Colloid-Facilitated Transport of Radionuclides through the Vadose Zone

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Objectives

1. Determine lability and thermodynamic stability of colloidal material under a range of conditions expected under both reacted and unreacted zones.
2. Determine potential for *in situ* colloid mobilization in different sediments.
3. Evaluate colloid mobility through sediments under different degree of water saturation and ionic strength in packed and undisturbed columns.

Objectives (2)

4. Assess the extent of colloid-facilitated transport under a range of relevant conditions.
5. Verify experimental results obtained in *uncontaminated* sediments with in situ colloid mobilization in *contaminated* sediments.
6. Implement colloid-facilitated transport mechanisms and thermodynamic stability constants for colloids into a reactive transport model.

Contaminants

Cs, Am, Eu

- Cs-137
- Am(III) and Eu(III):
  - interactions with aluminosilicates have not been studied extensively

Sediment Materials

- 4 different samples:
  - cataclysmic flood deposits
  - fluvial/aeolian deposits
  - caliche layer
  - fluvial overbank deposits

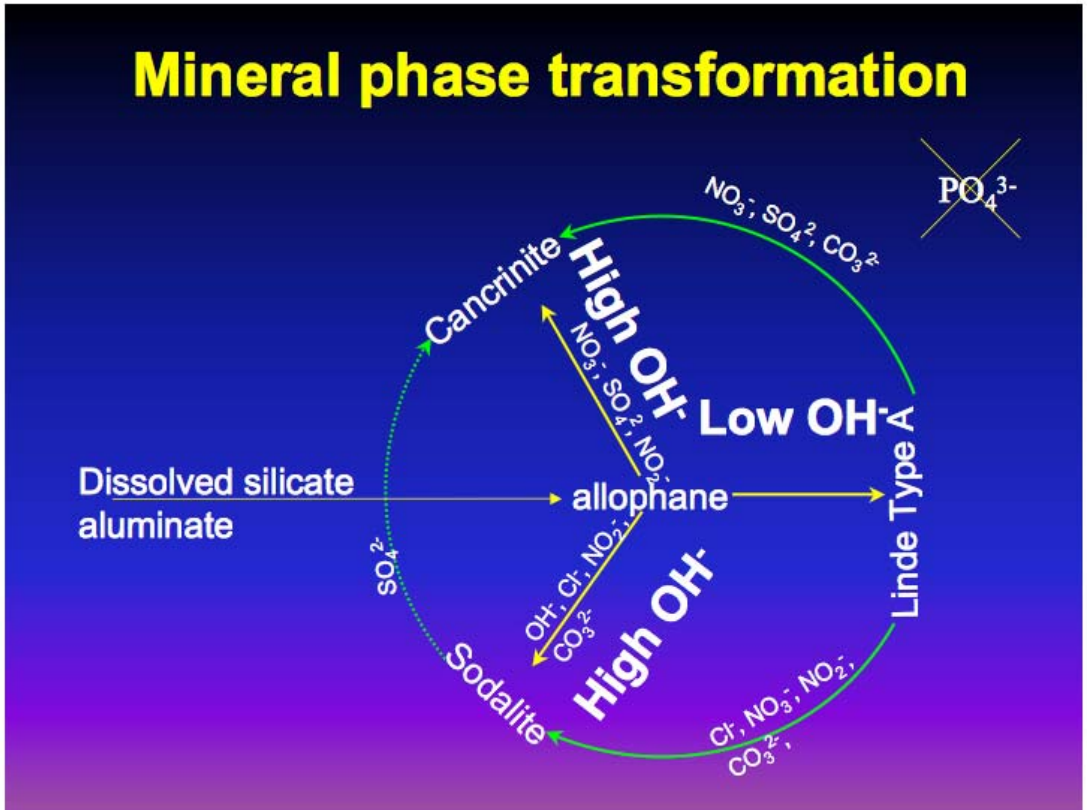
(4-inch diameter split-spoon core 299-E24-21 from 200 East Area is available)

- Undisturbed sediment cores from cataclysmic flood deposits (diameter 50 cm, height 60 cm)

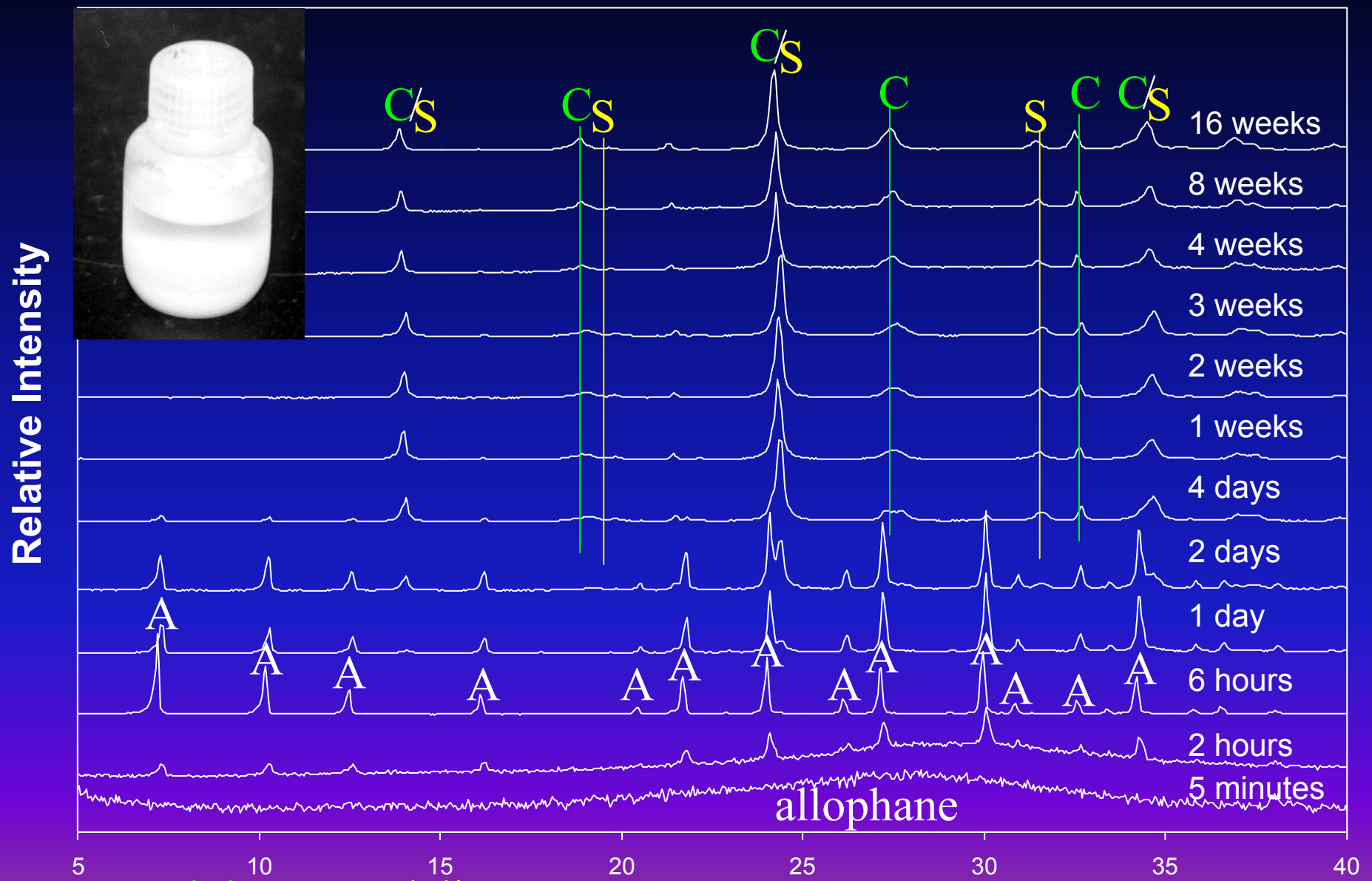
Task 1

Thermodynamic Stability of Colloids and Transformation Products

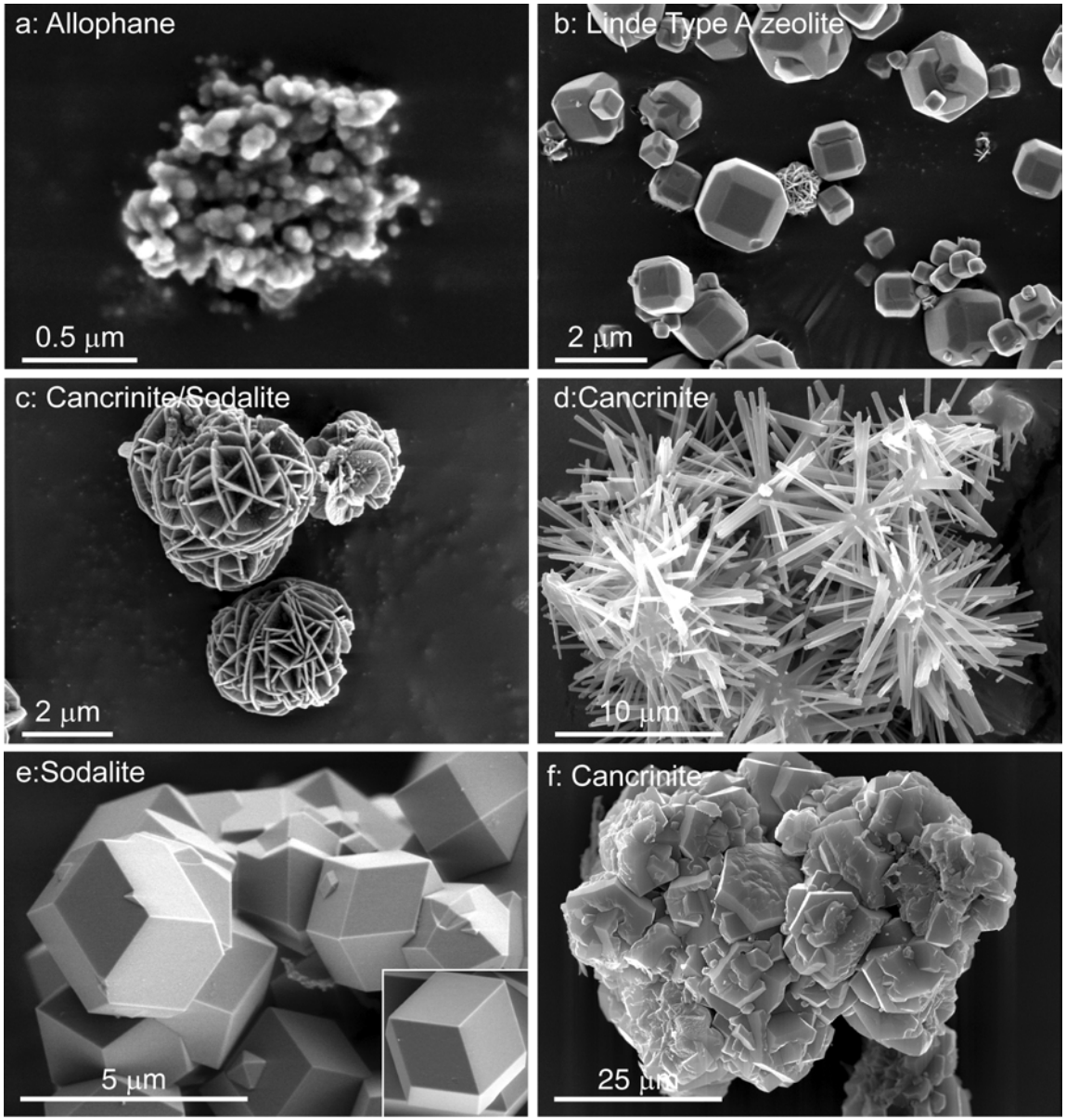
- Stability/solubility experiments
- Construction of solubility/stability diagrams



Minerals formed in 1 M NaOH, 0.5 M $NaNO_3$, 80 °C



Minerals


a: Allophane
0.5 μm
b: Linde Type A zeolite
2 μm
c: Cancrinite/Sodalite
2 μm
d:Cancrinite
10 μm
e:Sodalite
5 μm
f: Cancrinite
25 μm

Task 2

Colloid Stability and in situ Colloid Mobilization

- PCS and batch experiment
- Time and particle concentration effects
- Column flow-through experiments:
  - Change of ionic strength to initiate mobilization
  - Characterization of colloids in outflow
  - Verify with undisturbed monoliths

Task 3

Colloid and Colloid-facilitated Transport in Disturbed and Undisturbed Sediments

- In situ colloid mobilization (wetting/drying effects)
- Unsaturated steady-state and transient flow
- Colloid-facilitated contaminant transport
- Colloid mobilization from contaminated cores

Task 4

X Ray Tomography and NMR

- X-ray computed tomography to map flow pathways and fluid/water distribution
- NMR: - F-19 NMR spin probe
  - F-19 used to see rotational diffusion as function of water saturation

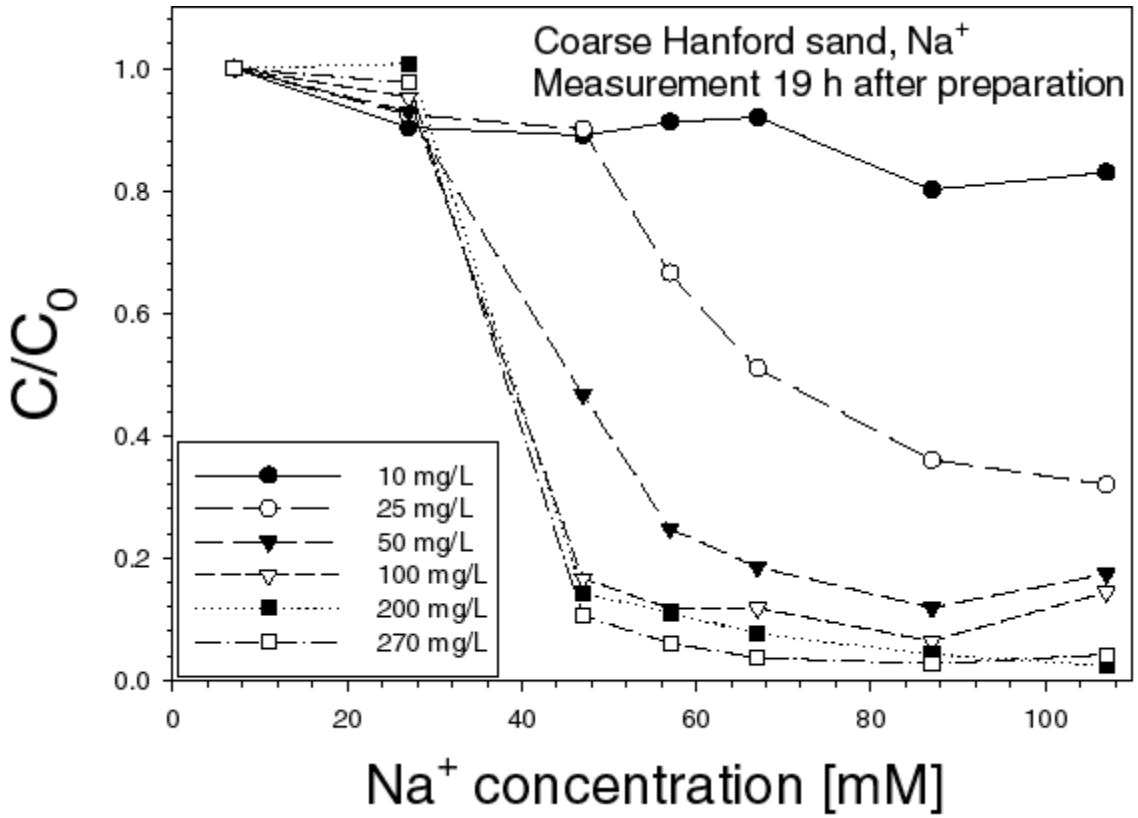
Task 5

Reactive Transport Modeling

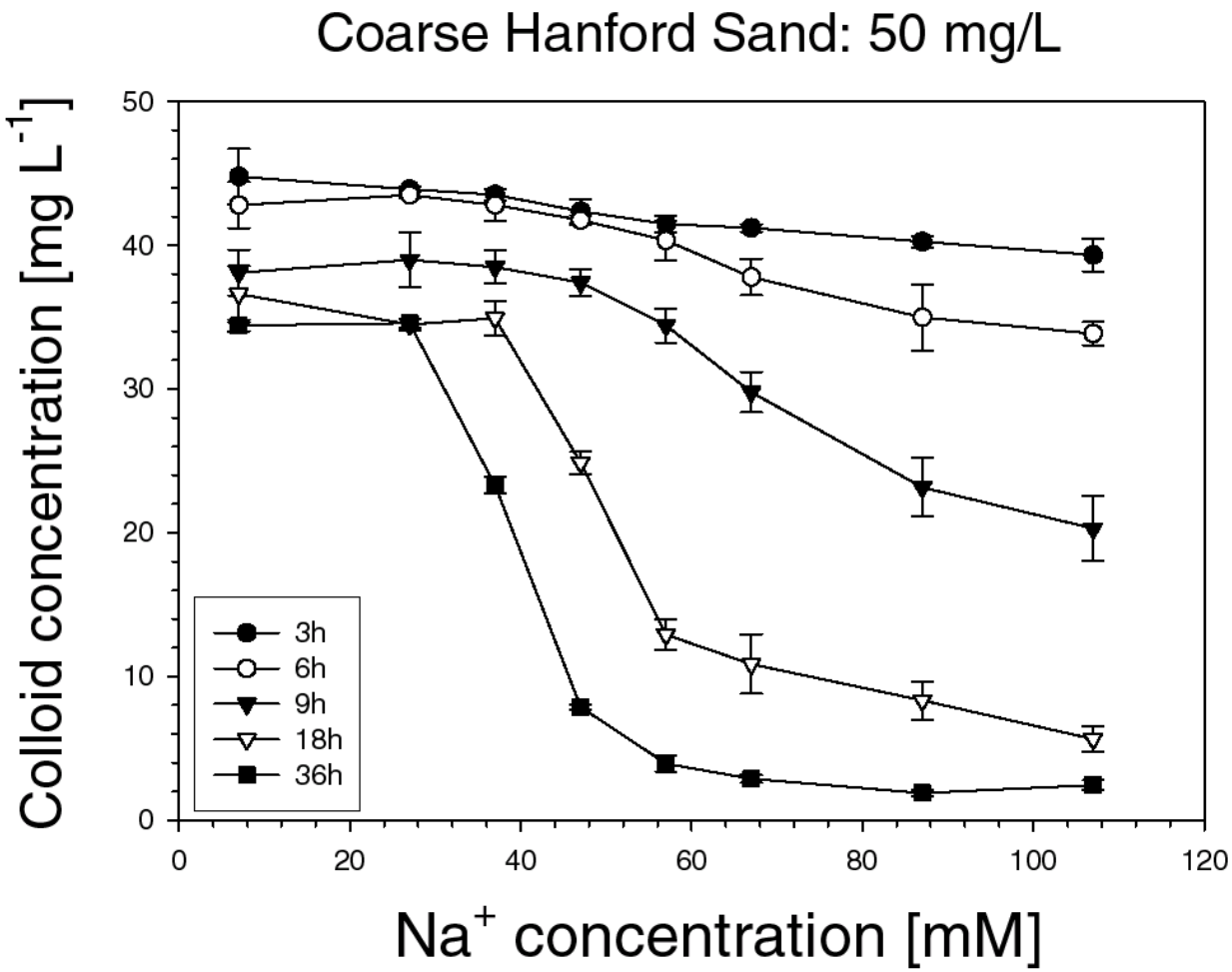
- Incorporation of colloid transport in FLOTRAN
- 2-Phase flow model
- Pitzer equations
- Integration of FLOTRAN with PEST

Preliminary Results

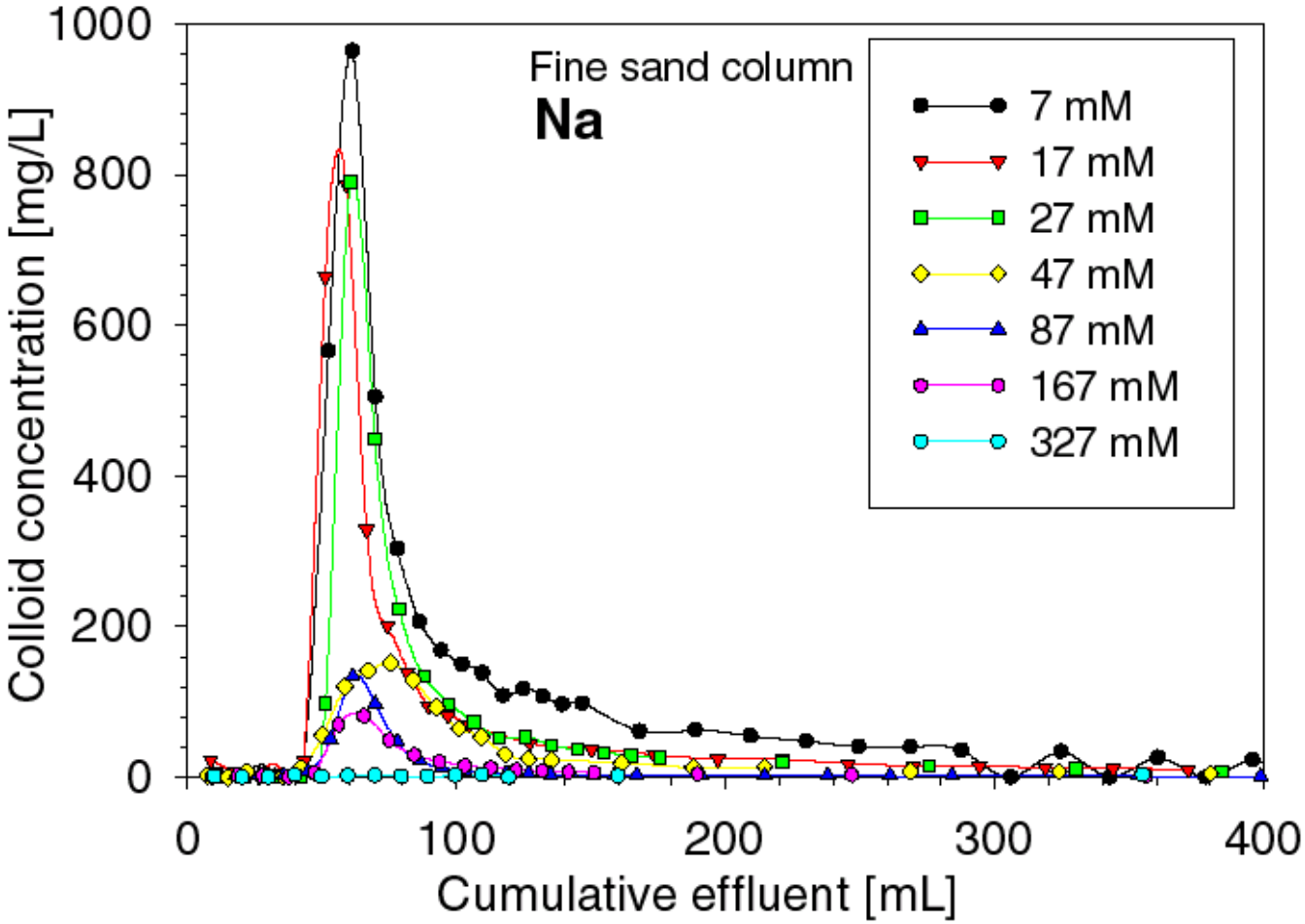
Colloid Stability



Colloid Stability

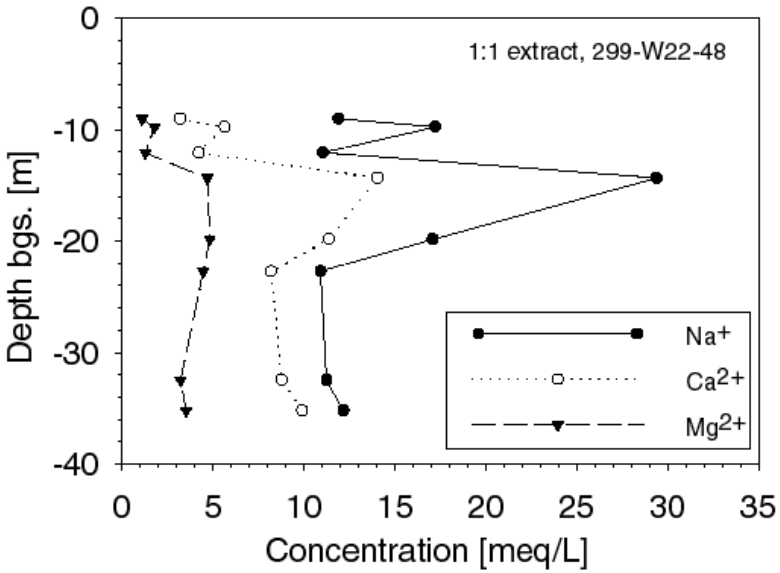


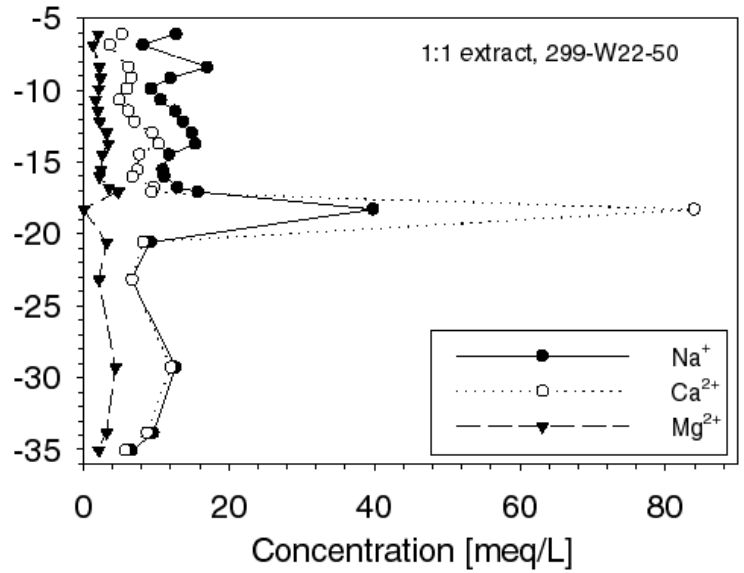
Colloid Stability



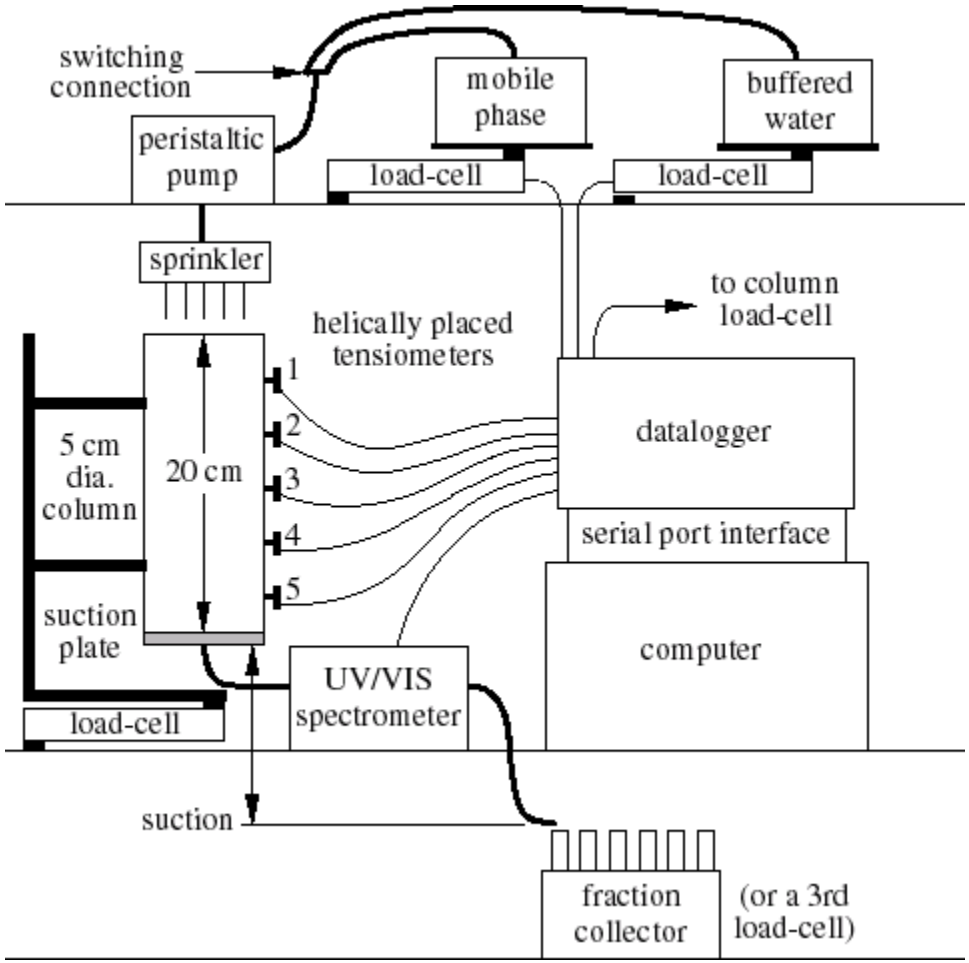
Hanford Sediment Pore Water

Serne, et al., 2002

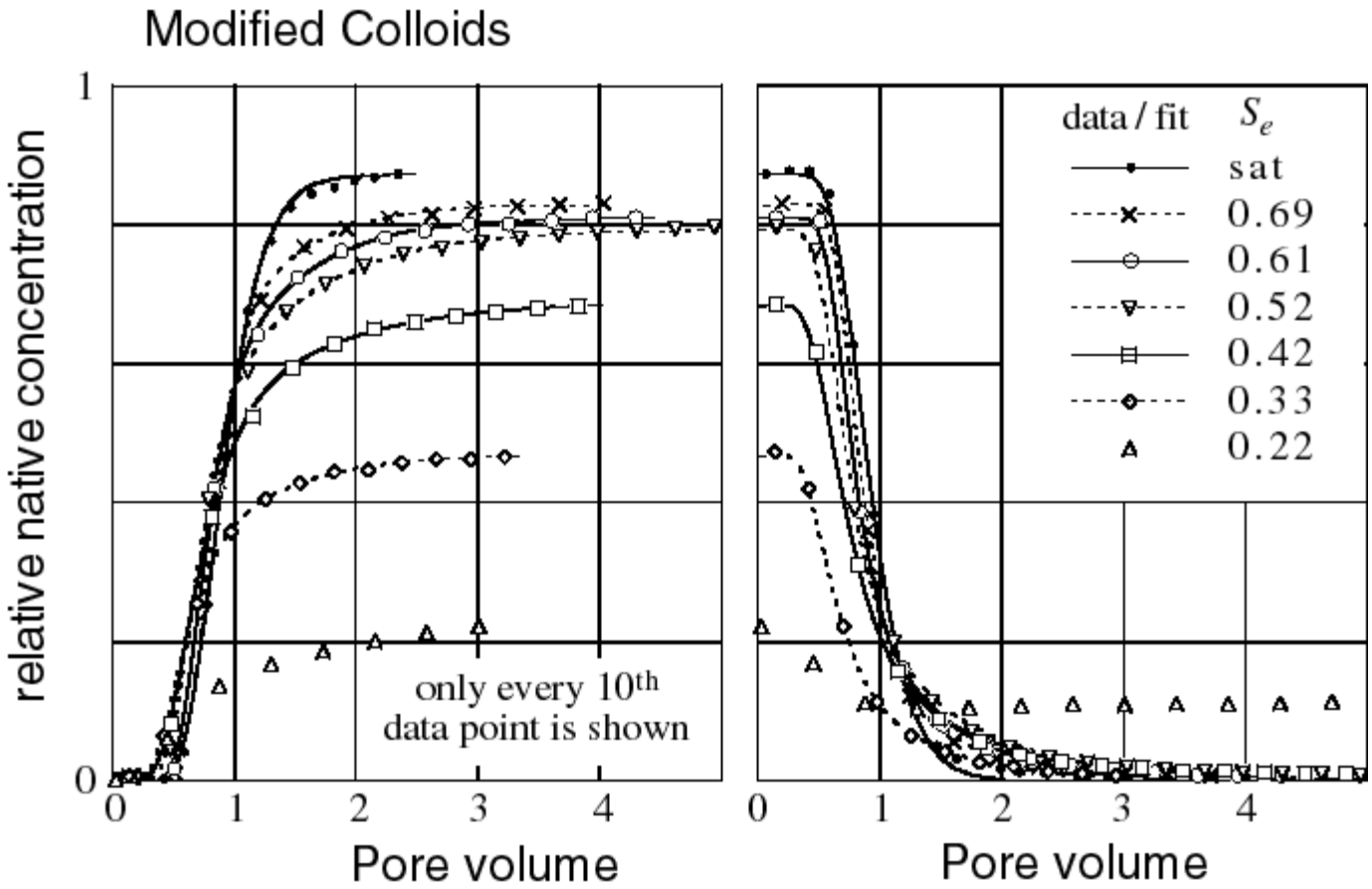




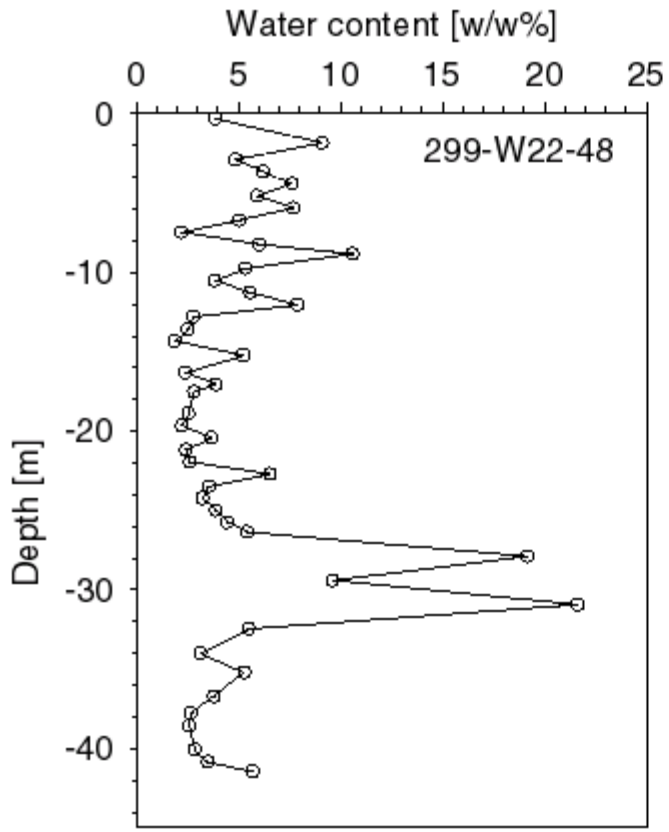
Colloid Transport

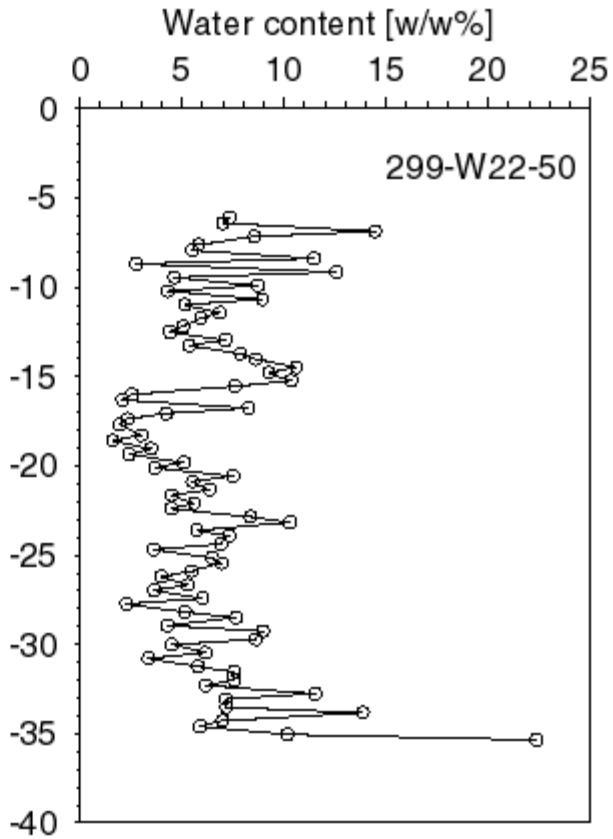


Colloid Transport



Hanford Sediment Water Content





Serne, et al., 2002

Sediment Materials

Sediment Sampling

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