VARIABILITY OF THERMAL CONDUCTIVITY – PRELIMINARY STUDY OF KRAKÓW AREA (GeoPLASMA-CE)

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Introduction

The thermal conductivity (TC) parameter is crucial for geothermal exploitation. Its meaning is especially important in shallow geothermal resources exploitation, where TC controls the volume of rock influenced by the borehole heat exchanger's (BHE) operation as well as the heat transfer rate. Although thermal conductivity of rocks is homogeneous (within one order of magnitude) and small compared to other materials, there is a need for mapping its actual value for proper recognition of shallow geothermal energy potential. The meaning of this value may be observed in previous (eg. Trans GeoTHERM) and current projects (eg. GeoPLASMA-CE, GRETA), which all work towards the development of shallow geothermal energy potential and seek the optimal way of mapping TC.

Like any other physical property of rock, thermal conductivity value is changing not only from one rock type to another, but also within rock types, and it is influenced by porosity, mineralogical composition and pores saturation (Przelaskowska 2018; Clauser and Huenges 1995; Robertson 1988). Thus, thermal conductivity may be dependant on rock facies, yet clear identification of these dependencies would require massive, locally focused research which would include also the influence of pressure on the in situ TC value. The last mentioned indicates, that also depth may modify the ability of heat transfer.

The current paper briefly describes the method, input data and results of conducted activities within the implementation of GeoPLASMA-CE project in Kraków.

Samples and methods

In the GeoPLASMA-CE project, local modeling of thermal properties based on geological modeling and performed measurements have been performed in the Petrel software. The structural model has been parametrized with porosity and thermal conductivity along with information about saturation zone depth. The parametrization was based on 25 thermal conductivity values obtained from direct measurements of solid and unconsolidated rock samples and a massive thermal conductivity database created from literature during the project. Since for geothermal potential mapping only mean values of the interval are meaningful, within geological units given by the structural model the values have been distributed stochastically to fit set distribution curve. The last part of the procedure was rendering maps of average thermal conductivity values for presumed intervals, harmonized in the entire project. Additionally, the results of modeling were compared with locally available data derived from thermal response test (TRT).

Results and conclusions

Obtained maps show significant thermal variability of rocks within the geologically complex Kraków area (Fig. 1). The highest values of mean thermal conductivity (up to about 4.0 W/m/K) were obtained in the areas, where solid rocks are dominating. Examples are the southern part of Kraków, where the Carpathian overthrust extends and western part of the city, where horst of Jurassic limestones exists. Lowest values may be observed when poorly consolidated materials are in thick deposits. This may be clearly visible in the eastern part of the city, where thick Quaternary and Miocene deposits occur and in the graben filled with Miocene clay deposits in the southwest part of the city.

Vertically, mean thermal conductivity tends to increase, what may be observed in the following maps. Clearly, it is related to the increase of the share of more consolidated rocks, yet some exceptions may be observed with the most obvious one occurring in the southern part of the city.

Performed modeling indicates that thermal conductivity parameters may exhibit significant variability even in areas as small as the Kraków city and are strongly and directly related to the geological structure.

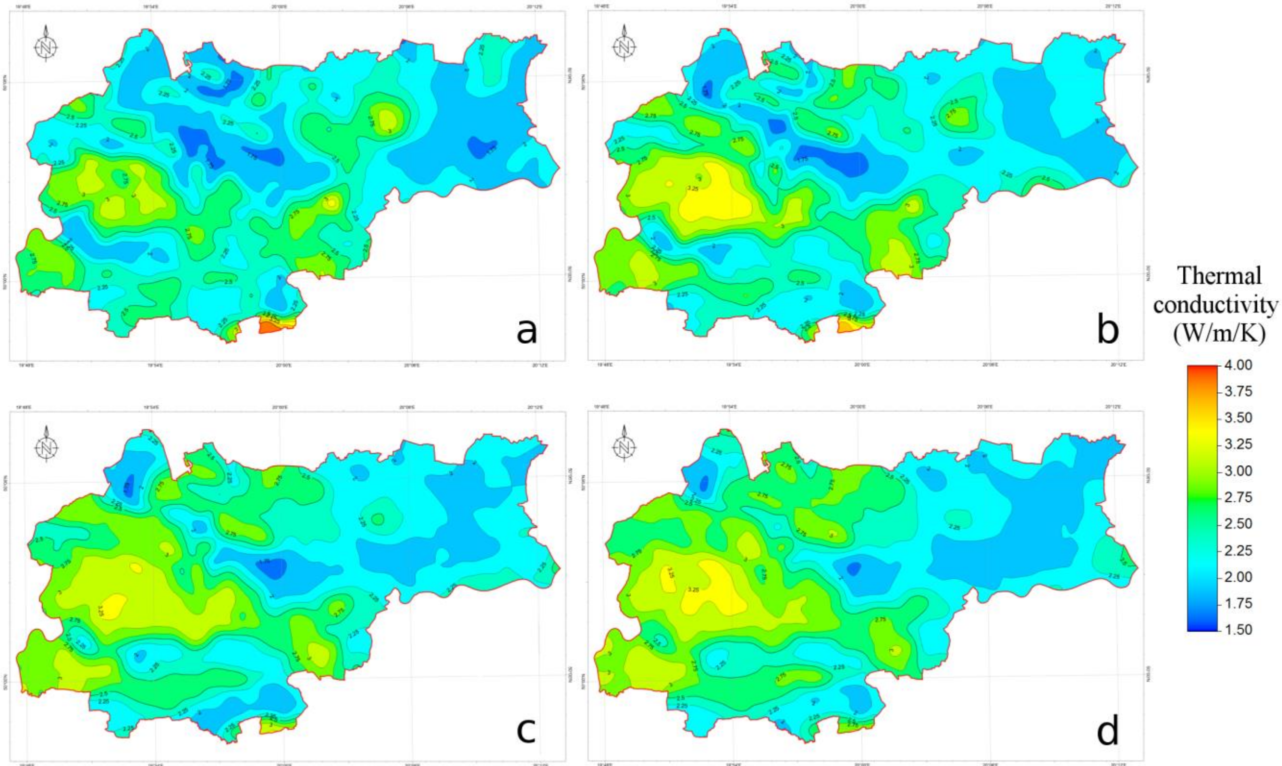

Figure 1. *Average thermal conductivity maps for four depth intervals: 50, 100, 150 and 200m depth (miniatures a, b, c, d, respectively).*

This, along with observed exceptions in the vertical trend of increasing thermal conductivities values put into doubt a possibility of assessing shallow geothermal potential without performing detailed structural modeling.

The results of the project, including presented preliminary maps of thermal conductivity are going to be used for the Kraków City strategic planning purposes.

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References

Clauser, Christoph, and Ernst Huenges. 1995. “Rock Physics & Phase Relations: A Handbook of Physical Constants. Thermal Conductivity of Rocks and Minerals.” American Geophysical Union 3 (Thermal Conductivity of Rocks and Minerals): 105–26. https://doi.org/10.1029/RF003.

Anna Przelaskowska. 2018. “Szacowanie Wartości Współczynnika Przewodności Cieplnej Piaskowców Fliszowych Na Podstawie Składu Mineralnego.” Nafta-Gaz, 74 (6): 435–42. https://doi.org/10.18668/ng.2018.06.03.

Robertson, Eugene C. 1988. “Thermal Properties of Rocks. Report 88-441.” US Department of the Interior: Geological Survey, 106. https://doi.org/10.3133/ofr88441.