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Rational Use of Land Resource During the Implementation of Transportless System of Coal Strata Surface Mining

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Abstract. Surface mining and open pits engineering affect the environment in a very negative way. Among other pollutions that open pits make during mineral deposits exploiting, particular problem is the landscape changing. Along with converting the land into pits, surface mining is connected with pilling dumps that occupy large ground. The article describes an analysis of transportless methods of several coal seams strata surface mining, applied for open pits of South Kuzbass coal enterprises (Western Siberia, Russia). To improve land-use management of open pit mining enterprises, the characteristics of transportless technological schemes for several coal seams strata surface mining are highlighted and observed. These characteristics help to systematize transportless open mining technologies using common criteria that characterize structure of the bottom part of a strata and internal dumping schemes. The schemes of transportless systems of coal strata surface mining implemented in South Kuzbass are given.

1. Introduction

For the last decade coal mining in Kuzbass increase by 6-10 million tons annually. As far as the main part of Kuzbass' coal in mined by open pit enterprises (65%), the increase of coal production causes landscape destruction by 35-40 square kilometers every year [1-4]. The transportless system of surface mining may significantly decrease the earth consumption but requires more complicated technological schemes of coal deposit exploiting [5-9]. Special difficulties appear when transportless mining system is implemented for the strata of several coal seams development [10-14]. Currently transportless methods allow efficient developing the several flat or inclined coal seams strata with a total capacity of 50 m or more, along with forming three-layers dumps of overburden rock. Often there is an excess of transportless quarry face over transport one that leads to leads to a reduction in the volume of rock developing with transportless technology [15-19]. The capacity of internal dump is not fully used as potentially possible. In order to avoid this limitation, it is necessary to increase the volume of overburden rock, piled in internal dump. This requires solving a number of techno-economic issues related to the placing additional volumes of overburden in the internal dumps and to the calculation of economically proved cutback overburden layer height [20-21].

For optimization of parameters of surface mining transportless technology it is necessary to satisfy conditions of mining efficiency target indicators preservation and to decrease the general costs of overburden [22-24]. This article describes transportless technological schemes of surface mining and generalizes their common characteristics [25-26]. Accordingly the method of overburden distribution (with preparation of additional capacity in earlier piled dump layer and without preparation), two types of transportless technology are analyzed.

2. Material and Methods

In Tomusinsky and Mrassky geological and economic areas of Kuzbass (Western Siberia, Russia) coal deposits are characterized by succession bedding of coal seams in the rocks (Fig. 1).

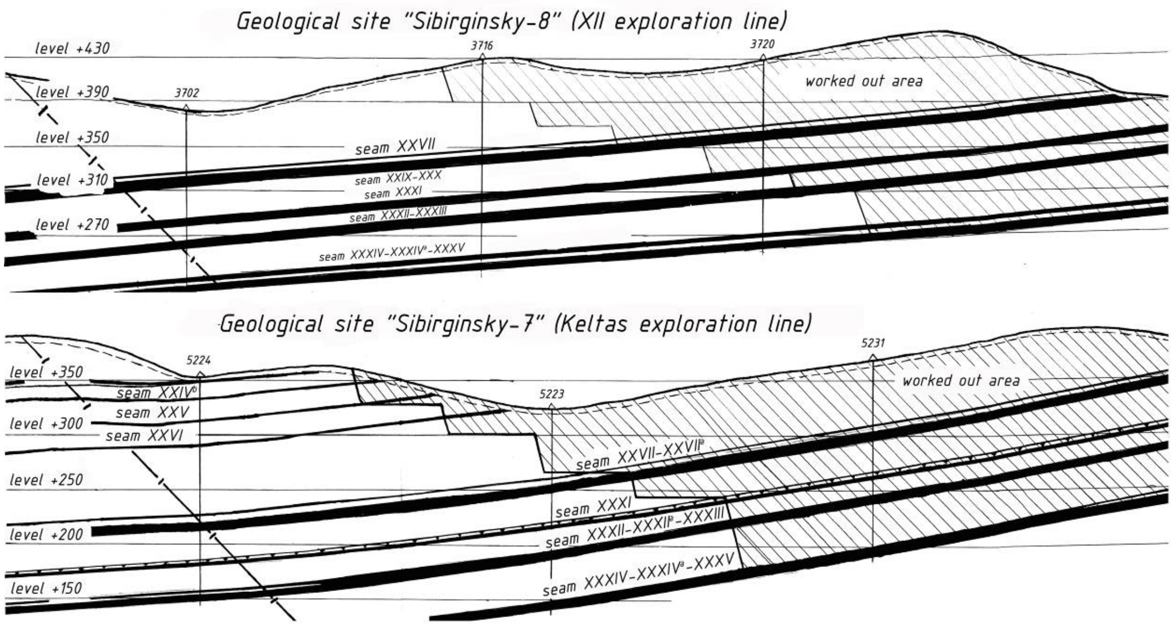

Figure 1 – Typical geological sections on exploration lines for "Krasnogorsky" open pit.

The coal fields are exploited by modern large open pits: "Krasnogorsky", "Sibirginsky", "Mezhdurechensky", "Olzherassky". The overburden rocks are siltstone and mudstone [Tyulenev & Lesin, 2014; Lesin *et al.*, 2015] with Protodyakonov scale of hardness of 5-7, as well as large-sandstone with hardness coefficient (*f*-rate) of 8-10.

The exploiting of open pit fields is made by mixed deepening-and-continuous longitudinal semi-locating mining method. Accordingly this, the upper part, up to 30-70 m, with one or two seams is developing by transport technology with carrying of rocks to the outer and inner dump; the lower part, with a total capacity of rock strata 49-52 m, and including one or two coal seams, is developed by transportless technology with transshipment of rocks into the internal dump. Analysis of the parameters of coal seams bedding in strata showed that according to the conditions of seams bedding in the strata the structures of geological sites can be divided in terms of τ, which characterizes the type of structure of the lower part of strata to a height of two seams and their interbed.

$$\tau = H_2 / H_1 , \quad (1)$$

where: τ – the rate characterizing location of the middle seam in a strata; H_1 – the height of the lower interbed, m; H_2 – the height of the upper interbed (between the second and the third seams), m.

We defined the average τ rate for "Krasnogorskiy" open pit the following way:

$$\tau = 13/33.6 = 0.38 \tag{2}$$

for "Mezhdurechenskiy" open pit (as shown on Fig. 2):

$$\tau = 30/25 = 1.2 \tag{3}$$

On Fig. 2 *Ws* is a stope width.

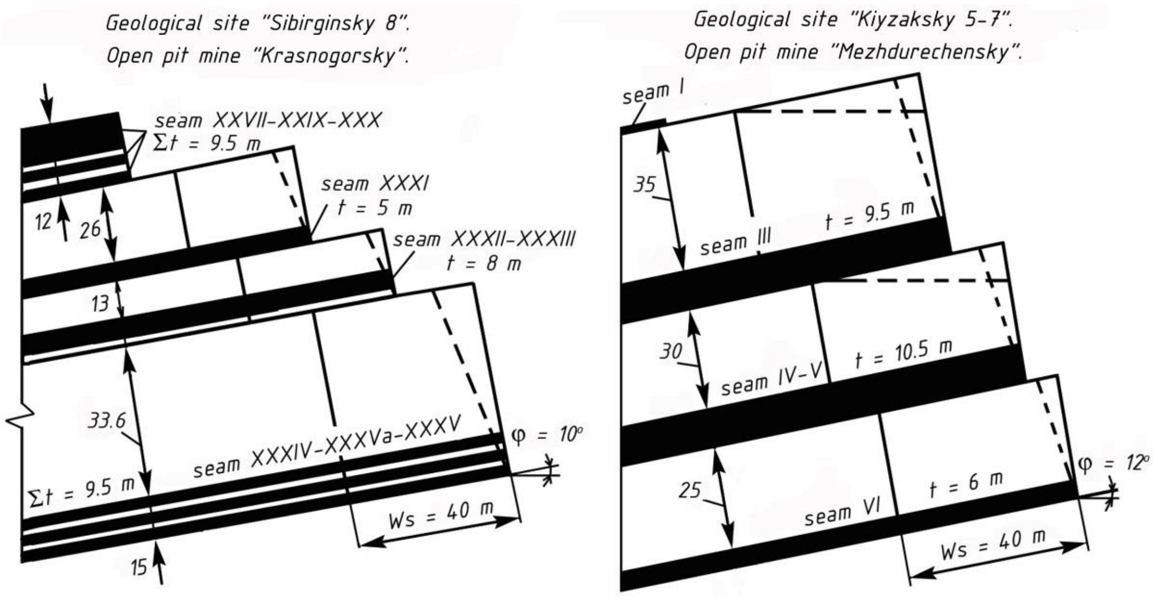

Figure 2 – Average parameters of coal seams bedding on geological sites of "Krasnogorsky" and "Mezhdurechensky" open pits

The introduction of this indicator lets us consider rock strata from the soil of the upper (third) bank to the roof of the lower seam as the mountain massif of the total thickness of 49-52 meters, divided by a median seam on interbeds of the same or different capacities. Based on this, we can exercise a single methodological approach to the analysis of the development of all geological sites.

Describing the bedding conditions of seams in geological areas as a whole, the significant differences between them, as indicated by the index τ, should be noted.

The schemes of excavation of flat coal seams strata for the development by transportless technology have a number of common features, which we defined having analyzed some papers. These features include: the number of seams and interbeds exploiting by transportless technology; the method of strata of two seams exploiting; the number of piled layers of inner dump; allocation scheme of coming into the dump overburden rock by piled layers. The equipment used and its parameters are not applied to the generalizing features because in each case its choice is based solely on the parameters of the seams bedding [27-32]. In some researches in surface mining technological schemes and methods there were several characteristics of coal strata development described. They include number of exploiting seams and interbeds, simultaneous or consequent exploiting, number of piled layers of internal (and, in some cases, external dump).

Considering all characteristics of surface mining technological schemes and methods for inclined coal strata development, we defined special features for transportless system for the conditions of

South Kuzbass geological area described in Fig. 1 and Fig. 2. These special features of transportless system include the following:

1. The priority number of exploiting seams and interbeds is two. One seam and one interbed are developed on two sites (administrative section №4 on the geological site "Sibirginsky 8" and the geological site "Kiyzaksky 5-7"). In the geological section "Sibirginsky 1-3" by transportless technology strata of two seams and two interbeds is developed, but the top high interbed (42-49 m) is developed by one bench by transportless technology, and the bottom, with low height (4-7 m) by transport.

2. To develop the strata of two seams two ways are used: with the simultaneous (parallel) development of two interbeds and two layers; with a sequence in descending order working of interbeds and layers. The simultaneous method is used in those areas where the rate $\tau = 0.3 \div 1$; consequent – when $\tau > 1$.

3. The number of piled layers of internal dump basically equals three, which is determined by the height of working out rock strata (49-52 m), placed in a dumping site by using draglines with boom length of 85-90 m. In the development of rock strata with less height a two-layer dump is piled.

In exceptional cases, four-layer dumps are piled. It's possible in mining rock strata with height of more than 52 m in a specific profile of dump layer [33]. In addition, in piling of three-layer dumps in case of exceeding the volume of the rock their stacking capacity the preparations for the additional capacity for the third layer are made [34]. Removed rock in this case is placed in the fourth layer.

The distribution of entering to the dump rock in dump layers is carried out by two known schemes.

The first scheme. All incoming to the dump rock is located in the first and second layers, and to increase the capacity of the second layer in the previously piled dump the additional content for the second layer is prepared, and extracted rock is piled in the third layer. This scheme is applied at the simultaneous development of two seams and two interbeds.

The second scheme. All incoming to the dump rock is distributed in three layers without preparing any additional content. The scheme is applied to both simultaneous and consequent ways: with the first and second strokes of dragline extracted rock is being piled in the first and second layers of the dump, being intermediate bulk which requires recasting [35]. With special stroke dragline, being set at the top of the second layer moves the intermediate bulk to the third layer.

The described schemes differ in dragline's movement along the front-line of work in the development of rock banks.

3. Results and Discussion

We generalized and organized transportless systems of several coal seams strata open pit mining in terms of τ rate and proposed the dump schemes of piled layers (Fig. 3, Fig. 4).

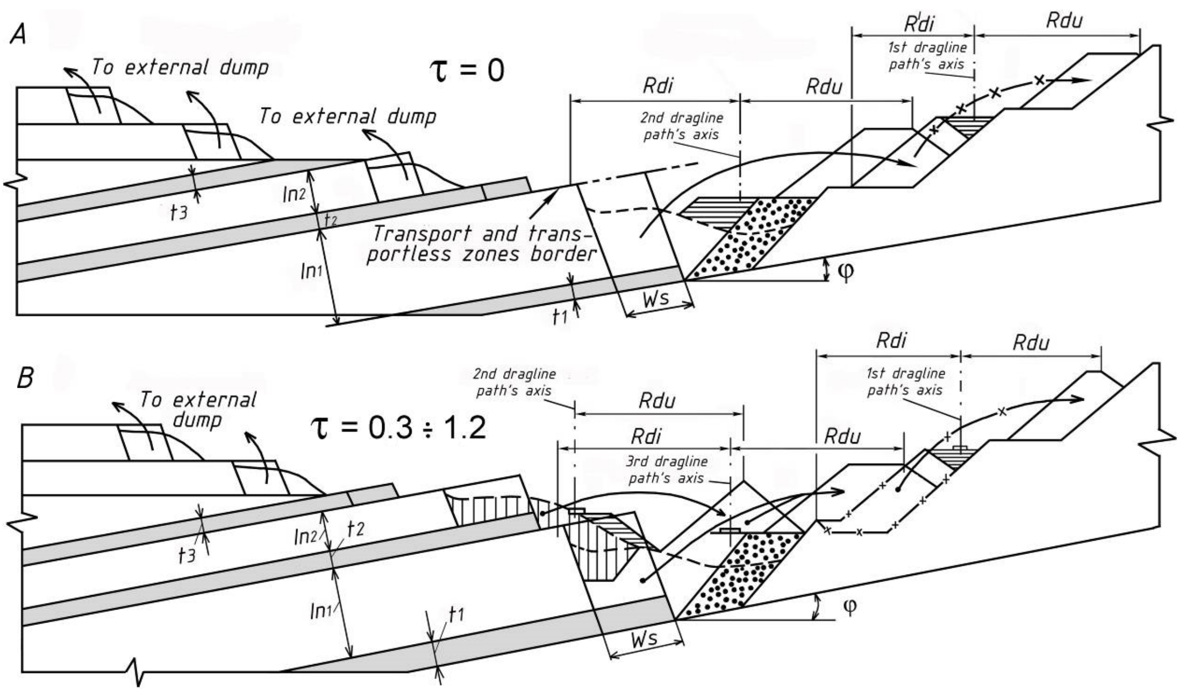

Figure 3 – Transportless schemes of excavation for conditions of South Kuzbass open pits fields
A – exploiting of one interbed (τ = 0); B – simultaneous exploiting of two interbeds (τ = 0.3-1.2)

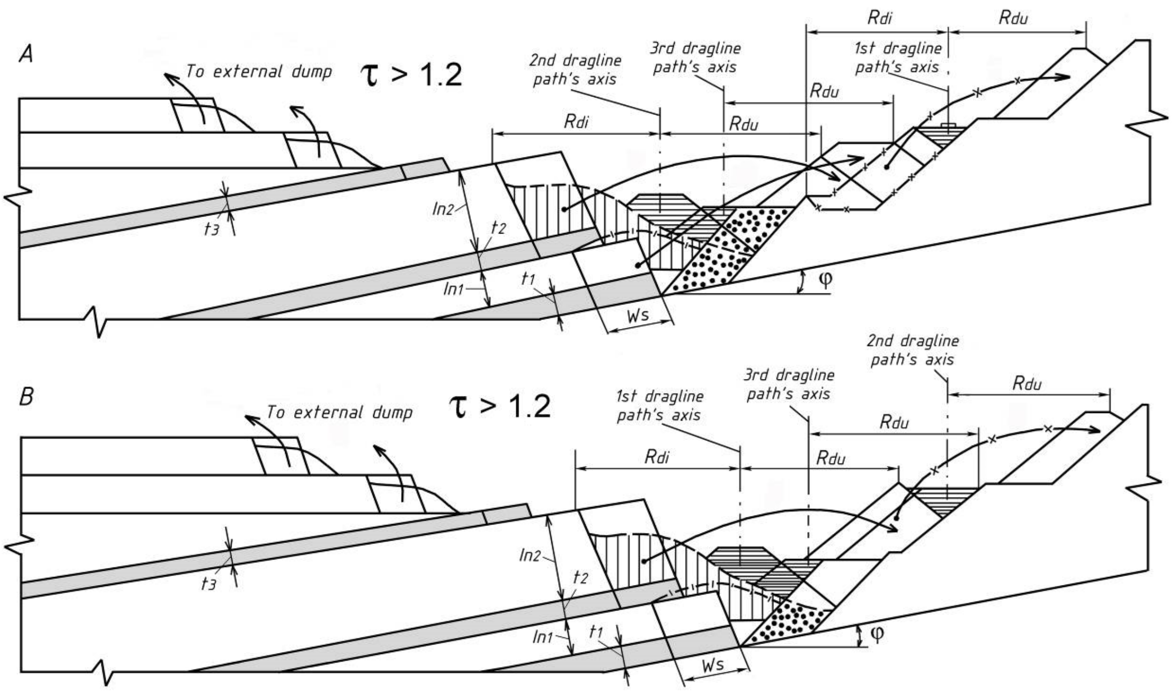

Figure 4 – Transportless schemes of excavation for conditions of South Kuzbass open pits fields with consequential exploiting of two interbeds (τ > 1.2): A – the scheme with preparing of primary capacity in the third layer; B – the scheme without preparations

On these figures: t_1, t_2, t_3 – thickness of 1st, 2nd and 3rd seams respectively, m; In_1, In_2 – thickness of 1st (lower) and 2nd (upper) interbeds, m; *Ws* – stope width, m; *Rdi* – dragline's digging radius, m; *Rdu* – dragline's dumping radius, m; φ – bedding angle, degrees.

All four technological schemes of transportless system of coal strata surface mining were implemented at different districts of "Krasnogorsky" and "Mezhdurechensky" open pits. The result of pilling internal pumps in the mined-out space of these quarries was saving 3 km^2 of the land suitable for agriculture in 2012, 4 km^2 in 2013 and 3 in 2014 (assumed for all six open pits of South Kuzbass).

Systematization of transportless technological schemes was made using **τ** rate which characterizes location of the middle seam in strata of three flat or inclined seams. Introduction of this indicator allows considering the strata as a solid array with a general thickness of 49-52 m (for conditions of Southern Kuzbass). On this basis we developed common methodical approach to analysis of development of geological segments with similar conditions of bedding of coal seams. It was defined that at values of **τ** rate less than 1.5 it is effectually to use consequent exploiting system and with **τ** rate from 1.5 to 3 – simultaneous exploiting system. If **τ** rate is more than 3 than both exploiting system are effective. Specificity of defining the most preferable transportless scheme of excavation and dumping permits mining enterprises to safe large land resources transferring maximum volumes of overburden in internal dumps [36]. In general high perspectives of transportless system implementation at surface mining are expected to expand the limits of using mining machines [37-39].

4. Conclusions

Analysis of transportless technological schemes used in existing open pits showed that basically two inclined seams are developed, more rarely one seam. The generalization of transportless technological schemes is made using some selected features: the order of overburden bench at the coal-face side (simultaneously or sequentially), the scheme of piling of internal three-layer dump (the preparation of additional container in the second layer or without preparation). As a result four currently used typical schemes of excavation and internal dumping were emphasized.

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