



Marcellus Shale Energy and Environmental Laboratory (MSEEL) Seismic Attribute Application Distributed Temperature & Acoustic Sensing Data Activities Underway for MSEEL 2

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Project Objectives



MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY MSEEL

The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a **long-term collaborative field site** to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development





Outline

□ Overview of MSEEL Project

- History
- MIP 3H Well - Completion

□ Fiber Optic Data

- Distributed Acoustic Data (DAS)
- Distributed Temperature Data (DTS)

□ Long-Period Long-Duration Seismic Events:

- Borehole geophone data
- DAS data

□ Long-Term Reservoir Monitoring by DTS:

- Snap-shot of production at one time
- Engineered stages improve production efficiency

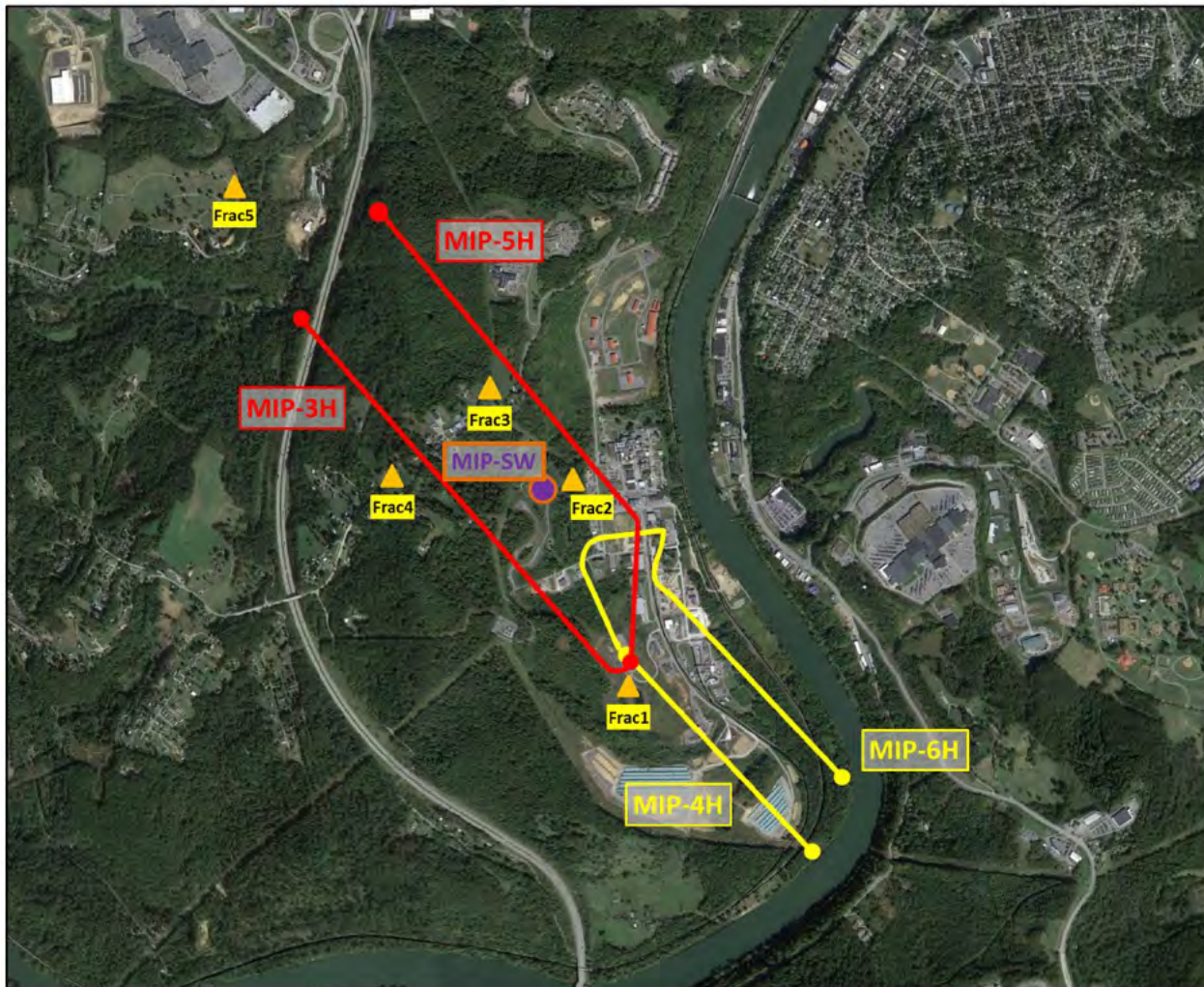
□ MSEEL 2 Underway:

- Plans
- Core WV Site





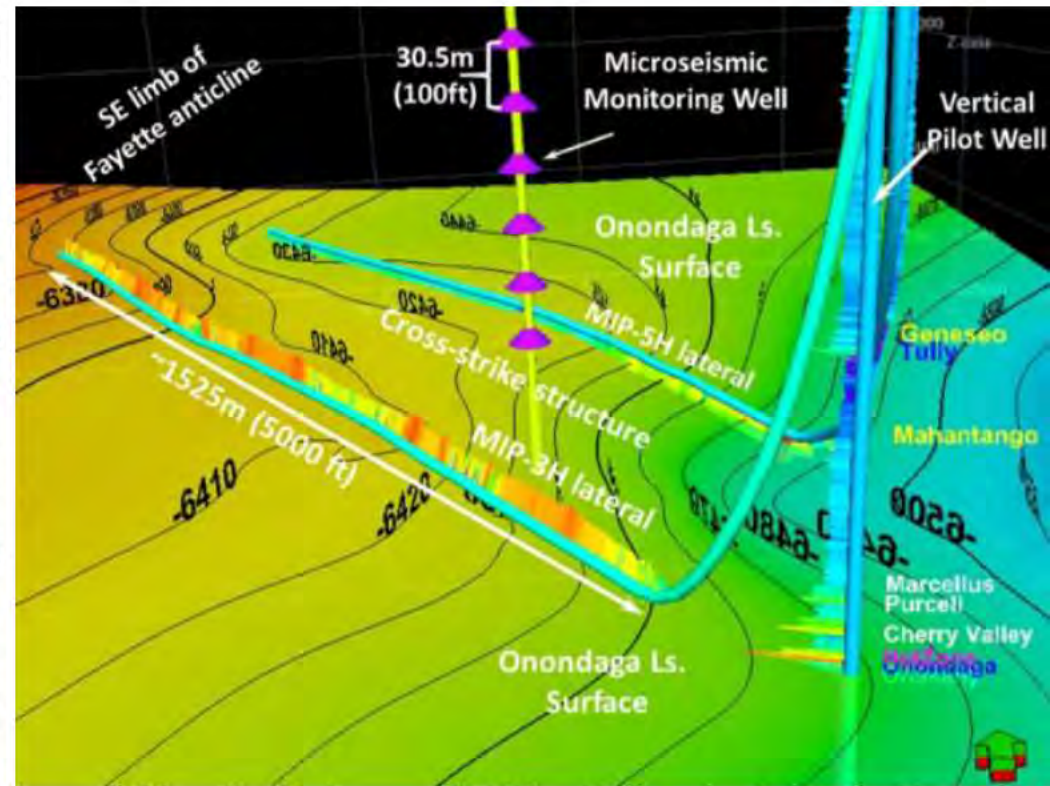
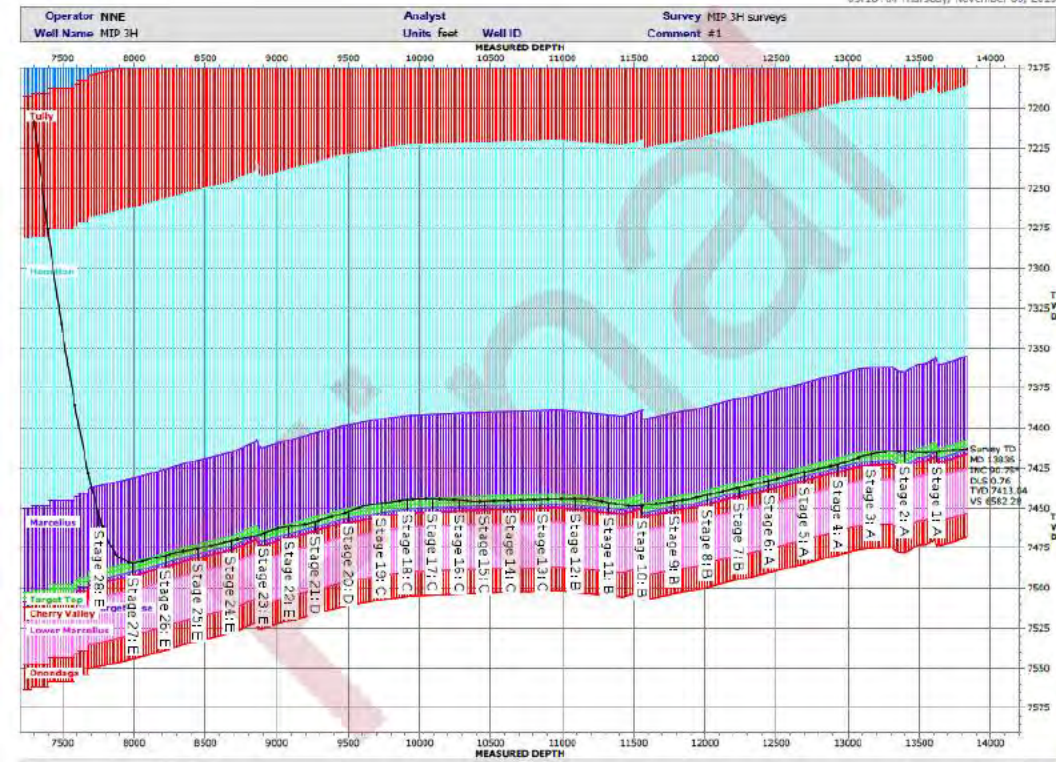
MSEEL MIP Site





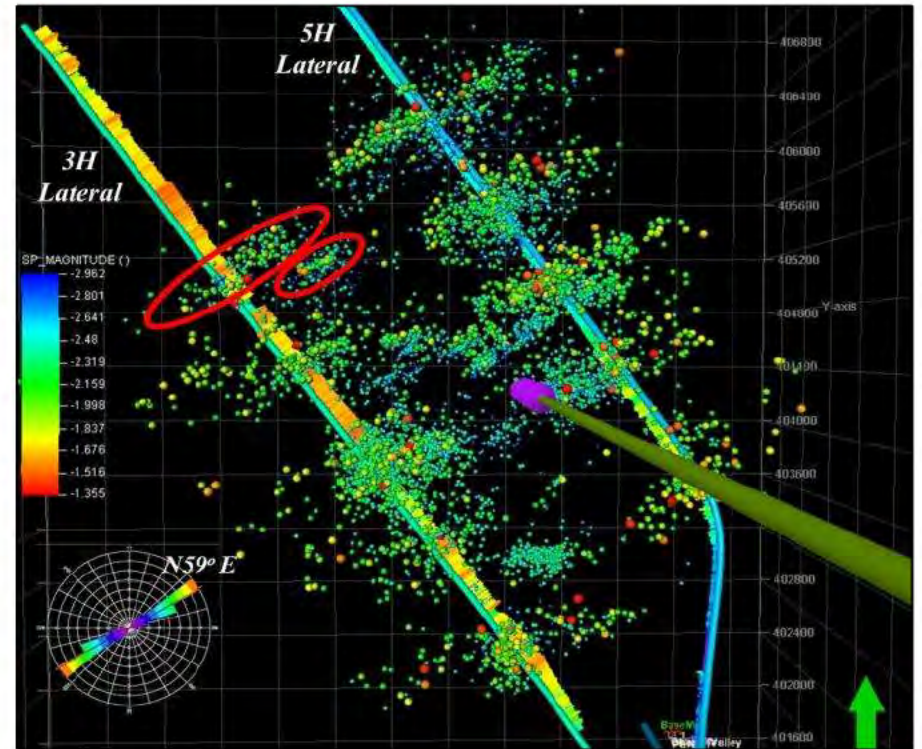
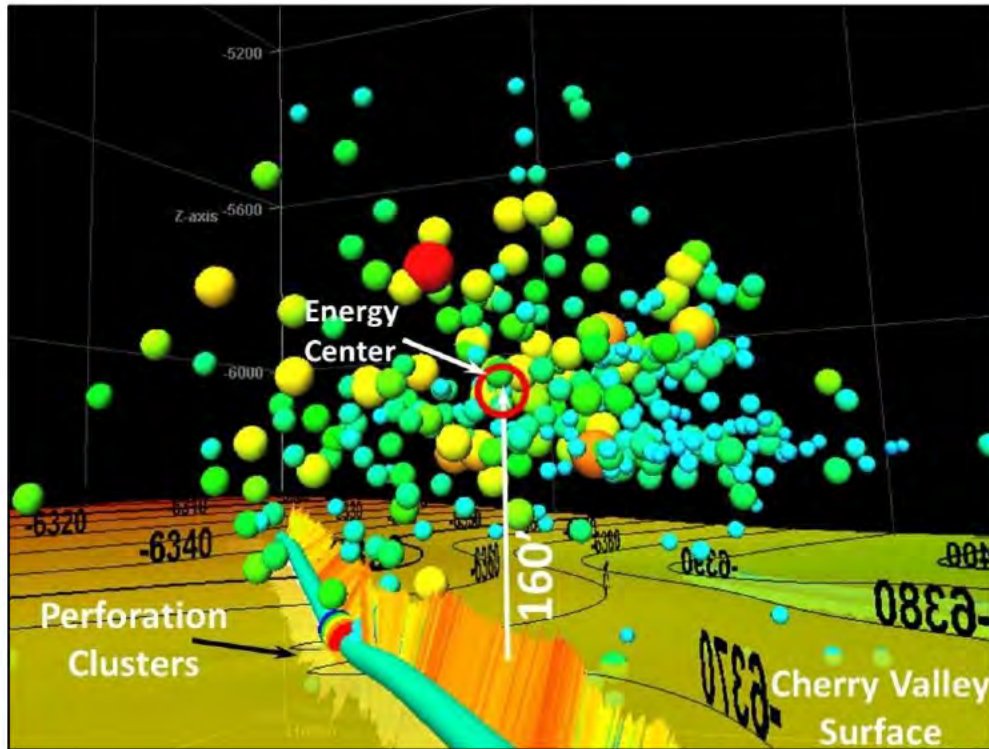
Geologic Background

09:18 AM Thursday, November 05, 2013



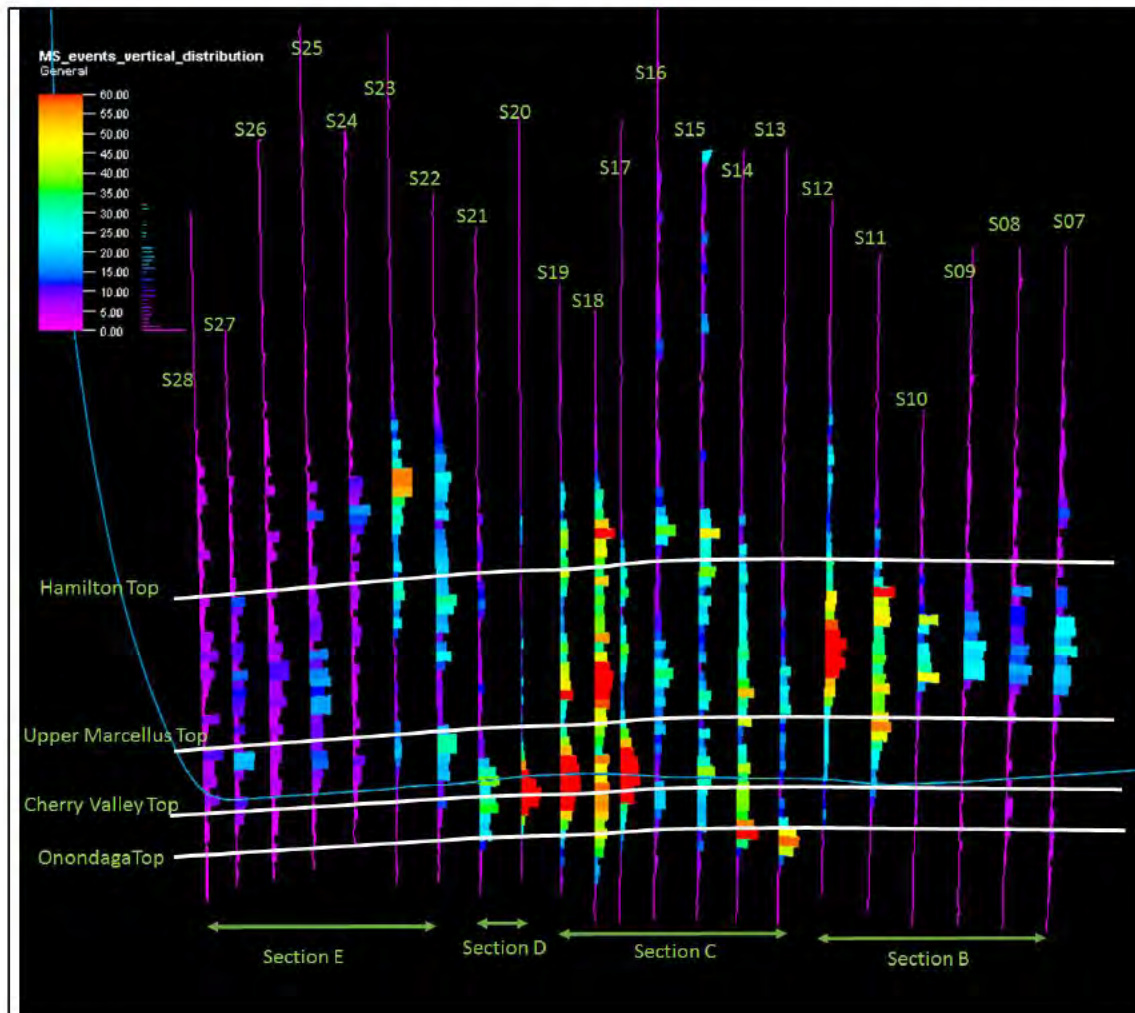


Microseismic



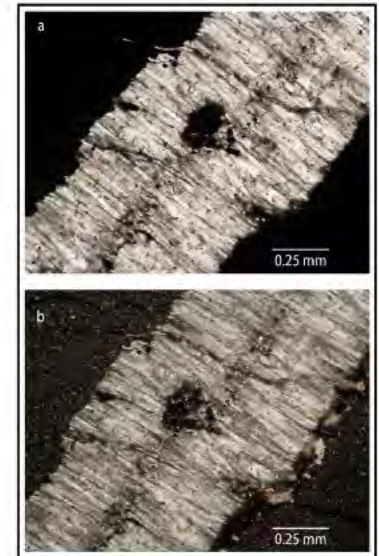
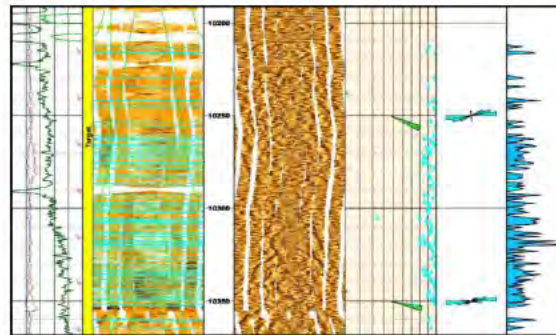
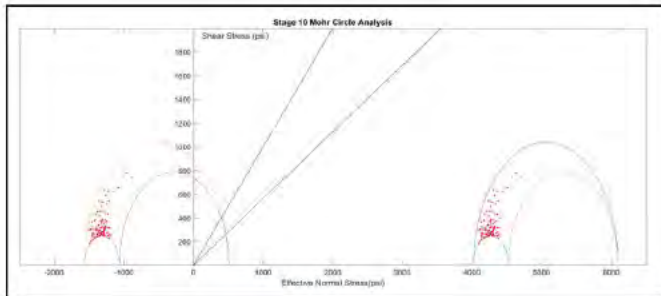
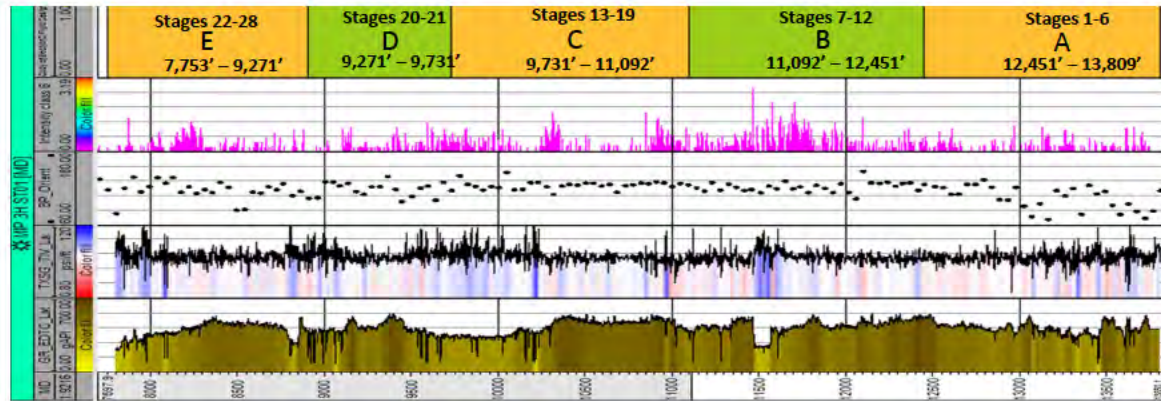


Microseismic Events Distributions



Logging Lateral MIP-3H

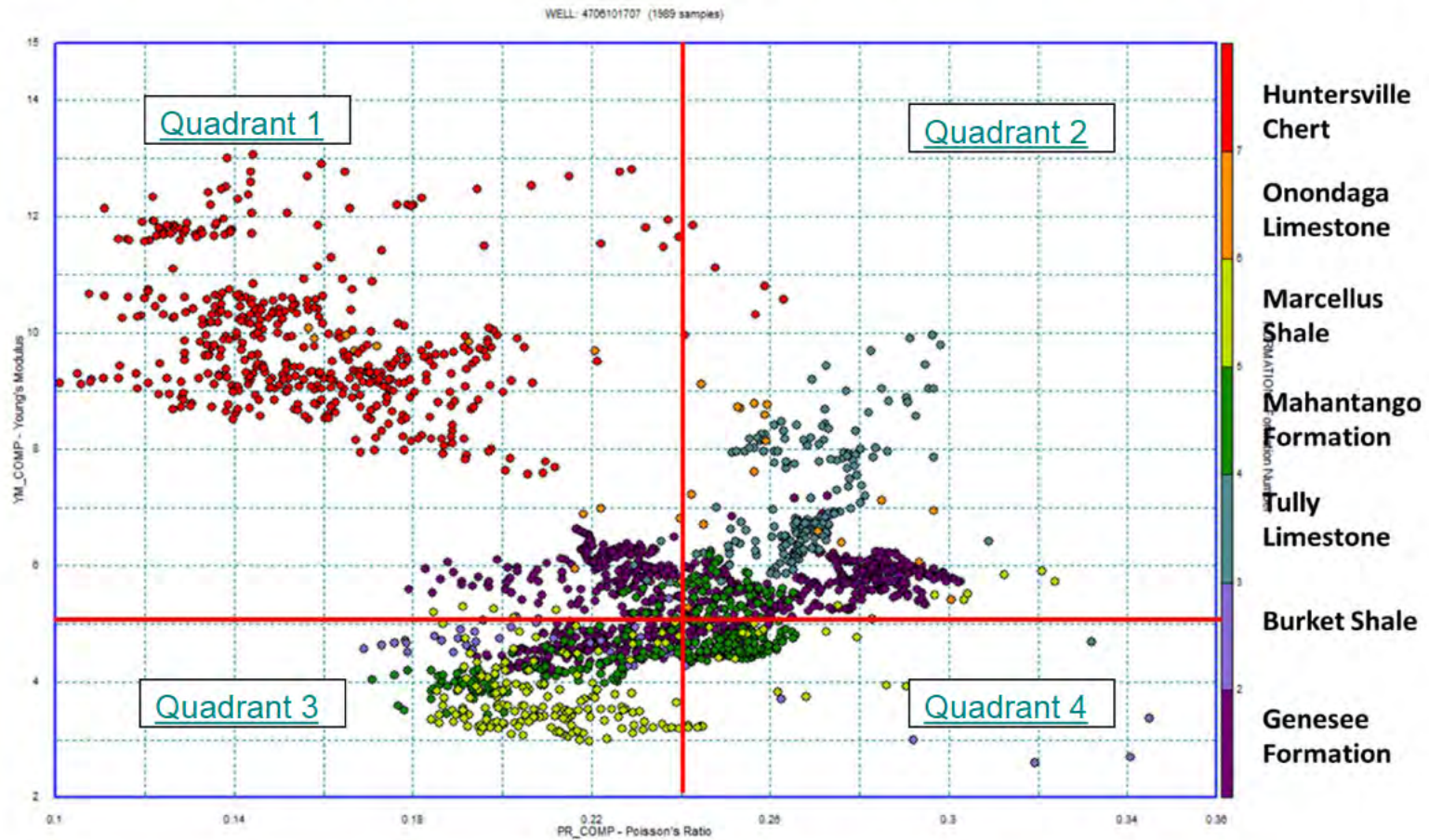
3H Lateral



Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
No of Faults	3				2	1				2	1																	
No of Fractures	41	25	48	29	15	69	47	51	97	160	86	65	72	17	14	90	25	56	68	71	37	46	21	41	42	89	66	28



Geomechanical Logs 3H Vertical Pilot





Engineered Stages and Fiber-Optic Data DAS & DTS

❑ Challenges

- Expense
- Borehole Risk
- Data Overload (Big Data)
Volume, Velocity, Variety, Veracity

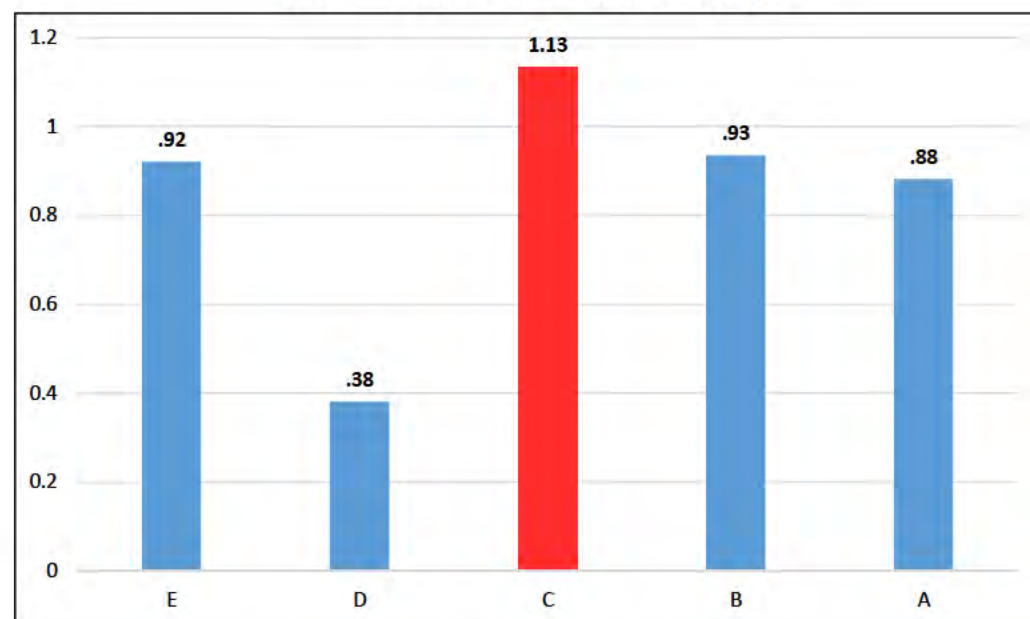
❑ Benefits

- Improved Stimulation Efficiency
- Improved Production Efficiency

❑ Don't have the solution, but progress

- Lower Costs
- Decrease Time
- Increase Production

MIP 3H Gas Production – mcf/ft

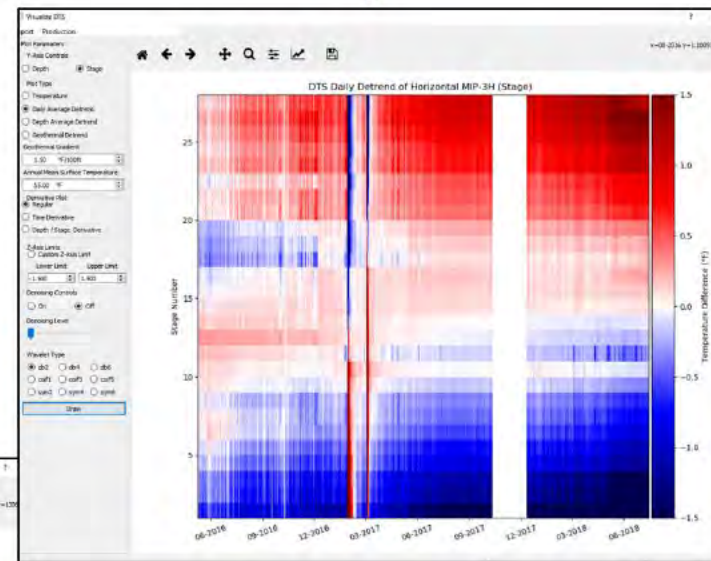
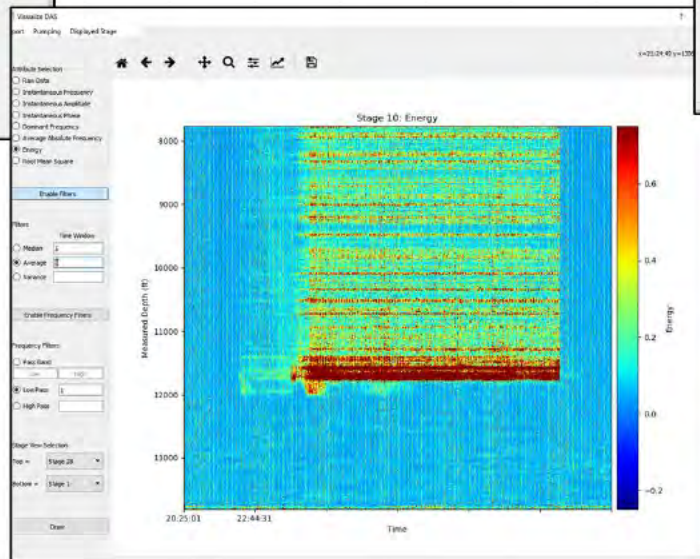
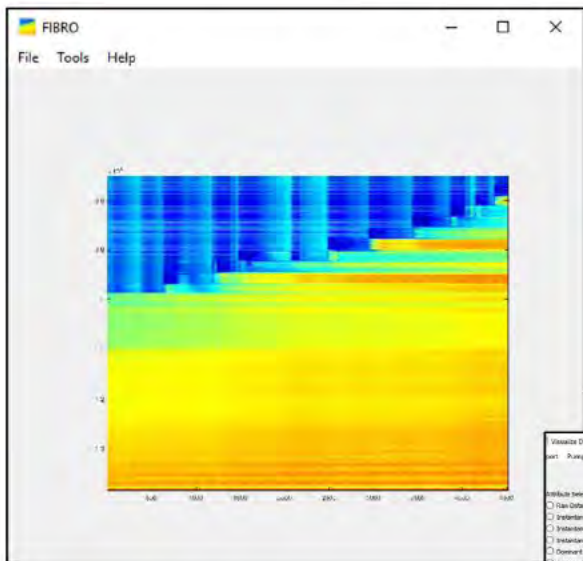


Engineered design using data obtained during MSEEL has ~20% increased production compared to standard NNE completion techniques EUR for future wells could be ~10-20% greater **IF** we can exploit the technologic advantages gained through MSEEL in a more cost-effective fashion



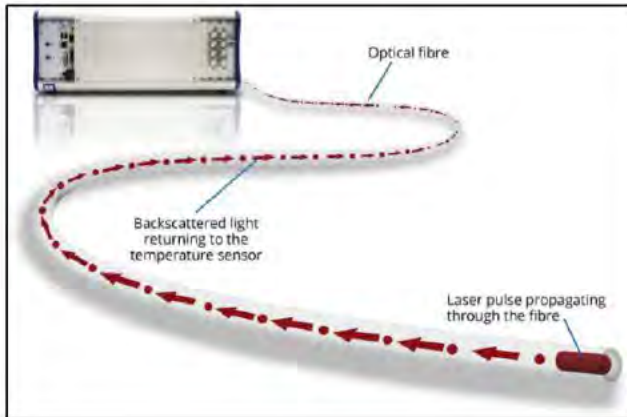
DAS, DTS and Terabytes – Oh My

FIBRO
Payam Kavousi

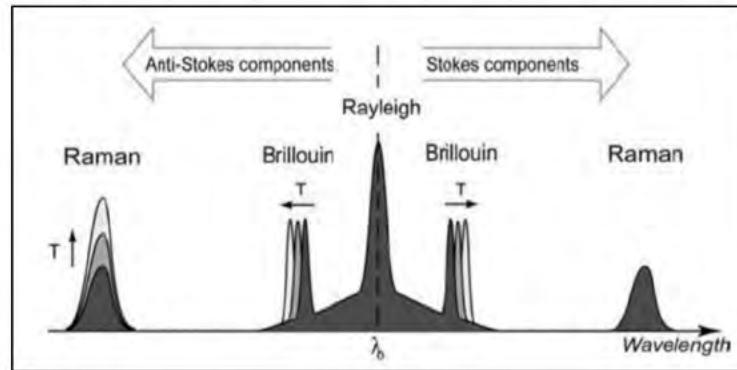




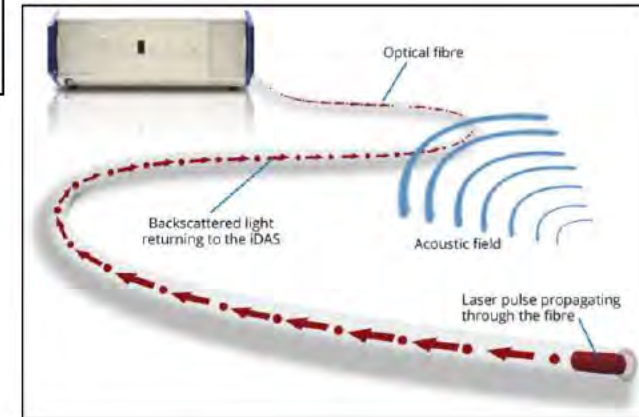
Fiber-Optics Distributed Acoustic Sensing (DAS) & Distributed Temperature Sensing (DTS)



Courtesy of Silixia Ltd., UK



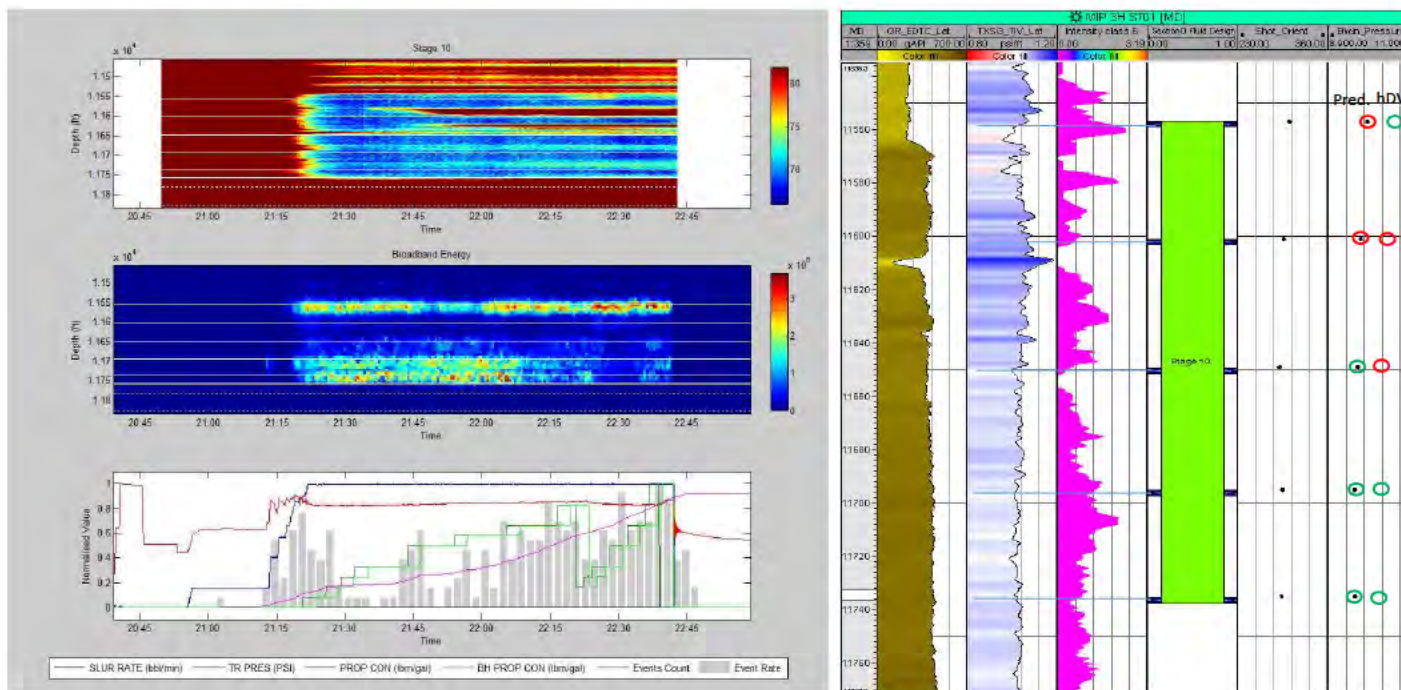
Courtesy of Mishra et al., 2017



Courtesy of Silixia Ltd., UK



Section B (Stage 10) - Geometric



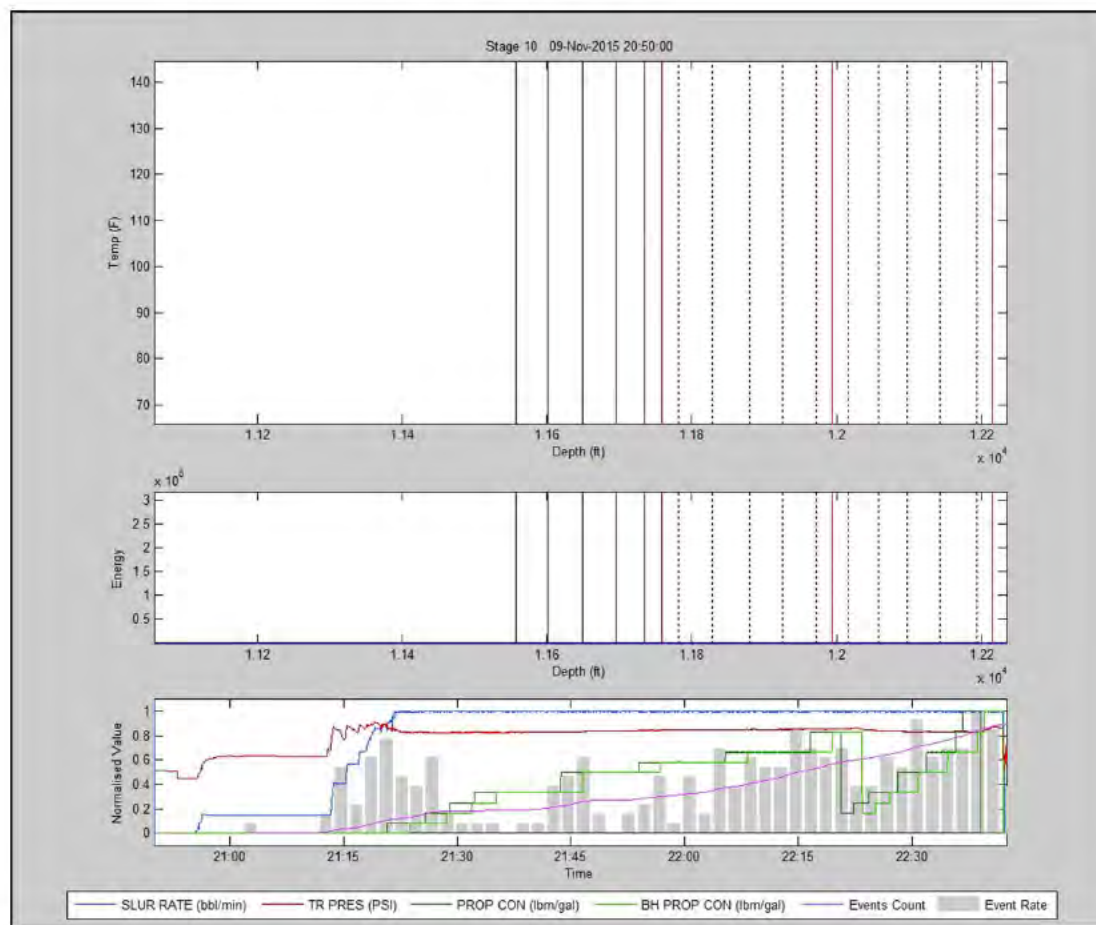
- DTS show cooling effect on all clusters
- hDVS show intermittent energy on all clusters
- Clusters 1,2,5 seem to breakdown initially based on hDVS
- 60% match between predicted and actual breakdown

Design Parameters:

- 5 clusters, 5spf, 50 holes, 0.42", 100 bpm
- Perforation friction ~ 1120 psi
- In-situ stress contrast ~ 393 psi
- BD pressure contrast ~299 psi



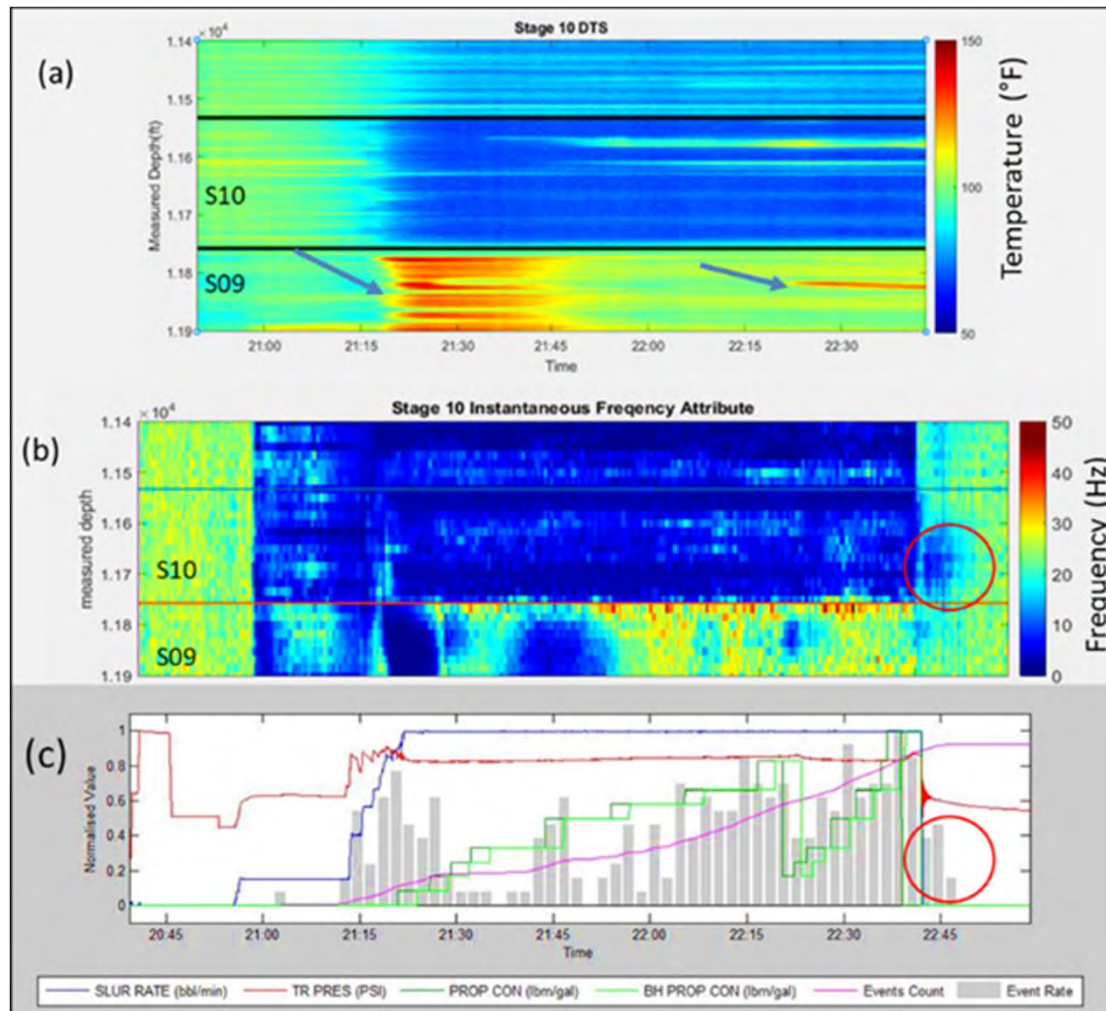
Section B (Stage 10) - Geometric



Courtesy of Schlumberger

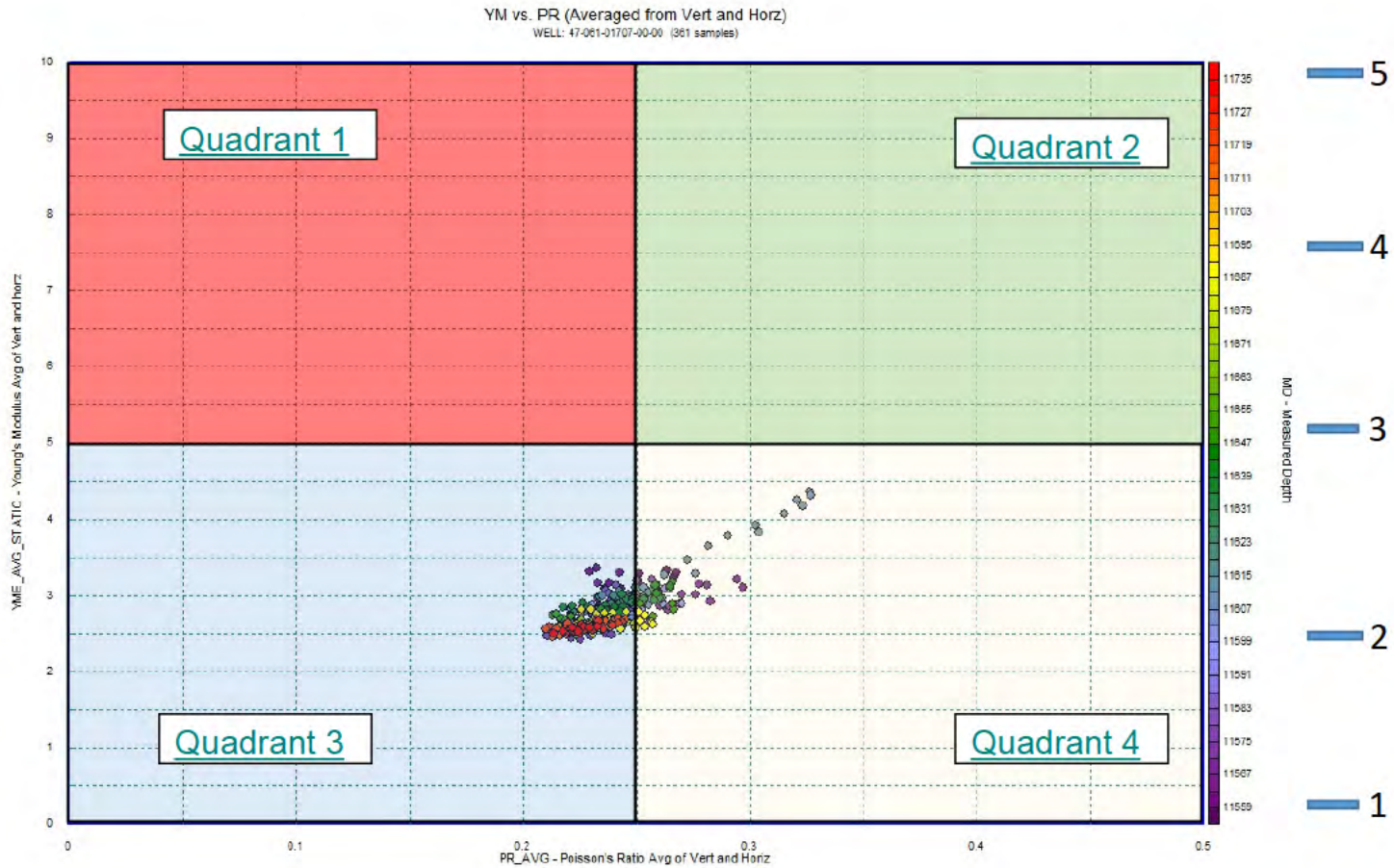


DAS and DTS of Stage 10 Stimulation



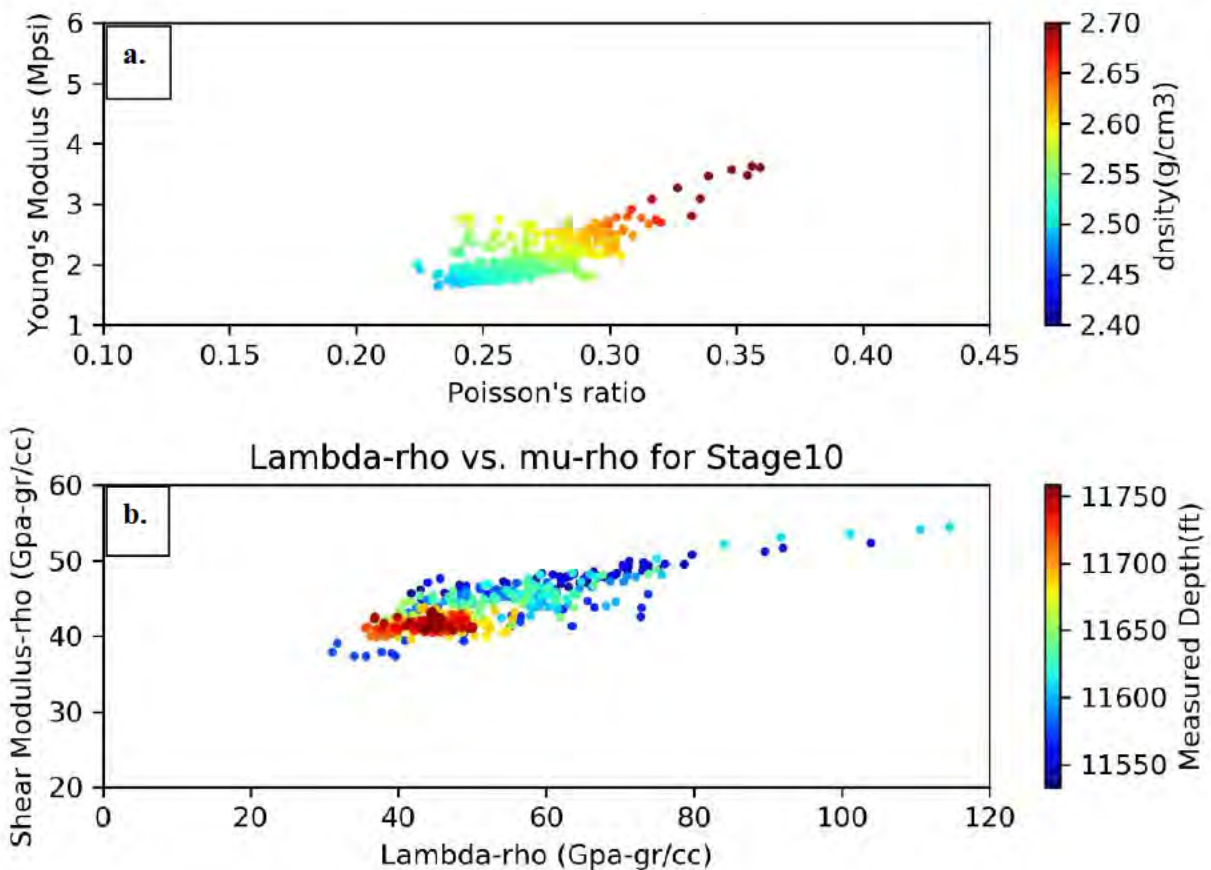


Stage 10 (Top Cluster to Bottom)



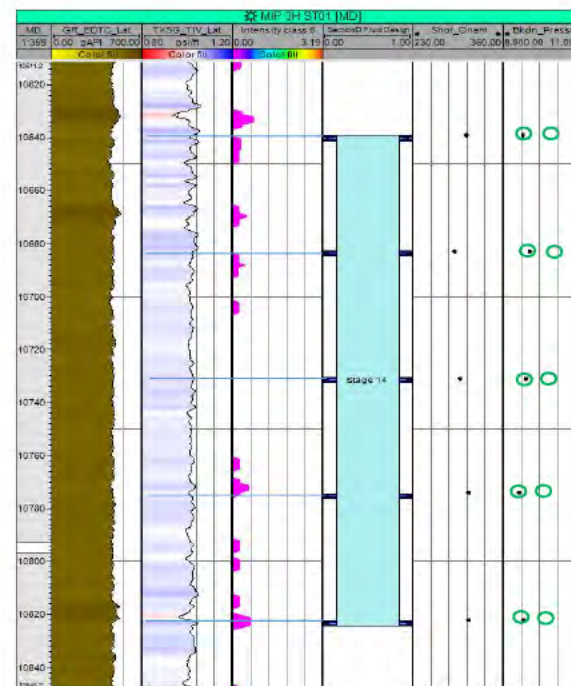
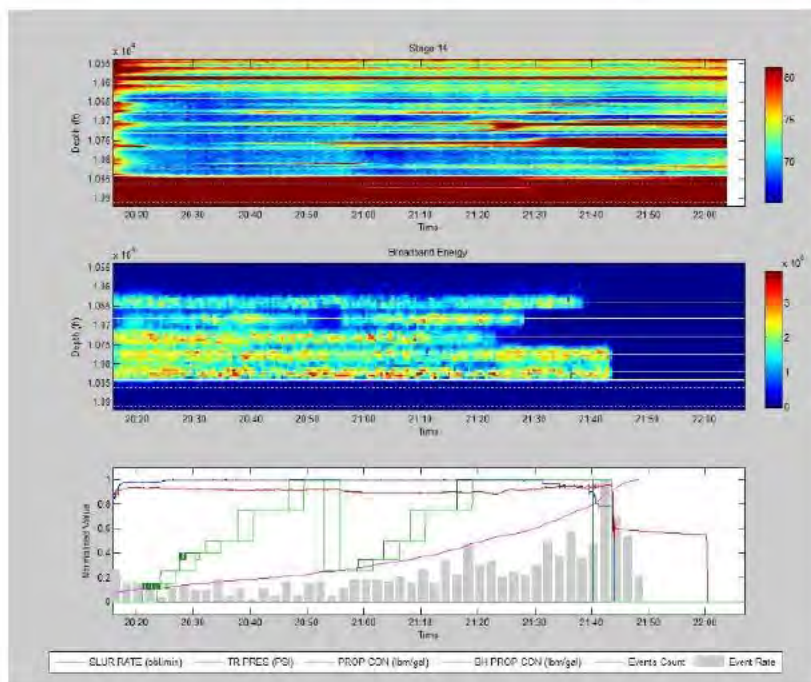


Stage 10 (Top Cluster to Bottom Cluster)





Section C (Stage 14) – Engineered and Limited Entry



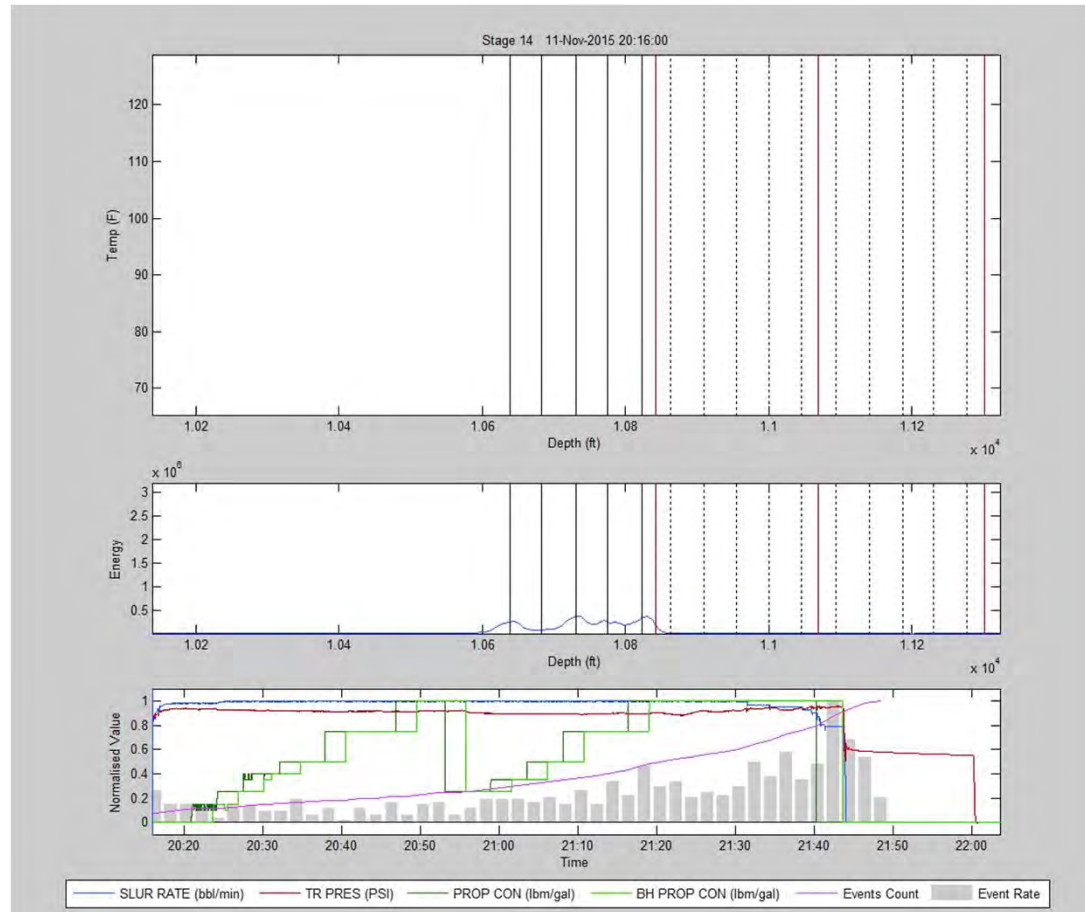
- DTS show cooling effect on all clusters
- hDVS show more uniform energy on all clusters
- All clusters seem to breakdown initially based on hDVS
- 100% match between predicted and actual breakdown

Design Parameters:

- 5 clusters, 3spf, 30 holes, 0.42", 100bpm
- Perforation friction ~ 3000 psi
- In-situ stress contrast ~ 294 psi
- BD pressure contrast ~ 242 psi



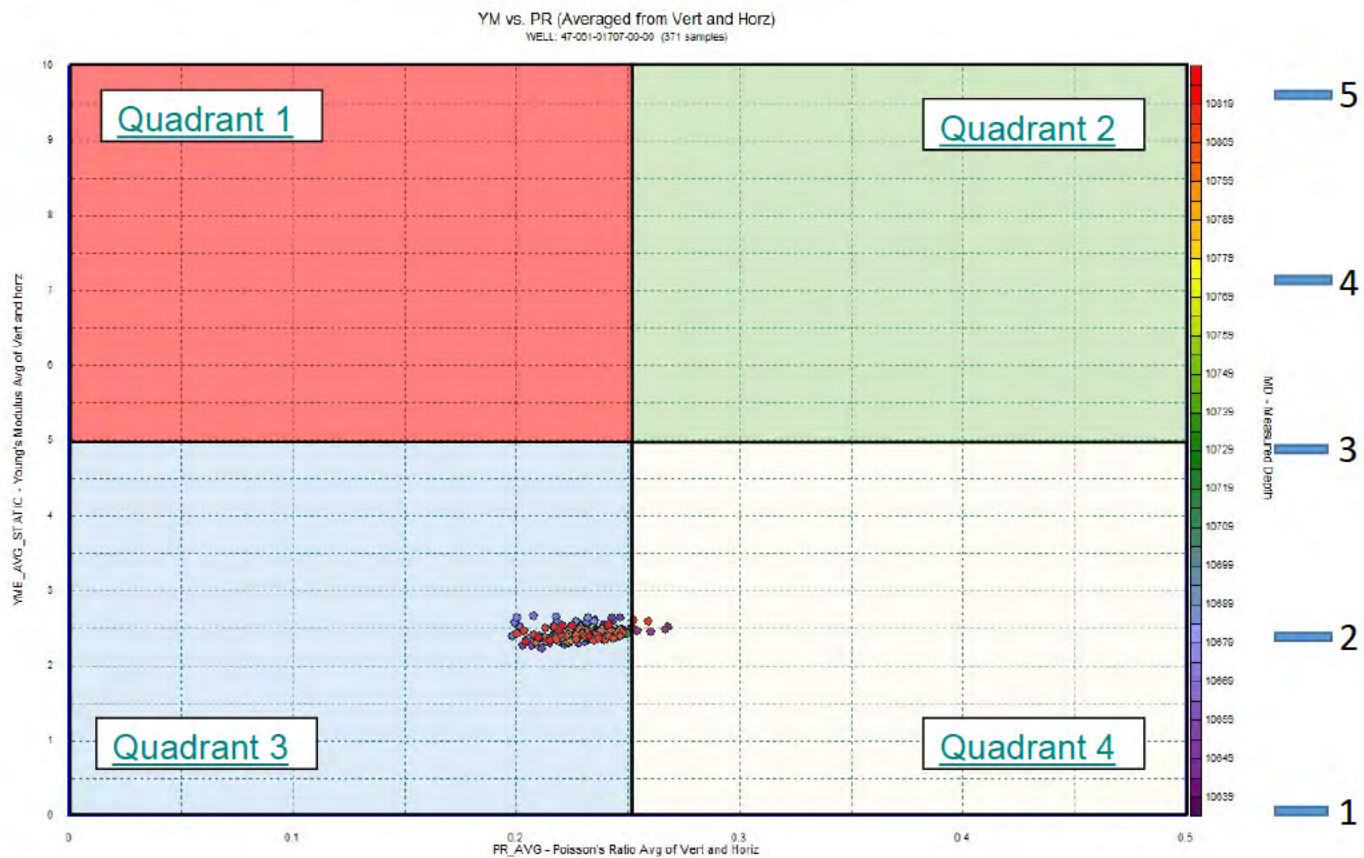
Section C (Stage 14) – Engineered and Limited Entry



Courtesy of Schlumberger

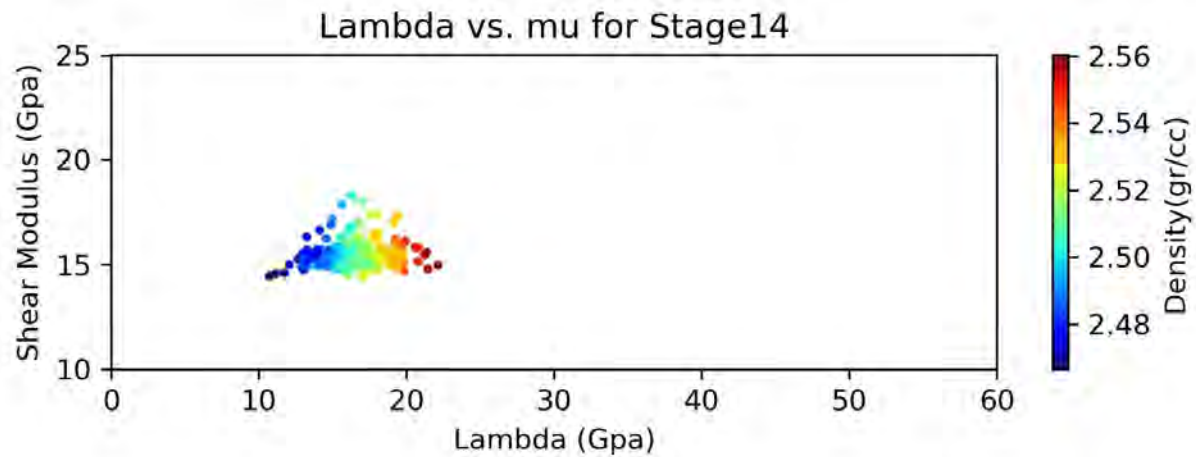
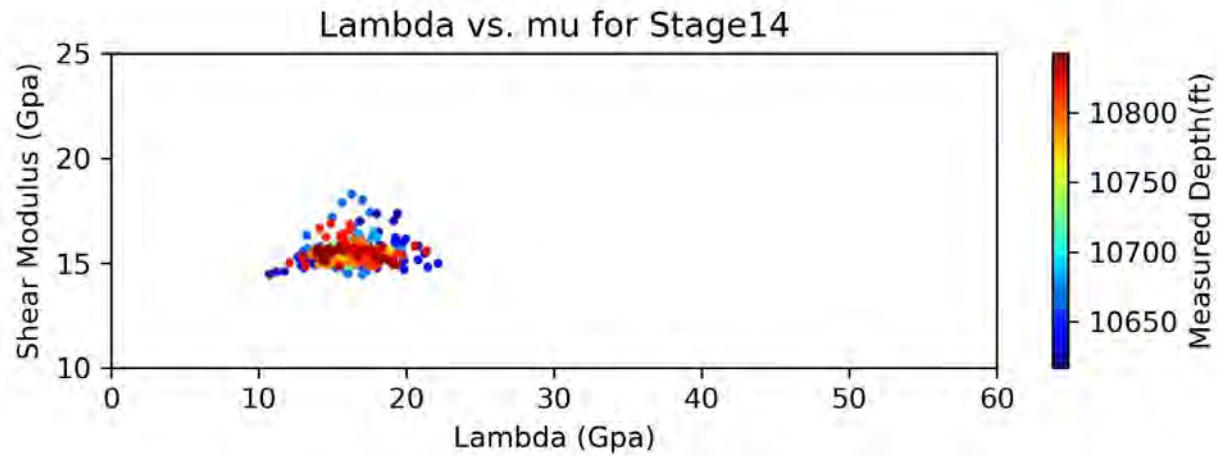


Section C (Stage 14) – Engineered and Limited Entry





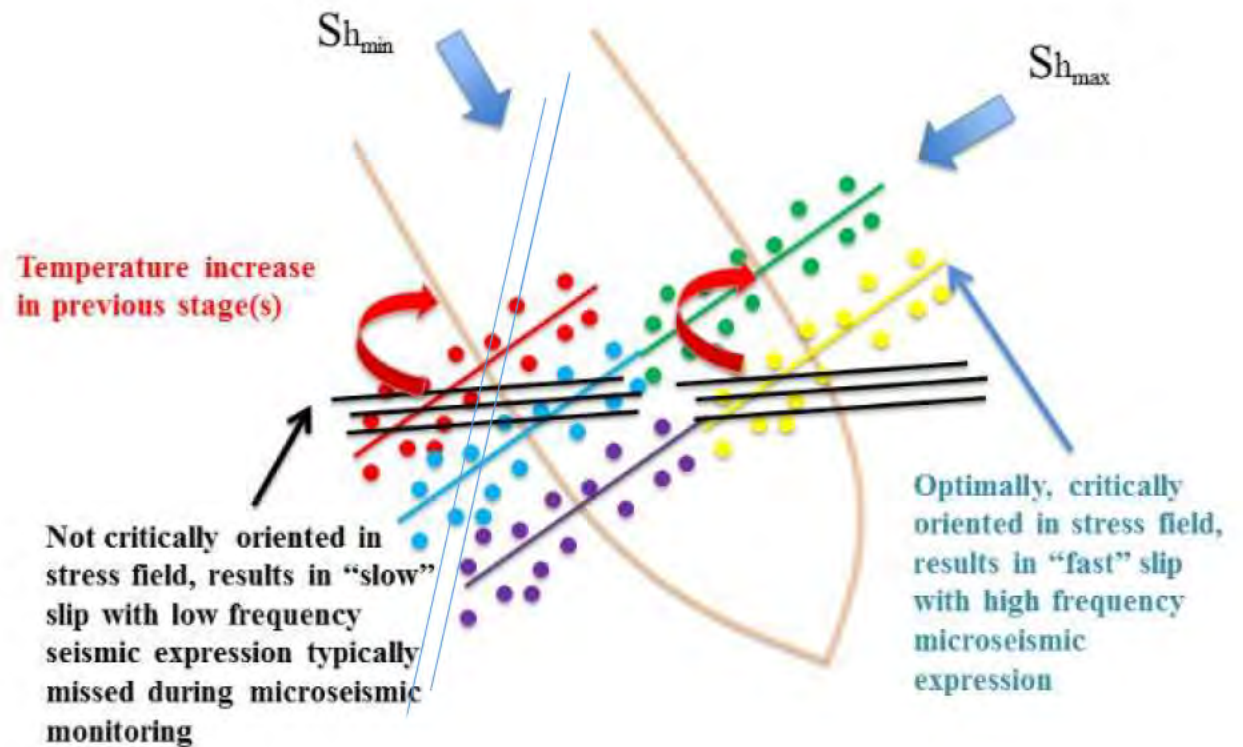
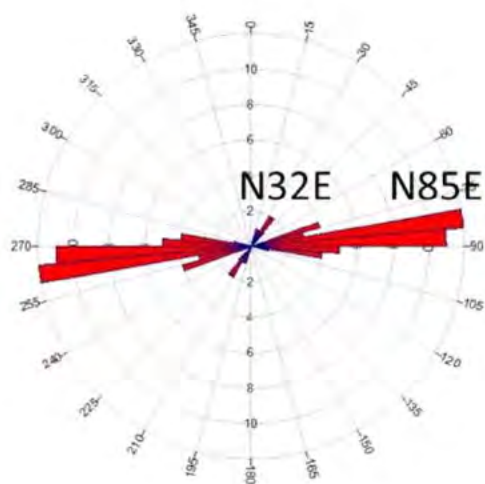
Section C (Stage 14) – Engineered and Limited Entry





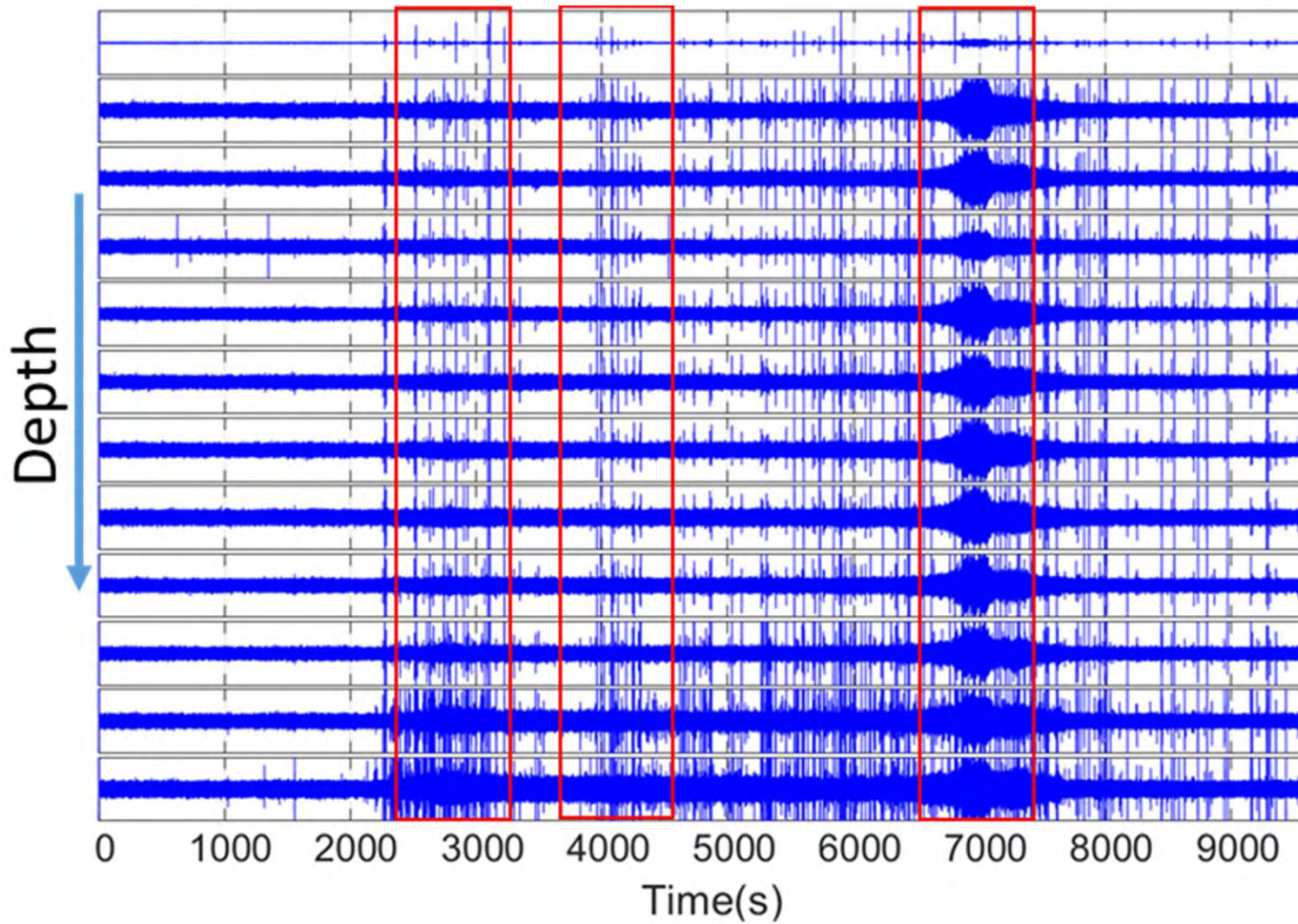
Cross-Stage Flow Communication

3H Lateral



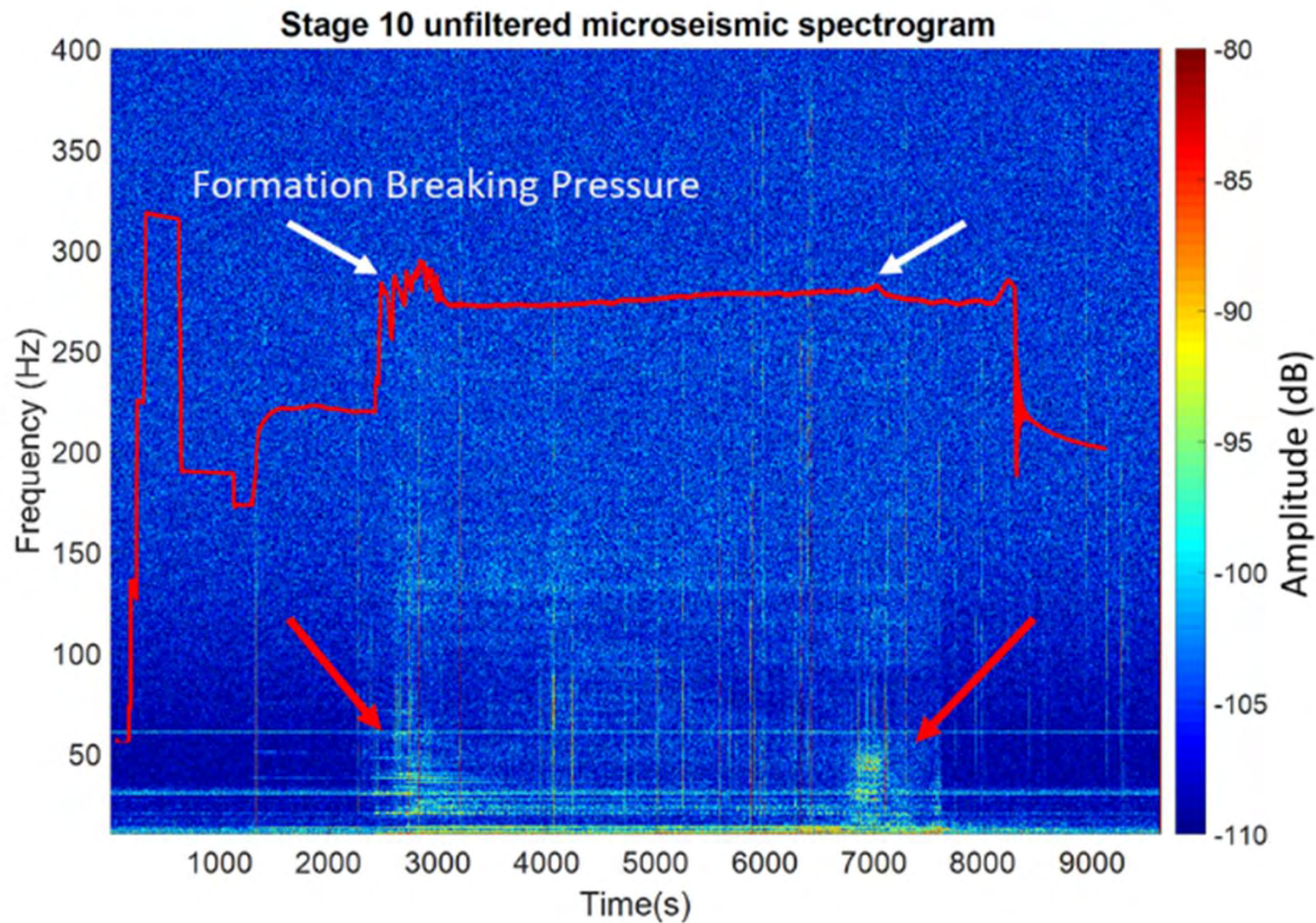


Stage 10 Geophones Data



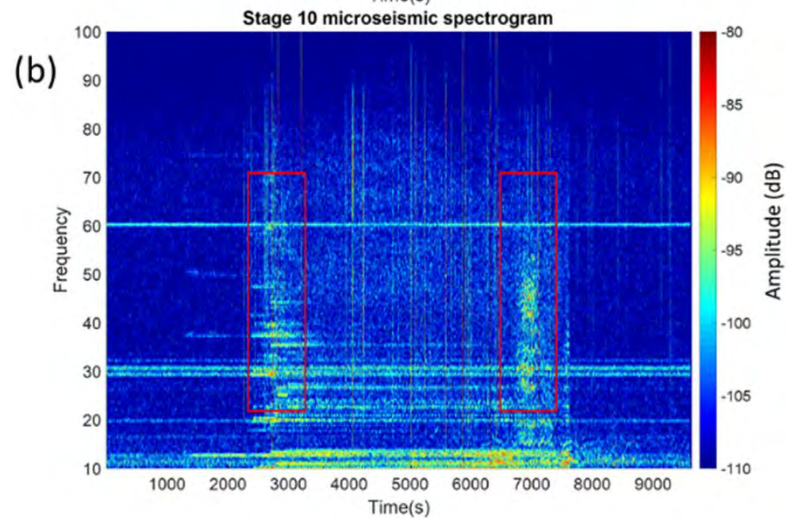
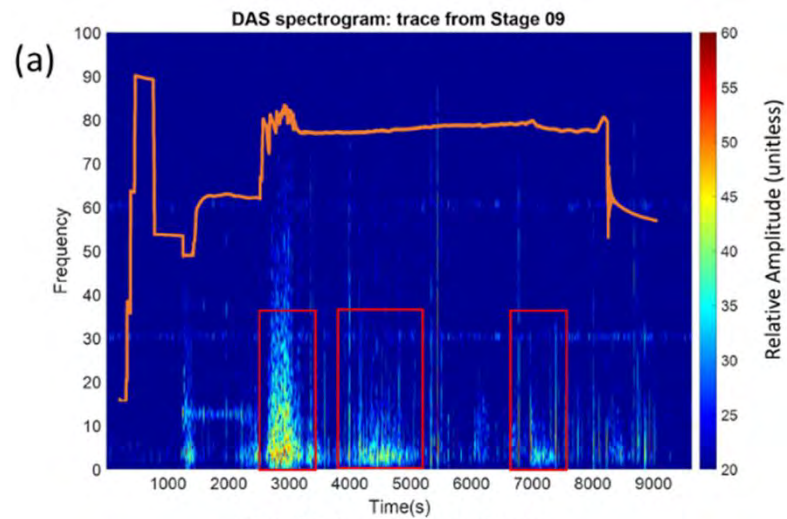


Spectrogram of Geophones Data



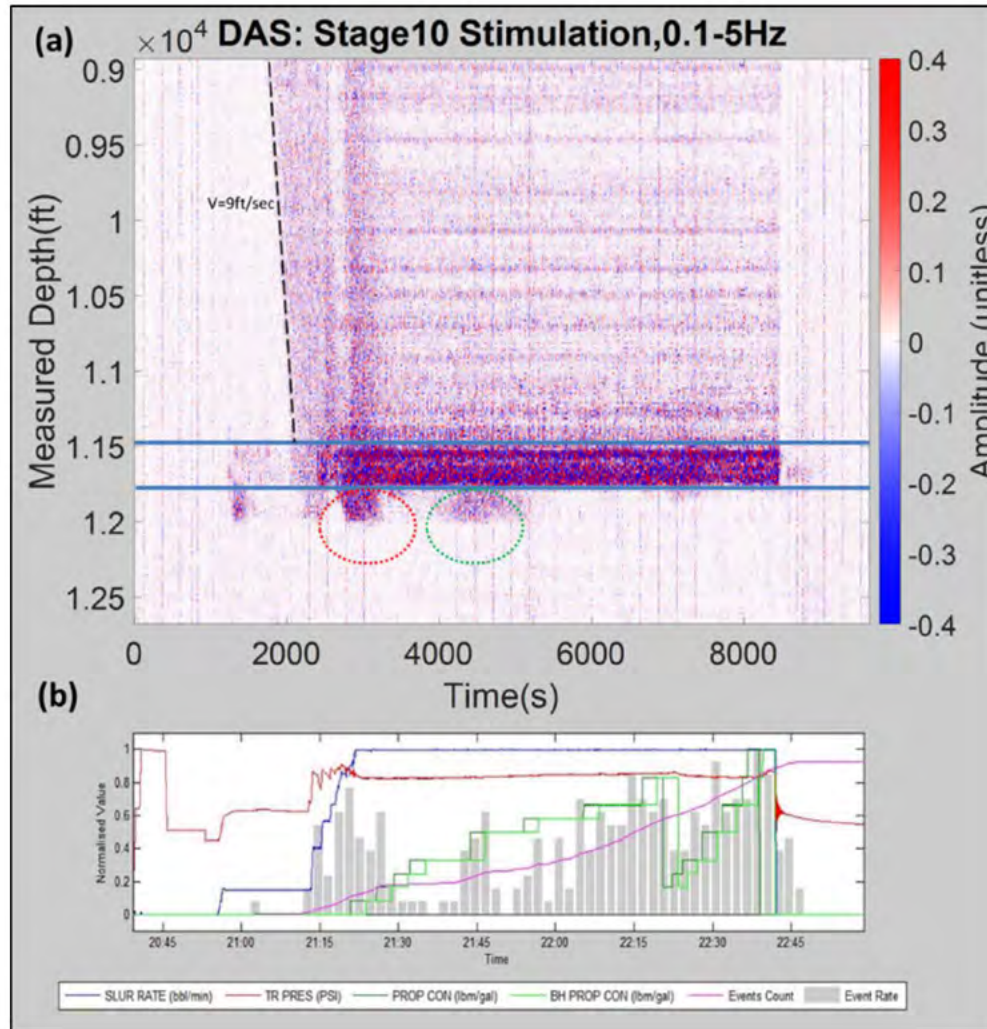


DAS and Geophone Spectrograms



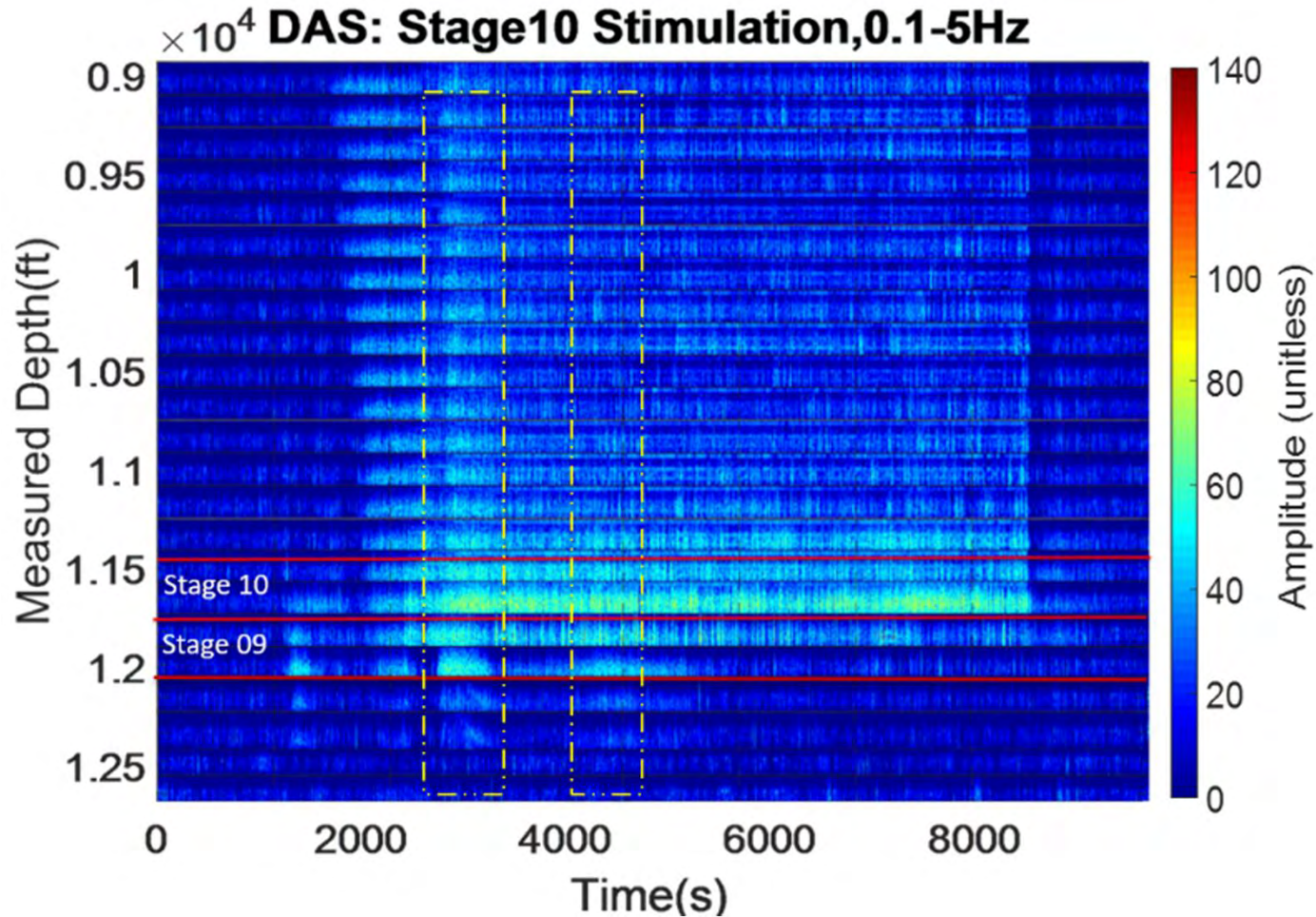


Stage 10 DAS Data



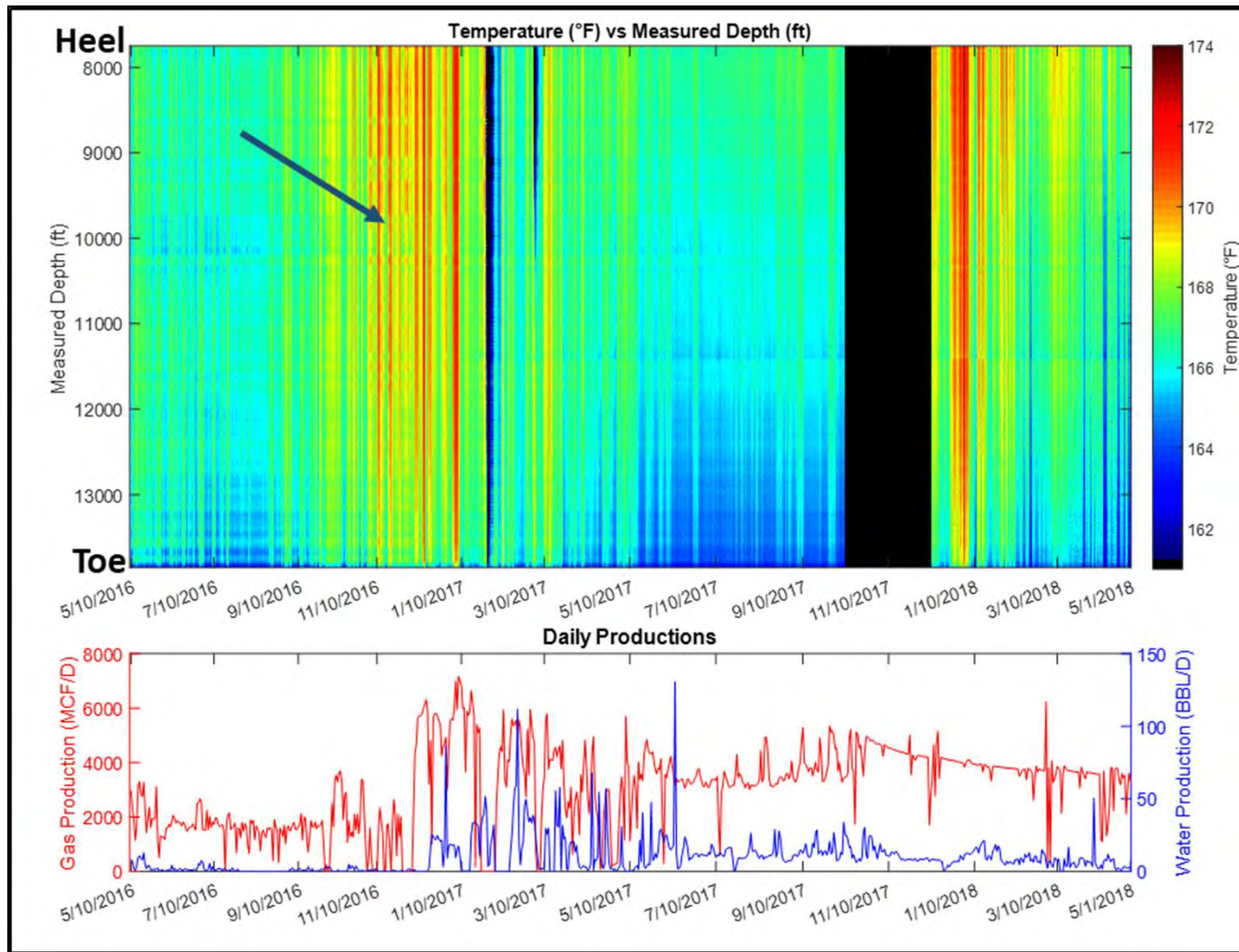


Stacked Spectrograms of Stage 10



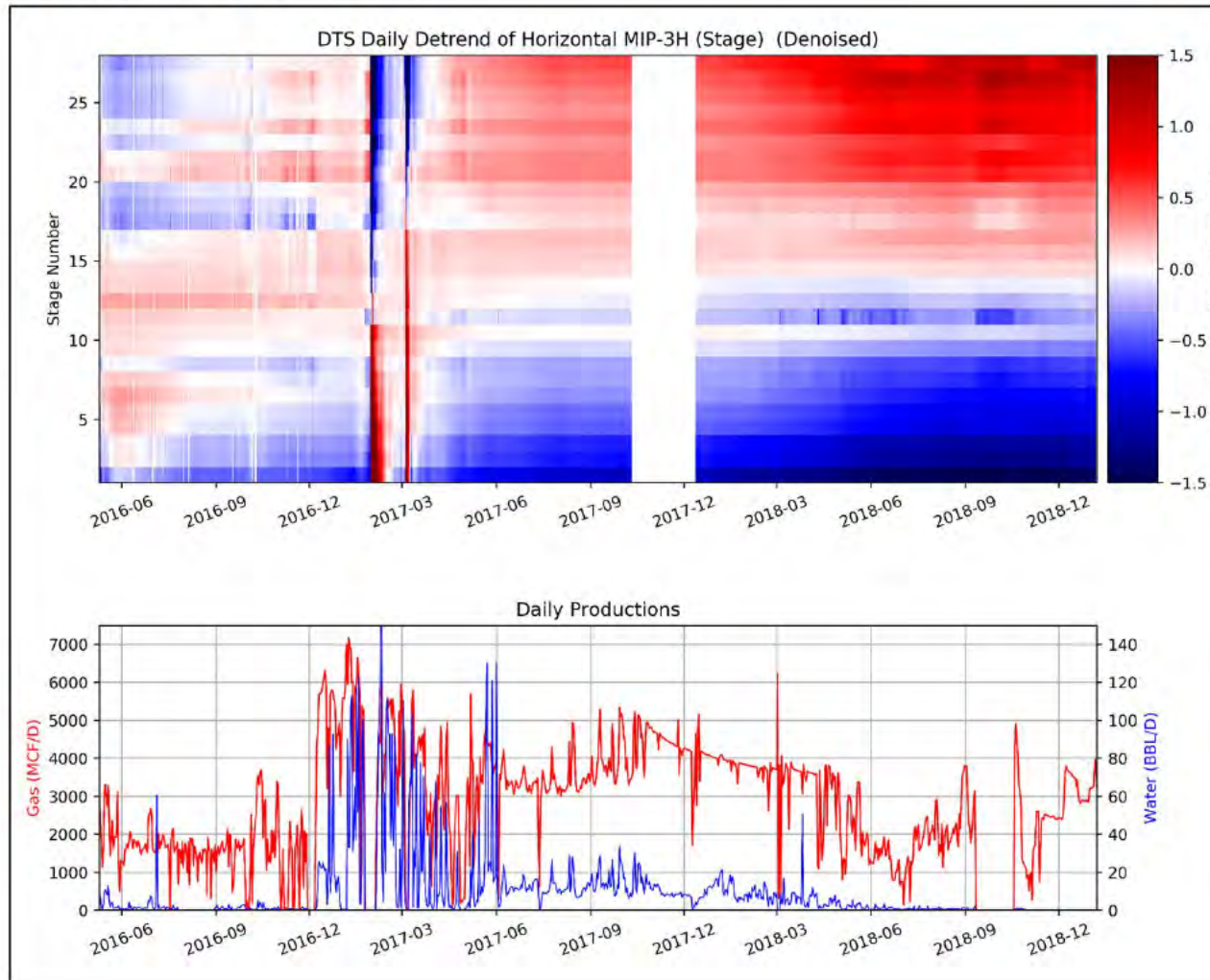


Long-Term DTS Monitoring



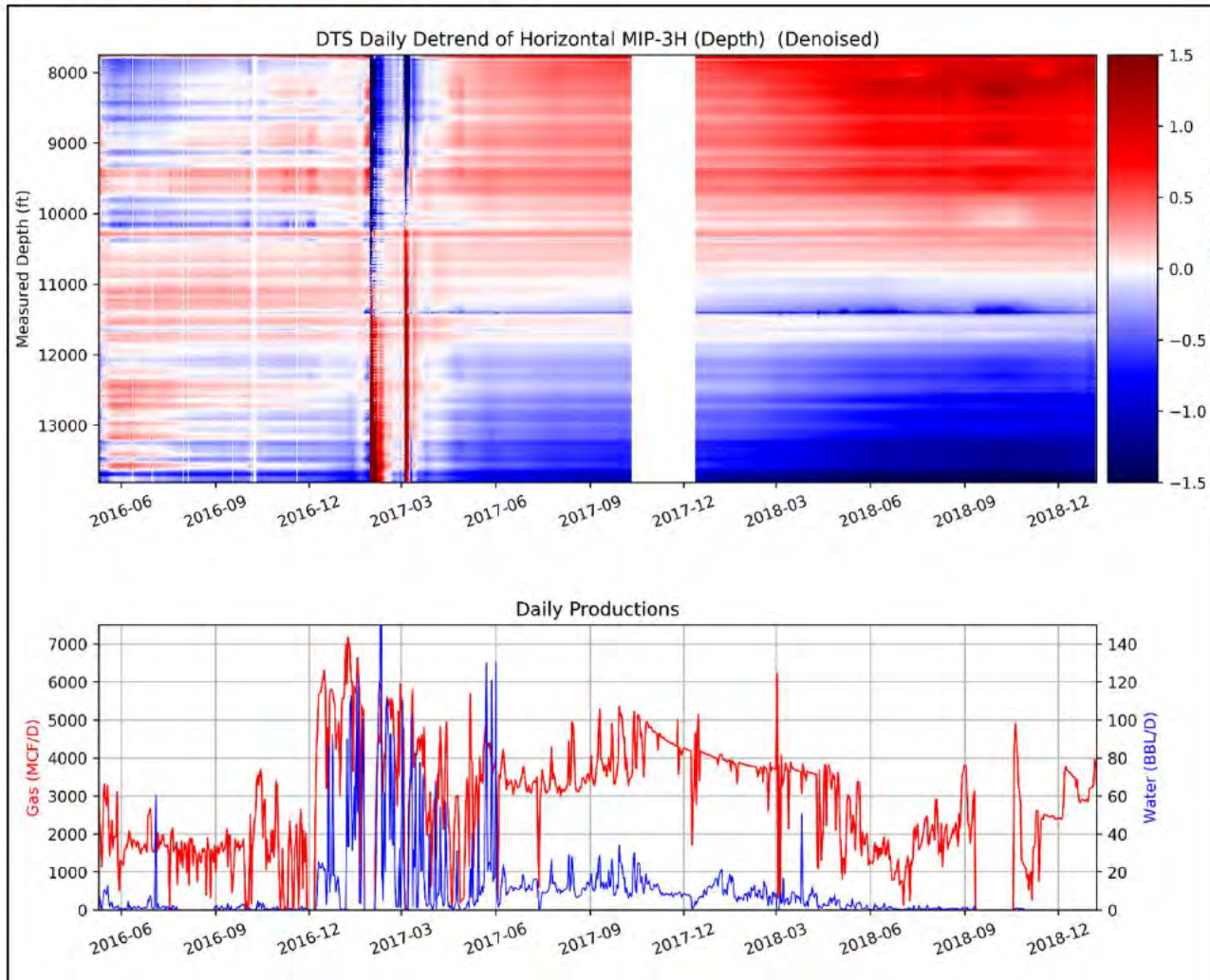


De-Trended DTS



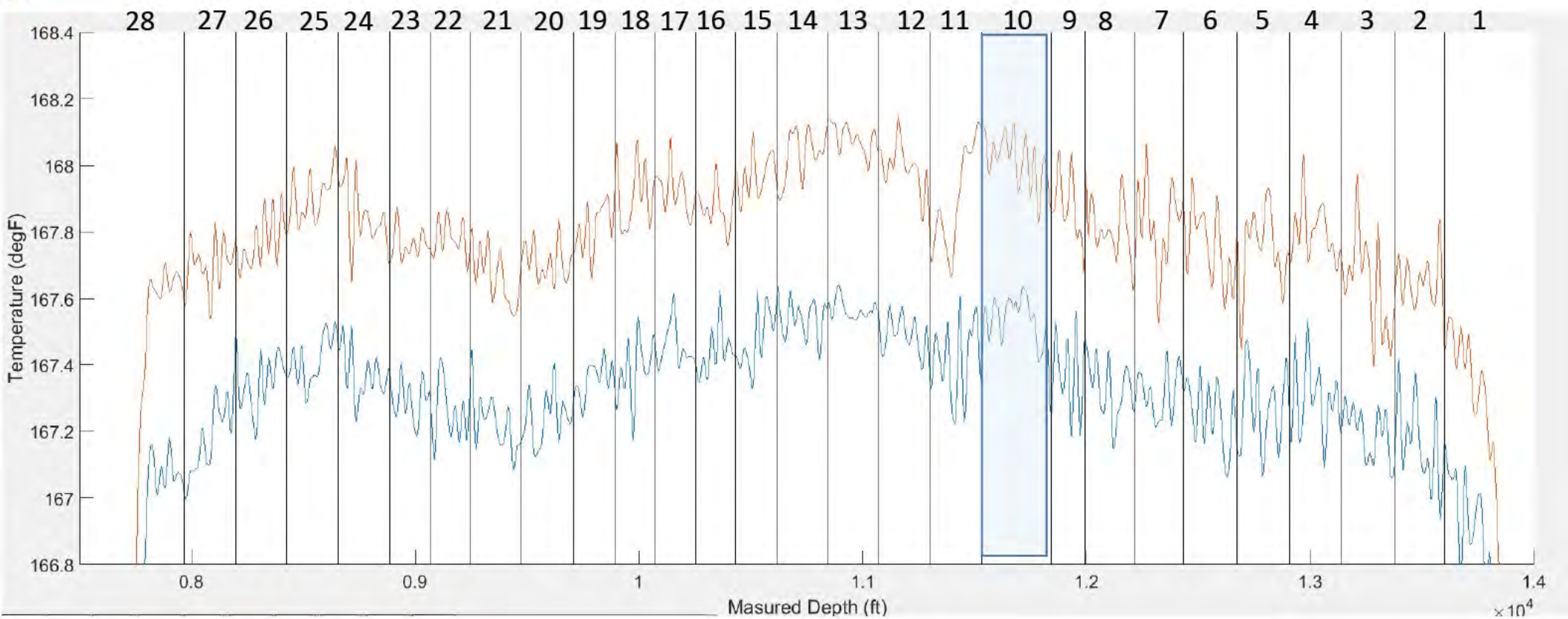


De-Trended DTS





DTS Traces at Two Different Rates



Jan 24, 2019 - 165MCF/hr.

December 02, 2018 - 100MCF/hr.



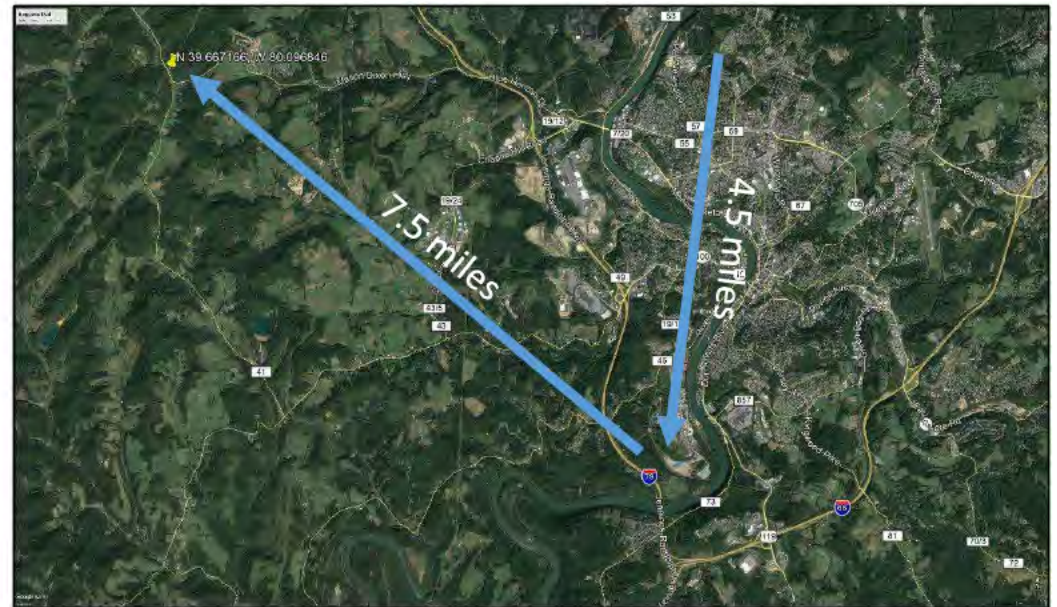
MSEEL Phase 3 - MSEEL 2 Wells

□ Continued Testing on MIP3

- Continued DTS Monitoring
- Temporary DAS Coupled with Pressure Transients to Develop Continuous Production Log

□ MSEEL 2 - Boggess Pad

- Vertical Pilot Hole
- 6 Laterals





MSEEL Phase 3 -MSEEL 2 Wells

- ❑ “How can one leverage this improved understanding gained through MSEEL to drill better wells?”
 - More gas extracted, minimal risk, similar/lower costs
- ❑ Test next generation cost-effective technologies in an area with previous drilling to determine feasibility of applying lessons learned on an “every well” basis to determine if we can get more gas from each well
- ❑ Work toward real-time intervention and modification during stimulation
- ❑ Improved Fracture Characterization
 - Natural and Induced
 - Unconventional Fracture Modeling



MSEEL 2 Pilot

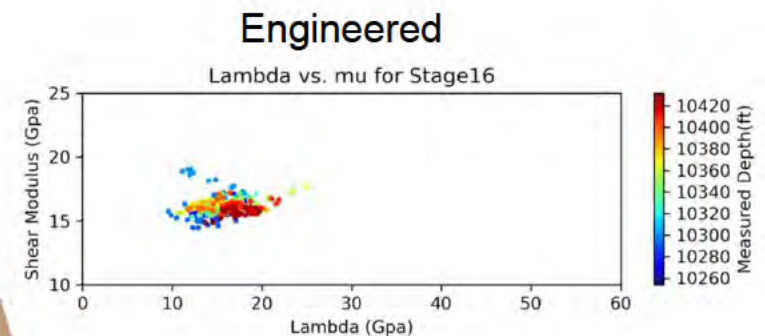
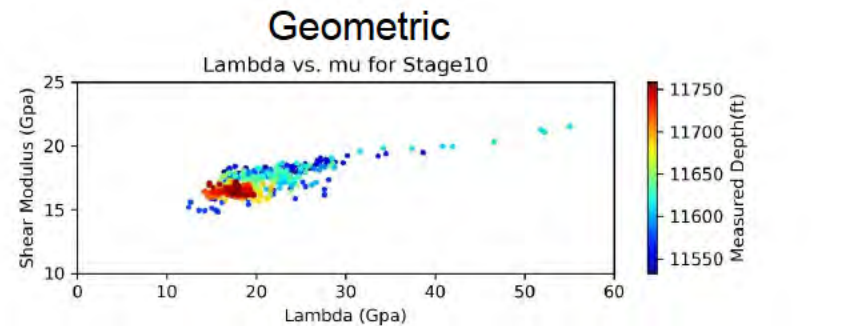
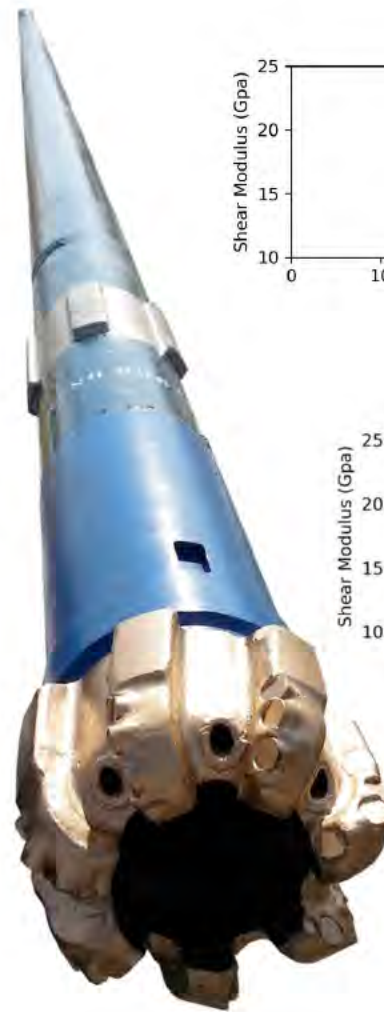
❑ Vertical Pilot Hole

- Core and Sidewall Cores
- Core with FractureID
- Complete Log Suite

❑ MSEEL 2 Tie to Vertical

- Develop algorithms to efficiently incorporate thin low-cost data during the drilling process (e.g., LWD geomechanics).

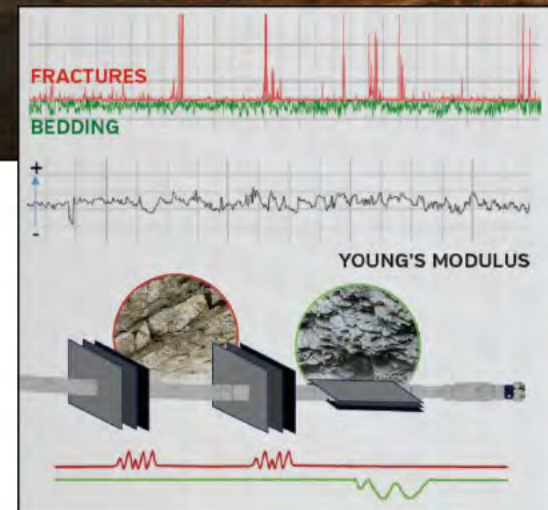
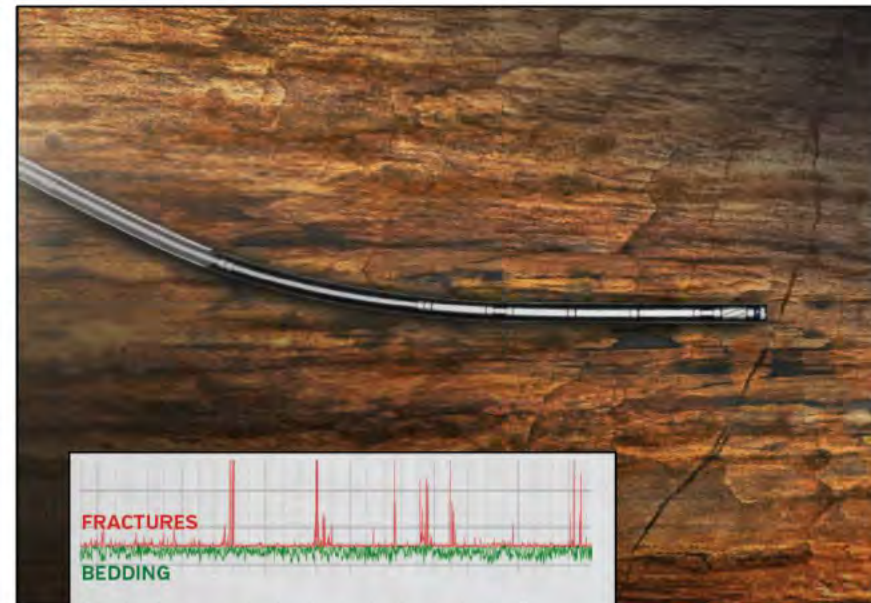
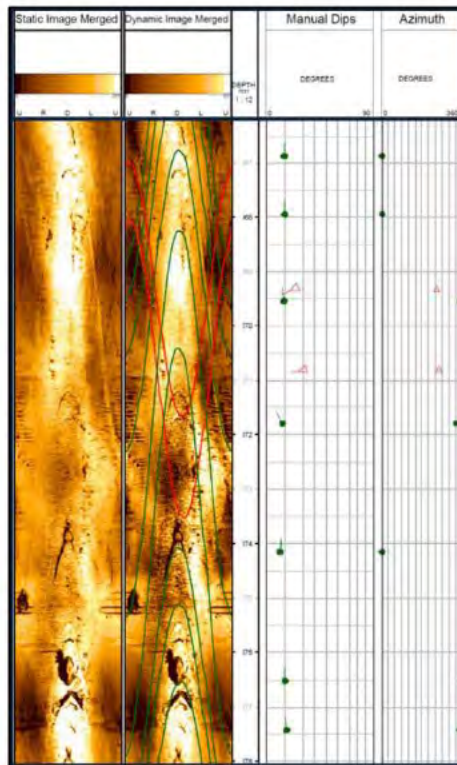
❑ Engineer Completions





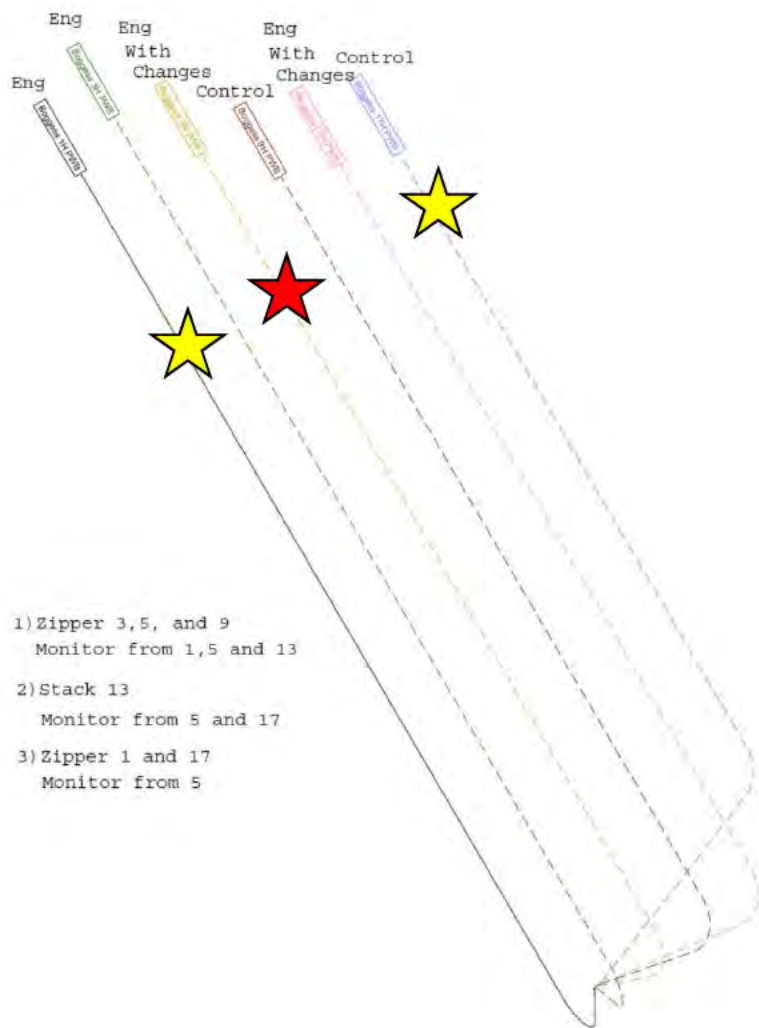
MSEEL-2 Wells

- All Six Laterals
- Tie to Vertical Pilot
- FractureID
- Petromar FracView
- Active Proppant





MSEEL-2 Wells

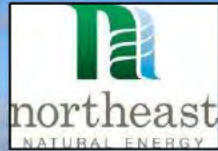


★ Permanent Fiber

★ Intervention Fiber

- Advanced Fiber
- Distributed acoustic and distributed temperature sensing data acquisition.
- Actionable Information During Stimulation.
- Microseismic and Active Proppant Monitoring
- Long term Monitoring with Permanent Fiber

Building Partnerships for Research, Education, and Outreach



Industry



Community

MSEEL

Academia



Government

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