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1. Introduction: Why does it matter?

The stability of underground excavations is attracting growing attention, as an expanding urban population pushes **infrastructure below surface** and the clean energy transition drives **mineral extraction ever deeper**.

Rockburst

A concern in deep underground
 A sudden release of stored strain energy

Brittle Rock
 Large amount of stored strain energy

High Pressure
 Increasing stresses as depth increases

Seismic Event
 Dynamic loading from e.g., fault slip



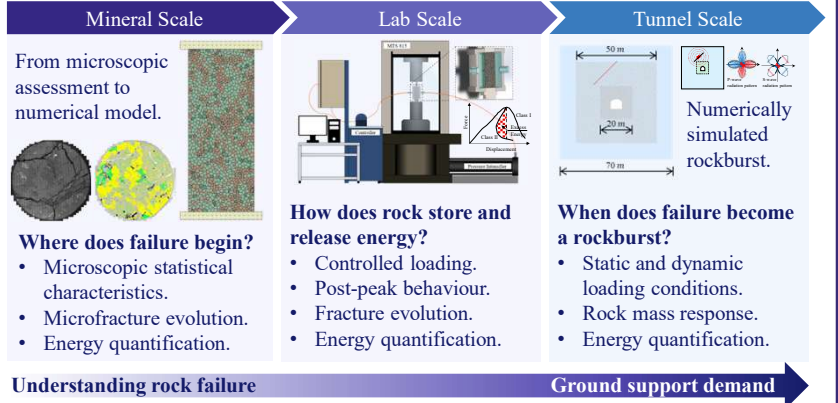
Rock Ejection
 Violent ejection of rock fragments

Instability
 Damage to excavation and ground support

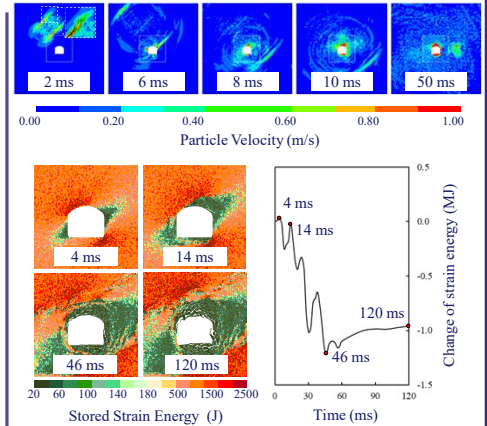
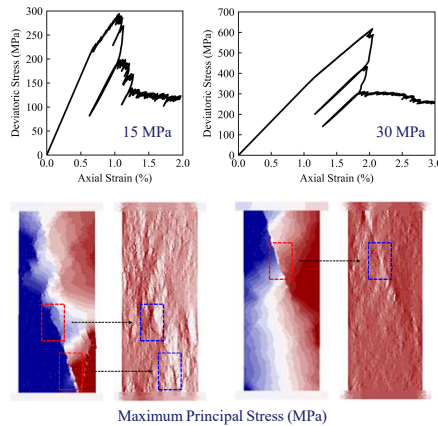
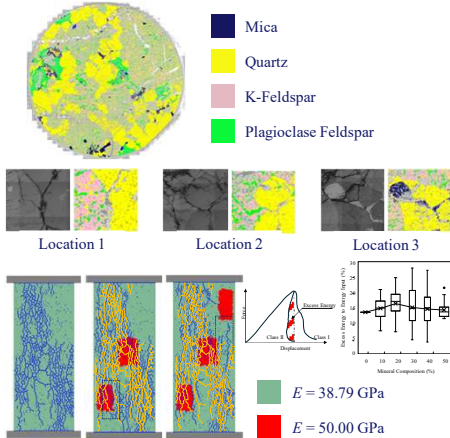
Safety Risk
 Threats to personnel and equipment

? How many released energy needs to be absorbed?

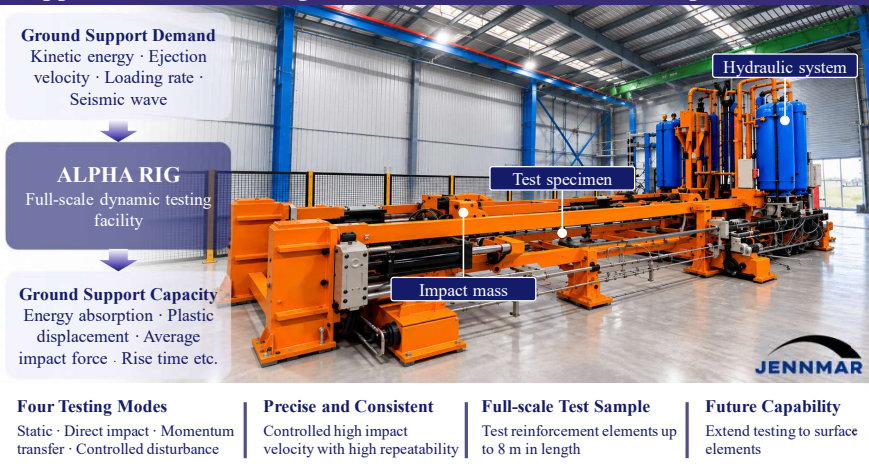
2. Methodologies: A multi-scale approach



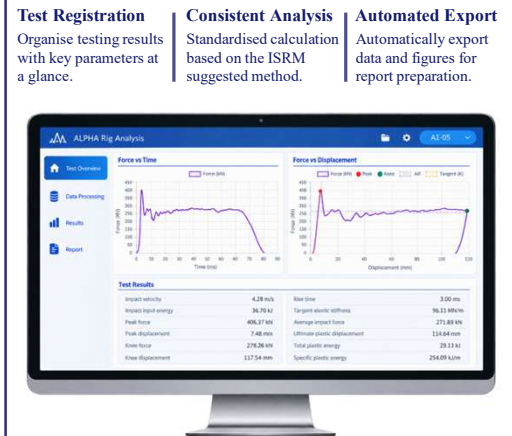
3. Key Findings: From microfracturing to energy release during rockburst



4. Application: ALPHA Rig - From research to real-world impact



5. Web app: Efficiency and Consistency



Organizers

