Supplement of

Discussion of parameters used to distinguish suitable from less suitable HLRW bentonites

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Discussion of parameters which can be used to distinguish suitable from less suitable HLRW bentonites

Bentonite will be used as geotechnical barrier mostly in crystalline rocks.

Bentonite:
backfill + blocks

KBS-3 concept (SKB)
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Most relevant: geotechnical barrier
(compacted bentonite blocks to seal canister from crystalline rock)

Sources: SKB + POSIVA
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Why bentonite?

Bentonite = swelling clay = low hydraulic conductivity

since decades: sealing of landfills, contaminated sites, groundwater,…
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SKB started to systematically investigate bentonite as possible HLRW-barrier more than 40 years ago!

...and the possible problems / challenges of this new application
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Desired / required properties of the bentonite barrier?

1. Sealing (swelling capacity)
2. Stability: Drying (T)
3. Stability: Cement water
4. Corrosion
5. Erosion
6. Stability: Salt solutions
7. Retention (radionuclide adsorption)
8. Canister displacement
9. Thermal conductivity
10. Stability: Radiation


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Problem: Bentonite is a highly variable natural material!!

BGR: Comparison of 38 different bentonite samples from all over the world
+ large scale tests
ABM, LOT, PTR, FEBEX, HotBent,...
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Which bentonite is most suitable??

Some properties depend more on compaction than on type of material (no suitable criteria for bentonite selection)

Higher compaction:

- Higher dry density
- Lower hydraulic conductivity (sealing)
- Less canister displacement
- Higher thermal conductivity
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Stability Drying

High temperature = cation fixation = loss of swelling capacity

not specific for different bentonites
Kaufhold & Dohrmann (2010)

Stability Cement (Kaufhold et al., 2020)

Highly alkaline cement solutions dissolve bentonite

Reactive silica (opal) present in some bentonites buffers the pH


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Corrosion (Fe)
Kaufhold et al. (2015)
Low charge = high corrosion


Corrosion (Cu) Kaufhold & Dohrmann (2017):
only pyrite interacts with copper


rate: 2 – 5 µm/a

opal + pyrite – charge +

Greece (0.33) Germany (0.3) Slovakia (0.2)
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Erosion

Kaufhold Dohrmann (2008)
High Na-content = high erosion

Kaufhold et al. (2021)
Cation exchange is fast and cannot be avoided

=> No reasonable criteria


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Stability salt solutions
Kaufhold & Dohrmann (2009, 2010), Kaufhold et al. (2019)
Complex interaction with clay minerals – poorly understood…

Reactive (partly soluble) phases should be absent

No pyrite, no calcite, no gypsum, no organic matter


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Radionuclide adsorption

Different radionuclides have different properties, bentonites cannot adsorb all

=> focus on the most hazardous?

I$^{129}$ is considered one of the most hazardous – not retained by pure bentonite

Bentonite can be modified with respect to adsorption of specific radionuclides (Kaufhold et al., 2007), but no generally applicable criteria

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Stability against radiation

Fe rich bentonites are more affected by radiation


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Selection of suitable bentonites

Positive

- presence of some opal
- low pyrite, high charge

Presence of opal?carb?
- low pyrite,
- low calcite
- low gypsum
- low organic matter
- low Fe

Currently: use domestic bentonite or buy MX80 (Wyoming bentonite)

No bentonite selection decision taken yet (even not Posiva)
thanks