Oak Ridge Field Research Center Highlights

August 2004

Presentation Outline

Organizational Highlights

- *FRC strategic plan*
- *Working groups*
- *Conceptual model*
- *Strong research collaborations*

Research Highlights

- *Conductivity profiling*
- *Geophysics applications*
- *In situ bioreduction of U*
- *Biosensor for U*
- *Novel microbial sampling techniques*
- *Microbial characterization, microarrays, and sequencing*
- *Interfacial interrogation and contaminant speciation*
- *Site wide numerical model*

Personnel Highlights

Publication Highlights

Organizational Highlights: Strategic Plan

FRC strategic plan has been finalized and serves as an excellent guide as to the short, medium, and long term goals and objectives of the Oak Ridge FRC.

Field Research Centers Mission

To serve as premier field research sites at which NABIR and other BER investigators can obtain samples and conduct *in situ* studies that will lead to new insights into the bioremediation of metals and radionuclides and related contaminant fate and transport processes.

S-3 Disposal Ponds During Denitrification

Organizational Highlights: Working Groups

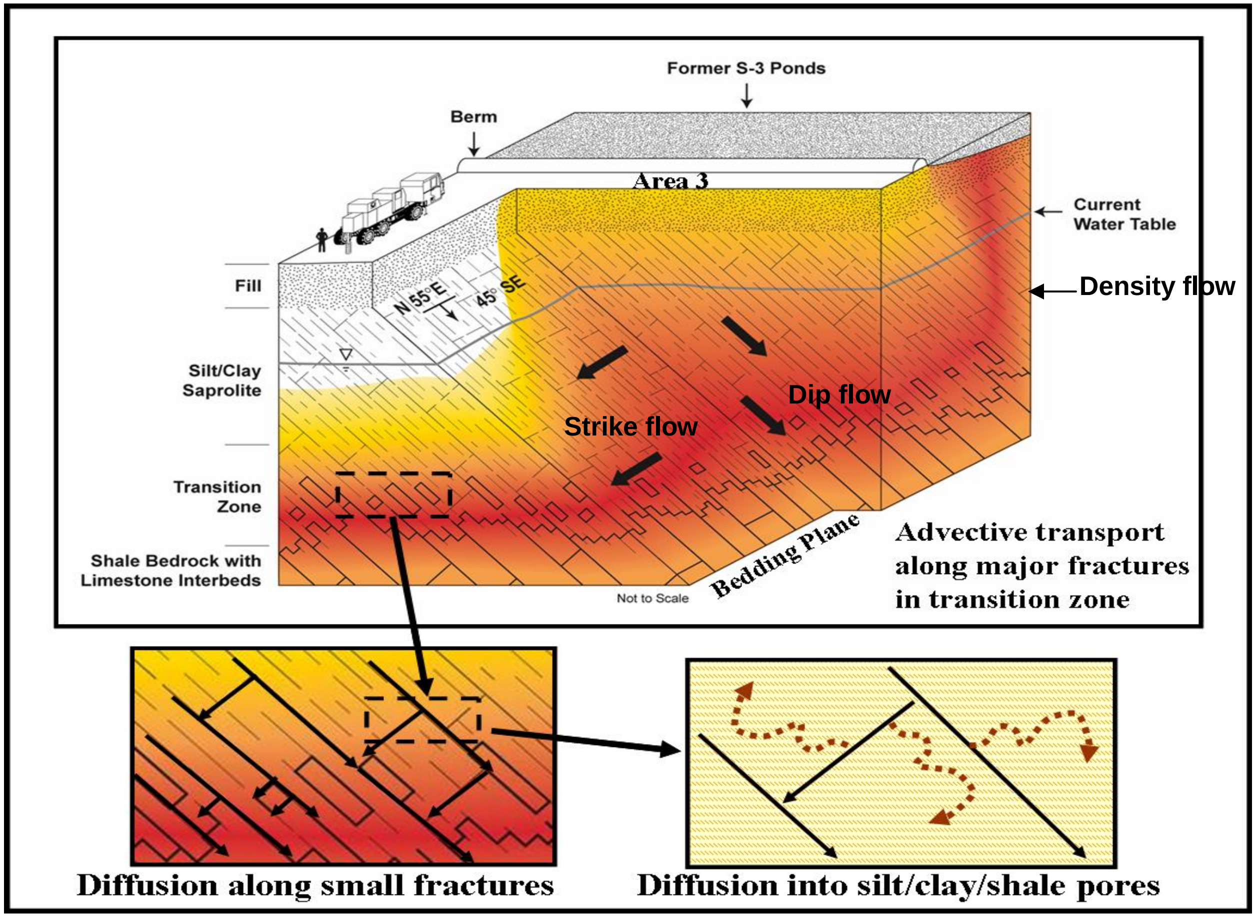
Four working groups have been established to implement collaborations and knowledge transfer among various projects associated with the Oak Ridge FRC.

Formal documentation and a description of group activities (*NABIR Field Research Center Analysis of Links and Interactions Among Projects*) has been finalized and working group leaders have been coordinating activities within and between groups for nearly 2 y.

(1) Microbial Community Analysis (Kostka)
(2) Rates of Microbially Mediated Metal Reduction and Oxidation (Burgos)
(3) Geochemical/Geophysical Characterization (Jardine)
(4) Numerical Modeling (Parker)

Organizational Highlights: Conceptual Model

An extensive document has been prepared that describes the Oak Ridge FRC conceptual model. It provides researchers with up to date information of hydrological, geochemical, mineralogical, and microbial processes in both the background and contaminated areas.



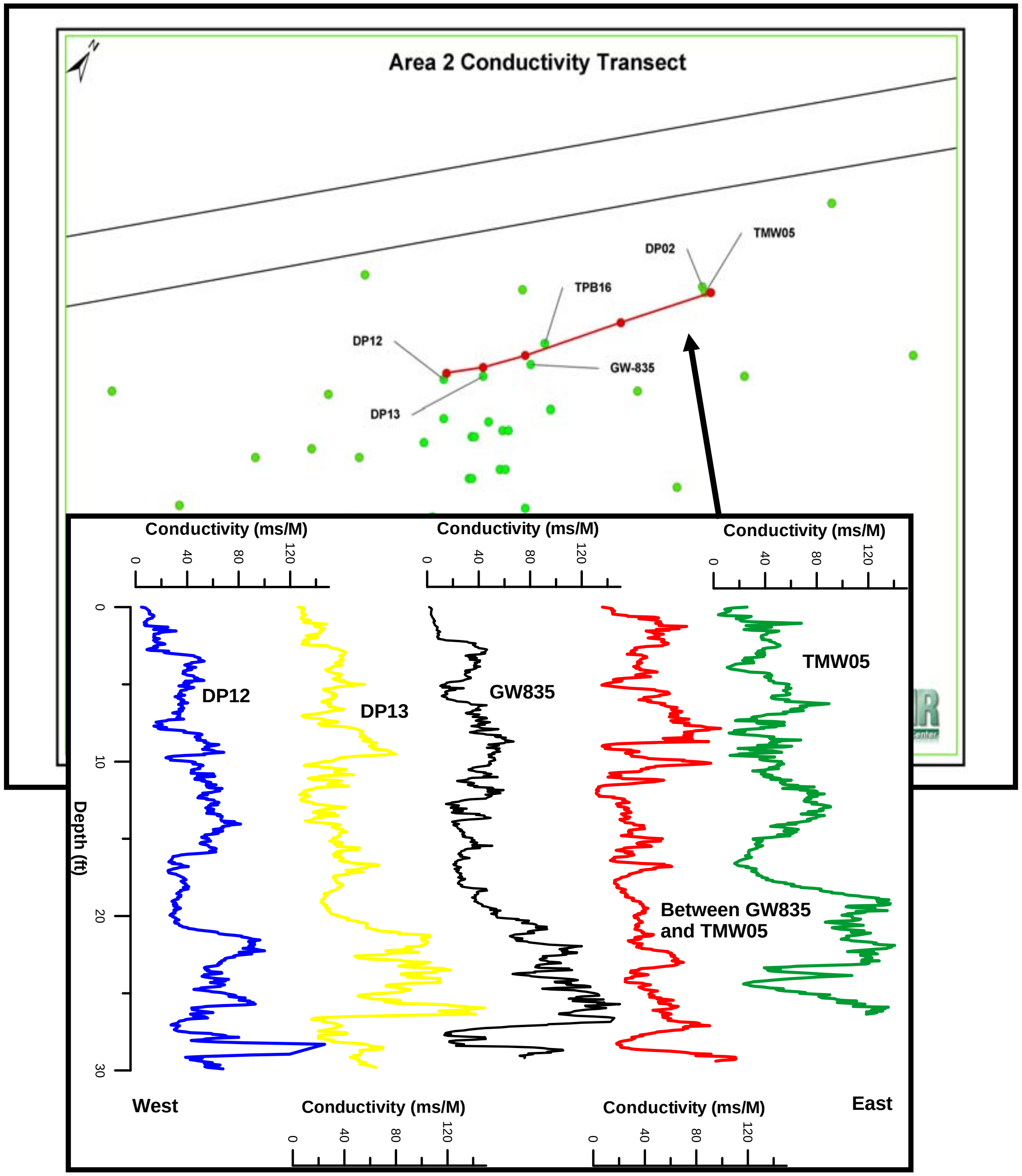
Organizational Highlights: Strong Research Collaborations

Strong coupling of research at the molecular scale with research endeavors at the field scale.   Multi-disciplinary and multi-institutional.

Area 1	
Example: Istok (OSU)	**- Macroscopic field scale biostimulation via push-pull. Data suggestive of U bioreduction.**
Kostka (FSU)	**- Microbial community structure and activity consistent with a bioreduction process.**
Stucki (Purdue)	**- Fe-oxide Mossbauer data consistent with bioreduction process.**
Area 3	
Example: Criddle (Stanford)	**- Macroscopic field scale biostimulation via dynamic flow technique. Data suggestive of U bioreduction.**
Doll/Hubbard (ORNL/LBNL)	**- Coupling of geophysical techniques for confirming plume dynamics and hydrogeochemical changes during biostimulation.**
Fields (Miami)	**- Microbial community structure and activity consistent with a bioreduction process.**
Fendorf (Stanford)	**- XAS results confirm that U(VI) is being reduced to U(IV). All evidence points to bioreduction.**

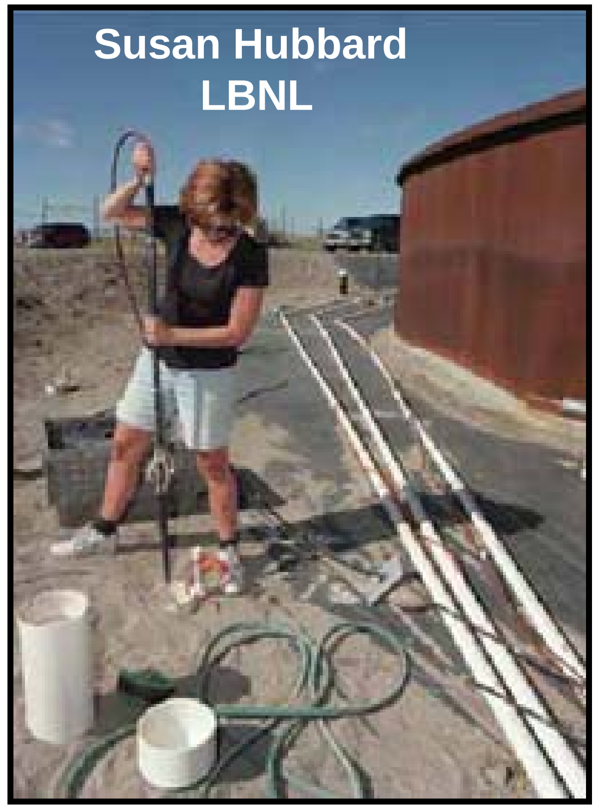
Research Highlights: Conductivity profiling

Electrical conductivity profiling during simultaneous well installation has served as a quick in situ method for interrogating subsurface geochemistry and the location and magnitude of potential contaminant plumes. This strategy has resulted in significant savings with regards to time and money (Watson and Hyder, ORNL).

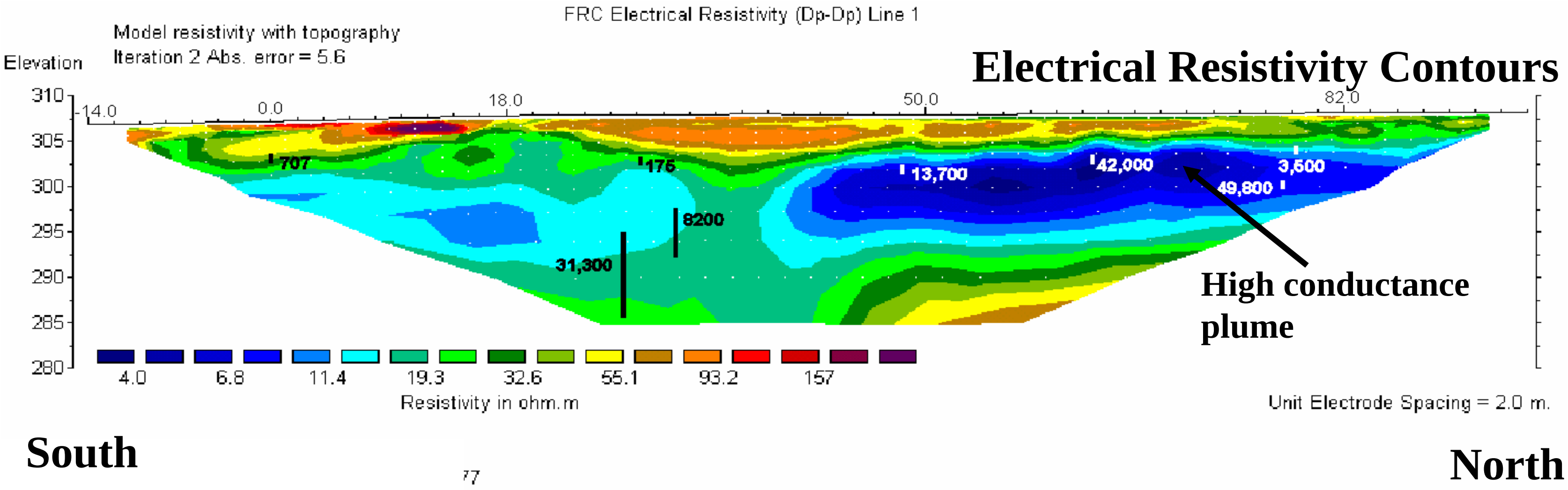


Research Highlights: Geophysical applications

Highly successful use of various non invasive and semi invasive geophysical techniques for locating and tracking contaminant and tracer plumes at the FRC. Electromagnetic induction logging, seismic and radar tomography have been used to quantify contaminant/tracer plumes and material heterogeneities over vast 3-dimensional spatial domains.



Electrical Resistivity at Area 3



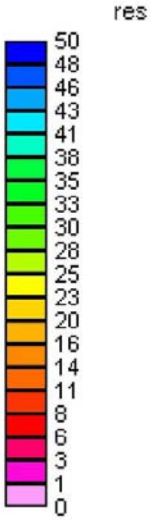
- Surface based geophysics used to identify probable areas of contaminant transport
- Electrical resistivity: light to dark blue = high ionic strength
- Monitor success or failure of biomanipulation by tracking conductivity of plume (e.g. nitrate reduction).
- Has been successfully used in Area 1, 2, 3 and 4.

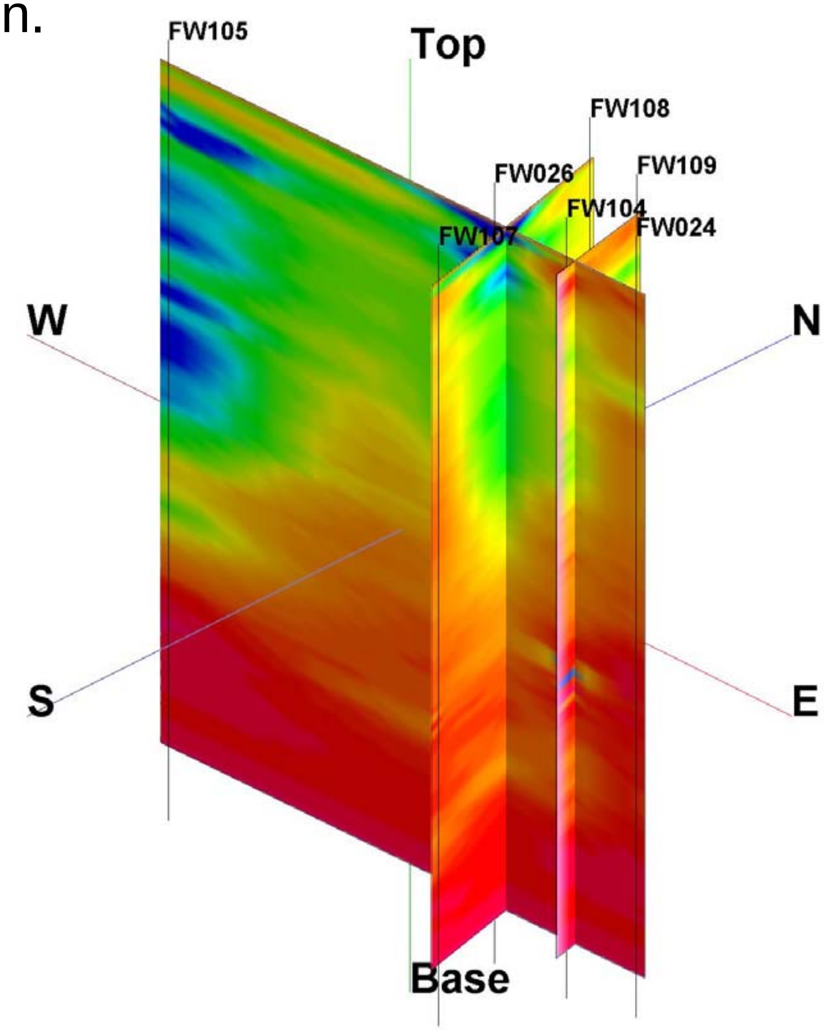
(Doll and Beard, ORNL)

Electromagnetic Induction Logging

Spatial and temporal plume mapping during manipulation.

Complements direct groundwater geochemical tracer measurements.





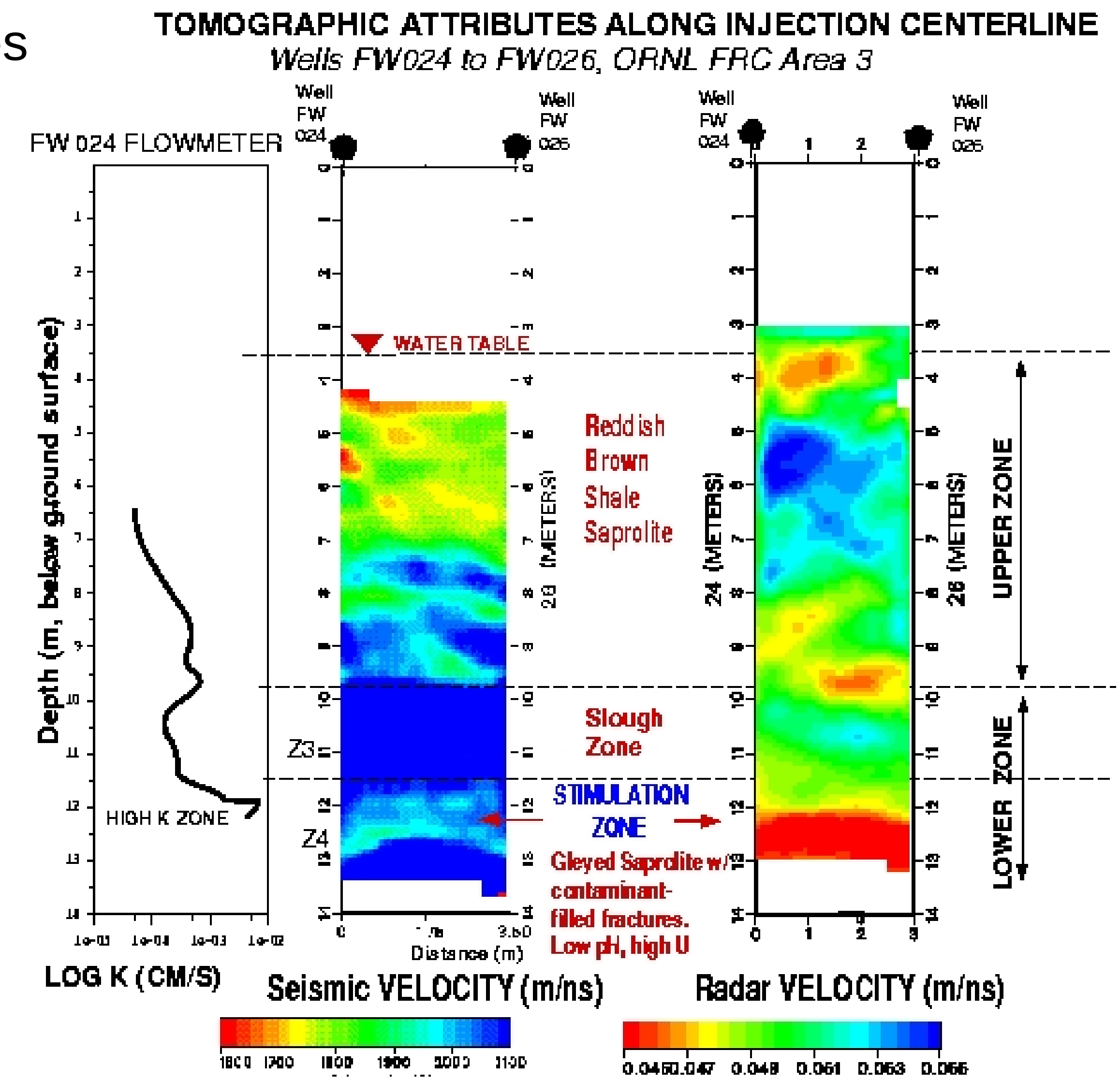
Has been successfully deployed in Area 3, with plans to use this in Area 2.

Beard/Gamey/Doll, ORNL

Seismic and Radar Tomography

Mapping subsurface material heterogeneities using cross-borehole techniques.

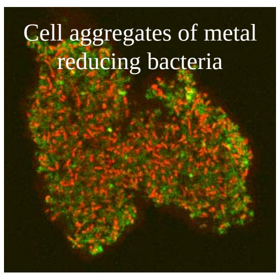
Potential use for assessing sustained bioreduction of metals and radionuclides.



Hubbard et al., LBNL

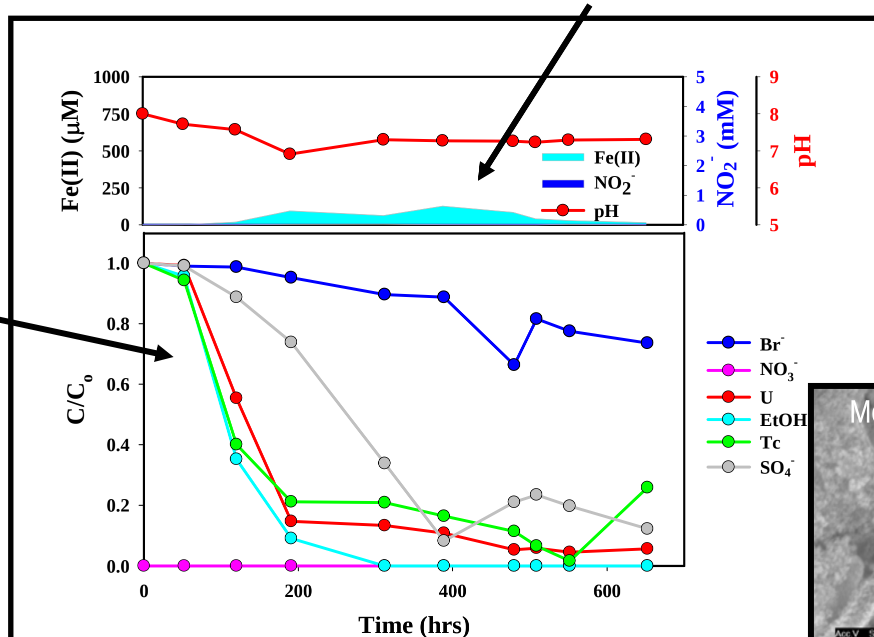
Research Highlights: *In situ* Biostimulation and U(VI) reduction in Areas 1 and 3

Several field studies that have shown simultaneous bioreduction of nitrate, iron(III), and uranium. This is most likely due to the formation of bioaggregates that can reduce multiple competing terminal electron acceptors at the same time. Similar findings have been shown in the laboratory (Istok, Criddle, Fendorf).

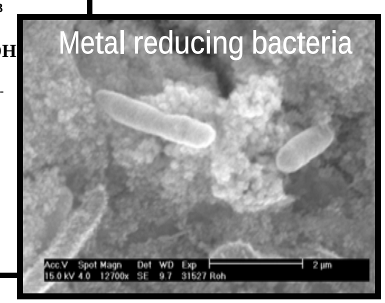


In situ bioreduction of metals and rads. occurs even in the presence of competing electron acceptors (e.g. Fe-oxides)

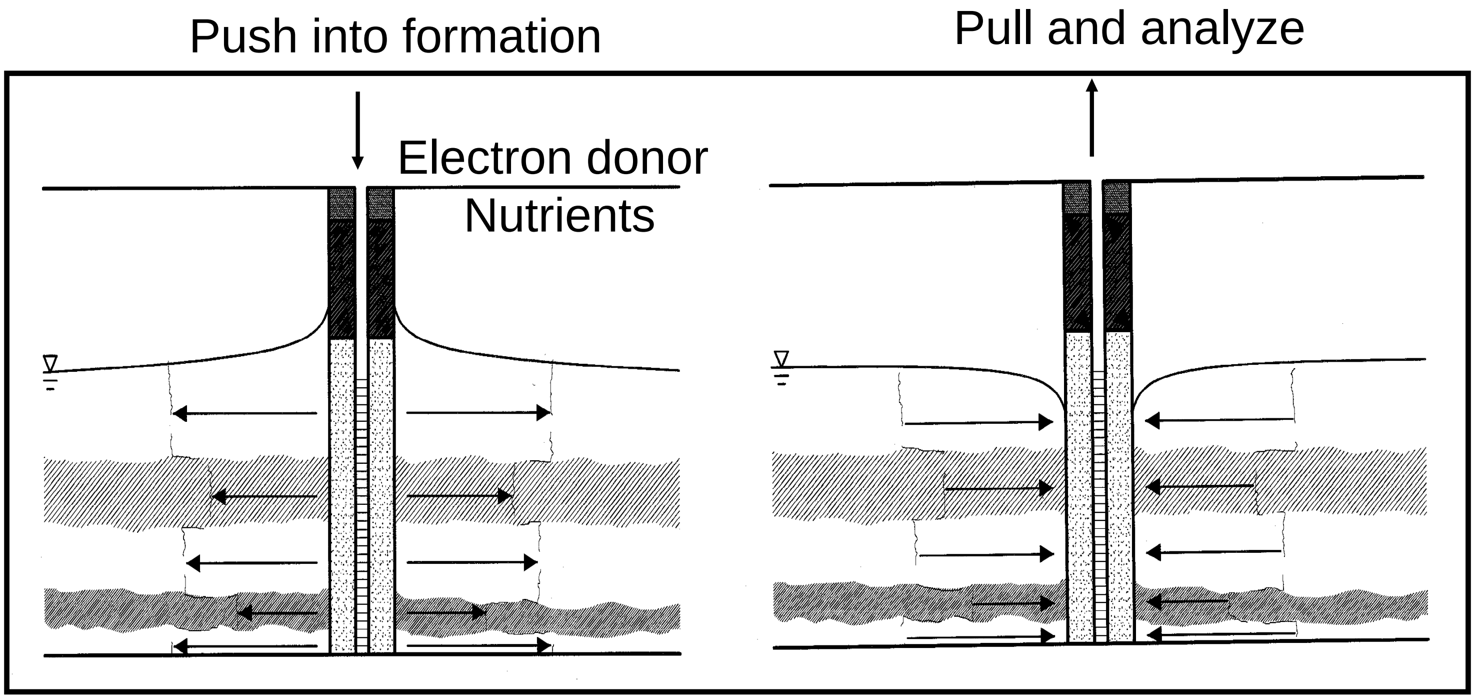
In situ U(VI) and Tc(VII) reduction following biostimulation with ethanol



Istok et al., 2004

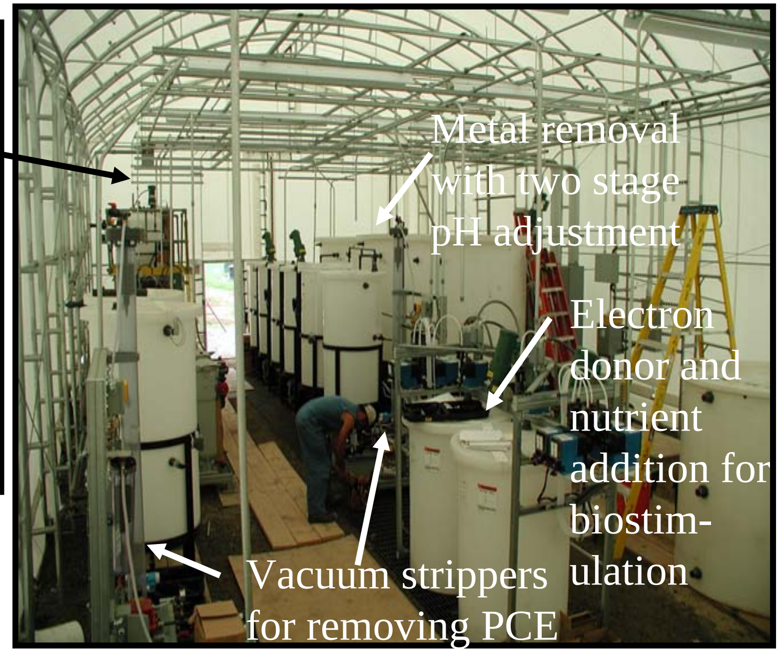


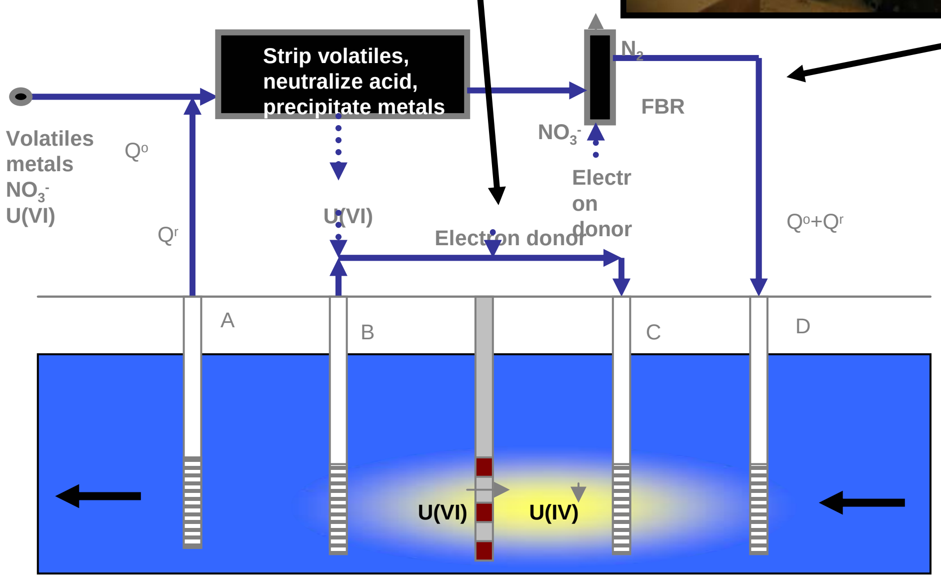
Push-pull technique for assessing far field *in situ* bioreduction of metals and radionuclides at Areas 1 and 2 (Istok et al.)



Biocage designed to intercept near field metal and radionuclide plumes with *in situ* immobilization via bioreduction at Area 3 (Criddle et al.)

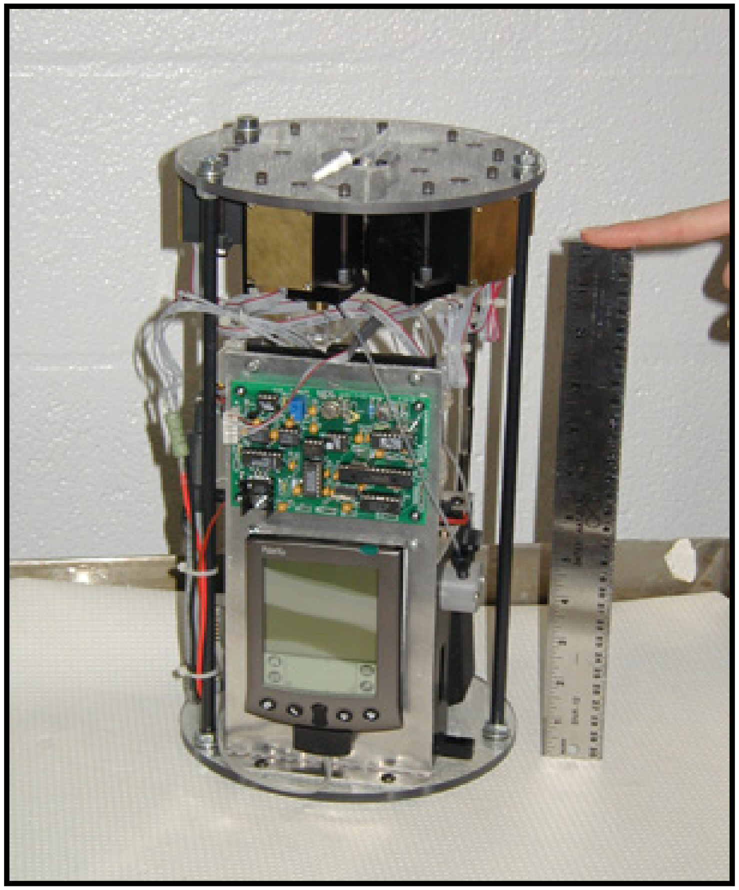
Near-source groundwater processing setup





Research Highlights: Biosensor for detection of U(VI)

A field portable immunoassay biosensor was developed for the determination of uranium in groundwater; both in situ or ex situ (Blake). Recent applications to Area 3 groundwater.

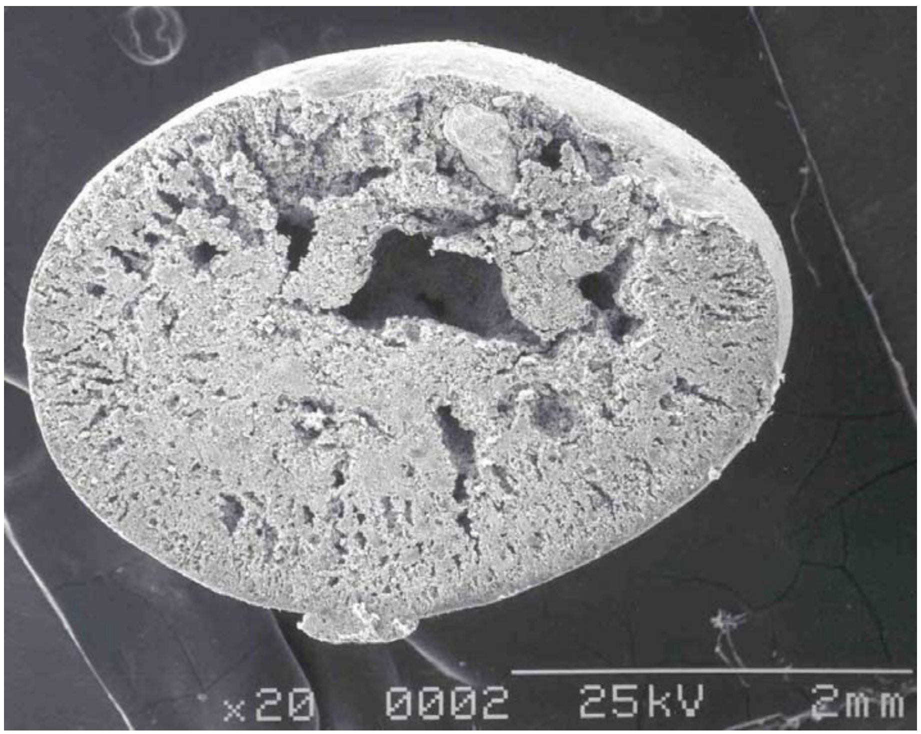


Research Highlights: Novel Bio-trap Coupons

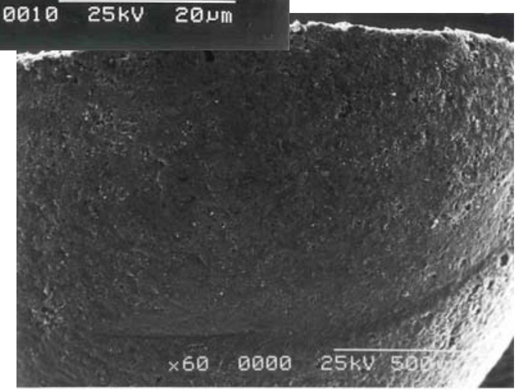
Application of novel biofilm coupons for the collection and concentration of groundwater microorganisms. Research endeavors are coupled with ongoing field scale biostimulation investigations and are providing information on changes to microorganism activity and structure.

2-3 mm in diameter
25 % Nomex, 75% PAC
74% porosity
600 m2 of surface area/g
Surrounded by ultrafiltration-like membrane with 1-10 micron holes
Autoclavable
Cleaned of fossil biomarkers by heating to 300ºC

SEM of Bio-Sep® Beads



Biofilms Form Rapidly in Bio-Sep® Beads



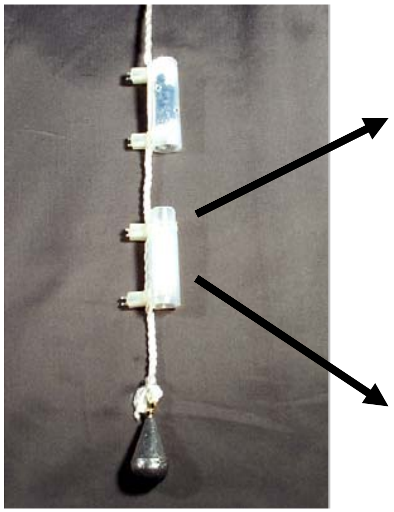
(Peacock and White, Univ. Tenn)

Research Highlights: Novel Bio-trap Coupons

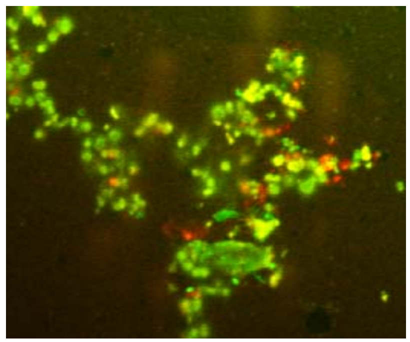
Down-well "bio-trap" coupons for enhanced microbial monitoring

(Peacock and White, Univ. Tenn)

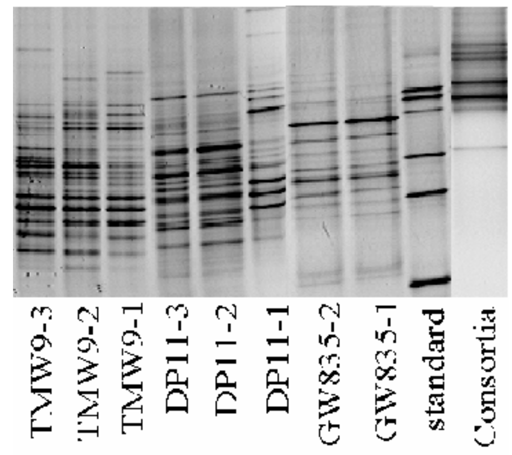
Traps



Colonized Surface



DGGE Profiles of 16S rDNA



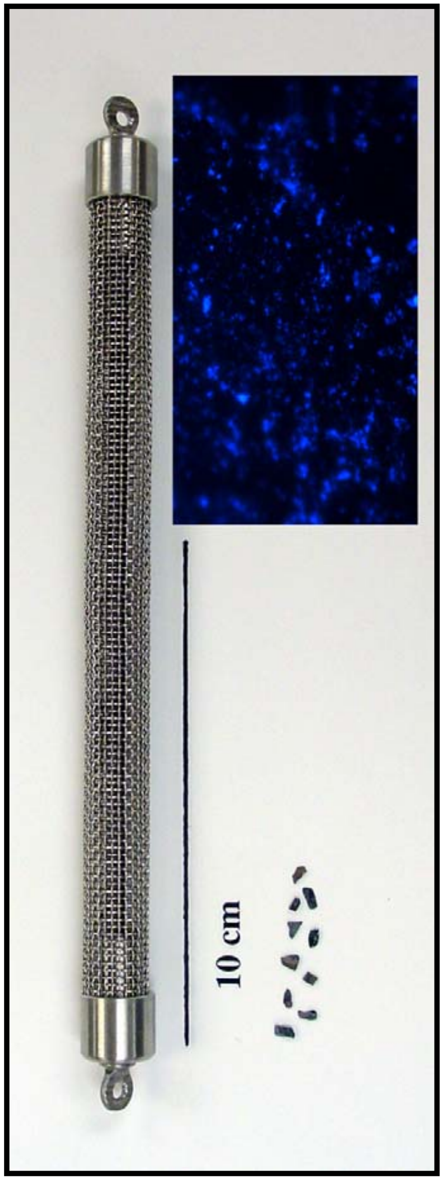
Rapid and efficient sampling of biofilms

Biofilm community structure is more indicative of *in situ* microbial ecology than samples of planktonic organisms

Rapid and efficient prediction of the effects of amendments on *in situ* microbial ecology

Integrated response over time is better than "grab samples"

Research Highlights: "Bug traps"



Coupons, or "bug traps," for rapidly assessing *in situ* microbial activity.

Various material such as Fe-oxides and indigenous sediments used for colonization.

Rapid assessment of microbial community dynamics as a function of space and time.

Provides evidence that the correct organisms remain active in the biostimulated zone.

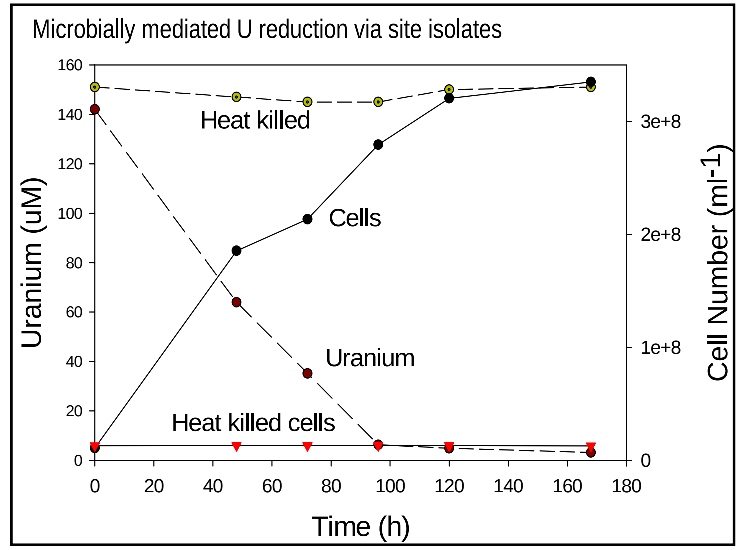
Coupled with on-going field scale biostimultion experiments in Areas 1, 2, and 3

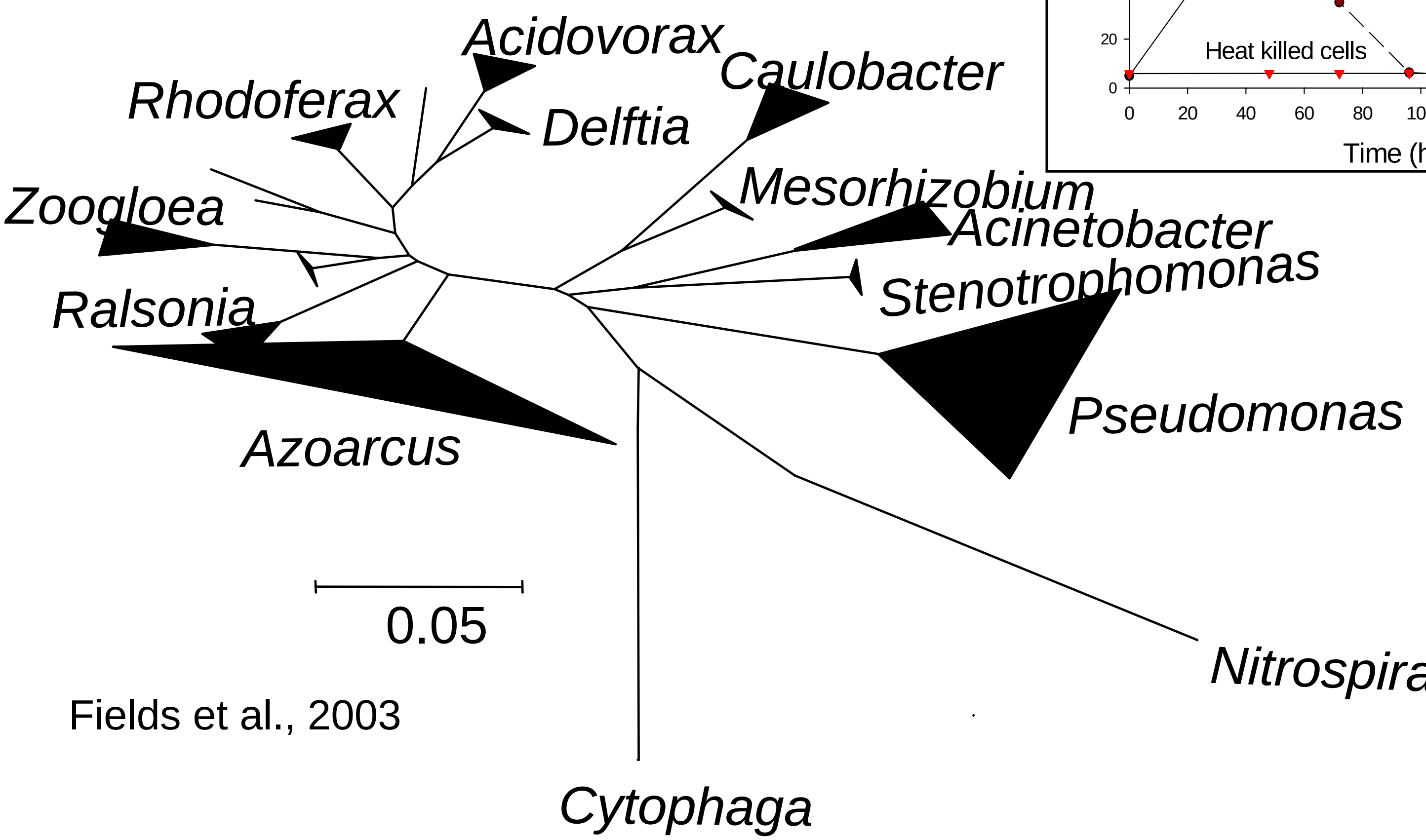
(Cummings / Geesey of INEEL)

Clonal Libraries

Phylogenetic analysis of groundwater 16S rRNA clonal library. Iron, nitrate, and sulfate reducing organisms are isolated with the later shown to effectively reduce uranium.

Extensive clonal libraries of the 16S rRNA gene have been constructed on numerous groundwater and sediment samples with varying levels of pH, uranium, nitrate, heavy metals, and TOC, and the partial 16S gene sequence has been determined for thousands of clones. The sequences are being used for the development and testing of oligonucleotide arrays.





Fields et al., 2003

Research Highlights: Novel DNA Microarrays

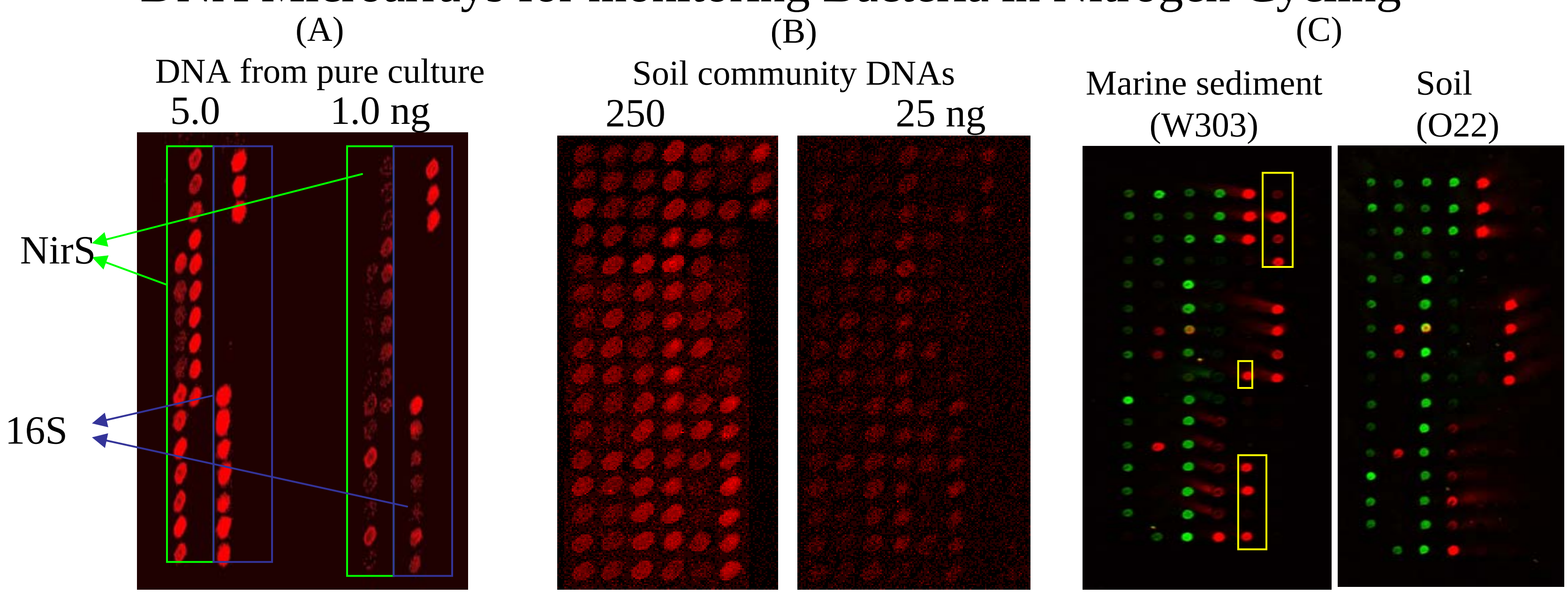
Rapid method to assess shifts in microbial community structure via gene detection and expression. Currently being used during Area 3 field scale biostimulation experiment.

Indirect detection of activity - presence of genes (DNA)

Direct measurement of activity - expression of genes (mRNA)

An increase in the quantity of a given gene (DNA) may indicate an increase in the numbers of the source organism. RNA would be a more direct measurement of activity but is more difficult to extract from environmental samples

DNA Microarrays for monitoring Bacteria in Nitrogen Cycling



Zhou et al., 2003

Research Highlights: Community Sequencing Program comes to the Oak Ridge FRC!

Zhou/Fields: Genome-level understanding of the diversity and structure of a groundwater microbial community in the NABIR Research Field Research Center (funded through the Joint Genome Institute Community Sequencing Program)

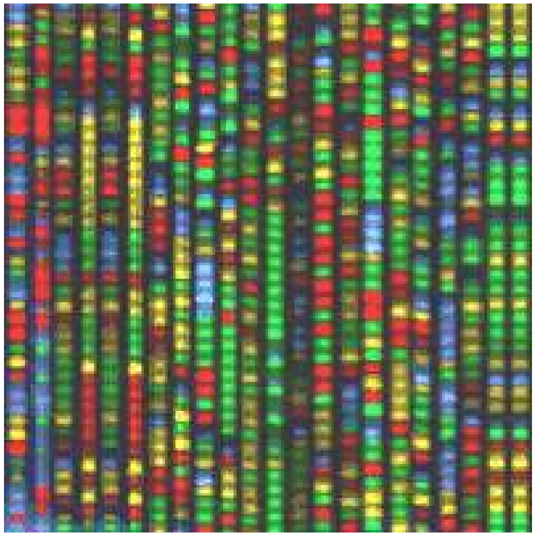
Objective: to provide fundamental and comprehensive understanding of microbial community diversity at the NABIR-FRC in response to mixed waste.

Rationale: Based on sequence information, whole community microarrays will be constructed and used to address ecological questions related to bioremediation by using FRC samples from three, large scale FRC field projects.

Scientific Importance:
Discovery of many new genes, pathways, and organisms.

This study will be the first study to examine at the genome level how contaminants will affect microbial community structure and how microbial communities respond and adapt to contaminated environments.

This study will also provide genetic basis and mechanistic understanding of microbial community diversity, structure and dynamics which is crucial for the design and implementation of bioremediation strategies.

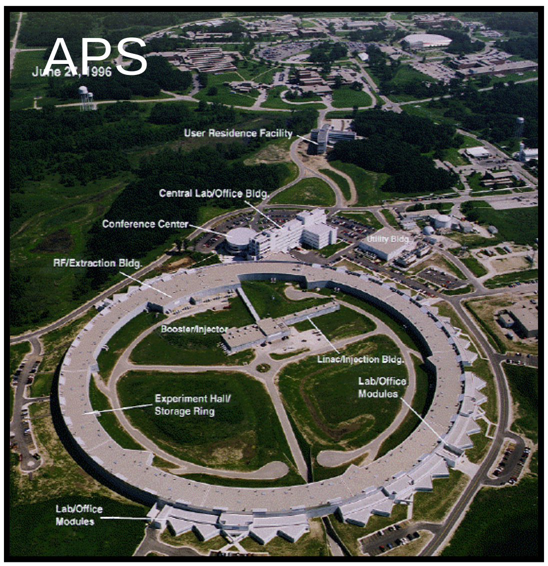


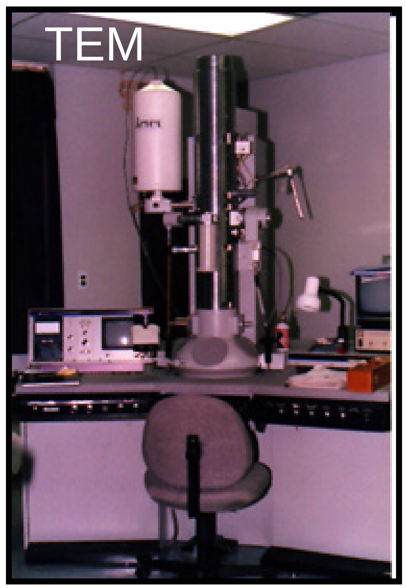
Research Highlights: Interfacial Surface Interrogation

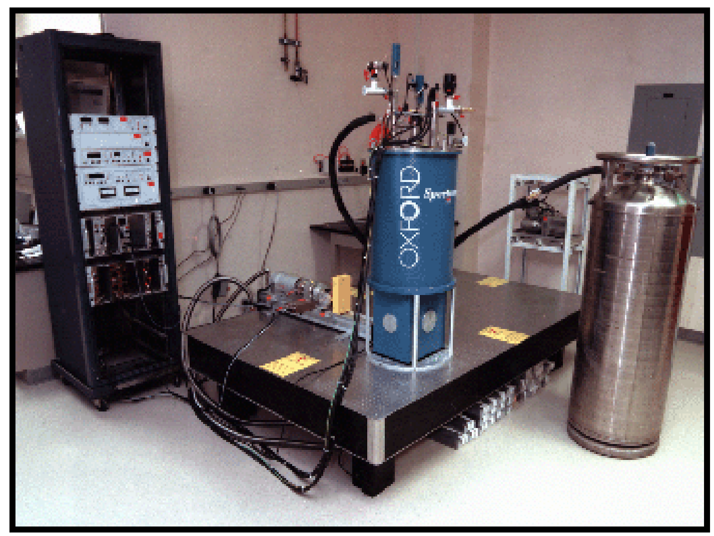
Strong coupling of research at the molecular scale with research endeavors at the field scale.

Variety of high-resolution surface analysis techniques being used to assess contaminant speciation and chemical environment as well as changes in solid phase mineralogy due to biostimulation.

EMSL

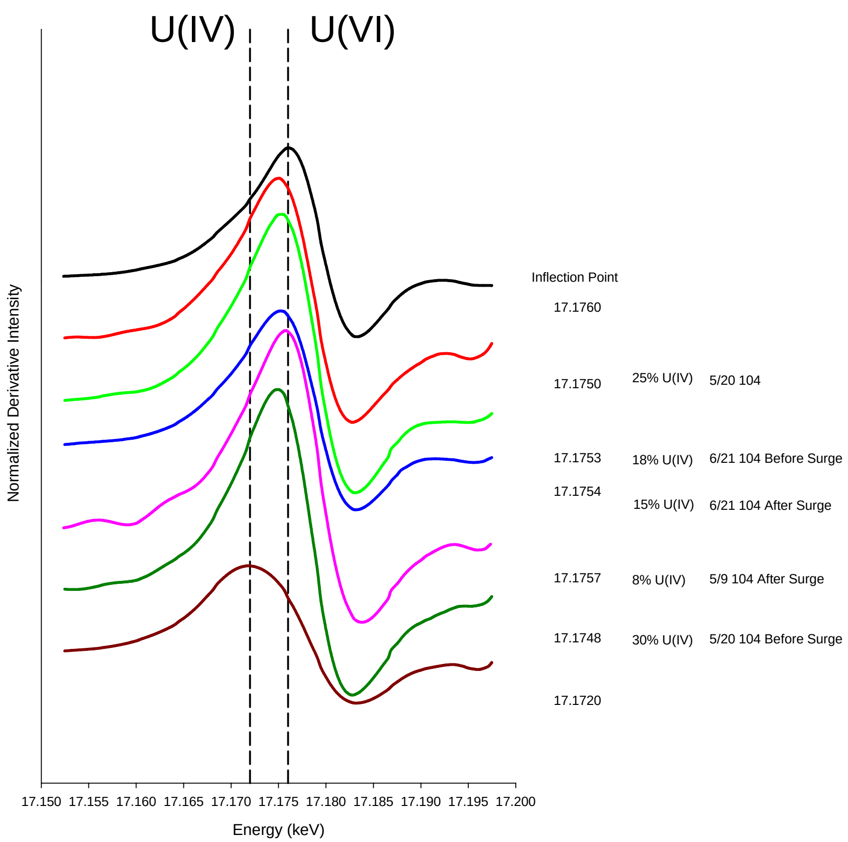






Mossbauer spectroscopy

X-ray absorption spectroscopy (XANES)



Used at Area 3 to confirm U(VI) reduction to U(IV) during in situ biostimulation

Quantify valance state and chemical environment of contaminant species. Speciation controls kinetics and mechanisms of the bioreduction process.

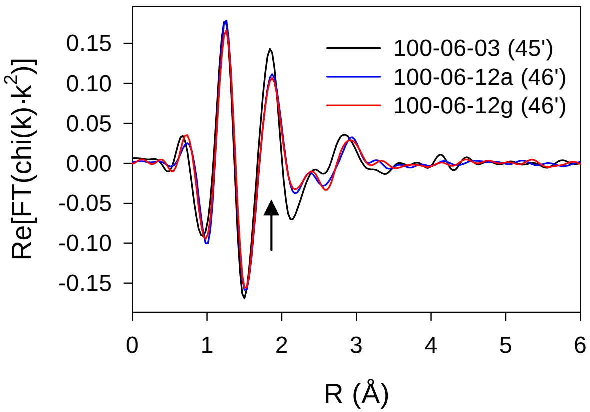
Indigenous solid phase is used (no alteration of subsurface media)

(Fendorf et al.)

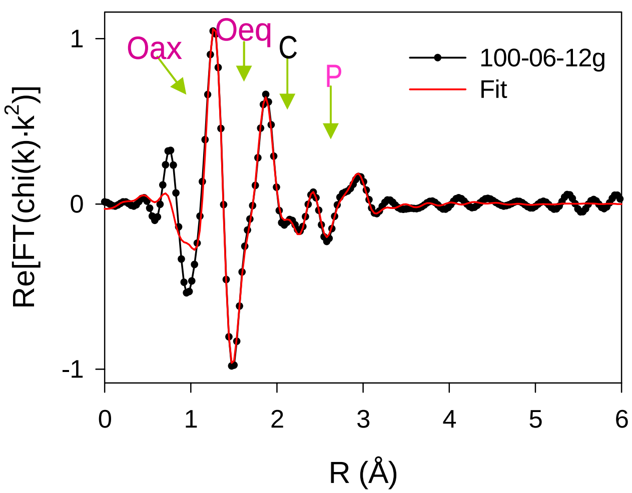
Can be coupled with x-ray tomography to assess mechanism of metal reduction

High resolution surface spectroscopy techniques for quantifying contaminant speciation and chemical environment

Real part of Fourier transform of data from samples taken at 45, and 46 (with replicate) feet

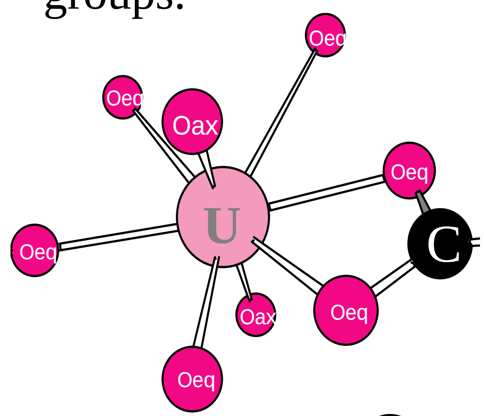


Real part of Fourier transform of data and model from sample taken at 46 feet

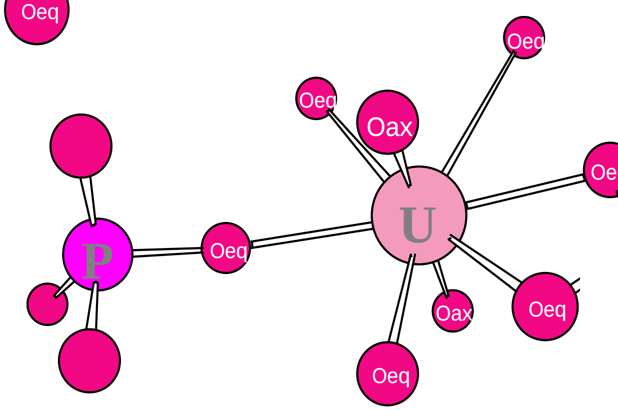


<u>Example:</u>

- **EXAFS** used to quantify the chemical environment of solid phase U at Area 3.
- U is coordinated by bidentate carbon containing groups and/or monodentate phosphorous containing groups.



Speciation controls rate of contaminant bioreduction



Kelly and Kemner, ANL

Mossbauer spectroscopy

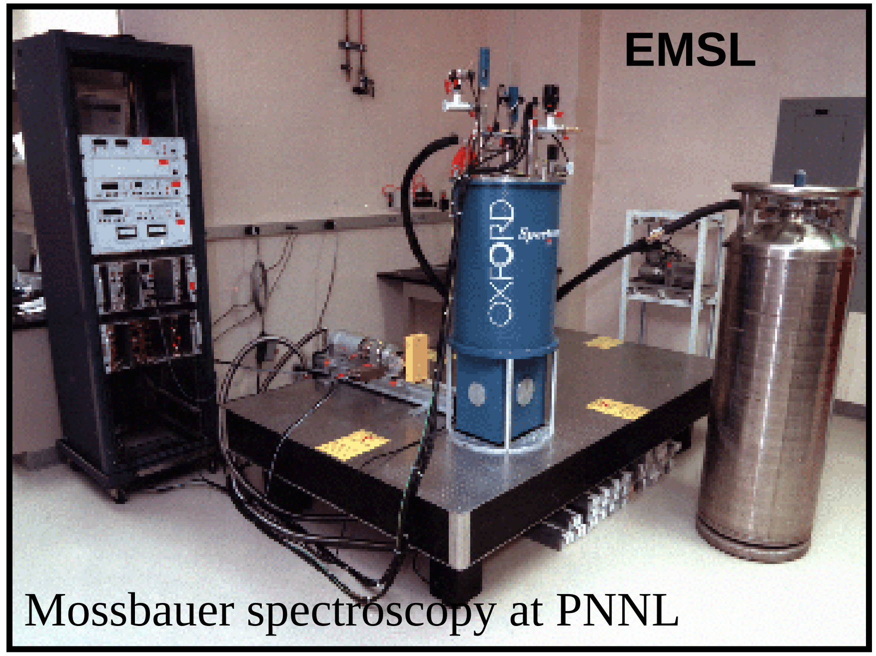
Characterizing the role of biogenic Fe(II) on contaminant bioreduction

Mossbauer used to quantity the types, amounts, and distributions of various Fe-bearing minerals and oxides in heterogeneous FRC background and contaminated samples. Knowledge of Fe type is important to understand the rates and mechanisms of contaminant bioreduction.

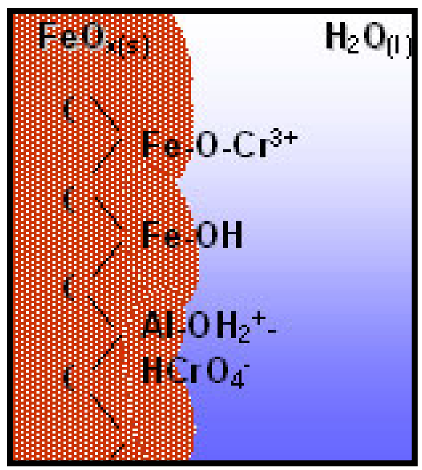
Quantify changes in Fe mineralogy following in situ biostimulation using various electron donors. Used in Area 1 coupled with in situ push pull biostimuation experiments.

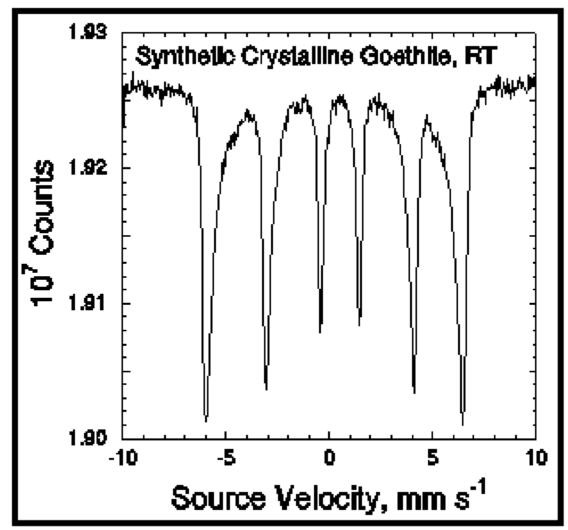
Quantify mechanisms of biogenic Fe(II) reactivity with the solid phase and its influence on the rate of contaminant bioreduction.

Stucki and Zachara, Purdue and PNNL



Mossbauer spectroscopy at PNNL



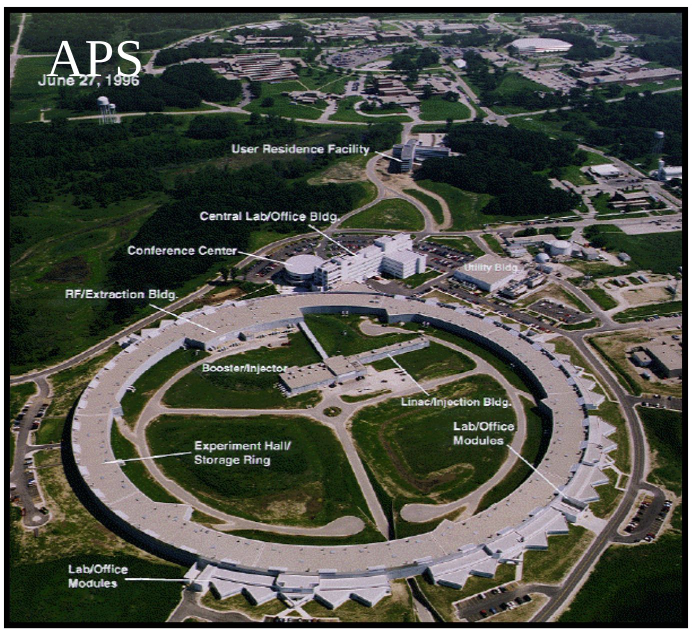


High-resolution spectroscopy for quantify reactive minerals in soils

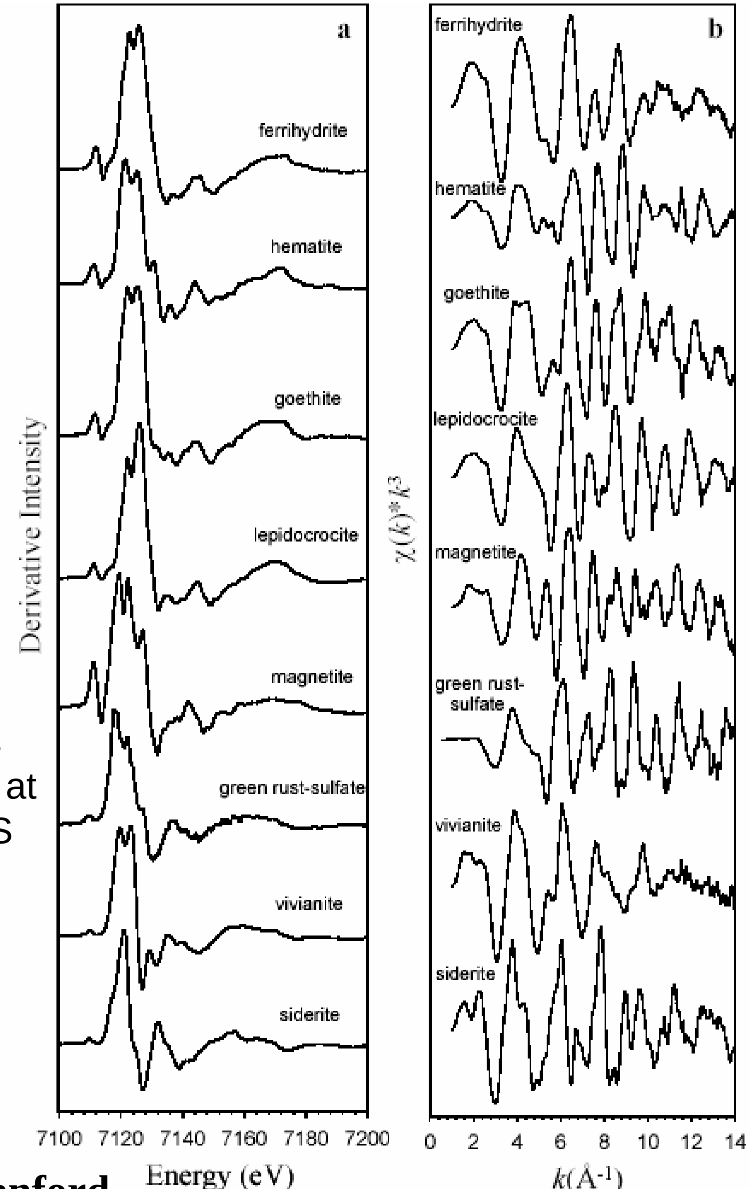
Extended X-ray Absorption Fine Structure (XAFS) used to quantify the Fe-oxide mineralogy in heterogeneous samples from the FRC.

Quantifying biogenic Fe products and changes in mineralogy during biostimulation.

Information on chemical state of competing electron acceptors important towards knowing likelihood of sustained contaminant reduction.



Research is typically done at both the APS and SSRL



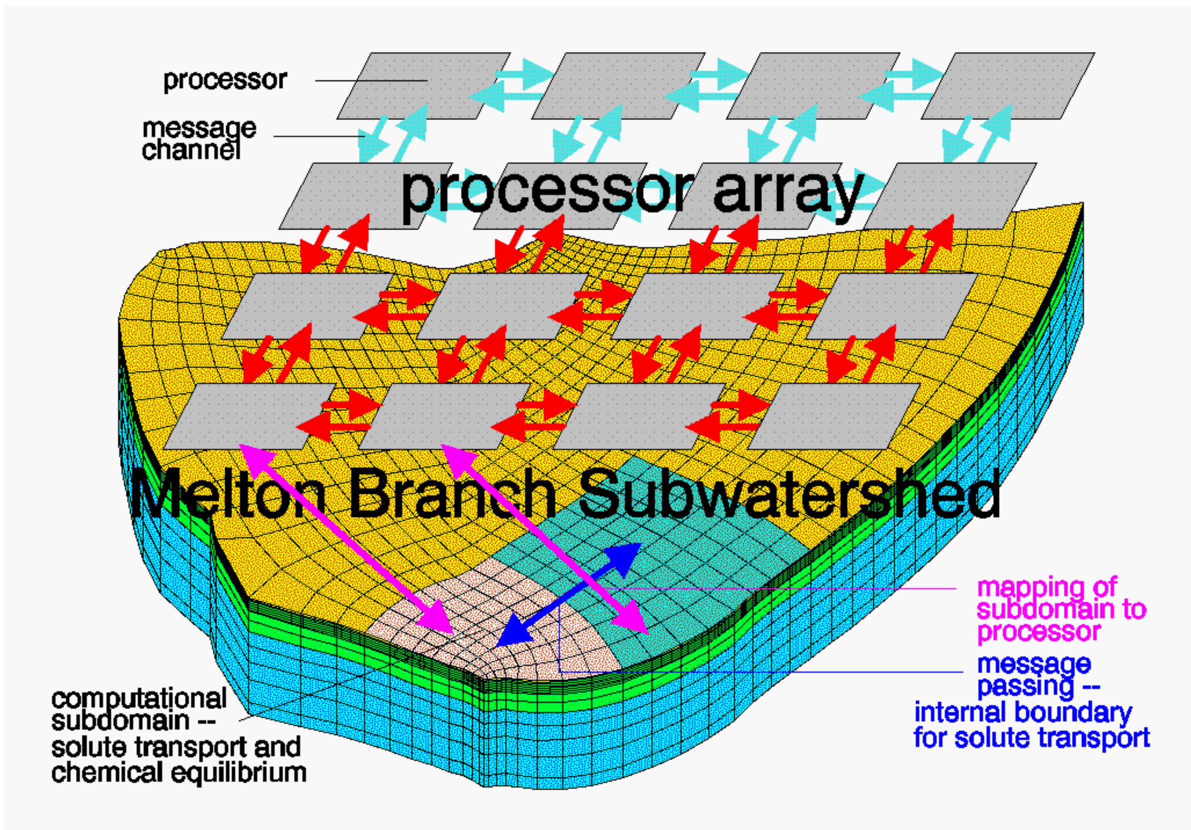
Fendorf, Stanford

Research Highlights: Site-Wide Numerical Model

Formulation of a site wide high-performance multiprocess, multipermeability flow and transport numerical model (Parker).

Parameterized with experimental data acquired from the various research activities at the FRC and that are being organized within the working groups.

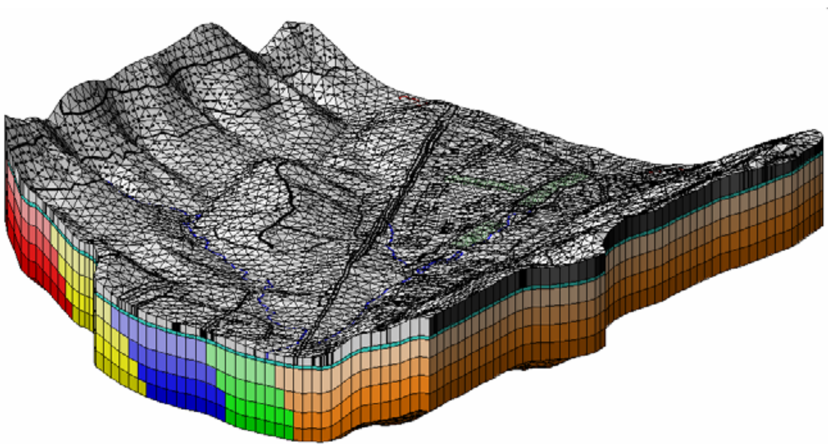
An example showing the use of a high performance multiprocess code on the ORR



Site-Wide Numerical Model

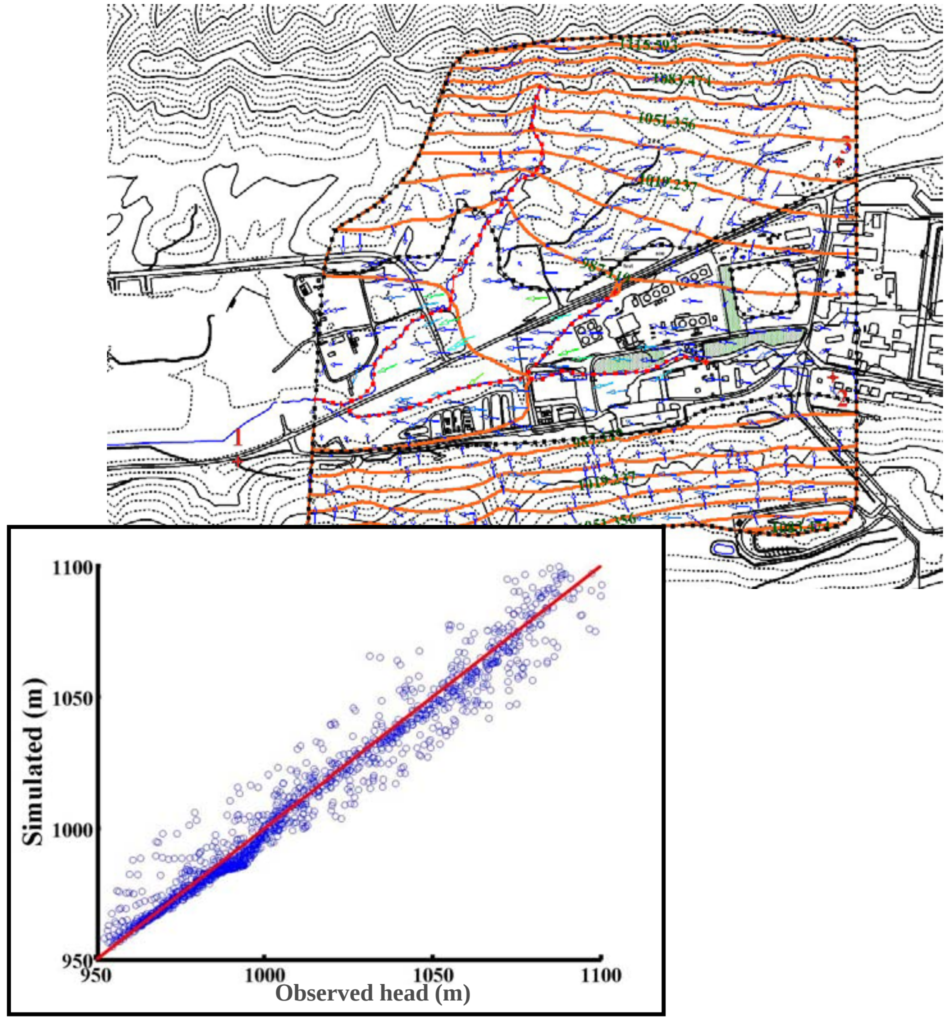
We held a mini-workshop at the NABIR PI meeting in 2003 and all participates were in favor of a site-wide numerical model.

Discretized Model Domain



Bedrock is overlain by soil/saprolite zone and "transition" zone

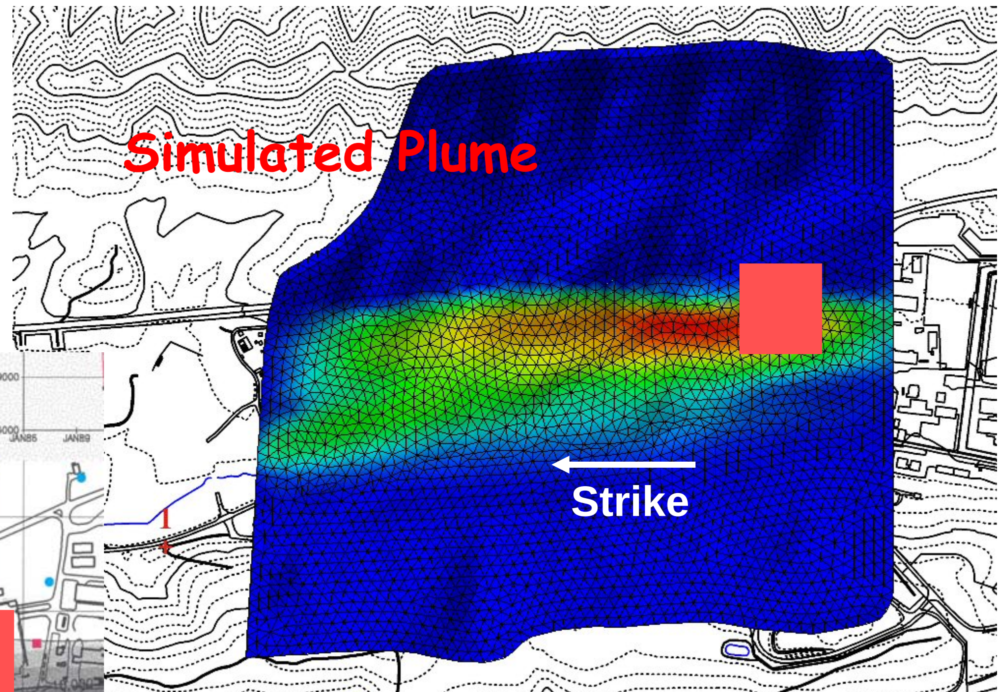
Preliminary Steady State Groundwater Flow Model Calibration

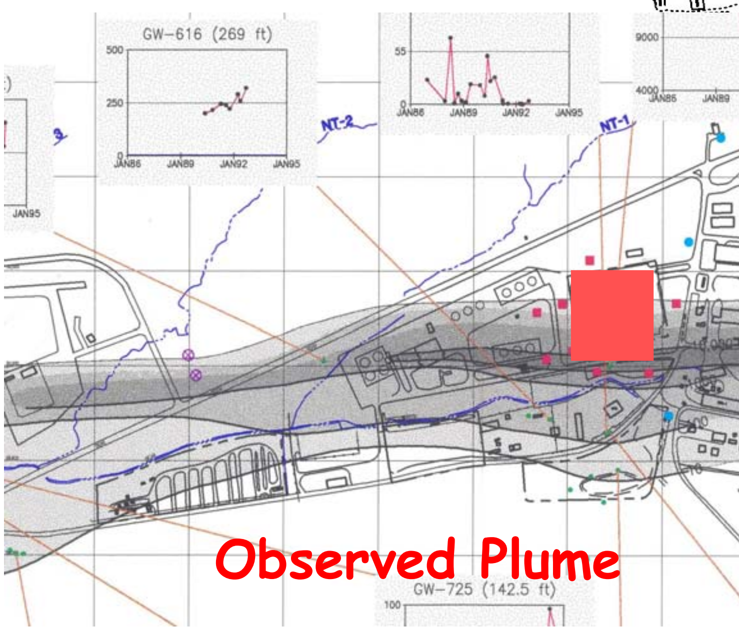


Site-Wide Numerical Model (nonreactive transport)

Preliminary Transport Model Results for Nitrate Plume from S3 Ponds ca. 1953-1996

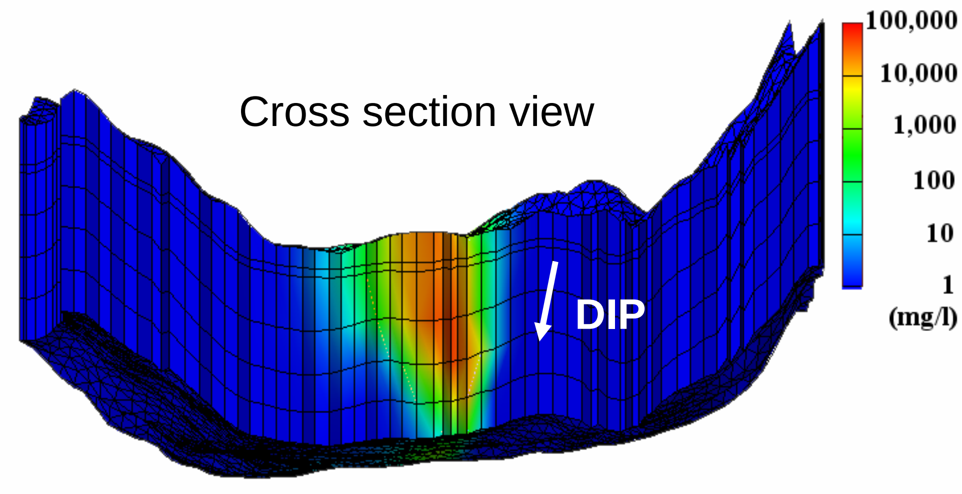
Birds-eye view



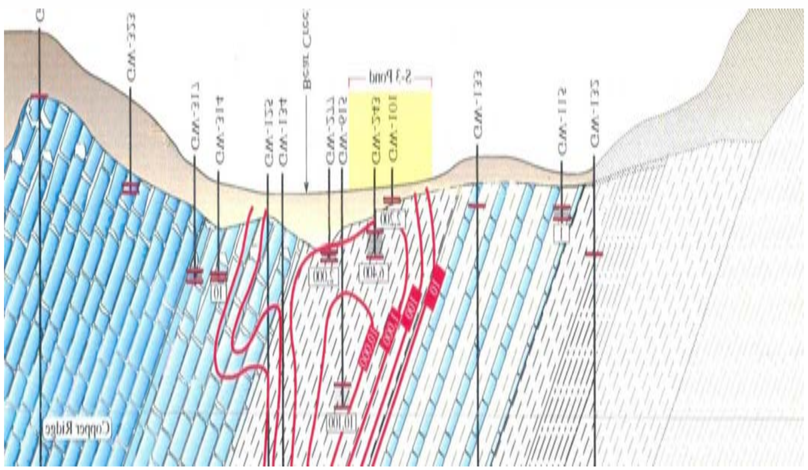


Site-Wide Numerical Model

Preliminary Transport Model Results for Nitrate Plume from S3 Ponds ca. 1953-1996



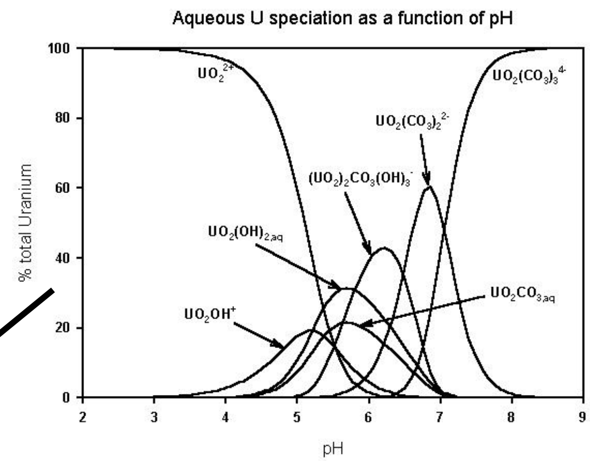
Simulated Plume



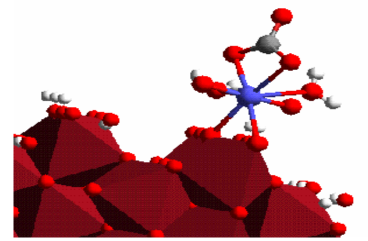
Observed Plume

Site-Wide Numerical Model (Reactive Transport)

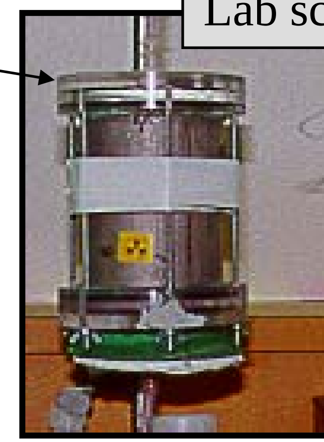
Preliminary investigations on an undisturbed FRC core.



U-CO_3 complexes on Fe-oxides



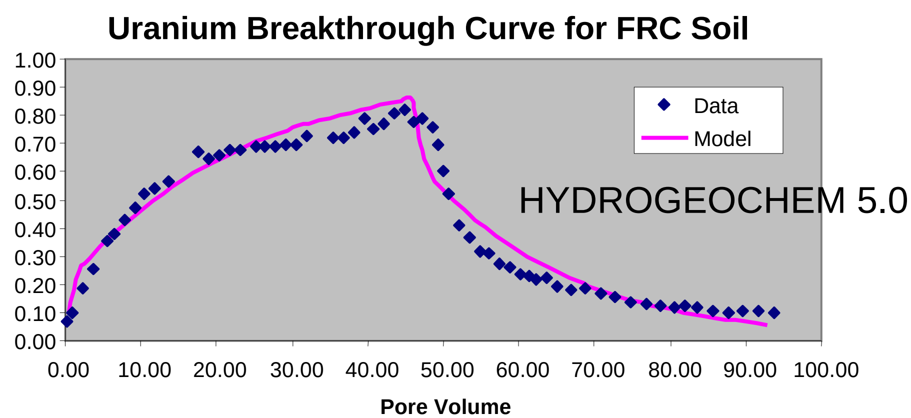
Undisturbed core
42 ft. Area 3



Lab scale

Lots aqueous and solid phase reactions!

1. $Fe(OH)_3 + 3H^+ = Fe^{3+} + 3H_2O \quad \log K = 4.9$ [2]
2. $UO_2^{2+} + H_2O = UO_2OH^+ + H^+ \quad \log K = -5.2$ [1]
3. $UO_2^{2+} + 2H_2O = UO_2(OH)_{2(aq)} + 2H^+ \quad \log K = -10.3$ [1]
4. $UO_2^{2+} + 3H_2O = UO_2(OH)_3^- + 3H^+ \quad \log K = -19.2$ [1]
5. $UO_2^{2+} + 4H_2O = UO_2(OH)_4^{2-} + 4H^+ \quad \log K = -33.0$ [1]
6. $2UO_2^{2+} + H_2O = (UO_2)_2OH^{3+} + H^+ \quad \log K = -2.7$ [1]
7. $2UO_2^{2+} + 2H_2O = (UO_2)_2(OH)_2^{2+} + 2H^+ \quad \log K = -5.62$ [1]
8. $3UO_2^{2+} + 4H_2O = (UO_2)_3(OH)_4^{2+} + 4H^+ \quad \log K = -11.9$ [1]
9. $3UO_2^{2+} + 5H_2O = (UO_2)_3(OH)_5^+ + 5H^+ \quad \log K = -15.5$ [1]
10. $3UO_2^{2+} + 7H_2O = (UO_2)_3(OH)_7^- + 7H^+ \quad \log K = -31.0$ [1]
11. $UO_2^{2+} + CO_3^{2-} = UO_2CO_{3(aq)} \quad \log K = 9.68$ [1]
12. $UO_2^{2+} + 2CO_3^{2-} = UO_2(CO_3)_2^{2-} \quad \log K = 16.94$ [1]
13. $UO_2^{2+} + 3CO_3^{2-} = UO_2(CO_3)_3^{4-} \quad \log K = 21.6$ [1]
14. $3UO_2^{2+} + 6CO_3^{2-} = (UO_2)_3(CO_3)_6^{6-} \quad \log K = 54.0$ [1]
15. $2UO_2^{2+} + 4H_2O + CO_{2(g)} = (UO_2)_2CO_3(OH)_3^- + 5H^+ \quad \log K = -19.01$ [1]
16. $> Fe_sOH + H^+ + CO => Fe_sOH_2^+ \quad \log K = -13.0$
17. $> Fe_sOH => Fe_sO^- + H^+ + CO \quad \log K = -9.61$
18. $> Fe_s(OH)_2 + UO_2^{2+} = (> Fe_sO_2)UO_2 + 2H^+ \quad \log K = -2.57$ [1]
19. $> Fe_w(OH)_2 + UO_2^{2+} = (> Fe_wO_2)UO_2 + 2H^+ \quad \log K = -6.28$ [1]
20. $> Fe_sOH + H_2CO_3 => Fe_sCO_3H + H_2O \quad \log K = -3.34$
21. $> Fe_sOH + H_2CO_3 => Fe_sCO_3^- + H_2O + H^+ + CO \quad \log K = -4.25$
22. $> Fe_s(OH)_2 + UO_2^{2+} + H_2CO_3 =$ [1][2]
    $(> Fe_sO_2)UO_2CO_3^{2-} + 4H^+ + 2CO \quad \log K = -13.0$
23. $> Fe_w(OH)_2 + UO_2^{2+} + H_2CO_3 =$ [1][2]
    $(> Fe_wO_2)UO_2CO_3^{2-} + 4H^+ + 2CO \quad \log K = -17.10$
24. $FeOH^{2+} + H^+ = Fe^{3+} + H_2O \quad \log K = 2.19$ [2]
25. $Fe(OH)_2^+ + 2H^+ = Fe^{3+} + 2H_2O \quad \log K = 5.67$ [2]
26. $Fe(OH)_3^0 + 3H^+ = Fe^{3+} + 3H_2O \quad \log K = 12.56$ [2]
27. $Fe(OH)_4^- + 4H^+ = Fe^{3+} + 4H_2O \quad \log K = 21.6$ [2]
28. $H_2O + CO_{2(g)} = H_2CO_3^0 \quad \log K = -1.47$ [2]
29. $H_2CO_3^0 = H^+ + HCO_3^- \quad \log K = -6.35$ [2]
30. $HCO_3^- = H^+ + CO_3^{2-} \quad \log K = -10.33$ [2]
31. $> Fe_wOH + H^+ + CO => Fe_wOH_2^+ \quad \log K = -13.0$
32. $> Fe_wOH => Fe_wO^- + H^+ + CO \quad \log K = -9.61$
33. $> Fe_wOH + H_2CO_3 => Fe_wCO_3H + H_2O \quad \log K = -3.34$
34. $> Fe_wOH + H_2CO_3 => Fe_wCO_3^- + H_2O + H^+ + CO \quad \log K = -4.25$
35. User specified mass action type = -4
    $0 \cdot Fe(OH)_3 => Fe_sOH + 0 \cdot > Fe_sOH_2^+ +$
    $0 \cdot > Fe_sO^- + 0 \cdot > Fe_sCO_3H + 0 \cdot > Fe_sCO_3^- +$
    $0 \cdot (> Fe_sO_2)UO_2 + 0 \cdot (> Fe_sO_2)UO_2CO_3^{2-}$
    $0.004273727C_{Fe(OH)_3} = C_{>Fe_sOH} + C_{>Fe_sOH_2^+} + C_{>Fe_sO^-} +$
    $C_{>Fe_sCO_3H} + C_{>Fe_sCO_3^-} + 2(C_{(>Fe_sO_2)UO_2} + C_{(>Fe_sO_2)UO_2CO_3^{2-}})$
36. User specified mass action type = -4
    $0 \cdot Fe(OH)_3 => Fe_wOH + 0 \cdot > Fe_wOH_2^+ +$
    $0 \cdot > Fe_wO^- + 0 \cdot > Fe_wCO_3H + 0 \cdot > Fe_wCO_3^- +$
    $0 \cdot (> Fe_wO_2)UO_2 + 0 \cdot (> Fe_wO_2)UO_2CO_3^{2-}$
    $0.870726273C_{Fe(OH)_3} = C_{>Fe_wOH} + C_{>Fe_wOH_2^+} + C_{>Fe_wO^-}$
    $+ C_{>Fe_wCO_3H} + C_{>Fe_wCO_3^-} + 2(C_{(>Fe_wO_2)UO_2} + C_{(>Fe_wO_2)UO_2CO_3^{2-}})$
37. User specified mass action type = -5
    $0 \cdot > Fe_sOH => Fe_s(OH)_2 \quad C_{Fe_sOH} = 2C_{Fe_s(OH)_2}$
38. User specified mass action type = -5
    $0 \cdot > Fe_wOH => Fe_w(OH)_2 \quad C_{Fe_wOH} = 2C_{Fe_w(OH)_2}$



Personnel Highlights: Caliber of Typical FRC Participant

Recent Honors and Awards for Long-Time FRC Investigators

Scott Fendorf   (Stanford University) **M.L. Jackson Soil Science Award**, Soil Science Society of America, 1998, **Stanford University Fellow,** 2004.

Peter K. Kitanidis (Stanford University) **L. G. Straub Award**, 1979, ASCE and **National Research Council** technical committees. W. L. Huber **Civil Engineering Research Prize,** 1994, **Highly Cited Researchers in Environmental Studies**, The Institute for Scientific Information, (ISI), 2003.

Ken Kemner (ANL) National Research Council **Fellow**, 1993-1996, Department of Energy, Office of Science **Early Career Scientist Award**, 2000. International Union of Crystallography **Young Scientist Award**, 2000, **Presidential Early Career Award** for Scientists and Engineers in 2001.

Baohua Gu (ORNL) ORNL **technical achievement award**, 2000, ESD **Distinguished Achievement Award,** 2001, ORNL **Inventor of the Year**, 2003, Southeastern Federal Laboratory **Excellence in Technology Transfer award**, 2003, **R&D100 award** - Highly selective regenerable perchlorate treatment system 2004, 3 patents.

Philip Jardine (ORNL) **Young Independent Scientist Award**, Department of Energy, Office of Energy Research, 1996, **Presidential Early Career Award for Scientists and Engineers**, The President of the United States of America, 1996, **Presidential Citation for Outstanding Achievement**, University of Delaware, 1997, **Ten Outstanding Young Americans**, United States Junior Chamber of Commerce,1998, **M.L. Jackson Soil Science Award**, Soil Science Society of America, 1998, **Highly Cited Researchers in Environmental Studies**, The Institute for Scientific Information, (ISI), 2003.

Jack Parker (ORNL) American Board of Forensic Engineering and Technology – **Diplomate**, Extensive **expert** testimony experience, **Faculty Research Award,** Gamma Sigma Delta, **Invited presentations and workshops in 15 different countries**, **Highly Cited Researchers in Environmental Studies**, The Institute for Scientific Information, (ISI), 2003.

Zizhong Zhou (ORNL) **Presidential Early Career Award** for Scientists and Engineers in 2001, DOE Office of Science's 2001 **Early Career Award** for Scientists and Engineers, Environmental Sciences Division **Distinguished Scientific Achievement Award** in 2001, and ORNL Research Achievement Awards, 1997 and 2001.

Terry Hazen (LBNL) George Westinghouse **Signature Award for excellence** Corporate, 1994, **R&D 100 Awards** 1995, 1996, George Westinghouse **Innovation Award,** 1996,
Federal Laboratory Consortium **Award for Excellence in Technology Transfer,** 1996.
Wake Forest University **Distinguished Biology Alumni Lecture**, 1999.

David White (University of Tennessee) P. R. Edwards Award, **Outstanding Microbiologist**, 1981, **Scientific and Technological Achievement Award** USEPA, 1987, Procter and Gamble **Award in Applied and Environmental Microbiology**, 1993, Frank N. Nelson **distinguished Lecturer in Molecular Biology, Biotechnology, and Medicine**, 1994, Athalie Richardson Irvine Clarke Prize for **Outstanding Achievement in Water Science and Technology**, 1995, **Science Team Leader** for Assessment and Community Dynamics, Natural and Accelerated Bioremediation Research Program, Office of Health and Environmental Research, DOE, 1996-1999.

Susan Pfiffner SCAVMA **Outstanding Educator Award**, 1984, 1994, 2000; UT National Alumni Association **Outstanding Teacher Award,** 1990; Norden **Distinguished Teacher Award,** 1990, 1994,1999; **Woman of Achievement Award** for UTK Faculty Women, 1995; Southeastern Society of Parasitologists, **Meritorious Service Award,** 1996; **R&D 100 Award**, 1996; Chancellor's **Teaching Scholar,** 1996-98; **Distinguished Service Professorship** – 1999; North American Norden **Distinguished Teacher Award** for the Outstanding Teacher in Veterinary Medicine in NA, 1999; **President-Elect American Society of Parasitologists,** 2000/**President** 2001, 2002

George Yeh (University of Central Florida) Martin Marietta **Publication Award,** 1987, **Presidential PIP Award,** 1988, **National Research Council Senior Research Associateship,** 1995 - 1996, PSES **Outstanding Research Award,** 2000.

Anne Summers NIH **Research Career Development Award**, Member, NSF **Genetic Biology Panel**, Member, NIH Microbial Physiology/Genetics Study Section, **Guggenheim Fellow**, **Director,** NSF Summer Workshop in Microbial Physiology.

James Tiedje **Distinguished Faculty Award**, Michigan State University, 1986, **Soil Science Research Award**, Soil Science Society of America, 1990, **Applied and Environmental Research Award**, American Society for Microbiology, 1992, University **Distinguished Professor**, 1992, **Carlos J. Finlay Prize** presented by UNESCO for international research contributions in microbiology, 1993, **American Academy of Microbiology**, 1994, Elected to **U.S. National Academy of Sciences**, 2003.

Gill Gessey (Montana State Univ) William Evans **Visiting Scientist**, Otago University, Dunedin, New Zealand, 1986, 3M Corporation **Research Award**, June 1993, American Society for Microbiology 2001 Proctor & Gamble **Award in Applied and Environmental Microbiology.**

John Zachara (PNNL) Laboratory **Fellow** since 1993, National Academy of Sciences/**National Research Council study panel** on "Intrinsic Remediation of Groundwater", 1997 to 1999, Associated Western Universities **Distinguished Lecturer**, 1994, DOE's Office of Biological and Environmental Research/ **Natural and Accelerated Bioremediation Research Scientific Advisory Panel**, 2003.

James Fredrickson (PNNL) **Emil Truog Award**,1985, Member of the **Organizing Committee** for the 1993 International Conference on Subsurface Microbiology, Bath, England and the 1996 International Symposium on Subsurface Microbiology, Davos, Switzerland; **Fellow** in the American Academy of Microbiology, 1999, **Three patent award**s including "Enhancement of In Situ Microbial Remediation of Aquifers"

FRC *Published* Peer-reviewed Manuscripts

Chang, I., J. D. Ballard and L. R. Krumholz, 2003. Evidence for Chimeric sequences during random arbitrarily primed PCR. *J. Microbiol Meth.* 54:427–431.

Chang, I.S., *et al*., 2004. Differential Expression of *Desulfovibrio vulgaris* genes in response to Cu(II) and Hg(II) toxicity. *Appl. Environ. Microbiol.* 70:1847–1851.

Elias, D. A., *et al*., 2004. The periplasmic cytochrome C3 of *Desulfovibrio vulgaris* is directly involved in H2 mediated metal-, but not sulfate-reduction. *Appl. Environ. Microbiol.* 70(1):413–420.

Fienen, M. *et al., 2004.* An application of Bayesian inverse methods to vertical deconvolution of hydraulic conductivity in a heterogeneous aquifer at Oak Ridge National Laboratory. *Mathematical Geology* 36(1):101–126.

Gu, B., Y. K. Ku, and P. M. Jardine, 2004. Sorption and binary exchange of nitrate, sulfate, and uranium on an anion-exchange resin. *Environmental Science & Technology* 38: 3184–3811.

Gu, B. H., *et al.,* 2003. Geochemical reactions and dynamics during titration of a contaminated groundwater with high uranium, aluminum, and calcium. *Geochimica Et Cosmochimica Acta* 67(15):2749–2761.

Istok, J. D. *et al*., 2004. In situ bioreduction of technetium and uranium in a nitrate-contaminated aquifer. *Environmental Science & Technology* 38(2):468–475.

North, N. N. *et al.,* 2004. Change in Bacterial Community Structure during In Situ Biostimulation of Subsurface Sediment Cocontaminated with Uranium and Nitrate. *Applied and Environmental Microbiology* 70(8): 4911–4920.

Peacock, A. D. *et al*., 2004. Utilization of Microbial Biofilms as Monitors of Bioremediation. *Microbial Ecology*47:284–92.
Shelobolina, E. S., *et al*., 2003. Potential for in situ bioremediation of a low-pH, high-nitrate uranium-contaminated groundwater. *Soil & Sediment Contamination* 12(6):865–884.

Steger, J. L.*et al*., 2002. *Desulfovibrio* sp. Genes involved in the metabolism of Hydrogen and Lactate. *Appl. Environ. Microbiol.* 68(4):1932–1937.

Yan, T., *et al.,* 2003. Molecular diversity and characterization of nitrite reductase gene fragments (nirS and nirK) from nitrate- and uranium-contaminated groundwater. *Environmental Microbiology* 5(1):13–24.

FRC *In-Press* and *Submitted* Peer-reviewed Manuscripts

In Press

Jardine, P. M., 2004. Soil Chemistry and Mineralogy: Kinetic Models. *In* D. Hillel (ed.), *Encyclopedia of Soils in the Environment*, Academic Press, London, UK. In press.

North, N. N., *et al*., 2004. A cultivation-independent investigation of microbial communities during in situ biostimulation of subsurface sediment co-contaminated with uranium and nitrate. *Applied and Environmental Microbiology*. In press.

Palumbo, A. V., *et al*., 2004. Coupling functional gene diversity and geochemical data from environmental samples. *Applied and Environmental Microbiology.* In press.

Watson, D. B., *et al.,* 2004. Use of geophysical profiling to characterize the DOE NABIR Field Research Center. *Ground Water.* In press.

Submitted

Fields, M. W., *et al.,* 2004. Impacts on microbial communities and cultivable isolates from groundwater contaminated with high levels of nitric acid-bearing uranium waste. Submitted to: *FEMS Microbiol. Ecol.*

Harris, S. H., J. D. Istok, and J. M. Suflita. 2004. Changes in organic matter quality influencing sulfate reduction in an aquifer contaminated by landfill leachate. Submitted to: *Applied Environmental Microbiology*.

Lu, J., *et al.,* 2004. Mass-transfer limitation for nitrate removal in a uranium-contaminated aquifer at Oak Ridge, TN. Submitted to: *Ground Water.*

Roden, E. E. and T. D. Scheibe, 2004. Conceptual and numerical model of Uranium(VI) reductive immobilization in fractured subsurface sediments. Submitted to: *Chemosphere.*

Wu, W. M., *et al.*, 2004. Reduction and Sorption of Uranium (VI) by Microbial Biomass from a Denitrifying Fluidized Bed Reactor. Submitted to: *Bioremediation Journal.*

The Oak Ridge FRC Students and Post-grads

Example of Students and Post-grads that have contributed to the Oak Ridge FRC

Tamar Barkay (Rutgers)
Dr. Jonna Coombs, current postdoc

Diane Blake (Tulane)
James B. Delehanty., Ph.D. 2001, Current Position, Research Biologist, Naval Research Laboratories, Washington, D.C.
R. Mark Jones, Ph.D. 2002, Current Position, Director of Technical Applications and Business Development, Sapidyne Instruments, Inc. Boise, ID
Alison M. Kriegel, Ph.D. expected October 2004
Ibrahim A. Darwish, postdoc, Current position, Associate Professor, Department of Pharmaceutical Analytical Chemistry, Faculty of Pharmacy, Assiut University, Assiut 71516, Egypt
Xia Li, current postdoc

Craig Brandt (ORNL)
Matt Jenkins - AA, Computer Science and Information Technology, currently employed by Pfizer, Inc.
Emil Harris - AA, Computer Science and Information Technology, completes his internship September 04, currently applying for employment in greater Knoxville area.

Scott Brooks (ORNL)
Young-Jin Kim, current postdoc
Wiwat Kamolpornwijit, current postdoc
Jamie Philips, undergrad Geology Major, UTK
Ram Kannapan, PhD student Environmental Engineering, U-Texas Austin
Corinne Deibel, faculty intern from Earlham College

Craig Criddle (Stanford)
Jennifer Nyman, PhD candidate
Margy Gentile, PhD candidate

The Oak Ridge FRC Students and Post-grads

Bill Doll (ORNL)
John Rivers, former postmasters, now a PhD candidate at Queen's University, Kingston, ON
Abraham Emond, former UT subcontract/ postgraduate, now a PhD candidate at Univ. Utah
Jacob Sheehan, current postmasters at ORNL

Scott Fendorf (Stanford)
Shawn Benner, (post-doc 2000-2002), Currently Asst. Professor, Boise State Univ.
Matthew Ginder-Vogel, active doctoral student
Colleen Hansel (doctoral student 1999-2004), Post-doc, Woods Hole Oceanographic Institute
Benjamin Kocar, active doctoral student

Susan Hubbard (LBNL)
Jinsong Chen (UCB) - currently at LBNL
Michael Kowalsky (UCB) - currently at LBNL
Ken Williams (UCB and LBNL)

Jack Istok
Mandy Sapp, PhD student in Environmental Engineering at OSU who is working at the FRC site.
Robert Laughman, undergraduate in Mechanical Engineering at OSU who does field and lab work in support the Istok project.
Aeriel Selko, undergraduate in Chemical Engineering at OSU who spent one summer at the FRC as an intern.

Philip Jardine (ORNL)
Jack Carley, postmasters and site operator for Criddle field project
Eric Tsai, PhD candidate Stanford
Molly Pace, postmatsters candidate

The Oak Ridge FRC Students and Post-grads

Peter K Kitanidis (Stanford)
Mike Fienen, PhD candidate
Jian Lou, postdoctoral candidate

Joul Kostka (FSU)
Lainie Petrie, PhD at Florida State University.

Lee Krumholz (University of Oklahoma)
John Senko Ph.D. student – will graduate Sept. 04 and move to post-doc at Penn State U.
Anne Spain – current Ph.D. student
Dwayne Elias Ph.D. student- Currently a post-doc at PNNL
Denny Wong – Post-doc.
Tillman Graham - Undergraduate
Tobin Vigil – Undergraduate- Currently owns bike shop

Derek Lovely (U. Mass)
Kevin Finneran, postdoc. Currently an assistant professor in Environmental Engineering at the University of Illinois.

Jack Parker (ORNL)
Fan Zhang - PhD program at U Central Fla

Scheibe, Timothy (PNNL)
Yilin Fang, postdoctoral associate. Good possibility of transitioning to full-time PNNL staff next year.

Patricia Sobecky (Georgia Tech)
Ivy Thomson., graduate student Georgia Tech.
Hiro Nakahara., former undergraduate. Currently employed as a research technician at Emory University in Atlanta.