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GEOLOGICAL STRUCTURE AND OIL-AND-GAS OCCURRENCE OF PRORVA GROUP OF THE SOUTHERN DEPOSITS OF THE CASPIAN DEPRESSION IN TERMS OF GEOPHYSICAL INFORMATION

Purpose. Purpose is to generalize and analyze the currently accumulated geological and physical as well as field data to study productive strata of Prorva group of oil-and-gas occurrence of the Southern deposits of the Caspian Depression in Kazakhstan.

Methodology. Deep Triassic rock systems were studied thoroughly relying upon the explained new data by seismic data together with logging and field information using current processing and interpretative systems according to the newly drilled deep wells within the unexplored northwest part of the structure.

Findings. The specified geological model of the field has been obtained. Twenty-one estimation targets have been singled out in the Jurassic-Trias structures; three new oil-and-gas-bearing formations have been identified as part of the Lower Cretaceous share of a productive stratum within the Valanginian level. According to geophysical analysis, Western Prorva and S. Nurzhanov deposits are the unified system with the oil-water contact level.

Originality. Selection of the recommended location of the new wells is based upon specificity of the innovative scientific and technical approaches while studying regularities of facies substitution of reservoir rocks with enclosing systems of each productive stratum; and studying permeability and porosity of the reservoir rocks as well as fluids saturating them.

Practical value. The obtained data have become the basis to assess the remaining carbohydrate reserves, and identify new opportunities increasing the reserves within the Western area of S. Nurzhanov deposit; moreover, they raise a question on the expediency to develop the Unified Project of the field mining.

Keywords: *the Caspian Depression, deposit, oil-and-gas occurrence, seismic prospecting, logging, productive stratum, assessment of reserves*

Introduction. The geological structure is incredibly diverse, comprising a wide range of rock formations, tectonic plates, and sedimentary basins. These geological structures play a crucial role in the occurrence of oil and gas deposits. Oil and gas occur in various geological settings around the world. One common occurrence is in sedimentary basins, where layers of sedimentary rocks accumulate over millions of years. These basins provide the necessary conditions for the formation and preservation of hydrocarbons. The presence of oil and gas deposits is often associated with specific geological features, such as anticlines, fault traps, and stratigraphic traps. Anticlines are upward-folded rock layers that can trap hydrocarbons in reservoir rocks. Fault traps occur when a fault displaces reservoir rocks, creating a seal and trapping oil and gas. Stratigraphic traps result from changes in rock types and their ability to hold hydrocarbons [1, 2].

Oil and gas occurrences are also influenced by the presence of source rocks, which contain organic matter that, under heat and pressure, transforms into hydrocarbons. These hydrocarbons migrate from the source rocks to reservoir rocks, which have sufficient permeability and porosity to store and transmit oil and gas. The distribution of oil and gas occurrences across the world is not uniform. Exploration and extraction of oil and gas resources require extensive geological surveys, including seismic surveys, drilling, and reservoir analysis. Understanding the geological structure and oil-and-gas occurrence is essential for identifying potential reserves, optimizing production strategies, and ensuring efficient resource utilization [3, 4].

In Kazakhstan, south and southern part of the Caspian Depression (being the Caspian Sea petroleum province) are the areas where oil-and-gas fields are widely-spread and carbohydrate deposits have been known and mined since the early 1900s. Prevailing share (almost 60 %) of the resources is connected with the terrigenous complexes; about third part of them is connected with carbonaceous complexes; and their minor part is connected with the siliceous and clayish ones. Oil-and-gas potential of the area has been prospected in the post-salt complex (being more than two hundred small carbohydrate deposits associated with salt domes) as well as in the subsalt complex where such giant deposits as Astrakhan gas condensate reservoir (the RF); Tengiz and Kashagan (RK), and other oil field have been prospected [5].

Orientation of oil and gas exploration by Kazakhstan geologists towards the post-salt deposits (being mainly the Jurassic-Trias ones), and discovery of a number of new fields has helped understand that the oil-bearing potential of the Mesozoic deposits within the area was not revealed completely; thus, there is an opportunity for further great discoveries [6]. Recent geological prospecting activities have shown that there are prerequisites in the Caspian region for opening not only small but also large deposits within the post-salt reservoirs [7]. To compare with subsalt deposits, the fields are shallow. Their development in the area with the advanced infrastructure is an important stage of efficient economic growth in the Northern Kazakhstan.

Currently, there are different viewpoints as for of oil and gas potential within the post-salt complex in the south of the Caspian Depression south as well as in its margins; consequently, further study of geological structure and discovery of new reservoirs within Mesozoic deposits are quite important. It remains a matter of some urgency to select the most optimal objects from the viewpoint of carbohydrate accumulation search in the post-salt deposits of the Depression [8, 9].

The last three decades have helped the analyzed region accumulate geological and geophysical as well as geochemical materials specifying geological structure of certain deposits, and a degree to which they are promising as for oil and gas [10]. Use of the modern geological survey techniques and engagement of powerful computational modeling complexes have made it possible to obtain information providing high quality, and in some cases, high reliability of the results [11, 12]. It becomes necessary to correct substantially the available ideas of geological structure of the region taking into consideration the new geological and geophysical materials basing upon the up-dated concepts of the formation of sedimentary basins and their oil-and-gas content [13, 14].

The paper represents findings of the integrated geological and geophysical research intended to study possibilities of the post-salt complex of Prorva group of deposits in the south of the Caspian Depression. The research task included additional consideration of specificity of geological structure of the deposits; specification of a productive strata structure; analysis of petrographic characteristics; and development of methods for lithogenetic typification of complex structure terrigenous reservoirs of Prorva group of deposits based upon an integral analysis of geophysical exploration, core analysis, and field data [15].

Prorvinsk petroleum zone is within southwest periclinal of the South Embinsk elevation passing under the Caspian Sea level. In turn, the South Embinsk elevation is tectonically in the southern margin of the Caspian Depression on the border with the North Ustyurt Depression. A deep-seated separating fault is a boundary between the largest tectonic elements. Tengiz and Karaton hydrocarbon-bearing zones are to the north of Prorvinsk elevation zone. They border Astrakhan-Aktyubinsk system of elevations; Biikzhal anticline is among them [16, 17]. Structurally, Prorvinsk group is a gently sloping anticline stretching sublaterally (Fig. 1).

Within the anticline, elevations are seen. According to a seismic survey, they are complicated by tectonic disturbances differing in amplitude and orientation. Such oil fields as Prorva Morskaya, Western Prorva, and S.Nurzhanov, inclusive of the Central and Eastern Prorva (hereinafter referred to as Western and Eastern elevations) are associated with the local elevations.

Central and Eastern Prorva structure was identified in 1954–1955 through seismic SRT operations. In 1960, well No1 defined commercial oil-and-gas occurrence of the Upper Jurassic deposits. In 1963, production sampling of S. Nurzhanov deposit (Central and Eastern Prorva) started. The oil-and-gas pools are associated with *1st*, *2nd*, *3rd* and *4th* levels; they are represented by aleurites and sandstones. In 1964, commercial oil flow was made from middle Jurassic deposits. To study pools in the Jurassic formations, wells were drilled within the Upper Jurassic levels where the projected depths were 2400 m, and within middle Jurassic levels where the projected depths were 2870 m.

A new stage of deposit opening within the Central-Eastern Prorva started in 1968 when 3442 m well was drilled in the Permian-Triassic formations. No oil Triassic flow was obtained; nevertheless, the data on the structure of the Triassic formations gave additional information to continue the prospecting. Further procedures and drilling of new wells helped identify five production levels in the Trias. Two tested levels produced commercial oil flows. Hence, a new Trias oil-and-gas occurrence level was prospected within the Central and Eastern Prorva. To detect and map the Trias deposits, wells were drilled with an average of 2850 m depth. The structures were applied to assess oil/gas occurrence of subsalt deposits. 4951 m well was drilled in the area. However, the well achieved only upper share (Artinskian formations) of the subsalt complex. In this area, carbonates of subsalt Palaeozoic were exposed within Yuzhnoe elevations; the results were negative. Nevertheless, the available geological and geophysical data speak for the necessity of the detailed analysis to forecast oil-and-gas occurrence potential of subsalt Palaeozoic within the area [18, 19].

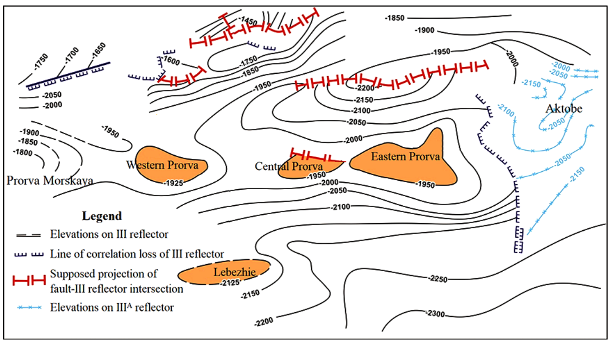


Fig. 1. Tectonic scheme of Prorvinsk group of deposits (*Popova, L. A, Korostyshevski, M. N., 1986*)

It is quite important component of the research to detalize structure of the Jurassic-Triassic productive formation of the most promising S. Nurzhanov deposit for the determination of oil-and-gas occurrence possibilities of its northwest side and sampling of the new identified levels.

Additional appraisal of geological structure of S. Nurzhanov deposit is based upon the following. Currently, there are three alternatives of a structural model in terms the basic production levels (J-II) of the field. Alternative one (the year of 1986) characterizes a structure of S. Nurzhanov formation as an anticline with one central fault (f_1) which divided the structure into southern and northern sides with two fields being western and eastern. Two low-amplitude disturbances (f_2 and f_3), and f_4 fault between two fields of the northern side began to show in the east. In the context of alternative two (the year of 2001), structural map of the same J-II level is without any disturbances in the eastern part of the deposit. Instead, according to the alternative, the structure is divided on the west into four blocks by means of f^{I}, f^{II}, and f^{III} faults. Later, 3D interpretation of seismic materials together with drilling data helped develop alternatives three and four of a structural model of the same surface, i. e. roof of J-II. In accordance with the alternative, there is no transit fault f^{I} which stretched from Western Prorva deposit through S. Nurzhanov pool. Two faults are singled out instead of it. One of them passes through the anticline of the Central-Western elevation; another one is an independent fault within the Western elevation restricted by one more northeastern fault in the north-west. The basic fault, passing through the Western elevation anticline, comes with feathering low-amplitude faults.

In such a way, nowadays selection of place to drill new wells or deepen those ones holed at the upper objects of wells to search for new deposits should involve additional studies of the characteristics of geological structure of a field, specification of a production level structure, and identification of regularities of facies substitution of reservoir rocks with non-reservoir rocks of each productive stratum.

So, the Caspian Depression, located in Kazakhstan, is renowned for its rich oil and gas resources, attracting considerable attention from the petroleum industry. Within this region, the Prorva group of oil-and-gas deposits presents a significant opportunity for exploration and development. Understanding the geological and physical characteristics of these deposits is crucial for assessing their potential reserves and optimizing extraction strategies.

This paper aims to provide a comprehensive analysis of the Prorva group of oil-and-gas occurrence in the Southern deposits of the Caspian Depression. The study focuses on the productive strata within the Prorva group, specifically targeting the Deep Triassic rock systems. By integrating geological, physical, and field data, we aim to establish a detailed geological model and identify new opportunities for reserves and production enhancement.

The research methods. The basic analysis stages of geological and geophysical data are shown in terms of S. Nurzhanov deposit. They are as follows:

1. 3D and 2D reinterpretation of seismic techniques taking into consideration new drilling information, well log data, and construction of 3D model of the pool.

2. Development of the updated petrographic model of the deposit which included following operations:

- analysis and generalization of the available petrographic materials and study of geological and geophysical characteristics of rocks of Prorva deposit group;
- development of the methods of rock lithogenetic typification relying upon the standard GIS complex data as well as specific geophysical studies;
- specification of petrophysical dependencies taking into consideration lithogenetic belonging of the rocks on the core data;
- analysis of influence by postsedimentary processes on the filtrational and capacity characteristics of rocks.

3. Determination of the basic calculation parameters of the formations.

4. Preparation of geological basis to construct a hydrodynamic model of the deposit.

Starting from 2002, the structure has experienced intensive exploration and prospecting activities with extensive use of the current procedures of field seismic operations as well as geological, geophysical, hydrogeological, and geochemical research [20]. The complex of prospecting actions involved 2D and 3D seismography; well drilling and sampling; hydrodynamic and geophysical well survey; studies of filtrational and capacity characteristics (FCCs) of reservoir rocks and fluids saturating them; long-term tests of productive strata and levels; and use of approaches intensifying inflows [21, 22]. Innovative data have been obtained based upon the results of following geological and geophysical studies: gravity-and magnetic surveying; prospecting seismology; experimental drilling; core analysis; and reinterpretation of well log data (WLD) materials [23].

Use of the modern processing and interpreting systems to analyze the new drilled wells by means of the complex of geophysical and field data in the context of promising areas of Prorva structure has helped solve following key problems:

- determination of age and lithological structure of rocks, composing the explored section, its partition, and correlation across area;
- definition of facies variation of the formation;
- study of physical and reservoir rock characteristics, and lithological features of caps;
- identification of rock occurrence conditions;
- specification of hydrogeological characteristics of the section;
- assessment of direct and indirect peculiarities of oil-and-gas occurrence;
- consideration of the initial parameters to calculate the reserves;
- analysis of physicochemical properties of fluids;
- investigation of geotechnical conditions for well making.

On the whole, within the deposits of Prorva group, the drilled wells have penetrated a series of Palaeozoic and Meso-Cenozoic deposits with up to 3530 m thickness. Its structure involves rocks of Permian, Triassic, Jurassic, Cretaceous, Paleogenic, and Quaternary systems (Fig. 2). In terms of the field geology, Prorva formations belong to 2^{nd} group objects characterized by extensive development of disjunctive disturbances; and high nonuniformity of reservoirs depending upon the area and plan [24].

Sequential study of Prorva by means of exploratory wells has helped identify commercial oil-and-gas occurrence of the new Middle Jurassic and Triassic levels. Wells have been drilled to analyze rather completely deposits within the main, southern block, and obtain the first data on the continuation of favourable westward structural conditions of the formation towards a sea [25]. The data on the section of the Jurassic and Triassic deposits put the question of the carbohydrate reserve transition to higher industrial grades in terms of old and newly prospected productive levels.

Further research has confirmed the high potential of oil production increase within Prorva group pools which are connected with the Triassic productive stratum at the depths exceeding 3 km. The ratio of residual oil from the Triassic productive strata of C_2 and C_1 grades is more than 80 %. The abovementioned turns out to be the basis for further exploration at the deposits for the transition of the reserves from C_2 grade to C_1.

Carbohydrate reserves within Prorva structure pools were represented and approved repeatedly in 1962, 1963, 1971, 1987, 1990, 1991, 2000, 2009 and 2019. The key factors, resulting in the reserve increase, are as follows: more accurate definition of a structural and tectonic model based upon the data

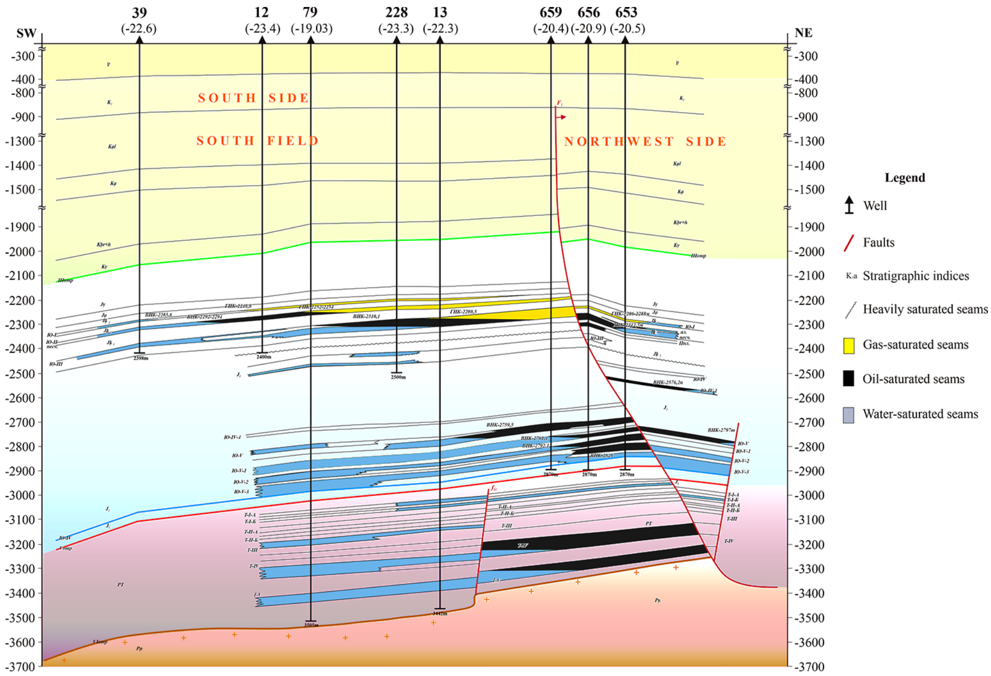


Fig. 2. Lithostratigraphic profile on the transverse 2^{nd}–2^{nd} profile within S. Nurzhanov deposit

by seismic survey and well analysis throughout the formations; identification of the calculation parameters at a higher qualitative level; drilling of new wells; and pilot production within the areas where reserves have been assessed as C_2 grade.

S. Nurzhanov deposit (C. E. Prorva) has operated since 1963; it produces almost 17 % of oil of the extracting company. Currently, the field is developed in a natural depletion way in accordance with the approved procedure.

Specific research concerning exploration project of the Triassic levels and particularization of the northwest side was carried out within S.Nurzhanov deposit using 3D seismic technique as well as geological and geophysical studies of deep exploration, development, and production wells (Fig. 3).

The integral analysis and reinterpretation of seismic materials have helped identify location of the designed exploratory wells to detalize the totally unknown northwest side of the structure. The side was not studied thoroughly before due to the area flooding by means of the Caspian Sea piled-up water. It becomes necessary to assess the recently explored predictable Triassic formations.

The detailed analysis of the deep Triassic rock complexes involved interpretation of seismic results together with logging and field data in terms of the newly drilled deep wells. Results of the activities created real prerequisites for substantial adjusting the geological model of the key production levels. According to the results, thirty new wells are recommended to be drilled. Of that number, ten exploratory wells have been drilled; oil free-flowing has been obtained in three wells. A geological structure of the Triassic productive complex has been specified which also helped transfer carbohydrate reserve of the field from C_2 to C_1 grade.

In addition, thirty-two wells from the liquidated stock have been put into operation through the second shaft drilling, and the wellbore deepening. In such a way, it has become possible to analyze thoroughly the understudied J–I, J–II, J–III, and T–I accumulations of the northwest block of S. Nurzhanov deposit.

Results and discussion. On the whole, the basic explored oil pools within S.Nurzhanov deposit are connected with the Jurassic and Triassic strata. The deposit is of multilayer nature; it is complicated by a series of various tectonic disturbances (Fig. 4).

Analysis of the geological and geophysical as well as seismic materials has made it possible to develop the improved geological model of the deposit. Within the section of the Jurassic and Triassic strata, twenty-one estimation targets were singled out:

- the Upper Jurassic involves six estimation targets J–I; J–II, aleurolite seam; J–II, sandstone seam; J–II, *2nd* seam; J–II–A; J–III;
- the Middle Jurassic involves eight estimation targets J–IV, J–IV–1, J–IV–2, J–IV–3, J–V, J–V–1, J–V–2, J–V–3;
- the Triassic involves seven estimation targets T–I–A, T–I–B, T–II–A, T–II–B, T–III, T–IV, T–V.

Seven development objects have been singled out for the program:

1st object – the Upper Calloway (J–I level);
2nd object – the Mid Calloway (J–II level);
3rd object – the Lower Calloway (J–III level);
4th object – the Middle Jurassic (J–IV level);
5th object – the Middle Jurassic (J–V level);
6th object - the *1st* Triassic (T–I level);
7th object – the *3rd*, *4th* and *5th* Triassic levels.

Oil accumulations of the natural reservoir type are stratal, roof, tectonic, and lithologically restricted. Lithologically, the productive strata are represented by alternation of sandstones, aleurites, and argillites [26]. The reservoirs are characterized by lithological inconsistency, and mudding. All of them are outlined with stratal water (Fig. 5).

The following has been singled out in the composition of the Upper Jurassic productive complex: J–I, J–II layers (aleuritic), J–II (arenated), J–II–2 layer, and J–II–A, J–III

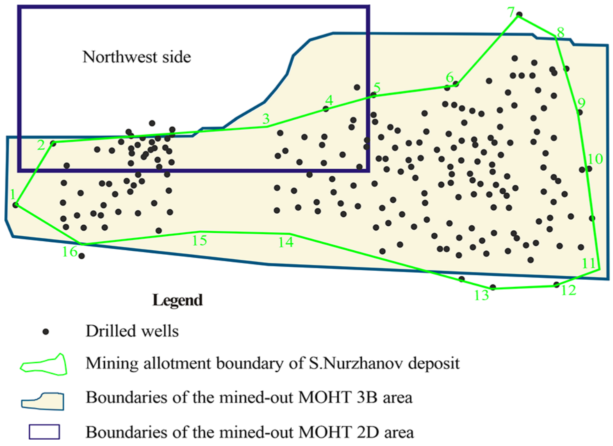


Fig. 3. Boundaries within which 3D and 2D seismic techniques were applied at S. Nurzhanov deposit

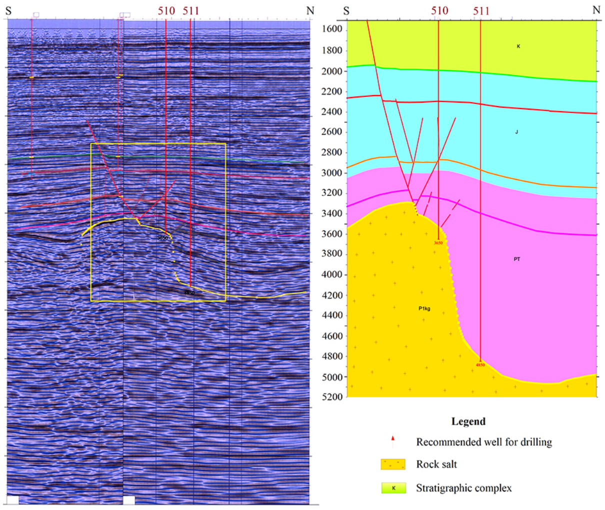


Fig. 4. Geological and geophysical section along 05_05 profile line

associated stratigraphically with the Callovian stage. Structural map for J–2 (a productive layer roof), resulted from the interpretation of 3D seismic surveying, has become a seismic basis of the structural mapping of the Jurassic strata.

In the context of the stratigraphic level, it has become possible to perform structural imaging within a narrow line northwardly from the main fault F1 where numerous low-amplitude fractures were recorded (Fig. 6).

The complex knot, which may possibly explain many hydrodynamic features of the Upper Jurassic strata, is not engaged in 3D analysis. Obviously, constructions within the marginal parts of the area are of less accurate nature. Low-amplitude f_4, f_5, and f_6 divide the northwest side into *1st*, *2nd*, *3rd* and *4th* blocks. Gas deposit with a single gas-water contact has been explored in the *1st* and *2nd* blocks. Oil accumulation with a gas cap has been explored in *3rd* and *4th* blocks.

J–I level is singled out in the upper share of the Callovian stage. Reservoir rocks of the level are developed nonuniformly; vast areas of substitution by impermeable rock are separated as within Prorva Tsentralnaya as well as Prorva Vostochnaya. The seam thickness varies from 2.6 up to 15 m.

The number of permeable intervals varies within 1–3 being 1.2 on average; sand fraction is within 0.2–1 being 0.61 on average. According to well sampling within the Southern side, the level is considered as gas-saturated. Commercial oil inflows were obtained only inside of the northwestern side being currently one of oil production facilities.

J–II level is separated from J–I level by means of a clay layer with 13–25 m thickness; its total thickness is almost

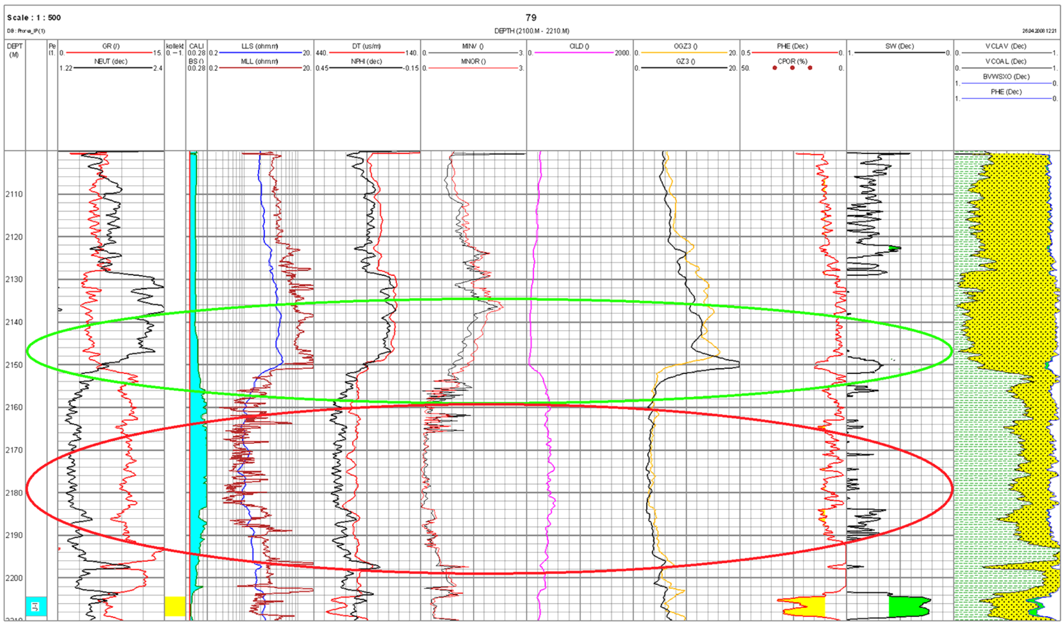
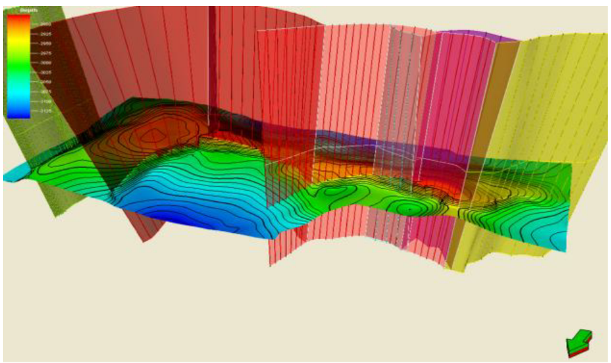


Fig. 5. Example how supporting layers are marked: tight sandstone (green), and layer of Oxford clay (red)



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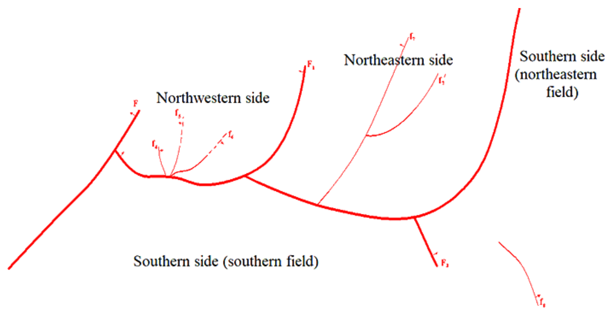

b

Fig. 6. Simulation of the tectonic faults within S.Nurzhanov deposit:

a – a model of the Triassic stratum faults; b – a scheme of the Upper Jurassic stratum faults

30 m. the level is penetrated by all wells drilled within the field. Early research analyzed it quite fully (Fig. 7).

The level consists of two layers; in this context, an upper aleuritic part, characterized by the degraded reservoir properties, and lower arenated part are singled out. Lower layer (the second one) of the level is completely sandy. Thin argilliferous separation between layers 1 and 2 is 7 m. The thickness of aleurite part of the layer varies from 2.0 up to 10.2 m. The efficient thickness is 0.8–8.4 m. The gas-saturated thickness is 0.4–8.4 m; and the oil-saturated one is 0.9–8 m. The number of permeable intervals is 1–3 being 1.3 on average; and the sand fraction is 0.16–1 being 0.76 on average.

Reservoir layers of the sand fraction are developed all over the pool; they are not available only in some wells. The sand fraction thickness varies from 4.0 up to 25 m. The efficient thickness is 1.3–20.9 m. The gas-saturated thickness is 1.1–17.5 m; and the oil-saturated one is 1.0–20.9 m. The number of permeable intervals varies within 1–6 being 1.9 on average; and the sand fraction is 013–1 being 0.65 on average. Reservoir seams of aleuritic and arenated parts as well as a layer 2 of J–II layer shape the integrated hydrodynamic pool; gas and oil-gas accumulations are connected with it. However, taking into consideration the fact that the aleuritic layer has the degraded reservoir characteristics, the three estimation targets are separated within J–II layer: aleuritic, arenated, and layer 2.

Inside the Northwestern side, a gas deposit is associated with the level. Gas content of the layer is assumed according to the processing of GIS materials as well as by analogy with the Southern side where gas content was identified while sampling. Inside the Southern side, oil-and-gas pool is associated with the level; the pool has been developed mainly within a southern field of the structure; in turn, it has been developed restrictedly within the northwestern field; it is of local lens-shaped nature (Fig. 8).

The results of the integrated interpretation of GIS materials, taking into consideration sample data, have made it possible to specify the water-oil contact as the single one for the aleuritic and arenated part and for layer 2 at the absolute depth being 2281–2283 m, and corresponding to the majority of the recorder values of fluid contacts.

During 40-year operation, productive strata of J–2 level have experienced heavy water intrusion. Involving the fact that all the wells operate with high water content, it has been concluded that current WOC undergo large-scale changes. Each wet stratum, located above the initial WOC level, is considered as the productive one.

Below the J–2 layer, formation member of chiefly clay rocks with 8–10 m thickness occurs. It is characterized by shallow alternation of argillaceous and sandy rocks as well as frequent lithological substitutions. Oil stratum has been singled out for the first time relying upon the interpretation of GIS results (the Southern side; the northeastern field). In terms of wells, efficient oil-saturated thicknesses vary from 1.5 up to 8.7 m. The oil pools are of restricted distribution; they are of lens-shaped nature. The oil-bearing area is limited by a

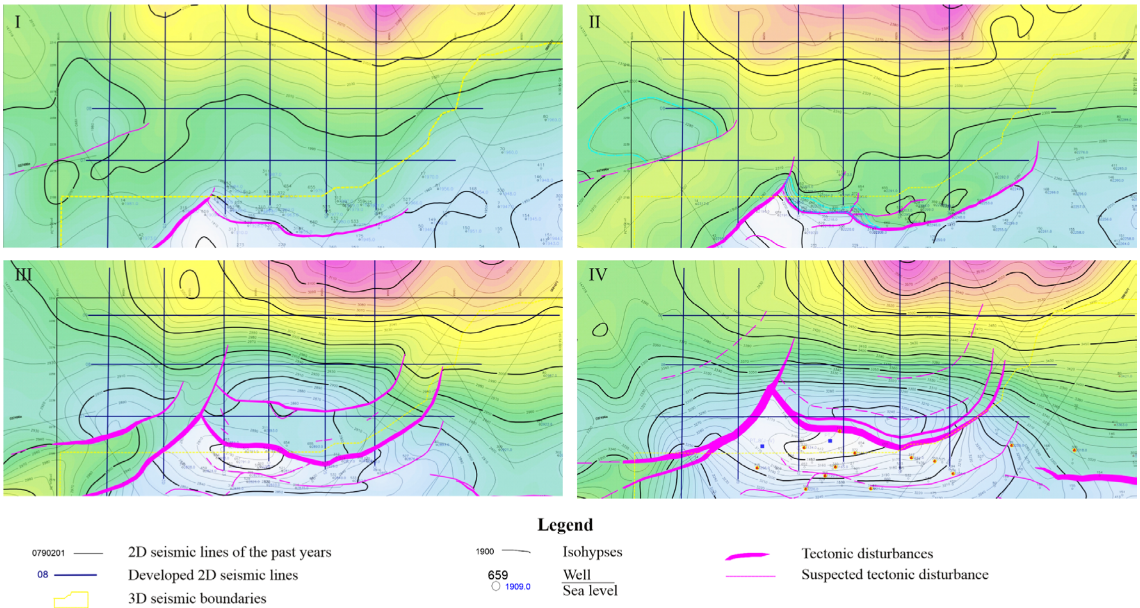

Fig. 7. Structural maps of S.Nurzhanov deposit:
a – reflectors in terms of level III; b – reflectors in terms of level IV; c – roof of the produced level J–II; d – bottom of the produced level T–IV

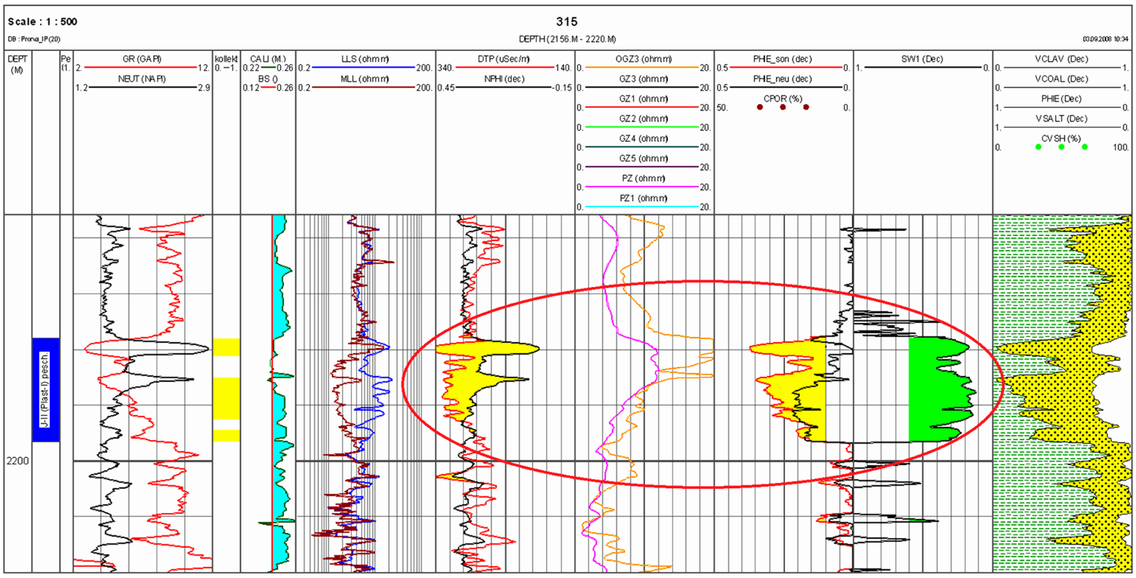

Fig. 8. Separation of gaseous strata relying upon the GIS data

zone of lithological substitution and water-oil boundary assumed on the upper water mark at 2293.3 m depth.

J–3 level is separated in the lower part of the Callovian stage (Fig. 7). It contains 1–5 sandstone strata substituted with clay within the elongated sites. Argillization of reservoir zone stretches from northeast to southwest dividing the deposit into two parts. The oil-and-gas pool of a structural-roof type corresponds to the definite level; at the geological level, it is shielded both lithologically and tectonically. The main oil reserves of J–3 level within Tsentralnaya Prorva are concentrated in a relatively narrow tape along the basic F_1 fault complicating its roof. The site, being the most promising, has already been engaged in commercial production. Taking into consideration the assumed partition, the height of a gas share of the pool is 46 m; and the height of an oil share of the pool is 28 m. Its gas-bearing area is 2328 thousand square meters; and its oil-bearing area is 4936 thousand square meters.

Relying upon the interpretation of GIS materials and sampling, J–IV and J–V levels have been separated in the Middle Jurassic productive complex. In the context of the levels, more fraction classification has been introduced for layers singled out inside them since they have independent importance as gas- and oil-bearing objects with proper system of gas, oil, and water distribution. The abovementioned levels are broken down into following layers: J–IV, J–IV–1, J–IV–2, J–IV–3, J–IV–4 and J–V, J–V–1, J–V–2, J–V–3.

A conditional roof map of the productive J–II level has been taken as the seismic basis while structural mapping of the Middle Jurassic deposits for J–IV, J–IV–1, J–IV–2 and J–IV–3 layers; as for J–IV–4, J–V, J–V–1, J–V–2 and J–V–3 layers, the conditional roof map of the productive J–V level was used; the maps result from 3D seismic interpretation.

Oil pool of a structural-roof type, connected with J–IV layer, has been explored within the Southern and Northwestern sides of the deposit. The pool is shielded both lithologically and tectonically. The reservoirs are aqueous completely within the Northeastern side as well as within the northeastern field (the Southern side) (Fig. 7).

J–V level can be observed in the bottom of the Middle Jurassic complex across the deposit. It is characterized by the most complicated structure of reservoirs as well as pools connected with them. J–V level in the area of the Western field has been assumed as the integrated oil reservoir with more than 100 m total thickness. The geological and geophysical data, obtained on new wells and involved sampling information as well as interpretation of GIS materials, have helped single out four oil strata (i.e. J–V, J–V–1, J–V–2 and J–V–3) as part of J–V level. The strata have their independent importance as for oil and water distribution inside both northeastern and southern fields (the Southern side), and the Northeastern side (Fig. 10).

Despite the fact that argillization and sandstone substitution with impermeable rock is mainly typical for upper part of the level, previously unexplored extra reservoirs [27] have been identified in its roof within the northeastern field of the Southern side; hence, early mapping of J–V level in the area of the northeastern field [28] correlates with our J–V–1 level.

Structural imaging on the well data of J–V level is based upon a map of J–V reflector (conditional roof of a reservoir of the Middle Jurassic productive stratum J–V) (Fig. 7).

Structure of the Triassic deposits follows structural behaviour of rock salt. Reliability of existence of the vast elevated zone of the Southern side of the structure, being promising for oil production increase, was also forecasted by early papers [9, 16]. Structural mapping over the inter-Triassic levels (i. e. T–I, T–II, T–III, T–IV and T–V) is based upon the map over T–IV reflector (a conditional bottom of a reservoir of the Triassic productive stratum T–IV) (Fig. 7).

The Middle Trias deposits, belonging to terrigenous types, are the formation place for the Triassic strata. They involve extremely dismembered productive formations as well as reservoirs being heterogeneous in terms of their areas and sections. The new correlation has corrected distribution of oil pools of the Triassic producing complex. The obtained extra geological and geophysical data on the new drilled wells have helped single out small additional oil pools within the Triassic producing complex, namely T–I–A, T–I–B and T–II–B. The oil pools are the formation, roof, and bottom water-drive reservoirs (Fig. 11).

In spite of numerous drilled wells, the analyzed territory involves the understudied cretaceous deposits of the Valanginian stage. The matter is that during many years, much attention was paid only to the productive underlying Jurassic and Triassic strata. Analysis of the new data makes it possible to draw a conclusion on the positive future of the cretaceous deposits.

The available body of geological and geophysical information as well as the implemented dynamic forecasting of the capacity parameters on the seismic data has helped identify three producing layers in the structure of the Valanginian stage. The layers are associated with different lithological units:

- layer 1 being associated with the upper terrigenous unit of low apparent resistivity;
- layer 2 being associated with the middle terrigenous-carbonate unit of moderately increased resistivity;
- layer 3 being associated with the carbonate-terrigenous unit of high resistivity.

Structural map of *3rd* reflector has been applied as the seismic basis while building structural maps on the producing layers of the Valanginian stage. The map corresponds to a bottom of the Valanginian stage formations singled out as a result of 3D seismic interpretation (Fig. 7).

Within the logging diagrams, the layer upper share differs in the availability of high-resistivity limestone and malmstone unit with up to 10 m thickness and 15–40 ohm resistivity. Its lower part contains terrigenous-carbonate unit with up to 25 m thickness where apparent resistivity in the upper share is 3.0–9.0 ohm and low resistivity in the lower share is 0.8–1.0 ohm.

Systematic studies of the Valanginian formations since 2010 have factored into new information on the core materials as well as the complete GIS complex. 1856–1887 m perforation interval testing has resulted in oil flow to surface. Oil reserves and dissolved gas have been assessed promptly on C_1 and C_2 grades after the commercial oil flows were explored.

Currently, it is the priority for new pool searching to drill new wells or deepen those ones bored for upper well objects within S. Nurzhanov and Western Prorva deposits. The vast Northwestern side of the structure, consisting of two blocks, is especially attractive for the increase in hydrocarbon potential of the pool. Selection for each new well sinking relies upon the exploration degree and completeness of the prospective area; and the results of studies of regularities of facies substitution of reservoir rocks with non-reservoir rocks of each productive stratum.

The findings of this study will contribute to a more comprehensive understanding of the Prorva group of oil-and-gas occurrence. Through the identification of estimation targets within the Jurassic-Trias structures and the characterization of new oil-and-gas-bearing formations within the Lower Cretaceous share of the productive stratum, we aim to delineate potential areas for further exploration and exploitation. Furthermore, our analysis of the geological and physical properties of

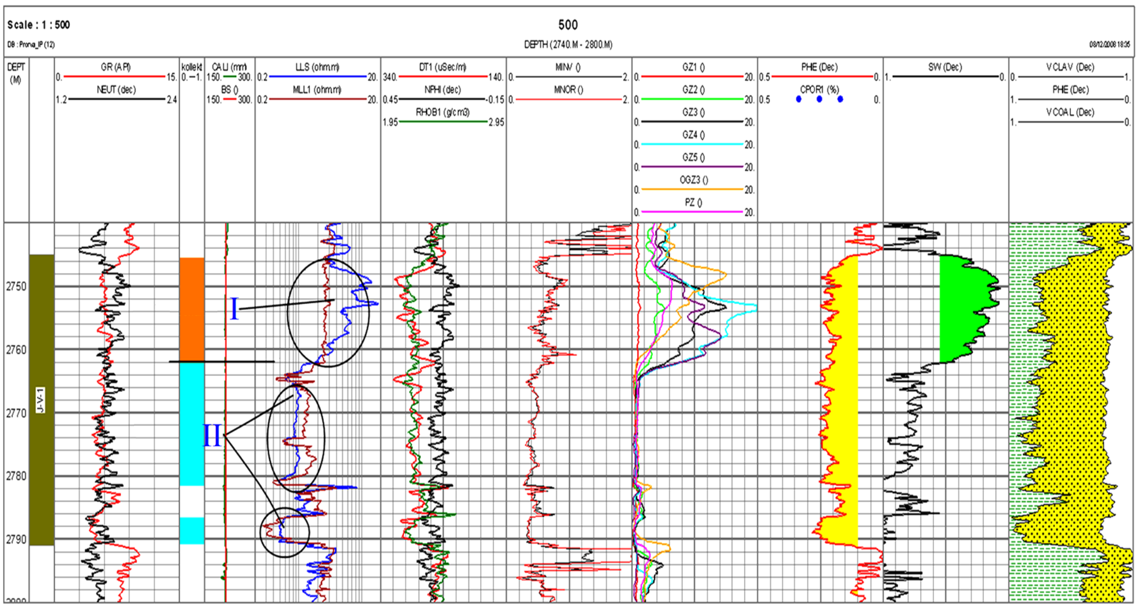

Fig. 10. J–V–1 level. WOC on the data of geophysical analysis I – oil containing area; II – water containing area

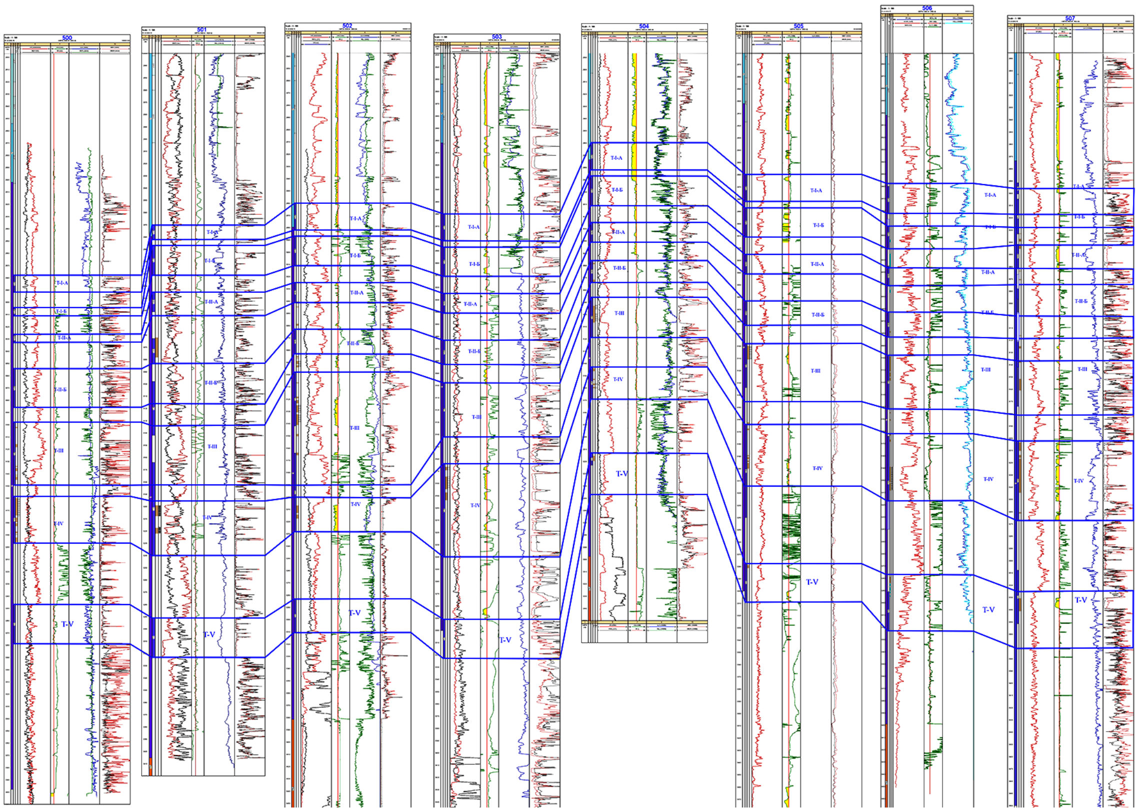

Fig. 11. Correlation scheme of the Triassic strata within S. Nurzhanov deposit

reservoir rocks, including permeability, porosity, and fluid saturation, will provide essential insights into the hydrocarbon potential of the Prorva group. These findings will not only help in assessing the remaining carbohydrate reserves but also raise pertinent questions regarding the feasibility of a unified mining project for the field.

Conclusions. Consequently, the considerable amount of information concerning geology, geophysics, and commerce, accumulated recently within Prorva structure, have helped expand knowledge about geology; explore new promising levels; and obtain additional parameters to assess the reserves and mine the deposits.

Based upon the available materials, it is possible to state that Prorva deposit group, inclusive of S. Nurzhanov pool, is the low-disturbed structure on the Meso-Cenozoic complex connected with poor manifestation of salt tectogenesis. The structure has several peaks on the Jurassic and Triassic deposits with the sole water-oil contact. New materials of 3D and 2D seismic survey have shown wider development of tectonic Triassic disturbances to compare with the Jurassic ones.

The new data have made it possible to transfer the hydrocarbon reserves from C_2 grade to higher industrial grades (J–V–I, T–V, T–IV, T–III and T–II levels of A seam are meant). As a result, a new plan to re-estimate oil-and-gas reserves has been approved in 2019. The plan used the results of the integrated seismic 3D and 2D survey as well as drilling of 269 wells; 90 of them were bored after previous estimation of the reserves. Industrial oil flows have initiated prompt assessment of oil and gas, dissolved in it, according to C_1 and C_2 grades.

Identification of the united hydrodynamic system with the common water-oil contact mark has become the important achievement on the latest 3D seismic survey as well as correlation of well logs within Western Prorva and S. Nurzhanov deposits. The current Projects of the Jurassic and Triassic strata mining at S. Nurzhanov pool as well as its western filed, ignore the influence by hydrodynamic connection on the operation conditions, and on the oil recovery factor (ORF). Both residual reserves and new prospects of increase in the reserves on the western field supports the idea that it is an expedient initiative to develop the Common Project for the development of S. Nurzhanov deposit.

The significance of this research lies in its originality and practical implications. By adopting innovative scientific and technical approaches, we have sought to overcome existing knowledge gaps in understanding facies substitution and reservoir characteristics within the Prorva group. This paper will serve as a valuable reference for the petroleum industry, guiding future exploration and production activities in the region.

In summary, this paper aims to contribute to the knowledge of the Prorva group of oil-and-gas occurrence in the Southern deposits of the Caspian Depression. Through a comprehensive geological and physical analysis, we seek to provide valuable insights into the reservoir characteristics, estimation targets, and potential reserves within this region. Such information is essential for optimizing extraction strategies, assessing remaining reserves, and exploring new opportunities for increased production.

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Геологічна будова та нафтогазоносність Прорвінської групи родовищ Півдня Прикаспійської западини за геофізичними даними

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Мета. Узагальнення та аналіз накопичених на сьогоднішній день геолого-геофізичних і промислових даних для вивчення продуктивних горизонтів Прорвінської групи нафтогазових родовищ півдня Прикаспійської западини в Казахстані.

Методика. Детальне вивчення глибокозавантажених тріасових комплексів гірських порід здійснено за результатами інтерпретації нових даних сейсморозвідки в комплексі з каротажними та промисловими даними із застосуванням сучасних обробних та інтерпретаційних систем по заново пробуреним глибоким свердловинам у невивченому північно-західному крилі геологічної структури.

Результати. Отримана уточнена геологічна модель родовища. У розрізі відкладень юри та тріасу виділено 21 підрахунковий об'єкт, у складі нижньокрейдяної частини продуктивної товщі у валанжинському горизонті виділені 3 нових нафтогазоносних пласта. За даними геофізичних досліджень, родовища Західна Прорва і С. Нуржанов представляють єдину гідродинамічну систему із загальною відміткою водонафтового контакту.

Наукова новизна. Вибір місця залягання рекомендованих нових свердловин базується на особливостях нових науково-методичних прийомів при вивченні закономірностей фаціального заміщення порід-колекторів із вміщуючими комплексами кожного продуктивного горизонту, вивченні фільтраційно-ємнісних властивостей порід-колекторів і флюїдів, що їх насичують.

Практична значимість. Отримані дані покладені в основу оцінки залишкових запасів вуглеводнів і встановлення нових перспектив приросту запасів по Західному полю родовища С. Нуржанов і порушують питання доцільності складання Єдиного Проекту розробки родовища.

Ключові слова: *Прикаспійська западина, родовище, нафтогазоносність, сейсморозвідка, каротаж, продуктивний пласт, підрахунок запасів*

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