NABIR FRC Characterization Activities
Oak Ridge, Tennessee

March 20, 2002 FRC Breakout

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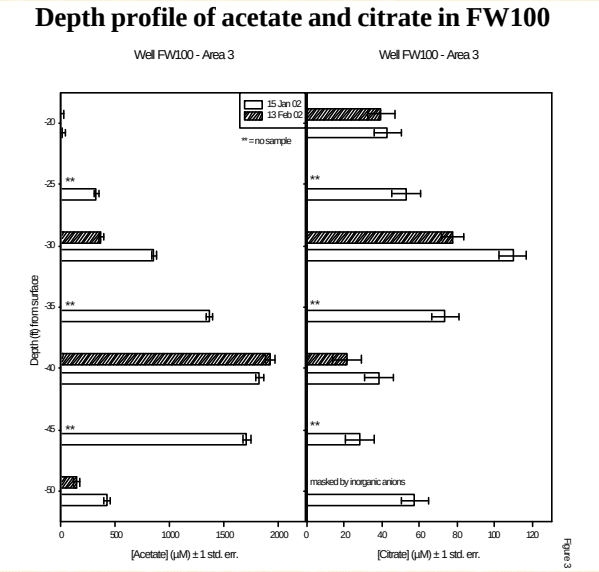
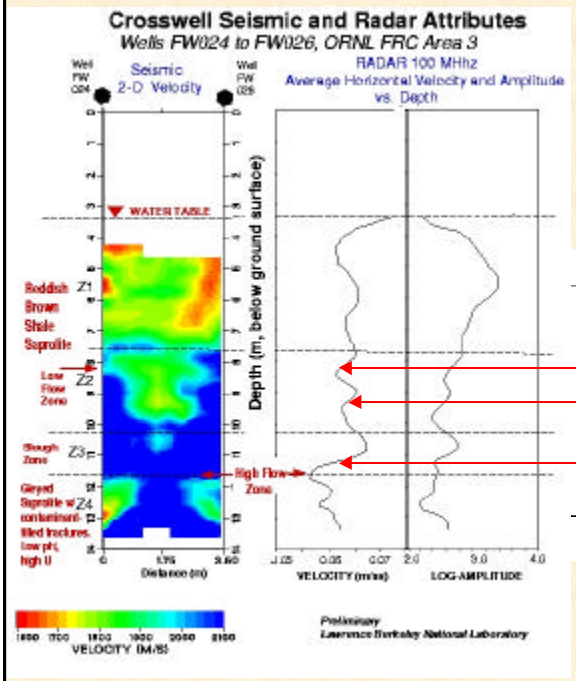
Update on FRC Characterization Results

- **Geophysics**
  - **ORNL seismic and resistivity surface tomography at Area 2 and NT-1 (down gradient of Area 3)**
  - **LBNL crosswell seismic and radar tomography**
- **Geochemical characterization of groundwater in Area 3 Field Plot**
- **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 (FRC and INEEL)**
- **Bug traps – PLFA and rDNA (FRC/UT collaboration)**

Organic Anion Analysis Method

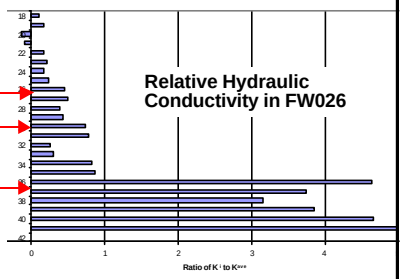
- **Organic anion IC analysis method developed - Isocratic elution by ion chromatography**
  - **Analytical column: Dionex IonPac ICE-AS6 Analytical Column**
  - **Eluant: 0.4 mM Heptafluorobutyric acid**
  - **Detection: Suppressed conductivity**
  - **Suppressor: Dionex Anion-ICE MicroMembrane Suppressor**
  - **Regenerant: 5 mN Tetrabutylammonium hydroxide**
- **Acetate and Citrate detected in Area 1 and 3 wells at a maximum concentration of 1821 mM/L and 110 mM/L**





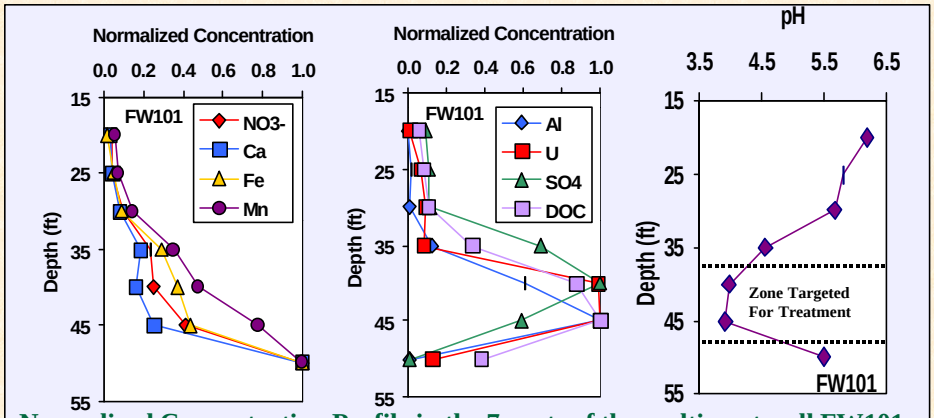
Comparison of stratigraphy and borehole flow meter data with LBNL (Susan Hubbard, Ernie Majer, and Ken Williams) crosswell seismic and radar study

Borehole flowmeter data



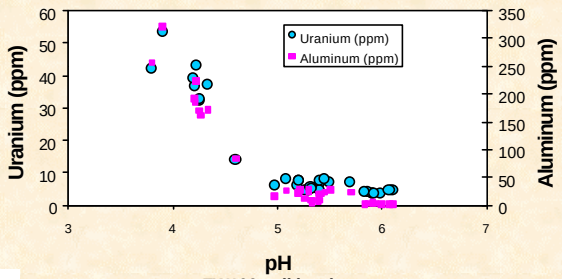
Field Research Center

Characterization of Area 3 Field Plot Geochemistry



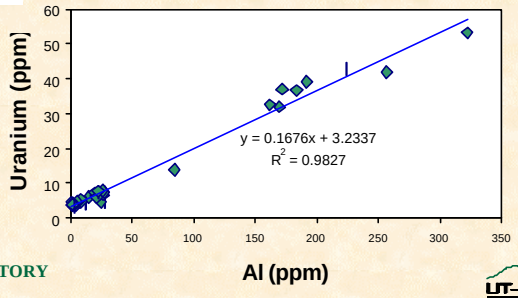
Normalized Concentration Profile in the 7 ports of the multi-port well FW101

FW100 - all levels

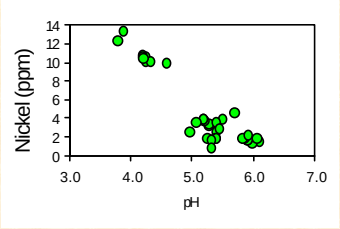


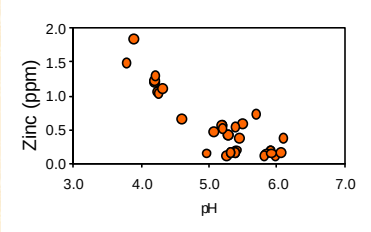
Good correlation observed between U, Al, and pH

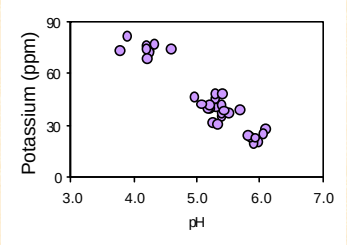
FW100 - all levels
(Great correlation between dissolved Al and U)



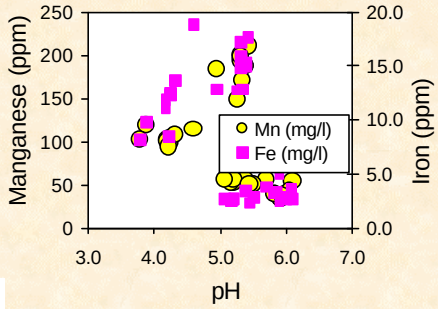
Other cations that show a good correlation to pH in FW100



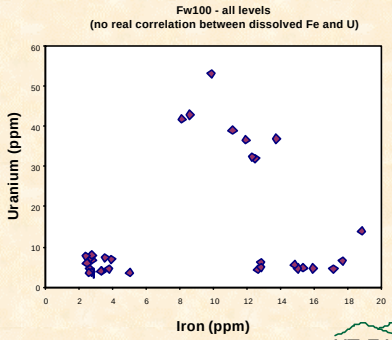




Field Research Center

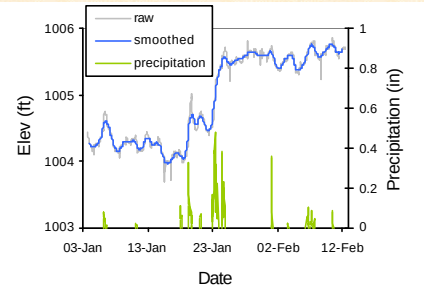


Poor correlation observed between Mn, Fe, and pH and U

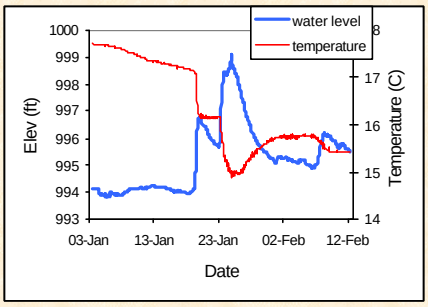


Storm Response

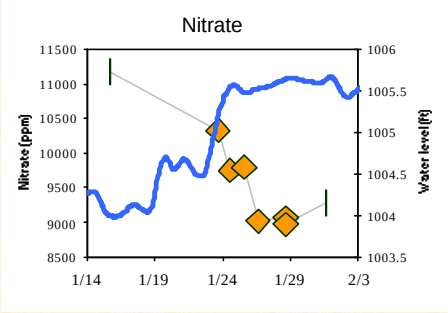
Rainfall and Groundwater level in FW024



Groundwater levels in ED08 (trench at Area 1)



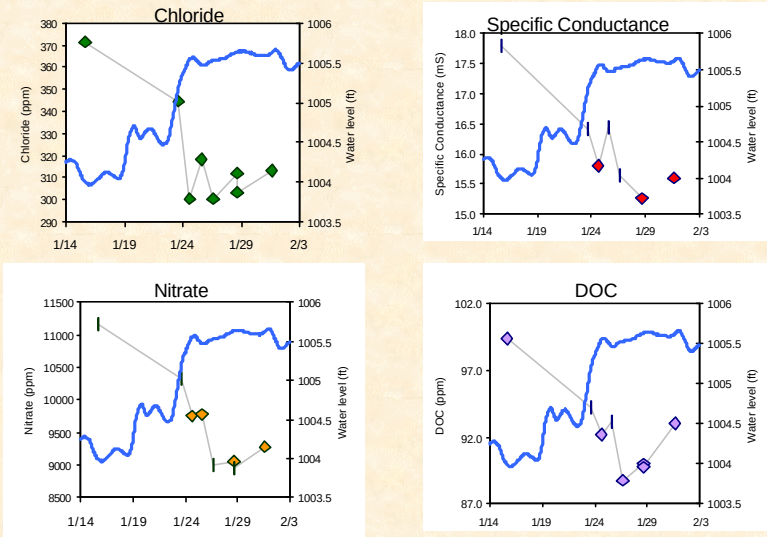
Change in Nitrate in 40' port during storm



- **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**

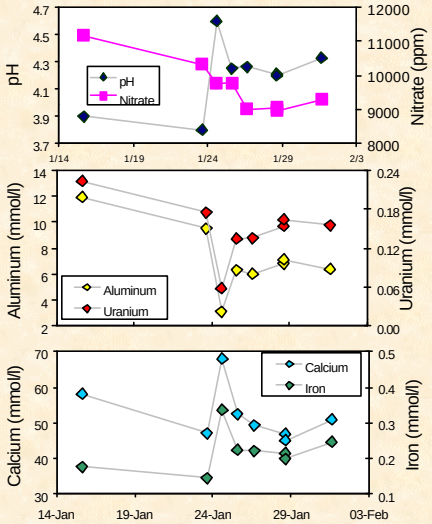
Field Research Center

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

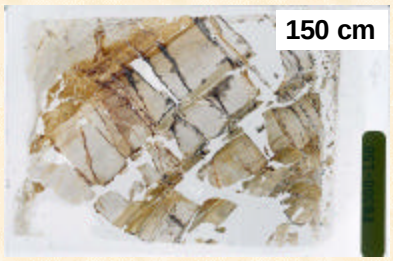


Field Research Center

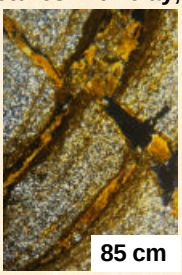
Ions respond differently to storm event but some response appears to be partially related to pH changes



Background Core Mineralogical Evaluation

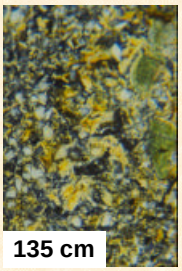


Shallow and deep thin sections showing bedding parallel and orthogonal fractures with clay, Fe and Mn infillings



Shallow - clay infilling with sand matrix

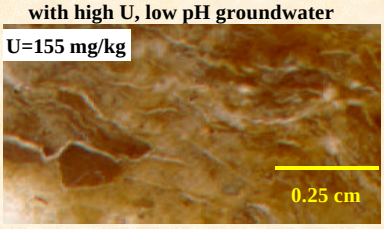
Deep - Fe/Mn lining with silt matrix



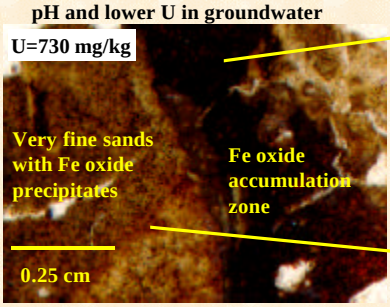
Sand matrix with clay and Fe/Mn

Area 3 Core Mineralogical Evaluations

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



Black precipitate Zone with higher pH and lower U in groundwater

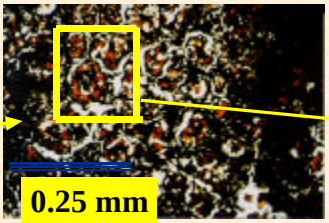


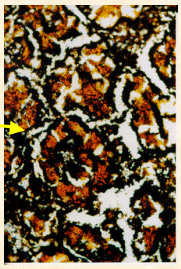
A high U zone was detected in FW100 (Area 3 field site) at a depth of 46'.

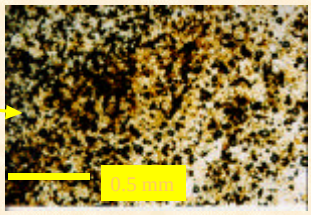
XRD results:

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

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







<u>XAS on black zone</u>

Ferrihydrite: 44%

Goethite: 47%

Hematite: 7%

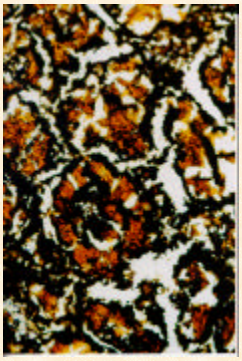
Hornblende: 22%

U identified as U^{+6}

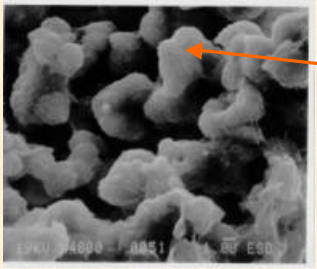
SEM-EDX Analysis of Black High Rad Zone

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

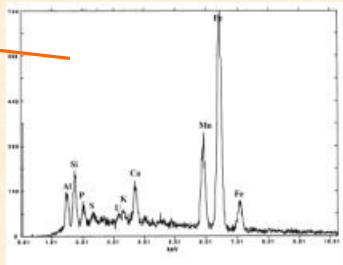
U^{+4}:U^{+6} detected at 64%:36% with XPS.



Thin Section



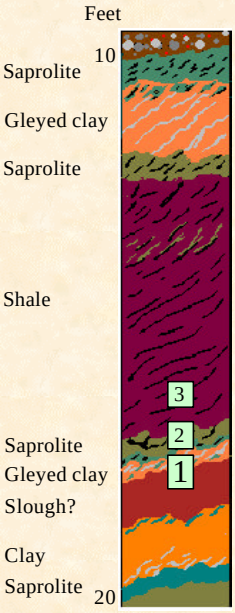
SEM



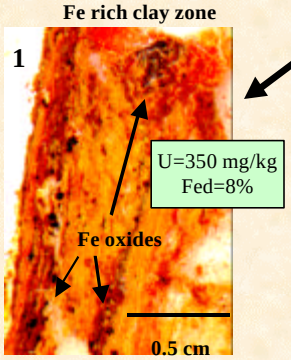
EDX

Area 1 Core Analysis

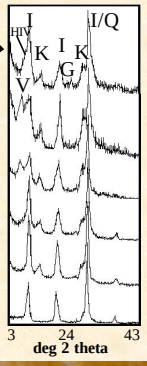
Core 21



Fe rich clay zone

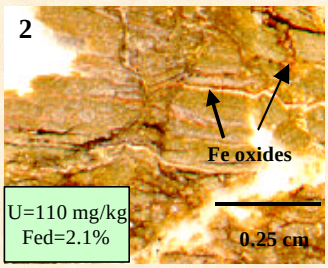


XRD of Clay zone

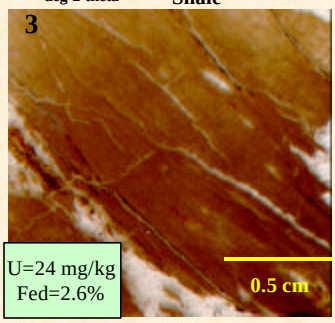


I>V>HIV>
K>G>Q

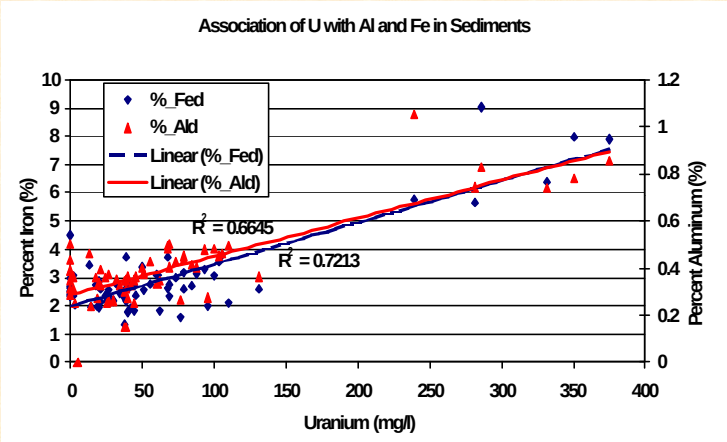
Highly weathered leached saprolite



Shale



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



INEEL Mineralogical Analyses (David Cummings) - Work Conducted

- **Goal - determine the diversity of indigenous metal-reducing bacteria and to understand the nature of the metal oxides available for reduction by the metal-reducing populations**
- **Chemical analyses - include sequential extractions of Fe and Mn, and simultaneously extracted trace metals, secondary-ion mass spectrometry (SIMS) to identify surface adsorbed species, and X-ray absorption spectroscopy (XAS) to identify the species intimately associated with the metal oxides.**
- **Microbiological analyses - include enrichments for Fe-, Mn-, and sulfate-reducing bacteria, plate counts of aerobic heterotrophs, and construction of Bacterial and Archaeal 16S rDNA libraries.**
- **Work conducted on 2 Area 3 cores and 3 Background Cores**

INEEL Mineralogical Analyses (David Cummings) - Conclusions

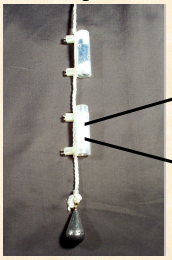
- Little Fe(II) could be detected in any extraction
- Large quantities of the Fe in the systems are tied up in recalcitrant mineralogical forms
- The Mn data suggest that a large fraction of the Mn at both Areas is in a potentially bioavailable form
- Ni is bound in some potentially bioavailable forms with both Fe and Mn and Co may also be in a highly bioavailable form

INEEL Mineralogical Analyses (David Cummings) – Conclusions (continued)

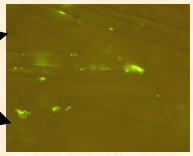
- Plate counts
  - Area 3 no colonies (10^{-4})
  - Background Area – increased with depth (dominated by 1 or 2 colonies)
- Enrichments
  - Area 3 sulfate and H^2 only positive
  - Background Area multiple enrichments reducing Fe, Mn, SO4 and NO3 from all depths
- Clone libraries for saturated background Area
  - 8 ribotypes were identified by RFLP, but 2 dominate

Example - Down-Well Coupons For Enhanced Microbial Monitoring FRC Area 2

Traps



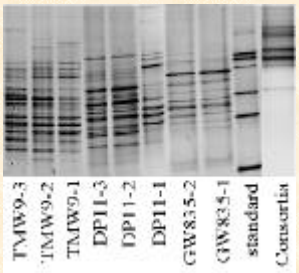
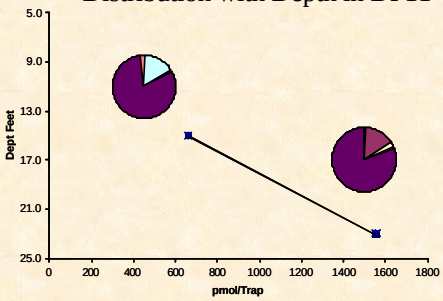
Colonized Surface



Areas deployed:

- **Areas 1, 2, and 3**
- **Background Area**
- **Maynardville Limestone**

DGGE Profiles of 16S rDNA



PLFA Biomass and Distribution with Depth in DP11