

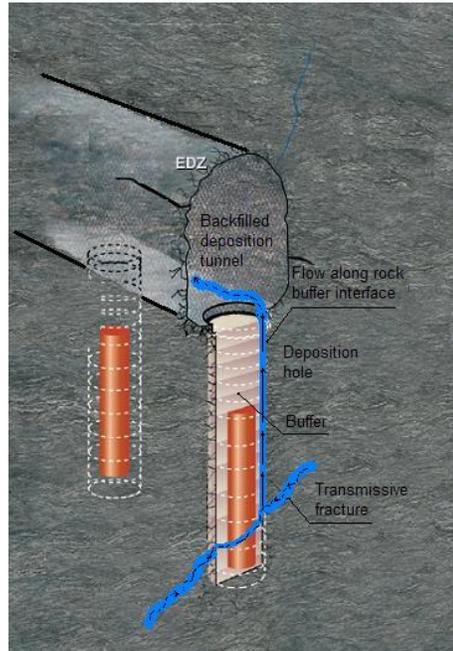
Erosion of buffer caused by groundwater leakages

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In the Finnish HLW disposal concept the most important properties of the bentonite clay being considered for these isolation purposes are its thermal behaviour, low hydraulic conductivity, diffusion limited transport, rheology, plasticity, sufficient swelling potential, and exchange capacity. All of these properties depend critically on bentonite density; therefore, any potential mass loss or redistribution events must be well characterized. One such event or process is the erosion of bentonite by flowing groundwater and the groundwater flowing in newly formed channels, in special. Mechanical erosion during the operational phase, due to high groundwater pressure gradients in open excavations, has been identified as a critical issue in TKS-2006 (Posiva 2006) and SR-Can (SKB 2004, SKB 2006). This work addresses the mechanical erosion of bentonite by fluid shear. The context is depicted in figure 1.

Figure 1. The system composed of deposition hole, buffer, deposition tunnel and backfilling with a flow from deposition hole intersected by leaking transmissive fracture to the backfilled deposition tunnel.



In order for buffer erosion to occur three processes must take place: detachment, entrainment, and transport. These processes are followed by the settling of the material and redistribution of buffer mass. Erosion begins with the detachment of a particle from surrounding material, which requires the application of shear forces greater than the attractive force between the particle and parent structure. Entrainment is the process by which the eroding medium lifts the detached particle into the flow. The most important aspect in entrainment is transfer of fluid's inertial forces via surface friction to particles' inertial forces, which, in turn, must overcome the frictional resistance between the particle and its surroundings. Factors influencing frictional resistance include gravity, particle mass, saturation degree of parent structure, composition of water present in parent structure, particle size, and surface roughness.

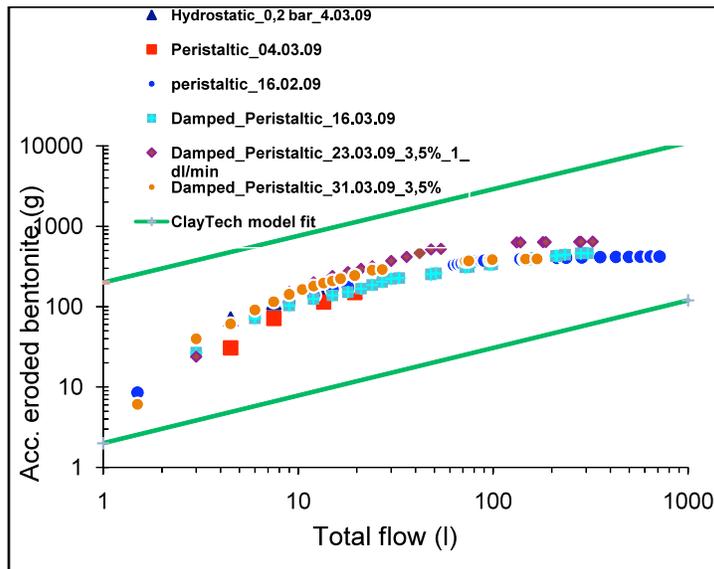
Recent erosion tests, whereby water flow was directed over compacted bentonite blocks or through a system of bentonite pellets, have indicated that bentonite erodes at a total mass of 1-10 g per litre of accumulated water flow (Börgesson and Sandén 2006). The erosion rates were observed to depend on

several different parameters such as salinity, flow rate, length of flowpath and type of bentonite and, therefore, the present results, which are based on limited types of bentonite, flow rates and salinities, are regarded as preliminary only. Erosion test have been carried out to simulate the erosion with different types of experimental set-ups using different flow rates and salinities. See Figure 2. The actual flow rate, $Q(t)$, depends on the opening of the flow channel, pressure difference between inlet and outlet together with the length of the flow channel. The complete phenomenological modelling of these subtle phenomena is going on and it will probably take few years before those results can be used directly for erosion modelling. The mass of the eroded material within a channel was estimated in the first phase of work using a 1-D erosion model. In this model the mass of eroded material was considered in terms of concentration of eroded solids, c , in a predefined volume of fluid. The change of concentration in time is considered to depend on advection of solids to and from the volume in question by fluid flow, change of radius, $R(z,t)$, entrainment of material and gravitational settling. The model is expressed in the following form:

$$\frac{d}{dt} \int_{V(z,t)} c \, dV = - \int_{V(z,t)} \frac{dc}{dt} \, dV + \int_{V(z,t)} \frac{dV}{dt} c + \int_{V(z,t)} \frac{dV}{dt} c + \int_{V(z,t)} \frac{dV}{dt} c$$

Entrainment, $\alpha(z,t)$ is modelled using a power law function combined with a Heaviside step function to reflect threshold shear stress for the onset of entrainment. In the current version the gravity term, $G(z,t)$, lumps various effects like buoyancy, Soret and Magnus effects. The results of work imply that the physical and theoretical model developed can simulate the clear dependency of erosion rate on flow rate, salinity and time.

Figure 2. Accumulated eroded bentonite versus total flow(double logarithmic graph) .



References

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