The New Classification of Reserves and Resources of Oil and Combustible Gas – Movement Onward or Backward?

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Abstract. The new classification of reserves and resources of oil and combustible gas is officially introduced since 2016. The paper evaluates the advantages and disadvantages of the new classification and compares it with previous existing classifications of reserves in the Russian Federation, as well as with the similar major classifications of the Western countries. The author evaluate the usefulness and relevance of the new classification in the approval process and the use of oil reserves. The conclusion is made that the new classification and accompanied documents will not improve but worsen the situation in the Russian subsoil use, methods of calculation and accounting of reserves, and reliability of field development parameters. A more rigid approach of the Soviet era is replaced by a formal liberal one; the degree of reserves reliability is substantially lower, economic calculations are complicated and highly bureaucratized with no apparent need; labour content and complexity of procedures increases considerably. The classification essentially withholds the fundamental problems (the concepts of absolute and effective pore space, geological and balance reserves, the ideology of building geological and hydrodynamic models). The new classification does not solve urgent issue of placing reserves into different categories according to their possible cost-effective and efficient development, namely placing hydrocarbon reserves in hard-to-recover and (or) unconventional, the development of which requires the use of new, more expensive technologies and fold increase in capital and operating production costs.

Keywords: categories of reserves and resources, new classification of reserves, geological, balance, recoverable oil reserves, reserves difficult to recover, unconventional oil deposits, geological, geological and hydrodynamic models, the state commission on reserves, oil companies.

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There are 150 classifications in the world of resources of energy commodities, built on different parameters and different interpretations of the same terms. Naturally, this causes confusion and discourages potential investors to participate in projects of development of deposits.

To solve this problem, the Economic Commission for Europe about 10 years ago proposed the development of an international United Nations Framework Classification for the fields of solid fuels, uranium and hydrocarbon crude, which was implemented. The UN countries currently use the Framework Classification for Fossil Energy and Mineral Reserves and Resources of 2009 (UNFC-2009). It is a universal system in which quantities are classified on the basis of three fundamental criteria: economic and social viability of the project (E), status and validity of the field development project (F), and geological knowledge (G), using a numerical code system. Combinations of these criteria provide three-dimensional system.

In the US, at the same time there are several reserves classifications: Classification of the Securities and Exchange Commission (SEC), Classification of the Society of Petroleum Engineers (SPE), classification of the American Association of Petroleum Geologists (AAPG), and others.

In Russia, the main issues of functioning of the oil and gas industry are solved by a single reserves classification. Prior to 2016, "Temporary Classification of field reserves, perspective and inferred resources of oil and combustible gases" of 2001 was valid. It established uniform principles for the Russian Federation of calculation and state accounting of field reserves and prospective resources of oil and combustible gases in the subsoil according to their degree of knowledge and economic significance, conditions that determine the readiness of the explored fields for industrial development, as well as the basic principles of assessment of inferred oil and gas resources.

Prior to that, classification of the Soviet period successfully worked, which was approved in 1983. It provided common principles of accounting oil and gas reserves in the subsoil by categories based on the degree of knowledge of these reserves and their readiness for commercial development. It has stood the test of time and was a document that optimized accounting and reporting for the Russian Federation reserves. But then, in order to bring the Russian classification of reserves to the western standards new classification has been developed and adopted, "Classification of reserves, perspective and inferred resources of oil and combustible gases", which supposedly maintains continuity with the current classification for the allocation of categories of resources and reserves a t the level of geological knowledge and confidence. In it, oil and gas reserves are classified by the degree of geological exploration, industrial development and economic efficiency of development.

The new classification of reserves had to be implemented in 2009. But for transition it was necessary to conduct an audit of the reserves balance in all oil and gas fields of the country with hydrodynamic and economic calculations on the accepted categories. This great work was physically impossible to carry out in due time. But there was nothing wrong with that. The transition to the international classification is needed mainly to attract foreign investment. But even in the absence of Western sanctions against Russia, investments attracted a limited number of oil companies, which held annually inaudit of reserves by well-known western consulting companies, by the results of which Western banks were granting a credit.

Our classification of the Soviet era provided the necessary accuracy for oil companies and the government of reserves and resources of oil and gas. In this respect it is more progressive and would continue to function. There was no need to change anything. Those oil companies who want to attract foreign investment, may do so by conducting audit of reserves by Western companies. Nevertheless, it had to be done regardless of transition of Russia to the new classification. But due to the introduction of Western sanctions against the Russian Federation currently the matter was dropped.

Therefore, there was no rush in the introduction of new reserves classification. However, the higher authorities thought otherwise and without sufficient study, expertise and extensive discussion adopted the new reserves classification and introduced it into effect from 2016. They did not even have time to prepare the necessary documents on the project of the State Commission on reserves for the implementation of the new reserves classification.

In Soviet times, there was the notion of balance reserves, which stood out from the geological reserves, using the so-called conditional values of reservoir rocks. Conditional values are limit values of properties for hydrocarbon-saturated rocks, dividing them into reservoirs and non-reservoirs, as well as reservoirs with different field characteristics. These limit values are also called lower limits of productive reservoir properties (by porosity, permeability and oil saturation). Objects that have parameters below conditional are not included, and we simply do not take them into account.

In the classification of 2001 the concept of balance reserves was automatically replaced by geological reserves, which was a gross mistake of the authors (Zakirov and others, 2006; Muslimov, 2003).

At present, the State Commission on reserves is not ready for drastic changes in matters of reserve calculation. But at the design of development, we still need to proceed from the fundamental principles of geology.

In 1933, on the basis of studying the characteristics of productive strata regimes of Novogroznensky region, V.M. Nikolaev made an important conclusion that every oil reservoir should be regarded as dual physical field that combines several physical fields, and particular importance should be given to the study of pressure, temperature fields and hydraulic regime of the strata : "... the study should not be limited only to the oil-bearing area, it is necessary to study the entire hydraulic system, which must have a beginning and an end." Thus, one of the main points underlying in the "new approach" to the geological and reservoir simulation, was stated more than 70 years ago, and, as noted by V.N. Shchelkachev, this idea of V.M. Nikolaev, while being advanced, still lies in the foundation of the modern petroleum science.

American geologists on the results of geological and hydrodynamic analysis of oil production facilities in the 1960-1962 showed that liquid system in the sedimentary complex is a continuous medium. The flow of liquid through the sedimentary section should be evaluated for all kinds of rocks, regardless of their capacity, that is, from highly permeable to the least permeable clays. Therefore, there is no need to draw the boundary between the permeable and impermeable rocks. Indeed, with new technologies, modern techniques of well completion, hydraulic fracturing etc. it became possible to produce hydrocarbons in the industrial scale from rocks that were previously considered impenetrable. This was brilliantly confirmed by oil and gas revolution in the United States.

VNIIneft conducted in 1980 on the Uzen field studies of cumulative distribution curves of permeability for receiving and non-receiving reservoirs and separately for productive horizons and jointly for all of these horizons. They have convincingly shown that virtually all rocks are linked with mutual transitions, and that there is no sharp boundary between reservoir and non-reservoir.

In view of the above, there is a need to reassess the geological oil resources as balance and recoverable reserves in the old sense leave behind unconditional reserves, and they, according to preliminary estimates, could amount to 15-20% of the approved reserves. Thus, the geological reserves should mean all the amount of oil that is in the depths, regardless of whether it is possible today to remove from the interior or not (Fig. 1). As can be seen from Fig. 1 such an approach total resources will increase and value of oil recovery factor will decrease.

It seems appropriate to develop a methodology for calculation of geological reserves in view of the huge progress in the West of geological exploration and extraction of hydrocarbons experience from dense rocks (or even shale); in order to avoid registration of unconditional by today's standards reserves, we should recall that earlier oil and gas fields on the economic significance were divided into two groups, subject to a separate accounting: balance reserves, involvement in the development of which is now economically feasible, and off-balance reserves, the involvement of which currently economically impractical or impossible technically and technologically, but which further with the development of technologies can be transferred to the balance reserves.

Currently, this term, unfortunately, is not used. In this case, we will not put on record inflated reserves. But in the total

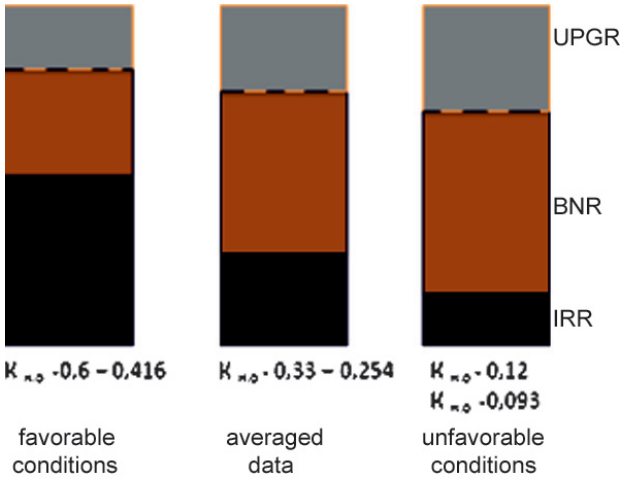


Fig. 1. Schematic representation of geological balance and recoverable oil reserves.

balance unconditional reserves will be as object of activity of oil company to conduct R&D and pilot development and find ways to extract them (the so-called off-balance reserves). With the new technology created we could translate them into the category of balance reserves, and then extract. This approach will help to improve the efficiency of drawing up development projects.

Advances in the development of oil fields will be more significant if we radically change the ideology of geological and then geological and hydrodynamic models. Models practiced today do not take into account geological features of the accumulation and transformation of sediments and the formation of oil deposits.

S.N. Zakirov (Zakirov et al., 2006) rightly considers wrong the ideology of building models. In his opinion, guidance documents require to not include "non-reservoirs" into 3D geological models. That is, all (almost all) created 3D geological models in the country are defective. Since they distort geology of fields manually. This was have repeatedly written (Muslimov, 2003; 2012; 2014).

Fig. 2 shows the new models of the horizon D1 of Romashkino field: with justified in a number of papers (Khusainov, 2011; Afanasiev et al, 2011) conditional values of reservoir rocks (permeability> 1 mDa, porosity <11, content of pelitic fraction> 0.20), we obtain a model (Figure 2b), and taking into account all the so-called dense partitions – completely different model (Figure 2c).

The construction of such models is of particular importance for carbonate rocks. Currently used methods of building models for reservoir intervals from the roof to the oil-water contact account only part of the so-called effective oil-saturated thickness of reservoir rocks. This part in different conditions ranges from 20 to 75-80 % of the total oil saturation thickness. Oil is in almost entire thickness of the rocks. But most importantly – researches conducted in Tatarstan have proven active participation of so-called dense partitions in filtration processes (Khusainov 2011; Muslimov 2014).

In modern conditions it is time to move on to the next level of calculating indicators of development.

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

According to the concept of effective pore space (EPS) (Zakirov et al., 2006), it is necessary to built petrophysical relationships on the results of determining the actual coefficient of effective permeability and effective porosity, because the reliability of petrophysical relationships within the EPS concept is significantly higher than in the concept of absolute pore space (APS). Then it is obvious that the accuracy of logging data to build 3D models will be much higher.

In our opinion, we need to change the ideology of building models, taking into account the allocation of geological, balance, off-balance, and recoverable reserves. But to build such models it is not sufficient to use current methods for the preparation of information. First of all, we need to diversify and deepen the laboratory research of rocks and fluids saturating them, as well as improving logging techniques.

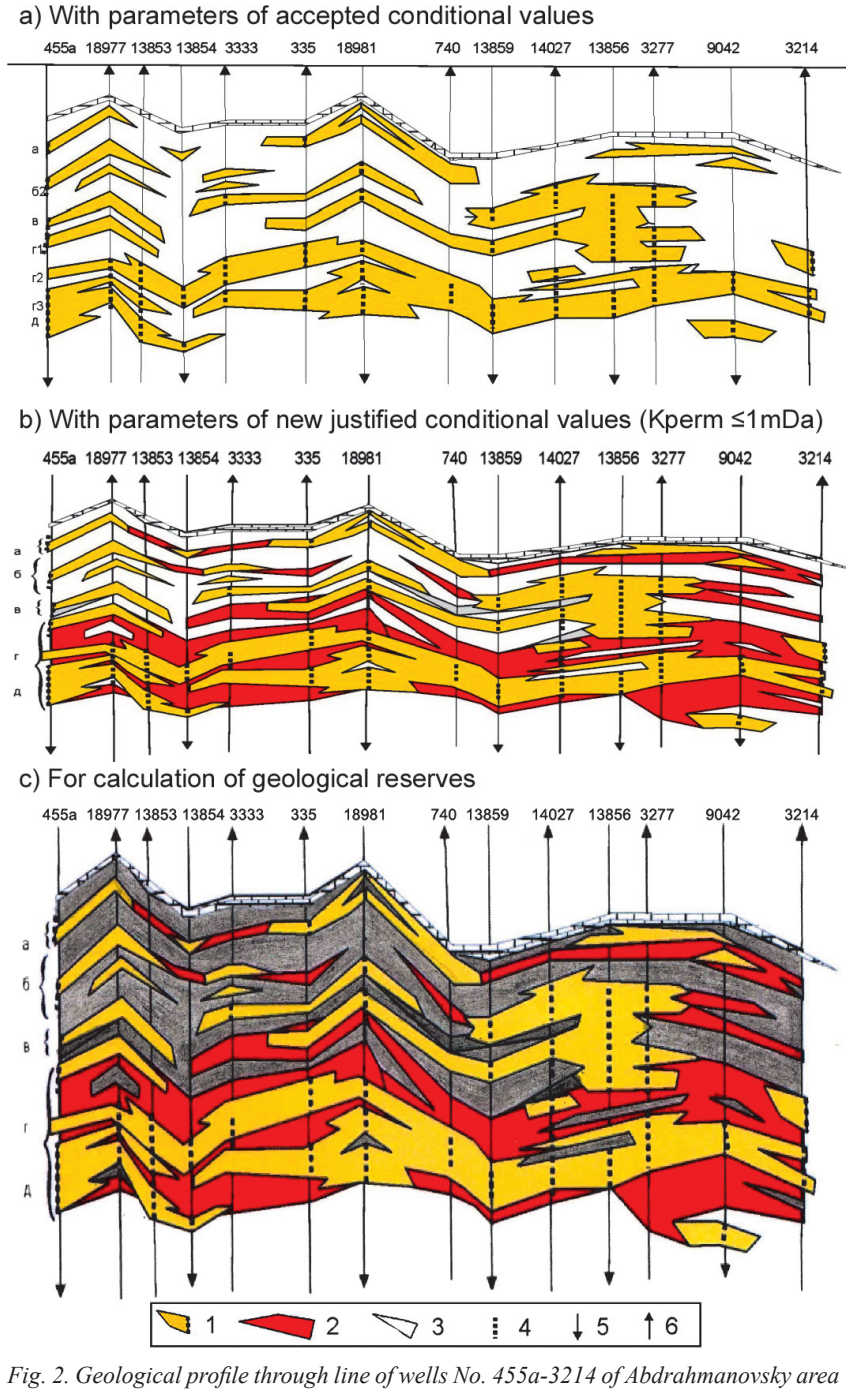
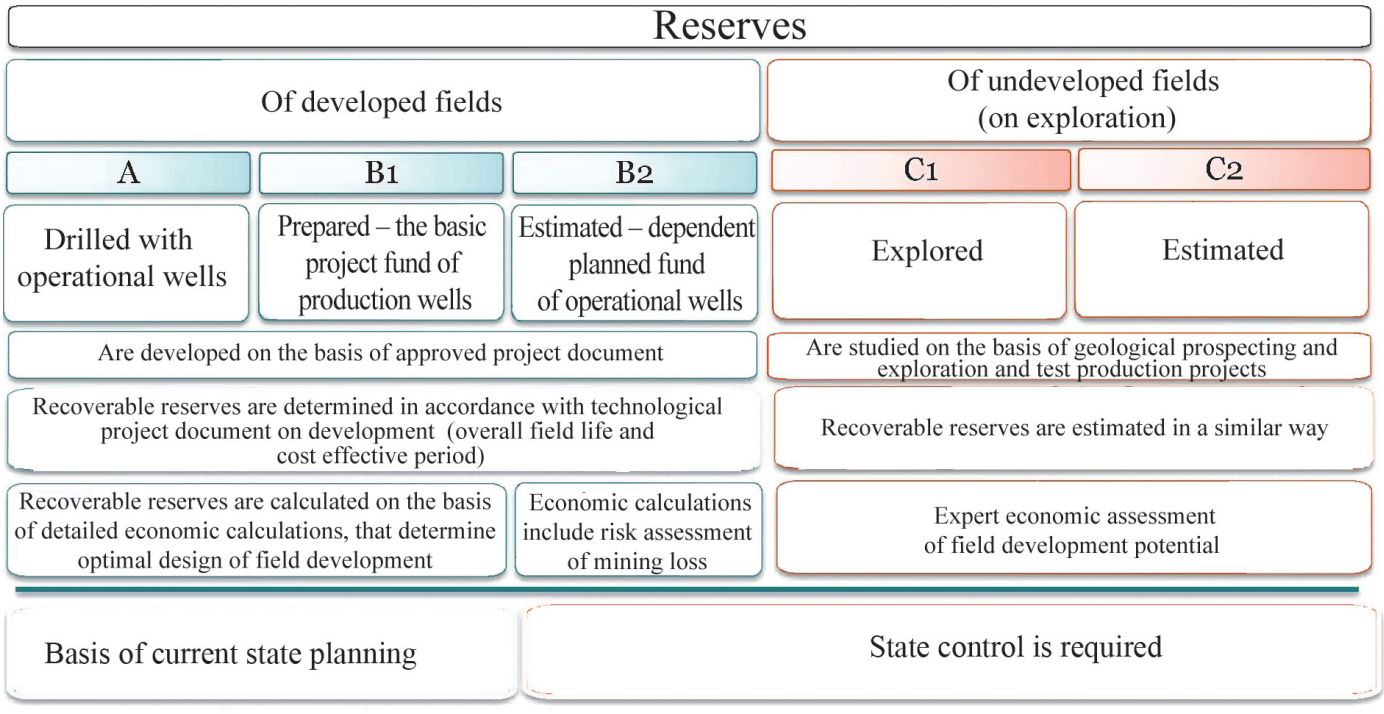


Fig. 2. Geological profile through line of wells No. 455a-3214 of Abdrahmanovsky area of Romashkino field. 1 - Reserves with parameters of officially accepted conditional values (Kperm ≤30mDa); 2 - Reserves with parameters of new justified conditional values (Kperm ≤1mDa); 3 – Not accounted oil-saturated rocks; 4 -Injection well; 5 - Production well.



Basis of the new classification of reserves is an economic assessment of hydrocarbon development potential, accomplished in different detail in accordance with the field exploration status.
New classification allows to separate two types of recoverable reserves:
- Technological, allowing for full field (deposit) development,
- Economic reserves – period covering viable field (deposit) exploitation.

Fig. 3. Basic principles of the new reserves classification of hydrocarbons (by I.V.Shpurov).

The above relates to the fundamental provisions. Probably, we will not immediately solve them and move to the new models. But it is time to set out the problem and work on it. Compared to the Soviet period in the practice of oil reserves approval, there has been a trend of weakening attention to authenticity of oil reserves taken into balance. This results in a lighter attitude toward C_2 category. In the design of development and reports on growth of oil reserves, as a rule, all reserves of categories A + B + C_1 + C_2 are accounted. But the category C_2 is considered as pre-estimated. In practice, the conversion factors in the C_2 category reserves are higher (verifiability rates) up to the different conditions from 0.4 to 0.7-0.8, and sometimes higher. Earlier the category C_2 was treated more gently – it

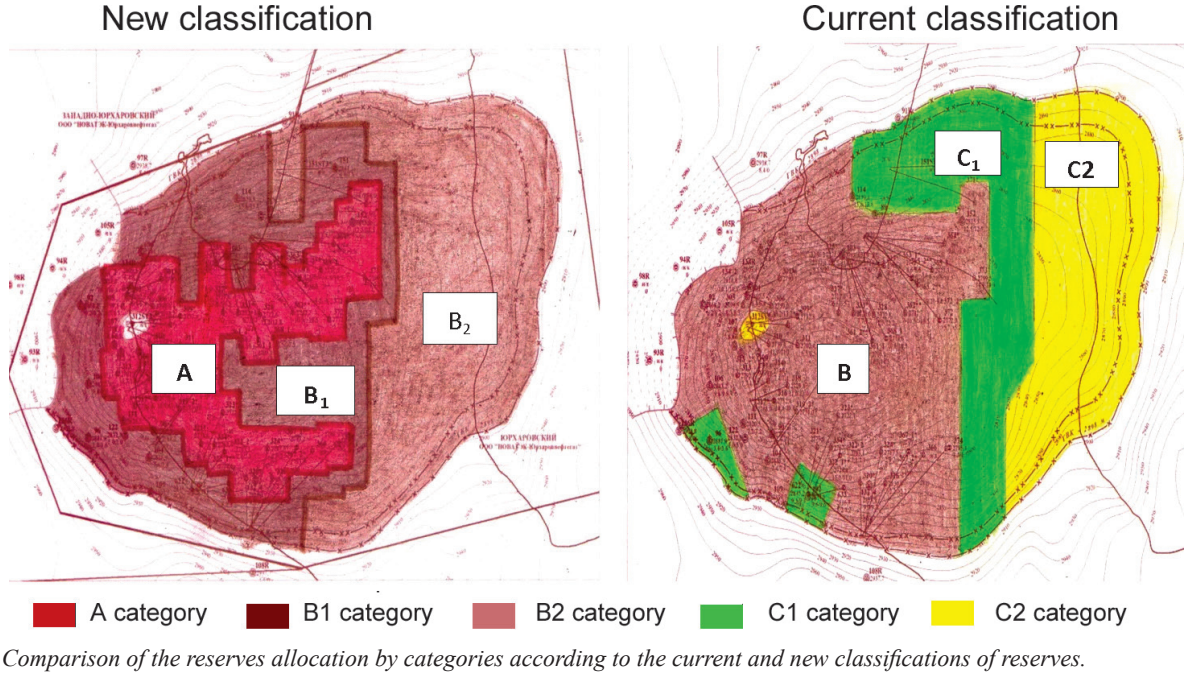


Fig. 4. Comparison of the reserves allocation by categories according to the current and new classifications of reserves.

	Russian Federation	Current classification of reserves – Russian Federation		New classification of reserves – Russian Federation		Western classification of reserves
Reserves	Explored	A	Drilled with operational wells, developed	A	Drilled with operational wells	Drilled, developed
		B	Drilled with operational wells	B_1 B_2	Prepared – the basic project fund of production wells Estimated – dependent planned fund of operational wells	Undeveloped
		C_1	Exploration wells are drilled	C_1	Explored	Marked
	Preliminarily estimated	C_2	In contour deposits, adjoined to areas of higher categories	C_2	Estimated	Probable (calculated)
Resources	Prospective	D_0 (C_3)		D_0		Possible
	Expected localized	$D_{1Л}$		$D_{1Л}$		Hypothetical
	Expected	D_1		D_1		
		D_2		D_2		Theoretical

Table 1. Comparison of old and new Russian classification of reserves and their comparison with Western analogues.

was allowed to design reserves, when the proportion of C_2 did not exceed 20% of the total reserves received for the design. The State Commission on reserves was tougher on accepting reserves of C_2 category. This provided higher reliability of the resource base for the planning; especially design of the development of specific fields.

However, the assessment of the reserves reliability in the new reserves classification is even more reduced. Fig. 3 shows the basic principles of the new reserves classification (According to I.V. Shpurov). There reserves of category A are in the areas drilled with operational wells. It seems that the same requirement remained in the new reserves classification. But in the old sense, and in the western classifications the concept of developed areas was added to drilled areas. Practice and experience of development shows that not all reserves drilled by project wells are produced. Depending on the complexity of geological structure of drilled area at full introduction of the waterflooding system, 50-80 %, rarely more percent of reserves are involved into the development. 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 had always been considered in the areas actually drilled by project well grid. In the new reserves classification we have more than a vague concept: B1 – prepared – the basic fund of production wells and re-allocated category B2 – estimated – dependent fund of operational wells (while it is not quite clear what dependent fund is). Therefore to category B we can include areas where design well point are marked on the map, and not actually drilled. Based on the development experience, confirmation of design reserves with actual drilling out is 70-80 %, less – up to 90-100 % (depending on the geological complexity of the area). Categories C_1 and C_2 are even more uncertain. In fact, reserves of categories B_2, C_1, C_2 according to the new reserves classification can be attributed as B1, without conducting any work on the field, but simply placing the project wells on paper (Fig. 4). The Western countries more accurately refer to the categories C_1 and C_2, as well as perspective and inferred resources (Table 1).

Even greater difficulties arise with the economic assessment of reserves. The economic assessment of recoverable reserves of categories A, B1, B2 is required as part of the coordination of each development option of the operational facility. According to the analysis of JSC Neftekonsortsium, the appendices contain 37 tables on economic evaluation, in three options (37*3) = 111 tables on a single object. And if they are 5, then there will be 555 tables only by industrial categories. If we take Romashkinsko field with 15 productive horizons and with development period up to 2150, it turns to be 1665 tables (about 70,000 pages). For typical for Tatarstan small deposit (5 million tons of the initial recoverable reserves) there should be 555 tables. Preparing data for 37 economic tables and carrying out economic calculations will require a long-term operation of the subsoil user and designers, multiple appreciation of the work.

Instead of reducing administrative barriers and reducing the time of work on the documents we obtain an increase in terms and a multiple increase in the cost of works.

Table 2 shows our assessment of the usefulness and relevance of the new classification on reserves for the approval and use of oil reserves. 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 calculation and accounting of reserves and the reliability of calculating development parameters.

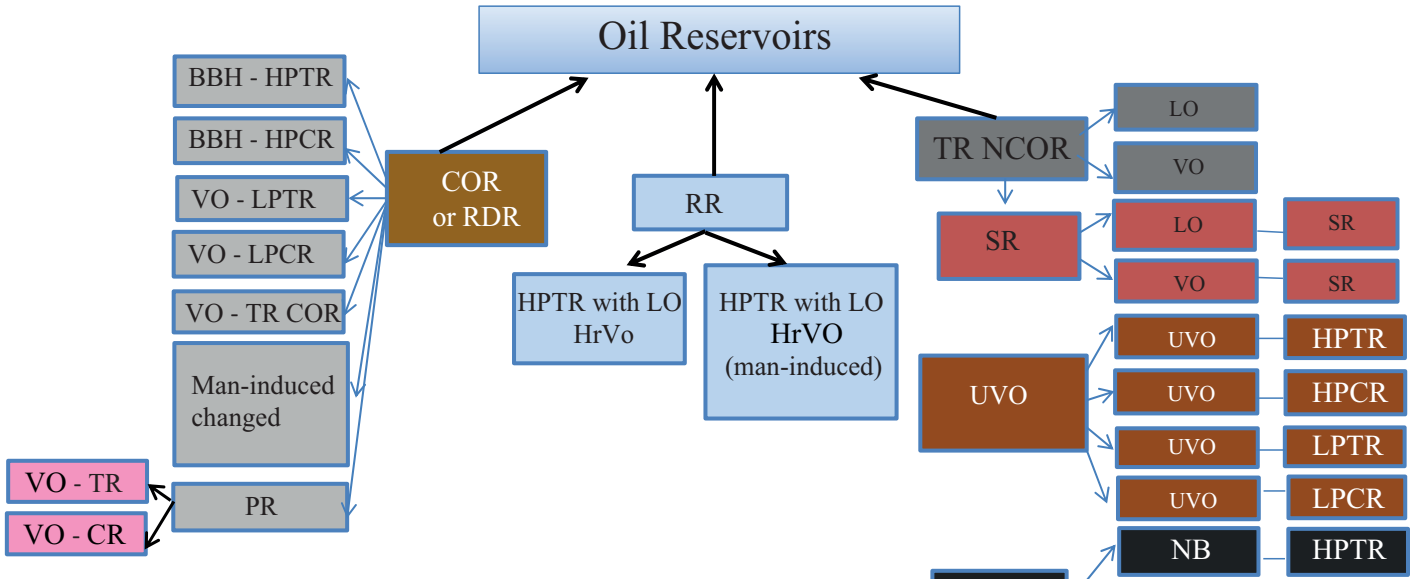
The new reserves classification does not solve topical issues of development of the oil industry, namely, placing reserves into different categories according to their possibilities of cost-effective and efficient development. Here we are referring to the assignment of hydrocarbon reserves to difficult to recover and (or) unconventional, the development of which requires the use of new, more expensive technologies and multiple increase of capital and current production costs.

On the basis of the new classification on reserves it is required to develop a classifier, which would give a clear definition of the various concepts (reserves difficult to recover, unconventional reserves, ets.). The revised terms would form the basis for the creation of new techniques and technologies.

The classification issue is not only of a scientific and technical nature. Without its solution it is impossible to build strategic plans for development of the industry, as well as the development of oil companies themselves. But other than that, the classification is necessary for government agencies to establish tax regimes that provide input to the development of deposits with reserves difficult to recover, unprofitable under the current taxation. At the end of the last century the Russian geologists have undertaken a number of efforts to develop a classification for the tax authorities.

According to the classification developed 20 years ago in 1994 year by N. Lisovskoy and E. Khalimov, four criteria were allocated for classifying reserves as difficult to recover. They are: viscosity (30 cps at reservoir conditions), the presence of low permeability reservoirs (below 0.03 darcy), depletion (over 70%) and regional coefficient (in the range 1, 2) (TrIZ: turn the brain on?.., 2014) . This classification caused great objections of experts and therefore was not accepted.

Today, the Tax Code contains very different values, allowing to rank deposits to reserves difficult to recover: viscosity – 200 cps, permeability – 2 mDa, depletion – 80%. Regional coefficient is replaced by a list of specific areas in which reserves can be considered hard-to-recover. Today it is possible to recognize that such criteria are not scientifically justified.



COR – Conventional oil reservoirs
NCOR – Non-conventional oil reservoirs
RDR – Reserves difficult to recover
HPTR – Highly-permeability terrigenous reservoir (TR)
HPCR – Highly-permeability carbonate reservoir (CR)
LPTR – Low-permeability terrigenous reservoir
LPCR – Low-permeability carbonate reservoir
NCR – Non-conventional reservoirs
TR COR – Tight reservoir COR (non-economic) permeability above 1 mDa
PR – Problem reservoirs
TR NCOR – Tight reservoir NCOR, permeability below 1 mDa
SR – Shale reservoirs
LO – Light oil (viscosity below 10 centipoise)
HrVO – Higher viscosity oil (viscosity 10-200 centipoise)
HVO – High-viscosity oil (viscosity 200-1000 centipoise)
UVO – Ultra viscous oil (viscosity 1000-10000 centipoise)
NB – Natural bitumen (viscosity >10000 centipoise)
VO – More than 20 centipoise viscosity oil

Fig. 5. Classification of oil fields with reserves difficult to recover, conventional and non-conventional oil (by R.Kh. Muslimov).

The benefits of the new scheme of reserves approval according to the New Classification of Reserves (by Shpurov I.V.)	The actual impact of the New Classification of Reserves on the approval process and reserves use (by Muslimov R.Kh.)
It provides the basis for the current and medium-term state planning of the raw material production levels	Tough approach to the reserves approval of the Soviet era is replaced by a less strict (volatile) in the new classification (categorization is unreasonably overstated – drilling with production wells does not guarantee involvement in the development of drilled reserves; projected coverage of reserves by project wells grid does not guarantee confirmation of reserves based on actual results, and designation of current reserves C_1 and C_2 as the B_2 is generally incorrect. The basis for the development design does not guarantee the necessary level of production planning.
It creates a basis for scientifically justified mechanism for promoting the development of reserves difficult to recover.	It is not clear - at the expense of what? To address this issue, special geological and commercial classifications are required, depending on the geological conditions of the regions and (or) regulations.
Reduction of administrative barriers - implementation of a single-window principle.	Due to what? The volume of materials has increased multiple times.
Reliable geological model is the basis of design solutions.	Reliable geological model can be obtained only on the results of drilling by the project wells grid, development of waterflooding system, analysis of the development of reserves. Practical volume of recoverable reserves often does not correspond to the project one.
The volume of recoverable reserves corresponds to the actual volume according to the Project technical documents for the development of fields.	**Long overdue positive decision.**
The concepts are applied - technologically recoverable reserves and recoverable reserves for the cost-effective development period.	These concepts are present in the projects for a long time. But in today's volatile conditions (especially in Russia) for determining parameters (price on the world and domestic markets, permanently changing legislation on subsoil use, taxes, inflation, expenses, etc.) it does not make sense.
Time for the documents preparation is significantly (by 40%) reduced.	**It has increased substantially**
Recoverable reserves are harmonized with international classifications and can be used as a basis for decision-making on investment in the development of fields	Harmonization with international classifications is not visible; it is not possible to use it for justifying investments.
Conclusion: A more rigid approach of the Soviet era is replaced by a formal liberal one; the degree of reserves reliability is substantially lower, economic calculations are highly bureaucratized and complicated with no apparent need, the cost and the complexity of procedures increases considerably. Classification is essentially silent about the fundamental problems (absolute pore space, effective pore space, geological and commercial reserves, construction ideology of geological and hydrodynamic models)	

Table 2. The so-called benefits of the new scheme on reserves approval.

In order to solve practical problems of development of the industry we need to have workers of classification, allowing purposefully carry out work on the development of new technologies of reservoir development and application of methods for enhanced oil recovery.

These classifications have been developed in Tatarstan for the past 30 years.

The latest classification is developed by R.Kh. Muslimov (Fig. 5). Such classifications should be developed for the major oil regions, as they may reflect the specifics of the geological structure of deposits in different regions, since it is different. However, for the public use and issues of referring hydrocarbons to reserves difficult to recover and unconventional reserves, for the purpose of tax incentives we need to develop criteria for placing reserves into different categories. This will help to create for them different taxation systems and solve the problem of supplying Russia with oil and gas.

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