Geochemical Signs of Oil and Gas Potential in the North-East of Yakutia

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Abstract. Currently, intensive research is being carried out on the oil and gas content of the eastern Arctic region of Russia. This article discusses geochemical studies carried out in the northeastern part of Sakha (Yakutia). The northeastern part of the Republic of Sakha (Yakutia) is promising for hydrocarbons. This article presents the results of surface geochemical sampling of rocks, waters, and gases performed in Eastern Yakutia under the program of direct oil and gas prospecting. Geochemical studies have shown the promising oil and gas content in the north-eastern part of the Republic of Sakha (Yakutia), which provide an opportunity to carry out prospecting and discovery of predicted deposits of hydrocarbon raw materials.

1. Introduction

The northeastern part of the Republic of Sakha (Yakutia) is promising for hydrocarbons [1,7,13,16]. Currently, intensive research is being carried out on the oil and gas content of the eastern Arctic region of Russia. This article discusses geochemical studies carried out in the northeastern part of Yakutia.

2. Objects and research methods

The methodology of the study is based on a comprehensive synthesis and analysis of all available data from different years on the oil and gas industry of the Russian Federation. The theoretical and methodological basis of the study was the works of Russian scientists on the theoretical and practical problems of the oil and gas complex. To obtain the results, methods of theoretical analysis of information sources, compilation and comparison of information on the studied question were used. Conducted comparative and statistical analysis. Used tabular and graphical methods for presenting research results.

3. Results and discussion

In order to assess the prospects for the oil and gas potential of the Kolyma massif, the Momo-Zyryansk depression and the Primorsky trough, a group of authors analyzed the results of special geochemical studies of natural waters, gases and bitumen in this region [12]. Free gas showings in springs with less intense water exchange were observed both on the southwestern side of the Momskaya trough and on the southern slopes of the Ilin-Tas megaantiklinorium. Here, the gas is characterized by a sharply increased total content of saturated hydrocarbons, represented by the entire range of heavy homologues. In some cases, the total gas flow rate at the source was 0.5-1.0 m³ / min.
Within the Momsky and Indigiro-Zyryansky troughs, despite the insignificant total bituminous content of the rocks (0.02-0.03%), the bitumen contained in them is characterized by reduction, as indicated by the high content of chloroform bitumen in them. The large thickness of bitumen-bearing rocks suggests that they could generate huge quantities of liquid and gaseous hydrocarbons that form oil and gas deposits. According to the authors, the most promising in terms of oil and gas content within Eastern Yakutia are deposits of the Middle Paleozoic, developed in the Kolyma median massif, the New Siberian Islands and the Primorsky trough. This is indicated, in particular, by the fact of obtaining liquid oil from Silurian rocks in a shallow core well. High prospects of oil and gas content are also associated with the Upper Jurassic and Lower Cretaceous deposits, combined into the "Zyryansk complex" [12].

Koloskov K.N. during 3 field seasons surveyed the valley of the river. Indigirka from the river. Closed to the mouth of the river. Uyandina, lower reaches of the Selenyakh, Druzhina, Uyandina, Badarikhi, Kyllakh, Burunas rivers. There are 180 watercourses in total. 78 water samples were taken, 14 - gas samples. The mineralization of water sources and temperature have been investigated. The area of detected emissions of combustible gases in the northeast is limited by the latitude of the village. Major-Krest in the south-west is a strip of articulation between the foothills and the lowlands. The main results of the studies performed allow, in general, to positively assess the prospects for oil and gas content in the northwestern part of the Zyryansk trough [11]. Ivanov K.N. in 1979 and Klubov B.A. within the framework of generalized geochemical studies in the north, north-east and the Far East of the USSR, naphthides, naphtoids and natural bitumens were identified and studied [5,10]. The results of gas production in wells and reservoirs are shown in Table 1.

**Table 1.** Gas occurrences in wells and reservoirs.

| №  | Sedimentary basins, folded systems          | Sampling location, description                                                                                      | Source of information, notes |
|----|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------|
| 1  | Laptev-Yansky basin                         | In shallow well №. 5 in the Dmitri Laptev Strait from a depth of ~ 80 m from KZ sediments.                      | [12]                          |
| 2  |                                            | In a shallow well at the mouth of the river. Yana from a depth of ~ 20 m                                         | [5]                           |
| 3  | Indigiro-Zyryanskiy basin                   | In p. Red from sediments K1                                                                                      | [10]                          |
| 4  |                                            | In the Indigirka River near the Usturtakh-Yuriete creek from K1 sediments; flow rate 15 m³/day                  | [2,3]                         |
| 5  |                                            | In the Taas-Kuturgun River                                                                                       | [10]                          |
| 6  |                                            | In the lake on the right bank of the Indigirka River                                                            | [10]                          |
| 7  |                                            | In the lake 19 km east of the village of Mayor-Crest.                                                            | [2,3]                         |
| 8  |                                            | In the lower reaches of the Sulakkan River                                                                       | [4]                           |
| 9  |                                            | In the left tributary of the Chechelugyun river, 15 km from the mouth                                          | [4]                           |
| 10 |                                            | In the lake 6.5 km east of the mouth of the left tributary of the Chechelugyun river                           | [4]                           |
|   | Description                                                                                                                                            | Reference |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 11 | In the lake 3.5 km south of the left tributary of the Chechelugyun river                                                                          | [4]       |
| 12 | In the lake 11 km northwest of the mouth of the Kynraidakh River                                                                                     | [4]       |
| 13 | In the lake, 7 km north-northeast of the mouth of the Kynraidakh River                                                                            | [4]       |
| 14 | In the lake 6.2 km northeast of the mouth of the Arga-Yuryakh River                                                                              | [4]       |
| 15 | In the lake near the mouth of the Silyap River                                                                                                        | [12]      |
| 16 | In the Silyap River at the mouth of the Vstrechnaya River                                                                                        | [5]       |
| 17 | **Momsky basin** In a lake on the right bank of the Moma River, 6.5 km north of the mouth of the Erikit River | [4]       |
| 18 | In the Taryn-Yuryakh River in the head of the ice                                                                                                      | [4]       |
| 19 | In the lake 2 km southeast of MtF Kycham-Kuel                                                                                                         | [4]       |
| 20 | In the lake near MtF Kycham-Kyuel (the mouth of Ot-Yuryuye creek)                                                                                      | [12]      |
| 21 | **Momsky basin** In the Kurather River                                                                                                                   | [12]      |
| 22 | In a creek 5.5 km southeast of the mouth of the Kalgar River                                                                                           | [4]       |
| 23 | On the right bank of the Arga-Tarynnakh River, 1 km east of Darky Lake                                                                               | [4]       |
| 24 | **Laptev-Yansky basin** Mouth part of the river. Yana river (in wells)                                                                                 |           |
|    | According to Kosolapov, the gas composition is similar to the gas composition at the Vilyui mouth                                                        |           |
| 25 | Coastal zone of the southern coast of the Laptev Strait                                                                                               | [12]      |
| 26 | Lake Tastakh (within the Yano-Kolyma artesian region)                                                                                            | [9]       |
| 27 | **Alazey-Oloi fold system** Mouth of the Vetrennaya Creek at the inflow of the Berezovka River into the Kolyma                                           | [9]       |
| 28 | On a lake on the shore of the Kolyma River, 3 km northeast of the mouth of the Krestovka River                                                            | [9]       |
| 29 | On the lake on the right bank of the Kolyma River, 2.5 km south of the Alyoshkino lodge                                                                | [9]       |

Bituminous manifestations The results of bituminous occurrence according to the data of V.V. Ivanov and B.A. Klubov are given in Table 2 [5].
| №   | Class of bitumen occurrences                  | Sampling site                                                                 | Description, notes                                                                 |
|-----|-----------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1   | Anthracrysolites in strata                    | Belkovsky Island, Mt. Northern Island;                                        | Brushes and crusts along cracks in limestones of the Sokolov Formation (D$_2$)       |
| 2   | Anthracrysolites in strata                    | Northwestern coast of Kotelnoye Island;                                       | Small inclusions among calcite streaks in Silurian limestones;                       |
|     |                                               |                                                                                | Filling of pores and caverns in limestones of the Sokolov Formation (D$_2$);         |
|     |                                               |                                                                                | Filling of pores and fissures in limestones of the Sloop Formation (D$_{1,2}$)      |
| 3   | Malta                                         | Basin of the Uyandina River;                                                   | Uniformly saturated limestones of the Frangian Stage                                 |
| 4   | Malta                                         | Selenyakh block, Seimchan and Talyndzha rivers basin;                         | Fracture fillings in the $S_2$ limestones;                                         |
|     |                                               |                                                                                | Fillings of pores and caverns in limestones of the Upper Silurian roof;             |
|     |                                               |                                                                                | Fillings of faunal formations                                                       |
| 5   | Asphalts and asphaltenes in strata            | Semi-axial uplift, Selenyakh block, Uyandina River;                           | Stained saturation and priming on fractures in limestones D$_2$                      |
| 6   | Asphalts and asphaltenes in strata            | Semi-axial Rise, Selenyakh Block, Seimchan River;                             | Stained saturation and priming on fractures in limestones D$_1$                     |
| 7   | Anthraxolites, intertwined with manifestations of mercury | Gal-Khaya field;                                               | Inclusions in carbonate veins among Lower Silurian rocks                              |
| 8   | Vein anthraxolites among terrigenous rocks    | Ilin-Tas Anticlinorium, upper reaches of the Chechelyugin River;              | Inclusions in quartz veins in sandstones of the Bastakh Formation J$_3$              |
| 9   | Anthracrysolites in the formation             | The interflues of the Uchat, Urultun, and Taskan rivers;                     | Nests in limestones of the Bitumian Formation D$_2$                                 |
| 10  | Anthracrysolites in strata                    | The basin of the Omulevka and Taskan rivers;                                 | Nests in limestones and dolomites of the Bison Formation S$_2$                      |
| 11  | Oil                                           | Popovka river, 118 km from the mouth;                                         | Liquid bitumen in nodule cavities of the Nyatva sequence C$_2$;                     |
|     |                                               |                                                                                | Oil priming through fractures in limestone rubble                                    |
| 12  | Vein kerites                                  | Middle reaches of the Yasachnaya River;                                      | Veins and nests in association with calcite in Upper Carboniferous sandstones;     |
|     |                                               |                                                                                | Veins and nests together with                                                        |
Kislyakov V.N. in 1976 carried out a comprehensive assessment of oil and gas potential of the Primorskaya area in order to select objects for geophysical works location. It was shown that the main oil-and-gas bearing strata in the Tastakh trough are confined to the section of Upper Jurassic and Lower Cretaceous, Upper Cretaceous-Paleogene and Lower Neogene. Paleozoic carbonate rocks may be promising in the Khrom massif. According to gas-hydrogeochemical data indirect signs of oil-and-gas content are noted: presence of hydrocarbons in surface waters, including propane, rarely ethane, in a number of places, high content of methane, naphthenic acids is established [7].

In 1987-89 the trust "Yakutskgeophysika", PGO "Lenaneftegazgeologia" conducted regional geochemical studies on the program of direct search for oil and gas on the Selenyakh, Myatis, Chukcha, Badiarikha, Indigirka and other rivers. The results of these studies highlighted a number of geochemical anomalies, zoning of the territory by geochemical data, possible oil and gas-bearing areas were identified. The possibility of formation of small gas and gas-condensate deposits in Upper Jurassic-Cretaceous and Paleogene-Neogene sediments was confirmed [18-20].

Yashin D.S. and Kim B.I. obtained bottom sampling materials and analyzed more than 700 ground stations [17]. According to the existing ideas, the vertical migration of HC-gases from the deposit to the day surface leads to the formation in the overlying sediments (including bottom sediments) of anomalous contents of methane and its homologues, which can be "direct" signs of oil-and-gas-bearingness of the subsurface. The processing of the entire data set (without hurricane concentrations >10 cm³/kg) made it possible to classify as anomalous the methane content exceeding 0.05 cm³/kg, and heavy hydrocarbons with a concentration >0.001 cm³/kg. On the Laptev shelf, gas-geochemical studies were conducted mainly on the upper (50-80 cm) layers of sediments, where biochemical processes are most intense. At the same time, no fundamental differences in the background gas saturation were observed in the columns, which penetrated deeper horizons. A characteristic feature of the gas composition of the Ust-Lena graben sediments is the presence in many samples of hydrogen (up to 48%), which has a high migration capacity, as well as argon and helium 0.915-1.325% and 0.004-0.009%, respectively, which significantly increases the probability of hydrogen-gases from deep horizons. A significant part of the anomalous HC-gas concentrations in the bottom sediments of the Laptev shelf is of migratory nature and may indicate the prospects of the water area for oil and gas. From the position of gas and geochemical studies, the Ust-Lena graben is the most promising. On the shelf of the East Siberian Sea the gas composition of the bottom sediments was studied mainly in its southern part, in the area of Bear Islands and Ayon Island (about 200 samples). Anomalous HC-gas content was detected only in nine samples. Bottom sediments in this area are formed under the direct influence of the Kolyma River outflow and are largely enriched with organic material. No clear signs of the migratory nature of gases were found. On the shelf of the Chukchi Sea, the gas composition of
Sediments were studied for practically all main structures of the southern part of the shelf. A total of about 200 samples were analyzed. Most of the anomalous hydrocarbon gas concentrations were recorded within the South Chukchi Trough, which is promising for hydrocarbons. The most convincing geochemical signs of oil and gas bearing capacity look in the southeastern part of the trough, in the area of Hope trough. Thus, gas-geochemical studies of bottom sediments of the Laptev and Chukchi Seas have established the presence of anomalous HC concentrations - gases of various nature. Structural control of their distribution, the confinement of much of it to the weakened fault zones, as well as features of the qualitative composition of gases give reason to consider many anomalous HC-gas content as "direct" signs of oil and gas content of the shelf of the Eastern Arctic seas. Within the shelf, the structures that, according to geochemical data, may be of interest as the most promising for hydrocarbon prospecting. In the Laptev Sea this is the Ust-Lena graben, in the south of the Chukchi shelf - Hope Depression. Gas-geochemical studies once again proved to be a noteworthy prospecting method, first of all, within the poorly studied water areas [9].

4. Conclusion
These studies indicate the possible formation of small gas and gas condensate deposits in this area [6]. Thus, the studies carried out in Northeast Yakutia show that intensive resumption of exploration works in this area is necessary [14,15].

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