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# ON THE ROLE OF POTENTIAL METHODS TO STUDY THE SALT AND REEF STRUCTURES IN THE DNIEPER-DONETS BASIN

*(Reviewed by the editorial board member S. Vyzhva)*

***The article deals with some of the results of integrating geophysical methods applied in prospecting for unconventional hydrocarbon deposits under salt-stock bodies in the areas of concentration of small and low-amplitude anticlines and reef sites in the Dnieper-Donets basin (DDB).***

***Analysis of potential methods shows that within the DDB there are three types of salt-diapirs, which have certain characteristics in gravimetric and magnetic fields. The first and most common characteristic is the intense minima in gravity and no reflection in the magnetic field. The less common second type is stocks that outline the minimum gravity against maximum in the magnetic field. The third one, having a peculiar nature, shows both gravimetric and magnetic positive anomalies. Such a variety of manifestations of stocks in the gravimetric and magnetic fields is due, primarily, to their complex morphology.***

***The results of the geophysical surveys over the reef structures and the low-amplitude elevations formed over them show that they are mapped by linear, sometimes isometric, local maxima of the force of gravity of moderate intensity.***

***The comparison of results of previously performed studies of gravimetric and magnetic fields shows their high geologic efficiency in studying the morphology of salt stocks and identifying prospective near-stock objects when combined with seismic data and the data from exploration drilling.***

***Low-cost geophysical gravimetric and magnetic methods significantly reduce the cost of drilling deep exploration wells.***

**Introduction**. Improving the efficiency of exploration for oil and gas requires further development of non-traditional methods. These activities have been conducted by various research and industrial organizations in Ukraine for many years. The theoretical basis to identify the unconventional hydrocarbons (HC) fields in the crystalline basement, under the salt-dome bodies, in the areas of concentration of small and low-amplitude anticlines and reef sites, etc are developing [2, 3, 6]. The accumulated data on exploration show that in order to reduce the exploration cost, the developments should focus on an integrated system of effective and relatively cheap non-seismic methods, while the detailed 3D seismic surveys ought to be carried out mainly at the stage of preparing objects for exploration drilling. The need for combining seismic with other geophysical methods can also be explained by the inability to obtain a sufficient geological dataset and the parameters of the oil and gas reservoir by individual methods [1, 4, 5]. A balanced combination of geophysical methods ensures effectiveness of solving inverse geophysical problems in prospecting.

**The study of salt stocks.** Salt domes in DDD represent the tectonic uplifts differing from the classic anticline uplifts in the presence of the salt core (Figure 1). During the penetration process of the stock, its upper part is dissolved, which often leads to the accumulation of a kind of cap. This cap consists of a poorly soluble accompanying mineral (gypsum, anhydrite) or pieces, or even large blocks, of various solid rocks trapped by salt when it moves upward.

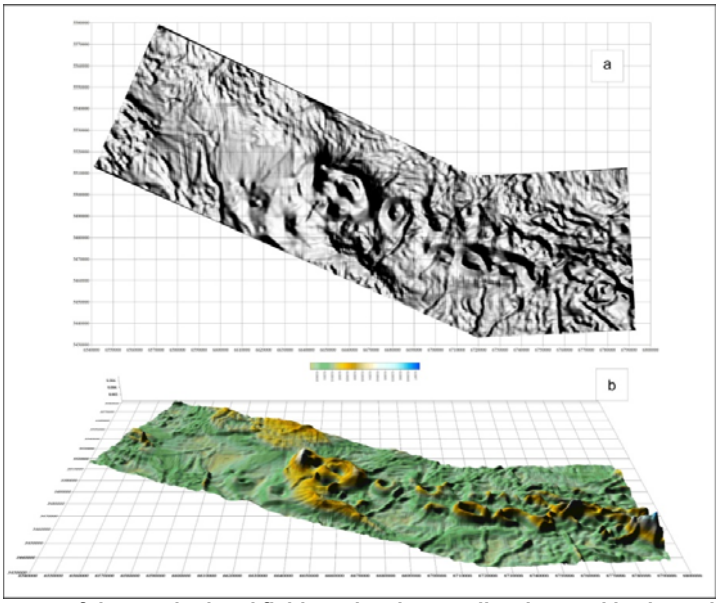


**Figure 1. 3D maps of the gravitational field: a – local anomalies, b – total horizontal gradient**

Analysis of the physical properties of rock salt shows that it is characterized by slightly varying low density of 2.0-2.2 g/cm3. In most cases, the DDD salt stocks of pre-Mesozoic Age break through the enclosing rocks of higher density forming the bodies with negative mass anomaly resulting in the intense minima in gravitational field. Such features are well manifested in the various transformations of the gravity field, for example, in local anomalies (Figure 1a) and in the total horizontal gradient (Figure 1b).

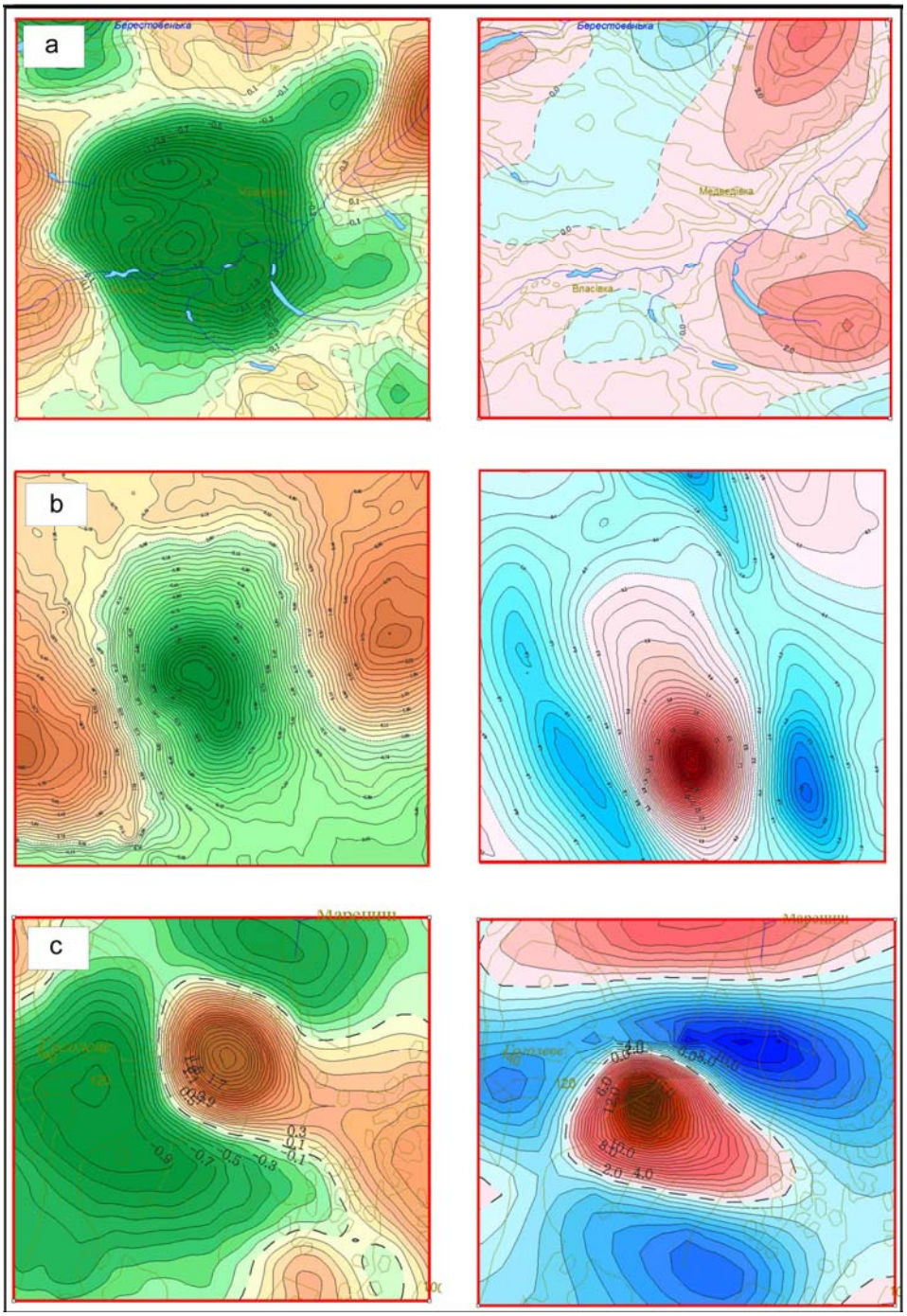


**Figure 2. Reflection of salt dome structures in the gravity and magnetic fields:**
a – Krestischensky stock, b – Runovschinsky stock, and c – Leykovsky stock

Salt domes in DDD are always located in groups and are characterized by columnar structure with steep and almost vertical slopes, sometimes even widening up. The height of the salt stocks is a few kilometers and can reach 6-10 km. Such salt forms are generally isometric in the cross section structures with a diameter from 1 to 8-10 km (Figure 1.2).

Salt is a weak diamagnetic rock. Therefore, big salt bodies are likely to cause negative magnetic anomalies. However, the combined effect of salt and weakly paramagnetic capturing clastic rocks does not account for their specific structure in a magnetic field. In some cases, the salt-core moving upwards captures rock blocks with significant magnetic susceptibility, which in DDD may be represented by diabases. Elevated by salt to the surface from the Devonian, diabases create magnetic anomalies with intensity of a few hundred nT which can be easily mapped in detailed surveys. It should be noted that some salt domes in DDD tend to contain large caps of dense rocks which gravitational effect being greater than that caused by the salt itself. In this case, the salt domes give maximum in gravitational field (Figure 2b).

The results of applying potential methods show that there are three types of salt-diapir identified within the DDD, with characteristics clearly seen in the gravity and magnetic fields (Figure 2). The most common ones are the intense gravity minima which are not actually observed in the magnetic field (Figure 2a).

The stocks identified with minima in gravity and maxima in the magnetic field are less common (Figure 2b). The stocks mapped by both gravity and magnetic positive anomalies are very rare (Figure 2c). This fact can possibly be explained by the presence of the Devonian volcanic rock fragments of considerable thickness in the caprocks. These volcanic rocks are characterized by high excess density compared with the surrounding sediments.

Such a variety of stock manifestations in a gravitational field is explained, first of all, by their complex morphology. It is the main factor in predicting oil and gas structures in zones near the stocks. In these zones, seismic is not always effective since it cannot accurately determine the position of the salt screen for optimal planning of exploration wells. Based on the experience in the DDD, the most correct solution of this problem can be obtained by using 2D and 3D modeling of the gravitational field. Reliability and accuracy of the obtained models depend on the quality and quantity of initial data, first of all, seismic, geological data and the degree of scrutiny of the density section [1, 4, 5]. An example is the joint high accuracy gravity and magnetic data and 3D seismic surveys in the Budyschansko-Chutovsky area in the central part of the DDD. It resulted in discovering a hydrocarbon field in the near-stock part of Runovschinsky salt dome. The results of density modeling for the Runovschinsky stock are shown in Figure 3.

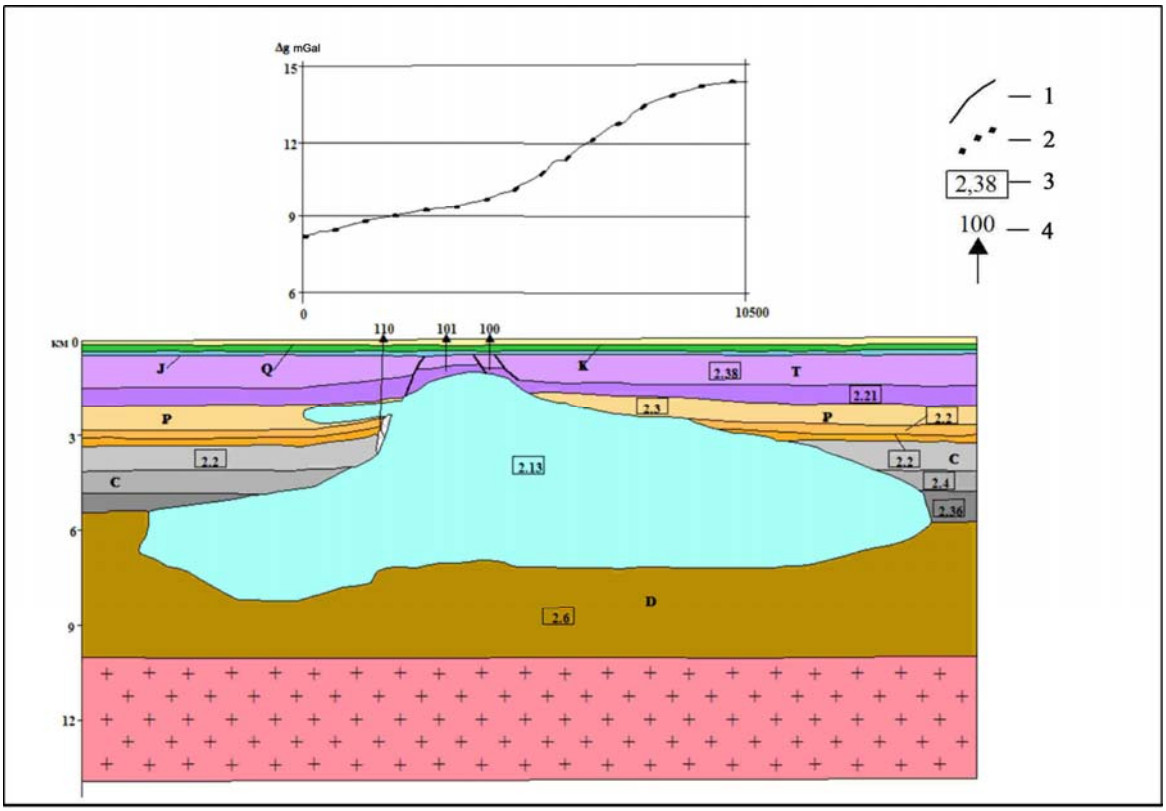


**Figure 3. Density modeling of the Runovschinsky structure**

As for other potential methods, it should be noted that the magnetic surveys are used as a complimentary method in the study of salt stocks to detect the presence of salt uplifts of the Devonian volcanic formations in the caprocks (the detection of their tops and thicknesses).

In the geoelectric sections, the salt stocks appear as rather high impedance heterogeneity. Resistance of a dry salt is equal or larger than 1,000 Ohm · m, while the caprock presented by carbonate-clastic rocks have resistance of 1-25 Ohms · m. The strong contrast in geoelectric properties between the stock and the caprock is the physical basis for using electrical methods to study the stock's morphology.

The authors have compared the results of previous gravimetric and electric studies with the exploration drilling and seismic data to investigate the morphology of salt stocks and allocation of near stock objects under prospecting. The comparison (Krestischenskaya, Rozpashnovskaya, Andreevskaya, Vostochno-Alekseevskaya (Figure 1), and other areas) shows high efficiency of these geological and geophysical methods.

The study of reef structures. Recently, due to the decrease in the collection of classical pericline structures, the hydrocarbon potentials are increasingly associated with the objects extensively developed in the coal formations of the northern near-edge part of the DDD and the Northern Donetsk Basin, the reef structures and the low-amplitude structures formed above them [6]. Stratigraphically, they are confined at Visean and Serpukhovian ages and possibly in the Bashkirian one.

Analysis of the density characteristics of the rocks from these stratigraphical units suggests that the Visean and Serpukhovian carbonate rocks have a slight excess of density compared to their caprock mudstone and siltstone. In the Bashkirian deposits, the density excess of carbonate rocks still further increases.

Therefore, in the gravitational field, they are mapped by linear, sometimes isometric, local maxima in the force of gravity of moderate intensity. A good example is the results from the Stelmahovskaya area in Lugansk region (Figure 4).

It should be noted, that nowadays, magnetic and electric exploration for reef structures in the DDD is not currently being carried out.

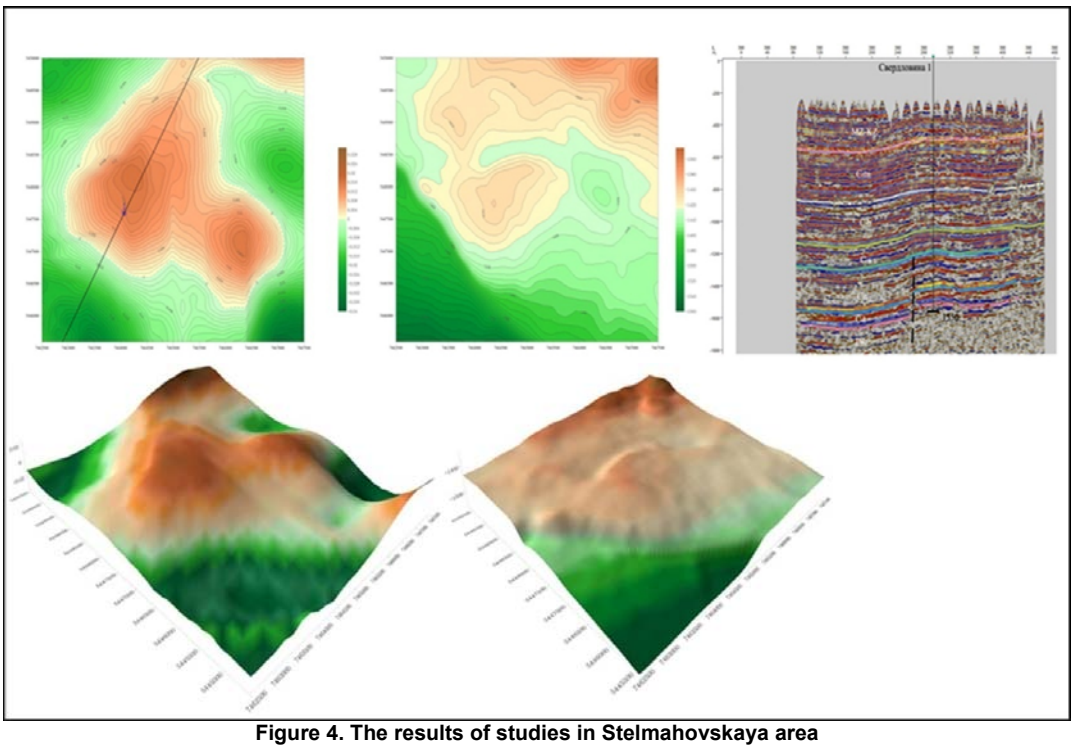

**Figure 4. The results of studies in Stelmahovskaya area**

**Conclusions**. Analysis of research data obtained with potential methods has made it possible to distinguish between three types of salt diapirs within DDB that have specific features manifested in gravimetric fields. The first and most common ones are characterized by intense gravitational minima and are not reflected in the magnetic field. The less common second ones show gravitational minima and maxima in the magnetic field. The third ones, those of a peculiar nature, are mapped with both gravimetric and magnetic positive anomalies.

Analysis of these results shows high efficiency of gravimetric methods in prospecting for unconventional oil and gas structures. Evaluation of their oil and gas prospects requires an application of joint detailed high-accuracy gravimetric and seismic surveys. Evaluation of their prospects is related to joint detailed gravimetric studies of high accuracy together with seismic. Comparing the results of the combined potential fields and wave field allows to quantify their geological efficiency. Certain difficulties in measuring their effectiveness are related to the study coursing unequally in prospecting areas, when using different methods and techniques both in the field and in the interpretation of the obtained data.

However, taking into account the complete set of results of the potential field interpretation will increase the productivity of exploration drilling. The effectiveness of these works is, in our view, evident, since the cost of gravimetric, magnetic and electric methods is much lower than the cost of deep well drilling.

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## ПРО РОЛЬ ПОТЕНЦІЙНИХ МЕТОДІВ ПРИ ДОСЛІДЖЕННІ СОЛЯНИХ ТА РИФОВИХ СТРУКТУР У ДНІПРОВСЬКО-ДОНЕЦЬКІЙ ЗАПАДИНІ

***У статті розглянуті деякі результати узагальнення проведених геофізичних робіт потенціальними методами при пошуках родовищ вуглеводнів нетрадиційного типу під соляно-штоковими утвореннями, в зонах концентрації малорозмірних і малоамплітудних антиклінальних і рифогенних об'єктах в Дніпровсько-Донецькій западині (ДДЗ).***

***Узагальнення результатів досліджень потенціальними методами показує, що в межах ДДЗ виділяється три типи соленосних діапірів, які мають характерні особливості прояву в гравімагнітних полях: перші, найбільш поширені, характеризуються інтенсивними мінімумами сили тяжіння і практично не відображаються в магнітному полі; інші, зустрічаються рідше, штоки, що відбиваються локальними мінімумами сили тяжіння, до яких приурочені максимуми магнітного поля; треті, з ексклюзивною природою, які картуються поєднаними позитивними гравітаційними і магнітними аномаліями. Така різноманітність прояву штоків в гравітаційному і магнітному полях обумовлена, передусім, їх складною морфологією***

***Узагальнення результатів геофізичних досліджень над рифогеними спорудами і сформованими над ними малоамплітудними підняттями показує, що в гравітаційному полі вони картуються лінійними, іноді ізометричними локальними максимумами сили тяжіння не високої інтенсивності.***

***Виконані авторами зіставлення результатів раніше проведених гравіметричних і магніторозвідувальних досліджень з метою вивчення морфології соляних штоків і виділення перспективних приштокових об'єктів в комплексі з даними пошукового буріння і сейсморозвідки показало високу геологічну ефективність цих геофізичних методів.***

***Низька вартість геофізичних досліджень методами граві-магніторозвідки істотно знижують витрати на буріння глибоких пошуково-розвідувальних свердловин.***

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## О РОЛИ ПОТЕНЦИАЛЬНЫХ МЕТОДОВ ПРИ ИССЛЕДОВАНИИ СОЛЯНЫХ И РИФОВЫХ СТРУКТУР В ДНЕПРОВСКО-ДОНЕЦКОЙ ВПАДИНЕ

***В статье рассмотрены некоторые результаты обобщения проведенных геофизических работ потенциальными методами при поисках месторождений углеводородов нетрадиционного типа под соляно-штоковыми образованиями, в зонах концентрации малоразмерных и малоамплитудных антиклинальных и рифогенных объектах в Днепровско-Донецкой впадине.***

***Обобщение результатов исследований потенциальными методами показывает, что в пределах ДДВ выделяется три типа соленосных диапиров, которые имеют характерные особенности проявления в гравимагнитных полях: первые, наиболее распространенные, характеризуются интенсивными минимумами силы тяжести и практически не отражаются в магнитном поле; вторые, встречаются реже, штоки отражающиеся минимумами силы тяжести к которым приурочены максимумы магнитного поля; третьи, с эксклюзивной природой, которые картируются совмещенными положительными гравитационными и магнитными аномалиями. Такое разнообразие проявления штоков в гравитационном и магнитном полях обусловлено, прежде всего, их сложной морфологией***

***Обобщение результатов геофизических исследований над рифогенными сооружениями и сформированными над ними малоамплитудными поднятиями показывает, что в гравитационном поле они картируются линейными, иногда изометричными локальными максимумами силы тяжести не высокой интенсивности.***

***Выполненные авторами сопоставления результатов ранее проведенных гравиметрических и магниторазведочных исследований с целью изучения морфологии соляных штоков и выделения перспективных приштоковых объектов в комплексе с данными поискового бурения и сейсморазведки показало высокую геологическую эффективность этих геофизических методов.***

***Низкая стоимость геофизических исследований методами грави-магниторазведки существенно снижают затраты на бурение глубоких поисково-разведочных скважин.***