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The influence of extension and inversion events on the burial, thermal and maturity history of the Glueckstadt Graben and adjacent areas, North German Basin

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Study area

The Glueckstadt Graben is a major structural element of the intra-continental North German Basin and represents its deepest part. The graben evolution was affected by a major extensional period in Triassic times which caused rapid subsidence providing space for more than 4 km of Triassic sediments. At the northwestern margin the Glueckstadt Graben is bordered by the West Schleswig Block and at the eastern margin by the East Holstein Block. During the Late Jurassic to Early Cretaceous the area around the Glueckstadt Graben was affected by relative uplift with regional erosion of the elevated relief (Maystrenko et al. 2004). The Glueckstadt Graben shows signs of inversion – the formation of a subsequent marginal trough, the so-called Hamburg pit, on the eastern shoulder of the graben, which is assumed to be of Eocene age (Kockel, 2003). Towards the margins of the graben NNE-SSW to N-S striking, parallel aligned salt walls of Rotliegend and Zechstein salt were formed since Triassic times which are related to graben faults. Their rise had an important influence on the subsidence pattern of the area. In the West Holstein and East Holstein Trough, which are deep rim synclines of salt walls bordering the Glueckstadt Graben, the Late Jurassic uplift was overwhelmed by subsidence due to salt movement.

1D burial, thermal and maturity history modelling

Several studies on the burial, temperature and maturity history of different areas in the Central European Basin were performed in the past (e.g. by Littke et al. 1993; Neunzert et al., 1996; Petmecky et al., 1999) revealing a different timing for maximum

burial and maximum temperatures. It was the aim of this study to provide maturity data of Mesozoic and Palaeozoic sedimentary rocks for the central part of the CEBS, the Glueckstadt Graben area and bordering regions, and to bring this data into the context of burial and temperature history. For this purpose vitrinite reflectance measurements and 1D numerical simulations on selected wells were performed. Maximum burial and maximum temperatures for Paleozoic and Mesozoic rocks were calculated based on these simulations. The burial histories of all simulated wells show a major subsidence period from Upper Rotliegend until Middle Jurassic times followed by an uplift and erosion of Jurassic and partly also Triassic strata due to Cimmerian movements. In the West Holstein and East Holstein Trough sediments of Lower, Middle and Upper Jurassic age are present due to continuing subsidence based on salt migration. After a period of non-deposition at the beginning of the Lower Cretaceous sedimentation started again in Hauterivian times and lasted, with several interceptions in the Tertiary, until recent times. Best accordance between measured and calculated present-day temperatures was achieved with present-day heat flows in the range of 50 to 60 mW/m^2. For all wells a constant heat flow of 65 mW/m^2 was assumed for the time from the Devonian to the end of Carboniferous in accordance with the global average continental heat flow suggested by Allen & Allen (1990). For the rifting phase during the early Permian increased heat flow values, with a maximum of 90 mW/m^2, were applied decreasing with time. For the Jurassic to Tertiary period, a constant heat flow value was used which ranges from 50 to 60 mW/m^2 in the different 1D models.

Interestingly maximum temperatures were reached at different times in the various tectonic settings within the study area. Generally two times of maximum burial and temperatures resulted for the wells which are not situated on top of major salt diapirs: the Mid-Jurassic and the Tertiary. Due to inversion, temperatures were lower during the Cretaceous.

Maturity maps

Based on the results of the vitrinite reflectance measurements as well as the 1D numerical simulations maturity maps were constructed for the study area. All maturity maps for the North German Basin previously published by other authors (Teichmüller et al., 1984; Koch et al., 1997) ended south of the river Elbe. For the first time maturity maps have been compiled for stratigraphic levels north of the river Elbe in the Schleswig-Holstein area, namely for the base of the Keuper as well as for the base of the Zechstein formation.

Due to highest subsidence both maps show highest maturity values in the central part of the Glueckstadt Graben. High values are also reached in the West Holstein Trough and to a lower extent in the East Holstein Trough. Lowest maturity values are found

in the northernmost part of the West Schleswig and East Holstein Block. Maturity of the Keuper formation is between 0.5 and 1.0 %VR_r on the West Schleswig and East Holstein Block and increases to over 2 %VR_r in the central part of the Glueckstadt Graben as well as in the West Holstein Trough where the base of the Keuper formation descends to more than 6 km depth. Maturity of the Zechstein formation is between 0.5 and 2 %VR_r on the West Schleswig and East Holstein Block and increases to over 4.6 %VR_r in the central part of the Glueckstadt Graben where the base of the Zechstein formation descends to more than 10 km depth. The maturity pattern shown in the two maturity maps reflects the depth of burial of the Keuper and the Zechstein formation, respectively, as well as the different thermal histories of the individual tectonic areas.

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