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Reservoir Assessment for the Application of Enhanced Geothermal Systems in Tight Sediments of a Neogene Basin

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The lithological, structural and facial properties of the Neogene Vienna Basin determine varying requirements for geothermal utilization, especially regarding the different geothermal conditions of the Neogene basin fill and the Alpine and Subalpine basement (for example the Triassic dolomites of the Alpine basin floor are suited for hydrothermal utilization). The Vienna Basin is a hydrocarbon reservoir in Austria. Besides geological consideration this area was chosen to assess the feasibility of geothermal utilization because of the detailed geological database and available hydrocarbon infrastructure, with the possibility of a geothermal adaption of abandoned wells. At present a commercial utilization of geothermal energy is not established. In one pilot-project a deep heat exchange system is tested currently. Findings concerning energy extraction by deep heat exchange systems were conducted to determine the possibility of an application of enhanced geothermal systems in the Vienna Basin to make energy extraction more efficient. The geological analyses may provide a basis for further technical and economical considerations.

The Vienna Basin is a Tertiary pull-apart basin, located between the Bohemian Massive, the Eastern Alps and the Pannonian-Carpathian-System, with a SW-NE extension of about 200 km and a width of approximately 60 km. The Neogene basin fill is mainly composed of sandstone, shale and conglomerates. The substructure of these sequences is formed by Calcareous Alpine nappes and sections of other tectonic units (Flysch Zone, Greywacke Zone and Central Alpine Zone). The third floor is built up by Autochthonous Mesozoic strata. Large normal faults separate shallow marginal blocks around the flanks of the basis from a system of depressions. These synsedimentary faults created space for deposits up to more than 5000 m thickness. Except for an area of an elevated block south of Vienna with some thermal anomalies, average thermal conditions prevail, with a geothermal gradient of approximately 30 °C/km.

For a possible implementation of geothermal enhanced systems in the Vienna Basin an area with the maximum thickness of low permeable siliciclastic sediments was chosen. The sedimentary thickness of this depression zone is related to the position of the large fault system with a synsedimentary offset of 5.6 km. Within this Neogene succession the Badenian and Karpatian with transgressive-regressive cycles corresponding to layers of terrigenous material, were selected. Based on geological and geophysical investigations of

the hydrocarbon exploration and production the lithologic composition and stratigraphic succession, the porosity and permeability of the considered formations were available, as well as information concerning the stress components.

On the basis of the available date the following analyses were carried out: (a) The delineation of the reservoir in a 3D-model showing the structural features, the stratigraphic succession and the complex fold and fault system was performed by application of a geological modeling software. Geological cross sections and maps were imported as images and as grid files, the interpretation was performed directly on the geological profiles. For surface generation also information from wells was regarded. The surface and faults were generated based on polygons. In several steps a skeleton framework was defined. Horizons, zones and layers were inserted into a 3D-grid. The created model consists of regular, rectangular cells with a grid size of 100x100x50 m. Each of these cells can be filled with reservoir parameters to obtain a 3D property model which is the input for a reservoir simulation. (b) As for the thermal regime of the basin, a simplified algorithm for predicting subsurface temperatures for different depths was developed. The calculations based on corrected bottom hole temperatures and hydraulic drill stem test results. (c) The investigations concerning the thermal parameters were carried out on the one hand by log-analyses and on the other hand by laboratory measurements. By means of electric logs a rough estimation of lithology (sand/shale-ratios), compaction, porosity and pore content was possible. In addition density-, sonic- and neutron logs were used. The detailed analyses of the thermal parameters were carried out by laboratory measurements of selected core samples under dry and saturated condition. Additionally density, porosity and effects of anisotropy were considered. Concerning the sandstones detailed analyses of the different types of matrix and cement took place. (d) Generally the thermal conductivity rises with increasing depth due to the compaction of the sedimentary sequences. To establish relation between thermal conductivity, lithologic properties and depth dependency core samples of different depth were investigated. For these analyses probes with similar mineralogical composition, determined by qualitative and quantitative X-ray diffraction, were chosen.

The evaluation of the results showed both, the influence of the mineralogical composition on thermal conductivity and the connection to the depth dependency of these parameters. For example the thermal conductivity of shale samples with similar qualitative and quantitative composition increases at an amount of 0.4 W/(K*m) from a depth of about 2500 m to 4100 m. The Neogene pressure gradient identified by using Sigma-log amounts up to 1.80 bar/10 m. In a depth of 4150 m an overpressure zone sets in which affects the thermal properties of the sediments. With a similar mineralogical composition the thermal conductivity decreases or remains constant with increasing depth. Further steps in order to examine the application of enhanced geothermal systems in tight sediments of the Vienna Basin are investigations on the influence of sedimentary properties and their response on hydraulic fracturing.