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Subsidence and basin-fill architecture of a lignite-bearing salt rim syncline: insights into rim syncline evolution and salt diapirism

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In the last decades, salt-withdrawal basins achieved much attention due to their significant hydrocarbon potential like in the Gulf of Mexico, along the Brazilian passive margin and in northern Germany. The Helmstedt-Staßfurt salt wall and the related Schöningen rim syncline are an ideal natural laboratory to study the evolution of salt-withdrawal basins in detail. An excellent data set of 358 wells allows a detailed assessment of the basin-fill architecture. The aim was to expand on the classical cross-section based rim syncline analysis by the use of 3D models and basin simulations. The Helmstedt-Staßfurt salt wall is 70 km long, 6-8 km wide and one of the most important diapiric structures in northern Germany, based on the economically significant lignite-bearing rim synclines. The analysed Schöningen rim syncline, located on the southwestern side of the Helmstedt-Staßfurt structure, is 8 km long and 3 km wide. The basin-fill is up to 366 m thick and contains 13 major lignite seams with thicknesses between 0.1 and 30 m. Cross-sections perpendicular to the basin axis indicate that the basin-fill has a pronounced lenticular shape. This shape varies from more symmetric in the NW to clearly asymmetric in the SE. It coincides to the broadening of the salt diapir from NW to SE. The geometry of the rim syncline therefore seems to be a function of the diapir morphology. Sediments close to a diapir margin tend to be sheared by the rising diapir and this effect is probably enhanced where the diapir becomes broader and as a result, the related rim syncline is more asymmetric. Isopach maps imply a two-fold depocentre evolution. The depocentre migrated over time towards the salt wall and also showed some distinct shifts parallel to the salt wall. The shifts parallel to salt wall were abrupt, in contrast to the more gradual migration of the depocentres perpendicular to the salt wall. The basin modelling part of the study was carried out with the software PetroMod®, which focused on the burial history of the rim syncline. Modeling results also show the progressive migration of the rim syncline depocenter towards the salt wall. The extracted geohistory curve shows initial rapid subsidence between 57 and 50 Ma and more moderate subsidence from 50 to 34 Ma. This pattern is interpreted to reflect salt migration from the source layer into the salt wall. The initial salt-withdrawal rate was rapid but later decreased probably due to depletion of the source layer. From a regional perspective, the sediments associated with the salt wall vary in age along strike. The oldest sediments are present at the northwestern and southeastern ends of the structure. The youngest sediments are present towards the central part of the salt wall. This age pattern implies that the break-through of the salt wall was initiated at the edges. The evolution of the Helmstedt-Staßfurt salt wall can be subdivided into the three stages reactive, active and passive diapirism. Initial salt rise was probably triggered by extension. Diapirism was enhanced due to contraction during the Late Cretaceous. The salt movements in the Tertiary were mainly driven by sediment loading in the rim synclines.