TECHNICALLY speaking

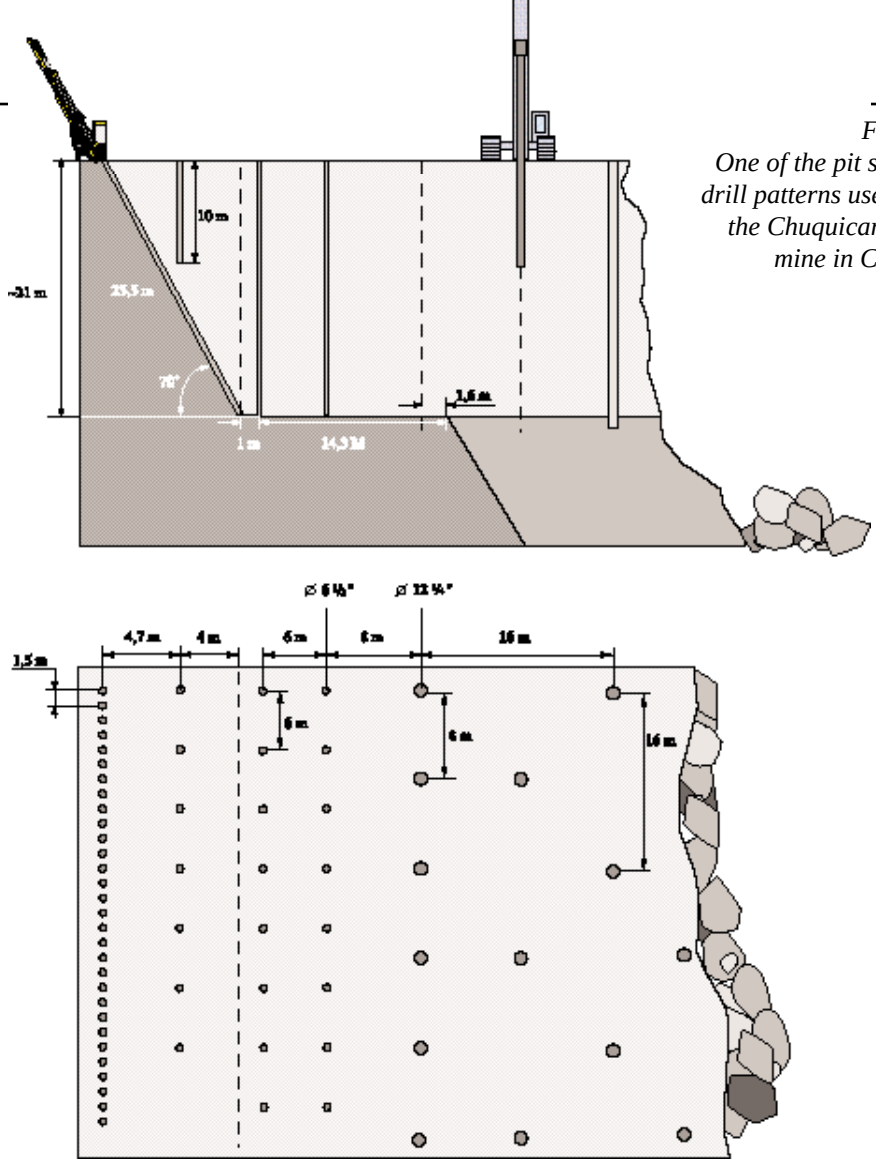

Fig 2. One of the pit slope drill patterns used at the Chuquicamata mine in Chile.

An increasing number of open pit mines are discovering that the slope angle of a pit has a direct bearing on the cost of operations. The steeper the angle, the less rock has to be drilled, blasted and hauled away.

NEW TRENDS IN OPEN PITS

By Hans Fernberg, M.Sc., Mining Engineering, Atlas Copco Rock Drills

For years, open pit mines have investigated the possibility of increasing the angle of their slopes in order to reduce the amount of rock they need to remove over time. But doubts about the impact of such a move on slope stability and safety has made them reluctant to deviate from industry norms.

Today, these doubts are being swept away as more and more open pits mines, notably in South America, are proving that steeper slopes can save considerable amounts of money, without compromising on either slope stability or safety.

Minimizing the waste

The large quantity of waste material that is usually excavated to get to the metallic ore or non-metallic minerals is the economic basis of any drilling operation. The difference between quarries and open pit mining is the geological conditions and the characteristics of the blasted material. Whereas quarries deliver the majority of rock in various sizes via the crushing and screening plant, the open pit mine attempts to deliver the ore as pure as possible via crushers to the dressing plant which consists of mills, separators and/or flotation or biochemical processes, and finally to smelters converting the minerals to metals.

The demand on rock fragmentation of the waste rock in open pit mines is simple. It should merely suit the loading and trucking equipment used for removal to the waste dump. On the other hand, good fragmentation of the blasted ore will result in substantial savings in the total cost of the ore dressing process.

As no orebodies have the perfect conical shape, which would be tailor-made for the pit geometry, vast quantities of waste usually have to be removed from both the hanging wall and the footwall to provide access to the ore. (Fig 1 shows a principal cross-section of a pit.)

The waste to ore ratio increases as the pit gets deeper. Eventually, for economic reasons, the pit will be abandoned, or underground mining will take over. Without jeopardising stability, it pays to keep

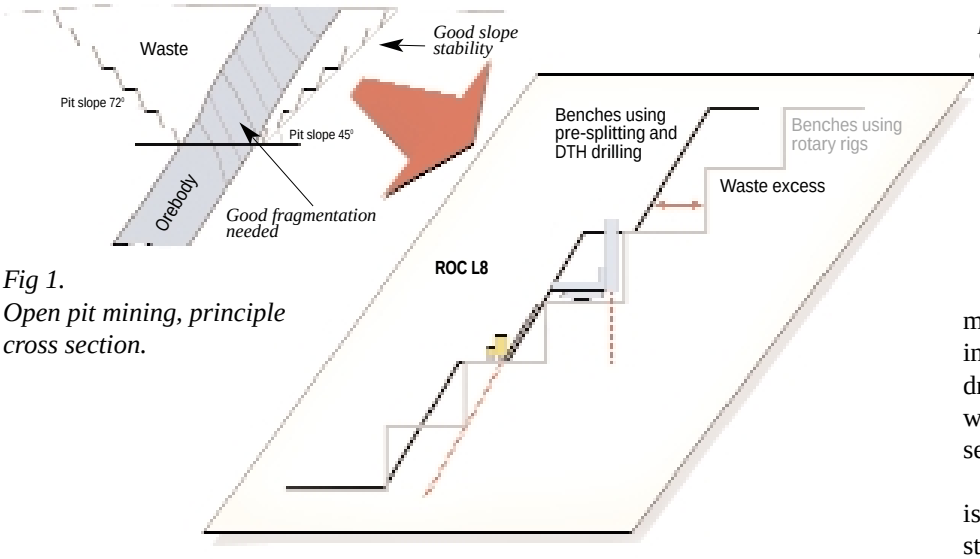

Fig 1.
Open pit mining, principle cross section.

Fig 3.
Enlargement of the slope showing the principle difference between DTH drilling and rotary drilling.

the pit slope angle as steep as possible, thus keeping the excavated waste to a minimum.

Rotary versus percussive

Today, increasing attention is being paid to creating steep, stable and safe pit slopes with no risk of rockfall. And recent experience has shown that by applying pre-splitting and restricted blasting in the zone closest to the final pit contour, great savings can be obtained.

A typical example is the huge Chuquicamata open pit in Chile. Some 8 km long, 2.5 km wide and 750 m deep, the pit has introduced DTH drilling of inclined holes for pre-splitting using the ROC L8 crawler rig, and with two rows of holes, 6 1/2 inches in diameter, to reduce the amount of explosives used close to the pit slope. This keeps the shock waves that are reflected back into the side rock to a minimum. (Fig 2 shows a typical drilling layout).

Using the geometry of Chuquicamata, each degree by which the angle of the slope dips represents a staggering 150 million cubic metres of rock – in other words, huge potential savings.

For the same reason, the world's largest open pit mine, Muruntau in Uzbekistan, has also introduced the ROC L8 as part of a plan to extend its depth to 1180 metres.

Traditionally, the predominant method in open pit mining has been large hole rotary drilling using hole sizes in the 250 to 400 mm range (5 3/4 – 9 7/8 inches). No doubt this implies lower cost for drilling, but it ignores the expense of creating excess waste and less favourable fragmentation. A recent survey of 36 open pit operations in Chile using hole sizes between 75 and 345 mm (3–13 1/2 inches) reveals that hole sizes above 200 mm (8 inches) do not generate any substantial savings in total drill metres per tonne.

This indicates that burden and spacing cannot be increased indefinitely. One important reason for replacing rotary drilling with other methods, such as DTH, is the inflexibility of the heavy rotary rigs, which are suited to wide, vertical benches and single pass drilling only. (Fig 3 shows the principal difference between using DTH drilling and rotary drilling.) Inclined holes, higher and narrower benches contribute to steeper pit slope and less waste rock that needs to be extracted.

Soufflé blasting

Mining of rich, narrow, irregular and stratified ore zones requires extra attention in order not to introduce unnecessary quantities of waste into the ore stream. Consequently, this type of mining has to be progressed on a selective basis in close liasion with surveyors and geologists, taking frequent samples after each individual blast. Short benches and small holes are used to cope with the ore zone irregularities.

A recent method, invented in Australia, called soufflé blasting is becoming increasingly popular. (Fig 4 illustrates the principle of this cautious blasting yielding a minimum of dilution as practised at the Björkdal mine in Sweden.) To a depth of merely 5.8 m, 100 vertical holes, 127 mm in diameter, are drilled using COPROD drilling and then fired in one single blast with a delay of 42 ms between each consecutive number, 1 – 6.

As no free surface for expansion exists and thanks to the high amount of stemming (2.5 m), the blasted material simply swells like a baked soufflé.

This means that the pre-blasted, original geology is undisturbed. After this, selective extraction by backhoe loaders is carried out, resulting in maximum recovery of the rich, narrow gold-bearing veins.

The message is clear: by applying smaller holes, pre-splitting and controlled blasting in the ore and especially adjacent to the pit slopes, offers new possibilities to cut costs. Also, by adopting selective, cautious drilling and blasting to narrow ore zones, ore recovery can be greatly improved.

Realizing these trends, Atlas Copco is focused on developing new products for DTH and COPROD drilling that will help open pit mines to achieve the best possible overall economy. M&C 1•02

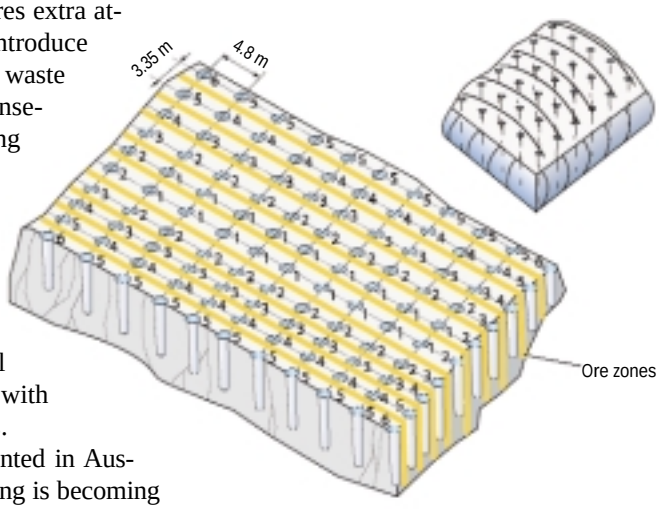

Fig 4. Soufflé blasting: Main diagram shows the firing sequence (42 ms between consecutive numbers 1–6). Small diagram, above right, shows the result.