Container – Bentonite Interface Evolution: Insights from InCoManD

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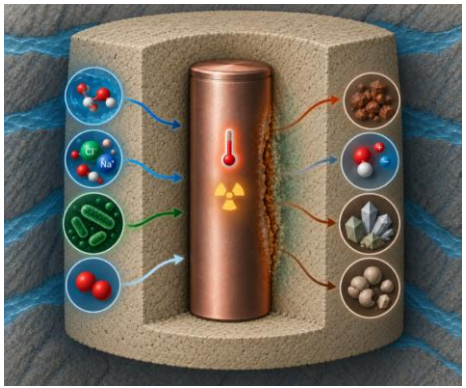
Container – Bentonite interface: InCoManD view

BENTONITE ROLE → **CONTAINER DURABILITY** → **BENTONITE IMPACT**

- Water availability
- Porewater chemistry
- O_2 – redox
- Microbial activity

- Temperature
- Radiation



- Corrosion products
- Secondary mineral phases
- Geochemical changes
- Gases formation

It is an evolving reactive zone

Container – Bentonite interface: Scientific gaps

WHAT REMAINS UNCERTAIN (SotA)

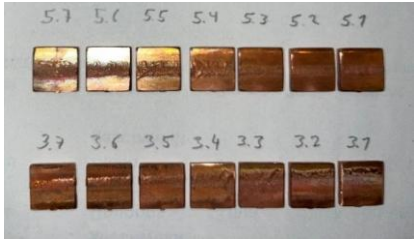
- Insufficient understanding of the hydration, thermal, redox microbial and corrosion processes across different timescales.
- Limited quantification of their coupled impact on container corrosion and bentonite evolution.

RESEARCH NEEDS

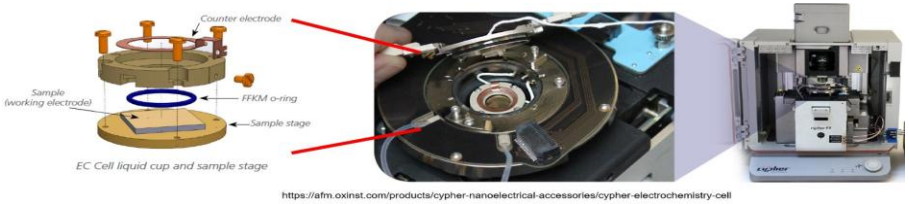
- Representative container-bentonite systems and porewaters.
- Experimental designs considering coupled – relevant- transients.
- Long-term monitoring of interface evolution.

Container – Bentonite interface: Studied systems (1/3)

- Welded **Cu coupons** in **Wyoming bentonite** environment (slurry) with granitic and clay formation waters.

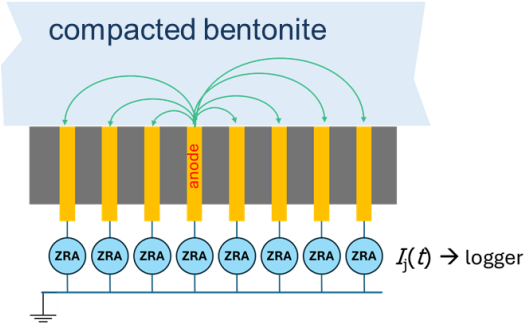


- AFM electrochemical analysis



- Localized corrosion on **Cu / steel** in contact with **compacted and partially saturated bentonite**, Coupled multi-electrode array (CMEA):

- Stepwise decreasing **[O_2]** atmosphere.



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Container – Bentonite interface: Studied systems (2/3)

- Long-term **Cu and C-steel corrosion in compacted FEBEX bentonite at high T (80 °C) , including redox front.**

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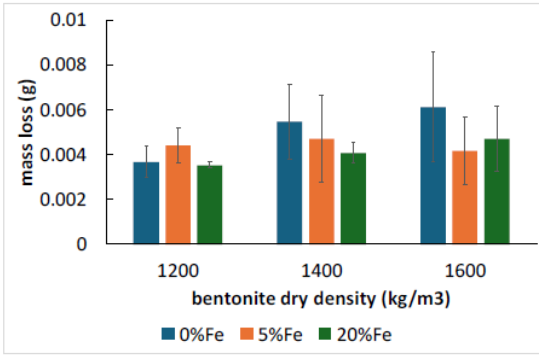
- Corrosion **of C-Steel in BCV compacted bentonite** including **Fe powders,** and ongoing **MIC analyses**



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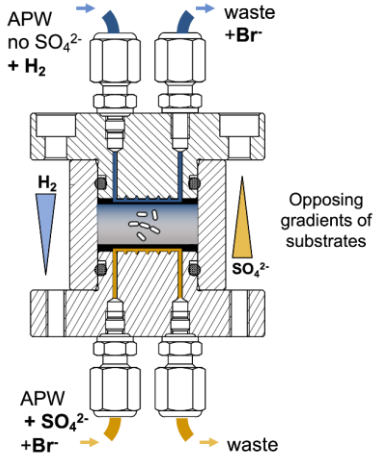
Container – Bentonite interface: Studied systems (3/3)

- *In-situ* experiments at Mont-Terri (Switzerland).
- Impact of O_2 on metal corrosion and compacted bentonites

nagra. EPFL

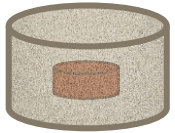
- Anoxic microbial analyses in bentonite

HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF



- Role of MIC on Cu and Ti corrosion in compacted bentonite under gamma irradiation.

7 kGy



1.6 g/cm^3

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Container – Bentonite interface: Key findings

- **Coupled transients jointly determine interface evolution: they produced O_2 depletion, H_2 accumulation and the development of a redox front, controlling corrosion and bentonite changes.**
- **Redox evolution: *In-situ* experiments showed that bacteria activity, and oxygen transients affect microbial activity and Fe(III)/Fe(II) transformations**
- **Bentonite compaction density reduced *bacteria* abundance but did not consistently reduce corrosion.**
- **Irradiation: Bacteria recovered after irradiation at 1 kGy but were irreversibly inactivated after 7 kGy.**

Container – Bentonite interface: Beyond corrosion

INTERFACE EVOLUTION: IMPACTS

Present and future projects

RADIONUCLIDE MIGRATION

Linked, but not explicitly addressed

BARRIER PROPERTIES
Swelling, integrity,…

LONG TERM PREDICTION / MODELLING
Thermodynamic data

eurad

Acknowledgments

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…… and EURAD-2 funding.

THANK YOU!