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# Prediction of Oil and Gas Occurrence in the Southern Part of Perm Krai Based on Regional 3D Modeling

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# Прогнозирование нефтегазоносности южной части Пермского края с использованием регионального трехмерного моделирования

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Regional modeling, structure, trap, oil and gas occurrence , field, hydrocarbons, step-by-step linear discriminant analysis, reflecting horizon, seismic survey, machine learning, organic matter, geochemistry, hydrogeology, prediction, probability model, Pearson criterion.

The territory of the southern part of Perm Krai is well studied in terms of oil and gas prospecting. About 150 oil and gas fields have been discovered there, over 7000 deep wells have been drilled, and 3D seismic surveys have been completed on the area exceeding 5000 km$^2$. The state of exploration of the territory allows us to have an immense array of geologic information, which can be used to search and predict oil and gas occurrence in structures that remain left out or that have not been studied yet. The research area was limited by the confines of Perm Krai in the south, west, and east and by a conventional line in the north along the boundary of the completed seismic surveys.

To study the territory based on the reflecting horizon surface of Perm Krai, a 3D geological model has been built within IRAPRMS software system. The model calculates a regional, a zonal and local constituents of the reflecting horizon of Perm Krai. The local constituent allowed us to single out structures divided into three categories: structures of ascertained oil and gas occurrence, structures that do not contain oil and gas (empty), and structures for which a prediction is needed. In the model, structural parameters representing a trap potential for the accumulation and retention of hydrocarbons were calculated. Moreover, geochemical parameters showing a generation potential and a migration constituent, as well as hydrogeological parameters as indirect data to determine the saturation of structures with hydrocarbons, were downloaded into the model. The obtained data about the importance of each parameter for all structures allowed us to generate a single database and predict oil and gas occurrence by the machine learning method, i.e. through the step-by-step linear discriminant analysis. Based on the results of the linear discriminant analysis, 138 predicted structures were arranged in groups in accordance with degrees of their potential. By applying the built individual probability models, a map of the regional probability of structures' saturation with hydrocarbons was obtained; this map served as a basis and amendment of oil and gas geological zoning boundaries of the southern part of Perm Krai.

*Ключевые слова:*
региональное моделирование, структура, ловушка, нефтегазоносность, месторождение, углеводороды, пошаговый линейный дискриминантный анализ, отражающий горизонт, сейсморазведка, машинное обучение, органическое вещество, геохимия, гидрогеология, прогнозирование, вероятностная модель, критерий Пирсона.

Территория южной части Пермского края характеризуется большой нефтегазогеологической изученностью, здесь открыто порядка 150 месторождений нефти и газа, пробурено более 7000 глубоких скважин, проведены сейсморазведочные работы в формате 3D на площади более 5000 км$^2$. Изученность территории позволяет получить огромный массив геологической информации, который можно использовать для поиска и прогноза нефтегазоносности пропущенных или не исследованных ранее структур. Область исследования была ограничена с юга, запада и востока границами Пермского края, а с севера – условной линией по границе проведенных сейсморазведочных работ.

Для изучения территории на основании поверхности отражающего горизонта Пермского края была построена трехмерная геологическая модель в программном комплексе IRAP RMS. В модели рассчитаны региональная, зональная и локальная составляющие отражающего горизонта Пермского края. Локальная составляющая позволила выделить структуры, которые поделены на три категории: структуры с установленной нефтегазоносностью, структуры, не содержащие нефть и газ (пустые), и структуры, по которым необходимо выполнить прогноз. В модели были рассчитаны структурные параметры, отражающие потенциал ловушки для аккумуляции и сохранения залежей углеводородов. Также в модель были загружены геохимические параметры, отражающие генерационный потенциал и миграционную составляющую, и гидрогеологические параметры как косвенные при определении насыщения структур УВ. Полученные сведения о значении каждого параметра по всем структурам позволили собрать в единую базу данных и провести прогноз нефтегазоносности структур методом машинного обучения – пошаговым линейным дискриминантным анализом. По итогам пошагового линейного дискриминантного анализа 138 прогнозируемых структур были отранжированы по степени их перспективности. На основании построенных индивидуальных вероятностных моделей получена карта региональной вероятности насыщения структур углеводородами, которая послужила основой для уточнения границ нефтегазогеологического районирования территории южной части Пермского края.

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## Introduction

In Perm Krai, the best studied area is located in its southern part. A big array of information has been collected to further analyse the potential of structures by means of the machine learning method [1]. Data on oil and gas occurrence prediction in local structures unrevealed earlier can be used to decide on a sequence of involving structures into deep exploratory drilling operations [2]. Based on probabilistic and statistical models obtained in the statistical analysis, it is possible to determine parameters that have the most significant influence on oil and gas occurrence. To collect data on parameters, a regional 3D geological model of the studied territory was built [3].

The purpose of this work is to outline Perm Krai reflecting horizon structures, predict their oil and gas occurrence, and evaluate the influence of various parameters on saturation of the structures with hydrocarbons with due regard to a number of various uncertainties [4–20].

## Regional 3D Modeling of the Southern Part of Perm Krai

The research territory was limited by a modeling framework selected so that all 2D and 3D data available on completed seismic surveys could be used to the fullest extent.

The 2D and 3D completed seismic surveys of Perm Krai reflecting horizon are associated with the roof of the Tournaisian carbonate sediments and served as a basis for the regional model. Very close to Perm Krai reflecting horizon, there is one of the main oil and gas play of the Volga-Ural Petroleum and Gas Province: the terrigenous lower Visean oil and gas play [9]. According to the contour lines of the completed seismic surveys in the 2D and 3D formats, a single surface of the reflecting horizon was built. To study changes in the reflecting horizon structure, a trend analysis described in [1, 4] was made. Such method allowed us to single out a regional constituent, where big tectonic elements are clearly seen, i.e. Order I structures, domes, deeps, and depressions. By subtracting the regional constituent from the reflecting horizon of the initial surface, a zonal constituent, showing Order II structures (swells, protrusions) was obtained [6–8]. Moreover, a local constituent, in which structures of Order III were determined, was singled out [21]. Fig. 1 shows surfaces of Perm Krai reflecting horizon, its regional, zonal, and local constituents.

Anticlinal and synclinal closures were singled out on the surface of the local constituent. Further, we are going to discuss the anticlinal structures only. For this purpose, on the surface of the local constituent, we outlined the last closed contour lines of the anticline-type structures, which polygons were compared to the polygons of already discovered fields and structures of the known saturation with hydrocarbons. Thus, all the obtained local remainders were divided into three categories: those saturated with hydrocarbons, empty (no hydrocarbons are found there), and predicted ones.

For each structure in a 3D cube the following parameters were calculated: amplitude (*Ampl*), area (*S*), the highest absolute mark of the structure (*Abs.Otm.*), the structure intensity (*Int*), the distance to fracture (*FD*) [4, 22, 23]. In addition to this, for a quantitative description of the morphology of the local constituent's structures, the cubes containing information on the surface curvature (*Dip*) and the surface slope azimuth (*Dip_az*) were calculated in a 3D model. These parameters demonstrate the structural potential of a trap, the ability of the trap to get and store hydrocarbon accumulations.

In addition to the described structural parameters, to predict oil and gas occurrence in the area of research [13], parameters of the hydrocarbon-generating potential of the territory were included. Geochemical parameters of the oil source rock suite reflect the hydrocarbon-generating potential of the territory [5, 10–12]. In our case, the main oil source rock formation is represented by the Semiluk sediments of the Upper Devonian Period [24, 25]. To evaluate hydrocarbon generation capabilities, the following geochemical parameters were included in the regional model: organic carbon content in rock – *C_org* (based on regional maps of *C_org* contents in Semiluk sediments); chloroform extracted bitumen content (*BHL*); vitrinite reflectance (*RO*); domanik thickness (*M_dm*). The organic carbon content in the rock shows the territory's

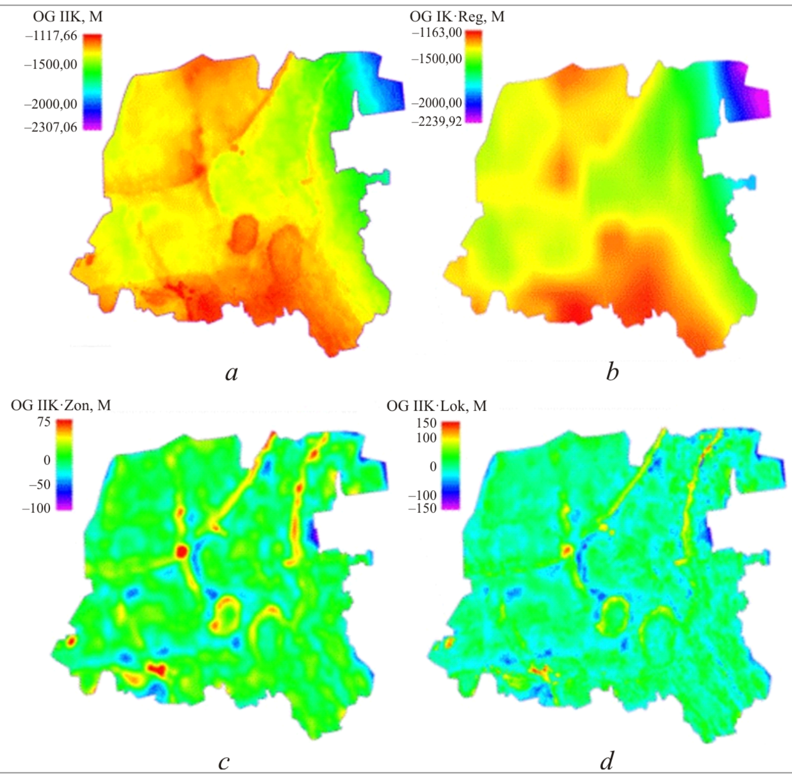


Fig. 1. Surface constituents: *a* is the constituent of Perm Krai reflecting horizon (m); *b* is the regional constituent (m); *c* is the zonal constituent (m); *d* is the local constituent (m)

hydrocarbon-generating potential, as well as the degree of catagenesis-driven transformations in the rock. Vitrinite reflectance shows the transformation degree of the organic matter in the rock, as well as the maturity of the oil source rock by the change in vitrinite contents in it. The content of chloroform extracted bitumen in the area varies from 0 to 6 %. The higher the value of this parameter, the more bitumen is contained in the organic matter, which is indicative of oil and gas potential of the oil source rock. The highest values of the content of chloroform extracted bitumen in the rock are registered in the territory of the Bashkir dome and Babkinskaya depression. Moreover, this parameter is slightly increased in the territory of the Verkhnekamskaya depression. Domanik thickness shows the oil source rock thickness, which has a direct influence on oil and gas occurrence in overlying beds. All the above mentioned geochemical parameters, as maps, were downloaded into the regional 3D geological model. Values of these parameters were downloaded for each structure.

Hydrogeological criteria determined in the territory of the research [26] were added as indirect indicators of oil and gas occurrence. The following parameters were selected from hydrogeological parameters: average chlorine and bromine contents in water of the carbonate Visean – *Cl-Br*(*Vk*); average sulfur contents in the water of the carbonate Visean – *S*(*Vk*); water mineralization in the carbonate part of the Visean sediments – *Min(Vk)*; water mineralization in the terrigenous part of the Visean – *Min(Vt)*; average sodium and chlorine contents in the water of the terrigenous and carbonate Visean – *Na-Cl(Vt)*, *Na-Cl(Vk)*. These parameters were downloaded into the regional model and an averaged value parameter was obtained for each structure.

Hydrogeological parameters are indirect and included in the list of applied criteria to amend the prediction of oil and gas occurrence in the region. The average chlorine and bromine contents in the Visean's water is indicative of oil and gas formation [26]; it is caused by a significant addition of organic genesis bromine in the Visean's water as a result of oil and gas formation. The average chlorine and bromine contents in water of the carbonate Visean in the research territory varies in the range of 166,04 to

454,6 mg/l. The high sulfur contents in the Visean's water is indicative of the integrity of the oil and gas accumulations, as well as the hydrocarbons themselves. The sulfur content in water of the carbonate Visean is limited to the rage of 0,05 to 2,28 mg/l. High mineralization of the water shows the integrity of hydrocarbon accumulations, the absence of physical and chemical destruction, when there are no salt beds and/or bunches. This figure indirectly indicates favorable conditions for the integrity of the accumulations and absence of mechanical destruction. In addition to this, the water mineralization and data on sodium and chlorine contents in water indirectly indicate favorable hydraulic conditions for the retention of accumulations. The water mineralization in the carbonate part of the Visean varies from 139,66 to 271,31 mg/l, and, in the terrigenous part, it varies from 241,61 to 271,48 mg/l. The average sodium and chlorine contents in water of the terrigenous Visean sediments is within the range of 0,617 to 0,794 mg/l, and in the carbonate Visean, it is within the range of 0,585 to 0,878 mg/l.

Therefore, all types of parameters (structural, geochemical, hydrogeological) provided values for each singled out local remainder. A unified database was developed based on such parameters.

## Prediction of Oil and Gas Occurrence in the Southern Part of Perm Krai

Depending on a selected parameter, individual models, showing the probability of the structure saturation with hydrocarbons, were obtained. The analysis demonstrated that the amplitude had the most important influence on the structure saturation with hydrocarbons. As an example, Fig. 2 shows changes in the probability value of structures' saturation with hydrocarbons depending on the values of parameters used. It is important to note that *Ampl* parameter demonstrates an insignificant nonlinearity of changes in *P(Ampl)* value depending on *Ampl* values; at the same time, *P(Ampl)* values vary from 0,21 to 0,96. The dependence of the structural saturation probability change on the surface curvature is nonlinear. The values of the saturation probability vary in the range of 0,32 to 0,98. Among the geochemical parameters, only the dependence of the structural saturation probability change on vitrinite reflectance is inverse; *P(RO)* values vary from 0,25 to 0,65. As to all other saturation probability change dependences on geochemical parameters, there is a direct dependence, i.e. the higher the value of a parameter, the higher the probability of the structural saturation with hydrocarbons. Among hydrogeological parameters, the structural saturation probability dependence on the water mineralization of the terrigenous part of the Visean is inverse as well. All other dependences on the hydrogeological parameters are linear and represent a direct relation between the saturation probability and the parameter used. When we checked the correctness of the evaluation of the structural saturation based on the models obtained, the maximum correctness value for the empty structures and for the saturated structures was 61 % and 53 % respectively. The statistical models of predicting oil and gas occurrence based on particular parameters are given in Table 1.

The analysis of individual probabilistic models shows the presence of dependences of the structural saturation with hydrocarbons on each parameter used, but for a more exact forecast of oil and gas occurrence, a comprehensive approach, including a set of such parameters, should be applied.

It was decided to use the step-by-step linear discriminant analysis (step-by-step LDA) to predict oil and gas occurrence on the basis of a big array of data on structures. The step-by-step LDA based on all parameters allowed us to obtain the saturation probability of the predicted structures in the research territory. The examples and prospects of this method to solve various problems are given in scientific papers [8, 11, 27–31]. The step-by-step LDA allowed us to find a linear combination of characteristics dividing the selection in two [32–45] parts and more. In our case, the selection is made into the empty and saturated structures based on the structural saturation with hydrocarbons. We can apply this method by using relationships between all parameters included in the model in order to find the probability of the predicted structural saturation with hydrocarbons. Before we started, the examination selection that included structures

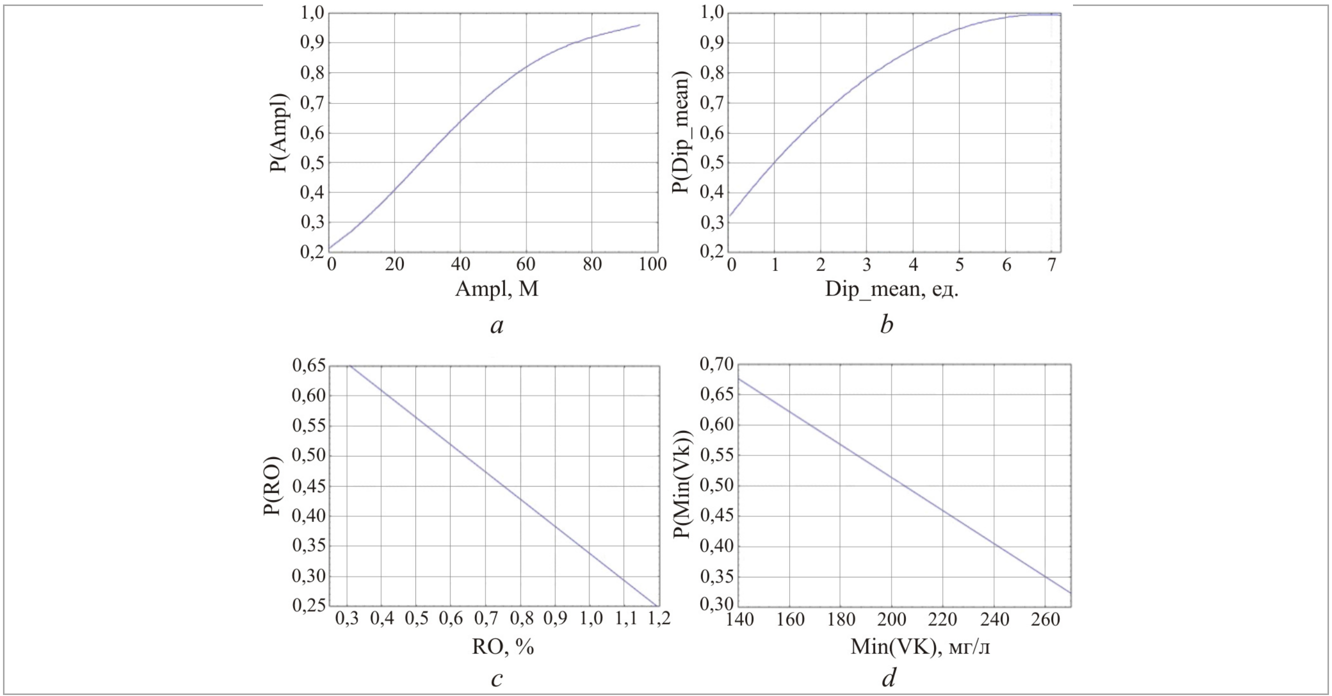


Fig. 2. Change in the probability of the structural saturation with hydrocarbons depending on the following parameters: *a* – amplitude (m); *b* – surface curvature (units); *c* – vitrinite reflectance (%); *d* – mineralization of water of the carbonate Visean (mg/l)

of the proved oil and gas occurrence was to contain an equal number of values given for the empty structures and structures saturated with hydrocarbons. Initially, the number of the empty structures was lower than that of the saturated structures; therefore, by means of the random number method, the random empty structures were excluded from the analysis. The examination selection contained 483 structures of known oil and gas occurrence among which 250 structures were saturated with hydrocarbons and 233 structures were empty. The predicted structures in the amount of 228 units were included into the selection, in which the saturation was to be determined by the step-by-step LDA results. During the analysis, the reached level of significance (*p*-value) was set to 0,05.

Based on the analysis results the following parameters, included in the statistical model as the parameters having the most significant influence on structures' oil and gas occurrence, were determined: amplitude, mineralization of water in the carbonate part of the Visean sediments, chloroform extracted bitumen content, domanik thickness of the Semiluk sediments, the absolute mark of the structure's dome, vitrinite reflectance, and chlorine and bromine contents in water of the carbonate part of the Visean sediments. In all the above mentioned parameters, the significance level, *p*-value, does not reach the critical point equal to 0,05 unit fractions. In addition to this, the model includes the following: the water mineralization of the terrigenous part of the Visean sediments, the structure intensity, the surface slope azimuth, sodium and chlorine contents in water of the carbonate part of the Visean sediments, and a distance to fractures. *P*-value of significance for such parameters exceeds 0,05 unit fractions. The statistical model did not include the structure's area, its curvature, organic carbon contents in the rock, sulfur contents in the water of the carbonate part of the Visean and sodium and chlorine contents in the terrigenous part of the Visean sediments (Table 2).

The calculation of the evaluation correctness degree showed that for the saturated structures it equals to 78,4 %, for the empty structures it equals to 74,7 %, and, in general, it equals to 76,6 %. The correctness of evaluations obtained with the comprehensive method, in percentage, was higher than that obtained with the use of the individual probabilistic models. The Pearson correlation coefficient also shows a significant difference between the selections of the structures saturated with hydrocarbons and the empty structures.

Table 1

Statistical models to predict oil and gas occurrence depending on parameters

| Parameter | Probability of belonging to the saturated structure class: upper line; application: central line; probability change range: lower line | Statistical characteristics of parameters | |
|---|---|---|---|
| | | saturated structures | empty structures |
| *Ampl*– amplitude, m | *P(Ampl)* = 0,1832 + 0,0131 · Ampl–0,000048 · $Ampl^2$<br>1–94 m<br>0,21–0,96 | 0,605 ± 0,231 | 0,389 ± 0,172 |
| *S* – area, thous. $m^2$ | *P(S)* = 0,4926 + 9,92 · $10^{-7}$ · S<br>40–6900 thous. $m^2$<br>0,39–0,91 | 0,562 ± 0,032 | 0,426 ± 0,029 |
| *Dip* – surface curvature, units | *P(Dip)* = 0,3135 + 0,2005 · Dip-0,0148 · $Dip^2$<br>0,04–7,57 units<br>0,33–0,98 | 0,531 ± 0,126 | 0,454 ± 0,089 |
| *C_org* – organic carbon content in rock, % | *P(C_org)* = 0,1912 + 0,0615 · C_org<br>1,8–5,2%<br>0,31–0,71 | 0,535 ± 0,089 | 0,499 ± 0,098 |
| *BHL* – chloroform extracted bitumen content, % | *P(BHL)* = 0,4174 + 0,079 · BHL<br>0,0–5,0%<br>0,42–0,79 | 0,542 ± 0,117 | 0,489 ± 0,108 |
| *RO* – vitrinite reflectance, % | *P(RO)*= 0,7897 – 0,4522 · RO<br>0,39–1,09%<br>0,30–0,61 | 0,522 ± 0,039 | 0,513 ± 0,053 |
| *M_dm* – domanik thickness, m | *P(M_dm)*= 0,1944 + 0,0146 · M_dm<br>6,75–37,34 m<br>0,30–0,73 | 0,532 ± 0,085 | 0,503 ± 0,081 |
| *Cl-Br(Vk)* – chlorine and bromine content in water of the carbonate Visean, mg/l | *P(Cl-Br(Vk))* = 0,3299 + 0,0006 · Cl-Br(Vk)<br>175,91–409,91 mg/l<br>0,44–0,59 | 0,520 ± 0,037 | 0,515 ± 0,037 |
| *S(Vk)* – sulfur content in water of the carbonate Visean, mg/l | *P(S(Vk))* = 0,3582 + 0,1803 · S(Vk)<br>0,07–2,26 mg/l<br>0,37–0,75 | 0,536 ± 0,104 | 0,497 ± 0,089 |
| *Min(Vk)* – mineralization of water of the carbonate Visean, mg/l | *P(Min(Vk))* = 1,0573 – 0,0027 · Min(Vk)<br>142,25–267,09 mg/l<br>0,33–0,66 | 0,538 ± 0,103 | 0,496 ± 0,099 |
| *Na-Cl(Vk)* – sodium and chlorine content in water of the carbonate Visean, mg/l | *P(Na-Cl(Vk))* = -0,4405 + 1,2611 · Na-Cl(Vk)<br>0,59–0,88 mg/l<br>0,32–0,66 | 0,526 ± 0,067 | 0,509 ± 0,063 |
| *Min(Vt)* – mineralization of water of the terrigenous Visean, mg/l | *P(Min(Vt))* = –1,4819 + 0,0076 · Min(Vt)<br>243,48–271,48 mg/l<br>0,38–0,59 | 0,521 ± 0,037 | 0,514 ± 0,038 |

It equals to 209,97 units, which is much higher than the critical value (3,841 units) and exceeds values obtained with the use of one group of parameters to determine the potential saturation of structures. The ratio of the calculated Fisher criterion to the theoretical Fisher criterion is $Fp/Ft$ = 23,8.

As a result of the step-by-step LDA, the following linear discriminant function was obtained:

$$Z = -1{,}084 - 0{,}033 \cdot Ampl + 0{,}006 \cdot Abs.Otm. - 0{,}067 \cdot FD + 0{,}007 \cdot Dip_{az} + 0{,}009 \cdot Min(Vk) - 0{,}033 \cdot Min(Vk) - 0{,}22 \cdot BHL - 0{,}057 \cdot Int - 0{,}058 \cdot M_{dm} - 7{,}716 \cdot RO + 0{,}005\ \mathrm{ClBr}(Vk) + 4{,}376 \cdot \mathrm{NaCl}(Vk);$$

$$clas = 76{,}6\ \%;\ Fp/Ft = 23{,}8;\ p < 0{,}00001,$$

where *clas* is the percentage of the correct classification; $Fp/Ft$ is the ratio of the calculated Fisher criterion to the theoretical Fisher criterion; $p$ is the significance level.

Based on this function, we determined the probability values of belonging to the class of the saturated (oil-bearing) structures $P(Z)$. It was established that, when $Z$ values alter from negative to positive ones, $P(Z)$ values naturally decrease. The dependence of $P(Z)$ on $Z$ is given in Fig. 3. The average $Z$ value for the saturated structures and empty structures is equal to 0,72 and to 0,76, respectively. At the same time, the

Table 2

Results of the step-by-step LDA for a set of parameters

| Parameters ($n = 483$) | Conventional sign | $P$-value | Wilks' lambda | Coefficients for canonical variables |
|---|---|---|---|---|
| Parameters included in the statistical model | | | | |
| Amplitude | Ampl | 0,000 | 0,789 | –0,033 |
| Mineralization of water of the carbonate part of the Visean | Min(Vk) | 0,020 | 0,650 | 0,009 |
| Mineralization of water of the terrigenous part of the Visean | Min(Vt) | 0,081 | 0,646 | –0,033 |
| Chloroform extracted bitumen content | BHL | 0,001 | 0,656 | –0,220 |
| Intensity | Int | 0,613 | 0,643 | –0,057 |
| Domanik thickness | M_dm | 0,001 | 0,656 | –0,058 |
| Absolute mark | Abs.Otm. | 0,000 | 0,667 | 0,006 |
| Vitrinite reflectance | RO | 0,000 | 0,663 | –7,716 |
| Chlorine and bromine content in the carbonate part of the Visean | Cl-Br(Vk) | 0,018 | 0,646 | 0,005 |
| Surface slope azimuth | Dip_az | 0,099 | 0,645 | 0,007 |
| Sodium and chlorine content in the carbonate part of the Visean | Na-Cl(Vk) | 0,130 | 0,645 | 4,376 |
| Distance to fractures | FD | 0,276 | 0,644 | –0,067 |
| Parameters not included in the statistical model | | | | |
| Area | S | 0,798 | 0,642 | Constant term |
| Surface curvature | Dip | 0,653 | 0,642 | –1,084 |
| Organic carbon content in rock | C_org | 0,339 | 0,641 | – |
| Sulfur content in the carbonate part of the Visean | S(Vk) | 0,561 | 0,642 | – |
| Sodium and chlorine content in the terrigenous part of the Visean | Na-Cl(Vt) | 0,508 | 0,642 | – |

average $P(Z)$ value for the structures saturated with hydrocarbons and for the empty structures is equal to 0,69 and 0,32, respectively.

In total, 174 potentially empty structures and 54 structures saturated with hydrocarbons were obtained [38]. The location scheme of the oil fields and potential structures in the southern part Perm Krai shows that the structures potentially saturated with hydrocarbons are located next to already discovered fields. Such structures are singled out at a small distance from the Shumovskoye field, Nozhovskaya group of fields, Kokuiskoye field, Shagirtsko-Gozhanskoye field and others. It should be noted that a big amount of the potential structures are concentrated in the south-eastern part of Perm Krai and located next to the Veslyanskaya swell-like zone and Dorokhovsky swell. Big structures were singled out in the regions of the Verkhnekamskaya depression, Perm dome, and Babkinskaya depression. Smaller structures refer to the Bashkir dome and Bymsko-Kungur monocline.

## Explanation of New Boundaries of Oil and Gas Geological Zoning of the Territory

Individual probabilistic models built for each parameter allowed us to receive a dependence of the saturation on the parameter values; such dependence is described by a linear function. These functions were used in the 3D regional model to develop cubes based on the previously calculated parameters. In this way, the probabilities of saturation depending on each parameter were obtained and classified by the type of parameters (structural, geochemical, and hydrogeological). The summarized maps of the territory's saturation probability were obtained by summing up the probability maps of the used parameters and divided by their number. After that, the regional maps of saturation were obtained based on the structural, geochemical, and hydrogeological parameters, which served as a basis for a comprehensive map of the structures' saturation in the southern part of Perm Krai (Fig. 4).

The map shows the probability of the territory's saturation with hydrocarbons and, based on this map, it is possible to amend boundaries of the current oil and gas geological zoning in the research region. New suggested boundaries of the oil and gas geological zoning are associated with the boundaries of the territory's saturation probability, which were obtained as a result of the analysis described above. The map showing the alteration of the area zoning boundaries is also shown in Fig. 4.

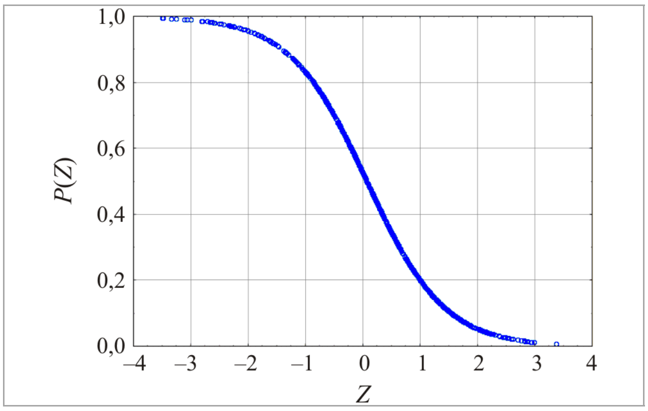


Fig. 3. Dependence of *P*(*Z*) on *Z*

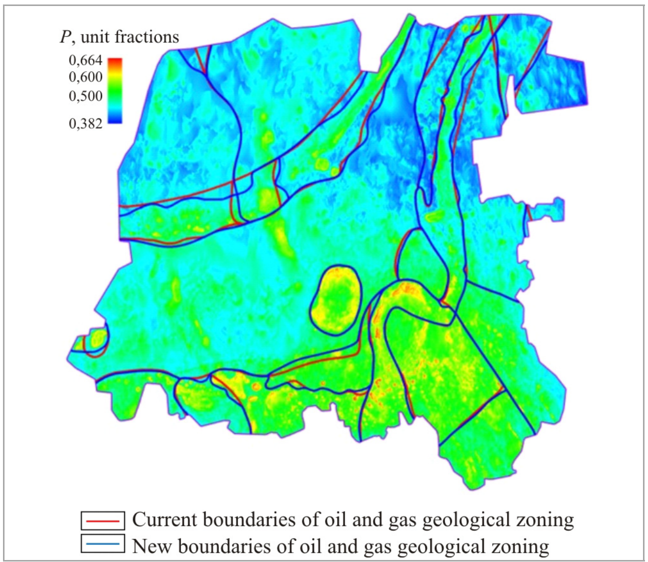


Fig.4. Regional map of the probability of the researched territory saturation with hydrocarbons showing boundaries of oil and gas geological zoning (red colour corresponds to the current boundaries and blue colour corresponds to the new boundaries)

## Conclusion

During the research, we built the 3D regional geological model, which allows a comprehensive analysis and obtaining data on structural, geochemical, and hydrogeological parameters.

The 3D regional geological model resulted in revealing the local remainders, which saturation with hydrocarbons is still unknown.

The analysis of the individual probabilistic curves gives us a possibility to evaluate the influence of the separate parameters on the saturation of structures with hydrocarbons and single out more informative ones among them.

In order to predict oil and gas occurrence of the potential structures, a step-by-step linear discriminant analysis was applied. Based on the analysis results, the statistical model of the structural saturation probability was built for the southern part of Perm Krai. Moreover, information about the potential saturation of the local remainders, unstudied previously, is received.

Based on the individual probabilistic models and with the employment of all the used parameters, the regional map of saturation of the researched territory with hydrocarbons was built. The regional map of the saturation probability with hydrocarbons allowed us to amend boundaries of theoil and gas geological zoning.

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