

Thermal history of the southern North German Basin based on organic maturation and clay mineral analysis - impact on hydrocarbon potential

H. Jäger*, Butz-Braun, R.**

*GeoResources STC, Heidelberg, **Tonmineralogische Beratung

Abstract

The North German Basin (NGB) covers northern Germany to the North Sea, recording a polyphase basin development, including huge Mesozoic and Upper Palaeozoic sediment infill. During the Devonian-Carboniferous several organic rich shale units are developed basinwide, even within the carbonate shelf and flysch basin facies. In the Carboniferous three major phases of 'black shale' deposition are developed, which have become targets for unconventional shale gas exploration: Lower Alum Shales, Cherty Transitional Beds and Upper Alum Shales. The current study is focused on these shale units in southern NGB. Published maturation data from the area indicate upper-gas to overmature conditions, representing good thermal conditions for the development of shale gas plays. Towards the north maturation decreases down to the oil window, showing peak to late oil conditions.

New maturation data from the southern NGB from Rock Eval analysis (Tmax) are strongly inconsistent: partially highly mature to overmature conditions, but partially immature to lower oil window conditions, which is clearly contradicting the established maturation model. Optical analysis shows a bipartite kerogen composition, dominated by highly mature with mostly small amounts of less mature organic matter. While less mature organic matter represents the in-situ basin maturation, the highly mature organic matter is recycled from previous depositional systems. Vitrinite reflectance (VR) of the in-situ vitrinite assemblage shows uniform maturation along the southern NGB representing late oil conditions. To verify these new results clay mineral analysis was performed additionally. Due to the presence of mixed-layer clay minerals (ML) Illite crystallinity (standard clay maturity parameter) could not be used. Thus a new workflow was developed, thermo-coupled clay mineral analysis (TCCMS), using the thermally controlled change of layer distance within the ML. This is an irreversible process recording the maximum temperature of the rocks. TCCMS also shows temperatures of late oil conditions in all samples, clearly confirming the results from VR analysis. Also some conodont colour data available from the study area indicate late oil conditions.

In contrast to previous models the maturation of the southern NGB is similar to the maturation of the rest of the NGB. The previously described decrease of maturation towards the north is controlled by the decrease of highly mature recycled organic matter towards the north, linked to the decreasing sedimentary input from the active Palaeozoic continental margin in the south. Therefore no shale gas plays can be expected in the southern NGB, but only shale oil plays, in places where kerogen composition suits oil generation.