PINCOCK Perspectives

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Underground Mining Methods

CALENDAR

- ***Mines and Money London 2010***
  November 30 – December 1, 2010
  Business Design Centre, Islington
  London, England
  www.mining-journal.com

- ***Northwest Mining Association Convention***
  December 5 – 10, 2010
  Spokane Convention Center
  Spokane, Washington
  www.nwma.org

- ***Mineral Exploration Roundup 2011***
  January 24 – 27, 2011
  Westin Bayshore Resort & Marina
  Vancouver, BC, Canada
  www.amebc.ca

- ***Mining Indaba 2011***
  February 7 – 10, 2011
  Cape Town International Convention Centre
  Cape Town, South Africa
  www.miningindaba.com

- ***2011 SME Annual Meeting and Exhibit / CMA 113th National Western Mining Conference***
  February 27 – March 2, 2011
  Colorado Convention Complex
  Denver, Colorado
  www.smenet.org

- ***PDAC 2011 – International Convention, Trade Show and Investors Exchange***
  March 6 – 9, 2011
  Metro Toronto Convention Centre
  Toronto, ON, Canada
  www.pdac.ca

Introduction

One of the most important decisions facing a mine planner is the selection of a suitable mining method. Often the decision is made without a thorough knowledge of the ground conditions.

Very good ground conditions are required for open staging or minimum support methods, such as shrinkage stoping. On the other hand, poor quality ground is a necessity for block caving. The application of sublevel caving usually requires competent ore and incompetent easily caved host rock. The consequences of implementing block caving in competent, high strength rock with little or no fracturing is extremely coarse fragmentation, excessive drawpoint wear, high secondary blasting costs and, in general, unacceptable production costs. Conversely, the consequences of attempting sublevel caving of weak, highly fractured ground is poor brow control, ore loss, excess dilution, unnecessary blasting and, again, unacceptable production costs.

The choice of an underground mining method must be tailored to the ground conditions if the mining operation is to be successful. The emphasis should be put upon objectively assessing suitable mining methods and choosing the method most compatible with ground conditions.

Block Caving

(up to 160,000 tpd)

Block caving (Figure 1) is historically one of the lowest cost bulk underground mining methods. Because of this, a detailed rock mechanics assessment of the ore body must be completed to determine its suitability .

The principal considerations in determining whether or not an ore body is suitable for block caving are: local geology, rock strength, hydrology, pre mine rock stress, ore body geometry and the characteristics of the capping rock.

Depending upon the project scope and time constraints, a qualified mine engineer should be involved in order to gather and interpret the data used in making the final decision regarding the cavability of an ore body. Mine planning efforts for block caving projects should involve engineers with practical experience in the parameters that are under consideration for each particular project.

Extensive experience in evaluating cutoff grades and ore reserves for potential block caving deposits along with level placement, type of caving most applicable, (i.e., gravity draw, slusher extraction or loader extraction) equipment, manpower, and cost estimation is required.

Blasthole (Sublevel) Stoping

(up to 20,000 tpd)

This stoping method (Figure 2), along with it's variations of sublevel stoping, vertical crater retreat (VCR) or end slicing, is especially suitable for ore bodies with the following characteristics:

1. The rock in the ore bodies and in the host ground is reasonably competent.

2. The ore zones have relatively large horizontal and vertical dimensions.

3. The number and size of barren or waste zones within the ore body is minimal.

When conditions are favorable for blasthole stoping, this method will produce reasonably low mining costs because it can be highly mechanized and result in good productivity per employee. Large diameter blastholes combined with modern, diesel powered load hauldump (LHD) equipment can usually be used to good advantage when this stoping method is employed. However, close supervision is required and an effective preventative maintenance program must be enforced.

Shrinkage Stoping

(up to 2,000 tpd)

Shrinkage stoping (Figure 3) is the preferred method for mining steeply dipping relatively narrow vein deposits that have competent rock for the hanging wall and footwall. This method does, however, require that 60 to 70 percent of the broken ore be left in the stope until mining of the stope is completed, since the broken ore pile serves as the work platform for the miners. Consequently, the total revenue from the broken ore is delayed until sometime after each stope is completed. Also, ores that are susceptible to rapid oxidation upon exposure to air are generally not considered for shrinkage stoping.

Drilling and blasting is difficult to mechanize in shrinkage stopes because of the inherently uneven floors and generally limited working space. Drawing of the broken ore from the stopes can be mechanized using slushers or LHD equipment loading from drawpoints, or it may be done conventionally with chute loading of train cars or mine trucks.

In general, shrinkage stoping is labor intensive and its use is limited to relatively small producers of higher grade ores.

Cut and Fill Stoping

(up to 5,000 tpd)

Cut and fill stoping (Figure 4) is an extremely versatile mining method that can be applied to both flat dipping and steeply dipping deposits under almost all types of ground conditions. It permits the mining of erratically shaped ore bodies with a minimum of dilution, and a high degree of selectivity. Where ground conditions are reasonably good, an overhand extraction system is employed in which slices of ore are removed from a stope by starting at the bottom and advancing upward. Backfill is placed in the stope upon completion of each slice and serves as a working floor for extracting the succeeding slice. Where ground conditions are extremely poor in the ore body, an underhand extraction system is used in which work advances from the top of the orebody to bottom. In this case cement is added to the backfill material to stabilize it and provide a safe roof to work under.

Cut and fill stopes can often be highly mechanized so that employee productivity is good, but ore production from each stope must be periodically interrupted to allow for placement of backfill materials. A sufficient number

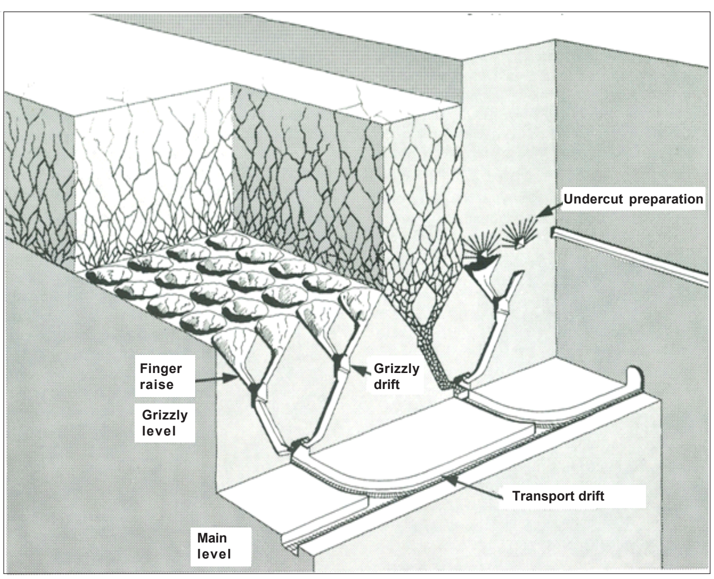

Figure 1: Block Caving

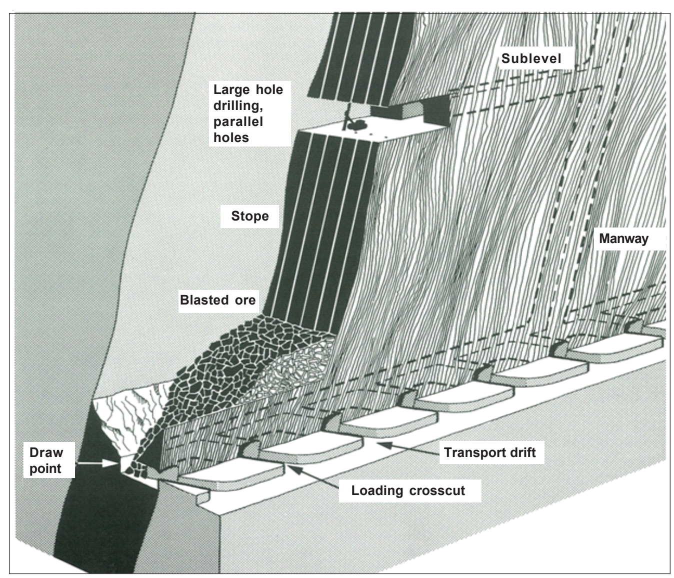

Figure 2: Blasthole (Sublevel) Stoping

of stopes must be made available so that mine production does not suffer because of the backfilling operations.

The backfill material usually consists of deslimed concentrator tailings, and may be augmented by waste muck from mine development or by surface sand and gravel. Cement is commonly added to the backfill material to help stabilize it, either to provide a sound working floor or to make a safe roof for underhand stoping. Hydraulic placement of the fill is the most common practice, with the material prepared in a surface plant and transported underground through pipelines.

Open Stoping

(up to 20,000 tpd)

Open stoping is a mining method for extracting small, erratic ore deposits encountered as veins, sills or mantos in relatively competent rock . The method does not require a large investment in expensive mining equipment and can be used to effectively follow ore shoots on a blast round to blast round basis. In flat lying ore zones, the footwall of the deposit is used as a working floor, while in steeply dipping deposits timber staging is commonly used to work from or pillars of low grade material may be advantageously used as a working base. Transport of the broken rock down to the haulage level may be by gravity alone, or utilize slushers where the dip of the ore zones is too flat to permit 100 percent gravity movement of the blasted ore.

Open stoping of small deposits permits high selectivity of the material to be mined, but daily production is generally very limited at mines employing it as the principal method of extraction. It is commonly used as a scavenging method for recovering ore that might otherwise be lost at larger mines where the principal production methods are based on blasthole or shrinkage stoping systems. It is a mining system commonly employed at smaller precious metal mines where ground conditions are good, and the orebody consists of small ore shoots. It is especially prevalent in many lesser developed nations where mining regulations are less stringent, labor costs lower and mining equipment is relatively high priced.

Sublevel Caving

(up to 50,000 tpd)

Sublevel caving (Figure 5) can be applied to those large ore deposits in which the ore itself is relatively strong, but the host rock is weak enough to cave when the ore is removed. The geometry of the ore deposit influences the selection of this stoping method. A steeply dipping deposit is more satisfactory for it's application than a relatively flat deposit, unless the latter has considerable thickness. Sublevel caving can often be used to extract ore bodies whose limited size or rock competency precludes extraction by the block caving system, and is flexible enough to be applied to irregular ore bodies of varying widths.

The principal disadvantages of sublevel caving is the resulting high dilution of the ore caused by caving of waste material from the walls and the relatively high development cost to bring the mine into production. Since sublevel caving induces failure of the wall rock and overburden, surface subsidence results in locating all permanent structures outside of the area of influence.

Sublevel caving mines lend themselves to mechanization and mining activities can be specialized simplifying the training of underground personnel. Mining activities on each level are similar, i.e., development of the levels, production drilling on the intermediate levels and production blasting with ore extraction on the upper levels, consequently the supervision of the activities is also

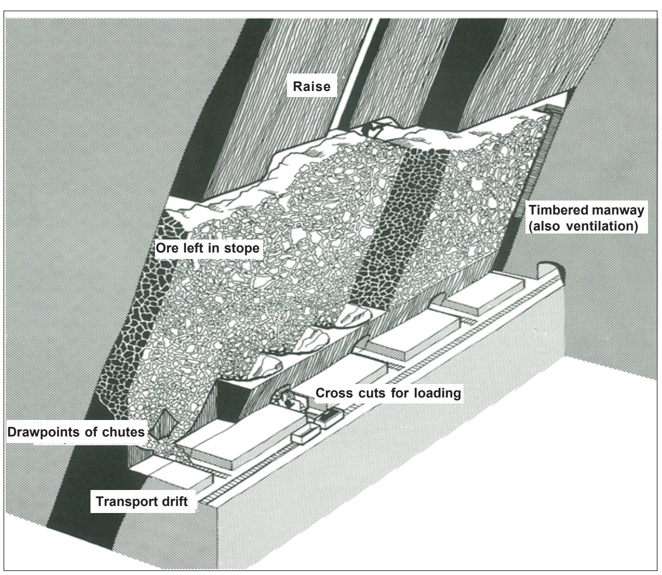

Figure 3: Shrinkage Stoping

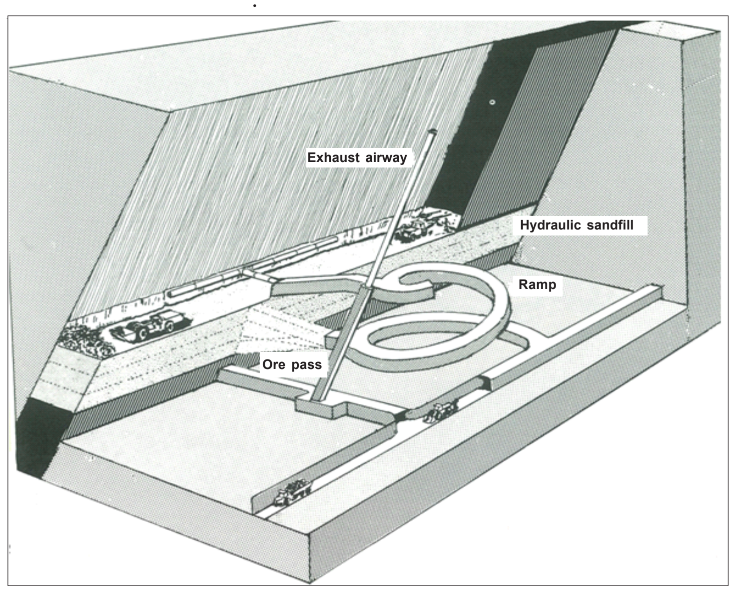

Figure 4: Cut and Fill Stoping

simplified and interference between the activities is minimized.

Room and Pillar Stoping

(up to 20,000 tpd)

Tabular, flat dipping ore deposits in competent rock are usually mined by room and pillar stoping methods (Figure 6). If the ore zone is continuous over long distances, a regular pattern of support pillars can be laid out to yield maximum recovery of the ore and at the same time provide sufficient support for the hanging wall or roof. If the ore zones are erratic, random support pillars can be left in areas of waste or low grade material.

The principal advantage of room and pillar stoping is that it is readily adaptable to mechanized mining equipment, which results in high productivity and a relatively low cost per ton of material extracted. For large ore bodies, a large number of working places can be easily developed so that high daily rates of production can be counted upon. Most of the mine development work is in ore so waste extraction is kept to a minimum.

The main disadvantage of room and pillar mining is that a large area of roof is continuously exposed where work activities or movement of men and supplies are carried out. Consequently, roof soundness is a primary concern for the safety of personnel and ground support is generally a major cost, especially in rooms with high backs. Also, recirculation of ventilating air can be difficult *to* minimize in room and pillar mines .

Miscellaneous Stoping Methods

Three stoping systems that were commonly used in the past, but because of their labor intensive characteristics are no longer favored are the square set, top slicing and resuing methods.

The square set and top slicing methods are used in extremely poor ground where other extraction methods are not practical. Both methods require large amounts of timber and an experienced work force to be successfully implemented. Because of the large amount of timber used, both methods present a definite fire hazard for the entire mine. The characteristics of top slicing and square setting preclude mechanization of their operations, so their application is limited to very high grade ore bodies.

Resuing is a method of stoping in which the ore is broken and removed first followed by the blasting of the waste or vice versa. Usually the material which breaks easier is blasted first. The broken waste is left in the stope as filling and a plank floor laid on the fill to prevent mixing of ore and waste. Resuing is applicable where the ore is not frozen to the stope walls and works best if there is a considerable difference between the hardness of the ore and the wall rocks. The method is labor intensive and is rarely practiced anymore, except in very high grade, narrow vein, gold and silver deposits.

This month's article was provided by PAH's Mining and Geological Services Department.

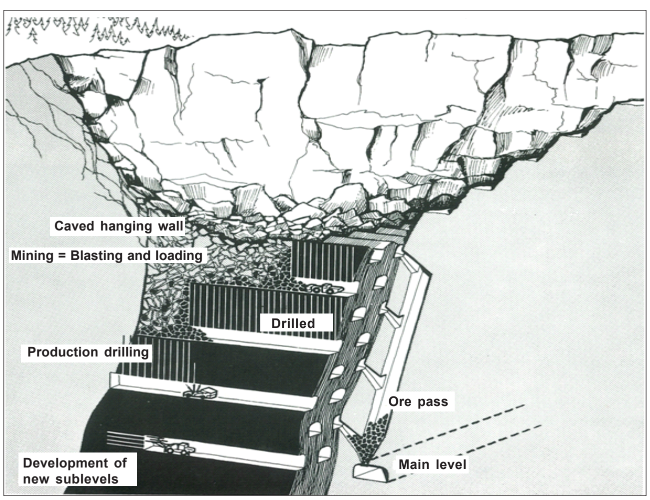

Figure 5: Sublevel Caving

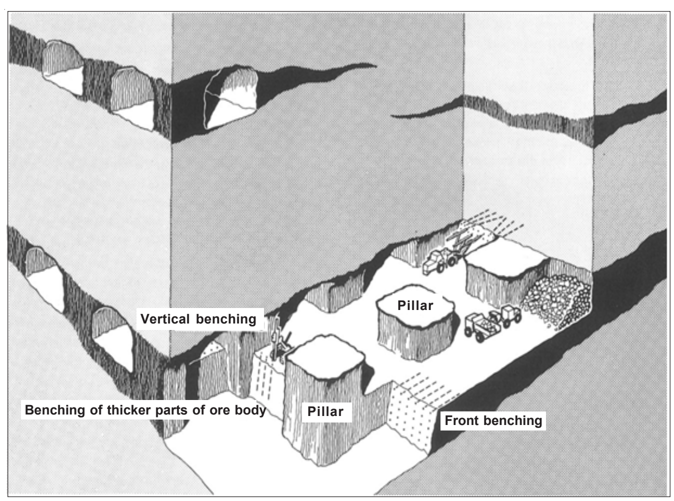

Figure 6: Room and Pillar Stoping

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