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PIONEERING PROGRESS :
THE FUTURE OF ROCK ENGINEERING

Back Analysis of Ore Pass Designs at Big Gossan Mine, Indonesia

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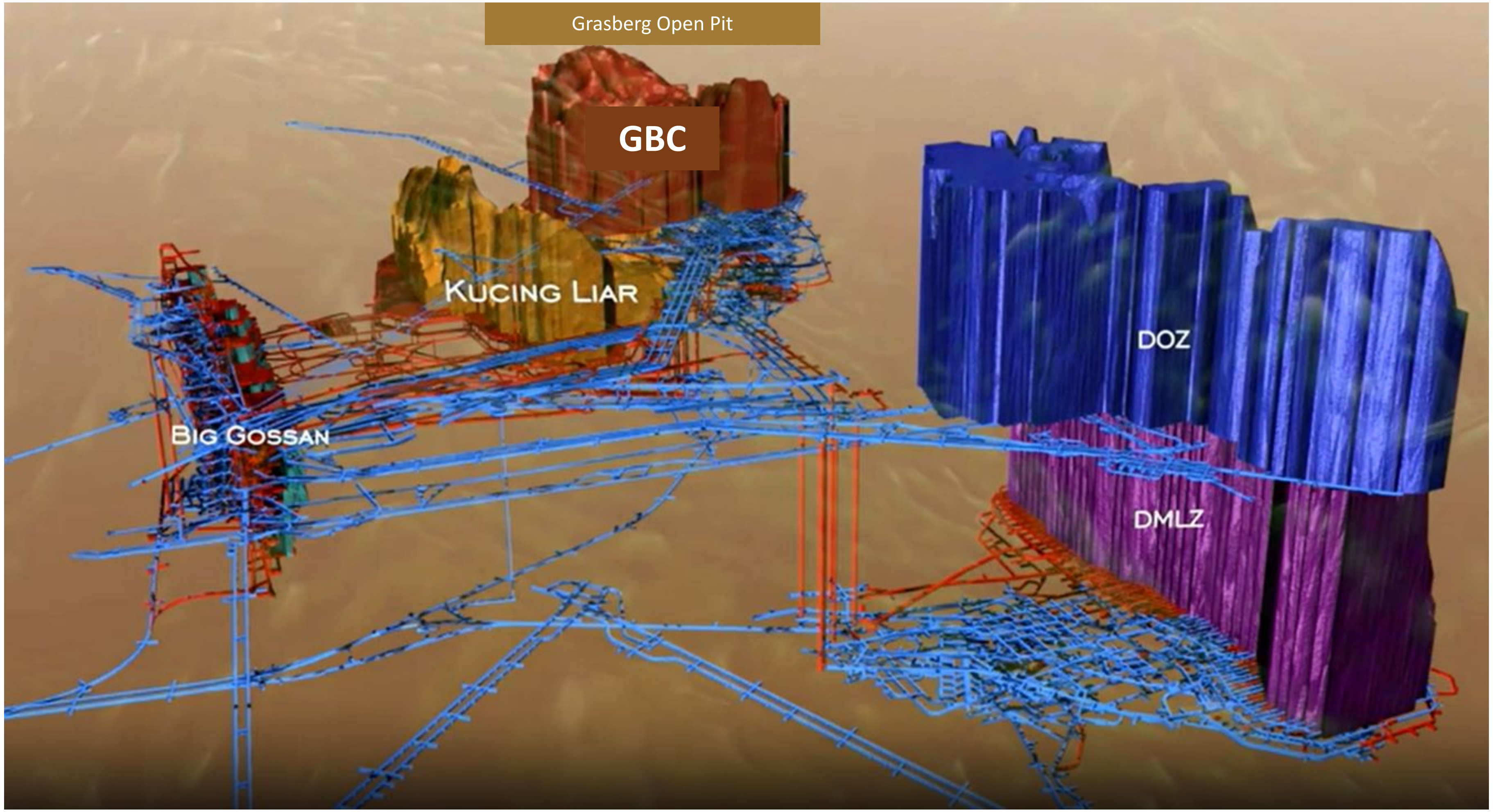
Background

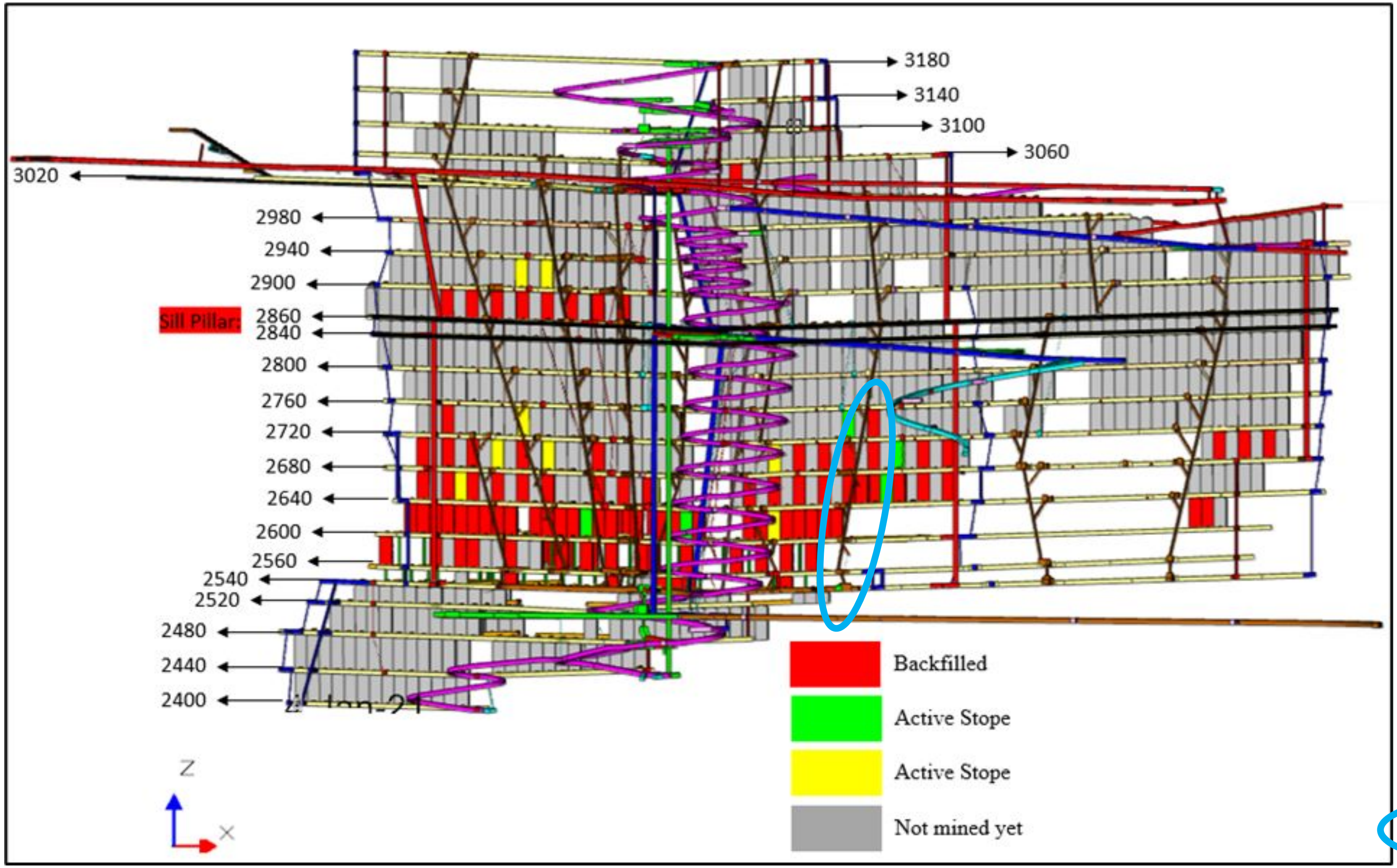

PAPUA
SKALA 1 : 5.000.000
Lautan Teduh
(Samudera Pasifik)
P.WAIGEO
SORONG
P.SALAWATI
P.MISOOL
KOTA SORONG
Manokwari
KAB.MANOKWARI
P.BIAK
Biak
KAB.BIAK-NUMFOR
Serui
P.YAPEN
Teluk Cenderawasih
Fakfak
KAB.FAKFAK
Kaimana
P.SERAM
Nabire
KAB.NABIRE
KAB.PANIAI
Enarotali
PEG.SUDIRMAN
PUNCAK JAYA
Tembagapura
KAB.MIMIKA
Mimika
TIMIKA
Wamena
KAB.JAYA WIJAYA
PEGUNUNGAN JAYA WIJAYA
Sarmi
KOTA JAYAPURA
JAYAPURA
KAB.JAYAPURA
KAB.YAPEN-WAROPEN
PAPUA NUGINI
PROPINSI MALUKU
KAB.MERAUKE
P.DOLAK
(YOS SUDARSO)
Merauke

Grasberg UG Mining Complex (Producer Copper 8th ; Gold 2nd)



- Grasberg Open Pit
- 2 Producing Cave Mines
  GBC and DMLZ
- 1 Developing Cave Mine
  KL
- 1 Stope Mine
  Big Gossan
- PTFI Production
  300 000 Tons / day

Big Gossan Mining Layout



- Mining Method

  Sub Level Open Stope with CPF

- Stope Dimension

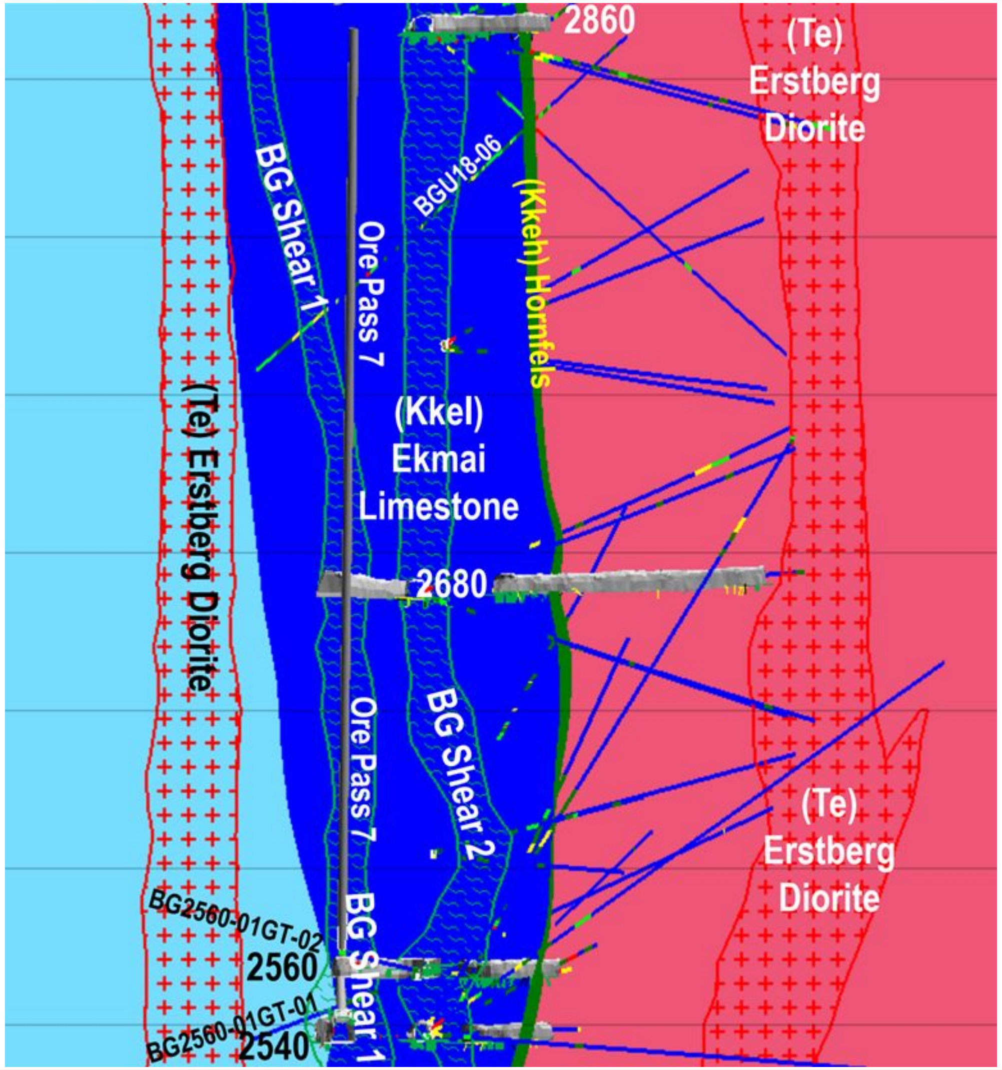
  15m (W) x 40m (H) x up to <60m (L)

- Production Rate

  10 000 Tons / day

- Ore Pass 7

Geotechnical Information



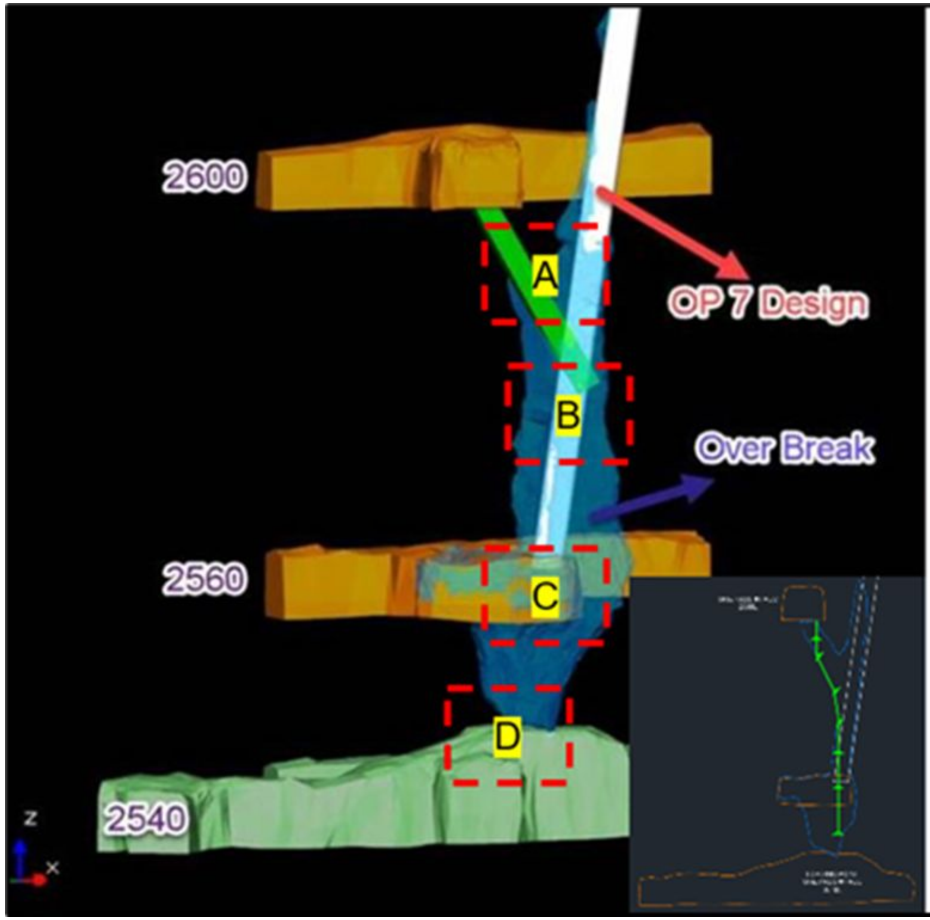
Horizontal Stress Field +- 40MPa

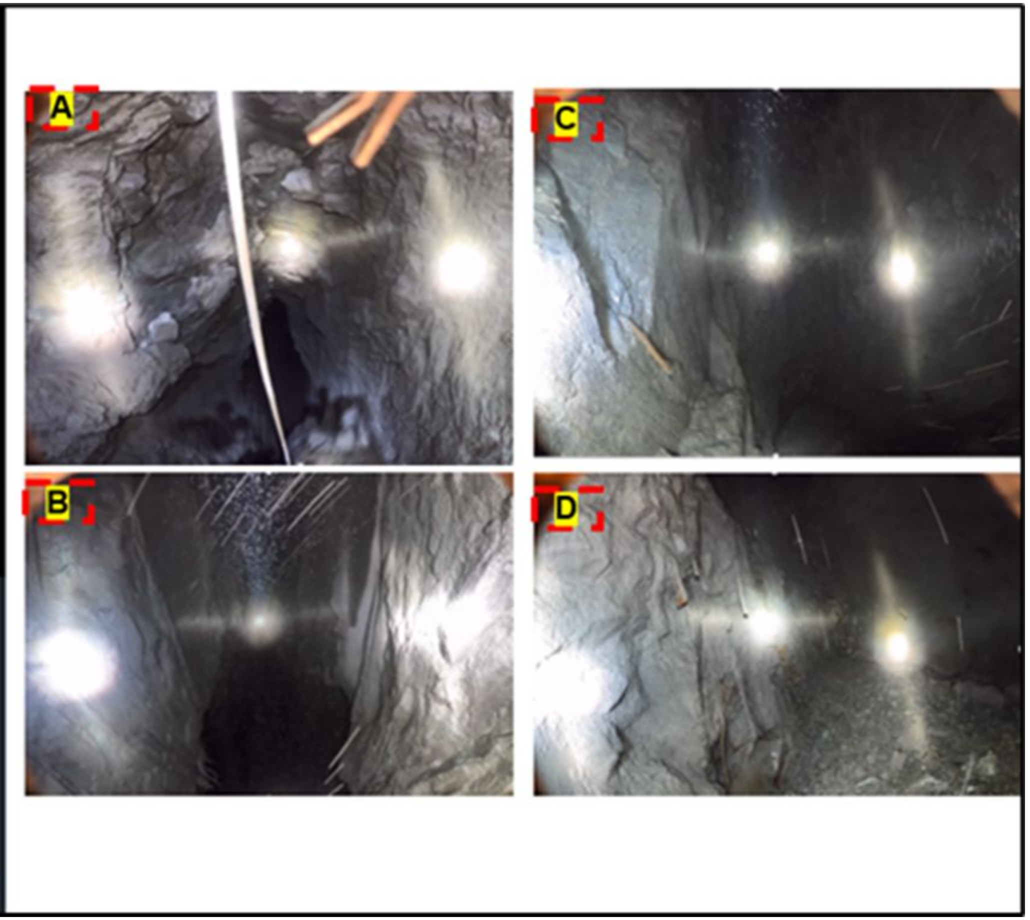
[illegible]		[illegible]		[illegible]	
Magnitude	Orientation	Magnitude	Orientation	Magnitude	Orientation
38 MPa	225°/ 15°	19 MPa	160°/ 64°	18 MPa	135°/ 7°

Limestone : UCS 197MPa ; GSI 74

	UCS (MPa) based on PLT					Mean UCS (MPa) from Laboratory (Intact Samples)		Laboratory Rock Properties (Intact Samples)									UCS (MPa)
	10%	16%	25%	50%	90%	All Data	H-B	E_i (Gpa)	GSI	m_i	E_{rm} (Gpa)	υ	m_b	s	a	±20%
Kkel (2138 Samples)	96	120	144	197	235	83	159 (16 Samples)	72	74	13.8	58	0.22	5.5	0.056	0.501	150
BG SZ_2 (2204 Samples)	96	120	144	197	235	-	-	-	74	-	58	0.22	5.5	0.056	0.501	150
Kkel / SZ_2 [1]	96	120	144	197	235	-	-	-	74	-	58	0.22	5.5	0.056	0.501	150
Kkel / SZ_1	-	-	-	-	-	120	164 (31 Samples)	72	74	12.6	58	0.22	5.0	0.056	0.501	150
SZ_1 (304 Samples)	139	154	168	206	235	153	178 (15 Samples)	72	74	10.8	58	0.22	4.3	0.056	0.501	150
Kkes (1903 Samples)	154	168	182	211	235	-	177 (9 Samples)	72[2]	75	12.9	58	0.22	5.5	0.056	0.501	175
Te (2356 Samples)	38	67	105	168	235	117	182 (35 Samples)	53	75	21.5	44	0.27	8.8	0.062	0.501	170

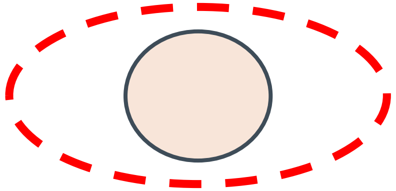
Ore Pass 7 Deterioration



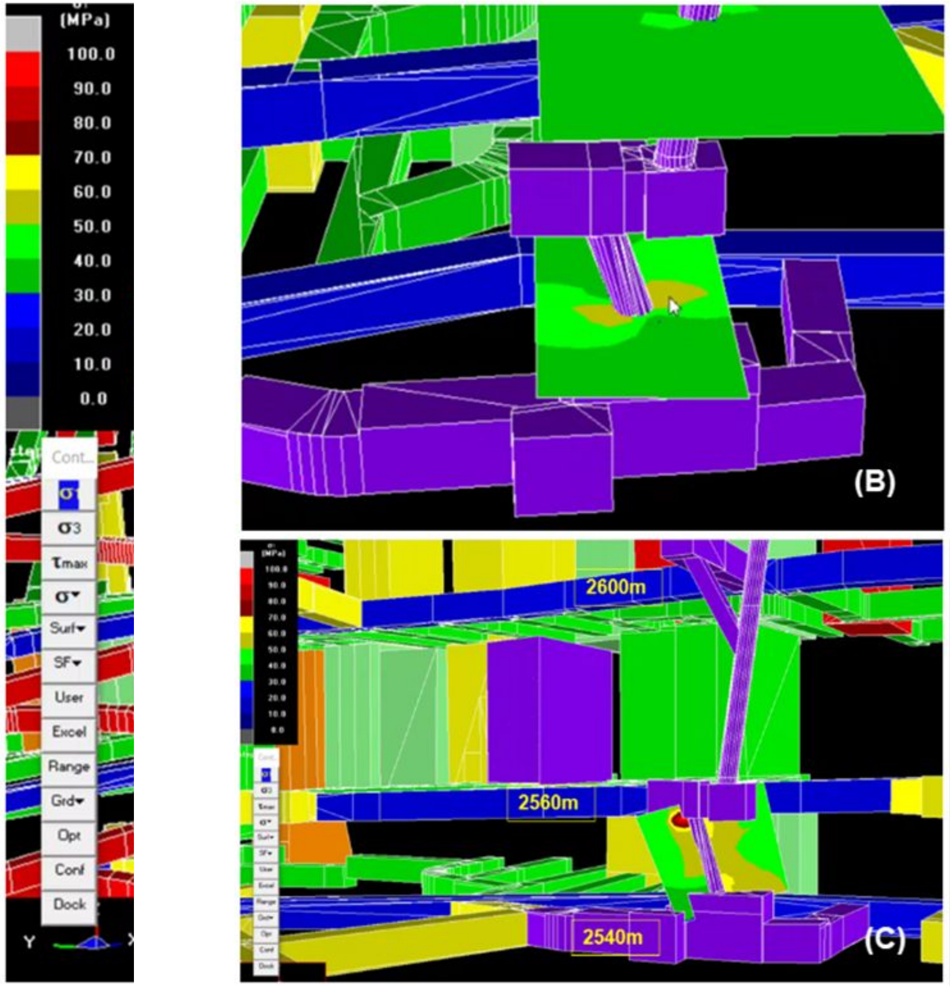


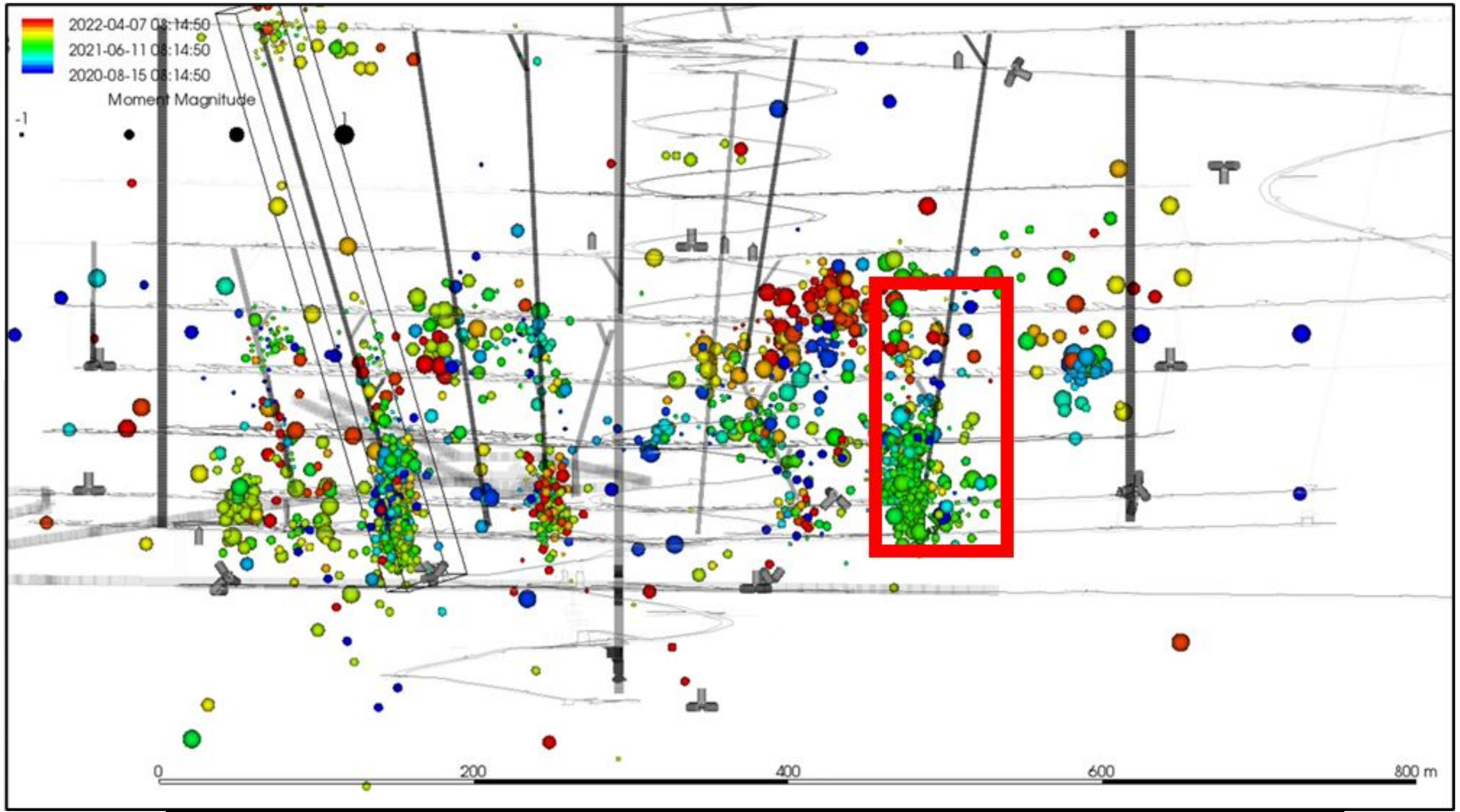
Original Design:
3.6 m Diameter Raise Bore

Scaled Out Dimension:
8 m x 5 m



Stress Modelling / Seismicity

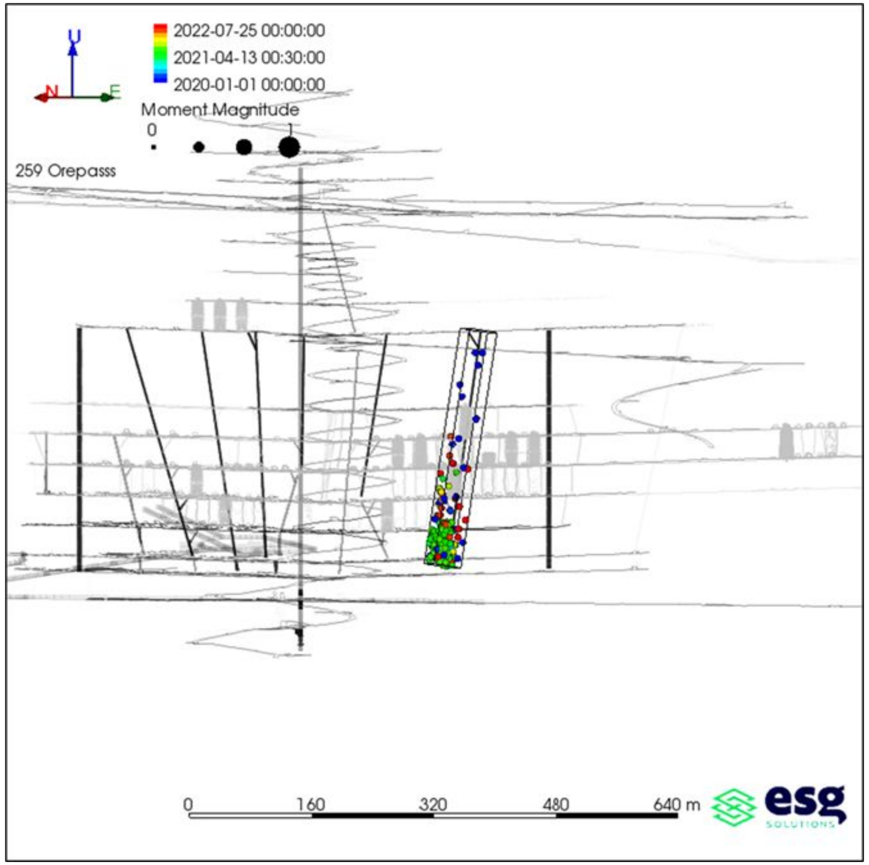


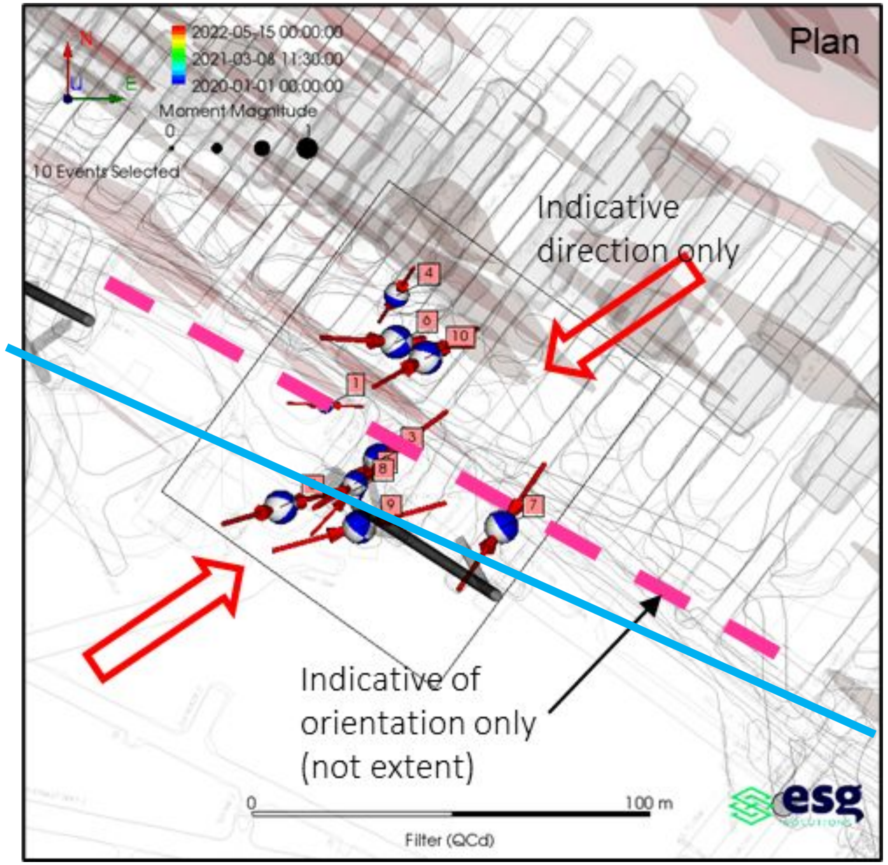


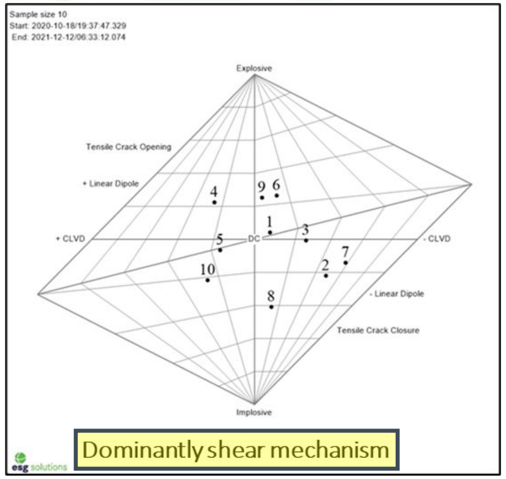
Tangential Stress at Ore Pass +- 60 - 80MPa

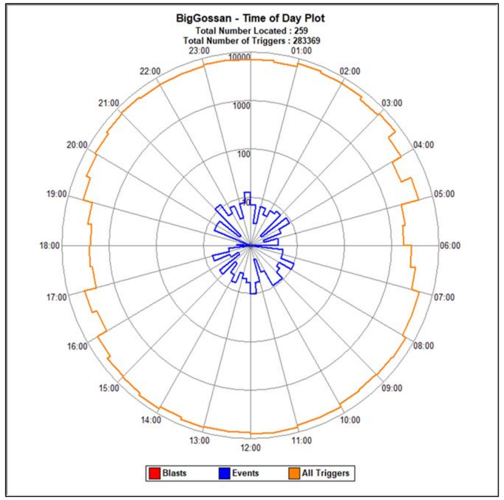
Mostly minor events related to dumping down an empty ore pass

Seismicity





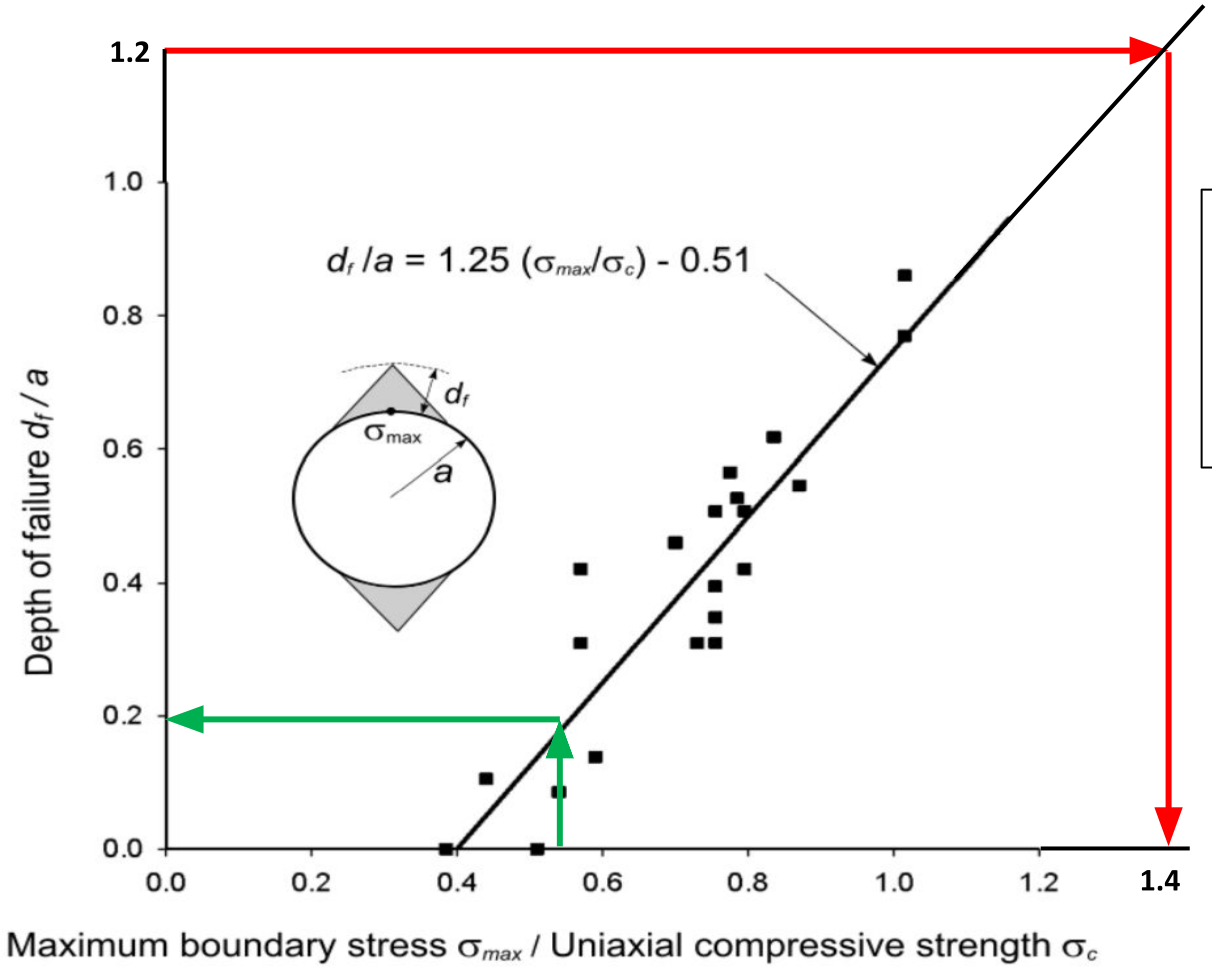




Estimated average orientation of one set seismic failure planes
Shear Zone 1

Minor Events = Dumping in Empty Ore Pass

Quantifying Stress – Spalling



Expected Spalling Depth 0.4m ; Tangential Stress 80 – 100MPa

Actual Spalling Depth 2.2m ; Tangential Stress 280MPa

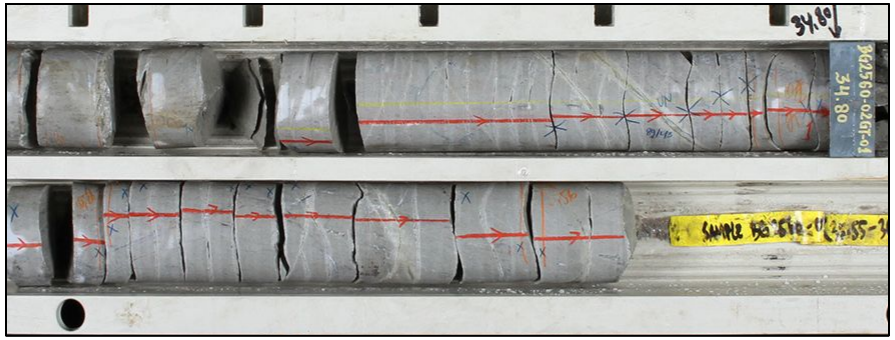
Major Stress +- 100MPa ; Minor Stress =-20MPa

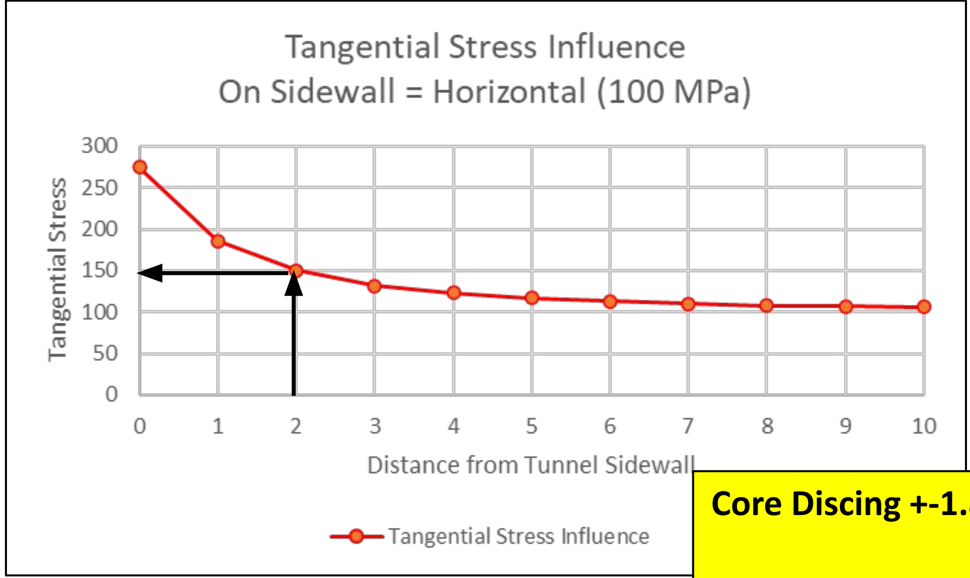
Back analysis of OP 7

Mining-induced stress alone cannot explain the depth of failure

Quantifying Stress – Core Discing

Term	Core Photo	Description	Disk Thickness t / d	Stress Condition σ_1 / BT
Core Disking		Crushed disking: The disks are crushed due to the extremely high stress.	< 0.05	> 11
		Very thin disking: The majority of the disks are intact but a few are crushed.	0.05 - 0.12	9 - 11
		Thin disking: The shape and spacing of the core disks are uniform.	0.12 - 0.2	8 - 9
		Medium disking: The shape and spacing of the core disks are uniform. Most commonly observed disk thickness.	0.2 - 0.4	7 - 8
		Thick disking: The shape of the core disks is uniform.	0.4 - 2.2	6.5 - 7
Partial Disking		Partially disking: Distinct white lines appear at regular spacings, similar to that observed when the complete disks form, but the core remains intact. Spacing between these lines is similar to that of Medium disking.	0.2 - 0.4	6 - 7
No Disking		No disking: Solid core but the core maybe microcracked which can be seen with the naked eye.	-	-





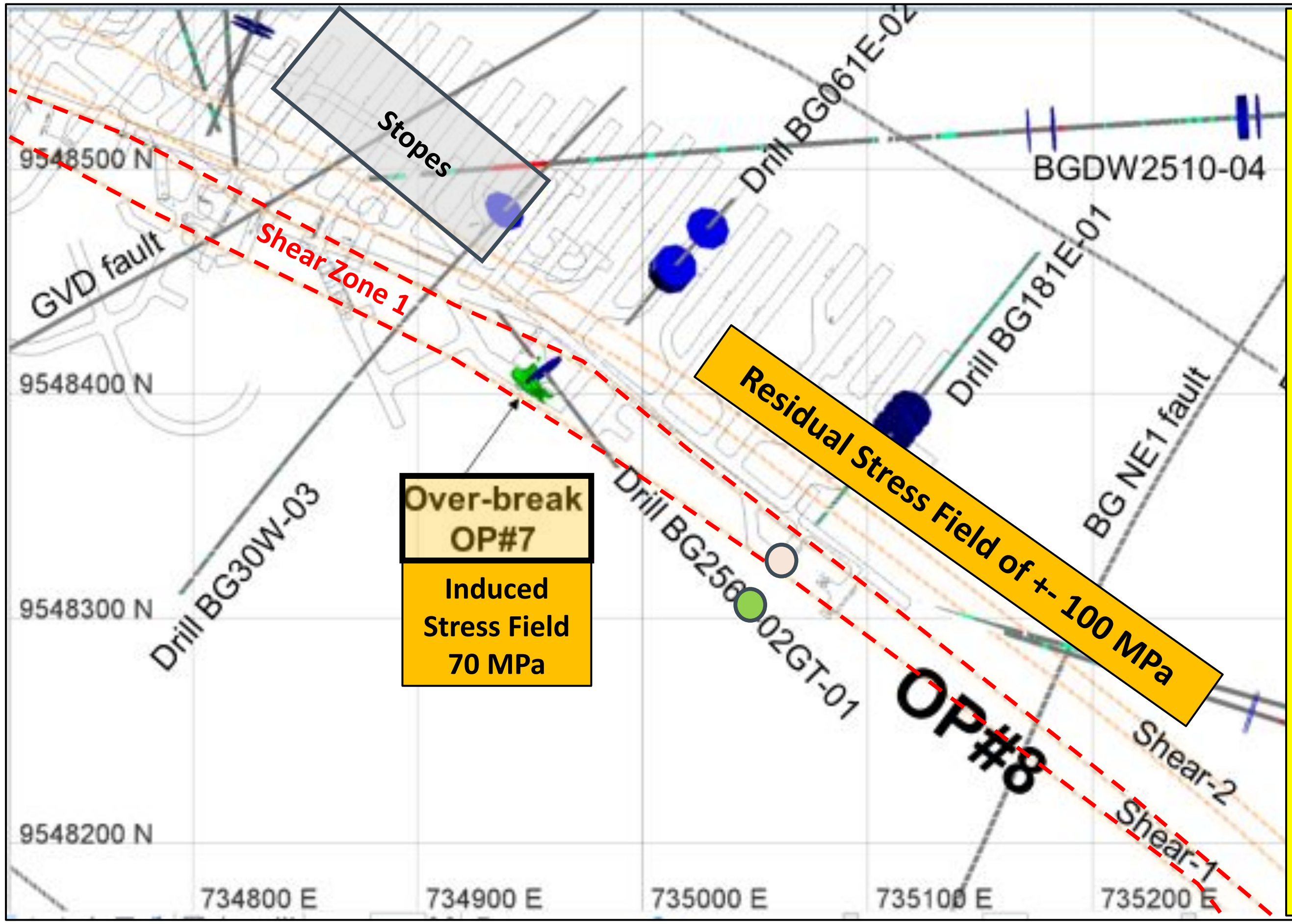
Core Disking 5mm – 40mm; Core Diameter 63.5mm				
UCS			150 MPa	197MPa
mm	t/D	Si/St	UTB 14.0 MPa	UTB 19.0 MPa
5	0.08	9.5	133	181
10	0.16	8.1	113	154
15	0.24	7.2	101	137
20	0.31	6.8	95	129
25	0.39	6.8	95	129
30	0.47	6.8	95	129
35	0.55	6.8	95	129
40	0.63	6.8	95	129
Induced Field Stress BG SZ (Residual Stress)			60 MPa (Map 3D) 80 - 90MPa (Martin et al)	

Core Discing +-1.8m from the Ore Pass

Core discing is indicative of a Stress of 130 – 150MPa

Indicate a Major Stress of +- 100MPa.

Conclusion



Multiple contributing factors:

- Mining-induced Stress
- Residual Stress ≈ Shear Zone 1 (SZ 1)
- Dumping in empty Ore Pass (Abrasion / Impact Damage)

Evidence :

- Spalling Depth
- Core Discing
- Seismic Events ≈ Failure planes // Shear Zone 1
- Minor events indicate dumping in empty ore pass / shift time

Improved Design for Ore Pass 8 :

- Design OP 8 at +75m from stopes
- Design OP 8 at +20m from SZ 1

BG SZ 1 Sensitive to Mining Induced Stress

THANK YOU

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