Drill & Blast Workshop

L. Mirabelli and A. Lislerud

QUARRY ACADEMY

Improving Processes. Instilling Expertise.

QUARRY ACADEMY

Balcones Quarry – 11.19.2014

Rock type	***Limestone***
Bench height	***72 – 88 ft***
Drill-hole	***Ø6½"***
Spacing	***19 ft***
Burden	***25 ft***
Bottom charge	***15 ft / 35%Emul-65%ANFO***
Pipe charge	***~ 60 ft / ANFO***
Subdrill	***5 ft***
Uncharged	***10 ft***
Stem material	***½" - ¾"***
Rows	***1***
Hole delays	***39 ms / Digishot***
Primers	***Bottom 1 lb / Top ¾ lb***
	Same delay top & bottom

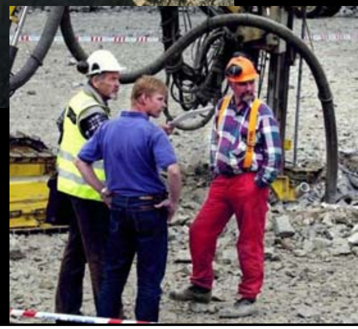
QUARRY ACADEMY

Safety of inpit operations

Tramming

Fire in motor

Drilling into dynamite



QUARRY
ACADEMY

Safety of inpit operations

- ***unwanted incidences do not just happen – they have root causes***
- ***actions can be taken so as to reduce frequency and consequences of unwanted occurrences***
- ***the relationship between complexity and knowledge in the workforce is often unbalanced - e.g. operator hazard training is a must!***

Premature ignition of electric detonators and blast due to lightning

Pit wall failure burying 3 drill rigs in rubble

QUARRY ACADEMY

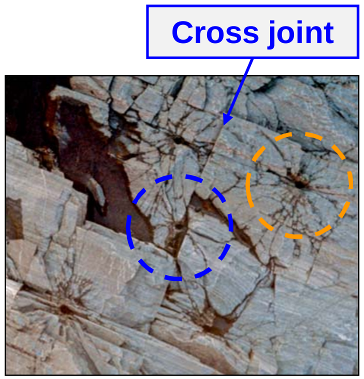
Some elements for successful blasting operations

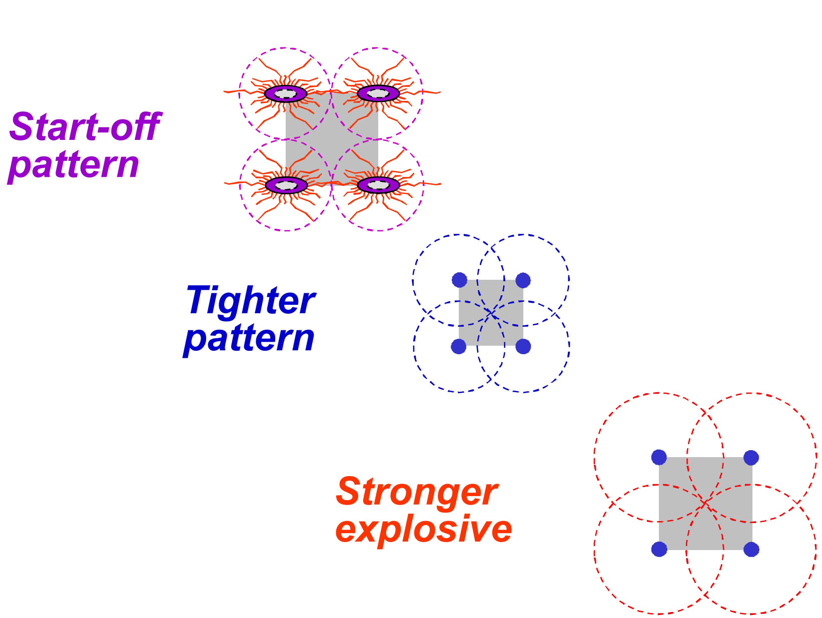
- ***match drill and blast patterns to rock conditions***
- ***match shotrock fragmentation to worksite requirements***
- ***match muckpile profiles to digger***
- ***rate explosives performance by VOD measurements***
- ***minimise blast damage in highwalls, control ground vibrations and flyrock***
- ***straight hole drilling***

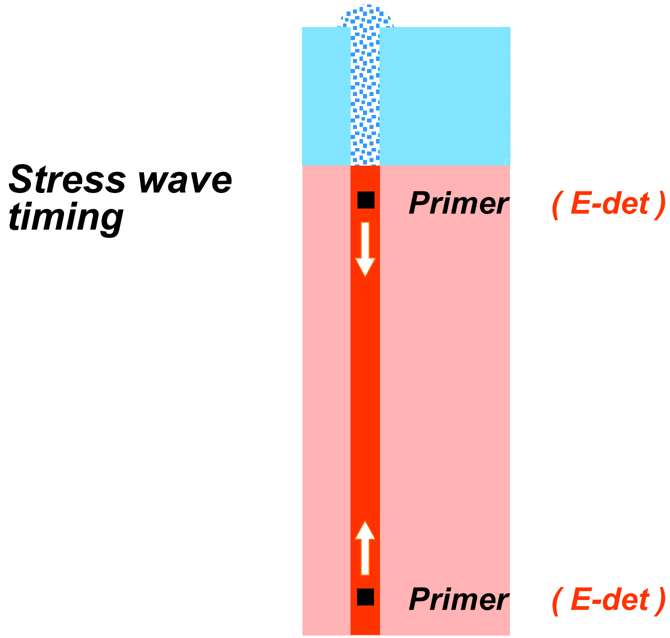
QUARRY ACADEMY

How finer fragmentation can be achieved

- *enhance overlap of <u>radial fractures</u> from neighbouring blastholes*
- *enhance growth of radial fractures by <u>stress wave re-enforcement</u>*



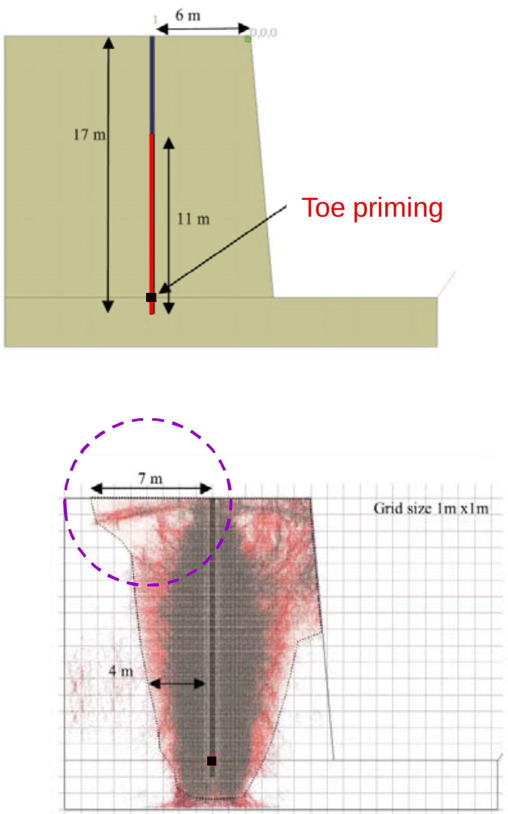


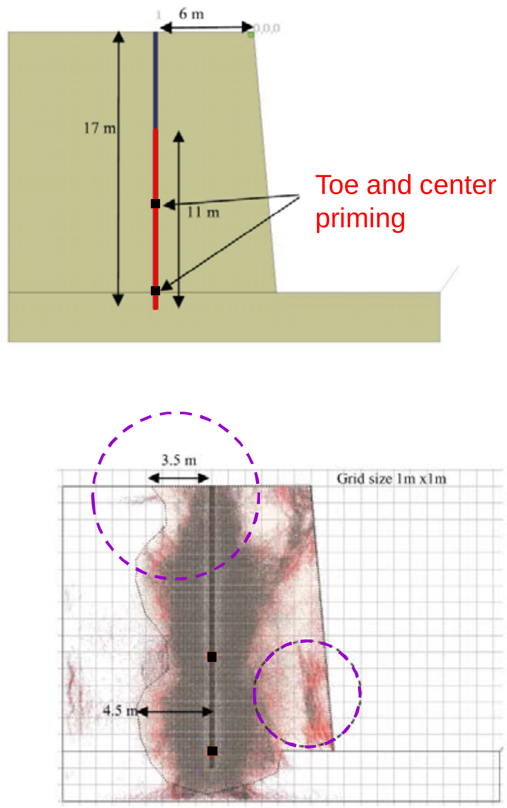


Example of blasting tighter drill patterns and use of E-dets

Blast damage reduction to crests

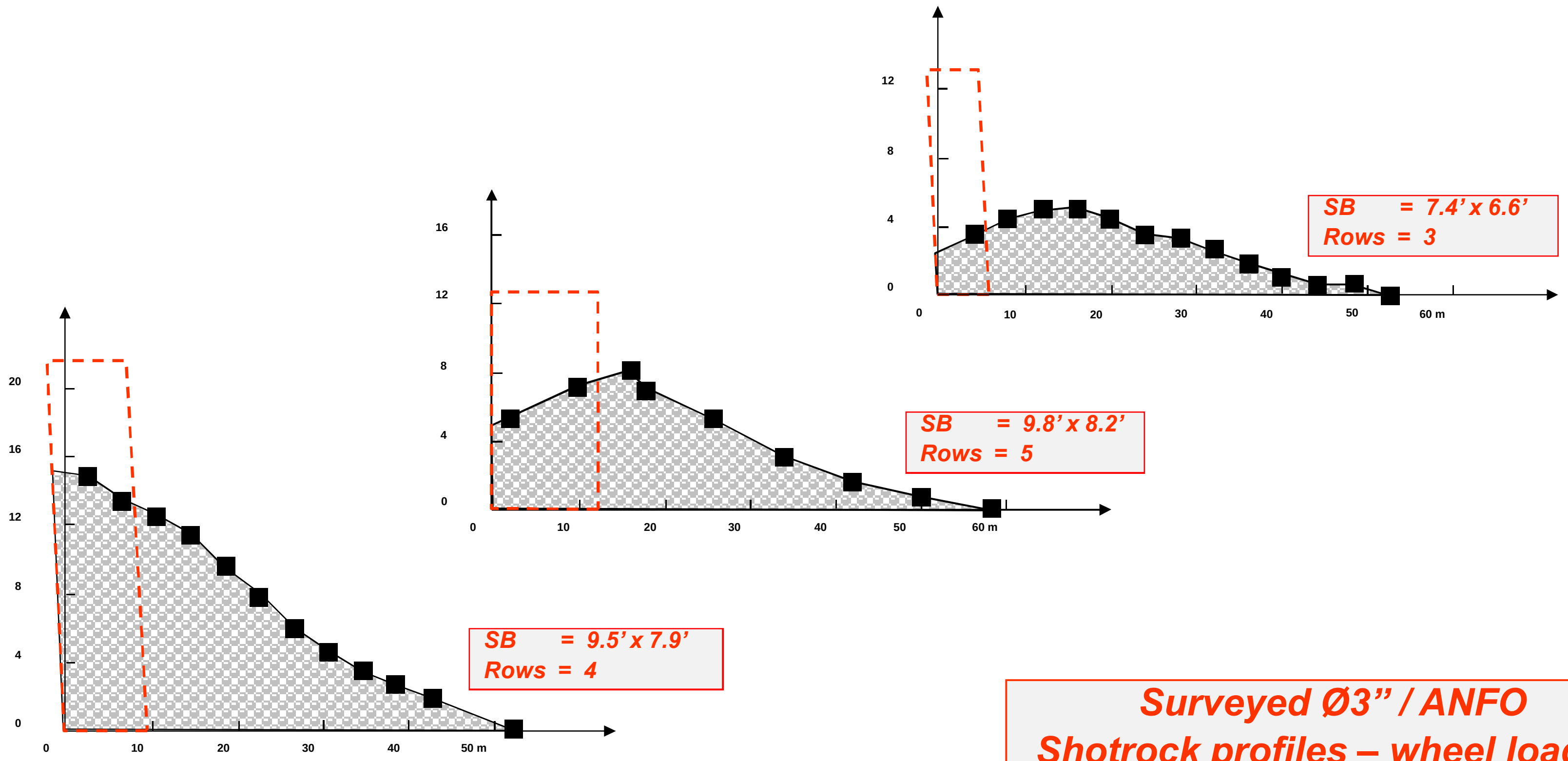
Example of HSBM modelling of a Ø9⅞" emulsion charged blasthole with E-dets





QUARRY ACADEMY

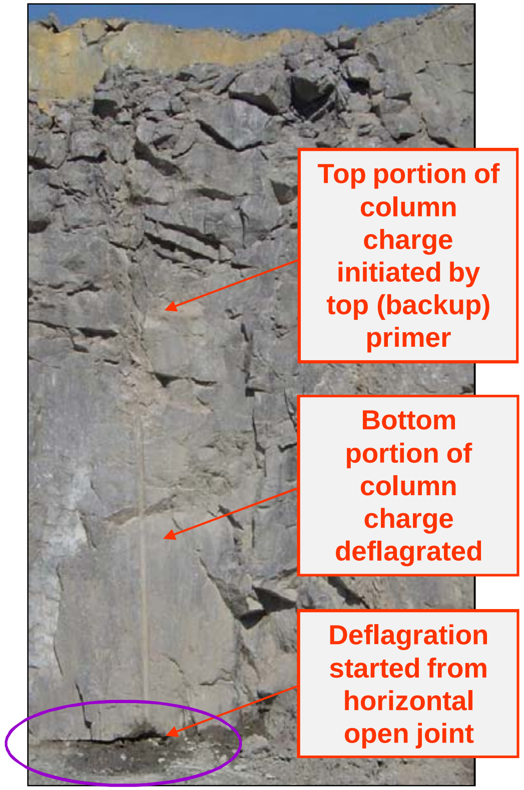
Shaping muckpiles to maximise dig rates

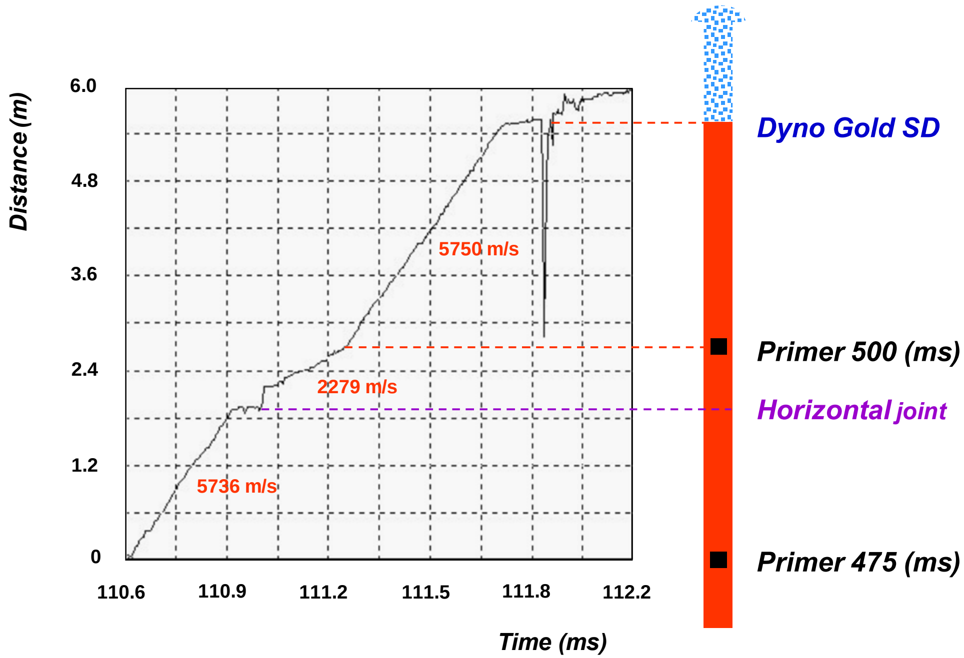


Surveyed Ø3" / ANFO
Shotrock profiles – wheel loaders

QUARRY ACADEMY

Explosives performance rated by VOD measurements

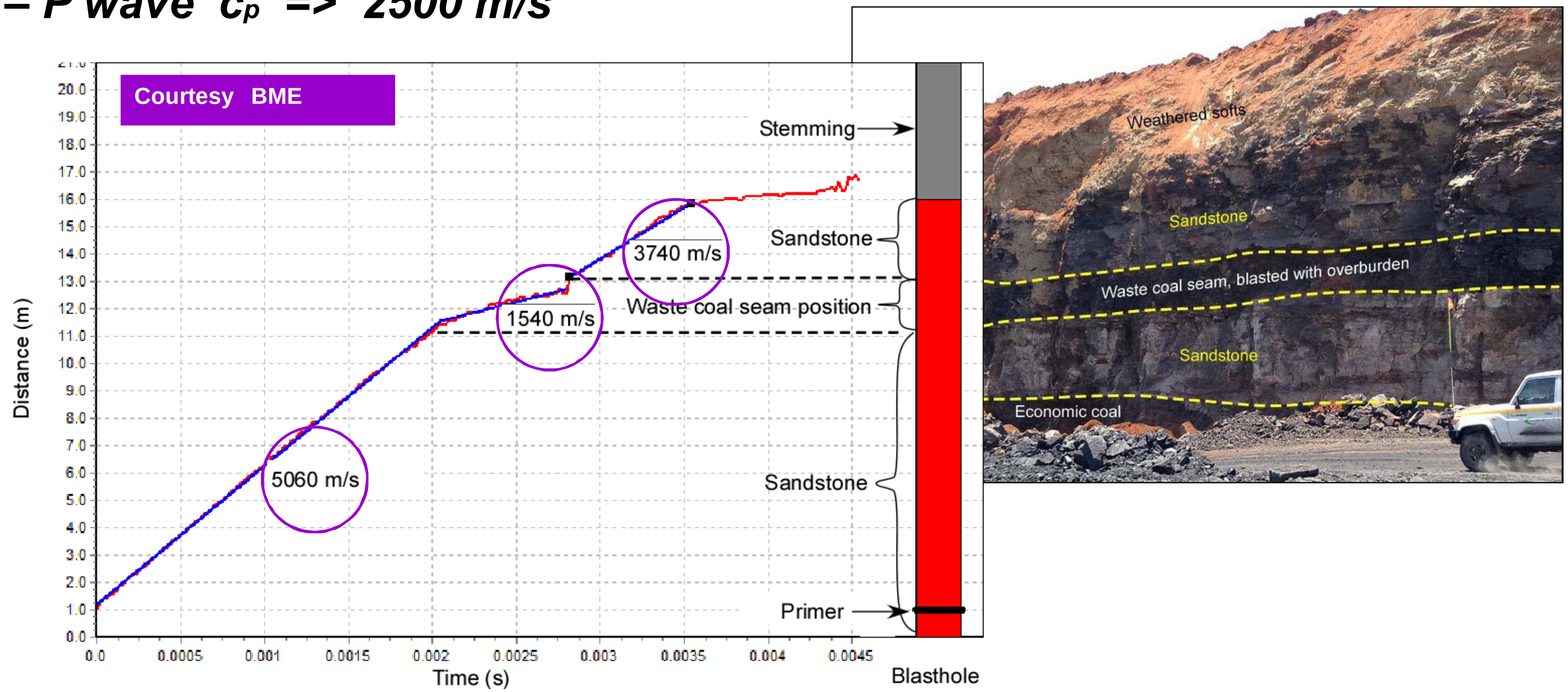




QUARRY ACADEMY

Explosives performance rated by VOD measurements

- ***Ø9⅞" – gassed emulsion blend***
- ***sandstone – P wave c_p => 3900 m/s***
- ***waste seam – P wave c_p => 2500 m/s***



QUARRY ACADEMY

Shocked loaded E-dets

- ***retrieved E-det from misfired blasthole internal electronic components damage by shock wave / pressure from adjacent blasthole***
- ***always consider time delay between adjacent blastholes and their effect on explosives or detonators***
- ***consider geology and water conditions in rock mass. Easy path for transmission of high shock / pressures.***
- ***select cast booster with shock resistant feature as best practice***
- ***brass sleeve within the detonator well. Protects the electronic components of the detonator.***

QUARRY ACADEMY

Some local site conditions

- ***hole size (versus backbreak)*** => *charge concentration (lbs/ft)*
  => *charge distribution (length of stem)*

- ***terrain benches*** => *excessive amount of boulders*
- ***shotrock fragmentation*** => *boulders, fines in shotrock and plant processing*

- ***backbreak*** => *difficult 1st row drilling*
- ***floor humps*** => *shotrock diggability*

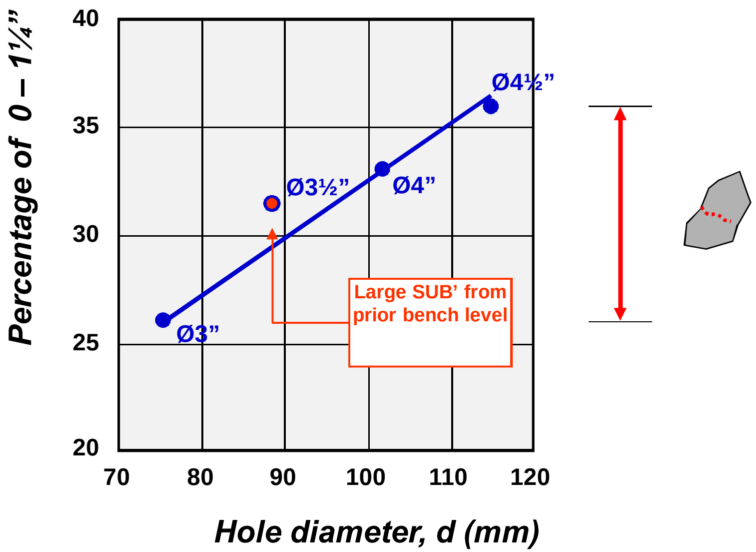
- ***drill-hole deviation*** => *floor humps, flyrock, broken steels, …*
- ***broken rock / open joints*** => *best with DTH*

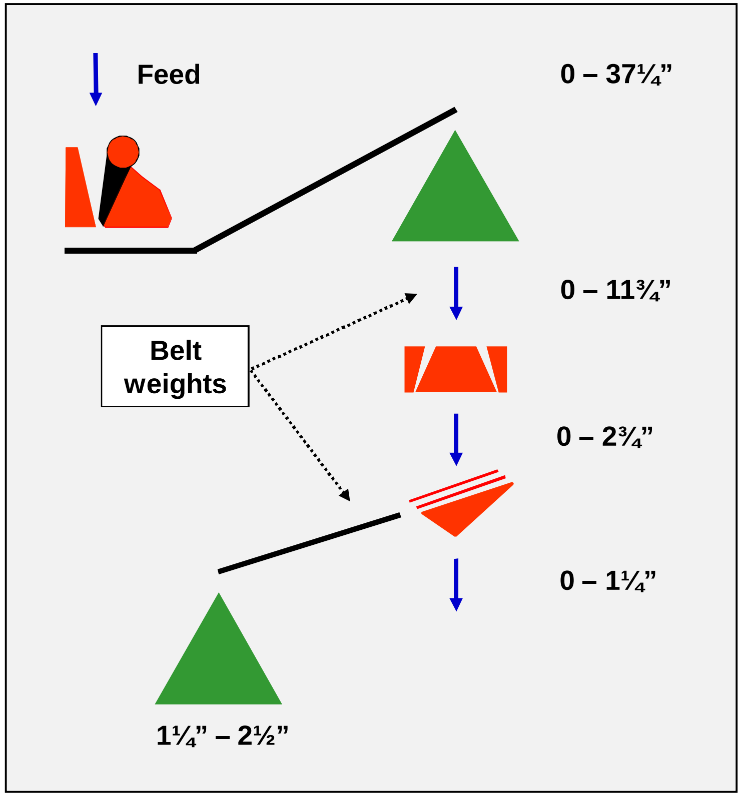
- ***blast vibrations*** => *record keeping, data analysis, neighbourly relations*

QUARRY ACADEMY

Quality plant feed – effect of fragment micro-fracturing

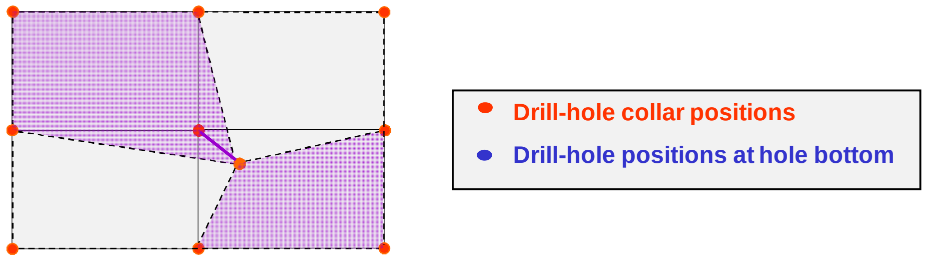
Rock type	*Anorthosite*
Explosive	*Gassed emulsion*
Test blasts	*4 x 50,000 tons*
Bench height	*36'*





What happens when we shoot holes that look like spaghetti?

- ***blast patterns change locally (at hole bottoms)***



- ***floor humps*** => ***poor loading conditions, uneven floors***
- ***poor walls*** => ***unstabile walls***
  => ***difficult 1st row drilling and blasting***
- ***flyrock from walls*** => ***safety, dust, toes, …***
- ***blast direction*** => ***quality of floors and walls***
- ***shothole deflagration / misfires*** => ***safety / explosives in muckpile***
  => ***locally choked muckpiles (poor diggability)***
- ***good practice*** => ***max. drill-hole deviation up to 2 – 3% for production drilling***

QUARRY ACADEMY

How D&B affect down-stream operations

Drilling ↔ **Blasting** ↔ **Digging** ↔ **Crushing**

Drilling
- *sizing drill patterns*
- *drilling accuracy*

Blasting
- *field performance of explosives*
- *shotrock fragmentation*
  - *boulders*
  - *floor humps*
  - *fines and fragment micro-fractures*
- *muckpile profiles & swell*

Digging
- *diggability and digging capacities*
- *selectivity in mining & industrial mineral operations*

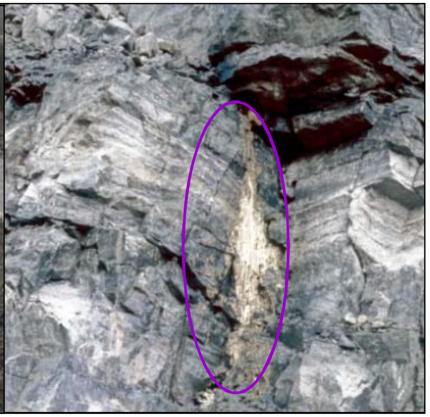
Crushing
- *boulder downtime*
- *crushing capacities*
- *power consumption*
- *production of fines and waste*

QUARRY ACADEMY

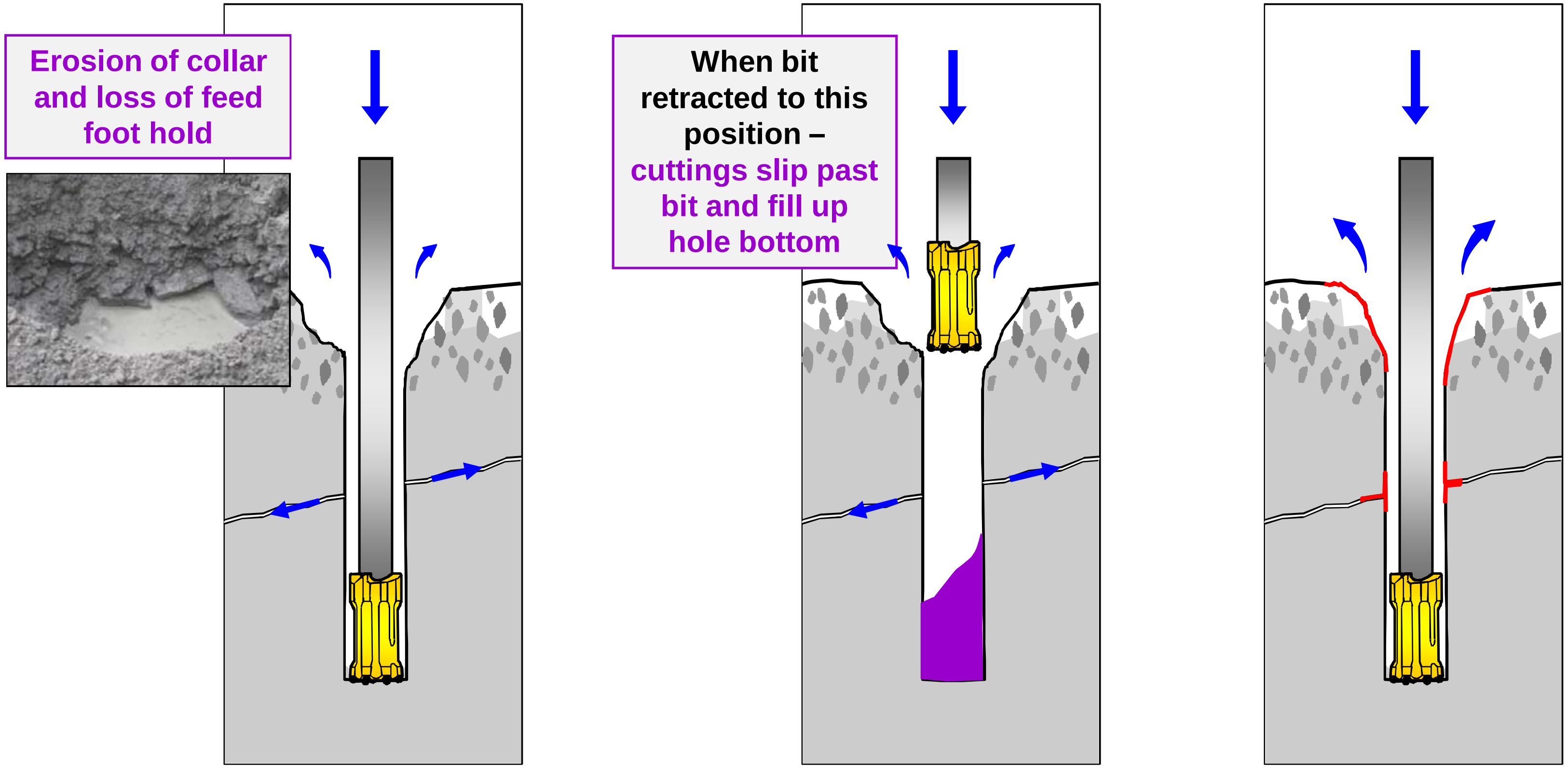
Some typical problems in drilling operations

- ***flushing / cuttings removal / collapsing holes***
- ***over-worn bits***
- ***pressure settings / low drill steel service life***
- ***drill-hole deviation***
- ***difficult 1st row drilling***



Foams seal and stabilise walls - and improve flushing



Over-worn bits – what to do?

Gauge buttons heavily worn down due to too high bit RPM's (i.e. adhesive wear)

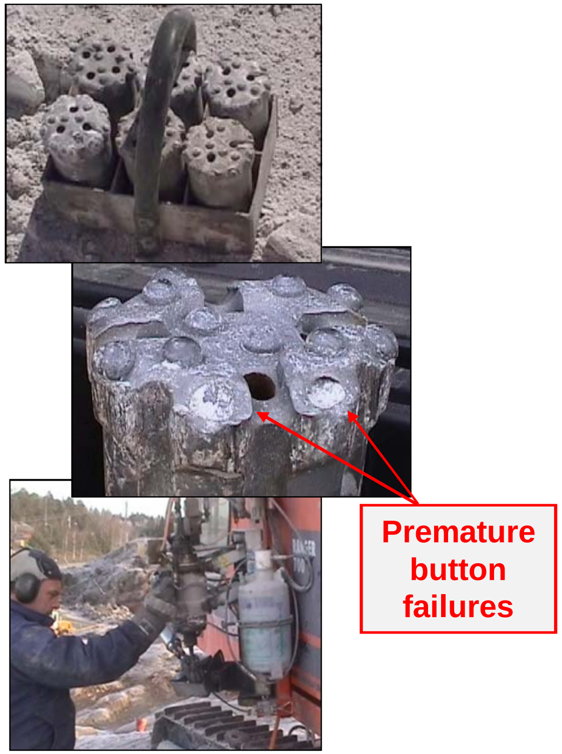
$$V_{gauge} = \pi \cdot 4/12 / (60/122) = 1.6 \text{ ft/s}$$

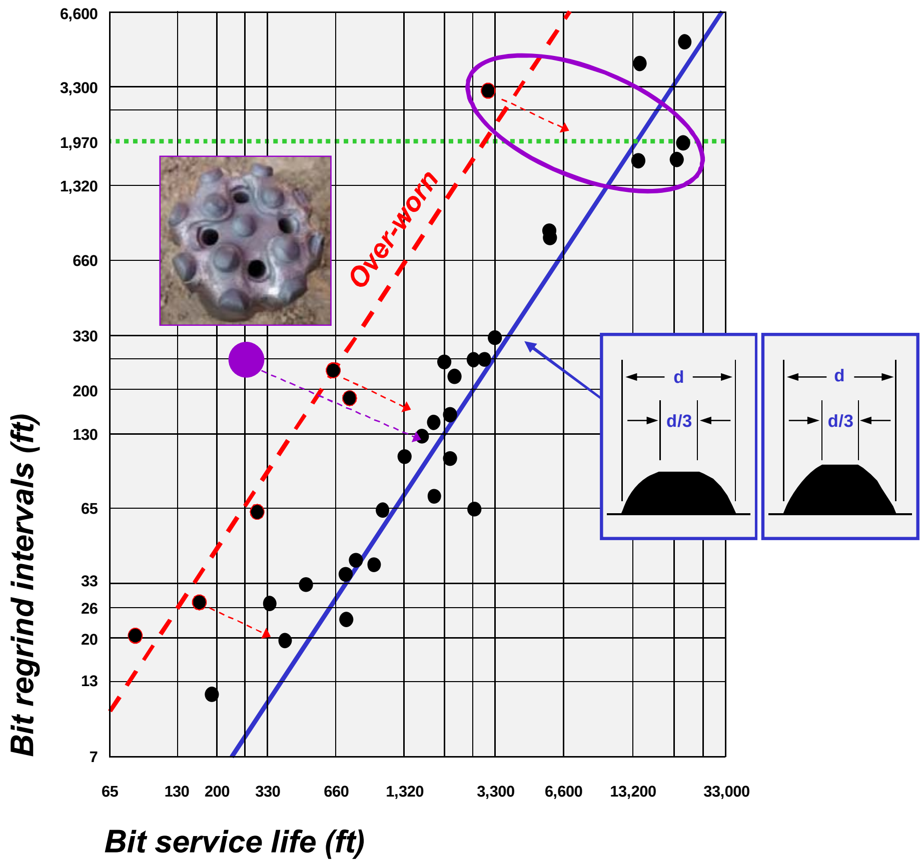
Broken buttons due to snakeskin – regrind more so as to remove the snakeskin layer !

Limestone	*2.3 ft/s*
Granite	*1.3 ft/s*
Quartzite	*0.8 ft/s*

QUARRY ACADEMY

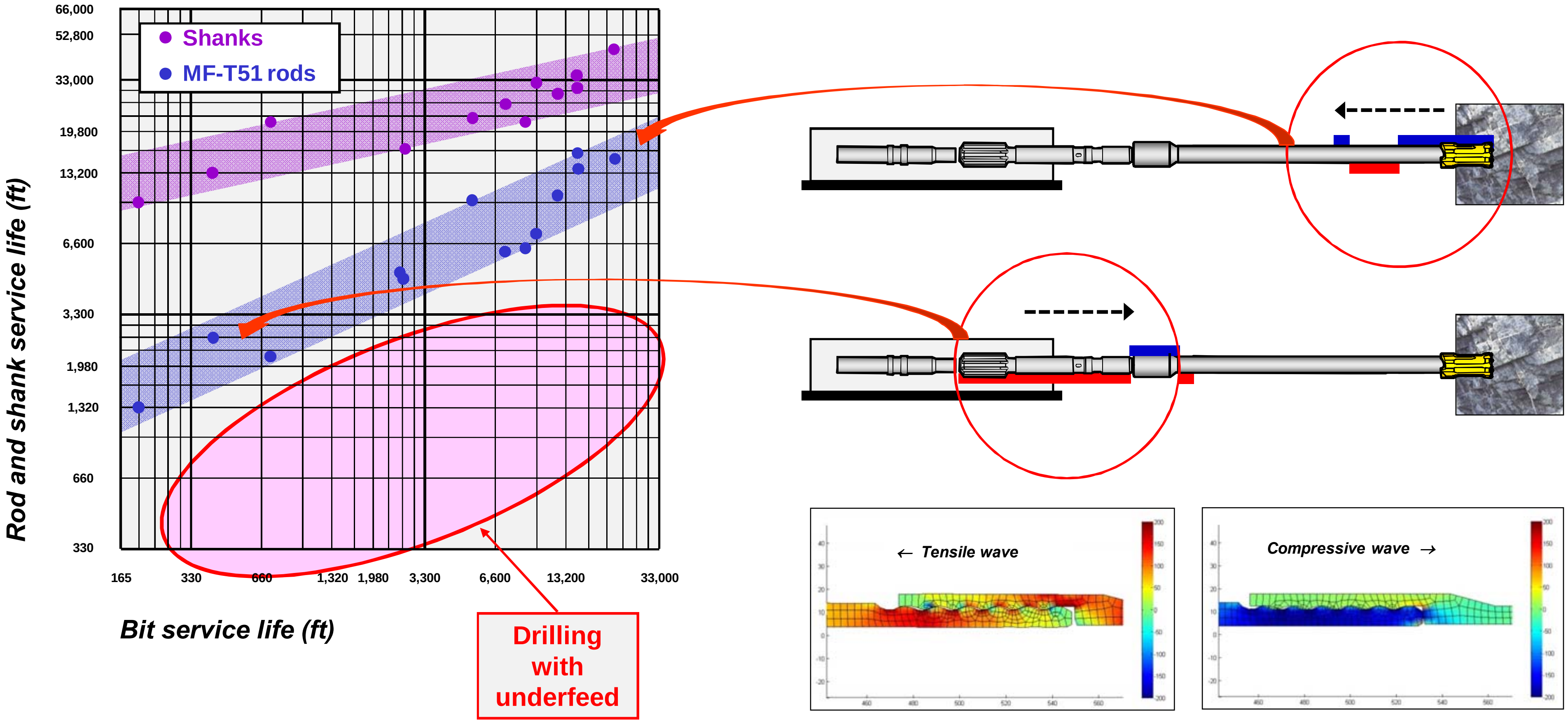
Bit regrind intervals, bit service life and over-worn bits





QUARRY ACADEMY

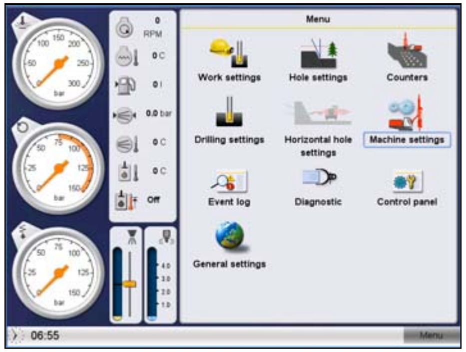
Tensile waves reduce drill steel service life



QUARRY ACADEMY

What drilling controls do

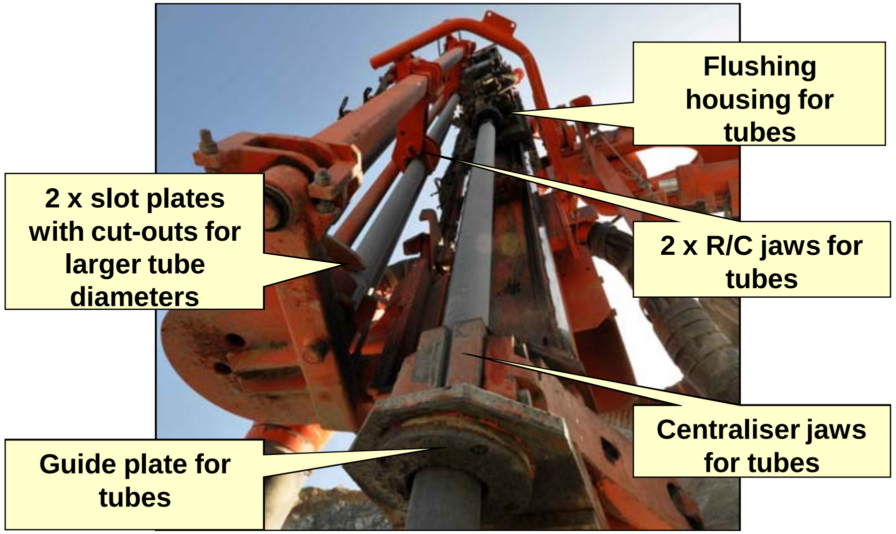
- *feed speed control* => *avoid bit rushing through joints and voids*
- *anti-jamming* => *avoid stuck drill steel and rod breakage*
  => *frequently activated – a sign of poor flushing?*
  => *frequently activated - results in STOP-GO drilling due to recollaring algorithm*
- *percussion-feed linkup* => *avoids under and over feeding*
- *torque control* => *smooth drilling through joints, avoids STOP-GO, …*
- *no system for bit selection …*



QUARRY ACADEMY

TH Tube drilling – avoid:

- ***bending*** ***of drill string*** **-** *leads to premature tube failures*
- ***heavy rebounds*** ***or bit service life < 5700 ft*** **-** *leads to poor tube life*
- ***jerky tube rotation*** **-** *leads to an unstable bit which initiates drill-hole deviation*



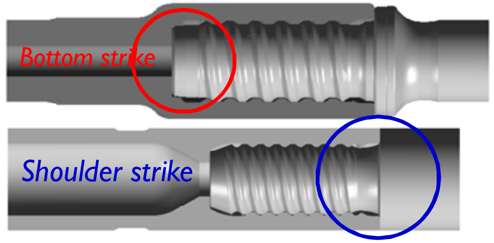
QUARRY ACADEMY

Case study - Singrauli Mine

- ***Rock*** — ***Overburden sandstone***
- ***Drill rig*** — ***P1524 / HL1560 / chain feed***
- ***Tubes*** — ***ST68 threads / Ø96mm / 2 x 12' SP***
- ***Bits*** — ***6" Retrac***

- ***Bit penetration rate*** — ***367 ft/ph = 6.13 ft/min***
- ***Feed ratio*** — ***90 bar / 150 bar = 0.60***

- ***bit service life*** — ***18,620'***
- ***shank service life*** — ***11,770' / 62,745' / 84,720'***
- ***tube service life*** — ***4,465' / 16,585' / 36,680'***

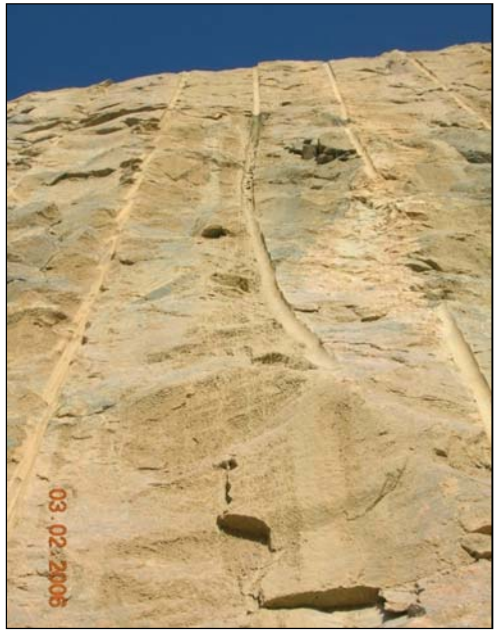


Guide plate for tubes

QUARRY ACADEMY

How do we go about drilling straighter holes?

- ***understand the many issues leading to drill-hole deviation***
- ***technically good drill string***
- ***technically good drill rig, instrumentation, …***
- ***motivate the drillers!***

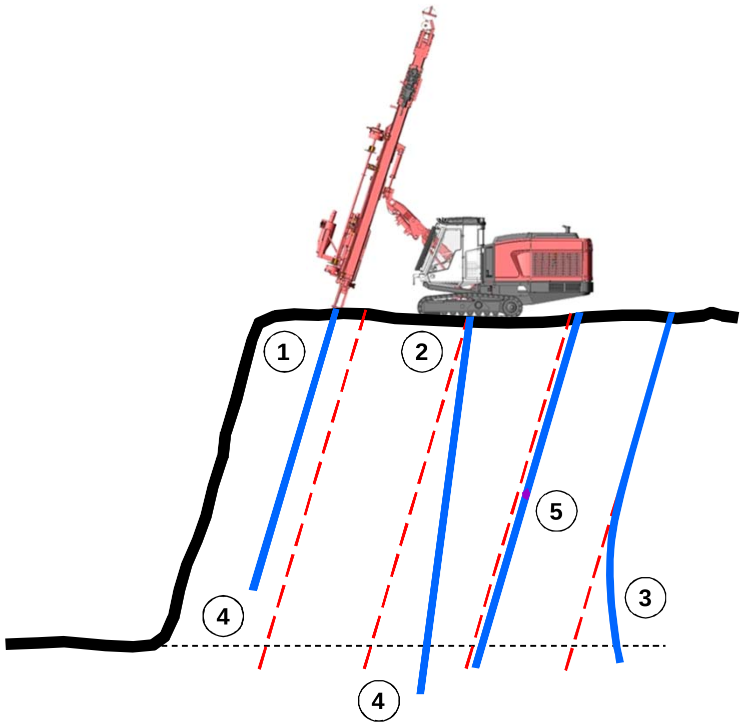


QUARRY ACADEMY

Accurate drilling gives effective blasting

Sources of drilling error

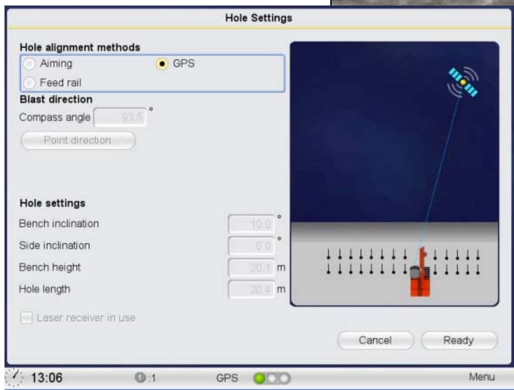
1. ***Collar position***
2. ***Hole inclination and direction***
3. ***Deflection (bending)***
4. ***Hole depth***
5. ***Omitted or lost holes***
6. ***Shothole diameter (worn out bits)***



QUARRY ACADEMY

Collar position error control

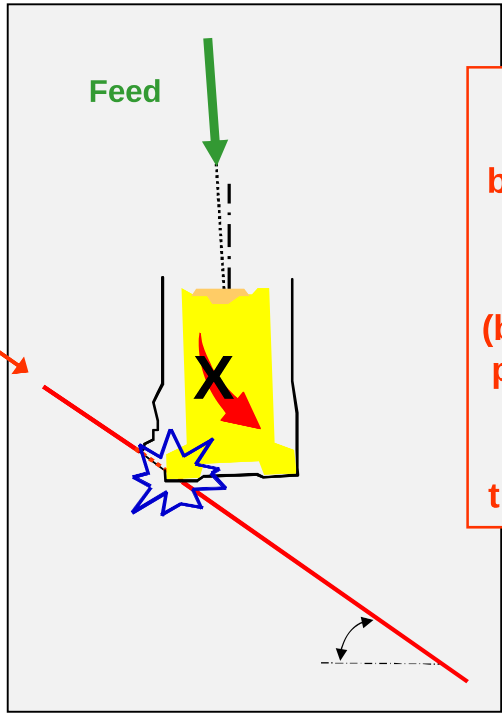
- ***use tape, optical squares or alignment lasers for measuring in collar positions***
- ***use GPS or total stations to measure in collar positions***
- ***collar positions should be marked using painted lines – not movable objects such as rocks etc.***
- ***completed drillholes should be protected by shothole plugs etc. to prevent holes from caving in (and filling up)***
- ***use GPS guided rig mounted collar positioning devices e.g. TIM-3D***



Difficult 1st row drilling:
- avoid flyrock
- avoid floor humps

QUARRY ACADEMY

How bit face designs enhance drill-hole straightness

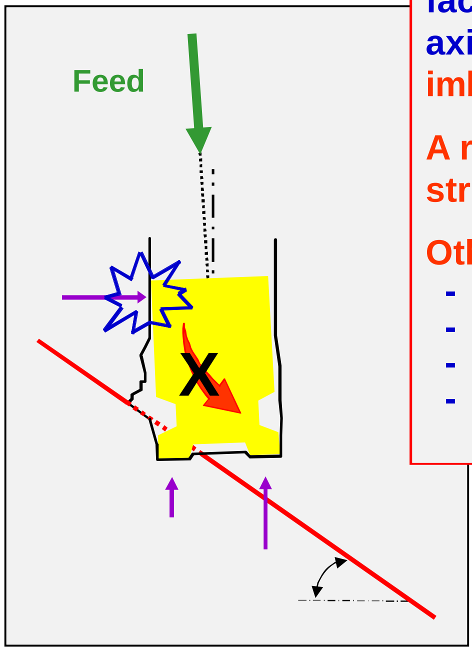


When the bit first starts to penetrate through the joint surface on the hole bottom - the gauge buttons tend to skid off this surface and thus deflect the bit.

More aggressively shaped gauge inserts (ballistic / chisel inserts) and bit face gauge profiles (drop center) reduce this skidding effect by enabling the gauge buttons to "cut" through the joint surface quickly - thus resulting in less overall bit deflection.

QUARRY ACADEMY

How bit skirt designs enhance drill-hole straightness



As the bit cuts through the joint surface - an uneven bit face loading condition arises; resulting in bit and drill string axial rotation - which is proportional to bit impact force imbalance.

A rear bit skirt support (retrac type bits) reduces bit and string axial rotation by "centralizing" the bit.

Other counter measures:
- longer bit body
- add pilot tube behind bit
- lower impact energy
- rapid drilling control system reacting to varying torque and feed conditions

QUARRY ACADEMY

Some strength and weaknesses

	TH	DTH	Rotary
■ ***General weaknesses***	***- drill string - operator skills***	***- fuel efficiency***	***- heavy rig***
■ ***Drill steel***	***- rods / tubes***	***- tubes***	***- tubes***
■ ***Soft rock***	***good***	***good +***	***good +***
■ ***Hard rock***	***good +***	***good - (rot. heads)***	***good (for big bits)***
■ ***Broken rock (flushing)***	***good -***	***good***	***good -***
■ ***Running water***	***OK***	***OK -***	***OK -***
■ ***High altitude***			

QUARRY ACADEMY

Lafarge Bath Operations, Ontario

Annual production ***1.6 mill. tons***
Rock type ***Limestone***

Bench height	*105’*
Bit	*Ø115mm - 4½” guide XDC*
Drill steel	*Sandvik 60 + pilot tube*
Hole-bottom deflection	*< 1.5 %*
Gross drilling capacity	*220 ft/hr*
Drill pattern	*14¾’ x 15¾’ (staggered)*
Sub-drill	*0’ (blast to fault line)*
Stemming	*9¼’*
No. of decks	*3*
Stem between decks	*5.9’*
Deck delays	*25 milliseconds*
Charge per shothole	*520 lbs*
Explosives	*ANFO (0.95 & 0.85 g/cm^3)*
Powder factor	*0.57 lb/yd^3*

QUARRY ACADEMY

www.quarryacademy.com

QUARRY ACADEMY

Improving Processes. Instilling Expertise.

DYNO
Dyno Nobel

SANDVIK