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DEVELOPMENT OF PROBABILISTIC AND STATISTICAL MODELS FOR EVALUATION OF OIL AND GAS POTENTIAL OF Tl_{2-b} AND Bb RESERVOIRS OF POZHVINSKIY SECTOR

Konstantin A. Koshkin

Uraloil LLC (4 Sibirskaya st., Perm, 614990, Russian Federation)

РАЗРАБОТКА ВЕРОЯТНОСТНО-СТАТИСТИЧЕСКИХ МОДЕЛЕЙ ДЛЯ ОЦЕНКИ ПЕРСПЕКТИВ НЕФТЕГАЗОНОСНОСТИ ПЛАСТОВ $Тл_{2-б}$ И Бб ПОЖВИНСКОГО УЧАСТКА

К.А. Кошкин

ООО «УралОйл» (614990, Россия, г. Пермь, ул. Сибирская, 4)

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The necessity to apply probabilistic and statistical methods for evaluation of oil and gas potential of small-size local structures is substantiated. The existing large amount of geological and geophysical data on the characteristics of structures is a good basis to use probabilistic and statistical methods to forecast their oil and gas potential. The paper presents a methodology for predicting the oil and gas potential of local structures by probabilistic and statistical methods on the Pozhvinskiy sector for Tl_{2-b} and Bb reservoirs. Geological and geophysical parameters that control the oil and gas potential of local structures are analyzed. Those parameters are as follows: altitudes on the roof of layers Tl_{2-b}, Bb, net oil-bearing thickness of Tl_{2-b}, Bb, net reservoir thickness Tl_{2-b}, Bb, interval time between reflecting layers 2K-2P – dT_{2K-2P}, interval velocities between layers 2K-2P – V_{2K-2P}, interval time between reflecting layers 3-2K – dT_{3-2K}, interval velocities between layers 3-2K. Informativeness of each parameter was determined on reference sectors with determined oil and gas potential and sectors that have deep wells but oil and gas potential is unknown. To solve the prediction problems, it is necessary to comprehensively take into account all the considered informative parameters considering the contribution of each parameter to the final result. The complex P_{com} criterion which estimates the oil and gas potential for a set of parameters was used for that purposes. Oil and gas content is evaluated by the developed method over the entire study area by constructing maps of equal probabilities. Minimum, maximum and average P_{com} values for Tl_{2-b} and Bb reservoirs are calculated within the contours of local structures. The work resulted in an evaluation of the oil and gas potential of the structures for Tl_{2-b} and Bb reservoirs. As a result of analysis, it is established that Bezgodovskaya and Ryabovskaya b structures within the Pozhvinskiy sector are the most promising ones in terms of oil and gas potential.

Ключевые слова:
вероятностно-статистическая модель, коэффициент корреляции, нефтегазоносность, месторождение, нефть, критерии нефтегазоносности, геолого-геофизические показатели, уравнение множественной регрессии.

Обосновывается необходимость применения вероятностно-статистических методов для оценки нефтегазоносности малоразмерных локальных структур. Имеющийся большой объем геолого-геофизической информации о характеристиках структур является хорошим основанием для использования вероятностно-статистических методов с целью прогноза их нефтегазоносности. В работе представлена методика прогноза нефтегазоносности локальных структур вероятностно-статистическими методами на Пожвинском участке по пластам $Тл_{2-б}$ и Бб. Для этого были проанализированы геолого-геофизические показатели, которые контролируют нефтегазоносность локальных структур: абсолютные отметки по кровле пластов $Тл_{2-б}$, Бб, нефтенасыщенные толщины по пластам $Тл_{2-б}$, Бб, эффективные толщины по пластам $Тл_{2-б}$, Бб, интервальное время между отражающими горизонтами 2К-2Р – $dT_{2К-2Р}$, интервальные скорости между горизонтами 2К-2Р – $V_{2К-2Р}$, интервальное время между отражающими горизонтами 3-2К – $dT_{3-2К}$, интервальные скорости между горизонтами 3-2К. Информативность каждого показателя определялась на эталонных участках с установленной нефтегазоносностью и на участках, где имеются глубокие скважины, но нефтегазоносность в этих пластах не установлена. Для решения прогнозных задач необходимо комплексно учитывать все рассматриваемые информативные показатели с учетом вклада каждого из них в окончательный результат. Для этих целей использовался комплексный критерий $P_{ком}$, который оценивает нефтегазоносность по совокупности показателей. По разработанной методике оценена нефтегазоносность всей территории изучения путем построения карт изовероятностей. В пределах контуров локальных структур рассчитаны минимальные, максимальные и средние значения $P_{ком}$ по пластам $Тл_{2-б}$ и Бб. Результатом работ стала оценка нефтегазоносности структур по пластам $Тл_{2-б}$ и Бб. В результате анализа было установлено, что в пределах Пожвинского участка наиболее перспективными в отношении нефтегазоносности являются Безгодовская и Рябовская б структуры.

Konstantin A. Koshkin – Head of the Team for Geological Prospecting and Exploration (tel.: +007 912 887 25 26, e-mail: konstkoshkin@rambler.ru).

Кошкин Константин Александрович – руководитель группы геолого-разведочных работ (тел.: +007 912 887 25 26, e-mail: konstkoshkin@rambler.ru).

Introduction

There is a certain order according to which formations have to be involded in deep exploration drilling. To determine that order it is neccessary to rank formations for oil and gas potential. In order to do that geological and geophysical parameters controlling the oil and gas potential of local structures have to be determined. Development of a theory and practice of the probabilistic and statistical forecast of oil and gas potential plays a special role in this direction. Tutorial questions of constructing the probabilistic and statistical models to forecast various phenomena in prospecting, exploration and development of oil and gas fields are described in detail in the works [1–21]. Various mathematical apparatuses and ways of their use for solving various forecasting problems are given in [22–35]. A significant accumulated amount of geological and geophysical data allows solving the task set using the methods of mathematical statistics and probability theory [19–21, 26, 27, 32, 35]. Despite the significant theoretical and practical progress in forecast of oil and gas potential, a high degree of exploration complicates the problem, since it is necessary to evaluate the oil and gas potential of small size structures that are difficult to find. There are risks to find the oil and gas deposits in them. A huge amount of geological and geophysical data availibale is another feature of highly explored areas. Having such a large amount of data, the application of probabilistic and statistical methods is a justified research tool. The paper presents a methodology to forecast the oil and gas potential of local structures at the Pozhvinskiy sector on formations $Tl_{2\text{-}b}$ and Bb. The developed probabilistic and statistical methodology for estimating the oil and gas amount of structures at the Pozhvinskiy area is used to rank the structures according to the degree of oil and gas amount on formations $Tl_{2\text{-}b}$ and Bb. It is established that Bezgodovskaya and Ryabovskaya b structures are the most promising in terms of oil and gas potential.

Analysis of the impact of geological and geophysical parameters on the amount of oil and gas

In order to determine the oil and gas potential the following parameters were determined: altitudes on the roof of layers $Tl_{2\text{-}b}$, Bb – A_{a}, m; net oil-bearing thicknesses of $Tl_{2\text{-}b}$, Bb – $H_{\text{n.o.-b}}$, m; net reservoir thicknesses $Tl_{2\text{-}b}$, Bb – $H_{\text{n.r}}$, m; interval time between reflecting layers 2K-2P – $dT_{\text{2K-2P}}$, ms, interval velocities between layers 2K-2P – $V_{\text{2K-2P}}$, m/s; interval time between reflecting layers 3-2K – $\text{d}T_{\text{3-2K}}$, ms; interval velocities between layers 3-2K – $V_{\text{3-2K}}$, m/s. The informativeness of each parameter is determined in reference areas with established oil content (class 1) and with no oil content (class 2). In order to create a training sample the grids of mentioned above parameters are used. Class 1 grids are used within the pool outline of $C_{1\text{-}2}$ category reserves. Class 2 grids are used on the surrounding area behind the pool outline (Fig. 1). For each parameters the main statistical characteristics (average, standard deviation, minimum and maximum value) histograms and probabilistic curves are calculated. At the first stage of constructing individual models, the mean values were compared by the criterion t, which was calculated by the following formula:

$$t_p = \frac{\left|X_1 - X_2\right|}{\sqrt{\frac{1}{n_1} + \frac{1}{n_2}\left(\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}\right)}},$$

where X_1, X_2 are the mean values of a parameter for the 1st and 2nd classes; S_1^2, S_2^2 are dispersions of parameters for 1st and 2nd classes.

The difference in mean values is considered statistically significant if $t_p > t_t$. The values of t_t are determined depending on the amount of data compared and level of significance ($\alpha = 0.05$).

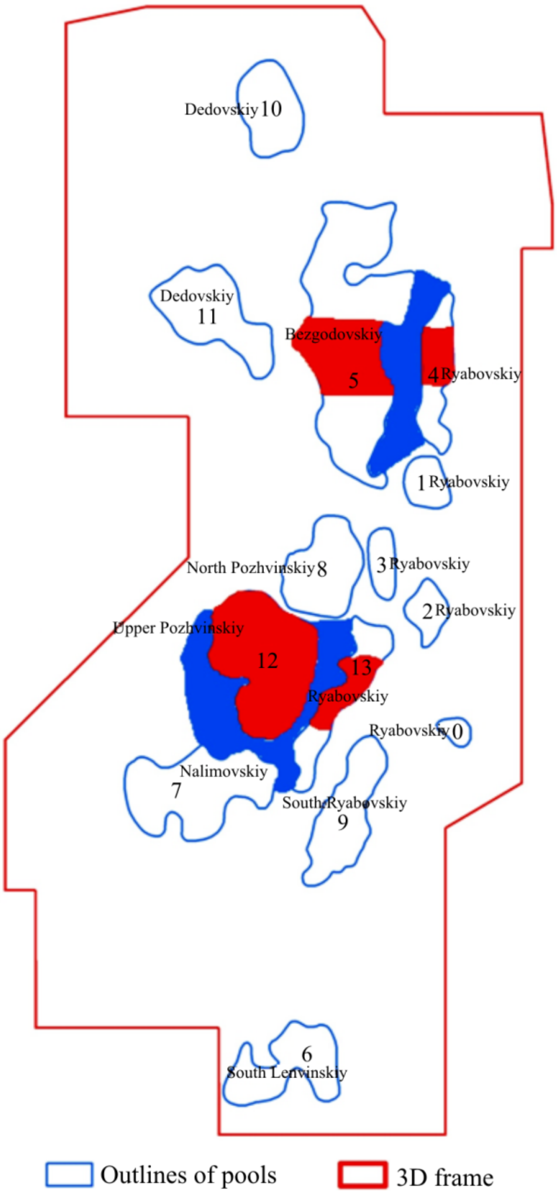

Fig. 1. Scheme of justification of reference formations: perspective formations (names and indices) and reference areas (red – oil, blue – empty) along the reservoir $Tl_{2\text{-}b}$

The main statistical characteristics for the studied parameters are given in Table 1.

Table 1 shows that the average values for all parameters are statistically different for the $Tl_{2\text{-}b}$, Bb. For a deeper statistical analysis of the parameters their distributions ar studied.

The need to study the distributions in the oil-and-gas-bearing forecast is described in the works [2, 3, 11]. In order to do that, optimal values of intervals of variation of the parameters were determined first by the Sturges formula

$$\Delta X = \frac{X_{\max} - X_{\min}}{1 + 3{,}32 \cdot \lg N},$$

where X_{max} is the maximum value of the parameter; X_{min} is the minimum value of the parameter, N is the amount of data.

Table 1

Main statistical characteristics of parameters

Parameter	Bed	Statistical characteristics of parameters: oil zones	Statistical characteristics of parameters: empty zones	Criteria t / p
A_a, m	$Tl_{2\text{-}b}$	–1601.8 ± 6.2	–1614.0 ± 5.9	127.3 0.000000
	Bb	–1605.7 ± 7.0	–1622.6 ± 5.9	92.8 0.000000
$H_{n.o.\text{-}b}$, m	$Tl_{2\text{-}b}$	1.40 ± 1.06	0.00 ± 0.03	107.54 0.000000
	Bb	1.31 ± 1.14	0.00 ± 0.0	73.76 0.000000
$H_{n.r}$, m	$Tl_{2\text{-}b}$	3.05 ± 1.18	2.65 ± 1.16	20.838 0.000000
	Bb	4.27 ± 2.76	3.10 ± 3.15	17.007 0.000000
$dT_{2K\text{-}2P}$, ms	$Tl_{2\text{-}b}$	0.019 ± 0.003	0.021 ± 0.005	29.954 0.000000
	Bb	0.018 ± 0.003	0.022 ± 0.005	38.451 0.000000
$V_{2K\text{-}2P}$, m/s	$Tl_{2\text{-}b}$	3668 ± 258.6	3613 ± 295.8	12.427 0.000000
	Bb	3668 ± 242	3633 ± 302	5.576 0.000000
$dT_{3\text{-}2K}$, ms	$Tl_{2\text{-}b}$	0.185 ± 0.005	0.184 ± 0.005	18.284 0.000000
	Bb	0.187 ± 0.003	0.184 ± 0.004	69.538 0.000000
$V_{3\text{-}2K}$, m/s	$Tl_{2\text{-}b}$	5405 ± 14.5	5404 ± 19.6	4.155 0.000000
	Bb	5401 ± 6.8	5400 ± 2.1	17.033 0.000000

Frequencies are determined in the each interval:

$$P(X) = \frac{N_k}{N_q},$$

where $P(X)$ is the frequency of k interval for oil and empty zones; N_k is the number of cases when $P(X)$ is located in the k interval; N_q is the amount of sample of the 1st and 2nd classes. Next, in each interval the $P(X)$ were compared with mean values of a parameter in the variation interval. Distribution of frequencies in the classes studied on A_a parameter for the reservoir $Tl_{2\text{-}b}$ is given in Table 2.

It can be seen that oil zones are structurally located at higher level than empty ones. For the rest of parameters distributions of values within the oil and empty zones are built as well. Using the data probabilistic models were constructed based on the fact that they best describe the ratio of the average interval values of the parameters and interval probabilities of $P(X)$. Information on construction and use of individual probabilistic models for forecast of oil and gas potential are presented in the papers [2, 3]. Individual probabilistic models are built based on these methods and given in Table 3.

Using the formulas given above probabilities of oil and gas potential for structures were calculated. Mean values of the probabilities for a $Tl_{2\text{-}b}$ formation are given in Table 4.

It is clear that values of individual probabilities vary significantly. Consequently, parameters have a different degree of informativeness. Similar calculations were performed for a Bb reservoir.

In order to perform the more complete analysis the values of correlation coefficients r between the parameters are calculated (Table 5).

Analysis of data given in Table 5 shows that there are no very strong correlation links between the parameters. That also proves their different information content. Note, that in a number of cases values of coefficients r for the layers under the study differ from each other. For example,

Table 2

Distribution of values A_a

Zone	Variation intervals A_a, m											
	–1640… –1635	–1635… –1630	–1630… –1625	–1625… –1620	–1620… –1615	–1615… –1610	–1610… –1605	–1605… –1600	–1600… –1595	–1595… –1590	–1590… –1585	–1585… –1580
Empty	0.001	0.005	0.006	0.082	0.242	0.468	0.177	0.016	–	–	–	–
Oil	–	–	–	–	–	0.050	0.291	0.351	0.150	0.101	0.050	0.005

Table 3

Individual probabilistic model

Parameter	Reservoir	Probabilistic model
A_a, m	$Tl_{2\text{-}b}$	$P(A_a) = -1.1202\cdot10^6 - 2087.8114\,A_a - 1.2971\,A_a^2 - 0.0003\,A_a^3$
	Bb	$P(A_a) = -9.4798\cdot10^5 - 1765.2266\,A_a - 1.0956\,A_a^2 - 0.0002\,A_a^3$
$H_{n.o.\text{-}b}$, m	$Tl_{2\text{-}b}$	$P(H_{n.o.\text{-}b}) = 0.56 + 0.038\,H_{n.o.\text{-}b}$
	Bb	$P(H_{n.o.\text{-}b}) = 0.56 + 0.038\,H_{n.o.\text{-}b}$
$H_{n.r}$, m	$Tl_{2\text{-}b}$	$P(H_{n.r}) = 0.3589 + 0.0368\,H_{n.r} + 0.0141\,H_{n.r}^2 - 0.002\,H_{n.r}^3$
	Bb	$P(H_{n.r}) = 0.3522 + 0.0905\,H_{n.r} - 0.0123\,H_{n.r}^2 + 0.0005\,H_{n.r}^3$
$dT_{2K\text{-}2P}$, ms	$Tl_{2\text{-}b}$	$P(dT_{2K\text{-}2P}) = 1.5054 - 68.2355\,dT_{2K\text{-}2P} + 822.8466\,dT_{2K\text{-}2P}^2$
	Bb	$P(dT_{2K\text{-}2P}) = 1.7823 - 97.6289\,dT_{2K\text{-}2P} + 1395.1523\,dT_{2K\text{-}2P}^2$
$V_{2K\text{-}2P}$, m/s	$Tl_{2\text{-}b}$	$P(V_{2K\text{-}2P}) = -7.7356 + 0.0056\,V_{2K\text{-}2P} - 1.2635\cdot10^{-6}\,V_{2K\text{-}2P}^2 + 9.4949\cdot10^{-11}\,V_{2K\text{-}2P}^3$
	Bb	$P(V_{2K\text{-}2P}) = -6.867 + 0.0049\,V_{2K\text{-}2P} - 1.0712\cdot10^{-6}\,V_{2K\text{-}2P}^2 + 7.7496\cdot10^{-11}\,V_{2K\text{-}2P}^3$
$dT_{3\text{-}2K}$, ms	$Tl_{2\text{-}b}$	$P(dT_{3\text{-}2K}) = -34.0695 + 358.3739\,dT_{3\text{-}2K} - 926.6127\,dT_{3\text{-}2K}^2$
	Bb	$P(dT_{3\text{-}2K}) = 427.679 - 7021.185\,dT_{3\text{-}2K} + 38285.936\,dT_{3\text{-}2K}^2 - 69256.484d\ dT_{3\text{-}2K}^3$
$V_{3\text{-}2K}$, m/s	$Tl_{2\text{-}b}$	$P(V_{3\text{-}2K}) = -1.7875\cdot10^5 + 98.6665\,V_{3\text{-}2K} - 0.0182\,V_{3\text{-}2K}^2 + 1.1134\cdot10^{-6}\cdot V_{3\text{-}2K}^3$
	Bb	$P(V_{3\text{-}2K}) = 1.3929\cdot10^5 - 78.1132\,V_{3\text{-}2K} + 0.0146\,V_{3\text{-}2K}^2 - 9.0909\cdot10^{-7}\,V_{3\text{-}2K}^3$

Table 4

Average probability values for structures

Structure	$P(A_a)$	$P(H_{n.o.-b})$	$P(H_{n.r})$	$P(dT_{2K-2P})$	$P(V_{2K-2P})$	$P(dT_{3-2K})$	$P(V_{3-2K})$	P_{com}
Bezgodovskiy	0.750	0.588	0518	0.595	0.515	0.468	0.722	0.898
Ryabovskiy d	0.714	0.505	0.518	0.463	0.512	0.501	0.590	0.710
Ryabovskiy b	0.689	0.553	0.454	0.649	0.515	0.503	0.593	0.837
Upper Pozhvinskiy	0.668	0.575	0.542	0.543	0.518	0.447	0.717	0.830
Dedovskiy b	0.667	0.537	0.507	0.635	0.518	0.431	0.709	0.835
Ryabovskiy a	0.664	0.550	0.490	0.696	0.520	0.496	0.722	0.869
Dedovskiy a	0.663	0.558	0.539	0.584	0.516	0.434	0.718	0.839
Upper Pozhvinskiy	0.659	0.504	0.509	0.515	0.518	0.478	0.676	0.731
Nalimovskiy	0.658	0.550	0.512	0.592	0.513	0.444	0.736	0.847
South Ryabovskiy	0.652	0.594	0.551	0.581	0.511	0.523	0.550	0.822
Ryabovskiy g	0.621	0.483	0.519	0.597	0.515	0.517	0.658	0.778
Ryabovskiy v	0.618	0.496	0.521	0.543	0.518	0.492	0.550	0.675
South Levinskiy	0.610	0.357	0.532	0.528	0.509	0.502	0.606	0.612
Ryabovskiy e	0.251	0.518	0.505	0.683	0.524	0.479	0.742	0.654

Table 5

Correlation matrix

	A_a	$H_{n.o.-b}$	$H_{n.r}$	dT_{2K-2P}	V_{2K-2P}	dT_{3-2K}	V_{3-2K}
A_a	1.00 1.00	0.55 0.66	0.04 0.06	–0.36 –0.49	0.11 0.03	0.34 0.61	0.04 0.07
$H_{n.o.-b}$		1.00 1.00	0.44 0.36	–0.16 –0.28	0.07 0.01	0.19 0.50	–0.01 0.04
$H_{n.r}$			1.00 1.00	0.09 0.02	–0.03 –0.04	0.09 0.08	0.07 0.08
dT_{2K-2P}				1.00 1.00	–0.47 –0.47	0.06 –0.31	0.33 0.03
V_{2K-2P}					1.00 1.00	–0.13 0.03	–0.13 0.10
dT_{3-2K}						1.00 1.00	0.65 0.30
V_{3-2K}							1.00 1.00

Note: top line – formation Tl_{2-b}, bottom line – Bb.

between $H_{n.o.-b}$ and dT_{3-2K}. Herewith, it is clear that none of the parameters taken separately does not reflect the oil and gas potential of the area under the study.

Construction of multidimensional oil and gas potential forecast models

In order to solve forecast tasks all parameters under the study have to be comprehensively considered taking into account the contribution of each of them to the final result. A complex criterion that assess the oil and gas content more correctly is used for those purposes. Application possibilities of the criterion to forecast various geological and technological phenomena are given in the works [5, 9, 10, 14, 17, 20, 26–28]. Values of the complex probability for the parameters used are calculated using the following formula:

$$P_{com} = \frac{\prod_{j=1}^{m} P(W_1|X_j)}{\prod_{j=1}^{m} P(W_1|X_j) + \prod_{j=1}^{m}\left(1 - P(W_1|X_j)\right)},$$

where $P(W_1/X_j)$ is the probability parameters studied. The calculations performed according to this formula for the grid points of the reference sample showed the maximum average class recognition equal to 93.1 % (Fig. 2).

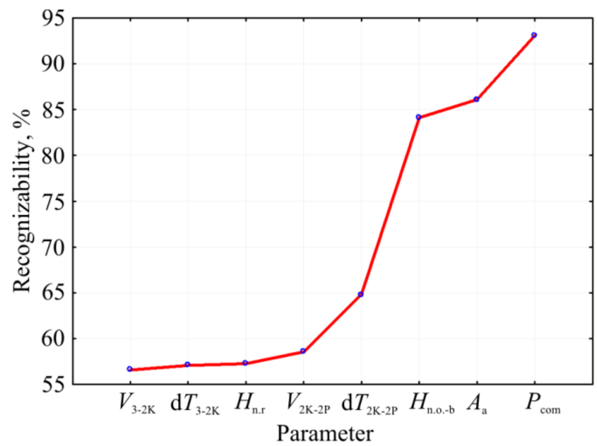

Fig. 2. Master sample recognizability

In order to take into account the variety of different and multidirectional (in a number of cases) influences of the parameters studied on P_{com} multidimensional models are built using step-by-step regression analysis (RA).

Calculation of the regression coefficients in the model being developed is performed with the help of the method of least squares. Regression analysis is understood as a statistical method of investigating the dependencies between the dependent variable Y and one or more independent variables X_1, X_2, X_p. A dependent feature in a regression analysis is called resultant, independent – factorial. Usually several factors act on the dependent variable. The cumulative effect of all independent factors on the dependent variable is accounted by multiple regression.

In the general case, multiple regression is evaluated by the parameters of a linear equation such as

$$Y = a + b_1X_1 + b_2X_2 + \ldots + b_pX_p.$$

In the equation regression coefficients (b-coefficients) represent independent contributions of each independent variable in the prediction of the dependent variable. The regression line expresses the best prediction of the dependent variable (Y) on independent variables (X).

In our case, P_{com} plays a role of the dependent variable and values of A_a, $H_{n.o.\text{-}b}$, $dT_{2K\text{-}2P}$, $V_{2K\text{-}2P}$, $H_{n.r}$, $dT_{3\text{-}2K}$, $V_{3\text{-}2K}$ represent independent factors. The residual function is introduces to solve the problem of regression analysis by the least squares method

$$\sigma(\bar{b}) = \frac{1}{2}\sum_{k=1}^{M}\left(Y_k - \hat{Y}_k\right)^2.$$

The minimum condition for the residual function:

$$\begin{cases} \dfrac{d\sigma(\bar{b})}{db_2} = 0 \\ i = 0 \ldots N \end{cases} \Leftrightarrow \begin{cases} \sum\limits_{i=1}^{M} y_i = \sum\limits_{i=1}^{M}\sum\limits_{j=1}^{N} b_j x_{i,j} + b_0 M, \\ \sum\limits_{i=1}^{M} y_i x_{i,k} = \sum\limits_{i=1}^{M}\sum\limits_{j=1}^{N} b_j x_{i,j} x_{i,k} + M b_0 \sum\limits_{i=1}^{M} x_{i,k}, \\ k = 1 \ldots N. \end{cases}$$

The system obtained represents a system of $N + 1$ of linear equations with $N + 1$ unknowns $b_0 \ldots b_N$.

If the free terms of left-hand side of the equations are represented by the matrix

$$B = \begin{Bmatrix} \sum\limits_{i=1}^{M} y_i \\ \sum\limits_{i=1}^{M} y_i x_{i,1} \\ \ldots \\ \sum\limits_{i=1}^{M} y_i x_{i,N} \end{Bmatrix},$$

and the coefficients for the unknowns on the right-hand side of the matrix are

$$A = \begin{Bmatrix} M & \sum\limits_{i=1}^{M} x_{i,1} & \sum\limits_{i=1}^{M} x_{i,2} & \ldots & \sum\limits_{i=1}^{M} x_{i,N} \\ \sum\limits_{i=1}^{M} x_{i,1} & \sum\limits_{i=1}^{M} x_{i,1}x_{i,1} & \sum\limits_{i=1}^{M} x_{i,2}x_{i,1} & \ldots & \sum\limits_{i=1}^{M} x_{i,N}x_{i,1} \\ \sum\limits_{i=1}^{M} x_{i,2} & \sum\limits_{i=1}^{M} x_{i,1}x_{i,2} & \sum\limits_{i=1}^{M} x_{i,2}x_{i,2} & \ldots & \sum\limits_{i=1}^{M} x_{i,N}x_{i,2} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \sum\limits_{i=1}^{M} x_{i,N} & \sum\limits_{i=1}^{M} x_{i,1}x_{i,N} & \sum\limits_{i=1}^{M} x_{i,2}x_{i,N} & \ldots & \sum\limits_{i=1}^{M} x_{i,N}x_{i,N} \end{Bmatrix},$$

then the matrix equation is obtain $A \times X = B$, which can easily be solved by the Gauss method. The resulting matrix represents the matrix containing the coefficients of the regression line equation:

$$X = \begin{Bmatrix} b_0 \\ b_1 \\ \ldots \\ b_N \end{Bmatrix}.$$

The multiple regression equation for the $Tl_{2\text{-}b}$ formation looks like:

$$P_{com} = 25.9224 + 0.0180A_a + 0.0753H_{n.o.\text{-}b} - 23.4552dT_{2K\text{-}2P} + 0.0001V_{2K\text{-}2P} + 0.0250H_{n.r} - 5.5702\,dT_{3\text{-}2K} + 0.0009V_{3\text{-}2K}.$$

The model was created in several steps. At the 1st step the model included the parameter A_a

(R = 0.78), at the 2nd step – $H_{n.o.-b}$ (R = 0.84), at the 3rd step – dT_{2K-2P} (R = 0.87), at the 4th step – V_{2K-2P} (R = 0.89), at the 5th step – $H_{n.r}$ (R = 0.90), at the 6th step – dT_{3-2K} (R = 0.91) and at the 7th step – V_{3-2K} (R = 0.92).

The multiple regression equation for the Bb formation looks like

$$P_{com} = -7.0116 + 0.0042A_a + 0.18755H_{n.o.-b} + \\ + 8.9975dT_{3-2K} - 11.8635dT_{2K-2P} - 0.0021H_{n.r} + \\ + 0.0023V_{3-2K} + 0.0001V_{2K-2P}.$$

The model was created in several steps. At the 1st step the model included the parameter A_a (R = 0.76), at the 2nd step – $H_{n.o.-b}$ (R = 0.79), at the 3rd step – dT_{3-2K} (R = 0.82), at the 4th step – dT_{2K-2P} (R = 0.84), at the 5th step – $H_{n.r}$ (R = 0.87), at the 6th step – V_{3-2K} (R = 0.88) and at the 7th step – V_{2K-2P} (R = 0.89).

Using the formulas given above P_{com} values are calculated and isobar probability maps are drawn. An example of such a map for the Tl_{2-b} formation is shown in Fig. 3.

The minimum, maximum and average values of P_{com} are calculated within the pool outlines for Tl_{2-b} and Bb formations.

It is seen that all structures in a given area are characterized by a complex probability higher than 0.5, which varies from 0.612 (South Levinskiy formation) to 0.889 (Bezgodovskiy formation). Oil potential probability within the pool outlines of C_1 and C_2 categories of reserves (Upper Pozhvinskiy formation) varies from 0.153 to 0.910 with an average value of 0.830. Minimum values of probabilities are observed near the oil pool outline.

Thus, it can be stated that the developed probabilistic and statistical methodology for estimating the oil and gas potential of structures at the Pozhvinskiy sector can be used to rank the formations according to the degree of oil and gas potential. A comparison of the oil and gas potential estimation of the Tl_{2-b} and Bb reservoirs by the values of complex probabilities is shown in Fig. 4.

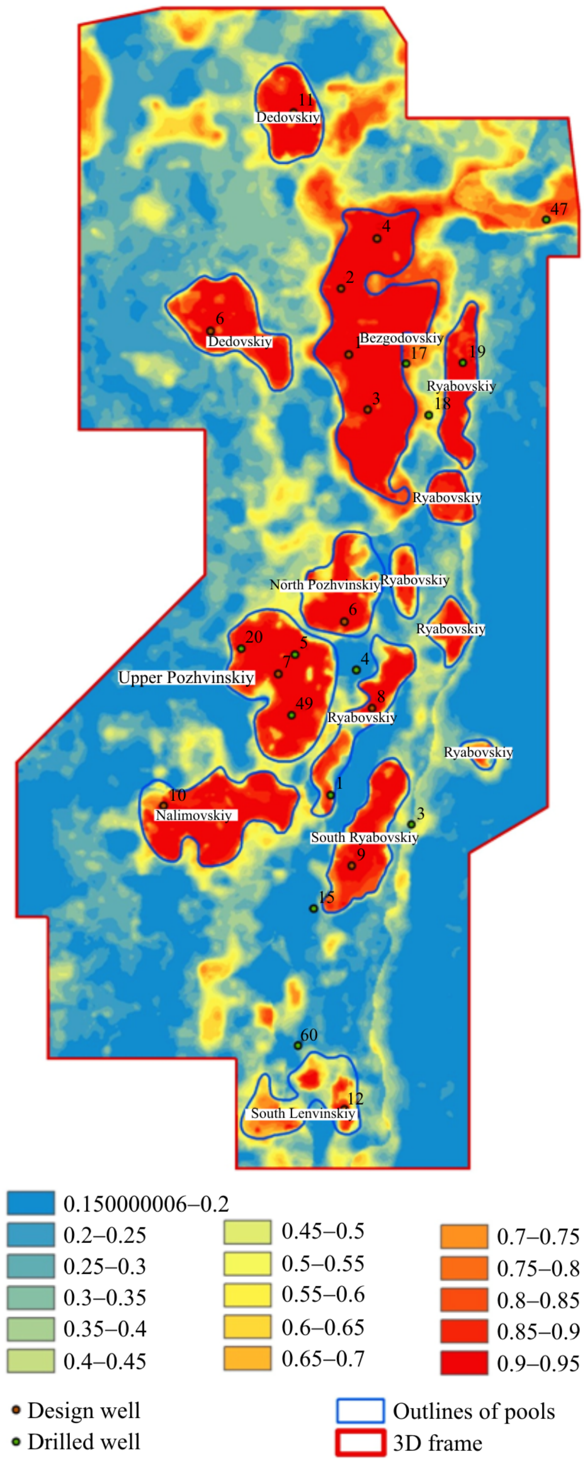

Fig. 3. Probabilistic scheme of oil and gas potential of the reservoir Tl_{2-b} for P_{com}

An analysis of Fig. 4 shows that it is possible to asses the oil and gas potential of both layers according to 10 formations. For that it is proposed to use the formula which is as follows:

$$P_{\text{com}}^{\text{Tl}_{2\text{-b}}+\text{Bb}} = -1.401 + 2.5543 P_{\text{com}}^{\text{Tl}_{2\text{-b}}} + 2.609 P_{\text{com}}^{\text{Bb}} - 0.3409 \left(P_{\text{com}}^{\text{Tl}_{2\text{-b}}}\right)^2 - 2.0781 P_{\text{com}}^{\text{Tl}_{2\text{-b}}} \cdot P_{\text{com}}^{\text{Bb}} - 0.3747 \left(P_{\text{com}}^{\text{Bb}}\right)^2,$$

where $P_{\text{com}}^{\text{Tl}_{2\text{-b}}}$; $P_{\text{com}}^{\text{Bb}}$ are respectively complex probabilities of the studied layers. Calculation data are given in Table 6.

Bezgodovskiy formation is the most promising one. Graphic representation of the formation of $P_{\text{com}}^{\text{Tl}_{2\text{-b}}+\text{Bb}}$ values from the parameters $P_{\text{com}}^{\text{Tl}_{2\text{-b}}}$ and $P_{\text{com}}^{\text{Bb}}$ are given in Fig. 5.

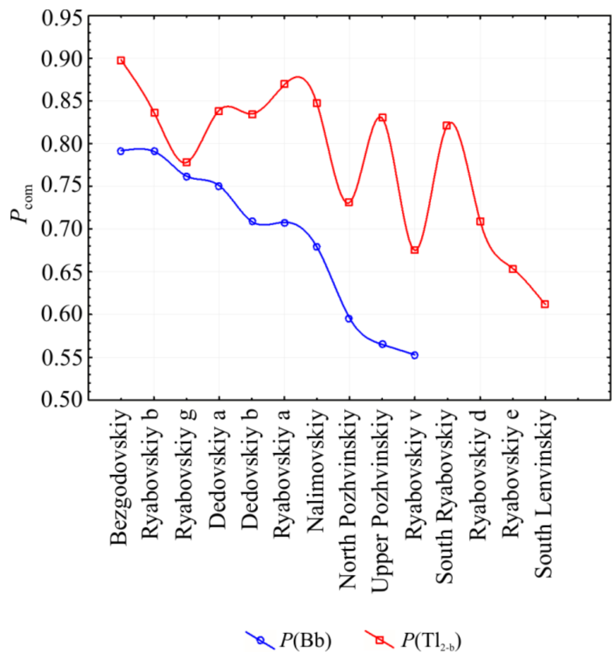

Fig. 4. Complex probabilities for formations of the Maikorskiy sector by reservoirs $\text{Tl}_{2\text{-b}}$ and Bb

Table 6

Ranking of formations by probability $P_{\text{com}}^{\text{Tl}_{2\text{-b}}+\text{Bb}}$

Formation	$P_{\text{com}}^{\text{Tl}_{2\text{-b}}+\text{Bb}}$
Bezgodovskiy	0.971
Ryabovskiy b	0.951
Ryabovskiy g	0.918
Dedovskiy a	0.942
Dedovskiy b	0.924
Ryabovskiy a	0.941
Nalimovskiy	0.921
North Pozhvinskiy	0.800
Upper Pozhvinskiy	0.865
Ryabovskiy v	0.720

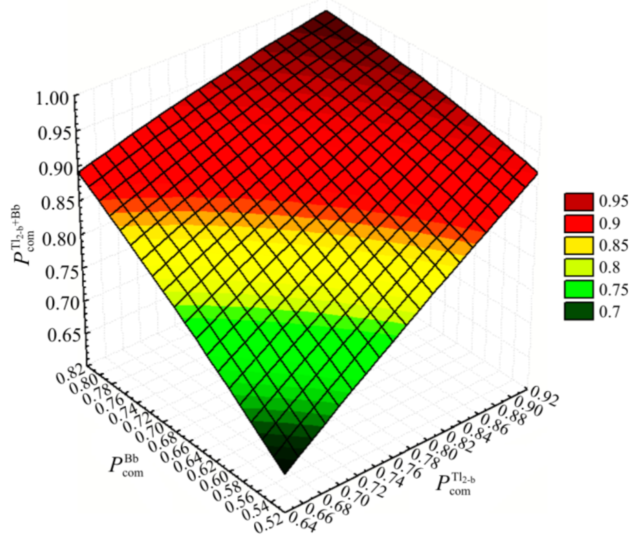

Fig. 5. $P_{\text{com}}^{\text{Tl}_{2\text{-b}}+\text{Bb}}$ as a function of $P_{\text{com}}^{\text{Tl}_{2\text{-b}}}$ and $P_{\text{com}}^{\text{Bb}}$

Conclusion

It is possible to state that the developed probabilistic and statistical methodology for estimating the oil and potential of formations at the Pozhvinskiy area can be used to rank the degree of oil and gas potential of formations for $\text{Tl}_{2\text{-b}}$ and Bb reservoirs. That allows believing that the most promising in terms of oil and gas potential are Bezgodovskiy and Ryabovskiy b formations.

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