EXPLOITATION AND CAPITALIZING OF NON-METALLIC USEFUL MINERAL SUBSTANCES IN ROMANIA

Dumitru FODOR, Ioan Călin VEDINAŞ***

Abstract:
The hereby paper emphasizes the importance and development of non-metallic substances mining in Romania, including available non-metallic deposits, implemented and possible future exploitation methods as well as maximal production amounts to be reached in the case exploitation is resumed.
Key words: *deposit, non-metallic substances, exploitation methods, work technologies, etc.*

1. Introduction

During the inter-war period Romania comprised only a few non-metallic mining units, which displayed a low degree of mechanization and processing of raw mineral materials and whose production was poor and inferior in quality.

As a result of the use of non-metallic raw materials in various fields of material production, during the second half of the 20th century geological research of non-metal substances registered a growth throughout the country and a powerful industry exhibiting large exploitations employing modern exploitations and processing techniques developed, resulting in a newly derived branch of national mining industry.

In time, the derived branch of extracting and processing non-metallic useful mineral substances had to provide the raw materials required by the development of a series of industrial branches whose demands, both quantitative and qualitative, registered a continual increase and diversification.

Various non-metallic ores are used as raw materials and, consequently, are massively exploited and employed. Their preparation and transformation result in fundamental products for a series of industrial branches. Accordingly, out of sulfur ores, sulfur is extracted, which, at its turn, is an essential element of chemical industry. Rock salt represents a raw material for producing soda and chlorine.

A series of non-metallic substances are extracted from ores and are used as such, owing to their natural characteristics, for instance: they do not extract magnesium from talc, which, due to its features, is used as such.

Limestone is indispensable in metallurgy and the building materials industry. Fireclay and those of superior quality are more and more required by several technological processes.

In metallurgy, the development of ferroalloys is conditioned by the providing of a series of quartz and high quality quartz ores.

The industry of machines building employs large amounts of silica sands, bentonite, etc. required by casting technologies.

The industry of construction materials demands significant amounts of limestone, plaster, shale, tuffs, bentonite, and clays necessary in order to grow the production of cement, gypsum, lime, etc. Meanwhile, feldspar and kaolin are required in order to produce fine ceramics used in the field of constructions.

The levels of maximal production achieved during the last decades of the previous century by the Romanian mining industry vary as follows: rock salt (6,000,000 t/year); potassium salts (1,000,000 t/year); graphite rock (75,000 t/year); sulfur rock (3,000,000 t/year), alabaster and Celestine (7,000 t/year); barites (250 t/year); mica (100,000 t/year); asbestos rock (10,000 t/year); talc (120,000 t/year); pegmatite with feldspar (300,000 t/year); quartz (10,000 t/year).

The reaching of the previously mentioned production levels was possible owing to:
- The increase of physical production in the case of extraction units, the increase of the degree of exploitation and retrieval in the case of processing units;
- The exploitation and complex capitalizing of new perimeters comprising well-known deposits;
- The intensification of geological and technological researches with a view to identifying and capitalizing new deposits;
- The shortening of the research-planning-production cycle.

Nowadays, the technologies of extracting and processing non-metallic mineral substances have in view to:
- Obtain the lowest cost per product unit. As a result, they tend to implement, whenever possible, surface exploitation, in quarries, which is cheaper than underground exploitation;
- Obtain finite products displaying a higher quality than the quality of the ore, so that, in a large number of cases, they resort to the processing of the extracted ore;

** Prof.eng. Ph.D. University of Petroşani, Romania*
*** Eng. Ph.D SC Deva Gold S.A.*

- Permanently adapt to the requirements and exigency of the market, which implies a continual improvement of the quality of products.

The analysis of future tendencies shows that the need of non-metal raw materials is going to grow. During the next stage, the need of mineral raw materials will grow both in quantity and in quality.

In order to match the continually increasing requirements of the national economy for non-metal mineral raw materials, in the case of small or average ores, as those in Romanian are, significant efforts should be made both by research and by production and capitalization.

Consequently, let's stress that those products displaying a higher degree of processing and refining will prevail in the assortments to be produced.

At the moment, there are *more than one hundred non-metallic mineral substances ores* in Romania, as a result of the vast works of geological researches – prospecting and exploring – undergone throughout the country until the beginning of the 3rd millennium, according to table 1.

The analysis of the data contained by table 1 show that, at present, in Romania, they have displayed an important potential of non-metal substances, which is not yet capitalized and made available for the national economy.

Table 1 *Stages of capitalizing the registered ores of non-metallic substances in Romania*

GROUP OF SUBSTANCES / STAGE OF CAPITALIZING	TOTAL ORES	OBSERVATIONS
1. Haloids salts, d. c. :	**28**	Rock salt and potassium salt
- in exploitation	8	
- under research	3	
- activity stopped	17	
2. Non-metal substances, d.c.:	**84**	Graphite, sulfur, plaster, alabaster, Celestine, baritine, aragonite, cyanide, wollastonite, mica, talc, asbestos, feldspar, quartz.
- in exploitation	25	
- under research	19	
- activity stopped	40	

Observation: The ores under research or whose activity has been stopped do not possess definitive technologies of exploitation and processing according to the demands and requirements of potential beneficiaries.

2. Characteristics of capitalizing the deposits of non-metallic substances and ores

From a geological, technical, and economic perspective, the deposits of non-metallic substances display a series of characteristics as compared with the deposits of metal ores.

When exploiting metal ores, the fundamental criterion for capitalizing is the economic issue, which is the existence of a metal content that provides the profitability of exploitation and capitalization.

The introduction within the economic circuit of a series of ores exhibiting lower and lower contents compulsorily requires the improvement of extractive and processing technologies, which are going to result in decreased costs and, as a consequence, in a profitable operational result: -exploitation – processing – delivery of the finite product.

In the case of the deposits of non-metal ores and in order that they may be capitalized, such ores have to observe, first of all, a series of quality requirements, which, are eliminatory, in most cases. Sometimes, lacking to observe one of the requirements established according to quality standards, results in the impossibility of using such ores, no matter how cheap their obtaining might be. For instance, lacking to notice the requirements concerning tixotropy and rheological characteristics of kaolin makes their use for manufacturing fine ceramics impossible.

In the case when certain products continue not to display the quality requirements after they have been processed, the issue of manufacturing synthetic assortments is often taken into consideration. Such an approach incorporates the favorable characteristics of the substances coming from several deposits. For instance, the mixture of **bentonite** from Razoare and **kaolin** from Parva is perfect for manufacturing fine ceramics and paper.

Limestone exploitations have to face a series of hardships due to the impossibility of capitalizing important amounts of fine granulation limestone (0 ÷ 40 mm), which comes out of the flux of calibration-selection. Such hardships exert a negative influence upon the cost of marketable assortments. They require new dump locations, but the finding out of a series of capitalizing fields may determine the decrease of the cost of basic assortments.

For instance, in the case of Bistriţa-Pietreni – Govora – Ramnicu Valcea quarry, the 0 ÷ 40 mm assortment results in high amounts and is not used. Consequently, each year, this type demands larger

dump locations as well as a continual maintenance of the dumps.

The superior capitalizing of non-metallic ores requires, in most cases, the use of complex technologies of processing and enriching, such as: flotation, ultra-flotation, separation in a powerful electromagnetic field or in electrostatic field, which are, as a rule, accompanied by chemical treatments with a view to eliminating the damaging components and carrying out advanced grinding.

Certain deposits of non-metallic ores contain interesting concentration of rare and dispersed elements, which are not capitalized through the acknowledged processing technologies and, as a result, are to be found in finite products or in the sterile located in dumps and ponds. The choosing of proper processing technologies might determine the retrieving and capitalizing of such elements for the benefit of economic units and various industrial branches.

Besides the advantages of exploiting and capitalizing the deposits of non-metallic substances, let's mention a series of drawbacks:

- The mining and processing unites of non-metallic ores are located on large areas comprising the production and the storage of finite products, of dump goods, and sterile.
- The exploitation as well as the dry and chemical processing fluxes pollutes the air, the land, and the waters in the region. The decrease of the negative effects, of the area of affected lands, and the planning of recreation areas within the locations of the former quarries is still a topical issue among the other, much many and difficult, issues concerning the capitalizing of non-metallic ores in Romania's subsoil.

3. Non-metallic substances exploited in Romania

The geological complexity of Romania's territory associated with the varied petrography (igneous rocks, metamorphic and sedimentary rocks) determine the vast diversity of known non-metallic substances, exploited and capitalized in Romania as well as the perspective of identifying new accumulations worth capitalizing.

In time, beginning with the elements and ending with organic compounds, the following items were exploited and used:

Elements – sulfur and graphite.

Haloids salts – rock salt; potassium and magnesium salts; fluorite.

Oxides and hydroxides – quartz and brucit.

Carbonates – calcite; aragonite; magnetite and witherite.

Phosphates – apatite.

Silicates – cyanide; garnets; asbestos; talc and soap stone; glauconite; vermiculite and wollastonite.

Pegmatite – mica pegmatite; feldspar pegmatite; spodumene pegmatite.

Organic compounds – amber.

Fig. 1 *Location of non-metallic mineral substances and useful rocks deposits in Romania*

The knowledge of geological and genetic characteristics of non-metallic substances in Romania, their location (fig. 1), and the knowledge of the technical and mining exploitation conditions display a series of important conclusions:

1. Non-metallic substances are characterized by a large variety that turns Romania into a country rich in non-metallic deposits.

2. Depending on the amount of estimated and confirmed reserves, non-metallic substances are classified into three categories:

- **Abundant**, characterized by important reserves which provide internal consumption and offer export opportunities, too. Rock salt and cast belong to this category;

- **Sufficient**, characterized by sufficient reserves, which provide internal consumption. Sulfur, quartz, cyanide, garnets, mica and feldspar pegmatite, etc belong to this category;

- **Deficient**, displaying small reserves and frequently determining imports in order to cover the requirements. Potassium and magnesium salts, high quality graphite, baritine, magnetite, phosphates, high quality talc, etc. belong to this category.

3. In the case of non-metallic substances, it is necessary to correlate geological researches with technological researches with a view to establishing their use fields according to attainable quality parameters.

4. In order to decrease the imports of non-metallic substances, it is necessary to thoroughly capitalize all deposits, including those displaying a low quality whose features may be improved through processing; meanwhile, new possibilities for capitalizing might be identified.

Envisaged production, during the next years, in the case exploiting and capitalizing of non-metallic deposits of Romania are resumed, may attain the levels shown in table 2.

Table 2 *Level of maximal production attainable in Romania in the case of the main non-metallic substances (grossly extracted)*

No.	SUBSTANCE	ATTAINABLE PRODUCTION tons)	OBSERVATIONS
A	**Haloids salts**		
1	Rock salt	6,500	
2	Potassium salts	100	informing
B	**Non-metallic substances**		
1	Graphite rock	80	informing
2	Sulfur rock	3,300	
3	Plaster		
4	Alabaster	2	
5	Celestine	5	
6	Baritine	230	
7	Aragonite	5	
8	Wollaston	2	
9	Mica (pegmatite)	95	
10	Talc rock	120	
11	Asbestos rock	10	
12	Feldspar (feldspar pegmatite)	300	
13	Quartz	10	
14	Magnetite rock, magnetite serpentine	500	informing
15	Quartzite	300	
16	Limestone	52,000	
17	Dolomite	2,650	
18	Shale	6,000	
19	Kaolin rocks	450	
20	Kaolin argil	250	
21	Bentonite	475	
22	Diatomite	800	

4. Methods of exploitation and work technologies

The deposits of useful non-metallic mineral substances may be found in the crust as deposits, layers, strands, lenses, nests, impregnations, depending on the nature of the substance, on its genesis and forming conditions.

Depending on form, size, and location, of the deposits in the crust as compared with the

surrounding rocks and the topography of the region, their exploitation may occur as follow:
- Day exploitation is evident for the whole reserve of useful mineral substance in the deposit, fig. 2.
- Day exploitation represents an advantage only for a part of the reserves of the studied deposit, fig. 3;
- Due to the depths of the deposit, day exploitation is excluded, so that its exploiting will occur through underground mining, only.

While exploiting and capitalizing the deposits of non-metallic ores in Romania, all the three types of exploitation are encountered, depending on the specific conditions of each analyzed deposit.

The next mentioning is not going to refer to **salt deposits**, as they have already been studied by various, detailed, and valuable works dealing with the salt deposits of Romania.

Most of the deposits of useful non-metallic substances in Romania, depending on their form, size, and location in the crust as compared with the surrounding rocks and the topography of the region, are completely exploited owing to day quarries. The deposits of sulfur, baritine, plaster, cyanide, talc, feldspar, quartzite, limestone, chalk, dolomite, diatomite, various assortments of sands, etc. enter this category.

The method of exploitation that may be implemented in all non-metallic quarries is the "*Method of exploitation with the transport of rock dumps to external dumps*". Depending on the tilt deposits, the method of exploitation appears as in figures 4a – in the case of exploiting a broad tilt deposit and 4b – in the case of exploiting a narrow tilt deposit.

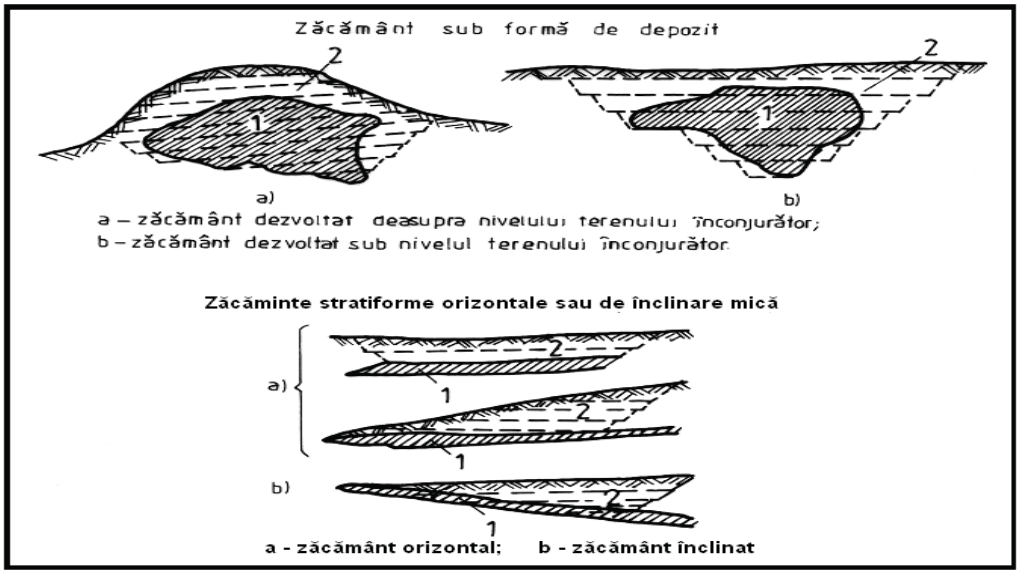

Fig. 2 *Deposits that can be completely exploited through day mining*
1- useful mineral substance; 2- surrounding rocks

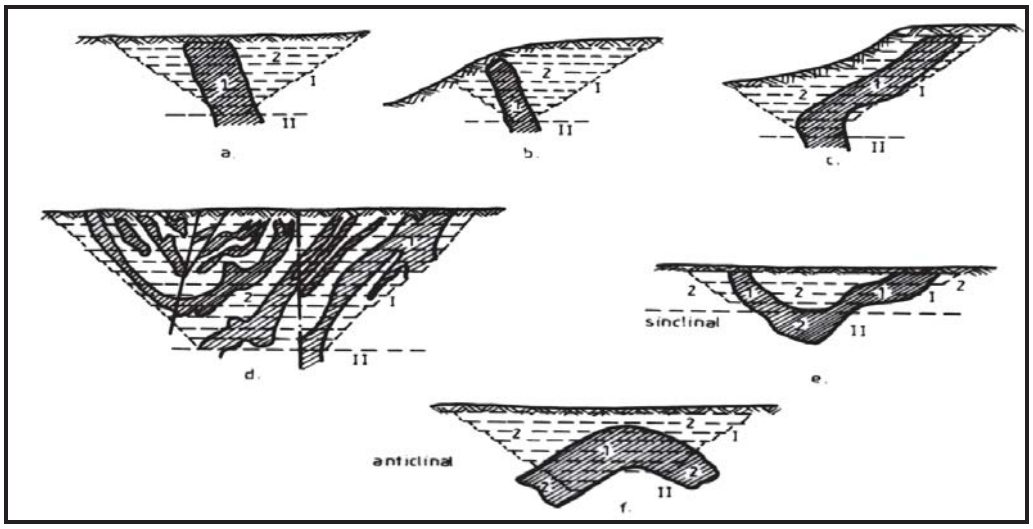

Fig. 3 *Deposits that may be partly exploited through day mining: a,b- large tilt deposits; c- average tilt deposit, hillside location; d,e,f- folded deposits.*
1- useful mineral substance; 2- covering rocks; I- day exploiting; II- underground exploiting.

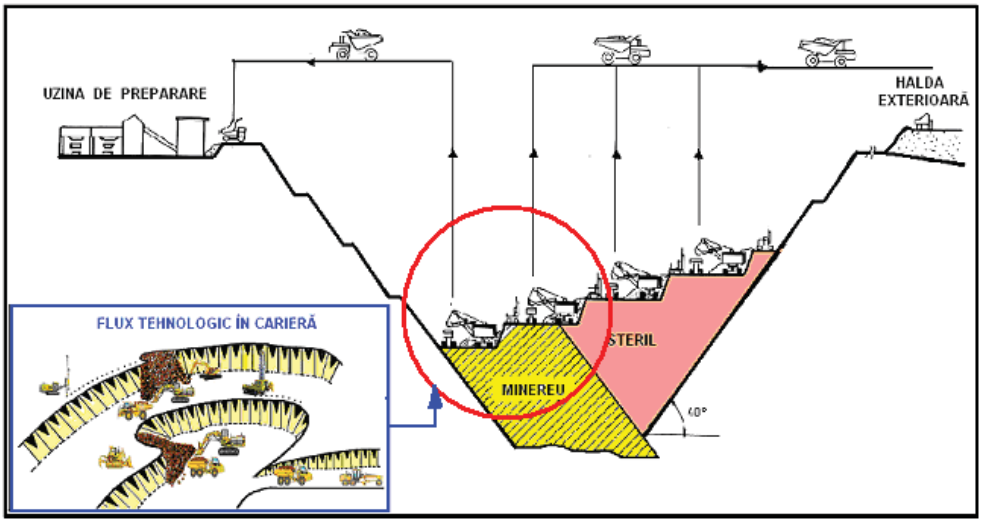

Fig. 4a *Method of exploitation with transport of dump rocks to external dumps, in the case of broad tilt deposits*

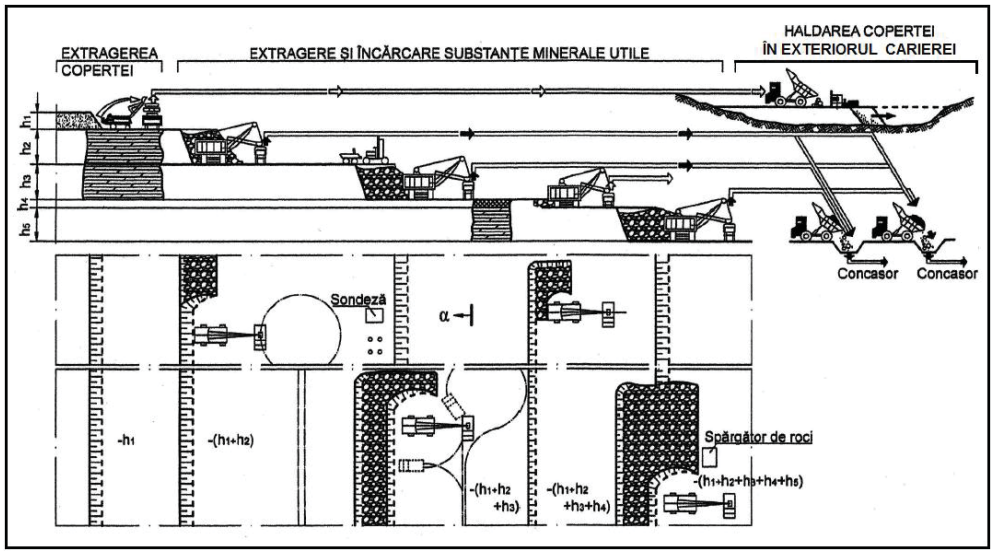

Fig. 4b *Method of exploitation with transport of dump rocks to external dumps, in the case of narrow tilt deposits*

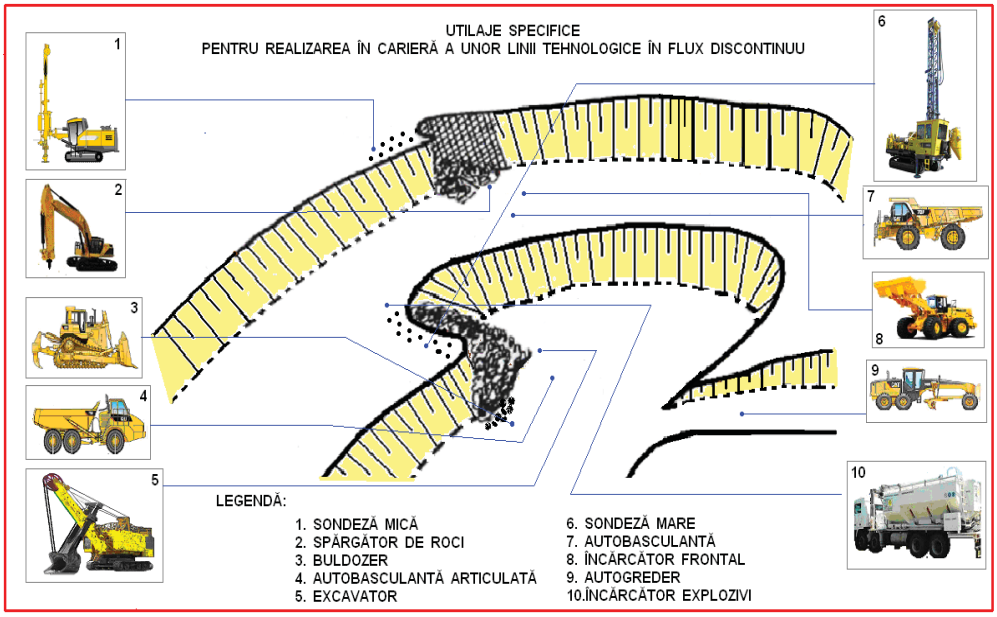

Fig. 5 *Specific equipments for discontinue flux technological lines used in quarries*

The working technologies implemented in quarries are discontinue work technologies, both in the case of extracting small and average size rocks and in the case of extracting large and very large size rocks.

The four main operations are carried out with the equipments shown in fig. 5, which may be combined according to various technological schemes and production fluxes.

Planning and providing the quarries of non-metallic useful mineral substances in Romania has been made according to the experience gathered worldwide for this type of exploitation, to the real geological and mining conditions of each deposit, to the envisaged productions as well as to the equipments at disposal, given by the inner or external production and required by technological fluxes.

The technological process in such a quarry includes **extraction from the massif**, which is done either with mechanical equipments, one-bucket excavators, frontal loaders, in the case of less or average hard rocks (Fig. no. 6) or owing to works of drilling and blasting, in the case of hard rocks, (fig. 7).

Drilling holes afferent to quarry blasting works are made depending on the diameter of the hole to be drilled, on the rocks' characteristics and the structure and nature of the massif to be extracted. Generally, in the case of hard rocks, when dealing with 150 mm-diameter holes, they use rotary drilling-machines with the striker inside the hole or outside the hole; in the case of over 150 mm-diameter holes, they usually employ rotating drilling devices, with dig rollers, fig. 8.

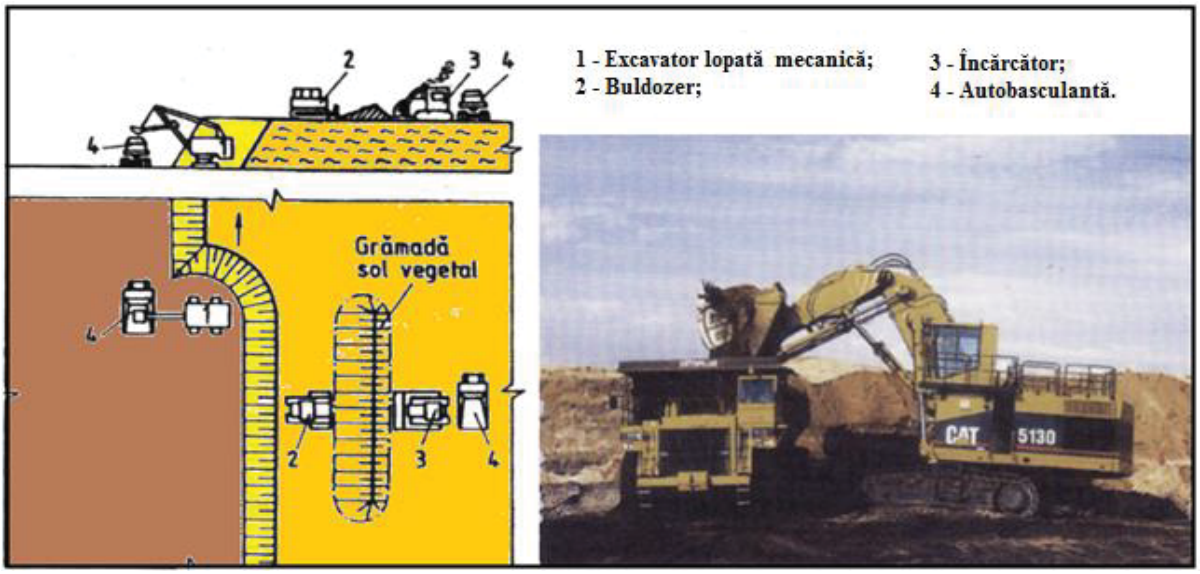

Fig. 6 *Use of one-bucket excavators and loaders for extracting and loading quarry rocks*

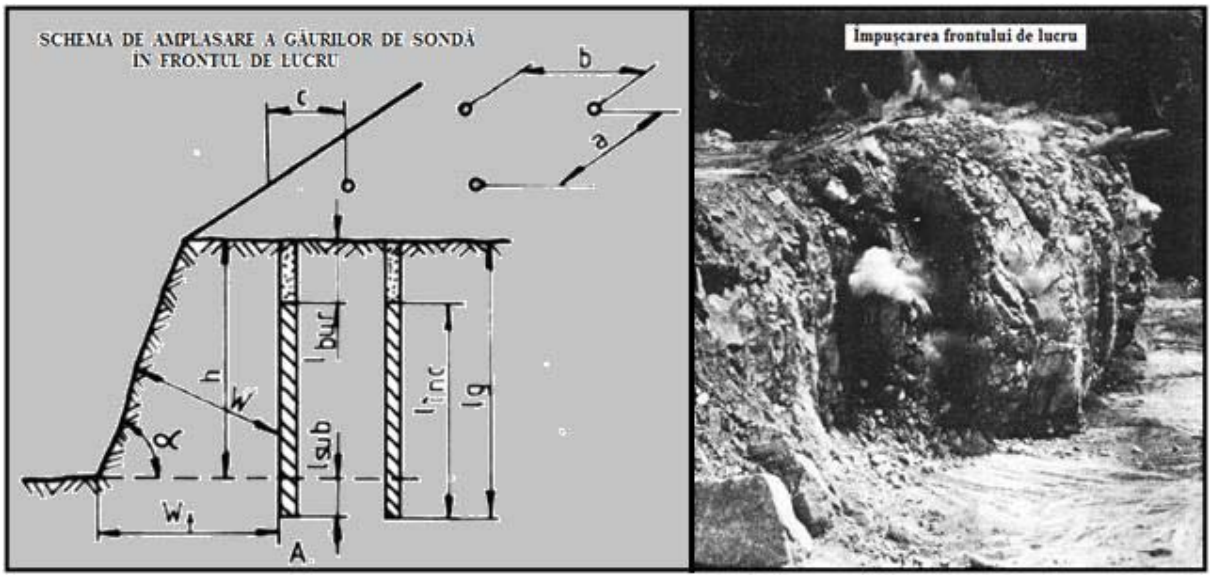

Fig. 7 *Quarry blasting extraction of hard rocks*

Fig. 8 *Rotary and rotating drilling devices*

The drilling speeds occurring in the case of the new types of drilling machines are over 5 times higher than those occurring in the case of older drilling machines.

Blasting configurations are accurately planned and chosen to be implemented, so that the most efficient technical and economic parameters are obtained.

In most cases, drilling holes are vertical or aslant made, at 15-25° from the vertical; they seldom use horizontal drilling holes.

In the field of explosives, let's notice the general use in all quarries of ammonium nitrate explosives and oil, of muddy explosives type slurry with metallic powders added, and of explosive emulsions.

Priming through non-electric initiation and priming systems containing electronic staples have been introduced on the market and are generally used today.

The loading of extracted stuff is done with one-bucket excavators or, more recently, with loaders.

One-bucket excavators, which work according to stages, loading the stuff on a transport device, have a 5-15 m^3 bucket. All the types of modern excavators exhibit extreme power and clean the hearth they work on quite well, fig. 9.

Frontal loaders, as compared with excavators, display a higher mobility, are cheaper, and are amortized more rapidly.

The main drawback of loaders is that they do not own a pushing and penetration force into the stuff detached from the massif, which may be compared to that of an excavator.

The transport of the stuff having resulted from quarries is made owing to tippers, with a transport capacity of 27, 40, 50 and 100 tf.

Fig. 9 *Excavator loading and vehicle transportation of quarry stuff*

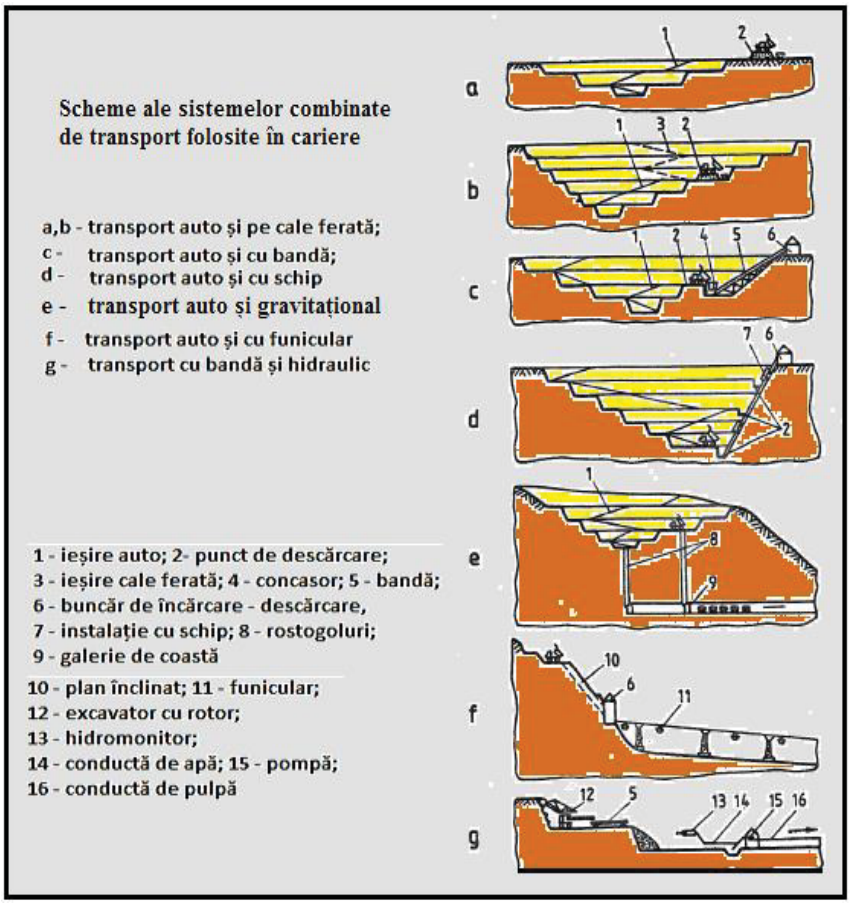

Fig. 10 *Configurations of combined transport systems used in quarries*

Within a lot of quarries, with a view to obtaining higher technical and economic parameters, they implement combined transport variants. The most known combined transport systems are the following ones: vehicle and railroad; vehicle – inclined plan skipper; vehicle – breaking station – conveyor, fig. no.10.

Useful stuff is transported to the processing plant, while sterile goes to the external dumps, which should be located in the proximity of the quarry so that mechanical transport is limited.

Important progress has been registered during the last decades in implementing mathematical calculations both while planning and managing quarry technological processes. Owing to specialized programs and computers, they determine the quarry model and the optimal size of day exploitation fields, the exploitation depth in the quarry, the most efficient opening and exploiting solutions, quarries' stable embankment, and the proper solutions allowing the dewatering of the deposits that are going to be exploited, etc.

In order to exploit graphite, Celestine, Wollaston, feldspar, molybdenite, mica pegmatite, talc, asbestos, etc. deposits, *and underground exploitation* is used.

Depending on the genesis, configuration, and size of such deposits, the exploitation methods employed are the following ones: descendant horizontal slices method of crumbling exploitation, fig. 11, and the ascendant horizontal slices exploitation method with supporting and lining of the exploited area, fig. 12.

In the case of both exploitation methods, the opening of the deposits is done owing to flank galleries, directional galleries within the deposit's hearth, and transversal galleries acceding to the deposit.

Preparing works consist in panel elevators and directional slice galleries, which connect the elevators on a certain level. The galleries are made into the deposit. From the directional pre-slaughter gallery, located around the central area, they go to the chamber slaughters, so that exploitation occurs backwards directed to the panel elevators.

When dealing with the descendant horizontal exploitation crumbling method, within the slaughter, they perform the drilling and blasting, the manual loading of the stuff, and the wooden support of exploited area. As a result, technical and economic parameters displayed low values, while the costs per product unit are quite high.

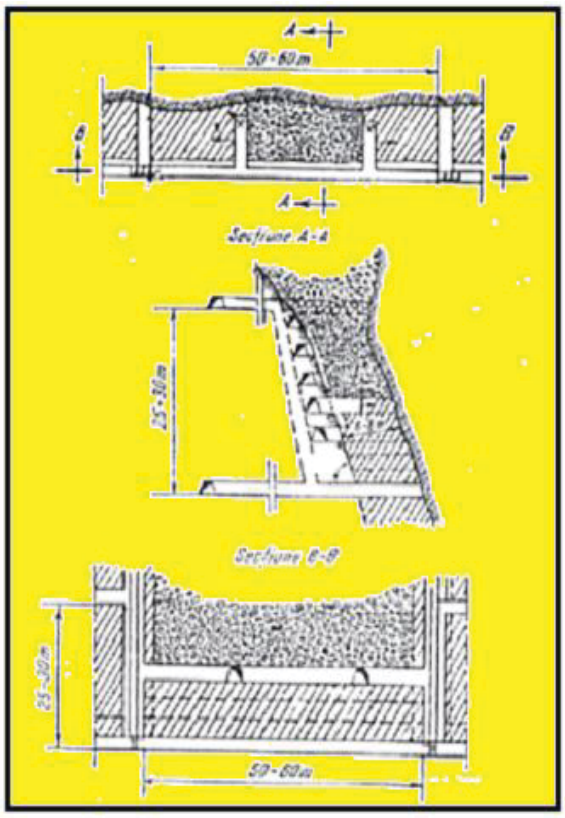

Fig. 11 *Descendant horizontal slices exploitation method with crumbling, used au Baia de Fier graphite mine*

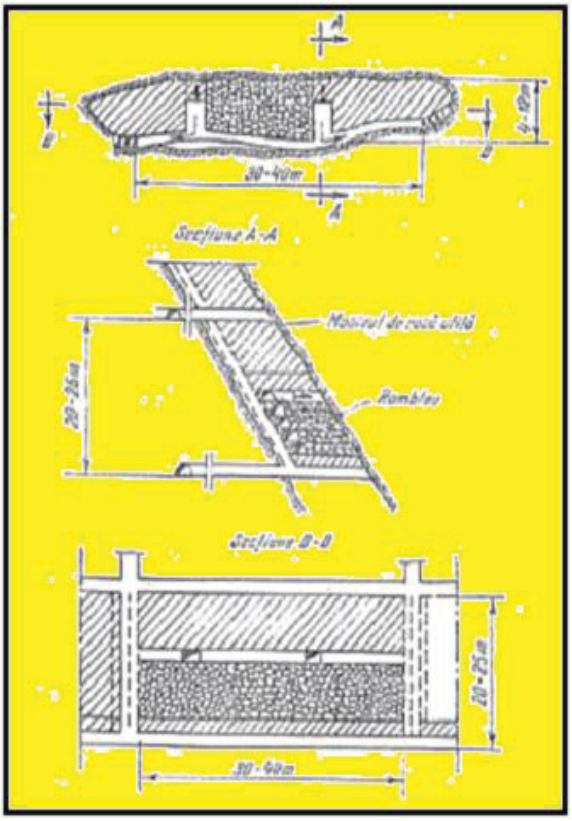

Fig. 12 *Ascendant horizontal slices exploitation method with embankment, used at the feldspar and mica pegmatite deposit in Voineasa - Cataracte*

Possible improvements would come out in the case activity is resumed and concern mechanization and the decrease of wood consumption through implementing metallic support and artificial ceiling with metal net.

In the case of the ascendant exploitation embankment method, deposits detachment was done through drilling and blasting, while stuff loading was done manually in small-capacity coaches, when ore's sorting was also carried out.

Lining is done manually through rowing with the detached stuff in front, which results after selecting the useful stuff.

The technical and economic parameters showed small values in the case of the hereby exploitation method, too.

A series of deposits as those at Armenis, Muntele Rece and Vasilatu Brezoi, depending on the geological and deposit conditions, were exploited both underground and at surface, in quarries, in the case of the higher parts of those deposits.

5. Conclusions

1. Romania owns multiple and varied deposits of non-metallic useful substances, which, during the years, were analyzed and capitalized in various fields of the national economy.

2. After 1990, the "non-metallic" branch of the Romanian mining industry entered a period of deep restructuring and, as a result, most productive units ceased their activity.

3. Nowadays, a reconsideration of this field of activity should be done together with the resuming of researches for non-metallic deposits and continuing the exploitation of those substances demanded by the country's economy and export. It is important to use the potential of non-metallic raw materials disclosed by researches and not yet capitalized.

At present, Romanian industry requires larger amounts of high quality quartz and quartzite, silica sands, limestone, bentonite, diatomite, plaster, shale, tuff, feldspar, kaolin, etc. As a result, it is necessary to start researching for non-metallic substances, in new areas, and to continue research in over 50 perimeters of prospecting and exploring where activities were terminated immediately after 1990.

4. Meanwhile, it is important to capitalize secondary resources of non-metallic substances which may be found in decantation dumps and ponds, coming from the former mines and processing plants of non-ferrous ores in Romania.

5. The high capitalization of non-metallic ores through employing proper exploitation methods and modern preparation technologies, which allow the retrieval of all useful components and of rare and dispersed elements included in the ore. Such a policy should start with the improvement of retrieving coefficients of the useful mineral substance to be found in mines and quarries as well as of the extraction efficiency within processing plants.

6. The modernizing of the methods and technologies of extraction and processing, the advanced mechanization of processes and the increase of the degree of automation represent the main objective of technological researches, which are going to be carried out and would contribute to a large extent to providing the required levels of production, both quantitatively and qualitatively.

References

1. Almăşan, B.
Exploatarea zăcămintelor minerale din România. Volumes I and II, Technical Publishing House, Bucharest, 1984.

2. Fodor, D., Baican, G.
Impactul industriei miniere asupra mediului, Infomin Publishing House, Deva, 2001.

3. Brana, V.
Zăcămintele nemetalifere din România, Technical Publishing House, Bucharest, 1967.

4. Fodor, I.
Rezultate şi orientări în exploatarea şi valorificarea nemetaliferelor, "Valorificarea substanţelor nemetalifere" Symposium, Cluj-Napoca, 26-28 November, 1979.

5. Brana, V., Avramescu, C., Călugăru I.
Substanţe minerale nemetalifere, Technical Publishing House, Bucharest, 1986.