

Natural gas and condensate reserves in the Angara–Lena gas-bearing region

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Abstract

Large gas reserves have been discovered in the Vendian terrigenous rock complex of the Angara–Lena step in the southern Siberian Platform. In recent years, regional and areal exploration has yielded substantial data on the structure of gas-promising sedimentary strata and their reservoir properties. The author has analyzed the main structural features of Vendian gas-producing deposits and has made deterministic and probabilistic estimation of initial hydrocarbon resources in place with regard to the discovered field reserves.

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Introduction

The prospects for increasing proven reserves and the establishment of major centers of gas production in East Siberia are largely associated with the Angara–Lena petroliferous region (PR) located in the south of the Lena–Tunguska petroliferous province and including the area of the homonymous tectonic structure—the Angara–Lena step. This area has significant reserves of condensate gas enriched in C₂–C₄ methane homologues and helium in the Vendian terrigenous rock complex of the sedimentary cover.

The high probability of discovering Upper Proterozoic oil and gas fields in the Siberian Platform was first noted by Academicians Usov (1936) and Trofimuk (1960). The Angara–Lena PR was characterized as a predominantly gas-bearing area by Kontorovich, Surkov, and Trofimuk as early as in the 1970s (Drobot et al., 1970; Kontorovich et al., 1975, 1981a, 1982). The program of development of the gas industry in East Siberia stipulates that a gas, gas-chemical, and helium cluster will be developed in this region. The route of the Power of Siberia main gas pipeline built under the program reaches the Kovyktinskoe gas condensate field, the largest in the Lena–Tunguska Province.

Hydrocarbon resources within the Angara–Lena PR are concentrated mainly in the Vendian terrigenous rock complex overlain by Vendian and Lower Cambrian thick carbonate strata. At the beginning of 2015, the gas and condensate reserves of the C₁ and C₂ categories in this complex were about 4 trillion m³. Active geological exploration in the Irkutsk region over the past 10 years has resulted in the discovery of a number of new fields: the Levoberezhnoe field in the basal horizon of the sedimentary cover, the Angaro-Lenskoe, Chikanskoe, Angaro-Ilimskoe, and Nar'yagninskoe fields with deposits in the Parfenovo Horizon, and the Zaslavskoe and Abaiskoe fields with deposits in the Shamanka and Bokhan Horizons. The main gas-bearing horizon in the area is the Parfenovo Horizon (Table 1).

The hydrocarbon fields discovered in the Angara–Lena PR mostly have nonanticlinal traps in the terrigenous rock complex. The structural traps of the Atovskoe and Bratskoe fields are an exception.

The peculiar geological structure, history of formation of producing strata, and their polyfacies character significantly complicate the search for and exploration of deposits. In many cases, conventional two-dimensional seismic surveys are not very effective for predicting gas reservoirs and should be integrated with other geological and geophysical methods.

The results of geological and geophysical studies of the last decades and the problem of developing the Irkutsk gas, gas chemical, and helium cluster necessitate reestimation of the

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Table 1. Reserves of gas fields in the Angara–Lena PR

Producing horizon	Field, year of discovery										
	Bratskoe	Atovskoe	Kovyktinskoe	Levoberezhnoe	Angaro-Lenskoe	Chikanskoe	Zaslavskoe	Angaro-Ilimskoe	Abaiskoe	Atovskoe	Nar'yaginskoe
	1975	1977	1987	2004	2006	2006	2009	2009	2010	2010	2010
Parfenovo	S	S	U	–	U	S	–	M	–	–	S
Shamanka	–	–	–	–	–	–	S	–	S	S	–
Bokhan	–	–	–	–	–	M	S	–	–	S	–
Basal	–	–	–	L	–	–	–	–	–	–	–

Note. U, Unique; L, large; M, medium; S, small.

resource potential of the Angara–Lena PR in order to clarify the prospects and areas for further exploration and prospecting of hydrocarbon deposits. In this study, this problem is confined to the Vendian terrigenous rock complex.

Geological and geophysical knowledge of the area

The problem of finding oil in the Siberian platform, in particular, on the Angara–Lena step, was posed in the 1930s by I.M. Gubkin. However, purposeful study of the petroleum potential of the southern areas of the Siberian Platform began after World War II. In different years, the work was headed by outstanding specialists I.P. Karasev, M.M. Mandel'baum, V.V. Samsonov, B.L. Ryb'yakov, A.I. Shamal', B.A. Fuks, L.F. Tyshchenko, and others (Kontorovich et al., 1981a; Samsonov, 1975; and others).

The scientific support of geological exploration work throughout the study of the Angara–Lena PR was performed by IGG SB RAS (A.A. Trofimuk and Yu.N. Karogodin), IPGG SB RAS (A.E. Kontorovich and S.A. Moiseev), VNIIGAZ (V.G. Vasil'ev), VNIGRI (Yu.A. Pritula, E.A. Bazanov, V.V. Zabaluev, and others), and SNIIGGiMS (V.S. Surkov, A.E. Kontorovich, I.N. Sulimov, V.N. Vorob'ev, A.I. Larichev, N.V. Mel'nikov, V.S. Starosel'tsev, and others), Vost-SibNIIGGiMS (A.S. Antsiferov, S.L. Arutyunov, V.N. Vorob'ev, D.I. Drobot, A.N. Zolotov, G.Ya. Shutov, and others).

The first minor inflows of hydrocarbons were detected in the south of the Angara–Lena PR in 1949–1950 from Cambrian deposits in the Bol'sherazvodninskaya and Osinskaya areas. In subsequent years, commercial gas inflows were obtained from Vendian terrigenous deposits in the Atovskaya, Yuzhno-Raduiskaya, Parfenovskaya, Khristoforovskaya, Bil'chirskaya, and Birkinskaya areas. Later the Atovskoe and Bratskoe fields were discovered. All the work was conducted by Vostsibneftegazgeologiya production geological association (PGA) and Eastern Geophysical Trust (Vostochnyi Geofizicheskii Trest) and later by Irkutskgeofizika PGA (now Irkutskgeofizika). In 1987 the Kovyktinskoe gas condensate field with unique resources was discovered, which greatly improved the outlook for the search of hydrocarbons in this region. In the

hard economic times after the collapse of the Soviet Union, the work was stopped.

In the last years of the 20th century and at the beginning of the 21st century, exploration of the Kovyktinskoe field was conducted by OAO Rusiapetroleum and TNK-BP and currently by PAO Gazprom, and the Angaro-Lenskoe and Levoberezhnoe fields were explored by OOO Petromir. Several small and medium-sized companies also operate in the region.

The Angara–Lena step has been studied by seismic methods (refraction wave method, controlled direction shooting, reflection wave method) since the mid-1950s. The common depth point method (CDP) began to be introduced since the early 1980s, and in the 1980–90s, there was complete conversion to the CDP method.

Since the early 2000s, there has been significant intensification of geological exploration in areas adjacent to the East Siberia–Pacific Ocean pipeline. Surveys along the Prisayano-Lenskii and Kovyktinskoe field–Cis-Patom trough regional profiles were financed by the state budget. Deep drilling and seismic prospecting have been actively carried out in the central areas of the PR. Over the past decade, regional seismic surveys have been conducted in a number of areas within the western part of the PR, in the north in the region of its junction with the Nepa–Botuobiya and Cis-Sayan–Yenisei PR (Katskaya, Verkhnekatangskaya, and other areas), resulting in an estimation of the hydrocarbon prospects in the Vendian and Riphean oil and gas complexes.

During the exploration of the Angara–Lena step, more than 400 wells were drilled, which provided a drilling density of 4.34 m/km² (Fig. 1). Most of the wells were drilled in the south of the Angara–Lena step. The central and western parts of the PR were explored by deep drilling to a lesser extent.

The average density of seismic exploration in the region is 0.25 km/km².

Structure of the Vendian terrigenous rock complex

In most of the Angara–Lena PR, the Vendian terrigenous section is represented by the Chora Formation. The lower subformation corresponds in volume to the Nepa stratigraphic horizon of complex substantiation, and the top corresponds to

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