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ИЗВЕСТИЯ

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CLASSIFICATION OF HYDROCARBON DEPOSITS IN THE SOUTH-EASTERN PART OF THE BUKHARA-KHIVA REGION, JUSTIFICATION OF ITS METHODOLOGY AND ANALYSIS OF THE RESULTS

Abstract. This article is devoted to the analysis of the classification of hydrocarbon deposits in the southeastern part of the Bukhara-Khiva region, the justification and methodology and the results obtained. It shown that according to the complexity of the structure, deposits divided into such types as simple structures. In addition, their characteristics are given. The description of single-phase and two-phase deposits and the division of the latter in relation to the volume of the oil-saturated part of the deposit to the volume of the entire deposit is given. Along with this, the classification of deposits by the complexity of the geological structure into deposits of a folded geological structure and simple, by the number of productive horizons – into single – layer and multi – layer, by the number of objects-into single-object and multi-object, by the presence or absence of condensate-into gas and gas condensate. Other types of deposits considered by classification and their characteristic features are described. Various geological, technological and mathematical methods of classification of hydrocarbon deposits are proposed. The results of calculations on the classification of hydrocarbon deposits in the fields of the southeastern part of the Bukhara-Khiva region analyzed.

Key words: classification, field, southeastern part, Bukhara-Khiva region, method, analysis, calculation, condensate, hydrocarbons, oil saturation.

Introduction. At present, in the study of the geological structure of deposits and their development, numerous classifications of hydrocarbon deposits are proposed. As their main features, genetic ones are used according to the conditions of formation of hydrocarbon deposits; by type of fluids (gas, gas condensate, oil and gas condensate) and reservoirs; morphological (according to the conditions of occurrence of hydrocarbon deposits) according to the industrial value of the deposits [1; P. 199].

All work carried out in the process of prospecting and exploration, development of hydrocarbon deposits aimed at rational exploitation of deposits and maximum recovery of oil and gas from productive formations. With this in mind, let us consider the classification of hydrocarbon deposits adopted in the current guidance documents for the development of oil and gas deposits [2; P. 5-7].

Materials and methods. According to the guidance document, according to the complexity of the structure of the field (deposits) are divided into the following types [3; P. 6]:

Simple structure, confined to tectonically undisturbed or weakly disturbed structures, the productive layers of which are characterized by consistency of thicknesses and reservoir properties over the area and section;

A complex structure, characterized by inconsistent thicknesses and reservoir properties of productive strata in area and section, or by the presence of lithological replacements or tectonic disturbances, dividing single deposits into separate blocks;

A very complex structure, characterized by both the presence of lithological replacements or tectonic disturbances, dividing the reservoir into separate blocks, and the inconsistency of the thickness of the reservoir properties of productive strata within these blocks.

The categories of a complex and very complex structure should also include gas-oil and oil-and-gas deposits, in which oil in the gas cap zones underlain by bottom water and is contained in thin rims of heterogeneous formations.

Results and discussion. According to the initial phase state and the composition of the main hydrocarbon compounds in the depths, the deposits are subdivided into single-phase and two-phase [2; P. 5].

Single-phase include:

a) Oil deposits confined to reservoirs containing oil saturated to varying degrees with gas;

b) Gas or gas condensate deposits confined to reservoirs containing gas or gas with hydrocarbon condensate.

Two-phase reservoirs include reservoirs confined to reservoirs containing oil with dissolved gas and free gas above the oil (an oil reservoir with a gas cap or a gas reservoir with an oil rim). In some cases, the free gas of such deposits may contain hydrocarbon condensate [1-6]. According to the ratio of the volume of the oil-saturated part of the reservoir to the volume of the entire reservoir ($\bar{v}_H = \frac{V_н}{V_н + V_г}$) two-phase deposits are subdivided into [2; P. 5]:

a) Oil with gas or gas condensate cap ($\bar{v}_H > 0{,}75$);

б) Gas or gas condensate oil ($0{,}75 < \bar{v}_H < 0{,}75$);

в) Oil and gas or oil and gas condensate ($0{,}25 < \bar{v}_H < 0{,}5$);

г) Gas or gas condensate with oil rim ($\bar{v}_H \leq 0{,}25$).

In terms of recoverable oil reserves and balance gas reserves, oil and oil and gas fields are subdivided into [2; P. 6–7]:

Unique, containing more than 300 million tons of oil or more than 500 billion cubic meters of gas;

Large, containing from 30 to 300 million tons of oil or from 30 to 500 billion cubic meters of gas;

Medium, containing from 10 to 30 million tons or from 10 to 30 billion cubic meters of gas;

Small, containing less than 10 million tons of oil or less than 10 billion cubic meters of gas.

Based on the tasks of developing gas and gas condensate fields, the following classification criteria are adopted in the "Rules for the development of gas and gas condensate fields in the Republic of Uzbekistan" [2; P. 7].

According to the complexity of the geological structure of productive horizons, gas and gas, condensate fields are divided into two main groups [2; P. 7]:

a) deposits of a complex geological structure, divided by tectonic disturbances into a number of blocks and zones that have a variable nature of productive horizons - lithological composition, reservoir properties, etc.;

b) Deposits of a simple geological structure, the productive layers on them characterized by the relative consistency of the lithological composition, reservoir properties and productive horizons over the entire area of the deposit.

The number of productive horizons (deposits) subdivides into the deposits into [2; P. 7]:

a) Single-layer;

b) Multi-layer.

The number of development objects subdivides into the deposits into [2; P. 7]:

a) single-site, when there is only one deposit, or all deposits combined into one development site;

b) Multi-object, when several development objects selected.

According to the presence or absence of condensate, the deposits are subdivided into [2; P. 7]:

a) Gas, from the gas of which, with a decrease in pressure and temperature, the release of liquid hydrocarbons does not occur;

b) Gas condensate, from the gas of which, with a decrease in pressure and temperature, liquid hydrocarbons released.

Gas condensate fields (deposits) by the content of stable condensate are divided into the following groups [2; P. 7-8]:

Group I with an insignificant content – up to 10 cm^3/m^3;

Group II with low content - from 10 to 150 cm^3/m^3;

Group III with an average content - from 150 to 300 cm^3/m^3;

Group IV with a high content - from 300 to 600 cm^3/m^3;

Group V with a very high content - over 600 cm^3/m^3.

Gas condensate fields are developed depending on the content of stable condensate, thermodynamic characteristics and geological conditions [2; P. 8];

The following images:

a) Without maintaining reservoir pressure (as purely gas fields);

b) Maintaining reservoir pressure.

According to the presence or absence of oil in the reservoir, gas and gas condensate deposits are subdivided into [2; P. 8]:

a) Deposits without an oil rim or with an oil rim of non-commercial significance;

b) Deposits with an oil rim of industrial importance.

According to the flow rate (maximum possible working flow rate) of wells, gas and gas, condensate fields (deposits, development objects) are divided into the following groups [2; P. 8]:

a) low-flow rate – up to 25 thousand m^3 / day;

b) Marginal – from 25 thousand to 100 thousand m^3 /day;

c) Average production rates – from 100 thousand to 500 thousand m^3/day;

d) High-flow rate – from 500 thousand to 1 million m^3 / day;

e) Super high-rate – over 1 million m^3 / day.

According to the value of the initial reservoir pressure, deposits are distinguished [2; P.8]:

a) Low pressure – up to 6 MPa;

b) Medium pressure – from 6 to 10 MPa;

c) High pressure – from 10 to 30 MPa;

d) Ultra-high pressure – over 30 MPa.

According to the above criteria, hydrocarbon deposits in the southeastern part of the Bukharo-Khiva region are classified as [2; P.8]:

Complex and very complex structure;

Single-phase (gas, gas condensate, oil) and two-phase (oil and gas condensate);

Mostly small and medium-sized;

From low-rate to high-rate;

From low to ultra-high pressure.

The analyzed classifications of hydrocarbon deposits mainly use one or two parameters. Therefore, it becomes necessary to clarify the validity of the parameters adopted in the classification based on the use of a complex of geological and physical factors [7-12].

Nowadays, various geological, technological and mathematical methods of classification of hydrocarbon deposits are widely used [3; P. 232], [4; P. 48], [5; P. 145], [6; P. 185], [7; P. 112], [8; P. 120–129], [9; P. 28-51], [10; P. 113-119], [11; P. 202–204], [12; P. 114-115], [13; P. 79–84], [14; P. 40–43], [15; P. 584-588]. Most of them make it possible to single out homogeneous objects only because of qualitative characteristics.

Since three-dimensional methods of geological and hydrodynamic modeling are widely used in the geology of oil and gas, there is a need to express the similarity of objects in quantitative terms. One of the ways to solve this problem is the widely used method for constructing dendrograms [16; P.161-168] which is as follows.

Let there be a class of objects A_{1i}8=1, 2, n, characterized by a set of geological and commercial attributes a_{ip}, p-1, 2, k. The main idea of the method is to build a hierarchical system that unites groups of similar objects. In this case, the correlation coefficient given a geometric meaning, which consists in interpreting it as the cosine of the angle between two vectors in a multidimensional Euclidean space. Arcos of the correlation coefficient is considered as a measure of the distance between vectors, and therefore, as a measure of the similarity between objects. The correlation coefficient calculated by the formula [16; P. 161]

$$\sqrt{A_i, A_j} = \frac{\sum_{p=1}^{k}(a_{ip}-\overline{a_i})*(a_{jp}-\overline{a_j})}{\sqrt{\sum_{p=1}^{k}(a_{ip}-\overline{a_i})^2 * \sum_{p=1}^{k}(a_{jp}-\overline{a_j})^2}} \ , \qquad (1)$$

where a_i – are arithmetic means determined by the set of values a_{ip} and a_{jp}. It should be borne in mind that signs can have a completely different nature and a characteristic interval of change. Therefore, it is necessary to preliminarily normalize them, for example, by bringing them to a single change interval. The basis for the application of any method of grouping objects into mutually related groups is the symmetric matrix S_l, whose elements S_j are the distances between the objects A_i, A_j:

$$S_{ij} = arccos\sqrt{A_i A_j} \ . \qquad (2)$$

The construction of dendrograms is a sequential procedure of combining the nearest elements or groups into a new group.

At the first stage, two objects A_i, A_j, combined, which correspond to the minimum element (distance) of the matrix S^l. The value of the measure of proximity of the two most similar objects remembered and considered in the future as a value that characterizes the hierarchical level of the first stage of grouping.

At each subsequent stage, it is necessary to re-select the two closest objects, combine them and remember the value of the hierarchical level formed by the groups. Obviously, with the initial number of elements equal to *n*, the whole procedure ends at the (*n* – 1) – m step.

When combining two objects containing several elements, the arithmetic mean distance between the elements of the combined groups taken as the measure of group similarity.

To carry out calculations on the classification of hydrocarbon deposits, the following parameters selected, which are reliably justified when objects exit from geological exploration:

Conditions of occurrence of hydrocarbon deposits (depth of oil-water and gas-water contacts, reservoir temperature, reservoir pressure);

Sizes of hydrocarbon deposits (areas of gas and oil content, total thickness of the productive horizon, oil and gas-saturated thickness of the productive horizon);

Reservoir properties of reservoirs (porosity, oil and gas saturation);

Properties of gas and formation fluids (density of oil, gas, water, potential condensate content).

It was found that hydrocarbon deposits in the southeastern part of the Bukharo-Khiva region are more homogeneous in terms of such parameters as the mark of gas-water and water-oil contacts, reservoir temperature, porosity, oil and gas saturation, oil, gas and water density. At the same time, they differ greatly in terms of oil and gas content, total and effective thicknesses of productive horizons, reservoir pressure and potential condensate content in gas.

Based on the results of calculations based on expressions, a dendrogram of the classification of deposits in the southeastern part of the Bukharo-Khiva region built, according to which, at the hierarchical level of 0.64, the following four groups of deposits identified. According to the phase state of hydrocarbons, they subdivided into oil, oil and gas condensate, gas condensate and gas. At a lower hierarchical level of about 0.2 of these groups, the type of deposit distinguishes deposits: massive, reservoir-vaulted, reservoir-massive, which in some cases complicated by lithological replacements and screened tectonic faults [13-18].

It was revealed that in the southeastern part of the Bukharo-Khiva region, two qualifications of the fields are combined, in which the criteria are the phase state of hydrocarbons and the geological structure of the deposits.

Conclusion. The results of the classification of hydrocarbon deposits in the southeastern part of the Bukharo-Khiva region recommended using when:

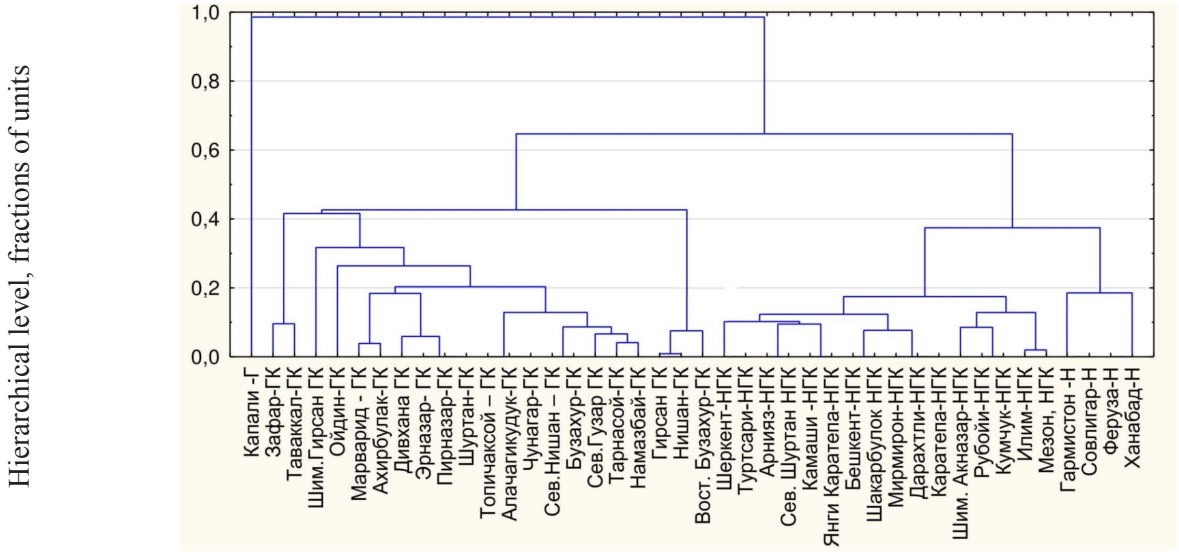
Justification of the choice of analog objects;

Using the experience of developing long-term exploited fields in the process of drawing up projects for new discovered objects;

Substantiation of the effectiveness of geological and technical measures and new technologies;

Solving various problems of a geological and technological nature.

The proposed classifications of hydrocarbon deposits in the southeastern part of the Bukharo-Khiva region will contribute to the discovery of new deposits, an increase in production and the degree of extraction of geological reserves [19-25].



Dendrogram of the classification of deposits in the southeastern part of the Bukhara-Khiva region (O. G. Khayitov, 2020)

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БҰХАРА-ХИУА АЙМАҒЫНЫҢ ОҢТҮСТІК-ШЫҒЫС БӨЛІГІНДЕГІ КӨМІРСУТЕКТЕР КЕН ОРЫНДАРЫН ЖІКТЕУ, ӘДІСТЕМЕСІН НЕГІЗДЕУ ЖӘНЕ НӘТИЖЕЛЕРІН ТАЛДАУ

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КЛАССИФИКАЦИЯ МЕСТОРОЖДЕНИЙ УГЛЕВОДОРОДОВ ЮГО-ВОСТОЧНОЙ ЧАСТИ БУХАРО-ХИВИНСКОГО РЕГИОНА, ОБОСНОВАНИЕ ЕЕ МЕТОДИКИ И АНАЛИЗ РЕЗУЛЬТАТОВ

Аннотация. Данная статье посвящена анализу классификации месторождений углеводородов юго-восточной части Бухаро-Хивинского региона, обоснованию и методики и получаемых результатов. Показано, что месторождения по сложности строения подразделяются на такие типы, как простого строения. И дана их характеристика. Приведено описание однофазных и двухфазных залежи и подразделение последних по отношению объема нефтенасыщенной части залежи к объему всей залежи. Наряду с этим осуществлена классификация месторождений по сложности геологического строение на месторождения сложенного геологической строения и простого, по числу продуктивных горизонтов – на однопластовые и многопластовые, по числу объектов – на однообъектные и многообъектные, по наличию или отсутствию конденсата – на газовые и газоконденсатные. Рассмотрены и другие типы классификацией месторождений и изложены их характерные особенности. Предложены различные геологические, технологические и математические методы классификации месторождений углеводородов. Проанализированы результаты расчетов по классификации месторождений углеводородов месторождений юго-восточной части Бухаро-Хивинского региона.

Ключевые слова: классификация, месторождение, юго-восточная часть, Бухаро-Хивинский регион, метод, анализ расчет, конденсат, углеводороды, нефтеносыщенность.

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