Understanding the homogenisation behaviour of bentonite: Laboratory and field observation
3-4/11/15

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Laboratory experiments – homogenisation of porewater and stress
Porewater flow tracking

Sample sections

Longitudinal profile: Section X

End view: Section X
Laboratory experiments – homogenisation of permeability and thermal influences

Heterogeneity in distribution of micro-fracturing in post-test bentonite bares no relationship to original bentonite clast “domain” fabric
Laboratory experiments – homogenisation under different hydraulics gradients and coupling in dual density systems

\[ \sigma = p_w + \pi_0 e^{-\beta p_w} \]

A repository should fall on this line

'Locked in' stress

Flow influenced by low density zone

\[ \sigma = p_w + \pi_0 e^{-\beta p_w} \]
Field-scale observations (Lasgit)

- Complex porepressure history
- Stress development not linked to internal porewater pressure (poor proxy for hydraulic equilibrium)
- After 10 years stress and pore pressure yet to reach equilibrium
Chemical heterogeneity: **steel corrosion**

- Alteration of bentonite induced by the corrosion of steel produces chemical heterogeneity in exchangeable cation distribution.
- Potential for heterogeneity in distribution of physical properties related to cation exchange capacity and exchangeable cation chemistry: e.g. swelling, shrinkage, microfracturing.

*Milodowski et al., 2009. SKB Report TR-09-03*

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Chemical heterogeneity: **high pH cement pore fluids**

- Hyperalkaline groundwater discharges through fractured Pillow Lavas into bentonite.
- Bentonite shows only minimal mineralogical alteration.
- However, significant heterogeneity in exchangeable cations is observed over metre-scales, induced by exchange of Na⁺ by Ca²⁺ cations.

*Alexander & Milodowski et al., 2015. Posiva Report WR2014-02*
Summary and way forward

- Multiscale laboratory experiments provide an essential route to explore key fundamental processes governing bentonite behaviour:
  - Evolution in density from emplacement to saturation
  - Temporal and spatial development of stress, porewater pressure and swelling response (importance of local vs average values)
  - Distribution, availability and pressure gradients of interstitial fluid (wetting history) during hydration and its impact on bentonite behaviour
  - Impact of thermal load on mechanical and transport behaviour
  - Impact of chemical alteration (e.g. cation distribution when exposed to Fe) on physical properties
  - Development of heterogeneities and their impact on swelling pressure (e.g. loading of retaining plugs)

- Undertake multiscale experiments, in support of numerical modelling, to assess the influence of hydration processes on homogenisation efficiency and its impact on safety function