INFLUENCE OF PHYSICO-CHEMICAL, CRYSTALLOCHEMICAL AND COMPOSITIONAL PROPERTIES OF CLAY MINERALS ON EROSION PROCESSES

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INTRODUCTION
An understanding of the main mechanisms of colloid and gel layer formation from compacted bentonite during erosion is one of the main objectives of the BELBAR Project. The erosion mechanisms and colloid generation process are influenced by the physico-chemical, crystallochemical and compositional properties of the clay minerals, which are analysed in this work. The settling and flocculation processes of the clay particles depend on a lot of factors, such as the size and shape of the particles, surface properties, ionic strength of the incoming water, etc. For example, smectite particles in gels and suspensions are strongly influenced by: a) decreases in dry densities of the compacted bentonite due to swelling or changes in the chemical stability of smectite (montmorillonite/bentonite volume fraction or concentration), b) pore water/groundwater chemistry; ionic strength (I), pH, chemical composition, which govern the edge charge; c) changes in cation composition at the interlayer sites (in particular the Ca/Na content), and d) crystallochemistry of the clay minerals.

Different tests about the formation and stability of colloids from compacted bentonite have shown that degree of erosion is related to the quantity of smectite in the system and, therefore, the presence of other minerals and/or different clay minerals seems to affect the erosion of bentonite (Missana et al., 2015; Alonso et al., 2015). Indeed, bentonite is defined as a naturally occurring material that is composed predominately of the swelling clay mineral montmorillonite (>75%). However, it contains more than one type of minerals (main and accessory minerals), and other type of clay minerals can be present. Furthermore, chemical and structural heterogeneity is typical for smectites. Therefore, a study of the properties and compositional characteristics of different bentonites and clay minerals has been performed in order to identify which plays a major role on the colloid generation process and, hence, in the bentonite erosion behavior.

EXPERIMENTAL MATERIALS
Around 40 years ago few commercial high quality bentonites were acquired for the study of bentonites as buffer and backfill materials in the construction of engineering barrier systems (EBS) for the isolation of high-level radioactive waste. The natural selected bentonites are industrially processed to fabricate highly compacted bentonite blocks, which have been used in different situ large-scale EBS experiments (e.g., FEBEX-in situ, LOT, Prototype, TBT, etc.) and Mock-Up tests. Nowadays, new reference designs for the EBS consists on compacted blocks and pellets for filling the gap between the bentonite compacted blocks and the host-rock (e.g., EBS-Experiment and FE experiments at Mont Terri, Switzerland).

In this work, different raw bentonites and clay materials were analysed, which have different characteristic structures: 2:1 (TOT) or 1:1 (TO) layer type, Di- or Tri-cation sites, TOT layers with low or high layer charge, charge location at tetrahedral or octahedral sites, dioctahedral clay minerals with cis- or trans-vacant positions. These clay minerals can be grouped as: a) Ca-Mg smectites (ROC6-KF02, FEBEX, Bezo, SAz-2) or Na-smectites (MX-80, Nanocor, MSU, Sabenil S65, B75), b) bentonites made up of low layer charge smectites: beidellite SBdI-1, Ypresian Clays from Belgium (YD40, YK38); c) bentonites made up of high layer charge smectites; d) other type of clay minerals: saponite (MCA-C, B64), nontronite (NAd-1), illite (illite du Pui, Ibd-2), kaolinite (Kga-1b); and e) granular bentonite material (Pellets) used at Mont Terri Research Laboratory; GBM non activated Na-smectite (FE-Experiment) and GBM non activated Ca-Mg smectite (EB-Experiment).

EXPERIMENTAL RESULTS

MINERALOGICAL ANALYSIS

PHYSICO-CHEMICAL CHARACTERISTICS

GEOCHEMICAL AND CRYSTALLOCHEMICAL COMPOSITION

PORE WATER COMPOSITION: Salinity, Free water composition and Anion Accessible Porosity

CONCLUSIONS

Different properties and compositional characteristics of the clay materials analysed have a direct relationship with the mechanisms of colloid formation from compacted bentonite during erosion process. The clay characteristics that seems to affect the colloid characteristics and stability behaviour depends on: a) the total smectite content in the sample, b) the Na content in the exchange complex (Ca vs. Na), c) the type of cation at octahedral sites (Al vs. Mg or Fe) and location of the layer charge (tetrahedral vs. octahedral), d) the type of structural cation sites (dioctahedral vs. trioctahedral), e) the salinity of pore water (low vs. high), i.e., CEC behaviour, f) the presence of kaolinite and other accessory minerals, such as oxides, which prevent erosion.

REFERENCES

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