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Well-log based prediction of temperature models in the exploration of sedimentary settings: Examples from the North German Basin

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Temperature-depth distributions are pivotal in subsurface studies in academia as well as in georesources applications. In this regard, high-resolution temperature profiles, logged under equilibrium thermal borehole conditions, are the ultimate measure. However there are circumstances in which these measurements are not available or only measured to a certain depth so that a temperature model needs to developed. A prerequisite for such a model is the knowledge of the regional heat flow and the geological conditions translated into lithology and thermal rock properties.

For the determination of the rock thermal conductivity (TC) we propose a two-step procedure: (1) the use of standard petrophysical well log and (2) the inversion of predicted TC to temperature gradients by applying Fourier's law of heat conduction. The prediction of TC is solved by using set of equations (Fuchs & Förster, 2014) developed for matrix TC of sedimentary rocks. The equations resulted from a statistical analysis of an artificial set of mineral assemblages (consisting of 15 rock-forming minerals) typical for the different types of sedimentary rocks. The matrix TC was transformed into bulk TC by using a well-log derived porosity. TC vs. depth profiles corrected for in situ (p, T) conditions finally were used in conjunction with a published site-specific heat-flow value to model a temperature profile. The methodology is shown on the example of a 4-km deep borehole at Hannover in the North German Basin. This borehole, drilled for geothermal use, penetrates thick Mesozoic sediments and terminates in the Triassic Middle-Buntsandstein formation. The temperature computation was performed, inter alia, for a borehole section in a depth range between approx. 2,320 and 3,750 m. The applied approach is able to match both predicted and measured equilibrium borehole temperature profiles with a resulting uncertainty of less than 5 %. Interval temperature gradients vary on average by < 3 °C/km.