear Waste Forms for Actinides

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Here we look at radiation damage in potential actinide host phases for nuclear waste storage, comparing the results of studies conducted using ion irradiation, synthetic samples doped with ^{244}Cm or ^{238}Pu, and natural samples containing Th and U. These approaches provide valuable information on radiation effects over short (e.g., hours), intermediate (years), and long time (10^6-10^9 years) scales. The problem of radiation tolerance is framed by extensive research using ion irradiation and natural analogues. These studies allow an immediate assessment of the general aspects of resistance to amorphization in waste form materials over short to long time scales. Based on ion irradiation experiments (relatively high dose rate) wherein temperature is a variable, materials are identified that either 1) remain crystalline to very high ion fluence a very low temperature, 2) can be rendered amorphous at very low temperature but exhibit a critical dose at moderate temperature, or 3) become amorphous at low dose and have a very high critical dose for recovery of damage. At the other extreme (low dose rate), the mineral analogues can either confirm the radiation tolerance or reveal certain aspects of the recovery process due to dose rate and effects of thermal history. In natural analogue studies, understanding the thermal history of the host rocks is one of the most important (and difficult) aspects of the research. Due to the difficulty of performing experiments using ^{244}Cm or ^{238}Pu, only a handful of materials have been tested in this manner. Nevertheless, the results provide important clues to waste form performance at higher dose rates than the natural samples, including limited data on thermal annealing.

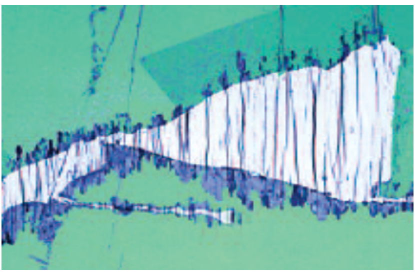

Figure 1: Radiation damage, cracking, and alteration of allanite from Amelia, Virginia, USA. High Th areas (green) are amorphous and low Th areas (white) are crystalline. Altered areas (blue) are adjacent to cracks.