Sandsloot Exploration Project using Drill and Blasting and Mobile Tunnel Boring Methods

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Confidential

Contents

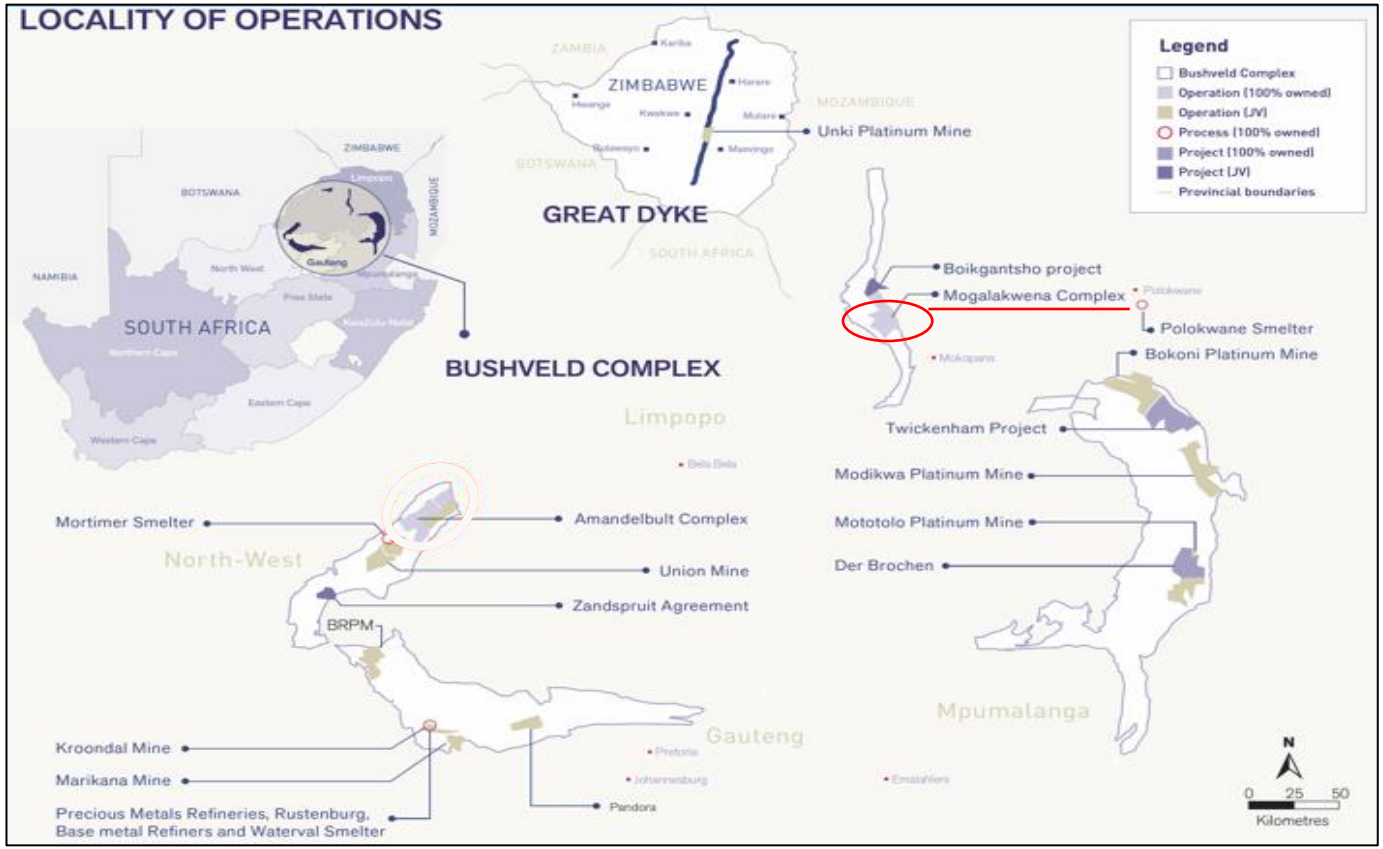
OVERVIEW

- Mogalakwena Mine has started an exploration project consisting of two tunnels developed into the highwall of Sandsloot open pit

- Purpose of the tunnels is to provide an underground drilling platform for resource drilling of the orebody located below the current pit bottom
    - Gathering data for input into a study evaluating massive mining options for an underground mine

- Two different mining methods:
    - Mechanized Drilling and Blasting (D&B)
    - Mobile Tunnel Borer (MTB)

LOCATION


LOCALITY OF OPERATIONS
Legend
Bushveld Complex
Operation (100% owned)
Operation (JV)
Process (100% owned)
Project (100% owned)
Project (JV)
Provincial boundaries
ZIMBABWE
Unki Platinum Mine
GREAT DYKE
BOTSWANA
NAMIBIA
SOUTH AFRICA
MOZAMBIQUE
Gauteng
BUSHVELD COMPLEX
Boikgantsho project
Mogalakwena Complex
Polokwane Smelter
Bokoni Platinum Mine
Limpopo
Twickenham Project
Modikwa Platinum Mine
Mototolo Platinum Mine
Der Brochen
Mortimer Smelter
Amandelbult Complex
North-West
Union Mine
Zandspruit Agreement
BRPM
Mpumalanga
Kroondal Mine
Marikana Mine
Precious Metals Refineries, Rustenburg,
Base metal Refiners and Waterval Smelter
Pandora
N
0 25 50
Kilometres

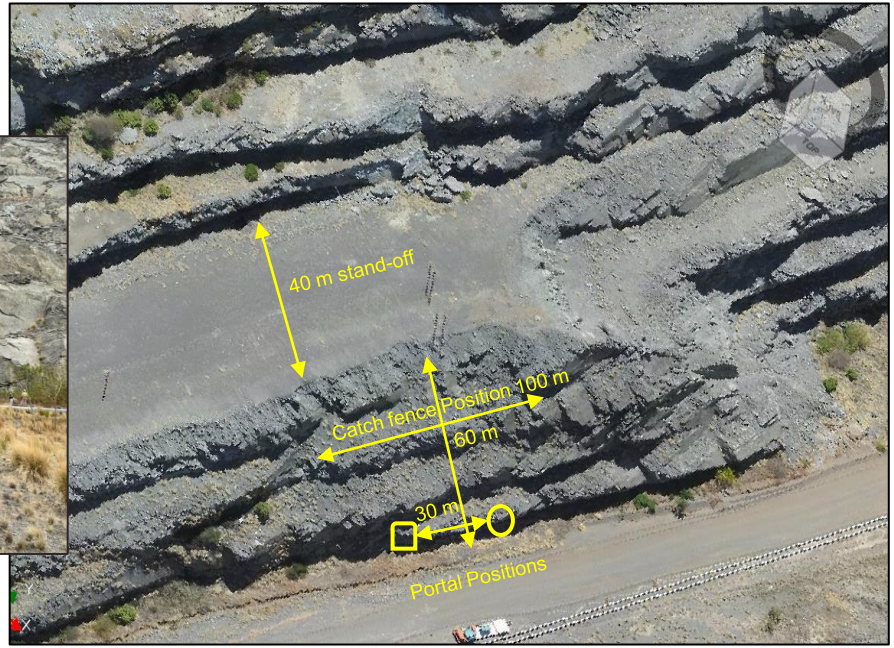
LOCATION


N
North Pit
Central Pit
South Pit
Zwartfontein South Pit
Sandsloot Pit

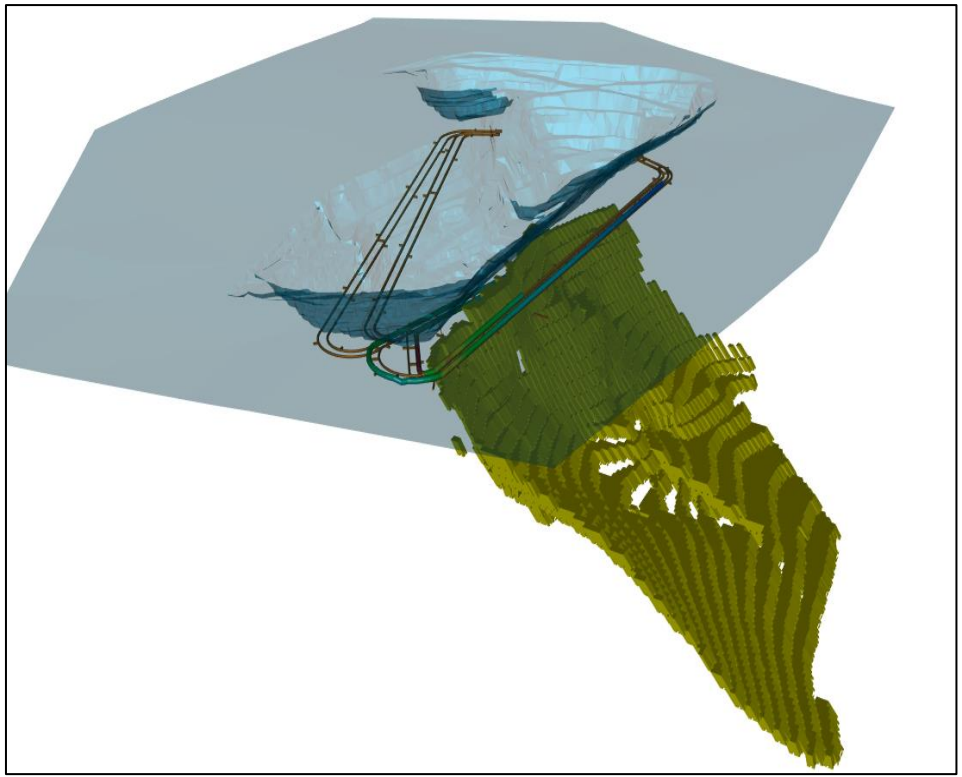
LOCATION

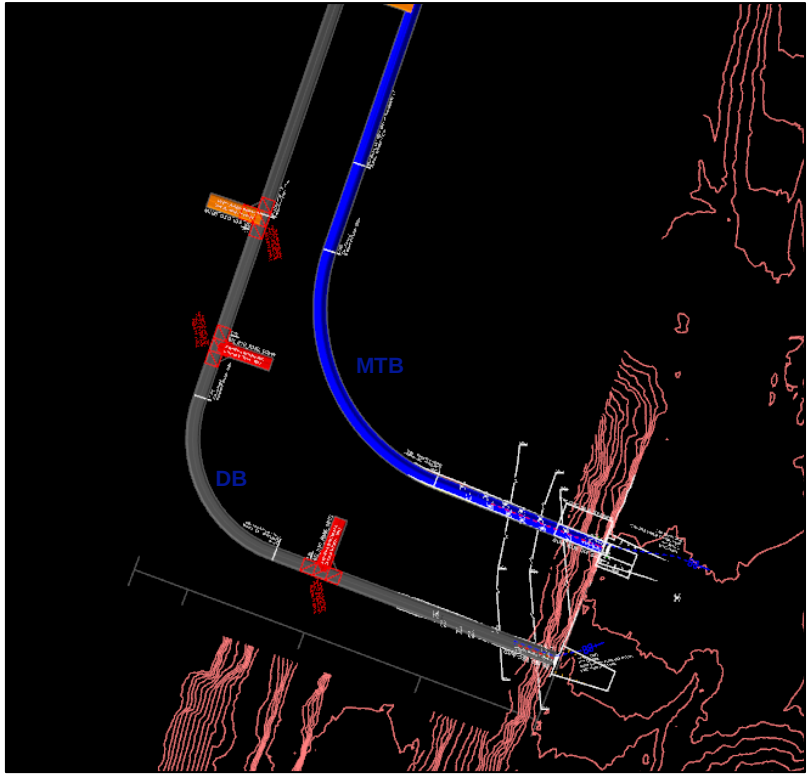

N
HW decline portal


6 x 5.5 m
30 m
5.5 m


40 m stand-off
Catch fence
Position 100 m
60 m
30 m
Portal Positions

LAYOUT





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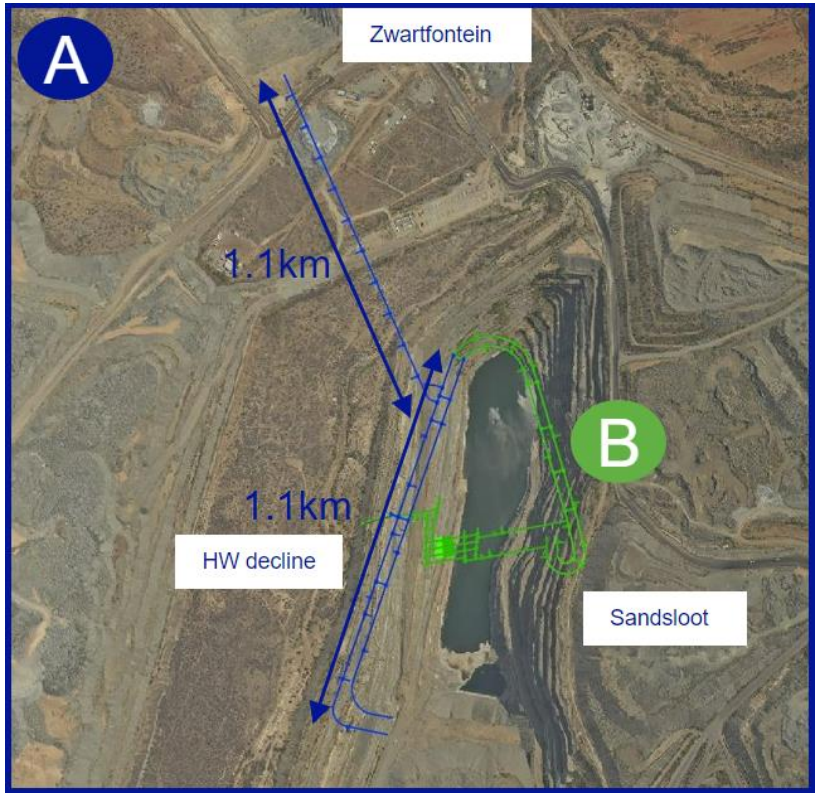


Phase A

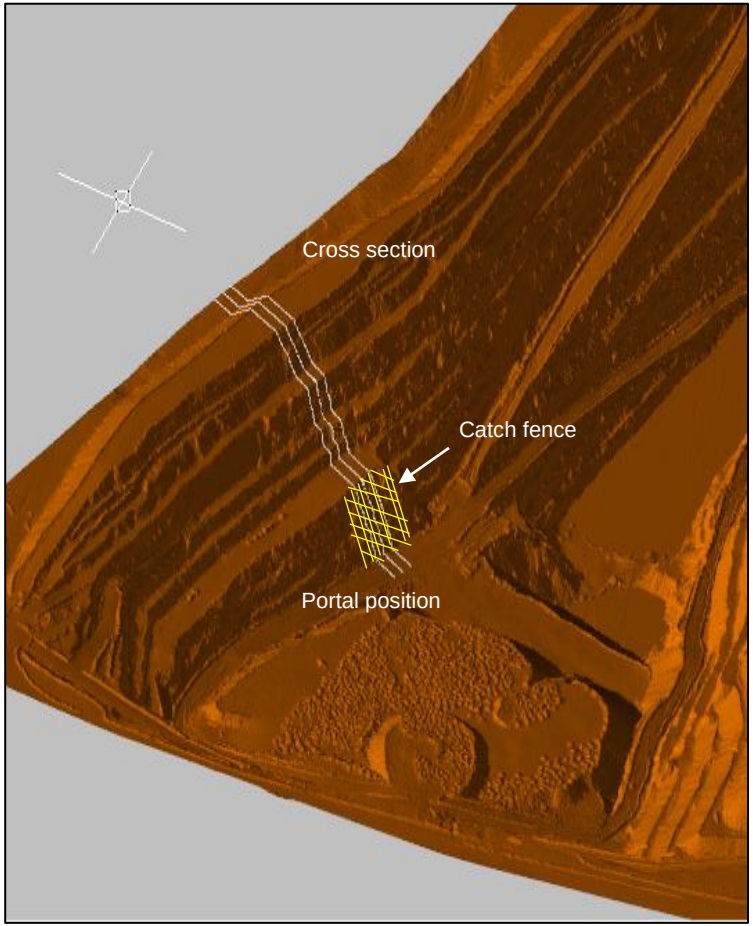
4.1km Development

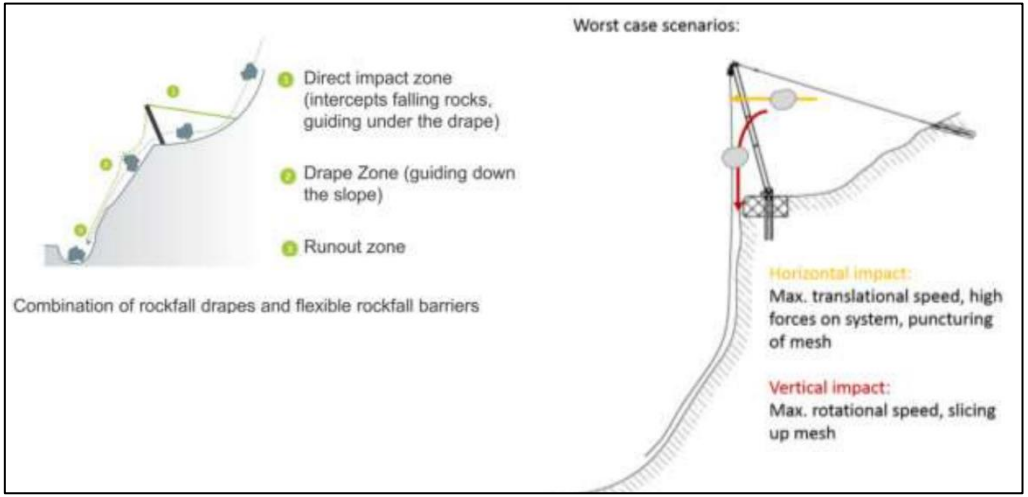
- 1.2km Cutting
- 2.9km Drill & Blast

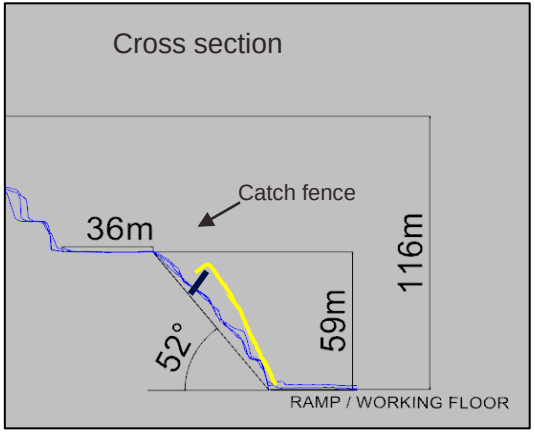
Phase B

5.8km Development

HIGHWALL STABILITY







HIGHWALL STABILITY

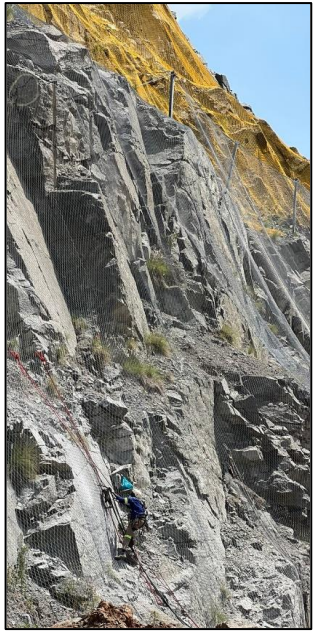
Process:

- Dressing the highwall
- Identify areas requiring additional spot bolting

HIGHWALL STABILITY

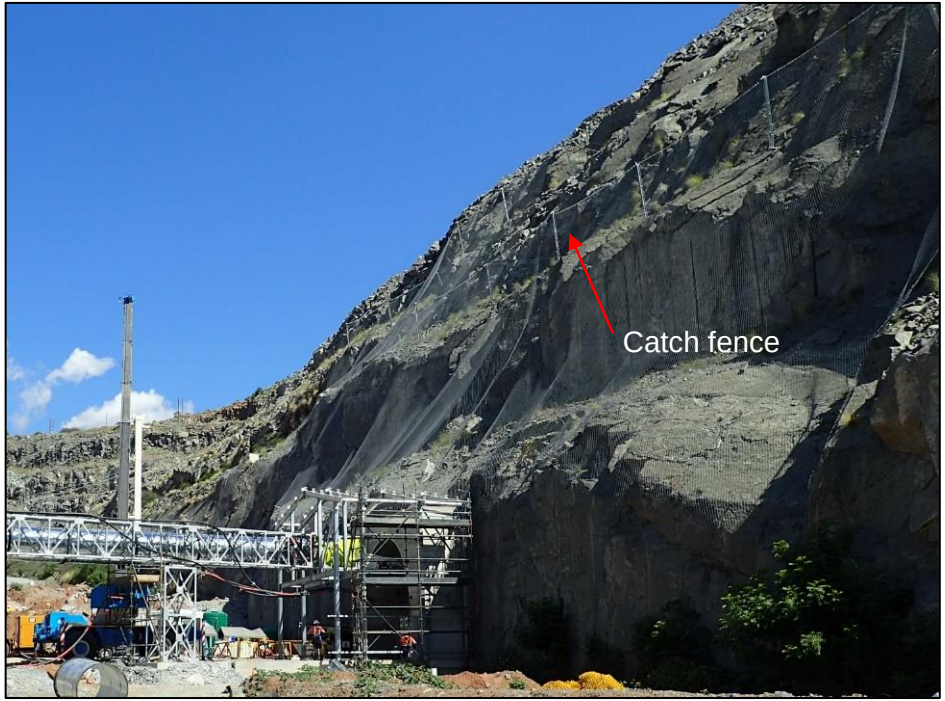
Process:

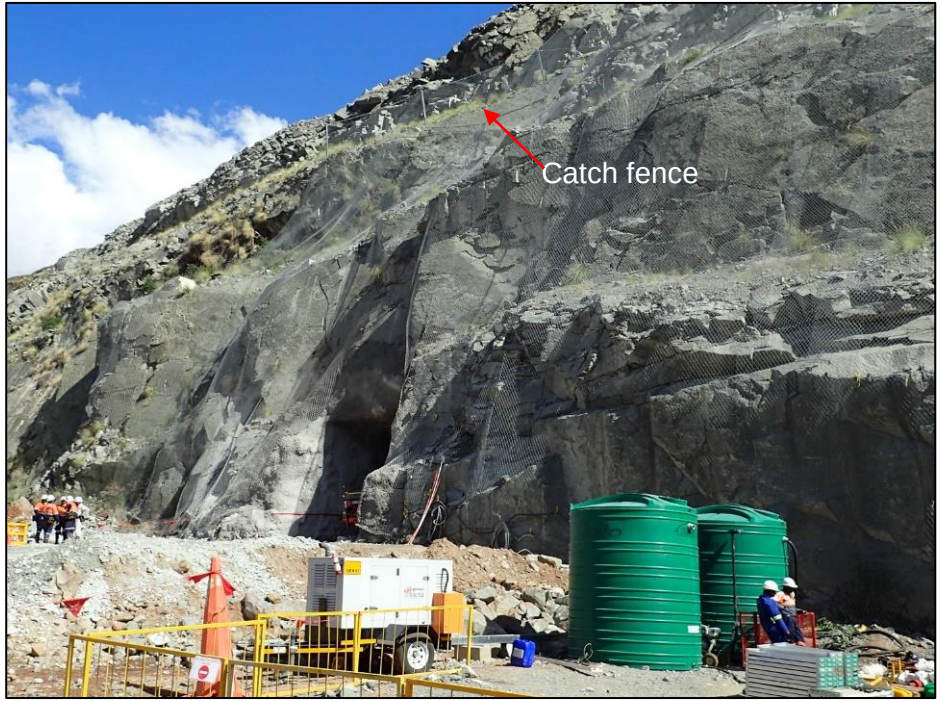
- Temporary netting to protect workers during catch fence installation
- Execution of catch fence installation



HIGHWALL STABILITY

Completed catch fence

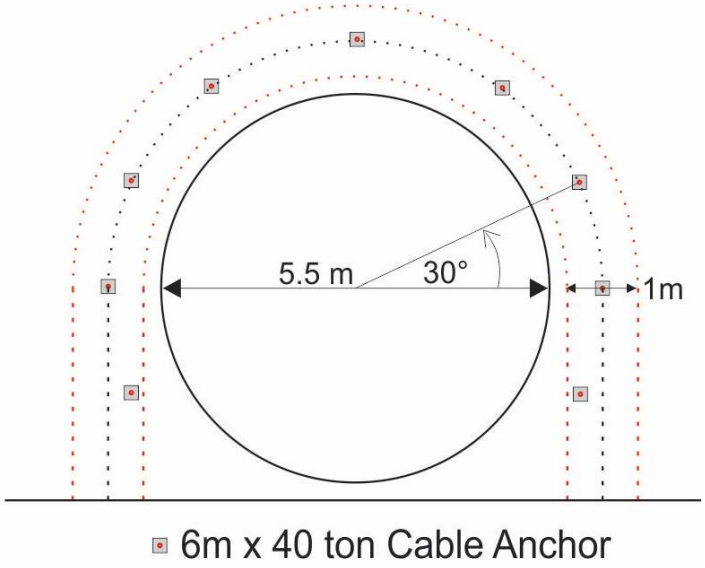




SUPPORT DESIGN

Portal Highwall Support – MTB

- Cable anchors
- Concrete Structure against Highwall

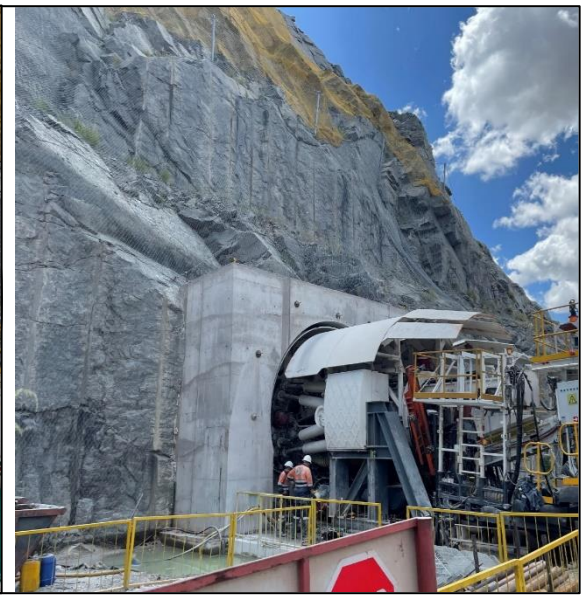


SUPPORT DESIGN

MTB- Concrete structure was build against the highwall

- Concrete constructed for MTB to bore through

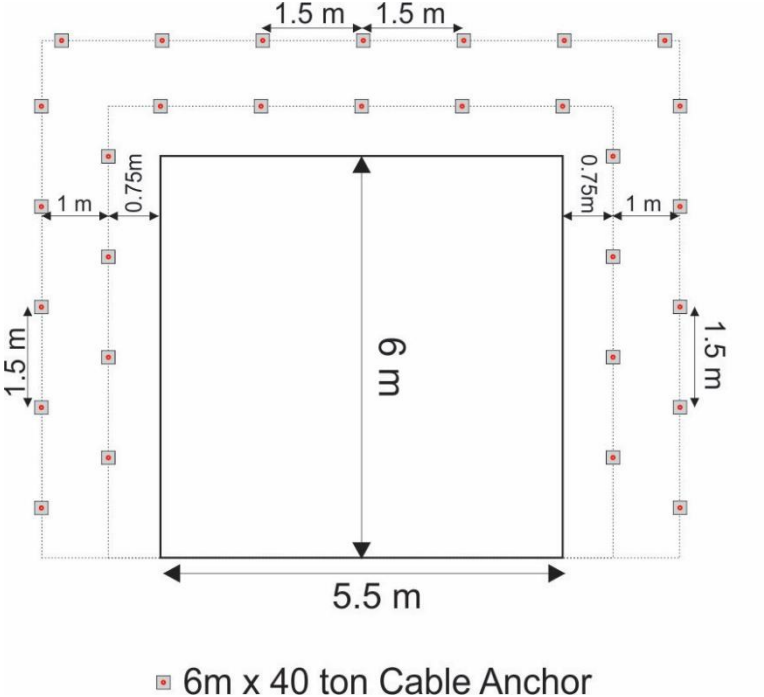


SUPPORT DESIGN

Portal Highwall Support – D&B

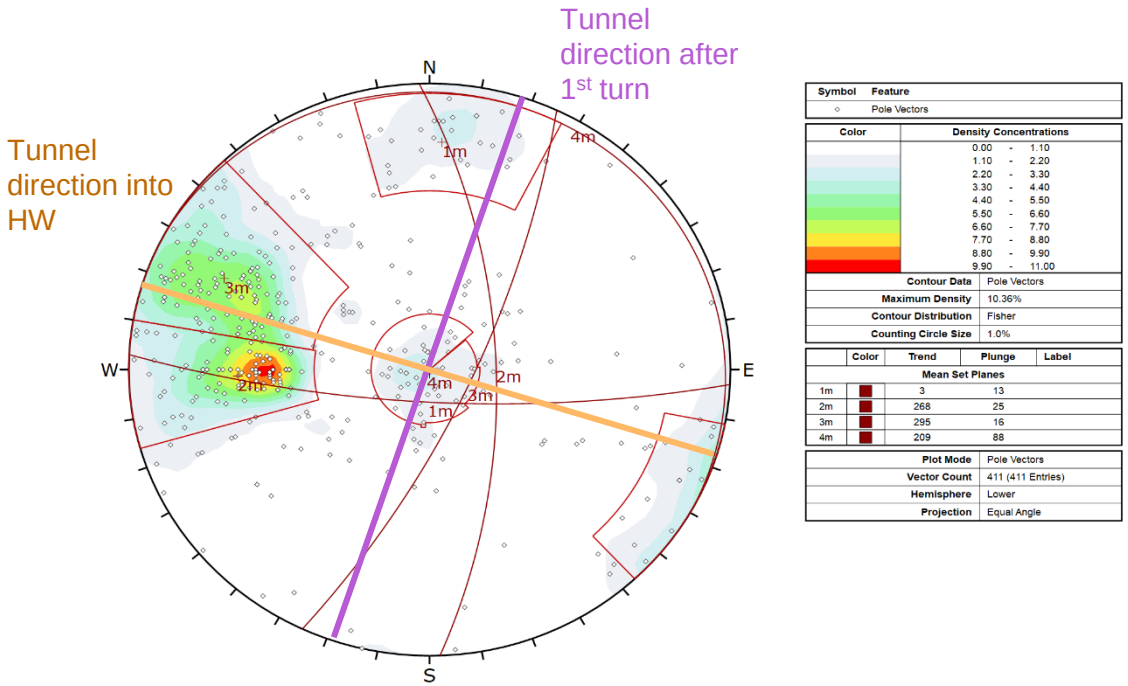
- Cable anchors
- Mesh



SUPPORT DESIGN

- Detail highwall mapping
- Exploration drilling
- Stereonet plot analysis showing tunnel directions

Set	Dip	Dip Direction
J1 (Minor)	77	183
J2 (Major)	65	88
J3 (Major)	74	115
J4 (Minor)	2	29



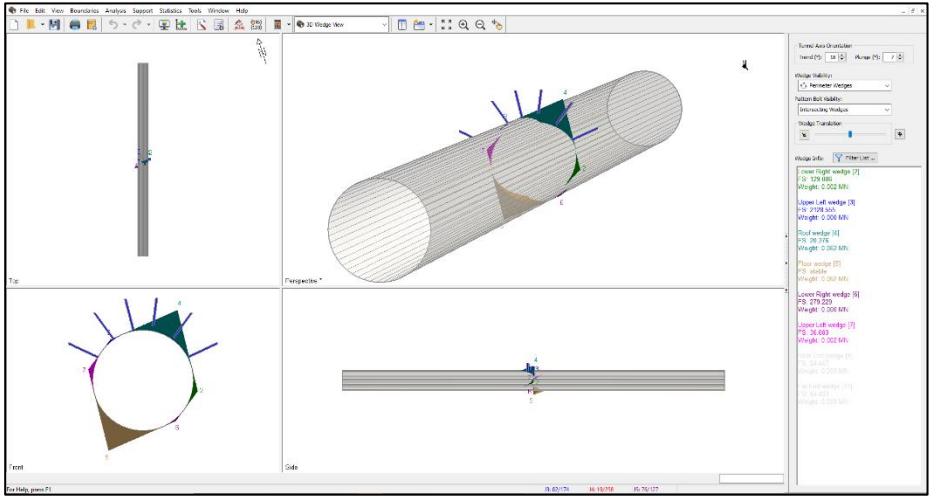
SUPPORT DESIGN

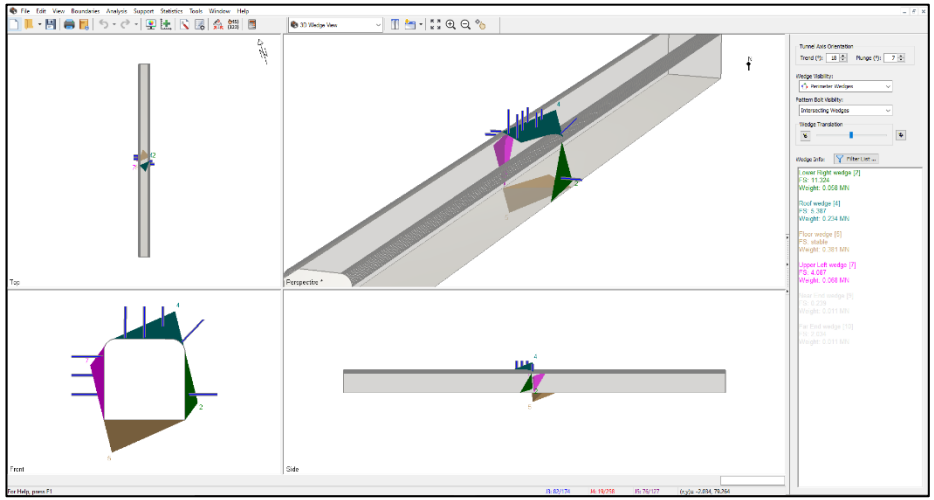
Input parameters for modelling:

MINING TECHNIQUES	MTB	DB
MODEL INPUT PARAMETERS		
Friction angle (Phi) (°)	35	35
Cohesion (MPa)	0.05	0
Tensile strength (MPa)	0.05	0
Dimensions (m)	5.5 Ø	6 x 5.5
SUPPORT PROPERTIES		
Bond strength (MN)	0.2	0.2
Bolt Length (m)	1.8	2.4
Bolt Yield Strength (kN)	200	200

SUPPORT DESIGN

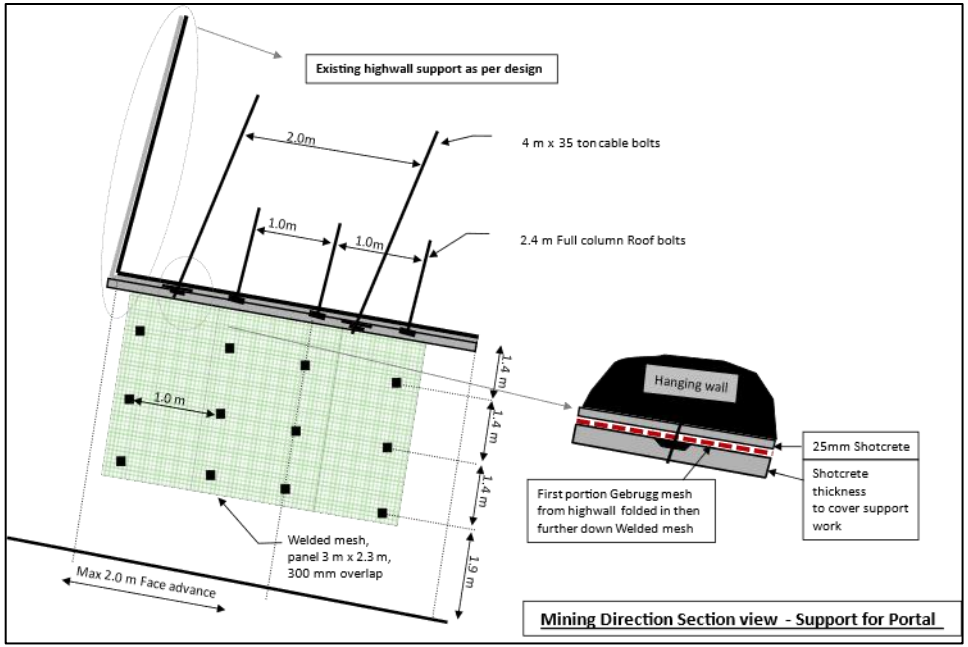
- Various kinematic models were used
- Estimate the possible failure mechanisms
- Results was used as input into support design
- 10 of 10 Joint Combinations were run
- Possible wedge failures from hangingwall, sidewall and face were analyzed as well

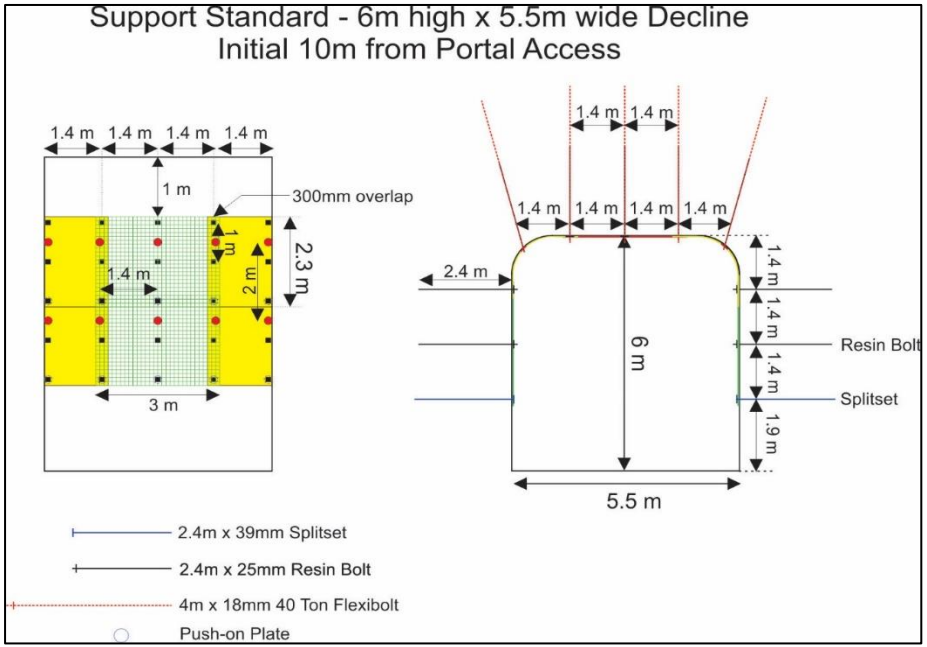




SUPPORT DESIGN

D&B - Portal Support





SUPPORT DESIGN

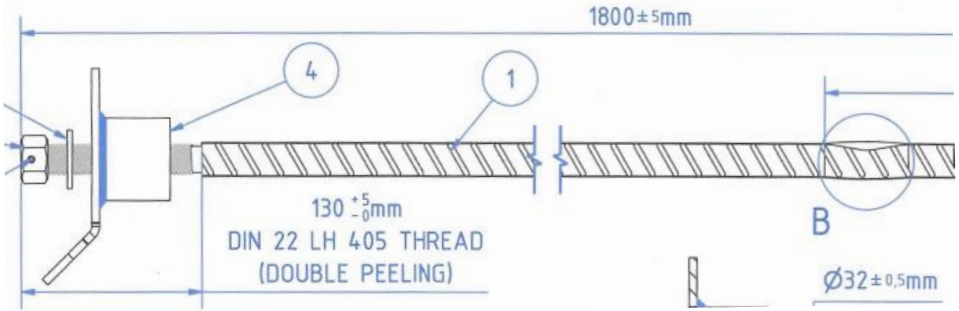
Support product list used as Primary and Secondary Support

Method	D&B	MTB
Support Function	**Product**	**Product**
Primary bolt	2.4 m, 25 mm Secura bolts 0.9 m and 2.4 m Split sets	1.8 m, 25 mm Secura bolts
Secondary bolt	4.0 m, 18 mm Flexi cable bolt	4.0 m, 18 mm Flexi cable bolt
Primary resin	1050 mm x 30 mm Slow and fast resin capsules	800 mm x 30 mm Slow and fast resin capsules
Secondary grout	Pumpable grout	Pumpable grout
Primary mesh	5.6 mm dia Galvanized welded mesh	
Secondary support	Fibre reinforced shotcrete	3.2 mm dia Galvanized welded mesh and or Fibre reinforced shotcrete

SUPPORT DESIGN

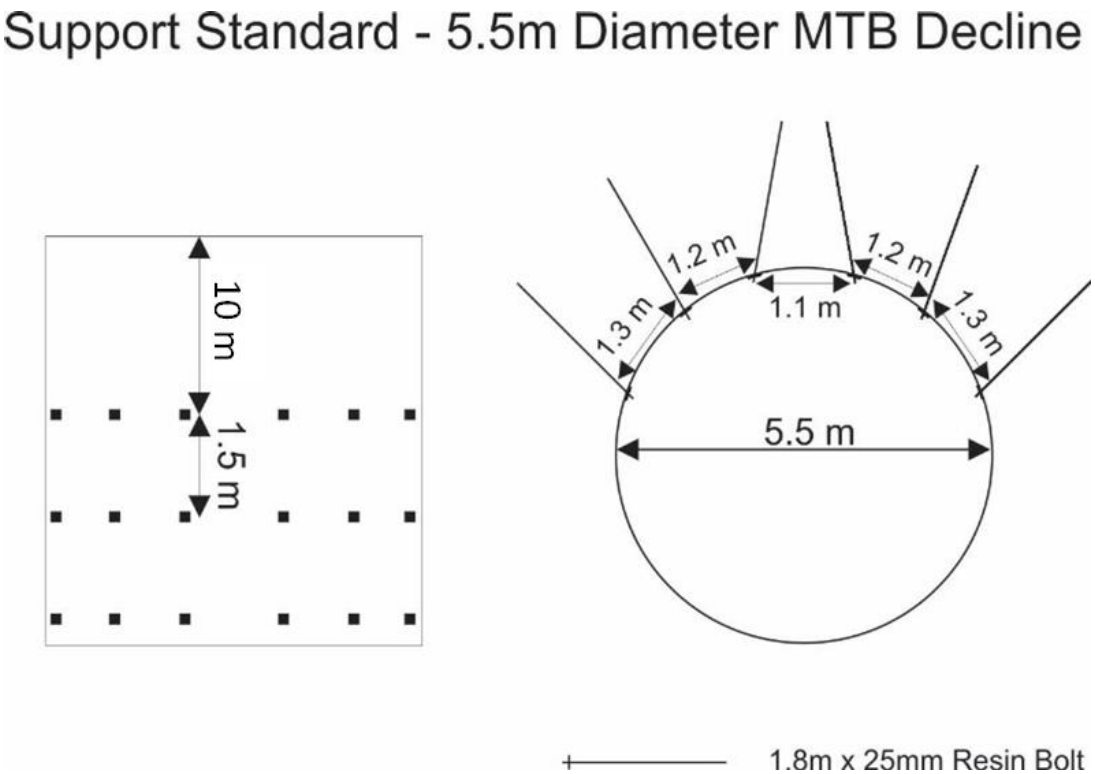
Using initiatives Support products

- Countersink bolts – to create smooth tunnel surface in the MTB



SUPPORT DESIGN

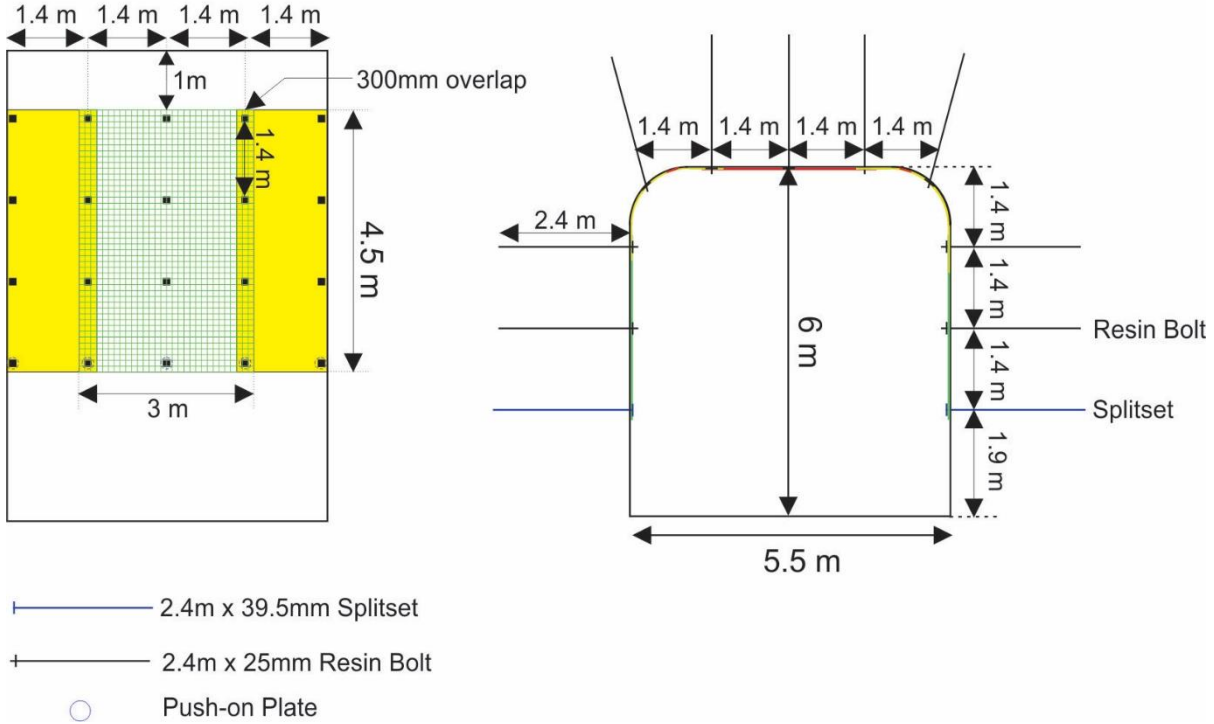
MTB – Support Standard



SUPPORT DESIGN

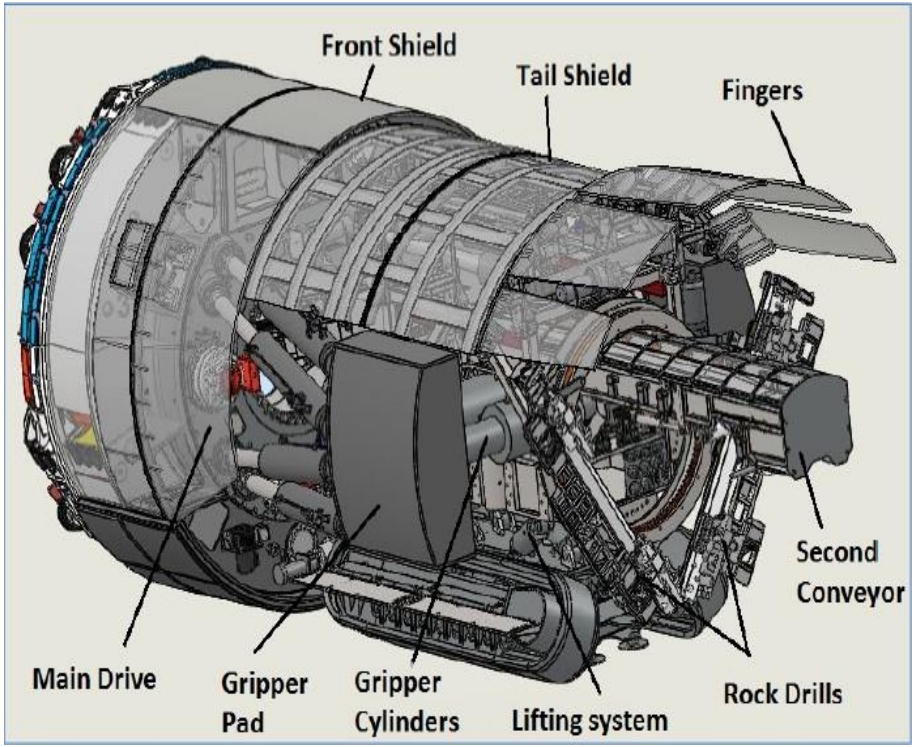
D&B – Support Standard

Support Standard - 6m high x 5.5m wide Decline



MOBILE TUNNEL BORER (MTB)

- Bolter rig – Works in a fixed rotated angle
- Countersink bolts installed flush with rock profile

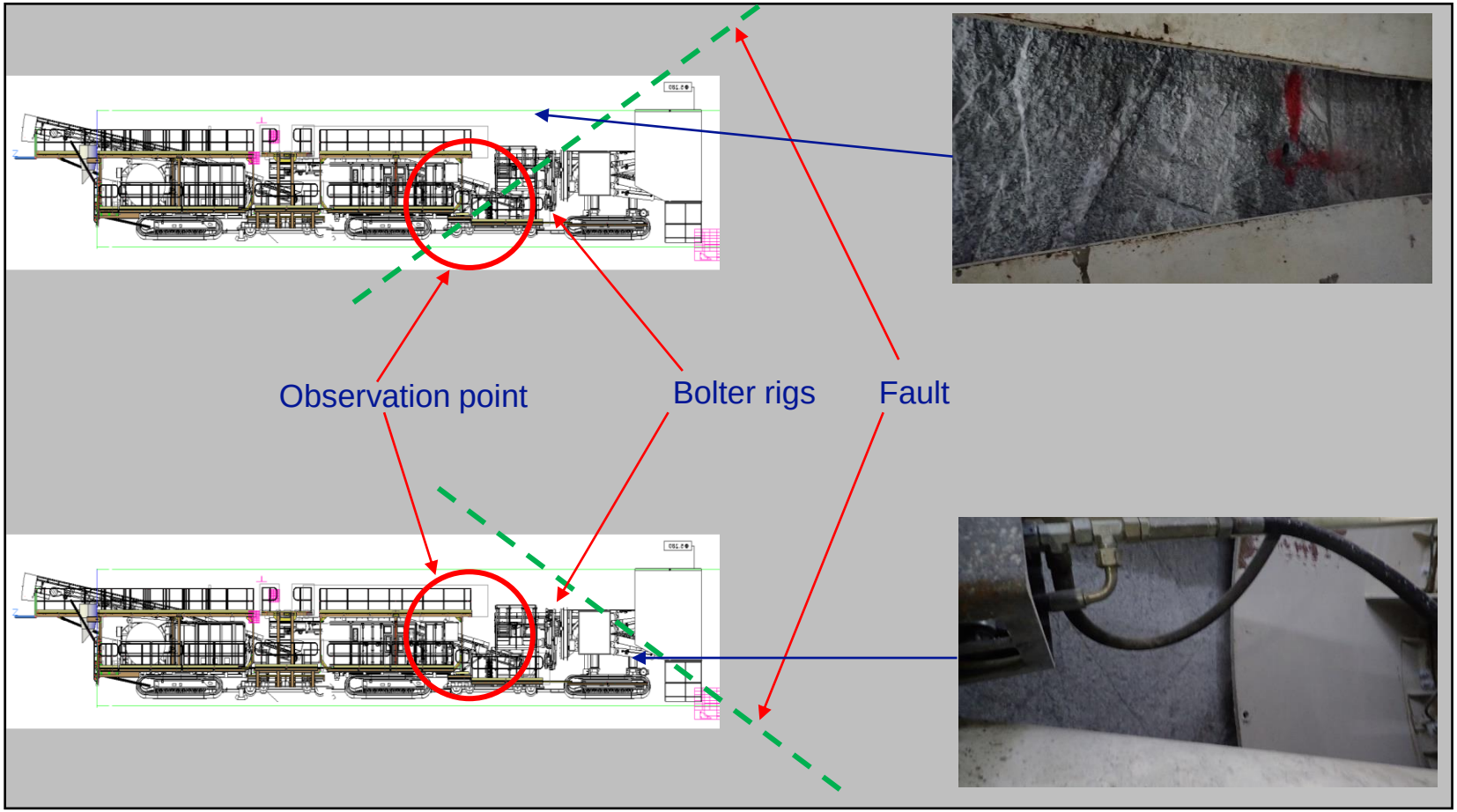


MOBILE TUNNEL BORER (MTB)

Bolter rig – Finger plates where support is installed through
(finger plates only allows support spacing to be 1.1 to 1.3 m apart)

MOBILE TUNNEL BORER (MTB)

Identification is limited on TARP triggers for geological feature



MOBILE TUNNEL BORER (MTB)

MOBILE TUNNEL BORER (MTB)

Phase 2 - bottom part will be cut out to make flat roadway in the MTB

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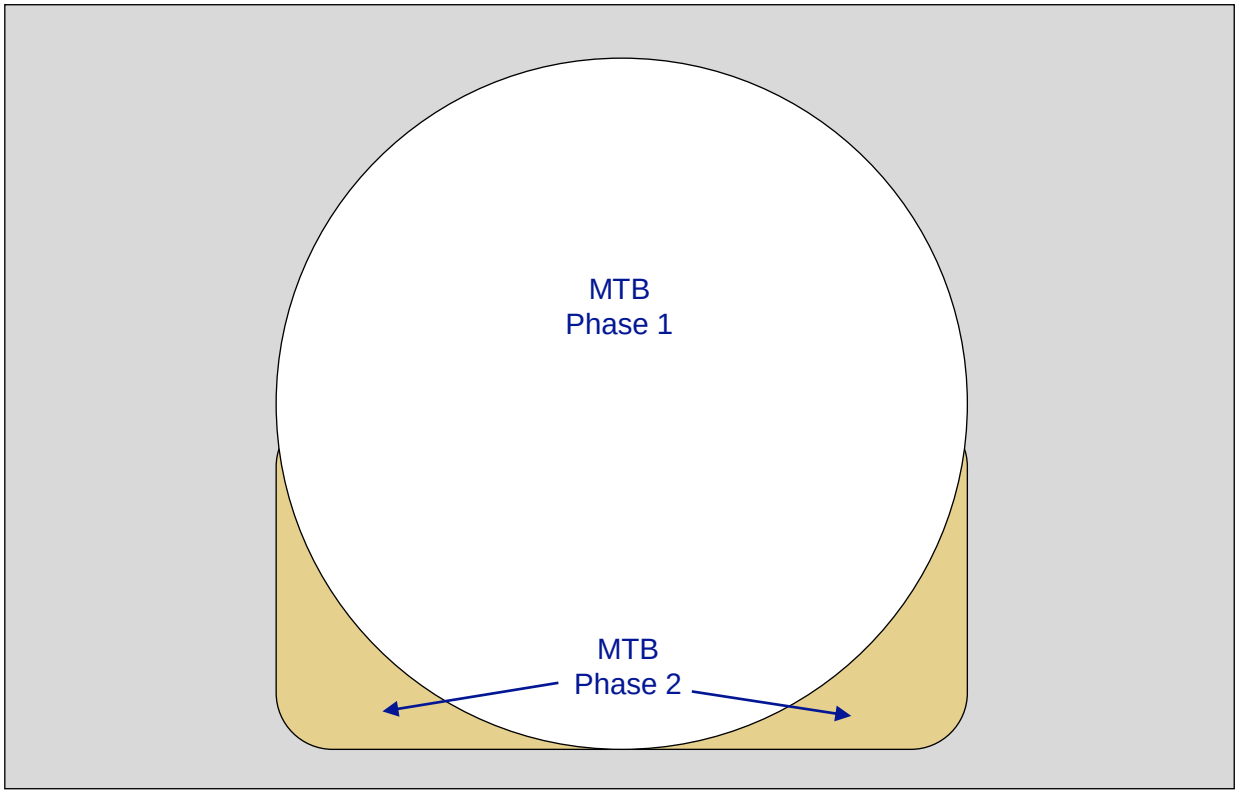


DRILL AND BLAST (D&B)

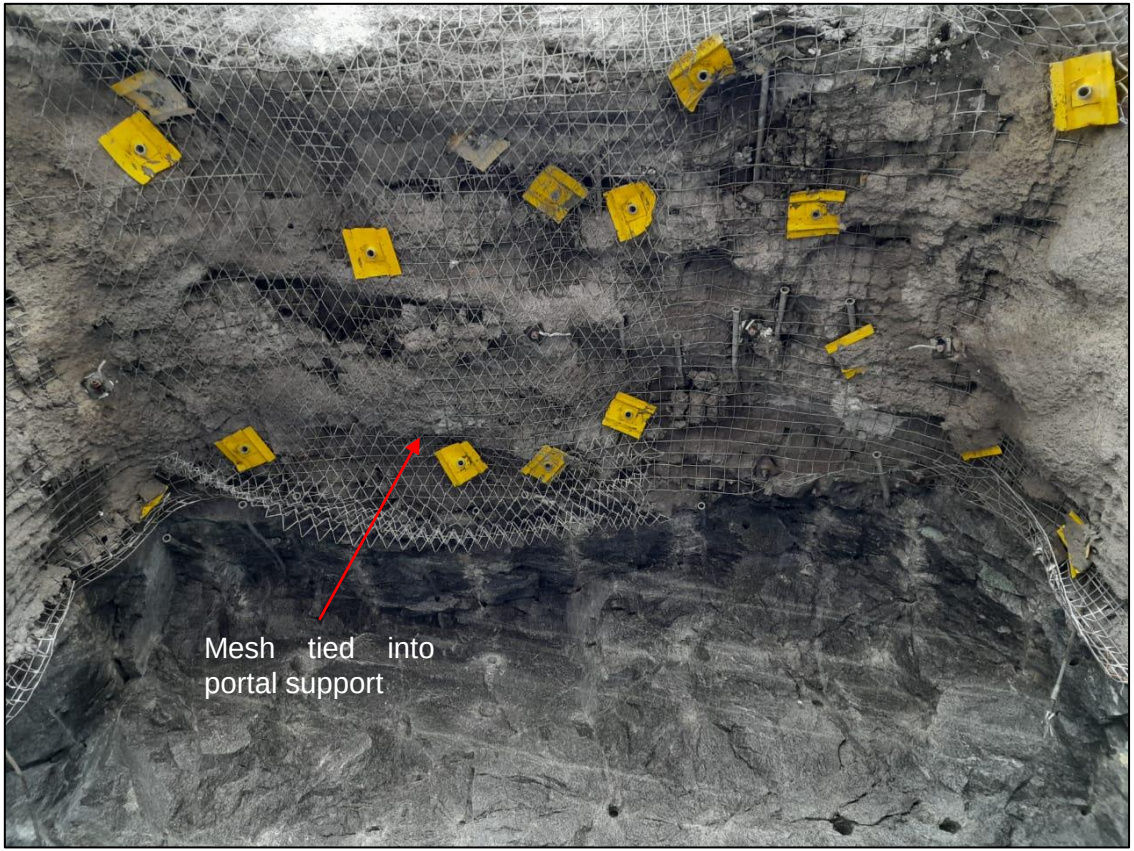
Dressing the highwall and short rounds were taken to negotiate fractured rock caused by open pit blasting

DRILL AND BLAST (D&B)

Spilling bolts and Cable anchors proved successful for undercutting highwall

DRILL AND BLAST (D&B)

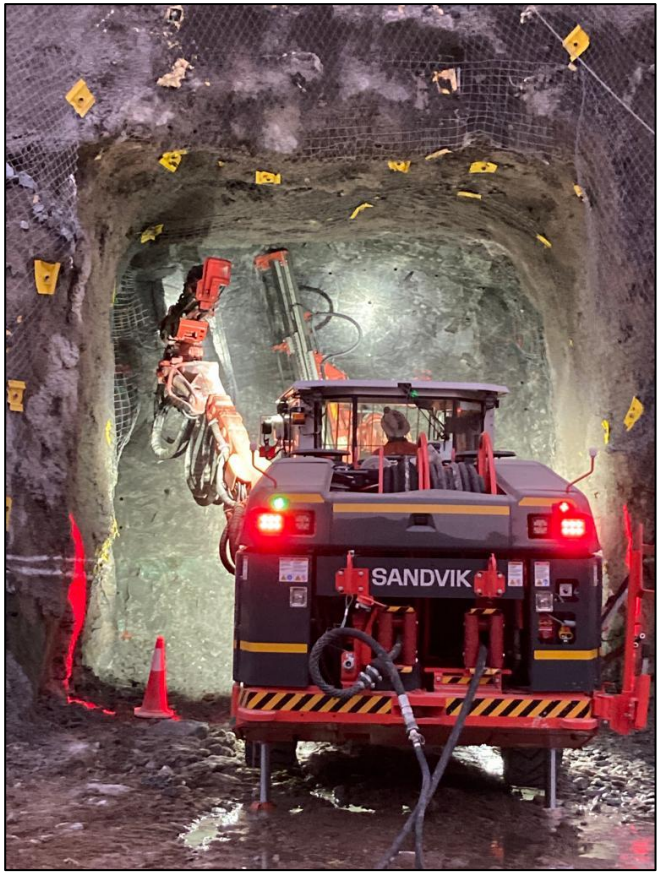
Portal taking shape



DRILL AND BLAST (D&B)

Conditions changes with each blast resulted in additional support (cable anchors) being installed as per instructions

DRILL AND BLAST (D&B)

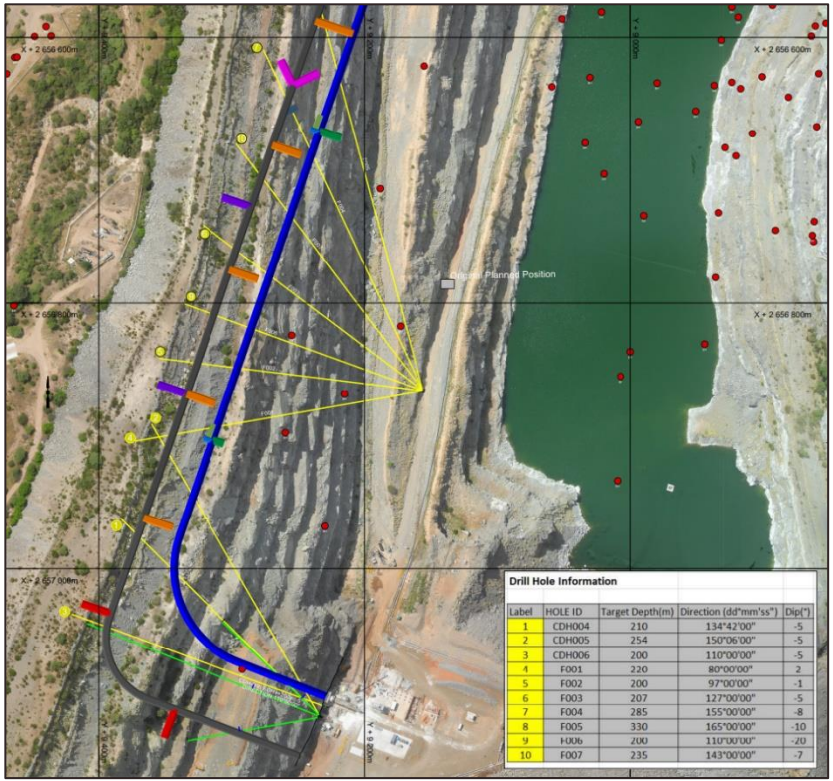


DRILL AND BLAST (D&B)

RISK MITIGATION

Cover drilling program was done to identified adverse geological structures established

- Unexpected water intersection



LEARNINGS

- Underestimated the volume and complexity of the work
- The mind set and alignment of employees from open pit going underground
- Resource the project correctly from the start, two tunnels requires the same input as for a new underground mine

SUCCESSES

- No injuries
- Short rounds assisting negotiation of poor ground conditions
- No FOG from highwall during blasting
- Project delivered on time
- Very good collaboration between Geotechnical and Mining discipline
- Ground condition in MTB significantly better than D&B

AngloAmerican

Thank you

Questions ?