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Аннотация. В последнее время всё чаще встречаются работы, в которых обсуждается превышение накопленной добычи нефти над извлекаемыми запасами на длительно разрабатываемых месторождениях. При попытке объяснения возможных механизмов поступления нефти в залежь возникает ряд новых противоречий. Представленная статья посвящена разрешению основных противоречий в нефтепромысловой геологии и разработке нефтяных месторождений за счет новейших достижений физики. Рассмотрены результаты эксперимента по увеличению поступления нефти в залежь.

Ключевые слова: углеводороды, восполнение запасов, синтез элементов, первичные материи, искривление пространства, экспериментальные исследования.

Introduction

Despite the considerable dependence of mankind on hydrocarbons and huge experimental material accumulated during almost two centuries of oil fields development, there is still no holistic understanding of all the unsolved petroleum-related issues. Among these problems, the following are the main:

- different concepts of hydrocarbon generation (biogenic - A.D. Arkhangelsky, V. I. Vernadsky, N. B. Vassoyevich, E.M. Galimov, I.M. Gubkin, A.F. Dobryansky, A.E. Kontorovich, S.G. Neruchev, A. Petrov Ave, A.B. Ronov, V.A. Sokolov, N. M. Strakhov, A.A. Trofimuk, V.A. Uspensky, J. Moldovan, K. Peters, S. Silverman, B. Tissot, A. Treibs, D. Welte, J. Hunt, J. Espitalie, etc.; the abiogenous - G. N. Dolenko, P. N. Kropotkin, N. A. Kudryavtsev, V. B. Porfiryev, V.D. Sokolov, E.B. Chekalyuk, E. Cost, F. Hoyle, R. Robinson, T. Gold, etc.; the combined - V.P. Gavrilov. A.N. Dmitriyevsky, A.A. Barenbaum, etc.)

- oil reserves replacement in depleted fields (R. H. Muslimov, V.P. Gavrilov, N. P. Zapivalov, S. N. Zakirov, V.A. Trofimov, V. G. Izotov, V. I. Korchagin, A.I. Timurziyev, K.B. Ashirov, A.A. Barenbaum, I.N. Plotnikova, etc. [1-9]),

- age of hydrocarbons, presence of short-lived isotopes in oil, etc.. (V.P. Gavrilov, J.M. Peter. P. Peltonen, S.D. Scott. And. A.A. Barembaum, etc.),

The authors usually tend to consider only one aspect of the observed natural processes, and completely disregard the researches of other authors. The words of the famous polymath Nikolay A. Morozov are appropriate here: “The greatest tragedy of science is that one miniscule fact can destruct an excellent theory.” Unfortunately, the researches are often blind to these small and not very small facts, which give rise to the numerous various contradictory hypotheses and concepts. For instance, the hypothesis of biogenic nature of oil was very popular and prevailing. Currently, the balance shifts towards the inorganic hypothesis. However, both categories of researchers have discovered and described the real facts..

RENEWABLE OIL

What is more, new assumptions should be made for each subsequent hypothesis, which in turn require the addition of new ones. For example, the hypothesis of biogenic origin of oil first appeared based on the fact that oil is formed from flora and fauna organic remains in sedimentary rocks. This hypothesis is supported by the similarity of C3 to C2 isotopes ratio in oil and in living organisms, as well as the presence of biomolecules or their fragments in oil: for example, porphyrins having analogues in hemoglobin and chlorophyll.

Later, the hydrocarbons evidences and reserves have been discovered in magmatic rocks, and hydrocarbons are found to be widespread in the outer space. All this resulted in creation of abiogenic hypothesis that happens to be in total contradiction with the biogenic hypothesis. In order to explain the abiogenic hypothesis, the assumptions were made that oil comes from crystalline basement or source rocks through the oil feeding channels. Still, it is unclear why oil saturation through these channels occurs only in certain layers while the water-saturated layers situated between the oil-saturated ones remain oil-free. Or another question, how oil-feeding channels reach pools or layers and saturate them with oil of varying composition, but bypass seals of the other development targets (Fig. 1)? Undoubtedly, oil-feeding channels do exist. The simplest evidences are mud volcanoes erupting hydrocarbons that were not trapped. However, the introduction of the oil-feeding channel does not explain the above-mentioned contradictions.

Abstract. An increasing number of researchers have submitted papers in which they write that cumulative oil production exceeds the amount of recoverable reserves at old oilfields. New contradictions arise when attempts are made to explain possible mechanisms for the ingress of oil into fields. This article is devoted to the attempts made to settle the main contradictions of oilfield geology and oilfield development based on the latest physics discoveries and the results of an experiment to increase the ingress of oil into an oilfield.

Keywords: hydrocarbons, reserves replacement, total synthesis, primal matter, space wrinkles, experimental research.

It was discovered that hydrocarbons evidences and reserves exist in magmatic rocks, and hydrocarbons are found to be widespread in outer space

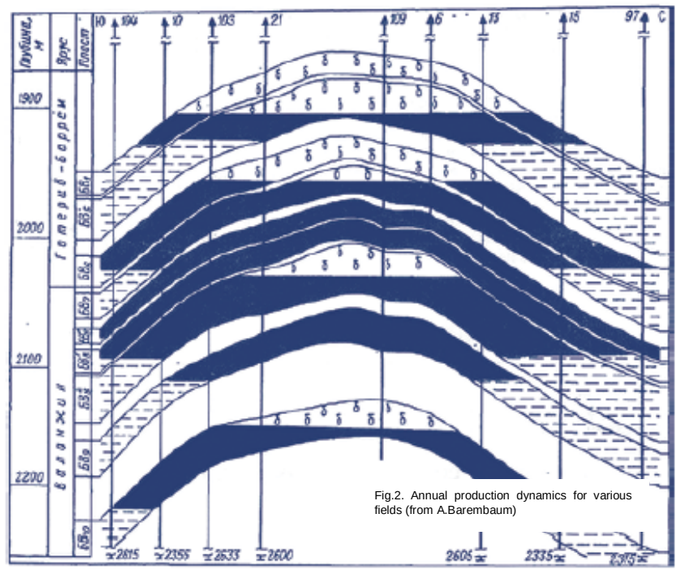


Fig.2. Annual production dynamics for various fields (from A.Barembaum)

Fig.1. Geological section of the Varizhegan field

Source:
http://www.geolib.ru/OilGasGeo/1989/og/Stat/stato6.html

1-gas, 2-oil, 3-water, 4-clay

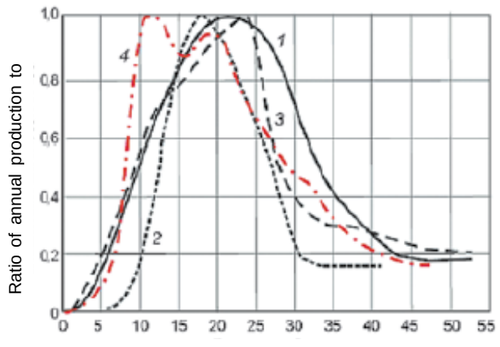
In the Romashkinsky field, for example, the Vorobyovsky formations should be the first oil-saturated ones in the course of oil migration from the basement as they are of high reservoir quality and are overlaid by the solid seal (Mullinsky clay) [10].

Actually, for some reason the Kynovsky-Pashiisky formations are oil-saturated while they occur above the Vorobyovsky but below the Domanik formations, which are considered to be potential oil source rocks.

Therefore, other assumptions should be introduced; for instance, that oil saturation occurred in different geological epochs with different formation pressures. We can agree with this reasoning; but why reserves replacement takes place nowadays as well (Fig. 2)? And again, oil does not enter the water-saturated layers. In addition, is it worth considering the different geological epochs given that works of the American researchers with the use of carbon-14 dating showed that the oil from different wells in Gulf of California is as young as 4 to 6 thousand years [11]. Moreover, this age is comparable to the time of hydrocarbon destruction. In addition, it is unclear how reserves replacement occurs in the fields where difference between formation pressure and initial pressure is negligible. Another question: if oil migrates from the Earth's depths, then where did it come from? Or, assuming that its generation is caused by liberation of deep-seated hydrogen and various chemical reactions, the question is how the hydrogen was formed in the depths of the Earth, and how in general our planet was formed?

Of course, these considerations are simplified since we are not taking into account numerous works devoted to investigations of minor constituents in oil, biomarkers, isotopic signature of carbon and hydrogen in oil and gas. Broadly speaking, this doesn't change the situation: each study or observation can be explained when taken separately, while it is impossible to put the observations together.

Fig.2. Annual production dynamics for various fields (from A. Barembaum)

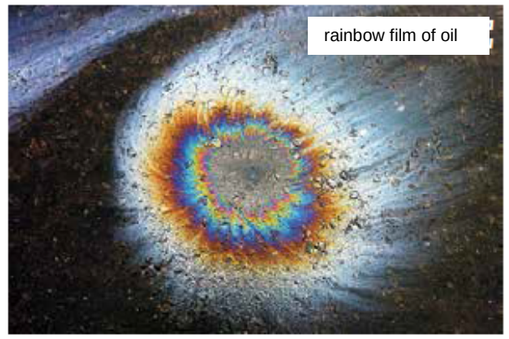


1 - Romashkinskoe, 2 – Samotlor,
3 - Tuymazinsky (R. Muslimov, 2004),
4 - Shebelinskoye fields (A. Barembaum, 2004)

Suggested conceptual idea of hydrocarbon origin and reserves replacement

The observed trend is an evidence of petroleum science crisis, and first of all the crisis relates to in oilfield geology and oil fields development. Different efforts are made to overcome this crisis, e.g. attempts of combining different hypotheses of oil origin; however, this doesn't solve the problem fundamentally, because some issues are still open. Note that we can observe such a trend in other sciences, say, in physics, astrophysics, biology, and medicine.

In order to solve the problem of hydrocarbon generation and reserves replacement we can broaden the definition of matter and present it as primary matters (elementary matters); under certain conditions (changes in space dimensionality) they merge into hybrid matters and, as a particular case, into dense matter that exists in solid, liquid, gaseous and plasma states [12]. The second important aspect is anisotropic space; i.e., space properties and features vary in different directions. There are some evidences of such phenomenon. The third aspect is the interaction of matters and space. In other words, the matter that fills the space affects properties and features of the space it fills, and the space affects the matter. As Stephen W. Hawking said, acceptance of these three aspects allows creating "a single theory of everything", including explanation of origin of our planet, various minerals, hydrocarbons, and also reserves replacement as fields are depleted. According to this concept, the cause of planets formation is the occurrence of global zone of space deformation, where the conditions for different hybrid matters are formed, including the dense matter synthesis from the Universe's "primordial bricks" – primary matters.



Resolution of this crisis is only possible through the revolutionary change of our views on fundamental processes in geology and the universe as a whole [12]. One of the starting points is the so-called "dark matter" discovered by physicists – the matter that our sensory organs and tools cannot perceive. In accordance with calculations, amount of this matter is an order of magnitude larger than dense matter we got used to deal with. Then it turns out that all our ideas of the world order are based on the knowledge of only 10 percent of matter, which is obviously insufficient to form even an approximate conception. Note the fact that our sensory organs developed primarily to adapt us to the living conditions, and not for the cognition of the nature. Devices made it possible to widen the range of sensory organs perception, but, again, not to move beyond them. Understanding of matter will inevitably be limited because of limited nature of our organs. Therefore, today the definition of matter as "the objective reality given to us in sensation" (given by V.I. Lenin) limits the progress of science.

When formation of planetary spheres in the zone of space heterogeneity ends, dimensionality of space returns to the initial level. Since the planet looses parts of its matter in the form of a gas plume when it moves and due to radioactive decay, an insignificant additional synthesis of the dense matter takes place, and dimensionality balance restores. As a result, such a system may exist quite a long time, which can be confirmed by the works of V.I. Vernadsky; he notes in them, that geochemical system of out planet previously was and currently is in the state of stable dynamic equilibrium.

There are local anisotropic zones inside the global zone of inhomogeneity; and primary matters of different spectra run through them. Depending on the specific spectrum of matter, different chemical elements and substances are formed. The synthesis of hydrocarbons may be attributed (in the first approximation) to this process as well. The difference is in the fact that the matters that were previously participating in vital activities of organisms

are used as the primary matters. That is why the great variety of composition is typical of oils, and they have the carbon isotopic abundance similar to living organisms. This process may take place in different areas of the Earth's crust and at different depths, so hydrocarbon traces and reserves can be found almost everywhere: in conventional reservoirs, shale, igneous rocks [6]. In the case oil-feeding channels exist, hydrocarbons can migrate into the trap or expel to the surface in the form of mud volcanoes or "black smokers". For isolated traps, e.g., those "floating" within the salt formations, the field can indeed be the place of birth and storage of hydrocarbons. More detailed description of these processes can be found in [13].

This hypothesis differs fundamentally from the existing concepts of hydrocarbon generation, and contributes to additional understanding of all the existing experimental observations in oilfield geology and development, including reserves replacement. This process looks as follows: during the course of recovery of reserves in the field, the original dimensionality changes, which provokes the repeated synthesis of the same elements and substances as in the spectra of the primary matters. Dimensionality balance restores upon completion of the synthesis. This process is not instantaneous, but occurs with some delay. The mathematical model describing this process has been developed, it has shown that the delay for different fields ranges between 60 and 230 years [14]. In general, the modelling resulted in the following conclusions:

Is no danger of resource base depletion and therefore there is no need for active development of new fields in underexplored regions of the country with poor infrastructure

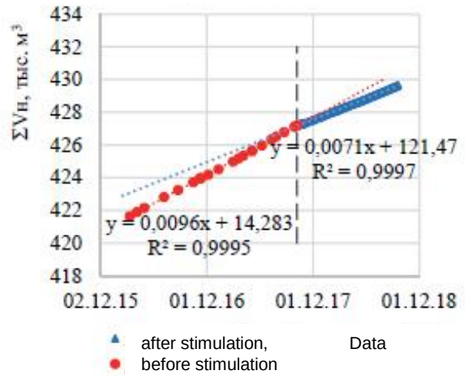
- Stimulation of production gives rise to greater oil inflow;
- As reserves are depleted, the rate of synthesis is practically comparable to the production level, and this trend can last for hundreds and thousands of years;
- The impact of saline water injection not always leads to positive results, as it can reduce the rate of oil synthesis; therefore, there is an optimum of this problem solution.

Findings that meet the conclusions of other authors are indicative of the need in the fundamental revision of future developments in the brown fields and basic principles of development taking account of oil synthesis in accumulations (modification of material balance equations, development of hydrodynamic simulators with reserves replacement, methods of Recovery Factor estimation, optimal rates of production and reservoir stimulation, audit of reserves, etc.).

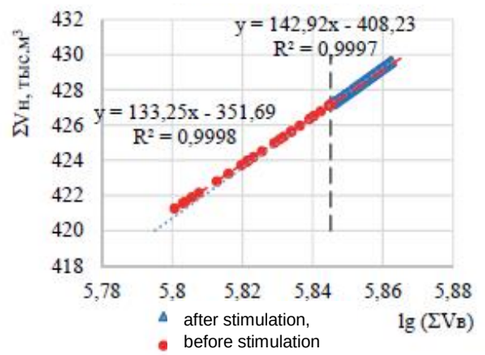
volcanic lava erupting into the ocean

Fig.3. Example of decline curve analysis (DCA) after Maksimov and production analysis (PA) after stimulation

a) PA



b) DCA after Maksimov



In addition, it should be noted that, clearly, there is no danger of "resource base depletion in fuel and raw material sectors as the existing fields are depleted" (Art. 12, Sub-art. 13 of the Strategy of the RF Economic Security),
and therefore there is no need for active development of new fields in underexplored regions of the country with poor infrastructure, for example, on the Arctic shelf.

It is necessary in the fundamental revision of future developments in the brown fields taking account of oil synthesis in accumulations

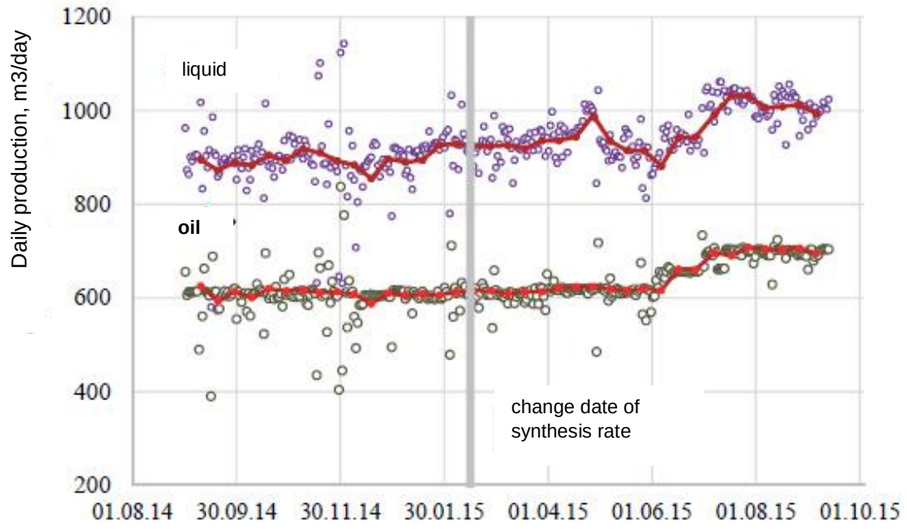
Overestimated role of EOR and IOR methods

With the recognition of field recharge, a completely different insight in Enhanced Oil Recovery (EOR) and well stimulation methods appears. For example, the reported fraction of oil recovered owing to EOR in PJSC Tatneft at year-end 2014 made 25% of cumulative oil production. Production resulting from the tertiary methods applied in the Datsin field in 2018 was about 32% of total amount. If we take into account the real fact of the natural "recharge" of fields, then most of the additionally produced oil is due to natural factors rather than human impact on the reservoir. However, it is undoubtedly advantageous for oil companies to show that oil production in the brown fields is maintained thanks to their efforts and high degree of proficiency.

The uncovered overestimation of additional oil production using the decline curve analysis (DCA) supports our conclusion while this very method is widely used in oil companies. Let us also note, that there is still no approved standard for EOR efficiency assessment in Russia, which leaves space for vague explanations of the additional production. This fact is discussed in more details in [15].By the way, the main indication of the specific DCAs use in extrapolation for the forecast period is selection of relationship of the straight-line nature. However, it was found that even strict compliance with this requirement does not accuracy. In particular the following situation was often observed while evaluating the EOR efficiency: the rate of cumulative production growth after reservoir treatment decreased while integral DCA demonstrated the production increase (Fig. 3). In their work, M.I. Maksimova. B.F. Sazonova, A.M. Pirverdyan, G.S. Kambarova et. al [16] discussed these trends in the context of drive characteristics. Production growth was observed as the increase in cumulative oil production following the stimulation compared to the trend before it. Correlation factors for the trend line were very close to unity while formation pressure in the studies development targets was maintained constant.

Similar issues are related to the different methods of bottomhole zone treatment, hydraulic fracturing, construction of wells with complicated geometry of hole (holes), new methods of completion, infill drilling, and reducing bottomhole pressure to the optimum, etc. In all these cases the effect is estimated on the basis of well flowrate changes, including their absence (no change). At the same time, the influence of wells interference is always disregarded, which results in the fact that total increment over the field/area is always less than the increment in the well. Influence of interference can be considerable when the well spacing is close; the resulting effect of EOR activities can be reduced to 0.3-0.4.

Fig.4. Daily production in the field before and after increasing the rate of oil ingress (synthesis)



Finally, the substantial part of numerous EOR technologies yield less returns than it was initially calculated or measured in the well. In this regard, the recharge of the fields can again be considered as a “magic wand” for maintaining oil production level.

In the light of the above discussed, the role of EOR and IOR methods in the brown fields is obviously overestimated. Most of the additional oil produced is due to natural factors rather than human impact on the reservoir or near-wellbore zone. At the same time, introduction of EOR, near-bottomhole treatment, hydraulic fracturing, infill drilling, new completion technologies, etc., give rise to more intense oil synthesis, and these methods are certainly necessary to apply.

Experiment on increasing oil ingress to deposit

A theory is correct if it can be confirmed by practice. The unique experiments on increasing the rate of oil ingress (synthesis) was carried out in one of the small fields in Russia. Flowrates, watercuts, bottomhole and formation pressures before and after stimulation were analysed. The stimulation involved the increase in dimensionality gradient within the reservoir location. The experiment produced an unexpected result: there was no flowrate increase in the wells, bottomhole and formation pressures did not change. In addition, the neighbouring fields were investigated; no significant changes were found. Instead, it was found that oil production from new-drilled wells showed the initial flowrates two or three times the amount of similar initial flowrates from the wells drilled earlier [13]. This is evidenced by the apparent step-by-step growth of daily production over the area starting from the second half of the year 2015.

ЦВЕТ НЕФТИ

This fact is an indirect proof of the fact that the reservoir stimulation was successful. The explanation for the obtained results is probably as follows. First: reserves addition does not mean independent gain in production if the field has not reached the final stages of development. Second: it is known from the development of different fields that sidetracking in 50-100 m from the old hole is also almost always successful, which is not actually a satisfactory explanation even when the initial pressure gradient above which the flow begins is used. In this case, hydrodynamic models show a "shortage" of oil production. Therefore, the cause of reserves replacement in both cases (artificial condition and under the influence of natural factors) is in the fact that oil synthesis takes place mainly in the segments of the field, where low pressure gradients are typical, i.e., far from the wells or when they are shut off.

Note that the “dimensionality gradient” is a much broader concept compared to the pressure gradient; and change in dimensionality causes change in pressure. The opposite effect also may be observed when the maximum pressure gradients near the well affect the dimensionality gradients responsible for oil synthesis. In general, this problem requires further studies and investigations. Below are the main requirements to the fields to be examined: high exploration maturity and reserves depletion; availability of metering facilities; data openness and accuracy; monitoring of dynamics for several years; no solution gas drive; scheduled sidetracking and infill drilling; availability of measurements in pressure-observation wells. The stimulation can be performed over the large area, including petroleum province.

The role of EOR methods in the brown fields is overestimated, most of the additional oil produced is due to natural factors rather than human impact on the reservoir

Conclusions

The proposed conception allows summarizing very different observations and investigations in the area of oilfield geology and development, and thus resolving the existing crisis in petroleum science. The business end of reserves replacement may have many aspects. This is not only refocusing the development of brown and green fields, reallocation of E&P costs, correction of tax privileges for the “old” fields, but also the possibility for artificial increase (and even decrease) of reserves replacement rate, which may radically change situation with reserves and their development in the country. The future researches should be focused on the studies of the spectra of matters that are responsible for synthesis of a particular substance, including hydrocarbons. Looking ahead, this will allow influencing the process of synthesis and educing all the necessary substances and elements.

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