

MODERNIZATION OF THE RUSSIAN OIL INDUSTRY ON THE WAY FOR INNOVATIONS AND GLOBAL TRENDS

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Abstract. The main task of the new Russian energy strategy until 2035 is formulated succinctly and accurately – the transition from resource-based to resource-innovative development of the oil industry. However, it does not have sufficient geological and economic assessment of proven and promising resources, and most importantly – there are no mechanisms for the implementation of tasks.

Powerful technical progress of the West in the exploration and development of unconventional hydrocarbon deposits has a great influence on the efficiency of conventional oil and gas deposits. It becomes possible to make the transition from the balance to the geological reserves and from the concept of absolute pore space to the effective pore space in matters of reserves calculation and development design.

US example on the stabilization and further significant increase in oil and gas production after a long period of its fall allows us to rethink these achievements for solving problems of the Russian Federation concerning a significant increase in the efficiency of hydrocarbon resources. All this should be applied taking into account the specific geological structure of deposits in Russia and the history of their development. At the same time in the oil industry the solution is required for fundamental problems: calculation of reserves, justifying oil recovery, building fundamentally new geological and technological models of deposits, innovative design of development systems, justifying the rationality criteria and principles of the rational development of fields.

Keywords: subsoil use, government support of subsoil users, reserves and resources of hydrocarbons, oil difficult to recover, non-conventional oil reserves, oil recovery factor, enhanced oil recovery methods, tax incentives, fundamental problems

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The peculiarity of the present development stage of the oil industry in the Russian Federation and the Republic of Tatarstan is that up to now science has dealt mainly with problems of active involvement into development of deposits with reserves difficult to recover. This problem also remains one of the most important in the perspective.

But for the further development it is not enough.

Powerful technical progress in the Western countries for the development of non-conventional hydrocarbons, heavy oil and natural bitumen in Canada, the USA, Venezuela, oil and gas shale revolution, research on other types have fundamentally changed the situation in the oil and gas sector and the global environment.

The complex international situations, price conflicts in the world market, serious sanctions imposed by the West against Russia, are an additional challenge to our country. Let us remember how through the use of established in the Soviet period of strong potential we got access in market conditions to reliable western techniques and technologies (the USSR lagged behind the West for 30-40 years in equipment for the oil industry), we ran this distance in 6-7 years.

Observations of a fundamental nature have been made on a new “Energy Strategy of Russia until 2035” (ES-2035), when considering it at the extended meeting of the Scientific Council of the Russian Academy of Sciences on the problems of geology and development of oil, gas and coal fields. The main observations are as follows: low validity to ensure production of oil resource base (lack of justifications for oil and gas potential, directions and volumes of geological exploration, in-depth analysis to ensure the growth of oil production, the absence of quality analysis and reserves structure, their authenticity, conditions and development of oil recovery factor, focus on the extraction of active reserves, which are already severely depleted and the meager share of producing reserves difficult to recover – only 4-5 % of the total production, the lack of specificity for innovative development of the fuel and energy complex.

The main task of the new Russian energy strategy until 2035 is formulated succinctly and accurately – the transition from resource-based to resource-innovative development of the oil industry. However, there is no defined mechanism for the implementation of all the objectives and tasks.

In-depth analysis of the oil and gas industry allows evaluating its close to a critical level: low volumes of geological exploration, poor replenishment of profitable reserves, low rates of oil recovery factor at the level of 35 %, steady increase in the proportion of oil hard to recover, for the development of which 3-5 times more money are required, a high degree of depreciation of the basic funds (almost 60 % in the oil and gas industry and 80 % in the processing).

The situation is exacerbated by the lack of reliable information base for the systematic analysis of the situation in the oil and gas sector at all levels, secrecy by oil companies of directions for replenishment of the mineral resource base and development of fields under the pretext of commercial confidentiality, lack of stimulation for investment and innovation mechanisms, sharp decline in professional government level of planning, forecasting, management and control over the processes of exploration, replenishment of reserves, rational development of fields on the part of the federal government entities.

As the experience have shown of the failure of previous development strategies, obviously, the authors are not able to make this important document as the real guide to actions because of inadequate assessment of the state of the oil and gas industry in Russia and world trends. Apparently, all these issues will be addressed at the regional level, as it has done in Tatarstan, where in 2015 addition was made to the development strategy of the fuel and energy complex till 2030.

But a single list of all necessary regulatory documents in the subsoil use shall be designated in its entirety, taking into account the need for clarification and processing of existing and development of new documents with a road map of performers, dates of compilation, review and approval order.

Creation of the rules and regulations in all areas of subsoil use is crucial in the development of oil and gas production. This is particularly evident in the development of oil and gas sectors of the United States.

Today we have a paradoxical situation: in the United States – the citadel of free enterprise, there is a strict regulation of subsoil use, which leads to the intellectualization of oil production and development.

The efficiency and simplicity of rules and regulations related to the provision of licenses and issues of land ownership led the US to a rapid increase in the number of licenses for subsoil use: by 2012 the number had reached 63000 (in Russia – just over 3000). The whole system of US oil and gas sector regulation is aimed at stimulating the subsoil users to apply new production methods (Kryukov, 2013).

It is important that individual states have their own significant niche in fostering innovations in the oil and gas sector. The dominant policy in the field of regulation

of the oil and gas sector in the US is to stimulate subsoil users to take higher risks in testing and development of new innovative production methods.

The application of enhanced oil recovery methods is of special attention in the United States. The main objective of incentives – rewards of subsoil users for high financial costs and technical risks in testing and development of enhanced oil recovery methods compared with conventional methods of oil production.

The results of this approach for the subsoil sector are great. On the territory, where oil production is carried out since 1860 and oil is produced more than on any other area of the world, the US oil industry has achieved stunning results. After a long period of falling production, growth of oil production has been achieved (20-25 million tons a year). Especially Texas – the leading state in the oil industry – has advanced, where for 5 years by 2014 oil production has doubled, and over the next 5 years it is planned to be further doubled (Kryukov, 2013).

This is not only due to the development of a new type of resource – the so-called shale oil, but also through innovations in conventional oil of existing fields. This example is worth to be role model, and even obligatory for Russia and Tatarstan (Muslimov, 2014 a).

Unfortunately, Russia is continuing the neo-liberal course that focuses on market fetishism in the management of subsoil use and minimization of the government role in this process, leading to the de-intellectualization of the oil and gas complex. The main taxes are taken not for the performance results (profit), the degree and quality of deposits (rent payments), but for the right to produce oil and develop fields.

Moreover, the regulatory documents in the subsoil use either left over from the Soviet command-administrative system, or were badly reformatted to a market economy (which turned out to be unsound) (Zakirov et al., 2016). Let us show this on the example of the main subsoil document – “Classification of reserves and resources of oil and combustible gases”. Classification successfully worked in the Soviet era, but was replaced by a temporary in 2001.

It established uniform for the Russian Federation principles of counting and state accounting of field reserves and prospective resources of oil and combustible gases in the subsoil according to the degree of exploration and their economic significance, the conditions that determine the readiness of explored deposits for industrial development, as well as the basic principles for assessment of forecast oil and gas resources.

However, the practice of this classification is poor. Requirements to take on the state balance of reserves have been significantly weakened. Often excessive oil reserves were taken into the balance, about what others and we have repeatedly written (Muslimov, 2014 b).

Therefore it is impossible to be completely sure of the authenticity of official reserves of oil and gas (Kimelman, Poldobsky, 2010; Savushkin, 2010). In 2015, Russia on the international classification has lost about 16.8 trillion m³ of proven natural gas reserves. Of course they really exist, but there is no justification of the reliability of these reserves (Zolotukhin, Levinbuk, 2016).

The oil situation is different. Compared to the Soviet period, the practice of approval of oil reserves has a trend of weakening attention to authenticity of oil reserves taken into the balance. This results in a lighter attitude toward C₂ category. In the development design and reports on oil reserves increment, as a rule all categories A+B+C₁+C₂ are accounted. But the category C₂ counts as preliminary estimated. In practice, the conversion factors from the C₂ category to higher ones (verifiability factors) in different conditions are from 0.4 to 0.7-0.8, and sometimes higher.

Earlier the category C₂ was treated more carefully – the design was allowed for the reserves, when the share of the category C₀ did not exceed 20 % of the total amount received for the design of reserves. The State Reserves Committee had a tougher approach to the adoption of reserves categories C₁ and C₂. This provided higher reliability of received resource base both for the planning, and especially design for the development of specific fields.

But from 2016 the Russian Federation has a new classification of reserves and resources of oil and combustible gases. Here, the degree of reserves reliability is even lower than in the temporary classification of 2001 (Zakirov, 2016; Muslimov, 2016 b).

Category A includes reserves in areas drilled by production wells grid. It seems that the same requirement remains in the new classification of reserves. But in the old sense, and in the Western classifications, the concept of developed ones was added to drilled.

Practice and experience of development shows that not all reserves that drilled by project wells are produced. Depending on the complexity of geological structure, 50-80 % (rarely more) of reserves are involved in the development, drilled by project wells at full development by the project waterflooding system. It takes decades of additional various geological and technical measures to engage in the development of major (95-100 %) reserves of operational object (Romashkino field experience).

Earlier Category B has always been considered in the areas of actually drilled project wells. In the new classification of reserves we have more than vague notions: B₁ – prepared – the basic fund of production wells and re-allocated Category B₂ – estimated – dependent fund of production wells (while it is not quite clear what kind of dependent fund it is). Therefore, in category B we can include areas where wells-points are indicated on the map, rather than actually drilled. Based on the development experience, confirmation of project reserves in actual drilling is 70-80 %, less- up to 90-100 % (depending on the geological complexity of the area).

Even more uncertain situation is with category C₁ and C₂. In fact, if desired, categories B₂, C₁ and C₂ can be classified as B₁ according to the new classification of reserves, without conducting any work on the field, but simply placing the project wells on paper (Figure 1). In the West, specialists more accurately relate to the categories C₁ and C₂, as well as promising and forecast resources.

Based on the above it can be said that the introduction of the new classification and related documents will not improve, but worsen the situation in the domestic subsoil use, in the methodology of both calculation and accounting of reserves, and the reliability of calculating development parameters.

The same can be said about the documents accompanying the new classification of reserves – Regulation of development and the “Rules of designing of oil and gas fields development”. In addition to them,

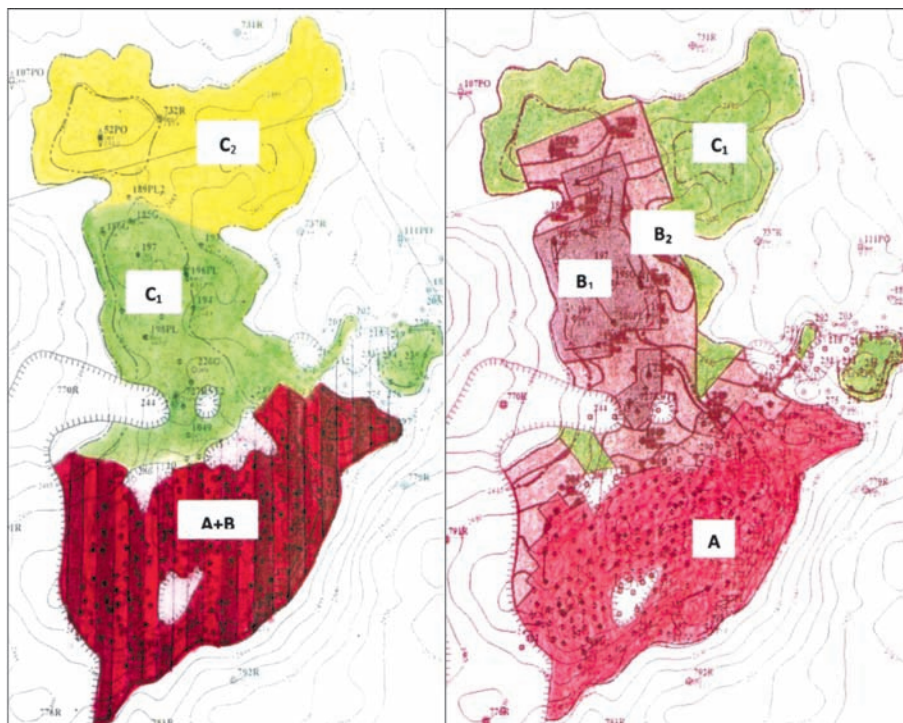


Figure 1. Example of comparing calculation plans for the current and new classification of hydrocarbon reserves.

hastily drafted temporary methodological guidance is now published on the calculation of mobile oil reserves for fractured and fractured-porous reservoirs of shale type (Zakirov, 2016).

The main advantage of Russia in the global oil and gas sector are huge reserves of mineral resources. Russia for proven oil reserves holds the sixth place in the world (after Venezuela, Saudi Arabia, Canada, Iran, Iraq), for gas reserves – the second after the United States. As for gas, it does not correspond to the real situation. We should restore with minimum efforts the ‘potential’ reserves 16.8 trillion m³ of gas lost in 2015.

The 6th place for oil reserves also does not correspond to the real potential of Russia. The main reason is extremely low exploration degree of huge territories of the Russian Federation (Western and Eastern Siberia, the Far East, the North-European part of Russia), as well as being in its research infancy shelf in the Arctic, the northern and eastern, and even the Caspian and Black Seas, heavy oils and natural bitumen in Siberia and the Volga-Urals, dense, shale and the like deposits of Western Siberia and Volga-Ural oil and gas provinces. With these resources, the oil potential of Russia should be in the first lines of the world ranking of liquid petroleum resources. The first and second places in oil production, which Russia holds, are consistent with its current proven reserves.

But the situation is complicated. High depletion of large and medium-sized oil fields, providing hitherto the main production in the country, requires a decisive transition to a massive development of oil difficult to recover both at oil and new fields, as well as the development of unconventional hydrocarbon deposits both on producing fields and new prospective areas and territories.

The old oil-producing areas – the Volga-Ural oil and gas province, Western Siberia, North European, Southern regions of the country must remain the priority for stabilization of oil production (at least up to 2030). Conventional oil (including reserves difficult to recover), prospecting of non-explored lands, additional exploration of producing fields, massive, widespread use of modern enhanced oil recovery methods, development of tight reservoirs and residual oil reserves at existing fields with a high degree of depletion should remain as target objects.

In these areas it is necessary to strengthen the work on the development of the best part of unconventional resources: heavy oil of the Permian complex of the Volga-Ural oil and gas province, tight, shale deposits and the like, for example, Bazhenov Formation of the Western Siberia (Muslimov, 2016 f; Panarin, Fomin, 2016).

The next direction should consider works on the development of the most favorable resources of Eastern

Siberia and the Far East in relatively small volumes.

The development of resources in the Arctic, the Arctic shelf and shelf of eastern seas is advisable to postpone to a later date because of the great complexity of geological and environmental conditions, lack of qualification to such works and high cost of hydrocarbons production in such difficult conditions.

This approach was already applied in Tatarstan and recorded in two documents: the updated energy strategy of the Republic of Tatarstan until 2030 and the “Concept of the study and development of unconventional hydrocarbon deposits in Tatarstan”. The first document determines oil production levels, reserves preparation and ways to improve and develop reserves difficult to recover to existing and new fields. The second document considers ways of unconventional oil deposits development in Tatarstan (Muslimov, Shakirov, 2016).

This strategy provides stabilization and even some growth in Tatarstan oil production for the period to 2030 and at the same time creates conditions for further development of oil production by 2050 and over the longer term.

It would be nice to have such documents in other regions and the whole Russia.

For successful implementation of the above directions on the instructions of the President of Tatarstan R.N. Minnikhanov, the Academy of Sciences of Tatarstan has made up “Development program of priority research in the field of geology, engineering, oil extraction and oil processing in Tatarstan for 2015-2025”.

It includes the following sections.

1. Ways and methods of exploration and development of unconventional hydrocarbon deposits in Tatarstan (tight reservoirs, shale deposits and the like, heavy oil and natural bitumen).

2. Assessment of the prospects and ways to increase the resources and recoverable reserves on long-developed (mature on the current definition) major fields of Tatarstan, commissioning of mobile reserves and exploring the possibilities of using immobile reserves, production of capillary held film oil, increased oil recovery, extending production from depleted reservoirs on tens and hundreds of years due to the investigation of the processes of deposits reformation, introduction of new enhanced oil recovery methods. The expected increase in recoverable reserves – is about 1 billion tons. At the same time the prospects of studying oil-bearing solid rocks and cap rocks of the sedimentary cover.

3. Improving the development of oil deposits in carbonate reservoirs in the low-profitable fields; ways to improve the development of heavy oil deposits in carbonate reservoirs (optimization of oil production and maximization of oil recovery).

4. Improvement of the theory and practice of application of enhanced oil recovery methods and

bottom hole treatment in Tatarstan fields with reserves difficult to recover (increase of recoverable reserves by 400 million tons).

5. Analysis and ways to improve the use of technologies of horizontal and multilateral drilling to increase the efficiency of oil field development (horizontal wells, horizontally branched wells, multilateral wells, lateral wells).

6. Creation of new development systems for oil fields located at the late stage of operation (IV stage of development in the modern sense), taking into account reorganization of oil fields and reservoirs.

7. Development of new methods for construction of geological and hydrodynamic models that fully considers the peculiarities of geological structure of objects and filtering in a formation. There are fundamentally new presentations about the processes of oil recovery (concept of the effective pore space), compared to the previously based for more than 70 years on the concept and calculation formulas of the absolute pore space.

8. Nanotechnologies at the exploration and development of hydrocarbon raw materials; the use of EOR of higher generations for very complex geological conditions of hydrocarbon occurrence.

9. Improving the methods of designing efficient development systems on the principles of innovative development.

It is envisaged to conduct the design at fundamentally new models to test new technologies in the field and at the experimental site.

10. Works on the study of the in-situ destruction of heavy oils, ensuring high conversion of high molecular components of heavy oil into light fraction in reservoir conditions and related technologies.

11. Scientific substantiation and development of organizational and legal measures to optimize the management and tax regulation in the sphere of subsoil use.

12. Improvement of methods of oil refining.

The foregoing concerns mainly the fundamental problems, the return on which is also outside of the planning period.

The foregoing rules, technical regulations and approaches to address the major issues of subsoil use in the US, which showed their high efficiency for the subsoil user, the government and society, are possible to fully implement in the Russian Federation.

While we understand that because of our mentality, we cannot repeat such measures to improve the efficiency of the development of new reserves categories, but something even remotely similar to this has to be taken. Otherwise, the backlog will deepen (Muslimov, 2016 d).

But the technologies for development of Western fields cannot be carried out on our fields with no

additional studies and justifications. The reasons for this are as follows.

- In the world there are no two exactly same fields, they are different in the specifics of geological structure; furthermore they differ vertically (deposits with various properties) and horizontally (each reservoir has both vertical and zonal areal heterogeneity of its properties).

- Historically, the different ideology has been established of oil field development: the former Soviet Union focused on the technology of waterflooding, which applied from the start of operation, in the West flooding was used as a secondary method, and in the later stages of development, regard for well spacing and stages of drilling was different, as well as to the EOR methods.

For these reasons, we must create technologies for the development ourselves in our specific objects, but facilities and equipment should be western (of course, if we do not produce domestic ones of the same quality) (Muslimov, 2016 f).

The combination of domestic technologies with modern western equipment and facilities, adapted to the specific geological conditions of our fields and deposits, gives a synergistic effect, and will be called innovative and the best of them – high-tech. The latter is rare and mainly relate to modern geological and geophysical surveys of mineral resources.

Commissioning of reserves difficult to recover and non-recoverable reserves into commercial operation requires a substantial increase in new geophysical, hydrodynamic and especially laboratory studies. The design of development of multi-model, multivariate methods of stimulation, on the principles of innovative development also requires fold increase of costs.

The pilot tests are the final and crucial in this scheme. Only its results can be the basis for the mass replication of new technologies, the most effective for the specific geological and physical conditions. For deposits with reserves difficult to recover and non-recoverable reserves such works should be done at the experimental sites. The oil produced from such sites should have tax incentives for the duration of pilot tests (5-10 years). This would allow performing self-financing R&D and pilot tests (Muslimov, 2016 d).

Currently, Tatarstan followed the path of organizing scientific grounds for the creation and testing of new, innovative technologies. “Tatneft” has organized two scientific target sites “Bitumen” (solving problems and working out technologies of heavy oil and natural bitumen) and “Domanik” (technologies for extraction of oil from tight, shale and similar rocks). For small oil companies a major training ground of innovative technologies has been created, which aims to create and develop technologies for a wide variety of geological and physical conditions of small deposits with reserves difficult to recover (very heterogeneous deposits in

carbonate reservoirs with heavy oil, clastic reservoirs with highly viscous oil, tight carbonate and clastic reservoirs, problematic deposits of hydrocarbons). According to our estimates at the involvement of the entire system for small deposits of Tatarstan we can obtain additional recoverable reserves of 400 million tons.

Testing of advanced technologies for the extraction of non-recoverable reserves can also be done at special projects approved by the Central Committee on Reserves, justifying the regime of granting tariff preferences for oil production in the period of implementation of the project up to the government co-financing of pilot tests (for very complex geological objects).

Implementation of already proven technologies should be carried out on the projects of innovation development of production in a particular field. In this case, tax incentives are required for the additional oil production through the use of new technologies. List of parameters for granting tariff preferences should be determined in accordance with the classification of reserves difficult to recover and non-recoverable reserves, for favorable categories of reserves difficult to recover (exemption from the mineral extraction tax) up to the maximum for the unfavorable categories of reserves difficult to recover and non-recoverable reserves (exemption from all taxes).

In any event, approaches to the development of reserves difficult to recover and non-recoverable reserves will be different than the development of conventional fields with a significant proportion of active oil reserves. All this will require additional efforts and resources. The increasing complexity of geological conditions will increase the cost of production of oil through the introduction of more complex and expensive EOR. More complex EOR (thermal, gas) are expensive, but less expensive methods (physical, chemical, etc.) may require infill drilling, which also makes them expensive.

The very system of taxation should be different for conventional fields with reserves difficult to recover and non-recoverable reserves. Inside these systems tax incentives should be applied depending on the complexity of geological conditions.

Since all technologies are introduced on the basis of projects (technological schemes) for the field development, the design itself is of particular importance. But here we have only disadvantages.

Despite the formal updating of standards, design is essentially maintained at the level of the 70-ies of the last century. Analogy method used by the authors of projects (especially the geophysical characteristics of deposits), the imperfection of simulation methods and hydrodynamic calculations, ignoring the generally accepted classical methods of solving problems of development, lack of in-depth professional analysis of reserves development, lack of control and regulation

of the development process – all this lead us into the unknown.

All these problems lead not only to a short 'life' of projects, but also to a decrease in oil reserves. Especially unacceptable level of design of field development is related to fields with the main share of reserves difficult to recover. The lack of scientifically based systems of exposure, EOR and bottom hole treatment for specific geological and physical conditions of deposits does not allow to project the rational development systems with introduction of innovative exposure systems, to address the problem of optimizing production and maximizing oil recovery.

All development should be based on the innovative design of the development. In order to practically implement the innovative design system it is necessary to establish rules, standards and other regulatory documents, i.e. the efforts of government bodies, science and oil companies (Muslimov, 2014; 2016 a).

However, innovative design will not be effective if we use methods and simulating techniques used in practice today. They do not reflect the real picture of the geological structure of fields. But most importantly, these models do not take into account the geological features of accumulation and transformation of sediments and formation of oil deposits.

S.N. Zakirov rightly considers wrong the ideology of building models. According to him guidance documents require not to include 'non-reservoirs' into 3D geological models. That is, all (almost all) created 3D geological models in the country are defective. Since they distort the real geology of deposits (Zakirov et al., 2006).

To this day, thanks to the concept of absolute pore space, initial petrophysical parameters are based on the results of mass definitions of non-informative absolute permeability coefficient of gas and open porosity (of dry cores!).

In order to construct such models we need to solve the fundamental problems of development of the industry (Muslimov, 2016 f).

In Soviet times, there was the concept of balance reserves, which stood out from the geological, using the so-called conditional values of reservoir rocks.

Conditional values are boundary values of properties of hydrocarbon-saturated rocks that divide them into reservoirs and non-reservoirs, and also reservoirs with different field characteristics. These limit values are also called lower limits of productive reservoir properties (porosity, permeability and oil saturation). Objects that have parameters below the conditional are not included, and we simply do not take into account.

In the classification of 2001 the concept of balance reserves was absent and was automatically replaced by geological reserves, which was a gross mistake of the authors.

Especially evident this error in the calculation of reserves in carbonate formations, when thickness of only conditional layers is counted, whose share in oil-saturated part of the deposit (thickness from top to bottom of the formation or oil-water contact) – is referred to as oil-saturated thickness, in different deposits it is from 20-30 to 70-80 %.

This thickness is called the effective oil-saturated thickness. But the reserves development of involves the entire carbonate array. This leads to a significant underestimation of reserves and inadequate design of development technologies (Muslimov, 2016 e) (Figure 2).

Approximately the same position is for clastic strata, but here it is more hidden.

Existing methods of geological modeling and reserves estimation involve studying only that part of oil resources, which is extracted by conventional methods. At that, it is considered to be obvious that for reservoirs with parameters below the ‘conditional’, oil is not extracted at all. This oil is excluded from consideration in the reserve calculation stage. As a result, to date geological oil reserves are not known on any object.

In the development of deposits with the use of horizontal wells, ‘drainage architecture’ of the formation is changing dramatically, filtering surface is greatly increased; there are mechanisms of interaction between the fluid and the reservoir.

There is reason to assume that part of ‘unconditional’ oil will be involved in the development. On this basis, we believe that at the stage of geological modeling it is necessary to abandon the traditional consideration of only the balance reserves and study the characteristics of distribution of oil resources in the formation. In this case it makes sense to consider the strata as the entire hydrodynamic system that incorporates all, without exception, oil-saturated, weakly oil-saturated, water-saturated and tight interlayers.

In view of the above, there is a need to reassess the geological oil resources as balance and recoverable

reserves in an old, steady sense leave behind unconditional reserves, and they, according to preliminary estimates, could amount to 15-20 % of the approved ones. Thus, the geological reserves should mean the entire amount of oil that is in the depths, regardless of whether it is possible today to extract (Muslimov, 2016 c).

This approach will increase the total resources and decrease the value of oil recovery factor. It seems appropriate to develop a methodology for calculation of geological reserves in view of the huge progress in the West in the field of geological exploration and existing experience for extraction of hydrocarbons from tight rocks (or even shale).

According to the concept of effective pore space, petrophysical relationships are necessary to be built on the results of realistic factors of effective permeability and effective porosity, because the degree of reliability of petrophysical relationships within the concept of effective pore space is significantly higher than in the concept of absolute pore space. Then it is then obvious that the accuracy of logging data to build 3D models will be much higher (Zakirov et al., 2009).

But to prepare information is not enough to build such models of currently used methods. First of all, it is necessary to significantly strengthen laboratory research of rocks and fluids saturating them. Until recently, we didn’t have necessary equipment. Today, at least the Kazan Federal University has it.

Next problem is justification of oil recovery factor and measures for its increase, which is very important for the late stage of development, which is relevant for almost all the important fields in the Russian Federation.

The fact is that the whole vast amount of commercial, geophysical, hydrodynamic researches and analysts to build a geological and hydrodynamic models was limited to determining the extent of flooded areas and reservoirs, ultimately, to defining waterflood sweep efficiency K_{sw} . At the same time displacement coefficient K_d was defined during the initial resource estimation by laboratory methods.

It was determined by pumping water through the core, as is written in all the textbooks by “endless washing of the formation”. There were no doubts in the determining the displacement coefficient. But with the accumulation of experience in the development, we noticed that the washed sections obtained in some cases very high values of displacement coefficient. In taking these values of K_d , in laboratory data K_{sw} had to be

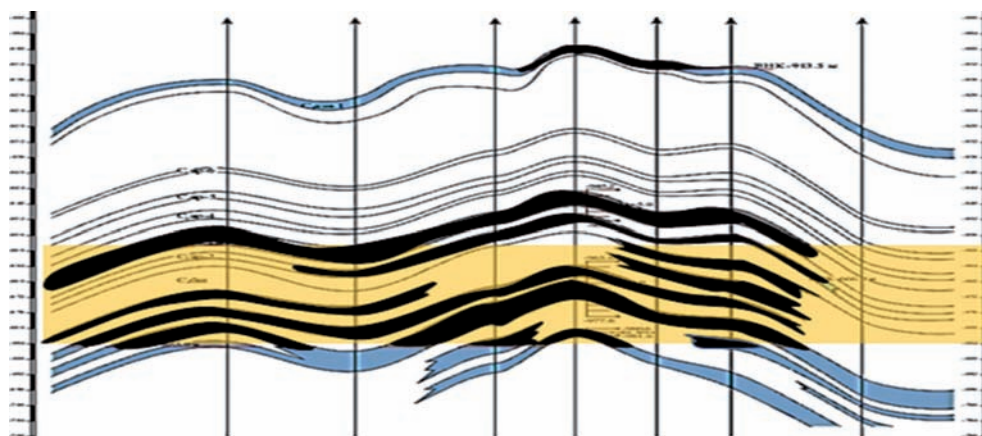


Figure 2. Berezovsk field. Schematic geological profile of productive deposits of the Middle Carboniferous.

close to one or more, which in the conditions of real heterogeneous reservoirs is impossible.

Solving the problem of the reliability of displacement coefficient laboratory determination and transferring it to the commercial terms have not yet succeeded. A paradox: for the cores we have a maximum value of K_d ('endless washing'), and in real formations it is more.

The paper (Zakirov et al., 2009) made the following conclusions: "In contrast to the common point of view, it is argued that determined on the basis of laboratory experiments values of oil displacement efficiency by water are underestimated in their magnitude".

We can make a fundamental conclusion: in most cases, we have underestimated displacement coefficient, thus the analysis of oil recovery factor in depleted areas overstates displacement factor, i.e. on the basis of which the major (at least 80-90 %) geological and technical measures are performed. To achieve the project oil recovery factor we need to increase the volume of geological and technical measures in order to achieve the project displacement coefficient. So we need to drill more wells and more influence on the reservoir. Oil recovery factor in this case will be higher than those obtained currently in development design.

Simultaneously it is necessary to organize a broad discussion on the rational and optimal development of hydrocarbon deposits.

For the first time the term rationality was formulated by Academician A.P. Krylov as "...achievement of a given oil production at the lowest cost" (Krylov, 1955). This criterion of rationality has existed for more than half a century.

Then, in 1986, the Central Commission for the development of oil fields formulated another criterion of rationality, which is to ensure the national economy's demand for oil at the smallest possible national economic costs and more complete extraction of oil from the subsoil.

In Soviet times, in accordance with the accepted criteria principles were formulated of rational development of oil fields, which have played a positive role in the exploitation of deposits (Shchelkachev, 2004).

During the years of market reforms a lot of problems have accumulated related to the replenishment of the mineral resource base, irrational use of mineral resources, causing irreparable harm to the development of the country's most important oil fields.

The absence of a common formulation of rational development of oil deposits in the market conditions is non-allowable phenomenon. If we don't have it, then, the targets are not designated, which to be achieved at the development of oil fields.

Justification of the initial Criterion was given by (Muslimov, 2003; 2014 b). In the latter work the wording was as follows: "the development of each of the oil

(gas) field should be designed on the modern scientific and technological base, realized with modern scientific support, providing maximum profit at acceptable for the subsoil user payback of capital investment, achievement of the approved values of the current and ultimate oil recovery, observance of protection of mineral resources and environment, and should continue creating favorable conditions for the continuous improvement of production processes in order to achieve maximum economically allowable oil recovery".

In today's clarified version, it is as follows: "a rational system of development of oil (gas) field and arrangement of fields is deemed to be a system, which is designed in a modern scientific, technical and methodological basis, has passed the state examination, discussion and approval by the Central Committee on Resources and the State Committee on Reserves, is implemented by modern scientific support and government control, provides a balance of interests of the population, in particular, of the local population, as well as the subsoil user, compliance with environmental and subsoil protection requirements, the "Law on Subsoil" and regulatory documents, as well as positive social impacts and guarantees" (Zakirov et al., 2015).

Optimality criterion of field development in the market economy has closed on the NPV (net present value). In modern conditions it is not enough. It is known that the value of NPV, payback period costs depend on oil prices in the international and domestic market. Recent events convince anyone that there is no reason for the absolute priority of the most important component in the value of NPV – the oil price.

Subsoil users need high profit and a faster payback, and for population – long receipts from the exploitation of deposits (greater oil recovery factor). Therefore, in general, optimization of production and maximization of oil recovery is needed. This should be addressed at the design stage and examination of documents to develop the field on the principles of rationality.

In addition, each of the main economic criteria (NPV, IRR, ID, QAP) is not sufficient to select the option of field development. This decision should be made based on the values of integral indices in the interests of all stakeholders (government, including regions and municipalities, investor, subsoil user). Main stages and principles of the rational oil field development for design purposes are shown in Table 1.

Today, few people think about the question of how Russia should produce oil. Today, the strategy of oil production prevails "as much as possible".

Different figures are given of oil production in the future – one more than the other. However, there is no rigorous scientific justification.

Based on the level of oil consumption in the US and other developed countries, it would be possible to

1. The harmonization of economic interests of the government and business
2. The innovative design of development systems:
2.1. Creation of real geological model using modern research methods, including at the nanoscale;
2.2. Selection of adequate geological structure of development technologies and EOR;
2.3. Designing with consideration of man-made changes in the characteristics of fields in the process of development;
2.4. Creation of a unified geological and hydrodynamic model that takes into account the availability of unconditional and possible permeability of interstratal sections;
2.5. Economic justification of design decisions.
3. Management of oil fields development
4. Implementation of modern technologies to ensure optimum dynamics of oil production and project oil recovery factors
5. The economy of oil field development:
5.1. Limit of object operation (limits of production profitability) under the current taxation system;
5.2. Tax incentives to ensure approved oil recovery factor;
5.3. Optimum rate of return;
5.4. Provisions for environmental protection of subsoil and environment.

Table 1. Main stages and principles of rational development of oil fields (by R.Kh. Muslimov).

identify the maximum level of oil production in Russia for the long term and to focus on its implementation in the ways of resource innovative development.

Excessively high levels of oil production do not make our people happy. Rather, it creates preconditions to deepen Russia's recurring economic and global crisis. This is very clearly written by E.T. Gaidar in his book "The Fall of the Empire". Let us remember the sad experience of the former USSR, which had the first place in oil production, and the level of life significantly lagged behind the developed countries.

However, to ensure an optimum level of oil production in view of the current threats to Russia we must on some kind of short period try to keep the oil at the level of 500 million tons. This is possible to implement with great potential of the Russian Federation, but at very great effort and radical change in the development strategy. The government must create favorable conditions in the oil subsoil use, fully adopting the US experience in licensing, access to the subsoil, planning, taxation, incentives and co-financing of significant industry projects, approach to innovation with the creation of innovative development environment, preparation of new and modernization of the existing regulatory documents on the full range of oil and gas subsoil use issues and performance monitoring.

The creation of such an intellectual environment with the support of the government innovations will contribute to the development of new (including high) technology in exploration, oil production and oil recovery enhancement in the specific geological and natural conditions of Russia. We should purchase modern development and production facilities and equipment (those that are not produced in Russia). Our science and specialists of oil companies can still perform this task.

However, today officials in the government, obviously, cannot perform the first problem: the creation of regulating subsoil documents, rules, regulations, stimulation of innovation and high technology. This is evidenced by the formation of new Russia for quarter of century. They will need to be changed. Fortunately there is some reserve in the bottom. It is a time when we can predict that if all this will not be done, the production in Russia inevitably falls. But its decline to level less than 400 million tons per year cannot be allowed for safety of Russia.

Most analysts of the Russian Federation have a clear understanding of the need to strengthen the works on oil and gas processing for the absolute increase in its volume and depth of processing. This will provide the desired economic effect at much lower production volumes. And here, as is usually done in Russia, we continue to talk a lot on this subject, but do almost nothing.

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