Natural cracking and the methods of its research when searching for oil and gas deposits (for example the southern areas of the Tyumen region)

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Abstract. Thanks to the complex approach to the study of natural cracking (use of modern remote and geochemical research) in the southern regions of Western Siberia (south of theTyumen region), large regional tectonic blocks and depression zones have been identified by space and geological-geophysical data. Their potential for detecting hydrocarbon deposits was evaluated, taking into account the geodynamic and fluid dynamic approaches.

Introduction

Natural crack zones and faults of various orders are inextricably linked with oil and gas saturation of reservoirs. It has been established that within the fields there are different-scale blocks and their structures delimiting - inter-block zones. In this regard, in recent years, geodynamic and fluid dynamic approaches based on the use of space and ground-based geophysical and geochemical information have been widely used to explain oil and gas accumulation processes [1].

The history of the issue, problem state, methods for solving it

Deciphering satellite images in the visible and infrared ranges, analyzing maps by the gravitational field Δg, magnetic field ΔT and structural maps by the roof of the pre-Jurassic base, the southern part of Western Siberia (south of the Tyumen region) can be conditionally divided into large tectonic blocks - Schuchinsk, Karabash, Miass, Tobolsk, Alym, Severo-Alym, Zaozern, Alymsko-Kalchisk, Nagornensk, West Nagornensk, Abalaksk, East Abalaksk, Mikhailovsk, East Mikhailovsk.

Structures are clearly distinguished between the blocks, which according to the marks of depths (heights) can be characterized as inter-block depression zones - Karabash-Noskinskaya, Sogrinsko-Kalchinskaya, Greater-Uvatskaya, Chelnokovsko-Prirakhtovaya, Malinovsko-Prirakhtovaya, Nagornensko-Tyapuginskaya, Abalaksko-Tobolsk, Abalaksko-Malinovskaya, Karabash-Sogrinskaya.

Thus, in the regional plan, the southern part of the Tyumen region has a fault-block structure. Along the depression zones there are signs of horizontal displacement of large tectonic blocks. Depression zones have a northwest and northeast direction and extend quite a long distance - from a few hundred to the first thousand kilometers. According to seismic data, depressions of an isometric or ellipsoidal shape are noted at the intersections of the depression zones.

Over the past 25 years, it has been shown that large domed structures, to which hydrocarbon deposits are associated, are, as a rule, also “broken up” by tectonic disturbances in the northwest and northeast directions. Moreover, the anticlinal structures themselves and the surrounding area are complicated by small overlap faults, grabens and

horsts. Thus, only at a different hierarchical level, the inheritance of crack systems from large tectonic blocks and depression zones to smaller, local ones is noted.

On the numerous structural plans of the roof of the pre-Jurassic foundation, systems of northwestern and northeastern tectonic disturbances are clearly traced everywhere in many territories. Therefore, it can be stated with confidence that these crack systems were laid back in the Paleozoic time and are "operating" to the present moment.

In addition to the above-mentioned system of tectonic disturbances, the meridional-latitudinal lineament system was recorded on the structural plans of the Upper Jurassic, Cretaceous, Paleogene-Neogene and Quaternary sediments, up to the very day surface, which subsequently found its reflection on temporary seismic sections. Probably, this system arose in the Late Cretaceous period of tectonic activation that occurred in Western Siberia. Numerous deposits of gas, gas condensate and oil are confined and controlled by this particular system.

At the regional level, the meridional-latitudinal crack system is reflected in the form of the Mendeleev depression zone, which belongs to the Ural-Kazakh edge deflection.

For example, consider the intersection of two regional depression zones: the Greater-Uvat (north-eastern direction) and the Abalak-Malinov (north-western direction). Junction node of these two depressions an elongated depression in the north-west direction depression called the Abalak-Uvat basin.

In connection with the discovery of large and giant deposits in the Shirotniy Priobye (Samotlor, Pokachevskoye, Fedorovskoye, Surgutskoye, Pravdinskoye, Salymskoye, Priobskoye, Krasnoleninskoye, Zapadno-Talinskoye, etc.), the southern regions of the Tyumen region for a long time remained in third roles.

However, in the 80-90s of the last century A.L. Klopov [2-6] conducted oil prosspective research in the south of the Tyumen region using the geo-indication method. This made it possible to create maps of oil-promising cosmophotomalanias. The ideological part of the method was that hydrocarbons seeping from the hydrocarbon deposits into the overlying sedimentary deposits saturated the upper part of the soil and plants. As a result of this, the previous changed the spectral brightness coefficient and corresponded to a different phototone in cosmophotographic images.

On the northeastern, eastern, and southern sides of the Abalak-Uvat basin, extensive promising cosmophoto anomalies (CFA), presumably representing oil-bearing lands, are distinguished. Southern CFA is spatially located in the northern part of the large Mikhailovsk tectonic block. Earlier, within this block, the Mikhailovskaya 1 exploration well was drilled, and within the Abalak-Malinovsk depression, closer to its southwestern side, respectively, the Mikhailovskaya 2 exploration well. When testing the supposedly promising intervals of gas and oil inflows were not obtained. As shown by geo-indication studies, these wells were drilled outside the prospective CFA, in a phototone that displays unpromising lands.

Later, at the beginning of the XXI century, according to the method of qualitative and quantitative analysis of space materials using the reference classification for predicting oil prospective areas [7–9] in the northern part of the biggest Mikhailovsk tectonic block, as well as within the Abalak-Malinov depression zone, several small , medium and large anomalies, which according to the set of features corresponded to the Taylakovsky (east Khanty-Mansi Autonomous Okrug), Yakkun-Yakhsky (south Khanty-Mansi Autonomous Okrug) and Polunyakhsky (south Khanty-Mansi Autonomous Okrug) oil fields.

As a rule, the results of distance research are subject to ground verification (verification). Employees of the West Siberian branch of the IPGG SB RAS in the northern part of the Mikhailovsk tectonic block were carried out ground-based complex geochemical research. Their goal was: confirmation of the filtration mechanism of the formation of geochemical anomalies in zones of tectonic disturbances; confirmation of promising

cosmophoto anomalies identified by the geo-indication method; confirmation of oil promising areas identified by the method of qualitative and quantitative analysis of space materials using the reference classification and identification of the most promising areas in order to search for hydrocarbon deposits.

Before conducting ground-based geochemical work, cosmogeological research were carried out.

They are aimed at identifying and studying the structures of the upper part of the sedimentary cover, promising for the migration and accumulation of hydrocarbons.

Cosmogeological research methods can be conditionally divided into: cartographic, structural-geomorphological and lineament. Cartographic are associated with the construction of special maps and geodynamic content schemes that allow you to determine the plotting structures favorable for the formation of oil and gas fields. Structural-geomorphological methods are effectively used in the direct search for hydrocarbon deposits. Lineament methods are based on the analysis of dislocations and deformations of the upper part of the sedimentary cover and, recently, have been successfully adapted to the search, exploration and exploitation of oil and gas deposits.

The results of cosmogeological research of different scales make it possible to trace tectonogenic objects that appear on a day surface in the form of various structural and morphological features of the research territory [10-14].

The methodology for processing and interpretation of cosmogeological data consists of three parts: processing and interpretation of satellite imagery materials in various ranges (visible, infrared, etc.), geological interpretation of seismic, gravimagnetic, thermal and other geological and geophysical (GIS, petrophysics, etc.) data and integrated geological interpretation of Earth remote sensing materials.

Using this methodology, systems of geodynamically stressed zones (GDSZ) and tectonic blocks were identified. GDSZ systems are weakened linear sections of the earth's surface. Conventionally, they are vertical channels for the translation of deep fluids in the form of a narrow parallelepiped. Projection GDSZ from the earth's surface deep into the section, with their confirmation on temporary seismic sections, are treated as faults of the sedimentary cover.

One of the oil-search attributes at the analysis of the study area is the presence of the weakened in the tectonic relation place of crossing (junction) of the GDSZ. It is in such places that local geophysical, geochemical, hydrogeological and other anomalies are recorded.

This approach is the main and most effective tool for predicting and diagnosing the oil and gas potential of the subsoil of the research territory.

The final stage of the cosmogeological methodology is the construction of a model of the study area in the fault-block variant.

Results

The result of cosmogeological research on Mikhailovsk area was the identification of three systems GDSZ: 6 - north-west, 5 - north-east and 2 - meridional directions.

By comparison the results of a qualitative and quantitative analysis of thermal cosmic images with GDSZ systems, it was found that 2 large and 2 small promising anomalies within the Mikhailovsky tectonic block are confined to nodes of geodynamically stressed zones. In addition, 2 large promising anomalies within the Abalak-Malinov depression zone are located on the on a northeast board and also coincide with the nodes of GDSZ.

The results of ground-based complex geochemical research (verification) on Mikhailovsk area showed that:

1. Abnormal concentrations of mercury emanations from ground samples from a depth of 2 meters gravitate, on the one hand, to the GDSZ, forming elongated linear anomalies,

and on the other hand, to the nodes of the GDSZ. Moreover, linear anomalies are confined to the structural nose of the Mikhailovsky anticline structure (within the tectonic block), and the anomalies in the nodes of the GDZ are located on the southwestern side and in the middle part (on the saddle between the Iksky deflection and the Ivanovo depression) of the Abalak-Mikhailovsk depression zone.

2. The oil currently extracted conditionally consists of 70% alkanes (methane homologs) and 30% arenes (benzene homologs). The total concentrations of vaporous alkanes (hexane, heptane, octane, nonane and decane) and arenes (benzene, toluene, xylenes) in ground samples from a depth of 2 meters have a slightly different distribution compared to the area distribution of mercury emanations. On the one hand, the chains of anomalies of these hydrocarbon components gravitate toward GDSZ the north-west directional, including nodes, and on the other hand, the most contrasting anomalies are noted on the sides of the Abalak-Mikhailovsk depression zone, as well as in the northern part of the saddle between Iksky deflection and Ivanovo depression. Within the Mikhailovsk anticlinal structure, anomalies of alkanes and arenas were not recorded. From this it becomes clear why the Mikhailovskaya 1 prospecting well, drilled in the dome of the structure, turned out to be unproductive.

3. The distribution of the activity parameter of hydrocarbon-oxidizing bacteria (HOB), which are “fed” by hydrocarbon emanations, practically repeats the areal location of anomalies of alkanes and arenes. This confirms not only the cross-cutting (“open”, fluid-conducting) nature of the identified tectonic disturbances, but also the long process of vertical migration of hydrocarbon components from a probable deposit to the day surface.

4. Spatial coincidence of anomalies in alkanes, arenas, and parameter activity HOB, as a rule, is a reliable sign for detection of hydrocarbon deposits.

5. The results of 2D seismic surveys carried out later confirmed the correct orientation of the identified GDSZ and the presence of hydrocarbon traps in the section beneath the recorded geochemical anomalies in the Triassic deposits (within the Mikhailovsk tectonic block) and in the Lower Cretaceous and Upper Jurassic deposits (within the Abalak-Malinov depression zone).

6. Geochemical research carried out before, during and after seismic surveys on Mikhailovsk area revealed the fact that, when seismic impacts on the geological environment, part of the GDSZ (tectonic disturbances) are revealed (become fluid-conducting), and the other part is “sealed”, i.e. remain impenetrable.

Conclusion

Thus, research on the identification of natural cracking at various hierarchical levels showed that in the northern part of the Mikhailovsk tectonic block deposits of the pre-Jurassic base are promising , and in within the Abalak-Malin depression zone - deposits of a sedimentary cover.

References

1. A.Y. Prokhorov, A.R. Kurchikov, O.S. Martynov, A.D. Mitrofanov, A.A. Korobeinikov, E.Y. Tryachin, Scientific and technical collection News of gas science, **9**, 158-166 (2012)
2. A.L. Klopov, Ways to improve the efficiency of exploration for oil and gas in the Tyumen region (Pr. of WSOGRI), **148**, 57-61 (Тюмень, 1979)
3. V.V. Borovsky, A.L. Klopov, L.L. Podsosova, I.D. Peskovsky, Exploration of the Earth from Space, **6**, 80-86 (Science, Moscow, 1980)
4. A.L. Klopov, Bulletin of the subsurface user, **2**, 105-107, (Khanty-Mansiysk city, 1999)
5. A.L. Klopov, M.V. Larina, Bulletin of the subsurface user of Khanty-Mansi Autonomous Okrug, **24** (2011)

6. A.L. Klopov, Bulletin of the subsurface user of Khanty-Mansi Autonomous Okrug, **25** (2012)
7. V.I. Gorny, B.V. Shilin, G.I. Yasinsky, Thermal aerospace survey, 128, (Nedra, Moscow, 1993)
8. V.I. Gorny, S.G. Kritsuk, Second international conference "Prospects for development and development of the fuel and energy base of the North-Western economic region of the Russian Federation", Abstracts, 41-42 (2000)
9. V.I. Gorny, I.V. Stepanov, Exploration and protection of mineral resources, **9**, 39-43 (2001)
10. A.Y. Belonosov, A.R. Kurchikov, S.V. Prozorov, Materials of the II All-Russian scientific conference "Geology and oil and gas potential of the West Siberian megabasin", 78-83 (TSOGU, Tyumen, 2001)
11. A.R. Kurchikov, A.Y. Belonosov, O.S. Martynov, Materials of the VII scientific-practical conference «Ways of the Western Siberia's oil and gas potential realization of Khanty-Mansiysk Autonomous Okrug», **1**, 41-44 (Khanty-Mansiysk city, 2003)
12. A.Y. Belonosov, O.S. Martynov, S.A. Sheshukov, International Academic Conference "State, Trends and Problems of the Development of Oil and Gas Potential of Western Siberia", Conference proceedings (Tyumen, 2008)
13. A.R. Kurchikov, A.Y. Belonosov, A.S. Fefelov et al., Materials of the All-Russian Scientific and Practical Geological Conference "Geological Survey and Mineral Resources of Russia on the Threshold of the 21st Century", 206-209 (VNIGRI, St. Petersburg, 2000)
14. A.R. Kurchikov, A.Y. Belonosov, Bulletin of the subsurface user of Khanty-Mansi Autonomous Okrug, **27**, 58-60, (Tyumen, 2001)