MN5.5: Surface Mining

Module-4

Blasthole Drilling

Comparison of blasthole drilling methods

Criteria of comparison	*Top hammer drilling*	*Down the hole hammer drilling*	*Rotary blasthole drilling*
Means of Achieving Formation Disintegration	By means of blows generated at the drilling machine located above the ground.	By means of blows generated in the down the hole hammer placed just above the drill bit in the drill hole.	By means of static pressure given by the feed force exerted by the drilling machine placed on ground.
Type of Drill String	Relatively slender as it comprises of drilling rods coupled together by means of sleeves.	Relatively rigid because it comprises of large diameter drill pipes that have male and female threads on their ends. No sleeve is required for coupling the pipes.	Rigid because it comprises of even larger diameter and heavier drill pipes that have male and female threads on their ends. No sleeve is required for coupling the pipes.
Transfer of Impacts and Rotary Motion	Both impacts and rotary movement are transferred through drill string.	Only the rotary movement is transferred through drill string. Impacts are generated at the hammer in the hole just above the bit.	Very heavy static feed force instead of impacts and rotary movement are transferred through the drill string.
Practical Hole Dia. Range	38 mm to 150 mm.	89 mm to 250 mm.	150 mm to 445 mm.
Practical Hole Depth Range and Susceptibility to Hole Deviation	0 to 18 m. Highly susceptible to deviation at higher depths due to high slenderness ratio of the drill rods.	0 to 100 m. Hole deviation is relatively small because drill pipes have low slenderness ratio.	0 to 60 m. Hole deviation is relatively small because drill pipes have low slenderness ratio.

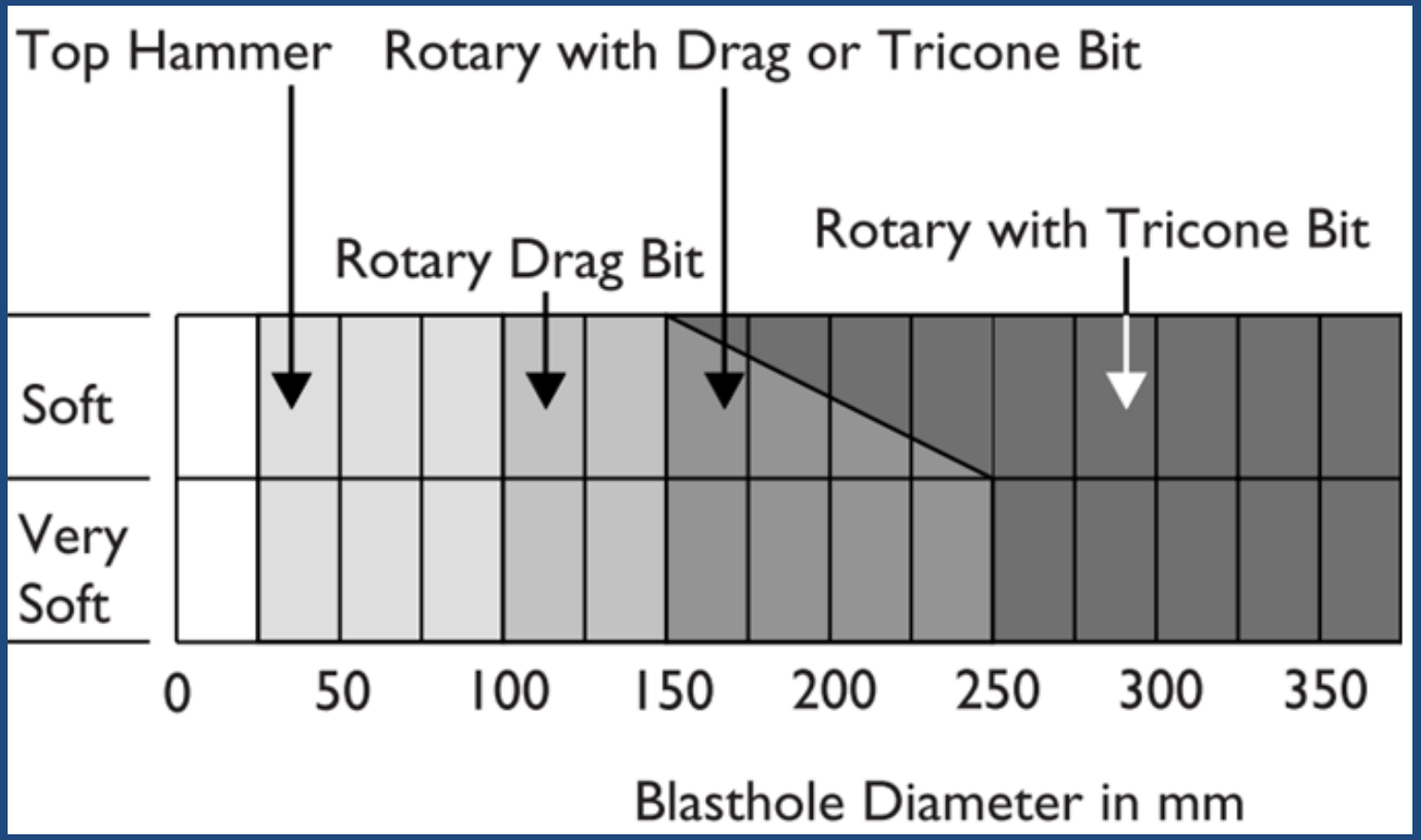
Comparison of blasthole drilling methods

Criteria of comparison	*Top hammer drilling*	*Down the hole hammer drilling*	*Rotary blasthole drilling*
Possibility of Angle Hole Drilling	As holes are drilled with light equipment they can be drilled at any angle.	As holes are drilled with medium equipment drilling holes in direction other than vertical or near vertical is difficult.	Drilling equipment is very heavy. Vertical or slightly inclined holes are possible.
Effect of Depth on Penetration Rate	Penetration rate is considerably reduced with depth because of loss of percussion energy. It is absorption by drill rods.	No significant loss of penetration rate as the hole depth increases because no energy is lost in transmission.	Penetration rate is unaffected by increase in the depth of the hole because impact energy is not used.
Means of Cutting Removal from the Hole	By means of compressed air circulated through the drill string. Sometimes water is also used as circulation medium.	By means of compressed air circulated through the drill string.	By means of compressed air circulated through the drill string.
Magnitude of Feed Force Required on Drilling Tool	Small force is essential to ensure that the bit is in contact with the formation.	Small force is essential to ensure that the bit is in contact with the formation.	Very heavy force is essential to ensure that the bit remains in contact with the formation and crushes the formation beneath it.
Effect of Extreme Cold Weather	As hydraulic oil is the medium of power transfer, great difficulties are experienced due to oil viscosity changes.	As compressed air is the medium of power transfer, difficulties in cold weather are easily surmountable.	Electric drills operate satisfactorily. In hydraulic drills difficulties are experienced due to oil viscosity changes.

Comparison of pneumatic, hydraulic and electrically operated drilling machines.

Pneumatic	Hydraulic	Electric
The machine is compact, rugged in nature, having high power-to-weight ratio, Pollution is less.	It is more compact, precise control is possible, low noise level, High rate of penetration	Pollution is less, power loss
Moisture in compressed air may freeze in low temperature operating zone. Mosisture may cor-rode the exposed metal Surfaces.	Possibility of pollution in case of leakage in oil line. They required greater maintenance.	Requires more space, Creates noise.

Selection of drills for soft formation



Soft OB

dia. = 150 to 381 mm

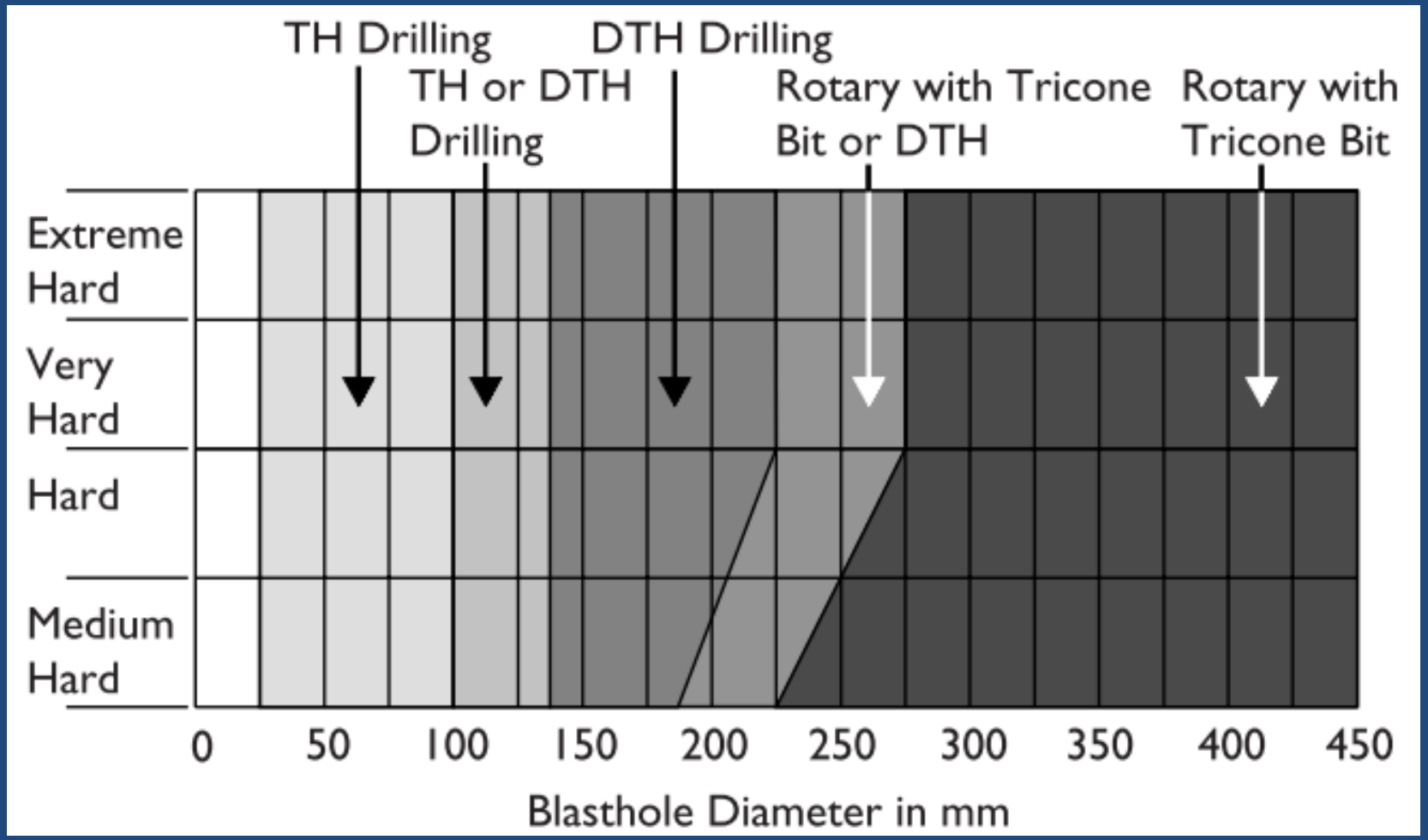
depth = 15 to 55 m

Soft thick coal beds

dia. = 150 to 200 mm

depth = 10 to 20 m

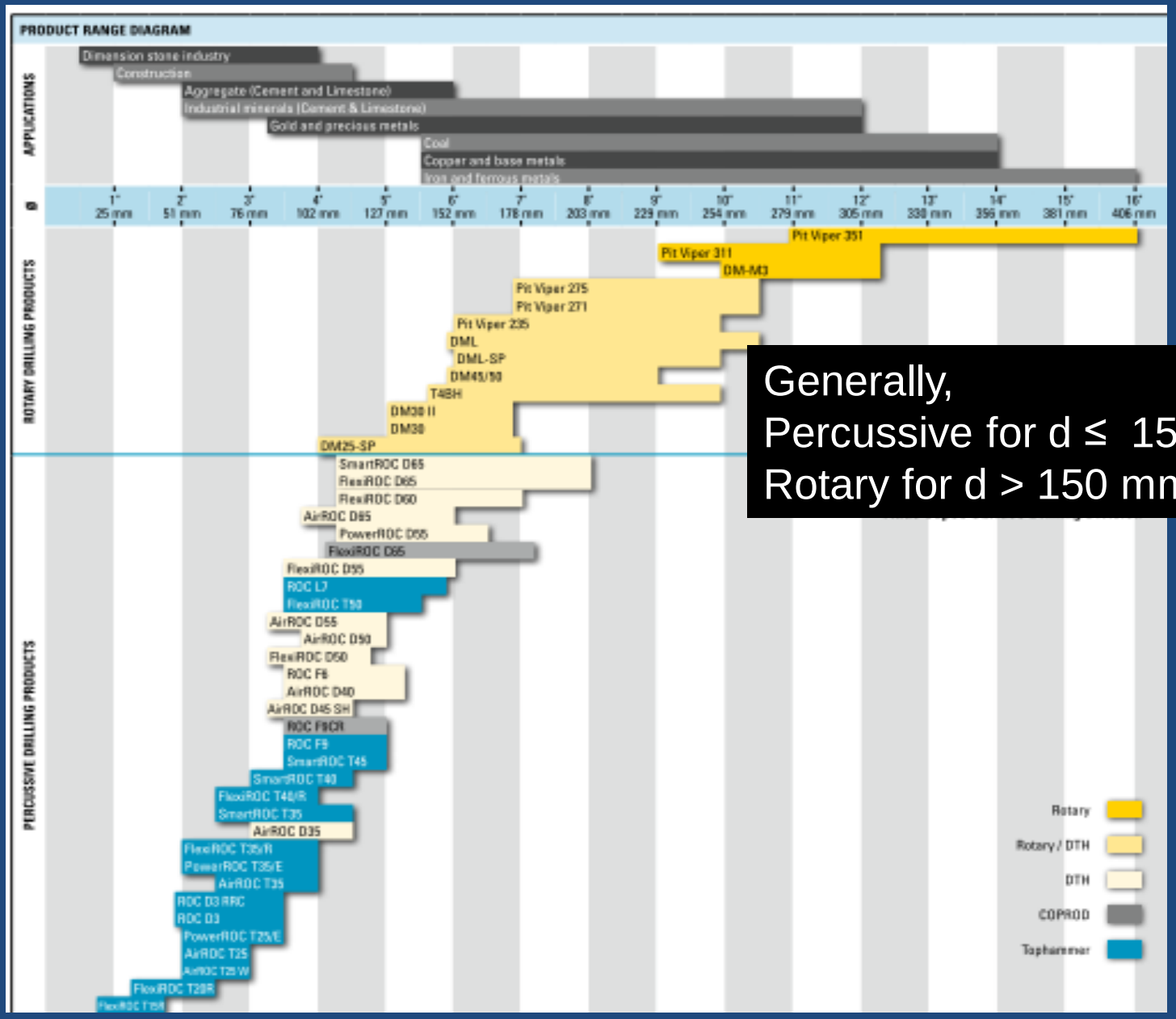
Selection of drills for hard formation



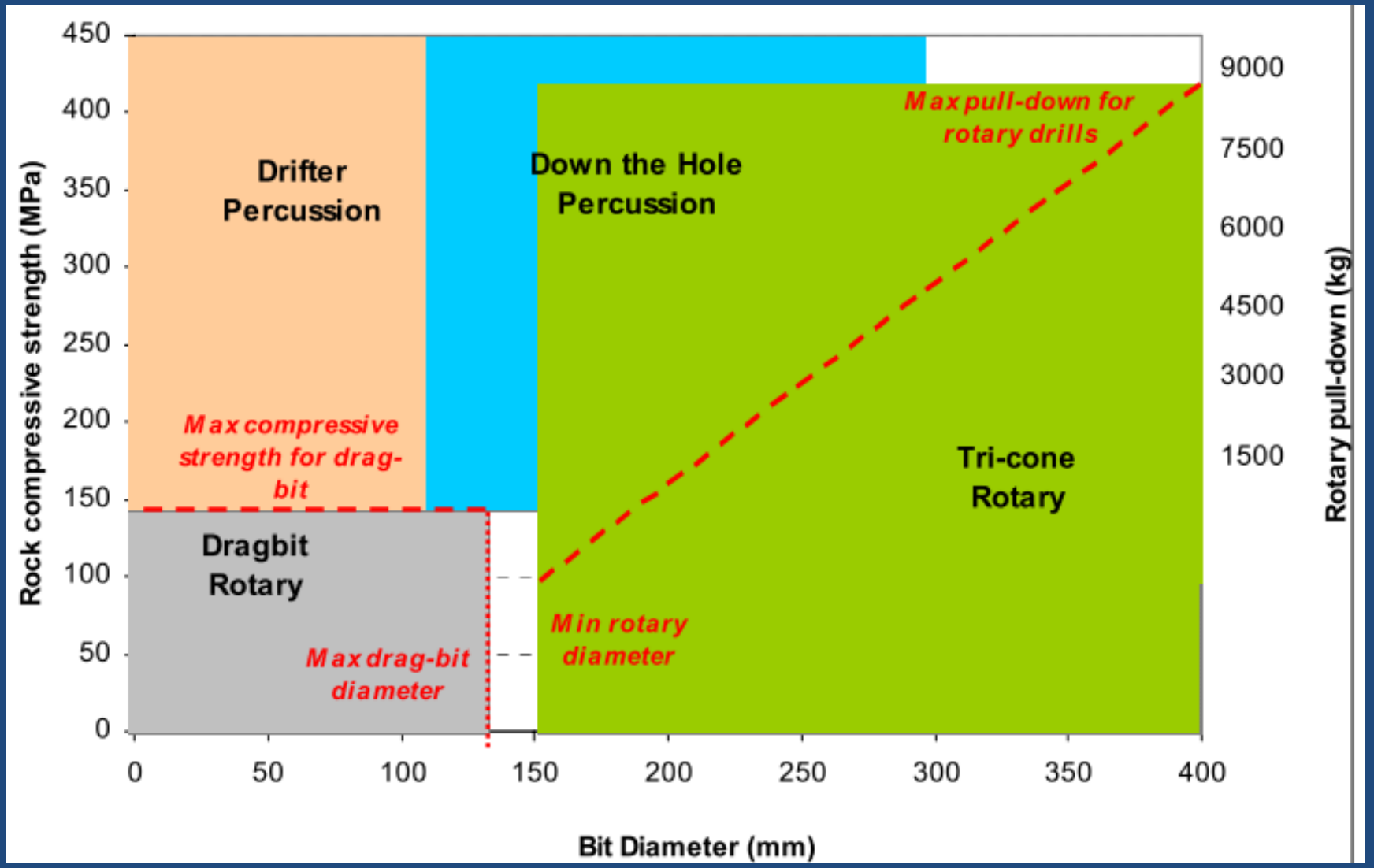
Hard rock formation

dia. = 100 to 381 mm depth = 10 to 20 m

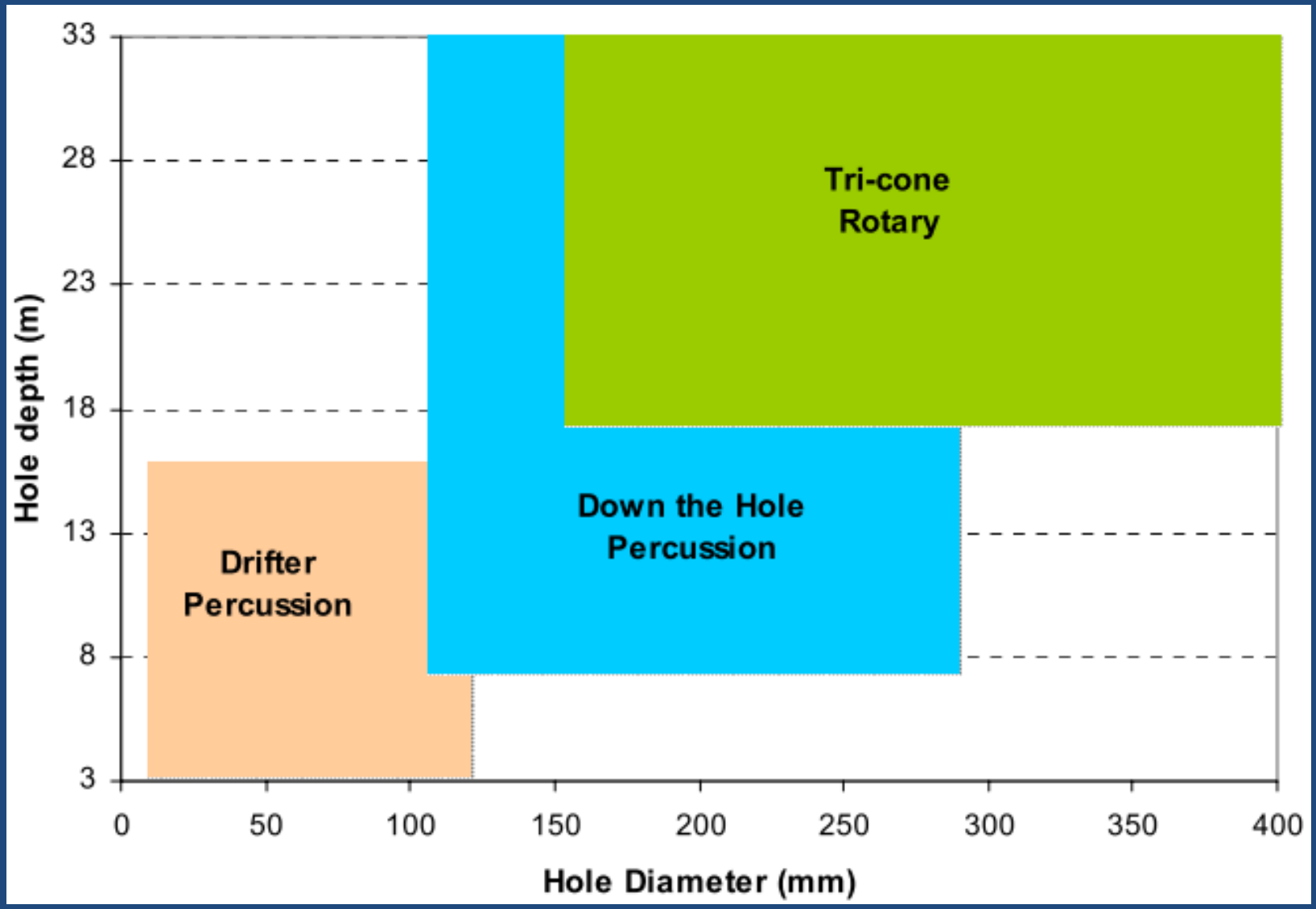
Selection of drills for surface mining



Generally,
Percussive for d ≤ 150 mm
Rotary for d > 150 mm



Selection of drills for blasthole drilling at surface mines



Hole dia. & depth limitation for different types of drills

Selection of Hole Diameter

Bench Height	Hole Diameter in Inches																	
feet	3	3.5	4	4.5	5	5.5	6	6.25	6.5	6.75	7	7.88	9	9.88	10.6	12.3	13	15	16
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82																			

$d \text{ (inches)} \leq H/5 \text{ (in feet)}$

Selection of drills for open pits

Rotary? Percussive? Rotary-percussive?

1. Nature of rock (drillability, abrasitvity)

2. Depth, direction and diameter of holes

3. Speed and cost of drilling
(penetration rate, drilling rate)

Points to be remembered while choosing the right drill for blasthole drilling

1. Rotary drilling requires exerting a heavy feed force in the downward direction on the drill string. Hence the drills are very heavy. If they are not heavy, their ability in drilling large diameter blastholes remains limited.

2. Percussive drills need not exert heavy feed force, but when drilling upward holes the weight of the piston acts adversely to the blow energy. Percussive drill performance must be judged in the light of this fact.

Factors affecting drill performance 1/4

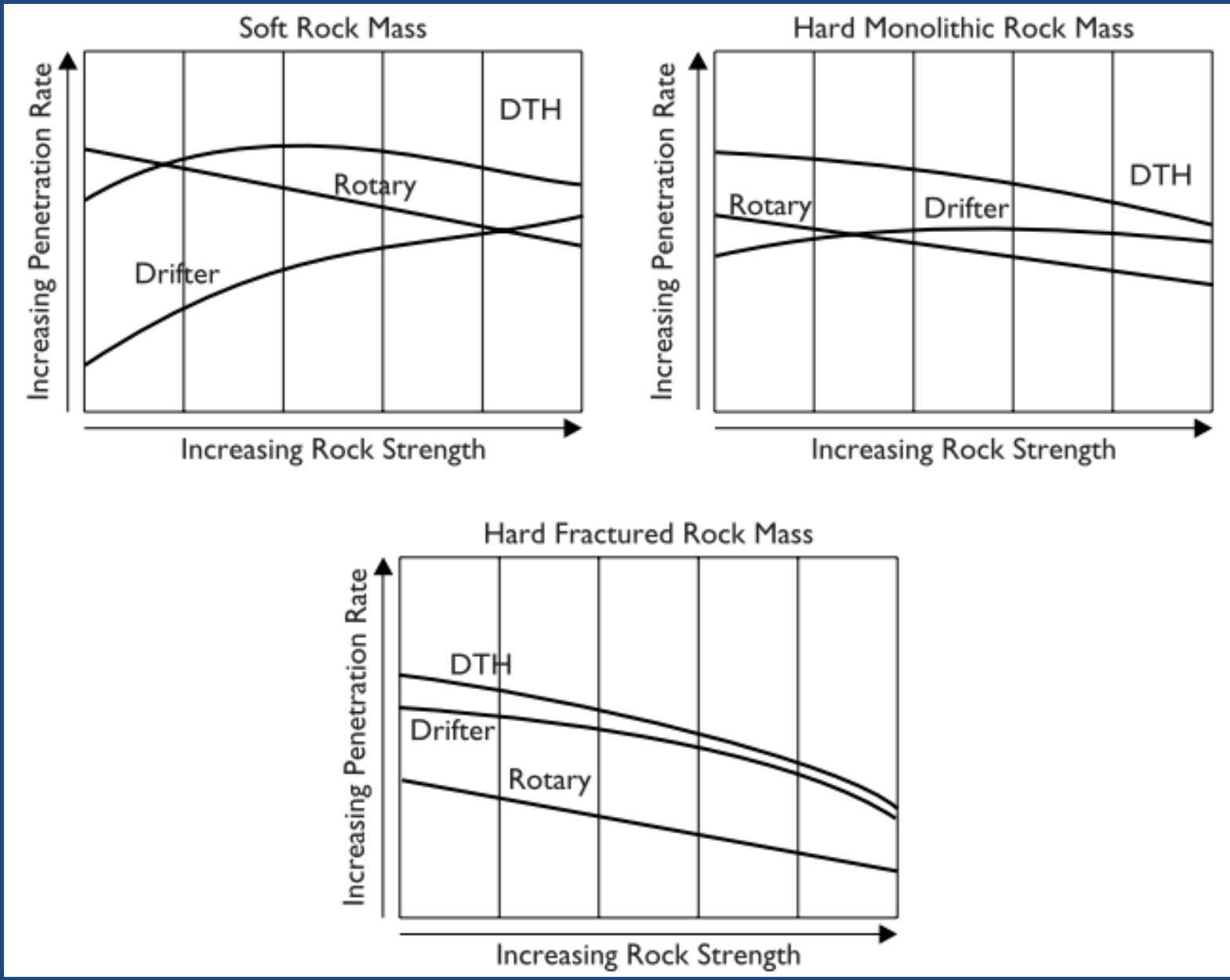
1. Drill operating factors	Drill	1. Drill power 2. Drill Thrust 3. Drill Torque 4. Drill Rotary Speed 5. Blow energy 6. Blow frequency
	Rod	1. Rod dimensions 2. Rod Geometry 3. Material Properties
	Bit	1. Bit diameter 2. Bit geometry 3. Material Properties
	Circulation Fluid	1. Fluid flow rate 2. Fluid properties

Factors Affecting Drill performance 2/4

2. Drillhole Factor	1. Hole Size 2. Hole Depth 3. Hole Inclination

Factors Affecting Drill performance 3/4

3. Rock factors	1. Physico-mechanical properties 2. Discontinuities



Penetration rates with 150 mm dia holes in limestone

Factors Affecting Drill performance 4/4

Site and managerial factors	1. Labour quality 2. Supervision quality 3. Scale of operations 4. Power availability 5. Weather conditions 6. Site lighting conditions 7. Coordination

Selection of drills involves evaluation of

- energy and power consumed
- Bit wear and replacement cost
- Drilling rate
- Cost of drilling

This evaluation depends on the following factors

1. The operating parameters comprise drill, rod, and bit which should be selected to match the rock type.
2. Lubrication and cleaning variables, *i.e.*, circulation fluids usually either water, air or mud.
3. The hole geometry, *i.e.*, size and geometry which are exogenously determined.
4. Environmental geologic factors such as the rock properties, structural and petrological properties of the rock as well as the overburden stress, all of which determine the drillability of the overburden.
5. Environmental considerations to reduce noise and dust, *etc*. The down-the-hole drills produce least noise, and also limit the fog and visibility problems. Besides cuttings absorb the moisture in the air flow. For dust control water jet drilling is favoured.
6. Factors external to drilling such as cost of labour, job site, scale of operation, type and availability of power to the site, climatic conditions and management and supervisory efficiency.

Hole size will limit drifter selection, since these rigs are designed for specific range of hole sizes. But efficiency will be good only within the specified range.

Desired drilling capacity

Rigs that take longer time to move and set up may not be efficient to give higher capacity. Grater mechanisation may increase capacity.

Terrain also influences the choice of the drill

Crawler based drills for rough terrain or steeper grades

Rubber tyres based for level terrain

As the hydraulic rigs give higher productivity, reduced drill steel costs and reduced energy costs per metre drilled, the trend these days is towards the use of hydraulic units. These drills can be easily automated also. However, for some operations the pneumatic drills are still the best choice because they are reliable, flexible, easy to service and fairly quiet.