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The large scale structures of the Late Permian Zechstein 3 intra-salt stringer, northern Netherlands

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The three dimensional study of the internal structure of salt structures on the several different scales is of fundamental importance to understand mechanisms of salt tectonics, for intra-salt storage cavern stability, and for drilling in salt-prone petroleum systems with associated problems like borehole instability and overpressured fluids. While most salt-related studies depict salt as structureless bodies, detailed field-, well- and mining gallery mapping have shown an amazing spectrum of brittle, complexly folded, faulted and boudinaged intra-salt layers ("stringers"), but mostly on a very local scale. First detailed insights into these three-dimensionally heterogeneous and very complex structures of the layered evaporites were provided by observations in modern high-resolution 3D seismic data, such as across the Late Permian Zechstein in the Southern Permian Basin (SPB). In the northern Dutch onshore part of the SPB, the Z2 and Z3 halite interface is characterized by the seismically visible reflections of the 30-150 m thick Z3 anhydrite-carbonate layer that clearly resolves the complex intra-salt structure. This stringer shows a high fragmentation into blocks of several tens of meters to kilometres diameter with complexly folded and faulted structures that correlate to the regionally varying deformation stages of the Zechstein, as it is implied by the shape of Top Salt.

After an extensive seismic mapping over the entire northern Netherlands, structures observed include an extensive network of thicker zones, inferred to result from early karstification. Later, this template of relatively strong zones was deformed into large scale folds and boudins as the result of salt tectonics. Non-plane-strain salt flow produced complex fold and boudin geometries that overprint each other. There are some indications of a feedback between the early internal evolution of this salt giant and the position of later salt structures.

The stringer has a higher density then the surrounding halite, and in the literature there is some controversy concerning the sinking rates of single stringer fragments. We observed no structures indicative of sinking, but conclude that the present-day position of the blocks can be explained by internal folding of the entire salt section.

In the end, this study aims at (i) improving the understanding of the development and dynamics of Zechstein halokinesis, (ii) gaining new insights into the 3D internal deformation in salt, and (iii) a linkage of processes in the layered evaporites with the deformation of the enclosing sub- and supra-salt sediments.