BELBaR objectives “Setting the scene”

BELBaR: *Investigation of erosion processes in bentonite engineered barriers systems of a repository in crystalline rock and their impact on the long-term performance of the repository*

Outline

- The BELBaR project
- The problems to study
- Activities
- Expected outcome

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THE BELBaR PROJECT

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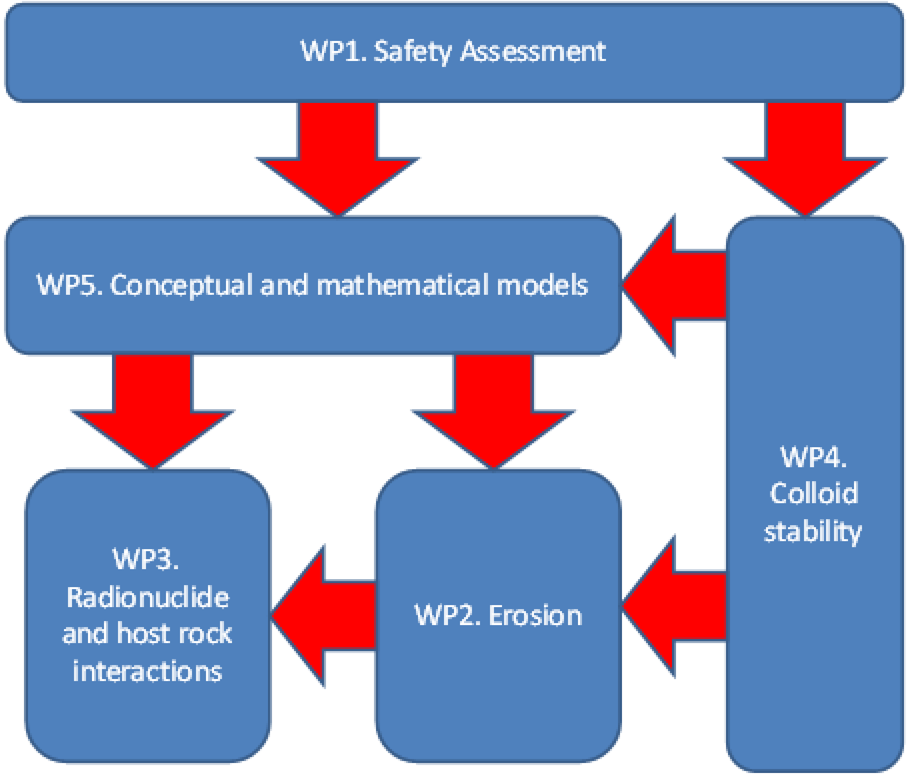
- BELBaR is a Collaborative Project within the Seventh Framework Programme of the European Atomic Energy Community (Euratom) for nuclear research and training activities.
- The main aim of BELBaR is to increase knowledge of the processes that control clay colloid stability, generation and its ability to transport radionuclides.
- The overall purpose of the project is to come up with a new way of treating issues in long-term safety/performance assessment.
- The project started March 1, 2012 and has a duration of 48 months.
- The project has 14 partners from seven European countries

Outputs – onset of project



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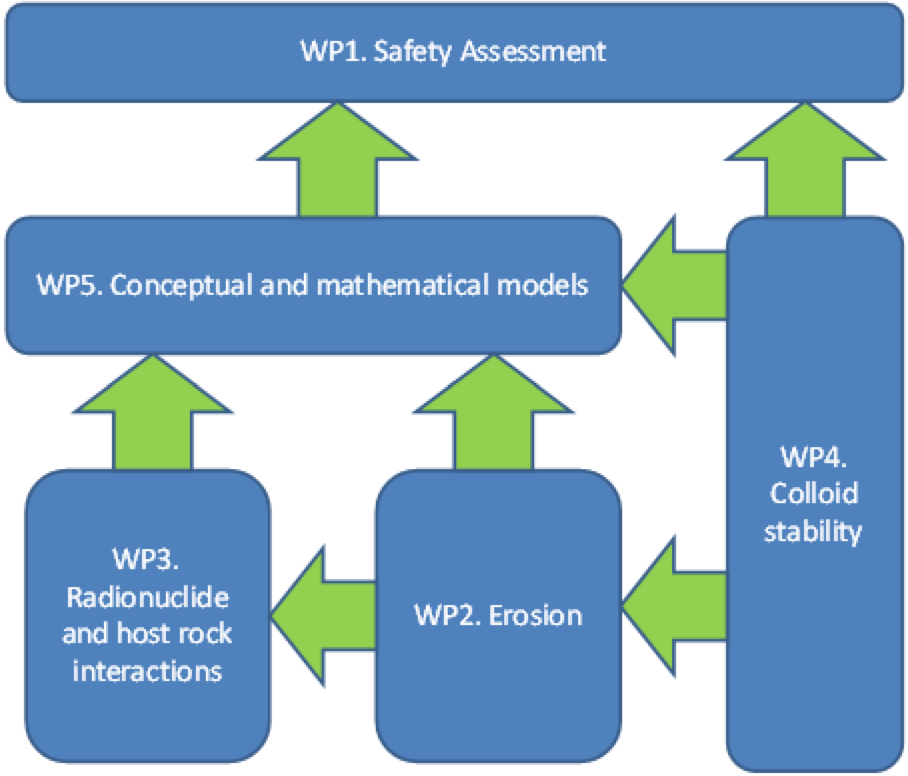
Outputs – during project



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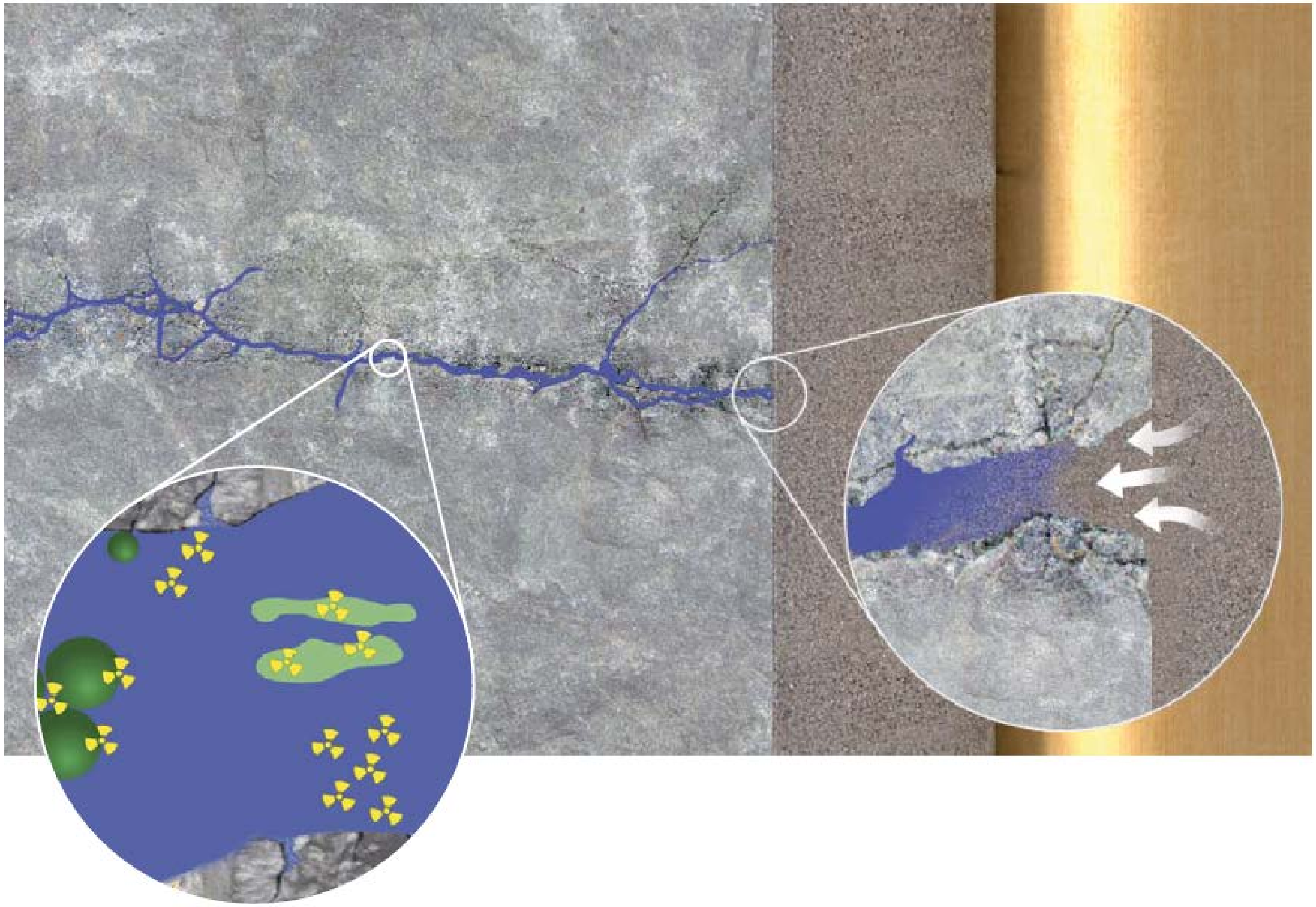
Partners

- SKB: Svensk Kärnbränslehantering, Sweden
- CIEMAT: Centro de Investigaciones, Energeticas, Medioambientales y Technologicas Spain
- NRI: Nuclear Research institute Rez plc, Czech Republic
- KIT: Karlsruhe Institut of Technology, Germany
- Posiva OY, Finland
- VTT:Technical Research Instuitute of Finland
- Clay Technology AB, Sweden
- University of Jyväskylä, Finland
- KTH: Kungliga Tekniska Högskolan, Sweden
- NDA: Nuclear Decommissioning Authority, United Kingdom
- B+Tech Oy, Finland
- University of Manchester ,United Kingdom
- Helsinki University, Finland
- Lomonosov Moscow State University, Russia

THE PROBLEMS TO STUDY



Issues (WP1)

- Bentonite Erosion
  - Under what conditions can erosion occur?
    - On/off process
  - What is the mass loss rate?
- Sorption on bentonite colloids
  - What are the colloid concentrations?
    - Strongly linked to the erosion issue
  - Is sorption reversible?
- Examples from the SR-Site Safety Assessment

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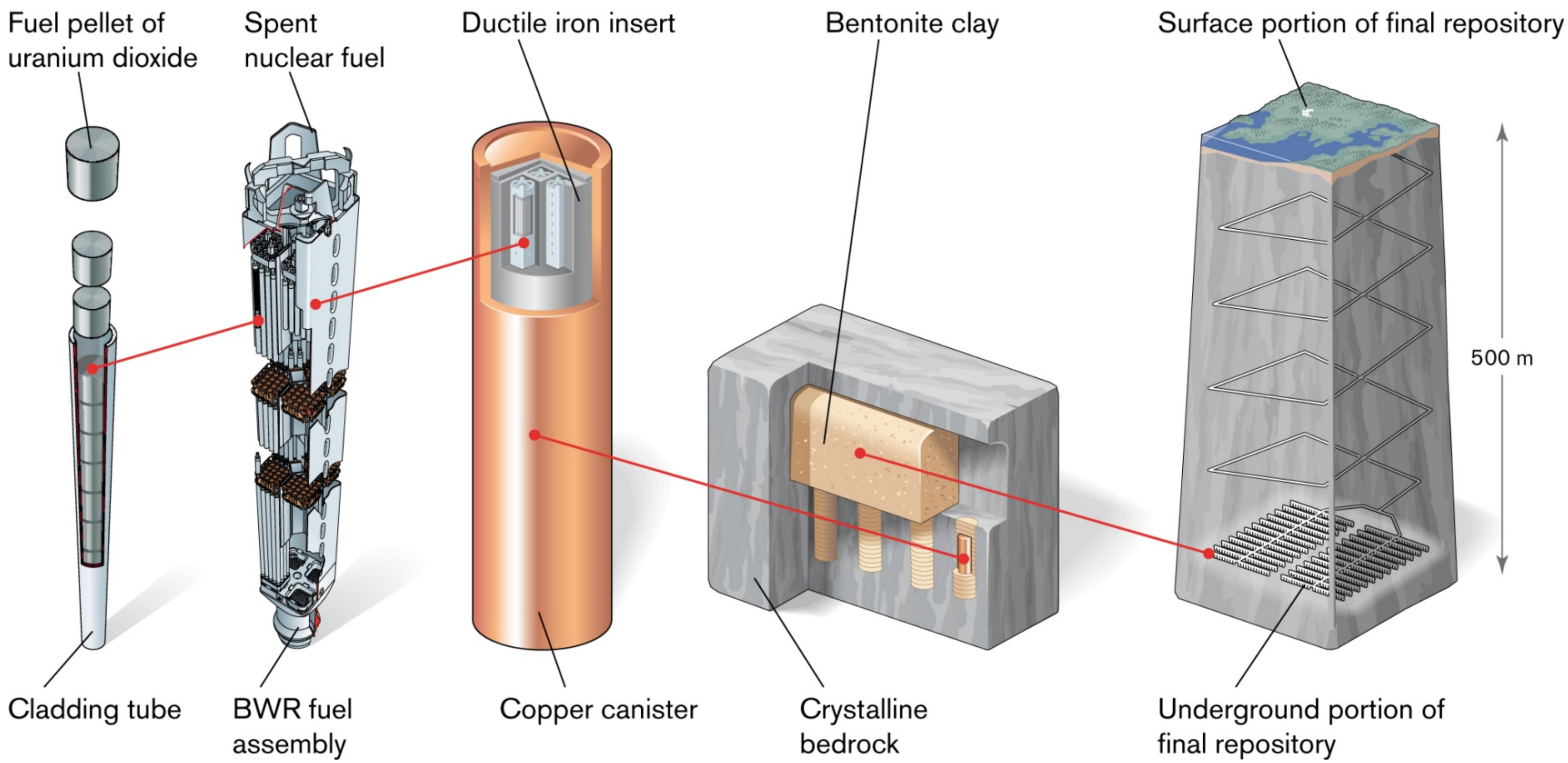
SR-Site Safety Assessment



Primary safety function: Complete containment

Secondary safety function: Retardation

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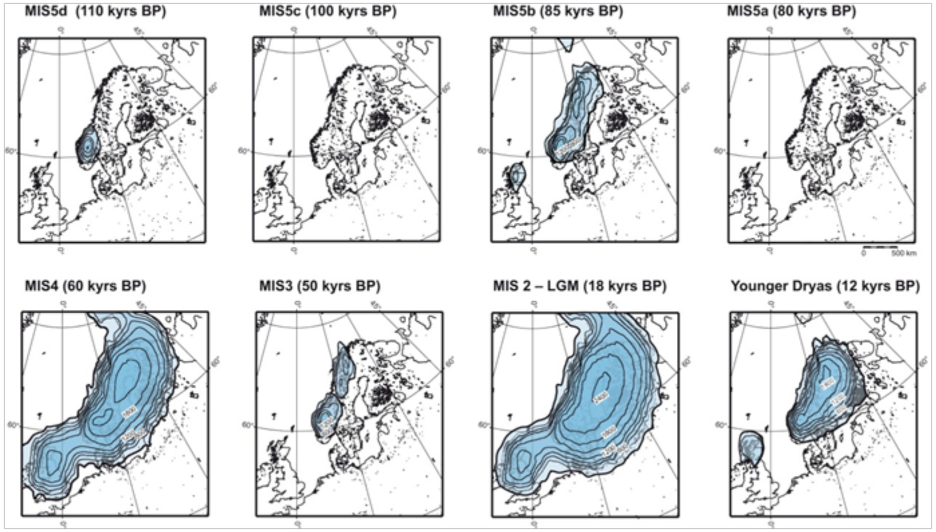
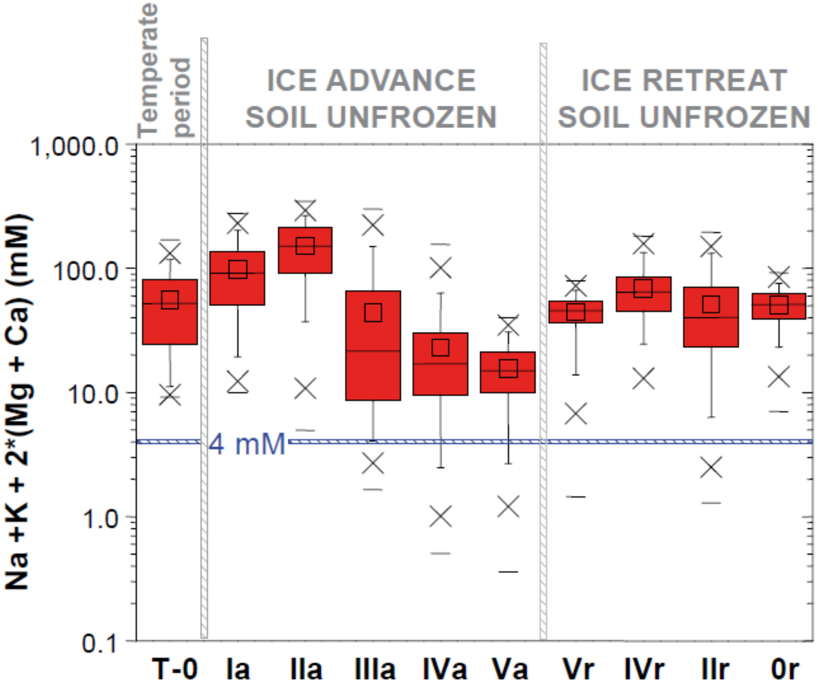
Future GW





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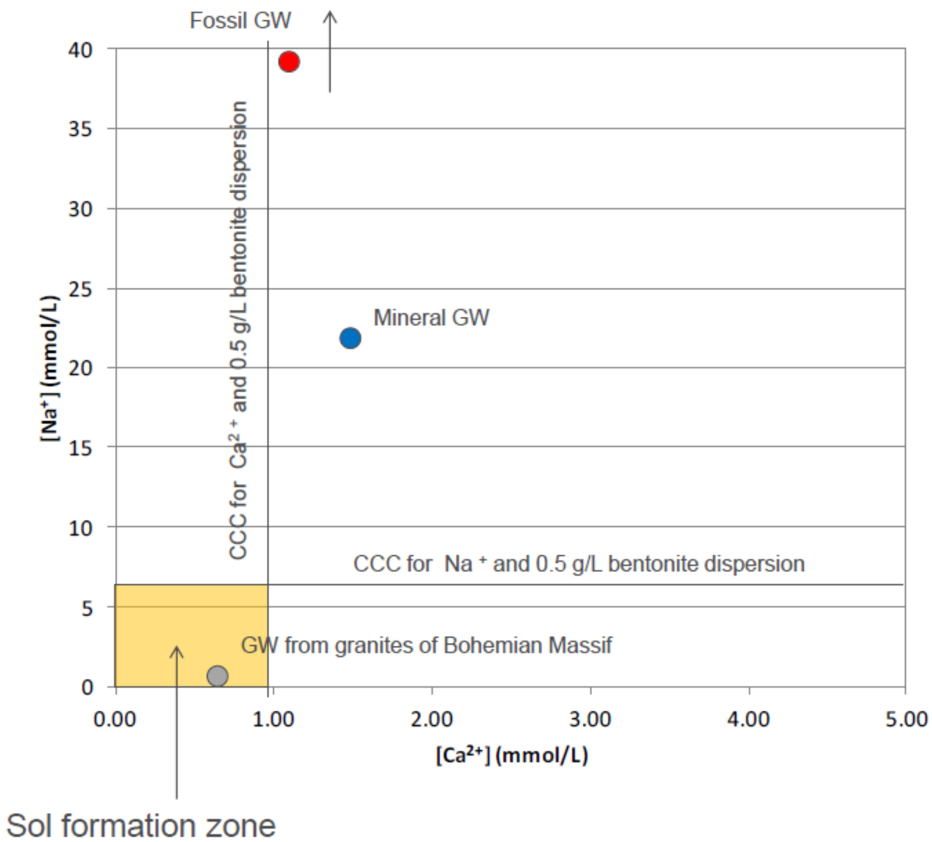
Present groundwaters



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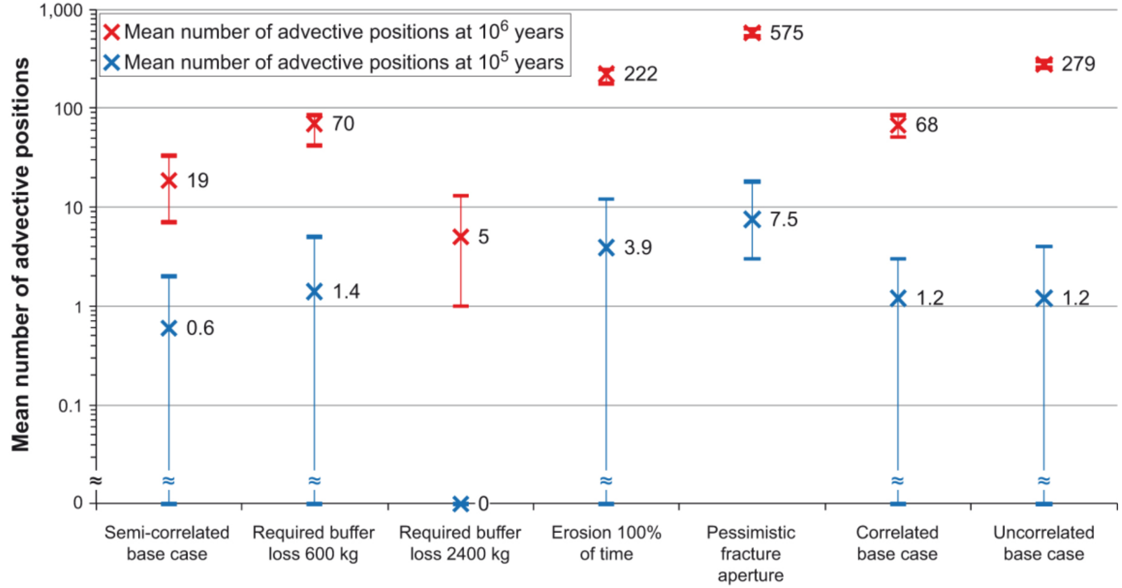
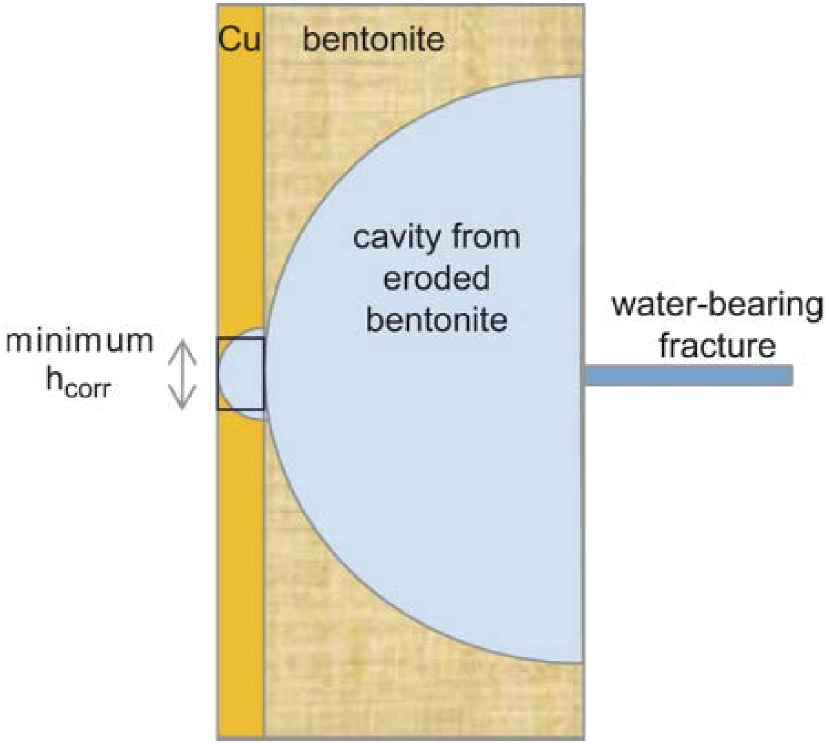
Colloid Release From Buffer

Uncertainties:

- How much bentonite can be lost before advective condition occur
- Homogenisation?
- Fracture apertures?
- Future groundwaters?



Effect on Corrosion



Hydrogeological DFN model		Mean number of advective positions (at 10^5 yrs)	at 10^6 yrs	Mean number of failed canisters (at 10^5 yrs)	at 10^6 yrs
Uncorrelated	Initial advection	(6000)	6000	(0.055)	1.2
	SR-Site erosion model	(1.2)	280	(0.004)	0.65
	No advection	(0)	0	(0)	0
Semicorrelated	Initial advection	(6000)	6000	(0.013)	0.18
	SR-Site erosion model	(0.6)	19	(0)	0.12
	No advection	(0)	0	(0)	0
Fully correlated	Initial advection	(6000)	6000	(0.043)	0.86
	SR-Site erosion model	(1.2)	19	(0.005)	0.57
	No advection	(0)	0	(0)	0

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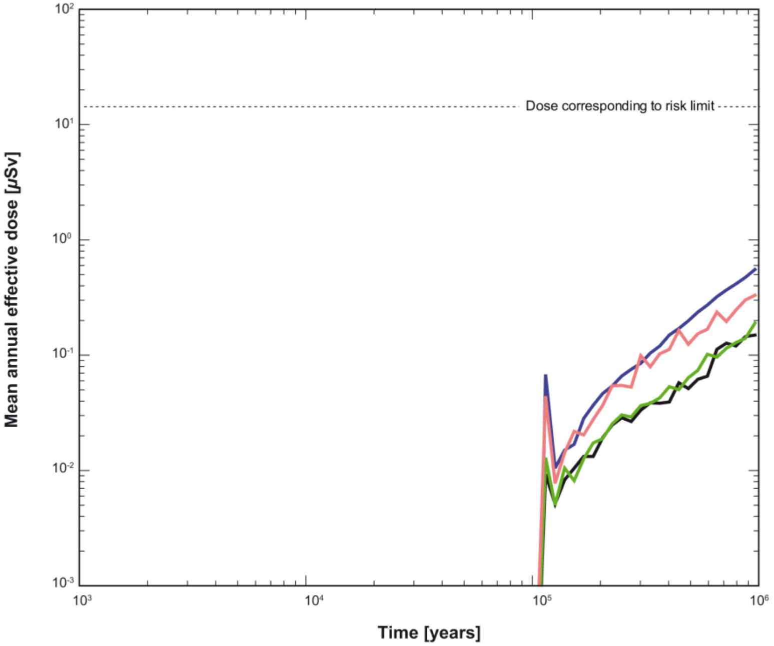
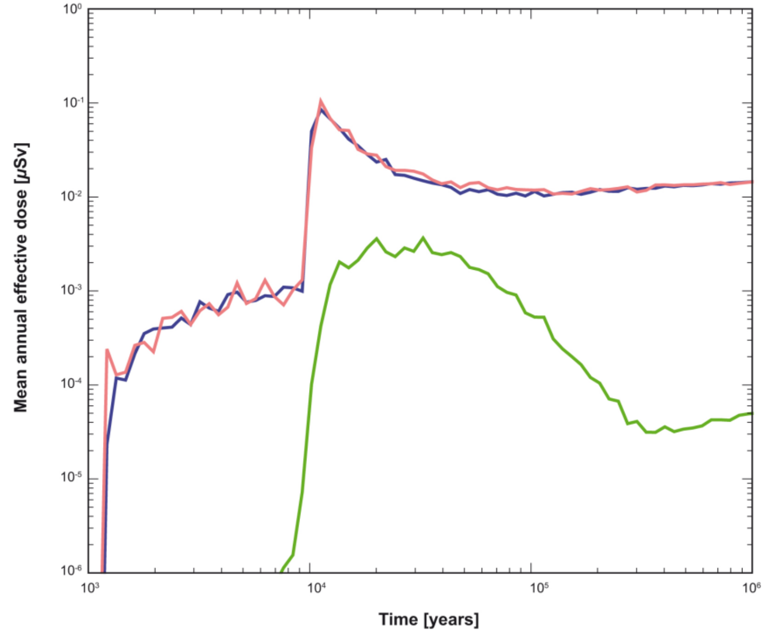
Colloid Transport

Reference corrosion case (reversible)



Black: no colloids
Green: 10 mg/l
Pink: 10 g/l
Blue: *near-field dose equivalent release*

Early pin-hole failure case (irreversible)



Green: dose due to the colloid-associated component
Pink: total dose with irreversible sorption to colloids
Blue: total (all-nuclides) dose without colloids

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Under what conditions are bentonite colloids stable?

Usefulness of the critical coagulation concentration (CCC)

- A CCC may be determined for monovalent systems, and used as a pessimistic concentration limit for spontaneous colloid sol formation
- For a pure calcium bentonite in a calcium solution, the CCC concept is not strictly valid
- For a system with mixture of monovalent and divalent ions, such as most groundwaters, the picture gets more complicated:
  - Ion-exchange
  - Solid/liquid ratio
  - Diffusion
- Charge equivalents?

ACTIVITIES - EXAMPLES

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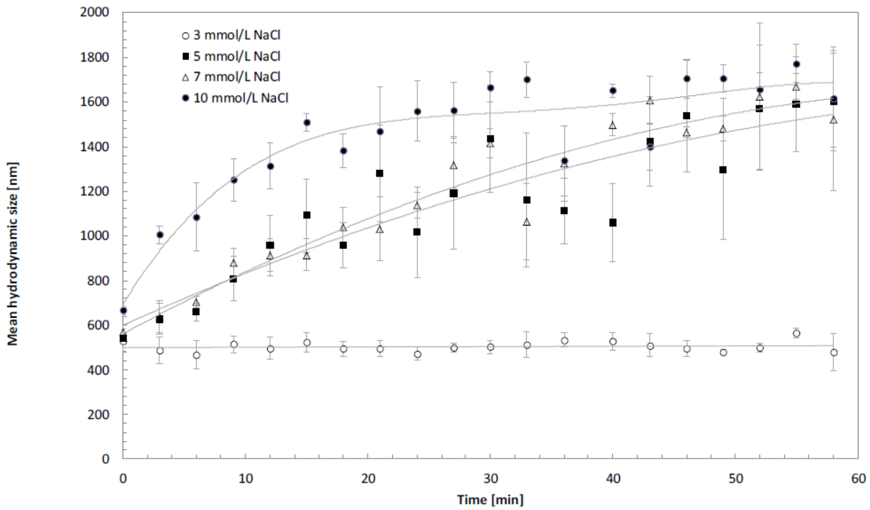
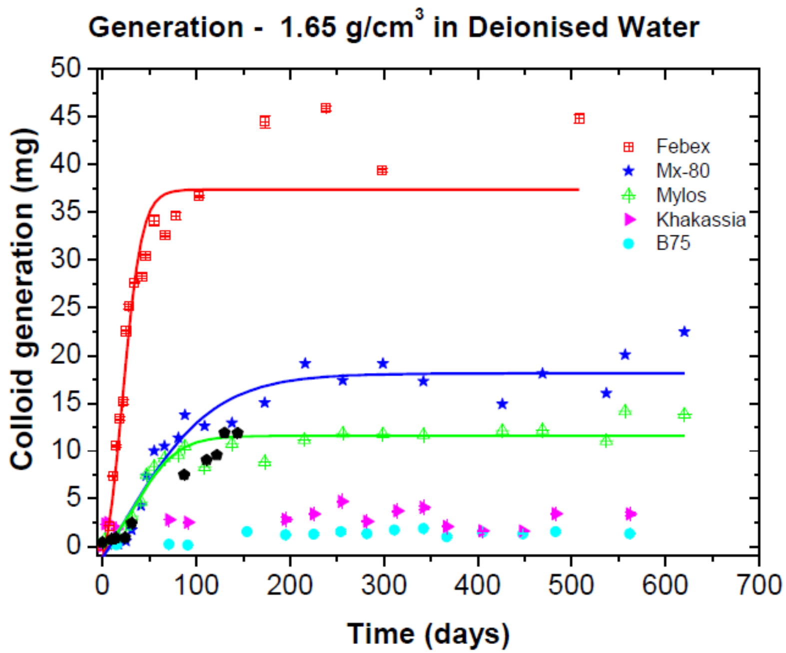
Under what conditions can erosion occur? (WP4)

Coagulation kinetics of clay dispersions by inorganic cations

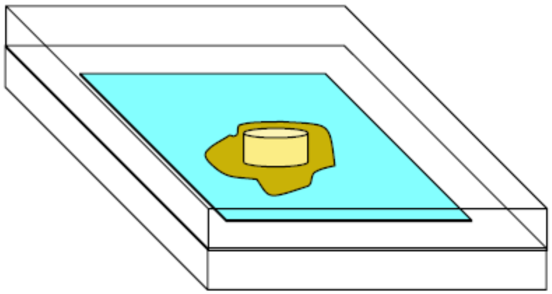


Bentonite B75 in Na^+ as suspension in distilled water - 0.005 % w/w



What is the mass loss rate? (WP2)

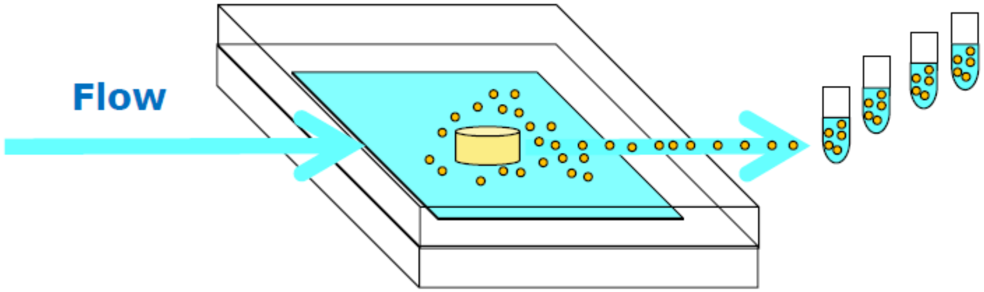
Phase 1: Stagnant conditions (30 days with NaCl 10^{-3} M)



- Pictures
- Extrusion distance as a function of time
- Diameter increment (t)

Phase 2: Low Flow conditions (14 days) 10^{-6} m/s with NaCl 10^{-3} M

Phase 3: High Flow conditions (14 days) 10^{-4} m/s



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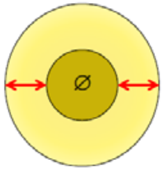
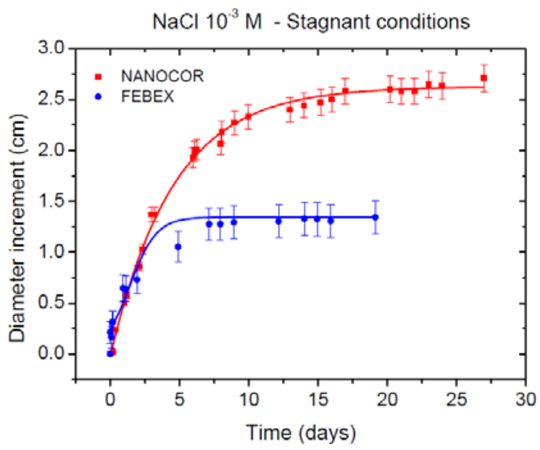
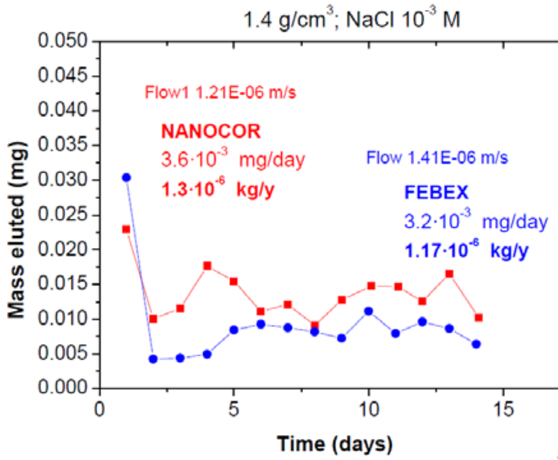
What is the mass loss rate? (WP2)

Phase 1: Stagnant conditions (30 days with NaCl 10^{-3} M)

Extrusion distance
Diameter increment







Bentonite exposed surface not corrected: S = 6 mm²

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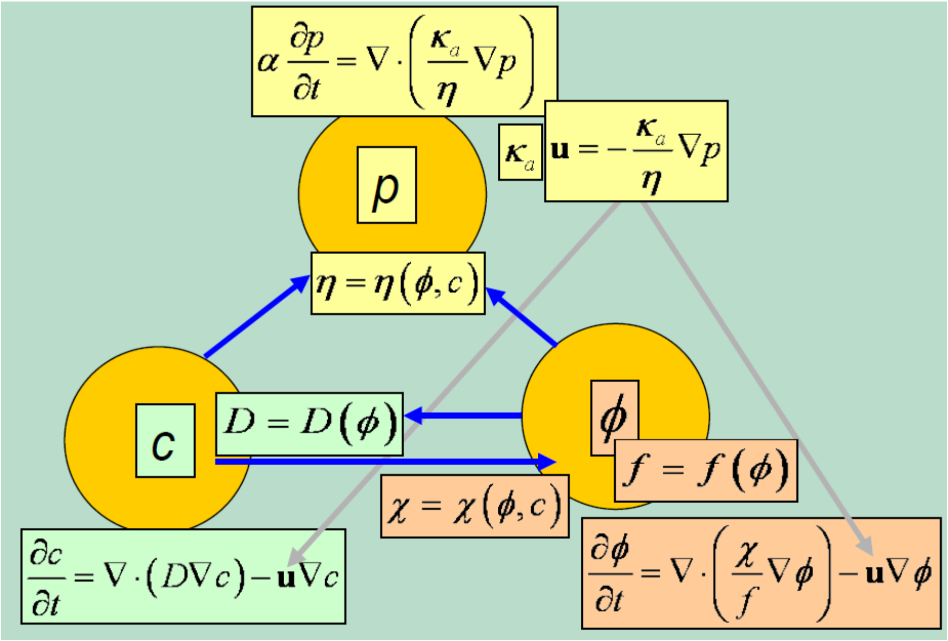
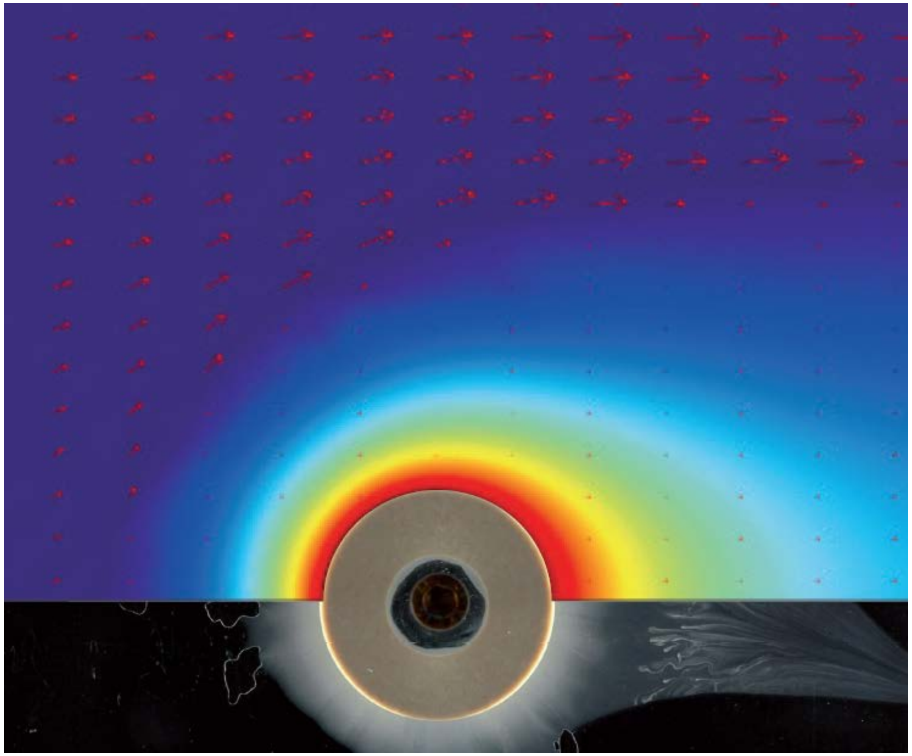
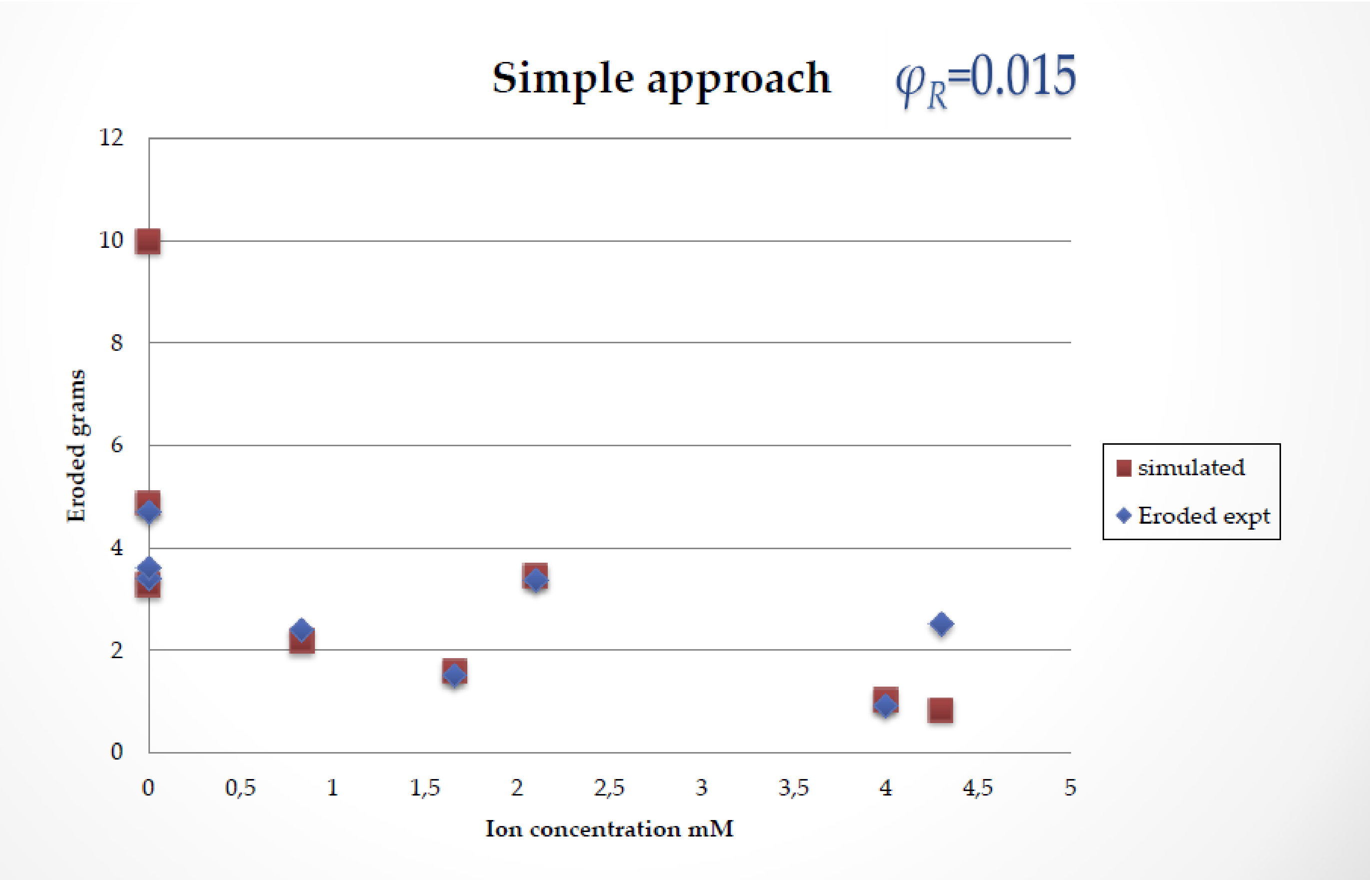
What is the mass loss rate? (WP2)

Modelling of mass loss (WP5)

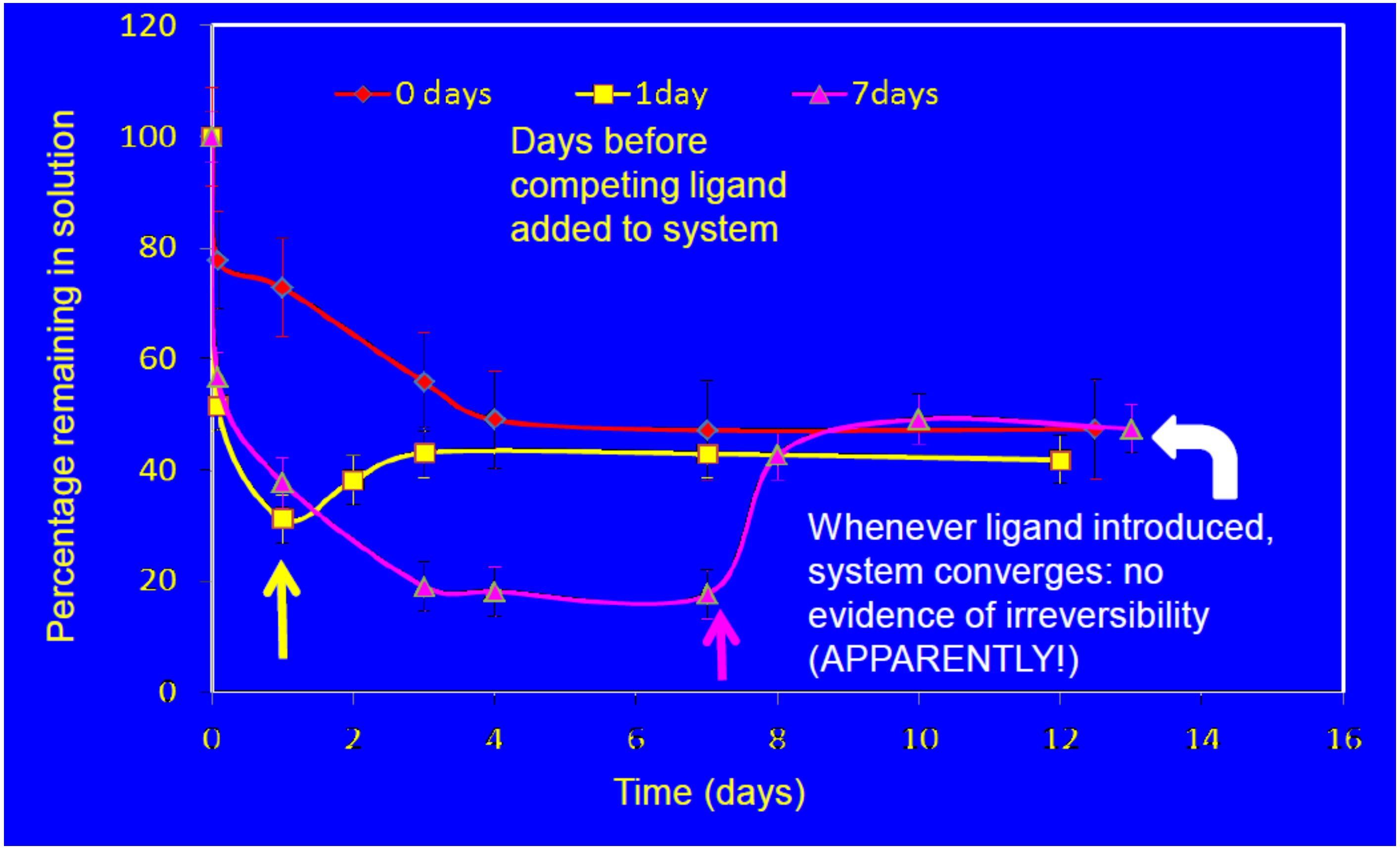




Modelling of mass loss (WP5)



Sorption reversibility (WP3)



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EXPECTED OUTCOME

Impact on future assessments (WP1)

- Under what conditions can erosion occur?
  - Reduced uncertainty
    - May eliminate process under some circumstances
  - Material understanding
    - May aid repository design
- Mass loss rate?
  - Reduced uncertainty
    - May limit consequences
- What are the colloid concentrations?
  - Reduced uncertainty
    - May limit consequences
- Is sorption reversible?
  - Reversibility confirmed
    - May limit consequences

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Results so far

- Colloid generation from bentonite is confirmed to be a clear on/off process
  - Depends on ionic strength
  - Depends of ion assemblage in clay
  - Depends on type of bentonite
- Erosion in experiments tends to be slower that what current models predict
  - However, the trends and parameters seems to be captured by the models
- The effect of gravity is a strong uncertainty
- Reversibility of sorption seems to be confirmed

The research leading to these results has received funding from the European Atomic Energy Community's Seventh Framework Programme (FP7/2007- 2011) under grant agreement no 295487.