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THE JUSTIFICATION OF ZONAL OIL AND GAS POTENTIAL OF THE TERRITORY OF VISIMSKAYA MONOCLINE BY GEOCHEMICAL CRITERIA

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ОБОСНОВАНИЕ ЗОНАЛЬНОЙ НЕФТЕГАЗОНОСНОСТИ ТЕРРИТОРИИ ВИСИМСКОЙ МОНОКЛИНАЛИ ПО ГЕОХИМИЧЕСКИМ КРИТЕРИЯМ

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probability, linear statistical model, multidimensional statistical model, correlation coefficient, oil and gas potential, statistical criteria, geochemical and bitumen characteristics, organic matter, geochemistry.

The paper presents the zonal probability and statistical assessment of the generation potential of deposits that form oil and gas potential of the territory of Visimskaya monocline. Databases on geochemical and bituminological characteristics of dispersed organic matter (DOM) in Domanicoid type deposits of the Upper Devonian-Tournaisian formation were used. The following indicators were used: content of organic carbon S_{org}, %; organic matter OM, %; composition of DOM (content of bitumoids: % – chloroform – CBE, petroleum – PB, alcohol-benzene – ABB, humic acids – HumA, %, insoluble residue – IR, %) and characteristics of DOM conversion (ratio of chloroform bitumen to alcohol-benzene one – CBE/ABB, bitumoid coefficient – β), as well as the conversion factor for S_{org} – K_c. In order to determine the informativeness of these characteristics, the Student's (t) and Pearson's (χ^2) statistical criteria were used. When building models for predicting the zonal oil and gas potential of the territory of Visimskaya monocline, one-dimensional and step-by-step multidimensional regression analyzes were used, which allowed to construct one-dimensional and multidimensional regression linear models. Using the step-by-step multidimensional regression analysis a complex criterion was developed taking into account influence of each geochemical indicator separately and their combinations.

This made it possible to construct a scheme for distribution of probability of petroleum potential of the territory of Visimskaya monocline. Analysis of the scheme showed that the most favorable geochemical conditions for the formation of petroleum potential due to DOM are observed in the central part of Visimskaya monocline (within the Maykorskoye field and surrounding area, bounded by the likelihood more than 0.5). Besides, areas in the south of Visimskaya monocline in the territories where $P^{гх}_{comp}$ > 0.5 are of particular interes in terms of zonal oil and gas potential. North of Visimskaya monocline probably has a certain interest as well.

Ключевые слова:
вероятность, линейная статистическая модель, многомерная статистическая модель, коэффициент корреляции, нефтегазоносность, статистические критерии, геохимические и битуминологические характеристики, органическое вещество, геохимия.

В статье выполняется зональная вероятностно-статистическая оценка генерационного потенциала отложений, формирующих нефтегазоносность территории Висимской моноклинали. Использованы базы данных по геохимическим и битуминологическим характеристикам рассеянного органического вещества (РОВ) в отложениях доманикоидного типа верхнедевонско-турнейской толщи. Были использованы следующие показатели: содержание органического углерода $C_{орг}$, %; органического вещества ОВ, %; состав РОВ (содержание битумоидов, %: – хлороформенных – $Б_{хл}$, петролейных – $Б_{пэ}$, спиртобензольных – $Б_{сб}$, гуминовых кислот – ГумК, нерастворимого остатка – НО, %) и характеристики преобразования РОВ (отношение концентраций хлороформенного битумоида к спиртобензольному – $Б_{хл}/Б_{сб}$, битумоидный коэффициент – β), а также коэффициент пересчета для $C_{орг}$ – $К_к$. Для определения информативности этих характеристик использованы статистические критерии Стьюдента (t) и Пирсона (χ^2). При построении моделей прогноза зональной нефтегазоносности территории Висимской моноклинали использовались одномерный и пошаговый многомерный регрессионный анализы, что позволило построить одномерные и многомерные регрессионные линейные модели. С помощью пошагового многомерного регрессионного анализа разработан комплексный критерий, учитывающий влияние как каждого геохимического показателя в отдельности, так и их сочетаний.

Это позволило построить схему распределения вероятности нефтегазоносности для территории Висимской моноклинали, анализ которой показал, что максимально благоприятные геохимические условия формирования нефтегазоносности за счет РОВ наблюдаются в центральной части Висимской моноклинали (в пределах Майкорского месторождения и территории вокруг него, ограниченной изовероятностью больше 0,5). Также определенный интерес с точки зрения зональной нефтегазоносности представляют участки на юге Висимской моноклинали на территориях, где $P^{гх}_{комп}$ > 0,5. Вероятно, определенный интерес имеют территории и на севере Висимской моноклинали.

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Introduction

Conventional methods for estimating oil and gas potential do not always allow identifying those local objects that could contain oil accumulations. Many authors propose the use different quantitative or qualitative criteria for zonal prediction of oil and gas content.

The paper presents the zonal probability and statistical assessment of the generation potential of deposits that form oil and gas potential of the territory of Visimskaya monocline. As for entire Perm region, there are conventional oil and gas source formations presented by sediments of the Upper Devonian-Tournaissian carbonate (D_3-C_1t) complex [1-12].

In order to overcome this challenge, we used databases on geochemical and bituminological characteristics of dispersed organic matter (DOM) of the Upper Devonian-Tournaisian carbonate sediments determined in wells in the Visimskaya monocline.

The following indicators were used: the content of organic compounds in the rock (organic carbon C_{org}, %, and organic matter OM, %); DOM composition (bitumoid content, % – chloroform – B_{CBE}, petroleum – B_{PB}, alcohol-benzene – B_{ABB}, humic acids – HumA, insoluble residue – IR) and characteristics of DOM conversion (ratio of chloroform bitumen to alcohol-benzene one – B_{CBE}/B_{ABB}, bitumoid coefficient – β as well as the conversion factor for S_{org} – K_c.

Statistical analysis was performed according to 325 core tests on geochemical characteristics.

Oil and gas source formation In the Upper-Devonian-Tournaisian oil and gas complex are of the Domanicoid type, which are currently associated with the formation of the main volume of oil and gas deposits in the entire sedimentary cover of the northeastern Volga-Ural oil and gas province, which includes the Visimskaya monocline. Earlier, various authors reviewed the geochemical features of each stratigraphic unit of these sediments, revealed their generating role, and carried out studies on the prediction of oil and gas content. Geological and geochemical features of these deposits were studied by the authors in sufficient detail for the entire territory of the Perm region [1–8]. It should be noted here that in works mentioned little attention has been paid to the peculiarities of the distribution of DOM over the territory of the Visimskaya monocline. This is largely due to the fact that there are currently few oil and gas fields discovered in this area, while in a rather limited stratigraphic range. According to the authors of this article, the use of mathematical methods will allow to assess the relationship between the characteristics of DOM and the oil and gas potential of the territory of the Visimskaya monocline.

Methods to build geological and mathematical models for solving various problems are given in [13-38]. Elements of mathematical statistics and probability theory were used in constructing one-dimensional and multidimensional linear statistical models. Those elements are described in detail in the works of both domestic and foreign authors [1, 11, 20, 27, 29, 30, 39-46].

Construction of one-dimensional models

Results of studies of samples from wells located within the boundaries of the Visimskaya monocline and near by are analized. Initially, indicators characterizing DOM on the studied deposits were conventionally divided into two groups. The first group includes tests on DOM for wells located near the fields and directly in their contours. The second one includes tests from wells located outside the oil fields.

The first statistical tool for estimating the degree of difference of parameters for two samples is to test hypotheses about differences or non-differences between the mean values of DOM characteristics under consideration using Student's *t*-test:

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

where X_1, X_2 – average values of DOM for oil and “empty” areas respectively; S_1^2, S_2^2 – dispersion of indicators. Differences in mean values are considered statistically significant if $t_p > t_t$. The t_t values are determined depending on the amount of compared data and the level of significance (α = 0.05).

The data of statistical calculations of average values (*t*-criterion and attained significance level *p*) of geochemical and bitumen parameters in groups for deposits of the Domanic type of Upper-

Devonian-Tournaisian deposits (D_3-C_1) are given in Table 1.

The statistical significance of differences in the average values of geochemical and bitumen characteristics of the DOM of the Upper Devonian-Tournaisian sequence was established for three indicators: K_c, B_{ABB}, B_{CBE}. The maximum statistical difference by criterion t is obtained for B_{CBE}, minimal – OM. In order to assess the possibility of the formation of the petroleum potential of the Visimskaya monocline according to the DOM characteristics of the Upper Devonian-Tournaisian formation, individual forecast models were constructed for them to assess the petroleum potential. The method of constructing such models is described in sufficient detail in work [1]. Consider the construction of individual probabilistic models.

Table 1

Comparison of average values of geochemical and bituminous characteristics and individual probabilistic models of oil and gas for deposits of domanic type D_3-C_1

Indicator	Statistical characteristics of indicators		Student's criterion $\frac{t}{p}$	Top line – the equation of probability of belonging to a class of territories within the contours of deposits; medium line – scope of the model; lower line – range of probability change
	territory of contours of deposits (group 1)	territory beyond the contours of deposits (group 2)		
(in the contour n = 95, beyond the contour n = 142)				
IR, %	47.4 ± 42.4 0.501 ± 0.002	53.5 ± 42.0 0.499 ± 0.001	–1.21853 0.22424	P(IR) = 0.502–0.0005 IR 0.35–99.75 % 0.497–0.502
C_{org}, %	0.64 ± 1.23 0.501 ± 0.003	0.44 ± 0.62 0.499 ± 0.002	0.61471 0.53933	$P(C_{org}) = 0.499 + 0.00425\ C_{org}$ 0.02–24.33 % 0.499–0.602
OM, %	0.81 ± 1.54 0.501 ± 0.003	0.57 ± 0.86 0.499 ± 0.003	0.54493 0.58631	P(OM) = 0.499 + 0.00321 OM 0.03–32.36 % 0.499–0.603
B_{PB}, %	0.006 ± 0.018 0.511 ± 0.072	0.0003 ± 0.01 0.489 ± 0.072	3.49030 0.00054	$P(B_{PB}) = 0.488 + 3.9047\ B_{PB}$ 0.000–0.08 % 0.488–0.800
B_{CBE}, %	0.056 ± 0.258 0.504 ± 0.038	0.021 ± 0.030 0.496 ± 0.004	1.61845 0.10690	$P(B_{CBE}) = 0.495 + 0.15082\ B_{CBE}$ 0.000–2.5 % 0.495–0.872
B_{ABB}, %	0.064 ± 0.086 0.504 ± 0.021	0.033 ± 0.011 0.497 ± 0.010	3.65523 0.00031	$P(B_{ABB}) = 0.488 + 0.24752\ B_{ABB}$ 0.000–0.940 % 0.489–0.723
HumA, %	0.003 ± 0.010 0.500 ± 0.005	0.004 ± 0.057 0.500 ± 0.006	–0.77114 0.48314	P(HumA) = 0.501–0.4559 HumA 0.00–0.08 % 0.464–0.501
B_{CBE}/B_{ABB}, rel. units	1.63 ± 3.54 0.503 ± 0.020	0.78 ± 1.39 0.498 ± 0.008	1.76051 0.07962	$P(B_{CBE}/B_{ABB}) = 0.495 + 0.00572\ B_{CBE}/B_{ABB}$ 0.00–20.8 % 0.495–0.613
β, %	10.47 ± 14.54 0.501 ± 0.001	7.21 ± 14.82 0.499 ± 0.010	0.62548 0.53226	$P(\beta) = 0.496 + 0.0092\ \beta$ 0.05–88.88 % 0.496–0.577
K_c, rel. units	1.27 ± 0.04 0.516 ± 0.085	1.29 ± 0.041 0.483 ± 0.090	2.87379 0.00581	$P(K_c) = 3.399–2.259\ K_c$ 1.25–1.33 rel. units 0.394–0.575

Note: * – in the numerator – average values of the indicator and standard deviation in the class, in the denominator – the average value of the probability and standard deviation in the class.

Table 2

Distribution of B_{CBE}/B_{ABB} values on Domanic type deposits

Feature class	Variation interval B_{CBE}/B_{ABB}, rel. units								
	0.0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	More 16.0
Territories within the contours of deposits (n = 95)	0.886	–	0.031	0.010	–	0.010	0.021	0.021	0.021
Territories outside the contours of deposits (n = 142)	0.922	0.036	0.021	0.007	0.007	0.007	–	–	–

As an example, let's perform a statistical analysis on the B_{CBE}/B_{ABB} indicator for samples taken within the contours of deposits and beyond. Comparison of the average values given in Table 1 shows that the average value for territories within the contours of the deposits is 1.634, for the territories beyond the contours of the deposit 0.782. According to the criterion *t*, the mean values are not different, since $p = 0.07962$.

Distribution of B_{CBE}/B_{ABB} values over the Domanic deposits is given in Table 2.

That shows that distribution of B_{CBE}/B_{ABB} values for the territories of oil fields and beyond them is significantly different. For oil filed areas B_{CBE}/B_{ABB} values in the range of 0.0-4.0 fractions of units are found with a frequency of 0.886, while for areas beyond the fields – 0.956. In the range of 2.0-10.0 in the first case 0.041, in the second – 0.042, i.e. there is a practical equality of the values of the frequency. With $B_{CBE}/B_{ABB} > 12.0$ for the territories of oil fields, the frequency is 0.063; there are no such high values beyond the oil fields. The performed evaluation of differences by criterion χ^2 showed that the distributions are statistically different. This allowed the use the characteristic to build a probabilistic model.

In accordance with the methodology used at the first stage of constructing a probabilistic model in each interval, the probabilities of belonging to the territories of oil fields are determined ($P(B_{CBE}/B_{ABB})$). Next, interval probabilities of belonging to the 1st class are compared with the average interval values B_{CBE}/B_{ABB}. By magnitude of $P(B_{CBE}/B_{ABB})$ and B_{CBE}/B_{ABB} the pair correlation coefficient *r* is calculated and the regression equation is constructed. The subsequent adjustment of the models built is carried out from the condition that the average value of the probabilities for the territories of oil fields must be greater than 0.5, and for the territories outside the oil fields less than 0.5. Thus, linear models built for a given strata allowed to evaluate the individual informativity of each geochemical indicator with respect to oil and gas content. An example of a graphic image of the constructed linear model in terms of B_{CBE}/B_{ABB} is shown in Fig. 1.

This shows that with increasing values of B_{CBE}/B_{ABB} from 0 to 21 shares, *P* value (B_{CBE}/B_{ABB}) increases from 0.494 to 0.617.

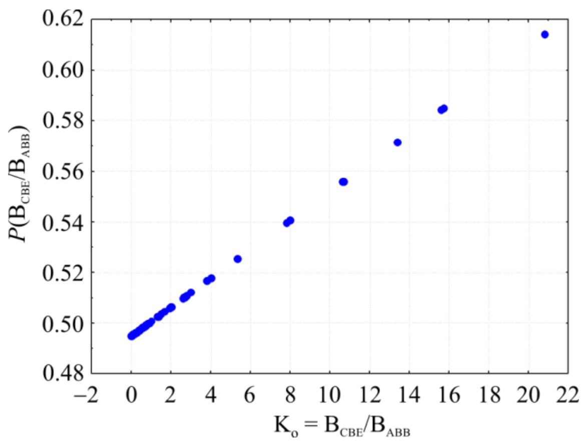

Fig. 1. Dependance $P(B_{CBE}/B_{ABB})$ on B_{CBE}/B_{ABB}

Building of multidimensional models

In the next step in forecasting estimates, the authors of the work justified a complex criterion that takes into account the constructed linear individual probabilistic models of each geochemical indicator for this complex. The criterion was calculated by the following formula:

$$P_{com} = \frac{\prod P_{ind}}{\prod P_{ind} + \prod (1 - P_{ind})},$$

where P_{ind} – individual probabilities of $P(K_c)$, $P(IR)$, $P(C_{org})$, $P(OM)$, $P(B_{PB})$, $P(B_{CBE})$, $P(HumA)$, $P(B_{CBE}/B_{ABB})$, $P(\beta)$, and Π – their multiplication.

A combination of *m* probabilities was used while calculating a complex criterion P_{com} for the Upper Devonian-Tournaisian oil and gas complex. Mean values of probabilities P_{com} in groups are the most statistically different (Table 3).

Combinations of probabilities selected in this way, calculated by geochemical indices from $m = 2$ to $m = 10$, are given in Table 3. It can be seen from the Table 3 that in the first step of building the model, with $m = 2$, the values of $P(B_{PB})$ and $P(B_{ABB})$ were used, when $m = 3$ the $P(K_c)$ probability was included in the model, then following probabilities were consistently included in the model $P(B_{CBE}/B_{ABB})$, $P(B_{CBE})$, $P(IR)$, $P(HumA)$, $P(\beta)$, $P(C_{org})$, $P(OM)$.

Dependence of P_{com}^{m} values on *m* is given on the Fig. 2.

It is showed that with *m* increasing from 1 to 6 the average value of P_{com}^{m} for territories within the field contours regularly grows from 0.515 to 0.533 and remains constant when $m > 6$. There is a tendency to decrease in values for territories beyond field contours with *m* increasing. In order to develop a method for calculating P^m_{com} values for the sediments based on the indicators we will use the values P^m_{com} at $m = 7$. This is caused by the fact that there is a maximum value of the criterion *t* with this combination.

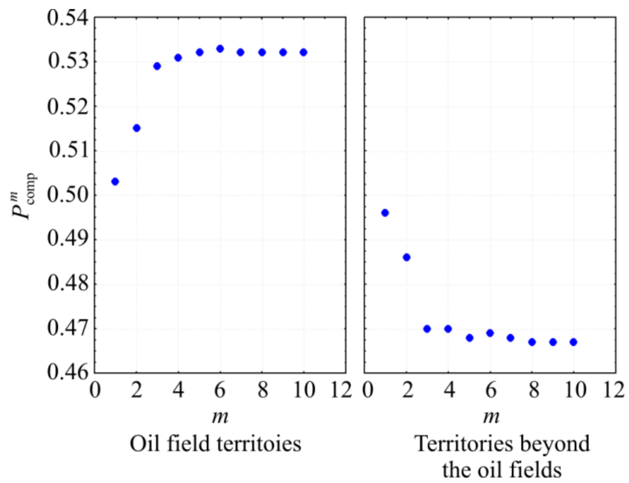

Fig. 2. Dependence of values P^m_{com} on *m*

The need to build a multidimensional model is caused by the fact that the studied indicators have a different effect on the complex criterion P^m_{com} both in strength and in direction

The influence of all the studied parameters was investigated by calculating the correlation coefficients *r*, defined in three options: the first option – according to all data, second – according to geochemical samples taken within the contours of the fields, third – beyond the contours of fields. The results of calculations of the values of *r* are given in Table 4.

Table 4 shows that the values of the correlation coefficients *r* between the studied parameters are different. For example, the correlation between P^m_{com} and β for samples taken within field contours has a statistically positive relationship, whereas for samples taken outside field contours, it is also statistically significant, but inverse.

Differences in the direction and closeness of correlations for two classes under the study are also observed between P^m_{com} and other geochemical indicators (see Table 4). It should also be noted that there are different statistical relationships between the indicators that form values P^m_{com} for two classes under the study. For example, the correlation between B_{PB} and B_{CBE} for samples taken within the fields' contours has a statistically positive relationship, whereas for samples taken outside the contours of deposits, it is practically absent.

Table 3

The study of combinations of the probability of belonging to a class of territories within field contours at different values of *m*

Probability	Combination of probabilities with different *m*								
	2	3	4	5	6	7	8	9	10
P(IR)					+	+	+	+	+
$P(C_{org})$								+	+
P(OM)									+
$P(B_{PB})$	+	+	+	+	+	+	+	+	+
$P(B_{CBE})$				+	+	+	+	+	+
$P(B_{ABB})$	+	+	+	+	+	+	+	+	+
P(HumA)						+	+	+	+
$P(B_{CBE}/B_{ABB})$			+	+	+	+	+	+	+
P(β)							+	+	+
$P(K_c)$		+	+	+	+	+	+	+	+
Mean value of the probability of the territories within field contours	0.515	0.529	0.531	0.532	0.533	0.532	0.532	0.532	0.532
Mean probability value for territories beyons the field contours	0.486	0.470	0.470	0.468	0.469	0.468	0.467	0.467	0.467
$\frac{t}{p}$	$\frac{4.267}{0.00002}$	$\frac{4.3953}{0.000017}$	$\frac{4.6082}{0.000007}$	$\frac{4.7188}{0.000004}$	$\frac{4.7591}{0.000003}$	$\frac{4.7792}{0.000003}$	$\frac{4.7542}{0.000003}$	$\frac{4.7511}{0.000004}$	$\frac{4.7445}{0.000004}$

Table 4

Correlation Matrix

	P^m_{comp}	K$_c$	IR	C_{org}	OM	B_{PB}	B_{CBE}	B_{ABB}	HumA	B_{CBE}/B_{ABB}	β
P^m_{comp}	1.00 1.00 1.00	–0.73* –0.85* 0.96*	0.28* 0.22 0.57*	–0.02 0.14 –0.30*	–0.02 0.13 –0.31*	0.50* 0.54* 0.07	0.29* 0.35* –0.52*	0.37* 0.35* –0.22	–0.19 –0.00 –0.37*	0.24 0.51* –0.33*	0.09 0.42* –0.39
K$_c$		1.00 1.00 1.00	–0.53* –0.45* –0.68*	0.16 –0.09 0.33*	0.17 –0.08 0.34*	0.16 0.14 0.25	0.23 0.06 0.63*	0.21 0.08 0.42*	0.10 –0.01 0.26*	0.03 –0.21 0.42*	0.25* –0.11 0.46
IR			1.00 1.00 1.00	0.14 0.25 –0.01	0.14 0.25 –0.02	–0.22 –0.24 –0.15	–0.10 0.04 –0.62*	–0.25 –0.20 –0.52*	0.08 0.30 –0.04	–0.12 0.05 –0.38*	–0.39* –0.08 –0.52
C_{org}				1.00 1.00 1.00	1.00* 1.00* 1.00*	0.10 –0.04 0.41*	0.28* 0.65* 0.26	0.15 0.17 0.43*	0.11 0.26 0.57	0.02 –0.05 –0.05	–0.11 –0.11 –0.21
OM					1.00 1.00 1.00	0.10 0.04 0.41*	0.28* 0.65* 0.26	0.15 0.17 0.43*	0.11 0.26 0.57	0.02 –0.05 –0.05	–0.11 –0.11 –0.21
B_{PB}						1.00 1.00 1.00	0.45* 0.39* 0.06	0.64* –0.06 0.51*	–0.09 0.03 0.04	0.31* 0.64 –0.02	0.33* 0.48* –0.05
B_{CBE}							1.00 1.00 1.00	0.41* 0.19 0.49*	0.00 0.31 0.22	0.26* 0.34 0.47*	0.32* 0.42* 0.57*
B_{ABB}								1.00 1.00 1.00	0.01 0.13 0.15	–0.03 –0.19 –0.02	0.15 –0.03 0.01
HumA									1.00 1.00 1.00	–0.05 –0.08 –0.04	–0.11 –0.07 0.11
B_{CBE}/B_{ABB}										1.00 1.00 1.00	0.66* 0.90* 0.75*
β											1.00 1.00 1.00

Note: the top line is all the data, the middle line is the fields' contour, the bottom line is beyond fields' contour; * – statistically significant correlations.

All these data show that there are statistical differences in both the distributions and correlations for samples taken within the contours of deposits and beyond their contours. Consequently, the oil and gas potential of the Visimskaya monocline depends on the geochemical characteristics of the DOM of the Upper Devonian-Tournaisian sediments. According to the authors of this work, these indicators can be used to produce the zonal oil and gas potential of the study area.

Multidimensional models using step-by-step regression analysis are used in order to account for the diversity of different, and in some cases multidirectional, effects of the studied indicators on $P^{m=7}_{comp}$. The calculation of the regression coefficients in the developed model is performed using the least squares method.

A regression analysis is a statistical method for studying the dependencies between the dependent variable Y and one or several independent variables X_1, X_2, X_p. A dependent attribute in the regression analysis is called resultant, independent – factorial. Usually, several factors act on a dependent variable. The cumulative effect of all independent factors on the dependent variable is taken into account due to multiple regression.

In the general case, multiple regression is estimated by the parameters of the linear equation $Y = a + b_1X_1 + b_2X_2 + \ldots + b_pX_p$.

In this equation, the regression coefficients (b-coefficients) represent the independent contributions of each independent variable to the prediction of the dependent variable. The regression line expresses the best prediction of the dependent variable (Y) with respect to the independent variables (X_n).

Table 5

Values P_{comp}^{GC}

Areas	Well	Age	Number of samples	P_{comp}^{GC} mean	P_{comp}^{GC} min	P_{comp}^{GC} max
Visim-Istokskaya	33	D_3f_2–C_1t	10	0.458 ± 0.164	0.369	0.887
Visimskaya	11	D_3f_2–C_1t	7	0.408 ± 0.043	0.379	0.502
Visimskaya	13	D_1–D_3f_1	21	0.445 ± 0.067	0.373	0.574
Visimskaya	14	D_3f_2–C_1t	9	0.467 ± 0.087	0.379	0.646
Visimskaya	15	D_3f_2–C_1t	21	0.536 ± 0.111	0.381	0.695
Visimskaya	16	D_3f_2–C_1t	17	0.556 ± 0.157	0.397	0.972
Visimskaya	23	D_3f_2–C_1t	2	0.384 ± 0.008	0.378	0.390
Garinskaya	62	D_1–D_3f_1	27	0.552 ± 0.012	0.540	0.581
Dmitrievskaya	2	D_3f_2–C_1t	7	0.545 ± 0.003	0.542	0.551
Dmitrievskaya	5	D_3f_2–C_1t	3	0.384 ± 0.015	0.369	0.401
Invinskaya	71	D_3f_2–C_1t	6	0.387 ± 0.016	0.370	0.413
Karnashevskaya	90	D_3f_2–C_1t	7	0.378 ± 0.021	0.363	0.410
Kasibskaya	15	D_3f_2–C_1t	4	0.411 ± 0.013	0.393	0.421
Kasibskaya	2	D_3f_2–C_1t	2	0.390 ± 0.025	0.372	0.409
Kasibskaya	3	D_1–D_3f_1	6	0.573 ± 0.018	0.548	0.592
Kuprosskaya	9	D_1–D_3f_1	13	0.552 ± 0.007	0.546	0.562
Mayikorskaya	13	D_3f_2–C_1t	6	0.794 ± 0.212	0.373	0.982
Nazarovskaya	Durinskaya	D_3f_2–C_1t	16	0.385 ± 0.022	0.346	0.442
Nazarovskaya	Ivazhinskaya	D_1–D_3f_1; D_3f_2–C_1t	30	0.434 ± 0.077	0.366	0.561
Nylobsko-Urayskaya	17	D_1–D_3f_1; D_3f_2–C_1t	14	0.434 ± 0.086	0.369	0.548
Rodnikovskaya	12	D_3f_2–C_1t	1	0.369		
Romanshorskaya	1	D_3f_2–C_1t	16	0.552 ± 0.060	0.372	0.696
Senkinskaya	Belopashninskaya	D_1–D_3f_1	4	0.553 ± 0.015	0.533	0.576
Slutskaya	279	D_1–D_3f_1; D_3f_2–C_1t	18	0.423 ± 0.062	0.375	0.558
Tukachevskaya	3	D_1–D_3f_1	10	0.560 ± 0.015	0.546	0.584
Ust-Kondasskaya	3	D_3f_2–C_1t	3	0.489 ± 0.090	0.385	0.543
Chermozskaya	3	D_1–D_3f_1; D_3f_2–C_1t	14	0.585 ± 0.043	0.544	0.691
Shatovskaya	287	D_1–D_3f_1; D_3f_2–C_1t	22	0.524 ± 0.110	0.371	0.808
Shatovskaya	293	D_3f_2–C_1t	9	0.412 ± 0.066	0.374	0.586

Table 6

Distribution of values P_{comp}^{GC} mean, P_{comp}^{GC} min, P_{comp}^{GC} max

P_{comp}^{GC}	Variation intervals P_{comp}^{GC}									
	0.0–0.1	0.1–0.2	0.2–0.3	0.3–0.4	0.4–0.5	0.5–0.6	0.6–0.7	0.7–0.8	0.8–0.9	0.9–1.0
Mean	–	–	–	0.241	0.351	0.373	–	0.035	–	–
Min	–	–	–	0.758	–	0.242	–	–	–	–
Max	–	–	–	0.068	0.208	0.448	0.138	–	0.069	0.069

In our case, $P_{comp}^{GC-m=7}$ is a dependent attribute, and values of K_c, IR, C_{org}, OM, B_{PB}, B_{CBE}, HumA, B_{CBE}/B_{ABB}, β as independent factors.

The model derives based on geochemical characteristics of the DOM of the Upper Devonian-Tournaisan sediments has the following formula

$$P_{comp}^{GC} = 2.952 - 2.26761K_c + 2.26761\ B_{PB} + 0.16153\ B_{CBE} + 0.22506\ B_{ABB} + 0.000742\ B_{CBE}/B_{ABB} - 0.45018\ HumA - 0.00005IR + 0.00005\beta + 0.0001OM$$

if $R = 0.999$, $p < 0,0000$, forecast error is 0.00311.

The sequence of input of indicators in regression equations was done in a sequence of indicators given in the equation. In the first step of equation formulation, the indicator K_c was included when $R = 0.726$; further, the value of R was changed as follows: 0.956; 0.981; 0.991; 0.994; 0.996; 0.997; 0.998; 0.999.

Using this model, the P_{comp}^{GC} values for all geochemical samples taken from these sediments were calculated. Information on well numbers from which samples were taken, age, their number and P_{comp}^{GC} values is given in Table 5.

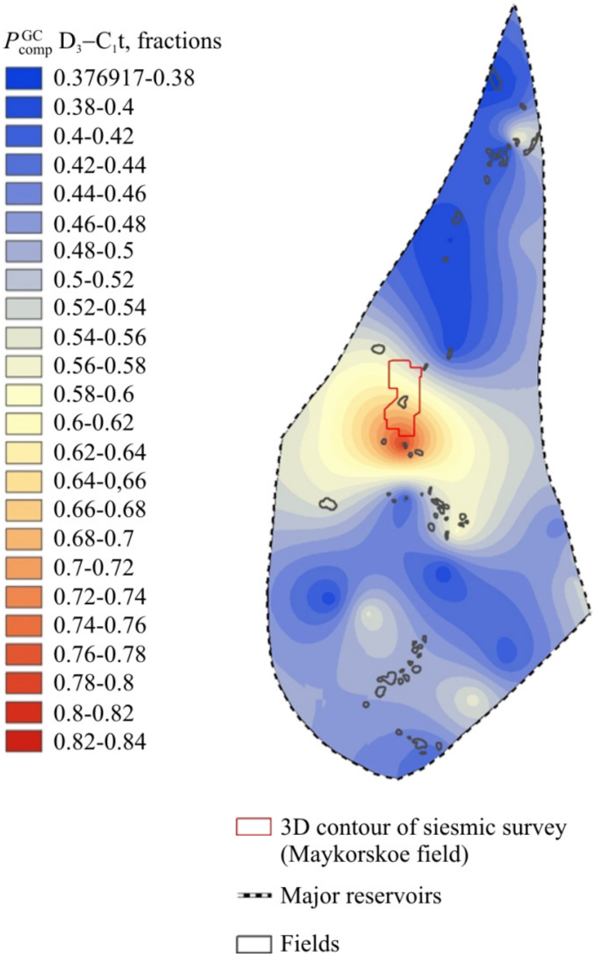

Fig. 3. Scheme of the oil and gas distribution probability on geochemical and bitumen characteristics for Visimskaya monocline territory

According to 29 wells and 322 determinations of DOM indicators, the average value of P^{GC}_{comp} = = 0.480 ± 0.094; it varies from 0.346 to 0.982.

According to the Table 5 plotted density distribution of values P^{GC}_{comp} mean, P^{GC}_{comp} min, P^{GC}_{comp} max, are given in Table 6.

This shows that P^{GC}_{comp} values in all three cases change slightly. For example, the mean probability in most cases has values in the range 0.4-0.6 (0.724). The average values in the wells were used to construct a pattern of oil and gas potential distribution for the territory of the Visimskaya monocline (Fig. 3).

Conclusion

As a result of the studies performed, it was found that the most favorable geochemical conditions for the formation of petroleum potential due to DOM are observed in the central part of the Visimskaya monocline, within the Maykorskoye field and the area around it, limited by the probability level greater than 0.5.

Territories in the south of the Visimskaya monocline where P^{GC}_{comp} > 0.5 are of particular interest in terms of zonal petroleum potential. Probably, there is a certain interest in the territory in the north of the Visimskaya monocline. This scheme will be used in further assessments of zonal oil and gas potential of the Visimskaya monocline.

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