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"Spatial distribution of the selected parameters of the terrestrial thermal field within the Polish Carpathians and the Carpathian Foredeep"

Abstract: A set of 538 thermal well logs, 388 of which are located within the Polish Carpathians and the Carpathian Foredeep, was collected. This set was acquired over a period of 50 years. This data set was described in detail and the data quality was evaluated. Most of the logs were acquired in perturbed conditions and needed correction. Commonly used correction and transformation methods from the perturbed- into the equilibrium conditions were described and analyzed. For the purpose of this work a *KUKKONEN-SZEWCZYK* or *equilibrium method* was selected from a broad array of methods. It was shown that this method is optimal for the Polish conditions.

There were modelled three selected parameters of the terrestrial thermal field: the temperature, the thermal gradient and the reciprocal thermal gradient. The modelling techniques, methods of interpolation, log upscaling and data averaging and generalization were described and motivated.

The result of the modelling process is a coherent three dimensional model of the temperature and the thermal gradients within the interval between the ground level and the surface of the 160°C isotherm. The quality of the model was described and critically analyzed. The model was illustrated by a series of maps and cross-sections. The maps present the temperature distribution at several selected depths and structural surfaces as well as the average thermal gradient and interval thermal gradients computed for the selected intervals. The cross-sections present the distribution of the temperature and the thermal gradient along four arbitrarily selected lines perpendicular and one parallel to the northern limit of the Carpathian Overthrust.

The modelling process resulted in the mapping of several previously unknown, mostly positive, thermal anomalies located within the Carpathian Foredeep.

The modelling process results, especially the lateral and vertical thermal gradient distributions were correlated with other geological phenomena such as the structural development and tectonics, lithology and facies development, as well as with the Bouguer anomaly distribution and hydrocarbon accumulation occurrences. These correlations were discussed and interpreted. This interpretation resulted in the following conclusions:

- The standardization of the thermal logs is an absolute necessity. All well thermal logs, if they were acquired in the quasi-equilibrium conditions or in the perturbed ones, require the calibration to the equilibrium conditions. The main goal of calibration is the removal of the influence of the surface conditions, like season of the year or the weather or drilling processes, as well as the drilling mud circulation on the thermal conditions of the drilled rock formations.
- The number and the spatial distribution of the thermal logs acquired in the wells, suggest the application of three dimensional modelling as a tool for investigation of the temperature and thermal gradients changes.
- The thermal anomalies, expressed as anomalies of the thermal gradient are related to the geology of the investigated area. They result from the structural position of the consolidated basement manifested at the map of the Bouguer anomaly, and a system of faults and fault zones mapped at the base of the Carpathians and the Carpathian Foredeep. Subsequently, they are moderated by the vertical facies and lithology changes, particularly by alterations of high- and low-conductive layers.
- The modelling results seem to confirm the hypothesis, presented in the introduction to this paper, that the thermal parameters of the lithosphere (especially gradients) are irregularly differentiated in three dimensions to a considerably higher degree than imagined before.

This last statement leads to the recommendation: when it is feasible from the technical and financial point of view, to provide the thermal logging in each well, especially during logging after drilling completion.

It is strongly advised to continue the works in the following directions:

- a new archival query should be done in order to collect a similar dataset for the area of the Polish Lowland, and subsequently to extend the model to the whole area of Poland;
- a detailed study should be done which could find and quantitatively describe the relationship between the thermal gradient observed in the wells and lithology, and other petrophysical properties, especially measurable by the well logging;
- a numeric model of the structural development of the Carpathians and the Carpathian Foredeep should be constructed in order to verify the hypothesis about the influence of structural development on the present-day thermal field of the Earth within the investigated area;

- numeric three dimensional parametric models of lithology, facies and petrophysical parameters should be constructed in order to explain other factors which influence the present-day distribution of the thermal parameters and to verify and refine the existing model;
- a detailed analysis of the relationship between the Bouguer anomaly distribution and the thermal gradient distribution should be prepared in order to explain the influence of the structural development of the deep basement and/or lithological development of the Carpathians and the Carpathian Foredeep on the present-day terrestrial thermal field within the investigated area;
- a detailed analysis of the correlation between the positive thermal anomalies distribution and the appearance of gas accumulations within the Carpathian Foredeep should be prepared in order to explain the origins of this phenomenon.