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Analysis of a Drained Rock Volume: An Eagle Ford Example

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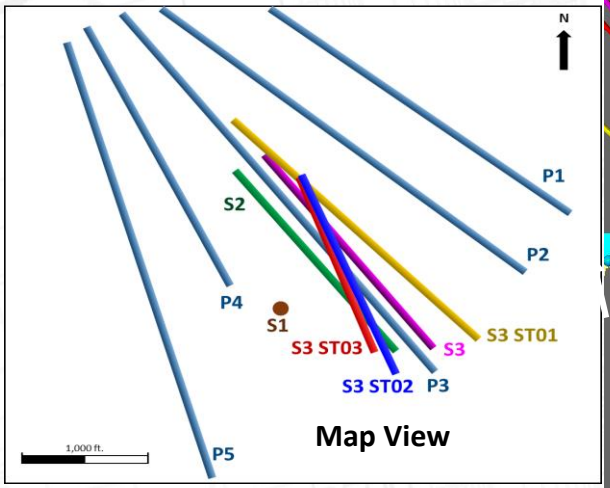
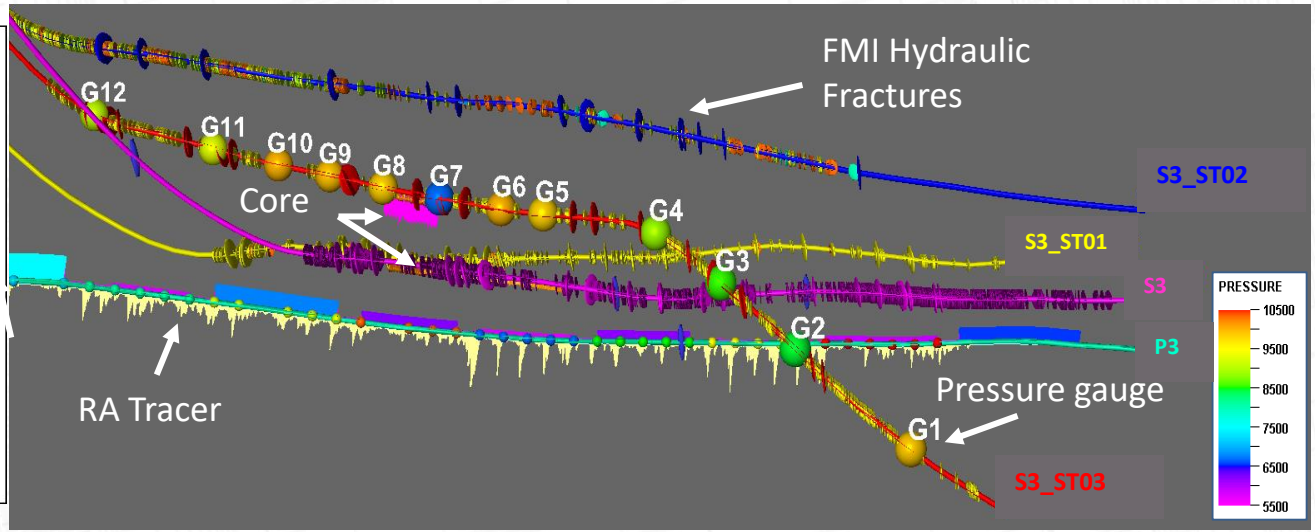
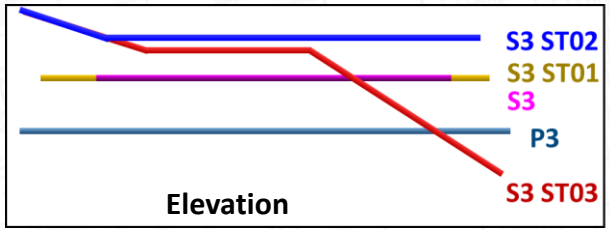
Outline

- Background: Pilot layout and static SRV description
- Analysis objectives
- Dynamic Performance Data
  - Near-field temperature warmback
  - Far-field pressure
- Integrated Reservoir Model
- Conclusions

Pilot Layout and Major Data Acquisition

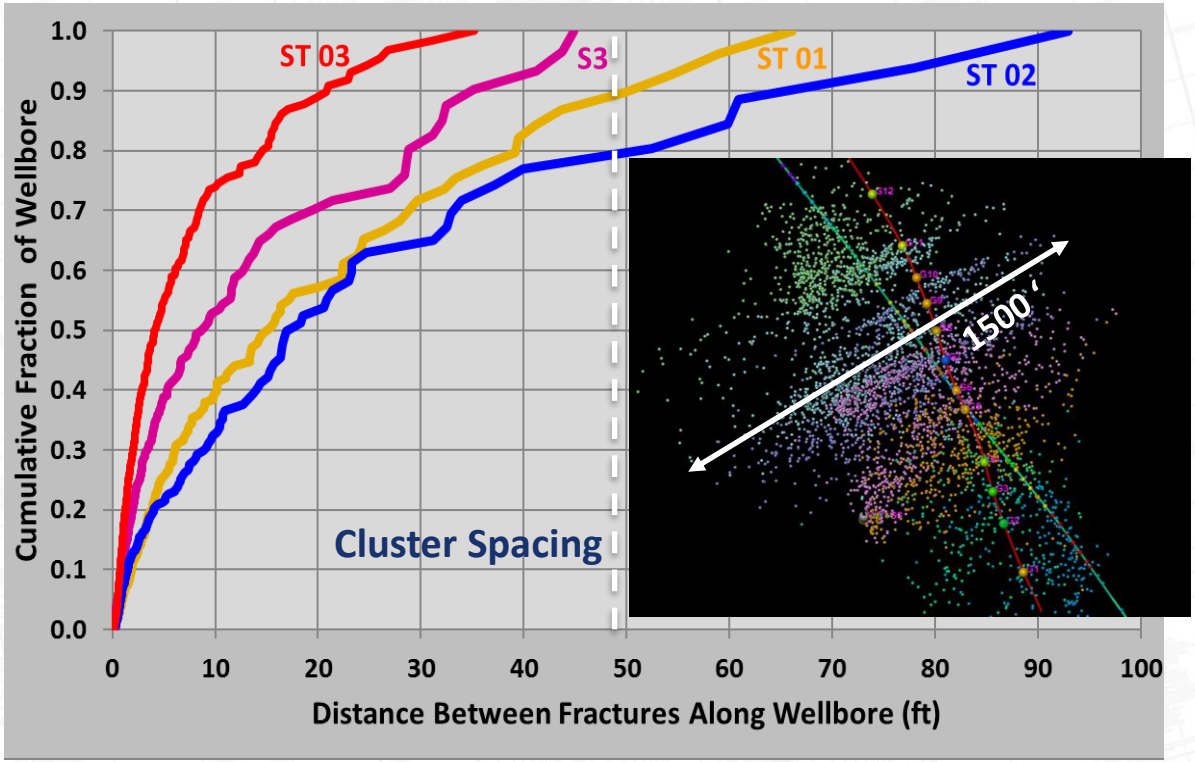






- **Post stimulation data acquisition**
  - 600 feet core
  - 7000 feet FMI-HD
  - 15 far-field pressure gauges
  - DTS / DAS

SRV Character… Extensive and Highly Fractured



- **Hydraulic fractures:**
  - Numerous, >> 1 / cluster
  - Appear in swarms
  - Diminish with distance
  - Subparallel
  - Some extend large distances (> 1500 feet)
  - Sparsely propped at sampled distances
- **See SPE-191375-PA for further detail**

The Drained Rock Volume… Outstanding Questions

- Is the presence of a hydraulic fracture necessary and sufficient to establish spatial drainage?
  - How are the observed fractures connected to the producer?
- Is knowledge of spatial drainage necessary to decide cluster spacing, well spacing and well stacking?
- Can near-field temperature data and far-field pressure data provide meaningful insights? Value?

Temperature Data: Post Completion Warmback

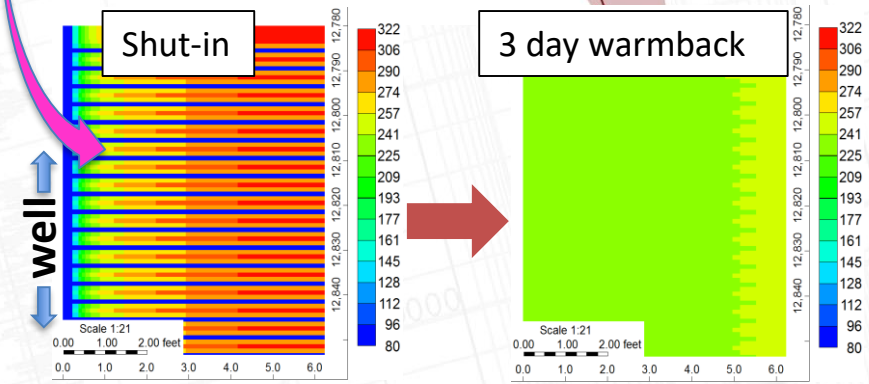
Multi Fracture Connection

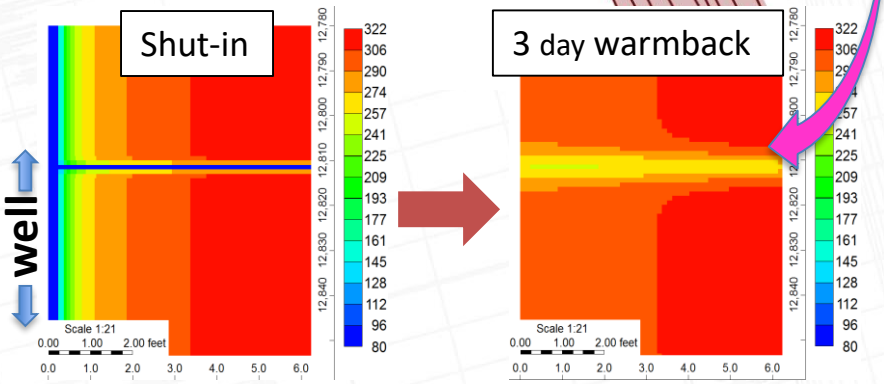
Single Fracture Connection

well

Unknown – near-well fracture distribution.

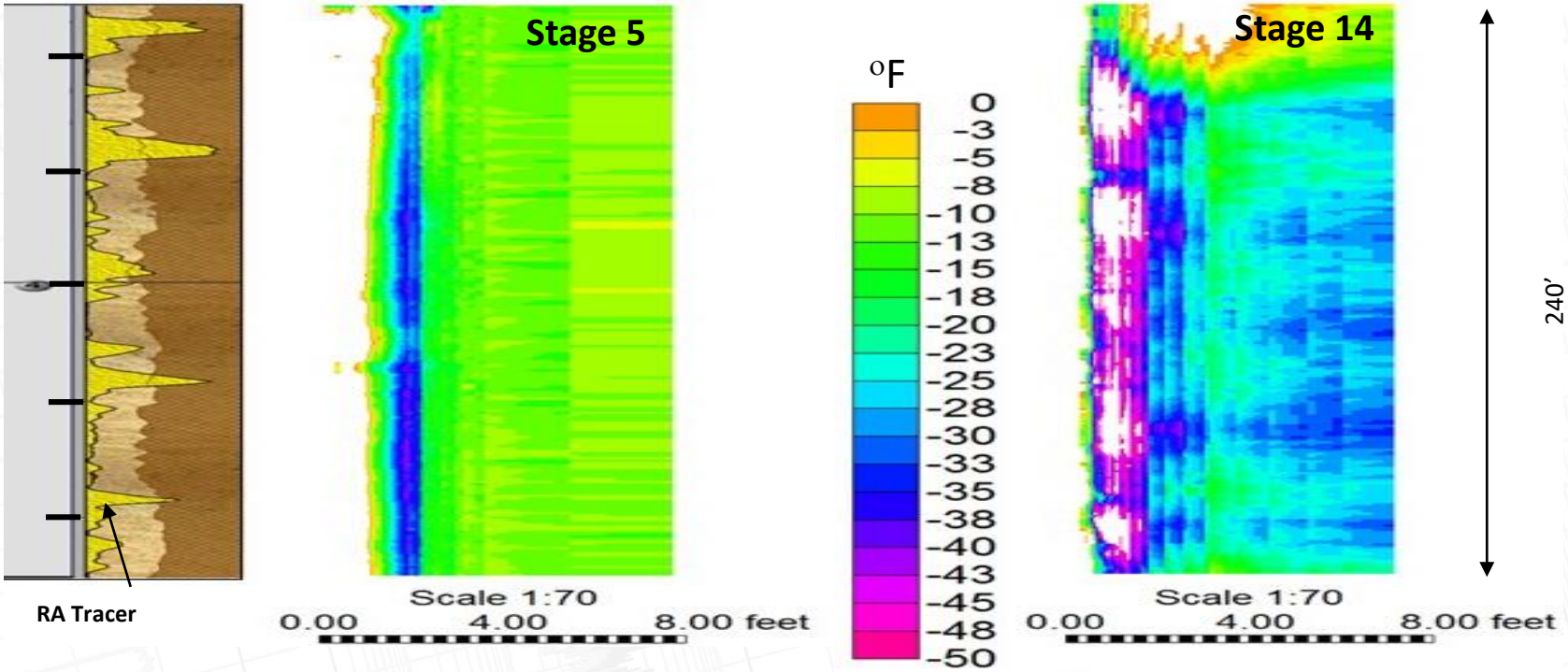
Known – fractures verified by core and image logs.



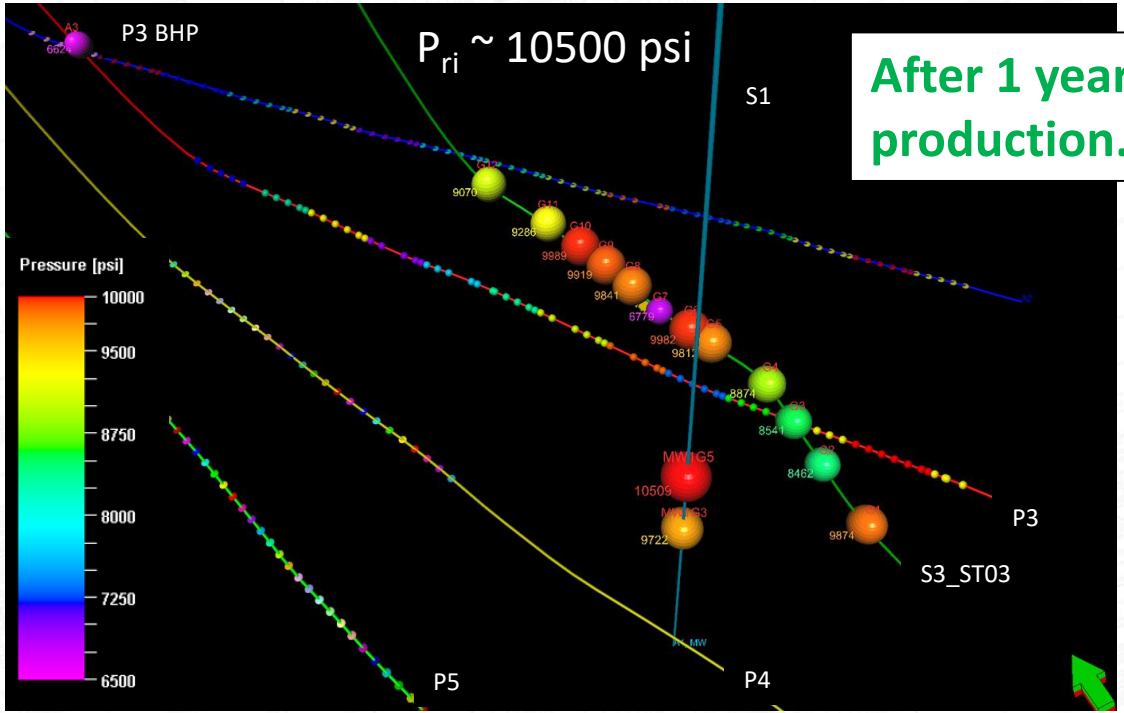


DTS Data Supports a Secondary Fracture System.

Temperature Difference Map – convective heat transfer only

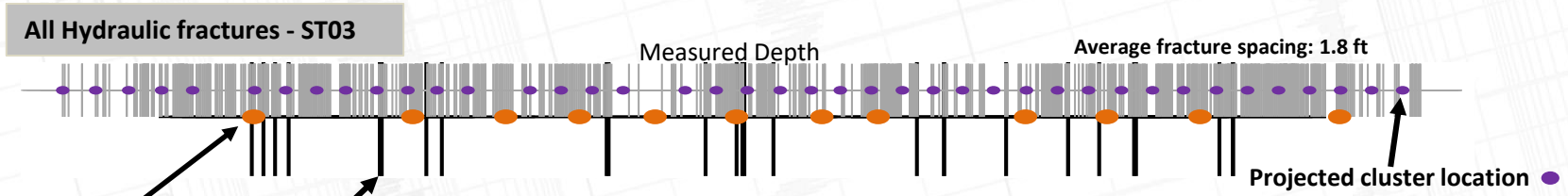


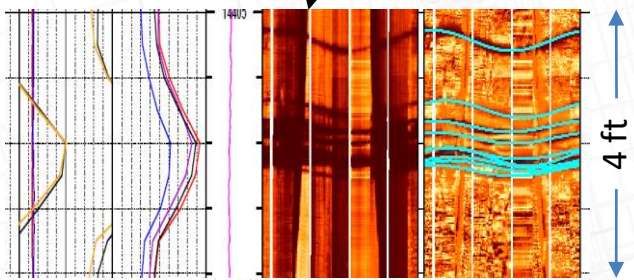
Far-Field Pressure Data… Depletion is spatially non-uniform.

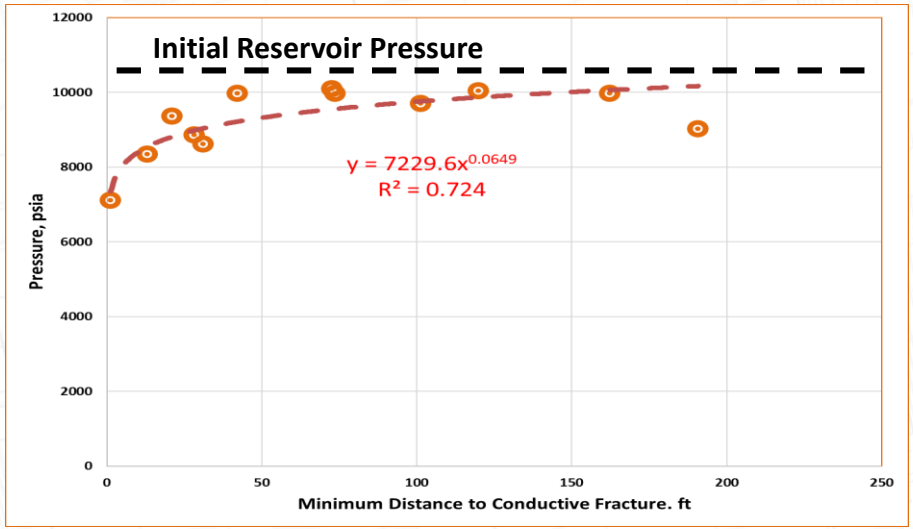


Gauge #	Closest Distance P3 (ft)	Shut-in Pressure (psia)
1	231	9937
2	181	8551
3	135	8345
4	100	8839
5	56	9848
6	56	9997
7	72	6963
8	104	10008
9	131	9958
10	161	10026
11	184	9426
12	218	9050
S1_G3	615	9722
S1_G5	630	10509

Far-Field Pressure Data… Drainage Correlated to Proximity to a "Principal" Fracture.

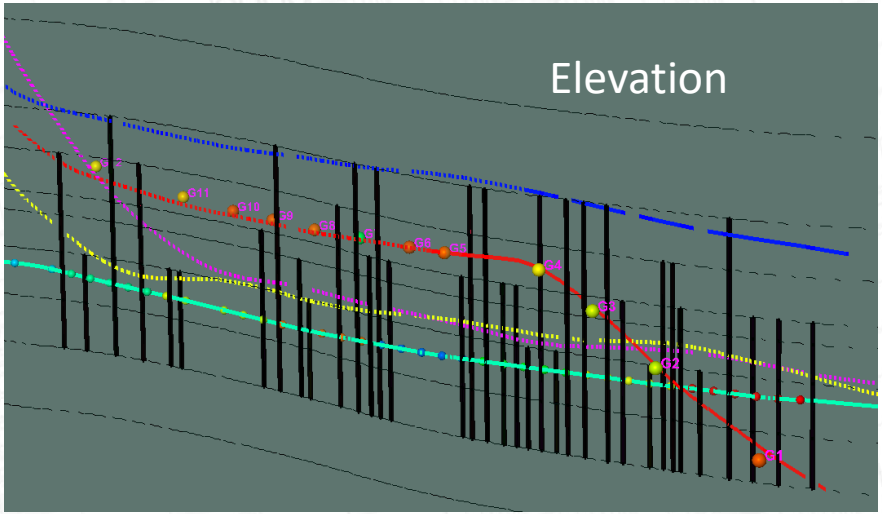


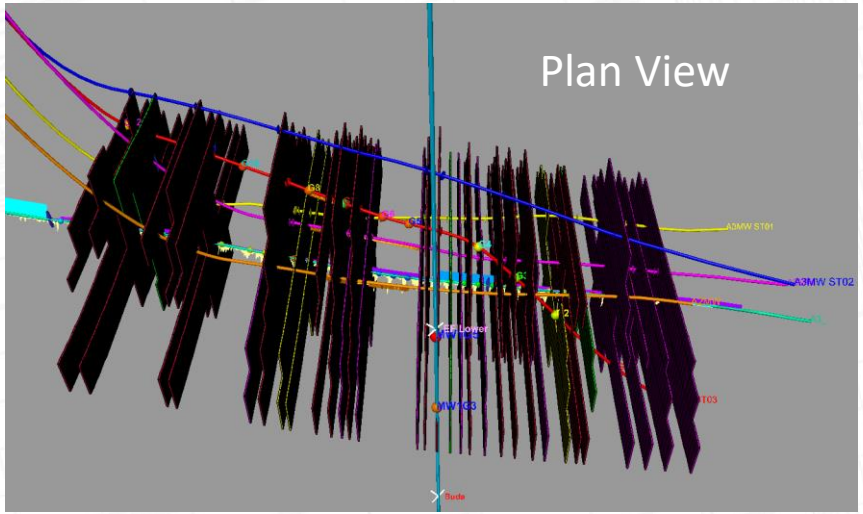




The Integrated Reservoir Model… Principal Fractures

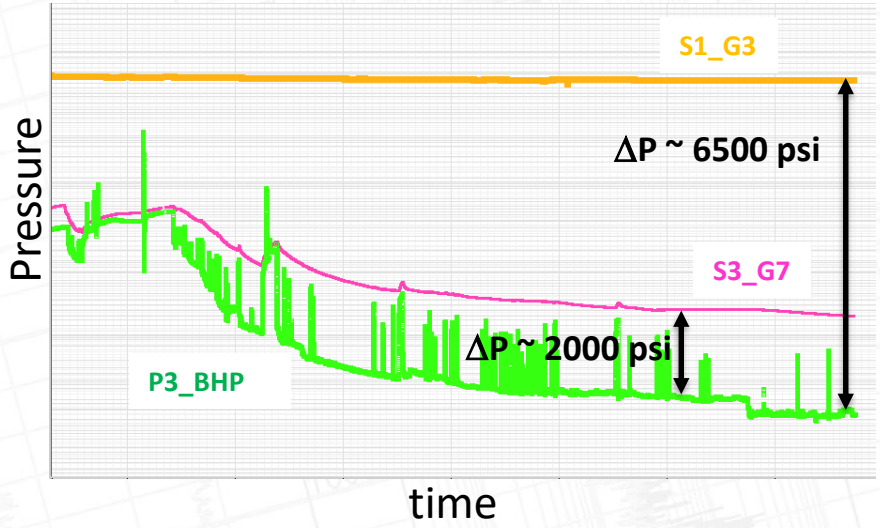
- Irregular geometry (honor sample well control)
  - Asymmetrical height and length
- Non-uniform spacing

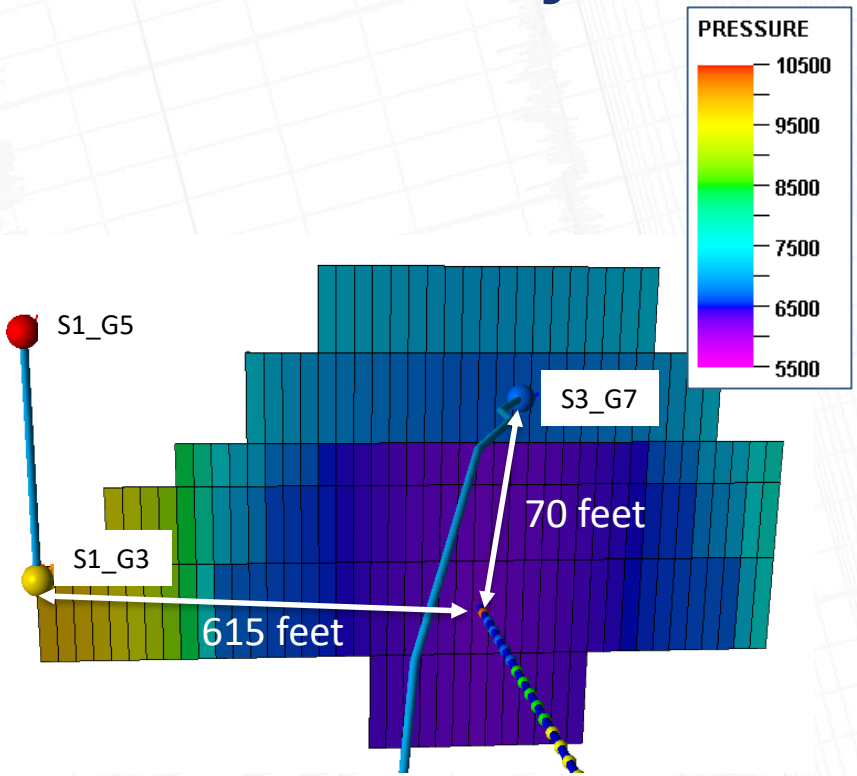




The Integrated Reservoir Model… Fracture Conductivity

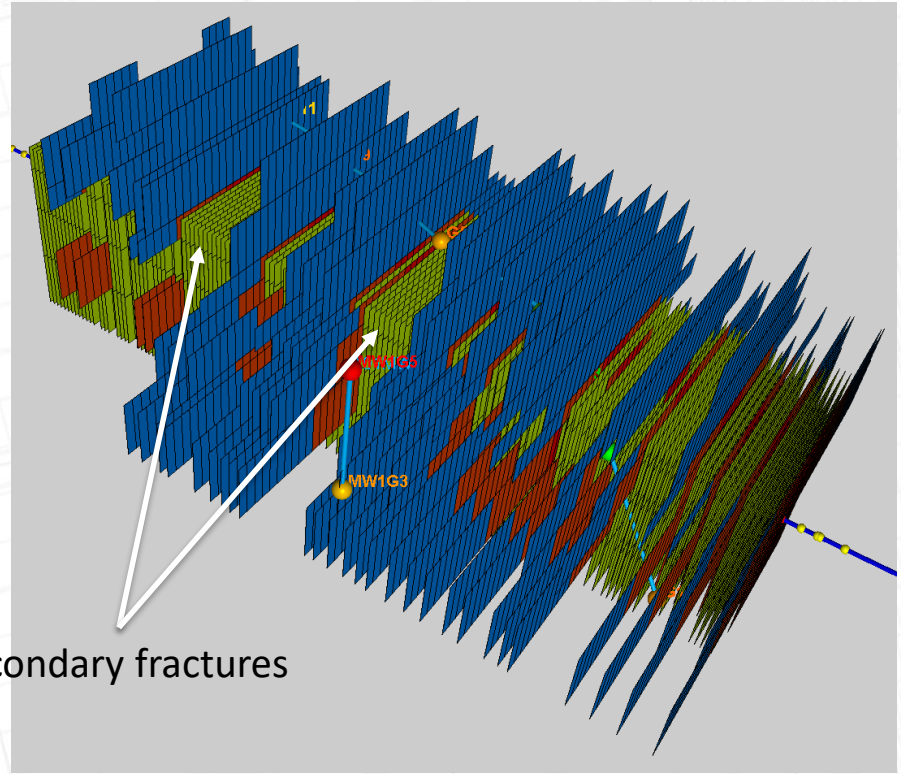
- Multiple conductivity regions
  - Stress dependent
- Calibrated to pressure data



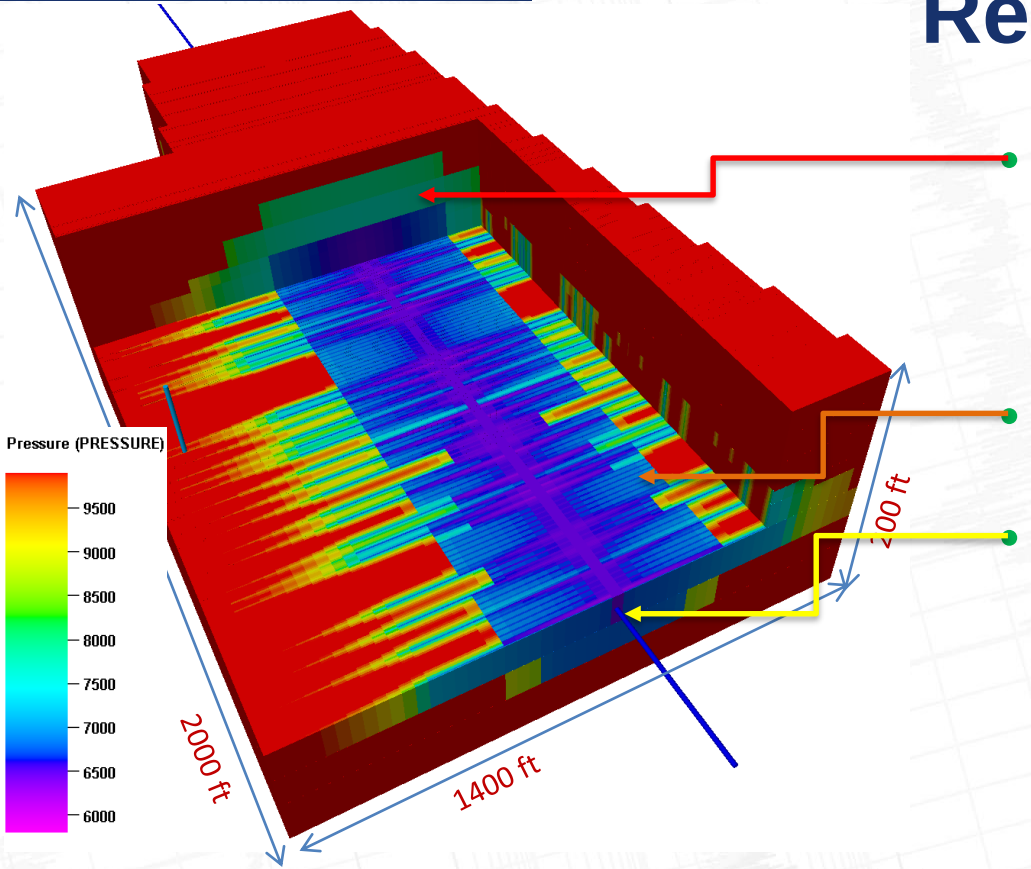


The Integrated Reservoir Model… Secondary Fractures

- Regularly spaced between clusters
- Arbitrarily rectangular
- Globally adjusted for history match
- Connected by high conductivity corridor along the well



A History Matched Integrated Reservoir Model



Principal Fractures

- Mediate inter-well communication
- Extend long distances
- Drawdown diminishes with distance
- Drainage becomes “patchy” with distance

Secondary Fractures

- 40% of production

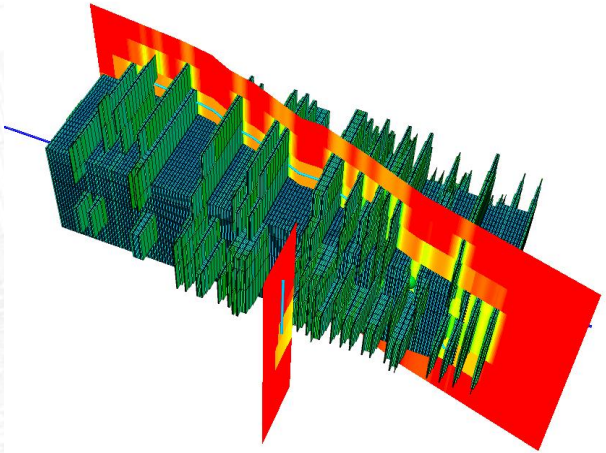
Near well connection

- Connects secondary fractures to the perfs
- Concentrates drainage near well

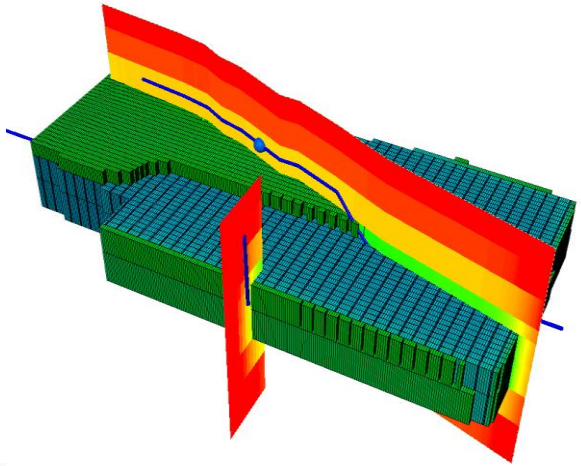
Spacing and Stacking… Which Description is Adequate?

- Can interference be equated to competitive drainage?
- Is cluster spacing adequate?
- Is production history matching alone sufficient to determine spacing?

Production History Matched Models…
equivalent cumulative produced



Integrated Model



Uniform Fracture Model

Summary

- Far-field pressure data and in-well DTS data are invaluable in defining the DRV.
- Drainage is non-uniform.
- Drainage is largely mediated through Principal Fractures.
  - Asymmetric, irregular geometry; not regularly spaced
- Near-well secondary fractures likely exist and contribute significantly to drainage.
- Significant implications for cluster spacing and well spacing

Acknowledgements

- ConocoPhillips management
- Extended technical team, contractors and vendors who met the unique operational and analysis challenges
- Helen Farrell