Ecology and safety in the technosphere: current problems and solutions IOP Conf. Series: Earth and Environmental Science **50** (2017) 012012

Environmental Improvement Of Opencast Mining

S Prokopenko^{1,2,a}, A Sushko¹, Yu Filatov², M Kislyakov³ and I Kislyakov³

 ¹ Yurginsky Technological Institute (Branch), Tomsk Polytechnic University 652055, Kemerovo Region, Yurga, Leningradskaya St., 26, Russia;
² JSC «NC VostNII», 650003, Kemerovo, Institutskaya str., 3, Russia;
³Kemerovo Institute of Russia Economic University named after G.V. Plekhanov 650992, Kemerovo, avenue Kuznetskiy, 39 Russia;

^aE-mail: sibgp@mail.ru

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 m³ 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 m³.

The largest dumps are formed by open-cast mining. The dumps' heights vary in a wide range: singlestage 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 m³. Hydraulic-mine dump heights vary from 4 to 73 m, areas from 6 to 736 m, capacities - from 0.6 to 100 million m³ [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 hydraulicmine 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.

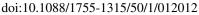
Results and discussion

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.

IOP Publishing



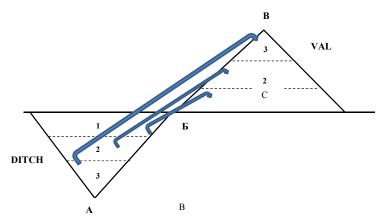


Figure 1 - Formation of val (rampart) from ditch ground

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).

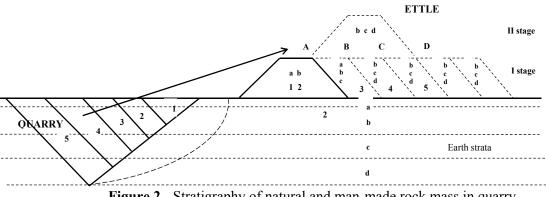


Figure 2 - Stratigraphy of natural and man-made rock mass in quarry

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 ridgelike 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 m³ 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).

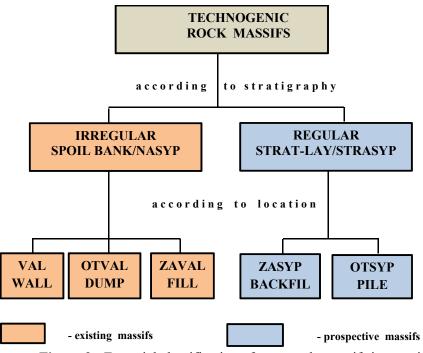


Figure 3 - Essential classification of man-made massifs in quarries

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.

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

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

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.

References

- Zharikov V P, Ermoshkin V V and Kleimenov R G 2012 Sustainable land management in the formation of dumps and gidrootval on cuts of Kuzbass The Mountain of inform.-analit.newsletter. 2 pp 78–83.
- [2] Mikhal'chenko V V and Prokopenko S A 1992 Clean technology the future of the open coal production in the Kuzbass Coal 1 pp 11–14.
- [3] Prokopenko S A and Ludzish V S 1991 Classification of structures dump arrays mines Kuzbass Labour Safety in industry 10 pp 35–36.
- [4] Prokopenko S A 2005 To coal power high technologies coal' 7 pp 55-57.
- [5] Prokopenko S A, Ludzish V S, Kurzina I A and Sushko A V 2015 Alternative source of energy in operation of power-driven machines in coal mines Gornyi zhurnal/ Mining Journal 1 pp 75–77.
- [6] Mikhailov A A, Lesin Yu V and Prokopenko S A 1989 Improvement of dumping to improve the effectiveness of remediation on the mines of Kuzbass Coal 10 pp 41–42.
- [7] Kryachko O Yu 1980 Management of waste dumps of open cast mining Moscow, Nedra, 180 p.
- [8] Maleev N G and Kurowski M N 2003 The construction plans and the formation of multilevel dumps Modern technologies of mineral resources development. SB scientific papers 1 Krasnoyarsk: Publishing house Khusmith pp 67–69.
- [9] Kutepov Yu I and Kutepova N A 2008 Regularities of formation pore pressure while hydrochlorothiazie and dumping dry tailings The Mountain of inform.-analit. newsletter 11 pp 54–57.

- [10] Instruction to prevent spontaneous combustion, fire and dismantling dumps Approved. by order of Rostekhnadzor 738 from 23.12.2011 Available at: URL: http://docs.cntd.ru/document/902324483 (Last accessed date 04.06.2016).
- [11] Bahaeva S P Prostov S M 2011 Integrated monitoring of technogenic soil massifs of coal mines Safety in industry 4 pp 34–36
- [12] Cheskidov V V 2011 Complex sensing alluvial deposits gidrootval No. 3 cut "Kedrovsky" Mining industry 6 pp 25-29[13] Kalashnik A I Zaporozhets D V Dyakov A Yu and Demagin A Yu 2014 GPR sounding of snow-rock dumps of JSC "Apatite" Bulletin of the Kola science centre of RAS 3(18) pp 65–67.
- [13] Gaponov Yu S 2015 Geomechanical substantiation of stability of dumps taking into account the influence of the characteristics of the destroyed rock mass/ abstract Dis c and. tech. sciences S.-Petersburg 212 p.
- [14] Macarisina Yu I 2016 Improvement of environmental safety of waste dumps of coal mines of Donbass with the help of physical and phyto-techniques Dis. cand. of agricultural sciences Lugansk pp 235.
- [15] Lesin Yu V, Luk'yanova S Yu and Tyulenev M A 2015 Formation of the composition and properties of dumps on the open-pit mines of Kuzbass IOP Conference Series: Materials Science and Engineering 6 Article number 012093.
- [16] Nevelev A B and Khudyakova N L 2015 Philosophy of cognition: proc. manual Chelyabinsk: publishing house of Chelyabinsk. state University press 123 p.
- [17] Lizunkov V G, Marchuk V I and Podzorova E A 2015 Identification of Criteria, Features and Levels of Economic and Managerial Competencies Development for Bachelors in Mechanical Engineering Procedia - Social and Behavioral Sciences 206 pp 388–393.
- [18] Mikhal'chenko V V, Prokopenko S A, Orlov V G and Koksin A V 1991 Semessersesy the technology for thick sloping and steep deposits Coal 5 pp 44–46.
- [19] Prokopenko S A and Ludzish V S 2014 Problems of innovative development of the mining Enterprises of Russia Gornyi zhurnal/ Mining Journal 1 pp 47–49.