Modeling Uranium Uptake in Fossilized Teeth and Bones: Potential for Long-Term Uranium Waste Storage

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Oxidized uranium (U) is soluble in groundwater and can be incorporated in or adsorbed to porous materials it encounters in the environment. In the early stages of fossilization, mammal teeth and bones provide this environment through bacterial decay and mineralization of the previously living tissue. The purpose of this study is to quantitatively model the uptake of uranium in porous biomaterials to 1) predict age of fossilization for samples whose origin is unknown, and 2) to understand the systematics of an exponential falloff uranium uptake in phosphates in order to improve the function of nuclear waste remediation tactics. Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) was utilized to determine isotopic ratios and ultimately calculate the isotopic age for a small elemental map spanning several of the hydroxyapatite-bearing biomaterials. A model was devised based off the isotopic age equation to describe the uptake history of uranium in several fossilized biomaterials. Parameters for the model were described by an exponential fall off of uranium (U) uptake, with the initial U being zero and lead (Pb) only being produced as a product of decay. Simulated and measured data assured a good fit for the model's predictive property. Conjugate gradient technique was utilized to solve for local values of initial uptake, e-folding time, and predicted age, with the e-folding time for the bone sample being 1.3 Ma, and the tooth 0.9 Ma, respectively. These provide insight into the process of uranium uptake in porous biomaterials to further the knowledge of nuclear waste sequestration.