BENTONITE SWELLING PRESSURE IN PURE WATER AND SALINE SOLUTIONS

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Bentonite clays are known to have a high swelling capacity in low electrolyte water solutions. This gives rise to a macroscopic swelling pressure if the volume is restricted, which in combination with the associated low permeability are the main reasons for using bentonite clay as buffer material in HLW repositories. Salt solutions reduce the swelling capacity of bentonite, and no swelling pressure will obviously develop if the swelling capacity is reduced to an extent where the actual volume is not filled by the maximum swollen clay. The reduction may be described by the expression:

$$P_s = -\frac{RT}{M \cdot \varphi_w} \ln \frac{p}{p_e} \quad \text{pe} < \text{p}_0$$

Where $P_s$ is swelling pressure, $R$ is gas constant, $\varphi_w$ is partial specific volume of the water, $p_p$ is vapor pressure of clay adsorbed and of external salt solution, and $M$ is molecular weight of the water.

This paper presents a refined way to model swelling pressure for pure water and saline conditions. The swelling pressure in montmorillonite in contact with pure water may be calculated by use of the Possion-Boltzmann equation in combination with expressions for attractive forces at dry clay densities below 1200 kg/m$^3$. The effects of hydration of the charge compensating ions and changes in the dielectric constant of water are discussed for higher clay densities. Comparison is made with measured results from homo-ionic montmorillonites with calcium and sodium as charge compensating ions, and discrepancies are discussed.

The effects of saline solutions are calculated by use of ion equilibrium between the montmorillonite porewater and the external solutions. The calculations take into account the changes in ion activity as a function of salinity by use of the B-dot approach of the extended Debye-Hückel expression. A systematic swelling pressure decrease with increasing solution concentration in the external solution is postulated. However, there is still a significant bentonite swelling pressures also in 3M solutions at high clay densities. The validity of this model approach has been examined by comparison with measured results of the swelling pressure, water activity and pore-water concentration in the clay for a wide range of clay/water/salt conditions. In practice, the results show that there will be a sufficient swelling pressure in the buffer in a KBS3-repository, also if the system is exposed to brines.

![Graph](image.png)

**Figure 1:** Modeled (lines) and measured (dots) swelling pressures in pure water and sodium chloride solution. Legend shows solution concentrations in moles/L.