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High Pressure Cavern Analysis

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October 2002

10   Summary

The goal of these investigations is to develop a model which forms a basis for evaluating and/or assessing the conditions in an abandoned cavern in domal salt that is filled with brine. Here simultaneously the mechanical and thermal state variables of the rock matrix as well as the pore pressures have to be taken into consideration.

With respect to the internal pressure in a sealed cavern, there is a coupling effect between

- the volume change of the cavity as a result of the stressing of the rock matrix (cavern volume convergence),

- the volume change of the material occupying the cavern (brine) as a result of temperature changes (thermal expansion of the brine),

- the volume changes of the material occupying the cavern as a result of the infiltration of brine into the rock mass.

The conditions of the rock mass and the internal pressure development of the cavern are calculated in a simultaneous computation of the state variables of all three systems involved (rock matrix, temperature, pore space) assuming the above mentioned coupling via the internal pressure of the cavern.

The description of the infiltration behavior of the rock salt under stress conditions as existing under cavern abandonment conditions is based on the results of the laboratory tests carried out by LMS within the 2001-1-SMRI research projects. A subsequent review of these results formed the basis for the development of three criteria to describe the permeability development dependent on the effective tangential stress in the rock matrix. In addition, the experience from the Etzel in-situ test is also taken into account.

The three criteria are implemented in the software to calculate the state variables of the rock and validated on the basis of the recalculation of the LMS tests. In addition, an iteration method to take into consideration the pressure build-up in the sealed cavern was implemented and validated for the sensitivity analysis of various boundary conditions of a sealed cavern.

The aim of the research project is to compare different cavern configurations and abandonment conditions with a focus on describing the effects of these differences with respect to long-term behavior. This study will therefore not attempt to formulate any safety margins. The safety-related evaluation of a cavern under abandonment conditions is dependent on a number of location-specific and operational constraints which cannot be included to their full extent within the

framework of this study. For this reason, every cavern which is to be abandoned, needs to be investigated on a project-specific basis.

With the intend to show that with the present research work under 2002-2-SMRI projects not more questions have been risen than answers were given. A possible way by example procedure for cavern abandonment is outlined.

The following summarizes the most important results of the research project according to 2002-2-SMRI :

- The permeability behavior of rock salt can be described dependent on the tangential effective stress. This means that a parameter has been found which enables the results of the laboratory and in-situ tests to be understood and interpreted.

- The same parameter, the tangential effective stress can be used as a design parameter for the description of state of a cavern under sealing conditions.

- The most important impact on the peak level of the tangential effective stress originates from the thermal state of the brine and the rock mass at sealing. If the thermal balance between brine and the rock mass has to be achieved during plugging, an intermediate state of high tangential effective stresses and hence large zones where permeabilities are enhanced will develop. For the long- term behavior a more favorite state will be reached. This state is equivalent with the case of a cavern where the brine is in thermal equilibrium with the rock mass at the sealing.

- Besides thermal aspects and with a focus on long-term conditions under plugging cavern height, cavern shape, material characteristics of the rock salt and primary rock salt permeability are of major impact on the tangential effective stresses and the maximum cavern pressure reached after sealing.

- The simulation model of an abandoned cavern which has been developed is suitable for the long-term modeling of the infiltration process which begins after cavern sealing.

- The results of these simulations can be used as the basis for answering the question of whether a cavern can be abandoned under the project-specific local constraints.

- The evaluation criteria for abandonment of a brine-filled cavern need to be determined on a case-by-case basis.