Abstract No. tito0610

Th Incorporation in Phosphatic Fossils of the Green River Formation

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Beamline(s): X26A

Introduction: High Th concentrations were detected in a phosphatized (francolite) fish fossil from the lacustrine Green River Formation [Nienstedt et al., 2001]. The focus of the research presented here is towards understanding if the mobility and incorporation of Th is controlled by depositional facies. We hypothesize that the breakdown of organic matter that is deposited preferentially in deep lake settings may aid in the dissolution of Th bearing phases during early diagenesis. The organic acids produced by the breakdown of organic matter may also complex Th and thus mobilize it, but it is uncertain what the fate of this aqueous species might be. Phosphate is released with the degradation of organic matter and would also complex the Th and a phosphate species is the most likely source of Th and U to phosphatized fossils. We analyzed additional phosphatic vertebrate fossils and one carbonized plant fossil from deep to shallow lacustrine facies. An additional focus is on the oxidation state of U and its relationship to the facies as U(IV) would behave similarly to Th while U(VI) is generally the more important species in an aqueous environment. The investigation was undertaken at the X26A beamline at the NSLS where it is possible to map trace element concentrations at about a 10 μm resolution and to perform in situ U-XANES analysis.

Methods and Materials: Three fish fossils from separate geographic localities (sample U1), a fossil branch, fossilized fish scales and a section of a turtle shell plate (sample TS1) were analyzed in this study. Analysis was done using x-ray fluorescence and x-ray absorption spectroscopy. Line scans and point scans were executed across fossil specimens to record compositional data for the fossil material and the background rock.

Results: X-ray fluorescence spectra were obtained from the fossil samples and their surrounding matrix. All phosphatic fossils showed a very noticeable increase in Th and U in the fossil compared to the matrix. Concentrations of Th and U can be estimated using the counts of each discrete energy detected. Fossil Th levels are about 3-4 times more than the surrounding matrix and U levels are about 3 times as the matrix. These values depend strongly on thickness of the sample and type of fossil. Carbonized fossils tended not to preferentially uptake Th or U because they were at identical levels to the background rock. Oxidation states of U based on XANES data appear to be mixed, but further analysis is needed for better certainty.

Conclusions: Phosphatic fossils from the Green River Formation have remarkable enrichments of Th, up to 2600 ppm calculated on a thick bone sample similar to U1. We see a general trend in enrichment of Th as well as in U and the REE's in deep water facies over shallow water facies. This observation is consistent with the interpretation that the degradation of organic matter plays a role in the mobilization of Th as the deep facies are highly enriched in organics. Mode of fossilization appears to be a factor in the incorporation of Th. Analyses of a carbonized branch fossil and host carbonate revealed no discernable difference U, Th or REE concentrations in the fossil region, however, the rock sample had a modest level of U (around 2 times U1/TS1 matrix values) and a slightly elevated level of Th (1.5 times U1/TS1 matrix values). More work is necessary to isolate the source of Th, U and REE's, however, on the basis of the carbonized plant sample the source could be minerals in the host rock.

Acknowledgments: Thanks to Richard J. Reeder, Scott M. McLennan for knowledge and input.

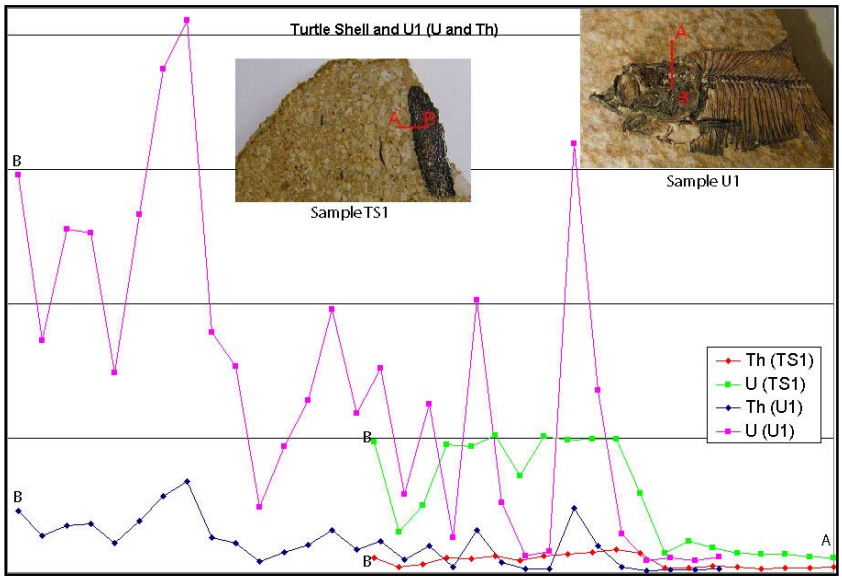

Figure 1. Comparison of Turtle Shell (TS1) and Fish Sample (U1) line scans. Y axis represents counts and X is distance.

References: J. Nienstedt et al. "Incorporation of U and Th in Phosphatized Fossils", NSLS Activity Report FY 2001.