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PIONEERING PROGRESS :
THE FUTURE OF ROCK ENGINEERING

Effect of Pyroxenite Layers on the Strength of UG2 Pillars

Presenter: Tatenda J. Maphosa

Affiliation: University of the Witwatersrand

Supervisor: Prof B.P Watson

SANIRE
SOUTH AFRICAN NATIONAL INSTITUTE OF ROCK ENGINEERING

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THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY

Background

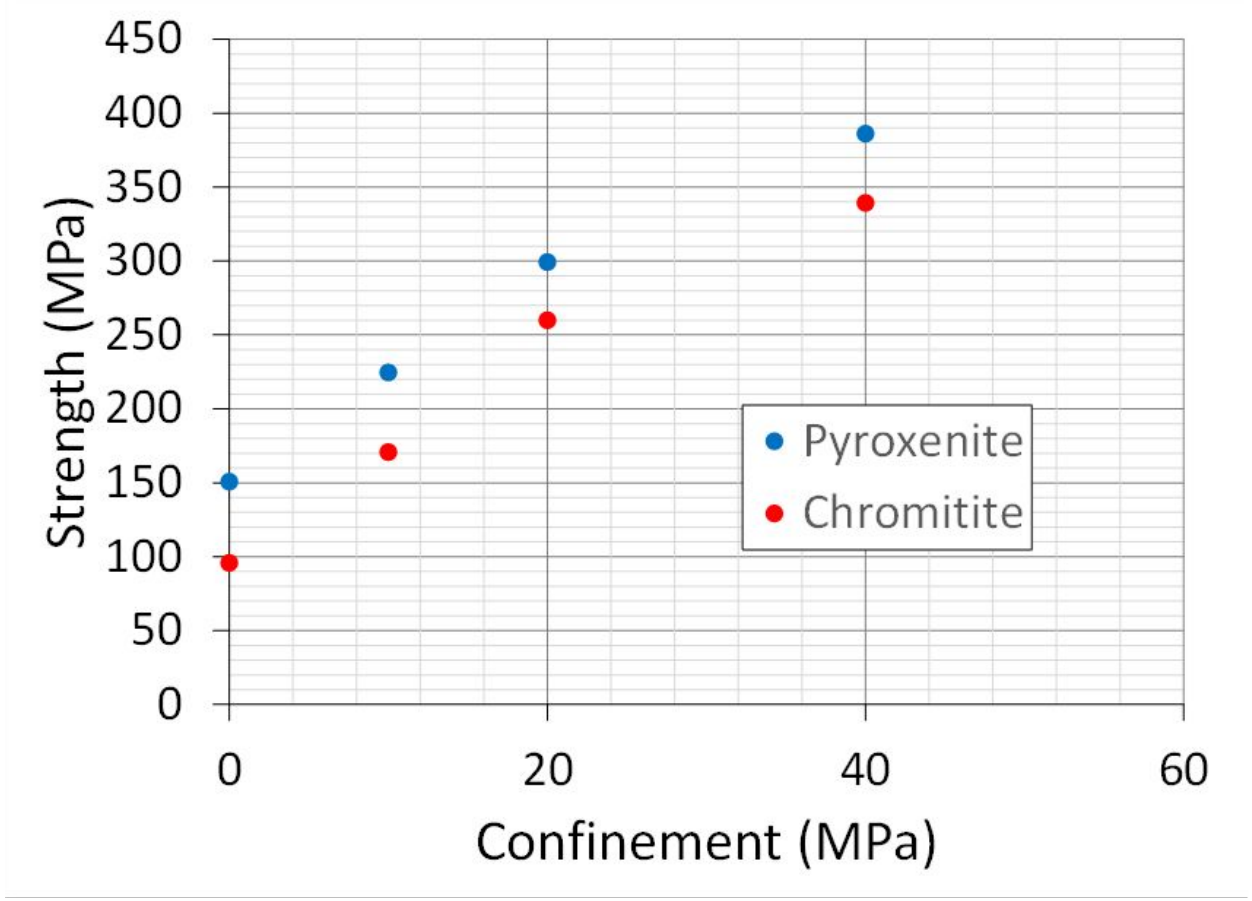
- Bushveld Complex hosts Merensky and UG2 Reefs
- UG2: chromitite reef with pyroxenite layers

Background

- The UG2 Reef is commonly mined using bord-and-pillar method
- Pillars critical for support and resource recovery

Problem Statement

- Pyroxenite is stronger than chromitite



Problem Statement

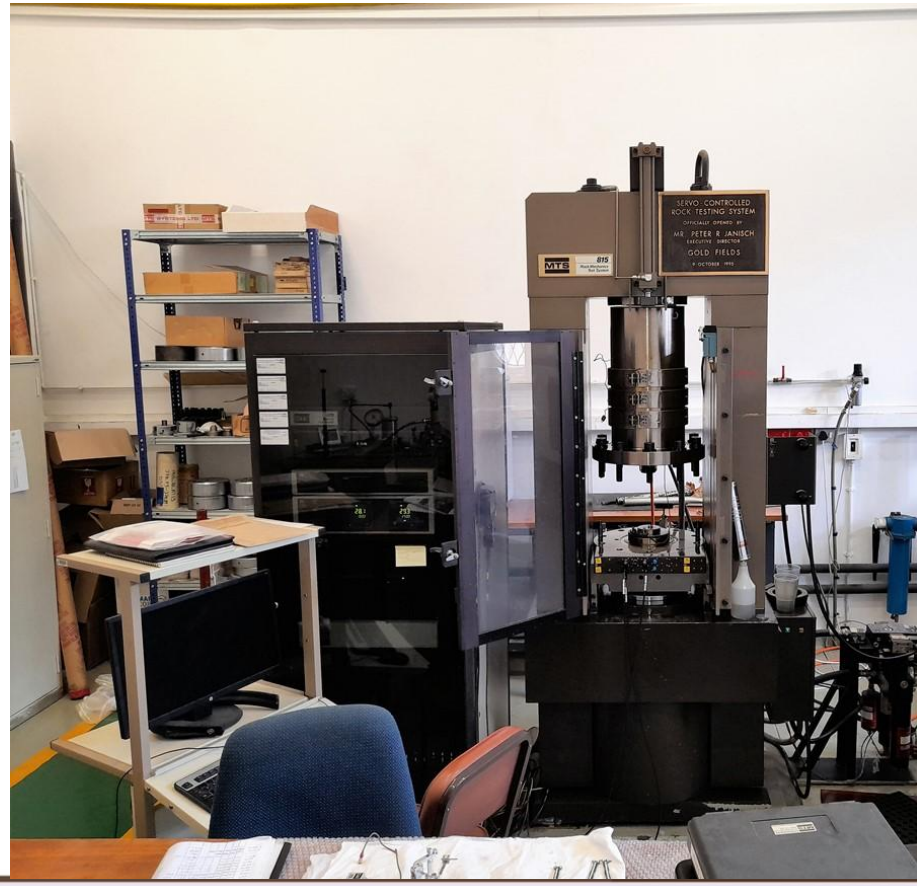
- The impact of pyroxenite on pillar strength is not well understood
- Existing formulas don’t isolate the pyroxenite effect
- Objective: Quantify the pyroxenite’s effect via modelling

Research Objectives

- Assess the influence of pyroxenite layer thickness
- Develop a strength equation based on pyroxenite%
- Investigate post-peak pillar behaviour
- Evaluate potential for laboratory validation

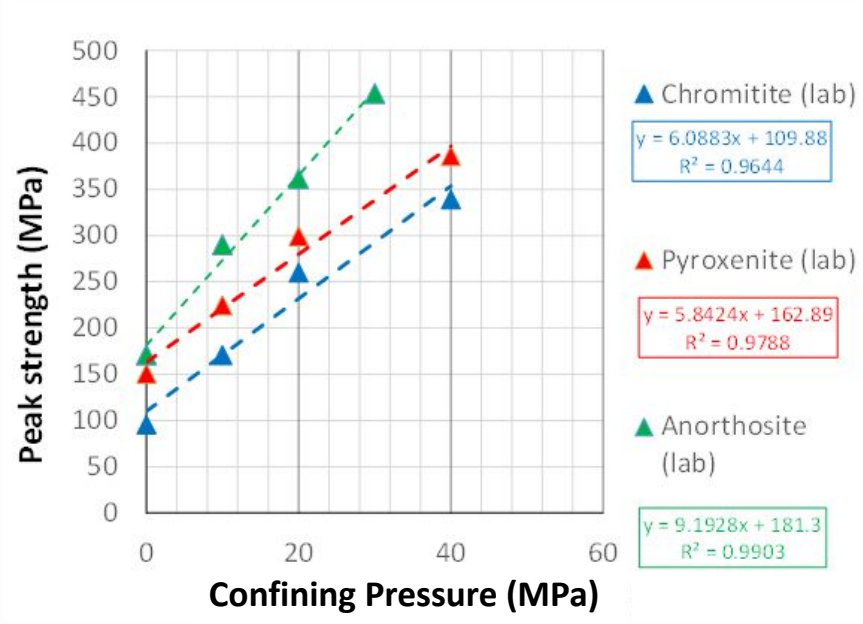
Laboratory Testing

- Rock types: Chromitite, Pyroxenite, Anorthosite
- Tests: UCS, Brazilian, Triaxial (10–40 MPa)
- Pyroxenite showed the highest strength and modulus
- Standards: ISRM (Ulusay & Hudson, 2007)

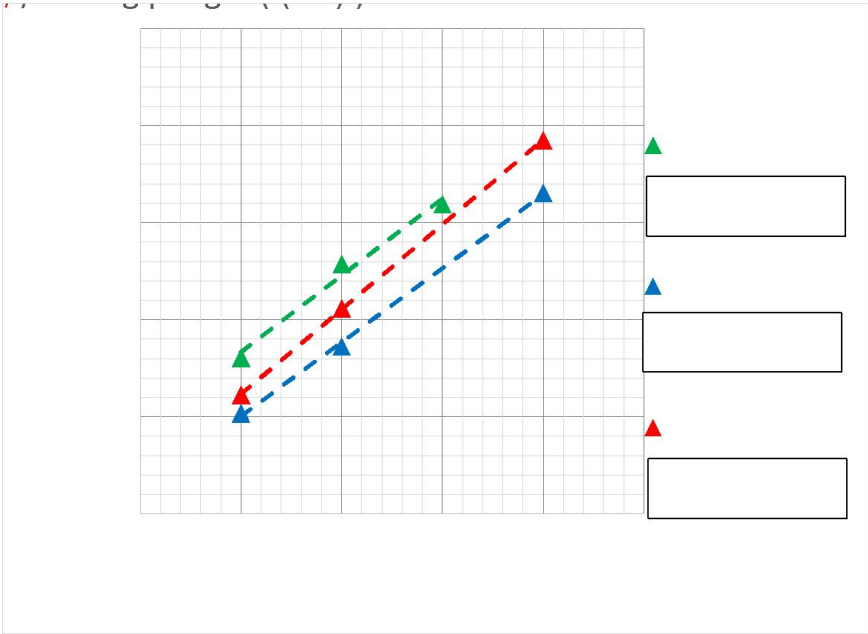


Laboratory Results

- Peak Strength



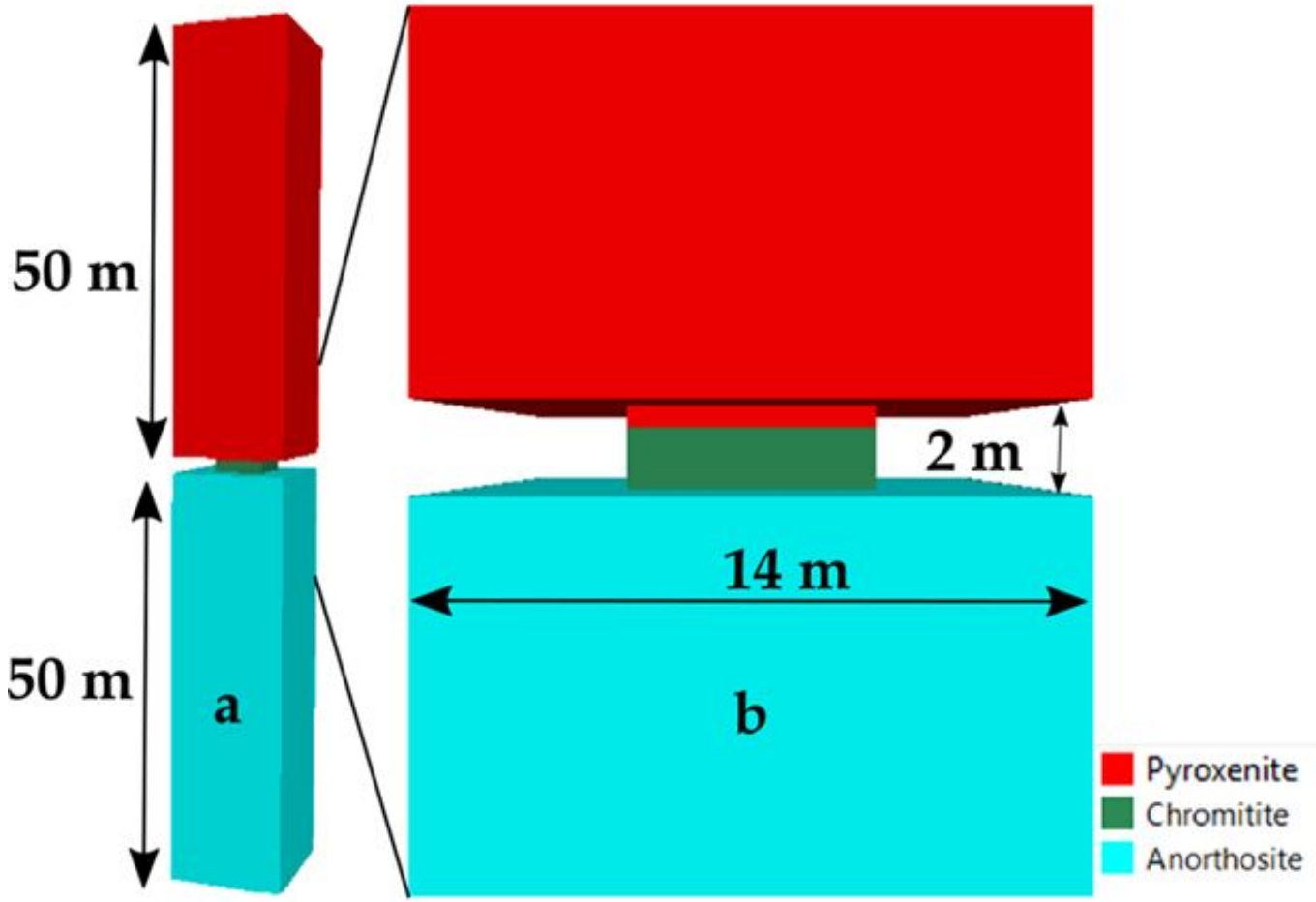
- Residual Strength



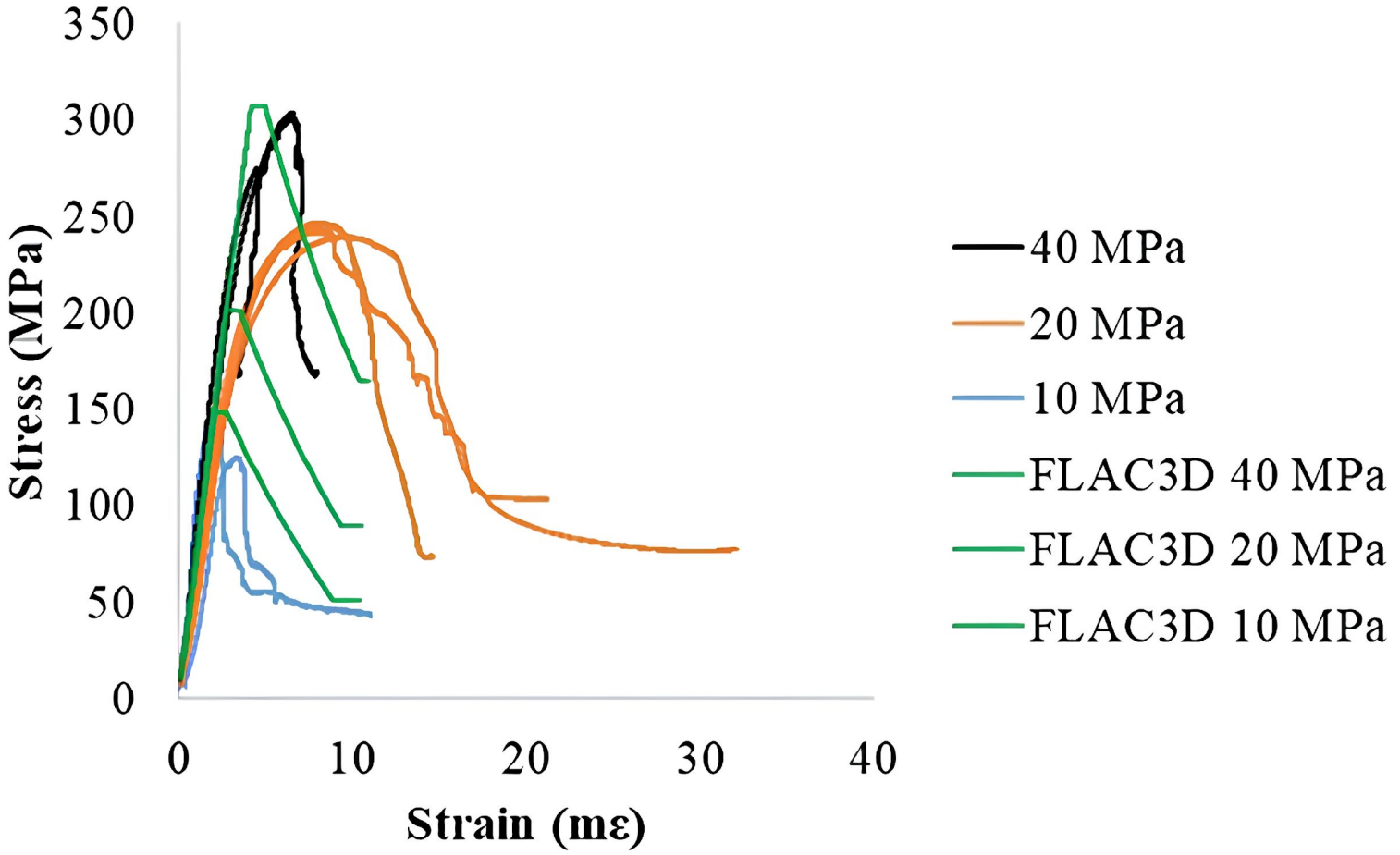
FLAC3D Model Setup

- Pillar: 6x6x2 m, Bords: 8 m wide
- 50 m hangingwall and footwall
- Roller side boundaries, fixed base
- Plastic strain parameters calibrated to lab triaxial data

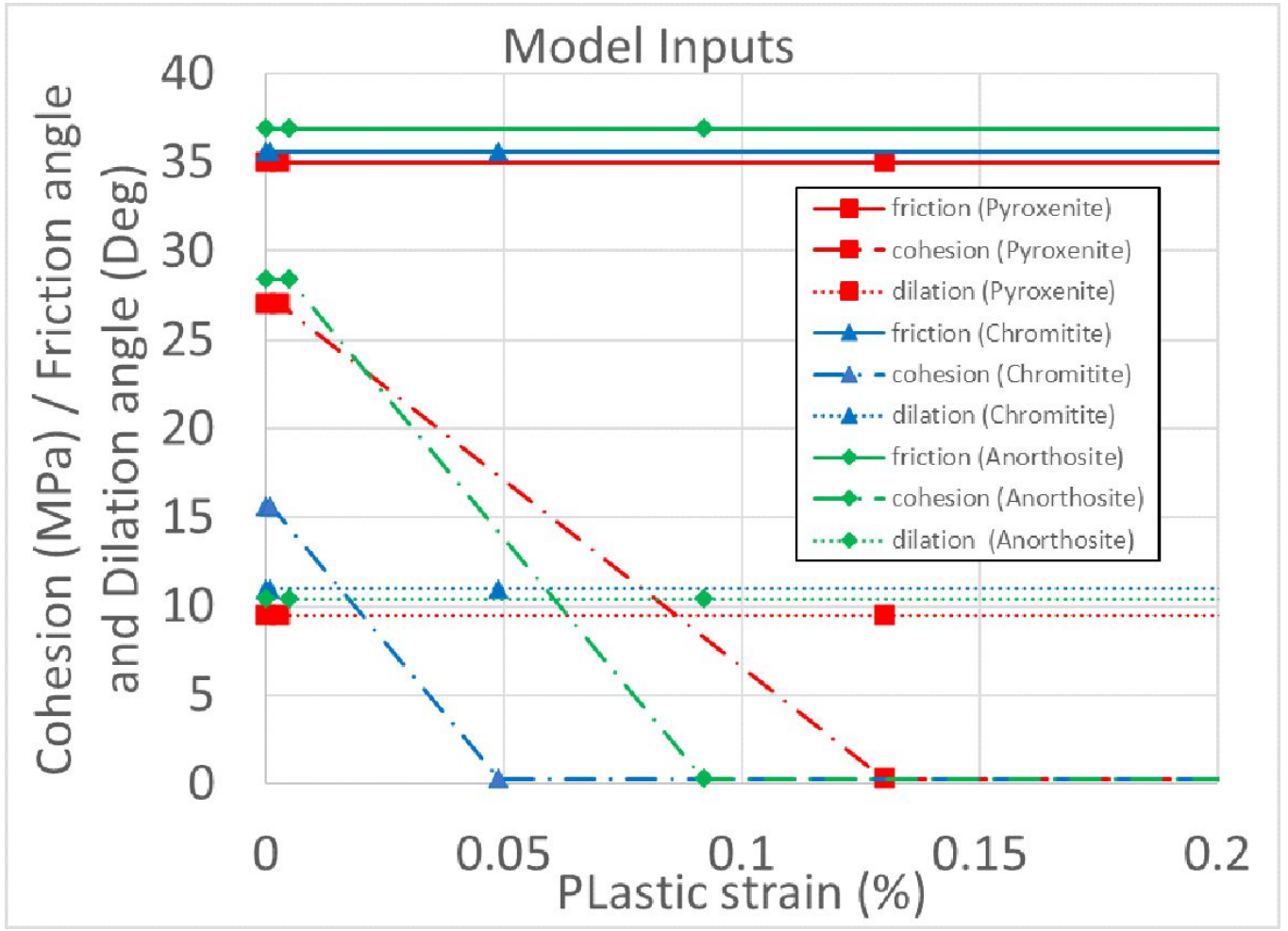
FLAC3D Model Setup



Model Calibration



Model Inputs



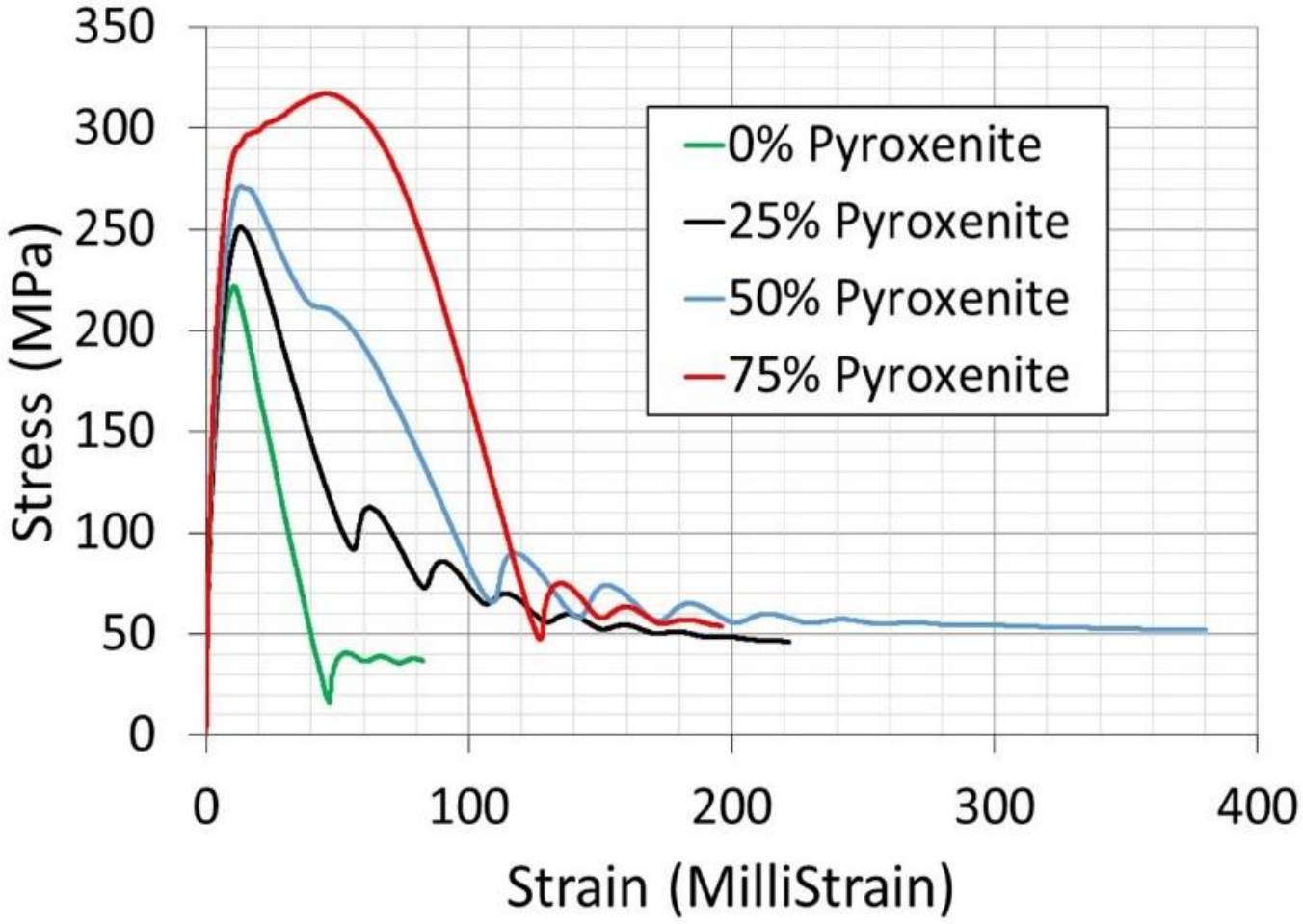
Modelling Approach

- Strain-softening, cohesion-weakening model
- Constant displacement rate: 10^{-6} m/s
- Pyroxenite content: 0% to 75%
- Sensitivity analysis – no strength downrating

Results – Pillar Strength

- 0% pyroxenite: 220 MPa
- 75% pyroxenite: 320 MPa
- Strength increased >30%
- More ductile post-peak behavior

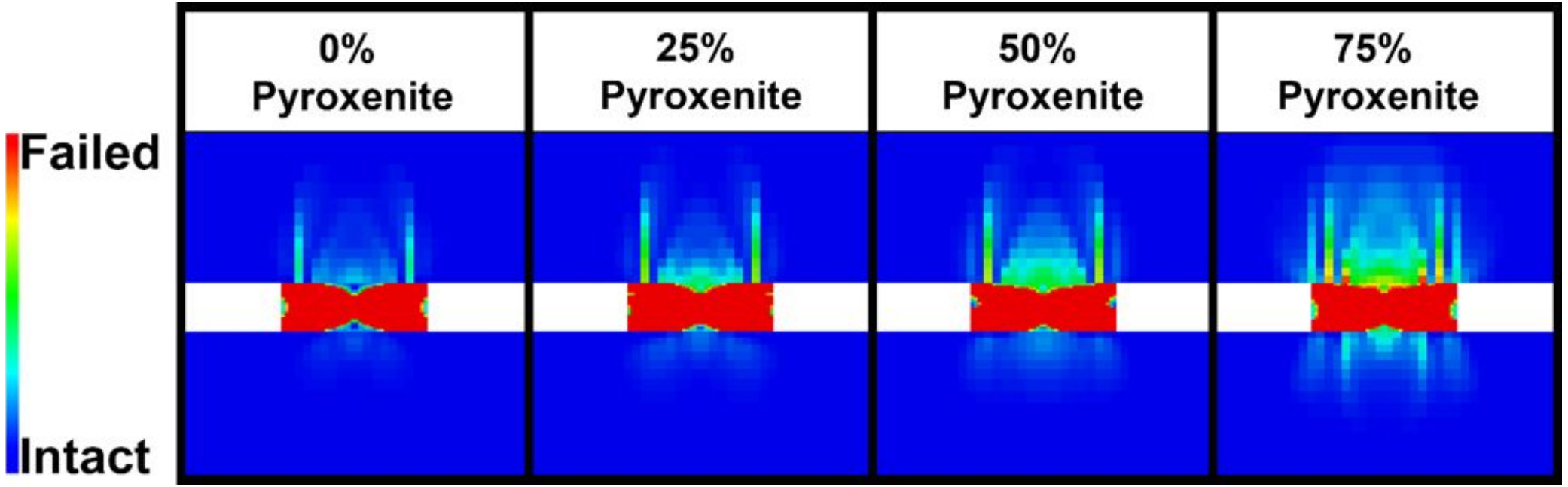
Results – Pillar Strength



Results – Foundation Damage

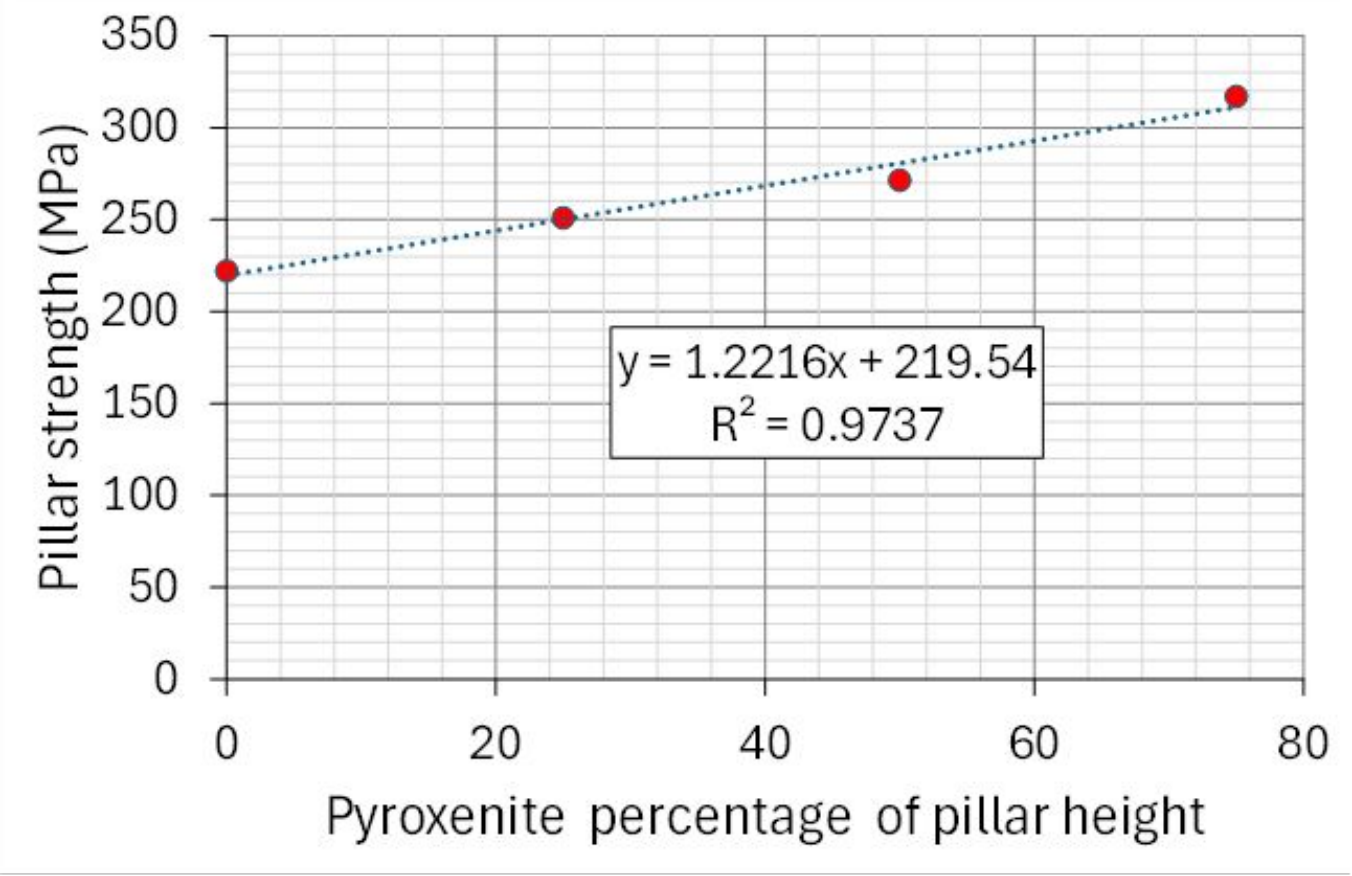
- Increased lateral expansion with pyroxenite
- Vertical cracks (Hertzian) in hangingwall
- Minimal foundation damage at 0% pyroxenite

Results – Foundation Damage



Strengthening Equation

- Linear relation: Strength vs. pyroxenite %



UG2 Pillar Strength Equation (Including Pyroxenite Content)

- The pillar strength (σp) is calculated using the strengthening linear relationship and the UG2 pillar strength formula, adjusted for pyroxenite content:

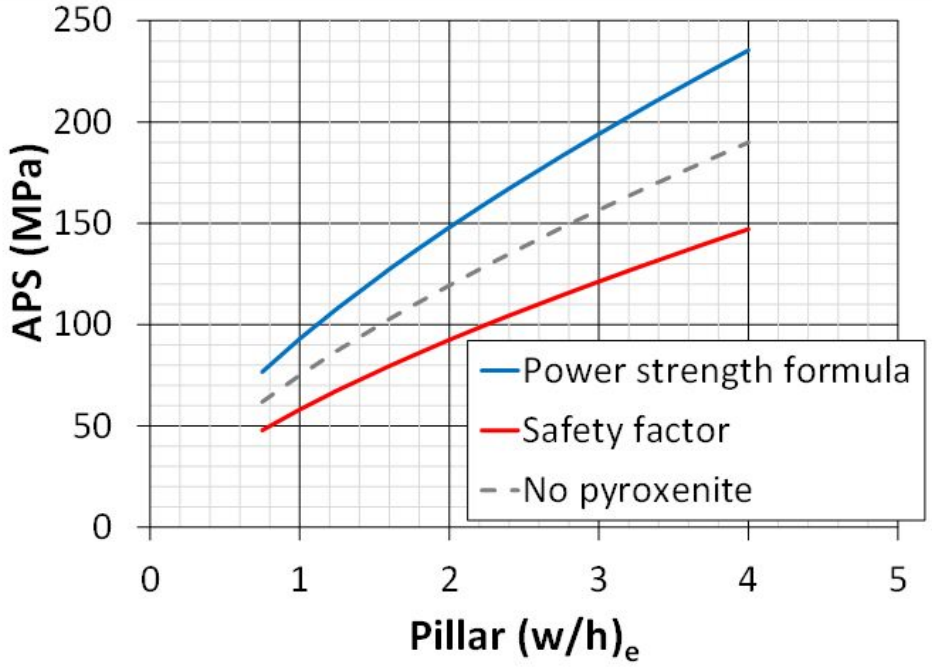
$$\sigma_p = \left[82\left(\frac{w_e}{h_e}\right)^{0.71}\right][0.0045 \times PP + 0.8065]$$

Where:

- σ_p : Pillar strength
- w_e :Effective width
- h_e :Effective height
- PP : Percentage of pyroxenite

Implications

- Improved pillar strength prediction
- Potential for optimised designs and reduced resource lock-up
- Safety factor of 1.6 still adequately covers variations due to pyroxenite



Conclusion

- Pyroxenite significantly strengthens UG2 pillars
- New equation to quantify impact
- Supports updated pillar design standards
- Enables safer and more efficient mining

Recommendations

- Validate with lab w/h tests
- Investigate chromitite-pyroxenite interfaces

THANK YOU