CENTRO MORAES RÊGO

CAP. 11

II SIMPÓSIO DE MINERAÇÃO

SOME ASPECTS OF MINE PLANNING

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Mine-Plan.

I - INTRODUCTION:

I am honored to be with you today and I thank you for inviting me.

When I received the invitation, on Agust the 21st. to present a paper to this congress, I truly felt frightened; I was asking myself what can I prepare in so short a time. As you know, the 24th International Geological Congress was in sessions; I had to attend some of the functions, consequently there was very little time left to prepare a conference in the three days before my departure for Brazil.

It was suggested to me that I could discuss mine planning with you. This is a subject which I personally feel is of critical importance being the main part of any mine feasibility study. Depending how it is done, mine planning could lead to very costly decisions either by letting a company drop a good project or, even worse, by bringing a company to go ahead with an uneconomical one.

Role and Extent of Planning in a Mine Operation.

The primary objective of a mining operation is to make money for those who supply the venture capital. Therefore, all decisions concerning a mining operation should be made in the light of the resulting effect on profit. The obvious way to maintain profit at the optimum level is to exercise strict control over costs.

I know of only one way to control costs, and that is through careful planning at the early stage of a proposed operation. These two aspects are inter-dependent and must be dealt with together.

Some define mine planning of a given orebody as the development of a pit design which minimizes stripping at any desired level of extraction or the pit configuration which maximizes the total profit. It is certainly this but it is also more; mine planning starts

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with the exploration phase, it includes ore reserves calculations, the determination of the rock properties and its structural defects for pit slope determination, the concentrating characteristics of the ore, marketing considerations, capital expenditures and evidently the cash flow of the venture and its present value. Mine planning must be correlated to all phases of a mining operation. All elements are so closely related to each other and are influencing each other in such a way that they must be considered as a whole. If more than one deposit is beeing mined in an area, the planning of both or more deposits should be integrated to assure optimal profitability to the company.

Proper planning is especially important in a country which is under great expansion, such as Brazil. This expansion requires important capital to be spent in a relatively short time, and unless the expenditures are made according to a logical plan, it will not benefit the country.

Mine Planning varies from company to company. Some companies use completely computerized methods starting with reserves calculations, going to pit limits selection and finishing with ore extraction scheduling. Others are using a combination of manual methods and computer assistance. Personally, I am not against manual methods; in certain cases they are still the best choice.

I have here a long list of articles reporting on the various facets of mine planning. I am not going to review these articles, you can do it yourself as well as I can. What I would like to do is to discuss some of the points of mine planning which, in my opinion, are neglected and would need improving. These problem areas are not restricted to Brazil.

(2)- SOME IMPORTANT ELEMENTS IN OPEN PIT PLANNING.

2.1 - Exploration: topographical map, diamond drilling, geological interpretation, ore reserves calculations, grade calculations, hardness of the ore, etc...

Mine planning is only as good as the accuracy of the basic information which is used. Too often there is a lack of effective communications between the geology department responsable for the exploration of an orebody and the operations department responsable for planning. When such a situation exists, there is a real danger that the basic information will not be sufficient or accurate enough for proper mine planning. Usually, berch plans are prepared from the geological sections; the main purposes of these bench plans are ore blending and short range planning. Both of these points have a great influence on the yearly profit of a company. It is evident

that the geological sections must be accurate otherwise, how can one make an accurate evaluation of a project ?

The human being has a tendency to forget and, more often than usual, the mining engineer will come to accept the bench plans as final even if he knew, at one time, that they had been prepared from poor sections.

Good geological sections do not happen by themselves, they must be planned right from the beginning. Before the main drilling campaign starts, it is beneficial to drill a few holes for structural interpretation to help select the proper distance between the proposed sections and to plan the drilling grid. Except for very special situations, as for example an horizontal sedimentary orebody, I am personally against vertical holes because of the resulting deviation which, I admit with you, can be controlled but is rarely done. At one time, I asked a geologist why he was drilling vertical holes in nearly vertical formations. He answered that, with vertical holes, he could draw sections in any direction; it did not occur to him that a vertical hole in steep formations gave information along a narrow bed only

To minimize deviation, it is usually good practice to drill holes nearly perpendicular to the formations. Knowing that deviation will occur no matter how careful one is, dip tests should be taken at 50 meter intervals. To save on drilling, each new hole should be located with the benefit of the information gained from the holes already completed. This implies that geological and structural interpretation be done concurrently with the drilling; otherwise, a fair percentage of the exploration budget is being wasted.

Besides tonnage and grade, there is other information which is as important. For certain orebodies, the hardness of the ore could become more important than grade itself; if so, hardness tests should be run concurrently with metal assaying. In other situations, the proportion of hematite to magnetite becomes the critical element. The assaying program should then be modified accordingly.

Before closing this subject, let us examine the domain of slope stability for open pit mines. Here again, the exploration program often fails to provide the information required for selection of the steepest slope consistent with human safety criteria. During the drilling campaign, there is a wide spectrum of information related to rock mechanics which should be collected, such as faults and shearing jointing, gauging in fractures, water level, etc...

You will have to admit with me that is rarely properly done. I do not want to create the impression that only the Geology Department is responsable for this situation, far from it. It is the responsibility of the Mine Planning Department to cooperate with the

Geology Department to jointly set up a system that will attain the objective which is the gathering of all information necessary for the preparation of accurate bench plans and subsequent mine planning.

The situation is never as bad as I just described it. I drew a black picture purposely to draw your attention to a phase which influences all other steps leading to management decisions to either accept or reject a project. I hope I have succeeded to alert you to this particular problem.

2.2 - Optimum Pit Ratio or Cut Off Ratio:

Brazil is fortunate in having huge reserves of high grade iron ores. Taking advantage of these reserves, hard and soft hematite have been selectively extracted from various orebodies for many years. Profit per ton for this very valuable type of ore has been good and costs have not been critical. Soft, hard and pulverized itabirite are mixed with the above types of easily marketed ores. However, to meet the demand for different products and to provide a more orderly depletion of the reserves, concentrating plants are being built to treat the soft itabirite that otherwise would have to be wasted or stockpiled. For this reason, Brazil might stand to lose some of the competitive edge it has over countries like Canada. Even if its concentrating plants will be handling high grade material by comparison with the low grade ores treated elsewhere, the fact that there is a plant will bring its costs closer to competition. This means that Brazillian companies have to become more cost-conscious. This is a philosophy that must prevail from top management down to the production people. This is not easy to achieve. Until now, hard and soft hematite has been extracted without bothering about ore-to-waste raties. With the extraction of other types of material, it becomes imperative that pit limits be drawn along a predetermined ore-to-waste ratio.The value at the mine for each type of ore must be known to establish the raties wich will vary depending of the type of ore present in a particular section, and depending of the quantity and type of waste that has to be extracted to give access to the ore. To obtain this information, one must subtract from the sale price all expenses, including handling and loading costs at the harbor, railroad transportation, administration, etc... This accounting could become quite revealing: it could indicate for example that costs are not as well known as one believes. It could also indicate that the profitability of certain types of ore is much lower than realized by most people.

2.3 - Mine Personnel - Mine Equipment.

The same mining equipment utilized by most north ameri-

can companies are found in Brazil. Therefore, the number of employees per ton produced should be comparable. In fact, it appears much higher in Brazil. This situation might be considered tolerable considering that the workers' salaries are lower; but the situation will change in the future. An agressive company must have definite long range plans which take into account changes that might affect its profitability. Mine personnel is certainly an item worth looking into.

Also, some mining operations have a tendency to use too much equipment. Experience shows that surplus equipment, even if it is considered as spare equipment only, normally results in an increase of maintenance costs.

At one stage during mine planning, the required equipment will be calculated and the list of workers needed to operate this equipment will be established accordingly. If the specialist responsable for this task takes into consideration the indirect costs, such as housing, townsite facilities, transportation, etc... which increase in proportion to additional employees, I am sure that the personnel roster would be decreased substantially.

At the time of expansion, a company can decrease its personnel without laying off any employee. One way to achieve this is as follows: at the end of the year, when the mining plan for the following year is being prepared to meet the ore sales, the number of pieces of equipment: shovels, trucks, dozers, etc... should be calculated and only these numbers should be used. The other units, particularly the trucks, should be stored away from the mine and no one permitted to use them except with special authorization. Knowing the number of pieces of equipment which will be operated, a list of personnel is prepared and only those persons whom the mine manager can account for should appear on that list. The surplus manpower thus created can be re-allocated to the expansion program. If the level of production is changed during the year, then the equipment and personnel requirements are modified accordingly.

2.4 - Shovel - Truck Efficiency.

This subject does not really belong to mine planning in the truesense of the word, but it certainly fits well in this cost-conscious philosophy that should prevail in any organization.

In the past, it was customary to overtruck the shovel because the shovel operating cost was 3 times higher than the truck operating cost. It is not so any longer. Trucks have increased in size and the amount of money invested in each unit is such that delays of any sort should be minimized to the absolute minimum not only for shovels but also for trucks.

During a recent visit to large mining operations, I inquired about the means used to optimize the tandem shovel-truck. Each company visited is trying to achieve better truck utilization; in Canada, one company is installing a small desk computer in the dispatching tower to help the foreman-type dispatcher in his task of combining blending with optimum utilization of trucks. That installation is the most advanced I have ever seen.

2.5 - Plant Site Selecetion - Blending Pile.

It is evident that plant location and mining methods are closely related. The topography in the Minas Gerais Iron Range is quite hilly and it is rather difficult to find a location large enough to accomodate a concentrating plant. The surface area required is large, mostly because of the generally accepted 5 day blending stockpile ahead of the plant. This stockpile could be in the order of 1500 meter long, depending of the size of the plant.

There are advantages in having a blending stockpile ahead of a plant: first, it reduces blending in the mine and secondly the plant should operate in a more efficient manner because of narrower variations of grade or material mix. But, rehandling is expensive and because of the large area needed for such a stockpile, the plant might have to be located further away from the mine, thus increasing transportation costs. The plant people should ask themselves two questions: 1 - What is the optimal material mix the plant should handle ? 2 - What increase in cost would the plant incur if variations from this optimal range were to occur ? Knowing this information, the Mining Department should determine if they can blend the crude ores to meet these minima and maxima and at what costs. Only they can a rational decision be made on the necessity of a blending stockpile.

2.6 - Waste Dumps - Materials Stockpiles.

Some might not realize it but waste disposal could be a major problem in difficult terrain, especially if the valleys surrounding a deposit drain towards a town. Silting from waste material could seriously affect the drainage system of the area and endanger facilities such as roads and railroads.

One should resist the temptation to solve the immediate problems associated with waste disposal; a global approach should be taken. It is necessary to plan the waste disposal for the entire life of all the orebodies owned in an area.

Once the best sites have been selected considering the existing restriction: roads, railroad, tailing disposal, drainage, towns, etc... a quick evaluation of the expected damages from the

various possible disposal sites should be made.

When dealing with 67% Iron, one might be willing to waste material which would be called good ore elsewhere to gain access to the desired material required to meet the sales requirements. No matter how large the reserves of an area, there is always a limit to these reserves. Since material presently treated as waste will eventually become ore, one should stockpile it in such a way that it could be reached at a later date without undue expenses.

2.7 - Environmental Problems.

Before ending these brief considerations, I would like to raise the question of environment with you. Last year, I came to Brazil to give a course on open pit mining; at the end of the course I had in mind to present a lecture on environment which I had prepared before leaving Canada. Realizing the lack of interest towards this problem considered acute in other countries, I did not cover this subject. Moreover, some Brazillian specialists attending the course expressed the opinion that the environmental problem can be deferred until the country is more industrialized. It is hard to fight such a statement but, nevertheless, I believe it would be cheaper in the longer run to get ahead of government regulations which generally tend to be excessive when prompted by popular feelings.

There are other points of Mine Planning that could be discussed. However, I would like to take a few minutes to tell you what training, we in Canada, think the new mining engineer should be given to fill the job we expect of him.

3 - MINING ENGINEERING EDUCATION IN CANADA.

Here in Brazil you are fortunate to be mining rich ores but in other parts of the world, decreasing grade deposits are being mined. This requires the handling of ever greater tonnages, equipment units of larger capacity and more concentrated methods of mining. It also calls for increasingly sophisticated management. The range of permissible error in a low grade operation is so small that a mine manager must be familiar with modern engineering operation and business methods.

In Canada, the mining engineer as we used to know him about fifteen years ago is past history. Let me qualify this statement. In the past, most Canadian companies made use of the young mining engineer as a technician rather than as a professional man. His first job was usually as a surveyor or sampler. This was not wrong in itself, but what was wrong was to keep him in such a job for so long that he became bored and disillusioned. Eventually, he was promoted to a supervisory position in "production": he was expected to work as

a Shift Boss and than Mine Captain for several years. Finally, he could be promoted to Mine Superintendent or Chief Mine Engineer.Having been kept away from highly technical tasks for years, the new Chief Mine Engineer was no longer capable of assuming highly technical functions, but nobody really worried or even thought about it ; the ore was rich and the profit good, so everything seemed right. This kind of a mining engineer's career used to be typical, but is no longer so. Because of the challenge of the newer analytical technologies, the young mining engineer of today is not willing to spend several years on shift work and to have to concentrate almost exclusively on productivity targets.

What then are the functions of the new mining engineer and what is the role he is expected to fulfill ?

Wide Knowledge.

The mining engineer must be familiar with the exploration methods used in search for new deposits, since this search mustoften proceed under his guidance coincidentally with ore extraction. He must have a good knowledge of rock mechanics, because mining is dealing with rock stability, and of environmental engineering to cope with the unusual conditions of work underground.Mineral industry economics is also essential: the mining engineer is concerned with the supply and demand of stores and products, the evaluation of mineral properties, operating costs and cost data analysis, and depletion and finance problems. He must know some mineralogy and geology, the factors controlling the formation of and mineral association in ore deposits, and also the principles of mineral dressing and beneficiation. He must be competent in statistical analysis, in the application of mathematical models and in programming the use of computers for the solution of complex problems. In addition, he must have a basic knowledge of industrial relations and managerial concepts.

After thus describing what I would term "the new mining engineer", I shall attempt to answer the question of wether or not he is really needed by the mining industry, since it has been said that other engineers (mechanical, electrical, civil, industrial engineers, all needed by a large mining operation) could replace him. This is a very relevant question, since it is for the mining industry that a special engineering curriculum has been created.

In view of the fact that the small underground mine is losing importance and that the trend is towards larger open pit operations (nearly 70% of all mining in Canada is by open pit),some think that the mining engineer should be replaced by specialists.

While this is subject to argument, I personally believe that the modern mining engineer should be regarded as a bridge or co-ordinator between the other engineering disciplines used in his own field, which is mining. He is a very special type of engineer who is hard to replace.

Trainee - Executive.

In a sense, because this makes him capable of coordinating the various disciplines that serve the industry, he should be regarded during his early professional years as a trainee-executive and after gaining greater maturity and experience in production and planning, he would eventually become a manager or comptroller, ultimately in charge of integrated operations.

This is why mining engineering departments of Canadian Universities now offer courses in the following:

Probabilities and statistics
Computer programming
Minerals economics
Mining evaluation
Industrial legislation
Corporate finance
Corporate administration
Cost analysis
Operations research and optimization
Human and industrial relations
Environmental factors and controls

This is the type of mining engineer that is now highly valued and effective in mining and that is the prototype now produced by universities.

While some managements may still be of the opininon that they do not require engineers of this type, that they would not fit into their organization, others think highly of such a training and recognize that, if the Canadian mineral industry is to remain competitive in the world markets, this is the type of young executives who will help to maintain the industry on a technologically advanced level.