Geological Model as a Basis for Re-Estimation of Geological Oil Reserves Based on the Pavlovskaya Area of the Romashkinskoe Oil Field

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Currently Romashkinskoe is a mature oil field. It has both a low production rate and a high water cut. The problem of active development of low drained and trapped reservoir zones remains one of the main challenges for increasing reservoir development efficiency.

In this work a static base for a filtration model was made in order to perform the future estimation of the remaining reserves and provide recommendations for their extraction. The object for consideration was the terrigenous deposit of Pashiysky horizon D1 that belongs to Pavlovskaya area.

For geological modeling of the Pavlovskaya area Roxar software was used. This is the most modern geological modeling package available and has been widely and successfully used.

The process of geological modeling included the following steps:

- Gathering and processing initial data, checking quality and completeness; creating a data base of geological-geophysical data (project creation and loading);
- Calculation and construction of geo referenced structural grids of zonal intervals; the construction of a structural-stratigraphic model;
- Construction of a well model and analysis of borehole data;
- Construction of a lithology model and distribution of reservoir properties;
- Analysis of fluid contact position and construction of an initial oil saturation model;
- Estimation of initial balance reserves of oil.

Having this database structure provides a high level of efficiency at all stages of modelling. When checking the quality of the initial information, inaccuracies in wellhead and bottom-hole coordinates and altitudes of wells were identified and corrected (Figure 1). The logging intervals and the results of log data processing were also analyzed for the purpose of qualitative performance (Figure 2). All data was analyzed and processed in the ResView ll software package which allows for time optimization when modelling at this stage of work.

The creation of a structural-stratigraphic framework started with a detailed study of the geological feature of the exploitation object of the area, in other words with a detailed stratigraphic correlation based on well sections (Figure 3).
Fig. 1 The quality control of the initial information (a is map of wells’ altitudes, b is the fragment of map of wells’ bottom-hole coordinates comparison)

Fig. 2 Logging data plate for well №18811
At this stage of work, all wells in the given area were correlated. A detailed correlation was made using key wells. Marker horizons, which have a regional distribution, have been identified: marker horizon "upper limestone" at top of the horizon D1 and "mullinskye clays" at the base of the D1, as well as an additional marker horizon of local distribution "claystone".

As a base surface in the construction of the structural/stratigraphic framework, for the geological model of the Pavlovskaya area, a grid was used representing the bottom (base) of the marker horizon "upper limestone"(Figure 4). This base stratigraphic surface was constructed taking into account seismic mapping. The process used for creating a geo referenced structural grids was based on the convergence method.

The three-dimensional grid for the geological model of the Pavlovskaya area contains four zones - zonal intervals "A", "B", "V" and "GD". For each zone, a proportional division into layers was chosen. The orientation of the cells is based on the direction of the filtration flows.

Fig. 3 The correlation scheme of the Pashiysky horizon sediments along the line of wells №18762, 784, 8286
Fig. 4 Structural map according to the bottom (base) of the marker horizon "upper limestone"

In order to get a high correspondence of initial information from the wells, different mathematical averaging methods were used to create the well model (Figure 5).

Fig. 5 The porosity coefficient distribution histogram in the horizon D1 reservoir using wells’ data and averaging by 3D grid.
Obtaining a cube for the distribution of different rock lithology is one of the most important stages of modeling. This is because the three-dimensional distribution of reservoir properties and saturations are modelled in the future taking into account variations in lithology (Figure 6).

Fig. 6 The reservoir distribution in the productive deposits section of the Pashiysky horizon

The porosity cubes for the zonal intervals of the horizon D1 were constructed by petrophysical distribution of borehole data obtained from the interpretation of well logs with the lowest condition value of 11% (Figures 7-8).

Fig. 7 The porosity cube
Fig. 8 The quality analyzing instruments of the petrophysical modeling (a is the porosity distribution histogram in the D1 horizon collector according to the well log interpretation data and the averaged wells data, b is the vertical distribution of the porosity values constructed according to the well data and the cube).

The analysis of the statistical dependencies between porosity and permeability, taking into account the clay coefficient of well data, made it possible to identify two groups of reservoir rocks (Figures 9). The resulting relationship between these parameters was confirmed by statistical dependencies obtained from the correlation of core data analysis, adopted in the company standard 105-2013 "Logging Interpretation, algorithms for determining the parameters of reservoirs of oil deposits in the Republic of Tatarstan".

The cube of absolute permeability (Figure 10) was calculated taking into account the identified groups of reservoir rocks, the statistical dependencies for which are presented in the table 1.

<table>
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<tr>
<th>Modeling interval</th>
<th>Dependence for permeability</th>
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<tr>
<td>Pashiysky horizon</td>
<td>( C_p = 10^{5.007 \cdot \log K_p - 3.85} ), when ( C_{clay} &lt; 2% )</td>
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<tr>
<td>Pashiysky horizon</td>
<td>( C_p = 10^{5.658 \cdot \log K_p - 5.0} ), when ( C_{clay} &gt; 2% )</td>
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Fig. 9 The permeability statistical dependence on porosity, taking into account the clay coefficient according to the well data.

Fig. 10 The cube of permeability.
The position of the oil-water contact (OWC) was carried out based on wells drilled before the active development of the Pavlovskaya, Zelenogorskaya and Vostochno-Leninogorskaya areas of the Romashkinskoye field, extension of which does not exceed 20 m (assuming vertical wells). Additionally, information was analyzed on the nature of reservoir saturation based on well log interpretation, perforation and insulated intervals, test and sampling results, production data and well injection.

Based on this information, an OWC value was accepted at the vertical depth of -1490 m for the model of the Pavlovskaya area (Figure 11).

![Fig. 11 The analysis scheme of the fluid contact position along the line of wells № 1038, 1133, 2025, 2040](image)

The initial oil saturation cube was constructed using the Leverett J-function, calculated from the results of capillarometric core studies.

The estimation of the initial balance reserves of oil based on the model was carried out according to the volumetric method. A comparison of the geological reserves of oil obtained by the model with the reserves that are on the balance sheet of PJSC Tatneft was made. Differences in the geological reserves of oil, estimated by the geological model, exceed the permissible error. The resulting increase in oil reserves is explained by the updating of the parameters, primarily the
thicknesses and volumes of oil-saturated rocks, based on additional information from wells drilled after the last estimation of reserves.

The created geological model of the Pavlovskaya area corresponds to the study of the Romashkinskoye field and is suitable for performing calculations of technological values. Furthermore, a geological model was calculated in automated-working station (AWS) LASURIT hydrosimulator for the purpose of selection of candidate wells for geological and technological measures (GTM). These activities will be evaluated in the TEMPEST software package for further recommendations on the extraction of remaining oil reserves from poorly drained and trapped reservoir zones.

References
3. Analysis of the development of the Pavlovskaya area (D1) of the Romashkinskoye field (with specification of project indicators) / under the direction of A.V. Nasybullin, V.M. Vasilieva; TatNIPIneft. - Bugulma, 2009. - Book 1- 296 p., Book 2- 287 p., 1st folder –application №33+ 1 CD. - SCI.