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3D basin and petroleum system modelling study from the northwestern offshore Germany (Entenschnabel)

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Abstract

A 3D basin and petroleum system modelling study covering the northwestern German North Sea (Entenschnabel), has been carried out to reconstruct the thermal history, maturity and petroleum generation of three potential source rocks, namely the Namurian-Viséan coals, Lower Jurassic Posidonia Shale and the Upper Jurassic Hot Shale. The 3D-model's extent includes parts of the southern end of the North Sea Central Graben and its surrounding platforms and structural highs. The geological components of the model are leant on recently compiled maps and structural information from the Entenschnabel area. These include thickness and depth maps of prominent stratigraphic horizons as well as locations of faults and salt structures. The time span from the Late Palaeozoic to the Present is represented by the model including three erosional phases related to large-scale tectonic events: the Saalian (Late Carboniferous-Early Permian), the Late Cimmerian (Late Jurassic) and the Subhercynian inversion phase during the Late Cretaceous. Additionally, the salt movements through time expressed as diapirs and pillows are considered within the model.
Modelling results indicate that the northwestern study area did not experience the Late Jurassic heat flow peak of rifting as in the Central Graben. Therefore, two distinct heat flow histories are needed since the Late Jurassic to get a match between measured and calculated vitrinite reflection data. The Namurian-Viséan source rocks entered the early oil-window during the Late Carboniferous, and reached an overmature state in the Central Graben during the Late Jurassic. The oil-prone Posidonia Shale entered the main oil-window in the Central Graben during the Late Jurassic. The deepest part of the Posidonia Shale reached the gas-window in the Early Cretaceous showing maximum transformation ratios of 97% at present-day. The Hot Shale source rock exhibits transformation ratios of up to 78% within the northwestern Entenschnabel and up to 20 % within the Central Graben area. The existing gas field (A6-A) and oil shows in Chalk sediments of the Central Graben can be explained by our model.