A comprehensive analysis of the properties of reservoir rocks to determine the productive oil horizons

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Abstract. The purpose of the research is to study the reservoir and filtration properties of reservoir rocks of the Aptian horizon of formation No. 1 within the Kovylnoye field. The initial data were reservoir-filtration and geological-geophysical parameters within the exposed rocks of the reservoirs of the Aptian horizon of formation No. 1, for wells No. 1 and No. 2, which were drilled at the search and evaluation stage of work: porosity coefficient, permeability coefficient, rock resistivity, oil-saturated thickness. High values of effective porosity, permeability, and oil and gas saturation are found in biomorphic, organogenic, and clastic carbonate rocks where the void space has not been subjected to secondary changes (salt deposits), resulting in reservoirs characterized by low capacitance and filtration properties. Analysis of carbonate reservoirs gives values of permeability up to 0.3-1 mm\textsuperscript{2} and porosity of 20-35 %. Rocks are lumpy, loose, weakly cemented with cement content up to 10%. Their initial water saturation in the oil deposit does not exceed 5-20 %. The research has shown the effectiveness of conducting a comprehensive analysis of reservoir rock properties to determine the oil and gas content of the site.

1. Introduction

In the Prikumsky district, oil and gas content was detected in deposits from the Permian-Triassic to the Neogene ages. Several oil and gas complexes of the following age have been identified within this section interval: Permian-Triassic, Jurassic-Cretaceous, and Paleogene-Neogene.

Permian deposits are the most ancient, from which oil inflows are obtained.

In recent years, commercial oil flows have been produced from the fractured-cavernous carbonate reservoirs of the Lower Triassic age related to deposits of Neftekumsk Suite (Vostochnaya, Vostochno-Bezvodenskaya, Pushkarskaya, Russkii Khotor Severnyi, etc.).

Mixed oil and gas and pure gas condensates were produced from sand layers of the Middle Triassic age in the Sukhokum, Vaidzhano, and other areas.

A slight inflow of oil is obtained from the Upper Triassic limestones of Zakumskaya and Novokolodeznaya areas.
Jurassic and Cretaceous deposits are regionally oil and gas-bearing within the entire Eastern Stavropol territory.

Industrial inflows of oil were produced from stratum VII of Jurassic age in the Maksimokumsk area, from stratum V of Jurassic age in Polevaya, Molodezhnaya, Prignanichnaya, Russkii Khutor Yuzhnyi, Russkii Khutor Severnyi, and other areas.

Oil was obtained from the upper Jurassic in the Ozek-Suatskaya and Uvarskaia areas, and a gas-condensate Deposit was discovered in the third layer of the Jurassic.

Sandy-aleurolite-carbonate strata of the Lower Cretaceous deposits are connected on the squares Border, Youth, Ozek-Suats, Feather, Russian farm Northern, non-oil inflows received in the Volynsk area on the Manych area in well No. 1 of the Ilmen VIII of the Lower Cretaceous reservoir received inflow water with 25% oil.

The upper Cretaceous carbonate reservoirs are associated with oil inflows in areas: East Bezbednosti, Winter Rate.

A slight show of oil in Paleogene deposits was identified at the Ozek-Suat field, and oil occurrences were also noted at the Vostochno-Bezdnowenskoye field.

Testing of wells to study the oil content of the Kovylnoye field was performed in a significant stratigraphic range from Triassic to Maikop deposits.

**Layer No. 1.**

Oil-saturated sandstones of the No. 1 formation represent the lower part of a single Deposit in the strata. The water-oil contact (WOC) was opened at the absolute level of -3100 m timed to the structural uplift. The lift was opened by well 1.

An independent Deposit was opened by well 1 within the Kovylnoye area. The boundaries of the Deposit were previously determined by the position of the WOC at the absolute level of -3100 m. The boundaries of the Deposit, of course, are somewhat expanded in comparison with the operational calculation of reserves. Taking into account that the ratio of oil-saturated and water-saturated sandstones exposed by perforation is 2/3, the predominance of water in the product testing is quite understandable.

The Deposit of the Kovylnoye area has a rounded appearance. The height of the Deposit in the VIII layer is 10 m. The reservoir is Plast, vaulted.

The prospects for deposits of the formation are mainly related to the Kovylnoye area, where the area of the Deposit in layer VIII is probably larger than expected.

### 2. Materials and methods

In this work, a capacitive-filtration and geological-geophysical parameters of reservoir rocks of the Aptian horizon Grass field was evaluated in comparison with similar rocks East Bezbednosno field. To perform this task, the variability graphs of reservoir-filtration and geological-geophysical parameters were constructed and their correlation analysis was performed [1, 2].

For this purpose, data from the geo-information system (GIS) and data from laboratory studies of reservoir cores [3-6] obtained during drilling of wells No. 1 and No. 2 of the Kovylnoye field were used. The productive Aptian horizon of formation 1 is well lit with core material. For all samples under laboratory conditions, the following parameters were determined: porosity coefficient, permeability coefficient, resistivity, and effective thicknesses.

### 3. Characteristics of the lithological composition of reservoirs of the Aptian horizon

The Aptian productive horizon at the Kovylnoye Deposit is lithologically represented by a stratum of interlayers of light gray and greenish-gray sandstones, fine-and medium-grained, quartz-glaucinite, oil-saturated, with traces of fauna, with dark gray mudstones, weakly silty, layered with traces of fauna and flora of poor preservation and dark gray siltstones, clay, mica massive, with rare thin layers of Sandstone or Dark gray mudstone.

Vertical cracks made by calcite are observed in the core samples. There are also layers of Sandstone, mixed-grained, mica, with rare inclusions of glauconite and carbonaceous material.
Limestones are mostly Micrograin structure with an uneven shell fracture. There are inclusions of spherical organogenic formations, the number of which varies in different areas - from 10-15% to 25-70%. Rare secondary leaching voids are observed, unevenly located in the rock, not interconnected, oval-rounded shape, size 0.02-0.3 mm, formed by the dissolution of calcite.

Allothigenic components of Sandstone are represented by quartz, feldspars, micaceous minerals, and accessory minerals. Operational objects of neighboring fields of similar age have a similar material composition.

4. Comparative analysis of reservoir properties
In addition to core studies, the results of geophysical studies [7-10] and hydrodynamic studies of wells in the Kovylnoye field were used to evaluate reservoir properties.

A comparative analysis of the results of research of the Kovylnoye field for wells No. 1 and No. 2 is presented in figures 1-4.

![Figure 1](image1.png)

**Figure 1.** A graph of the variability of oil-saturated thickness with changes in the depth of wells No. 1, 2, Kovylnoye.

![Figure 2](image2.png)

**Figure 2.** A graph of the variability of porosity factor with changes in the depth of wells No. 1, 2, Kovylnoye.
Figure 2. Graph of the variability of the porosity coefficient of rocks with changes in depth for wells No. 1, 2 Kovylnoye.

The ratio of the porosity of rocks (Figure 2) is an increase in the values in interval Upstage skyline reservoir number 1 (from 3080 3095 to – field No. 1; from to 3099 3105 – field No. 2). The maximum value is observed in the range from 3085 to 3091-for field No. 1 and at a depth of 3100 m-for field No. 2.

Figure 3. The variation graph of rocks resistivity with depth for wells No. 1, 2, Kovylnoye.

On the graph of rock resistivity (Figure 3), there is an increase in the value in the range of the Aptian horizon of formation No. 1 from 3084 to 3097 – for field No. 1 and from 3097 to 3104– for field No. 2. The maximum value was observed at a depth of 3.090 m in field 1 and 3.100 m in field 2.
**Figure 4.** Chart of the variability of the permeability coefficient with changes in depth for wells No. 1, 2 Kovylnoye.

The graph of rock permeability coefficient variability (Figure 4) shows an increase in the value in the range of the Aptian horizon of formation No. 1 from 3087 to 3101 – for field No. 1 and from 3099 to 3103 – for field No. 2. The maximum value was observed at a depth of 3,099 m - for field No. 1 and depths of 3,100 and 3,103 m-for field No. 2.

Based on the analysis findings of the distribution graphs of indicators in wells No. 1 and 2 Kovylnoye, it can be concluded that the formation is not uniform, there are layers of mudstones with other reservoir-filtration and geophysical characteristics. The intervals (3080-3090 – for well No. 1) and (3096-3106 – for well No. 2) are oil-bearing horizons [11, 12], which is indicated by increased relative resistance values.

Correlation coefficients [13, 14] between the oil-saturated thickness (osth), porosity coefficient (por), resistivity (r) and permeability coefficient (perm) obtained during the correlation analysis of research results for wells No. 1 and 2 of the Kovylnoye field:

- for field No. 1:
  \[ k_{\text{osth,por}} = 0.71; \ k_{\text{osth,r}} = 0.74; \ k_{\text{osth,perm}} = 0.59; \ k_{\text{por,r}} = 0.83; \ k_{\text{por,perm}} = 0.52; \ k_{\text{r,perm}} = 0.57; \]

- for field No. 2:
  \[ k_{\text{osth,por}} = 0.31; \ k_{\text{osth,r}} = 0.43; \ k_{\text{osth,perm}} = 0.67; \ k_{\text{por,r}} = 0.35; \ k_{\text{por,perm}} = 0.34; \ k_{\text{r,perm}} = 0.27. \]

The following pairs of parameters have a significant positive correlation: porosity coefficient and oil-saturated thickness of rocks, rock resistivity and porosity coefficient, resistivity, and oil-saturated thickness [1].

The dependence of porosity on resistance is observed, which indicates the presence of hydrocarbons in the reservoir rocks, i.e., with increasing porosity, the resistance increases, which is also observed in the graphs [15, 16].

5. **Conclusion**

Having studied the distribution of indicators at the Kovylnoye field for two wells (No. 1 and No. 2) on the same horizon, we can conclude that these indicators differ very slightly, which indicates the uniformity of the reservoir properties. The quality indicators remain unchanged. Thus, on the territory of the Grass, you can expect similar rates within the entire area prospect reservoir number 1.

The analysis showed the dependence of porosity on resistance, which indicates the presence of hydrocarbons in the reservoir rocks, i.e., with increasing porosity, the resistance increases.

The use of a comprehensive analysis of reservoir rock properties makes it possible to determine the effective areas of the oil and gas potential of the Kovylnoye territory.

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