

# Influence of Material and Solution Composition on the Extrusion/Erosion Behaviour of Compacted Bentonite

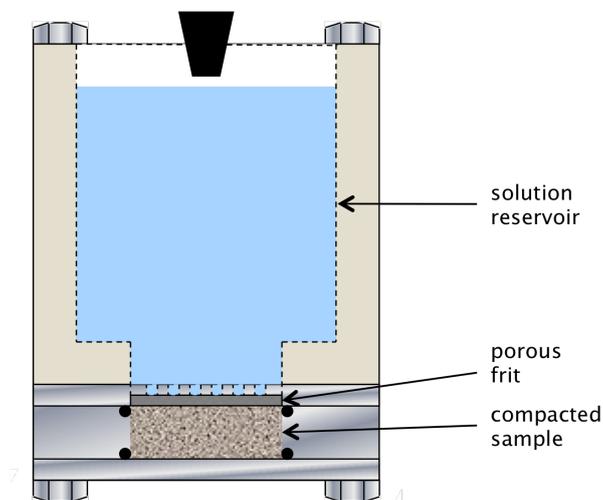
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In principle, in a KBS-3 type repository, the volume of a deposition hole is fixed and the bentonite buffer mass accordingly balanced to lead to the development of a suitable swelling pressure upon saturation. However, fractures intersecting the deposition holes give rise to the possibility that volume constrained conditions do not universally exist. Such fractures may provide pathways for the continued, localised, free swelling of bentonite buffer material. Loss of mass from the deposition hole by extrusion into intersecting fractures may compromise the long-term safety and performance of the buffer component of the engineered barrier system. Furthermore, the continued hydration and expansion of extruded bentonite in these fracture environments could lead to the separation of colloid-sized (or larger) particles by diffusion or shear which may have to be accounted for in possible radionuclide migration scenarios.

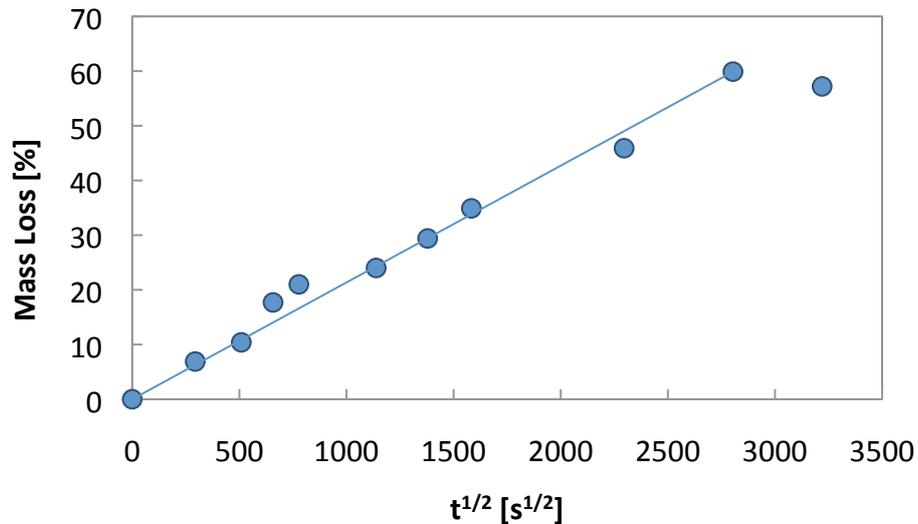
Geochemical conditions, with respect to both solution and material composition, are considered to play important roles regarding the fracture extrusion/erosion of bentonite buffer material. For example, calcium-montmorillonite exhibits limited free swelling relative to sodium-montmorillonite and the colloidal and rheological properties of montmorillonite dispersions are sensitive to the presence of electrolytes [Pusch 1983, Luckham and Rossi 1999]. Insofar as both the buffer material composition (due to ion exchange) and groundwater composition (dilution resulting from infiltration of glacial meltwater) are expected to evolve with time [Posiva 2006], so too might the potential for fracture extrusion/erosion of buffer material vary over time. The hydraulic characteristics of the intersecting fracture are expected to influence the extrusion/erosion process as well [Liu and Neretnieks 2006].

To evaluate the effect of material and solution composition on the potential for extrusion of buffer mass into intersecting fractures, a series of batch experiments were performed. In these experiments, total material mass loss through a compacted material/porous frit/solution reservoir interface (see Figure 1) was measured as a function of time. The effect of material and solution composition on extruded mass loss was analysed using combinations of compacted, homo-ionised bentonite (Ca-, Na-, Mg-Mt and admixtures thereof) and aqueous solutions of interest (from deionised water to high salinity concentrations). In some cases, measurements of stable colloid concentrations, above the distinct gel/sol phase boundary, were performed as well. Additionally, mechanical effects on mass extrusion were also analysed by varying both the porosity and the length of the interface.



**Figure 1.** Schematic illustration of batch extrusion/erosion cell with main features indicated.

Results from these experiments indicate that the extrusion of compacted buffer mass is a self-limiting, diffusion-controlled process (see Figure 2). These observations are in accordance with a view that ascribes the driving force of the extrusion process to swelling pressure with resistance provided by the viscosity of the extruded material and friction with the fracture surface. Moreover, material and solution composition effects on the rate of mass loss were clearly observed as well.



**Figure 2.** *Relative mass loss versus square root of time over a 50/50 Ca/Na-Mt : 100  $\mu$ m/1.3 mm porous frit : deionised water interface.*

Additionally, the mass fraction of spontaneously generated colloids, relative to the total extruded mass, was small to negligible for every measured case. As with the overall rate of mass loss, there were also clear material and solution composition effects on the magnitude of the measured colloidal mass fractions.

## References

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