301 – Part B – The Chemical Crusher: Drilling and Blasting

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LIGHTEN UP!

Blast Dynamics
Stress / Pressure Dissipation

H_d = Hole Diameter

UCS = Unconfined compressive Strength of rock

Step 1= Pulverized Zone

Blast hole diameter expanded

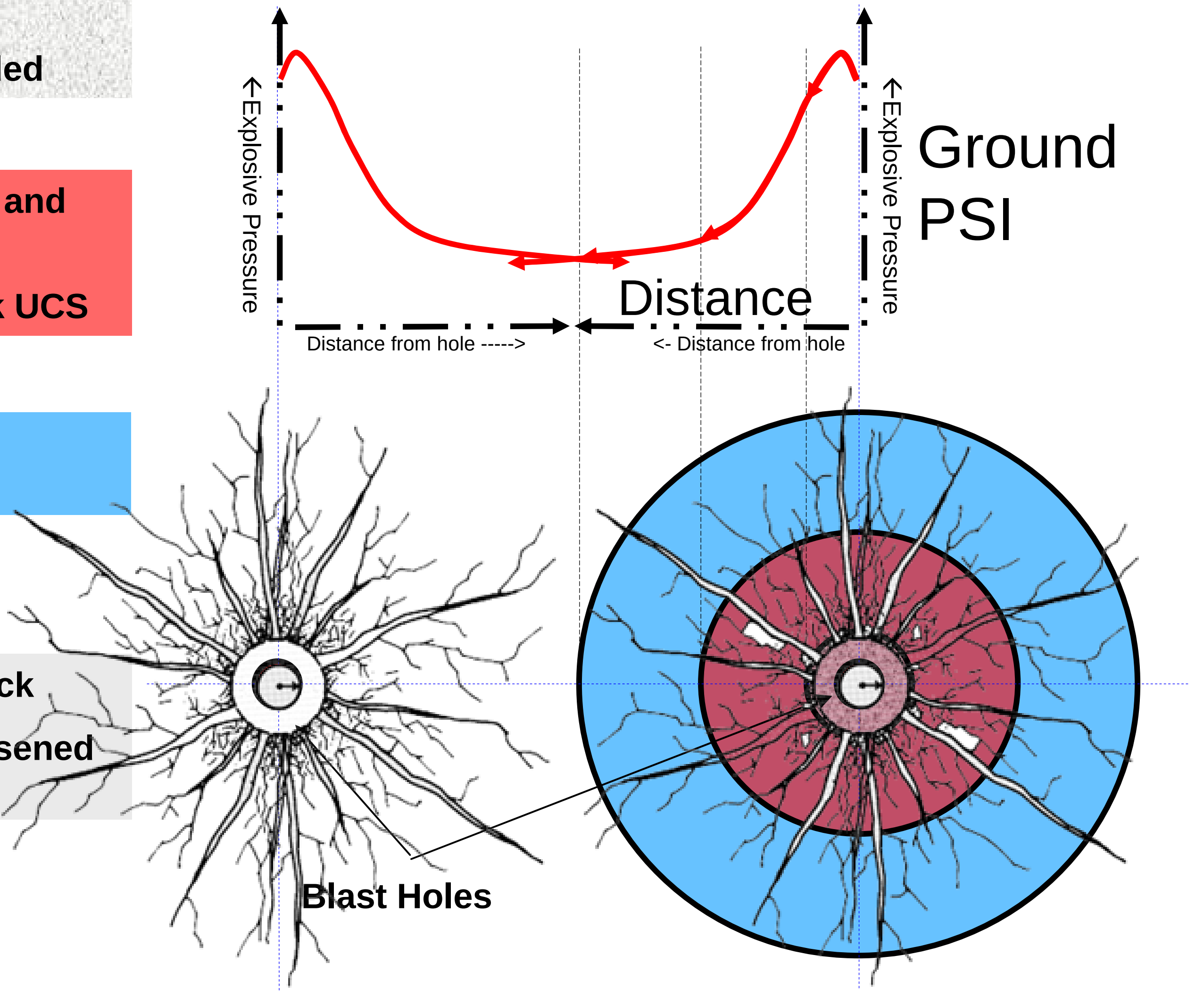
Step 2 = Intense fracturing and cleaving of minerals

Blast Hole Pressure > Rock UCS

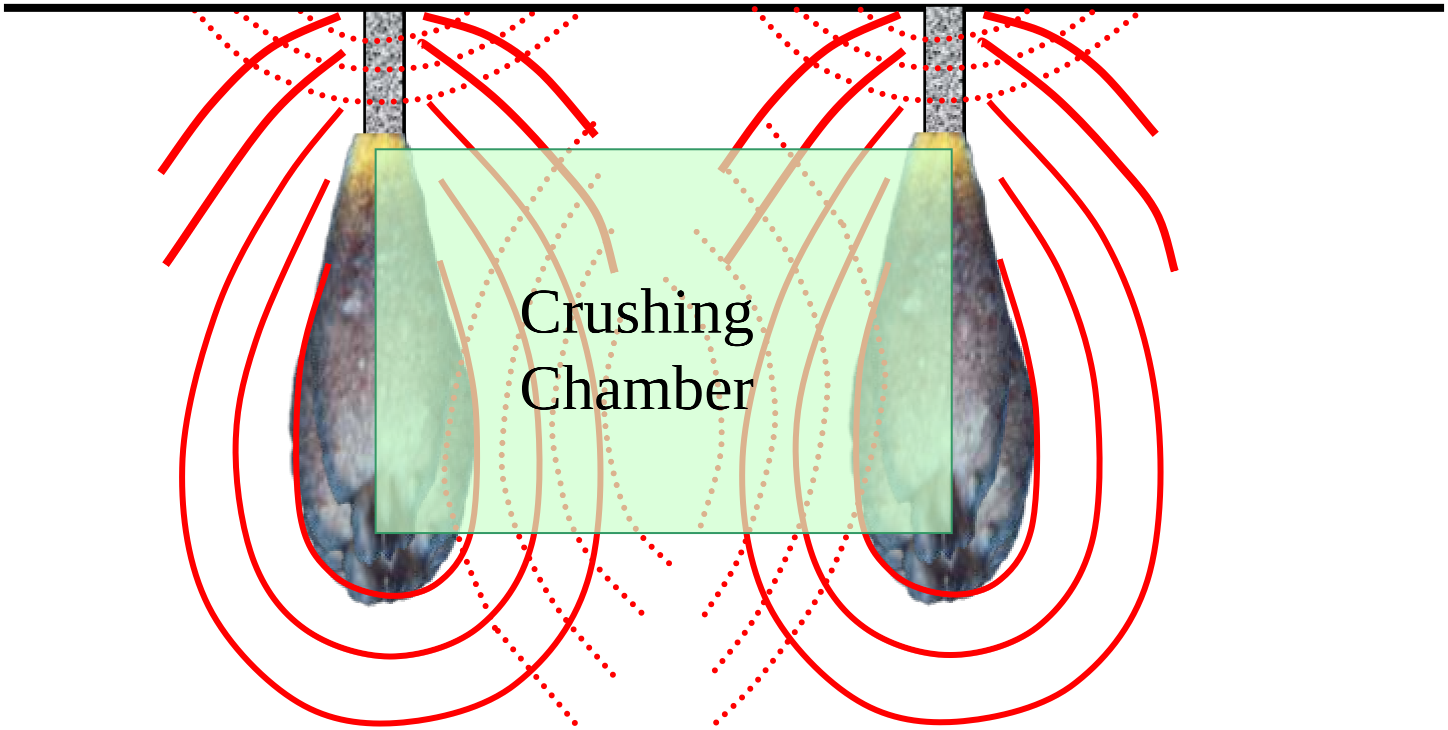
Step 3 = Minimum stress pressure in rock from blast

Step 4 = Damage limit to rock

Pre-existing blocks are loosened and moved



Chemical Crusher (conceptually)



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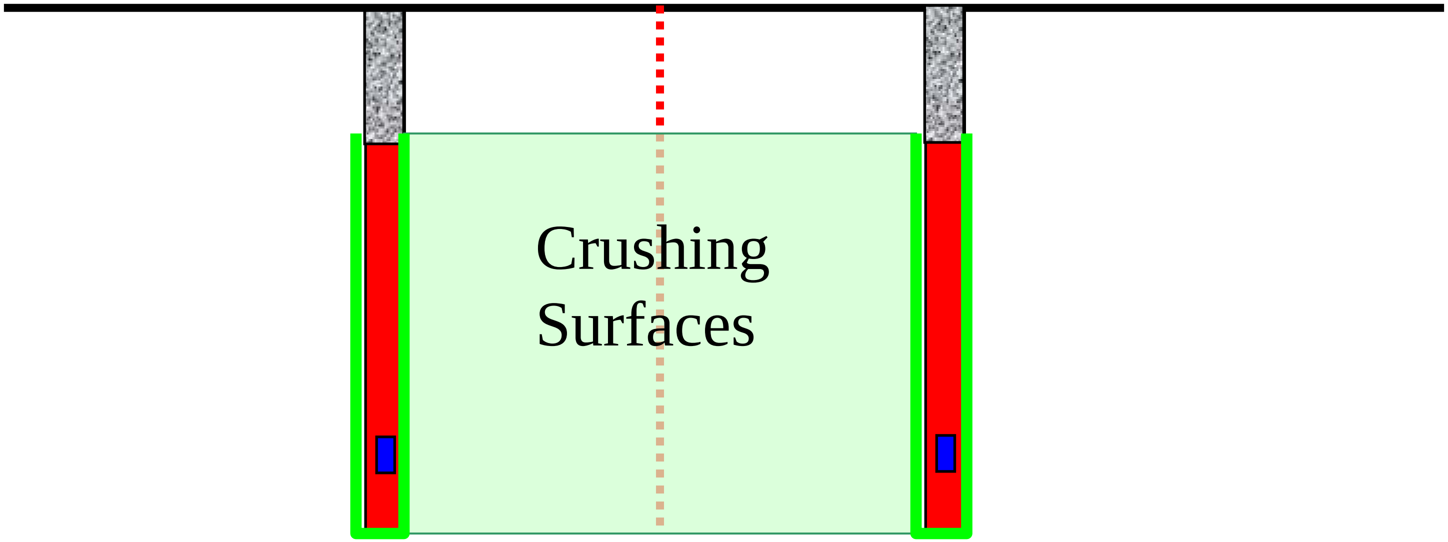
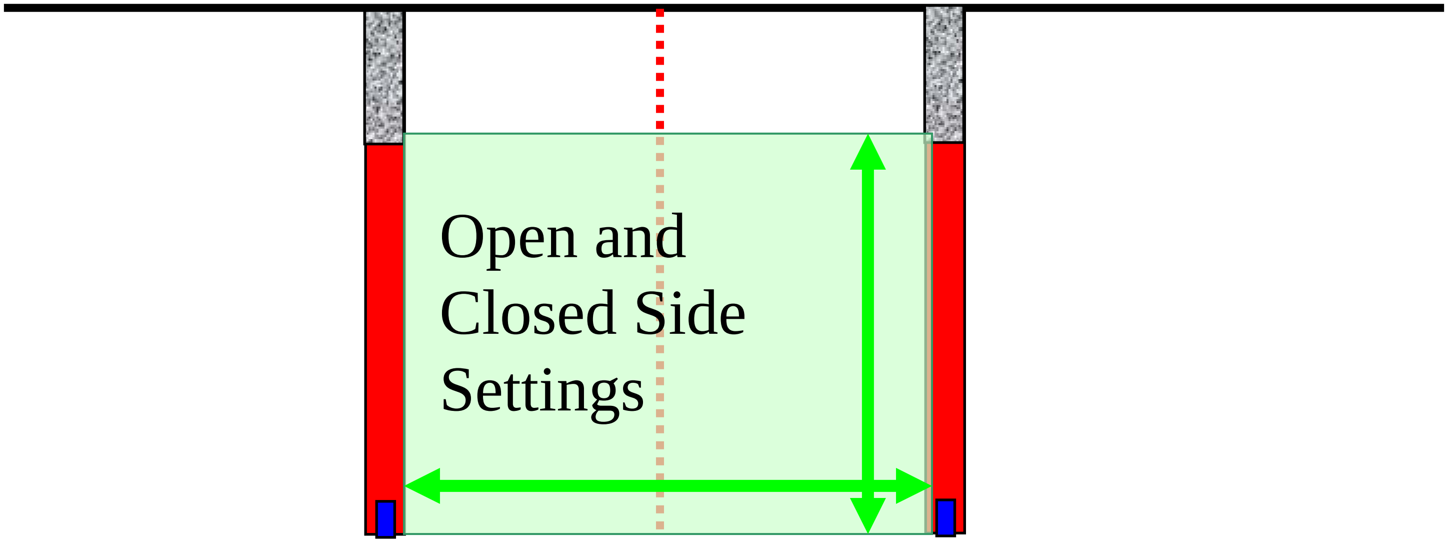
Chemical Crusher (conceptually)



Chemical Crusher (conceptually)



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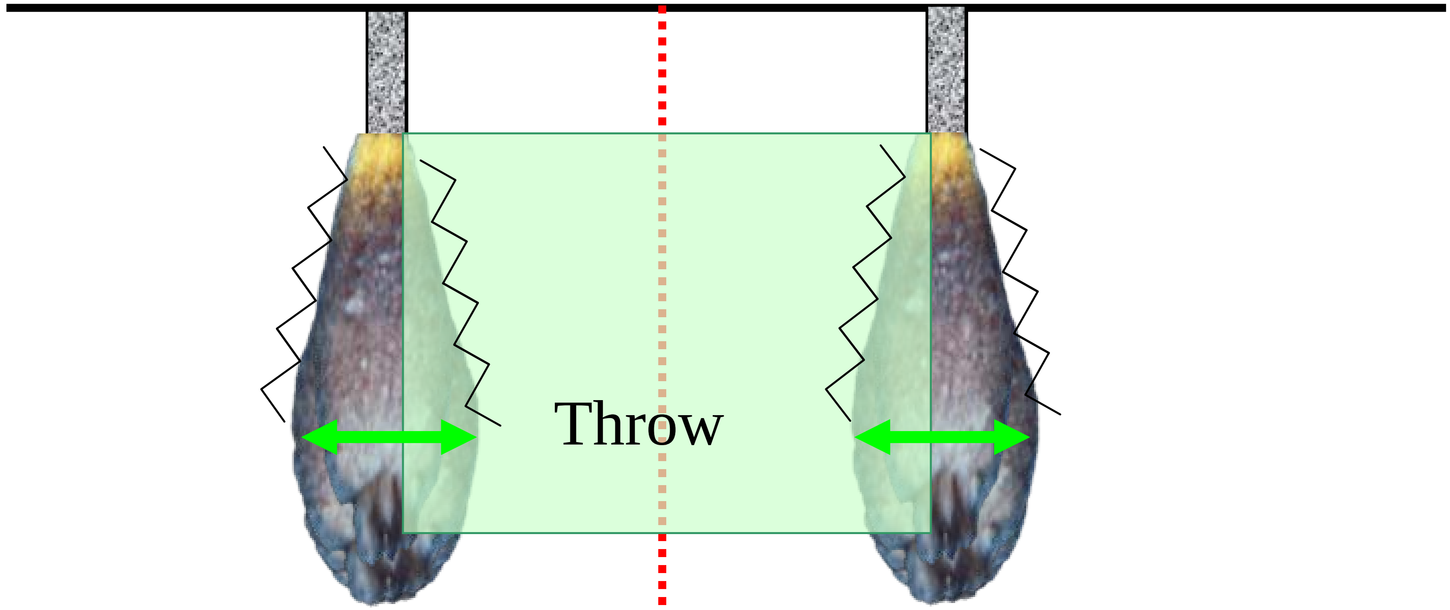
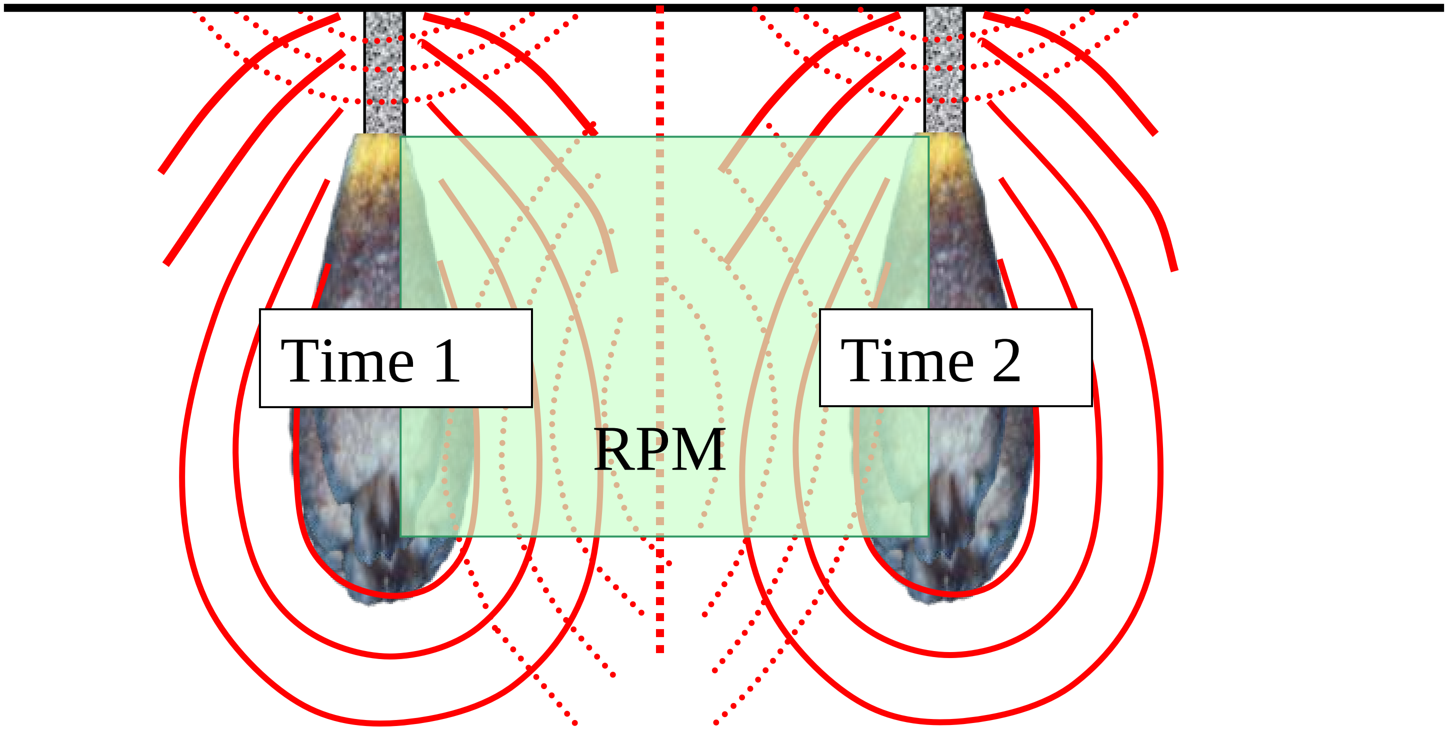
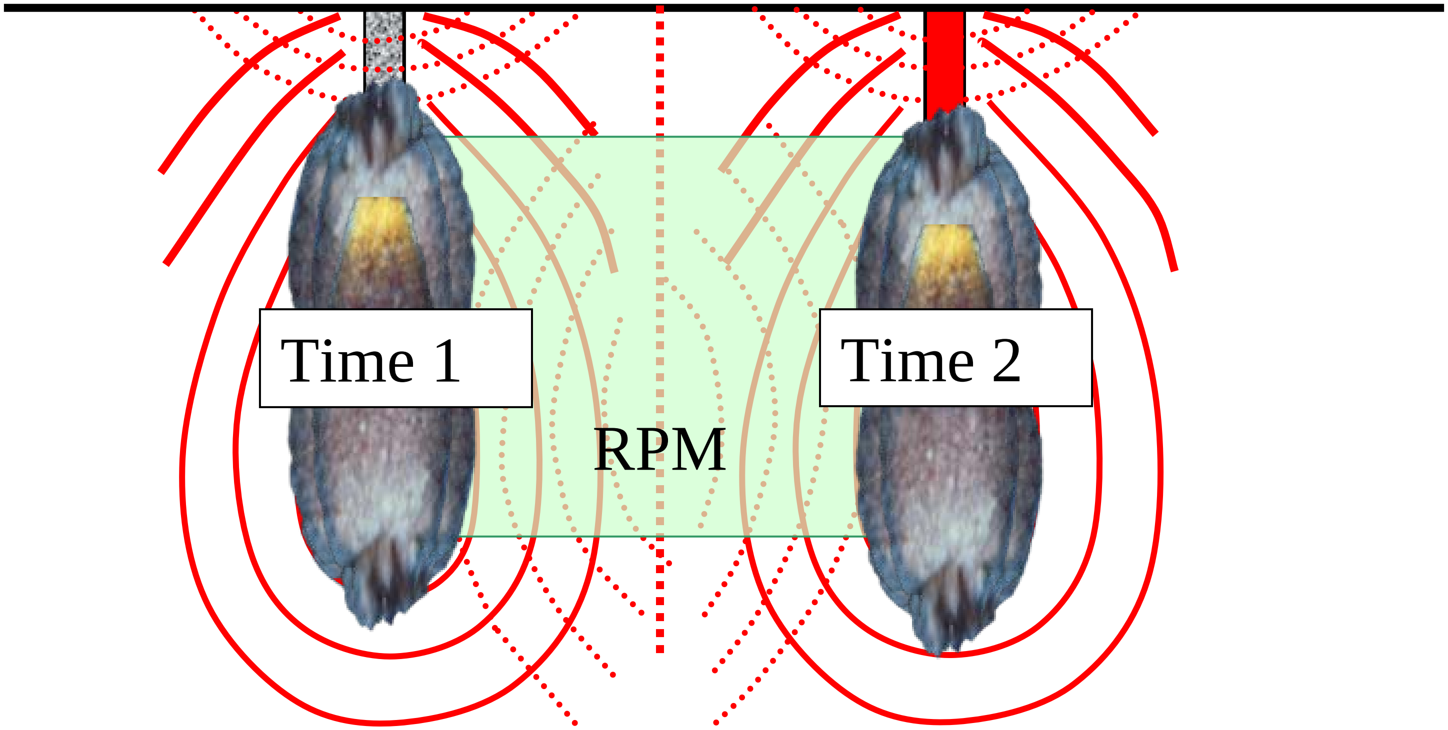
Chemical Crusher (conceptually)



Chemical Crusher (conceptually)



Chemical Crusher (conceptually)



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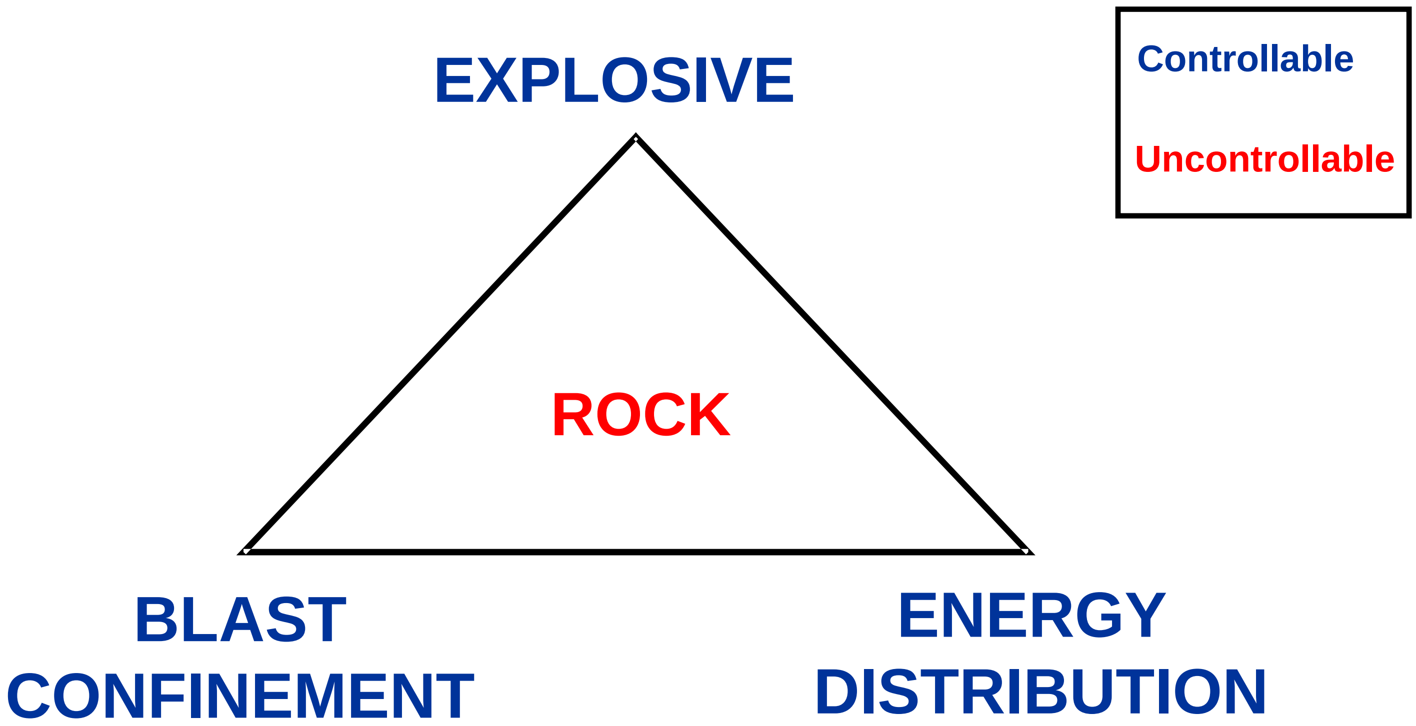
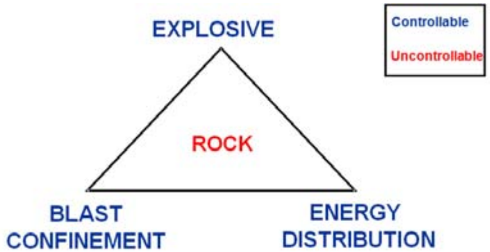
Chemical Crusher - Key Design Factors



Explosive

A controllable factor in building the Chemical Crusher

- **The energy, pressure and after blast fumes generated by an explosive detonation are determined by the explosives:**
  - ✓ **Composition**
  - ✓ **Density (g/cc)**
  - ✓ **Diameter**
  - ✓ **Velocity of Detonation (ft/sec)**
- **Commercial explosives are available in both:**
  - ✓ **Packaged**
  - ✓ **Bulk**
    - Dry Blend / Free Flowing
    - Wet Blend / Augerable
    - Pumpable Blend



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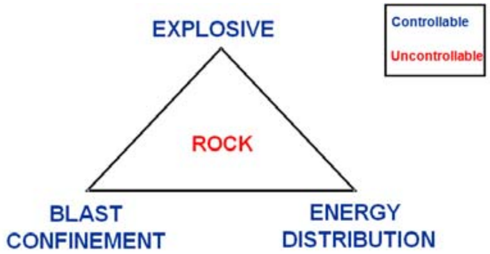
Blast Confinement

A controllable factor in building the Chemical Crusher

- **Confinement determines the amount of the explosive's energy that does effective work. Confinement is provided by:**
  - ✓ **Material surrounding the explosive in the drill hole.**
  - ✓ **The amount of material between the drill hole and any static or dynamic free space or what we call the burden.**
    - **Burden is a critical blast dimension. All blast design parameters are based on burden.**
  - ✓ **The distance between drill holes (Spacing) relative to one another in a row.**
  - ✓ **Stemming / non explosive decking. Size and quality is critical.**
  - ✓ **Initiation sequence and time between and within individual blast holes.**



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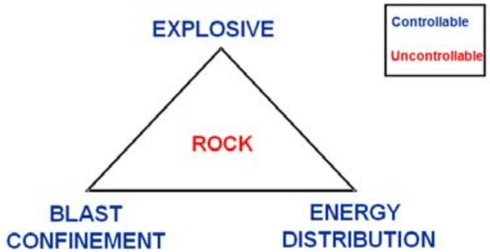
Energy Distribution

A controllable factor in building the Chemical Crusher

- **How the explosive energy is distributed throughout the rock mass to be blasted – vertically and horizontally to do work. Energy Distribution is controlled by:**
  - ✓ **Diameter of the drill hole.**
    - ✓ **Limits the diameter of explosive.**
  - ✓ **Diameter of the explosive.**
    - ✓ **Packaged explosive limits the effective diameter of the blast hole.**
  - ✓ **Depth / Length of the drill hole.**
    - ✓ **Single column of explosive - Amount loaded with explosive versus amount filled with stemming.**
    - ✓ **Multiple separated columns of explosive – the amount loaded with explosive and the amount filled with stemming and their relative positioning throughout the rock mass**
  - ✓ **Orientation of drill holes**
    - ✓ **Relative to one another – staggered, in-line**



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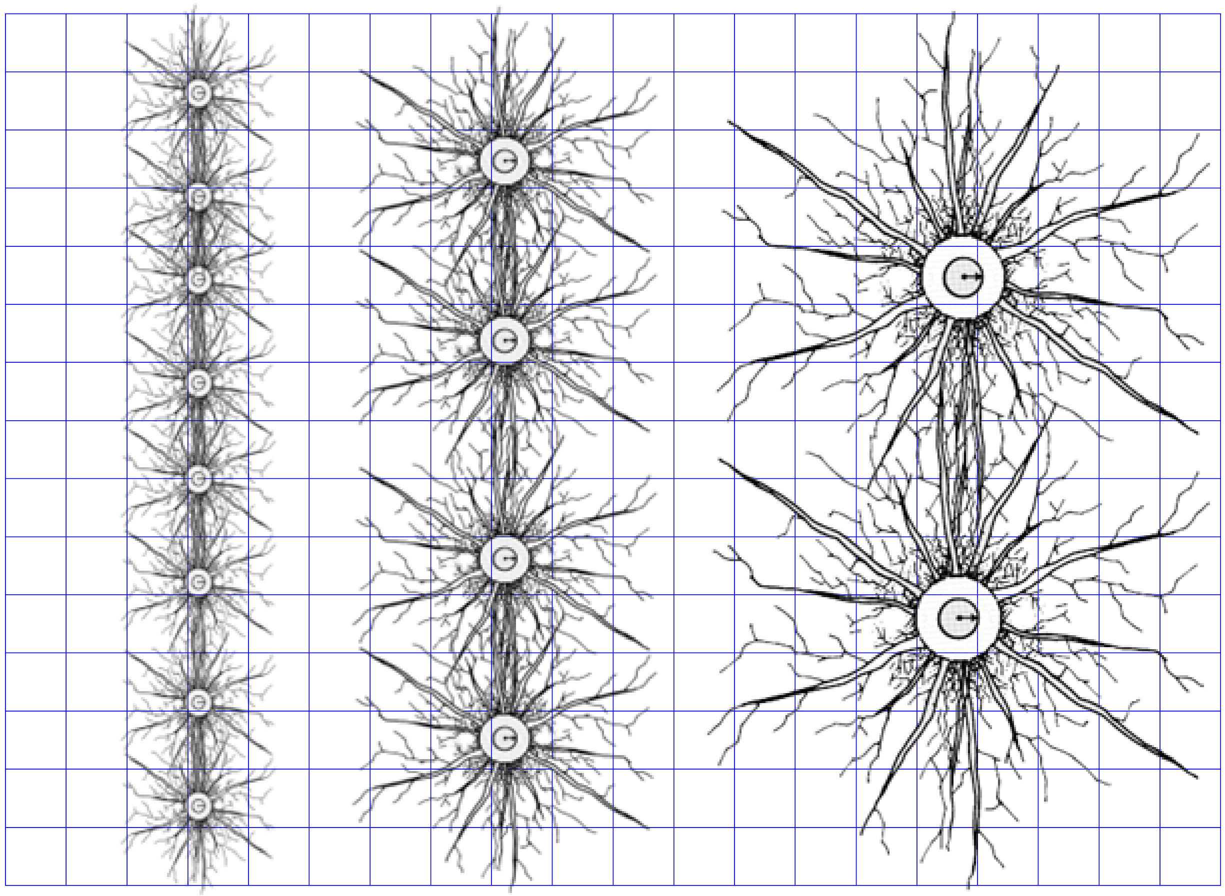
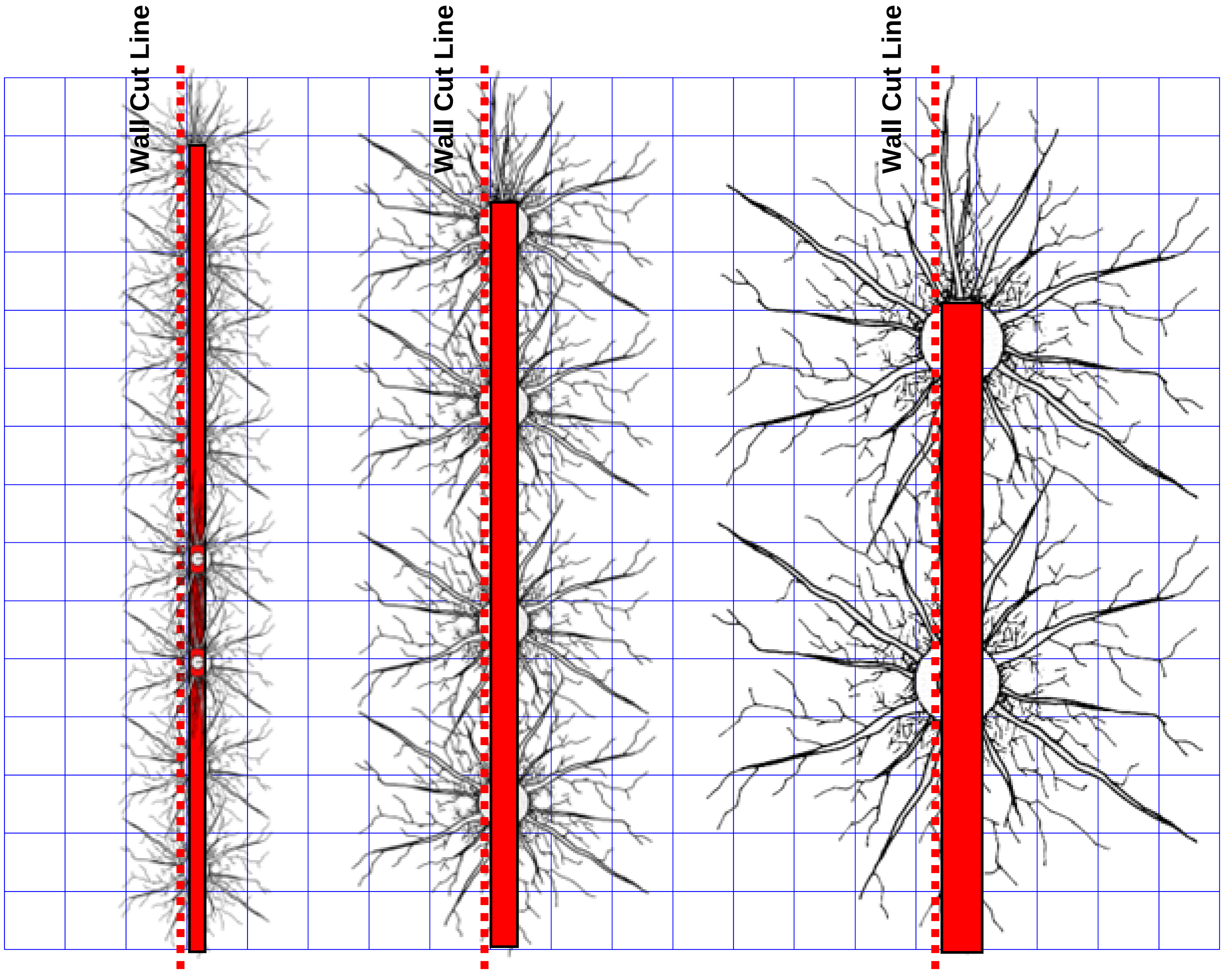
Effect of Hole Diameter on Fragmentation Control (Small to Large)

As hole size increases, the area of influence around each hole *<u>and</u>* the geometry of the fragmentation changes.



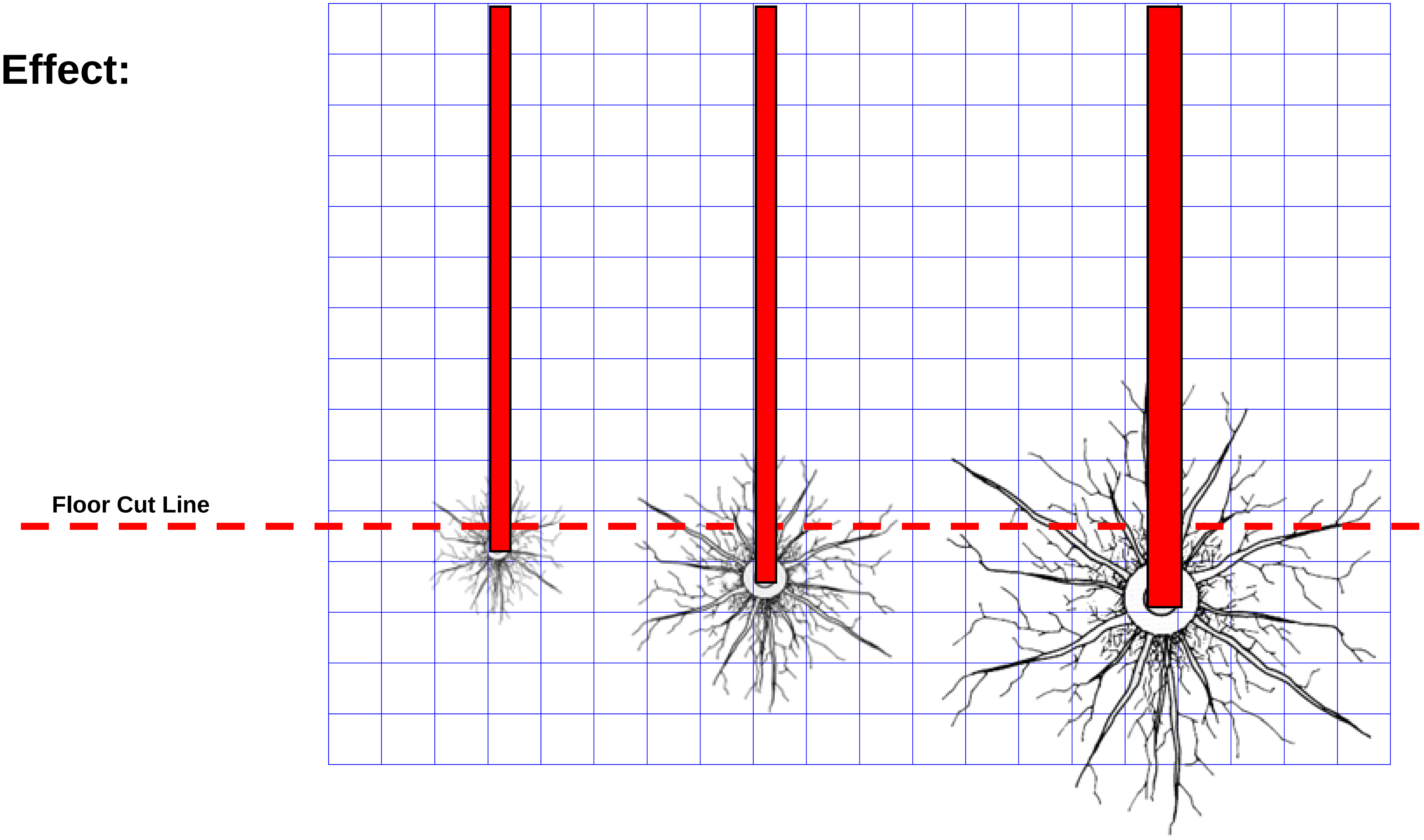
Effect of Hole Diameter on Fragmentation Control (Small to Large)

Wall Effect:



Effect of Hole Diameter on Fragmentation Control (Small to Large)

Floor Effect:



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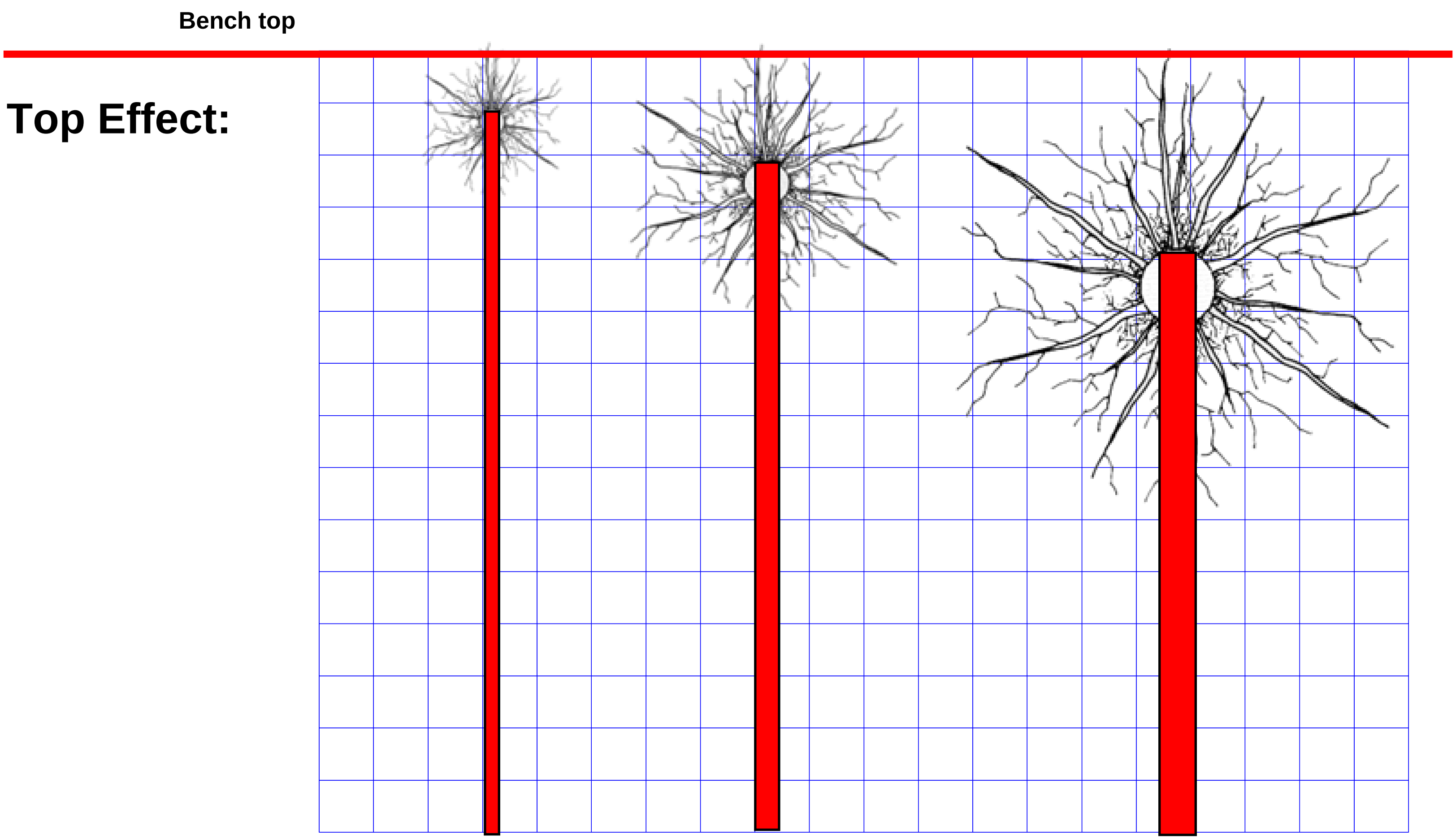
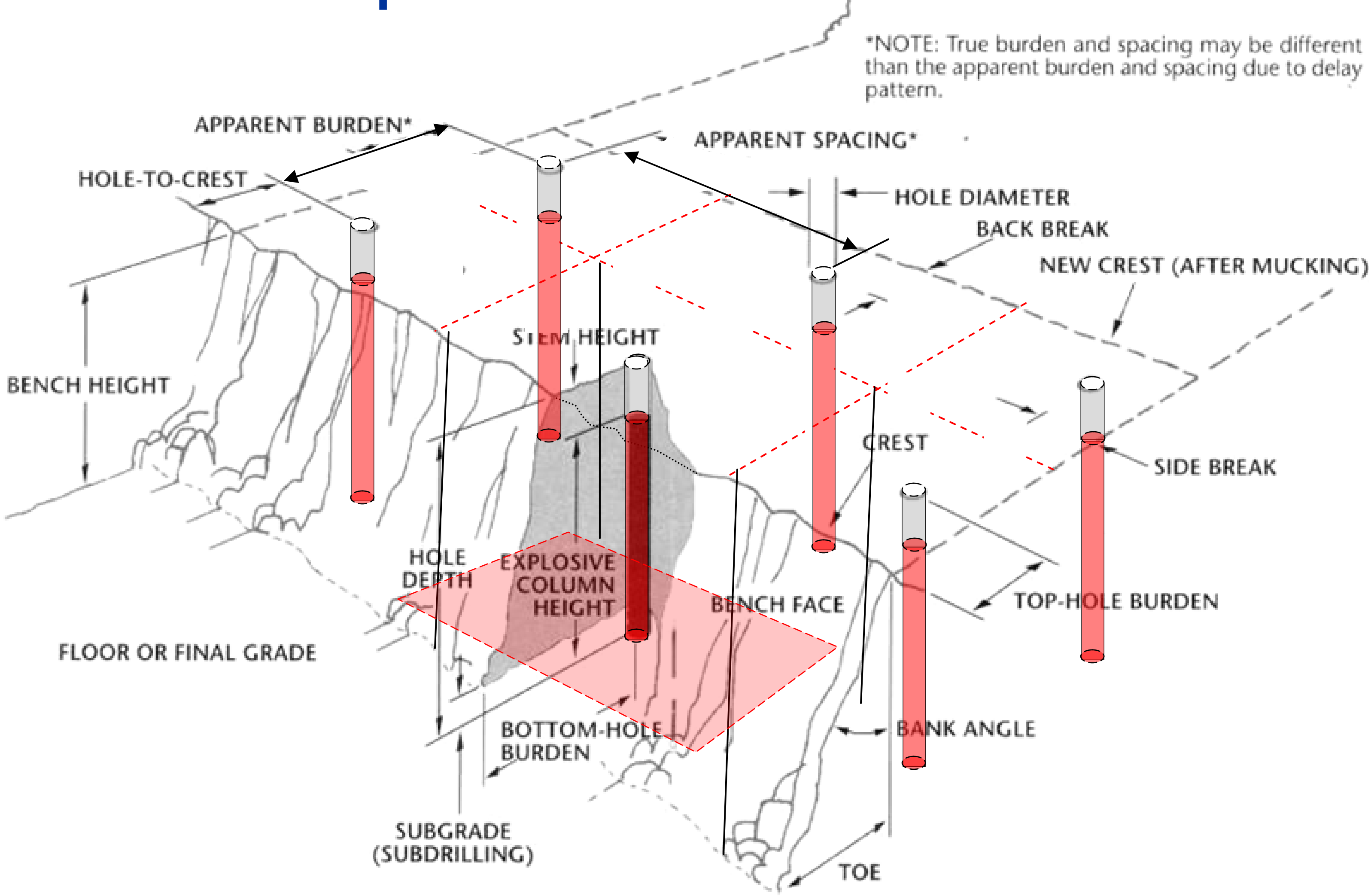
Effect of Hole Diameter on Fragmentation Control (Small to Large)

Bench Top Effect:



Building the Chemical Crusher
Static view of explosive distribution



Larger Diameter Holes

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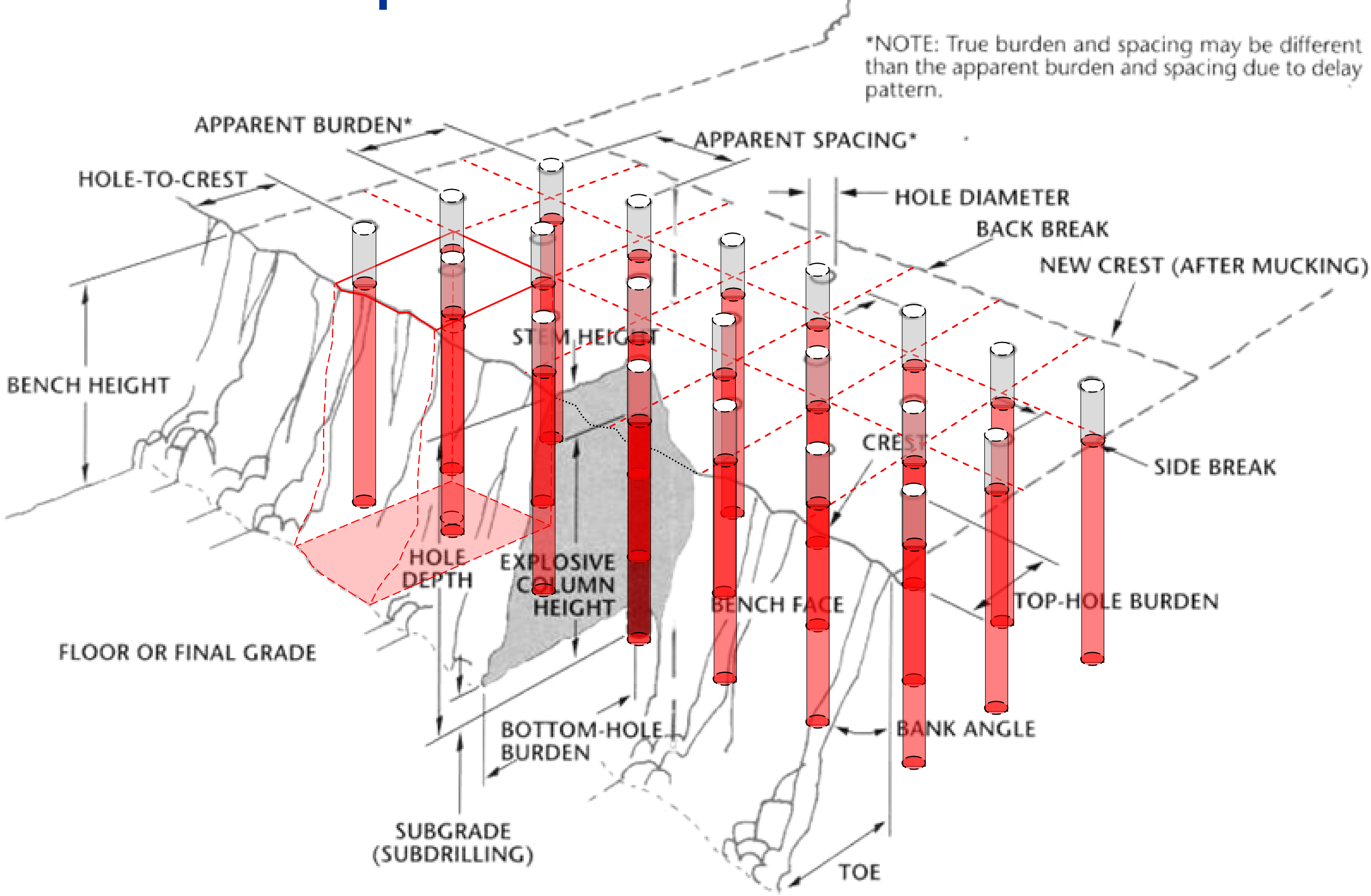
Building the Chemical Crusher

Static view of explosive distribution



Smaller Diameter Holes

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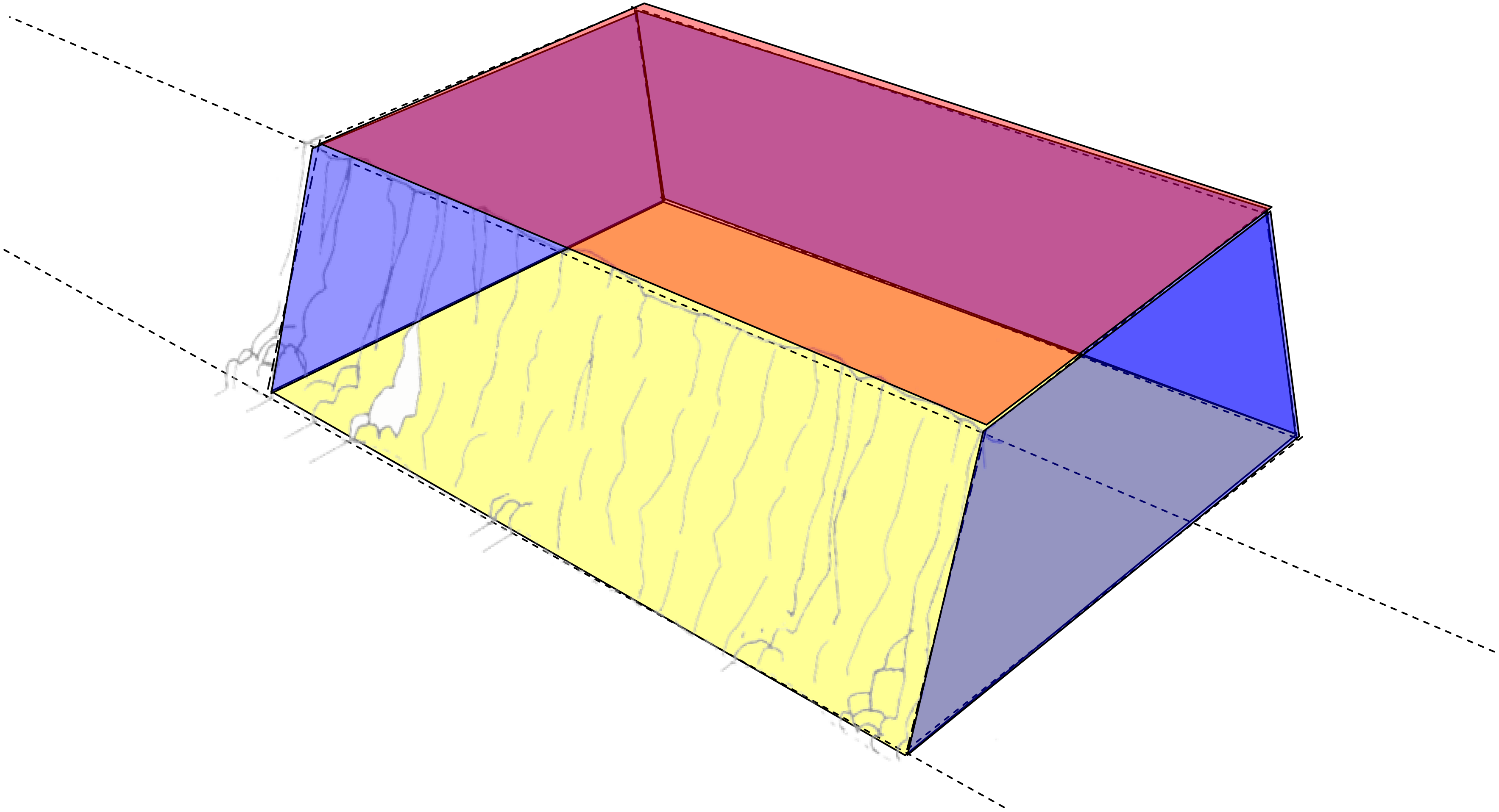
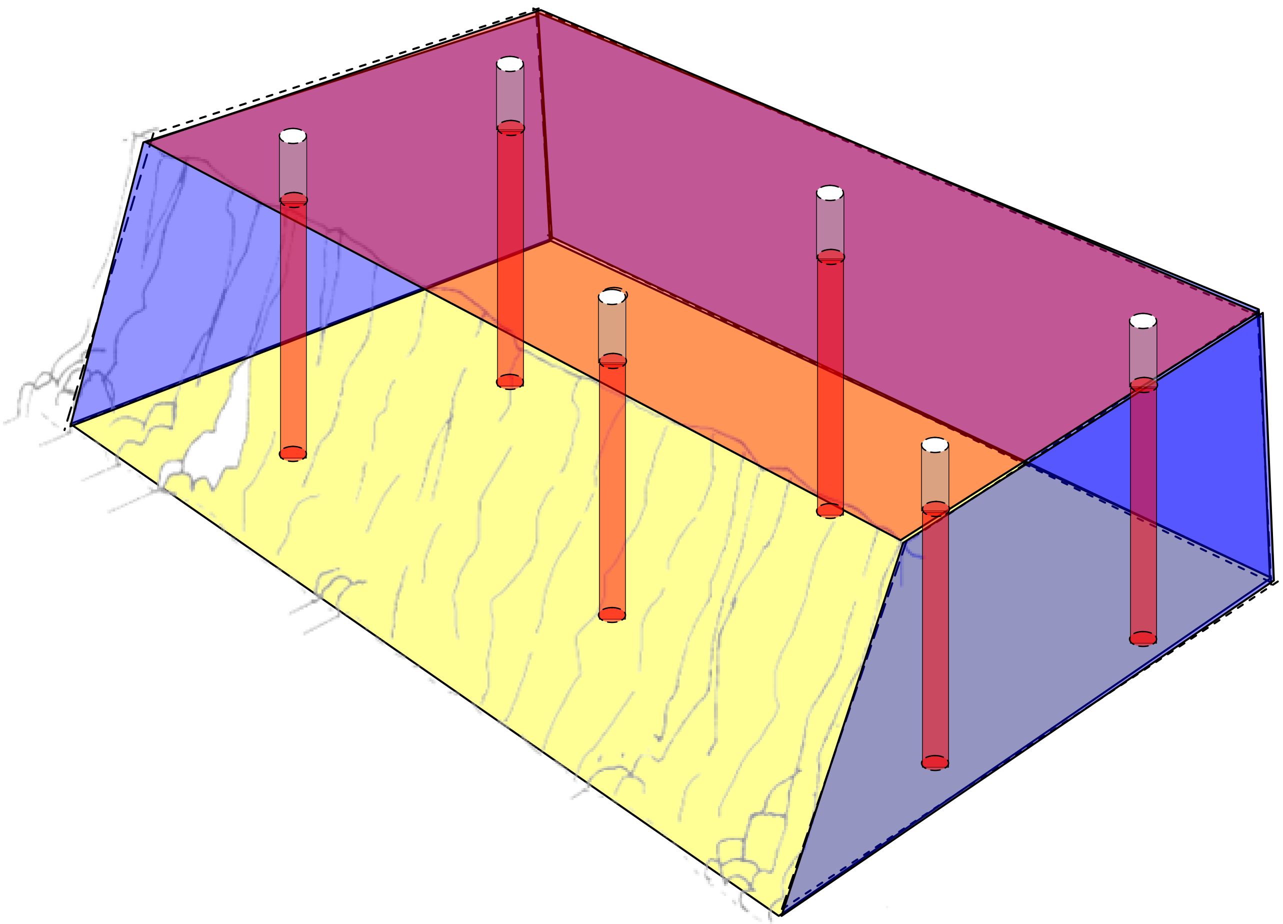
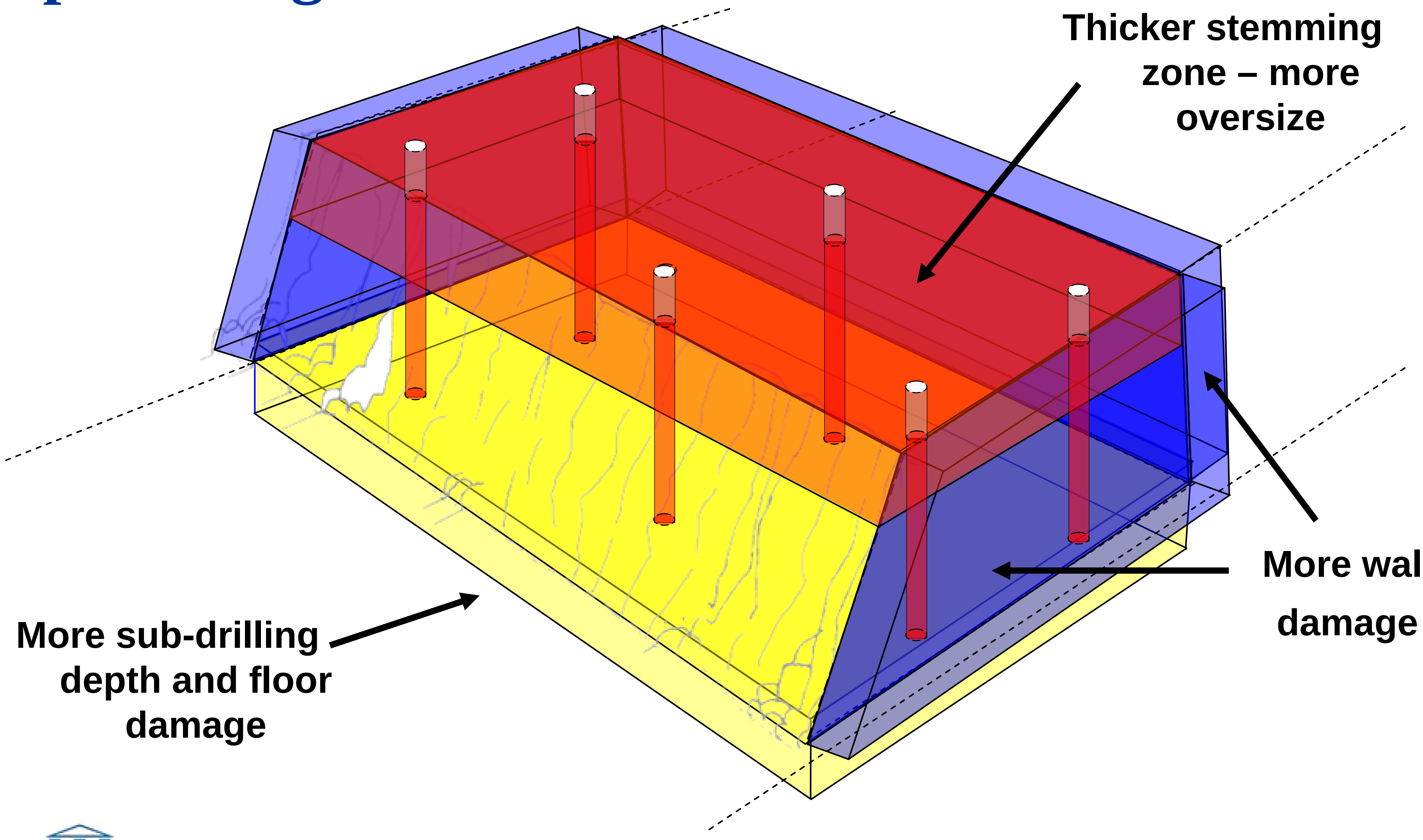
Target Work Zone for Chemical Crusher



Larger diameter holes in Target Work Zone



Larger diameter holes allow for smaller overall percentage of crushed rock



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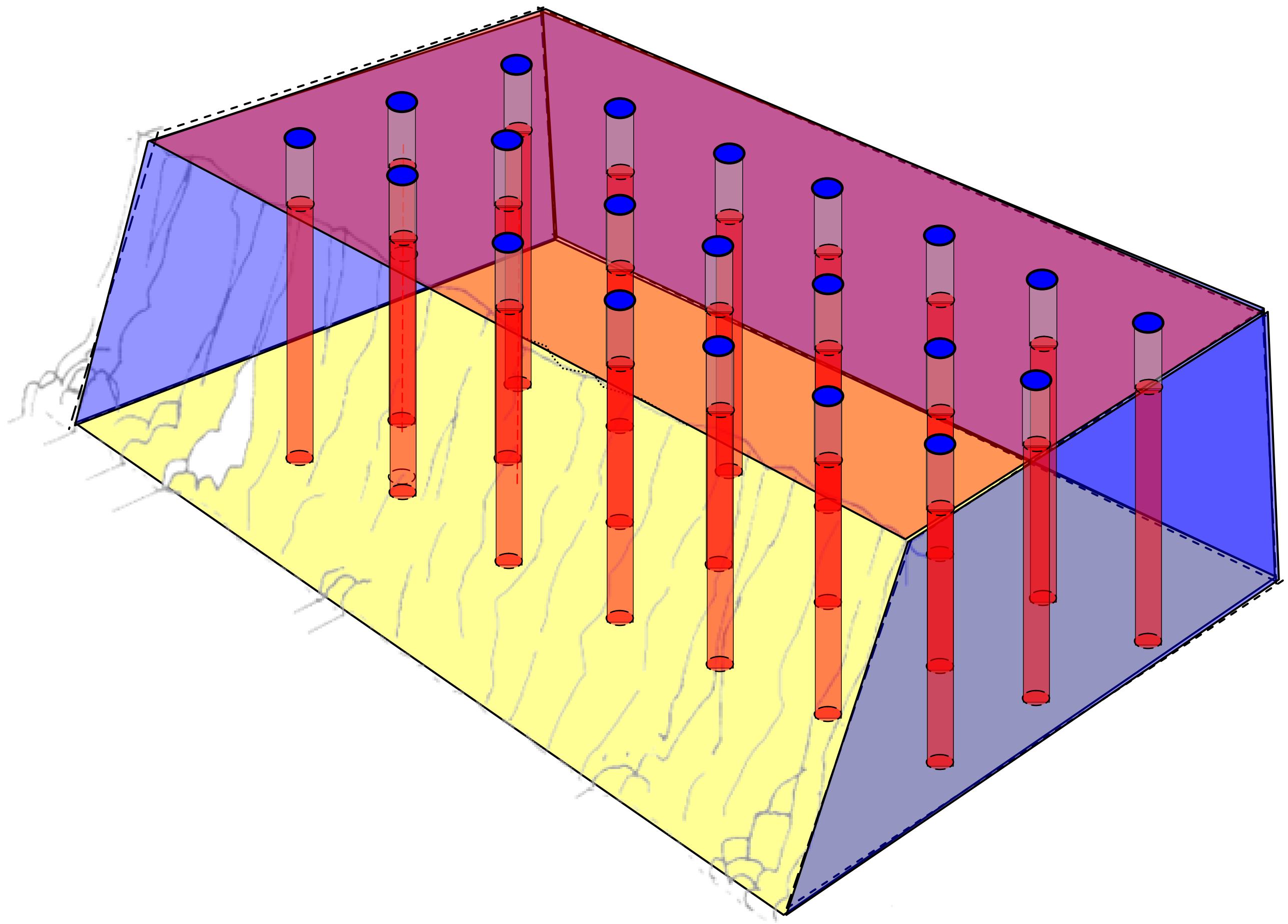
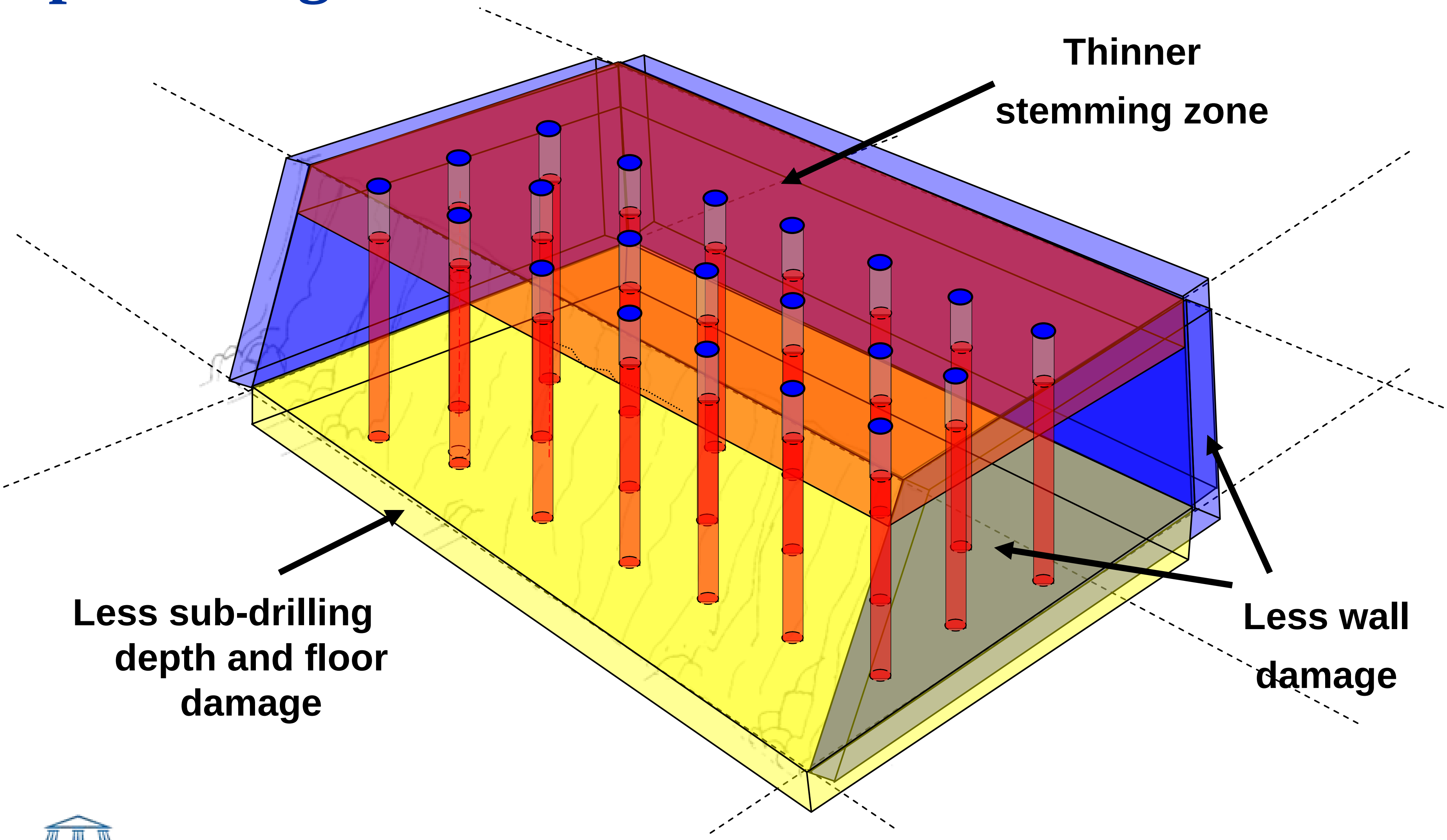
Small diameter holes in Target Work Zone



Smaller diameter holes allow for higher overall percentage of crushed rock



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Operations Process Improvement*
Leveraging Drill & Blast – Case Work #1

Capital Quarries Company Inc.
Holts Summit, MO

* From Drill to Pre-wash Product. Waste defined as minus 3/8”.

Operations Process Improvement
Case Work #1 Project Outcomes

- **Drilling and Blasting cost increased by 28%.**
- **Waste was reduced by 19%.**
- **Impressive cost savings and increases in plant tonnage throughput within the “Blast to 1 inch minus” process of the Holt Summit Value Map were realized over the validation phase of the project.**

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Operations Process Improvement
Case Work #1 Project Outcomes

- **The standard cost model for the "Blast to 1 inch minus" process of the Holt Summit value map showed that over the total process:**
  - ✓ **There was a 10% to 27% increase in crusher plant capacity**
    - ✓ **27% from baseline of 373 TPH to an average of 475 TPH. A plus 102 TPH shift in capacity.**
  - ✓ **There was a 7% to 31% reduction in net total cost per ton when scalping was used.**
  - ✓ **When scalping was not utilized an 8.8% reduction in the net cost per ton was achieved.**

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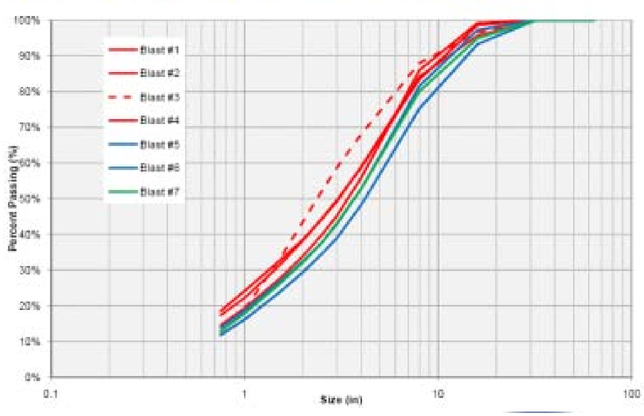
Fines Reduction*
Leveraging Drill & Blast – Case Work #2

*Increase saleable product. Lower total cost.
Increase profit margin. Fines defined as minus ¾ ”.

Operations Process Improvement
Case Work #2 Project Outcomes

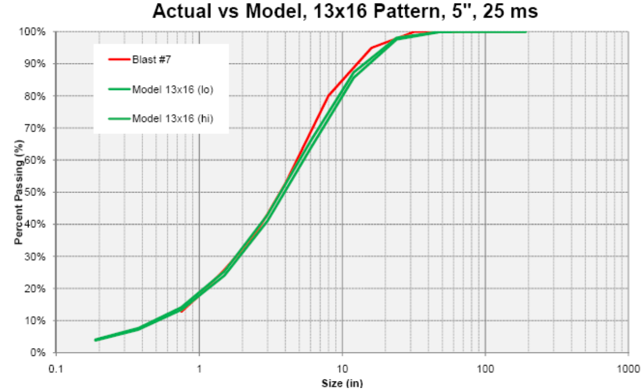
- **Pattern Optimization**
  - ✓ **Expanded 58%**
    - ✓ **Baseline 12 ft x 14 ft**
    - ✓ **Current 14 ft x 19 ft**
  - ✓ **$0.082 savings per ton drill and blast (including electronic detonators)**
- **4 % reduction in fines with changes to drill & blast design.**

Actual Fragmentation for All Blasts



Comparison of Model & Wipfrag Results

Actual vs Model, 13x16 Pattern, 5", 25 ms



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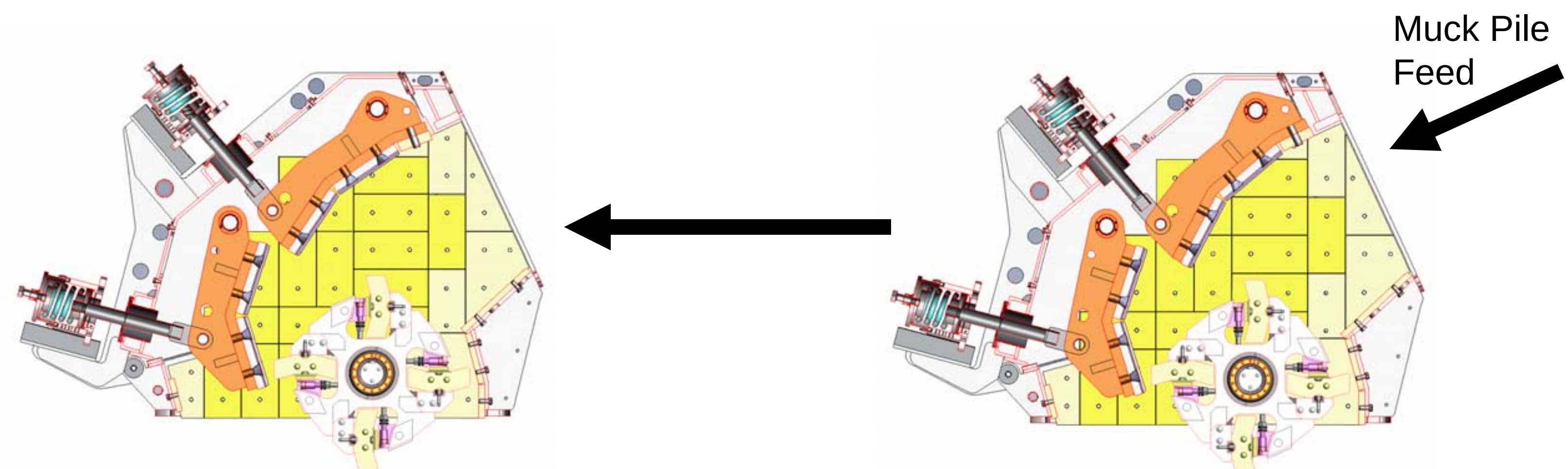
Operations Process Improvement
Case Work #2 Project Outcomes

- **11% reduction in fines achieved with changes in plant operation**
- **Total fines reduced from 73% to 56% of total plant output.**
- **Increased saleable product by approximately 10% increase.**



Secondary

Primary

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Summary

- **Drill and Blast can be used to produce fragmentation that will enable the mechanical crush/screen process to be more efficient.**

- **The optimized distribution of explosive energy as a function of drill hole diameter, accurate location, explosive product, and timing is the key to leveraging the chemical crushing influence and control.**

- **Case work to date indicates that implementation of drill and blast programs that leverage chemical crushing of stone, yield process stream cost savings that are better measured in dollars per ton than in cents per ton.**

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