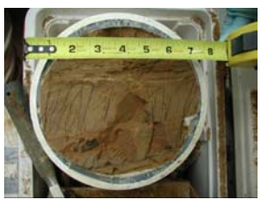
In Situ Immobilization of Uranium in Structured Porous Media via Biomineralization at the Fracture/Matrix Interface

Intact Column Studies

Above: Background area excavation showing one of the intact blocks being prepared for removal.

Left: A fully-shaped intact core, sealed with epoxy and encased in PVC, ready for removal to the laboratory.

Right: End view of the core.



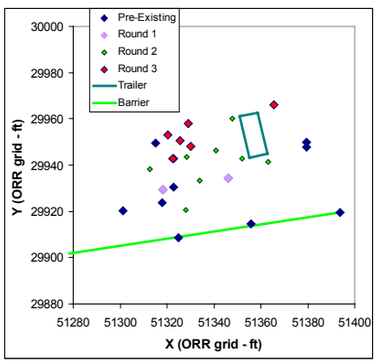
Three large (~15 cm diameter × 30 cm long) intact core specimens were collected from an excavation in the background area (uncontaminated), and have been instrumented for long-term laboratory flow-through and biostimulation experiments. The large cores have been saturated and placed under partial vacuum in preparation for loading with uranium(VI) contamination.

Intact Column Studies

Intact saprolite blocks from the FRC background area will be subjected to three treatments:

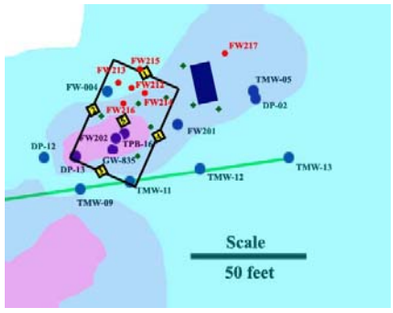
- Tracers only (control)
- Tracers plus electron donor
- Tracers plus electron donor and electron shuttle

Field Site Development



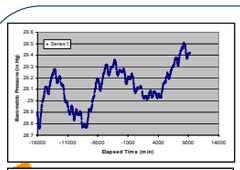
Three Rounds of Well Installation:

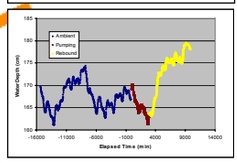
1. Exploratory dual wells FW201 and FW202 (sediment and aqueous samples)
2. Deep wells FW204-FW211 (intact saprolite characterization)
3. Shallow wells FW212-217 (disturbed saprolite characterization)



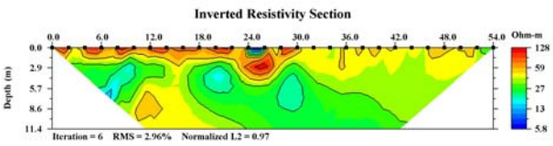
Approximate dissolved U contours from survey by Istok group Sept 2002. Highest levels (pink) are ~ 5 µM.

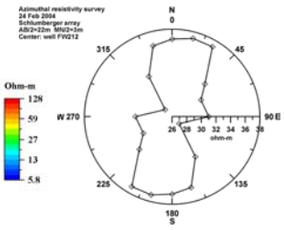
Based on aqueous and sediment chemistry, and hydraulic properties, we have chosen to focus on the disturbed (fill) saprolite zone below the water table (approximately 13-20 feet depth)



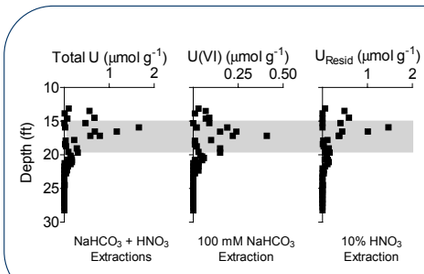


Wells completed in the intact saprolite exhibit strong barometric response (similar to a confined aquifer). Eight pressure transducers and one multiparameter probe have been installed.

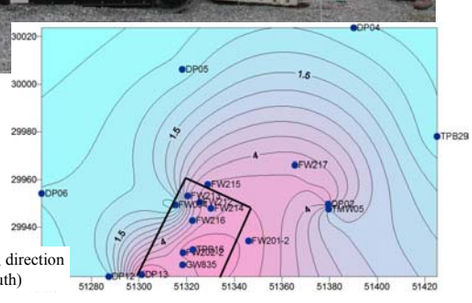




Above Left: Estimated electrical resistivity along a cross-section perpendicular to the proposed flow cell axis (about 4 meters downgradient of FW212. **Above Right:** Partial results of azimuthal surface electrical resistivity survey conducted by ORNL Feb. 2004. The survey shown focused on the deep (intact) saprolite and indicates maximum resistivity in N-S direction → minimum resistivity (dominant fracturing) in E-W direction.



Sediment-associated uranium peaks at ~17 and 20 feet depth, low below 20 feet.



Above: Round 1 well installation at Area 2 of the NABIR FRC.

Right: Aqueous U(VI) contours from survey of new wells March 2004. Contour interval = 0.5 µM.

Head gradient ~0.02 feet/foot; direction ~30 degrees west of south)

Planned Field Biostimulation

Our ultimate goal is to conduct a field-scale biostimulation experiment to evaluate the key hypothesis:

- Inject electron donor into macropore domain in manner prescribed by numerical simulation design
- Target area in a high-U(VI) plume to the northeast of the existing iron barrier in Area 2.
- A gallery of low-rate e- donor injection wells and several monitoring wells will be operated for several months.
- Geophysical characterization will also be performed at selected time intervals
- Drill back after experiment to collect sediment for post-stimulation microbial characterization and microscopic analysis of precipitated phases.