Idaho National Laboratory

INL Subsurface Science Scientific Focus Area:

Subsurface Immobilization of Metal Contaminants by Amendment-Driven Mineral Precipitation

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April 9, 2008

Science Theme: Amendment transport, mixing, reaction, and precipitation

- Motivation: Recurring issue with metal immobilization is that the reaction of amendments is governed by transport and mixing.
  - Sr at INL, Tc, Cr, U at Hanford, U at SRNL, ORNL
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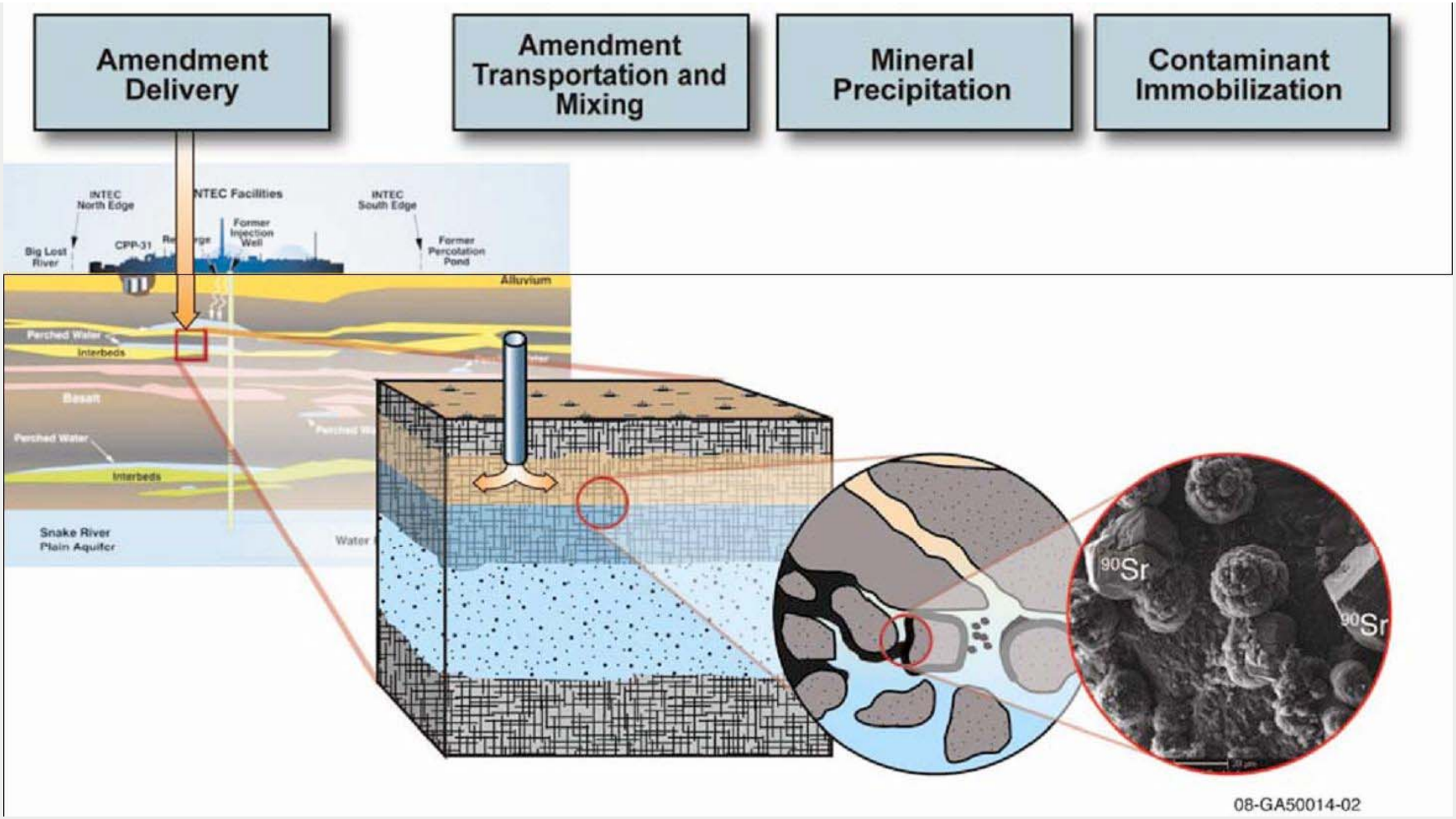
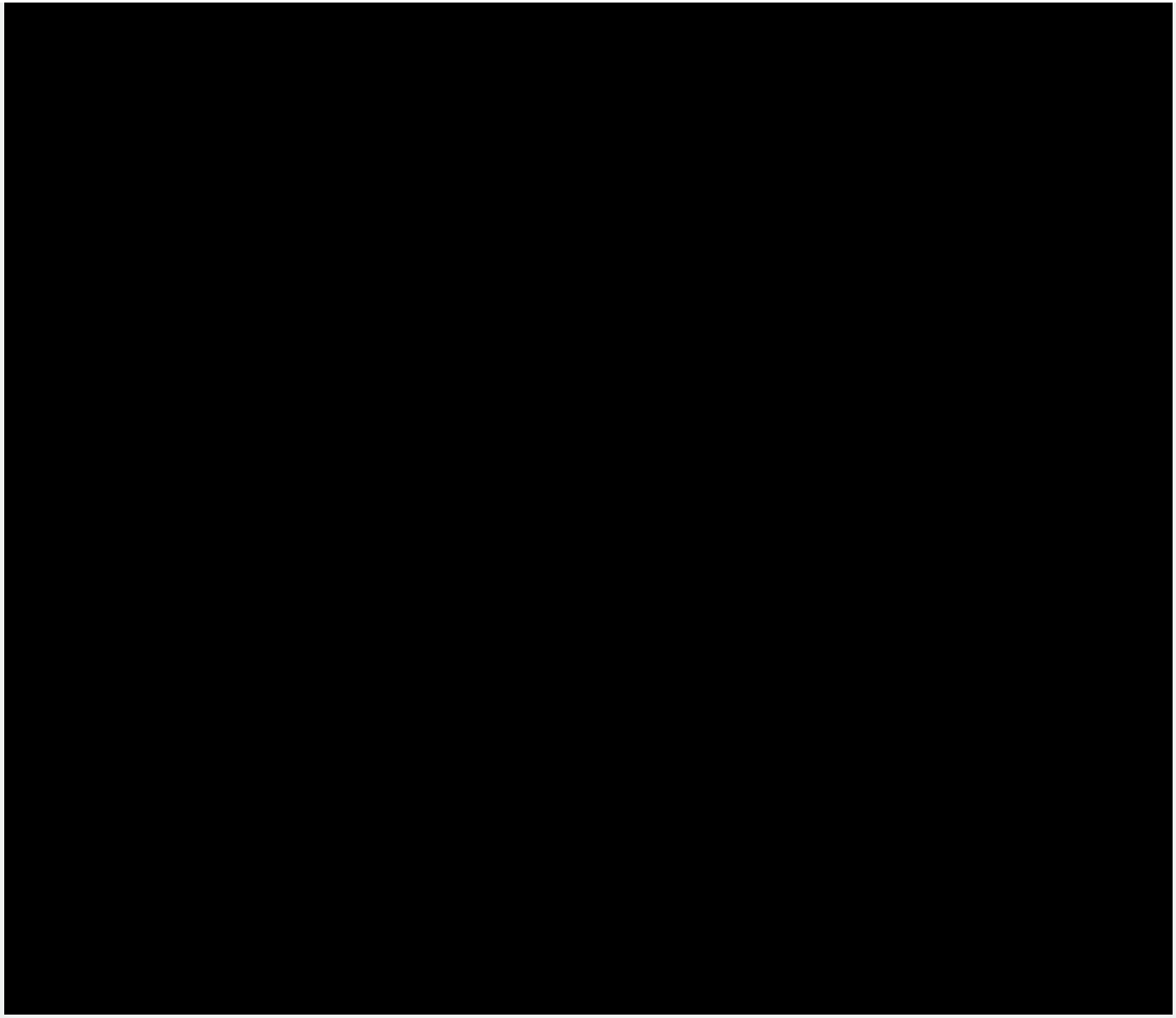
Knowledge Gaps

- Mixing of reactants in heterogeneous porous media
- Coupling of mixing to spatial and temporal distribution of precipitates
- Understanding the macroscopic expression of microscopic processes and properties



Needs: Control the *in situ*, amendment-stimulated formation of mineral phases and biomass to effectively reduce the transport of metal contaminants in subsurface porous and fractured systems



Predict, control, and monitor the spatial and temporal distribution of mineral precipitates and biomass that depend on the macroscopic transport and pore-scale mixing of reactants.

Principal Research Elements

RE 1. Transport/Precipitation Coupling in Porous Media:

Spatial and temporal distributions of precipitates, and impacts on contaminant mobility, will be determined as functions of amendment delivery and media properties in physical experiments. This is the centerpiece of the SFA.

RE 2. Basic Processes and Parameters:

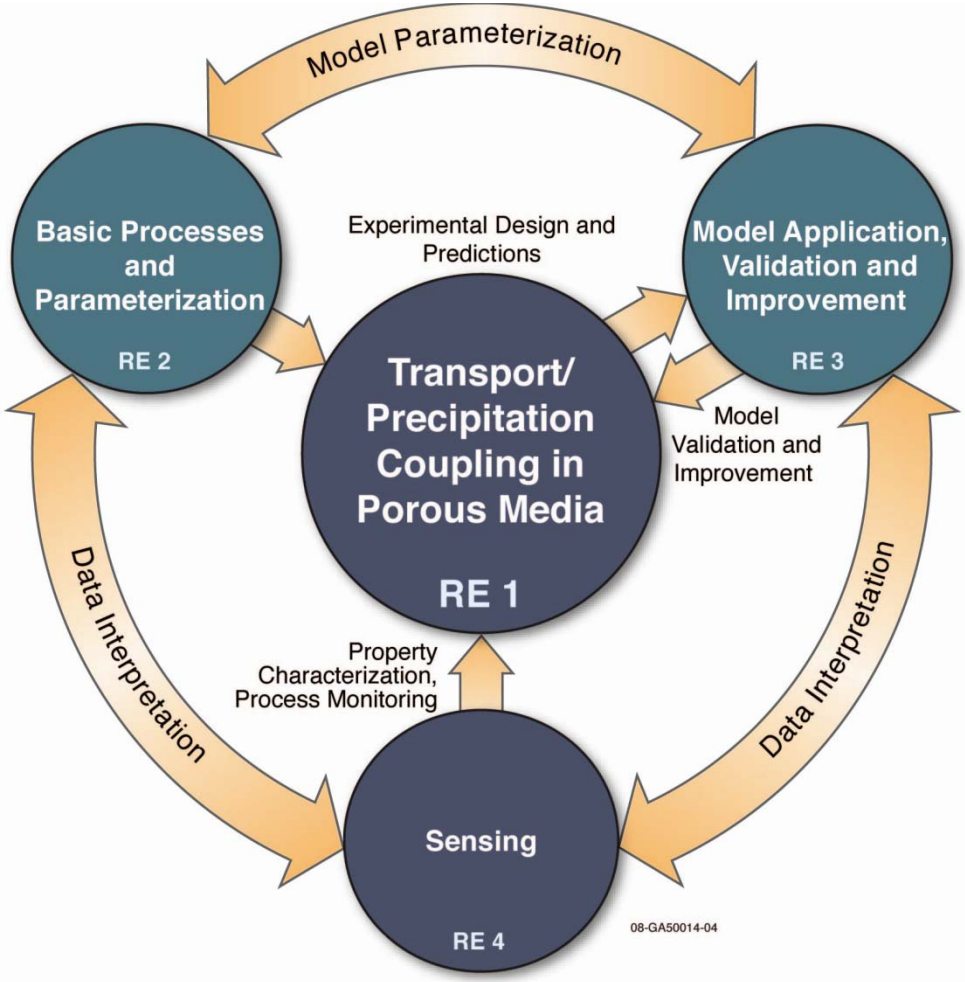
Governing relationships and parameters for mineral precipitation and contaminant sequestration will be determined or validated for conditions relevant to the experiments and to the field.

RE 3. Model Application, Validation, and Improvement:

Model predictions for amendment transport, mixing, precipitation, and detectable physical property changes will support the experiment design. Experiments in turn will be used to validate the models.

RE 4. Sensing Methods:

Noninvasive methods to infer biogeochemical processes from detectable geophysical signatures will be developed and tested using the physical experiments and computer simulations.

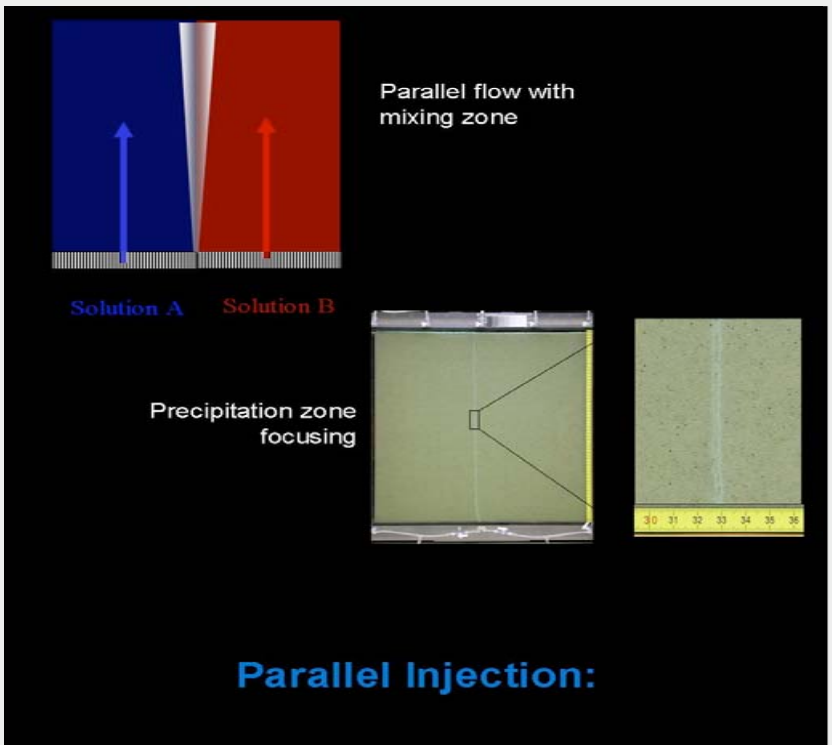


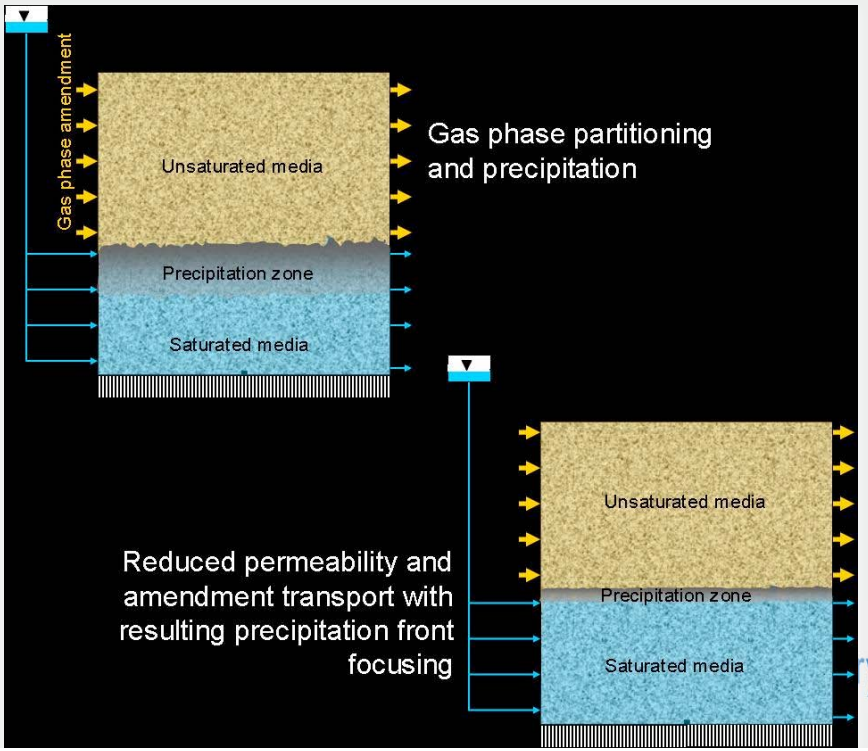
Research Plan:

Use experiments at appropriate scales to investigate the coupling between solute transport and precipitation, test-validate-improve model simulations, and investigate the use of macroscopic geophysical signatures to monitor precipitate formation

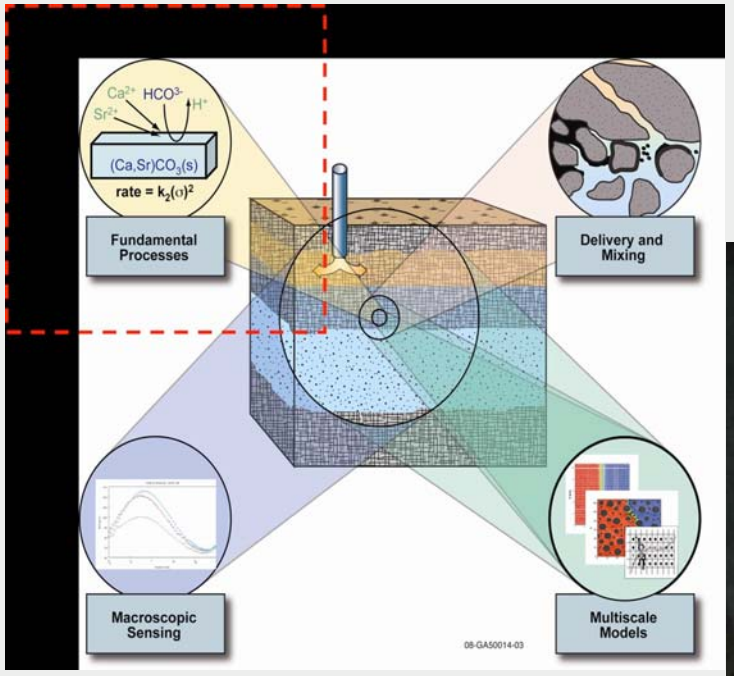
Research Element 1 - Transport and Precipitation Coupling in Porous Media

Understanding how the spatial and temporal distributions of mineral precipitates, and their impact on mobile contaminant metals, depend on reactant mixing in porous systems

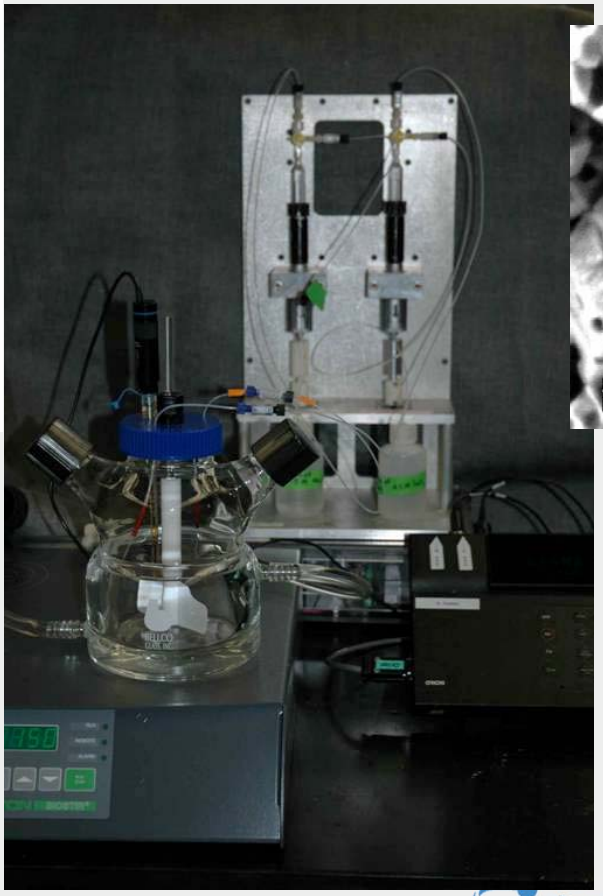


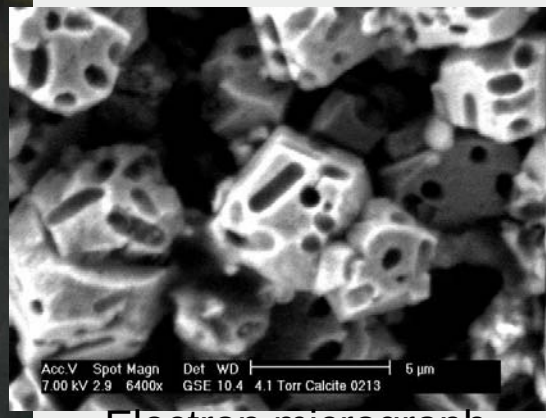


Research Element 2 - Basic Processes and Parameters



Obtain functional relationships between system conditions and process rates and products





Electron micrograph of calcite precipitated by bacteria actively hydrolyzing urea.

Constant composition reactor

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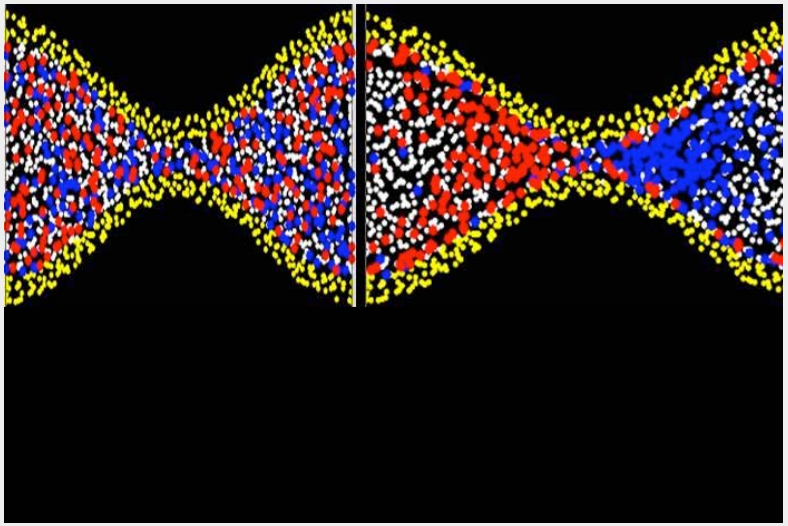
Research Element 3 – Model Application, Validation and Improvement

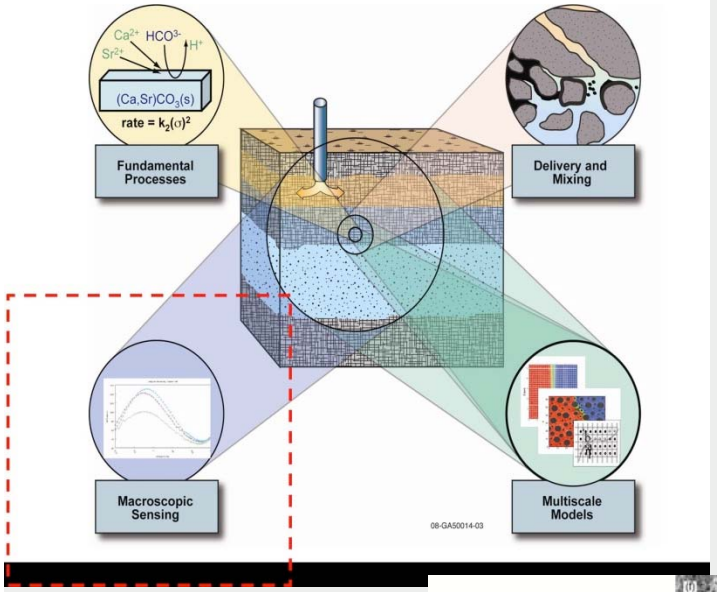


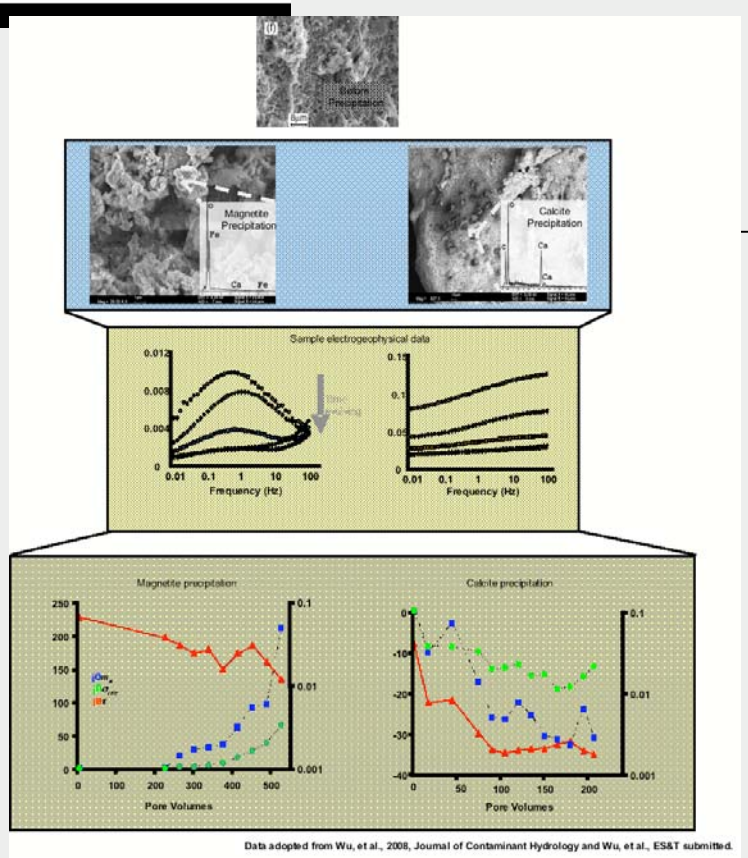
Dissipative particle dynamics simulation of "membrane polarization" near a pore throat:

left-initially random uniform distribution of ions;

right-induced polarization near pore throat after imposing an external electric field

Research Element 4 - Sensing





Data adopted from Wu, et al., 2008, Journal of Contaminant Hydrology and Wu, et al., ES&T submitted.

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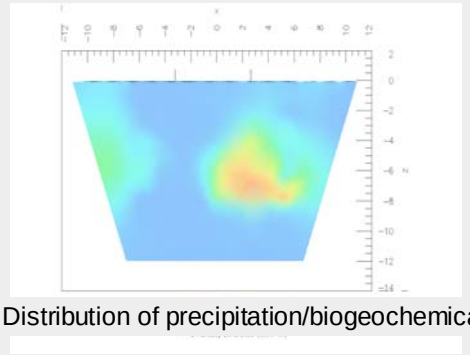
Joint inversion / Petrophysical mapping / Physics based modeling



Distribution of precipitation/biogeochemical properties

Related Efforts

- Other ERSP projects
  - PNNL, LBNL, UI
- SciDAC
- EM-22
- INL geoscience signature
- INL LDRDs