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Anna Alexandra Vackiner

Sedimentary Facies Reconstruction and Kinematic Restoration of Tight Gas Fields

Studies from the Upper Permian in Northwestern Germany

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Doctoral Thesis accepted by
the RWTH Aachen University, Germany

Springer

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Anna Alexandra Vackiner, Philipp Antrett, Frank Strozyk, Harald Stollhofen, Stefan Back and Peter Alfred Kukla (2012) Reconstructing the Upper Permian sedimentary facies distribution of a tight gas field in Central Europe on the basis of a modern analog field study in the Panamint Valley, western U.S., Geosphere, Vol. 8(5), p. 1129–1145.

Anna Alexandra Vackiner, Philipp Antrett, Frank Strozyk, Harald Stollhofen, Peter Kukla, Stefan Back (accepted) Integrating salt kinematics and regional tectonics across a Permian gas field: a case study from East Frisia, NW Germany. International Journal of Earth Sciences.

When you reach the end of your rope, tie a knot in it and hang on

—Thomas Jefferson

Supervisor's Foreword

Natural Hydrocarbon Gas is considered to represent the "bridging fuel" until new energies become technically and economically viable. Among hydrocarbon gas, one can classify conventional, unconventional and tight gas resources. The unconventional and tight gas resources have recently received much interest because of the potential very large reserves, which could be produced with suitable technology. Tight gas reservoirs which are found throughout the world and which occur in all common types of reservoir have been produced for many decades, but still pose a major technical challenge owing to their heterogeneous reservoir characteristics and in particular their low permeability and low porosity. Given the global importance of such reservoirs, the understanding of the complexity of tight gas fields therefore requires an integrated approach involving geological, geophysical and petrophysical analysis which very few publications to date have achieved.

The thesis of Alexandra presents such a multidisciplinary approach towards the analysis of complex tight gas reservoirs using the example of the Permian in the Northwest European Basin. Despite a long exploration and production history in this basin, previous work in Germany has mainly concentrated on the overall basin evolution based on seismic and wireline borehole data and the diagenesis of the reservoirs based on core data. Very little work on the other hand has been undertaken to discern the multiple reactivations of structural elements within the basin and to separate syntectonic versus post-tectonic deformation patterns and styles. The methods used in this work therefore include geological and geophysical analyses, remote sensing, 2D retro-deformation modelling and log- and core analysis.

In a first step, a detailed and high-resolution facies analysis of fluvio-eolian sediments of the Upper Rotliegend II sequences was undertaken. A separation of different dune types and interdune deposits was achieved and supported by a comparison with modern reservoirs in Panamint Valley, western USA leading to a palaeo-sedimentary and palaeo-geomorphologic model through time. A sequential retro-deformation of the study area aimed at a differentiation between salt rise mechanisms, their timing and their relation to regional tectonic events. It involves

sedimentation, decompaction, fault-related deformation, salt movement, thermal subsidence and isostasy. Results suggest that reactive diapirism started with lateral salt movement and local injection of salt into the overburden during the Lower Triassic Buntsandstein deposition. During the Upper Buntsandstein, rafts developed and small diapirs first breached through the sediment surface. Active diapirism during the Upper Triassic (Lower Keuper) was accompanied by salt piercement of the overburden. For the Jurassic, hydrothermal fluid circulation along active faults in an extensional regime is postulated. In the Lower Cretaceous, the salt rise mechanism changed to passive diapirism, which is still continuous until today. The downbuilding phase was accompanied by the development of large salt rim synclines leading to local development of faults. The structural analysis further shows multiple reactivations which demonstrate that syn- and post-sedimentary tectonics exert a strong control on facies' architecture in the basins. The importance of fault tip geometries and pull-apart structures for sedimentation and fluid flow could further be established.

Alexandras's research formed part of the Tight Gas Initiative (TGI) between RWTH Aachen University and Wintershall Holding GmbH which supported this study. She has presented her work in several international publications and at international conferences. Her thesis is a well-documented piece of work which presents for the first time an integrated model in which the influence of regional tectonics, salt tectonics, sedimentation, compaction, thermal subsidence and isostasy on tight gas reservoir evolution and distribution can be discerned. It therefore represents a major step forward in the understanding of this complex reservoir type.

Aachen, September 2012 Prof. Dr. Peter A. Kukla

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