Hydrofracking in Block Caves

Hydrofracking

Evolving from

1. **Hydrofrack to Propagate**
2. **Hydrofrack to destress seismic plane**
3. **Hydrofrack to Pre condition development Le**

John Stacpoole
3rd April 2019

Surface Hydro Fracking
Drill BQ-H String Shackling System

Drill string shackling system to safeguard against up-thrusts

- **4 x 3 tonne concrete bollards**
- **4 x 6 tonne straps**
- **Custom 20 tonne rated steel plate**

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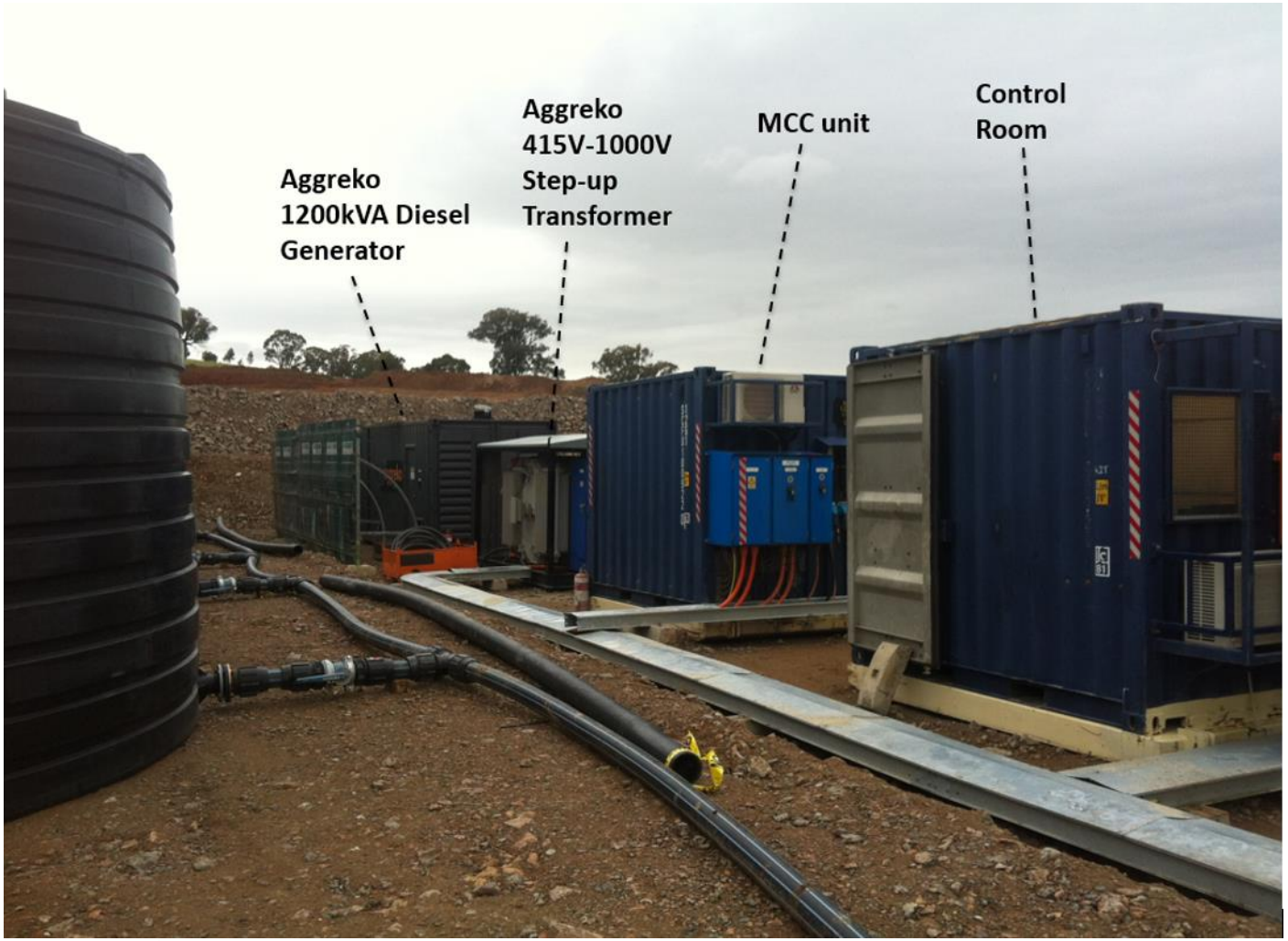
Surface-based Hydraulic Fracture System



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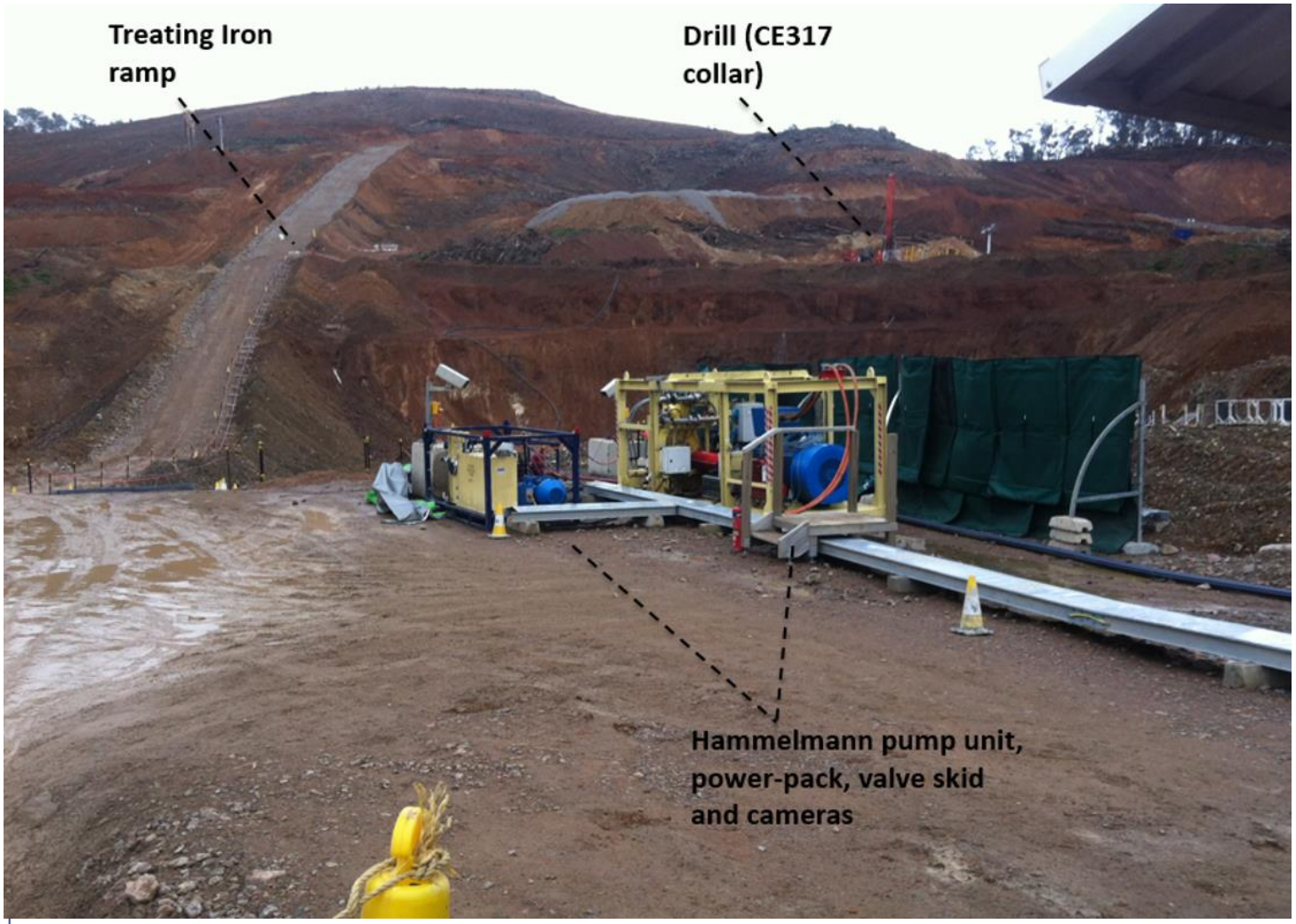
Surface-based Hydraulic Fracture System



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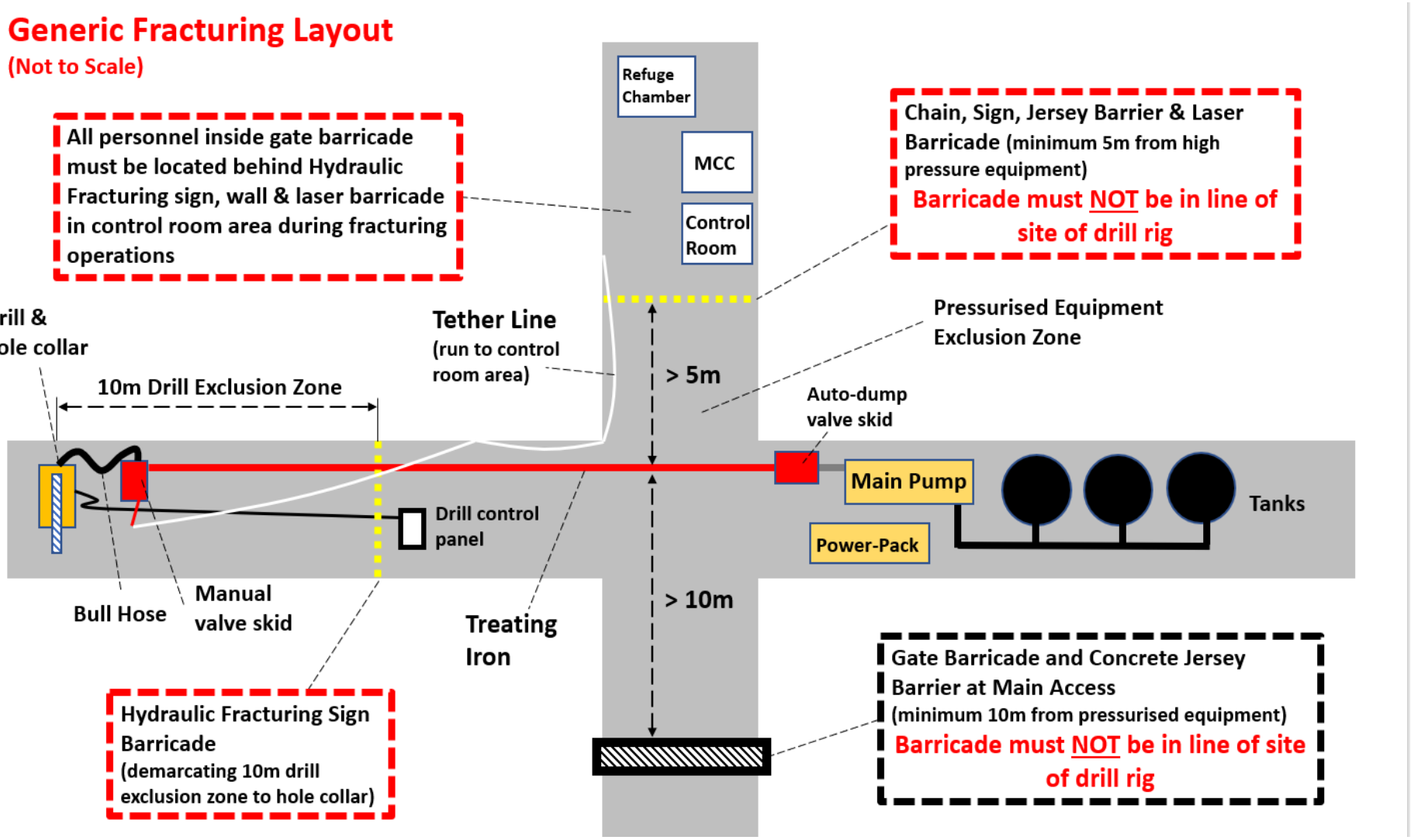
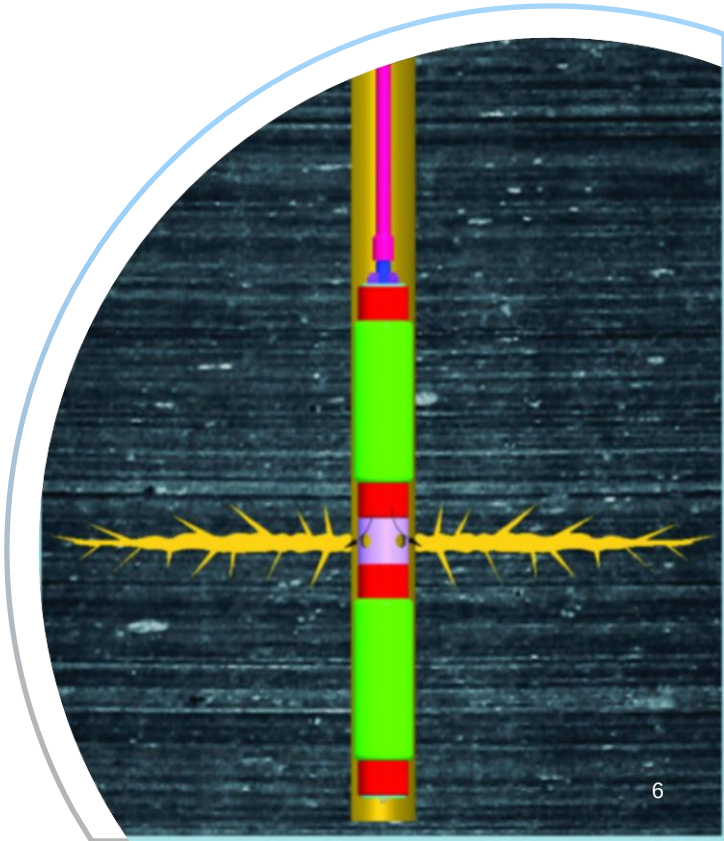
Underground-based Hydraulic Fracture System





Underground Hydrofracking Rig

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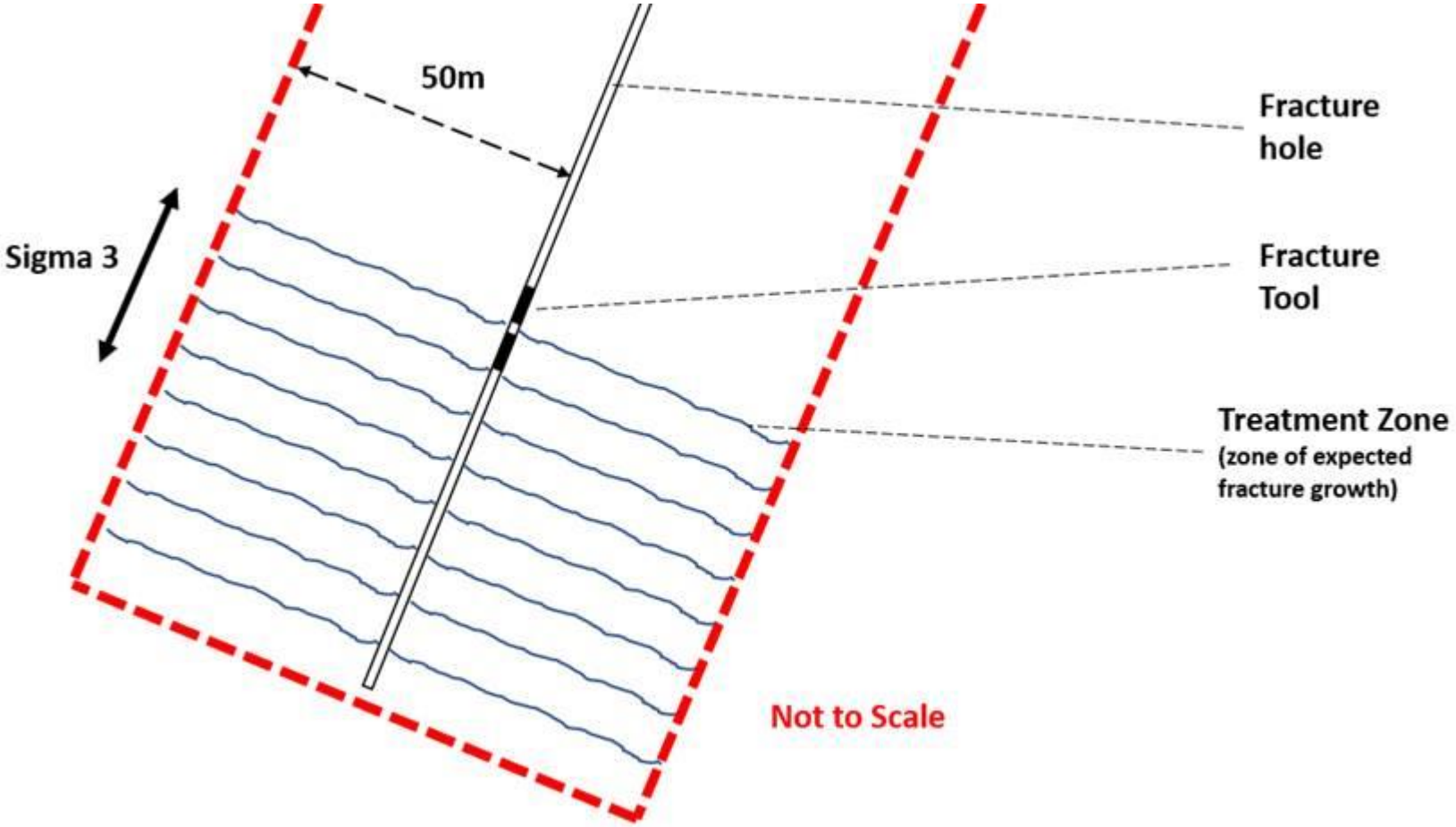
Hydrofracking - Packer

Hydro – Water and Green Phosphine

Hydrofracking – Fracture Mapping

Hydrofracking –How?



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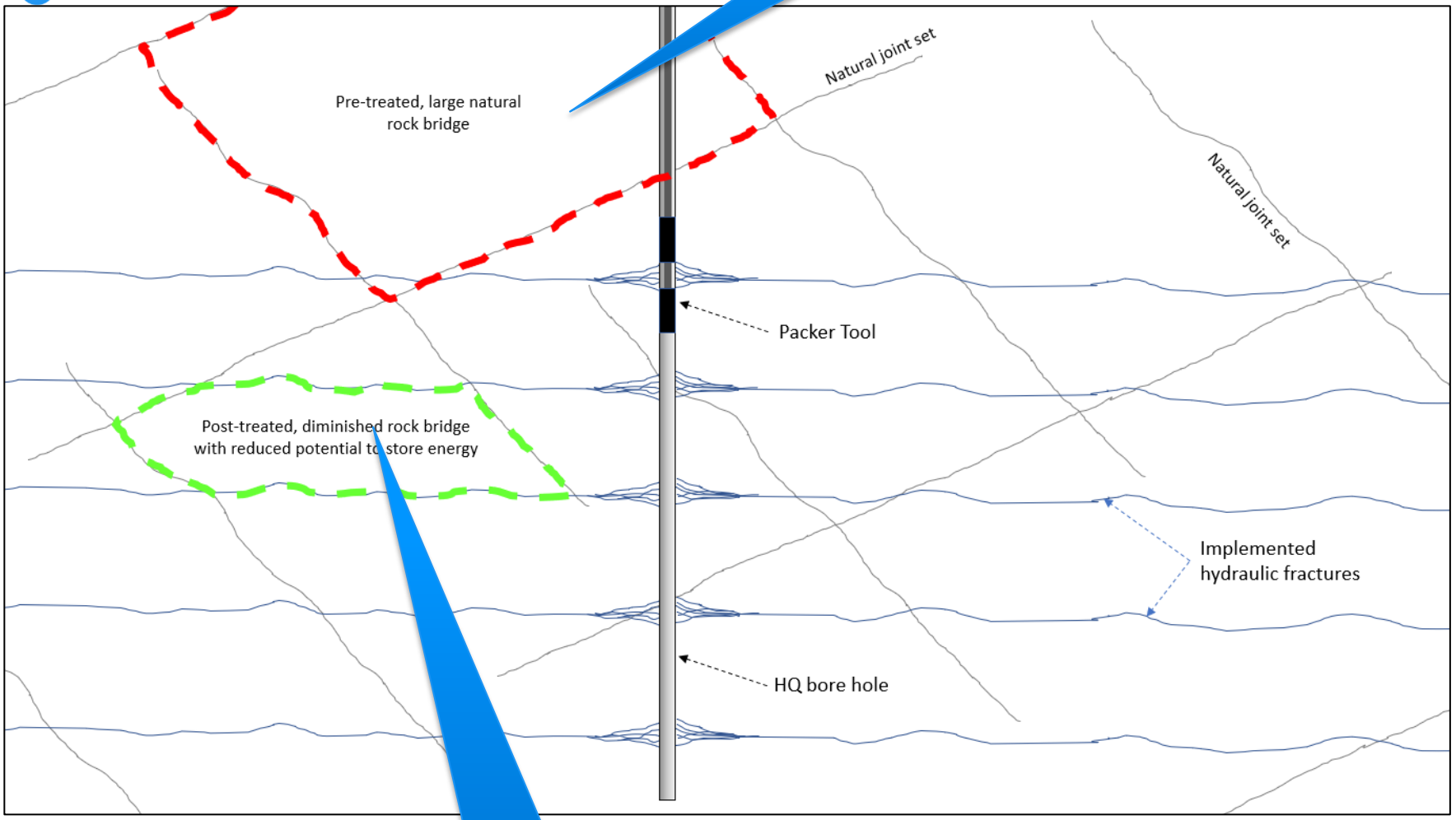
Hydrofracking –How?



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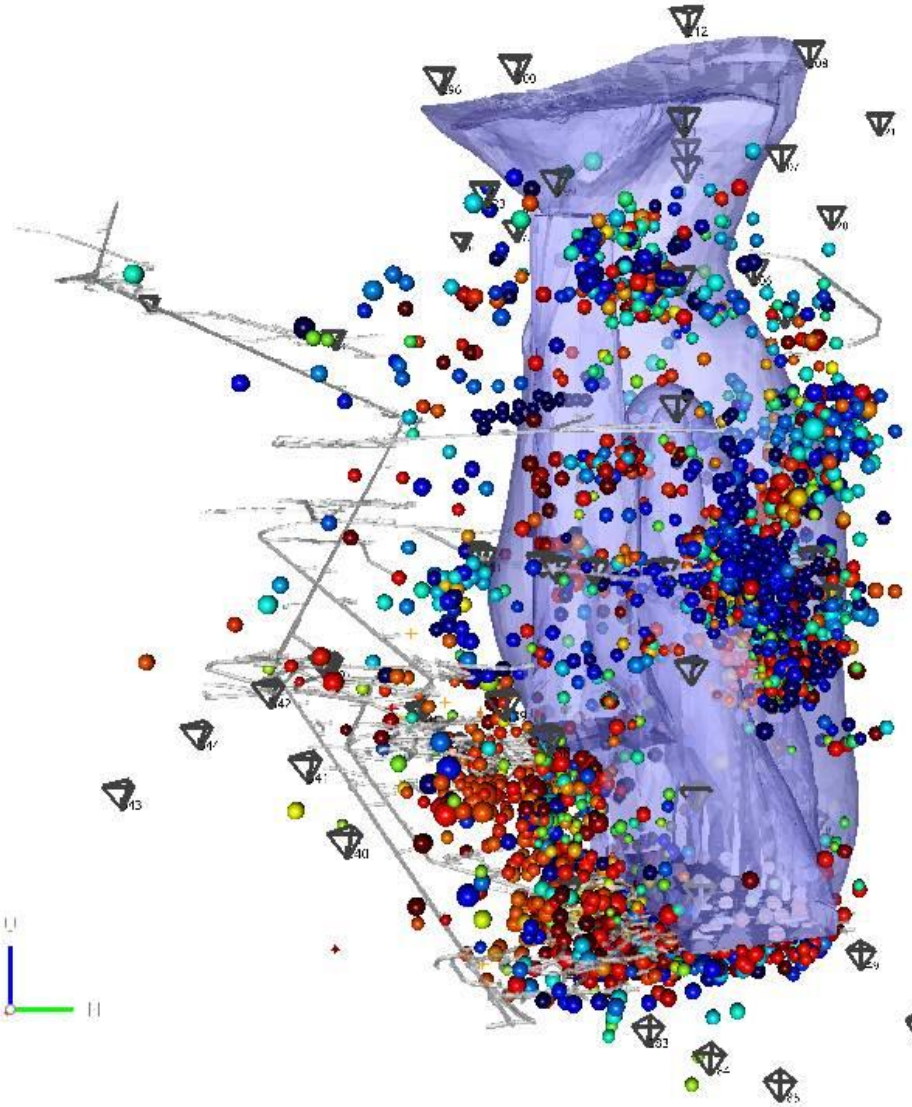
Seismic Monitoring



Event Time | Filter-NormalEvents | 01 Feb 2018 - 02 May 2018

1. Hydro Fracking to Cave Propagation

Hydraulic fracturing, in order to precondition the rock mass, is aimed at degrading the quality of a competent rock mass to assist in obtaining an improved cave performance and has become an integral part of cave mining at Cadia.

The first industrial application of hydraulic fracturing (HF) in Cadia occurred at RWD from August 2008 to February 2009 for an 80 m column within part of the orebody.

Cadia East conducted hydrofracturing programs for PC1 and PC2. These programs were completed from 2011–2013 and from 2014–2016, respectively, and aimed to precondition the 400–550 m of the base of the ore column. Cadia has now completed over 5,000 downhole fractures

Mine	RWD	PC1	PC2
Number of fractures	508	1,619	2,640
Fracture spacing (m)	3	2.5	2
Long axis from injection point (m)	50	60	60
Short axis from injection point (m)	35	25	30
Average hole depth	250	350	520
Fractures per shift (min. and max.)	2–9	6–13	6–13
Break down pressures Mpa (average and max.)	49–70	48–71	48–76

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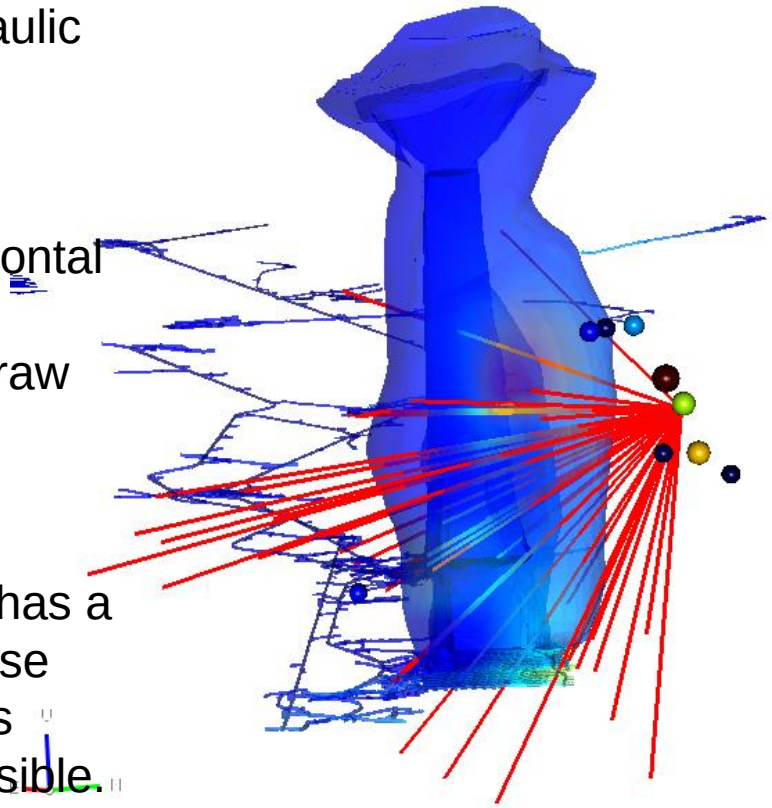
Why Hydrofrack to Propogate?

Cave performance from RWD, PC1 and PC2 have confirmed the substantial improvement from hydraulic fracturing regarding two key areas:

Cave propagation: Increase the caveability of the orebody through the introduction of new sub-horizontal fractures. This has a direct, positive effect on eliminating/mitigating airblast risk and improved draw rates.

Primary fragmentation: Reducing the number of oversize rocks reporting to the drawpoints, which has a positive impact on production ramp-up. To maximise the benefit, this requires fractures to be created as close to the elevation of the undercut level as possible.



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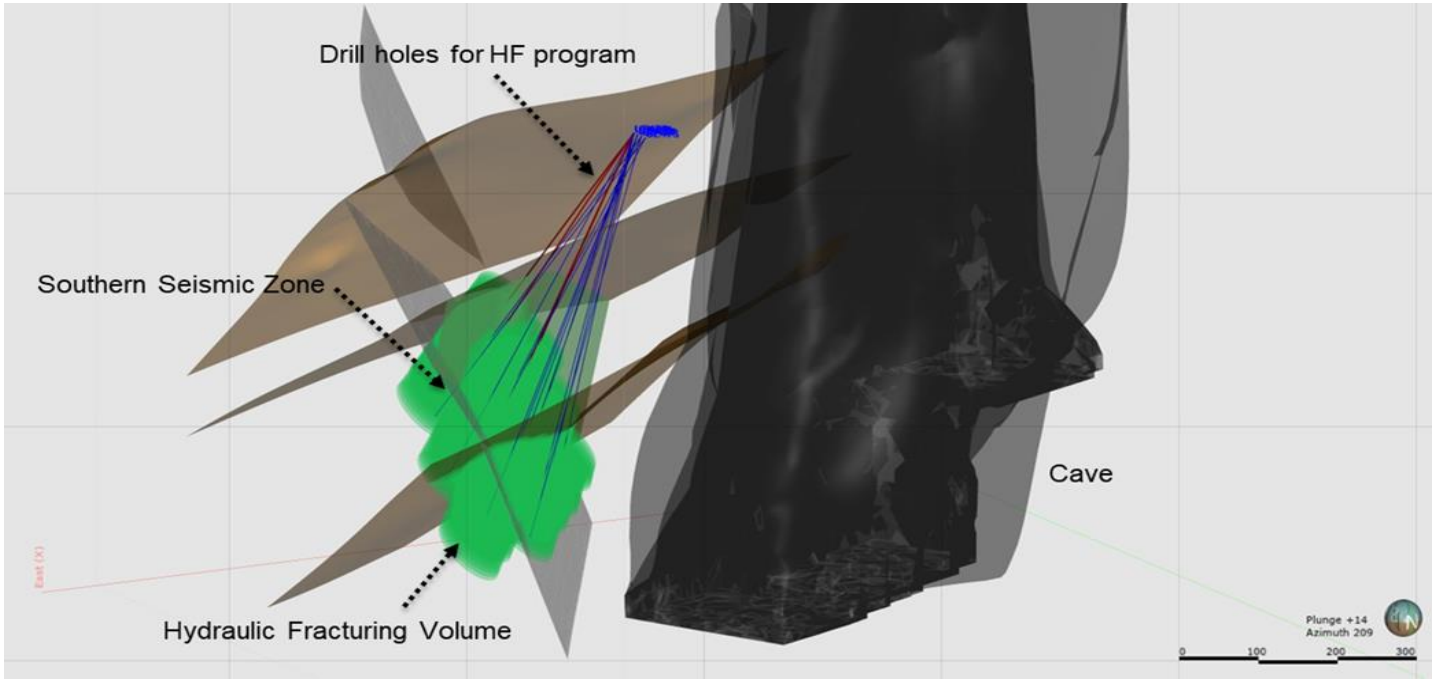
2. Hydrofrack to Reduce Seismic Hazard

- Reduction in seismic hazard: Reduction in magnitude of large seismic events within the treated volume during undercutting and cave propagation. Similar findings were found at the El Teniente mine (Pardo & Rojas 2016).



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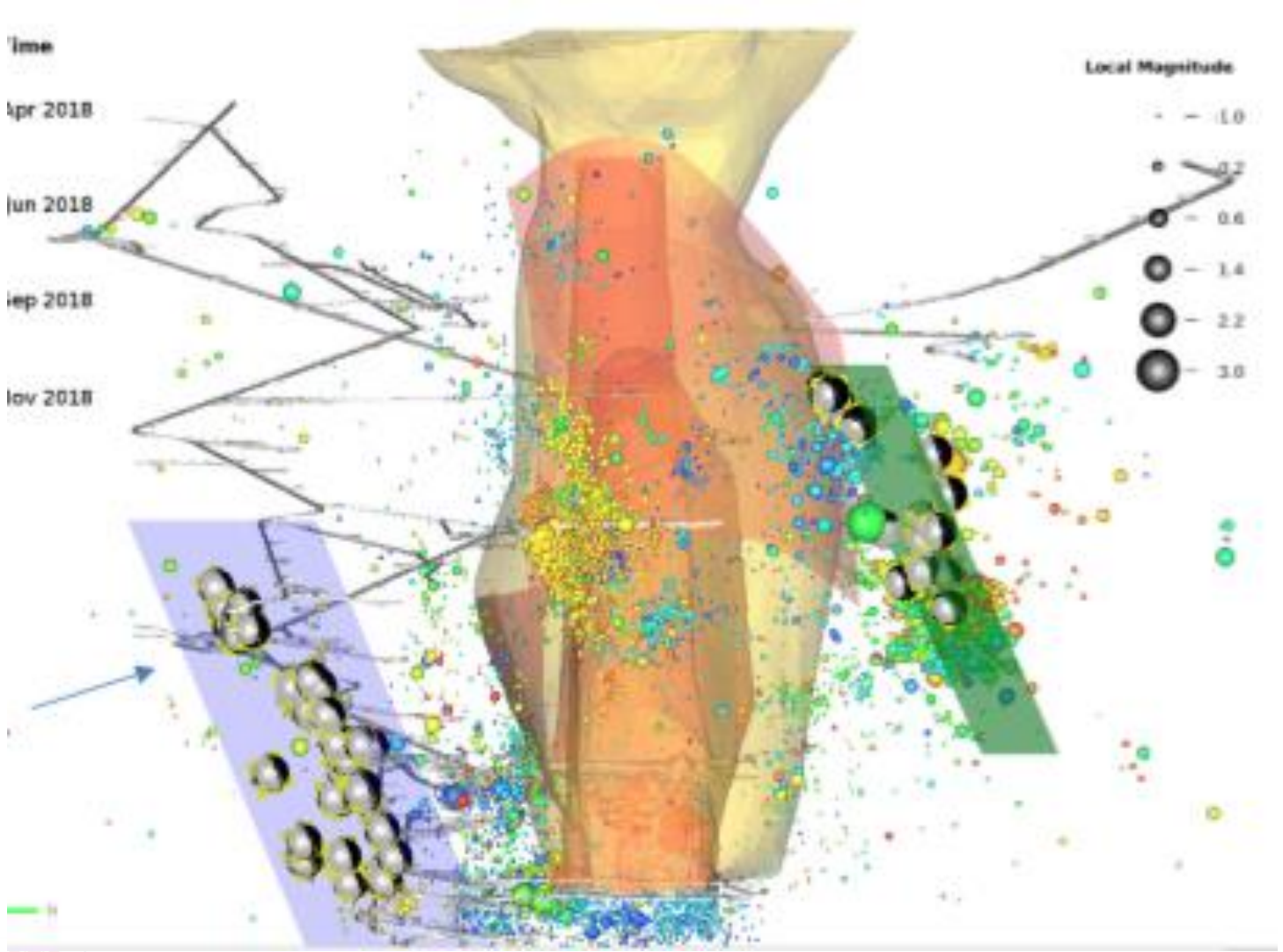
Cadia Seismic Plane



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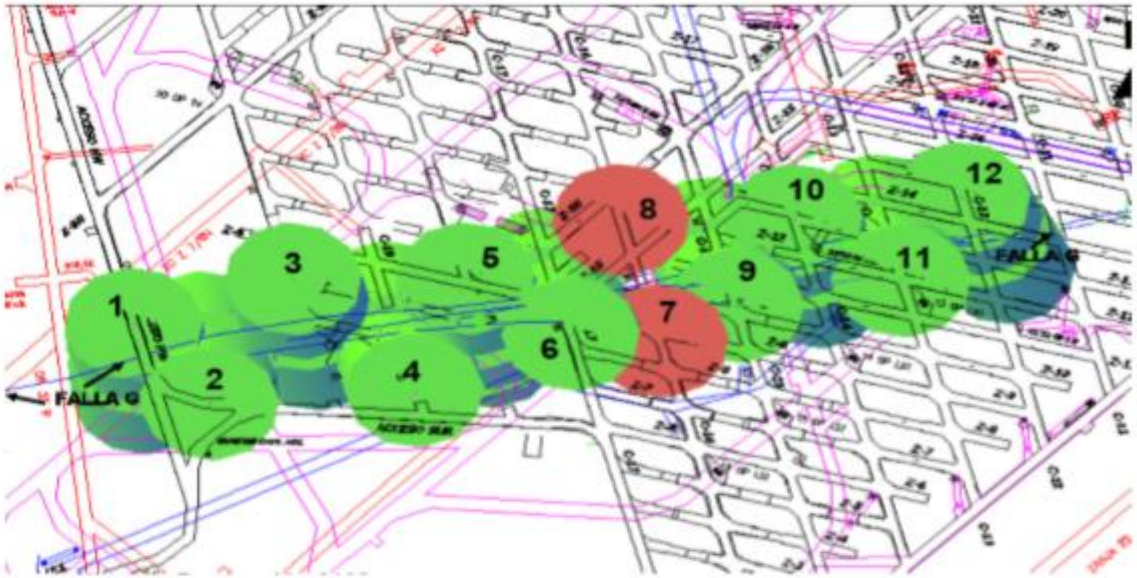
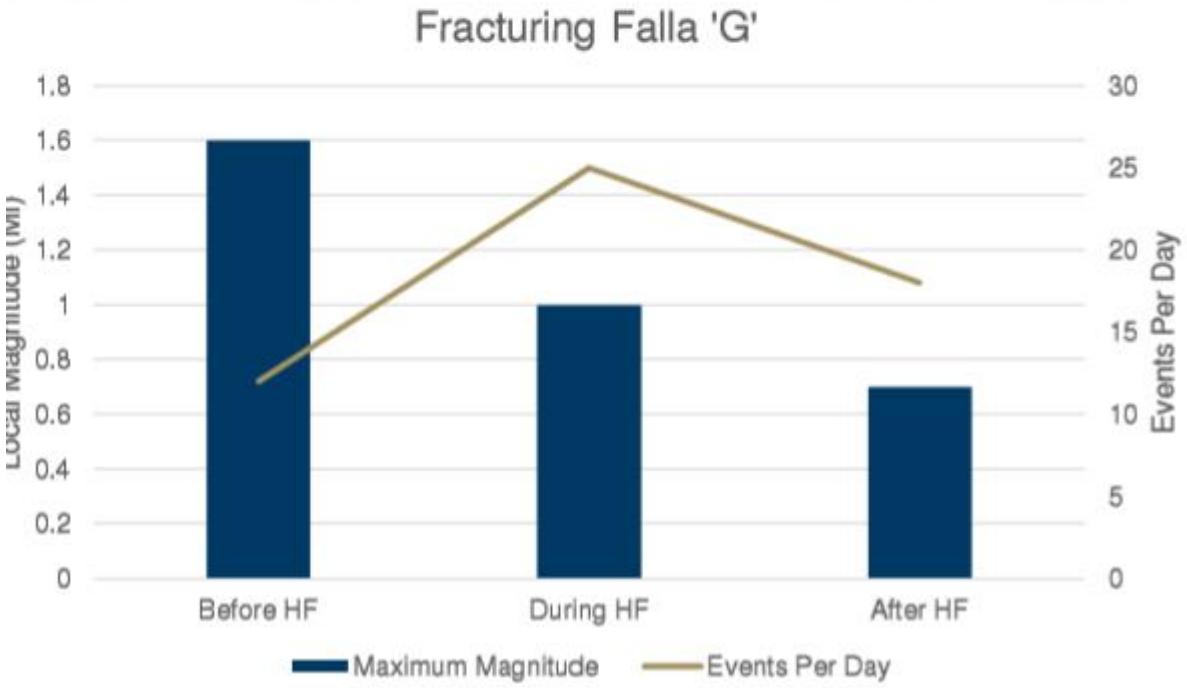




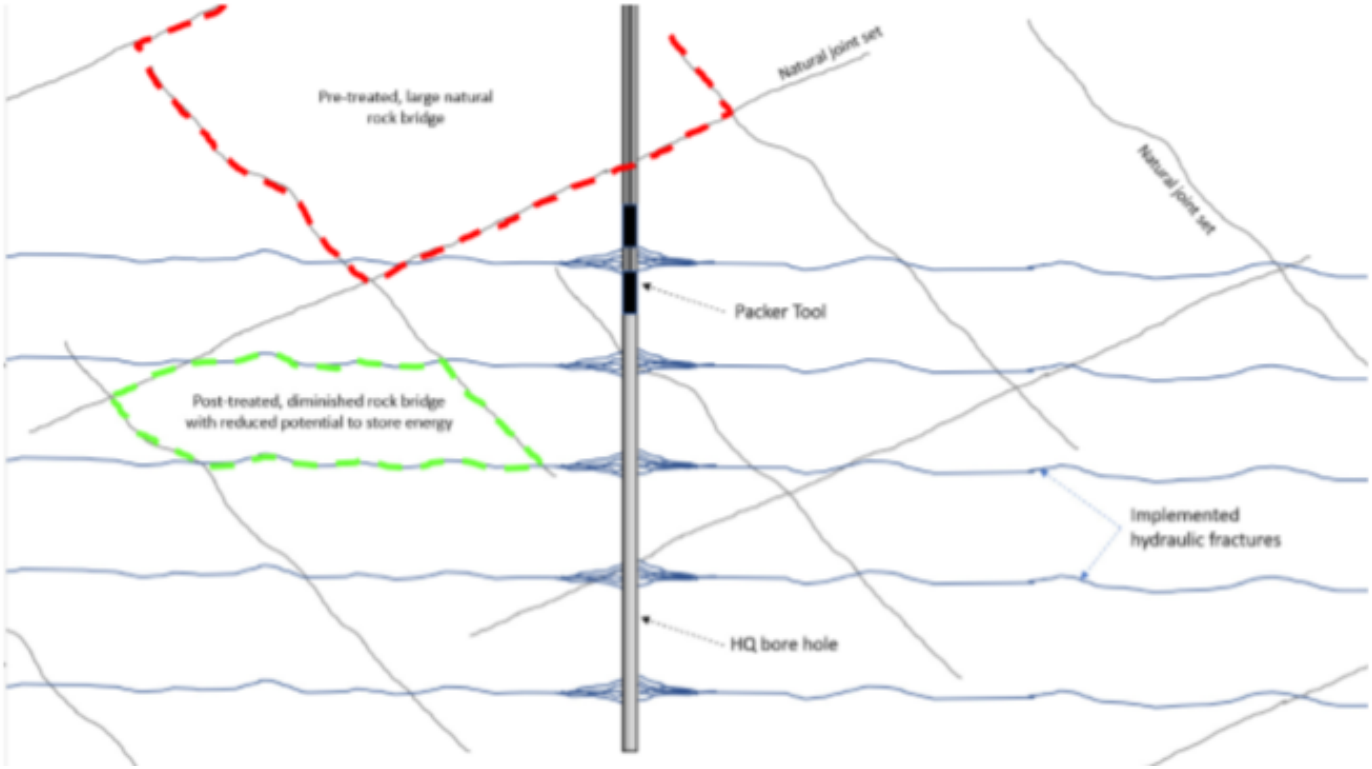
El Teniente Mine has successfully reduced the seismic hazard around a fault within their cave zone using hydraulic fracturing.

This targeted program used 12 drill holes to fracture 'Fault G', where the largest event before fracturing was $1.7M_L$.

In the following 4 months after fracturing, the largest event was $0.6M_L$.

This is the only case found where the targeted hydraulic fracturing around a geological structure has successfully to lowered seismic hazard

- Hydraulic Fracturing has Primarily used as a Cave Propagation and Size Fragmentation tool, and this is the first time at Cadia, that a Hydrofracturing Program is breaking the rock mass to mitigate against large seismic events.
- Fracturing the rock mass is expected to reduce the seismic risk to smaller magnitude events that could be managed through our current dynamic ground support practises.



Reducing seismic Potency

- The Southern Seismic Plane (SSP) has been identified by the Cadia East micro seismic system and has with increased frequency and magnitude of seismic events as a response to mining.
- The SSP has a strike of 215^{0}, a dip of 70^{0} and is positioned south of the cave flank, intersecting multiple points on the decline. The SSP is believed to have been contact between a porphyritic intrusion and the sediment rock.
- To decrease the likelihood of a large magnitude event along the SSP, a hydraulic fracturing program has been designed to target the SSP and soften the surrounding rock mass and reduce its ability to so store energy.
- At Cadia Valley Operations, areas that have previously been pre-conditioned with hydrofracturing have not experienced a seismic event larger than 1.3 ML.

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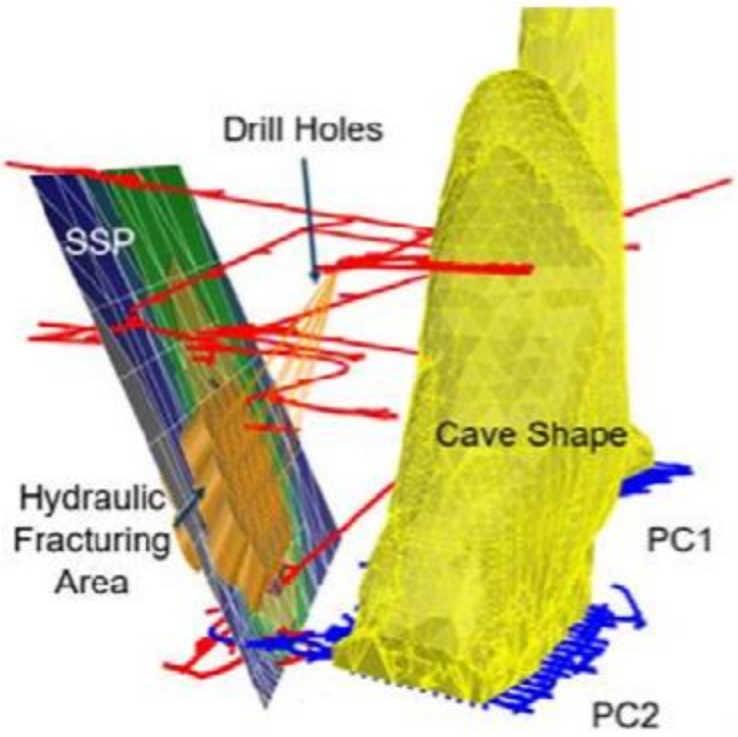
Hydrofracking - Seismic Planes



- It is planned to conduct 700 targeted hydraulic fractures, evenly distributed within the SSP volume among 18 drill holes that are currently being completed from the 5050 level
- The closest drill holes to the decline will be fractured first to target the areas of higher seismic risk earlier, forming a pre-conditioned buffer around the excavation.
- This will be the first program in Australia, and the first outside Chile, where a hydraulic fracturing program is targeting a known seismically active structure and to mitigate seismicity at the source.

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3. Hydrofrack to Precondition development

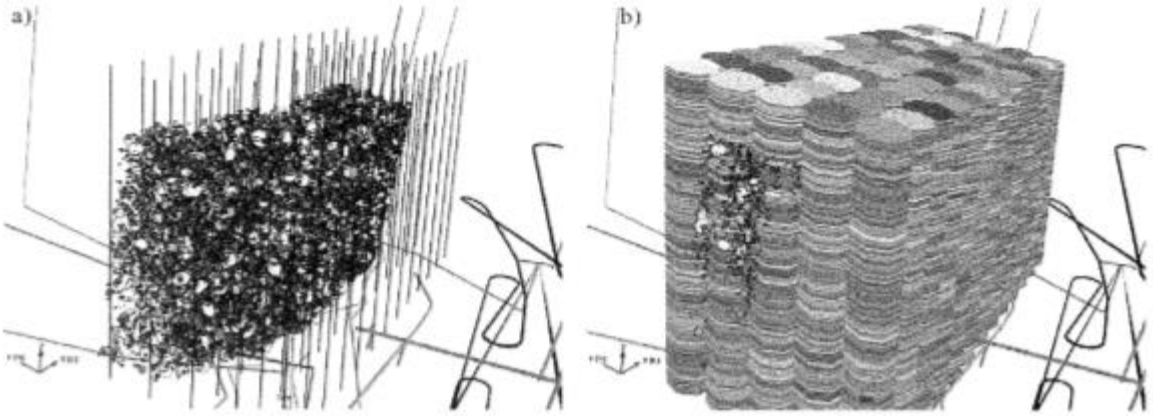

Figure 5 (a) Preconditioning boreholes configuration through one of the lift volumes; and (b) simulated HF array on those boreholes. View looking northeast

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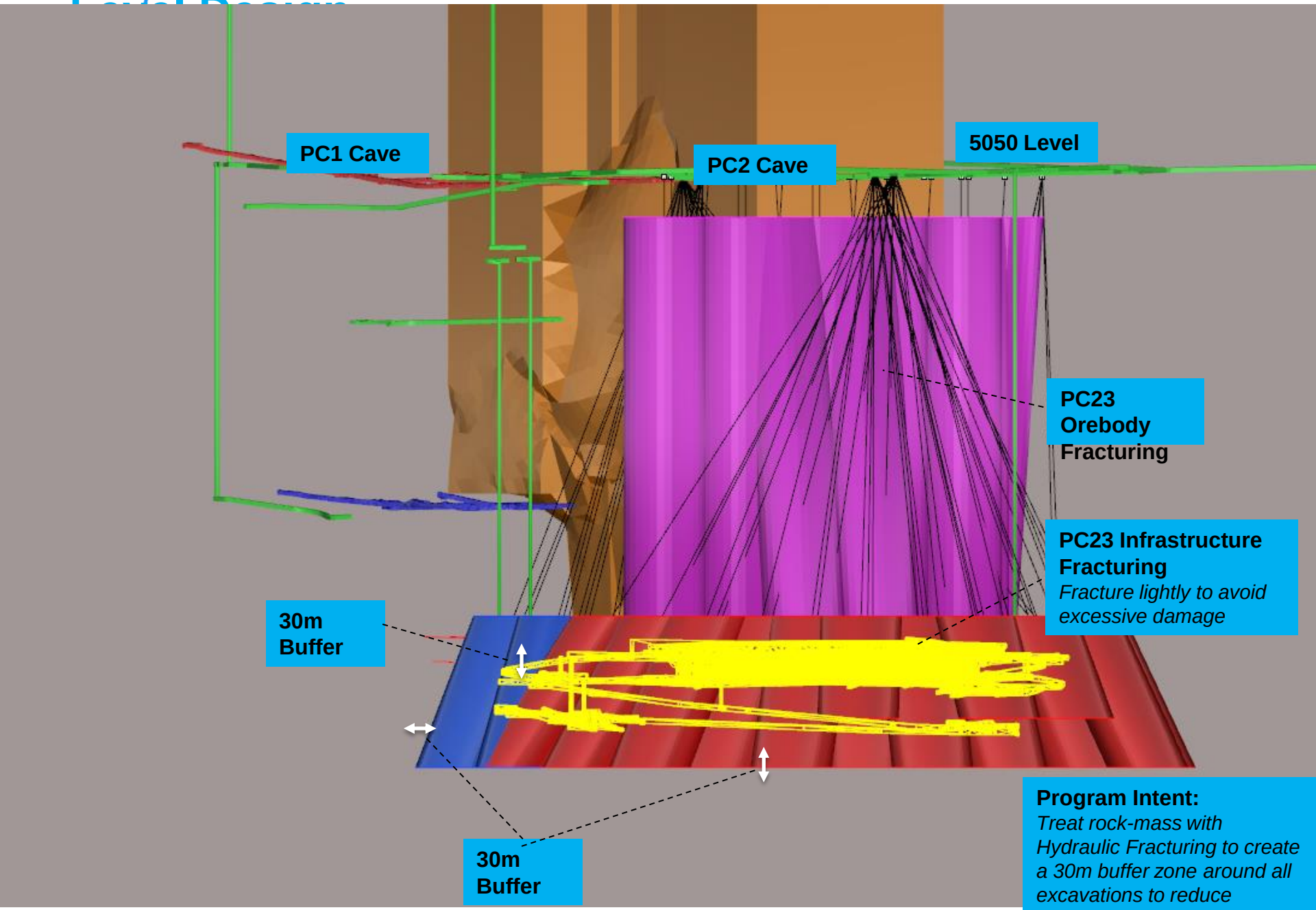
Hydraulic Fracturing Program – PC23 Revised 5050 Level Design



Program Intent:
Treat rock-mass with Hydraulic Fracturing to create a 30m buffer zone around all excavations to reduce seismic risk

Hydrofrack program

1. **Propogate – Production $**
2. **Target seismic Potency $$**
3. **Precondition Development Levels $$$**

Questions

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