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Research Article

FORECAST OF THE OIL AND GAS POTENTIALITY OF THE GAZLIN RIFT BASED ON THE RESULTS OF MODELING THE PETROPHYSICAL PROPERTIES OF THE TERRIGENIC CRETACY DEPOSIT

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ABSTRACT
In the current modern world practice, positive results in the development of hydrocarbon deposits with an increase in their recovery factor are obtained through the construction of 3D technological and geological models that take into account the real physical (reservoir) properties of target objects, thereby making it possible to systematically regulate and control the processes of drilling and exploitation of fields. In turn, the creation of 3D models is based on a set of seismic survey materials, well loggings, laboratory core data, formation fluid samples, well testing and well production.
In connection with the foregoing, special attention is paid to the development of innovative approaches and methodological techniques for three-dimensional geological modeling of complexly constructed traps to obtain the required calculated parameters, quantitatively predict the dynamics of their change during operation, determine production characteristics, inflow composition, etc.

Keywords: *Well Logging, Analysis, Reservoir Properties, Research, Petrophysics, Geological and Technological Modeling, Core, Interpretation, Boundary Values, Porosity*

INTRODUCTION
In connection with the foregoing, special attention is paid to the development of innovative approaches and methodological techniques for three-dimensional geological modeling of complexly constructed traps to obtain the required calculated parameters, quantitatively predict the dynamics of their change during operation, determine production characteristics, inflow composition, etc. To solve these problems, systems of petrophysical algorithms for geological 3D modeling are being created based on the dynamic properties of target productive formations, the methodology for interpreting geophysical surveys is being improved; establishing the types and conditions for the formation of hydrocarbon traps; complex geological and geophysical criteria for assessing their oil and gas content are being developed, which is an urgent problem (Nazarov, 2019).
The goal is to create a petrophysical algorithm for calculating porosity and permeability properties (PPP), which provides subsequent geological and technological modeling of hydrocarbon deposits based on the dynamic characteristics of reservoirs.
The structure of the Gazli field is administratively located on the territory of the Romitan region of the Republic of Uzbekistan in the north-west of the city of Bukhara, and tectonically located in the Gazli uplift. Accumulations of oil and gas are associated with anticline structure, the field belongs to sheet-like accumulation (Nazarov, 2019).
The distribution of deposits over the area is determined by the tectonic features of the river, which is also realized by the position of the initial excellent oil-water contacts (OWC).
The structure was revealed in 1959 year as a result of structural drilling beginning in 1959 (Petrov et. al., 1962).
As is known, there are three main sources of information about the petrophysical parameters of reservoirs and, in particular, about their reservoir properties.

1. find and justify a step-by-step algorithm for petrophysical calculations that determine the correct dynamic properties of target objects for subsequent technological and geological 3D modeling;
2. to carry out forecasts of the prospects for oil and gas content, calculations of the coefficient of current oil and gas saturation of reservoirs based on their dynamic properties;
3. confirm the accuracy of the approaches used in modeling by evaluating the ranges of uncertainties of the obtained parameters and risk zones, including the influence of the uncertainty of the interwell space.

MATERIALS AND METHODS

To determine the methodology for processing and interpreting the complex of field geophysical studies of terrigenous Cretaceous deposits, the identification of gas-bearing and oil-bearing strata, the following results are presented: generalizations of the physical and lithological characteristics of the rocks of the productive stratum from the core; determination of boundary values for core and petrophysical characterization of terrigenous rocks, by using two generally accepted approaches - comparison of open (Kp) and dynamic porosity for oil and water saturated reservoirs, comparison of open porosity with effective porosity for gas reservoirs and statistical analysis (comparison of cumulative distribution curves - reservoir and non-reservoir); determination of porosity, electrical resistivity in Cretaceous terrigenous deposits and mineralization, electrical resistivity in formation waters; determination of petrophysical dependences of the "core-core" and "core-well log" types; determination of porosity by various logging methods (Nazarov *et. al.*, 2021).

As a result of all correlation and statistical plotting and a detailed analysis of the quantitative interpretation of well logging, the cutoff values of the porosity coefficient are rounded to integers and accepted for use in the following values: for gas-saturated reservoirs - layers IX-XI-20%, layers XII-XIII-A-19%, layers XIII-B–XIII¬¬-E–16%; for oil-saturated reservoirs - formation XIII-A–19%, formations XII-B–XIII-D–16%, formation XIII-E–17%.

When updating and expanding the core sample due to the introduction of information from new wells 1002, 1003, the Dakhnov-Archie equations were built and based on the data from new wells, analyzed and compared with previous results. So, Fig.1 shows the dependence of the porosity parameter on the coefficient of open porosity Pp=f(Kp) for all studied horizons (Nazarov, 2020).

Table 1 presents the Dakhnov-Archie equations for calculating oil and gas saturation factors from new well core data

Table 1: Dakhnov-Archive Equation for Calculating Oil and Gas Saturation Factors Based on New Core Data

Formation	Рн=f(Кв)	Рр=f(Кр)
IX	$Рн = 1.00*Кв^{-1.38}$ $R^2 = 0.98$	$Рр = 1.00*Кр^{-1.52}$ ($R^2 = 0.98$ атм) $Рр = 1.00*Кр^{-1.68}$ ($R^2 = 0.93$ рл)
X	$Рн = 1.00*Кв^{-1.3}$ $R^2 = 0.96$	$Рр = 1.00*Кр^{-1.52}$ ($R^2 = 0.95$ атм) $Рр = 1.00*Кр^{-1.54}$ ($R^2 = 0.99$ рл)
XI	$Рн = 1.00*Кв^{-1.47}$ $R^2 = 0.94$	$Рр = 1.00*Кр^{-1.53}$ ($R^2 = 0.98$ атм) $Рр = 1.00*Кр^{-1.64}$ ($R^2 = 0.97$ рл)
XI-A +XII	$Рн = 1.00*Кв^{-1.58}$ $R^2 = 0.71$	$Рр = 1.00*Кр^{-1.51}$ ($R^2 = 0.99$ атм) $Рр = 1.00*Кр^{-1.62}$ ($R^2 = 0.98$ рл)
XIII	$Рн = 1.00*Кв^{-1.43}$ $R^2 = 0.77$	$Рр = 1.00*Кр^{-1.54}$ ($R^2 = 0.97$ атм) $Рр = 1.00*Кр^{-1.68}$ ($R^2 = 0.94$ рл)

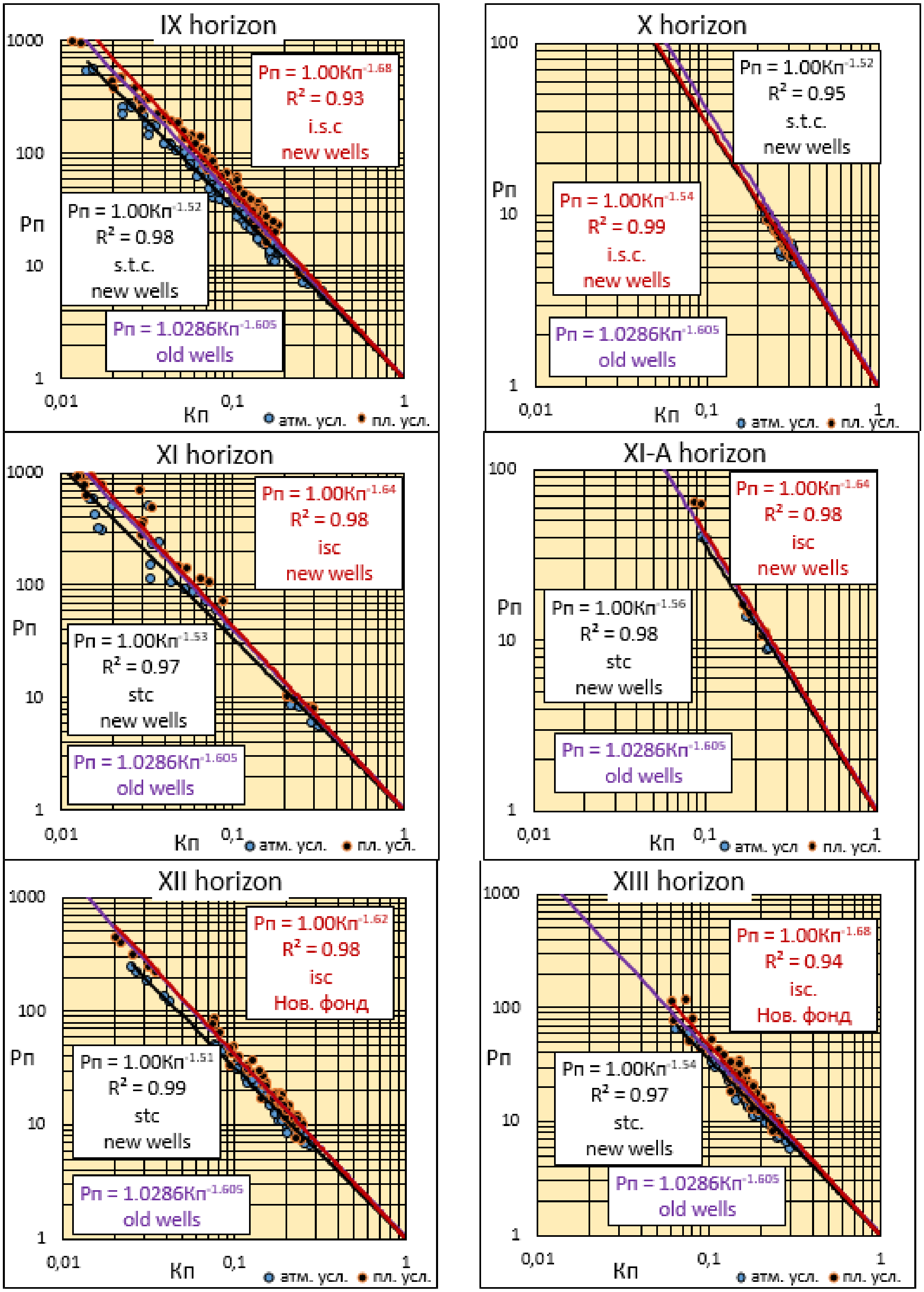

Figure 1. Dependence of the porosity parameter (Pp) on the coefficient of open porosity (Kp) for sandy-silty rocks of IX–X–XI–XI-A–XII and XIII horizons under atmospheric and thermobaric conditions

The dependences of the saturation parameter on the coefficient of residual water saturation Рн=(Kw), in turn, are shown in Fig. 2.

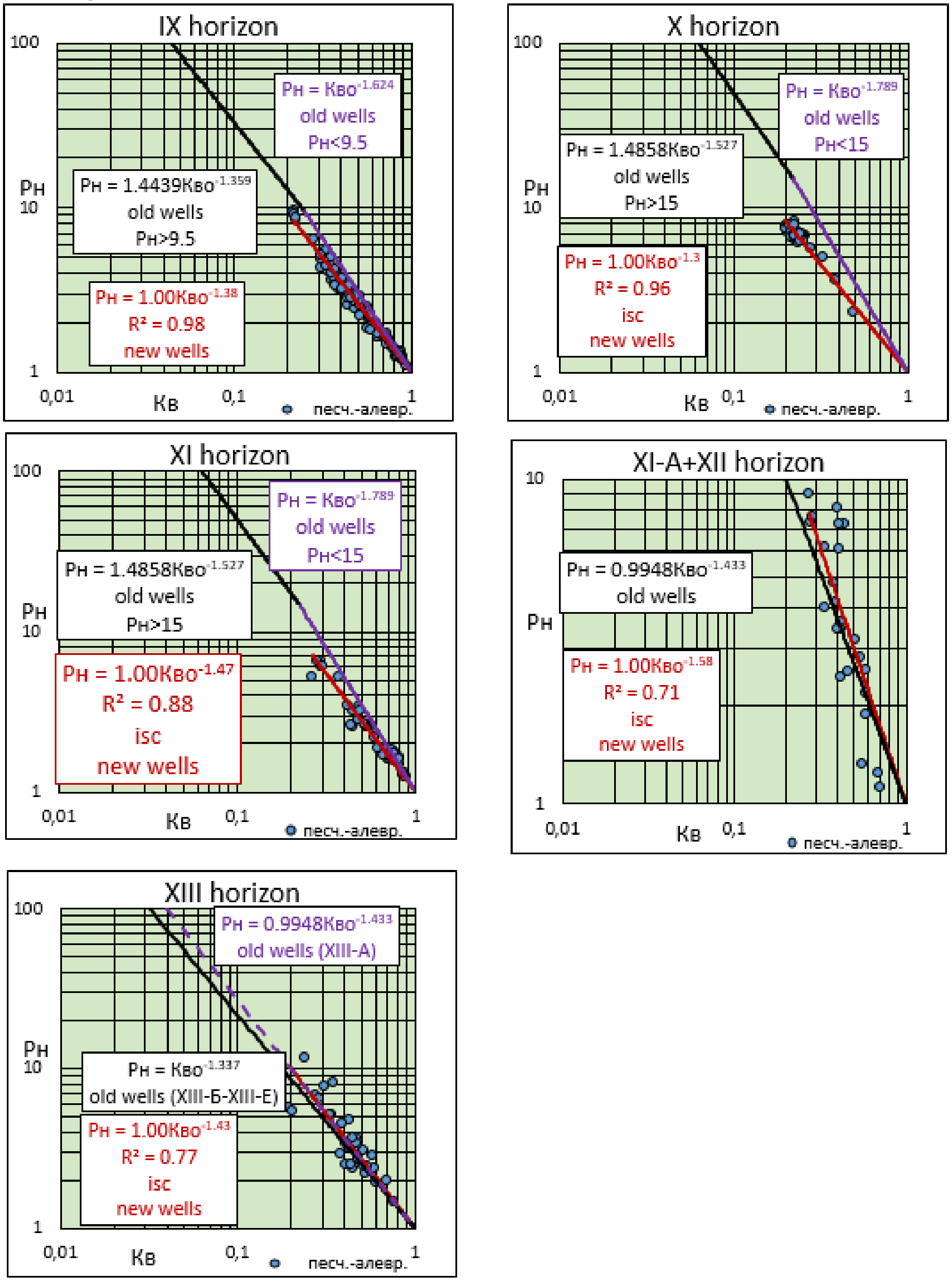

Figure 2. Dependence of the saturation parameter (Рн) on the water saturation coefficient (Кw) for sandy-silty rocks of IX–X–XI–XI-A–XII and XIII horizons

An analysis of the relationships and their corresponding calculation methods revealed that the disparity between the Kog values (ΔKog) calculated using the 1959 and 1962 reserve calculation equations (solely under atmospheric conditions), and those derived from the data of new wells obtained from core samples (considering both atmospheric and reservoir conditions), when iterated over a range of input options for Rp - Kp pairs, yields the following set of values:

- ΔKog (РЗ_59-62 г. atm. cond. – new atm. cond.)in horizon IX from 1.5 to 10 % at Rp > 15 Ом·м;
- in horizon X from 0.8 to 4.5 % at Rp > 18 Ом·м;
- in horizon XI from 1.4 to 7.5 % at Rp > 19 Ом·м;
- in horizon XII from 1.5 to 16 % at Rp > 16 - 20 Ом·м;
- in horizon XIII from 1.6 to 15 % at Rp > 16 - 18 Ом·м.

ΔKog (РЗ_59-62 г. atm.cond. – new atm.cond.)

- in horizon IX from 2.5 to 15 % at Rp > 19 Ом·м;
- in horizon X from 0.1 to 2.6 % at Rp > 19 Ом·м;
- in horizon XI from 1.5 to 9.4 % at Rp > 23 Ом·м;
- in horizon XII from 1.5 to 3.5 % at Rp > 20 Ом·м;
- in horizon XIII from 0.9 to 10 % at Rp > 20 Ом·м.

The author concluded that Kng calculations using the Dakhnov–Archie equations depend on the availability and quality of electrical resistance curves. There are objective difficulties, limitations and ambiguities in determining the electrical resistivity of the formation from the recorded probe gradient curves. Along with this, an alternative calculation of the oil and gas saturation coefficient was carried out using the dependences of the residual water saturation coefficient on the open porosity coefficient found on the new core, assuming extremely saturated deposits. Core data from new wells made it possible to reveal their very close relationship when calculating residual water content, in contrast to previous determinations.
An analysis of the available measurements of the petrophysical properties of the core showed that obtaining individual core dependencies for each formation is not optimal, both because of the small number of core measurements for some formations, and because of the similarity in the properties of individual formations with each other. In the course of further work on obtaining petrophysical dependencies, the author decided to combine core measurements in layers into groups with similar petrophysical properties. The results of the distribution of petrophysical properties of terrigenous Cretaceous deposits by depth and area are presented.

RESULTS AND DISCUSSION

The author created a database for building a digital geological model of the Gazli field. All the initial data necessary for building a 3D geological model are included in the project created in the tNavigator software (Rock Flow Dynamics) (Nazarov and Zakirov, 2018).
Based on the available stratigraphic picks, a structural model and a 3D grid were built. Structural surfaces along the tops of the horizons were built using the method of convergence from the top of horizon IX due to the comfortable occurrence of the layers. In total, 27 vertical zones were identified in the geological model, taking into account clay barriers between productive horizons. To build structural surfaces along the bottoms of horizons IX–XII, maps of the thicknesses of clay bridges were built, using which maps were built for the bottoms of horizons.
When the structural frame was completed, the construction of the geological grid was carried out. The polygon for constructing a 3D geological model is determined by the outer contour of the gas content of horizon IX, since it is the largest area comparing to all other horizons.

Next, the process of well log upscaling was considered in order to correctly transfer the raw data (logs) to a three-dimensional geological grid (UpScaling) while maintaining the average, minimum, maximum and statistical characteristics.
In order to build maps of gas- and oil-saturated thicknesses, a lithology cube was modeled. The propagation of discrete lithology model was implemented by the stochastic method SIS (Sequential Indicator Sumulation). For each horizon, a geo-statistical section (GSR) was created, which was used as a vertical trend to reproduce the distribution of reservoirs along the section.
The modeling of the porosity parameter was implemented by the stochastic interpolation method Sequential Gaussian Simulation (SGS) with an exponential variogram type for reservoir cells (Nazarov, 2019).
The calculated model of residual water saturation was made by the author according to the petophysical dependence of the residual water saturation coefficient on the open porosity coefficient.
Based on the results of calculation of models and maps of properties (effective porosity, oil saturation, phase permeability, specific productivity), the author developed recommendations for optimizing exploration and field operations at the Gazli field, including: priority drilling wells within the zone of increased oil productivity identified by the results of 3D model; determination of dynamic properties of reservoirs according to logging data (porosity and oil saturation, phase permeability, capillary pressure); construction and updating of geological and hydrodynamic models of the reservoir with a forecast of the dynamic parameters of the reservoirs; drill exploration wells to the depths of occurrence of exploration objects; conducting directional research with the latest devices; conducting research using geological, hydrodynamic and geophysical methods in the process of drilling and testing both in an open hole and in a production string; study of the physical properties of productive rocks and fluids by laboratory methods and well logging, including modern well logging methods; special core studies (capillarmetric studies, studies of relative phase permeability; apply the methods of intensification of inflows (Yuldashev *et al.,* 2020).

CONCLUSION

Based on the results of the work performed, the following conclusions were formulated:
1. When substantiating the well logging interpretation algorithm, it is recommended to base it on the value of the coefficient of normalized effective porosity, and in the systems of equations adopted for petromodeling, take into account such influencing factors as: sedimentation conditions, the degree of secondary transformation of the minerals that make up the rock, occurrence conditions, etc.
In addition, the interpretation algorithm must be based on a reservoir model with an intergranular type of pore space tuned to the reference characteristics of the reservoir properties.
2. It is advisable to apply methods for estimating the value of primary water cut (f initial) and productivity (correlation between the specific productivity of each object and the value of the effective porosity coefficient (Ω specific). i-th object = f (Kp eff,)) in the inter-well spaces, distributions of phase permeabilities in it, with the use of well test results.
3. The developed blocks of the petrophysical algorithm were the input data for 3D geomodel: dynamic properties of productive objects, oil and gas saturation coefficient (Kog), relative permeability, connectivity model in the transition zone, capillary pressure (Pcap), predicted flow rates, etc. At the same time, taking into account the magnitude of the errors in the calculations of the coefficients eff. Kp, Kog, K by capillary model, made it possible to take into account errors in the assessment of flow rates in the cells of the 3D model.
4. The proposed algorithm for petrophysical and geological modeling is able to solve such urgent problems as: a) increasing the reliability of identifying complex reservoirs, b) assessing their dynamic properties, taking into account the data of field geophysics and core studies (the composition of the rock matrix and the cement filling the pore space) , c) control during the development of fields of filtration reservoir heterogeneity.
5. It is recommended to take into account the relationship between capillary pressure in the transition zone and dynamic reservoir properties in 3D models in order to increase the reliability and efficiency of field development, as well as when calculating hydrocarbon reserves.

6. In petrophysical modeling, it is obvious that it is expedient to take into account the properties of rocks by the core: total and open porosity, residual water saturation, component composition of the main rock-forming minerals and clays (in particular, the swelling ability of some clay minerals), grain size, type and properties of cement, etc. , to take into account changes in electrical, radio-geochemical, mechanical, density, water-retaining and other properties of the reservoir during the development of the field.

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