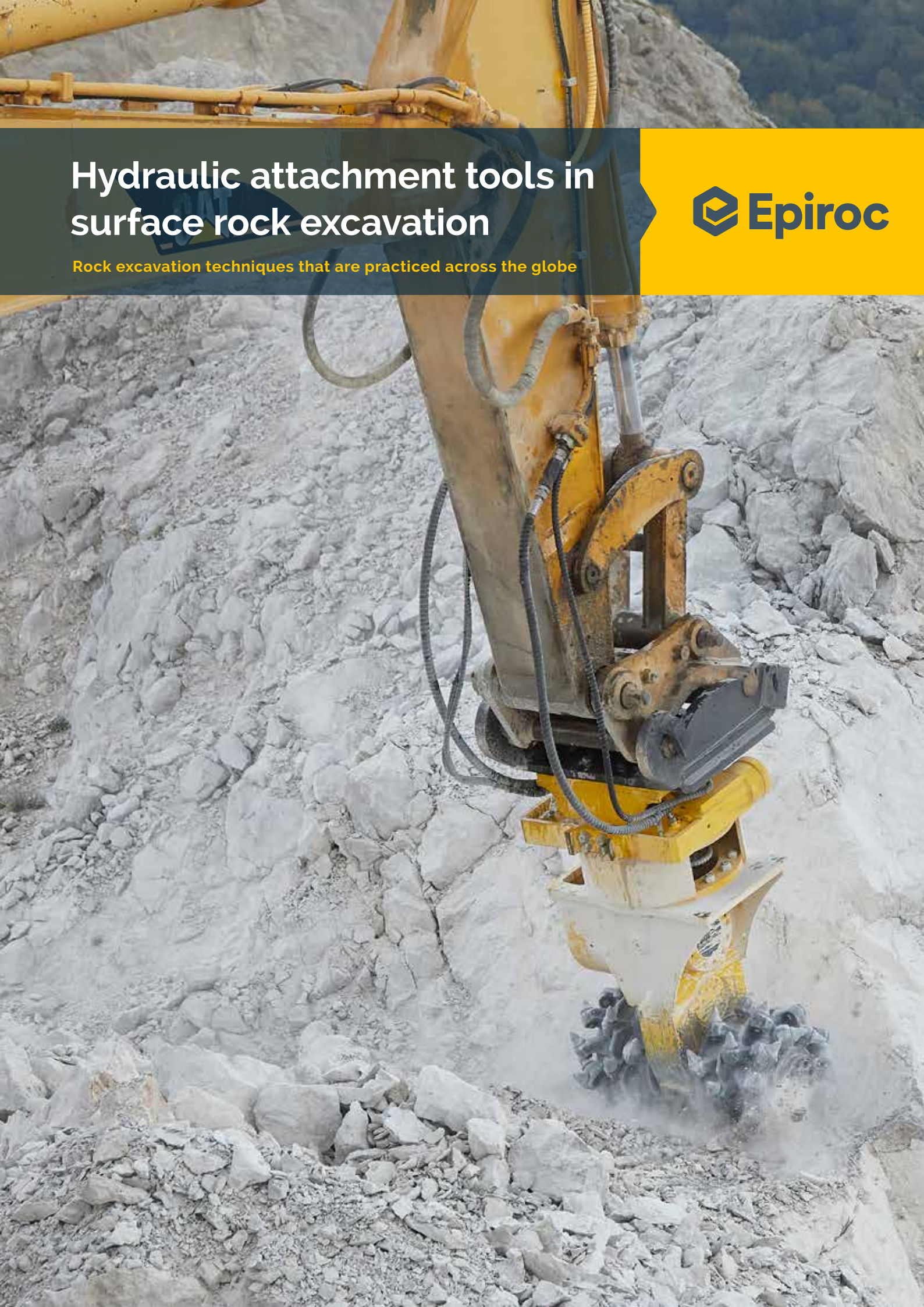
Hydraulic attachment tools in surface rock excavation

Rock excavation techniques that are practiced across the globe

Epiroc



Contents

Hydraulic attachments in surface rock excavation

In modern rock excavation operations, each step in the process is subject to profitability analysis. Overall, hydraulic breakers are often the most economical and safest option.

One standard application is secondary reduction of oversize boulders in the rock pile. The use of hydraulic breakers here has made safety problems a thing of the past.

Selective mining with heavy-duty hydraulic breakers is a worthwhile consideration in many quarries, as it frequently allows improved material grades to be excavated that bring higher sales revenue. Using hydraulic breakers can also reduce the amount of fine grain material that may be unsuitable for use in applications such as road construction, compared to blasting.

Using hydraulic breakers to remove the overburden allows the entire deposit to be utilized.

Environmental protection regulations and safety restrictions are prompting many quarry operators to look at alternative mining methods. Rock mining companies all over the world have already had great success using Epiroc heavy-duty hydraulic breakers for primary rock excavation as a substitute for blasting.

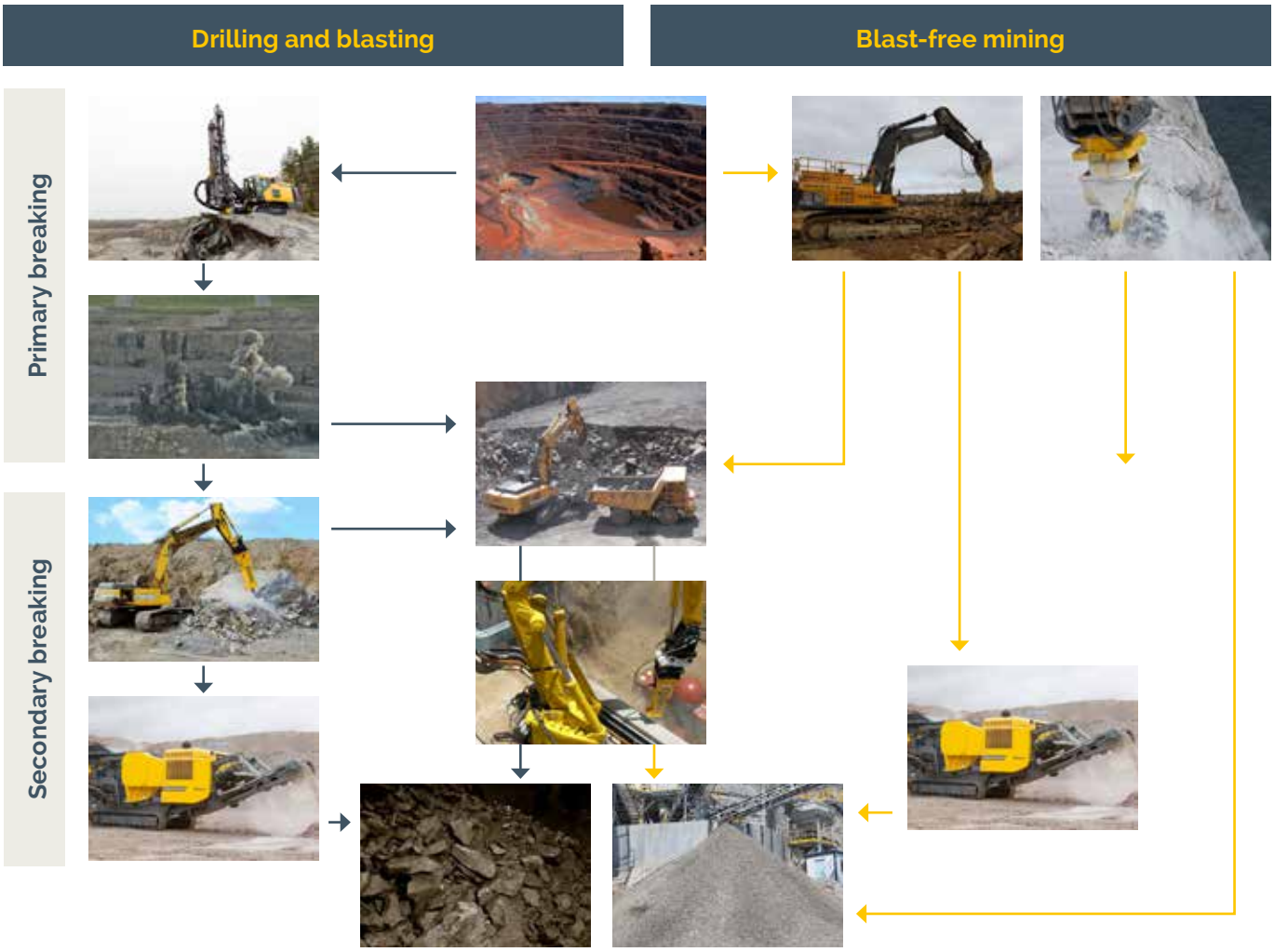
When you use Epiroc hydraulic breakers, you benefit from our many years of experience in assessing mining methods around the globe.

Finally, there are no two identical quarries anywhere in the world, so whether the use of hydraulic breakers represents a viable option has to be analyzed on a case by case basis. We provide a questionnaire on the key data required on page 28.

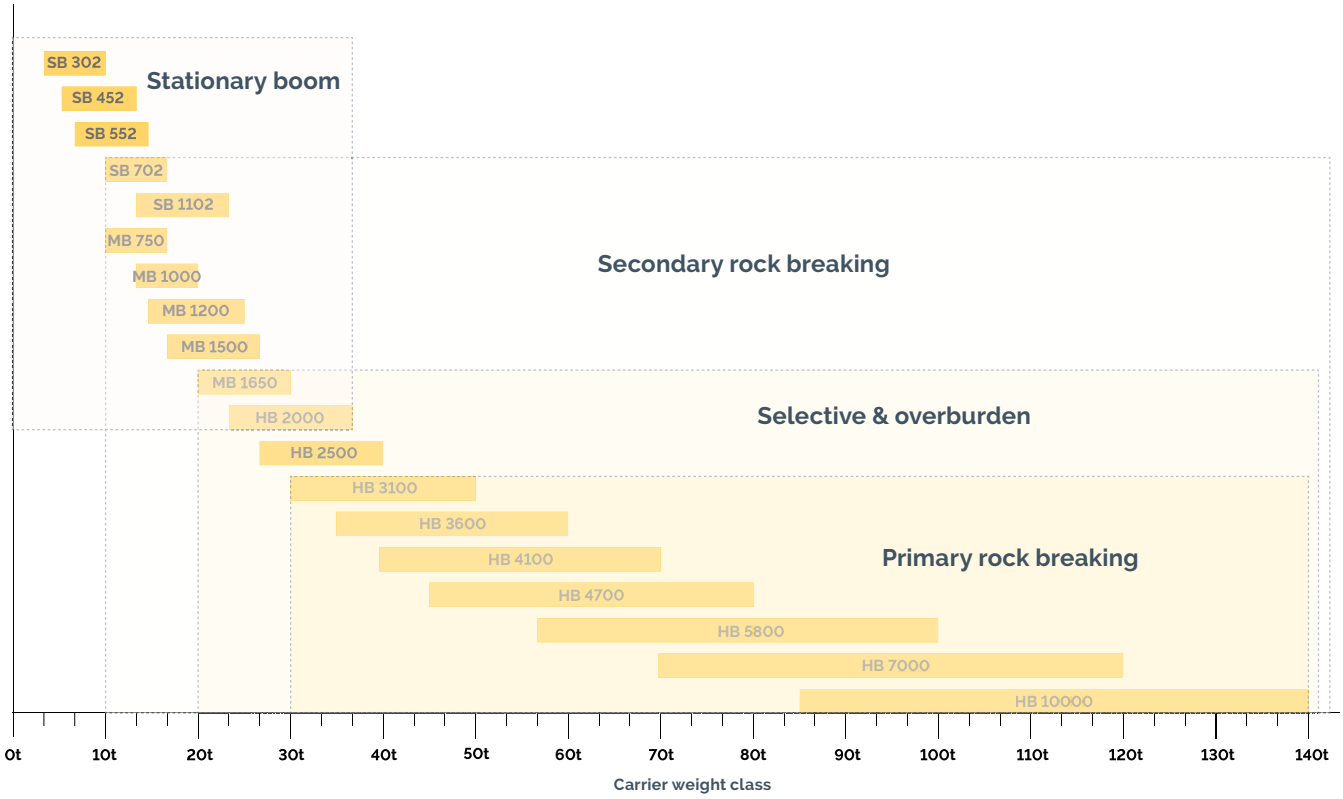
Our team would be pleased to provide advice and information on your personal requirements.

Rock excavation is done for multiple purposes or applications. In open pit mines, it extracts metallic or non-metallic deposits and bedded deposits like coal or in quarries; rock excavation extracts building materials like aggregates or stones in the dimension stone industry.

Rock excavation applications in the construction industry include trenching, underwater dredging or excavation for foundations. In addition, you can successfully use hydraulic attachments for excavation of frozen ground where a standard bucket is too weak.



Hydraulic breakers in rock excavation



Prospects for breaking and cutting

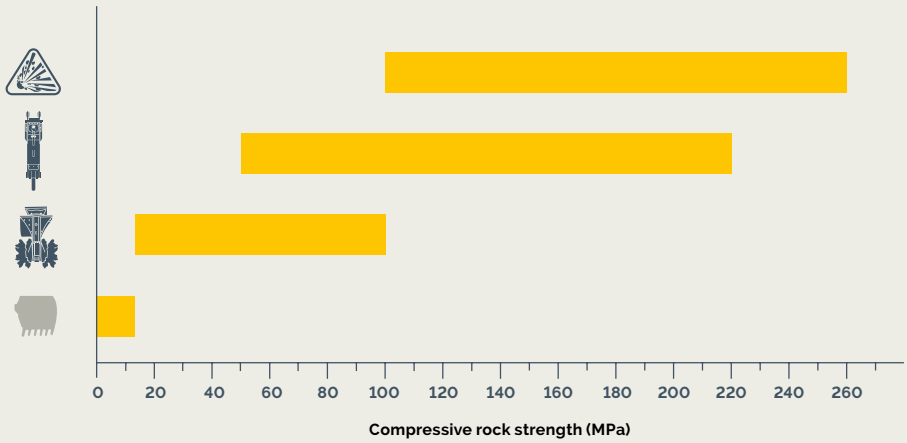
The ease of excavating depends on many properties of the rock material and rock mass. In some circumstances, certain mineral characteristics directly influence the mining method. Many salts, for example, are especially elastic and can absorb the shock from blasting. The rock may not only combine the properties of the minerals, but also exhibit properties resulting from the way in which the rocks were formed or subsequently altered by heat, pressure and other forces in the Earth's crust. It is comparatively rare to find a homogeneous rock mass and the discontinuities such as faults filled with crushed material, major jointing and bedding non-conformities are hard to predict.

Discontinuities are very important (often denoted by joints); these are horizontal and vertical as well. We can divide the rock based on our experience in

- highly fragmented with spacing <0.4 m
- fragmented (blocky) 0.4-1.0 m and
- compact (massive) > 1 m

Cutting ability in case of drum cutters depends on many properties of the rock material and rock mass. However, the most important properties are hardness (compressive strength) and rock structure. The quartz content is of crucial significance to cutting. Abrasive rocks with higher quartz content result in higher wear of picks, pick boxes and the cutter drum.

Rock excavation method according to compressive rock strength



Properties of the rock mass relating to the in place rock mass are:

- Discontinuity: any distinct break or interruption in the integrity of a rock mass. Discontinuities within a rock mass, reduce its strength and stability and reduce the energy required to excavate or erode it
- Structure
- Texture
- Shearing resistance
- Consolidation

Properties of the rock material are:

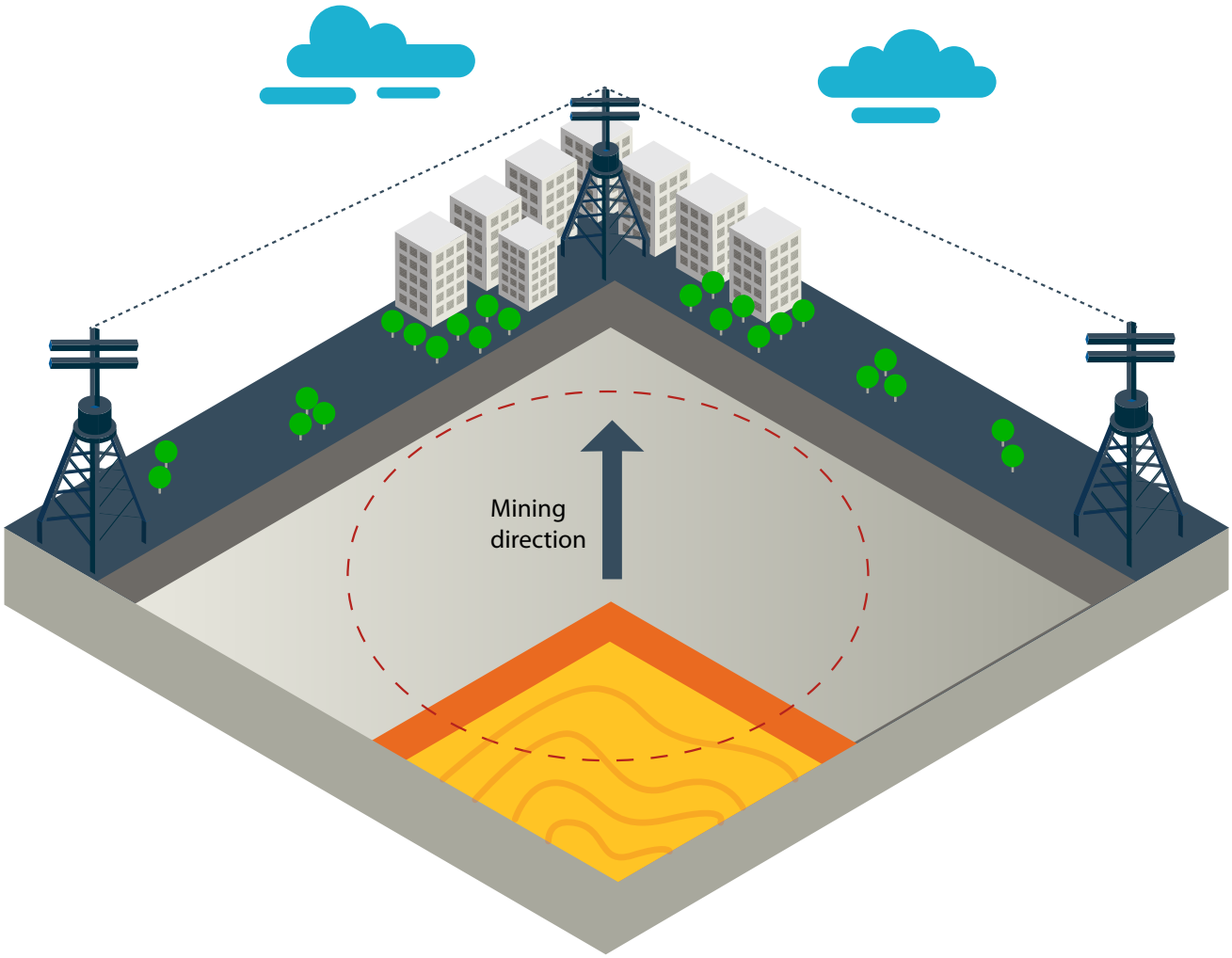
- Rock type and color
- Strength: the ability of a material to resist deformation induced by external forces
- Hardness: characterizes the strength properties of rock mass. It is the resistance of the material to scratching or indentation
- Density
- Particle size, mineral composition, shape of grains, texture, crystallinity, stratification, lamination influences the strength

Primary rock excavation

Rock quarries or open pits are long-term projects where deposits are usually mined over several decades. These quarries are part of the landscape, and during operation residential developments often expand up to the edges of the site. It can become impossible to use explosives in these areas because of the safety and reduced tolerance for noise and vibration. In some countries the tough regulations around using explosives has made blasting difficult and expensive therefore, rock excavation methods without blasting have become competitive:

- Cutting with drum cutters in soft to medium hard rock
- Breaking with hydraulic breakers in medium to medium-hard rock

The performance capacity and adaptability of heavy-duty hydraulic breakers or drum cutters make them an interesting alternative for rock excavation.

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Factors that can influence the choice of a blast free method:

Low production volumes requested
Use of hydraulic breaker or drum cutter is more economical, than use of a drill rig and explosives.

Rock structure (geology)
Heavily fissured rock sometimes makes it difficult to drill and blast.

Selective mining
To improve rock material quality and mineral purity the deposit layers could be excavated depending on the desired rock material quality.

Legal regulations (Statutory or safety guidelines)
No blasting allowed or blasting to be subject to strict and costly regulations.

Environmental requirements
Reduction of blasting emissions for example noise (airblast overpressure), ground vibration, ground born noise, dust, flyrock, fume emission because of deposit location close to nature reserve, water reservoir, residential areas, and infrastructure facilities.

The decision for blast free rock excavation is often made as the last option to continue production in the quarry. With the latest hydraulic breakers and carriers it can be more profitable method **even when drilling and blasting is allowed**, especially in smaller quarries.

It is always good to look at all the existing processes and evaluate the production costs with alternative methods, there's always a better way!

Working principle in high-cut

Bench height and angle will vary according to the excavator manufacturer and local legal regulations.

Break the last layers from above, to avoid larger rock boulders falling on the chisel

If needed use broken rock material to reach higher layers

3x HB 10000 in primary limestone excavation in China

2x HB 5800 and HB 10000 excavating limestone in Poland

ER 3000 on 52t excavator with specially designed gypsum cutter drums excavating 150 t/h gypsum in Turkey

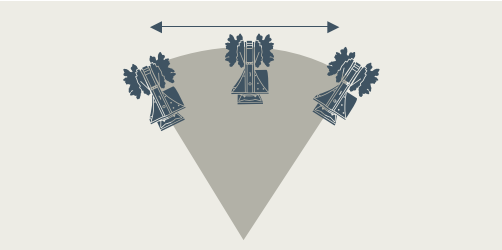
ERC 2000 working in limestone quarry in Spain

Drum cutting technology

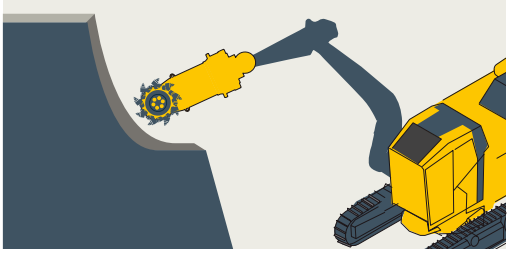
Drum cutting technology compared to breaking or drilling and blasting is used to remove rock or concrete in a selective and precise manner without causing damage to the surrounding structures. Drum cutters are used in a wide variety of applications.

- The drum cutter's productivity directly relates to the rock hardness
- It's productivity decreases with increasing rock hardness
- The harder the rock is, the higher the cutting force should be selected (i.e. higher hydraulic motor displacement)
- The harder the rock is, the lower the cutter head speed should be selected
- The higher the cutter head speed will be, the higher is the pick wearing
- The drum cutter's productivity directly relates to the oil flow rate provided by the excavator (i.e. higher oil flow rate = higher productivity)

It is possible to choose the drum design and number of picks depending on the grain sizes. Standard cutting drums have 56 revolving round shank picks. Cutting drums for soft rock (ball shape design) have 44 picks. The ball shape with a lower number of picks increases the fracture size and the productivity at the same time. Thanks to its design, the picks have a wider spacing so the material is not milled again, resulting in bigger fractures and less dust. Different pick designs can be used depending on the rock properties like hardness or abrasivity. For example, for soft rock, narrow head with small tungsten insert or for hard rock, standard head with big tungsten insert. For soft materials like coal, the static dredging picks (dragon tooth picks) are a good choice.

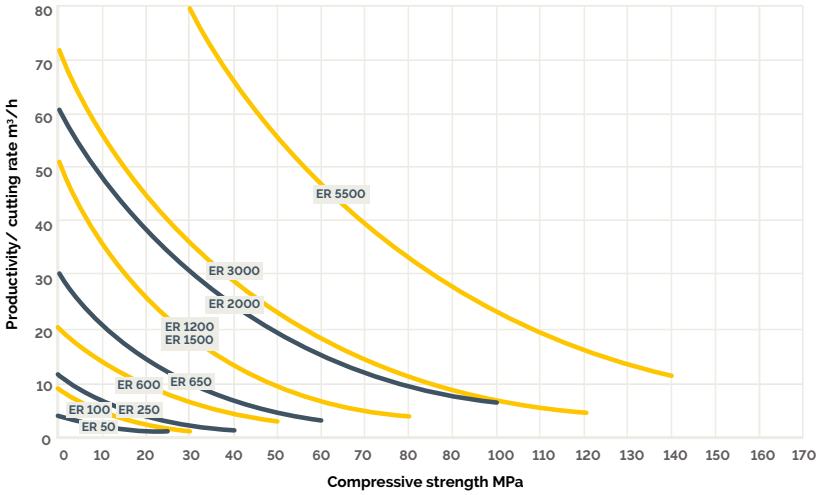


Fan-shaped cut



Working with cutters in high cut position. Generally cutting is done with horizontally fan shaped cuts. Moving from top to bottom

Cutting rate m³/h of the rock mass (not broken material)



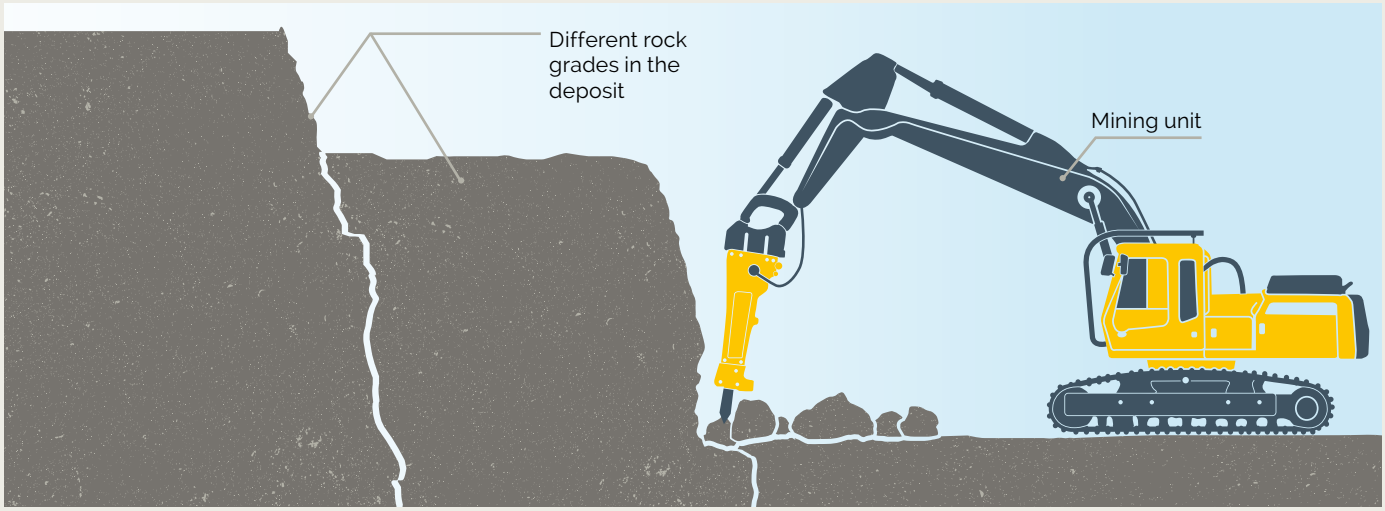
Selective rock excavation

Selective excavation allows different rock grades to be removed separately from an inhomogeneous deposit. Deposits with high impurity levels and distinct fault zones can be very difficult to excavate and result in raw materials of sharply differing grades.

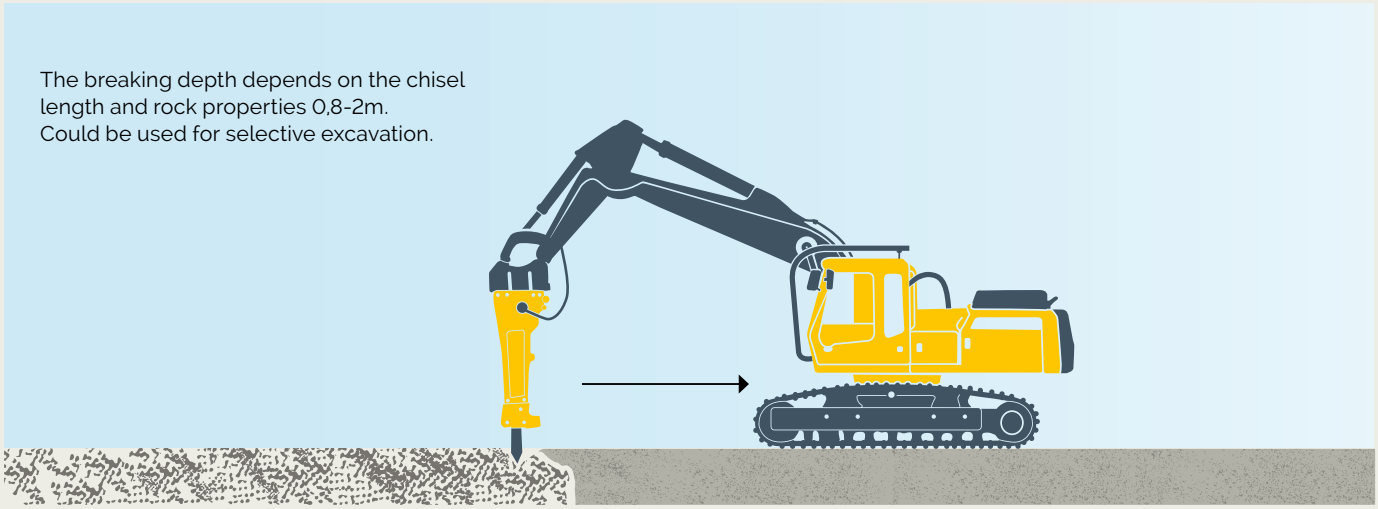
Using hydraulic attachment tools as flexible excavation units, deposits can be mined selectively regardless of the complexity or direction of the seams. Comparing drum cutters with breakers, breakers cause a lower percentage of fine grain material.

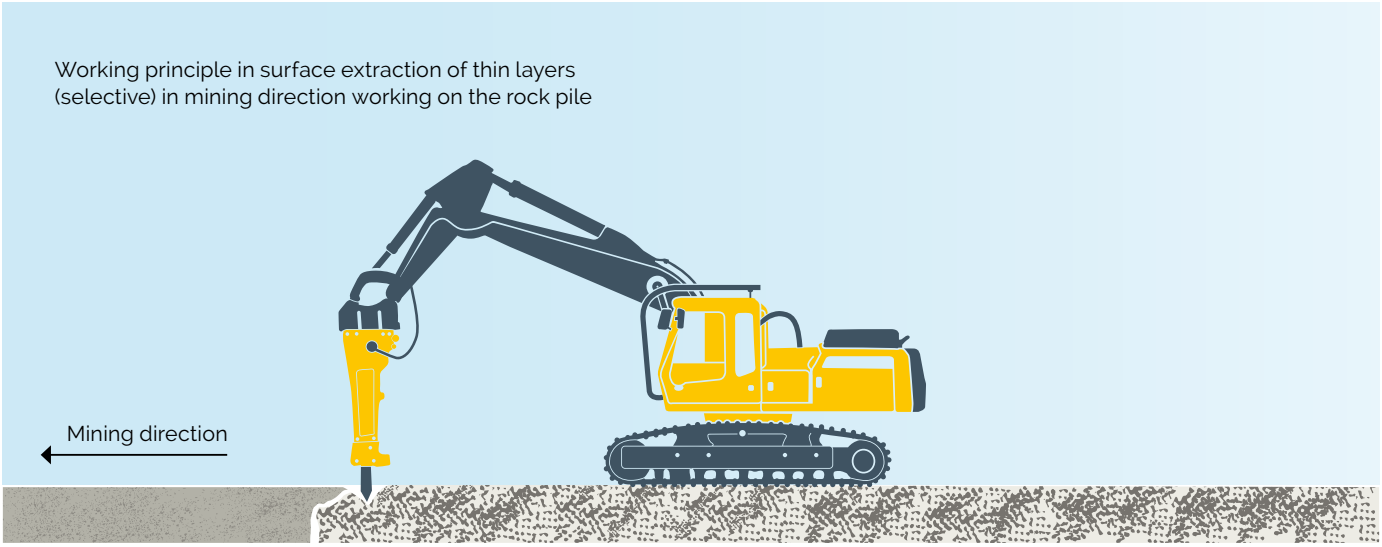
Selective excavation with a heavy-duty hydraulic breaker or a drum cutter makes sense when:

- special demands are made on mineral purity
- higher product quality provides higher sales revenues
- sharp fluctuations in raw material properties result in higher processing costs
- losses from mining must be minimized
- special demands are made on the grain size



Working principle in surface extraction of thin layers





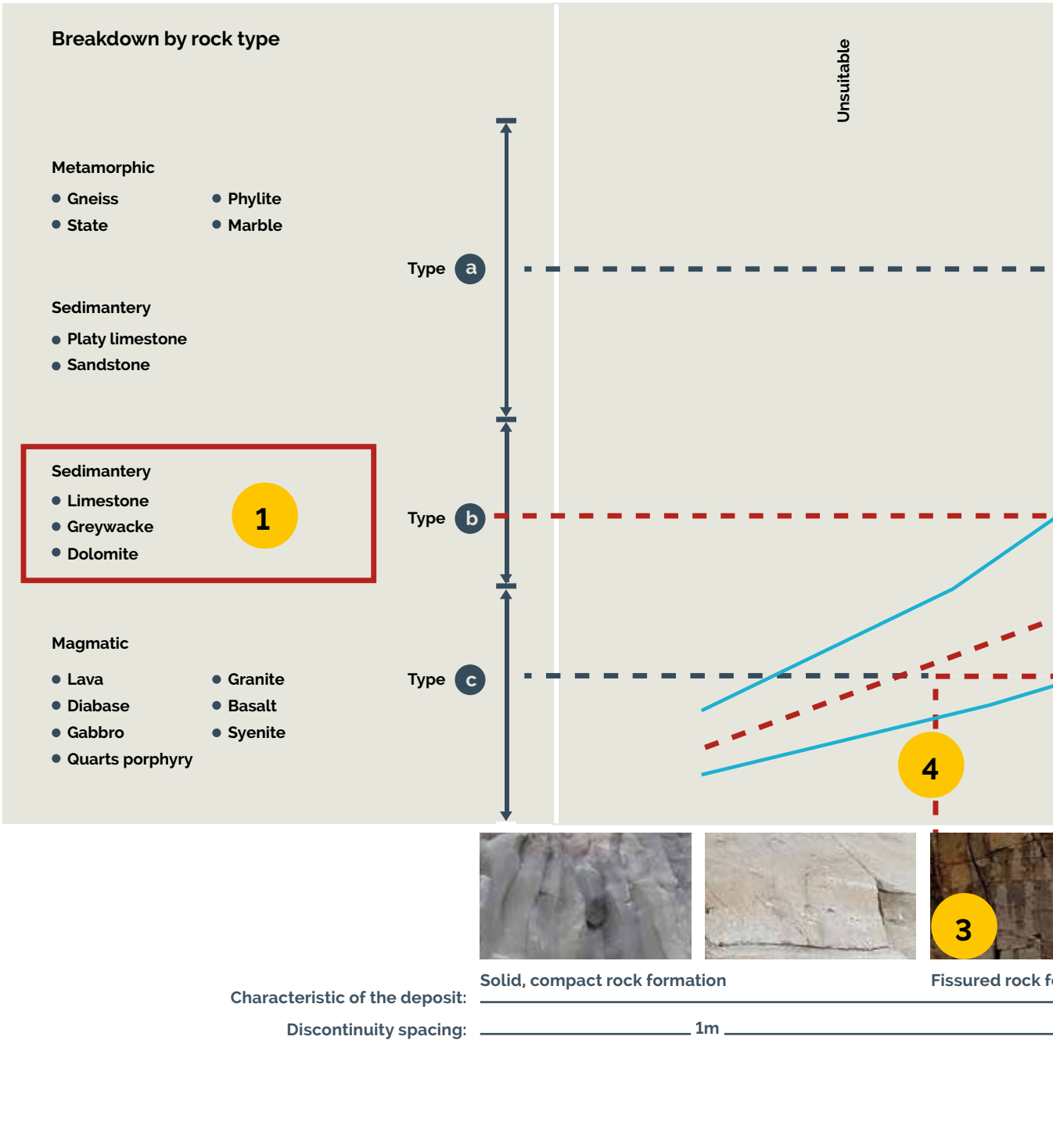
HB 4100 in selective excavation of low quality rock layer from a sandstone deposit in England

ERC 2000 working in Spain

No two quarries are alike!

The diagram shows the correlation between mining rate and deposit characteristics. The rates that can be achieved vary from one application to the next.

Non-binding data



Breaker productivity largely depends on:

- Properties of rock material like hardness and strength
- Properties of rock mass (deposit) like discontinuities and texture

Example: HB 4100 in limestone, fissured deposit

Step 1. Select rock – common rock types have been classified a, b or c depending on fracture characteristics. In this example, the limestone is class (b).

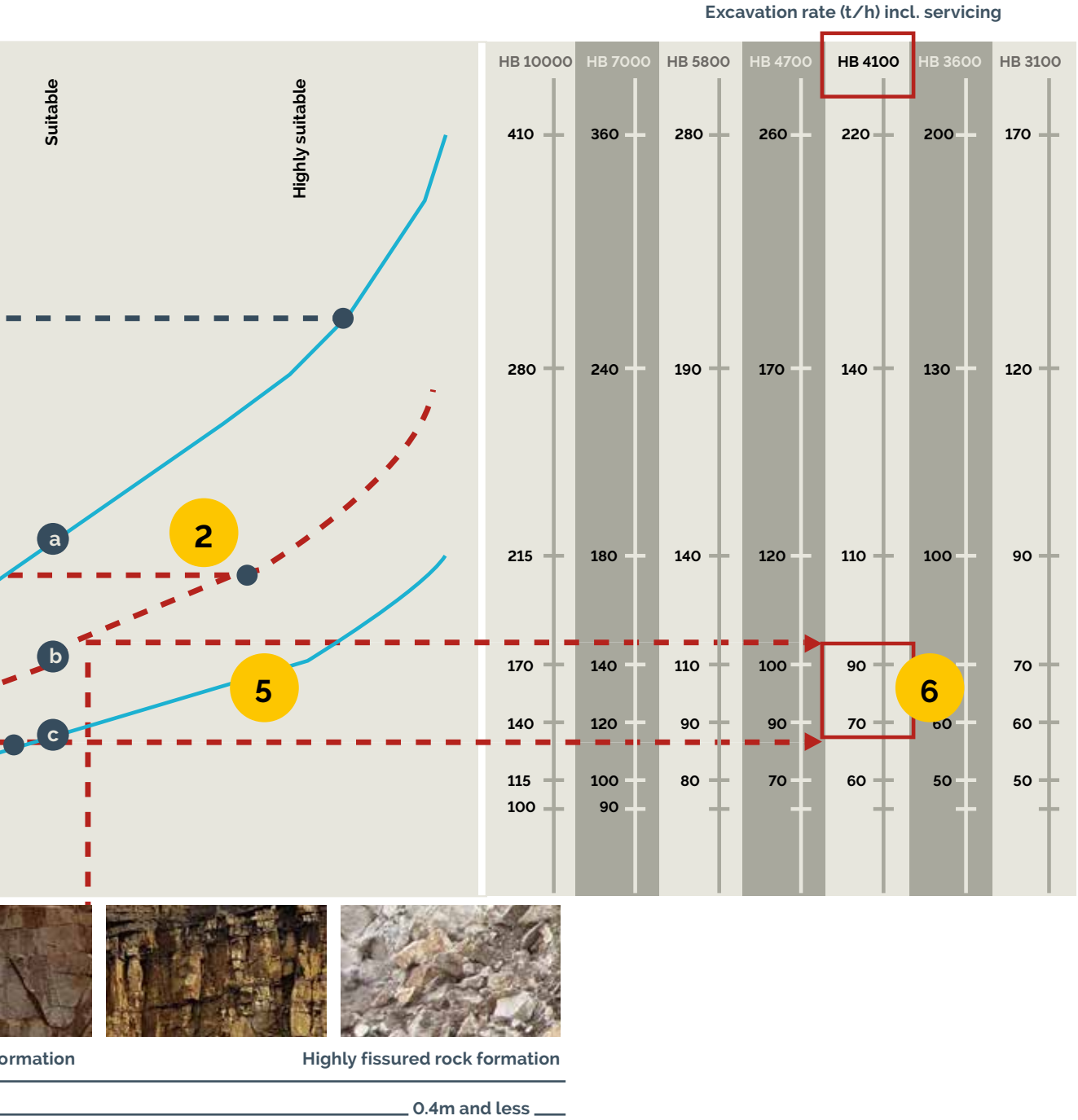
Step 2. Highlight line b.

Step 3. Compare quarry face with photos – in this example, the face that most resembles the photo

Step 4. Draw lines upward from the two corners of the photo until they intersect with the highlighted rock line.

Step 5. Draw horizontal lines from each of these intersections as far as the performance data for the relevant breaker sizes at the right hand edge of the diagram.

Step 6. The lines mark the upper and lower average productivity limits; in the case of the HB 4100, these are between 70 and 90 tons



ormation

Highly fissured rock formation

0.4m and less

Productivity of hydraulic attachment tools in open pit mine depends on many factors:

Material:
- Properties of rock material
- Properties of rock mass

Operator:
- Skills
- Experience
- Training

Installation:
- Hydraulic input
- Professional installation by
  - Epiroc
  - Authorized & trained partner

Jobsite conditions & organization:
- Accessibility
- Visibility
- Planned interruptions

Carrier & attachment selection:
- Carrier size
- Carrier oil flow
- Attachment size (performance)

Service & maintenance:
- Checking of machine conditions
- Lubrication
- Exchange of wear parts
- Chisel shape

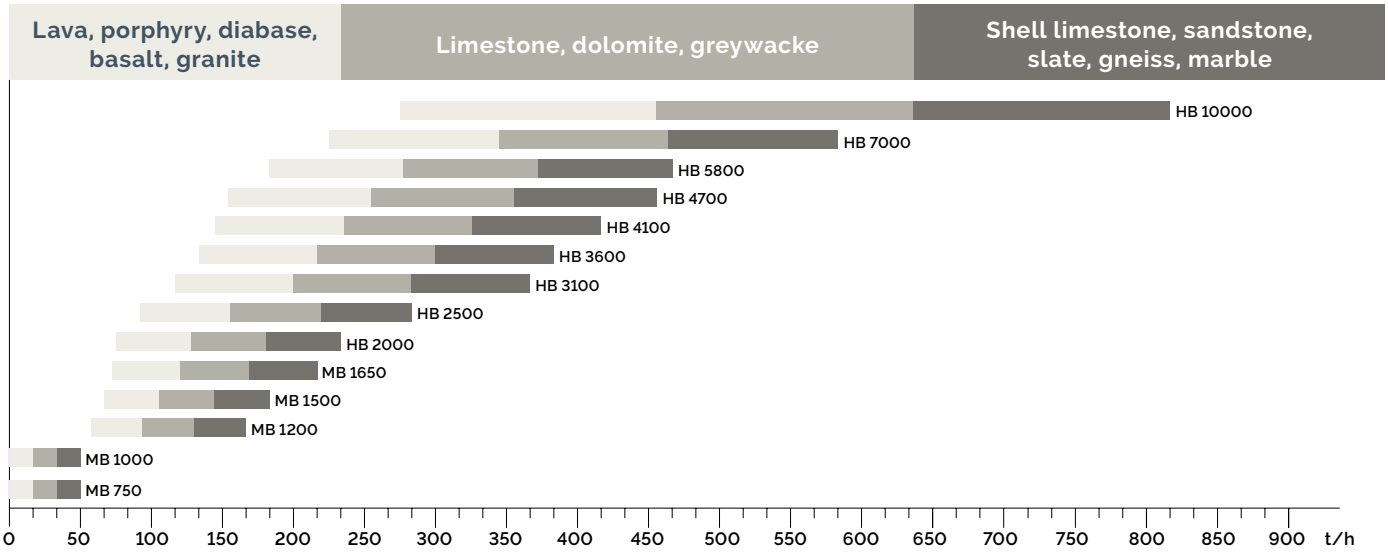
Factors influencing productivity

Secondary breaking with hydraulic breakers

Whenever the blasted rock is too big to handle by loading equipment or fed through the crusher, secondary reduction is required. Even with the most advance blasting techniques, it is inevitable that there will be oversize boulders, and these need to be broken as economically as possible.

Hydraulic breakers are particularly suitable for all quarries and mines where secondary reduction is needed. Wide range of breaker models together with capabilities of modern carriers makes our breakers competitive in all secondary reduction applications. Mounting the secondary reduction breaker on a mobile carrier provides a flexible unit which can be used at several points in the quarry for various different tasks like digging, loading & carrying. In many cases, oversize boulders can be sold profitably for use in embankments, dry walls or as breakwater rocks. In suitable rock types, hydraulic breakers can be used to create appropriate blocks.

Secondary reduction performance of the breakers



*Non-binding guideline values

Comparison of secondary breaking methods

Sledgehammer	Drop ball	Blasting	Free-fall hammer	Hydraulic breaker
The lowest energy of all methods. Manual process that has the highest risk of personal injuries. Because of the distance to the rock and use of handheld working tools.	The highest energy which can cause flying bigger rocks and injuries in surrounding area and damage of the excavator parts. Slow and low productive method for small amount of oversized boulders.	Risk of fly rock, because of geology and quality of drilled hole. In some cases the vibration can endanger the buildings or gas pipelines. Disturbs other processes.	High energy at low impact rate that can cause flying rocks. Can be used only in vertical position limiting the applications.	Very high impact rate at high energy. Only small risk of fly rocks near to the breaker compared to other methods. Easy positioning in all directions. Double power compared to free-fall hammer of the same weight.

Hydraulic breakers are the most effective way to do secondary breaking

When hydraulic breakers are used for primary breaking, secondary breaking operations are normally not needed - unlike with mechanical rippers when large boulders may occur more often.

There are three common areas for secondary breaking:

- Directly on the pile of blasted rock
- On the dedicated area (stockpiling) for oversized boulders or
- Directly at the grizzly/ crusher using pedestal booms - generally when there is a blockage

HB 2000 on the 30t excavator reducing sandstone (Yorkstone) boulders on the dedicated area for the secondary breaking

MB 1650 on 21t excavator breaking oversized granite boulders on the rock pile

MB 1650 on the 21t excavator in the dedicated area for secondary breaking near to the crusher and screener station

HB 10000 on a 90t excavator reducing boulders in limestone quarry in China

HB 4100 on a 40t excavator helping to remove the blockage in mobile crusher

EC 180 reducing diorite boulders in Russia

Selection of hydraulic breakers

Secondary rock breaking on pedestal boom systems

Rock hardness	Soft to medium (<80 MPa)			Hard (80-160 MPa)			Very hard (>160 MPa)		
Boulder size	< 1 m^3	< 1-2 m^3	< 2-4 m^3	< 1 m^3	< 1-2 m^3	< 2-4 m^3	< 1 m^3	< 1-2 m^3	< 2-4 m^3
	< 35 ft^3	< 35-70 ft^3	< 70-140 ft^3	< 35 ft^3	< 35-70 ft^3	< 70-140 ft^3	< 35 ft^3	< 35-70 ft^3	< 70-140 ft^3
SB 202	•								
SB 302	•								
SB 452	•	•							
SB 552	•	•		•					
SB 702		•	•	•					
MB 750		•	•	•					
MB 1000		•	•	•	•		•		
SB 1102			•	•	•		•		
MB 1200			•	•	•		•		
MB 1500			•		•	•	•	•	
MB 1650					•	•	•	•	
HB 2000						•		•	•
HB 2500						•		•	•
HB 3100									•
HB 3600									•

•=Suitable
Final breaker selection based on pedestal boom system size & type and number of boulders per hour

HB 2000 on a pedestal boom at the crusher station

Removing overburden

HB 10000 on a 92t excavator breaking limestone boulders in the overburden

Before excavating open-pit deposits, we need to remove overlaying soils or rocks (overburden). This is done continuously or in phases. The overburden is kept and reused subsequently for restoration.

Once the overburden is removed, benches and ramps are built for transport. As this work frequently takes place in the border areas of the quarry, drilling and blasting involves considerable outlay. With no benches in place, it is very difficult for the drill rig to access the overburden, which can be several meters deep.

In addition to the loss of tools and drill rods in fissured deposits there is risk of injury and equipment damage from flyrock. In many cases, public roads and paths need to be closed, which can cause major problems on heavily used routes. The costs of initial work impacts the profitability of the overall mining operation.

The costs of removing overburden can be reduced using a heavy-duty hydraulic breaker or a drum cutter, and the work can be carried out faster with more flexibility.

In many cases, the yield from a deposit can be increased because selective removal allows materials to be extracted which would normally have been removed along with the overburden by conventional methods. Opening up mines without the use of explosives can also simplify approval procedures.

Trenching

Trenching with hydraulic breaker

Basically trenching is an excavation method that involves digging the ground or cutting/breaking rock formations to install, maintain or inspect the pipes. The trench is long and deeper than it is wide. On the market special dedicated trenching machines can be found but the hydraulic attachments like drum cutters or breakers are more flexible on the construction site and the investment costs are much lower than for a dedicated machine. Compared to the breaking method, the drum cutting technology allows more accurate shape of trenches.

Up to 70 % of cut material using a drum cutter can be used again as a refill material.

Transverse drum cutter ER excavating trenches

Axial Drum Cutter ER-L excavating trenches for foundation

Supportive works in a quarry

Hydraulic attachments are an easy solution to take care of special supportive works for example; smoothing the benches after blasting and building the ramps and roads for mine trucks. Heavy hydraulic breakers can do the job easily even on the hardest rocks and existing machinery can be used as a carrier. In northern parts of the world, melting water during the springtime may form massive ice blocks at night that are very fragile and dangerous.

Hydraulic breakers are fast and easy to use for scaling these walls safely and they are proving popular for these applications. Adapted on a long reach excavator boom they can scale the tallest benches using the breaker in vertical position, which increases the lifetime of the breaker and eases the job. Drum cutters are very helpful digging trenches for surface dewatering system.

MB 1500 on the long-reach excavator removing ice blocks

Underwater rock excavation

Both rock excavation methods using drum cutters and hydraulic breakers work successfully underwater. Drum cutters can work underwater without any technical changes up to 30 m depth. Hydraulic breakers require a special underwater kit that keeps the percussion chamber under pressure to avoid the water coming inside the breaker and automatically switches off the breaker in case of no air supply.

The typical applications here are cutting or breaking rock for underwater trenching or harbor deepening projects. Other drum cutter applications include the primary excavation of sand and gravel on the dredger or excavation of salt on the excavator. In case of cooking salt, the biggest advantage of Epiroc attachments is that the drum cutter comes without external lubrication and hydraulic breakers can be used with Bio Chisel paste to avoid pollution. Some competitors drum cutters require external lubrication.

HB 4100 underwater rock excavation in Italy

Salt mining with ER 1500X in Saudi Arabia

Salt mining with ER 1500-1 in China cutting drainage channels in brine solution

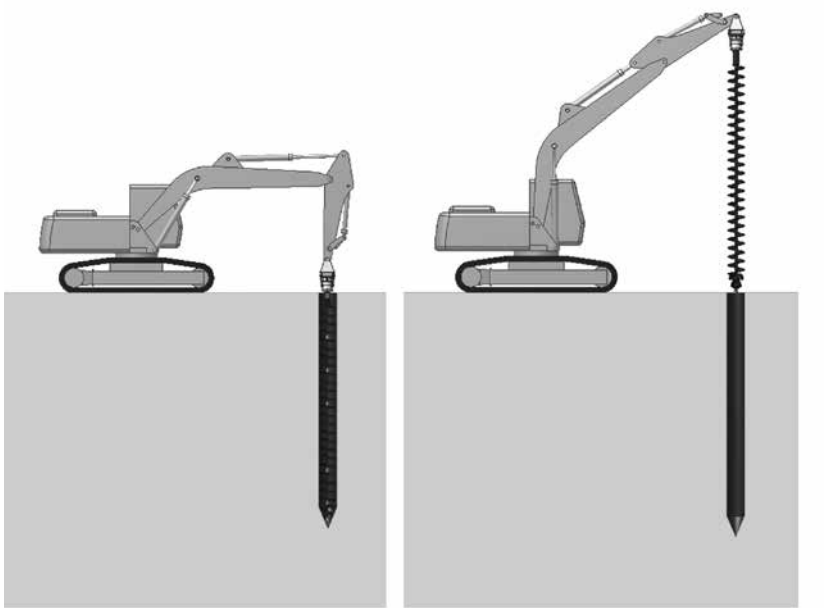
Auger drilling with ADU (ERL) units

The ADU range of Epiroc auger drive units are designed for use on excavators from 3 to 50 tons.

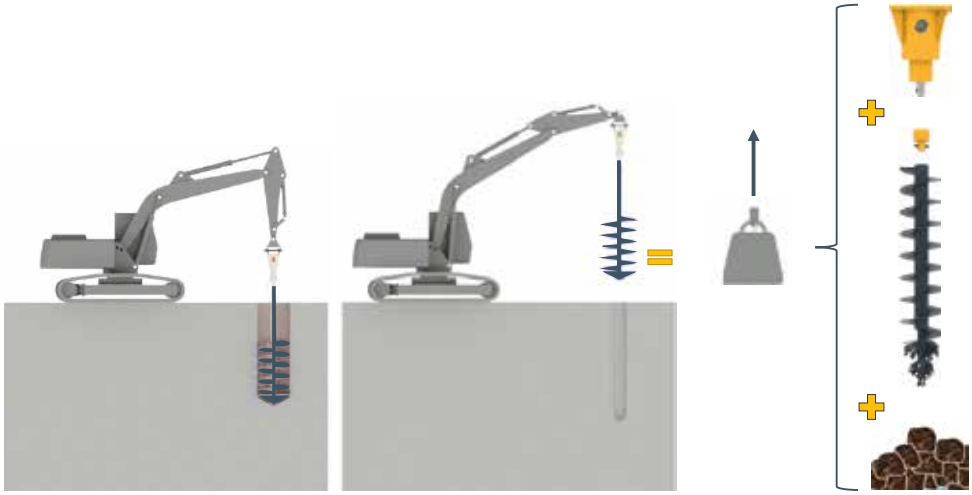
They are ideal for drilling shallow holes in soft to compact soils, cobbles and in soft to medium hard rock with compressive strengths up to 60 MPa. They operate with high torque radial piston motors and having a massive drive shaft bearing system and are highly reliable even in tough drilling conditions.

The connection is done by two way hydraulic circuit (shear hydraulics). Vertical position while drilling is a must to avoid bending stresses on the hexagonal drive shaft.

Case 1: small diameter, deep hole
Max. drilling depth = lifting height of the excavator



Case 2: large diameter
Auger length according to lifting capacity (starter auger combined with extension rods)



Consider the weight of material (soil/rock) on the auger

Choice of drill heads depending on soil types

	1	Topsoil
	2	Liquid soil
	3	Soil easy to excavate
	4	Soil medium hard to excavate
	5	Soil hard to excavate
	6	Rock easy to excavate (max. 60 MPa) & similar soil
	7	Rock hard to excavate (max. 60 MPa)

Data survey "Blast-free mining“

Date: .....

Customer

Company: .....
City / Country: .....
Contact: .....
Tel.: / Fax: .....
Email: .....

Information on deposit

Rock type: ..... deposit ..... / overburden .....
Compressive strength (MPa): .....
Density (t/m³): .....
Quartz SiO_2 content (%): .....
Brief description of deposit: .....

.....

Deposit (fissure density): .....
..... densely fissured (< 0.4 m)
..... fissured (< 0.4 – 1.0 m)
..... massive (> 1.0 m)
Reserves (economically mineable part of Resource) (t)

.....

Information on quarry and annual production

Average face / bench height (m): .....
Numbers of levels: .....
Selective mining: .....
if so, why? .....
Use of end products: .....
Average annual production (t/a): .....
Working days a year (d/a): .....
Daily working hours (h/d): .....

Production details

Type of primary crusher: ..... jaw crusher / ..... impact crusher / ..... cone crusher / ..... other .....
Crusher capacity (t/h): .....
Max. feed size (mm): .....

Current mining method

Drilling and blasting: Number of blasting operations per year: .....
Pro blasting boreholes numbers ..... / borehole depth ..... / borehole diameter: .....
Secondary reduction required after blasting:
..... YES ..... NO
Secondary reduction method: ..... hydraulic breaker
..... blasting
..... ball
..... other .....
Average oversized boulders in broken rock (%):

.....

Average size of oversized boulder (m³): ..... /
approx. dimensions: .....

Breaker use

Do you already have experience working with hydraulic tools in your quarry? ..... YES ..... NO
If so, please provide details (application, since when, equipment size): .....

.....

Breaker manufacturer / type: .....

.....

Service weight (t): .....
Built year: .....
Excavator type, model, built year .....
Have you already applied other blast-free mining methods? If so, please provide details: .....

.....

Loading – transportation

Do you have a wheel loader with >4m³ bucket?
..... YES ..... NO
Broken rock transported by ..... truck / ..... conveyor / ..... other .....
Do you have data on wear to loading equipment or primary crusher? .....

Objectives of blast free methods

..... Alternative mining method
..... Reduced mining costs
..... Clearance / removal of overburden
..... Other .....

Base values for estimation of operating costs

Diesel costs (€/L): .....
Diesel consumption (L/h): .....
Labor costs machine operators incl. non-wage costs (€/h): .....
Previous costs for mining by drilling and blasting (€/t): .....
Parameters used to control the costs: .....

Attachments

Photos (machines, rock mass, rock samples)
Additional documents (description of deposit, geological cross section etc.)


erkat
cutting
technology

Notes

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