Deep geothermal reservoirs of the Lower Exter Formation (Upper Keuper, Triassic) in the North German Basin: the geothermal potential of distributive fluvial systems

Gregor Barth[1], Matthias Franz[2], Carmen Heunisch[3], Markus Wolfgramm[4]

[1]gregor.barth@geopal.de
[2]matthias.franz@geo.tu-freiberg.de
[3]carmen.heunisch@lbeg.niedersachsen.de
[4]markus.wolfgramm@gtn-online.de

The North German Basin (NGB) is the largest geotectonic structure of the Central European Basin (CEB) with most promising opportunities for geothermal heat production. Among the main geothermal reservoirs of the (1) Middle Buntsandstein, (2) Schilfsandstein, (3) Rhaeto-Liassic, (4) Middle Jurassic and (5) Lower Cretaceous the Upper Keuper (Rhaetian) reservoirs of the Exter Formation have promising potential but up to now a more intensive use is hampered because knowledge about spatial distribution of reservoirs and their properties (porosity, permeability) is rather preliminary.

The reservoirs of the Lower Exter Formation ("Postera-Sandstein") have been subject to a high-resolution basin-scale study incorporating outcrops, more than 20 cored wells (> 2000 m cored intervals) and more than 400 logged wells. Based on a combined approach of micropalaeontology, palynology and sequence-stratigraphy 3 time-slices were evaluated using sedimentolgical, petrological and petrophysical methods resulting in 3 high-resolution facies maps for the Lower Rhaetian. Implementation of an extensive data set on petrology and reservoir properties enables the evaluation of potential production sites.

Deposition of the Lower Exter Formation was controlled by two major sedimentary environments a shallow epeiric sea in the western part of the CEB and a large distributive fluvial system (DFS) in the NE part. In the West the early Rhaetian Sea terminated terrestrial clastics of the Norian. Supplied with clastics from Scandinavian source areas a large DFS spread from NW Poland to NE Lower Saxony and was characterised by a distributive network of fluvial channels that decrease downstream in with and depth. Between both a sandy shoreface marked the transition from terrestrial to shallow and restricted marine environments. Within this general setting six lithofacies associations are identified. (I) distributive channels: up to 10 km broad and up to 40 m thick strings of fine- to coarse-grained sandstones of high maturity, (II) sheet sands: up to a few meters thick fine- to medium-grained sandstones of high maturity and immature pedogenic overprint, (III) dry playa: up to several decameter thick reddish to variegated pedogenic overprinted shales often comprising mature calcisols, (IV) wet playa: up to several decameter thick grey to greenish less pedogenic shales and shaly clays with conchostracans, fish- and plant remains, (V) shoreface: up to 10 m thick bioturbated fine- to medium-grained sandstones of high maturity, (VI) offshore: up to several decameter thick dark grey to grey partly bioturbated shales and siltstones comprising a brackish fauna.

Sandstones of distributive channels and shoreface comprise excellent reservoir potentials with porosities between 3.7–41.0 % (average 22.6 %) and permeabilities between 0.1–4.5 D (average 1 D). Although sheet sands have comparable porosities between 1.9–36.8 % (average 22.4 %) and permeabilites between 0.1–3.0 D (average 1.1 D) their low thicknesses exclude their use as geothermal reservoir.