Environmental Improvement Of Opencast Mining

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Abstract. Existing classifications of waste dumps in the quarries are given and their phenomenological nature is clarified. The need to identify the essence of the term "dump" is shown as well as the idea of "dump" as an artificial formation with everted and mixed rocks distanced from the quarry. Essential classification of man-made rock formations in quarries is developed. Characteristic of variations of man-made waste formations in quarries is developed. To reduce harmful effects of open-pit mining, dumps should be substituted with strat-lays - man-made structures relevant to natural stratification of litho-substances. Construction of strat-lays would improve ecological and technological culture of open cast mining.

Introduction

Kuznetsk coal basin is characterized by a variety of geological and mining conditions of coal seams exploitation. Currently, in the Kemerovo region, there are 60 active and 5 coal pits under construction with total production capacity more than 150 million tons of coal per year. In 2015, almost 140 million tons of coal were mined opencast and 76 million tons - underground; that is, more than 400 million m^3 of overburden and country rock were displaced into waist-rock disposals (ettles). In recent years, waste rocks are displaced by road (over 50%), railway (20%), excavator dumping (20%) and hydraulic transport (5%).

Kuzbass open pits and mines are winning coal at depths of 0-500 m, bringing to the surface all characteristic lithological varieties: loose overburden (clay, loam, sandy loam), half-rock (siltstone, mudstone, coal, burnt rock) and bedrock (sandstone, pyrite). Since coal deposits mining hundreds of waste dumps have been formed in Kuzbass region. The dumps total volume overtops 25 billion m^3.

The largest dumps are formed by open-cast mining. The dumps' heights vary in a wide range: single-stage dumps, piled at slope of response, have a height of 15 to 90 m; multistage dumps have heights of 40 to 160 m with the resulting angles of slopes 16-36 degrees. The region has 50 hydraulic-mine dumps with a total volume of clay soils about 1 billion m^3. Hydraulic-mine dump heights vary from 4 to 73 m, areas - from 6 to 736 m, capacities - from 0.6 to 100 million m^3 [1].

Rock mining dumps are the most large-scale technosphere objects of the Earth. As a result of the rocks loosening, their total volume exceeds quarry production itself. Waste rocks occupy vast areas of the Earth's surface, contaminate surrounding agricultural and forest lands with fugitive fine particles, change conditions and movement of ground- and surface waters and damage the biosphere [2].

Magnitude and hazard of waist grounds and rocks cause attention of scientists and experts. As a result of investigation they developed versatile classification of dumps:

1. According to a construction technology: bulldozed, excavated, aggraded, and combined.
2. According to a construction method: areal, peripheral, combined.
3. According to position relative to the quarry: external and internal.
4. According to rock transporting: road, rail, hydraulic dumping and combined.
5. According to a number of dumped stages: single-stage and multistage.
6. According to configuration: conical, ridge-like, truncated pyramid.

These classifications are phenomenological considering dumps as phenomena. Classification of dumps' structural composition organizes them into two classes of composition (one-component and composite) and into 6 structural groups and 16 types [3]. However, none of classifications concerns the nature of the dump, its idea and conceptual content. Consequently, variant structures may be called "dumps"; that may confuse mining experts and bring errors in design and construction documents. To eliminate possible inconsistencies we should clarify the nature of the concept "dump", define range of application of the term, identify its varieties, define their distinctive characteristics.

Materials and research methods

The researches were conducted in coal pits of southern, central and northern Kuzbass. More than 60 dumps of various configurations were examined: truncated pyramid, ridge-like, conical and technogenic hydraulic-mine dumps, constructed on various technologies [4-6]. Results of scientific investigations on construction methods, structure and properties of dumps, obtained by other authors for conditions of the Kuzbass, the Donetsk Basin, Kazakhstan, Yakutia, South Africa, Australia, have been used [7-16]. Revealing of the nature of dumps was carried out with methods of dialectical cognition and etymological analysis. Methods of scientific analysis, generalization and systematization were used to determine distinguishing characteristics and classification of man-made dumps.

Results and discussion

Updating the idea of the dump requires a deeper knowledge. Knowledge, philosophically, is a form, a relationship, extracted from the thing and indicated by a sign or text. In the process of scientific investigation one should "transpose... a form (idea) immersed in the thing "into the human mind" [17]. These cognitive abilities are determined by the skills to use already acquired knowledge and habits, to critically assess their own abilities and weaknesses, to be able to strive for personal and professional development, the ability to concentrate and be immersed in the object under study [18]. Let us clarify the concept "otval" (dump). Etymological analysis of the word shows that it contains two components: the prefix "ot-" (out/ from/away) and the root "val" (rampart/wall). The word “val” (wall) has been used since ancient times, when people shielded their homes with a ditch and a rampart (wall). The ditch "tore" and lowered the Earth's surface, the rampart increased it. This large height difference prevented penetration of animals or enemies. In the Middle Ages the ditch and the rampart were widely used in fortification of cities and fortresses in Europe and Asia.

The word "val" in the Russian language means not only "piled up", but also "brought down", "upside down". The rampart was formed on the edge the ditch while digging by stacking surface soil, then the middle soil. At the top of the rampart (point B) the soil from the ditch bottom (point A) was laid (Figure 1).

Thus, the natural soil layers in the rampart were everted "upside down". Stratification of a man-made rampart/dump was opposite to the natural litho-structure. With the emergence of powerful excavation and transport equipment and increasing of depth of excavation there emerged a necessity to erect the dump/rampart distant from the quarry (trench/ditch). At this time, there appears the concept "ot-val" – a dump distanced, moved away. If the "rampart" (val) is adjacent to the ditch with bottom edge (point B), the "dump" (otval) is already formed in the distance, beyond the possible collapse of the pit (the ditch) wall, reducing risk of ground fall. Thus, the "dump" means an artificial formation with everted, mixed grounds and distanced from the quarry.

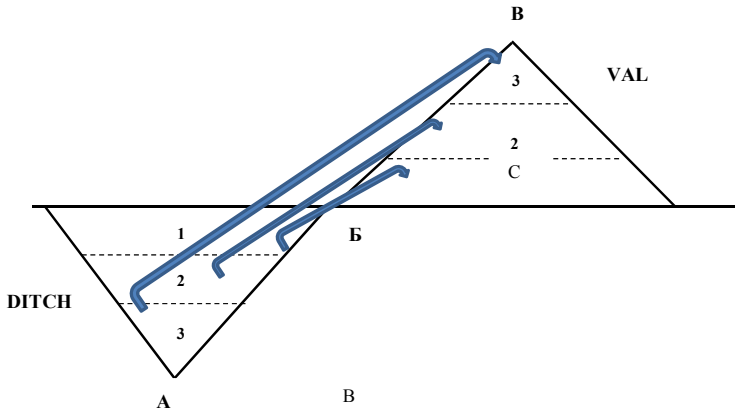

Figure 1 - Formation of val (rampart) from ditch ground

Excavated rock/soil layers 1, 2, 3, 4, 5 are displaced to the dump, wherein, in order to reduce costs, the rock/soil is usually dumped downward from points A, B, C, D, etc.; that mix rock material is taken from different working levels (Figure 2).

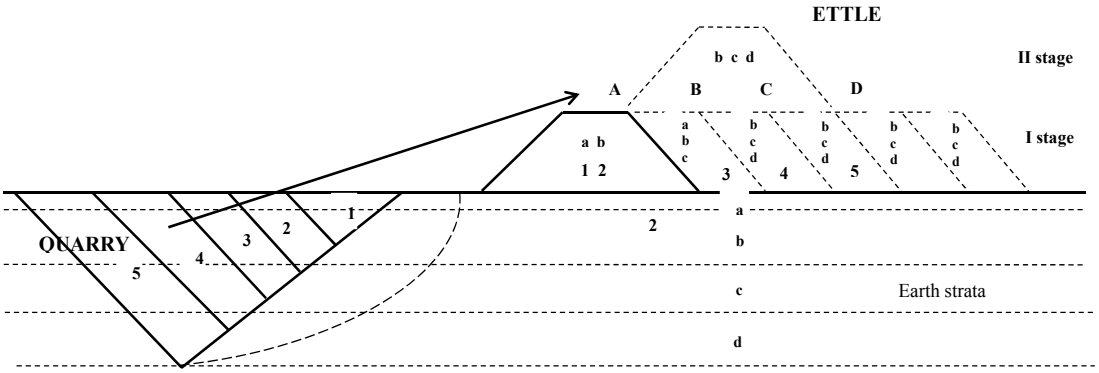

Figure 2 - Stratigraphy of natural and man-made rock mass in quarry

Mining operations are accompanied by cutting new working levels in the thickness of the earth's crust underlying strata. As a consequence, the underlying rocks are laid into the dump, bringing to the surface “dead” metamorphic and igneous rocks. Wherein, quaternary deposits "a" and sediments "b" occur at the bottom, under dump thickness. Deformation of natural lithosphere stratification sequence damages ecological well-being of mining areas, because the deeper into earth crust interior, the more lifeless substance is. All natural environments suffer: water, air, soil, plants and animals. Mine reclamations are not able to restore natural well-being, as they are chronically falling behind deformations. Long-term effects of unfavorable transformation of the earth's crust is currently difficult to predict without the relevant studies, however, it is obvious that in the future adaptive capacity of the Earth can not cope with anthropogenic impacts of this kind and magnitude.

The essence of the concept "otval" (dump) makes evident inadequacy of using such term for naming anthropogenic soil massifs, dumped in the quarry stripped area; since no "distancing" or "displacing" from the quarry does not occur. Word combination "vnutrennii otval" (internal dump) is an oxymoron; more representative is the term "zaval" (fill/heap), which contains the concept of "zavalivat *-verb*" (filling/heaping). Other word combination "vneshnii otval" (external dump) is a tautology.

It seems appropriate to replace a general term "otval" with a number of more precise terms. So a ridge-like construction, formed with dragline, shovel or hydraulic shovel along the working trench, we propose to

call "val" (wall). Rocks, transported from the quarry or dumped with the excavator, form a “otval” (dump) distanced, disposal, moved away. When moving soil with directed explosion, as well as formation of dragline spoil banks or motor-dumps, a "zaval" (heap/fill) occurs - a massif of mixed soils/rocks inside quarry. It differs significantly from the dump in shape, hydrological properties and environmental friendliness [19]

Cultural development of current and future mining determines the need for a new approach to construction of waste rock dumps. The dump, as a place of waste disposal, should be considered from the point of view of Stratigraphy. Millions of cubic meters of overburden, extracted from the depths to the surface (only in Kuzbass almost 1.0 billion m^3 every two years), actually form a new lithosphere stratum. When forming these rock strata, it’s essential to restore natural formation of lithological varieties for preservation living conditions on the surface.

This change in mining is feasible technologically, organizationally and economically. When adjusting values, and the economic side of the question solvable [20]. Anthropogenic construction preserving the Earth's stratification may be called a new composite term "strasyp"(strat+layer=strat-lay) from "stra-" (stratum) and "sypat - *verb*" (to layer) i.e to lay material orderly under control. "Strasyp" (strat-lay) should replace the current "dump" - a stratigraphically irregular and disordered construction, in the near future to reduce the negative impact on the environment (Figure 3).

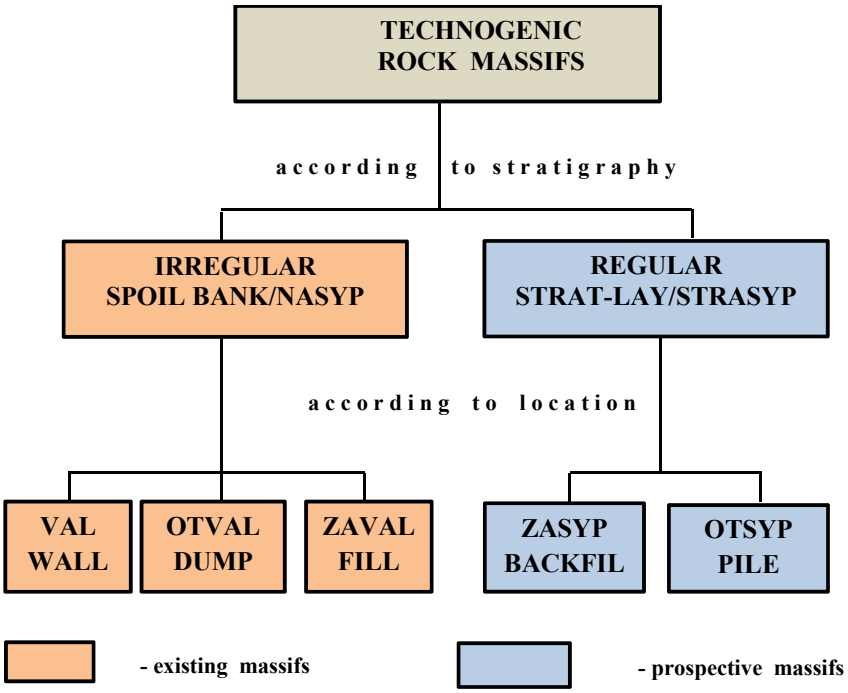

Figure 3 - Essential classification of man-made massifs in quarries

In the pits with continuous mining (Krasnoyarsk Territory of Russia, Ukraine, Australia, USA, etc) "heaps" (zaval), constructed in the stripped area, are formed as "strat-lays" since rocks are displaced from work areas to dump areas level-by-level. In such massifs natural sequence of rock placement is maintained; that minimizes the adverse impacts. It is advisable to name such formations "zasyp" (back-fill) as it is a filling formation with regular stratification of the bulk material (Table. 1).

This experience should be applied in pits with dragline mining; layered dumping in compliance with natural interposition of rock layers will improve man-made rock formations. There appear rock formations, named "otsyp" (pile); that is, distanced rocks layered in accordance with natural bedding. Change-over

from "ot-val"(dump) to "ot-syp"(pile) and "za-syp"(back-fill) marks a new stage of technological and ecological culture of open cast mining.

Table 1 Essential characteristic of man-made rock formations in quarries

Essential characteristic	Man-made rock formations				
	SPOIL BANK			STRAT-LAY	
	WALL	DUMP	FILL	BACKFILL	PILE
Location relative to the quarry	In contact	At a distance	Inside	Inside	At a distance
Stratigraphy	Reversed order	Absent. Irregular	Absent. Irregular	Complies with natural	Complies with natural
Location relative to the earth's surface	Above	Above	Below	Below	Above
Spatial form	Ridge-like	Truncated cone or pyramid	Fills quarry space	Fills quarry space	Truncated cone or pyramid
Rock laying technology	Stratified	Irregular	Irregular	Stratified	Stratified

Conclusion

The study results allow revising the idea of rock man-made dumps and define the scope of the term. The essential classification of man-made rock formations helps to clarify specific terminology, thereby improving ecological and technological culture of mining, and construction of man-made formations preserving the natural stratification of litho-substances. Construction of strat-lays reduces waste formation and increases environmental friendliness of open pit coal mining; that reduces negative consequences of violating the integrity of the Earth's crust**.**

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