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Seismic interpretation of the internal geometry of the Zechstein evaporites – Large scale structures and internal stability

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Salt structures are illustrated in two strikingly different ways; publications focussing on the over- and underburden (often based on reflection seismic data) generally depict the salt as structureless layers. On the other hand, detailed field-, well- and mining gallery mapping have shown an amazing spectrum of complexly folded, faulted and boudinaged anhydrite, clay, various salts and other interlayers inside the halite, but these are often small scale. These interlayers often have different material properties, making salt layers less homogenous as often assumed. We compared observations from 3D seismic reflection data from the Dutch subsurface with data from salt mines and analogue and numerical models to better understand the large scale geometry of salt bodies. The techniques presented here can be used to study the internal structure of salt bodies all over the world.

We present a first-order description of large-scale structures observed in the complexly folded and faulted internal structure of Zechstein salt bodies in NW-Europe. We focus on a relatively brittle, folded and boudinaged claystone- carbonate- anhydrite member (the non-halite lower section of the Lower Leine (Z3) Formation, called "Z3 stringer" in this work), which is fully encased in ductile salt and forms an excellent seismic reflector. This or similar stringers play a role in the production of hydrocarbons and the stability of denser anhydrite blocks in the Zechstein forms also a factor in the development of underground storage sites.

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. Flow of salt during tectonic phases was rarely plane-strain, producing 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 tectonism, suggesting a further control for the position of salt structures in addition to basement faults.

The stringer has a higher density then the surrounding halite, and there is some controversy concerning the rates at which these blocks sink. In this work we observed no structures indicative of sinking, but rather conclude that the present-day position of the blocks can be explained by internal folding of the salt.

This work has shows that the internal geometry of the Zechstein evaporate is extremely complex, but can be studied using high-quality 3D reflection seismic dataset. The internal geometry of salt deposits rival the internal structure of mountain belts, both in complexity and size.