Geodynamic remarks in the deep borehole TH1 (Vienna Basin)

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The Vienna Basin (VB) is a pull-apart basin formed in the Miocene due to the sinistral movement along the Mur-Mürz-Vienna Basin Transfer Fault. The sigmoidally shaped basin formed at large-scale left-step of the fault system. The VB infill consists of up to 6,000 m of Early Miocene-Quaternary sediments, whereas the substrate is represented by the imbricated Eastern Alps including the Northern Calcareous Alps (NCA). Seismicity occurs mainly along the SE margin, at 3–10 km of depth, and is of moderate magnitude. Recent activity of the VB is further indicated by captured rivers and faulted Pleistocene terraces. TH1 was drilled NE of Vienna to investigate the potential for deep geothermal operations in the VB. The well is situated close to the Aderklaa Fault system (ADF), which offsets the Gänserndorf Terrace (Pleistocene). In this area the ADF displays a curved shape, striking NNE in the northern part and NNW to the South (close to TH1). The main target of the well TH1 was the fractured carbonates of the VB substrate, below 3,400 m, however, instead of the expected Hauptdolomit, other formations of the NCA were encountered (Furth Formation, Werfen Formation, Lower Gosau Group). The well was drilled to a depth close to 4,220 m, where repeated borehole collapses led to stop of the operations. Several data were acquired in TH1: open hole logs (OHL), 3 LOT and micro-resistivity image log (FMI) (3,473–3,888 m). Analysis of the FMI revealed a complex structure in the NCA section, with a normal fault between Werfen Formation (in the hangingwall) and Lower Gosau Group (in the footwall). The fault strikes NNW and dips 54° to the WNW, parallel to the local orientation of the ADF, as also indicated by newly acquired 3D seismic data. The analysis of the drilling induced failures indicates only borehole breakout (BO). In both, Furth and Werfen Formation, BO is oriented close to E-W, whereas in the Lower Gosau Group the BO is oriented SW-NE. Thus, there is a rotation of about 45° at the NNW-SSE normal fault of the ADF. Similar rotations of the BO close to faults are often interpreted as resulting from active faulting. Rock properties (UCS, coefficient of internal friction, elastic moduli) were derived from OHL, based on wellknown correlations of log data with the petrophysics. Vertical stress and mud pressure were modeled respectively from density log and mud weight of the drilling report. The pore pressure is close to hydrostatic in the VB infill (used mud density 1.12 g/cm³) and moderately overpressured in the NCA (used mud density 1.22–1.24 g/cm³). The magnitudes of the two horizontal stresses were modeled with poroelasticity method and calibrated against the LOT (for Shmin) and by comparing the predicted drilling induced failures and actual failures observed on the FMI data (for SHmax). The model indicates a NF stress field over the entire interval, that is close to critically stressed conditions in the NCA. These remarks indicate that not only the central sector of the ADF is active, where it offsets the Gänserndorf Terrace, but also the southern part, as observed in well TH1. Deep geothermal activities are associated with a pore pressure perturbation in the area of operations, which under some circumstances could lead to both induced and triggered seismicity. In the TH1, fluid migration under operational conditions (injection flow and pressure) should be carefully evaluated, in order to minimize the risk of reactivating faults of the ADF.