Fragmentation Management for the Downstream Value Chain

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QUARRY ACADEMY

Topics to be Covered

- The purpose of drilling & blasting in producing crushed stone
- Relative cost of drilling & blasting vs. other quarrying activities
- Cost/production opportunities offered with optimized fragmentation
- Factors affecting fragmentation
- Self-evaluation of fragmentation

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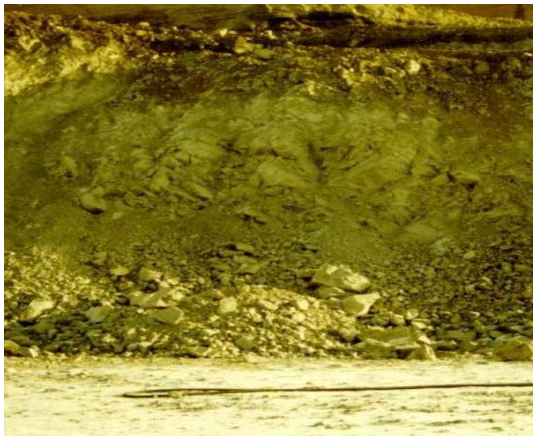
Why Drill and Blast ?



Blasting intensity

- **Drill and Blast is the first step in the breakage and separation process. Therefore, it impacts all the subsequent downstream process efficiencies.**
- **Drill and Blast is still the most cost effective method to break and move the large volumes of rock - when done correctly!**

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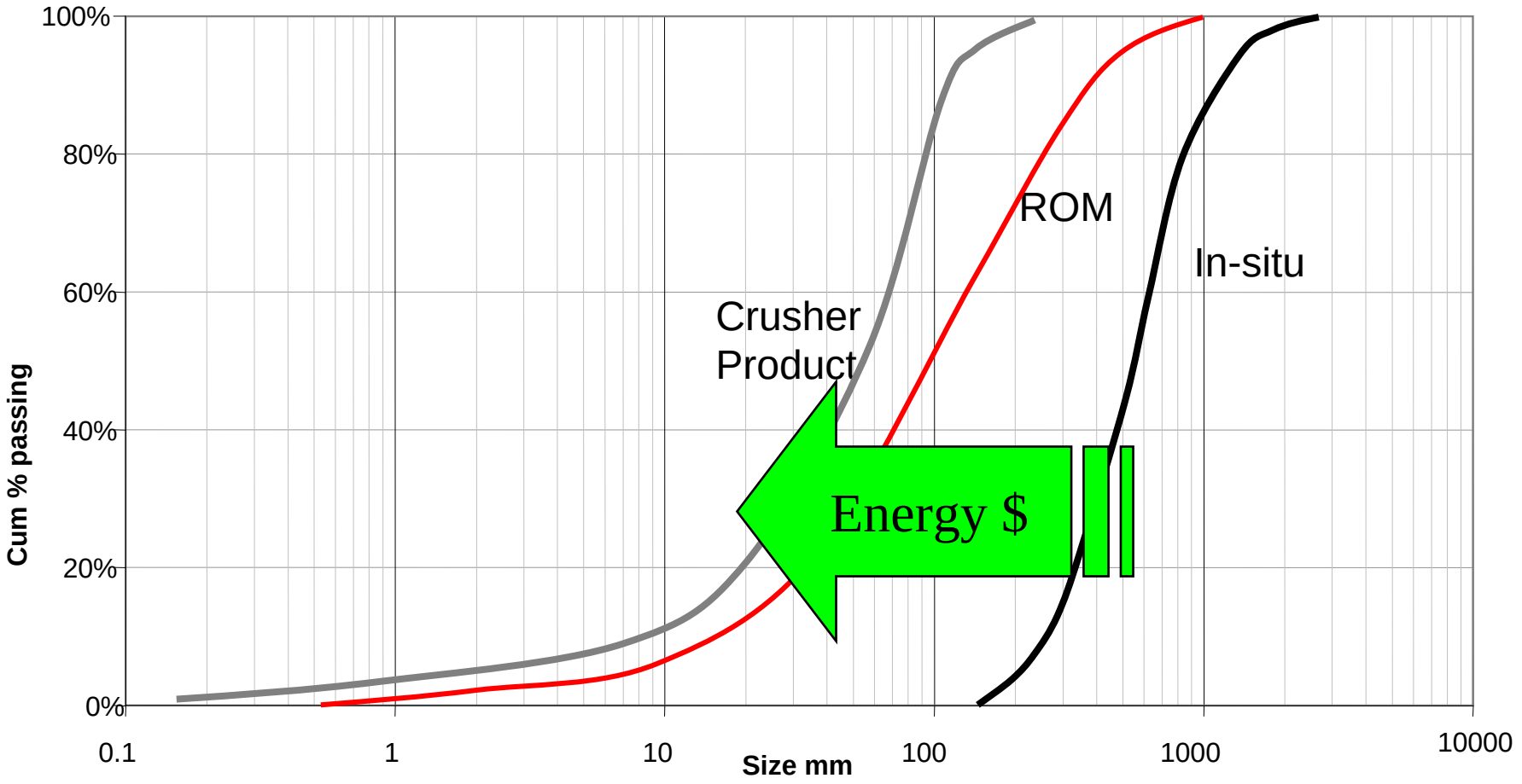
Rock Breakage Phases



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Relative Energy and Costs

	Specific energy kwh/t	Energy factor	Cost factor
Drill and Blast	0.1 – 0.25	1	1
Load and haul	0.2 – 0.5	1 - 5	2 - 10
Crushing	1 – 2	4 - 20	2 - 10

Lighten Up

Generally the harder the rock, the higher the factor.

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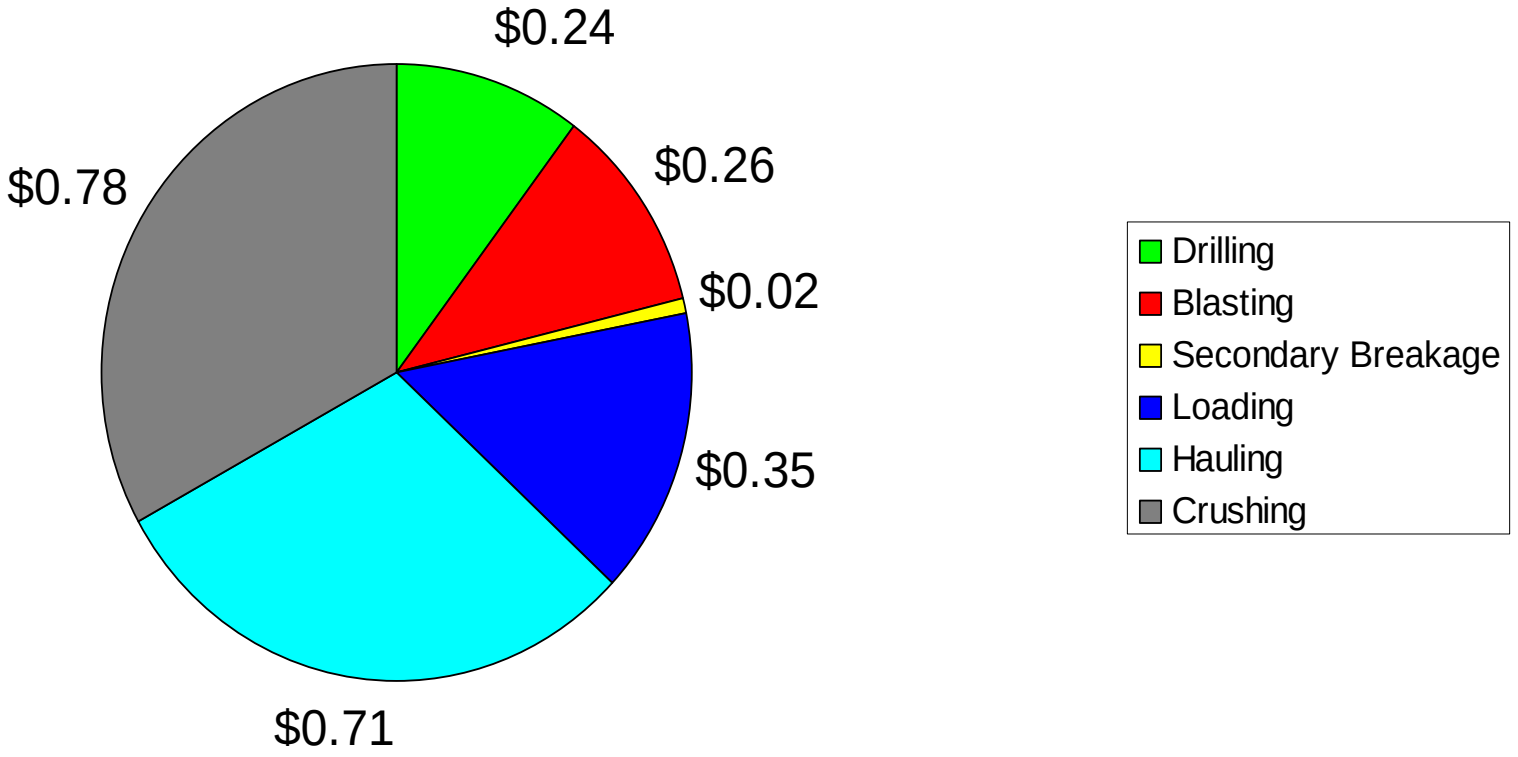
Drilling & Blasting - Leverage



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Drilling & Blasting - Leverage

- Drilling and blasting is the first step in the comminution processes
- A 10% increase in drilling and blasting cost can be compensated by
  - ✓ **4.6% reduction in excavation and hauling costs**

  or

  - ✓ **6.4% reduction in crushing**

1% decrease in excavation/hauling = 2.1% increase in D&B

or

1% decrease in crushing/benefaction = 1.6% increase in D&B

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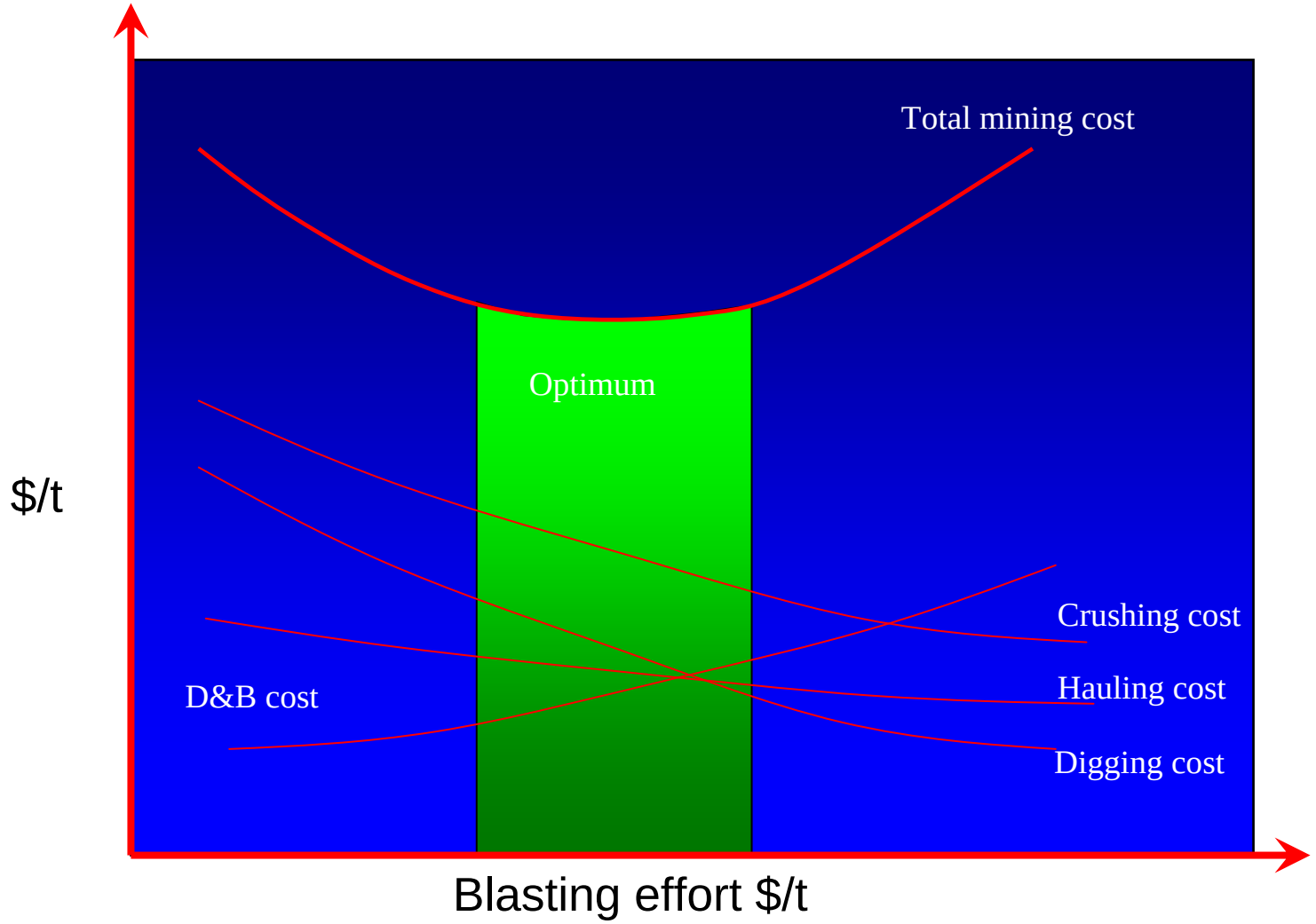
Traditional Blast Optimization



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Common Fragmentation Issues

- Oversize breakage costs
- Excavator costs (diggability)
- Crusher costs (throughput)
- Recovery (fines)

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Fragmentation Optimization Opportunities

- Better digging and bucket fill factors
- Consistent crusher throughput and power draw
- Reduction in blast induced damage
- Reduction in material losses ***(more saleable product)***
- Potential to produce better priced end product

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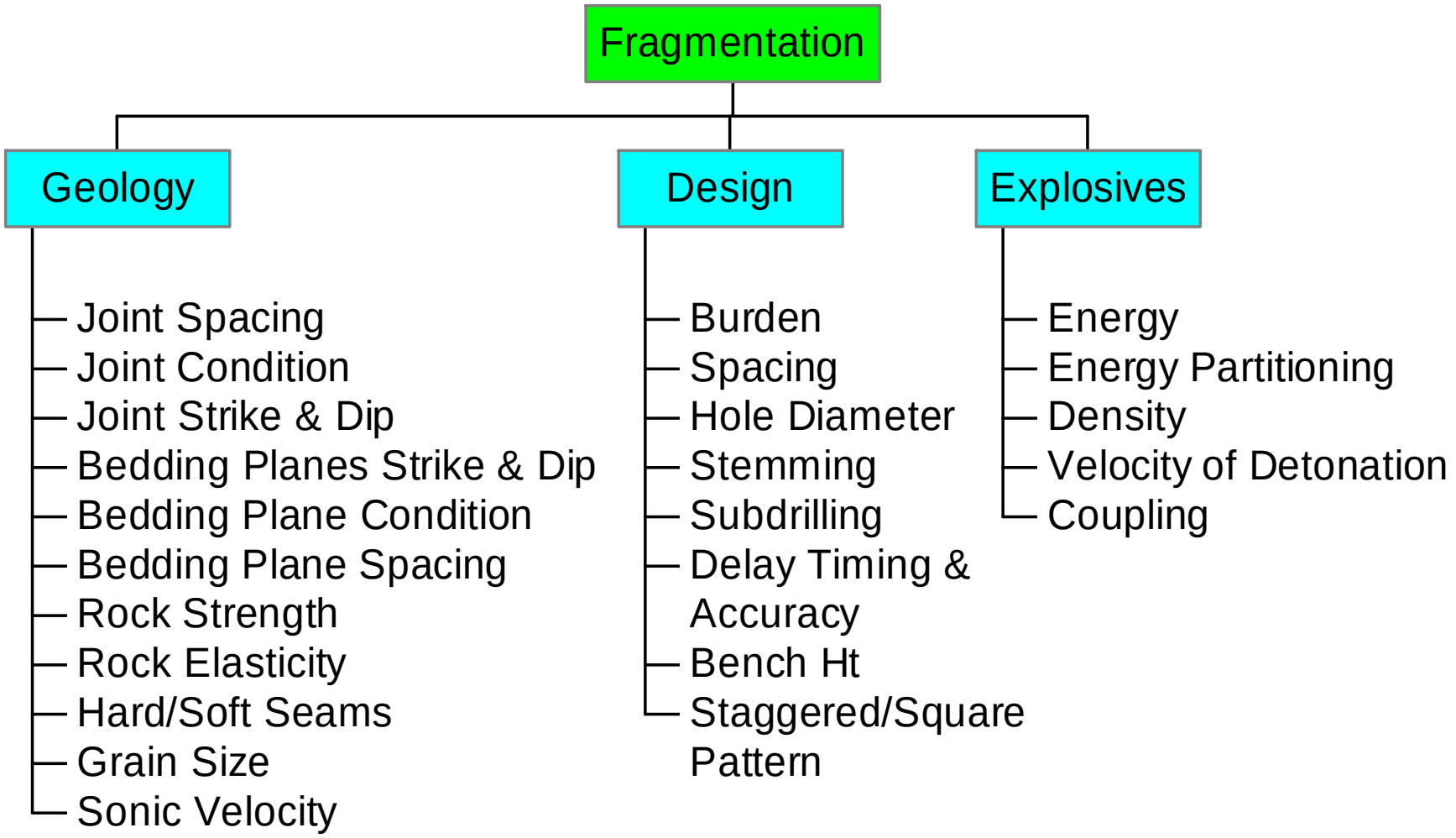
Factors Affecting Fragmentation



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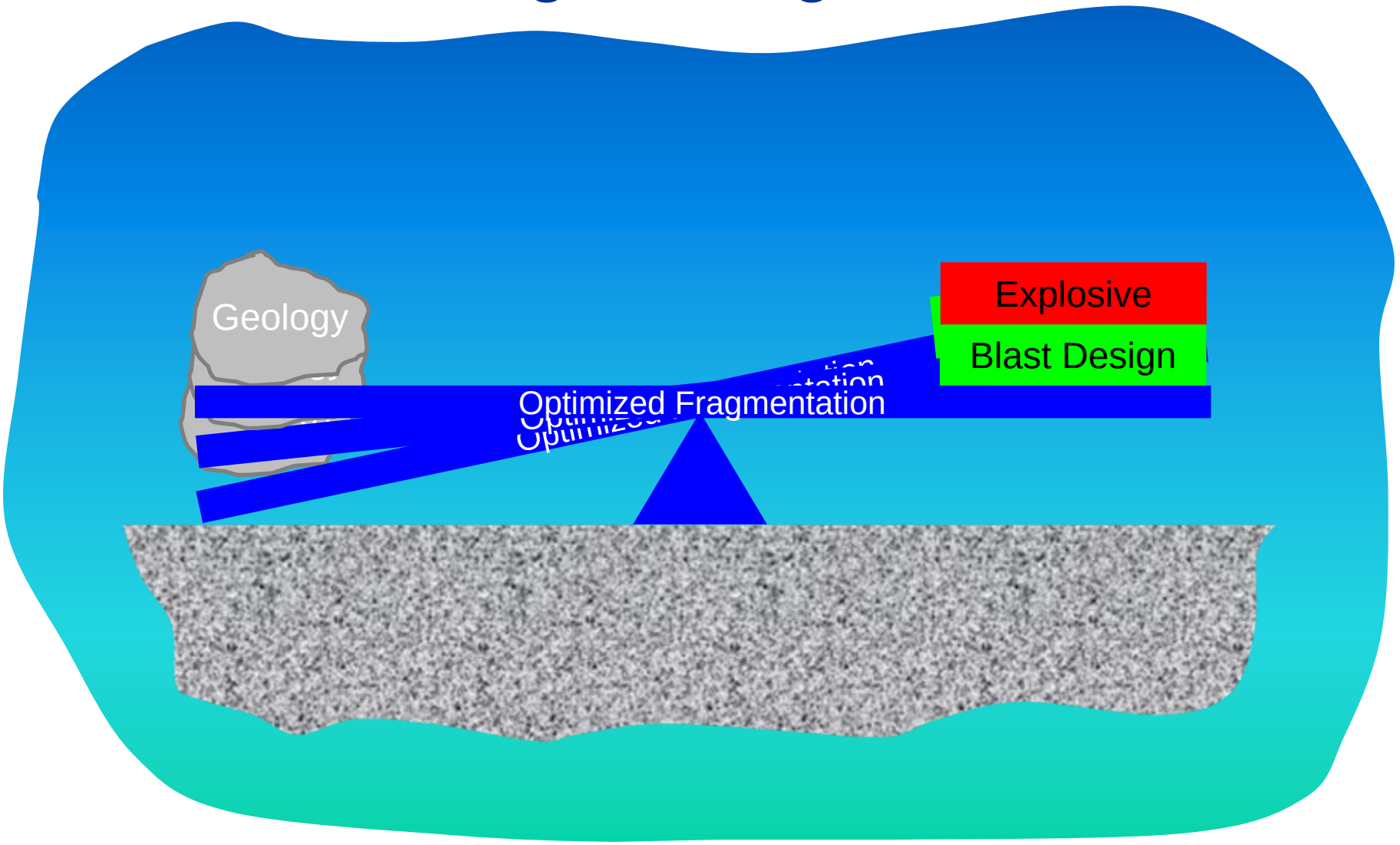
Balancing for Fragmentation



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Geology Factors

Structure describes the features which primarily determine the fragmentation performance of the rock mass.

- Jointing/Bedding
  - Defines maximum fragment size
  - Influences transmission of stress wave
  - Influences gas penetration
- Rock Strength & Elasticity
  - Determines how the rock mass responds to the explosive energy applied
  - Influences confinement on explosive

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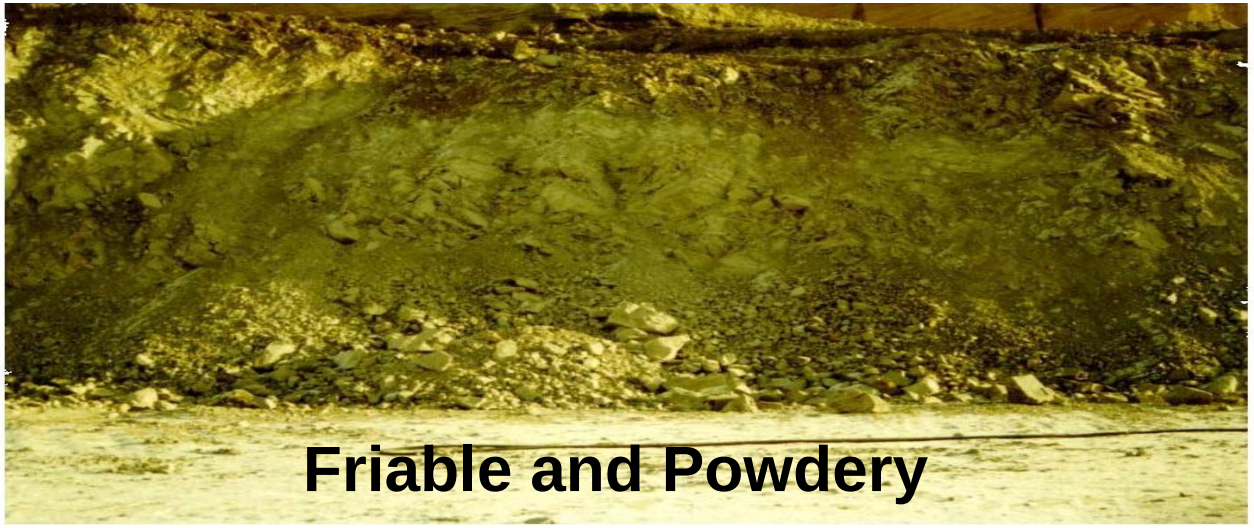
Rock Structure

Block size < 0.7 ft (0.2 m)



Block size > 6.5 ft (2 m)

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Rock Structure

Block size
0.6 – 3 ft
(0.2 – 1 m)

Block size
0.3 – 0.8 ft
(0.1 – 0.25 m)

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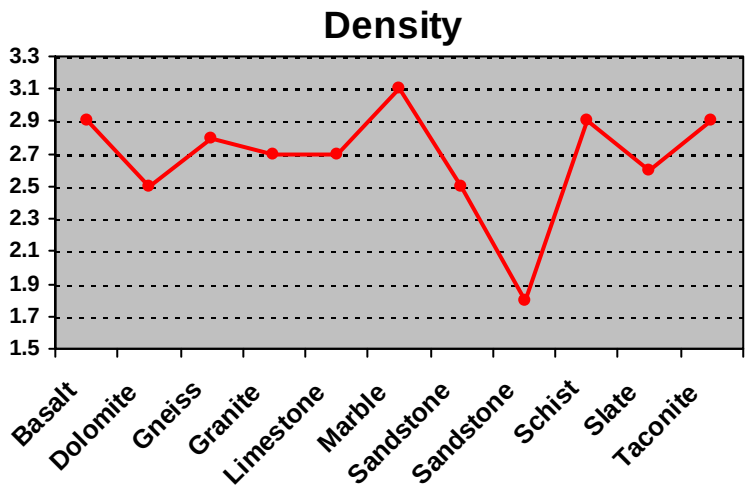
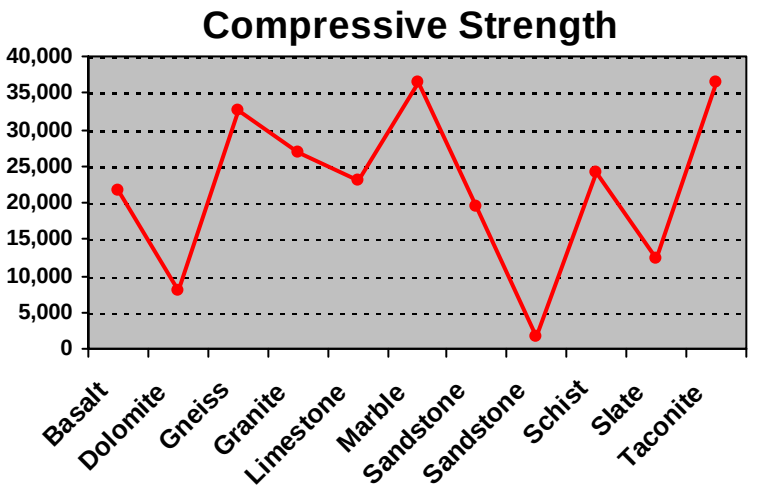
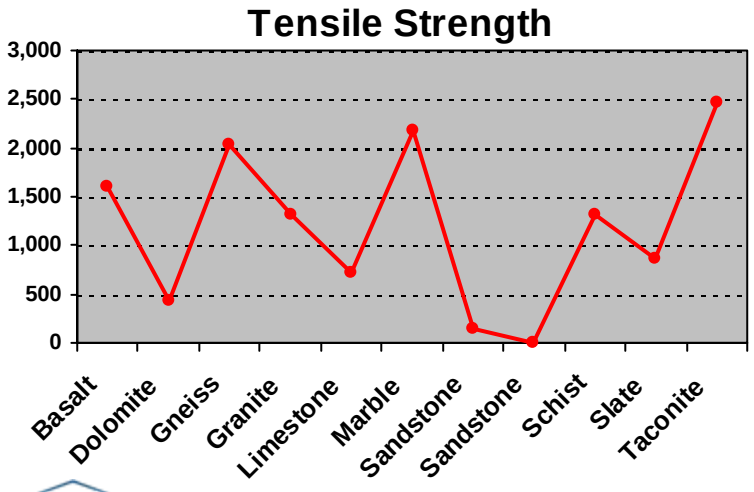
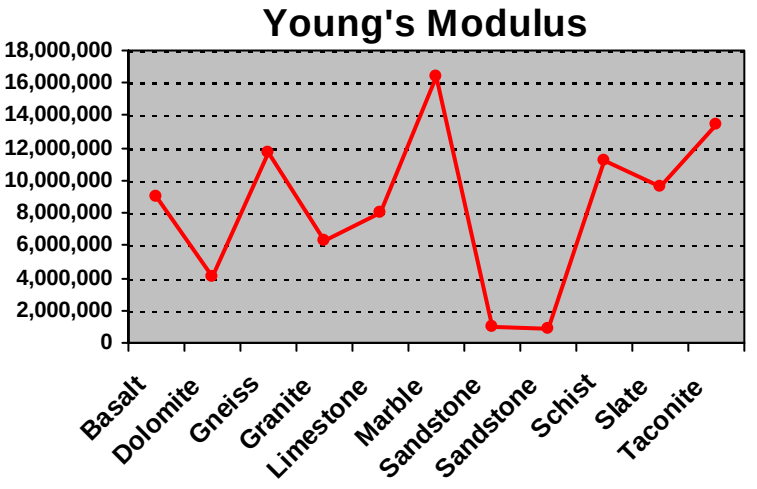
Rock Properties









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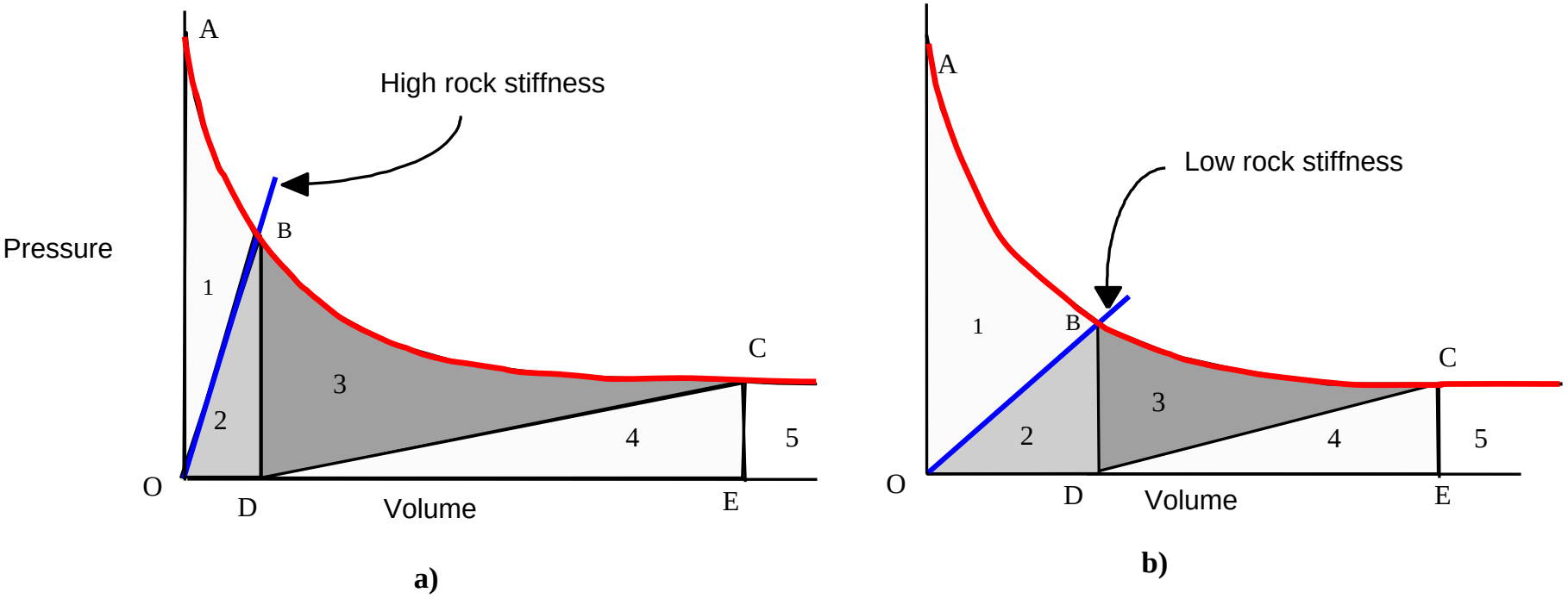
Effect of Rock Stiffness



Blast Design Factors

- **Hole Diameter**
  - **Influences energy distribution and burden stiffness**
- **Burden/Spacing**
  - **Influences energy distribution and burden stiffness**
  - **Relationship with joint spacing affects oversize**
- **Bench Height**
  - **Influences burden stiffness**
- **Delay Time & Accuracy**
  - **Influences interaction between detonating holes**
- **Staggered/Square pattern**
  - **Determines distribution of energy in rock mass**

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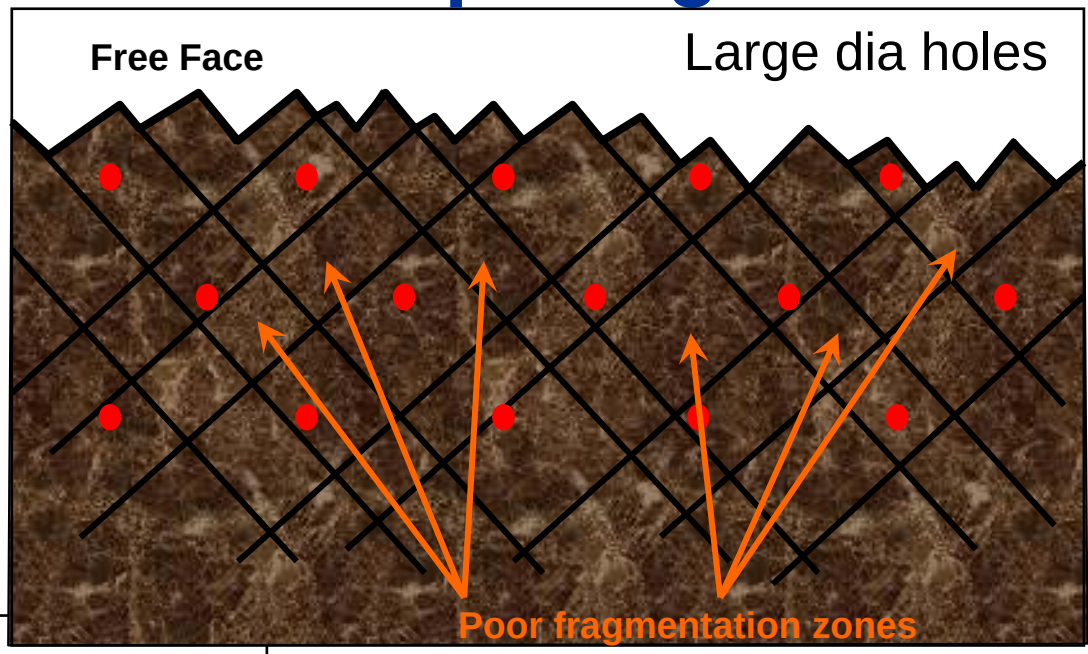
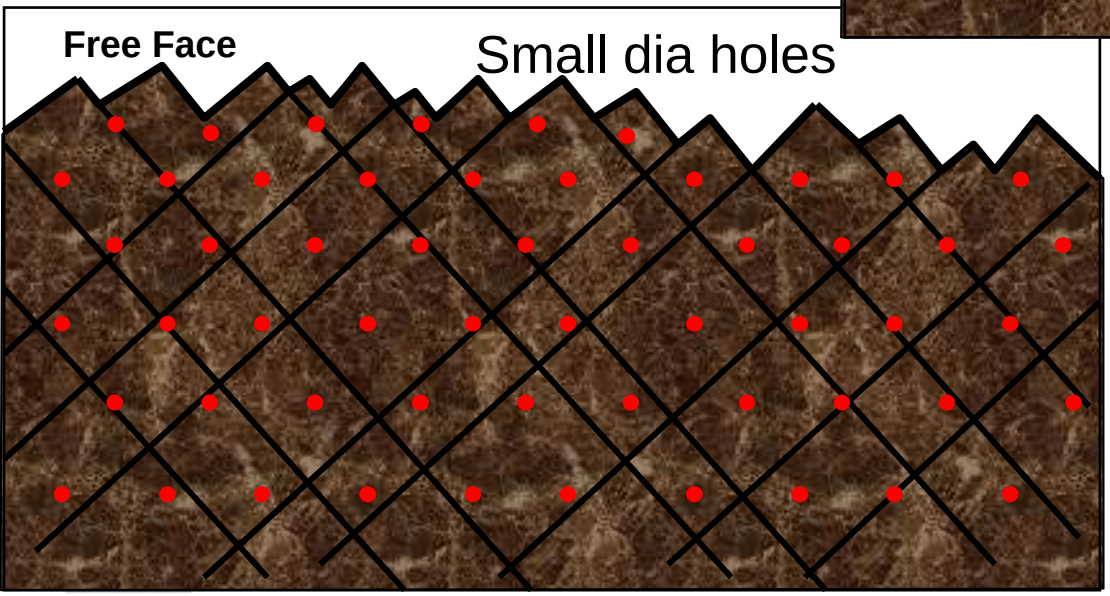
Hole Diameter & Burden/Spacing





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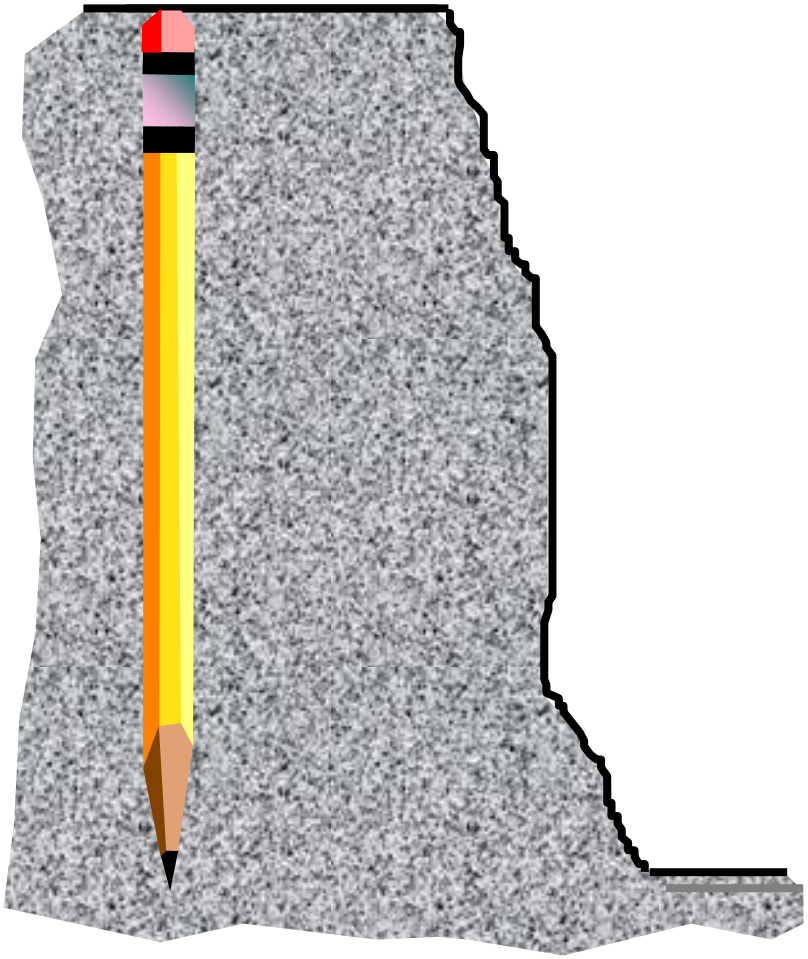
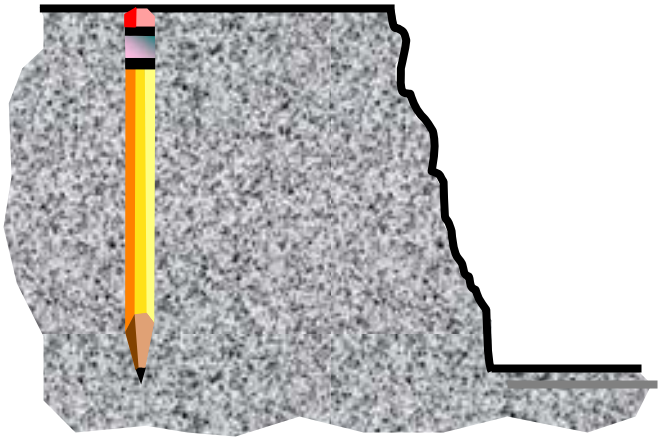
Burden Stiffness





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- **Delay Time & Accuracy**
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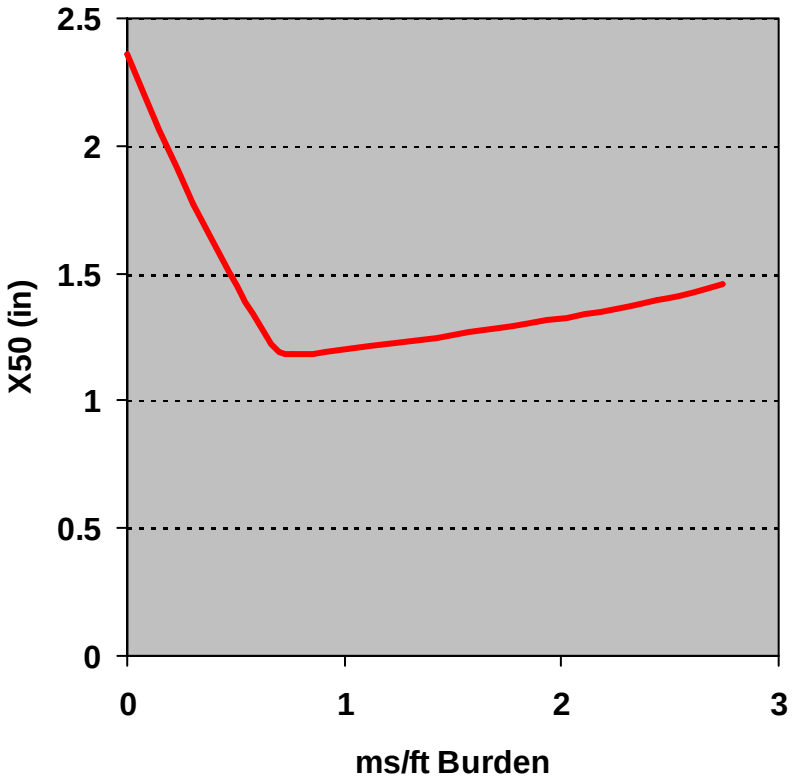
Interhole Delay Time & Fragmentation



(after Cunningham, 2005)

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Blast Design Factors

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  - Influences energy distribution and burden stiffness
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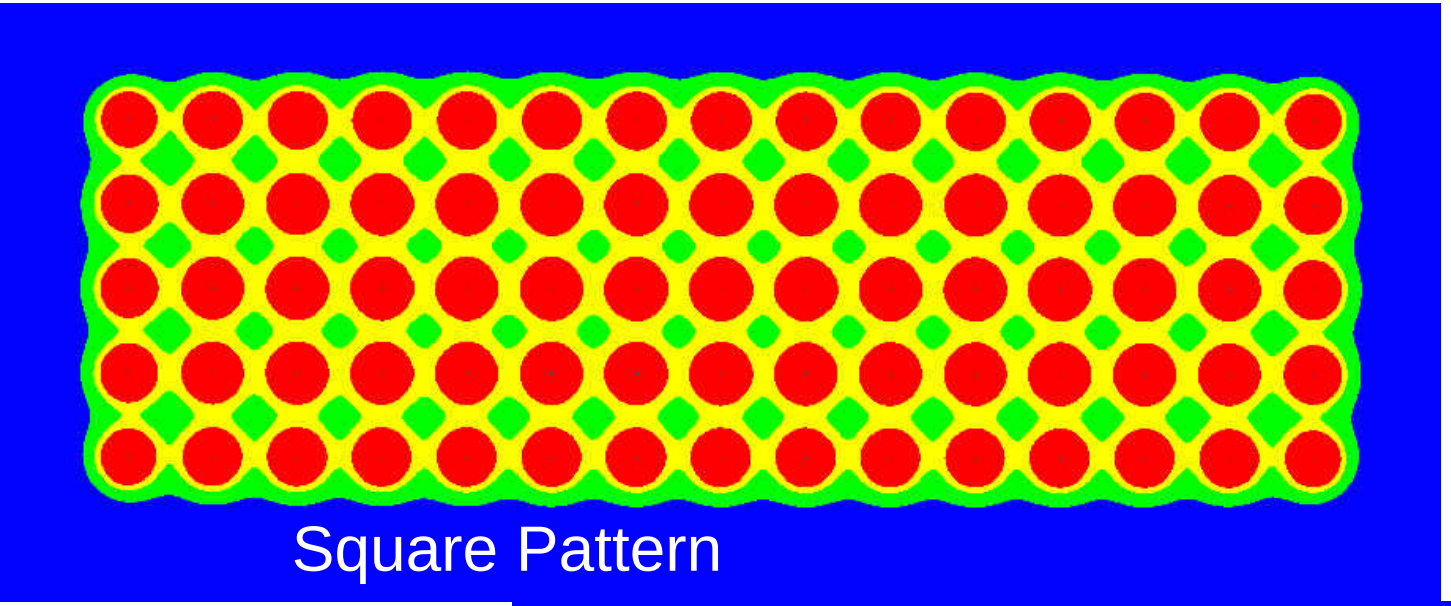
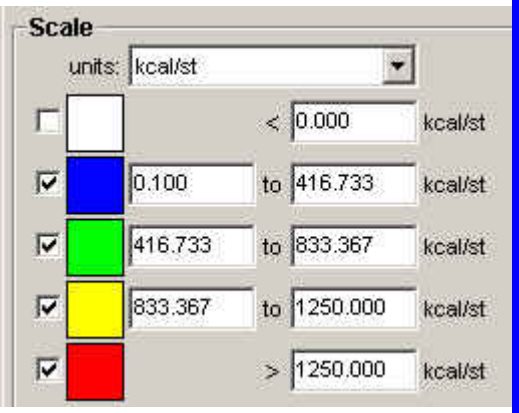
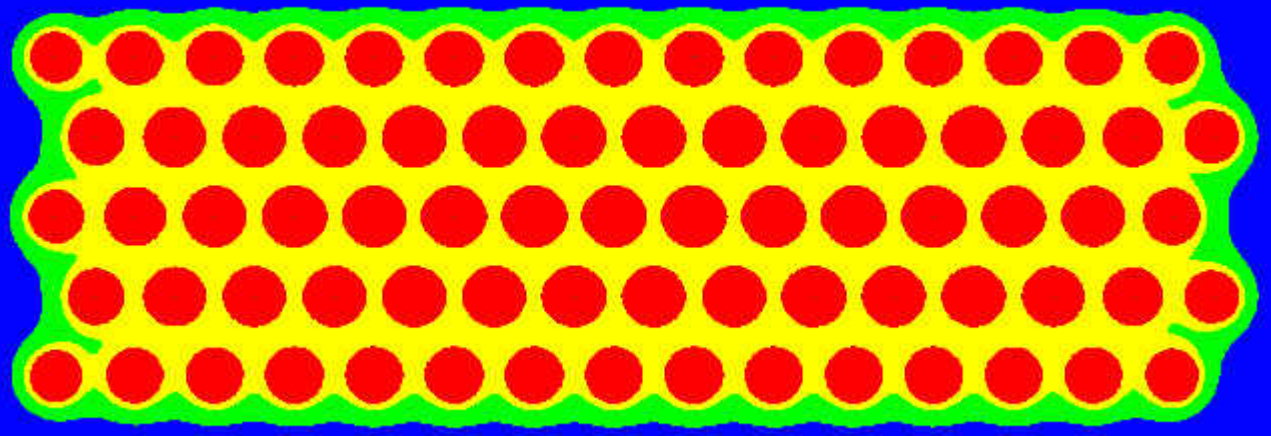
Explosive Energy Distribution



Square Pattern





Staggered Pattern

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Explosives Factors

- Velocity of Detonation
  - Indication of energy available
  - Indicator of energy partitioning (shock vs. gas)
  - Determines how explosive energy is applied to rock mass
- Density
  - Influences total explosive energy available in a hole
- Coupling
  - Influences transfer of explosive energy to rock mass

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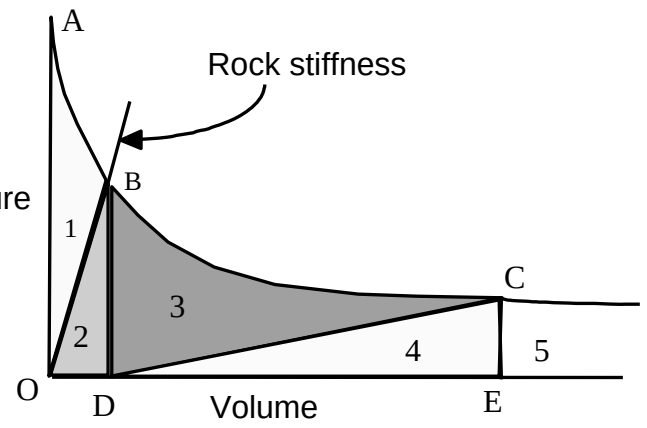
Explosive Selection

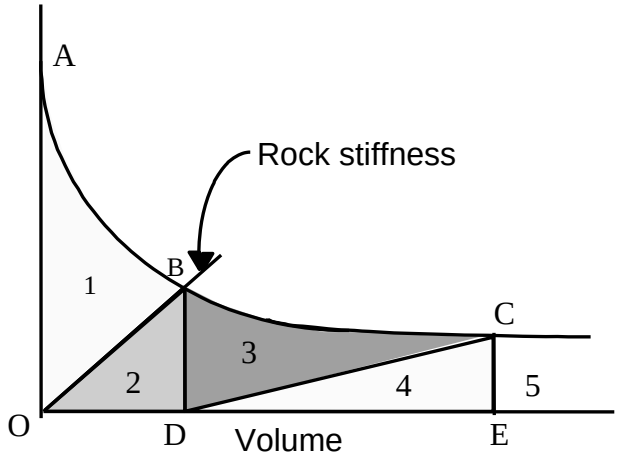
Hard and Brittle Rock

Soft and Plastic Rock

High VOD

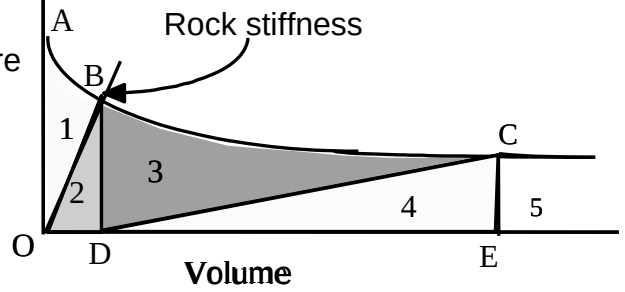


a)



b)

Low VOD



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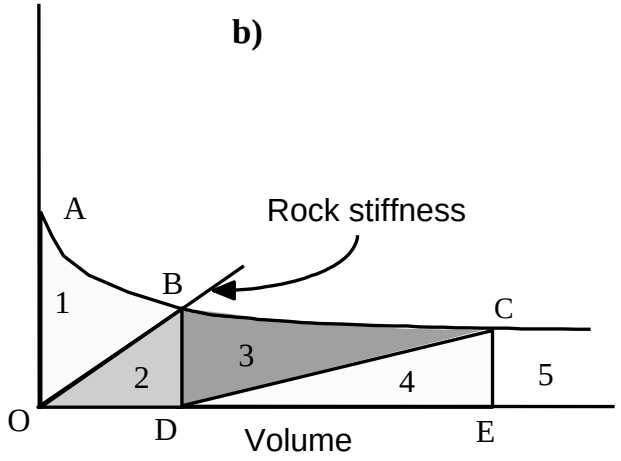

d)

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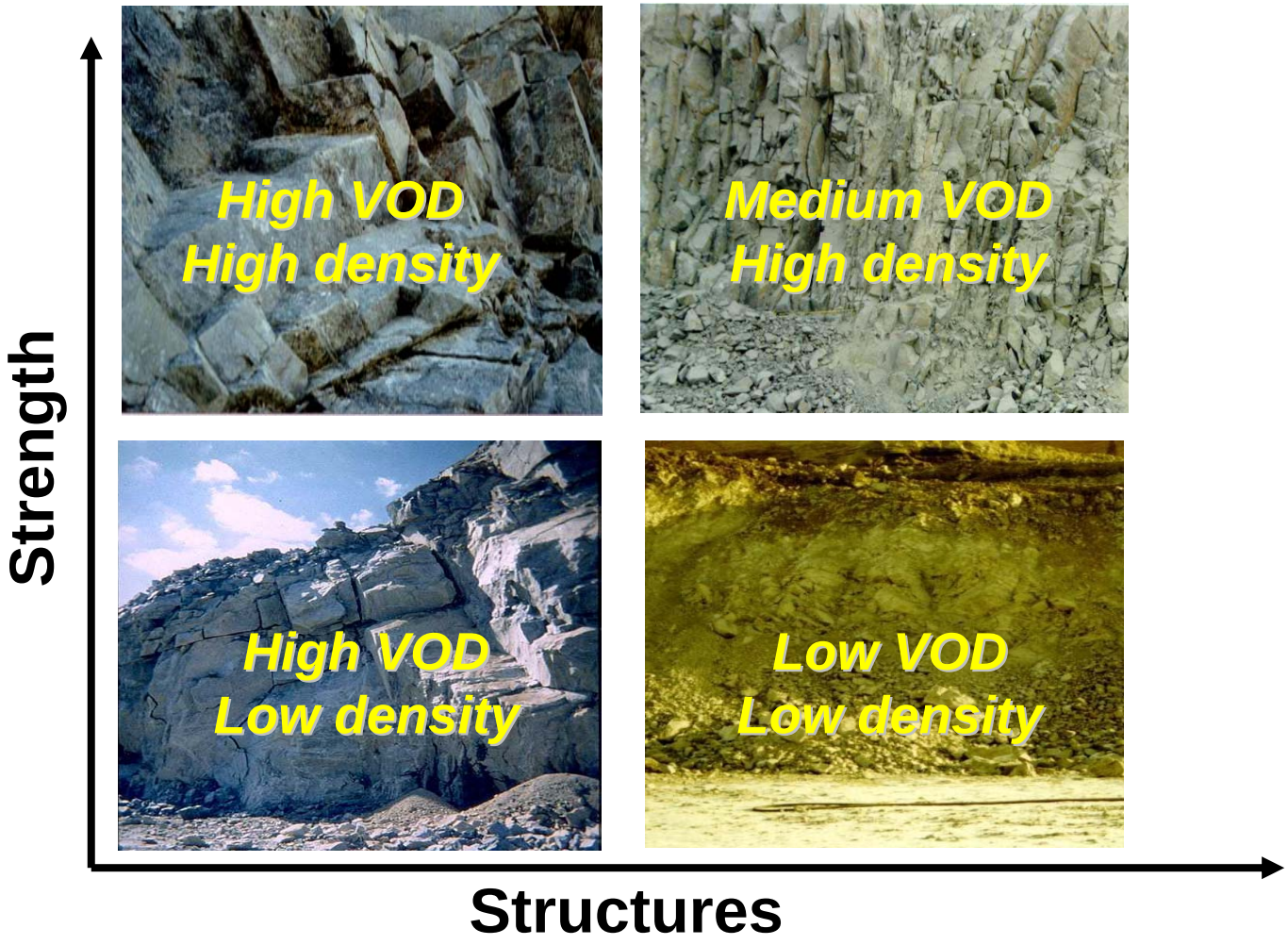
Explosive Selection to Meet Rock Structure and Strength Properties



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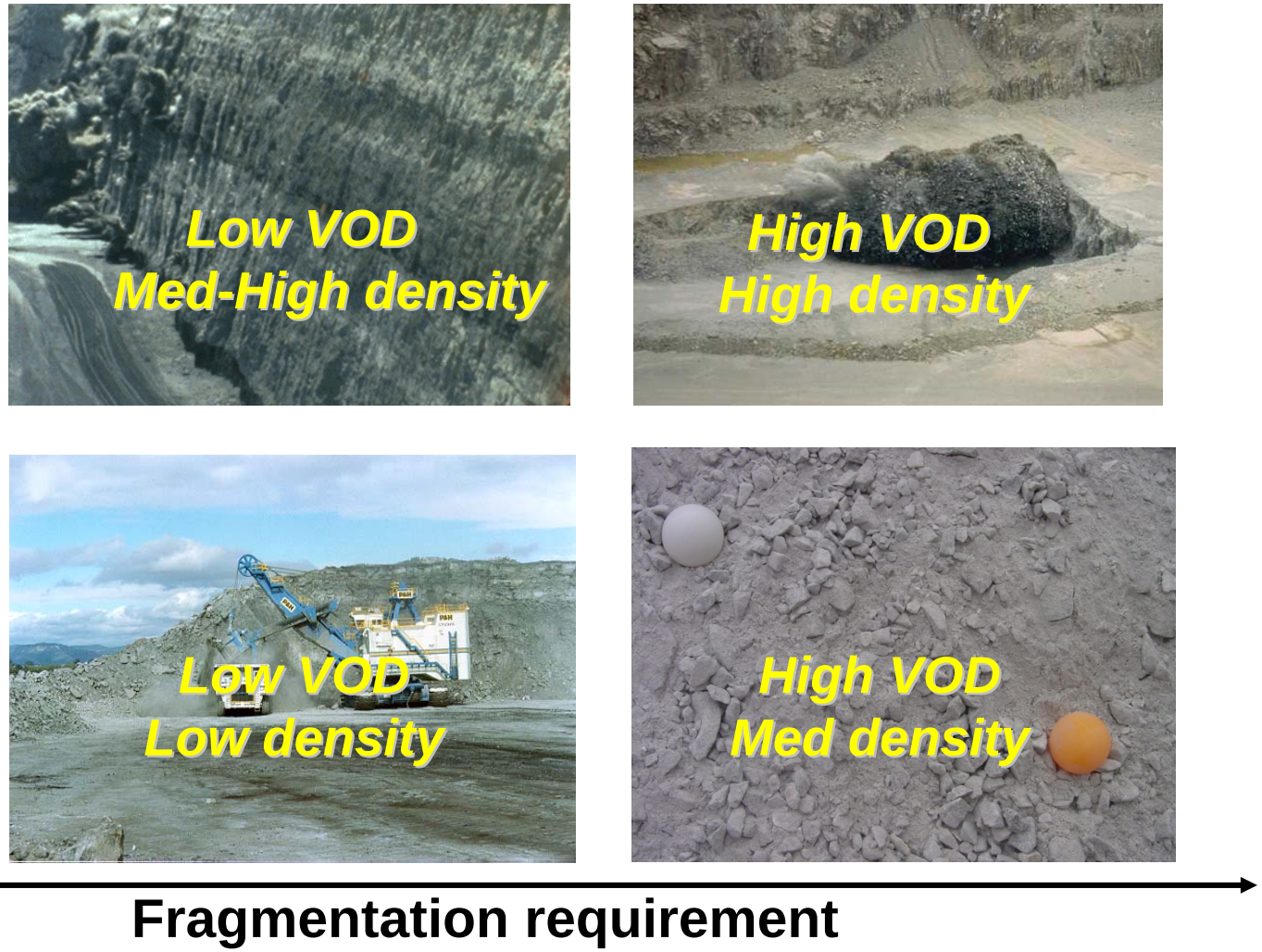
Explosive Selection to Meet Blast Objectives



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In Summary, Fragmentation Results...

- **Have significant impact on quarry economics**

- **Therefore Fragmentation Optimization …..**

- **Should consider all the downstream processes rather than just drill and blast costs**
- **Should consider quality as well as quantity**
- **Should be site specific**
- **Should be flexible to cope with site specific changes and market conditions**

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‘Take Home’ Questions on Fragmentation

- **Does the shovel/loader bucket fill with a single smooth pass?**
- **Does the shovel/loader remain stable during digging (no rocking or violent movements)?**
- **Does the muckpile flow during digging?**
- **Do the haul trucks dump at the crusher without delay?**
- **Is the throughput and power draw of the crusher consistent?**
- **Is secondary breakage required on a regular basis?**
- **Are the desired product sizes produced without waste (fines or other unsaleable/low profit products)?**

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