DISCUSSION ARTICLE

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Replenishment of oil deposits from the position of a new concept of oil and gas formation

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Abstract. The article is devoted to the problem of replenishing of oil reserves and considers it (the problem) in the aspect of deep degassing of the Earth. Based on an analysis of the results of a long-term study of the Precambrian crystalline basement in the territory of Tatarstan and adjacent areas, a number of new criteria are formulated that allow us to identify the processes of deep degassing of the Earth within the studied region.

The article provides a brief overview of current views on the problem of replenishing oil reserves, considers options for possible sources and the mechanism of replenishment of hydrocarbons in the developed deposits. The arguments in favor of the modern process of deep degassing within the South Tatar arch and adjacent territories are examined, which are unequivocally confirmed by: the dynamics of the hydrochemical parameters of the deep waters of the crystalline basement obtained in the monitoring mode at five deep wells; uneven heat flux and its anomalies, recorded according to many years of research under the guidance of N.N. Khristoforova. The degassing processes are also confirmed by the dynamics of gas saturation of decompressed zones of the crystalline basement recorded in well 20009-Novoelkhovskaya, the dynamics of gas saturation of oil of the sedimentary cover and the composition of the gas dissolved in it, identified by oil studies in piezometric wells located in different areas of the Romashkinskoe field; the seismicity of the territory of Tatarstan, as well as its neotectonic activity. As criteria proving the existence of a process of replenishing the reserves of the developed oil fields of the South Tatar Arch, the features of the deep structure of the Earth's crust according to seismic data, as well as the results of geochemical studies of oils are considered.

Key words: replenishment of reserves, deep degassing of the Earth, criteria for oil inflow into deposits, origin of oil and gas, geochemical studies, tectonic activation, Romashkinskoe oil field, a new concept of oil and gas formation

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The absolute dependence of the existence on energy consumption and the key role of the energy sector in mankind, the development of other components of the economy have led experts for decades to constantly ask the question "How much oil and gas remains in the bowels of the Earth, and when will they end?". The paradox is that, despite repeated attempts to predict the timing of the fall in world oil production and the prediction that it will end in twenty to thirty years, oil does not end at all. And on the contrary, the volume of oil produced annually is not just stable, it is gradually growing, which, according to the widespread opinion, is due to the dominant influence of new production technologies and the development of unconventional resources, the development of which was previously unprofitable.

Against the background of a seemingly quite clear picture of the industry development, fundamental basic problems, such as the genesis of oil and gas, the mechanism and stages of the formation and completion of their fields, continue to be unresolved. The appearance that clarity has long been achieved in solving these problems is reflected on the one hand in classical textbooks and numerous scientific works and articles. On the other hand, the facts obtained thanks to many years of experience in the exploration and development of oil and gas fields and the development of fundamental Earth sciences give reason to believe that the formation of oil and gas fields have long failed to meet the outdated concepts of sedimentary basins, as closed systems, where the formation hydrocarbon accumulations stretch for tens and hundreds of millions of years, and the reserves of oil and gas fields traditionally belong to non-renewable natural resources.

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The fact of modern replenishment of the extracted hydrocarbon reserves – recharge of deposits was established in the last two decades. It makes significant additions to existing ideas and involves the consideration and discussion of those new conceptual foundations of naphthydogenesis, from the position of which this process, fixed by geological, geophysical, and geochemical methods, can be fully explained and taken into account in modeling and development.

In particular, the replenishment of oil reserves has already been repeatedly considered on the example of the Romashkinskoe field both from the position of deep degassing of the Earth (Muslimov et al., 2019) and from the position of the continued generation of light hydrocarbons from high-alumina gneisses of the Greater Chemshan series (containing up to 15 % graphite) under the influence of high temperatures and deep hydrogen (Gavrilov, 2008).

The almost complete restoration of reservoir pressure and oil production rates recorded in the fields of the Kinzebulatov group of the Republic of Bashkortostan after a 20-year break, in the works of I.A. Dyachuk is explained by the gravitational redistribution of oil in the deposits (Dyachuk, 2015).

In his works E.Yu. Goryunov, who conducted an analysis of the reserves in the deposits, the properties of hydrocarbons and reservoir temperatures for the Ural-Volga region, assumes the staged flow of hydrocarbons into the sedimentary cover and the modern migration of hydrocarbon fluids into the region's fields (Khalikov et al., 2014, Goryunov et al., 2014).

A.V. Bochkarev and S.B. Ostroukhov at a number of fields in the Volga and the Caspian Basin described the facts of gas condensate entering oil fields at the last stages of development and the restoration of reservoir pressure in them (Bochkarev et al., 2010, 2011, 2012, Dorofeev et al., 2014).

The restoration of the anhydrous and slightly watered oil production in the fields of the Tersko-Sunzhensky district after lengthy interruptions in development is described in the works of V.P. Gavrilov (Gavrilov, 2008).

O.N. Kasyanova proved the saturation of the developed fields with migration hydrocarbon fluids within the areas of development of modern geofluidodynamic processes (Kas'yanova, 2009, 2010).

The most difficult, debatable and unexplored issue is the source and mechanism of modern reservoir replenishment, as the views of experts diverge both on the nature and the presence of the substance entering the reservoir (Fig. 1), and on the sources of this substance (Fig. 2).

In our opinion, the fundamental factor in the formation and replenishment of oil and gas deposits is the deep degassing of the Earth. The explanation of the

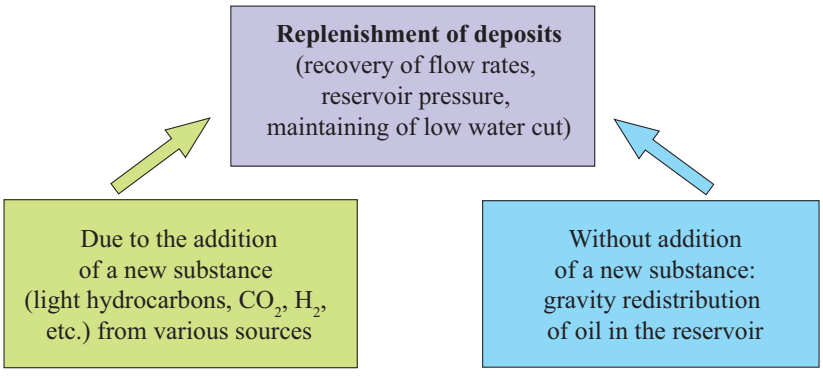

Fig. 1. Options for a possible mechanism for replenishing hydrocarbon deposits

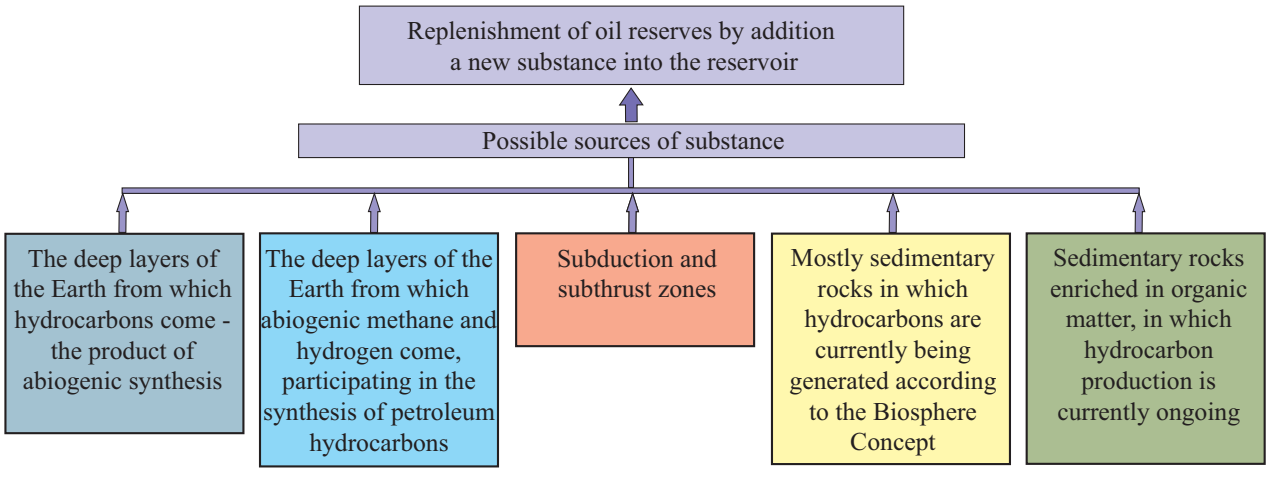

Fig. 2. Sources of replenishment of hydrocarbon reserves in the light of different views on the origin of oil and gas

ongoing modern development of open hydrodynamic systems, such as oil and gas deposits, deposits or their individual sections, requires the use of new geological paradigms and postulates of the so-called "non-linear oil and gas geology" (definition proposed by A.E. Lukin in 2004). The creation and approval of the theoretical foundations of renewing hydrocarbon reserves in developed formations is possible only on the basis of studying the deep degassing of the Earth – the global process of planet self-development, which determines the formation and development of high enthalpy, high-pressure fluid systems that generate a variety of geological events (Kropotkin, 1985, 1991, Lukin et al., 2018; Shestopalov et al., 2018).

An analysis of new concepts and models of naftidogenesis that have arisen over the past 50-60 years and are actively developing today, shows that each of them is based on different types of manifestations of gas discharges: the theory of degassing the Earth by P.N. Kropotkin (Kropotkin, 1985, 1991), the theory of abiogenic synthesis of hydrocarbons, developed by V.B. Porfiriev, N.A. Kudryavtsev, V.A. Krajushkin et al. (Krayushkin, 1984; Kudryavtsev, 1973; Porfir'ev, 1959), "fluidodynamic" concepts of A.N. Dmitrievskii, B.M. Valyaev, B.A. Sokolov, E.A. Abli (Dmitrievskii, 1991, Dmitrievsky et al., 2002, Pavlenkova, 2002), condensation model of O.Yu. Batalin and N.G. Vafina (Batalin et al., 2008), which develops the idea of B.M. Yusupov on the deep methane role in the formation of naphthides, a model for the development of restored fluid basement systems and sedimentary cover, created by R.P. Gottich and B.I. Pisotsky (Gottikh et al., 2007), the theory of naphthydogenesis by A.E. Lukin, based on the nonlinear nature of the main laws of oil and gas accumulation (Lukin et al., 2018).

All these theories, concepts, and models give the mantle source – the deep endogenous factor – either an absolute or dominant role in the formation of hydrocarbon deposits.

The acquisition of new knowledge and the formation of new ideas about the geodynamics, tectonic stratification of the Earth's crust, and the laws governing the formation and development of fractures in the sedimentary cover and the basement of oil and gas basins made it possible to look at macro-accumulations of oil and gas in the aspect of fluid dynamic processes and from the perspective of the deep structure of the crust and mantle under oil and gas by regions. The anomalous structure and energy instability of the upper mantle and the Earth's crust beneath large hydrocarbon accumulations was revealed by various geophysical methods and reflected in the works of N.K. Bulin, A.V. Egorkin, V.A. Trofimov, V.I. Sharov et al. (Bulin et al., 2000; Trofimov et al., 2002).

According to (Kas'yanova, 2000; Kayukova et al., 2012; Lukin et al., 2018; Muslimov et al., 2004; Plotnikova, 2004), it is erroneous to consider the sedimentary cover mainly as insulated, self-sufficient, closed (except for conductive external heating) system in which the conversion of organic matter leads to oil and gas accumulation. At present, a large amount of geological and geophysical information has been obtained that indicates the sedimentary shell of the Earth as an open, thermodynamically nonequilibrium, and unstable system with a non-linear nature of development. The exchange of matter and energy with the environment is its obligatory attribute, which ensures the functioning of the system in an active mode.

Since the formation and reorganization of hydrocarbon deposits is a consequence of cross-formation fluid systems development in first-order degassing pipes (Lukin et al., 2018), the concept of feeding oil and gas deposits and replenishing their reserves is determined by the main aspects of plumectonics and "cold" degassing in the understanding of P.N. Kropotkin. Consequently, replenishment of hydrocarbon deposits is possible primarily in those fields that are confined to currently active deep degassing pipes.

According to (Lukin et al., 2018), 20 criteria are justified that indicate the modern activation of the deep degassing of the Earth. The results of studying the crystalline basement (CB) in Tatarstan over the past 40-50 years made it possible to formulate additional criteria that indicates fluid and geodynamic activity as a reflection of the modern degassing of our planet.

Modern degassing processes within the South Tatar arch and adjacent territories are unequivocally confirmed by the following factors.

The results of monitoring the water composition of the decompressed zones of the crystalline basement. A study of the hydrochemical parameters of the deep waters in the crystalline basement in the monitoring mode showed that throughout the entire observation period, the salt and microcomponent composition of the water changed (Ibragimov et al., 2009; Plotnikova, 2004). The acidity of the waters, for example, being slightly acidic, in certain periods changed to acidic and slightly alkaline. In addition to acidity, the mineralization of water changed (Fig. 3): the content of chlorine, iron, boron, copper, and molybdenum in them. In some wells, this was accompanied by a decrease in the density of water, while in others, the density was maintained due to an increase in the iron content. At certain periods, in all the examined wells, gas indicators showed a surge in the content of hydrogen, methane, and in some cases helium. Similar changes were also found in the composition of water-soluble organic matter; spikes in the total nitrogen content were observed in all wells, which were sometimes accompanied by an increase in the content of bitumen carbon. An analysis of temporary

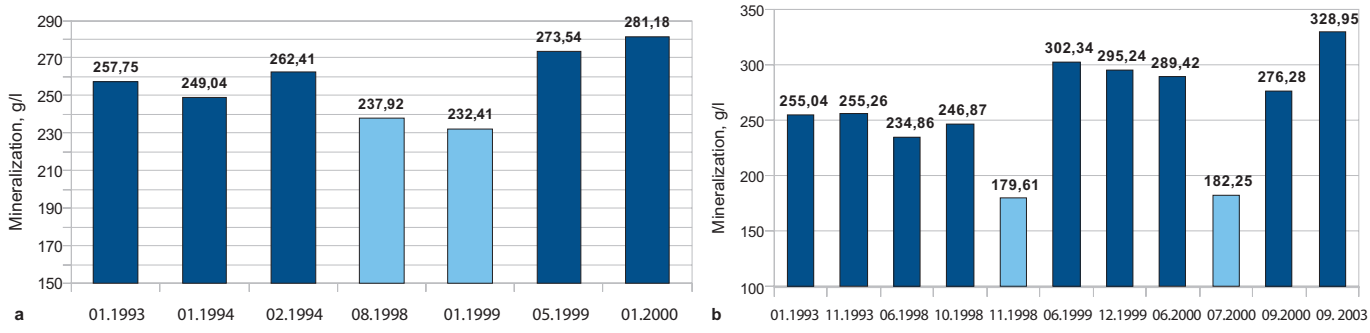

Fig. 3. The change in time of mineralization of formation water of the crystalline basement: a – well. 29419, b – well 966

variations in the gas-hydrochemical components of the groundwater in the CB showed their close relationship with the seismic activity of the territory. Total nitrogen, hydrogen, methane, and, to a lesser extent, carbon dioxide and helium, were identified as indicators of this relationship.

Uneven heat flow. Anomalies in the heat flow with an intensity of 10 mW/m^2 or more according to the data (Lukin et al., 2018) are the criterion for the modern activation of the deep degassing processes. The territory of Tatarstan according to N.N. Khristoforova (Khristoforova et al., 2000, 2008) is characterized by an uneven heat flow, which varies from 29 to 74 mW/m^2 within the Volga region. The thermal field also characterizes a pronounced heterogeneity. On the roof of the CB in Tatarstan, temperature differences reach 900 °C (Fig. 4), and at a section of 12 km – 600 °C. The colossal difference in the temperatures of the deep thermal field in such a limited space as the territory of Tatarstan clearly indicates in favor of active heat and mass transfer at the neotectonic and modern stages of development of the South Tatar arch and adjacent territories. The activity of the fluid dynamic processes of the South Tatar arch is indicated by the greatest warming of the CB, in comparison with the less warmed foundation of the Melekess Depression and the cold

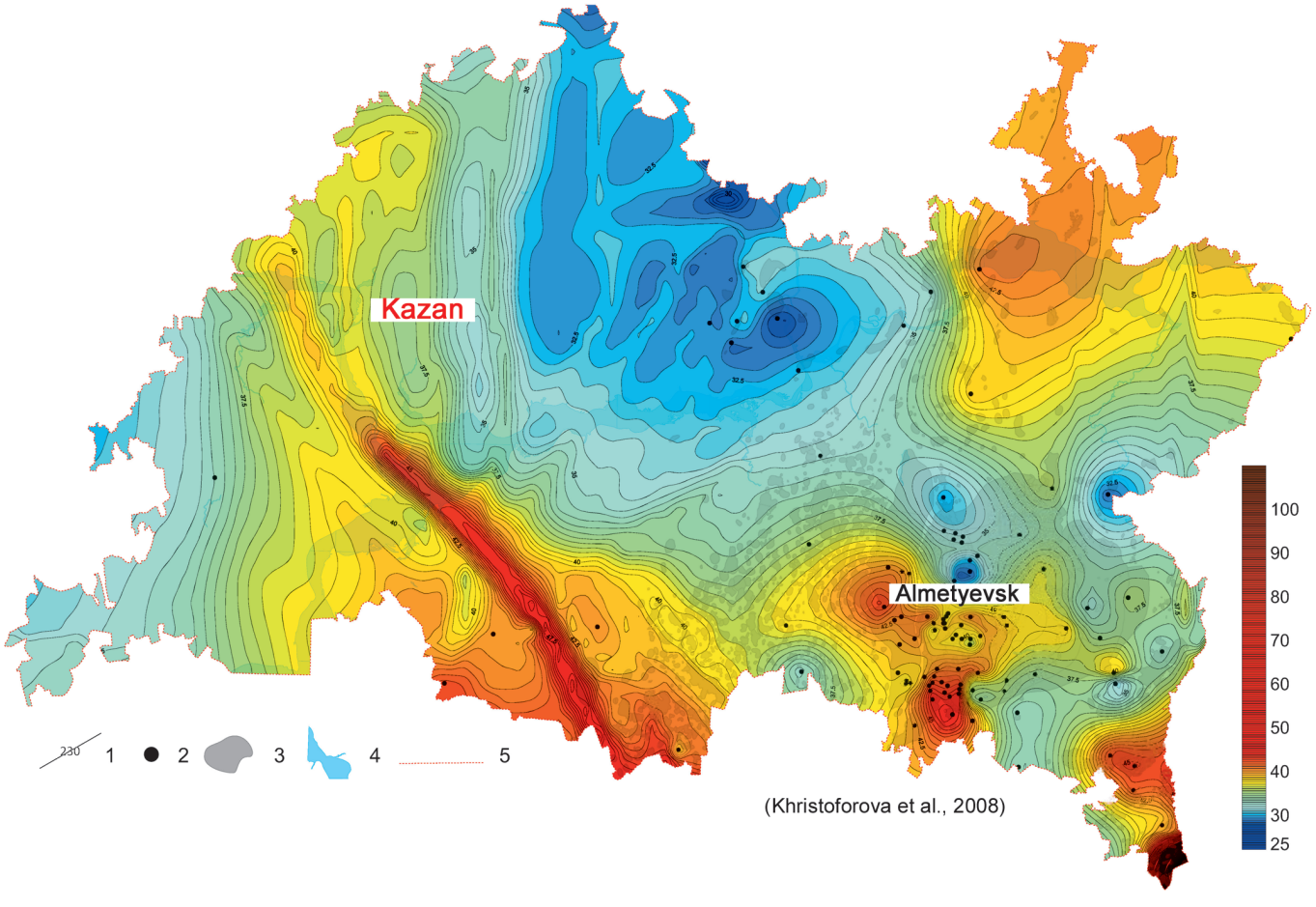

Fig. 4. Map of isotherms on the top of the crystalline basement (Khristoforova et al., 2008). Scale 1: 500,000. 1 – temperature isolines (^{0}C); 2 – location of wells in which temperature measurements were taken in the deep horizons of the sedimentary cover and basement; 3 – oil pool outlines; 4 – river network; 5 – district border of the Republic of Tatarstan.

CB of the North Tatar Arch, which practically does not contain oil deposits.

Modern fluctuations of temperature anomalies. Another factor indicating active modern heat and mass transfer are fluctuations and a change in temperature anomalies in the context of the crystalline basement (Khristoforova et al., 2000, 2008), recorded in the well 20009-Novoelkhovskaya after seismic events.

Dynamics of the total gas saturation of decompressed zones of crystalline rocks and gas composition. Monitoring the composition of gases in the well 20009-Novoelkhovskaya allowed us to establish that the gas saturation of decompressed CB zones varies over time (Fig. 5), in particular, periods of increase in gas indications of individual intervals are noted, despite cement filling of the wellbore (Plotnikova, 2004). Changes in the gas saturation of the intervals of the well section over time, including the periodic increase in gas readings after drilling and cement pouring in, indicate the presence of freely circulating gases, including hydrocarbon gases, in decompressed zones of CB and saturating them with formation water. The dynamics of gas saturation and gas-hydrochemical parameters of decompressed zones in the crystalline basement testify to the modern geodynamic and fluid activity of the latter.

The dynamics of gas saturation of oil sedimentary cover and the composition of the gas dissolved in it. An analysis of the composition of gas dissolved in oil made it possible to trace the dynamics of changes in the concentrations of methane, nitrogen, hydrogen, and carbon dioxide in oils from piezometric wells (Plotnikova, 2004) over a time period of more than 10 years. Significant changes observed in modern development, both in the composition of the gas and in the content of its components (Fig. 6, 7), indicate the frequency of activation of the entry of light hydrocarbons and other gases (CO_2, CH_4, N_2, etc.) into the sedimentary stratum and reservoir However, this does not exclude the fact that deep degassing occurs throughout the entire period, but is less active. It is possible that the introduction of gases is local in nature and is determined by the time periods of crack opening and the formation of open transit zones in the thickness of the crystalline basement and sedimentary cover.

Seismicity of the territory of Tatarstan. Another factor supporting the activity of modern deep degassing

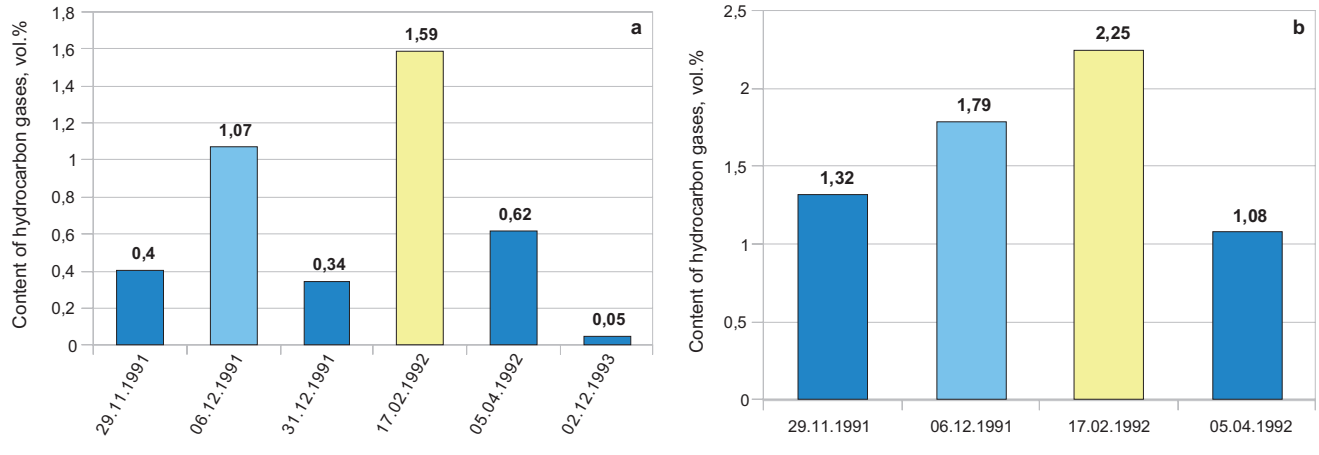

Fig. 5. Variations in the content of hydrocarbon gases in deep samples (OPT) of the mud in the well No. 20009-Novoelkhovskaya: a – at a depth of 5280 m, b – at a depth of 5300 m

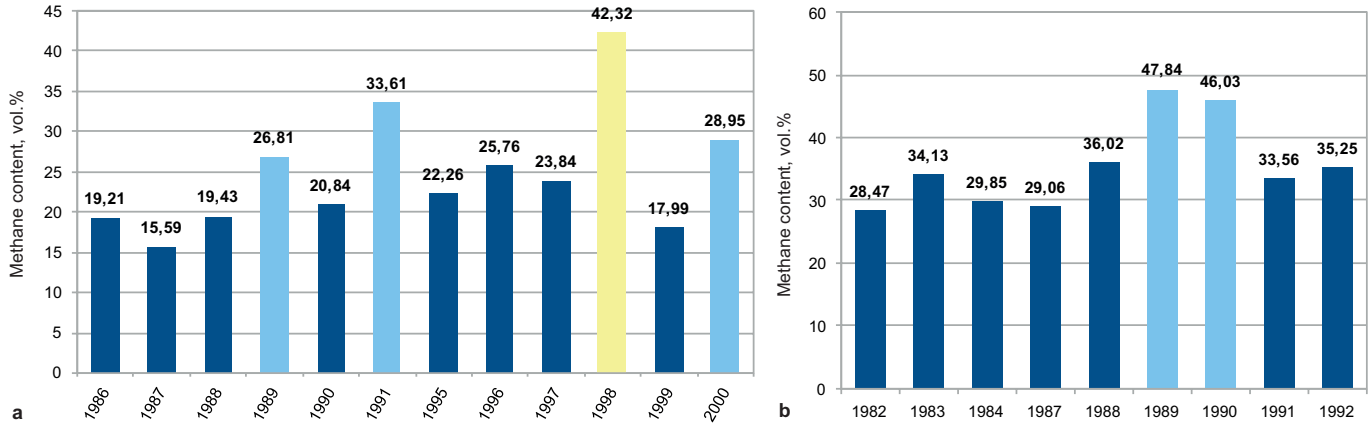

Fig. 6. An example of variations in the methane content in the dissolved gas oil of the Romashkinskoe field: a – Bobrikovian horizon, b – Pashian horizon

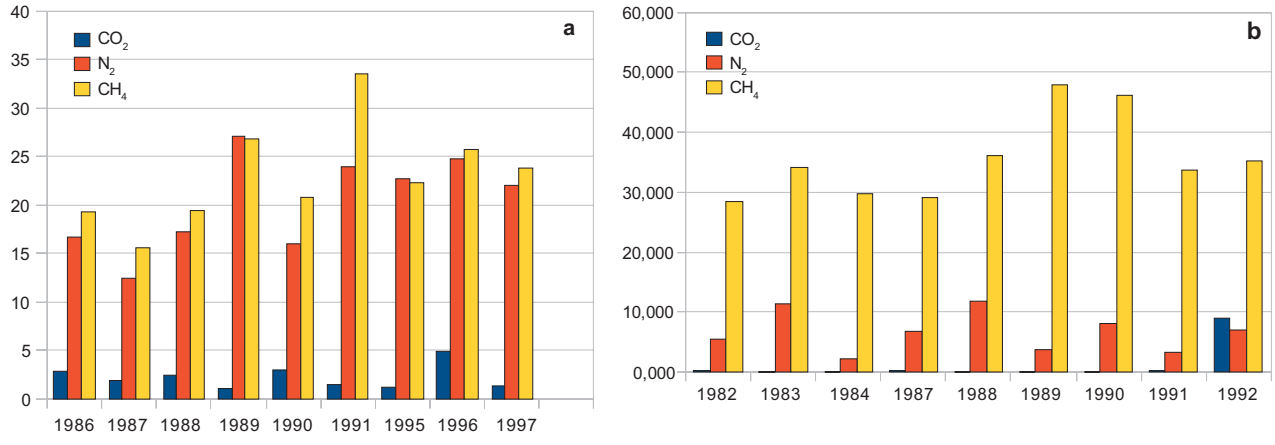

Fig. 7. Dynamics of methane, nitrogen and carbon dioxide content in dissolved gas: a – gas from oil from the Bobrikovian horizon of the Zelenogorsk area of the Romashkinskoe field; b – gas from the oil of the Pashian horizon of the Kholmovskaya area of the Romashkinskoe field

processes is the seismicity of the territory of Tatarstan, as well as the establishment of a stable correlation between the dates of seismic events and periods of decrease in the density of oil in piezometric wells and mineralization of formation water in the CB (Mirzoev et al., 2004).

Neotectonic activity of the Earth's crust. Another criterion that indicates the current activity of the deep degassing processes (Lukin et al., 2008) is the elevation of the Earth's surface by 25 meters or more over the past 3 million years. According to (Mingazov et al., 2012, 2014), neotectonic activation of the Earth's crust of the territory of Tatarstan over the past 1.5-2.0 million years has led to much more amplitude uplifts (Fig. 8). The uplift rate of the South Tatar arch during the neotectonic stage according to (Mingazov et al., 2014) reached 1-10 mm/year.

The neotectonic activity of the South Tatar Arch is evidenced by the sharp differentiation of the relief, where individual peaks reach elevations of 360-370 m, and river valleys, crashing into the arrays, drop to elevations of 150-160 m.

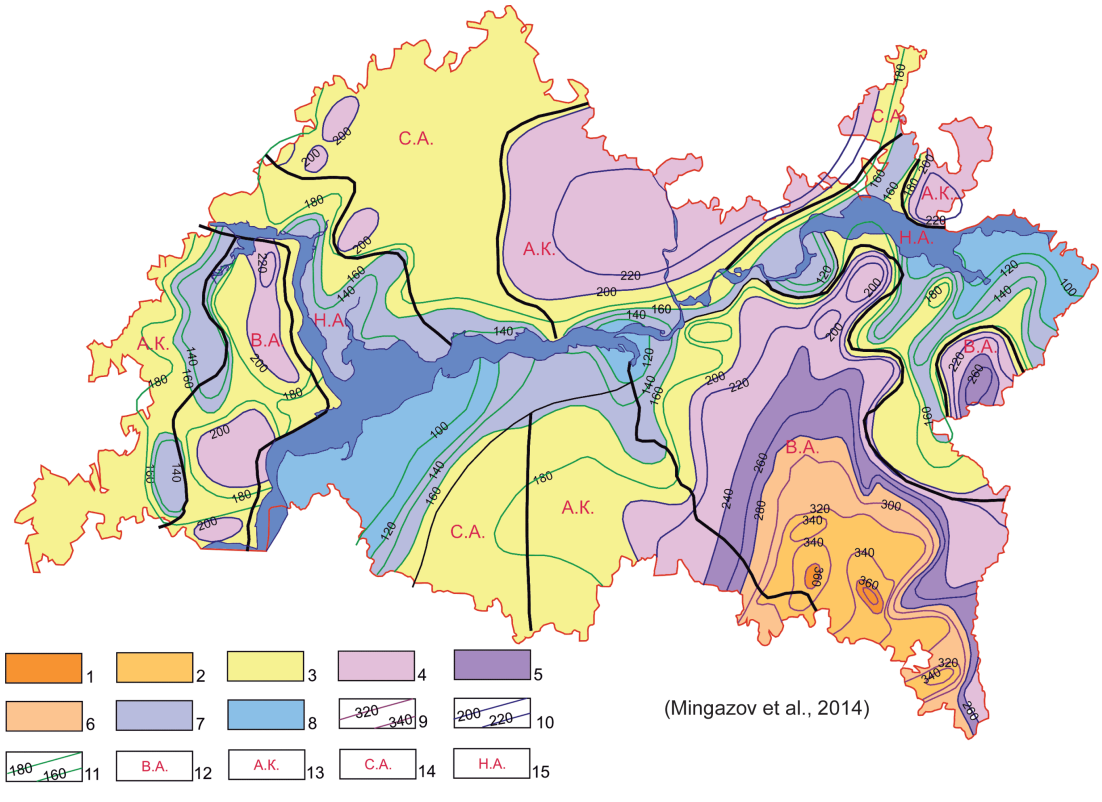

Fig. 8. Map of the latest tectonics of the Republic of Tatarstan (Mingazov et al., 2014). Average total amplitudes of the latest tectonic movements (m); 1 – 400-360; 2 – 360-320; 3 – 320-280; 4 – 280-240; 5 – 240-200; 6 – 200-160; 7 – 160-120; 8 – 120-80. Isolines of tectonic movements (m): 9 – during the period Pg3-Q; 10 – N1-Q; 11 – N2-Q. Modes of neotectonic movements: 12 – very active; 13 – active; 14 – weakly active; 15 – inactive.

In addition, a direct relationship was established between the activity of neotectogenesis and the oil potential of the South Tatar Arch (Mingazov et al., 2014).

Geochemical features of oil and bitumen. The idea of Romashkinskoe and a number of other oil fields as an open hydrodynamic system characterized by a multi-stage flow of oil and gas fluids into its reservoirs is also confirmed by the results of geochemical studies of oils (Ostroukhov et al., 2014, 2015; Plotnikova et al., 2013, 2014, 2017).

The presence of supply channels. The totality of the identified vertical and inclined structural and tectonic formations, which cut the sedimentary cover, the Earth's crust and upper mantle (Trofimov et al., 2002), reflects the role of degassing pipes in the development of open fracturing and are one of the main criteria indicating the possibility of activation of deep degassing processes and replenishment of hydrocarbon reserves of developed fields.

Thus, the results of the studies made it possible to expand the number of previously developed criteria (Lukin et al., 2018) indicating the activation of the deep degassing of the Earth. Using these criteria will allow us to differentiate the developed hydrocarbon deposits according to the principle of "renewable" or "non-renewable", which help localizing zones of hydrocarbon inflow, estimate the intensity of replenishment of reserves, and estimate the duration of this field on a completely different level.

Degassing processes recorded in decompressed zones of the basement and their periodic activation, the relationship of the block-fault structure of the basement of the South Tatar Arch with the phenomenon of modern hydrocarbon migration at Romashkinskoe and other fields (Muslimov et al., 2012; Plotnikova, 2004), geochemical studies of oil and bitumen of the sedimentary cover, which proved that the carbonate rocks of the Semiluk-Mendymian deposits are not a source of hydrocarbon inflow into the deposits of the terrigenous Devonian of the South Tatar arch (Ostroukhov et al., 2014; Plotnikova et al., 2013, 2014). I.e., these facts are a powerful scientific and practical basis for the creation of a concept of oil and gas fields' formation in the Volga-Ural anticline, involving multi-stage pulsed flow of hydrocarbon fluid systems in sedimentary cover pressure on transit zones of fracturing fields.

According to this concept, the replenishment of oil reserves is one of the manifestations of "cold" degassing and can be identified and localized using field geological and geochemical criteria considered in previous works (Muslimov et al., 2004, 2019; Plotnikova et al., 2014, 2017), and based on the use of the criteria for the manifestation and activation of the deep degassing of the Earth.

Today, when the relevance of replenishing oil and gas reserves is increasingly discussed on the pages of scientific publications, causing well-deserved interest among specialists of oil companies, comprehensive research is needed in the field of monitoring the flow and developing criteria for its registration and the quantitative-temporal (periodicity, duration) assessment (Muslimov et al., 2019). The criteria developed earlier for the deposits of Tatarstan are the basis for these studies in other regions.

Conclusion

Despite the fact that the existence of oil replenishment in the developed deposits is justified and proven by many examples, the study of this process and its consideration in planning development, estimating residual reserves, constructing field models and assessing the "life" of fields has not yet begun, since the replenishment process itself requires comprehensive detailed research. First of all, it is necessary to determine the spatio-temporal patterns of changes in the properties of oil and dissolved gas, the fluid regime of the reservoir, flow rates, and pressures. It is necessary to localize the inflow zones, determine their sizes, modes of fluid activity and its relationship with modern geodynamic processes and the development of fracture fields, estimate the volumes of incoming fluids and determine their composition.

At the stage of regional work, search and exploration of oil and gas fields, the geological exploration complex, along with traditional research, should include studying the deep structure of the sedimentary basin, assessing modern geodynamic activity, as well as obtaining information about a complex set of heat and mass transfer processes that are multiphase pulsed and controlled geodynamic regime (Lukin et al., 2018).

The same work can be carried out at the developed fields. In addition, they require special comprehensive geological-field and geochemical studies in the monitoring mode for a long time to obtain quantitative parameters of hydrocarbon inflow.

It is advisable to organize monitoring of the geological and production indicators and geochemical characteristics of oil and dissolved gas from the first years of development in the fields, which are just beginning to be developed, so that already in the early stages it is possible to localize the inflow zones and select a competent reservoir stimulation system.

Undoubtedly, these studies are very complex and go beyond the scope of routine work stipulated by licensing agreements and development projects. However, the unique information that will be obtained in the course of such work will reveal abnormal areas of deposits where oil production rates and low water cuts will be stable over time, ensuring high production at the field.

The monitoring system should be two-level. The first level is the analysis of geological and field data and the identification of potential areas of hydrocarbons migration into the deposits based on the use of geological and field criteria of anomaly. The second level is the geochemical studies of oils and gases dissolved in them both within wells with signs of anomalies and in adjacent areas of the reservoir (Plotnikova et al., 2017; Muslimov et al., 2019).

References

Batalin O.Yu., Vafina N.G. (2008). Condensation model of oil and gas field formation. Moscow: Nauka, 248 p. (In Russ.)

Bochkarev A.V., Ostroukhov S.B., Sianisyan S.E. (2010). The concept of a two-stage formation of hydrocarbon deposits on the western side of the Caspian depression. *Proc. All Russ. Conf.: Advances in organic geochemistry*, Novosibirsk: INGG SO RAN, pp. 64-69.(In Russ.)

Bochkarev V.A., Ostroukhov S.B. (2012). Inexhaustible and exhaustible resources as a result of multistage field formation. *Neftepromyslovoe delo*, 7, pp. 4-10. (In Russ.)

Bochkarev V.A., Ostroukhov S.B., Bochkarev A.V., Krashakova A.V. (2011). Conditions of hydrocarbon accumulations formation of the Ukatnoe field, Northern Caspian. *Geologiya, geofizika i razrabotka neftyanykh i gazovykh mestorozhdeniy = Geology, geophysics and development of oil and gas deposits*, 11, pp. 4-13. (In Russ.)

Bulin N.K., Egorkin A.V., Solodilov L.N. (2000). Prediction of oil and gas content by deep seismic criteria. *Regional'naya geologiya i metallogeniya*, 10, pp. 195-204. (In Russ.)

Dmitrievskii A.N. (1991). Theoretical problems of predicting oil and gas subsurface resources. *Coll. papers: Theoretical and regional problems of the geology of oil and gas*, Novosibirsk: Nauka, pp. 66-71. (In Russ.)

Dmitrievskii A.N., Valyaev B.V. (2002). The main results and prospects of research on the problem of "Degassing the Earth". *Coll. papers: Earth degassing: geodynamics, geofluids, oil and gas*, Moscow: GEOS, pp. 3-6. (In Russ.)

Dorofeev N.V., Bochkarev A.V., Ostroukhov S.B. (2014). Formation, reformation and degradation of oil deposits in the Middle Caspian. *Geologiya, geofizika i razrabotka neftyanykh mestorozhdenii = Geology, geophysics and oil field development*, 12, pp. 4-10. (In Russ.)

Dyachuk I.A. (2015). Reformation of oil fields and reservoirs. *Georesursy = Georesources*, 1(60), pp. 39-45. DOI: http://dx.doi.org/10.18599/grs.60.1.8. (In Russ.)

Gavrilov V.P. (2008). Possible mechanisms of natural resources renewability in oil and gas fields. *Geologiya nefti i gaza = Oil and Gas Geology*, 1, pp. 56-64. (In Russ.)

Goryunov E.Yu., Ignatov P.A., Chesalova E.I., Klimentyeva D.N. (2014). The regularities of spatial distribution of oil types and its properties in oiland gas-bearing complexes of Volga-Ural territory. *Geologiya nefti i gaza = Oil and gas geology*, 2, pp. 27-37. (In Russ.)

Gottikh R.P., Pisotskii B.I. (2007). Deep reconstructed fluid systems in the processes of oil formation and oil accumulation. *Coll. papers: Fundamental problems of the geology and geochemistry of oil and gas and the development of petroleum complex in Russia*, Moscow: IPNG RAN, pp. 55-65. (In Russ.)

Gottikh R.P., Pisotskii B.I., Zhuravlev D.I. (2007). The role of endogenous fluids in the formation of carbonaceous rocks in the geological section of oil and gas bearing provinces. *Doklady Akademii nauk*, 412(4), pp. 524-529. (In Russ.)

Ibragimov R.L., Plotnikova I.N. (2009). Monitoring of water from crystalline basement of South-Tatar arch. *Georesursy = Georesources*, 3(31). pp. 9-13. (In Russ.)

Kas'yanova N.A. (2000). The influence of modern subsoil geodynamics on the fluid regime of oil and gas deposits of folded and platform areas. Moscow: Geoinformmark, 50 p. (In Russ.)

Kas'yanova N.A. (2009). The history of the development of views on the influence of the latest and modern geodynamic processes on the oil and gas potential of the subsoil. *Geology, Geography, and Global Energy*, 2(33), pp. 27-32. (In Russ.)

Kasy'anova N.A. (2010). Geofluidodynamic evidence of modern replenishment of oil and gas reserves. *Geology, Geography, and Global Energy*, 3(38), pp. 14-17. (In Russ.)

Kayukova G.P., Romanov G.V., Plotnikova I.N. (2012). Geochemical aspects of the study of the process of replenishment of oil deposits. *Georesursy= Georesources*, 47(5), pp. 37-40. (In Russ.)

Khalikov A.N., Goryunov E.Yu., Motorin I.V. (2014). Oil reserves replacement in Kinzebulatov type group of deposits (Bashkortostan). *Geologiya nefti i gaza = Oil and gas geology*, 6, pp. 30-34. (In Russ.)

Khristoforova N.N., Khristoforov A.V., Bergemann M.A. (2008). Analysis of geothermal maps and prospects of oil and gas potential of deep sediments (on the example of the Republic of Tatarstan). *Georesursy= Georesources*, 3(26), pp. 10-12. (In Russ.)

Khristoforova, N.N., Khristoforov A.V., Muslimov R.Kh. (2000). Temperature and heat flow in the granite-gneiss layer of the Earth's crust (according to the results of experimental measurements in the wells of the Tatar arch). *Georesursy= Georesources*, 1(2), pp. 2-11. (In Russ.)

Krayushkin V.A. (1984). Abiogenic-mantle oil genesis. Kiev: Naukova Dumka, 267 p. (In Russ.)

Kropotkin P.N. [Red.] (1985). Proc. II All Union Conf.: Earth Degassing and Geotectonics. Moscow: Nauka, 199 p. (In Russ.)

Kropotkin P.N. [Red.] (1991). Proc. III All Union Conf.: Earth Degassing and Geotectonics. Moscow: Nauka, 261 p. (In Russ.)

Kudryavtsev N.A. (1973). The genesis of oil and gas. Leningral: Nedra, 176 p. (In Russ.)

Lukin A.E., Shestopalov V.M. (2018). From new geological paradigm to the problems of regional geological-geophysical survey. *Geofizicheskii zhurnal*, 4(40), pp. 3-72. (In Russ.)

Mingazov M.N., Strizhenok A.A., Kamyshnikov A.G., Kiyamova A.G. (2014). Regional Aspects of Recent Tectonics of Tatarstan Republic (Russia). *Georesursy =Georesources*, 2(57), pp. 44-50. (In Russ.)

Mirzoev K.M., Gatiyatullin N.S., Tarasov E.A., Stepanov V.P., Gatiyatullin R.N., Rakhmatullin M.Kh., Kozhevnikov V.A. (2004). Seismic hazard of the territory of Tatarstan. *Georesursy= Georesources*, 1(15), pp. 44-48. (In Russ.)

Muslimov R.Kh., Glumov I.F., Plotnikova I.N. et. al. (2004). Oil and gas fields – a self-developed and permanently renewable objects. *Geologiya nefti i gaza = Oil and Gas Geology*, 10, pp. 43-49. (In Russ.)

Muslimov R.Kh., Plotnikova I.N. (2012). Are the oil reserved renewed? *EKO*, 1, pp. 29-34. (In Russ.)

Muslimov R.Kh., Trofimov V.A., Plotnikova I.N., Ibatullin R.R., Goryunov E.Yu. (2019). The role of deep degassing of the Earth and the crystalline basement in the formation and natural replenishment of oil and gas deposits. Kazan: FEN, 290 p.(In Russ.)

Ostroukhov S.B., Plotnikova I.N., Nosova F.F., Pronin N.V. (2015). Geochemical Criteria for Facies Conditions in the Formation of Shale Deposits. *Georesursy =Georesources*., 3(62), pp. 42-47. (In Russ.)

Ostroukhov S.B., Plotnikova I.N., Nosova F.F., Salakhidinova G.T., Pronin N.V. (2014). Peculiarities of the composition and structure of the oils of Pervomaisky and Romashkinskoye oil fields. *Khimiya i tekhnologiya topliv i masel*, 6, pp. 70-75. (In Russ.)

Pavlenkova N.I. (2002). The fluid concept of global tectonics. *Coll. papers: Earth degassing: geodynamics, geofluids, oil and gas*, Moscow: GEOS, pp. 58-60. (In Russ.)

Plotnikova I.N. (2004). Geological, geophysical and geochemical preconditions for oil and gas potential of the crystalline basement of Tatarstan. St.Petersburg: Nedra, 171 p. (In Russ.)

Plotnikova I.N., Pronin N.V., Nosova F.F. (2013). On the source of oil generation in Pashiysky horizon of Romashkinskoye oil field. *Neftyanoe Khozyaystvo = Oil industry*, 1, pp. 33-35. (In Russ.)

Plotnikova I.N., Salakhidinova G.T. (2017). Geochemical criteria for identification of unprocessed sections of oil deposits at a late stage of their development. *Neft' i gaz*, 5, pp. 83-102. (In Russ.)

Plotnikova I.N., Salakhidinova G.T., Nosova F.F., Pronin N.V., Minnullin R.M. (2014). Geochemical criteria for detecting of the areas of the oil deposits replenishment. *Neftyanoe Khozyaystvo = Oil industry*, 3, pp. 84-87. (In Russ.)

Plotnikova, I.N. (2004). The modern process of renewing hydrocarbon reserves: hypotheses and facts. *Georesursy= Georesources*, 1, pp. 40-41. (In Russ.)

Porfir'ev, V. B. (1959). To the question of the time of formation of oil fields. Book: *The Problem of Oil Migration and Oil Formation and gas clusters*. Moscow: Academy of Sciences of the USSR, pp. 165-193. (In Russ.)

Trofimov V.A., Korchagin V.I. (2002). Oil-bearing channels: spatial location, detection methods and methods for their activation. *Georesursy = Georesources*, 1(9), pp. 18-23. (In Russ.)

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