Geological Effects on Blast Performance

Scott G. Giltner

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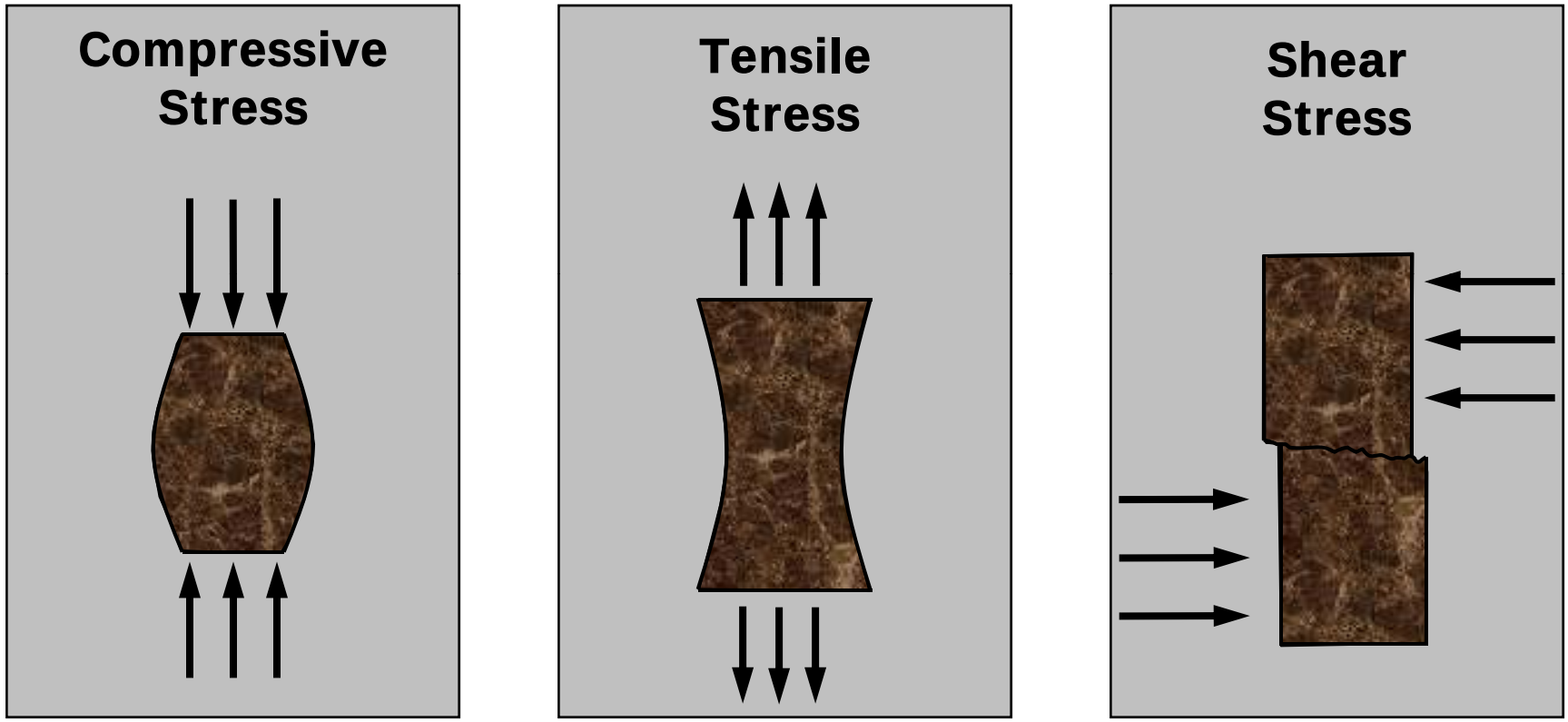
Geologic Factors to Consider

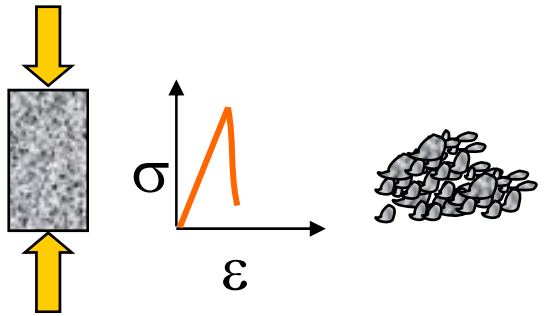
- **Rock Properties**
- **Rock Structure**
- **Strata Variations**

Rock Strength

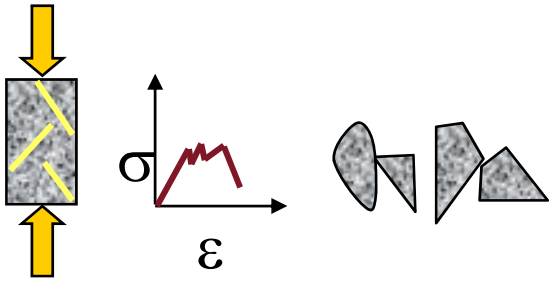


Note: confined or triaxial testing will give significantly higher results for these tests

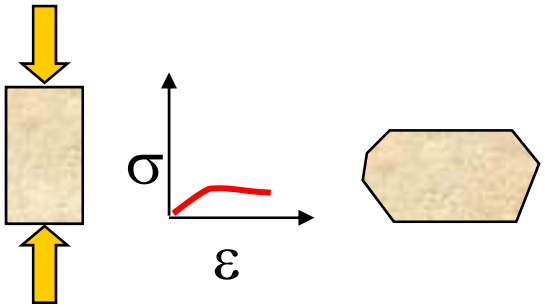
Model of Failure



Brittle



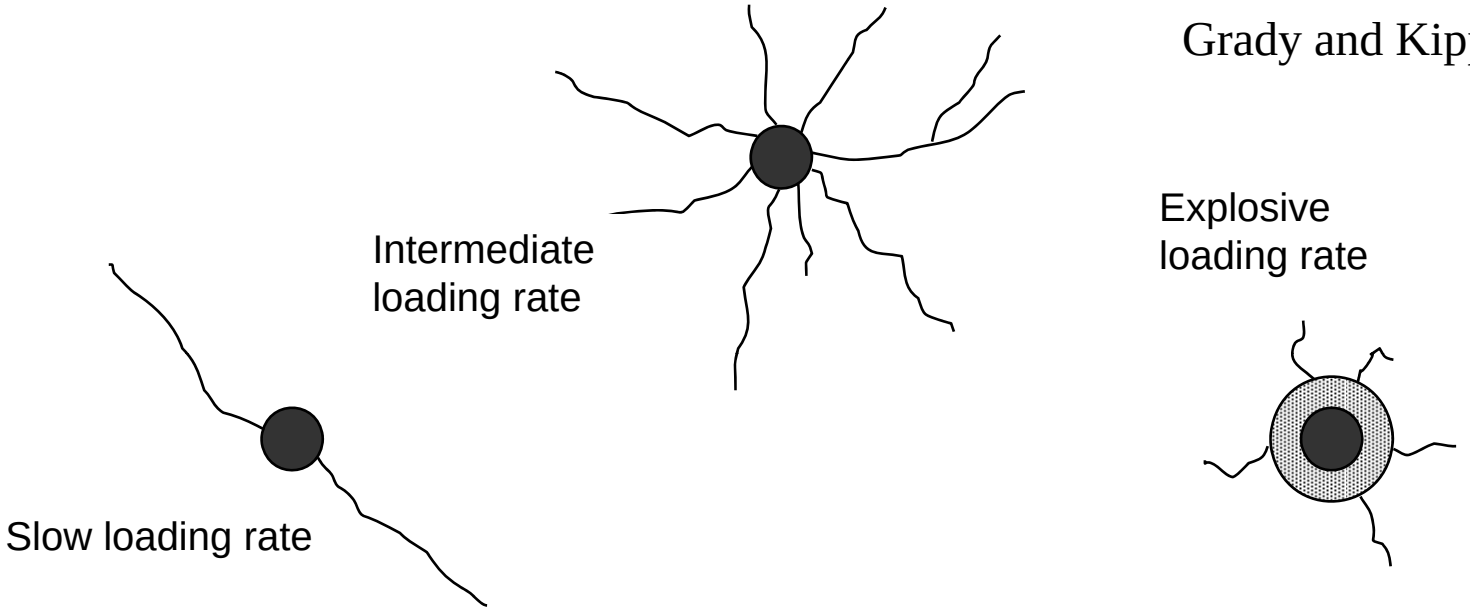
Fractured



Plastic

- Stiffness indicates
  - The mode of failure
  - Type of fragmentation
- Stiffness is represented by the Young's modulus
- Stiffness can be measured by the stress – strain curve in a stiff testing machine

Dynamic Properties



- Dynamic properties are generally higher than static measurements
- Dynamic measurements are expensive to conduct
- Static measurements should be used to represent relative strength rather than absolute

Rock Properties cont…

- **Poisson's Ratio** - relationship between lateral and longitudinal deformation under load (lower values indicate success for pre-splitting)
- **Young's Modulus** – also known as modulus of elasticity, ability to resist deformation (higher values indicate rock will be harder to break)
- **P Wave velocity** - the speed of sound in the rock, high P Wave velocities generally indicate the need for high VOD explosives

Rock Properties cont…

Rock Type	Density (g/cc)	Compressive Strength (psi)	Tensile Strength (psi)	Young's Modulus (psi)	Poisson's Ratio	P Wave Velocity (ft/s)
Basalt	2.9	21,610	1,595	8,992,340	0.27	17,155
Dolomite	2.5	7,977	435	4,061,057	0.32	13,202
Gneiss	2.8	32,488	2,030	11,748,600	0.22	18,805
Granite	2.7	26,977	1,305	6,236,623	0.33	15,892
Limestone	2.7	23,061	725	7,977,076	0.25	16,404
Marble	3.1	36,404	2,175	16,374,000	0.28	21,998
Sandstone	2.5	19,435	145	1,015,264	-	12,903
Sandstone	1.8	1,595	0	870,226	0.31	6,873
Schist	2.9	24,076	1,305	11,167,910	0.2	17,985
Slate	2.6	12,328	870	9,572,491	0.17	16,955
Taconite	2.9	36,404	2,465	13,488,510	0.25	20,144

Rock Properties cont…

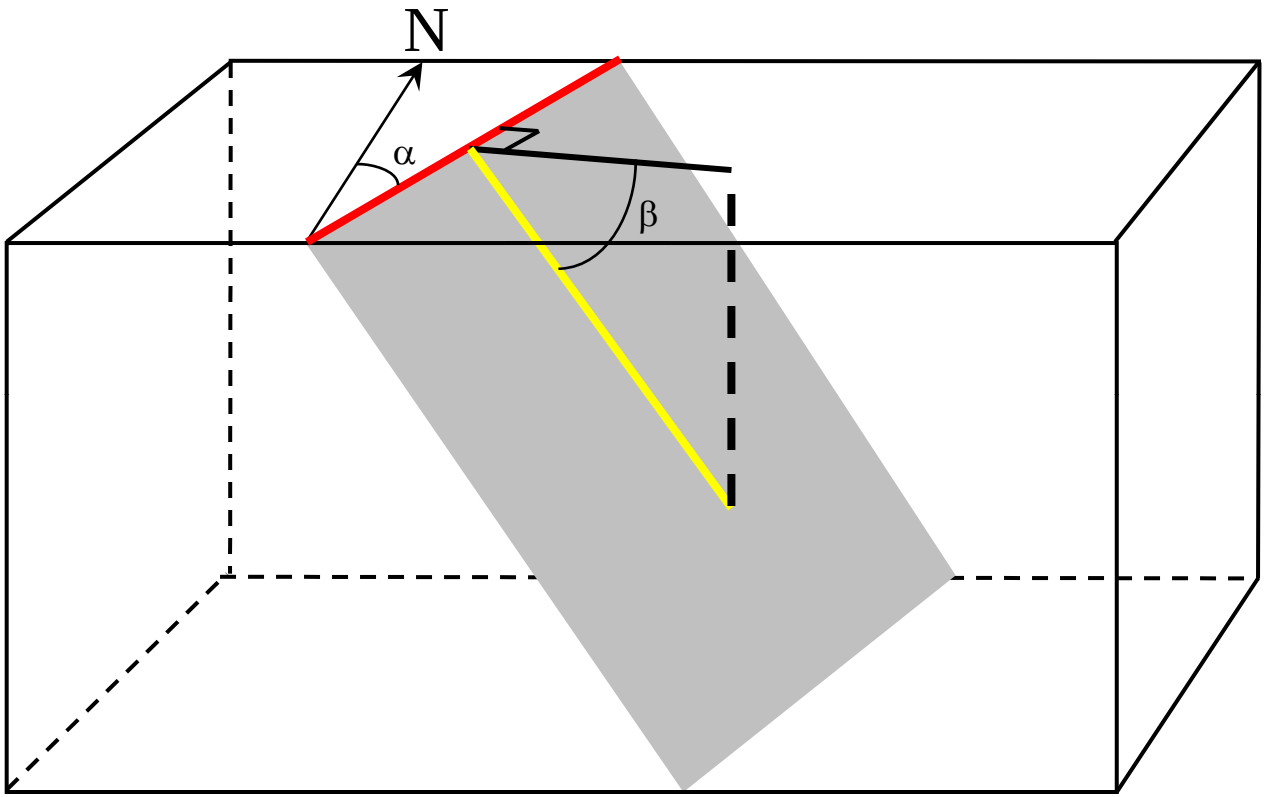
Rock Type	Density (g/cc)	Compressive Strength (MPa)	Tensile Strength (MPa)	Young's Modulus (GPa)	Poisson's Ratio	P Wave Velocity (m/s)
Basalt	2.9	149	11	62	0.27	5229
Dolomite	2.5	55	3	28	0.32	4024
Gneiss	2.8	224	14	81	0.22	5732
Granite	2.7	186	9	43	0.33	4844
Limestone	2.7	159	5	55	0.25	5000
Marble	3.1	251	15	106	0.28	6705
Sandstone	2.5	134	1	7	-	3933
Sandstone	1.8	11	0	6	0.31	2095
Schist	2.9	166	9	77	0.2	5482
Slate	2.6	85	6	66	0.17	5168
Taconite	2.9	251	17	93	0.25	6140

Rock Structure

Structure describes the features which primarily determine the fragmentation performance of the rockmass.

- Jointing
- Bedding
- Intrusions/Faulting

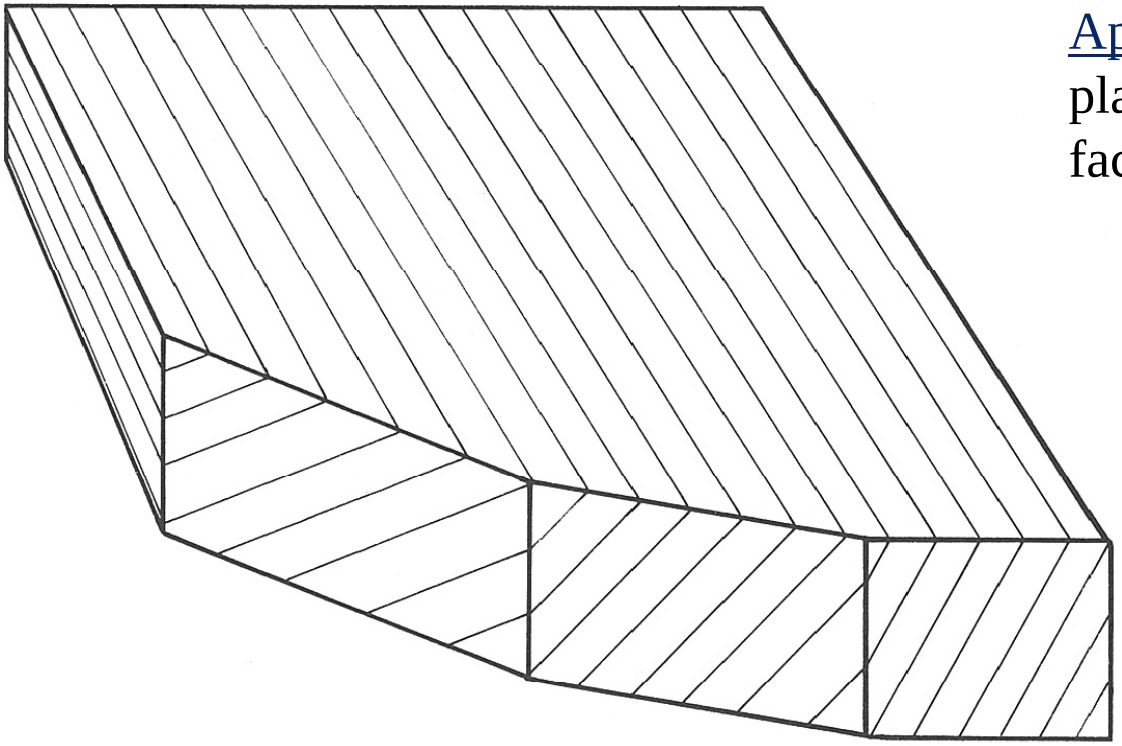
Rock Structure



Strike – direction of the intersection between a given plane and a horizontal plane

Dip – angle between a given plane and a horizontal plane

Rock Structure



Apparent Dip – trace of a plane on random vertical faces

Rock Structure

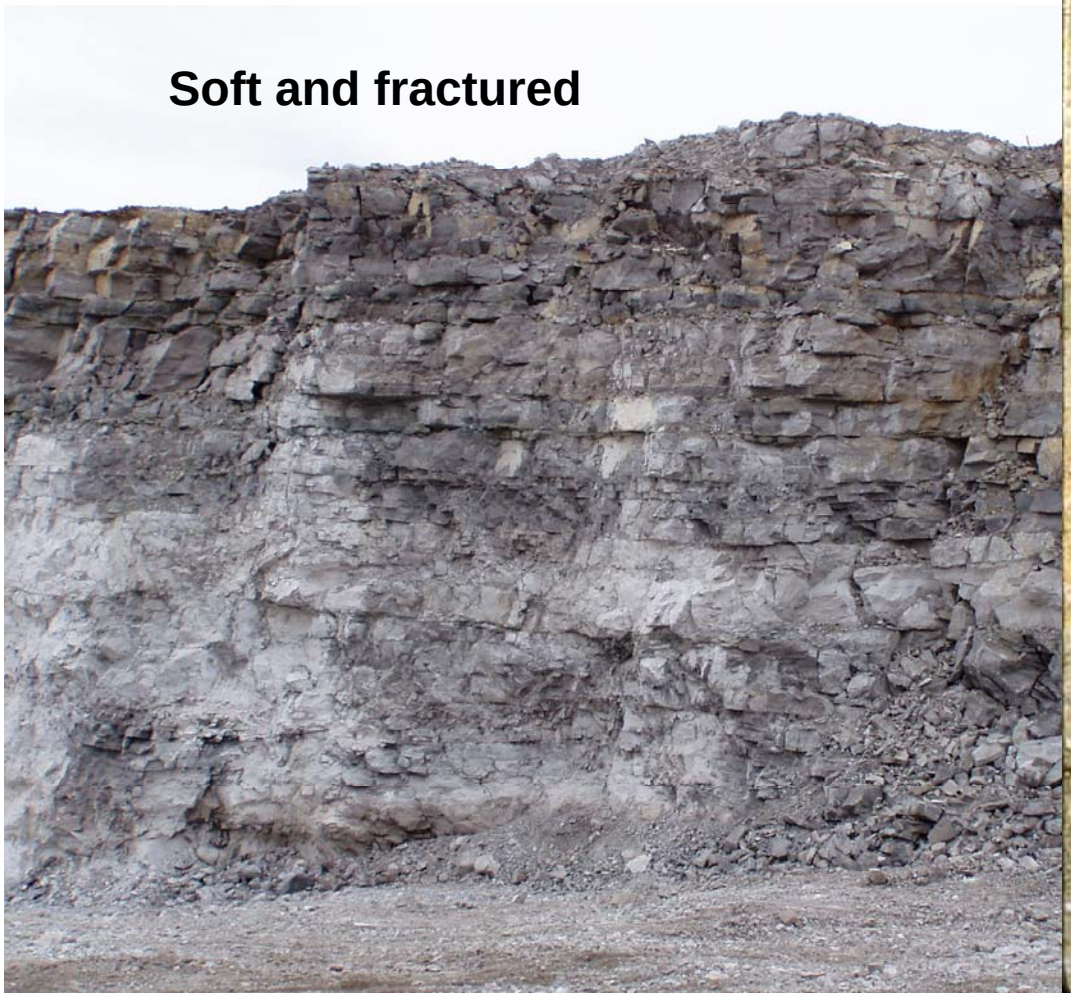
- Jointing

Rock Structure

- Jointing

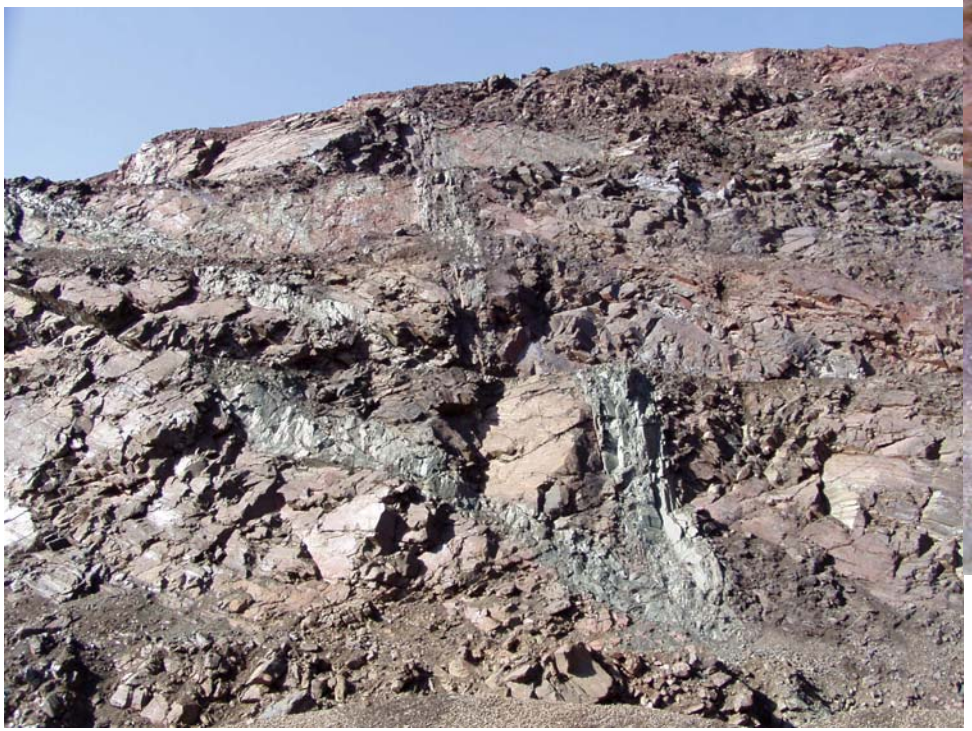
Rock Structure

- Bedding



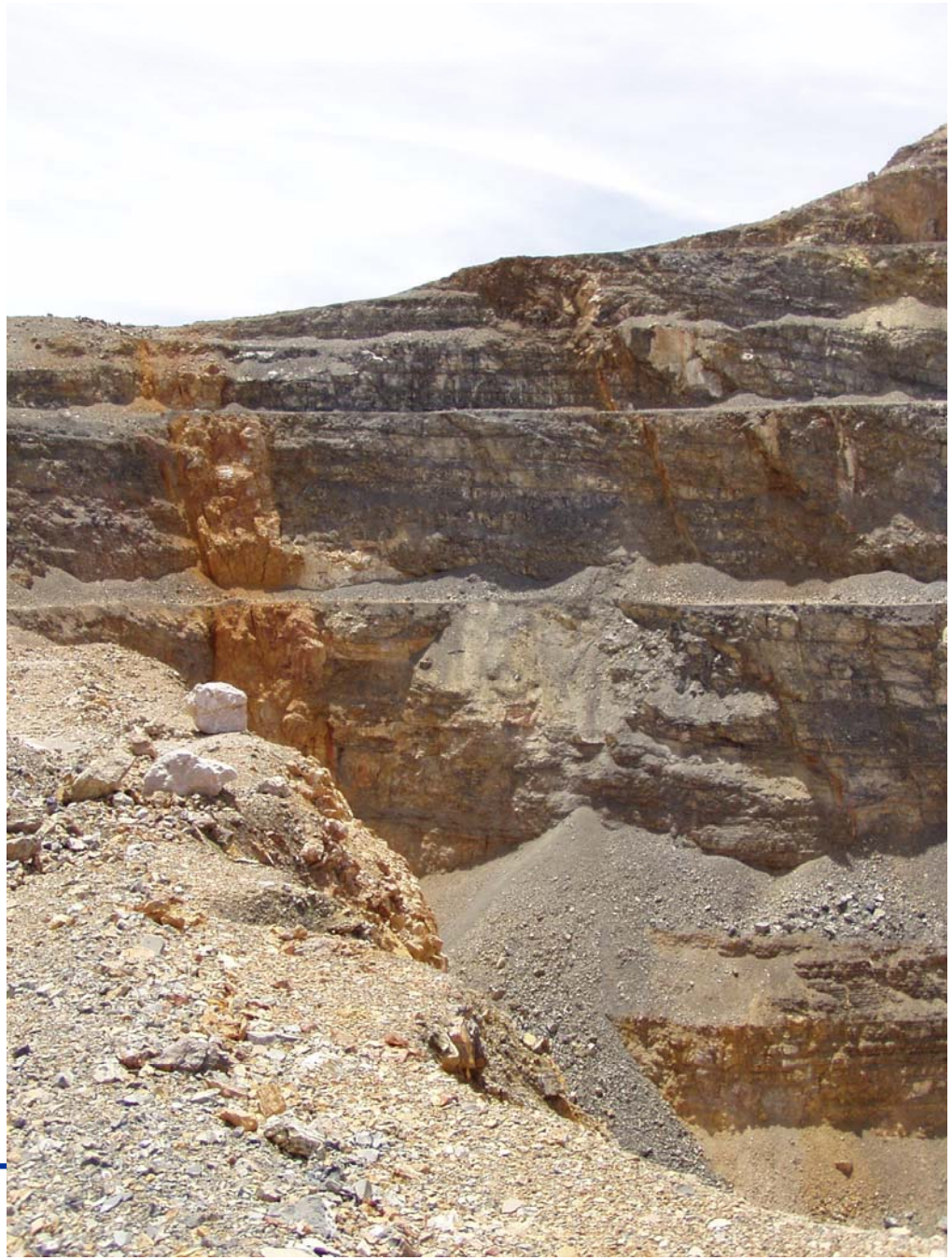
Rock Structure

- Intrusions



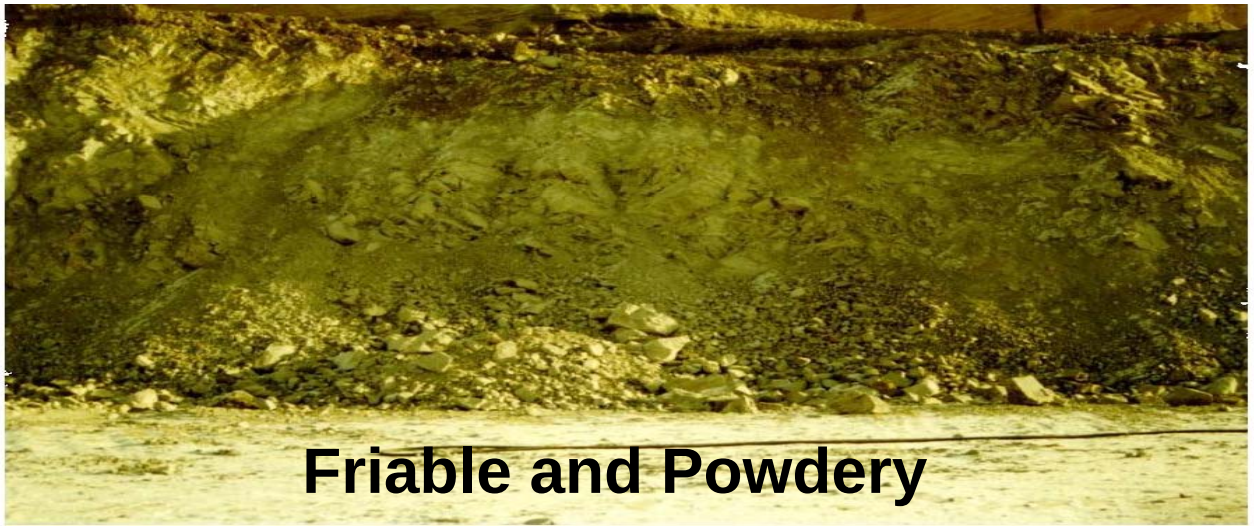
Rock Structure

- Faulting



Rock Structure

Block size < 0.2 m (0.7 ft)



Block size > 2 m (6.5 ft)

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Rock Structure

Block size
0.2 – 1 m
(0.6 – 3 ft)

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

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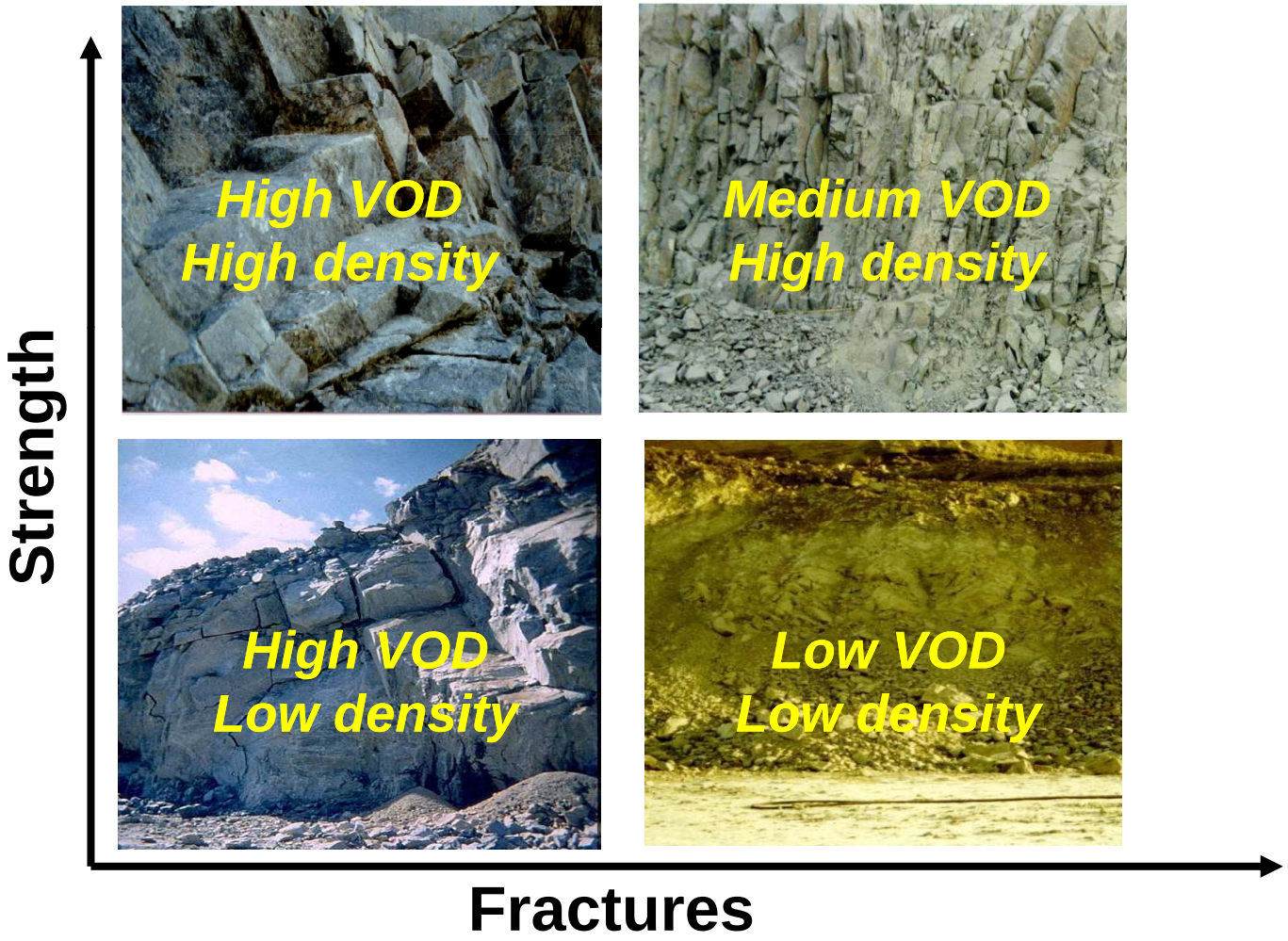
Explosive Selection to Meet Rock Structure and Strength Properties



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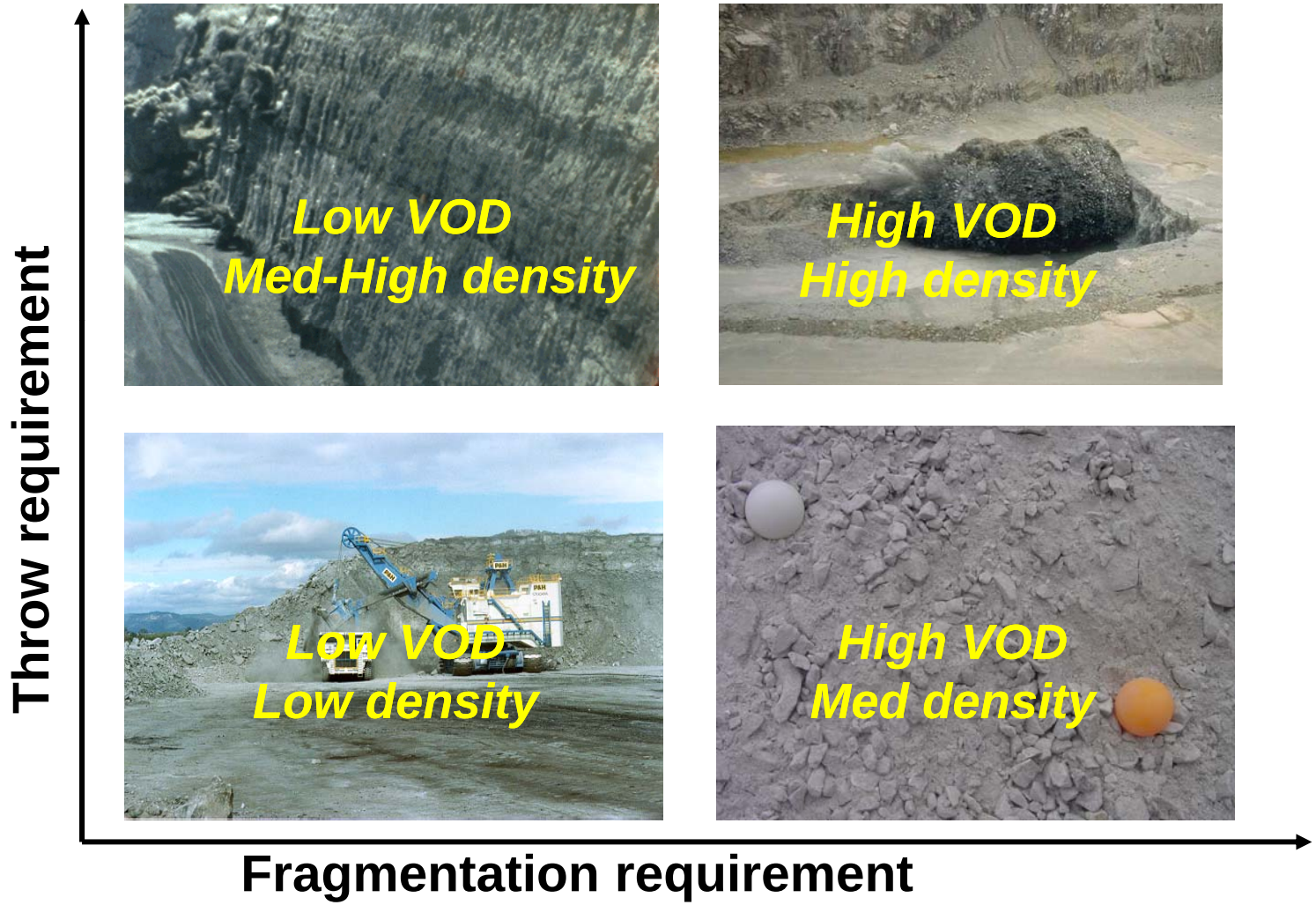
Explosive Selection to Meet Blast Objectives



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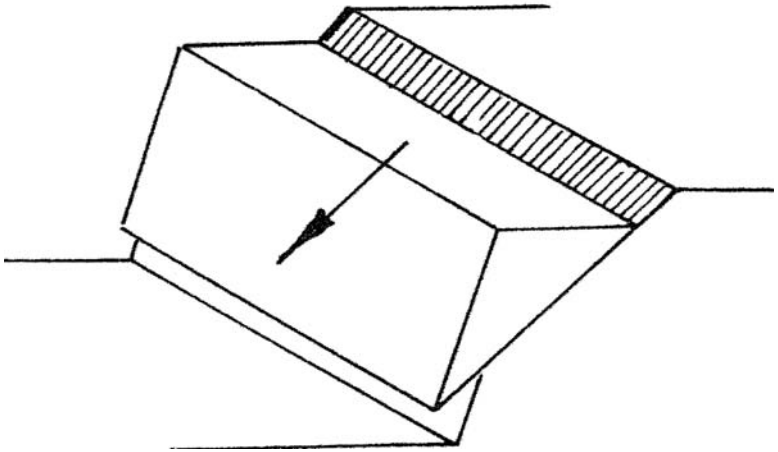
Rock Structure

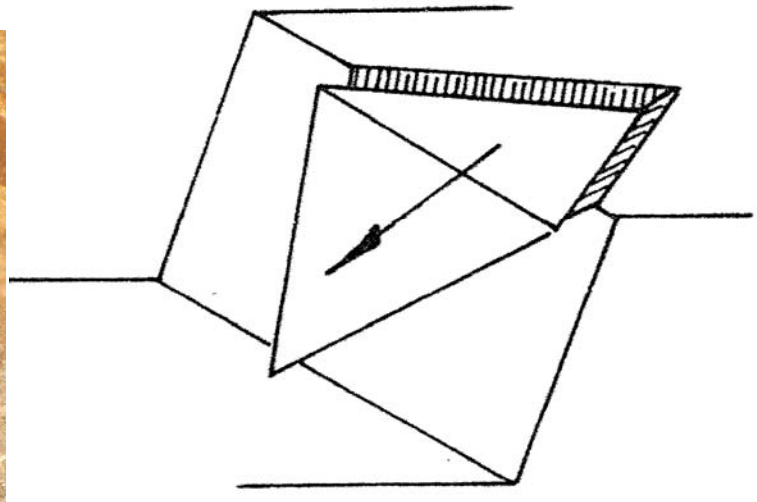
Plane Failure



Highly ordered structure with planes dipping into the pit.

Rock Structure

Wedge Failure



Two intersecting discontinuities.

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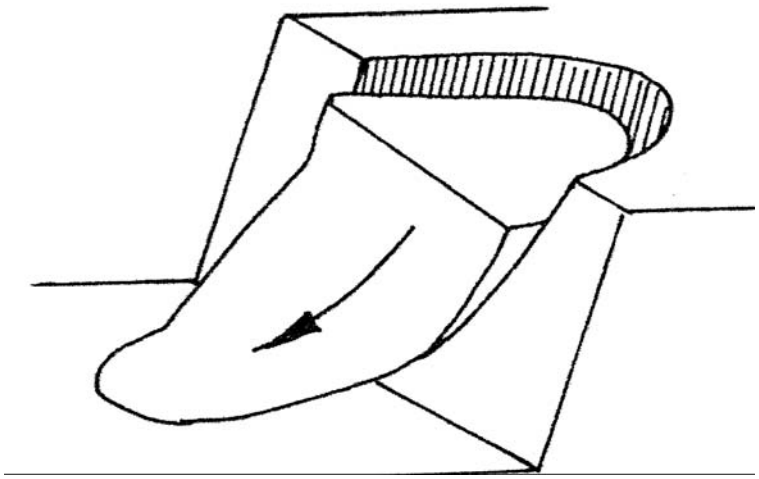
Rock Structure

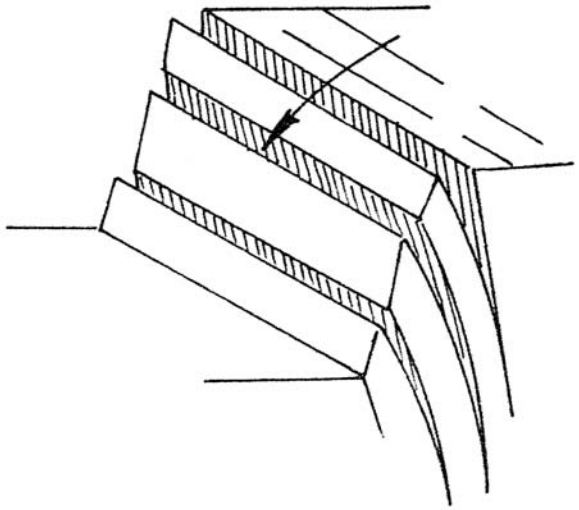
Slump Failure



Circular failure with no identifiable structure pattern.

Rock Structure

Toppling Failure



Forms in hard rock with steeply dipping discontinuities.

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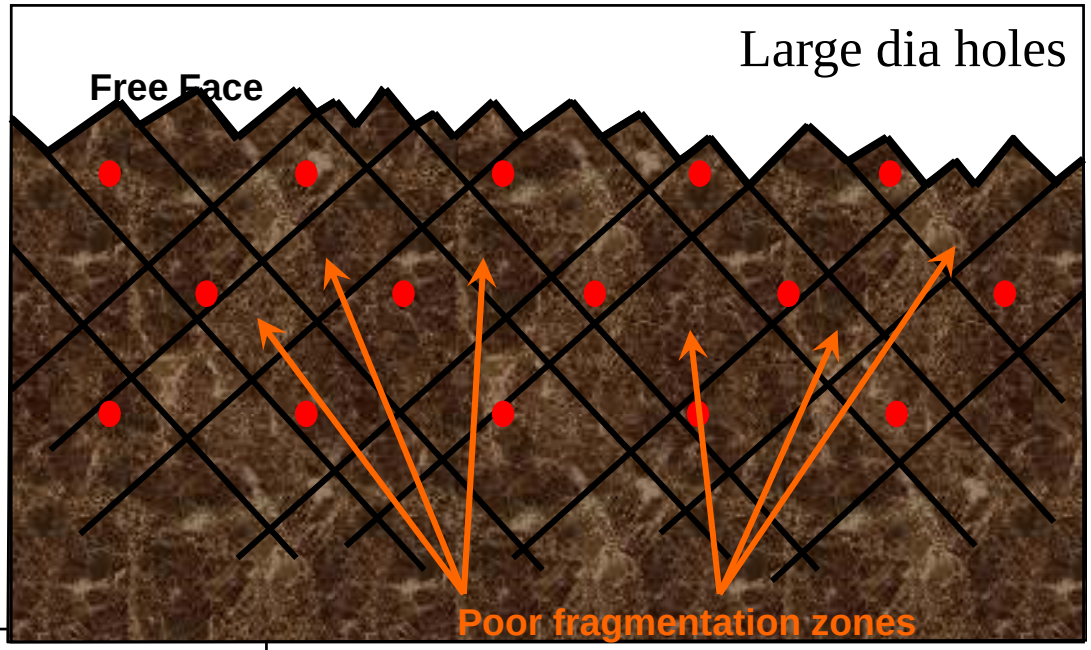
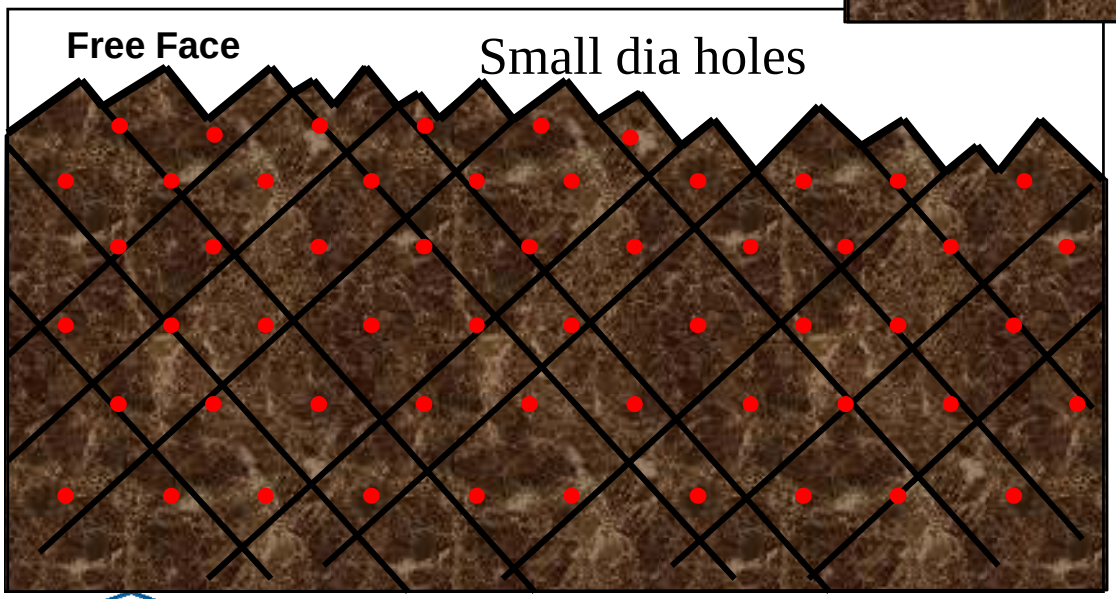
Joint Spacing





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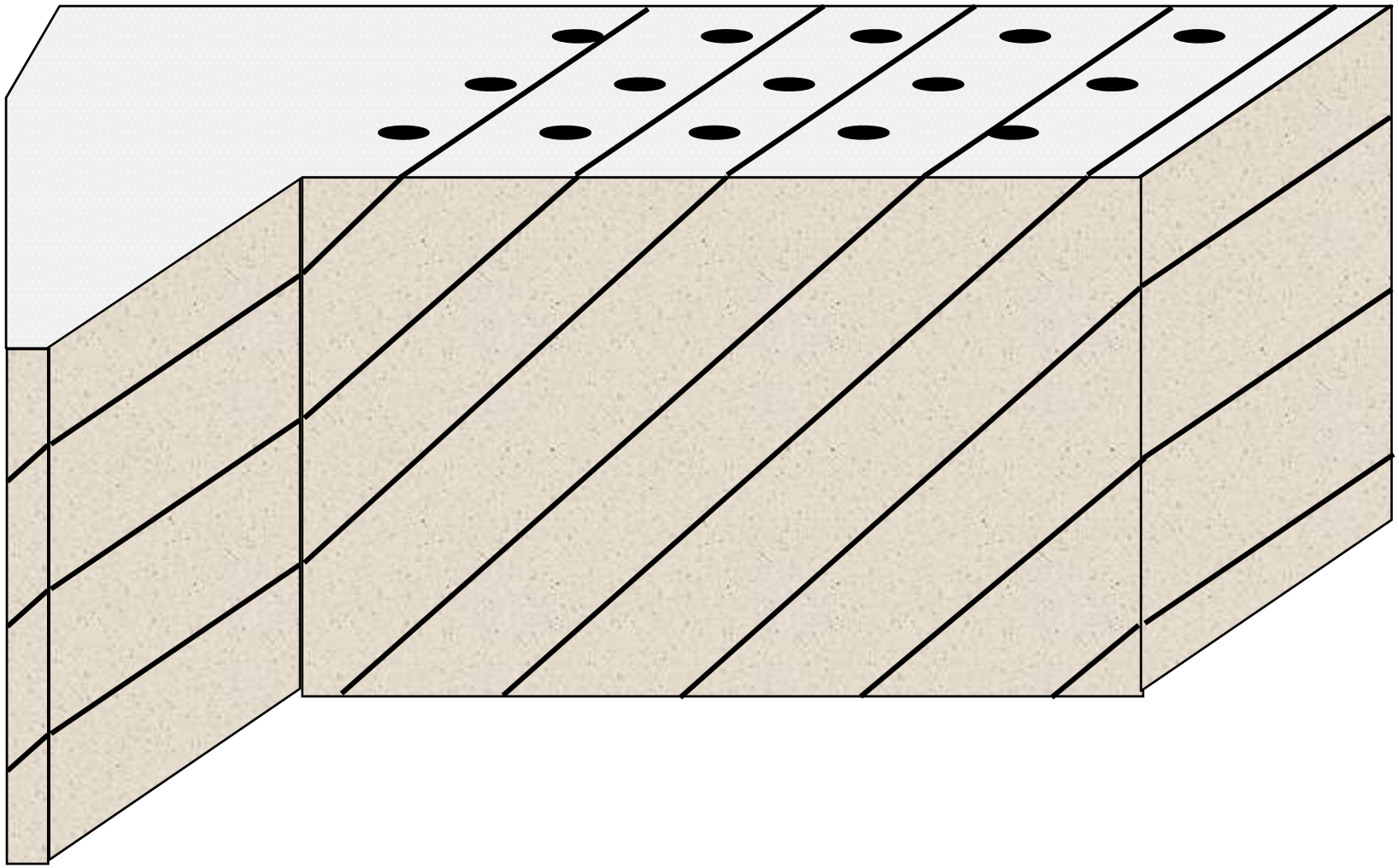
Consider structures when deciding where to open shot



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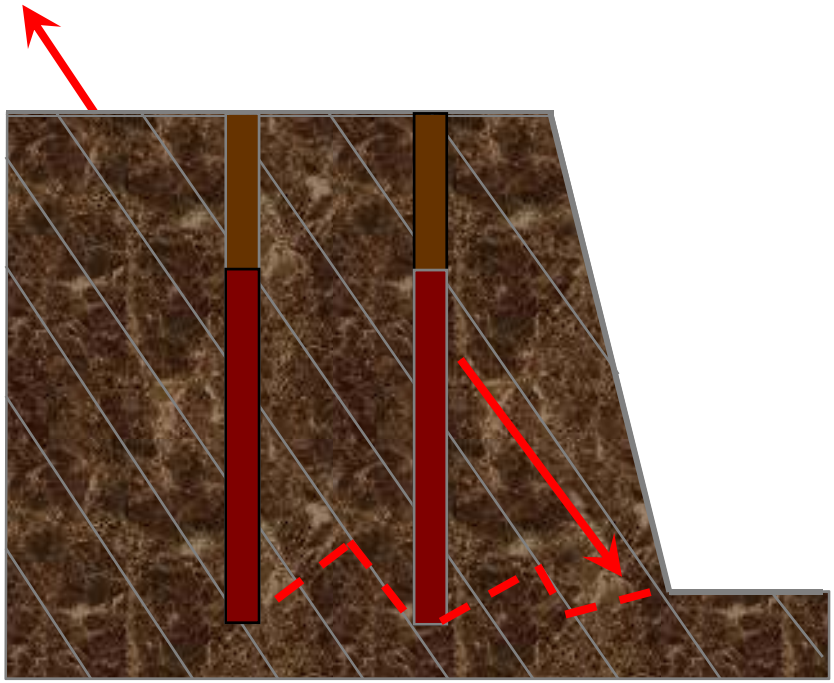
Structure Orientation cont…

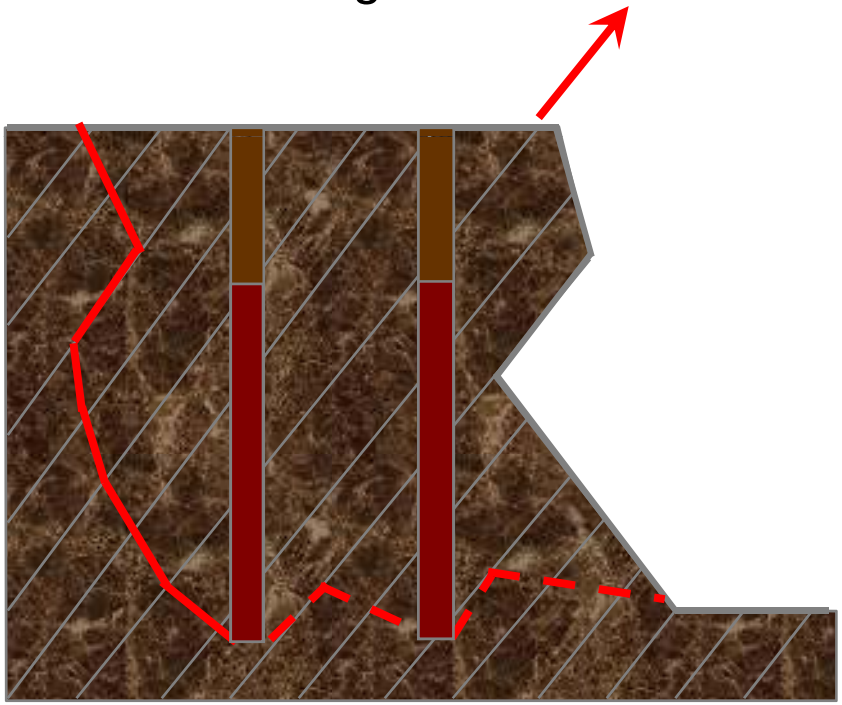
Bedding planes towards the face:

- Unstable walls
- Excessive backbreak
- Difficulty digging to grade line



Bedding dipping away from the face:

- Unbroken toe
- Excessive flyrock
- Overhangs in face



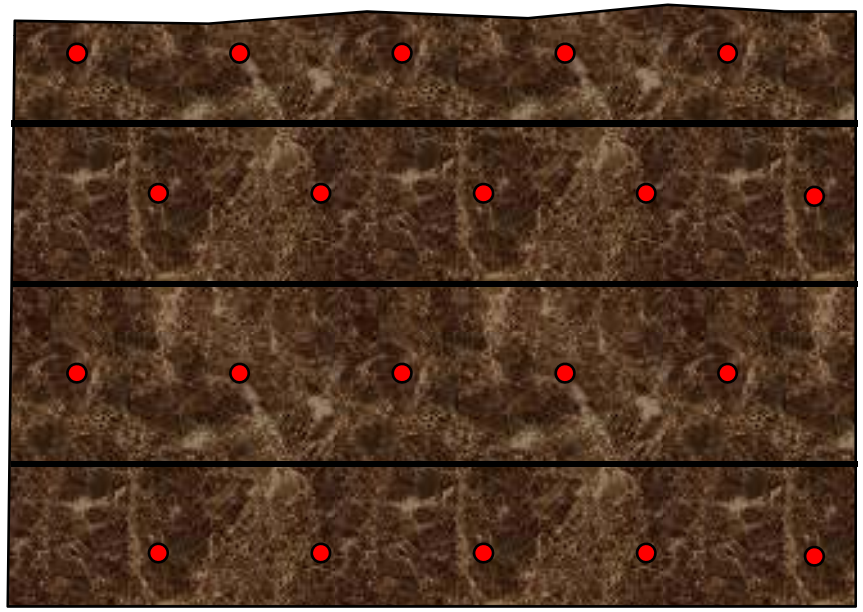
Structure Orientation cont…

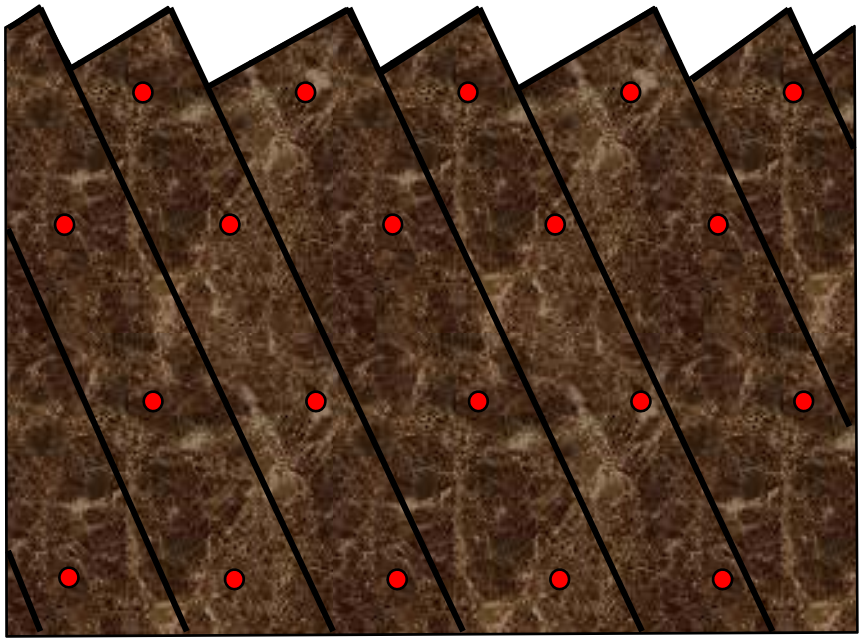
Structure Parallel to Free Face:

- Good wall control
- Can be best orientation for wall control

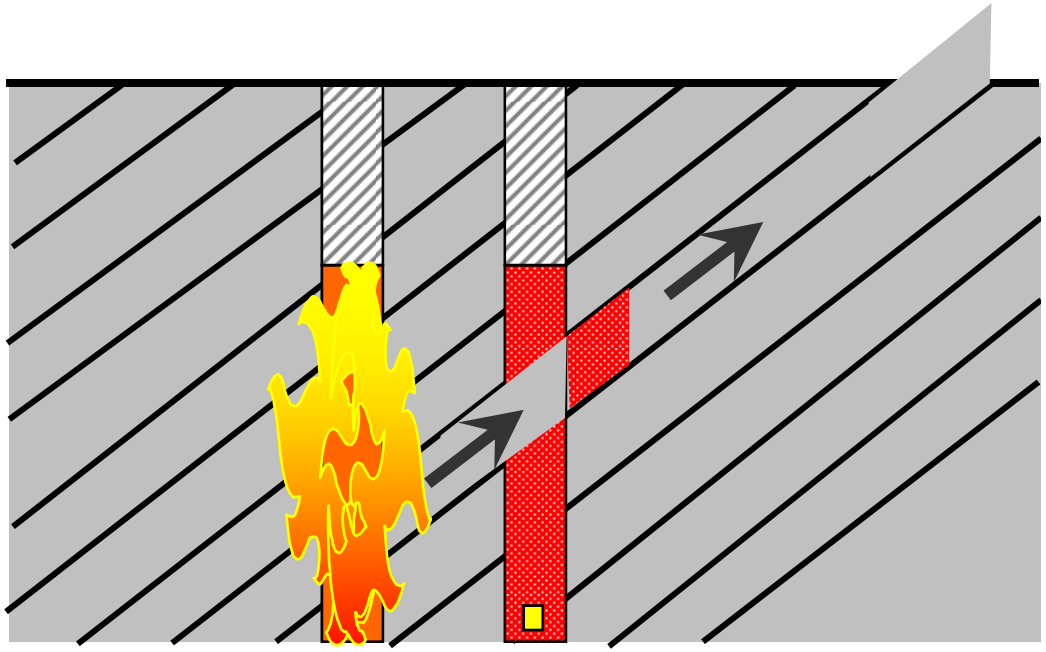
Structure Angled to Free Face:

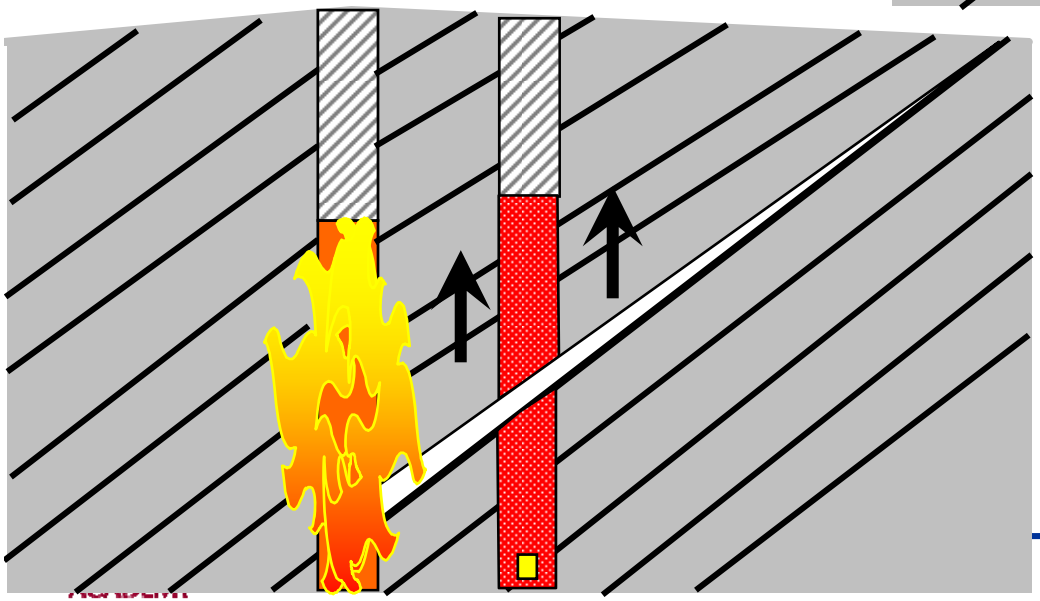
- Blocky faces
- Excessive end break





Explosive Charge Separation





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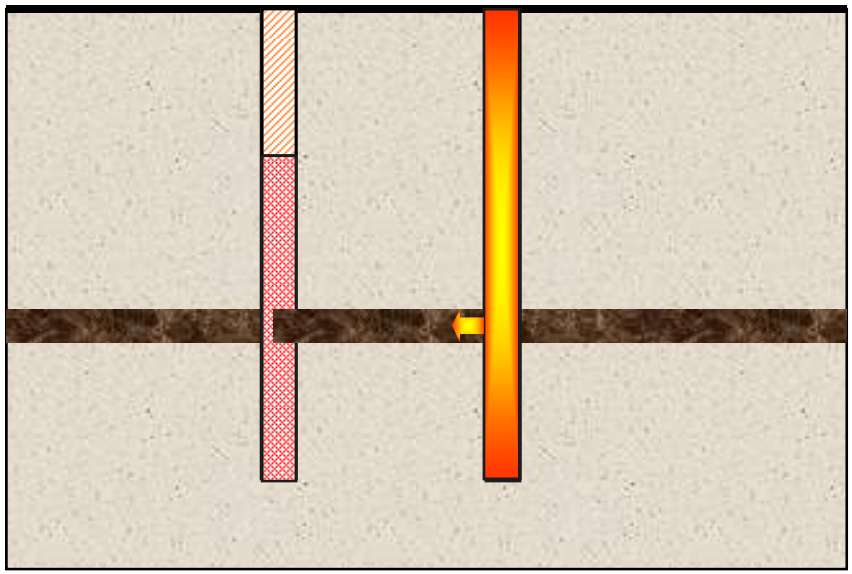
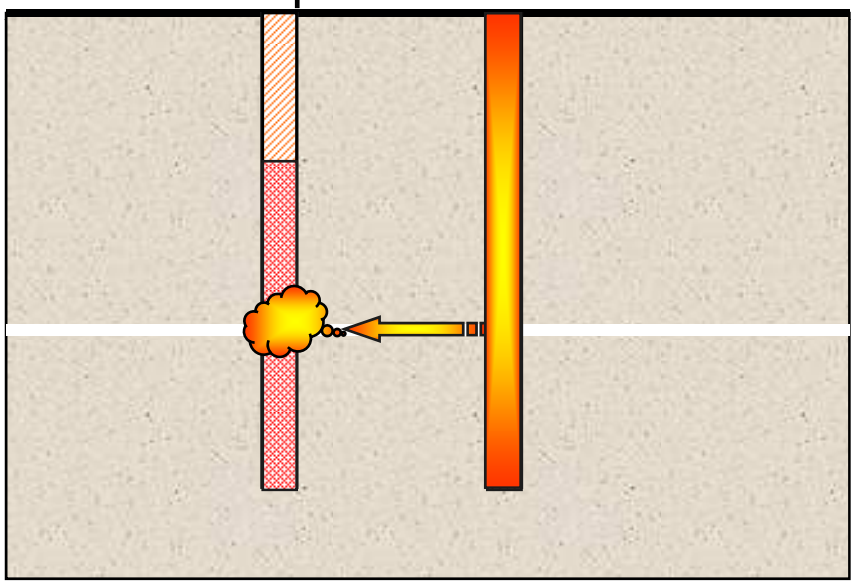
Weak Bands



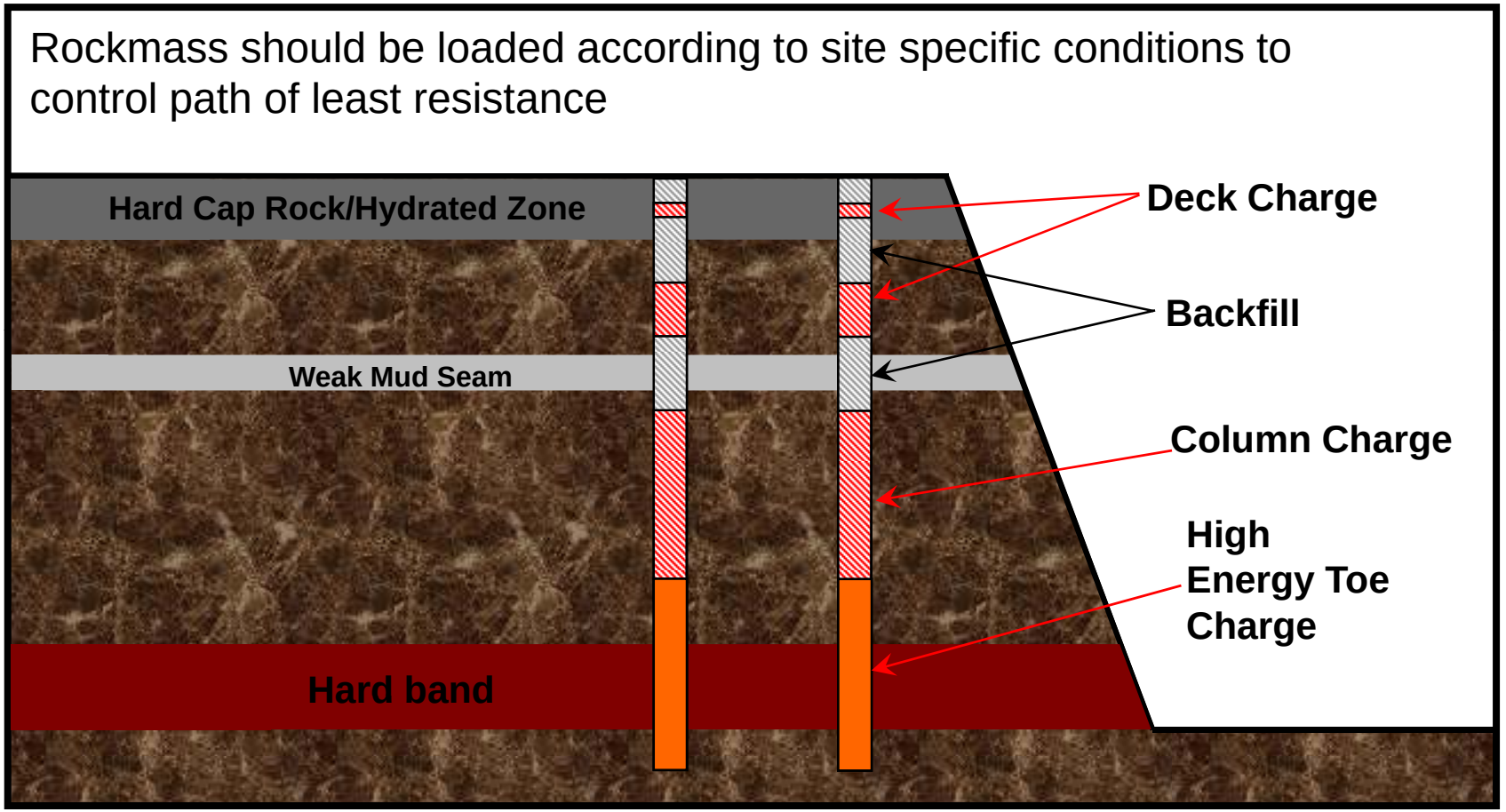
Differential rock movement

Gas penetration

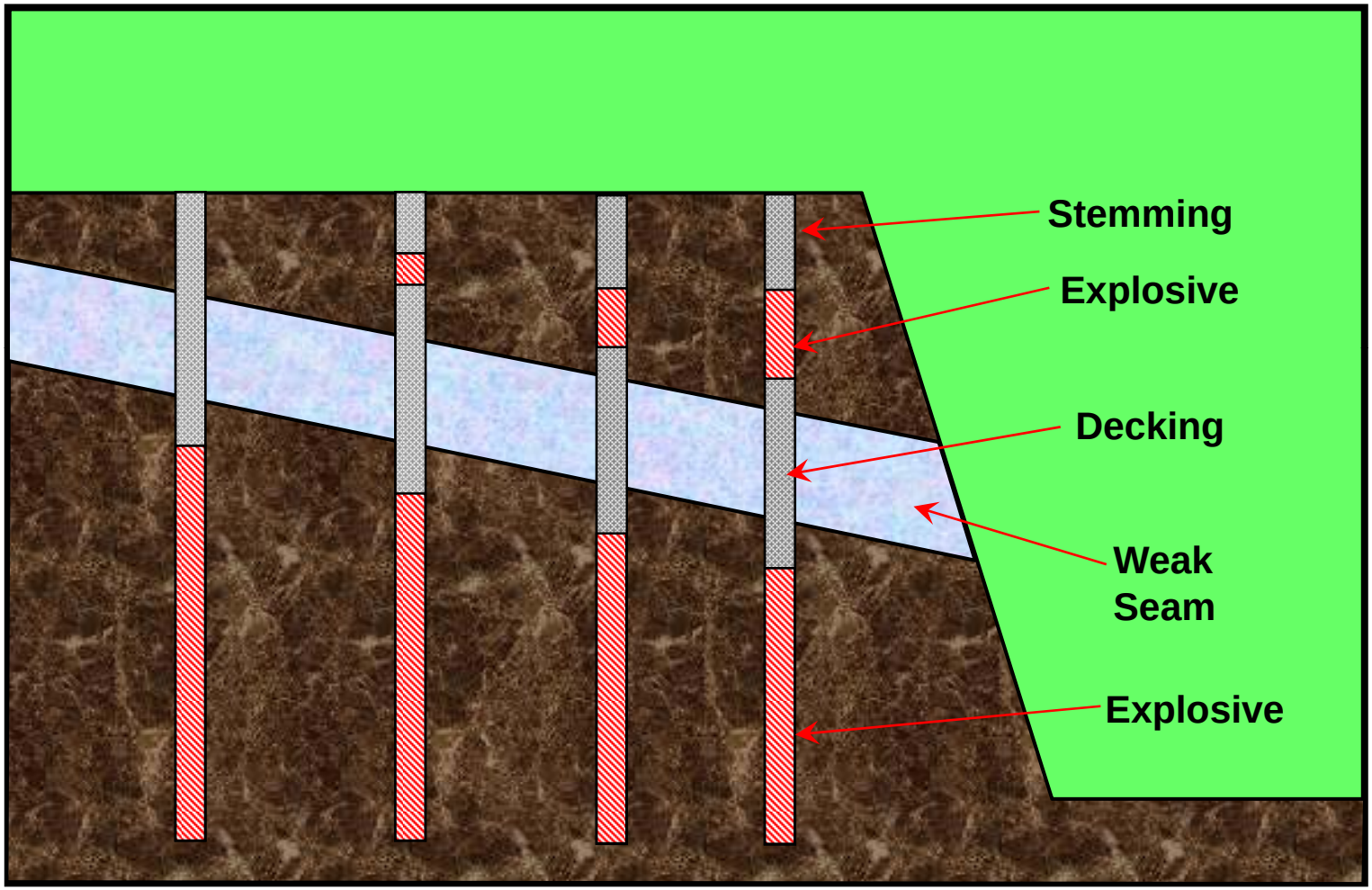


Weak and Hard Bands

Rockmass should be loaded according to site specific conditions to control path of least resistance



Weak Bands



Effect of Structures & Weak Rock Bands

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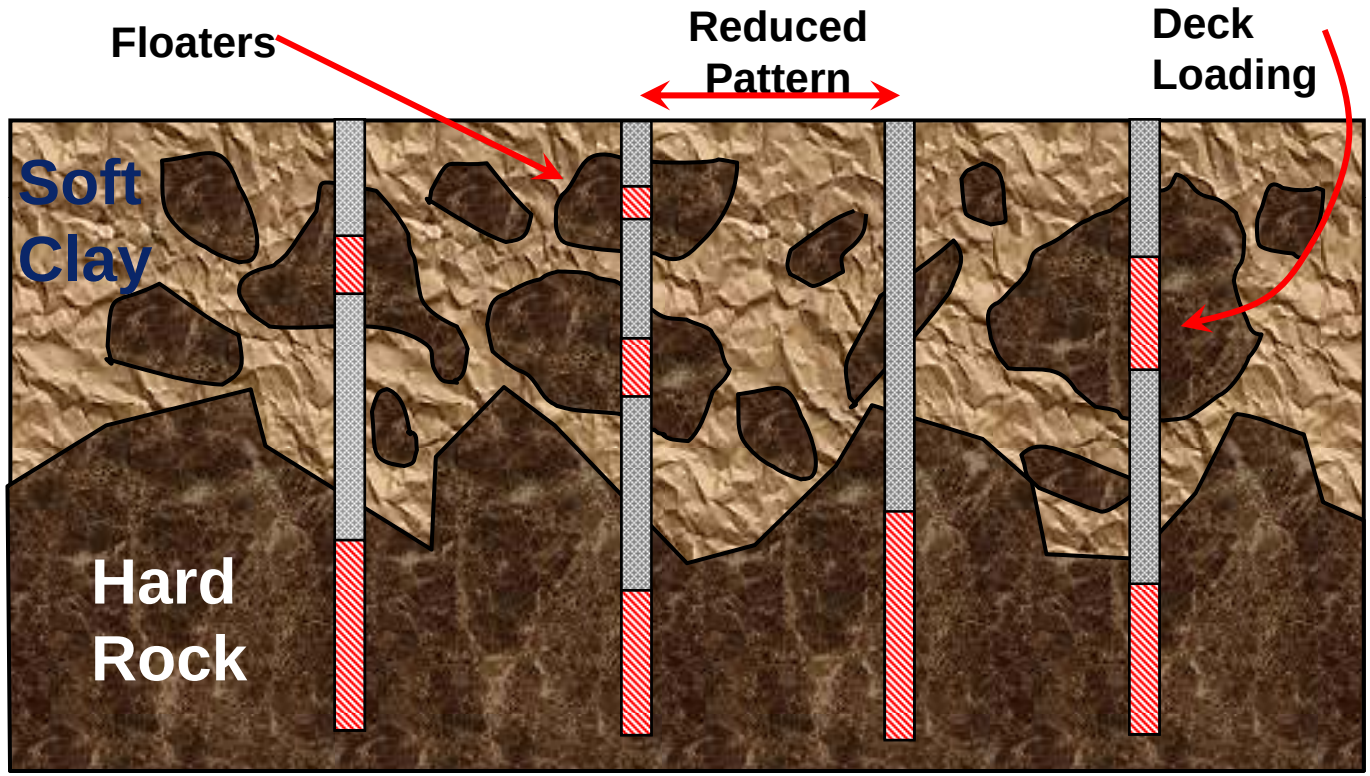
Effect of Hard/Soft Rock Bands

Floaters

- Requires that drillers record floater locations in holes
- Difficult to control blasting in floaters – 3D problem



Floaters

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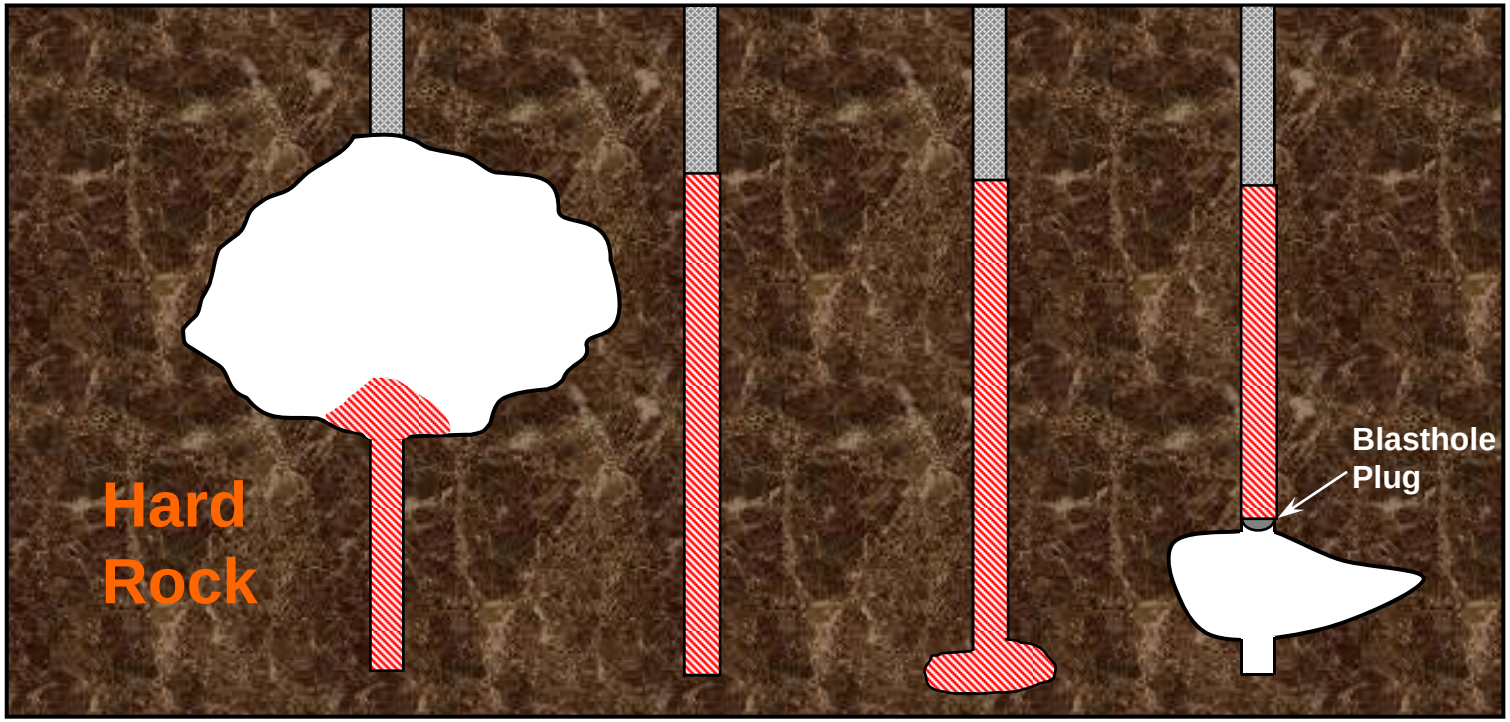
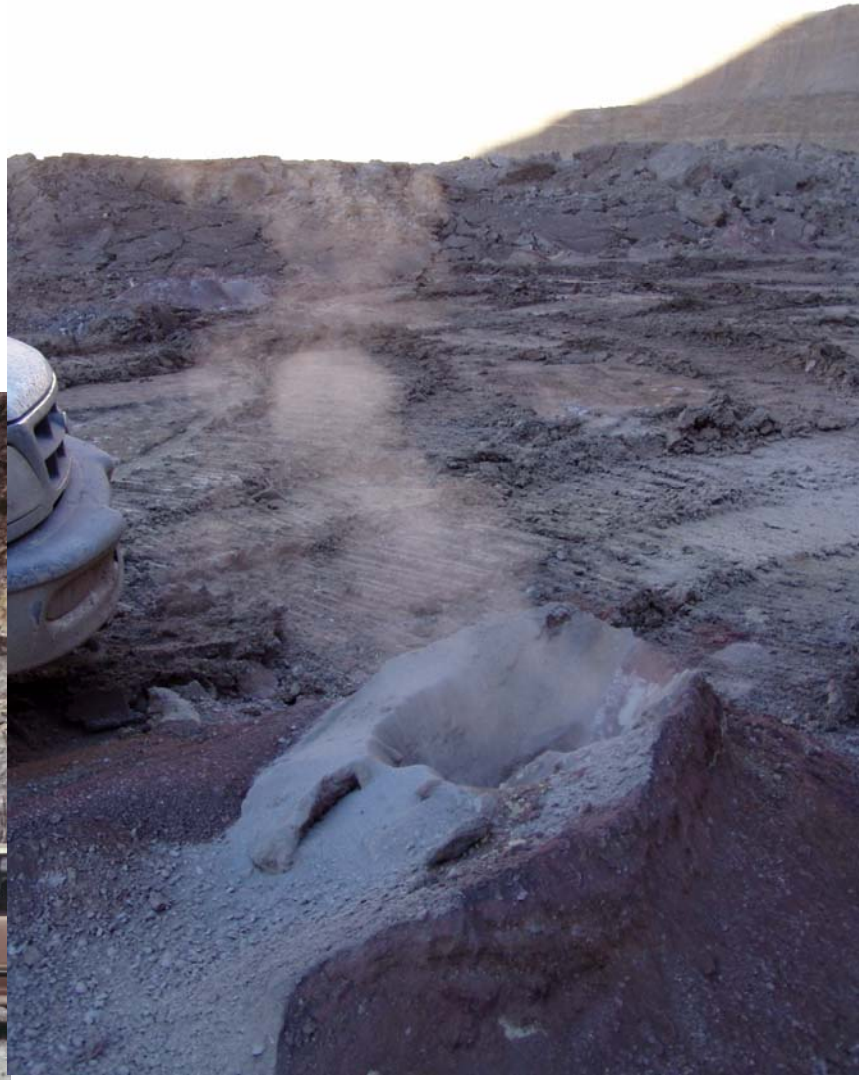
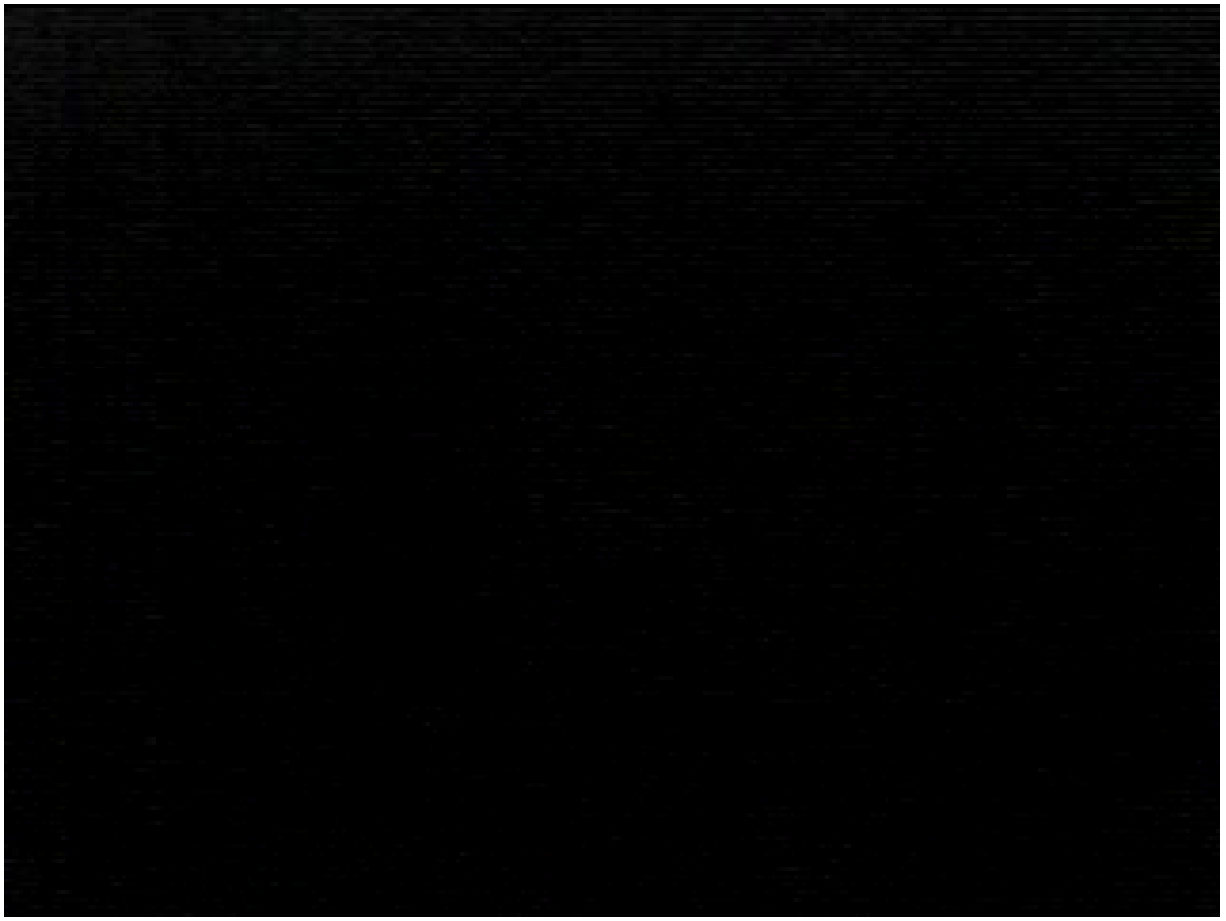
Cavities

- Poor fragmentation, toe etc
- Excessive flyrock and noise
- High powder factors

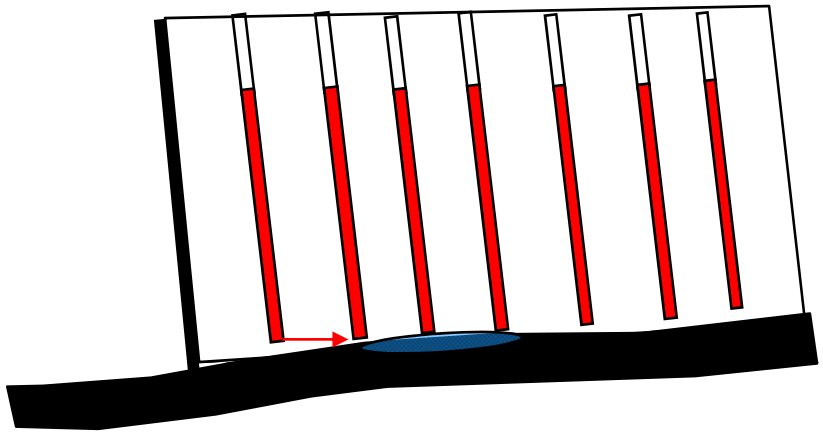




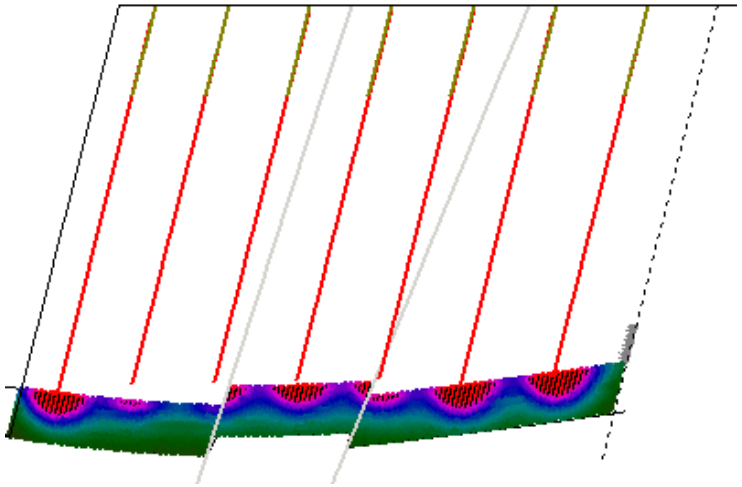
Cavities



Rolling Seams and Faults



- Geological models are based on exploration holes with wide grid spacing, hence they are not accurate
- In order to get a better accuracy, normally one in every fifth hole is drilled to coal
- Design and implementation of stand off



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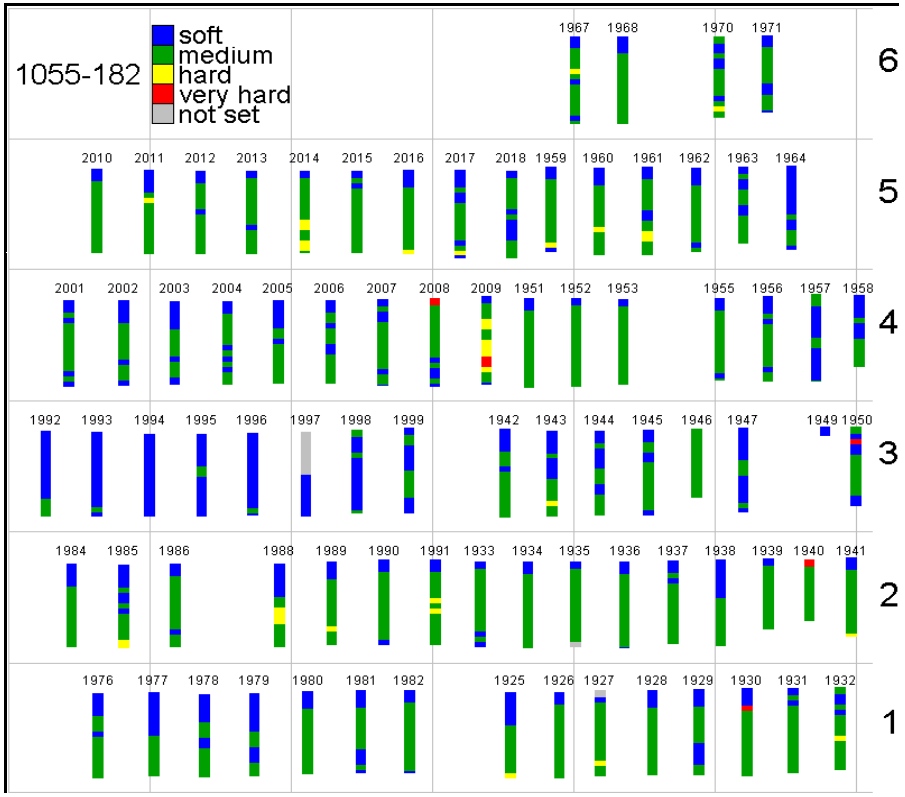
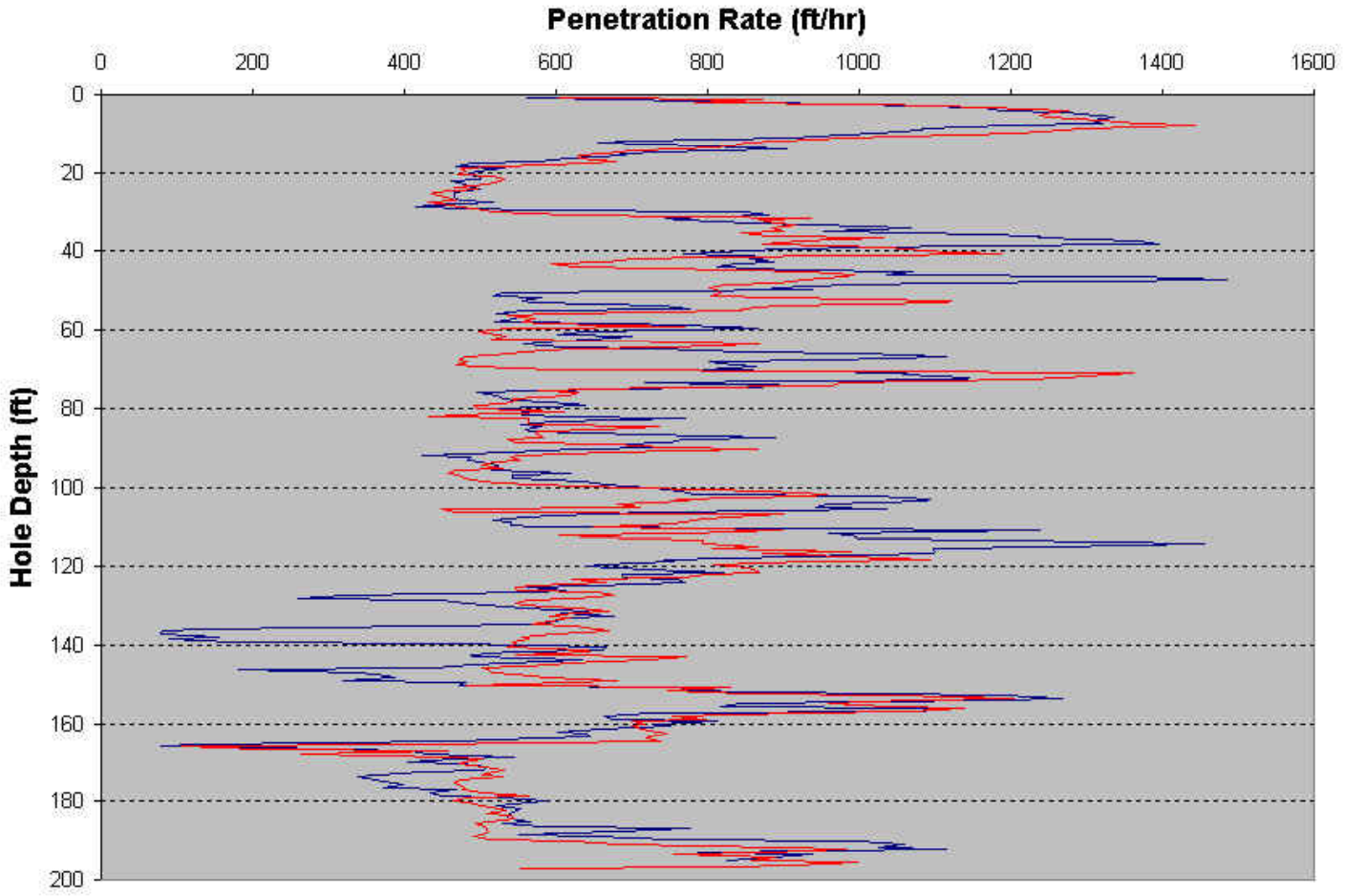
Measurement While Drilling (MWD)

Drill Monitor

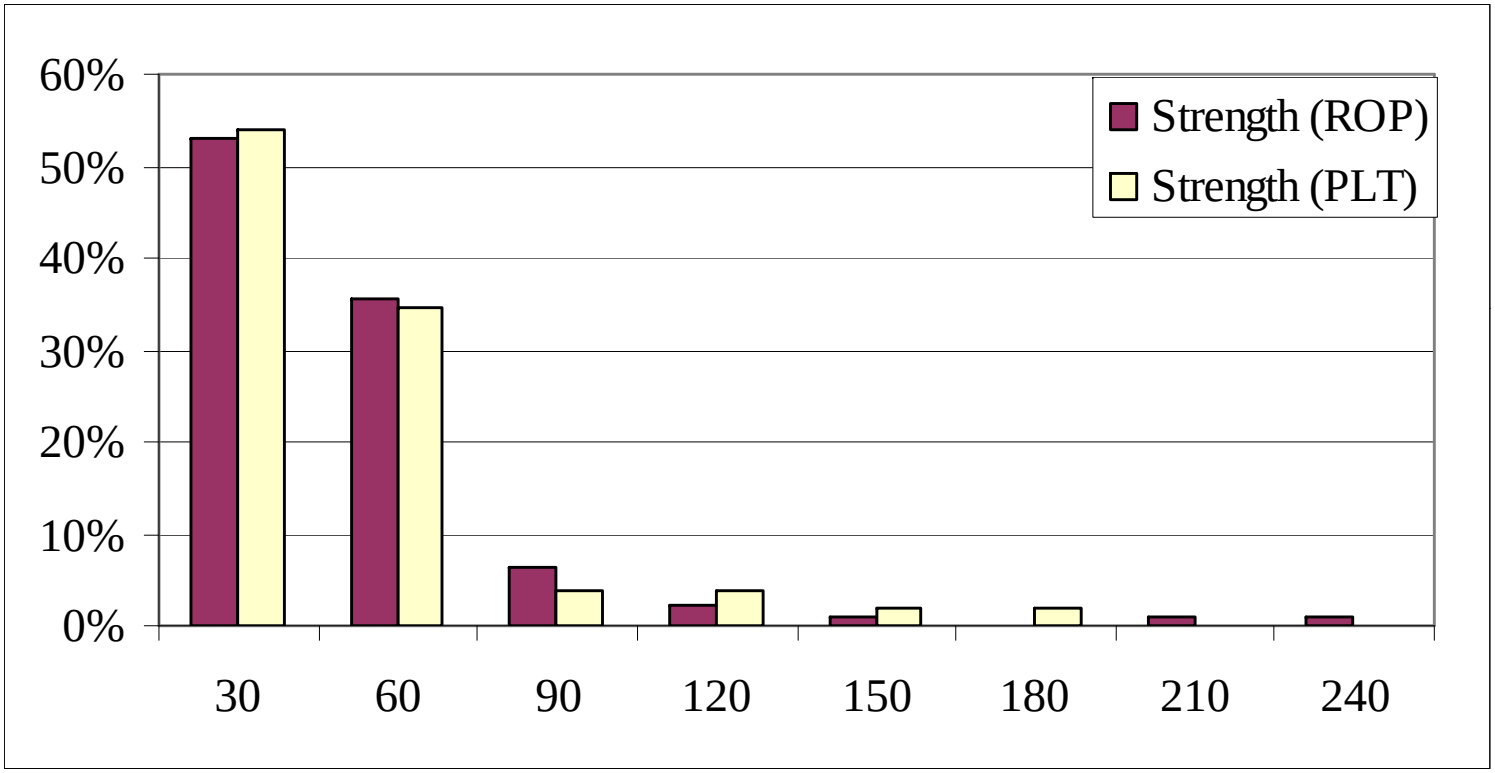
Analysis and Presentation



Drill ROP at Various Depths

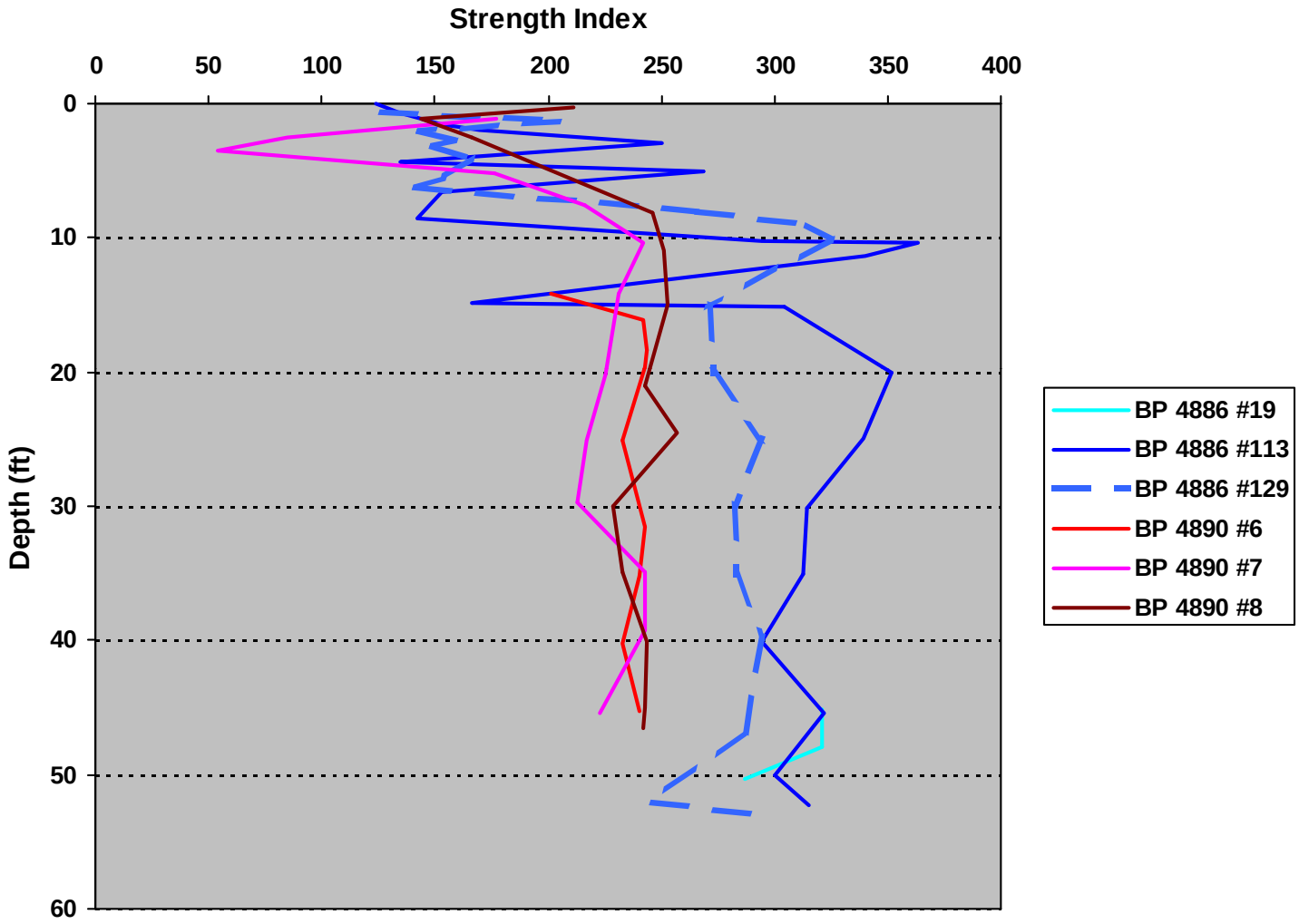


Correlation Between MWD Parameters and PLT



Strength = K1 x Pull down pressure x $(RPM / ROP)^{K2}$

Drill Data for Rock Characterization



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