Introduction

The Dnieper-Donets petroleum province takes the lead among all hydrocarbon-prone regions of Ukraine due to its proven reserves, remaining potential resources and cumulated hydrocarbon production. Petroleum potential of its Northern Flank has been proved by discovering of oil and gas commercial reserves in Carboniferous sediments as well as in the underlying basement rocks at several fields like Bezlyudivka, Vasyshchivka, North Korobchyn, Skvortsivka, Yuliivka and others. The main oil and gas prospects are related to the Carboniferous sediments and Pre-Cambrian rocks of the crystalline basement, which are regionally productive within the Northern Flank.

Despite the large number of discovered fields to the date, Northern Flank is evaluated as explored only by 18% due to the complexity of its geological structure, which is reflected in structural unconformities in sedimentary cover and development of the tectonically screened, anticlinal and lithological traps as well. Another reason is poorly understood regularities of hydrocarbon entrapment in the perspective formations within the crystalline basement.

Figure 1 *Location of studied area*

In such conditions, the widest possible use of available geological and geophysical data is an essential precondition to increase efficiency of exploration for oil and gas.

An example of integration of seismic data, well log data, gravity and magnetic observations in order to provide due selection of top priority prospects for further drilling within Molodovska area (Fig. 1) of the Northern Flank is presented.

Method

The complex of geophysical methods has been used for prediction of perspective hydrocarbon formations. At the research stage, seismic information has been supplemented with the building of spatial integral geo-density model for the territory under investigation through the joint inversion of geological, seismic, gravimetric, field and well log data.

As it is known, application of gravity data for mapping of hydrocarbon-prone formations is based on the presence of certain effects in observed gravity field which are associated with uncompacted/dilated domains in the geological section caused by the increasing of porosity and hydrocarbon saturation of the host rocks (Fig. 2). Experimental calculations of direct 2D gravitational effects for the fields of different oil and gas provinces of Ukraine have shown that changing of the saturation in reservoir rocks from formation water to gas causes a gravitational effect up to 1.6 mGal when the root-mean-square values is 0.245 mGal.

To map the above effects within the investigated fields, a building of integral models of deep structure of the studied territory has been conducted. The algorithm consists of stages as follows:

– Building of 3D structural models consisting of the structural horizons retrieved from 2D seismic data;

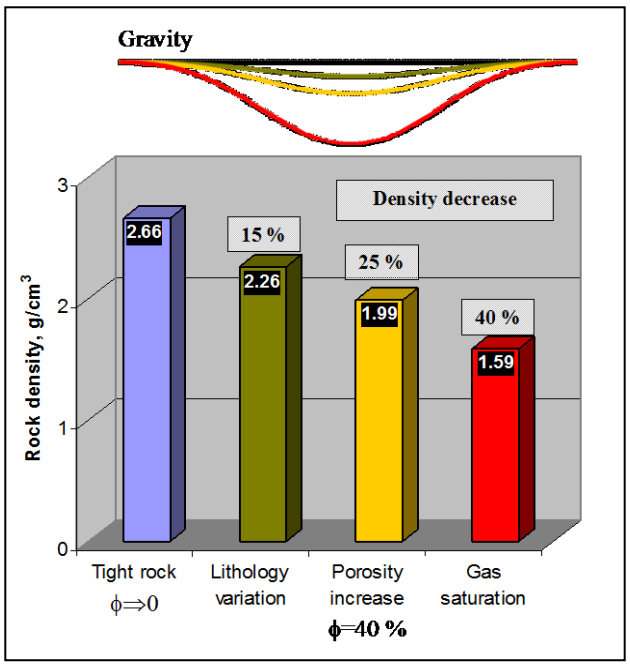

Figure 2 *Density deficiency caused by changing of lithology, porosity and rock saturation*

– Development of the initial voxel density model using density characteristics determined by core samples and well log data analysis. The parameters of model approximation are listed in the table below.

– Correction of the density characteristics of the model based on the solution of inverse problems of gravimetry in criterial setting (Petrovskyy O.P.) taking into account geologically reasonable constraints on the parameters variation.

Peculiarities of the basement tectonic structure were studied taking into account of the results of qualitative interpretation of magnetic data.

Table 1 *Parameters of inverted 3D density model*

Field, area	Density grid mesh, meters			Model size			Gravity misfit, mGal	
	X	Y	Z	X/Y/Z number of points	Total number	Mb	Initial density model	Final inverted model
Molodovska, 851 sq.km	100	100	10	380/224/800	68 096 000	519 5	6.3	0.09

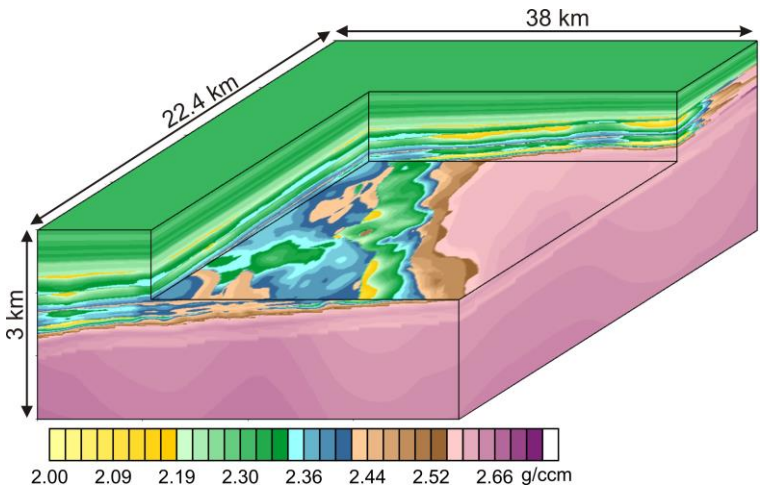

Figure 3 *Molodovska prospect, 3D integral density model*

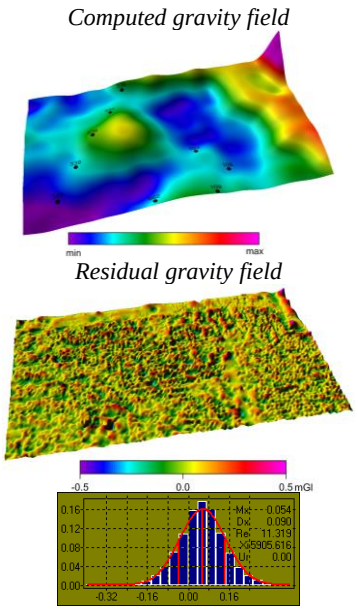

Figure 4 *Molodovska prosepct. Computed gravity field*

Results

Spatial density distribution model resulted from the inversion of seismic-gravity data and well log data has been used for density distribution analysis within the main hydrocarbon perspective formations. For that purpose, intrastratal slices within all perspective horizons and the basement weathered crust were built (Fig. 5). Local low density areas were delineated for each horizon. Those zones were interpreted as favorable for improved reservoir properties development and high probability of hydrocarbon saturation.

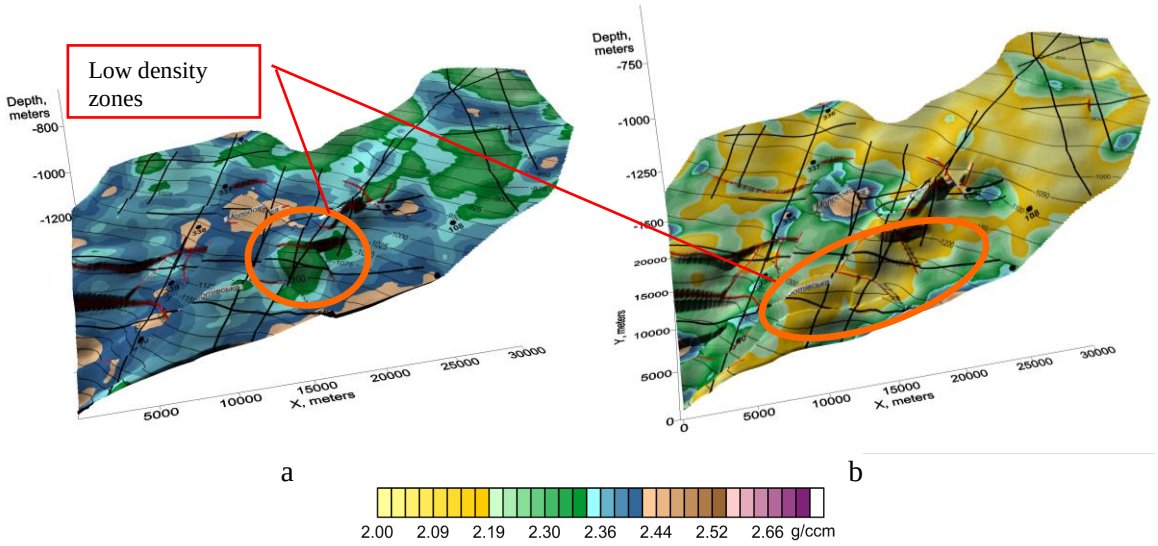

Figure 5 *Density distribution within Serpukhovian (a) and Visean (b) stages. Intrastratal slices.*

Within the basement formations, matching the characteristics of magnetic field and density distribution allowed formulation of some additional conclusions about the features of regional depth structure of the investigated territory and the hydrocarbon sources. The analysis was conducted for Molodovska prospect itself and neighboring Malynivska structure with proven hydrocarbon pools where similar geodensity model was built previously.

The analysis has shown that within both areas plunging of the basement towards the Dnieper-Donets Basin is accompanied by increasing of basement rocks regional density. Obtained values of density in two wells penetrating basement within the area studied are well correlated with average values of density retrieved from the core samples analysis. There is also a correlation of basement subsidence with the reduction of regional component of magnetic field (Fig. 6-7).

Analysis of the local component of the magnetic field has revealed the presence of abnormal zones with increased values of the magnetic properties in the section corresponded to local areas of increased density in the basement. Within Malynivska structure discovered hydrocarbon pools are confined to the traps located upwards the sediment stratification from the abnormal nodal areas (Fig. 8-9). Detected abnormal zones of increased density and properties could potentially be related to the presence of intrusive formations in the basement. The process of formation of such geological elements can be a favorable factor in terms of possible updeep migration of hydrocarbons and further their accumulation in sedimentary traps. This factor has been used as an additional criterion for selection of the most prospective traps for hydrocarbon exploration within the studied areas of the Dnieper-Donets basin Northern Flank.

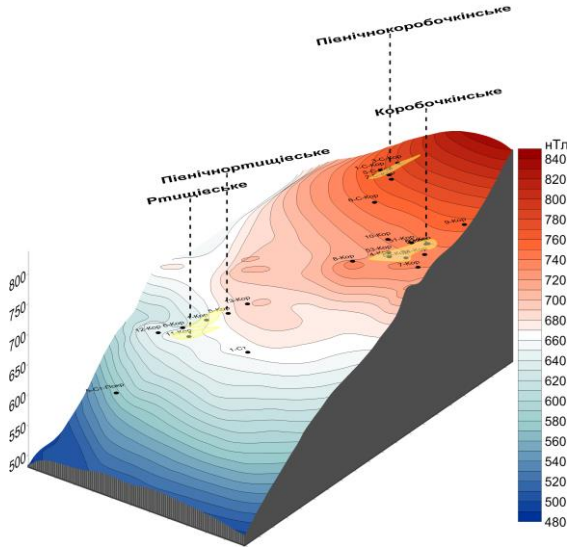

Figure 6 *Malynivska prospect, magnetic field*

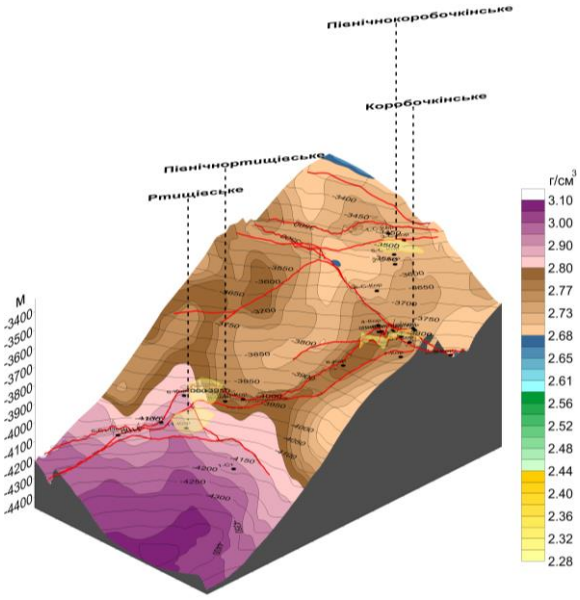

Figure 7 *Malynivska prospect, basement structure and density at its top*

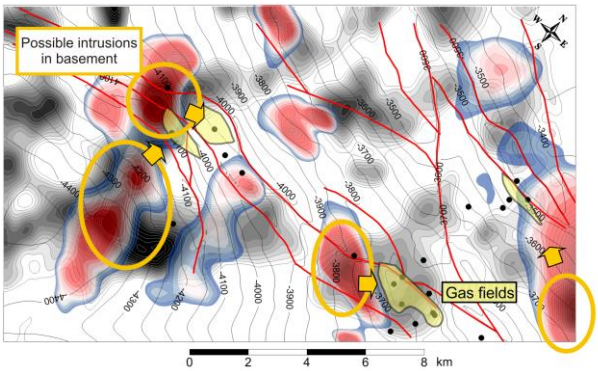

Figure 8 *Malynivska field. Spatial coincidence of local magnetic maximums (in red) and high density zones in basement (in black)*

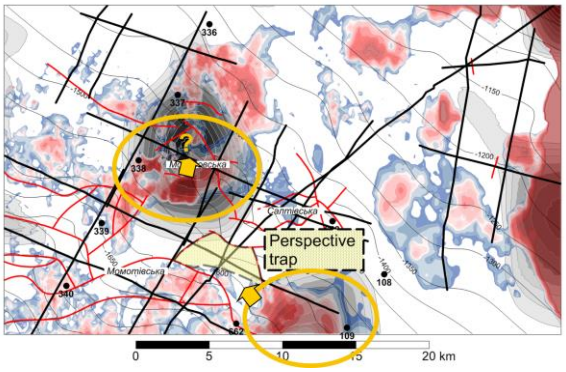

Figure 9 *Molodovska prospect. Similar settings of local magnetic maximums (in red) and high density zones in basement (in black)*

Conclusions

Most promising prospects for hydrocarbon exploration have been selected from available portfolio of tectonically sealed and non-anticlinal traps as a result integral geophysical study. Integration of seismic, well logging, gravity and magnetic data into single 3D model allowed justification of regional characteristics of the depth structure, identification of new features favorable for hydrocarbon accumulation within the Northern Flank of the Dnieper-Donets basin to define top priority prospects for further exploration drilling within the area studied.

Acknowledgements

Authors are grateful to SE "Ukrgeofizika" for initiating the research to evaluate Molodovska and Malynivska prospects of the Dnieper-Donets basin Northern Flank.

References

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