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CHAPTER 29

Secondary fragmentation and special blastings

:9.1 INTRODUCTION

:he rock fragments produced by blasting which are ex-essively large, also called boulders, need to be broken up n order to be handled by the loading equipment and the ›rimary crusher without causing obstruction.

The methods in use today for secondary fragmentation re classified in two groups: the first, where explosives re used inside the blastholes or in contact with the urface, and the second by special or mechanical means.

In this chapter, other types of non-conventional blasts re also explained.

:9.2 POP SHOOTING

:9.2.1 *With the drilling of blastholes*

:he boulders are drilled with hand held drills or light rigs, ›pening small diameter blastholes with a length of be-ween ½ and ⅓ of the diameter or largest dimension of the ›oulder, and parallel to it, Fig. 29.1. If the blocks have a olume larger than 2 m^3, two blastholes should be drilled nd fired instantaneously.

The powder factors for a gelatin type explosive are ıdicated in Table 29.1. Depending upon the degree of urial of the boulder, the quantity increases from 50 g/m^3 p to 200 g/m^3.

If less potent explosives are used, the charges should e increased by 25 to 50%.

In all these cases, the blastholes should be stemmed in rder to obtain satisfactory results. In surface mines, the op shooting of boulders is usually carried out in stages to educe the noise problems produced by this type of perations.

9.2.2 *Plaster shooting*

'he fragmentation by placing the explosive in contact vith the surface is carried out with shaped charges or, ıore often, with charges made up of several small caliber artridges, Fig. 29.2.

It is recommended that the charge be covered with a ıyer of at least 10 cm of mud or sand to reduce the level f noise and achieve breakage of the rock with less uantity of explosive.

The normal powder factors oscillate between 700 and 000 g/m^3 for gelatin explosives, which are the most ıdicated.

When the charges are not covered, they should be increased by approximately 25%.

The advantages of this method are that no drilling is necessary, little fly rock is produced and the job is taken care of rapidly. On the other hand, the amount of explosives requires is four to five times greater than with pop shooting, and it is limited to areas that are not inhabited because of the intense noise and air blast produced.

29.2.3 *With miniblasts*

When high strength explosives are available, such as those described in Chapter 21, the secondary breakage can be carried out by drilling small blastholes of 22 mm in diameter, using powder factors of 0.02 to 0.04 kg/m^3. These amounts can be reduced to 0.01-0.02 kg/m^3, depending upon the shape and number of blastholes, Fig. 29.3.

When the boulders are covered with earth, they should be partially uncovered to provide a free face thus improving the fragmentation, Fig. 29.4.

29.2.4 *With shaped directional charges*

In underground mining where hang-ups are an everyday happening in draw points and chutes, ore passes, etc, classic pop shooting is dangerous for personnel, costly and timeconsuming.

Recently, shaped charges have been developed that when exploded propel a metallic slug against the boulders from a far off point with enough energy to fragment them and remove the blockage, Photo 29.2 and Fig. 29.5.

29.3 SECONDARY BREAKAGE BY MECHANICAL MEANS AND SPECIAL METHODS

Some of these methods, apart from their use in secondary breakage, are used in demolition operations.

29.3.1 *Impact hammers*

These hydraulic hammers have a utensil which hits the rock repeatedly until fragmentation is achieved. The number of impacts required to break a boulder depends upon the energy used in each impact and the rock strength.

Table 29.2 gives and idea of the mean yields in m^3/h

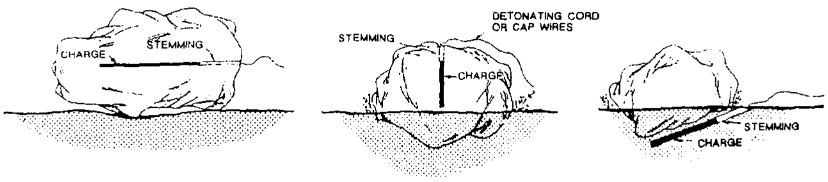

Fig. 29.1. Pop shooting of boulders with blastholes.

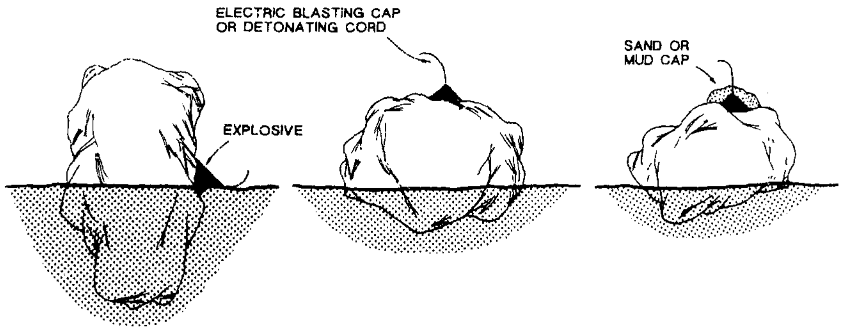

Fig. 29.2. Pop shooting with surface charges.

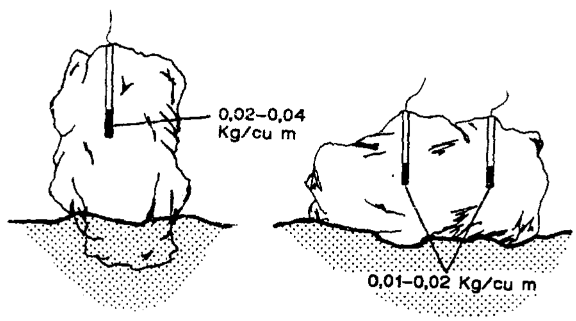

Fig. 29.3. Pop shooting with miniblasts.

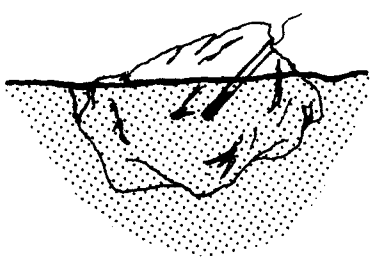

Fig. 29.4. Situation of a mini-blasthole in a partially uncovered boulder.

Table 29.1.

Boulder condition	Specific charge CE (g/m^3)
Uncovered	50-100
Half buried	100-150
Completely buried	150-200

Table 29.2.

Power (kw)	Rock strength RC (MPa)		
	< 120	120-180	> 180
12	10-30*	8-15	–
18	14-40	9-28	2-15
24	19-60	13-40	3-20

*Yields in m^3/h.

the three types of hammers, according to their power and compressive strength of the rock.

There are hydraulic hammers with weights of 50 to 3500 kg which can be mounted upon autopropelled rigs, with the advantages of having great percussion force and strength. In Table 29.3 some of the characteristics of these hammers are shown.

29.3.2 *High pressure water*

This technique consists in drilling a blasthole in the rock and projecting about 2 liters of water into the hole at very high pressure (40 MPa). The liquid hits the bottom of the hole at very high speed generating a shock wave which travels back through the water creating a radial high pressure during a fraction of a second. Radial and axial

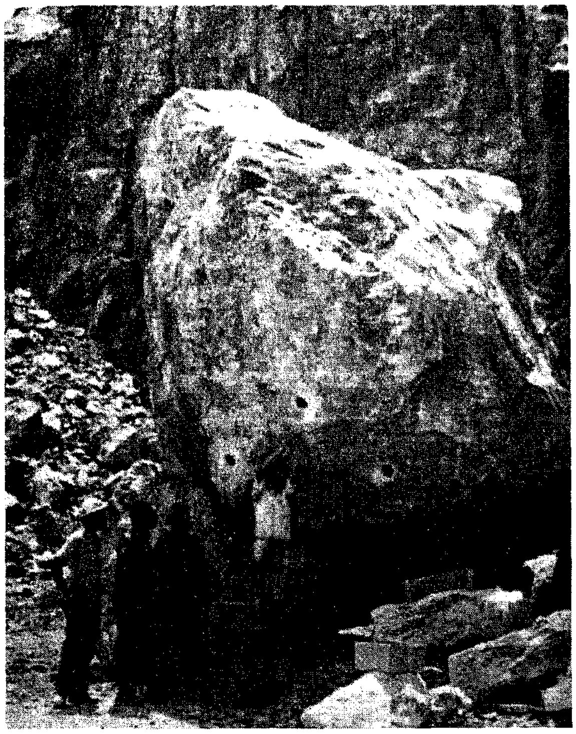

Photo 29.1.

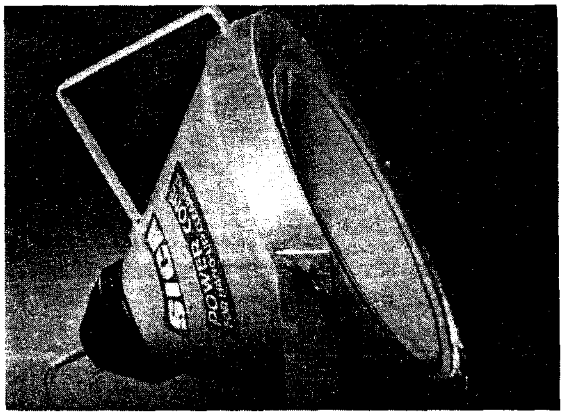

Photo 29.2. The Sica version directional charge.

cracks are produced and the water pressure forces them to the surface, Fig. 29.6.

29.3.3 *Wedges*

In a similar manner to the antiquated method of breaking ornamental rocks with metallic wedges, nowadays hydraulic equipment is available that can be mounted on the boom of a mobile unit. This equipment can, after first drilling a blasthole, repeatedly introduce a wedge by the pushing of a piston that is hydraulically powered and, this way, progressively achieve the fragmentation of the rock, Fig. 29.7.

Table 29.3.

Weight (kg)	Energy of the impacts (Joule)	Power (kW)
50	50–100	1–2
100	150–200	3–4
250	400–600	6–9
400	700–900	9–10
600	1000–1500	10–11
900	1500–2000	12–16
1500–3000	3000–8500	16–40

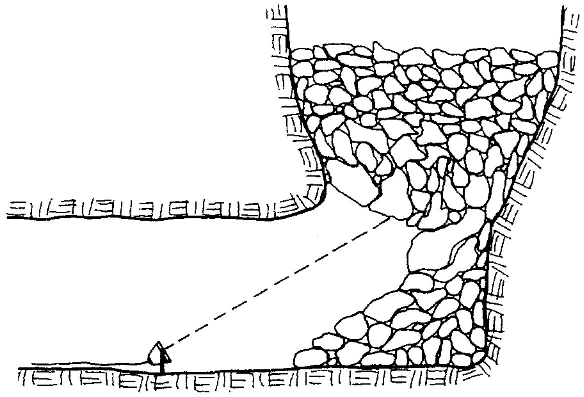

Fig. 29.5. The use of shaped or ballistic disk charges that are projected.

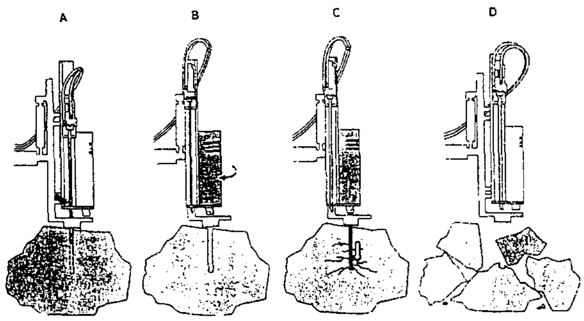

Fig. 29.6. Water cannon 'Crac 200' (Atlas Copco).

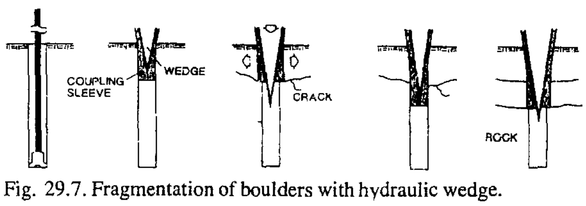

Fig. 29.7. Fragmentation of boulders with hydraulic wedge.

29.3.4 *Breaking agent*

This method consists in filling the blastholes drilled into the boulders with a cement, either in a cartridge or a bulk mixture of lime and silicates, which when wetted increase in volume and generate expansive pressures of around 30 MPa. The main advantage is the total absence of environmental alterations, and the problem, its cost.

The quantities used oscillate between 3 kg/m^3 for soft rocks up to 8 kg/m^3 for hard rocks.

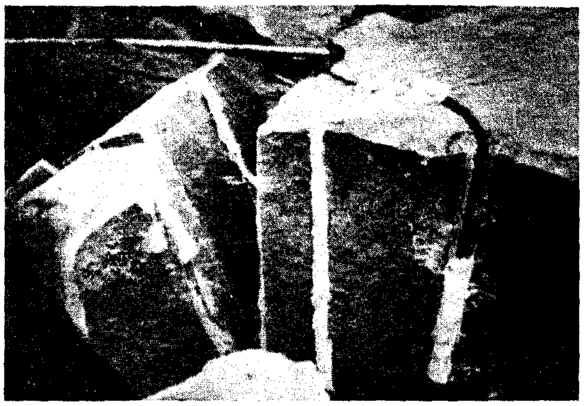

Photo 29.3. Fragmentation of a boulder with expansive cement (Calmite).

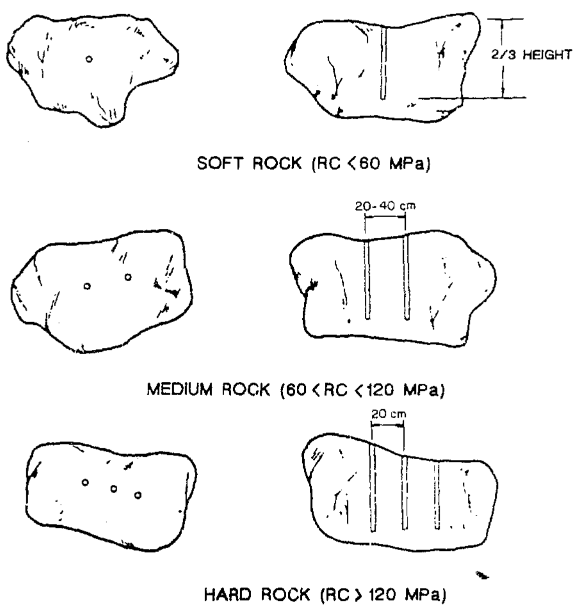

Fig. 29.8. The fragmentation of 1 and 2 m^3 boulders with expansive cements.

Normally, the proportion of water that is added to the cement is 25%, and the time taken for the rock to break goes from 30 minutes for some types up to 12 and 14 hours for others.

Although these cements are basically safe, some measures should be observed during their use:

– Use protective gloves and glasses, as they are usually alkaline substances with a high pH and any spattering could harm the skin or eyes.

– Once the blastholes are charged, do not look in their direction.

– Place light protection upon the rock to be fragmented if there is a risk of bursting or projection of small splinters, especially if the blastholes are tightly closed.

29.3.5 *Drop ball*

This is the classic method used in demolition work and surface operations to break rock by impact of a metal ball or block with a weight of between 2 and 6 tons. The main problems are the cost of the crane and the precision required to place the ball in the vertical of the block of rock.

29.3.6 *Other methods of secondary breakage*

The CARDOX system consists in introducing a steel tube in a blasthole with a capsule of a chemical product which, when initiated projects the carbon dioxide in an adjacent chamber at high pressure and velocity, acting upon the walls of the hole and cracking the rock, Fig. 29.9.

Recently, diverse substance have come on the market, some of which are mixtures of dynamite with a powdered metal, contained in rigid plastic cartridges with a space to house the initiating capsules. These capsules are similar to the conventional detonators, as they carry an electric ignition system and an initiating system, which in some instances is gas and is energized by a conventional blasting maching.

Once the tube has been inserted in the blasthole, it is necessary to stem them with a cement mortar to which an accelerating agent has been added, or a very compact clay plug. In the first instance, it is necessary to wait until the mortar is hardened, usually 30 to 60 minutes.

The connection of the circuit is done as with the electric detonators, recommending the connection in series.

The areas to be fragmented should be protected to avoid uncontrolled throw of rock fragments due to the action of the gases. The specific charges for secondary blasting of boulders oscillates between 30 to 60 g/m^3 for soft rocks and between 90 and 120 g/m^3 for hard rocks.

29.4 SPECIAL BLASTINGS

29.4.1 *Blasting of ditches in earth*

The blasting of ditches in earth are used frequently when mechanical means of excavation are not possible, such as in swamp areas or forests, Fig. 29.10.

The method consists in using cartridges of explosives to make up charges of 0.2 to 0.3 kg each, which are placed in blastholes with a distance of 0.6 to 0.8 m and drilled to approximately half of the desired ditch depth.

The explosives used must be water resistant when working in swamps.

The initiation is usually done with detonating cord, firing all the charges instantaneously.

The indicated patterns should be adjusted to the ground conditions, after the first blasts, and in function with the obtained results.

29.4.2 *Blasting of stumps*

Two methods exist to blast stumps and roots which are left after cutting down trees: with charges under the stump and with charges in blastholes drilled in the stump, Figs 29.11 and 29.12.

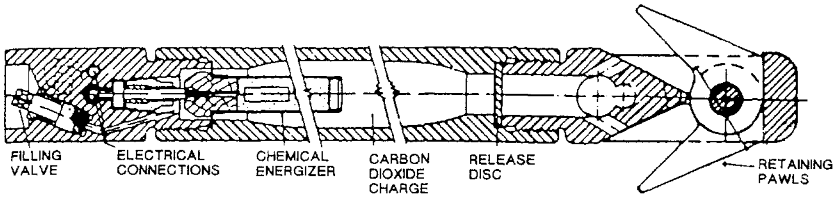

Fig. 29.9. CARDOX tube.

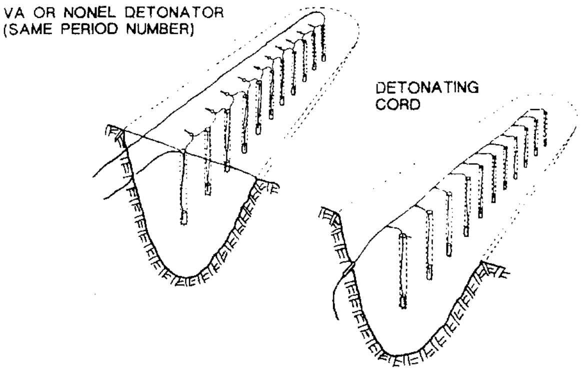

Fig. 29.10. Blastings to create ditches in earth.

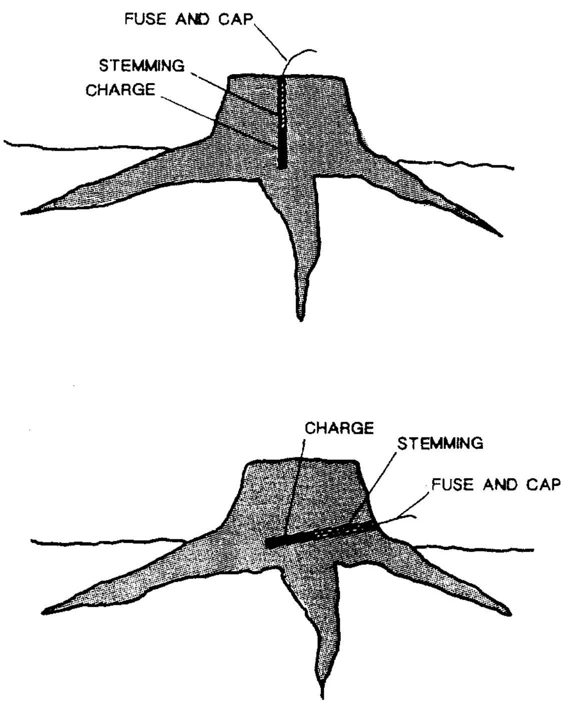

Fig. 29.11. Blasting of a stump and its roots with blastholes and small charges.

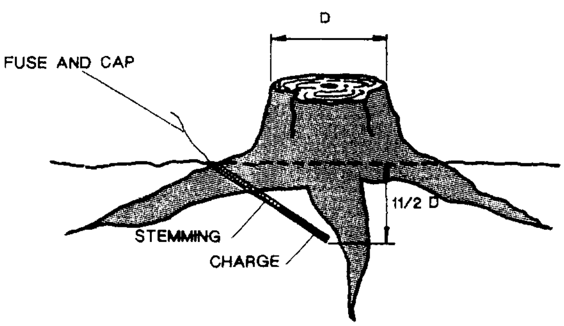

Fig. 29.12. Stump blasting with buried charge.

The factors to be taken into account are the following:
- The diameter of the stump.
- The age and species of the tree.
- The nature of the underlying ground.
- The permitted throw distance.

With blasting under the stump, the charges should be places at approximately 0.5 m underneath, and 0.2 to 0.3 kg is calculated per 10 cm of stump diameter. This rule is valid for soft ground and fresh stumps. Oak and beech stumps require twice the charge. In hard ground the charges should be reduced to one half the above mentioned.

When the stump size requires large charges, they should be placed in chambers created by blasting 1/3 of a cartridge.

This method has the problems of creating large holes under the stumps and produces uncontrollable throw of wood and earth.

The second method consists in drilling blastholes in the stumps and large roots and charging them with explosive cartridges to break it up. Precautions should be taken in case of air blast and throw.

29.4.3 *Blasting of ice-holes*

The safest way of blasting ice-holes is to place the charges underwater at a depth of 1.25 m. If the water is not deeper than 2.5 m, the charges should be placed at half the depth of the water.

In Table 29.4 the spacing between holes and the recommended gelatin or emulsion explosive charges is given.

If the depth of the water is under 2.5 m, the diameter of the hole opened will be smaller and the spacings between holes should be adjusted accordingly, Table 29.5.

The holes in the ice are made with an ice-pick or with a special drill called ice-drill. The charges are inserted at the desired depth and if currents are present, a sinker should be hung from the charge to hold it in place.

The charges are fired instantaneously with a detonating cord connected to the charges.

Table 29.4.

Thickness of the ice (m)	Width of the ice-hole (m)	Charge (kg)	Spacing (m)
Under 0.4	5	1	4
Under 0.4	6	2	5
Under 0.4	8	3	8
0.4-0.6	8	4	8
0.6-1.0	8-10	5	8

Table 29.5.

Depth (m)	Spacing (m)		
	3 kg	4 kg	5 kg
2.0	5	7	8
1.5	4	6	8
1.0	4	5	6
0.5	3	4	5

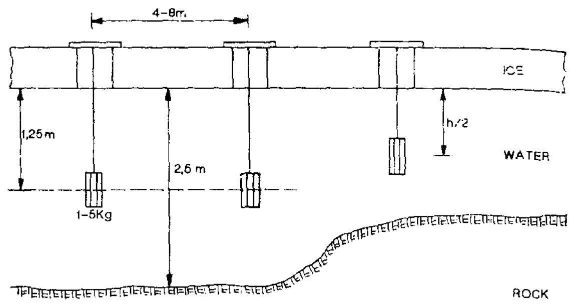

Fig. 29.13. Placing of the charges underwater to blast a layer of ice.

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