



NUMERICAL INVESTIGATION OF HYDRAULIC FRACTURING DURING MULTI-STAGE STIMULATION

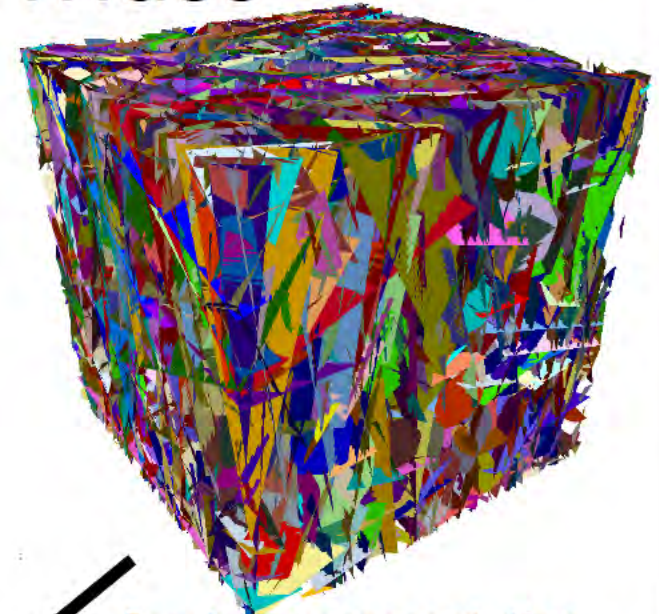
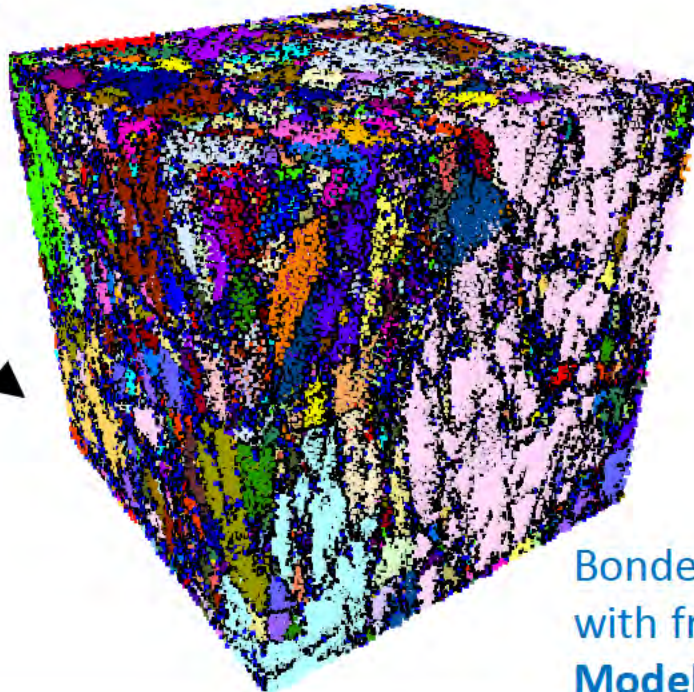
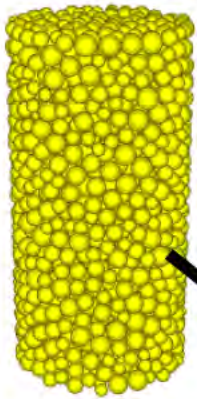
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presented at 2018 ARMA-DGS Workshop
April 3-5, 2018, Bahrain

New Methodology

- Itasca has been developing and applying the Synthetic Rock Mass (SRM), which was based on the code PFC2D/3D
- PFC2D/3D is a distinct element code (DEM) that models an elastic/brittle rock as a bonded assembly of spherical particles, so called bonded particle model (BPM)
- The joints of the SRM are represented by a special contact model (the smooth joint model, or SJM) that respects the sliding planes, independently of the local contact normals

Synthetic Rock Mass

Intact rock
representation by
DEM
(including brittle
fracture)



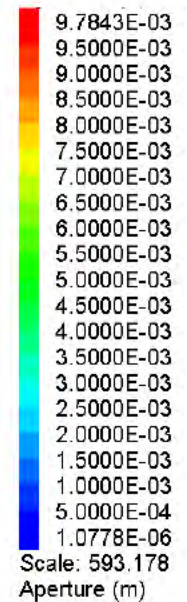
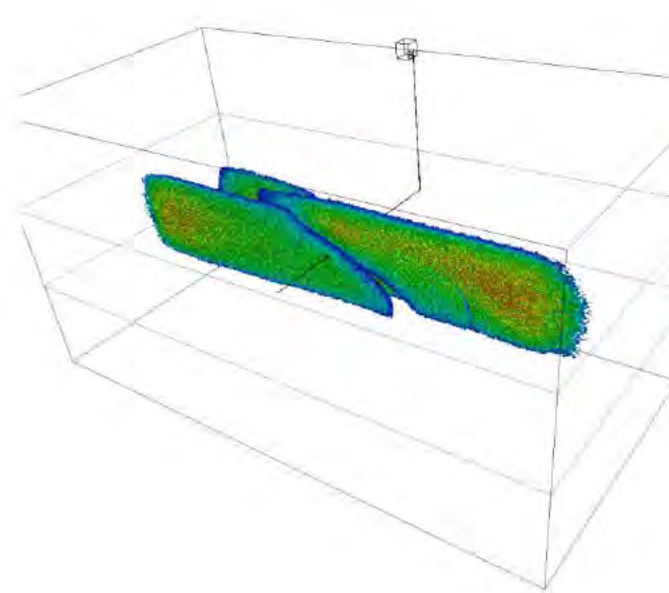
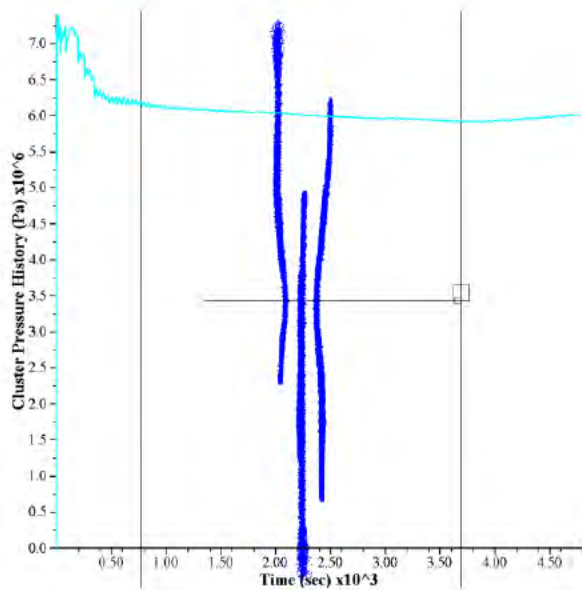
Fracture representation –
3D DFN (Discrete
Fracture Network)

Bonded-particle assembly intersected
with fractures (using the **Smooth Joint
Model – SJM**)

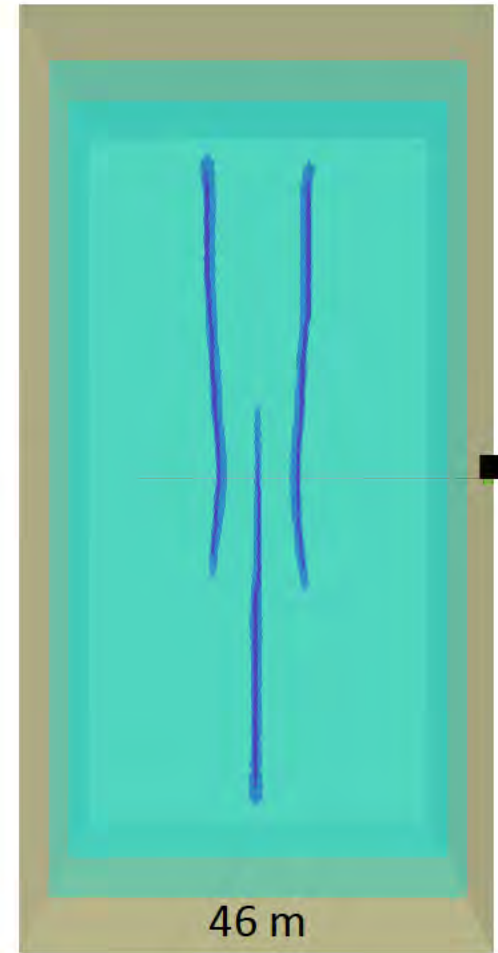
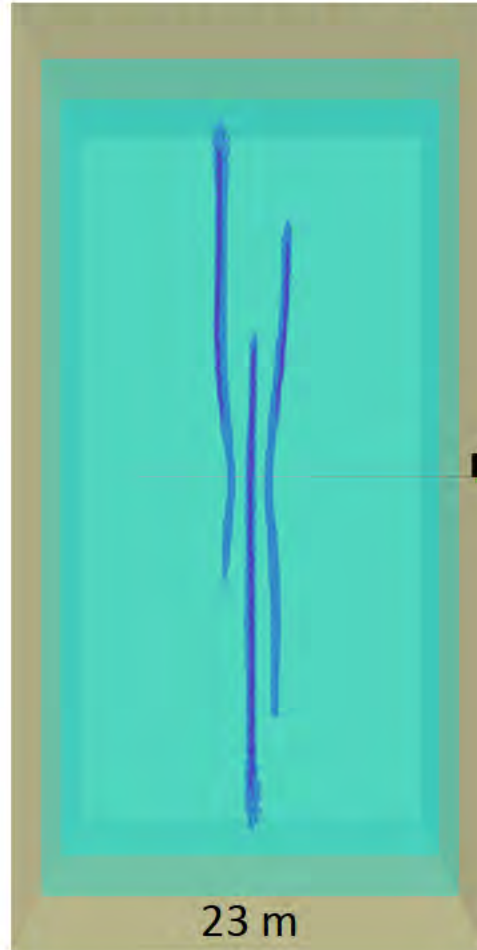
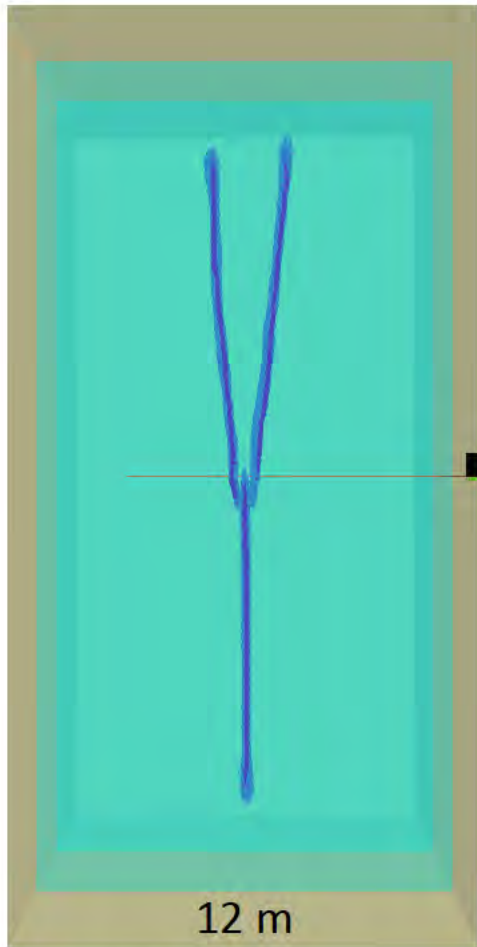
Advantages of SRM

- Mechanics based approach
- Represents the dominant mechanisms
- Standard testing methods can be used to provide necessary input parameters for both model components

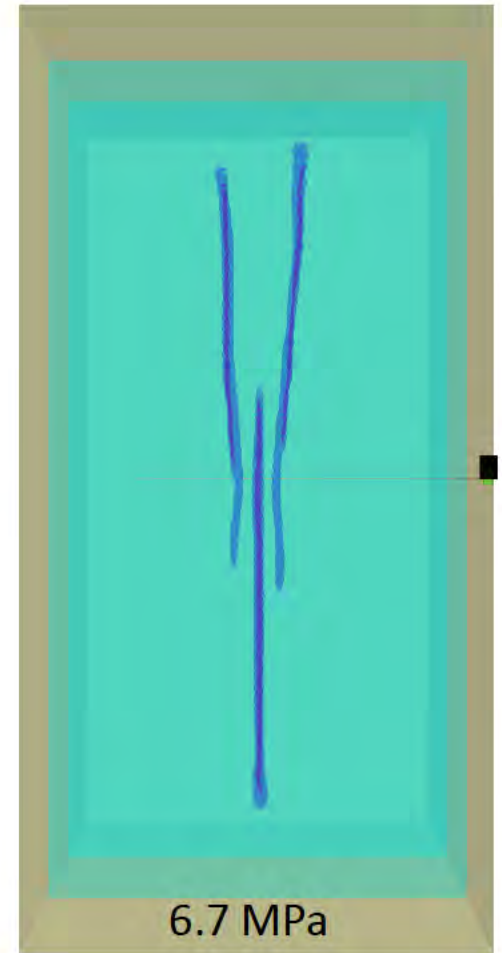
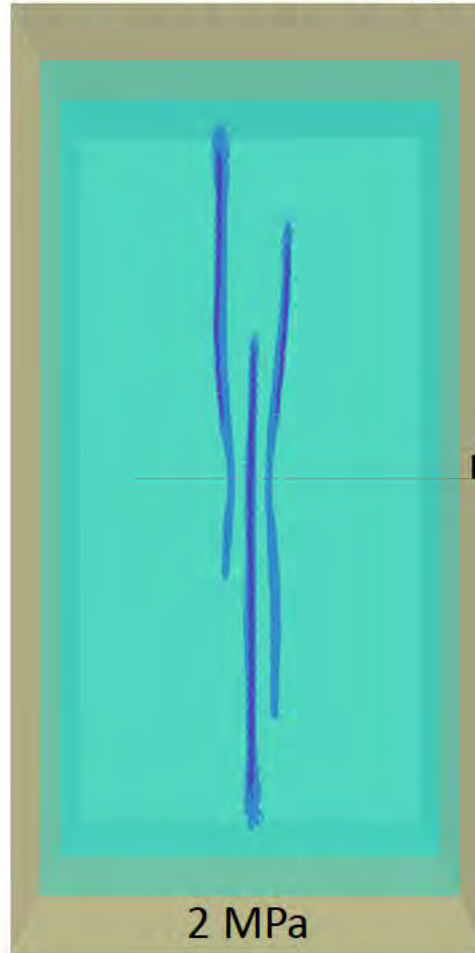
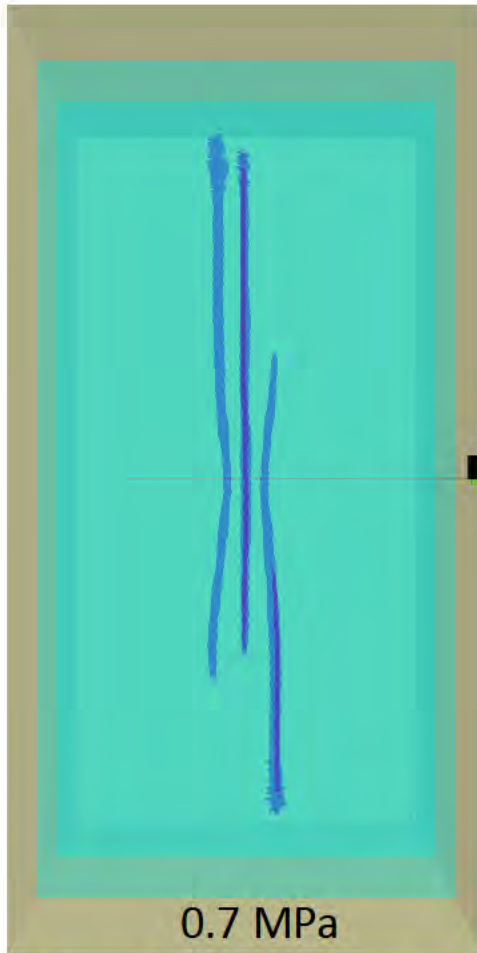
Cluster Interaction – Single Layer 150 m Height



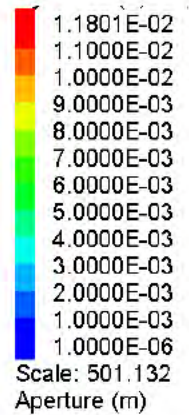
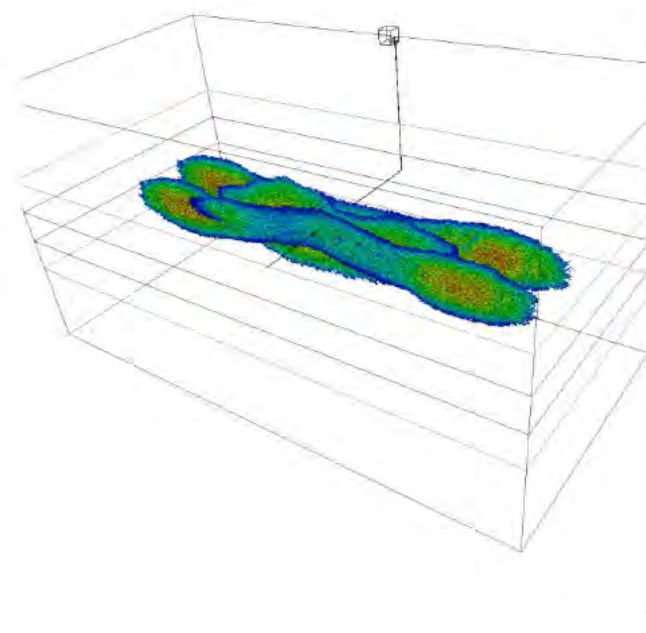
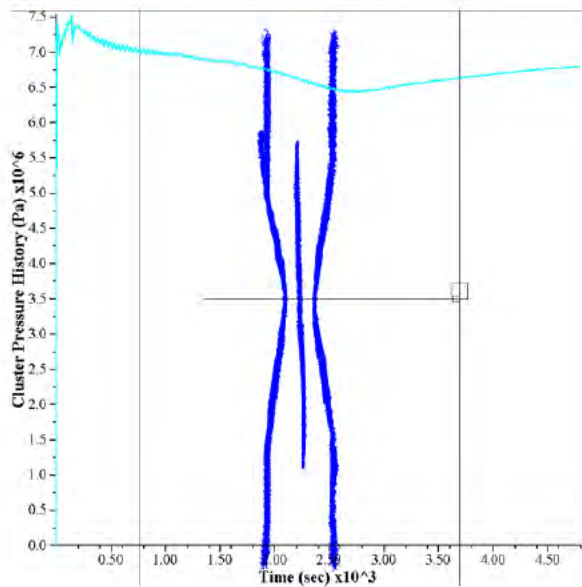
Fracture Spacing Effect – 150 m Height



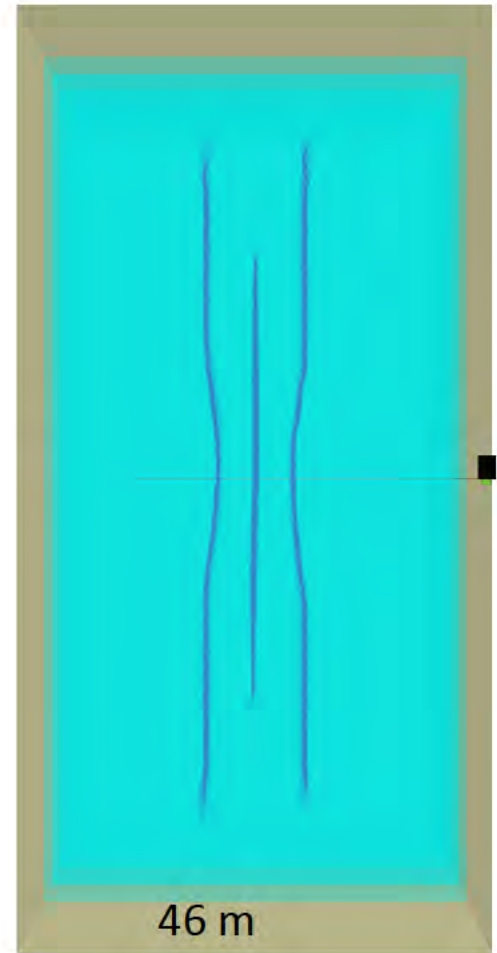
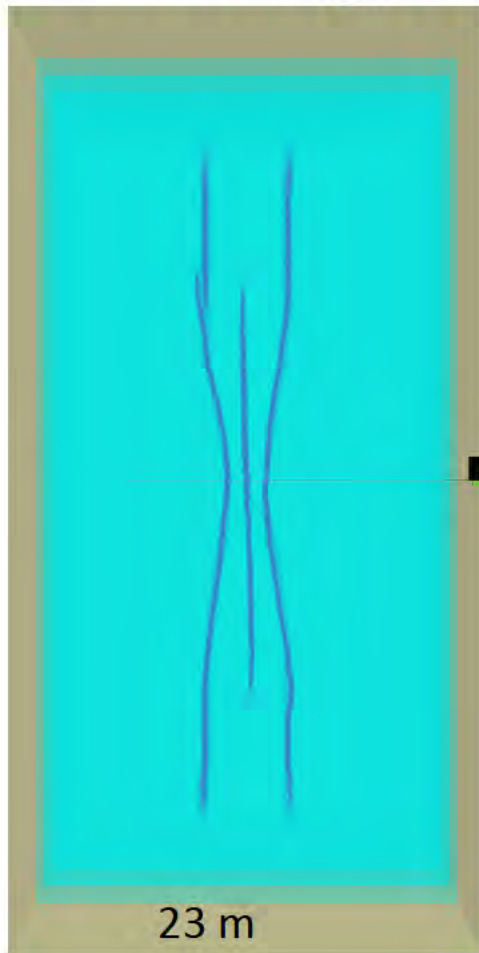
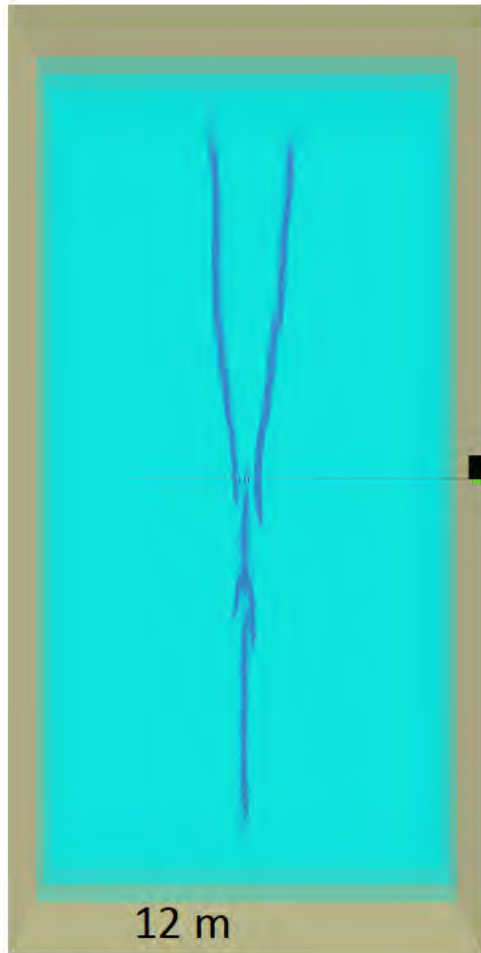
Stress Difference Effect – 150 m Height



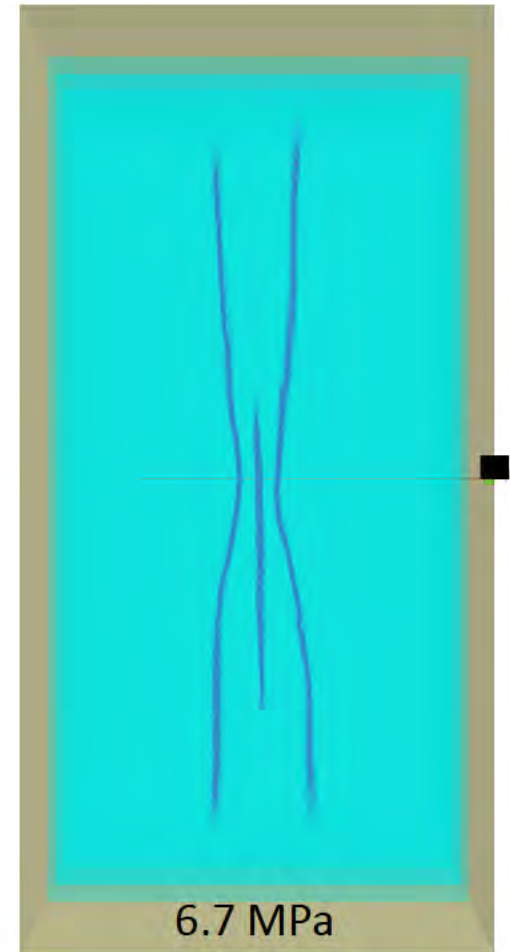
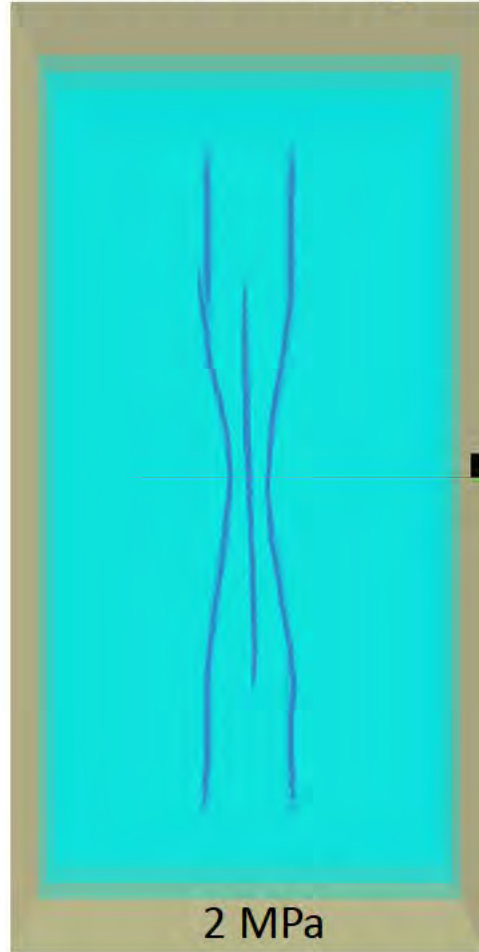
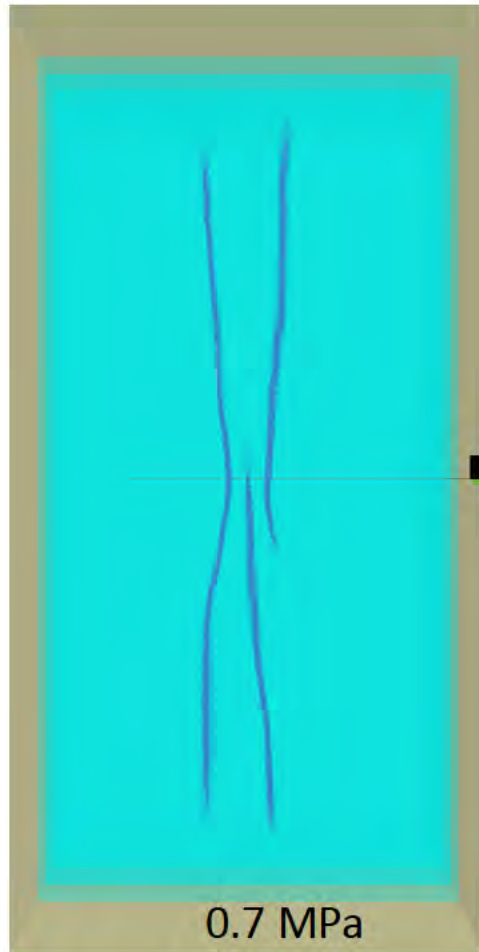
Cluster Interaction – Single Layer 60 m Height



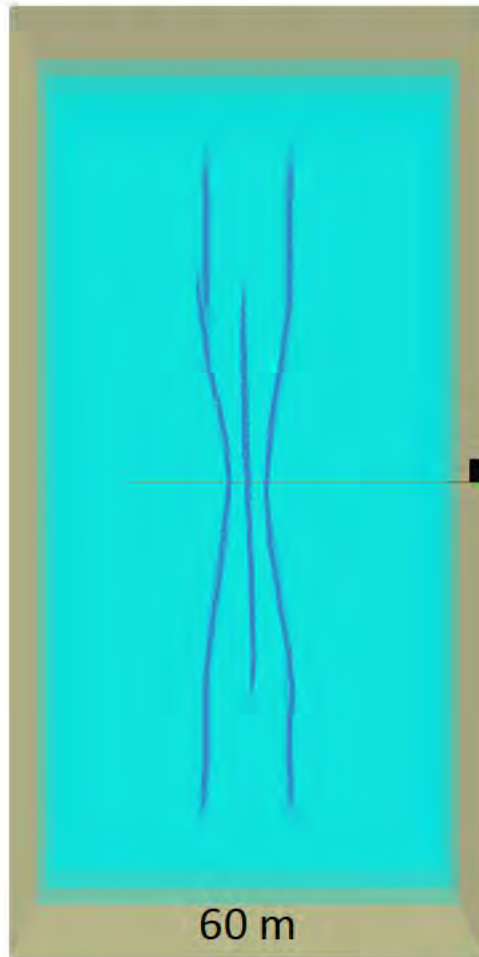
Fracture Spacing Effect – 60 m Height



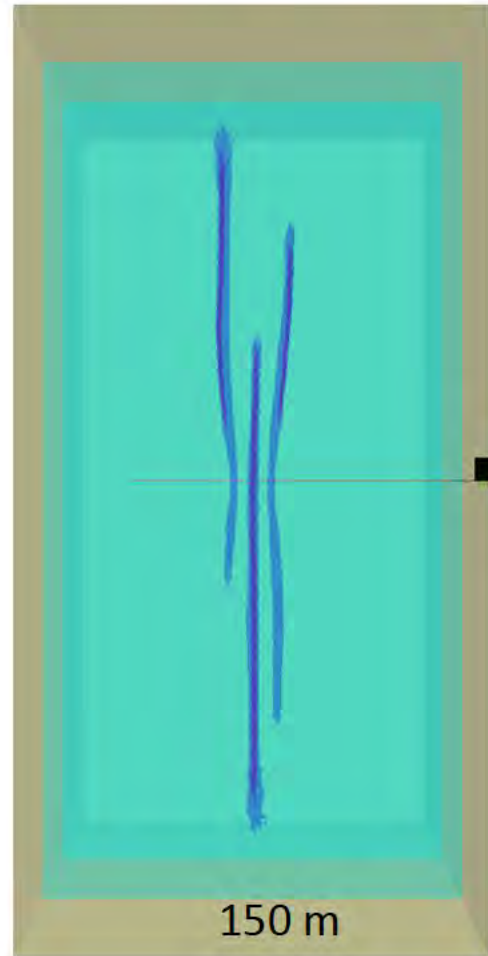
Stress Difference Effect – 60 m Height



Fracture Height Effect

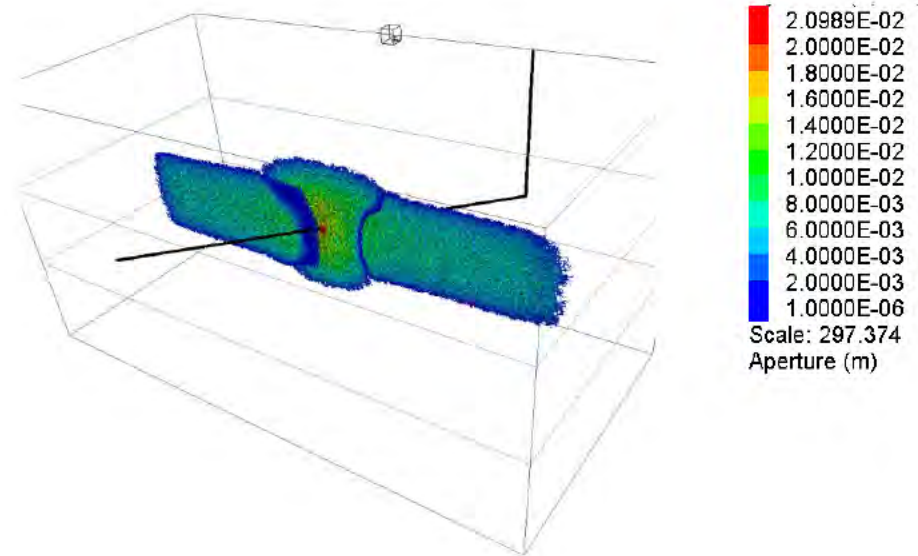
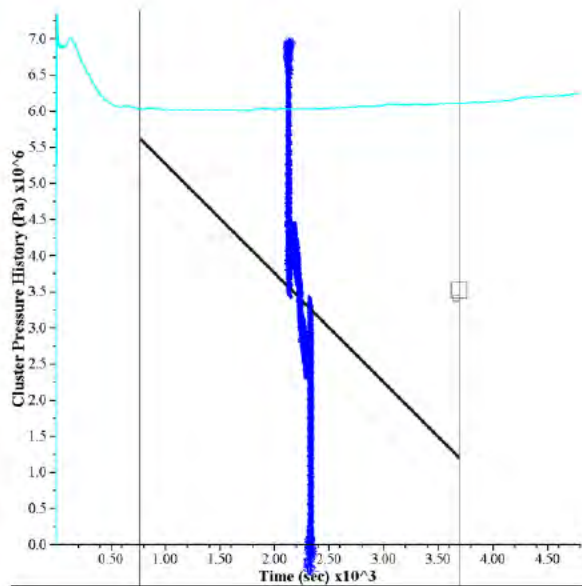


60 m

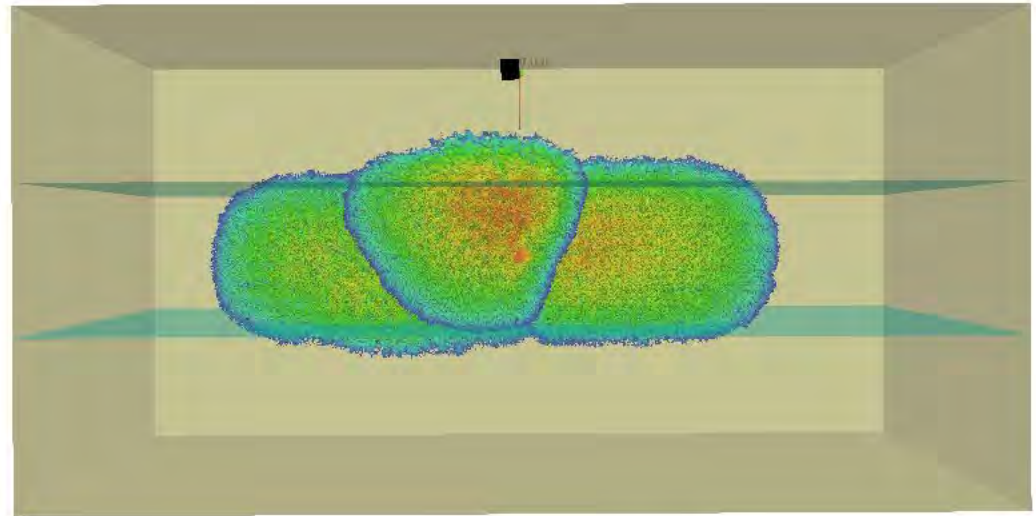
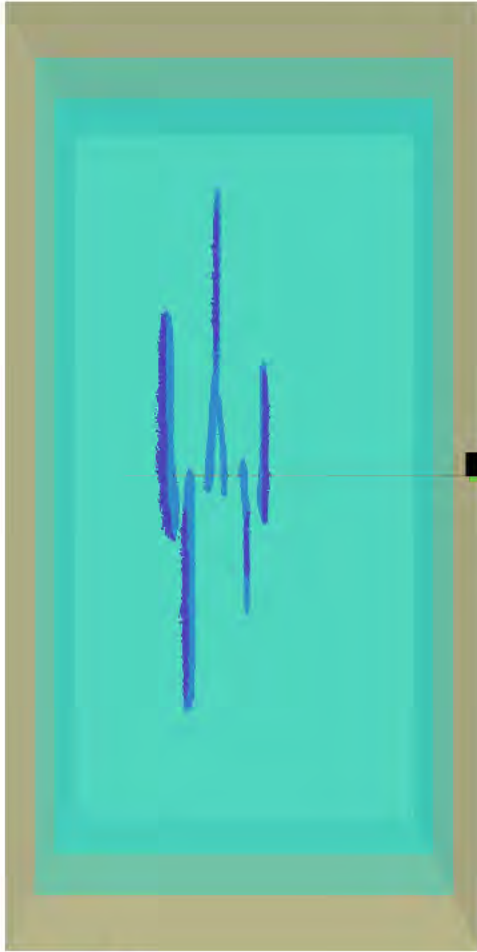


150 m

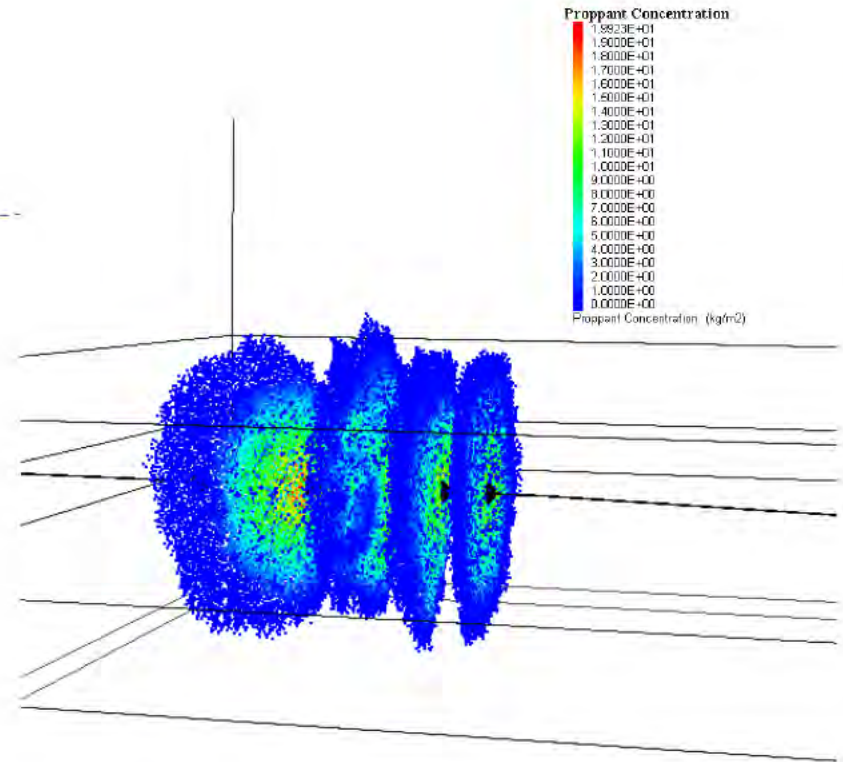
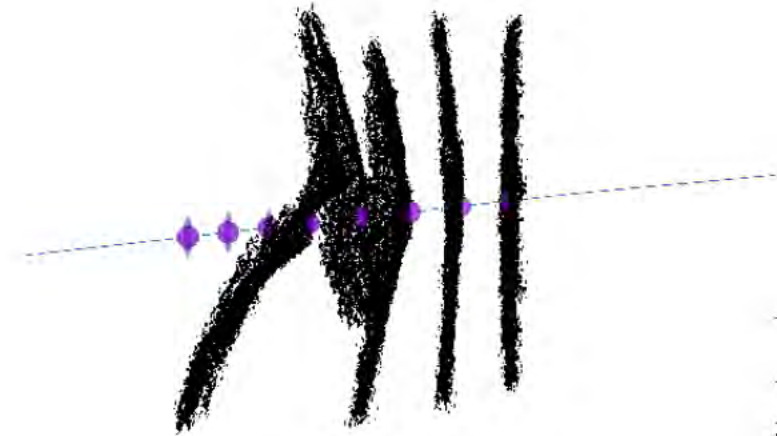
Cluster Interaction – Borehole at Oblique Angle with Principal Stresses



Two-Stage Model



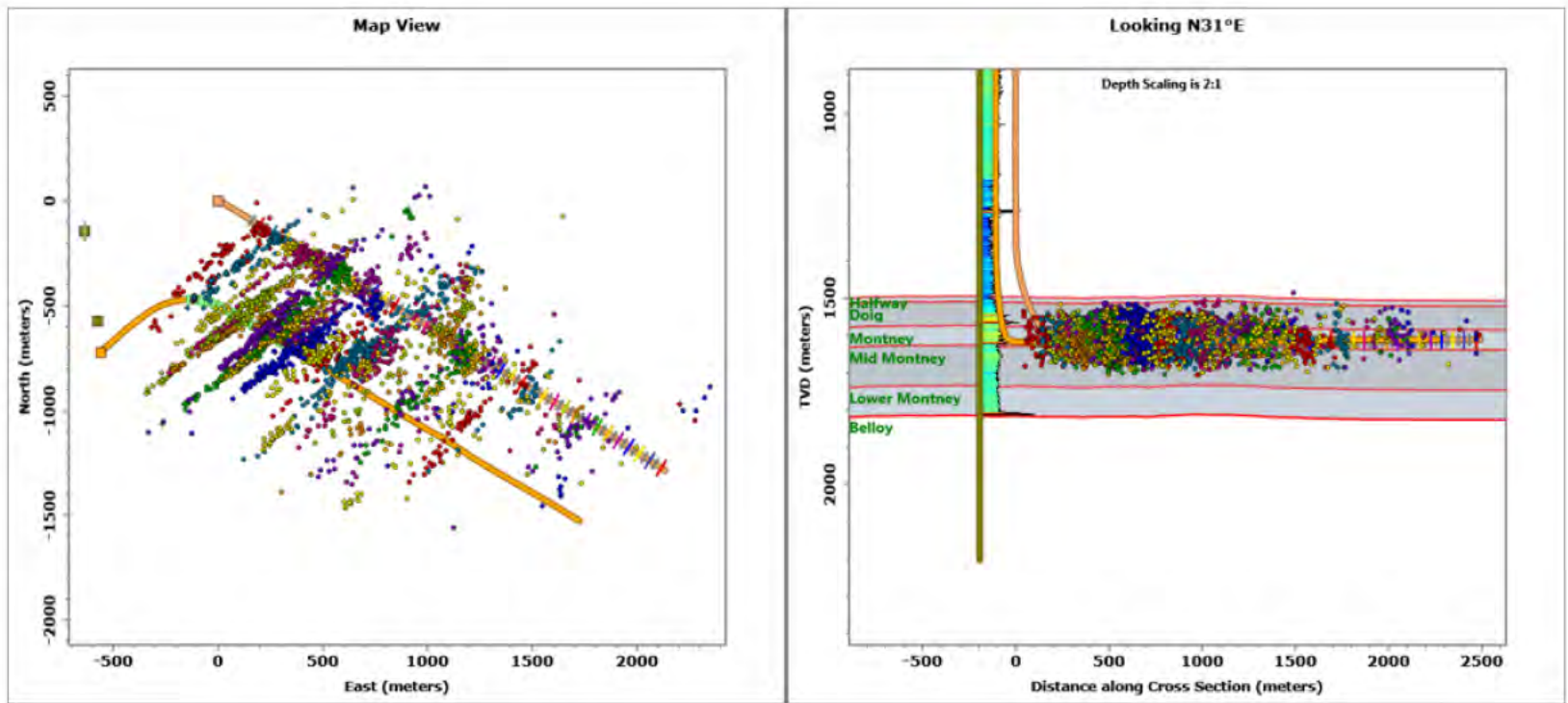
Sequential Injection





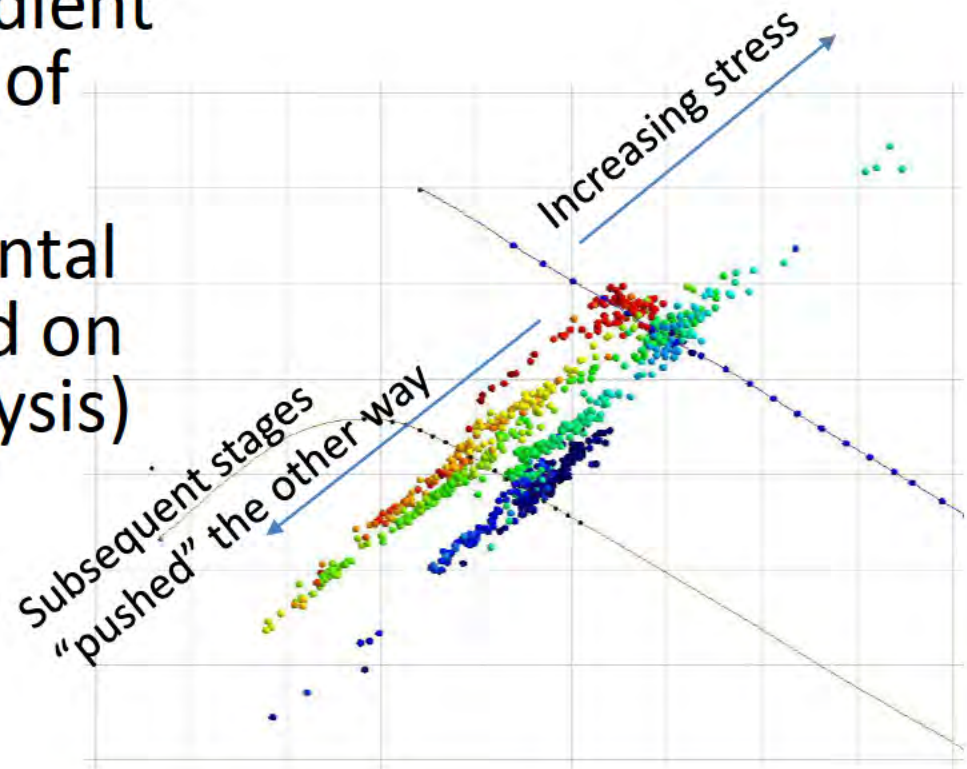
INTERPRETATION OF MICROSEISMIC DATA AT MONTNEY

Field Data

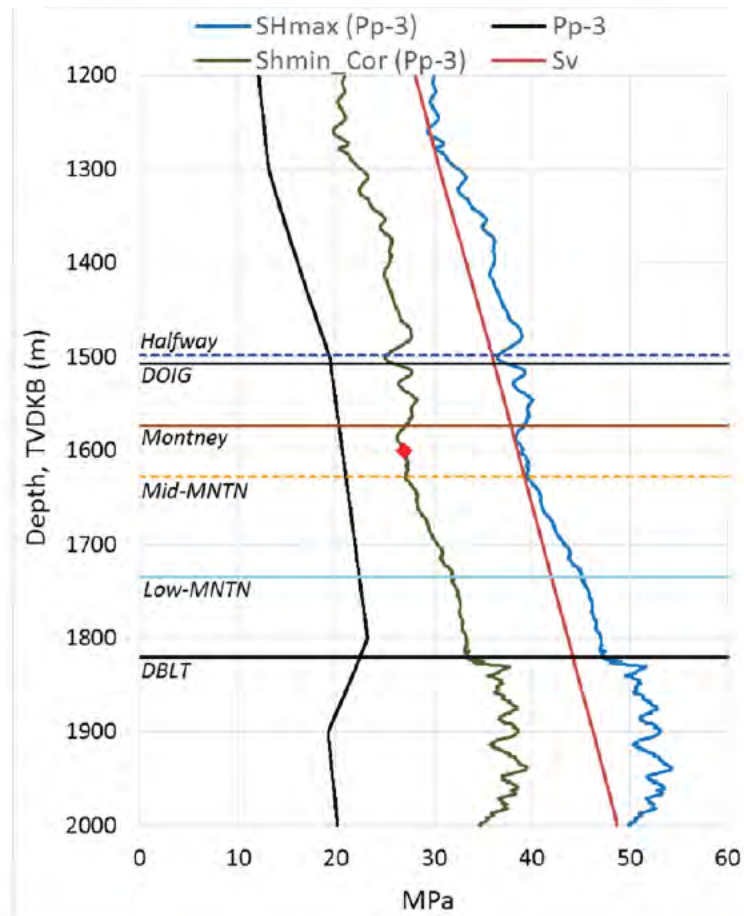


Interpretation of Field Data

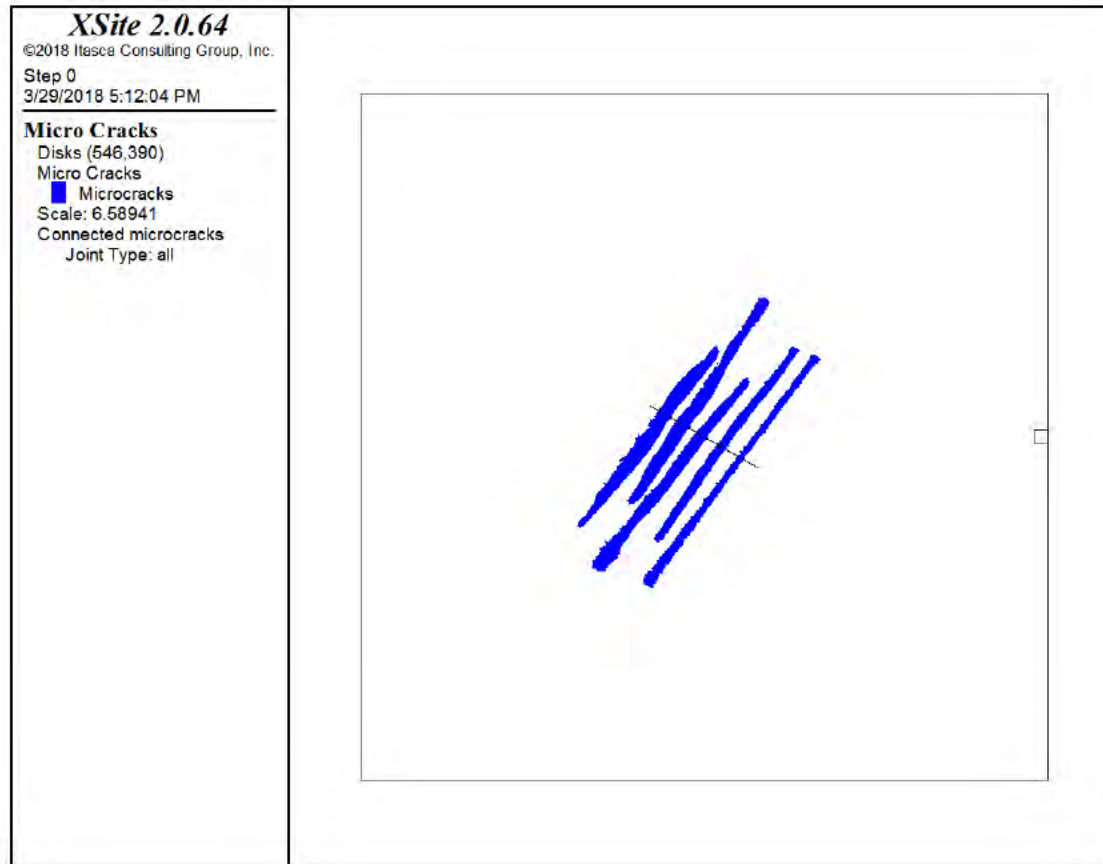
- Stress shadow and horizontal stress gradient are potential causes of fracture asymmetry
- 3MPa/1.3 km horizontal stress gradient based on field data (DFIT Analysis)



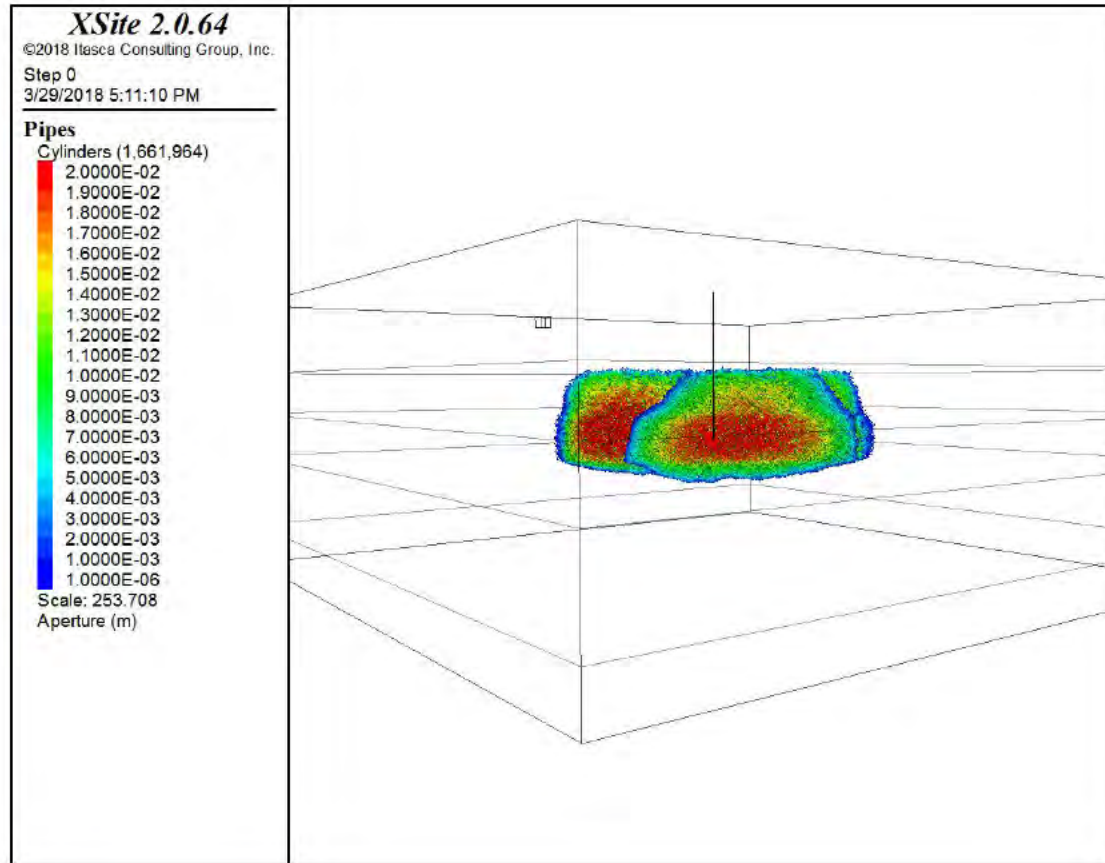
Vertical Profiles



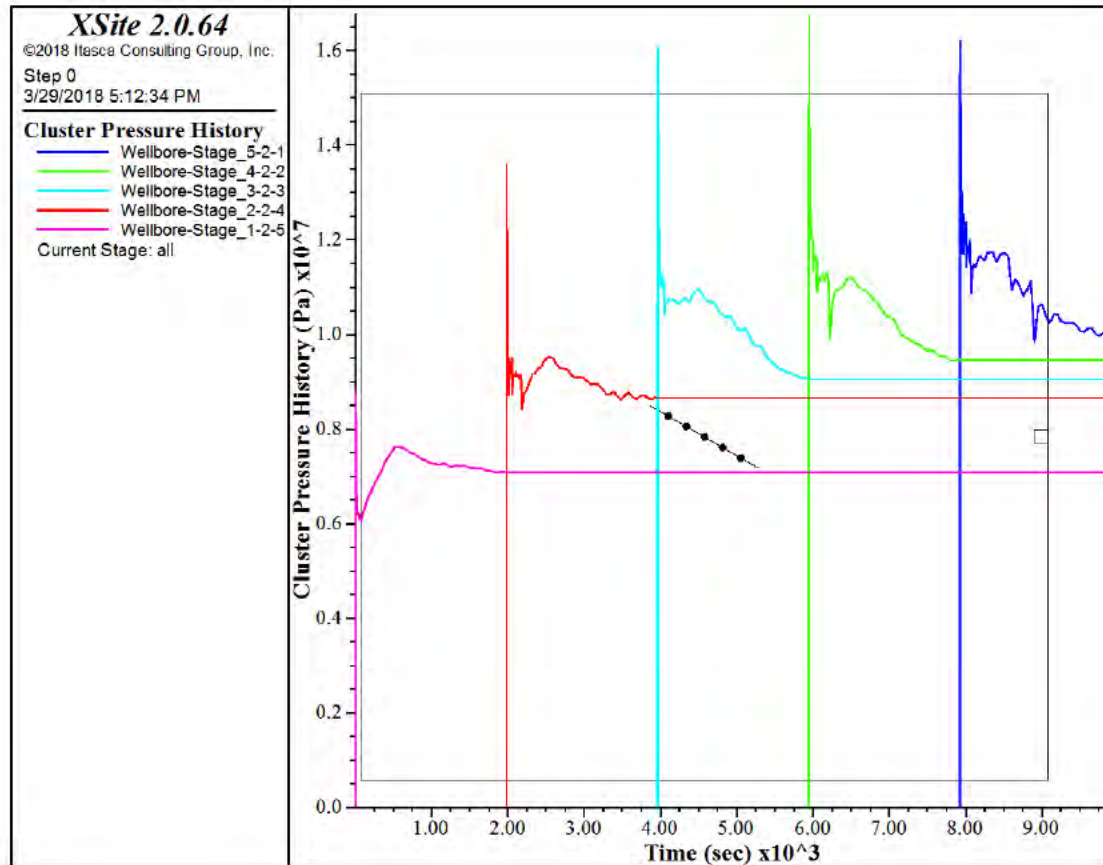
Fracture Geometry Plan View



Fracture Widths (m) Isometric View



Injection Pressures



Conclusions

- Numerical code illustrates interaction between hydraulic fractures within one stage and within adjacent stages
- Interaction is caused by stress-shadow effect and hydraulic connection of the clusters within a stage
- Interaction causes:
 - Some clusters not propagating fractures
 - Asymmetric fracture propagation
 - Variable fracture height
 - Non-planar fracture propagation