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EURATOM

(WP2)

Erosion behavior of different compacted bentonites (WP2)

Ursula Alonso, Tiziana Missana, Nairoby Albarran, Ana Mª Fernandez, Miguel García-Gutierrez, Manuel Mingarro

CIEMAT, Spain

Helsinki, March 2013

AIM

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To identify most relevant parameters affecting bentonite erosion

Qualitative and quantitative information
Erosion rates - (SA)

Two scenarios:

- **Static: Diffusive conditions**
- **Dynamic : Flow conditions**

Compacted and confined clay

To consider wide range of water/clay experimental conditions

To consider the possibility of scenario evolution chemical or physical changes

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Overview

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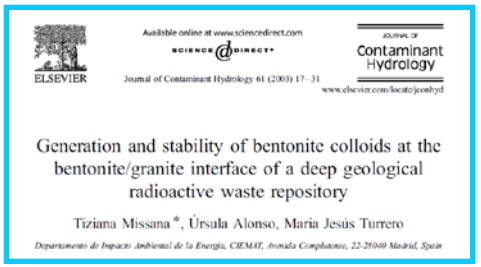
Previous Experience

- Lessons learned
- Identification of uncertainties

Experimental planning within BELBAR

✓Main findings obtained so far



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Generation and stability of bentonite colloids at the bentonite/granite interface of a deep geological radioactive waste repository

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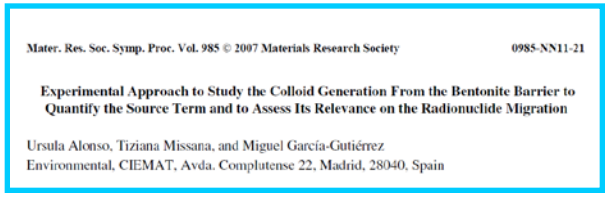

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Experimental Approach to Study the Colloid Generation From the Bentonite Barrier to Quantify the Source Term and to Assess Its Relevance on the Radionuclide Migration

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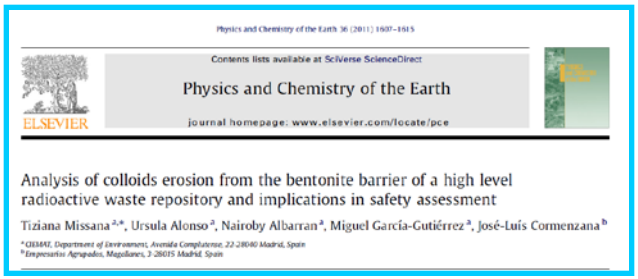

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Analysis of colloids erosion from the bentonite barrier of a high level radioactive waste repository and implications in safety assessment

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✓Results from FUNMIG and other recent projects

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EXPERIMENTAL CONDITIONS

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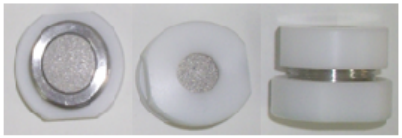
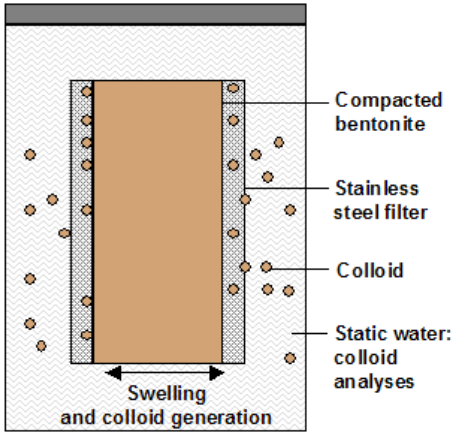
Static: Diffusive conditions ⇔ Dynamic: flow conditions

(a)



(b)



FILTER

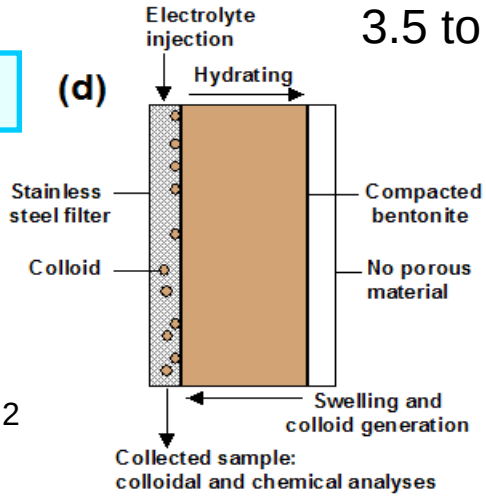
4 g clay
S = 3.5 cm²
200 mL

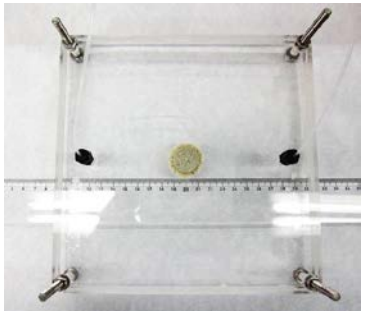
(c)

45 g clay
S = 20 cm²
3.5 to

FRACTURE

(d)





- **Quantitative analyses of colloid concentration and size distribution were periodically carried out in the electrolyte by Photon Correlation Spectrometry.**

EXPERIMENTAL CONDITIONS

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- **FEBEX bentonite**
- **Homoionic Na- and Ca- bentonite**

Natural clays
FEBEX
MX80
Mylos
(Rockle, Russian bent)

- **Different compaction densities (1.2, 1.4, 1.6 g/cm^3)**

1.65 and 1.8 g/cm^3

➢ **Effect of main exchangeable cation**

➢ **Swelling ; effect of smectite clay content**

- **Several electrolytes : DW, NaCl, $CaCl_2$, GWG**
- **Ionic strengths, Ca content,..**

Aspö, …

➢ **Water/clay interactions**

➢ **Cation exchange**

➢ **Colloid stability**

- **Surface exposed to hydration.**

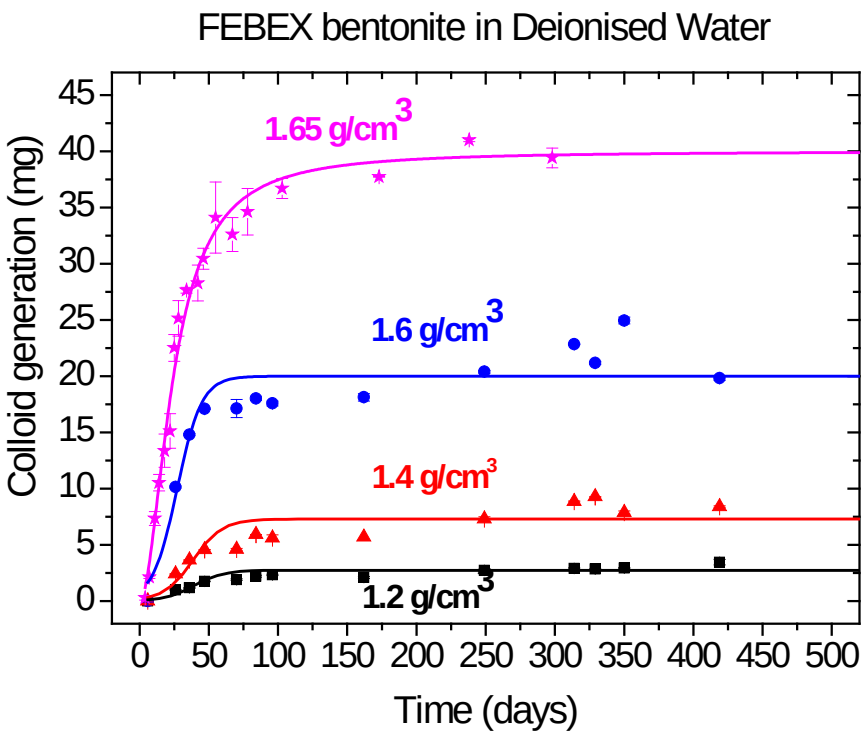
Fracture aperture
Real surface/fracture

- **Water flow rates**

Longer times / water

➢ **Physical aspects**

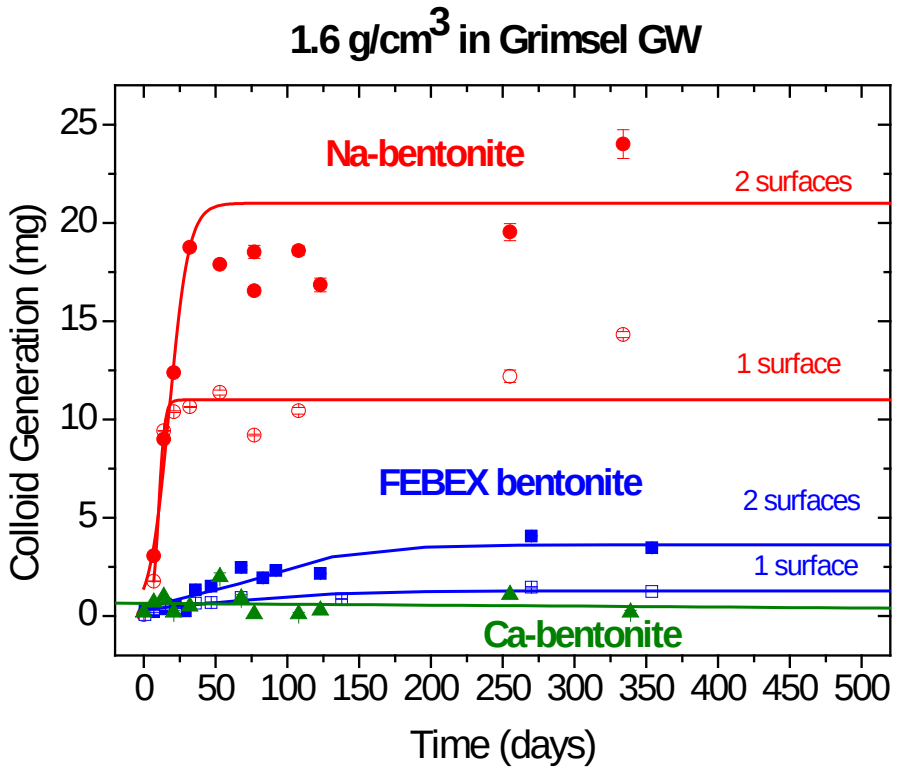
COMPACTION DENSITY



- ✓ Stable colloidal particles are released!
- ✓Dependence on compaction density (swelling)
- ✓ Higher generation in DW
- ✓ Not real "rate"- EQUILIBRIUM

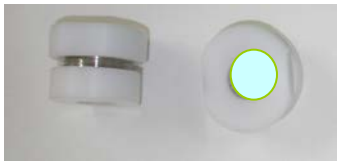
FEBEX (1.65 g/cm³ in DW)

Colloids erosion: 0.1 kg/m²



CLAY TYPE

- ✓ Dependence on main exchangeable cation
- ✓ Higher rates Na-bentonite



SURFACE

- ✓ Available surface for hydration /transport

Na-bentonite (1.6 g/cm³ in DW): 7.3E-2 kg/m²

FEBEX 1.6 g/cm3 in DW: 6E-2 kg/m²

Ca-bentonite 1.6 g/cm3 in DW: 6E-2 kg/m²

Data normalised to extrusion area: mg/m²

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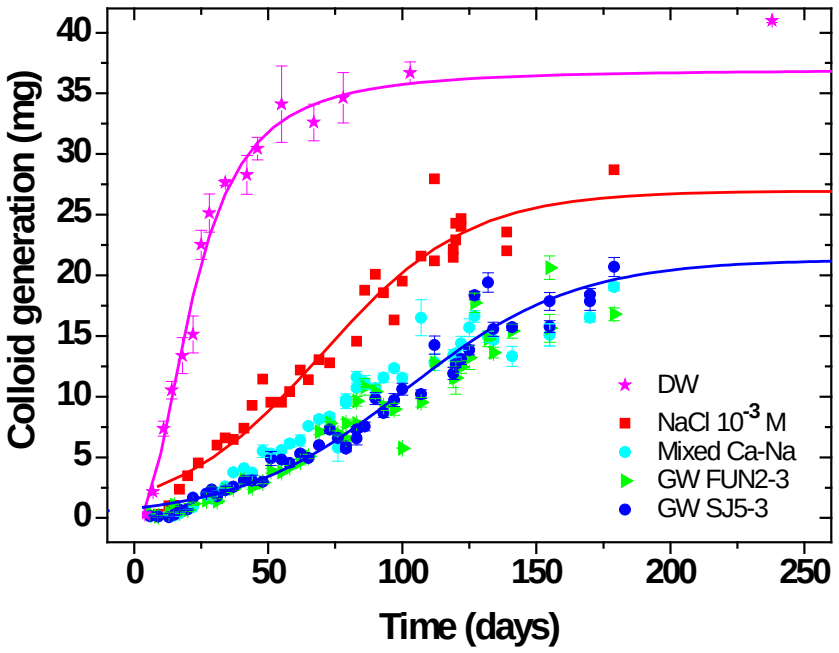
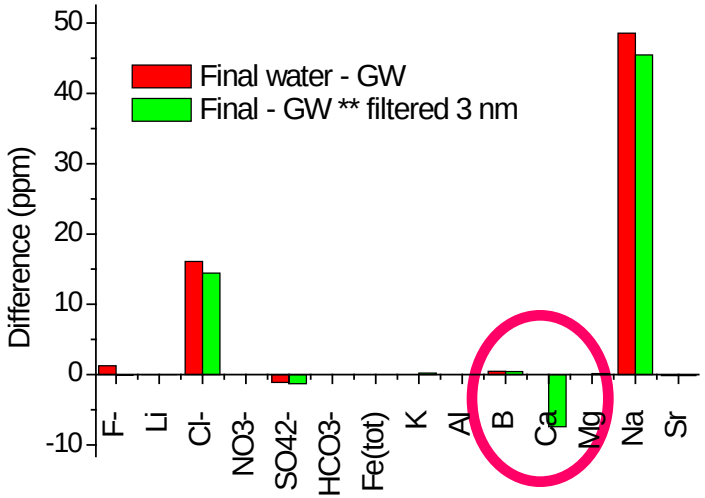
FEBEX bentonite 1.65 g/cm^3 in different electrolytes



Chemical analyses of final electrolyte (initial GGW)



- ✓ Ca in the electrolyte is incorporated to bentonite: inhibits colloid generation
- ✓ Relevance of cation exchange processes

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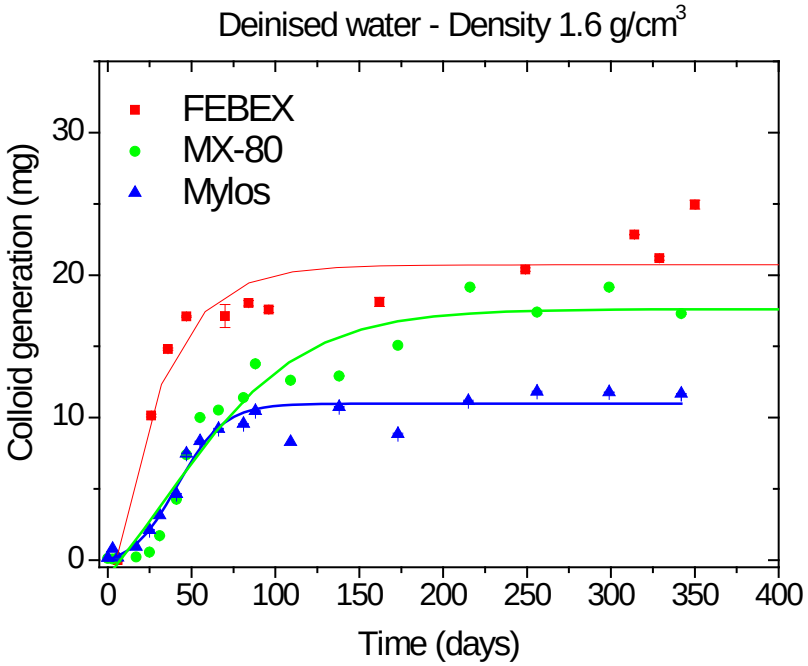
RESULTS
Static conditions



NATURAL CLAYS

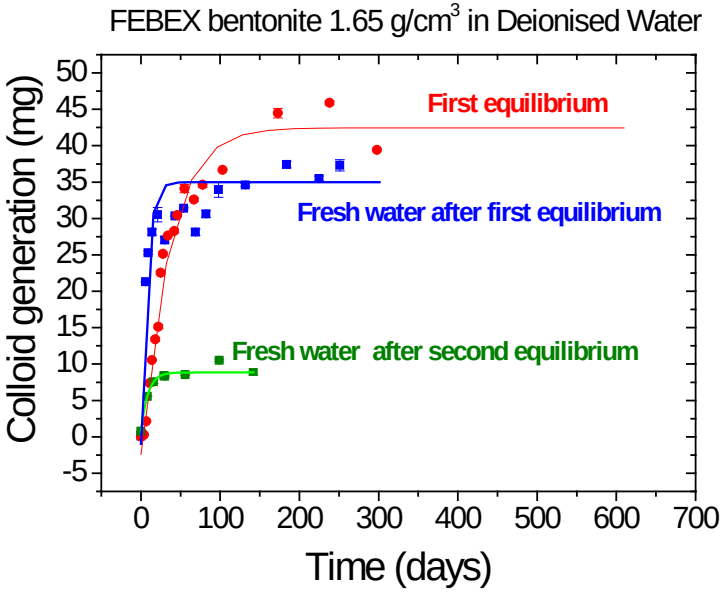
- **FEBEX: 92% smectite content.**
- **Mx-80: 88% smectite content**
- **Mylos 79% of smectite.**

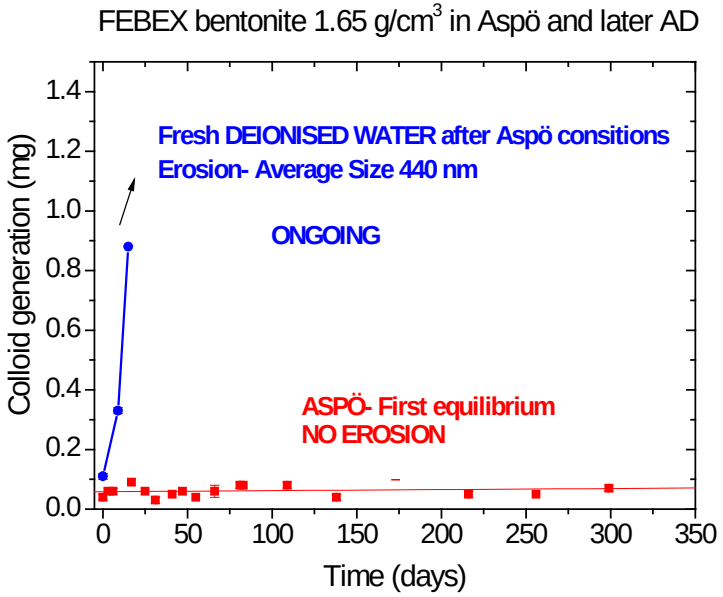
✓ **Results suggests erosion related to smectite content.**

✓ **Ongoing experiments with Czech and Russian bentonites.**

	Na	K	Mg	Ca	Sr	Ba	Σcation
	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g
Febex	24.57	2.14	33.27	32.58	0.31	0.007	**102**
MX-80	49.01	1.44	5.88	18.92	0.37	0.008	**76**
Mylos	22.54	1.75	27.90	29.62	0.16	0.014	**82**

After equilibrium reqched : consecutive changes in water chemistry





✓Changes with fresh DW

✓Comparable initial rates but

lower equilibrium masses.

✓Aspö GW: No erosion

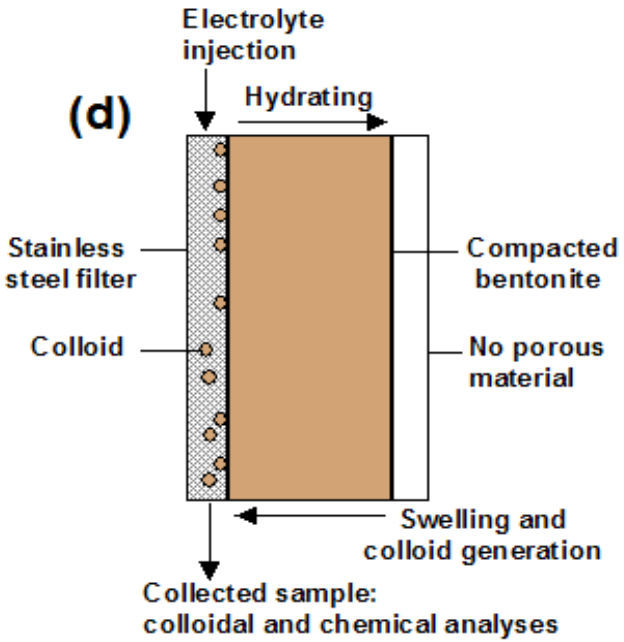
✓ Fresh water (DW) launches erosion

(at lower rate-)

Dynamic: flow conditions

(c)

(d)



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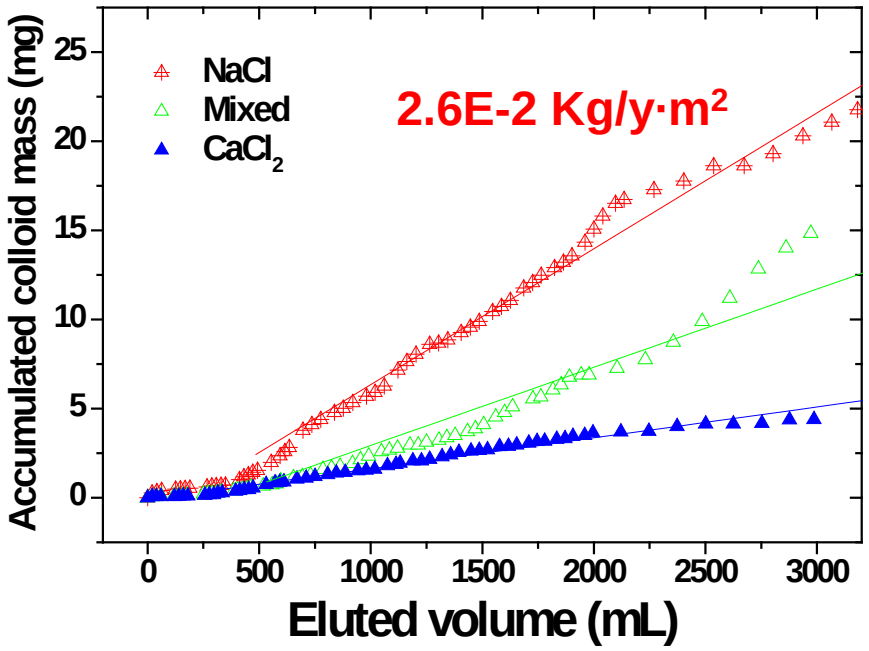
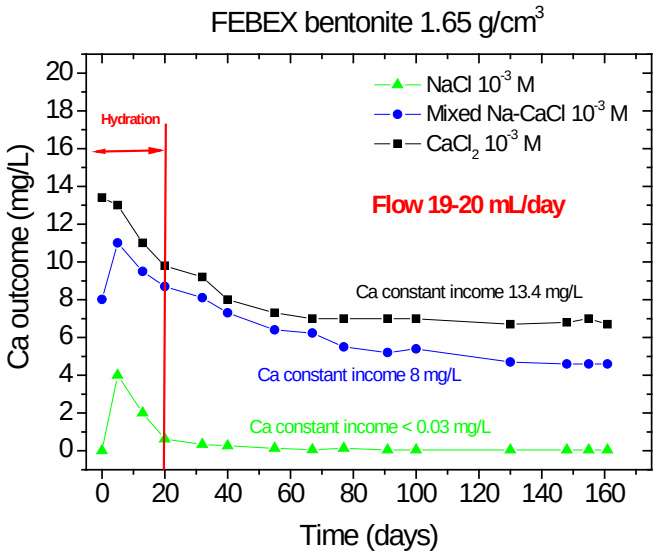
Accumulated eroded mass from FEBEX 1.65 g/cm^3; Flow 20 mL/day = 1.2E-7 m/s



Concentration Ca+in eluted samples

- ✓ First results indicated fairly linear generation rates (early end)
- ✓ Dependence on electrolyte.



- ✓ Ca incorporated : Cation Exchange

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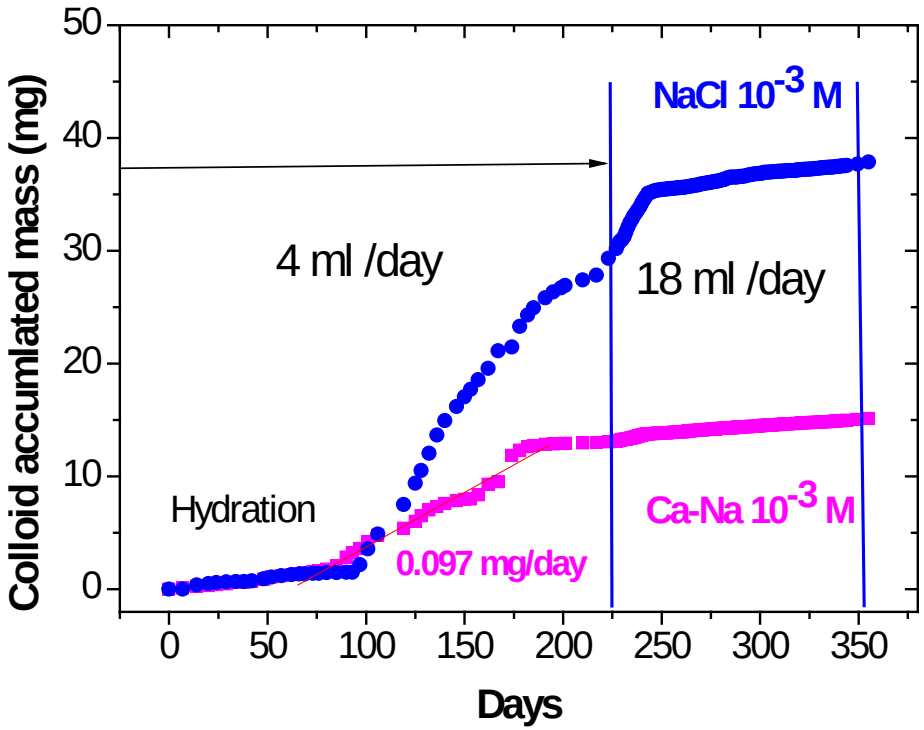
Accumulated eroded mass from FEBEX 1.65 g/cm^3

Flow 20 mL/day ; v = 1.2E-7 m/s

Flow 4 mL/day ; v = 2.4E-8 m/s



- ✓ **After certain time, colloid release clearly slowed down, even with NaCl.**
- ✓ **RATE or EQUILIBRIUM?? Maximun generation**

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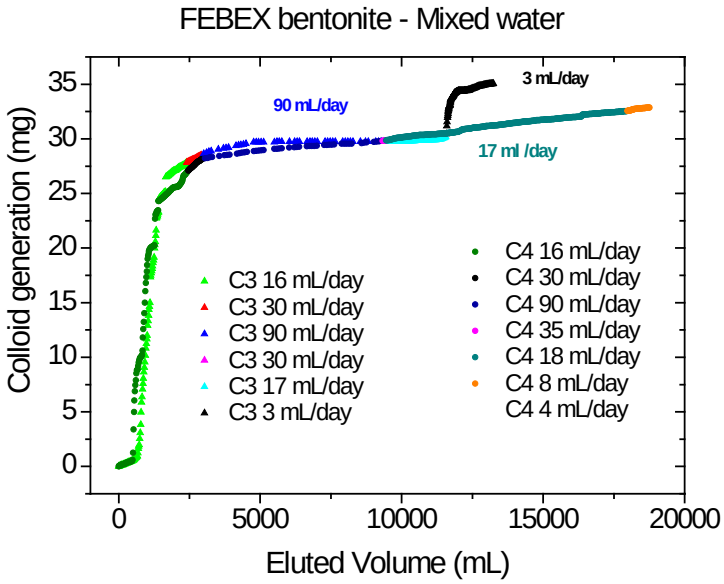
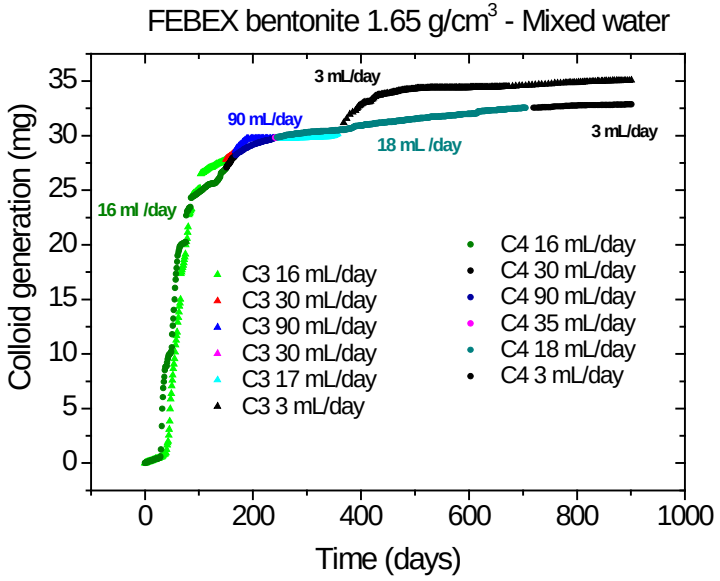
Accumulated eroded mass - FEBEX 1.65 g/cm^3 in mixed Ca-Na 10-3 M electrolyte





✓**Colloid release clearly slowed down.**

✓ **Little effect of flow changes**

NEXT

Scenario evolution

(change water to DW)

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- **Colloid erosion from confined and compacted bentonite was measured upon different conditions (clay density, exchangeable cation, electrolytes ..).**

- **Maximum eroded mass was measured from Na-bentonites, at higher clay compaction density and in Ca-free electrolytes of low ionic strength (DW).**

- **FEBEX bentonite with a 30% Na behaves similar to Na-bentonite.**

- **The erosion behavior of the natural raw clays (FEBEX, Mylos and Mx80) seems to be related to their content in smectite. Further tests required.**

- **Eroded mass has to be normalized to available extrusion paths (Kg/m^2).**

- **Information from different systems (static/dynamic) is coherent and indicates that colloid erosion is slowed down at a certain time (volume) and tends to steady state.**

- **"Maximum" eroded mass vs Rate**

- **<u>Scenario evolution:</u> Chemical and physical changes launched again colloid releases. To what extent?**

Thank you for your attention!