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JUSTIFICATION OF SYSTEMS OF OPEN CAST DEVELOPMENT OF USEFUL FOSSILS AND THEIR NEW CLASSIFICATION

Abstract. To substantiate the new definition of an opencast development system of minerals, the standard approaches of the systems analysis are used. The patterns of moving of the mine workings in the quarry field are expressed through the analytically found velocities of moving the bench face, moving of the bench slope and the deepening of the quarry bottom. These kinematic characteristics of the moving of mine workings are the basis for the classification of the opencast development systems.

A new well-reasoned definition of an opencast development system is given. The properties inherent in it as in any system are disclosed: organization, structure, connections and functions. A new classification of the minerals opencast development systems has been created. The velocities of the bench face moving, the bench slope moving and the quarry bottom deepening were found analytically. These kinematic characteristics of the moving of the development system elements are successfully correlated their parameters with the productivity of the excavating and loading equipment.

It is substantiated for the first time that the complex of the interdependent and interconnected with each other the development, stripping and excavating workings, moving at the quarry field by time for rock extraction from the Earth bowels, is a system of the minerals opencast development. For the first time in the mining science, the kinematic characteristics of the moving of mine workings in a quarry field have been theoretically found. The format of the new classification of the minerals opencast development systems is substantiated.

The proposed new classification of minerals opencast development systems and the kinematic characteristics of moving of the mine workings in the quarry field make it possible to reasonably choose the development subsystems, their parameters and indicators in relation to the working dimensions of excavating and loading equipment, transport, and opencast mining technology. This solution provides a safe, high-performance, economical mining operation in the quarry.

Key words: quarry field, minerals opencast development, systems of the minerals opencast development, their classification, velocities of the mine workings moving at the quarry field, regulation of these velocities.

Problem statement. There are many definitions of the concept “system of opencast development of the deposit” and their classifications [1-8].

In the above definitions, as the system of opencast development of the deposit in the various interpretations the order and sequence of development and stripping operations at the quarry field are understood. They do not reflect the essence of the generally accepted concept of “system”. They do not pay attention to the role of development, stripping and excavating workings designed to extract rocks (minerals) from the Earth bowels in creating a system for mineral resources developing. Meanwhile, in the deposit development projects, the key task is to establish rational parameters for working benches,

extracting blocks, and a quarry as a whole, ensuring the achievement of the necessary productivity in minerals, stripping and rock mass. Therefore, the development and stope workings (benches), containing these parameters, should be considered as the determining components of the system of minerals opencast development.

New definition of the system of minerals opencast development. To formulate the desired definition, we pay attention to the concept of "system". As is known, "the system (from the Greek "systema" – the whole, consisting of the parts; combination) is a great number (the whole complex) of the elements, being in relationship and connections with each other, which forms the certain integrity, unity. Only within the framework of such a family of definitions it is possible to express the basic system principles: integrity, structure, interdependence of the system and the environment, hierarchy, plurality of descriptions of each system, etc. [9].

In accordance with these requirements, we consider the development of minerals as the extraction of rocks (minerals, including oil, gas, water) from the Earth bowels in the various ways (opencast, underground, borehole, underwater and combined) after the deposit stripping [11]. When the opencast method of development, this process is realized by carrying out of the working trenches (foundation pits) from the passed permanent mine workings and extraction, loading of stripping rocks and minerals from the working trench and the formed stope workings [11].

Thus, minerals opencast development is excavation of rocks (minerals) from the Earth bowels by some given complex of the development, stripping and excavating workings, moving at the quarry field within time.

Taking into account the listed system principles and, based on a new definition of the minerals opencast development, one can give the following definition of an opencast development system.

A system of the minerals opencast development is a complex of interdependent and interconnected with each other the development, stripping and excavating workings, moving in the quarry field within time to extract rocks (minerals) from the bowels of the Earth.

Elements of the development system: development workings – working trenches (foundation pits), stripping and excavating benches are in constant motion until they reach their limit (or intermediate) position stipulated by the project for the deposit development. Consequently, the development system is a moving, dynamic object of a quarry.

The above definition of the system fully discloses the essence of opencast development of minerals - the extraction of rocks (minerals) from the Earth bowels in an open way. For it, as for any system in the generally accepted sense, the organization, structure, connections and functions are inherent [10-12].

As is known, "organization" expresses the complex of properties, characterizing certain ordering of the elements in system and their interaction. For example, the development workings precede the stripping and excavating workings and are placed in the quarry field in accordance with the established rules and norms. The stripping workings in a certain way get ahead the excavating workings. This relationship between the elements ensures the normal functioning of the system of opencast development of minerals.

"Structure" is comprehended as the complex of the elements and the methods of their unification in a single whole (it is mechanical connection between the elements). In the mineral development system, the benches working platforms act as such, since they join the benches into a single whole - the system (see figure 1). On all the working benches, their sizes should be not less than some of their minimum value, necessary to ensure the normal functioning of the system.

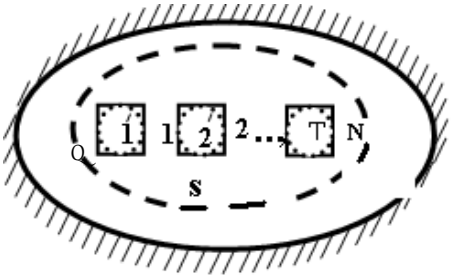

Figure 1 – Structural model of the system of minerals development

In the broad sense, “connection” is understood as what unites individual elements into a system. Connections are diverse in their forms, meaning, and content. Usually the energetic, information and material connections are selected. In our case, individual elements (working benches) are integrated into the development system by a material connection, i.e. the required amount of rock mass of a given quality, extracted from each working horizon (bench). This connection is flexible and changing in the process of the system functioning.

Each system performs some functions - it simply exists, serves as the habitat of another system, serves a system of a higher level, etc. The mineral development system is designed to provide the sustainable extraction of rocks of a given amount and required quality from the Earth bowels for a certain period of time. It serves a higher-level system “the exploitation of a mineral deposit” and at the same time serves as a habitat for another system “the mining technology”.

A mineral development system, like any system, can be represented by a structural model that displays only the construction, the system structure and the relative position of elements in space. In the model shown at the figure 1, the elements (the working benches) 1, 2, .., N form the development system S, which is part of the environment (quarry field) Q. Another system lives in the S system - “the mining technology” with the elements 1’, 2’, ..., T (the working faces of the benches).

Thus, in the proposed definition of a system of minerals opencast development, the assignment of the interconnected with each other development and stripping workings is clearly indicated, all basic system principles are observed: integrity, hierarchy, structure, interdependence of the system elements. It is reasoned and in tune with the generally accepted concept of "the system". The new definition of the system of minerals opencast development is fundamentally different from the previously known ones [1-8].

New classification of the minerals opencast development systems. Mining operations mentioned in [1-3] are a technological process by which purposeful movement of the development, stripping and excavating workings in a quarry field is carried out to extract rocks from the Earth bowels. The general nature of the moving of the system elements in plan and into the depth of the quarry is determined by the mining-geological conditions of minerals bedding, the type of deposits being developed and the tasks of shipment to the consumer the required amount of rock mass of the required quality [3].

When developing the horizontal and gentle beddings with a thickness of up to 50 m during the deposit’s exploitation, the slopes of the working benches of almost constant height make plane-parallel or fan-shape motion relative to their initial position. This moving of the mine workings characterizes *a continuous development system.*

When developing the inclined, steep, as well as powerful gentle-dipping beddings, the development workings are carried out both during the construction period and during the quarry exploitation. At the same time, the bottom of the development working makes a discrete vertical moving into the depth of the quarry relative to the previous horizon, and the slopes of all the working benches make horizontal moving. In general, the totality of the mine workings in this case makes a mixed (vertical, horizontal) moving and characterizes *the deepening development system*.

When developing the deposits that are complex in terms of topographic and mining-geological conditions within the same quarry field at different periods of exploitation, both varieties of moving of mine workings totalities can be used. For example, the upper part of the stripping rocks and minerals can be extracted with the regular vertical and then horizontal moving of the workings, the lower part - with the horizontal moving of the workings; or the upper part of the deposit can be extracted with the horizontal moving of the workings, and the lower part - with the vertical, then horizontal moving of the workings. In general, the deposit exploitation in this case can be carried out by a combination of the vertical and horizontal moving of the mine workings. These movements characterize *the combined development system*.

At the base of the carried analysis of the moving of the stope workings in the quarry field and the concept of acad. V. V. Rzhevsky, a new classification was designed of the systems of minerals opencast development (see table). It is based on the nature of the moving of the development, stripping and excavating workings in the quarry field - the kinematic characteristics of moving of the elements of an opencast development system. This approach has been used in the theory of opencast mining for the first time.

New classification of the systems of mineral opencast development

Development systems	Development subsystems
Continuous	Continuous longitudinal one-board or two-board Continuous transversal one-board or two-board Continuous fan-shaped central or dispersed Continuous ring-shape central or peripheral
Deepening	Deepening longitudinal one-board or two-board Deepening transversal one-board or two-board Deepening fan-shaped dispersed Deepening ring-shape central
Combined	The same, in different combinations

In the new classification, only three opencast development systems are accepted: continuous, deepening and combined, which are named in [3] as the groups of systems. Further, by analogy with [3], they are divided into subsystems in the direction of moving of the slopes of the working benches relative to the axes and the contour of the quarry field: longitudinal, transverse, fan-shape, ring-shape, in addition to the one-board, two-board, etc. There are only 12. These subsystems in [3] are called the development systems, there are 18 of them.

As is seen, the new classification in essence, form and structure compares favorably with the classification of acad. V. V. Rzhevsky. It is based on the kinematic characteristics of the moving of the elements of the development system, more compact, specific and contains only 3 systems and 12 subsystems.

Development systems are predetermined by the specified specific mining and geological conditions of the minerals bedding and the nature of the moving of the stripping workings in the quarry field. Development subsystems are selected based on the form, parameters of mineral bedding, physical and technical properties of rocks, the required quality of marketable products and economic indices of the enterprise.

The main parameters of the development system are the height of the bench, the width of the working trench (pit dimensions), the slope angles of the working benches, the stope width, the width of the working platform, the length of the excavator block, the length of the excavating and stripping blocks on the bench, the number of working benches, the height and width of the working zone, slope angle of the working board of the quarry.

Methods for determining the parameters and indicators of the development system are constantly being improved, as evidenced by the data of papers [13-18]. The selected development subsystem in specific mining-geological and mining-technical conditions with the best parameters and environmentally friendly development of the deposit with the complete extraction of all reserves from the subsoil, useful components from mineral raw materials.

Kinematic characteristics of moving velocities of the elements of development systems. The passing velocity of working trench, the velocity of the face moving, the moving velocity of the working bench slope, the velocity of the quarry bottom deepening are usually calculated according to the empirical formulas given in [1-6]. Analytical solution of the problem is adduced below. Naturally, the theoretical definition of these quantities is more universal. To derive the desired equations, the volume of the extracted rock mass from the massif can be represented as a rectangular parallelepiped (see figure 2):

$$V = ABC, \tag{1}$$

where A, B, C are the length, width and height (thickness) of the parallelepiped, respectively. In the general case, all of these quantities are variables.

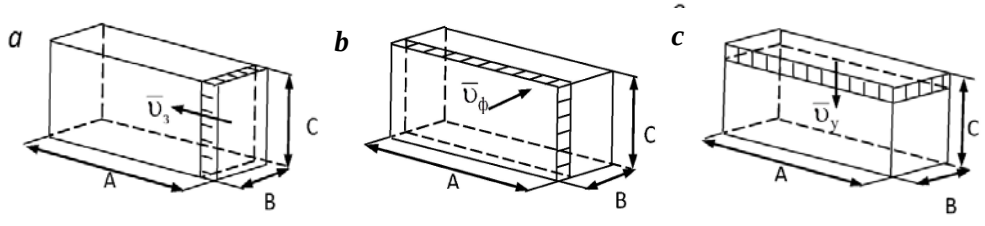

Figure 2 – Schemes to determination of moving velocities of the mine workings

Dividing both sides of equation (1) by the developing time t of the considering volume, it is possible to obtain the dependences for the desired characteristics. In this case, the expression V/t will represent the productivity of excavating and loading equipment in time t, and the number on the right side divided by t is the velocity of moving of the mine working in this direction.

For example, in the expression

$$V/t = A/t \cdot BC$$

the variable V/t represents the productivity of the excavating and loading equipment (ELE) during developing of the excavator block layer, and the variable A/t is the velocity of the face shift along the slope line of the bench (see fig. 2a). B and C are the constants.

Thus, velocity of the bench face shift is determined by the formula:

$$\upsilon_з = Q_t/BC = Q_t/S_{пу}\ , \tag{2}$$

where υ_3 is the face shift velocity within the time t (usually a shift, day, month); Q_t is the ELE productivity when the block's layer developing within the same time; $B \cdot C = S_{пу}$ ($S_{пу}$ is the cross-sectional area of the bench (entry) panel); $B=B_з$ ($B_з$ is the width of the panel (entry)); C=h (h is the bench height).

Dependence (2) is also valid for velocity of the working trench passing. In this case, the trench transverse section is trapezium, therefore

$$S_{пу} = (B_{р.т} + hctg\alpha)h.$$

Here $B_{р.т}$ is the width of the working trench in the bottom, α is a slope angle of the working trench flank.

In expression

$$V/t = A \cdot B/t \cdot C$$

the variable V/t represents the productivity of ELE during developing of the bench panel, the values A and C are constant, the variable B/t is the velocity of the bench slope into the panel cross (see fig.2b). It is determined by the formula:

$$\upsilon_ф = Q_t / AC = Q_t \Big/ S_{ву} \tag{3}$$

where $\upsilon_ф$ is moving velocity of the bench slope during the time t (usually a month, a year); Q_t is the productivity of ELE when developing of the bench part with the width B during the same time; $A \cdot C = S_{ву}$ ($S_{ву}$ is the area of the longitudinal vertical section of the bench panel); $A=L_ф$ ($L_ф$ is the length of the bench front); C=h (h is the bench height).

In expression

$$V/t = AB \cdot C/t$$

the variable V/t represents the productivity of during (ELE) developing of rocks of the bottom horizon, the values of A and B are constant, the variable C/t is the velocity (pace) of the quarry bottom deepening (see fig.2b). It is determined by the formula:

$$\upsilon_y = Q_t / AB = Q_t \Big/ S_{гс}\ , \tag{4}$$

where υ_y is the deepening velocity of the quarry bottom during the time t (usually a year); Q_t is the productivity of ELE when developing of the rocks of the current lower bench within the same time; $AB=S_{гс}$ ($S_{гс}$ is the area of the middle horizontal section of the current lower horizon); $A=L_ф$ ($L_ф$ is the length of the work front at the current lower bench); $B = B_{ср}$ ($B_{ср}$ is the width of the middle horizontal section of the lower bench) (see figure 3).

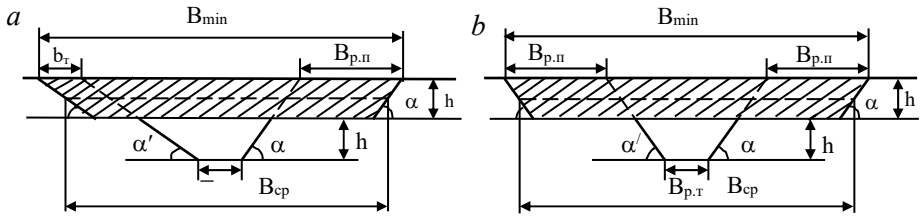

Figure 3 – Schemes to determination of the minimum values of $S_т$

For the normal development of mining operations in the quarry, which provides creation of conditions for stripping the next underlying horizon, the current lower bench should have the necessary working platform. Its dimensions are determined by the length of the work front $L_ф$ and the total width B. The minimum size of this platform $S_{зс}^{min}$ is different for the different subsystems of opencast development. When the one-board development subsystem (figure 3a):

$$S_{зс}^{min} \geq \left[в_m + B_{p.m} + B_{p.n} + 1{,}5h\left(ctg\alpha' + ctg\alpha\right)\right] L_ф \,, \tag{5}$$

When the two-board development subsystem (figure 3*b*):

$$S_{зс}'' \geq \left(B_{p.m} + 2B_{p.n} + 3hctg\alpha\right)L_ф \,, \tag{6}$$

where $в_т$ is the width of the transport (safety) berm; $B_{р.т}$ is the width of the working trench on the stripping horizon; $B_{р.п}$ is the width of the working platform of the current lower bench; h is the height of the bench; α', α is the slope angle of the non-working and working benches, respectively.

Thus, the maximum velocity (pace) of the quarry bottom deepening when the one-board development subsystem is determined by the dependence:

$$\upsilon_y^{max} = \frac{Q_t}{\left[в_m + B_{p.m} + B_{p.n} + 1{,}5h\left(ctg\alpha' + ctg\alpha\right)\right]L} \tag{7}$$

when the two-board development subsystem by the dependence:

$$\upsilon_y^{max} = \frac{Q_t}{\left[B_{p.m} + 2B_{p.n} + 3h\,ctg\,\alpha\right]L} \,. \tag{8}$$

As is seen from (3), at a given height of the bench, $\upsilon_ф$ is regulated by changing the productivity of excavating and loading equipment Q_t and the length of the work front $L_ф$. If the total length of the bench front is fixed, which usually takes place in practice, the set goal is achieved by choosing the appropriate type of ELE and a clear organization of its work.

When the deepening development system, to ensure the quarry's set productivity in minerals and stripping, it is necessary to control the value of both $\overline{\upsilon}_ф$, and $\overline{\upsilon}_y$, i.e. maintain them on the appropriate level. The values $\overline{\upsilon}_ф$ on each working horizon should provide that conditions (5-6) are met, and the values $\overline{\upsilon}_y$ should provide the development of mining operations into the depth (7, 8).

To increase the deepening pace of the quarry bottom $\overline{\upsilon}_y$, as can be seen from (7, 8), it is necessary to increase the productivity of ELE on the lower horizon using the methods mentioned above and to minimize the area value $S_{зс}$ (see (5) and (6)). Moreover, the shorter the length of the developing block, the higher the deepening pace υ_y.

Regulation of the values $\overline{\upsilon}_ф$ and $\overline{\upsilon}_y$ is dictated by the need for the planned execution of a set amount of stripping and excavating operations. This should be reflected in the development project for a specific deposit.

Conclusions. The analysis of existing systems of the deposit development and their classifications is carried out. It is noted that they do not explicitly reflect the essence of the generally accepted concept of "system".

Based on system analysis, a new definition of the system of the minerals opencast development is given. It is justified that the system of the minerals opencast development is a complex of interdependent and interconnected with each other the development, stripping and excavating workings, moving in the quarry field within time, to extract rocks from the Earth bowels.

A new classification was designed of the systems of minerals opencast development. It is based on the nature of the moving of the development, stripping and excavating workings in the quarry field – the kinematic characteristics of moving of the elements of an opencast development system. This approach has been used in the theory of opencast mining for the first time.

In the new classification, only three opencast development systems are accepted: continuous, deepening and combined. In the direction of moving of the slopes of the working benches relative to the axes and the contour of the quarry field, they are divided into subsystems: longitudinal, transverse, fan-shape, ring-shape, in addition to the one-board, two-board, etc.

For the first time in mining science, analytical dependencies were derived to determine the velocities of the working trench passing, of the bench face moving, the bench slope moving and the quarry bottom deepening.

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ПАЙДАЛЫ ҚАЗБАЛАРДЫ АШЫҚ ИГЕРУ ЖҮЙЕЛЕРІН НЕГІЗДЕУ ЖӘНЕ ОЛАРДЫҢ ЖАҢА ЖІКТЕЛУІ

Аннотация. Терминология – ғылым мен техниканың әр саласындағы тілдің ерекше маңызды құрамдас бөлігі. Терминдерді, ұғымдарды бір мағыналы анықтау және түсіндіру әр түрлі теориялық және практикалық міндеттерді қарау кезінде шындықты дұрыс қабылдауға және дұрыс шешім қабылдауға ықпал етеді. Негізсіз анықтамалар теріс салдарларға әкеп соғады. Олар жүйелі тәсілді мысалы, «пайдалы қазбалар кен орнын игеру», «пайдалы қазбаларды игеру», «пайдалы қазбаларды игеру жүйелері» және т.б. ұғымдарды анықтау кезінде пайдалану көп қтындықтарды шешеді.

Осыған байланысты пайдалы қазбаларды ашық игеру жүйесін жаңа айқындауды негіздеу үшін жүйелік талдаудың стандартты тәсілдері пайдаланылды. Олар жер қойнауынан тау жыныстарын (пайдалы қазбаларды) алуға арналған және бір-бірімен белгілі бір қарым-қатынаста болатын тау-кен қазбаларының кейбір жиынтығынан тұратын карьер объектісі ретінде игеру жүйесін қарастыруға мүмкіндік берді. Осының арқасында пайдалы қазбаларды ашық игеру жүйесін жаңа дәлелді анықтау тұжырымдалған. Кез келген жүйеге тән қасиеттер: ұйым, құрылым, байланыс және функциялар анықталынған. Пайдалы қазбаларды ашық игеру жүйелерінің жаңа жіктелуі жасалды. Кемер кенжарының қозғалу жылдамдығы, кемер еңісінің жылжуы және карьер түбінің тереңдеуі аналитикалық түрде табылды. Өңдеу жүйесі элементтерінің орын ауыстыруының осы кинематикалық сипаттамалары оның параметрлерін алу – тиеу жабдықтарының өнімділігімен өзара байланыстырады.

Осылайша, бірінші рет өзара тәуелді және өзара байланысты, жер қойнауынан тау жыныстарын алу үшін уақыт ішінде карьер алаңында орын ауыстыратын дайындық, аршу және өндіру қазбаларының жиынтығы пайдалы қазбаларды ашық игеру жүйесі болып табылатыны негізделген. Тау-кен ғылымында алғаш рет тау-кен қазбаларының карьер алаңында орын ауыстыруының кинематикалық сипаттамалары теориялық тұрғыдан табылды.

Жаңа жіктемеде ашық әзірлеудің тек үш жүйесі ғана қабылданған: тұтас, тереңдетілген және аралас. Олар одан әрі осьтерге қатысты жұмыс кемерлерінің еңістерін ауыстыру бағыты бойынша және карьер алаңының контуры ішкі жүйелерге бөлінген: бойлық, көлденең, желе, сақиналы, қосымша тағы бір бортты, екі бортты және т.б.

Белгілі әдістерден жаңа классификация кен қазбаларының карьер алаңында орын ауыстыру сипатын ескеретін, оның анықтамасынан тікелей пайда болатынымен ерекшеленеді.

Қазу жүйелері пайдалы қазбалар жатуының нақты тау-кен-геологиялық жағдайларымен және карьер алаңында тазалау қазбаларының орын ауыстыру сипатымен алдын ала анықталады. Әзірлеудің кіші жүйелері пайдалы қазбалардың орналасу түріне, параметрлеріне, жыныстардың физикалық-техникалық қасиеттеріне, тауарлық өнімнің талап етілетін сапасына және кәсіпорын жұмысының экономикалық көрсеткіштеріне сүйене отырып таңдалады.

Пайдалы қазбаларды ашық игеру жүйесінің ұсынылған жаңа жіктелуі және кен қазбаларын карьер алаңында орын ауыстырудың кинематикалық сипаттамалары қазбаның кіші жүйелерін, олардың параметрлері мен көрсеткіштерін кен алу-тиеу жабдықтарының, көлік құралдарының жұмыс көлемдерімен, ашық тау-кен жұмыстарының технологияларымен өзара байланыстыра отырып, негізді таңдауға мүмкіндік береді. Мұндай шешім карьерде тау-кен жұмыстарын қауіпсіз, жоғары өнімді, үнемді орындауды қамтамасыз етеді.

Түйін сөздер: карьерлік алаң, пайдалы қазбаларды ашық қазу, пайдалы қазбаларды ашық қазу жүйесі, олардың жіктелуі, кен қазбаларының карьерлік алаңдағы орнын ауыстыру жылдамдығы, осы жылдамдықтарды реттеу.

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ОБОСНОВАНИЕ СИСТЕМ ОТКРЫТОЙ РАЗРАБОТКИ ПОЛЕЗНЫХ ИСКОПАЕМЫХ И ИХ НОВАЯ КЛАССИФИКАЦИЯ

Аннотация. Терминология – важнейшая составляющая специфического языка любой отрасли науки и техники. Однозначное определение и толкование терминов, понятий способствует правильному восприятию реалий и принятию верных решений при рассмотрении различных теоретических и практических задач. Необоснованные определения приводят к негативным последствиям. Они могут быть предотвращены при использовании системного подхода, например, при определении понятий «разработка месторождения полезных ископаемых», «разработка полезных ископаемых», «системы разработки полезных ископаемых» и др.

В связи с этим для обоснования нового определения системы открытой разработки полезных ископаемых использованы стандартные подходы системного анализа. Они позволили рассмотреть систему разработки как объект карьера, состоящий из некоторой совокупности горных выработок, предназначенных для извлечения горных пород (полезных ископаемых) из недр Земли и находящихся в определенных отношениях между собой. На этой базе сформулировано новое аргументированное определение системы открытой разработки полезных ископаемых. Раскрыты присущие ей, как любой системе, свойства: организация, структура, связи и функции. Создана новая классификация систем открытой разработки полезных ископаемых. Аналитически найдены скорости подвижения забоя уступа, перемещения откоса уступа и углубления дна карьера. Эти кинематические характеристики перемещения элементов системы разработки удачно взаимоувязывают ее параметры с производительностью выемочно – погрузочного оборудования.

Таким образом, впервые обосновано, что совокупность взаимозависимых и взаимосвязанных между собой подготовительных, вскрышных и добычных выработок, перемещающихся в карьерном поле во времени для извлечения горных пород из недр Земли представляет собой систему открытой разработки полезных ископаемых. Впервые в горной науке теоретически найдены кинематические характеристики перемещения горных выработок в карьерном поле.

В новой классификации принято только три системы открытой разработки: *сплошная, углубочная и комбинированная*. Они далее по направлению перемещения откосов рабочих уступов относительно осей и контура карьерного поля подразделены на подсистемы: продольные, поперечные, веерные, кольцевые, дополнительно еще на однобортовые, двухбортовые и т.д.

Новая классификация от известных принципиально отличается тем, что названия систем разработки непосредственно вытекает из ее определения, учитывающего характер перемещения горных выработок в карьерном поле.

Системы разработки предопределяются заданными конкретными горно-геологическими условиями залегания полезных ископаемых и характером перемещения очистных выработок в карьерном поле. Подсистемы разработки подбираются исходя из формы, параметров залегания полезных ископаемых, физико-технических свойств пород, требуемого качества товарной продукции и экономических показателей работы предприятия.

Предложенные новая классификация систем открытой разработки полезных ископаемых и кинематические характеристики перемещения горных выработок в карьерном поле позволяют обоснованно выбрать подсистемы разработки, их параметры и показатели во взаимосвязи с рабочими размерами выемочно-погрузочного оборудования, транспортных средств, технологии открытых горных работ. Такое

решение обеспечивает безопасное, высокопроизводительное, экономичное выполнение горных работ в карьере.

Ключевые слова: карьерное поле, открытая разработка полезных ископаемых, системы открытой разработки полезных ископаемых, их классификация, скорости перемещения горных выработок в карьерном поле, регулирование этих скоростей.

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REFERENCES

[1] Sheshko E.F. Opencast mining of the minerals deposits. M-Kharkov: Ugletekhizdat, 1951. 222 p.

[2] Mel'nikov N.V. Selected publications: State and problems of development of mining science and techniques in the USSR. M: Nauka, 1992. 230 p.

[3] Rzhevsky V.V. Opencast mining works. P. 2. M.: Nedra, 1985. 550 p.

[4] Arsentyiev A.I., Kholodnyakov G.A.Mining works projecting by the deposits opencast mining. M.: Nedra, 1994. 336p.

[5] Novozhilov M.G. Otkrytye gornye raboty: «Tecnnologiya i complexnaya mechanizatsiya» [Text]: / M.G.Novozhilov, G.D.Pchelkin, V.S.Eskin. 2nd ed. K.: Vissha shkola, 1990. 320 p.

[6] Trubetskoy, K.N., Krasnoyarsky, G.L., Hronin, V.V., Kovalenko, V.S. Proektirovanie kar'erov [Projecting of the quarries]. M.: Vysshaya shkola, 2009. 694 p.

[7] Sekisov G.V. Sposoby i sistemy otkrytoi razrabotki mestorozhdenii. Frunze: Ilim, 1966. 160 p.

[8] Yakovlev V.L., Kornilkov S.V. Metodologicheskie osobenosti osvoeniya nedr na sovremenom etape // Vestnik UrO RAN. Nauka. 4. 2013. P. 43-49.

[9] Bolshaya sovetskaya encyclopediya [The Large Soviet Encyclopedia]. Vol. 21, P. 301-307; Vol. 23, P. 463-470. M.: Sovetskaya encyclopediya, 1976.

[10] Gornaya encyclopediya [Mining encyclopedia] Vol. 4. 301 p. Vol. 1, 439 p. M.: Sovetskaya encyclopediya, 1989.

[11] Rakishev B.R. Opening of the quarry fields and the systems of the open-cast mining: Textbook. Almaty, 2013. 304 p.

[12] Rakishev B.R. Technological resources for improving the quality and completeness of use of the mineral raw materials // Series of geology and technical sciencis. 2017. N 2. P. 116-124.

[13] Sobko B., Lozhnikov O. Determination of cut-off wall cost efficiency at motronivskyi pit mining // Natsional'nyi Himychyi Universytet. Naukovyi Visnyk. 2018. N 3. P. 44-49.

[14] Rakishev B.R Copper ore mining at the Bozshakol and Aktogai deposits of Kazakhstan // Mining journal. Moscow, 2019, N 1. P. 89-93.

[15] Meisam Saleki, Reza Kakaie, Mahammad Ataei. Mathematical relationship between ultimate pit limits generated by discounted and undiscounted block value maximization in open pit mining // Journal of Sustainable Mining. May 2019. Vol. 18, Issue 2. P. 94-99.

[16] Giovanni Franco-Sepulveda, Juan Camilo Del Rio-Cuervo, Maria Angelica, Pachon-Hernandaz. State of the art about metaheuristics and artificial neural networks applied to open pit mining // Resources Policy. March 2019. Vol. 60. P. 125-133.

[17] Whittlea D., Brazilb M., Grossmana P.A., Rubinsteinc J.H., Thomasa D.A., Combined optimisation of an open-pit mine outline and the transition depth to underground mining // European Journal of Operational Research. July 2018. Vol. 268, Issue 2,16. P. 624-634.

[18] Hongquan Guo, Hoang Nguyen, Diep-Anh Vu, Xuan-Nam Bui Forecasting mining capital cost for open-pit mining projects based on artificial neural network approach // Resources Policy. Available online 23 August 2019,101474.

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