



# **NABIR FRC Characterization Activities Oak Ridge, Tennessee**

## **March 20, 2002 FRC Breakout**

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<http://www.esd.ornl.gov/nabirfrc/>



## **FRC Contributors**

- **Sample Collection, Processing, Shipping, Analysis**
  - Barry Kinsall (Shipping)
  - Kenneth Lowe (Drilling and ICP/MS and Tc analysis)
  - Mary Anna Bogle (Health and Safety Officer)
  - George Houser (Radiological Safety)
  - Annett Sullivan and Gerry Moline (Storm monitoring and Water levels)
  - Steve Childs (Waste Management)
- Norman Farrow - Drilling Expert
- Bill Doll, Les Beard, Jeff Gamey, and Barry Kinsall – Geophysics
- Debra Phillips and Yul Roh - Sediment Characterization
- Brian Spalding – Developed use of NaI detector
- Craig Brandt – Database
- Susan Holladay – Data processing and webpage
- Lynda Campbell – Administrative assistance
- Harry Quarles, and Monty Ross – Regulatory issues
- Scott Brooks and Phil Jardine – Geochemistry
- Susan Pffnner and Tom Phelps - Microbiology
- Amy Wolfe –BASIC
- Tonia Mehlhorn and Shannon Graves - Isotherms



## Update on FRC Characterization Activities

- Existing RI data, reactive barrier studies, and original FRC characterization
- Organic Anion Analysis Method
  - Organic anion IC analysis method developed - Isocratic elution by ion chromatography
- Geophysics
  - ORNL seismic and resistivity surface tomography at Area 2, 3, and NT-1 (down gradient of Area 3)
  - LBNL crosswell seismic and radar tomography
- Geochemical characterization of groundwater in Area 3 Field Plot



## Update on FRC Characterization Activities (continued)

- Storm event monitoring at Area 3 Field Plot (FW100)
  - Four ports in FW100 monitored during 6.24" rainfall event
  - Field parameters, anions, cations, and DOC
- Mineralogical evaluations (thin sections, SEM, EDX, XRD, XPS, XAS)
  - Background Area (FRC/UT collaboration)
  - Areas 1 and 3 (sonic core analysis from Area 3)
  - Isotherm analysis (Jardine/Mehlhorn/Graves)
- PNNL, LBNL, LANL, ORNL Sampling Event
  - Select samples from Background Area and Areas 1, 2, and 3
  - U and metals (XRD and ICP/MS)
  - Sequential extraction of Fe, Al, Mn, Si etc.
  - TOC, TIC, pH, nitrate, nitrite
  - Live/dead cell counts



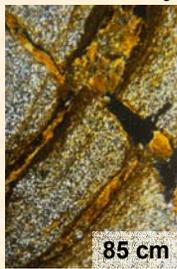
## Sources of Information

- FRC Website
  - Data Server
  - PI data exchange page
  - PI research summary table
- Field Research Teams
  - Stanford/ORNL – Area 3
  - OSU/OU – Areas 1 and 2
  - PNNL/ORNL/U. Alabama
- Other NABIR Researchers (e.g.)
  - MSU, Terry Marsh
  - INEEL, David Cummings
  - FSU, Joel Kostka
  - Bug Traps (coupons)
    - UT, David White and Aaron Peacock
    - INEEL, Gill Geesey

## Background Core Mineralogical Evaluation



Shallow and deep thin sections showing bedding parallel and orthogonal fractures with clay, Fe and Mn infillings



85 cm  
Shallow - clay infilling  
with sand matrix



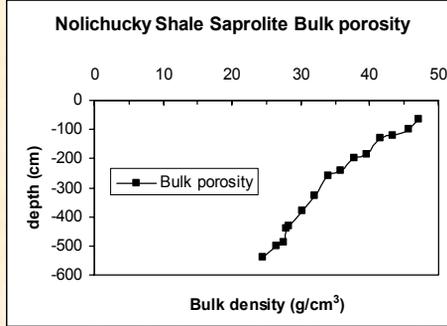
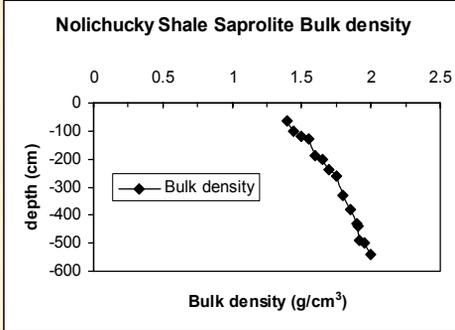
445 cm  
Deep - Fe/Mn lining  
with silt matrix



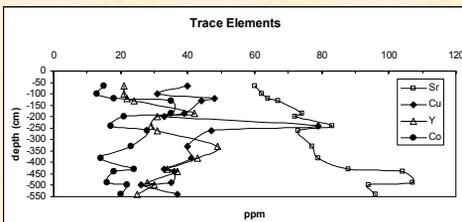
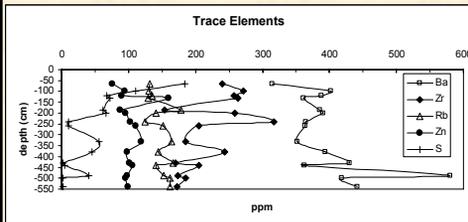
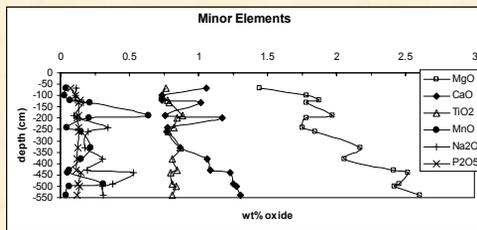
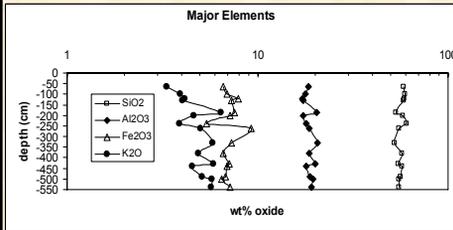
135 cm  
Sand matrix with  
clay and Fe/Mn



## Bulk Density and Porosity of Background Core

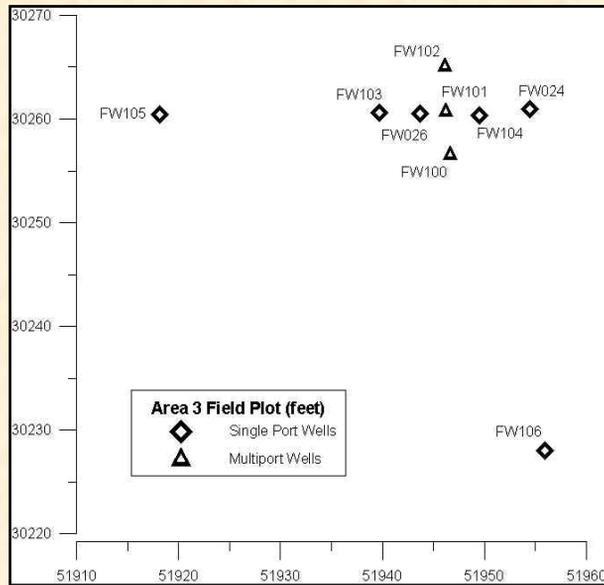
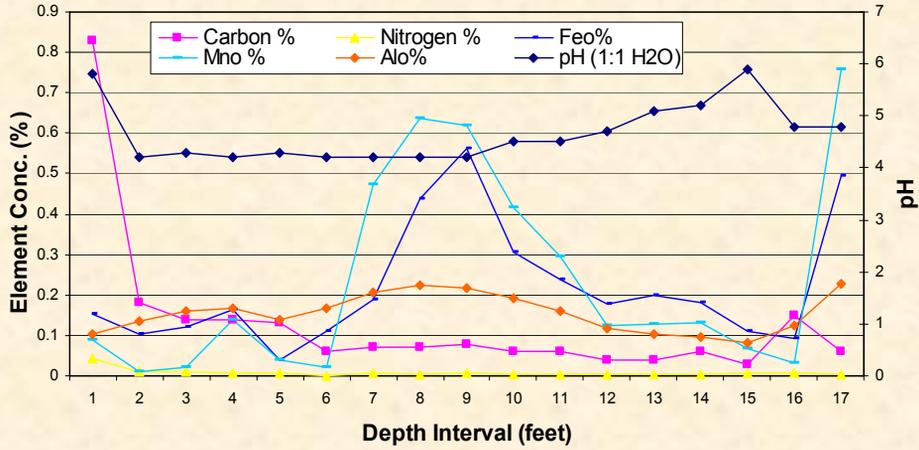


## XRF Analysis of Background Core



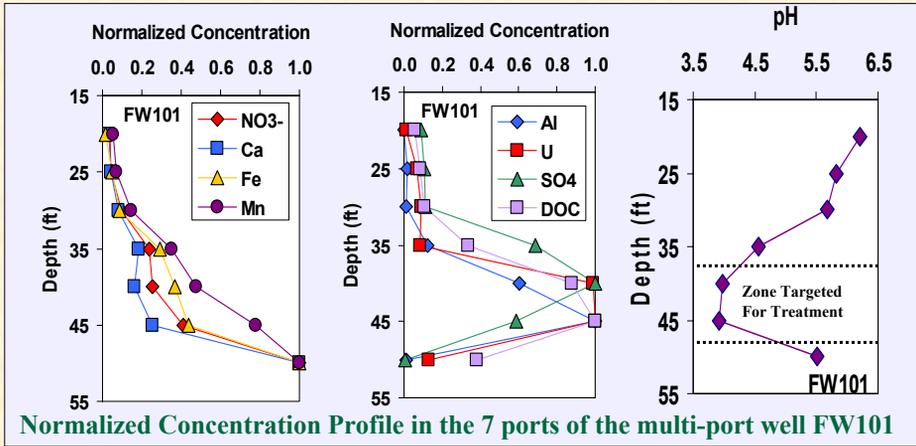


### Oxalate Extraction Analysis of Background Core





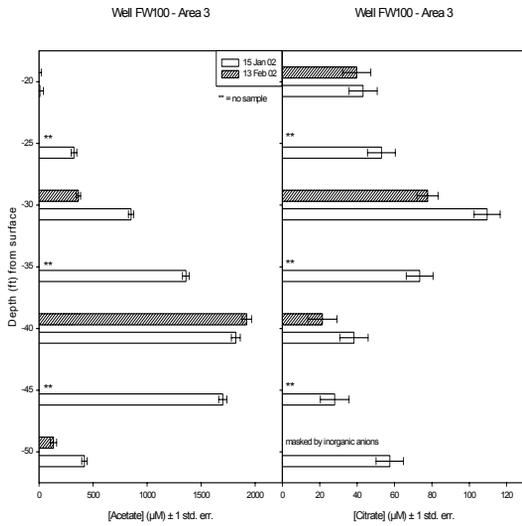
# Characterization of Area 3 Field Plot Geochemistry



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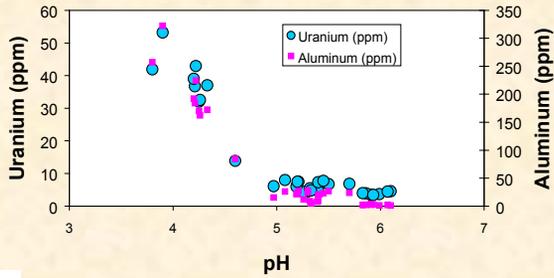
## Depth profile of acetate and citrate in FW100



**Acetate and Citrate detected in Area 1 and 3 wells  
- maximum concentration of 1821 uM/L and 110 uM/L**

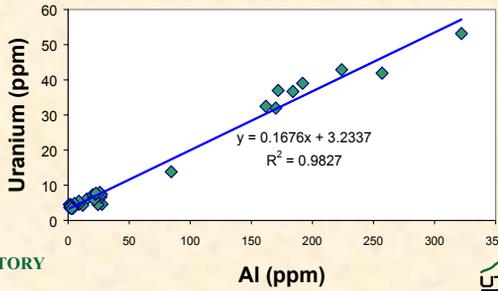


FW100 - all levels

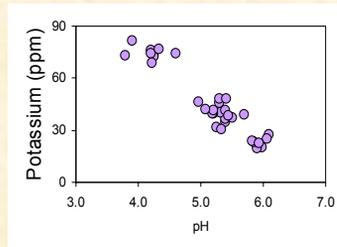
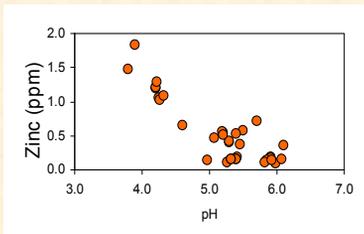
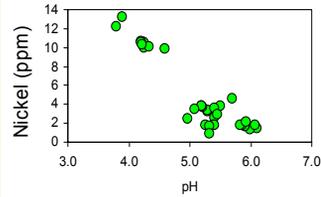


Good correlation observed between U, Al, and pH

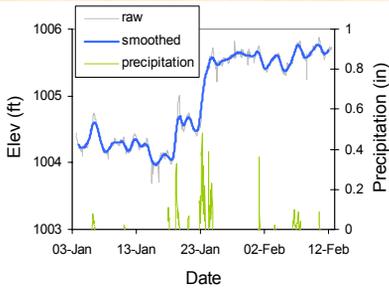
FW100 - all levels (Great correlation between dissolved Al and U)



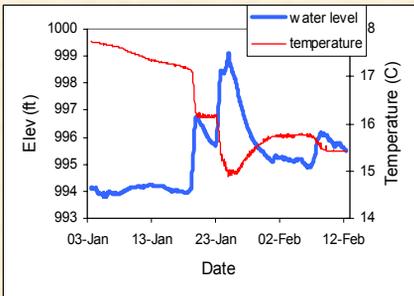
Other cations that show a good correlation to pH in FW100



### Rainfall and Groundwater level in FW024

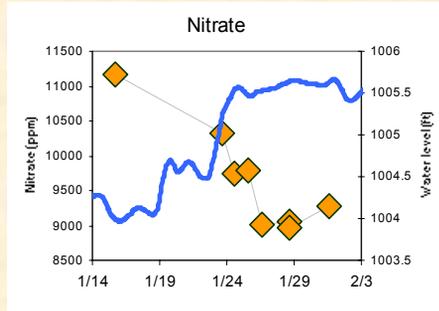


### Groundwater levels in ED08 (trench at Area 1)



## Storm Response

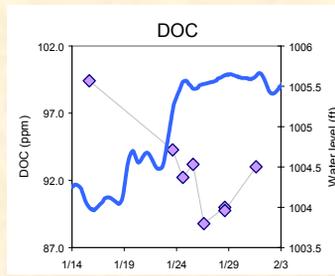
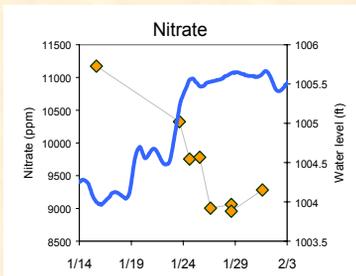
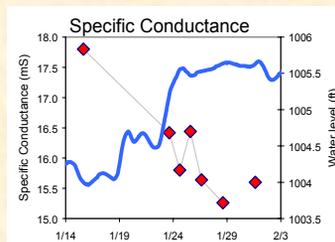
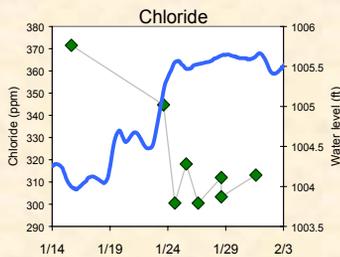
### Change in Nitrate in 40' port during storm



- Groundwater levels increased 1.5' in response to 6.24" rainfall event in Area 3 Field Plot
- Nitrate concentration decreased 20% in 40' deep port and 31% in 20' deep port
- Stronger storm response is observed in Area 1

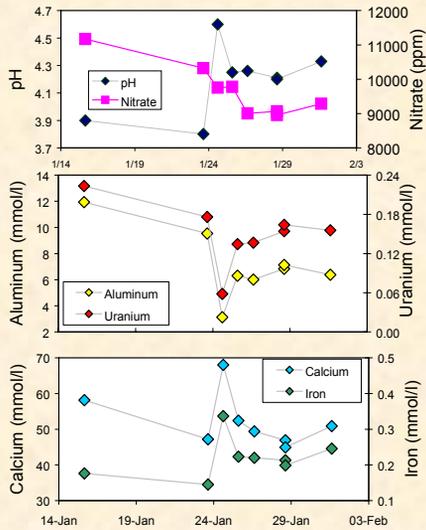
NABIR **Field Research Center**

40 foot depth, selected solute concentrations (and sp. Conductance) in FW100 vs. water level in FW026

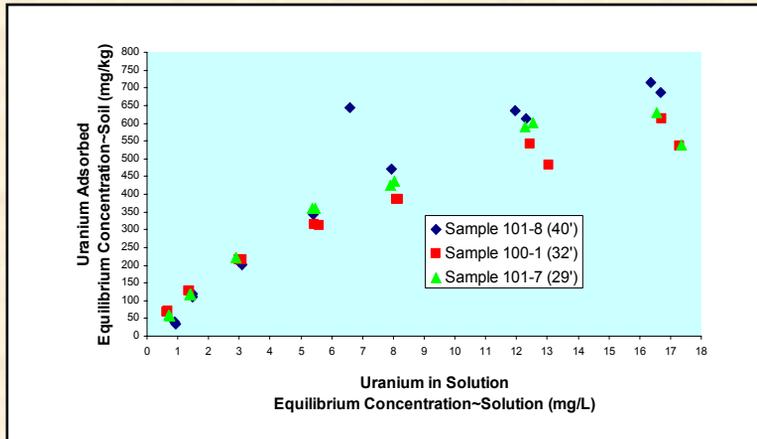




Ions respond differently to storm event but some response appears to be partially related to pH changes

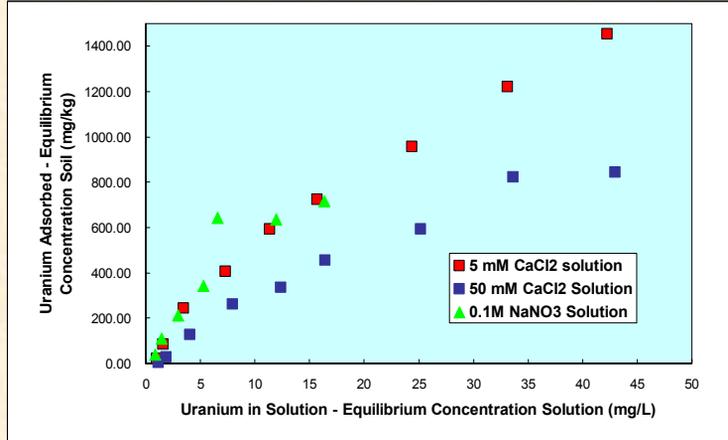


## Uranium Adsorption 0.1M NaNO<sub>3</sub> Solution Three Depths From Area 3, pH~4

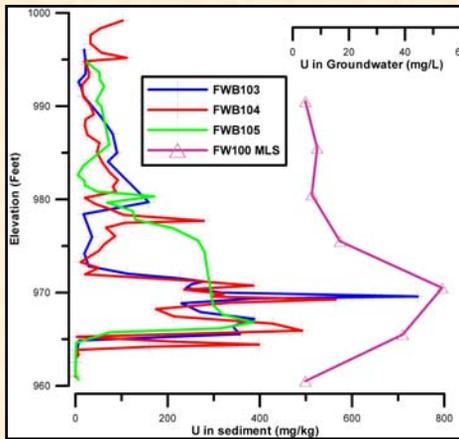
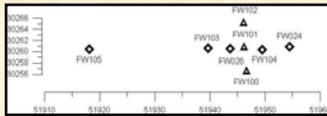




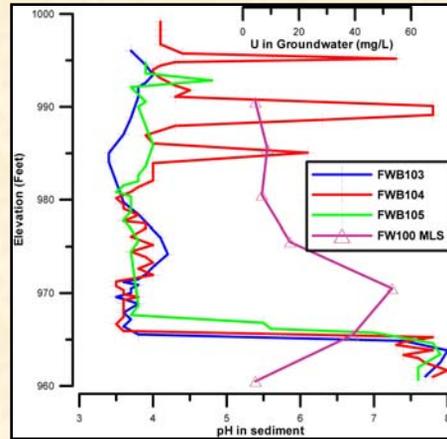
# Uranium Adsorption Solution Impact pH~4



# Rotasonic Core Analysis Area 3 Field Plot

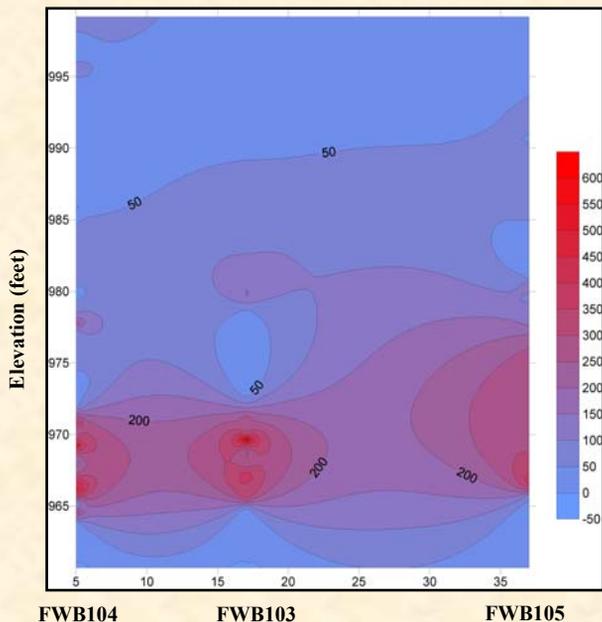


Uranium

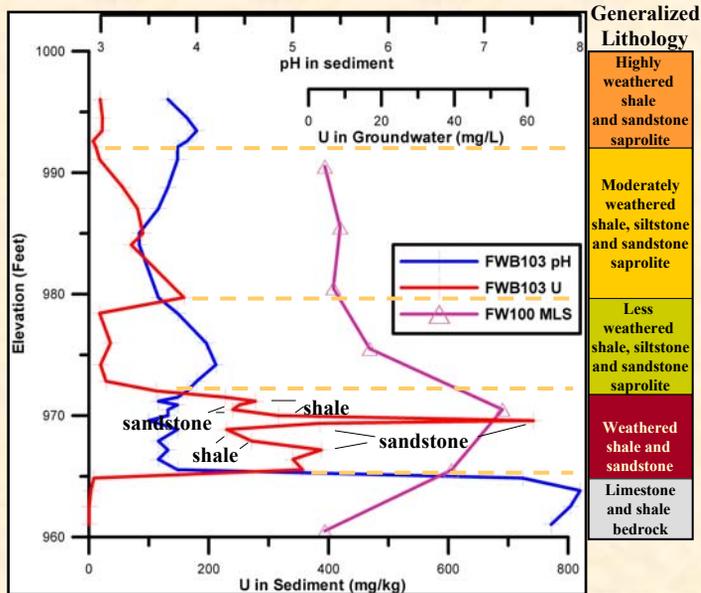


pH

### Uranium Sediment Concentration Area 3 Field Plot



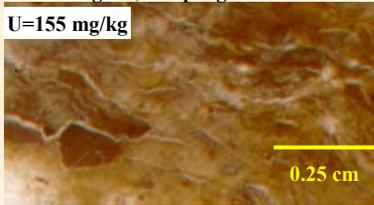
### Uranium and pH on Sediment compared to U in Groundwater Area 3 Field Plot (FWB103)



## Area 3 Core Mineralogical Evaluations

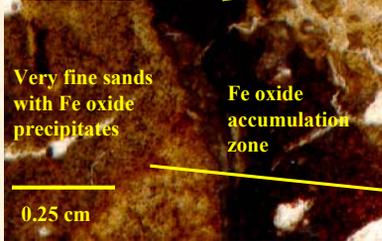
Overlying Gleyed leached flow zone with high U, low pH groundwater

U=155 mg/kg



Black precipitate Zone with higher pH and lower U in groundwater

U=730 mg/kg

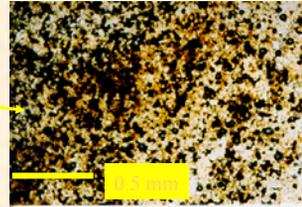
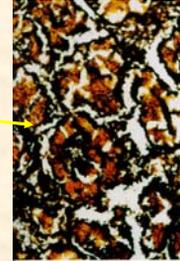
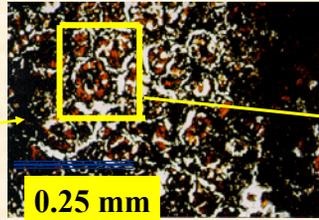


A high U zone was detected in FW100 (Area 3 field site) at a depth of 46'.

XRD results:

Gleyed Zone - Quartz, Vermiculite, Mica, HIV, Ca-feldspar

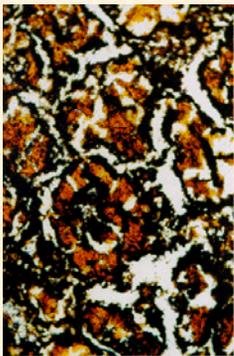
Black Zone - Quartz, Ca-feldspar, Vermiculite, Mica, Goethite



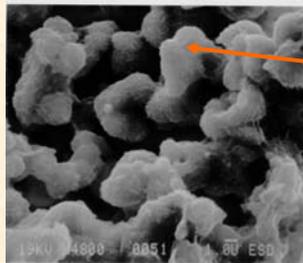
## SEM-EDX Analysis of Black High Rad Zone

U detected with SEM/EDX in black zone in association with Fe, Mn, mica, sulfur and phosphorous.

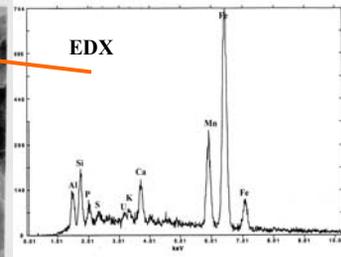
U<sup>+4</sup>:U<sup>+6</sup> detected at 64%:36% with XPS.



Thin Section



SEM



XAS on black layer

Ferrihydrite: 44%

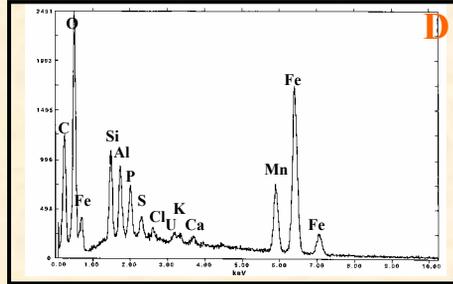
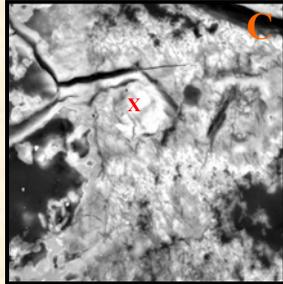
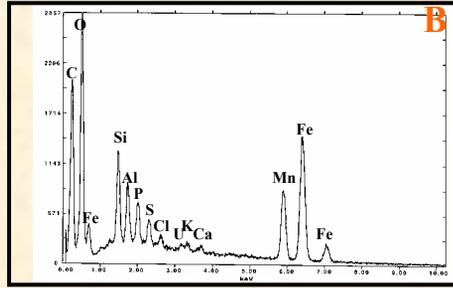
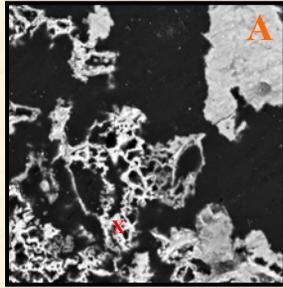
Goethite: 47%

Hematite: 7%

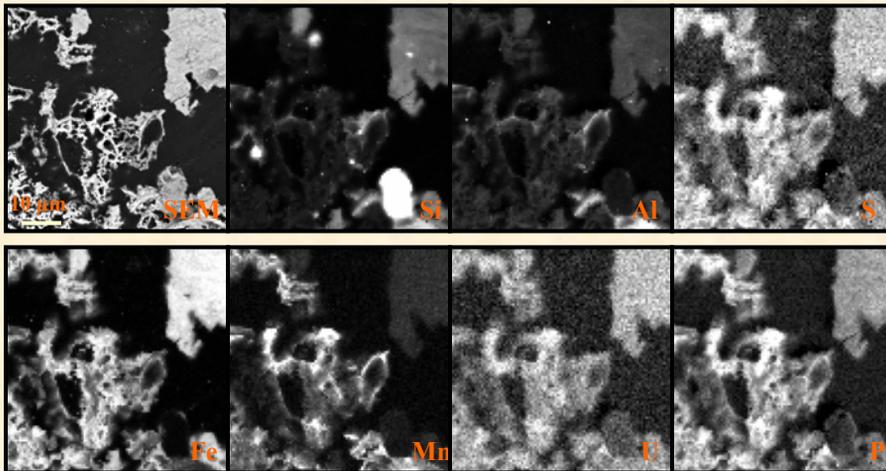
Hornblende: 22%

U identified as U<sup>+6</sup>

## SEM-BSE-EDX analysis of FWB100-06-09 sample Black Rad. Zone

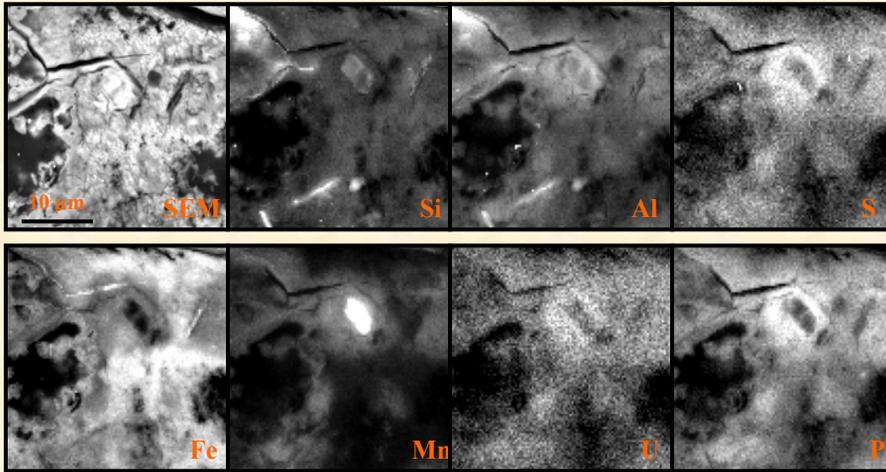


## SEM-BSE-Element Mapping of FWB100-06-09 Sample Black Rad. Zone





**SEM-BSE-Element Mapping of FWB100-06-09 sample Black Rad. Zone**

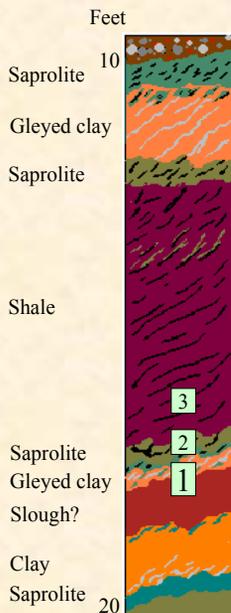


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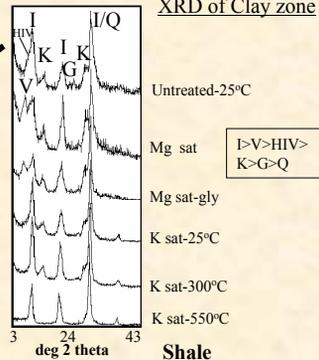
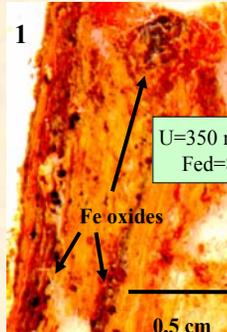


**Area 1 Core Analysis**

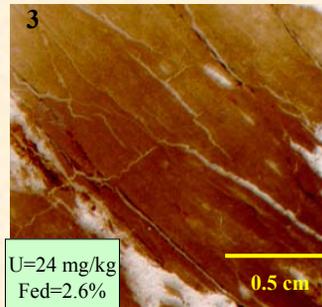
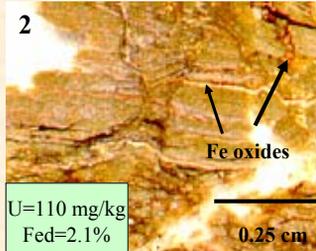
**Core 21**



**Fe rich clay zone**



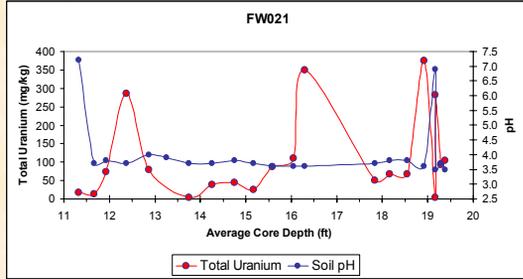
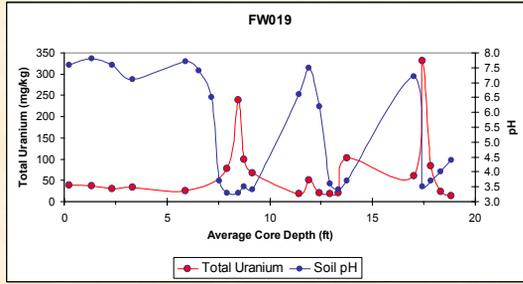
**Highly weathered leached saprolite**





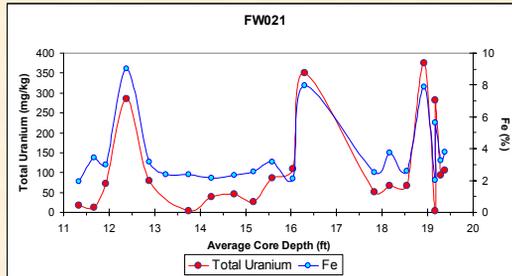
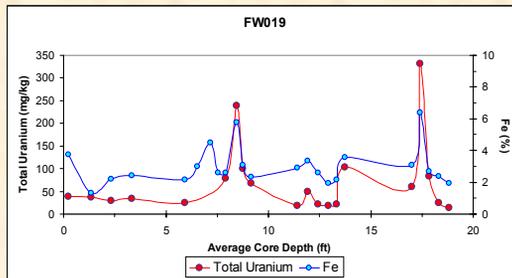
### Comparison of U versus pH in sediment at the OSU/OU Site

Inverse relationship observed at FW019, little correlation observed at FW021



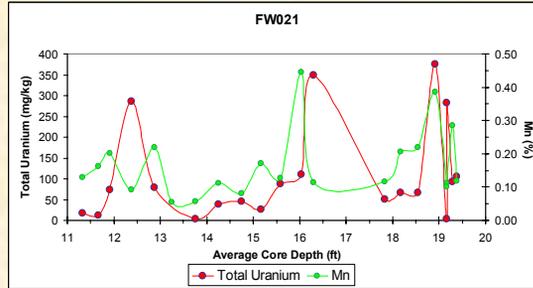
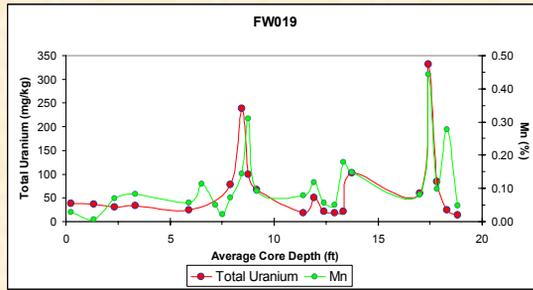
### Comparison of U versus Fe concentrations in sediments at the OSU/OU Site

Excellent correlation observed at FW019 and FW021

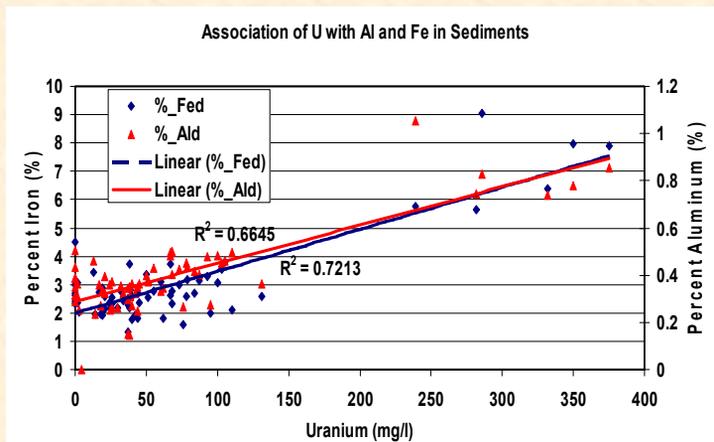


## Comparison of U versus Mn in sediment at the OSU/OU Site

Excellent correlation at FW019 but not as good at FW021.

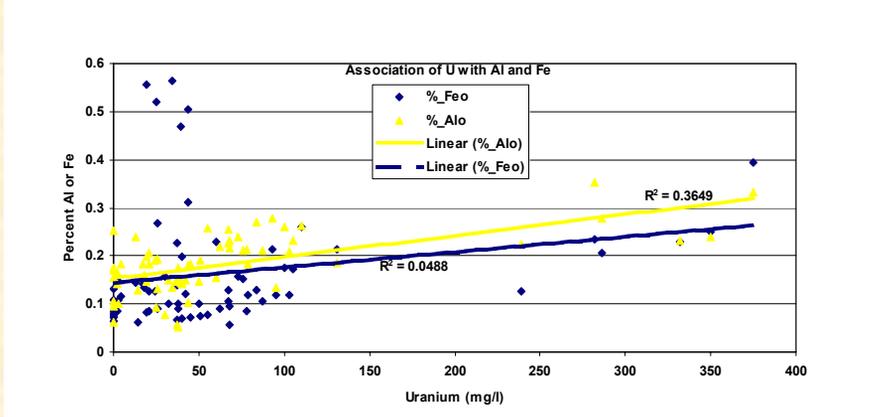


Fair correlation observed between occurrence of U with crystalline Fe and Al oxides in Area 1 and 3 core material

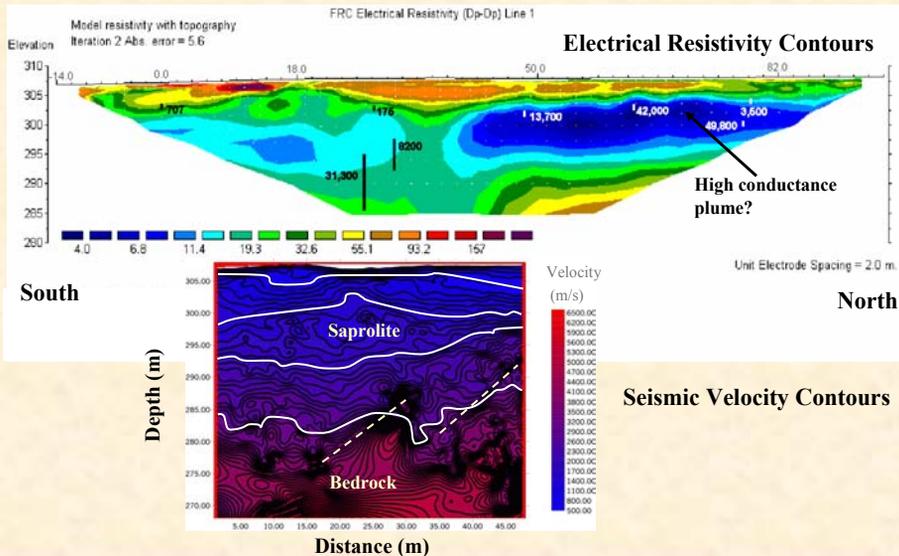




### Poor correlation observed between occurrence of U with amorphous Fe and Al oxides in Area 1 and 3 core material

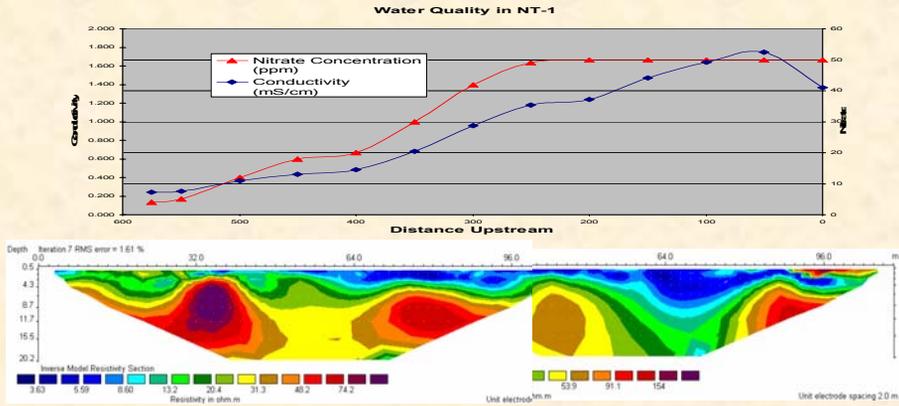


## Seismic and Resistivity Surveys





## Comparison of Surface Resistivity Tomography Profile at NT-1 to Surface Water Quality



## Future FRC Characterization Work

- **Area 1**
  - Coring to obtain sediment for OU lab tests – in 3 weeks
  - Coring to assess manipulations – in 2 months
- **Area 2**
  - Groundwater sampling by OSU – This week
  - Coring and well installation to characterize site for new projects – Starting in October
- **Area 3**
  - 3 new boreholes drilled and logged for geophysics work – Starting this week
- **Background Area**
  - Concentration of forest soil humics
  - Cores for PNNL project
- **Bug trap work in Areas 1, 2, 3 and Background Area**