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CONCERNS AND ACHIEVEMENTS REGARDING THE INCREASE OF THE OPEN PITS' ECONOMIC EFFICIENCY

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Abstract: *Starting from the remark that in the 20th and early 21st century open pits have experienced an unprecedented expansion, the paper analyzes the current and future concerns related to the open pits of useful mineral substances and highlights with concrete data and notable achievements all the activities carried out in an open pit, finally presenting the technical-economic indicators obtained in Romanian open pits.*
Keywords: *open pits, techniques and technologies, economic efficiency*

1. Introduction

In the 20th and early 21st century, we witnessed an unprecedented expansion of the open pits of deposits of mineral substances and useful rocks, both as production per exploitation unit and as the number of enterprises, raising the production of mineral raw materials extracted in quarries, to over 70% of the total production, of over 30 billion tons, of useful solid mineral substances produced annually worldwide.

Various analyses, studies and statistics made at the global and national level, foresee for *the future, if not an increase in the production of the mining industry, at least a maintenance of the current productions.*

This will be due to the following three causes:

- the population of the globe increases from year to year;
- the per capita consumption of metals and, in general, mineral substances increases continuously;
- we are put in the position of exploiting, from one period to another, increasingly poor deposits.

The recent progress in day-to-day mining is due to several factors, *but the main factor is the creation of very powerful and increasingly improved drilling, extraction-loading and transport aggregates.* Such aggregates ensure obtaining the products extracted in quarries at much lower prices than those obtained through underground exploitation, the complex mechanization of the operations of the technological production process and the achievement of high labor productivity.

2. Exploitation methods in the open pits

Exploitation of deposits of useful solid mineral substances is done both by underground mining works (mines) and by surface mining works (open pits).

The methods by surface mining work (open pits) of the deposits represent the order established in time and space for the execution of the complex of works of discovery, preparation and extraction of useful mineral substances that ensure the planned productions through a rational exploitation of the reserves of the deposit.

The exploitation methods in open pits can be clarified according to a whole series of ***elements and criteria***, and as a result, in the specialized literature, there are a multitude of classifications of the exploitation methods applied on the surface (in open pits).

Taking into account that in open pits 5, 10, 20 and even 25 times more waste is extracted than useful mineral substance - coal or ore - it is logical to classify the exploitation methods in open pits ***based on the criterion that takes into account the way of organization and execution of the discovery works, characterized***

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mainly by the extraction process, the way of transport to the dumps and by the position of the dumps in relation to the work fronts or the exploitation field in open pits.

With all the great difference existing between coal and ore deposits in terms of genesis, shape, dimensions and placement in the crust and unlike the classifications of mining methods adopted for the underground, which are separate for coal and separately for ores, in open pits, a common classification of exploitation methods is accepted, because here, regardless of the nature of the deposit, the classification is primarily interested in the method of extraction, loading, transport and the place of storage of tailings.

According to the way the wastes are extracted and loaded in the working front and transported to the dumps, the mining methods on the surface, in open pits, are classified into five classes according to those presented in table 1.

Within each of the five classes of daily exploitation methods, several groups and exploitation methods will be distinguished, depending on: the type of equipment used for excavation-loading; the type of equipment used for transport, the place and manner of forming the dumps etc.

Table 1 presents in detail the classification of exploitation methods in open pits according to the criterion stated above, with the exception of special exploitation methods, where large-scale discovery works are not carried out, the division of exploitation methods into groups is made according to the type and shape of the deposit exploitable on the surface, which advertises machines and special work technologies. This includes the exploitation of construction materials, peat, ornamental rocks etc.

Table 1. The classification of exploitation methods in open pits [1]

Classes of exploitation methods	**Groups of exploitation methods**	**The exploitation methods within the groups**
I. DIRECT DEPOSIT OF TAILINGS IN DUMPS METHODS	1.Direct deposit of tailings in internal dumps in one regain methods	a) Exploitation method using the mechanical shovel excavator. b) Exploitation method using dragline located on upper bench. c) Exploitation method excavator pit. d) Exploitation method using a mechanical shovel excavator and a dragline e) Exploitation method using two draglines.
	2.Direct deposit of tailings and partial or total re-excavation of it from internal dump methods	a) Exploitation method with tailings partial re- excavation from internal dump where it was originally stored. b) Exploitation method with tailings total re- excavation from internal dump where it was originally stored.
	3.Direct deposit of tailings and partial or total re-excavation of it from external dump methods	a) Exploitation method with tailings partial re- excavation from external dump where it was originally stored. b) Exploitation method with tailings total re-excavation from external dump where it was originally stored.
II. PASSAGE OF WASTE ROCKS TO DUMPS METHODS	1.Passage of waste rocks in a bench of the dump methods	a) Exploitation method with passage and storage waste rocks with use of ferry bridge with overhanging arm. b) Exploitation method with passage and storage waste rocks with use of aerial ferry.
	2.Passage and storage of waste rocks in two or more dump benches	a) Exploitation method with passage and storage waste rocks with use of ferry bridge with overhanging arm. b) Exploitation method with passage and storage waste rocks with use of aerial ferry.
III. TRANSPORT OF WASTE ROCKS TO DUMPS METHODS	1.Transport of waste rocks to internal dumps methods	a) Exploitation method with railway transport of waste rocks to internal dumps. b) Exploitation method with rubber conveyor belts of waste rocks to internal dumps. c) Exploitation method with automotive transport of waste rocks to internal dumps. d) Exploitation method with intermodal transport of waste rocks to internal dumps
	2.Transport of waste rocks to external dumps methods	a) Exploitation method with railway transport of waste rocks to external dumps. b) Exploitation method with rubber conveyor belts of waste rocks to external dumps. c) Exploitation method with automotive transport of waste rocks to external dumps.

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		d) Exploitation method with intermodal transport of waste rocks to external dumps
	3.Transport of waste rocks to internal and external dumps methods	a) Exploitation method with railway transport of waste rocks to internal dumps. b) Exploitation method with rubber conveyor belts of waste rocks to dumps. c) Exploitation method with automotive transport of waste rocks to dumps. d) Exploitation method with intermodal transport of waste rocks to dumps
IV. INTERMODAL METHODS	1.Partial storage of waste rocks in internal dumps and partial transport of waste rocks to dumps methods	Exploitation method with partial transport of waste rocks to internal dumps and partial storage in internal dumps. Exploitation method with partial transport to external dumps and partial storage in internal dumps
	2.Partial passage of waste rocks in dumps and partial transport of waste rocks to dumps methods	a) Exploitation method with partial passage of waste rocks in internal dumps and with transport to internal dumps. b) Exploitation method with partial passage of waste rocks in internal dumps and with partial transport to external dumps.
	3.Passage of part of waste rocks and storage of the second part of waste rocks to internal dumps methods	a) Exploitation method with passage with ferry bridge with overhanging arm. b) Exploitation method with passage with aerial ferry of part of waste rocks to internal dumps and storage of the second part of waste rocks in internal dump.
	4. Simultaneous routing or waste rocks to dumps by direct passage and by transport	a) Exploitation method with transport of part of overlying rocks to external dump, of a second part to internal dump and direct storage of the third party in internal dump. b) Exploitation method with transport of part of waste rocks to external dump, of a second part to internal dump and passage of the third part in internal dump. c) Exploitation method with transport of part of overlying rocks to external dump, passage of a second part to internal dump and direct storage of the third part in internal dump. d) Exploitation method with transport o part of overlying rocks to internal dump, passage of the second part to internal dump and direct storage of the third part in internal dump. e) Exploitation method with transport of part of overlying rocks to external dump, of the second part to internal dump, passage of the third part in internal dump and direct storage in internal dump of the fourth part.
V. SPECIAL METHODS	1.Exploitation method of lens and blankets deposits	a) Exploitation method with longwall. b) Exploitation method with transverse streaks. c) Exploitation method with directional streaks. d) Exploitation method with radial fronts.
	2. Exploitation method of sheet deposits with shallow and medium depth without uncover of enclosure formation	a) Exploitation method with drilling rigs. b) Exploitation method with dwarf shearers.
	3. Exploitation method of peat deposits	a) Exploitation method by milling. b) Exploitation method in slices. c) Exploitation methods over the entire thickness of deposit at once
	4. Exploitation methods of bed deposits	a) Exploitation method with drawing and mechanical transport of bed deposits. b) Exploitation method with drawing and hydraulic transport of bed deposits. c) Exploitation method of bed deposits using full floating installations.
	5. Exploitation methods of ornamental rocks deposits	a) Exploitation method in horizontal slices. b) Exploitation method in panels c)Exploitation method in blocks after natural cracks or cleavages. d) Exploitation method in inclined slices.

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For the economic assessment of an exploitation method, different methods can be used, simpler or more elaborate, of which **the method most used in design and analysis is the one that takes into account the profitability indicator (R) expressed by the financial result corresponding to a ton of useful extracted in the open pit through a certain mining method** [2].

The result of the analysis is expressed by the relationship:

$$R=V-P, \text{ lei/t} \quad (1)$$

in which: V is the value of an extracted ton, which will be taken equal to the selling price of this ton, lei/t;
P - the technological (production) expenses for extracting, transporting and processing a net ton of coal or useful ore, (lei/t), which are established as the sum of expenses for extracting-loading and transporting a useful ton (c_u, lei /t), of the tailings needed to be removed (c_s, lei/m^3) to be able to extract a ton of useful ($c_s \cdot S/U$, lei/m$^3 \cdot$ m^3/t = lei/t) and of the processing or marketing of the extracted ton (c_p, lei/t).

Consequently,

$$R = V - (c_u + c_s \cdot S/U + c_p), \text{ lei/t} \quad (2)$$

where S represents the volume of waste required to be extracted and removed (m^3) to be able to exploit a quantity U of useful (t).

It can often be admitted that a ton of useful material is extracted with the same expenses as a ton of waste ($c_e = c_u = c_s/\gamma$; γ - the volumetric weight of the waste), and the processing expenses are very little or not at all influenced by the exploitation method applied (c_p is not take into consideration).

In these cases, the financial result can be established with the relationship:

$$R = V - c_e \cdot (\gamma \cdot S/U + 1), \text{ lei/t} \quad (3)$$

To compare two exploitation methods, the R_1 and R_2 indicators of these methods are calculated and compared by making their difference, i.e.:

$$D = R_1 - R_2 \quad \text{or} \quad D = R_2 - R_1 \quad (4)$$

If the difference D is below 10-15%, it is recommended to choose that exploitation method that ensures minimum losses or maximum production.

It is obvious that the term $c_e \cdot (\gamma \cdot S/U + 1)$ must be as short as possible to have a favorable economic result.

To reduce it to the maximum, you can act in two ways:

- whether the S/U ratio is limited, i.e. the volume of waste to be extracted, but in this case the amount of useful, which will be exploited daily from the entire deposit, is also limited;
- whether the S/U ratio is increased, therefore the amount of useful extracted per day, but looking for the exploitation method and work technologies that allow to decrease as much as possible the term c_e.

Using the modern technologies in open pits we have today, we can achieve a sharp decrease in the unit cost of extraction. Considering the large and very large investments required for these technologies, they can only be used in open pits that have appreciable amounts of reserves to exploit.

From this it follows that the choice of the exploitation method is of particular importance, not only for reducing the term, but also for determining, under the conditions of a given deposit, the amount of useful that will be exploited through the open pit, in conditions of its profitability.

Due to the mining methods and high-performance work technologies used in the exploitation of coal deposits as well as the reevaluation of the energy price, it is found that the S/U (m^3/t) ratio, which was in the years after The Second World War of the order of 3/1 (m^3/t), has progressively increased to (5-6)/l (m^3/t) and then reached around (8-10)/l (m^3/t). This ratio will be able to reach (15-20)/l (m^3/t) and even more, for certain deposit conditions and in the context of applying a certain exploitation method.

There are examples of open pits in the world that exploited and exploit superior coal with a discovery coefficient of up to 30/1 (m^3/t).

When mining ore deposits, the discovery coefficient has variable values from 3/1 to 20/1 (m_s^3/m_u^3) and they depend on the quality of the ore, its content in useful components and especially on the value of the metals, respectively the useful that is extracted laborious. There are also cases when the definitive choice of the exploitation method is obvious and no technical-economic calculations need to be made.

In many situations, several exploitation methods can be applied for the same deposit conditions. Those for which the car manufacturing industry, from the country that owns the deposit that also deals with exploitation, has the possibility to create the machine system from the technological flow will be chosen especially for the application.

Finally, it must be stated that the efficiency of the entire mining unit is related not only to the exploitation methods applied, but to all other activities on the surface of the open pit, which must be given due attention.

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3. Working technologies and machine systems used in the open pits

Various analyses, studies and statistics made at the world and national level, predict, as has been shown before, for the future if not an increase in mining production, at least a maintenance of current productions, due to the year-on-year increase in the population of the globe and the fact that we are put in the situation of exploiting, from one period to another, increasingly poor deposits, so with lower useful contents.

The recent progress in surface mining is due to several factors, but the main factor is the creation of very powerful and increasingly improved drilling, extraction-loading and transport equipment. Such equipment ensures the production of products extracted in open pits at much lower costs than those extracted through underground exploitation, the complex mechanization of the operations of the technological extraction process and the achievement of high labor productivity.

In the open pits, both hard and very hard mineral substances and useful rocks, as well as medium and low hardness useful mineral substances and rocks are exploited. For the exploitation of the two categories of mineral substances and useful rocks, two large categories of extraction, loading, transport and storage technologies were thought up and realized over time, thus we have: technologies in discontinuous flow and technologies in continuous flow, table 2 [3].

For the two categories of technologies, two specific machinery systems were designed for the construction of discontinuous flow technological lines in open pits, fig.1 and for the construction of continuous flow technological lines, fig.2 [3]

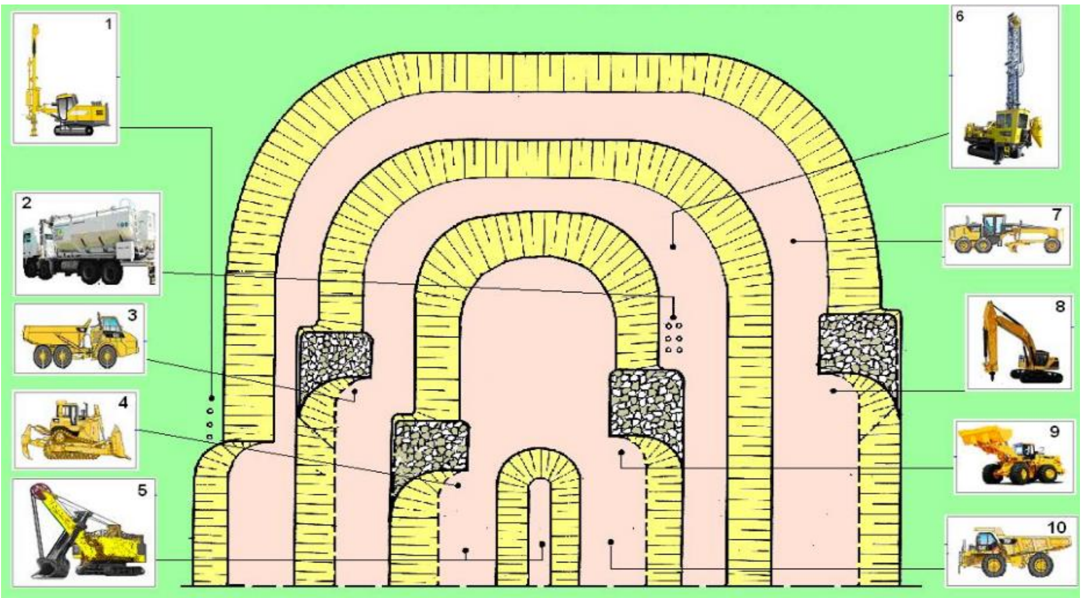

Fig. 1. Specific equipment for the construction of discontinuous flow technological lines in open pits
1-small drill; 2-explosive loader; 3-articulated dumper; 4-bulldozer; 5-excavator; 6-large drill;
7-moto grader; 8-rock breaker; 9-front loader; 10-tip lorry

Looking at things over time, it must be said that at first discontinuous flow technologies were developed and later machines and equipment were made for continuous flow technologies.

In the case of open pits that exploit magmatic and metamorphic rocks affected by discontinuities, the advance of the working fronts will be made perpendicular to the main discontinuities, and in open pits with sedimentary rocks, the advancement of the working fronts will be made perpendicular to the stratification planes. In this way, a good stability over time of the work fronts will be ensured.

In the last decades, a series of achievements and performances have been obtained in the surface exploitations in the performance of the main operations in the production technological flows [4].

Thus, in high-strength rocks, boreholes for open pit blasting are generally drilled with diameters of 100-350 mm. For drilling, new types of drills are used, working according to the percussive, rotary or rotary percussive system. In world practice drilling in ore open pits with high and very high productions, rotary drilling with roller hoes is used, and in so-called stone quarries with productions up to hundreds of thousands of tons annually, rotary percussive drilling with the hammer outside is used or inside the borehole.

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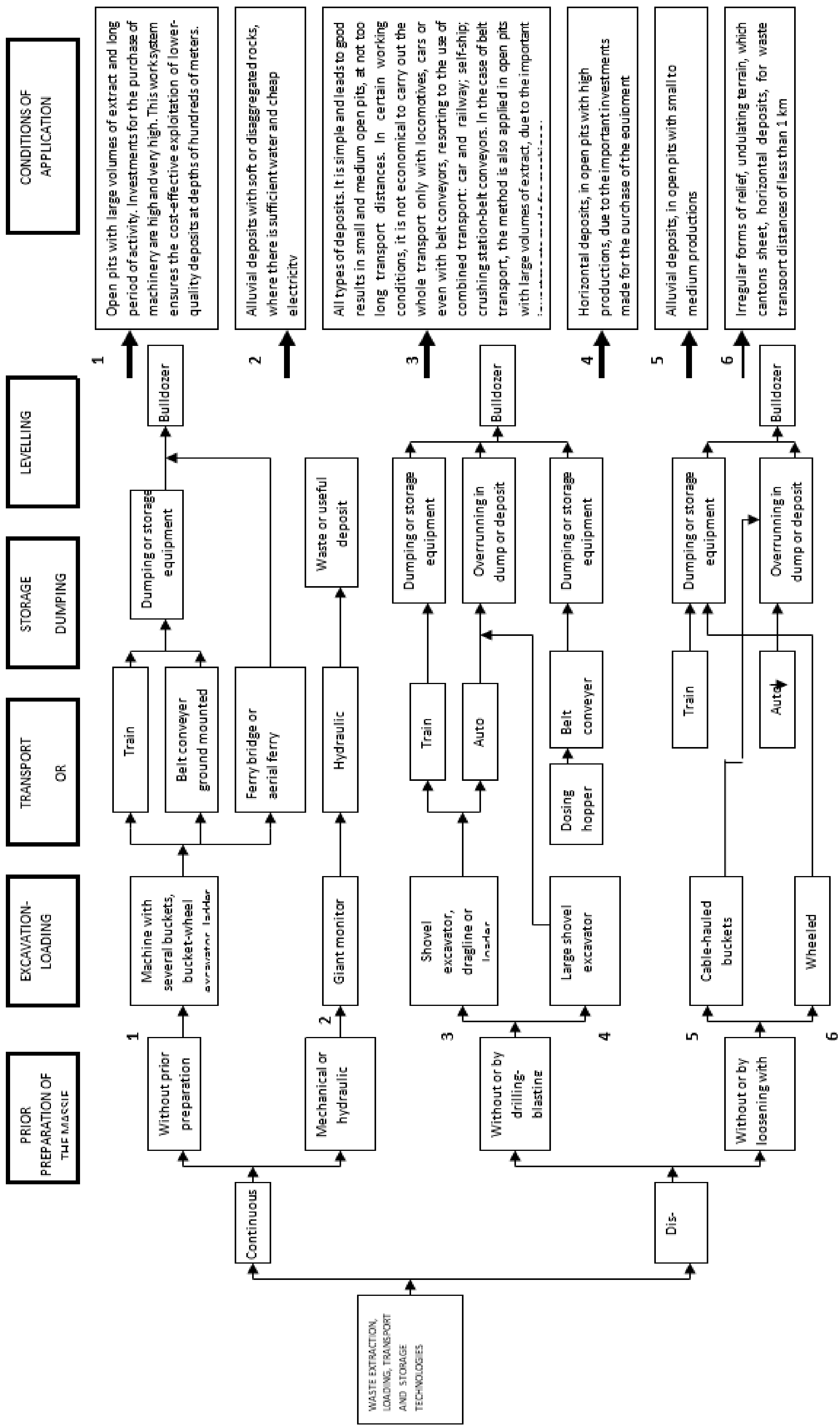
Table 2. Technologies of extraction, transport and dumping or storage in open pits



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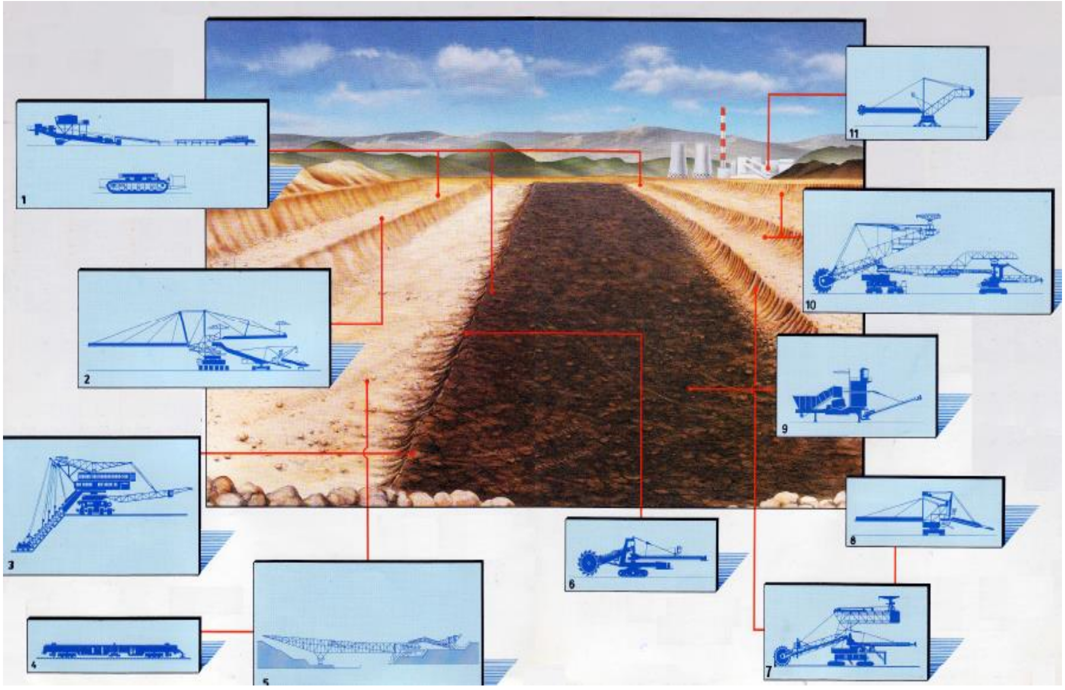

Fig. 2. Specific equipment for the construction of technological lines in continuous flow in open pits
1-rubber conveyor belt; 2-dumper; 3-ditcher ladder; 4-installation for laying railway lines in open pits; 5-overburden bridge; 6-compact excavator; 7-small bucket-wheel excavator; 8-intermediate driven traverser with overhanging arm; 9-mobile or semi-stationary breaker mounted on a bench; 10-large bucket-wheel excavator; 11-loading-unloading equipment from the storage of useful mineral substances

Rotary drills can be equipped with roller bits, fig. 3, paddle bits, fig.4, or diamond bits or crowns, and rotary percussive wells can be with the perforator outside the borehole, fig.5, or with the perforator at the bottom of the wellbore, located immediately above the drill auger, fig. 6.

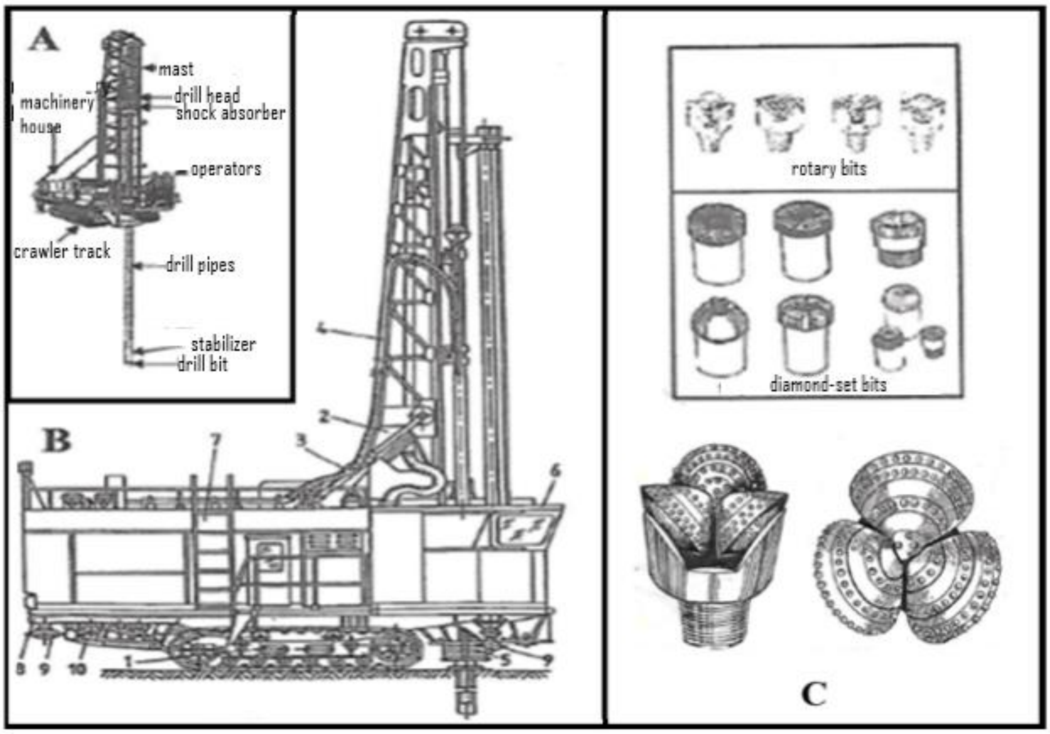

Fig. 3. Drilling rig with rolling cutter bit
A - overview, B - component parts, C – rolling cutter bits
1 – track vehicle system; 2 – drilling tower-mast; 3 – the system for raising and lowering the drilling tower; 4 – hydraulic pipes; 5 – dust collection facility; 6 – cabin; 7 – engine room; 8 – platform; 9 – hydraulic winches for fixing the drilling rig; 10 – the travel system reducer.

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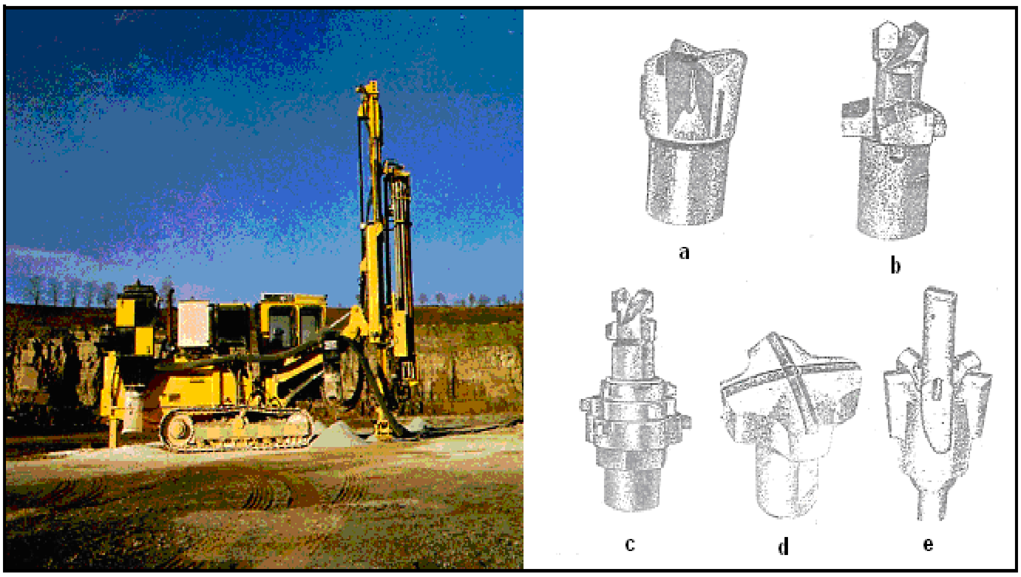

Fig. 4. Rotary drilling rig with cutter bit with paddles
a-simple cutter with Ø 75-115mm; b- compound cutter with Ø 80mm; c- compound cutter with Ø 80-145mm; d- cross roller-bit with Ø 120mm; e- compound cutter with Ø 100mm.

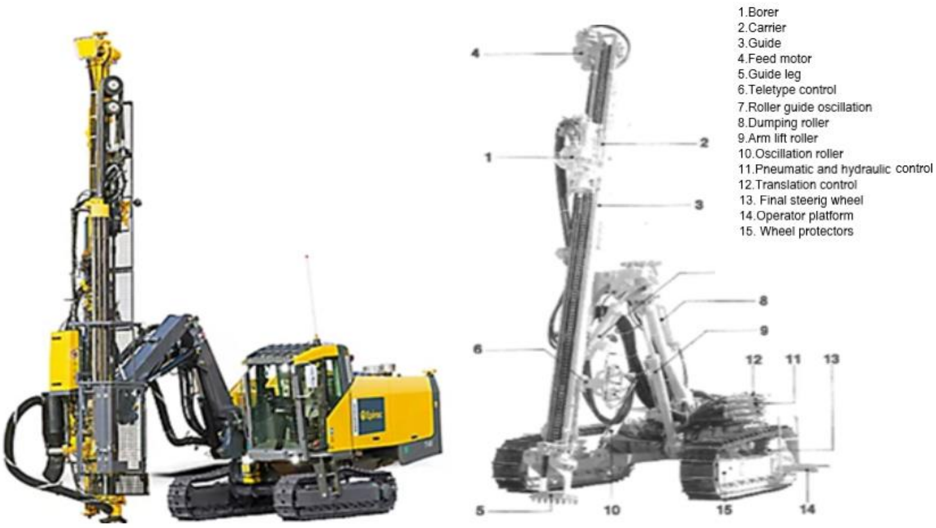

Fig. 5. Drilling rig with the drill outside the bore hole and its components

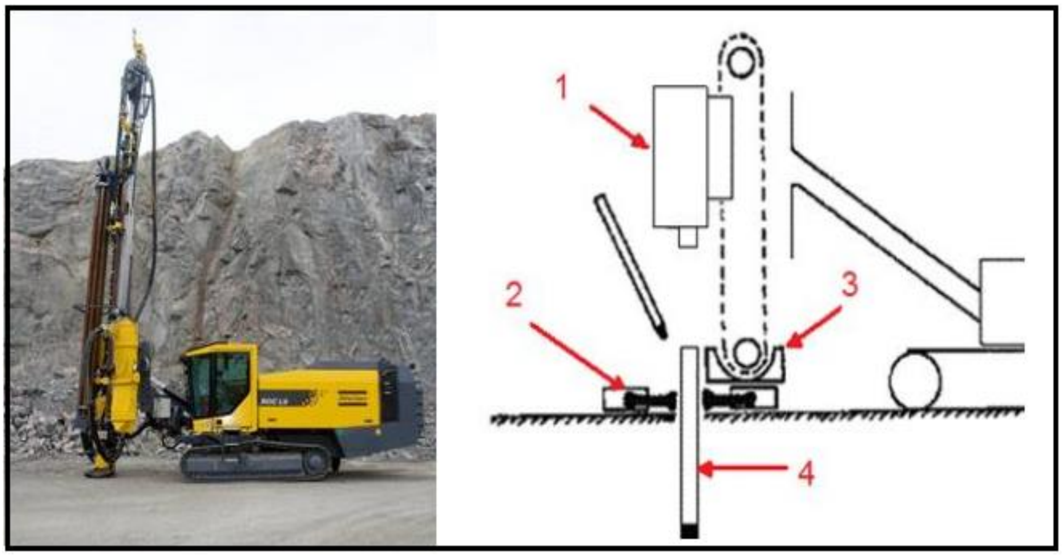

Fig. 6. Drilling rig with the drill at the bottom of the bore hole and the main components:
1- rotary engine; 2- pliers for change of rod; 3- feed motor; 4- hammer and cutter bit

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The drilling equipment used and the working methodology used are very important in the overall shooting process, because the holes executed must not present deviations, or if they exist, they must be as small as possible.

Many types of large-diameter hole drilling rigs are known, of which the rotary FC-60 rigs with the evacuation of detritus with a stream of compressed air and equipped with paddle bits have been manufactured and used in our country for decades, and the type FC-250 rotary, with detritus evacuation also with a stream of compressed air and equipped with roller bits.

In recent years, the drilling of holes of large diameter and depth of 20-25 m through a single pass has been developed, which eliminates the need to add rods frequently and as a result, the damage to the threads is reduced, the dead times for changing rods are eliminated, and it is easier to clean the drilled hole, fig.7.

As a result of long observations made in the field, in different working conditions, in relation to the past and current practice of drilling shot holes, the diagram in fig.8 was drawn up, which can be used with good results when choosing the method and respectively of drilling rigs for certain specific working conditions.

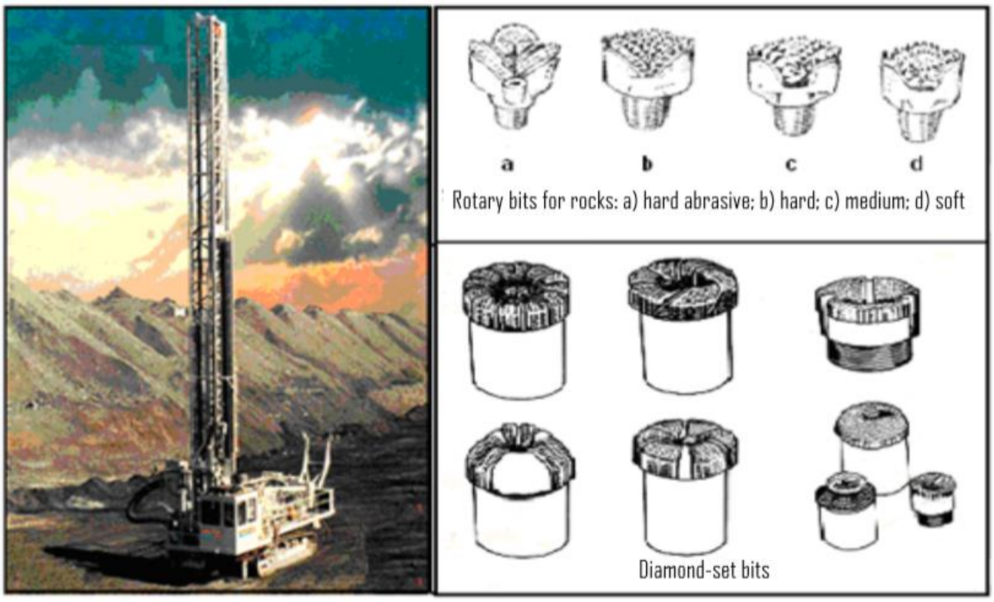

Fig. 7. Overview of drilling rig with rolling cutter bit or diamond used for drilling large diameter and deep holes

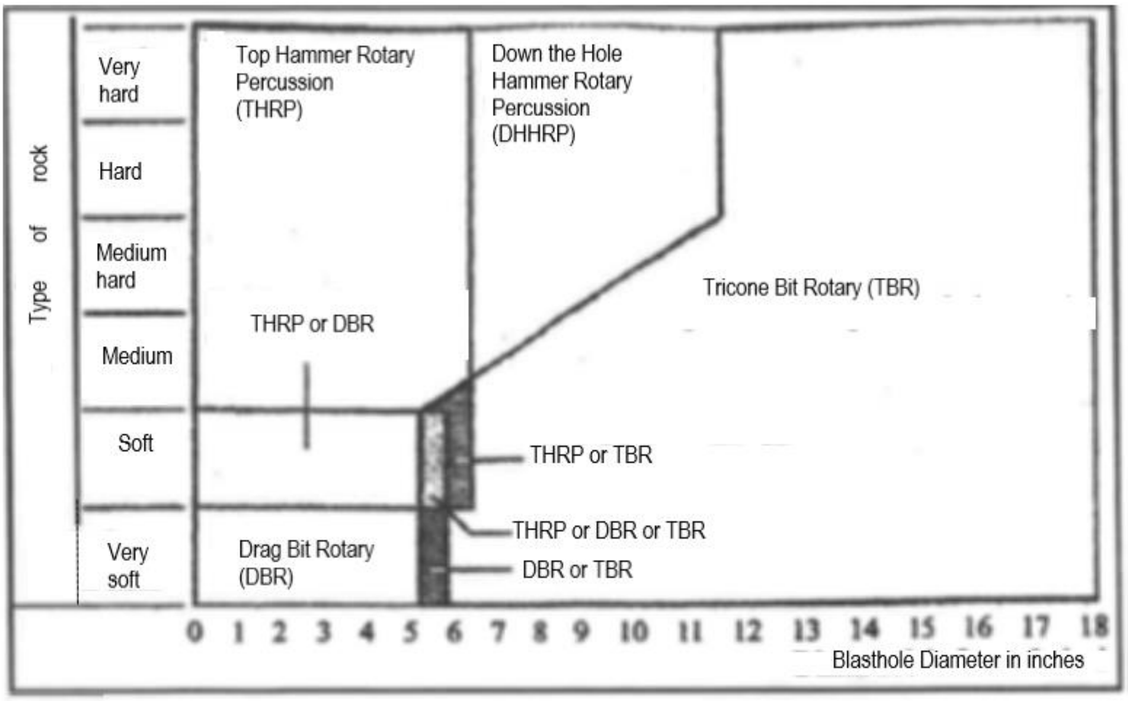

Fig. 8. Applications of different mining methods

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The efficiency of drilling boreholes is decisively determined by the speed of drilling, which in turn depends on the ability of rocks to dislodge under the action of the drill bit, the type and shape of bits used, the pressure and speed with which the bit acts on the bottom borehole, borehole diameter and depth. Also, an important role on the drilling speed is played by the manner, speed and process of removing the drilling cuttings from the bottom of the borehole. The drilling speeds obtained with the new types of boreholes, which we frequently encounter on construction sites, are approximately 5 times higher than those obtained with the older type boreholes.

The research and follow-up of the quality of the drilling activity must remain a priority objective of the technical management and control personnel in the quarry, for which it is necessary to know the requirements in the field and to ensure that they are carried out on the construction site continuously.

In economic terms, it should be noted that drilling is quite expensive and represents approximately one third of the cost of extraction with explosives.

In relation to the materials used, it must be pointed out that we distinguish two categories of products used to carry out demolition works with the help of explosives, namely: explosives and priming means [5].

Explosives provide the energy to break rocks. Here we can cite the classic explosives among which we name granulated TNT, dynamite and astralite and modern explosives that consist of simple mixtures of ammonium nitrate and diesel fuel, explosives in the form of explosive gels and more recently explosives in the form of emulsions, which include a solution of nitrate of ammonium, various liquid fuels, sensitizers, emulsifiers and other components to ensure the required consistency and detonating quality.

Explosives are usually used that ensure simplicity and safety in use, minimal damage to the environment, accurate breaking of the work front and minimal costs.

In order to appreciate the capacity of dislocating explosives and their use under conditions of maximum efficiency and security, it is necessary to know their thermo-chemical, ballistic, physic-chemical and safety characteristics. There are many parameters to consider, but the most important ones to take into account are: heat, temperature and volume of the explosive gases, pressure, specific energy, detonation velocity, ability of the explosive to transmit the detonation, work capacity, product and charge density, hygroscopicity, water resistance etc.

Modern explosives are quite easy to manufacture, have a great power to break hard rocks, lend themselves to the mechanized loading of boreholes and have a fairly low cost.

It is also necessary to know well the priming products, which have the role of initiating the detonation of explosive charges and controlling the release of explosive energy over time. The group of initiation means includes pyrotechnic and electric detonators, Bickford fuse, detonating fuse, pyrotechnic relays, boosters, non-electric priming systems and electronic priming systems, which contain explosive substances, characterized by a high sensitivity and which detonate very easily under the action of a flame, spark or shock. In this way, the detonating shock wave or initiation impulse is formed, the energy of which causes the charges of explosive substances to detonate.

We also mention the modernization of the systems and means of priming explosive charges, noting in this regard the use of NONEL shooting systems and shooting systems with the use of electronic staples. New, modern shooting methods were developed: shooting with discontinuous charges with air intervals; shooting with close parallel charges; shooting with prior contouring of the maximum to be deployed; shooting in compressed environment; throwing shot, used to discover deposits etc.

The techniques of working with explosives applied in open pits are completely and utterly different from those used underground. In order to present, discuss and use the techniques of working with explosives, you must know: the mechanism of breaking rocks by explosion, the layout schemes of the holes in the working fronts, the calculation of the parameters of the holes, the load and the concentration of the explosive in the front holes, the priming methods that to allow detonation to be initiated and timed with precise delays between holes and groups of holes.

The arrangement of the holes in the rows and of them in the shooting area is of vital importance, since by shooting the following must be avoided: an inadequate fragmentation of the massif, a weak and improper distribution in the massif of the energy of the explosion, the throwing of rocks at a great distance from the front shots, the advanced cracking of the massif behind the front, etc.

In general, boreholes are drilled vertically or at an inclination corresponding to the slope angle of the step.

The location of the probe holes along the front is done in one or more rows, fig.9.

The placement in multiple rows leads to a more advanced crushing of the massif portion in the upper part of the step, to the reduction of the costs of arranging transport roads, to the increase of the productivity of excavators and drilling installations.

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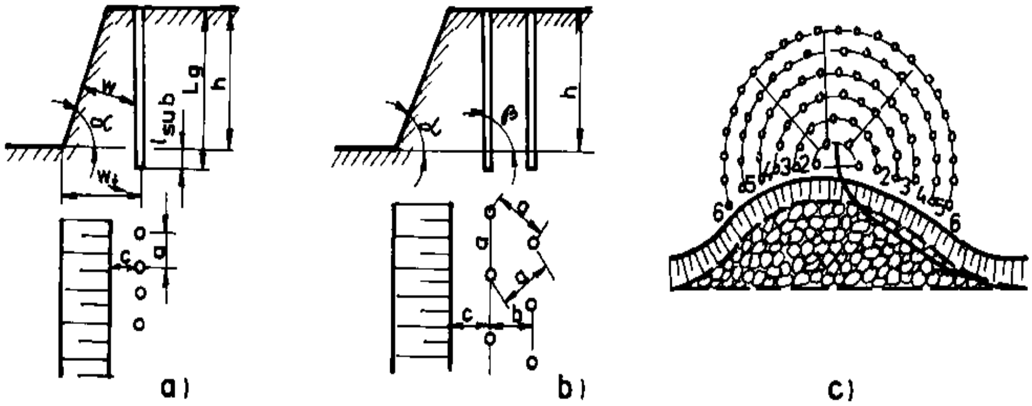

Fig. 9. Placement of boreholes on extraction steps.
a – on a row; b – in two rows; c – radial

The loading of the holes with explosives must be done mechanized and as carefully as possible. The creation of explosives practically insensitive to friction and shock allowed the complex mechanization of the preparation and loading operations in the boreholes. Also, in order to reduce expenses, the tamping of boreholes must be done mechanized with adequate equipment and materials.

The placement of the priming charge will be done at the levels calculated by the design.
In current practice in open pits, we distinguish several ways in which boreholes are loaded with explosives: loading in a continuous column with the same type of explosive, loading in a discontinuous column but using several types of explosives and loading in a discontinuous column with air intervals or with tamping between different portions of the load, fig. 10.

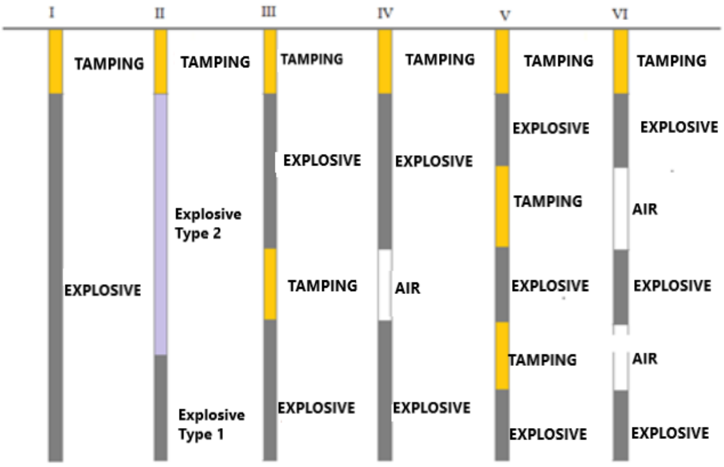

Fig. 10 Methods of charging boreholes with explosives
I – Continuous column – a single type of explosive; II - Continuous column – two types of explosive; III - Continuous column - one type of explosive - intermediate blast; IV - Discontinuous column – a single type of explosive – an air interval; V - Discontinuous column - with two portions of tamping; VI - Discontinuous column - with two air intervals

The monograph or shot plan is an essential document that the head of the mine, open pit or construction site must consult and approve. In it, the main parameters of the scheme and the shooting works are fixed, such as: the placement, depth and diameter of the mine or boreholes, the dimensions and plan shape of the location network of the holes to be shot, the nature, quantity and distribution of the explosive at each hole, the way of initiation, the priming sequences etc., fig. 11. All these elements are calculated based on the mode of action of the mass explosion and the complex interactions between the shooting parameters. Lately, a series of electronic calculation programs have appeared on the market that make work easier and increase the accuracy of the results.

If one of the above-mentioned elements is missing, the shooting plan is incomplete, certain points remain unexplained or unresolved.

It is important to note that an intended shooting plan will not be applied in a rigid and definitive manner, if necessary it must be modified to come as close as possible to the intended or desired results.

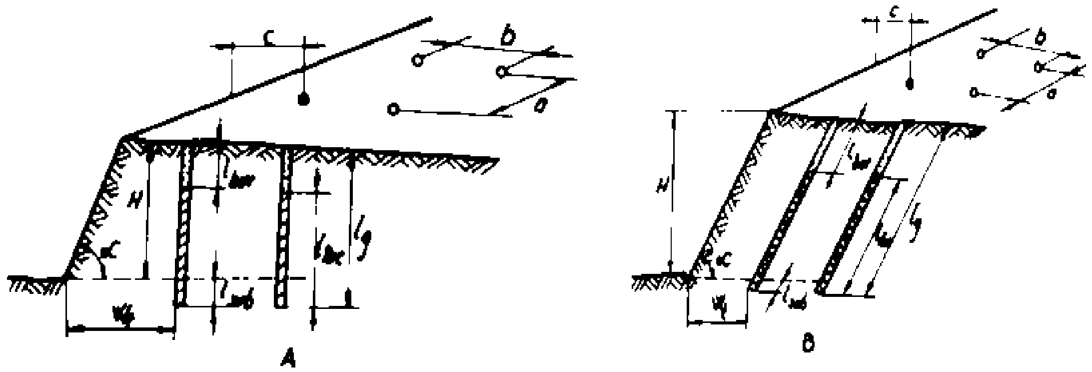

Fig. 11. Parameters nominated in the borehole shooting monograph:
A – vertical boreholes; B – inclined boreholes; W_t – line of resistance to the floor; a – distance between holes;
b – distance between rows; c – the distance from the edge of the upper berm to the first row of holes;
l_{sub} – the length of the sub-depth; l_{bur} – the length of the tamping; $l_{înc}$ – the length of the explosive column;
lg – borehole length; α – the inclination of the slope; H – step height

In table 3 presents a simple and easy-to-apply variant for calculating the borehole parameters and their location on the step, used with good results in the creation of monographs or pitting plans.

Table 3. Example of calculating the parameters of the shooting holes and their location on the step [6]

No.	Parameters			The source	Values used in calculations	Mathematical formulas used	The results of the calculations	Are accepted in the calculation
	Name	**Unit**	**Symbol**					
1	Height of bench	m	H	given	15	-	-	-
2	Hole diameter	m	D	given	0.381	-	-	-
3	Inclination of hole from the vertical	°	β	given	20	-	-	-
4	Explosive name	-	-	given	AM_1-AMFO	-	-	-
5	Energy of explosive	cal/g	Q_{expl}	given	885	-	-	-
6	Method of loading	-	Mec/Man	given	Mec	-	-	-
7	Explosive density	g/cm^3	ρ	given	0.85	-	-	-
8	Load density	g/cm^3	Δ	calculated	-	$\Delta=(1\div1.1)\ \rho$	0.935	-
9	Rock density	g/cm^3	γ	given	2.8	-	-	-
10	Report a/W_t	-	-	calculated	1.3	-	-	-
11	Under-deepening	m	l_{sub}	calculated	-	$l_{sub}=0.3W_t$	3.391	-
12	Tamping length	m	l_{bur}	calculated	-	$l_{bur}=0.7W_t$	7.9	8.00
13	Drilling deviation alignment error	m	F	calculated	-	$F=0.05+0.017h$	0.305	-
14	Line of resistance to the floor-theoretical	m	W_t	calculated	-	$W_t=D\cdot(Q_{expl}/30)$	11.303	11.50
15	Line of resistance to the floor-real	m	W_{tr}	calculated	-	$W_{tr}=W\cdot F$	10.998	-
16	Distance between holes	m	a	calculated	-	$a=m\cdot W_{tr}$	14.297	14.50
17	Borehole length	m	L_g	calculated	-	$L_g=(h+l_{sub})/\cos\beta$	19.571	19.60
18	Line of resistance to the floor-actual corrected	m	W_{trc}	calculated	-	$W_{trc}=W_{tr}/\cos\beta$	11.50	-
19	Volume of a hole	m^3	V_g	calculated	-	$V_g=L_g\cdot\pi D^2/4$	2.235	-
20	Volume of the explosive charge	m^3	V_{inc}	calculated	-	$V_{inc}=(L_g-l_{bur})\cdot\pi D^2/4$	1.323	-
21	Volume of tamping	m^3	V_B	calculated	-	$V_B=V_g-V_{inc}$	0.912	-
22	Weight of the explosive in the hole	kg	G_{expl}	calculated	-	$G_{expl}=1000\cdot\Delta\cdot V_{inc}$	1,236.544	-
23	Energy released	kcal	Q	calculated	-	$Q=G_{expl}\cdot Q_{expl}$	1,057,245.12	-

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24	Volume of rock obtained	m^3	VR	calculated	-	$VR=a \cdot W_t \cdot H$	2,501.250	-
25	Weight of rock	tons	GR	calculated	-	$GR=VR \cdot \gamma$	7,003.500	-
26	Explosive consumption	kg/m^3	q	calculated	-	$q=G_{expl}/VR$	0.494	-
27	Explosive consumption	kg/ton	q´	calculated	-	$q´=G_{expl}/GR$	0.177	-

In the field of road and railway constructions, where each excavating does not always represent a very important volume, the results of the first firings must be followed carefully and acted quickly if changes are required in the firing scheme and in the work system.

More than 50 years ago, the problem arose of finding work methods in the case of the use of explosives in mining and other fields of activity, which would lead to obtaining well-profiled and stable excavations, and the massif of rocks around the work should be as little affected.

Research and practice in the field have developed a series of special shots, the so-called contouring shots, among which we mention:

- pre-cutting or pre-cracking shot;
- shooting with smooth walls;
- damping shot or shot with reduced loads;
- perforation in line.

The use of these work methods have a direct impact on:

- work safety and timely use of the work;
- the stability and maintenance of the work during its use;
- the visual impact of the work on the area it crosses.

Today, the shooting technique has new fields of applicability, among which we mention: the demolition of civil and industrial constructions, the deepening and widening of waterways, the removal of tree stumps and roots, the destruction of ice, etc.

From the category of works mentioned above, the demolition works should be highlighted in particular, which in the current stage of modernization and expansion of the old productive capacities, as well as the urbanization of localities, occupy an increasingly greater weight.

In principle, depending on the needs, civil or industrial buildings must be partially or completely demolished, and in some cases only certain constructive elements made of masonry, concrete or reinforced concrete must be destroyed.

Due to the reduced consumption of time and manpower, as well as reduced expenses, the demolition and widening of navigable channels by means of blasting have become the most competitive work methods, ensuring at the same time a high degree of security.

The introduction of the shooting technique in these areas has recently become more and more frequently applied and at the same time more and more complicated. Demolition of buildings and their defense against fragments resulting from shooting, keeping production processes in operation, keeping traffic open immediately after shooting, seismic protection of neighboring objects, are just a few examples of problems and situations that arise and are asked to be solved in the field of special shooting.

So, for each shooting, a technical shooting project is drawn up, which, in addition to the actual solution, will also include safety measures and, in particular, protection of the environment. Each construction represents a special, separate case, the calculation of shooting parameters adapting to each situation. Due to the fact that in most cases work is done in inhabited areas, special attention must be paid to the prevention of accidents among the civilian population.

The charge required for shooting certain constructive parts is dependent on the type of explosive used, the material being shot, the type of construction to be demolished and the geometry of the placement of the holes. The effectiveness of the shot is in turn dependent on the ratio between the geometric parameters: anti-slope, the distance between the holes of the same row and the distance between the rows of holes, the number and size of the explosive charges, as well as the type of tamping and priming.

The monitoring and control of the works is for the technical staff a task as important as the preparation of shooting monographs.

In fact, they have the duty to carry out a certain number of checks to confirm and guarantee the results they will obtain and thus avoid certain conflicts and misunderstandings with the management of the company or the construction site.

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The exploitation in open pits of deposits of useful mineral substances by using the energy of explosives and the use of demolitions on public works sites with the help of explosives has a strong negative impact on the environment. The intensity of the impact is dependent on the amount of explosive used in a shot, the most unfavorable situation being registered in the case of using massive shots with the use of very large amounts of explosive.

In essence, the impact of shootings on the environment materializes through [7]:

- air pollution with dust and gases;
- throwing rocks from the work front;
- creating an overpressure in the front of the air shock wave;
- the production of a seismic effect, and
- strong noise pollution noticed through vibrations and noise.

Each of these elements has a certain effect on the environment and imposes a series of specific measures to mitigate the impact, so that the influence parameters fall within certain acceptable limits. The solutions and measures taken to reduce the degree of environmental pollution must satisfy the criterion of minimum costs under conditions of maximum efficiency.

Beyond the consequences on industrial and civil constructions and in a more general way on the environment, the use of explosives required the development and approval in the legislative forums of some very important regulations aimed mainly at two objectives:

• a public security objective, in which the emphasis is placed on the conditions of possession and use of explosives and protection during shooting works;

• an individual security objective, for those who handle explosives because when an accident occurs, it is always very serious.

The regulations in force are important and must be known by the manufacturer of explosives, by the one who transports these materials and by the user.

We conclude what has been presented so far by saying that **rock shooting is and will remain, at least 2-3 decades from now, the main method for demolishing hard rocks**, with all the deficiencies and disadvantages it presents.

Loading of the derocked material is done with excavators with a bucket or, more recently, with loaders.

In excavators with a bucket working on the step, loading the material into a transport device, its capacity increased from 3 - 8 to 20 and even 30 m^3. All modern types of excavators develop high pushing efforts and clean well the hearth they drive, fig.12 [8].

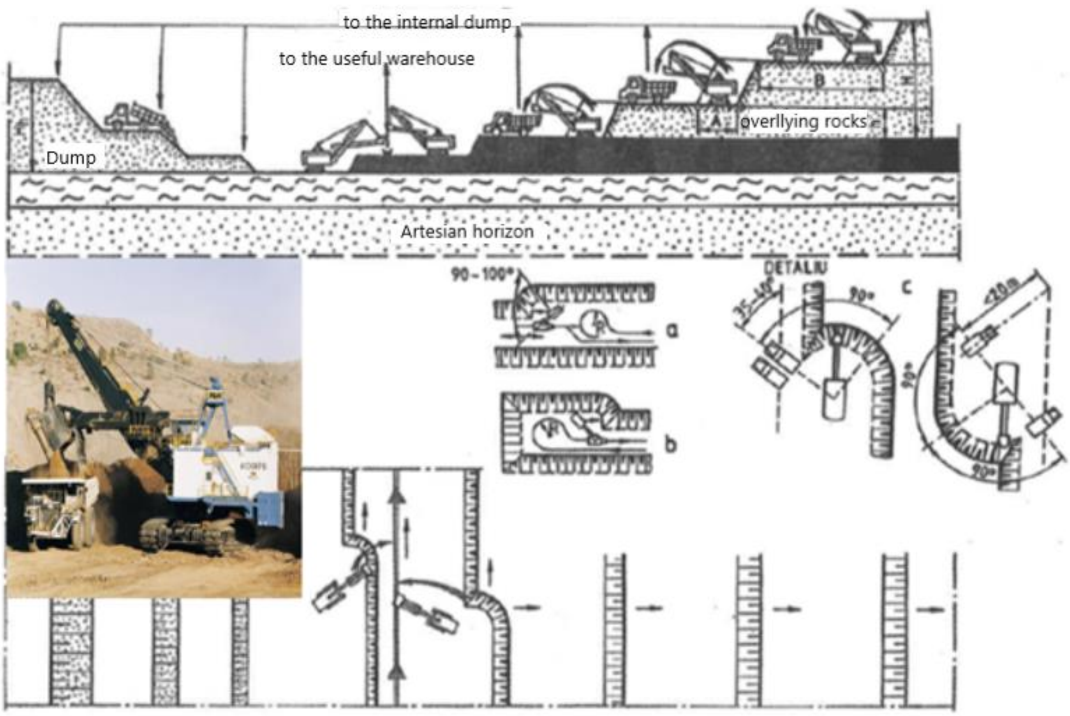

Fig. 12. Schematic of the mining method using power shovel to load rocks

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The volume of the bucket of excavators with a bucket, of the dragline type, intended for extracting the discovery and depositing it in the exploited space, currently has values of the order of tens of cubic meters, and the arm supporting the bucket has lengths between 20 and 100 m, fig.13.

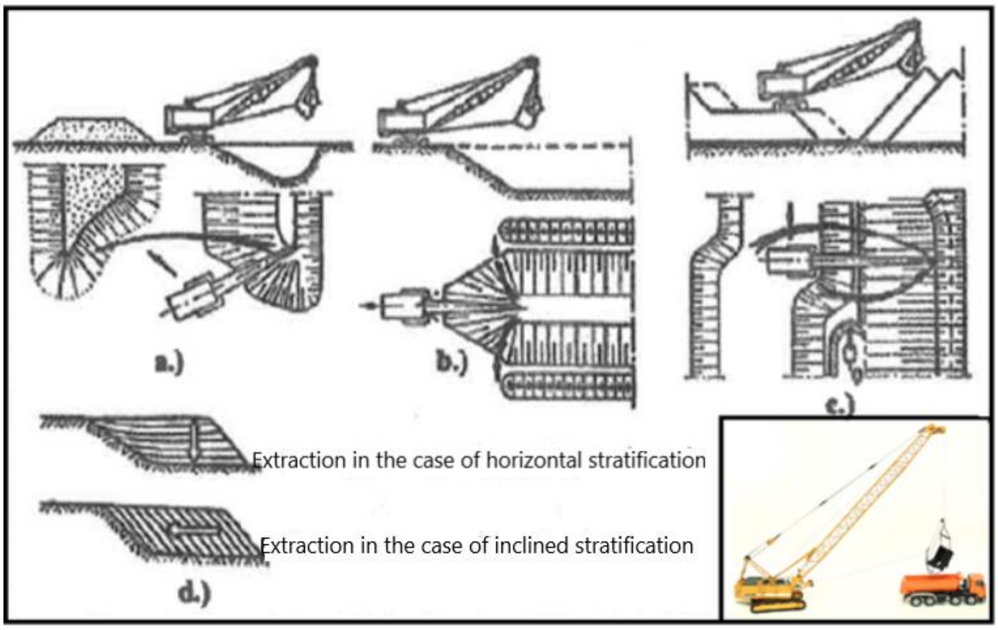

Fig. 13. Work execution schemes with the dragline excavator
a – digging trenches – side excavation, b - digging trenches – frontal excavation,
c – discovery – frontal excavation, d – ways of excavation depending on rock stratification

Loaders, which are used more and more, have high movement speeds and, unlike excavators, can be removed from the work front much faster. Their cost is about 1/2 of the cost of excavators, the depreciation period is 2-3 times lower, so they can be replaced much faster. The optimal transport distance of the loaders, with buckets of 4.5 - 10 m^3, is up to 1300 m and they are used in both high strength and low strength rocks, fig.14.

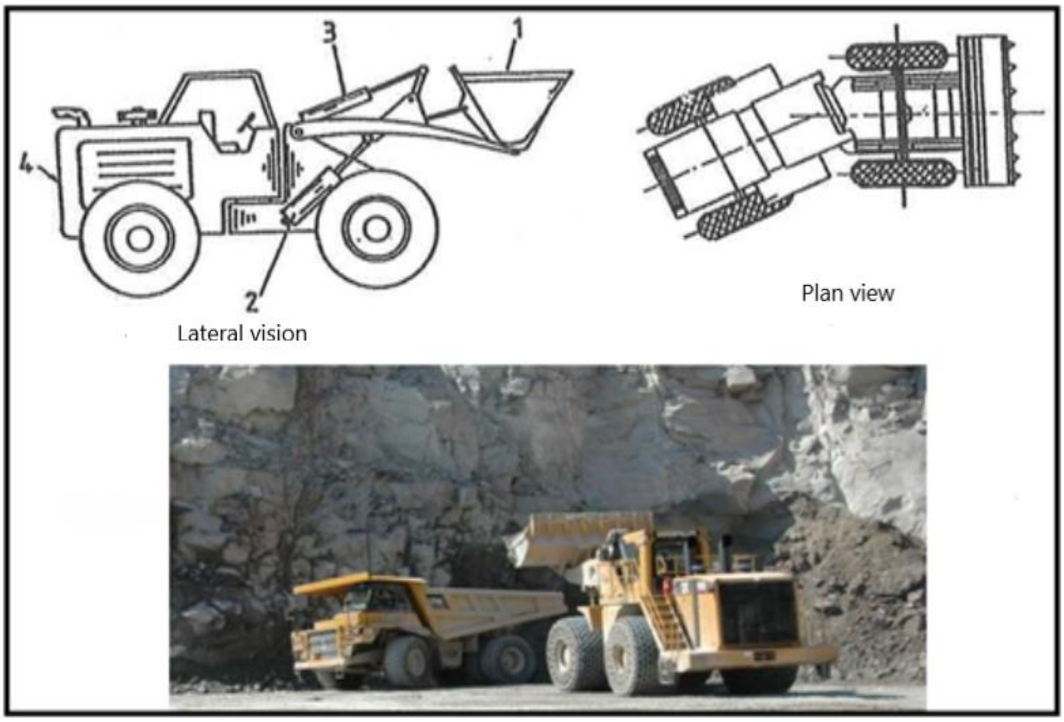

Fig. 14. Overhead loader:
1 – bucket, 2 – lifting piston, 3 – piston for rotating the bucket, 4 – engine

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In the problems of excavation and mechanical transport of low-strength rocks, a series of differences occurred. Wheel scrapers and tractor scrapers or auto scrapers with buckets of up to 30 m^3 and flow rates of up to 300 m^3/h are widely used for irregular landforms, for transport distances of over 200 m, with a very low cost price, fig. 15 and 16 [9].

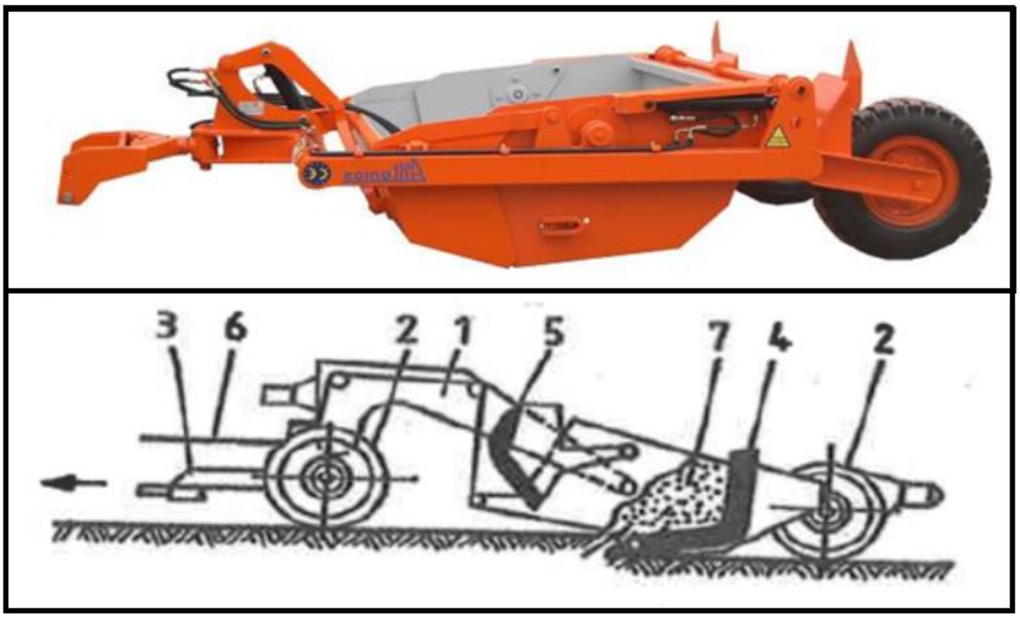


Fig. 15. Scheme of loading, transporting and unloading the scraper on wheels:
1 – frame; 2 – travel system; 3 – towing device; 4 – cup; 5 – cup shutters; 6 – driving device; 7 – material.

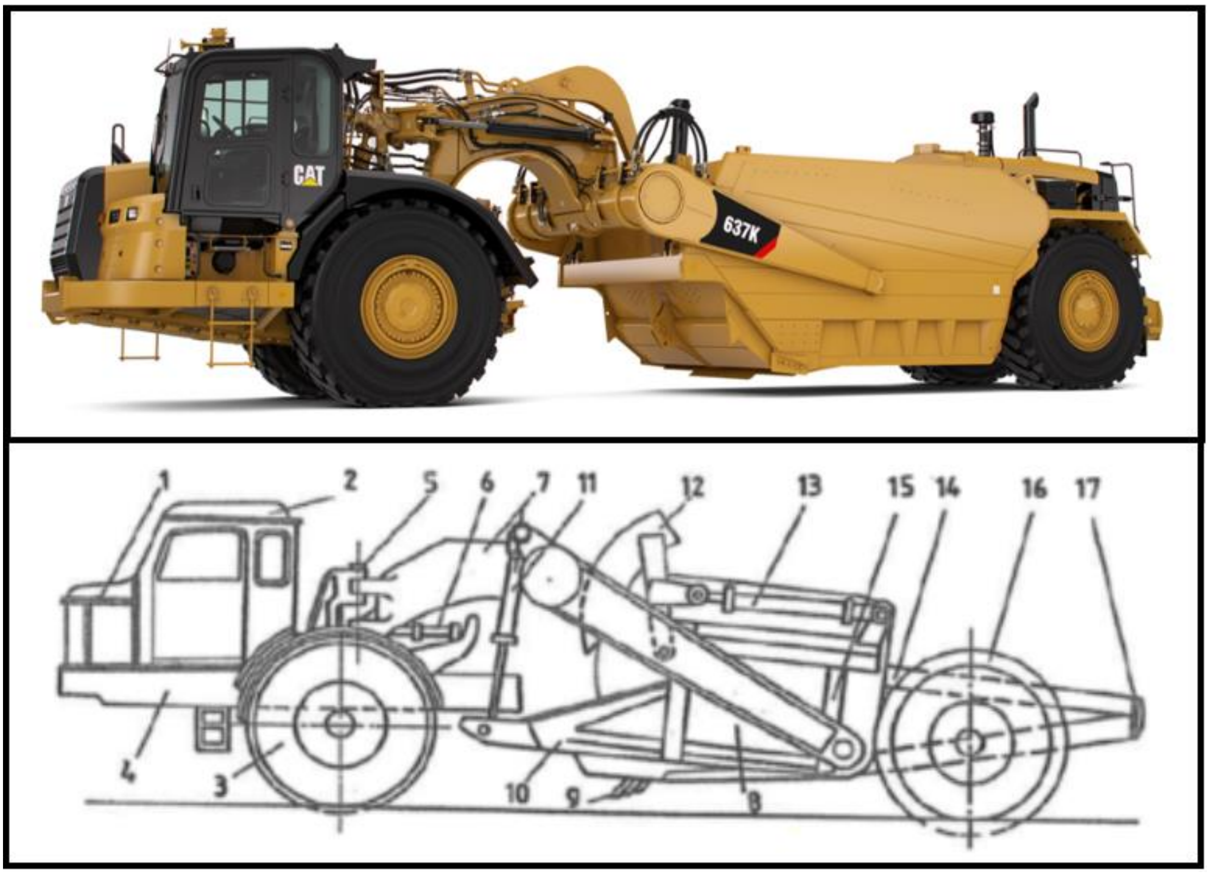
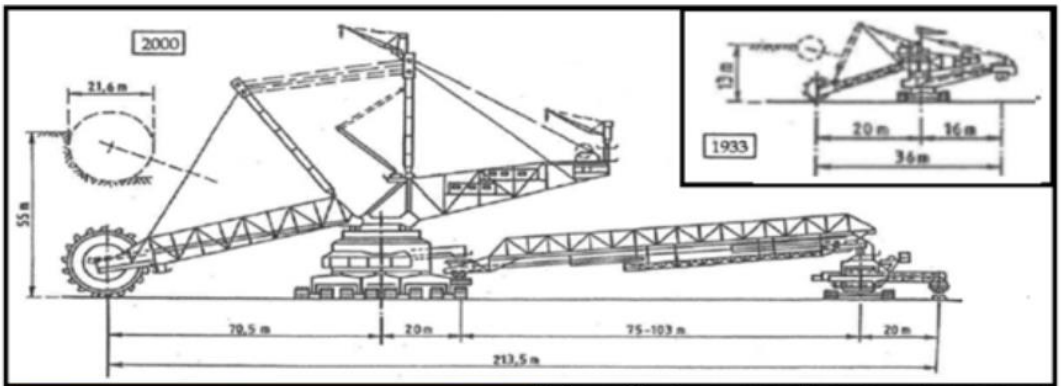


Fig. 16. Scheme of loading, transport and unloading of the buck scraper:
1 – engine; 2 – cabin; 3 – motor wheels; 4 – engine frame; 5 – the hinged support of the arched arm; 6 – hydraulic cylinders of the steering mechanism; 7 – arched arm; 8 – cup; 9 – knife; 10 – rear frame; 11 – hydraulic cylinders of the bucket lifting mechanism; 12 – shutter; 13 - hydraulic cylinders of the shutter lifting mechanism; 14 - bucket unloading hydraulic cylinders; 15 – mobile rear wall; 16 – rear wheels; 17 – buffer

For the transport of rocks by pushing up to a distance of 50 - 75 m, large bulldozers on tracks and respectively those on tires are used. In the future, it seems that the association between bulldozers and dump bridges will be expanded for the transport of tailings directly into the exploited space, forming internal dumps.

Bucket-wheel excavators have proven superior to other types of excavators with continuous and discontinuous action for mining coal, clay, sand, etc. The largest excavators in operation of this type produce 240,000 m^3/day. The experience so far and the technical-economic studies carried out have shown that these machines, of high productivity, can be used for profitable exploitation of lower quality deposits located at depths of several hundred meters, fig.17. For special working conditions, new, more reliable and economical excavation machines were designed and made, such as: compact excavators, front rotor excavators, surface mining combines etc.



Characteristics	UM	1933	1990	2000/1933
Bucket diameter	m	5,0	21,6	4,32
Bucket power	kW	74,0	3360,0	45,40
Total installed power	kW	300,0	16900,0	56,30
Excavator mass	t	352,0	132560,	37,68
Theoretical capacity	m^3/h	756,0	19100,0	25,13
Equipment length	m	36,0	213,5	5,93
Arm length	m	20,0	70,5	3,52
Excavation width	m	13,0	55,0	4,20
Bucket capacity	l	150,0	6640,0	40,00

Fig.17. Overview and comparison between bucket-wheel excavators manufactured in the years 1933 – 2000

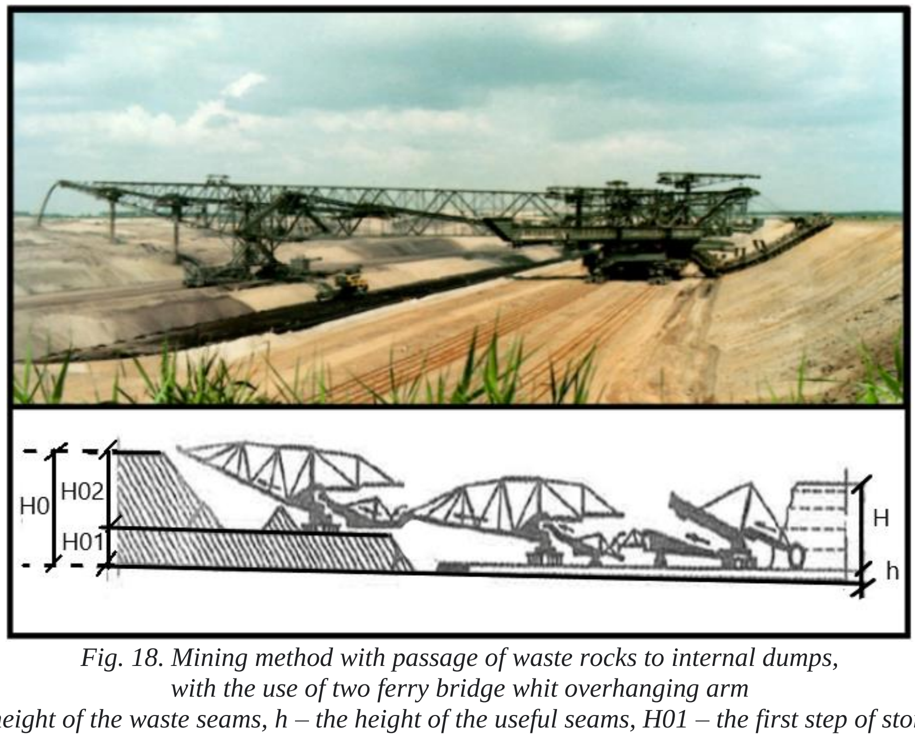


Fig. 18. Mining method with passage of waste rocks to internal dumps,
with the use of two ferry bridge whit overhanging arm
H – the height of the waste seams, h – the height of the useful seams, H01 – the first step of stored waste
H02 – the second step of stored tailings, H0 - the total height of the waste deposit

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Great progress has been registered in the field of exploitation and transport methods in quarries. In certain situations, the tailings excavated from the open pit are stored directly by the excavator in the exploited space, forming internal dumps.

For this purpose, giant excavators are used with buckets of tens of cubic meters and booms over 100 m long. This technology allows the exploitation of thin layers of coal or manganese, with a discovery ratio of up to 30:1.

In other situations, transshipments with cantilevered arms or transshipment bridges equipped with belts are used to deposit the tailings in internal dumps, a system that presents indisputable economic advantages compared to the exploitation methods with the transportation of tailings to the dumps, fig.18.

In favorable conditions of coal deposits and especially lignite deposits, a mining method can be applied in which the overlying rocks is divided into several steps, of which the upper ones are extracted with the help of bucket-wheel excavators and by means of large ferry bridges reaches the internal dump, and the waste from the last steps are extracted with a dragline and deposited in the internal dump, fig.19 [4,8].

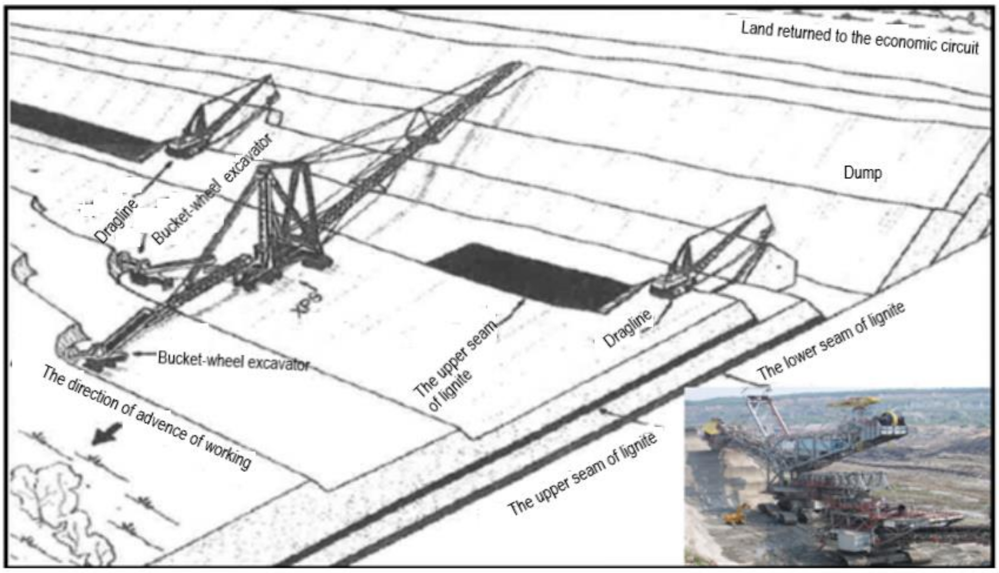

Fig. 19. Exploitation method with direct deposition of part of waste rock in the dump and with the passage of the second part in the internal dump

Transport by rail, which requires low gradients, large radii of curvature and long routes, is less and less used in large open pits, instead transport by trucks and rubber bands mounted on the ground is more and more practiced.

Many open pits in the world with productions of millions and tens of millions of tons annually are equipped today, exclusively, with 60, 100, 120tons trucks, which work on roads built on slopes of up to 15%.

More and more open pits whose objective is the extraction of rocks and useful mineral substances of low and medium strength, non-abrasive, use continuous transport with the help of rubber belt conveyors mounted on the ground, to the detriment of railway transport, fig.20.

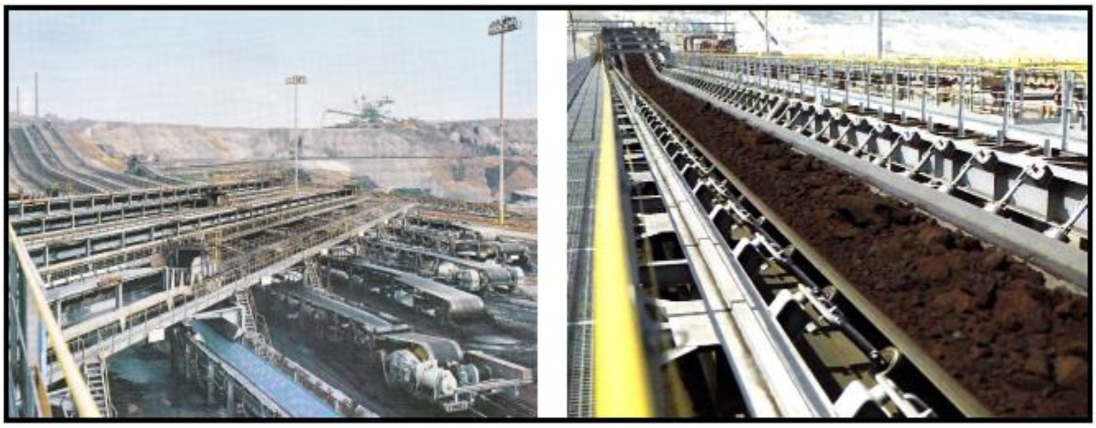

Fig. 20. Continuous transport with the aid ground mounted rubber belt conveyors

Important progress has been registered in the application of mathematical calculations and the widespread introduction of electronic computers, both in the design and in the management of the technological process of quarries. With the help of new calculating machines, the optimal dimensions of the exploitation fields are determined to date, the exploitation depth in the quarries, the most appropriate solutions for opening and exploitation, the stable slopes of the quarries, the appropriate solutions for drying the deposits to be exploited, etc.

Since it was found that the cost price decreases with the size of the production capacity, today quarries are designed with increasingly large production capacities, which reach tens of millions of tons of coal or ores per year.

During the last five decades, special attention has been paid to the drying of deposits located in difficult and very difficult hydrogeological conditions. The problem being very important for the smooth running of the exploitation today, the drainage works were modernized by using, above all, large diameter drainage boreholes equipped with submersible pumps.

In the last decades, there is an increasingly sustained concern for the return to the economic circuit of lands degraded by current exploitation and occupied by landfills. In this sense, the necessary technological stages for the mining redevelopment and the possibilities of recultivation of the lands have been developed.

The development of the economy of our country, in the second half of the 20th century, also attracted a considerable increase in the need for raw materials, and as a result, the problem arose of extracting large and very large productions of various useful mineral substances through quarries. especially lignite, iron ores, complex ores, non-metallic ores, building materials

Thus, in the last 50 years, the following were opened and put into operation, through up-to-date works [4]:
- the lignite deposits in the Rovinari, Motru, Husnicioara, Berbeşti-Alunu and Baraolt-Căpeni basins,
- complex ore deposits from Şuior - Baia Mare,
- the iron deposits from Căpuşul-Mic,
- bauxite deposits in the Padurea Craiului Mountains,
- the barite deposits from Ostra and Somova-Cortelu,
- the kaolin sand deposits from Aghireşu-Cluj,
- the limestone deposits from Bicaz, Lespezi, Săndulesti, Pietreni, Mahmudia,
- sulfur deposits in the Călimani-Harghita Mountains,
- the bituminous and coal shale deposits from Anina,
- the banatite and copper andesite deposits from Moldova-Noua and Roşia-Poieni,
- the lignite deposits in the Jilţ basin,
- part of the gold deposits from Săcărămb, Certej and Roşia Montană.

In the same period of time, a multitude of useful rock deposits, with various uses in the national economy, were prospected, explored and put into operation through daily works.

Table 4. Mining methods and the main technical-economic indies achieved in open pits

Classes of exploitation methods	Groups of exploitation methods	Heading face, m/year	Output per man-shift on discovery, %	The cost price of 1m^3 uncovered, %
I. Direct deposit of tailings in dumps methods	1.Direct deposit of waste rocks in internal dumps in one regain methods	200-400	120-130	55-65
	2.Direct deposit of waste rocks and partial or total re-excavation of it from internal dump methods	180-208	100	100
II. Passage of waste rocks to dumps methods	1.Passage and storage of waste rocks in a bench of the dump methods	200-250 100-180	85-90	110-120
	2.Passage and storage of waste rocks in two or more dump benches	200-250 100-180	85-90	110-120
III. Transport of waste rocks to dumps methods	1.Transport of waste rocks to internal dumps methods	150-200 50-100	85-90	110-120
	2.Transport of waste rocks to external dumps methods	100-150	25-29	185-300
	3.Transport of waste rocks to internal and external dumps methods	100-150	-	-
IV. Intermodal methods	1.Partial storage of waste rocks in internal dumps and partial transport of waste rocks to dumps methods	60-120 200-300	23-30	250-290

	2.Partial passage of waste rocks in dumps and partial transport of waste rocks to dumps methods	150-250	20-30	225-275
	3.Passage of part of waste rocks and storage of the second part of waste rocks to internal dumps methods	100-150	-	-
V. Special methods	Exploitation methods of lens and blankets deposits, of sheet deposits with shallow and medium depth without uncover of enclosure formation, of peat deposits, of bed deposits and of ornamental rocks deposits	-	40-45 hydraulic soil and rock dislocation	189-376 hydraulic soil and rock dislocation

In the open pits that will open in the future in Romania, new work schemes and methods will be consistently applied with the use of modern high-tech equipment, for the mechanization of the main operations in the technological production process, which will lead to obtaining productions and high productivity, thus reducing the cost price and creating optimal conditions for labor protection and rational exploitation of deposits.

The intensity of exploitation of a deposit in a mining field and the volume of production achieved is a direct function of the exploitation method applied. At the same production, depending on the exploitation method used, different lengths of the work fronts and of the route on which the waste are passaged or transported appear necessary. The shortest route is carried out by exploitation methods with the direct storage of waste in the exploited space, and the longest route is imposed by exploitation methods with the transportation of waste to external dumps.

The cost of extracting useful and waste in the working fronts does not depend on the exploitation method applied and can be considered as having a somewhat constant value. However, the real productivity of excavators is all the greater as their operation is more independent and is not linked to the mode of movement and the regularity of the operation of the transport device. This makes the respective excavation and loading expenses lower for exploitation methods without the use of means of transport, where the coefficient of use of excavators reaches maximum values.

The cost of forming dumps depends on the type of installations used for this purpose and is maximum in the case of ferry bridges and almost equal to the other processes and installations of landfilling.

The main characteristics of the exploitation methods in open pits and some approximate values regarding their technical-economic achievements are indicated in table 4 [10].

In all exploitation methods applied in open pits, the discovery and extraction of the useful works are carried out with extensive and intensive mechanization of the operations using: boreholes, excavators, loaders, equipment for passage and transport etc.

Work in the open pit is carried out on the basis of cyclical schedules, studied and established according to local conditions. According to these graphs, the technological processes take place in a certain period of time and in a certain order.

Based on the partial graphs determined for different works, a general graph or a complex graph is drawn up regarding the activity of a work front, a sector and an open pit. The graphs are accompanied by data on the productivity of the machines per working day.

4. Technical-economic indicators obtained in open pits

The current mechanization of exploitations in our country and everywhere, is characterized from the point of view of the machines and equipment used, by two main particularities:
- through a great diversity of machines intended for the execution of various operations of the production process;
- through the impressive dimensions and very high installed powers that can reach the order of several thousand kilowatts.

The first particularity, i.e. the diversity of the machines, is conditioned by the type of rocks and useful mineral substances to be extracted, the physical-mechanical properties, the mode of action of the working body, the type of energy used, the movement system etc. [10].

The second particularity, i.e. the practically unlimited power of the machines in the current exploitation technological flow, is currently characterized, for example, by the following data:

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- the driving power of the drilling machines varies within the limits of 4-12 kW that use heavy pneumatic percussive perforators, and up to 300-500 kW rotary drills for drilling with roller hoes;
- the power of the power plants of excavators with a single bucket varies depending on the capacity of the bucket from 250 kW to 22,000 kW for a variation of the bucket capacity from 3 m^3 to over 150 m^3;
- the power installed in the case of continuous action excavators of the type with rotor and cutting buckets varies depending on the number of buckets mounted on the rotor and their volume from 200 to 15,000 kW;
- the contact electric locomotives used in open pits have powers of over 3,500 kW, and the high-capacity conveyor belts are driven by drive groups placed at both ends whose power can exceed 4,000 kW.

The diversity of types and powers used in surface exploitations is imposed by the variety of natural and technical production conditions, in which these machines are put to work.

We emphasize that the choice of an extraction, transport and storage technology in open pits is determined by three main factors, namely:
- the physical-mechanical properties and especially the strength of the useful mineral substance and the rocks surrounding and covering the deposit;
- the geometric and placement elements in the earth's crust of the deposit of useful mineral substance as well as the tectonics and micro-tectonics of the deposit with the highlighting of fault planes and minimum resistance;
- the reserves of useful mineral substance and their quality, which determine by their value the production capacity possible to achieve per year in the respective open pit.

Choosing the machines that will perform the operations from the technological flow is a decision of great responsibility, difficult to take, due to the following particularities of the activity in surface exploitation:
- the work fronts where the basic operations of the technological process of cutting and loading are performed are in continuous movement and together with them the entire equipment from the open pit moves;
- the transport schemes in the open pits are quite complicated, having many ramifications, loading and re-loading points and undergo repeated changes due to the movement of the work fronts they serve;
- deposit conditions are different from one deposit to another, varying within very wide limits. Moreover, in many cases the deposit conditions vary quite a lot within the limits of the same exploitation perimeter.

After studying the specialized literature and following and analyzing for years the economic achievements of the open pits that operated on the territory of our country, we reached the following conclusions regarding the values of the technical-economic indicators obtained in the open pits:
- the limit coefficient of discovery is between 4 and 25 m^3/t, according to the operating conditions and the mechanized means used;
- the effective average productivity of boreholes for drilling large diameter holes varies from 5÷10 m/change, in the case of extremely hard rocks, up to 30÷40 m/change in the case of rocks of medium strength;
- the specific consumption of explosive depends on the type of explosive and the strength of the rocks to be extracted:

• the average consumption of explosives in coal quarries is: 0.15 - 0.20 kg per ton of coal and 0.10 - 0.25 kg per cubic meter of barren rock;

• the average consumption of explosives in ore open pits ranges between 0.3 - 0.6 kg per cubic meter of rock or peacock-ore, depending on the strength for primary blasting, and for secondary blasting or crushing it is about 5% of the consumption made at the primary shot;

- the annual specific productivity of a mechanical shovel excavator varies between 150,000 - 350,000 m^3 per 1 m^3 bucket capacity, depending on the nature of the rock being excavated and the specific working conditions;
- the productivity of dragline type excavators can be adopted as a guideline according to the productivity of mechanical shovels, using the following coefficients for reducing the productivity of mechanical shovels: 0.82 for soft rocks, 0.80 for compact rocks, and 0.64 for hard rocks;
- the productivity of excavators with continuous action of the bucket type or with rotor and cutting buckets is approximately 100 m^3 of rock per hour of operation for every 100liters capacity of the bucket;
- the productivity of electric locomotives with a curb weight of about 100 tons is about 3000 t.km/shift at a route length of 3.5 km. Electricity consumption for this transport is approximately 0.15 kWh per t.km;
- the productivity per shift of dump trucks for one ton of loading capacity is approximately 100 t.km at a transport distance of 2.5 – 3.0 km. Fuel consumption in the case of Diesel engines is 5.0 – 6.0 liters per 100 t.km;
- the productivity of ore work per quarry is 15-40 t/post in useful mineral substance or 50-250 t/post or m^3/post in tailings (low values are variable in the case of hard rock extraction, of small productions per quarry, and in the case of the use of railway transport, and the higher values refer to the case of mining methods with direct

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storage of tailings in the exploited space and large productions per open pit). The productivity of work in the quarry depends on the volume of discovery works performed, the work technique applied and the organization of the works;
- the percentage composition of the cost price of the useful mineral substance by expenditure chapter, shows as follows:
  • works with explosives 15-25%
  • loading 10-15%
  • transport 40-50%
  • dumping 15-20%

In the case of soft rocks, the works with explosives are not executed, changing the percentage of other expenses accordingly.
- the total cost price of a ton of useful mineral substance varies widely, depending on the value of the discovery coefficient, the cost price of a m^3 of tailings and the cost price of a ton of useful, without taking into account the unit cost sterile;
- the losses of useful mineral substance in the mining process (extraction, loading and transport) in the conditions of useful formations without intercalations of sterile rock amount to 2-4%. In the case of the presence of such an intercalation, the losses increase even in difficult mining and geological conditions, they can reach 8 - 10%;
- losses in safety pillars and berms are determined for each individual case;
- the dilution of the useful mineral substance in deposits without sterile intercalations is 2-3%, and in the case of the presence of sterile intercalations, the inevitable dilution must be determined for each case separately.

To reduce the qualitative and quantitative losses of useful mineral substance, the following measures must be taken:
- the correct determination of the size of the angles of the slopes of the working and final steps;
- the correct establishment of the width of the work, transport and safety berms to avoid surprises;
- extracting all the rest of the pillars during the liquidation and closure of the quarry;
- systematic sampling of the useful mineral substance in the explored sectors of the deposit;
- the complete extraction of the useful mineral substance between the bedding and the roof, through a good cleaning with appropriate equipment;
- the application of selective mining and the appropriate equipment to extract the useful mineral substance of various qualities or in the case of the presence of sterile rock intercalations. In selective extraction, small step heights, crowding of research boreholes, excavators with small bucket capacity, expansion of cutting fronts and creation of reserves of various qualities of useful mineral substance in the quarry and in the deposits on the surface of the open pit must be adopted.

The practice of the execution of works in the quarry shows that the effectiveness of the surface exploitation of the deposits of useful mineral substances can still be increased by appropriate technical-organizational measures. Among the main measures to increase the effectiveness of daily work should be considered:
- execution of discovery works, with the use of powerful excavators;
- exploitation of the deposits with the application in appropriate conditions of the exploitation methods without the use of means of transport or the methods with the transport of rock in internal dumps, over short distances;
- the use of mining transport and auxiliary equipment of appropriate types and well-dimensioned powers;
- mechanization of the works with the use in the case of quarries with high production of technically perfected equipment - powerful probes for drilling holes with a diameter of 200-300 mm, of electric excavators with a bucket capacity of 10-15 m^3, of electric locomotives, of high-tonnage dump trucks (50-100 t) and transport with wide and high-speed belt conveyors (in the case of soft rocks);
- execution of works according to schedules for all work fronts and activity sectors;
- good organization of the topographical and geological service in the quarries, which has the obligation to control the quality of the useful mineral substance and to take measures to reduce losses and dilution;
- timely execution of extension exploration and drainage of the sectors to be exploited. The problems of good organization of exploration and drainage with the help of wells with deep pumps must be treated with special attention, because the safety and indicators of work in the pit, the reduction of losses and dilution, the fulfillment of tasks in terms of the quality of the substance largely depend on them useful minerals, increasing the stability of the slope of the steps and sides of the quarry, reducing the volume of waste works, etc.;
- the mechanization of the works on the formation of heaps with the application of the appropriate equipment;
- the widest possible use of machines intended for the mechanization of auxiliary works.

5. Conclusion

The future improvement of production processes and the organization of discovery and extraction works from open pits are the main measures for raising the production of useful mineral substances extracted through mining works.

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