SATURATION OF BENTONITE DEPENDENT UPON TEMPERATURE

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The fundamental idea behind the long-term safe operation of a deep repository is the use of the multibarrier system principle. Barriers may well differ according to the type of host rock in which the repository is located. It is assumed that the buffer in the granitic host rock environment will consist of swelling clays which boast the ideal properties for such a function i.e. low permeability, high swelling pressure, self-healing ability etc. all of which are affected primarily by mineralogy and dry density. Water content plays a crucial role in the activation of swelling pressure as well as, subsequently, in the potential self healing of the various contact areas of the numerous buffer components made from bentonite. In the case of a deep repository, a change in water content is not only connected with the possible intake of water from the host rock, but also with its redistribution owing to changes in temperature after the insertion of the heat source (disposal waste package containing spent fuel) into the repository "nest". The principal reason for the experimental testing of this high dry density material is the uncertainty with regard to its saturation ability (final water content or the degree of saturation) at higher temperatures.

The results of the Mock-Up-CZ experiment (Svoboda & Va_í_ek, 2008) showed that when the barrier is constantly supplied with a saturation medium over a long time period the water content in the barrier as well as the degree of saturation settle independently of temperature. The Mock-Up-CZ experiment was performed at temperatures of 30° – 90°C in the barrier; therefore it was decided to experimentally verify this behaviour by means of targeted laboratory tests. A temperature of 110°C was added to the set of experimental temperatures resulting in samples being tested at 25°C, 95°C and 110°C.

The degree of saturation is defined as the ratio of pore water volume to pore volume which attains a value of 1.0 in the fully saturated material. In the case of fully saturated bentonite with high dry density this value may exceed this theoretical limit due to very strong forces acting within the structure of the solid material which change the properties of the fixed water monolayer (the highest values of water density are close to 2000kg/m^3) (e.g. Lamboj & Štěpánek, 2005).

The aim of the experiment was to compare the degree of saturation of samples saturated at different temperatures (25°C, 95°C and 110°C). Nine small physical models were used in the experiment. Cylindrically shaped samples with a height of 20mm and a diameter of 30mm were tested. The models were perforated and equipped with permeable plates on both bases to allow the supply of water. The expansion of the samples (volume change) was not permitted. The swelling pressure was not measured so as to keep the construction of the models as simple as possible. The saturation medium consisted of distilled water. The samples were compacted directly into the body of the individual models. The investigated medium consisted of Czech Ca-Mg bentonite from the Rokle locality, sieved to a fraction of 0-1mm. The target dry density was 1700kg/m^3 because Rokle bentonite at this dry density level contains the desired properties for use as a buffer (principally low permeability and a certain level of swelling pressure). A specific density of 2800kg/m^3 was used for further calculations. Three models were used for testing at a certain temperature. The three models were then placed in a pressure cooker and each pressure cooker was stored at a different temperature (25°C, 95°C and 110°C). The cookers had safety valves to limit the increase in generated steam pressure at higher temperatures; the exact monitoring of steam pressure was, unfortunately not possible. The models were dismantled after all the bentonite samples became fully saturated. The experiment was monitored by the regular weighing of the sample models.

The bentonite samples completely filled the available volume of the models. Following dismantling, the mass water content was determined so that the degree of saturation could be calculated. As far as the subsequent calculation of the degree of saturation was concerned, a problem with the exact identification of water density at higher temperatures occurred because the pressure within the pressure cookers was not monitored. Of course, the water density value does not change significantly but it does cause a degree of uncertainty regarding the calculated results. An estimation of two water density values for one sample was used for identifying the uncertainty range. It is believed that the real water density value lies within this range.

The resultant values of the degree of saturation were within the range 1.15 (25°C) – 1.24 (110°C). This would seem to show a nominal increase in the degree of saturation depending on temperature but that overall the degree of saturation is not significantly affected by temperature. This outcome is consistent with certain findings in literature (e.g. Villar, 2002) and it confirms the Mock-Up experiment hypothesis.

Figure 1: Physical model.

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