Neural geological-genetic and radiogeochemical forecast model of oil-bearing fields

S V Gorbachev[1], I K Kurkan[2]
[1]Department of Innovative Technologies National Research Tomsk State University, 634050 Russia, Tomsk, Lenina Avenue,36
[2]Head of laboratory Tomsk Polytechnic University, Lenina Avenue, 30, Tomsk, Russia

E-mail: spp03@sibmail.com

Abstract. In recent years, oil and gas exploration are increasingly turning to direct methods to identify accumulations of hydrocarbons (magnetometry, radiometry, geochemical methods, etc.). Similar works are tested high in the Tomsk region, near the Ob basin. In this paper we present some results of testing of geological and genetic models and radiogeochemical occurrence of hydrocarbons in relation to various oil and gas complexes, with the development of neural network methods of analysis and forecasting, formulated proposals for their integrated use.

1. Introduction

Systematic approach to the problems of recognition and classification of oil and gas complex objects as characterized by ill-conditioned, noisy background information requires high reliability, accuracy and reliability of the research results. Traditional leading geophysical methods used in prospecting and exploration of oil and gas fields, is seismic. It solves a number of problems of prediction of the geological section, but remains one of the most expensive methods of exploration. Despite progress in the development of seismic methods, the success of the forecast of deposits based on only this method is not sufficiently high, particularly in the case of complicated traps, which include traps, concentrated in the Cretaceous interval of the section of the sedimentary cover of West Siberia.

The way out of this situation can be widely used non-traditional, progressive methods of geochemistry and geophysics, their aggregation with the main, prevailing types of oil and gazopoiskovyh works. In modern practice petrosearch considered appropriate use of the cheapest methods of exploration on the largest possible area, followed by isolation of promising areas and focusing on them more detailed and expensive methods. In particular, in the United States on poorly known areas recommended to consistently apply: small-scale radiometric and magnetometric data obtained under the program NURE (National Assessment Program uranium reserves), geomorphological analysis Landsat, high sensitivity aeromagnetic and airborne gamma-spectrometric survey of large-scale, ground geochemical survey [1].

The search for oil and gas fields radiometric survey was first applied Bogoyavlinskim L.N. and Lomakin A.A. in 1926 in Maikop oil-rich region. From the measurements it was found a systematic decrease in the total radioactivity of the backoff oil deposits. Start of intensive research to identify opportunities for the use of radioactive methods for forecasting and search for oil and gas accounts for

50-60-ies of XX century. During this period, the method being tested radiometric surveys, and sometimes used in the US, Canada, France, the Soviet Union. Subsequently, in spite of some positive results, methods have not been widely used. Primarily, this was due to insufficient sensitivity of the apparatus is not clearly captures minor variations radioactive derivative of the oil and gas fields, the lack of an integrated approach and multi-variant interpretation of the radio geochemical anomalies.

In the last 30 years abroad (USA, China, France, Mexico) due to improved measuring techniques, teaching methods of work and interpretation of results using computer data processing systems there is increasing interest in radio geochemical methods, as one of the ways to search for hydrocarbon accumulations [1–3]. For a more complete understanding of these methods based on secondary changes in the surrounding rocks, in our opinion, it is necessary to include a fourth coordinate - time, and geologic time, and consider the appearance of deposits as part of an integrated system of natural geological forms of motion (the origin, development and destruction). Productive deposits that are in the integrity of the natural system as their component, in turn, are composed of many individual elements in the historical and genetic relationship with each other. These elements experienced qualitative and quantitative changes in the background continuously, intermittent motion and recorded in the pages of geological history in the form of geochemical lithological complexes caused by certain genetic spatio-temporal structural links with the surrounding geological environment [4].

2. Geological-genetic model of oil and gas complex

To create a geological-genetic model is important for the correct differentiation of the considered column on components. Their selection must be in a dialectical relationship with the natural system as a whole and productive thickness in particular. Using the known series is a chemical element, mineral, rock, geological body, you need to add the geological complex, characterized by its own peculiarities, however, similar to other, mainly in relation to geochemical formations.

For hydrocarbons in this complex include the presence of source rocks, migration in reservoirs, tanks, tires, favorable conditions for generation and preservation of these traps for quite a long geological period of time.

Now consider two geological stage sedimentation of organic material and enclosing strata and structural-lithological complex after the formation of deposits, i.e., its state at the moment. Including consideration of the mechanism of formation of oil, it is necessary to consider the structural factor at the time of burial of the sediments and their immersion depth of 1 km to 2 km under the action of heat begins the process of transformation of organic carbon compounds and polymers. This process occurs in the same structural buildings that exist at the moment. Thus, we can trace the migration routes of micro-oil and hydrothermal solutions as their imprint created in the process of formation of hydrocarbons and buried together with the already formed and sealed by a deposit after the onset of the stage of stabilization.

In the formation of a simple oil hydrocarbon spectrum which is characteristic of living organisms, is transformed into a complex spectrum of oil as a result of the formation during diagenesis of a wide range of hydrocarbon - derived primary biological structures, as well as the arrival of huge quantities of hydrocarbons that occur during thermal conversion of deeply buried organic matter. The greatest number of petroleum hydrocarbons formed at the expense of the latter in the subsurface is heated to temperatures from about 60 to 150 degrees [5].

Start warming up, the presence of catalysts (clayey sediments) leads to the formation lithology retort, converting organic matter into hydrocarbons (gas, oil and others), and compaction of sediments that occurs under the action of gravity and increasing as the burial of the sediments, leading to the expulsion of fluids from the parent species in the reservoir. The compressed fluids migrate through compactible precipitation from area of higher pressure usually up in the early stages of compaction, and later towards the neighboring less compressible to reservoir beds.

The peculiarity of the structural-tectonic position of oil and gas is confined to zones of high-temperature fluid flows. In the field of fluid flow are formed not only hydrocarbon deposits, but also complexes of mineral associations with certain regularities in the spatial distribution of the mineral

component. In the oil and gas section are formed in the zone of secondary mineral formation, differing from each other by the nature and associations of mineral growths. In the loop petroleum, "halo blight" area of the reservoir, in the underlying reservoir rocks and in the far out of loop areas are formed of contrasting mineral paragenetic association tumors.

Hydrocarbon deposits are located in the vaults of the elevations of different orders, or in their slope parts. Oil and gas zones often bizreport on the most deep basins and valleys [4]. Conservation of oil and gas accompanies heat flux (it is the most intense in the deep hollows) and flow of fluids. Deep fluids include water, carbon dioxide, methane and other low molecular weight hydrocarbons, contribute to the transformation of organic matter and secondary mineral formation, having certain characteristics and patterns of mineral distribution in the sequence of mineral tumors and their zonal distribution. Epigenetic mineralization in the area hydrocarbon plume, on the sites of occurrence of oil and gas in the halo of the invasion of hydrocarbons and in the peripheral part of the sub-vertical hydrocarbon column has its own unique features and patterns that occur in a particular assemblage of tumors, the sequence of deposition and forms associations of minerals.

The main phase of the formation of oil fell on the depth interval of 2-3 km The maximum decrease in porosity when submerged rocks 3 km (depth of 1 km, corresponding to the beginning of intensive hydrocarbon formation to depths of more than 3 km, corresponding to the end) is about 20 %. Consequently, the layer of sediments 1 m, with an area of 100 square km and accordingly volume 10 * 109 cubic meters, during the formation of oil separated from 0.5 to 2*109 cubic meters of water.

Literature data and the results of scientific research carried out on the core material Vahsky, South Vakhsky, Koshinsky, Yuryev, Ininsky fields of Aleksandrovsky Bank, Nizhnetabagansky, Kalinovy, Ostankinsky fields of Pudinsky Bank of Western Siberia has shown that the pathways of hydrocarbon flow and areas of concentration, including in the emerging hydrocarbon formed mineral assemblages of non-contiguous areas and, in turn, carrying the information about the field of education [4,5].

Authigenous mineralization in zones of hydrocarbon streams and areas of their concentration is related to changing physico-chemical conditions at the contact of movable hydrocarbons and water is due to dissolved gases in the water, variations in pH and Eh environment, the activity of anaerobic bacteria, etc. In the process of secondary mineral formation in the zone of the hydrocarbon stream and the loop petroleum minerals mostly dissolved. In the area of concentration of hydrocarbons and halo blight in part formed the zone of disintegration. A large part of the dissolved substance paratragedy below the boundary of the water-oil contact, where a zone of cementation. Lots of cementation and decompression in the case of a stage of formation of the deposits and the formation of the intermediate water-oil contacts form a parallel-banded structure.

As a result of interaction of hydrocarbons with enclosing rocks over oil and gas deposits are sub-vertical zone-annular geochemical, geophysical and biogeochemical fields. This part of the geologic section above the hydrocarbon is the most informative for assessing hydrocarbon potential and is based on the vertical migration of hydrocarbons from hydrocarbons.

The decay products of hydrocarbons, carbon dioxide, water, hydrogen sulfide and other migrating by diffusion and filtration of the deposits of gases and water stimulate epigenetic conversion processes leading to the change of physico-chemical environmental parameters that appear in the transformation of species over the productive complex, the occurrence of specific mineral assemblages, changes in redox conditions and the reallocation of some chemical elements.

3. Radiogeochemical oil and gas field model

Radiogeochemical oil and gas field model is based on a common genetic trait of oil and gas complexes - the presence of post secondary altered rocks under the influence of migrating hydrocarbons and hydrothermal fluids during the formation of deposits and further his life up to the present time [6].

These methods are based on the understanding that the system is rock - water - oil is a complex geochemical environment where processes of transformation of the original constants are so strong that geological objects are changed beyond recognition. The breed is sometimes reaches the level of mono - mineralization [6].

Problems in the study of the formation of geochemical field of oil and gas fields, secondary mineral deposits in the halos of many papers. Such studies in the region in different years were engaged A.E. Kantorovich, O.L. Kuznetsov, R.S. Sahibgareev, E.N. Ilyasova, V.A. Ezhova, N.F. Stolbovaya, S.L. Shvartsev, G.I. Tishchenko, V.A. Bazhenov.

With the use of this research and the results of geochemical work in other oil and gas regions, as well as with independent mineralogical and petrographic studies (microscopic mineralogical, petrochemical, microstructural analysis, Resonant nuclear, chemical analysis) built geochemical model hydrocarbon deposits. Particular attention was paid to the construction of the model of secondary mineral. The model constructed has convincingly shown that the oil and gas potential in the circuit, in the underlying reservoir rocks and distant aquifer areas are formed of mineral paragenetic associations tumors other than the host reservoir rocks and is characteristic for the oil and gas saturation zone. Such associations for different minerals paleosrezov petroleum cut different. In the sub-surface zone characterized by a spectrum of newly formed minerals, including preference in setting mineralogical subsurface (ground surface) research should be given quite easily determined microscopically secondary minerals. Among them: skutterudite, fosforuranit, hydrogoethite, magnetite, Colombia and others. For geochemical halos characteristic abnormal distribution of U, Nb, Hg, Co, Ni, V, and others.

According to the model of formation of radio geochemical anomalies (Figure 1), the proposed S.J. Pirson [6] on the oil and gas fields there is a peculiar geochemical post, the origin of which is due to selective mineralization repressed during compaction water, which led to the migration and accumulation of oil and gas in structural and stratigraphic traps.

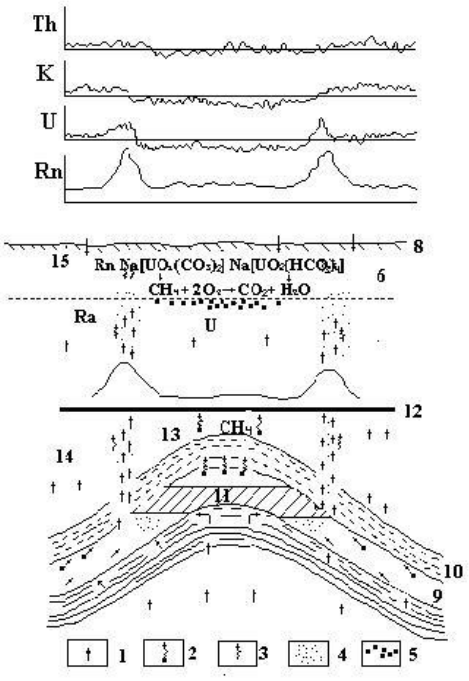

Figure 1. A model of radio geochemical anomalies over hydrocarbon deposit: 1 – water; 2 – oil; 3 – accumulation of Ra; 10 – limiting layer; 11 – trap; 12 – radiogeochemical anomaly according to drilling; 13 – a zone of increased migration, 14 – zone of reduced migration; 15 – area of penetration of atmospheric precipitation.

During electrophoresis under the influence of currents electrotelluric redistribution of radioactive elements. Thus, under the influence of epigenetic processes caused by the influence of hydrocarbon deposits, over oil and gas fields over a long geological time, is the formation of a kind of

radiogeochemical field, characterized by fields of distribution of the total radioactivity, the levels of accumulation of radioactive elements and the nature of their relationship

Concentration field over oil and gas fields are characterized by a high degree of differentiation in the distribution of R, Th, U, and has a much more complex structure than abroad.

More clearly heterogeneous structure radiogeochemical field caused by the influence of hydrocarbon deposits, reviewed the analysis of Th/U, the intensity of redistribution of natural radionuclides and intensity of thermoluminescence.

At midday Square West in the selection radiogeochemical abnormalities were 91.7% of exploration wells penetrated the hydrocarbon deposits, 45.4% of them are in the loop area with high oil and gas potential.

In the North-Vasyugan area almost all exploratory wells, which gave commercial flow of hydrocarbons (with the exception of one well) are inside the contour petroleum potential.

All exploration wells in the Myldzhinskoye area, gave inflows of hydrocarbons found within the selected radio geochemical anomalies. Moreover, 69.2% of them fall into the contour plot with high petroleum potential [6].

The above abnormal patterns of radiochemical largely determines patterns of change in the physical properties of rocks in the oxidation zone of the deposits of various minerals and redistribution under the influence of migration of light hydrocarbons from the reservoir and atmospheric oxygen to form a powerful redox barrier in the upper part of the section (in the depth range of 300-500 m). X-ray radiometric analysis of samples of sludge blast holes confirms this phenomenon, showing abnormally high concentrations of thorium, iron, titanium and calcium on the background of a low manganese content in the area of fallow, consistent with a change in the magnetic properties. Hurricane calcium and anomalously high uranium recorded in the marginal zones of projection hydrocarbon deposits on the surface.

Comparison of anomalous geochemical effects with a series of geophysical methods for prediction of hydrocarbon accumulations and results of deep drilling shows high convergence manifestations of anomalies and forecast areas and the location of the identified oil and gas fields.

4. Neural network computer methods of processing and analyzing radio geochemical fields of oil and gas deposits

Radiogeochemical model oil and gas field allows you to create a multi-dimensional feature space, which can be used as a factual basis for the prediction of oil and gas potential circuit. In addition to traditional statistical methods for analyzing the mathematical apparatus of artificial neural networks, which allows you to enter a new level of interpretation of geological data related to intellectual analysis of the material [7,8].

Neural networks - this analytical technologies developed and verified by the nature millions of years of its existence. They allow us to solve the problem of forecasting, classification, pattern recognition [9], the search for optimal variants and absolutely indispensable in cases where under normal conditions, the solution of the problem is based on intuition and experience, rather than the strict (in the mathematical sense) its description. Relevance of research in this area is confirmed a mass of different applications of neural networks [10].

To improve the efficiency of post-processing of geochemical data the author developed and tested software for calculating the integrated predictive parameter based on neural network analysis methods, means training artificial neural network exploration well data [8]. In general terms, the problem reduces to the problem of non-formalized classification, and in accordance with the logging instruments and digitized test chart exploration wells in the simplest case can be used two classes (I - producing wells, II - "blank"), and more complex problems the number of classes may be increased on any grounds.

The input is calculated by digital maps of various radio geochemical parameters, and for each class is formed by the standard, assuming that all the points that fall in this space near the well, bear some information load. On the basis of the reference neural network is trained to classify the membership of

each point of the map a particular class. For training on the basis of the standards of a two-layer neural network (Figure 2) with sigmoid activation function of neurons:

$f(A)=A/(c+|A|)$,

where A - adder output neuron, the constant c - steepness parameter sigmoid.

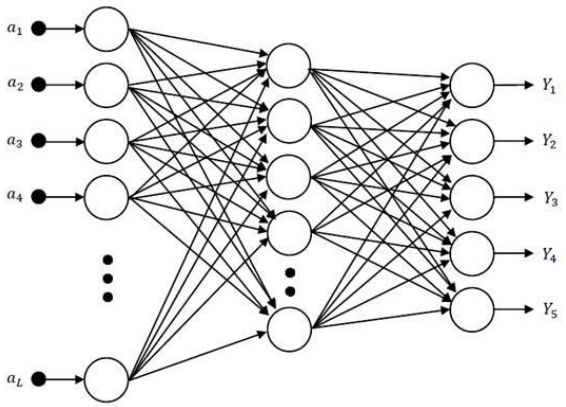

Figure 2. The two-layer neural network.

Neural network algorithms developed marked medal and diploma of Ministry of Industry "For the introduction of neural network methods of complex analysis and interpretation of geophysical and geochemical data" at the international exhibition of high technologies in St. Petersburg, and diploma at the "Siberian Athens" (Tomsk).

5. Prognostic criteria

Theoretical background and analysis of geological materials treated neural network programs in the North-Kalinovoye, North Luginetskoye, West Ostaninskaya, South Cheremshanskaya, pole and Krapivinskoe fields Tomsk region revealed the following predictive criteria.

Formation radiogeochemical anomalies over oil and gas fields based on the idea of the existence of deposits peculiar geochemical column, formed as a result of the election mineralization repressed during compaction of rock water movement which resulted in the migration and accumulation of oil traps [11]. Redistribution of stresses in areas forming anticlinal structures leads to elastic and plastic deformation of the sedimentary cover, creating a permeable zones favorable for the filtration of groundwater and hydrocarbon migration. In turn, the enrichment section of the geological hydrocarbon fraction having strong reducing properties and penetration into the formation oxidant - atmospheric oxygen - leads to a substantial change in the redox environment of the mine, the formation of geochemical barriers. Thus, under the influence of epigenetic processes caused by the influence of hydrocarbon deposits, the oil fields and gas complex formed radiogeochemical field characterized by a peculiar distribution of total radioactivity levels of accumulation of radioactive elements and features of their relationship.

To evaluate the effectiveness of geological neural network techniques were tested in a test mode for a single profile by identifying hydrocarbon deposits, where the opportunity to track changes informative features radiogeochemical fields associated with the identification of hydrocarbons, depending on their phase state (oil, gas, gas condensate) and stratigraphic position of the traps .

The above-mentioned group of fields is all the major oil and gas complexes: the Cretaceous, Jurassic and the contact zone of rocks of Paleozoic and Mesozoic. In addition, in order to improve the methodology of interpretation was conducted areal processing and neural network analysis integrated with other geological and geophysical methods in the South Cheremshanskaya oilfield.

In conjunction with the methods of forecasting seismic data convergence results are obtained using the analysis of gravitational and magnetic fields, which also recorded locations of anomalies in oil and gas accumulations.

The use of this group of methods is based on the laws of changes in the physical properties of rocks in the oxidation zone of the deposits of various minerals and redistribution under the influence of migration of light hydrocarbons from deposits and atmospheric oxygen to form a powerful redox barrier in the upper part of the section (in the depth range 300-500 m).

6. Conclusion

The experience of many years of geophysical studies for oil and gas south-eastern part of Western Siberia shows that the structure of the observed gravity, magnetic, radio geochemical fields natural way reflects the geological structure of the section and the spatial location of hydrocarbon deposits.
Introduction staging, common throughout the civilized world, before directing involves carrying out seismic surveys modern "direct" searching for oil and gas (magnetometry, radiometry, geochemical methods, etc.). At the heart of many of them is the "breath" of deposits - diffusion and filtration of hydrocarbon gases in the section to the surface of the Earth and those geochemical changes that occur under the influence of hydrocarbons in the context of rocks, soil, as well as contact between the accumulations of hydrocarbons and water or rocks.

To improve the efficiency of geological prediction methods developed complex neural network processing and analysis of multidimensional information. The use of this software provides an interactive interpretive processing seismic data, as well as a comprehensive interpretation of it with other geophysical methods on the PC, the formulation of the reporting cartographic material in accordance with the national standards.

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