НАУКИ О ЗЕМЛЕ И ПЛАНЕТЫ

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NEW IDEAS ABOUT THE FORMATION OF HYDROCARBON DEPOSITS IN THE RIPHEAN-LOWER-PALEOZOIC SEDIMENTARY BASIN OF THE SOUTHERN SIBERIAN PLATFORM

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Abstract. To date, the main oil and gas deposits in the Cambrian and Precambrian section of the south of the Siberian platform are confined to the terrigenous part of the Precambrian sedimentary cover, while in a much more powerful halogen-carbonate (HC) complex of the Vendian-Cambrian and the Lower Cambrian, the little commercial hydrocarbon accumulations were found. Therefore, the prospect of the largest reserve for increasing oil and gas deposits is associated with the carbonate complex. Along with the urgency of identifying the causes of existing imbalance in the development of deposits, there is a need to assess the realistic prospects of carbonate complex based on the discussion of nature and the mechanism of deposits formation.

Methods of the study: correlation and cross-correlation analyzes of maps of geological reference points and seismic reflecting horizons, as well as maps of hydrodynamic performance according to the well test data, the results of which were correlated with the results of linear analysis based on data from space surveys and potential fields.

In the synchronous deposits of a single Riphean-Lower Paleozoic basin in the south of the Siberian platform, the linear destructive zones are identified, which inherit the strike of formerly activated basin-forming fault systems of various directions and generations that influenced the HC deposits formation and disintegration. As a result, a discordant correlation of local structural plans of the deposit in the carbonate formation and the deposit in the Precambrian terrigenous deposits is established on multi-layer deposits.

It is argued that deposits in the productive formation of the Precambrian terrigenous complex were formed due to sub-vertical fluid flows from sub-fundamental sources under the influence of fault activations of early northeastern generations, and in the productive carbonate horizons of the Vendian-Cambrian and Lower Cambrian - due to the re-formation of deposits in terrigenous formations under the influence of faults of late north-western generation. At the same time, the deposits were formed in the zones overlapping to faults of earlier generation. This means that in the carbonate reservoirs it is impossible to achieve the advanced development of deposits, and in determining the order of prospecting the terrigenous horizons should be considered as basic or priority.

The results of the studies are consistent with the deposits distribution on 35 fields in the south of the Siberian Platform.

Keywords: Nepa-Botuobin anteclise, sedimentary and rock basins, activation, fault systems, HC traps, terrigenous rocks of Precambrian, carbonate rocks of Vendian-Cambrian and Lower Cambrian.

INTRODUCTION

"Overview of the productive horizons in the Cambrian and Precambrian section of the Siberian platform shows that the main oil and gas deposits are confined to the terrigenous part of the Precambrian sedimentary cover. At the same time, in a much more powerful Lower-Middle Cambrian halogen-carbonate complex, a few industrial accumulations of hydrocarbons have been discovered" [6]. This conclusion, made by a team of authoritative geologists of oil companies more than 3 decades ago, continues to remain unchanged by now and makes it urgent to identify the causes of this imbalance in the deposit development.

Section of the sedimentary cover of the Nepa-Botuoba anteclise (NBA) in the south of the Siberian platform, which contains the predominant part of the oil and gas reserves established here, mainly form the Vendian and Cambrian deposits. In their comlocation, a number of productive horizons of terrigenous and carbonate comlocation have been established and are forecasted [5].

To date, at the attained degree of geological and geophysical knowledge of the said territory deep drilling, predominantly gas-saturated clastic horizons occurring in the lower sedimentary cover and allocated in part of early Vendian terrigene complex are dominated. The carbonate horizons, on the one hand, and the oil-saturated collectors of the Vendian-Cambrian and the Lower Cambrian, on the other, play a subordinate role against this background.

According to the existing concept, the carbonate horizons in the Siberian platform are associated with prospects of the largest reserve for increasing oil and gas deposits. In the sedimentary cover of NBA the productive formations are $B_{3\text{-}4\text{-}5}$ in the Upper Danilov sub-horizon of subsalt carbonate complex (Vendian-Cambrian) and formations B_1, B_2 in the Lower Usolsk halogen-carbonate complex (Lower Cambrian). In the territory of Yakutia, these are the Yuryakh (Vendian-Cambrian) and Osynsk (Lower Cambrian) carbonate formation [7]. There is a need to assess the feasibility of these prospects based on the discussion of the nature and mechanism of deposits formation herein.

In this regard, we should note that the existing distribution of open hydrocarbon deposits, including those in the Vendian-Cambrian and Lower Cambrian carbonates, is not only in the NBA, but also in other adjacent areas of the Siberian platform: Baikit anteclise, Katanga and Vilyuchansk saddle, the sedimentary cover of which is represented by one Riphean-Lower Paleozoic sedimentary and rocky basin (SRB) (Table 1, Fig. 1).

Table1

DISTRIBUTION OF FIELDS WITH DEPOSITS IN THE TERRIGENOUS COMPLEX OF RIPHEAN AND EARLY VENDIAN AND CARBONATE FORMATIONS OF THE VENDIAN-CAMBRIAN AND LOWER CAMBRIAN [22]

Superorder structures	Baikit anteclise	Katanga saddle	Nepa-Botuobin anteclise within the boundaries of		Vilyu-chansk saddle	Total
			Republic of Sakha (Yakutia)	Irkutsk Region		
Total Deposits	5	2	17	8	3	35
With deposits in the carbonates of Vendian-Cambrian and Lower Cambrian	0	0	2 (1)*	5	3	10 (9)*
With deposits in the Vendian	3	2	17	7	3	32
With deposits in the Riphean.	2	0	0	0	0	2

** In the territory of Yakutia, the author refers only Talakan deposit to deposits with deposits in carbonates of the Osynsk horizon. The central block of the Mid-Botuoba field, where the oil and gas manifestations in the Osynsk horizon were noted in 3 wells, the HC reserves were not counted due to their insignificance.*

In the territories of listed above superorder structures, most of the oil and gas deposits of the Siberian platform have been explored and operated. The main prospects for increasing HC reserves in the East of the country are also associated with them [13]. Note that the north-eastern part of NBA within boundaries of the Republic of Sakha (Yakutia) together with the adjacent Viluchanskaya saddle form the Nepa-Botuoba oil and gas area (OGA).

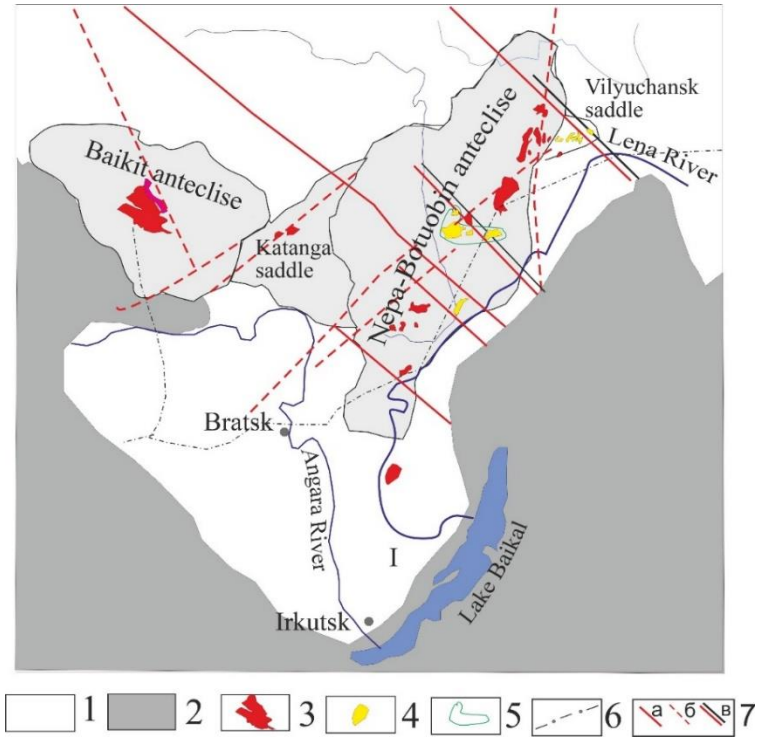

Fig. 1. The overview map of superorder structures for the Siberian platform with hydrocarbon deposits. 1. Siberian platform; 2. Folded environment; 3. HC deposits, wherein there are no deposits in the Vendian-Cambrian and the Lower Cambrian carbonates; 4. HC deposits, wherein there are deposits in the Vendian-Cambrian and the Lower Cambrian carbonates; 5. Structurally tectonic zone; 6. Route of the ESPO gas pipeline under construction; 7. The largest violation, intersecting the basement and sedimentary cover of [6]: a) north-west strike, b) other than the north-west strike; c) violations coincided with the allocated "A-A" and "B-B" (Fig.7-II).

Of the 35 fields listed in the table above, only 9 have deposits in the carbonates of stratigraphic range under consideration and are characterized by extremely uneven spatial distribution and zonal concentration: 3

fields are located in the Vilyuchansk saddle and 4 out of 6 are in the NBA (Talakan, Vakunaysk, Upper Chonskoye, Danilov) are confined to one structural-tectonic zone (Fig. 1). Such statistics and distribution of deposits in carbonates on such vast and well-studied territories cannot be explained by the possible omission of reservoirs during drilling for various geological and technological reasons, and a scientific discussion is required on the genesis of HC deposits.

An important role in substantiating the nature and mechanism of deposits formation in the carbonate strata has a choice of the fluid dynamic paradigm for the deposits formation. The nature of open deposits in the NBA area lying near the crystalline base in the sedimentary cover of low power, cwhich is haracterized by a low content of organic carbon and the absence of conditions for long-term hydrocarbon migration, cannot be explained from the standpoint of the sedimentary-migration theory of oil and gas formation. In this matter, we refer to the authoritative opinion of a correspondent-member of the RAS, B.A. Sokolov [18].

Due to revealed giant scales of deep degassing of the Earth, including hydrocarbon degassing (CH_4, CO_2, N_2, H_2, etc.), the fluid dynamic schemes of oil and gas accumulation processes are being developed in addition to the classical biogenic, also due to degassing processes both direct and with an intermediate accumulation of bacterial mass and its processing into oil [2, 6]. The theory of convergence in the formation of HC deposits among the latter, in our opinion, is the most acceptable for explaining the nature of NBA deposits [10]. The correctness of this theory application presupposes the existence of a sub-fundamental source, a sub-vertical filtration of HC fluids, and a powerful sedimentary stratum. Thus, in particular, the geological and geophysical studies and modeling carried out in recent years have made it possible to confirm such conditions in the territory of the Nepa-Peleduy arch within the Nepa-Botuoba anteclise [15].

In fluid dynamic theories, the activated deep faults with key characteristic "activated" are an important and integral part of oil and gas basins [14]. The concept of "active fault" appeared in the early 70s and came from the definition of "live fault" [26]. Its meaning may vary in different authors, depending on what features are taken as a basis for the method of isolating the active faults. The influence of fault tectonics on the processes of oil and gas formation is universally recognized and reflected in a variety of publications, but the mechanism of influence, which is linked with the activation parameters: cyclicity of the manifestation, the direction of generation, the time and the period of activation of the basin-forming fault systems (which are defined below), remains insufficiently studied.

The intensive development of deformation and fluid dynamic processes, which lead to a change in the physical properties of the medium and to mass transfer, established by modern methods of geodynamics in the areas of active faults [17] allows us to presumably link the formation and disintegration of multi-layer HC deposits in the NBA with periodic activation processes of the basin-forming fault systems of various spatial generation.

METHODS AND RESULTS OF THE STUDY

The theoretical basis of the study was the idea of sedimentary rock (SRB) and oil and gas bearing basins (OGBB) formation and development; methodical - complex processing and analysis of multi-dimensional geological and geophysical information based on the modern geoinformation technologies. The article is based on the results of current and past studies conducted by authors, selected and consolidated by its thematic focus for the argumentation of the dominant role of fault tectonics in the nature of oil and gas deposits in the south of the Siberian platform.

Methods of the study: correlation and cross-correlation analyzes of maps of geological reference points and seismic reflecting horizons, as well as maps of hydrodynamic performance according to the well test data, the results of which were correlated with the results of linear analysis based on data from space surveys and potential fields.

Earlier in the marginal depressions of the east of the Siberian platform (Vilyui syneclise), executed by several sedimentary-rocky basins (SRB), the lower one of which is the Riphean-Lower Paleozoic basin, the periodic processes of different ages activation for the previously laid deep faults of different directions and generations. We call such a fault system as a pool-forming system. It is shown that those consedimentation active systems have a significant effect on the sedimentation, formation and stages of the SRB development [3]. It is suggested that they reflect the relation between the evolution of sedimentary basins and fault formation in the tectonosphere and, in particular, with the phenomenon of the main divisibility of the earth's crust, its blocky structure, and certain primary faults [1]. The turn seems to be caused by the gradual activation of already existing, previously embedded fault systems of various directions and generations [12], and is also caused both by a planetary mechanism [8] and the processes occurring in the Proterozoic-Phanerozoic in the areas of Siberian continent articulation with other continental blocks.

It is established that activation processes of the fault systems are characterized by cyclic (stage) manifestation, the time and period of activation, as well as the direction of generation. The cyclicity is expressed in the directed turn of the structural plans of the overlying SRBs in relation to the underlying ones from the east-north-east to the north-west direction; activation time - the time of SRB embedment, and activation period - the time of SRB existence [3].

In this regard, based on the universality of the principle of cyclicity, it can be argued that all activation processes of the basin-forming fault systems in the post-Paleozoic time also took place in synchronous deposits of a single Riphean-Lower Paleozoic basin in the south of the Siberian platform, incl. in the territory of NBA. These processes did not change the structural plan of the formed basin, but left in it the linear destructive zones, which inherit the strike of systems activated in the past that had an impact on the HC deposits formation and deformation.

If one maintains the viewpoint of the dynamic nature of deposits formation (deformation) during the

geological time, the formation of deposits in carbonate reservoirs belonging to the upper productive part of SRB section was decisively affected by fault systems of the last activation (during the post-Cretaceous period and to the present), having a north-west strike. The activation of such fault systems and its nature are identified in the territory of the Viluyi syneclise, according to the results of processing various scale lineaments of the earth's surface relief from the data of space images and is confirmed by data of special processing of gravitational and magnetic fields [3] (Fig. 2).

It is assumed that under the influence of faults of the north-west generation the simultaneously forming processes of reservoir-filtering properties in the reservoir carbonate rock and reorientation local structural plans of traps that fall in their zone of influence took place. The processes took place, obviously, as a result of a directed change in the physical properties of carbonate matrix skeleton (primarily porosity - fractured vuggy) under the influence of aggressive fluid solutions (or magmatic masses and post-magmatic solutions) that enter the faults during their activation. This leads to a change in the compression characteristics of the formation (Young's modulus and Poisson's ratio) and its transition to a new stress-strain state, which inherent the strike of the activated fault system.

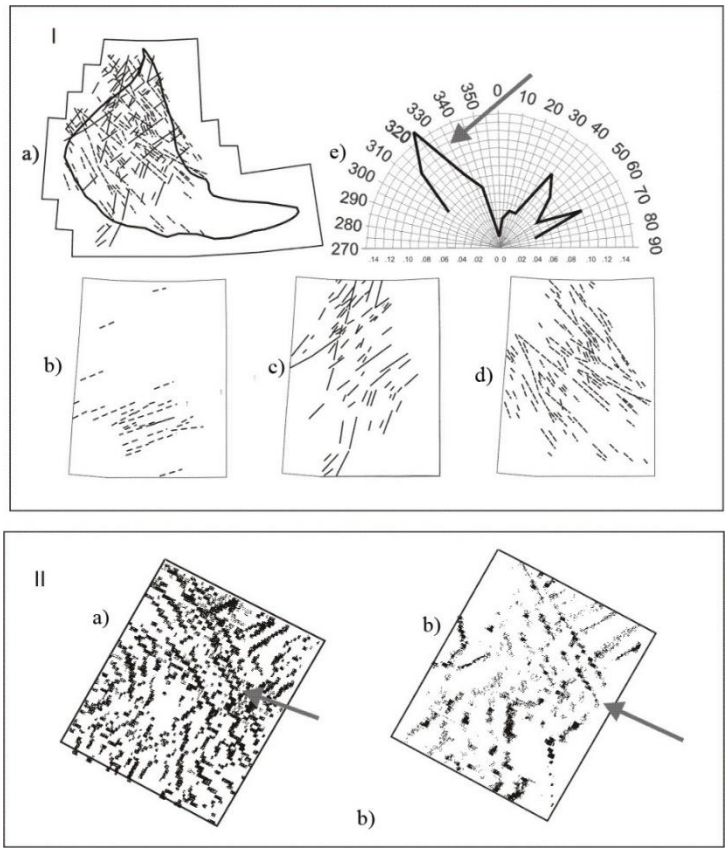

Fig. 2. Manifestation of the deep faults activation (north of the north-west direction)

I– generalization of different-scale lineaments based on space survey data (SSD) for the territory of Vilyui syneclise: a) assembly of lineaments with various directions; lineaments for directions: b) east of the north-east; c) north-east; d) north of the north-west; e) rose-diagram of lineaments; II– lineaments of magnetic (a) and gravitational (b) fields at the Atyakha square in the Kempendyai basin. The arrow points to the lineaments reflecting the fault system for the north-west strike of the last activation, which "cross" lineaments of other directions.

We emphasize that the reorientation concerns only the local structural plans of the deposit, with respect to the regional structural plan of SRB, resulting in a discordant relation between the structural plan of deposit in the carbonate reservoir with respect to the regional plan or deposit plan in the Vendian terrigenous deposits on the multi-layer fields, and the correlation coefficient between the structural plans drops below 0.7.

Let us illustrate the existence of a different age activation of fault systems and the associated discordant occurrence of deposits in the Lower Cambrian and Vendian sediments in two typical structural-tectonic zones noted in Fig. 1. In the first zone - the Vernet-Vilyuchansk field (Vilyuchansk saddle) according to the processing of structural plans (Fig. 3-I). In the second zone – Talakan gas and oil condensate (carbonate reservoir of the Lower Cambrian) and Chayandinsk oil and gas condensate field (Vendian terrigenous reservoir) (central part of the NBA) according to the test data of gas and oil inflows in the wells in order to establish the nature of permeable zones [4] (Fig. 3-II).

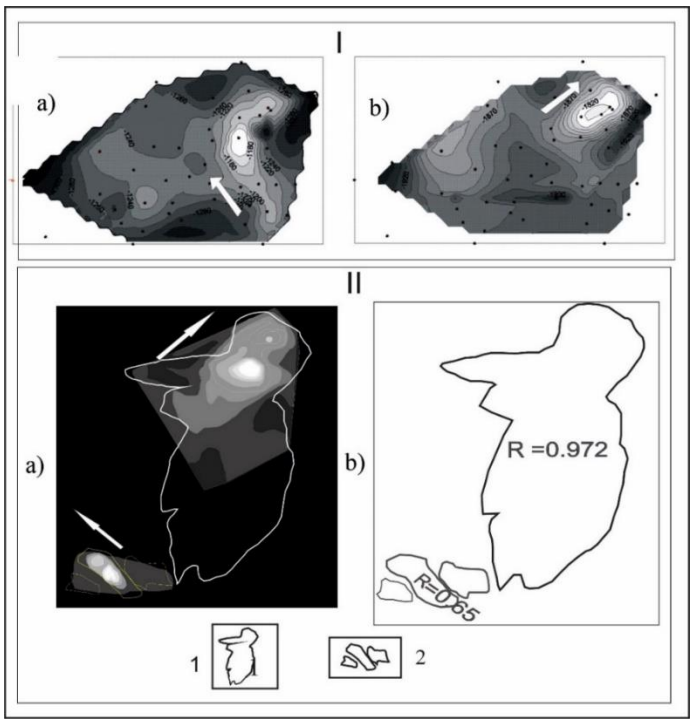

Fig. 3. To the substantiation of the existence of a different age fault systems activation

I. Structural plans for Upper Vilyuchan field by productive horizons of: a) Yuryakhsky Yu-1 (the Yuryakhsky formation of the Vendian-Lower Cambrian; б) Kharystansky (Kharystansky formation of the Vendian) (matrix representation: light tones - rising, dark - dipping); point - wells.

II. a) comparison of maps for the hydraulic conductivity coefficients of gas reservoir in the Botuobinsk horizon of the Vendian (the Chayandinsky deposit) and the oil deposit of the Osinsk horizon of the Lower Cambrian (the Central Talakan field) (matrix representation: light tones - high, dark - low values of coefficients); b) Correlation coefficients between the structural plans of Lower Cambrian and Vendian horizons at the deposits. Deposit contours: 1– Chayandinsky; 2– Talakan.

We give examples of the conformal behavior of local structural plans for the Vendian and the Lower Cambrian in the fields, where the HC deposits are developed in the terrigenous Vendian deposits, but there are no deposits in the Lower Cambrian carbonate strata (Fig. 4).

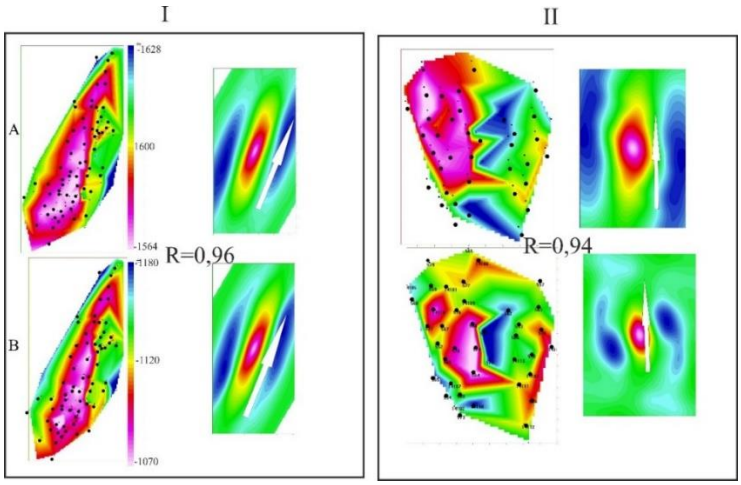

Fig. 4. Structural plans and their two-dimensional autocorrelation functions for the Mid-Botuoba deposit (I) and the Taas-Yuryakhsky deposit (II) (matrix representation).

A – by Botuoba horizon of the Vendian;

B– by Osynsk horizon of the Bilir formation of the Lower Cambrian. Points - wells. Arrows - direction of the structural plans strike. R – a correlation coefficient between the plans.

For the practical application of the established effect of the age-dependent fault systems activation on the HC deposits formation in solving the oil and gas field search problems, it is particularly important to identify the pool-forming fault tectonics, which was activated in anthropogenous times, and the traces of its manifestation in past eras.

The isolation of such tectonics, especially in the first case, presents certain difficulties. The period of activation of the basin-forming faults is equal to the time of existence of the SRB (tens and hundreds of millions of years), in the first half of which the basin and fault are subjected to various-period deformations, but the mode of expansion of the crust dominates, and the second is the compression regime. For example, detection methods and fracture activity indices have been developed with a period of activation (hundreds or less years) that trigger the trigger mechanism of earthquake processes [24, 25], but the issue of the identity of activated faults and the faults of basin-forming systems identified by them has not been studied. There are supposed indirect indications of the active faults detection, to which, in our opinion, the transregional nature of the distribution and the linear-zonal nature of the deposits location formed under their influence can be attributed.

In the territory of the NBA and Vilyuchansk saddle in the borders of the Republic of Sakha (Yakutia), there are no problems in identifying the formerly activated fault systems of the north-eastern and sub-medial directions. On the maps of fault tectonics of various authorial collectives, these directions are predominant. The spatial location of fields developed here with deposits in the Vendian (20 of 32 in Table 1) inherits the dominant northeasterly strike and confirms the unequivocal connection between the nature of these deposits formation and fault systems of such directions (Fig.5-I).

It is less unambiguous to single out the fault systems of north-western direction of late generation on fault-tectonic maps. At a qualitative level, one linear tectonic zone can be identified, which is close to the northwestern strike in the south of the territory and passing through the Talakan gas and oil field, in which, along with the faults of north-eastern and sub-median directions, there are faults of predominantly north-west strike (location of the conditional center line "A-A", Fig. 5-I). It can be regarded as a zone overlapping the fault systems of various generations of directions, where conditions exist for the HC deposits formation in Vendian-Cambrian and Lower Cambrian carbonates. The Talakan field enters this zone and further on its continuation the Vakunay, Upper Chonsk, Danilov deposits in the territory of the Irkutsk region (Fig. 5-I, see Fig.1).

Finally, on the maps of fault tectonics, the structural-tectonic zone of the north-western strike, through the territory of Vilyuchansk saddle (location of the conditional center line "B-B", Fig.5-I), whose existence could explain the local spatial location of fields discovered here with deposits in Vendian-Cambrian carbonaceous rocks in the framework of the presented concept (Iktekh, Verne-Vilyuchansk and Vilyuisk-Jerbinsk deposits) cannot be seen at all (see Fig. 1).

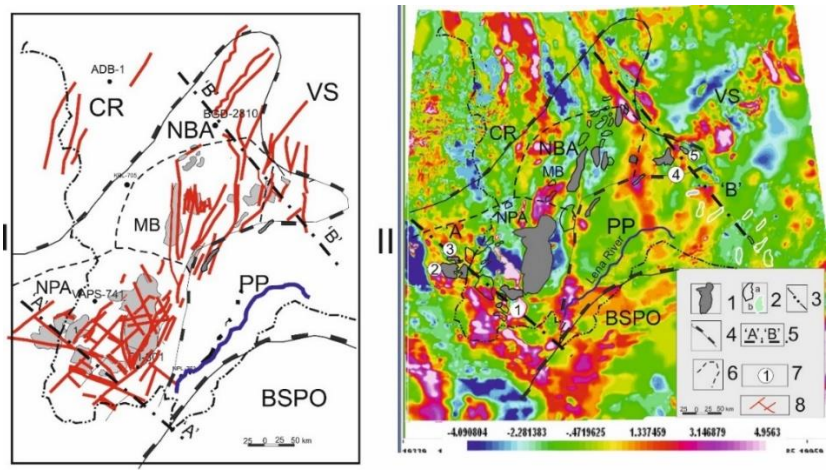

Fig. 5. To the substantiation of the spatial location and localization of hydrocarbon deposits with deposits in Vendian-Cambrian and Lower Cambrian carbonates

Maps with an overlay of local and superorder structures within the Republic of Sakha (Yakutia): I. fault tectonics of All-Russian Geological Research and Development Oil Institute [12]); II. Map of the magnetic field ΔT.

1 – field contours; 2– contours of the structures: a) – in training funds, b) – inherit the strike of the fault system; 3 – administrative border of Yakutia; 4 – boundaries of superorder structures (names of structures are in Fig.2); 5 – location of the conditionally axial lines for fault systems of the north-west strike; 6 – contours of the Nepa-Peleduy arch (NPA) and Myrninsky protrusion (MP) of the NBA; 7 – deposits that are referenced in the text: 1 – Talakan, 2 – Upper Chon, 3 – Vakunai, 4 – Upper Vilyuchan, 5 – Vilyuisk-Djerba.

In our opinion, the available maps of fault tectonics for the reasons noted above, incl. author's subjectivity, are not a reliable basis for the identification of activated fault systems of north-western generation.

Our studies in the territory of the NBA and the Vilyuchansk saddle within the boundaries of the Republic of Sakha (Yakutia), followed by [19], confirm the relation between the spatial location of deposits and linear magnetic field anomalies. The connection is that some extended anomalies will inherit the location of

fault systems of the last activation, associated with the deposits formation in carbonate strata, the determination of which location on the maps of fault tectonics is ambiguous or difficult. On the presented map of magnetic field ΔT, after its processing, two linear anomalies along the conditional axial lines, which we associate with the fault systems of the north-west strike, are clearly distinguishable (Fig. 5-II).

The first of them along the conventionally axial line “A-A” in the south of the territory confirms the location of structural-tectonic zone of the north-west strike marked on the map of fault tectonics. The second one along the conventionally axial line "B-B" reveals a structural-tectonic zone of a similar strike in the northern part of the NBA, which also passes through the territory of the Vilyuchansk saddle and does not appear on the map of fault tectonics. (Fig. 5-II).

Other structural-tectonic zones of the north-western strike within the Republic of Sakha (Yakutia) under consideration are not distinguished.

In search of justification for the allocated structural and tectonic zones of the north-west strike and establishing the nature of regional behavior outside the north-eastern part of the NBA, their location is combined with a fragment of fault tectonics scheme borrowed from the classical *oil and gas potential map of the Siberian platform, edited by A.E. Kontorovich and A.A. Trofimuk, covering* the territory of the NBA, Katanga saddle, and Baikit anteclise [11]. On the fragment of this scheme, the map;s legend shows only the general deep faults, according to the classification of S.I. Sherman, in the crystalline basement and sedimentary cover with a length of more than 150 km [23] (see Fig. 1).

Such a "thinned" by the extent of the fault circuit is dominated by the diagonal system, provided by regional faults of north-eastern and north-western directions, two faults of the latter direction are confirmed in the north-eastern part of the NBA as the faults of last generation (see Fig. 5-II). For these reasons, in the first approximation, we can assume that in the scheme the activated in the past and the present faults of different spatial generation are shown.

We should note two important features of the spatial faults distribution on the diagram, which are consistent with the above provisions on the nature of deposits and the nature of deposits location in the areas of the above-mentioned superorder structures. First - the faults of late north-western generation pass through the territory of the NBA and the Vilyuchansk saddle or are located on it and do not affect the territory of the Katanga saddle and Baikit anteclise. Two of these faults - one is in the north, the second is in the center of the NBA, have a trans-regional distribution and cross the entire Siberian platform. Second, most of the faults of early north-eastern and sub-medial generation pass through the NBA and the Vilyuchansk saddle (see Fig. 1). These features of fault tectonics, in our opinion, explain the reason for overwhelming number of open fields location with deposits in terrigenous strata and carbonate reservoirs (28 of 35, Table 1) in the territory of the NBA and Vilyuchansk saddle.

In this regard, the prospects for developing deposits in the Vendian-Cambrian and Lower Cambrian carbonates in the NBA territory within the Republic of Sakha (Yakutia) are associated with areas adjacent to the identified fault systems in the central and northern NBA (conditional axial lines "A-A" and " B-B"), as well as on the continuation of the latter in the Predpatom trough, which width of influence zones remains unknown. For the rest of the NBA territory, recommendations regarding the prospects for areas adjacent to the fault systems of the north-west strike remains relevant, but the location of fault systems should be specified in this case.

DISCUSSION

With the outlined concept, if it is correct, the expected stages of fluid saturation and deposits formation upwards along the section are closely linked.

When the early Paleozoic faults were generated in the early north-eastern generation, the deposits in the HC traps were probably formed initially in deep-seated reservoirs of the basal Precambrian terrigenous complex under the influence of ascending fluid flows from sub-fundamental (cryptogenic) and mantle sources. The subsequent generation of faults of other directions, prior to the manifestation of the activation of northwestern generation system, obviously influenced the fluid saturation of the overlying Vendian strata and the reorganization of HC deposits between them, but did not lead to the formation of deposits beyond its boundaries. In the territory of the NBA, within the Republic of Sakha (Yakutia), these are productive horizons in the Talakh, Parshin, Kursk, Kharystakh and Buchka sunks, which are overlapped by a thick stratum of low permeability carbonates from the Uspun and Kudulakh sunks.

The influence of fault tectonics of late north-western generation on carbonate strata led directly to the formation of deposits therein due to the reformation (or deformation) of those in the underlying terrigenous complex. The effect was more complex and occurred taking into account the above-mentioned intensive flow of deformation and fluid dynamic processes. It was accompanied by a change in the physical properties of the environment, the inheritance of local reservoir plan with the direction of activated fault system and led to a discordant relation between it and the regional structural plan or local reservoir plans in terrigenous reservoirs.

Mindful that the deposits formation in the HC traps depends on many other factors not related to the intensification of fault systems, we believe that the proposed staging of their development under the influence of faults is not sufficient, but a necessary condition for the deposits formation. This makes it possible to explain the statistics of discovered fields in general, including with the HC deposits in Vendian-Cambrian and Lower Cambrian carbonates (Table 1).

The traps of fields, wherein the HC deposits are developed in the Riphean and Early Vendian formations, the influence stage of faults of the north-eastern and/or subsequent north-north-eastern and sub-meridional generations were conducted. This is evidenced by the fact that the overwhelming majority

of such fields, 27 of 34, were developed in the NBA and Vilyuchansk saddle (Table 1), on the structural maps of the territory of which the faults of marked orientation predominate, as well as the similar extent of the NBA contour and deposits on it (Fig. 7-I).

The traps in the fields, wherein the HC deposits were dieveloped in the Vendian-Cambrian and Lower Cambrian carbonates, were supposed to be in the zones of influence of the activated system of late north-western generation and one or more zones of influence of the activated systems of earlier generations. In other words, the HC deposits in the carbonate strata of these deposits can be developed in the fields, wherein the HC deposits were previously formed in productive strata of the Precambrian terrigenous complex and which are located in the zones of interference of fault systems of early and late generation. It explains the low statistics of such deposits development (Table 1).

The conducted hydrodynamic and structural constructions on the gas-oil deposit of Osynsk carbonate horizon (the Lower Cambrian) at the Talakan field made it possible to reveal the features of such a zone of superposition of fault systems. There is a low similarity of the flow maps and reservoir deposits R = 0.67 in the central block with the almost identical direction of plan strikes on the maps reviewed. It was found that the location of areas with improved reservoir properties and increased productivity of wells is not controlled by the deposits hypsometry, but their confinement to nodes crossing the faults of north-west directions with faults of other directions (Fig. 6).

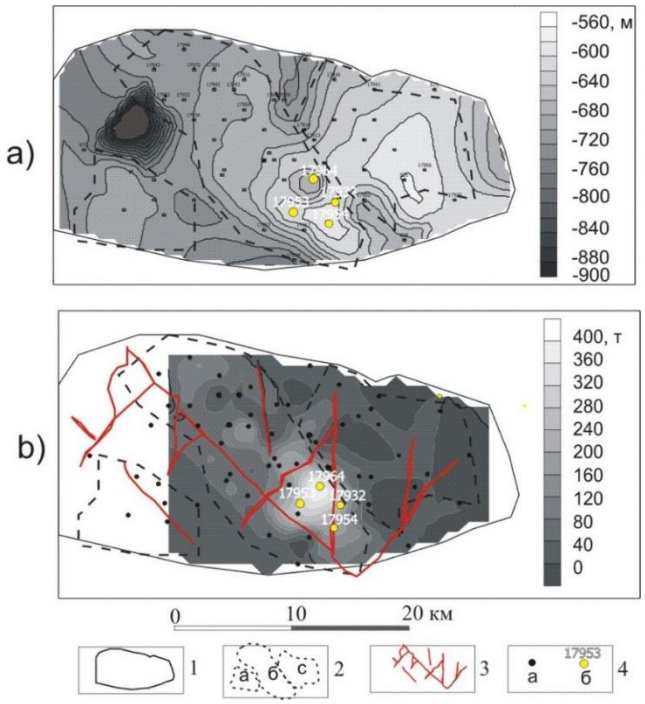

Fig. 6. Map comparison on Talakan square (matrix representation: high marks and debits - light tones): a) structured along the Osynsk horizon; b) Osynsk horizon productivity map with the author's option of fault tectonics.

1 – contour of the Talakan field; 2 – blocks of the field: a – Talansky; b – Central Talakan; c – East Talakan; 3 – scheme of fault tectonics; 4 – wells: a – not considered, b – considered.

The figure maximum flow rates (around wells 17964, 17952.17953) is displaced relative to the surface maximum marks near the well 17954, and their location fits into the triangle formed by faults of north north-western, sub-meridional and north-eastern strike.

On this basis, two assumptions were made. The first is that the location of such nodes is a vertical projection of the channels of fluid flow migration; second - during the deposits formation in the Lower Cambrian carbonates, the faults of late north-western generation were primarily active, and the associated fault sections of earlier generation – inductively active and participated in the reservoir fluid-saturation processes.

The stated relation between fluid dynamic processes in the zones of active faults and processes of the simultaneous HC deposit formation, and filtration-volumetric characteristics of the reservoir in the carbonate rock is evidenced by the data of the acoustic well logging in parameter D, reflecting the rhythm of sedimentation, in the Talakan deposit spectrally-depth scanning (SDS) [5]. The activity of fluid dynamic processes, caused by the activation of faults, is related to the fracturing and accompanying secondary porosity of carbonate formation, and manifested in different nature of the SGS in the supply and not supply wells along the productive Osynsk horizon. In this case, differences in the SGS patterns cover the interval of occurrence of the entire carbonate (Vendian-Cambrian) and carbonate-halogen complex (the Lower Cambrian), as most susceptible to fracture and cavernous formation processes (Fig.7).

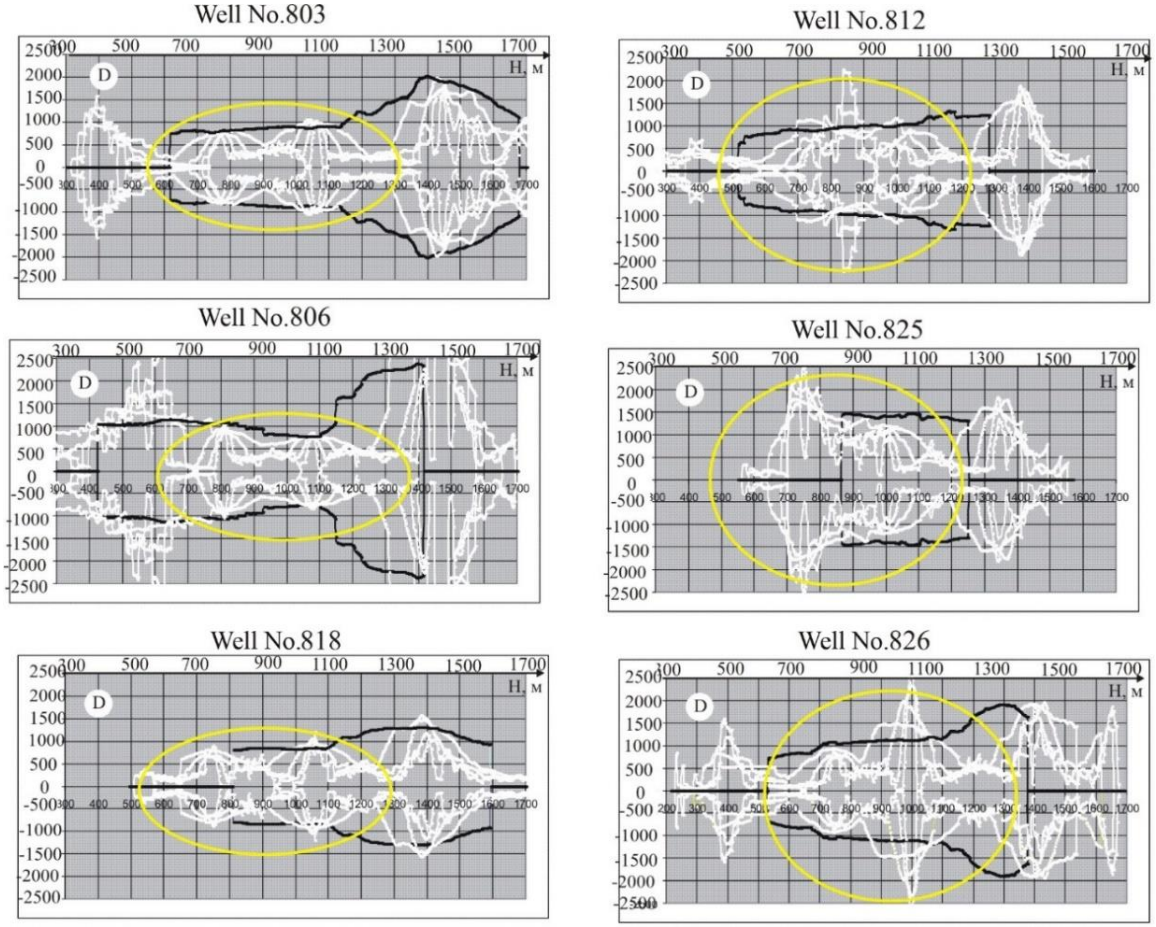

Fig. 7 Comparison of GGRs on the entire trunk for unproductive (803,806,818) and productive (812,825,826) wells along the Osynsk horizon of the Talakan field [3].

Within ellipse - the interval of occurrence of carbonate and carbonate-halogen complexes of Vendian-Cambrian and Lower Cambrian.

The fault systems that determine the block divisibility of the earth's crust and play an important role in the HC ontogenesis, according to most researchers, fit into a planetary grid of faults, the main of which are orthogonal (latitudinal and meridional directions) and diagonal sub-perpendicular (north-eastern (NE) - oriented from the south-west to the north-east, and the north-western (NW) - oriented from the south-east to the north-west directions). Priority of the systems manifestation in any other region is determined by the specific character of its geological structure [1].

In the above-mentioned influence of fault systems on the stage of HC deposits formation and the fault-block structure of NBA, in particular, the more significant role of diagonal fault system of planetary directions with the subordinate role of the orthogonal [16], the nature of which is still to be ascertained, is identified.

CONCLUSION

1. Fields formation in the HC traps of synchronous deposits of a single Riphean-Lower Paleozoic SRB within the NBA probably occurred due to subvertical fluid flows from sub-fundamental sources and the HC deposits reformation between productive Vendian strata under the influence of periodic activation of fault systems of different spatial orientation.

2. HC deposits in productive strata of the terrigenous Vendian complex were formed under the influence of active faults of early north-eastern and / or subsequent north-north-eastern and sub-meridional generations, and HC deposits in the Vendian-Cambrian and Lower Cambrian carbonate horizons - under the influence of active faults of late north -west generation with the inheritance of local structural plans for the strike horizons of these faults. This leads to a discordant correlation of the local structural plan of deposit in the carbonate strata with respect to the regional plan or formation plan in the Vendian deposits at the multi-layer fields.

3. A stage is established in the deposits formation in the SW traps upwards along the section. At the first stage, under the action of fault systems of the early north-eastern and subsequent generations, the north-east and sub-meridional north form and then reform deposits in the productive Vendian strata. Deposits in the productive Vendian-Cambrian and Lower Cambrian carbonate horizons are formed at the second stage under the influence of faults of late north-western generation in the zones of their overlapping to faults of earlier generation due to reformation (de-formation) of deposits in terrigenous Precambrian reservoirs.

4. From the standpoint of the HC deposit in the Vendian-Cambrian and the Lower Cambrian carbon rocks, the HC deposits can be developed in the territory of traps in which HC deposits were previously formed in the productive strata of the Precambrian terrigenous

complex. At the same time, the success rate of field development with such deposits in relation to the total number of discovered fields is about 0.25 (according to Table 1). This means that in carbonate reservoirs it is impossible to achieve the advanced deposits development and in determining the order of prospecting surveys the terrigenous horizons the surveys should be considered as basic or priority.

5. Prospects for the deposits development in the Vendian-Cambrian and Lower Cambrian carbonates within the Republic of Sakha (Yakutia) are associated with areas adjacent to the identified fault systems of the north-western strike, which width of the zones of influence remains unknown, as well as continuation of the fault system B'- 'B' in the Predpatom trough.

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PICTURE CAPTIONS

Fig. 1. The overview map of superorder structures for the Siberian platform with hydrocarbon deposits.

Siberian platform; 2. Folded environment; 3. HC deposits, wherein there are no deposits in the Vendian-Cambrian and the Lower Cambrian carbonates; 4. HC deposits, wherein there are deposits in the Vendian-Cambrian and the Lower Cambrian carbonates; 5. Structurally tectonic zone; 6. Route of the ESPO gas pipeline under construction; 7. The largest violation, intersecting the basement and sedimentary cover of [6]: a) north-west strike, b) other than the north-west strike; c) violations coincided with the allocated "A-A" and "B-B" (Fig.7-II).

Fig. 2. Manifestation of the deep faults activation (north of the north-west direction)

I– generalization of different-scale lineaments based on space survey data (SSD) for the territory of Vilyui syneclise: a) assembly of lineaments with various directions; lineaments for directions: b) east of the north-east; c) north-east; d) north of the north-west; e) rose-diagram of lineaments; II– lineaments of magnetic (a) and gravitational (b) fields at the Atyakha square in the Kempendyai basin. The arrow points to the lineaments reflecting the fault system for the north-west strike of the last activation, which "cross" lineaments of other directions.

Fig.3. To the substantiation of the existence of a different age fault systems activation

I. Structural plans for Upper Vilyuchan field by productive horizons of:

a) Yuryakhsky Yu-1 (the Yuryakhsky formation of the Vendian-Lower Cambrian; б) Kharystansky (Kharystansky formation of the Vendian) (matrix representation: light tones - rising, dark - dipping); point - wells.

II.a) comparison of maps for the hydraulic conductivity coefficients of gas reservoir in the Botuobinsk horizon of the Vendian (the Chayandinsky deposit) and the oil deposit of the Osinsk horizon of the Lower Cambrian (the Central Talakan field) (matrix representation: light tones - high, dark - low values of coefficients); b) Correlation coefficients between the structural plans of Lower Cambrian and Vendian horizons at the deposits. Deposit contours: 1– Chayandinsky; 2– Talakan.

Fig.4. Structural plans and their two-dimensional autocorrelation functions for the Mid-Botuobinsky deposit (I) and the Taas-Yuryakhsky deposit (II) (matrix representation).

A – by Botuoba horizon of the Vendian; B– by Osynsk horizon of the Bilir formation of the Lower Cambrian. Points - wells. Arrows - direction of the structural plans strike. R – a correlation coefficient between the plans.

Fig.5. To the substantiation of the spatial location and localization of hydrocarbon deposits with deposits in Vendian-Cambrian and Lower Cambrian carbonates

Maps with an overlay of local and superorder structures within the Republic of Sakha (Yakutia): I. fault tectonics of All-Russian Geological Research and Development Oil Institute [12]); II. Map of the magnetic field ΔT.

1 – field contours; 2– contours of the structures: a) – in training funds, b) – inherit the strike of the fault system; 3 – administrative border of Yakutia; 4 – boundaries of superorder structures (names of structures are in Fig.2); 5 – location of the conditionally axial lines for fault systems of the north-west strike; 6 – contours of the Nepa-Peleduy arch (NPA) and Myrninsky protrusion (MP) of the NBA; 7 – deposits that are referenced in the text: 1 – Talakan, 2 – Upper Chon, 3 – Vakunai, 4 – Upper Vilyuchan, 5 – Vilyuisk-Djerba.

Fig.6. Map comparison on Talakan square (matrix representation: high marks and debits - light tones):

a) structured along the Osynsk horizon; b) Osynsk horizon productivity map with the author's option of fault tectonics.

1 – contour of the Talakan field; 2 – blocks of the field: a – Taransky; b – Central Talakan; c – East Talakan; 3 – scheme of fault tectonics; 4 – wells: a – not considered, b – considered.

Fig.7 Comparison of GGRs on the entire trunk for unproductive (803,806,818) and productive (812,825,826) wells along the Osynsk horizon of the Talakan field [3].

Within ellipse - the interval of occurrence of carbonate and carbonate-halogen complexes of Vendian-Cambrian and Lower Cambrian.

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