Geophysical Research Abstracts, Vol. 7, 02571, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02571

Periods of extension and inversion in North Germany: a basin modelling study on subsidence, uplift and petroleum generation

Danny Schwarzer and Ralf Littke

Institute of Geology and Geochemistry of Petroleum and Coal, Lochnerstr. 4-20, RWTH Aachen University, 52056 Aachen, Germany

schwarzer@lek.rwth-aachen.de

Introduction

The North German Basin is part of a complex system of sedimentary basins which originate from a regionally extensive phase of extension during Permian times. After Triassic post rift burial with high sedimentation rates and great thicknesses of sedimentary rocks, differentiation into various subbasins started in the Jurassic. Our study area is located at the margin between two of these subbasins: the Pompeckj Block in the north and the Lower Saxony Basin in the south.

In the study area a 2D modelling study was performed that intended to reconstruct temperature and burial history, uplift, maturation, as well as petroleum generation and accumulation within the so-called „Tight Gas Area“ north of Hannover. This area is characterized by partly low permeabilities in Rotliegend (Permian) sandstones which act as the major gas reservoir rocks of the basin (Gaupp et al. 2004). The 2D numerical modelling used the software package PetroMod® and the temperature history simulations were calibrated by a great number of vitrinite reflectance measurements performed in the framework of this study.

Thus it should be possible to to analyse the maturation of organic matter within Palaeozoic and Mesozoic rocks, to determine the timing of hydrocarbon generation as well as to evaluate the remaining generation potential at certain structural positions.

Burial and Maturation History

The chosen 2D section is situated nearby Hanover and runs from well-known gas fields in the north across the river Aller into the vicinity of the unique gasfield Thönse in the south (Fahrion & Betz 1991). Approximately at the Aller River (section km 40) the section crosses the Aller lineament, which separates the Pompeckj Block in the north from the Lower Saxony Basin in the south. This causes the Paleozoic gas source rocks to be at vastly different depths at present. In the north mainly coal-bearing sedimentary rocks of the Westfalian C build the pre-Permian basement whereas older coal-bearing rocks of Westfalian B, Westfalian A and even Namurian age underlie the Permian strata in the south.

The geological history of the area can be described as a succession of extensional and inversional periods which acted at oppositional times for the northern (Pompeckj Block) and the southern part (Lower Saxony Basin) and thus led to a significant differentiation between both areas. Not only were sediments removed or deposited which accounts for the burial heating and the maturation of the organic matter but also the accompanying heat flows changed noticeably. Other phenomena such as salt diapirism could be triggered by tectonic events, too, and certainly would influence the temperature field and lastly the maturation. This development had a huge impact on the timing of hydrocarbon generation and is indicated by the present-day maturity distribution.

The basement of the Permian basement system consists of Carboniferous and older sedimentary rocks which were uplifted and partly eroded during Variscan orogeny. In the southern part of the 2D section, more than 1500 m of Carboniferous sediments were removed instead of only 400-1000 m in the north. Soon after this regional tectonic event rather local differentiation took place when Early Permian transtensional processes formed the typical horst-and-graben setting in the northern part of the section. The surface of the underlying Carboniferous coal-bearing sequence now already showed variations in depth reaching more than 1000 m over small distances of only a few kilometres.

During the Mesozoic, the burial history of both geological units remained similar until the Jurassic inversion of the Pompeckj Block which led to the removal of about 700 m of Jurassic sediments in the northern part. While the maturation within Carboniferous rocks stagnated in the north until renewed sedimentation in the Upper Cretaceous occurred (e.g. remained around 0.9% V_r in lower Westfalian C), the drastic rise in subsidence in the southern part of the section led to an increase in vitrinite reflectance to 1.5% V_r at Jurassic times and to around 3% V_r in the Santonian. At that time the Lower Saxony Basin became inverted and the maturity did not increase significantly since then. In contrast, the renewed strong sedimentation at the Pompeckj Block dur-

ing the Upper Cretaceous and partly during the Tertiary enhanced the maturity within the Palaeozoic source rocks to around 1.7% in lower Westfalian C rocks (Schwarzer et al. 2003).

While the Palaeozoic source rocks in the south have completed their full hydrocarbon generation potential (gas) from Early Jurassic to Late Cretaceous times, the northern part mainly generated hydrocarbons (gas) since the Late Tertiary until the present. Presumed oil generation and migration from Palaeozoic rocks is indicated by locally occurring solid bitumen in Rotliegend reservoir sandstones. Whether the oil is derived from the coal-bearing Upper Carboniferous sequence or even deeper, marine sediments, is not yet fully understood. In any case oil generation has been fully completed during late Triassic to early Jurassic times (Littke, Brauckmann, Radke & Schaefer 1996). At deeply buried graben positions in the north almost no gas generation potential is left in the Carboniferous source rocks, but there are horst positions that have not been buried to great depths that still have around 20-30% remaining hydrocarbon generation potential. Additionally, already existing large salt accummulations are characterised by high thermal conductivities which decreased temperatures below thus reducing maturation and preserving a significant gas generation potential, too.

Conclusions

While the study area (and most likely the major part of the North German Basin) can be simply divided into two parts regarding the structural and geological evolution, the maturation history and the present maturity pattern of Palaeozoic rocks within both units appears more complex. This is caused mainly by local tectonic displacement and varying erosional levels on the one hand and intense salt movements with great influence on the temperature field and thus on the maturation one the other hand. With respect to petroleum generation, it therefore can be assumed that locally preserved generation potential still accounts for active present-day hydrocarbon generation and migration within an otherwise definitely “mature basin”.

References

Fahrion, H. and Betz, D. (1991): Geologischer Rahmen, Fund- und Fördergeschichte. in: Das Gasfeld Thönse in Niedersachsen. Niedersächsische Akademie der Geowissenschaften, 6: 7-10. Hannover.

Gaupp, R., Baunack, C., Pudlo, P., Solms, M., Trappe, H., Schubarth-Engelschall, J., Littke, R., Schwarzer, D., Oncken, O., Krawczyk, C., and Tanner, D. (2004): Palaeo Oil- and Gasfields in the Rotliegend of the North German Basin: Effects upon Hydrocarbon Reservoir Quality. DGMK-Research Report 593-8, 236 pp., unpublished report. Hamburg.

Littke, R., Brauckmann, F.J., Radke, M. and Schaefer, R.G. (1996): Solid bitumen in Rotliegend gas reservoirs in northern Germany: Implications for their thermal and filling history. - Zbl. Geol. Paläont. Teil I, H.11/12: 1275-1291. Stuttgart.

Schwarzer, D., Tanner, D., Littke, R., Krawczyk, C., Oncken, O., Solms, M., Gaupp, R., Schubarth-Engelschall, J., Trappe, H., (2003): Strukturelle Analyse (3D) und Beckenmodellierung (2D) im Bereich von Tight Gas Arealen am Südrand des Rotliegend Gas Plays. DGMK Tagungsbericht 2003-1: 17-30. Hamburg.