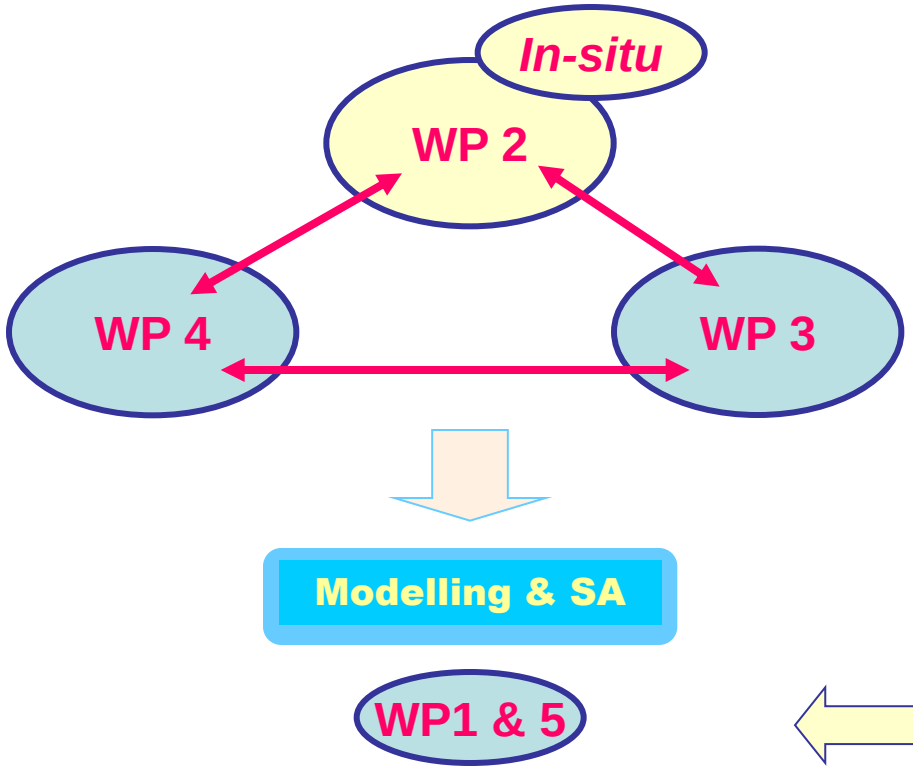
7- 8th March 2012

BELBaR Project
Start-up Meeting

CIEMAT ACTIVITY IN THE PROJECT

CIEMAT main effort: Experimental Work



The comprehension of processes in each WP must be focused to a global need: input of data for qualitative and quantitative models description in SA.

Work packages are totally inter-dependent. Collaboration and result transfer between them is needed.

Coherence in the selection of experimental conditions is always needed even the experimental approach is different.

Final aim: to understand realistic scenarios.

CIEMAT work is planned with these premises.

CIEMAT main aims

To compare the behaviour of different clays: for a generalised description of bentonite colloid generation processes in terms of clay properties (cation exchange complex, composition) and water/clay interactions.

All tests will be focused on the determination of quantitative parameters to be used in models for the long-term safety assessment.

To understand the overall role played by colloids on RN mobility

Main experimental conditions considered in different WPs

Realistic scenarios and their possible evolution

- Three different clays (FEBEX, Mylos, MX-80); Characterisation of both *as-received* material and *post-mortem*;
- Two/three different compaction densities (*1.8*/1.6/1.2 g/cm^3): initial stage and gel formation;
- Waters: DW; GTS and Äspö synthetic waters;
- Changes in porewater foreseen (scenario evoluton).
- Static (stagnant water) and dynamic (flowing water) conditions.

Aims

Smectite particles in gels and suspensions are strongly influenced by their own properties and porewater and groundwater chemistry (pH, I(M), ionic composition, exchangeable cations, dense/dilute systems).

Analyses of water - bentonite interactions important.

Selectivity coefficients and thermodynamic exchange constants (dense/dilute systems) will be derived. Input for conceptual models to analyze the clay/water interactions at repository conditions.

Characterisation of the 3 clays & clay-water interactions

INITIAL CHARACTERISATION

- Mineralogy, chemistry; physico-chemistry.
- Chemistry of porewater (squeezing).

SPECIFIC TESTS ON CLAY / WATER INTERACTIONS

- 2 types of water (high/low salinity), 2 different degree of compaction; 2 temperatures (22ºC and 40-60ºC //at bentonite-host rock interface).

FINAL CHARACTERISATION

- At the end of all the tests: analysis of the liquid phases (ICP-OES / ICP-MS) and analyses of the bentonite (XRD, FTIR, TG-DSC, etc.…)

Aims

Analyses of colloid erosion from compacted and confined clay.

Two possible scenarios: water hydrating the bentonite fairly immobile and water flowing at the bentonite surface.

Particular focus on chemical effects, as ionic exchange, that can be relevant on the stability and generation behaviour of bentonite colloids at the long term.

Processes understanding.
Colloid generation rates under different conditions .
Evaluation of maximum colloid concentration

Erosion tests

STATIC EXPERIMENTS

- Already mentioned exp. conditions + Different Ca/Na ratios (solid/water);
- Measurement of colloid concentration at different stages;
- Characterisation of generated colloids;
- PCS; SPC; ICP-MS; Microscopy techniques;
- Post mortem analysis of clays (comparison with *as-received*)

DYNAMIC EXPERIMENT

- Same chemical conditions as static;
- At least two water flow rates;
- Design of improved generation cell is needed first (dilution/detection)

Aims

Analyses of bentonite gel behaviour when environmental conditions (chemical and/or hydrodynamic) change, for its implication on colloid generation.

Kinetic and reversibility of processes are fundamental issues scarcely investigated so far.

Processes understanding.
Colloid generation rates modification.
Long – term evaluation

Scenario evolution analyses

STATIC & DYNAMIC EXPERIMENTS

- Same clay subject to consecutive changes in water chemistry (hysteresis/reversibility ??),

- Same type of analyses mentioned before.

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WP2 : Erosion

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EURATOM

Aims

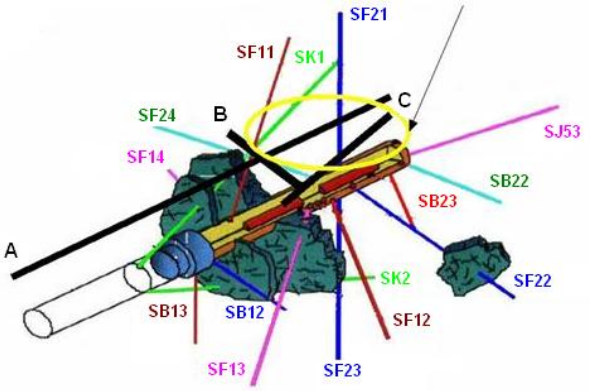
In-situ analyses of the bentonite colloid generation under realistic conditions.
Data from FEBEX tunnel in the Grimsel Test Site, where a real scale experiment simulating a deep geological repository in granite installed 15 years ago.
Study started in 2006.

Processes understanding.
Comparison with laboratory data.
Evaluation of colloid formation in a favourable case.

Field work

CIEMAT foresee to provide annually new field data on colloid analyses at the GTS.

Sampling from different boreholes in the FEBEX tunnel



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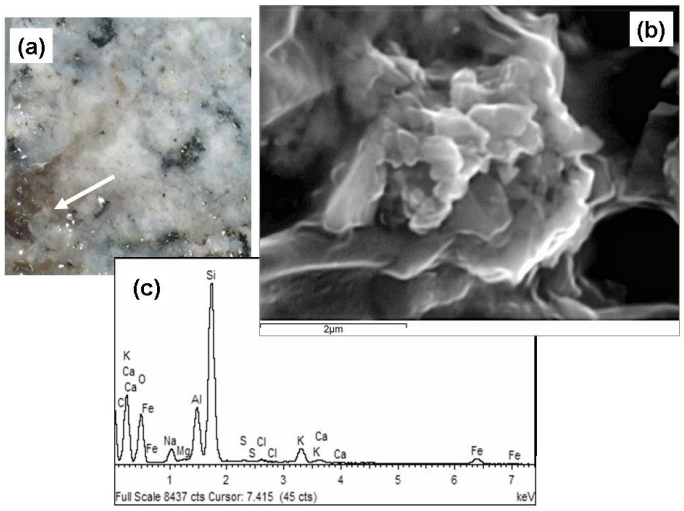
Aims

Mechanistic understanding of colloid/rock interactions in a crystalline rock. Data on colloid filtration obtained at the macroscopic scale (by performing transport experiments) have to be related with data obtained at the micro-scale, where colloid/rock interactions take place.

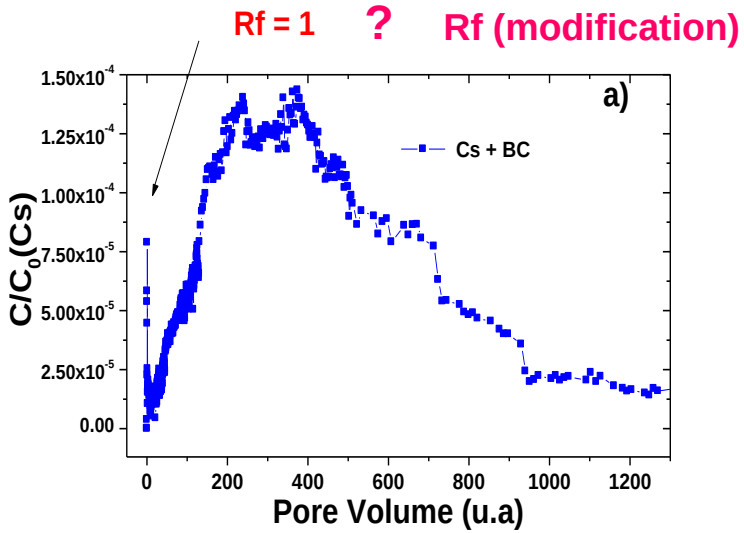


Colloid/rock

- **Dynamic experiments in fractures (GTS, Aspo?); Study of the fracture surface (drawbacks);**
- **Batch experiments;**
- **Bentonite colloids; model colloids to understand the effects of possible relevant parameters (colloid size, charge, morphology); traced colloids;**
- **The colloid/rock interactions at the microscale will be analysed by atomic force microscopy, field emission scanning microscopy, and µPIXE.**

Aims

Analyses of RN transport in the presence of bentonite colloids. Overall behaviour.



Link generation data to RN transport data

Colloid-RN transport

- **Dynamic experiments in fractures (GTS, Aspo?);**
- **Transport experiments in improved dynamic generation cells;**
- **Bentonite colloids;**
- **3 different radionuclides with different sorption behaviour (preferences on trivalent and tetravalent elements);**
- **Simultaneous analysis of colloid and tracer elution (Colloid concentrations & RN activity).**

Aims

The enhancement of radionuclide transport due to the presence of colloids is strongly dependent on the (ir)reversibility of colloid / radionuclide interactions and the presence of a third solid phase.

CIEMAT will study the reversibility of radionuclide sorption onto bentonite colloids.

Static and dynamic conditions (transport).

Link batch/dynamic results. Kinetics. Effects of competing phases (rock).

Colloid/RN

- Batch experiments (detailed description of sorption) first;
- Analyses of sorption in the frame of surface complexation/ ion exchange models; Theoretical & mechanistic approach to irreversibility.
- Study in the frame of dynamic experiments in fractures;
- Bentonite colloids
- 3 different radionuclides with different sorption behaviour (preferences on trivalent and tetravalent elements);

WP4 : Colloid stability

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Aims

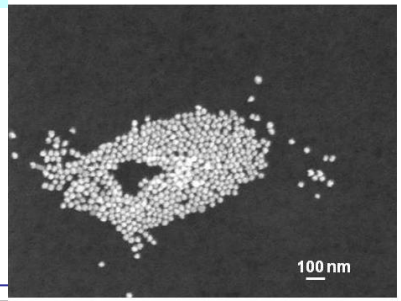
The stability of colloid generated from the compacted bentonite is a main conditions for assessing their relevance in contaminant transport.

CIEMAT will analyse coagulation kinetic of FEBEX, Mylos and MX-80 bentonite under the variation of the aqueous solution chemistry (pH, ionic strength, content of bivalent and trivalent ions).

To evaluate and to compare the intrinsic colloidal properties of different bentonites.

Colloid Stability (1)

- Time resolved dynamic light scattering (short time scale)
- PCS and SPC (larger time scale).
- Surface charge measurements;
- Microscopy;
- 3 different clays and synthetic waters



- In this WP, wider variation of experimental parameters (to be linked to erosion tests and real scenarios).

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Aims

A fundamental aspect that has to be evaluated is the (ir)reversibility of coagulation process.

Study of the (1) coagulation and (2) dispersion behaviour after changing chemistry of the aqueous solutions (i.e modified towards conditions favourable to stability);

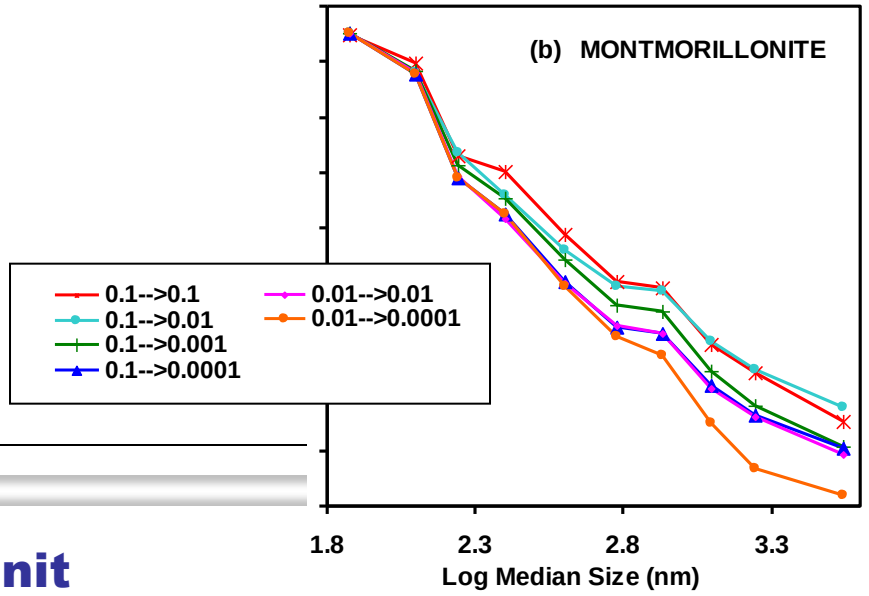
Analysis of the kinetic of the dispersion process.

Comparison with coagulation kinetics.

Kinetic and reversibility of processes are fundamental issues scarcely investigated so far. Great importance at a long-term.

Colloid Stability (2)

- Time resolved dynamic light scattering (short time scale);
- PCS and SPC (larger time scale);
- Surface charge measurements;
- Analysis of colloid structure);
- 3 different clays and synthetic waters;



Aims

Modelling is a necessity to assess the processes relevant to geological disposal.

Experimental work should be focused to obtain data useful as model input.

CIEMAT will provide experimental data (WP2 to WP4) and will contribute to evidence the parameters that mostly affect generation, stability and transport under the selected experimental conditions and to establish relations between them.

CIEMAT Modelling

- **Modelling of experimental lab CIEMAT data;**
- **Modelling work will be mainly focused on the chemistry of the bentonite/water system and its evolution at a long term based on the experimental results obtained within the project; Phreeq-C; Chess; Geochemical Workbench**
- **A sensitivity analysis on main chemical parameter (identified as relevant in generation)**

Previous Experience

CIEMAT will provide a detailed summary of previous results on bentonite colloid generation & bentonite colloid transport obtained in the frame of national/international projects (FUNMIG, CFM, CRR, CARESS, PROMICOL (ES), CROCKIS (ES), etc..). This "state of the art" will be discussed in order to identify main open issues. First deliverable.

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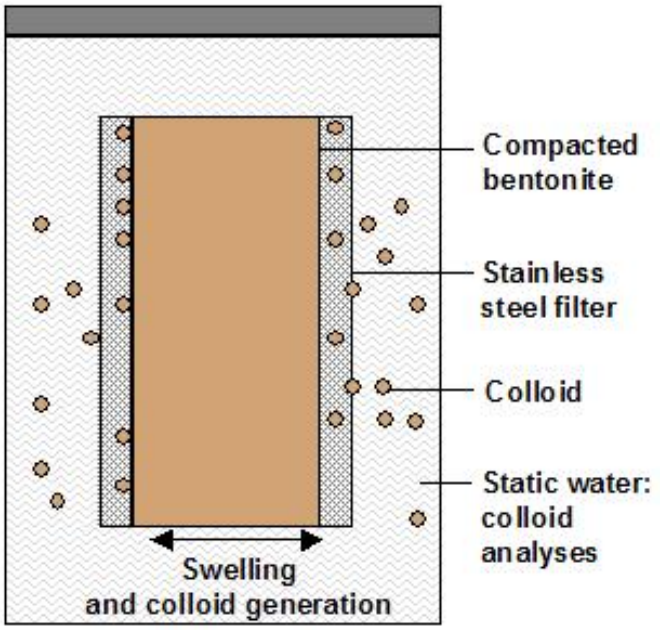
Throughout the duration of the project CIEMAT will integrate the information generated within WP 2 (Erosion), evidencing the most relevant parameters affecting erosion to allow adequately addressing the "colloid issue" in SA.

(a)

(c)

To be improved

(b)



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