

PS Integrated Magnetic Studies at Southwestern Edge of the East European Platform, Ukraine*

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Abstract

The recent results of the magnetic field studies confirmed the presence of geodynamic active faults which are often associated with tectonically screened hydrocarbon traps (Maksymchuk et al., 2013; Kuderavets et al., 2013; Gadirov et al., 2018). Such investigation is a key task under the integrated use of various magnetic methods for survey and prospecting of minerals. We performed a detailed study of the static characteristics of the local anomalous magnetic field (AMF) upon hydrocarbon deposits based on the magnetic survey profile. For a deeper understanding of the near-surface anomalies, as well as possible microseepage effects, studies of the magnetic susceptibility (MS) of surface sediments and soils were applied. Finally, we compiled the information about the dynamic features of the magnetic field.

Dynamic characteristics were observed at the locations of the long observation points by conducting repeated measurements over a certain period of time. The local magnetic anomalies with amplitudes up to 10 nT and a width of about 3-5 km were detected in the structure of the anomalous magnetic field within the Outer zone of the Carpathian Foredeep. These anomalies relate to hydrocarbon deposits areas with complex morphology. The local magnetic anomalies with the amplitudes of several nT upon oil and gas deposits had the same shape as the structure contours. Such zones were approved by the magnetic measurements at areas of different hydrocarbon structures. The anomalies of soil magnetic susceptibility were marked close to productive hydrocarbon areas. We suggested these local magnetic anomalies and the anomalies of soil magnetic susceptibility can to be the searching criteria for hydrocarbon traps.

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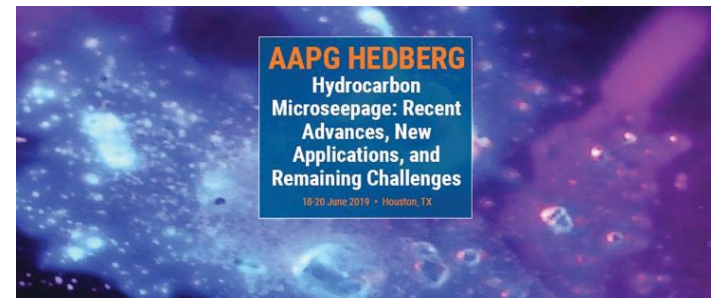
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INTEGRATED MAGNETIC STUDIES AT THE SOUTH-WESTERN EDGE OF THE EAST EUROPEAN PLATFORM

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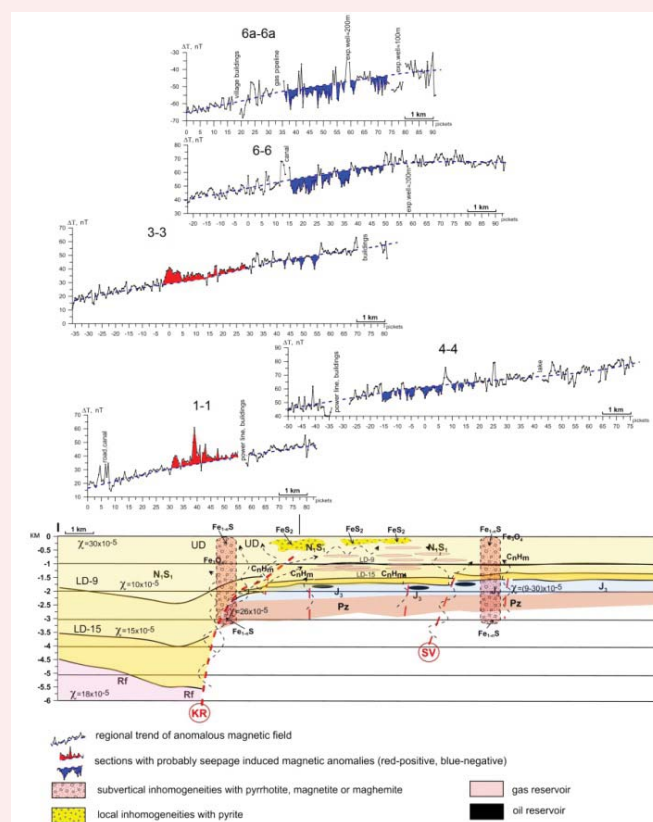
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INTRODUCTION

The recent results of the magnetic field studies confirmed the presence of geodynamic active faults which are often associated with tectonically screened hydrocarbon traps. Such investigation is a key task under the integrated use of various magnetic methods for survey and prospecting of minerals. We performed the detailed study of the static characteristics of the local anomalous magnetic field (AMF) upon hydrocarbon deposits based on the profile magnetic survey. For the deeper understanding of the nearsurface anomalous as well as possible microseepage effects, the studies of the magnetic susceptibility (MS) of surface sediments and soils were applied. Finally, we attracted the information about the dynamic features of the magnetic field. The dynamic characteristics were observed at the locations of the long observation points by conducting repeated measurements over a certain period of time.

STATIC LOCAL ANOMALOUS MAGNETIC FIELD

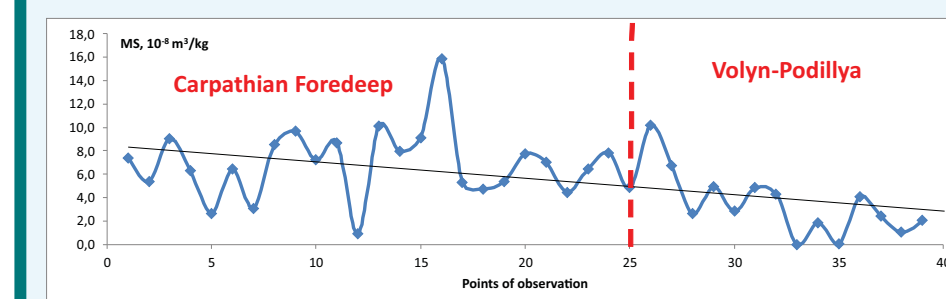


Two types of the ΔT_a anomalies were identified. One of them is positive, near 3 km wide and up to 10 nT intensity. The second anomaly is negative with 4-8 nT amplitude, and 4-5 km wide. Comparison of identified ΔT_a anomalies with structure of seismic GA (gypsum-anhydrite, up to Upper Badenian surface) horizon allows to make a conclusion that positive ΔT_a anomalies have relations with Krakovets deep fault and negative anomalies spatially co-relate with some oil and gas fields in the NE direction from Krakovets fault. Interpretation of local anomalies of ΔT_a has been carried out within the framework of theoretical models assuming the zones (inhomogeneity) with different magnetic properties inside, outside and above the oil and gas reservoirs. It can be suggested, that the presence of probably seepage induced by hydrocarbon alteration local magnetic anomalies can be explained by the fact that magnetic minerals (magnetite, pyrrhotite or maghemite) formed at the edges of the hydrocarbon fields in the fault zones and paramagnetic pyrite is located near the surface more in central part above the gas reservoirs in Upper Dashava Beds.

Residual anomalous magnetic field at the separate ground magnetic transects, sections of probably seepage induced by hydrocarbon alteration local magnetic anomalies, geological cross section with schematic magnetic inhomogeneities and values of magnetic susceptibility of sediments in the NW part of Carpathians Foredeep

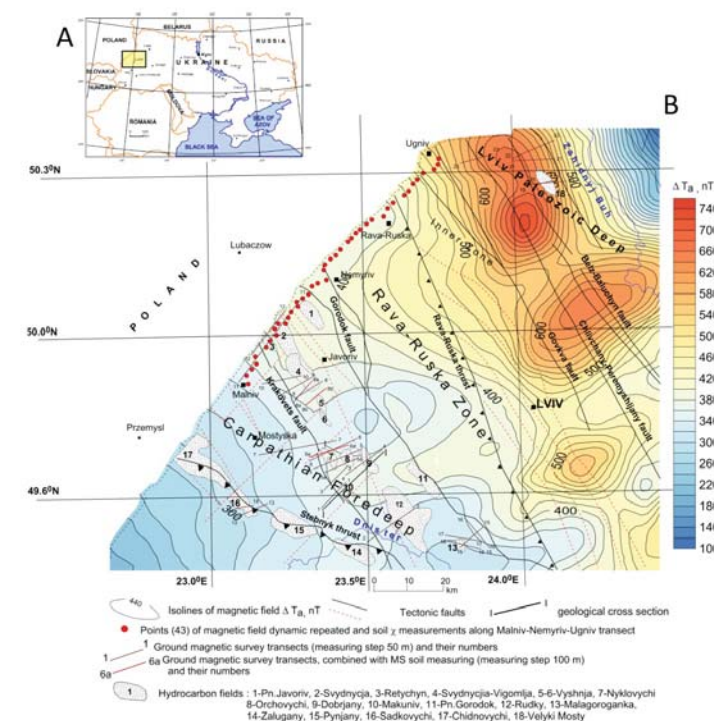
SOIL MAGNETISM

Hydrocarbon migration and microseepage effect cause the changes of the composition of magnetic minerals in the nearsurface layers and soils. The result is the new local magnetic anomalies and changes of the soil magnetic properties. We analyzed the specific features of the local magnetic field structure and soil MS. Soil magnetic properties showed close relation to the geomorphology and landscape position. The anomalies of soil MS were marked close to productive hydrocarbon areas. The results of the magnetic mineralogical analysis confirmed the presence of the significant amount of paramagnetic minerals in soils. The paramagnetic minerals predominant in soils collected at the area of Lviv Paleozoic Depression. The samples collected in Carpathian Foredeep contain the small amount of soft magnetic phase, likely magnetite.



Soil magnetic susceptibility along Malniv-Nemyriv-Ugniv transect

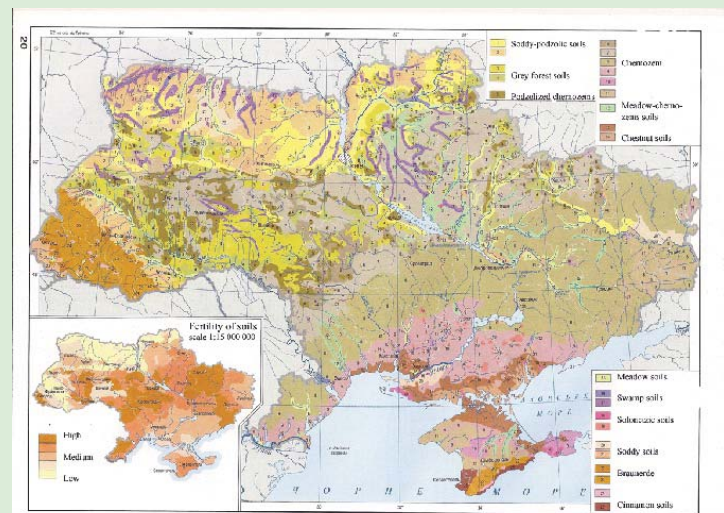
SITE DESCRIPTION



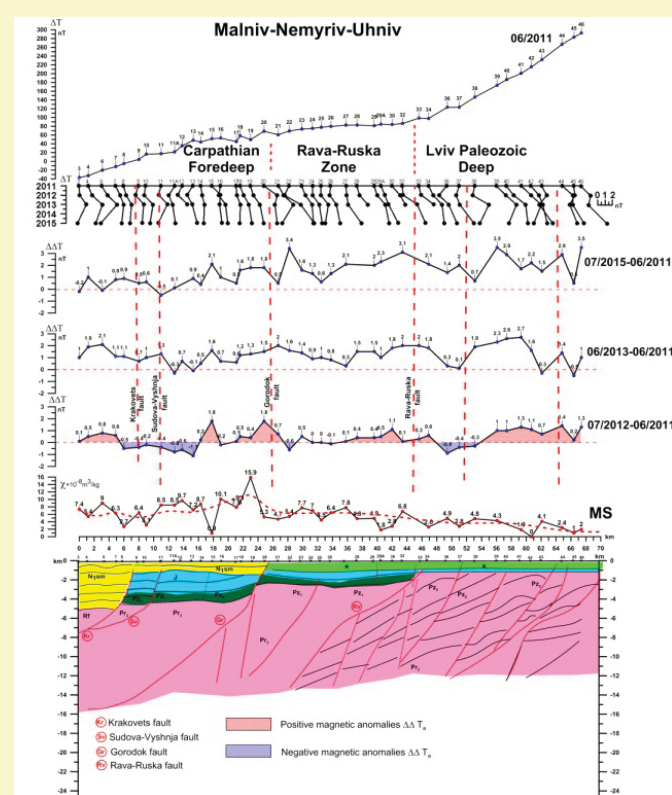
Location of studied area (A) and magnetic field (B) in the South-Western edge of the East-European platform (according to aeromagnetic survey, scale 1:1000 000, the data of the Pivnichgeology, 2002), ground magnetic surveys transects, points of the repeated magnetic field dynamic observation and soil MS measurements (43) along Malniv-Nemyriv-Ugniv transect

The ground magnetic survey was fulfilled on few oil and gas fields (Makuniv, Rudky, Nyklovychi, Orhovychi, Dobriany, Vigomilja, Swydneytsia, Retychyn, Kochanivka) located in the NW part of Bilche-Volytsa zone in the Carpathian Foredeep. Investigated structures are located in the Upper Miocene deposits and are adjusting with the Krakovets, Sudova Vyshnia and Gorodok regional fault system. Their oil-and-gas content is connected with two complexes of sediments: under-gypsum (oil-bearing) and over-gypsum (gas-bearing). To obtain real experimental data about thin AMF structure high-precision ground magnetic survey was done upon selected objects. Measurements of total magnetic field module T were done every 50 meters by means of proton magnetometer with 1.0 nT sensitivity.

Soil types: Albeluvisols (Soddy-podsolic), Phaeozems (Gray forest), Kastanozems (Chestnut), Chernozems (Leached, Typical, Ordinary, Southern, Meadow), Gleysols (Bog soils), Cambisols (Brawn and Mountains soils)



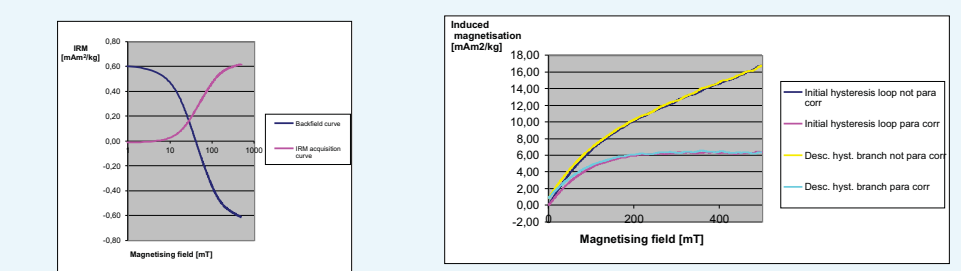
DYNAMIC MAGNETIC FIELD



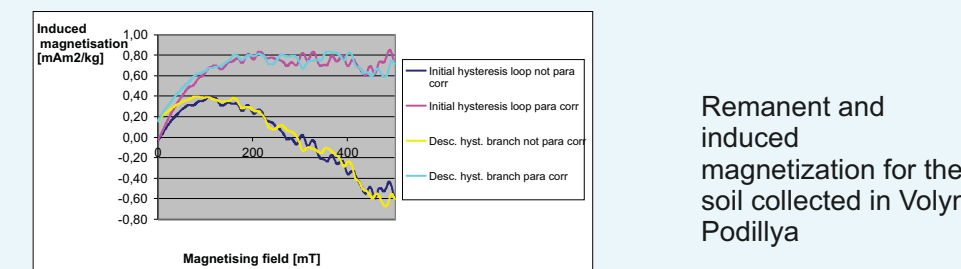
Classical methods of dynamic investigations of magnetic field's features consist of synchronous measuring of the magnitude of total geomagnetic field vectors on a fixed network of points (Tp) and a reference point (Tb) through definite time intervals. Such a scheme generally allows elimination of the influence of external magnetic field variations in differences $T=Tp-Tb$. Objective values of tectonomagnetic measurements are variations of T between pairs consecutive observation cycles ($\Delta\Delta T = T_2 - \Delta T_1$). The registration of the total field T at the basic point and at the all other points was fulfilled with proton magnetovariational station MV-01 (sensitivity 0.1 nT). The mean-square error was less than 1 nT. The repeated magnetic measurements along the transect Malniv-Nemyriv-Uhniv with the 43 observation points were conducted. The Malniv-Nemyriv-Uhniv dynamic transect with a length of about 70 km was laid in the NW part of the Carpathian Foredeep in the zone of its junction with the SW end of the East-European Platform. This zone is associated with the Teisseyre-Tornquist Zone (TTZ). The three observation cycles were performed 07/2012, 06/2013, and 07/2015 along the Malniv-Nemyriv-Uhniv transect with an interval of 1.5-2 km. The regional magnetic field of the study area is complicated by the presence of a regional Lviv magnetic anomaly. We identified the difference of the magnetic field ΔT and sharp growth in the northeast part of transect. The intensity of the $\Delta\Delta T$ anomalies of the first measurement cycle (07/2012-06/2013) changes from -1.1 to 1.8 nT. The most intensive anomaly of the magnetic field was found within the Bilche-Volytsia zone and the Lviv Paleozoic trough. Moreover, the variable anomaly $\Delta\Delta T$ (from -1.1 nT in p. 13 to 1.8 nT in p. 15 and 20 per year) was registered in the area of the Gorodok deep fault within the contact of the Carpathian Foredeep and the Rava-Ruska Zone. The small negative anomaly $\Delta\Delta T$ with amplitude of 0.9 nT/year in p. 36 was registered in the area of the Rava-Ruska deep fault. The increase of the $\Delta\Delta T$ values (to 3.1 nT in p. 32) and a decrease (to 0.7 nT in p. 38) were observed in the junction zone of the Rava-Ruska zone and the Lviv Paleozoic Depression. Both anomalies are repeating for the period 07/2012-06/2011.

Residual anomalous of magnetic field T, T at the observation points (43), MS of soil along Malniv-Nemyriv-Uhniv transect, difference $\Delta\Delta T$ during July 2012-June 2011, June 2013-June 2011, July 2015-June 2011 and fragment of seismogeotravers through the line Chyryv-Mostyska-Rava-Ruska-Velyki Mosty (Zajec, 2013)

Remanent and induced magnetization for the soil collected in Carpathian Foredeep



Remanent and induced magnetization for the soil collected in Volyn-Podillya



CONCLUSION

The local magnetic anomalies with the amplitudes of several nT upon oil and gas deposits had the same shape as the structure contours. Such zones were approved by the magnetic measurements at the areas of different hydrocarbon structures. We suggested this anomalous to be one of the searching criteria for hydrocarbon traps. The significant changes of the the local magnetic field during the time and the occurrence of dynamic magnetic anomalies of $\Delta\Delta T$ with the amplitude from -1.1 to 3.4 nT per year were registered. These anomalies are related to the tectonic faults of various ranks, mainly to deep faults (Carpathian Foredeep Fault, Rava-Ruska Fault). We assume the electrokinetic mechanism of their nature, namely the flow of intense fluid-dynamic processes causing the action of electric currents and changes in geophysical parameters including the magnetic field. The dynamic magnetic anomalies are associated with faults that shield hydrocarbon deposits and serve as channels for the migration of hydrocarbon fluids. The results of soil magnetic studies distinguished three patches. The Southern part of the Carpathian Foredeep with higher MS values up to 15×10^{-8} m³/kg. The Carpathian Foredeep and transition to the Rava-Ruska Zone through the Gorodok fault with high dispersion of the MS values from 1 to 15×10^{-8} m³/kg. The Lviv Paleozoic Depression with minor MS differentiation and low values from 4 to 7×10^{-8} m³/kg. The proposed method provides important information for the studies of the structural and dynamic features of the earth's crust. The results are important for the improvement of the oil and gas exploration technology.