# SUBDRILL THE UNDERUTILISED BLASTING PARAMETER

46TH ANNUAL CONFERENCE ON EXPLOSIVES AND BLASTING TECHNIQUE

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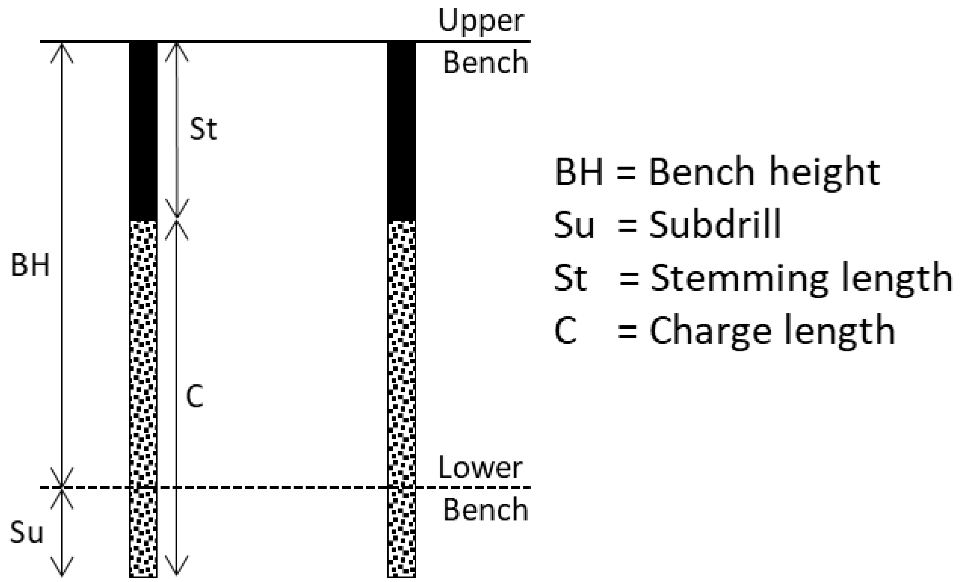
FIRST QUANTUM MINERALS

# WHAT IS SUBDRILL?

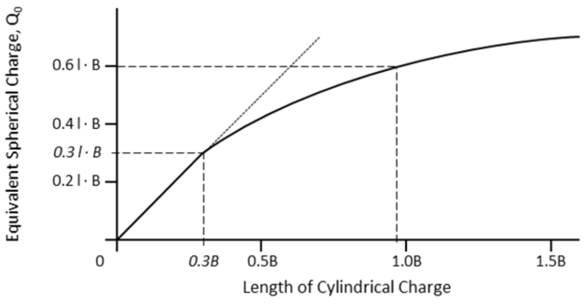
- The portion of a blast hole that is drilled below the target grade elevation, and in most cases loaded with explosives.



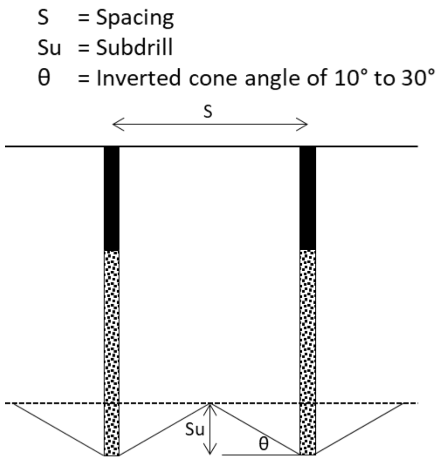

# WHY IS IT USED?

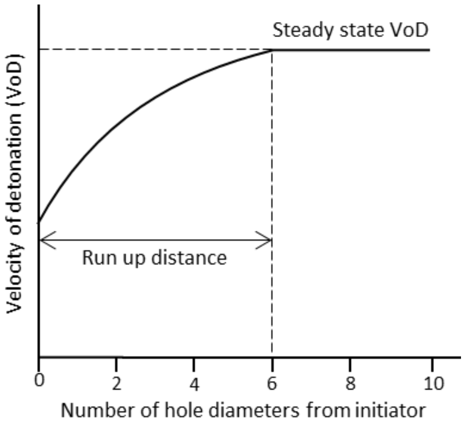
- To enable efficient excavation to the lower bench level.

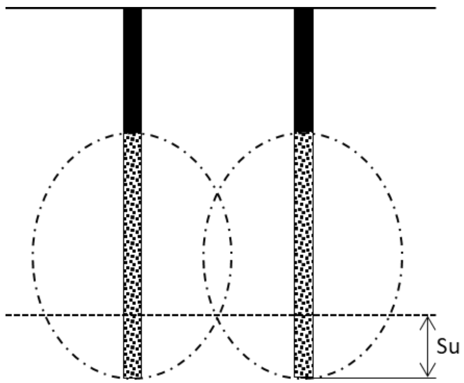
# SUBDRILL DESIGN STANDARDS




| $K_J$ | FREQUENCY |
|---|---|
| 0.0-0.09 | 15 |
| 0.1-0.19 | 18 |
| 0.2-0.29 | 27 |
| 0.3-0.39 | 26 |
| 0.4-0.49 | 25 |
| 0.5-0.59 | 2 |
| 0.6-0.69 | 6 |
| 0.7-0.79 | 2 |
| 0.8-0.89 | 0 |
| Total | 125 |
| Mean | 0.28 |
| Mode | 0.24 |
| Medium | 0.27 |




Langefors & Kihlström (1963)
0.3 x B

Ash (1963b)
0.3 x B (minimum)

Jimeno, Jimeno, & Carcedo (1995)
0.3 x B

Hustrulid (1999)
8 x D & 0.3 x B

ISEE (2011)
0.2–0.5 x B

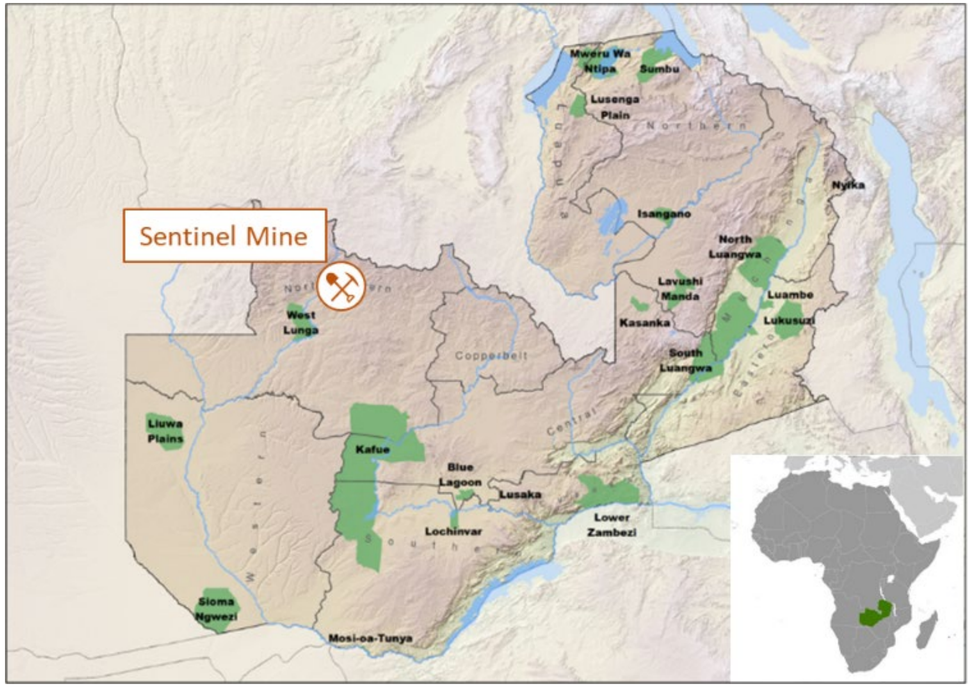
# SUBDRILL DESIGN RECOMMENDATIONS

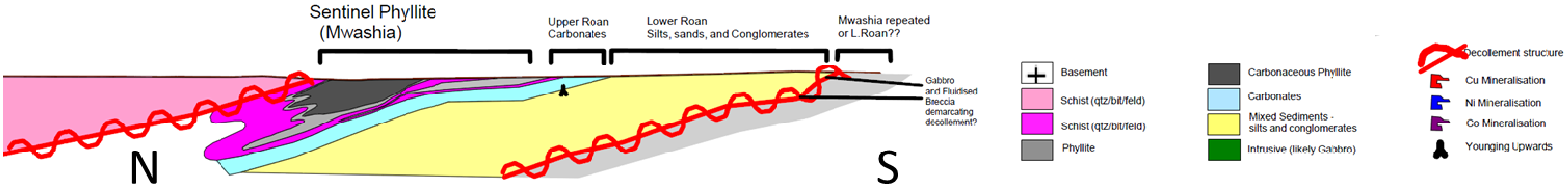
- Use minimal subdrill and if the rock mass properties are favourable, use no subdrill at all.

- Negative effects of using long or excessive subdrill include:
    - Wasting drilling and blasting time, resources and expenditure.
    - Increasing ground vibration due to over confinement of explosives in the subdrill.
    - Accentuated rock movement and displacement.
    - Damage to the rock mass at and below the target floor elevation.
    - Difficult drilling conditions in the underlying bench, including collaring, leading to problematic drilling conditions.

# SENTINEL MINE

- Located approximately 150 km (93 mi) west of the town of Solwezi in the North Western Province of Zambia.
- Structurally modified, sediment hosted copper deposit.
- Mineralisation is primarily sulphide, with sheet like horizons of ore that dip from south to north at between 20 and 30 degrees.



# SENTINEL MINE

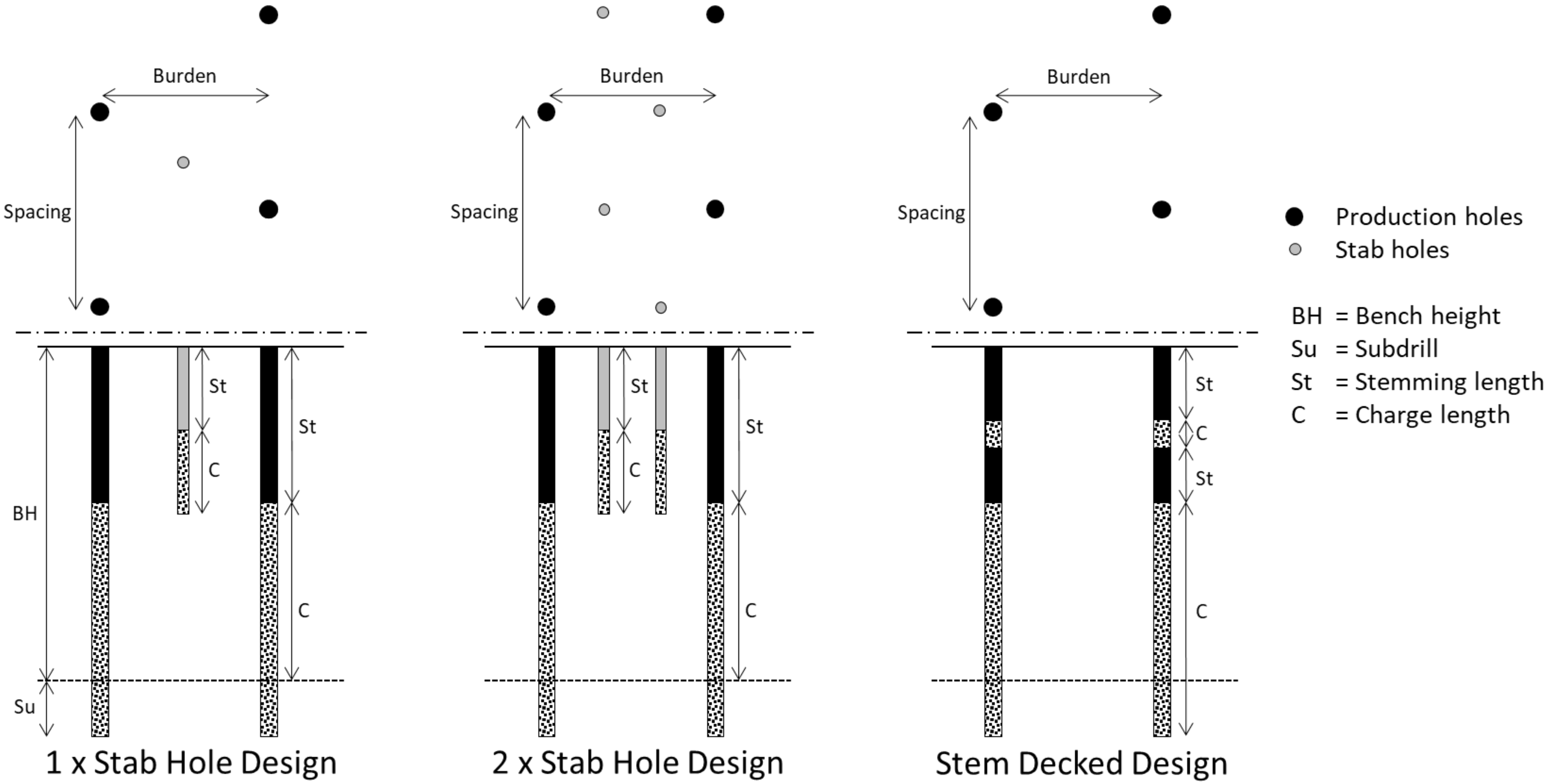
- Annual material movement of 150 Mtonne (165 Mton) and copper production of 230 ktonne (253 kton).
- Ultimate open pit of 5.4 km (3.4 mi), 1.5 km (0.9 mi) and 375 m (1,230 ft) deep, mined in stages.
- Electric trolley assist used to optimise waste haulage.
- In pit crushing and conveying strategy to minimise ore rehandling and lower operating costs.

# CHALLENGING GEOLOGY VS. STANDARD SUBDRILL PARAMETERS

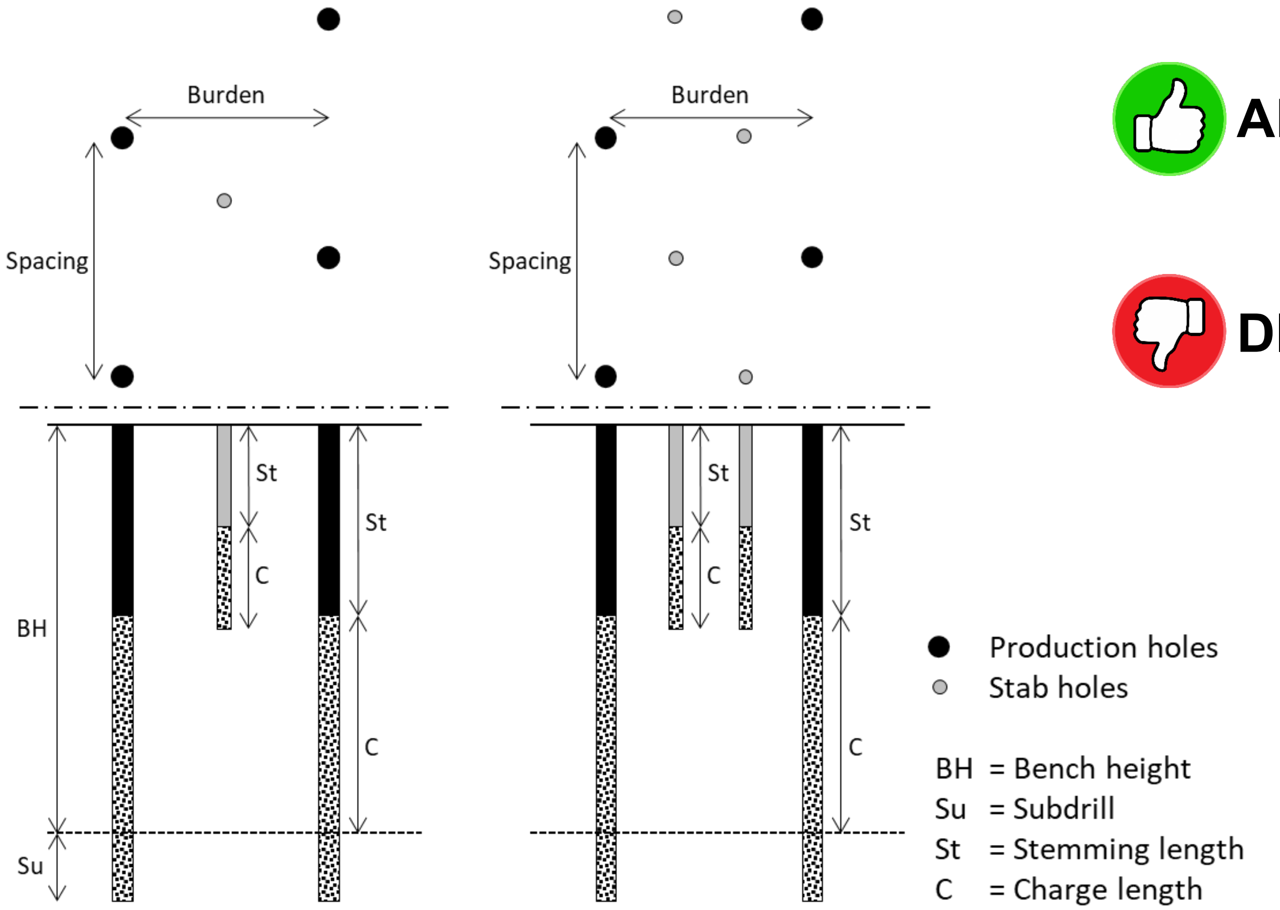
1. High production volumes requiring large sized fleet
2. Large production drills and large hole diameters
3. Standard blast design parameters
4. Challenging structural orientation and spacing
5. Blocky & slabby fragmentation in stemming region
6. Crusher blockages, bridging and reduced throughput

# CHALLENGING GEOLOGY VS. STANDARD SUBDRILL PARAMETERS

# STANDARD DESIGN STRATEGIES



# STAB HOLE TECHNIQUE



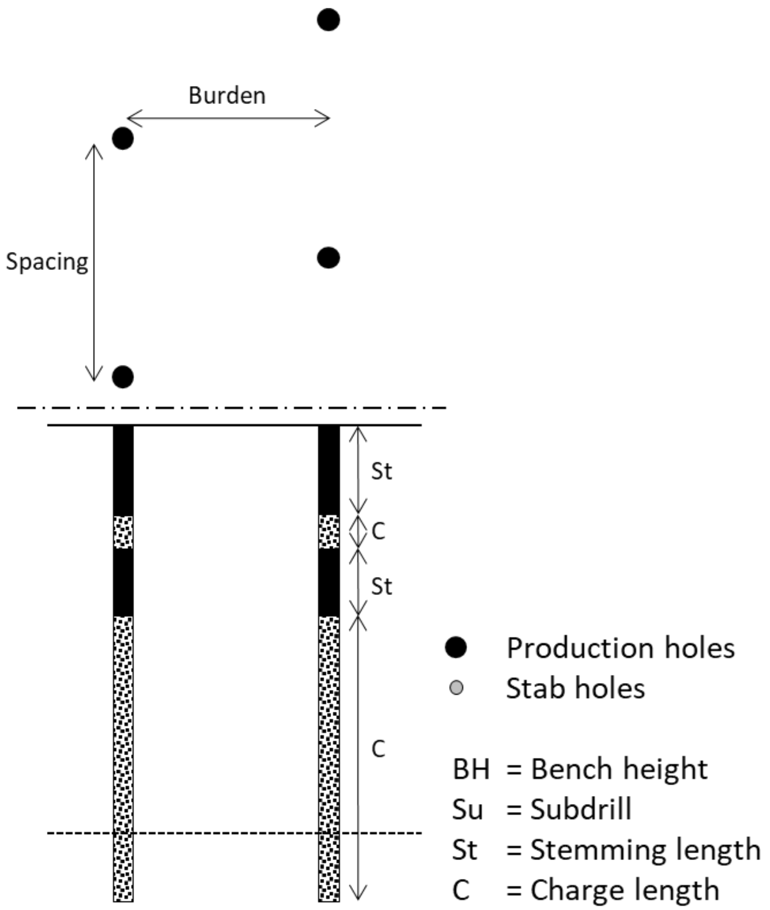

## ADVANTAGES

- Better fragmentation of the top of the bench.

## DISADVANTAGES

- An extra drilling stage is required for the stab holes.
- Stab holes need to be manually loaded due to small diameter.
- Three times the number of holes and twice the amount of drilling required.
- The pattern is very hard to navigate with machinery.
- Increased risk of flyrock and larger exclusion zones for equipment.

# STEM DECK TECHNIQUE



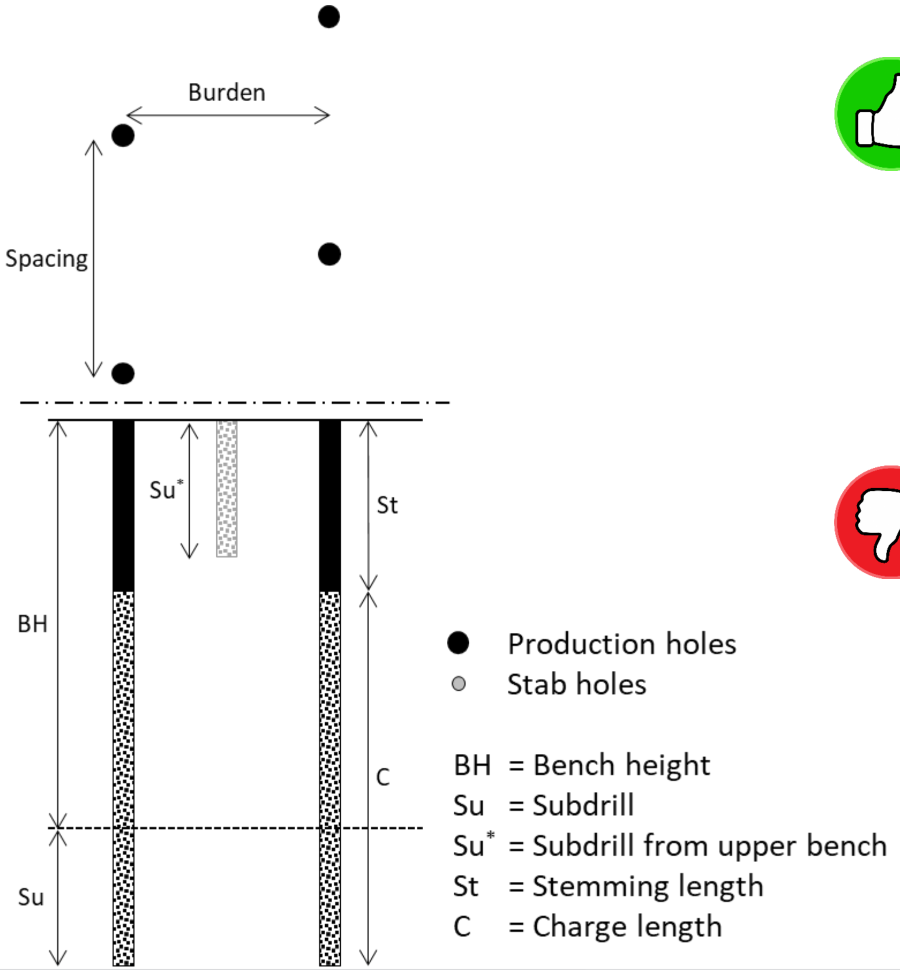

## ADVANTAGES

- Better fragmentation of the top of the bench.
- No extra drilling required.
- Technique can be applied as required.

## DISADVANTAGES

- Electronic initiating systems required.
- Accurate loading of explosive and stemming decks required.
- Loading a hole requires multiple visits or passes.
- Increased risk of flyrock and larger exclusion zones for equipment.

# PRECONDITIONING TECHNIQUE



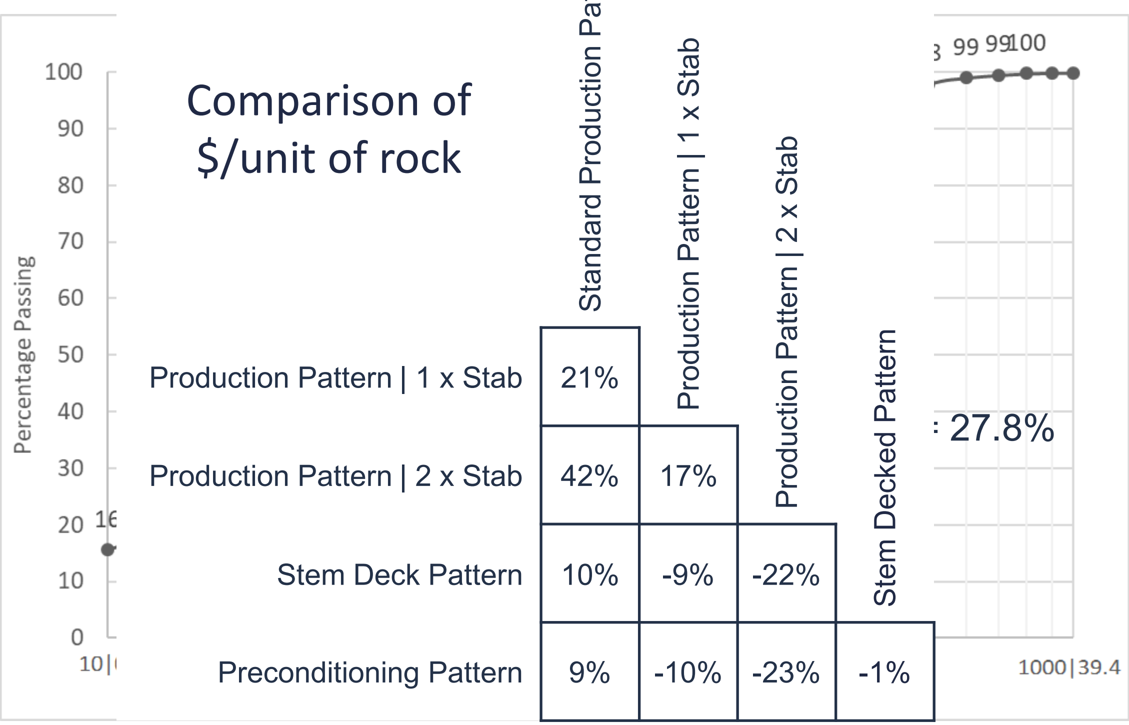

## ADVANTAGES

- Complete fragmentation of the top of the bench.
- Holes can be loaded in one pass.
- Non-electric or electronic initiation can be used.
- Decreased risk of flyrock, smaller exclusion zones.

## DISADVANTAGES

- Drilling through wet, broken ground is challenging.
- Rotary drilling is more successful than percussive.
- The preconditioned rock can become unstable and collapse.
- Preservation of hole depths is critical.
- Over mining the bench is easier for the excavators.

# PRECONDITIONING RESULTS


Comparison of $/unit of rock

| | Standard Production Pattern | Production Pattern \| 1 x Stab | Production Pattern \| 2 x Stab | Stem Decked Pattern |
|---|---|---|---|---|
| Production Pattern \| 1 x Stab | 21% | | | |
| Production Pattern \| 2 x Stab | 42% | 17% | | |
| Stem Deck Pattern | 10% | -9% | -22% | |
| Preconditioning Pattern | 9% | -10% | -23% | -1% |

# PROTECTING HOLE DEPTH

- To **preserve** hole depths a reusable device, called a Collar Keeper™, was invented to **prevent** collar rock and drill cuttings entering the hole during:
  - Drilling the pattern;
  - Adjacent blasting;
  - Priming; and
  - Loading explosives.

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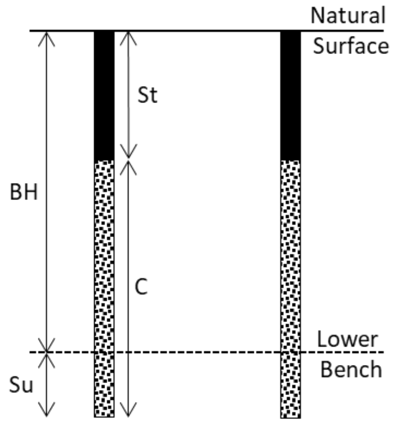
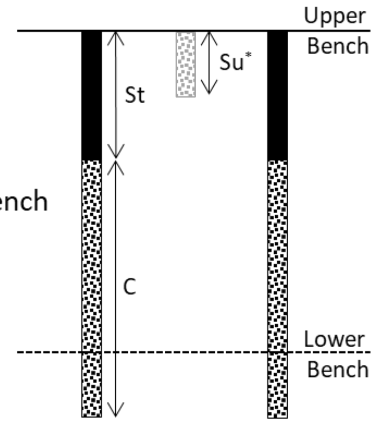
  - Adjacent Blasting;
  - Priming; and
  - Loading explosives.

# QUANTIFYING ENERGY IN BLASTING

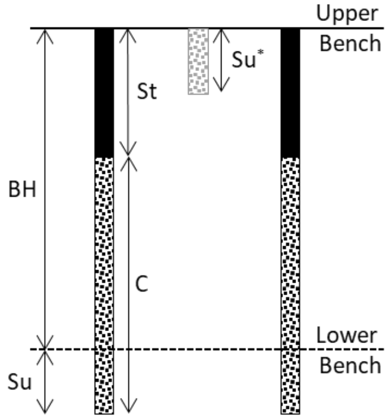
- Powder Factor
  - Ignores energy contributed by the subdrill of the previously fired bench.
  - If the upper and lower patterns are different the technique cannot be used.




BH = Bench height
Su = Subdrill
$Su^*$ = Subdrill from upper bench
St = Stemming length
C = Charge length




- Vertical Distribution
  - Explosive distribution calculated as a percentage of the bench height.
  - If the upper and lower patterns are different the technique cannot be used.



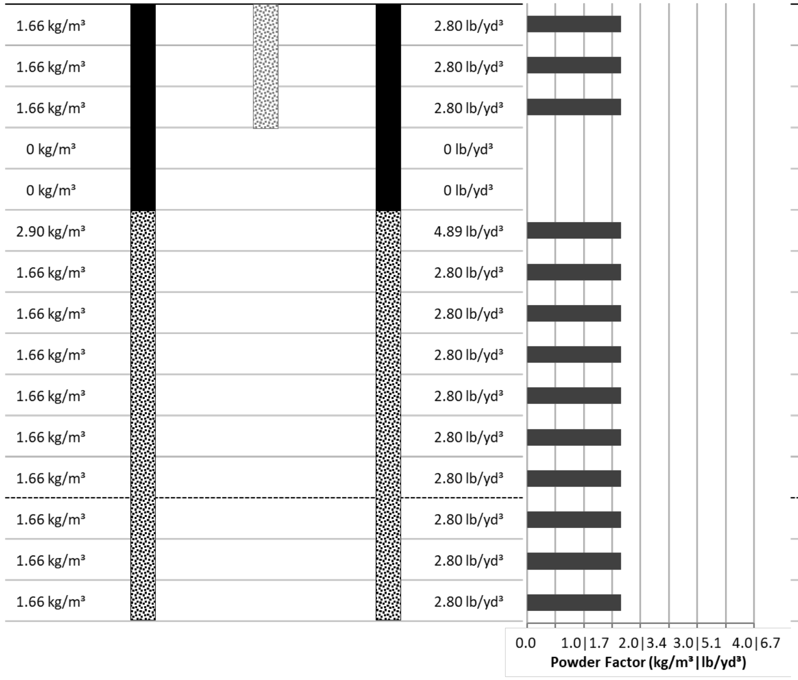

$$\mathbf{VD} = (\boldsymbol{BH} - \boldsymbol{St} + \boldsymbol{Su}^*)/\mathbf{BH}$$

Where,

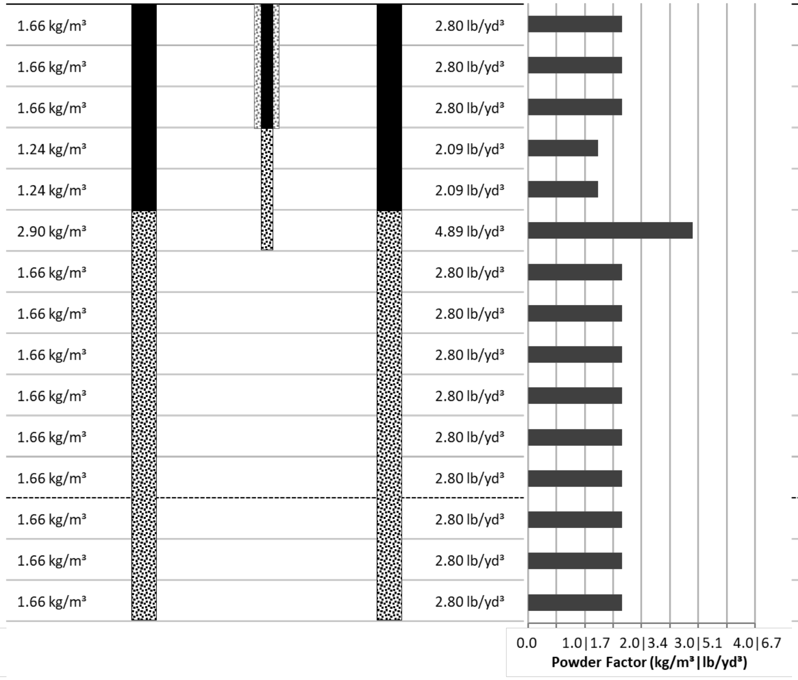
VD = vertical distribution of the explosives in the bench (%)
BH = bench height (m/ft)
St = stemming length (m/ft)
$Su^*$ = subdrill length from upper bench (m/ft), where present

# LINEAR POWDER/ENERGY FACTOR

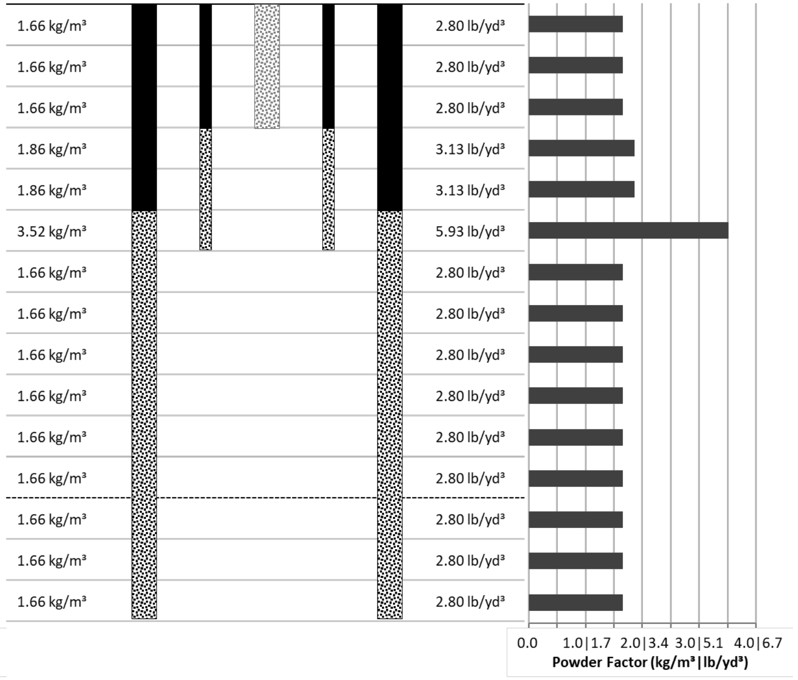
## STANDARD DESIGN




## SINGLE STAB HOLE DESIGN

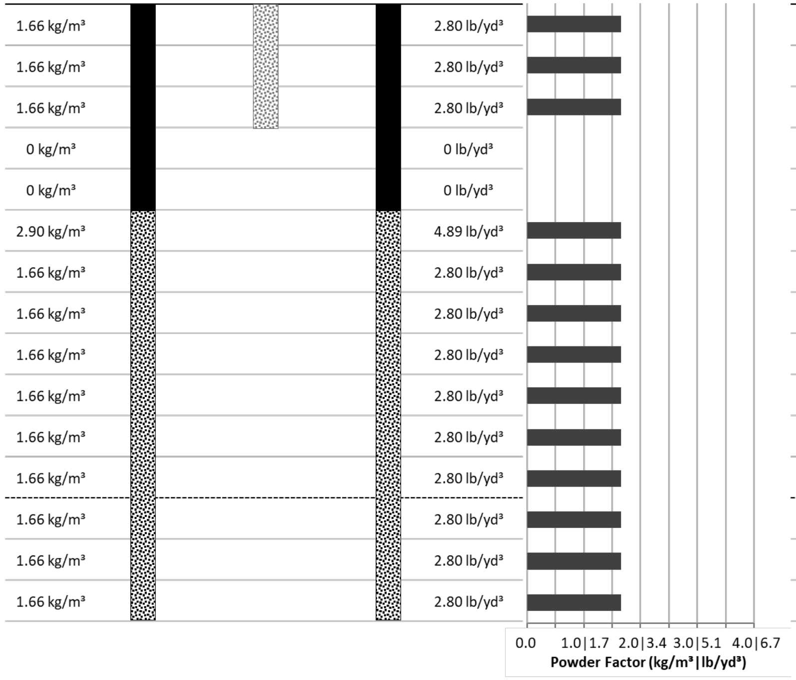



## DOUBLE STAB HOLE DESIGN

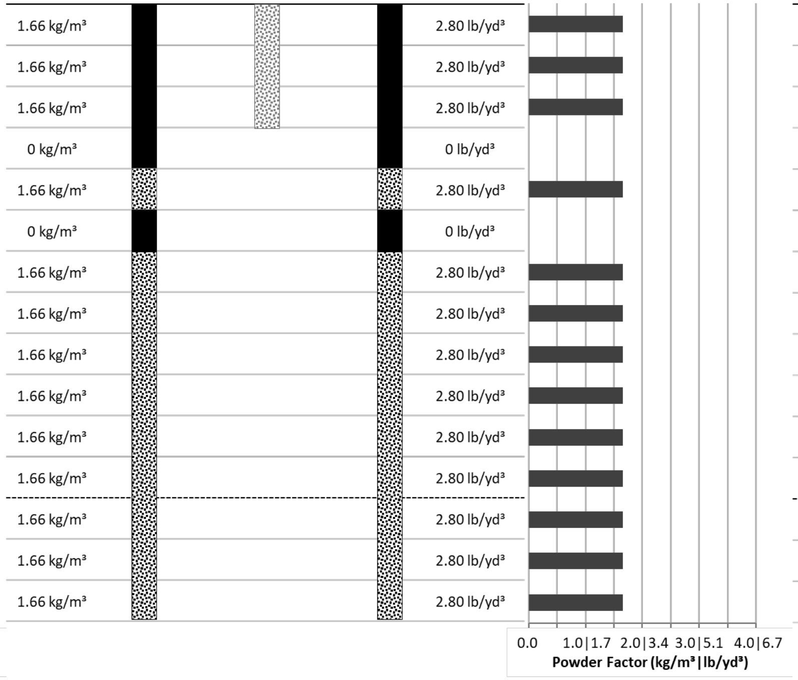


# LINEAR POWDER/ENERGY FACTOR

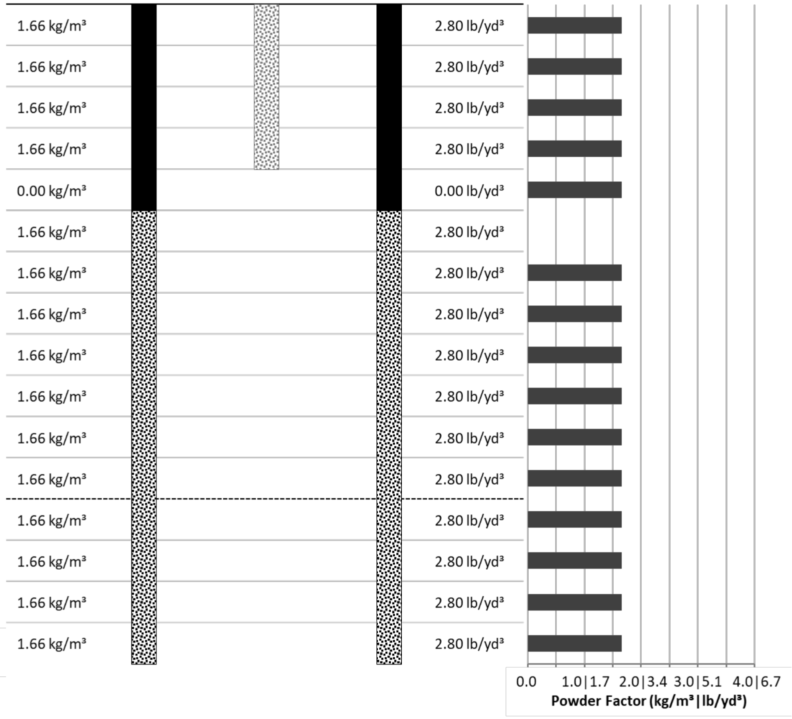
## STANDARD DESIGN




## STEM DECK DESIGN

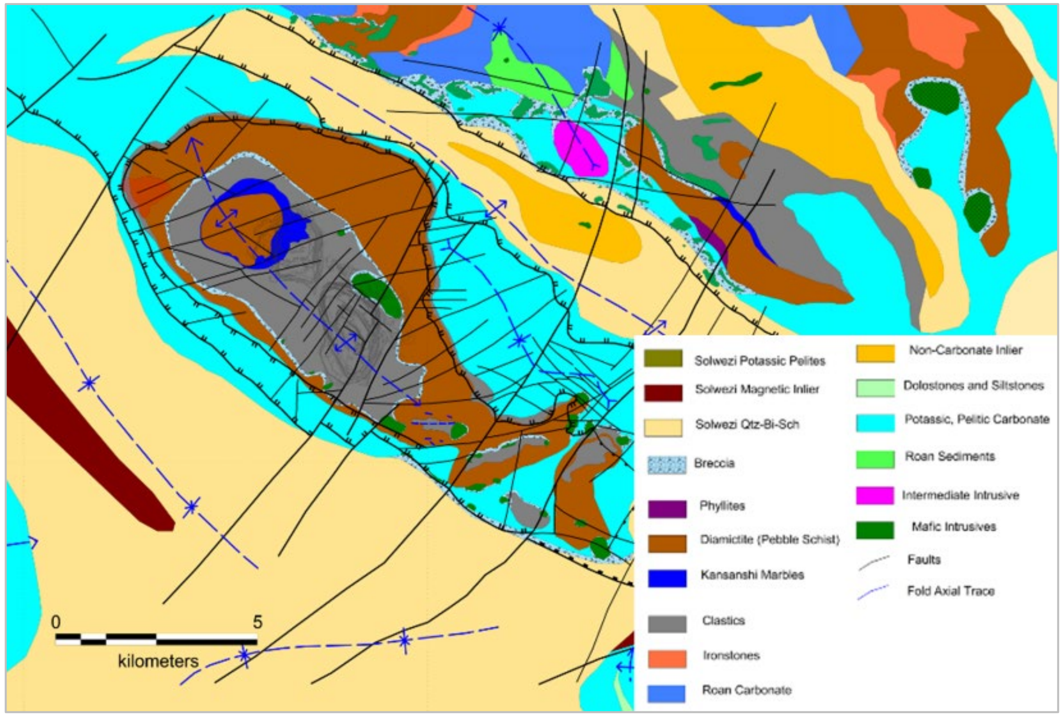



## PRECONDITIONING DESIGN



# KANSANSHI MINE

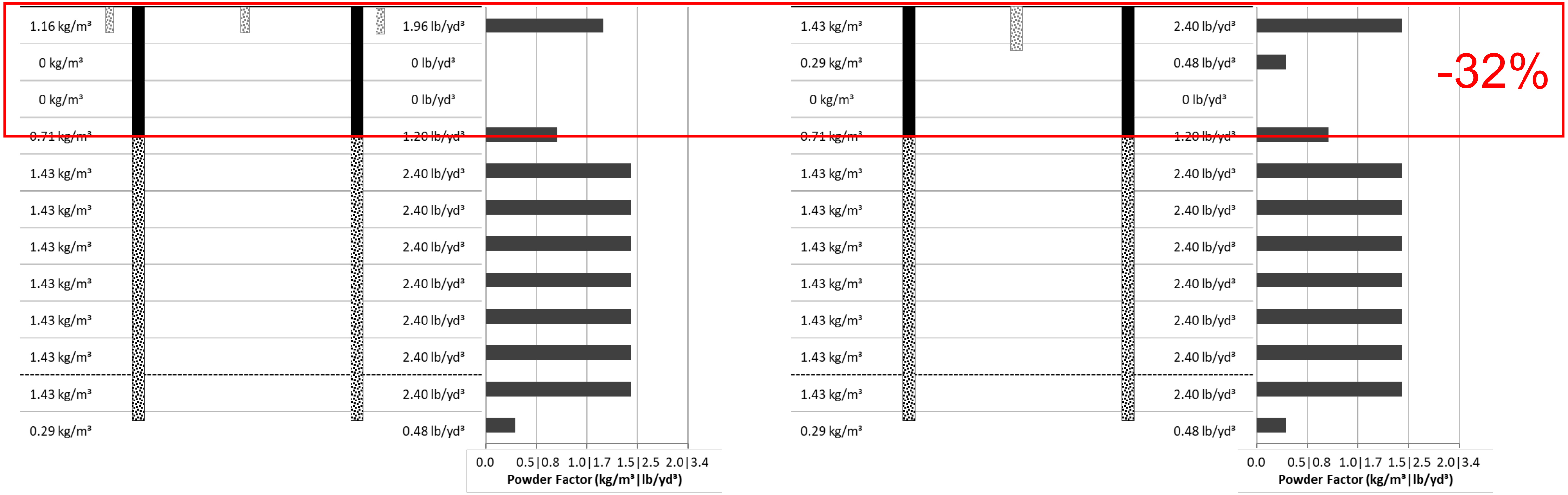
- Located 10 km (6 mi) north of the town of Solwezi in the North Western Province of Zambia.
- Mineralisation in sub-vertical veins, select lithologies and occasional fault breccia zones in the “Domes Region of NW Zambia.
- Two large open pits producing approximately 230 ktonne of copper and 130,000 ounces of gold annually.
- Mining occurs in 5 m (16.4 ft) and 10 m (32.8 ft) benches.



# KANSANSHI MINE

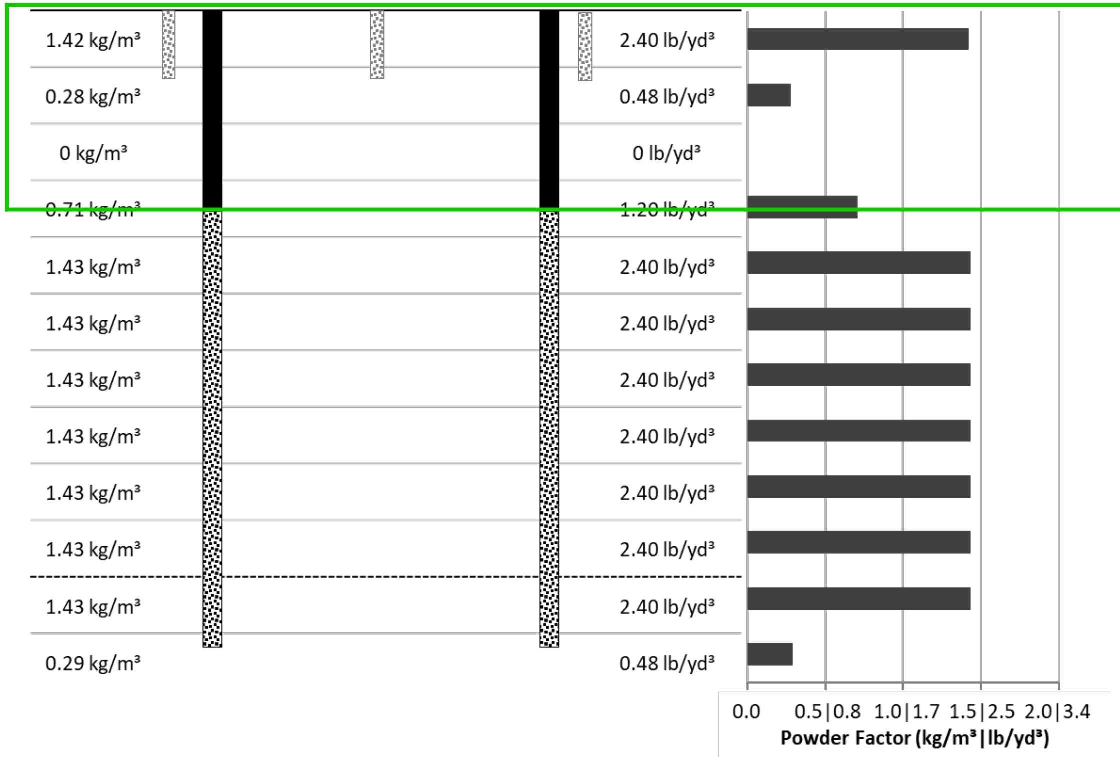
## 5m BENCH TO 10m BENCH

## 10m BENCH TO 10m BENCH

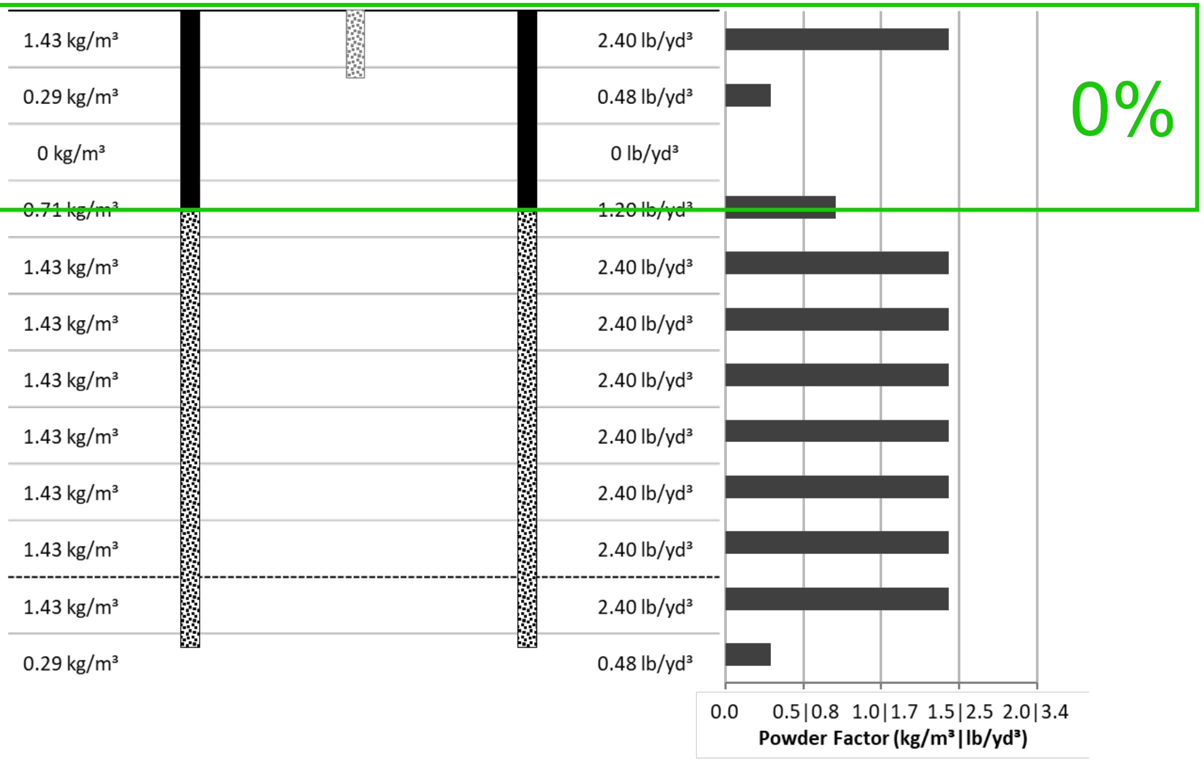


# KANSANSHI MINE – NEW DESIGN

## 5m BENCH TO 10m BENCH




## 10m BENCH TO 10m BENCH



# KANSANSHI MINE – NEW DESIGN

# SUMMARY

- Subdrill is not only a parameter for achieving the target bench level.
- Subdrill is essential in **preconditioning** the top of the underlying bench.
- Remember to consider the **impact** of subdrill on the **underlying** bench
- **Preserving** hole depths through the full life of a hole is **critical** for success.
- Linear powder factor can be used to better **compare** and **communicate** energy in a bench blast.

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# QUESTIONS?

THANK YOU

FIRST QUANTUM
MINERALS