Thermomechanical analysis of barrier integrity in a generic repository for nuclear waste in bedded salt formations

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This study focuses on numerical modeling to analyze the long-term barrier integrity in a generic repository for heat-generating waste in bedded salt formations in Germany. Based on two generic geological models for flat-bedded salt and salt pillow and two emplacement concepts for each model type, the numerical analyses were carried out considering thermal loading caused by the disposal of heat generating nuclear waste. The TM coupled calculations were performed with the FEM code JIFE (Faust et al. 2016). A literature review (Liu et al. 2017) summarized appropriate constitutive models and thermal, mechanical and hydraulic parameters of the geological units. It provides the input for the numerical calculations.

The integrity of the salt barrier is evaluated based on calculated stress by considering dilatancy criterion and fluid pressure criterion. The results of the thermomechanical calculations indicate that the dilatancy criterion is satisfied in case of the flat-bedded salt. In case of the salt pillow, dilatant rock zones develop at the top of the salt barrier during the first 20-82 years. These zones reach up to 50 m. The fluid pressure criterion is violated up to 60 m from the top into the salt barrier in all the modeling cases. However, at all times, at least 300 m intact salt barrier remains: The integrity of a large part of the salt barrier is not affected.

Furthermore, the analysis of the sensitivity of the generic models under different geological conditions and emplacement concepts may give guidance on future site-selection and repository design optimization processes.

Faust, B., Krüger, R., Lucke, A. & Tertel, S. (2016): Jife[MP] Java application for Interactive nonlinear Finite-Element analysis in MultiPhysics. Benutzerhandbuch für JIFE 5.1.1; Berlin.

Liu, W., Völkner, E., Popp, T. & Minkley, W. (2017): Zusammenstellung der Materialparameter für THM-Modellberechnungen - Ergebnisse aus dem Vorhaben KOSINA. Bundesanstalt für Geowissenschaften und Rohstoffe (BGR); Hannover.