CONFERENCE PROCEEDINGS

DOI: https://doi.org/10.18599/grs.2018.3.186-192

Consideration of the processes of oil deposit reformation during long-term operation and deep feeding in modeling the development of oil fields

R.Kh. Muslimov[1], I.N. Plotnikova[2]*

[1]Kazan (Volga region) Federal University, Kazan, Russian Federation

[2]Academy of Sciences of the Republic of Tatarstan, Kazan, Russian Federation

Abstract. The article is devoted to the study of replenishment of oil reserves in long-developed fields and contains a substantiation of the need for its monitoring and control. This will allow for a new approach to modeling the development and evaluation of residual reserves in the late stages of development of oil fields. In order to identify the conditions for the reformation of the deposits, special geochemical studies should be organized to localize the replenishment sites, as well as geological and commercial studies to determine the rate of oil accumulation in the trunks of highly watered wells. These works will allow selecting the most promising areas of the deposit to search for channels for deep degassing of hydrocarbons and recommending carrying out seismic studies with new innovative technologies for mapping channels and subsequent monitoring of degassing processes. The newly obtained results, combined with the information already available, will allow us to take a new approach to the development of an alternative geological and hydrodynamic model that will determine the rates of reservoir regeneration during development and the volumes of hydrocarbon reservoirs from the depths. It will also help to predict the role of reformation processes in the total oil production.

Keywords: oil, degassing, replenishment of reserves, flow of hydrocarbons, reformation of deposits, Romashkino field, long-term development, geochemical studies, oil composition monitoring

Recommended citation: Muslimov R.Kh., Plotnikova I.N. (2018). Consideration of the processes of oil deposit reformation during long-term operation and deep feeding in modeling the development of oil fields. *Georesursy = Georesources,* 20(3), Part 1, pp. 186-192. DOI: https://doi.org/10.18599/grs.2018.3.186-192

Introduction

The problem of localization and assessment of residual reserves at the late stage of oil and gas field development is relevant in petroleum geology. In the past two decades, the facts of obtaining light oils from fully developed and water-flooded areas have been repeatedly discussed and published (Gavrilov, 2007, 2008; Goryunov, 2015; Dyachuk, 2015; Dyachuk, Knyazeva, 2016; Kasyanova, 2010; Muslimov et al., 2012; Muslimov et al., 2009, 2013; Plotnikova et al., 2017). At the same time, giant oil fields with a long history of production are of the greatest practical interet, one of the examples of which is the Romashkino oil field.

About 20 years ago in Tatarstan, a group of experts from TatNIPIneft, under the leadership of R.Kh. Muslimov and I.F. Glumov began research on the phenomenon of the replenishment of oil reserves in the deposits of the terrigenous Devonian of the Romashkino field, aimed at solving problems of great scientific and practical importance for increasing the recoverable oil reserves of developed fields (Muslimov, 2014; Muslimov et al., 2004). The studies were started simultaneously in several directions and included the analysis of geological field information (under the direction of I.F. Glumov, R.R. Ibatullin), geochemical studies (under the guidance of R.P. Gottikh, subsequently with the involvement of specialists from the IOFKh and KFU), geophysical studies of the deep structure and fluid dynamics of the Earth's crust of the Volga-Ural region and adjacent areas (under the guidance of V.A. Trofimov with the involvement of specialists from the VNIIgeofizika, UGGU, IGF UrOR AN, etc.)

History of studying the process of replenishing oil reserves in Tatarstan

The synthesis of unique information obtained from the study of the basement of the Volga-Ural anteclise (VUA), its fracturing and fluid saturation, the compilation and study of geological and field information on the production wells, and the geochemical studies of oil and monitoring of their composition over time suggested

Corresponding author: Irina N. Plotnikova
E-mail: irena-2005@rambler.ru

that there are fast replenishment processes comparable in duration to human life, as well as their widespread in recent times (Kayukova et al., 2012; Muslimov et al., 2004, 2012; Muslimov, 2014 ; Plotnikova et al., 2017; Khisamov et al., 2012).

Modern studies have established that oil fields are associated with oil-bearing faults, which, in turn, appear as oil-supply channels (Trofimov, 2013).

Under the large oil fields there are oil supply channels, due to the activities of which they were formed. During the development of fields, these channels can be activated and replenish the trap with new portions of hydrocarbon fluids. We have shown that the crystalline basement plays a certain role in the constant "feeding" of oil fields of the sedimentary cover with new resources, ensuring the transit of hydrocarbons through hidden cracks and fractures from the depths (Muslimov et al., 1996; Gottikh et all., 2014). The existence of a single source of petroleum generation for oil and natural bitumen (NB) deposits of the South Tatar arch was shown, as well as the formation of fields due to the vertically upward migration of oil and gas fluids through fractures that intersect the crystalline basement and the lower horizons of the sedimentary cover.

Deep regional seismic surveys conducted in Tatarstan and adjacent regions not only provided new information about the structure of the earth's crust and the connection of its structure with the oil-bearing capacity of the sedimentary cover, but also confirmed the existence of a complex system of deep faults under the oil fields (Trofimov, 2013, 2014). Thus a great contribution to the development of the theory of N.A. Kudryavtsev.

Research results

Studies conducted at the Romashkino field suggest that the detected relics of the hydrocarbon destruction zones indicate the presence of hydrocarbon (HC) filters in these zones, which in a non-uniform thermal gradient field of the basement were successively distilled from the lower zones to the upper ones under the influence of the temperature field and compression phenomena. This is also confirmed by the similarity of the HC of the basement and the cover, by the specific composition of the waters in the zones of destruction and the cover (Plotnikova, 2004).

Degassing processes recorded in the decompacted zones of the basement, and their periodic activation (Plotnikova et al., 2013, Plotnikova, 2004, Gordadze et al., 2005, Gottih et al., 2004), the connection of the block-fault structure of the South Tatar arch (STA) with the phenomenon of modern migration of hydrocarbons to Romashkino and other fields, geochemical studies of oil and bitumen sedimentary cover, which proved that the carbonate rocks of the Semilukdkisn-Mendymdkskian deposits are not a source of HC inflow in the STA terrigenous Devonian deposits (Gordadze, 2007; Ostroukhov et al., 2014). All these facts are powerful scientific and practical basis for the creation of a different concept of the formation of oil and gas fields in the VUA, involving a multi-stage impulse flow of hydrocarbon fluid systems into the sedimentary cover under the pressure along the transit fracturing zones.

Bituminological and pyrolytic studies carried out earlier by various researchers have made it possible to establish the wide development of migratory bitumoids in the structural-material complexes of the pre-Paleozoic basement of the STA and adjacent territories. Signs of moving lighter hydrocarbons up the basement section were identified based on a study of crystalline bitumoids from the well 20000-Minnibaevskaya, 20009-Novoelkhovskaya, 23161-Alkeevskaya, etc. (Muslimov et al., 1996; Kayukova et al., 2012; Plotnikova, 2004). The decisive influence of deep-seated hydrocarbon-bearing systems on the formation of oil deposits in a sedimentary cover has been proven based on a study of the trace element composition of oils and organic matter of sedimentary and crystalline rocks (Gottih et al., 2004).

Analysis of geological field data (GFD) of many years of operation of production wells of the Romashkino field, performed at TatNIPIneft under the guidance of I.F. Glumov, made it possible to substantiate the presence of modern hydrocarbon inflows into the industrial oil reservoir of the Pashian horizon of the Romashkino field (Muslimov et al., 2004) and the existence of localized sections of the inflow of new hydrocarbons. During the analysis of the GFD, a number of criteria were developed, which made it possible to identify in which the HC inflow process was recorded with the highest probability from the total number of production wells. Such wells are called anomalous. Comprehensive analysis of geological field data, performed in TatNIPIneft 2005-2006 under the leadership of S.Uvarov, allowed to select from the entire stock of wells those that met certain criteria of anomaly. Abnormal wells are wells with a cumulative oil production of more than 0.5 million tons, with a production rate of more than 100 tons/day for at least 5 years, with a duration of more than 40 years, with a cumulative oil-water factor of no more than 0.5 m^3/ton, with increasing flow rates for at least 5 years in the period of declining oil production, i.e. when a long-term natural drop in oil flow rates is replaced by a "sudden" long-term increase in oil flow rates.

Figure 1 shows the dynamics of the ratio of average production rates of abnormal wells to average production rates of normal wells during 40 years of their operation. As can be seen, the maximum values of this parameter were recorded in 1962, 1976 and 1991, that is, at intervals of 14-15 years. Moreover, the effect of differences in flow rates is more noticeable in the initial years of development, then it fades as the technogenic impacts on the formation intensify and the total use of in-loop injection of water under excessive discharge pressure, but then, against the background of a decrease in water flooding, its intensity again increases (Khisamov et al., 2012). The effect of the flow of light hydrocarbons into terrigenous Devonian strata is confirmed by the dynamics of the density of oil recorded from the results of the analysis of changes in density in piezometric wells, performed by I.N. Plotnikova in 1998-2003 (Plotnikova et al., 2017). Figure 2 shows variations in the number of wells in which a decrease in density was observed.

It is noteworthy that the increase in the number of such wells was noted in 1991 and 1992, which is correlated with an increase in the ratio of average production rates of anomalous wells to average production rates of normal wells in 1991. Some discrepancy is explained by the fact that the density change was taken only from piezometric wells, that is, from a much smaller number of wells than the ratio parameter of flow rates. In addition, the effect of the flow could be, first of all, fixed in abnormal wells, and only then (as the newly received portions of hydrocarbons moved) could affect the characteristics of oil in piezometric wells. Nevertheless, the fact that even in piezometric wells the dynamics of density changes are noted, testifies to the scale of the flow of light hydrocarbons in productive layer – the object of development.

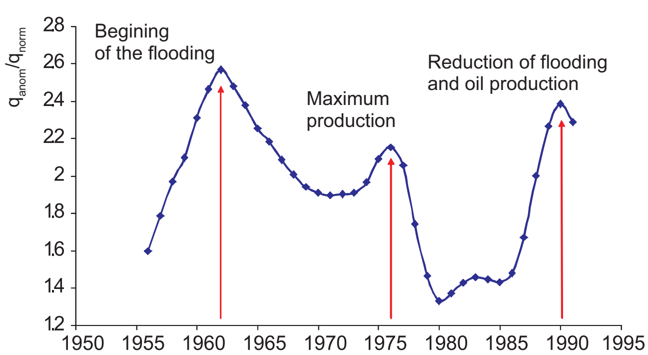

Fig. 1. Dynamics of the ratio of average production rates of anomalous wells to average production rates of normal wells in the Minnibayevsky area over 40 years of their operation (according to Khisamov et al., 2012)

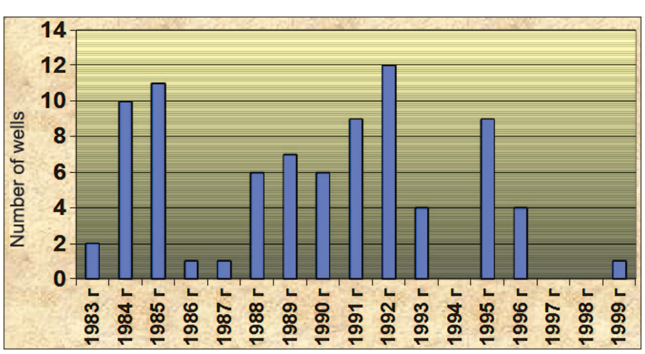

Fig. 2. The number of piezometric wells by years in which a decrease in the oil density from terrigenous Devonian sediments of the Romashkino field was recorded

Synthesis of multivariate studies of identification of wells with anomalous parameters and their relationships with wells with normal parameters made it possible to identify patterns of their location in area and a comparative change over time. The given actual field materials sharply contradict the "law" of falling oil production and are directly related to the established phenomenon – "Recharge", and therefore require special research and study.

Geochemical studies of oils from abnormal wells clearly indicate their differences in a number of parameters (Fig. 3) obtained from group, elemental, chromatographic, chromatography-mass-spectrometric analyzes and from isotope studies (Kayukova et al., 2012; Plotnikova et al., 2017). The results of these studies allow us to differentiate oil from abnormal wells and normal wells, and also indicate the relationship of the chemical composition of oil with the geodynamic situation of the area. In particular, it is shown (Plotnikova et al., 2017) that oil samples from anomalous wells of the South Tatar and North Tatar arches are characterized by a high content of oils (.> 60%) and lowered asphaltenes (<8%), in contrast to the oils of the Melekess depression, where signs of modern hydrocarbon inflow into deposits are not recorded (43% and 15%, respectively). For the samples under consideration, the relative distributions of n-alkanes also differ, which also show a higher

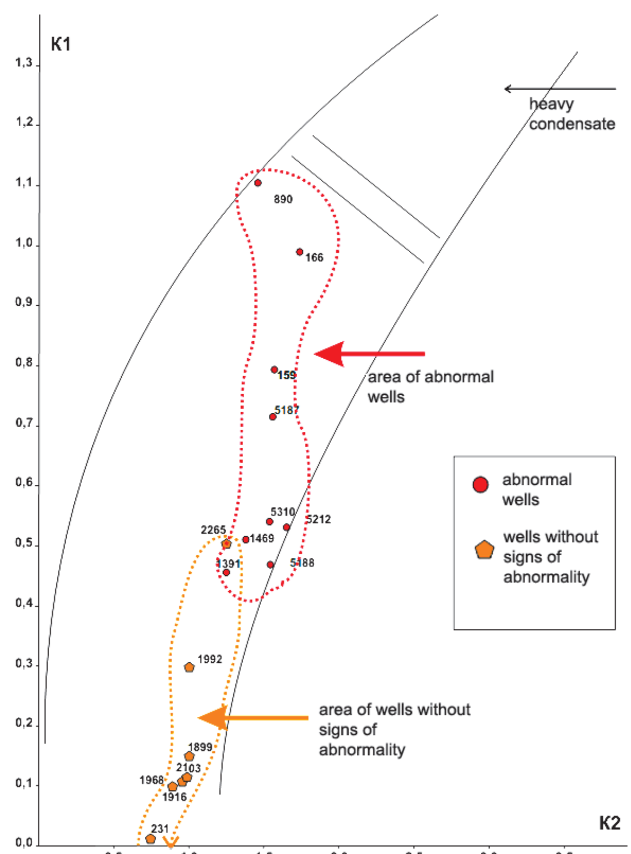

Fig. 3. Differentiation of oil samples from abnormal wells and wells without signs of abnormality by coefficients K1, K2 (Plotnikova et al., 2017)

content of light hydrocarbons in the North Tatar and South Tatar arches and the influence of the processes of biodegradation and oxidation in the oils of the Melekess depression. It is noteworthy that within the Minnibayevsky area of the Romashkino field of the STA, the previously identified various geodynamic activity of the deposits, associated with the differentiated activity of the block structure of the basement, determines the continuous intermittent flow of light hydrocarbons, which is confirmed by the results of geochemical and other studies (Kayukova et al., 2012; Plotnikova et al., 2017; Salakhidinova et al., 2013). Figure 4 shows the location of anomalous wells (prior to the start of flooding and the use of enhanced recovery methods) to the boundaries of the microblocks (Plotnikova et al., 2011), which were selected based on the analysis of the hypsometric position of the "average limestone" reference frame.

The scientific and practical significance of the results

The results obtained are of great practical importance, since they allow us to quickly carry out areal geochemical studies of produced oils. Application of the developed criteria will allow localizing areas of deposits in whose oils there are traces of newly received portions of light hydrocarbons. Over such areas, in the long term, special control should be established, since it is on them that reserves can be replenished, periodic increase in well flow rates, and recovery of oil accumulations in the washed zones.

At the later stages of field development, such geochemical studies are necessary, since they allow to identify those areas of deposits where the well operation can continue for a long time.

All of the above allows us to conclude that there is a fact of migration of hydrocarbons through the basement into the sedimentary cover by fracturing zones associated with multiple faults. Thus, it is possible to speak with full confidence about the "HC-breathing" and "feeding" of the lower horizons of the Romashkino field, caused by the degassing of the deeper layers of the Earth.

The analysis carried out allows for a new view of oil fields as a constantly evolving object fed by hydrocarbons from the depths of the subsoil.

The confinement of oil migration routes to fracture zones, the young age of oil deposits, as well as the structure fullness of less than 100% suggest that the oil formation process will continue and, therefore, there will be a modern oil migration and replenishment of the resources under development. The possibility of this process can be argued from various points of view. However, the approach to this problem from the point of view of the inorganic origin of oil is the most realistic

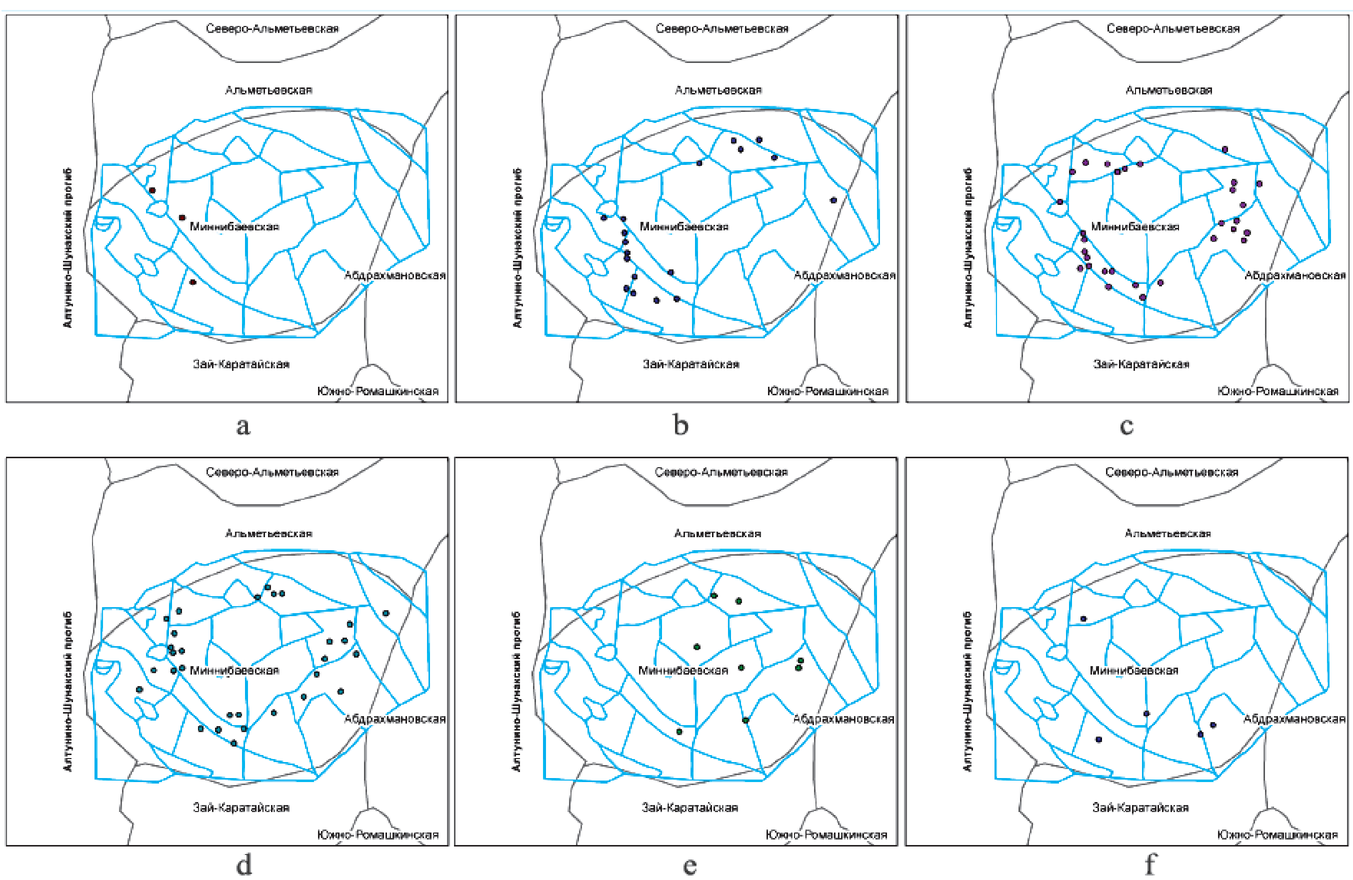

Fig. 4. Connection of the block structure of the basement and sedimentary strata with the placement of wells with different anomalous criteria: a – 1957, b – 1958, c – 1959, d – 1960, e – 1961, f – 1962

and theoretically determined, since the process of the deep generation of hydrocarbons and their periodic entry into the upper horizons of the Earth's crust and sedimentary cover is natural phenomenon controlled by certain geotectonic conditions.

Building models must begin with small fields (deposits) or areas of large fields for which previously approved reserves have been practically or already selected, or these reserves are close to depletion (more than 95% of the initial reserves have been selected). Then, an analysis of the parameters adopted in the calculation of the parameters (porosity, power, oil saturation, etc.) is necessary. Then oil recovery factor has to be analyzed in more detail (maximum possible and achieved displacement factors (according to laboratory and field data), waterflood coverage rates (by thickness and extent), possible man-made changes in deposits during their operation using waterflooding methods. Next, wells are to be selected with abnormal for this reservoir oil production rates and oil production is to be predicted for them and other wells. At present, methodological approaches have been developed (Plotnikova et al., 2017) to extract the anomalous wells and zones of hydrocarbon inflow based on a complex of geochemical studies of oil and gases dissolved in them. Localization of such wells and zones can be carried out based on the study of oil from production wells. Also using the geochemical characteristics of oil from abnormal wells (Plotnikova et al., 2017) it is advisable to monitor the process of the flow of hydrocarbons to determine the frequency and extent of the flow of light hydrocarbons into the reservoir.

Purposefully such geochemical studies in the oil fields of Tatarstan have not yet been studied, but they will allow to study the effect of deep degassing on the formation and re-formation of oil deposits, as well as on the replenishment of oil reserves in the process of long-term field development. At the same time, it is necessary to predict and model the processes of regeneration and re-formation of deposits in the fourth stage of development (Dyachuk, 2015; Dyachuk, Knyazeva, 2016).

After exhaustion of opportunities for increasing oil recovery factor in areas with high oil recovery and limiting watering, experimental work should be carried out to disconnect them from operation, but for a period of time (0.5-1 year or more) to reshape the deposit. The experience of the re-commissioning of previously withdrawn from development sites in the Republic of Tatarstan and other regions of Russia shows that as a result of the re-formation of a deposit, there is a significant (10-15% or more) reduction in water cut and, accordingly, an increase in oil production. Repeated operation of sites in such cases is carried out profitably. After carrying out the experiments, it will be possible to determine the duration of periods of stopping areas in different geological conditions and recommend a more powerful method of operation of deposits at a late stage with periodic shutdown of production of individual sections for re-formation at simultaneous exploitation of the rest of the highly watered part of the deposit in a special mode. Our estimate indicates a possible additional increase in oil recovery factor by 5 percentage points.

According to the hypothesis put forward by the mechanism of oil reservoir regeneration, the residual oil, migrating through the pore channels under the action of a pressure gradient, which is caused by the difference in the specific weight of the displacing agent and the residual oil, will accumulate at the top of the productive layer and flow into the area where the internal energy for it will be minimal under given thermodynamic conditions (Dyachuk, 2015). Conducted in the monitoring mode from 1998 to 2002 at the Pamyatno-Sasovsky field (Lower Volga) by the efforts of LUKOIL-VolgogradNIPImorneft LLC, detailed studies of the process of hydrocarbon inflow into the deposit clearly showed the need to study the spatial and temporal patterns of its fluid regime (Kasyanova, 2010). Our assessment of the role of "recharge" in the Romashkino field is shown in Fig. 5.

Conclusion

Considering that the modern vertical migration of fluid flows from the bottom up has geodynamic nature and it is characterized by selective localization both in terms of area and time, 4D analysis of geological, geodynamic and geochemical data in the monitoring mode is necessary to study the flow process (Kasyanova, 2010). Today, the practical possibility and necessity of organizing such monitoring studies in any developed oil field is obvious. In order to identify the conditions for re-formation of deposits, it is necessary to organize special field studies to determine the rate of accumulation of oil in the wells of highly watered wells and transfer wells to a selection not exceeding the inflow rate (candidates are wells in the micro-anticlines of the roof of the reservoir).

The work carried out will allow to choose the most promising areas of the reservoir to search for channels of "feeding" with hydrocarbons from the depths of the subsoil. In these areas, we can recommend seismic studies on new technologies (seismic sides-canner, SLOE, CDP 3-D, 4-D, etc.), monitoring of geological field data, geochemical characteristics of oil and dissolved gas, as well as geodynamic parameters of the deposit, field and the surrounding area.

The collection of accumulated data will allow creating a model, on which it will be possible to carry out calculations, determine the rates of regeneration of

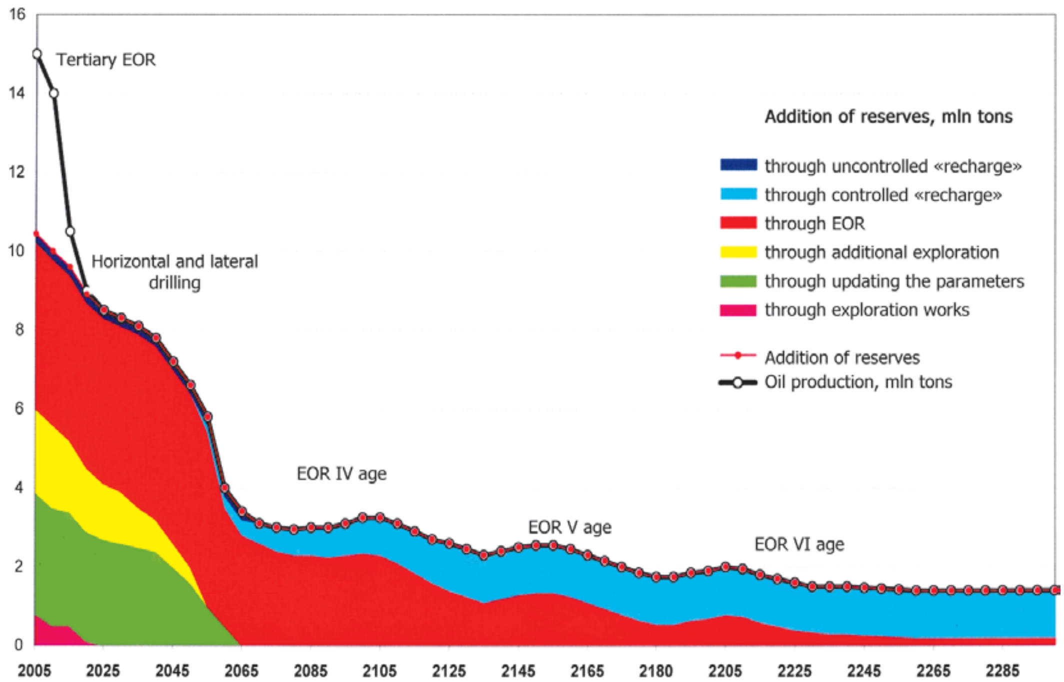

Fig. 5. Dynamics of oil production and reproduction of oil reserves in the Romashkino field since 2005

deposits in the development process and the volume of "feeding" of deposits with hydrocarbons from the depths and predict the role of processes of re-formation of deposits in total oil production.

Starting to model these processes is necessary today.

Acknowledgements

The authors are grateful to the V.A. Trofimov for valuable comments and recommendations which have been very helpful in improving the manuscript.

References

Dyachuk I.A. (2015). Reformation of oil fields and reservoirs. *Georesursy = Georesources*, 1(60), pp. 39-45. (In Russ.)

Dyachuk I.A., Knyazeva E.V. (2016). Features of the late stage of development of oil fields and measures to increase the oil recovery of depleted reservoirs. *Proc. Int. Scientific and Practical Conference*. Kazan: Ikhlas, vol. 1, 300 p. (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.).

Gavrilov V.P. Oil and gas – renewable resources. http://www.gubkin.ru/faculty/geology_and_geophysics/chairs_and_departments/geology/VP_statya_Neft%20gaz%20vozobnovlyaemy.pdf. (In Russ.)

Gordadze G.N., Tikhomirov V.I. (2005). Geochemical characteristics of oils and DOM rocks in the central regions of the Volga-Ural (using HC-biomarkers). *Geokhimiya = Geochemistry*, 11, pp. 1208-1223. (In Russ.)

Gordadze G.N., Tikhomirov V.I. (2007). On the oil sources in the northeast of Tatarstan. *Neftekhimiya = Petroleum Chemistry*, 47(6), pp. 422-431. (In Russ.)

Goryunov E.Yu., Ignatov P.A., Kliment'eva D.N., Khalikov A.N. (2015). The show of present hydrocarbon inflow into oil and gas complexes in the Volga-Ural oil and gas province. *Geologiya nefti i gaza = The geology of oil and gas*, 5, pp. 62-69. (In Russ.)

Gottikh R.P., Pisotskii B.I., Malinina S.S., Romanov Yu.A., Plotnikova I.N. (2004). Paragenesis of abnormal geophysical and geochemical fields and hydrocarbon accumulations in the Volga-Ural oil and gas province (on the example of the South Tatar arch). *Geologiya nefti i gaza = The geology of oil and gas*, pp. 20-27. (In Russ.)

Gottikh R.P., Pisotskiy B.I., Plotnikova I.N. (2014). Reduced fluids in the crystalline basement and the sedimentary basin (on an example of Romashkino and Verkhne-Chonskoye oil fields). *ARPN Journal of Earth Sciences*, 3(1), pp. 25-41.

Kasyanova N.A. (2010). Geofluidodynamic evidence of modern replenishment of reserves of oil and gas deposits. *Geologiya, geografiya i global'naya energiya = Geology, geography and global energy*, 3(38), pp. 14-16. (In Russ.)

Kayukova G.P., Plotnikova I.N., Kosachev I.P., Romanov G.V. (2013). Genetic link fluids oil and gas complexes Romashkinskoye fild with deep faults basement. *Abstracts of Kazan workshop on abiotic hydrocarbons*, Kazan: Kazan Federal University, pp. 22-23.

Kayukova G.P., Romanov G.V., Lukyanova R.G et al. (2009). Organic geochemistry of the sedimentary strata and crystalline basement on the territory of Tatarstan. Moscow: GEOS, 487 p. (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.)

Khisamov R.S., Ibatullin R.R., Amerkhanov M.I., Slesareva S.S. (2012). Estimation of deep hydrocarbon possible inflow into the developed deposits of the Romashkino field, Tatarstan Republic, Russia (on the example of Minnibayevo area). *Georesursy = Georesources,* 47(5), pp. 48-51. (In Russ.)

Muslimov R.KH., Galdin N.E., Gvozd' S.M. et al. (1996). The crystalline basement of Tatarstan and the problems of its oil and gas potential. Kazan: Denta Publ. 487 p. (In Russ.)

Muslimov R.H., Plotnikova I., Salakhidinova G. et. al. (2013). The proof of deep source of hydrocarbon on the Romashkino oil fields. *Abstracts of Kazan workshop on abiotic hydrocarbons*, Kazan: Kazan Federal University, pp. 36-37.

Muslimov R.H., Plotnikova I.N. (2009). Investigation of the up-to-date process of the replenishment of hydrocarbon reserves. *Journal of Geochemical Exploration*, 101(1), p. 72.

Muslimov R.Kh. (2014). Oil recovery: past, present, future. 2 Ed. Kazan: Fen Publ., 750 p. (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.)

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 = Chemistry and technology of fuels and oils*, 6, pp. 70-75. (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., Akhmetov A.N., Delev A.N., Usmanov S.A., Sharipov

B.R. (2011). Geoinformation approaches to study geodynamics of the Romashkino oil field. *Izvestiya VUZov. Gornyy zhurnal*, 7. pp. 63-69. (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 = Oil and gas*, 5, pp. 83-102. (In Russ.)

Salakhidinova G.T., F Nosova, I.Plotnikova, et. al. (2013). Comparative characteristics of organic matter of oils from the 'anomalous' and 'traditional' zones within the Minnibayevsky area of Romashkino field. *Abstracts of Kazan workshop on abiotic hydrocarbons*, Kazan: Kazan Federal Univer., pp. 43-44.

Trofimov V.A. (2013). Comprehensive solution of the enhanced oil recovery issue of "old" fields – oil production directly from the oil-bearing channels. *Georesursy = Georesources*, 4(54), pp. 65-67. (In Russ.)

Trofimov V.A. (2014). Deep regional seismic CDP studies of oil and gas areas. Moscow: GEOS, 202 p. (In Russ.)

About the Authors

Renat Kh. Muslimov – DSc (Geology and Mineralogy), Professor, Department of Oil and Gas Geology, Institute of Geology and Petroleum Technologies

Kazan (Volga region) Federal University

Kremlevskaya st. 4/5, Kazan, 420008, Russian Federation

Irina N. Plotnikova – DSc (Geology and Mineralogy), Leading Researcher, Academy of Sciences of the Republic of Tatarstan

Baumana st. 20, Kazan, 420012, Russian Federation

E-mail: irena-2005@rambler.ru

Manuscript received 09 July 2018;
Accepted 25 July 2018;
Published 30 August 2018