

# Geothermal Reservoirs within the Central European Basin - the Example of the Exter Formation (Upper Triassic, Rhaetian), NE Germany.

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## Introduction

Beside the Oberrheingraben the North German Basin (NGB) is one among two large geotectonic structures of the Central European Basin (CEB) with promising opportunities for geothermal heat production as well as the storage of natural gas and CO<sub>2</sub>. Within the NGB the northeastern part of Germany marks an area where several geothermal heating stations are already operating, taking advantage of triassic, jurassic and cretaceous geothermal reservoirs. Among those, the sandstones of the Exter Formation (Upper Triassic, Rhaetian) comprise high potential for geothermal purpose. Beside others the geothermal heating stations at Neubrandenburg, Neustadt-Glewe and Waren (Mecklenburg-Vorpommern) as well as

Rheinsberg (Brandenburg) are operating with sandstone horizons of the Exter Formation. Up to now the use within larger areas is hampered because the sandstones of the Exter Formation are laterally thinning out and terminating rather quickly. Contrary to the promising opportunities for geothermal heat production only few attempts have been made to evaluate the sedimentology and petrology of the Exter Formation. Especially the distribution and facial development of the sandstone horizons are poorly known.

This poster presents some first results of an integrated study analysing the sedimentology, petrology and facies of the Exter Formation with a main focus on geothermal reservoirs.

## Stratigraphy

Traditionally the Upper Keuper has been subdivided into informal units (BEUTLER 1976, 2004). The scheme is still in use by the geologic state survey of Mecklenburg-Vorpommern (LUNG M-V, Fig. 1). DSK (2005) introduced a homogenised stratigraphic concept for the Keuper based on Formations and Members. In addition up to 8 Unconformities of basinwide importance are to be observed within the Keuper section leading to quasi-isochronous units, so-called „Folgen“ and „Subfolgen“ (Fig. 1). The stratigraphic concept after DSK (2005) was used in this study and applied to 120 wells in NE Germany.

Ma	Epoche	Stufe	Diskord.	DSK (2005)		BEUTLER (1976, 2004)					
				Folge Subfolge	Formation Subformation						
201,5	Obere Trias	Rhaetium	D 8	k 6.3	Exter-Formation	Vahlbruch-Subfm.					
						Triletes-Schichten					
						D 7	k 6.2	Oeynhausens-Subfm.			
								Contorta-Schichten			
						D 6	k 6.1.2	Rinteln-Subfm.			
								Obere Postera-Sandstein			
						D 5.2	k 6.1.1				
								Postera-Schichten			
						206	Norium	D 5.1	k 5	Arnstadt-Formation	Untere Postera-Schichten
											Basisdolomit
		D 4									

Fig. 1: Upper Keuper stratigraphy of NE Germany after DSK (2005) and BEUTLER (1976, 2004). Numerical ages after BACHMANN & KOZUR (2004) and SCHALTEGGER et al. (2008). Diskord. = Unconformities after DSK (2005). Thicknesses not to scale.

## Sedimentology/Facies analyses

Sedimentological analyses on 10 cored wells (Fig. 2, 3) point to a larger number of facies types that have been grouped to facies associations for the Rinteln Member and Oeynhausens/Vahlbruch Members separately. The log characteristics of each facies association has been used to set up standards in preparation for log correlation and facies mapping (Fig. 2, 3).

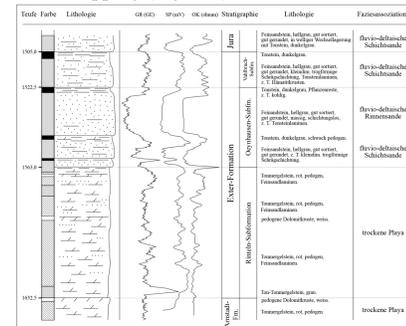


Fig. 3: Stratigraphy, lithology, facies associations and logs of well Gt Wa 1/82.

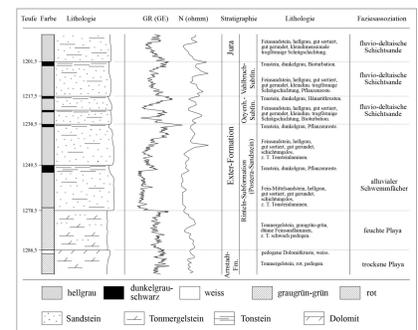


Fig. 2: Stratigraphy, lithology, facies associations and logs of well Gt N 2/85.

**Rinteln Member (FA):**  
predominantly dry Playa, predominantly wet Playa, alluvial sheetsands, distal part of terminal alluvial fan

**Oeynhausens/Vahlbruch Members (FA):**  
lacustrine shales, estuarine shales, fluvio-lacustrine sheetsands, fluvio-deltaic channels

## Facies maps

The log standards of facies associations could be applied to more than 100 logged wells in order to produce detailed facies maps (Fig. 4, 5).

### Rinteln Member (Postera Sandstein, Subfolge k 6.1.2)

The distal part of a large terminal alluvial fan with NE-SW to NNW-SSE trending, 10-35 km broad channel belts prograded from a Scandinavian source area onto a dry Playa in NE Germany. Within the channel belts up to 60 m thick

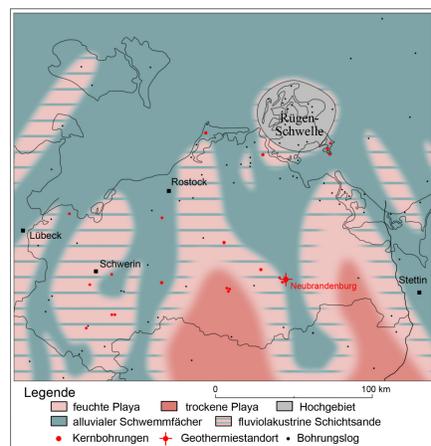


Fig. 4: Facies map of Rinteln Member (Postera Sandstein, Subfolge k 6.1.2).

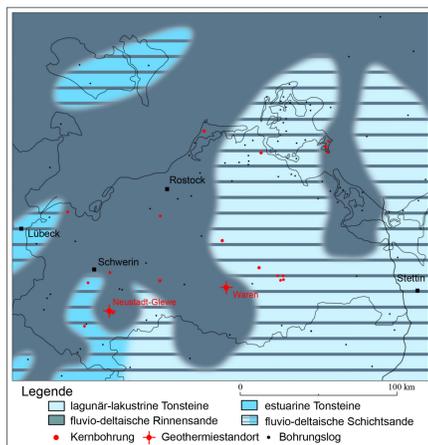


Fig. 5: Facies map of Oeynhausens Member (Contorta Sandstein, Subfolge k 6.2).

sandstone horizons (Fig. 2) are developed laterally thinning out to up to 2 m thick sheetsands (Fig. 4).

### Oeynhausens Member (Contorta Sandstein, Subfolge k 6.2)

A shallow incision from the W forced the prograding clastics in forming large fluvio-deltaic systems, with NE-SW to NW-SE trending, 10-50 km broad channel belts, dominated by up to 60 m thick massive sands. Laterally thinning out to 5 m thick sheetsands and interfingering with estuarine to lacustrine dark shales is to be observed.

## Petrology

Petrological analyses (thin sections, XRD, REM, EDX, Poro-Perm) on 17 cored wells support the sedimentological and facial analyses of geothermal reservoirs.

### term. alluvial fan (k 6.1.2)

Well sorted and angular rounded to well rounded fine (55 %) to medium grained (35 %) sandstones have average contents of 82 % Quartz, 4 % Kalifeldspat, 3 % Plagioklas, 3 % Lithics, 3 % Kaolinite, 4 % Illite/Chlorite/Smectite and 1 % Carbonates. Porosities have a wide range from 9 to 37 % and permeabilities from 29 to 3000 mD (average: 750 mD at Neubrandenburg).

### fluvio-deltaic channels (k 6.2)

Well sorted and angular rounded to well rounded fine (30 %) to medium grained (60 %) sandstones have average contents of 95 % Quartz, 3 % Kalifeldspat, 1 % Plagioklas and 1 % Kaolinite and Chlorite. Porosities have a wide range from 8 to 35 % and permeabilities from 20 to 5814 mD (average: 600 mD at Neustadt-Glewe and 2000 mD at Waren).

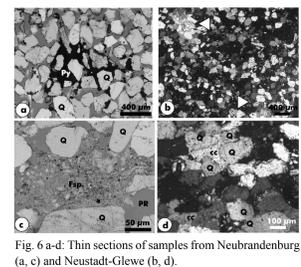


Fig. 6 a-d: Thin sections of samples from Neubrandenburg (a, c) and Neustadt-Glewe (b, d).

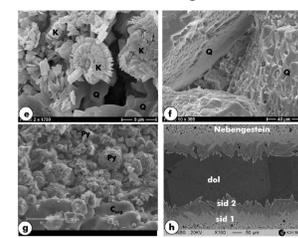


Fig. 6 e-h: REM images of samples from Neubrandenburg (e, f), Pritzwalk (g) and Karstädt (h).

## Results

- (1) The stratigraphic scheme after DSK (2005) comprising formations and members as well as quasi-isochronous „Folgen“ and „Subfolgen“ could be applied to 120 cored and logged wells.
- (2) The up to 170 m thick Exter Formation contains up to 60 m thick sandstone horizons that prograded from a Scandinavian source area southwards into the NE Central European Basin.
- (3) Facies analysis of the Rinteln Member suggests the distal parts of a large terminal alluvial fan extended well into NE Poland, Brandenburg and Lower Saxony. A reddish, predominantly dry playa facies was characteristic for the areas between channel belts.
- (4) Due to a shallow incision from the W the clastic input of Oeynhausens/Vahlbruch Members formed a large fluvio-deltaic system, dominated by massive sands, prograding onto estuarine to lacustrine environments, dominated by dark shales.

- (5) Both members comprise fine to medium grained, angular rounded to rounded sandstones with high contents of Quartz (Rinteln Member: 82 %, Oeynhausens Member: 95 %) and only subsidiary contents of Feldspar, Lithics, Clay minerals and Carbonates (Rinteln Member: 18 %, Oeynhausens Member: 5 %).
- (6) Alluvial sandstones (Rinteln Member) have porosities between 9 – 37 % and permeabilities between 29 – 3000 mD (average: ca. 750 mD) and fluvio-deltaic sandstones (Oeynhausens Member) porosities of 8 – 35 % and permeabilities of 20 – 5814 mD (average: 2000 mD).
- (7) Sandstones of alluvial and fluvio-deltaic channelbelts have high potentials as geothermal reservoirs, whereas the potential of alluvial and fluvio-lacustrine sheetsands has to be considered rather low.