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Compaction of crushed salt for safe containment – a summary of the KOMPASS projects

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Abstract. For the underground disposal of high-level nuclear waste in rock salt formations, the safety concept includes the backfilling of open cavities with crushed salt. For the prognosis of the sealing function of the backfill for the safe containment of the radioactive waste, it is crucial to have a comprehensive process understanding of the crushed-salt compaction behavior. The crushed-salt compaction process is influenced by internal properties (e.g., grain size, mineralogy, and moisture content) and boundary conditions (e.g., temperature, stress state, and compaction rate) and, therefore, involves several coupled thermal–hydro–mechanical (THM) processes (Hansen et al., 2014; Kröhn et al., 2017).

With the paradigm shift from the limited release of radionuclides to safe containment due to the German Repository Site Selection Act passed in 2017, the importance of crushed salt as geotechnical barrier has increased, with a focus on the evolution of its hydraulic properties. Based on the knowledge gaps in the current process understanding, the "Compaction of crushed salt for safe containment" (KOMPASS) projects were initiated to improve the scientific basis behind using crushed salt for the long-term isolation of high-level nuclear waste within rock salt repositories. The efforts to improve the prediction of crushed-salt compaction begun during the first phase of the KOMPASS projects (Czaikowski et al., 2020) and were followed up in a second phase ending in June 2023. The primary achievements of the projects are as follows (Czaikowski et al., 2020; Friedenberg et al., 2022):

- specification of the KOMPASS reference material, an easily available and reproducible synthetic crushed-salt material, for generic investigations;
- development of pre-compaction methods and successful production of samples in the short term and under in situ loading conditions;
- formulation of an extended laboratory program addressing the isolated investigation of known relevant factors influencing the compaction behavior of crushed salt (Düsterloh et al., 2022);

- execution of long-term compaction tests addressing isotropic and deviatoric load changes, temperature, and compaction state;
- construction of a backfill body using the KOMPASS reference material in the Sondershausen mine through collaboration with the SAVER (Entwicklung eines salzgrusbasierten Versatzkonzepts unter der Option Rückholbarkeit) project (Schaarschmidt and Friedenberg, 2022);
- advancement of the tools for microstructure investigation methods (Svensson and Laurich, 2022);
- generation (first stages) of a microphysical process list combining literature research with our own findings;
- benchmarking of long-term compaction test for model development and optimization of various existing models as well as the development of new models;
- application of a virtual demonstrator (2D model representing a backfilled drift in rock salt) for the visualization of developments and the quantification of the models (Rabbel, 2022).

In summary, the KOMPASS projects contributed to the reduction of uncertainties and the strengthening of the safety case for using crushed salt within rock salt repositories.

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