The neural network for grouping wells of different facies zones of productive layer

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Annotation. Grouping of many features of a well stock of layer of the large-scale deposit of oil of Western Siberia with use of artificial neural network was carried out. For grouping the initial set including 555 objects was used, 95 % were chosen from them as the training set and 5 % as test. For training of neural network 17 features characterizing both geological and physical, and technological parameters of layer were accepted. Based on the results of tuning and subsequent training of the neural network, four groups of wells were identified, the closest in their geological and technological parameters. For each group of wells, in operation, parameters characterizing the uniqueness of the selected group were described. The binding is given to localization in the spatial relation of layer and to remaining reserves of oil. For each group recommendations about involvement of remaining reserves of oil in active development were offered.

1.Introduction

Many large-scale deposits of Russia are at a late stage of development, characterized by low outputs of oil and high degree of water content. The remaining reserves, which have remained in the flooded alternations, are an important resource for the developer companies. In the current situation, it is necessary to understand structure of remaining recoverable reserves, for the purpose of effective selection of optimum methods of geotechnical jobs and introduction new or improvement of the existing technologies [1-8]. Objects of differentiation can be wells, as information carriers about the geological structure and features of pay zones, and about the technological parameters of the development of these layers. The ranking of wells and their grouping on a row, both geologically-physical and technological, makes it possible to understand the state of the degree of production of reserves from reservoirs and acts as an apparatus for further regulating and monitoring the state of development of productive strata. The object of a research is the most productive strata of one of large-scale deposits of Western Siberia, which is territorially belonging to the North of the Surgut arch. Layer contains more than 50 % of initial recoverable reserves. For the current date an object of a research is at a late stage of development which has been under development since 1987. The selection from initial recoverable reserves exceeds 65%, the average water-cut for the current operating well stock is about 78%. Most wells work with low oil and liquid flowrates (less than 8 tons per day) [9-13]. The value of porosity for layer reaches 23.4% (on average 0,19 of unit), permeability – 900 mD (on average 57 mD), stratification factor – 25 (on average – 7), the coefficient of sandiness averages 0,36 of unit fraction. The amount of remaining recoverable reserves for the studied layer is at the level, which researching demands an additional research, for the purpose of their optimum involvement in active development.

2.Research technique

For the purpose of classification of wells of the studied layer by a set of characteristics, grouping of a well stock with use of artificial neural networks was carried out. In the course of studying the components of vectors and constructing an artificial neural network, it was revealed that the network in the study is a network with a direct link. Such network is universal remedy of approximation of functions that allows to use them in the solution of problems of classification. Grouping or classification by means of artificial neural networks included several stages.

2.1. The first stage

The first stage is the formation of a matrix of well stock. The representative capacity of the received selection – 555 wells. It should be noted that at selection there is also a production well stock and injection well stock. 18 features are in total considered, in the quantitative relation there were enough chosen parameters for training of neural network.

2.2. The second stage

At the second stage the input parameters were normalized. Data normalization is necessary because neural networks work with data represented by numbers in the range 0.1, and basic data can have any range or in general to be non-numerical data. At the third stage of work on the analyzed parameters for the wells, a correlation analysis was performed, as a result of which a number of input parameters were excluded due to the presence of pair correlation between the parameters (above the threshold value of 0.5). Then the procedure was repeated for the remaining analyzed parameters.

2.3 The third stage

At the third stage the received selection with the remained 17 parameters was subjected to the neural network training procedure. In the author's opinion, despite the mutual correlation of some parameters for the input set, almost all the features were used. This fact is caused by need of increase in dimension of space of features (quantity of components of the entrance vector corresponding to a sample). This increase in the dimension of space did not affect the degree of network training. The following geological, technological and design parameters were evaluated: porosity coefficient, permeability, hydrocarbon saturation, net-to-gross sand ratio, sand-to-shale ratio, net thickness, water-cut current, water-cut accumulated, formation pressure current, remaining reserves, the current output of oil, the current output of liquid, operating time in hours, accumulated oil extraction, accumulated oil selection, an initial output of oil, initial output of liquid.

After that, the remaining input set was subjected to the training procedure of the neural network. The initial set included 555 data, 95 % of which was selected as learning set (527 data sets) and 5 % as test (28 units of data set).

3.Characteristics of groups distinguished by neural network modeling

Before training of neural network, the topology of network was chosen, namely the number of layers that the author determined to be 1, and the number of neurons in the layer was assumed to be equal to 2. The neuron activation function was specified as a "hyper tangent" with a steepness value of 1.0. The network learning algorithm "Resilient Propagation" (PRORP) was used. The specified algorithm uses so-called "training in epochs" when correction of scales happens after presentation to network of all examples from the training selection. The number of epochs was equal to 10.000. The training time of the neural network was 11578 ms (Figure 1). After setting the parameters of the neural network and conducting the training procedure, the architecture of neural network was optimized to the level which provided the best ability to generalization and assessment of quality of work on a test set.

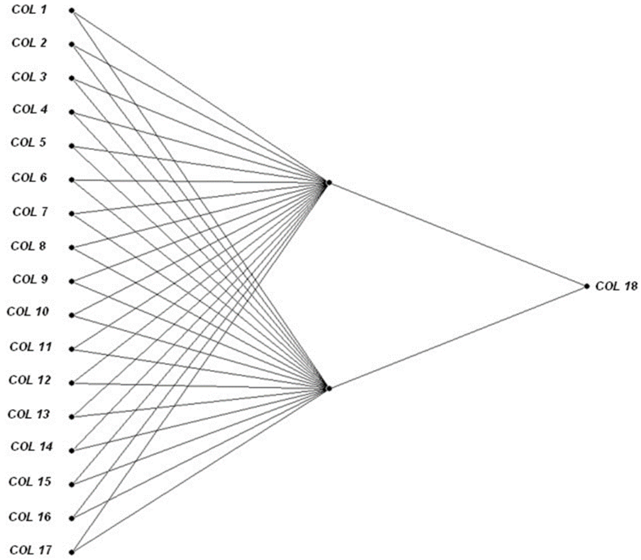

Figure 1. Neural network graph 1 layer with 2 neurons

The result of training the neural network was the classification of wells with different geological and technological parameters. In total, according to the results of the neural network, four groups of wells were identified (Figure 2), the closest in their geological and technological parameters. In total, according to the results of the neural network, four groups of wells were identified (Figure 2), the closest in their geological and technological parameters.

Figure 2. Distribution of classes in geometrical hyper space

In two-dimensional representation distribution of groups of wells on the land area of a research is presented in the figure 3.

Each of the allocated groups has the characteristic features.

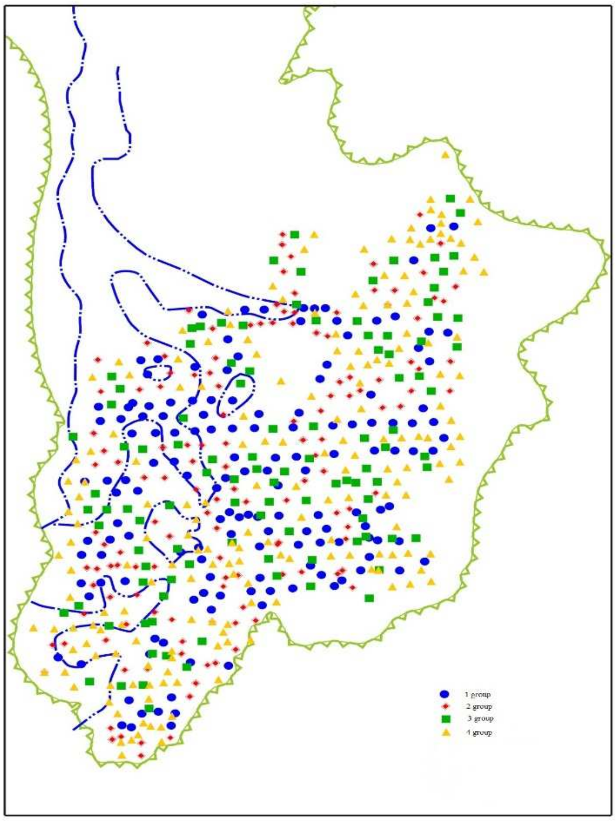

Figure 3. Distribution of groups of wells separated by neural networks in the area of the studied reservoir

The largest number of wells is the falls on group 4 (about 40 % of all analyzed fund). However, the main amount of remaining recoverable reserves falls on 1 group. (Figure 4).

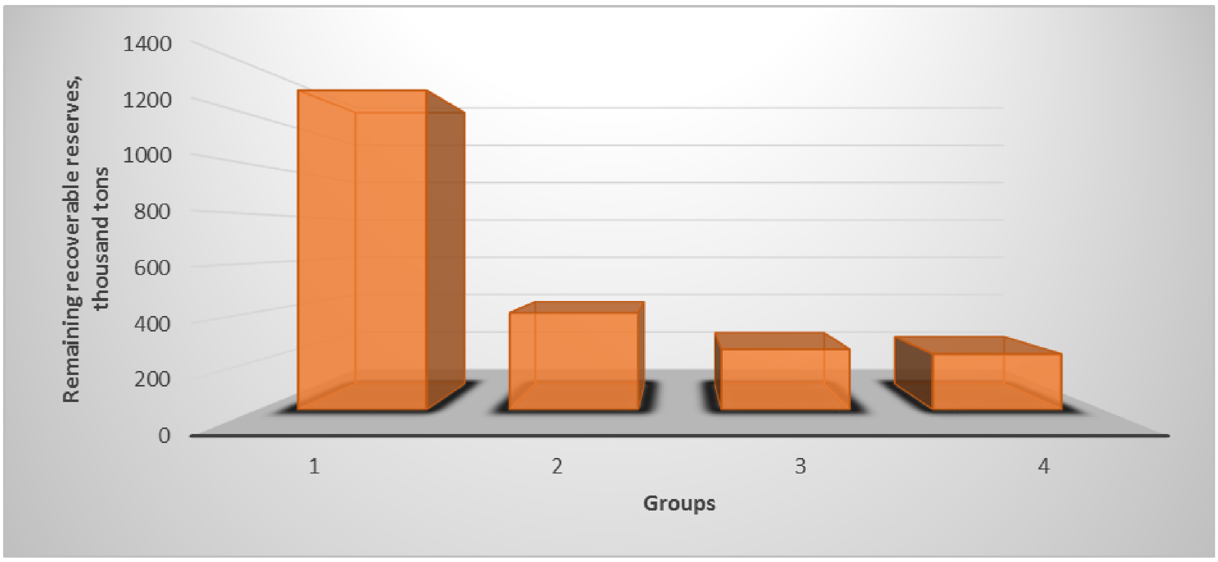

Figure 4. Distribution of remaining recoverable reserves on groups of a neural network

3.1 The first group of wells

The first group is presented by 146 wells that makes 30 % of the analyzed well stock. For 01.01.2017 the average output on liquid was 60.26 m^3/day (initial 18.57 m^3/day), for oil – 8.67 t/day (the initial output was 13.34 t/day), the current water-cut was 81, 73 %. The average reservoir pressure is 17 MPa. Comparison of the current reservoir pressures and the current outputs on wells of the first group doesn't allow to establish accurate interrelation between parameters. This group has ubiquitous extension and characterized by the increased reserves, a high stratification factor (from 1 to 10 alternations). The porosity coefficient is 0.18, the permeability is 23.2 units, with a high initial stratification factor of – 74 %.

For the considered date 21 wells of the first group are in inactivity, 3 of them are liquidated.

The first group, unlike the others, is the most productive.

3.2 The second groups of wells

The second group has similar parameters of the first group. Wells of the second group, like the first in the majority, are located in zones of increased effective net oil thicknesses (most of the area is localized in the pure oil zone). In the second group the wells are also located in zones of highly stratification factor with the maximum stratification factor up to 20. However, the average permeability in the second group of wells is several times lower than in the first. As in the first group of wells in the second one there is a high concentration of reserves in vertically, a high zonal and fissile heterogeneity. About 19 % of remaining recoverable oil reserves fall on the second group.

3.3 The third group of wells

The third group is represented by 107 wells (10 % of the total fund). The third group of wells has ubiquitous extension throughout the analyzed reservoir. Most of them are located in the pure oil zone (POZ) and part on the periphery of water and oil pay zone (WOZ). The difference of group of wells from the first two on initial and current technological parameters and also geological parameters is noted. The average values of the current well performance are following: fluid flowrate – 27.35 m^3/day (at the beginning – 40.64 m^3/day), oil flowrate – 6.87 tons/day (at the beginning of 17.16 tons per day), water cut – 65.39 %. Current reservoir pressure is – 19.3 MPa.

The third group has significant differences in technological parameters from the first two groups. Thus, high current reservoir pressure on the wells allocated to groups and rather low value of the current water cut are characteristics of wells of this group. Wells of this group have the lowest indicators as work time so also saved-up withdrawal of oil and liquid. Wells of the third group can be characterized as low-productive.

3.4 The fourth group of wells

The fourth group the most numerous, it includes 187 wells (40 % of the general selection). Wells of the 4th group are spatially confined, as well as to POZ and VNZ. A distinctive feature of the group is the high values of permeability, porosity, net-to-gross sand ratio in the wells and low values of stratification factor. On January 01.01.2017 the average flowrate for liquid was 38.65 m^3/day (initial output was 47.13 m^3/day), for oil – 10.92 t/day (initial output was 24.20 t/day). The average water cut value is 53.31 %. The average reservoir pressure is 15.7 MPa. Thus the wells of group 4 have better macroinhomogeneity and filtration-volumetric characteristics and also the best technological parameters. The zones of location of the fourth group of wells can be characterized as highly productive.

4.Conclusion

The performed grouping and identification of the active well stock on geological and technological features allowed to evaluate the structure of the active well stock, to determine the low-flowrate well stock allocated for the totality of features, and to identify possible causes of extremely low well production rates.

It is established that the condition of remaining reserves at this stage of development is determined by both geological factors (high heterogeneity of the reservoir porosity and permeability in terms of area and section) and technological ones.

In this regard recommendations will be submitted on involvement in the active development of wells with high specific remaining reserves, taking into account their geological and, whenever possible, technology factor. Work with the active well stock is represented to the most perspective.

References

[1] Valeev S A, Dulkarnaev M R, Kotenev Yu A, Sultanov Sh Kh, Chudinova D Yu and Brilliant L S 2016 Methodical bases of planning and organization intensive flooding systems (on example Vateganskoe and Tevlinsko-Russkinskoe fields) *Exposition Oil & Gas* **3 (49)** 38–42

[2] Chudinova D Yu, Kotenev Yu A and Sultanov Sh Kh 2016 Geological field and statistical reason improving of efficiency of development of oil reserves from heterogeneous flooded layers *Geomodel 2016 - 18th Science and Applied Research Conference on Oil and Gas Geological Exploration and Development* (Russia: European Association of Geoscientists and Engineers)

[3] Mukhametshin V V 2017 The need for creation of a unified comprehensive method of geological and field analysis and integration of data on effective influence on the bottom-hole formation zone *Oil Industry* **4** 80–84 DOI: 10.24887/0028-2448-2017-4-80-84

[4] Mukhametshin V V 2017 Eliminating uncertainties in solving bottom hole zone stimulation tasks *Bulletin of the Tomsk Polytechnic University Geo Assets Engineering* **328 (7)** 40–50

[5] Mukhametshin V V and Andreev V E 2017 Search and argumentation of decisions aimed at increasing the efficiency of bottom-hole zone stimulation in oil accumulations with challenged reserves *SPE Russian Petroleum Technology Conference* (Russia: Society of Petroleum Engineers) pp 23 DOI: 10.2118/187785-MS

[6] Greenwood B and Mittler P R 1979 Structural indices of sediment transport in a straight, wave-formed, nearshore bar *Marine Geology* **32** 191–203

[7] Ultsch A, Korus D and Wehrmann A 1995 Neuronal Networks and their Rules for Classification in Marine Geology *in: Raum und Zeitin Umweltinformationssystemen, 9th Intl. Symposium on Computer Science for Environmental Protection CSEP ´95, Vol. I, ed. GI-Fachausschuß 4.6 "Informatik im Umweltschutz"* **7** (Marburg: Metropolis-Verlag) pp. 676–693

[8] Wänstedt S 1991 Geophysical borehole logging in Malmberget *Technical Report* **14T** *(*Sweden: Luleå University of Technology)

[9] Finnie G J 1999. Using neural networks to discriminate between genuine and spurious seismic events in mines *Pure and Applied Geophysics* **154** 41-56

[10] Ambrozic T and Turk G 2003 Prediction of subsidence due to underground mining by artificial neural networks *Computers & Geosciences* **29** 627–637

[11] Akhmetov R T, Mukhametshin V V and Andreev A V 2017 A quantitative assessment method of the productive formation wettability indicator according to the data of geophysical surveys *SPE Russian Petroleum Technology Conference* (Russia: Society of Petroleum Engineers) DOI: 10.2118/187907-MS

[12] Akhmetov R T, Mukhametshin V V, Andreev A V and Sultanov Sh Kh 2017 Some testing results of productive strata wettability index forecasting technique *SOCAR Proceedings* **4** 83–87 DOI: 10.5510/OGP20170400334

[13] Wong P M and Shibli S A R 2001 Modelling a fluvial reservoir with multipoint statistics and proncipal components *Journal of Petroleum Science and Engineering* **31** 157–163