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A better understanding of the internal deformation of layered evaporite bodies with high mechanical contrasts for salt exploration: A case study from the NE Netherlands using numerical modelling.

Alexander F. Raith (1) and Janos L. Urai (2)

(1) DEEP.KBB GmbH, Bad Zwischenahn, Germany (alexander.raith@deep-kbb.de), (2) RWTH Aachen University, Structural Geology, Tectonics and Geomechanics, Aachen, Germany

The position and distribution of non-halite layers like potassium and magnesium (K-Mg) salts or anhydrite/carbonate stringers in evaporite bodies is crucial for many solution-mining and storage activities in salt. Depending on the enterprise, these lithologies can either state a serious drilling risk, have a negative impact on cavern shape development or cavern integrity, or, vice versa, could be the desired target for mineral mining. Either way, properties in these layers like viscosity, permeability and solubility can differ strongly from halite. Common K-Mg salts are typically 10 to 100 times less viscous than halite, while anhydrite and carbonate are about 100 times more viscous. In most parts, mechanically layered evaporite bodies experienced complex deformation, resulting in large-scale internal folding with ruptured stringers and shear zones. Although most of these extraordinary “soft” or “strong” layers are rather thin (<100 m) compared to the dominating halite, we propose they have first order control on the deformation and the resulting structures inside salt bodies.

In a case study, 2D plain strain models containing the key components of salt structures in the NE Netherlands were performed to analyze the influence of non-halite layers on the internal deformation during lateral salt flow. For some of these salt bodies, which are used for solution mining and/or hydrocarbon storage, the internal structure is relatively well known, based on 3D seismic images, seismic inversion and interpretation of well and core data and well-based surveys. Thus the outcomes of the numerical models can be compared to salt bodies with different degree of complexity.

The model results show that a continuous or fractured stringer is folded and thrusted during salt contraction, while soft K-Mg salt layers act as internal décollement. Depending on the viscosity of the fractured stringers, the shortening is mostly compensated by either folding or thrusting. This folding has major control over the early internal structure of the salt body imposing a dominating wavelength to the whole structure during early deformation. Beside the mechanically strong stringers, K-Mg salt layers also influence the deformation and salt flow inside the salt body. Thus, if a soft layer is present stratigraphically close to a stringer, the latter will experience more deformation. On the other hand, the structure of the soft K-Mg salt layers and the internal deformation of those beds is strongly influenced by nearby folding of a high-viscosity stringer. As a result, the les viscous K-Mg salts are withdrawn from areas above stringer anticlines to areas above stringer synclines.

Due to mostly limited exploration data, the knowledge of the internal structure of salt bodies is in many cases unsatisfying, not only in early stages of exploration. Thus, a good understanding of the processes and resulting geometries during deformation can help to develop better models and improve predictions.