Austin Chalk/Eagle Ford Field Laboratory

DOE Award No. DE-FE0031579

Texas A&M University

Lawrence Berkeley National Laboratory

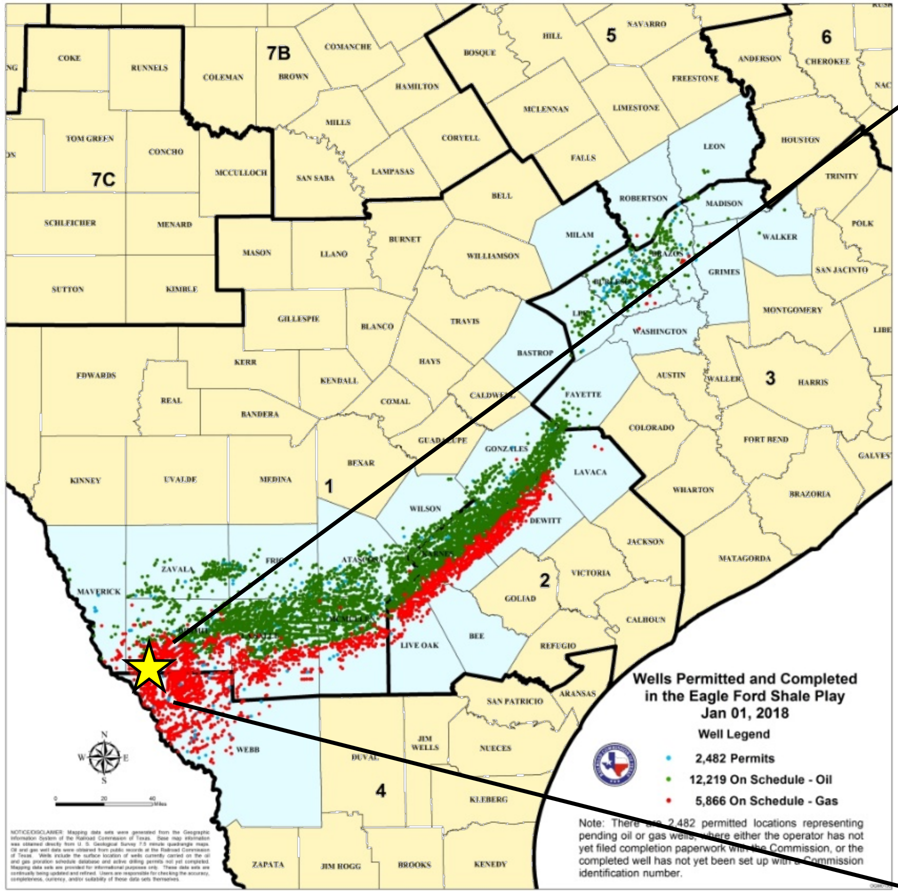
Stanford University

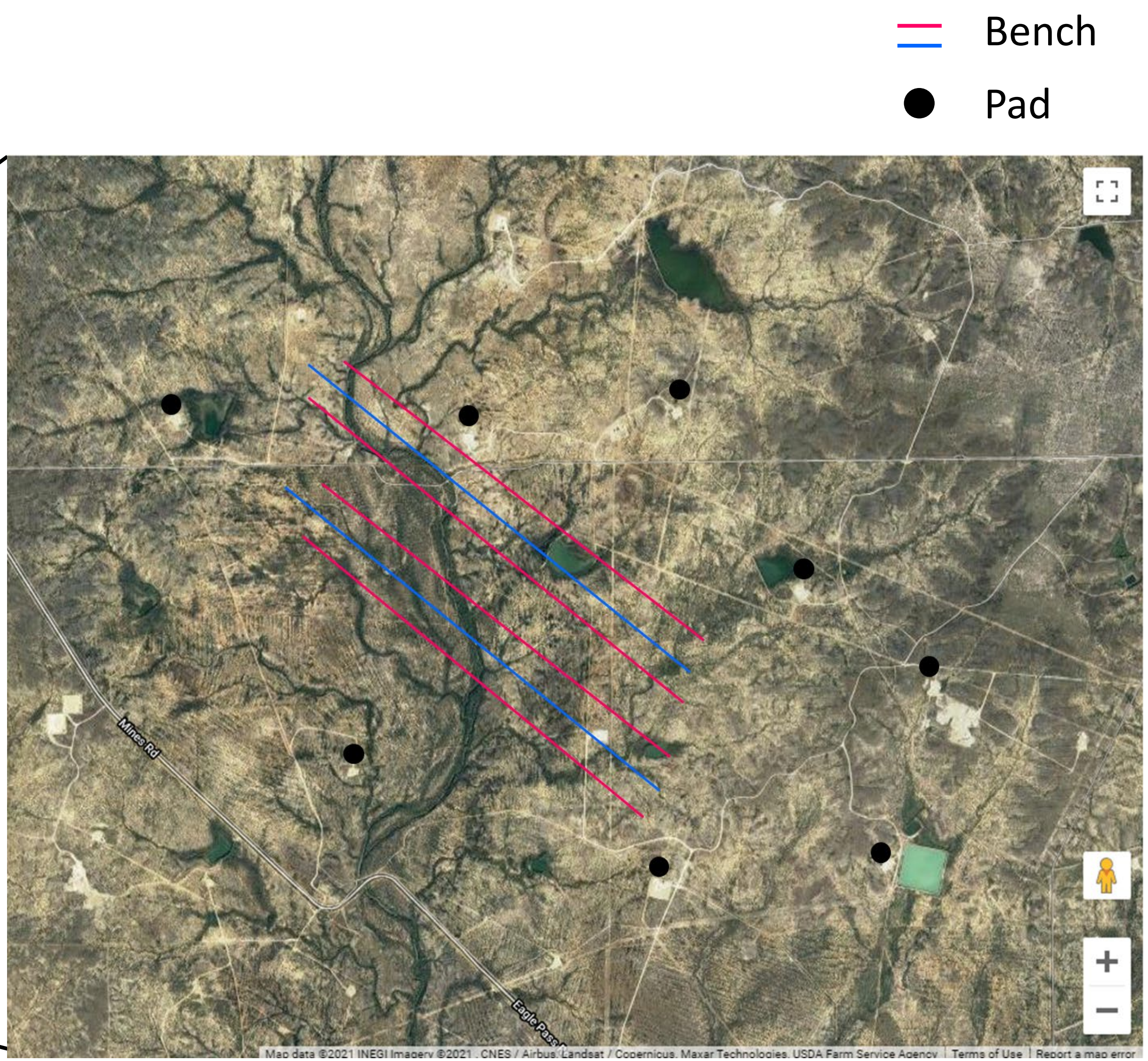
SM Energy

TEXAS A&M UNIVERSITY
Harold Vance Department of
Petroleum Engineering

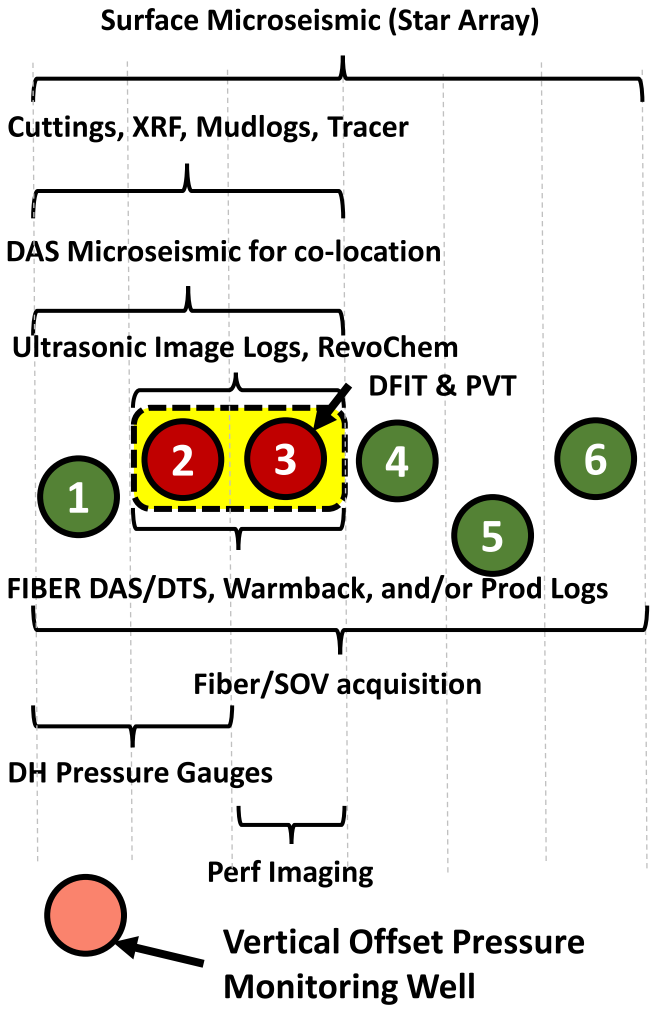
Austin Chalk/Eagle Ford Field Laboratory (ACEFFL)

Site Location

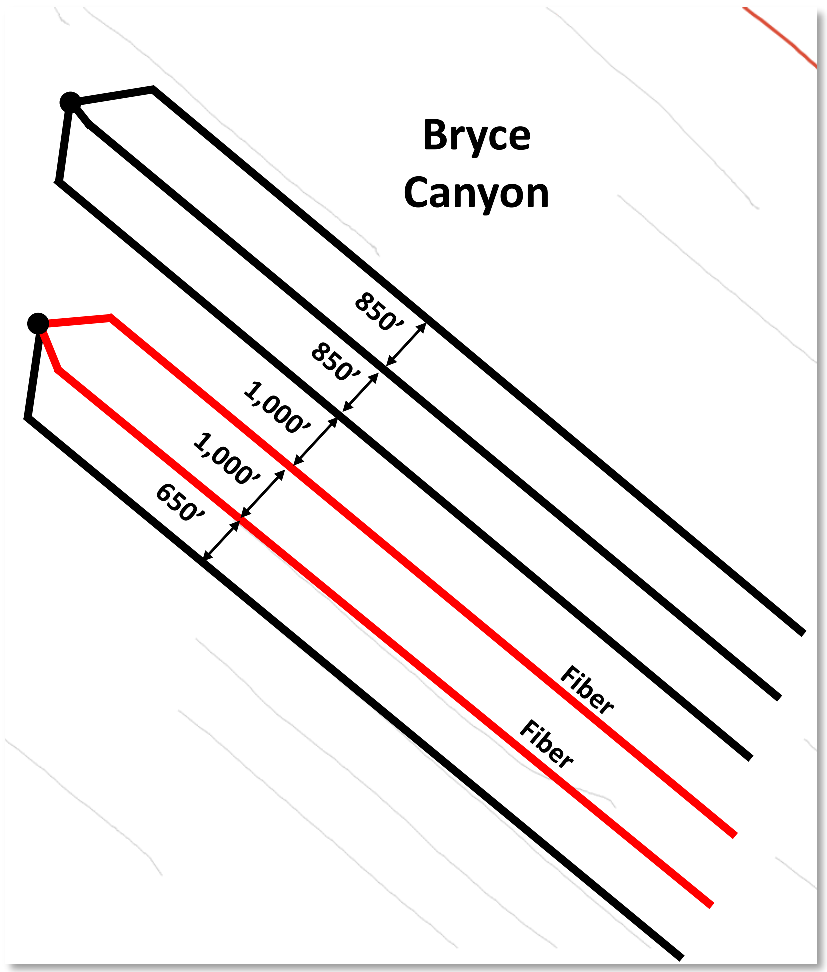




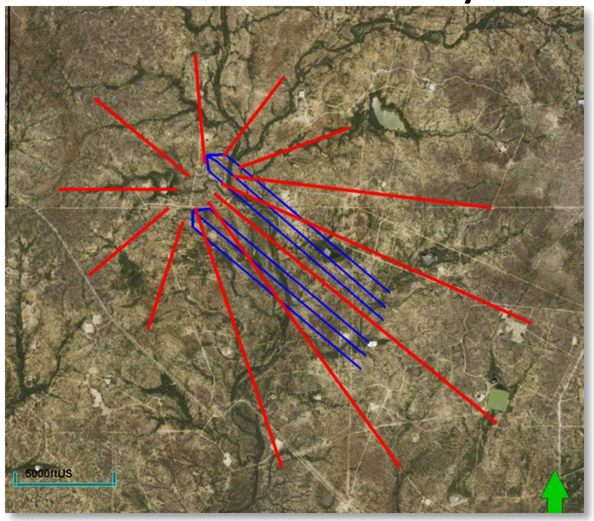
Doe Layered Science Program: Data Capture Scope



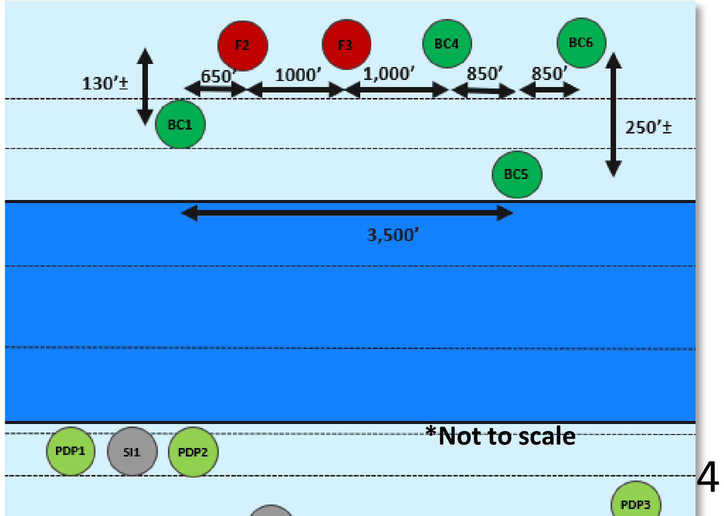
Aerial View of 6-Well Program



Microseismic Star Array



Gun Barrel View



*All diagnostics, well spacings, and landing zones are tentative

Fracture Network Characterization with Integrated Monitoring Technologies

1. DAS and DTS measurements for interpreting flow allocation
2. Low-frequency DAS monitoring for frac-hit detection
3. Sealed wellbore pressure response
4. Downhole pressure gauges
5. Downhole video for perforation erosion monitoring
6. Tracers
7. Microseismic mapping
8. Active seismic monitoring from SOV source to map fracture network
9. Production logging

History of Field Activities at ACEFFL

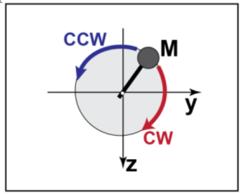
Year	2021				2022				
Month	9	10	11	12	1	2	3	4	... 10
SOV	Installation	Testing		Active Monitoring					
Well 1				Fracturing					
Well 2 (Fiber)			DFIT	Fracturing					
Well 3 (Fiber)			DFIT	Fracturing			Production		
Well 4				Fracturing					
Well 5				Fracturing					
Well 6				Fracturing					

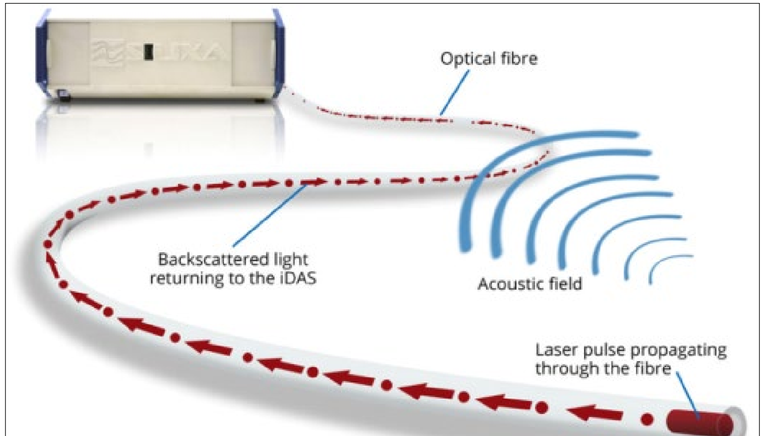
Surface Orbital Vibrator (SOV) + Distributed Acoustic Sensing (DAS)

Conventional campaign-based systems

SOV-DAS permanent monitoring system

Surface orbital vibrator (SOV)



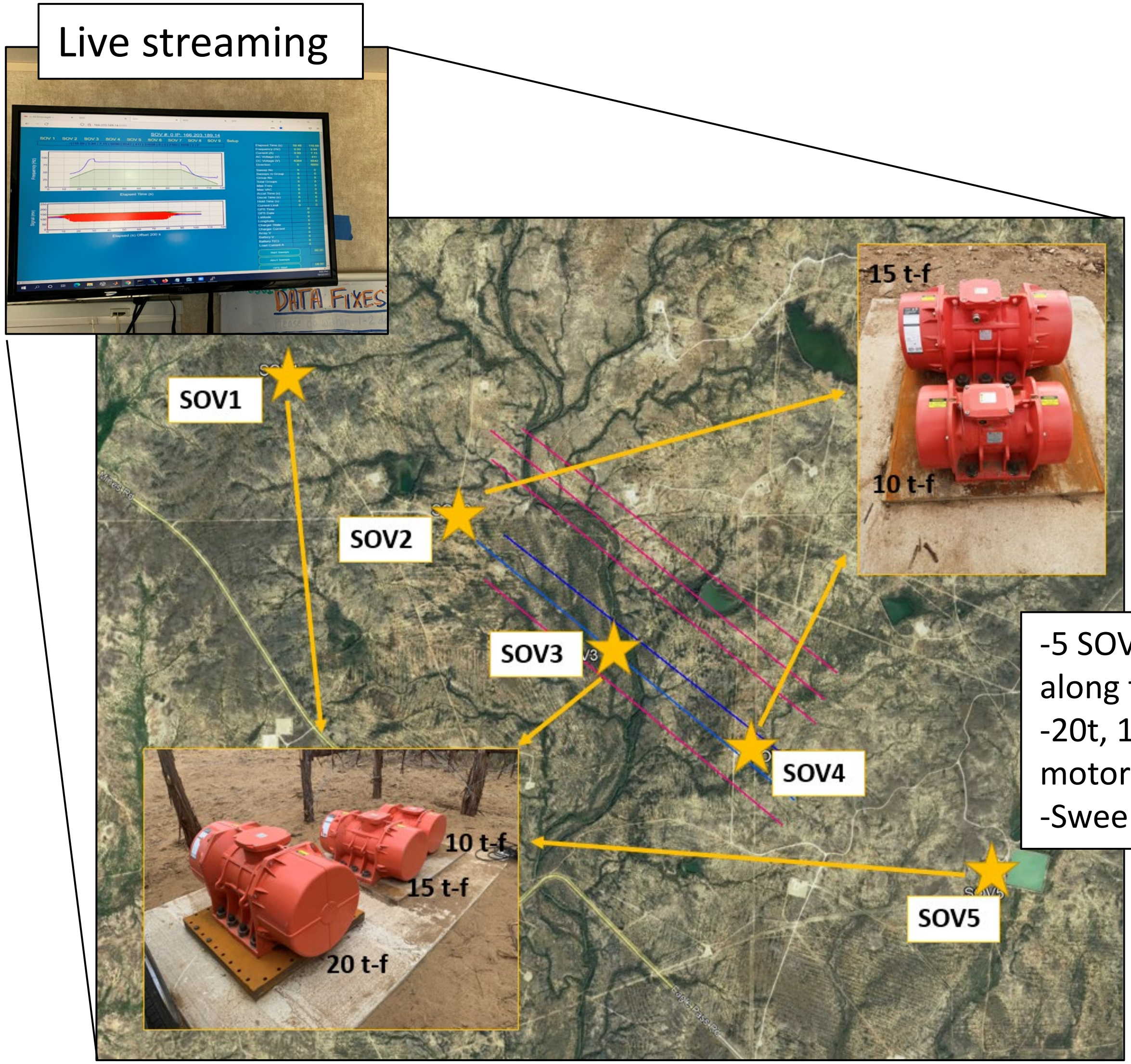


Distributed acoustic sensing (DAS)

Why using SOV-DAS?

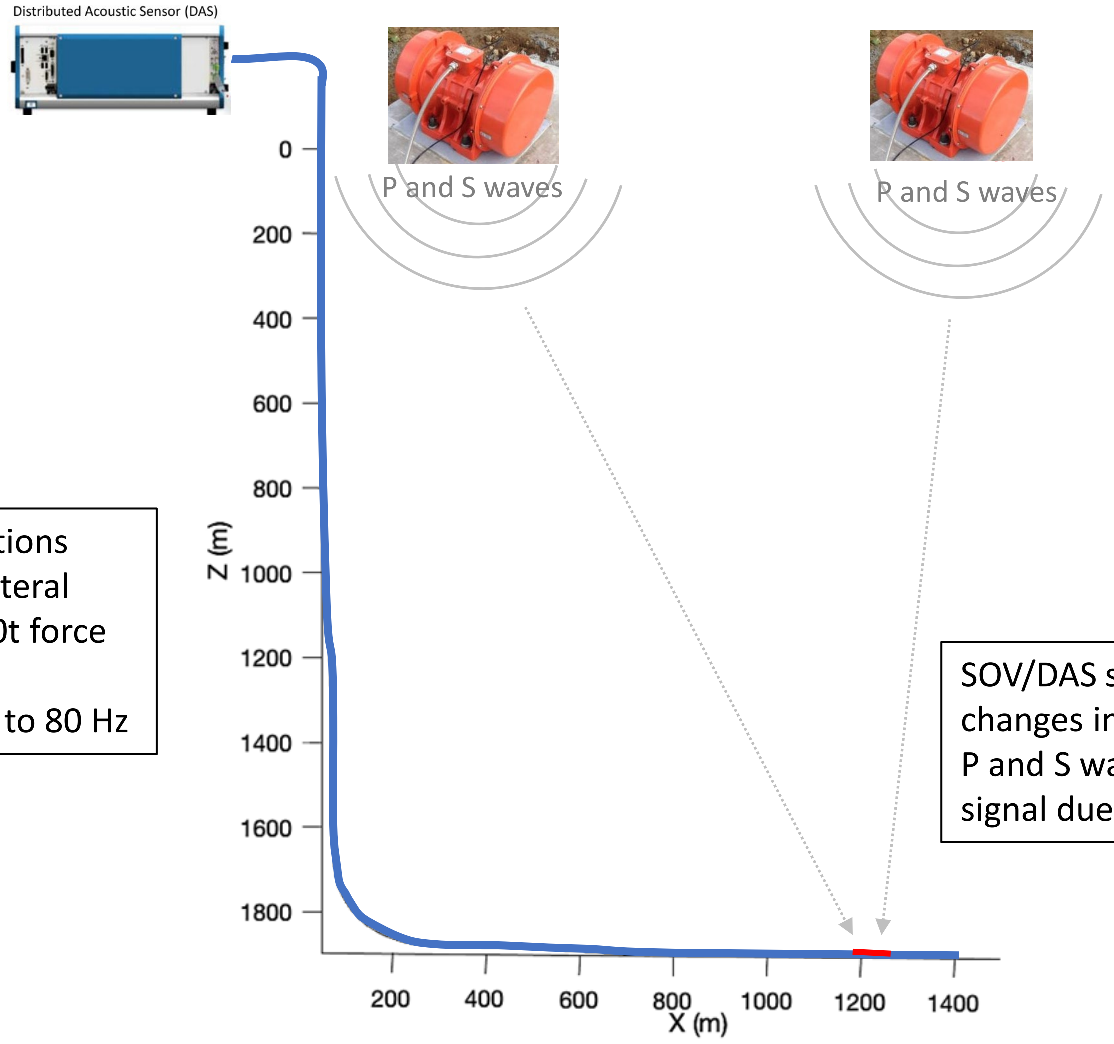
- **Cost-effective** solution for long-term seismic monitoring
- **Remote**, **on-demand** seismic acquisition
- Enables **real-time data processing** and analysis, leading to fast decision making
- **High temporal sampling** enables the detection of small changes

SOV/DAS Survey Design

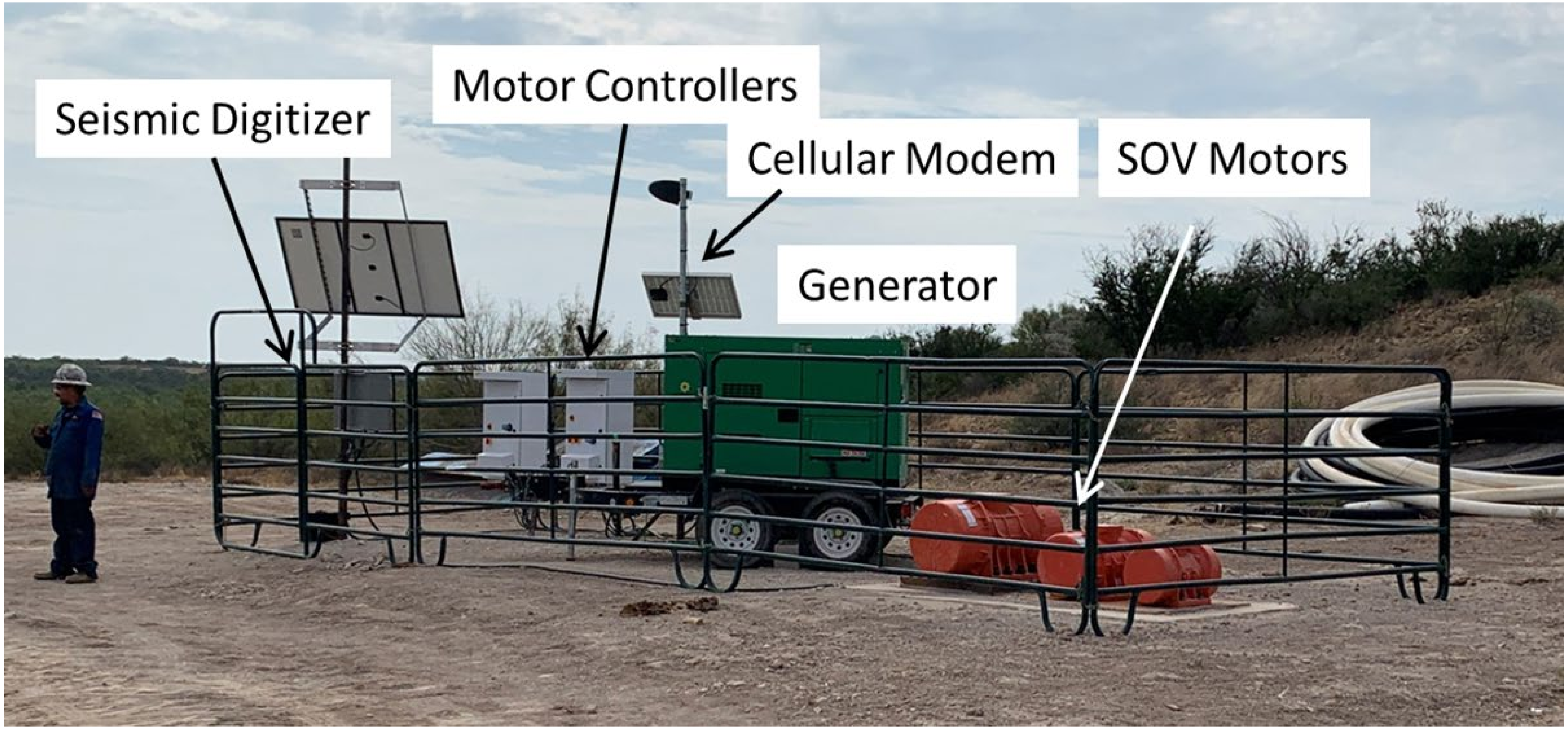


Aerial View

-5 SOV locations along the lateral
-20t, 15t, 10t force motors
-Sweeps up to 80 Hz

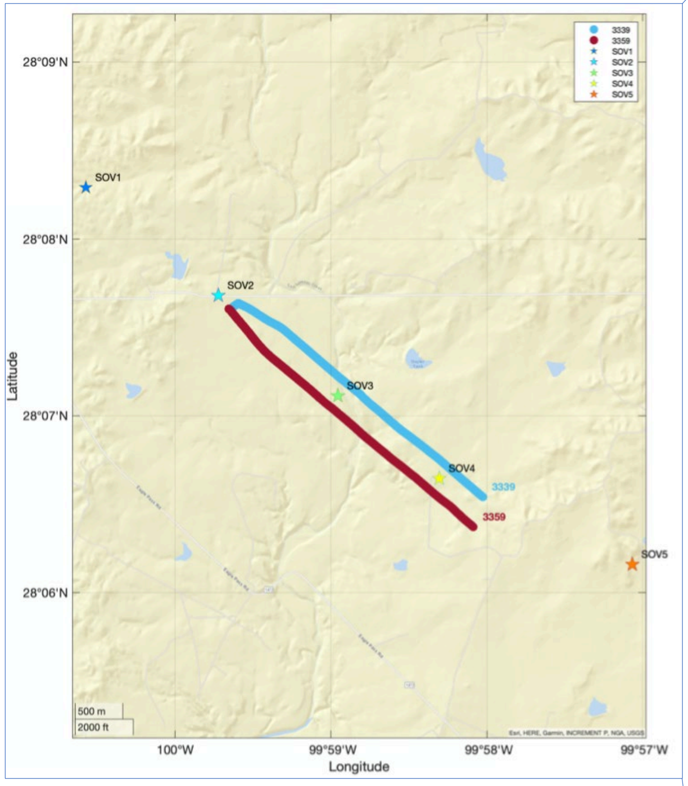


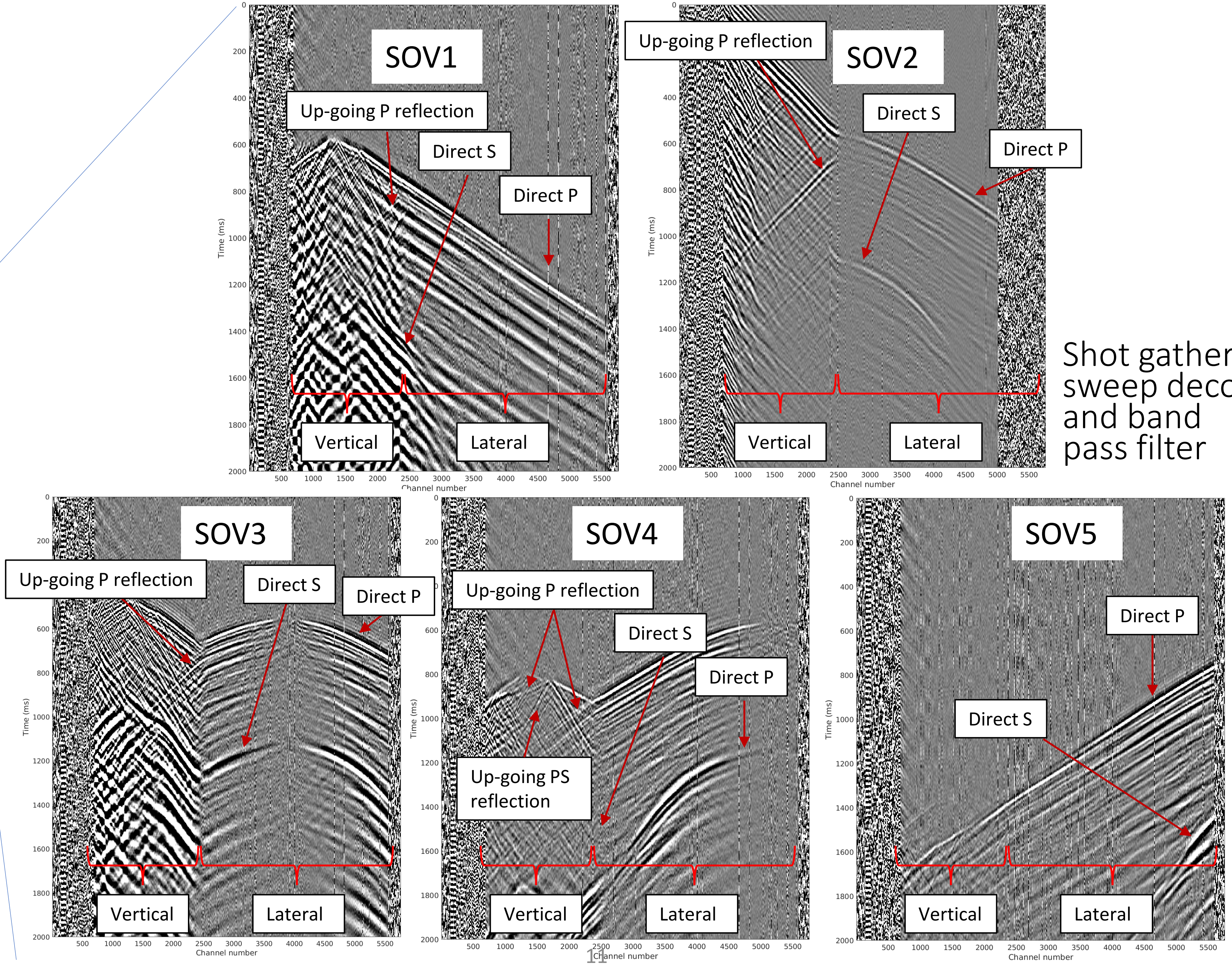
SOV/DAS senses changes in the P and S waves signal due to HF


Seismic Digitizer
Motor Controllers
Cellular Modem
SOV Motors
Generator

Well 1

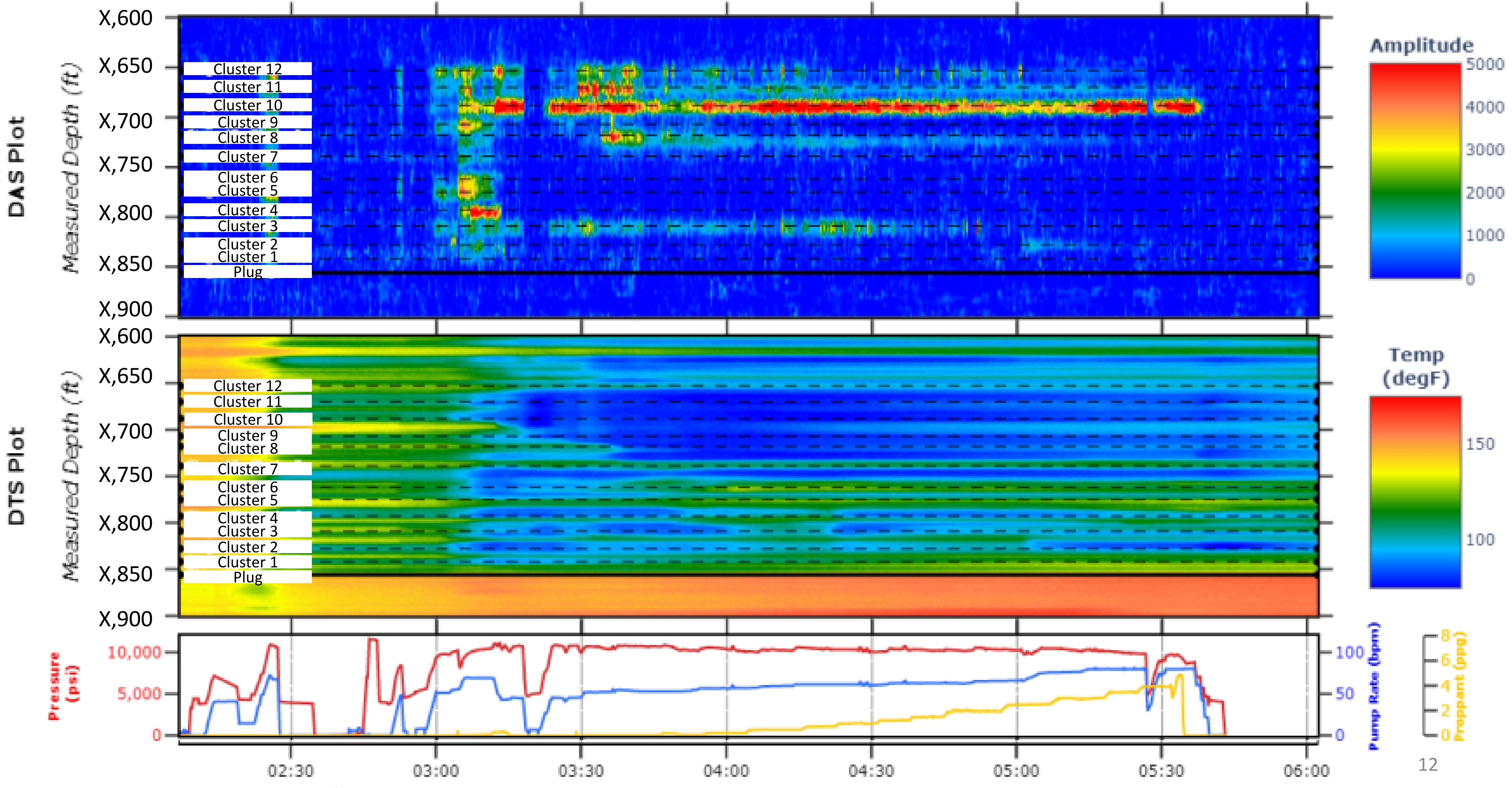
DAS/SOV baseline





Shot gathers sweep decon and band pass filter

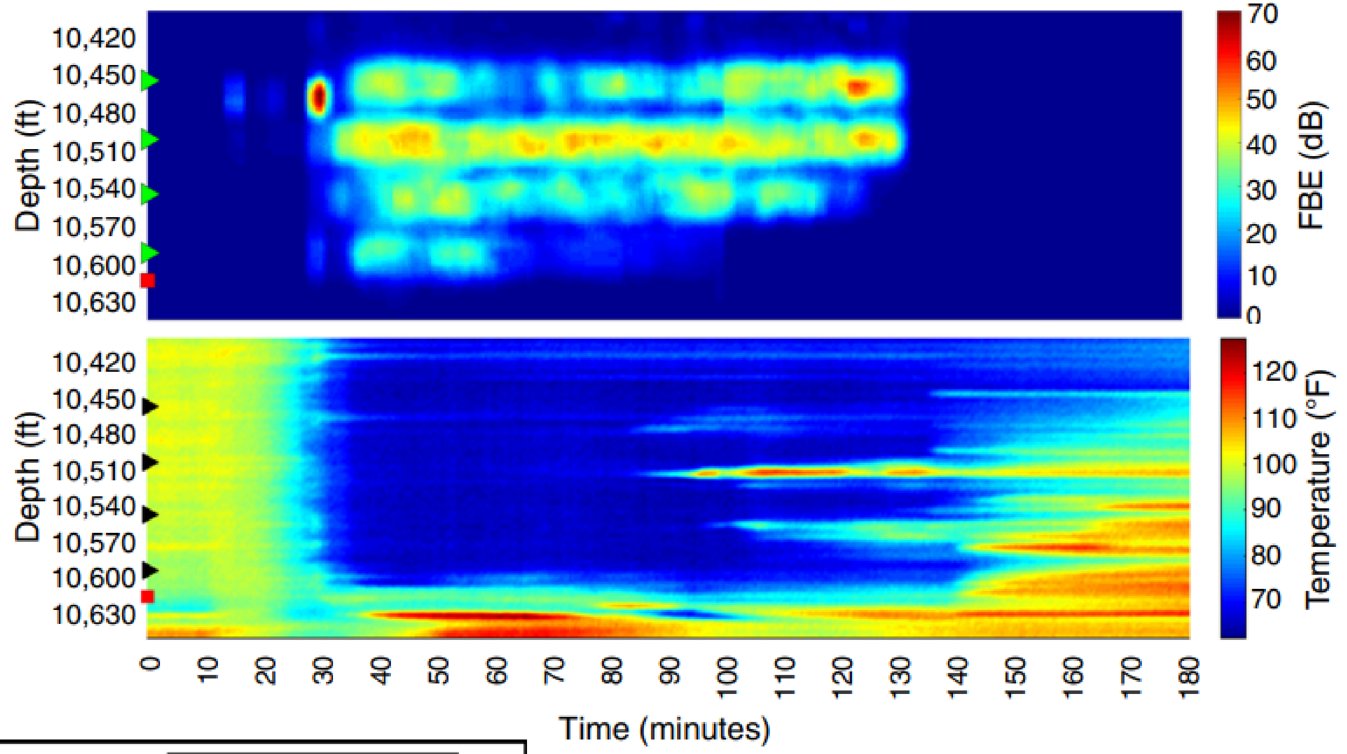
Flow Monitoring by DAS and DTS

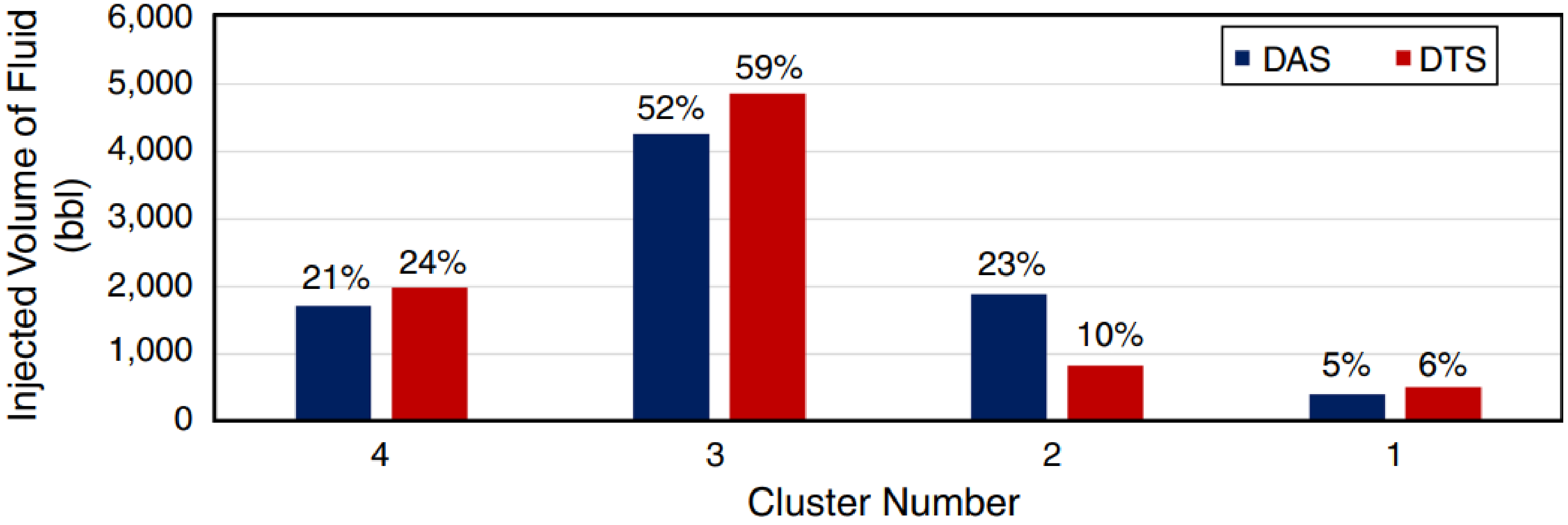


Fluid Volume Distribution by DAS and DTS

DAS

DTS

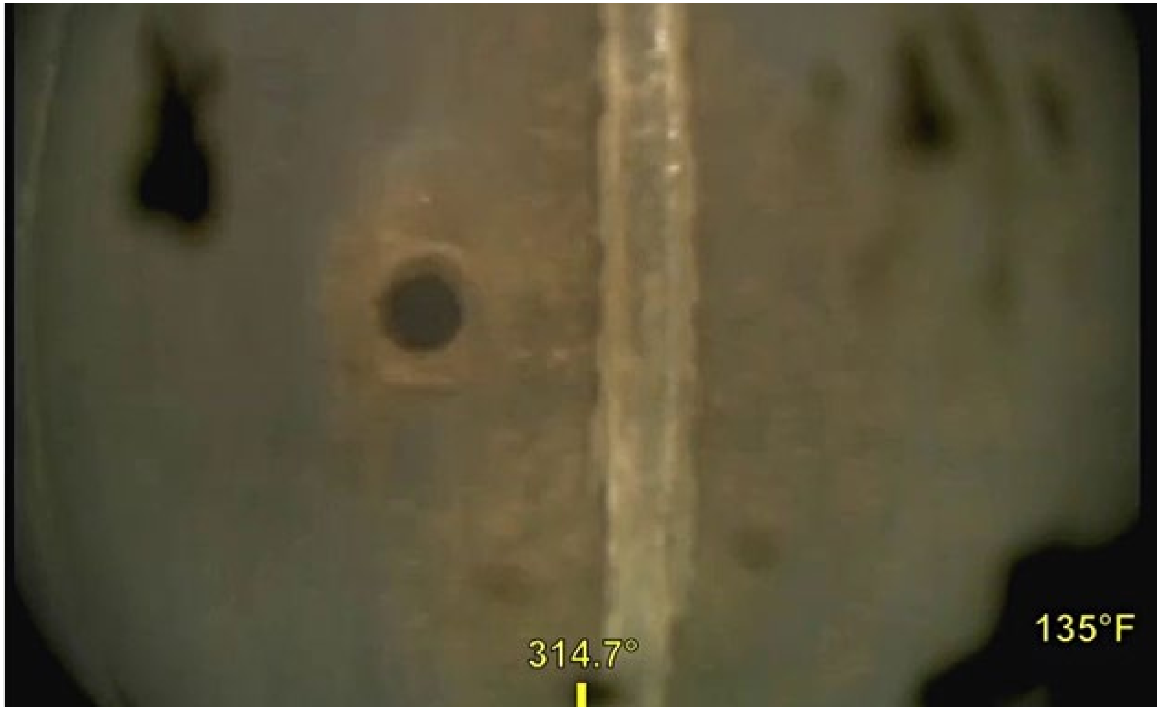




(Pakhotina et al. 2020)

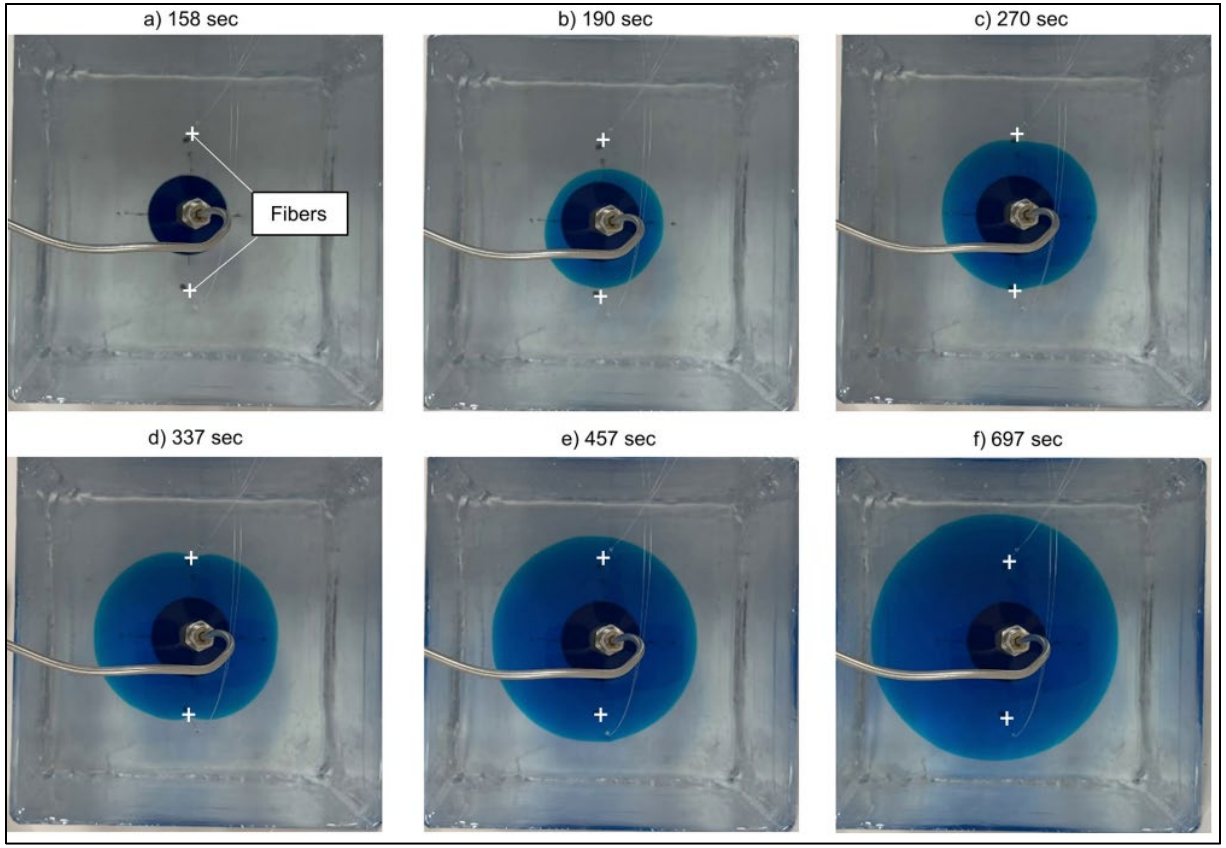
Perforation Erosion Observation

Not eroded

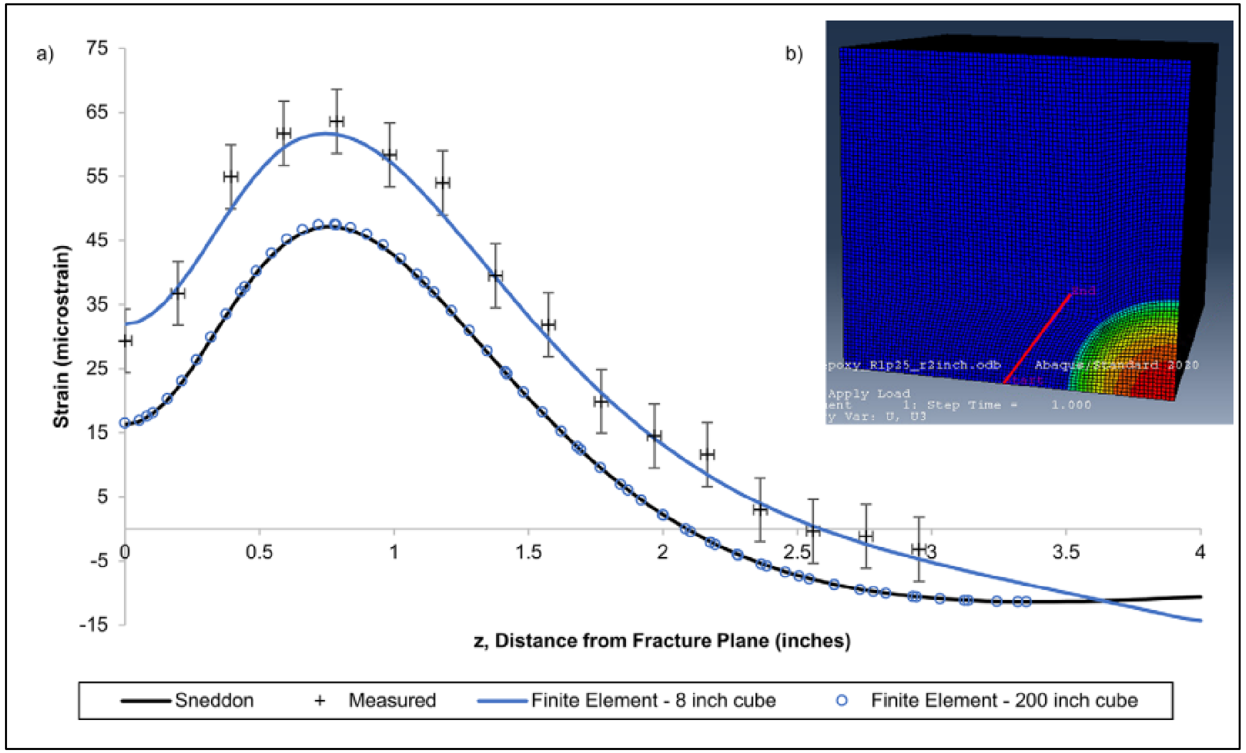


Eroded

Experimental Investigation of Low-Frequency DAS



(a) Radial fracture propagation highlighting the initial flaw filled with fracture fluid
(b & c) Fracture propagating in the epoxy toward the fibers
(d) Fracture intersecting the fibers
(e & f) Fracture growth beyond the fibers

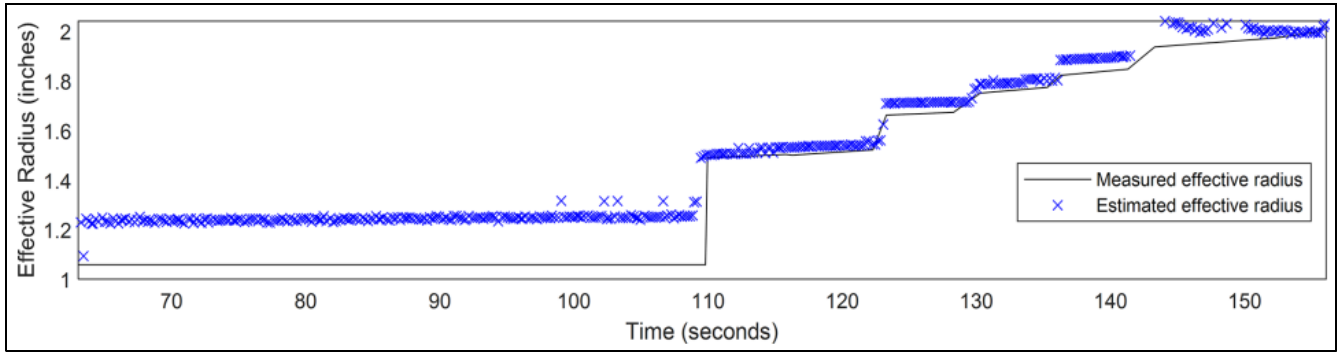


(a) Comparison of measured and modeled strains at a single time before the fracture hit and
(b) finite-element model domain with a red line indicating the location of the fiber.

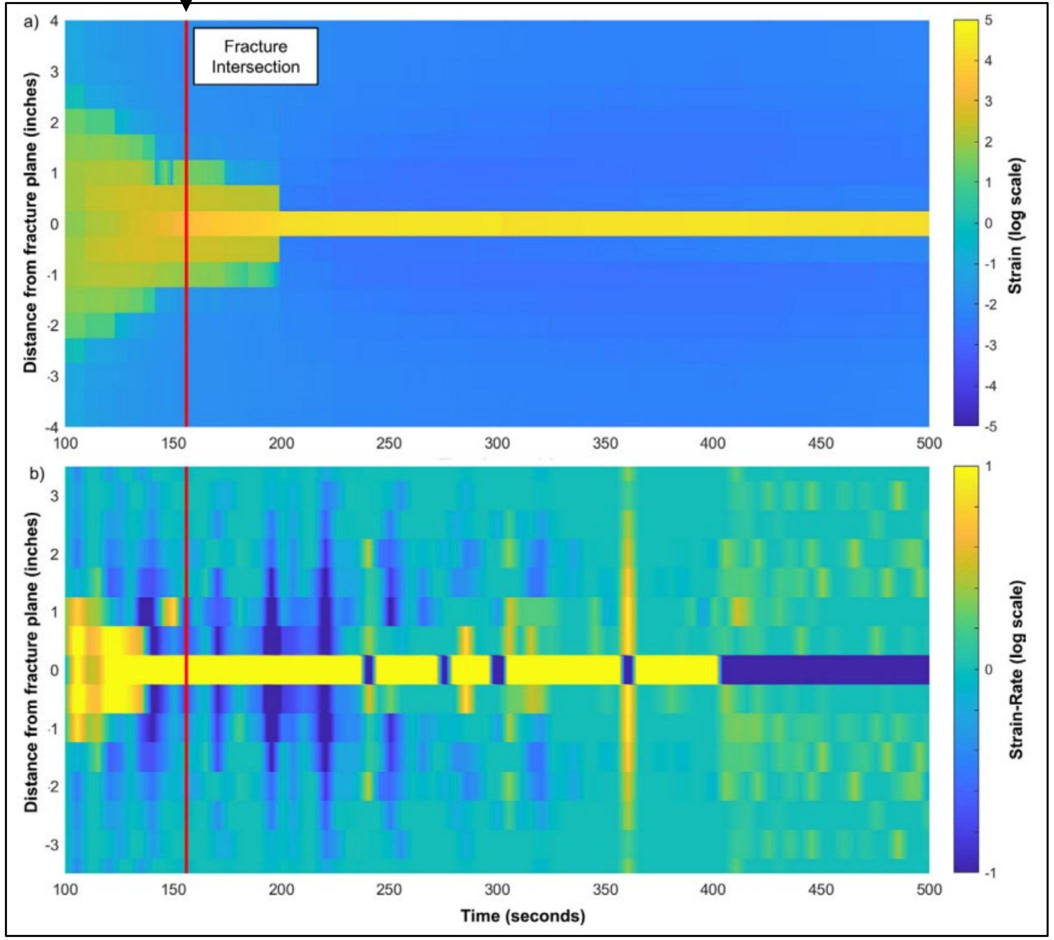
(Leggett et al., 2022)

Experimental Investigation of Low-Frequency DAS

when the fracture intersected the embedded fiber



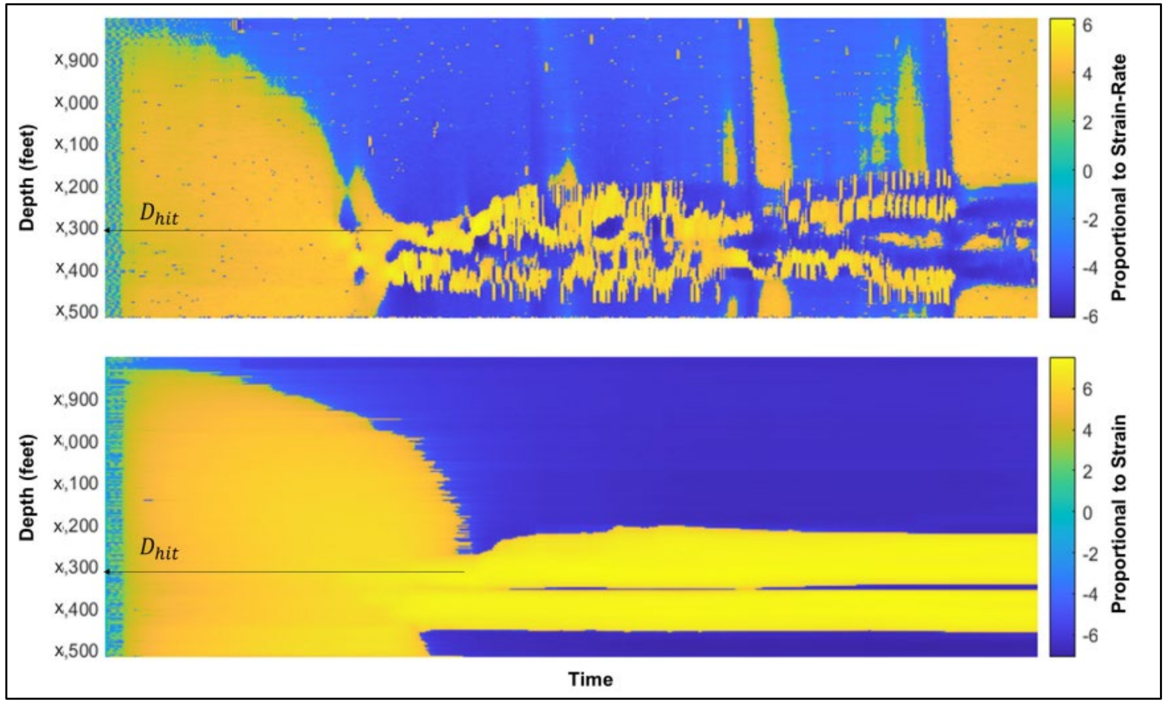
Measured and estimated fracture radius using the zero-strain location method.



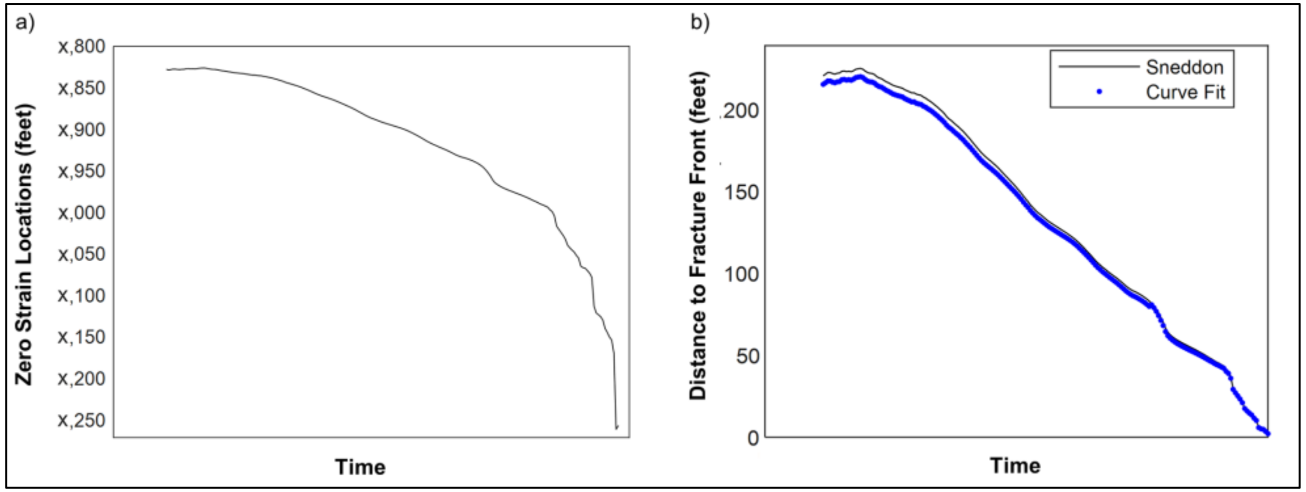
Strain and strain-rate waterfall plots from a fracture experiment

(Leggett et al., 2022)

Field Application of the Zero-Strain Location Method



LF-DAS strain-rate (top) and strain (bottom) waterfall plots, with the fracture hit location D_{hit} marked.

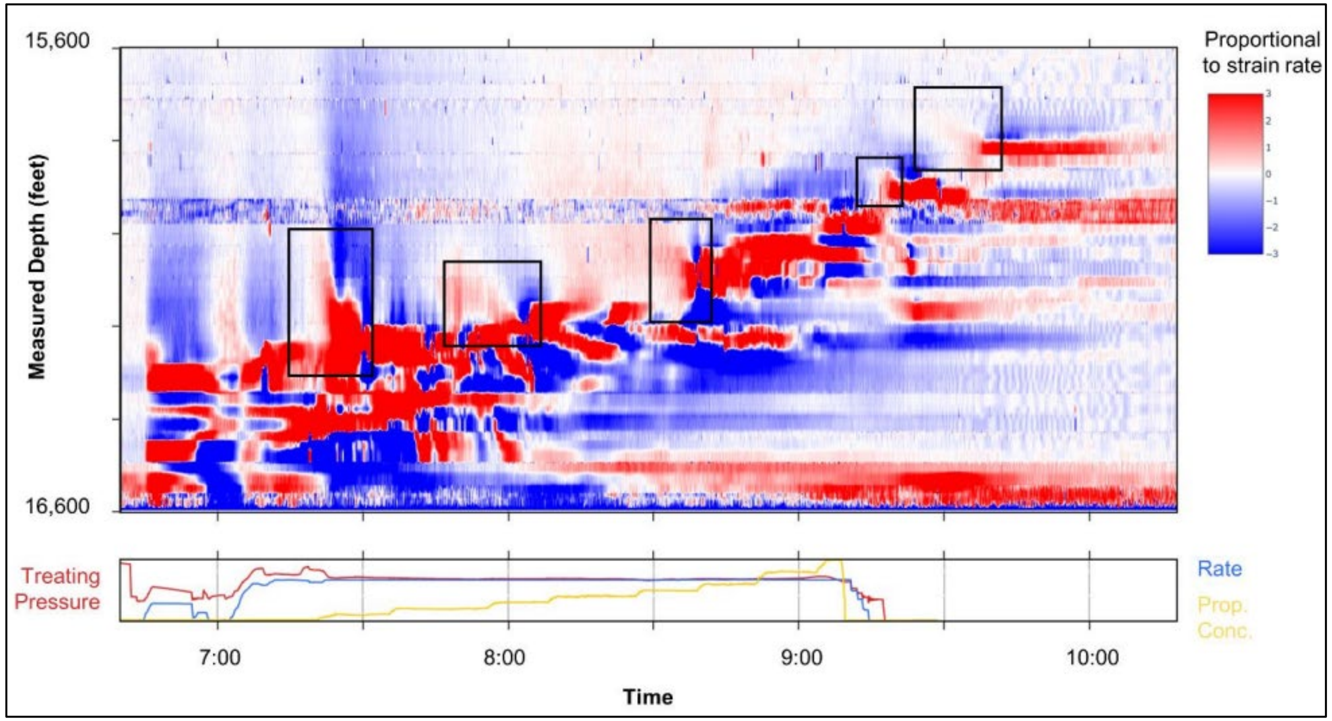


(a) Zero-strain locations D_0 extracted from the strain waterfall plot

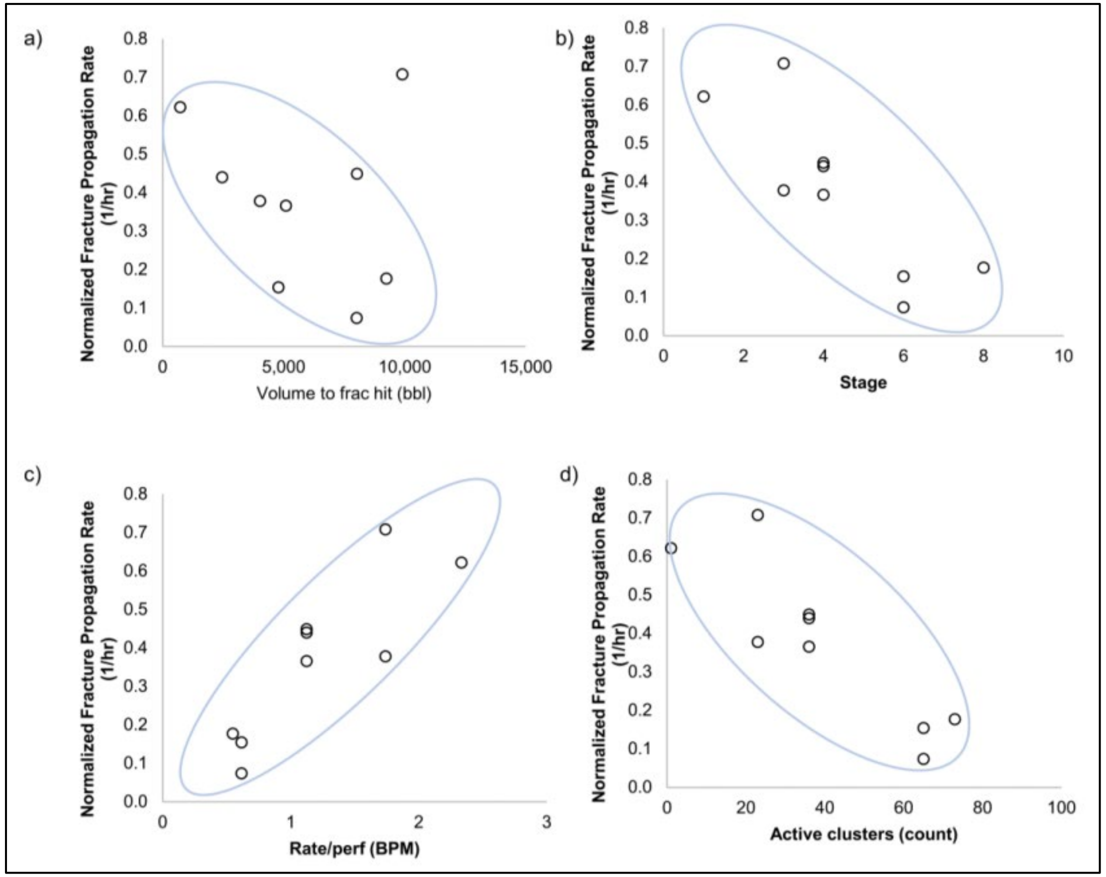
(b) Estimated distance to the fracture front.

(Leggett et al., 2022)

Far-field Strain Rate to Estimate Fracture Front



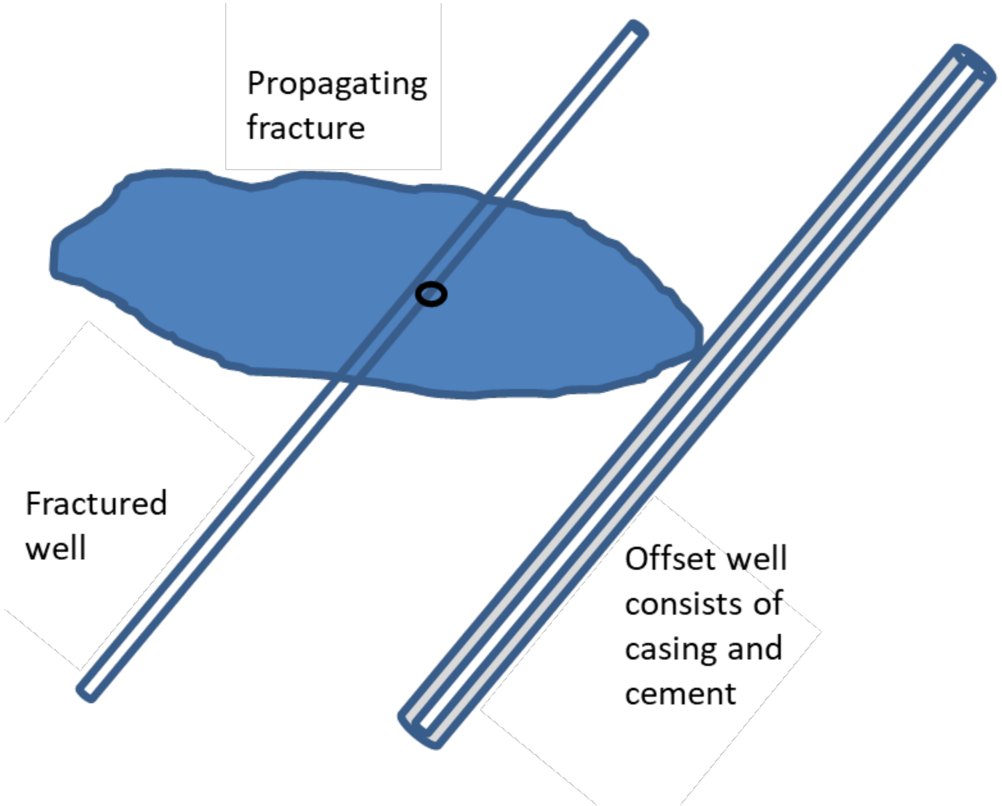
Waterfall plot with 5 frac hits exhibiting the characteristic cone-shaped convergence of the strain rate pattern.



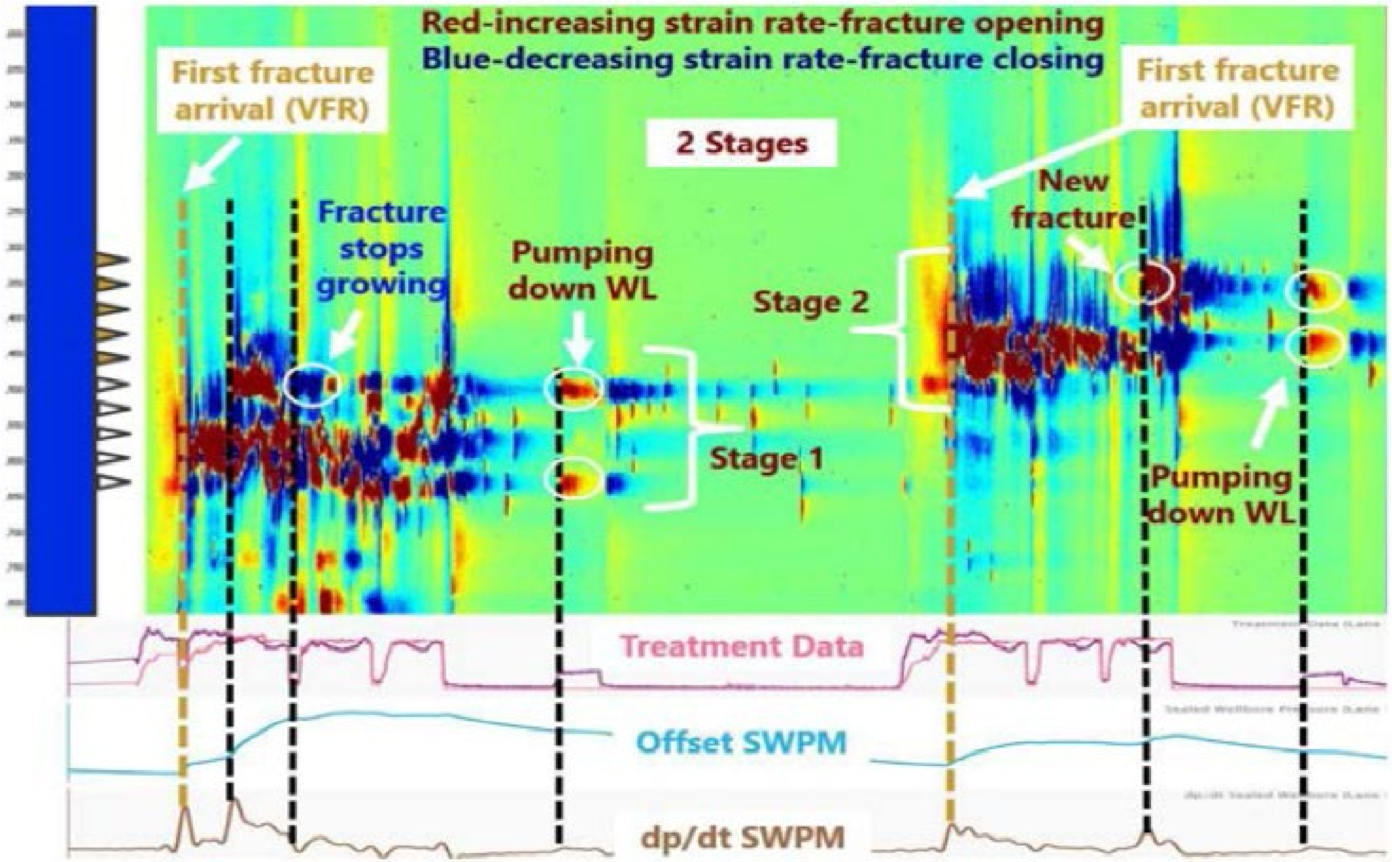
Cross plots comparing fracture propagation rates to various completion parameters.

(Leggett et al., 2022)

Sealed Wellbore Pressure Monitoring (SWPM)



Schematic of the simulation domain

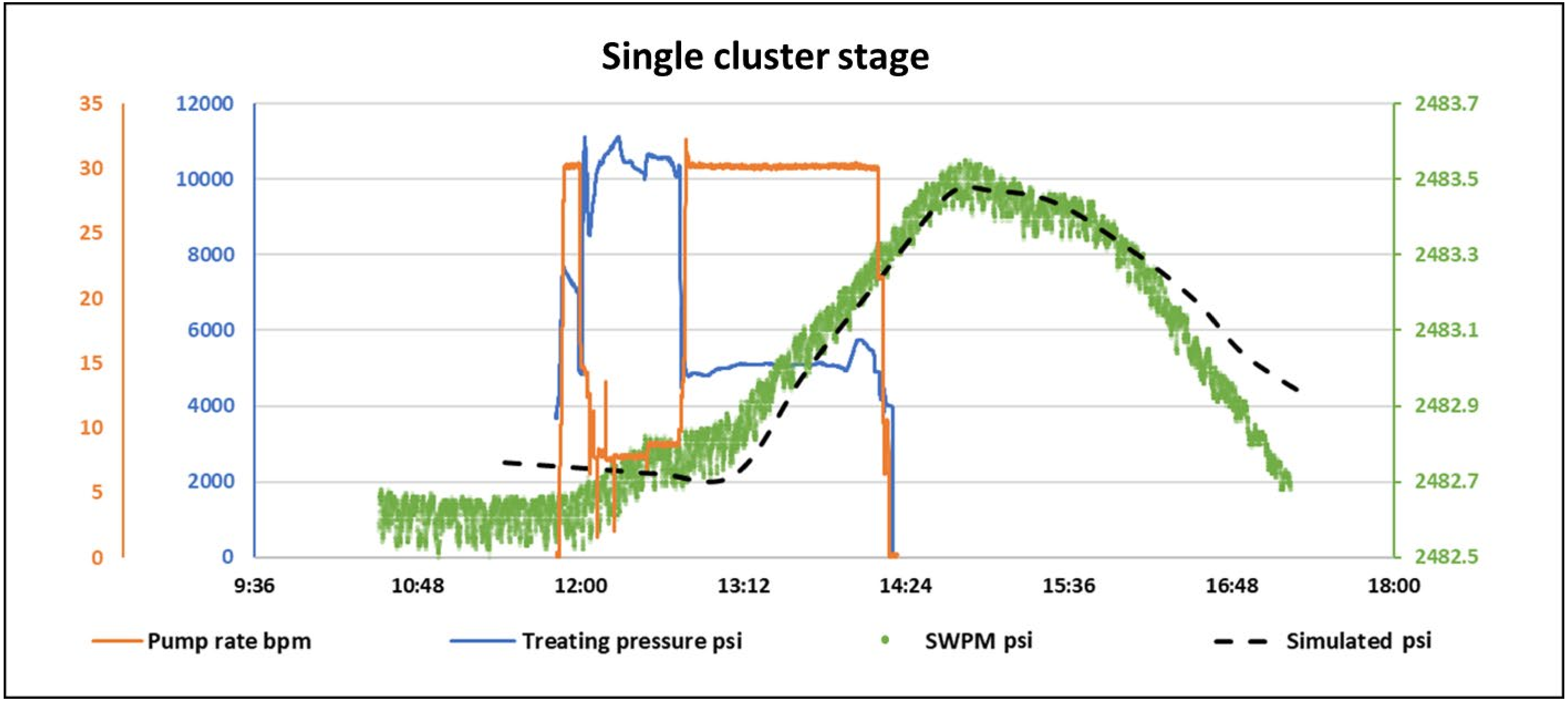


(Haustveit et al., 2020)

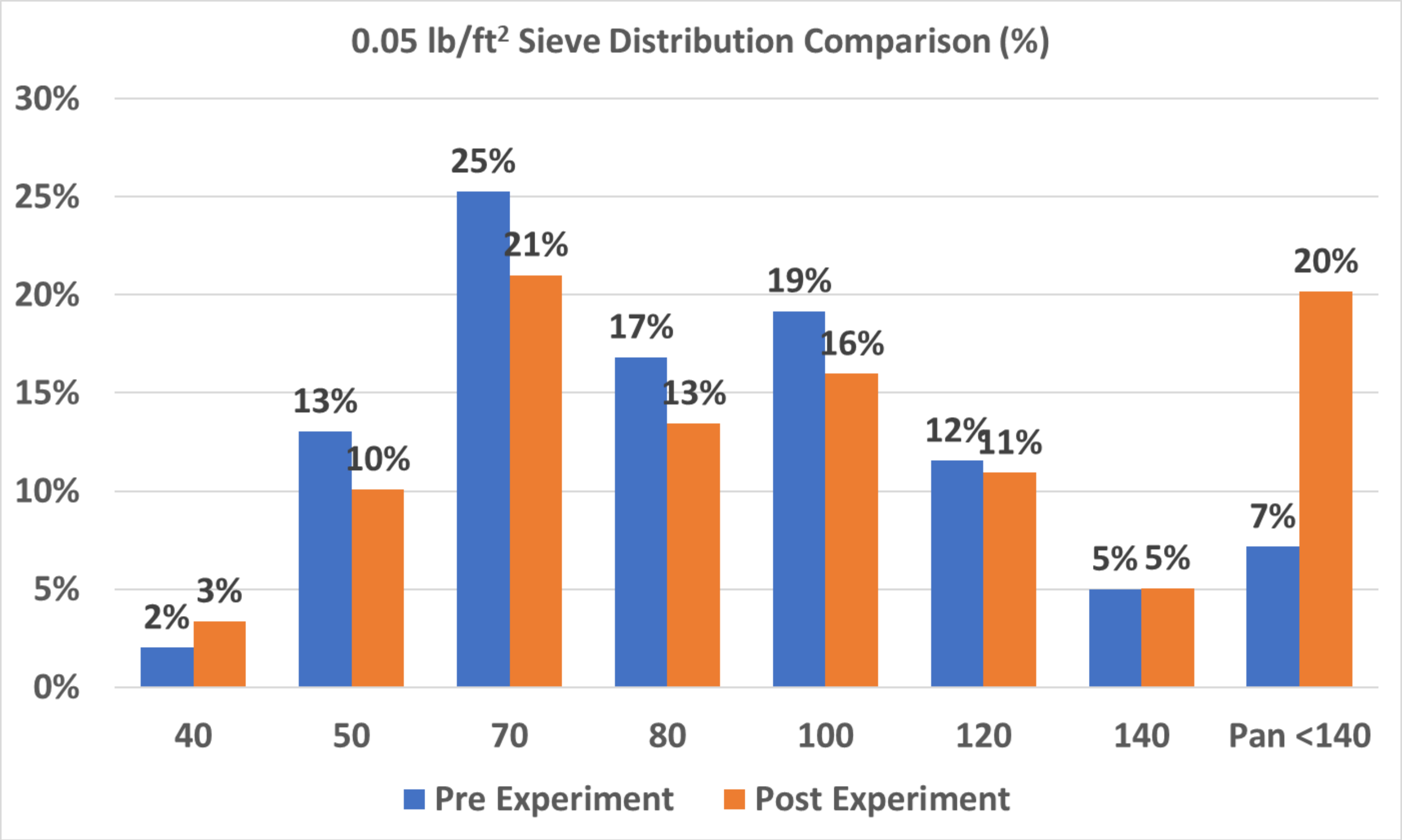
SWPM Simulated Result

Actual response 0.86 psi

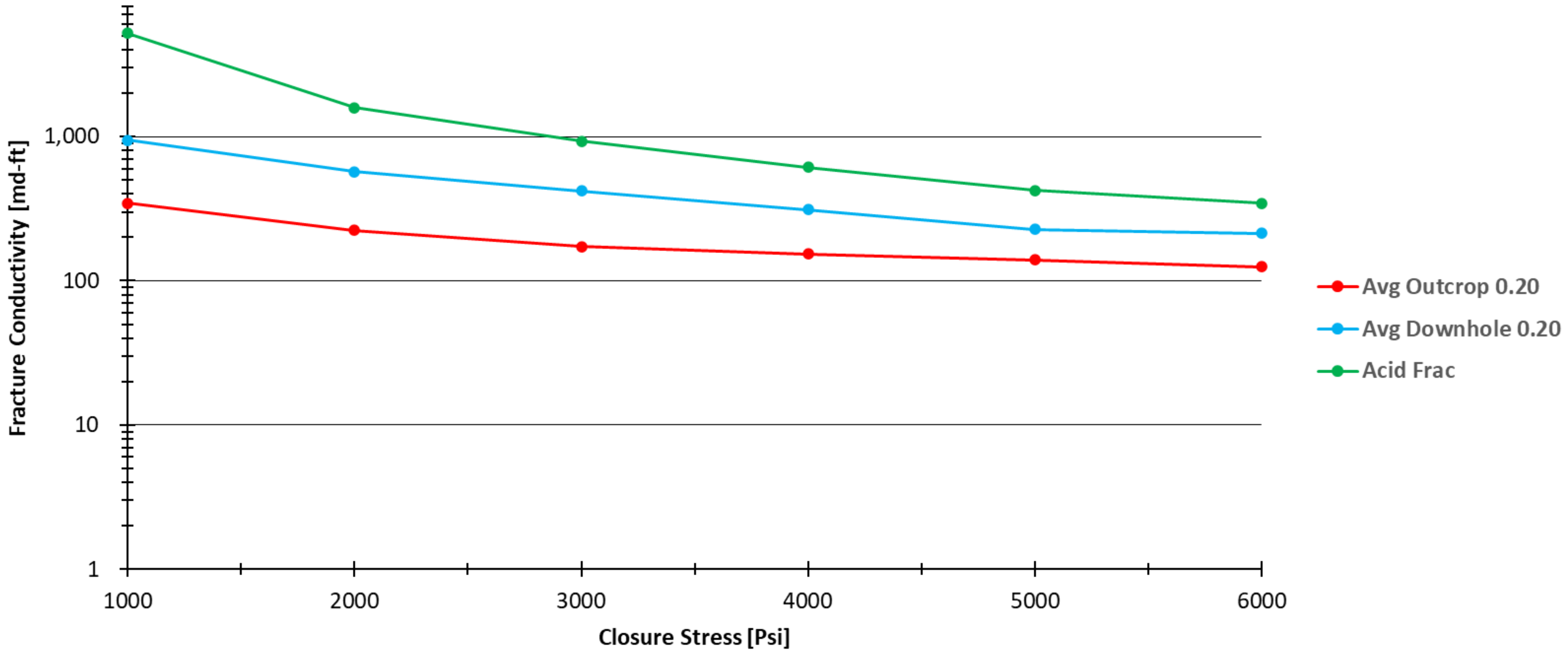
Simulated response 0.78 psi



Supporting Experimental Study: Fracture Conductivity



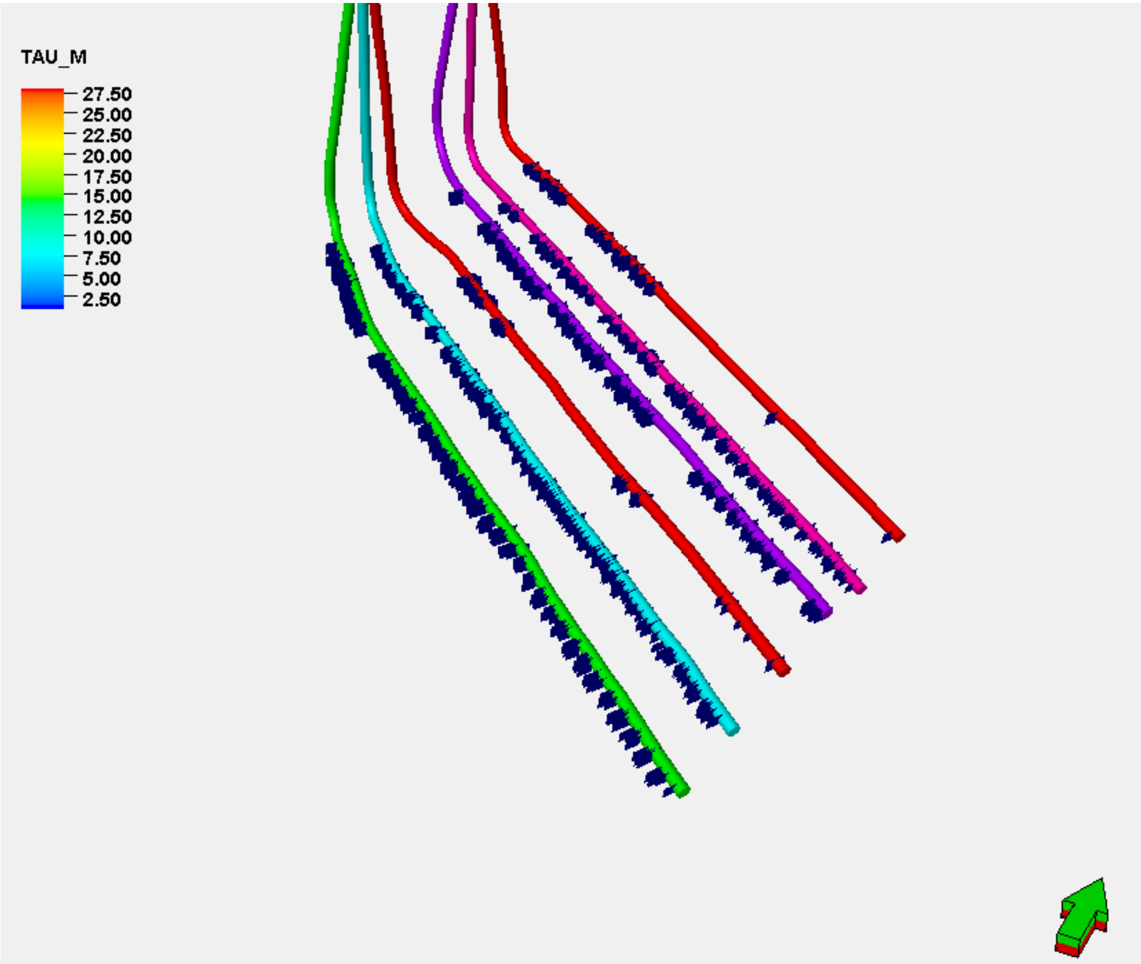
Supporting Experimental Study: Fracture Conductivity

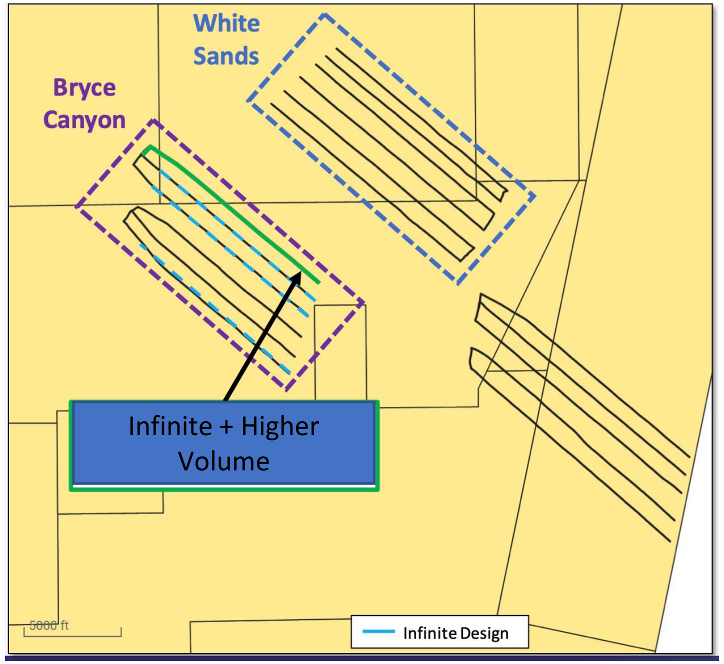


Supporting Modeling Work for Fracture Characterization

1. **Reservoir simulation** with field input from microseismic, fiber optic sensor measurements and geologic models
2. **Geomechanical modeling** for near-well fracture propagation complex
3. **Rock mechanical modeling and DFIT analysis** for rock mechanical property distribution and their impact on fracture propagation

Reservoir Simulation: Evolution of Drainage Volume and Well Interference

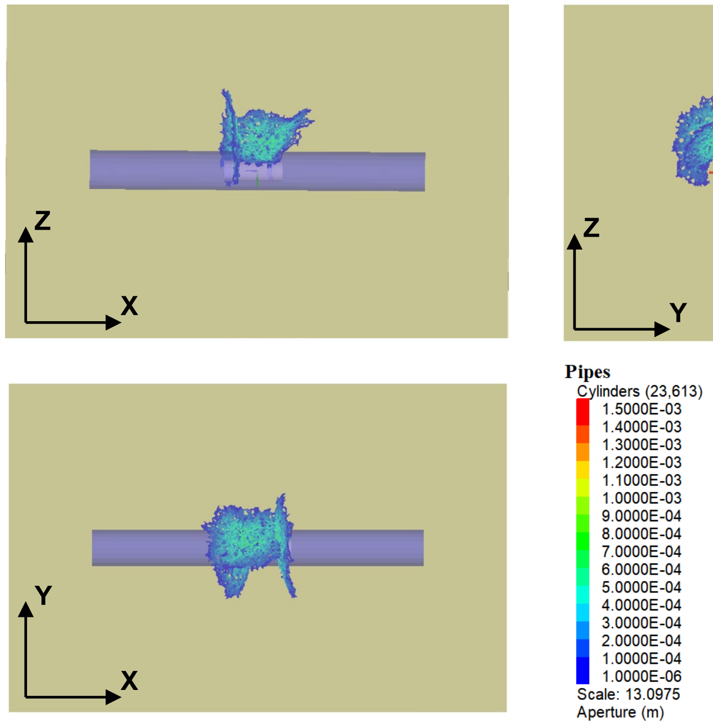




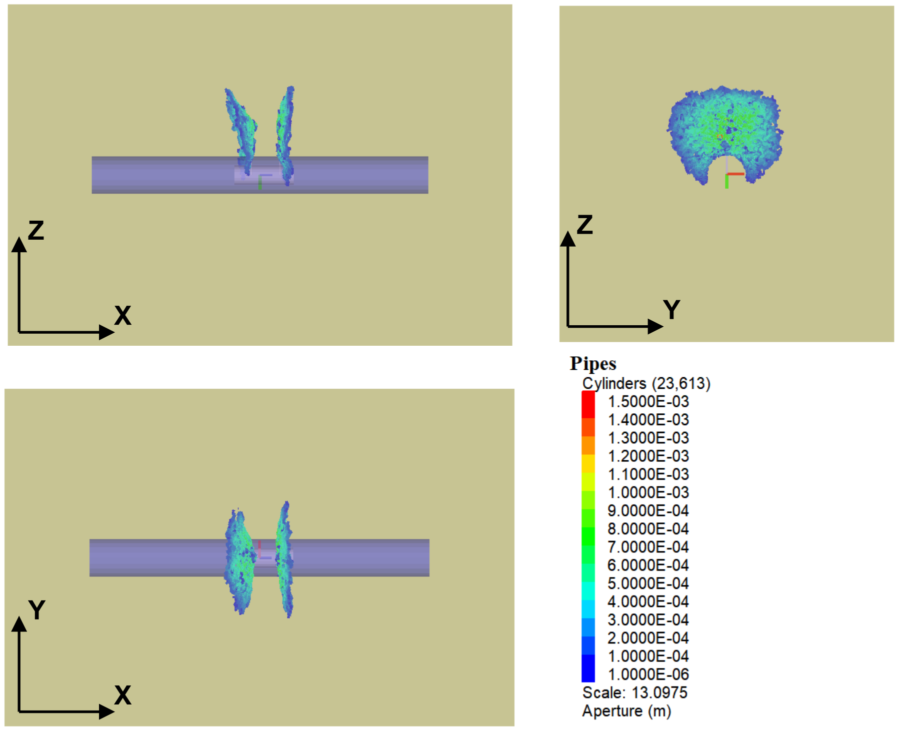
- **Fast Marching Based Drainage Volume Visualization**
- **Strong interactions observed between wells by 50 days leading to a multi-well problem**

Geomechanical Modeling: Near-Wellbore Fracture Initiation Optimization

L_{perf} = 2 in



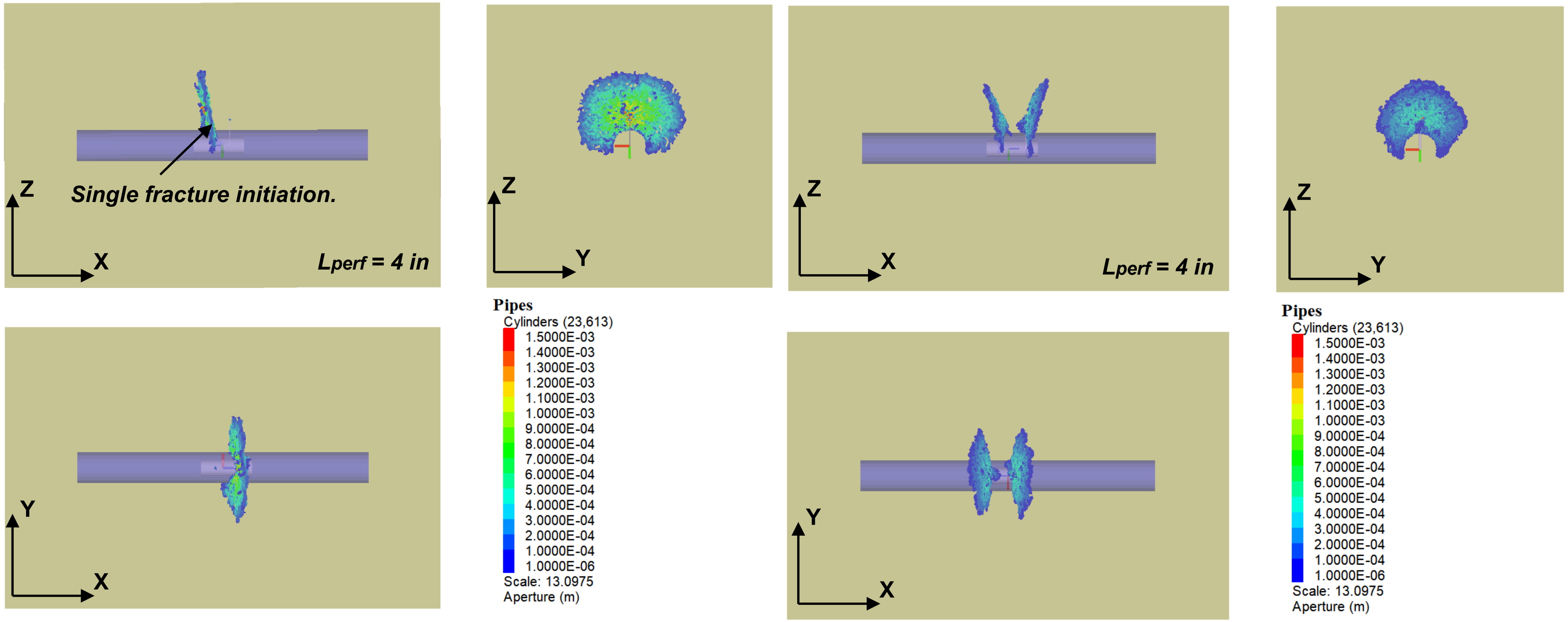
L_{perf} = 8 in



A short perforation tunnel length significantly increases the fracture tortuosity and leads to the initiation of a longitudinal fracture.

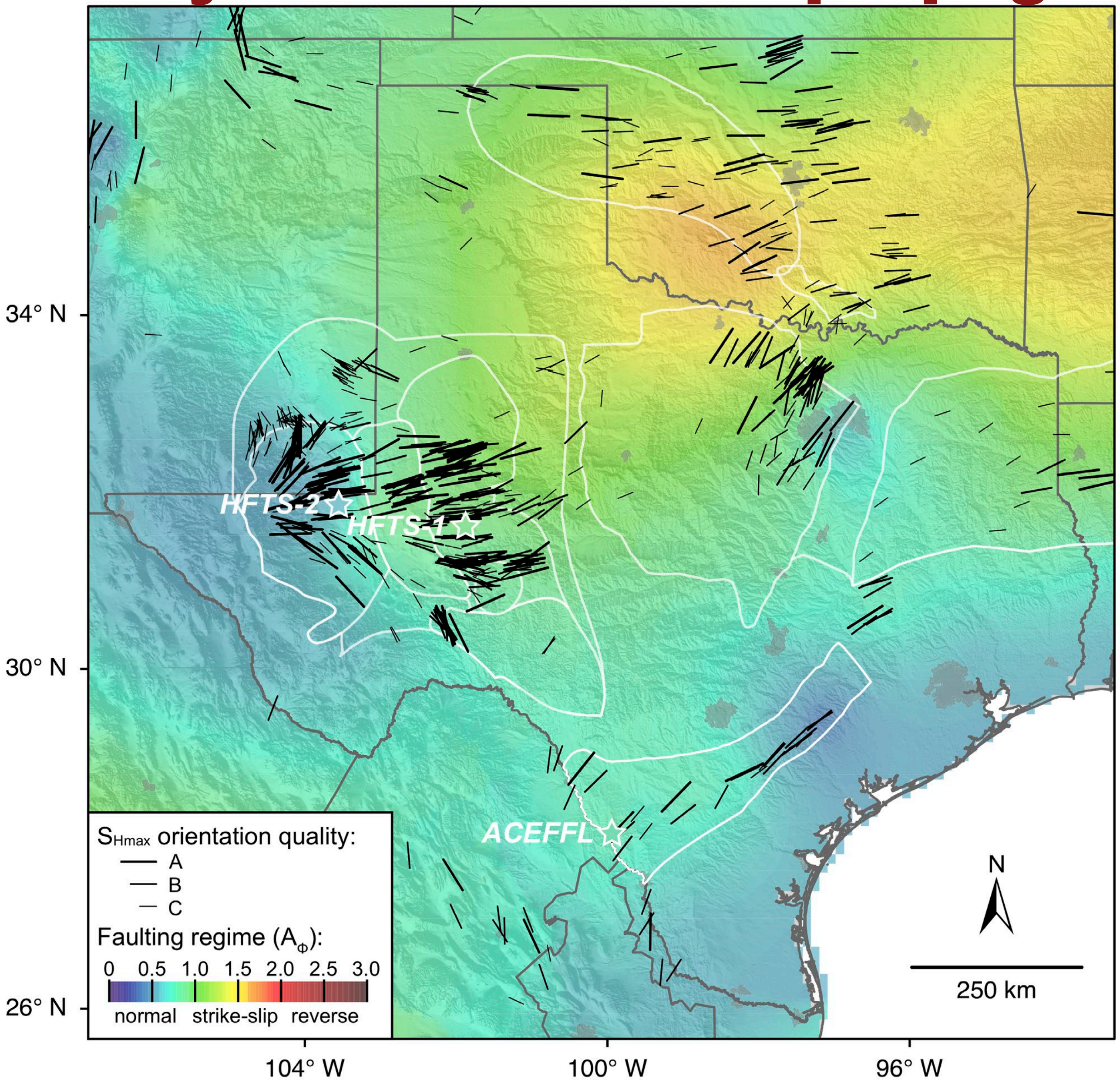
Geomechanical Modeling: Near-Wellbore Fracture Initiation Optimization

D_{perf} = 0.15 in　　　　　　　　D_{perf} = 0.8 in



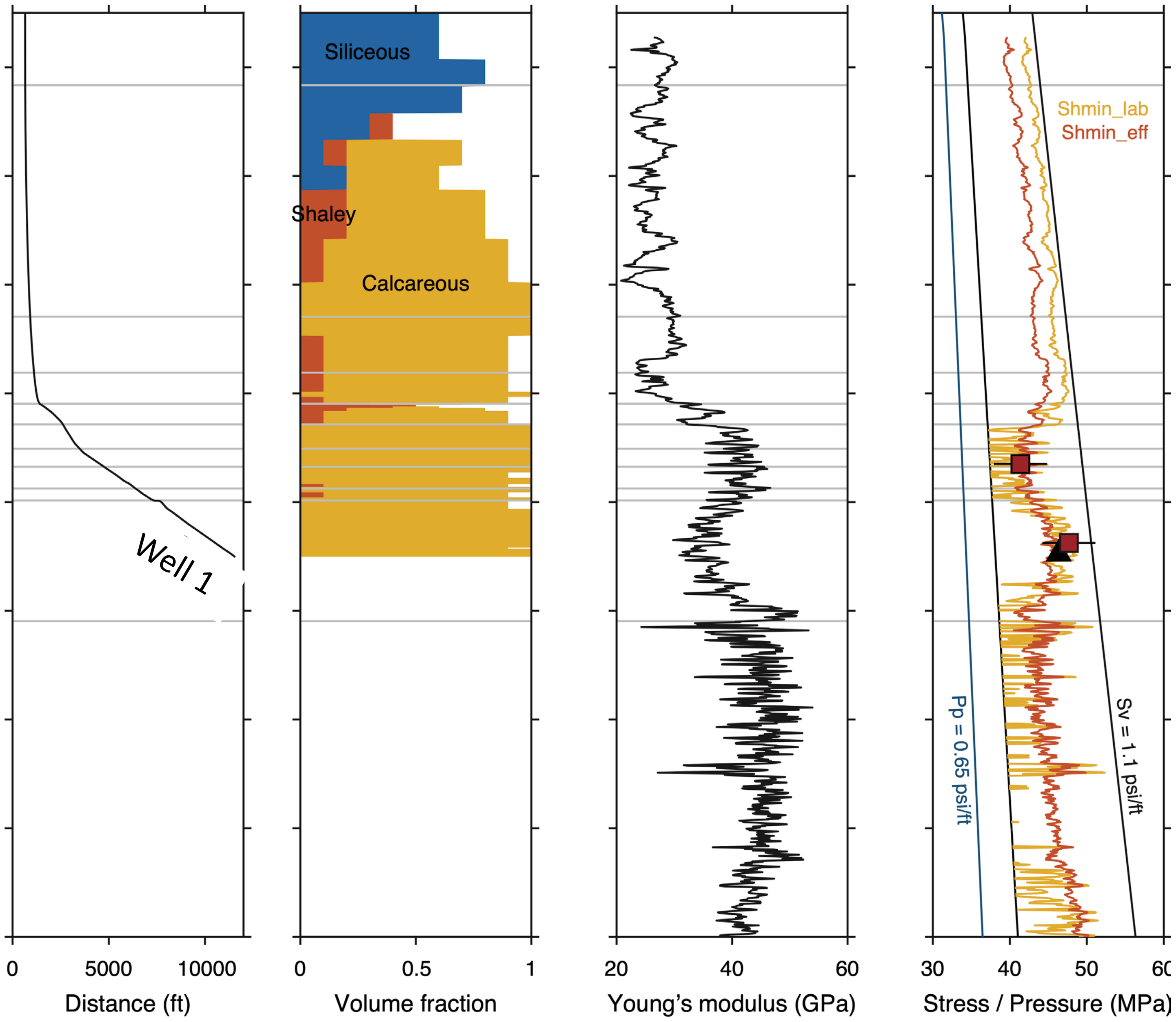
- **A small perforation diameter (left) leads to (a) significant stress shadowing within a cluster and (b) initiation of a single fracture.**
- **A large perforation diameter (right) reduces the near-wellbore fracture complexity.**

Characterizing the state of stress and modeling hydraulic fracture propagation at ACEFFL



Adapted from Lund Snee & Zoback (2018)

URTeC .org


Siliceous
Shaley
Calcareous
Well 1
Shmin_lab
Shmin_eff
Pp = 0.65 psi/ft
Sv = 1.1 psi/ft
0
5000
10000
Distance (ft)
0
0.5
1
Volume fraction
20
40
60
Young's modulus (GPa)
30
40
50
60
Stress / Pressure (MPa)

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Special thanks to Joe Renk, Project manager, NETL

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