Sand/Bentonite Homogeneity and the performance of EGTS

N. Giroud, P. Marschall & T. Spillmann

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nagra.

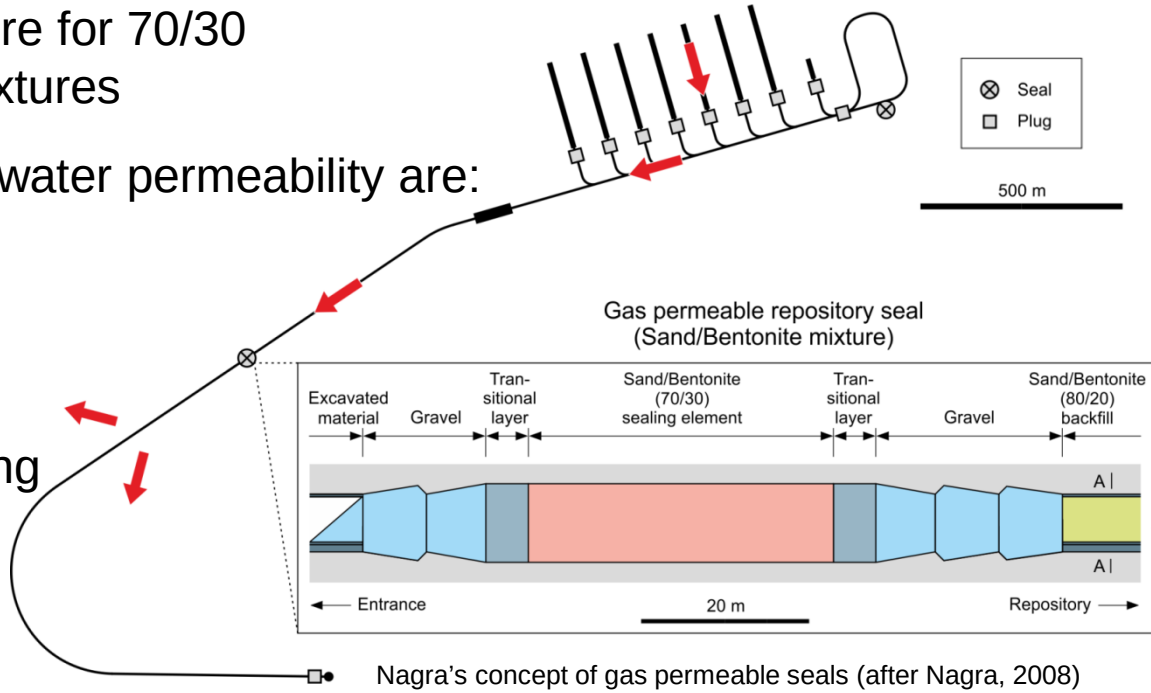
S/B in Engineered Gas Transport Systems

Objective

- Increase gas transport capacity of L/ILW repository seals to limit gas pressure build up
  - ➔ High gas permeability - Low hydraulic conductivity

Concept

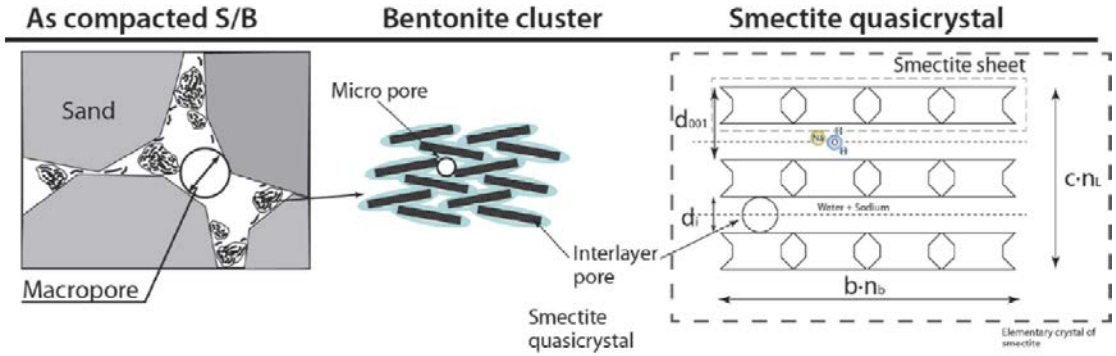
- Laboratory tests show air entry pressures in the range of 10-40 kPa above pore pressure for 70/30 or 80/20 %wt sand/bentonite mixtures
- Parameters controlling gas and water permeability are:
  - Sand/bentonite ratio
  - Emplacement density
- Large scale tests aim at validating the upscaling of properties from lab scale to full scale



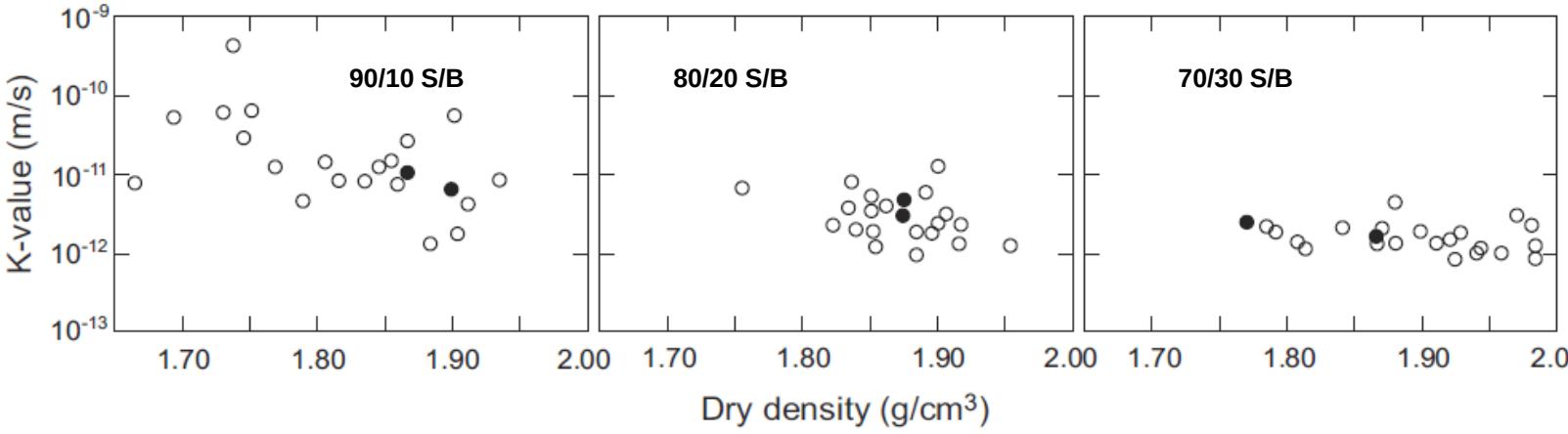
Nagra's concept of gas permeable seals (after Nagra, 2008)

S/B Properties

- With low bentonite content, the hydraulic properties of the mixture are very sensitive to the emplacement density
- In small-scale laboratory experiments, homogeneity is easily achieved, and confirmed by isotropic gas and water transport properties
- In large scale experiments, emplacement technique may play an important role leading to local heterogeneities and large scale anisotropy.



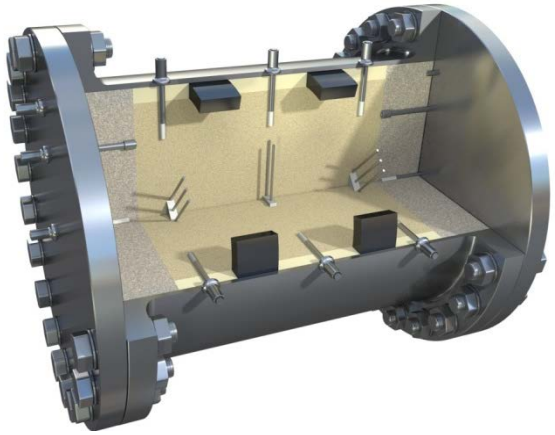
Manca (In press)



Hydraulic conductivity dependance on dry density and bentonite content (Nagra, 2008)

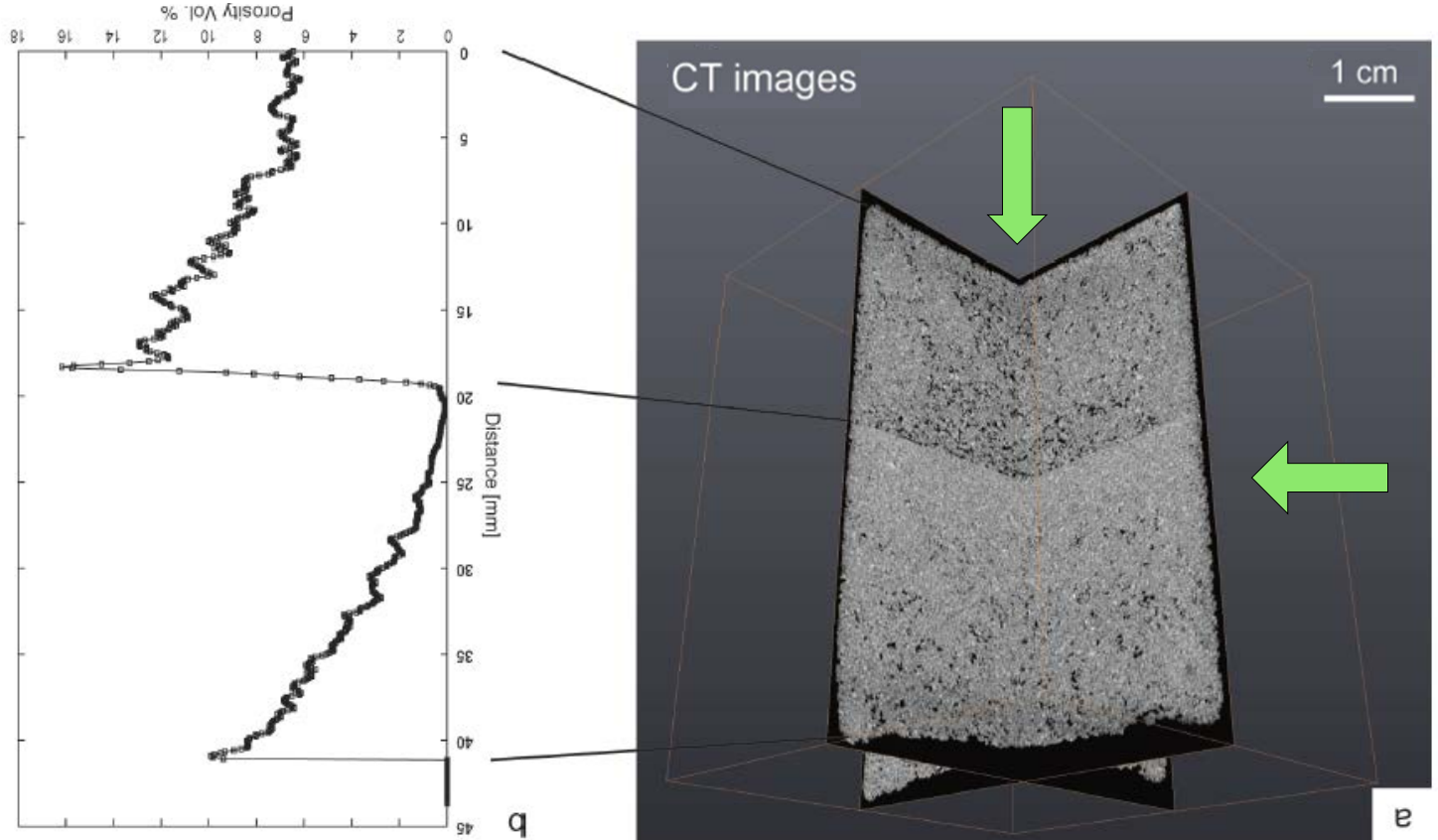
Porosity distribution in sand/bentonite layers

FORGE Mock-up experiment in Grimsel Test Site was dismantled early 2015



➔ X-ray CT shows a clear gradient of macroporosity (81µm voxel size)

➔ Water permeability and gas entry pressure measurements are ongoing in 2 orthogonal directions



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Summary

- Emplacement technique has a clear effect on the isotropy of the S/B
- Effect of anisotropy on gas and water transport properties still to be quantified
- In case of anisotropic properties, the direction of filling is crucial for the performance of the EGTS
  - Flow // layering ➔ highest porosity determines permeability
  - Flow ⊥ layering ➔ lowest porosity determines permeability

Processes potentially affecting homogeneity of S/B:

- Density variations due to compaction technique
- Phase segregation during emplacement
- Bentonite particle migration by gas transport may create local heterogeneities

Outlook

- Additional experimental work is needed to quantify the effect of S/B emplacement technique
- Pre-tests will address dependence of transport properties on emplacement technique
  - Several-dm scale emplacement tests will be subsampled and measured at EPFL for water/gas permeability and air entry pressure
  - Tests should determine if/how anisotropy can be minimized
- Pre-test results will be used to set up a new mock-up experiment at the Grimsel Test Site
- Future experiments should address phase segregation due to
  - emplacement, and
  - gas transport.

thank you
for your attention

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