How are geogenic contaminants affecting groundwater on the Colorado Plateau?

Chase Bebo[1], David Tibbits[2], Sean Kinney[2], Bennett Slibeck[2], Clara Chang[2], Abhishek RoyChowdhury[1], Paul Olsen[2]

[1]Navajo Technical University Lowerpoint Rd State Hwy 371, Crownpoint, NM 87313; [2]Lamont-Doherty Earth Observatory, Palisades, NY 10964

Abstract

The Navajo Nation is located on the Colorado Plateau and expands into Arizona, Utah, and New Mexico. Nearly 1/3 of the Navajo residents do not have access to electricity or running water and they rely on unregulated water wells. The majority of these water wells have arsenic and uranium levels higher than the USEPA limits for human consumption. Much of this contamination is linked to abandoned uranium and coal mines. However, contributions from geogenic sources are also significant but poorly understood. Very little is known about the distribution of these geogenic contaminants inside the bedrock and it can be a major factor of uranium and arsenic being distributed into groundwater. In this research project we used X-Ray Fluorescence Spectroscopy (XRF) to map naturally occurring arsenic and uranium in the bedrock of the Colorado Plateau. We analyzed 3 different cores collected by the Colorado Plateau Coring Project (CPCP-1) in Petrified Forest National Park in 2013. Cores were analyzed using the Minalyzer CS, a robotic XRF system that measures every element from sodium to uranium. From these measurements, we were able to map the vertical and lateral distribution of layers in the rock with high potential for geogenic contamination. This project will help us understand different sources of uranium and arsenic contamination in the groundwater of the Navajo Nation and the greater Colorado Plateau area.

Guiding Question: Can we rapidly estimate the distribution of potential geogenic groundwater contaminants in bedrock?

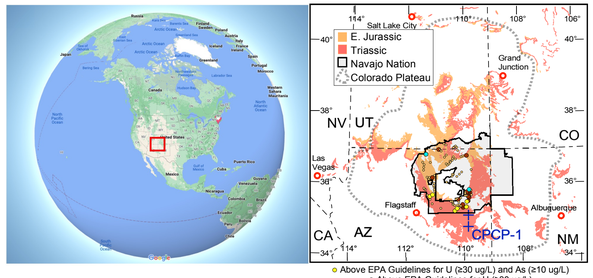
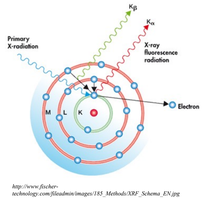


Figure 1. Left: location of Navajo Nation in the world. Modified from Google Maps. **Right**: This map shows the outline of the Colorado Plateau with the borders of the Navajo Nation. The little dots show the wells around the Navajo Nation. Modified from Corlin et al. (2016) and Olsen et al. (2018).

Methods

We analyzed 3 different cores collected by the Colorado Plateau Coring Project (CPCP-1) in Petrified Forest National Park in 2013.

Using the Minalyzer CS, a robotic XRF system, we collected data for every element from Mg to U. We scanned each core interval twice, first at a low energy X-ray setting to broadly survey and again at high energy to optimize detection of heavier elements.



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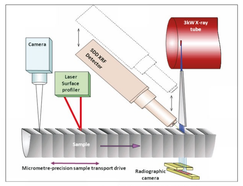

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Figure 2. Left: Schematic showing basic principles of X-Ray Fluorescence (XRF); **Right**: Schematic of analytical workflow for similar core scanning system

Experimental Approach

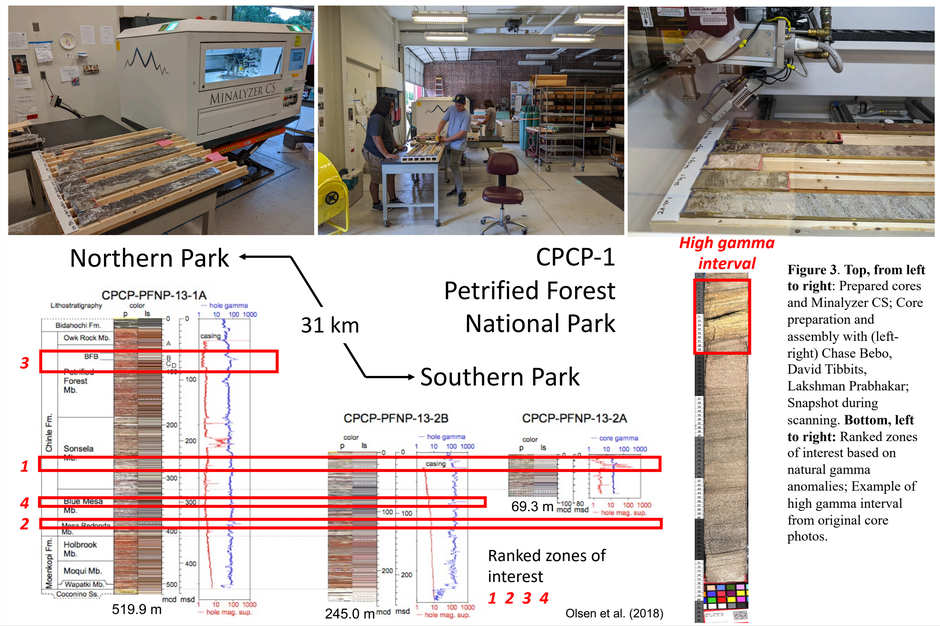

Figure 3. **Top, from left to right**: Prepared cores and Minalyzer CS; Core preparation and assembly with (left-right) Chase Bebo, David Tibbits, Lakshman Prabhakar; Snapshot during scanning. **Bottom, left to right:** Ranked zones of interest based on natural gamma anomalies; Example of high gamma interval from original core photos.

Preliminary Results

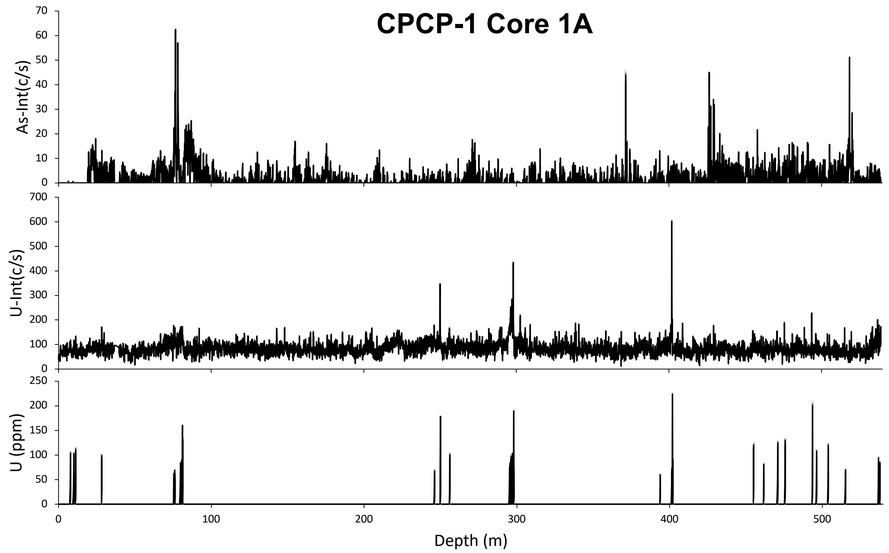

Figure 4. **Top**: Uncalibrated As data; **Middle**: Uncalibrated U data; **Bottom**: 'Calibrated' U data is preliminary pending further laboratory work

Conclusions

XRF core scanning has the potential to rapidly identify areas of anomalously high concentrations of elements harmful to human health

We show that there are several intervals of core with As and U above background detection limits

Due to the relatively quick analysis time for the scale of the project (>850 m of core), this approach has can be a useful approach to rapidly survey the potential of bedrock groundwater contamination

Future Research

We completed XRF scans of all cores from CPCP-1 in September 2022 and are currently in the process of processing data and improving reported values by calibrating our data to laboratory values by ICP-MS.

We intend to follow up with higher resolution XRF scans over intervals with elevated As and U to improve calibrated values

We will use additional techniques including X-Ray Diffraction (XRD) to provide a comprehensive assessment of both bedrock chemistry but also dominant mineral phases, porosity, permeability, etc.

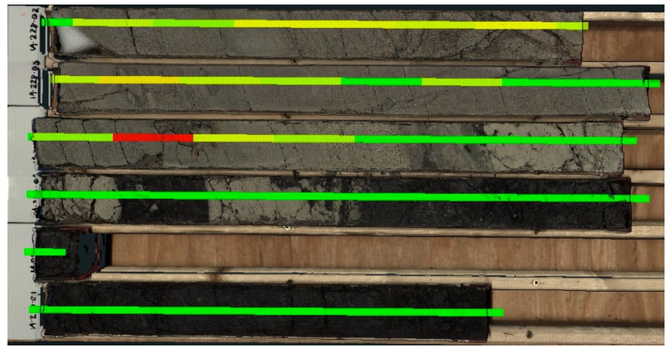

Figure 5. Example of core interval with potential U anomaly (plotted as heatmap) for further analysis.

Acknowledgements

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