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Influence of Geological Factors on the Formation of the Value of Oil Recovery in Different Geological and Physical Conditions

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ABSTRACT: The results of estimating the proportion of the influence of geological factors on the recovery factor on the basis of numerical experiments on the geological and statistical models based on a generalization of receiving long-processed oil deposits in Uzbekistan.

KEYWORDS: oil, reservoir, extraction, wells, models, development, water flooding, density, carbonate, terrigenous.

I. INTRODUCTION

Oil recovery factor is a complex function of many parameters of the reservoir and its saturating fluids, as well as development and water flooding systems.

At the same time, when studying the features of the development of a particular group of fields, it is usually possible to single out the beneficial effect on the oil recovery factor of a certain number of natural and technological factors, to estimate their share and the formation of the current and final oil recovery factor. This is evidenced by numerous statistical (regression) dependences of the oil recovery factor on geological, physical and technological factors, obtained for various oil-producing regions of the commonwealth of independent states and a number of foreign countries [1]. From them, in particular, it can be seen that if for one group of fields the predominant influence is the permeability of the reservoir and the density of the well grid, then for the other - the ratio of the viscosities of oil and water, as well as the rate of fluid withdrawal, etc. [1].

II. METHODOLOGY

A distinctive feature of the development theory of the last two decades is the widespread use of computer programs that allow forecasting tasks to be solved on the basis of constantly operating geological and technological models of deposits. These models consist of two organically related parts: geological and hydrodynamic models. In this case, the geological model of the field is the basis for creating a hydrodynamic (filtration) model, on the basis of which the development indicators are predicted. Therefore, the assessment of the share of the influence of geological factors on the formation of the value of the oil recovery factor (ORF) is one of the tasks of the theory and practice of oil field development.

We have solved this problem using a geological-statistical model for estimating oil recovery factor, obtained on the basis of multivariate regression analysis of long-term development objects in Uzbekistan [2,3].

One of the main advantages of geological-static models is that they make it possible to establish not only a qualitative, but also a quantitative effect of indicators on the process, with the simultaneous influence of other factors. This is one of the main reasons for the predominantly use of geological and statistical models to assess oil recovery factor in various geological and physical conditions of deposits [4]

In work [2] it was found that the highest correlation coefficient for the geological and physical conditions of the field in Uzbekistan is achieved with the following geological and static models:

- for carbonate reservoirs (r = 0.91)

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$$n_{cr} = 0{,}1748 + 0{,}0694\,T_l - 0{,}0137S + 0{,}2902K - 0{,}0015\mu_o + 0{,}2548K_g \quad (1)$$

- for terrigenous reservoirs (r = 0.76)

$$n_{tr} = 0{,}0927 + 0{,}0532T_l - 0{,}0048S + 0{,}3205K - 0{,}0221\mu_o + 0{,}8570\,K_g \quad (2)$$

Where n_{cr} и n_{tr} - is the final oil recovery factor for carbonate and terrigenous reservoirs, respectively;
T_l- the average annual rate of fluid withdrawal in% of the initial recoverable oil reserves;
S - density of wells grid, hec/well;
K – average formation permeability; μm^2 ;
μ_o – viscosity of reservoir oil, mPa s;
K_g – net-to-gross ratio, unit fraction

Assessing the degree of influence of geological factors on the formation of the oil recovery factor by geological-static models with a simultaneous change in the values of all parameters is practically impossible, since this leads to multivariate calculations and creates difficulties in analyzing the results obtained. In this regard, in numerical experiments, geological factors varied within the minimum, average and maximum values (Table 1), while the technological parameters remained unchanged and equal to their average values.

Table 1

Variation intervals and average values of geological and commercial factors

№	Geological field	units	Carbonate collector		Terrigeno collector	
			Change intervals	Average value	Change intervals	Average value
1	Permeability coefficient	μm^2	0,01-0,45	0,14	0,01-1,25	0,14
2	Reservoir oil viscosity	mPa s;	0,9-40,0	7,26	1,1-9,5	3,8
3	The ratio of effective oil saturated and total reservoir thickness	Share of units	0,10-0,89	0,5	0,13-1,00	0,49
4	Well grid density	hec/well	0,52-36,33	9,96	2,13-43,02	9,94
5	Average rate of selection	%	0,26-5,94	2,14	0,05-7,41	1,74
6	Final oil recovery factor	Share of units	0,08-0,69	0,34	0,04-0,75	0,35

The application of such a methodological approach is also due to the fact that geological-static models give the most reliable results. When the parameters included in the model are close to their mean.

The results of numerical experiments are presented in the form of dependences of the oil recovery factor on the range of changes in geological factors (Fig. 1) and the proportion of the influence of geological factors on the formation of oil recovery factors (Fig. 2)

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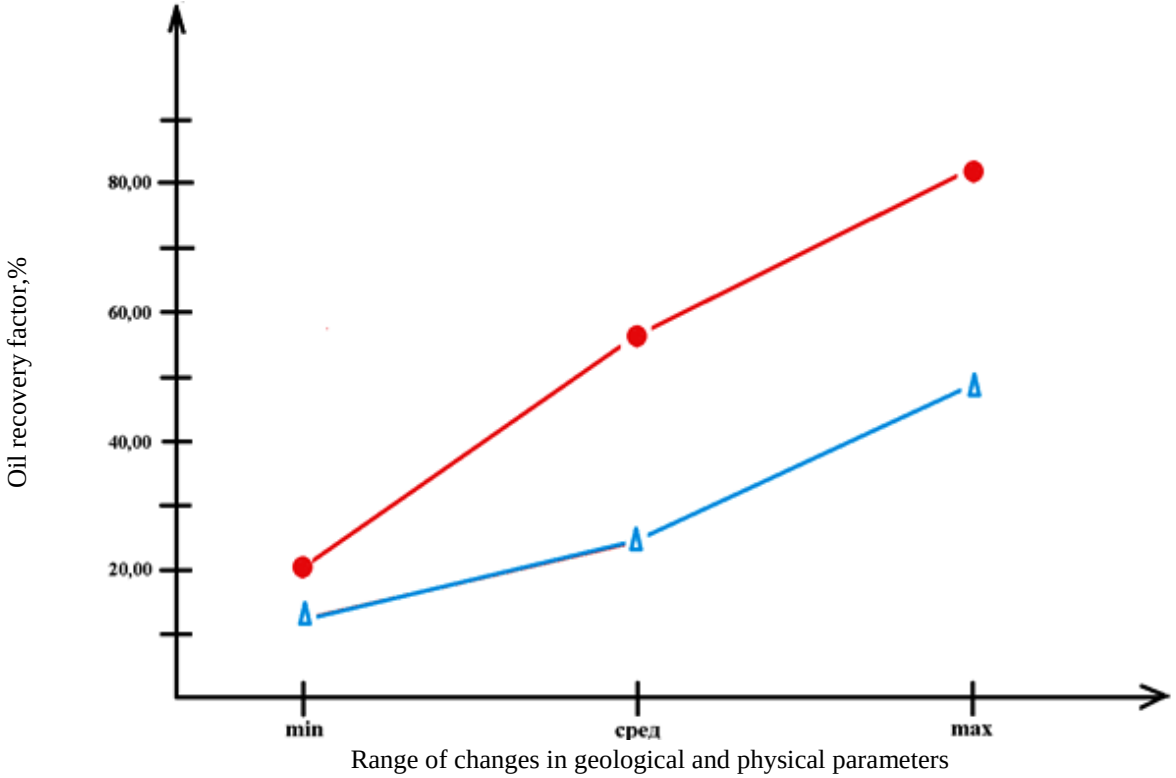

Fig. 1. –Dynamics of change in the share of oil recovery factor for different ranges of change in geological and physical parameters:
• - for deposits with terrigenous reservoirs;
- for deposits with corbonate reservoirs.

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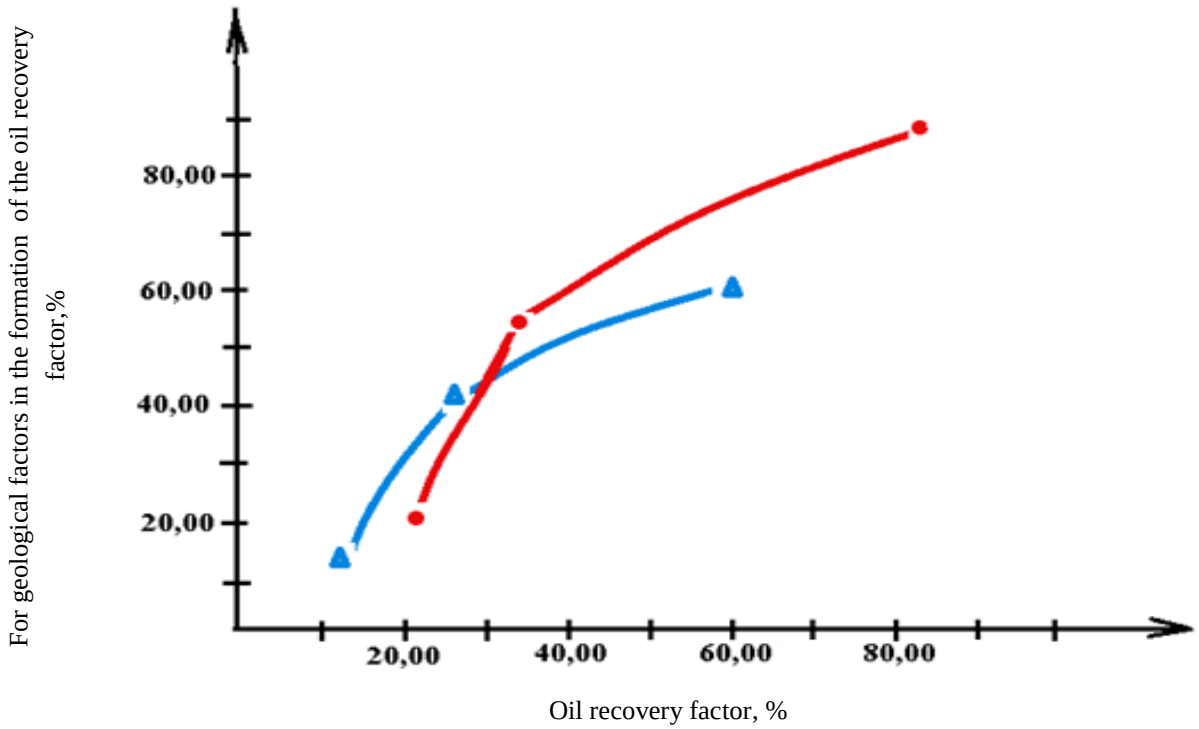

Fig. 2. –Dynamics of changes in the share of geological factors in the formation of the oil recovery factor:
• - for deposits with terrigenous reservoirs;
▲ - for deposits with corbonate reservoirs.

The analysis of these dependencies made it possible to obtain a number of interesting conclusions that have both theoretical and practical significance.

1. With the considered ranges of changes in geological factors, the oil recovery factor in carbonate reservoirs from 7.07% (worst case) to 32.25% (best option) is lower than in terrigenous reservoirs, which indicates a more complex geological structure and heterogeneity of formations associated with carbonate collectors.

2. Oil recovery factor in deposits represented by terrigenous reservoirs varies from 19.41% (with the worst combination of geological factors) to 77.53% (with the best combination of geological factors).

3. Oil recovery factor in deposits represented by carbonate reservoirs with the best and worst combinations of geological factors varies from 12.34% to 45.78%.

4. With the improvement of the geological characteristics of productive formations, the degree of influence of geological factors on the oil recovery factor increases. If in the worst combination of geological factors the share of geological factors in the formation of the oil recovery factor is 15-20%, then with the best combination of geological factors their share in the formation of the oil recovery factor reaches up to 60-80%.

5. With the worst combination (minimum values) of geological indicators of oil recovery factor in deposits with terrigenous and carbonate reservoirs, up to 20% and 15% are determined by geological and physical, and 80% and 85% of the applied development system, especially in such reports, high oil recovery factors can be achieved due to the correct choice of development systems and its elements.

6. Geological uncertainties in the creation of geological models can significantly increase the risk in assessing recovered oil reserves and field development indicators. At the same time, the magnitude of the geological risk increases as the geological and physical deposits of oil improves.

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III. CONCLUSION

In conclusion**,** it should be noted that geological and static models for assessing oil recovery factor cannot replace the use of hydrodynamic models of the process of oil extraction from the subsoil, carried out on the basis of three-dimensional three-phase filtration, but they can well be used in case of insufficient initial data, especially at the initial stage of industrial assessment of the field those. At the stage of drafting a pilot project, experimental- industry operation also to assess the effectiveness of geological and technical measures.

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