Methods and schemes of quarry fields opening-up under various conditions of deposits occurrence

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Abstract
The idea of opening, expressing the creation of conditions for cargo traffic mining companies transporting cargo from the bottom to the place of its reception within the boundaries of enterprise or outside it, is the same for cutting, quarry, or underground mine.
However, in open cast mining, the term "opening" is often understood as stripping or tunneling cutting trenches in contact with minerals, as there is no clear definition of the concepts of the method of opening, opening schemes and systems.
Based on a study of various options classifications methods of opening we offer a highlight of which is how to show what is done opening-up (by mine workings or without them), and all other descriptions should be attributed to the schemes, since they show the spatial position of the method (external, internal, individual, group and production, etc.)
Keywords: OPEN PIT MINING, CUTTING TRENCH, METHOD OF OPENING, SCHEME OF OPENING

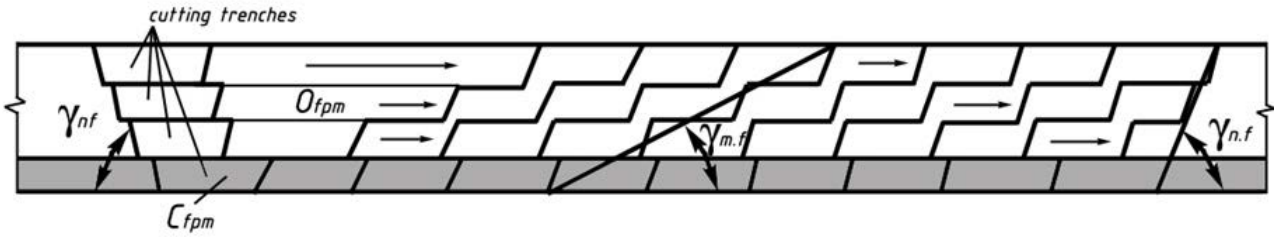
In recent decades, periodical literature on open cast mining is mostly applied in nature, aimed at solving specific technical problems, including various case-studies [1-9]. Also, considerable attention is paid to geo-ecology of opencasts [10-14], to solution of economic problems in mining [15, 16]. However, there is a distinct lack of theoretical works, in primarily it concerns the papers aimed at the modernization and adaptation of existing classifications, concepts and definitions related to open pit mining, applied to

current conditions. In addition, there are often discrepancies in some terms and definitions. Therefore, this article, in our opinion, highly relevant.

The concept of "opening" in the open cast mining should have a clear definition of its purpose, method of implementation and reporting schemes. Developing the theory of freight traffic overburden in the quarry, academician V.V. Rzhevsky found that freight traffic that determined the decision of opening the career field and that an opening is closely linked to the method of mining. At the same time it was emphasized features of the opening up the stripping and mining benches during the operation of career [17].

Open pit mining within the boundaries of the quarry field is carried out in accordance with the method of mining that determines the order of the mine-development, stripping and mining operations. This order should ensure the implementation of the specified production capacity quarry production of minerals and the appropriate volumes of overburden (Fig. 1).

Fig. 1 shows: O_{fpm} – overburden that removes in first phase mining; C_{fpm} – coal that removes in first phase mining; $\gamma_{m.f}$ and $\gamma_{n.f}$ – overall slope angle on mining and non-mining flanks of open pit, respectively; α_s – angle of coal bedding. The arrows indicate the direction of development of mining operations.



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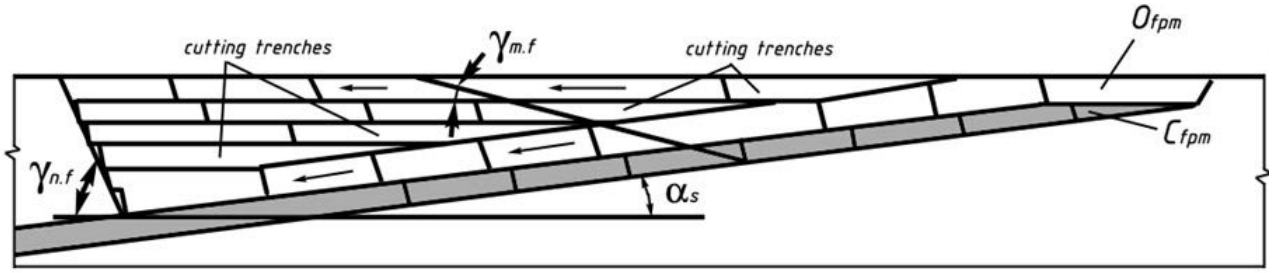

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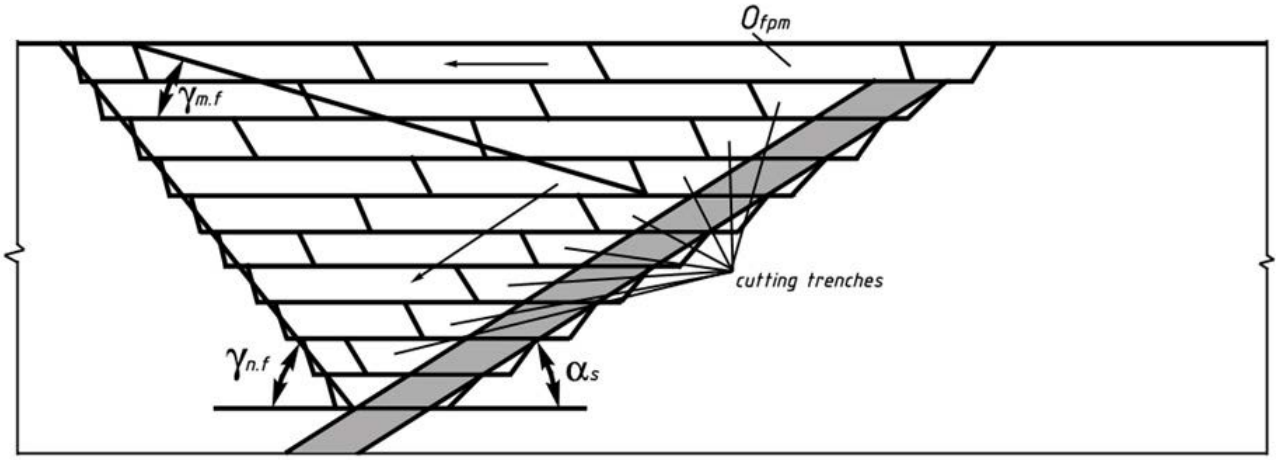

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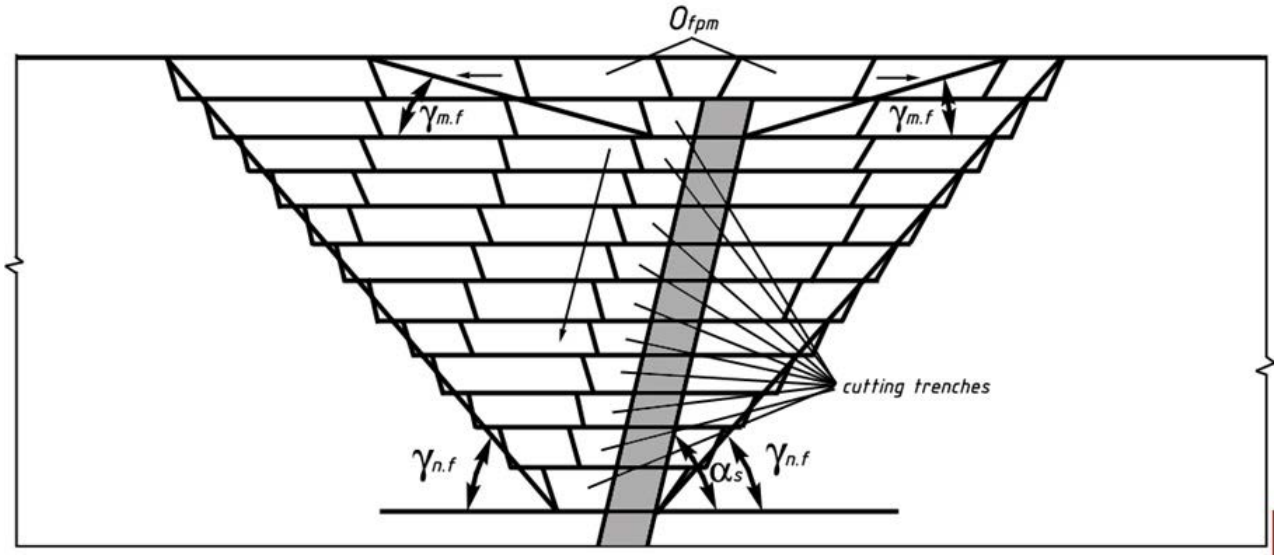

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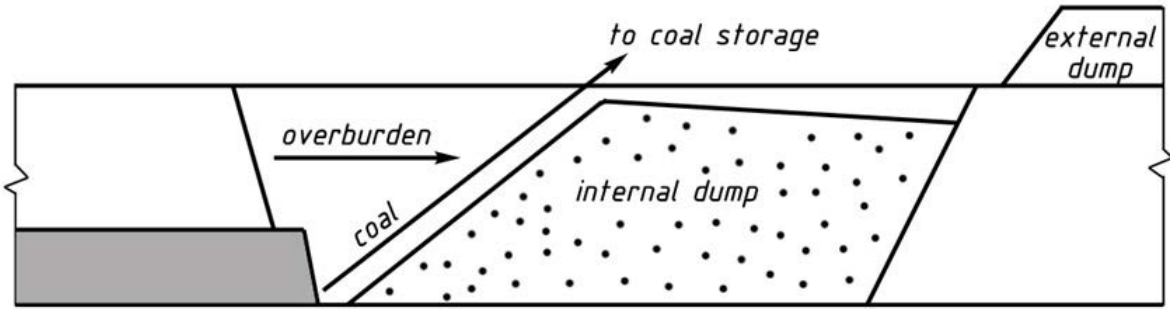
Figure 1. Directions of development open pit mining in various fields of bedding conditions:
a – horizontal seam; b – flat seam; c – inclined seam; d – steep seam

Formed stripping and mining freight traffic determines a set of equipment that must comply with conditions of developing deposit, as well as the order of preparatory, stripping and mining operations; therefore, they define the method of mining, in accordance with the classification by V.V. Rzhevsky [17].

Features of the development of mining operations and formation of stripping freight traffic determined the dividing of mineral deposits, developed by open pit, of the dip angle to the horizontal, flat, inclined and steep (Fig. 2).



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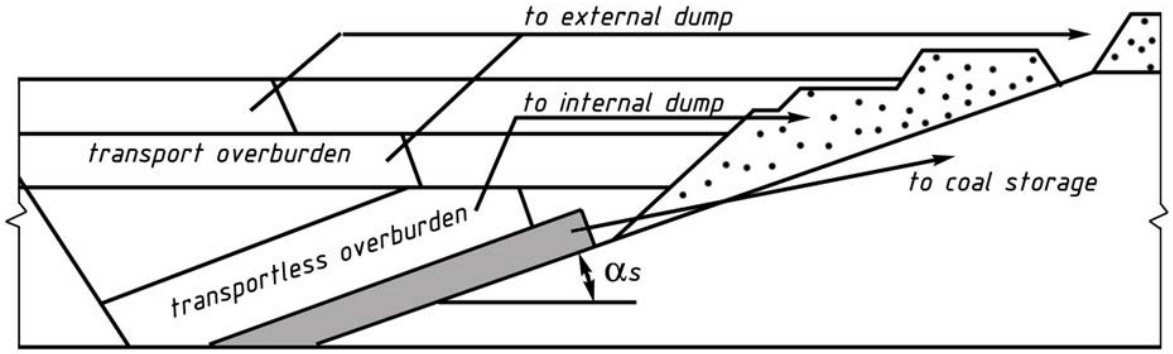

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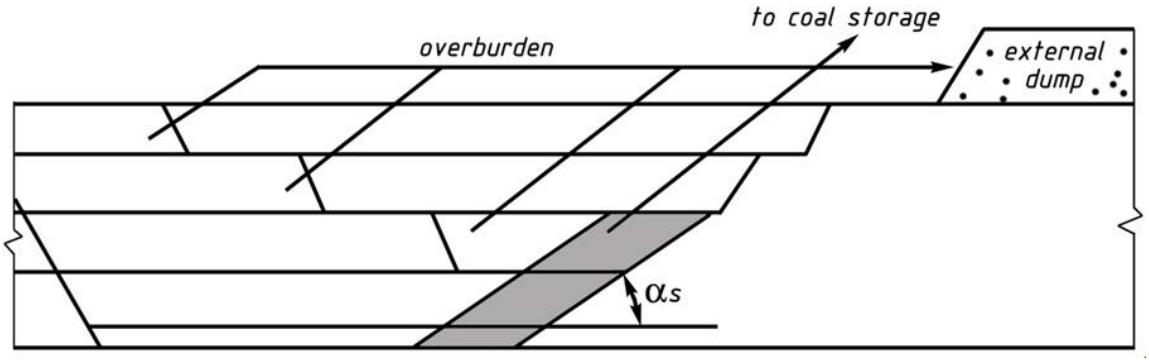

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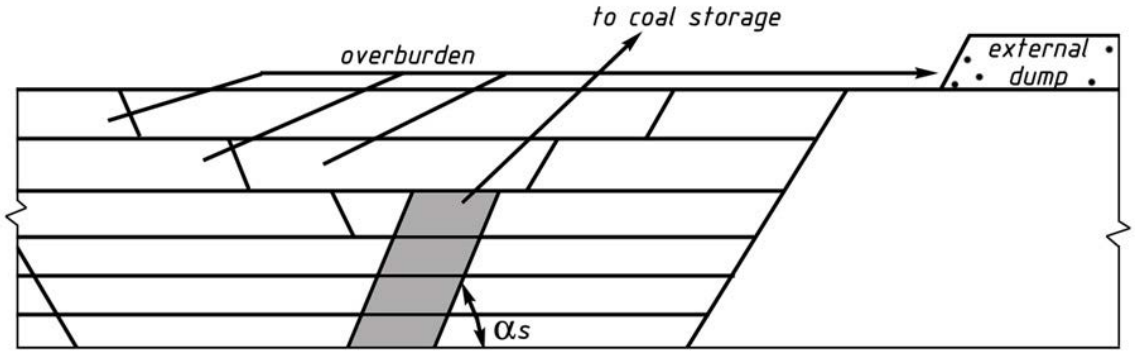

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Figure 2. Freight traffic quarry schemes at various angles of dip a – 0-5º, b – 6-14º, c – 15-45º, d – 46-90º

Horizontal deposits are seams with dip angle 0-5˚, which will be developed within the established quarry boundaries with the removal of overburden only from the hanging wall and complete placement of rocks during the operation of the quarry in the mined-out space as dredging the seam, where the overburden is moved by excavators or transport.

The limiting value of the dip angle 5º is determined by the possibility of direct vehicle entrance to the quarry face by seam floor, since it corresponds to the limiting gradient of 80 ‰.

Flat deposits are seams with dip angle 6-14º, which will be developed within the established quarry boundaries with the removal of overburden only from the hanging wall, placing it during the quarry operation partially in the goaf using draglines by transportless scheme, and the rest of the overburden will be transported to internal or external dumps.

The limit value of the dip angle 14º is determined by stable placement of the internal dumps on the seam floor without additional measures.

Inclined deposits are seams with dip angle 15-45º, which will be developed within the established quarry boundaries with the excavation of overburden only from the hanging wall and the rocks will be completely moved to external dumps.

The limit value of the dip angle of 45º is determined by stable position of non-mining flank of opencast with hard rocks.

Steep deposits are seams with dip angle 46-90º, which will be developed within the established quarry boundaries with the removal of overburden from both hanging and lying walls of the seam and the rocks will be completely moved to external dumps.

Quarry freight traffic overburden at various conditions of fields bedding have a different orientation. Mineral product in all cases is sent to the concentration plant or coal storage. The operation of all these freight traffic provided by one or another method of opening.

Method of opening is the creation of conditions for the transporting of working levels freight through open-cut workings (trench method) or underground mine workings (underground method), as well as using excavation equipment, special designs and constructions (special method).

Classification of opening methods by the presence and type of openings drilled (or their absence) presented in Table 1.

Table 1. Classification of opening methods

Opening method	Essence of the opening method
Trench	Opening by a system of open-cut workings
Underground	Opening by a system of underground workings
Special	Opening by a system of mining equipment, special designs and constructions
Combined	Opening by a combo of various methods, such as trench and special; trench and underground; underground and special; special, trench and underground

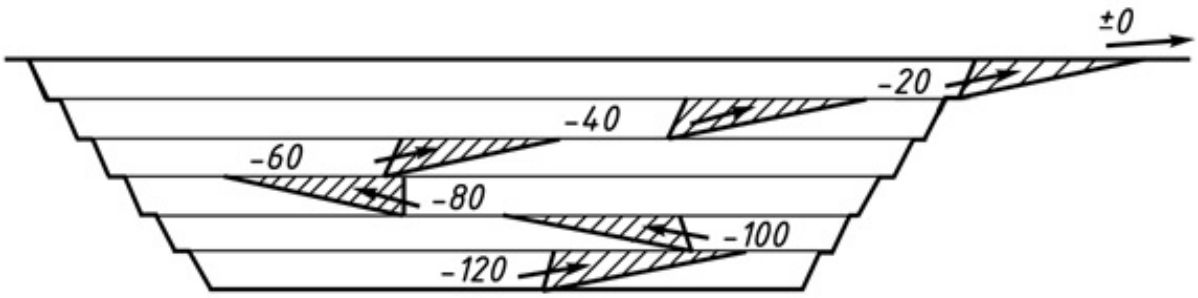
As can be seen from the table, each method is an opening system that provides quarry freight traffic working.

It is therefore proposed to consider that the purpose of opening is an establishing of communication of working levels freight traffic and places of freight acceptance inside the quarry and beyond its boundaries.

The opening method shows *what* opening of working levels is carried out, and the scheme – *how* does the transporting of freight at one or another method in a particular period of quarry operation.

Thus, the essence of the opening method is expressed through the opening system.

Opening systems on open cast mining are sets of incline trenches and semi-trenches, steep trenches, underground mines (crosscuts, tunnels, inclined shafts, adits), interconnected by transport communications and ensuring the conditions for the transport of minerals from the faces to their place of storage; set of excavation machinery, carrying out excavation and reexcavation of overburden for transportless scheme; excavators in combination with special designs for belt conveyors that providing rock mass transport; special structures (dams, viaducts, embankments, berms) to guide the freight traffic from the face to the storage places (Fig. 3).



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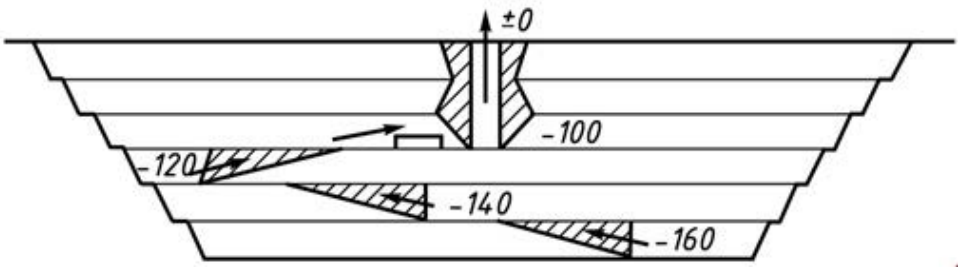

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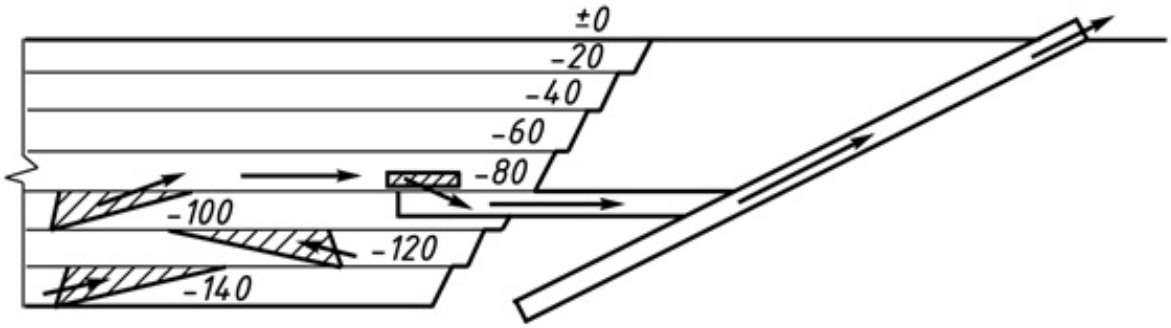

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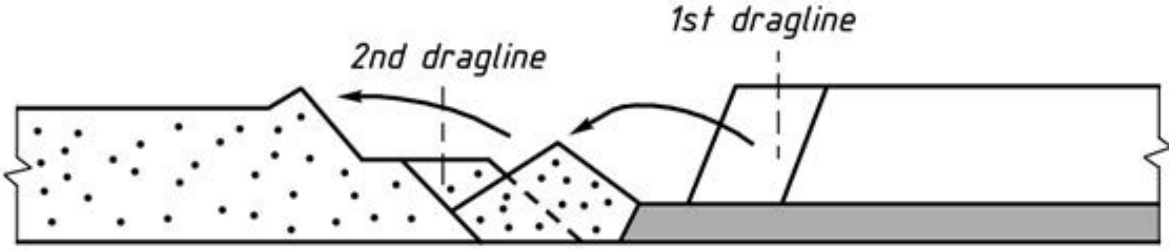

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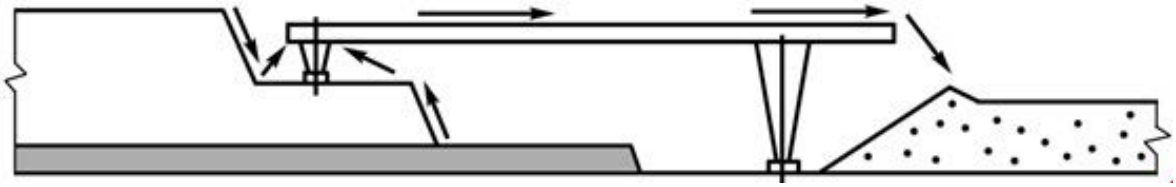

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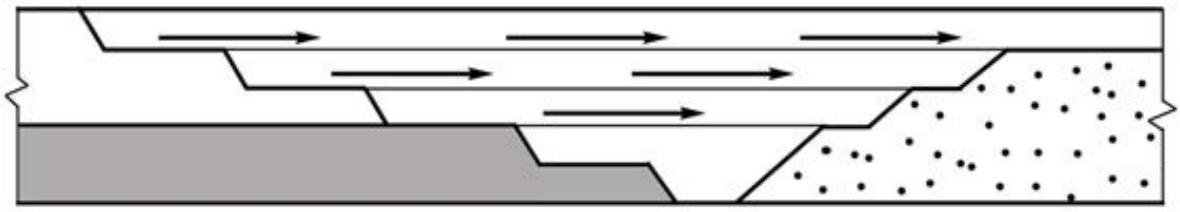

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Figure 3. Opening-up systems of : trench (a, b), trench-mine (c) and special opening methods (d, e, f)

Opening systems have various spatial development in different periods of the quarry operation depending on the method of opening, modes of transport, parameters of mining enterprises and other conditions.

Thus, embodiments of the spatial development of the working levels freight traffic are the essence of quarry opening schemes and are dependent on some factors, such as the methods of opening, conditions for doing opencast mining, system of mining, etc.

We propose the following definition: opening scheme is a description or graphic representation of opening systems spatial location of a one or another opening method in a certain period of the quarry exploitation.

The opening scheme is a qualitative characteristic of a quarry in a specific time period of its exploitation, and reflects the parameters of freight traffic that

corresponding to a given production facility, the parameters of opening workings and equipment, ensuring the operation of this traffic. Therefore, exactly the scheme of one or another opening method should be subject to select the rational option.

Underlying of quarries opening schemes are the main attributes – ways of creating conditions for freight traffic, which are expressed by the presence or absence of mine workings, construction, equipment. The type of opening workings, designs and constructions is a basic of the opening scheme, depending on mining conditions (Table 2).

Table 2. Interconnection of methods and basic schemes of career working levels opening

Conditions of use			Opening methods of quarry levels			
			Trench	underground	special	combined
Upland quarry levels		Basic opening schemes	Direct entries, inclined semi-trenches and trenches, steep trenches (ore rolls)	Tunnels, galleries with the ore passes	Excavators, rope constructions	A combination of two or three basic methods
Depth quarry levels	Horizontal seam		Direct entries, inclined trenches	Tunnels under internal dumps	Excavators, conveyor systems, embankments, blasting	
	Flat seam		Inclined trenches			
	Inclined seam		Inclined trenches, steep trenches	Shafts with crosscuts	Draglines, embankments	
	Steep seam					

Rational opening scheme determined, in the first place, by a rational way to move quarry benches' loads to places of their storage in accordance with the volume and orientation of freight traffic.

Dependence of the methods and schemes of quarries' opening on the parameters of the main freight flows is determined by technical parameters of options, which include number of mining and transportation equipment, options and volumes of the opening workings and others. These indicators are the starting values of economic calculations to select the effective variant.

Systematization of the main factors that determine the method and scheme of opening, and independent attributes that characterize the spatial development of load traffic in a specific period of exploitation, field observations and research of excavation, transportation and dumping machines, systematization of technological schemes and load traffic at the lateral and transverse development of the front of mining operations provided the basis to develop scientific and methodological principles for the calculation of technical parameters of opening schemes and economic indicators at the justification options for opening quarries.

The analysis of open pit mining and formation of load flows at the lateral and transverse mining systems applied to the conditions of various deposits shows a wide variety of schemes of any opening method, that are reflect the shape of the process, as well as all the possible methods of opening, that are reflect its kind (the content).

In the development of the depth type horizontal deposits, opening of rock benches carried out by direct entries on a relief and draglines that transship overburden in a goaf. Opening of coal benches carried out by sloping trenches with the creation of the transport lanes, usually on the ground of the worked-out seam in the zone of internal waste dumps.

In the development of the upland-depth type flat deposits, opening of transport benches in the upland part is carried out by direct entries on a relief or inclined semi-trenches. Transport benches of the depth part opened by inclined trenches.

Opening of rock benches that being handled by non-transport scheme, carried out by the dragline excavators. Coal seam at transportless stripping opened by inclined trenches on mining flank or by inclined semi-trenches that cuts on the seam ground in internal dumps zone.

In developing of the depth type inclined seams, opening of working benches is carried out by inclined trenches.

Working benches opening of upland-depth type inclined seams, carried out by direct entries and earth-fill coffer-dams on the horizon of the upland, and by inclined trenches on the depth part benches.

In developing of the depth type steep fields, opening

is carried out by inclined and steep trenches.

Given the considered experience of the opening working benches of coal and ore pits, it should be noted the possibility of using underground mine workings at open-pit mining, in the development of the depth type horizontal, flat and inclined seams and for upland horizons of upland-depth type deposits.

It is also possible the formation of freight traffic using the skip hoists and aero-geotechnical complexes.

All this confirms the conclusions that the basis for the quarries opening schemes are the main attributes – methods of creation conditions for freight traffic, which are expressed by the presence or absence of mining workings, constructions, equipment. Type of opening workings, structures and constructions is a basic scheme of the opening depending on mining conditions.

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