



NEW ASPECTS OF THE APPLICATION OF ELECTROMAGNETIC METHODS TO PETROLEUM EXPLORATION, POLISH EXPERIENCES

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Introduction

Saturation of geological medium with hydrocarbons causes anomalous changes of its physical properties. The saturated zones generate anomalies in physical parameters of environment distribution and measured geophysical fields allowing, in some step, discovering of oil and gas fields presence and even recognizing of its range, structure and changeability of its characteristics. From point of view of electromagnetic methods saturated by hydrocarbons complexes are characterized by increasing of its resistivity of 1-4 ranges of magnitude. Particularly distinct contrast appear on lower boundary of deposit, between reservoir rock saturated with highly mineralized water and saturated with oil or natural gas as well as on upper deposit boundary covered by low-resistivity, sealing clayey rocks. Moreover at the boundary between hydrocarbons and formation waters a contrast of ability to electric polarization of environment induced by electric current flow appear. As a result of the contrast, anomalous distribution of polarization parameters appear, particularly anomaly of so called phase parameter of polarization marking itself at deposit contour zone (Stefaniuk 2011). Direct reflecting of deposit in surface anomalies depends on its size and depth of depression so as effects from objects of small size buried to significant depth disappear among anomalies generated by petrophysical differentiation of overburden. The indirect gauge of hydrocarbon deposit presence is near-surface zone of mineralogical changes connected with diffusion of hydrocarbons from deposit zone to Earth surface. As a result of the changes a zone of scattered sulfide mineralization appear inside migration chimney, modifying mainly magnetic properties of geological medium and its electric polarization ability (Wojdyła et al 2011, Sternberg 1991). Examples of investigations made in the zone of Carpathian oil fields „Grabownica” and “Wańkowa” as well as gas field „Rudka” in the Carpathian Foredeep are presented in the paper.

Methods and results

The paper is illustrated by electromagnetic investigations made in zone of gas field “Rudka” located inside molasse type sediments of Carpathian Foredeep and oil fields „Grabownica” and “Wańkowa” that occur in the zone of outer flysch Carpathians. The geophysical survey was made with the use of electromagnetic methods: Audiomagnetotellurics (AMT), Controlled Source Audiomagnetotellurics (CSAMT), Induced Polarisation (IP) and Transient Electromagnetic Method (TEM). The objective of the investigations was to evaluate the usefulness of electromagnetic methods in recognition of structural and tectonic conditions of deposits, and particularly to determine hydrocarbon-saturated zones (Stefaniuk et al 2015). The “Rudka” gas field is relatively shallow so that it mark at interpreted geophysical parameters despite of its small sizes. Hydrocarbon fields in the Carpathians occur at rather shallow depths, but under highly complicated structural and lithological conditions, that is significant impediment to data interpretation. In such conditions the complex interpretation of different type of surface geophysical data as well as borehole and surface geological data was applied. Interpretation of electromagnetic data for “Wańkowa” oil field was supported by results of gravity and reflection seismic survey. Additionally, gravity and electromagnetic data was used for construction of shallow and deep seismic velocity models. The models were used for calculation of short and long-wavelength seismic static corrections and for Kirchhoff depth migration. Building of multivariate models was based on simultaneous joint inversion of seismic, gravity and electromagnetic data as constraints. In process of building initial geophysical model advanced statistical method was very useful. Use of independent velocity models to seismic processing allows to improve a quality of stacking seismic data and improves final results of Kirchhoff depth migration in relation to the classical methods.

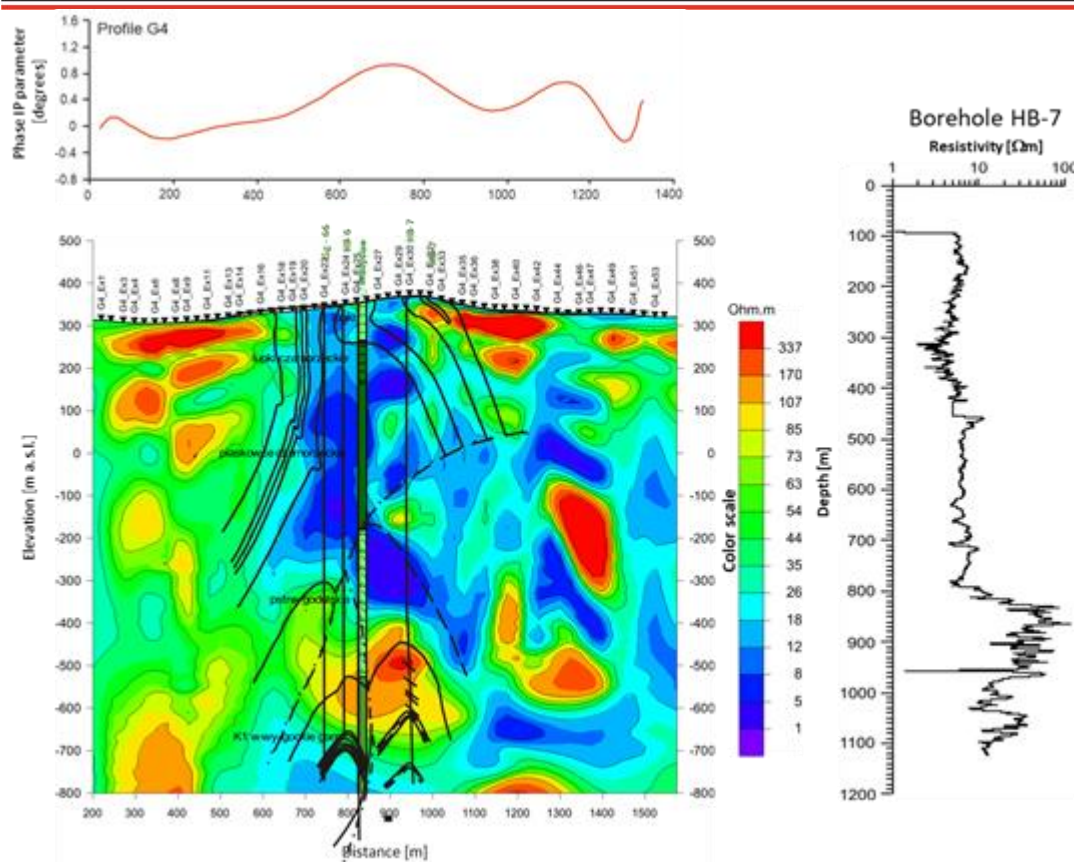


Figure 1. Results of 1D inversion of CSAMT data with distribution of phase IP parameters, borehole resistivity and geological interpretation, “Grabownica” oil and gas field, G4 profile.

Conclusions

Hydrocarbon deposit zones are reflected in resistivity distribution. The results show the connection between the resistivity distribution and reservoir’s geometry interpreted on the basis of log data. The characteristic anomalies of induced polarization phase parameter correlate relatively accurately with the predetermined reservoir’s contour. A significant impediment to electromagnetic data interpretation is the complex structure of the deposit. The integrated interpretation of geophysical and geological data is new and promising methodology interpretation of complex geological structures.

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