Geological evolution of the North Sea: a dynamic 3D model including petroleum system elements

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This study investigates the sedimentary basin evolution of the German North Sea with a focus on petroleum generation, migration and accumulation. The study is conducted within the framework of the project "Geoscientific Potential of the German North Sea (GPDN)", a joint project of federal (BGR, BSH) and state authorities (LBEG) with partners from industry and scientific institutions.

Based on the structural model of the "Geotektonischer Atlas 3D" (GTA3D, LBEG), this dynamic 3D model contains additionally the northwestern part ("Entenschnabel" area) of the German North Sea. Geological information, e.g. lithostratigraphy, facies and structural data, provided by industry, was taken from published research projects, or literature data such as the Southern Permian Basin Atlas (SPBA; Doornenbal et al., 2010).

Numerical modeling was carried out for a sedimentary succession containing 17 stratigraphic layers and several sublayers, representing the sedimentary deposition from the Devonian until Present. Structural details have been considered in terms of simplified faults and salt structures, as well as main erosion and salt movement events. Lithology, facies and the boundary conditions e.g. heat flow, paleo water-depth and sediment water interface temperature were assigned. The system calibration is based on geochemical and petrological data, such as maturity of organic matter (VRr) and present day temperature.

Due to the maturity of the sedimentary organic matter Carboniferous layers are the major source rocks for gas generation. Main reservoir rocks are the Rotliegend sandstones, furthermore, sandstones of the Lower Triassic and Jurassic can serve as reservoir rocks in areas where the Zechstein salts are absent. The model provides information on the temperature and maturity distribution within the main source rock layers as well as information of potential hydrocarbon generation based on kinetic data for gas liberation.

Finally, this dynamic 3D model offers a first interpretation of the current data base and an estimation of the structural- and burial evolution of the German North Sea area, including information on the petroleum system elements. It includes information about possible migration pathways, oil and gas accumulations, as well as the type of generated hydrocarbons and non-hydrocarbons.

References:

Doornenbal, J.C. and Stevenson, A.G. (editors), 2010. Petroleum Geological Atlas of the Southern Permian Basin Area. EAGE Publications b.v. (Houten).