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Methods to derive statistically proved input parameter for geothermal models: Examples from sedimentary basins and crystalline basement rocks.

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Numerical simulations are important tools for geothermal reservoir assessment, since they predict thermal and hydraulic reservoir conditions and are able to simulate the development of a reservoir with time. However, reliable forecasts are only possible, if position and geometry of the subsurface geological units are known and the corresponding thermal and hydraulic properties are well defined. Therefore, one objective of the research project MeProRisk, a joint project of the RWTH Aachen, FU Berlin, CAU Kiel, RWE Dea and Geophysica Beratungsgesellschaft mbH, was to develop methods and strategies to define and optimize input parameter for geothermal models. Input parameter required are, beside the basal heat flow density, thermal conductivity, thermal capacity, radiogenic heat production, porosity and permeability of the model units. The work performed during the research project was targeted to develop strategies to find reliable input parameter for models of different scales. On the one hand input data are needed for large scale models in a 10 to 100 km-scale, which serve e.g. for 3D-temperature maps. On the other hand information is needed for smaller scaled reservoir models predicting the thermal and hydraulic behaviour of e.g. a geothermal doublet.

During the project phase we developed and tested methods to extract representative data sets from existing wells for models of different scales. The methods and results are explained exemplary for two locations: a) sediment successions in the North-German Sedimentary Basin drilled by a RWE Dea oil/gas exploration well and b) crystalline rocks of the Bohemian Massif drilled by the KTB superdeep wells. From the oil and gas well, cutting samples were taken from each stratigraphic layer down to a depth of $\sim$ 5 km. The cuttings samples were measured for thermal conductivity and matrix density in the laboratory. In parallel, well logging data were analyzed for volumetric rock composition and porosity. Combined with the cuttings data, the log data predictions in turn were used to calculate continuous profiles of effective thermal conductivity down to a depth of $\sim$ 5 km. In addition, radiogenic heat production profiles were derived from the gamma ray logs. The profiles of porosity and the thermal properties allow a statistical description of the variability of porosity and the thermal property of each model unit. The reservoir layer was investigated in more detail. Here in addition, laboratory studies on petrophysical properties were performed on core material and by the use petrophysical data from other wells in the same reservoir, the porosity-permeability relation could be established.

In the case of the crystalline basement an extensive dataset could be composed from the KTB database including logging, core and cuttings data. The whole data set could be interpreted with respect to lithology, structure and alteration of the formation which mainly consists of alternating sequences of gneiss and metabasites. For the different rock types the data was analyzed statistically to provide specific values for geothermal key parameters. Important key parameters are for example: p-wave velocity, density, thermal conductivity, permeability and porosity.

The case study shows that a careful data handling and analyses will lead to representative input-values for numerical geothermal models. The applied methods of log–core-cuttings integration allowed the definition of statistically proven model input parameter for all geological units considered in a numerical model. Beside the case study presented, this method was successfully applied also for formations of the South German Molasse Basin, the West-Netherland Basis, the Lower Rhine Basin, the Rhenish Massif and the Gippsland Basin, Australia. In a slightly modified version, the method can be adopted also to drill holes located in the South German crystalline basement (Urach, KTB).