On evaluation of complex-structured coal deposits based on their typical geometric features

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Abstract. Information about the geological structure of Kuznetsky coal basin (Kuzbass) allows us to note that coal deposits developed by open-pit method are characterized by complicated conditions and have the following features: large length of deposits at significant depths of occurrence; coal series bedding of different thicknesses (from 1 to 40 m); different dip angles (from 3 to 90°); a significant number of dip and direction disturbances; different thickness of unconsolidated quaternary sediments (from 5 to 40 m); a wide range of strength values of rocks. In addition, there is a thickness irregularity and frequent variability of elements of occurrence of coal seams within the boundaries of a quarry field both in length and depth of mining. From the point of view of open-pit mining, such deposits are complex-structured. The factors listed above have a decisive influence on the choice of technical means, the order of development and the possibility of carrying out surface mining operations. Therefore, there is a need for a systematization of mining and geological conditions for the development of coal deposits, the purpose of which is to ensure a process of evaluation of complex-structured coal deposits for the development of coal-bearing zones by various complexes of equipment.

1 Introduction

The most general assessment of the conditions of mineral deposits is given in a number of works by Academician V.V. Rzhevsky [1, 2]. In them types of developed deposits are systematized according to typical geometrical features (general classification feature), and also quality of a mineral and prevailing types of rocks are considered. With respect to coal deposits of Kuzbass, the most significant is the systematization given in the paper by V.I. Kuznetsov [3, 4]. In this work systematization of Kuzbass deposits is made by the dip angle of coal seams (general feature) taking into account technological factors. In spite of the wide representation of classification features, the existing systematization is focused on the

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application of either longitudinal single- or double-sided mining systems, the features taken into account do not fully reflect the mining technical features, which can include the following:

- the presence of a common horizontal layer for all coal seams of the formation;
- possibility of working off all seams of the strata from the side of the hanging wall;
- alternating mining of seams of different thicknesses.

The solution of these problems should be based on the assessment of conditions for the occurrence of complex-structured coal deposits of Kuzbass. It is known [5-12] that the conditions of occurrence of deposits have a significant impact on the technology and efficiency of mineral extraction. The proposed systematization is based on the characteristic geometric features of the deposit. In contrast to V.V. Rzhnevsky, who proposed this general feature for the typification of the developed deposits of any minerals, in this case it is used to describe in detail the formation of coal seams in the Kuzbass open pits.

2 Methods

At the heart of systematization (Table 1) the criterion determining the division into groups is statistical processing of mining-and-geological and mining-graphical documentation of coal enterprises [7, 13, 15], i.e. identification of the most typical representatives with their further grouping by numerical value of each unit. In the tables 1 and 2: B – quarry width, L – quarry length.

Table 1. Systematization of the mining and geological conditions of coal deposits

General features	Types	Details, values
1. Surface and quaternary sediments		
Relief	Plain	Surface Gradient 0-2°
	Hillside slope	Surface Gradient 2-10°
	Elevated	Gradient of several surface areas between 0-2° and 5-10°
	Hilly	Gradient of several surface areas between 0-5° and 10-20°
Location relative to surface level and occurrence depth	Surface type	Quaternary sediments 20-30 m
	Depth type	Quaternary sediments 40-250 m
	Altitude type	Location above the prevailing level
	Altitude and depth type	Partially above and below the prevailing level
2. Structure of coal seams formation		
Form of deposit	Rounded	$B < L \leq 1,4B$
	Elongated	$1,4B < L \leq 4B$
	Lenghtened	$4B < L \leq 40B$
Quantity of seams in formation	Few-seams formation	≤ 5 seams
	Middle-seams formation	5-10 seams
	Multi-seams formation	≥ 10 seams
Evenness of occurrence	Regular	Coal seams and partings alternate by a constant value
	Irregular	Some of the seams are evenly distributed, some are not

Table 1 continuation

General features	Types	Details, values
Occurrence of the formation by the dip angle	Flat	Dip angle 6-14°
	Inclined	Dip angle 15-45°
	Steep	Dip angle 46-90°
	Complex	Variable dip angle 6-90°
Position of coal seams in the coal-and-rock stopes	Concordant bedding	The seams are falling in one direction
	Uncorcondant bedding	Falling of seams in different directions with some disturbances
Structure of deposit	Simple deposits	Homogeneous structure with no significant partings or inclusions
	Complex deposits	Contains conditioned and sub-conditioned mineral as well as partings and inclusions
3. Properties of rock and coal of the formation		
Prevailing rock type	Soft and dense soils	Does not require prior loosening (blasting)
	Semi-rock and rock	Require prior loosening (blasting)
Prevailing coal type	Soft and dense coal	Ultimate uniaxial compression strength of soil 5-20 MPa
	Hard coal	Ultimate uniaxial compression strength of soil 20-30 MPa
Coal quality	Regular quality	Energy coals or coking coals only
	Irregular quality	Some coals are suitable for coking, some for energy use

Table 2 presents the systematization of mining and geological conditions with respect to the coal seams bedding in Kuzbass. Classification takes into account linear parameters of coal-bearing zones in the profile and plan of the quarry; volume parameters of coal-bearing zones in the quarry field; quality parameters of the coal-bearing zone [13-18].

Table 2. Systematization of mining and geological conditions of coal-bearing zones of Kuzbass open pit mines

I. Linear parameters of coal-bearing zones in the profile and plane of quarry field				
1. The coal-bearing zone – plane form	Rounded ($B < L < 1,4B$)		Elongated ($1,4B < L < 4B$)	Lenghtened ($4B < L < 40B$)
2. Normal thickness of the formation, m	Low-thickness formations, from 50 to 200	Medium-thickness formations, from 200 to 500	Hi-thickness formations, from 500 to 1000	Heavy-thickness formations, >1000
3. Total thickness of the working strata of the formation, m	Low coal seams intensity, from 1 to 50		Medium coal seams intensity, from 50 to 100	High coal seams intensity, >100
4. Zone occurrence by dip, degrees	Inclined zone from 20 to 40		Steep zone from 40 to 90	Mixed zone from 20 to 90
5. Quantity of seams in the coal-bearing zone	Low-quantity zone, from 1 to 10		Medium-quantity zone, from 10 to 20	High-quantity zone, >20
6. Total thickness of the rock partings in the	Small rate of intensity of the zone with rock partings		Medium rate of intensity of the zone with rock partings	High rate of intensity of the zone with rock partings

Table 2 continuation

formation, m	from 10 to 50		from 50 to 100	>100
7. Number of partings in zone	Low-quantity partings zone from 1 to 5		Medium-quantity partings zone from 5 to 10	High-quantity partings zone > 10
9. Position of the coal-saturated zone relative to the surface level, m	Surface zone type: thickness of quaternary sediments from 5 to 40 meters	Depth zone type: thickness of quaternary sediments > 40 meters	High-altitude zone type (above the prevailing level)	Combination of high-altitude and depth type
II. Volumetric parameters of coal-bearing zones in the quarry field				
10. Proportion of the coal-bearing zone in the deposit, %	Small coal-bearing zone with predominance of coalless zone from 5 to 25		Medium, with equal participation of coal-bearing and coalless zones from 25 to 50	Large, with a predominance of the coal-bearing zone > 50
III. Qualitative parameters of the coal-bearing zone				
11. Prevailing type of coal in the zone	Soft and dense coal. Ultimate compression strength 5-20 MPa		Rock and semi-rock coal. Ultimate compression strength 20-40 MPa	Combination of soft, dense, semi-rock and rock coal
12. Prevailing type of rock partings	Soft and dense rocks (not requiring pre-loosening)		Rock and semi-rock partings (requiring preliminary loosening)	Combination of soft, dense, semi-rock and rock partings
13. Quality of coal seams of the zone	Even quality			Uneven quality
	Energy coals only		Coking coals only	Some of the coals are suitable for coking, some for power generation

3 Conclusion

The coal-bearing zones of the quarry fields are represented by coal seam formations from inclined to steep seams with unbalanced thickness, both on a fall and on a stretch with different dip angles even within one formation, with varying size of rock interbeds (partings) and strength. In addition, most coal seams have a complex structure that includes rock partings within them. In most cases, there is an uneven distribution of coal seams and, consequently, coal reserves over the area of open-pit fields.

In this connection, for the analysis of the pit fields there is a need to select criteria for assessing the complexity of coal-bearing zones for the purpose of their systematization and the choice of directions for the construction of technological schemes of excavation-and-loading operations and development mining systems.

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