



Applying classical shale gas evaluation concepts to Germany—Part I: The basin and slope deposits of the Stassfurt Carbonate (Ca₂, Zechstein, Upper Permian) in Brandenburg

Alexander Hartwig*, Hans-Martin Schulz

GeoForschungsZentrum GFZ Potsdam, Sec. 4.3 Organic Geochemistry, Telegrafenberg, D-14473 Potsdam, Germany

ARTICLE INFO

Article history:

Received 23 December 2009

Accepted 10 May 2010

Keywords:

Black shale
Shale gas
Maturation
Permian
Organic carbon
Kerogen
Maceral
Vitrinite reflectance
Migration
Petroleum

ABSTRACT

Organic-rich mudstones of the Stassfurt Carbonate basinal and lower slope facies (Ca₂, Zechstein, Upper Permian) occur in the eastern part of the North German Basin (southern Brandenburg, eastern Germany). These source rocks for oil and gas fields have been investigated as a test system for the application of procedures to characterize gas shales. Classic sedimentological investigation methods, including core descriptions and thin section microscopy, were coupled with standardized organic geochemical analysis procedures, such as total organic carbon determination, Rock-Eval pyrolysis, open system pyrolysis-gas chromatography, gas chromatography of aliphatic hydrocarbons, and thermovaporization employing microscale sealed vessels (MSSV). Furthermore, the maceral composition was analyzed and vitrinite reflectance measurements were carried out. Data from these interdisciplinary methods were evaluated to characterize the basinal Stassfurt Carbonate Ca₂ utilizing mainly established guidelines for shale gas exploration in North America.

The “Stinkschiefer” sediments in southern Brandenburg show a trend of increasing maturity from south to north, favoring the occurrence of gas shales near the basin center. A distinction between basin and lower slope deposits could be made for the investigated suite of samples. The Ca₂ basin facies occurs below 3800 m depth. It has reached a minimum thermal maturity of 2.2% *R_p* and is therefore in the dry thermogenic gas zone. In contrast the lower slope deposits occur at depths from 1250 to 3250 m and have oil window maturity, ranging from 0.7% to 1.0% *R_p*. The organic matter is a mixed Type II/III kerogen, the Hydrogen Index ranges from 7 to 105 mg HC/g rock. The low average TOC contents, varying between 0.2 and 0.8 wt%, and its low formation thickness, on average 6 m, are factors limiting the gas shale potential of the Ca₂. However, the effective sealing by evaporites below and above the Ca₂ may restrict expulsion of generated gas, leading to gas retention within Ca₂ black shales.

© 2010 Elsevier GmbH. All rights reserved.

1. Introduction

The term “Shale Gas” refers to self-sourced, unconventional resources contained in fine-grained siliciclastic sediments (referred to here as gas shales). Typically, these sediments are rich in organic carbon. Thermogenic (and/or biogenic) methane is stored either as free gas in the matrix or open fractures, or is adsorbed on the organic and/or clay fraction. The sediments act as source, reservoir and trap together in the same shaly succession (Hamblin, 2006). Additionally, this new frontier play concept includes the idea that black shales may also act as reservoirs and traps for upwards migrating gas, thus forming non-self-sourced shale gas plays.

Shale gas has been produced in the USA since 1821 (Curtis, 2002). Over the past decade, the Barnett Shale (Mississippian, Fort

Worth Basin, Texas) has become the economically most successful shale gas play in the United States. Recently interest has spread to the Marcellus Shale (Middle Devonian, Appalachian Basin) and Haynesville Shale (Upper Jurassic, East Texas Salt basin).

Shale gas is an “unconventional” resource and no generalized parameters – apart from organic richness in thick shaly successions – are characteristic for all the known shale gas plays in North America. It is the complex interplay and balance of the controlling factors of organic richness, thermal maturity, lithology, mineralogy, depth, and fracturing characteristics that lead to this type of gas accumulation. Factors like production technique and infrastructure determine the economic value of shale gas resources.

The GeoEnergie project, topic of this special volume, provides the scientific platform to investigate well-known German black shales in terms of their shale gas potential. Classical evaluation schemes employed in the US were applied to the “Stinkschiefer”, the basinal and lower slope facies of the Upper Permian Stassfurt Carbonate Ca₂ in the federal state of Brandenburg (eastern

* Corresponding author. Tel.: +49 331 288 2859; fax: +49 331 288 1782.
E-mail address: alexha@gfz-potsdam.de (A. Hartwig).

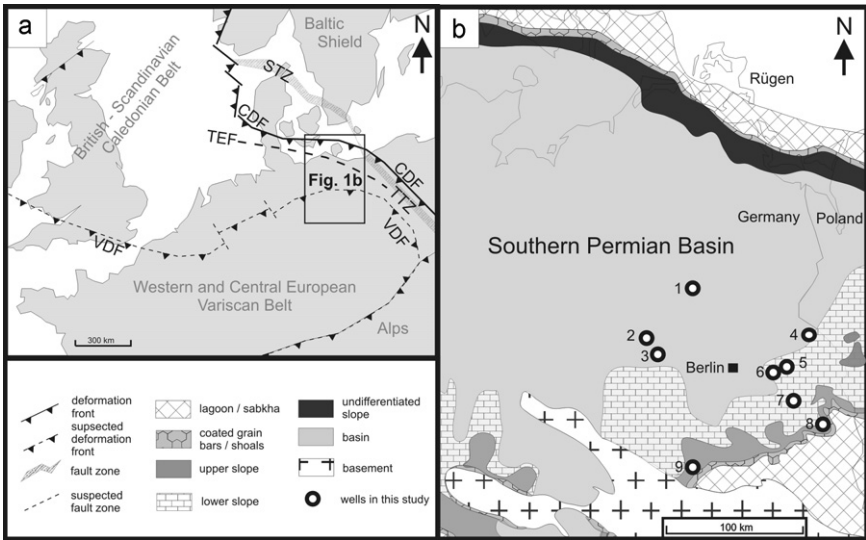


Fig. 1. (a) Structural units of Northwest and Central Europe; and the extent of the study area indicated by the rectangle (Katzung, 2004; Norden et al., 2008; van Wees et al., 2000; Walter, 2007). Abbreviations: CDF—Caledonian deformation front; VDF—Variscan deformation front; STZ—Sorgenfrei-Tornquist Zone; TTZ—Tornquist-Teisseyre Zone; TEF—Trans-European Fault. (b) Distribution of Stassfurt Carbonate (Ca2) facies in east Germany modified from Strohmenger et al. (1996) and Strohmenger et al. (1998) showing the location of sampled wells. 1—Gransee 2/67, 2—Rhinow 5 h/71, 3—Kotzen 2/72, 4—Neutrebbin 2/68, 5—Rüdersdorf 15 h/66, 6—Rüdersdorf 17/73, 7—Sprenghagen 3/73, 8—Grunow 4/69, 9—Schadewalde 2/75.

Germany, Fig. 1) to investigate its gas shale characteristics. It is a well explored source and reservoir rock in the framework of exploration activities in the Zechstein Formation of the Thuringian Basin and the Mesozoic of the North German Basin (NGB), which started in the 1950s (Plein, 1994; Rempel et al., 2009). Detailed data about Stassfurt Carbonate facies, diagenesis, and reservoir development have been published (e.g. Strohmenger et al., 1996, 1998) and provide basic parameters for the evaluation of gas shale properties.

The organic-rich mudstones are 5–10 m thick and lithologically characterize the basin and slope deposits of the Upper Permian Stassfurt Carbonate Ca2 (a lithostratigraphic term; Fig. 2). It is the source rock of oil and condensate found in isochronous Carbonate reservoirs of the Ca2 platform and isolated off-platform highs in eastern Germany (Gerling et al., 1996b; Merkel et al., 1998; Piske and Rasch, 1998). The Stassfurt Main Dolomite of the platform, lagoon, and especially the isolated island-like highs was the major hydrocarbon exploration target in former East Germany. The formation of “paleo-accumulations” occurred as early as the Upper Permian.

The approach of this contribution is to investigate sedimentological, diagenetic and chemical changes due to maturity trends in the southern part of the North German Basin. The focus lies on investigating organic matter type, richness and maturity, gas generation potential, and the sedimentology of black shales, with the final aim of comparing the results with data of US shale gas plays, and thereby evaluate the “Stinkschiefer” in terms of its gas shale properties.

2. Geological background

2.1. Basin history

The study area lies within the eastern part of the North German Basin (NGB), which is part of the Central European Basin system (CESB; Maystrenko et al., 2008; Littke et al., 2008). To the east the North German Basin is connected to the Polish Trough. The Phanerozoic sedimentary infill in eastern Germany reaches a maximum thickness of more than 8000 m (McCann, 1999).

German Zechstein Cycles			Lithostratigraphy		German Zechstein Sequences	
Upper Permian	Friesland	Z6	A6 T6	Friesland Anhydrite Friesland Clay	ZS 7	
	Ohre	Z5	Na5 A5 T5	Ohre Salt Ohre Anhydrites Ohre Clay		
	Aller	Z4	Na4	Aller Salt		ZS 6
			A4	Petmatite Anhydrite		
			T4	Red Salt Clay		
	Leine	Z3	Na3	Leine Salt	ZS 5	
			A3	Main Anhydrite		
			Ca3	Platy Dolomite	ZS 4	
			T3	Grey Salt Clay		
	Stassfurt	Z2	Na2	Stassfurt Salt	ZS 4	
			A2	Basal Anhydrite		
			Ca2	Stassfurt Carbonate		
	Werra	Z1	A1	A1β	Upper Werra Anhydrite	ZS 3
				Na1	Werra Salt	
				A1α	Lower Werra Anhydrite	
Ca1			Zechstein Limestone	ZS 2		
T1			Copper Shale	ZS 1		
T1Ca			"Mutterflöz" Carbonate			
Z1C	Zechstein Conglomerate					
Lower Permian		Rotliegend			Upper Carboniferous	

Fig. 2. German Zechstein cycles, sequences, and lithostratigraphy. The Stassfurt Carbonate is highlighted in grey; modified from Strohmenger et al. (1996).

The eastern part of the NGB formed during the late Upper Carboniferous and early Permian as part of an intra-continental basin (the so-called southern Permian Basin) on the remains of

Download English Version:

<https://daneshyari.com/en/article/4407104>

Download Persian Version:

<https://daneshyari.com/article/4407104>

[Daneshyari.com](https://daneshyari.com)