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Philipp Antrett

Characterization of an Upper Permian Tight Gas Reservoir

A Multidisciplinary, Multiscale Analysis from the Rotliegend, Northern Germany

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Characterization of an Upper Permian Tight Gas Reservoir

A Multidisciplinary, Multiscale Analysis from the Rotliegend, Northern Germany

Doctoral Thesis accepted by
the Rheinisch-Westfälische Technische Hochschule
Aachen, Germany

Springer

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Antrett, P., Vackiner, A. A., Kukla, P., Back, S. and Stollhofen, H. 2012. Controls of reservoir compartmentalization of an Upper Permian tight gas field in Germany and links to a modern analogue in the Western U.S. Petroleum Geoscience, Vol. 18, 2012, pp. 289–304.

What magically and rejuvenating qualities those dunes and canyons have; they heal the spirit and calm the troubled mind

—Writing on the wall at the Panamint Springs Resort, CA, USA

Supervisor's Foreword

Natural hydrocarbon gas is considered to represent the "bridging fuel" until new energies become technically and economically viable. Amongst hydrocarbon gas, one can classify conventional, unconventional, and tight gas resources. The latter two 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 Philipp tackles a complex problem associated with the geological history of tight gas sandstone reservoirs in the Permian of northern central Europe. It presents an approach of integrated modeling, laboratory, and field work including reservoir properties, petrography, lithofacies and sedimentology, seismic attribute analysis, core analysis, and nano-porosity studies. Despite a long exploration and production history in this basin, previous work in Germany has mainly concentrated on large-scale basin analysis based on seismic and wireline borehole data and detailed diagenetic work based on core data. The Permian sequences in Germany occur at depths of up to 5,000 m and are characterized by low permeabilities owing to deformation, fluid flow and hence diagenetic alteration of the largely fluvio-eolian clastics.

With the background of the considerable global importance of tight gas reservoirs, this work presents a multidisciplinary approach to explain the still enigmatic evolution and distribution of these reservoirs and their properties. Aims of the study thus included a model of processes responsible for the loss of good reservoir properties during burial and subsequent events in the basin. Methods were used to assess internal reservoir structure and diagenetic patterns, to understand hydrodynamic controls within the basin and the sedimentary facies' which dominate the architecture of such reservoirs and to describe the pore space characteristics.

Initially, seismic and subsurface data were interpreted and analyzed and finally compared with a modern analog in Panamint Valley, western USA, where structural and sedimentary features including arid-surface mega-cracks have been mapped and confirmed by geoelectric measurements. Based on the integrated analysis, Philipp can conclusively prove that the interaction of syn- and post-sedimentary tectonics and burial diagenesis plays a crucial role in the evolution of deeply buried tight gas reservoirs. The reason for the low permeability of these reservoirs is manifold and controlled by a large number of parameters and processes, mostly of sedimentary and structural origin. Depositional controls, burial history, and associated diagenetic changes play the main role in the protracted development of the reservoirs. The role of authigenic clay minerals for example is one of the main reasons for the low permeabilities encountered. It is particularly the high-resolution characterization of the pore space, the importance of early diagenetic illite and chlorite coatings in sand dunes and the role of arid surface mega-cracks leading to subsequent reservoir compartmentalization which are a major step forward toward the understanding of deeply buried clastic reservoirs.

Philipp's research formed part of the tight gas initiative (TGI) between RWTH Aachen University and Wintershall Holding GmbH which supported this study. He has presented his work in several international publications and at international conferences. His thesis is a well-written and well-illustrated piece of work which provides a comprehensive model of the multi-scale Permian tight gas reservoir evolution in space and time.

Aachen, September 2012 Prof. Dr. Peter Kukla

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