

Perspectives for the Transportless Mining Technology in Siberia and Far East Coal Deposits

Sergey Markov^{1,*}, *Juraj Janočko*², *Maxim Tyulenev*¹, and *Yaroslav Litvin*³

¹T.F. Gorbachev Kuzbass State Technical University, Vesennya 28, 650000 Kemerovo, Russia

²Technical University of Kosice, Faculty of Mining, Ecology, Process Control and Geotechnologies, Letná 9, 04200 Kosice, Slovak Republic

³Branch of the JSC “Kuzbassrazrezugol” Mokhovskiy Open Pit Mine, Pionersky Blvd. 4a, 650054 Kemerovo, Russia

Abstract. In accordance with the long-term program for the coal industry development in Russia until 2030, the growth in the share of the Far East Federal District in the total coal production should be 2.5% compared to 2018. Production volumes in the Siberian Federal District to 2030 should reach 309.5 million tons. These numbers are planned to be achieved through the implementation of large-scale infrastructure projects for the development of new coal deposits with convenient mining and geological conditions, as well as the creation of new coal mining centres in Yakutia, Zabaykalsky region, Tyva Republic and other eastern regions of Russia. Taking into account the development of power generating facilities in Far East and Baikal region, coal consumption is planned to increase from 119 million tons in 2020 to 150 million tons per year in 2030. The realization of the planned indicators should be carried out taking into account the use of coal mining technologies that meet the mining and geological conditions of the deposits in this region. For a large number of coal fields in Eastern Siberia and Far East, transportless technology will be preferred.

1 Introduction

The development of the fuel and energy and power generating industry of Russia implies the commissioning of preferring coal deposits in Siberia and Far East. It is due to the reduction of the transport component between the centres of coal mining and the places of its use, in particular for energy purposes. It also provides for an increase in the potential of the coal industry in the Baikal region and Far East through the implementation of the long-term program for the development of the coal industry in Russia for the period up to 2030 [1]. The shift of the coal industry to the east of the country will occur in accordance with the orientation towards the formation of new centres of coal mining [2, 3]. The main characteristics of coal basins and large referring deposits are presented in Table 1.

* Corresponding author: markovso@kuzstu.ru

Table 1. Main coal basins and deposits of Siberia and Far East regions.

Coal basins and deposits	Short characteristics
South Yakutian basin (Yakutia, Khabarovsk region)	high quality coking coals
the Elga deposit	coal resources 2.2 billion tons
Tungus basin (Krasnoyarsk region, particularly Yakutia)	brown coals, hard coals, anthracites; resources more than 2 trillion tons
Lensky basin (Yakutia)	brown coals, hard coals; resources more than 3.7 billion tons
Bureinsky basin (Khabarovsk region)	hard coals; resources 10.9 billion tons
Partizansky basin (Primorsky region)	hard coals; resources 320 million tons
Uglovsky basin (Primorsky region)	brown coals; resources 680 million tons
Beringovsky basin (Chukot region)	hard coals; resources 570 million tons

Much attention is paid to this region in the planned volume of coal production at 500 million tons per year in Russia by 2030.

2 General mining and geological conditions of prospective coal basins and deposits of the Krasnoyarsk region and the Far East of Russia

The coals of the South Yakut basin are humus, mostly shiny and semi-shiny, less common are matte and semi-matte. Coal grades is wide enough (fat, coke-fat, coke, weakly caked). According to the quality characteristics, the coals are classified as medium ash and high ash, difficult enriched and medium enriched, with a high yield of volatile matter ($V^{daf} = 18 - 20\%$). The resources of coking coal are more than two times higher than the resources of steam one.

The Elga deposit is located in the central part of the Tokinsky coal-bearing region of the South Yakutian coal basin (Fig. 1). For the Elga deposit, thick (up to 15 meters) flat seams of caking coals with overlying sediments of small thickness.

The reserves and forecast resources of coal of the South Yakutia basin amount to 47.6 billion tons, of which 7.4 billion tons are on balance reserves, and 37.97 billion tons on forecast resources.

In the Tungus coal basin (Fig. 2), coal was found in sediments of the middle and upper Carboniferous, Permian, Jurassic, and Paleogene. Coal content is associated with continental Permian-Carboniferous sediments with a thickness of 350 – 1460 m, overlapped by Permian-Triassic tuffaceous and lava formations with a thickness of up to 1500 – 2000 m, and numerous sills, dykes and rods of igneous rocks that form 10 – 75% of the formation volume.

They are form large flat structures in the sedimentary cover of the Siberian platform. The thickness of the suites, their coal saturation are subject to significant fluctuations. In the Norilsk region, individual layers reach a thickness of 15 – 20 m. Coals are low and medium ashes ($A^d = 9 - 25\%$), low-sulfur ($S_f^d = 0.2 - 1\%$) with a wide range of grades from brown to graphite. The widespread of thermal and contact metamorphism determines the limited reserves of well-coking coal, while increasing the degree of metamorphism of coal to anthracite and graphite. The main industrial coals are throughout the Permian sediments. The coal distribution is uneven. There is a gradual increase in the number and thickness of the layers from lower to the top strata.

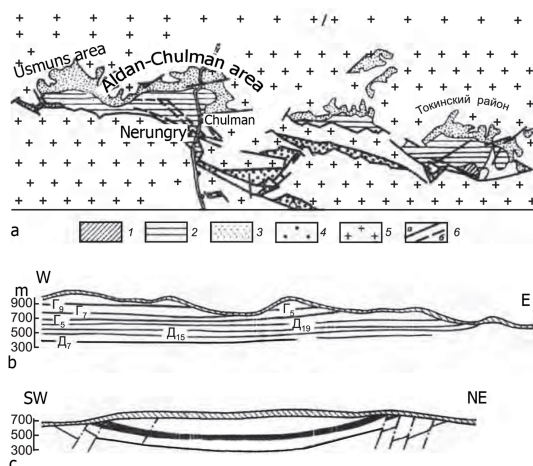


Fig. 1. Geological scheme of the South Yakut basin: 1 - Lower Cretaceous sediments, 2 - Middle Upper Jurassic sediments, 3 - Lower Jurassic sediments, 4 - Jurassic undifferentiated sediments, 5 - Archean foundation, 6 - faults; b - geological section of the Chulmakan field; c - geological section of the Nerungri field.

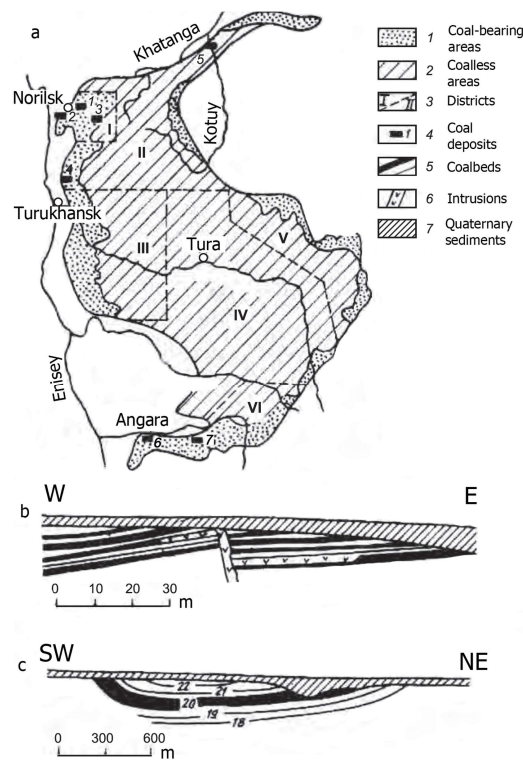


Fig. 2. Tungus coal basin (a), cross-sections of Kayerkan (b) and Kokuisky (c) deposits. Fields: I – Norilsk region: 1 – of the Schmidt and Nadezhda mountains (Norilsk-1), 2 – Kayerkan, 3 – Imangdinskoye; II – Arctic region: 4 – Kureiskoe, 5 – Kayakskoe; III – Western District; IV – Central district; V – Eastern district; VI – Southern district: 6 – Kokuiskoe, 7 – Boguchanskoe.

The Kayerkan field is represented by a coal-bearing formation with a thickness of up to 375 m and consists of Middle-Late Carboniferous and Permian sediments. Up to 24 coal

beads are enclosed in this sediments, 14 of ones have an operating thickness. Industrial coal bearing is associated with sediments of the Lower Permian and Middle Permian.

The geological structure of the Kayerkan-1 field is relatively simple. The layers lies monoclinaly with angles of incidence of 7 – 12°. The stratum contains hollow seated sills and is dissected by steeply dipping dolerite dikes. Coals can be used as energy fuel, and partly to get coke.

The Daldykan deposit is located southeast of the Kayerkan-1 field. The depth of the layers up to 200 m, with angles of incidence 2 – 10°.

The Imangdinsk deposit (Fig. 3) is represented by a coal-bearing formation up to 350 m thickness, associated with the Middle-Upper Permian deposits of the Tungus series. The geology is simple; faults and the intrusions of dolerites had no significant effect on him. The coal seams monoclinaly fall to the east at angles of 5 – 10°. Operating layers have an average thickness of 1.6 to 14.2 m.

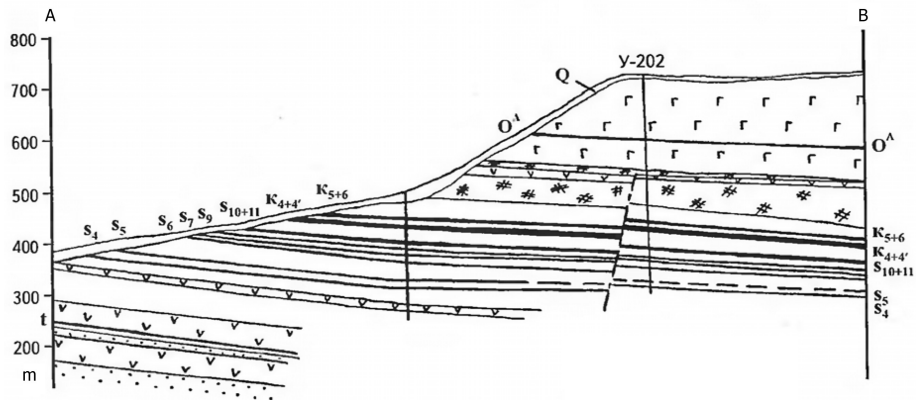


Fig. 3. The Imangdin hard-coal deposit cross-section.

The coals of the deposits are coking and energy grades. Ash content ranges from $A^d = 14.8 - 21.8\%$, the specific heat of combustion $Q_s^{af} = 7946 - 8347$ MJ/kg.

The Norilsk-1 coal deposit (the Schmidt and Nadezhda mountains) has a similar geological structure with the Kayerkan and Imangdin deposits. The deposit is confined to the brachyfold with dip angles on the limbs of 5 – 10°. The productive stratum consists of six coal seams, three of which have a thickness of 5 – 5.5 m. The average dimensions of the interburden vary from 4 to 26 m.

The Bureinsky coal basin (Fig. 4) is a graben-like syncline with dip angles from 7 – 15° on the western limbs to 35° on the eastern limbs. The thickness of the seams is from 1.5 m to 7.6 m which makes it attractive for the application of the transportless technology.

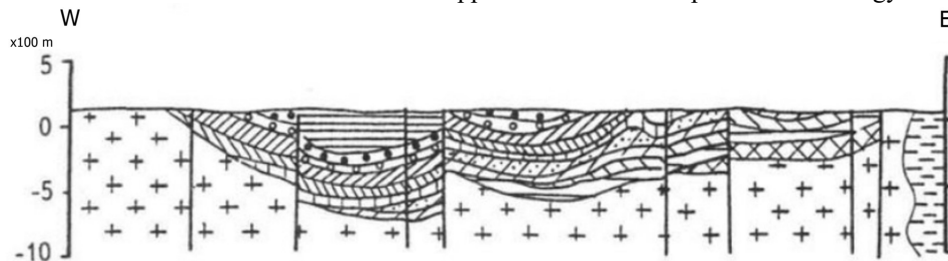


Fig. 4. The Bureinsky coal deposit cross-section.

The transportless mining technology using is limited to a coal seams dip angle of 10-15°, the physical properties of the overburden rocks of the internal dumps base and the

hydrogeological conditions of the coal deposit [4-11]. The main parameters of the “simple” transportless technology are shown in Fig. 5.

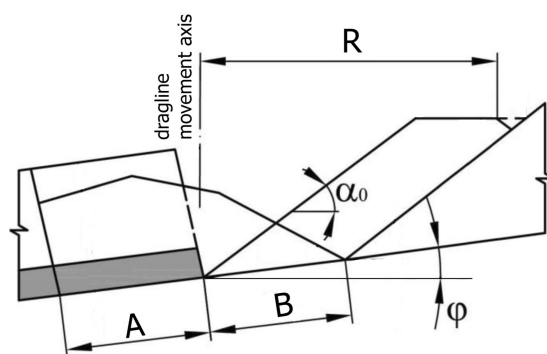


Fig. 5. The parameters of “simple” (one-tier) transportless technology of open pits: A – the excavator stope width; B – dump stope width; R – dumping radius; α_0 – angle of dump; φ – dump base angle (angle dip of coal seam).

3 Conclusion

Taking into account the intensification of the coal mining development in Siberia and Far East, the field of the transportless mining is wide. It is due to the suitable mining and geological conditions of the deposits: small coal seams inclination ($0 - 15^\circ$), significant coalbed thickness (three and more meters) and high overburden thickness (up to 200 m). This mining technology is also cost-effective due to the lack of a transport component, which will allow mining coal in the region with minimal costs and high productivity.

References

1. E. P. Amosenok, *System modeling and analysis of mezo- and microeconomic objects* (Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia, 2014)
2. V. L. Martyanov, *Journal of Mining and Geotechnical Engineering*, **1**, 35-41 (2018)
3. V. G. Pronoza, T.N. Gvozdikova, M.A. Tyulenev, *Bulletin KuzSTU*, **3**, 15-21 (2008)
4. M. M. Bereznyak, A.V. Kalinin, V.G. Pronoza, *Soviet Mining*, **6:6**, 638–643 (1970)
5. I. Vukotic, V. Kecojevic, W. Zhang, Q. Cai, S. Chen, *International Journal of Mining Science and Technology*, **23:6**, 901–906 (2013)
6. A. V. Vaneev, *Journal of Mining and Geotechnical Engineering*, **2**, 13-35 (2018)
7. M. Mohammadi, P. Rai, S. Gupta, *Acta Montanistica Slovaca*, **21:1**, 1-8 (2016)
8. H. Mirabediny, *A dragline simulation model for strip mine design and development*, (University of Wollongong, Wollongong, 1998)
9. P. Rai, *Indian journal of Engineering & Material Science*, **11**, 493-498 (2004)
10. M. Andrejiova, A. Grincova, D. Marasova, P. Grendel, *Acta Montanistica Slovaca*, **20(1)**, 26-32 (2015)
11. M. Grujic, D. Malindzak, D. Marasova, *Tehnicki Vjesnik*, **18:3**, 453-458 (2011)