MicroSeismic
Passive Monitoring, Active Listening

Eyes On The Prize – what microseismic monitoring is telling us about completions in unconventional reservoirs.

Peter M Duncan

Buenos Aires

Oct 23, 2017

1,500,000 HOURS
WITHOUT A LOST TIME INCIDENT

SPE International
Society of Petroleum Engineers
Argentine Petroleum Section

MicroSeismic
Passive Monitoring, Active Listening

Outline

- What is microseismic monitoring
- How are the data acquired
- How are the data analyzed
- How are the data used
- Some case histories
- Summary

Tapping the Shale Resources

Source: Whiting Petroleum

Frac Spread

Where Some Would Like To See All Frac Spreads!

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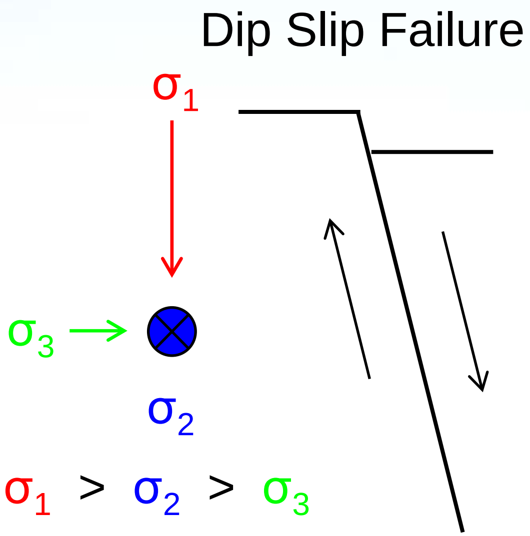
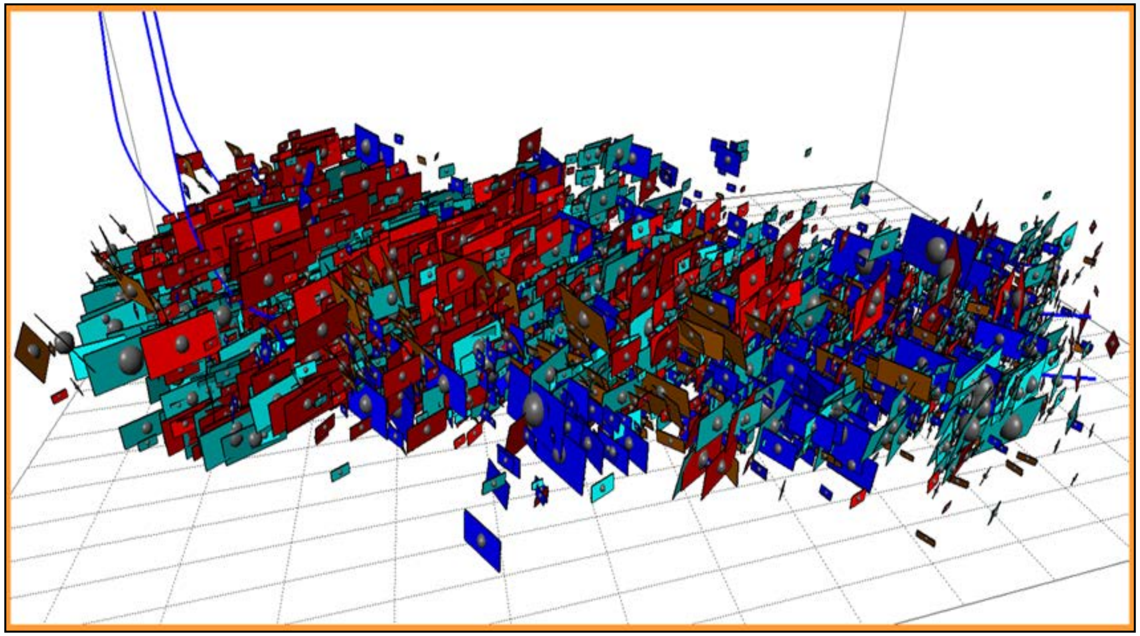
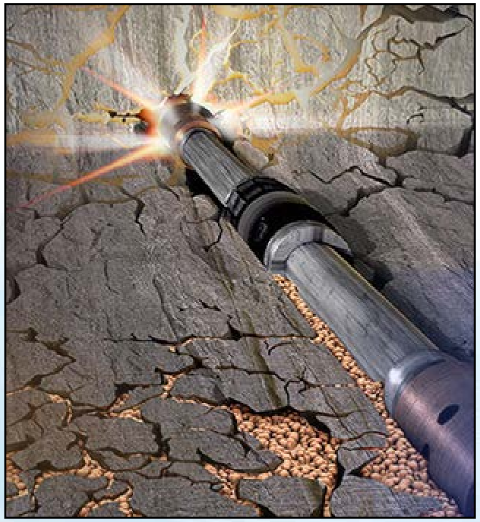
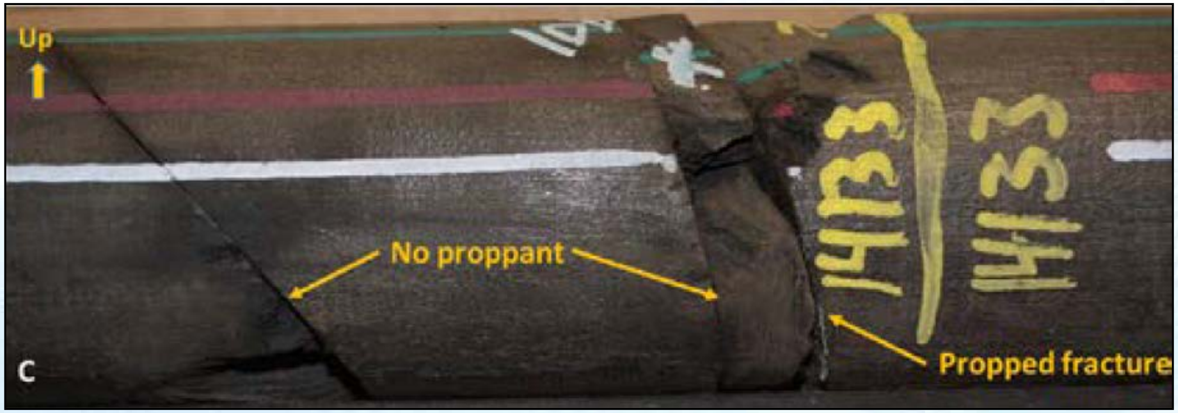
What Happens When You Frac?



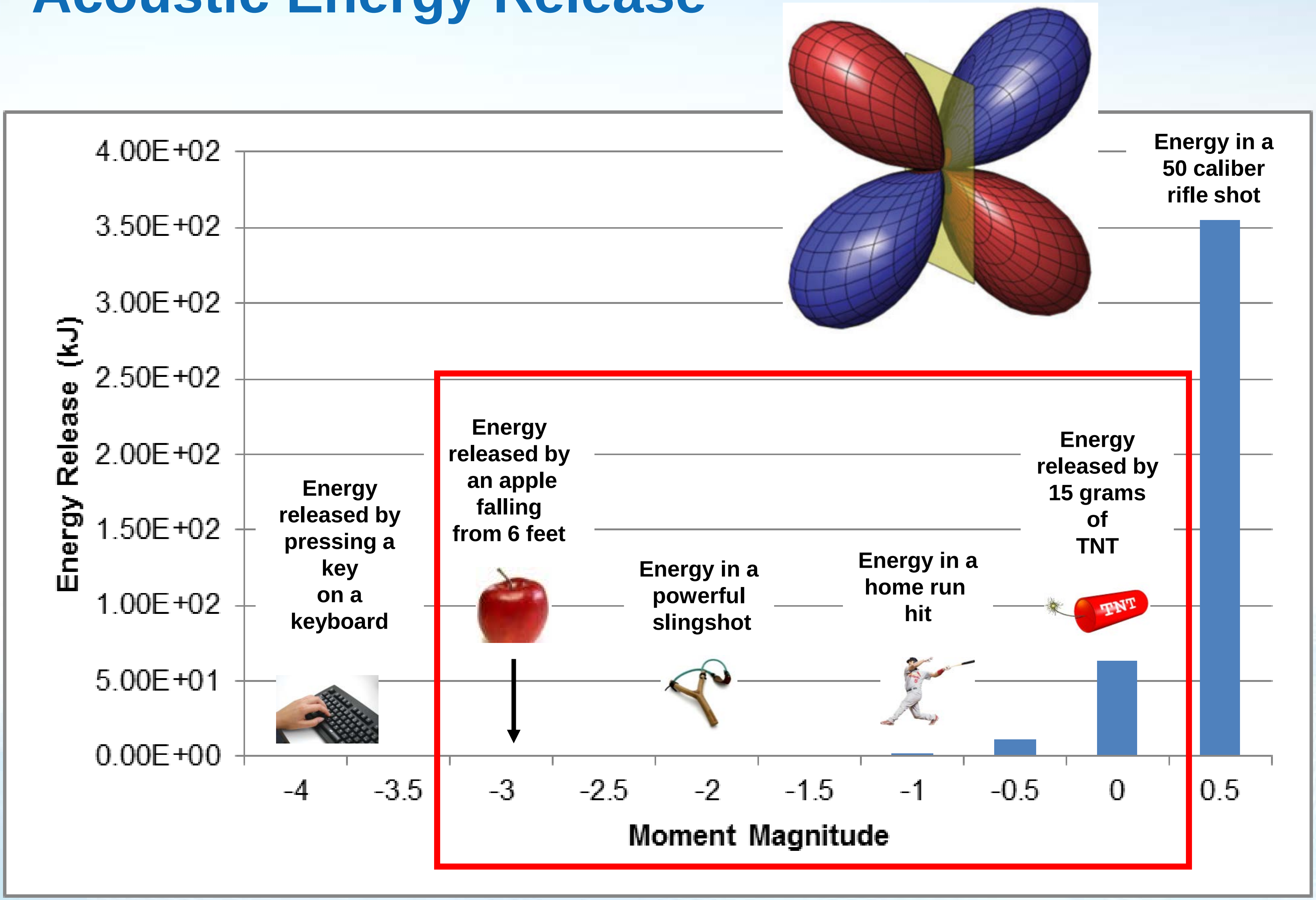




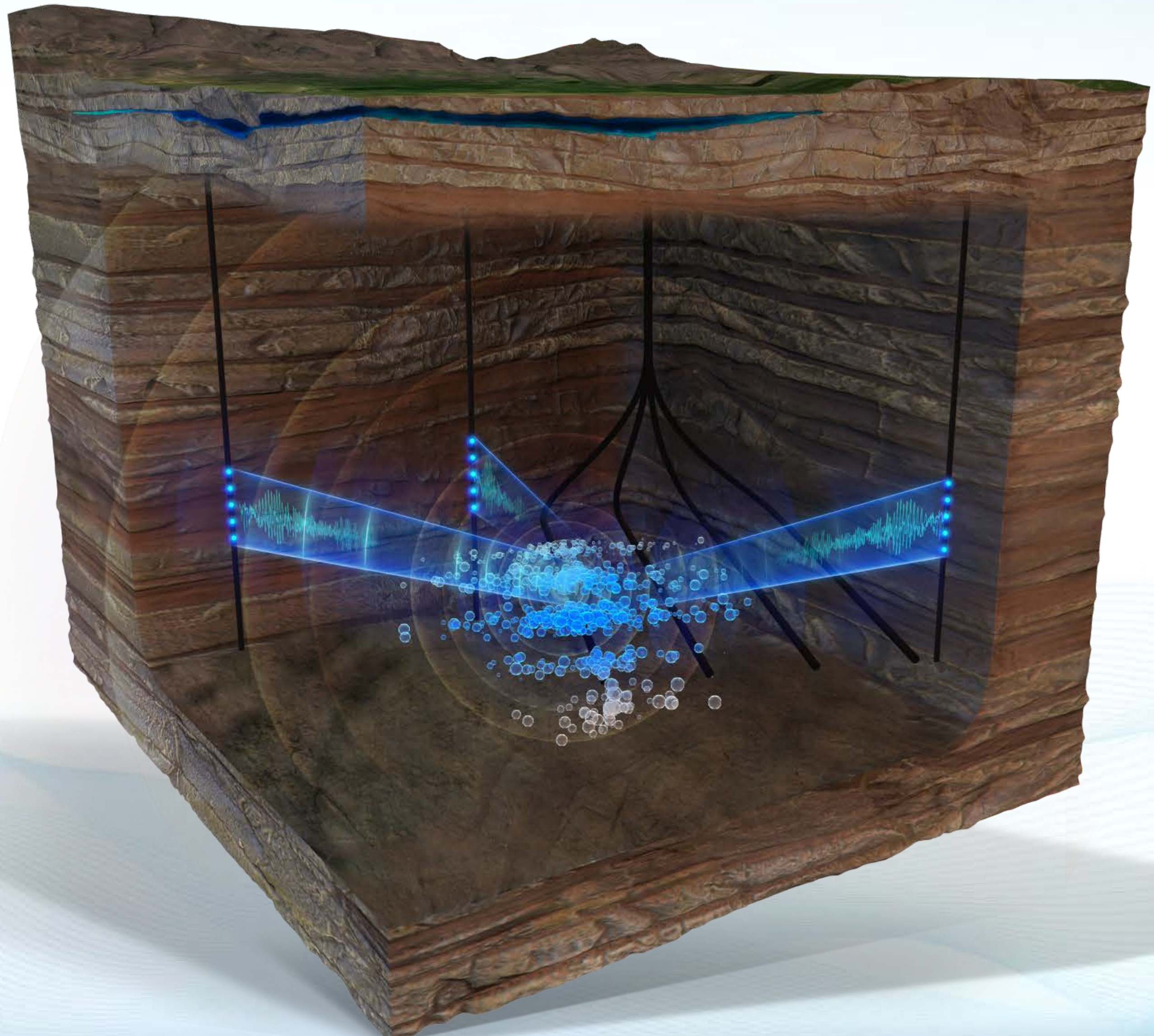


Source: URTeC 2670034

Acoustic Energy Release



Data Acquisition: Downhole



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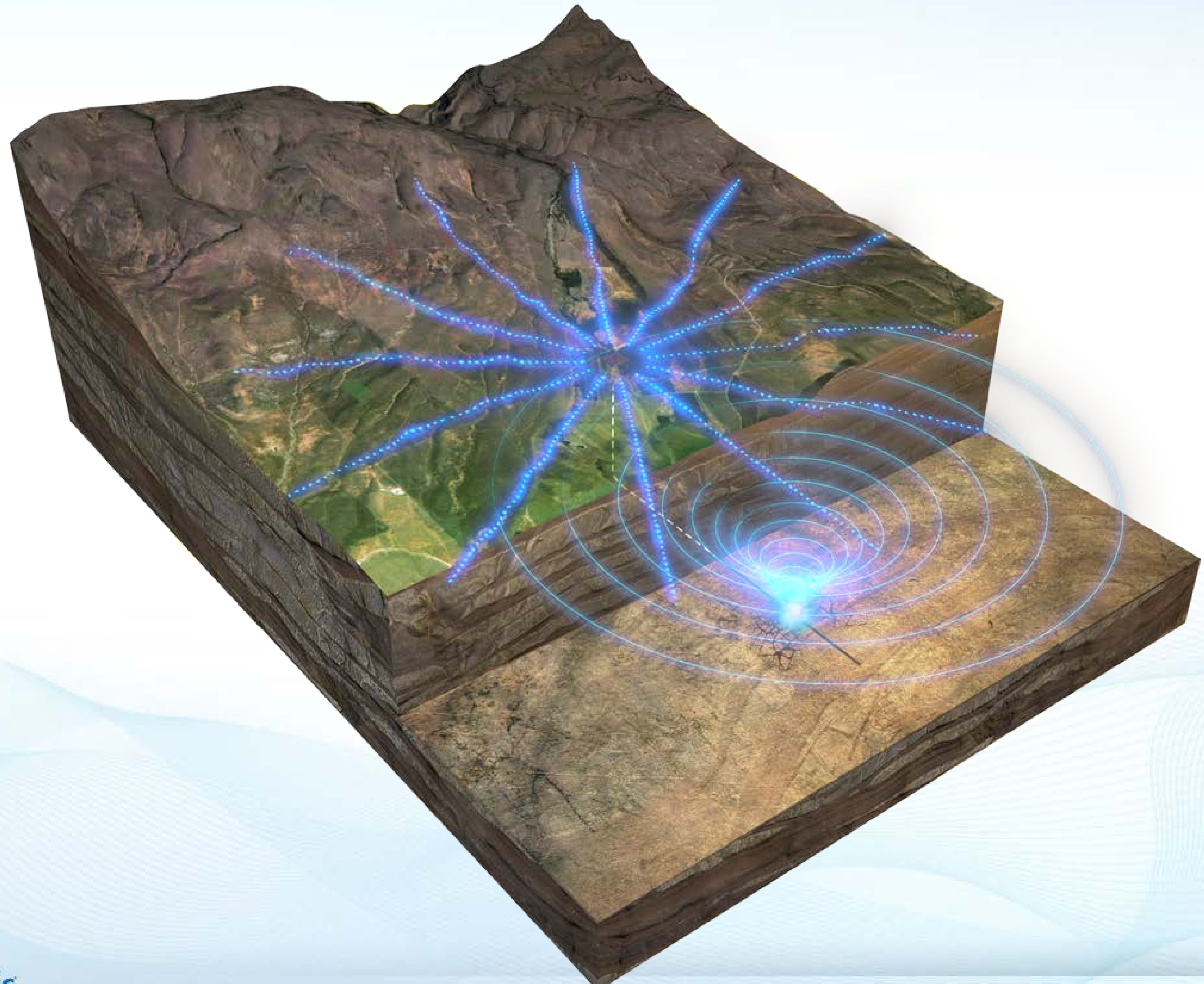
Data Acquisition: Surface



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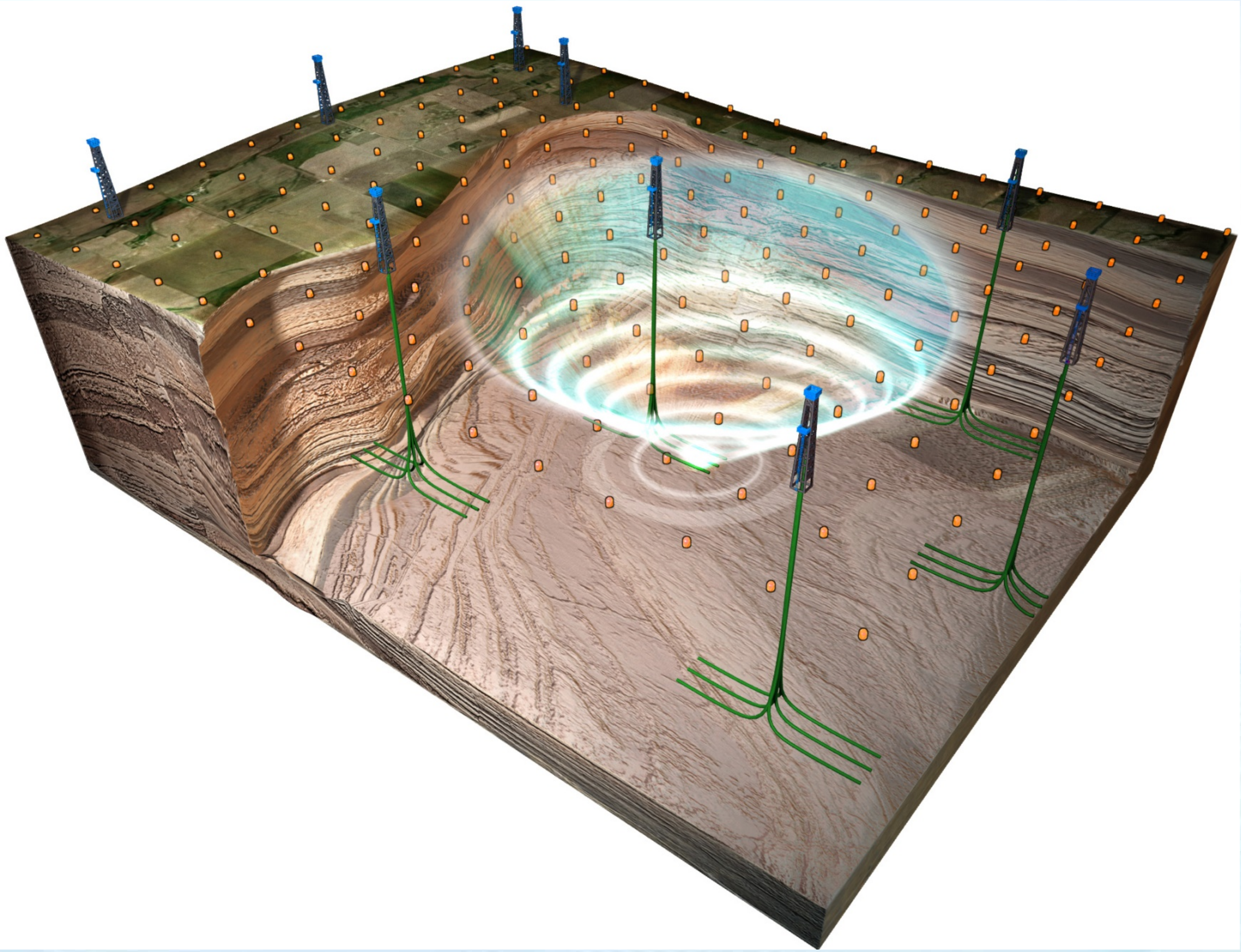
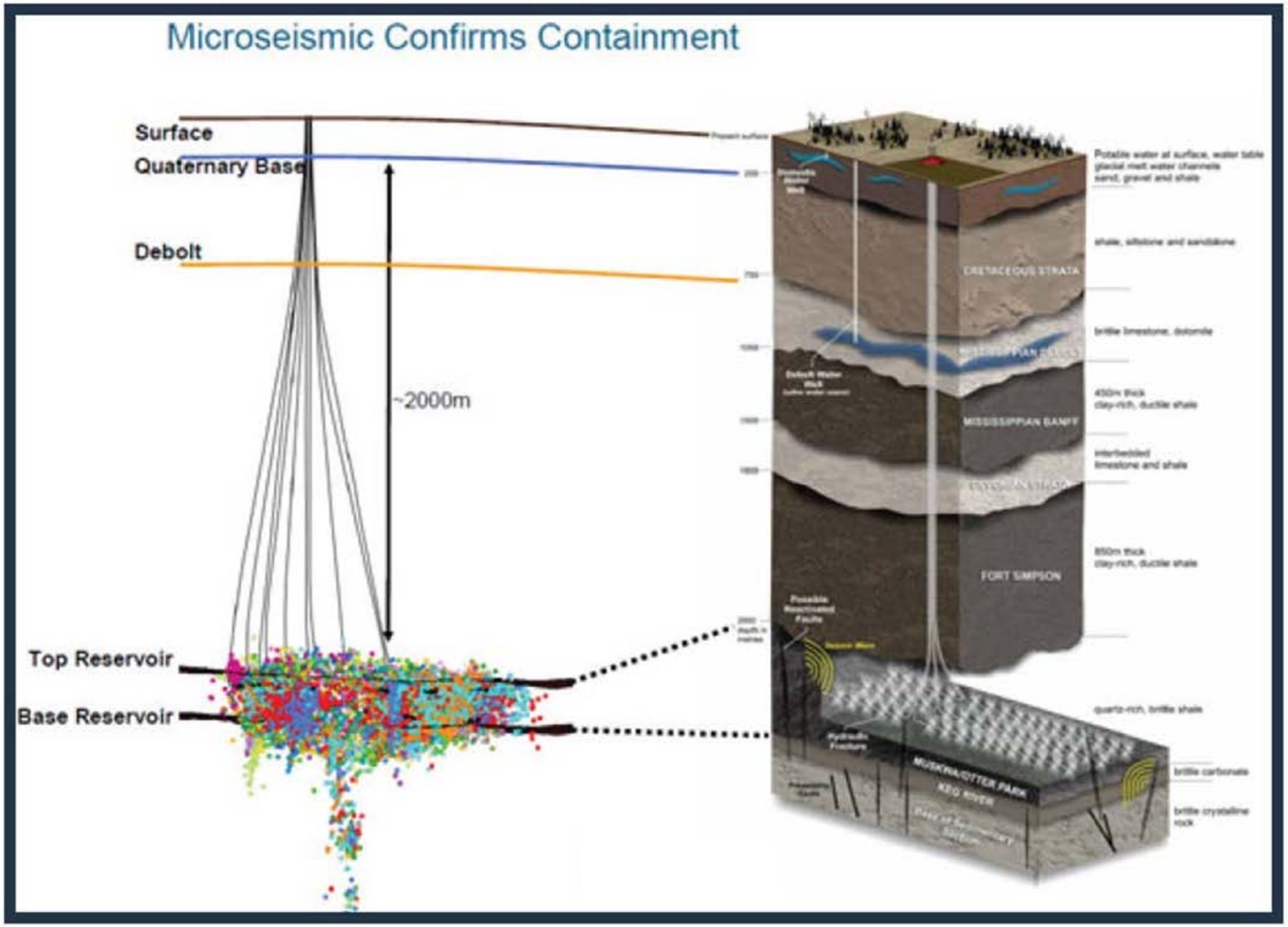
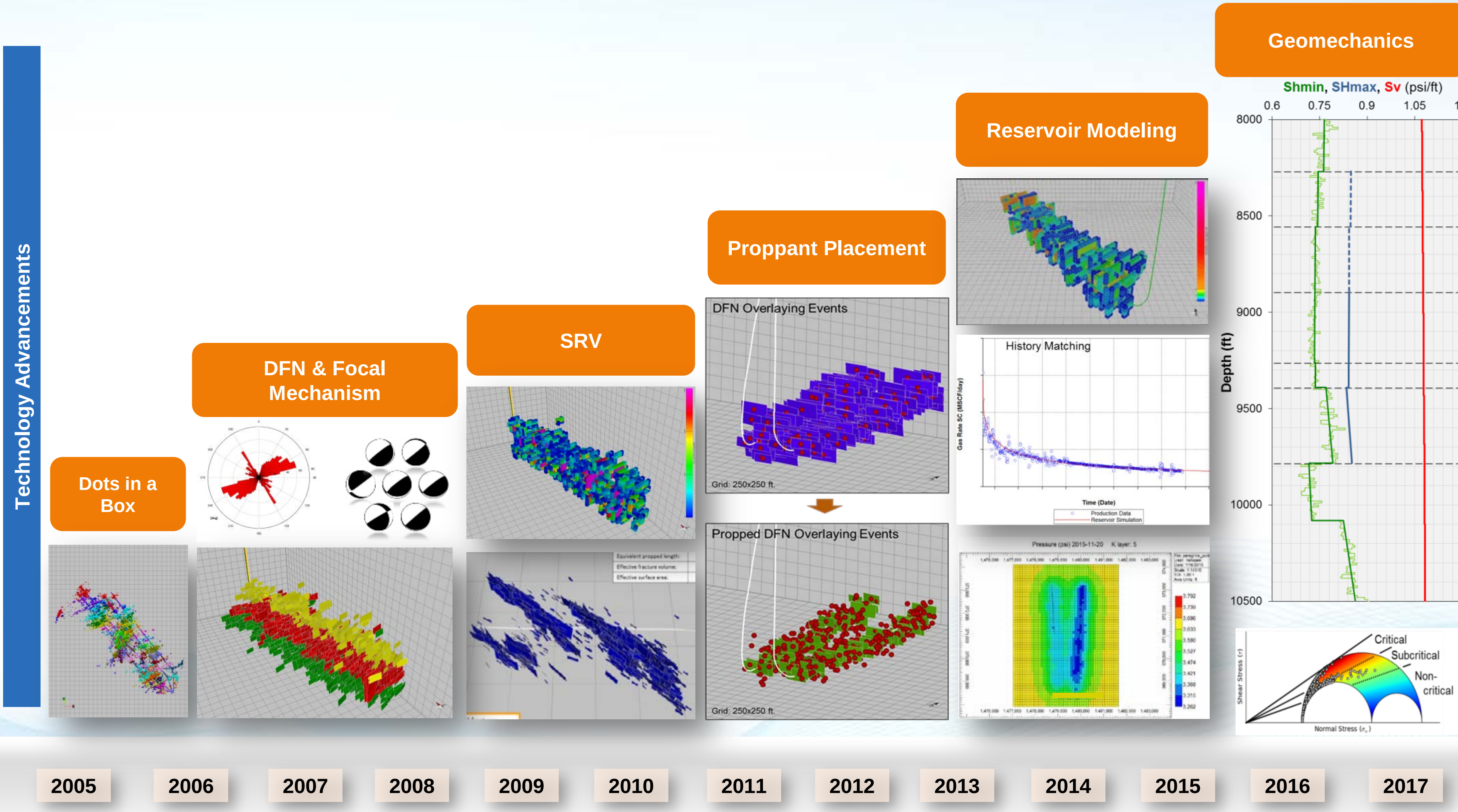
Data Acquisition: Near Surface



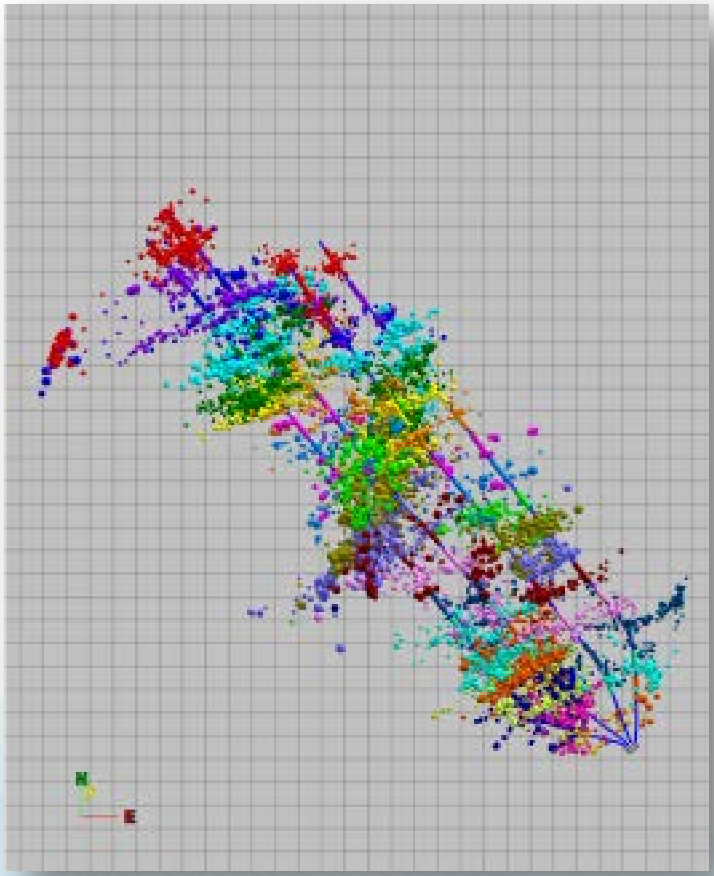
What We See


Microseismic Confirms Containment
Surface
Quaternary Base
Debolt
~2000m
Top Reservoir
Base Reservoir
CRETACEOUS STRATA
MISSISSIPPIAN BANFF
FORT SIMPSON

Complete MicroSeismic Analysis

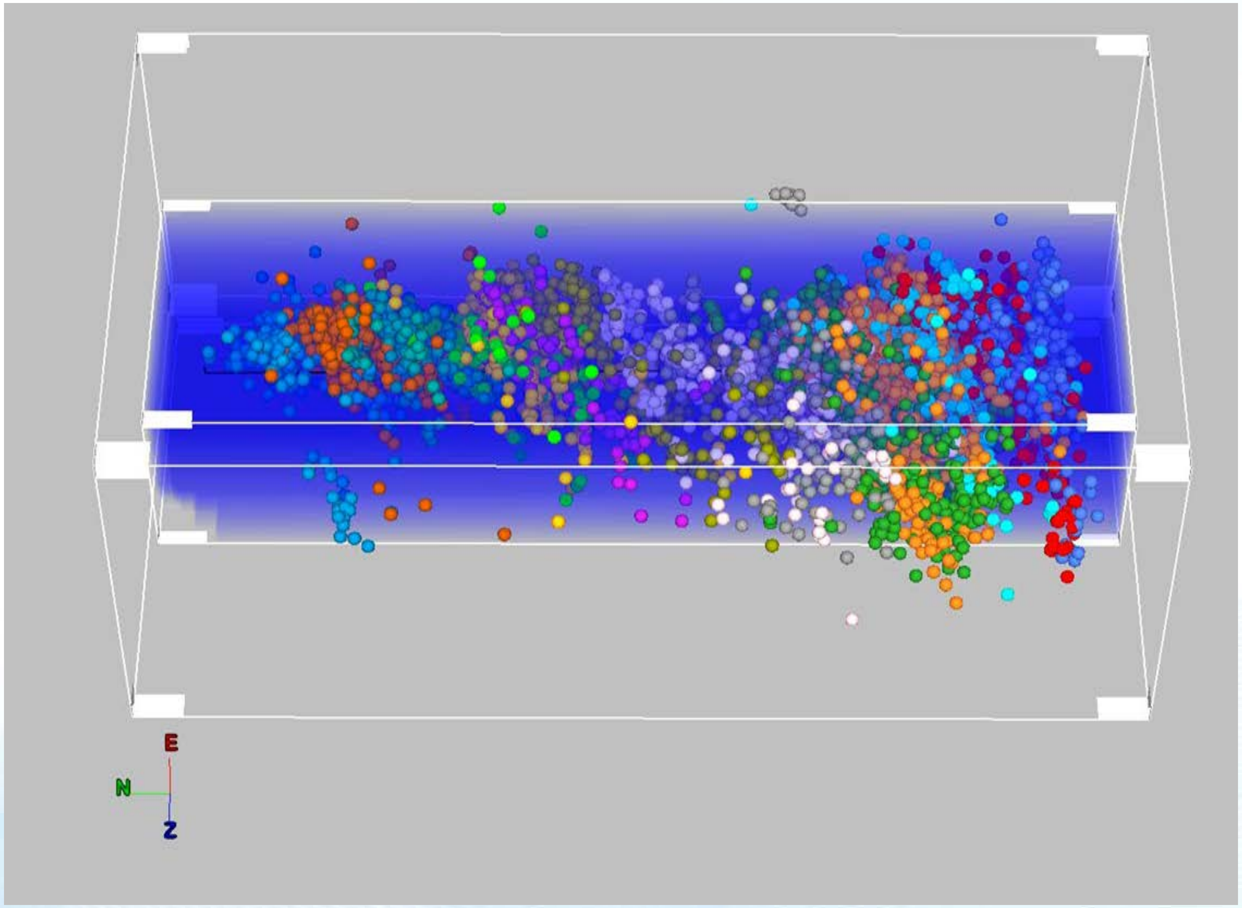


Dots in a Box



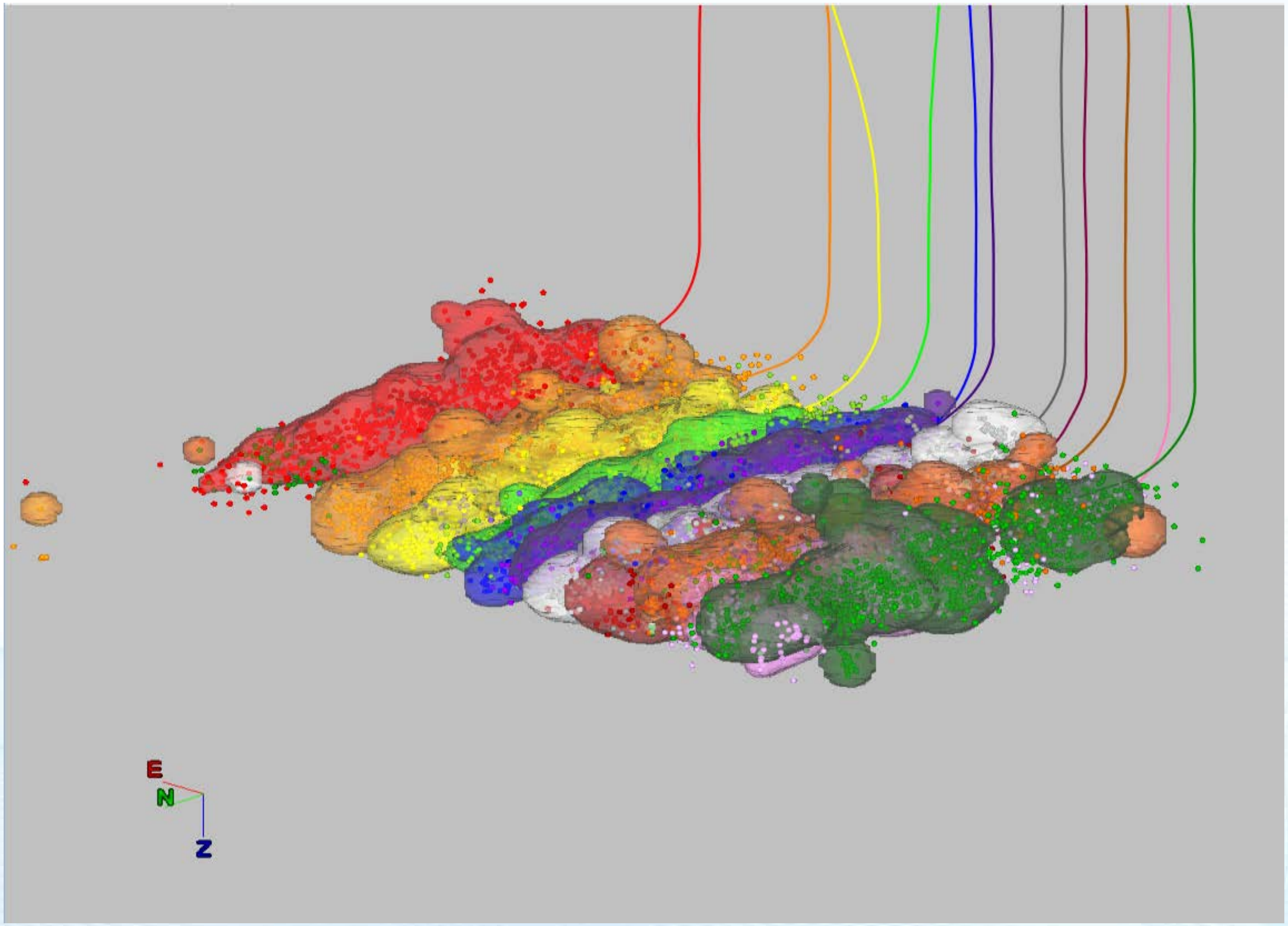
- Mechanical failures
- Geologic failures
- Gross geometry
- Gross efficiency

Dots in a Box – SRV?



- Average Length
- Stimulated Rock Volume

Shrink Wrap - SRV? Well Spacing?



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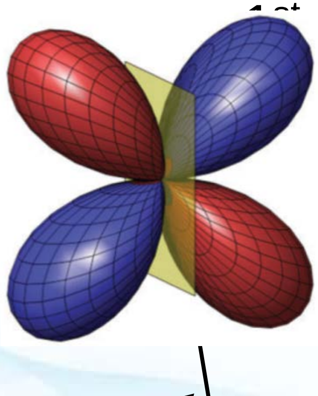
Beyond Dots in a Box

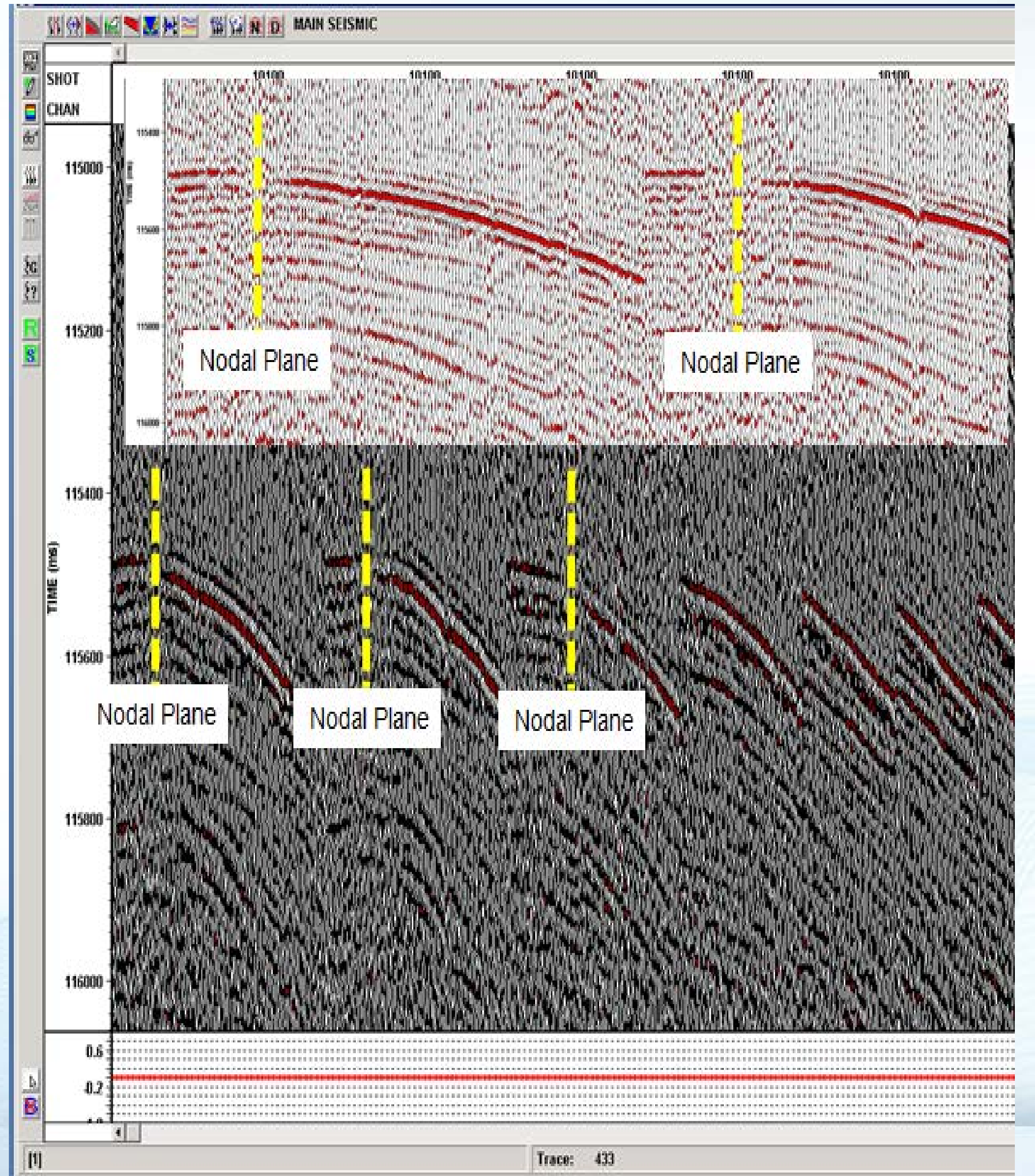
Response on FracStar or Buried Array

1st motion positive

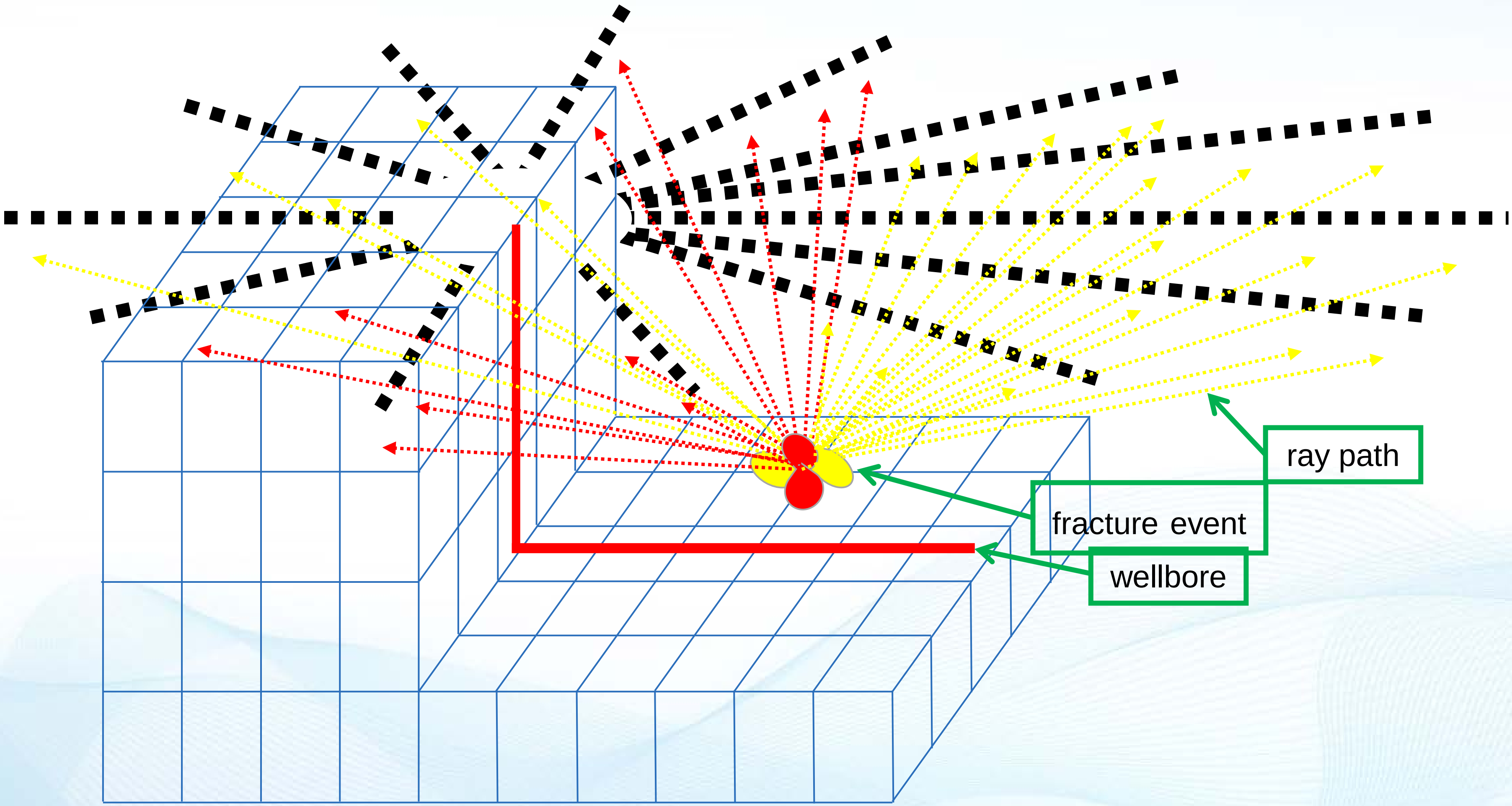
1st motion negative



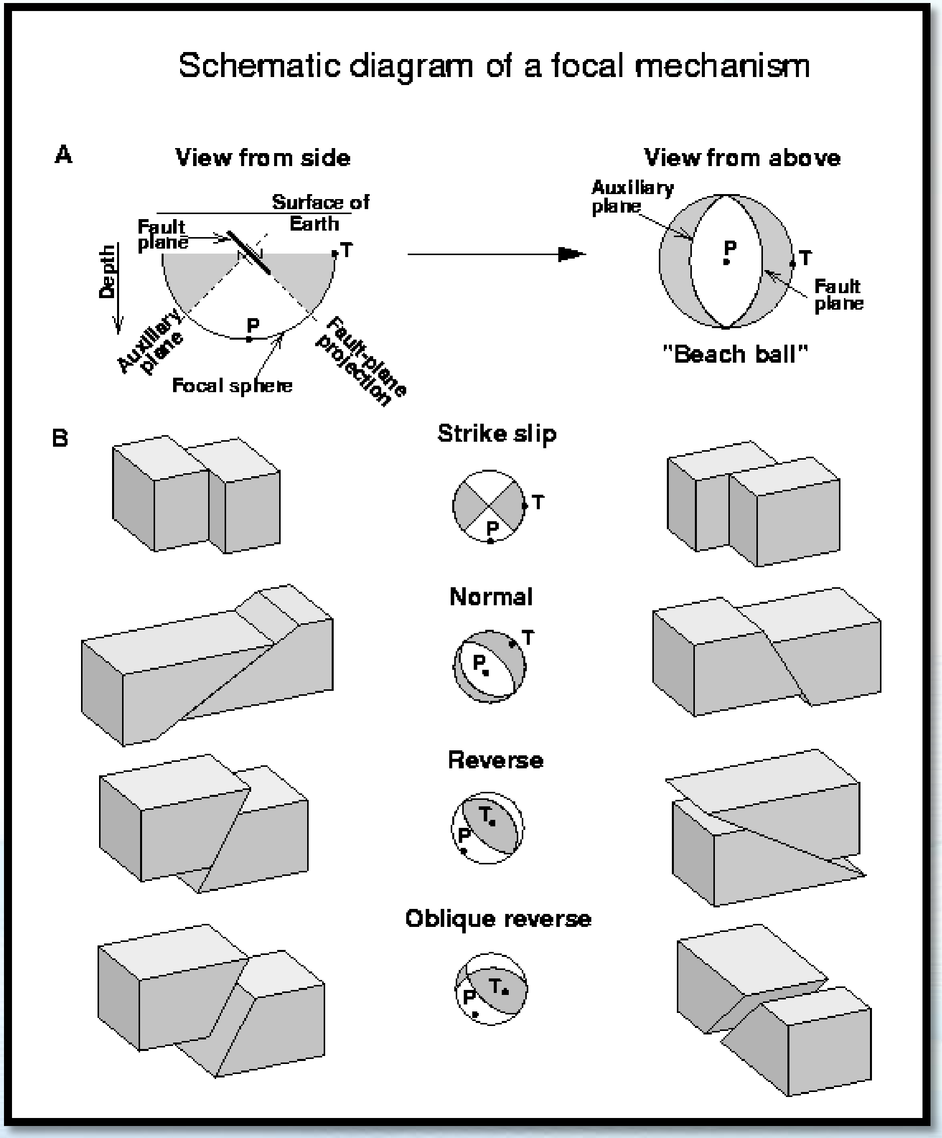
Blind normal fault in reservoir



Focal Sphere Capture

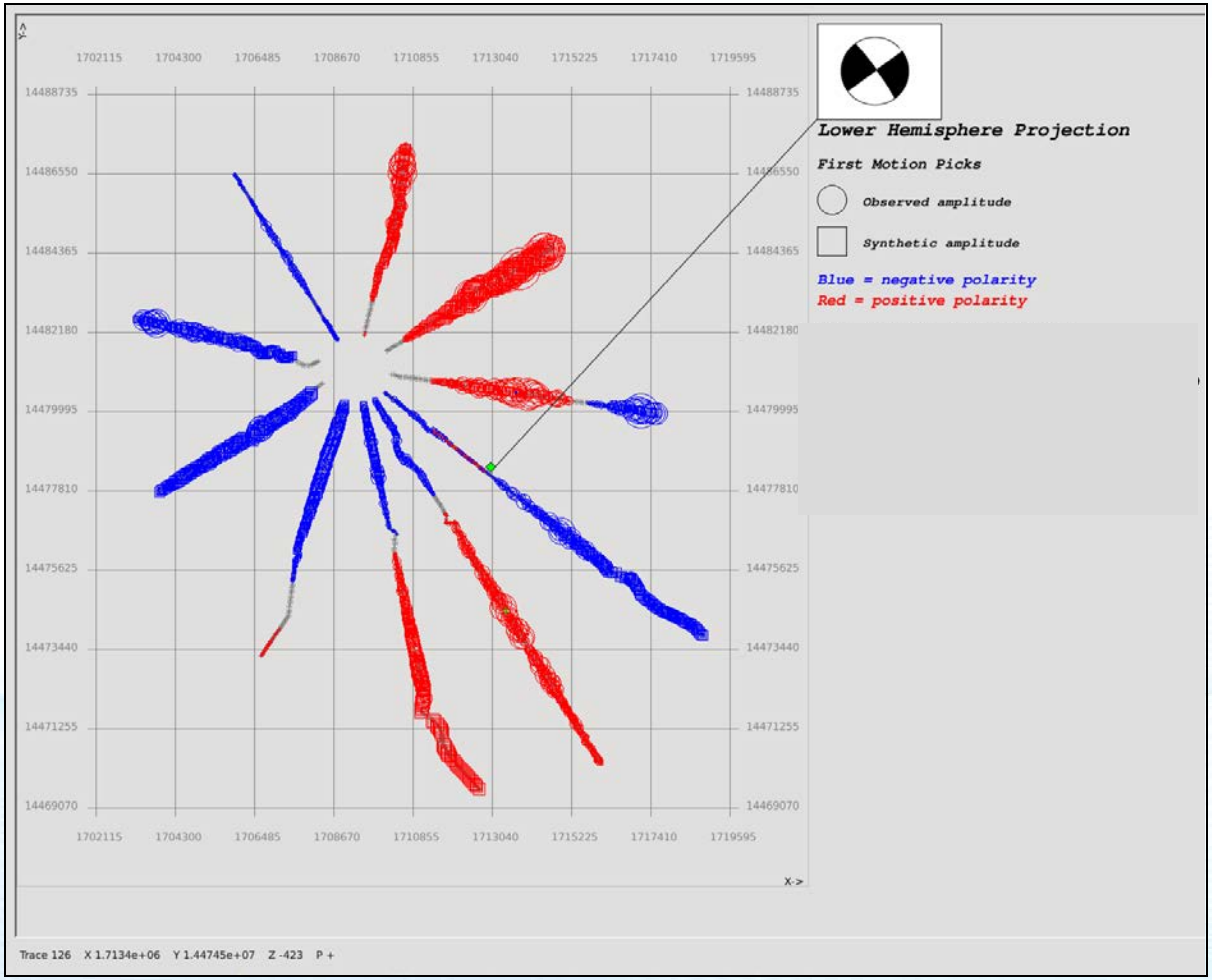


Shear Faults and Beach Balls

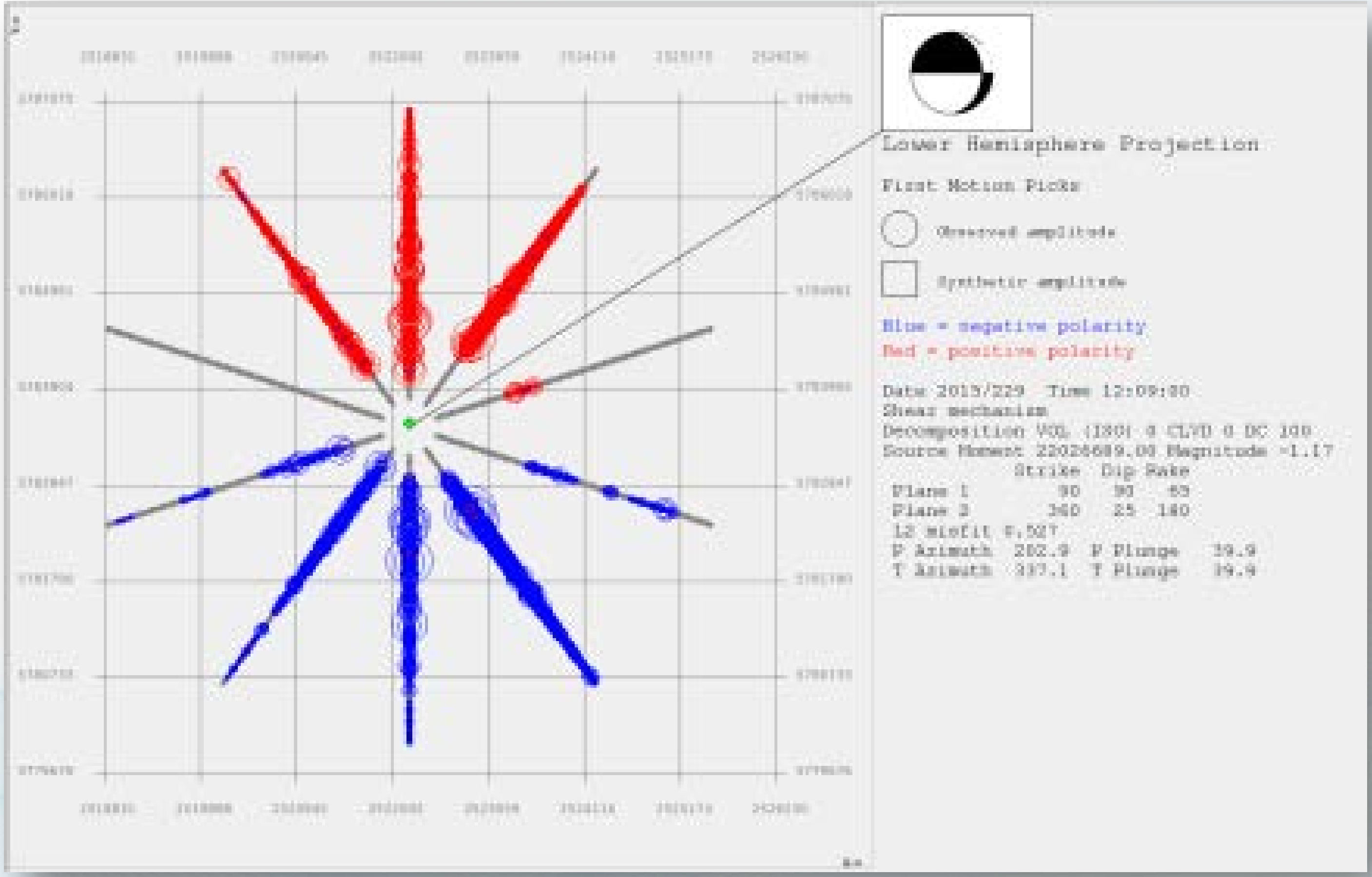


Focal Mechanism – not just where and when but how

Surface array enables – requires – a focal mechanism determination.
Knowing the focal mechanism enables a deeper analysis.



Moment Tensor Estimation



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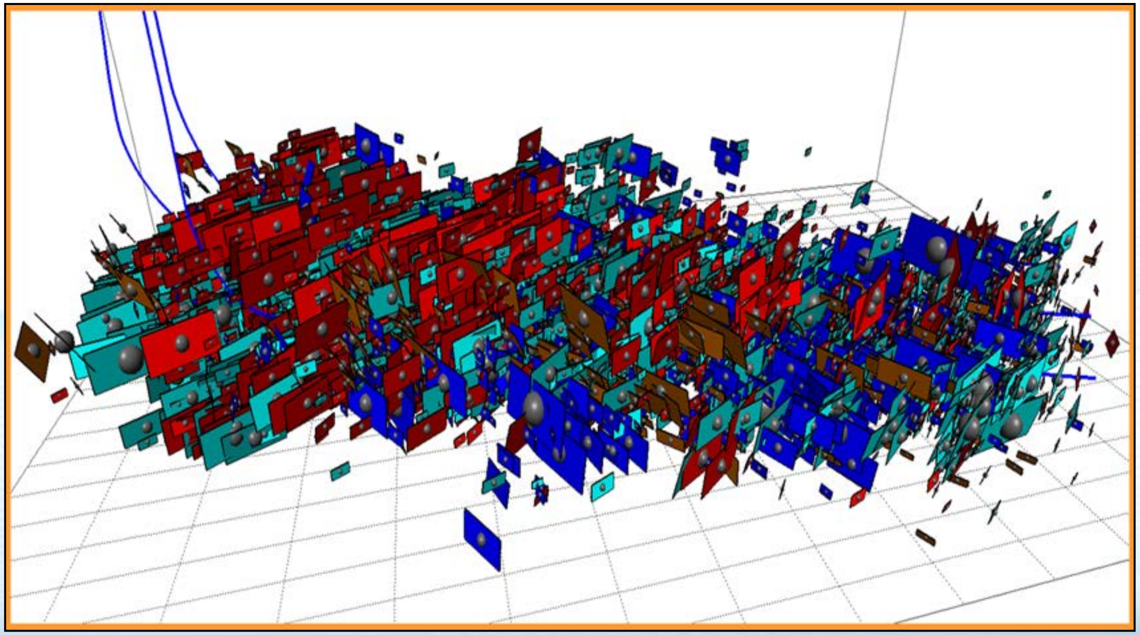
Moment Tensor Solution

A moment tensor solution enables 2 improvements to our microseismic analysis:

- A better geologic model
- A mapping of the insitu stress field



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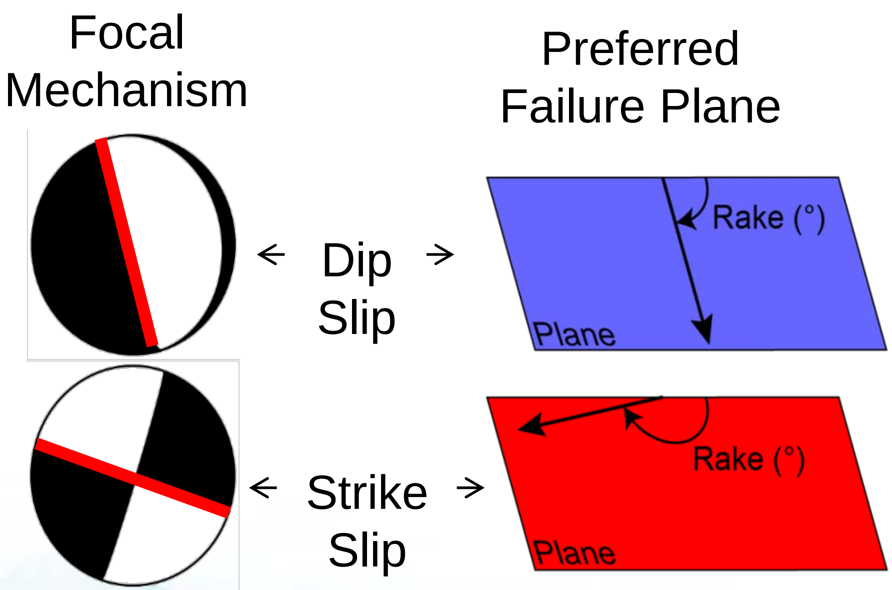
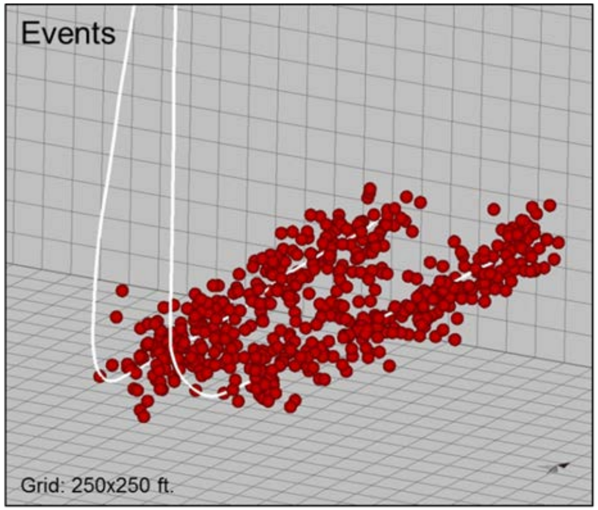
Focal Mechanism to DFN Model

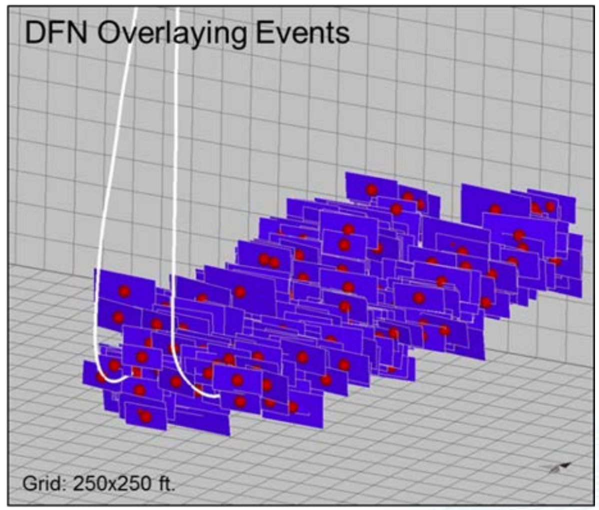


- Every event has a mechanism
- Equivalent energy fault model
- A more useful geologic model
- Enables further analyses:
  - permeabilty mapping
  - production prediction

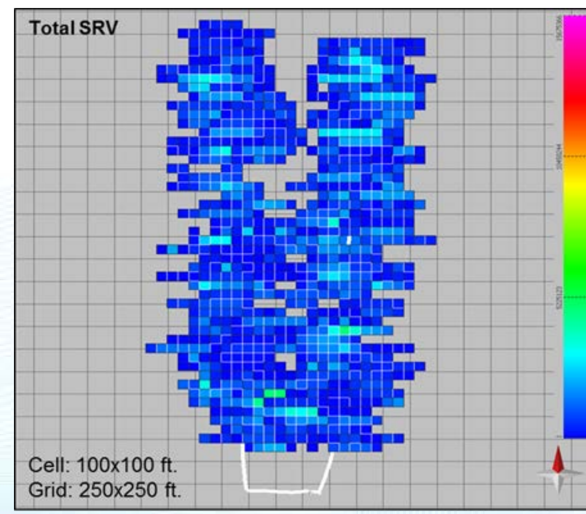
Discrete Fracture Network and SRV Modeling



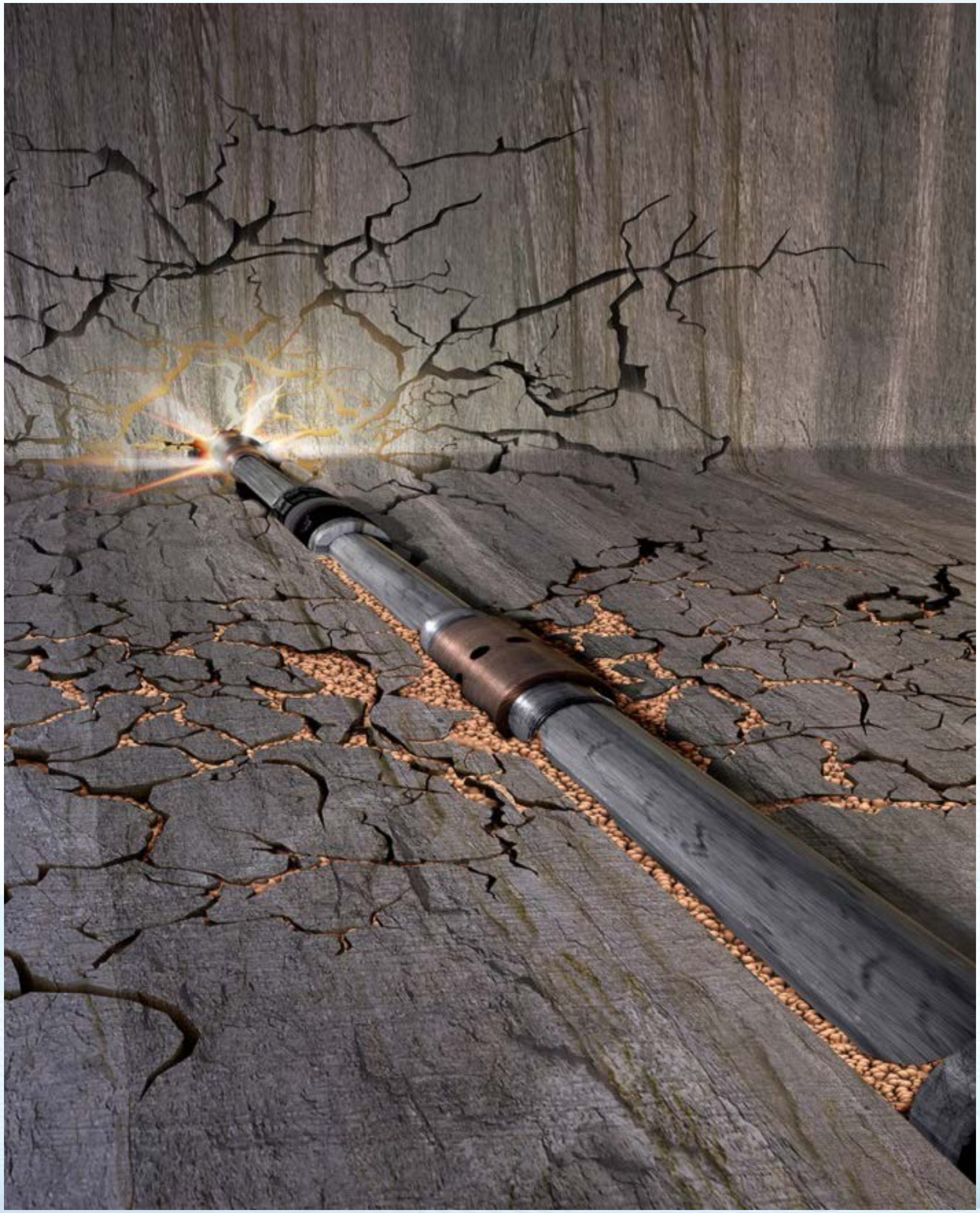
One fracture is modeled per microseismic event.



Individual fracture orientation is determined by focal mechanism, and the size is determined from event's seismic moment, rock rigidity, and injected fluid volume.

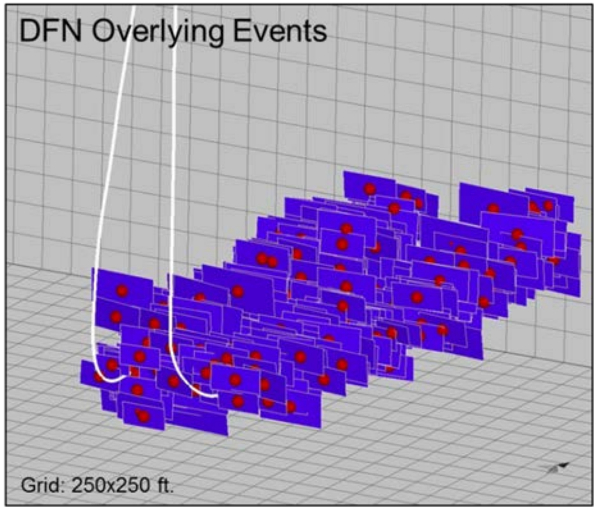


But Only the Propped Fractures Produce

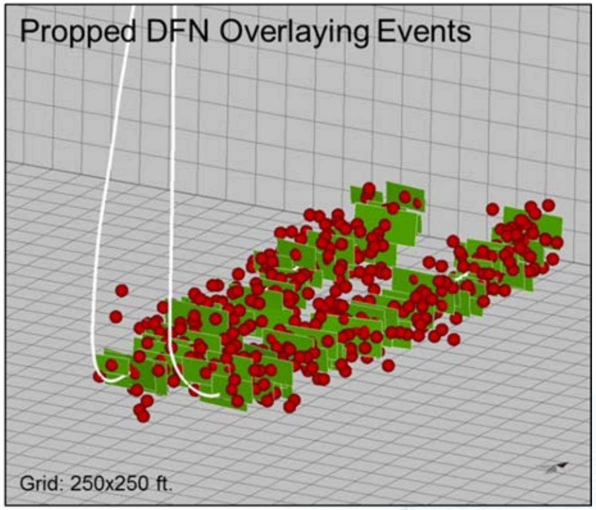


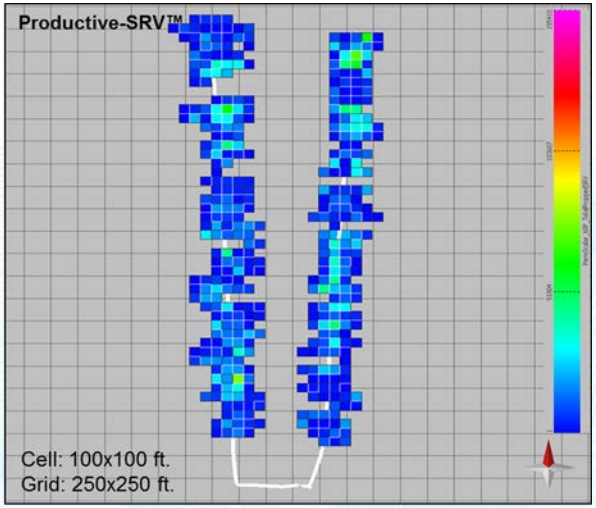
Where is the Proppant ?

P-DFN and P-SRV

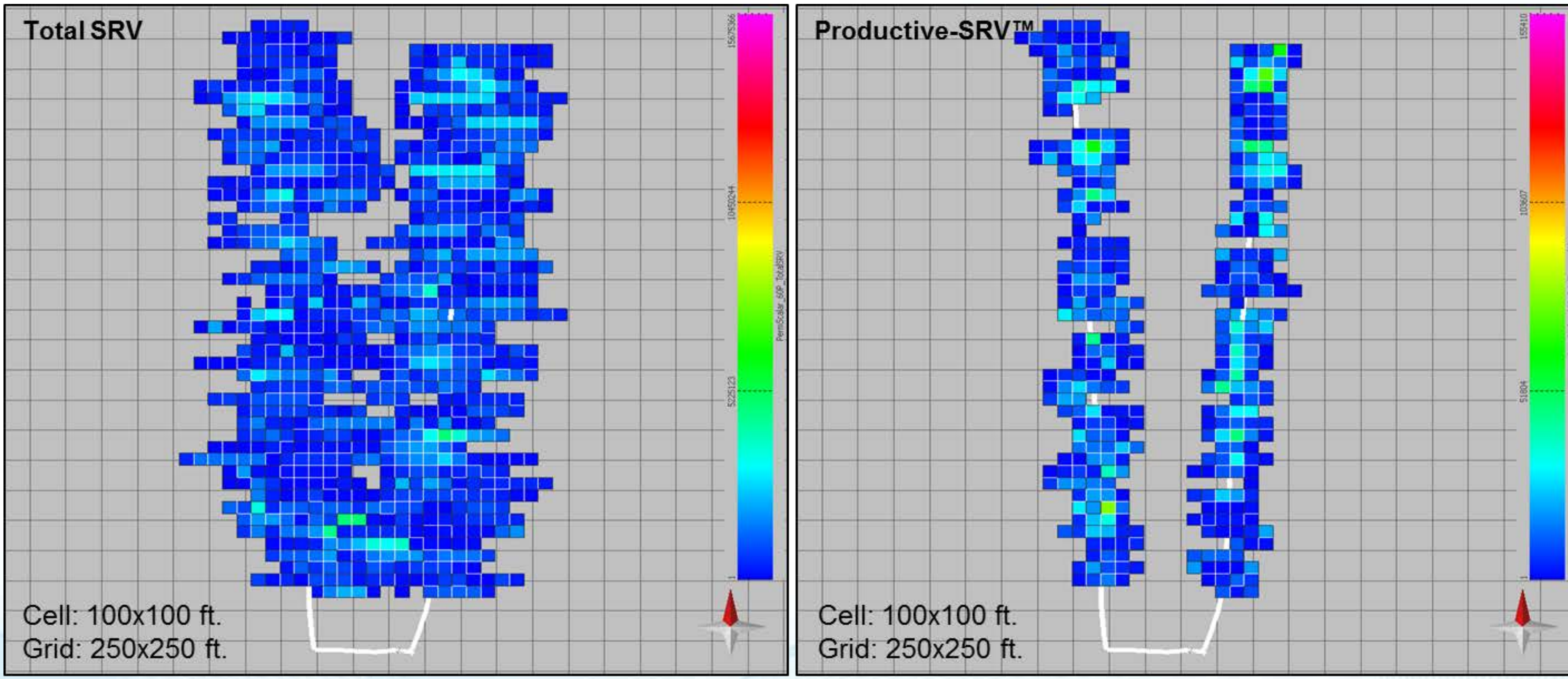


Modeled fractures are filled with proppant from the stage centers outwards on a stage-by-stage basis.

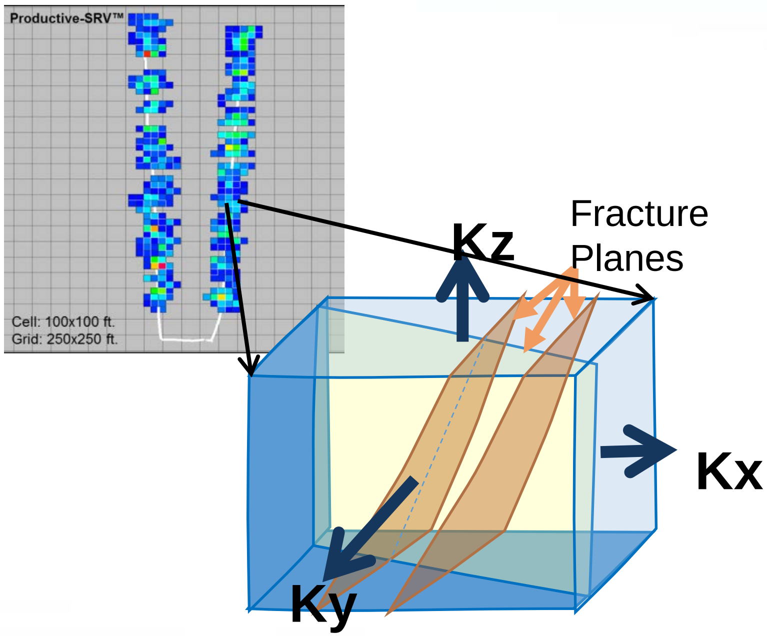


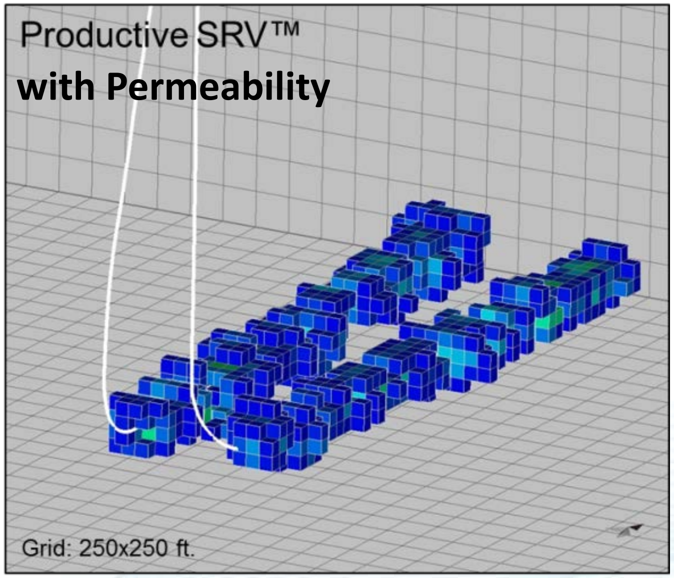


Stimulated and Productive Rock Volume



Translating Fracture Intensity to Unscaled Permeability





Compute Permeability Tensor based on:

1. Number of fractures
2. Orientation of fractures
3. Aperture of fractures

(Oda, 1986)

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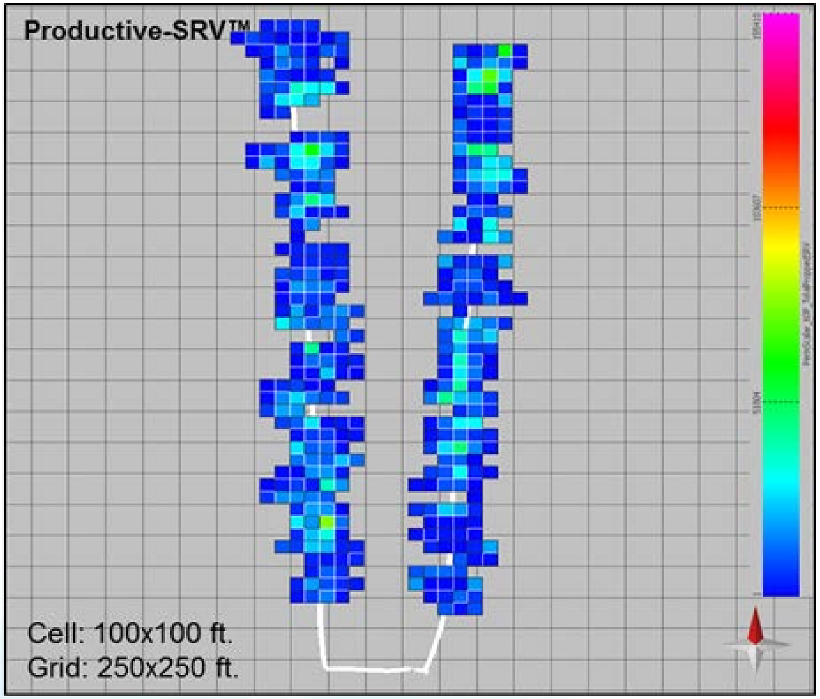
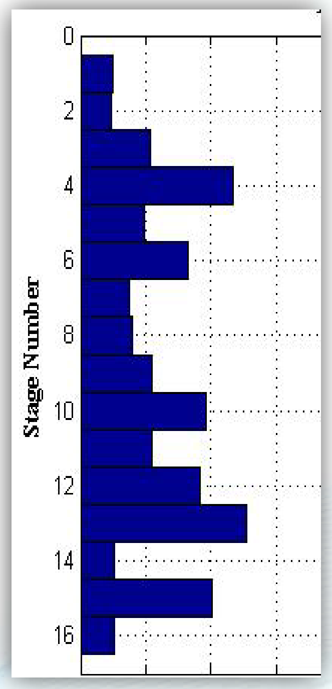
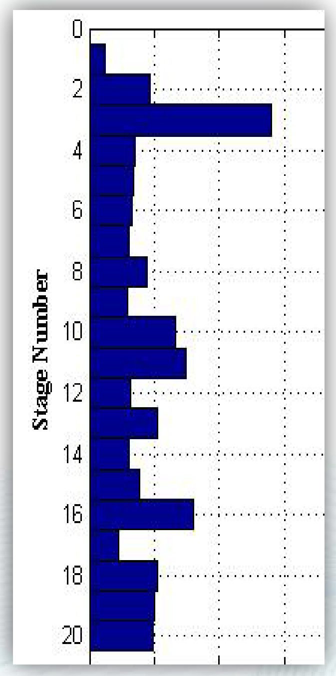
Stimulated and Productive Rock Volume with Fracture Intensity Permeability (PermIndex^{TM})



PermIndex^{TM}

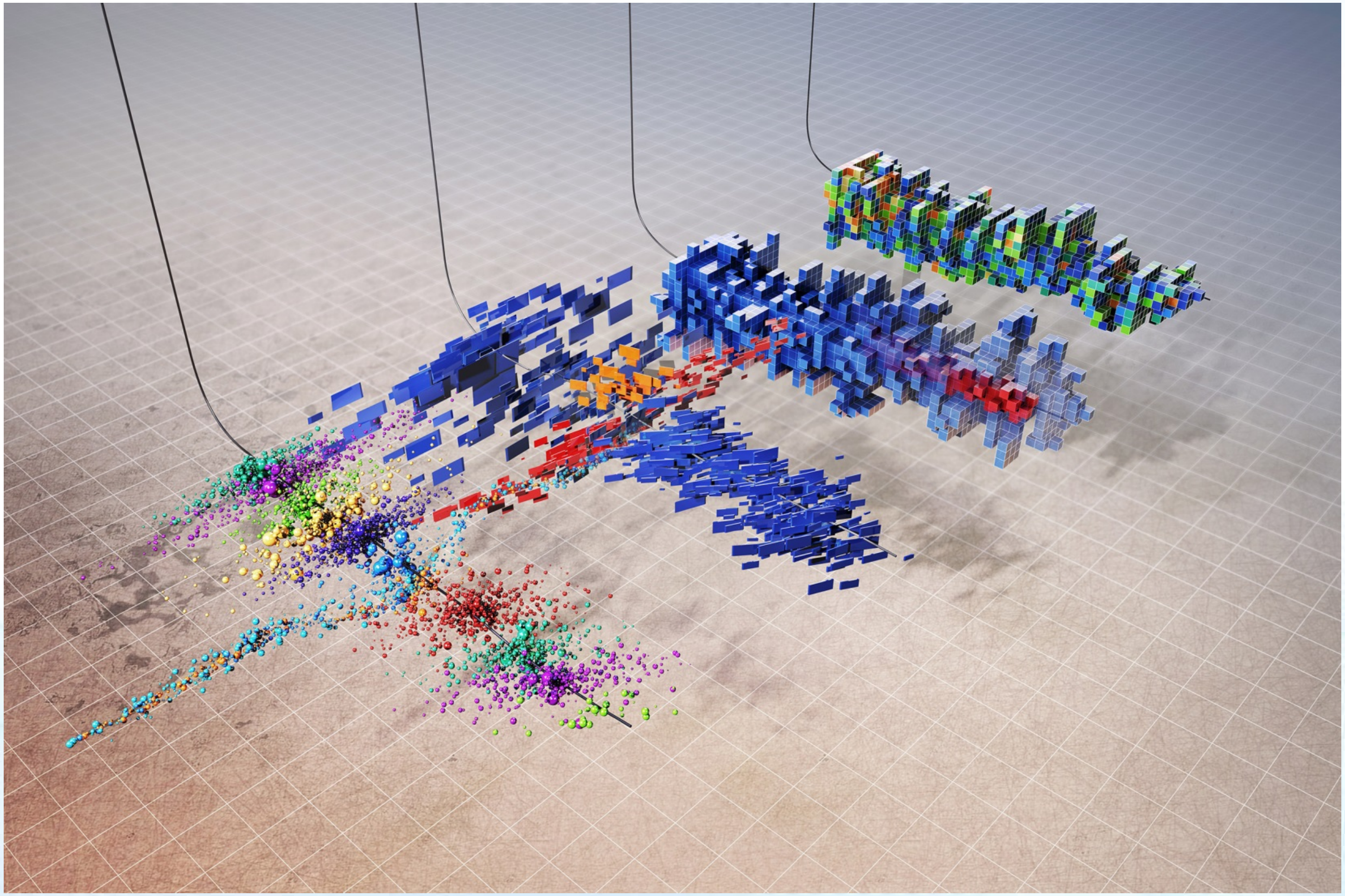


PI(A): 78



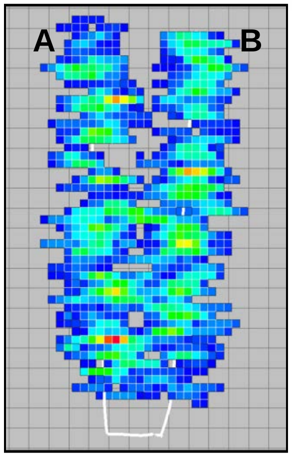
PI(B) : 72

An Evolution of Mapping the Stimulation

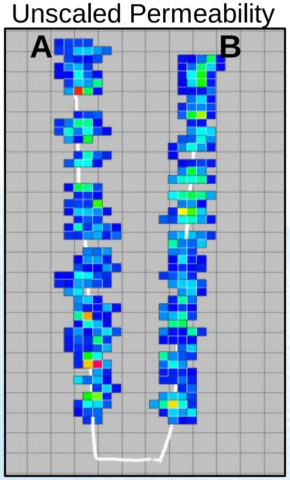


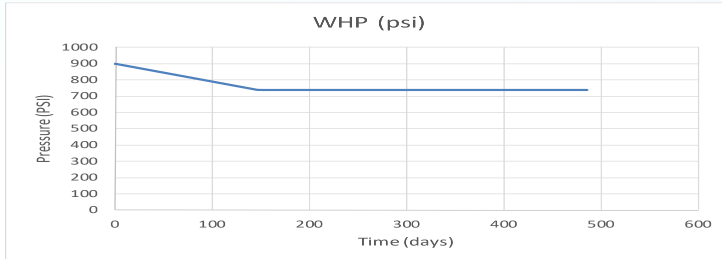
PIndex – Comparative Well Production / Decline

SRV
Unscaled Permeabililty

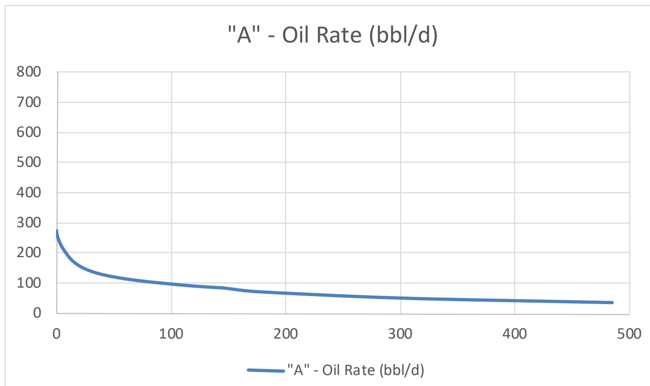


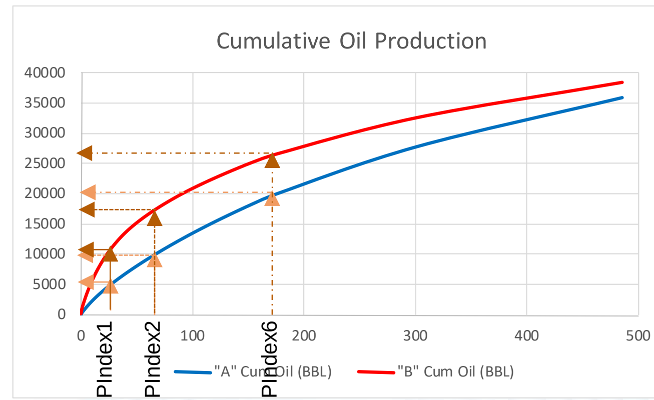
P-SRV
Unscaled Permeability

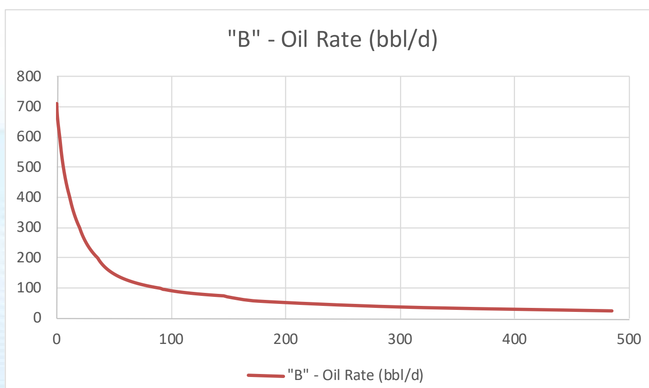


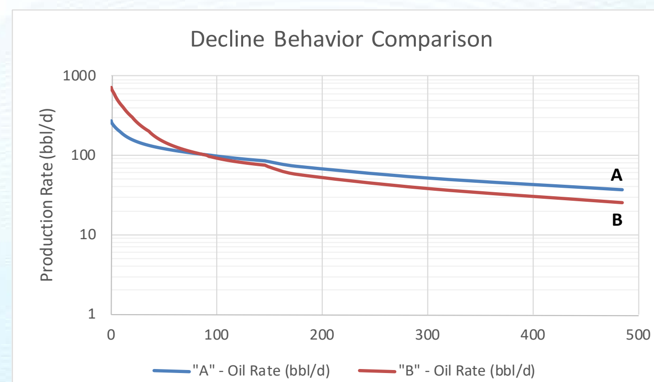


- Porosity
- Saturation
- PVT data









Help Design Appropriate WHP (Drawdown) to maximize production

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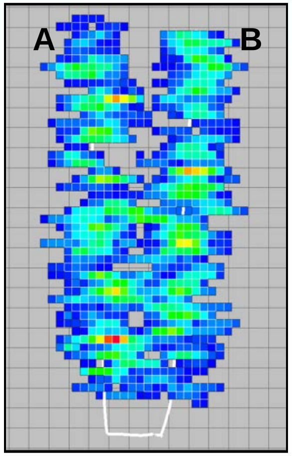
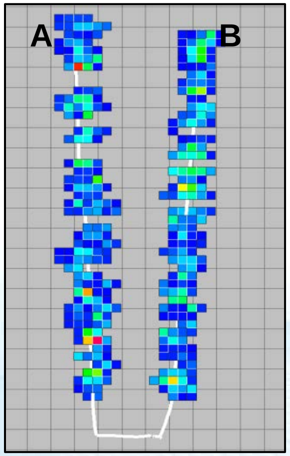
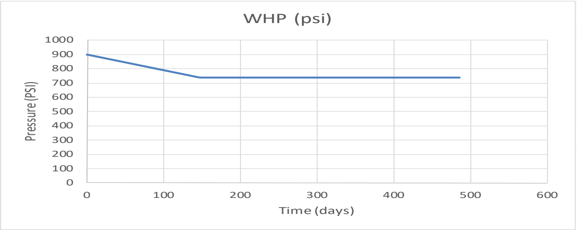
DIndex – Pressure Depletion Mapping

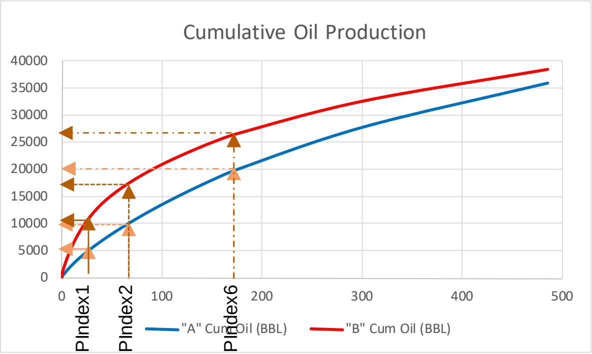
SRV

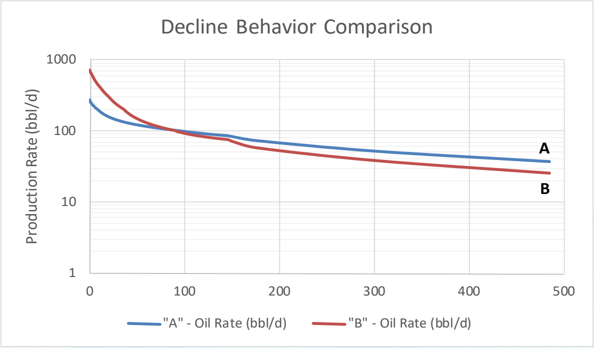


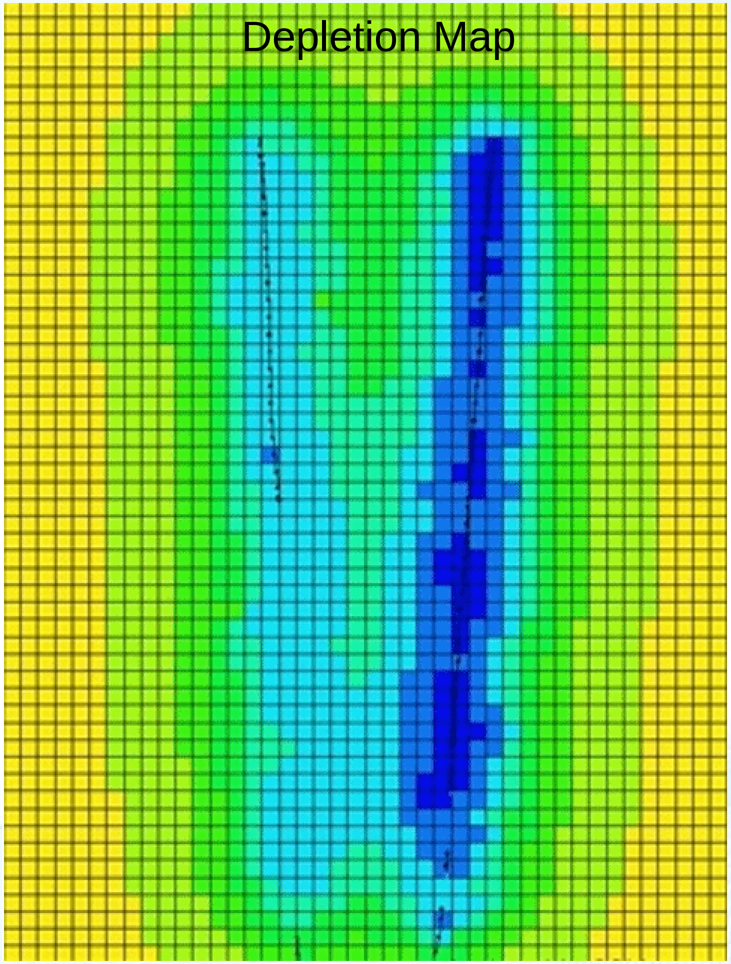
P-SRV











PermIndex^{TM} PIndex WSIndex

Accelerate Well Spacing decisions to maximize recovery

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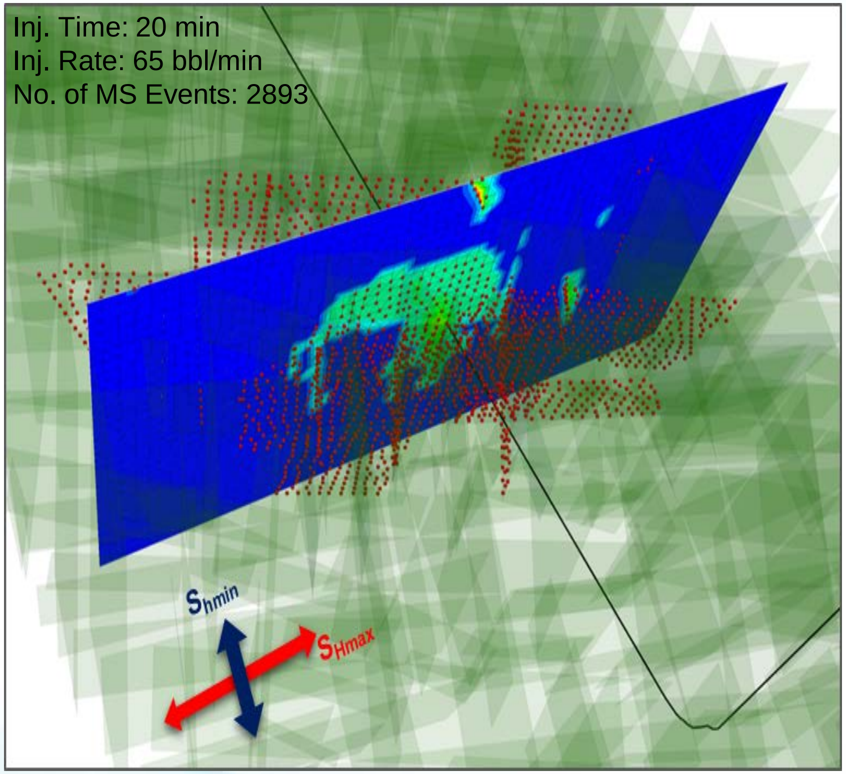
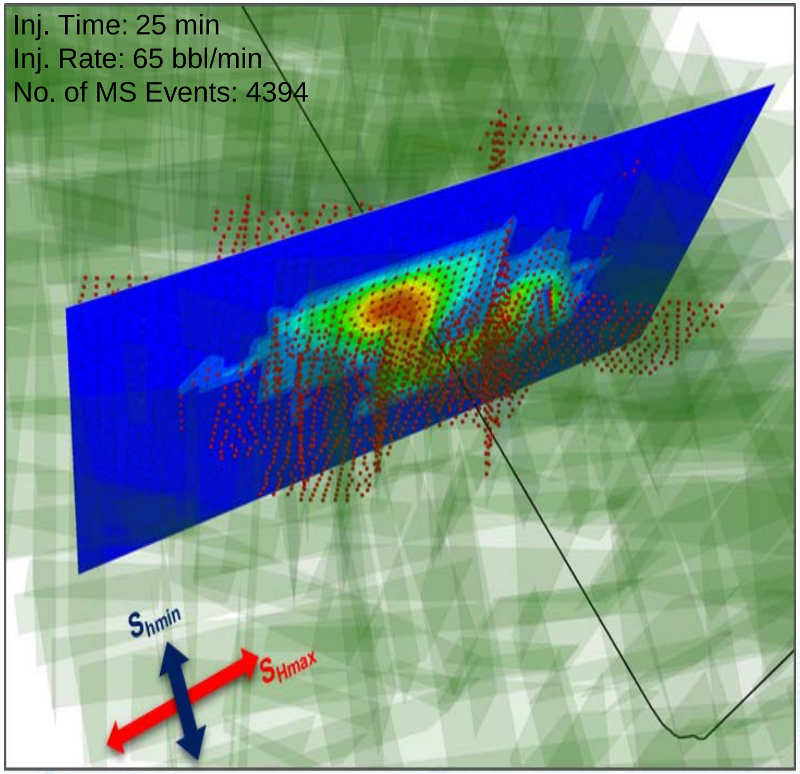
Insitu Stress Mapping

Geomechanical Modeling → Frac Design

Slickwater: 3 cP



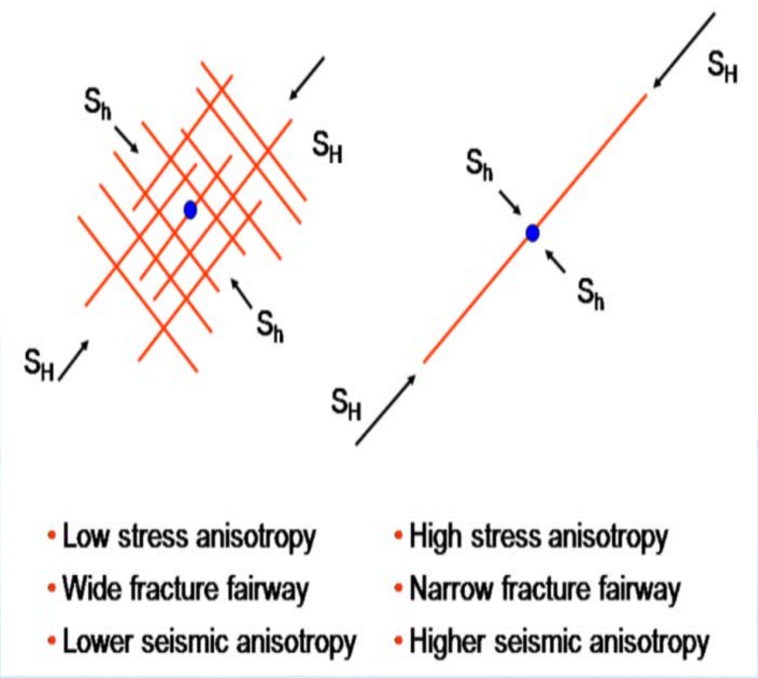
Linear Gel: 25 cP

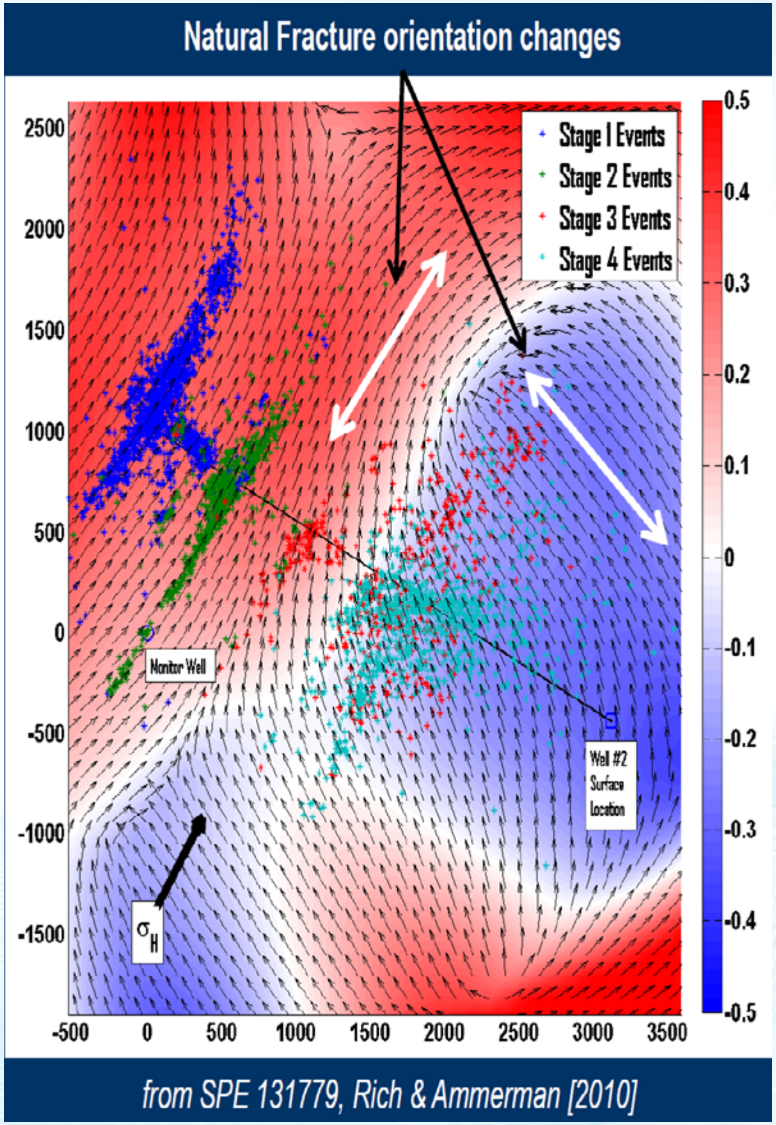


- Modelling requires accurate ***SHmax direction, magnitude and horizontal stress anisotropy***.
- Main inputs for most modelling software (i.e. FLAC3D, Mangrove, etc.)

SH_{max} & Horizontal Stress Anisotropy

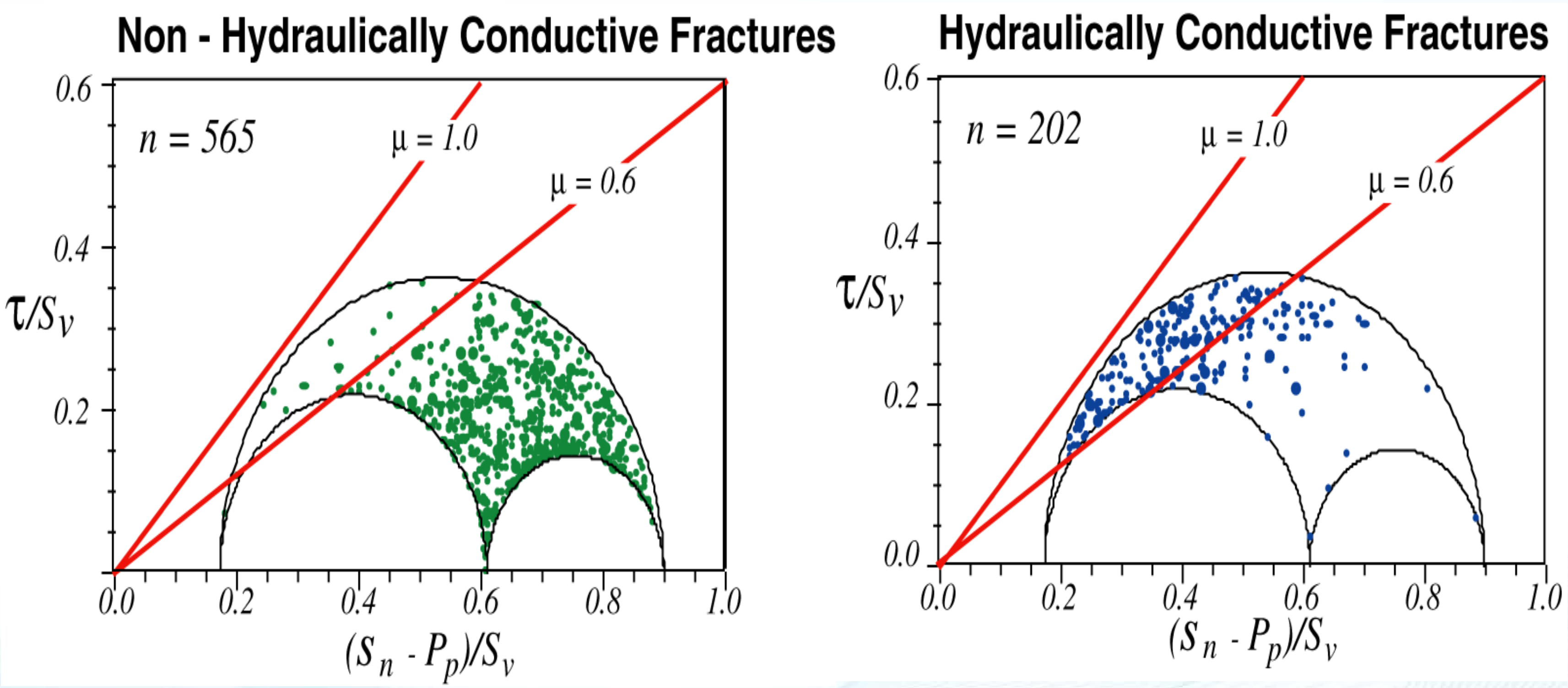
- Hydraulic fractures propagate perpendicular to Sh-min, b/c it is the least energy configuration (Hubbert and Willis, 1957).
- Horizontal stress anisotropy = S_H - S_h
- HFZ width inversely correlated to HSA.





Fracture Stress States – Other Studies

- Critically stressed fractures → Hydraulically conductive



- Statistically, hydraulically conductive natural fractures displaying an enhancement in permeability are also critically stressed.

(C. Barton et al., 1995)

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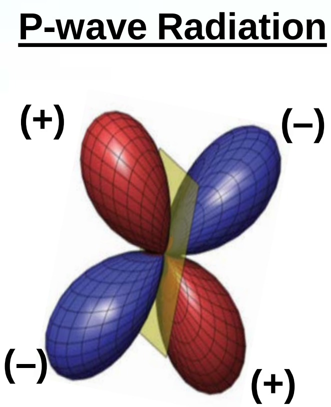
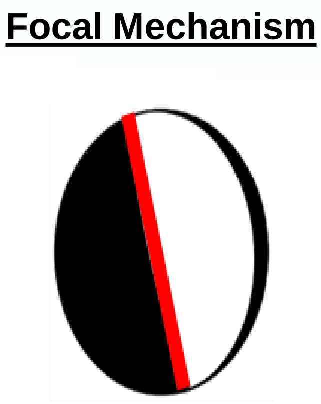
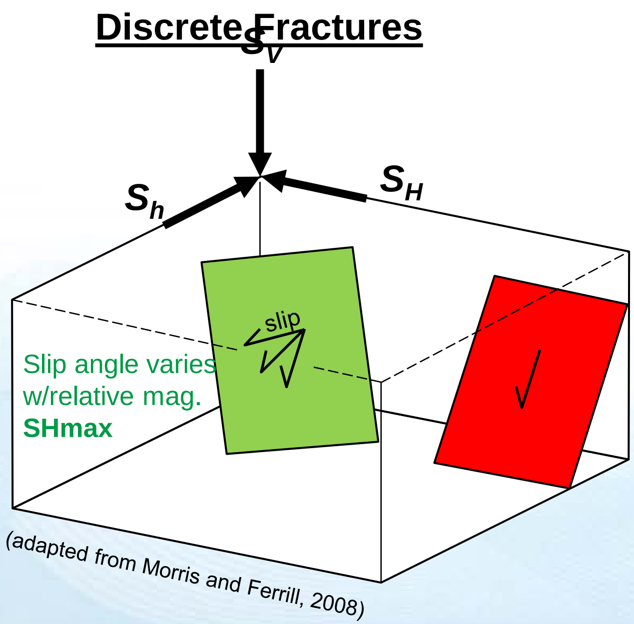
Focal Mechanism to Stress Field Model

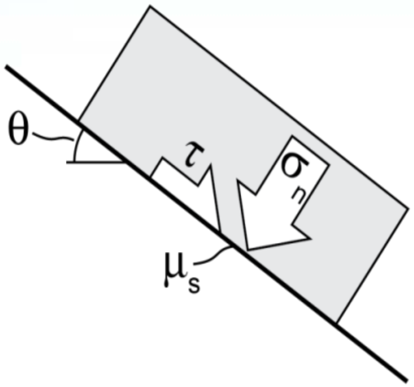






- Every event has a mechanism
- Failure plane specifies strike and dip
- Magnitude proportional to fault area
- Rake parallels the resultant shear stress
- Enables an estimate of Shmax;
  - direction
  - magnitude

Mohr-Coulomb Failure

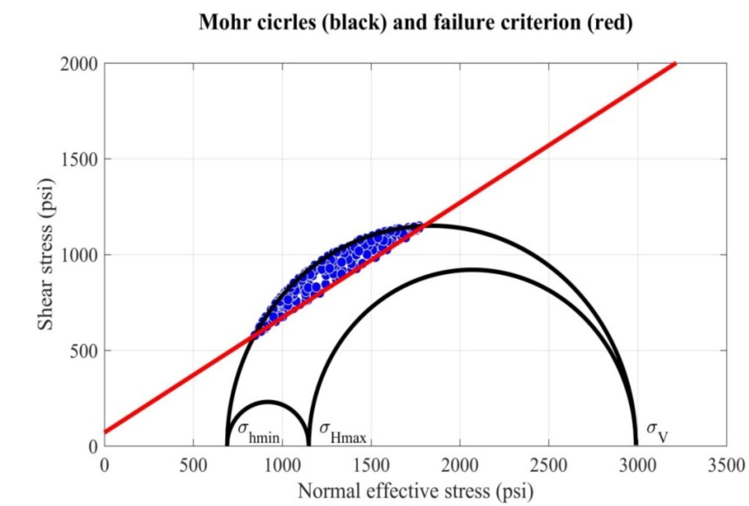


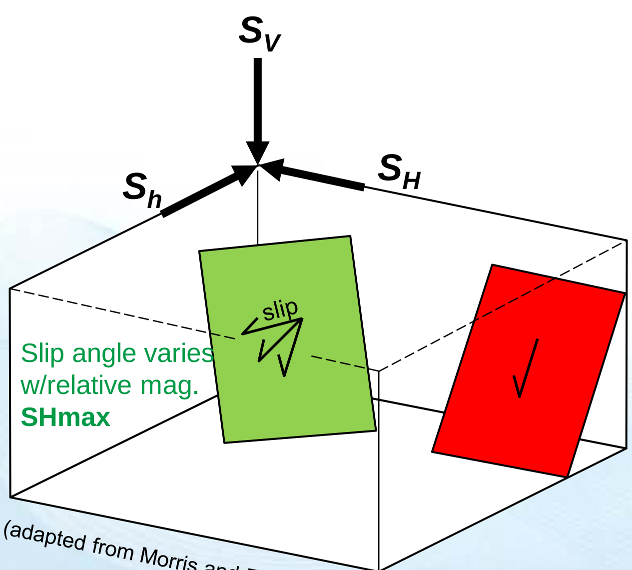
Mohr-Coulomb Criterion:

$$\tau = \mu_s \sigma_n + C_o$$

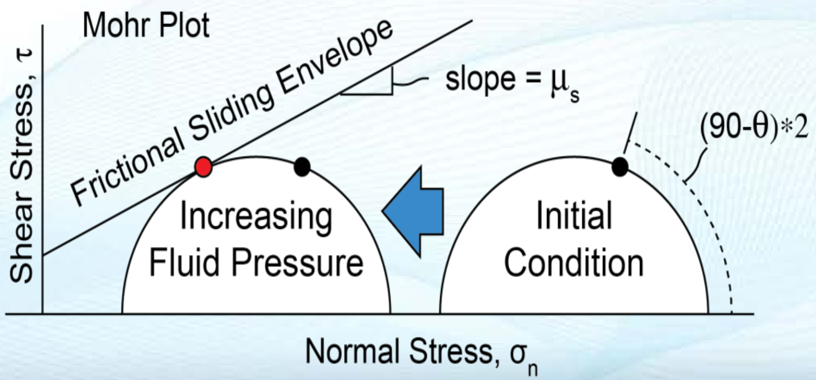
Failure occurs when:

$$\tau - \mu_s \sigma_n - C_o \geq 0$$



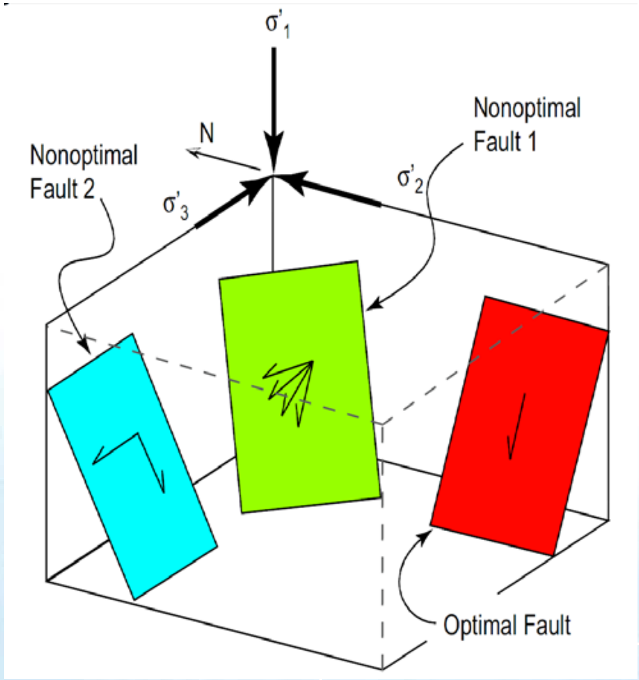


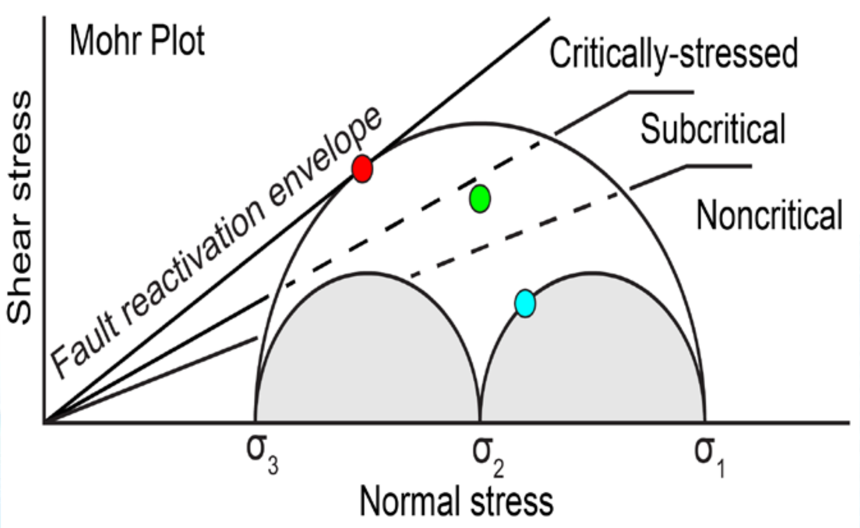
(adapted from Morris and Ferrill, 2008)



Estimating SH_{max} Direction & Magnitude

- Assume Sv is vertical and estimate magnitude from logs
- Assume SH and Sh are horizontal and orthogonal
- Estimate SH and Sh direction from dipping normal faults
- Estimate Sh magnitude from DFIT
- Estimate SH magnitude from distribution of rakes on various events



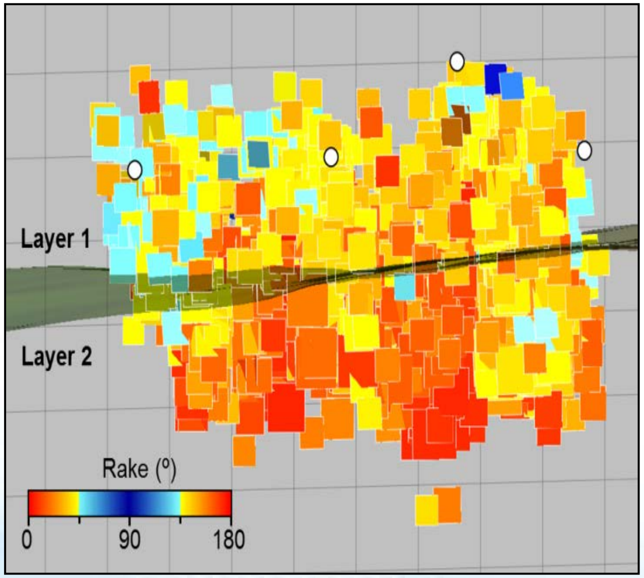


Determination of Maximum Horizontal Field Stress from Microseismic Focal Mechanisms – A Deterministic Approach, Agharazi, A, ARMA 16-691

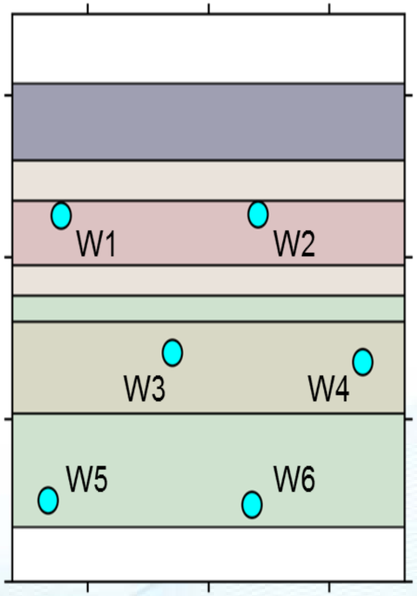
Stratified SH_{max} Model

- Depth distribution of focal mechanisms → Stratified SH_{max}
- More precise fracture model calculations

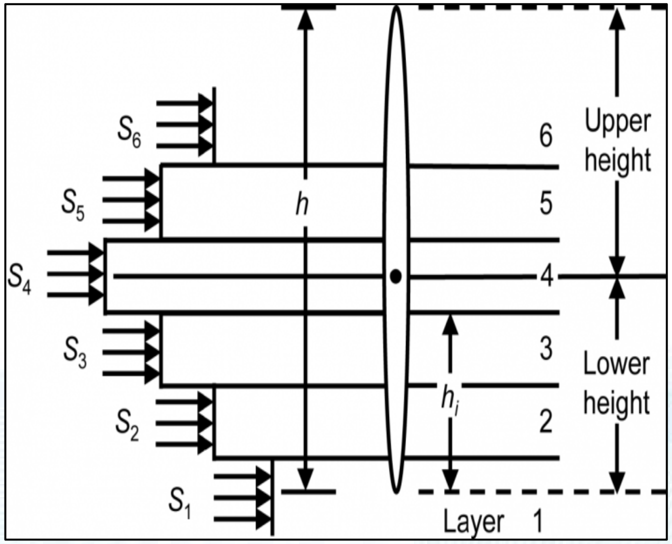
Microseismic DFN colored by rake



Gun barrel view

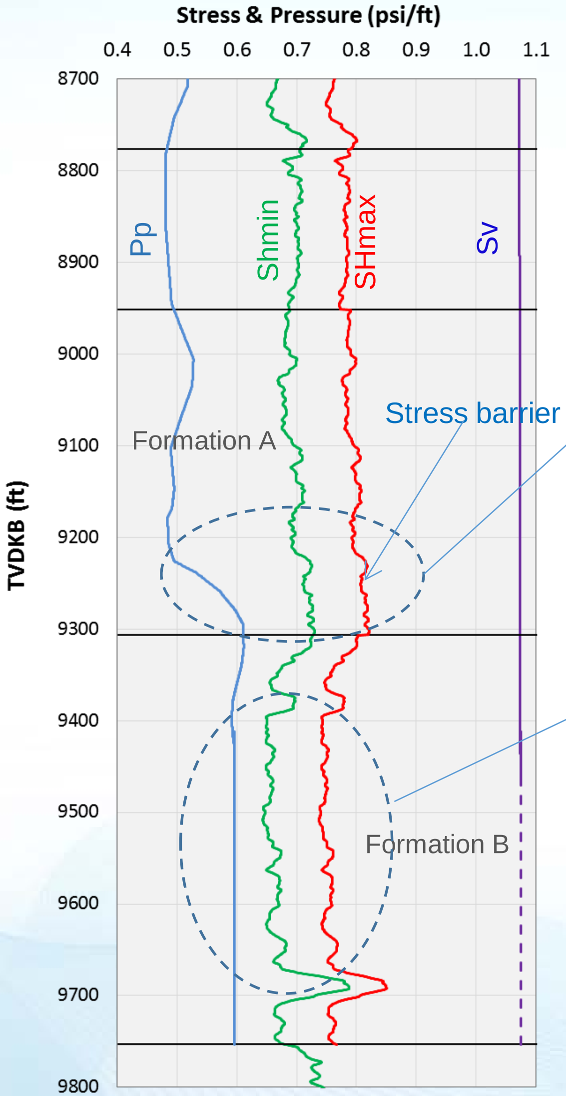


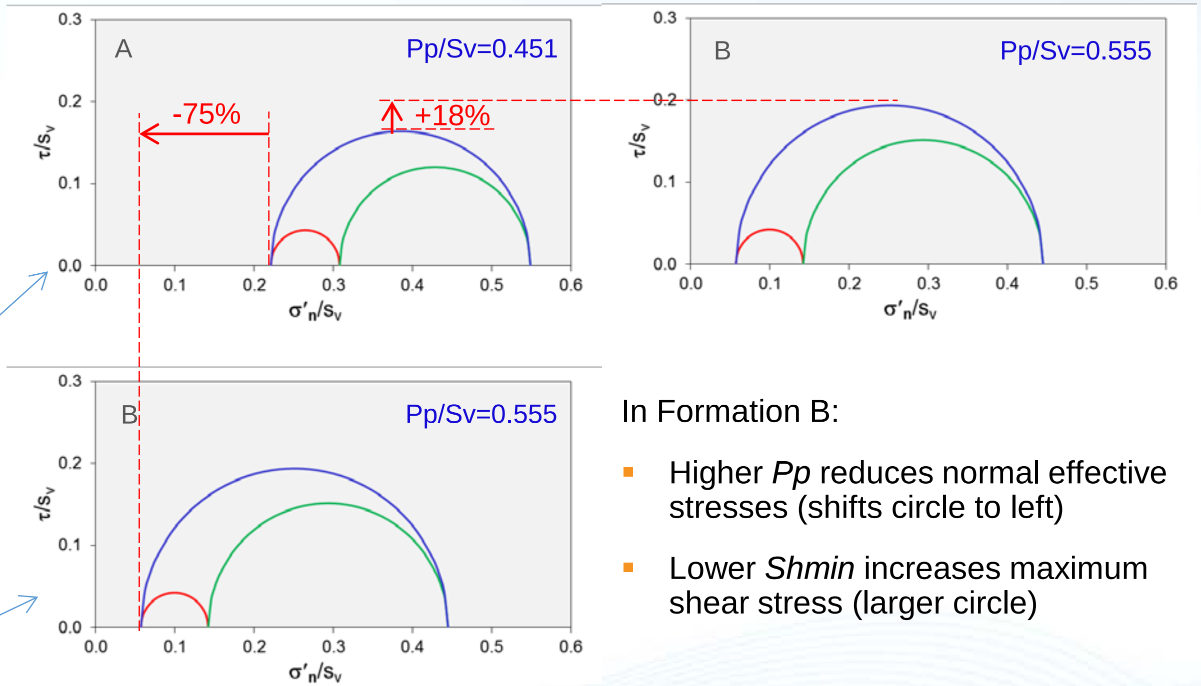
Fracture Propagation Modelling



(From http://petrowiki.org/)

Stress Analysis





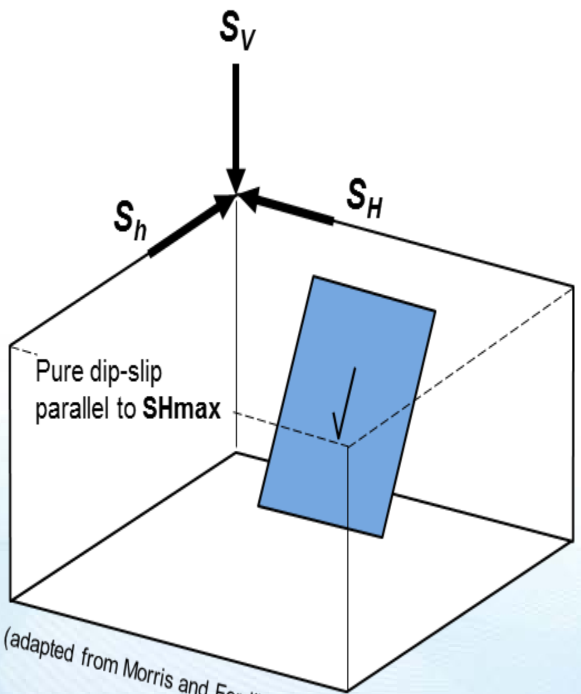
In Formation B:

- Higher *Pp* reduces normal effective stresses (shifts circle to left)
- Lower *Shmin* increases maximum shear stress (larger circle)

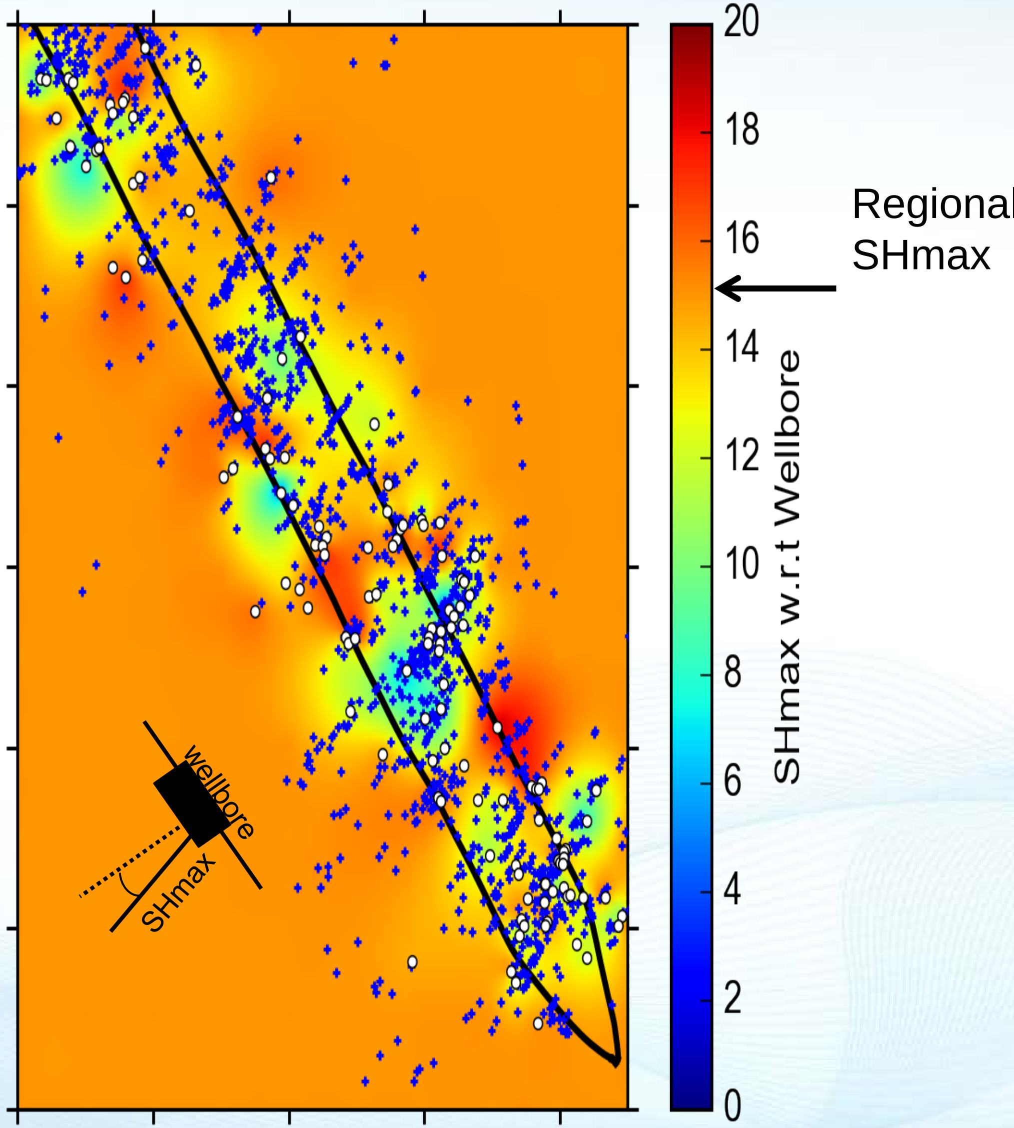
- More favorable stress state in B compared to A:
  - Lower effective normal stress (resistive force) by 75%
  - Higher shear stress (driving force) by 18%
- Microseismicity (stimulation) remained confined in B due to:
  - Stress barrier at top of B
  - More favorable stress state for rock stimulation in B

Mapping SH_{max} Direction

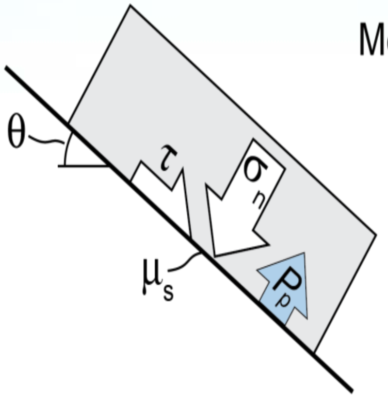
- Understand effects of SHmax rotations on job placement, frac geometry and geology.



(adapted from Morris and Ferrill, 2008)



SH_{max} & Fracture Stress States



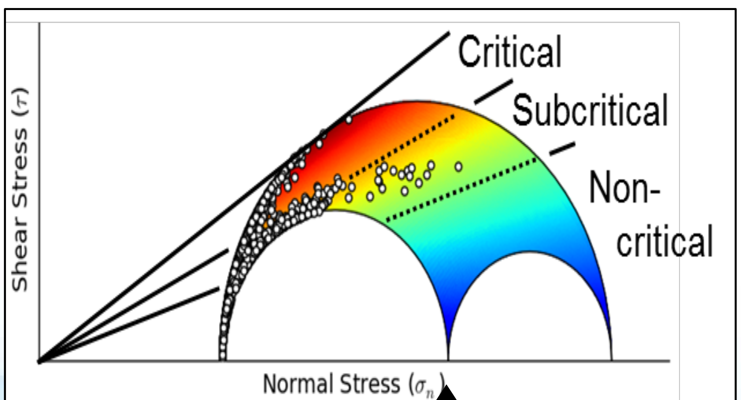
Mohr-Coulomb Criterion:

$$\tau = \mu_s \sigma'_n + C_o$$

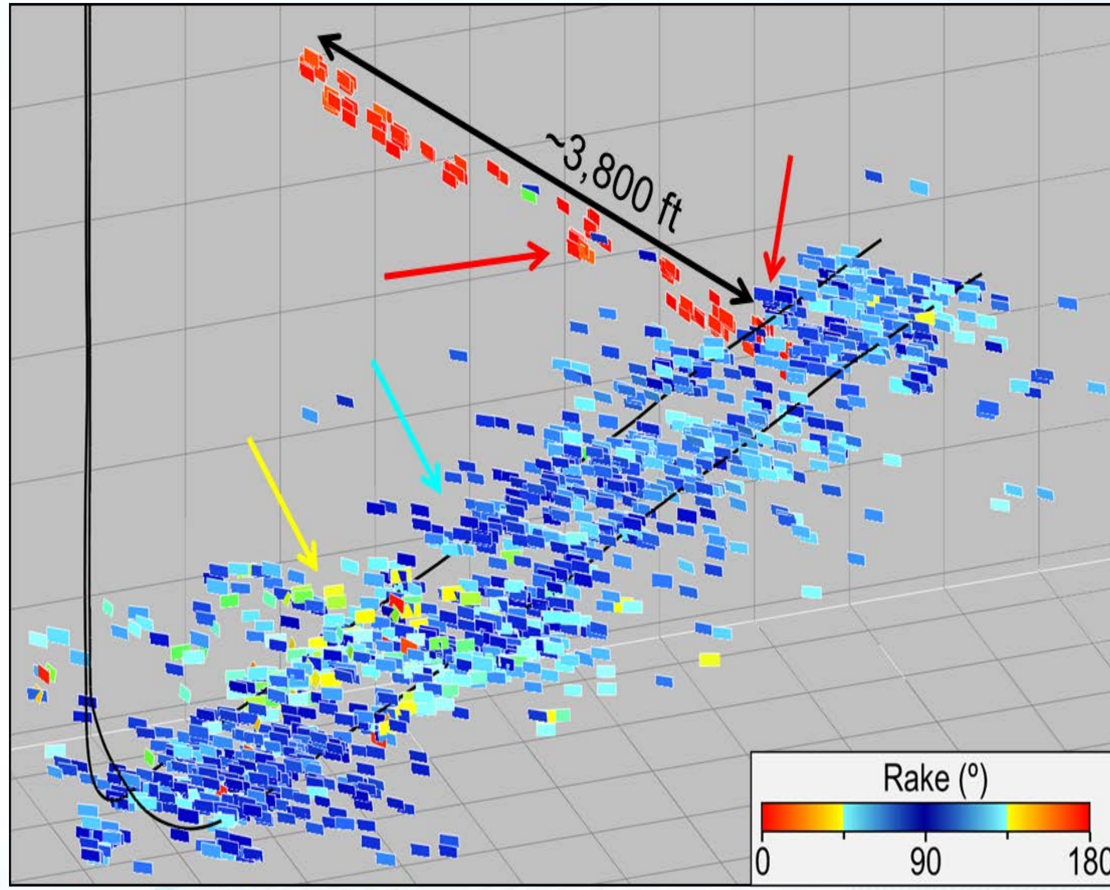
$$\sigma'_n = \sigma_n - P_p$$

Failure occurs when:

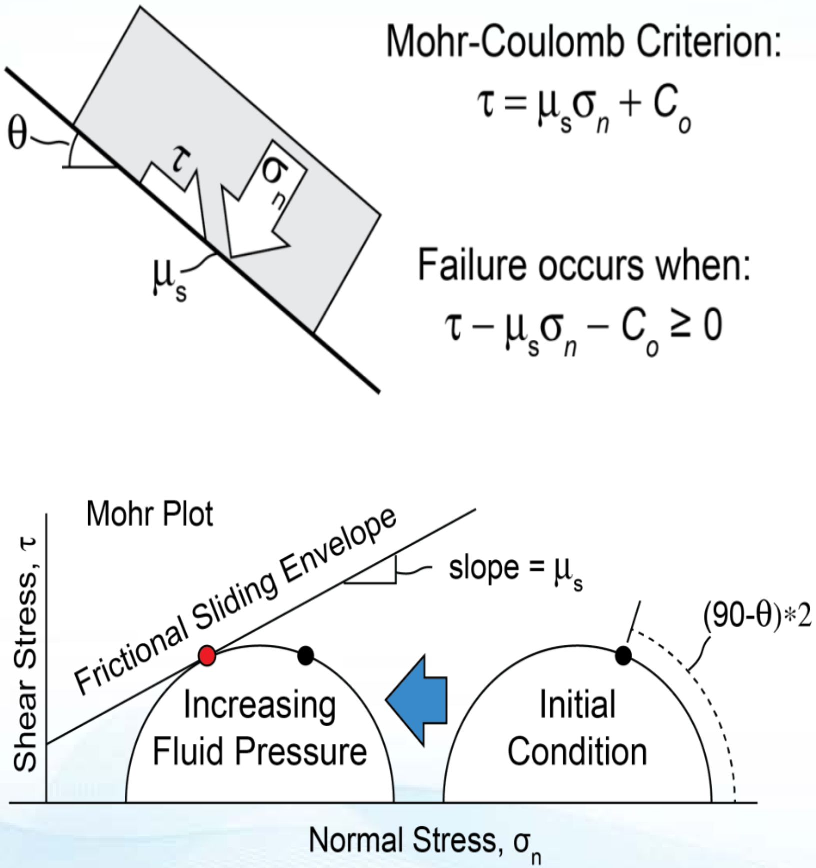
$$\tau - \mu_s \sigma'_n - C_o \geq 0$$

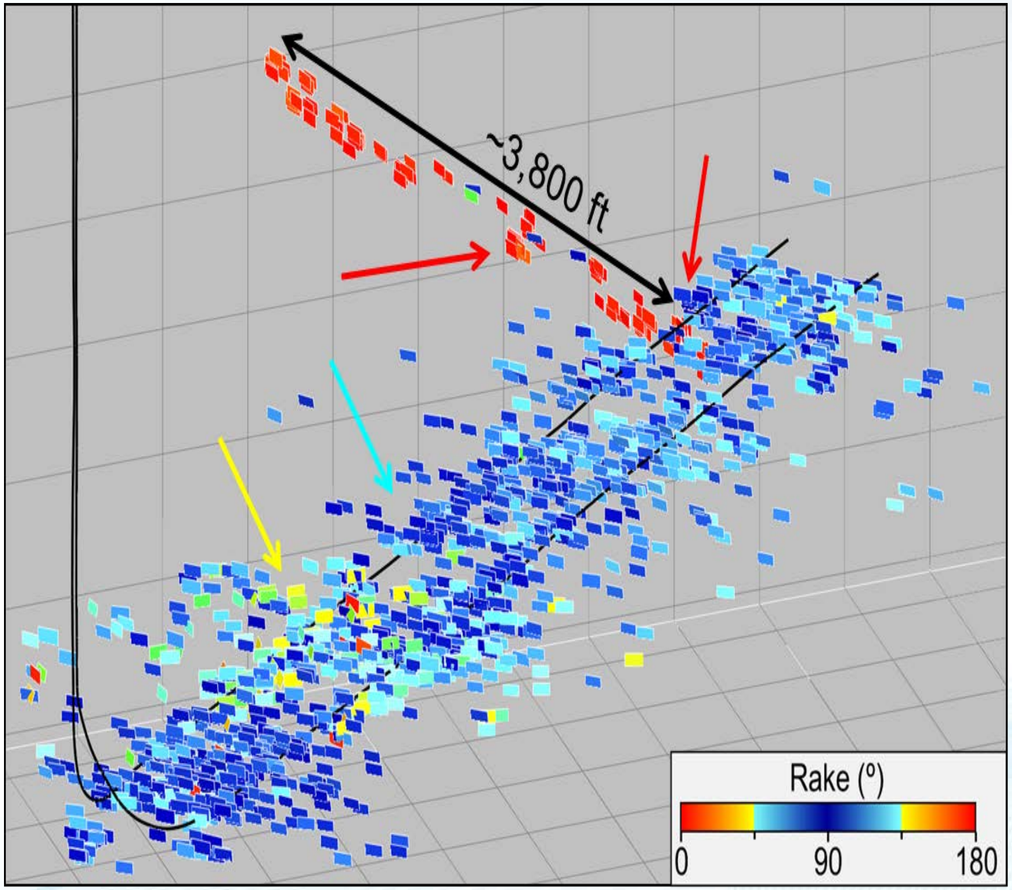


SH_{max}



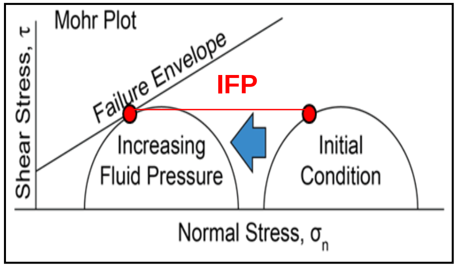
Fracture Stress States

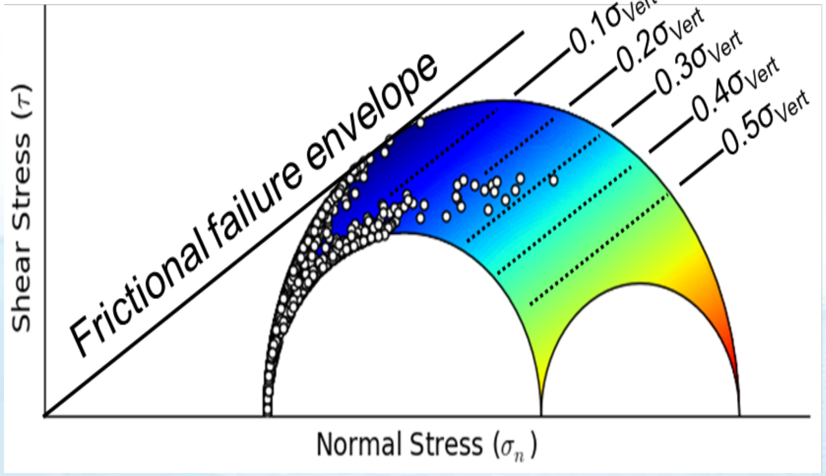


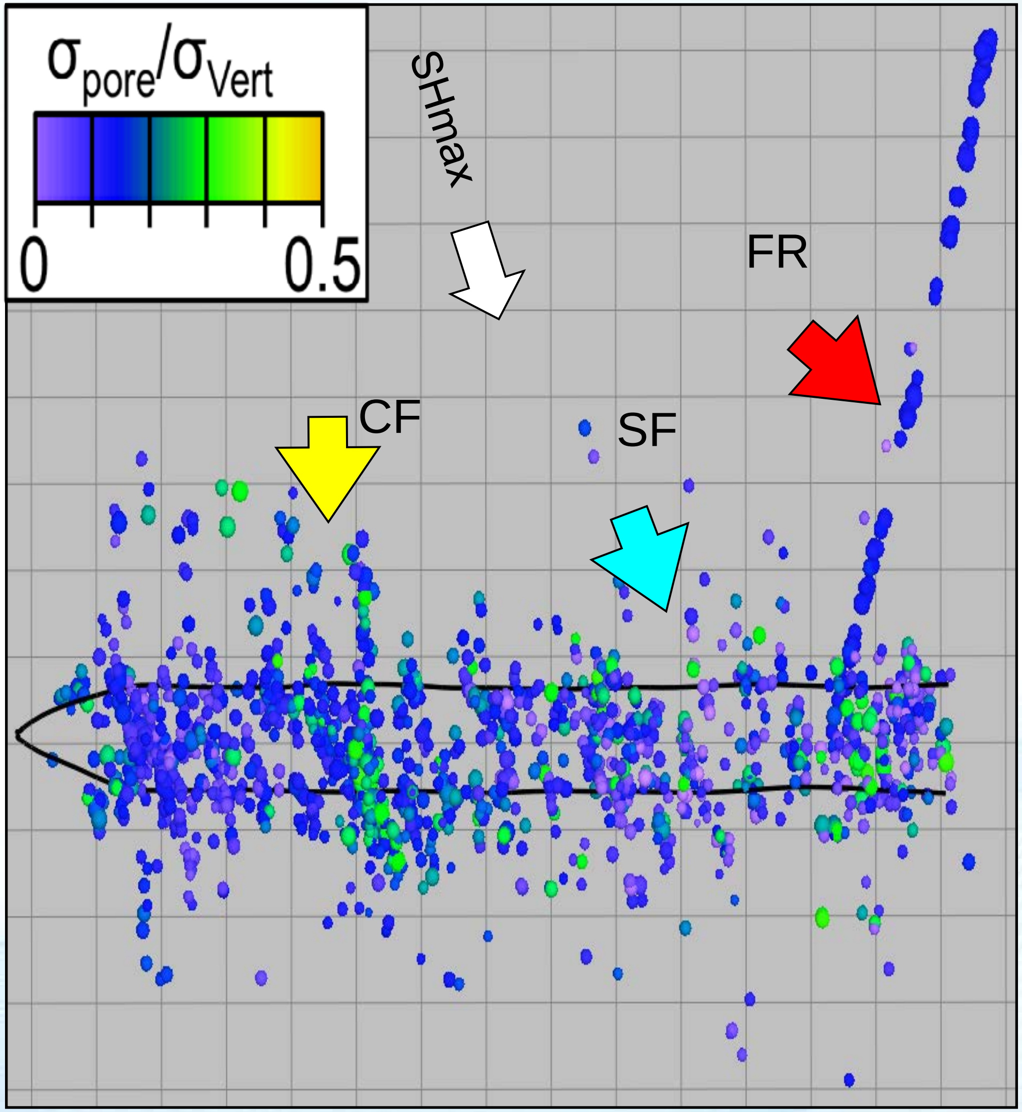


Induced Fluid Pressure (IFP) Distributions

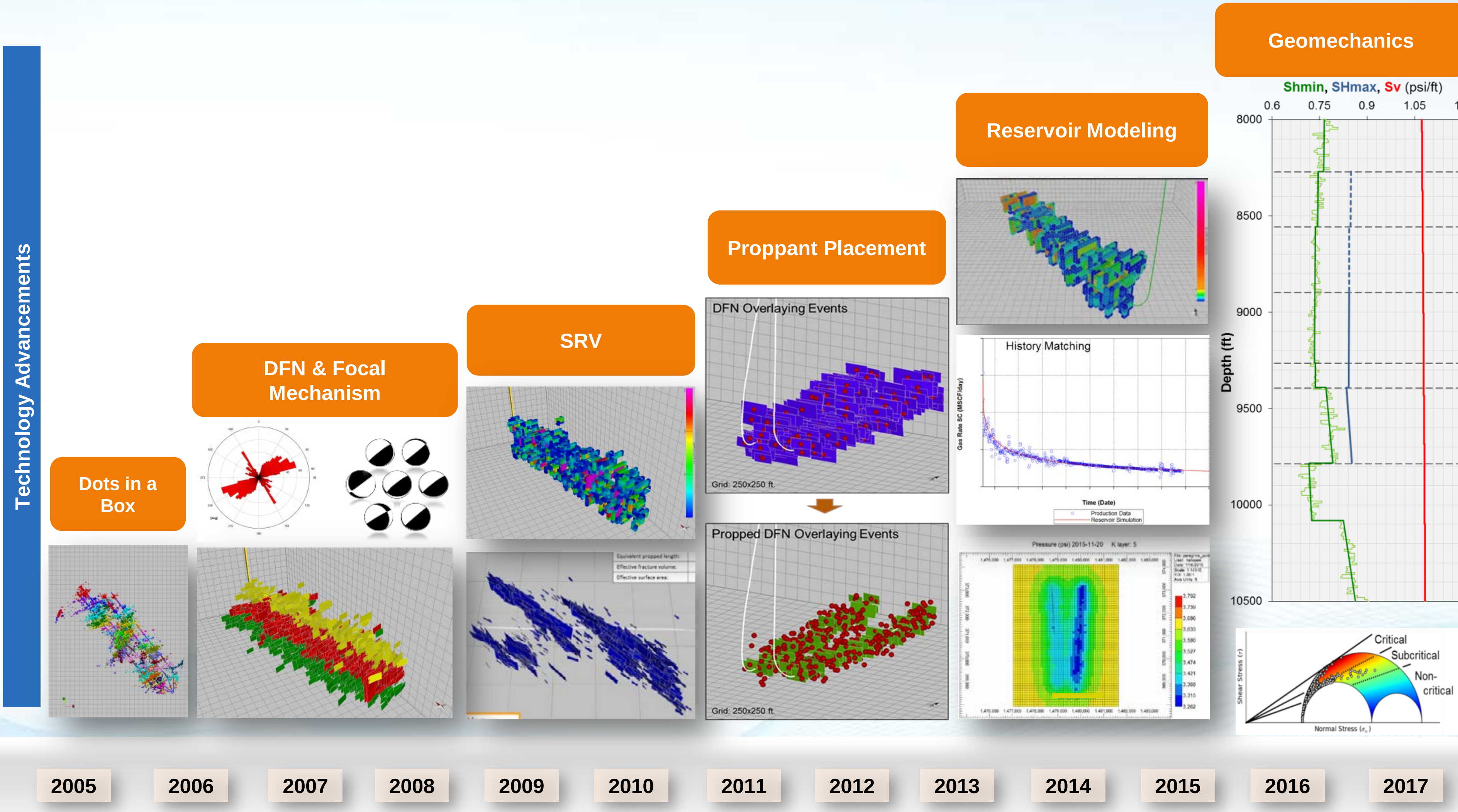
- Shear failure as a function of increasing fluid pressure.
- IFP: $\sigma_{P\text{-critical}} = \sigma'_n - \tau/\mu$





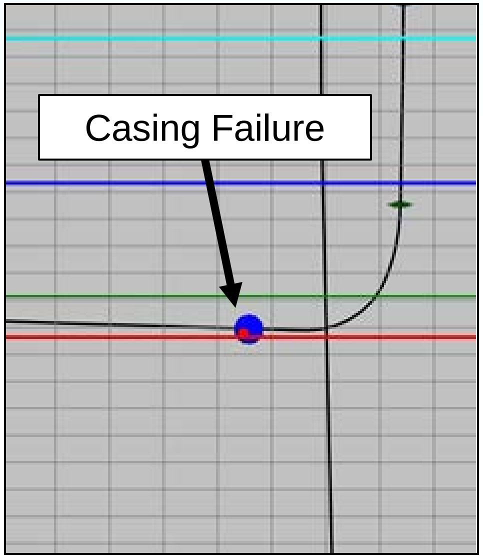


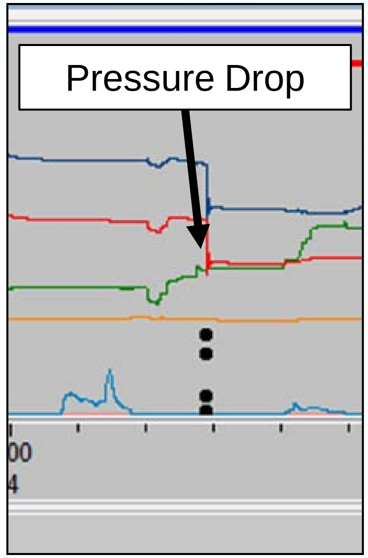
Complete MicroSeismic Analysis



Coffee Break

MicroSeismic Real-Time Applications



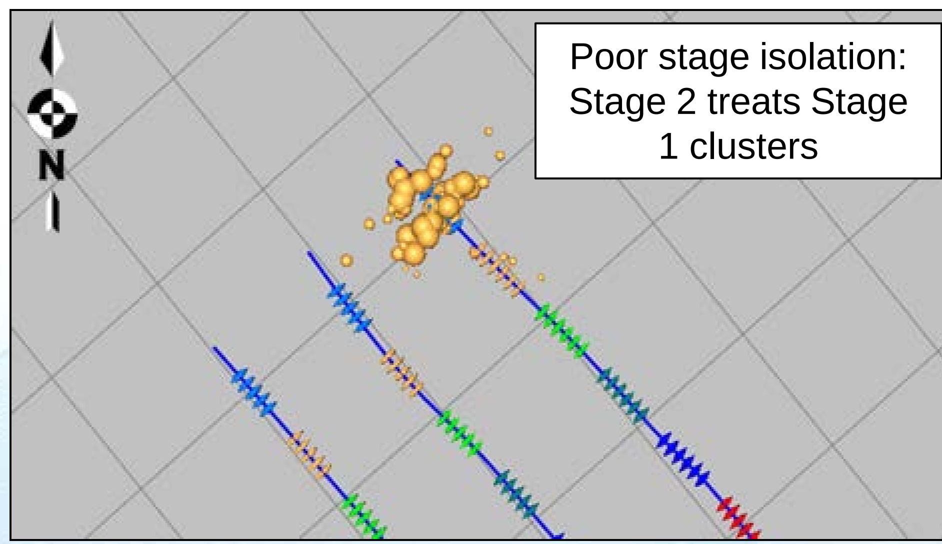


Casing Failure

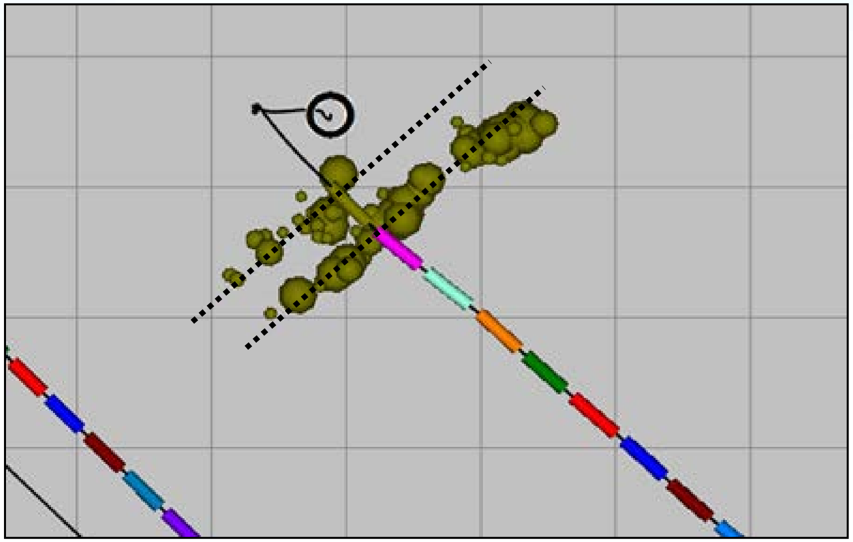
- Identify and locate casing deformation and failure as it happens
- Distinguish between mechanical events and frac events (source mechanism)

Stage Isolation

- Detect ball seats as they happen (mechanical events vs frac events)
- Understand stage isolation if treating pressure is inconclusive
- Identify areas of poor cement bond and resulting communication between stages in annulus



MicroSeismic Real-Time Applications

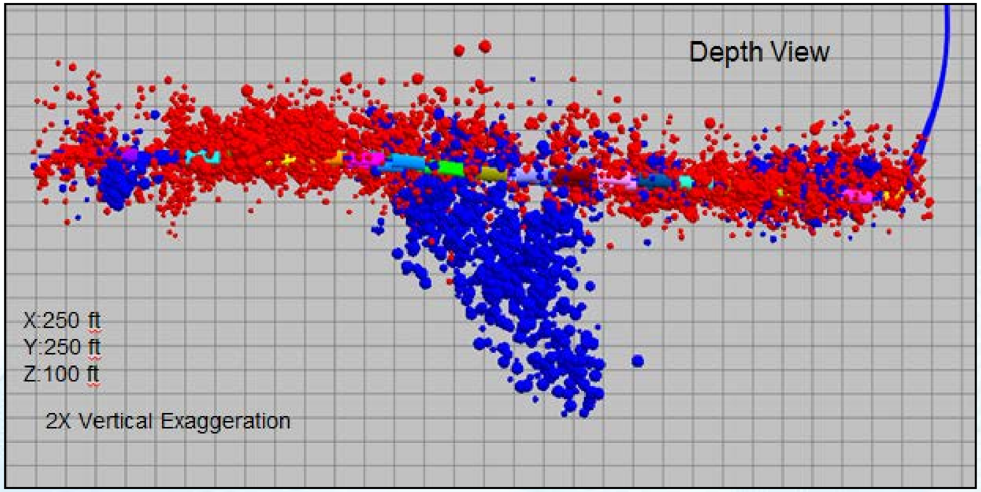


Increase Cluster Effiency

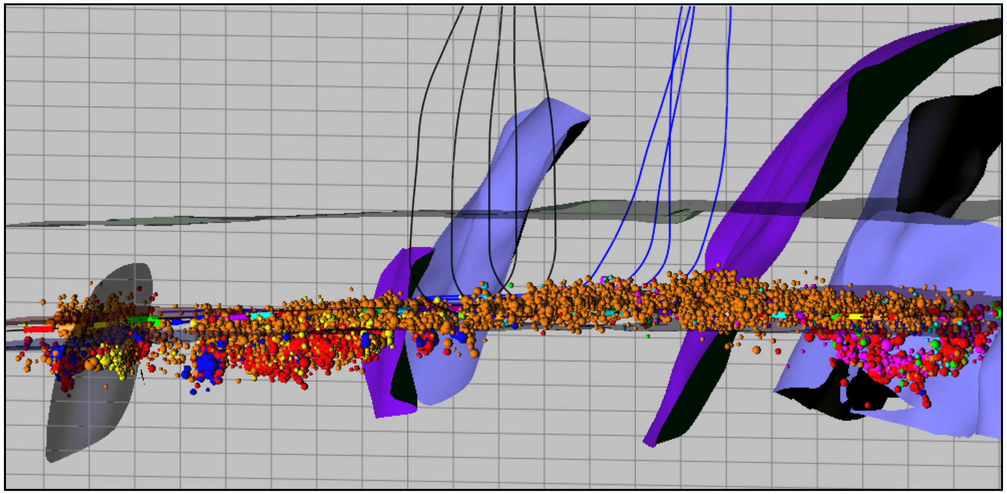
- Evaluate efficiency of various diverters
- Pump mid-stage diverter as needed to treat all clusters
- Ensure stimulation of entire stage interval

Geohazard Avoidance

- Avoid reactivation of a pre-existing fault that may not be visible in 3D seismic data
- Geohazards can act as costly thief zones decreasing treatment efficiency



MicroSeismic Real-Time Applications

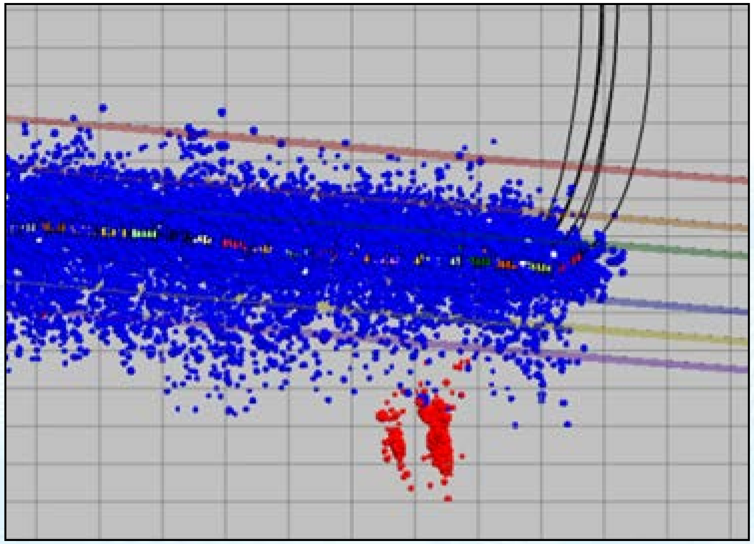


Induced Seismicity Monitoring

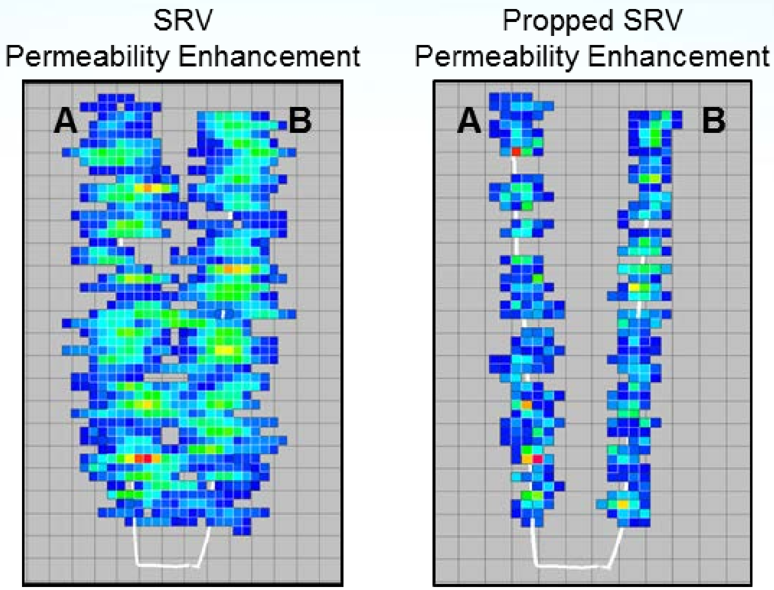
- Avoid triggering of induced seismic events in sensitive areas
- Adjust pump rates to avoid large magnitude events and continue to stimulate the wellbore

Target Zone Containment

- Ensure treatment remains in-zone for maximum return-on-investment
- Avoid frac'ing into a water-bearing zone
- Avoid communication with an H2S bearing zone



MicroSeismic Field Development Applications

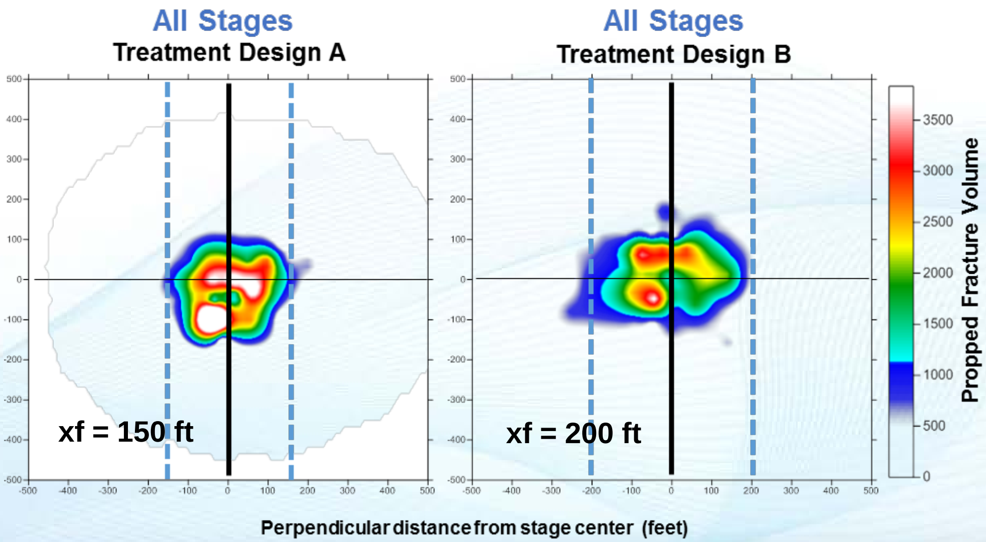


Static Wellbore Spacing

- Understand wellbore interference and determine optimum wellbore spacing
- Improve reservoir drainage and recovery factor

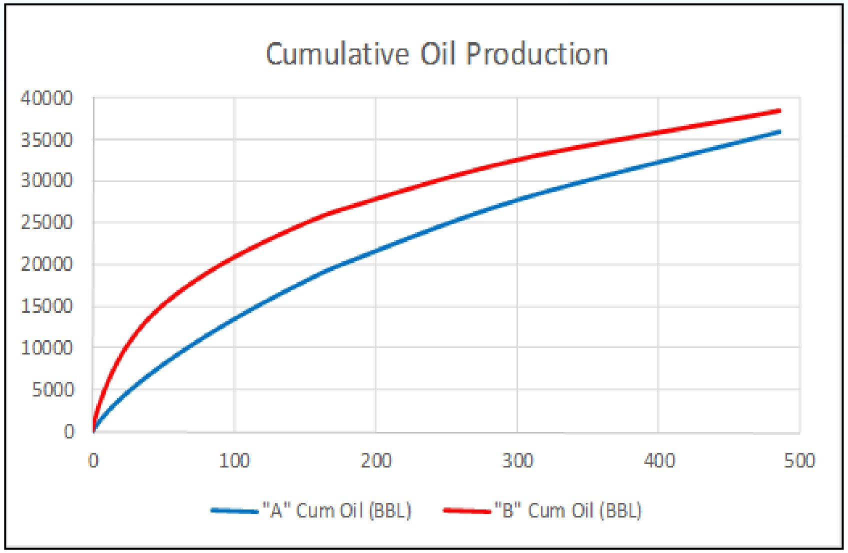
Completion Design

- Compare different completion and treatment designs
- Determine impact of completion and treatment design parameters on production



MicroSeismic

MicroSeismic Field Development Applications

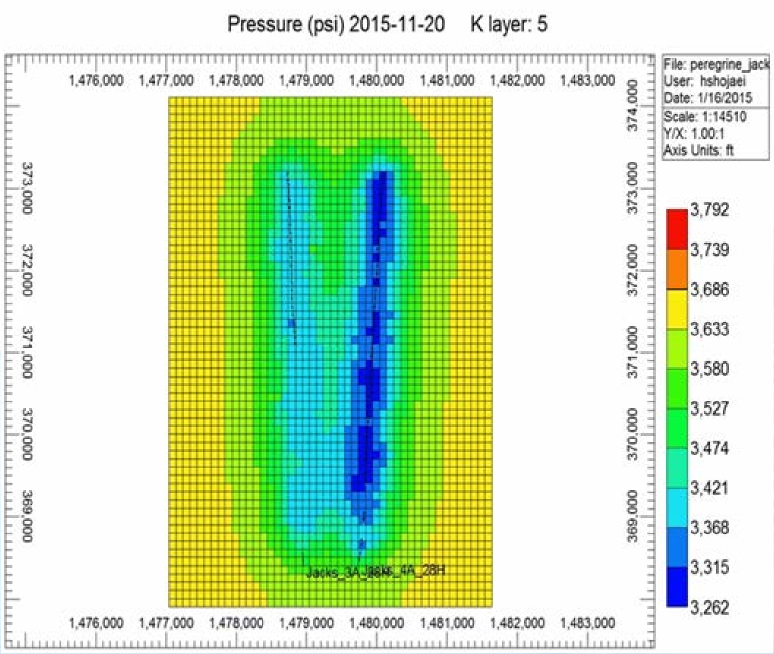


Production Forecast

- Determine relative productivity of wells
- Generate type curves and determine EUR
- Calculate NPV and optimize asset development

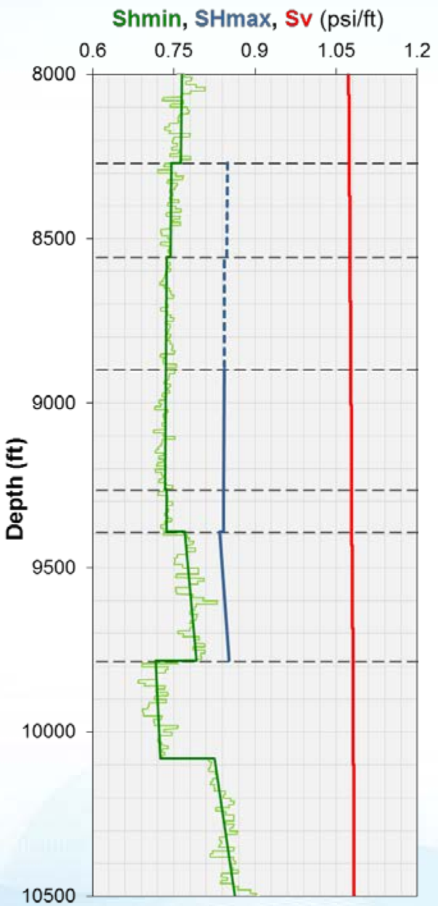
Pressure Depletion

- Dynamic wellbore spacing determination (optimize lateral and vertical wellbore placement)
- Predict pressure depletion and optimize field development plan



MicroSeismic

MicroSeismic Field Development Applications

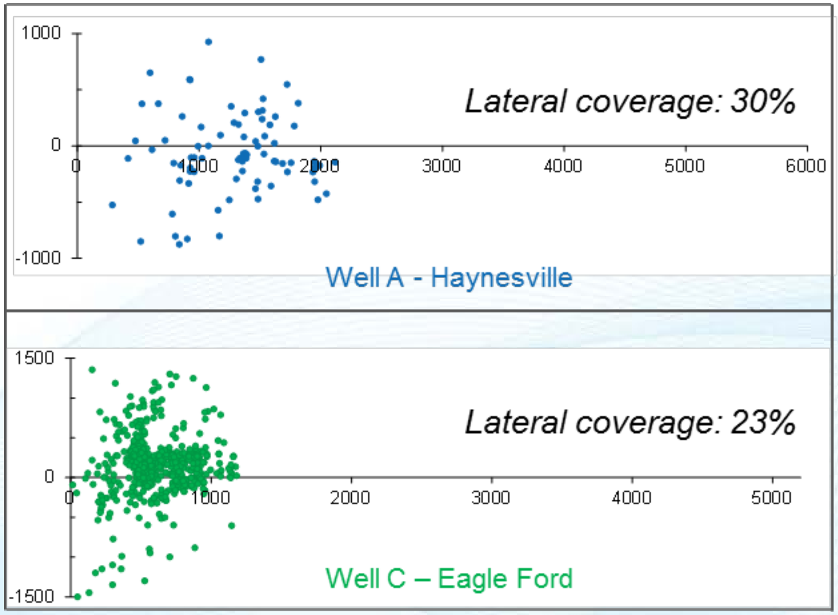


Stress Analysis

- Determine orientation and magnitude of three principal stresses
- Generate vertical stress profile and refine assumptions in internal frac models

Refrac Design

- Model pressure profile in lateral and design injection of refrac
  - Increase refrac success rate
- Ensure stimulation of entire lateral and not just the heel
- Monitor in real-time to time diverters and understand diverter effectiveness

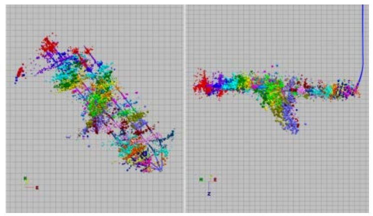


Integrated Microseismic Analysis

Geophysics

Dots in a Box

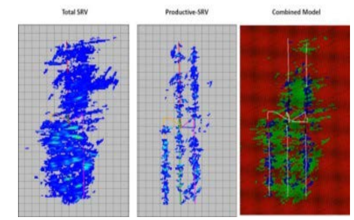
- Image fracture locations
- Identify geohazards
- Map gross stimulated reservoir volume
- Identify mechanical failures or problems



Engineering

Descriptive Completions Evaluation

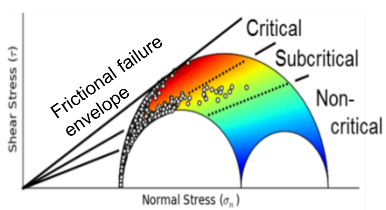
- Map stimulation as a discrete fracture network
- Estimate propped vs. unpropped frac volume
- Estimate the enhanced permeability and it's distribution



Geomechanics

Geomechanics Completions Evaluation

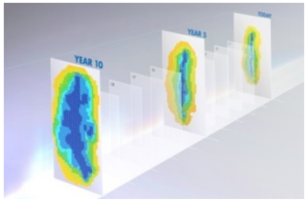
- Estimate the insitu stress field
- Estimate pore pressure at failure
- Identify the critically stressed fractures



Asset Management

Predictive Completions Evaluation

- Predict productivity for each stimulated stage
- Predict reservoir depletion patterns
- Predict EUR

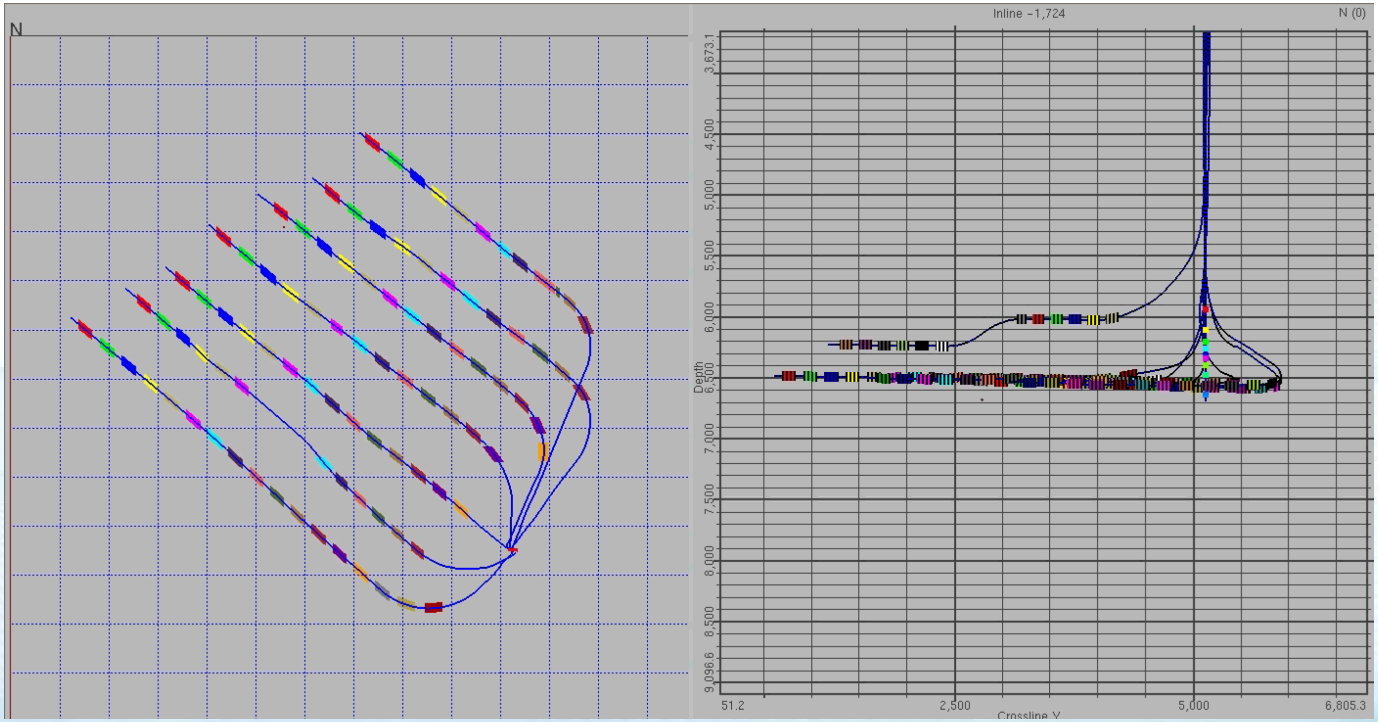


Using quantitative analysis to improve profitability for unconventional field developments.

MicroSeismic

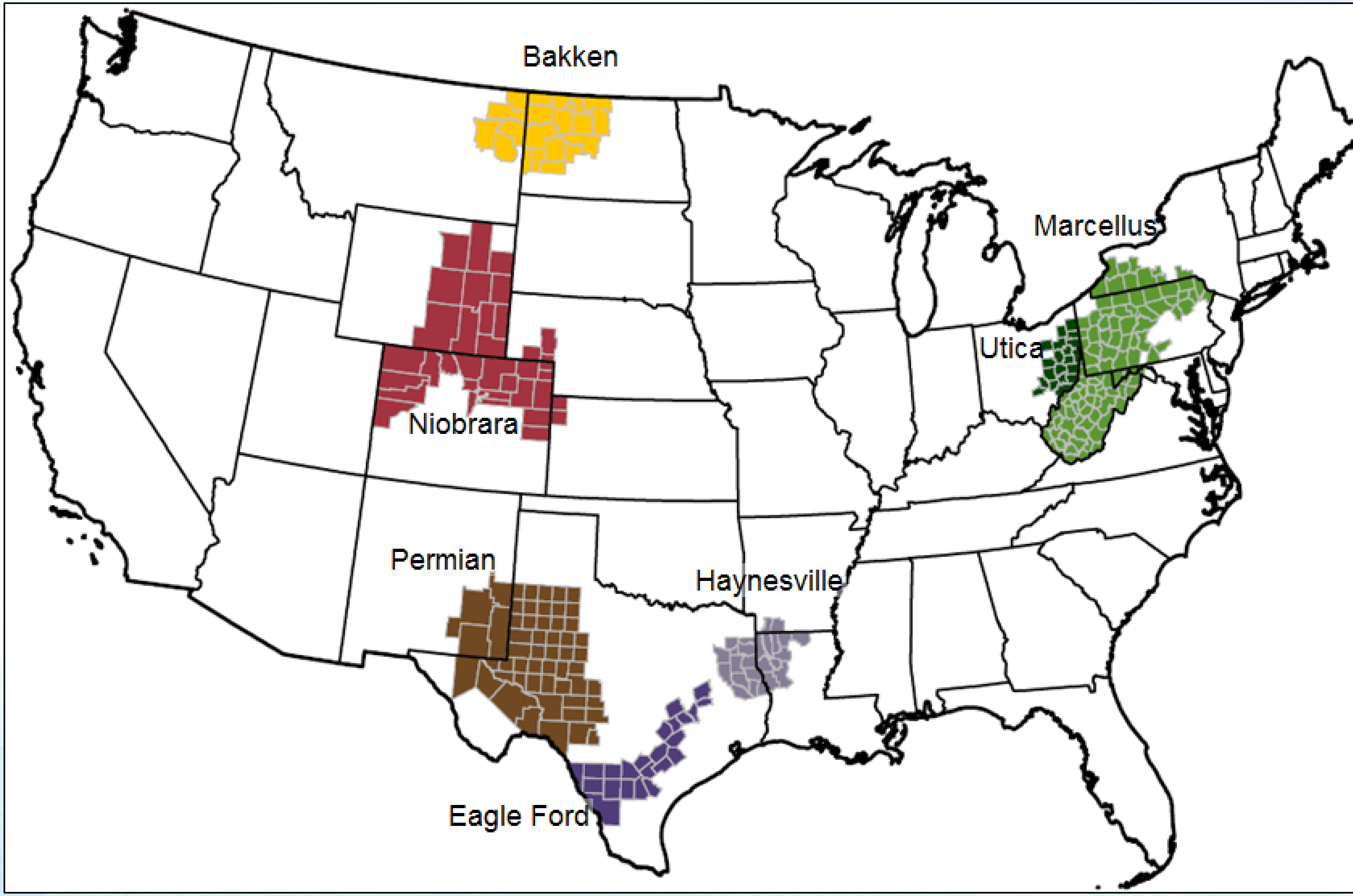
Quantitative Microseismic Analysis - The Proposition

- MicroSeismic data offers the opportunity to make a real time, well specific, in situ observation of the permeability enhancement achieved through stimulation.
- These observations can be turned into an more accurate, more robust and more timely well appraisal.



Case History 1
Appalachian Basin

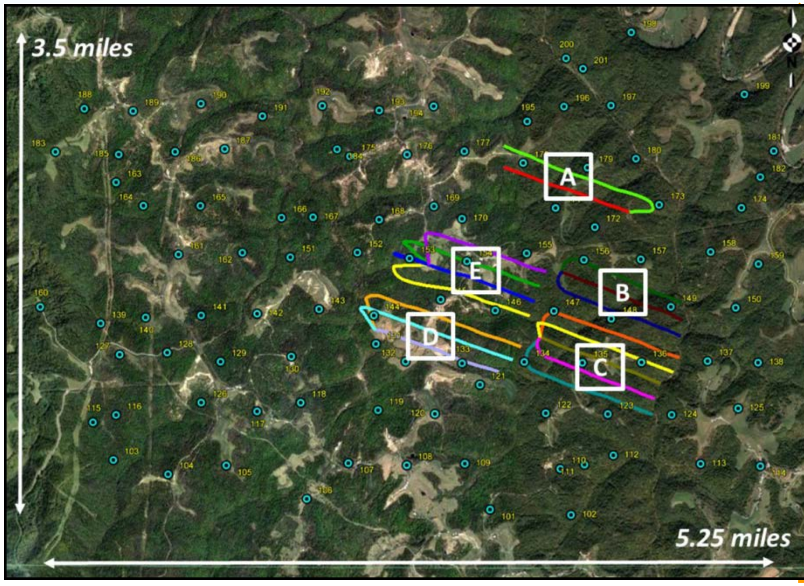
Key U.S. Shale Regions

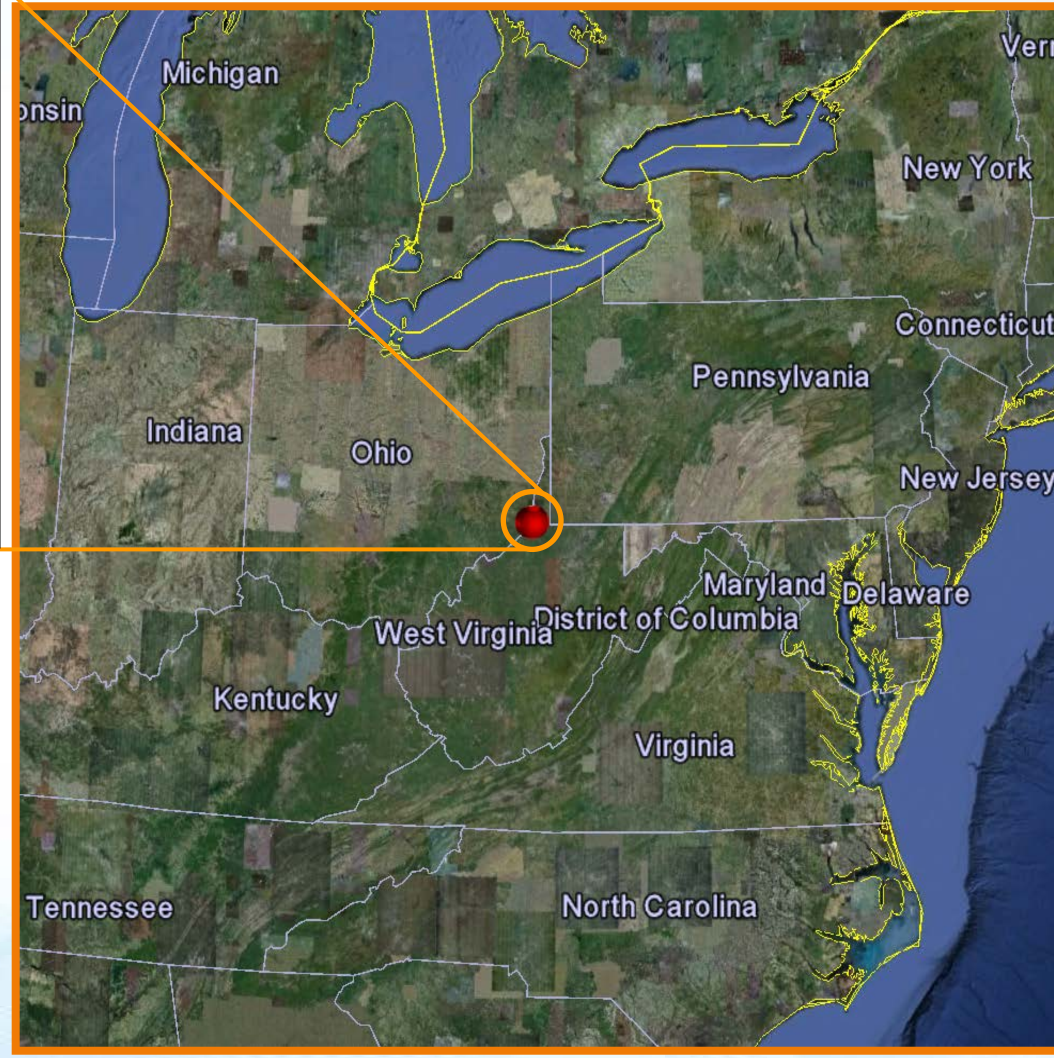


Source: U.S. Energy Information Administration

Marcellus Case Study

Location of BuriedArray™ Marshall County, West Virginia

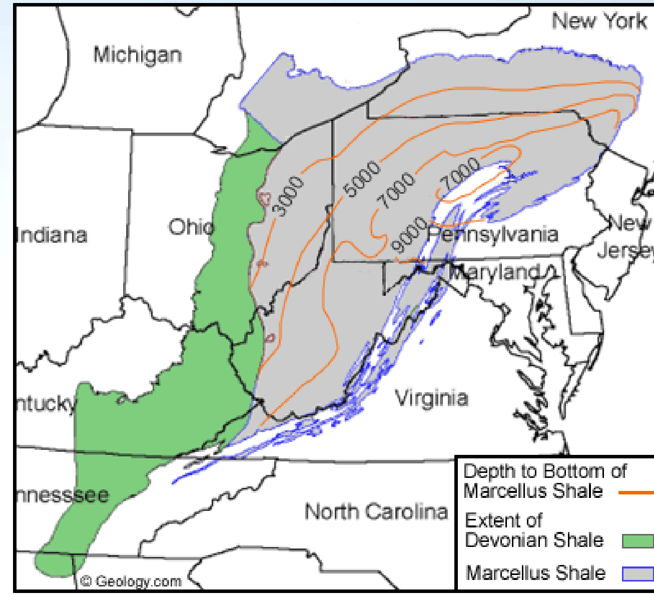


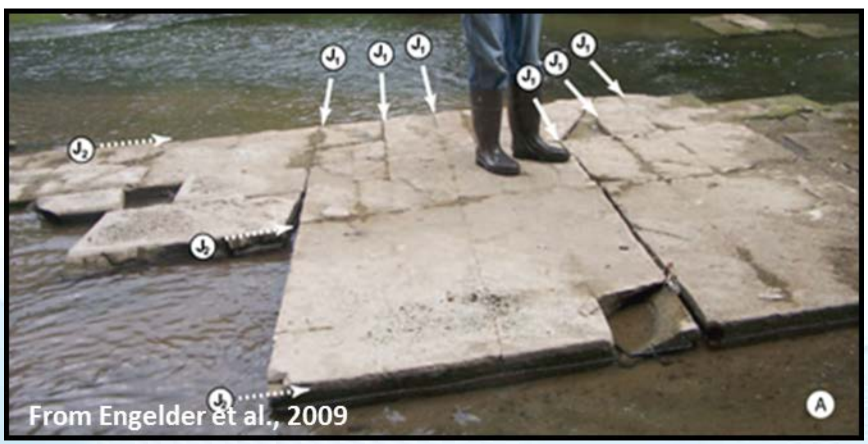


- 101 station BuriedArray
- 18+sq miles
- 17 wells monitored
- Geophones cemented in
- Wide azimuth, high fold
- Full waveform stacking
- High-confidence mechanisms and magnitudes

Geologic Setting

- Two dominant joint sets:
  - J1 formed at beginning of Alleghenian
  - orogeny by tectonic stress
    - ENE, roughly parallel to present day S_{Hmax}
  - J2 formed at end of Alleghenian orogeny
  - after rotation of S_{Hmax} by HC maturation
    - NW trend





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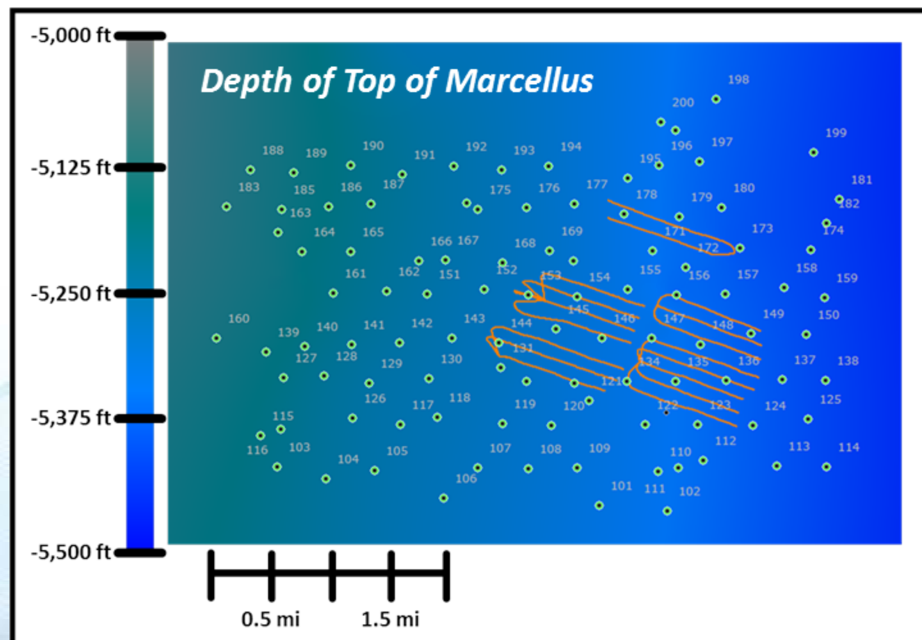
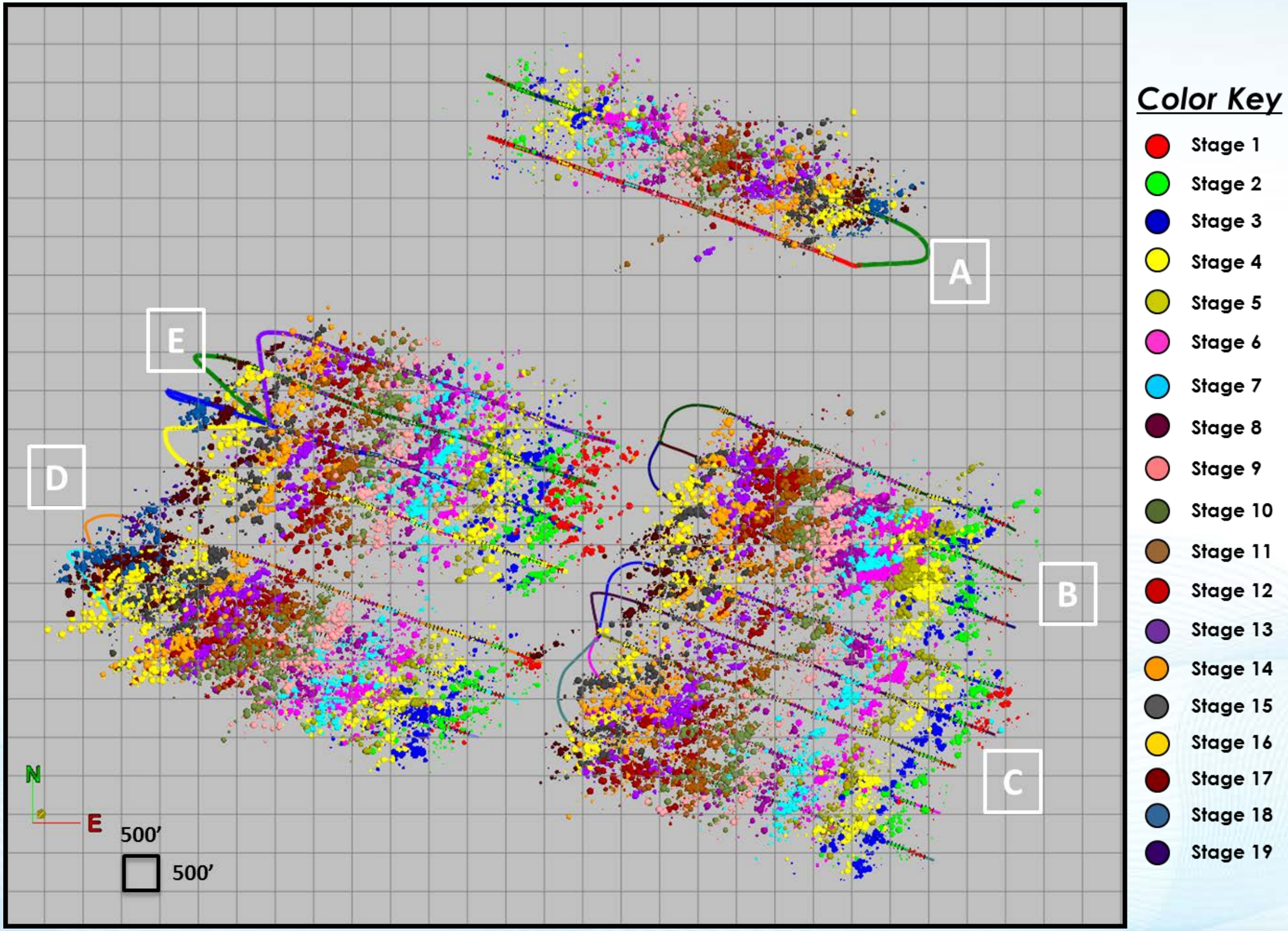
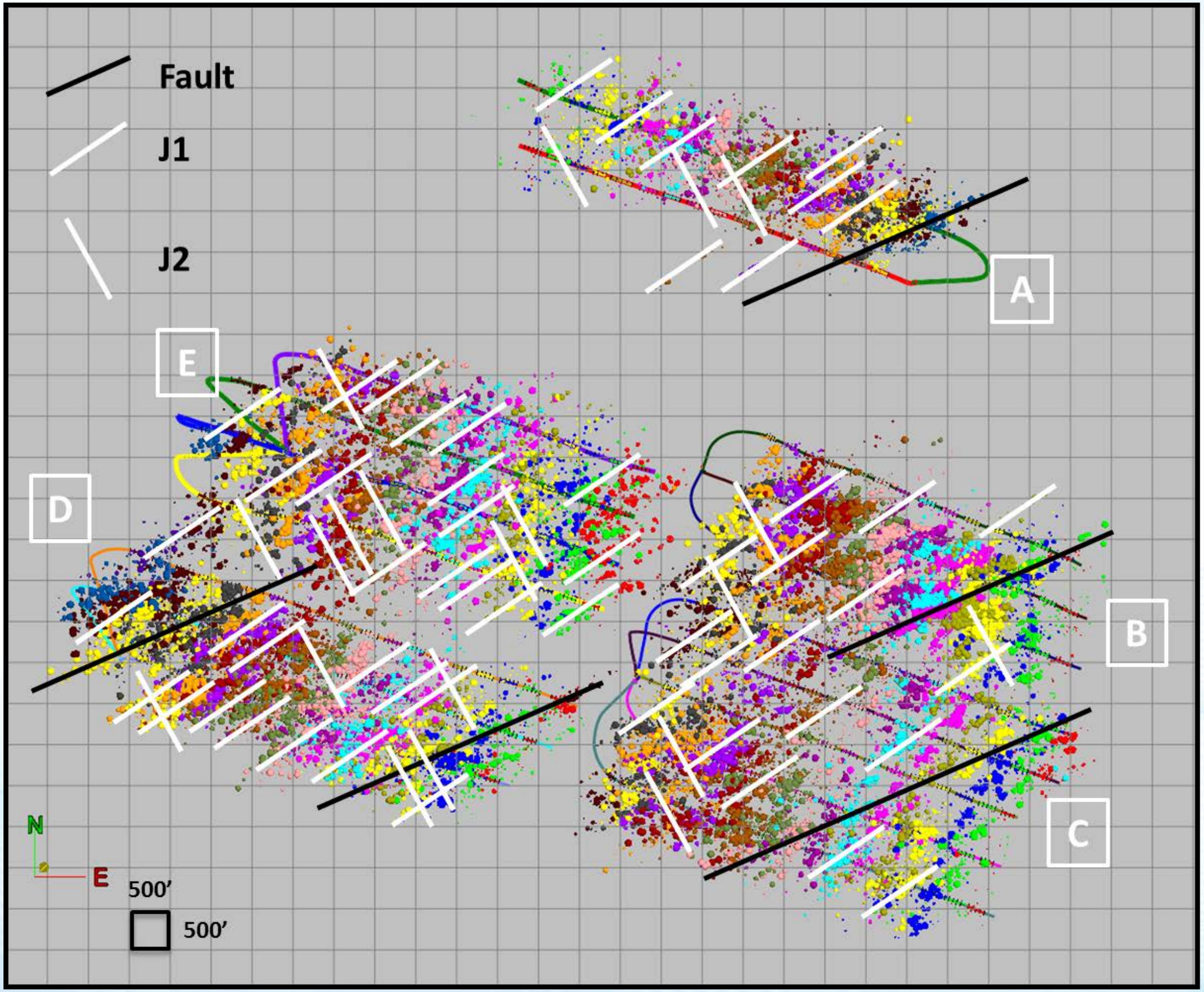


MicroSeismic

Microseismic Results



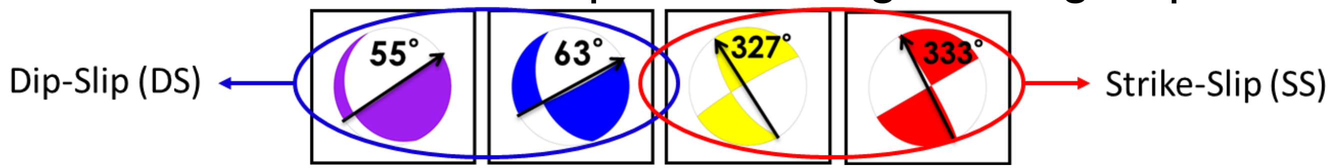
Microseismic Results



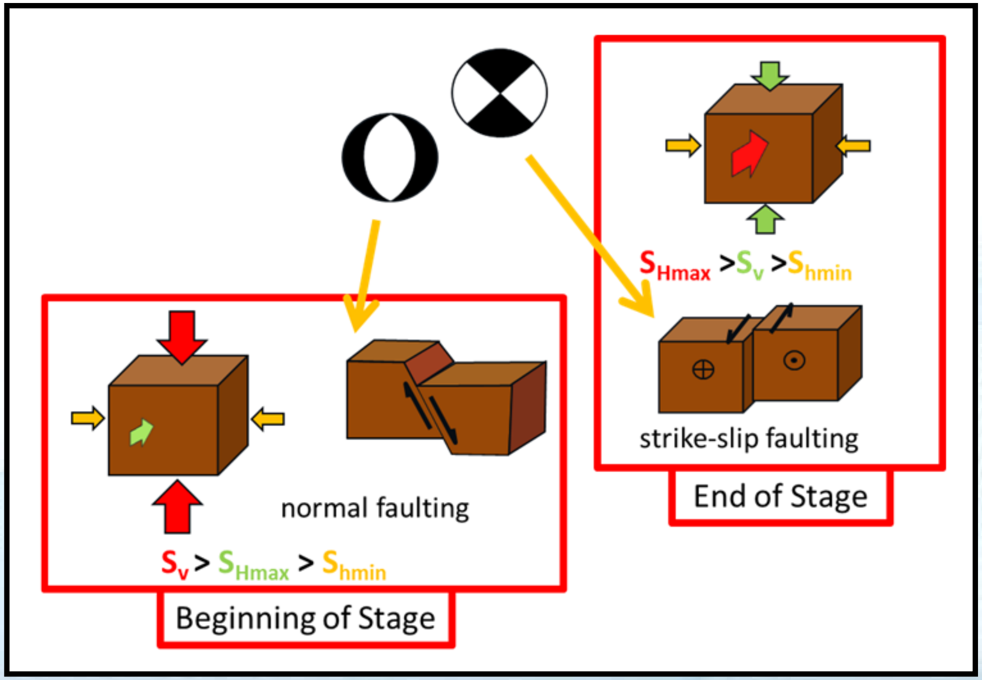
MicroSeismic

Source Mechanisms

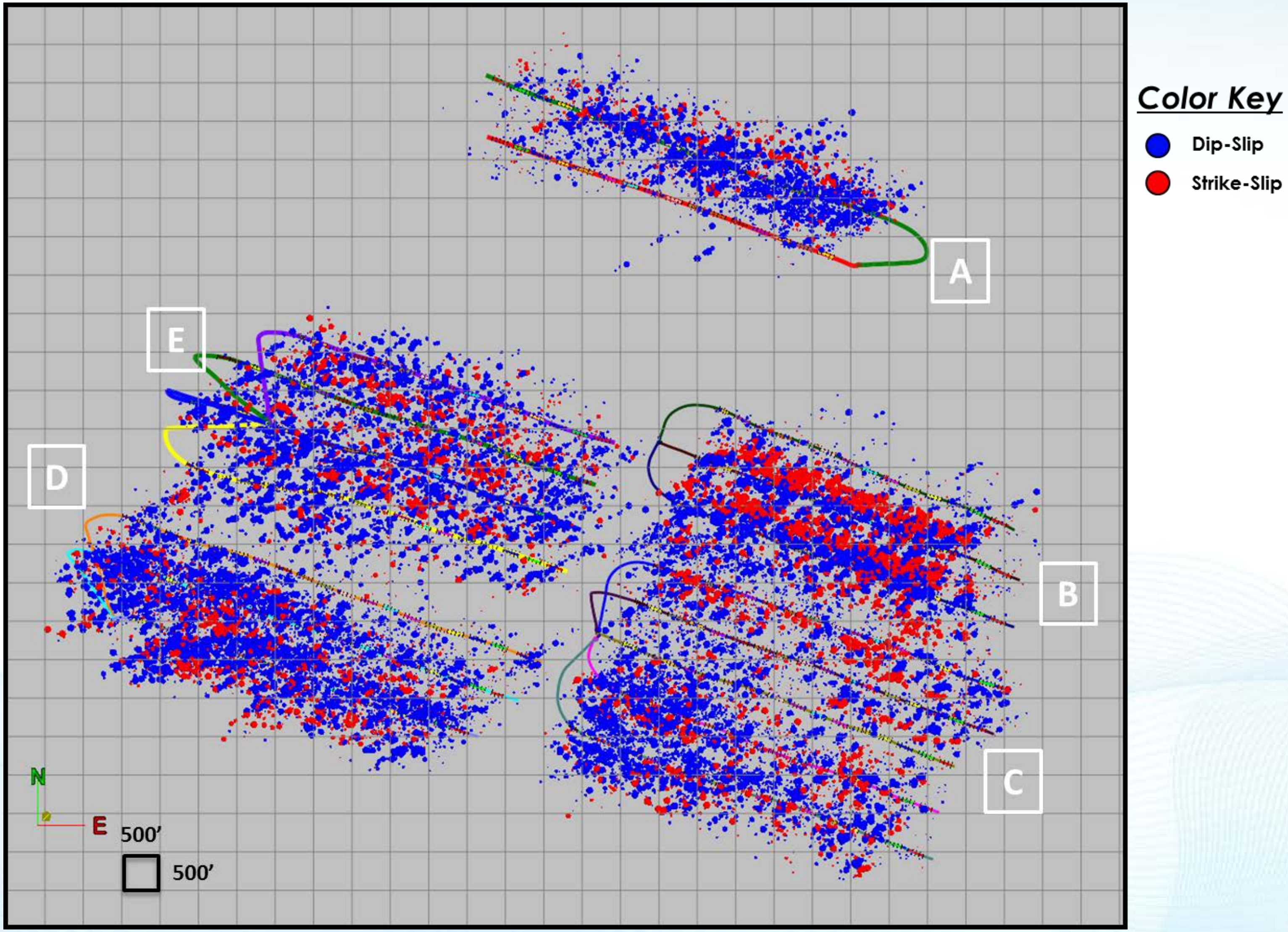
- Direction of S_{Hmax}: NE-SW following structural trend of Appalachian Mountains
- Hundreds of focal mechanisms picked → 4 general groups:



- Four source mechanisms define spatial and temporal subsets
- DS events tend to form trends in J1 direction; occur closer to wellbore and earlier in stage
- SS events form trends in J2 direction and occur further away from wellbore and later in stage

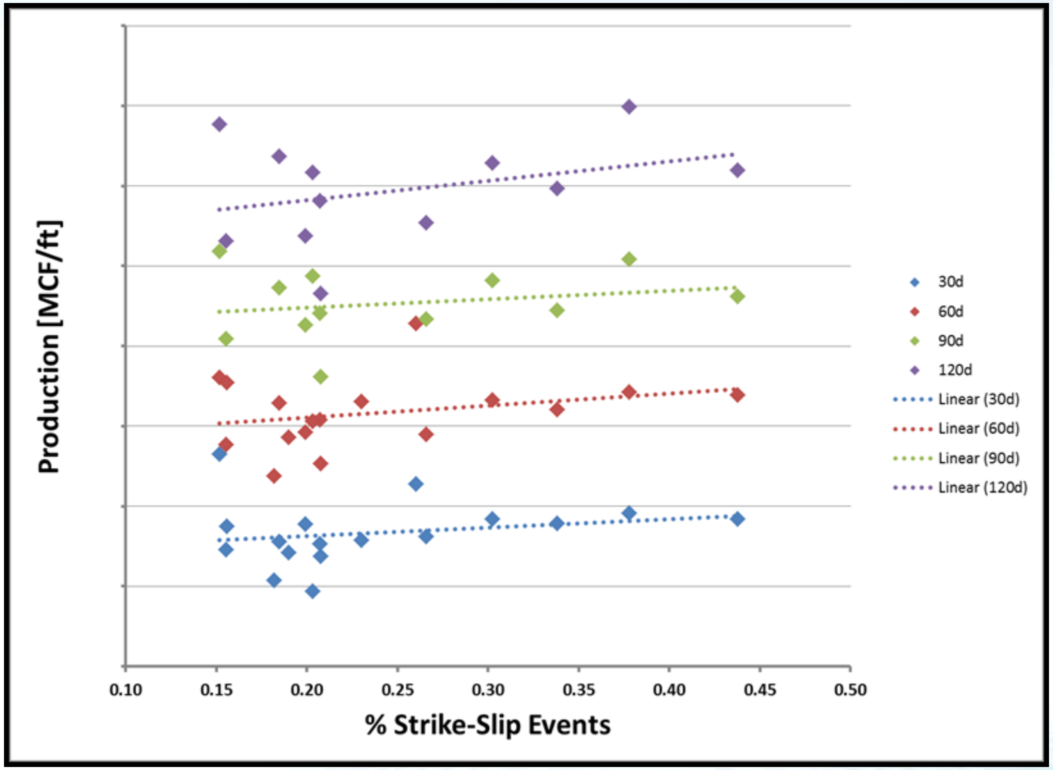


Source Mechanisms



Better Frac Design

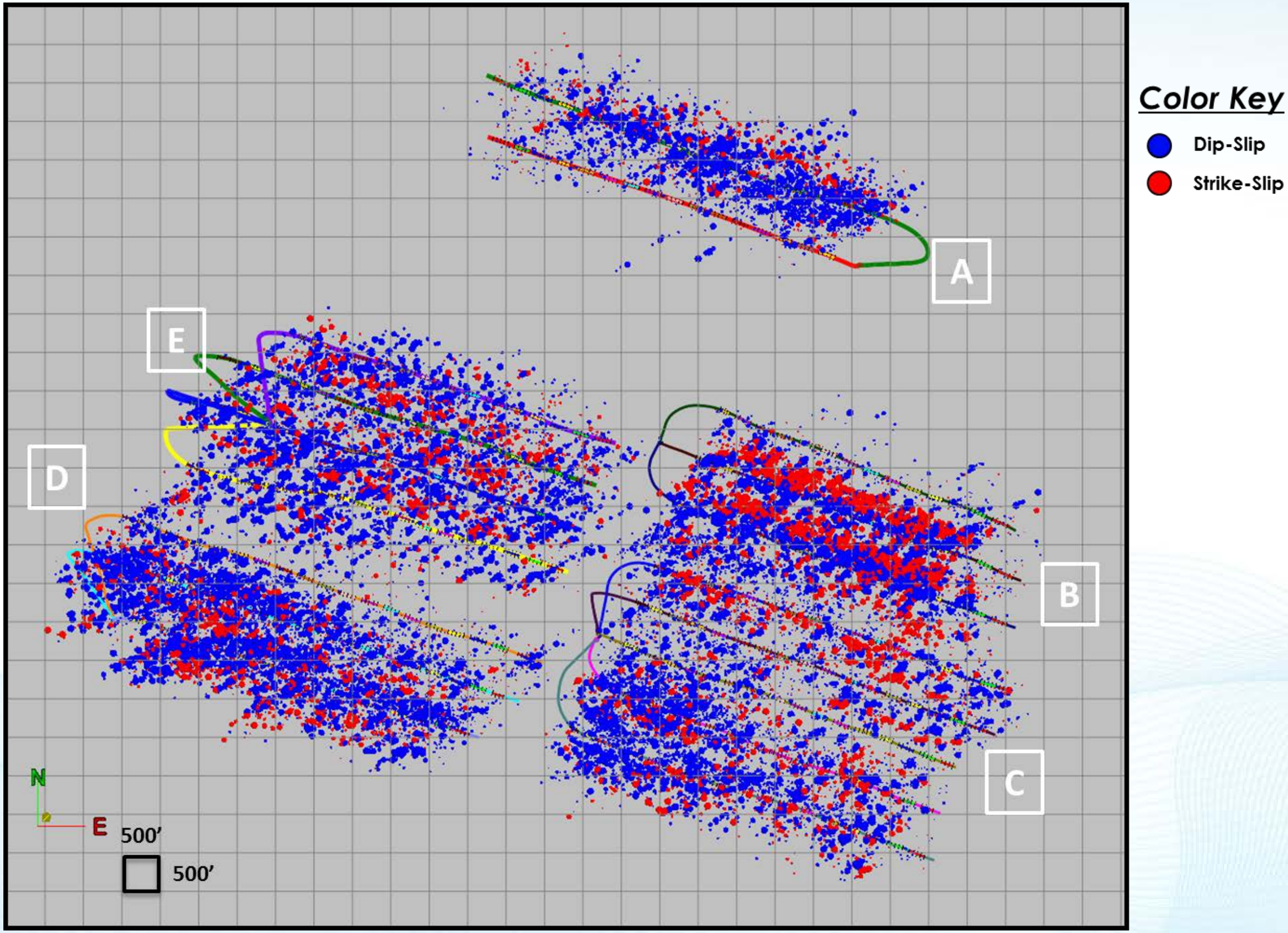
- Correlation between % of SS events and production
- Increased % of SS events is indication of reactivation of both joint sets
- Reactivation of intersecting joint sets increases overall permeability of fracture network



- Stimulation approach seems to play role as well: sequence in which stages are treated influences percentage of SS events
  - Toe-to-heel, one well at a time: 21% SS events
  - Zipper-frac'ed: 38% SS events

MicroSeismic

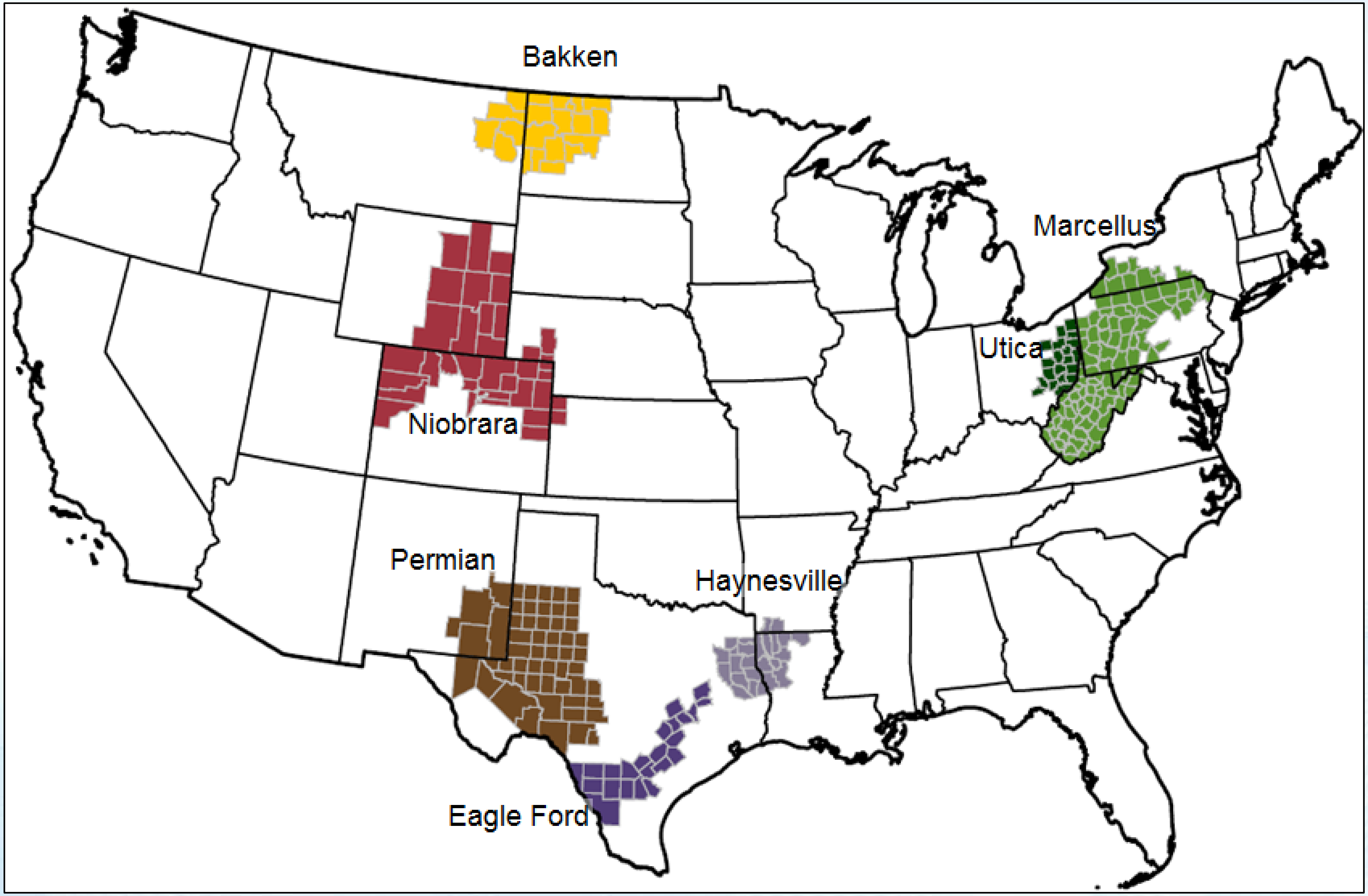
Better Frac Design



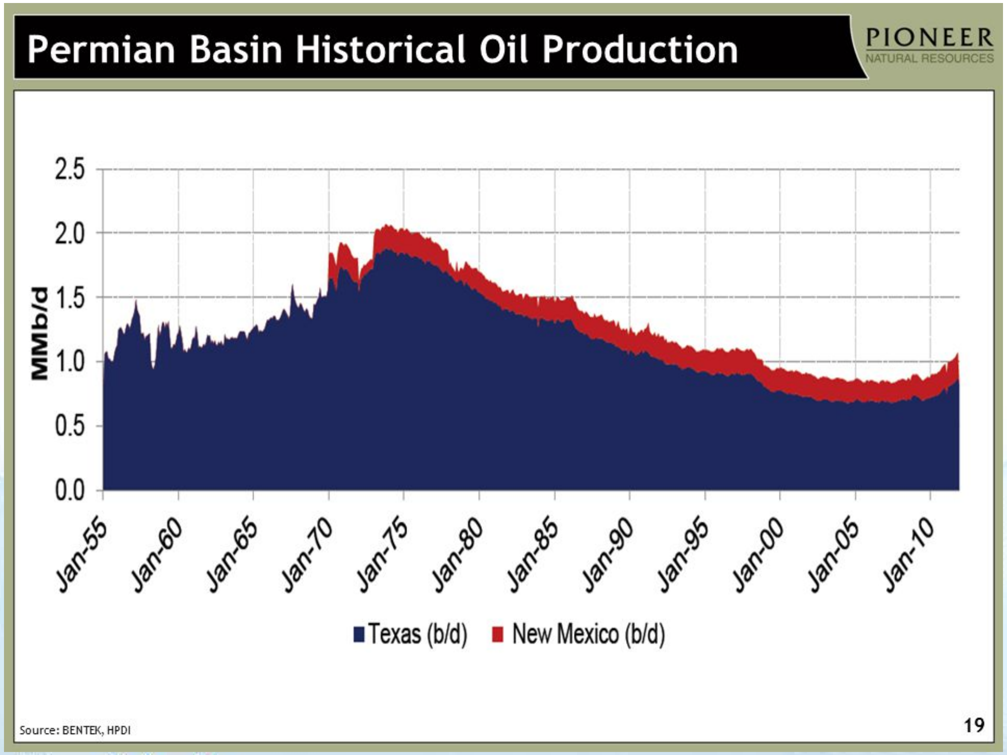
MicroSeismic

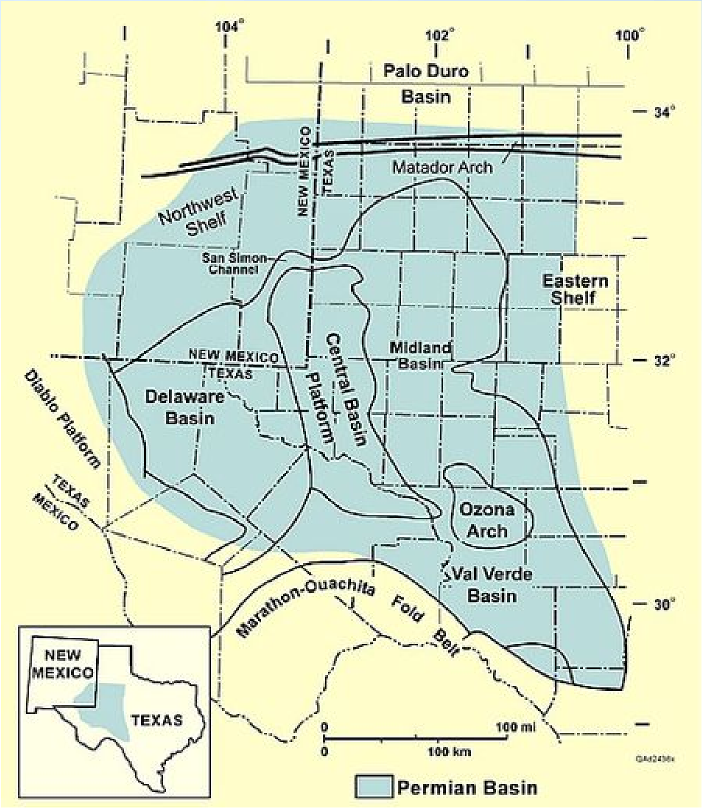
Case History 2
Permian Basin

Key U.S. Shale Regions

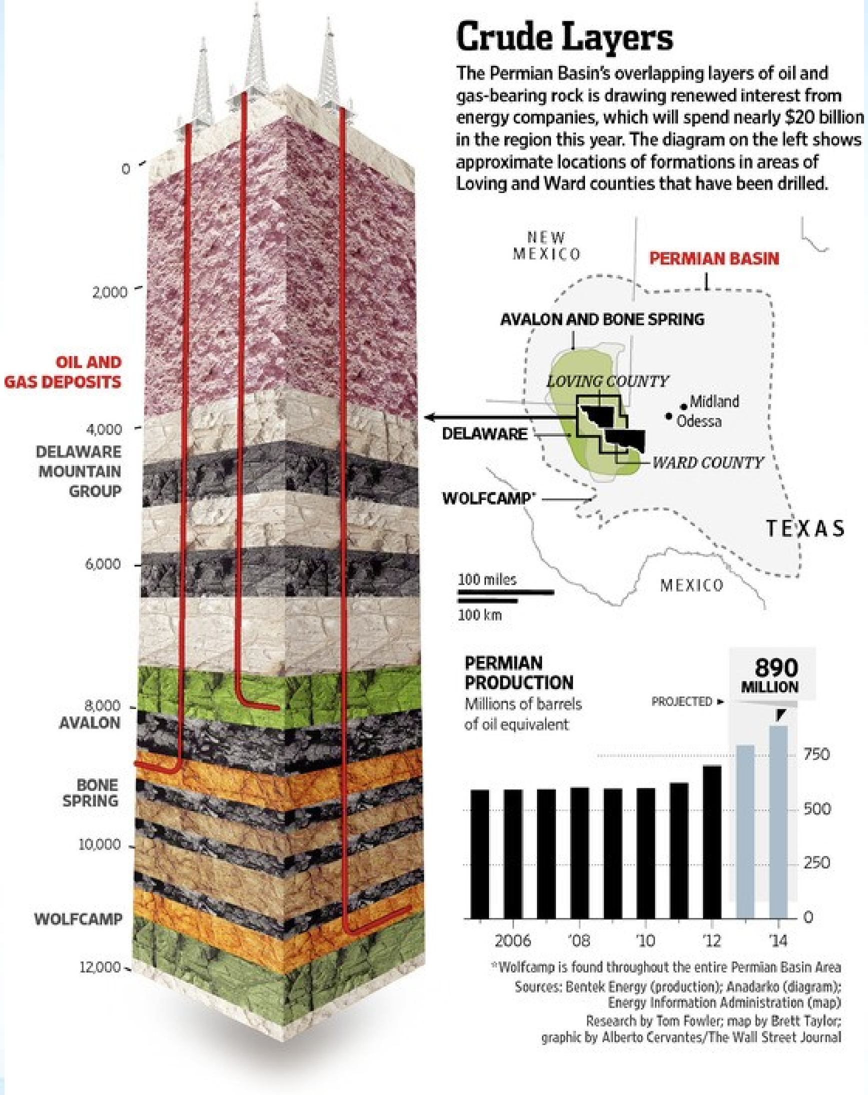


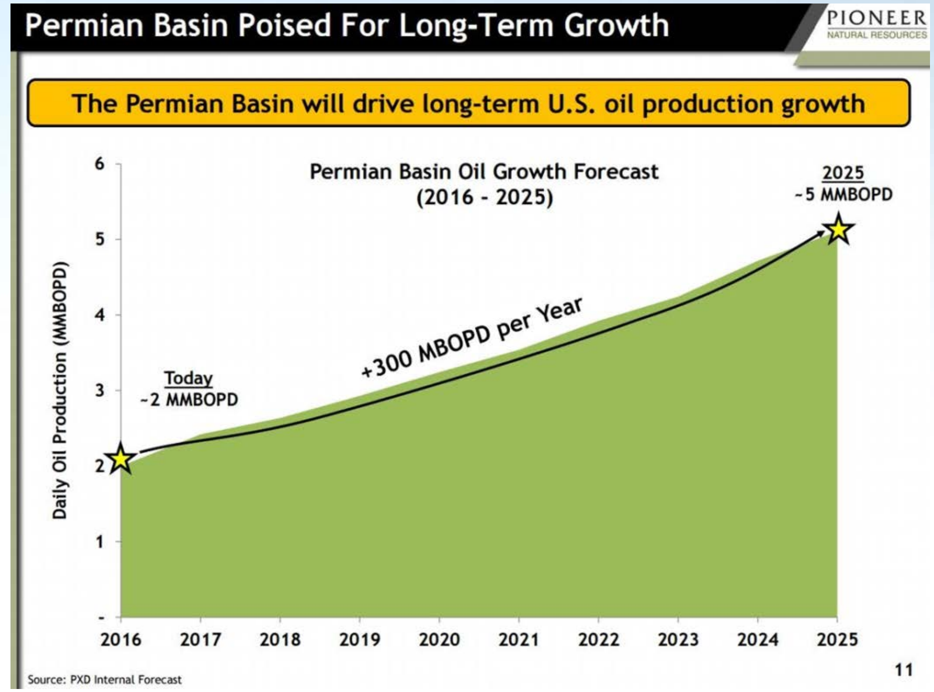
Source: U.S. Energy Information Administration

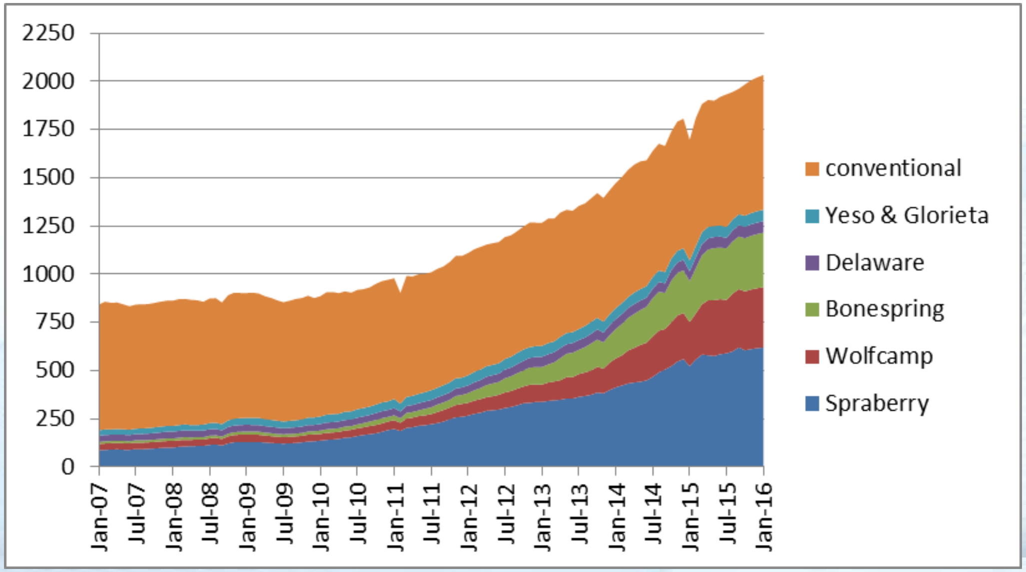




2nd largest US oilfield

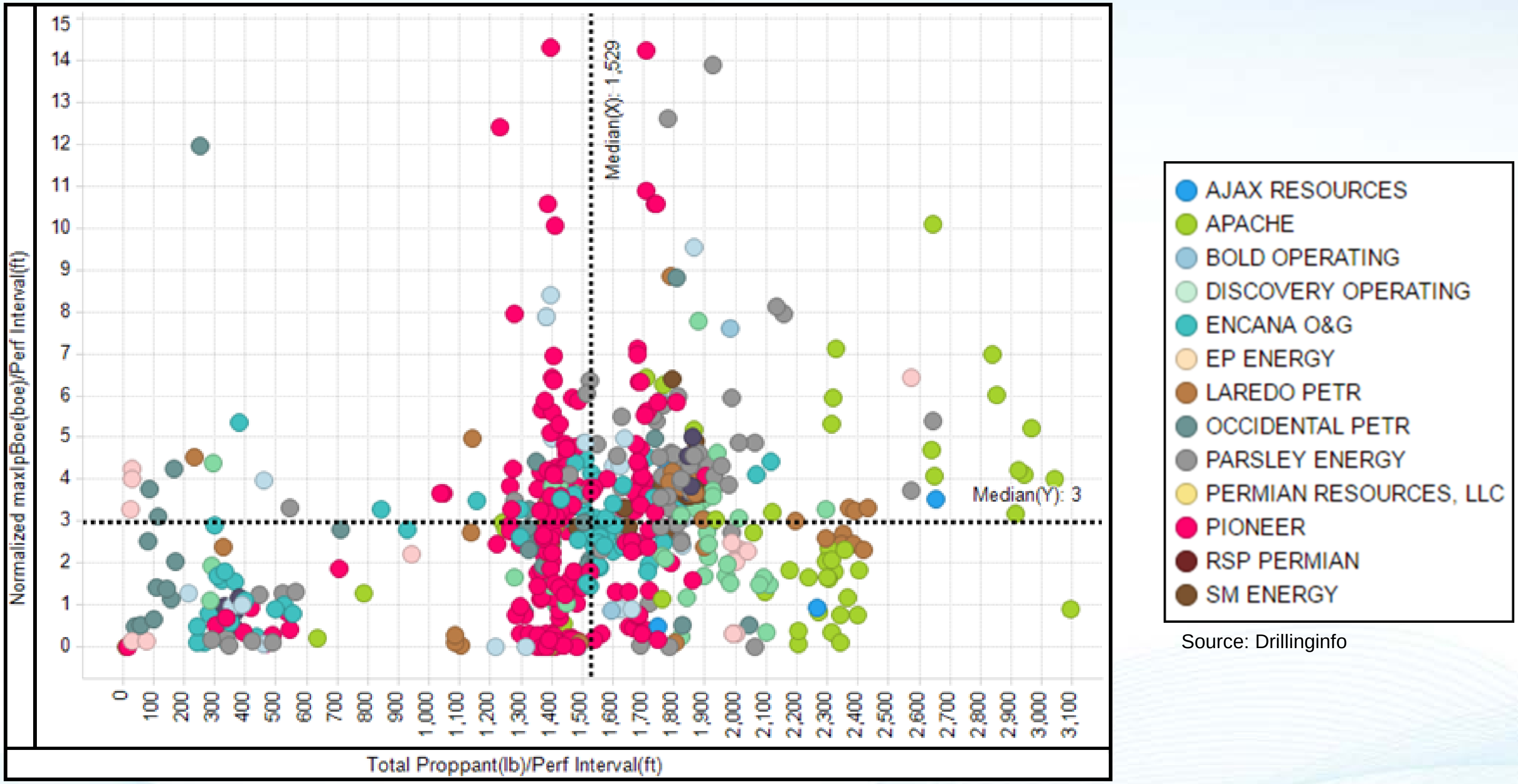






Return of a giant

Complexity in the Midland Basin



Source: Drillinginfo

Understand variability in:

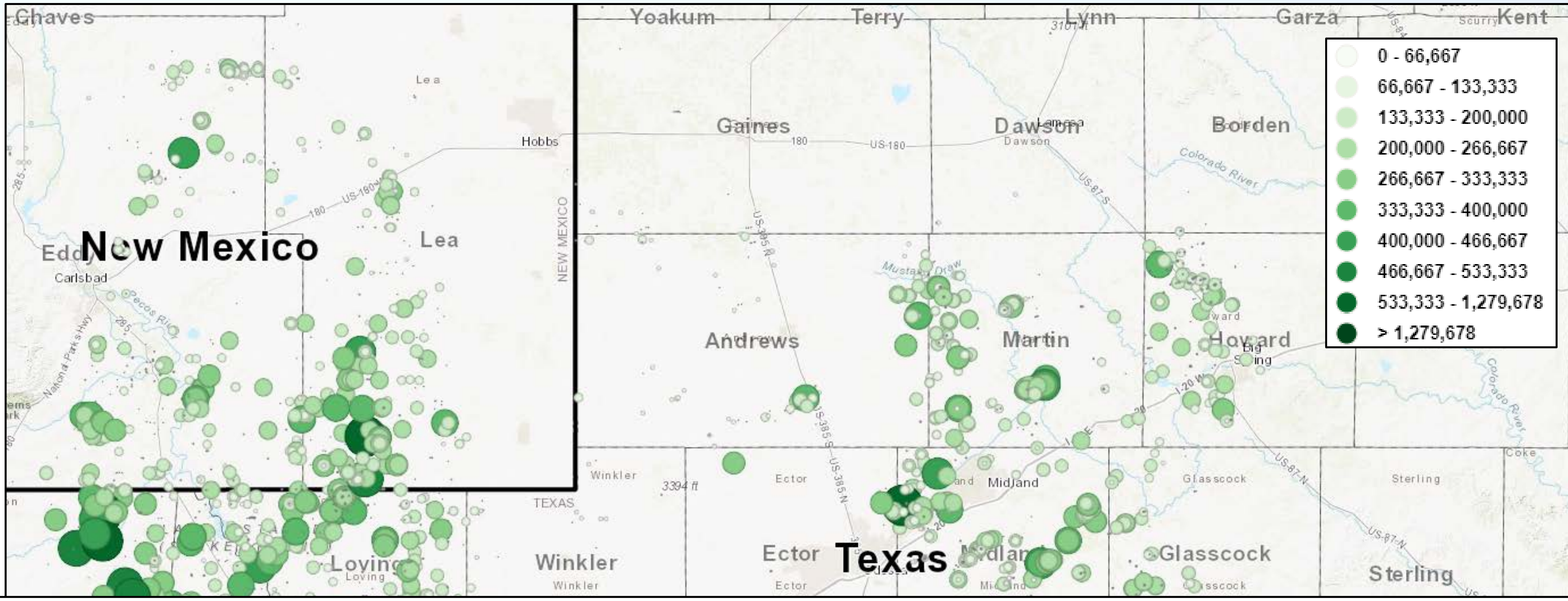
- Geology
- Production
- Impact of treatment design parameters

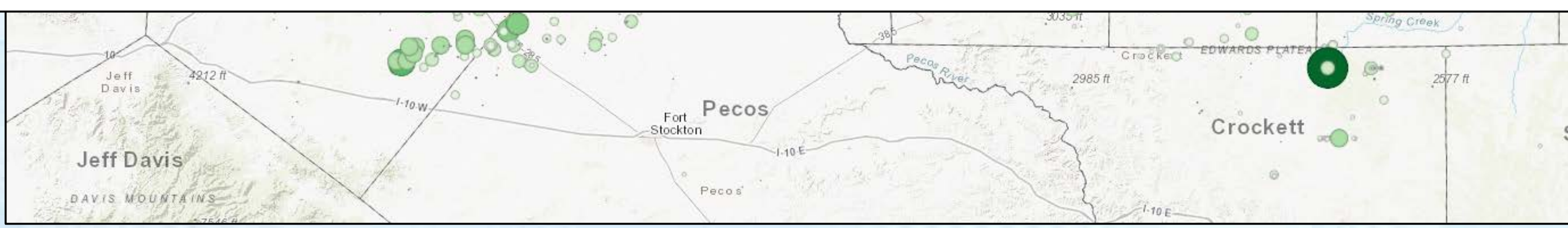
To refine and determine:

- Wellbore spacing
- Completion design
- Long-term drainage and EUR
- NPV

MicroSeismic

Variability (12 Mo. Cum. BOE 2016-17)





<u>Permian Basin:</u>

- Midland Basin: 7 out of top 10 operators used MicroSeismic in workflows (2016)
- Delaware Basin: 5 out of top 10 operators used MicroSeismic in workflows (2016)

Source: Drillinginfo

MicroSeismic

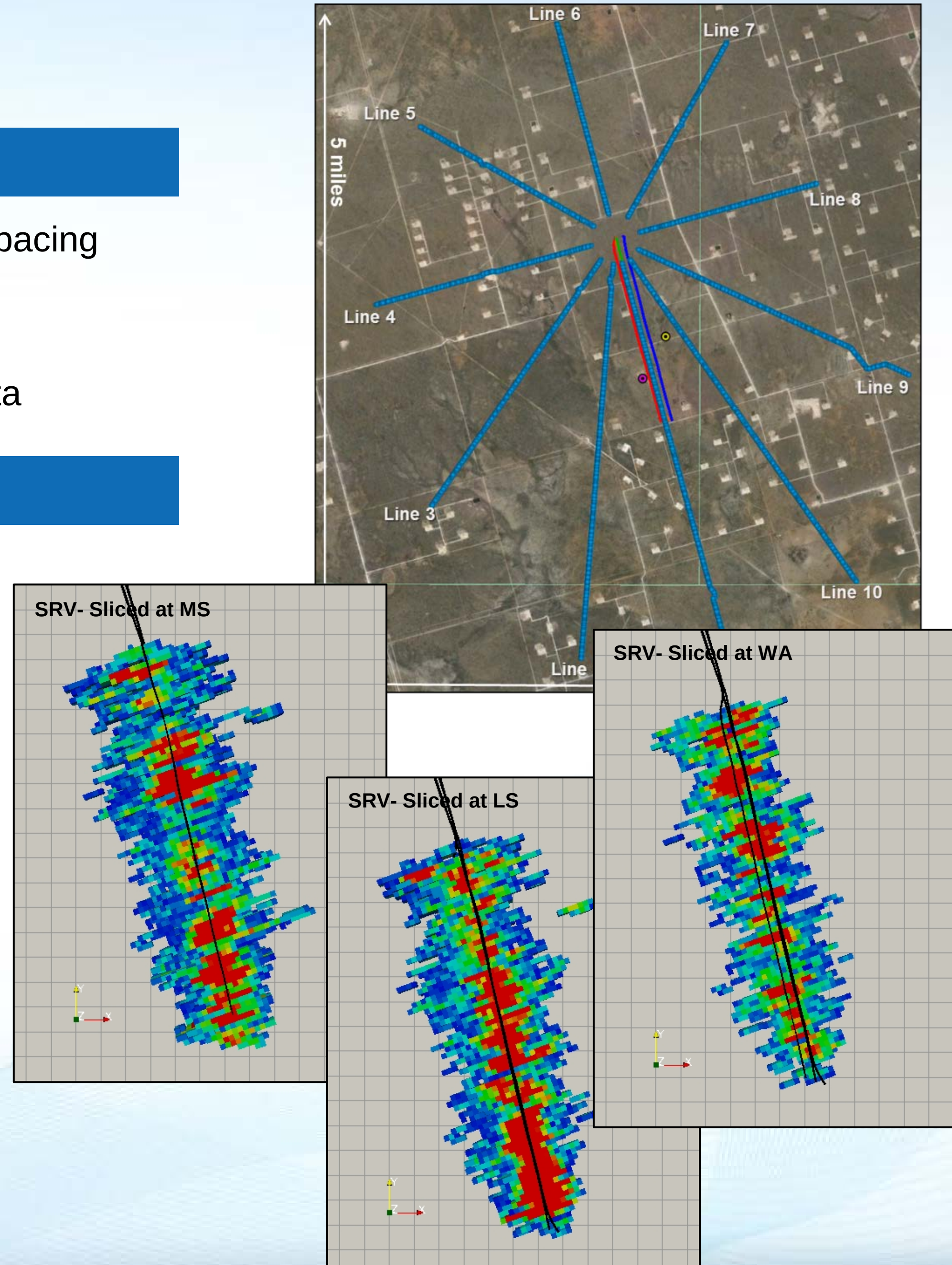
Case Summary

Case Study Objectives

1. Determine vertical and horizontal wellbore spacing
2. Forecast production at time of completion
3. Refine prediction with historic production data

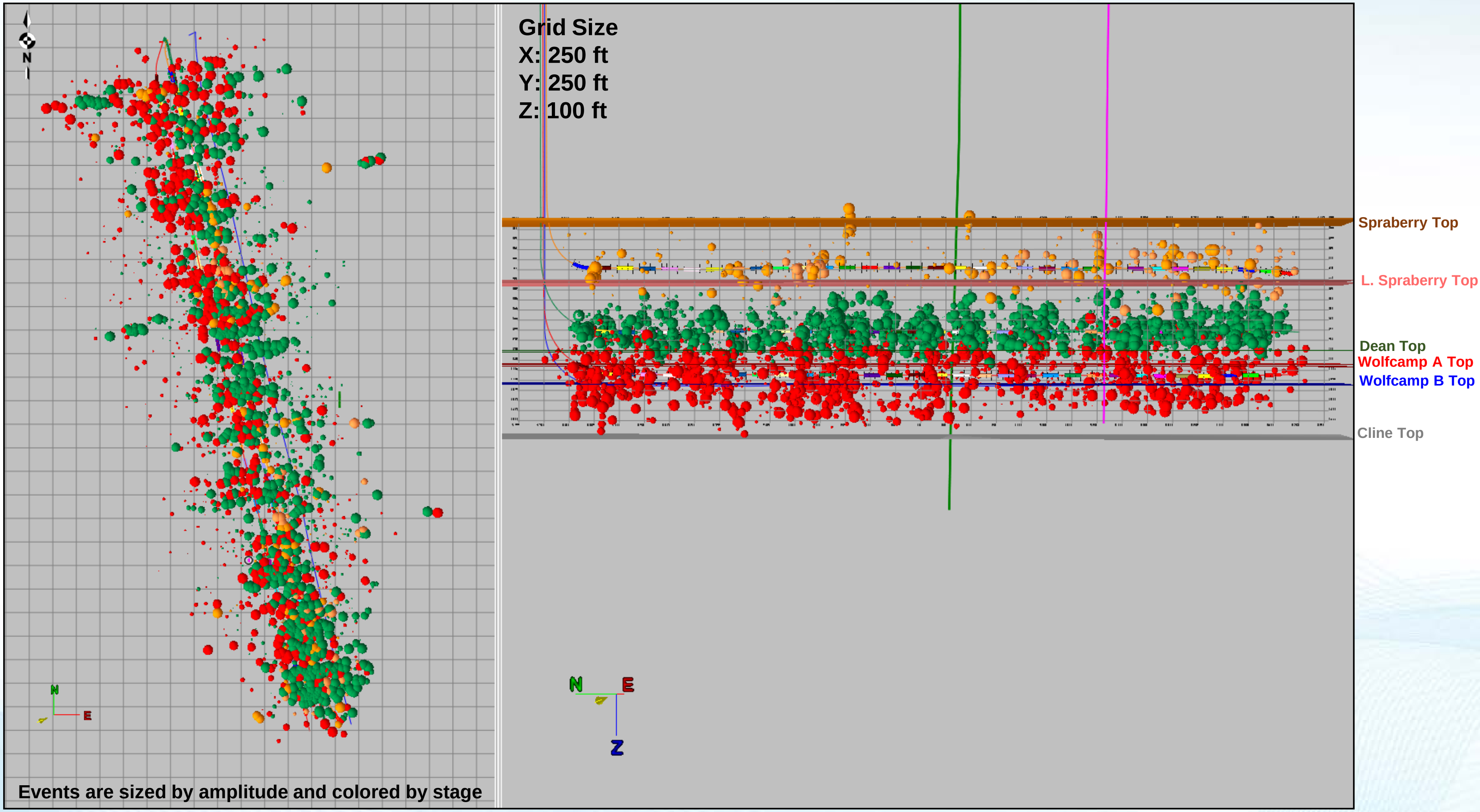
Project Overview

- Treatment dates: 8/4/14 – 8/24/14
- The array covers ~20 mi^2 and consists of 10 lines, 1,235 stations with spacing at 100 feet.
- Target formations:
  - Middle Spraberry at 8,600 ft from KB
  - Lower Spraberry at 9,250 ft from KB
  - Wolfcamp A at 9,650 ft from KB
- Similar completion design:
  - 32-33 plug-and-perf stages
  - 11 mmlbs of proppant (100 mesh with 30/50)
  - 300 kbbls of slickwater



Final Microseismic Results

Map View | **Depth View Looking East**



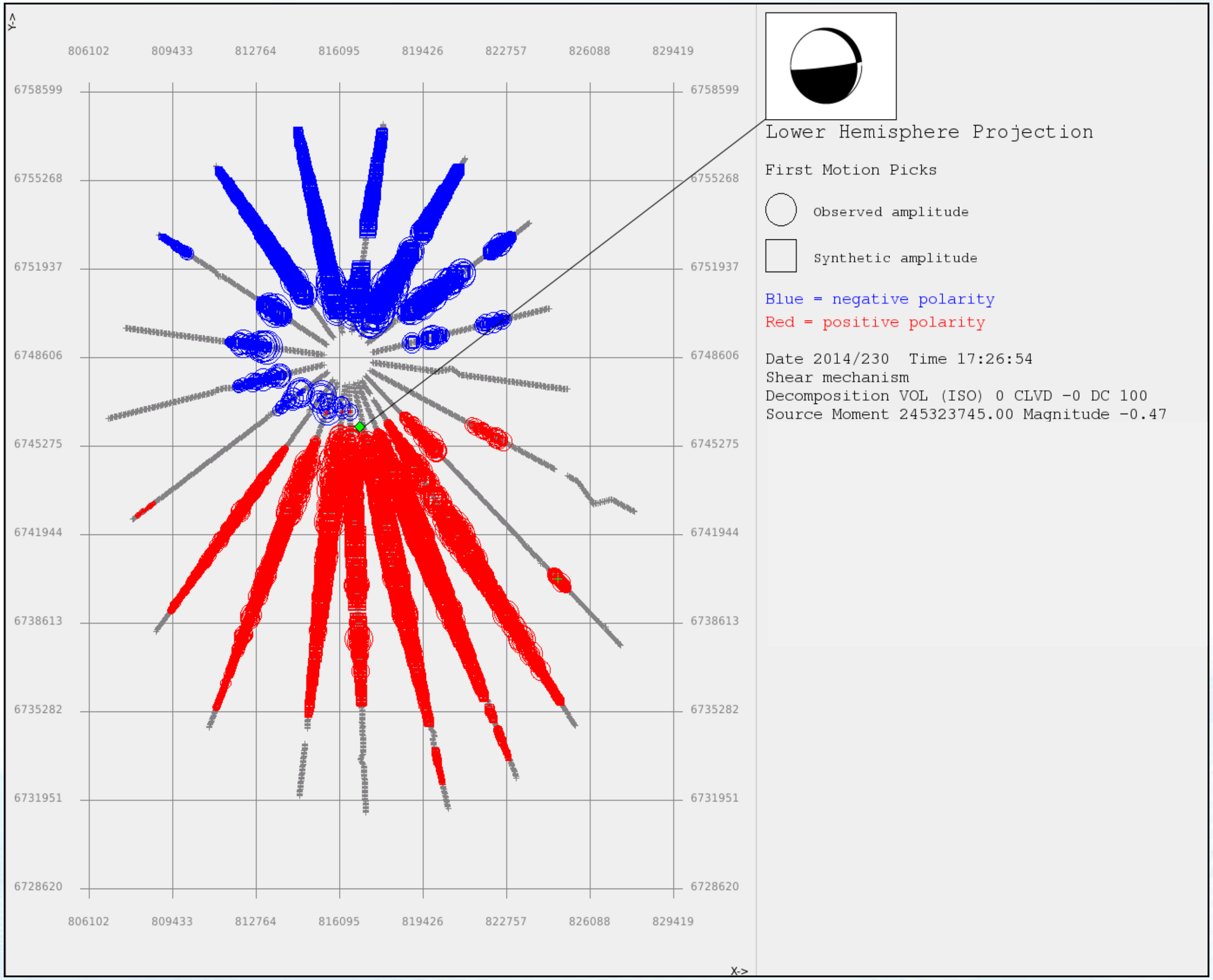
MS LS WA

Source Mechanism

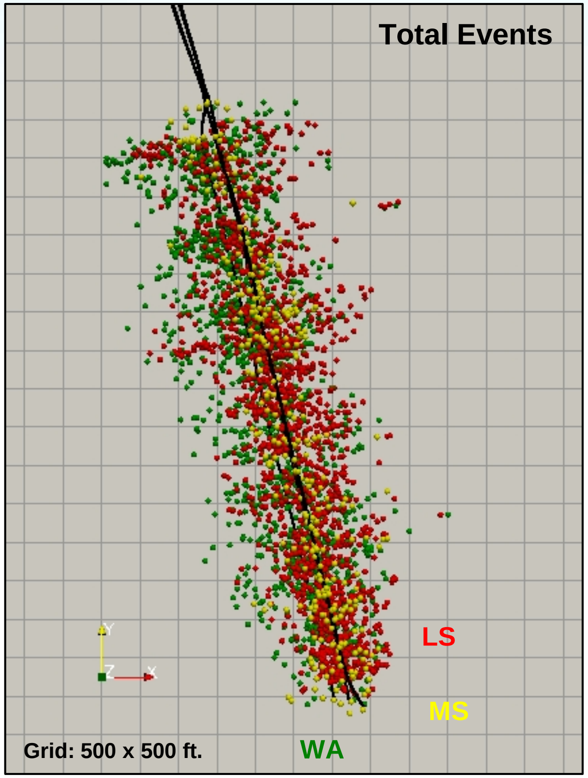
- Maps the orientation of the fracture plane (i.e. how the rock fails) for every event
- Clearly and accurately identifies multiple fracture sets
- The dip, strike, and rake for the solution is:

Strike	Dip	Rake
72	84	126

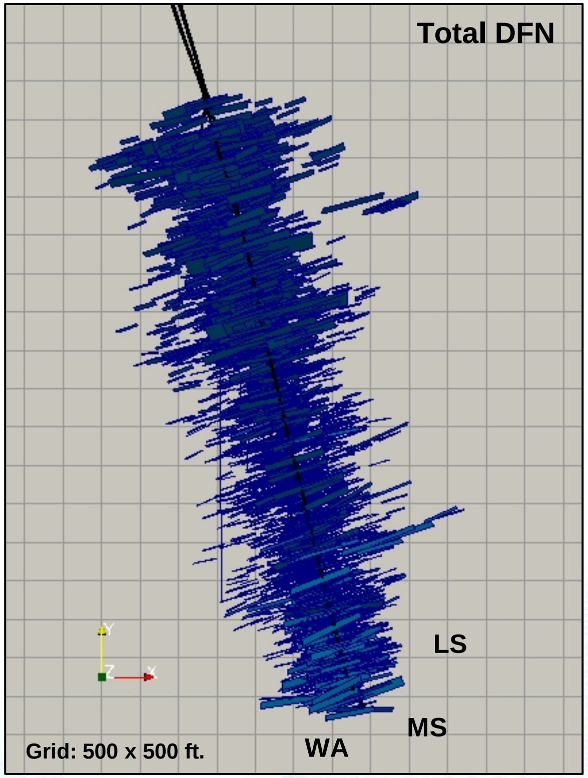
- Source mechanisms are also used in processing to obtain the best stack of each microseismic event



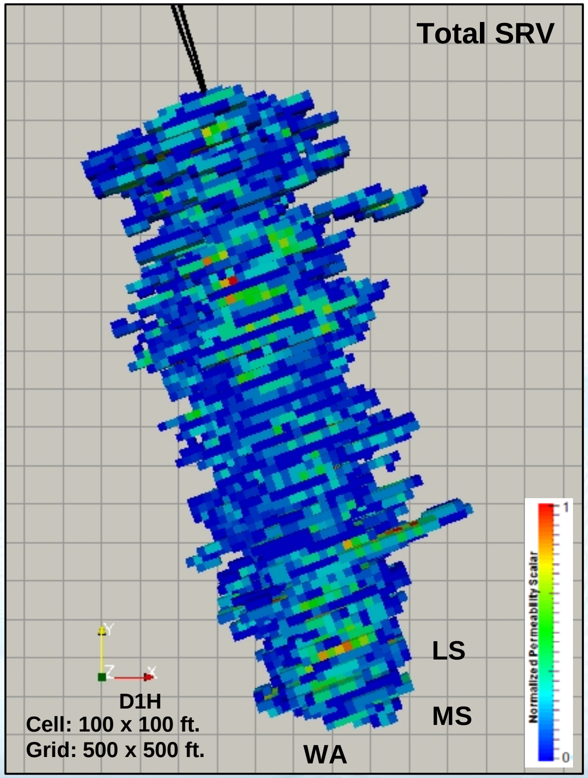
Discrete Fracture Network Modeling



One fracture is modeled per microseismic event. Individual fracture orientation is determined by focal mechanism. Fracture geometry is determined from moment magnitude, rock rigidity, and injected fluid volume.



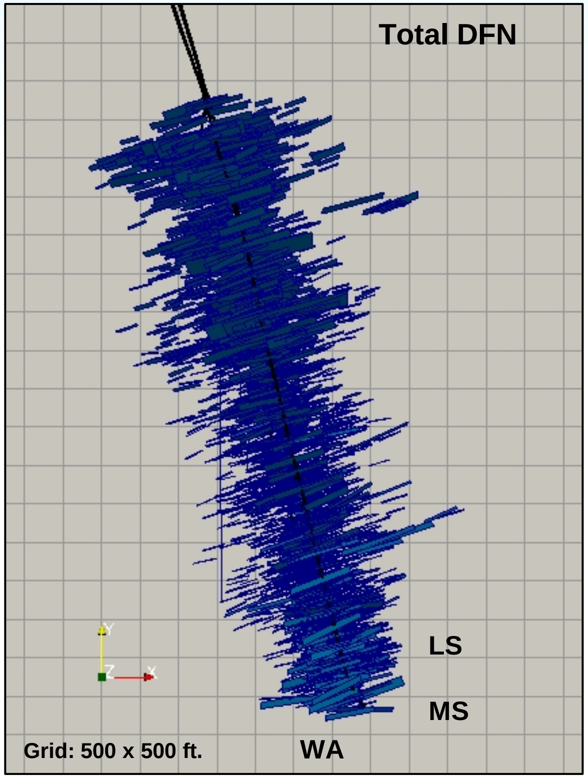
Permeability enhancement inside SRV is calculated for every cell and used as input for reservoir simulation and production forecast.



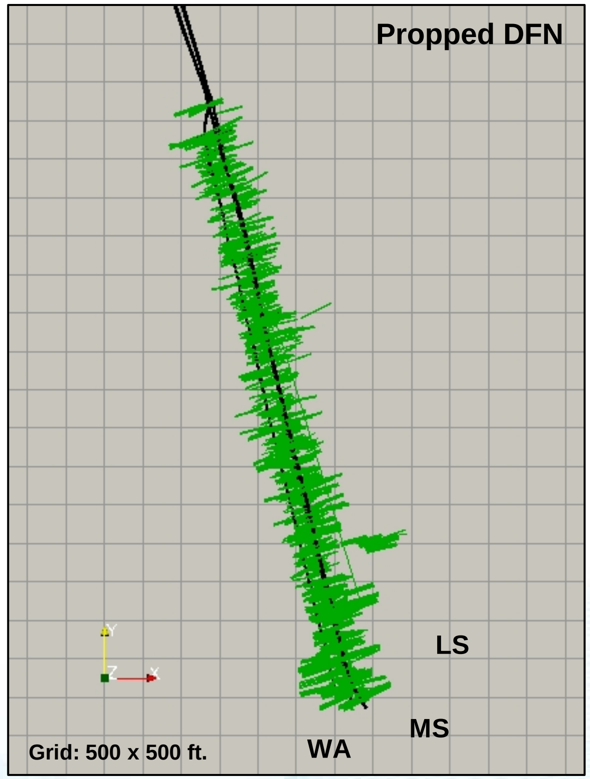
Only events that are considered fluid related are retained for DFN analysis.

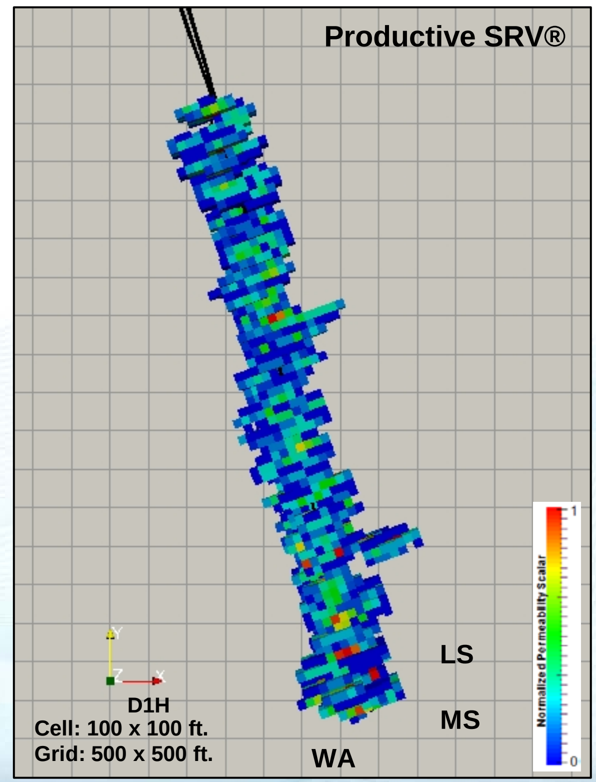
A network of 100 ft cells is placed over the DFN. Cells containing fractures form the Total SRV.

Where is the Proppant ?



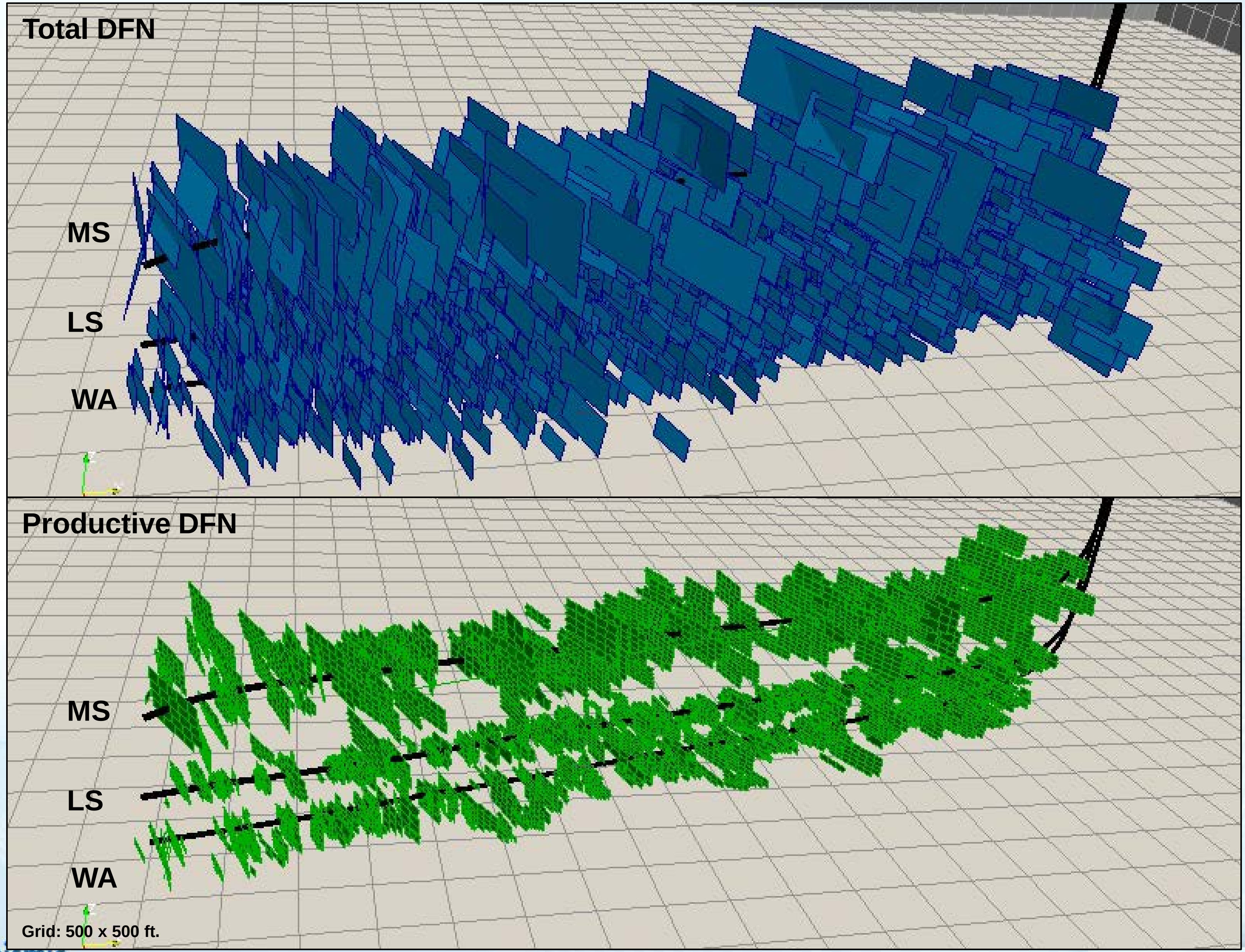
In order to distinguish between total fracture volume and proppant filled fracture, the DFN is filled with proppant from the stage centers out on a stage-by-stage basis honoring the shape of the microseismic event cloud.



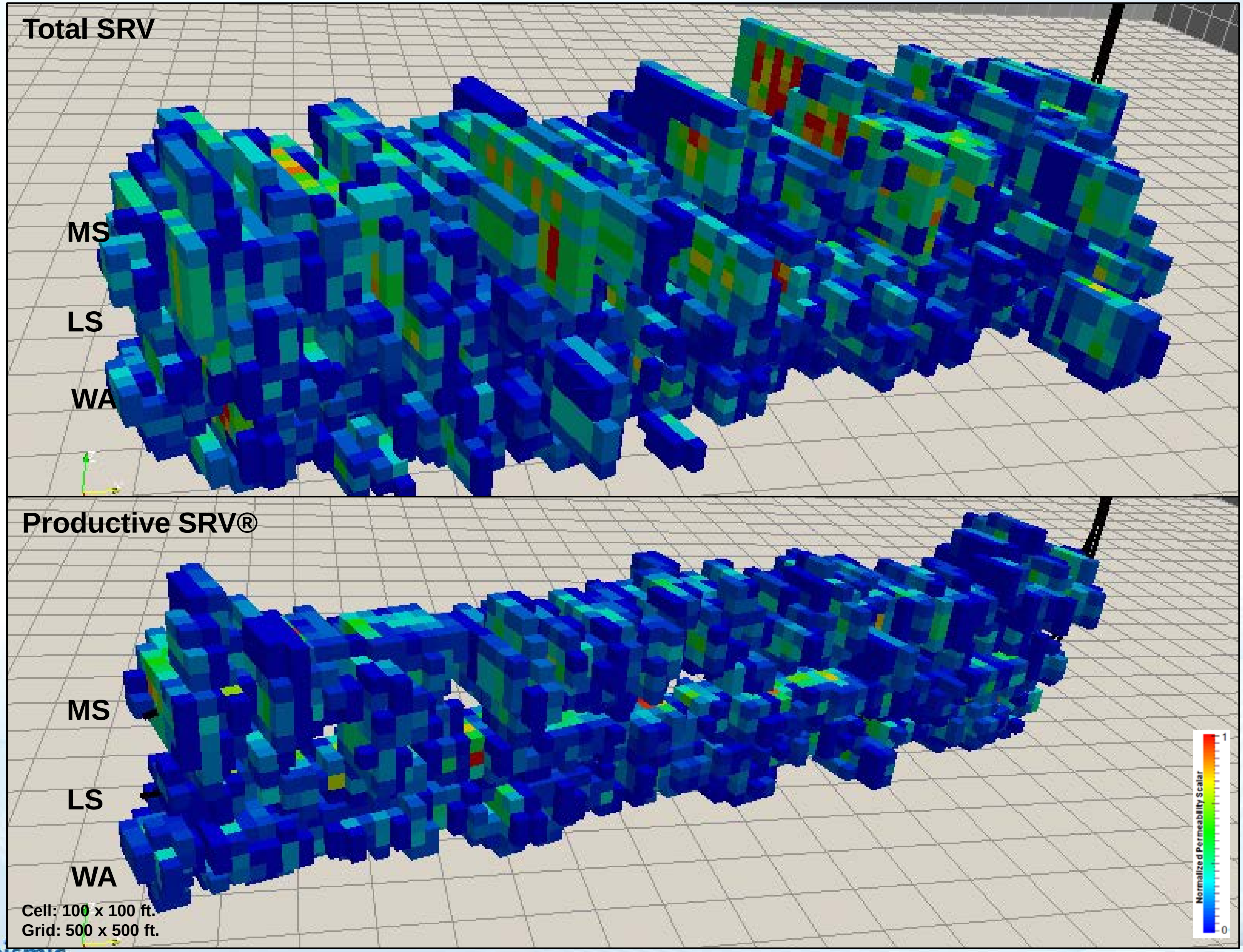


A network of 100 ft cells is placed over the Propped DFN. Cells containing proppant filled fractures form the Productive-SRV®.

DFN - Depth View with Formations

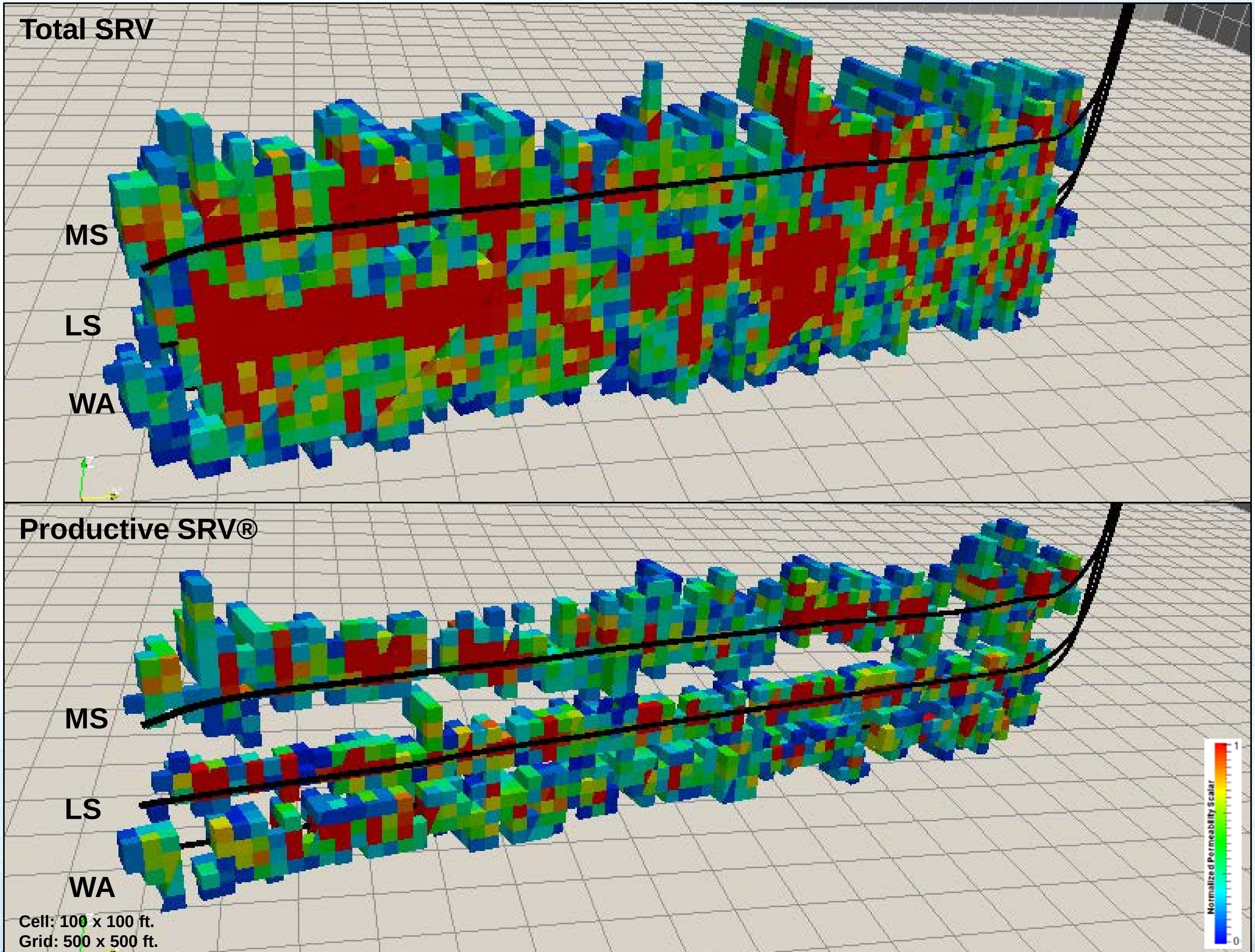


SRV - Depth View with Formations



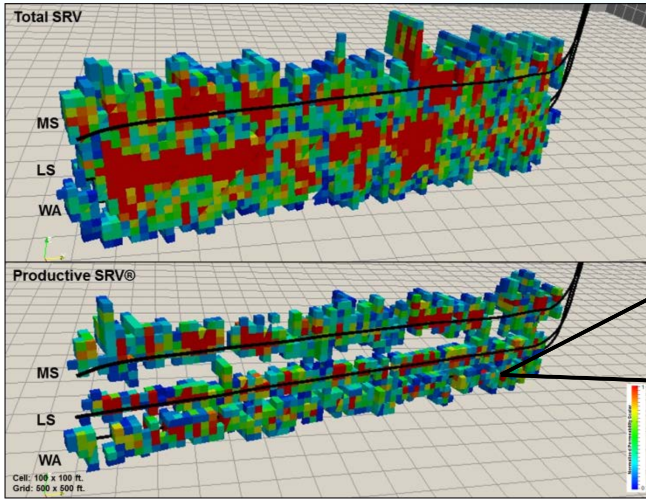
MicroSeismic

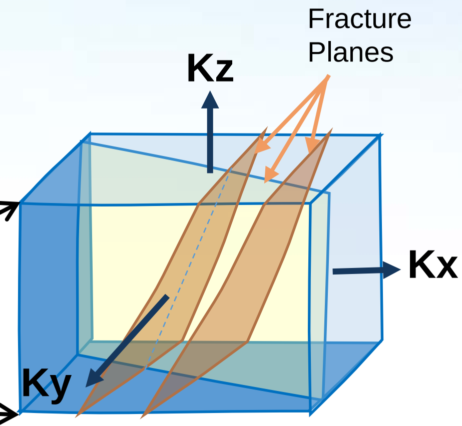
SRV – Oblique View Sliced at Wellbore



MicroSeismic

Translation into Reservoir Simulation

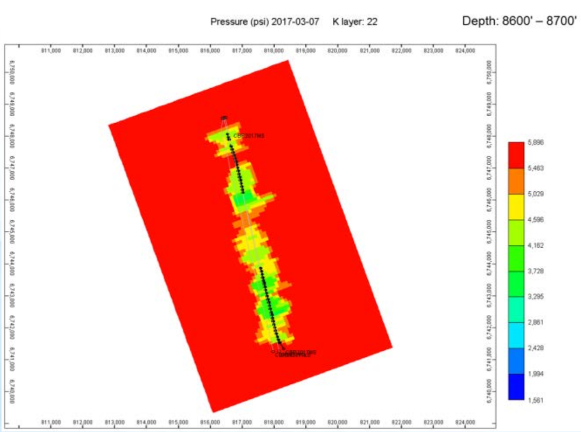




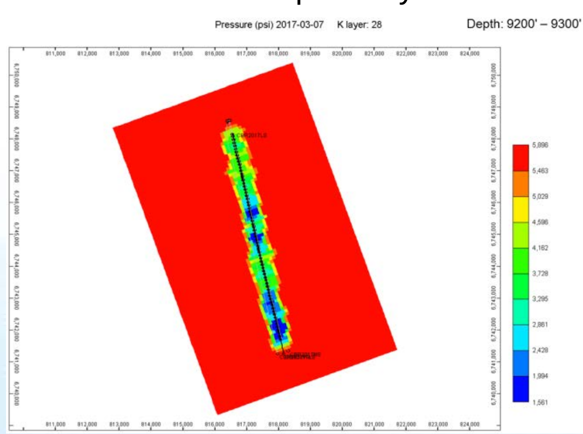
Compute Permeability Tensor based on:

1. Number of fractures
2. Orientation of fractures
3. Aperture of fractures

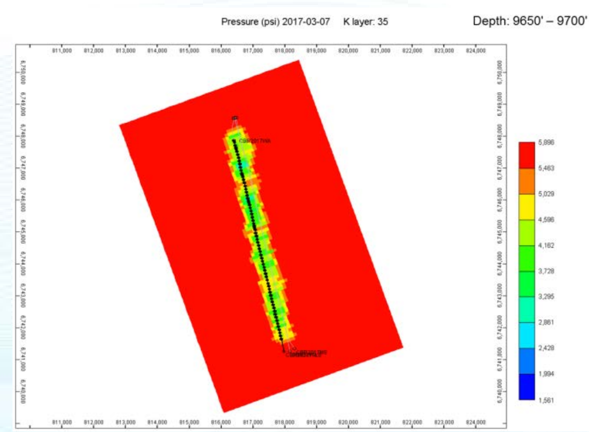
Middle Spraberry



Lower Spraberry

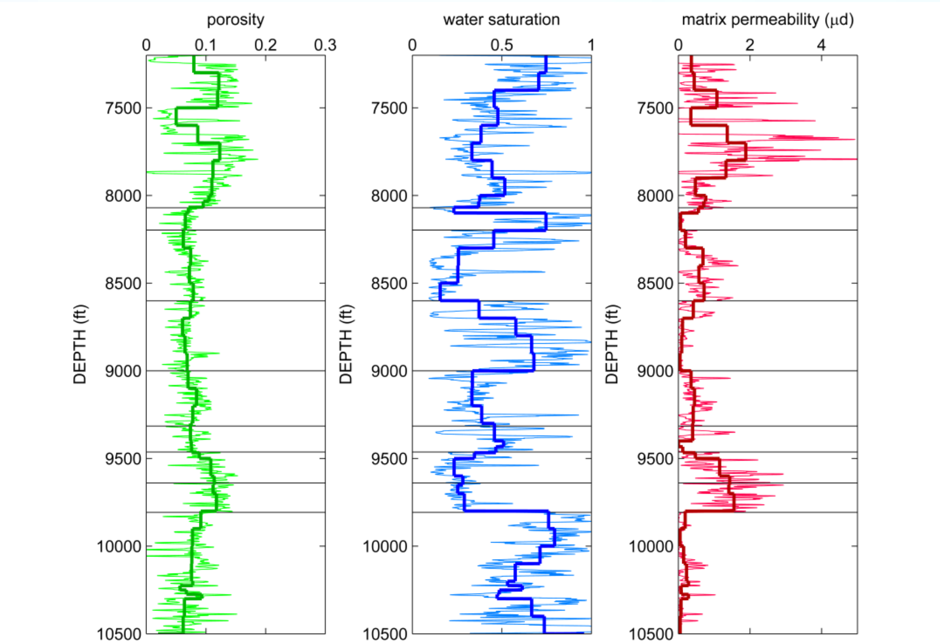


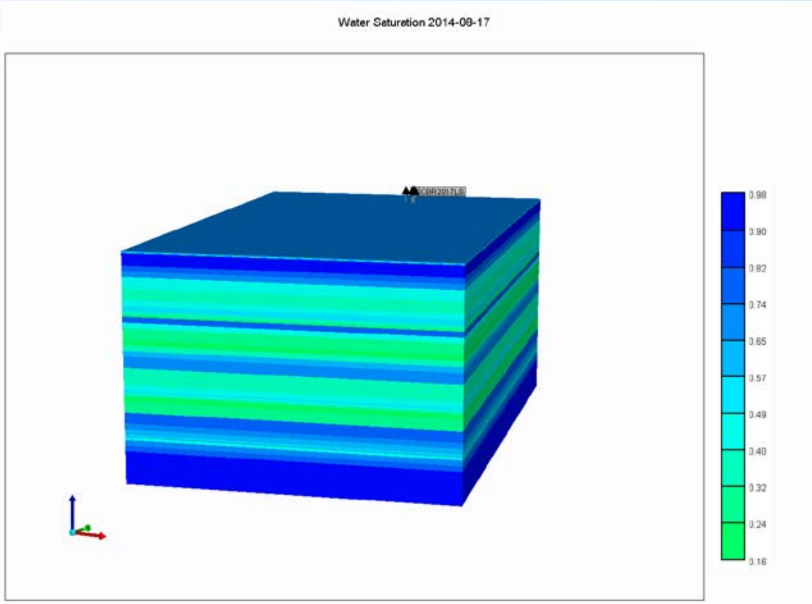
Wolfcamp A

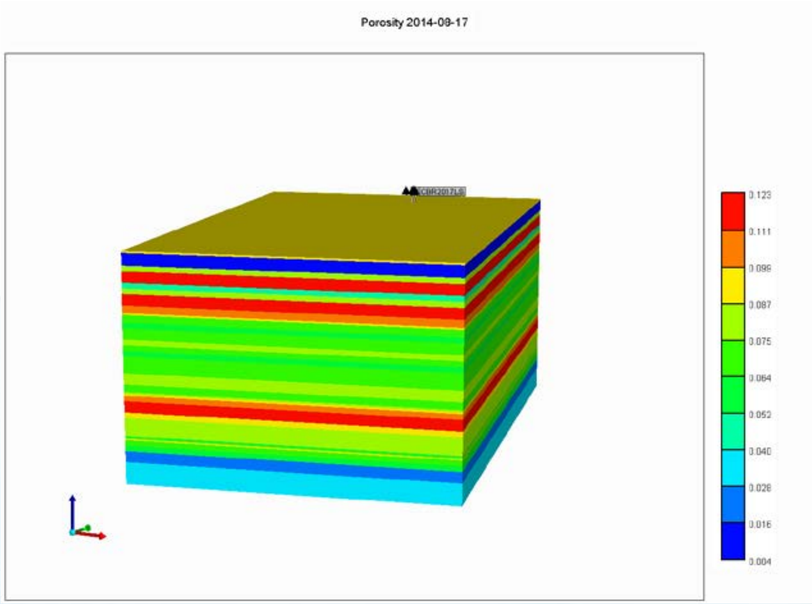


Reservoir Properties

Well logs from offset well



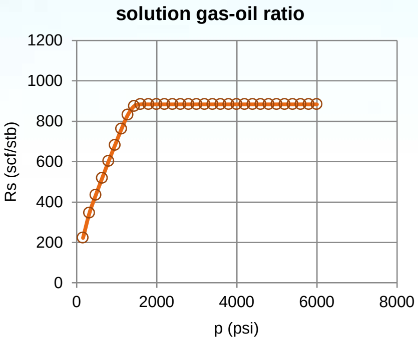


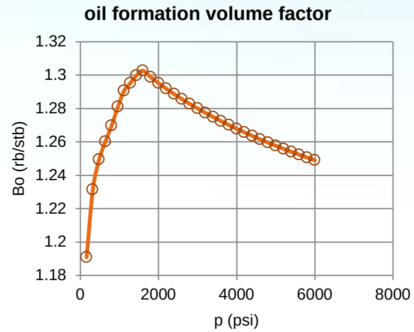


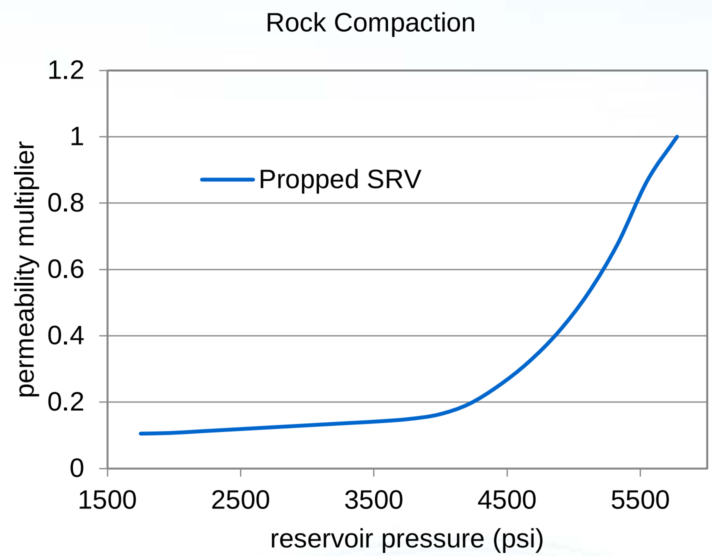
Property	Value		Property	Value
Matrix permeability (md)	variable		Bubble point pressure (psi)	1,600
Porosity	variable		Initial GOR (scf/stb)	883
Initial water saturation	variable		Stock tank oil density (API)	41.65
Reservoir pressure (psi)	5,775		Gas gravity (Air=1)	1.18
Reservoir temperature (˚F)	160		Water density (lb/ft^3)	66.77

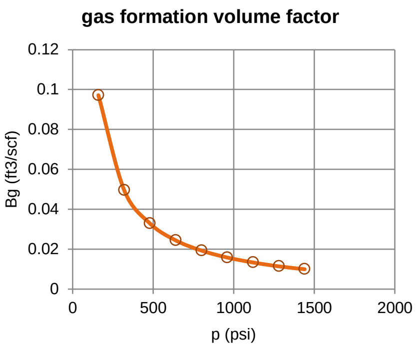
Fluid and Reservoir Properties

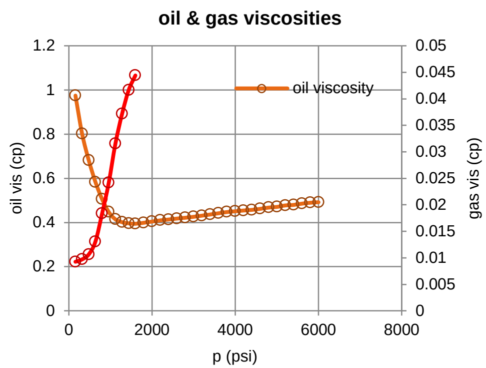
PVT Data from Spanish Trail 4818LS

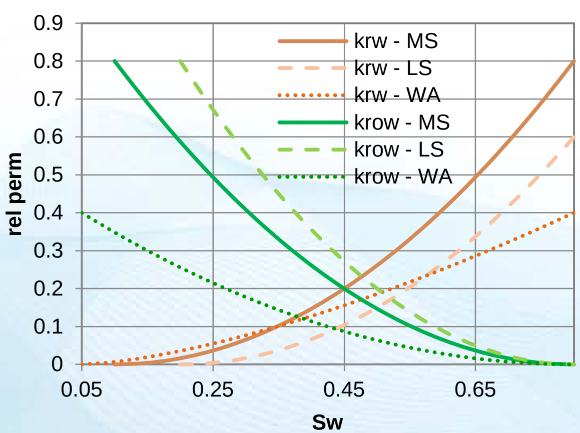


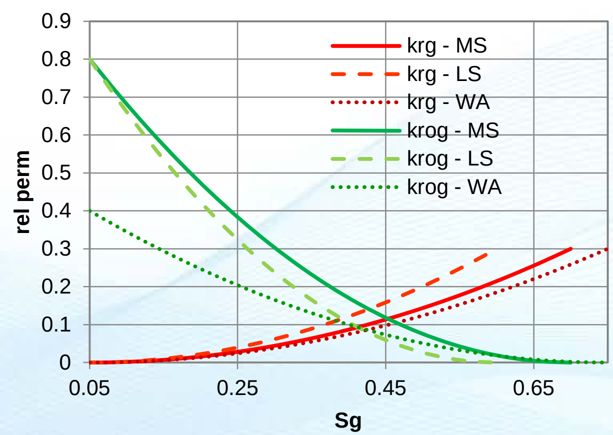












Three-phase rel-perm function based on Stone II model

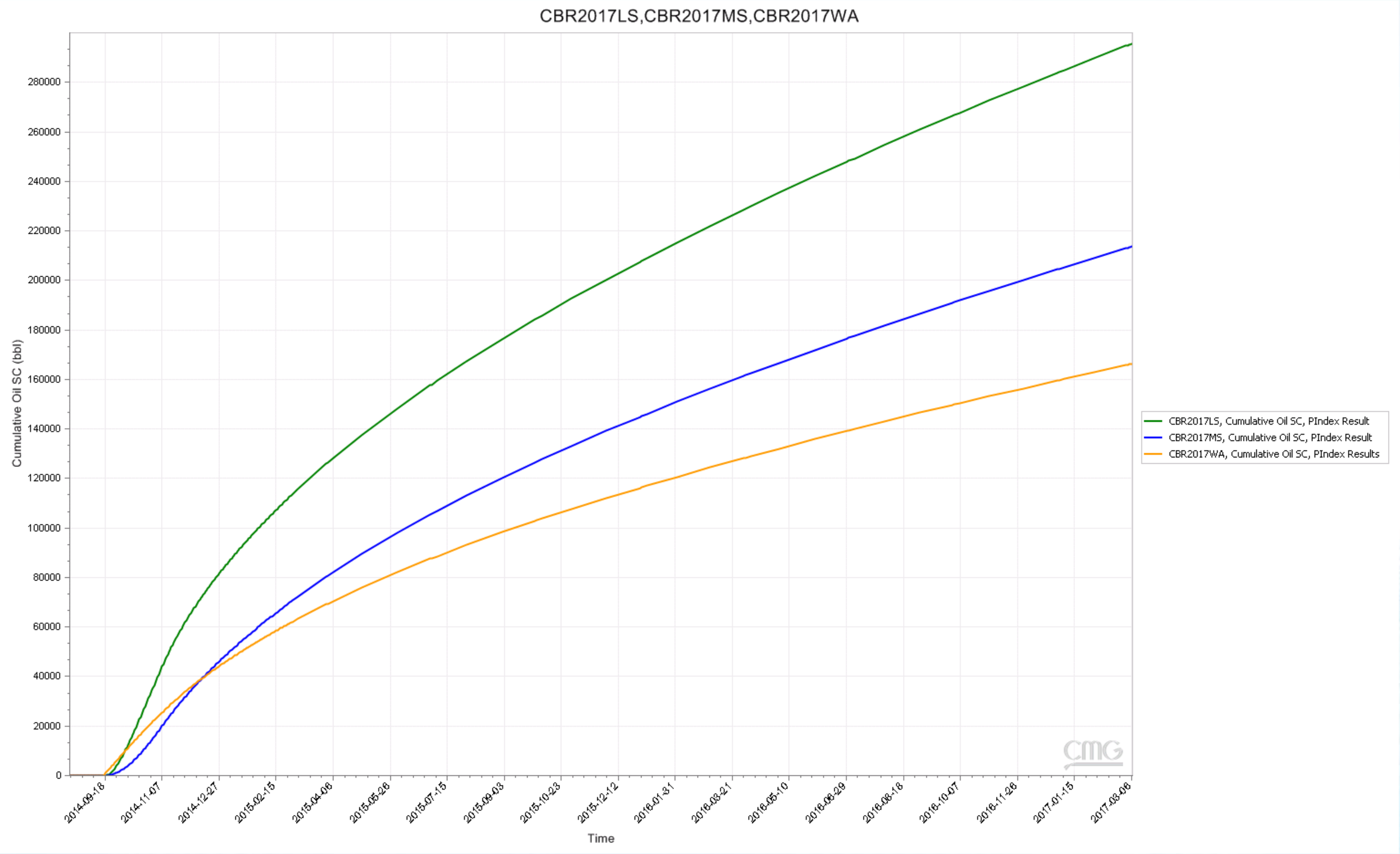
Reservoir Simulation Overview

- Microseismic derived permeability enhancement was used in numerical simulation to forecast oil, gas, and water production, as well as pressure depletion for 2.5 years
- The reservoir simulation results show the following productivity order for the project wells, which is consistent with field observations:

90-day production:	2.5-year production:
1. CBR2017 LS	1. CBR2017 LS (L. Spraberry, plug & perf completion, 33 stages)
2. CBR2017 WA	2. CBR2017 MS (M. Spraberry, plug & perf completion, 32 stages)
3. CBR2017 MS	3. CBR2017 WA (Wolfcamp A, plug & perf completion, 32 stages)

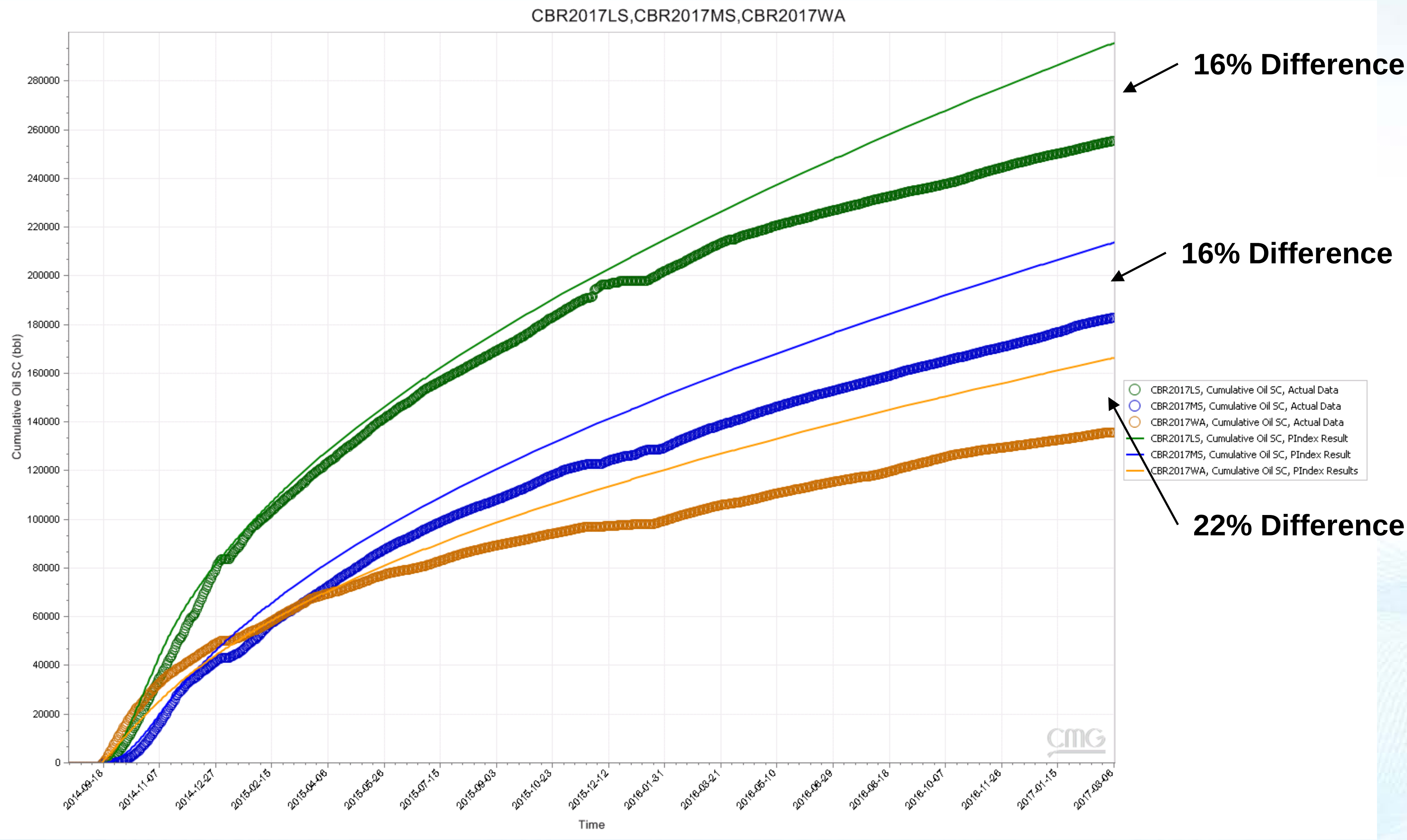
- Reservoir simulation was performed without historic production data to evaluate accuracy of model at time of completion
- Reservoir model was then calibrated using 2.5 years of production and pressure data

Production Forecast at Time of Completion (Oil Rate)



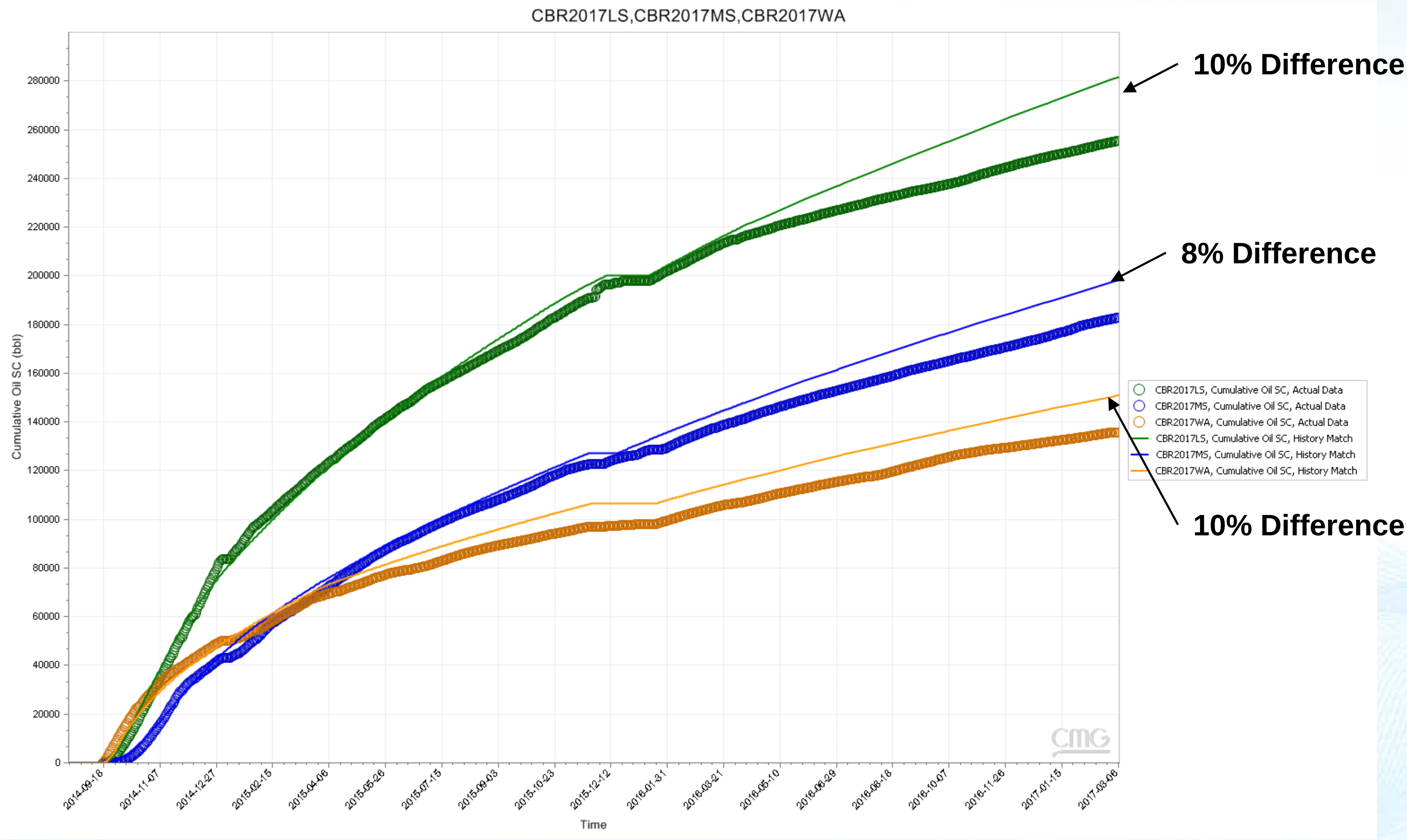
MicroSeismic

Production Forecast at Time of Completion (Oil Rate)



MicroSeismic

Production Forecast using 90-Day Production (Oil Rate)



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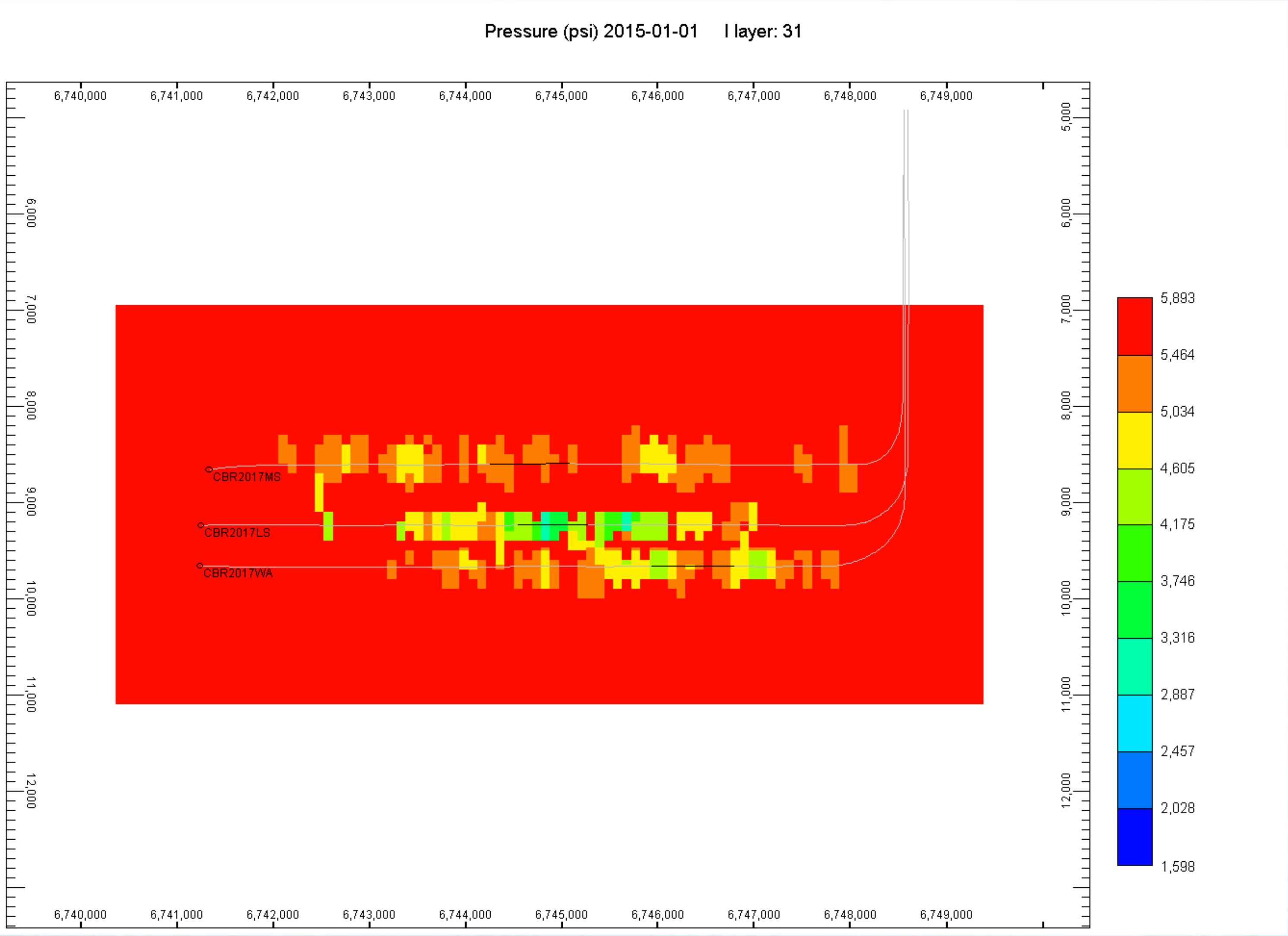
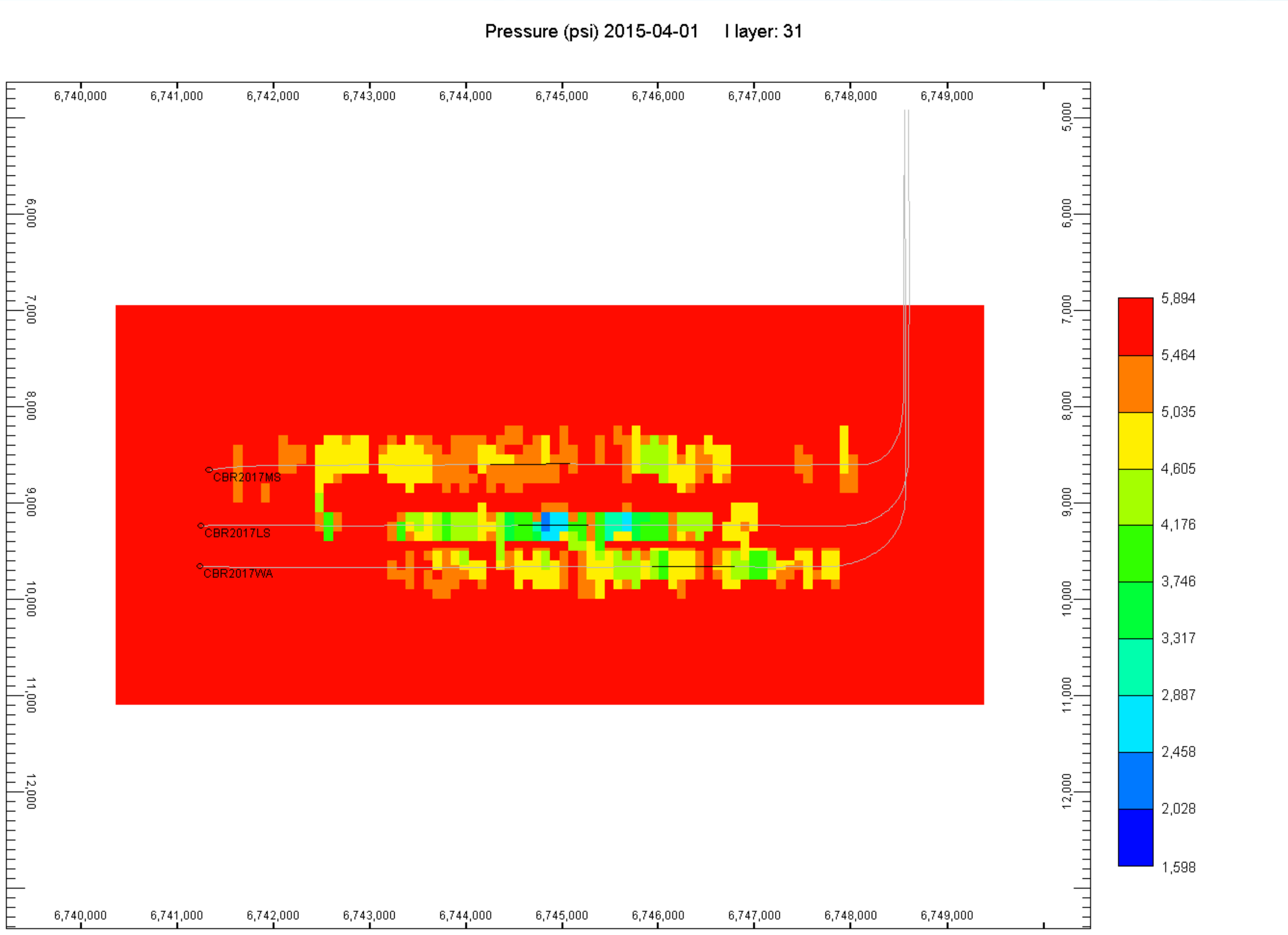
Reservoir Depletion (3 Months)

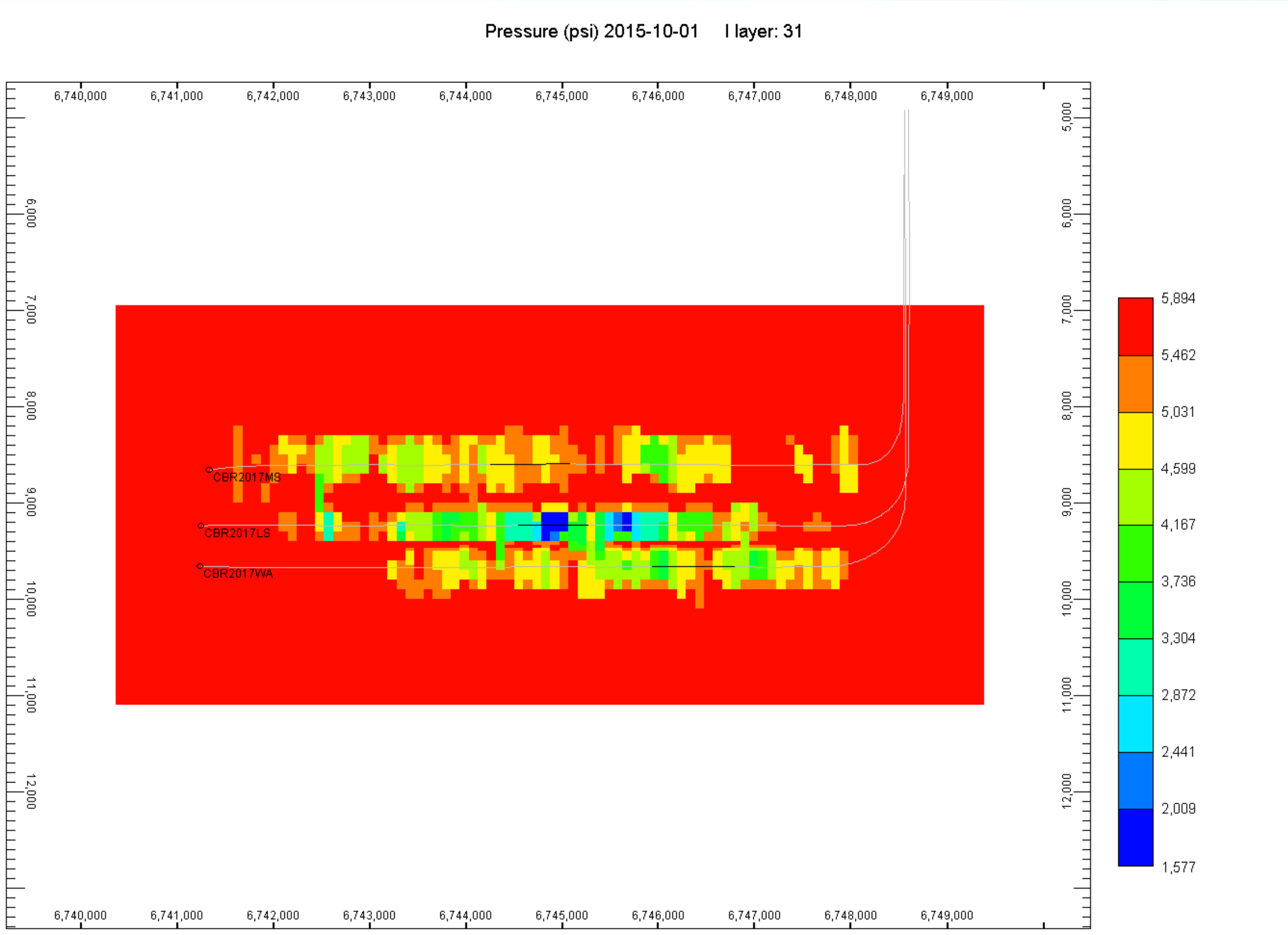


MicroSeismic

Reservoir Depletion (6 Months)

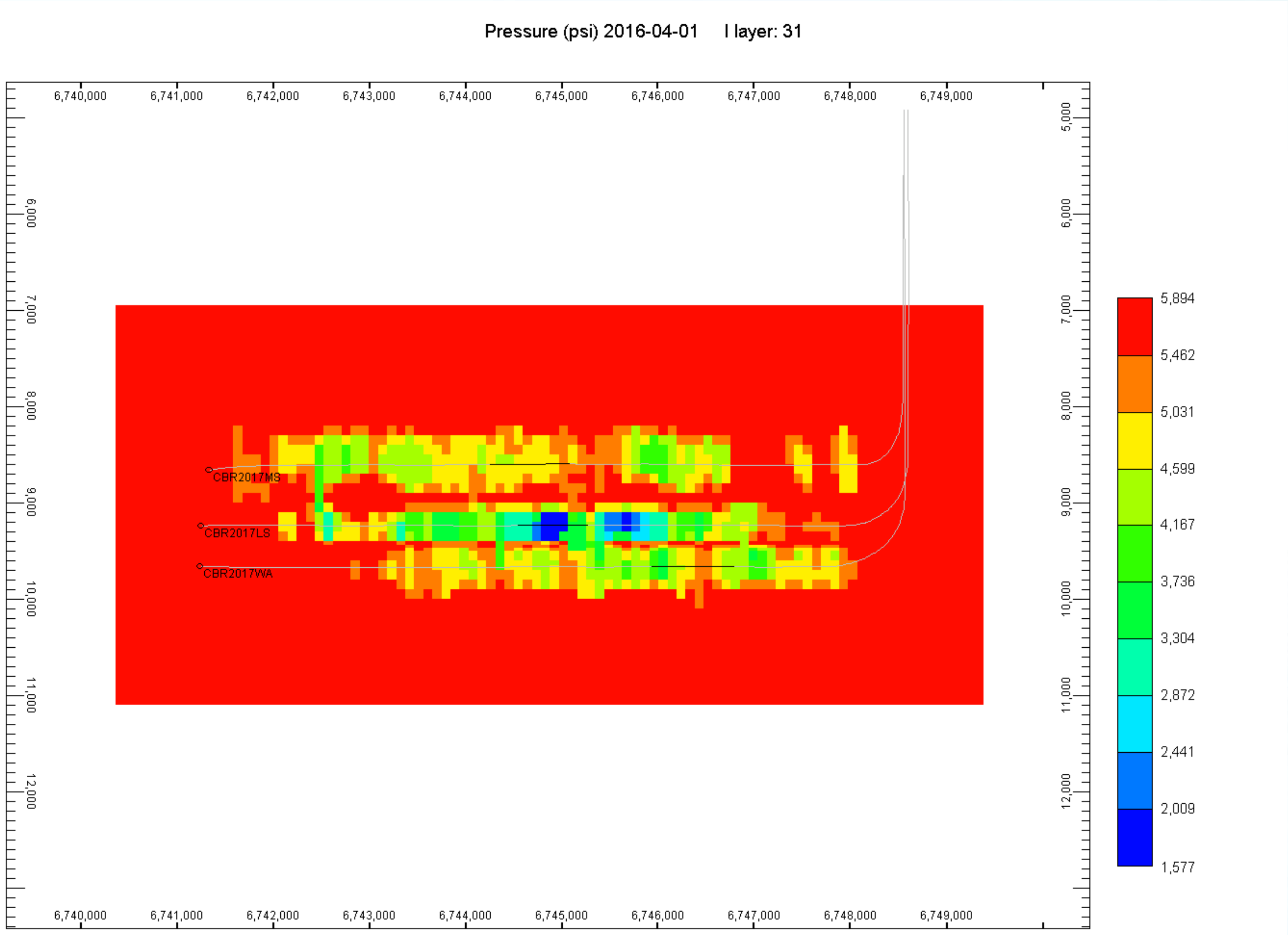


Reservoir Depletion (12 Months)



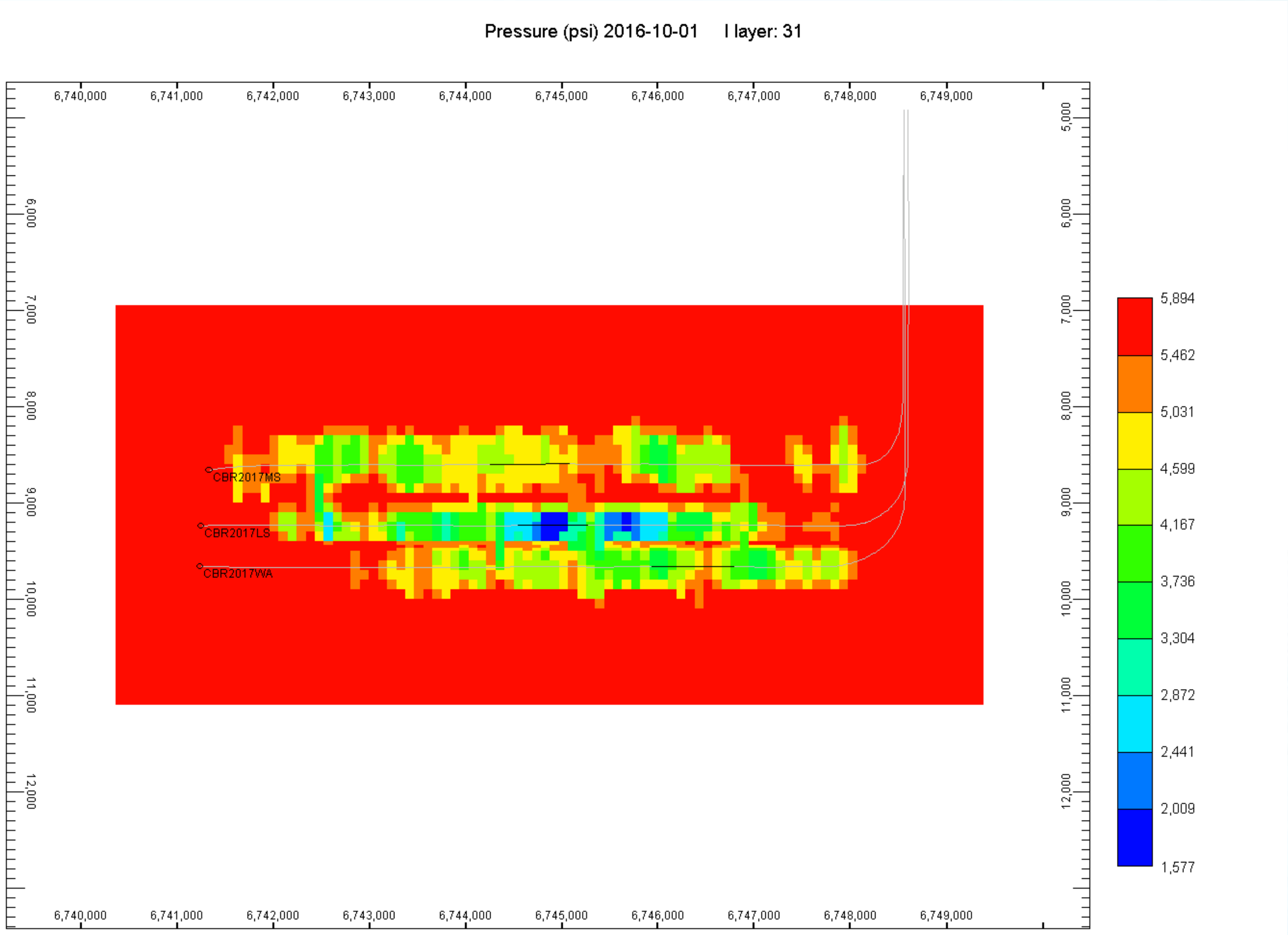
MicroSeismic

Reservoir Depletion (18 Months)



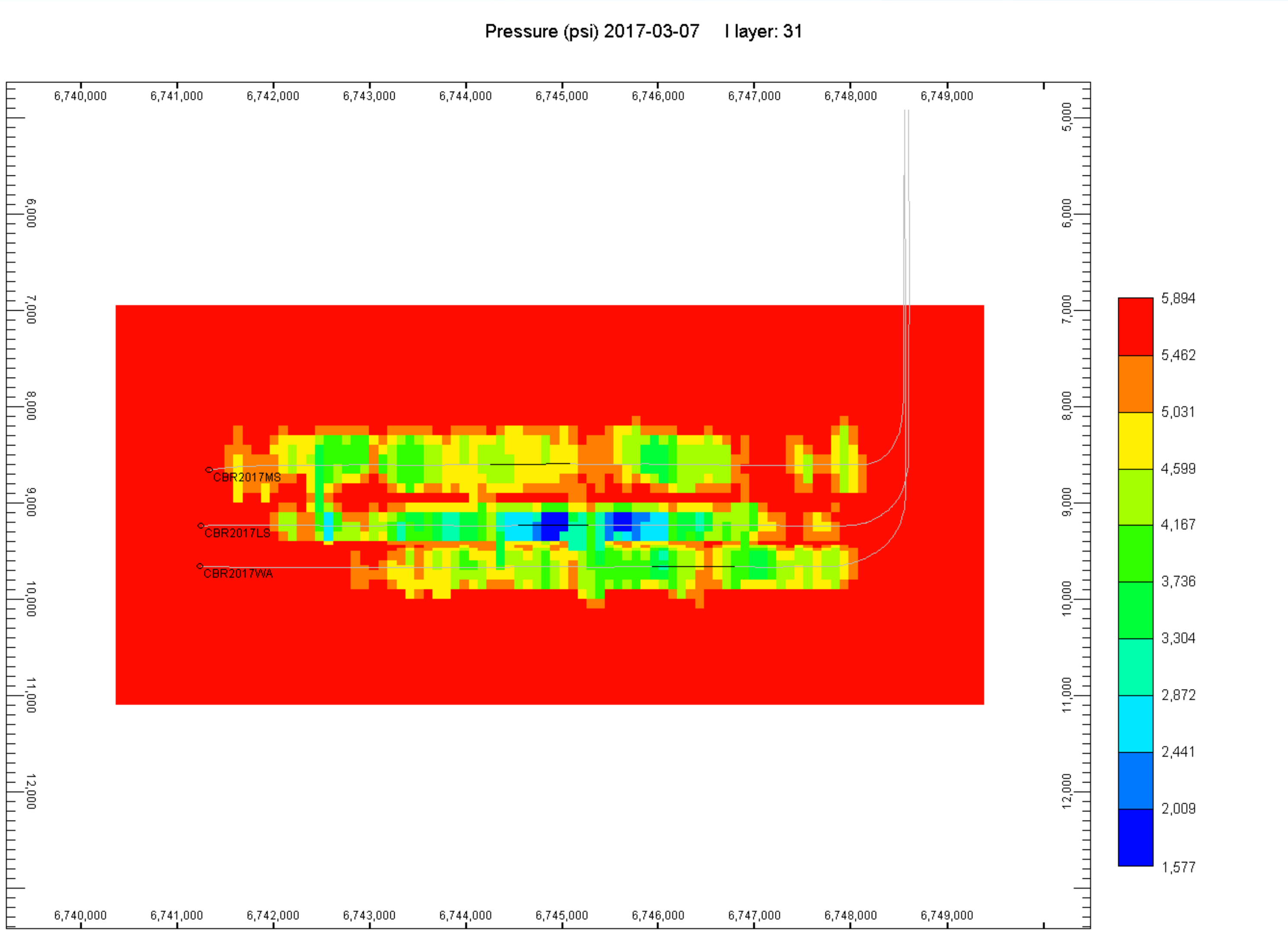
MicroSeismic

Reservoir Depletion (24 Months)



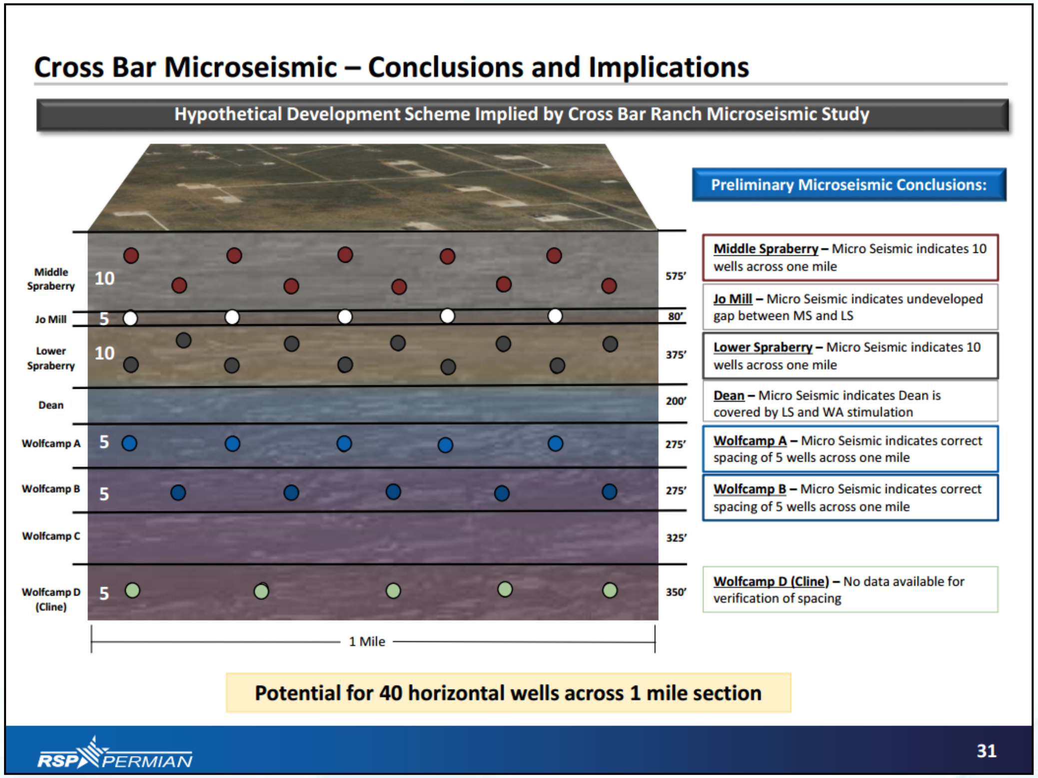
MicroSeismic

Reservoir Depletion (30 Months)



MicroSeismic

RSP Permian: Wellbore Placement



Source: May 2015 Investor Presentation; November 2014 Investor Presentation; Q3 2014 Earnings call transcript

"…**vertical wellbore spacing** between the MS and LS wells is **excessive**, leaving potential for possible Jo Mill locations…"

"The microseismic results indicated [the **Wolfcamp A** well] **communicated** with the **Wolfcamp B** and we expect even better results […] when both the Wolfcamp A and B are developed in unison in the future.

"Our effective stimulation calculations from the microseismic has helped **confirm our current spacing** of 450-500 feet."

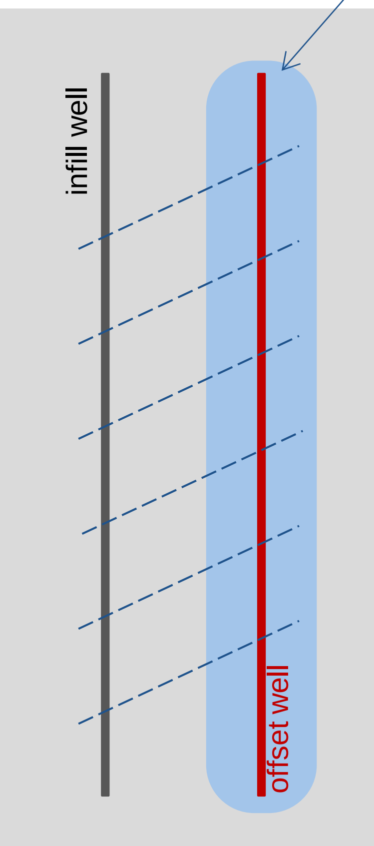
"The microseismic study indicated a **greater well density** in the Spraberry zones will be required for **optimum recovery of oil and gas**."

MicroSeismic

Case History 3
Treatment Order

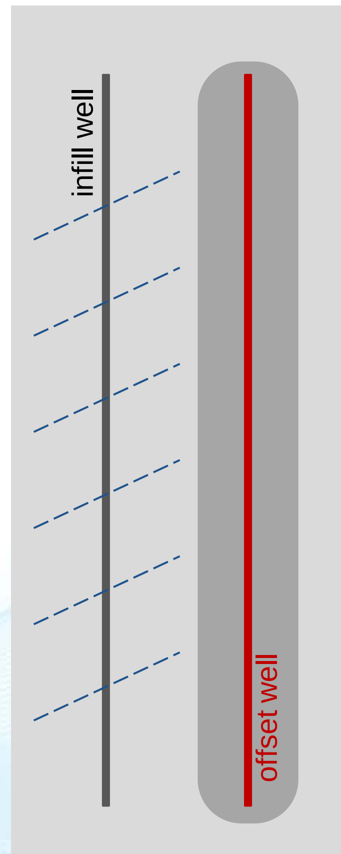
Well Interaction

Depleted zone



- Lower pore pressure:
  A sink for injected fluid
- Sweet spot for microseismicity
- Well interaction:
  Frac hit

Solution



Pressurization

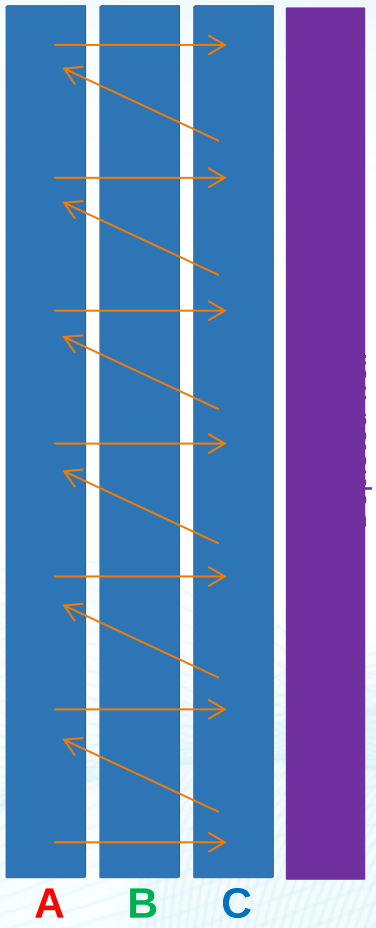
- Low rate injection:
  Build up pressure around offset well

Well Interaction depends on reservoir stress/pressure

MicroSeismic

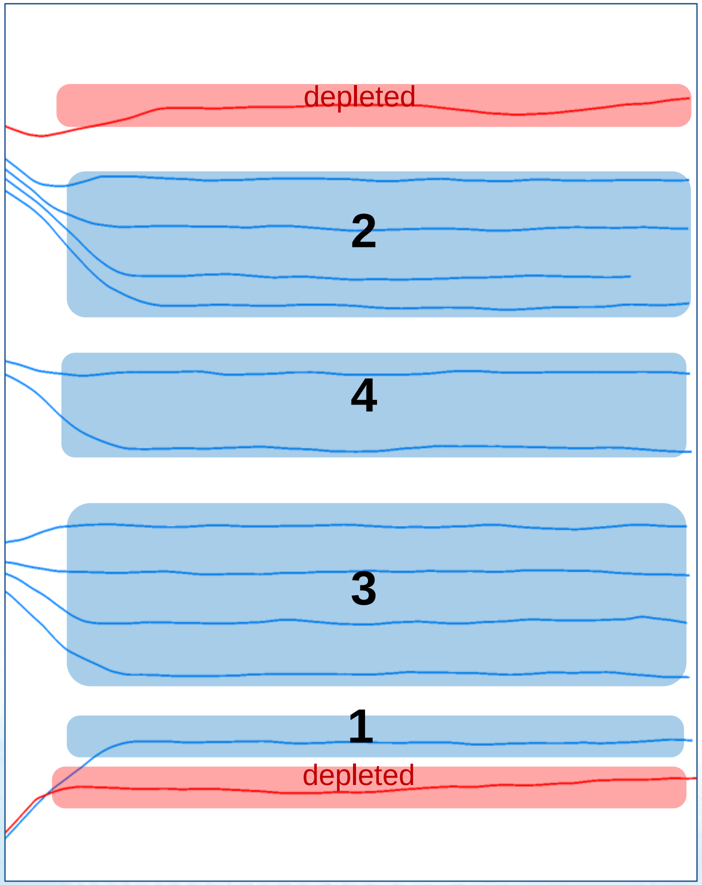
Multi Well-Completion Design

- Completion sequence:
  - Zipper-frac'ing
  - One-by-one:
    1. A ➔ B ➔ C
    2. A & C ➔ B
    3. B ➔ A & C
  - Pressurize?
- Treatment efficiency depends on wells interaction
- MicroSeismic monitoring is essential to understand well interaction and to make better decision on treatment order

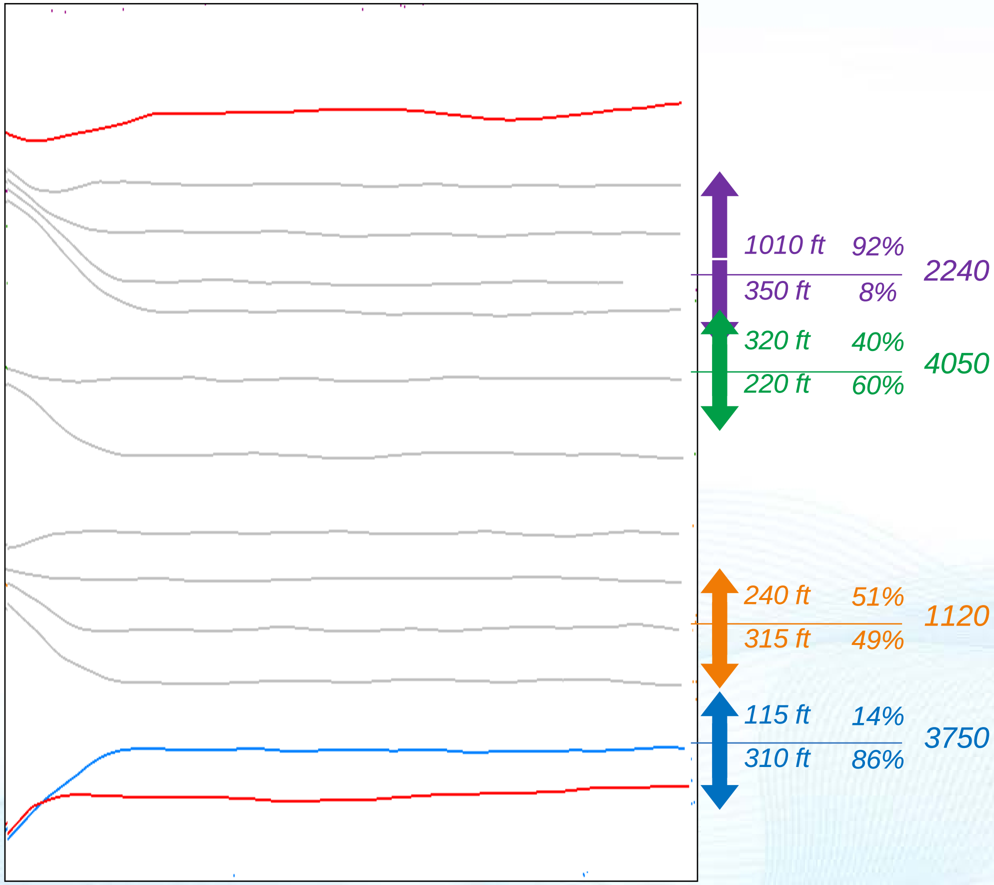


Multi Well Completion – Case Study

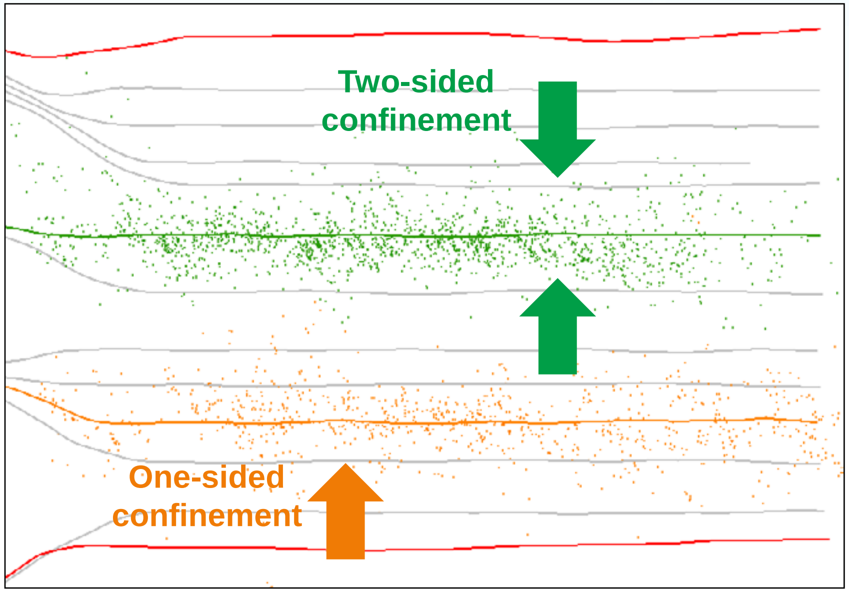
- Completion Sequence



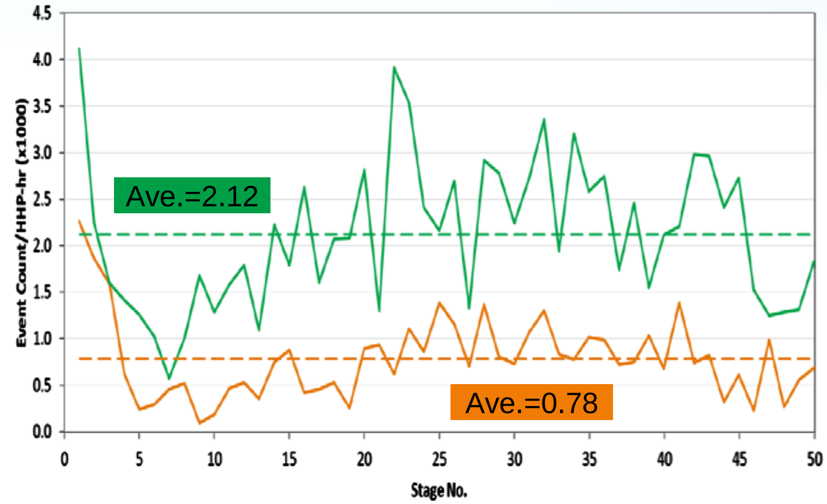
- MicroSeismic Results

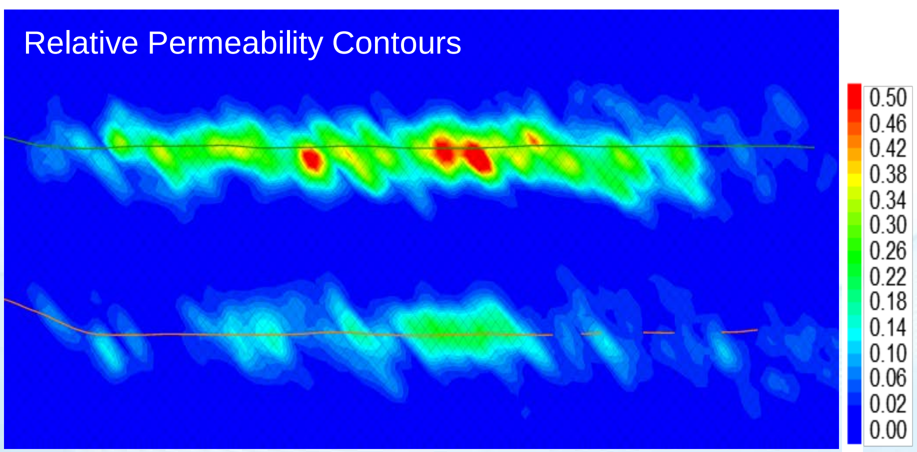


Multi Well Completion – Case Study



- **Completion Efficiency**

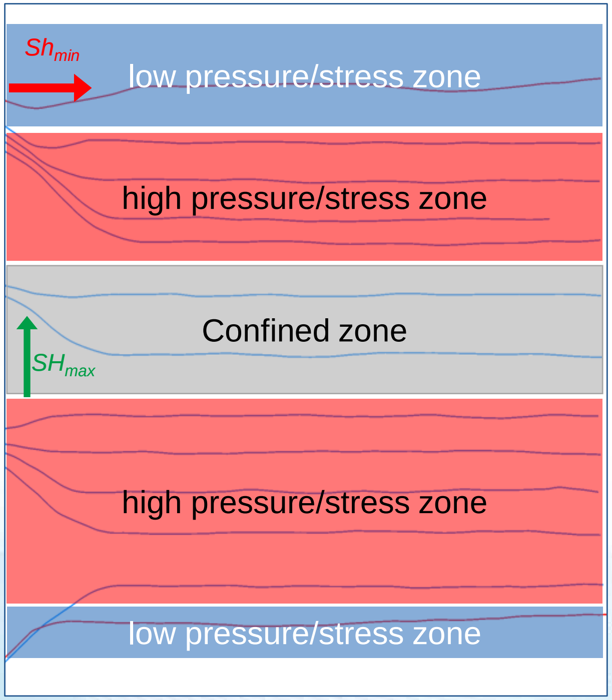


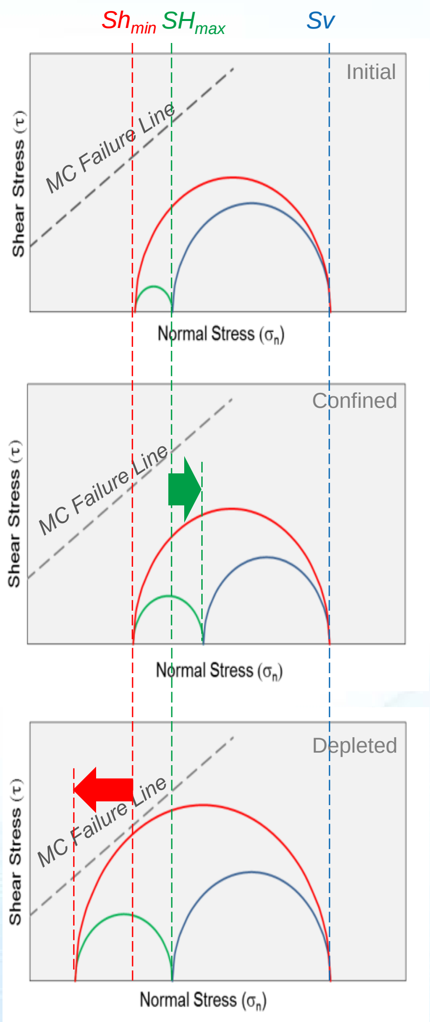


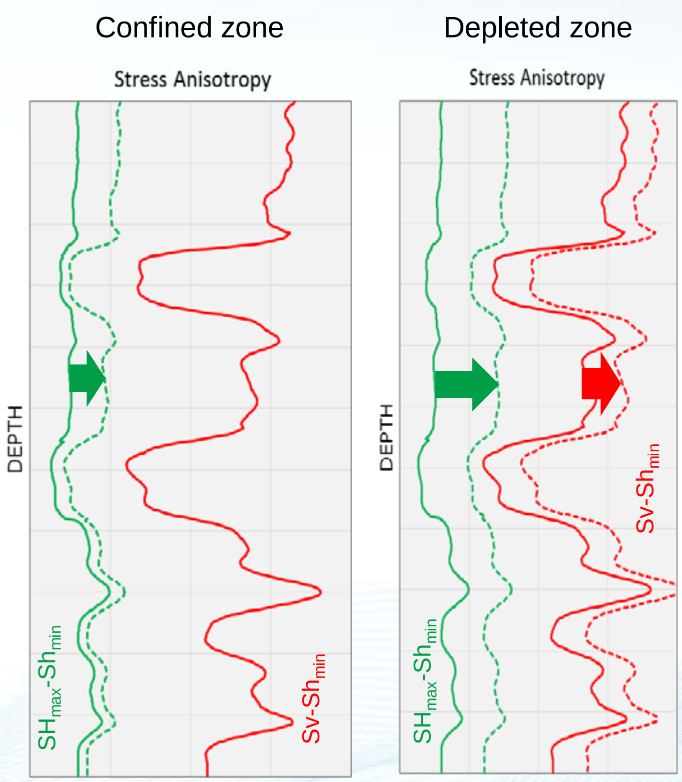
- **3x** more microseismic event per unit of pumped energy
- More induced fracture complexity ➔ better permeability enhancement

Multi Well Completion – Case Study

- **Why treatment order matters?**
  - Injection/production alters stresses/pressure
  - Stimulation/Microseismicity depends on stresses/pressure







Confined zone:

1. Higher hor. Stress anisotropy
2. Lower hydraulic gradient

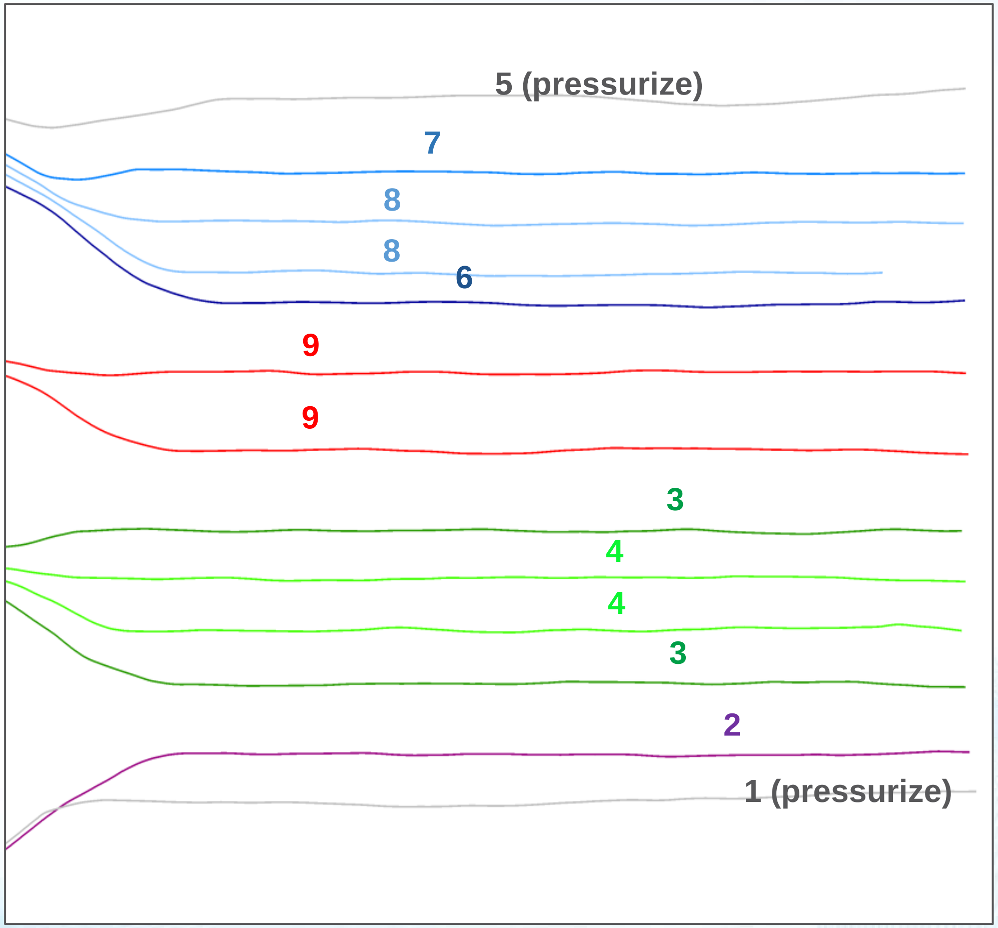
Depleted zone:

1. Higher ver. & hor. Stress anisotropy
2. Higher hydraulic gradient

MicroSeismic

Conclusion

- Treatment order matters!
- Pressurization is effective
- Stress/pressure changes result in well interaction
- Efficient treatment order:



MicroSeismic

Quantitative Microseismic Analysis

Opportunity

- MicroSeismic data offers well specific, in situ observations that are predictive of future well performance

Realization

Integrating with other measurements, microseismic observations can provide:

- ✓ Accurate and reliable fracture network model
- ✓ Prediction of stage performance and productivity
- ✓ Early prediction of well productivity and type curve
- ✓ Determination of drainage volume and depletion
- ✓ Detailed stress regime mapping

MicroSeismic

MicroSeismic
Passive Monitoring, Active Listening

Eyes On The Prize – what microseismic monitoring is telling us about completions in unconventional reservoirs.

Peter M Duncan

Buenos Aires

Oct 23, 2017

1,500,000 HOURS
WITHOUT A LOST TIME INCIDENT

MicroSeismic
Passive Monitoring, Active Listening

SPE International
Society of Petroleum Engineers
Argentine Petroleum Section