

## Formation of the composition and properties of dumps on the open-pit mines of Kuzbass

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**Abstract.** In 2012 the total volume of coal mining in the Kuzbass was about 200 million tons, including 116 million tons (60.3%) produced open way, Figure 1. In 2014, it was produced more than 203 million tons of coal. In addition, there is no reason to believe that in the near future volume of coal will decline. Accordingly, the volume of wastewater discharged by enterprises will increase. So, from 2006 to 2009 there was an increase of polluted water discharge coal mines from 217 to 245 million m<sup>3</sup>. Therefore, the problem of water pollution mines governmental waters and career is very important.

Despite its advantages, open coal mining does more damage to the environment than underground. The most significant impact has opened a way to develop on the hydrosphere and land resources, where the share of the total environmental damage to all elements of the biosphere is 66.4% versus 33.6% for underground mining.

Volume of coal mining in Kuzbass,  
million tons

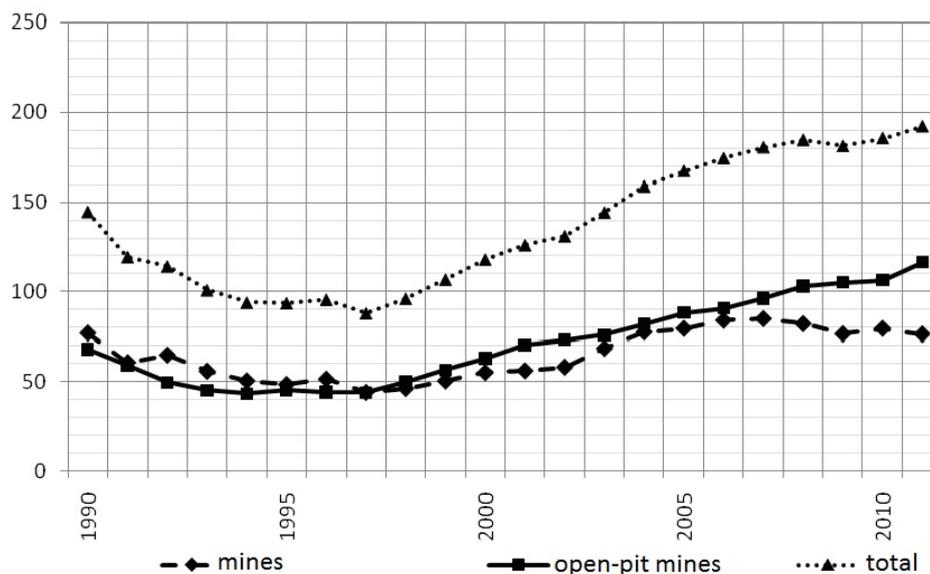


Figure 1. Dynamics of mining of coal in Kuzbass



Annually during open-pit mining on Kuzbass coal deposits hundreds of millions m<sup>3</sup> of overburden lay down in the dumps. To ensure the safety of the dumping process, use [1, 2] and subsequent effective recovery the rock mass it needs to know their material composition, structure and properties.

The material composition, in this case, is a content of different lithotypes and their particle size in the dump. Lithological composition of technogenic massives of overburden is determined, first of all, by the composition of rocks developed coal deposits and order removal of the blasted rock faces. A composition and properties of open-pit wastes around the world has been studied by many scientists [3-9]. We are considering this problem for mining and geological conditions of Kuzbass. In waste dumps of open-pit mines developed seams Kolchugino series of Kuzbass coal-bearing deposits, rocks prevails by siltstone (up to 51.2%), and Balakhonka series – sandstones (up to 53.5%), Table 1.

Table 1. Consist of overburden on Kuzbass coal-bearing deposits [%]

Series, subseries	Conglomerate, gritstone	Sandstone	Siltstone	Mudstone	Carbonaceous rocks
Kolchugino series	3.5	26.0	49.6	20.8	0.1
Erunakovo subseries	5.0	26.2	47.8	20.9	0.1
Ilyin subseries	1.8	25.8	51.2	21.1	0.1
Balahonka series	1.4	45.9	39.3	11.3	2.1
Upper subseries	1.3	53.5	37.2	5.5	2.5
Bottom subseries	1.6	39.4	39.1	17.0	2.9

The particle size distribution in dumps of overburden characterized by high heterogeneity: heterogeneity coefficient ( $C_h = d_{60} / d_{10}$ ) is greater than 5. It is also established that during the construction of the overburden dump occurs segregation of particle size that allows to select its different in particle size layers: the bottom – large-sized, middle – medium-sized and upper layer – small-sized. Researches on recently paved waste dump on a open-mine “Kedrovsky” found that the average diameter ( $d_{50}$ ) of clasts in the bottom layer is 1.3 m, in the middle – 0.8 m and in the upper – 0.2 m. As a result of mechanical stress, and exposure to water and weathering size distribution is constantly changing. Thus, the content of fractions plus-25 mm top layer of waste dump in less than a year decreased 1.8 times, and minus-1 mm fraction increased 3.3 times, Table 2. Two years later granulometric composition of different layers of overburden dump is significantly changed (Fig. 2).

Table 2. Particle size distribution in the upper layers of dumps

Dump age	Particle size [mm]						
	+25	25-10	10-7	7-5	5-3	3-1	-1
	Percentage fractions [%]						
3 months	33.4	15.9	10.4	7.9	9.7	15.2	7.5
12 months	18.5	19.3	7.6	5.9	8.6	15.4	24.7

Fineness different lithotypes overburden by blasting, loading, transporting and dumping depends on their mechanical properties. Most durable and resistant to water are sandstones. Their compression strength can be 100 MPa or more, and usually greater than the tensile strength of siltstones and mudstones more than one and a half to two times.

Table 3 shows the results of research strength and water resistance of rocks with a few open-pit mines of Kuzbass. The sandstones are more resistant to water. It should also be borne in mind that soaking of argillaceous rocks is much higher than sandstone.

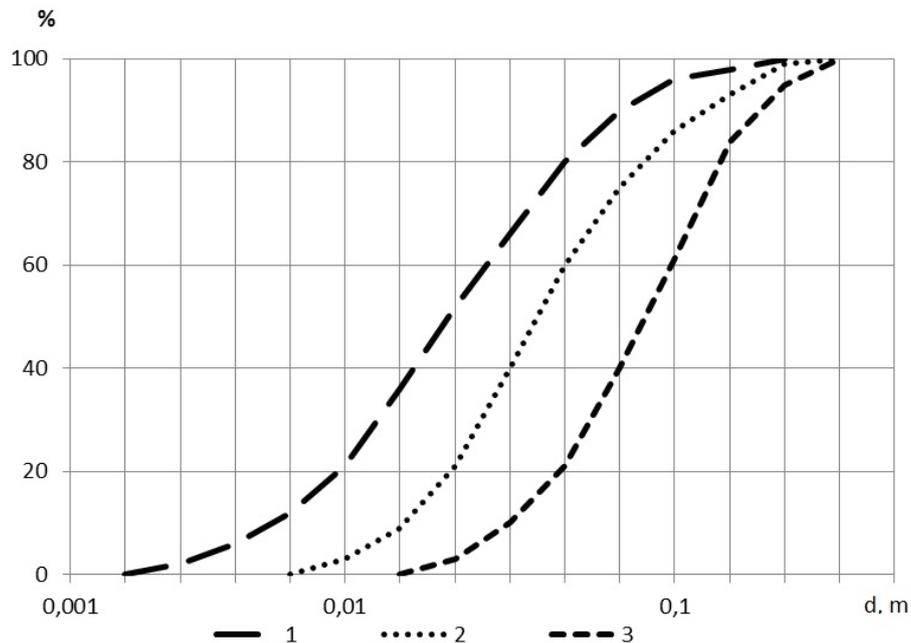


Figure 2. Curves of granulometric composition of different layers of dump paved two years ago: 1 – upper layer, 2 – middle layer, 3 – bottom layer.

Table 3. Strength and water-resisting of bedrock overburden

Place of sampling	Lithotype of rock	Strength of dry rocks [MPa]	Strength of water-saturated rocks [MPa]	Strength reduction ratio $S_r$
Open-pit “Kedrovsky”	sandstone	67.1	43.1	0.64
	siltstone and mudstone	38.7	19.2	0.50
Open-pit “Mohovsky” (Mohovsky section)	sandstone	60.2	30.9	0.51
	siltstone and mudstone	27.6	17.7	0.64
Open-pit “Mohovsky” (Sartakinsky section)	sandstone	36.7	36.7	1.0
	siltstone and mudstone	32.3	15.0	0.45
Open-pit “Krasnobrodsky”	sandstone	100.5	75.8	0.75

Assessment of the degree of grinding various lithotypes overburden at the same mechanical actions performed on a specially designed drop-hammer, Fig. 3.



Figure 3. Drop-hammer for assessment of the degree of grinding various lithotypes overburden

These researches were carried out on a samples of overburden from the open-pit mine “Krasnobrodsky”. 200 samples of rocks (100 - sandstone, 100 - siltstone) were used. Fractional composition of broken rocks was determined by sieve method. Granulometric composition of sandstone is given in Table 4, of siltstone – in Table 5.

Indicators of granulometric composition of the rock after fracture are given in Table 6.

Table 4. Granulometric composition of sandstone

Fraction size [mm]	Percentage fractions [%]	Total (integrated) content [%]
> 40	-	-
40 – 30	2.34	100
30 – 20	43.49	97.66
20 – 10	33.39	54.17
10 – 7	5.42	20.78
7 – 5	3.18	15.36
5 – 3	2.58	12.18
3 – 2	1.49	9.6
2 – 1	1.95	8.11
1 – 0.5	1.00	6.16
0.5 – 0.25	0.27	5.16
< 0.25	4.89	4.89
Total	100	-

Table 5. Granulometric composition of siltstone

Fraction size [mm]	Percentage fractions [%]	Total (integrated) content [%]
> 40	-	-
40 – 30	-	-
30 – 20	10.62	100
20 – 10	44.31	89.38
10 – 7	21.02	45.07
7 – 5	8.59	24.05
5 – 3	6.84	15.46
3 – 2	2.73	8.62
2 – 1	2.75	5.89
1 – 0.5	1.01	3.14
0.5 – 0.25	0.22	2.13
< 0.25	1.91	1.91
Total	100	-

Table 6. Indicators of granulometric composition of the rock

Lithotype of rock	Controlling particle diameter $d_{60}$ [mm]	Median particle diameter $d_{50}$ [mm]	Acting (effective) particle diameter $d_{10}$ [mm]	Heterogeneity coefficient $C_h$
sandstone	21	19	3,5	6
siltstone	12	11	3,5	3,4

As can be seen from Table 6, the sandstone is less prone to crushing under mechanical stress than siltstone. Controlling diameter  $d_{60}$  and average diameter  $d_{50}$  of sandstone clasts in the 1.7-1.75 times more than siltstone. It should also be noted that an increase in the sandstone fracture minus-0.25 mm fraction is more than double. This is due to the presence in the sandstone cement component. Thus, it follows from this conclusion that the content of sandstone in the lower layers of waste dumps is significantly higher than the average content in backfilled overburden. In the upper layers of dumps, on the contrary, clay lithotypes prevails: siltstones and mudstones.

Grading and lithological heterogeneity dump layer of indigenous overburden is the cause and filtration heterogeneity. Permeability lower blade layers composed of larger rock clasts is significantly higher than the upper fine-grained [10].

The researches found that the filtration coefficients of the upper, middle and bottom layers of the recently paved waste dump are respectively 4, 7 и 84 · 10<sup>-3</sup> m/s [11]. The movement of water in the upper layers of the dump corresponds to a linear Darcy's law, i.e.  $V = K_f \cdot J$ , and in the bottom layers of the dump – quadratic:  $V = K_f \cdot \sqrt{J}$ , where  $V$  – filtration velocity,  $J$  – hydraulic gradient;  $K_f$  – coefficient of filtration.

Overburden dumps consisting primarily of sand types less susceptible to softening and soaking and more resistant to water, and hence water filtering them does not significantly change their permeability. Dumps of mudstones and siltstones impacted by water change their properties and can form aquitard. Permeability of bottom layers that largely represented by sandstones, eventually reduced to 0.012-0.017 m/s, while the filter coefficient of the upper layers is reduced hundreds of times.

## Conclusion

Thus, heterogeneity of the material composition at dump height is revealed. This heterogeneity is the cause of spatial and temporal variations of filtration and mechanical properties of the waste dumps that must be considered when designing the filter arrays of overburden dump sewage waters, as well as the development of measures to prevent landslides in the dumps.

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