Revealing of regularities of gas condensate distribution in northern part of West Siberian oil and gas province in order to increase quality of resource assessment

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Abstract. Gas condensate is a unique raw material that plays an important role in the production of hydrocarbons in Russia. Unfortunately, there are no easy and effective methods for forecasting and quantity estimation of this kind of hydrocarbons. In this paper, authors describe the features of the gas condensate concentration depending on the depth in the oil and gas fields of the Yamal-Nenets Autonomous District. The research is based on the results of condensate studies in prospecting and exploration wells within 128 hydrocarbon fields containing gas condensate. To create the regularities, a large amount of factual material accumulated during the industrial development of the north of West Siberia was selected and sorted. For most of the oil and gas bearing areas of the study area, the authors have established regularities of the gas condensate concentration as a function of depth. Two types of regularities are established: linear and exponential. With the help of the established regularity, it is possible to determine the resources of the gas condensate in a prospective gas deposit quickly. The results of the study should improve of the quality of gas condensate resources estimation in the perspective areas of the Yamal-Nenets Autonomous District during geological exploration.

1. Introduction
Gas condensate is a mixture of liquid hydrocarbons (C₅H₁₂ + higher), which is released from natural gases during exploitation of gas condensate deposits because of decrease reservoir pressures and temperature. The content of condensate in the gas depends on the deposit thermobaric conditions, the composition of the formation gas and the presence of oil rim. The concentration of gas condensate in reservoir gases is represented as «gas condensate factor» and varies from 5-10 to 500-1000 grams of condensate per m³ of natural gas [1].

The fractional and hydrocarbon composition of the gas condensate varies over a wide range. Gas condensate consists of gasoline (boiling range from 30-80°C to 200°C), kerosene (from 200°C to 300°C) and, to a lesser extent, higher boiling components. The density of condensates is 660-840 kg/m³, the sulfur content - hundredths of a percent. There is distinguished crude (the primary product released from the gas of the gas condensate deposit under field conditions) and stable gas condensate, from which the dissolved gases are removed [2].
The main number of gas condensate and gas-condensate-oil deposits is discovered in the northern regions of Western Siberia. The biggest gas condensate deposits are located in the Middle Jurassic and Neocomian productive complexes [3].

Gas condensate is a unique raw material, which is much easier to process and from which higher-quality fuel is produced. Today there is no single methodology for estimating the resources of gas condensate during geological exploration. In this paper, we propose an author's methodology for estimating the content of a given type of raw material in perspective deposits on the basis of a simple and convenient empirically established regularity.

2. Obtained data and analysis.

In this paper, authors describe the regularities of the change in the gas condensate factor as a function of depth. Dependencies established as a result of standard condensate studies are implemented in the gas condensate and oil and gas condensate fields of the Yamal-Nenets Autonomous District.

The following dependencies are established for 128 hydrocarbon deposits containing gas condensate and open on the territory of Yamal-Nenets Autonomous District. It should be noted that the volumes of performed gas condensate studies are extremely small in comparison with the number of detected deposits containing gas condensate.

There are numerous cases where within a one formation, the value of the condensate-gas factor was determined only once - for a single deposit (as a rule, the maximum in size). Further, the obtained value of the gas condensate factor was assigned to the remaining reservoirs of the given formation. In order to build reliable dependencies of the change in the gas condensate factor with depth, such values must be weeded out.

The general graph of the change of the gas condensate factor as a function of depth within the territory of the Yamalo-Nenets Autonomous District is shown in figure 1, where all values of the gas condensate factor are reduced to the average depth of the top of the productive formation.

As follows from Figure 1, the change of the condensate-gas factor with depth can’t be approximated correctly by a simple linear function. In the depth range 1000-1700 m, the value of the gas condensate factor practically does not change with depth and varies from 0.3 to 43.0 g/m$^3$. In this depth interval, there are located deposits of Turonian, Cenomanian, Albian and Aptian ages. At the indicated stratigraphic levels of the section, the deposits of "dry" gas prevail. The increased content of condensate in the gas is established in the Albian deposits of the Kharampur (PK$^{13}_1$) formation field, in the Aptian deposits of Yuzhno-Russkoye (PK$^{18}_n$ and PK$^{20}_2$ formation) field, Bovanenkovsky (TP$^{12}_g$) and Kruzenshtern (TP$^{10}_g$) fields.

In the depth interval of 1700-2300 m corresponding to the upper and middle parts of the Neocomian productive complex, the value of the gas condensate factor begins to increase down the section, varying from 3-4 to 250 g/m$^3$ and more. Below 2300 m, there is a significant dispersion of the cloud of points, accompanied by a change in the gas condensate factor in the range from 21 (at a depth of 2326 m) to 495 g/m$^3$ (at a depth of 3692 m).

The nature of the distribution of the gas condensate factor values suggests that changes in depth are not the main factor determining the condensate content at a particular stratigraphic level of the sedimentary cover section.

In addition to depth, the thermobaric conditions of productive deposits, as well as the concentration of carbon dioxide, which determines the degree of solubility of condensates in the natural gas, have a significant effect on the magnitude of the gas-condensate factor.
Figure 1. Graph of changes in condensate gas factor as a function of depth for territory of Yamal-Nenets Autonomous District

3. Distribution of gas condensate in sedimentary cover.
This article shows the revealed regularities of gas condensate change with depth within the most promising areas of the north of Western Siberia - the central part of the Nadym-Pur-Taz interfluve, where Gubkinsky and Tazovsky oil and gas bearing areas were studied in detail.

The largest volumes of gas condensate research have been performed at the hydrocarbon fields of the Gubkinsky oil and gas bearing region. It has been established that the values of the gas condensate factor increasing regularly downward along the section in the depth interval 1620-3392 m from 2.0-9.4 to 276.0 g/m$^3$. Regularity approximated by a linear function (Figure 2).

Figure 2. Graph of changes in condensate gas factor as a function of depth for territory of Gubkinsky oil and gas bearing region

In the sediments of the BP$_2$ (2349 m), BP$_6$ (2426 m), BP$_7$ (2487 m), BP$_9$ (2560 m), BP$_{10}$ (2608 m) and BP$_{11}$ (2,644 m) formation of Zapadno-Tarkosalsinskoye field, the anomalous values of the gas condensate factor detected (229 to 327 g/m$^3$), which do not fit into the general regularity. In this oil and gas bearing area, it is projected to open one of the biggest condensate deposits.
The territory of the Tazovskoye oil and gas bearing region can be divided into two parts - northern and southern - according to the regularities of the change in the condensate gas factor with depth. The northern part covers the Tazovsky, East-Tazovskaya, Russko-Rechenskoye, Zapolyarnoe, Russkoye, Yaro-Yakhinskoye, Severo-Chaselskoye, Yuzhno-Russkoe, Yarvove, Severo-Russkoye, Raduzhnoye and Dorogovskoe fields.

The southern part includes Beregovoe, South-Geologicheskoye, Novochaselskoe, Naumovskoe, Fakhirovskoe, Kynskoe, Ust-Chaselskoe, Verkhnechashelskoe, Yuzhno-Khadyryakhinskoye, Khancheyskoe, Severo-Khancheyskoe and Yumantilskoye fields. Graphs of dependencies for the northern and southern parts of the Tazovsky oil and gas bearing region are shown in Figure 3.

As follows from the graphs, the value of the gas condensate factor over the deposits of the southern part of the Tazovsky oil and gas bearing region exponentially increases downwards along the section from 3.4 to 387 g/m$^3$. In the northern part of the oil and gas bearing region, the dependence is approximated by a linear function, while the values of the condensate factor vary from 7 to 403 g/m$^3$.

4. Results

Based on the analysis of the regularities presented above, it can be stated that there is no clear functional relationship between the values of the gas condensate factor and the depth of occurrence of productive deposits. In most cases considered, the regularity of the change in the condensate factor with depth is approximated by linear equations. Nevertheless, the differences between the numerical coefficients of the established linear equations are very significant. Also within the Ust-Yenisei, Kharampur, Vyngapursky oil and gas bearing regions and the southern part of the Tazovsky oil and gas bearing region, changes in the gas condensed factor with depth are approximated by an exponential function. The existence of such complex regularities points to the fact that in addition to depth, other geological factors influence the value of condensate concentration. These include the thermobaric conditions of the reservoir, as well as the specific features of the chemical composition of the reservoir gas.

The presented equations can be used for preliminary estimation of the gas condensate factor value in the course of geological prospecting works, as well as for performing various technical and economic assessments of the territories of the undistributed fund of the Yamalo-Nenets Autonomous District.

References

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