Heat flow refraction on structures with conductivity contrast

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[1]Geophysical Institute of SAS, Bratislava, Slovakia
geofmadu@savba.sk
geofhvoz@savba.sk
geofdubi@savba.sk

This contribution is devoted to the analysis of the refraction of the heat flow caused by the subsurface structures with contrasting thermal conductivity values. We enhanced the fundamental calculation and interpretation results [Carslaw, Jaeger, 1959; Ljubimova et al., 1976; 1983; Czeremensky, 1977, …] related to these effects by some new model configurations and by qualitative and quantitative analysis of their influence on the temperature and on the heat flow density distribution. The basic refraction effects were studied on models with the disturbing bodies bounded by the coordinate surfaces and buried in homogeneous half-space or in horizontally layered media [Hvo•dara, Majcin, 1985; Hvo•dara, 2008; 2009]. These model types were supplemented by more realistic 2D and 3D disturbing model structures with the contrasting thermal conductivity coefficients (various polygonal and polyhedral bodies). They were analysed in papers of [Hvoždara, Schlosser, 1985; Majcin, 1992; Hvoždara, Valkovič, 1999, Hvoždara, 2008; Hvoždara, Majcin, 2009] and other. The great attention was paid to the model problems related to the refraction of the heat flow near the border of the sedimentary basins also combined with the refractions on the Earth's surface topography [Majcin, Polák, 1995].

The solutions of mathematical problems were presented in the exact analytical form or they were received by the numerical approaches. The boundary element method and the finite difference method were the most frequently employed in our calculations.

The calculated model temperature distributions, the surface heat flow density data and also the distributions of the heat flow density vector components are analysed also with regard to the interpretation of measured surface data, to influence on calculation of representative heat flow density and to construction of the terrestrial heat flow maps over the geological structures with different thermal conductivity coefficients. The new models show the great importance of the refraction effects on contrasting structures in all mentioned branches of the geothermics. The anomalous temperature distributions, the step changes of the heat flow density components calculated in the directions not normal to the structure boundaries characterised by the step change of the conductivity parameters and the declination of heat flow density vectors from vertical direction near these boundaries force to apply refraction effects to measurements and interpretations mainly near the sedimentary basins borders and near the vertically or aslant layered structures or such narrow contrast rock zones. Such structures are typical and frequently occurred also inside the tectonic region of the West Carpathians.

References

Carslaw H. S., Jaeger J. C. Conduction of heat in solids. — Oxford: Claredon Press., 1959. — 510 p.

Czeremensky G. A. Applied geothermics. — Leningrad: Nedra, 1977. — 224 p. (in Russian).

Hvo•dara M. Geothermal refraction anomaly due to a spherical body buried in the halfspace // Contrib. Geophys. Geod. — 2000. — **30**, № 3. — P. 261—277.

Hvo•dara M. Groundwater and geothermal anomalies due to a prolate spheroid // Contrib. Geophys. Geod. — 2009. — **39**, № 2. — P. 95—119.

Hvo•dara M. Refraction effect in the heat flow due to

3-D prismoid, situated in two-layered Earth // Contrib. Geophys. Geod. — 2008. — **38**, № 4. — P. 371—390.

Hvoždara M., Majcin D. Calculation of a heat-flow anomaly generated by a cylindrical inhomogeneity // Contrib. Geophys. Geod. — 1885. — **15**. — P. 51—58.

Hvoždara M., Majcin D. Geothermal refraction problem for a 2-D body of polygonal cross-section buried in the two-layered Earth // Contrib. Geophys. Geod. — 2009. — **39**, № 4. — P. 301—323.

Hvoždara M., Schlosser G. Anomaly of the telluric and thermal field by the presence of a two-dimensional body in the homogeneous halfspace // Contrib. Geophys. Geod. — 1985. — **15**. — P. 35—49.

Hvoždara M., Valkovič L. The refraction effect in the geothermal heat flow due to a 3-D prism in two layered Earth // Studia geophys. et geod. — 1999. — **43**. — P. 407—426.

Ljubimova E. A., Ljuboshits V. M., Nikitina V. N. Effect of contrasts in the physical properties on the heat flow and electromagnetic profiles // Geoelectric and geothermal studies / Ed. A. Ádam. — Budapest: Akadem. Kiado, 1976. — P. 72—102.

Ljubimova E. A., Ljuboshits V. M., Parfenjuk O. I. Numerical models of temperature fields in the Earth. — Moscow: Nauka, 1983. — 124 p. (in Russian).

Majcin D. Refraction of heat flow on the near-surface structures with thermal conductivity contrast // Contrib. Geophys. Geod. — 1992. — **22**. — P. 67—80.

Majcin D., Polák S. Refraction of heat flow near the border of the sedimentary basins with topography // Contrib. Geophys. Geod. — 1995. — **25**. — P. 99—112.