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New workflow for petrophysical evaluation of Visean unconventional organic rich reservoirs within Dnipro-Donets Basin

***S. Iuras*[1], *M. Orlyuk*[1], *V. Drukarenko*[1], *S. Levoniuk*[2], *V. Karpyn*[1], *T. Popadynets*[3], 2024**

[1]S.I. Subbotin Institute of Geophysics of the National Academy of Sciences of Ukraine, Kyiv, Ukraine
[2]JSC Ukrgazvydobuvannya, Kyiv, Ukraine
[3]Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
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Increasing the resource base and extraction of hydrocarbons remains one of the main tasks of engineers and scientists, and this is especially relevant in the war conditions in Ukraine. Ultra-deep drilling (>6 km) and the extraction of hydrocarbons from low-permeability unconventional reservoirs are possible directions for the implementation of these tasks, especially taking into account the high depletion of active deposits (of about 75 %) and the good cover of the Dnipro-Donets Basin by exploratory drilling. The results of laboratory studies and the interpretation of well logging data of unconventional reservoirs of Visean sediments (V-23 and V-24-25) indicated that these intervals are promising. An important feature is that these layers are located within the northwestern and southeastern parts of the Dnipro-Donets Basin, with a total area of promising areas of about 8,000 km^2. However, ultra-deep drilling and extraction of hydrocarbons from unconventional reservoirs requires modern technological approaches and solutions. In order to choose the optimal location (a «sweet spot»), to investigate the optimal program of drilling, geological study, and completion of the studied wells, it is necessary to construct the most accurate geological model of this reservoir. This paper constructed a petrophysical model of unconventional-type reservoirs with high total organic content (TOC) based on well logging data of old fund wells with a typical complex of well logging. The model was calibrated on the data of modern geophysical complexes (SGR, neutron-gamma spectroscopy, NMR, lithodensity, etc.) and special core studies (XRD, LECO, TOC, etc.). The equation for calculating the target formations' total porosity, TOC, and mineralogical composition was derived using the method of multilinear regressions in the «Techlog» wellbore interpretation software complex. The results showed good correlations for unconventional reservoirs of Dnipro-Donets Basin North-Western Play (Glynsko-Solokhivskiy oil and gas region) and Dnipro-Donets Basin Southeastern Flank Play. The magnetic susceptibility of the target reservoirs was researched, and its correlation dependences with other physical parameters of the rocks were also investigated. In particular, a direct correlation of magnetic susceptibility and porosity was determined. This article is a continuation of a series of publications on the study of Visean unconventional reservoirs within the Dnipro-Donets Basin.

Key words: source rock, unconventional reservoir, total organic carbon, X-ray diffraction, Rudov beds, carbonates, Visean deposits, mineralogical composition.

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Introduction. Dnipro-Donets Basin (DDB) is a first-rank Super Basin with discovered reserves exceeding 0,2 billion tons of liquids and 1,6 trillion cubic meters of natural gas (1,5 billion tons of oil equivalent). Recent studies have pointed to a promising unconventional play within a thick succession of Visean marine source rocks. Mean recoverable resource estimates of 1,6 trillion cubic meters (1,2 billion tons of oil equivalent) represent an incremental target large enough to convert Ukraine into a significant natural gas exporter to Europe [Levoniuk et al., 2023; Lukin et al., 2020].

Dnipro-Donets Basin originated as a Late-Devonian failed arm of a triple junction between the Eastern European Craton and Voronezh Massif in Eastern Ukraine. Recent exclusive research highlighted two potential unconventional play fairways within the DDB, the North-West Play (NWP) and the Southern Flank Play (SFP) (Fig. 1), the geographic distribution of which are controlled by basin tectonic and depositional events [Misch et al., 2016; Orlyuk et al., 2018; Levoniuk et al., 2023].

DDB has world-class source rocks (shales and carbonates) that can be unconventional reservoirs with high potential in Visean formations. There are five landing targets characterized by different facies types layered within the gross «stack» of source rocks. In this paper, we will focus on the two most promising ones: 1) V-23 siliciclastic (NWP) and carbonate-rich (SFP) radioactive black shale with measured total organic carbon (TOC) values commonly ranging from 4 to 10 % (weight percentage); 2) in the underlying upper V-24 carbonate-dominated mudstone facies TOC values commonly range from 1 to 4 %. The depth of zone interests is mostly 4—5 km, with a decrease in the SE part of Southern Flank Play to 2.5—3.5 km.

This paper aims to provide a general overview of the workflow, methodologies, and results of derived equations for the main petrophysical properties of DDB unconventional formations and the conclusion of the petrophysical component of the investigation. The results show that the individual approach for evaluating the main shale gas reservoir properties consistently correlates better with advanced modern log methods and special

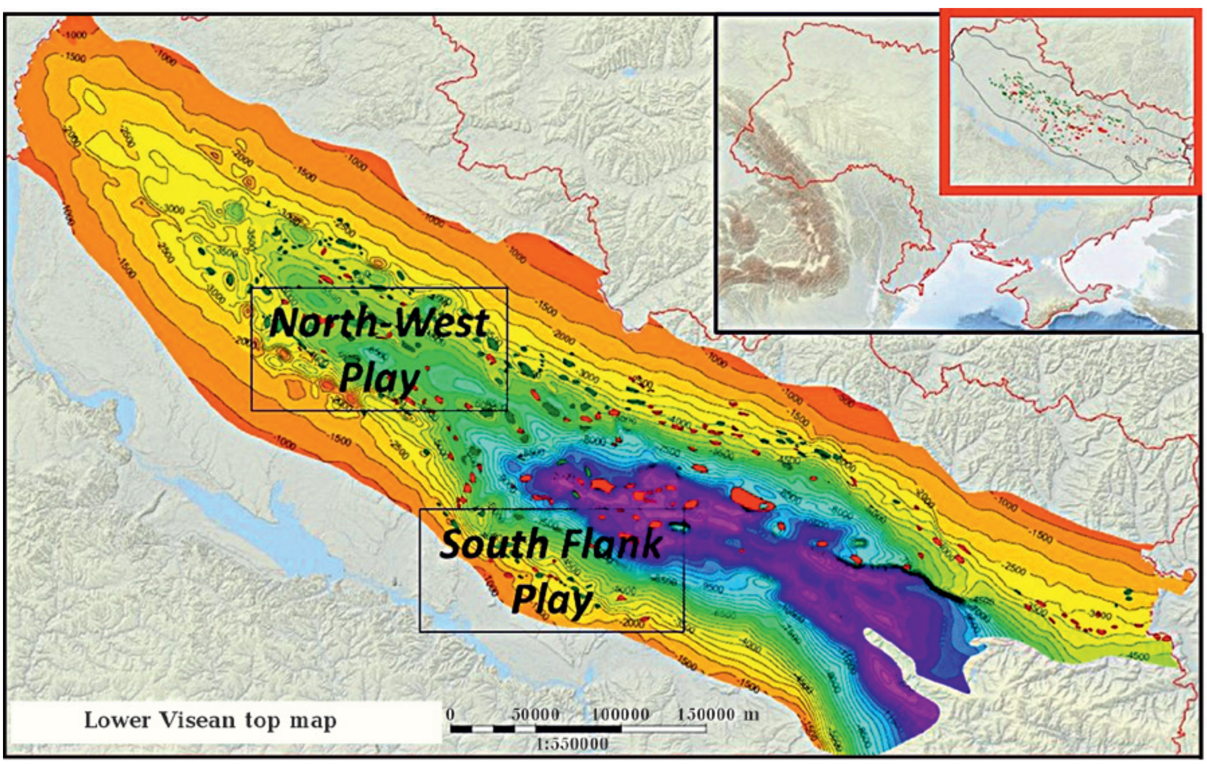
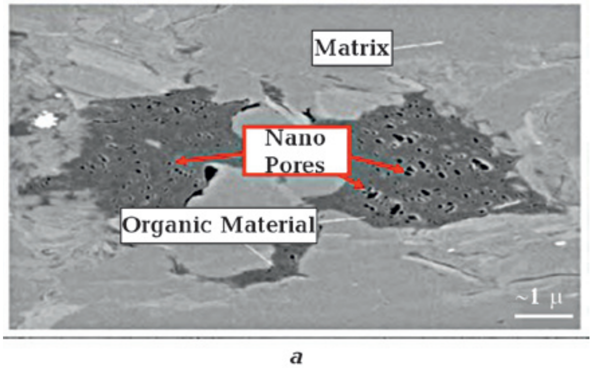


Fig. 1. Dnipro-Donets Basin Lower Visean structural map.

core analysis (SCAL) data than the other previously used approaches. It is very efficient when we have a limited logging dataset, especially from old drilled wells. This article is a continuation of a series of publications on the study of visean unconventional reservoirs within Dnipro-Donets Depression [Iuras et al., 2023a,b, 2024; Kruhlov et al., 2023; Levoniuk et al., 2023, 2024].

Theory. Method. Workflow. TOC is known to be the main organic-rich unconventional reservoir parameter. Accurate determination of TOC is important for kerogen content characterization, and is related to total porosity. In the constructed model of solid rock made by incorporating kerogen as a part of shale matrix, but at certain maturity temperature and pressure, organic matter (kerogen) can be converted into hydrocarbon and formed kerogen porosity as a pore space inclusion. Consequently, the shale's total porosity is naturally composed of matrix porosity and kerogen porosity (Fig. 2, *a*, *b*). According to Pater's classification, a source rock with TOC>1 % corresponds to good potential for target reservoirs. Recent experience of the world's hydrocarbon production shows this cut-off is TOC >2 %. It is very important to estimate the TOC of target formations accurately. Due to the limited presence of core samples/cuttings and discontinuous core data in big intervals, it is impossible to cover the zone of interest for precise studies completely. Moreover, the coring process is very expensive for operators. In that case, it is important to apply well logging data and wells, when we have typical logging data sets such as gamma ray, deep resistivity, and sonic logs, TOC estimation is much more complicated [Karpenko et al., 2020, Vyzhva et al., 2019]. Mineral content computation is more difficult with such data due to the limitation of the probabilistic formation evaluation approach. In case of porosity estimation, we have the same problem when using matrix properties at deterministic interpretation method.

One of the first and very common methodologies of identifying TOC from well logs uses open-hole sonic and resistivity logs and factors in thermal maturity. This method, known as the DlogR method, combines apparent resistivity and porosity logs, and it is calibrated with the local Level of Organic Metamorphism (LOM) [Hood et al., 1975; Passey et al., 1990]. Q.R. Passey analyzed data from hundreds of wells in North America. Ukrainian geoscientists often apply this method due to a lack of advanced modern logs data. In that case, we need to choose calibrated baseline points (water wet clays) and investigate LOM (levels of maturity), which are calculated from vitrinite reflectance data — Ro, % (Rock-Eval pyrolysis or microscope analysis). In the log data, we observe intervals with high TOC in the «crossover» between sonic and resistivity. High compressional slowness time and high resistivity values correspond with high organic matter interval (Fig. 3). For the interpretation, we used Rock-Eval pyrolysis data [Iuras et al., 2023b] of target formations, which corresponds to late oil window, and choose LOM=9. In Table 1 you can see the main inputs for TOC estimation.



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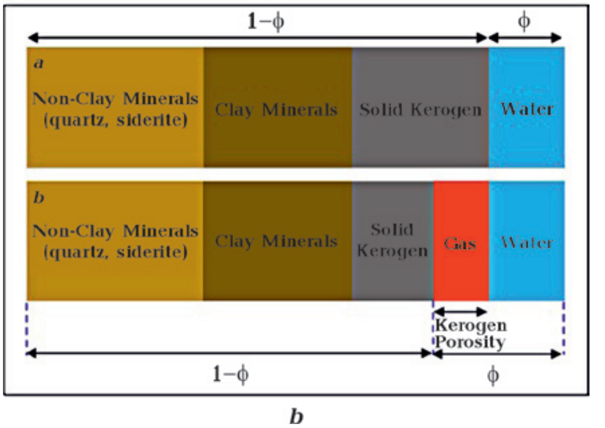


b

Fig. 2. Porosity in Organic Matter by [Zargari, Prasad, 2013] (*a*), shale reservoir constructed model composed of minerals and TOC (*b*).

One of the direct geophysical methods for TOC calculations is spectral gamma ray (SGR). With the well logging method, we can record the counts of gamma rays in different energy bins and then calculate the concentrations of three main isotopes — Uranium (U^{238}), Thorium (Th^{232}), and Potassium (K^{40}) by using a scintillation detector and a multichannel analyzer. Specifically, Uranium directly depends on kerogen accumulations in the formations and it highlights the presence of source rock formations or other geological environments, which corresponds to U^{238}. The data obtained from ratio between the Thorium and Potassium can provide important information about clay type in the formation. In some cases, these tools can also be used in cased hole environments. This valuable geophysical method was applied to several basic wells to determine TOC and to compare our results with other independent measurements [Iuras et al., 2023a].

Recently, advanced service companies and their engineers made huge progress in tool construction and developing technologies. It also refers to radioactive methods such as elemental spectroscopy (geochemical log). One has pulsed neutron generator, two LaBr3: Ce gamma-ray detectors, and a deep YAP ($YAlO_3$) detector. The acquisition scheme was optimized to record time and energy domain data simultaneously. In the time domain, formation Sigma and neutron porosity are self-compensated for the wellbore environment. We can construct an accurate mineral model and determine matrix properties using energy domain data. The important thing is that the TOC can be obtained by subtracting the

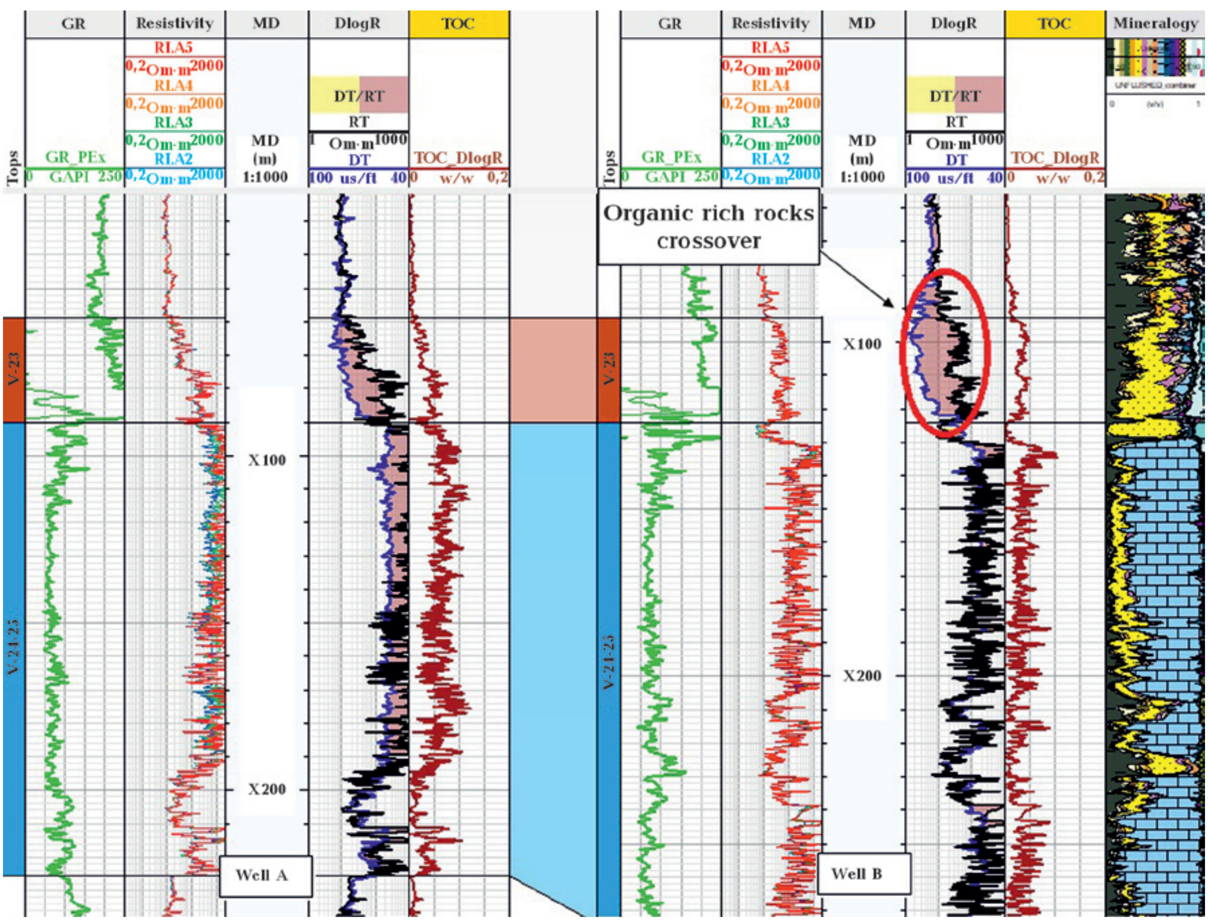


Fig. 3. Well logs data and interpretation of wells A, B. Tracks: *1* — Gamma Ray (uR/h), *2* — Multilateral log resistivity (Ohm×m), *3* — depth (m), *4* — *DT* and Deep Resistivity crossover, *5* — DlogR TOC estimated from sonic and resistivity logs (w/w), *6* — mineralogy model QElan.

T a b l e 1. Main parameters for DlogR TOC calculations

Name	Unit	Description	Value
Vitrinite Reflectance	Unitless	Vitrinite Reflectance value used in the Passey Equations	0.8
Resistivity Baseline	Ohm×m	Baseline Resistivity of Shale in non-organic rich intervals	5—7
DT_Baseline	Us/m	Baseline Compressional Slowness of Shale in non-organic rich intervals	310—320
DLogR_Model	Unitless	Option between Sonic, Density or Neutron Delta Log R Model. Only TOC is computed by the method based on the selected model.	Sonic
TOC_Type	Unitless	Either Type II or Type III is selected. TOC Type is used to compute HI of Gas or HI of Oil and S2.	II

inorganic carbon (from carbon-rich minerals) from the measured total carbon (Fig. 4). This technology can provide measurements in open and cased holes [Iuras et al., 2021]. Numerous scientific investigations show a high correlation between modern log (elemental spectroscopy, NMR) and SCAL data [Gonzalez et al., 2013; Craddock et al., 2019]. We have used this modern logging technology in our study as a reference for calibrating the petrophysical model of unconventional reservoirs.

Key Technologies:

– high-output Smart-PNG;
– 3 spacings / 4 detectors;
– state-of-the-art scintillators;
– compact Neutron Monitor (CNM);
– optimized pulsing scheme.

Measurements (simultaneous acquisition):

– time spectrum;
– fast neutron cross-section;
– sigma;
– neutron porosity;
– energy spectroscopy;
– elemental concentrations;
– TOC; Carbon/Oxygen.

Results. *Observations. Total organic carbon evaluation*. In well B, we computed the most accurate TOC estimation methods and compared the results with special core analysis data — LECO, TOC (Fig. 5). In our study, we analyzed 49 core samples and 12 mud cuttings samples of horizons V-23 and V-24-25 from NWP Play (Glynsko-Solokhivsky oil and gas region). The results at the log panel show that not all log methods match laboratory analysis well. The elemental spectroscopy

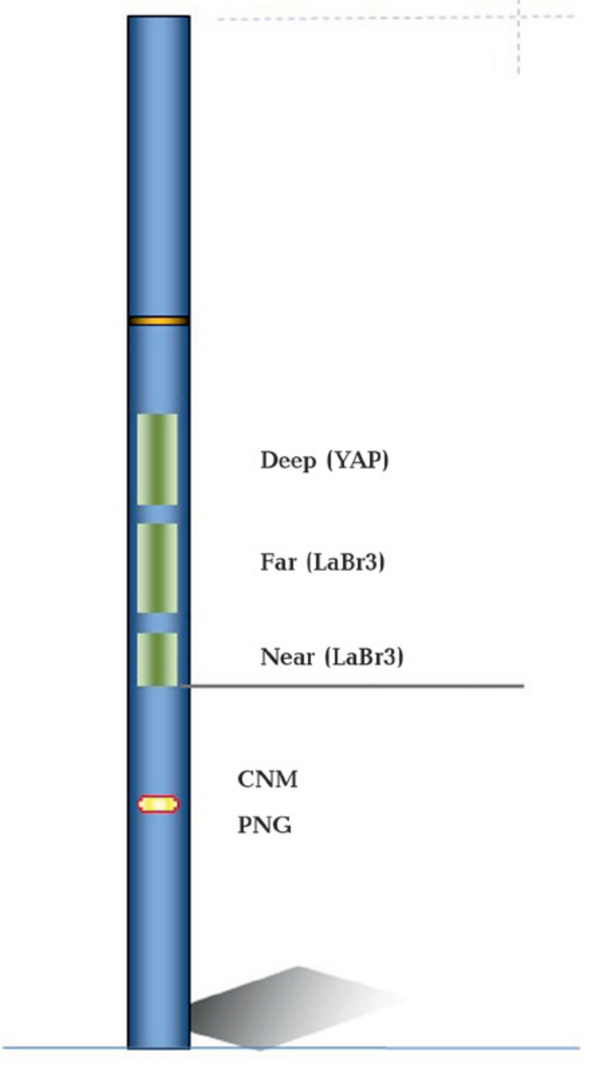


Fig. 4. An example of a pulsed-neutron elemental-spectroscopy tool and main outputs (Pulsar, SLB).

TOC and NMR_TOC have the best correlations with core measurements. The biggest mismatching is observed with the DlogR technique TOC for these target formations. It can lead to underestimation of TOC data for such shale gas reservoirs in DDB, their hydrocarbon potential, and their impact on the completion plan. The data from SGR show a better correlation with core data in carbonate intervals, but in V-23, it matches partially. Notably, core sample data are more reliable and have better depth shift samples than cuttings. For depth matching, all core samples from Well B were logged by the Gamma Ray tool at the laboratory [Iuras et al., 2023b].

When full logging data suite is available, the petrophysicists and geoscientists can estimate TOC properly without big challenges. However, in the case of limited logging datasets, which we usually deal with in old wells, they may be very complicated to evaluate. As observed, the DlogR method is not a robust solution for Visean formations in our case. When we did not have a big amount of SCAL data in the area of study and after reviewing international experience results, it was decided to build a multilinear regression between typical and modern logging data.

Due to quite good matches between elemental spectroscopy TOC and core data from Well B, we built multilinear regression between both logging data as well. In this case, elemental spectroscopy TOC and gamma-ray, formation resistivity, and compressional slowness logs were used. Finally, we have computed the equation for TOC estimation in

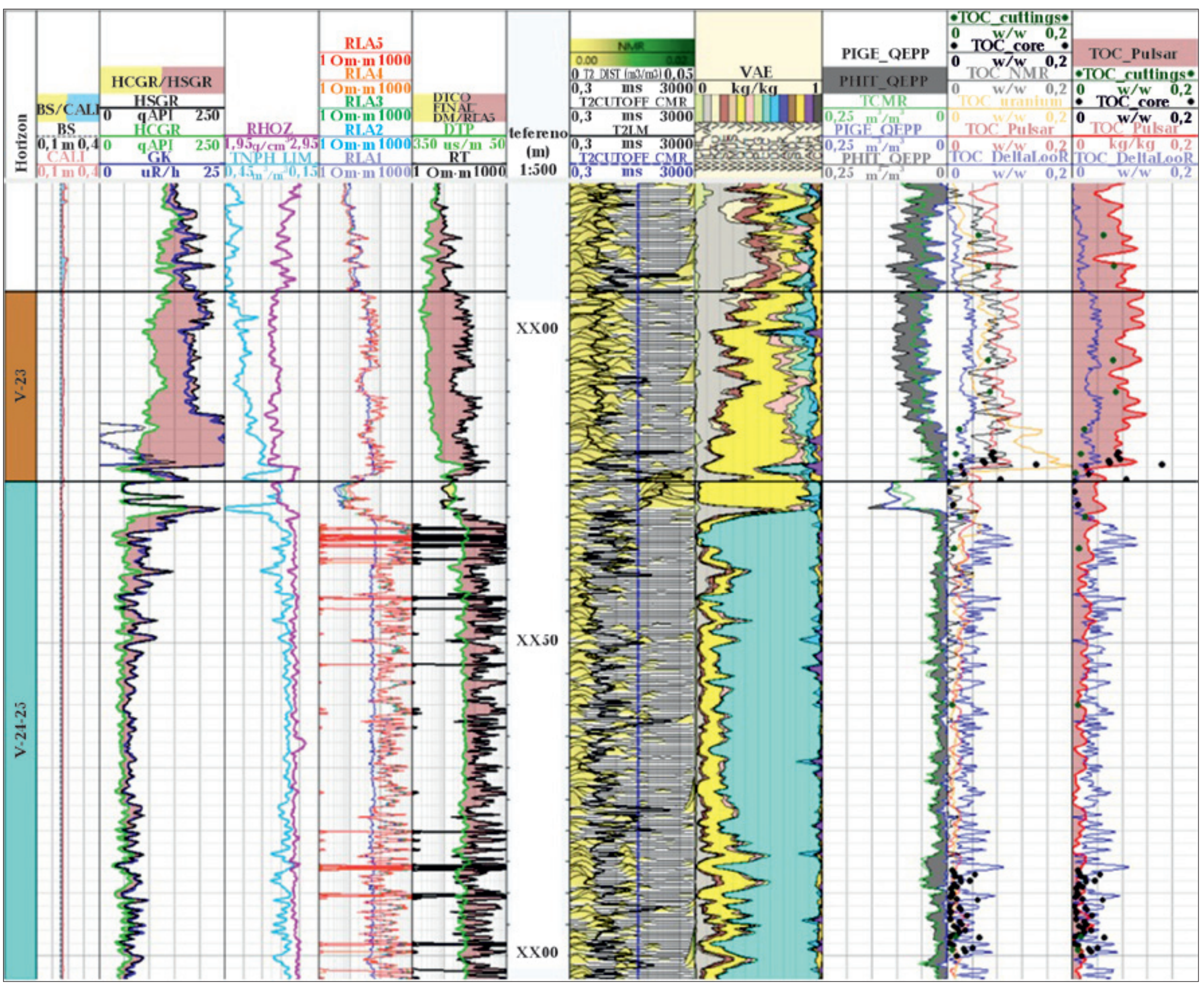


Fig. 5 Modern log data of Well B and different TOC estimation methods and their comparison with LECO TOC core (black dots) and cutting data results (green dots).

the organic-rich rocks (V-23 and V-24-25) of North West Play in DDB (Fig. 6). After reviewing and comparing TOC_ML values with real advanced logs data, a very good correlation between these parameters (R^2=0.825) was observed. Average TOC values are 6—9 % for Rudov beds (V-23) and 2—4 % for organic-rich carbonates from V-24-25 which corresponds to very good and excellent source rock according to Peters classification [Peters et al., 1994]. At the interval of sandstone with high porosity at the top of Horizon V-24-25, TOC values don't match very well due to oil presence at this interval which was confirmed by mud logging and coring data. This fact can increase TOC values from logs, especially at high-perm zone, and they were not included in our investigation. The carbonate volume (V_{carb}, %) also shows quite a good correlation between data (see Fig. 8, *b*):

$$\mathrm{TOC_{ML}} = 0.00016\times \mathrm{GR} + 0.00046\times$$
$$\times \mathrm{DTP} + 0.0021\times \log 10(\mathrm{RT}) - 0.084,$$

where DTP in us/m, RT in Ohm·m, GR in gAPI.

Porosity and mineralogy evaluation. It is quite difficult to provide petrophysical reservoir evaluation by applying a common triple combo logging dataset for such complex reservoirs. When advanced well logging methods such as nuclear magnetic resonance for porosity estimation and geochemical logs (pulsed neutron spectroscopy) for mineralogy and TOC determination are available to construct proper petrophysical model will not take much effort and time. Certainly, additional logging and coring data as calibration points and data quality control (QC) are also useful. When we are limited in the qualitative logging data suite, especially during the reinterpretation of data from old wells and fields, and there is no possibility of making SCAL analysis, using artificial intelligence or other similar techniques should be the best solution.

We decided to apply a similar approach for mineralogy and porosity estimation of target unconventional formations (V-23 and V-24-25) at the NFP area as it was for TOC computation. The advanced open-hole data, especially pulsed neutron elemental spectroscopy and nuclear magnetic resonance data with checking points of SCAL (X-ray diffraction — XRD) data (Fig. 7, 8) were used as calibration points. In this case, we also included neutron porosity as an input logging method, which makes our model and result equations more accurate. Finally, we computed equations for V_{shale}, V_{carb}, V_{qtz}, and total porosity estimation. The pyrite content was not included in our case due to limited input log data. It can only slightly affect the final results because of the minor content of this mineral in the total amount of rock. Perhaps with much more data, we can improve our workflow

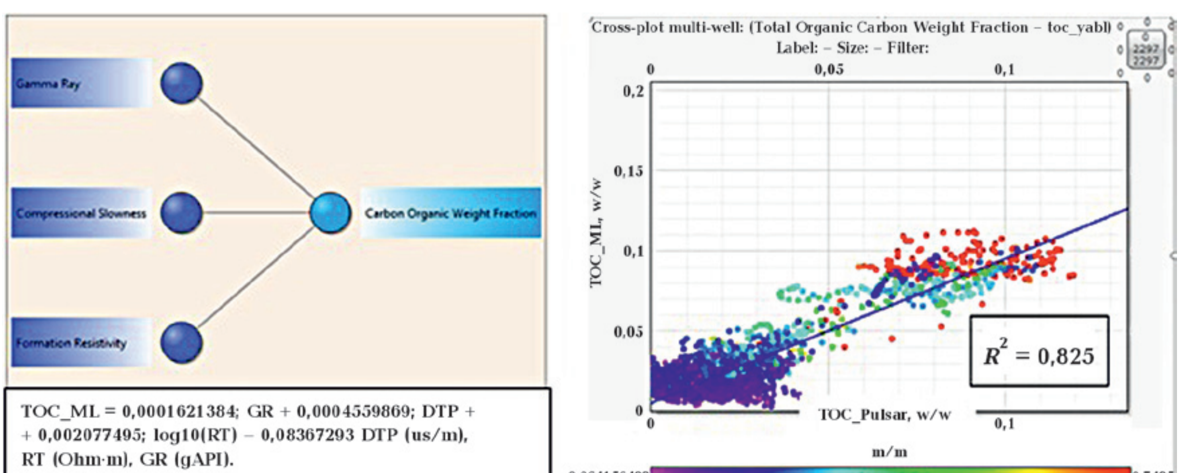


Fig. 6. Left —TOC_ML own equation with multilinear regression approach (GR, RT, and DTP vs TOC from elemental spectroscopy). Right — correlation between log TOC_ML and TOC_Pulsar data.

and equations in the future. Notably, fewer samples with clay content were determined from XRD data than petrography and modern logs data. The explanation is that determining the content and type of clay minerals is one of the most complicated tasks in laboratory measurements. In general, the clay-XRD analysis is used separately for more accurate evaluation of type of clay minerals in the industry. Unfortunately, in our investigations, it was impossible to apply such equipment, so we focused on the geochemical logging data:

$$V_{shale} = -0.00074 \times GR + 1.67 \times NPHI + 0.081,$$

$$V_{carb} = -1.52 \times NPHI - 0.00057 \times \times GR - 0.0019 \times DTP + 1.16,$$

$$PHI\_ML = 0.00028 \times DTP + +0.094 \times NPHI - 0.035,$$

$$V_{sand} = 1 - V_{sh} - V_{carb} - PHI\_ML.$$

where GR in gAPI, NPHI in v/v, DTP in us/m, V_{shale} — all clay minerals (kaolinite, illite, muscovite, etc.), V_{carb} — calcite, dolomite, ankerite, etc., V_{sand} — quartz, plagioclase, k-feldspar, etc., PHI_ML — total porosity in v/v.

Fig. 9 shows an example of how main reservoir properties — TOC, porosity, and mineralogy are derived by using our proposed equations corresponds to real well logging data from well A of NFP.

These petrophysical workflow and equations are also applied in the wells from the South Flank Play of DDB, where it was not possible to use elemental-spectroscopy or other advanced well logging methods. The results were compared with SCAL data in a few wells (Fig. 10). 110 samples were analyzed (appr. 105 m of core material) from depths 4—4.5 km as we had in North West Play. As has been shown, source rock formations correspond to late oil–wet gas window (*R*o=1.0÷1.3 %). We observed quite good matches of evaluated TOC, main mineralogy, and porosity data. Importantly, in that part of DDB, our shale

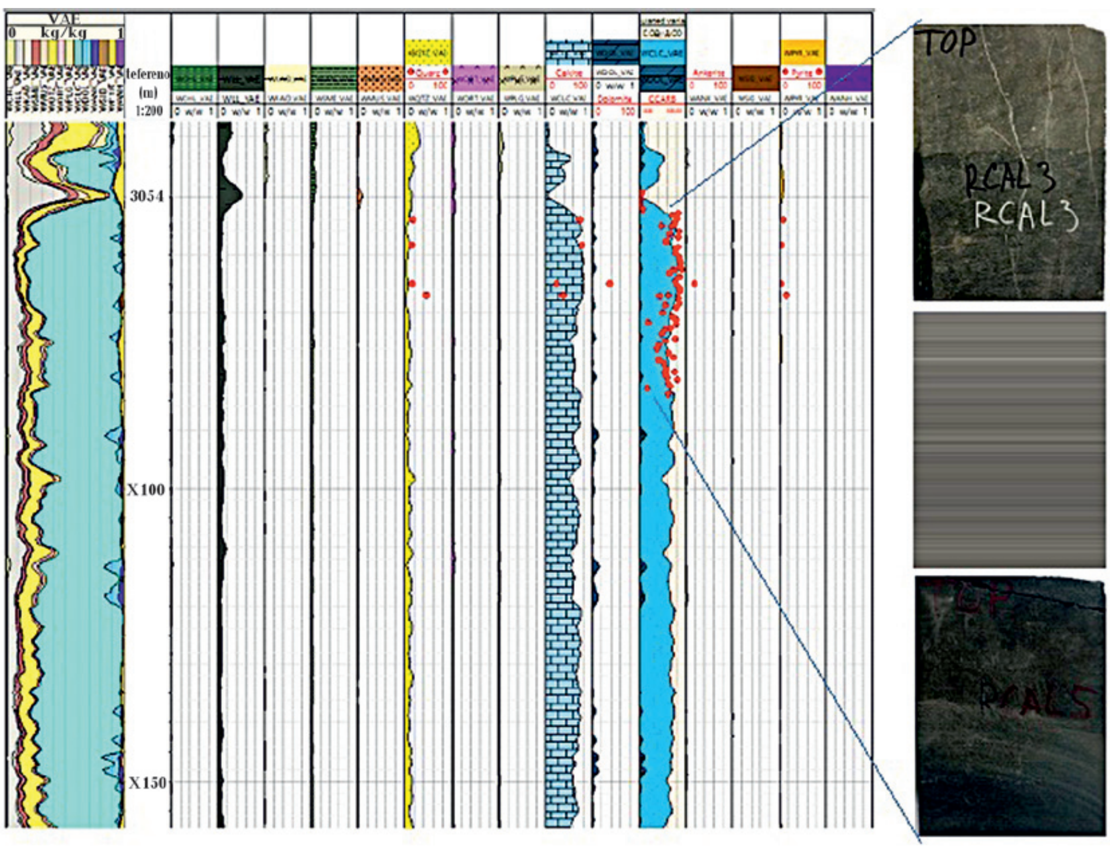
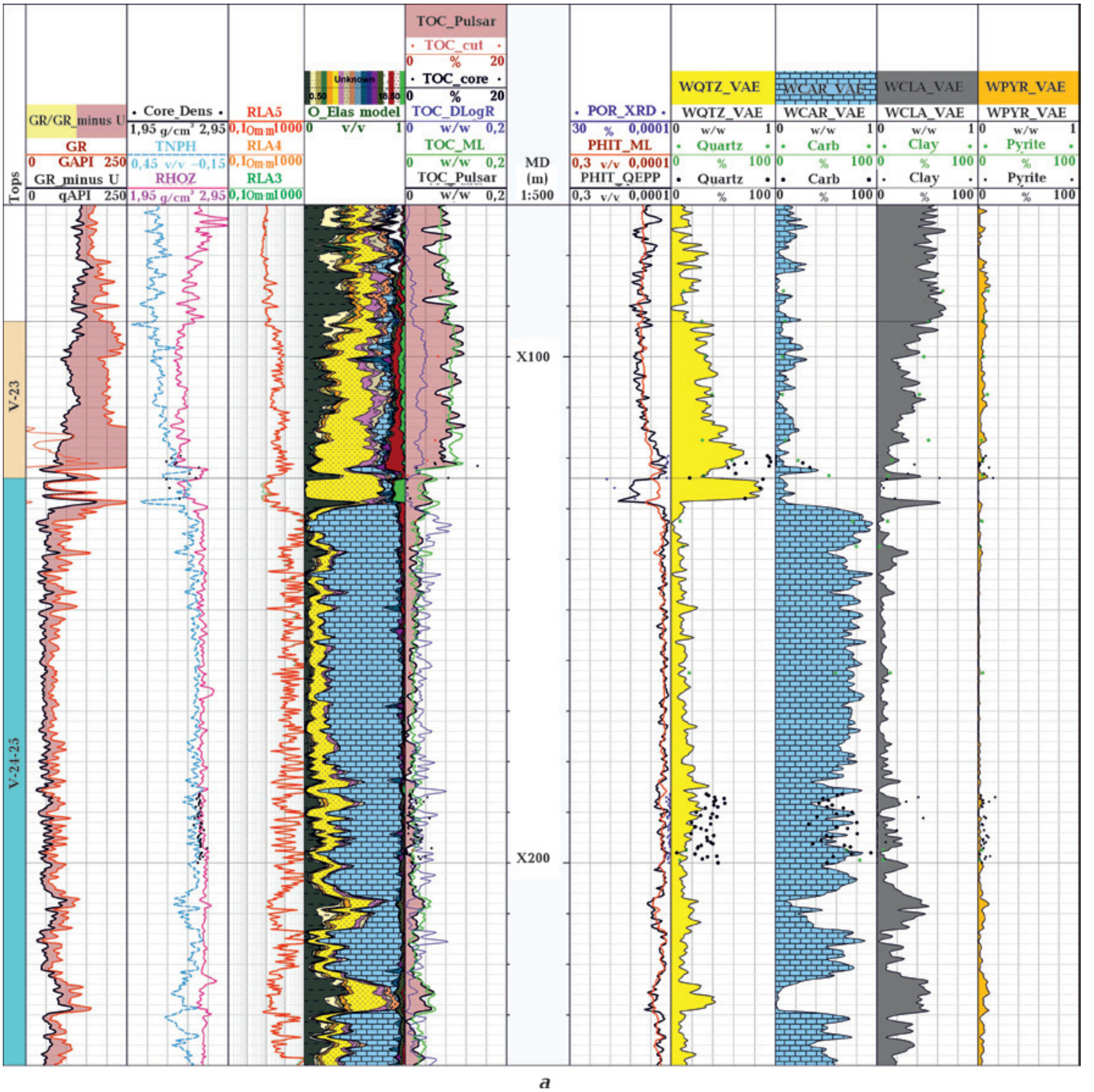


Fig. 7. Advanced PNL high-resolution spectroscopy results and advanced mineralogy (VAE) results versus to core XRD, well C.

reservoirs are more calcareous than in the NWP, but petrophysical evaluation results have a good correlation with core data, which makes such an approach quite flexible in dif-



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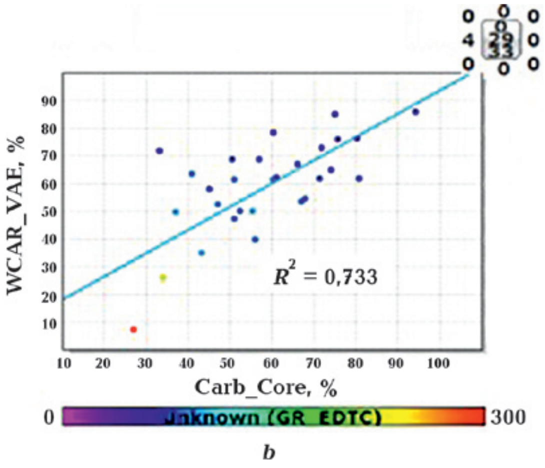

b

Fig. 8. Evaluated petrophysical parameters show a good correlation between TOC, XRD, derived mineralogy, and core porosity (*a*). Green dots are the cuttings laboratory analysis data, calibration well B. V_{carb} from log data, % (geochemical log) and carbonate volume from core, % (*b*).

ferent areas of study. Core porosity, which was estimated from grain density, is derived from XRD analysis and measured by bulk density because the typical RCAL approach of porosity analysis for such rocks usually yields an underestimate. Crushed rock analysis, which is most common for shale gas reservoirs, is not available in Ukraine nowadays.

Our results are important for estimating the target formations' reservoir properties and constructing robust geomechanical and rock physics models, which will be used for multistage fracking modeling and seismic QI.

Magnetic properties of the rocks. Oil and gas fields of the Glynsko-Solokhivsky oil and gas region are located within the limits of the Lokhvytska regional magnetic anomaly (with an intensity of 300 nT) of a northwestern strike, coordinated with the strike of the Central graben of the Dnipro-Donets Aulacogene and at the intersection of orthogonal and diagonal fault systems [Pashkevich et al., 2014], which are regional criteria for oil and gas [Starostenko, Rusakov, 2015] (Fig. 11, *a*). Most fields of the Glynsko-Solokhivsky oil and gas region are located within positive local magnetic anomalies (Fig. 11, *b*). Studies of the physical properties of rocks were carried out on rock samples from Well C (limestones and argillite, 14 samples) and Well B (mud, 39 samples) from the depths of the target horizons V-23, V-24, V-25 of the C_{1v1} and C_{1v2} age. The volume of the samples was determined by weighing in air and water (according to the standard method). The measurement of volume magnetic susceptibility χ was carried out using MFK1-B kappa bridge with a sensitivity of $6 \cdot 10^{-8}$ SI in the Demydiv Magnetic Station Central Scientific Center of the Institute of Geophysics NAS of Ukraine. The density and porosity of the samples were determined in the laboratory according to standard methods.

Let us consider the obtained characteristics

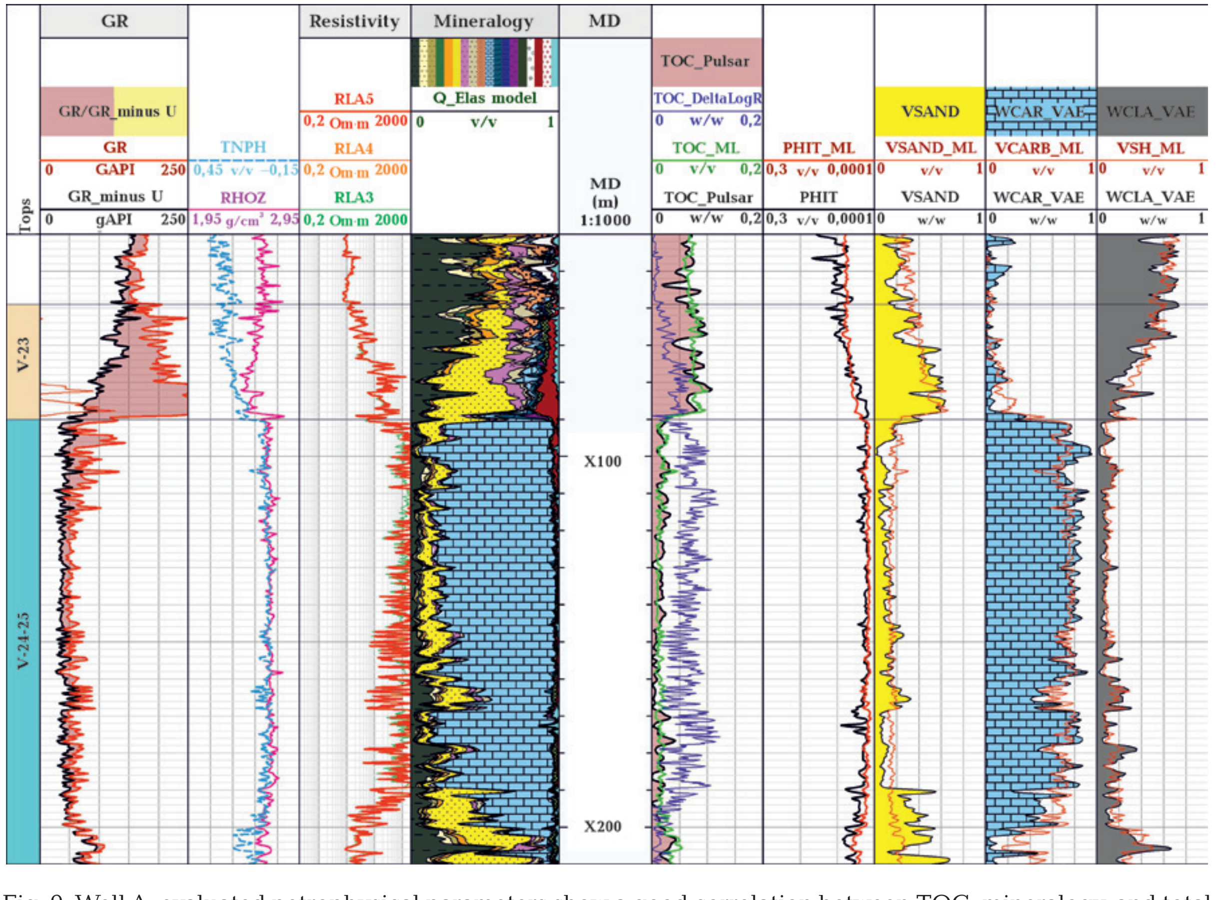

Fig. 9. Well A, evaluated petrophysical parameters show a good correlation between TOC, mineralogy, and total porosity derived from ML equations and advanced pulsed-neutron spectroscopy logging data.

in more detail. Rock samples from Well C are presented by limestones and shales. Magnetic susceptibility (determined by the sample volume), porosity, and density were studied. The values of magnetic susceptibility are quite low and vary from $\chi=0.02\cdot10^{-5}$ SI (limestone) to $\chi=3.2\cdot10^{-5}$ SI (shale). It should be noted that these samples have the lowest and the highest porosity — 0 and 0.1180 v/v, respectively. Basically, the values of magnetic susceptibility are in the range of $(0.33—1.99)\cdot10^{-5}$ SI, and the porosity — 0.0030—0.1137 v/v. The density varies between 2600—2710 kg/m^3 (Table 2). Correlation coefficients for magnetic susceptibility and density, magnetic susceptibility and porosity of rocks were investigated. For the first case, the coefficient of correlation is negative and is r=–0.15, for the second r=0.57, that is, there is a direct relationship between porosity and magnetic susceptibility of rocks. A certain exponential correlation is observed between the carbonate content of rocks and magnetic susceptibility, namely R^2=0.6, which indicates a decrease in the content of iron elements in more calcite rocks and, accordingly, less porous (Fig. 12). The mud from Well B is represented by limestones, mudstones, sandstones, and siltstones from horizons V-23 of the middle Visean and V-24-25 of the upper Visean age. Magnetic susceptibility was determined by the mass of the samples and is characterized by extremely low values — from $0.006\cdot10^{-5}$ SI to $0.4\cdot10^{-5}$ SI. According to the analysis of the sludge material, no characteristic trends and dependencies are observed.

Conclusions. In our research different approaches for TOC calculation and petrophysical evaluation of main reservoir parameters of Visean unconventional formations were used by applying modern log and SCAL data. Total organic carbon content, obtained from elemental spectroscopy and NMR logs, showed the best matching between core and log data. The well-known DlogR technique did not show such accurate results in our case. The equation of TOC estimation for wells with

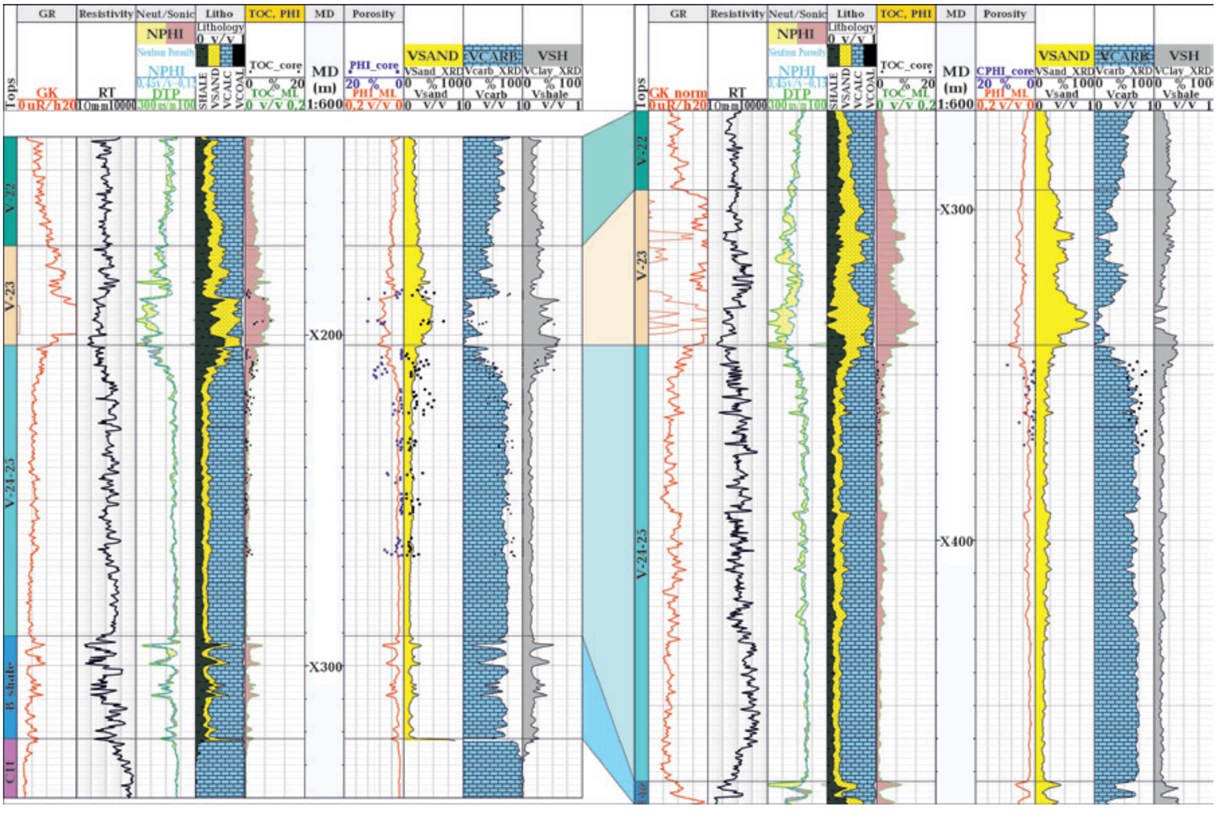

Fig. 10. Petrophysical model obtained using local equations for evaluation and SCAL analysis data in wells E and D with a higher calcareous content from South Flank Play of DDB.

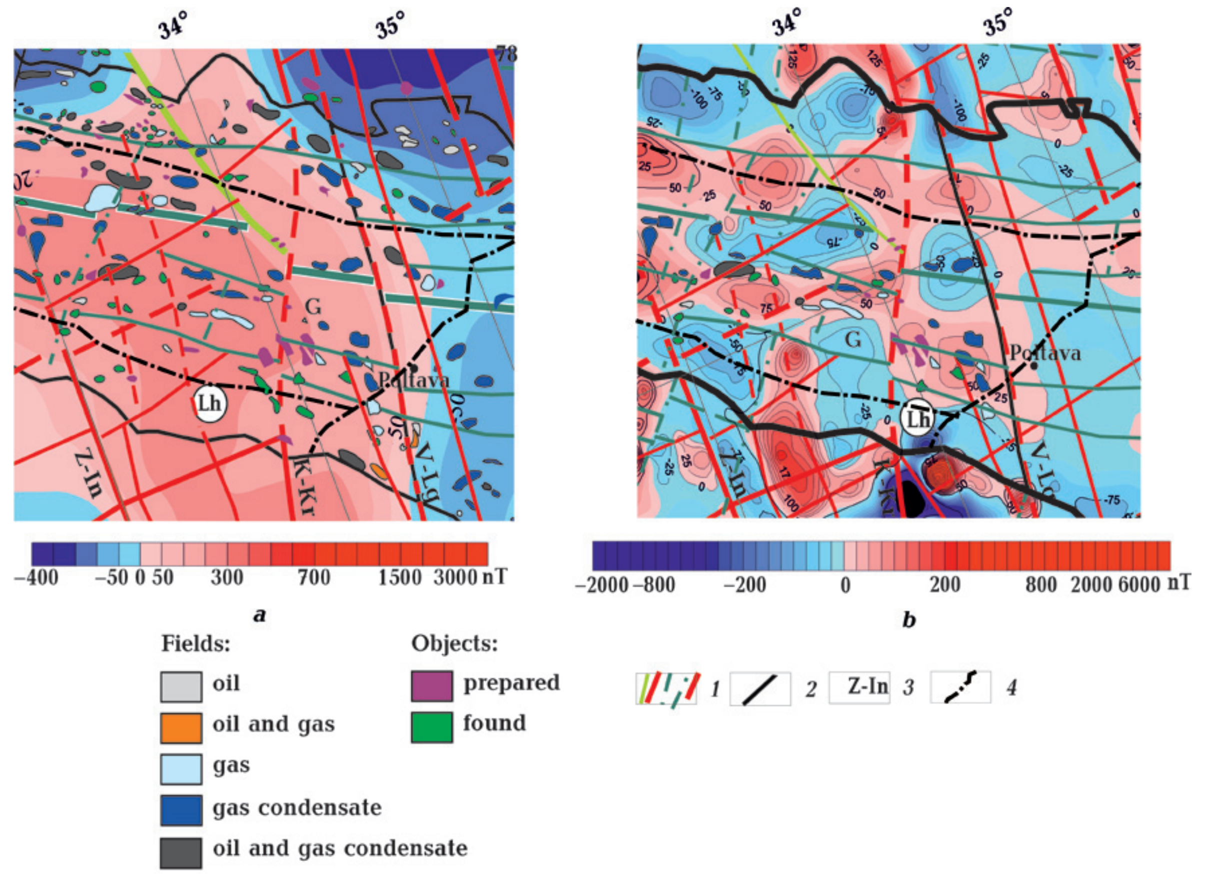

Fig. 11. Maps of regional $(\Delta T)_{a,reg}$ (*a*) and local $(\Delta T)_{a,loc}$ (*b*) components of geomagnetic field of Glynsko-Solokhivskiy oil-and-gas region: *1* — main faults; *2* — the border of the DDB; *3* — faults (K-Kr — Kryvoriz'ko-Krupetskiy, Z-In — Zakhidno-Inguletskiy, V-Lg — Verkhovtsevsko-L'govskiy); *4* — border of Glyns'ko-Solokhivskiy oil-and-gas region; Lh — Lokhvytskiy segment of the DDB; G — Glynsko-Solokhivskiy oil-and-gas region; fields location, faults and oil-and-gas location by [Starostenko, Rusakov, 2015].

Table 2. Laboratory measurements of core samples from well C

Number	Horizon	Lithology	Magnetic susceptibility, 10^{-5} SI	TOC, %	Carb, %	Bulk density, g/cm^3	Porosity, v/v
1	V-24	Shale	3.2	4.299	10	2.62	0.1180
2	V-24	Shale	1.73	1.691	38.4	2.63	0.1137
3	V-24	Limestone	1.83	2.21	49.5	2.66	0.0466
4	V-24	Shale	1.99	2.257	53	2.64	0.0197
5	V-24	Shale	1.64	1.489	77.7	2.71	0.0669
6	V-24	Limestone	0.5	1.609	92	2.68	0.0030
7	V-24	Shale	1.04	3.703	46	2.60	0.0637
8	V-24	Limestone	0.64	1.671	77.7	2.68	0.0355
9	V-24	Shale	0.97	4.192	48	2.63	0.0906
10	V-24	Shale	0.054	3.042	63.4	2.63	0.0591
11	V-24	Limestone	0.02	0.798	91	2.66	0.0000
12	V-24	Shale	1.63	3.679	47	2.68	0.0684
13	V-24	Limestone	0.71	3.344	36.6	2.66	0.0883
14	V-24	Limestone	0,33	0,93	88	2,65	0,0000

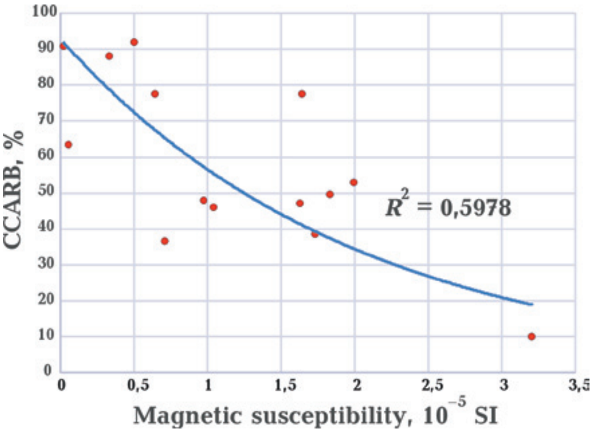

Fig. 12. Diagram of distribution of magnetic susceptibility and carbonate content of rocks, well C.

limited logging datasets (GR, RT, and DTP) was evaluated and proposed after applying the multilinear regression technique. The correlation between TOC data calculated by this equation and real modern logging data (two wells) is very good and characterized by a robust correlation coefficient of 0.825. It is very useful for situations when we operate by old wells logging data and can help better understand the potential of unconventional shale gas reservoirs in DDB. The mineralogy model and porosity estimation using our proposed equations show good matches not only in the North West Play of DDB but also in more calcareous formations in the South Flank Play. It confirms that in cases with «old style» datasets, we can apply such an approach for interpretation and obtain quite an accurate evaluation of the high-organic-rich unconventional reservoirs' properties and their potential for producing hydrocarbons. Additional advanced logging and coring data in the South Flank Play can improve the equations and increase the accuracy of the petrophysical model, which is essential for the successful assessment potential of the unconventional resources. Research was carried out by the scientific theme III-16-23 «Geophysical models of the deep structure of the lithosphere of oil and gas-bearing regions of Ukraine and determination of migration paths of mantle fluids».

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Новий робочий процес для петрофізичної оцінки візейських нетрадиційних збагачених на органіку колекторів Дніпровсько-Донецької западини

С. Юрас[1], М. Орлюк[1], В. Друкаренко[1], С. Левонюк[2], В. Карпин[1], Т. Попадинець[3], 2024

[1]Інститут геофізики ім. С.І. Субботіна НАН України, Київ, Україна
[2]АТ «Укргазвидобування», Київ, Україна
[3]Івано-Франківський національний технічний університет нафти і газу, Івано-Франківськ, Україна

Нарощення ресурсної бази та видобутку вуглеводнів залишається одним з основних завдань перед інженерами та вітчизняними науковцями. Особливо це актуально в умовах повномасштабної війни в Україні. З огляду на високу виснаженість діючих родовищ (близько 75 %) і достатньо добру вивченість Дніпровсько-Донецької западини (ДДЗ) пошуково-розвідувальним бурінням, одними з небагатьох можливих напрямів реалізації зазначених вище завдань є надглибоке буріння (>6 км) та вилучення вуглеводнів з низькопроникних колекторів нетрадиційного типу. Результати лабораторних досліджень та інтерпретації даних геофізичних досліджень свердловин (ГДС) нетрадиційних колекторів візейських відкладів (В-23 та В-24-25) вказують на високу перспективність цих інтервалів, особливо тому, що вони залягають у межах як північно-західної, так і південно-східної частин ДДЗ; загальна площа перспективних ділянок становить близько 8000 км^2. Проте надглибоке буріння та видобуток вуглеводнів з нетрадиційних колекторів потребує застосування сучасних технологічних підходів і рішень. Для того щоб обрати оптимальне місце («sweet spot»), запроєктувати оптимальну програму буріння, геологічного вивчення та закінчення даних свердловин, необхідно побудувати максимально точну геологічну модель даного колектора. Побудовано петрофізичну модель колекторів нетрадиційного типу з високим вмістом органічної речовини (ТОС) на підставі даних ГДС стосовно свердловин старого фонду з типовим комплексом ГДС. Модель відкалібровано за даними сучасних геофізичних комплексів (спектральний гамма-каротаж, нейтронно-гамма спектроскопія, ядерно-магнітний каротаж, літолого-густинний тощо) та спеціальних досліджень керна (XRD, LECO, TOC тощо). За допомогою використання методу мультилінійних регресій у програмному комплексі ГДС «Techlog» автори вивели і запропонували рівняння для розрахунку загальної пористості, ТОС і мінерального складу цільових формацій. Результати використаного підходу показали добрі кореляційні зв'язки як для нетрадиційних колекторів північно-західної частини ДДЗ (Глинсько-Солохівський газонафтоносний район), так і для прибортової південно-східної частини. Було також досліджено магнітну сприйнятливість цільових колекторів та визначено її зв'язок з іншими фізичними параметрами порід, зокрема виявлено пряму залежність з їхньою пористістю. Ця стаття є продовженням серії публікацій по вивченню візейських колекторів нетрадиційного типу в межах ДДЗ.

Ключові слова: нафтогазоматеринська порода, колектор нетрадиційного типу, загальний вміст органічної речовини, дифрактометр, рудівські шари, карбонати, візейські відклади, мінеральний склад.