The conception of developing unallocated fund of subsoil raw material resources base in the coal mining industry

V I Klishin, M V Pissarenko, T B Rogova and S V Shaklein

1The Federal Research Centre of Coal and Coal Chemistry of the Siberian Branch of the Russian Academy of Sciences, 10 Leningradskiy ave., Kemerovo, 650000, Russia
2T.F. Gorbachev Kuzbass State Technical University, 28 Vessenyaya str., Kemerovo, 650026, Russia
3Kemerovo Branch of the Federal Research center for Information and Computational Technologies, 21 Rukavishnikova str., Kemerovo, 650991, Russia

E-mail: klishinviccc.kemsc.ru

Abstract. Coal mining industry raw material bases analysis of allocated, newly introduced and unsold subsoil reserve fund demonstrates a fast depletion of the reserves with favorable geological factors of mining which meet the requirements of traditional mining technologies. In the coming years meeting the demand on certain technological coal ranks (K, KZh, KC, KCN, KO, OC, TC, CC) cannot be provided without exploiting coal deposit sites that contain hard to recover reserves and without developing and implementing new mining technologies oriented on complex mining and geological conditions. It requires a special program for fulfilling scientific researches on the development of methodological approaches, technical and technological solutions and testing new technologies for hard to recover coal reserves which can provide rational subsurface resources utilization and protection.

1. Introduction
Coal mining sector of Russia has significant reserves of different technological ranks of coal. Predicted coal resources in Russia are estimated as 1528.9 billion tonnes of P1+P2+P3 categories (where P1 category is 468.1 billion tonnes), balance reserves of A+B+C1+C2 categories are estimated at the quantity of 275.0 billion tonnes (where C2 category is 78.9 billion tonnes) [1, 2], so it makes about 15 percent of all global reserves [3]. Over half balance reserves of coal goes to brown coal, it is about 5.1 percent, 43.6 percent goes to bituminous coal (where 41.2 percent is coking coal, it is 49.5 billion tonnes) and 3.3 percent is anthracite coal [1].

Reserves allocation on the territory of Russia is rather uneven as about 73 percent of balance reserves and 80,6 percent of predicted coal reserves go to Kansko-Achinskey and Kuznetsk basins while the share of other 20 basins do not exceed 17 percent (table.1) [4].

A major part of the explored reserves accounted by the State balance was estimated during the Soviet period and only by the conditional parameters of thickness and ash-content of the coal seams. The reality of those times, when this sector was under the condition of allocating investment support, allowed utilizing mining technologies with low level of production efficiency: that is mining coal seams with high tectonic faulting (with the faulting indicator up to 250 m/ha) with the whole range of seam inclinations, with high level of gas-bearing capacity and other complicating mining and geological factors.
At present, coalmining enterprises are focused on the reserves, which mining and geological mode of occurrence can provide the implementation of high performance mining technologies. In underground mining, the longwall mining system with coal faces equipped with highly productive mechanized complexes is basically used. Their effective activity provides high stable load on the coal faces (over 6-8 thousand tonnes per day) which is possible only under the favorable mining-geological conditions [5]. The admissible faulty level of the mining fields decreased to 30-50 m/ha (depending on the value of the extracted coal). Longstanding years of selective involvement into the mining only of the areas with favorable (applicable only to the existing mining technologies) mining-geological conditions resulted in the significant decrease of mineral raw material base of the mining sector and first of all in the areas with the developed infrastructure.

Table 1. Balance reserves and resources allocation of the coal basins in Russia

| Basin title         | Share in reserves and predicted resources of Russia, % |
|---------------------|-------------------------------------------------------|
|                     | A+B+C1+C2 categories reserves | P1 category resources |
| Donetskey           | 3.8 | 0.2 |
| Podmoskovny         | 1.5 | 0.0 |
| Sos'vinsk-Salekhardsk | 0.6 | 0.1 |
| Pecherskey          | 2.9 | 0.1 |
| Kizelovskkey        | 0.1 | 0.0 |
| Yuzhno-Ural’skey    | 0.4 | 0.0 |
| Chelyabinskkey      | 0.2 | 0.0 |
| Golvoskey           | 0.4 | 0.0 |
| Taymyrskey          | 0.0 | 0.0 |
| Yano-Omoloyskey     | 0.0 | 0.2 |
| Zyryanovskkey       | 0.1 | 0.3 |
| Tunguska            | 1.8 | 0.7 |
| Lenskey             | 2.7 | 7.7 |
| Yuzhno-Yaketskey    | 2.9 | 2.4 |
| Bureinskey          | 0.8 | 0.9 |
| Kansko-Achinskey    | 46.4 | 28.3 |
| Kusnetskey          | 27.0 | 52.8 |
| Minusinskiy         | 2.1 | 2.4 |
| Ulughem             | 1.5 | 1.6 |
| Irkutskey           | 4.8 | 2.3 |
| Razdol'nenskey      | 0.1 | 0.1 |
| Uglovskiy           | 0.0 | 0.0 |
| Partizanskey        | 0.1 | 0.0 |

2. Operating underground mines and opencast fund
There are about 8.0 percent (22.0 billion tonnes) of all balance reserves of coal where over the half – 65.3 percent is bituminous coal and 1.3 percent is anthracite coal in allocated subsoil resources of Russia. About 45.8 percent of total ultimate reserves and 49.3 percent of total extracted bituminous coals goes to power-generating (steam) low-metamorphosed long flame coal (D and DG) and gas coal (G). The share of power-generating (steam) high-metamorphosed ranks of coal (CC, TC, T) is
insignificant, that is about 10.7 percent in reserves and 15.6 percent in extraction. Commercial reserves of coal, suitable for caking, makes about 38.0 percent, and their share in extraction is about 23.6 percent (figure 1) [6].

![Figure 1. Coal rank structure of extraction and commercial coal reserves of the operating enterprises in Russia.](image)

D – long flame
DG – long flame gaz
G – gas power-generating and coking
GZhO – gas fat lean
GZh - gas fat
Zh – fat
KZh – coking fat
K- coking
KO – coking lean
KCN – coking caking low-metamorphosed
KC – coking caking
OC – lean caking
TC- lean low caking
CC- low caking
T- lean
A - anthracite

The development of large El’ginskey coking coal deposit in Yuzhno-Yakutskey coal basin influenced positively on supplying the sector with technological ranks of highly valued caking coal such as fat coal (Zh) and gas-fat coal (GZh). The share of these coals in reserves increased to 25.1 percent (figure1) and in extracting coking coal it increased to 53.8 percent. This created production potential allows increasing the volume of extracting El’ginskey coal nearly in two times by the opencast method.

The share of highly-valued coke-forming group of coals such as coking fat coal (KZh), coking coal (K), coking lean coal (KO) is insignificant as in commercial reserves of bituminous coals (5.2 percent) so as in extraction (5.4 percent). The share of technological coal ranks such as coking caking coal (KC), low-caking low-metamorphosed coal (KCN), lean caking coal (OC) used as a component of the coke charge in commercial reserves of bituminous coals is 5.3 percent and 7.6 percent in extraction.

The share of anthracites in commercial reserves is 2.9 percent and 6.5 percent in extraction.

About 65.1 percent of all commercial reserves are meant for open casting, however, 38.9 percent of the reserves are represented by less valued long-flame coals (D) [5]. Over half of commercial reserves of highly valued coking coals are meant for underground mining. Thus, constant deterioration of mining-geological conditions in underground mining, when the medium depth of extraction prevails over 482.5 meters, makes 90.8 percent of all developed coal seams dangerous at least on one of danger factors [1].

Thus, raw material base of the coal mining enterprise operative fund demonstrates high intensity of medium-, high-metamorphosed coal reserves mining starting from coking coal (K) and finishing with
anthracite coal (A). Disbalance between the volume of the reserves and the volume of the extraction predetermines the changes in the existing coal market structure whereby the reserves and extraction of such coal ranks as low-caking low-metamorphosed coal (KCN), coking caking coal (KC), lean caking coal (OC), lean low caking coal (TC) and the major share of coking lean coal (KO) is produced only in Kuznetsk coal basin [6,7].

3. Newly introduced underground mining and opencast fund

For the purpose of developing operating and newly constructed mining enterprises (according to the data of the competitive tenders and auctions of 2008-2019) in Kuzbass the subsurface resources sites with total reserves and prognostic resources of 10.4 billion tonnes were delivered in possession.

In gross reserves additions of mineral raw material resource base the share of low-metamorphosed power-generating (steam) coals of D, DG, G ranks made 54 percent, coking coal made 31 percent, high-metamorphosed power-generating coals of CC, TC, T ranks and anthracites made 15 percent. In the structure of subsurface sites meant for new mine constructions these shares made 58 percent, 23 percent and 19 percent respectively and in the additional cuttings of spare lands of the acting coal enterprises it made 50 percent, 12 percent and 38 percent respectively (figure 2) [8].

Figure 2. Designated use of subsurface sites reserves and resources delivered to possession within the period of 2008-2019 in Kuzbass.

The volume of the reserves and the predicted coal reserves on the subsurface sites meant for underground mining is insignificantly (on 2 percent) low than the volume meant for open-casting. The reserves and the resources on the sites of new mine construction is about one third of the total volume for mineral-raw material base growth and are (72 percent) meant for constructing open-casts. At the same time, total explored raw materials potential of the basin for opencast method is four times less than the one for underground mining. It shows the resource disproportion in technological deployment of the basin that in the further will result negatively on social and ecological situation of industrially developed and densely populated region.
The results of competitive tenders and auctions show that mineral resources developers are interested in the sites with low-metamorphosed power-generating coals for underground mining only if they are referred to the first group of geological structure complexity. The subsurface sites of the second group of complexity can attract the interest of the mine owners only if there are the resources of coking and high-metamorphosed power-generating coals in their vicinity. In addition, the subsurface sites of the third group of geological structure complexity can be interested only for opencast development.

Similar trends are registered in other coal basins of Russia (figure 3). Thus during 2008-2019 the subsurface sites with total reserves and predicted resources about 29 billion tonnes: 15 percent of brown coals, 52 percent of power-generating low-metamorphosed coals, 23 percent of coking coals, 2.5 percent of high-metamorphosed bituminous coals and 7.5 percent of anthracite coals were offered by mineral resources developers at the competitive tenders and auctions.

![Figure 3. Allocation of bituminous coals and anthracites resources reserves delivered to possession within the period of 2008-2019 according to the group of geological structure complexity (without considering Kuznetsk coal basin).](image)

The grade composition of the coking coal reserves and resources is represented basically by fat (Zh) and gas-fat (GZh) coals, in lesser degree it is represented by coking (K) and coking fat (KZh) coals and in very insignificant degree it is represented by coking low-caking low-metamorphosed (KCN), coking lean (KO), lean (T) and low caking (CC) coals. Thus 55 percent of subsurface sites are referred to the second and the third groups of complexity and are subject only to opencast development.

4. Unallocated subsoil reserve fund

Unallocated subsoil reserve fund is a raw material reserve and mining geological and mining technological conditions of its exploitation define the perspective of coal mining industry technical and technological development policy.

The major part of all explored bituminous coal reserves (49 billion tonnes) of all ranks is concentrated in Kuznetsk coal basin. Mining and geological factors of coal seam occurrence of the Basin are characterized by a wide variety.

The analysis of unallocated subsoil reserve fund of Kuznetsk Basin revealed that more than half of the fund is represented by sites of the second and the third groups of geological structure complexity and basically containing coking and highly-demanded high-metamorphosed power-generating coals (figure 4). However, only 21 percent of all the reserves of the fund can be developed by opencast method and the share of highly demanded by the industry reserves of some coal ranks (GZh, Zh, KZh, K, KC, OC, CC) do not exceed 5 percent (figure 5).
Thus, the major part of the unallocated subsoil reserve fund (80 percent) of the coking and high-
metamorphosed bituminous coals are subject to underground mining under complex mining and
geological conditions and do not meet the requirements of the modern mining technologies.

Figure 4. Unallocated subsoil reserve fund of Kuzbass according to the geological structure
complexity groups.

Figure 5. The grade composition of Kuzbass unallocated subsoil reserve fund accounted by the state
balance (as on 01.12.2019).

5. Conclusion

Russian coal deposits raw material base according to its grade composition do not procure its
replenishment by the technological ranks of K, KZh, KC, KCN, KO, OC, TC, CC coal in the nearest
future as their explored reserves are concentrated mainly in Kuznetsk basin in the subsurface sites of
the second and the third complexity groups and cannot be developed by the opencast method.

Maintaining the achieved volumes and supplying the demand on some technological ranks of coal
such as K, KZh, KC, TC, KCN, KO, OC, CC is impossible without developing and applying new
modern mining technologies (underground mining first of all) which provide effective and safe mining
of the deposits with complex mining-geological and mining-technological conditions [9–10].

Considering the acting amendment to the Law of the Russian Federation “About Subsoil” devoted
to introduction of a new type of subsurface reserves utilization which is aimed at “developing
technologies for geological studying, exploring and mining hard-to-recover mineral resources
reserves” it is offered to refer such technological coal ranks reserves as K, KZh, KC, KCH, KO, OC,
TC, CC at the subsurface sites with complex mining and geological conditions the mining of which
applying commercial mining technologies is impossible or ineffective to hard-to-recover mineral resources.

The strategic program for conducting scientific researches directed on the development of the methodological approaches, technical and technological solutions, testing new technologies for hard-to-recover coal reserves exploitation, which will provide rational utilization and protection of subsurface resources is of the great need at present.

To motivate mineral resource developers for mining such subsurface sites it is supposed to waive them from recurring payments for subsurface sites usage and royalty [1] and to make provisions for introducing other preferential advantages.

Implementing the conception of coal deposits unallocated subsoil reserve fund exploitation in the nearest future will satisfy the demand on technological coal ranks, the expected deficit of which is demonstrated by the state of the coal mining industry mineral raw material resource base.

References

[1] The development strategy of the Russian coal industry to 2035 (approved on June 13, 2020. No. 1582-p. M. [Electronic resource] – Open access mode: http://publication.pravo.gov.ru/Document/View/0001202006180009)

[2] Coal deposits licensing program for the period up to 2020 (approved by Order of Russian Federation Ministry of Natural Resources on 06.12.2016 No. 639: M, 2016) p 64 Website BP: Coal http://www.bp.com/

[3] State report on the condition and utilization of mineral raw materials resources of the Russian Federation in 2018 2019 (Moscow: FGBU “VIMS”) p 424

[4] Shaklein S V and Pissarenko M V 2013 Ratsionalhoe osvoenie nedr (Mineral mining & Conservation) 2 38–40

[5] Rozhkov A A, Shaklein S V and Pissarenko M V 2019 Ugol’ 11 4–11

[6] Mazikin V P, Katrichenko V N, Frolov V A, Ulanov N N and Shaklein S V 2001 Mineral resources of Russia. Economics and Management 2 49–54

[7] Pissarenko M V, Rogova T B and Shaklein S V 2020 Nedropolzovaniye v XXI vek 2020 2 70–9

[8] Klishin V I 2019 IOP Conf. Series: Earth and Environmental Science 012027

[9] Klishin V I, Zvorygin L V and Lebedev A V 2011 Safety Issues and New Technologies of Underground Mining of Coal Deposits editor Yu N Malyshev (Novosibirsk: Novosibirsk pissateli’) p 427