Geophysical Research Abstracts
Vol. 12, EGU2010-5848-1, 2010
EGU General Assembly 2010

Relation between thermal conductivity and mineral content in connection with overburden pressure in Neogene shales of the Vienna Basin

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The lithologic, facial and structural properties of the Vienna Basin determine varying requirements for geothermal utilization, especially regarding the different thermic conditions of the Neogene basin fill on one hand and the Alpine and Subalpine basement on the other hand. The investigation of the connection between thermal conductivity, lithologic properties and depth dependency of the basin fill was done by means of drilling cores of the Zistersdorf depression zone, an area with the maximum Neogene thickness of the Vienna Basin. Within this succession the Badenian, with its transgressive-regressive cycles corresponding to layers of terrigenous material, was investigated. The sedimentary thickness of this depression zone is related to the position on the Steinberg fault with a synsedimentary normal offset of 5.6 km (Decker 2004). In order to obtain information of Badenian sediments closer to the surface, samples of the central Vienna Basin were additionally investigated.

Thermal conductivity of sedimentary rocks largely depends on mineralogical composition, fractures, porosity and pore content, and further on compaction, temperature and anisotropic effects due to mineral structures (Schön 1983). The correlation between mineralogical composition, overburden pressure and thermal conductivity was done by the analysis of impermeable shale core samples to reduce the influence of the pore content. The selection of shale cores of the Zistersdorf Superdeep wells was carried out on basis of log analyses, especially sonic-, density- and neutron-log. The qualitative and quantitative mineralogical composition was determined by means of X-ray diffraction. The mineral identification of all samples resulted in the following main components with different quantities: quartz, calcite, dolomite, illite, chlorite, mixed layer clay minerals, K-feldspar and plagioclase. The laboratory measurements of the thermal conductivity of the shale samples took place under dry conditions. Additionally, density, porosity and effects of anisotropy were considered.

Within the Badenian sequence, shale samples, with similar and therefore comparable qualitative and quantitative mineralogical composition, corrected for anisotropy (Vasseur et al. 1992) were combined. From a depth of about 2500 m to 4100 m the thermal conductivity increases at an amount of 0.4 W/(K*m). The Neogene pressure gradient identified by using Sigma-log amounts up to 1.80 bar/10 m (Ringhofer 1986). At a depth of 4150 m an overpressure zone sets in. With similar mineralogical composition the thermal conductivity decreases or remains constant with increasing depth. The influence of the mineralogical composition on the thermal conductivity shows the following example: an increase of a quartz content of about 50 %, coincident with a decrease of minerals with low thermal conductivity (illite and feldspar) of about 30 %, with a constant calcite and chlorite content (a decrease of dolomite by 50 % is implied) leads to an increase of the thermal conductivity by 20 % under same overburden pressure conditions.

Regarding the influencing parameters described above, such like the mineralogical composition, the total porosity and its dependence from overburden pressure as well as compaction and ambient rock temperatures, data-models of effective bulk conductivities have been established for the Zistersdorf depression. These models have finally been validated by means of inversion-analyses of measured subsurface borehole temperatures (corrected BHT- and DST measurements). The achieved results have been interpreted for observed anomalies of the heat flux distribution at the Zistersdorf depression and the efficiency of heat exchange between boreholes and surrounding formation rocks in case of heat recovery.