

Distinguished Lecturer Program

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Distinguished Lecturer Program
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What Have We Learned About Fracturing Shales After 12 Years Of Microseismic Mapping?

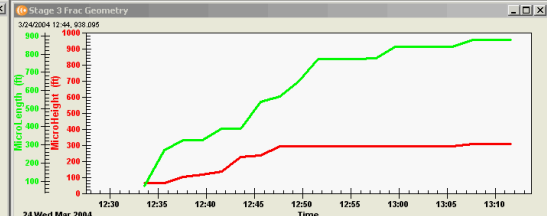
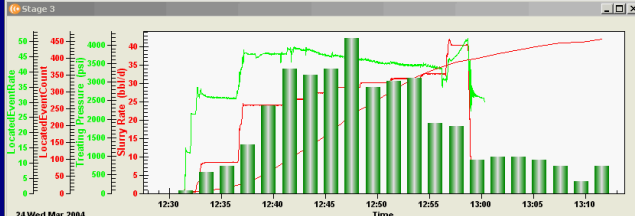
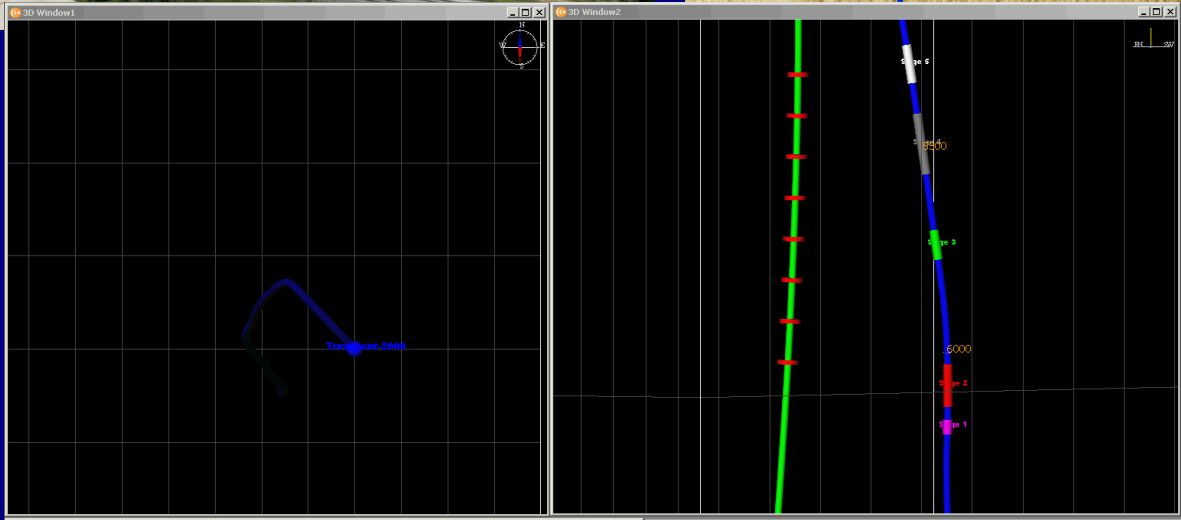
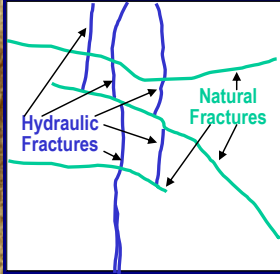
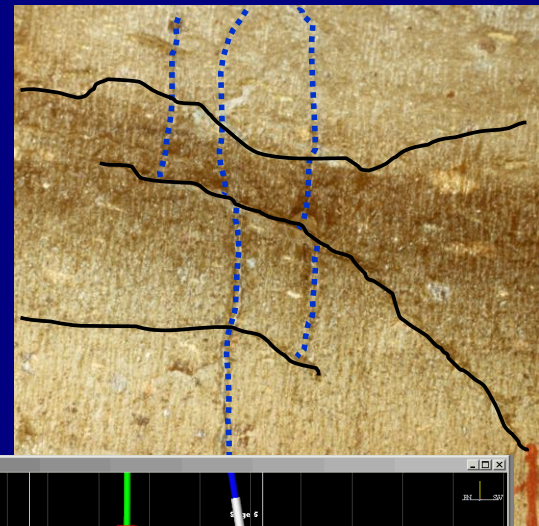
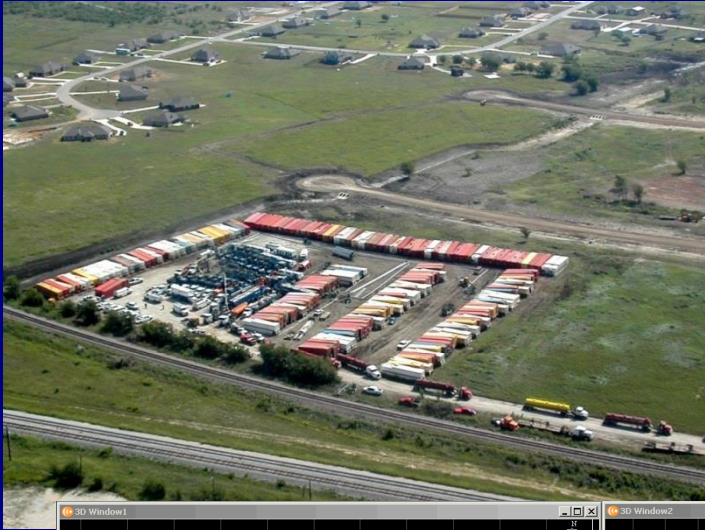
Shawn Maxwell
Schlumberger

Outline

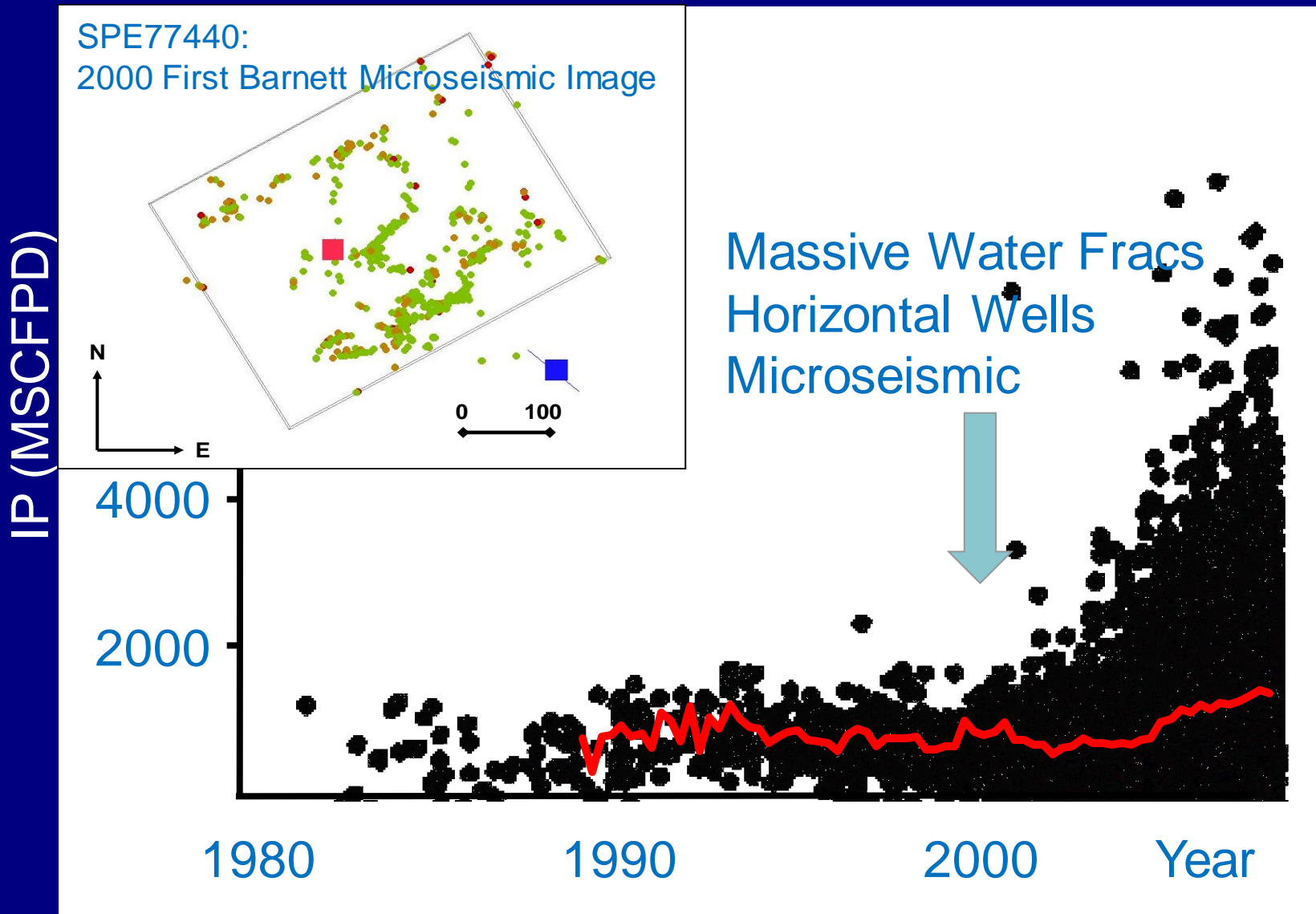
- Unconventionals/microseismic introduction
- Shale fracturing lessons from microseismic
- Geomechanical deformations
- Conclusions

Where Does It All Go?

Fracture Complexity & Natural Fractures



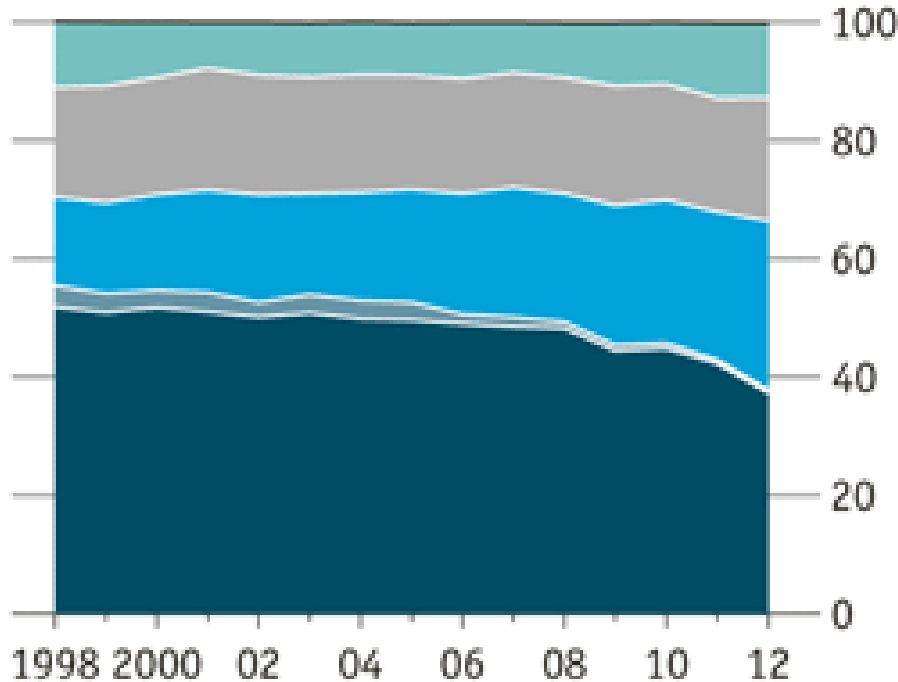
Barnett Shale Activity



Unconventional Energy Renaissance

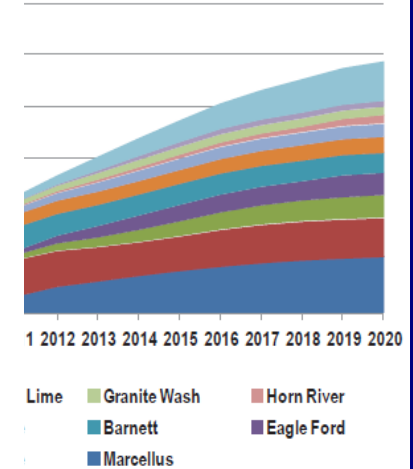
Step on the gas

US electricity generation mix, %

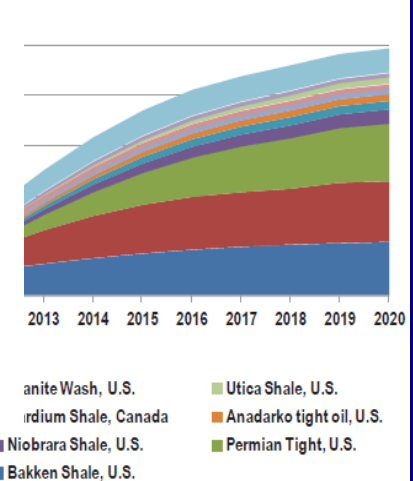


Source: EIA

Gas Production

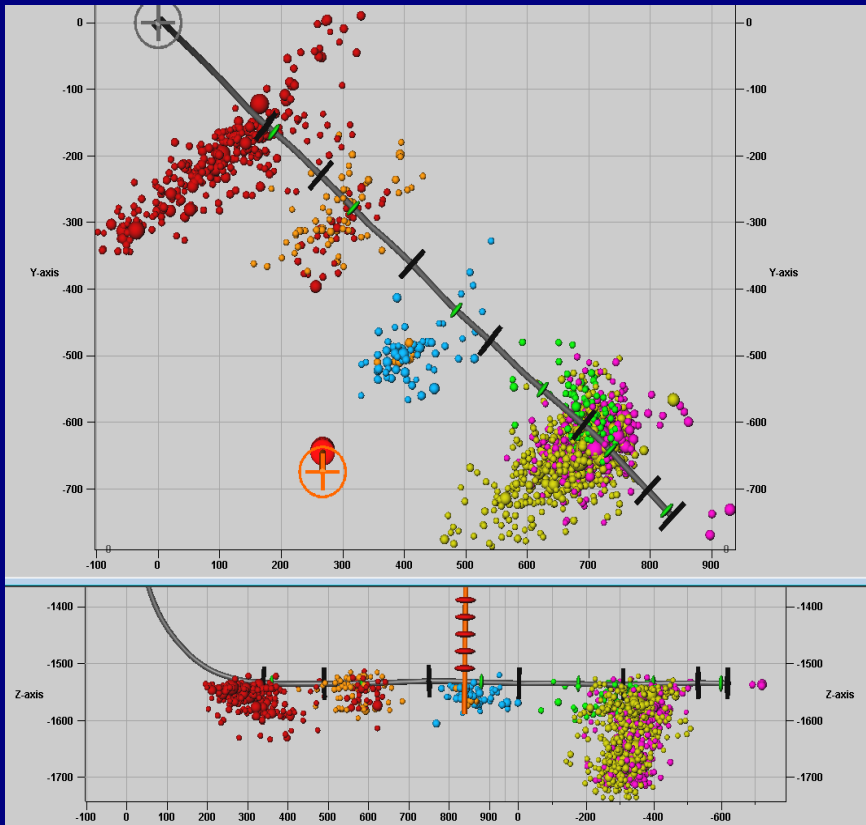


Production by Plays



Hart 2012

Hydraulic Fracture Applications

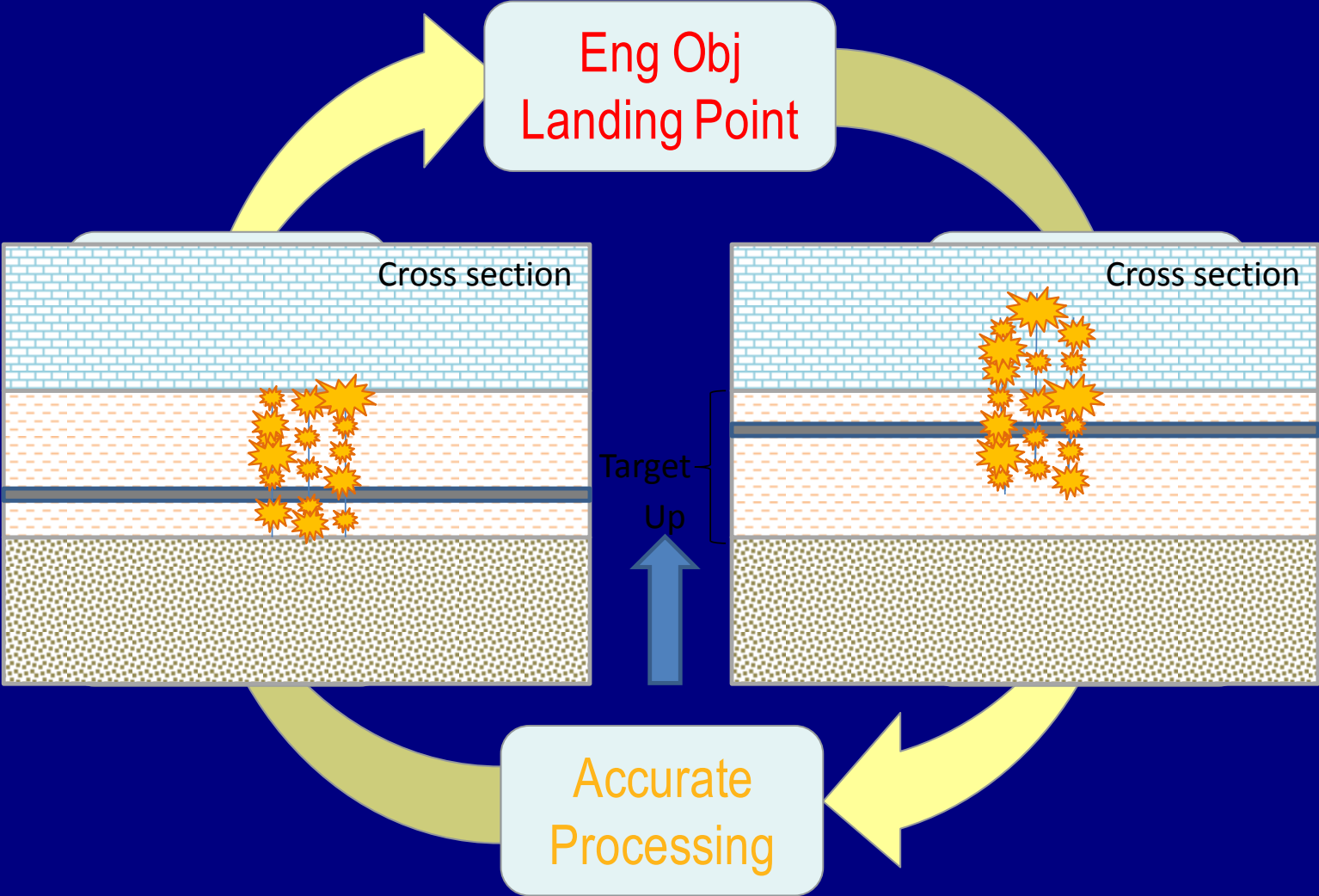


- ✓ Fracture direction
- ✓ Height
- ✓ Length
- ✓ Complexity

- Real-Time Fracture Control
 - ✓ Geo-Hazards
 - ✓ Re-fracturing
 - ✓ Stage modification
- Completion Strategy
 - ✓ Staging & Isolation
 - ✓ Frac Design
 - ✓ Perforation strategy & frac initiation
- Field Development
 - ✓ Well placement
 - ✓ Well spacing
 - ✓ Drainage patterns

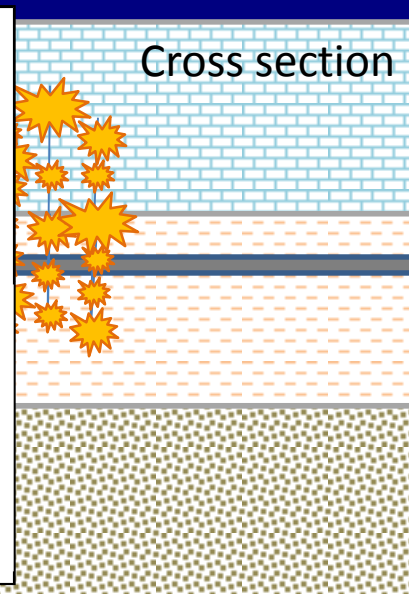
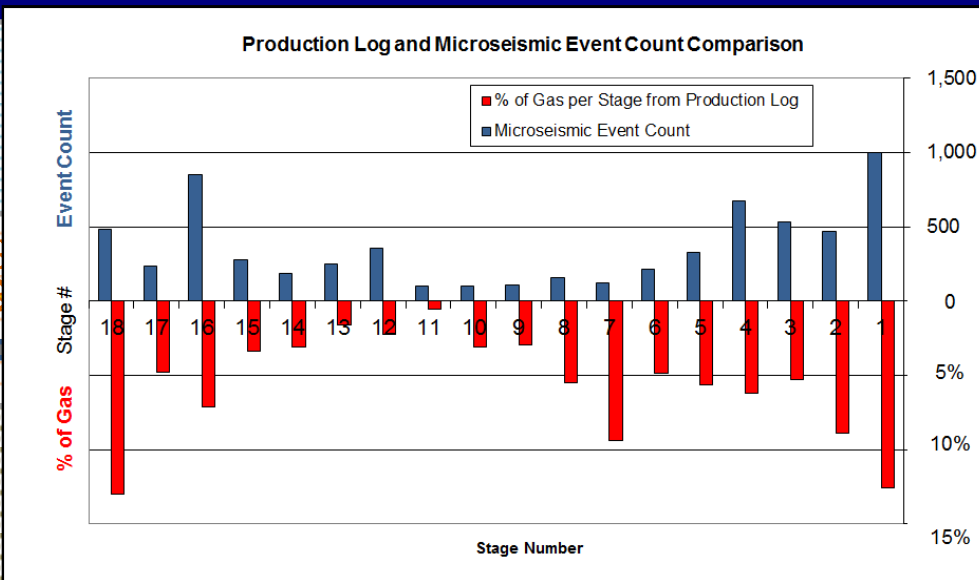
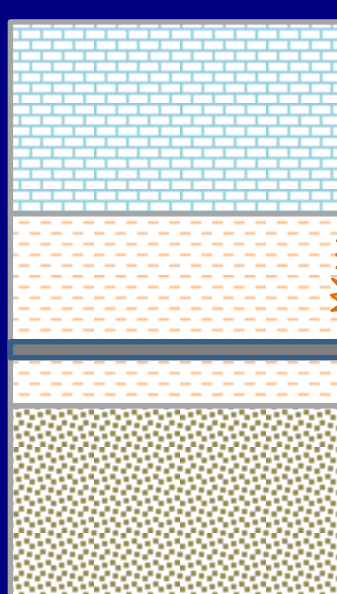
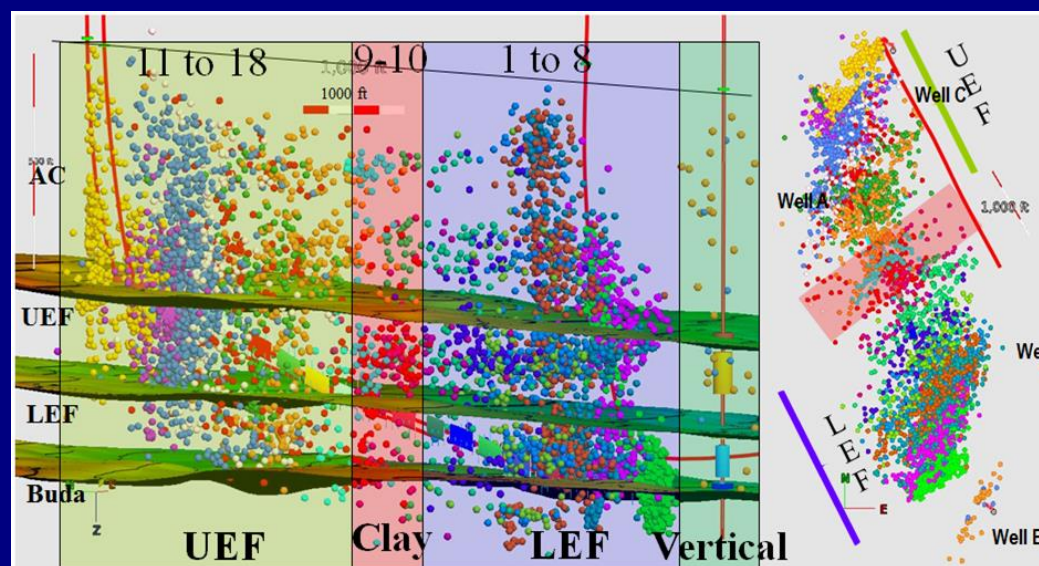
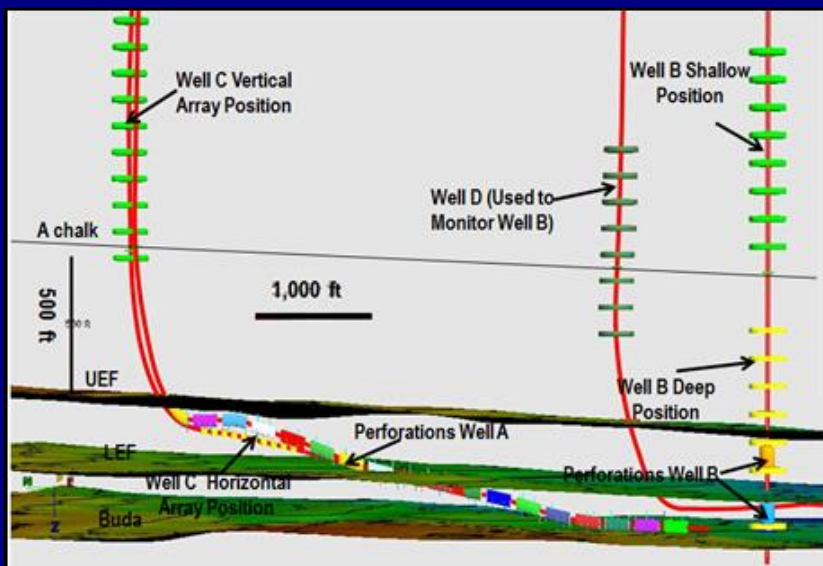
Improved fracs/production

Project Design for Value

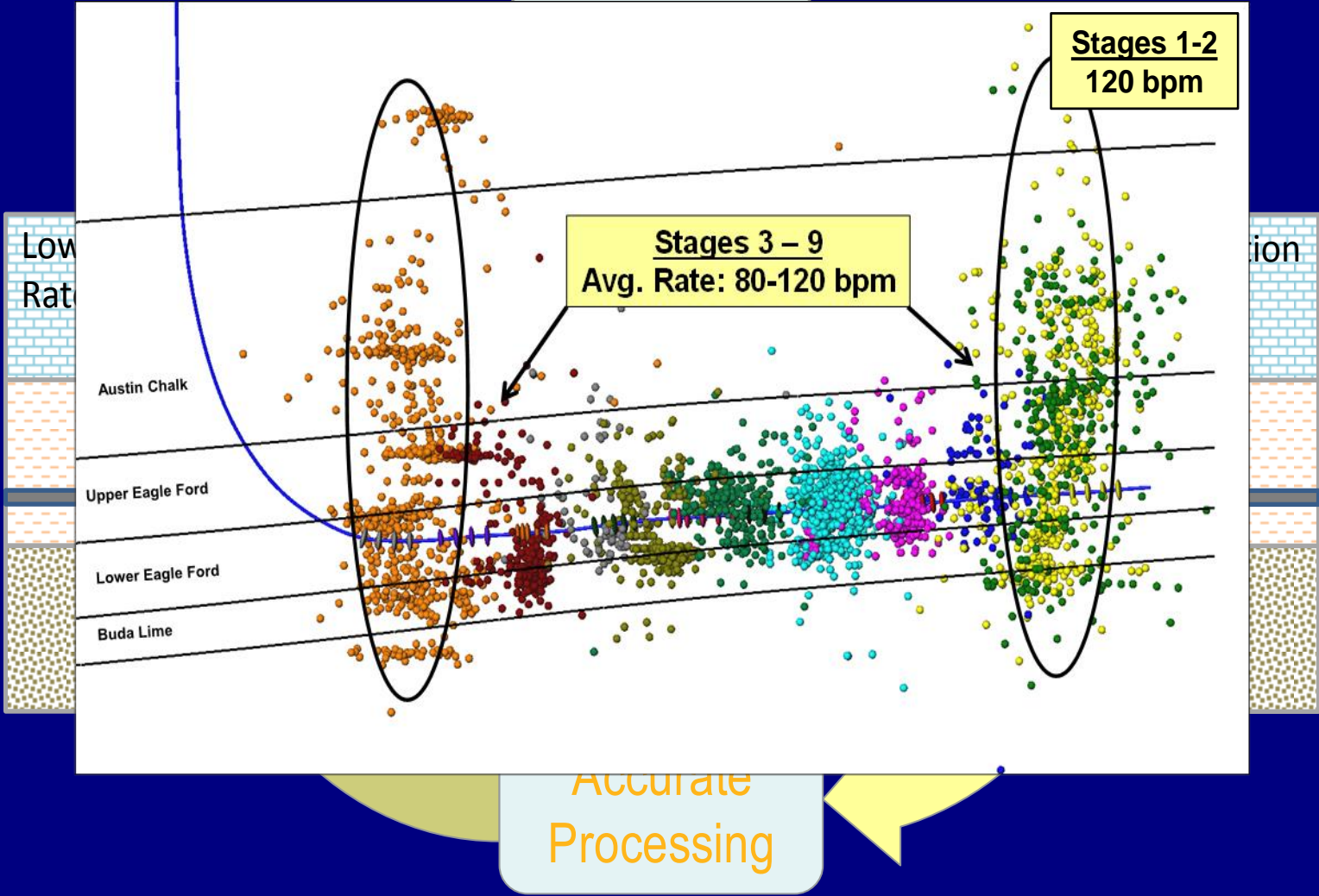


Eagle Ford Example

Petal et al., 2013
URTeC



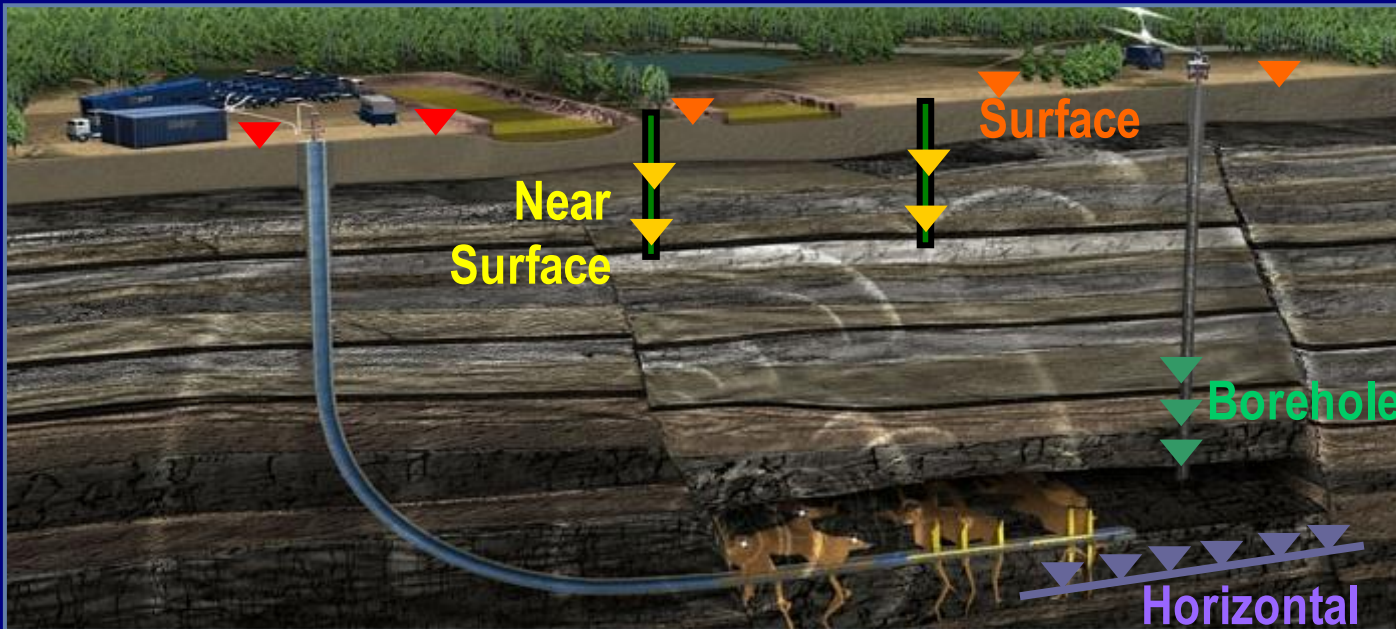
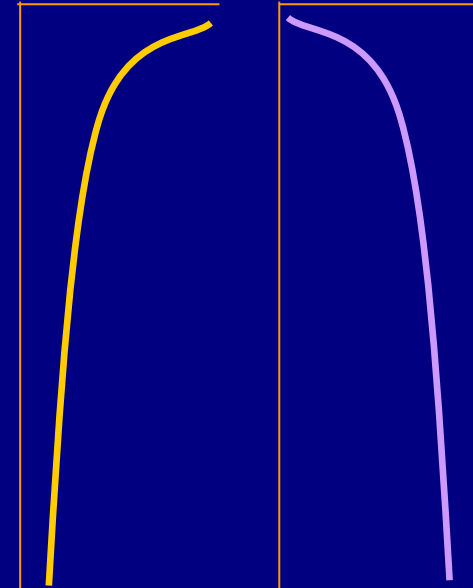
Project Design for Value



Evolution of Monitoring Geometries

Noise

Signal

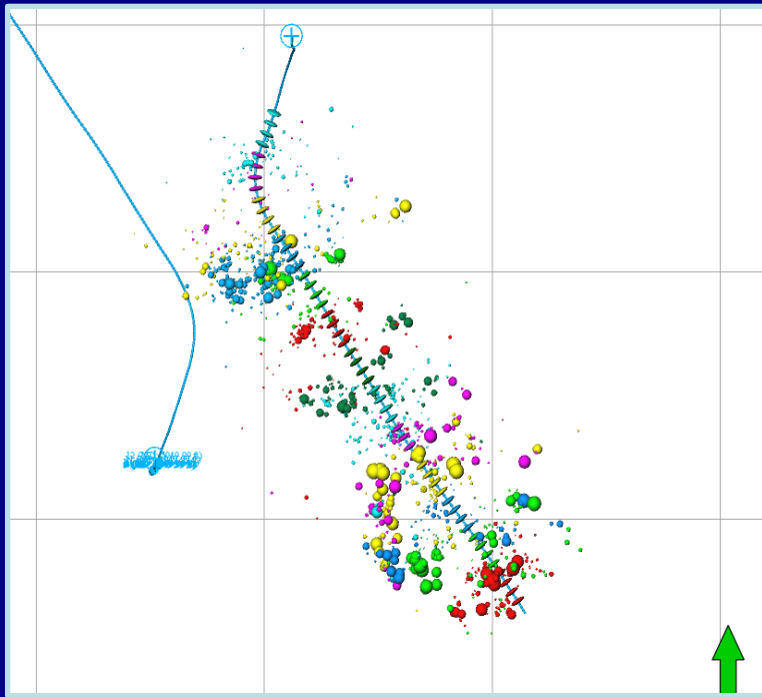


How do accuracies and sensitivities compare?
How do you decide which option?

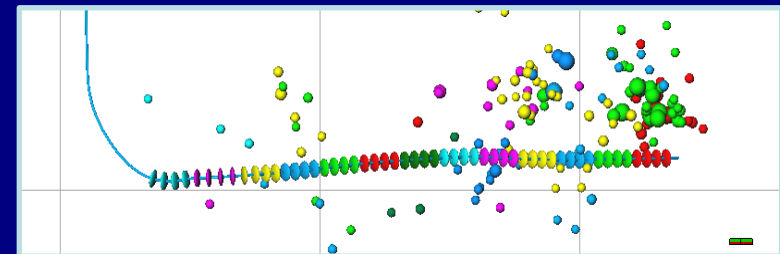
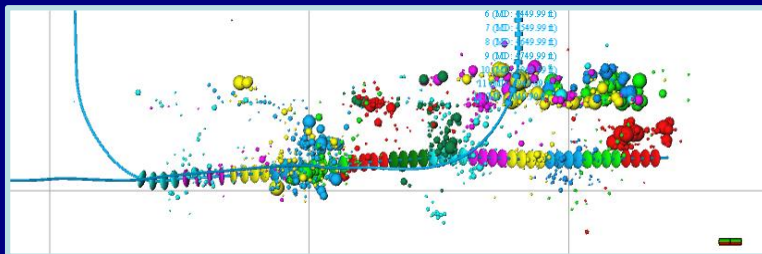
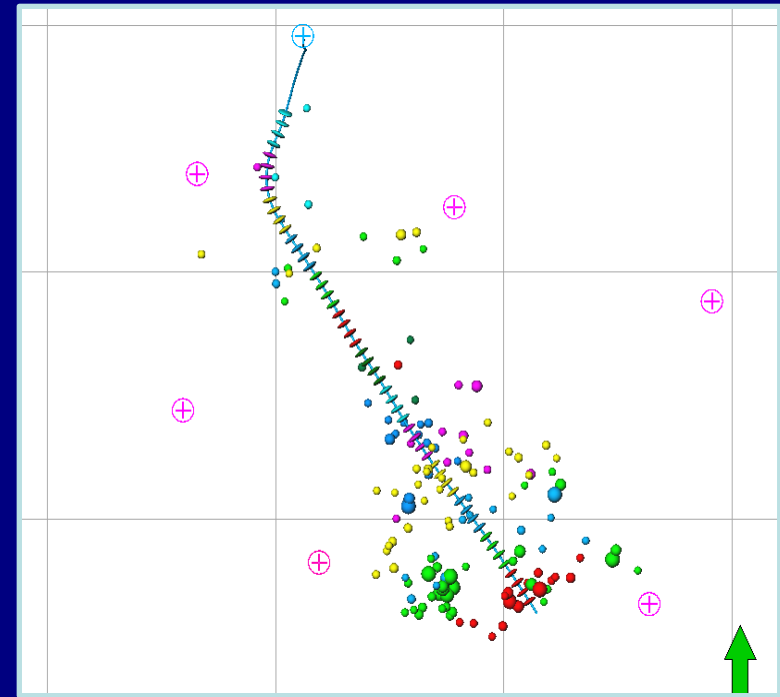
SPE159670

Acquisition Footprint

Downhole Array

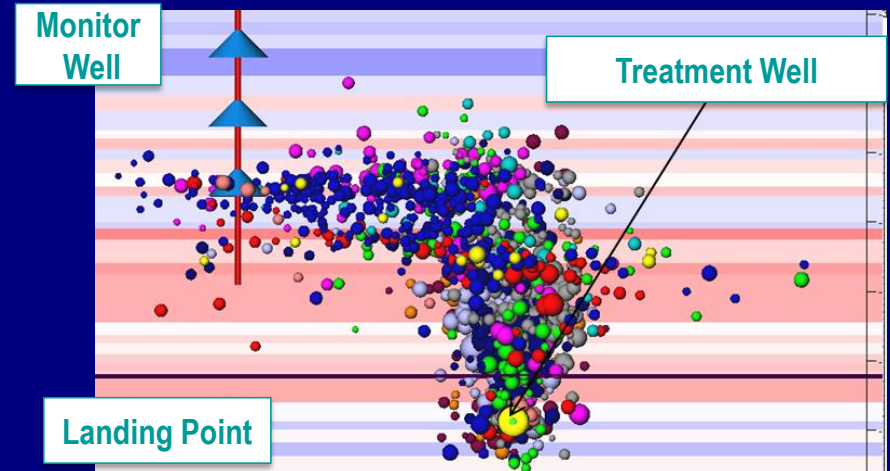
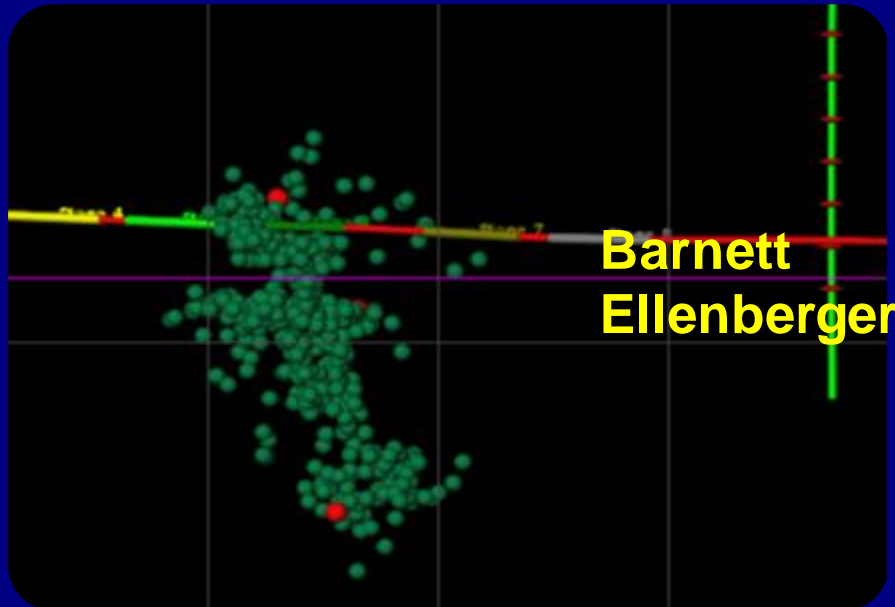
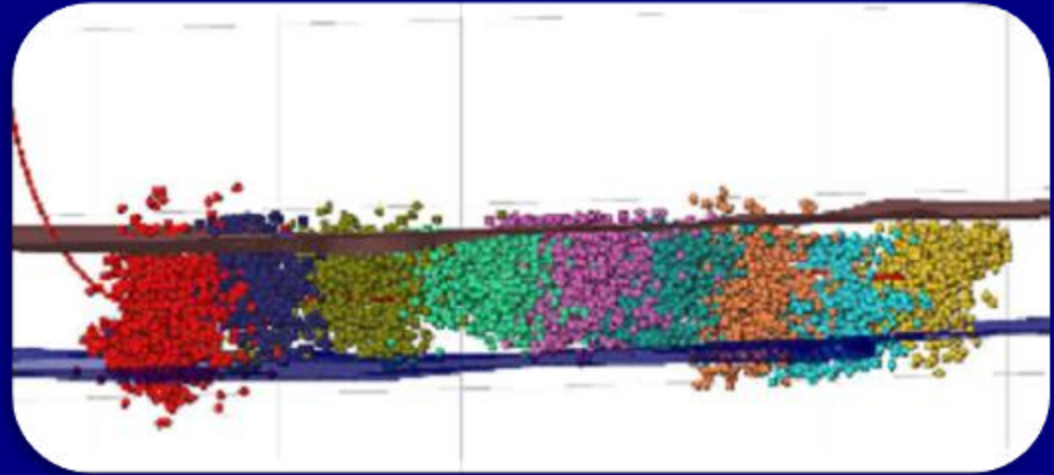


Shallow Grid



Shale Lessons: Containment

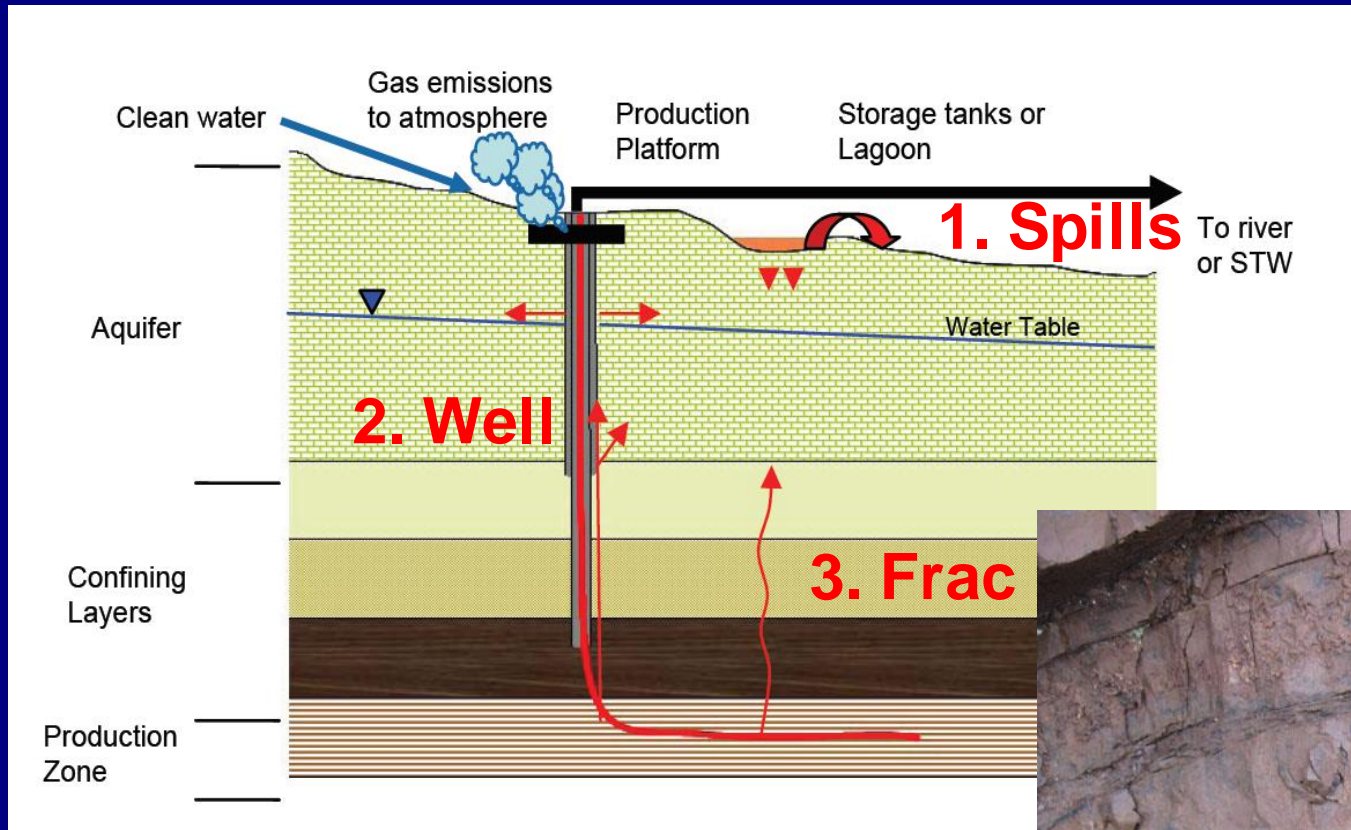
1. Depth Containment



Environmental Concerns

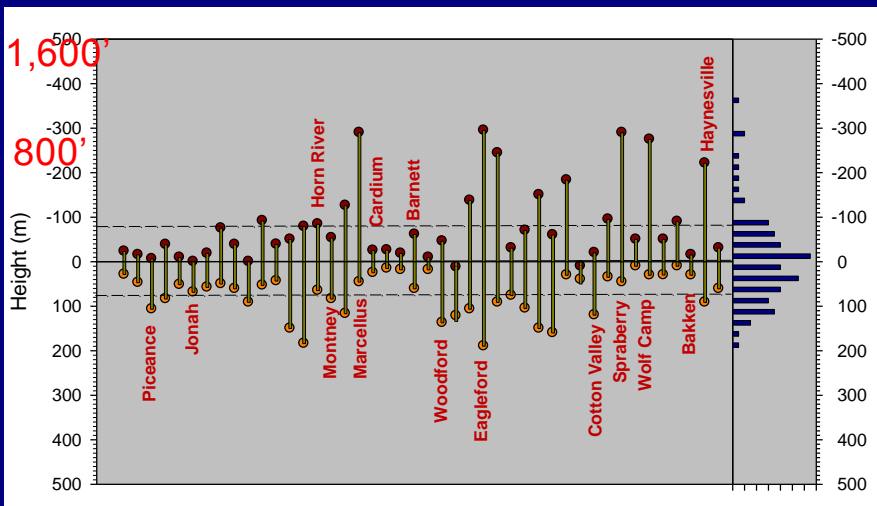
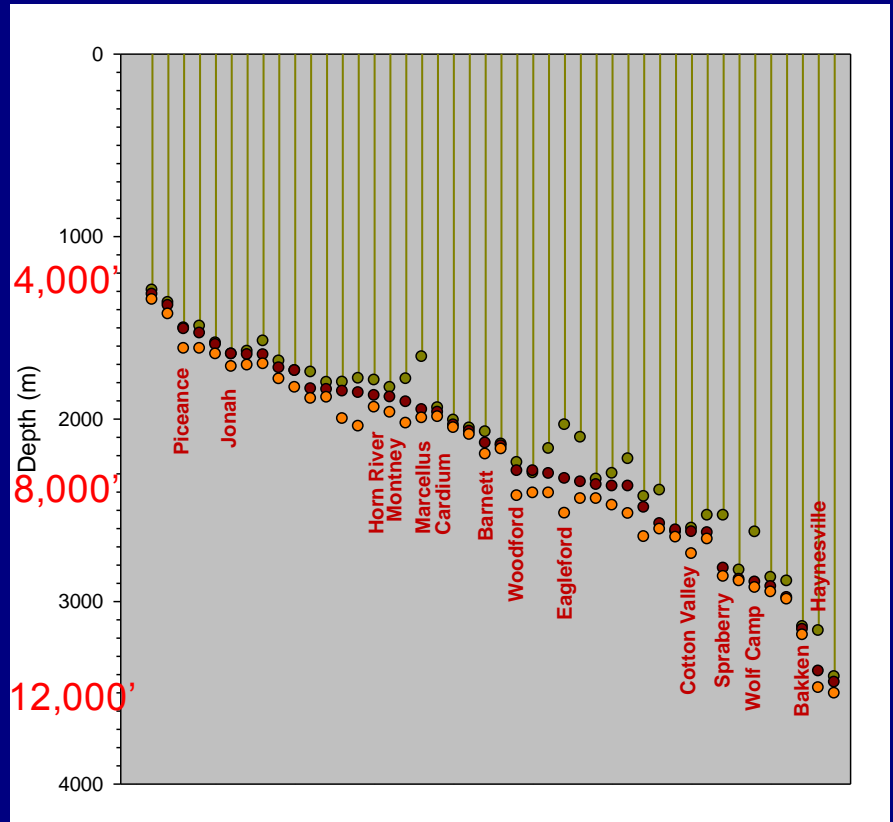
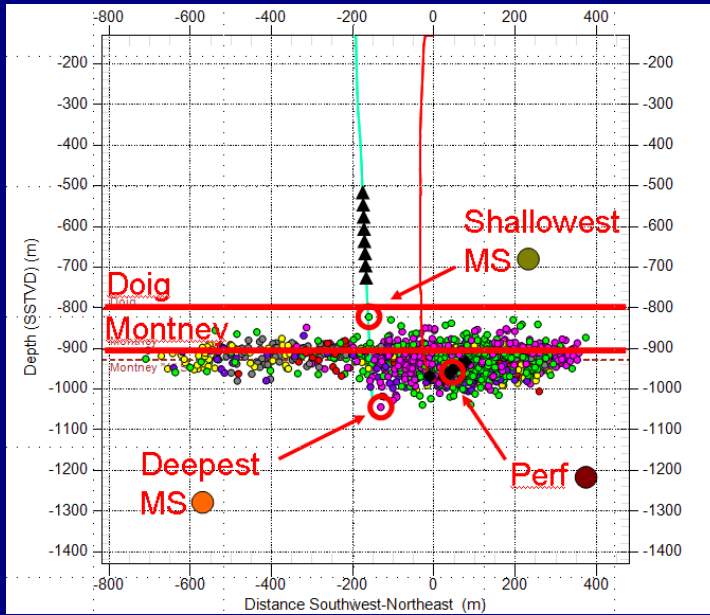


Aquifer Protection

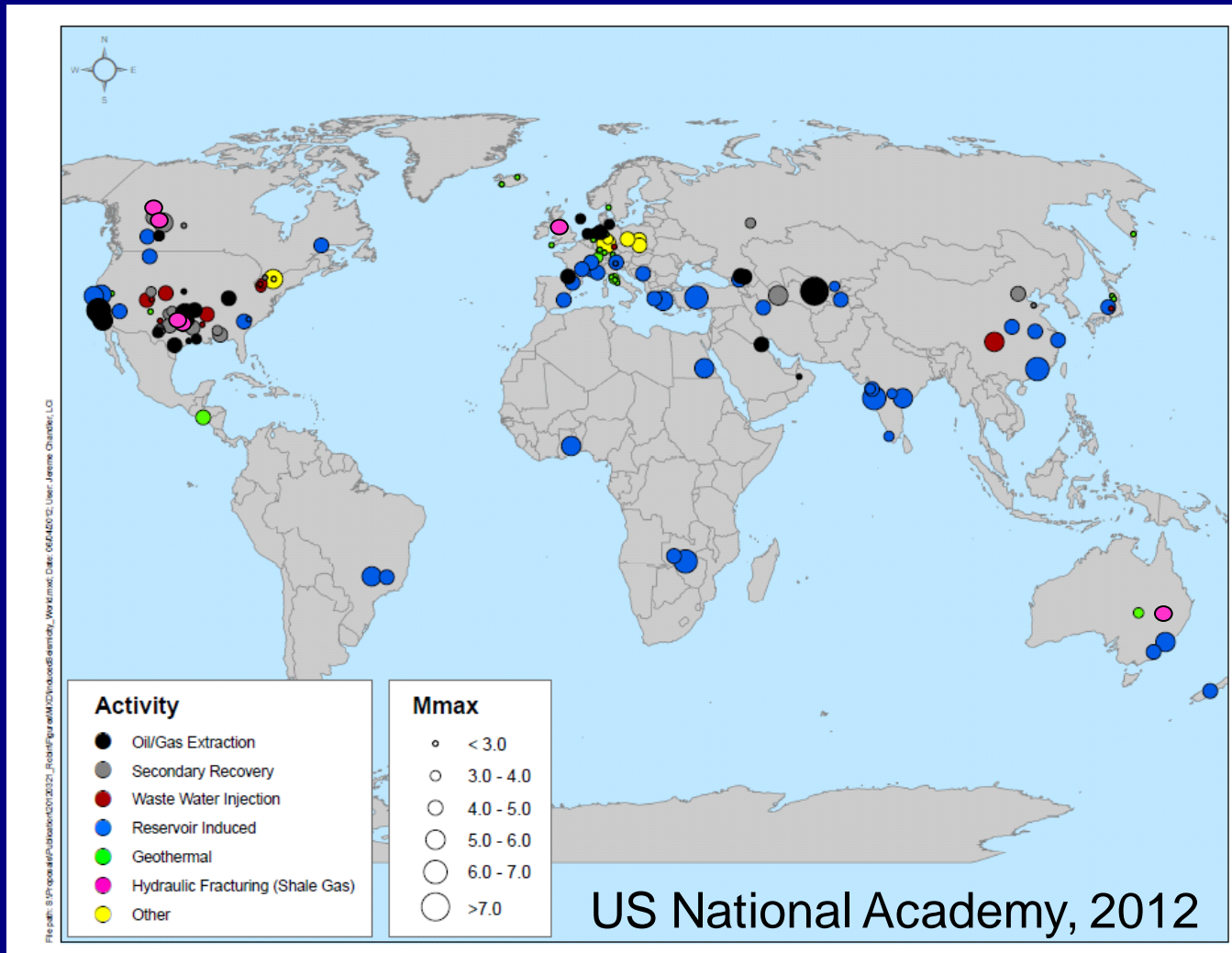


IEA

Fracture Height Growth



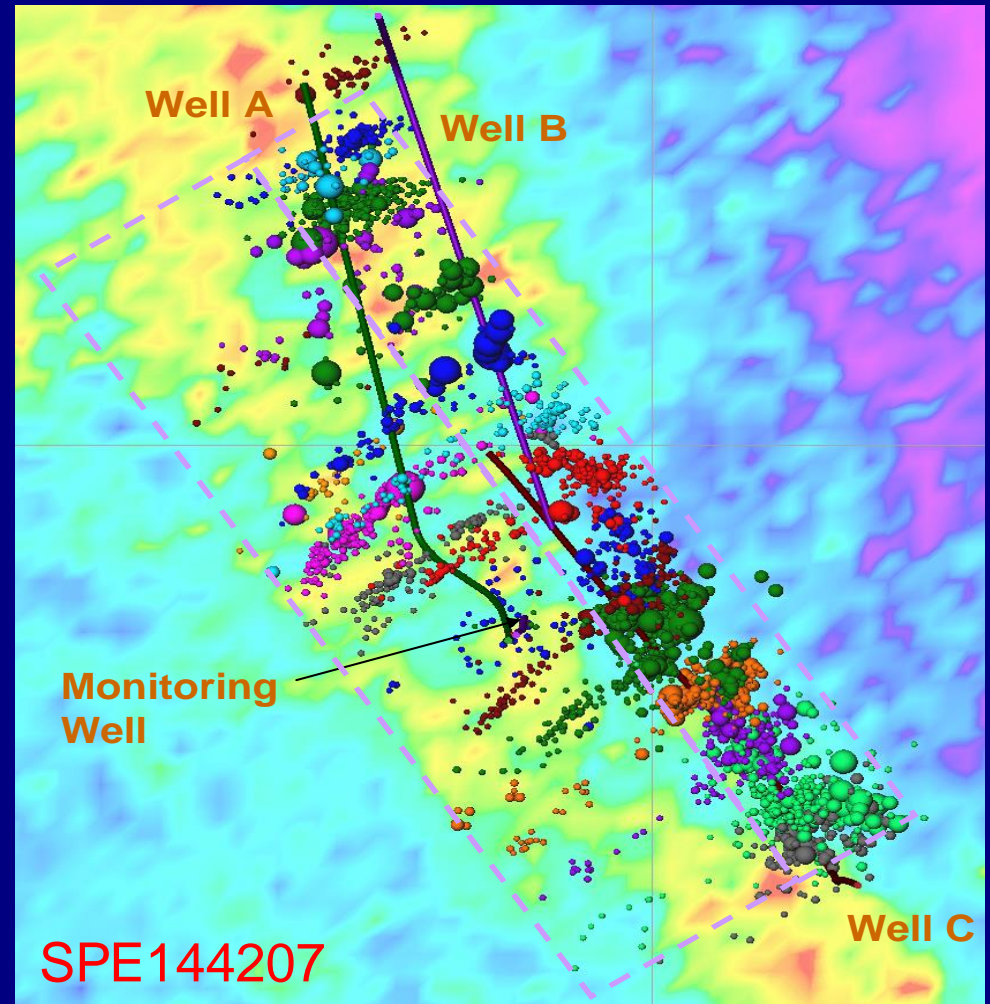
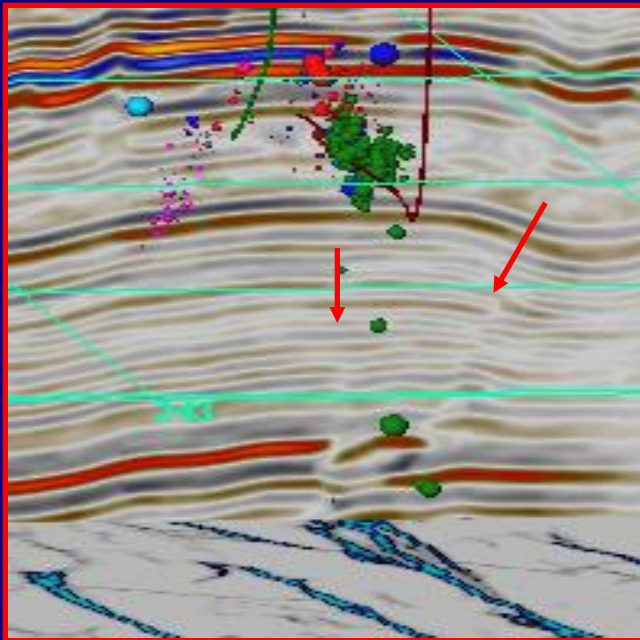
Induced Seismicity



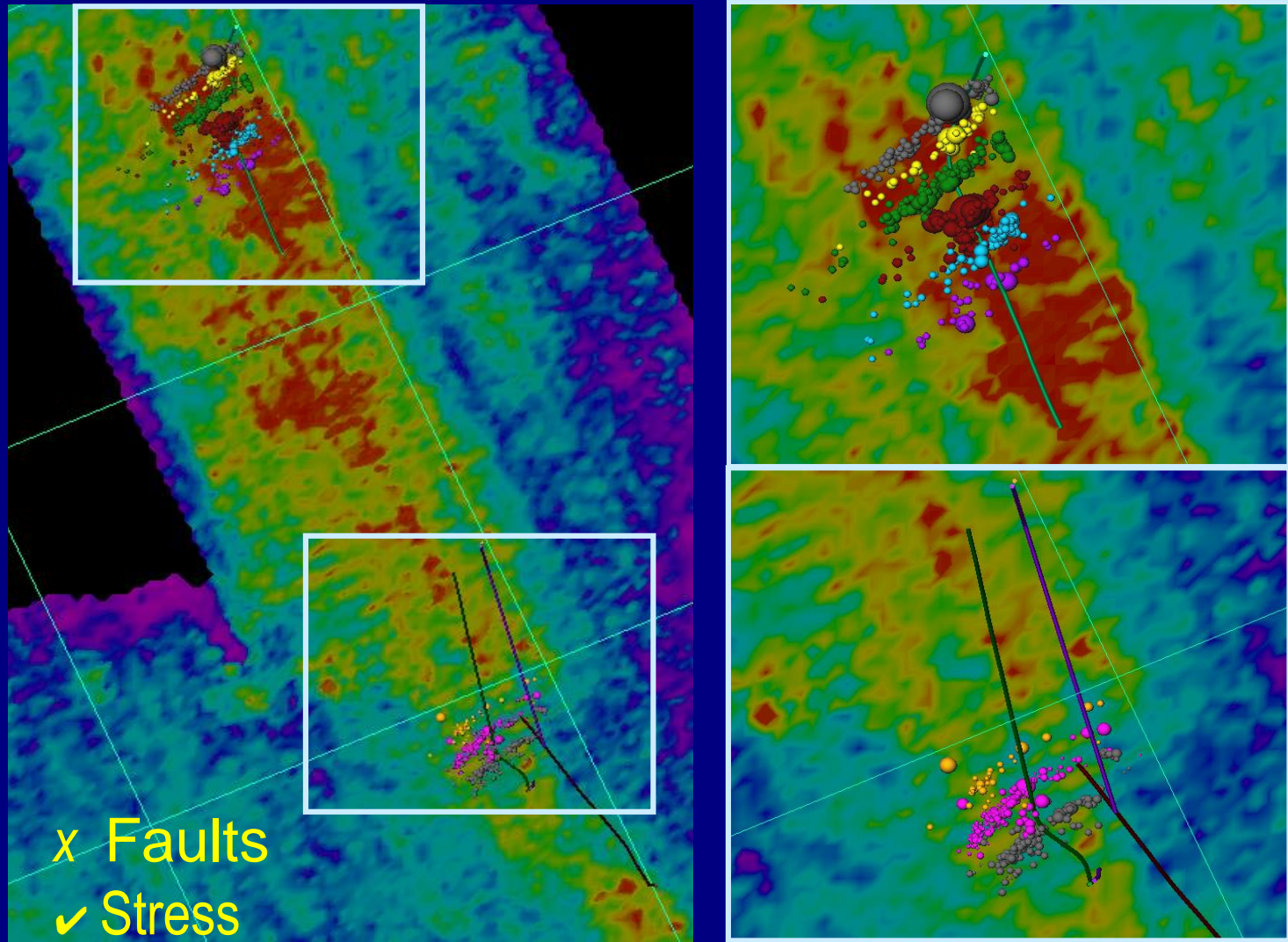
No damage and rare (5 cases from 3,000,000 fracs)¹⁷

Shale Lessons: Heterogeneity

1. Depth Containment
2. Fracture Variability



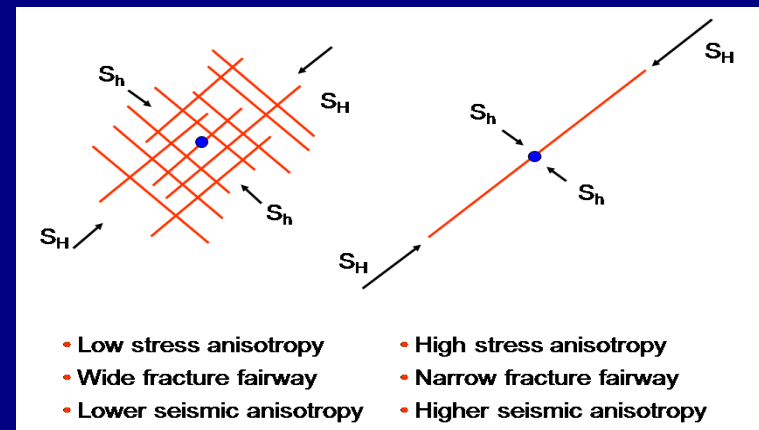
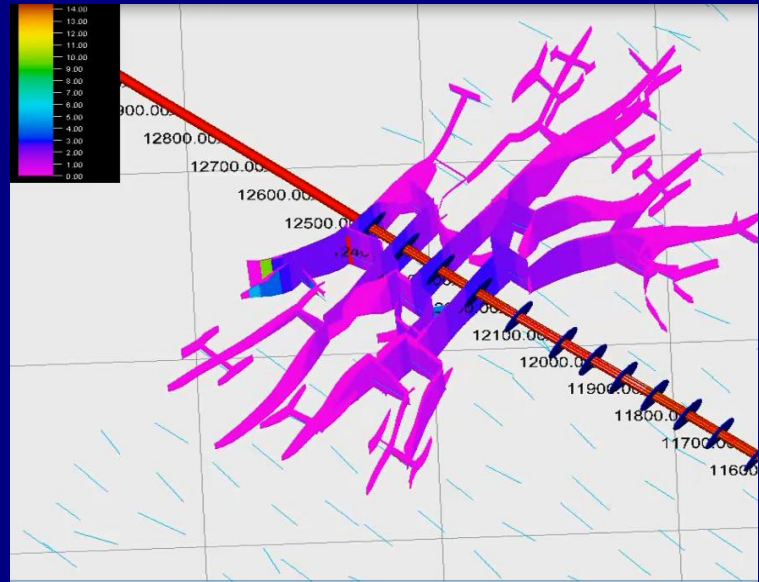
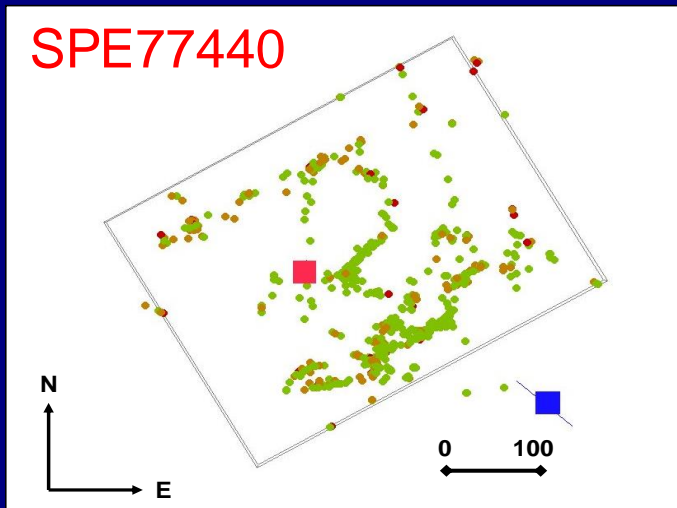
Geomechanical “Sweetspots”



Improved well placement using integrated reservoir characterization and microseismic

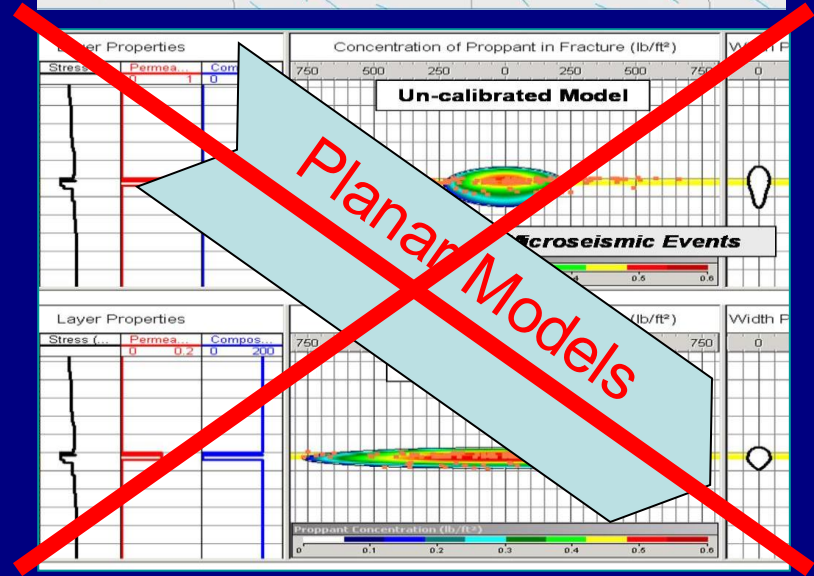
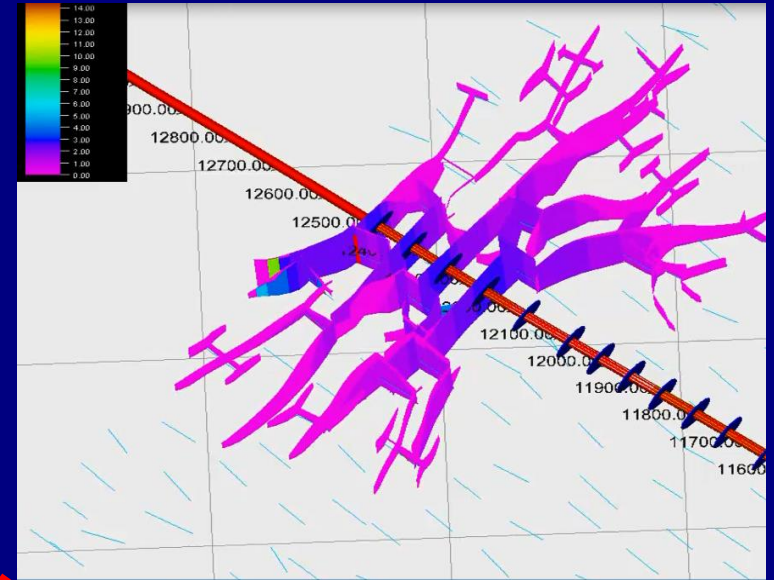
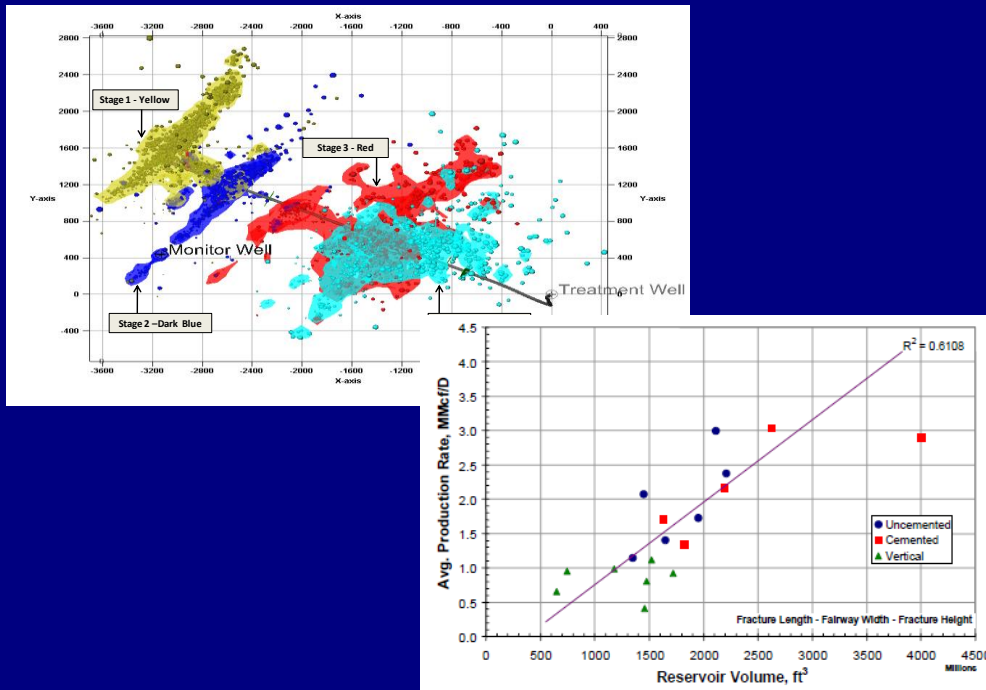
Shale Lessons: Complexity

1. Depth Containment
2. Fracture Variability
3. Fracture Complexity

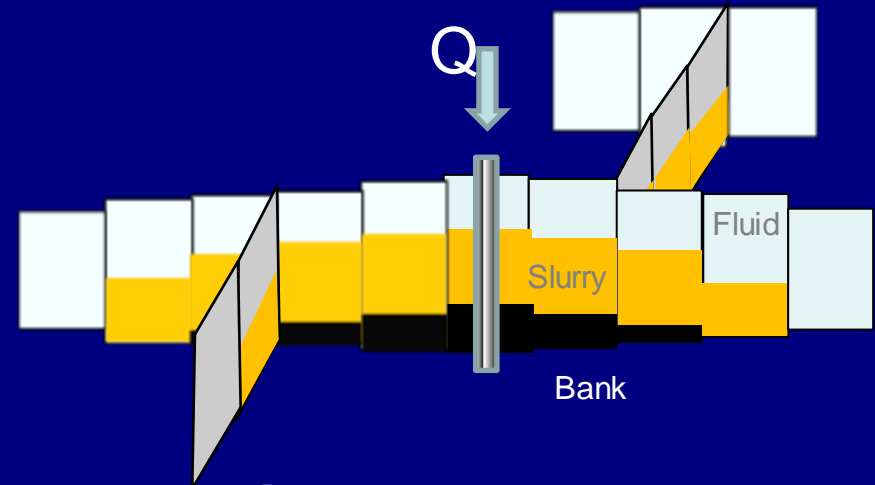
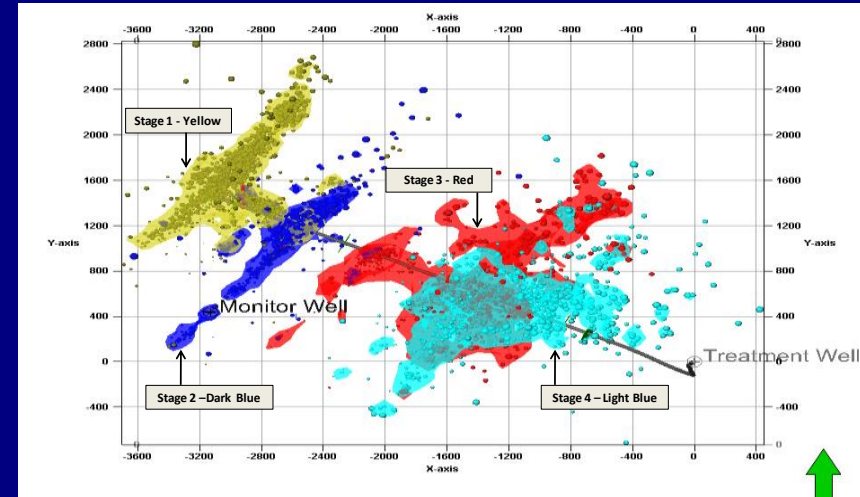
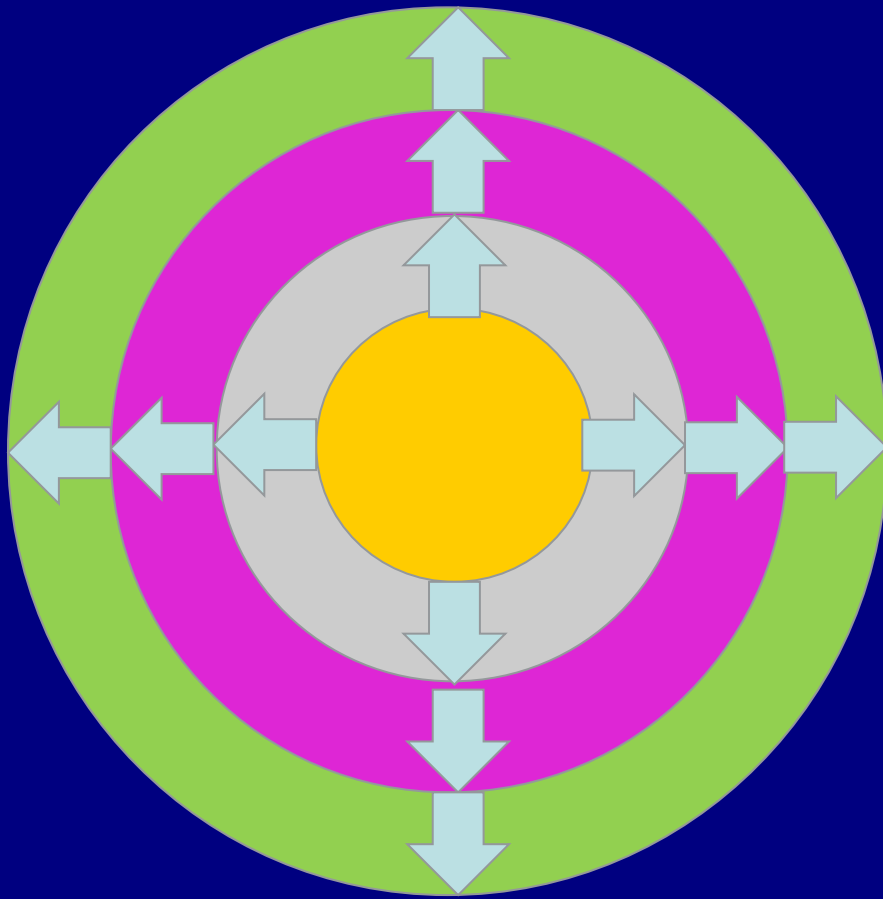


Shale Lessons: Reservoir Contact

1. Depth Containment
2. Fracture Variability
3. Fracture Complexity
4. Stimulated Reservoir Volume

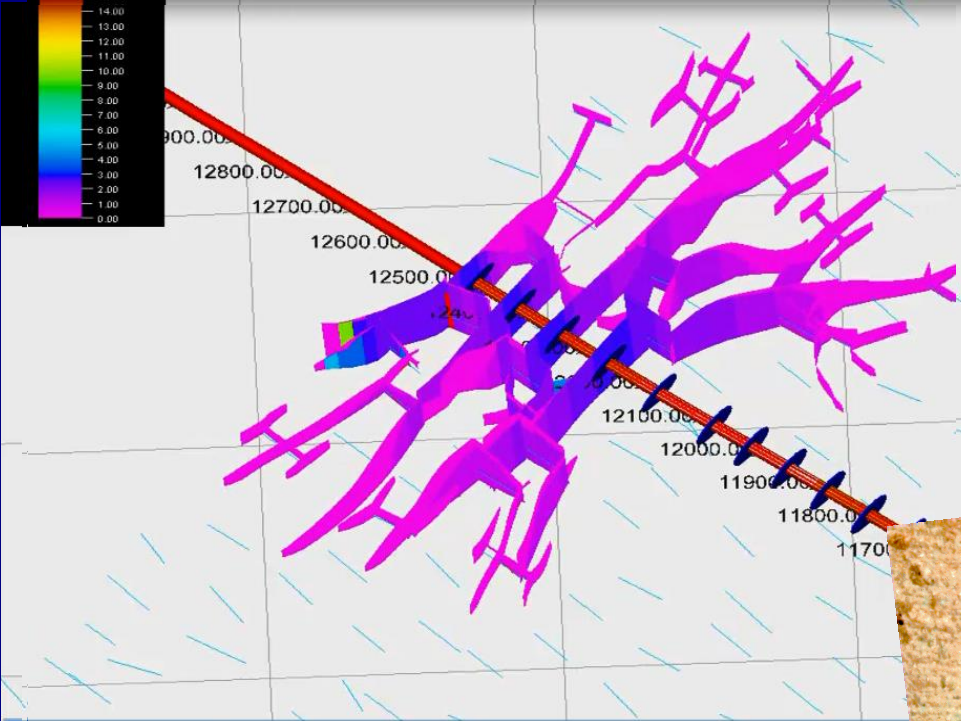


Stimulated Reservoir Volume

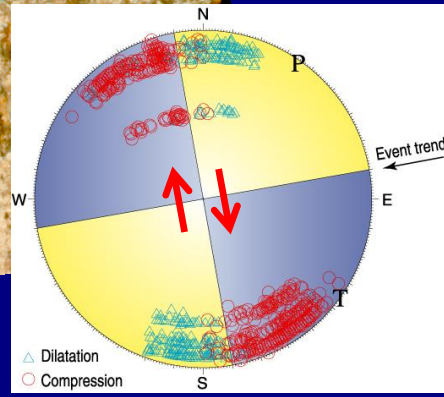
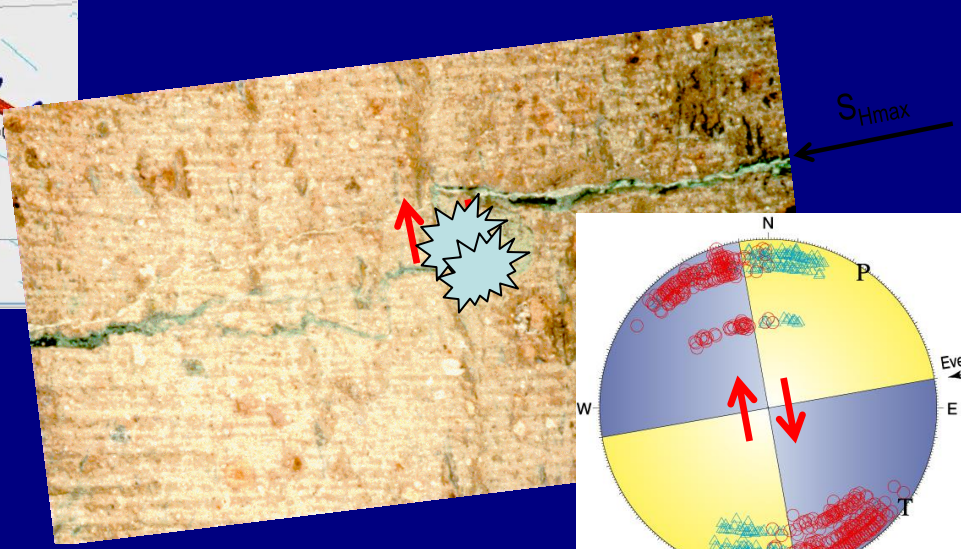
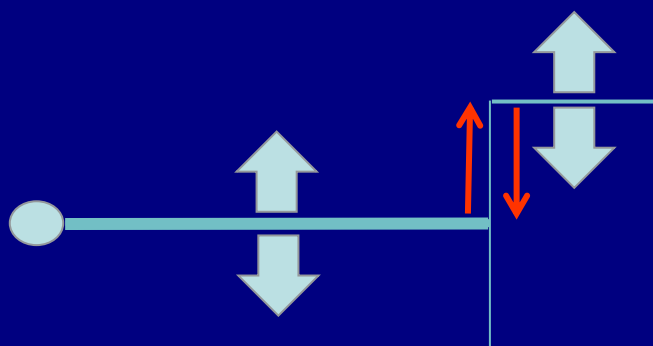


Microseismic Vol > Stress Vol > Hydraulic Vol > Propped Vol
 Location Uncertainty

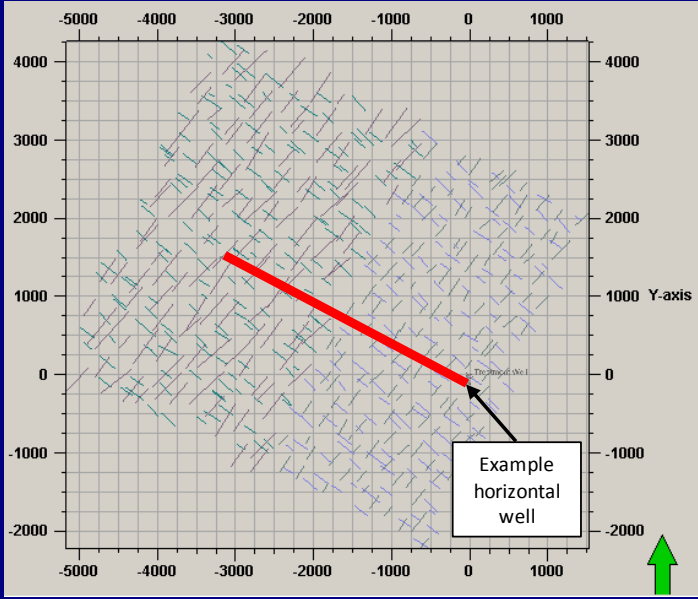
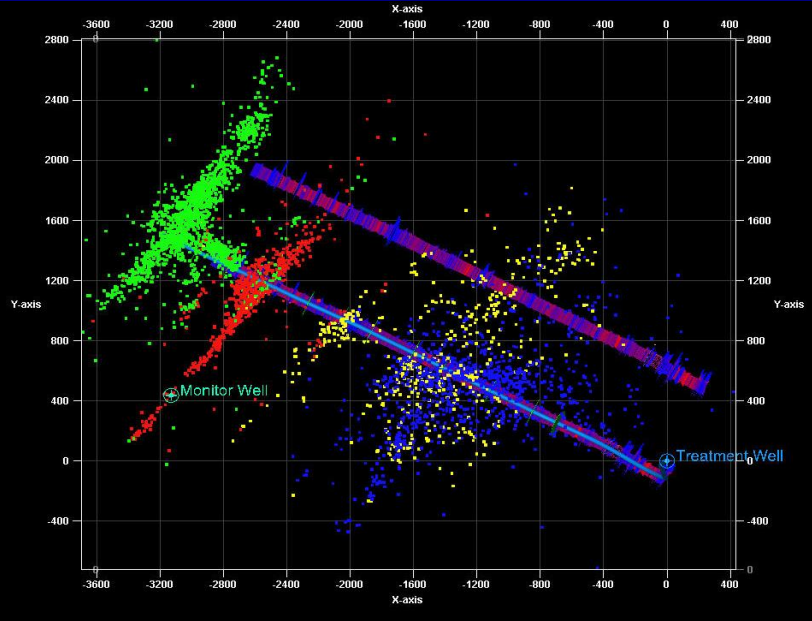
Geomechanics



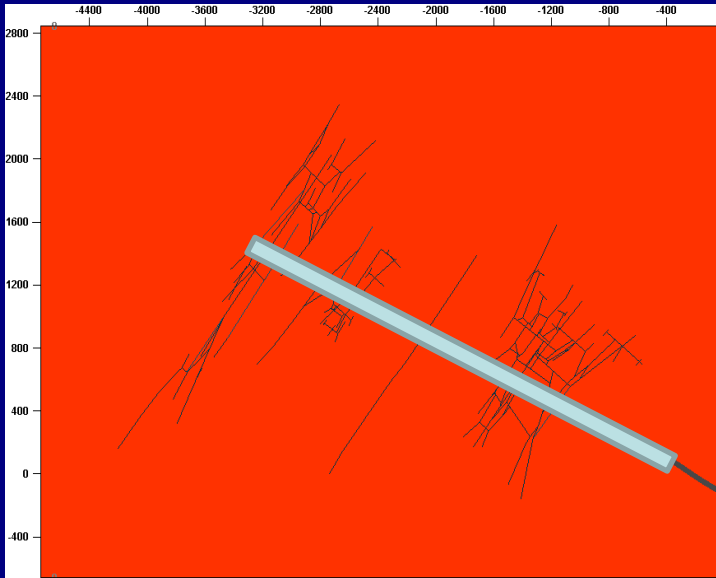
Proppant



Microseismic Calibration

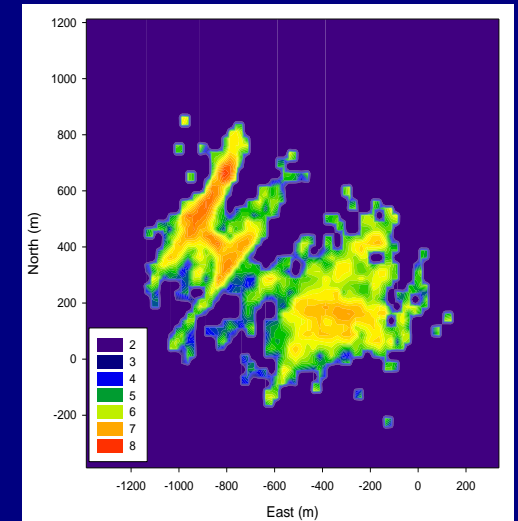
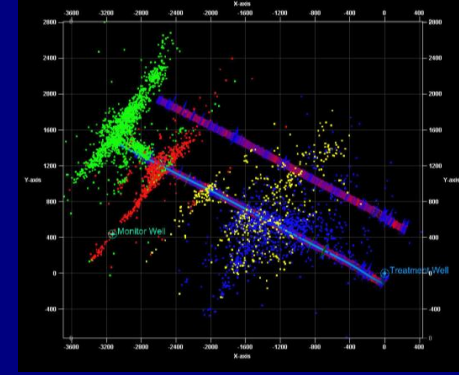
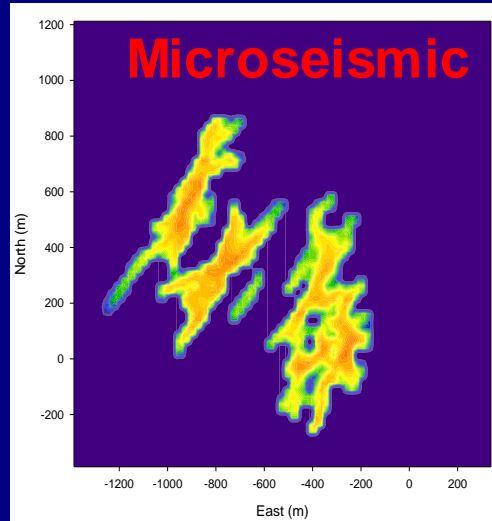
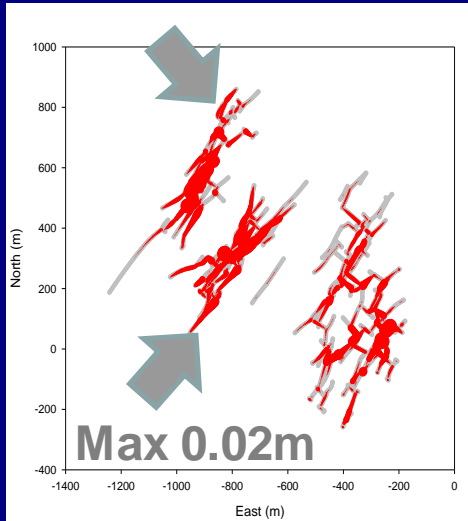
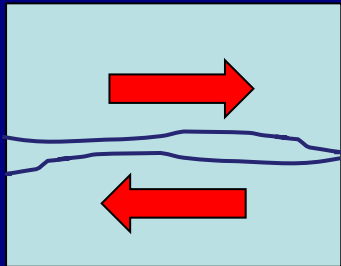


SPE152165

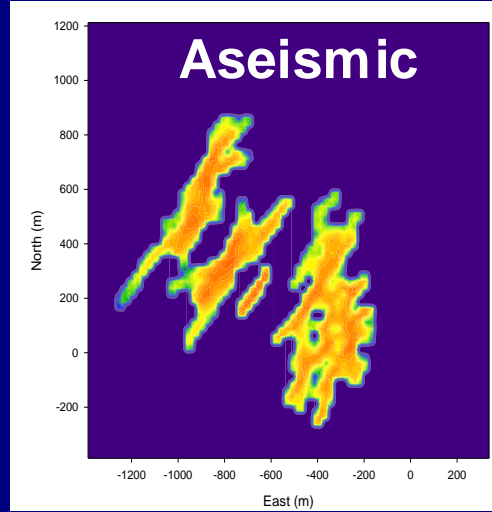
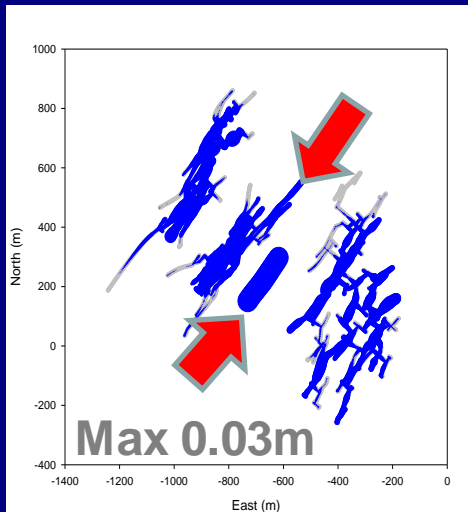
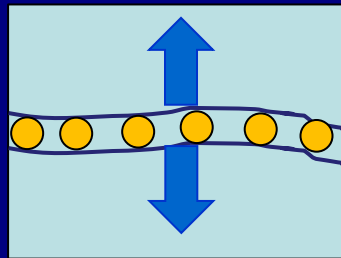


Partitioning Deformation

Shear



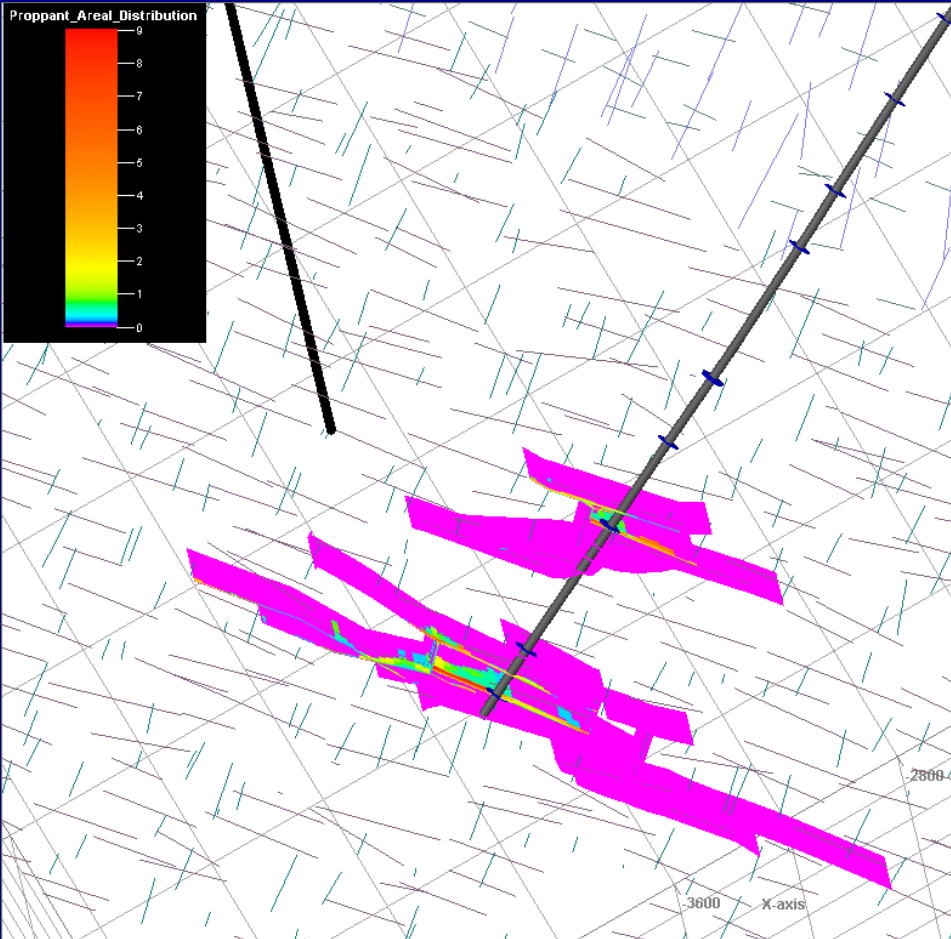
Tensile



Calibrate fracture density

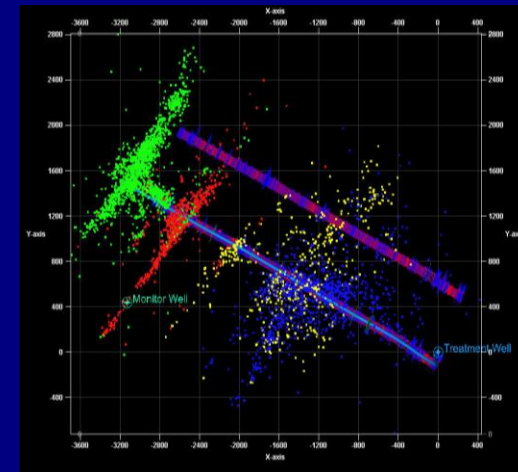
SPE 166312

Estimating Proppant Distribution

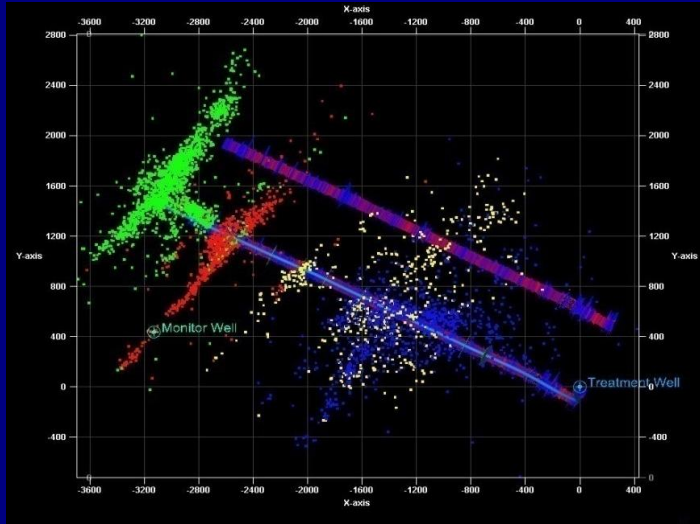


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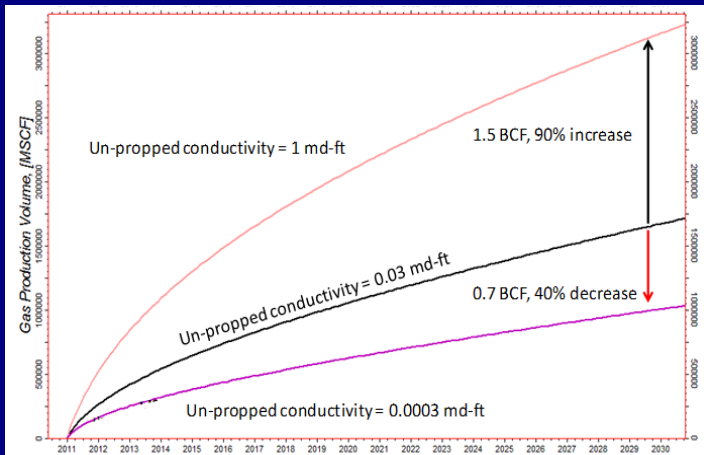
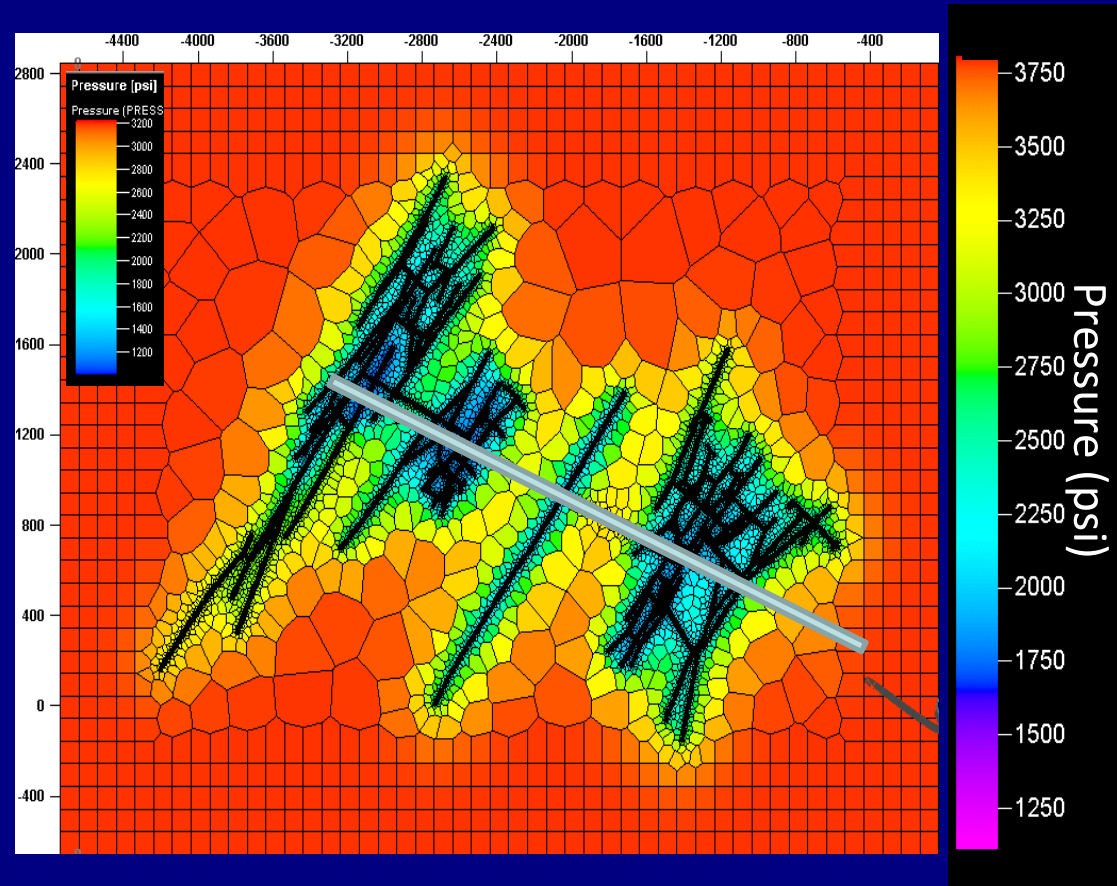
- Estimate propped component from mass balance
- Majority of the hydraulically activated network not propped



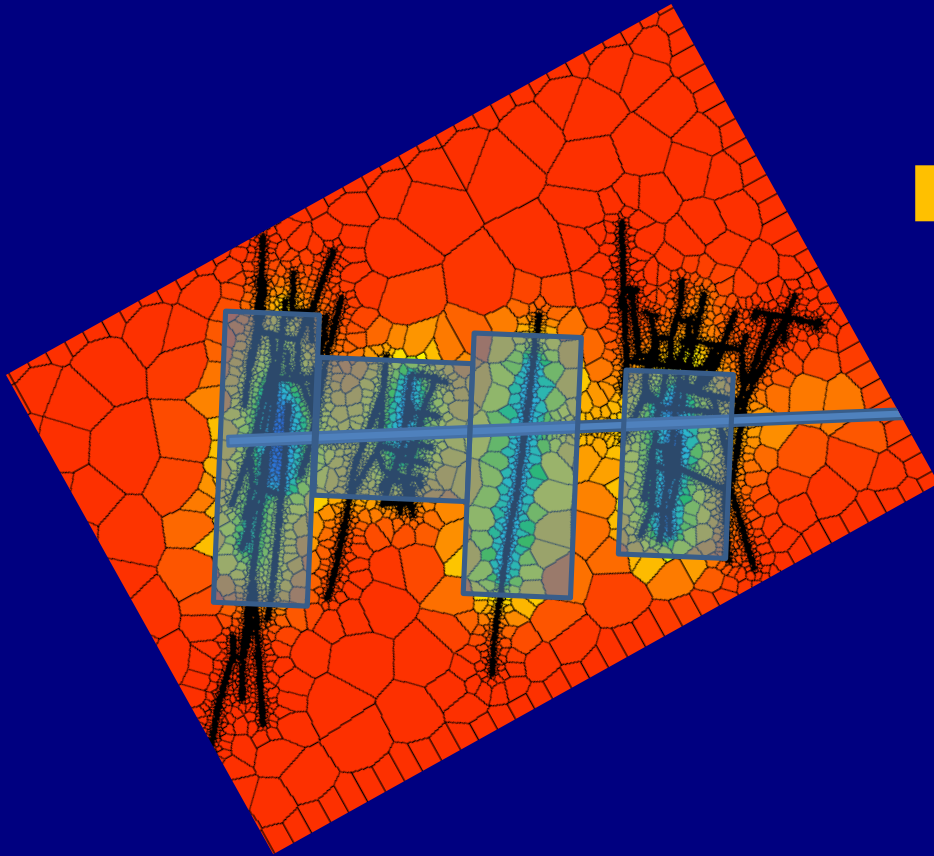
Reservoir Simulation



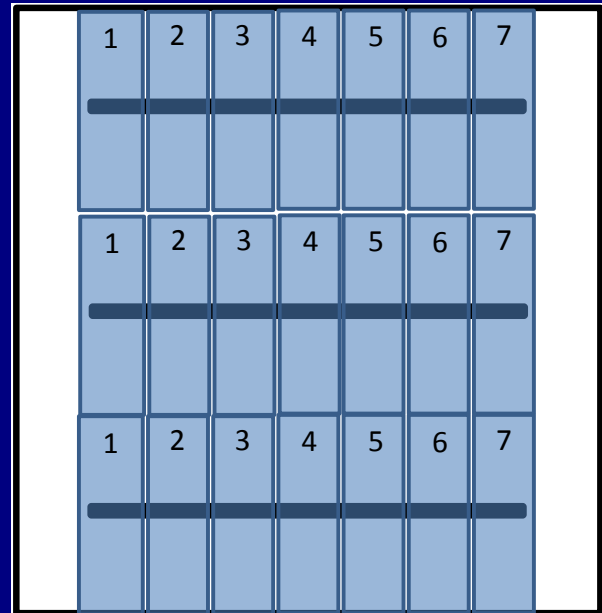
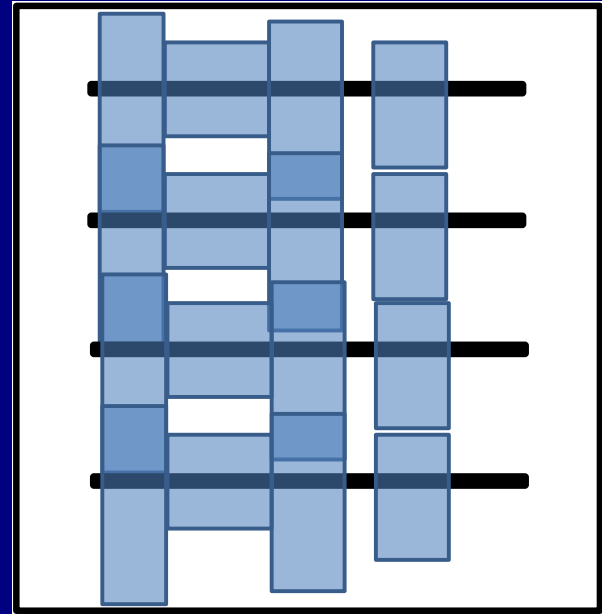
Production Forecast 20 Years



Reservoir Drainage



Optimized Fracturing
More stages smaller
proppant, more proppant



Conclusions

Evolving geomechanical interpretation tools
key to realize the full value from microseismic

- Microseismic demonstrated complex fracture networks
- Microseismic volume oversimplification
- Microseismic calibration of complex geomechanical fracture model
 - Enables reservoir simulation of well performance
 - Estimates effective propped network

Questions?

