Field classification of fractured reservoirs of crystalline basement

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Abstract. Development of oil and gas deposits in fractured reservoirs entails certain risks due to peculiarities of geological structure. Classification and identification of fractures in reservoirs is of high-priority importance and makes it possible to assess the impact of both fractured systems and matrix blocks on field development parameters.

This article presents the results of statistical and qualitative analysis of the influence of fracture systems and fracture heterogeneity to classify reservoirs in crystalline basement granitoids using the example of the White Tiger (Bach Ho) and Dragon (Rong) fields located on the southern shelf of the South China Sea (Viet Nam). Field classification of fractured reservoirs is based on a well-marked difference in parameters between wells within a field, due to fracture heterogeneity. In order to solve the tasks set, construction and analysis of graphs of well performance parameters distribution (productivity, flow rates, accumulated indicators, etc.) as well as Lorenz curves were carried out. According to the results, all the objects under study are characterized by asymmetrical shape of distribution curves, which indicates a significant influence of fracturing.

Based on the calculated values of the fracture influence coefficient, it is found that fractured reservoirs in crystalline basement, as a first approximation, belong to type 2. This fact is inconsistent with the earlier works on crystalline basement, in which rocks are classified as reservoirs of type 1. Such contradiction is explained by the fact that the microfracture systems and the blocky low-permeability part exhibit matrix properties, but are not fully matrix. This part of the reservoir is proposed to be called a "pseudo-matrix". If macrocracks dominate in the section, the basement rocks are identified as type 1 fractured reservoirs, but if microfracture systems ("pseudo-matrix") dominate in some parts of the void space, they may show the properties of type 2 reservoirs forming a mixed type of fractured reservoirs.

Keywords: crystalline basement, granitoids, fractured reservoirs, classification of fractured reservoirs, fracture influence coefficient, Lorenz curve

Introduction

The development of oil and gas deposits in fractured reservoirs is associated with certain risks due to the peculiarities of the geological structure. Thus, the presence of fractures is a critical factor associated with such major problems in the development of fractured reservoirs, such as high rates of production decline, high risks of watering wells along fracture systems, the complexity of determining the distribution of reserves, controlled by the distribution of fracture systems, etc. The development of such fields can be observed at any stage of their development, including drilling, completion and operation of wells, as well as plans to introduce enhanced oil recovery methods. According to many researchers, when developing fractured reservoirs, determining the type of reservoir and the effect of fracture systems on productivity and development indicators is a primary task even at the stage of exploration and reserves estimation.

Some naturally fractured reservoirs manifest themselves in emergencies at the beginning of field drilling. In other cases, the effects of fracture effects may be evident when the deviation of the design parameters of hydrocarbon recovery significantly exceeds the allowable limits. In practice, the data obtained on the presence of natural fracturing of rocks can be ambiguous, which leads to an additional risk of developing such deposits.

Naturally fractured reservoirs are characterized by a set of parameters that are difficult to design and predict. Geological-geophysical and seismic methods for investigating fractured reservoirs make it possible

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to partially simulate the geological structure and distribution of fracture systems in the volume of deposits. Laboratory core studies in fractured reservoirs, on the contrary, due to incomplete removal of reservoirs, namely with fractured voids, evaluate only the block low-permeability part of the reservoirs. Cracks will almost always be characterized by an insufficient level of knowledge.

In this regard, it becomes relevant to use such methods, which, along with geological and geophysical methods, make it possible to determine not only the influence of both fracture systems and matrix blocks on the reservoir properties of the reservoir, but also the degree of interaction between these systems. To solve such problems, various field and statistical methods for identification and classification of fractures in reservoirs have been developed. These methods for studying fractured reservoirs are based on a sharp difference in indicators for wells in the field, caused by heterogeneity of reservoir properties due to the distribution of fractured systems.

It makes sense to study the influence of fractured systems on the dynamics of production and the recovery factor of hydrocarbons using the example of fields with a long history of development. Studying the experience of developing hydrocarbon fields in fractured reservoirs will form a base of "best practices" for their subsequent use as analogues in more geologically complex objects. One of such analogous deposits, which is at the final stage of development, where the void space is formed by various systems of tectonic fractures, is the large White Tiger oil field in the granitoids of the pre-Cenozoic crystalline basement.

In order to classify fractured reservoirs in crystalline basement granitoids, this article presents the results of statistical and qualitative methods for analyzing the influence of fracture systems and fracture heterogeneity in relation to the White Tiger (Bach Ho) and Dragon (Rong) oil fields. To solve the set tasks, the article contains the construction and analysis of the shape of the graphs of the distribution of the parameters of the wells (productivity, flow rates, accumulated indicators, etc.), as well as the Lorentz curves.

Fractured basement collector at the White Tiger field

The White Tiger (WT) field is confined to the Kyulong Basin (Fig. 1), which stretches along the southern coast of Vietnam on the shelf of the South China Sea. A group of similar fields (Dragon, Zarya (Rang Dong), Black Lion (Su Tu Den), etc.), but much smaller in reserves than the WT field, was discovered and put into development here.

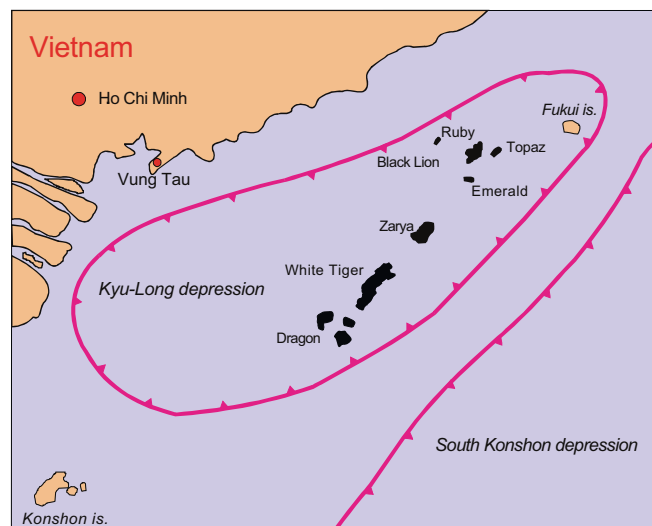In the absence of direct analogs of such deposits in world practice, fractured reservoirs in carbonate rocks

Fig. 1. Location of the main oil fields in the Kyu-Long depression

were taken as the basis for studying the structure of the void space and designing indicators for the development of the basement at the WT field. In this regard, the design of such a unique oil field as WT was carried out in several stages, since it is almost impossible to substantiate the most efficient system of its development at the initial stage (Gorshenev et al., 2008).

Based on the results of well drilling, the geological model of the reservoir in the basement, taking into account the distribution of fractures, and the design solutions for the development of the field were constantly updated and revised.

The hydrocarbon reservoirs at the WT field are classified as crystalline igneous rocks, primarily granitoids and their weathering crusts. The formation of the void space of the basement rocks was influenced by tectonic and metamorphic processes with the formation and localization of various systems of cracks and their geometric parameters. These factors ultimately explain the significant fracture heterogeneity of rocks with an uneven distribution of reserves in their volume and sharp differences in well parameters in terms of productivity.

Analysis of various sources (Shuster et al., 2003; Pospelov, 2005; Chan, 2008; Tiab, Donaldson, 2009; Nguyen, 2013) showed that, despite the final stage of field development, at the moment there is no common point of view on the nature of the space of the basement, as well as on the study and identification of fracture zones in the rock mass. Nevertheless, most authors agree on the prevailing influence of fracture systems compared to the rest of the low-permeability block part (matrix). Often, the WT basement reservoir is classified as fractured-cavernous (rarely fractured-porous-cavernous) or simply fractured type.

As a result of the impact of secondary processes in the basement granitoids, three types of voids are developed (Pospelov, 2005; Chan, 2008; Nguyen, 2013), which

determine their porosity and permeability properties:

1. Fractured reservoirs have well-developed systems of micro- and macrocracks, as a rule, these zones correspond to high reservoir properties;

2. Fractured-cavernous – the void space of reservoirs is represented by caverns of various sizes, microcracks, to one degree or another interconnected and having reduced reservoir properties;

3. Block type – characterized by primary inter-crystalline and individual microcracks and voids, there is practically no matrix permeability in the blocks.

According to the results of the laboratory core studies (Chan, 2008), the gas permeability of individual samples of fractured granites can reach few Darcy, decreasing along the block part to 1 mD. The average value of the permeability coefficient for the foundation varies from 0.2 to 226 mD. The study of the aperture of cracks showed that about 80% of them are characterized by low values (≤ 0.1 cm) and belong to systems of microcracks, the rest of the cracks have an aperture of up to 1 cm or more. According to petrographic studies, the bulk of the basement rocks of the WT deposit is represented by fractured granites, granodiorites are identified in the Northern block. With depth on the foundation, there is a tendency for the reservoir properties to decrease. It should be noted that core studies mainly characterize the dense and low-permeability part of the basement rocks; there are practically no macrocracks on the core samples.

Macro- and microcrack systems form a single hydrodynamic system for the main part of the basement deposit (Central Block), despite the fact that the rock mass is divided by faults into blocks. In some parts of the basement, isolated blocks of a smaller order are found.

In the work (Timurziev, 2010), the author systematized and summarized geological and geophysical data on the basement of the WT field. To analyze the structure of the void space, in this work, the concept of fracture systems is introduced, which is understood as the entire set of discontinuities in the continuity of rocks (from microcracks to faults). The whole variety of fracture systems in the rocks of the basement is divided into:

- impermeable systems of cracks, which turned out to be isolated and healed at certain stages of secondary rock altering;
- permeable fracture systems that play a major role in filtration processes.

On the basis of the conditions studies of fracture systems generation, three groups have been identified (Timurziev, 2010): cooled or primary fractures; cracks associated with tectonic deformations; cracks delamination and weathering. Of commercial interest for studying the localization of cracks and their reservoir properties are cracks associated with tectonic deformations or near-fault fracture zones. According to the author of the work (Timurziev, 2010), cracks of all

systems formed before oil migration into the basement are healed by secondary mineral new formations and are impermeable; young generations of cracks, on the contrary, have retained good reservoir properties. Probably, faults and systems of macrocracks, providing oil migration, were simultaneously the main channels of hydrothermal activity, which can explain the high mineralization of such zones. Thus, as a result of the manifestation of magmatic and metamorphic processes, not all fracture systems are permeable.

Based on the results of studying the mineral composition of the fracture filling material, their typification was carried out (Chan, 2008):

- materials of magmatic origin;
- minerals of hydrothermal origin, represented by zeolites, calcites, kaolinite, etc.;
- terrigenous material of secondary origin (siltstone and pelitic fractions).

The active manifestation of the processes of zeolitization of rocks with the formation of "healed cracks" led to the formation of hydrodynamically unconnected zones in the basement. Most often, such fracture systems are found in the Northern block of the WT field, which is the result of low productivity values and cumulative production from wells, compared to the Central block.

The simplest model that characterizes the structure of the void space of the foundation rocks is the double porosity model developed for carbonate fractured reservoirs. In a sophisticated form, the petrophysical model of a reservoir in the basement (Pospelov, 2005; Tiab, Donaldson, 2009) can be represented as a dense, practically impermeable matrix, divided into blocks by macrocracks and caverns. Peripheral zones of blocks bordering macrocracks are composed of rock areas with microcracks. The reservoir properties in such a model of basement granitoids are determined by geometric parameters and the nature of filling micro- and macrocracks.

Since the beginning of the discovery of a deposit in the basement at different periods of time, the authors have proposed various models of the structure of the crystalline massifs of the basement and heterogeneity of reservoir properties, a review of which is considered in (Shuster et al., 2003). Thus, models of sheeted-veined, intermittent-layered and discrete-sheeted structure of crystalline granite massif were recommended. In turn, Shuster et al. (Shuster et al., 2003) proposed an uneven-cellular model, which emphasizes the fractional structure of the rock mass with an uneven distribution of fractured zones and poorly permeable rocks, compared with earlier concepts. Figure 2 shows the considered model of the structure of the basement deposit, with the selection according to geological and geophysical data (results of production-geophysical and hydrodynamic
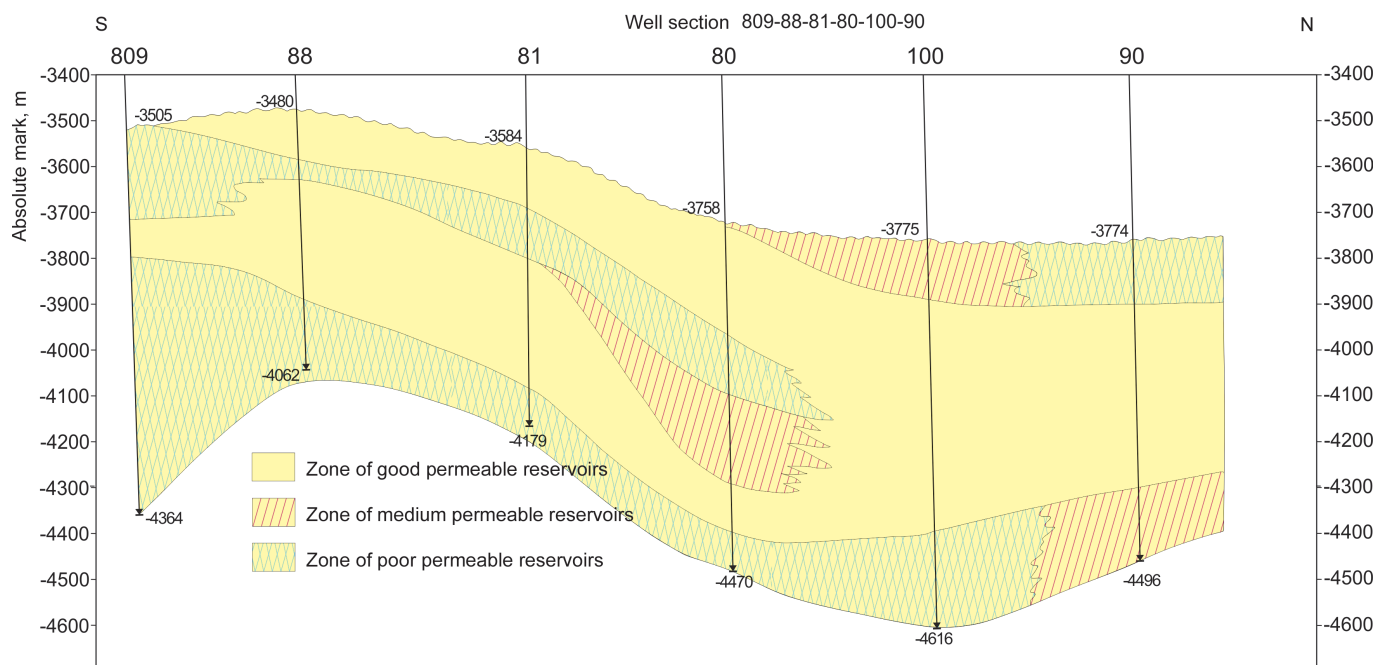
Fig. 2. Scheme of an uneven-cellular model of the structure of granitoids of the basement of the White Tiger field

studies of wells) in each well of zones (cells) with three types of rocks: good and medium permeable and poorly permeable. The use of such a model allowed the authors to confirm that the distribution of zones (with sizes up to hundreds of meters) of unconsolidated and compacted rocks in the basement has an uneven cellular character. The sizes of the zones are determined by the composition of the rocks, the structure of the rock mass (fault zones, blocks), the uneven distribution of fracturing and, as a consequence, the distribution of reservoir properties.

With an increase in the resolution of seismic studies and the accumulation of factual material, the non-uniform mesh model can be considered in a new quality. The meaning of the approach (Timurziev, 2011) lies in the localization and geometrization of fracture systems in the basement through the search for criterion differences in the physical properties of dense blocks and volumetric destruction zones in the attributes of the seismic wave field. In this case, the geological model of the basement will be an alternation of uncompacted and compacted zones in the rock mass. At the same time, the uncompacted zones, including systems of micro- and macrocracks, are differentiated depending on their geometric parameters, which ultimately determine the reservoir properties and well production rates. Thus, the low permeable zones correspond to the compacted zones, and the good and medium permeable reservoirs in the uncompacted zones correspond to the macro- and micro-fractured zones.

Summarizing the above, the study of such complex fractured objects as the basement of WT oil field is associated with uncertainty in understanding the structure of the void space, describing and identifying the type of reservoir and will always remain relevant.

Field classification and signs of fractured reservoirs

In fields with fractured reservoirs, the optimal development system, expected well rates, problems of their operation and the value of the oil recovery factor (RF) will be determined depending on the ratio of fractures and matrix in the void space. In this connection, the study and classification of fractured reservoirs is of interest not only from the point of view of the genetic origin of rocks and their ranking according to reservoir properties, but also the degree of interaction of fracture and matrix components.

Most of the field classifications distinguish several types of fractured reservoirs, for example, in the work (Aguilera, 1995), fractured reservoirs are classified into three types:

- type A – reservoir capacity is matrix, fractures provide only small capacity;
- type B – rocks with a similar degree of influence of fractures and matrix on reservoir capacity and permeability. In this case, type B collectors are subdivided into B-I and B-II, depending on the parameters of the matrix:
- subtype B-I – characterized by almost the same ratio and interaction of the matrix and cracks;
- subtype B-II – the matrix has deteriorated properties, cracks determine the voidness and permeability of the reservoirs;
- type C – the influence of the matrix is reduced to zero, and all the porosity and permeability are due to fractures.

A similar classification, which has recently become widespread, is presented by Nelson (2001), on the basis of which, depending on the qualitative indicators

of the degree of influence of the fracture and matrix components, four types of fractured reservoirs are distinguished:

- type 1 – fractures provide the main porosity and permeability of the reservoir;
- type 2 – fractures provide the main permeability of the reservoir, and the matrix provides the main porosity;
- type 3 – fractures complement the reservoir permeability;
- type 4 – fractures do not provide additional porosity and permeability, but form significant anisotropy of the reservoir.

On the basis of this classification, additional (intermediate) types are distinguished, for example, in (Bratton et al., 2006) type G is introduced to describe unconventional gas reservoirs. Most type G collectors are similar in properties to type 2 collectors.

Table 1 presents qualitative (diagnostic) signs and development problems for four types of fractured reservoirs, summarized according to the results of studies by various authors (Tiab, Donaldson, 2009; Aguilera, 1995; Nelson, 2001; Bratton et al., 2006; Kuchuk et al., 2015; Wayne, 2011; Baker, Kuppe, 2000).

Investigation of fractured basement systems based on historical wells operation data

In the work (Nelson, 2001), it is recommended to use statistical methods to identify a particular collector to a certain type for analyzing the shape of the distribution of well performance parameters (productivity, flow rates, accumulated indicators, etc.). As a rule, the identification of fractured reservoirs is based on a sharp difference in well performance in the field, due to the heterogeneity of reservoir properties caused by the distribution of fractured systems. It is assumed that in a homogeneous reservoir, the distribution of parameters on the frequency plot will be close to a symmetric (bell-shaped) form, while for fractured reservoirs asymmetric distribution curves are characteristic with a shift towards the ordinate axis.

To study the degree of influence of fracturing in crystalline basement rocks, let us consider a sample of

Type of fractured reservoir	Type 1	Type 2	Type 3	Type 4
Characteristic	Porosity and permeability are determined by crack systems.	Fractured systems provide the main permeability of the collector, the matrix - the main porosity.	The matrix mainly determines the porosity and partial permeability of the collector, cracks - additional permeability.	Cracks are absent or impermeable, porosity and permeability are determined by the matrix.
Signs	- large well drainage zones; - good correlation between well debits and reservoir properties; - high values of initial well flow rates, but often high rates of their decline; - risks of premature flooding of wells	- often high values of well flow rates, cracks increase productivity; - the productivity of wells, the rate of decline in flow rates and RF depends on the degree of interaction of cracks and the matrix	- collector properties are fairly homogeneous; - good and stable well flow rates, including due to fracturing; - reservoirs are maintained by area; - poor correlation between well production rate and reservoir properties	- reservoirs consist of unrelated isolated zones; - poor well productivity; - low RF due to the high heterogeneity of the layers and the absence of the influence of cracks; - RF can vary greatly by oil field
Problems	- determination of fracture heterogeneity and complexity with the calculation of reserves; - determination of the size of the well drainage zone; - risks of premature flooding of wells; - for cost-effective development, fractured systems should be characterized by a high reservoir capacity	- evaluation of crack-matrix interaction and crack distribution; - assessment of RF during flooding; - closing of cracks when pressure decreases; - risks of premature flooding of wells	- identification of crack systems; - high anisotropy in permeability is possible; - assessment of the RF during flooding; - crack systems may be not interconnected	- assessment and localization of reservoir heterogeneity; - low profitability of such collector's development

Tab. 1. Qualitative characteristics and development problems for four types of fractured reservoirs

wells confined to the White Tiger and Dragon deposits (southeastern section). It should be noted that the basement at the WT field is analyzed for two blocks (Central and North) separately, since, as mentioned earlier, a large number of healed fractures are typical for the North block. Figures 3 and 4 show graphs and histograms of the distribution of cumulative oil production and maximum production rates for basement wells at the WT and Dragon fields. Analysis of the graphs shows that several wells in the Central Block of the WT field dominate in cumulative production and have higher performance compared to the main amount and other analyzed objects. So, more than 15 wells are characterized by cumulative production of more

than 5 million m³, two of them – more than 10 million m³. If for the southeastern section of the Dragon field and the Northern block of the WT basement the main number of wells has a production of 250–500 thousand m³ per well, then on the WT basement this range is 1–3 million m³. A similar picture can be observed on the histograms of the distribution of wells by maximum flow rates, where high flow rates are observed in the wells of the Central block of the WT field, reaching 2000 m³/day and more.

The coincidence of the graphs of the distribution of wells by cumulative production in the Central block of the basement and throughout the sample of analyzed wells can be explained by the fact that the bulk of the
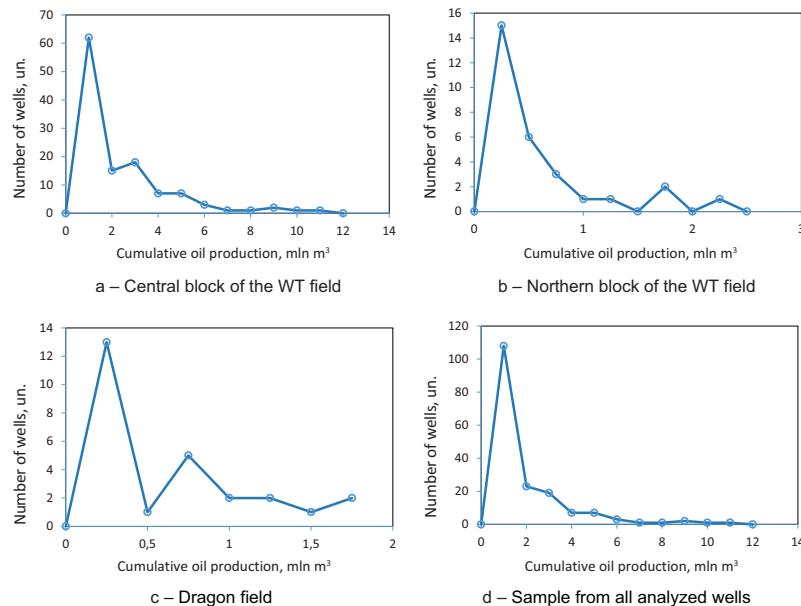

Fig. 3. Graphs of wells distribution by cumulative production in the crystalline basement of the White Tiger and Dragon oil fields. a – Central block of the WT field; b – Northern block of the WT field; c – Dragon field; d – sample from all analyzed wells.
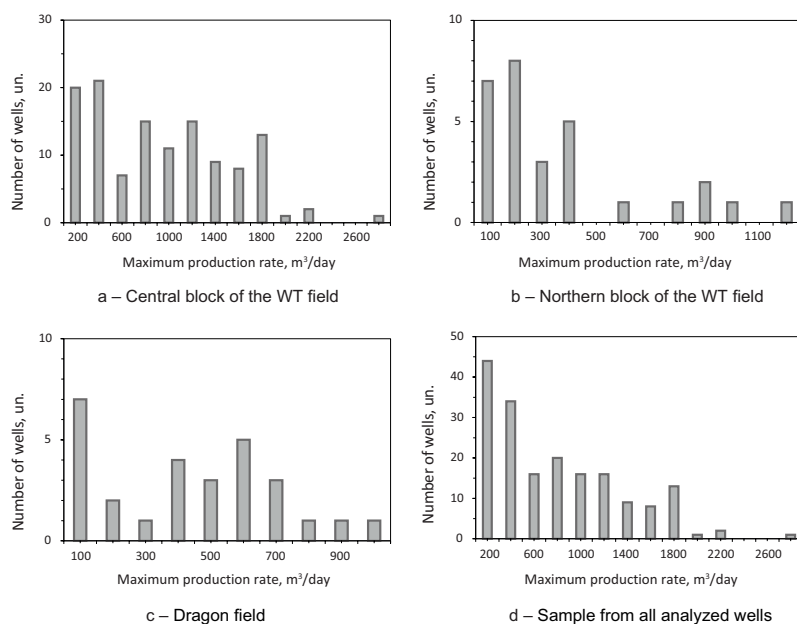

Fig. 4. Histograms of the distribution of wells by maximum production rates in the crystalline basement of the White Tiger and Dragon oil fields. a – Central block of the WT field; b – Northern block of the WT field; c – Dragon field; d – sample from all analyzed wells.

analyzed wells, including highly productive ones, are located in this block.

All the objects under consideration are characterized by asymmetric curves of distribution of cumulative production and maximum production rates by wells. The distribution of wells along the basement of the White Tiger field, both in the Central and Northern blocks, indicates the inherent influence of fracture heterogeneity. The northern block of the WT field and the southeastern section of the Dragon field have a comparable number of wells, but the last one has several "peaks" on the graphs of changes in accumulated indicators and maximum production rates for wells, which can be explained by the block structure (Karimov et al., 2014) and the allocation of unrelated blocks within the reservoir.

It should be noted that the use of indicators such as cumulative production and maximum production rates for wells may not objectively reflect the distribution of fracture heterogeneity across objects, including for the WT field. Considering that the basement at the WT and Dragon fields is developed using waterflooding (Gorshenev et al., 2008), and Dragon also with the occurrence of aquifer (Karimov et al., 2014), the results of premature waterflooding and disposal of wells may affect the cumulative production. Figure 5 shows a graph of the dependence of the cumulative oil and liquid production for the studied objects, on which, by the deviation from the centerline to the abscissa axis, it is possible to estimate the effect of water cut in wells on the value of cumulative oil production. Most of the wells presented are understated in terms of cumulative oil production due to wells flooding. The use of the maximum production rate of wells for analysis is also controversial, since its value is significantly influenced by a number of technical and technological factors, especially in shelf conditions. Different operating conditions of the lift, oil transportation, the presence of restrictions distort the potential of the wells, and, accordingly, the flow rate of the wells cannot objectively characterize the formation. For example, most of the production wells at the WT in the initial stages were operated in a natural flowing way and were limited by chokes.

Based on the above, for a correct analysis and objective assessment of the effect of fracture heterogeneity, it is proposed to use the distribution of wells by productivity index. Figure 6 shows the histograms of the distribution of wells according to the productivity index.

The histograms of the distribution of wells by the productivity index also have an asymmetric distribution with a shift towards the ordinate axis. For the Central block of the basement at the WT field, the graph is highly asymmetric and shows a significant range of productivity index changes, increasing about 20 times from the minimum values. Highly productive wells are associated
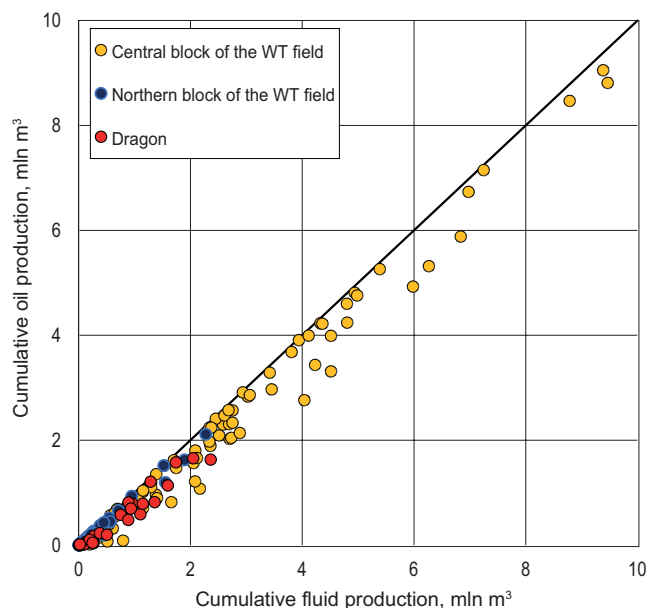

Fig. 5. Cumulative oil production vs. cumulative fluid production

with this block, the maximum values of the productivity index for individual wells reach 190 m^3/day/MPa, the main number of wells corresponds to the minimum values – up to 10 m^3/day/MPa. A weakly pronounced effect of fracture heterogeneity is noted in the Northern block, where low-productivity wells are located, as most of the wells have a productivity coefficient of up to 1 m^3/day/MPa, one well – up to 6 m^3/day/MPa. In the southeastern section of the Dragon field, in comparison with the Northern block of the WT field, the productivity factors for the wells are 10 times higher, reaching 50 m^3/day/MPa per well. As well as on the graphs of the distribution of cumulative production and the maximum production rate, the histogram for productivity ratios at the Dragon field has several "peaks".

Taking into account the disadvantages of comparing the frequency distribution plots in the article (Nelson, 2001), it is proposed to use the Lorentz distribution to assess the effect of fracturing on development indicators. As applied to field development, the Lorentz curve reflects the heterogeneity of the distribution of cumulative oil production by wells. Figure 7 shows the Lorentz curves for the analyzed objects. The abscissa shows the accumulated percentage of analyzed wells, the ordinate shows the percentage of the total accumulated oil production, i.e. their contribution to the total production. A line drawn at a 45 degree angle connecting the lower left and upper right points on the graph is called the homogeneous reservoir line. This line reflects a reservoir structure in which all wells would produce the same amount of oil. With an increase in reservoir heterogeneity, the non-uniformity in the distribution of cumulative production among the wells increases, and the Lorentz curve deviates from the homogeneous reservoir line towards the abscissas. Fractured reservoirs
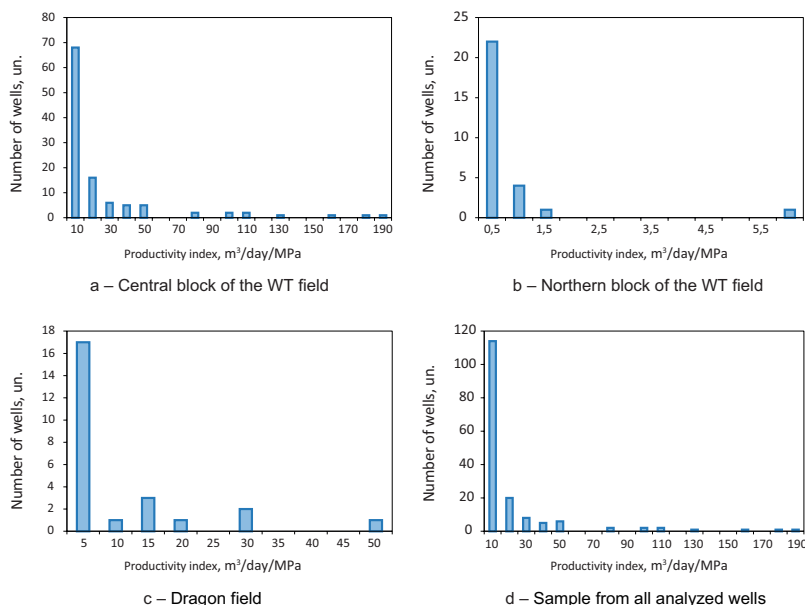
Fig. 6. Histograms of the wells distribution by the productivity index in the crystalline basement of the White Tiger and Dragon oil fields

will be characterized by the greatest deviation of the curve, matrix ones – the smallest, approaching a straight line.

To quantify the degree of influence of fracture heterogeneity according to the Lorentz curve, the Gini coefficient or the coefficient of influence of cracks can be determined. This coefficient is equal to the ratio of the area of the figure bounded by the homogeneous reservoir line and the Lorentz curve to the area of the entire triangle. The fracture influence coefficient can take values from 0 (homogeneous reservoir) to 1. The higher the value of this coefficient, the more the influence of the fracture component on the cumulative oil production is reflected, i.e. the bulk of the oil produced is accounted for by a separate group of fractured wells.

According to (Nelson, 2001), fractured reservoirs can be classified by type using the following approximate ranges of fracture influence coefficient variation:

Type 1 – more than 0.7;
Type 2 – 0.5–0.7;
Type 3 – 0.2–0.5;
Type 4 – less than 0.2.

The calculated values of the coefficients of the influence of fracturing for the analyzed objects are shown in Fig. 7 in parentheses. The maximum values are typical for the Central and Northern blocks of the WT field, amounting to 0.63 and 0.59, respectively. For the southeastern section of the Dragon oil field, the smallest value of the fracture influence coefficient was obtained – 0.56. According to the calculated values of the fracture influence coefficient, the fractured reservoirs of the analyzed objects, in a first approximation, can be classified as type 2, which contradicts the conclusions of the authors of a number of works (Li et al., 2004; Lefranc et al., 2011), according to which the basement
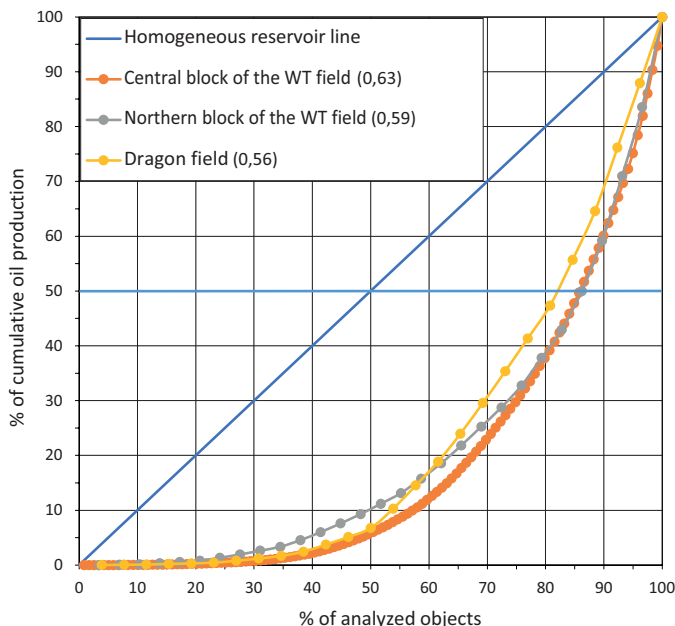

Fig. 7. Lorentz curves for the analyzed objects, characterizing the degree of uneven distribution of cumulative oil production by wells (the values of the fracture influence coefficients are indicated in parentheses)

rocks correspond to type 1 collector. Such ambiguity in the identification and typification of the complex void space of basement rocks, which does not allow them to be confidently attributed to type 1 or 2, implies the existence of a mixed type of fractured reservoirs.

Conclusion

Based on the research results, a significant influence of the distribution of fracture systems on the development indicators of the basement of the White Tiger and Dragon oil fields was established. Its productivity is determined as a function of the prevalence in the volume of the

rock mass of the basement of the systems of micro- or macrocracks opened by the well. Accordingly, statistically, a group of wells that has penetrated packed zones and zones with micro-fractured systems will have the worst productivity and shift the reservoir towards the matrix during analysis. The system of microcracks and the block low-permeability part, showing the properties of the matrix, is not it in full, therefore this part of the reservoir can be called a «pseudo-matrix». In other words, the basement rocks are classified as a type 1 fractured reservoir with dominance in the section of macrocracks, but with a predominance of microcrack systems in the void space («pseudo-matrix») in some of its parts, they can exhibit the properties of type 2 reservoirs. An additional factor that increases the degree of heterogeneity of fractured reservoirs is the influence of the processes of hydrothermal mineralization of fractures by calcite and the disruption of the interaction of fracture systems, in particular, in the Northern block of the basement of the White Tiger field.

In general, based on the findings, according to the classification (Nelson, 2001), granitoids of the crystalline basement at the WT field, depending on the prevalence of certain fracture systems, can be classified as types 1 and 2, forming a mixed type of fractured reservoirs.

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