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Current concerns related to the research and exploitation of useful mineral deposits

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Abstract. The profitable exploitation and beneficiation of the useful mineral deposits, under the economic circumstances existing worldwide require the attraction of most modern working methods and technologies in mining field. As a result, the present work presents the current preoccupations in the field of the deposit investigation and their exploitation and beneficiation. The focus is on the necessity to use more the geophysical working techniques for the deposit investigations and on the modernization and efficiency of the working methods and basic operations to be carried out within the mining industry: extraction of useful rocks and mineral from the massif, their loading, transport and stockpiling. There are also presented the current concerns and trends in the field of useful mineral processing. A suitable importance has been granted to the mechanization, automation and mining machine construction. The final part of work deals with the presentation of some conclusions regarding the possibility of modernizing the mining technologies.

Key words. Research, geophysical methods, extraction of rocks, mechanization, automation, mining machine construction, useful mineral processing.

Throughout the years the mining industry provided the world with impressive amounts of useful minerals and significantly contributed to the technical and economic progress of the world.
It is not a mistake to state that mining created the material base of the civilization. The ongoing operations and development of the national and world economies need useful minerals.

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The further functioning and development of national and world economies need the useful mineral production. Today, there are produced about 30 billions of tons of useful minerals and rocks worldwide.

In the future years, the production of the extractive industry will increase or at least will maintain at the current level. This statement is based on the following main reasons:

- The world population is growing every year;
- The metal consumption and in general the useful mineral consumptions per capita are continuously growing.
- We find ourselves in the situation to mine ever lower grade deposits from one period to another.

The goal of the present work is to reveal and review some of the main issues which should draw the attention of the decision makers, research and development entities, scientists and last but not least, of the production unit managers; these issues must be clarified within the next decades to be able to face the complex demands and expectations from extractive industry.

When making a global review it can be stated that the fundamental elements of the research, exploitation and beneficiation of the useful mineral deposits have not significantly changed since the XX century.

At a more attentive glance, it is to be noted that both the open pit technologies and underground mining ones have undergone some modifications, and some of these modifications are substantial, as for instance: there were designed and put into production new methods of deposit opening, preparation and mining; there were introduced high capacity and ever higher power and equipment and machineries of ever higher performance; computer modelling and modern planning and managing methods have been introduced in this field of activity.

Currently, the focus is on making more and more modifications of the deposit research and mining techniques. It is expected that within 2- 3 decades, by means of a better knowledge of the deposits, provided by the application of the geophysics investigation and use of latest achievement in the field of mining science and techniques, some basic operations such as ore extraction, loading and transport as well as ore processing will be performed within entirely mechanized automated and continuous systems.

The research institutes and famous scientists from worldwide provide that within the following two-three decades the mines will be endowed with mechanized equipment to carry out a detailed investigation and integral or selective deposit mining.

1. Ore deposit investigations

Today, the execution of exploration operations to know the deposits in order to put them in production is still based on mechanic core drilling. The amount of many

linear meters of drilling required to better know the deposit is high and sometimes, very high, and the drilling operations are often difficult to perform and with high costs.

Besides the investments necessary for the purchase of the equipment, the technological process is difficult and the deposit data are not always satisfying. As a result, in future, it is necessary to develop some geophysical techniques to foresee the geological potential and thus, to get a better and more precise knowledge of the mineralization boundaries, useful component grades, structure and tectonics of the investigated area as well as of the composition and characteristics of the drilled rocks.

Therefore, the geophysical and seismological, electrometric, radiometric etc. working techniques must be introduced in the field of geological investigations as these techniques are able to provide additional data to the ones obtained by drilling.

We have to admit that some of these techniques have already been introduced in underground mining, but not to a sufficient extent, because everybody, from top management to miners from the stope, have lived and still live thinking that nothing compared to holding a rock or a core sample in the hand to know and understand the nature of the investigated deposit.

The implementation and extension of the geophysical techniques is thus more and more necessary as the mining industry is more and more focused on high production obtained using highly mechanized performing equipment.

But currently, there are some obstacles on the way of large scale use of geophysics. This is explained by the fact that first, there have to be produced some robust and cheap sensors and to implement efficient methods for their opening and the data collection from their locations; such data are to be sent to processing stations where, by means of methods accessible to the operators with suitable qualifications, they can be easily processed and interpreted.

A first outcome of the better knowledge of the massif as a whole, and of the rocks in details, by improving the geological investigation using the classic and geophysical methods, will consist of the improving and enhancement of the accuracy of the designing methods of the deposit mining.

Another outcome of a significantly importance resulted at the improvement of the deposit investigation will consist of the increase of the drilling and blasting operations used for the opening and preparation works of the stopes as well as of the ore mining on the working faces.

2. Rock mining on working faces

Being fully aware about the current situation of world and national mining activity, it can be stated that in future, both in open pit and underground mines, depending on the deposit conditions, there will be applied several efficient mining methods involving complex or integral mechanization of production processes using

suitable high productivity equipment and based on an accurate planning and organization of the working face operations both in the open pit and underground mines.

Today, the soft and medium rocks are mined using specific equipment and among the most representative ones for underground mining, mention should be made on sharers for mining work excavations and stope operations while for open pit operations, the representative equipment consist of different types and capacity excavators. These techniques will still be used in future, but in combination with more and more higher performance equipment.

The hard and very hard rocks are currently mined mostly by drilling – blasting operations using explosives.

The better knowledge of the massif as a whole, and of the constituting rocks in details, by improving the geological investigations using classic and geophysical methods, will result in the correct choice and being fully aware about the most suitable equipment for mechanic mining of waste rocks and useful minerals and in the improvement of performances of the blasting operations developed in the waste and rocks.

The rock blasting is and will still be for at least two-three decades from now on, the main method for the hard rock displacement although this is a method which is quite inaccurate and with enough deficiencies.

To this aim, it is to be noted that at blasting it is difficult to control the size of the rock fragment detached from the massif, the walls of the pit or stope are damaged as it is difficult to perform a highly accurate mining operation within certain boundaries of the deposit shape or of the mining work, there is pollution of the environment (dust, noise, smoke, vibrations) and accidents may happen. Most of these disadvantages could be removed if a computer simulation of each blasting is done before its completion, on site.

Today, in different countries of the world there are used numerous computer modelling operations for rock blasting, and based on them, the rock fragmentation rate, the distance of the rock throw from the face , the wall condition, the ground vibration etc., are established. However, despite these advantages, the blasting modelling has a limited use at current mining, for two main reasons: first, the model is run for a certain location of the explosive charge in the massif and secondly, the modelling result is only approximate from the point of view of the blasting operation development and its results.

The above mentioned are due to the fact that modelling requires exact data about the explosive characteristics and behaviour, of the time sequences of blasting and of the characteristics and behaviour of rocks at blasting .

There exist and are available many data about the first two issues, but the information related to the rock characteristics is incredibly poor. This is caused by the fact that in several mines and open pits, the characteristics of the rock mass

change not only between the benches adjoining the working faces but also between the adjoining holes.

Obviously, a solution could be the analysis of the rock characteristics at each mine hole or borehole made in the massif. It is expected that within 15-20 years these analysis will become routine determinations within the drilling program.

There already exist manufacturers of drill rigs which make available for the industry drill which collect, store and transmit a series of data such as: drilling speed, torque, pushing effort, borehole deviation etc. Currently, there are developed software to carry out as close as possible correlations between the mentioned elements which can be collected on site and the characteristics of the drilled rocks. This is a significant step forward compared to the existing situation when almost no data is collected from the blasted holes.

The production drilling is a difficult and expensive operation. The data collected during drilling result in a relatively small increase of costs, but instead it ensures: the modification of the drilling grid if the rock requires it; modification of the depth or length of the hole depending on the hardness and continuity of the formation to be blasted; recalculation of the explosive quantity for each hole depending on the new mineralogy – petrography of the rock encountered and which is to be blasted.

In future, for an accurate characterization of the massif, the drill rigs will be provided both with mechanic and geophysical sensors. They will provide information about the rock mass in useful time. They will particularly allow the evaluation of some parameters such as: rock strength, location and orientation of discontinuities from the hole, water influx, boundaries of the mineralized zone and variation of the useful component content, presence and nature of waste intercalations within the mineralized bodies, etc. All these data will be used as immediate inputs in a digital model of the blasting and will allow the modification of the location of the hole grids in working faces. Also, the data collected, will allow the engineer to calculate the explosive charge for each hole individually and recalculate the time sequences of blasting so that to optimize the blasting process.

A judicious location of the holes in the working faces will be carried out depending on the rock characteristics, their correct charge with explosives, maximum efficiency and safe control of the blasts.

Also, based on the concerns and achievements in the field, it can be stated that, within the shortest time, there will be achieved the improvement and diversifying of the explosives of higher power, lower costs and maximum transport and handling safety.

The removal of most of the problems caused by the rock blasting could be obtained by using alternative methods – non-explosive one - of rock breaking and mining from working faces.

Despite the existing concerns throughout the time, to put in place non-explosive breaking and extraction methods the only industrial method which could be an alternative method to blasting is the mechanic excavation.

The use of mechanic excavation will turn the mining operation in a continuous one.

The continuous excavation equipment requires some continuous transport systems.

It is estimated that in a near future, many mines will use both continuous cutting and excavation equipment and belt conveyors or pumping systems of the mined ore from the face to the processing plant.
For now, the difficulty of large scale use of this working method is due to the fact that in hard rock mines we do not succeed in braking and mining the rock under profitable economic conditions. This is considered as an issue related to the "science of materials" and to the efficient utilization of the forces in the rock-tool interaction.
We have obtained so far only encouraging lab results regarding the cutting speed and power consumption. We expect that in the future years, there will be developed new series of abrasive hard rock mining based on the complex stress on the rocks from the mining face where the shearing and pull are prevailing unlike the systems used currently where the rock is subject to complex stress by prevailing compression efforts.
On the other hand, there should be enhanced the investigations and the modern unconventional methods should be more intensively promoted as for instance: special methods for rock blasting and displacement of the massif, hydraulic high pressure jet cutting of rocks, etc. Also, for the low grade copper, uranium, gold ores attention should be focused on the more aggressive promotion of the chemical – bacterial leaching.
Under certain circumstances, it is necessary to promote more intensively the special blasting methods such as: pre- cut of the stope, stope with smooth walls, line drilling etc.
In conclusion of this part of the paper I intend to underline that, in future in mining industry, the environment should be given more attention and concern, and the technologies to be used are to impact as little as possible the environmental elements: soil, water, air.
An important issue is the production of mining waste, its stockpiling and stockpile supervision so that their negative impact in the area is as low as possible.

3. Mechanization, automation and construction of mining machines

The progress obtained lately in the extractive industry is due to several factors, but the main factor is the construction of very powerful and more and more reliable drilling, loading and transport means.
Such means either operate in the open pit or in the underground mines, ensure the complex mechanization of the technological process operations, the provision of high work productivity and production of goods at much lower costs than those of some decades ago.
Rotary or rotary percussion based new types of drill have been used for drilling. Both types of drill are provided with automatic adjustment of the rotation speed

and pressure on the hole floor. The drilling rates obtained with these new drills are more than 5 times higher than those obtained with the older types.

In the field of explosives, besides some types of highly disruptive explosives of dynamite type, the almost general use of ammonia nitrate and diesel fuel based explosives, of muddy explosives and explosive emulsions has been noticed; these are powerful enough, safe and easy to handle and much cheaper than the highly disruptive ones.

The explosive priming is done using priming powders which have been largely developed lately and which have provided absolute accuracy at the release of the charges from working faces.

In case of underground mines, we have seen during the recent decades the improvement of the high productivity mining methods and working technologies development by using drilling – loading highly performing machines which are characterized by high movability and multi-purpose use as specific sub-assemblies can be attached to them. These assemblies are usually electrically- hydraulically driven, they provide high reliability throughout their life, they have low power consumption and they are provided with automatic control.

The material is loaded in the pit using bucket shovels and in underground, loading and transport machines. All modern types of loading equipment provide high pushing efforts and good cleaning of the floor on which they travel.

As for the transport, the extension of road transport based on high capacity trucks has been developed as well as the continuous transport using the rubber belt conveyors placed on the ground, hydraulic and air lift equipment, all these at the expense of railway transport.

In the second half of the XX century the processing industries improved significantly their productivity and economic outcomes using some automation based technologies.

For some tens of years many specialists speak about the mining operation automation, but nobody either saw or noticed significant achievements in this field.

When making a diligent review of this issue, it can be stated that automation has not had too many applications so far in the extractive industry because the mine represent a hostile environment with many unknowns and is continuously changing.

A mining machine such for instance a drill rig or loading equipment or even an excavator, represent a very complex assembly. It means that when it is running, the location of the driving body is uncertain and so is the location of the equipment which takes over the material to be transported. These uncertainties have to be removed by manufacturing some solid, but sensitive sensors which are able to permanently update both the equipment and the driving body's position and the geometry of the environment when it operates.

The automation in mining when it is implemented, will significantly improve the work productivity and safety. Also, the equipment reliability will be much

improved as the automatic systems prevent the overstressing of the equipment components.

It is expected that in future, the automation of several production processes of the extractive industry will be successfully carried out providing a profitable running.

The specialized literature reveal the preoccupations from worldwide regarding the automation of the excavation equipment of the open pits in order to optimize the bucket loading and reducing at minimum the working cycle.

Another preoccupation already existing and which results in mining sector are significant, consists of the automation of the silo equipment from ore mines.

In a future stage, it is envisaged that the loading equipment and trucks will be self-operated. The operators will be however, necessary to monitor and intervene whenever required, but they will monitor and intervene on several equipment and trucks at a time.

The equipment and trucks will strictly observe the programmed instructions and the operators will verify the way in which the vehicles are running and which is the wearing cycle of the main mechanisms and components requested so that there will not be allowed any defaults throughout their running.

Robots have been used for several years in mining industry, too, to perform the different operations which are difficult to carry out by operators or other equipment.

The robots which are actually programmable mining machines are used at workplaces where the access and aeration are difficult to carry out, in narrow spaces, at workplaces where the temperature and pressure are high, and in interventions after severe work accidents in underground.

The maintenance of the mining equipment represents about 40% of the total operating costs of a mine. This is why people are worldwide concerned to follow the machine operations with the time and to collect all the data required to make a correct decision concerning the reasonable exploitation of the equipment and to expand their lifetime.

The improvement of the equipment reliability results in the increase of productivity and thus, of the capacity of production. The increase of the equipment reliability by 10% would lead to the increase of the incomes by millions of dollars by year for each technological line in operation.

In the field of useful mineral processing the current preoccupations and trends of worldwide consist of the processing processes concentration in large scale processing plants, the almost complete automation of the production, increase of the recovery efficiencies and beneficiation of all the useful components existing in the ore; the beneficiation of gold and silver from secondary resources (waste dumps and tailings management facilities); application of chemical –bacterial leaching for copper and uranium and direct cyanidation of gold-silver ores.

The current focus in the field of processing and the future trends will lead to the increase of the work productivity, increase of metal amounts recovered from

processed ores, improvement of work safety and health and diminution of the total actual price of the products.

4. Conclusions

In future, mining activity has to make significant progress in terms of integral and efficient beneficiation of all useful minerals and diminution of production costs.
Progress is also necessary in the field of geological research and knowledge, exploration and production drilling techniques, as well as of working methods with such equipment and machines, of explosives, mechanic cutting of rocks, automation, use of mathematic and computer assisted modelling.
In the future two decades, the automated drill rigs which prepare the working face for blasting operations will accurately indicate the location, direction and dimensions of the holes to be drilled and will be provided with mechanic and geophysical sensors contributing to the determination of the characteristics of the rocks encountered in each drill hole.
More and more mining units will use the mechanic excavation of rocks from the working faces. Most of the equipment will be automatically operated, and the malfunctions will be rare as the equipment and machine condition will be permanently monitored.
The outcome of such improvements will consist of the improvement of the work safety and diminution of the actual cost of the ore extracted and energetic goods.
The mining units which will not pay attention to these issues and will not be able to face these modernizations will find themselves in a position where the production cost curve will reach its highest value and finally, their activity become unprofitable from economic point of view and will disappear.
In the end I want to underline that everything which will be done in the field of mining, will need to pay more and more attention to the environment protection or to its rehabilitation as the quality of current life as well as the future of generations to come can be ensured only by complying with the principles of a sustainable development.

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