Speciation and Reactivity of Uranium and Organic Matter in Abandoned Mine Wastes from Laguna, New Mexico

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Objective

Investigate the co-occurrence and reactivity of organic matter (OM) and Uranium (U) from the New Mexico Jackpile Morrison Formation using laboratory experiments, spectroscopy and electron microscopy analysis

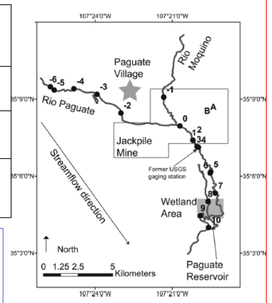
Background

Jackpile Mine – Laguna Pueblo NM

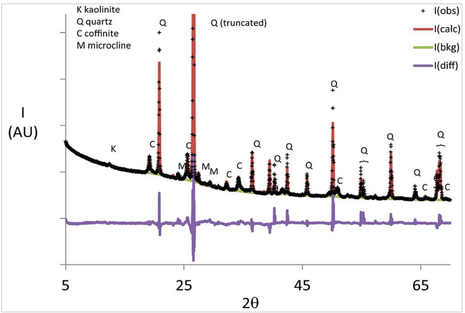
- American Utility Management: Grants Mining District
- 45 miles west of Albuquerque
- Operational period – 1952-1983
- Villages 2000 feet from mine site
- Largest open pit uranium mine in 1960's

Jackpile Mine Waste Characterization

Location	Uranium in Sediments	Organic Matter
	(mg.Kg^{-1})	%
Mine (A-B)	1-5	-
Wetland Area (9)	2-21	14-15



High U concentration in organic rich areas. **Why is this happening?**



Phase ID	Wt %
Halloysite-10A ($Al_2Si_2O_5(OH)_4 \cdot 2$)	0.8
Kaolinite-1A ($Al_2Si_2O_5(OH)_4$)	1.2
Albite (Na, Ca)Al(Si,Al)$_3$O$_8$	6.2
Microline ($KAlSi_3O_8$)	17.4
Quartz (SiO_2)	74.3

Blake et al, 2017, ES

Materials and Methods

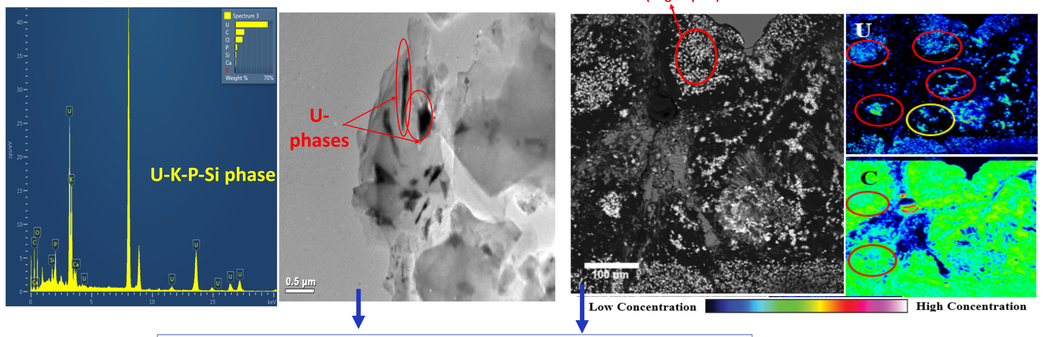
1. Microprobe Mapping, Fixed Angle X-ray fluorescence (XRF), Transmission Electron Microscopy (TEM) and Energy-dispersive X-ray spectroscopy (EDS), Thermogravimetric Analysis (TGA) and Excitation Emission Matrix (EEM) were performed to understand the character of the minerals and organic matter present in the mine waste

2. X-ray photoelectron spectroscopy (XPS) and Acid extractions were performed before and after heat treatment (Loss on Ignition -LOI- 550 ℃ - 5hr) on two mine sites from the Jackpile Mine in the Pueblo of Laguna

Results and Discussion

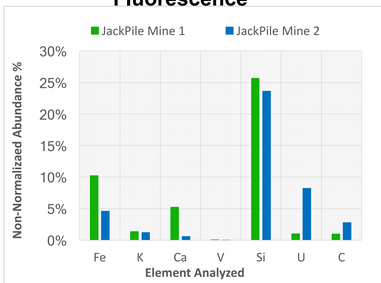
Transmission Electron Microscopy (TEM) and Energy-dispersive X-ray spectroscopy (EDS)

Microprobe Mapping

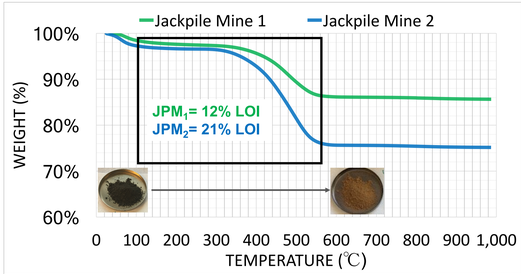


Carbon and Uranium Co-ocurrence in the Jackpile Mine Waste!

Fixed Angle X-ray Fluorescence



Thermogravimetric Analysis

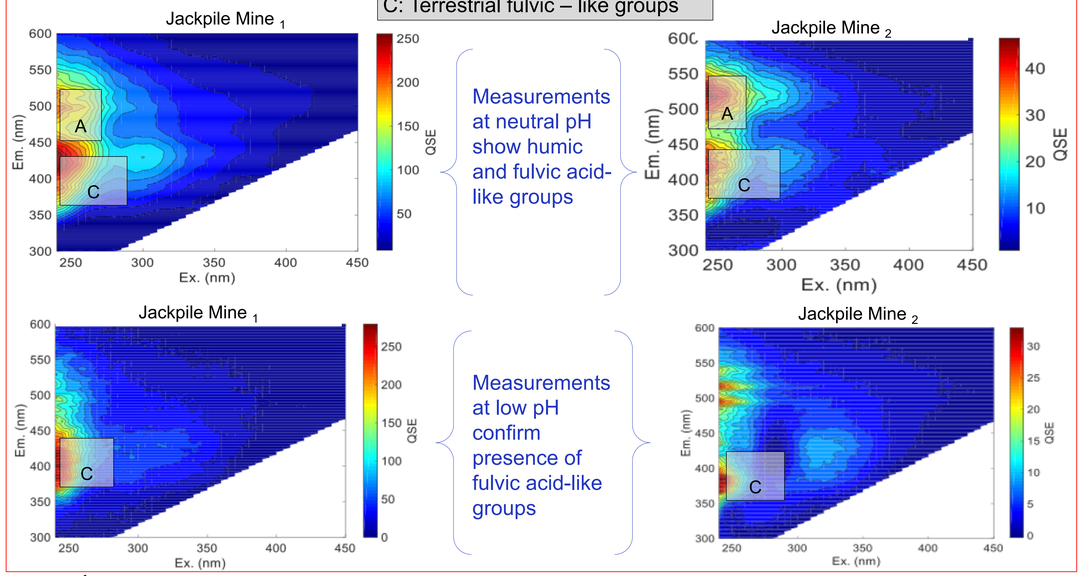


Loss on Ignition (LOI) is the loss in weight between 105℃ and 550℃ (5hr)

LOI is a representative measure of thermally labile carbon(OM)

Basic Extraction Particulate Organic Matter (BEPOM) and Excitation Emission Matrix (EEM)

A: Terrestrial humic – like groups
C: Terrestrial fulvic – like groups



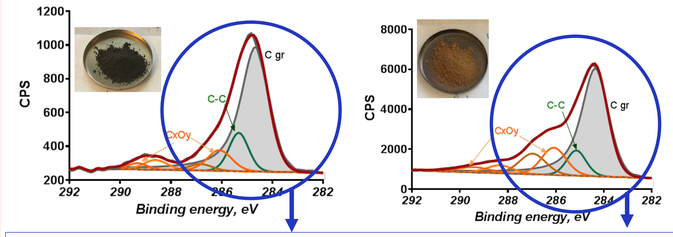
Measurements at neutral pH show humic and fulvic acid-like groups

Measurements at low pH confirm presence of fulvic acid-like groups

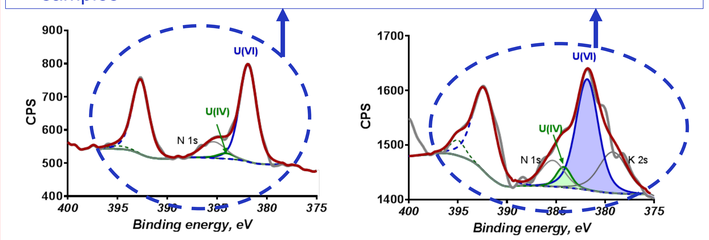
Results and Discussion

X-ray Photoelectron Spectroscopy Effect of LOI

Before LOI → After LOI

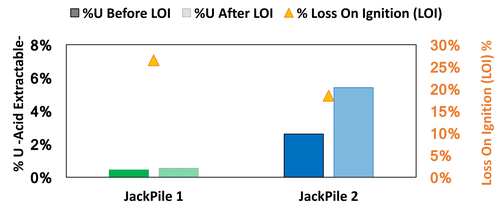


1. Change in C functional groups after LOI
2. Despite heat treatment, U(IV) is shown on the top surface of the samples



Acid Extractions

Higher U concentration from mine waste after LOI



Mine Waste Site	% LOI	% U extractable Before LOI	% U extractable After LOI
Jackpile Mine 1	12%	0.44%	0.54%
Jackpile Mine 2	21%	2.61%	5.41%

Conclusions

1. Spectroscopy, microscopy and thermal analysis confirm that organic matter and uranium co-occur in mine waste form the Jackpile Mine located in the Pueblo of Laguna
2. Humic and fulvic acid groups-like were observed on basic extractions on both sites
3. XPS analysis show changes on the carbon functional groups after the LOI experiments. Carbon and U was detected by XPS, confirming the co-occurence of U-OM
4. Higher concentration of U-extractable in samples with higher organic matter lost

Future Work

1. Mass Quadrupole Time-of-Flight (Q-TOF) and Tesla Fourier-Transform Ion Cyclotron Resonance mass spectrometer (FTICR MS) to understand the chemical composition of organic matter and to characterize specific groups interacting with U and preventing it from being released to the environment
2. Batch experiments to better understand the influence of organic matter in uranium released from the mine waste to the environment

E-H$_2$O Research Group

NM EPSCOR #IIA-1301346

NSF CAREER #1652619

NIH National Institute of Environmental Health Sciences Superfund Research Program NIH #1P42ES025589