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Real Mining. Real People. Real Difference.

Anglo American Platinum

MOSH DRILLING & BLASTING

The Story of Good Drilling Practice

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13 November 2014

CONFIDENTIAL

AGENDA

1. What changed?
2. Jumpers & bits
3. Rotation & percussion
4. Thrust leg
5. Direction
6. Flushing
7. Burden & Hole ϕ
8. Energy sources
9. Timing & UOD
10. People
11. Results
12. Conclusion

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1. What changed?

History of Rock Breaking from 1700 to 1889

- The arm of the early miner acts as a thrust mechanism to ensure contact of the chisel with the rock.
- The hammer striking the chisel imparts impact resulting in indentation of the rock face.
- The wrist of the miner facilitate rotational indexing to deliver the formation of successive rock indentations adjacent to each other.
- The stresses resulting from the indentation impact, forms sub surface cracks which propagates from one indent to the following, to achieve rock breaking and chip formation.

Evolution of the Rock Drill from 1889 to 1950

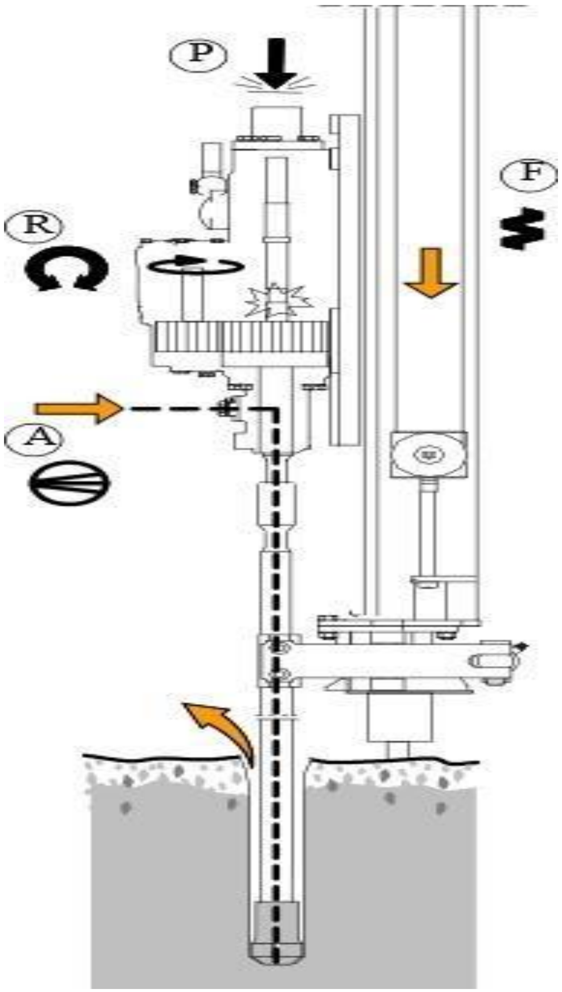
- 1889 - Atlas Copco develops the first drill driven by compressed air.
- 1905 – The first light weight drills were introduced with pneumatic impact and hand operated rotation.
- 1930 – The first light weight drills with percussion and rotation were introduced
- 1935 – Atlas Copco developed the first pusher leg which pioneered the “Swedish Method” of rock breaking
- 1945 – The first rock drilling bits with Tungsten carbide inserts were introduced.

Status quo pertaining to Rock Drilling today

In 1960 Professor HL Hartman stated the following:

- The past 15 years have seen rapid advances in the metallurgy of materials for drill machinery and bits, but rock drilling itself continues to be largely an art.
- The percussion rock drill, still used for 90% of the blast holes drilled in hard-rock mining, has undergone no major modification since pneumatic machines were first used successfully in the 1860's.
- More and more, in recent years, investigators in the field have come to realize, that to understand percussion drilling, they must study the basic action of percussion bits penetrating rock—not the performances of commercial rock drills, with their many attendant variables that cannot be isolated or controlled.

The mechanism that improves Best Practice Drilling

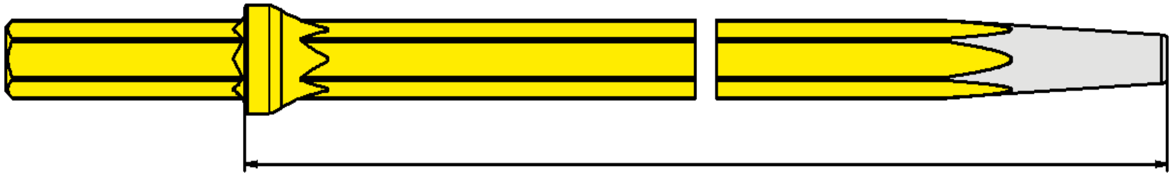


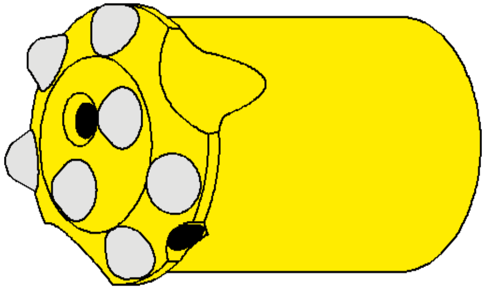
- **Sufficient flushing water (A) removes the broken rock chips produced during rotary percussion drilling** *(The quantity required varies between rock types).*
- **Percussion impact (P) creates the stress craters on the rock face** *(Blow energy varies inversely with increase in blow frequency).*
- **Bit rotation (R) creates the correct rotation index to ensure crack propagation resulting from (P)** *(The optimum index varies for different rock types and should be tested at regular intervals for optimum rotation speed).*
- **Feed Force (F) prevents loss of contact with the rock face thus ensuring minimum loss of blow energy.** *(The optimum thrust force varies for different rock types and should be tested at regular intervals to ensure optimum penetration rates).*
- **Drill string life and optimum penetration rate is responsible for achieving the optimum cost per hole drilled.** *(Improved drill bit life, Improved drill steel life and reduced drilling time per hole).*

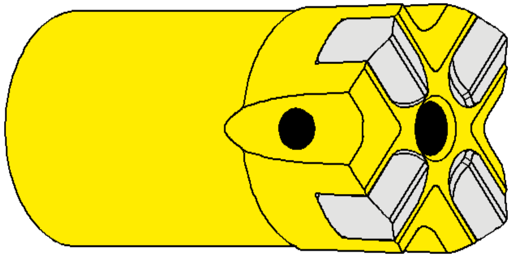
2. Jumpers & Bits

2. Jumper & Bits

1. **Move from rubber collars to forge collar's.**
2. **Move from integral steal to button bit steal.**
3. **Drilling faster / penetrating faster / water pressures?**







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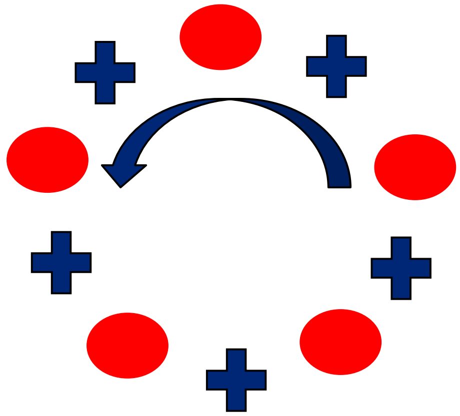
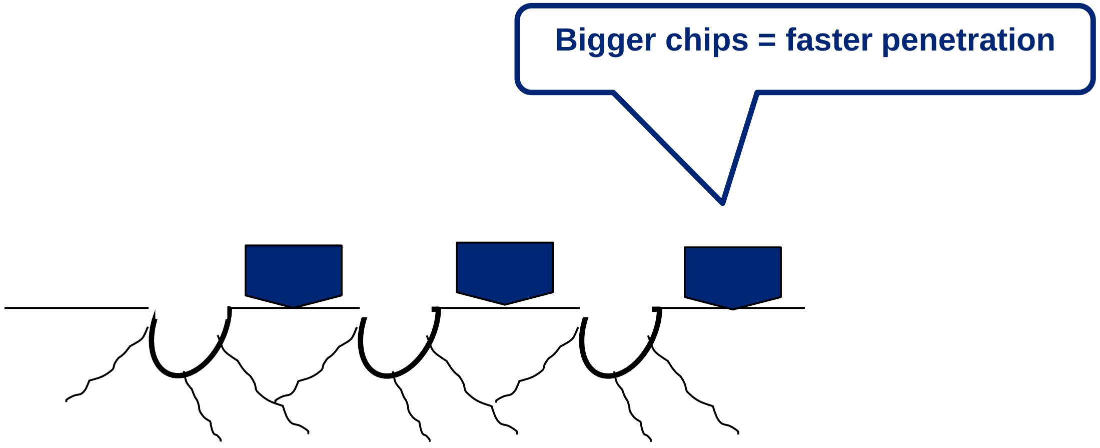
3. Rotation & Percussion

3. Rotation & Percussion

- Rotation very important to get right index for excellent drilling.
- Different compressed air levels = Different frequency Hz
- Cause for more Grind = Less penetration





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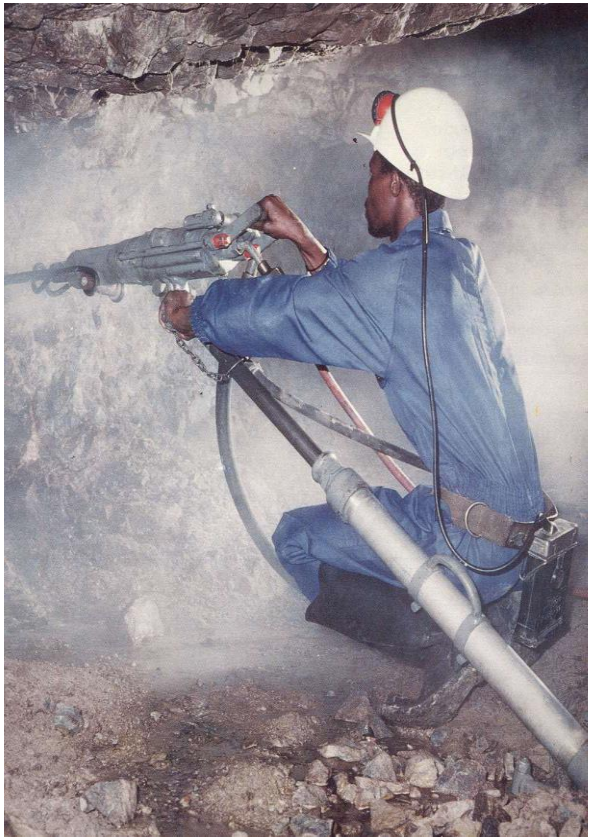
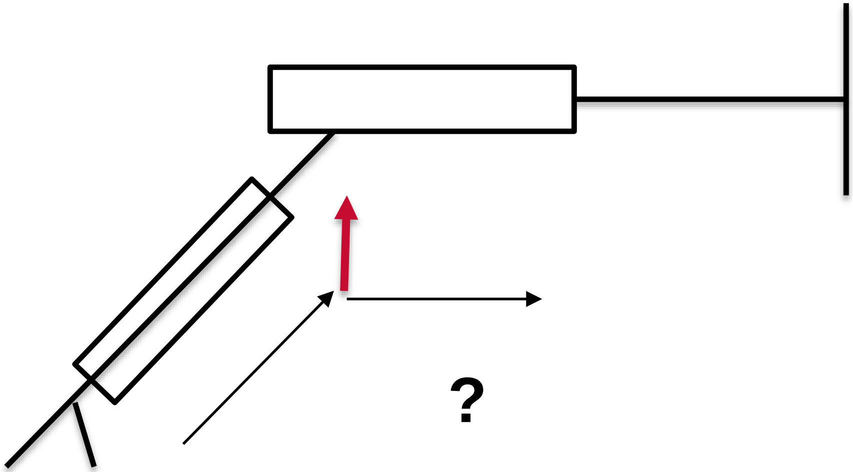
4. Thrust Leg

4. Thrust leg



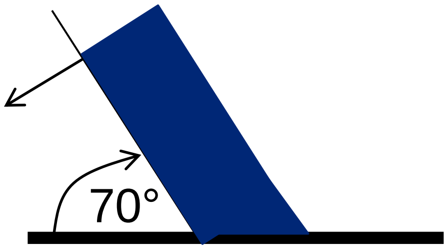
- Great invention
- Effectiveness controlled by operator
- Portion of thrust energy used.

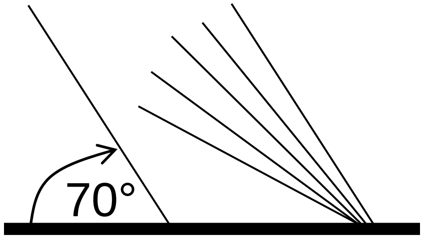


Angle that cause optimal performance.

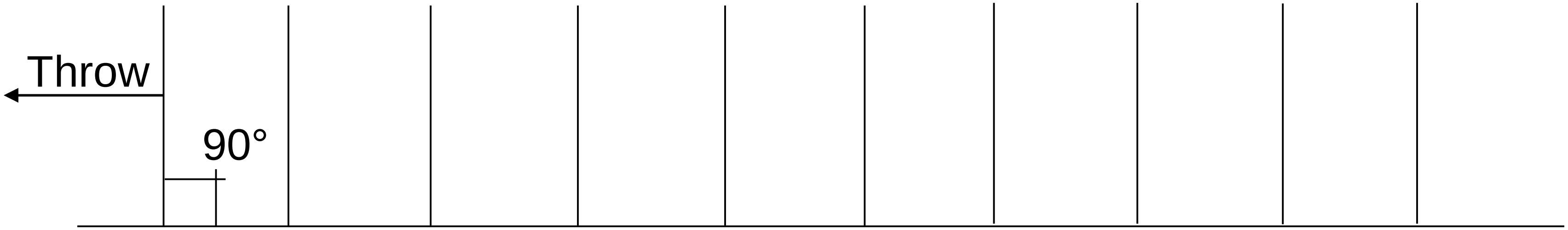
5. Direction

5. Direction





- **All trained 70 is the angle = Free face.**
- **Old fuse ignite cord 99 – 121s/meter delay .**
- **One hole at a time.**
- **Small area to move 1m x 0,5 x 0,5 x 2,78 = 0,7 t's**



- **150 holes =1,2m x1,0m x 25m x 2,78 = 84t's (120 x more rock same time).**

Meizmar Hole Director

Correct collaring (position)
Correct direction
Correct burden (toe end)
Correct spacing
Correct length of hole

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6. Flushing

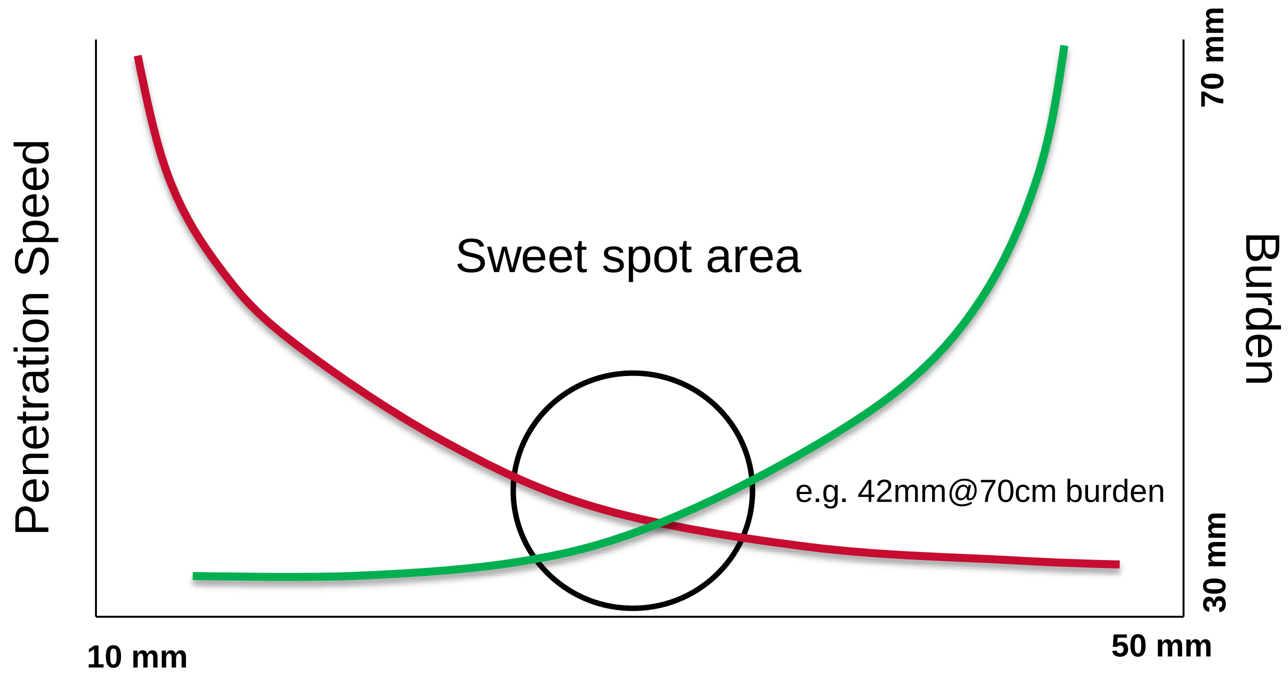
6. Flushing

- Water pressure = do you have enough?
- Penetration = Flushing / bit size.
- Rule of thumb do not count if you double rate.
- Need to have control on flushing.

7. Burden & Hole ϕ

7. Burden & hole ϕ

- Burden & hole ϕ play a crucial part in good drilling:
  - ✓ Bigger the hole the wider the burden!
  - ✓ Bigger the hole the slower the penetration.



➢ Parameter holes must have smaller burden to protect excavation size.

8. Energy Sources

8. Energy sources

- Man power.
- Compressed air.
- Hydraulic oil.
- Hydro power.
- Electric.

- Percussion is the killer:
  - ✓ Knuckle disease.
  - ✓ Frame cracks.
  - ✓ Machine vibration fatigue.

  Compressed air efficiency = 30% of energy used.

  Hydraulic oil = Contaminating effect.
- Hydro power = Power packers and attenuator - high maintenance.
- Electric = Not refined yet/electric shock.

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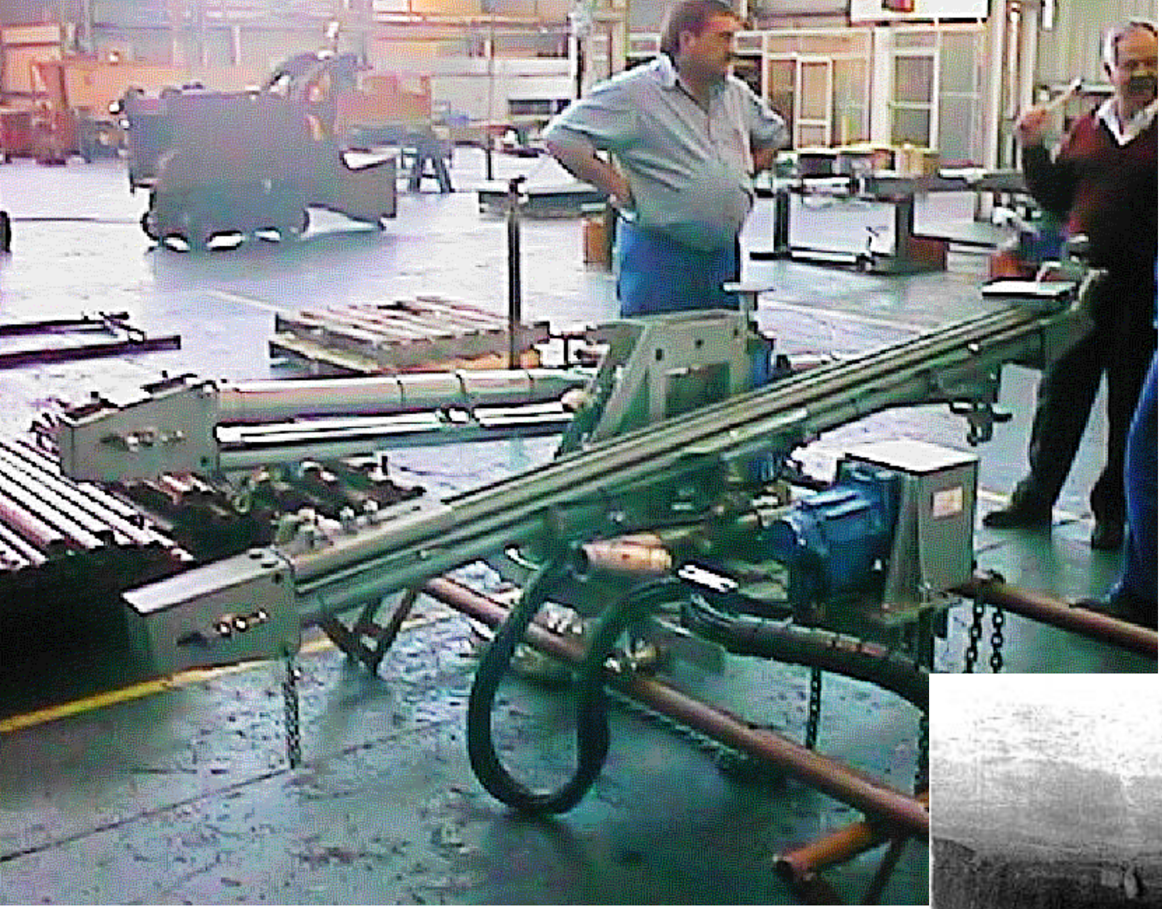
1990s onwards

Simple square pipe rail mounted drill feeder, where the thrust device is a cable hauled cylinder

All pneumatic twin rail mounted Stope Drill rig



1979 - 2000

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Level 5

1999 - 2002

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One solution from D.D.T.
Hanging Wall Mounted drilling equipment

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9. Timing & VOD

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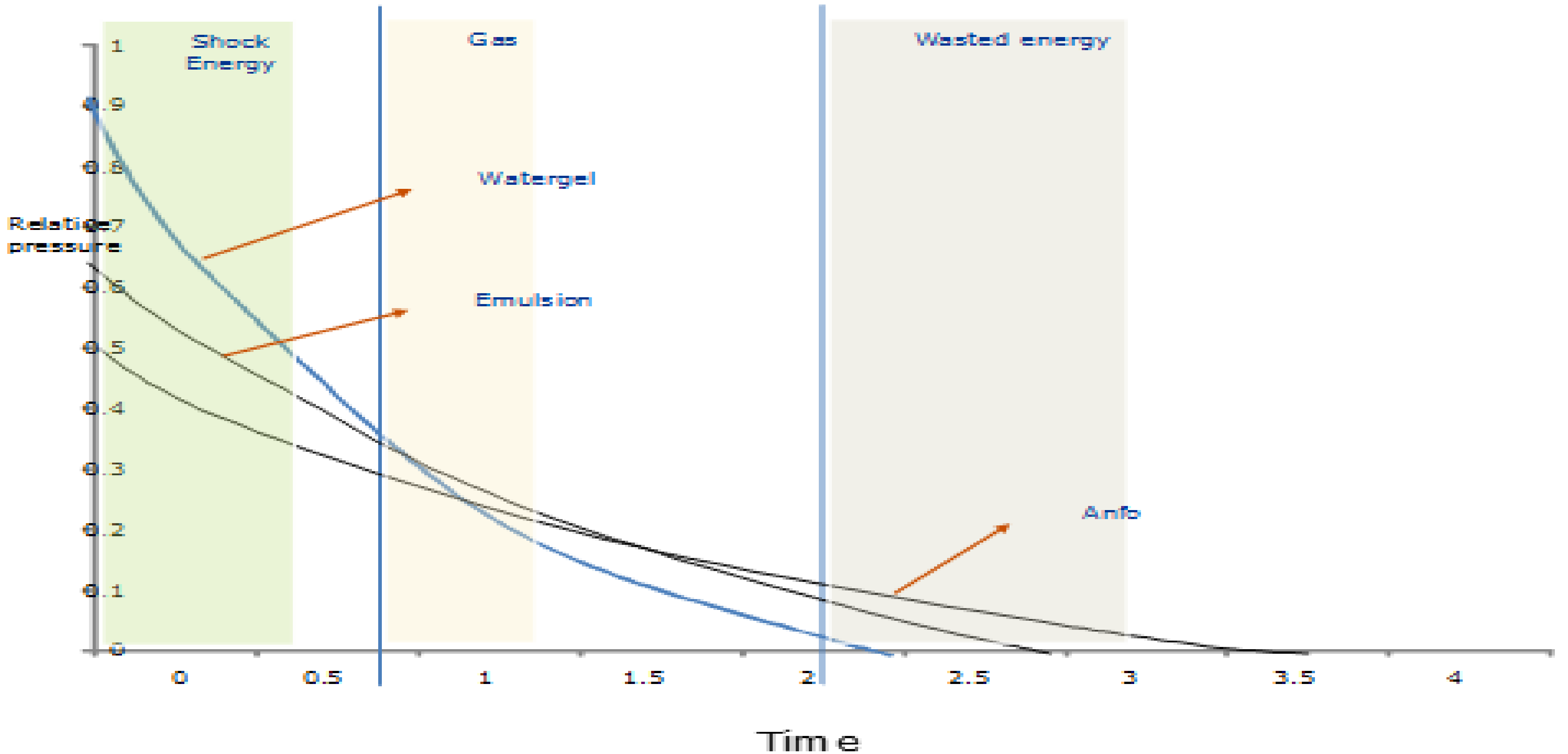
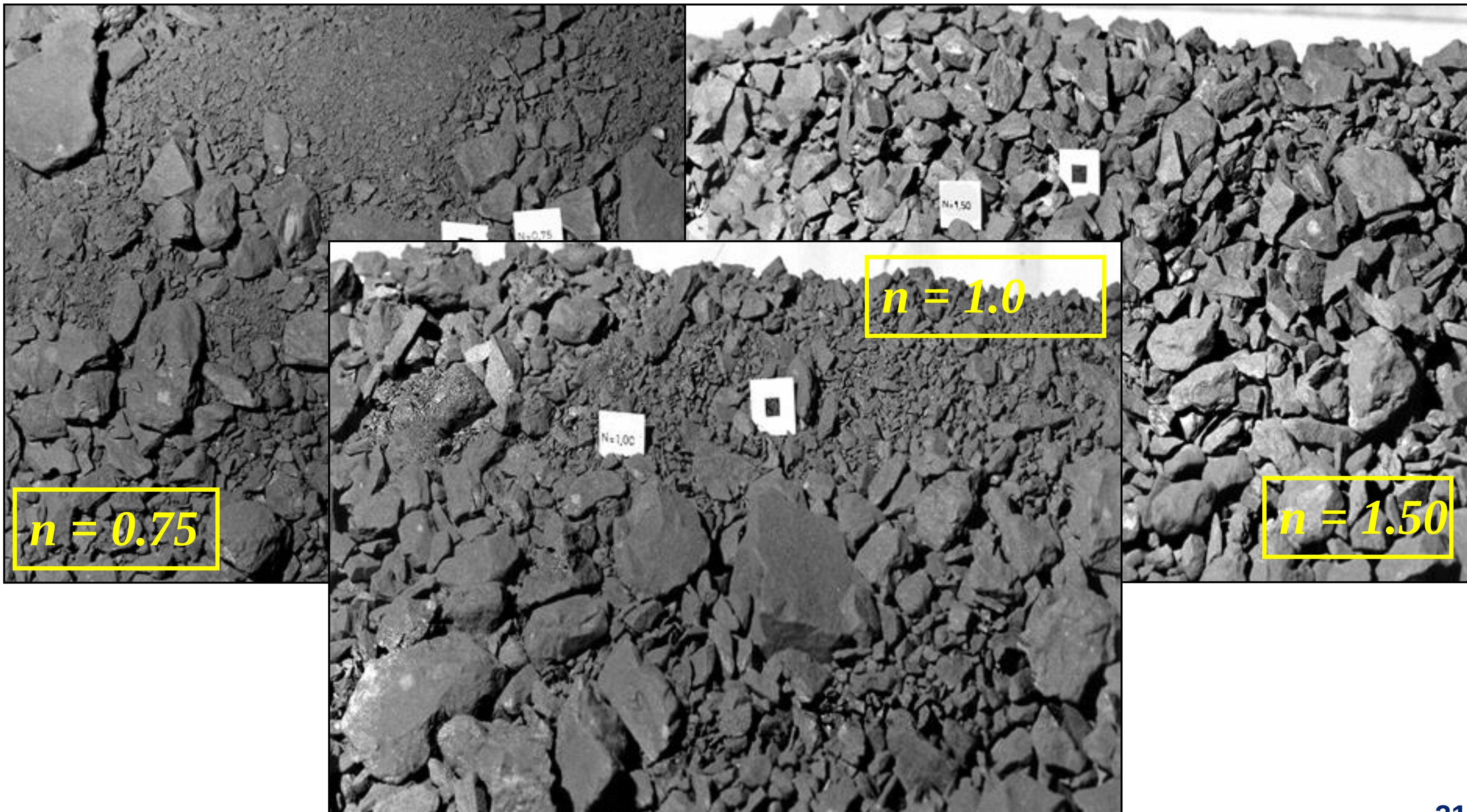
- Need to acknowledge the advancement in explosives.
- Velocity of detonation determining fragmentation size/through.
- Density changes = cause better conditions.




n = 0.75
n = 1.0
n = 1.50

10. People

10. People

- Top & Bottom Limits (Supervision points).
- Direction lines.
- Charging sticks = check direction/depth.
- Temporary support installation v/s marking.
- Clear Standards.
- Proper training & discipline.
- Incentive = Motivation.

11. Results

11. Results

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Fragmentation

(Blasts on Sunday morning 2013-08-18 after 4 days intensive coaching of Crew)

2013-08-15

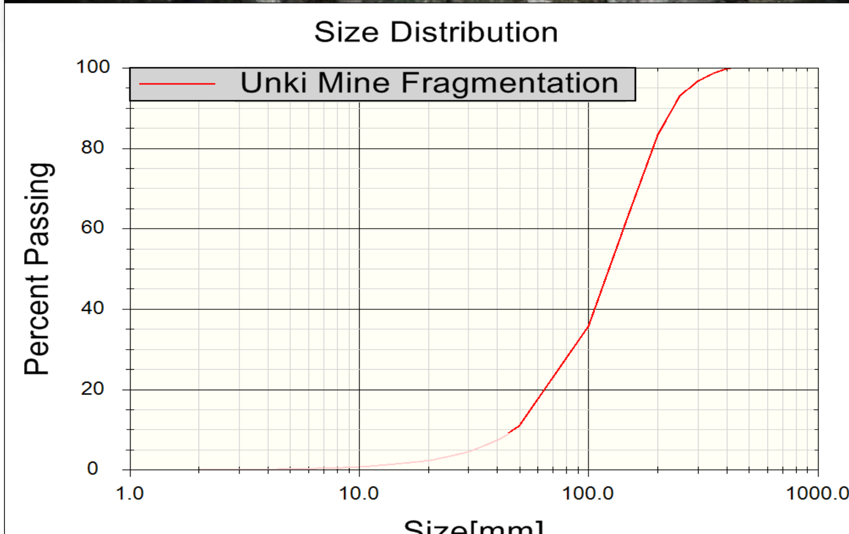
2013-08-18

Muck Pile

(Blasts on Sunday morning 2013-08-18 after 4 days intensive coaching of Crew)

Fragmentation

(Blasts on Sunday morning 2013-08-18 after 4 days intensive coaching of Crew)



SPLIT DESKTOP **Pass Rate Currently – 96.61** SPLIT ENGINEERING

Hanging Wall

12. The way forward

We need to mechanize

Remove the percussion effect

Find better energy source

Improve fragmentation

Become more effective and efficient

12. Conclusion

12. Conclusion

Mining starts with a hole in the face!

Good Drilling is absolutely important.