Geological and economic assessment of resources of oil field of the West-Siberian oil and gas province

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ABSTRACT: The presence of a geological structure partially determines the formation of the field. In addition, experts need to analyze other parameters that affect the accumulation of hydrocarbons in prospective traps. In this article a feasibility study of geological exploration of West-Siberian deposit was carried out, within which structural maps were built for 24 layers and the profitability of the proposed project was estimated. This article describes different methods (geological and economic) of identifying prospective oil and gas zones and deciding whether to involve the territory in the geological study project.

1 INTRODUCTION

The oil field is geographically located in the Yamalo-Nenets Autonomous District of the Tyumen Region. In the northeast corner of the license area, structures are identified that could potentially contain hydrocarbon fields. Based on the calculation of the resource potential and the analysis of geological risks, an appraisal was made of the feasibility of prospecting work, a tree of scenarios was built, and an analysis of VOI (value of information) was executed.

Tasks:

1. Construction of 1D-2D geological model, which will be used to evaluate and analyze information;
2. Answer the question about the need for geological prospecting;
3. Assess the resources of field;
4. Assess the appropriateness of conducting geological prospecting in the north-eastern section.

2 CHOICE OF RESEARCH FACILITIES

The first stage of the study is the determination of reservoirs. Of the 31 strata of the Cretaceous age, available on the territory of the field, 24 are selected. They are presented in Table 1. The criterion for the selection of strata is a change in isohypses to lower depths in the northeastern part, which leads to the presence of promising positive dome-shaped structures. The main factor in the study of this area was the location of the tectonic structure of

Table 1. Reservoirs with promising structures in the north-eastern part of the field.

№	Age of collectors		
	Sukhududinskaya suite	Malohetskaya suite	Pokurskaya suite
1	BU6-3	MH1	PC1-3
2	BU7	MH3	PC12-1
3	BU8	MH4	PC15
4	BU9	MH5	PC19
5	BU10-1	MH71	PC20-1
6	BU10-2	MH8-9	PC20-2
7	BU11-1		PC21-1
8	BU12-2		PC21-2
9			PC22-1
10			PC22-2

Figure 1. Fragment of map of full horizontal gradient module of gravitational field (Egorov T.N.).

the 3rd order (Figure 2) at the Ust-Port megaswell, adjacent to the Messoyakha megaswell (Egorov et al, 2016). Confirmation of the presence of hydrocarbons at the object of interest is a map of the module of the full horizontal gradient of the gravitational field (Figure 1), which shows abnormally low values in the north-eastern part of the field. When comparing detailed gravitational anomalies constructed from high-precision gravimetric measurements in oil and gas fields, it was found that oil and gas fields are displayed with relatively negative anomalies.

Table 2. Geometric parameters of perspective traps.

Horizon	Gross rock volume	
	Max (P10), thous. m ³	Min (P90), thous. m ³
BU12-2	406887.000	2202.130
BU11-1	398479.000	91846.400
BU10-2	422400.000	18160.800
BU10-1	423940.000	2643.580
BU9	442589.000	25475.300
BU8	289241.000	3510.220
BU7	333590.000	1329.390
BU6-3	392238.000	1994.120
MH8-9	415825.000	18481.500
MH7-1	82445.000	42239.000
MH5	96548.000	151.769
MH4	119869.000	22137.200
MH3	168850.000	47274.400
MH1	288077.000	26938.200
PC22-2	262542.000	88.335
PC22-1	305907.000	46030.300
PC21-2	192563.000	4930.790
PC21-1	160561.000	3417.710
PC20-2	118530.000	891.833
PC20-1	124591.000	42.546
PC19	91821.800	738.545
PC15	129476.000	4613.470
PC12-1	139719.000	13031.400
PC1-3	930820.000	4651.910

Figure 3. The distribution of resources in the north-eastern part of field No. 1 constructed by Monte-Carlo method.

Table 3. Initial recoverable resources calculated by the Monte Carlo method.

Probability	Resources, million tons
P90	26,97
P50	32,42
P10	38,29

the Monte-Carlo method, we obtained the normal distribution of resources (Figure 3) calculated in Microsoft Excel and the volumes of initial recoverable resources presented in Table 3.

Additionally, the calculation was performed in the Oracle Crystal Ball software package, which allows to process large amounts of data than the mathematical apparatus of Microsoft Excel allows. The methodology for selecting a random distribution is similar to that described above. A feature of the Oracle Crystal Ball software package is that it allows to perform more than 40,000 realization at a time. At the end of the calculation, the distributions of the initial recoverable re-sources were obtained (Figure 4), descriptive statistics (Table 5) and the values of probable re-sources (Table 6).

Analysis of the obtained values of probable resources and descriptive distribution statistics showed similar calculation results, which indicates the reliability of the work performed. The result is also confirmed by the sensitivity value, in which the main contribution to the distribution is made by the values of the geological volume of the rocks (75.9%).

5 DETERMINING THE PROBABILITY OF GEOLOGICAL SUCCESS

Geological Chance of Success ($gCos$, probability of geological success) - the probability which the discovery of an oil field will occur, estimated taking into account all existing uncertainties (Glebov, 2016).

This parameter is directly related to conditions for formation of hydrocarbon fields. The main probabilities reflect the result of a particular type of process, which form an accumulation of oil and gas in the reservoir (Shatrov, 2015). Depending on the method, the number of variables can vary from 4 to 6 (Gorbovsckaya, 2017). In this work, five parameters were used that reflect the entire process of formation of the field and take into account the necessary conditions for this: Formation of the oil source reservoir ($Posr$); Migration of hydrocarbons (Pm); The presence of a collector for the accumulation of hydrocarbons (Pc); The presence of traps (Pt); Safety (Ps).

The total probability of occurrence of independent events is equal to their product (2):

$$gCos = Posr \times Pm \times Pc \times Pt \times Ps \quad (2)$$

Probabilities of geological success for each formation are given in Table 7.

6 BUILDING A DECISION TREE

The decision tree is a graphical method of information analysis that displays the process of taking managerial decisions in the form of a set of sequential alternative actions and the realization of scenarios characterized by the presence of risks and uncertainties, combinations of which, at given probabilities, lead to the achievement of goals (Figure 5).

After the construction of the Decision Tree, information value (VOI) was estimated including NPV and probability for each outcome (Alekseeva et al, 2019), as well as EMV for all branches separated by probable events (Efimov & Tashlitskaya, 2013). NPV (Net Present Value): net present value of free cash flow (calculated by formula (3)):

Table 4. Estimated parameters by horizons.

Horizone	Geological volume of rocks, thousand, m3		NTG, fractions		Kporo, fractions		Ko, fractions		Density, g/cm3		Correction factor, fractions		ORF, fractions	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
BU12-2	2202.130	406887.000	0.300	0.700	0.163	0.209	0.439	0.631	0.816	0.865	0.554	0.870	0.210	0.290
BU11-1	91846.400	398479.000	0.200	0.400	0.187	0.188	0.532	0.538	0.839	0.842	0.702	0.718	0.210	0.290
BU10-2	18160.800	422400.000	0.500	0.800	0.164	0.210	0.440	0.633	0.816	0.865	0.553	0.868	0.210	0.290
BU10-1	2643.580	423940.000	0.400	0.800	0.164	0.210	0.438	0.632	0.816	0.865	0.552	0.872	0.210	0.290
BU9	25475.300	442589.000	0.300	0.700	0.164	0.210	0.580	0.617	0.816	0.865	0.553	0.872	0.210	0.290
BU8	3510.220	289241.000	0.300	0.700	0.164	0.210	0.442	0.633	0.816	0.865	0.551	0.870	0.210	0.290
BU7	1329.390	333590.000	0.300	0.700	0.164	0.209	0.440	0.632	0.816	0.865	0.553	0.868	0.210	0.290
BU6-3	1994.120	392238.000	0.300	0.700	0.164	0.210	0.580	0.617	0.816	0.865	0.553	0.872	0.210	0.290
MH8-9	18481.500	415825.000	0.400	0.800	0.212	0.252	0.409	0.545	0.830	0.910	0.829	0.910	0.210	0.290
MH7-1	42239.000	82445.000	0.400	0.800	0.211	0.252	0.409	0.543	0.848	0.907	0.830	0.910	0.210	0.290
MH5	151.769	96548.000	0.500	0.900	0.212	0.252	0.409	0.543	0.848	0.907	0.829	0.910	0.210	0.290
MH4	22137.200	119869.000	0.400	0.800	0.211	0.252	0.407	0.543	0.848	0.907	0.829	0.910	0.210	0.290
MH3	47274.400	16850.000	0.300	0.600	0.212	0.252	0.408	0.541	0.847	0.908	0.830	0.910	0.210	0.290
MH1	26938.200	288077.000	0.600	0.800	0.212	0.252	0.408	0.541	0.847	0.908	0.830	0.910	0.210	0.290
PC22-2	88.335	262542.000	0.200	0.600	0.233	0.289	0.421	0.617	0.873	0.923	0.875	0.918	0.210	0.290
PC22-1	46030.300	305907.000	0.200	0.700	0.233	0.289	0.420	0.618	0.873	0.923	0.875	0.918	0.210	0.290
PC21-2	4930.790	192563.000	0.200	0.700	0.233	0.288	0.421	0.617	0.873	0.923	0.876	0.918	0.210	0.290
PC21-1	3417.710	160561.000	0.300	0.700	0.233	0.289	0.420	0.619	0.873	0.923	0.876	0.918	0.210	0.290
PC20-2	891.833	118530.000	0.200	0.700	0.233	0.289	0.420	0.618	0.873	0.922	0.875	0.918	0.210	0.290
PC20-1	42.546	124591.000	0.300	0.700	0.233	0.290	0.420	0.617	0.873	0.923	0.876	0.917	0.210	0.290
PC19	738.545	91821.800	0.200	0.700	0.233	0.288	0.420	0.617	0.873	0.923	0.875	0.918	0.210	0.290
PC15	4613.470	129476.000	0.300	0.700	0.233	0.289	0.422	0.619	0.873	0.923	0.876	0.918	0.210	0.290
PC12-1	13031.400	139719.000	0.300	0.700	0.233	0.289	0.420	0.619	0.873	0.923	0.876	0.917	0.210	0.290
PC1/3	4651.910	930820.000	0.400	0.900	0.272	0.317	0.564	0.681	0.945	0.950	0.970	0.975	0.250	0.300

Figure 4. Calculation of the distribution of resources in the north-eastern part of field per-formed in the Oracle Crystal Ball software package.

Table 5. Descriptive statistics of resource allocation.

Statistics	Forecast values
Test	40 000
Base value	32 602,58
Mean	32 550,68
Average	32 439,68
Standard deviation	4 342,53
Discrepancy	18 857 562,34
Asymmetry ratio	0,1797
Excess ratio	3,03
Coefficient. Variations	0,1334
Minimum	16 195,62
Maximum	51 952,11
Average square error	21,71

$$NPV = Income_I - Consumption_I \quad (3)$$

EMV (Expected Monetary Value): expected cash value (calculated by formula (4)).

$$EMV = \sum (NPV_i \times p_i) \quad (4)$$

VOI (Value of Information): The value of Information (DI or VOI) is the increase or decrease in the value of an asset after acquiring information on its further study (Warren, 1983; Reidar, 2009; Whitney, 2010). The Value of Information is calculated by the formula (5):

$$VOI = EMV_1 - EMV_2 \quad (5)$$

Table 6. Probability resources.

Percentile	Forecast values, thousand tons
P100	16 195,62
P90	27 078,05
P80	28 860,11
P70	30 190,54
P60	31 338,40
P50	32 439,56
P40	33 521,78
P30	34 728,50
P20	36 133,22
P10	38 207,28
P0	51 952,11

Table 7. Probability of geological success in studied formations.

Horizon	Oil	Migration	Collector	Trap	Safety	gCos
PC1-3	1.00	1.00	0.64	0.4	0.7	0.182
PC12-1	1.00	1.00	0.64	0.4	0.7	0.182
PC15	1.00	1.00	0.65	0.4	0.68	0.178
PC19	1.00	1.00	0.63	0.4	0.67	0.171
PC20-1	1.00	1.00	0.67	0.4	0.71	0.19
PC20-2	1.00	1.00	0.67	0.4	0.69	0.186
PC21-1	1.00	1.00	0.65	0.4	0.68	0.178
PC21-2	1.00	1.00	0.66	0.4	0.71	0.189
PC22-1	1.00	1.00	0.63	0.4	0.69	0.174
PC22-2	1.00	1.00	0.64	0.4	0.72	0.182
MH1	1.00	1.00	0.66	0.4	0.71	0.186
MH3	1.00	1.00	0.64	0.4	0.71	0.181
MH4	1.00	1.00	0.68	0.4	0.7	0.191
MH5	1.00	1.00	0.67	0.4	0.69	0.185
MH7-1	1.00	1.00	0.66	0.4	0.7	0.185
MH8-9	1.00	1.00	0.65	0.4	0.69	0.18
BU6-3	1.00	1.00	0.64	0.4	0.69	0.18
BU7	1.00	1.00	0.66	0.4	0.69	0.184
BU8	1.00	1.00	0.65	0.4	0.71	0.185
BU9	1.00	1.00	0.63	0.4	0.69	0.177
BU10-1	1.00	1.00	0.64	0.4	0.69	0.175
BU10-2	1.00	1.00	0.65	0.4	0.69	0.181
BU11-1	1.00	1.00	0.66	0.4	0.71	0.189
BU12-2	1.00	1.00	0.64	0.4	0.68	0.173

Having analyzed the “Decision Tree”, three values of EMV were calculated:

- In the case of the purchase of area (EMV1 = 9.989 billion rubles)
- In the case of leasing of medical facilities and carrying out of construction and installation works (EMV2 = 9.934 billion rubles)
- In the case of a leased asset rental without carrying out of construction works (EMV3 = 4.219 billion rubles)

Next, an EMV must be selected, which will be used to evaluate the value of the information. Priorities for further evaluation are EMV2 and EMV3. Since $EMV2 > EMV1$, it is able to provide greater risk reduction.

$$VOI = EMV2 - EMV3 = 9.934 - 4.219 = 5.714 \text{ billion rubles}$$

Figure 5. The decision tree.

A positive VOI determines the planning of a solution for 2D seismic survey and reduces our costs and risks when choosing this scenario by 5.714 billion rubles.

7 DISCUSSION

The described methodology for assessing resources allows to study the investigated object from two perspectives: geological and economic. The basis for this analysis is a geological model that defines all the factors and parameters designed to calculate resources and economic indicators. Calculation of the cost of information allows to assess the risks that are always present in the work of specialists. This technique is intended to help the geologist in choosing a priority object for further exploration and to assess risks and uncertainties in the study area. The relevance of the method lies in the fact that the specialist forms a decision on the work, which allows to explore the area with minimal cost and maximum profit.

8 CONCLUSIONS

A study of the available data on the area of the field was carried out, a 1D-2D geological model was built, a decision tree was built, an assessment and analysis of the value of information was performed. A feasibility study has been drawn up for geological prospecting. Design solutions for the placement of prospecting work are presented. An assessment of the initial recoverable resources was made, which showed that with a probability of 90% oil resources will be confirmed in the amount of 26.97 million tons, with a probability of 50% - 32.42 million tons, and a probability of 10% - 38.29 million tons. Value of Information, amounting to 5.714 billion rubles. The project profitability calculation was estimated at 9.934 billion rubles. An assessment of the value of information, calculated on the basis of the constructed geological model, showed that the geological prospecting with 2D seismic surveys at the area is a reasonable option for choosing a company strategy in order to increase resource potential.

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