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ГЕОЛОГО-ПРОМЫШЛЕННАЯ ОЦЕНКА И ПЕРСПЕКТИВЫ ОСВОЕНИЯ ЮЖНО-АРГУНСКОГО УГЛЕНОСНОГО РАЙОНА*

Аннотация. Основанием для оценки состояния и перспективности освоения Южно-Аргунского угленосного района, который находится в пограничном с Китаем районе Забайкалья, послужила Программа развития угольной промышленности России на период до 2030 г., в которой говорится: «…для сохранения конкурентоспособности российской угольной продукции на внешних рынках представляется целесообразным осваивать в Восточной Сибири и на Дальнем Востоке новые месторождения углей, пользующихся спросом на внешних рынках. Расположение таких месторождений вблизи границ позволит существенно снизить транспортные затраты по сравнению с предприятиями, расположенными в центре территории страны». Забайкальский регион располагает крупной сырьевой базой и значительным ресурсным потенциалом углей различных технологических марок и разновидностей — от бурых и каменных до коксующихся. Южно-Аргунский угленосный район — один из крупнейших в Забайкальском крае. По разным оценкам его угольные ресурсы определены в 2 млрд т. В настоящее время, несмотря на развитую инфраструктуру района, эти месторождения практически не разрабатываются. В перспективе, на этой базе может быть создан мощный угледобывающий кластер, обеспечивающий топливно-энергетическим сырьем промышленность Юго-Восточного Забайкалья и прилегающих районов Китая, создать большое количество новых рабочих мест и значительно улучшить экономическую обстановку региона в целом.

Ключевые слова: бурый уголь, месторождения, угленосный район, угольные ресурсы, качество углей, горнотехнические условия отработки, энергетическое и комплексное сырье.

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The Transbaikal region has a large source of raw materials and considerable resource potential of coals of various technological brands and types — from brown and bituminous to coking. Forty eight deposits and eighteen coal's manifestations in Transbaikal region are known [4, 5, 10].

Raw material potential of Transbaikal region is a reliable basis for further development of the coal industry in region. It is general resources make about 7.0 billion tons of coal.

Coal is the basically source of energy production in the region. It does not have an alternative in Transbaikal region. Mining of power-generating coal in the region was about 12 million tons in 2017.

The Program of the coal industry's development in Russia until 2030 formed base for evaluation and prospects of the southern Argun's coal-bearing area exploitation which is in the district of Transbaikal region boundary with China. It is said in this program: «… for maintaining competitiveness of the Russian coal products in foreign markets it is advisable to develop in Eastern Siberia and in the Far East new coal deposits best-selling in foreign markets. The location near borders of such deposits will allow to lower logistic

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expenses in comparison with the enterprises located in the center of the territory of the country» [1].

The Southern Argun's coal-bearing area is one of the largest in Transbaikal region. Its coal resources are defined in 2 billion tons by different estimates [10, 15]. On this base the large cluster of coals mining providing with fuel and energy raw materials the industry of Southeast Transbaikal region and the adjacent regions of China in the long term can be created (fig. 1). Now these deposits are practically not exploited despite the developed area infrastructure.

Coal-bearing area belongs to the Southern Argun cavity about 120 km long and 16—20 km wide. The cavity is located on a left bank of the Argun River within the Priargunsk and Krasnokamensk administrative regions of Transbaikal region and on a right bank of the Argun River within

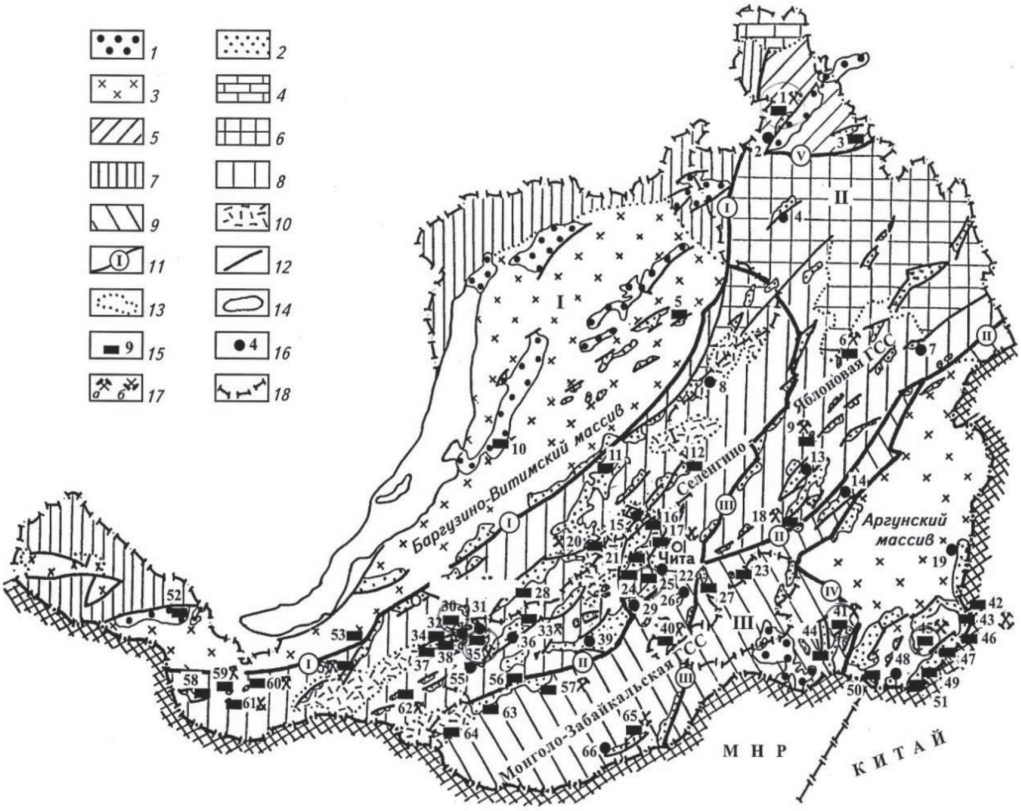

Fig. 1. Coal deposits and manifestations of Transbaikal region [10]: 1 — Apsatskoye; 2 — Sredne-Sakukanskoye; 3 — Chitkadinskoye; 4 — Sredne-Kalarskoye; 5 — Elandinskoye; 6 — Nerchuganskoye; 7 — Mogochinskoye; 8 — Vitimskoye; 9 — Bukachachinskoye; 10 — Bodonskoye; 11 — Tallinnskoye; 12 — Ushmunskoye; 13 — Staro-Orlovskoye; 14 — Levo-Delyunskoye; 15 — Ursinskoye; 16 — Taseyskoye; 17 — Chernovskoye; 18 — Arbagaro-Holbonskoye; 19 — Olochinskoye; 20 — Daban-Gorkhonskoye; 21 — Irgenskoye; 22 — Kukinskoye; 23 — Olentuyskoye; 24 — Sokhondinskoye; 25 — Tataurovskoye; 26 — Olenguyskoye; 27 — Tyrgetuy-Zhimbirinskoye; 28 — Manay-Azhilskoye; 29 — Uletovskoye; 30 — Olon-Shibirskoye; 31 — Kuznetsovsky Uval; 32 — Elanskoye; 33 — Burtuyskoye; 34 — Munkharskoye; 35 — Tarbagataiskoye; 36 — Halyartinskoye; 37 — Erdem-Galgatayskoye; 38 — Nikolskoye; 39 — Tanginskoye; 40 — Ureyskoye; 41 — Haranorskoye; 42 — Kuzhertayskoye; 43 — Kutinskoye; 44 — Chindantskoye; 45 — Urtuyskoye; 46 — Priozerskoye; 47 — Pogranichnoye; 48 — Matsiyevskoye; 49 — Sredne-Argunskoye; 50 — Daurskoye; 51 — Abagaytuyskoye; 52 — Akhalinskoye; 53 — Zagustayskoye; 54 — Gousinoozerskoye; 55 — Katayevskoye; 56 — Shimbilinsky; 57 — Zashuyanskoye; 58 — Sanaginskoye; 59 — Sanginskoye; 60 — Chara-Huzharskoye; 61 — Bayangolskoye; 62 — Okino-Klyuchevskoye; 63 — Krasnochikoyskoye; 64 — Urlukskoye; 65 — Mordoyskoye; 66 — Altanskoye

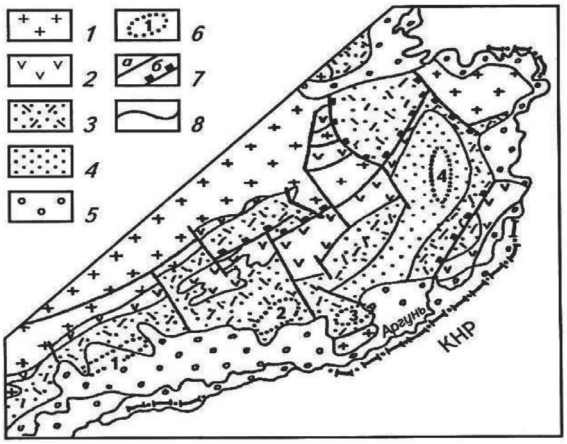

Fig. 2. Schematic geological map of the Southern Argun cavity [10]: 1 — riphean and Upper-Paleozoic granitoid of foundation, 2- Upper-Jurassic volcanogenic and sedimentary formations, 3 — Lower Cretaceous volcanogenic and sedimentary formations of Turginskoye series, 4 — Lower Cretaceous volcanogenic and sedimentary formations of Kutinskoye series, 5 — quaternary deposits; 6 — coal deposits and their numbers (1 — Pogranichnoye, 2 — Priozernoye, 3 — Kutinskoye); 7 — disjunctive violations: fracture (a), overlap (b); 8 — geological boundaries

China. The Argun River cuts the Southern Argun cavity on two parts (fig. 2).

In the territory of the coal-bearing area three deposits of brown coal are explored: Kutinskoye, Pogranichnoye and Priozernoye with workable reserves and several coals' manifestations with minor reserves (table 1).

Kutinskoye deposit is situated in the Priargunsk district of Transbaikal region. This deposit located on the left coast of the Argun River in 7 km to the southwest of the village Koutie and in 30 km from the railway station Priargunsk. Openly in 1956 and detail exploration is carried out in 1957—1959.

The deposit represent structurally the closed mould one of several within the Southern Argun cavity. Mould is extended in the northeast direction. Width it in the central part is 2.5 km and length about 7 km.

Pitch angle of wings of a mould ranging widely between 2—3 degrees and 15—35 degrees. The steepest dim of seam are noted on a southeast wing of a mould where coal seams approach. Considerable pitch angle are noted in a southwest part of structure where its width decreases and mould is flattened in a section.

The northwest wing of a mould is flat and an inclination of seams usually ranging within 6—12 degrees. Occurrence of seam in the central part of a mould is the most flat sometimes almost horizontal and pitch angle do not exceed 5 degrees.

Disjunctive violations are not revealed on the site of deposit. All seams of brown

Table 1

Coals reserves on deposits of the Southern Argun's coal-bearing area considered by the State balance of mineral recourses for 2000/01/01

Deposit	Balance reserves on categories, millions of tons		Non-commercial reserves, millions of tons	Geological resources, millions of tons
	$A + B + C_1$	C_2		P_1
Kutinskoye	85.3		76.2	43.0
Priozernoye	87.9	100.8	199.5	
Pogranichnoye	187.5		191.7	

coal well connect in cuts and have quiet occurrence. Probability of existence of small explosive violations with shift amplitude in the first meters is not excluded [4, 5, 8].

All coal seams are a part of average and mainly top series. There are two horizons: horizon of powerful coal seams and horizon of low-power coal seams. Together they contain 51 seams of coal and coaly argillite which power fluctuates from 0.3 to 21.90 meters. Besides are noted low-power interseams and lenses of coals from small extent within 0.1 to 0.4 meters.

31 seams are reduced in the top horizon of powerful seams and 6 seams of coal from them are operating powers.

The lower horizon of low-power seams consists of 20 seams with power from 0.4 to 1.6 meters. Some top seams of this horizon have the power of 3.0—4.0 meters on a southeast wing but the power decreases on dip of seam.

Macroscopically coal seams are stacked by semibright, semidull and dull coals. Semibright and transitional from semishining to semidull coals are black, striated, mostly layered; power of strokes of bright coal is 0.5—30 mm. There are frequently fragments of vegetable fabrics at the bedding planes. The semibright type of coals is spread on the deposit restrictedly and usually is deposited interbeds of the power 0.1—0.35 meters.

Semidull coal has striated structure and horizontal cleet which is caused by interbeds of dull coal with power up to several millimeters and interbeds of coaly argillite. Their color is black-brown, break is angular-step and tabular jointing is often observed. Fusainized and gelified fragments of tissues with good preservation structure are well visible on the formation plane. This type of coal is deposited cash to 5 meters in seams.

Dull coal is cleet, faintly striated and brownish-black color. Gelified fragments of tissues are present on the formation plane. The break is angular and separateness wrong. Coal seams contain from 20 to 84% of dull coals, from 11 to 49% semidull, from 4 to 14% semibright [9].

Humus coals belong to group of humoliths, sapropeliths are established in very limited quantities in the semibright and dull petrotypes presented by gelitoliths and fusainoliths. Petrographic composition of coals is difficult. The following petrographic types are microscopically allocated: geletiths, lipoido-geliths, fusainogeliths, gelito-fusainiths, lipoido-fusainiths. The main nonuniform weight including large lenses of structural vitrain, strongly decayed core tissues, lipoid components (spores, a cuticle and pitch inclusions) is characteristic of Kutinskoye coals. Sometimes it has the attrital composition. It prevails in semibright petrotypes; it is in the subordinated quantity in dull and cements the macrocomponents composing them. Microcomponents are located often lit-by-lit in semidull coals; sites of gelified timber with annual rings were found. Coals contain 39—67% of the guminith submitted mainly gumotelinith and 9—13% of the inertinith and less than 1.0% of the mentinith. Mineral dirt are present in the form of disperse inclusions and small angular fragments of feldspar and quartz in number of 4—13% but sometimes they compose in coals thin intercalation and lenses.

Coals of the deposit are medium and high-ash, few-sulfur and medium phosphorous. Quality of coals of various seams is close: all key indicators of quality except for ash-content change in insignificant limits both on the area of the deposit and in a section (table 2). Ash-content of power and medium-power seams on which calculation of balance stocks is below than few-power with off-balance coals. A low exit of huminic acids and incased resin yield of semi-coking (T^{daf}_{sk} > 10%) on local

sites and high-fusing ash is T_b = 1350—1500 C° are characteristic of Kutinskoye deposit's coals.

Deposit's coals can be carried to the brown brand and to the group 2B on the content of moisture, carbon and volatile yield.

Sporadically coals contain germanium in concentration of 0.1—0.003% and rare 0.005—0.01%. The content of other elements does not exceed level of percent abundance.

Data on self-ignition and gas content of coals are absent.

Two types of groundwater are allocated on the deposit:

- subsoil water of quarternary depositions;
- seam-cracked water of carboniferous depositions.

Three horizons of the seam-cracked water dated for seams A, B1 are established. The maximum water inflows to future opencast will be no more than 914 m^3/h.

Priozernoye deposit is located in the Priargunsk district in 120 km to the northeast from the railway station Zabaykalsk and in 40 km from the settlement of Priargunsk.

The preliminary exploration was executed in 1958—1960.

The deposit represent structurally the enclosed mould one of several within the Southern Argun cavity. Mould is extended in the northeast direction. Width of a mould fluctuates from 2.0—3.2 km in a southwest part of the deposit up to 6.0 km in northeast. Length of a mould is 11.3 km. The area it is equal to 38 sq.km.

Pitch angle of rock is small and ranging between 6 to 9 degrees.

The dim of seam of rock increases to 16—18 degrees in a northern part of deposit. Rocks lie almost horizontally in the central part of mould.

Disjunctive violations are not revealed on the site of deposit. All seams of brown coal well connect in cuts and have quiet occurrence. Probability of existence of small explosive violations with shift amplitude in the first meters is not excluded [4, 5, 8].

All coal seams are a part of two carboniferous horizons: horizon of powerful coal seams (top) and horizon of low-power coal seams (lower). Both horizons include 28 seams of coal with a power from 0.3 to 15.5 meters. Besides several coal interseams and interbeds of the carbonaceous rocks having the power of 0.4—1.0 m are noted at various depths which taped out quickly on strike and difficult coordinate among themselves.

The top horizon is limited to seam number XV. From 24 seams of the horizon 5 seams of coal of operating power accepted to calculation of stocks are emitted. Four seams of the lower horizon do not participate in calculation of stocks because of low power (up to 0.7 m) and the small area of distribution.

Macroscopically coal seams are stacked by dull and semidull coals: semibright and transitional from semidull to semi-shining coals meet extremely seldom. Semidull and dull coals compose separate bands of various power are closely connected among themselves and have transitional petrotypes. Semidull coals have harsh striated structure, striate-banded and thinly-banded, dull coals have darkly-striated structure. The break is usually step, angular and uneven.

Humus coals belong to group of humoliths. It is a class of gelitoliths and fusainoliths at prevalence of gelitoliths. Petrographic composition of these coals differs in a considerable variety. The following petrographic types are allocated: ultrageliths, fusaino-geliths, lipoido-geliths, geletiths, lipoido-fusainiths, gelito-fusainiths. Large lenses of the structural vitrinit contain in all microtypes in various quantities. Fusainith find considerably seldom. All microtypes are characterized by presence of the

gelified ground mass which mainly consists from humoustrinith and humotelinith with prevail ulminit. Rare maceral dissemination of the liptinith group (sporinith, rezinith, koutinith) are established in it along with maceral of groups of the guminith and inertinith [9].

Mineral impurity are present at a type of disperse inclusions and small and poorly rounded grains of silicates. In opaque coals mineral material sometimes forms considerable accumulations in dull coals and they pass into carbonaceous argillite.

Solid coals usually are brittle at the increased content of fuzainized tissues are very brittle and on air are very quickly scattered in fines. They are on ash-content from small to high-ash, few-sulfur and few-phosphorous (0.007—0.084%) and most coals of East Transbaikal region's deposits have a low exit of humic acids. The quality of coals of separate seams is studied insufficiently. Coals of the main working seams VII and XV are most fully studied (table 2).

Trace elements in coals were not studied. Coals of the Priozernoye deposit can be carried to brown coals of groups' 2B-3B on calorific value, carbon content, volatile yield, worker's moisture.

Ground waters of two complexes are developed on the deposit: quarternary depositions and Lower Cretaceous carboniferous depositions.

The horizon of seam-pore waters of quarternary deposits has the average power of 16.2 m, the static level from 0 to 16 m, discharge of a well of 3.67—7.4 p/a., coefficient of filtration of 12.3 m/days, radius of influence of 40—75 m. Seam-cracked waters of carboniferous depositions are dated for coal seams, the power of the horizon of 1—10.8 m, static level from 0.47 to 15.42 m, discharge of a well of 0.8—1.68 p/a., influence radius up to 500 m, the coefficient of filtration of 1.5—2.4 m/days, expected water inflow to opencast of 900 m^3/h.

Mining conditions of stopping of the deposit are favorable because of simple deposit's structure, quiet and flat bedding of coal seams, stability of their power and quality in a pit outline, lack of explosive violations and simple hydrogeological conditions. It is possible to opencast mining a half of volumes in-place in southwest, northwest parts of the deposit.

Pogranichnoye deposit is located in the Priargunsk district in 45 km from the railway station Priargunsk. On its square is the village of Bogdanovka.

Exploration works are carried out in 1958—1959. The deposit was mining by regional management of consumer services (the small inclined mine on seam B was passed) till 01.04.1963.

All coal seams on the deposit are a part of the top horizon of powerful coal seams. It includes 13 seams of brown coal which power fluctuates from 0.1 to 11 m.

Besides several coal interseams and interbeds of the carbonaceous rocks having the power of 0.1—1.2 m are noted at various depths which taped out quickly on strike and difficult coordinate among themselves. One seam (E) of operating power from 13 seams accepted to calculation balance and partly off-balance stocks is emitted.

Off-balance and in small quantity balance reserves are counted on seams (Б, В, Г). Only off-balance reserves are counted on A^{III}, A^{II}, A^{I}, А, Д, Ж, З, И, К seams.

Macroscopically coal seams are stacked by dull and semidull coals. Structure of semidull coals is homogeneous, faintly striated and lenticular-striated, dull coals have faintly striated and striate-banded structure. Streak is caused most often by presence at the ground semidull mass of inclusions of bright coal, banding is caused existence in it of dull and bright petrotypes. The break is usually angular, step and seldom wavy [13].

Humus coals belong to group of humoliths mainly to a class of gelitoliths which

Table 2

Key indicators of quality of coals (averages on seams with balance reserves), percent

Quality rating	Deposits		
	Kutinskoye	Priozernoye	Pogranichnoye
W_t	25.5–38.5 29.8	17.9–35.3 25.9	13.6–32.2 26.4
A^d	14.5–39.3 30.4	7.0–47.9 23.0	6.0–47.4 23.2
V^{daf}	37.9–49.5 44.6	43.5–49.9 46.3	42.9–53.8 47.0
C^{daf}	73.3–77.9 75.4	69.9–78.1 74.72	73.8–76.7 75.3
H^{daf}	4.7–6.1 5.4	5.2–6.3 5.8	5.9–6.6 6.0
N^{daf}	–	–	1.7–2.3 2.0
S^d_t	0.28–0.82 0.4	0.2–1.0 0.43	0.16–0.76 0.39
T^{daf}_{sk}	7.4–11.4 9.0	5.4–12.5 8.7	4.5–8.2 6.3
Q^{daf}_s	26.0–31.4 29.6	26.9–31.3 29.5	29.3–31.0 30.2
Q^r_i	10,4–17.5 12.5	10.8–17.1 15,7	14,9–16,4 15,9
$(HA)_t$	2.5–11.7 5,2	2.3–19,3 10.8	1,2–6,9 2.9
Note. Q^{daf}_s and Q^r_i — in MDzh/kg			

sharply prevail over fusainoliths. Various quantitative and structural combinations of bright, semibright and dull petrotypes and also mineral substances gave a number of micropetrographic types. Ultrageliths, fusaino-geliths, imetith are allocated in semidull coals; gelito-fusainiths, gelito-lipoidofusainiths are allocated in dull coals.

Petrographic composition of coals microscopically is studied at the qualitative level. Ground mass, structural vitrinite, intertinite and liptinite are established in them. Ground mass is the most essential part of coals which is present at all types and presented mainly humodetrinith and humotelinith in which prevails ulminith. Genesis of ground mass is gelified of vegetable fines (atrit) before almost total disappearance of primary structure of vegetable tissues. Structural guminith in the form of the textinith it is widespread. It is products of a gelified of stem and wood parts of plants with good safety. They form reinforced short lenses of dark-brown color.

Inertinit it is established in the subordinated quantity. It is presented fusainit and semifusainit which are characterized by good tissues safety. It has position in the form of lenses and fragments of irregular shape included in ground mass and streamline by ground mass. Macerals belong to liptinit groups (sporinite, cutinite and rarer resinite, souberinit) are also present at the subordinated quantity [9, 13].

Coals of deposit are solid and usually brash and they are very brash and on air quickly scattered in a trifle at increase in the maintenance of macerals of inertinit group. Ash-content is from small to high-ash and it has medium ash content when averaging on seams and on the deposit; few-sulphurous, it is generally few and

medium phosphorus (0.005—0.100%). Low exits of humic acids and yield of low-temperature tar and also the increased ash-content of coals of low-power seams are characteristic of them (table 2).

Silicium dioxide is the main component of ashes of Pogranichnoye coals. The fluxibility it was not studied.

The average chemical composition of ashes is (in percent): SiO_2 = 70.4; Fe_2O_3 = = 6.2; Al_2O_3 = 9.3; CaO = 4.4; MgO = 1.0; SO_3 = 2.5.

Germanium is identifying in ash to 50 g/t, gallium to 200 and beryllium up to 150 g/t.

Coals of Pogranichnoye deposit can be carried to brown groups' 2B-3B because of size of working moisture, calorific value, volatile yield and carbon content [11].

Mining conditions of the deposit are favorable for the organization of career stopping of E seam. B and G are subject to following mining which within some sites have industrial power.

The average coefficient of overburden o. E seam makes 4.83 m^3/t (taking following mining seam. B and G).

Aggradations of a Lower Cretaceous complex (silty rocks, argillites, sands) belong to breeds of IV an. V categories on rippability and drillability. Their excavation is possible with blasting workings. Special hydrogeological works on the deposit it was not carried out. But hydrogeological conditions are assumed by rather simple by analogy with Kutinskoye and Priozernoye deposits.

Geo-ecological conditions of exploitation the southern Argun deposit are studied in insufficient degree. The few sulfur content of coals and few content of free silicon dioxide in the enclosing rocks belong to number of the factors which are favorably influencing development. Additional researches of distribution in coals and the containing breeds of toxic, potentially toxic and radioactive elements and also potential of explosion of coal dust are required [10.15]

Conclusions

Prospectivity of the Southern Argun's coal-bearing area exploitation are very favorable and are estimated on the following factors:

- considerable resources of the coal-bearing area;
- favorable mining-and-geological conditions, namely: large and sustained power of the main coal seams, not great depth of their bedding, lack of tectonic violations and the small angle of slope of seams allow to mining by opencast way;
- insignificant water content;
- the quality indicators of coals allowing to use them as the good energy material for dust-like and seamed burning in stationary boiler installations and also for utility generation;
- coals using as complex raw materials after their more detailed research on the content of trace elements.

This factors along with the compact localization of deposits, well-developed region infrastructure and proximity of perspective sales market (China) allow to draw a conclusion on a possibility of creation the effective coal-mining and processing cluster on the basis of deposits of the Southern Argun coal-bearing district. It will allow to create a large number of new jobs and to considerably improve an economic situation of the region in general.

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Geological-industrial evaluation and prospects of the Southern Argun's coal-bearing area exploitation

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Abstract. The Program of the coal industry's development in Russia until 2030 formed base for evaluation and prospects of the southern Argun's coal-bearing area exploitation which is in the district of Transbaikal region boundary with China. It is said in this program: "... for maintaining competitiveness of the Russian coal products in foreign markets it is advisable to develop in Eastern Siberia and in the Far East new coal deposits best-selling in foreign markets. The location near borders of such deposits will allow to lower logistic expenses in comparison with the enterprises located in the center of the territory of the country". The Transbaikal region has a large source of raw materials and considerable resource potential of coals of various technological brands and types — from brown and bituminous to coking. The South Argun coal-bearing region is one of the largest in the Trans-Baikal Territory. According to various estimates, its coal resources are estimated at 2 billion tons. At present, despite the developed infrastructure of the region, these deposits are practically not developed. In the future, a powerful coal-mining cluster can be created on this base, providing industry of the South-Eastern Transbaikalia and adjacent regions of China with fuel and energy raw materials, creating a large number of new jobs and significantly improving the economic situation in the region as a whole.

Key words: brown coal, deposits, coal-bearing area, coal resources, quality of coal, mining and technical conditions of mining, energy and complex raw materials.

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