Update on the Artificial Fracture Testing Program at B+Tech

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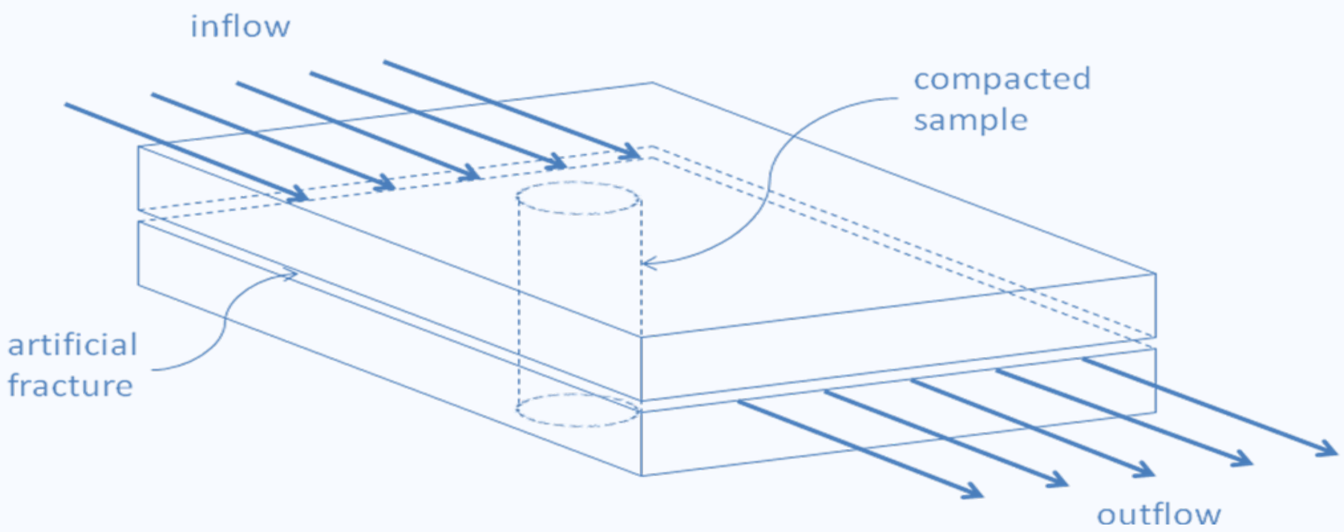
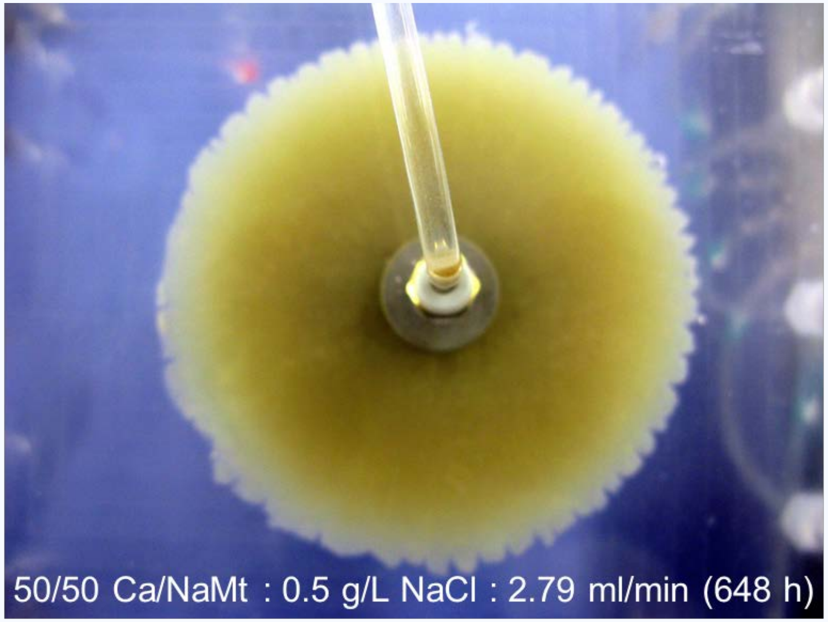
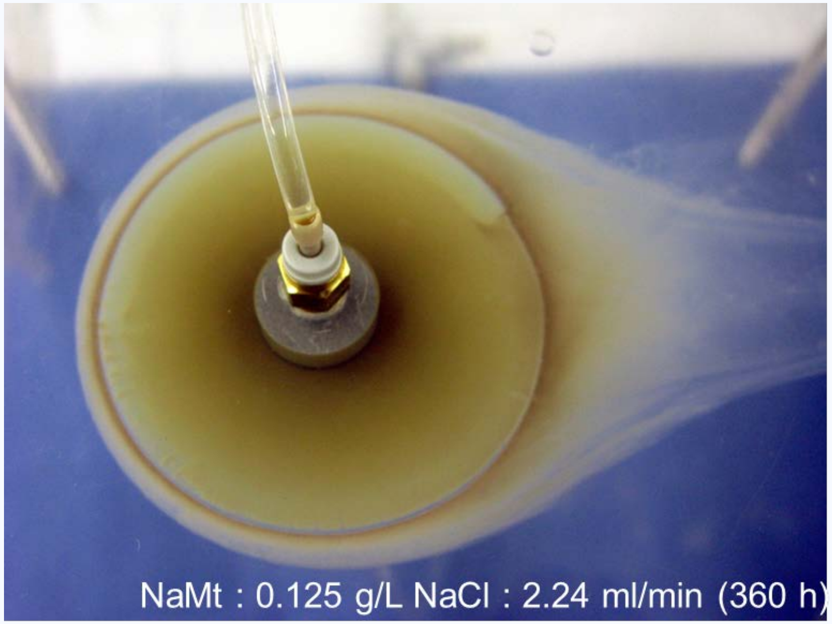
Artificial Fracture Experiments (WP2)



- Directly probe buffer erosion in a "fracture environment" under flow-through conditions relative to:
  - buffer composition
  - groundwater composition
  - groundwater velocity
  - fracture geometry
  - accessory minerals

Pre-BELBaR Work





- Series of artificial fracture tests in a horizontal, 1 mm aperture fracture.
- Posiva Report 2012-44

Some Findings of Previous Work

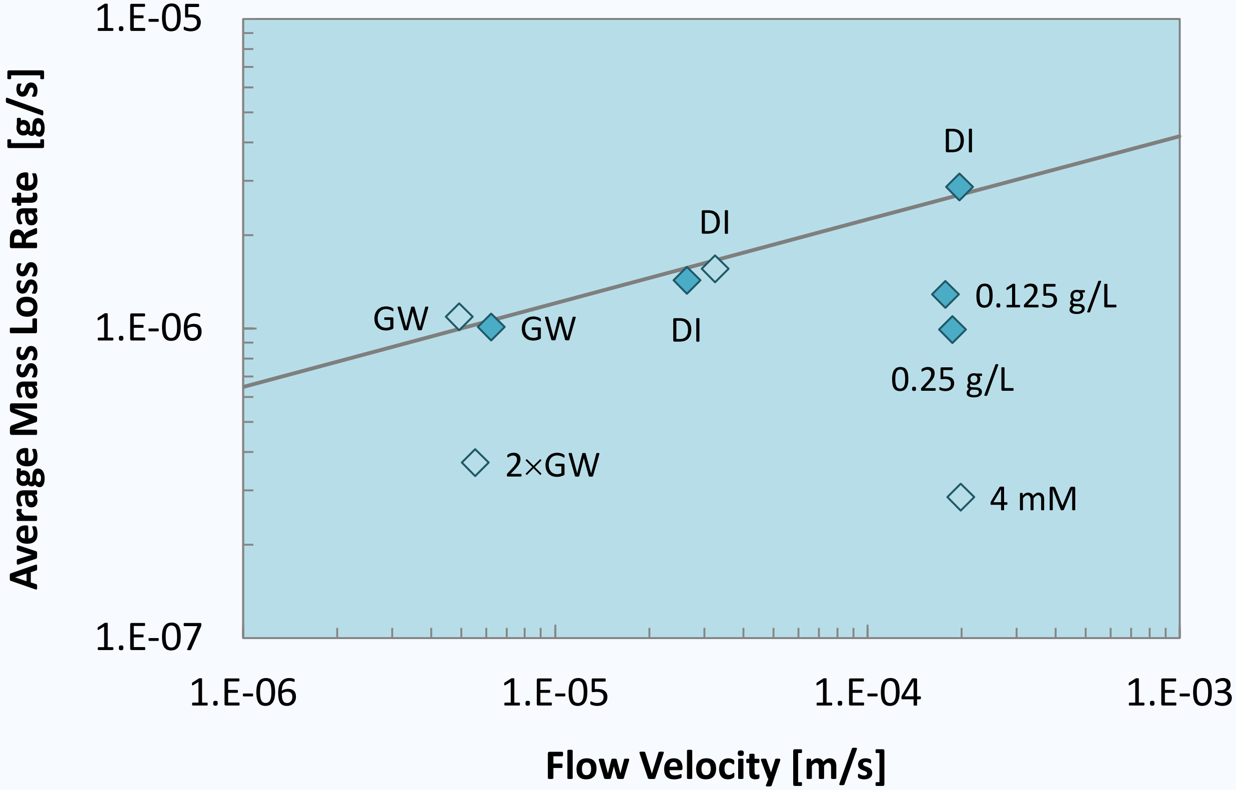
- Erosion Threshold

  - Erosion was not observed for NaMt against contact solution compositions from 10 g/L (171 mM) to 0.5 g/L (8.6 mM) NaCl or for 50/50 Ca/NaMt against 0.5 g/L (8.6 mM) NaCl.

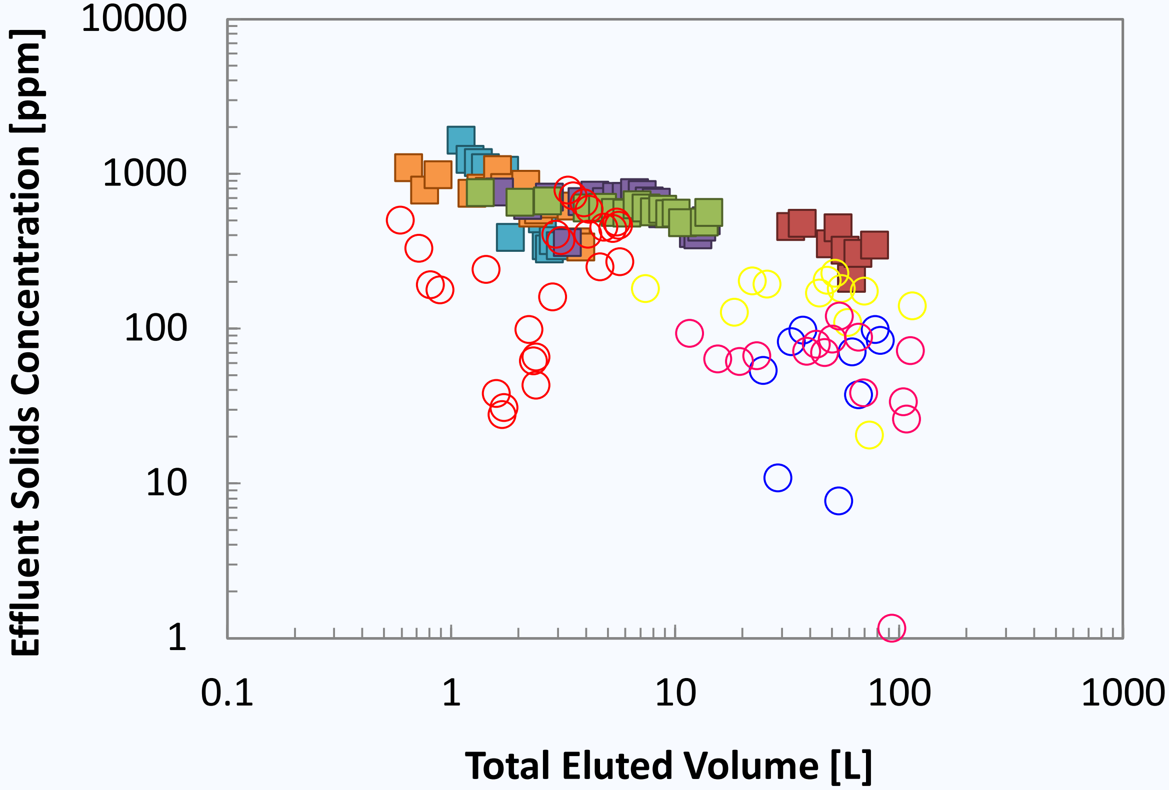
  - Erosion was observed for both NaMt and 50/50 Ca/NaMt against contact solution compositions ≤ 0.25 g/L (4.3 mM) NaCl.

- Not all eroding systems erode equally.

Average Erosion Rates

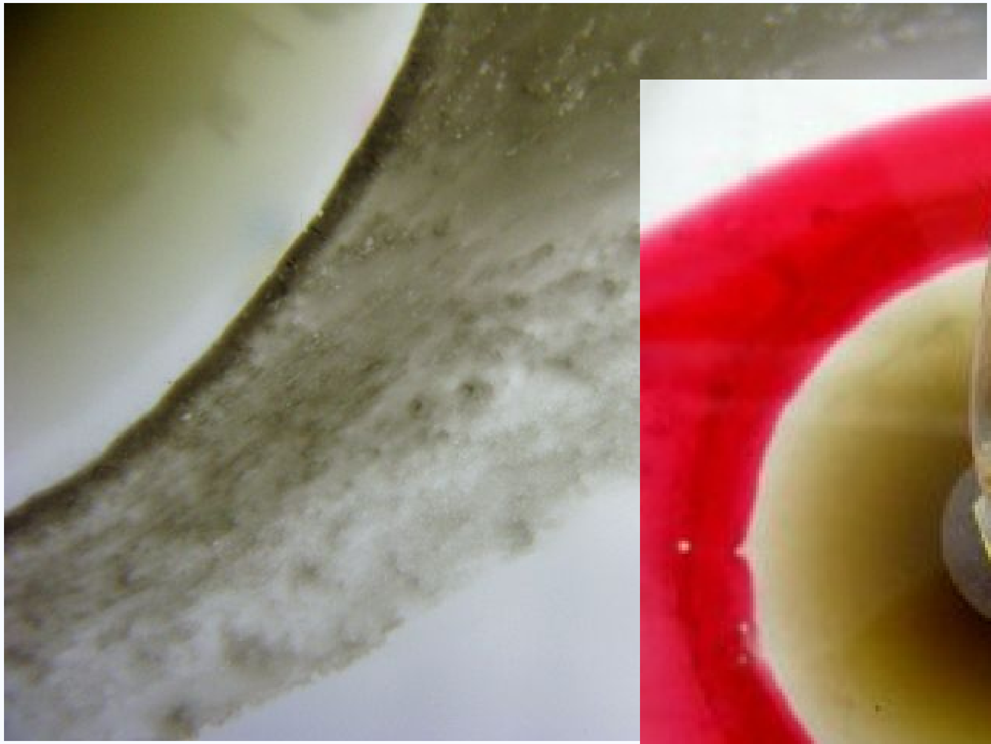


Effluent Data



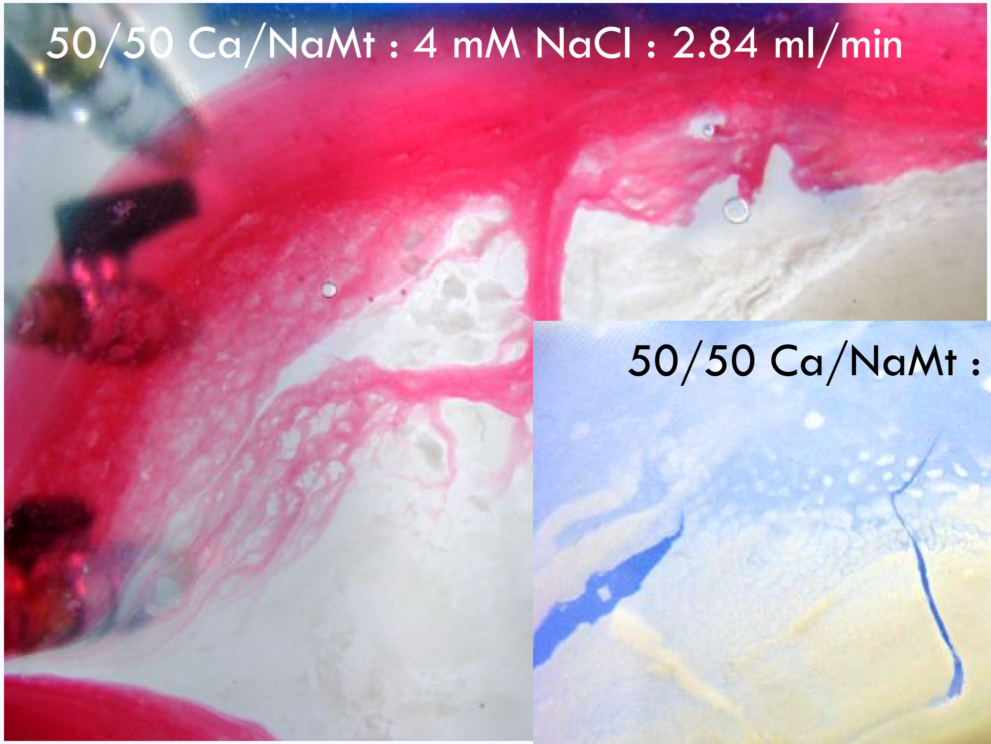
- Observed for the marginally less dilute solutions, i.e.,2.2 mM ≤ IS ≤ 4.3 mM

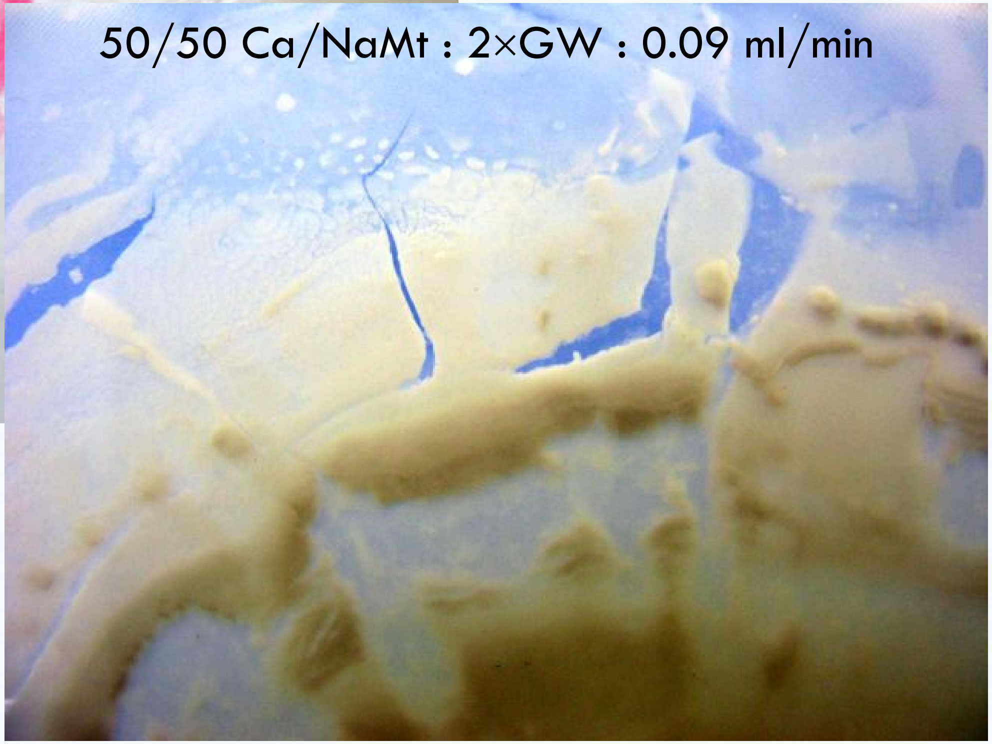
Extrusion/Erosion Interface



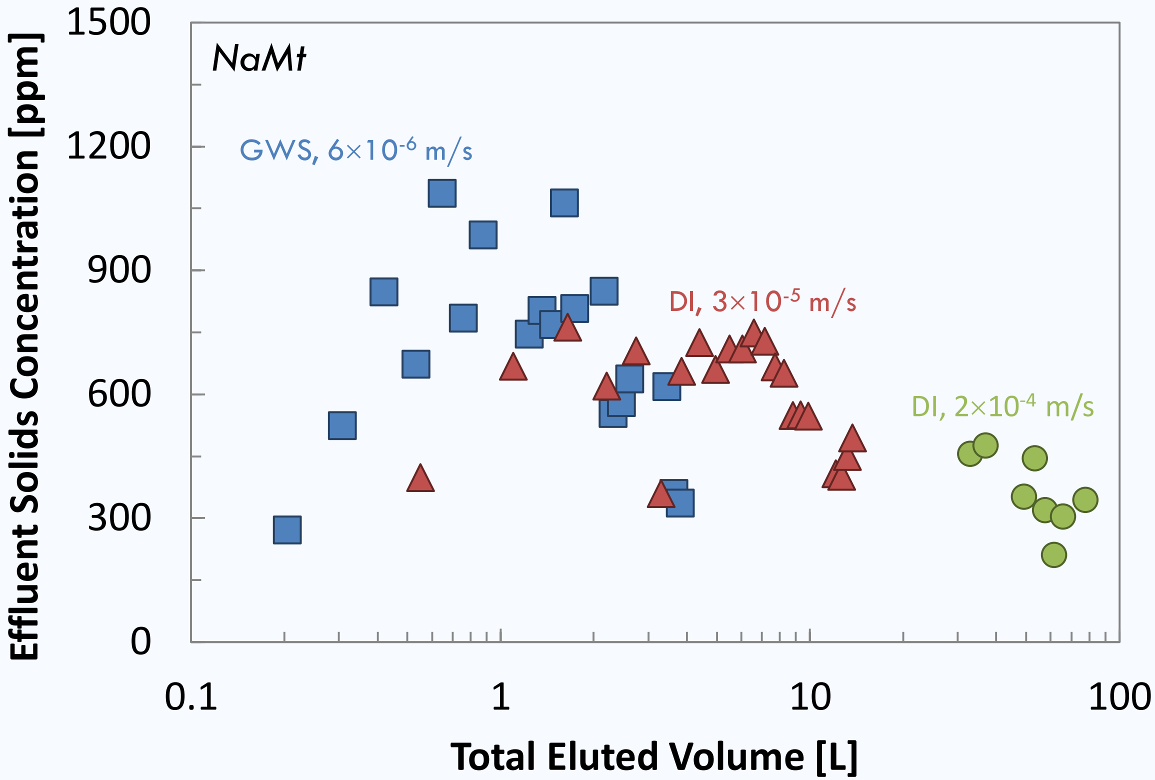
NaMt : DI : 2.84 ml/min

Structure Formation



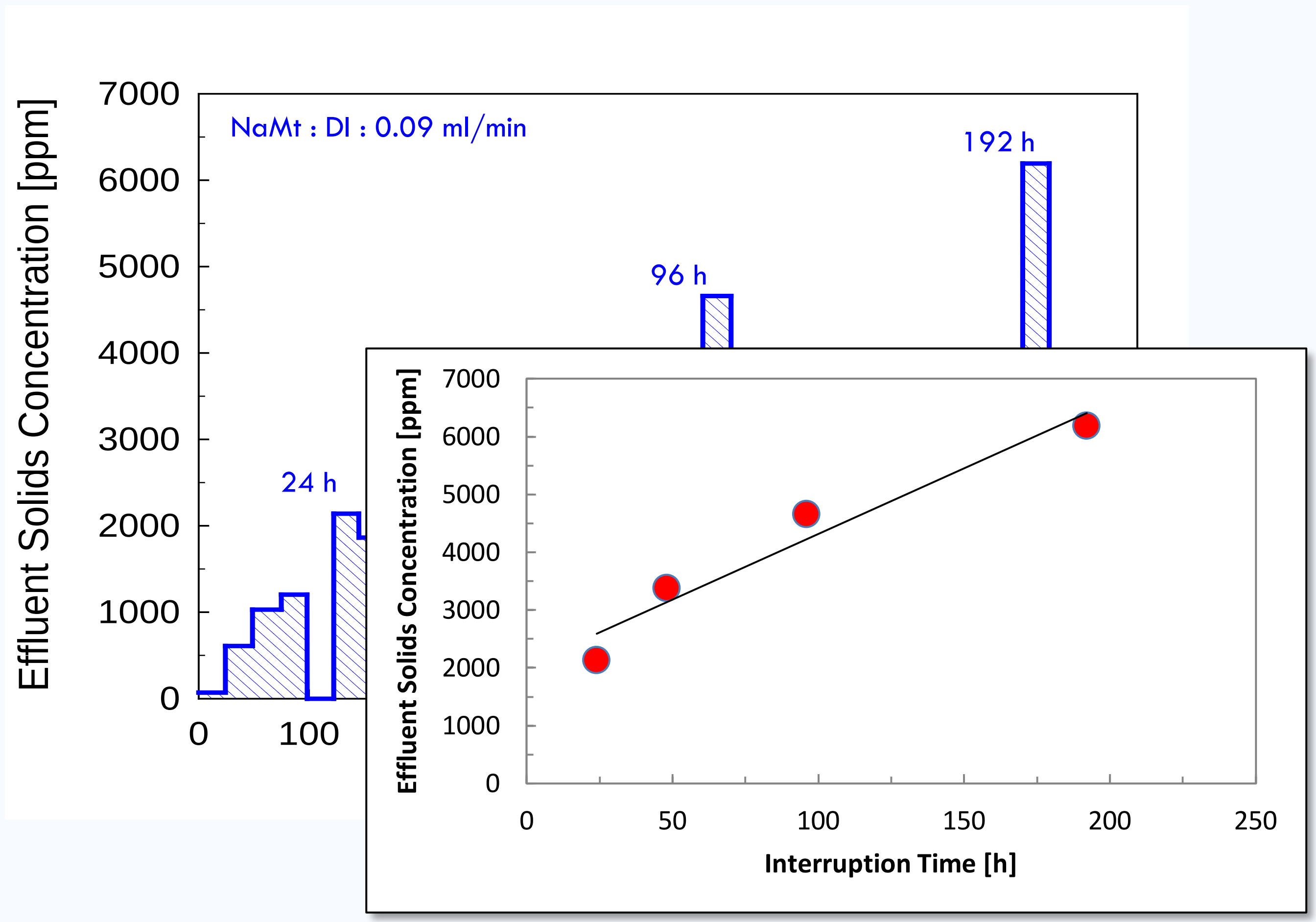


Response to Flow Velocity



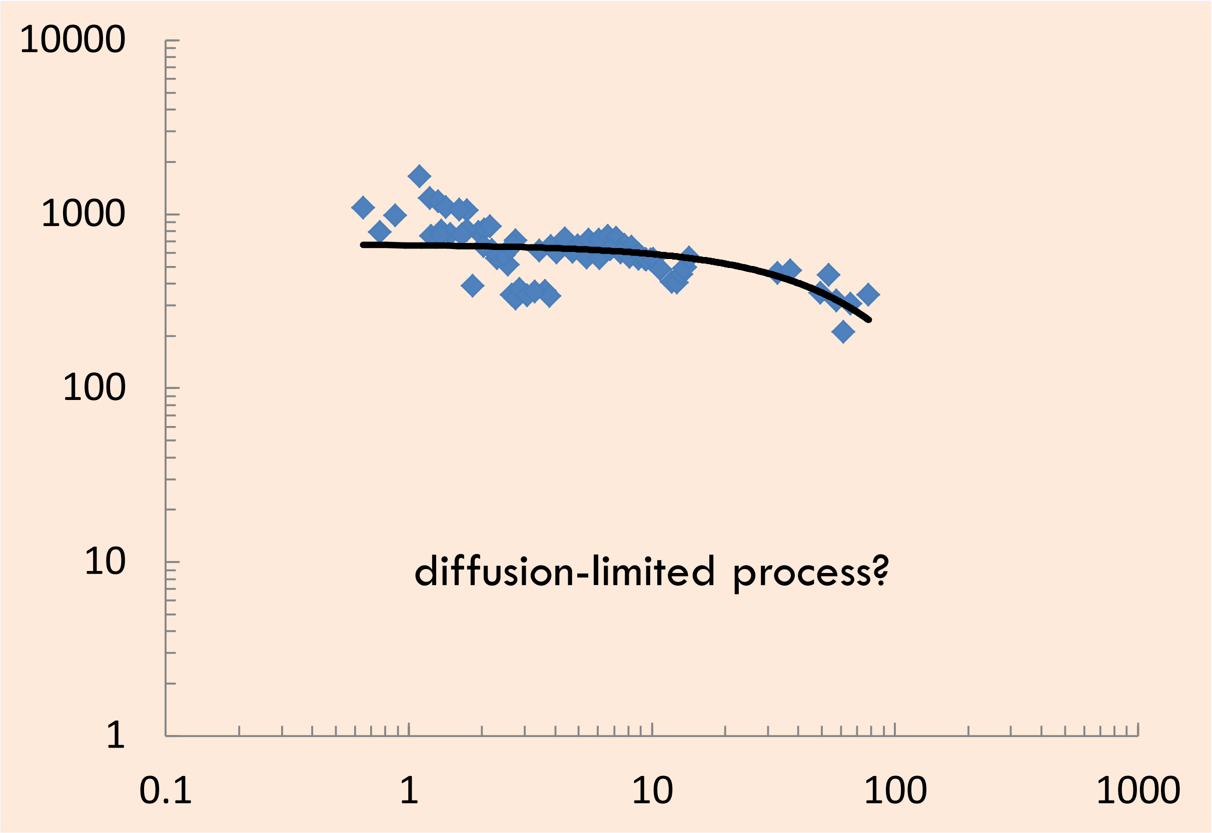
- ❑ Decrease in peak effluent concentrations with increasing flow velocity.
  - ➔ no mechanistic effect of flow velocity on erosion
  - ➔ rate-limited release

Response to Flow Interruption

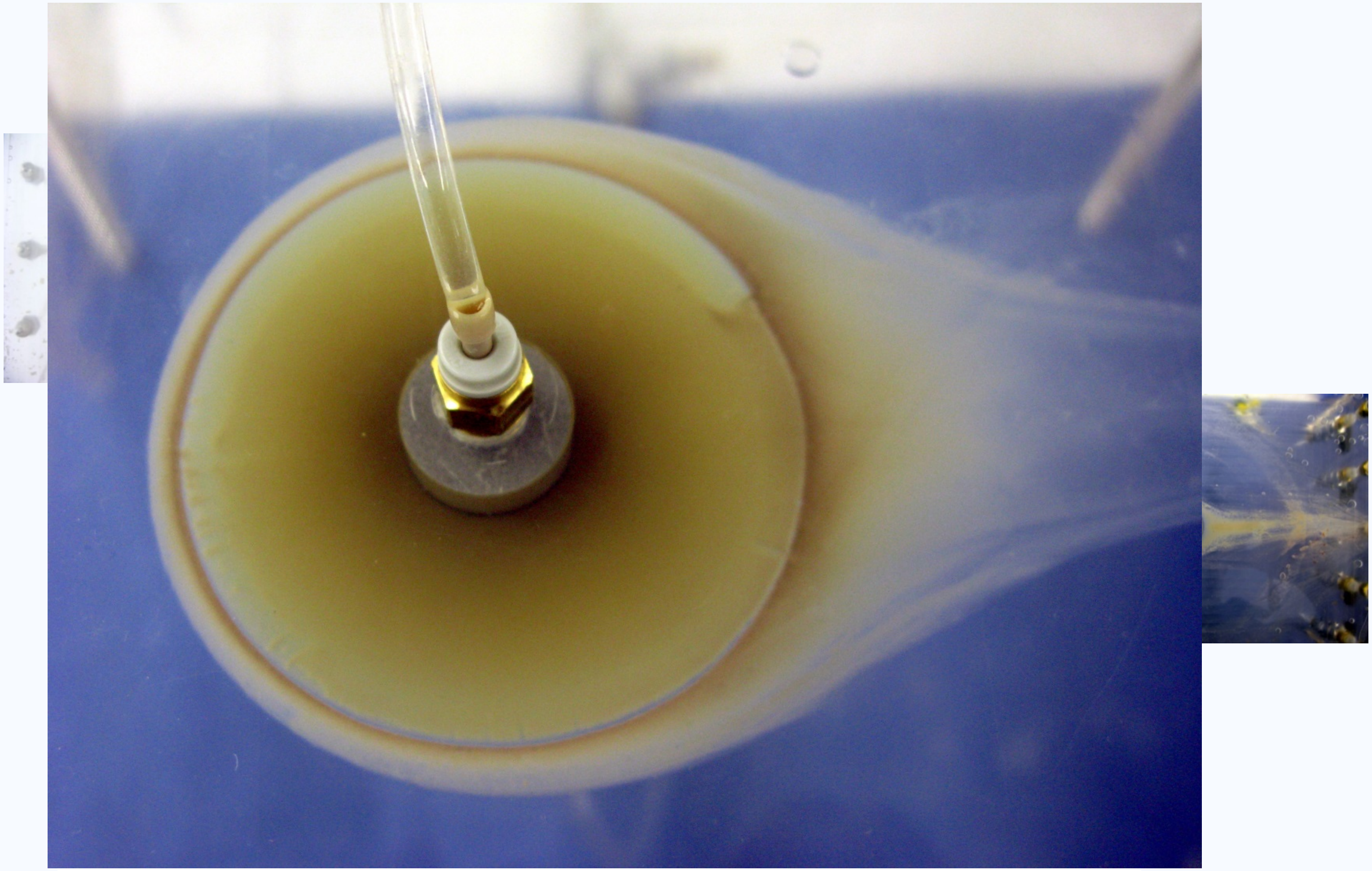


- ❑ Increased effluent solids concentrations upon resumption of flow.
  - ➔ rate-limited release

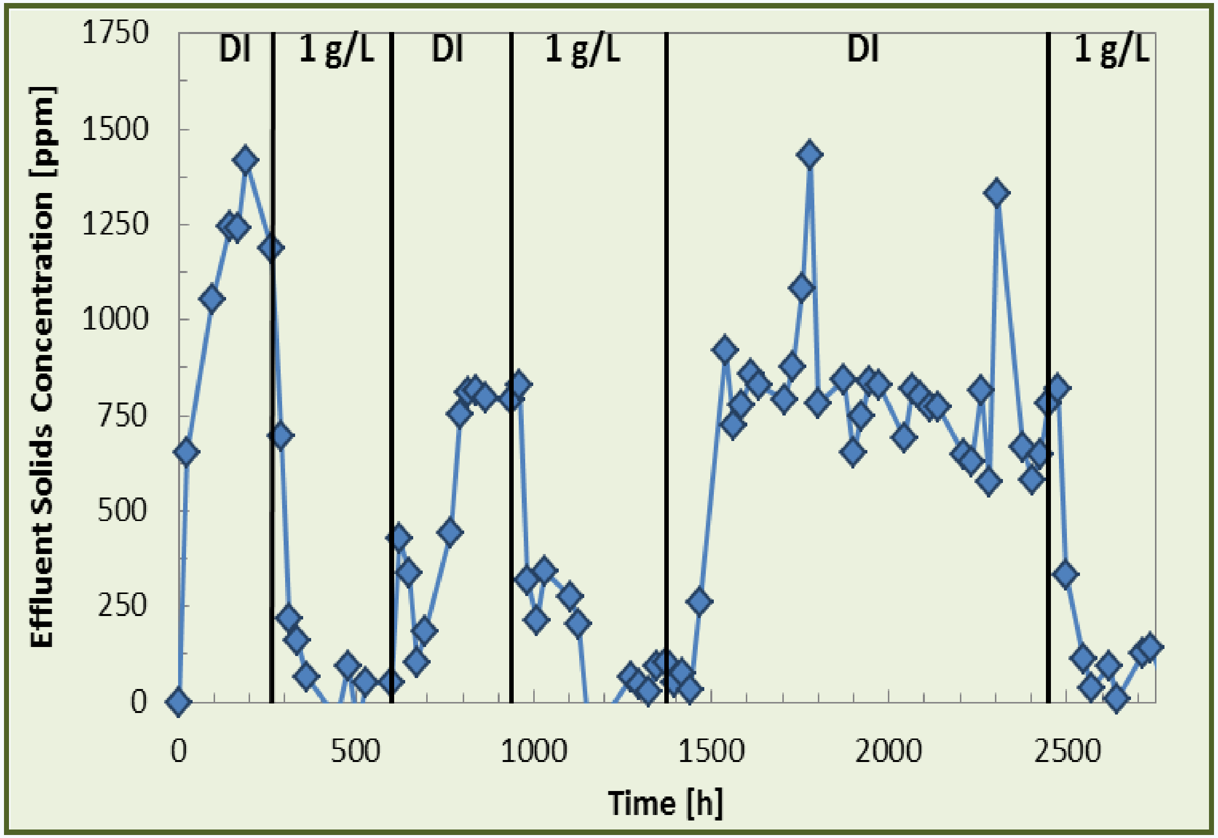
Effluent Data Revisited



Response to Gradient Elution

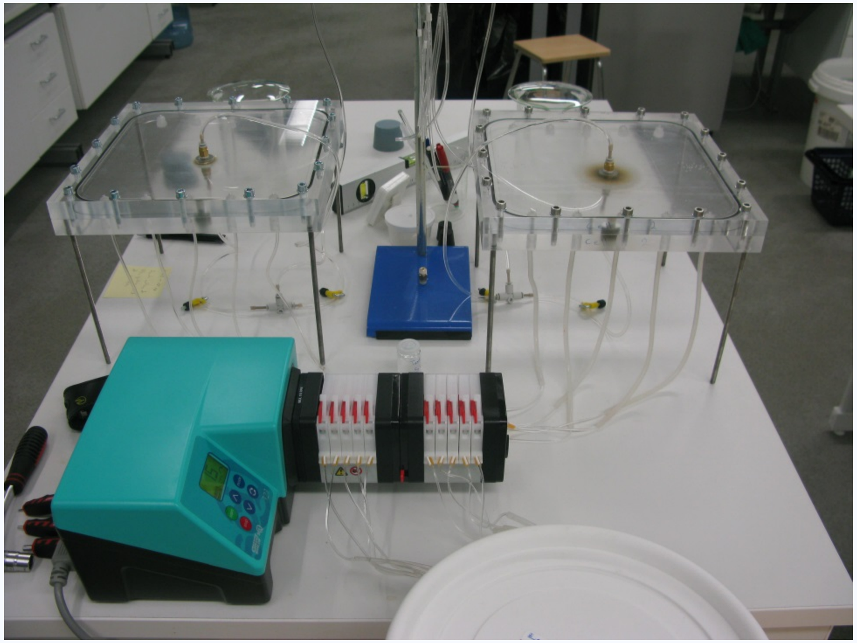


Erosion Switching

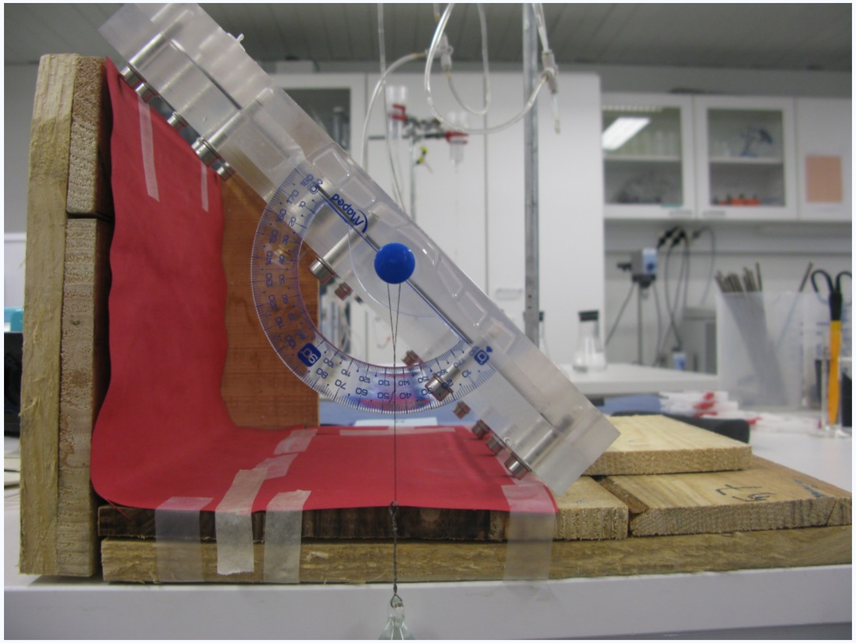


Fracture Position

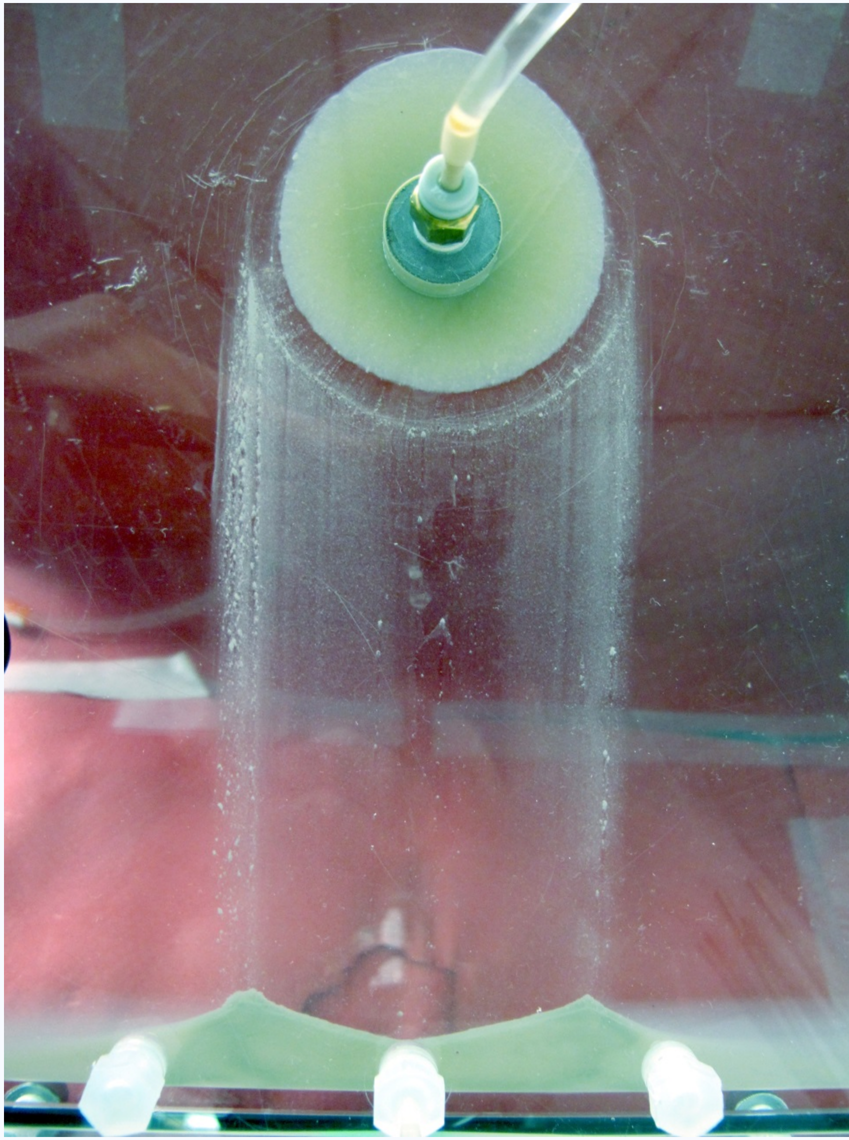
horizontal

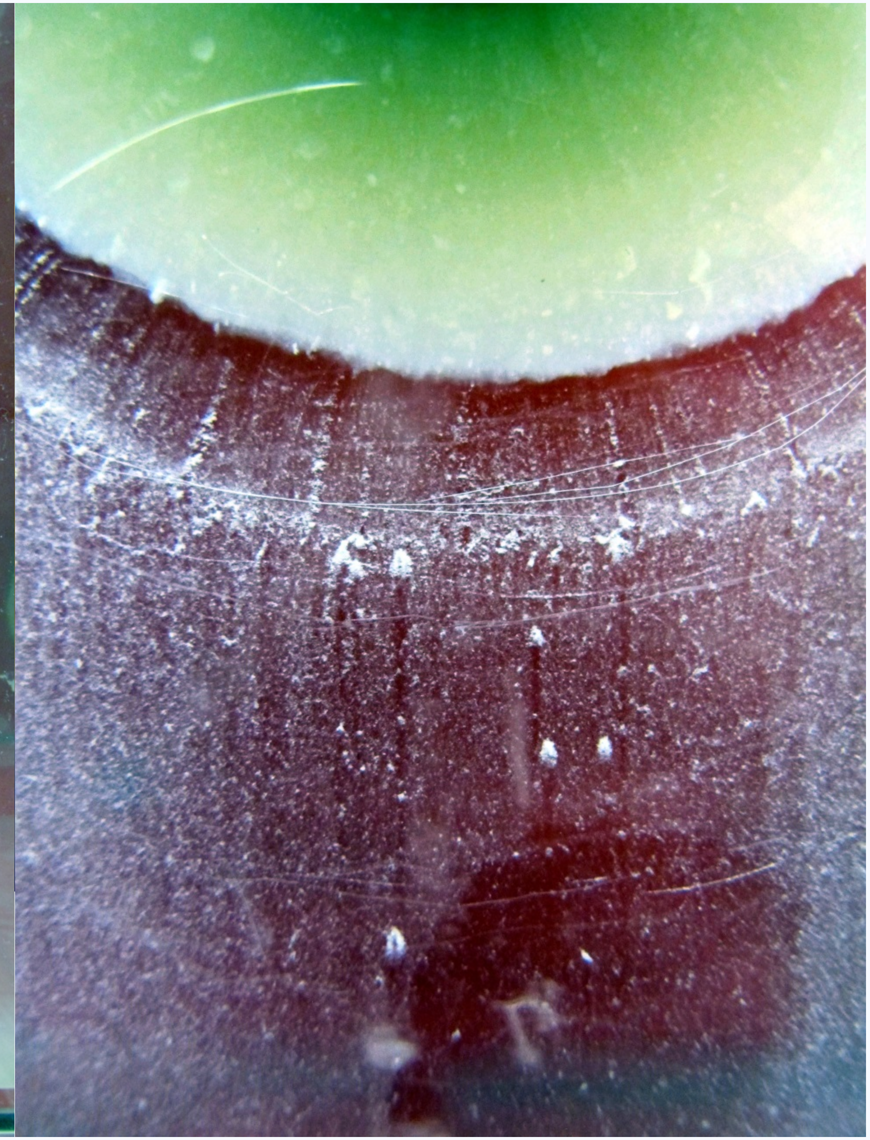


45°



Horizontal vs Sloped Fractures





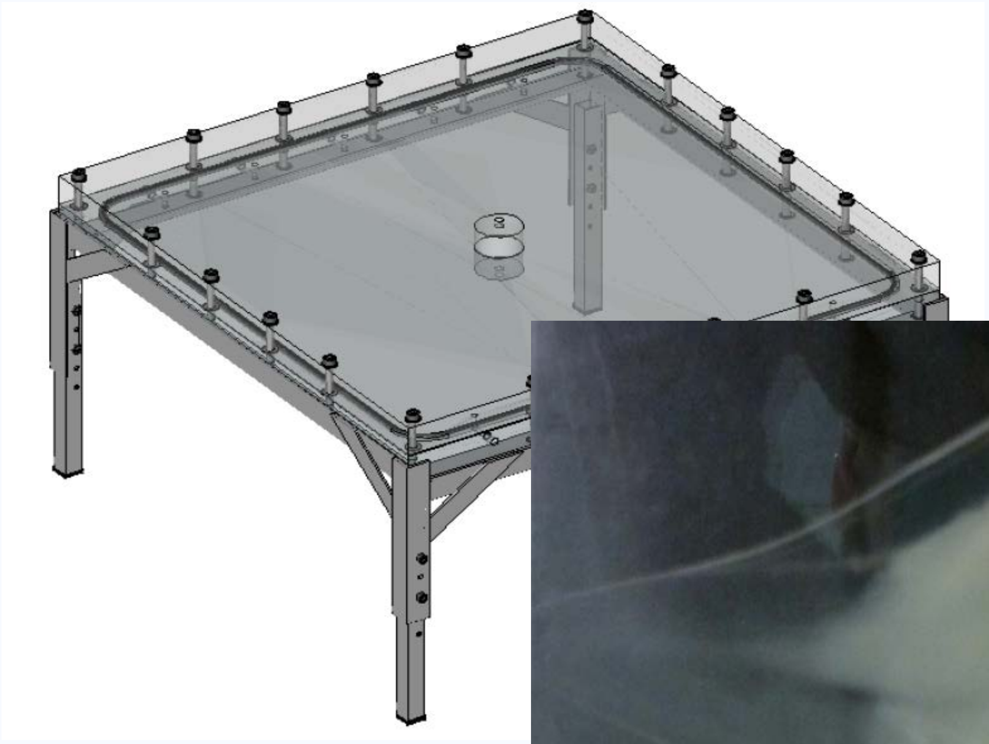
Response to Fracture Position

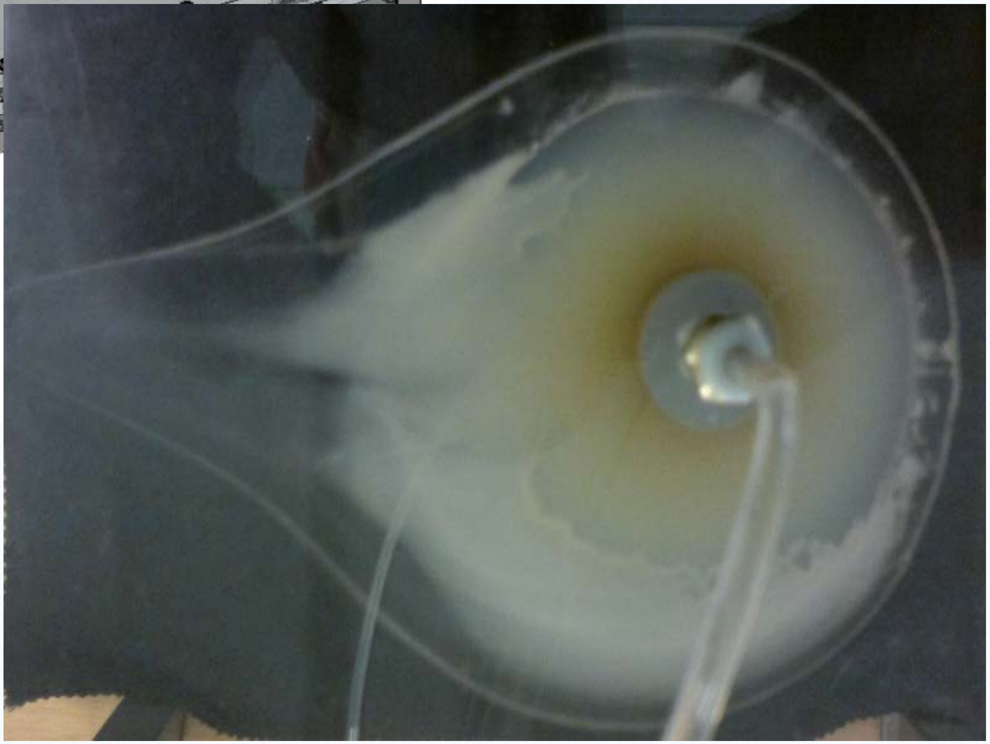
For NaMt or 50/50 Ca/NaMt against DI or GW at the same flow rate:

- average mass loss rates are nearly identical (2%)

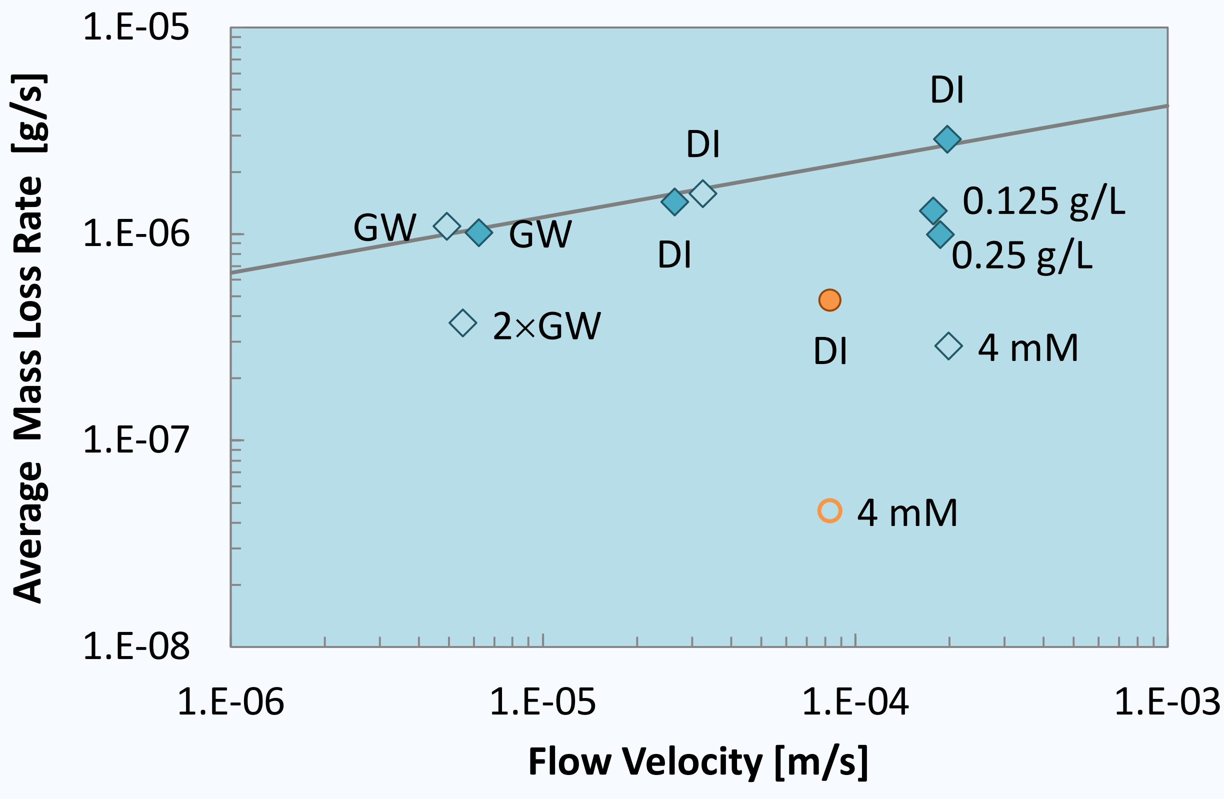
- average mass loss rates are faster in the sloped case compared to the horizontal case by almost exactly a factor of 2

0.1 mm Aperture Experiments





Effect of Fracture Aperture



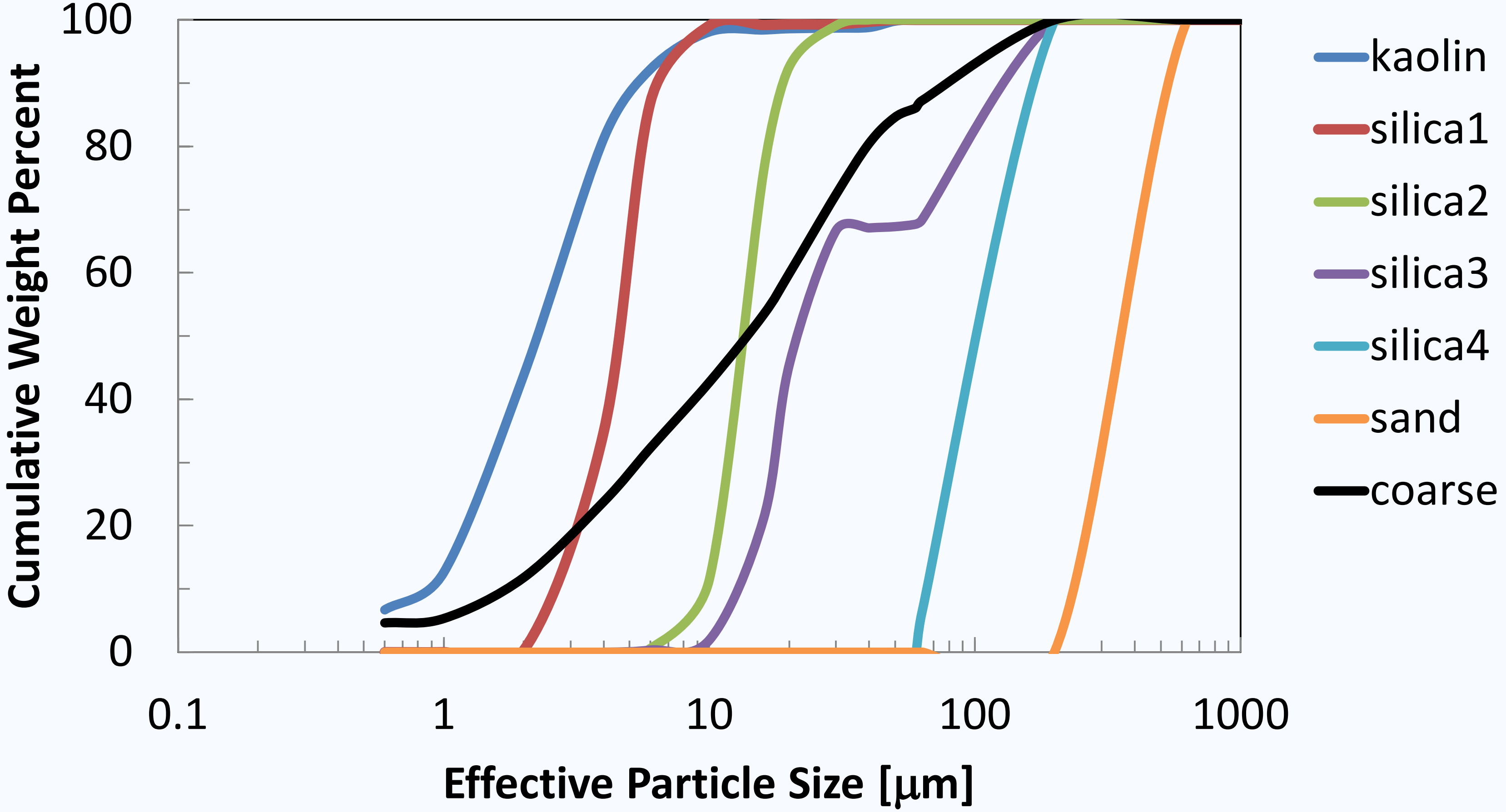
Fate/Role of Accesory Minerals

- Following erosive loss of colloidal montmorillonite through contact with dilute groundwater at a transmissive fracture interface, do accessory phases within bentonite, such as quartz, feldspar, etc., remain behind and form a filter bed or cake?

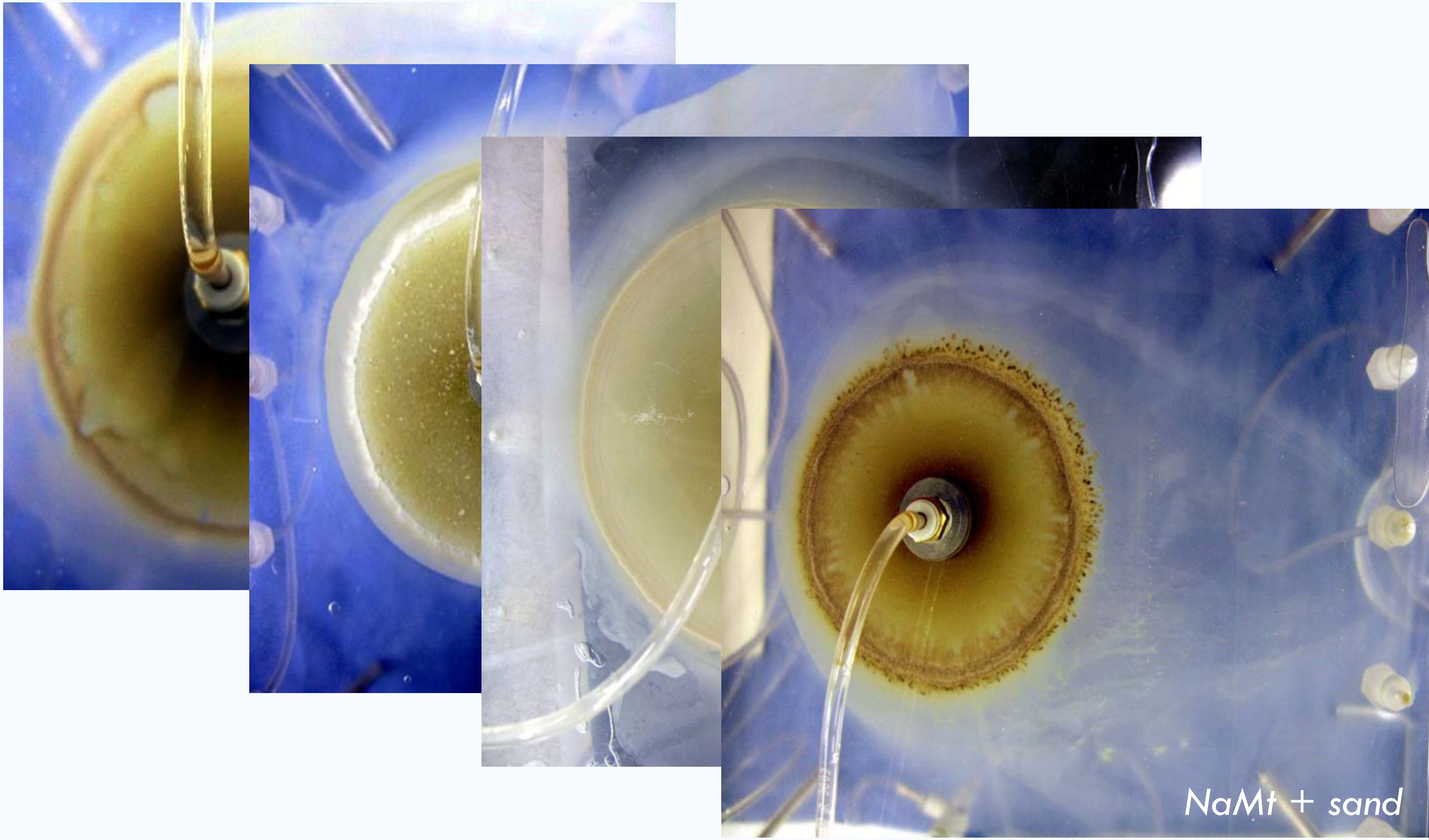
- Bentonite buffer material was simulated by using mixtures (75/25 weight percent ratio) of purified sodium montmorillonite and various additives serving as accessory mineral proxies (kaolin, quartz sand, chromatographic silica).

- Erosion tests were performed in a flow-through, horizontal, 1 mm aperture, artificial fracture ssytem using a Grimsel groundwater simulant (relative to Na^+ and Ca^{2+} concentration only) contact solution at an average flow rate of 0.09 ml/min through the system.

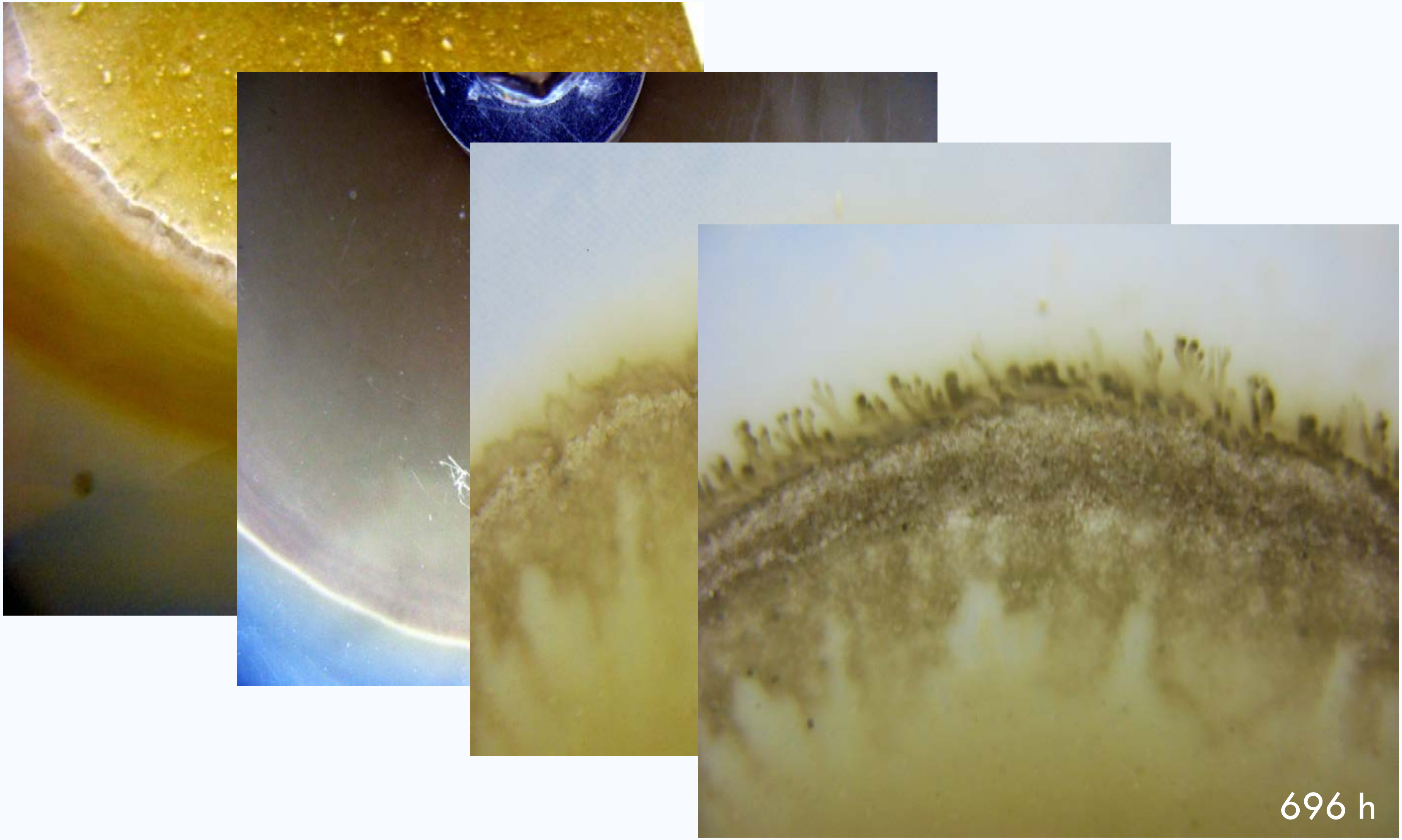
Added Materials



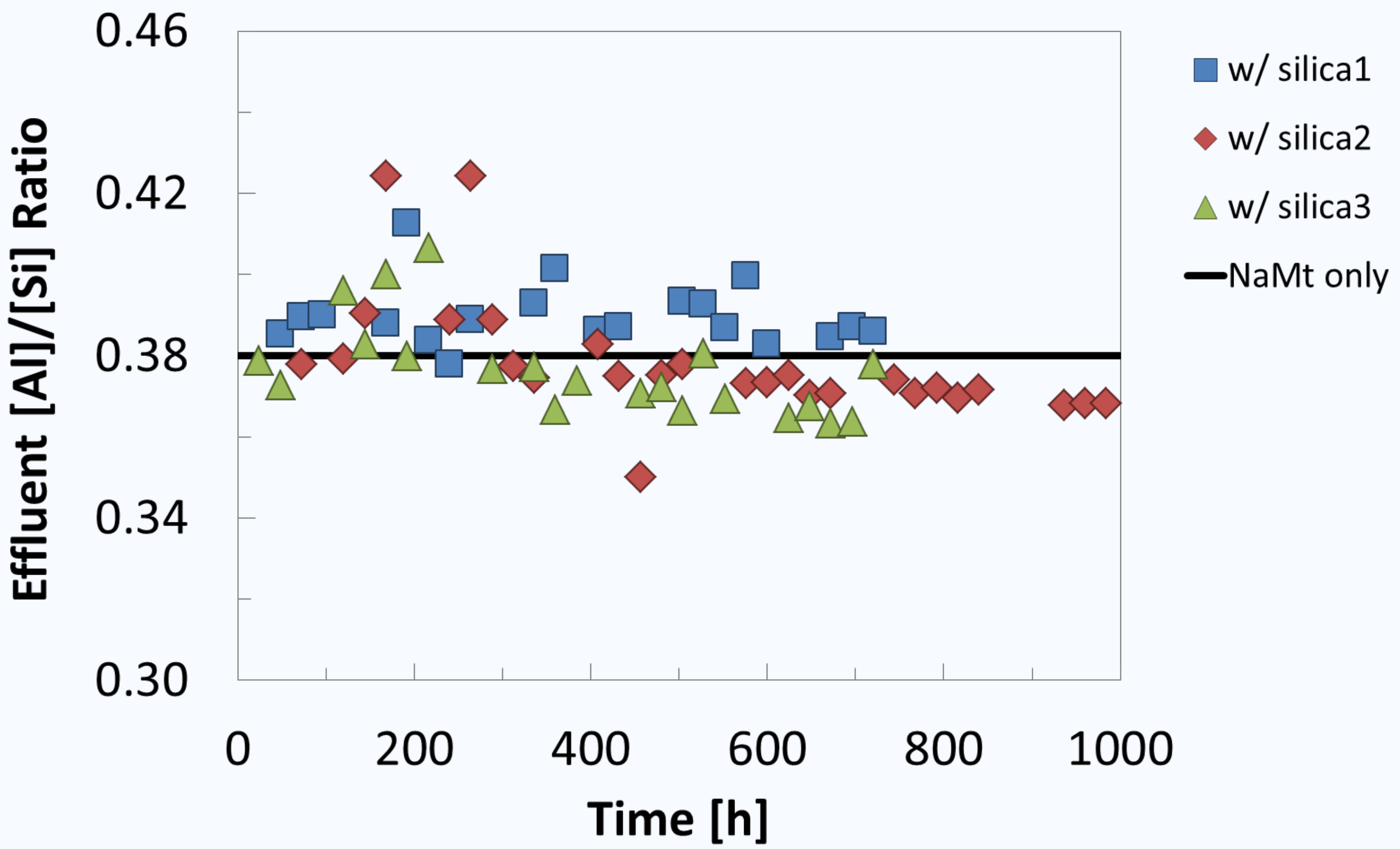
Erosive Test Conditions



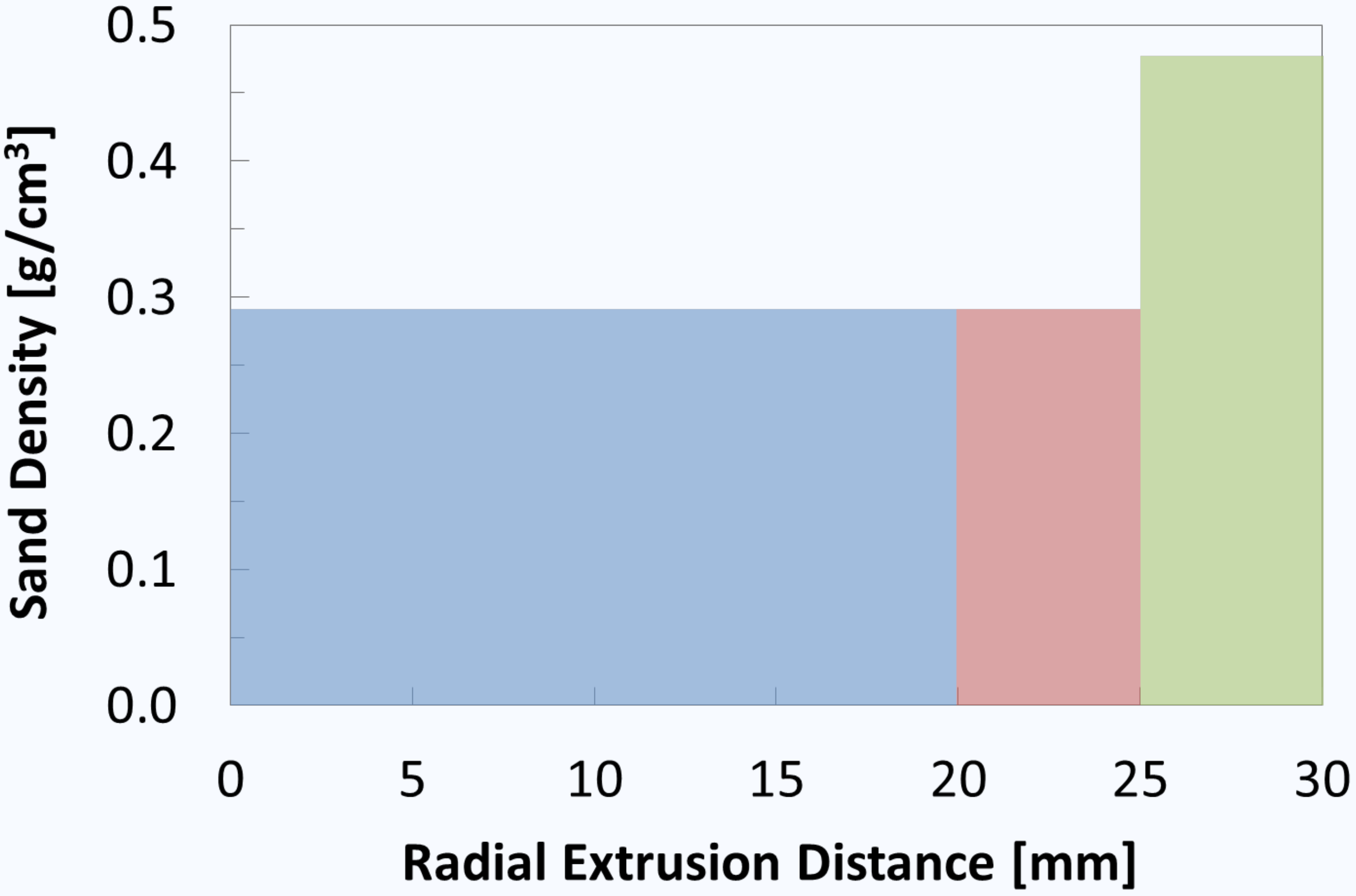
Layer Formation



Layer Stability



Distribution



- 92% of initial sand mass recovered in fracture

Ongoing

Summary

- These results provide evidence that, following erosive mass loss of montmorillonite through contact with dilute groundwater at a transmissive fracture interface, accesory phases (from within bentonite) remain behind and form layers at the solid/solution interface.

- No apparent attentuation of the erosion of montmorillonite was observed in the tests with added accessory materials relative to montmorillonite alone in a 1 mm aperture fracture.

- Similar tests will be performed in a 0.1 mm aperture fracture for comparison.