MODELLING BENTONITE EROSION

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Figure 3-3. Cartoon of how a sand region could develop in the fracture around a deposition hole and that it may be breached and sediment away in the lower parts of the fracture.
Dynamic model: Summary of processes

Expansion of bentonite paste.
Viscosity “infinite

Starting rotation.
Viscosity of sol drops, Sol flows

Colloidal particles diffuse into seeping water.
Concentration
Picture of rim zone

Viscosity of sol drops from 10* water to water in rim zone

Most flux in thin zone
Sol flows.
Flux picture of rim zone

Interface to rigid gel
Comparison w. experiments
Schatz et al. (2012) experiments

Just expansion no flow, DI water-
Fairly good prediction
Predicted erosion with 2-region model

Eroded complex model

![Graph showing predicted erosion with 2-region model with experimental (Eroded expt) and simulated data points. The x-axis represents ion concentration, and the y-axis represents eroded grams.]
Obviously this is not a good prediction

Model is wrong or model does not account for some mechanism(s)
Agglomeration to flocs, Low ionic strength water

Dynamic model

Expansion of rigid gel.
Viscosity “infinite

Starting rotation.
Viscosity of sol drops

Colloidal particles diffuse into seeping water.
Concentration Picture of rim zone

Sol flows.
Flux picture Of rim zone

Dynamic model with floc formation

Flocs form. Can sediment.
Floc slurry viscosity near water.
Simulated erosion with Simple 2-region model $\phi_R=0.015$
Loss of smectite by sedimentation
Schatz et al. (2012) erosion experiments

50/50 calcium/sodium montmorillonite in Di

Formation of flocs

Gravity pulling off flocs when slit is vertical

Maximum loss is set by maximum sedimentation flux

- Free sedimentation of small flocs
  - Modeled by Stokes law
- Larger flocs have friction against fracture walls
  - Modeled by flow in slot (fracture) driven by gravity
Loss of smectite by floc sedimentation
Stabilisation of width of expansion

Rate of loss from deposition hole $N_{PSS}$ (curved line) and rate of loss by sedimentation $N_{smeC}$ (straight line) as function of the radius to the rim
Aperture 1 mm, no restriction on release rate at rim.
In the range of measured values!

Rate of loss from deposition hole \( N_{PSS} \) (curved line) and rate of loss by sedimentation \( N_{smea} \) (straight line) as function of the radius to the rim.
Aperture 0.2 mm. Considerable expansion of clay in fracture

Rate of loss from deposition hole $N_{PSS}$ (curved line) and rate of loss by sedimentation $N_{smec}$ (straight line) as function of the radius to the rim
Aperture 0.1 mm. Considerable expansion of clay in fracture

Rate of loss from deposition hole $N_{PSS}$ (curved line) and rate of loss by sedimentation $N_{sme}c$ (straight line) as function of the radius to the rim
Concepts 2007

Still OK and Flocculation now added

But Detritus fate of not accounted for
Some queries I

Where does the bentonite end up?

Example 100 kg bentonite loss

Agglomerate volume fraction of bentonite = 0.01
Rock porosity of fractures $10^{-4}$

Fills 38 000 m$^3$ rock
A cube with 34 m sides

Could this be used as an argument against large loss?
Some queries II

• What does the detritus do to the loss of smectite?

• Where does the detritus end up?
Suggestions

• More experiments in narrow slots
• Develop a model for detritus migration in variable aperture fractures
  – Movement of small particles pushed by expanding
  – Movement of particles pulled by gravity in Buildup of filters for smectite
  – Smectite filtering

Some references on erosion modelling and background reports

SKB reports can be freely downloaded from www.SKB.se
Posiva reports can be freely downloaded from www.Posiva.fi
The reports marked yellow summarise modelling approaches

Liu L, 2011, A model for the viscosity of dilute smectite gels, Physics and chemistry of the earth, 36, p 1792-1798

Reports submitted to BELBaR 2015

1) Bentonite expansion and erosion- Development of a two-region model by Ivars Neretnieks, Luis Moreno and Longcheng Liu
2) Evaluation of some erosion experiments by the two-region model by Ivars Neretnieks, Luis Moreno and Longcheng Liu
3) Release and sedimentation of smectite agglomerates from bentonite gel/sol by Ivars Neretnieks
Thank you for your attention