Assessing Microbial Community Stability using Novel in situ Incubation Techniques

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Problem Statement

Biostimulation by electron donor addition promotes biological reduction of U(VI), however, U(VI) reduction is reversible, therefore the long-term stability of reduced U(IV) is a critical issue for application of biostimulation as a treatment technology. Will reduced U(IV) be reoxidized following cessation of electron donor addition in an aerobic aquifer?

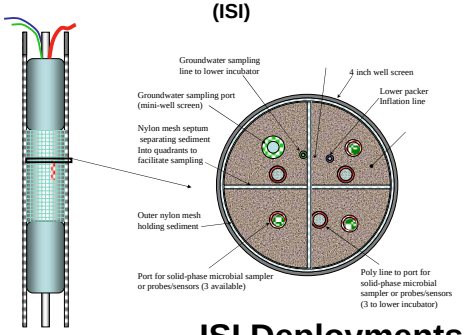
Overall Goal and Hypothesis

- Understand the mechanisms for maintenance of bio-reduced uranium in an aerobic aquifer under field conditions after electron donor addition has ended.
- Sulfate-reducing bacteria (SRB) play an important role in post-treatment maintenance of bio-reduced uranium either by direct U(VI) reduction or generation of H_2S and/or $FeS_{0.9}$.

Approach

- Laboratory scale microcosms allow precise control over system variables, but extrapolation of results to the field scale may be difficult.
- To investigate the role of microbial community composition in maintenance of bio-reduced U(IV), we developed in-well sediment incubators (ISI) allowing field deployment of laboratory-generated native sediment microbial communities.

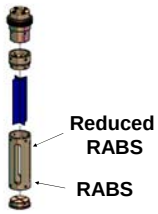
Conceptual design and top view (section) of In-Well Sediment Incubator (ISI)



Retrieval of ISI containing Reduced Rifle Aquifer Background Sediment (Reduced RABS) following 3-month deployment in B-02 (DO=0.44 mg/L)

ISI Deployments at Old Rifle Site

B-02



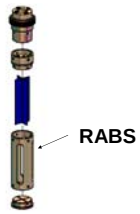
ISI Deployment in Background Well B-02

- The bottom of the ISI was filled with laboratory reduced RABS.
- The top of the ISI was filled with RABS.
- ISI was incubated in B-02 for 3 months.

ISI Deployment in Downgradient Well M-22

- The ISI was filled with RABS.
- ISI was incubated in M-22 for 3 months prior to the onset of acetate injection experiments.

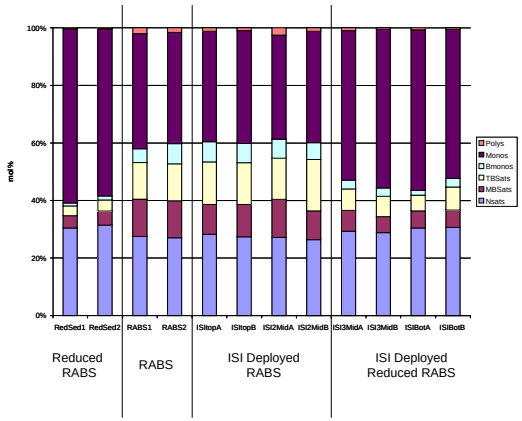
M-22



Sediment samples were retrieved from the ISI for PLFA profiles, DGGE profiles and qPCR enumeration of known iron- and sulfate-reducing bacteria.

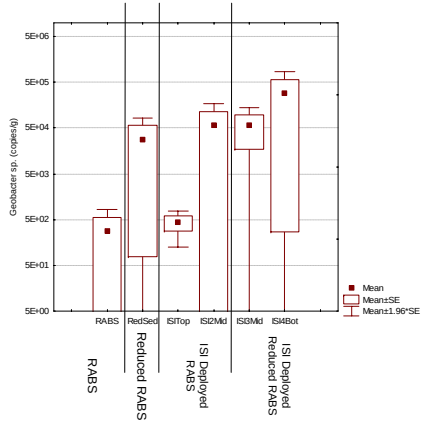
Results: B-02 ISI Deployment

PLFA Composition



- PLFA Composition results show loss of monounsaturated PLFA (the main PLFA of δ-*proteobacteria* including *Geobacter* spp.) in the reduced RABS following ISI deployment in background well B-02.

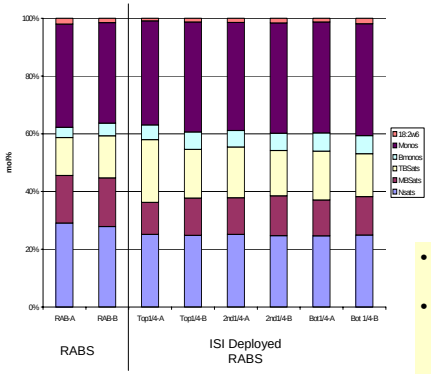
Quantification of *Geobacteraceae*



- *Geobacter* spp. 16S rRNA gene copy numbers from field deployed reduced RABS remained comparable to those detected in the reduced sediment prior to a 3 month deployment in B-02.

Preliminary Results: M-22 Deployment

PLFA Composition



- RABS was loaded into the ISI and deployed in M-22 for 3 months prior to the 2006 injection experiments.
- PLFA results showed an increase in monounsaturated PLFA when incubated in an area that had undergone previous stimulation.

Overall Results

- ISI results are consistent with observed environmental conditions and previous field experiments.
- ISI will permit expedient interrogation of microbial community response and will be a valuable tool for examining microbial community control of bio-reduced uranium.

Next Steps

Additional in-well sediment incubators are being constructed for deployment in November 2006.
Geochemical analysis of ISI sediment samples.

References:

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