



For this presentation, a few mines in the Kalgoorlie region have been used to exemplify the different styles of mining. In particular we would like to acknowledge the use of visual material from the Empress gold mine near Coolgardie and the Black Swan nickel mine near Kalgoorlie (MPI Mines), and from the KCGM Superpit in Kalgoorlie.

Mine planning

Once exploration drilling has defined a viable orebody to mine, geologists and engineers will work together to determine the most efficient method of mining.



Mining methods and techniques

There are two basic methods of mining:

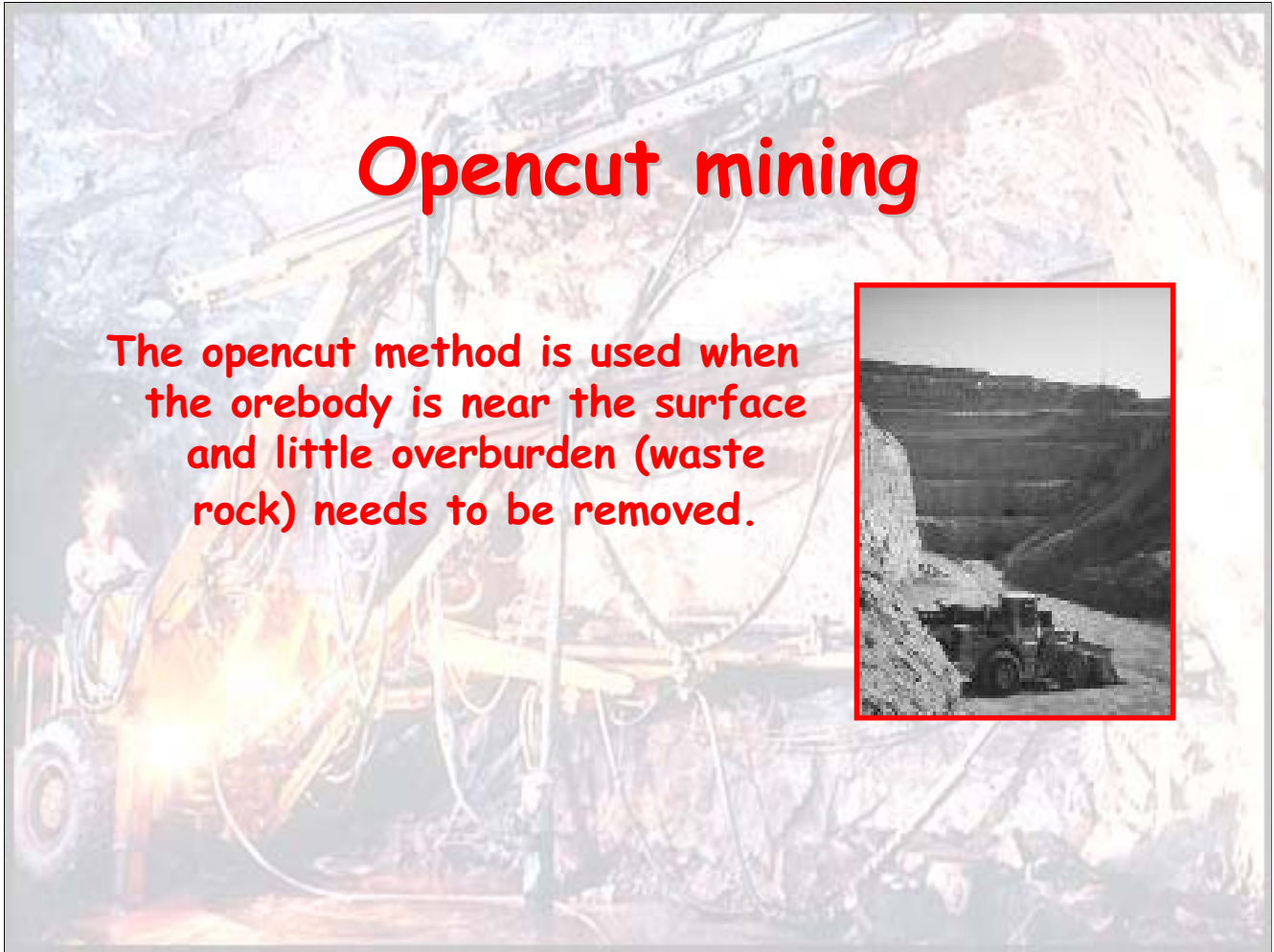
- Opencut
- Underground

Any ore can be removed from the ground using these methods



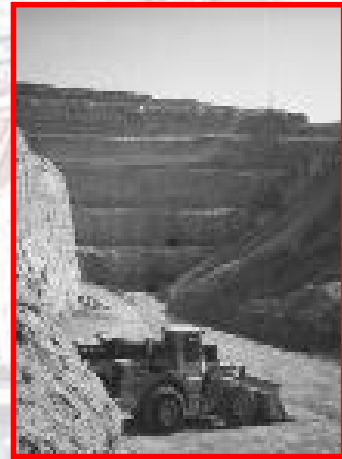
The opencut mine you will be most familiar with will be the Superpit in Kalgoorlie.

Many mines in the Kalgoorlie area extract the ore through a combination of opencut and underground methods.



Opencut mining

The opencut method is used when the orebody is near the surface and little overburden (waste rock) needs to be removed.



Equipment used underground is limited by the size of the shafts and tunnels and ventilation requirements.

Opencuts have no such limitation and may use very large mobile machinery to achieve high production rates.

Costs are much lower in opencut than in underground mining, although disturbance of the land is very visible and extensive rehabilitation may be required.

Opencut mining

Before mining commences, topsoil and overburden are removed and stockpiled. Excavation of an openpit can then commence.



KCGM

Topsoil is stockpiled for future rehabilitation. It contains organic material (including seeds) that will contribute to successful rehabilitation of plant species. There is an optimum thickness for storage of about 2 m. If possible, the topsoil will be reused as soon as possible to avoid sterilization due to climatic conditions.

Opencut mining

In shallow deposits the oxidized material is commonly soft enough to be removed without blasting by excavators or back-hoes.

With increasing depth the rocks are harder and it becomes necessary to drill and blast before excavating.

Blast rig



KCGM

Blast pattern



KCGM

Blast rigs will drill a closely spaced pattern of drillholes to the approximate depth of the bench (the height of each mined level). The drillholes will then be loaded with explosives and detonated to produce broken rock that can be moved by excavators or loaders. The material is then transported to the plant for processing.

Underground mining

More complex

- access
- ground support
- ventilation
- blasting
- haulage



MPI Mines

Underground mining is more complex than opencut mining, and requires considerable more planning to take into account access, ground support, ventilation, the effects of blasting, and haulage of material from the mine to the plant.

Underground mining

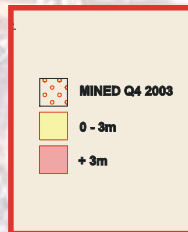
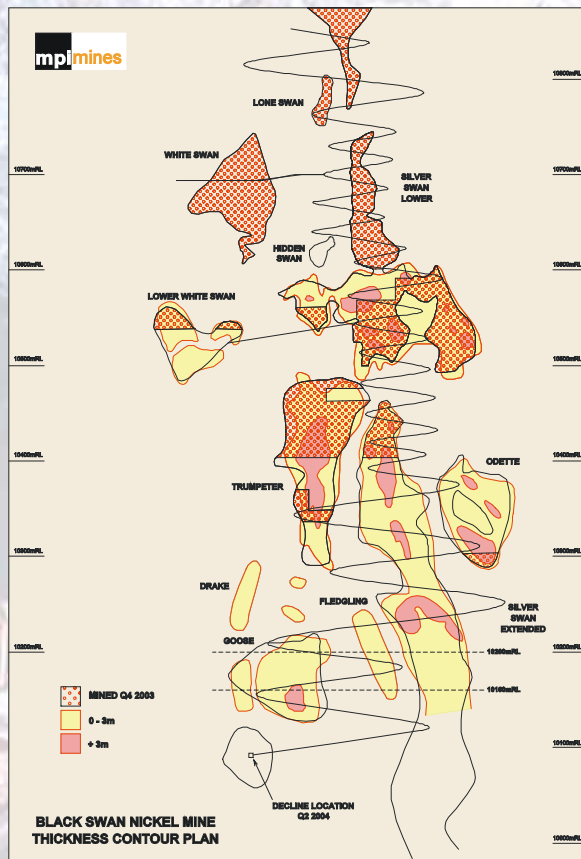
- To make underground mining economically viable, access must be well planned and efficient.
- Access to the underground orebody is based on the understanding of its characteristics and those of the surrounding rock.
- This is determined by initial drilling from the surface and then more closely spaced drilling and geological mapping as the underground development progresses.



MPI Mines

Underground mine planning

Orebody thickness contour plan for Black Swan nickel mine



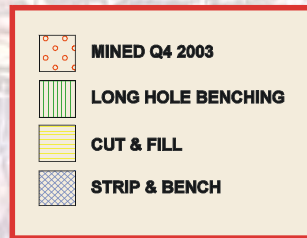
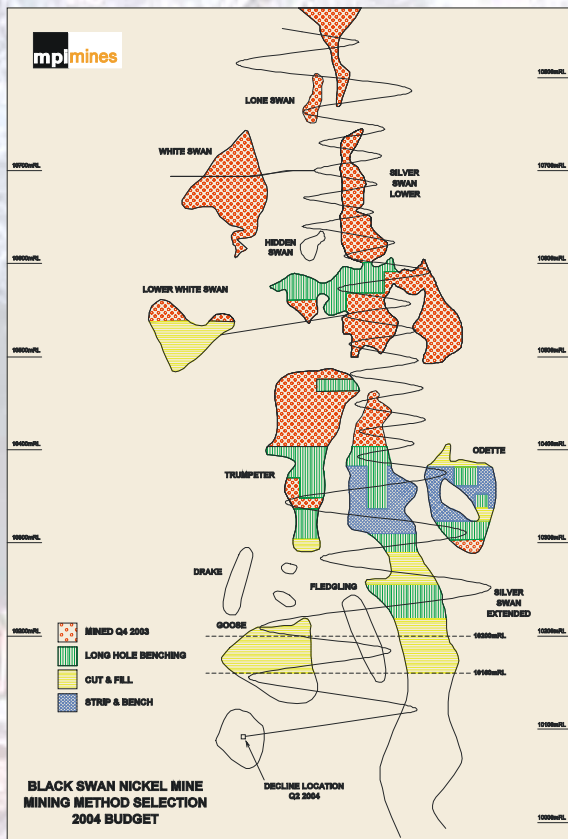
MPI Mines

Extensive drilling and mapping are used by the geologists to model the orebody, and determine its relative thickness at various positions. This modelling is then used to plan how underground mining is conducted, and to design the mine.

This planning is done initially, but also continues throughout the life of the mine, as different parts of the orebody become accessible and the orebody can be better modelled.

Underground mine planning

Mining method selection used at Black Swan nickel mine



MPI Mines

The mining method used will depend on the characteristics of the orebody, particularly thickness and dip, and the competency of the surrounding rock. Different methods can be used in different parts of a mine, as this plan from the Black Swan nickel mine exemplifies. This type of planning is done continuously as mining proceeds and more data are acquired on the orebody configuration through underground drilling.

Underground mining

Ground support is necessary when voids (empty spaces) are created underground.

The competency of the rock being mined will determine how large a void may be created and what ground support methods will be necessary to maintain a safe working environment.



MPI Mines

Ground support is essential during underground mining.

For example, the rock units at the Empress Decline near Coolgardie are generally quite competent and require no excessive ground support. The support methods used here are mesh, split sets, and gewi bolts, which are threaded solid bars grouted into the rock. The walls of an area that has been newly blasted need to be made secure before any further work can be done in the area.

Other mines may require more complex type of ground support.

Safety in a mine is always the first priority, and to ensure that appropriate safety methods and procedures are in place, government inspectors routinely visit mine operations.

Underground mining



MPI Mines

Adequate ventilation throughout the mine may be ensured by the provision of a separate shaft from the surface. This has a fan that draws fresh air through the mine.

Underground mining

Ore extraction and underground development is achieved by precise drilling and blasting techniques.

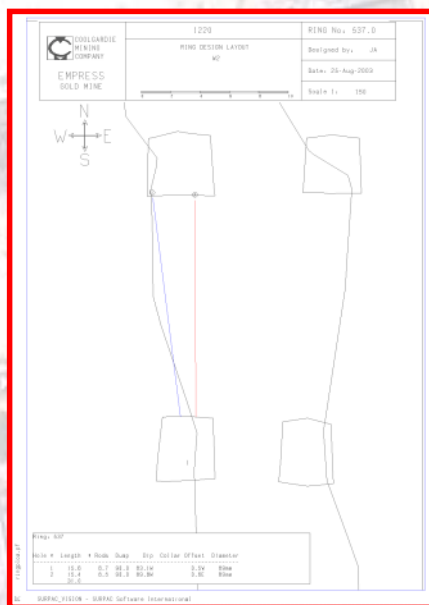
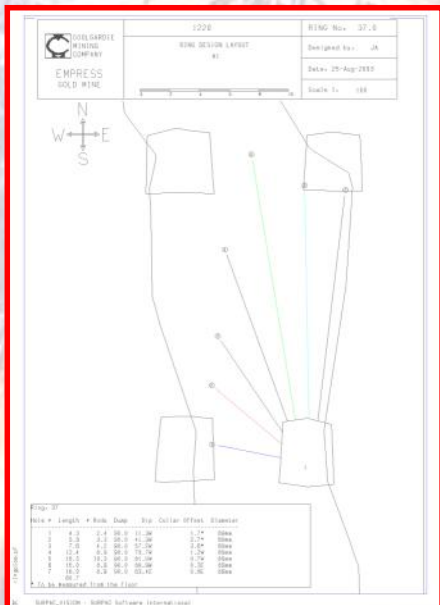


1. Drilling
2. Blasting
3. Bogging
4. Ground support



This is closely controlled and monitored by engineers, geologists, and surveyors.

Underground drilling Ring design layouts



MPI Mines

To allow for the accurate blasting and removal of ore from a stope, engineers, with assistance from geologists and surveyors, design drilling and blast patterns that radiate from each level access. Depths and directions are precisely designed to maximize ore recovery without dilution from the surrounding rock, so that waste is minimized.

Underground mining

Blasting occurs after the rock face or area to be mined has been drilled to a predetermined depth and pattern.



MPI Mines

These drillholes are then loaded with explosives and blasted to produce fragmented rock that can be easily loaded into trucks and transported. This ore is taken to the surface for processing. Waste may be used to fill voids or also be taken to the surface.

Safety is the prime concern during mining.

Blasts do not take place unless all workers are evacuated from the mine. Work is immediately stopped if unsafe conditions are identified. Ground support is of great importance.

Stoping

Stoping is the removal of the orebody from the surrounding rock. The stoping method used depends on the nature and extent of the orebody.

All methods involve:

- **drilling a pattern of holes into the rock**
- **charging (filling) the holes with explosive**
- **blasting the rock**
- **bogging (digging) it out**
- **transporting it to the surface.**



An open stope

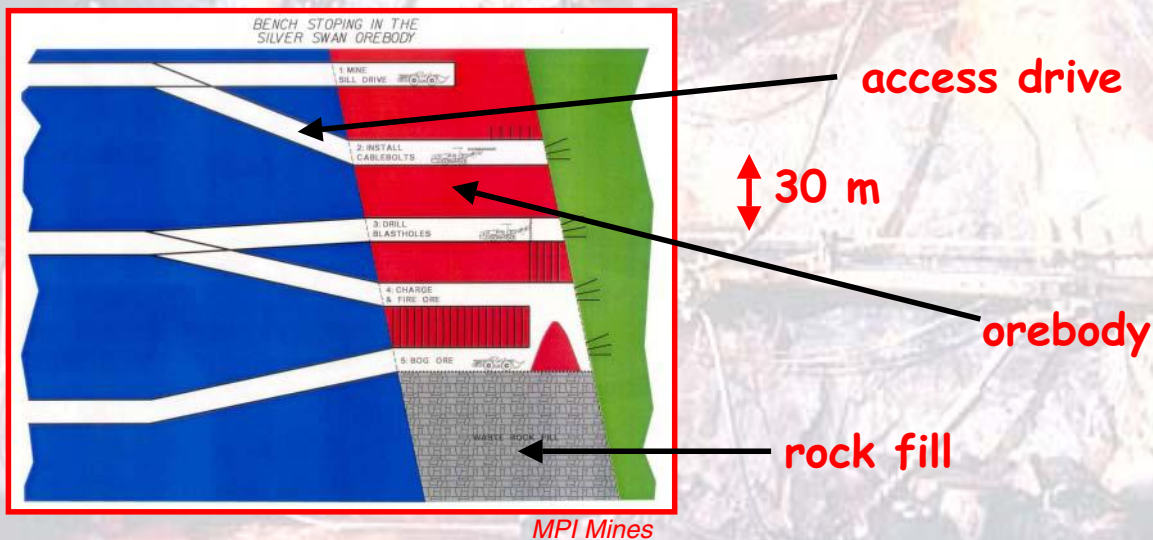
MPI Mines

There are two distinct ore bodies at the Empress Decline. Both are near-vertical in orientation. The Empress ore body is on average 4.5 m wide and 80 m long. The benches are 15 m thick. It is currently being mined at between 220 and 160 m below surface. It is returning an average of 6 g/t gold.

The Granodiorite orebody is composed of a central granodiorite with associated stockwork. The East and West lodes are narrow quartz structures that are generally of higher grade. This orebody is returning an average of 8 g/t gold. It is currently being mined between 240 and 160 m below surface. The stopes are up to 60 m long and have widths of up to 20 m.

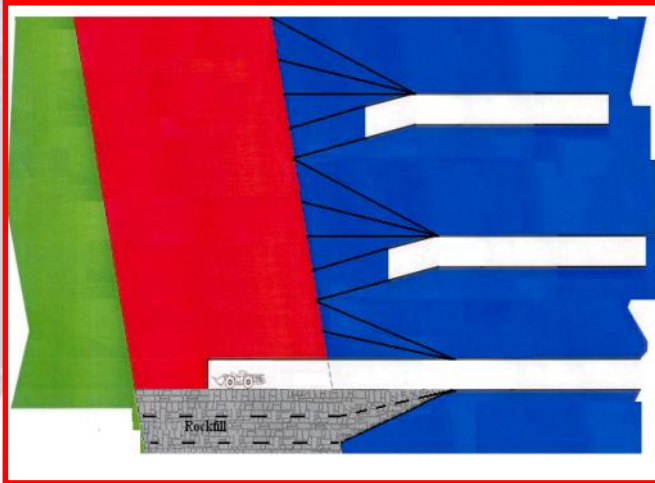
Underground mining

The general approach is to access the orebody at regular intervals (generally between 15 and 40 vertical metres) and then stope between these access drives.



All stopeing methods will have different characteristics, The stopeing method selected in each case will depend on the particular orebody and mine planning techniques. The methods used may vary throughout each mine, depending on the changing characteristics of the orebody.

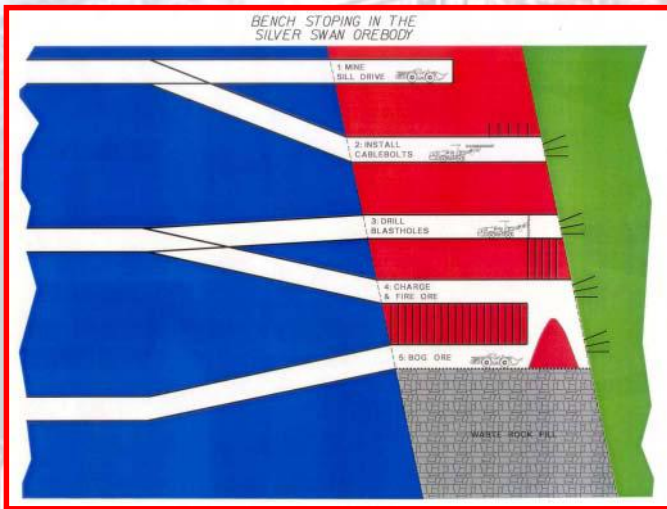
Traditional cut and fill stoping



- Bottom up mining method
- Selective mining method
- Generally uses no cement
- Moderate ground support
- Moderate production rates
- Good resource usage
- Not stress friendly

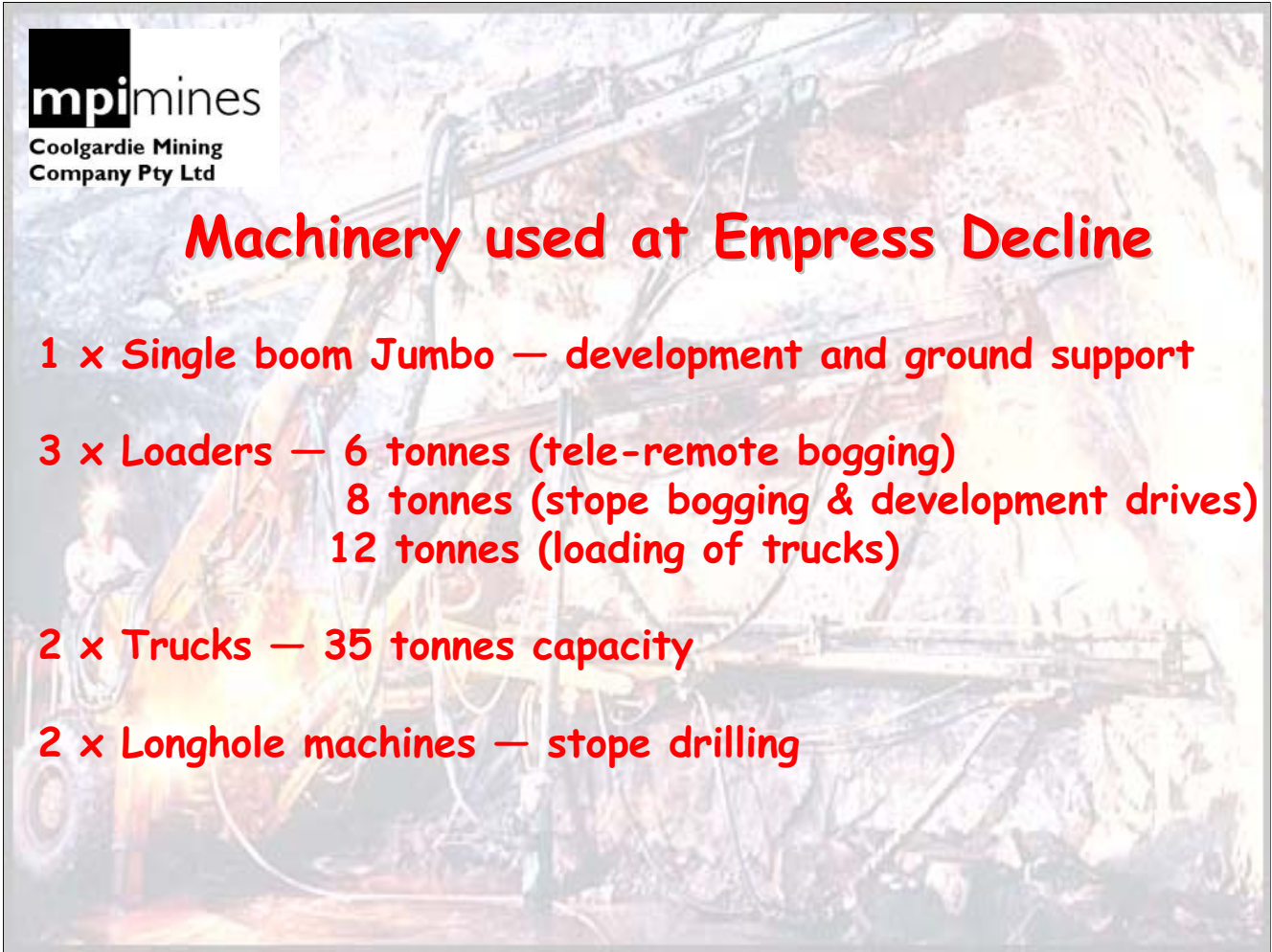
MPI Mines

Longhole mining method



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- Traditionally high production rates
- Large openings with long open times
- Bottom up mining method
- High ground support cost
- Uses some cement
- Non-selective mining
- Not stress friendly
- Many equipment types



mpimines
Coolgardie Mining
Company Pty Ltd

Machinery used at Empress Decline

- 1 x Single boom Jumbo — development and ground support**
- 3 x Loaders — 6 tonnes (tele-remote bogging)**
 - 8 tonnes (stope bogging & development drives)**
 - 12 tonnes (loading of trucks)**
- 2 x Trucks — 35 tonnes capacity**
- 2 x Longhole machines — stope drilling**

Equipment used will depend upon the size of the operation (how much rock is broken), the mining technique(s) used, the operating roster, and the maintenance and condition of equipment.

This slide exemplifies the equipment used in a relatively small gold mine.