PREOCCUPATIONS AND ACCOMPLISHMENTS CONCERNING THE USE OF EXPLOSIVES WITH A VIEW TO EXTRACTING HARD ROCKS

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At present, the industrial exploitation of hard and very hard rocks and useful mineral substances is almost exclusively done with explosives; other methods of extraction and detaching from massifs are only employed in the case when the use of explosives determines the cracking of the massif and, accordingly, the degradation of the rock.

During the last years, significant progress occurred in studying rock massifs as well as their physical, mechanical and elastic characteristics, in developing blasting technologies, and in assessing the results of blasting both at surface and underground. Remarkable performance has been attained in manufacturing explosives and means of priming, which determined the safety of sequential explosions and the close control of the energies provided by explosions.

The main stages of blasting engineering consist in: blast planning, site blasting and, finally, analyzing the in-site results; all these three stages may be rendered as a so-called pyramid of blast improvement (Fig.1).

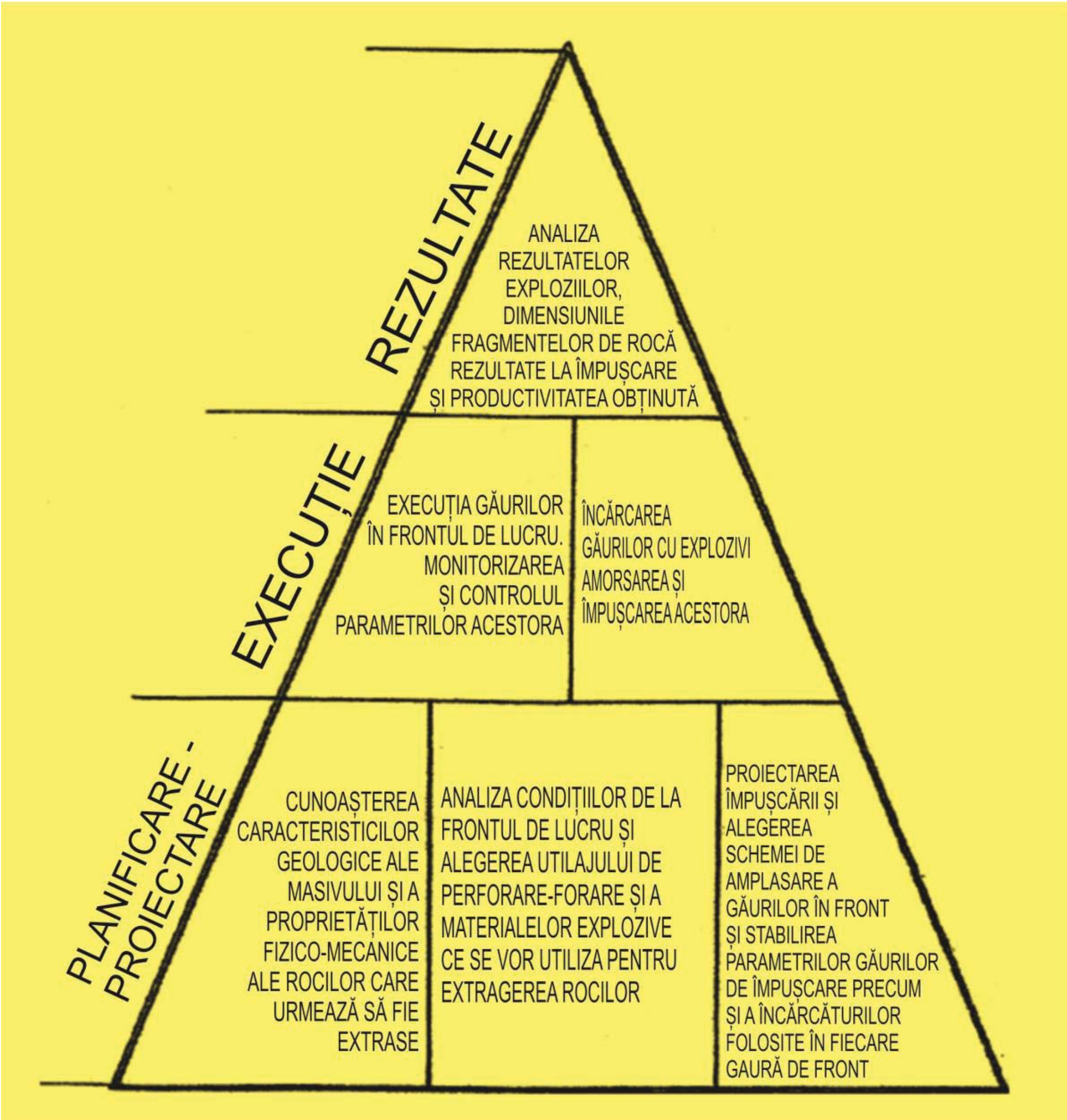

Fig. 1 *Pyramid of blast improvement*

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Blast planning and designing represents the basement of the pyramid, where the presentation and description of the rock massif and of the physical and mechanical characteristics of the rocks belonging to the work area are the basic elements that should be observed.

The analysis of the rock massif is a previous approach to be considered with a view to carry out a series of works that require the use of explosives and without which the correct designing and planning of blasting is not possible.

Both discontinuities within the massif and their origin should be known. Apart from the primary discontinuities of magma, sedimentary, and metamorphic origin, discontinuities having a tectonic origin, such as fractures, fissures, and traction fissures should be known (Fig. 2).

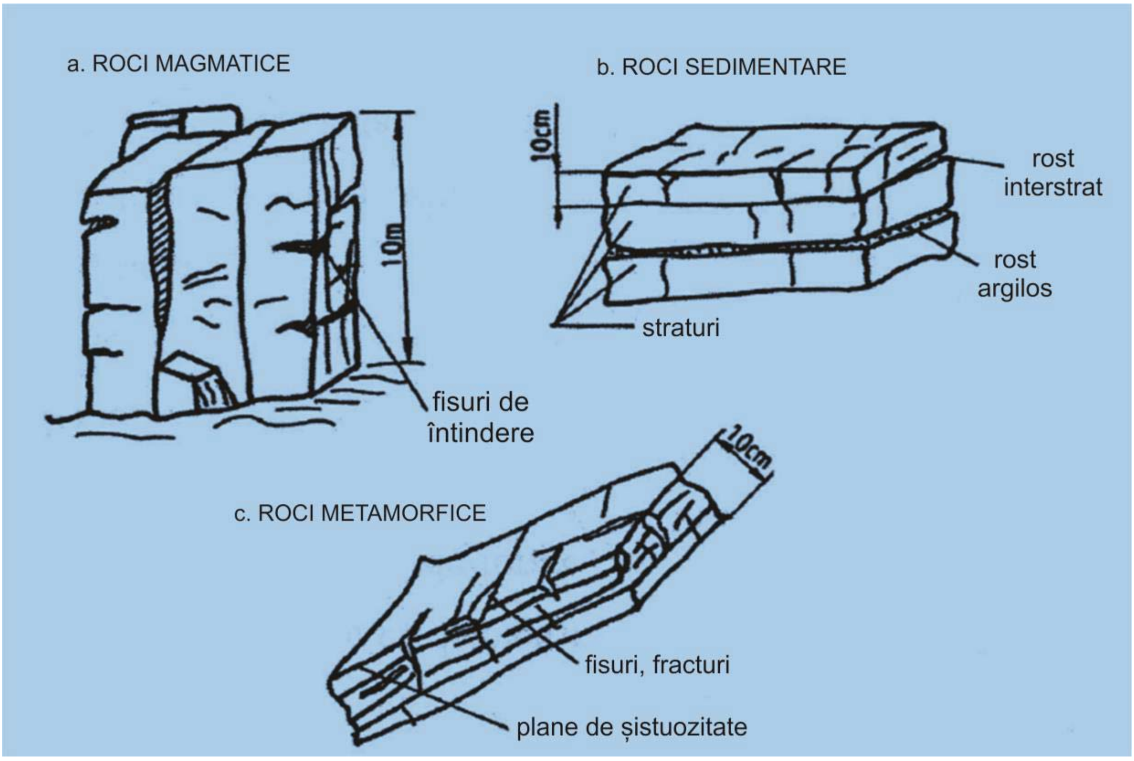

Fig. 2 *Primary discontinuities in rock massifs*

In the case of the quarries exploiting homogeneous magma and metamorphic rocks affected by discontinuities, the advancement of the work areas is going to be made perpendicular to the families of main discontinuities; in the case of sedimentary rocks, the advancement of work areas should be done perpendicular to the stratification plans (Fig. 3). In accordance, a good stability in time of the work areas is provided.

It is extremely important to accurately know the rock massif which is going to be extracted through blasting with a view to finding out the most suitable means of rock – explosive or explosive – rock coupling.

Due to their number, location, and disposal, the discontinuities within the massif influence the conception and carrying out of the blasting schemes.

The distribution of the explosives within the massif and the energy level of the explosions should match the geological characteristics of the massif as well as the physical and mechanical features of the rocks.

The initiation and the delay times between the initiations of the explosions of the various charges should be compatible with the mass of the rock and the charges of explosives employed.

It is very important, for blasts planning stage, to know in detail the physical and mechanical characteristics of the rocks to be blasted, which are going to influence the performance of the explosion. The main physical and mechanical characteristics that play an important part in the drilling and detaching of the rocks within the massif through blasting are the following ones: density, volumetric weight, porosity, compact character, breaking resistance at compression, stretching and shearing, strength, and abrasive feature. Meanwhile, one should also consider the elastic characteristics displayed through the static and dynamic elasticity module, Poisson coefficient, and deformation module.

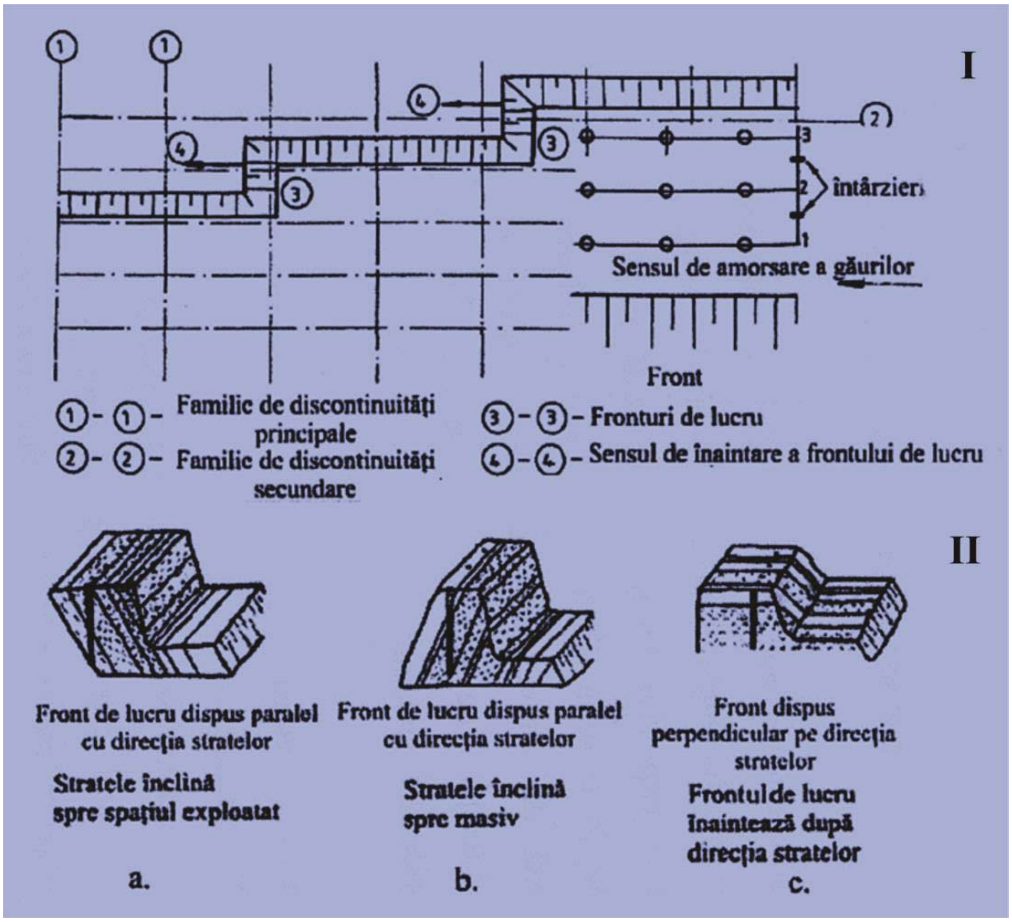

Fig. 3 *Disposition of work areas within homogeneous massifs with discontinuities and within layered massifs (I – Homogeneous massif affected by discontinuities; II – Layered massifs)*

Testing mainly occurs in specialized laboratories, on rock samples displayed as cylindrical drilling machines, extracted from the drillings made in the massif in accordance with the technique of drilling with continual mechanic drilling.

Meanwhile, the work area where blasting occurs should also be thoroughly known from the point of view of rocks location and geometric elements characterized by extension, height, width, inclining, etc.

In accordance with the geological complexity and difficulties specific to each area, site, mine or quarry and with the importance and thoroughness of previous researches, there are three stages that allow the recognition of the rock massif, whose complexity increases from one stage to another.

Analysis of existent documents. Quite often, such an analysis is neglected and, as a result, expenditures and labor costs increase together with a significant increase of the hours spent with a view to carry out something that has already been done.

Occasionally, the existing documents may be enough for the initial elucidation of the issues, provided that they are confirmed by a field research carried out by specialists in geology and geo-physics.

Land study carried out by specialists. This stage is essential for guiding the detail studies of the massif. Sometimes and mainly when carrying out restrained works, field researches made by one specialist might be enough so that the study of the massif ends with this stage.

Detailed specific studies. These are always required, especially in the case of mines and quarries owing to the fact that the previous stages do not allow the knowledge and precise description of the rock massif where explosives are going to be used.

In accordance, geo-physical measurements are required when drilling, collecting samples and carrying out various laboratory and in situ trials with a view to identifying and determining the values of the physical and mechanical characteristics of the rocks.

The structural features of the massif to be extracted should be well known together with its fissuring and compacting degree, the network of fissures in the massif and the manner of filling them with cementing and connective stuff, hydro-geological conditions, etc.

Rocks' characteristics play an important role in all the aspects connected with blasting performance. A first consequence of a good knowledge of the massif as a whole and of a detailed knowledge of its rocks, through improving geological researches by using classical methods and modern geo-physical ones, is the improvement of planning and blasting performance.

A correct planning of blasting requires detailed data regarding the characteristics and behavior of explosives and the features and behavior of the rocks when blasted.

There are several data about the first two aspects. Unfortunately, the information concerning rocks' characteristics are frequently extremely poor. This is due to the fact that in a series of quarries and mines, the features of the rock massif and of the individual rocks not only change between adjacent steps or work areas, but also between nearby mine or drilling holes.

It is clear that a solution to the issue might be the carrying out of a series of analyses of rocks' characteristics in each mine or drilling hole made within the massif. Today, such an operation does not occur; nonetheless, there is hope that within the near future these analyses become routine determinations within the drilling program. There are already producers of drilling equipment that provide the industry with drilling machines, which collect, store and transmit a series of data, such as: drilling speed, torsion effort, pushing effort, deviation of drilling hole, etc. At present, software products are developed with a view to strictly correlating the previously mentioned elements, which may be gathered in the field, with the characteristics of the rocks affected by the drilling works. Such a method represents an important step forward, as compared with the present situation, when few data are usually collected from the drilled holes.

Production drilling represents a difficult and expensive operation. The data collected during drilling determine a relatively small increase of costs, but, in exchange, provide the following: the modification of the networks of holes location, in the case rock requires such an operation, the modification of the depth or length of the hole depending on the strength and continuity or discontinuity of the formation to be blasted, and the calculation of the amount of explosive for each hole depending on the rock to be dislocated.

In the future, in order to precisely characterize the massif, drilling equipment is going to be equipped with mechanical and geo-physical sensors. These will provide data about the mass of rock in due time, while especially allowing the evaluation of a series of parameters, such as: rock strength, location and orientation of discontinuities within the massif, water flux, margins of mineralized areas and variation of the content of useful components, presence and character of sterile intercalations within mineralized structures, etc. All these data will be used as immediate input of blast mathematic model that allows the modification of the network of holes location in work areas. Meanwhile, the data collected will allow engineers to calculate the explosive charge for each hole and the recalculation of the temporal sequences of blasting, so that they are able to optimize the blasting process and to further improve the whole work process. As a result, a proper location of the holes in work areas is going to be carried out, depending on rocks characteristics, their proper charge with explosives, the maximum effect and safe control of detonation upon the massif.

The results of a blast largely depend on the quality of the holes and, implicitly, on the type and characteristics of the equipment that drill holes that are going to be loaded with explosives. Meanwhile, the fact that explosive energy is better transmitted to the rock when explosives completely fill the holes, determines the acceptance of the need for proper walls of the drilled hole.

Nowadays, in most cases, mine or drill holes, in quarries or underground, are made with perforation and drilling equipment, which operate in accordance with the rotating or rotating-hitting system. Worldwide practice of drilling in minerals quarries displaying large and very large production, they use rotating drilling with roller screeds, while stone quarries with thousands of tons per year use rotating-hitting drilling with striker placed outside or inside the drilling holes (Fig. 4)..

It is important to choose the best method and drilling equipment, which may be done through using the diagram in Fig. 5 as a guide.

The drilling devices and methodology employed play a very important role in the entire blasting process as the holes made in the rock should not display deviations, or, in the case such deviations exist, they should be as small as possible (Fig. 6).

Research and supervision of drilling quality should be a priority objective of the management and control technical staff in all quarries or mines owing to the fact that requirements in the field have to be acquired and supervised continually within all sites.

As far as the economic aspect is regarded, let's notice that drilling is expensive enough and represents about one third of the cost of explosive extraction.

Fig. 4 *General view of the drilling equipment in quarries*
a – Large size rotating equipment for drilling in large quarries
b – Rotating – hitting equipment for drilling in useful rocks quarries

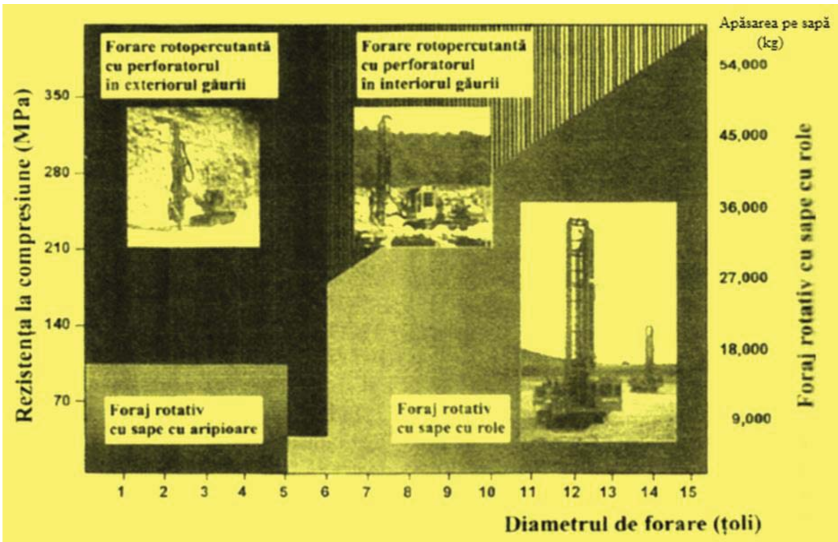

Fig. 5 *Applications of various drilling methods*

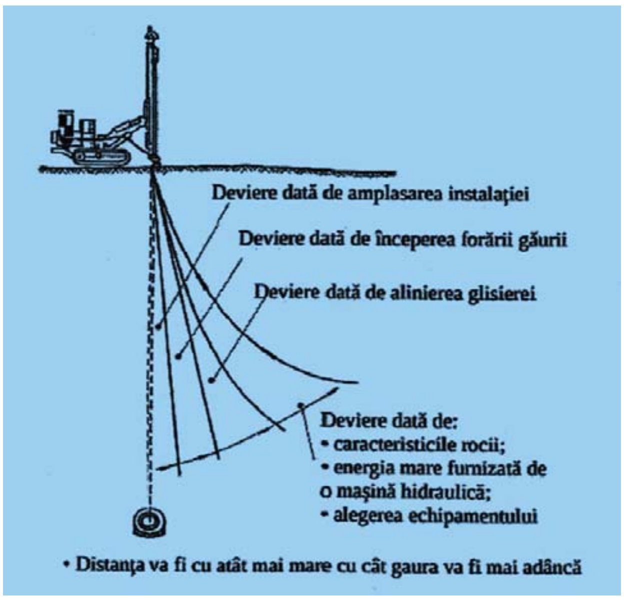

Fig. 6 *Drilling – various causes that determine the deviation of the drilling hole*

As for the stuff employed, there are two categories of products used for de-rocking works with explosives: explosives and priming means.

Explosives give the energy necessary for breaking the rocks and there are several types of them: classical explosives (granulated trotyle draughts, dynamites and astralites, etc.) and modern explosives, which consist in simple mixtures of ammonium nitrate and heavy oil, explosive gels and, more recently, emulsion explosives. Table no. 1 displays the standard composition of the main industrial explosives used at present in Romania.

As a rule, they use explosives that provide simple usage and safety, a minimal influence on the environment, an exact fracture of the work area, and minimal costs.

With a view to assessing explosives' capacity of dislocation and to their use under efficient and maximal security conditions, it is important to know their thermal, chemical, ballistic, physical, chemical, and safety characteristics.

There are a lot of parameters that should be observed, yet, the most important ones are the following: warmth, temperature and volume of explosion gases, pressure, specific energy, detonation speed, explosive's aptitude to transmit detonation, work capacity, products density and charge density, hygroscopicity, water resistance, etc.

Table 1 *Standard composition of the main industrial and common explosives used in Romania*

Explosive's appellation	Category	Standard composition	%
Granulated trotyle	Simple	Trotyle	100%
	With aluminum powder adding	Trotyle	85%
		Aluminum powder	15%
Dynamites	Plastic or goma	Nitro-glycerin	20-90%
		Ammonium nitrate	30-60%
		Cellulose	1-5%
		Wood powder	2-6%
		Trinitrotoluene	0-7%
		Aluminum	0-8%
	Powdering	Nitro-glycerin	10-15%
		Ammonium nitrate	30-80%
		Cellulose	1%
		Wood powder	2-10%
		Salt	0-50%
		Coal peat	0-5%
Astralites - Explosives enclosed in cartridges based on ammonium nitrate		Trinitrotoluene	10-15%
		Ammonium nitrate	65-85%
		Wood powder	0-5%
		Calcium stearate	1%
		Salt	0-20%
Mixture of ammonium nitrate and heavy oil	Simple	Ammonium nitrate	94%
		Heavy oil	6%
	With aluminum	Ammonium nitrate	88-92%
		Heavy oil	3-5%
		Sensitizer (aluminum)	5-10%
Explosive gels		Water	8-15%
		Ammonium nitrate, sodium or calcium	35-60%
		Sensitizer (explosive, aluminum, glass balls, etc.)	5-40%
		Various ingredients for jellification	2-5%
Explosive emulsions*		Water	8-15%
		Mineral ammonium nitrate	70-80%
		Heavy oil and emulsifiers	4-10%
		Sensitizer (chemical or glass balls)	0,2-5%

* During the last years, heavy explosive emulsions have also come out, which, in comparison with normal emulsions (mixtures in various proportions 20-80%, ANFO and emulsion for the rest), also contain 5-15% aluminum. Aluminum is a temperature hyper activator and, implicitly, an activator of explosion heat.

Meanwhile, priming products should be well known as they play an important part in the initiation of the detonation of explosive charges and in the control of the manner of issuing the explosive energy in time. The group of initiation means includes pyrotechnical and electrical detonating staples, Bickford tent, detonating tent, pyrotechnical relays, boosters, non-electric priming systems and electronic priming systems, which contain explosive substances characterized by an increased sensitivity and which easily detonate under flame, sparkle or shock. In accordance, shock dynamic wave or initiation impulse is formed; their energy determines the detonation of the charges of explosive substances.

Today, mining industry has at hand a series of priming systems, displayed by Fig. 7.

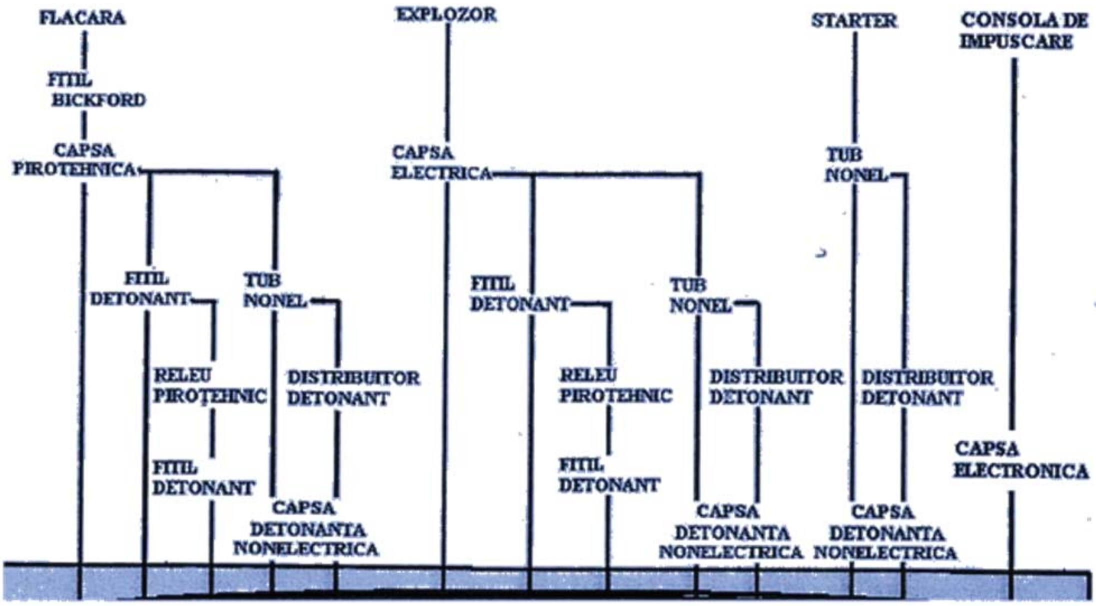

Fig. 7 *Priming systems of the charges of explosives used in quarries*

At present, pyrotechnical staples priming and Bickford tent as well as classic priming with electrical staples and various schemes for holes location and for connecting the staples is less and less applied.

Detonating priming tent and pyrotechnical relays as well as non-electric priming systems have entered the market and are used almost everywhere; during the last years, electronic staples priming has also been used.

These two categories of products, after a long period of stagnation, have witnessed a rapid evolution. In accordance with the preoccupations and achievements having occurred in the field up to the present moment, we may assert that the improvement and diversification of explosives types with increased blasting power, low costs and maximum transportation and manipulation safety is going to conquer the market.

In all cases, the explosives used should be considered depending on their blasting pressure and speed, which are measured today through very accurate methods, Fig. 8.

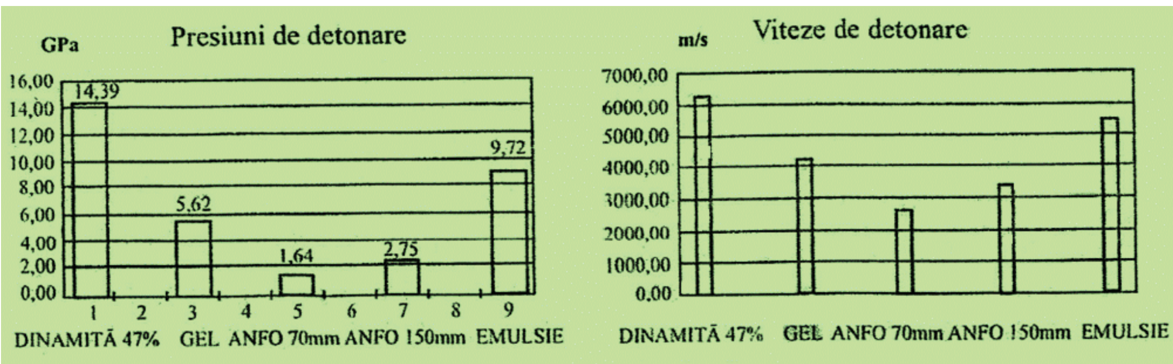

Fig. 8 *Blasting pressure and speed for the main industrial explosives*

The initiation of explosions is going to be carried out with absolute precision owing to the fact that, nowadays, adequate stuffs for this goal are at our disposal. Electronic staples make easier the sequential control of blasting, which is a critical parameter with a direct effect upon blasting performance.

Work techniques employing explosives used in quarries are totally different from those used underground. With a view to display, discuss and use explosives work techniques one should know: rocks breaking mechanism through explosion, the location schemes of holes in the work areas, the calculation of holes parameters, of charge and explosive concentration in the holes belonging to the front, the priming methods that enable the initiation of detonation and its deployment in accordance with precise delay times between holes and groups of holes.

The configuration of the holes in rows and of the rows in the blasting area is quite important as blasting should avoid: an inadequate fragmentation of the massif, a poor and improper distribution of blast energy in the massif, the dislocation of blasted rocks to a great distance from the front, the advanced fissure of the massif behind the front, etc.

Generally, drilling holes are vertically drilled or along an inclining that matches the embankment angle of the step.

The location of drilling holes along the front is made on one or several rows, Fig.9.

The location along multiple rows determines a more advanced fracture of the upper part of the massif's step, the decrease of road construction expenditures and the increase of excavators and drilling equipment productivity, Fig. 10.

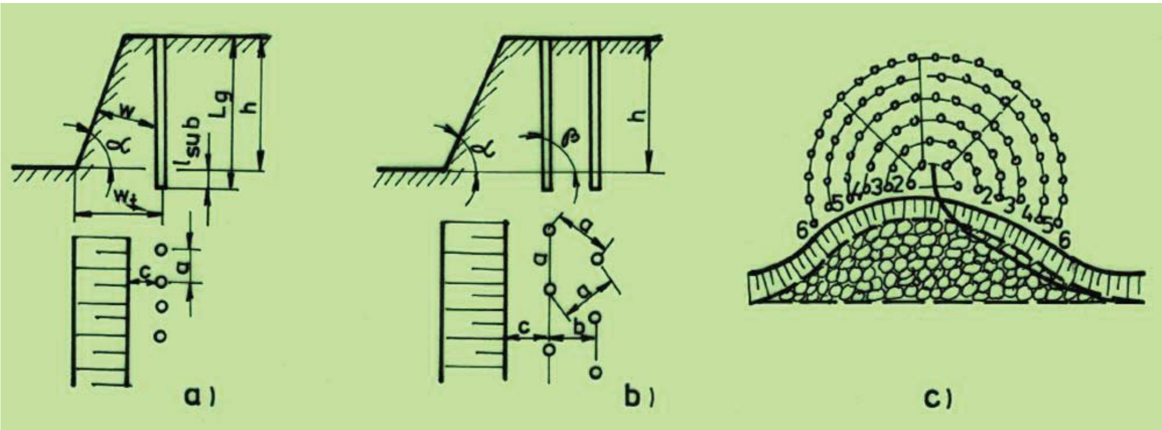

Fig. 9 *Location of drilling holes in accordance with the extraction steps*
a – along one row; b – along two rows; c – radial

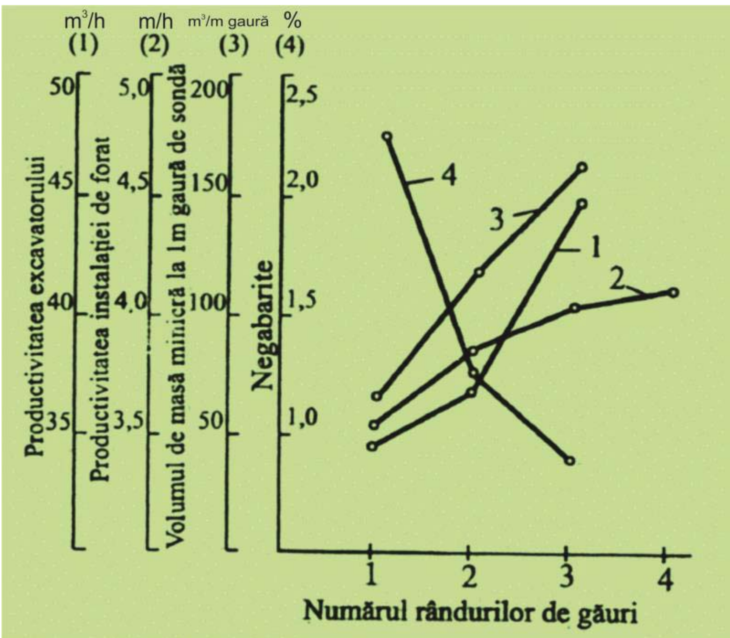

Fig. 10 *Efficacy of locating drilling holes on several rows*

The explosives charging of the holes should be mechanized and as accurate as possible. The manufacturing of explosives that are not sensitive to friction and shocks has determined the complex mechanizing of preparation and charging operations of the drilling holes. Meanwhile, in order to decrease expenditures, tamping of drilling holes should also be done mechanically with proper equipment and materials.

The location of initiation charges is done in accordance with levels calculated through planning.

Current practice in quarries shows that there are several manners of charging drilling holes with explosives: charging in continual column with the same explosive, charging in discontinue column with several types of explosives and charging in discontinue column with air intervals or buraj between the different parts of the charge, Fig. 11.

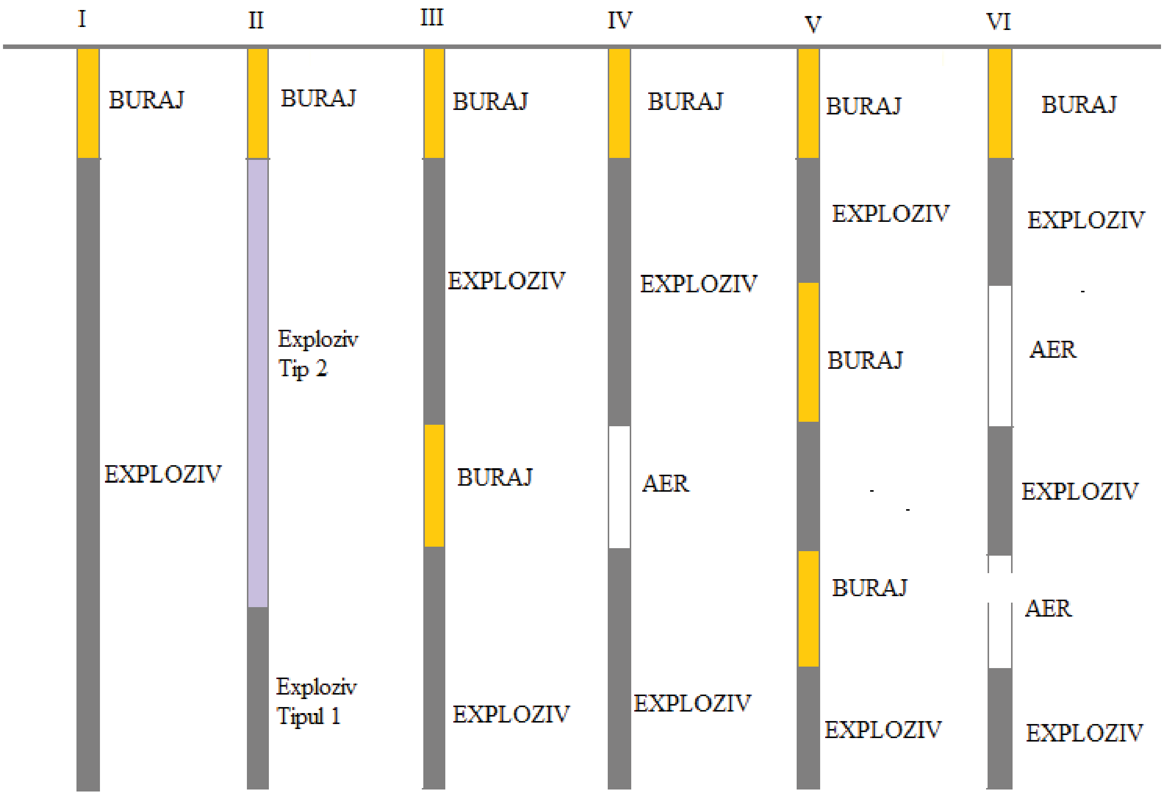

Fig. 11 *Manners of charging drilling holes with explosives*
I – Continual column – one explosive type; II – Continual column – two explosive types;
III – Discontinued column – one type of explosive – intermediary tamping;
IV – Discontinued column – one type of explosive – one air interval;
V – Discontinued column – two parts of tamping; VI – Discontinued column – two air intervals.

The monograph or the blasting plan represents an essential document that the manager of the mine, quarry or site should consult and approve. The plan settles the main parameters of the blasting planning and works, such as: location, depth and diameter of mine or drill holes, plan size and form of the location network of the holes to be blasted, characteristics, amount and distribution of the explosives for each hole, type of initiation, priming sequences, etc., Fig. 12. All these elements are calculated in accordance with the explosion's manner of action in the massif and the complex interactions among the parameters of the blasting.

Lately, a series of electronic calculation programs have come out on the market, which make work easier and increase the precision of the results.

In the case when one of the elements mentioned above lacks, the blasting planning is incomplete and several items remain unclear and settled.

It is important to observe that a blasting plan is not going to be implemented according to a rigid and definitive manner; if necessary, it should be modified so that it comes closer to the envisaged or desired results.

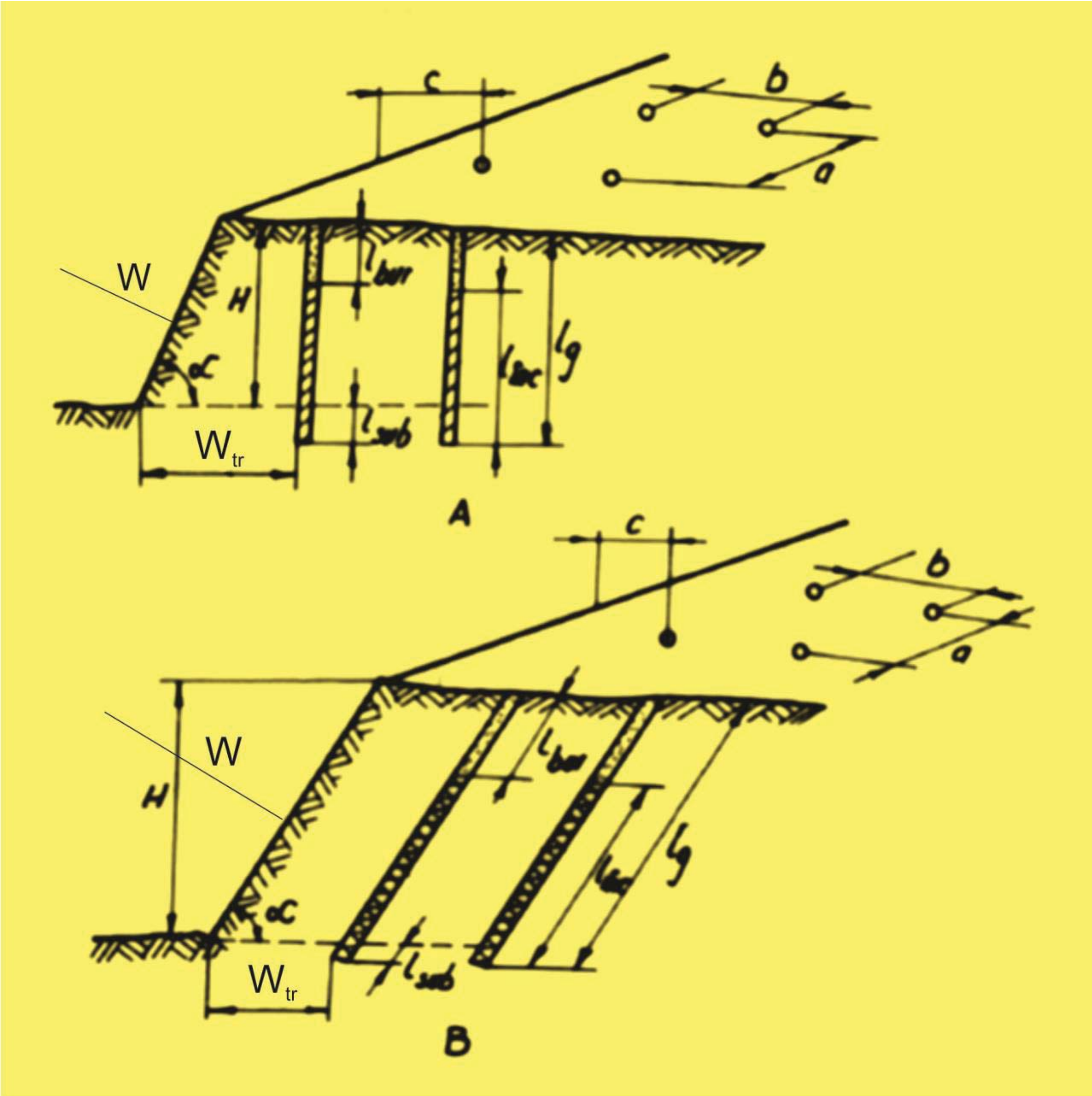

Fig. 12 *Parameters mentioned by the blasting monograph with drilling holes:*
A – vertical drilling holes; B – inclined drilling holes; W – anticipative; a – distance between holes;
b – distance between rows; c – distance at the edge of the upper side on the first row of holes;
l_{sub} – length of sub-depth; l_{bur} – length of tamping; $l_{înc}$ – length of explosive column;
lg – length of drilling hole; α – inclination of the embankment; H – height of the step

Table no. 2 shows a simple and easily applicable variant for the calculation of drilling holes and their location on the step, used with positive results for monographs or blasting plans in quarries.

In the field of road and railroad construction, where debris not always signifies a very large volume, the results of the first blasting should be accurately monitored and action should be undergone in the case changes of the blasting plan and the work system should be done.

More than 50 years ago, the issue of finding a work method in the case of explosives use in mining and other fields of activity was raised with a view to determine proper and stable excavations, which would less affect the rock massif around the works.

Researches and practice in the domain managed to outline a series of special blasts, the so-called contouring blasts, among which we may mention:

- Pre-decoupage pre-fissuring blasting;
- Blasting with smooth walls;
- Amortization blasting or small charges blasting;
- In-line perforation;

Table 2 *Examples of calculation of the parameters of blasting holes and their location on the step*

	PARAMETERS			Source	Values used for calculation	Mathematical formulas used	Results of calculations	Accepted when calculating
	Appellation	Unit	Symbol					
1	Height of step	*m*	*H*	given	15,000	-	-	-
2	Diameter of blasting hole	*m*	*D*	given	0,381	-	-	-
3	Inclination of blasting hole as compared with the vertical	*grade*	β	given	20,000	-	-	-
4	Explosive appellation	-	-	given	AM_1-AMFO	-	-	-
5	Energy of explosive	*cal/g*	Q_{expl}	given	885,000	-	-	-
6	Method of charging	-	*Mec / Man*		Mec	-	-	-
7	Explosive's density	g/cm^3	ρ	given	0,85	-	-	-
8	Charge density	g/cm^3	Δ	calculated	-	$\Delta=(1\div1{,}1)\rho$	0,935	-
9	Rock's density	g/cm^3	γ	given	2,8	-	-	-
10	Ratio a/W_t	-	*m*	calculated	1,3	-	-	-
11	Sub-depth	*m*	l_{sub}	calculated	-	$l_{sub}= 0{,}3W_t$	3,391	-
12	Length tamping	*m*	l_{bur}	calculated	-	$l_{bur}= 0{,}7W_t$	7,9	8,00
13	Error of alignment drilling deviation	*m*	*F*	calculated	-	$F= 0{,}05+0{,}017H$	0,305	-
14	Line of strength at hearth - theoretical	*m*	*W*	calculated	-	$W = D\left(\frac{Q_{expl}}{30}\right)$	11,303	11,50
15	Line of strength at hearth - real	*m*	W_{tr}	calculated	-	$W_{tr}= W - F$	10,998	-
16	Distance between holes	*m*	*a*	calculated	-	$a= m \cdot W_{tr}$	14,297	14,50
17	Length of blasting hole	*m*	L_g	calculated	-	$L_g = \frac{(H + l_{sub})}{\cos\beta}$	19,571	19,60
18	Line of strength at hearth really corrected	*m*	W_{trc}	calculated	-	$W_{trc} = \frac{W_{tr}}{\cos\beta}$	11,50	-
19	Volume of a blast	m^3	V_g	calculated	-	$V_g = L_g \cdot \frac{\pi D^2}{4}$	2,235	-
20	Volume of charge	m^3	$V_{înc}$	calculated	-	$V_{înc} = (L_g - l_{bur})\frac{\pi D^2}{4}$	1,323	-
21	Volume of tamping	m^3	V_B	calculated	-	$V_B = V_g - V_{înc}$	0,912	-
22	Weight of the explosive in the hole	*kg*	G_{expl}	calculated	-	$G_{expl} = 1000 \cdot \Delta \cdot V_{înc}$	1236,544	-
23	Delivered energy	*Kcal*	*Q*	calculated	-	Q = Gexpl · Qexpl	1057245,12	-
24	Volume of rock obtained	*m3*	*VR*	calculated	-	VR = a · Wt · H	2501,250	-
25	Rock's weight	*tone*	*GR*	calculated	-	GR = VR · γ	7003,500	-
26	Consumption of explosive	*kg/m3*	*q*	calculated	-	$q = \frac{G_{expl}}{V_R}$	0,494	-
27	Consumption of explosive	*kg/tonă*	*q'*	calculated	-	$q' = \frac{G_{expl}}{G_R}$	0,177	-

The use of these work methods have a direct influence upon:

- Labor security and time use of the works;
- Stability and maintenance of the works during their use;
- Visual impact of the works upon the area they cross.

Blasting technique is nowadays applied in new domains, among which we should mention: demolition of civil and industrial buildings, deepening and widening of navigable water routes, extraction of woods and tree roots, ice breaking, etc. Among the category of the above mentioned works we should stress demolition works, which, during the present stage of modernizing and enlarging the old productive capacities and of urbanization, own an increased part.

As a rule, depending on needs, civil or industrial buildings should be partially or totally demolished; in some cases, only parts – made of cement, concrete or reinforced concrete - of the building elements must be destroyed.

Owing to the decreased consumption of time and labor and to the low level of expenditures, demolition and enlargement of navigable water routes through blasting works have become the best working methods that also provide an increased level of security.

The use of the blasting technique in these fields has lately been used more frequently in such domains and has also become more sophisticated. The close proximity of buildings and their protection against the fragments resulting from blasting, maintaining the functioning of production processes, preserving circulation in the area immediately after blasting, seismic protection of neighboring constructions are only a few examples of issues that should be settled in the field of special blasting.

In accordance, with a view to carrying each blasting a blasting technical planning is drawn out, which, besides the solution it asserts, also includes the safety standards and the standards for the protection of the environment. Each construction represents a special case and the calculation of blasting parameters should be adapted to each particular situation. Owing to the fact that in most cases works are implemented in inhabited areas, a special attention should be paid to the prevention of accidents that concern civil population.

The charge required for blasting certain parts of constructions depends on the type of the explosive used, on the stuff to be blasted, on the construction that should be demolished and on the geometry of holes location. The efficacy of blasting is, at its turn, dependent on the ratio between geometrical parameters: anticipant, distance between the holes of the same row and distance between the rows of holes, number and size of explosive charges as well as the type of tamping and initiation.

The monitoring and control of the works represents, for the technical staff, an important task as the drawing out of the blasting monograph.

In fact, they are supposed to carry out a series of verifications with a view to confirm and guarantee the results they are going to obtain and to avoid conflicts and misunderstanding with the unit's management.

At the beginning of the works: they examine the proposals of the planner and of the unit's management; they check having taken into account all general and specific standards in force; they check the agreement concerning the general organizing and functioning of the site; they check and express their agreement upon the results of experimental blasting.

During the works: they monitor and control current blasting, pre-cutting or smoothing blasting, depending on the case; check the stuff resulted from blasting for a possible use of it; check the profile of the mining works or of the new embankment resulted after blasting; checks the seismic effects of blasting and the general effects upon the environment.

The evaluation of the results of blasting is made through rapid filming that allow the registration of the manner of breakage and of throwing the rocks from the front; the weak area of the massif where the rocks are projected to very large distances due to the blast of the explosion and in the final stage the arrangement of the stuff as a pile ahead of the work area.

Photo analysis is one of the most recent methods owing to which the photographs of blasted rocks are analyzed on computer through image processing techniques.

Films and photographs may be used to evaluate the results of the explosions and to compare explosions.

The general evaluation of the results of blasting may be done through monitoring the performance of charges, transport and mechanical breakage of extracted rocks.

Meanwhile, the evaluation of the blasting process may be done through the analysis of the efficiency of the equipment for mine or drilling holes and of the degree of breaking the blasted massif.

Most practitioners in the field of extracting hard rocks with explosives consider that the examining of blasting cost or of extraction cost, which includes drilling and blasting, should not be dissociated from the cost of other operations necessary for the work area, namely: secondary breakage of extremely large blocks, charging, transportation and primary breakage of rocks.

The accounting systems of monitoring and evidence employed make the economic analysis of these operations difficult and complicated, so that, up to the present, no complete study has been done and published in the country dealing with this topic.

In the case of quarries, where registering is more accurate, the cost of the main production operations (without opening and storage – delivery) ranges between the following variation limits as compared with the total cost:

- work area (drilling – blasting): 20-30%
- charging: 10-15%
- transport: 15-30%
- primary breakage: 25-45%
- breakage of extremely large rocks: 1-5%

Maximal values are typical for extreme cases.

The total cost of extraction in the work area varies from exploitation to another depending on: rocks characteristics, the method of extraction applied, breakage or absence of breakage of the stuff in the work area, characteristics of operations that are done downstream, etc.

In the case of quarries, where rocks are also broken, the cost of the work area varies between 20-30% from the total cost, where drilling is approximately equal, as far as the cost is concerned, with the cost of the explosive and of blasting operation.

The main objective of the operations of drilling-blasting is to fragment rocks to the granulometry required, with decreased costs while observing the technical specifications and the imposed security conditions.

The settling and approval of the monograph of blasting represents the first stage of the production process when extracting minerals and hard and very hard useful rocks from the massif. The operations at the work area consist in: drilling, blasting, breakage of extremely large rocks and sometimes even breakage of the stuff, loading and transportation of the stuff to the store-house.

In all mining exploitations, drilling and blasting are the first two basic operations that belong to an integrated production system and they are able to influence significantly the operations that follow, both from the point of view of productivity and of costs.

Fig. 13 shows that as fragmentation advances the drilling and blasting costs increase and breakage, loading and transport costs decrease.

The curve that results from putting together the two curves 1 and 2 displays a minimal point for those dealing with rocks exploitation look for.

In accordance, drilling and blasting of rocks should be studied in accordance with a global vision taking into account the rest of the operations applied to the stuff extracted from the massif during the technological flux.

A recent study in several quarries abroad that had as an objective the extraction of eruptive rocks show a variation of the costs according to those displayed by Fig. 14.

Finally, we may assert that the introduction of new technologies in an economic unit requires the decrease of exploitation costs, on the one hand, but brings supplemental costs connected with technology. The total cost of the exploiting operation represents the cost of technology plus the cost of exploitation. The level of technology efficiency varies from one mine to another. The optimal technology for a mine is the one that determines minimal global costs, as Fig. 15 shows.

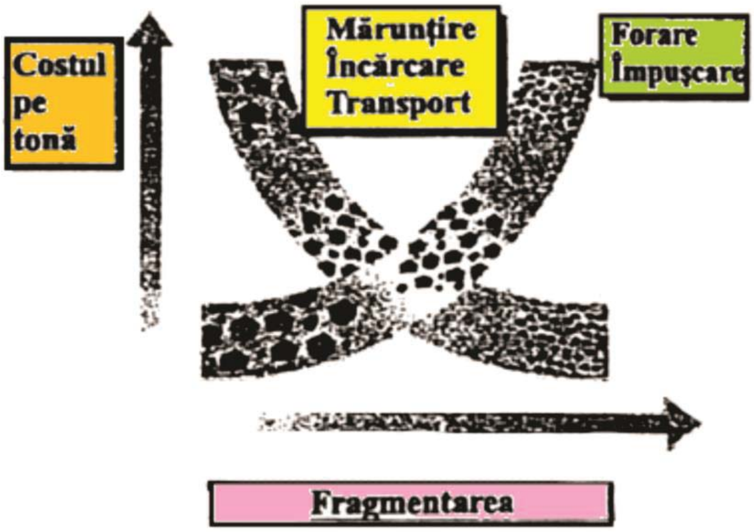

Fig. 13 *Variation of the costs of the operations in the work area correlated with the degree of rocks fragmentation*

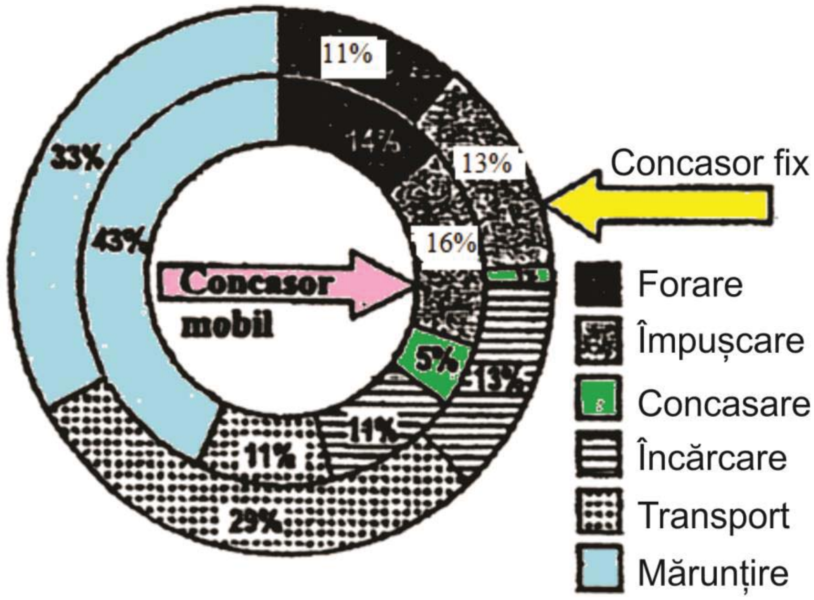

Fig. 14 *Typical distribution of costs in hard rocks quarries*

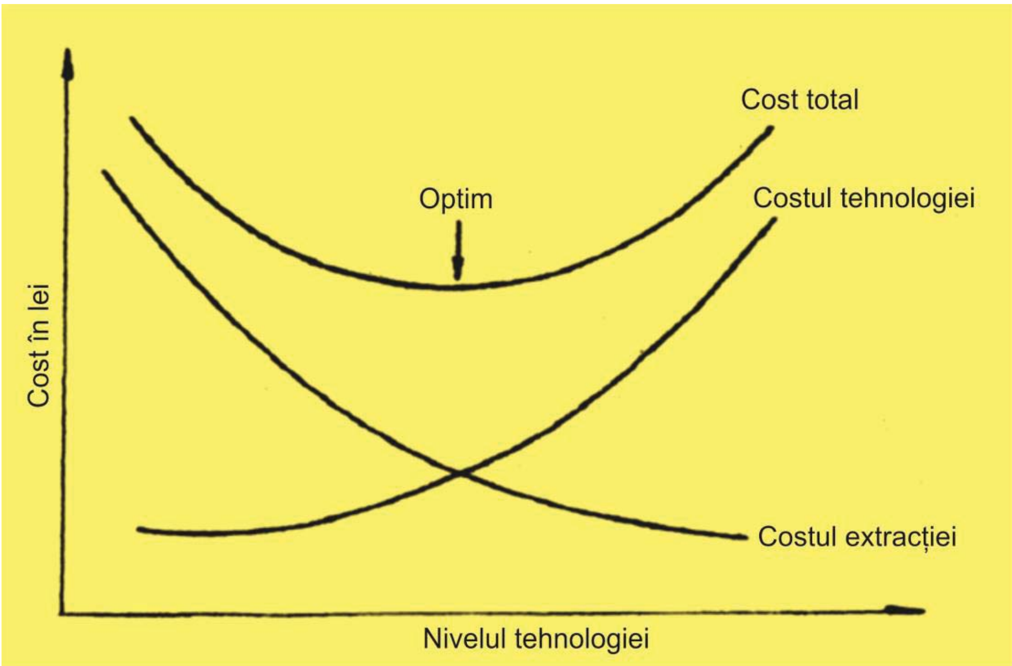

Fig. 15 *Optimal level of mining technology*

We are able to show that depending on the work conditions, the nature and hardness of the rocks to be dislocated, the method of exploitation applied, the geometrical elements of the work area, etc., the mining extraction with explosives is done in accordance with the following methods: extraction with explosives placed in usual mine holes, extraction with explosives located in drilling holes, extraction with explosives located in blasting chambers and combined extraction with explosives located in blasting chambers and drilling holes.

The quarry exploitation of the deposits of useful mineral substances through the use of the energy of explosives and breakage on the public works sites with explosives has a tremendously negative impact on the environment. The intensity of the impact depends on the amount of explosive used for a blasting, the most unfavorable situation occurring in the case of the massive blasting with large amounts of explosive.

In short, the impact of blasting upon environment may be perceived through:

- pollution of the air with dust and gases;
- rocks throwing from the work area;
- a supra-pressure of the aerial shock wave in the front;

- seismic effects
- noise pollution through vibrations and noise.

Each of these elements has a certain effect upon environment and requires a series of specific measures with a view to decrease the impact, so that influence parameters range within certain acceptable margins. The solutions and measures taken in order to diminish pollution degree upon environment should match the criterion of minimal costs under circumstances of maximal efficacy.

Besides the consequences upon the industrial and civil constructions and upon environment in general, the use of explosives required the outlining and approval by the legislative organisms of a series of very important rules that mainly targeted two objectives:

- an objective of public security, which emphasizes the conditions of detaining and using the explosives as well as the conditions of protection during the blasting works;
- an objective of individual security for those who manipulate explosives due to the fact that, in case of accident, such events are always serious.

Reglementările în vigoare sunt importante şi trebuie cunoscute de fabricantul de explozivi, de cel care face transportul acestor materiale şi de utilizator.

Stipulations in force are important and should be known by the manufacturer of explosive substances, by those who transport such stuff and by the user.

As a conclusion we should stress the fact that **rock blasting is and will be, at least for 2 or 3 decades, the main method for breaking hard rocks,** despite all deficiencies and drawbacks implied.

We expect that within 2 or 3 decades, owing to a better knowledge of the rock massif and through the use of the latest accomplishments of science and mining technique, basic operations, such as massif extraction, charging and transport of hard and very hard rocks as well as their processing is done through automated systems.

Most devices which are going to be included within the technological chain will be conceived so as to continually function and to provide high productivity and increased reliability. The functioning and ware of equipment’s components will be continually checked, which allows the elimination of unpredicted malfunctioning and stagnations within the production process.

Conclusions

With a view to deploying, under efficient and security conditions, blasting works, it is necessary to know the geological and mining conditions under which exploitation occurs as well as the security standards required for the use of explosive stuff and initiation means as well as the influence of a series of external factors upon them, the influence of explosives upon environment and a series of aspects regarding the economic efficiency of explosive works.

The researches undergone during the last decades in the field of mine blasting have had as a result the introduction of a series of procedures and work technologies that resulted in a high degree of energy of explosive substances, the carrying out of profiled excavations, the obtaining of works with smooth and stable walls for different categories of rocks, the intensification of works carrying out and of the extraction of ore, the more efficient and continual organizing of production, etc.

The continual development of mining technologies is provided by the rapid circulation of data and their immediate implementation into practice.

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