Effect of Freezing and Thawing on Compacted Bentonite Buffer Performance

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Over the time scale of the lifecycle of the spent nuclear fuel repository at Olkiluoto, local conditions are projected to experience both permafrost and glacial climactic phases, possibly repeatedly [Posiva 2006]. Permafrost typically occurs when cold and dry climate conditions prevail with no ice-sheet formation or during glaciation as subglacial permafrost [Hartikainen 2006].

Permafrost is generally defined as ground (soil or rock) that remains at or below 0 °C for at least two consecutive years. The growth and development of permafrost to some depth of the geologic subsurface depends on a complex heat exchange process across the atmosphere/ground interface and on the geothermal heat flow. Due to the potential impact on hydraulic, mechanical, and chemical subsurface properties and conditions, permafrost penetration is of interest for the performance and safety assessment of a deep, geologic repository [Vidstrand 2003].

Deleterious effects on porous soil material, resulting from freezing and thawing, are generally ascribed to the occurrence of ice formation. Of course exposure to permafrost does not necessarily imply the presence of ice in the affected material. Indeed the primary consequence of the confinement of water in small pores is a depression to lower temperature of the melting transition [Dash et al. 2006]. However, when ice forms in porous material, there is a corresponding increase in volume and/or pressure depending on the particular confining stresses at hand and the permeability to water migration [Smith and Onysko 1990].

If ice is not formed in the fully saturated buffer system, no increase in volume and/or pressure need be considered [SKB 2006]. If, on the other hand, ice does form, increased stress from the buffer on the canister and host rock will need to be taken into account.

In order to evaluate the effect of freezing and thawing on compacted bentonite buffer performance a series of experiments were conducted using constant-volume swelling pressure cells (see Figure 1) as follows:

- Pre- and post-freezing swelling pressure measurements were performed on fully saturated, high density, compacted Wyoming and Milos bentonite samples over five freeze/thaw cycles from RT to -18 °C with rapid (instantaneous) temperature exposure.
- *In-situ* swelling pressure measurements were performed on fully saturated, high density, compacted Wyoming bentonite samples during a temperature run from RT to -10 °C and back with relatively rapid temperature exposure.
- *In-situ* swelling pressure measurements were performed on fully saturated, compacted Wyoming bentonite samples encompassing a range of density values during a temperature run from RT to to -10 °C and back with slow, controlled temperature exposure (0.1 °C/h).
- In some cases, hydraulic conductivity measurements were performed before and after freeze/thaw exposure.

Initial results from these tests, for the high density samples (~2 g/cm^3), indicate that no significant irreversibility to swelling pressure function is incurred due to repeated freeze/thaw exposure (down to

-18 °C) and that pressure increases observed during freezing (down to -10 °C), presumably due to the formation of ice in the buffer material, are quite sensitive to the nature of the exposure.

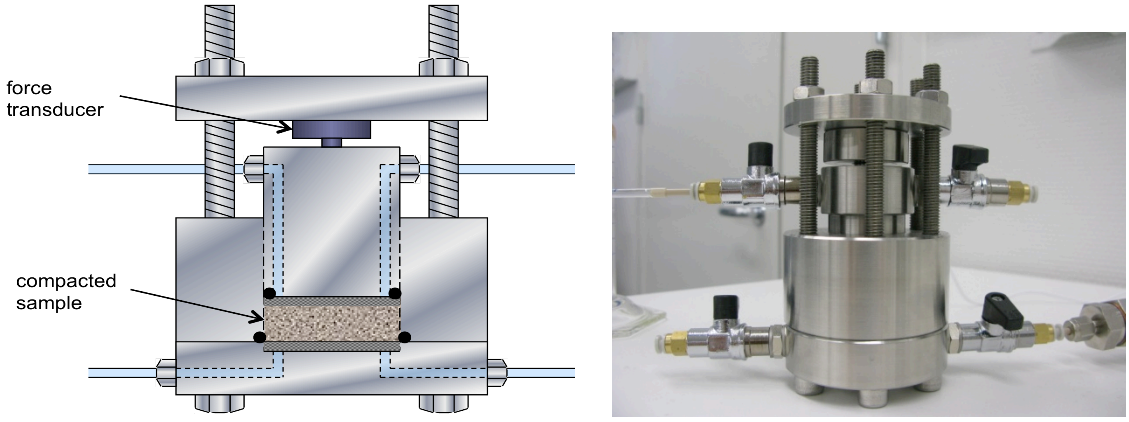

Figure 1. *Schematic illustration (left) and photographic image (right) of volume-confined swelling pressure cell.*

If available, results from similar preliminary freezing and thawing tests on selected backfill materials will be reported as well.

References

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