



April, 2017.

Active Seismic Monitoring of Rocks under Uniaxial Compression

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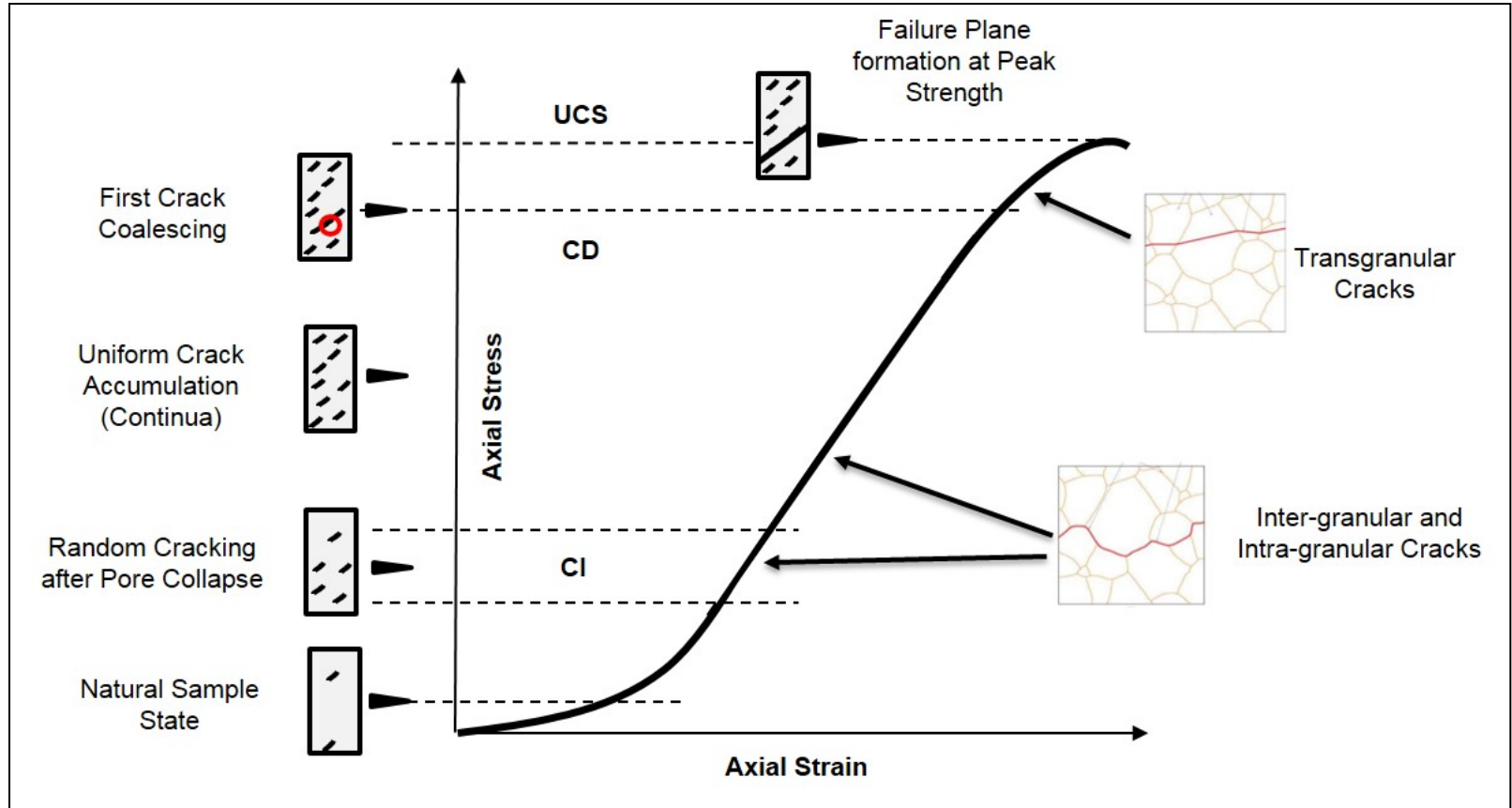
Dr. A. Hedayat and Dr. G. Walton

Underground Construction and Tunneling



- **Introduction-**
 - Rock Fracturing Processes
 - Fracture Monitoring Approaches
 - Objective
- **Wave Propagation Models**
 - Displacement Discontinuity Model
 - Friction Attenuation Model
- **Test Set-Up**
- **Results**
- **Conclusion**

Rock Fracturing Process and Its Importance



Different stages of crack damage accumulation



Fracture Monitoring Approaches

Traditional Approaches

Strain Analysis

Fracture Monitoring Approaches

Traditional Approaches

Strain Analysis

Flaws

1. Non applicability in insitu conditions.
2. Not an objective approach.
3. Highly sensitive to elastic parameters of the rock.

Fracture Monitoring Approaches

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Flaws

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Geophysical Monitoring

1. Acoustic Emission/Passive Monitoring
2. Ultrasound (Active Method)



Fracturing Monitoring Approaches

Passive Monitoring

The rock is made to talk.

Sensitive to:

Sensor Characteristics and frequency of seismic events.

Fracturing Monitoring Approaches

Passive Monitoring

The rock is made to talk.

Sensitive to:

Sensor Characteristics and frequency of seismic events.

Flaws

1. Limited information on seismic events which are outside the sensor frequency domain.
2. Low energy seismic events remain undetected.



Fracturing Monitoring Approaches

Active Monitoring

- Active seismic signals are sent for continuous seismic monitoring.
- Real time assessment of the different fracturing processes. (No Frequency Bias)

Fracturing Monitoring Approaches

Active Monitoring

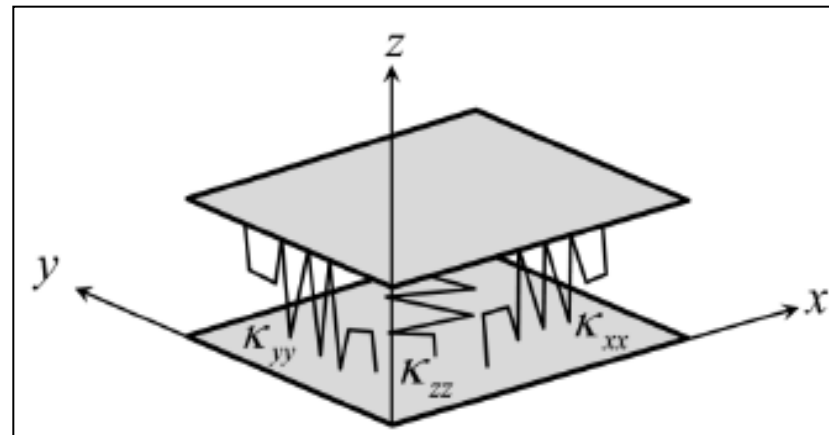
- Active seismic signals are sent for continuous seismic monitoring.
- Real time assessment of the different fracturing processes. (No Frequency Bias)

Objective of the study

- Fracture process characterization using active monitoring.

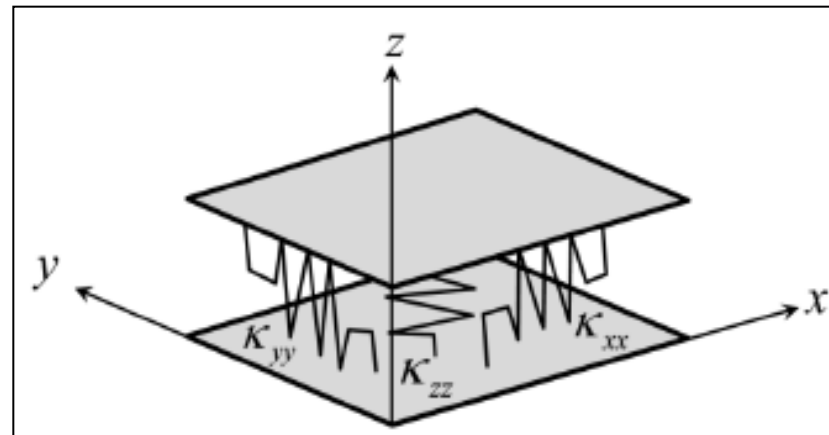
Displacement Discontinuity Model (DDM)

Analytical model for evaluating seismic wave propagation across open fractures (DDM).



Displacement Discontinuity Model (DDM)

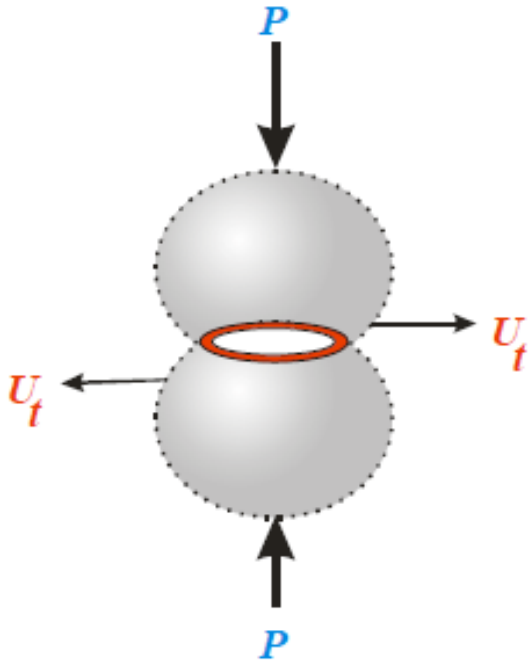
Analytical model for evaluating seismic wave propagation across open fractures (DDM).



Open fractures lead to a transmission and reflection loss in the seismic waves.

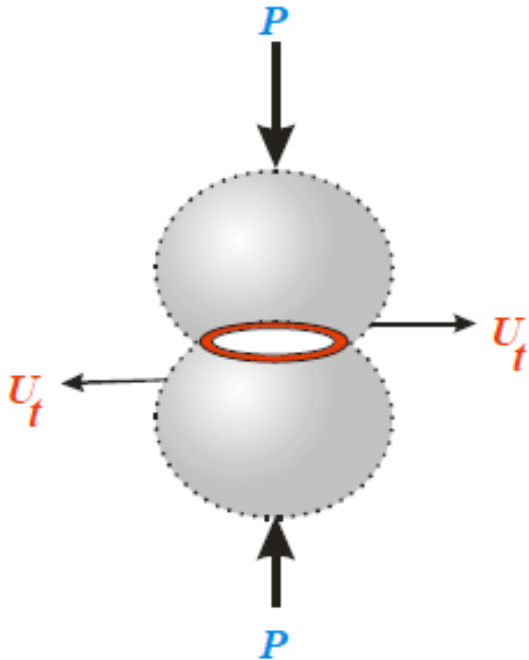
Friction Attenuation Model

At Grain Contacts (Mindlin Theory)

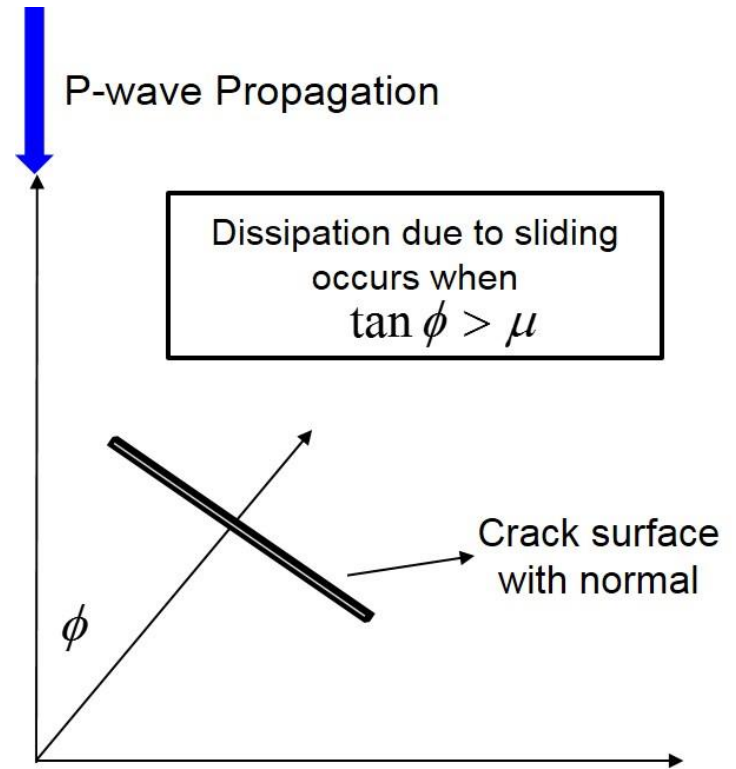


Friction Attenuation Model

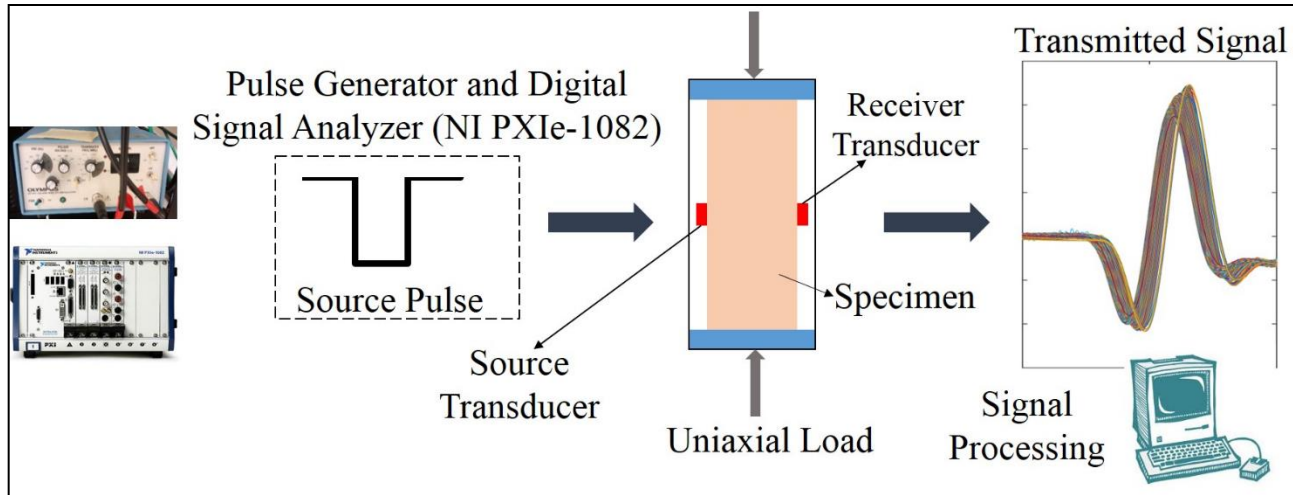
At Grain Contacts (Mindlin Theory)



At Crack Interfaces (Walsh Theory)



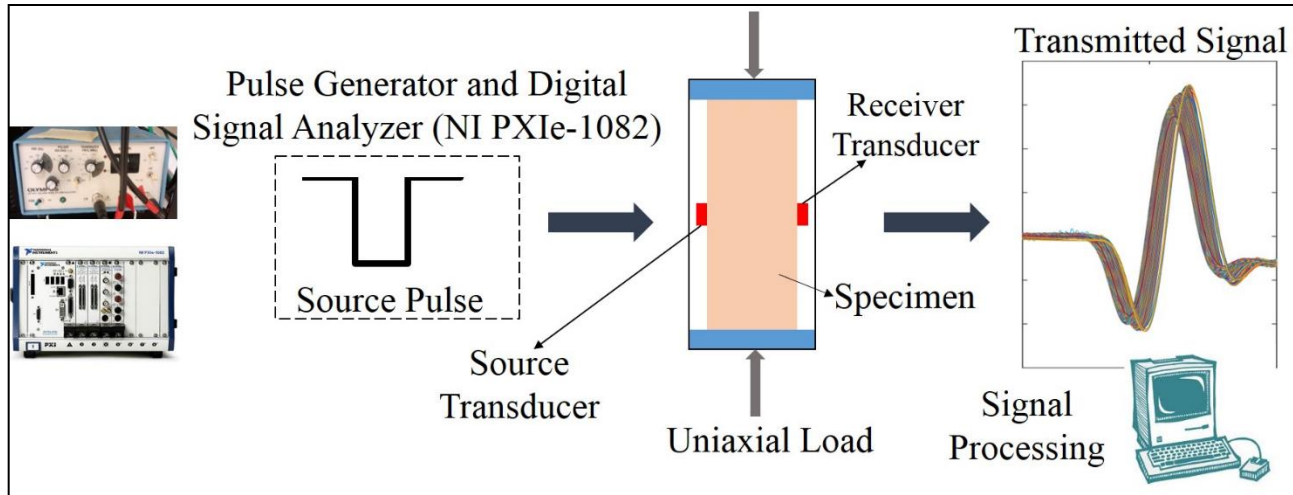
Crack in a Polar 3D Space



Characteristics of the ultrasonic transducers

Frequency (MHz)	Wavelength (mm)
1	5
5	1

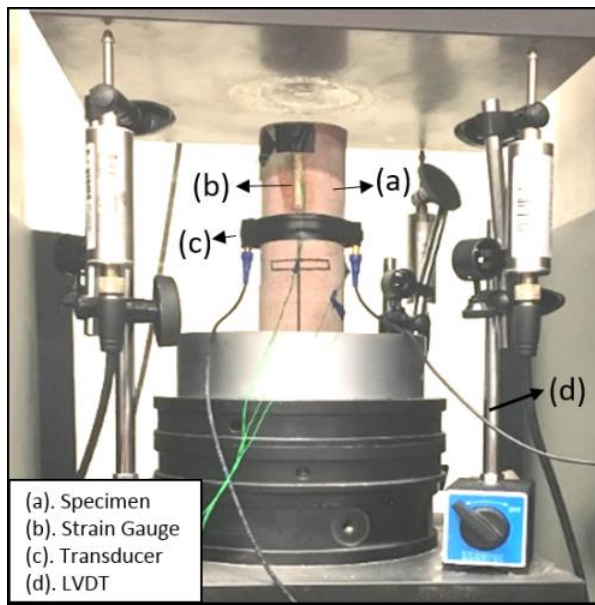
Schematic diagram of the very fast seismic monitoring system at the Colorado School of Mines

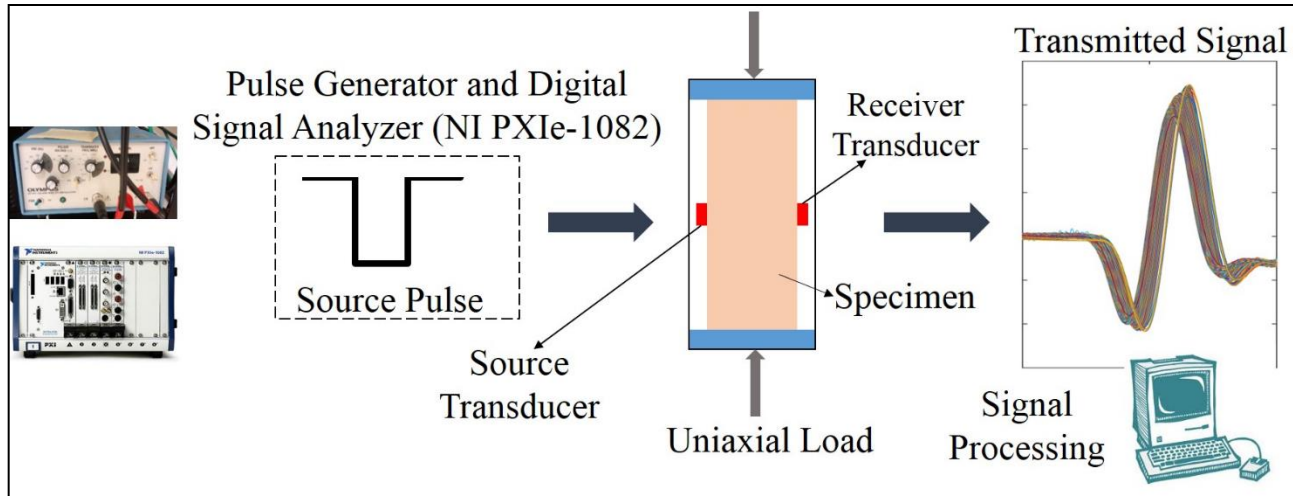


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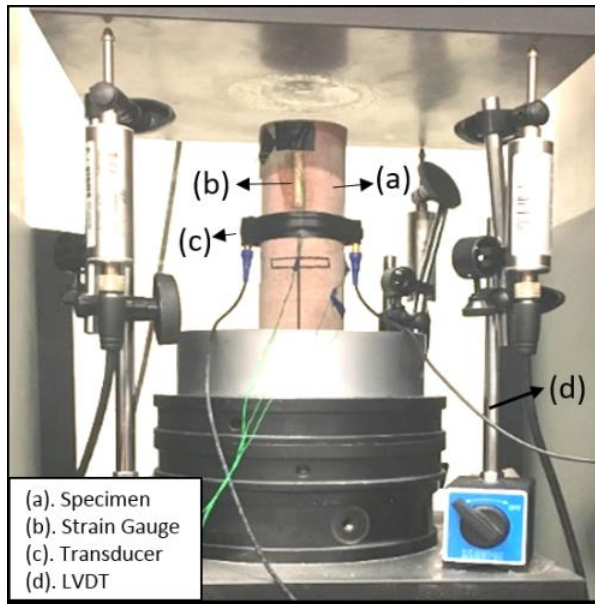




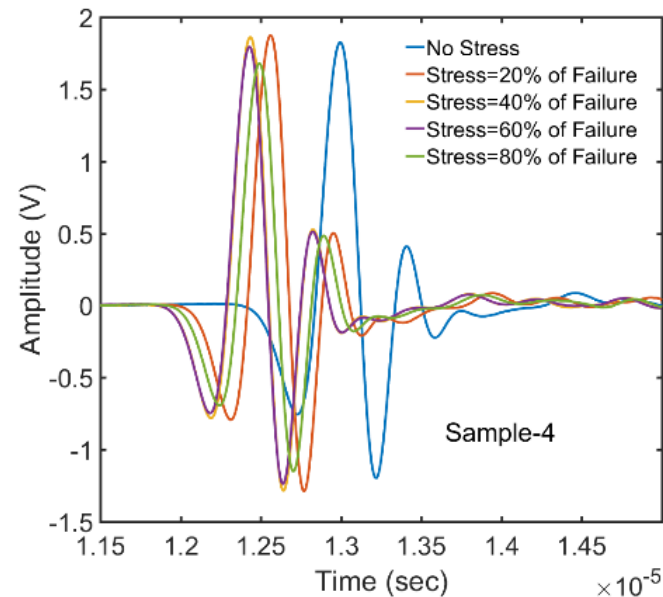
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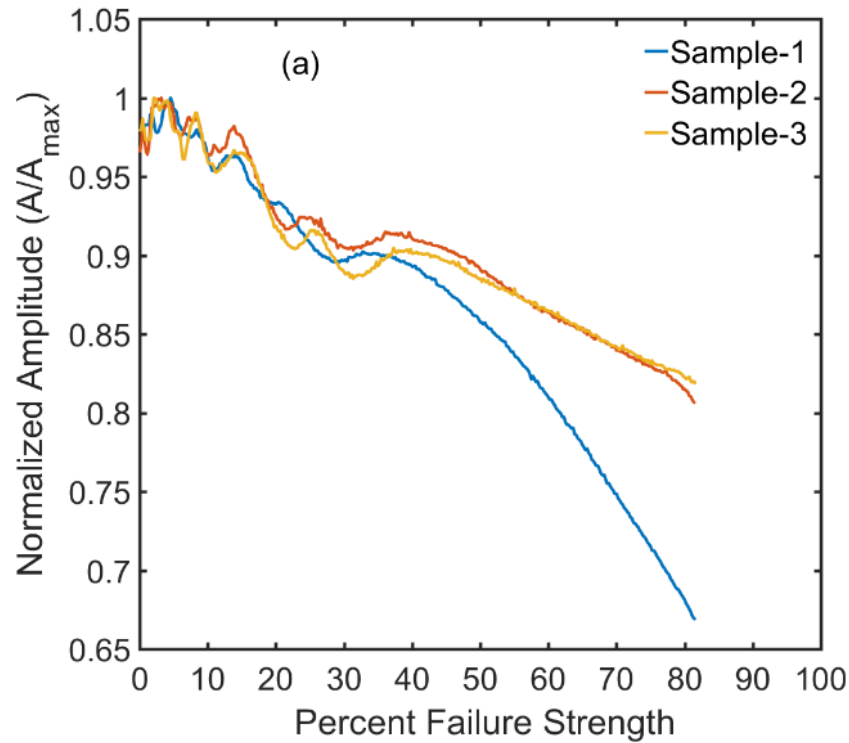
Schematic diagram of the very fast seismic monitoring system at the Colorado School of Mines



- (a). Specimen
- (b). Strain Gauge
- (c). Transducer
- (d). LVDT

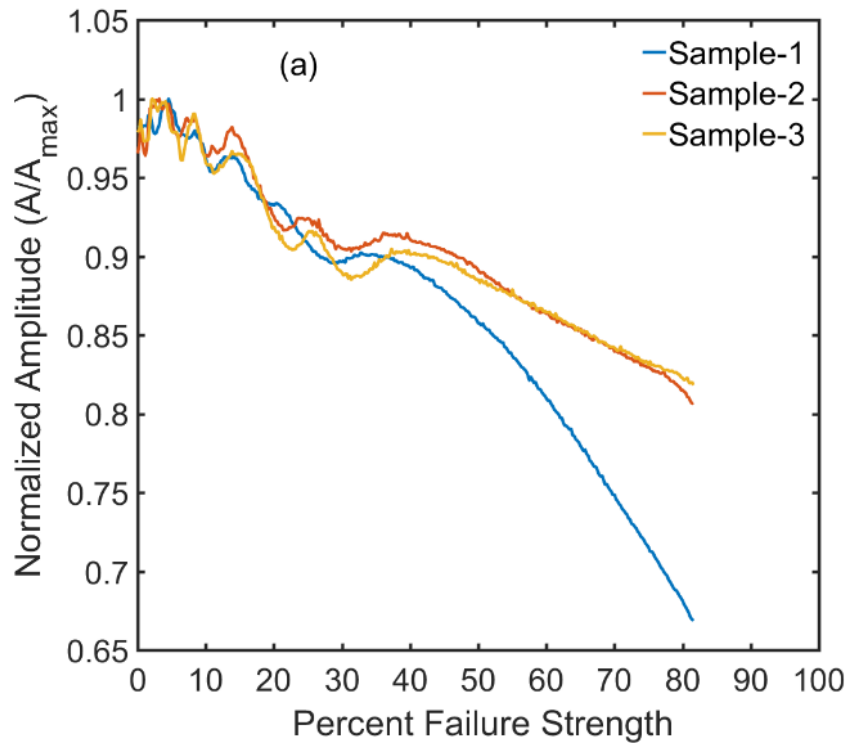


Amplitude Variation with Stress

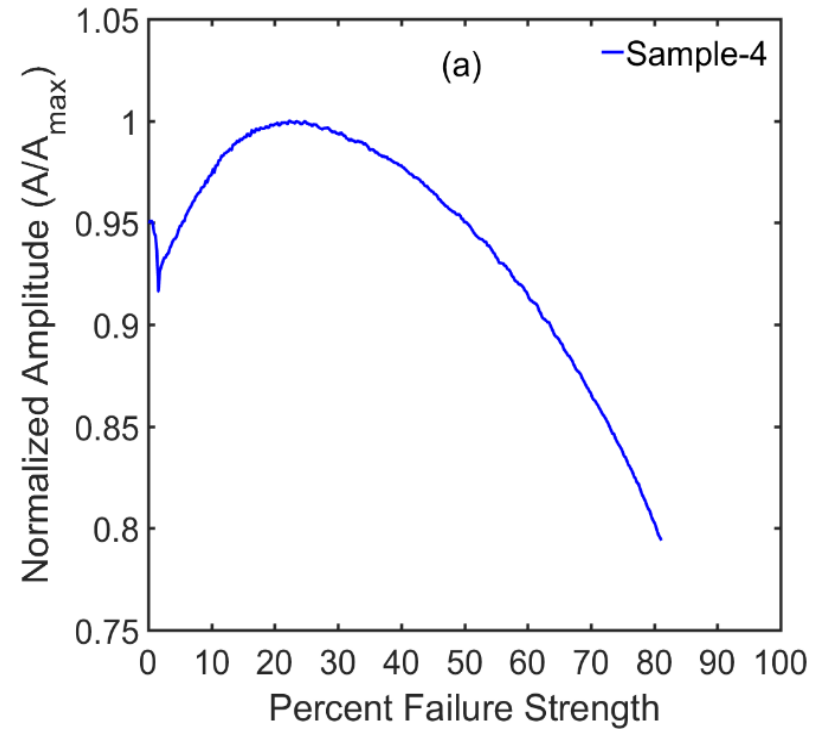


1 MHz Transducer

Amplitude Variation with Stress

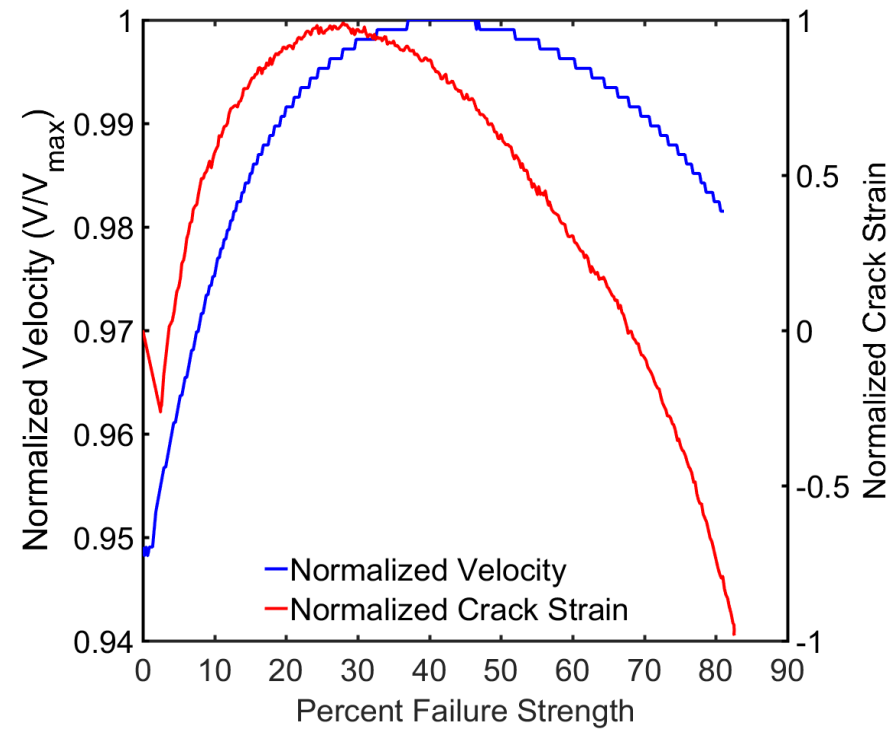
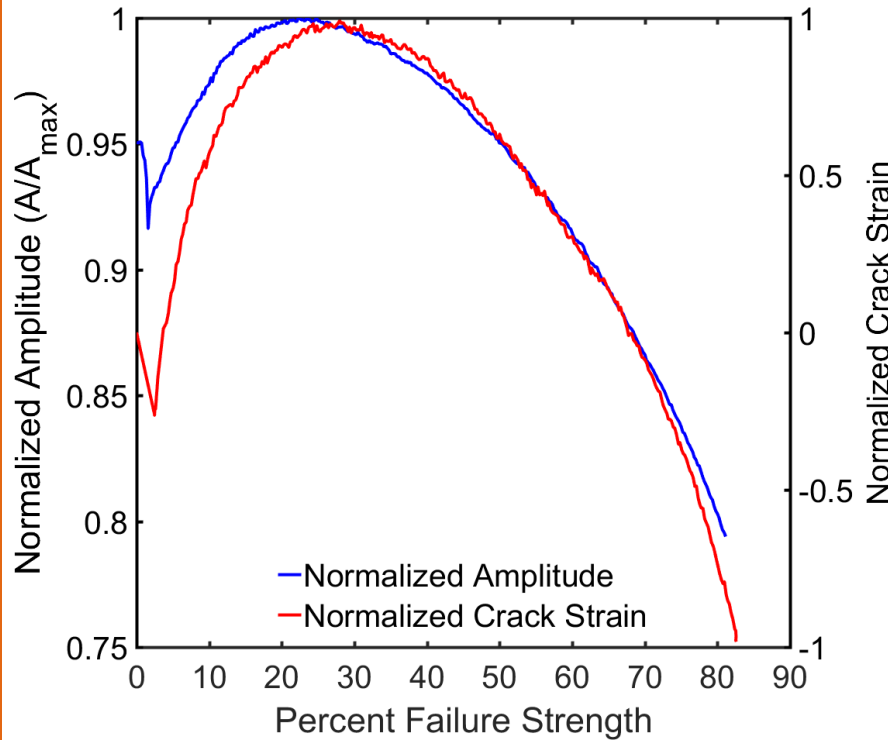


1 MHz Transducer

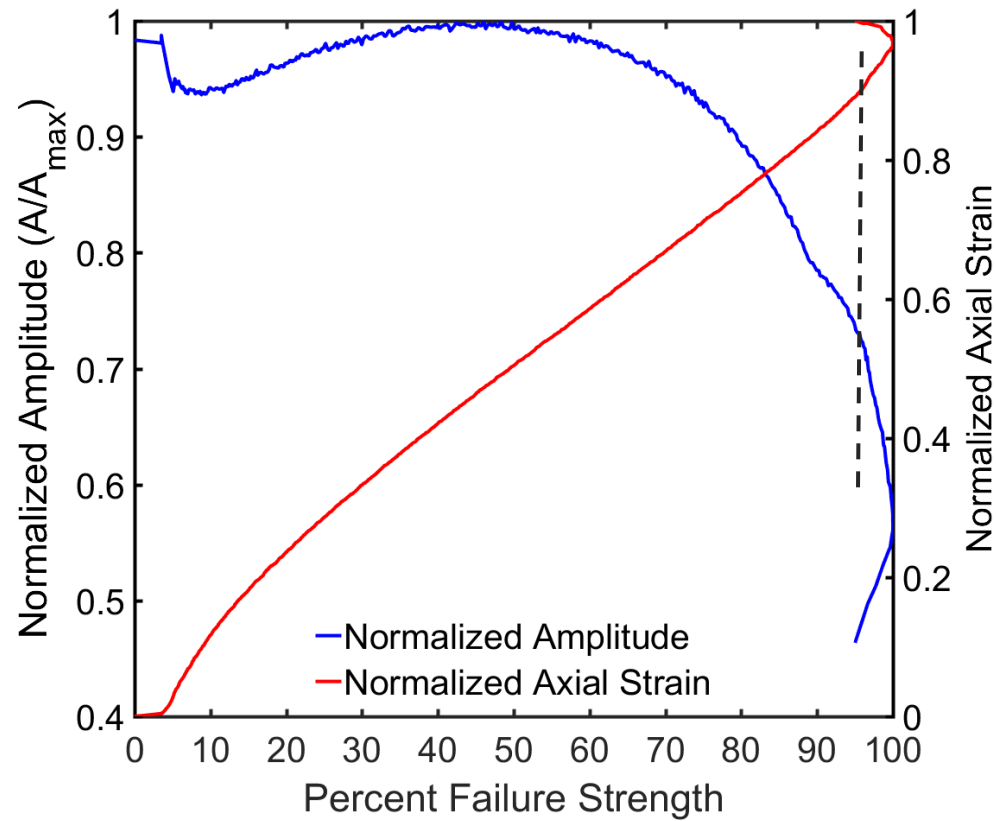


5 MHz Transducer

Mapping strain and seismic data



Amplitude Variation with Stress



Specimen Tested upto Failure



Active seismic monitoring is an objective way for characterization of fracturing in brittle rocks which can help in identifying precursors to failure.



Thankyou