Geophysical Research Abstracts
Vol. 21, EGU2019-1775-1, 2019
EGU General Assembly 2019
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System of potential geophysical field analysis in complex environments and some results of its application (Christiaan Huygens Medal Lecture)

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A system of advanced of advanced magnetic field analysis for areas with oblique magnetization, rugged terrain relief and complex geological media has been developed together with B. Khesin and V. Alexeyev (1996). Indubitably, this system effectively works and in more simple environments. This interpreting system includes the following components (besides conventional ones): (1) calculation of the second effect of magnetic temporal variations, (2) calculation of magnetization of the upper part of geological section for rugged and flat relief, (3) quantitative analysis of anomalies from the main interpreting models (thin, thick beds, horizontal plate and intermediate bodies, sphere and horizontal circular cylinder) under complex environments (inclined magnetization, arbitrary terrain relief and unknown level of the normal field), (4) multimodel approach to magnetic data analysis, (5) utilization of magnetic temporal variation effect for classification of hidden geological and other targets, (6) 3D combined modeling of magnetic (ΔT, ΔZ, ΔX and ΔY) and gravity fields (observed, free air, Bouguer and second derivatives of gravity potential) of complex geological media at different levels. The results of magnetic field modeling are accompanying with the 'paleomagnetic mapping' methodology.

The quantitative methods developed in magnetic prospecting were successfully transferred to gravity method where computation of some new parameters is proposed. In gravity was also suggested a novel approach for calculating surrounding terrain relief effect due the process of 3D direct problem solution.

In the near-surface thermal investigations in small holes (1-2 m) the developed successive methodology is based on the following components: (1) removing the temporal temperature variations delaying from the earth's surface, (2) elimination of the rugged terrain relief influence, (3) quantitative analysis of thermal anomalies (for the case of stable thermal regime) by the use of methodologies developed in magnetic prospecting.

In the Very Flow Frequency (VLF) method, the sequential technology covers the elimination of significant VLF temporal variations, removing the rugged terrain relief influence, and quantitative interpretation of VLF anomalies.

Numerous methods were developed for analysis of thermal data in intermediate and deep wells. I want to focus on the issue of the utilization of thermal data for the studying climate of the past. Application of the developed technology to thermal data observed in the boreholes of a few hundred meters depth (with comparatively uniform media) allowing to unmask the climate of the past for several hundred years.

The advanced quantitative methods developed for the magnetic anomalies analysis were productively transferred and approved to resistivity, induced polarization and seismoelectric methods.

For processing of results of single geophysical methods and for integration of methods of different physical nature, various information methodologies have been developed. Their effectiveness is confirmed by application on numerous field examples.

Elements of the developed system have been successfully applied at different scales in various regions of the world in such branches as archaeological prospection, environmental investigations, discovering economic minerals, geological-geophysical mapping and regional studies (including development of deep discontinuities in the Earth's crust and unmasking upper and lower mantle inhomogeneties).