Introduction to Mining

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Classes

Underground Mining

Lesson 10

Objectives:

a) Students will examine the baseline plan for a POGO mine in Alaska.

b) Students will summmarize the mine planning process.

Underground Mine Planning

The planning process will, in general move through four steps, irrespective of the design phase: baseline assessment, reserve determination, premine planning, and subsystem design.

BASELINE ASSESSMENT

Baseline assessment of all available data precedes any planning efforts. It is a comprehensive initial review of all available information on the potential reserve or mine from geographic, geologic, environmental, technical, and economic standpoints. An example: the geologic location of a resource would have a great influence on the economics and may dictate the mining method due to the equipment and power availability, labor availability, and skills level, supplies transport, etc. Negative aspects of the location of a mine may be overcome by the value of the resource but many problems such as permitting, environmental, or geographic issues may need to be overcome before it can become a profitable mine.

Geologic Factors

The geologic model is only an interpretation of the actual conditions based on the skill of geologists and the economic backing available to do thorough testing . Constant testing and drilling is done as the project moves through the design phases. The data collected dictates the changes that effect the geologic model.

Two approaches can be used to handle the uncertainty in the geologic model in mine planning efforts based on risk:

1) accept the geology and develop the plan accordingly

2) acknowledge the uncertainty in the geologic model and direct the planning effort to assure sufficient subsystem flexibility to accommodate any potential impact.

Environmental Factors

Today designing a mine requires planning for environmental protection and reclamation from the very beginning. Potential negative impacts can be minimized by including in the planning:

1) cost of environmental protection rather than trying to find a remedy for reclamation.

2) good community relations as negative publicity may have severe economic consequences

The planning process requires at least a minimum of baseline environmental data.

1) overburden analysis

2) soil surveys identifying topsoil and subsoil

3) hydrolic studies

4) determination of characteristics of surface and ground water

5) vegetation and existing land use surveys

6) air quality analyses

7) wildlife surveys

8) archeological surveys

***********More About EIS in Chapter 11*************

Geographic and Economic Factors

There are a number of geographic and economic factors to be considered in the baseline assessment. The location of a reserve with respect to transportation for equipment and shipment of the products, climate, labor force availability and skills, and power availability.

Other factors may influence the method of mining:

1) high labor costs

2) skill level

3) equipment availability

Economic factors that influence plan design are:

1) political and tax environment

2) stability of the present government

3) availability of replacement equipment and supplies

RESERVE DETERMINATION

The characteristics of a reserve are as crucial as the reserve magnitude or grade: the depth, inclination, geometry, type and properties of host and deposit rocks, quality, etc. and play a key role in the design.

Criteria

A mineral deposit or resource can only be classified as an ore body only when it can be mined at a profit. The planning and design attempts to identify the method to make this possible. Demand of the ore body and mining technology can affect the future of a project. As more knowledge is gained about the resource, the plan must include provisions for revisions such as:

1) technological advances

2) market or demand

3) depletion

4) new geographic factors

Data Presentation

Data is usually presented in a matrix form with one side presenting the degree of certainty of existence or an ore or mineral and the other side indicates the recovery viability. The use of computers offers huge masses of summary that often is overwhelming when trying to present data. The effective graphics of computers though, can often create a visual presentation that is easier to present data than a matrix.

Mathematical Methods

To estimate the reserve involves taking point data and transferring the data to block or grids for calculation purposes. Mapping involves using the determination of the of sample point coordinates to determine boundaries. Block size in terms of length and width may be defined on the basis of geologic structure, deposit variability, and data spacing or quality forecasting requirements. Mapping the block data is critical to the planning and design.

PREMISE PLANNING

The mine plan constantly evolves as the mine process changes physical characteristics. Engineering science and technology are constantly evolving while the mine is locked into the physical framework. An interesting fact is that equipment changes with time but the basic design of the mine remains the same. This is most obvious in comparing existing and newer mines.

The only way to obtain accurate cost forecasts for the project is to develop a life-of-the-mine plan for the reserve block. This must include the reclamation and final land use plan. There are limitless factors that go into mine planning.

Following is a **list of concerns** for underground mining:

1) Regulatory and Legal Factors

Permits and approvals may be at the federal, state, local, or regional level. These are subject to continual revision or reinterpretation requiring ongoing review of the mine plan. Review leases to insure that the mineral and surface rights are available.

Compliance plans include:

1) mine layout with projections

2) strata/roof control plan

3) ventilation plan

4) fan stoppage plan

5) dust control plan

6) medical / emergency evacuation plan

7) fire control/mine evacuation plan

8) escapee map/plan.

2) Geologic/ Geotechnical Factors

Depending on the mining methods under consideration, many geologic and geotechnical factors must be considered. The economics usually favor extraction of the best grade materials or the lowest mining cost areas to maximize the return on investments and shorten payback period. While the immediate extraction of the best grade materials enhances immediate finances it can compromise designs.

3) Environmental Factors

The impact on the environment must be considered from the beginning of the plan design. The impacts to the environments can include; noise, aesthetics, air quality, water discharge and run off. The environment must remain within regulation during the initial data gathering to the reclamation process.

Reclamation plans include; drainage control, segregation of waste material, erosion and sediment control, solid waste disposal, regrading and restoration of waste and mine areas. The plan must include the effects of the mine subsidence, vibration (induced by transportation, mining, processing or subsidence) and impact on surface water. The environmental items often dictate the economics and viability of the mine.

4) Technical Factors

The technical areas of the plan are the most extensive. It takes into consideration the regulations, geologic, and and environmental factors to develop each part of the plan. The layout of the mine is determined by the size and shape of the reserve. After the ore deposit is mapped, access development for the reserve area is figured into the plan. The size of the reserves determines the kinds of access and the number of

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access portals needed. Access can be vertical shafts, inclined slopes, and drifts or horizontal entries. The larger the reserve, the more complicated the plan becomes.

Surface Facilities

The productivity and the reserve size determine the size and placement of facilities. Consideration must be made for access, extraction, removal, and storage of the ore, the physical needs of the work force, and the operational needs of the facility. Land acquisition for disposal areas, dust, noise, safety, and layout are other design considerations.

Physical Factors

Isopach mapping is used to determine the reserve depth and develop the best mine layout. The plan lays out the number of benches and designates the portion of the reserve that will best meet the needs of the market. Economics drive the design to gain the most profit from the mine while still maintaining plans for reclamation.

The sequence of the extraction can be important to maximize the the reserve recovery. The mine may have multiple seams being extracted at once or only a single vein. The plan will take this into consideration and plan for the most efficient method of recovery. Poor mining conditions must be factored into the analysis to account for changes in productivity rates and mine costs.

Equipment

The equipment needed is determined by the dimensions and the hardness of the mineral deposit. Other factors that need to be considered are production rates, seam or working height, and property extent. Ventilation, size constraints, regulations, and floor pressures may impact the choice of diesel-or electric-powered equipment. The floor condition plays a a big part in the equipment needed.

Desired product size also determines the equipment selection. Some equipment is for fine-particle generation and some is for a courser product.

Schedules for equipment overhaul should be developed to assure productivity rates. New equipment purchase should consider the incorporation of new technology as it becomes available.

Support Systems/ Infrastructure

As the development of the mine progresses the mine entries, drifts, and levels become part of the infrastructure. All parts of the system must be evaluated for capacity and availability . The systems are built in a series so that if one of the systems fails the whole system is halted until systems are corrected. A series system design is usually used to keep costs low as many systems are parallel or redundant. They are designed to be as maintenance free as possible.

Transportation
Transportation encompasses provisions for the movement of materials, personnel and equipment into and out of the mine. Supplies, workers, equipment must be transported in a timely manner to maintain the planned production. One of the main transportation plans include moving the mined material from the face to the processing facility. A successful mine design will have a smooth transportation flow.

Manpower
Staffing of the system is a function of the required production level. Typically the manpower level is inversely related to the relative level of capital spending but related to the reserve size. Adequate personnel must be provided to allow the system to function properly. Personnel includes the supervisory work force as well. Consideration must be made for support staff levels such as administration, engineering, financial staff. The centralization of the the support personnel may be more effective if centrally located depending on particular circumstances. The physical location of the mine must be considered also.

Mine Power
The electrical power needs of the mine depends on the mine productive capacity and the mineral processing requirements. The availability of necessary power in the area will determine if the mine will produce it's own power. The power distribution system needs to be adequate to provide support for the life of the mine. It must be easily maintained and reliable. Safeguards must be in place and adequate backup capacity must be available when needed.
In many mine areas, backup systems are being designed where different forms of power are being utilized, including solar. radio transmitters, methane power generation and hydroelectric power. Communications can be wired or wireless and include data and voice transmissions. Backup systems for communication are also very important to consider. Timely and accurate documentation of the mining system status can be delivered all over the world to provide for efficient mine production.

Water
Various mine systems need the water for cooling , dust suppression, fire fighting,, processing, and personnel needs. If adequate local water supply is not available, the plan design must include a water system to meet all the potable and process water. Wells may have to be drilled.

Ventilation
After most of the other factors are laid out the ventilation is designed to provide the mine's life support system. The first consideration is providing clean respirable air to the workers. The dilution of contaminants is next. In other cases air can used to cool also.
Mine layout is dramatically impacted by the ventilation system. Proper airflow requires proper sizing , location and numbers of airways. Minimum and maximum velocities, and quantities are often specified by regulations and mine condition.

5) Mine Closing and Reclamation

After the deposit has been completely mined, the mine area must be cleaned up and returned to approximately it 's original condition. Permits require bonds to be set for protection against not completing this reclamation. Funds are allocated to cover this process from the onset of the mine. Much of the reclamation process begin with the first breaking of the ground. Openings are sealed, pits filled and revegetated, and the structures removed. We will cover more on the reclamation process in Chapter 15.

References**This article was adapted from George W.Luxbacher and Richard T. Kline. SME Mining Engineering Handbook, 2nd Edition, Volume 2. (Littleton, Colorado: Society for Mining, Metallurgy, and Exploration, Inc., 1992), pp. 1543-1549.

Mine Plant Layout

Mine planning layout is a general term for describing the process of configuring a complex and often expensive portion of an underground mine. This encompasses the placement of all development facilities such as buildings and structures, machinery, pipelines, power lines, equipment, cables ponds, roads, rails and other auxiliary works needed to support any underground mine activities. Mine plan layout is the design for integrating all structures, systems or activities, required to support the mine for economic gain.

The decisions are influenced by a number of major factors namely, depth of cover, location with respect to the reserve perimeter or ore body, surface topography, proximity to contract services, power and water, locations of railroads and market destinations, geological structure, proximity to population centers, regulatory and environmental constraints, and ease of of access by personnel.

Mine plant layout is divided into three major subcategories: surface, shaft and underground plant. The surface plant commenced at the entrance to the property to the mine opening site.This is generally seen in the form of roads, fencing, drainage, and runoff ditches, lighting/power lines, and other items needed to provide the site with materials and services.

The shaft plant subcategory begins at the shaft of the collar and consists of the airways and pumps, piping, water collection structures, communication and power lines, transportation systems and the components between the surface and the underground workings. This is generally seen in the form of roads, fencing, drainage, and runoff ditches, lighting/power lines, and other items needed to provide the site with materials and services. The shaft plant layout encompasses all of the equipment, buildings, yards and controls needed to service the mine.

The underground mine plant would include, but not be limited to, ventilation, drainage, transportation, supply and materials handling, mine power and communications.

There is a difference between designing the plants for large and small mines. The three basic parameters are duration of the underground facility, the profit expected from the mine, and the needs of the mine for auxiliary services. As a rule of thumb, the mines with a life longer than ten years need a more detailed plan and thorough mine plant engineering. Smaller mines that have a life of 3-5 years need a portable surface plant, little or no shaft plant, and a very basic underground plant layout.

Guidelines for Basic Plant Layout

1. Primary mine and preparation facilities should be designed to last the life of the mine unless other circumstances (economics, safety, regulations, etc.) dictate a change.

2. Size of the stockpile areas, mine supply yard capacity, bathhouse space, and throughout of the facilities should reflect the expected maximum design of the mining operations. Limitations to this guideline include space, topography, and climate.

3. Primary design components such as power, water, and access routes should reflect the most recent available technologies. Mine power 20 years ago was thought to be adequate at 440 V for primary machinery. Today the new trend is 950 V .

4. The shaft plan design should reflect sufficient flexibility in the placement of piping, cables, machinery, and wires to allow individual repair or replacement without significantly impacting any other component.

5. Shaft plant systems should be designed for the life of the mine unless circumstances dictate otherwise.

Secondary guidelines are concerned with the interdependence of the mine plant stems. Secondary guidelines are used during the second stages mine plant layout after the initial design is determined. There are three secondary design guidelines:

1. Competing uses for primary resources such as power and water should be designed to compliment each other. An example is where a thermal dryer fan motor comes on in the plant the lights should not dim or production machinery slow down.

2. The layout of any system should consider built in safety systems so that it can function without problems and that any failure won't cause other separate system failures.

3. The plan layout should, to the greatest extent possible, minimize any waste or inefficiency in repetitive operations between systems.

The final set, tertiary guidelines, is directed toward the layout of systems when competing regulatory agencies, outside oraganizations, and other unforeseen circumstances compel a change in the design. These instances generally occur when competing uses for natural resources are regulated by governmental actions based on law. They are set apart from other guidelines because they do not impact the design layout until the design itself is under review by external authorities such as state, federal , environmental or safety agencies, and the general public. These guidelines are summarized as follows:

1. To the greatest extent possible, input from the agencies or outside organizations should be gathered early in the design process. The environmental permit may not be submitted until the end of the design process but as much input as possible needs to be gathered from the outside agencies and general public in the beginning of the process. Public comment sessions are a necessary ingredient to good public relations and acceptance of the mine plan layout.

2. In public debates or public meetings over technical design issues, "facts speak louder than words". For the mining engineer, this means being prepared with correct and completed data, and the facts should be stressed against emotional arguments. To be effective with the "facts", the engineer must be able to break the number down to clear charts, graphs and tables.

3. Acceptable alternative solutions should be developed for those items within the design layout that may represent points of contention between various groups. These alternatives may serve to avoid costly delays or redesign problems later in the project design or construction phases.

4. Keep design parameters conforming to known standards to aid in maintaining effective project design. For example, in the US, electrical installations should reflect current National Electrical Code Standards as well as local utility construction standards, if necessary. Mine materials should conform to US Bureau of Mine published standards as ASTM standards or any other governmental agencies. Health and occupation standards need to be met at the onset to avoid costly design changes or expensive construction changes after completion.

References:

**This article was adapted from Scott G Britton, Mine Plant Layout. <u>SME Mining Engineering Handbook, 2nd Edition, Volume 2</u>. (Littleton, Colorado: Society for Mining, Metallurgy, and Exploration, Inc., 1992), pp. 1572-1579.