Appendix D

Description of Mining Methods

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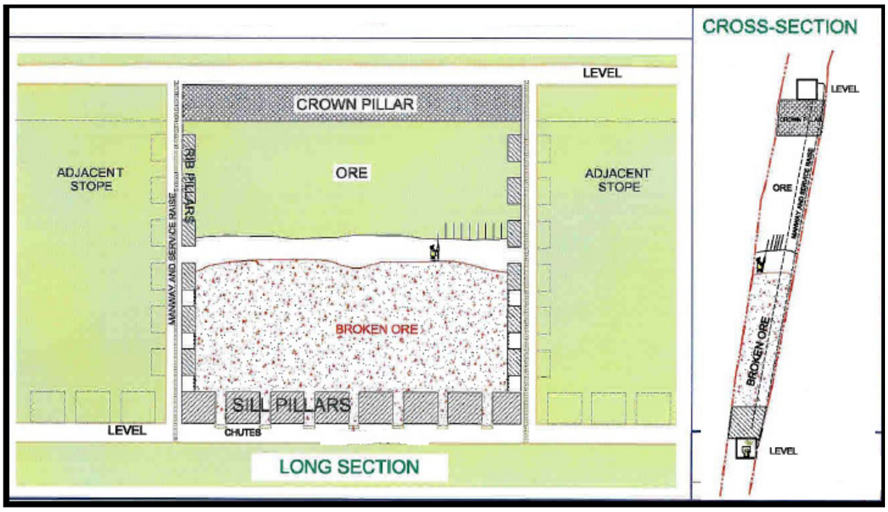
Shrinkage Stoping

Shrinkage stoping is applicable to ore zones that are dipping at least 55 degrees and that range in width from roughly 1.2 to 4.5 meters. The enclosing waste rock must be competent and not subject to failure so that when the ore is drawn from the stope, dilution is kept to a minimum. Another major requirement is that the contact between wall rock and the ore zone be relatively sharp without any abrupt changes in either strike or dip along the stope interval.

Stopes are commonly accessed by crosscuts driven into the ore body at regular intervals from a drift driven in the footwall, or from headings driven along the length of the ore. The stope is mined by drilling short holes (2 to 3 meters) along the length of the vein and blasting the ore down, or by a series of short horizontal holes, commonly called breasting. Access to the next lift is gained by standing on the broken ore, and repeating the process until the upper level is reached. During the mining phase, only enough muck is drawn out of the bottom of the stope to permit the miner to access the stope, and to drill off the next lift. Typically, during the mining stage of the stope, approximately 40% of the total broken muck is drawn off.

It can be seen that a considerable amount of development work is required to prepare a shrinkage stope for production. In addition, the productivity of the method is not high during the mining cycle, since the bulk of the muck must remain in the stope until the stope is finished.

Productivities within shrinkage stopes are largely dependent on the width of the ore zone, and can vary from 15 to 30 tonnes per manshift. Mines using this method as a sole source of ore typically produce between 200 to 800 tonne per day,



Mechanised Cut and Fill

This is the classic method for mining narrow orebodies and involves extracting the ore in small slices, 2 to 4m high, working from the bottom upwards. As each cut is extracted, the void is filled, primarily to form a working platform for the next lift. The fill can be waste rock, hydraulic fill, paste fill or a combination of these.

In mechanised cut and fill, stope drilling is carried out by a drilling jumbo and fragmented ore is extracted from the stope by a diesel loader. On each lift, the stope back and walls are supported by rockbolts/cable bolts and the fill provides high quality regional support.

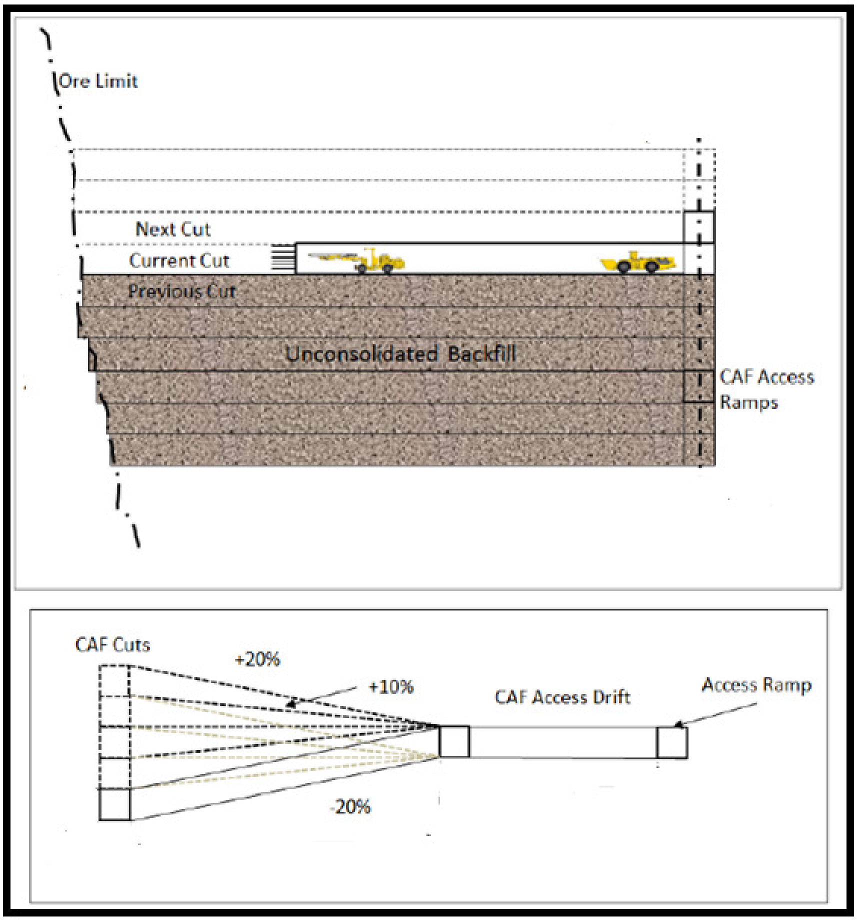
Because of the fill support, relatively large areas can be extracted without leaving pillars.

The major advantages of cut and fill are:

- it is a very selective method and these should be minimal dilution
- there is good ground control because of in-stope support and the stabilising influence of the fill

The major disadvantages are:

- it is a relatively low productivity method
- it is fill dependent and mining must cease while each void is filled
- miners are required to work under freshly mined backs and ground support can become onerous in wide orebodies



Overhand Bench/Avoca Stoping

Benching is a term used for mining methods where ore zones are extracted longitudinally with the majority of development in the orebody, advantages are:

- requires the least amount of development
- allows adjustment of the spans of unsupported hangingwall/footwall for the ground conditions
- facilitates high levels of ore recovery

Its main fall back is a dependency on remote controlled loaders to facilitate high recoveries.

Ore drives are developed at top and bottom of a slice of ore, typically with a spacing of 15m to 20m floor to floor. The ore between the ore drives is then blasted, using either upholes or downholes, and the broken ore is extracted from the lower level. When a certain block of ore is extracted, the void is filled and the process is repeated, using the fill as a working platform for the next lift.

Pattern cablebolting (in the sidewalls hangingwall/footwall) may be required on all ore drives to minimize the possibility of stope back failure, and subsequent difficulties in accessing the following benches. Drilling and blasting could be by either upholes or downholes. Some ore mucking will be off fill floors and as such some control will be needed to ensure that excessive dilution does not occur by digging into the floors.

The method has the advantage that access is required only to the upper and lower sublevels and slice by slice access as in cut and fill, is eliminated. Furthermore, miners work only in development size openings and it is generally a safer method. Its major disadvantage is that it is not possible to support the stope walls between the sublevels and ground control is less effective. Dilution will occur if wall collapse occurs before all ore can be extracted.

The ore between sublevels can be blasted selectively but, if the ore drives are wider than the ore, the remnant waste walls are fully undercut and wall failure will occur unless the rocks are very competent

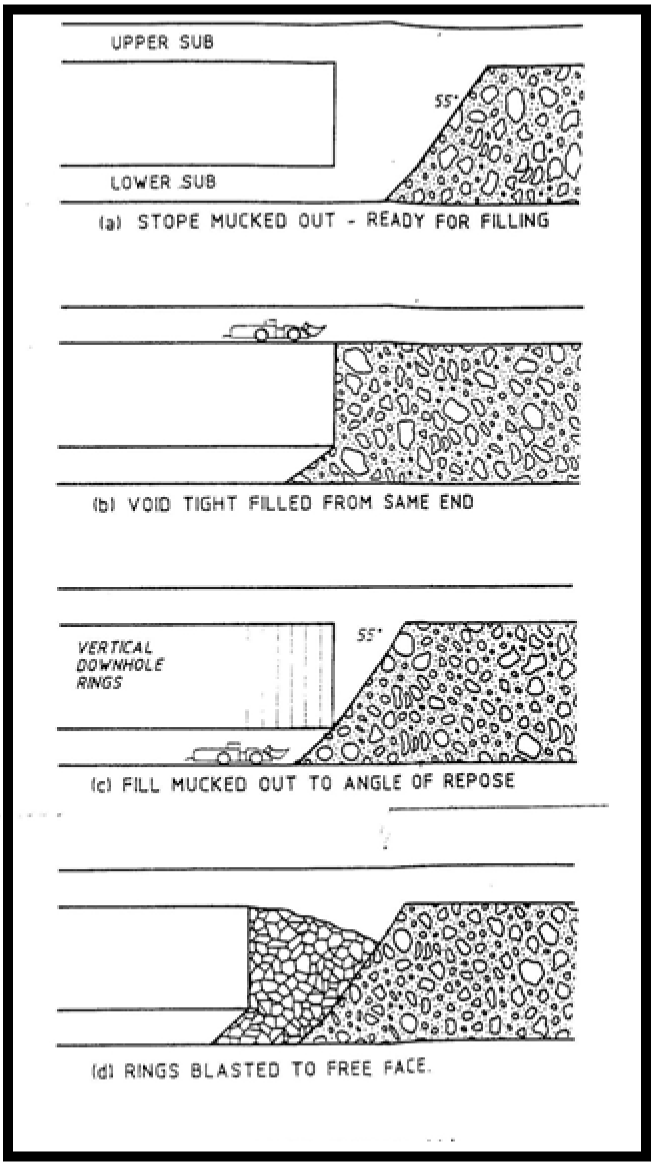
The Avoca Method is used in orebodies with weak wall rocks which are susceptible to premature wall collapse, only a relatively short strike length of the orebody is extracted and the void is immediately tight filled with waste rock. The next increment is extracted by choke blasting against the fill, which compacts and provides only a small amount of dilution.

Standard Avoca had double end access, with extraction from the lower sub-level at one end and filling from the upper sub-level at the other end. Modified Avoca has been adapted for single end access. The face is retreated a certain distance, dependent on hanging wall stability. The void is then tight filled with rockfill from the upper sub-level.

Two approaches are then available, as follows:

fill can be mucked out to a naturally compacted angle of repose (55deg) and subsequent rings are blasted to a free face.
subsequent rings are choke blasted against the fill - the blasting compacts the fill and causes it to stand steeply and contribute minimal dilution.

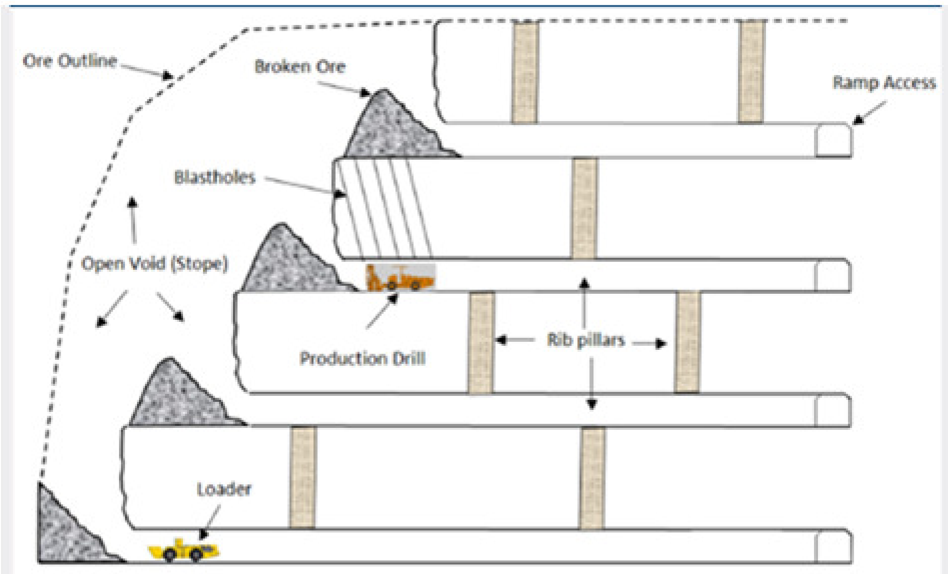
Modified Avoca – Overhand Benching Illustration



Underhand Benching

This is a widely used method of benching where extraction proceeds from the top of an ore block downwards. Development requirements are identical to those for overhand benching, as discussed above. However, fill cannot be introduced because the fill would be undercut on each lower lift. A progressively increasing void is generated and pillars must be left at regular intervals to provide support for the walls of the void.

This method is highly productive because it is not fill dependent. However, it has the same limitation on minimum mining width, as discussed above. It will have its main application in areas with better ground conditions, where a reasonably small proportion of the ore can be left as pillars to support the walls.



Alimak Stoping

This method extracts the ore in horizontal rather than vertical slices. An alimak stope is developed firstly by mining an alimak raise up the hangingwall contact of the orebody. Cablebolts or rockbolts are installed in the hangingwall of the raise, to provide reinforcement for the mid span of the future stope hangingwall.

Sub-horizontal blastholes are then drilled into the orebody, on both sides of the raise and these are blasted, progressively upwards from the bottom of the stope. The fragmented ore can be drawn from the base of the stope or some ore can be left to support the walls, as in a conventional shrink stope.

A key issue of the design is the support of the raise hangingwall to provide mid-span reinforcement of the final stope hang ingwall. Rings of 3 x 5m long single strand cablebolts at 2m ring spacing are specified for this purpose. Considering the confined working conditions, coupled rockbolts may be a preferable alternative.

A potentially major advantage of alimak stoping is the ability to selective extract narrow orebodies with minimal dilution. Operating the stope as a shrink stope is highly recommended. In this event, good fragmentation will be essential to avoid the possibility of hang-ups during draw. Small diameter blastholes are indicated for this purpose - these will be required, in any event, for narrow orebody stoping.

Alimak stoping has been trialed at several mines in Australia and overseas but is not a popular stoping method.
Possible reasons for this lack of popularity include:

- it needs specialised equipment and knowledge (Alimak raise climber)
- it tends to be a higher cost method than conventional benching

However, it has the potential to eliminate significant lateral development.

Risks: Though the method is intended to reduce dilution, it has a few operational issues.

Vertical development is meant to follow the orebody, but if the oredody varies in dip and pinches and swells the Alimak equipment is not sufficiently flexible to follow these moderate changes in direction.

Drilling access is via the rise, hence supervision is difficult and not as rigorous as on levels where access is easy. Due to the restricted nature of the rise itself and the fact that orebodies thin and swell drilling usually requires fan drilling, this in itself introduces drilling errors and potentially over drilling into the footwall and hanging wall. Again due to the difficult access geological control tends to be inadequate. The net result is that fan drilling and poor control results in over excavation and higher dilution than anticipated. The method is more difficult to manage than vertical drilling between levels.