

Shale gas potential of the Posidonia Shale, Hils Syncline, Germany

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Shale gas is a self-sourced resource in which thermogenic or biogenic hydrocarbon gases are contained within a fine-grained, organic-rich, low permeability matrix, occurring in free, adsorbed and dissolved states [1]. While no commercial shale-gas enterprises are currently known outside North America, many parts of Europe contain prime targets for shale gas exploration. One of these is the Posidonia Shale (Lias ϵ) of northern Germany.

The Posidonia Shale in the Hils Syncline is approximately 35m thick and subcrops at relatively shallow depth over a 500 sq km area. It displays a threefold stratigraphic subdivision: lower marlstone, middle calcareous shale with bivalve shells, and upper calcareous shale. It is organic-rich, and lateral variations in its maturity have been related to *inter alia* the effects of the Vlotho Massif, a purported deep seated igneous intrusion [2].

We have analysed a total of 300 whole core pieces and core plugs from 6 research boreholes, drilled in the 1980s, which completely penetrated the Posidonia Shale of the Hils Syncline (Wenzen, Wickensen, Dielmessen, Dohnsen, Harderode, Haddessen), covering the maturity range $R_m = 0.48 - 1.45\%$. The two fundamental components of gas shales, namely the origin/occurrence of in-situ gas and the nature of the rock matrix [1], have both been studied. Organic richness, quality and maturation characteristics were determined using Rock-Eval, pyrolysis gas chromatography and microscale sealed vessel (MSSV) pyrolysis. The carbon isotopic compositions of hydrocarbon gases as a function of maturity have been ascertained using MSSV pyrolysis followed by offline GC-irMS analysis [4]. All of the aforementioned chemical and isotopic compositional data have been integrated with published results on light hydrocarbons, solvent extractable bitumen components and kerogen structure of the KFA-Jülich group [2,3]. Petrophysical properties (nitrogen adsorption, mercury porosimetry), wireline log features and organic petrological textures have also been (re)assessed within a shale gas context.

The Posidonia Shale originally contained Type II kerogen of Petroleum Type Organofacies *Low Wax P-N-A* in all boreholes. Geochemical logging revealed that vertical heterogeneity in richness and quality is significant on a metre scale in single wells, in part related to the occurrence of mudstone and calcareous shale facies. However, maturity variability between locations is responsible for much larger shifts in TOC, S1 and S2 values. The relative amounts of the different

clay mineral groups remain constant with increasing levels of thermal maturity, though porosity and pore size are reduced.

Petroleum retention efficiencies for the represented maturation stages was calculated as a function of Transformation Ratio using a combination of bulk- and compositional mass balance models. The latter compositional model, based on pyrolysis gas chromatography data, also acted as a calibration in confirming that MSSV pyrolysis reliably predicts absolute masses of instantaneous and cumulative gas generated as a function of maturity. Gas yields for maturation levels beyond those exhibited in the 6 boreholes could therefore be reliably predicted, an important step because a great many of the most productive gas shales in the United States are at high levels of maturation [1]. As far as the bulk mass balance model is concerned, the gas-oil ratios from MSSV pyrolysis products were used to adjust S1 values to in-place estimates, thereby overcoming limitations caused by S1 loss during sample retrieval, storage and handling. MSSV gases at higher maturities are isotopically heavier than their counterparts at lower maturities.

Changing bulk petroleum PVT properties as a function of GOR and Transformation Ratio, ascertained using the PhaseKinetics approach, were input into published regional petroleum system models [5] to determine the timing of generation and migration events. The development of two-phase systems were predicted for Posidonia Shale with intermediate maturities during late uplift.

Only at very high maturity levels ($>1.4\% R_o$) does the Posidonia Shale fulfil the empirical organic geochemical criteria which label it as a gas shale candidate.

References

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