



ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

PMI-3325

***LAVRA DE MINAS:
MINERAÇÃO A CEU ABERTO***

AULA 6C - 2018

Lavra de Rochas Ornamentais

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SUMARIO

- Métodos de lavra para rochas ornamentais
- Características do planejamento e gerenciamento de lavra de rochas ornamentais
- Equipamentos e prática da indústria

(Material fornecido pela Profa. M. Cardu, Politécnico di Torino, 2016).

Quarrying of dimension stones











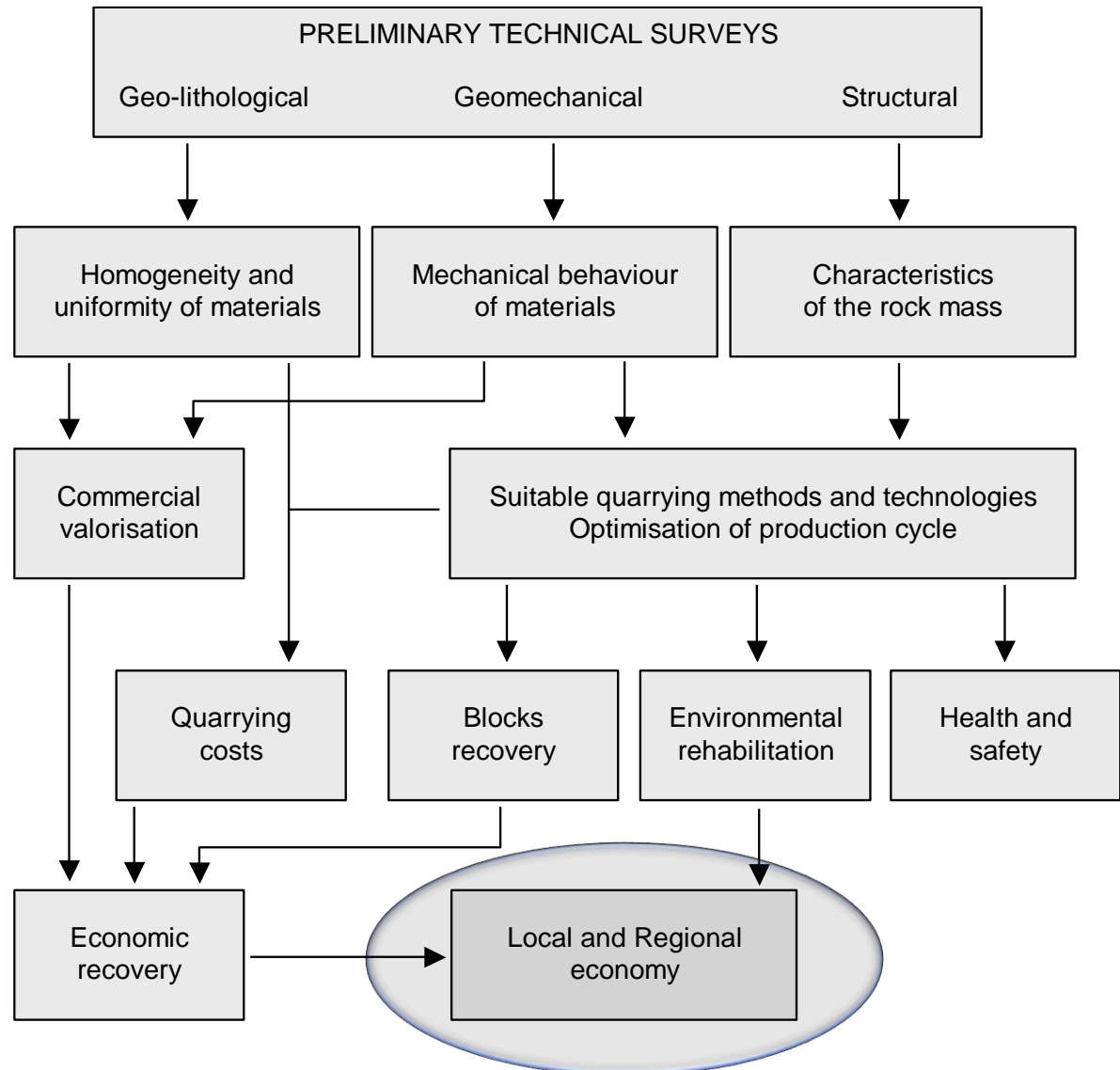




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Management and planning of quarrying activities for dimension stones





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GENERAL CHARACTERISTICS OF DIMENSION STONES

The morphological and structural variability of deposits, and the natural variety of physical characteristics of the stones exploited, give reason to the very large range of quarry layouts which can be found even in the same geographical area.





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GENERAL CHARACTERISTICS OF DIMENSION STONES

As a consequence, the range of technical solutions developed and adopted for the extraction of the rock is extremely wide too, often reflecting the traditions and the experiences of a specific contest.





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CARRARA Marble Basin (Gioia, Colonnata)

Same technique, with different methods
employed



Similar stones are exploited (soft rocks: limestones and marbles) adopting different techniques

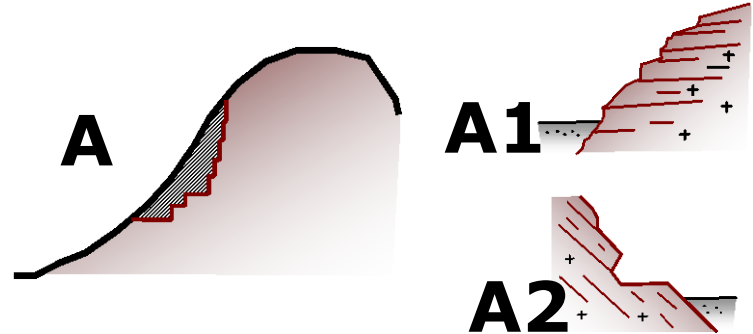


Quarry types

A – Surface hillside

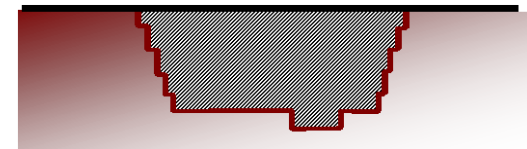
A1 – Horizontal slicing: in massive isotropic bodies or bodies with horizontal weak planes.

A2 – Inclined slicing: in bodies with inclined weak planes (gravity is exploited to ease blocks removal).



B – Surface, pit

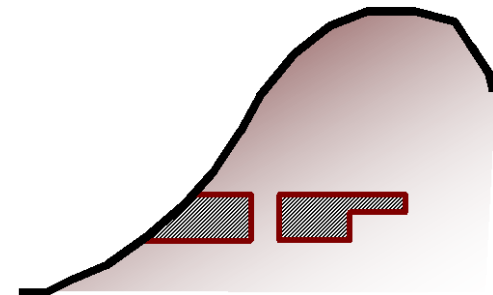
in flat land: descending horizontal slicing, below ground level.



C – Underground, room and pillars

C1 – Front attack: blocks are taken from the front wall of the room.

C2 – Descending slices: the stope is opened at the top and the body is then exploited by descending slices (often it's an evolution of C1)





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Dimension stone quarrying



Production of commercial blocks



Quarry of “Luserna Stone” – Piemonte



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EXTRACTION STRATEGIES

A – large volumes of rock are cut and then divided into blocks

B – blocks are directly cut from the rock body





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QUARRYING METHODS AND CUTTING TECHNOLOGIES

I – **Cutting**: blocks are separated by means of kerfs.

I1 – diamond wire

I2 – chain saw (or belt, or disc) cutter

I3 – flame jet

I4 – water jet

II – **Splitting**: blocks are separated by fractures, induced in pre-determined planes.

II1 – explosive (cord, gunpowder)

II2 – hammer and feather, wedging, other separating devices

II3 – line drilling

III – **Cautious blasting**: blasting with minimal breakage, suitable pieces are selected from the muck.





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Main cutting technologies:

➔ **Dynamic splitting**

Diamond wire sawing
(*hard and weak stones*)

Chain sawing





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Dynamic splitting



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➡ Chain sawing



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Dynamic Splitting

Goal

- to produce commercial blocks:
- regular shape
- volume between 2 and 15 m³,
- to be subsequently reduced into slabs
- architectural items.

Production cycle

- Primary cut
- Bench Tipping
- Clipping and squaring blocks
- Handling



HARD ROCKS: DYNAMIC SPLITTING



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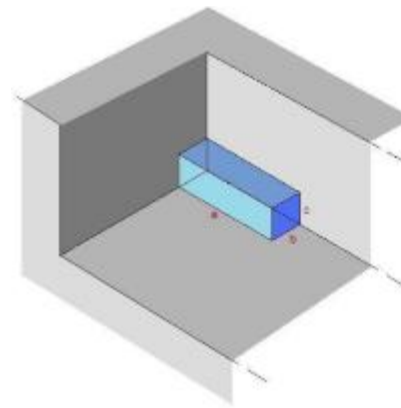
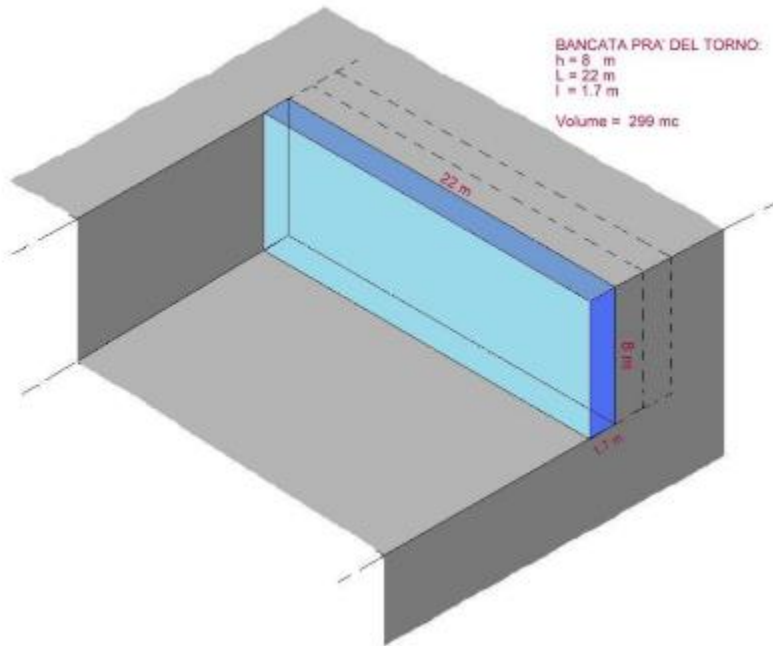
BANCATA PRA' DEL TORNO:

$h = 6 \text{ m}$

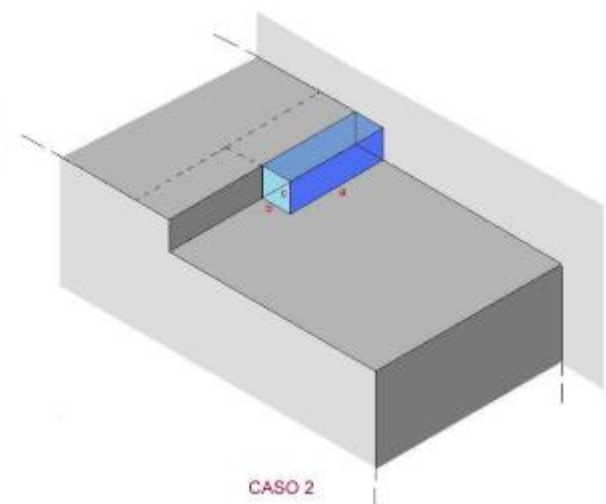
$L = 22 \text{ m}$

$l = 1.7 \text{ m}$

Volume = 299 mc



CASO 1



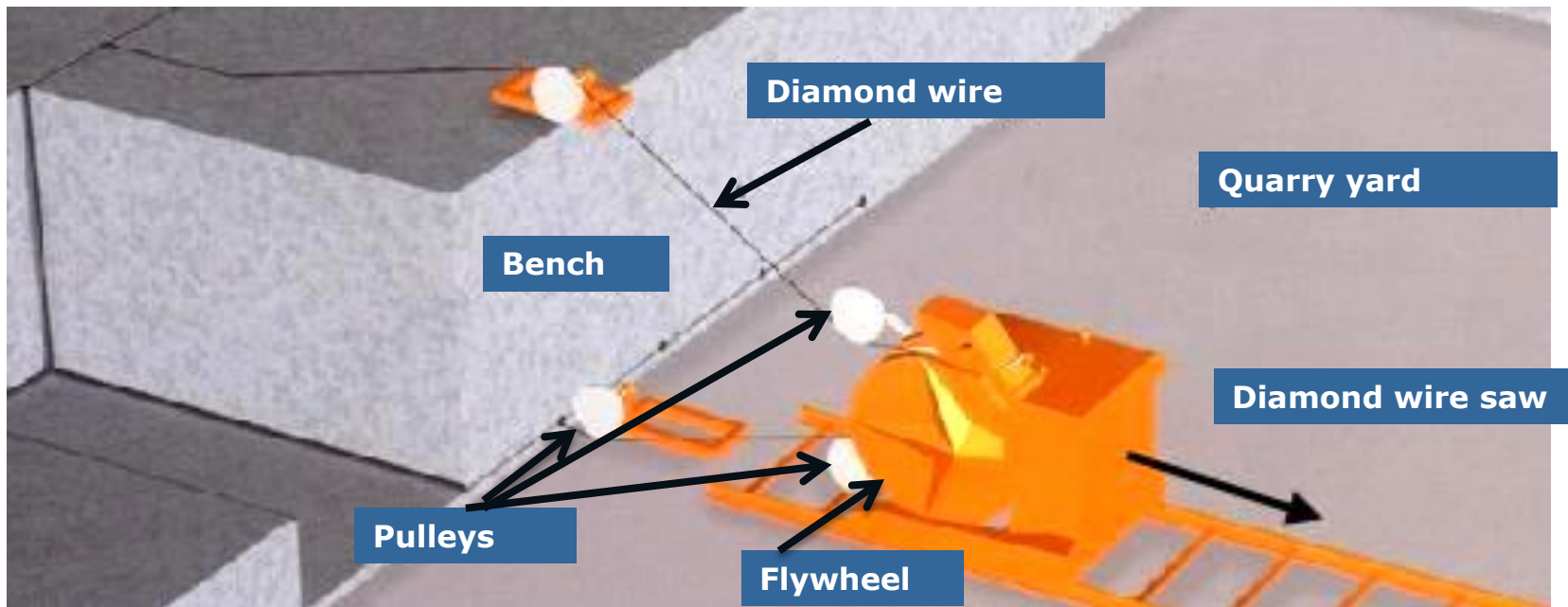
CASO 2

QUARRYING METHODS AND CUTTING TECHNOLOGIES

Diamond wire saw

General principle of operation: to cut the rock, according to a predetermined plane, by means of a flexible made abrasive .

“Standard” application: creation of a loop in which the wire runs at high speed, always sprinkled with water for cooling (15 - 50 l / min), to progressively affect the stone, creating an ever more deep groove.



Main features of the **diamond wire** sawing method:

<i>Tool material</i>	Diamonds
<i>Tools geometry</i>	Random
<i>Depth of the elementary cut</i>	$10 \div 30 \text{ } \mu\text{m}$, variable
<i>Width of the cut</i>	$\cong 1 \text{ cm}$
<i>Flushing</i>	Water ($\cong 50 \text{ l/min}$)
<i>Tools speed</i>	$20 \div 40 \text{ m/s}$
<i>Flexible support type</i>	Steel cable
<i>Length</i>	$> 100 \text{ m}$
<i>Guidance</i>	Pulleys
<i>Beads type</i>	Impregnated
<i>Beads</i>	$35 \div 40 \text{ number/m}$
<i>Wire cost</i>	$150 \div 170 \text{ US\$/m}$
<i>Productivity</i>	$1 \div 7 \text{ m}^2/\text{h}$
<i>Service life</i>	$9 \div 12 \text{ m}^2/\text{m}$

QUARRYING METHODS AND CUTTING TECHNOLOGIES

Diamond wire saw



QUARRYING METHODS AND CUTTING TECHNOLOGIES

Diamond wire saw

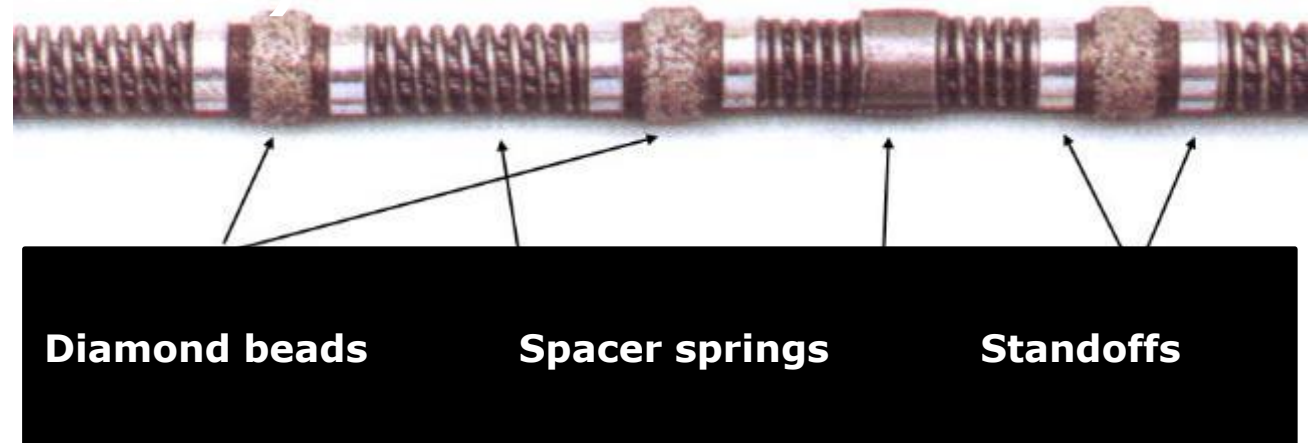


QUARRYING METHODS AND CUTTING TECHNOLOGIES

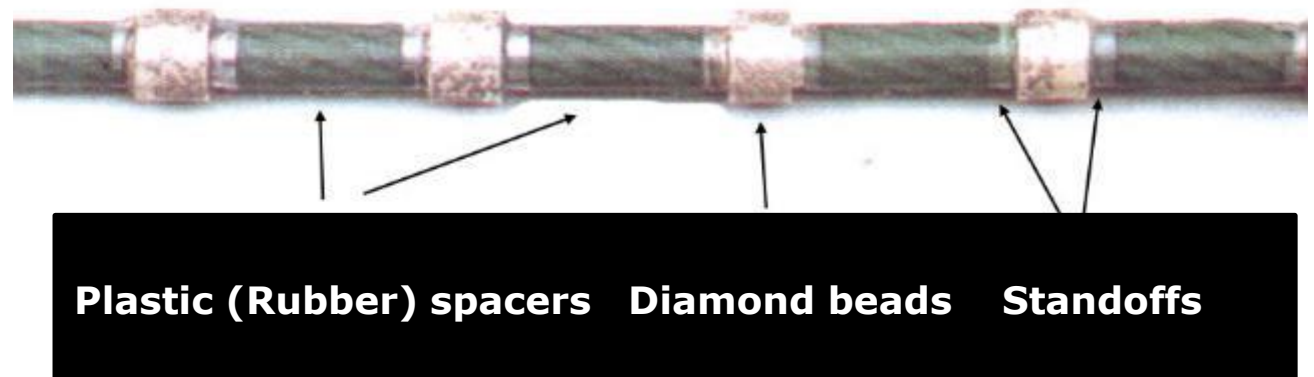


The wire: Galvanized steel cable

Traditional



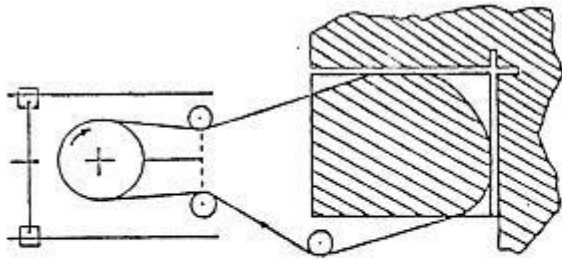
Plastified



(Continuous coating of the wire with thermoplastic resin)

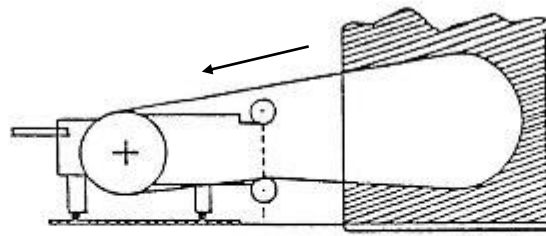
QUARRYING METHODS AND CUTTING TECHNOLOGIES

Operating configurations



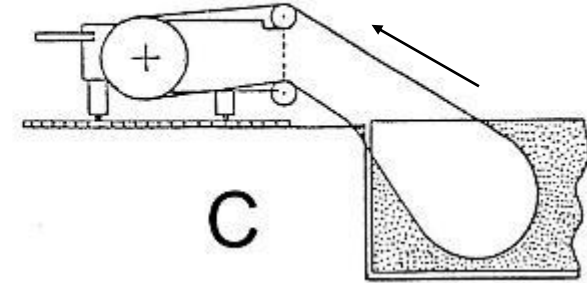
A

Horizontal cut



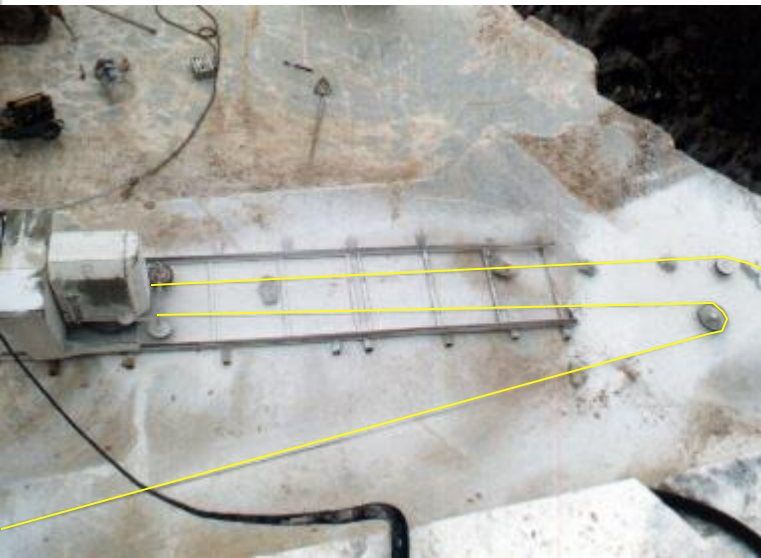
B

**Vertical cut with
descending loop**

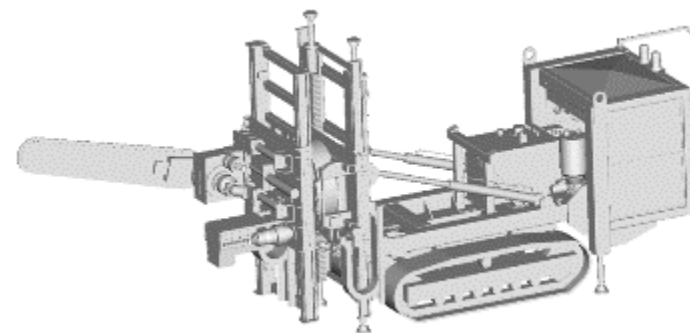
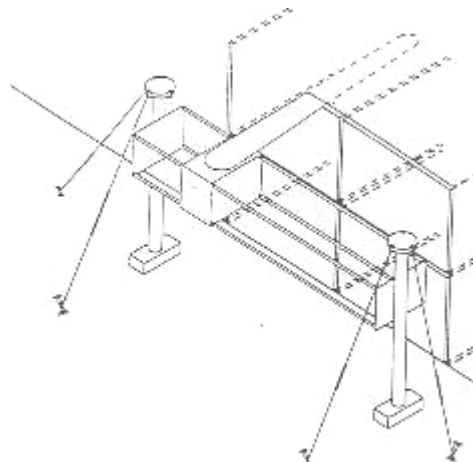
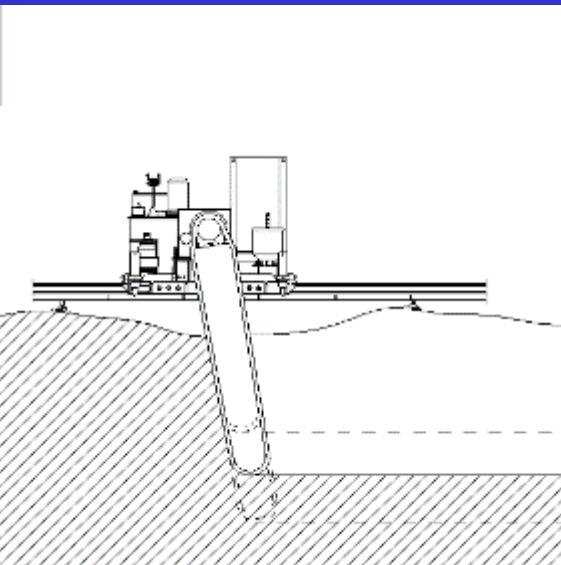


C

**Vertical cut
with ascending**



CHAIN CUTTER



CHAIN CUTTER

Control of "feed" and "cutting motion"

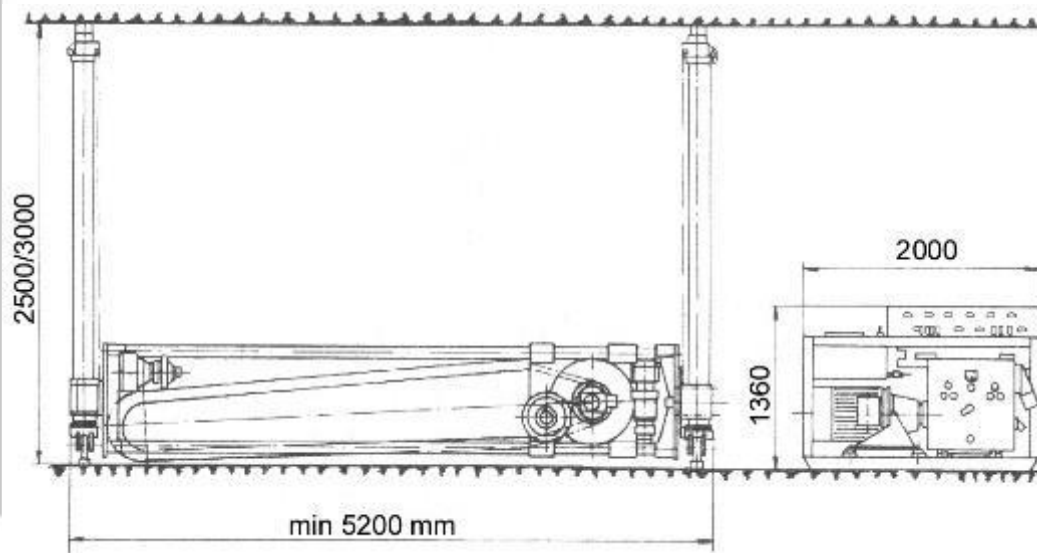


CHAIN CUTTING: UNDERGROUND

The arm is mounted on a tubular gun carriage, separate from the engine.

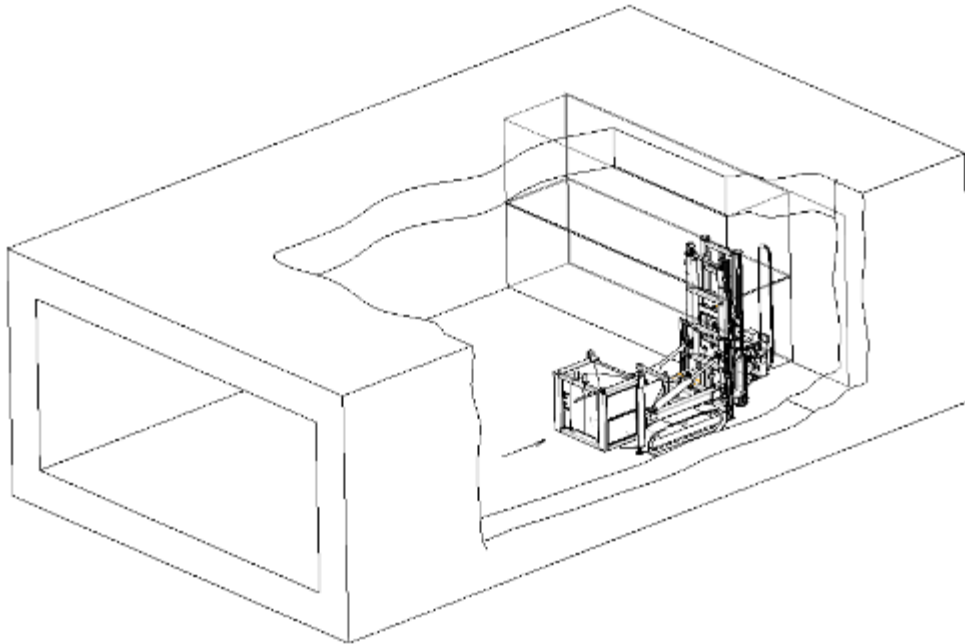
The arm usually has a length of 3.5 m and the frame that supports has a width of 5-6 m and a height of 3.2 to 4.5 m.

Cutting arm is able to make horizontal and vertical cuts on different planes.



Underground exploitation: weak rocks

- self moving chain cutter on tracks
- cutting arm is able to make horizontal and vertical cuts on different planes and "back cuts".



CHAIN CUTTING: UNDERGROUND

“self-moving” chain cutter - underground of the Lasa quarry (BZ)



Underground of the Lasa quarry (BZ)



The first phase of the excavation is realized only with the chain cutter; one can then proceed with mixed technology (chain cutting + diamond-wire saw).

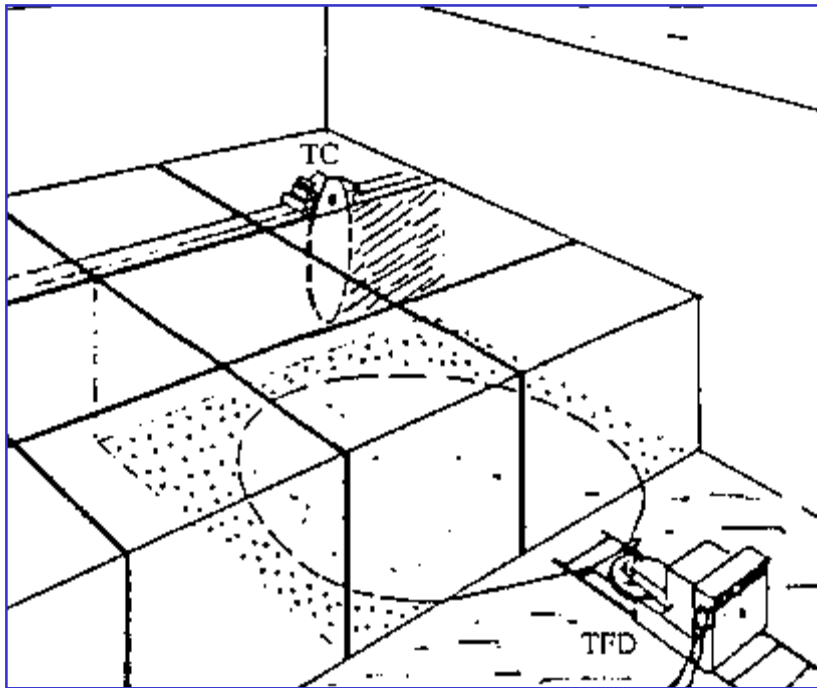
CHAIN CUTTING: UNDERGROUND



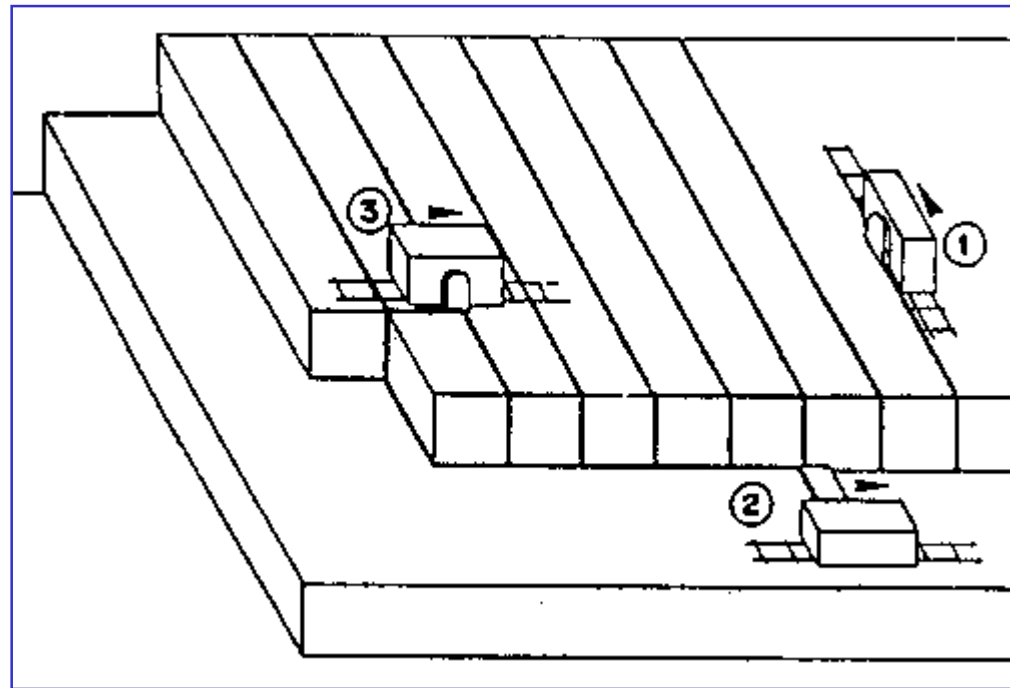


Weak rocks (low-step 3 m)

diamond wire + chain cutter



chain cutter only



Weak rocks (low-step 3 m)





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