RESERVOIR CHARACTERIZATION PROJECT

Phase XVIII – Chalk Bluff

RCP Chalk Bluff Team

Ali Downard, Balnur Mindygaliyeva, Nurbol Bekbossinov, Harrison Schumann

Gary Binder, Hossein Kazemi, Jim Simmons, Ge Jin, Ali Tura

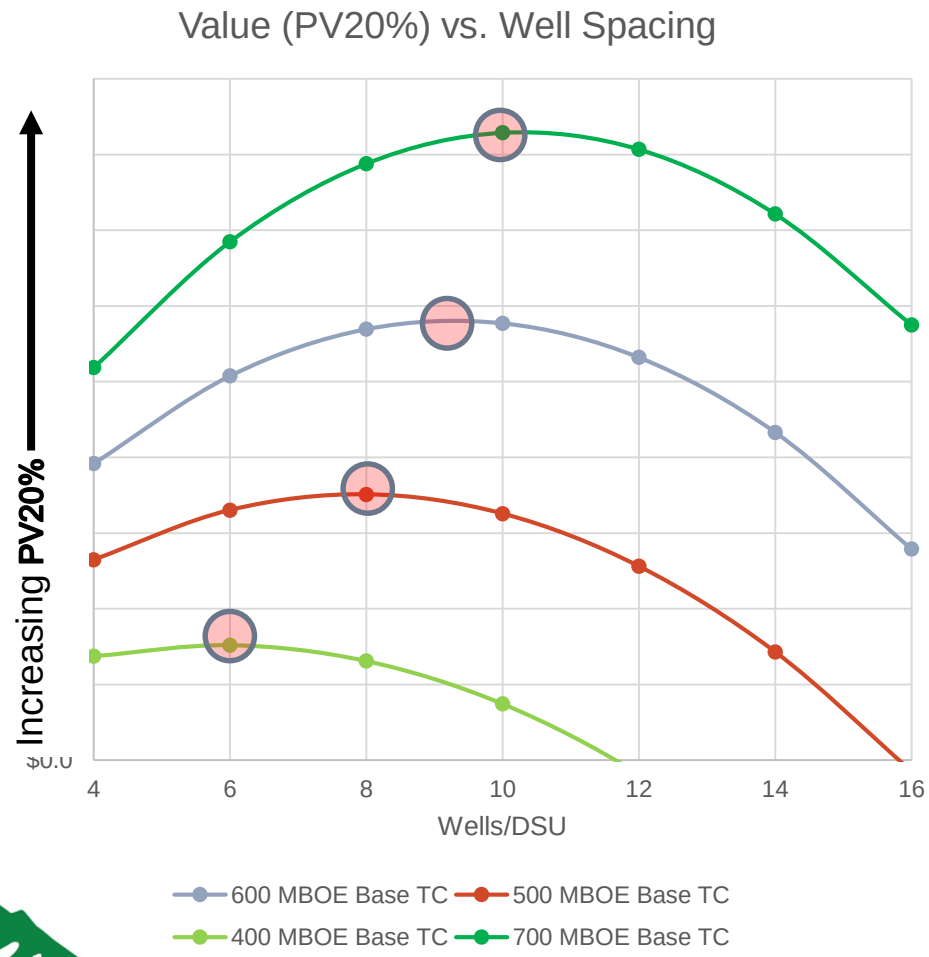
COLORADOSCHOOLOFMINES

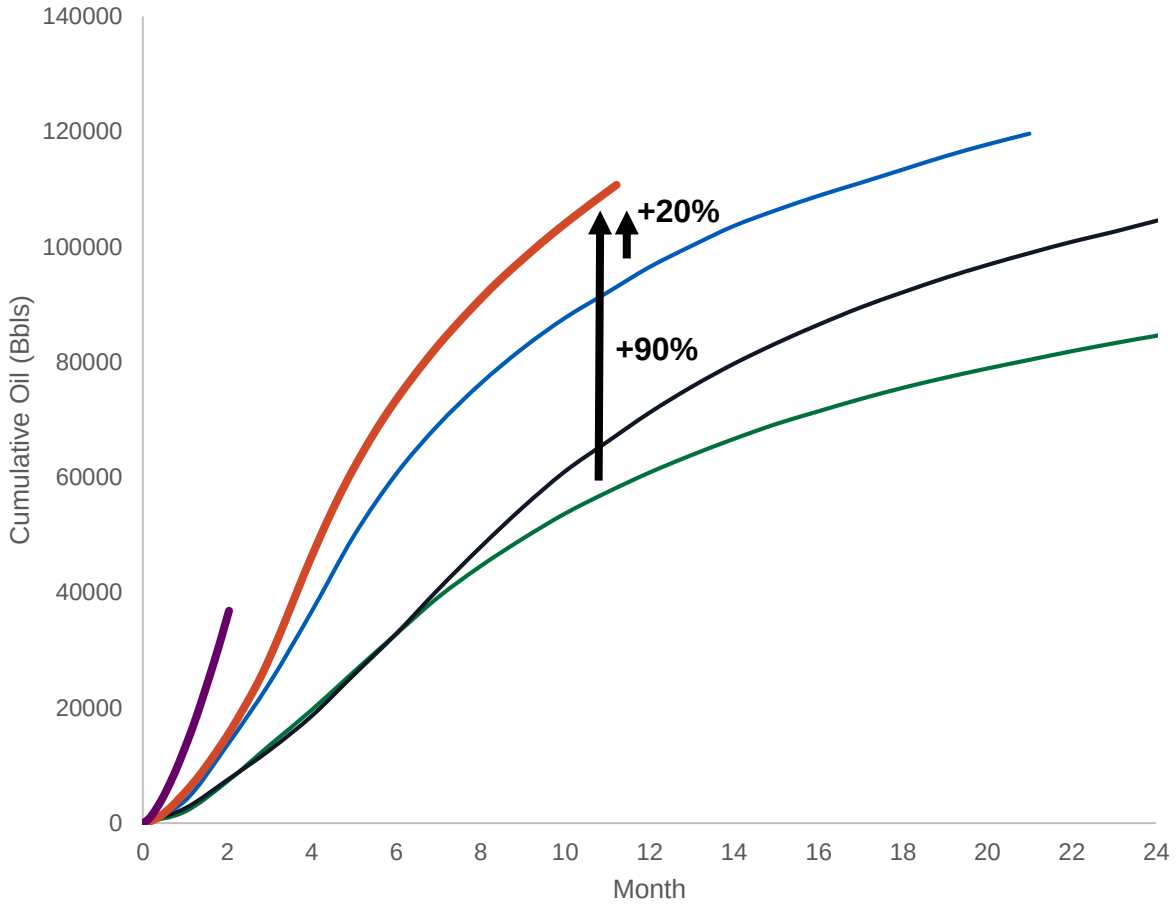
Outline

- Motivation
  - Optimization
- Data
- Project Plan
  - Geophysics
  - Petroleum engineering
- Conclusion

Motivation: Well Spacing & Completion Design

RCP
In pursuit of new ideas

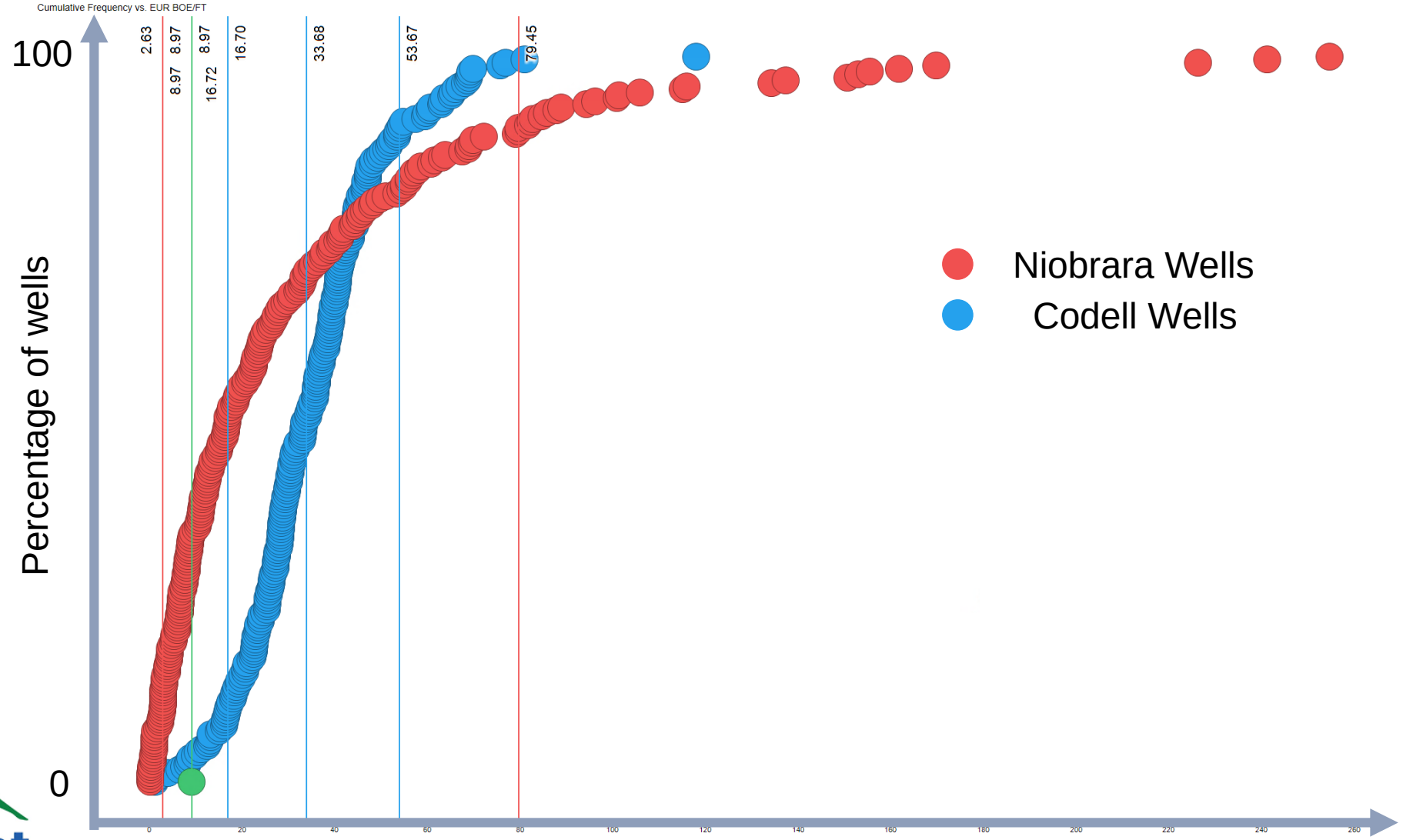




2015 2016 2017 2018 2019

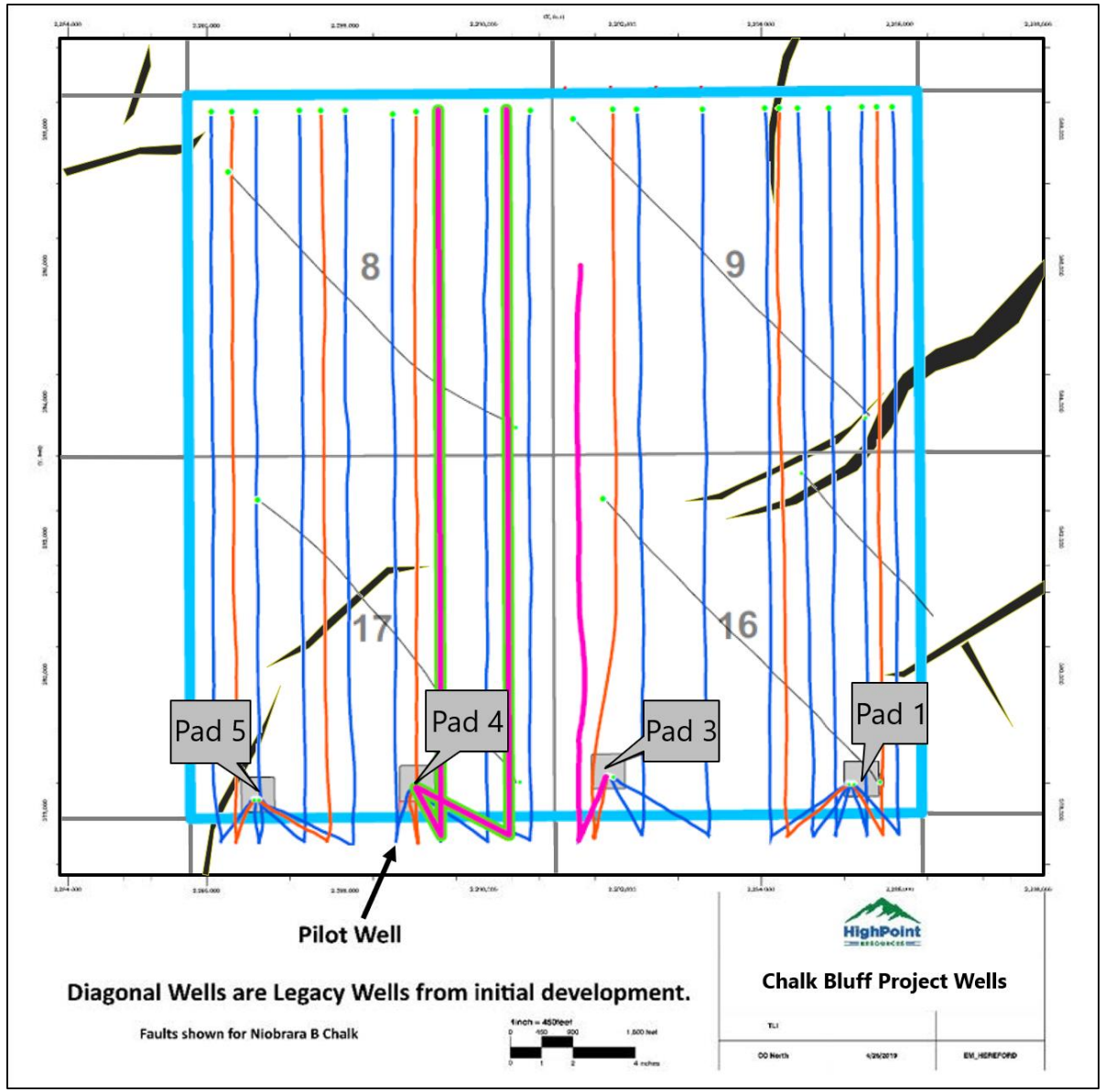
HighPoint RESOURCES

Understanding the Controlling Factors of Production

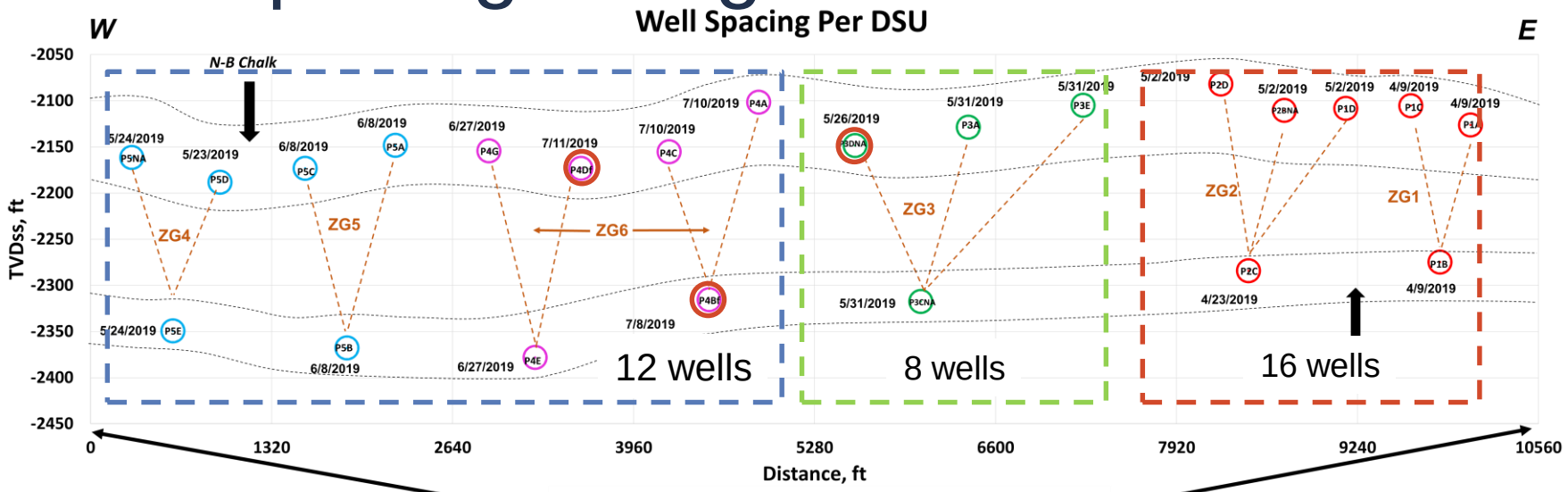


Data

- 3 instrumented wells
  - DAS/DTS
  - Borehole gauge
- 1 pilot well
  - Well log suits
- 23 new Niobrara and Codell wells
  - Well log
  - Completion/production data
  - Pressure data
- 3D seismic
  - Processed gathers
  - Inversion volumes
- Microseismic
  - Surface and DAS
- Surface tiltmeter
- Geochemistry data
  - Cuttings and oil samples



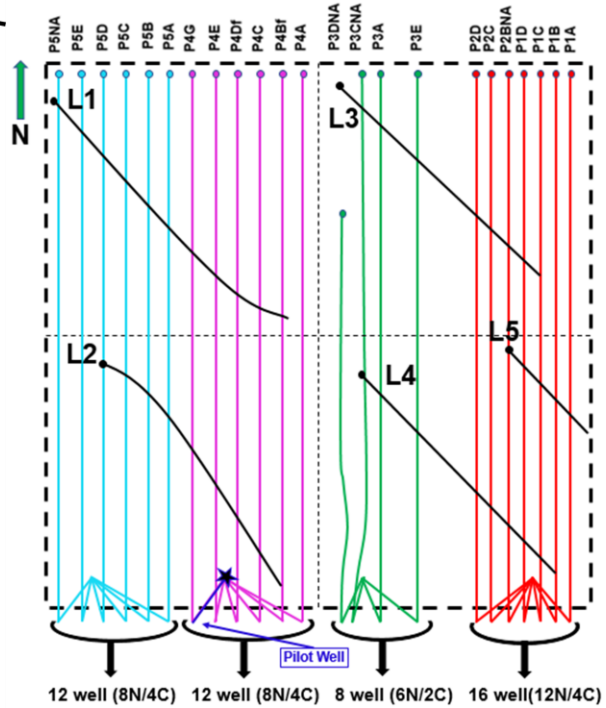
Various Well Spacing Designs



Completion designs of wells

Wells

Fiber	Fluid Type	Fluid Volume	Proppant Type	Proppant Volume	Well Spacing Scheme
	Slickwater	30	20/40	1500	16 well (12N/4C)
	Slickwater	30	40/70	1500	16 well (12N/4C)
	Hybrid	30	20/40	1500	16 well (12N/4C)
	Hybrid	30	20/40	1500	16 well (12N/4C)
	Hybrid	40	20/40	1500	16 well (12N/4C)
	Hybrid	30	20/40	1500	16 well (12N/4C)
	Hybrid	40	20/40	1500	16 well (12N/4C)
	Hybrid	40	30/50	1500	8 well (6N/2C)
	Hybrid	40	30/50	1500	8 well (6N/2C)
	Hybrid	40	30/50	1500	8 well (6N/2C)
x	Hybrid	40	30/50	1500	8 well (6N/2C)
	Slickwater	30	30/50	1500	12 well (8N/4C)
x	Fluid Test	40	30/50	1500	12 well (8N/4C)
	Hybrid	50	30/50	1500	12 well (8N/4C)
x	Fluid Test	40	30/50	1500	12 well (8N/4C)
	Slickwater	30	30/50	1500	12 well (8N/4C)
	Hybrid	50	30/50	2250	12 well (8N/4C)
	Hybrid	30	30/50	2250	12 well (8N/4C)
	Hybrid	30	30/50	1000	12 well (8N/4C)
	Hybrid	30	30/50	1000	12 well (8N/4C)
	Hybrid	30	30/50	1000	12 well (8N/4C)
	Hybrid	30	30/50	1500	12 well (8N/4C)
	Hybrid	30	30/50	1500	12 well (8N/4C)



Completion designs of fiber well stages

Design	Stage Spacing	Clusters	Perfs	Rate	bbl/ft	lbs/ft	Fluid Type	Comment
Stages 1-4	120	3	24	TBD	1.0x	1.0x	Hybrid	Rate/Cluster
A	120	3	24	TBD	1.0x	1.0x	Hybrid	
B	120	6	24	TBD	1.0x	1.0x	Hybrid	
C	120	9	24	TBD	1.0x	1.0x	Hybrid	
D	120	12	24	TBD	1.0x	1.0x	Hybrid	
E	180	Highest Achieved x2	24	TBD	1.0x	1.0x	Hybrid	Stage Spacing
F	240	Highest Achieved x3	24	TBD	1.0x	1.0x	Hybrid	
G	80	2	24	TBD	1.0x	1.0x	Hybrid	
H	40	1	24	TBD	1.0x	1.0x	Hybrid	
I	120	Highest Achieved	24	TBD	1.0x	1.0x	Hybrid	Fluid Types
J	120	Highest Achieved	24	TBD	1.0x	1.0x	Slickwater	
K	120	Highest Achieved	24	TBD	1.0x	1.0x	Reverse Hybrid	
L	120	Highest Achieved	24	TBD	1.0x	1.5x	Hybrid	Sand Volumes
M	120	Highest Achieved	24	TBD	1.0x	2.25x	Hybrid	
N	120	Highest Achieved	24	TBD	0.75x	1.0x	Hybrid	Fluid Volumes
O	120	Highest Achieved	24	TBD	1.3x	1.0x	Hybrid	
P	120	Highest Achieved	24	TBD	1.7x	1.0x	Hybrid	

Project Plan

RCP
In pursuit of new ideas

Feb. 2020 | May 2020 | Oct. 2020 | Dec. 2020

Static Model

Missing log interpolation
- Porosity, density, resistivity, and sonic logs
- Upscale the properties for the static model

PVT Analysis
- DFIT interpretation
- Static model property validation

Define structure of model
- Load well tops
- Seismic depth conversion
- Map surfaces of interest

Geologic interpretation
- Geochemistry data analysis
- Seismic attributes, HTI, VTI

Dynamic Model

Input static model

Production analysis
- Compare redevelopment to legacy wells

Fracture modeling
- Create geological section (using well logs as input)
- Input pumping schedule
- Fracture simulation for each well
- Obtain fluid propagation and fracture geometry
- Incorporate DFIT, microseismic, and tiltmeter

History Matching

Input dynamic model

Parameter tuning
- Permeability/transmissibility
- Pressure

Production matching

Optimization

Input final model

Well spacing analysis
- Run simulations with various spacing/clustering
- Economic evaluation
- Determine optimal spacing

Redevelopment
- Assess data available prior to redevelopment
- Determine improvements for future redevelopment

Ali Downard

Harrison Schumann

Geophysics

Balnur Mindygaliyeva

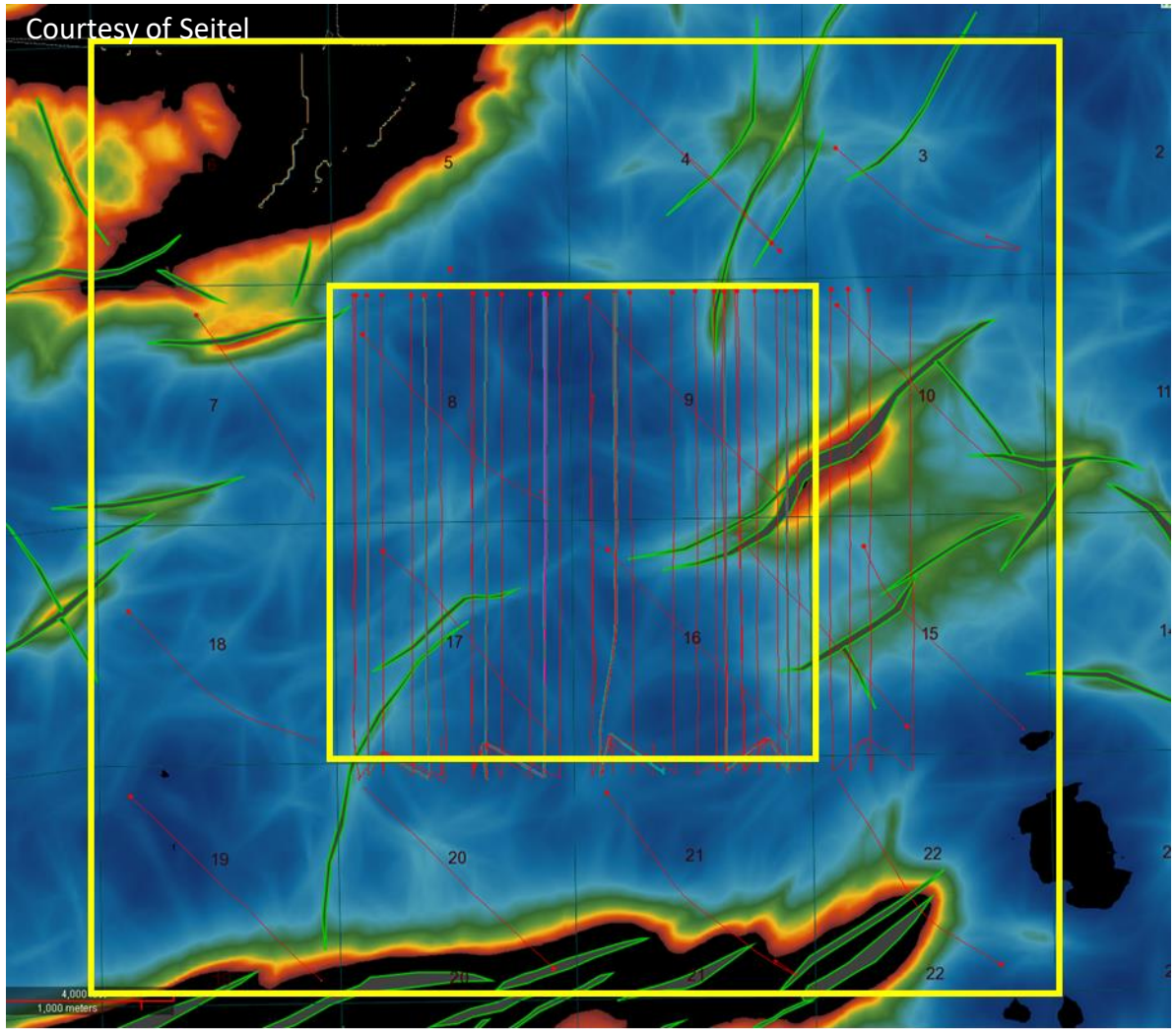
Nurbol Bekbossinov

Petroleum Engineering

Adam Simonsen

Geology

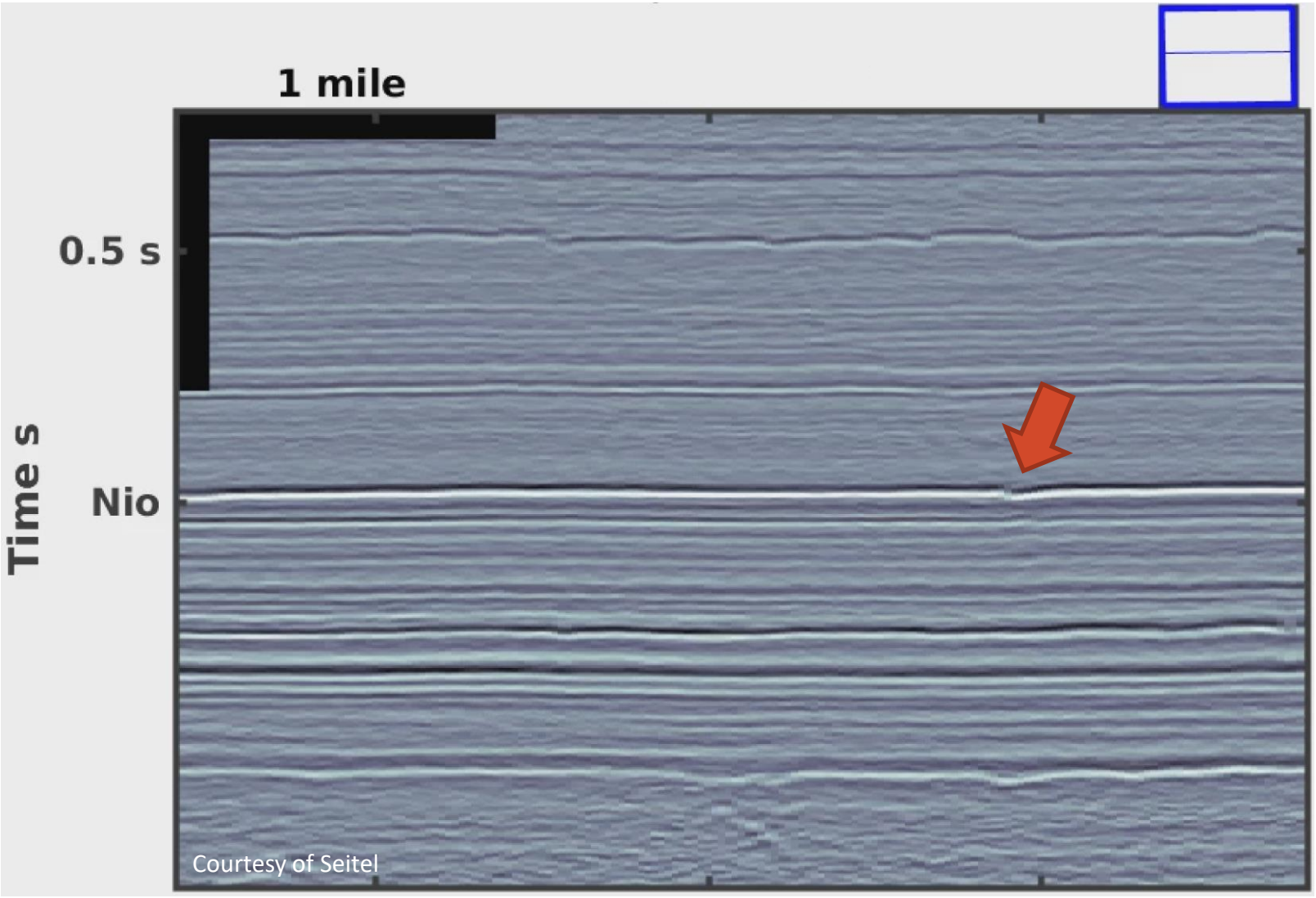
Geophysics Characterization



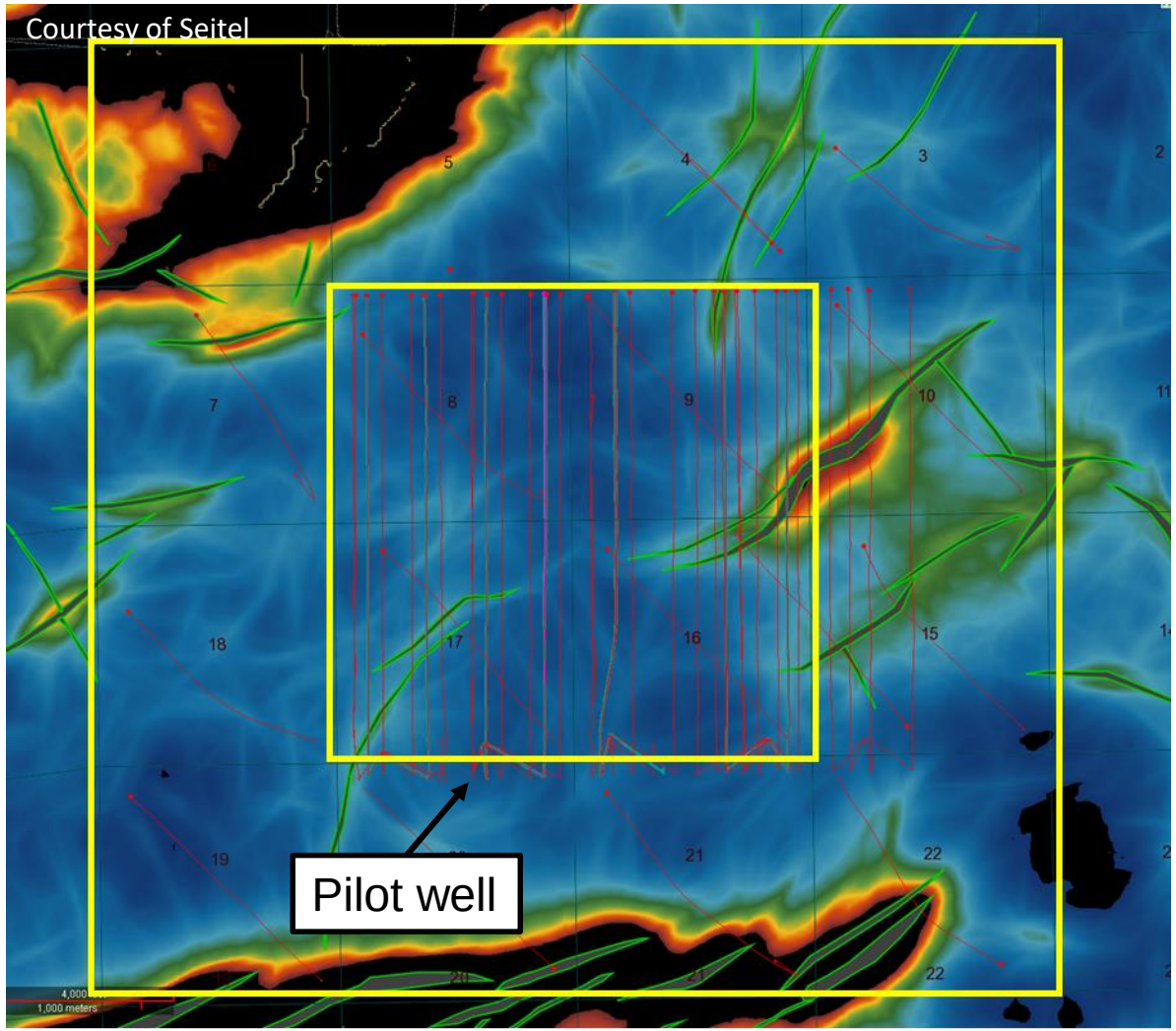
Niobrara B Marl Fault Likelihood Map

- 3D Surface Seismic
  - Time to depth conversion
  - Structural mapping of faults, boundaries, well tops
  - Populating the model with well properties using seismic structural constraints (e.g. horizons)
  - PP pre-stack inversion – reservoir static, dynamic models and geomechanics
  - Model and study if VTI and HTI anisotropy are appropriate
  - Apply new EF rock physics model to Chalk Bluff

3D Seismic Inline Example



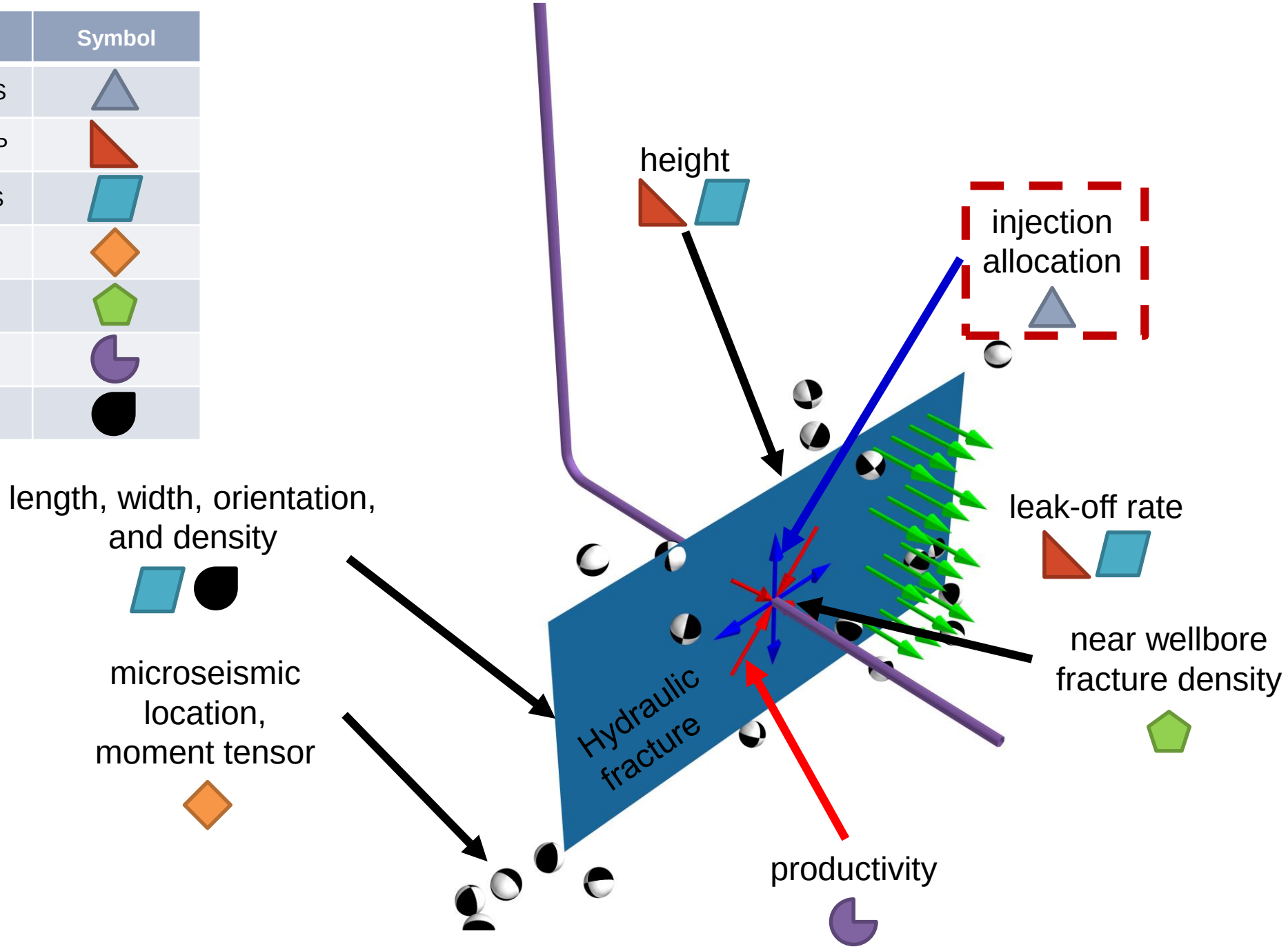
Geology Characterization



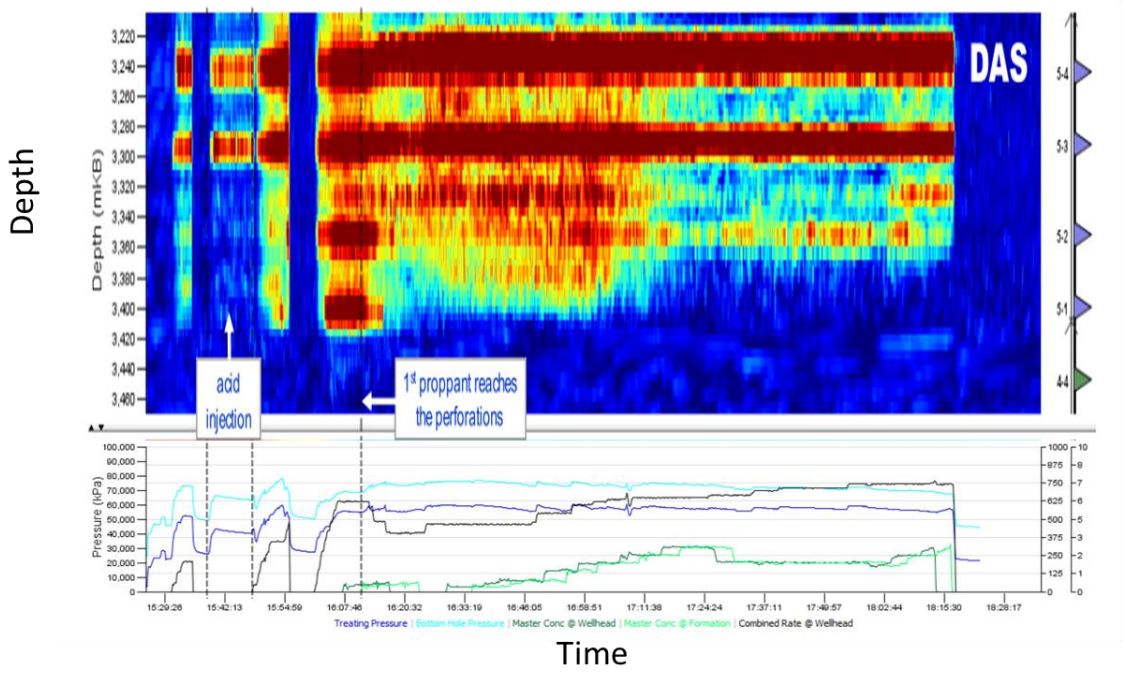
Niobrara B Marl Fault Likelihood Map

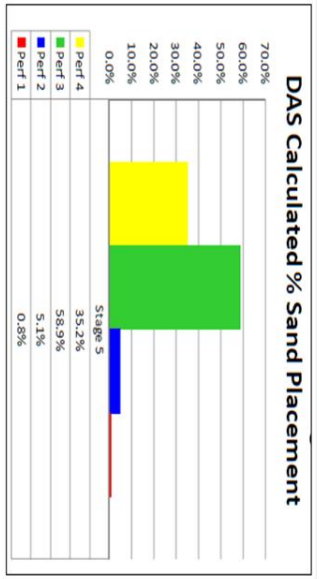
- Geochemistry
  - TOC
  - Minerology
  - Vertical drainage*
- Core data analysis

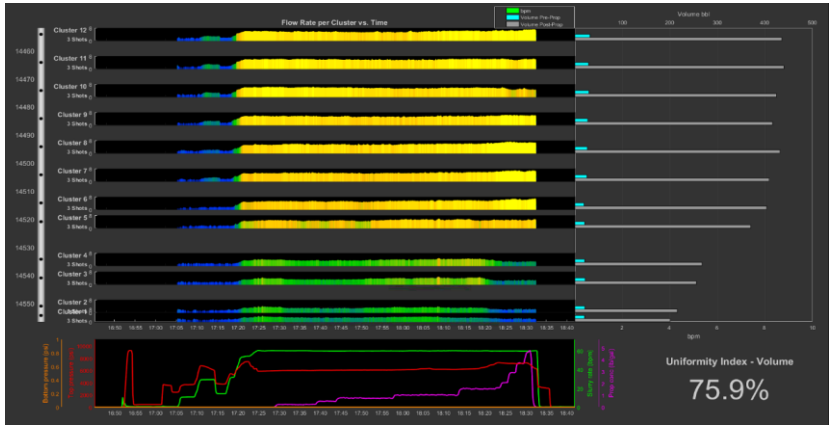
Method	Symbol
High-frequency DAS	
DAS time-lapse VSP	
Low-frequency DAS	
DAS/surface array	
DTS warmback	
DAS/DTS	
Surface tiltmeter	



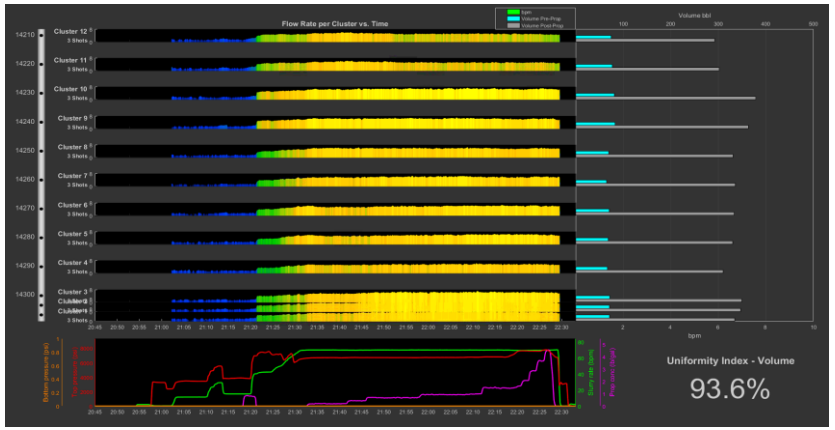
Perforation Injection Allocation





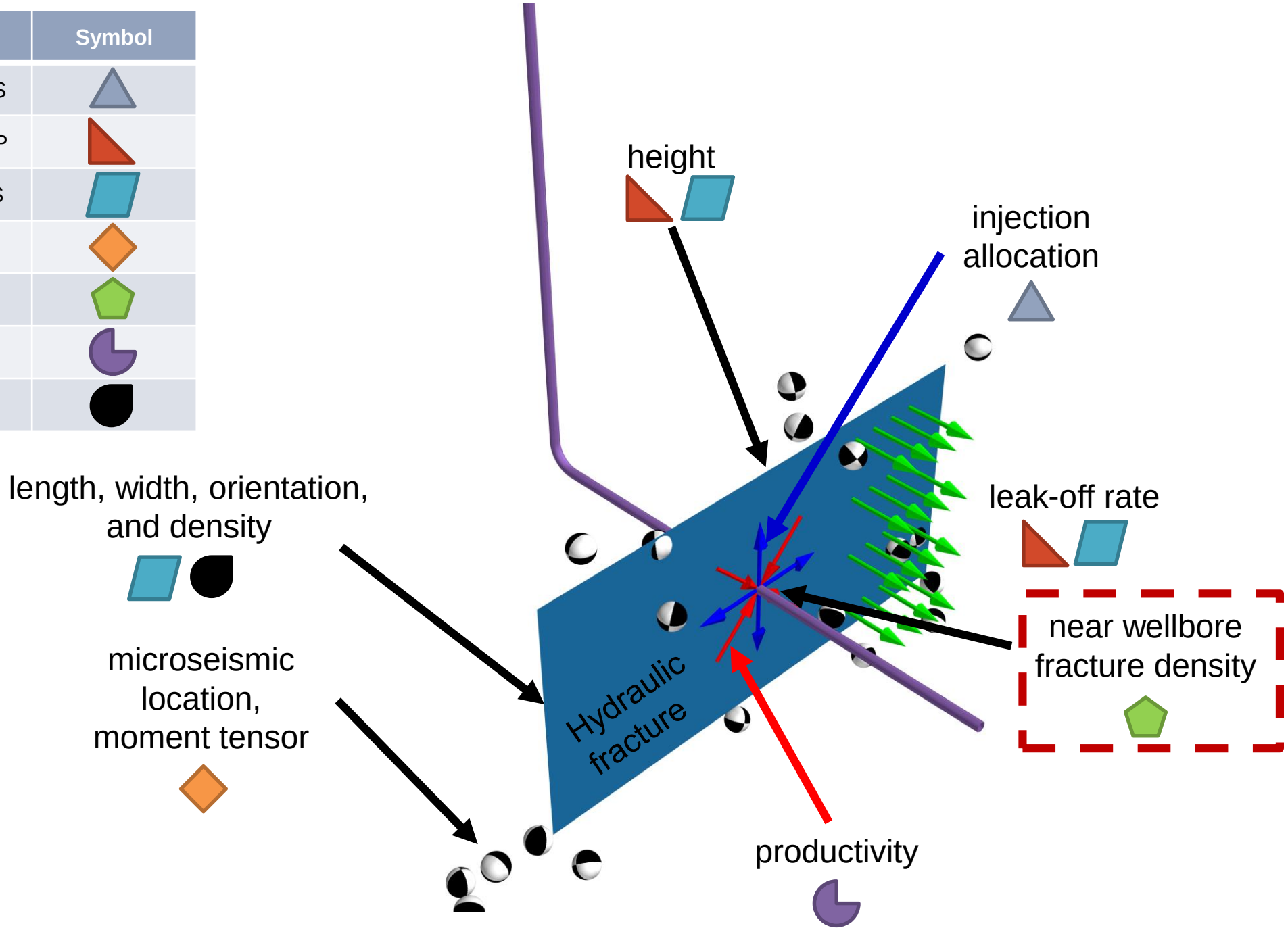


Completion design optimization

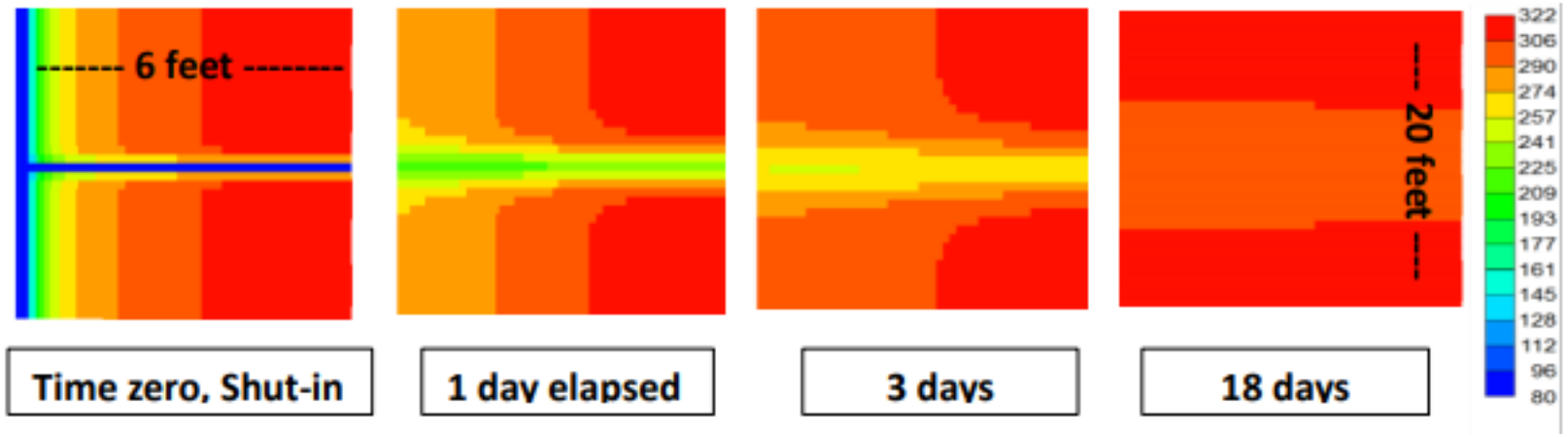


Webster et al. 2013

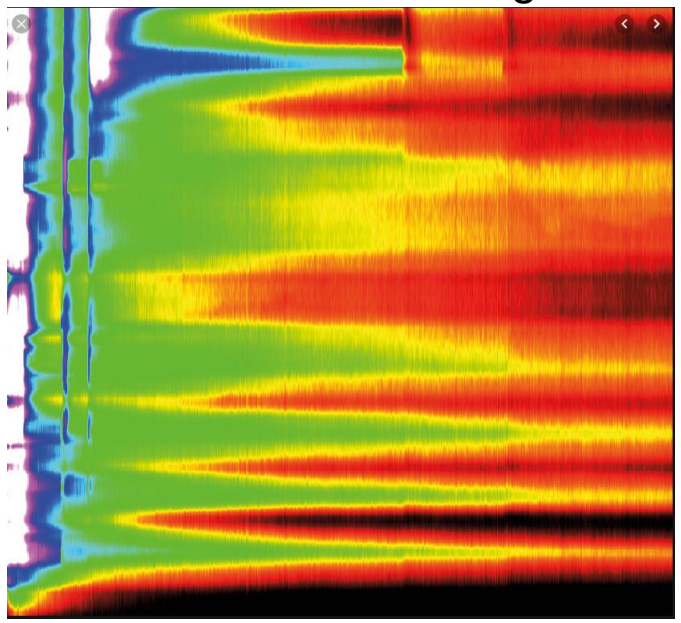
Method	Symbol
High-frequency DAS	
DAS time-lapse VSP	
Low-frequency DAS	
DAS/surface array	
DTS warmback	
DAS/DTS	
Surface tiltmeter	



Near Wellbore Fracture Geometry



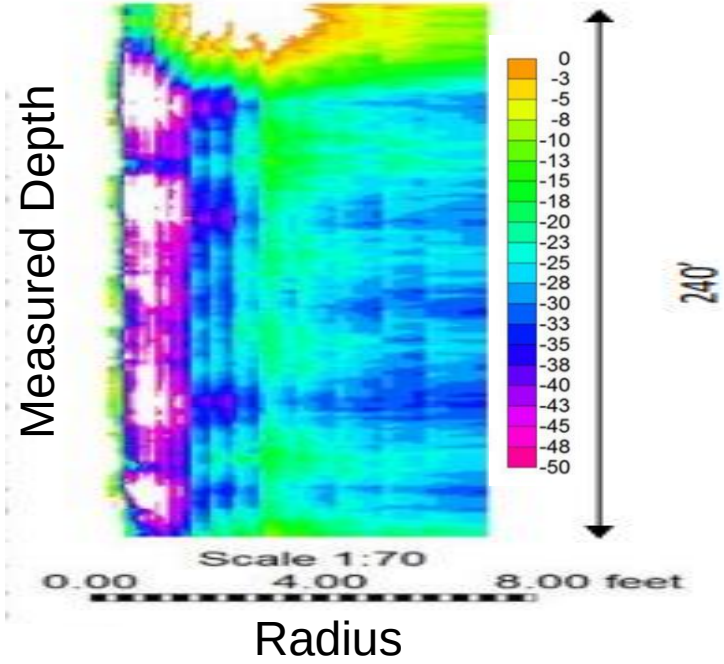
DTS warmback signal



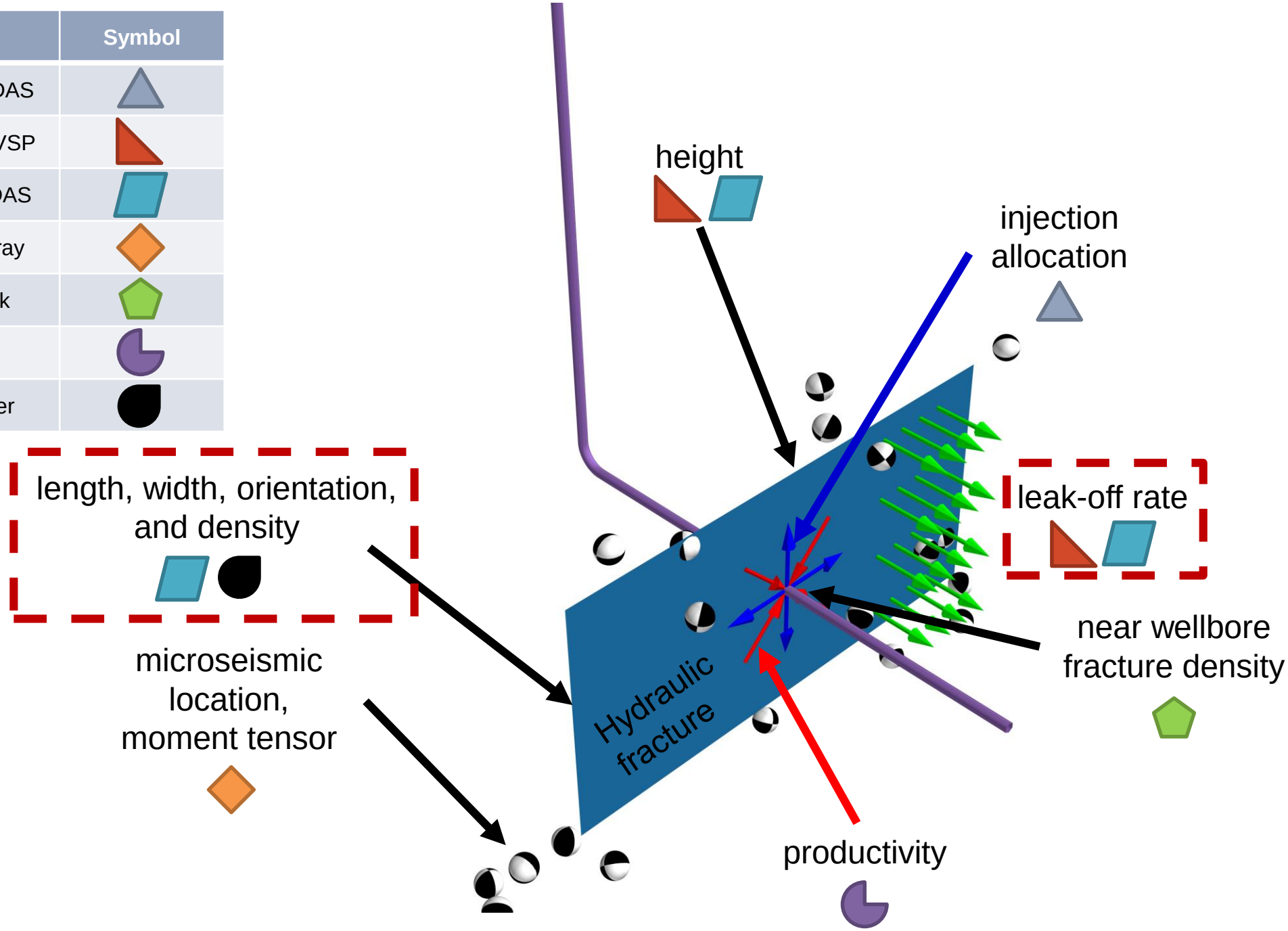
Reverse migration of thermal conduction

Raterman et al. 2019

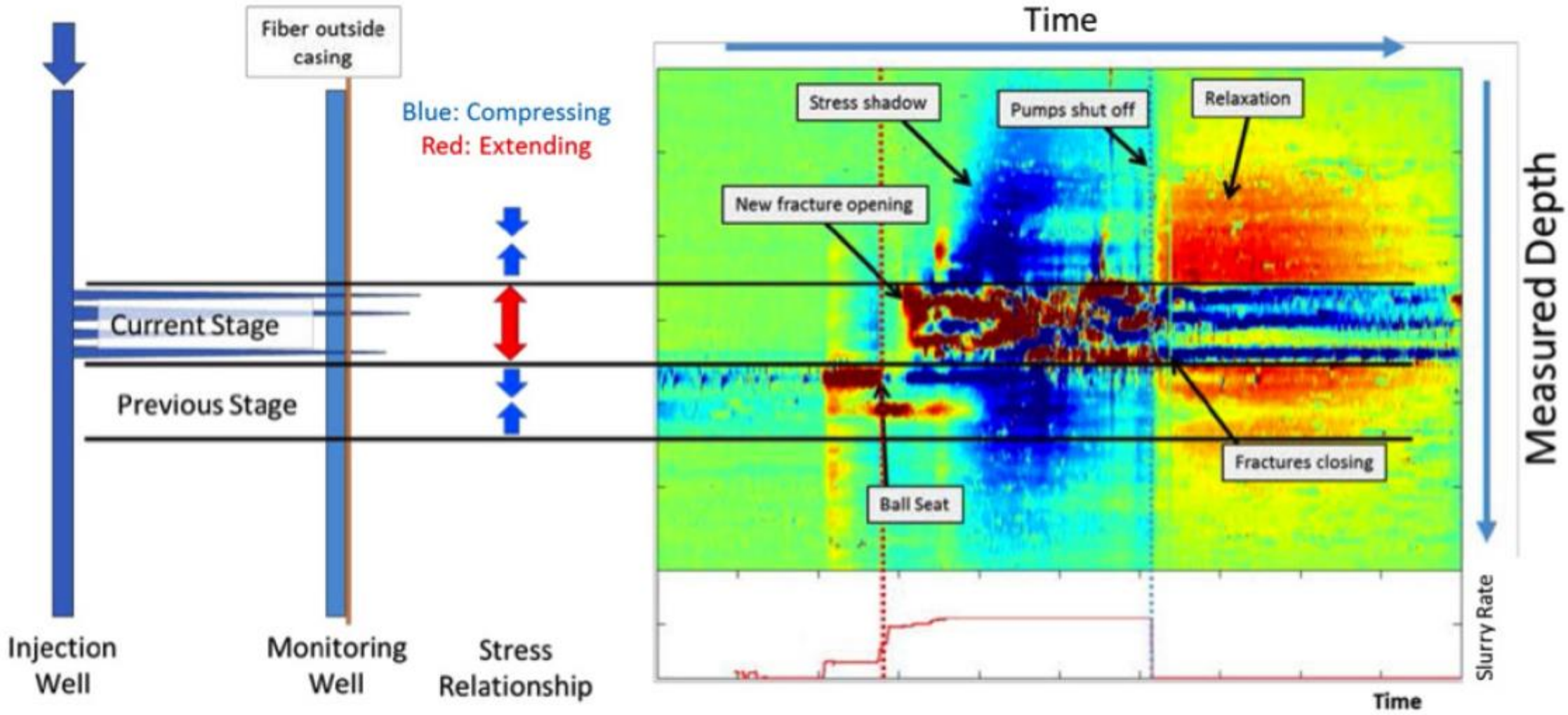
Temperature variation



Method	Symbol
High-frequency DAS	
DAS time-lapse VSP	
Low-frequency DAS	
DAS/surface array	
DTS warmback	
DAS/DTS	
Surface tiltmeter	

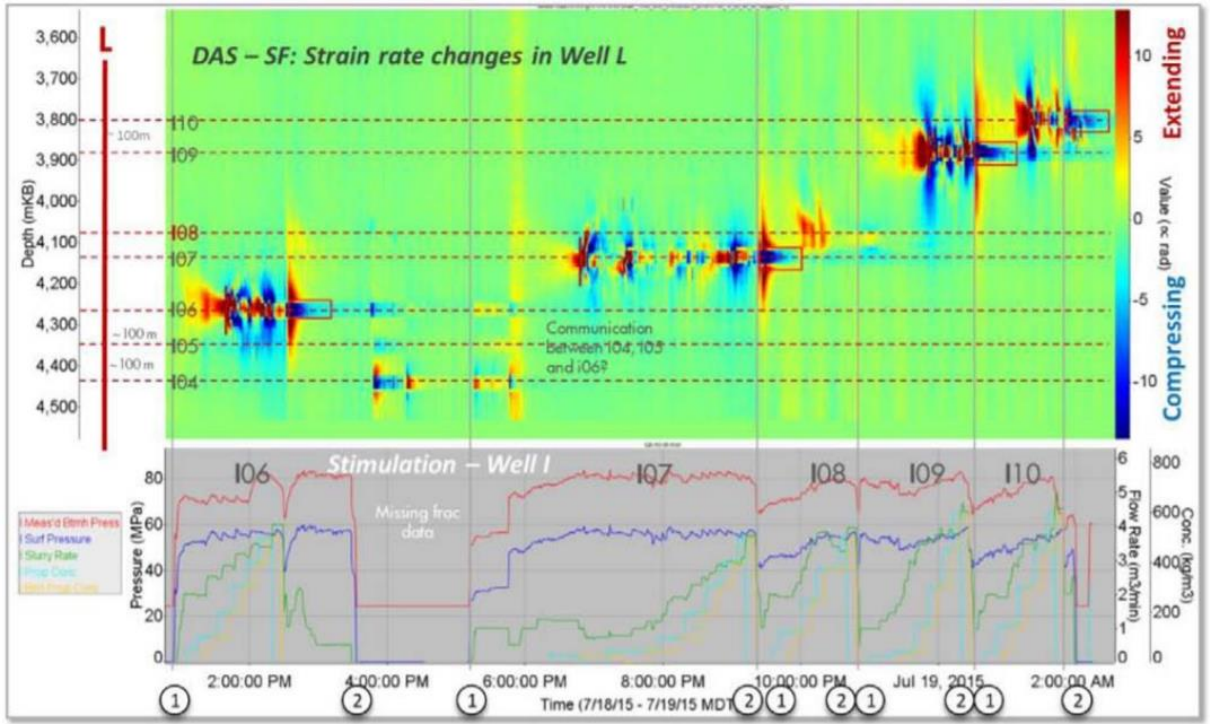


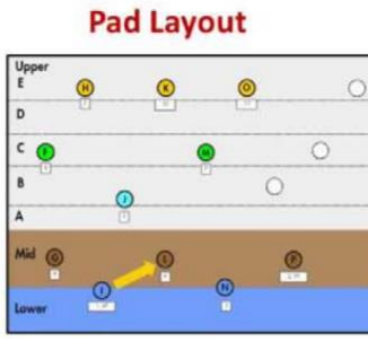
Far-field Fracture Geometry: Low-frequency DAS

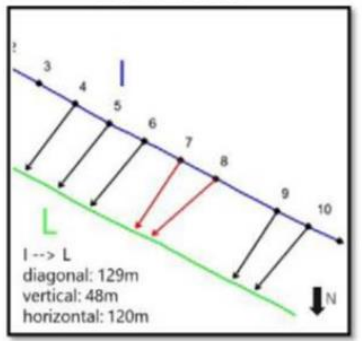


Jin & Roy, 2017

Far-field Fracture Geometry: Low-frequency DAS







Ugueto et al. 2019

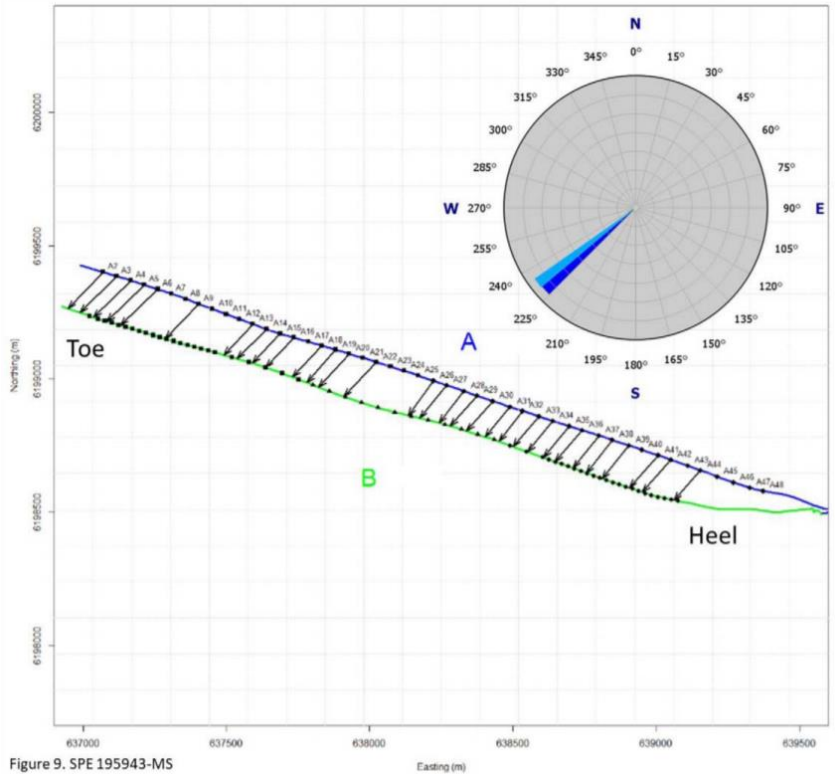
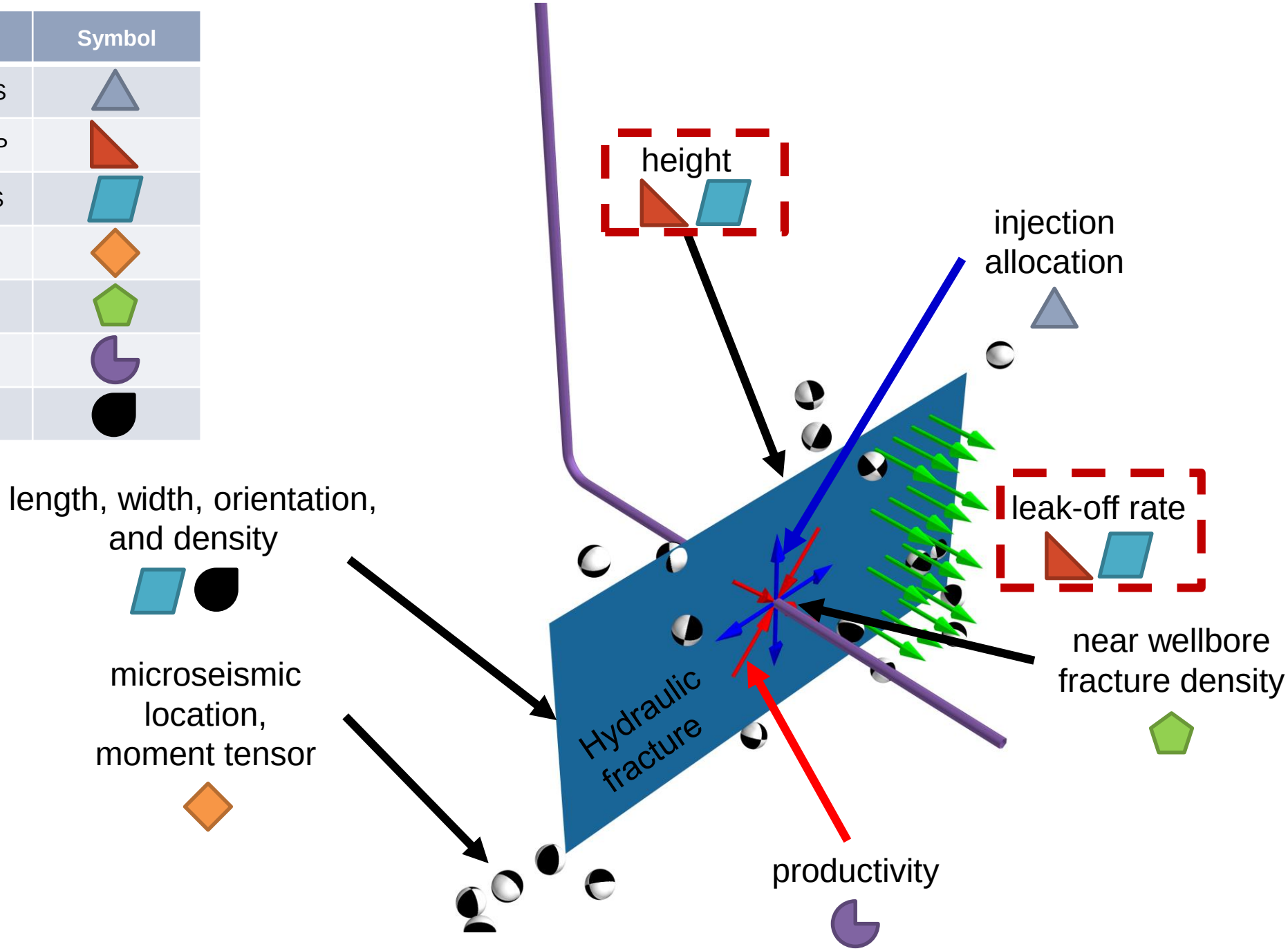


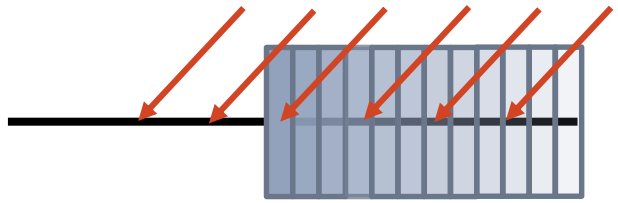
Figure 9. SPE 195943-MS

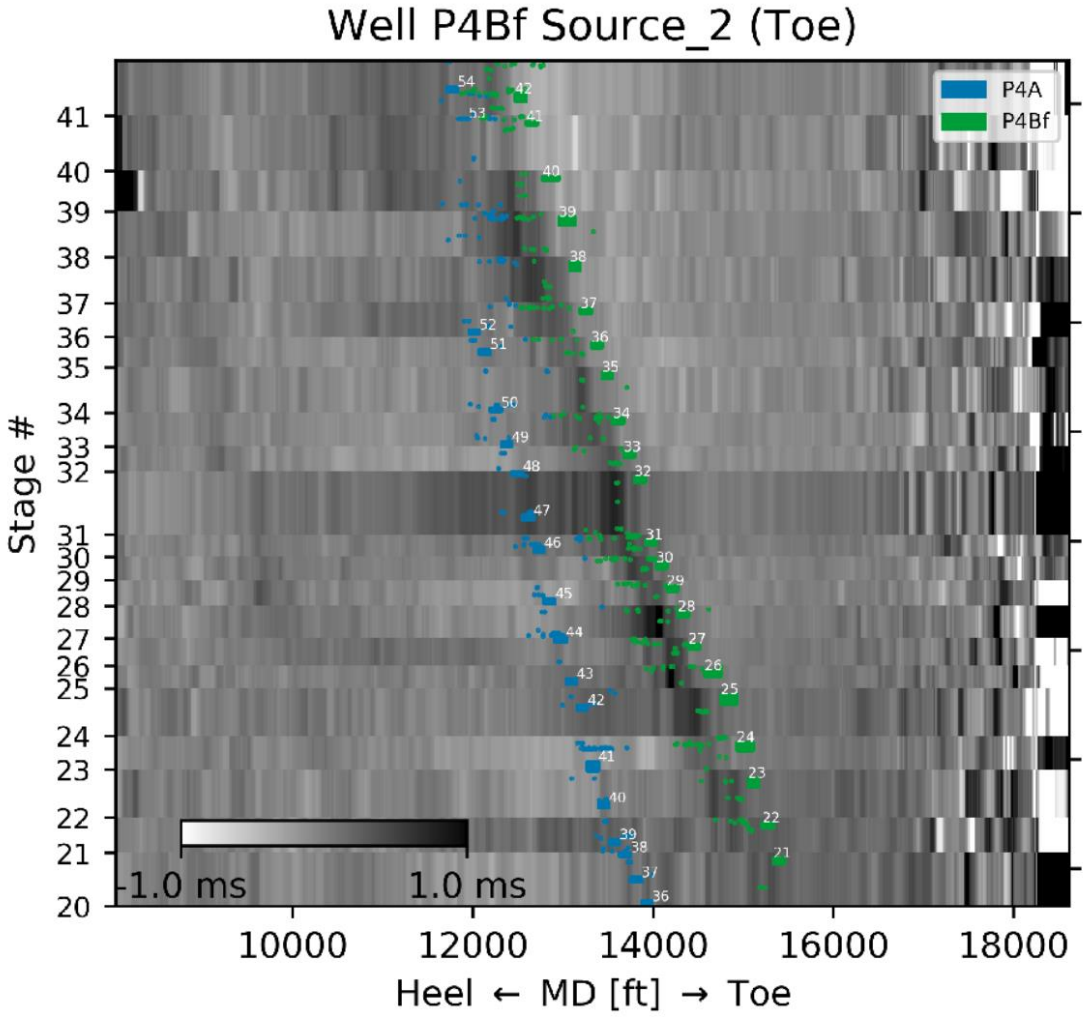
- Low-frequency DAS can accurately pick fracture-hit locations
- Fracture geometry and orientation can be precisely constrained

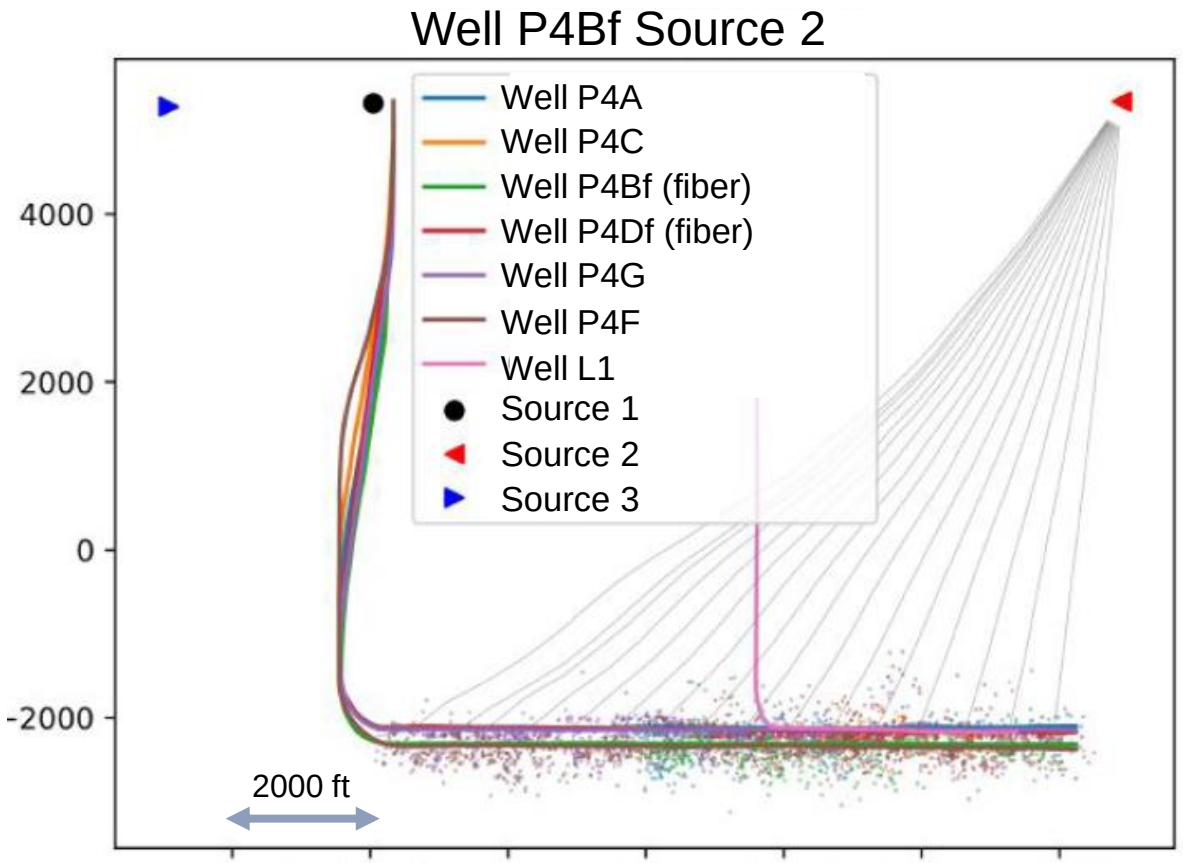
Method	Symbol
High-frequency DAS	
DAS time-lapse VSP	
Low-frequency DAS	
DAS/surface array	
DTS warmback	
DAS/DTS	
Surface tiltmeter	



DAS 4D Inter-stage VSP







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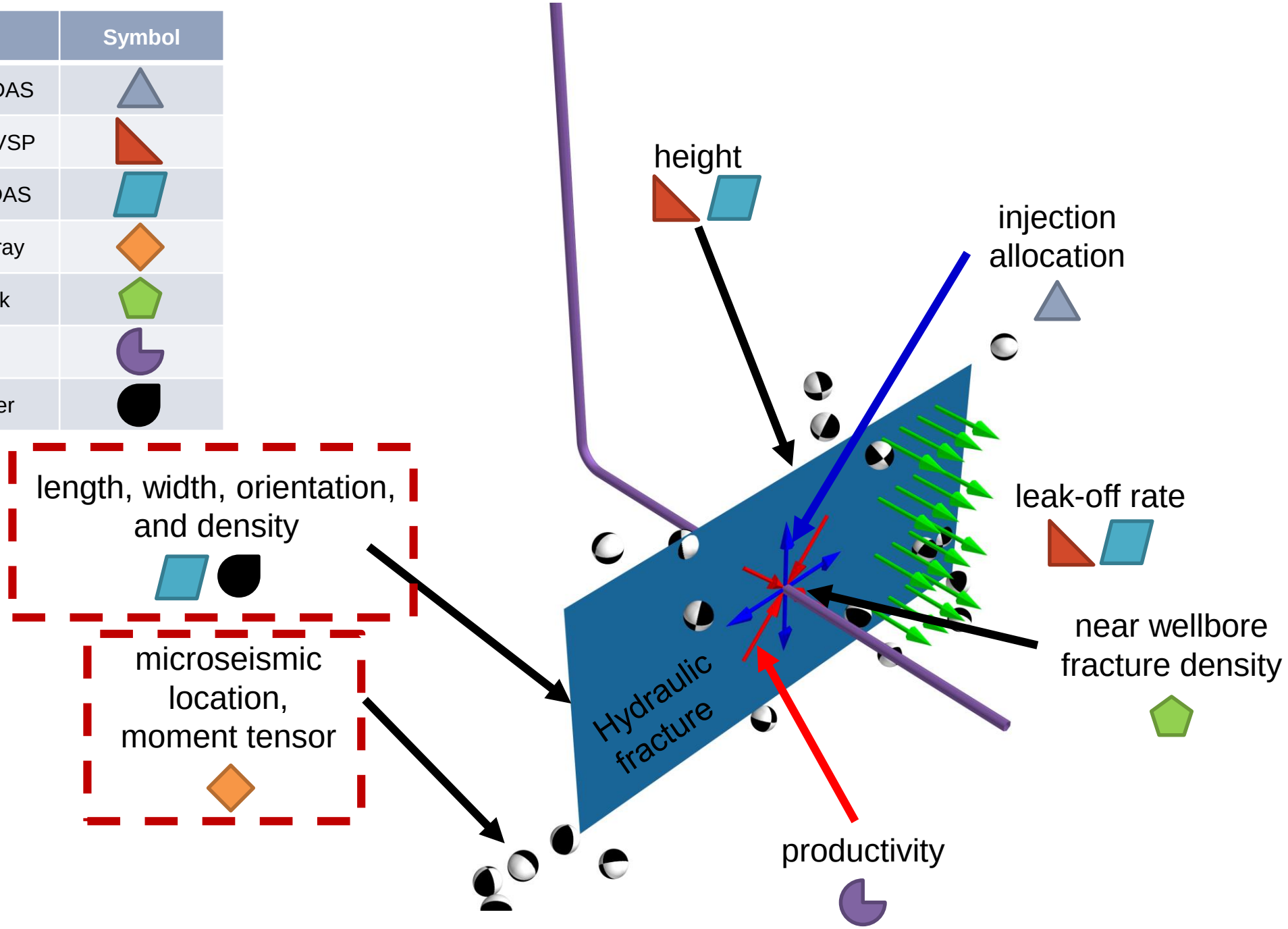
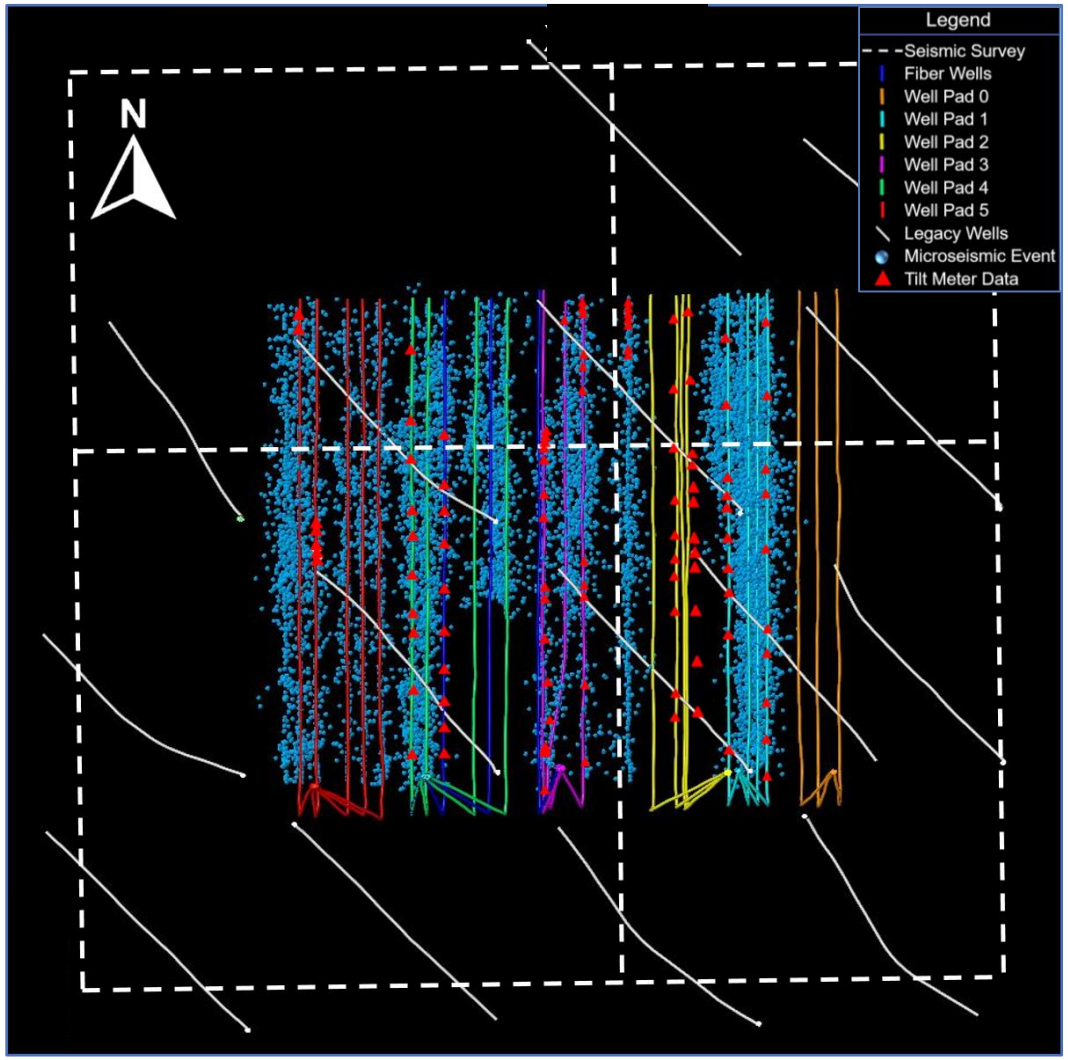
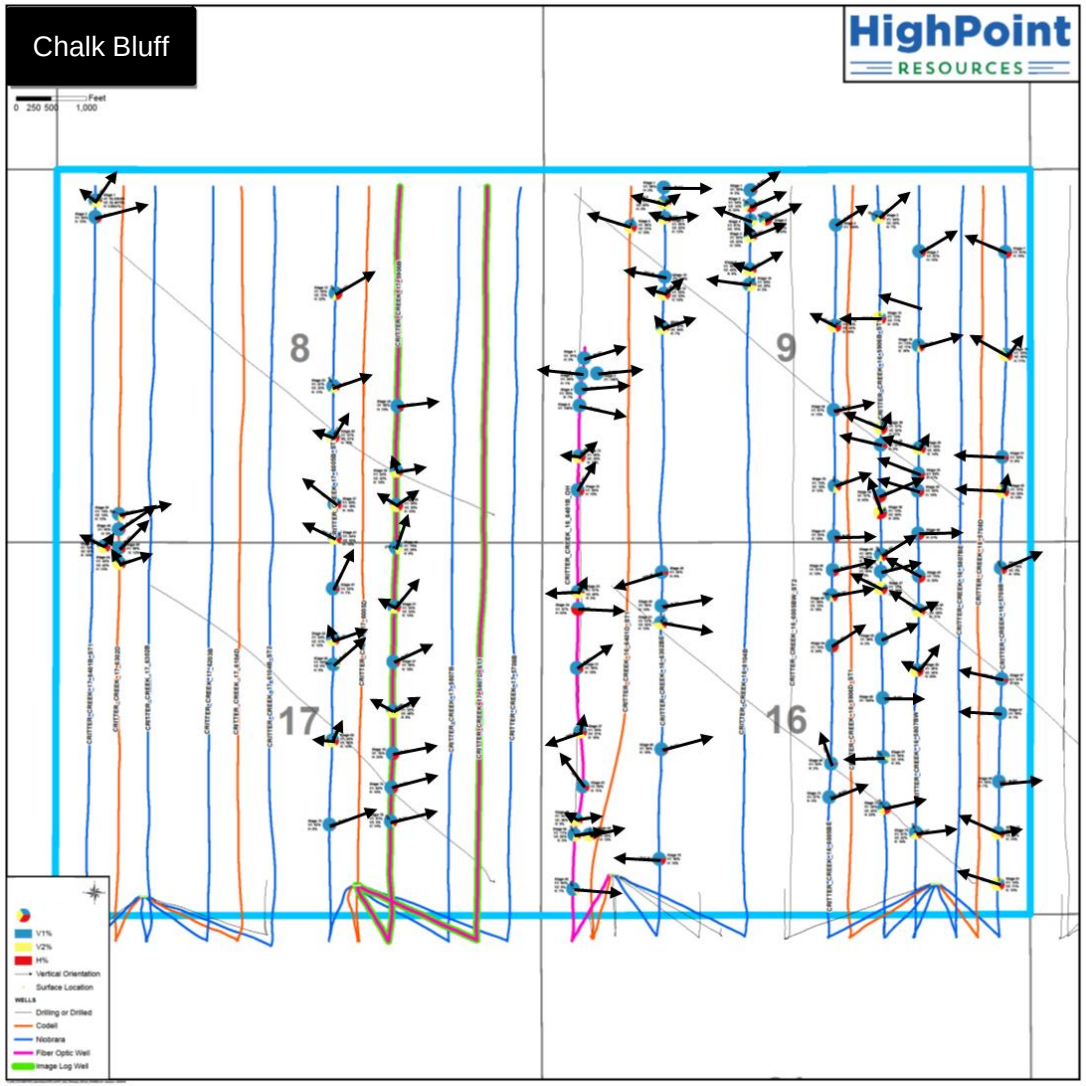


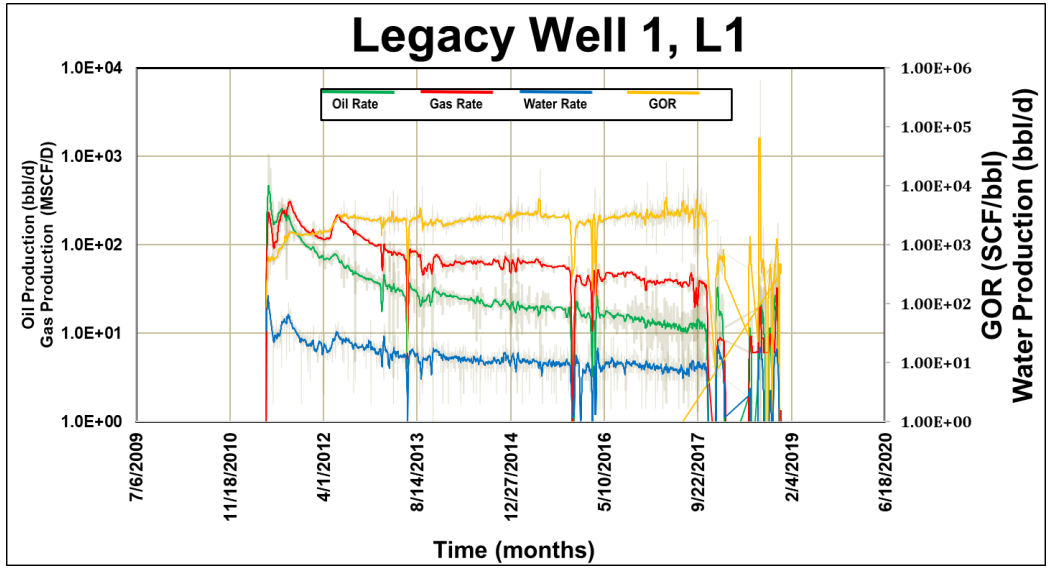
Fracture Geometry: Microseismic And Tiltmeter

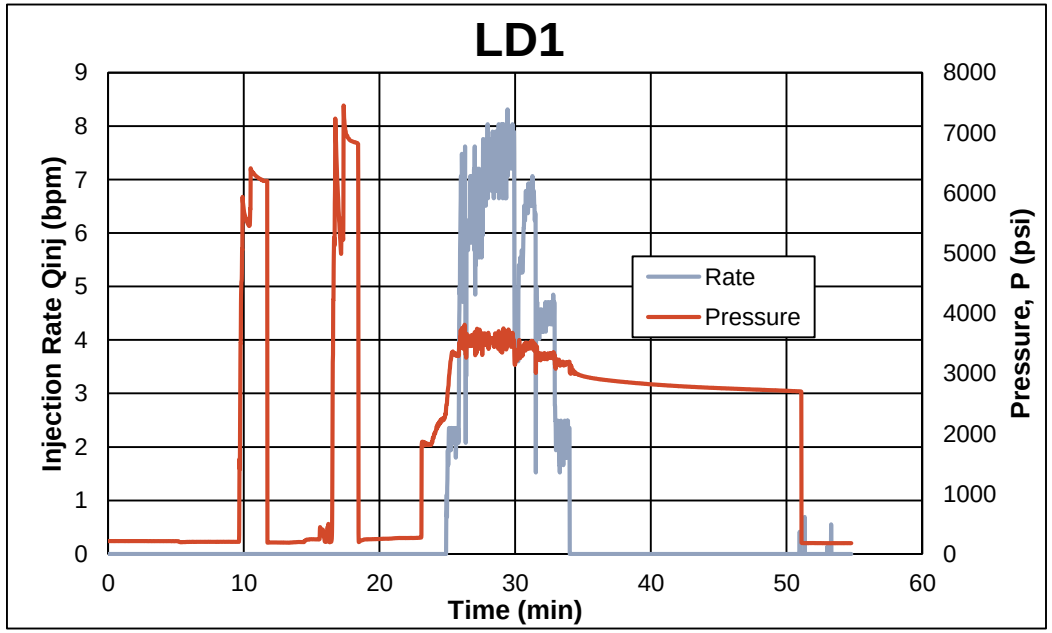




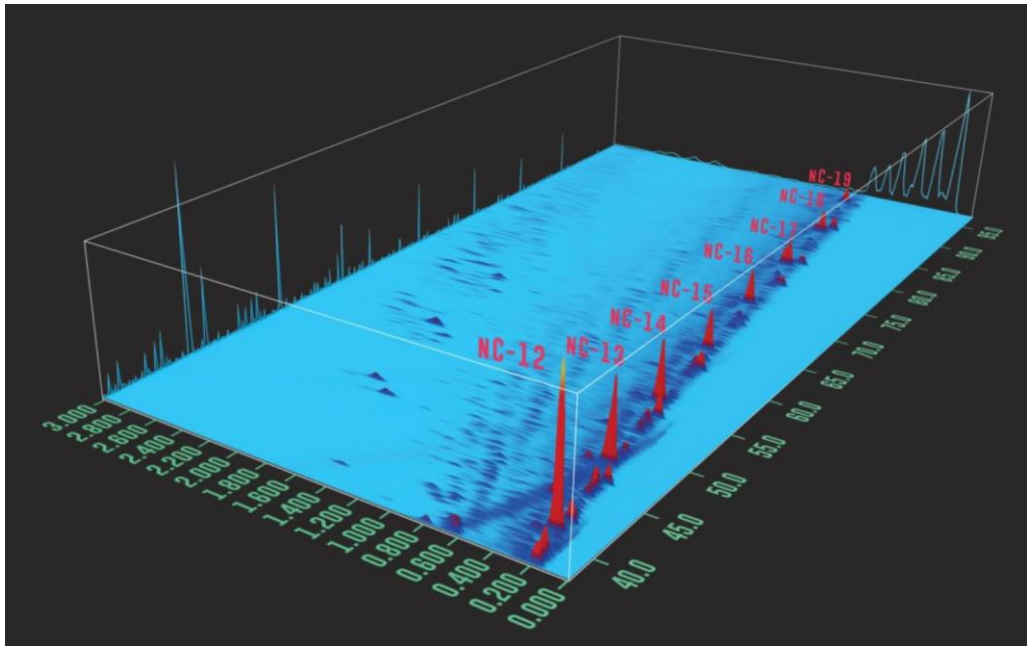
Reservoir Characterization

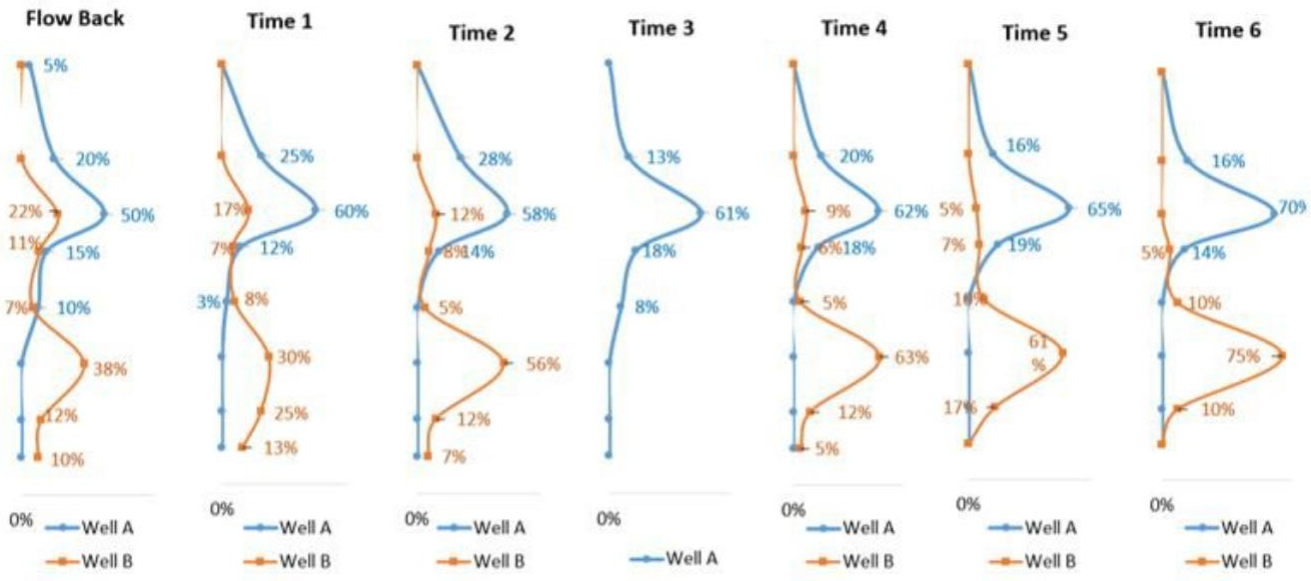
- Evaluate performance of legacy wells.
- Determine reservoir permeability from legacy wells using RTA
- Analyze Diagnostic Fracture Injection Test (DFIT) for:
  - Closure Stress (σ_h)
  - Permeability (k)

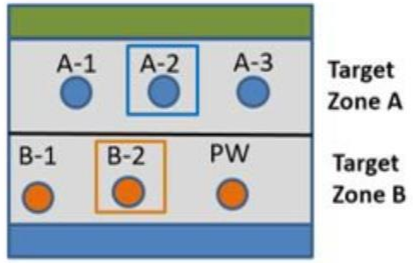




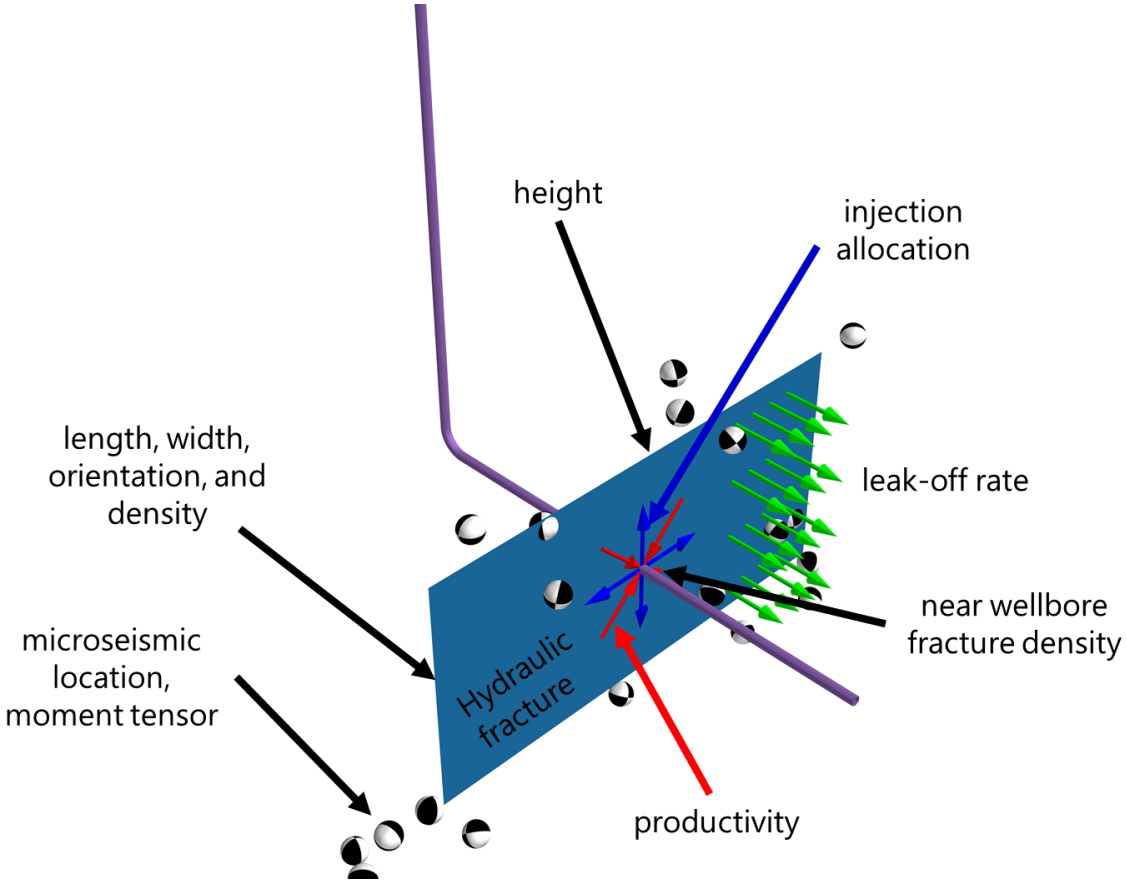
Time-lapse Geochemistry

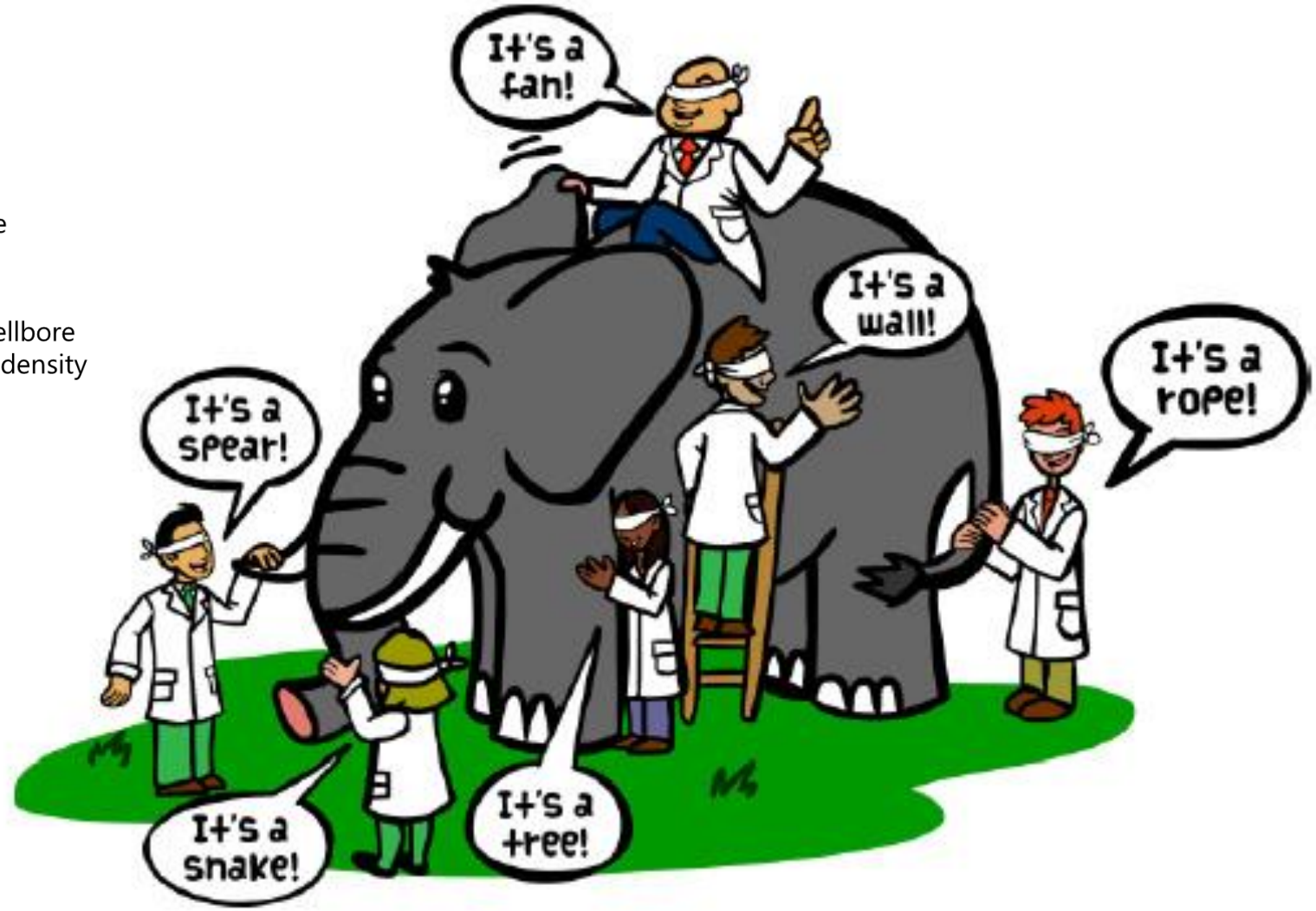






Jacob, 2019


height
injection allocation
length, width, orientation, and density
leak-off rate
near wellbore fracture density
microseismic location, moment tensor
Hydraulic fracture
productivity


It's a fan!
It's a wall!
It's a rope!
It's a spear!
It's a snake!
It's a tree!

Project Plan

Feb. 2020 | May 2020 | Oct. 2020 | Dec. 2020

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Geologic interpretation
- Geochemistry data analysis
- Seismic attributes, HTI, VTI

Dynamic Model

Input static model

Production analysis
- Compare redevelopment to legacy wells

Fracture modeling
- Create geological section (using well logs as input)
- Input pumping schedule
- Fracture simulation for each well
- Obtain fluid propagation and fracture geometry
- Incorporate DFIT, microseismic, and tiltmeter

History Matching

Input dynamic model

Parameter tuning
- Permeability/transmissibility
- Pressure

Production matching

Optimization

Input final model

Well spacing analysis
- Run simulations with various spacing/clustering
- Economic evaluation
- Determine optimal spacing

Redevelopment
- Assess data available prior to redevelopment
- Determine improvements for future redevelopment

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Petroleum Engineering

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Geology

Conclusion

- Chalk Bluff project is a pilot project aiming to optimize well spacing and completion designs in DJ Basin.
- Reservoir characterization and hydraulic fracture geometry will be well constrained by the data of various types.
- Complex reservoir models will be built to match the completion and production data. Economic analysis on well spacing and completion designs will be performed.


AFL


Anadarko
Petroleum Corporation


Apache


CGG


Chevron


CIMAREX


CNOOC


DAWSON
Dawson Geophysical Company


devon


drillinginfo
better, faster decisions


eog resources


ExxonMobil


Great Western
OIL & GAS COMPANY


HALLIBURTON
Landmark


HighPoint
RESOURCES


شركة نفط الكويت
Kuwait Oil Company


ikon
Science


LUMINA


Lundin
Petroleum


NANOSEIS


OptaSense®


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