Frac Replay Analysis What, How, and Why?

Stacy Newman

Quick Overview – WHAT?

- What is Frac Replay Analysis?
  - System used to evaluate and improve the hydraulic fracture stimulation plan
  - Tremendous amount of data gained during every frac
    - USE IT TO YOUR ADVANTAGE!!!
  - Frac data can be analyzed to gain:
    - Frac Geometry
    - Reservoir/Geomechanical Properties

Quick Overview – HOW?

- How do you analyze after the treatment?
  - Frac Replay Data is provided for an independent analysis and review.
    - At a minimum: Pressure, Volume (or Pump Time), Rate, and Prop Concentrations are needed
    - MUST **ASK** FOR THE JOB REPLAY DATA **IN THE FIELD** IMMEDIATELY FOLLOWING THE TREATMENT!!!
  - Other Data Provided
    - Well Logs of all types (including mud logs)
    - *Acoustic Logs are a HUGE asset to have*
    - Well Schematics & Deviation Survey
    - Proposed Design and Actual Treatment Pumped
    - Any other Geologic and/or Reservoir Data possible

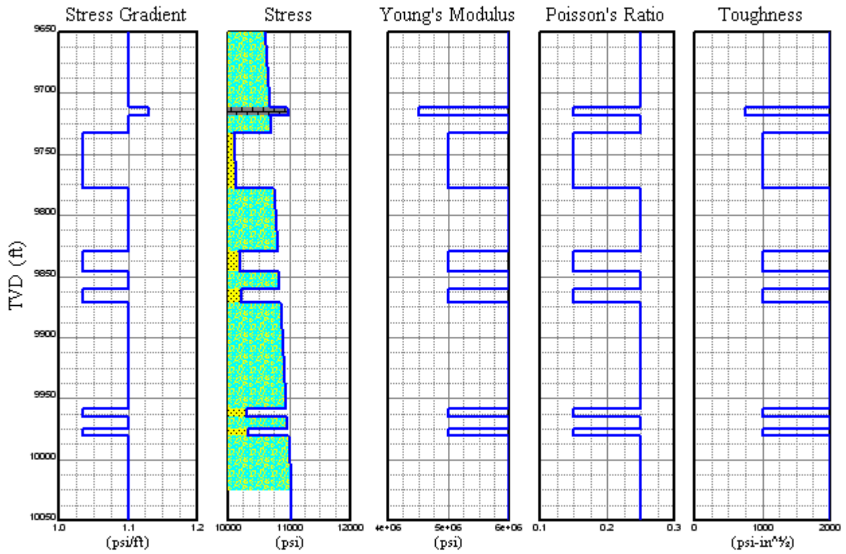
HOW - Analysis Order of Operations

- Import as much data as possible
  - Triage Data as needed
- Build Geo-mechanical Model of Rock Layers and Properties
- Analyze Minifrac
- Pressure Match Actual Frac Treatment
  - Confirm Geomechanical Model thru Simulation
- Postmortem of Stimulation Job

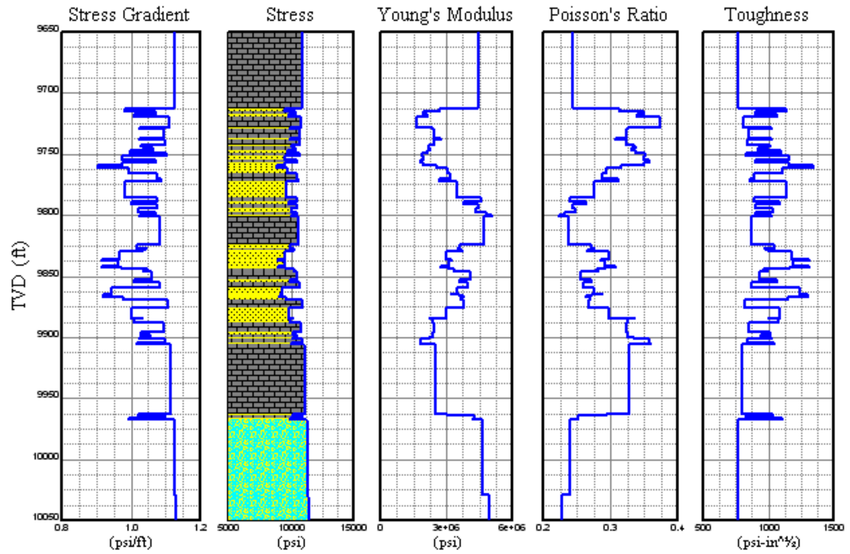
Geo-mechanical Model

The more data provided, the better the models get!

From Mud Log:



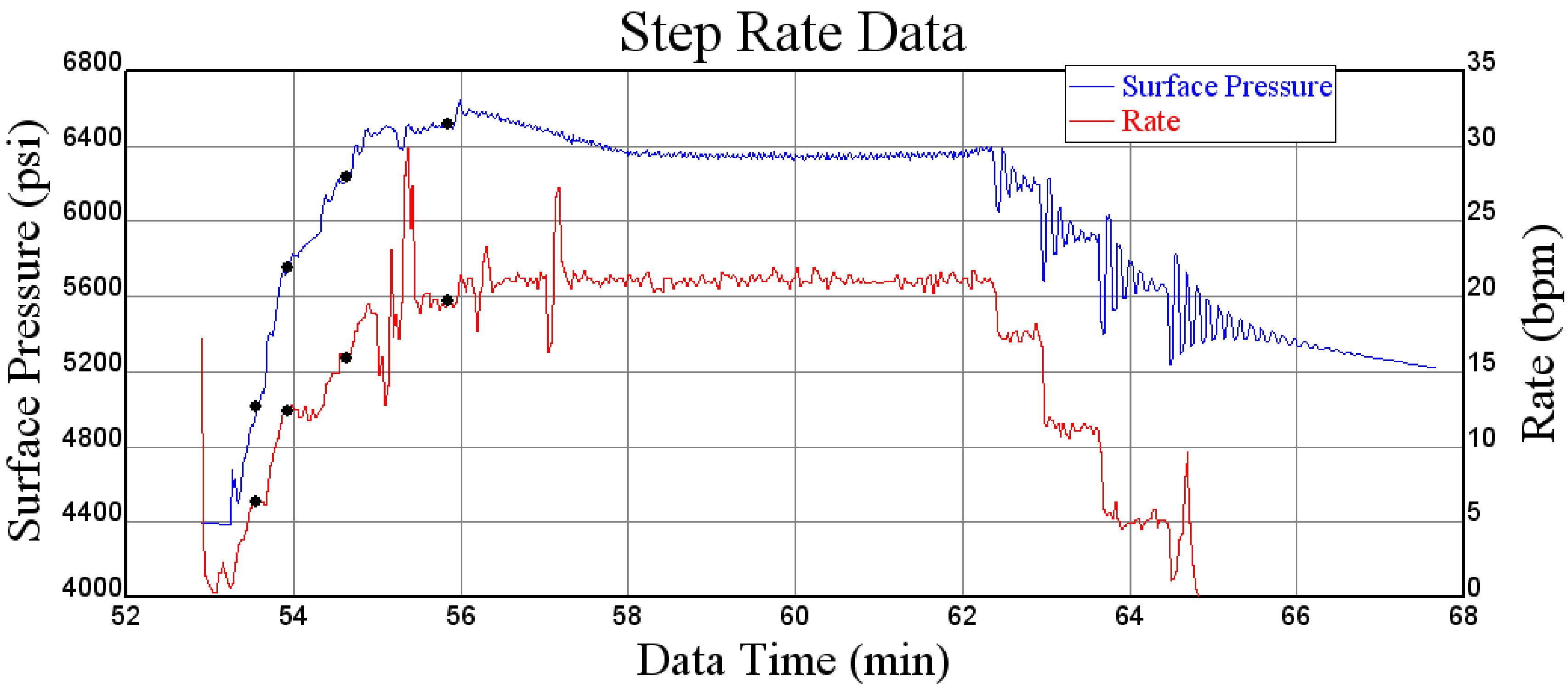
To Acoustic Logs:



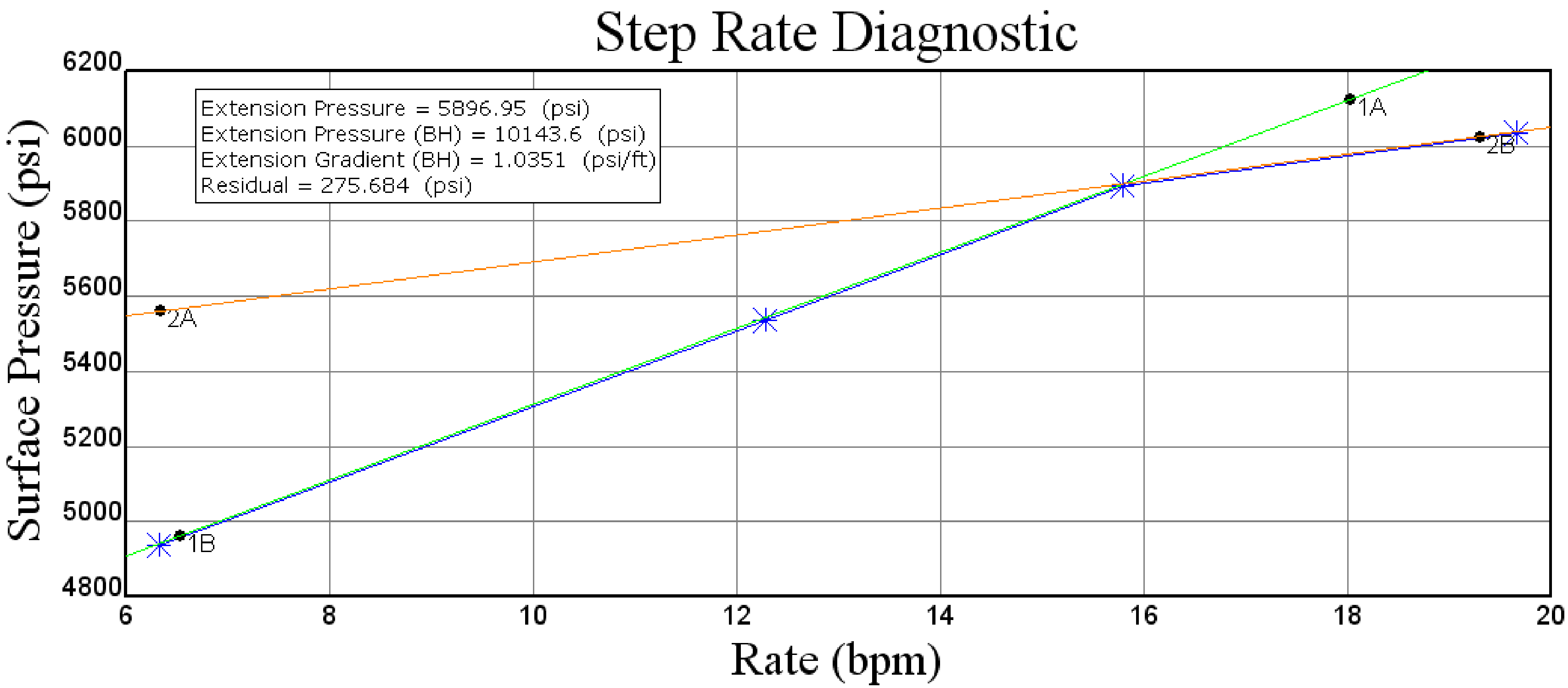
MiniFrac Analysis

- Step Rate
  - Max Closure Pressure (Pc)
- Step Down
  - Near Wellbore Losses
    - # Perfs Open
- Horner
  - Minimum Pc
- Regression
  - ISIP, Pc, ΔPnet, Time to closure, Efficiency
- History Matching of Data
  - Rock Properties, Frac Geometry
- After Closure Analysis
  - Pore Pressure (P*), Permeability

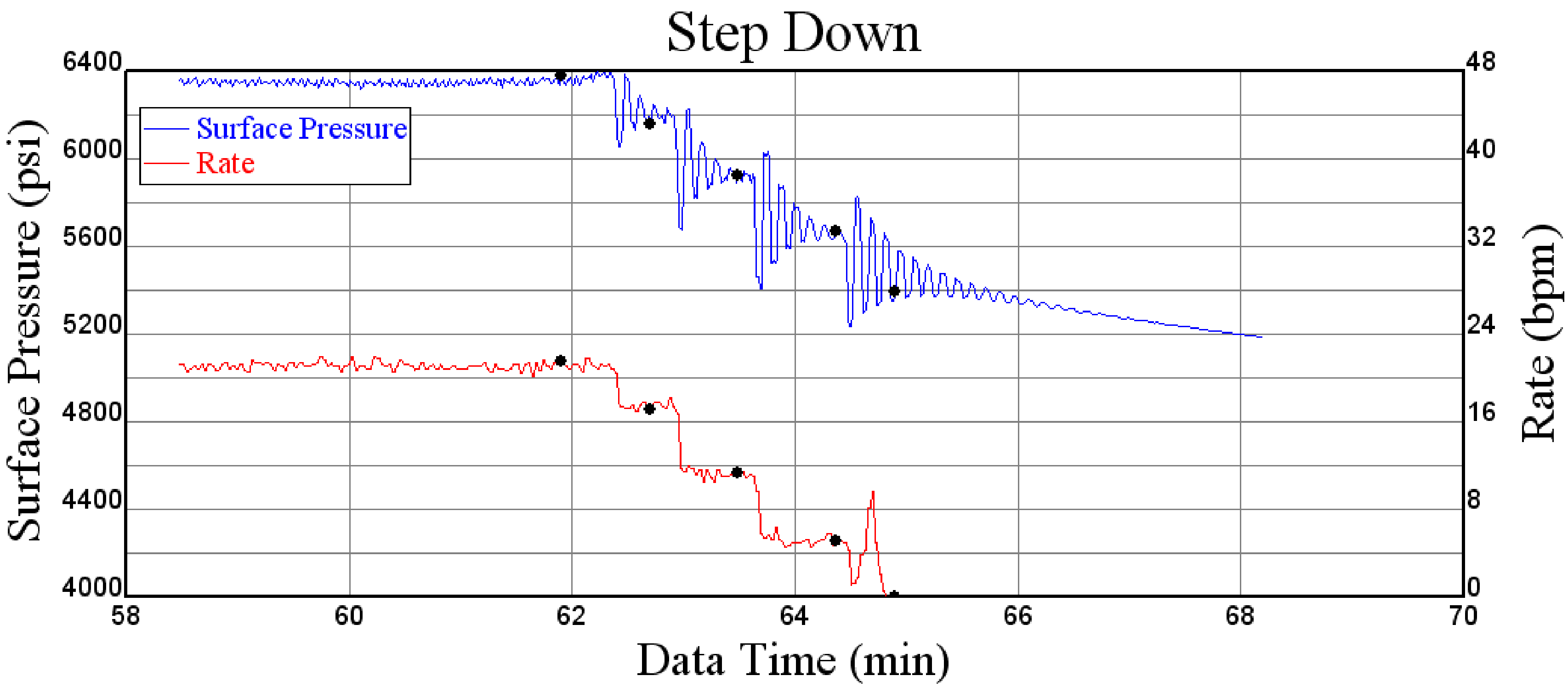
MiniFrac – Step Rate



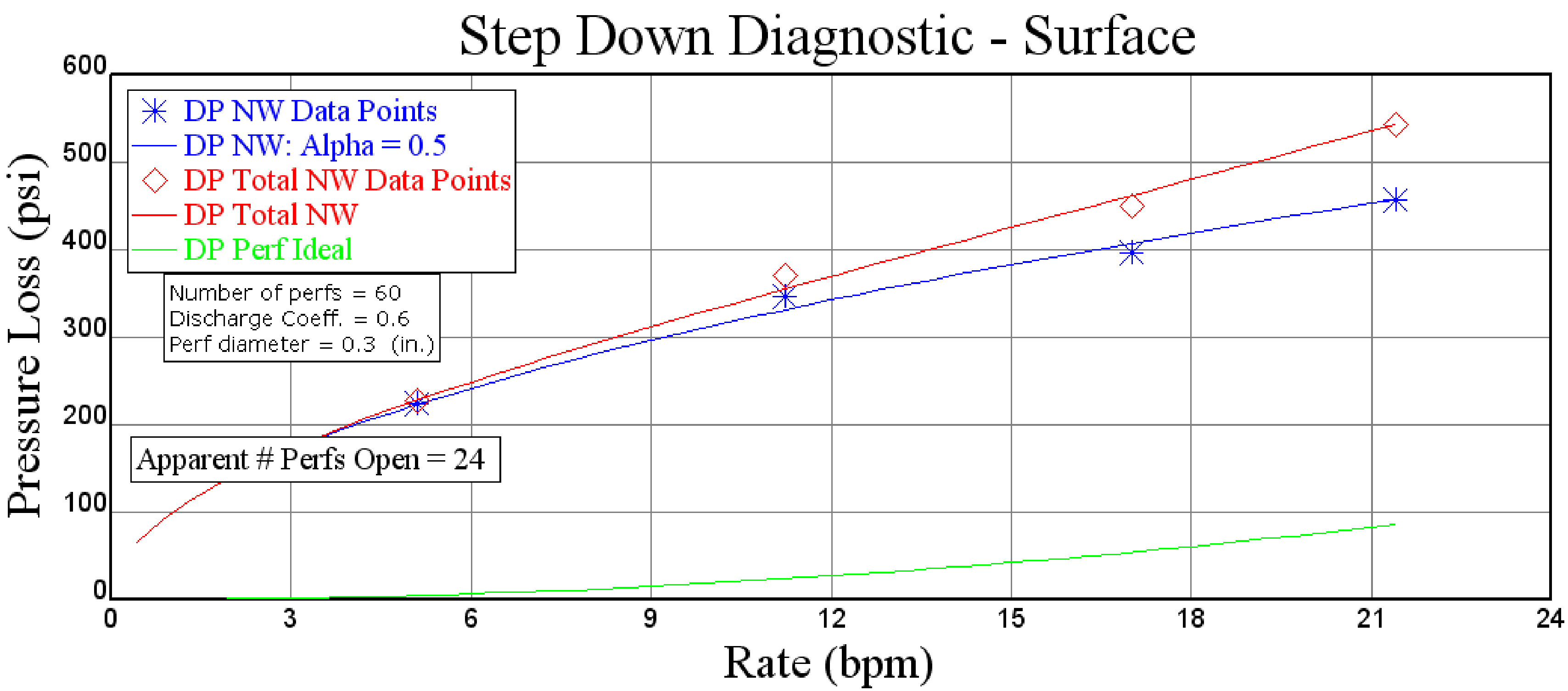
MiniFrac – Step Rate



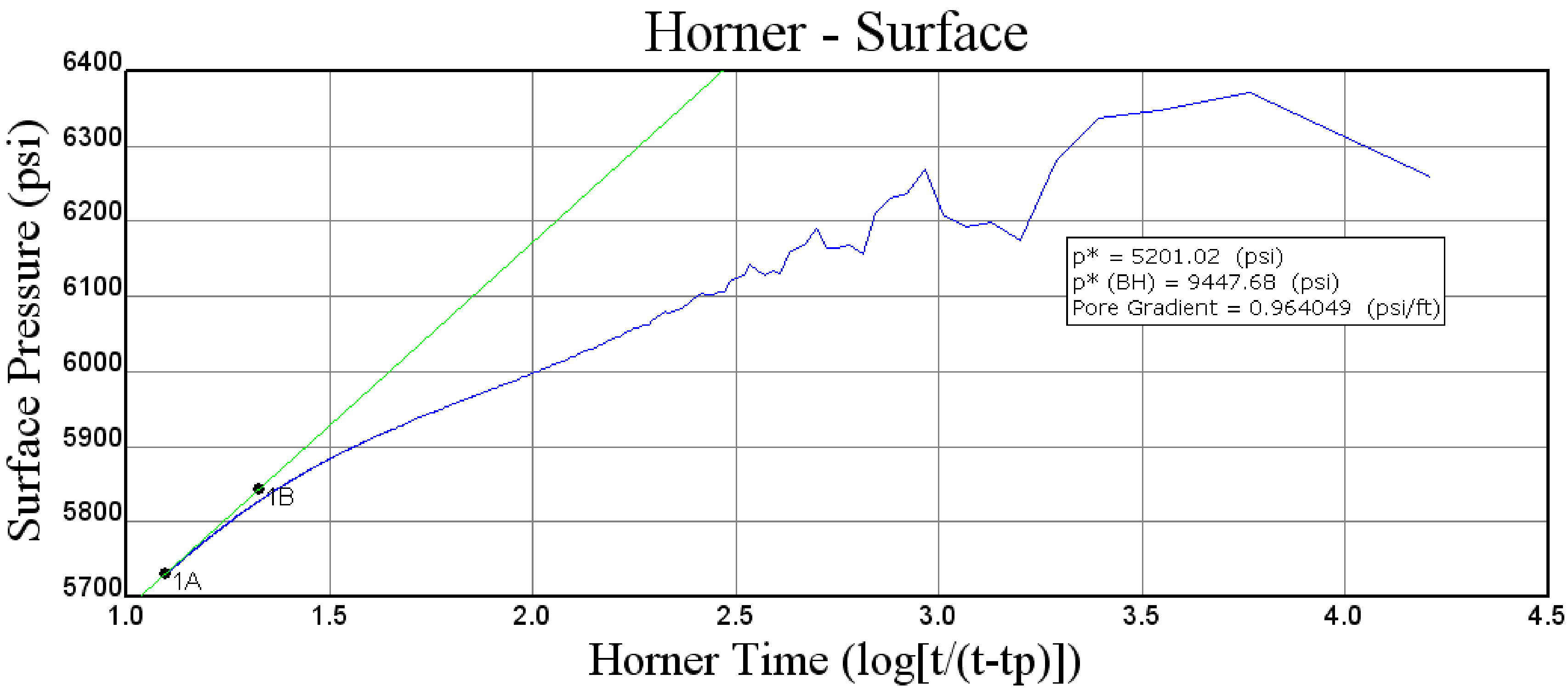
MiniFrac – Step Down



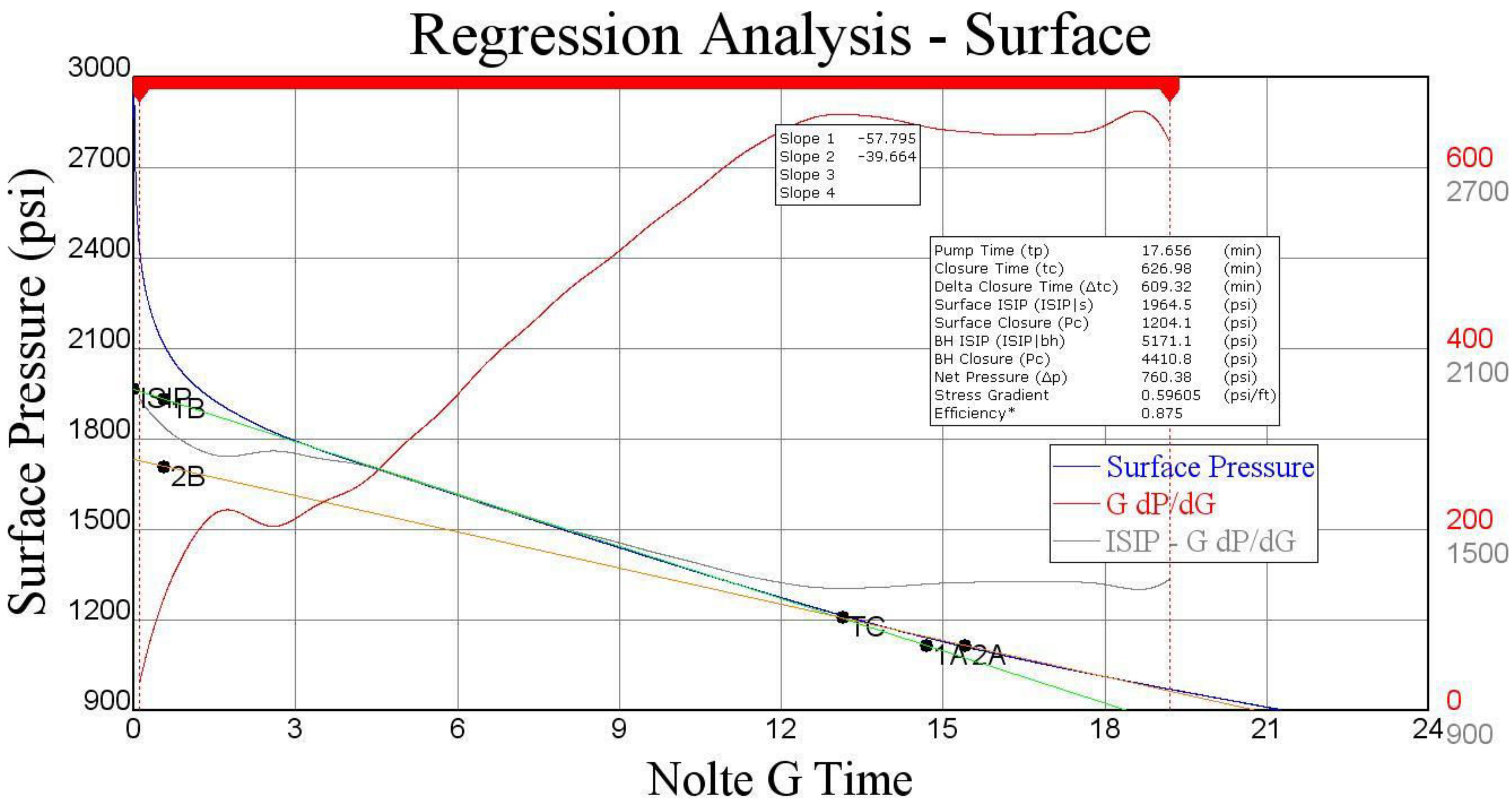
MiniFrac – Step Down



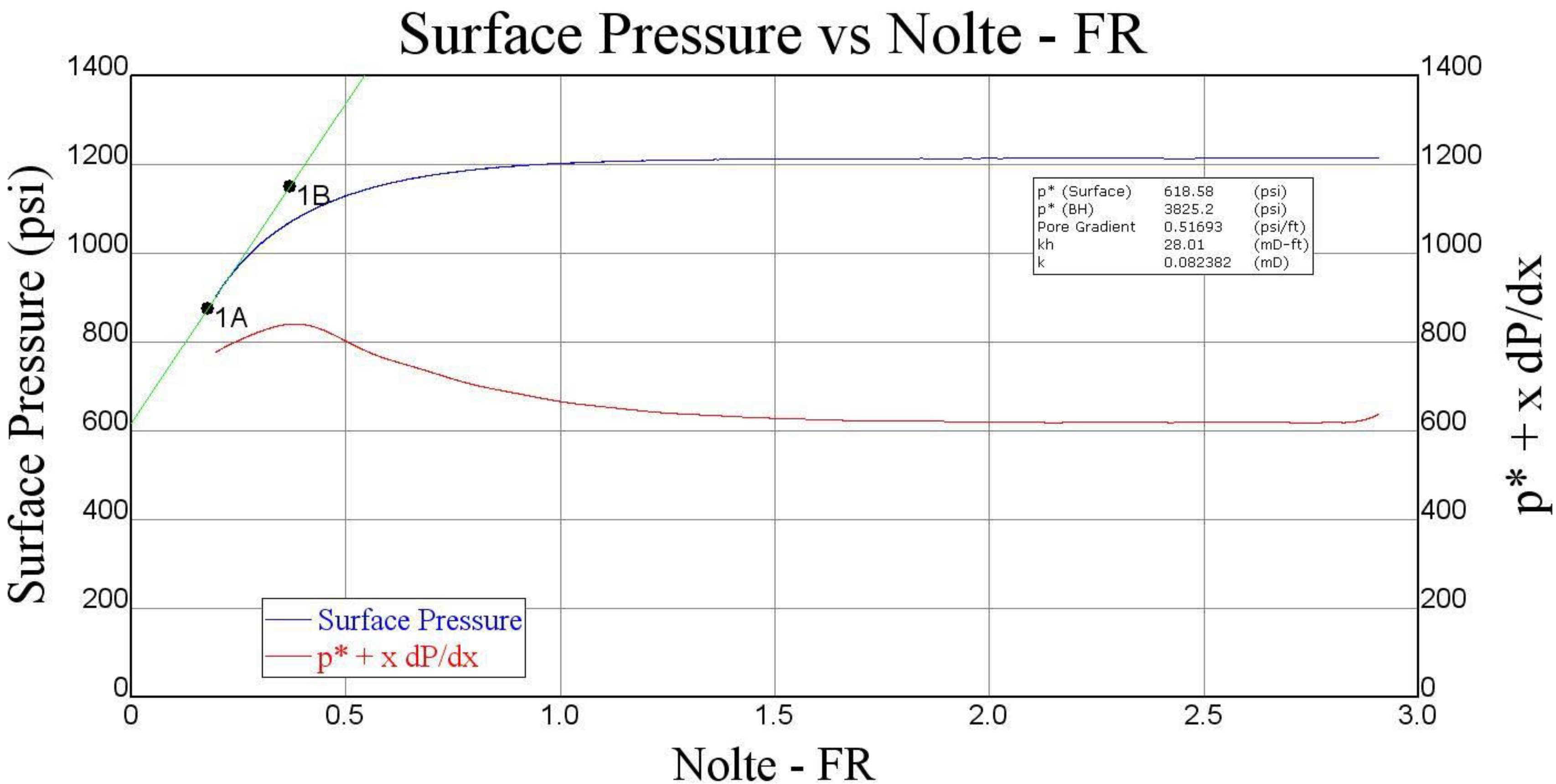
MiniFrac – Horner



Regression Results (Linear Plot)



After Closure Results (Linear)



MiniFrac Analysis

- Step Rate
  - Theoretical Closure Constraints
- Step Down
  - Near Wellbore Losses
    - Alpha 0.5 indicates near wellbore losses (tortuosity) dominant
  - Apparent Perfs Open
- Horner
  - Theoretical Closure Constraints

MiniFrac Analysis

- Regression
  - ISIP
    - Frac Gradient
  - Closure Pressure
    - Proppant Selection
  - Δpnet
    - Limited Entry Success?
  - Time to closure
    - Efficiency
      - Pad Sizing
      - Fluid Selection
- After Closure Analysis
  - Pore Pressure
  - Permeability

Geo-mechanical Model Confirmation

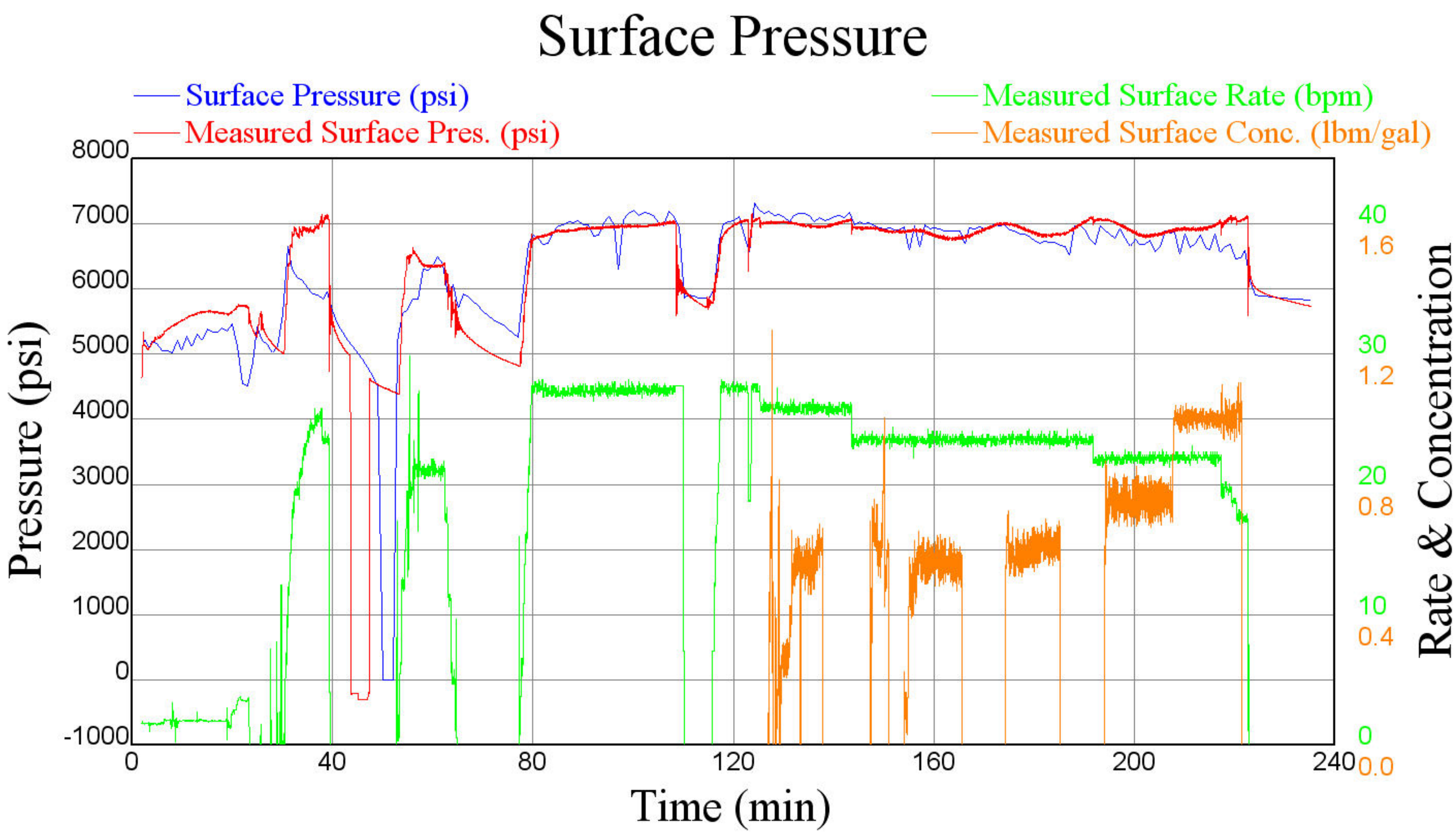
- Gradients "FIXED" based on MiniFrac Results
- Other rock gradients based on frac simulation runs
  - Pressure Matching

	TVD at btm	MD at btm	Stress Gradient	Stress	Young's Mod	Poisson's Ratio	Fracture Toughness
	ft	ft	psi/ft	psi	psi		psi
Claystone	9711.78	9735.89	1.1	10683	6.00E+06	0.25	2000
Limestone	9718.23	9742.45	1.13	10981.6	4.50E+06	0.15	750
Claystone	9732.73	9757.22	1.1	10706	6.00E+06	0.25	2000
Sandstone	9777.87	9803.15	1.0354	10124	5.00E+06	0.15	1000
Claystone	9829.47	9855.64	1.1	10812.4	6.00E+06	0.25	2000
Sandstone	9845.59	9872.05	1.0354	10194.1	5.00E+06	0.15	1000
Claystone	9860.11	9886.81	1.1	10846.1	6.00E+06	0.25	2000
Sandstone	9871.4	9898.29	1.0354	10220.8	5.00E+06	0.15	1000
Claystone	9958.51	9986.88	1.1	10954.4	6.00E+06	0.25	2000
Sandstone	9964.97	9993.44	1.0354	10317.7	5.00E+06	0.15	1000
Claystone	9974.65	10003.3	1.1	10972.1	6.00E+06	0.25	2000
Sandstone	9981.1	10009.8	1.0354	10334.4	5.00E+06	0.15	1000
Claystone	10026.3	10055.8	1.1	11028.9	6.00E+06	0.25	2000

Fracture Replay Simulation

- MiniFrac analyzed separately
  - No need to spend additional resources on simulation runs
  - Confirm the geomechanical model
- Focus on Actual Treatment Job
  - Pressure Match the replay file
  - Not perfect but close enough to get overall view of downhole situation after treatment
  - When the pressure matches, the parameters are dialed in for geometry

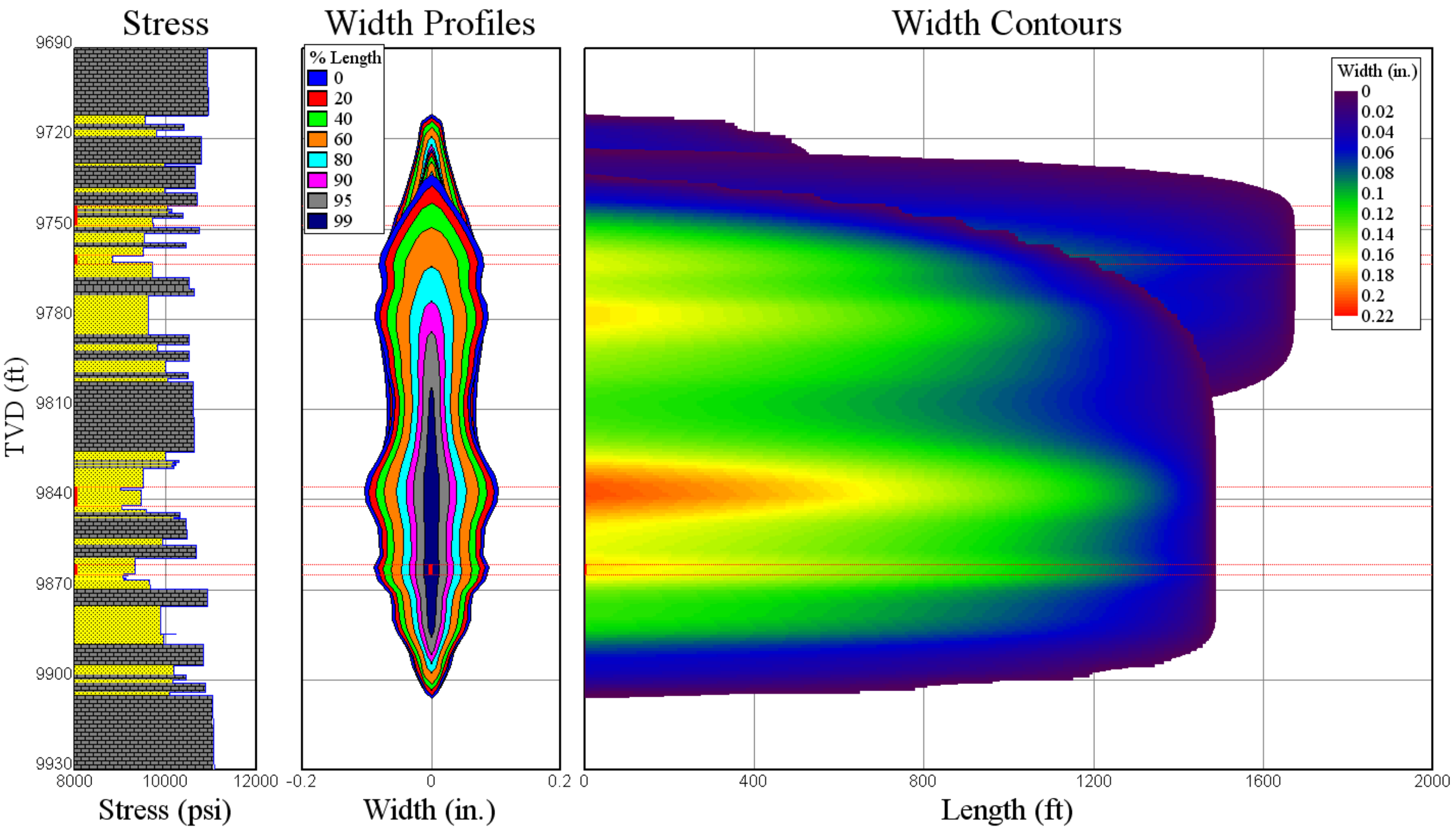
Pressure Match



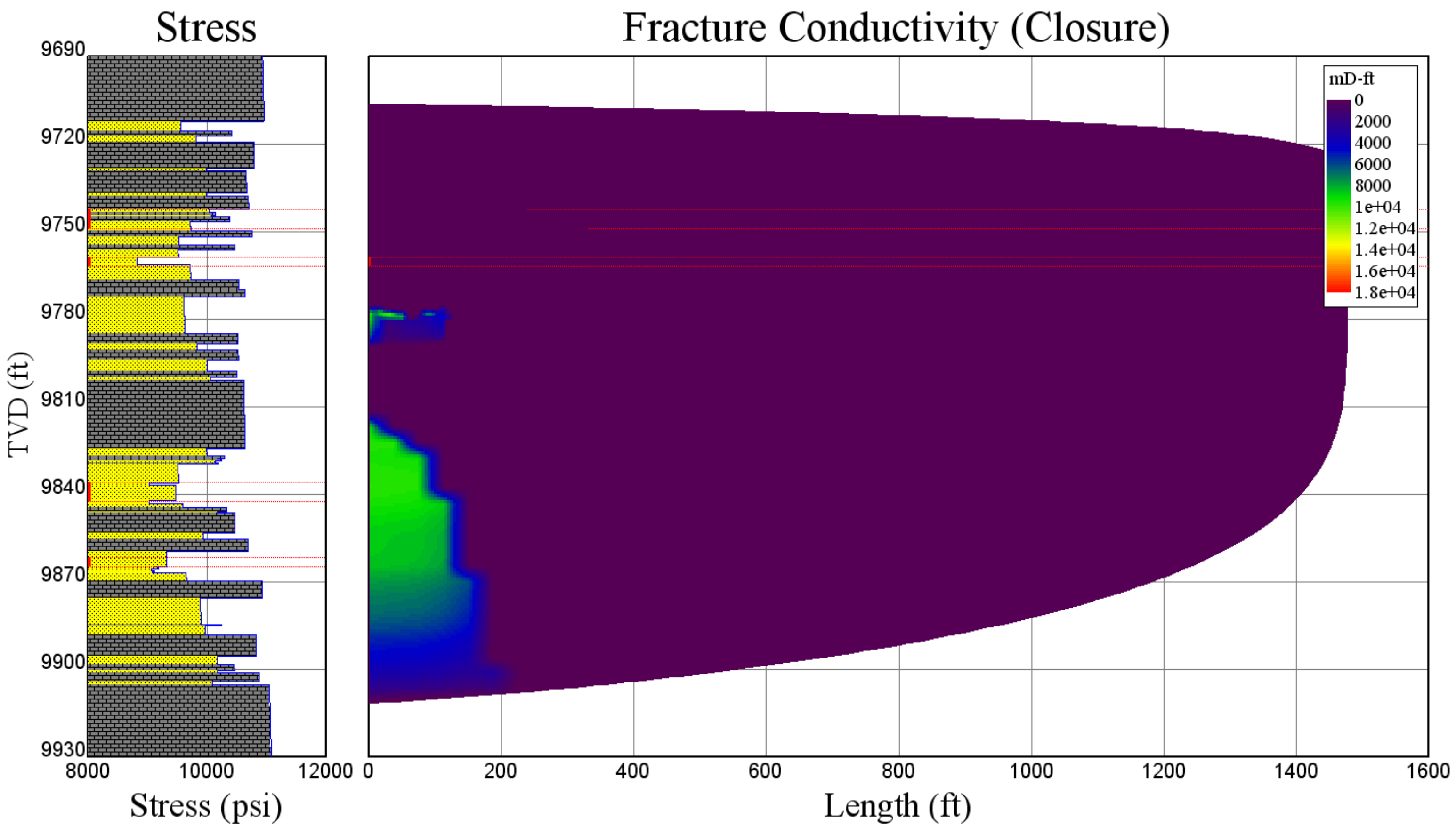
Frac Replay Results

- Frac Replay Analysis
  - Simplistic Geomechanical model can be proven to be sufficient through minifrac analysis and simulation runs of actual job
  - Actual resultant frac from Stimulation Treatment
    - Total 3-dimensional spacing during and after job
      - Height, Length, and Width
    - Proppant Placement during and after job (Conductivity)
    - Zonal Identification
      - Which zones were actually receptive to frac?

Fracture Geometry



Fracture Conductivity



WHY? - Frac Replay Analysis

- Gives ability to identify:
  - Frac Geometry
  - Conductivity
  - Zonal Entry
  - Reservoir Properties
- Provides confirmation of pumping service company results
- Allows for OPTIMAL SUCCESS by “tuning” each frac job in the field in a progressive manner.
- Better understanding of the reservoir/geomechanical properties of the field.

Why Analyze after a treatment?

- Maximize the R.O.I. of the entire field plan
- Optimize fracture designs for the future
  - Improved Geomechanical Models allow for frac design by computer modeling in the office rather than trial by error in the field
- Size the Fracture Treatments to the Reservoir
  - Optimum Rates, Proppant Types/Volumes, Fluid Types/Properties
  - Minimize Number of Effective Fracturing Stages per Well

Why repeat the same mistakes?????

Why spend money that you don’t have to?????