HYDRAULIC FRACTURING EFFECTIVENESS ASSESMENT IN TIGHT RESERVOIRS AND MAIN CONSIDERATIONS FOR TREATMENT DESIGN AND PLANNING

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AGENDA

1- SUMMARY.
2- INTRODUCTION.
3- LOCATION, FORMATION.
4- DIAGNOSTIC PUMPINGS.
5- PETROPHYSICS AND GEOMECHANICS.
6- HYDRAULIC FRACTURING.
7- DESIGN.
8- FRACTURE HEIGHT ASSESSMENT AND HF SIMULATOR MATCHING.
9- FRACTURE SIMULATION RESULTS.
10- CONCLUSIONS.

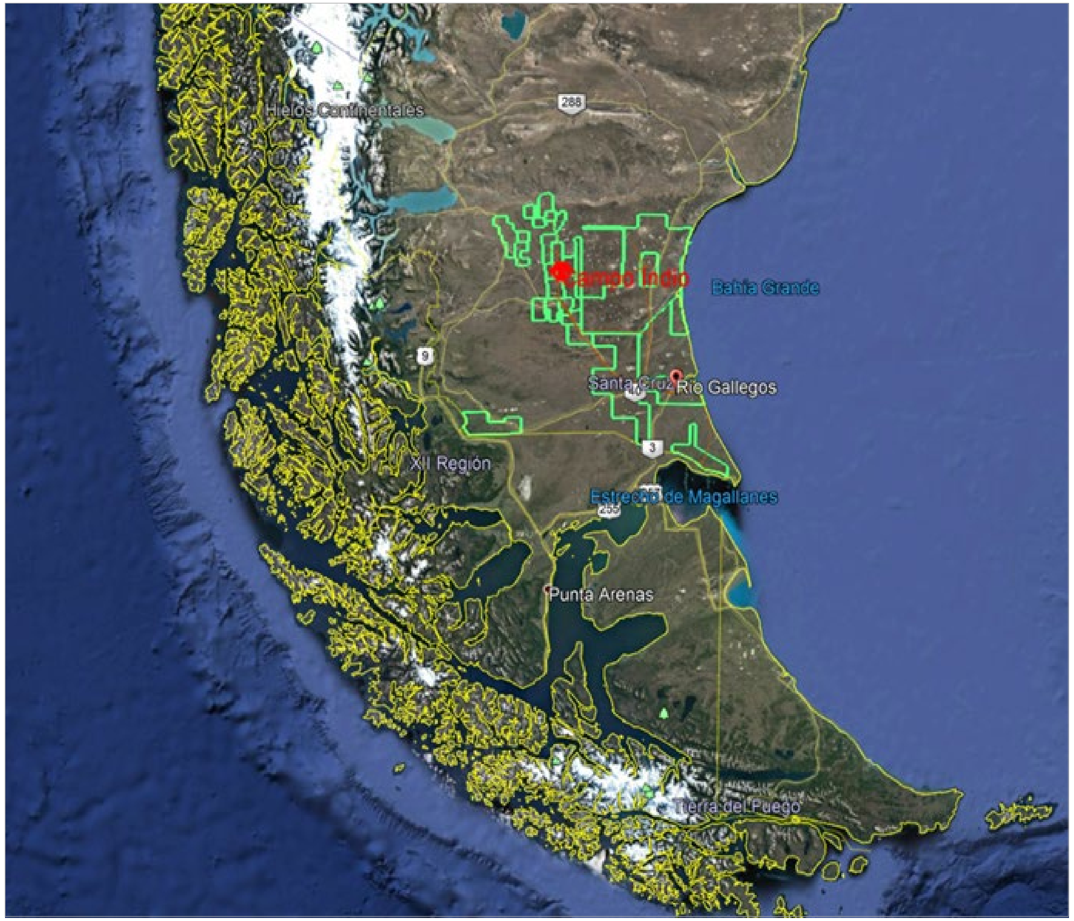
1-Summary

- Incentives for hydrocarbon production.
- Analysis of the effectiveness of stimulation treatments.
- New hydraulic fracture design.
- Relevant information – Well logs and post-operation analysis.
- Case study in Magallanes formation of the Austral Basin.
- Conclusions about the propagation of hydraulic fractures.

2-Introduction

- Evolution of hydraulic fracturing treatments.
- Vertical and horizontal wells.
- Vertical wells – Design based in statistics or the best design to produce.
- Horizontal wells – Lateral section has increased in length.
- Horizontal wells – Increasing number of stages.
- Analysis of the effectiveness of stimulation treatments.
- Factors that affect final geometry.
- New hydraulic fracture design.

3-Location-Formation

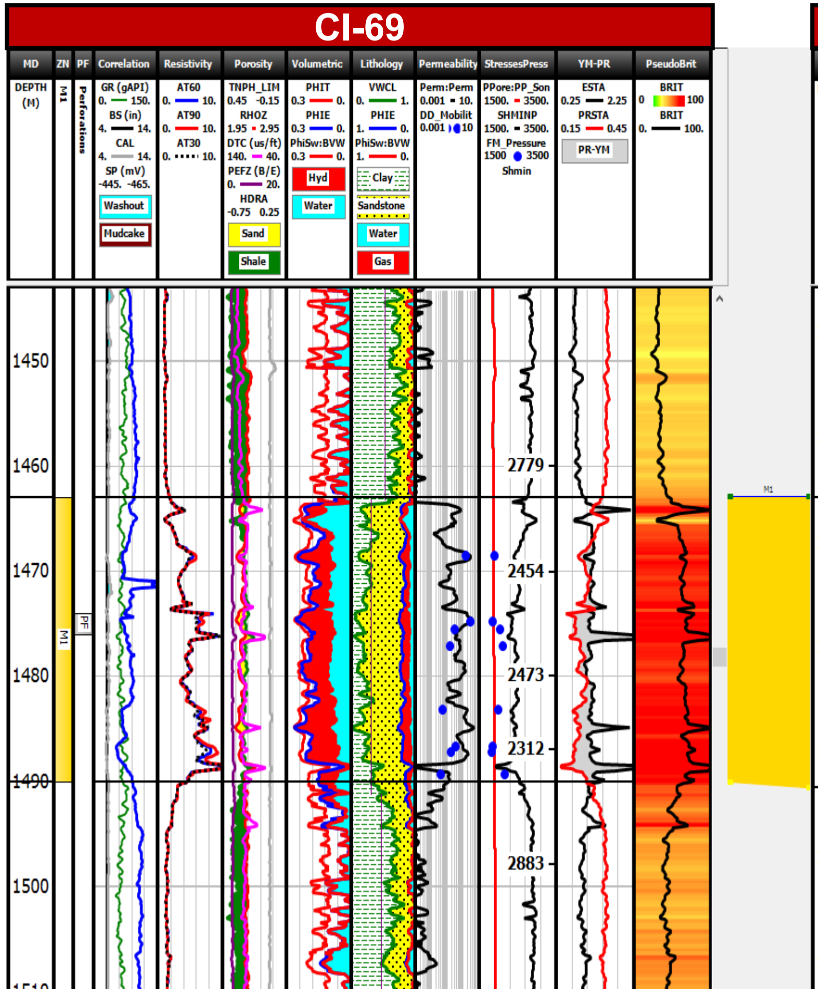


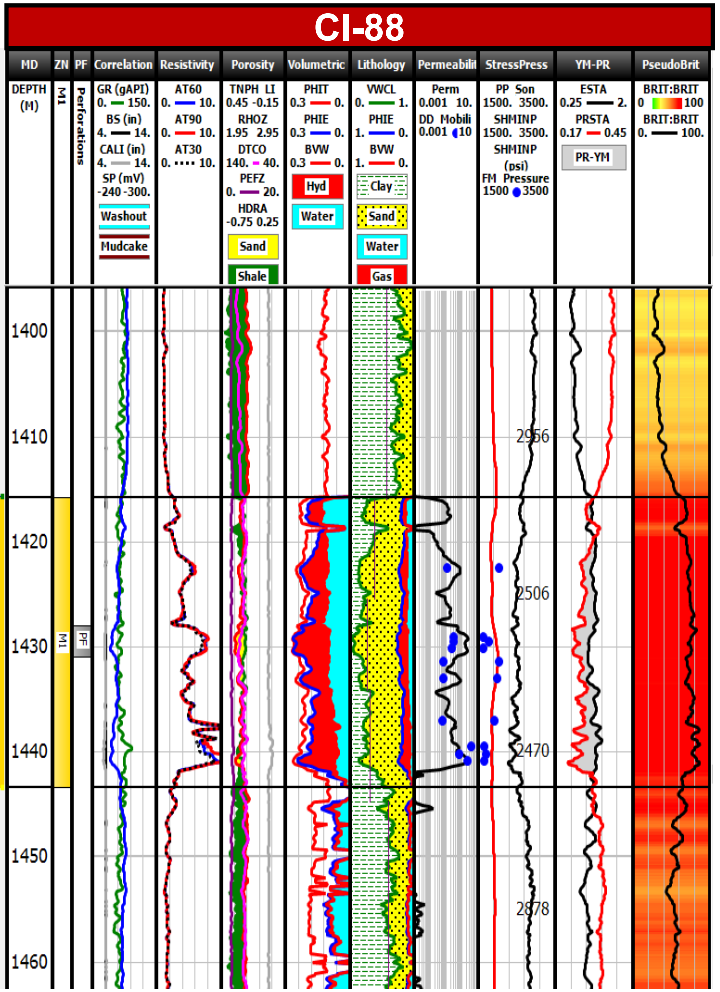
CHARACTERISTICS	MAGALLANES M1 Formation
Location	Campo Indio Field. 140 km northwest of Río Gallegos city.
Reservoir	Magallanes is gas producer with associated condensate.
Rock	Sandstone
Depth (m)	1380-1500
Temperature (°F)	150-165
Permeability (mD)	0.1-1 (Tight facies)
Fracture Gradient (psi/ft)	0.55-0.63
Closure Gradient (psi/ft)	0.50-0.55

4-Diagnostic Pumpings

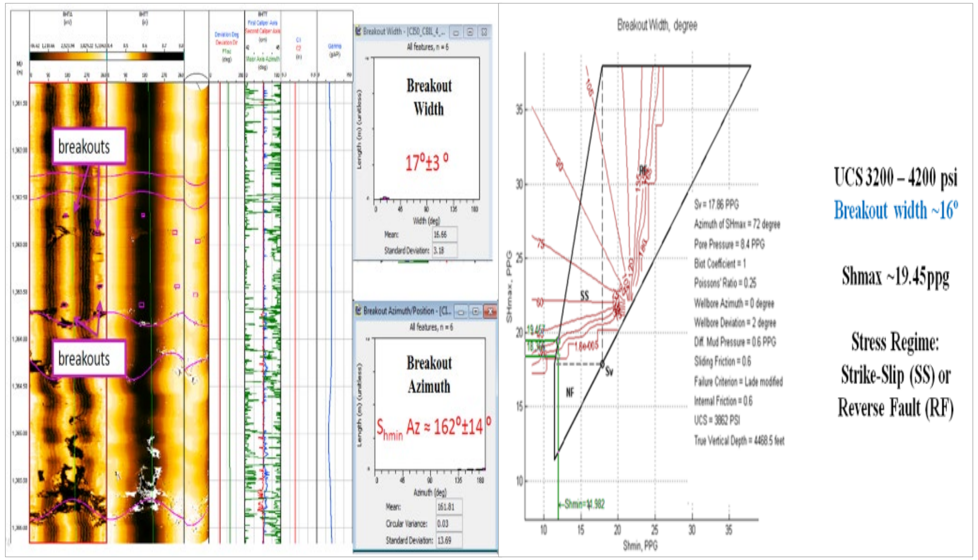
- DFIT-Water and Linear gel at low rates (Range 6-10 bbl/min).
- MINIFRAC-Linear gel at rates of the final treatment (Range 14-24 bbl/min).
- DFIT Objectives – Closure pressure, fluid efficiency, permeability (simulator matching).
- Minifrac Objectives – Perforations frictions and tortuosity (Step Down Rate Test). An estimation of fluid efficiency.

5-Petrophysics and Geomechanics





Formation Properties		
Parameters	**CI-69(d)**	**CI-88**
Closure pressure (psi)	2420	2575
Closure pressure gradient (psi/ft)	0.512	0.55
Pore pressure (psi)	1930	1650
Pore pressure gradient (psi/ft)	0.41	0.35
Porosity (%)	5 – 15	5 – 15
Temperature (°F)	160	157



6-Hydraulic Fracturing

- Sandstone of low permeability (average range: 0.1 - 1 mD)
- Low contrast downwards of the stimulation average depth.
- Assessment in two wells.

Proppant and Fluid Volume: Well CI-69(d)					
Proppant	**Sacks**	**%**	**System**	**gal**	**m^3**
Mesh 100	75	2	Linear gel	8,176.00	31
Proppant 20/40	2112	64	Gel XL	82,700.00	313
Ceramic 20/40	1110	34			
Total	3297	100	Total	90,876.00	344

Proppant and Fluids Volume - Well CI-88					
Proppant	**Sacks**	**%**	**System**	**gal**	**m^3**
Ceramic 20/40	2,125	69	Linear gel	7,701	29
NRT 20/40	955	31	Gel XL	74,700	283
Total	3,080	100	Total	82,401	312

6-Hydraulic Fracturing

Hydraulic Simulation Treatment - Well CI-69(d)										
Stage	Fluid System	Rate	Volume	Concentration		Proppant			Cumulative	
		bpm	gal	ppg	ppg	Type		Sacks	Sacks	gal
Treatment										
PrePad	**Linear gel**	**4**	**2000**							**5000**
PrePad	**Linear gel**	**8**	**2000**							**7000**
Pad	**XL gel**	**12**	**2000**					**0**	**0**	**9000**
Pad	**XL gel**	**18**	**15000**	**0.5**	**0.5**	**Mesh 100**		**75**	**75**	**24000**
Pad	**XL gel**	**18**	**4000**					**0**	**75**	**28000**
Proppant	**XL gel**	**18**	**3000**	**1**	**1**	**Sand 20/40**		**30**	**105**	**31000**
Proppant	**XL gel**	**18**	**3000**	**2**	**2**	**Sand 20/40**		**60**	**165**	**34000**
Proppant	**XL gel**	**18**	**4000**	**3**	**3**	**Sand 20/40**		**120**	**285**	**38000**
Proppant	**XL gel**	**18**	**10000**	**4**	**4**	**Sand 20/40**		**400**	**685**	**48000**
Proppant	**XL gel**	**18**	**10000**	**5**	**5**	**Sand 20/40**		**500**	**1185**	**58000**
Proppant	**XL gel**	**18**	**10700**	**6**	**6**	**Sand 20/40**		**642**	**1827**	**68700**
Proppant	**XL gel**	**18**	**6000**	**6**	**6**	**Sand 20/40**	**C.E.***	**360**	**2187**	**74700**
Proppant	**XL gel**	**18**	**9000**	**6**	**8**	**NRT 20/40**	**C.E.***	**630**	**2817**	**83700**
Proppant	**XL gel**	**18**	**6000**	**8**	**8**	**NRT 20/40**	**C.E.***	**480**	**3297**	**89700**
Displacement	**Linear gel**	**18**	**1176**							**90876**

*C.E. - Conductivity enhancer

6-Hydraulic Fracturing

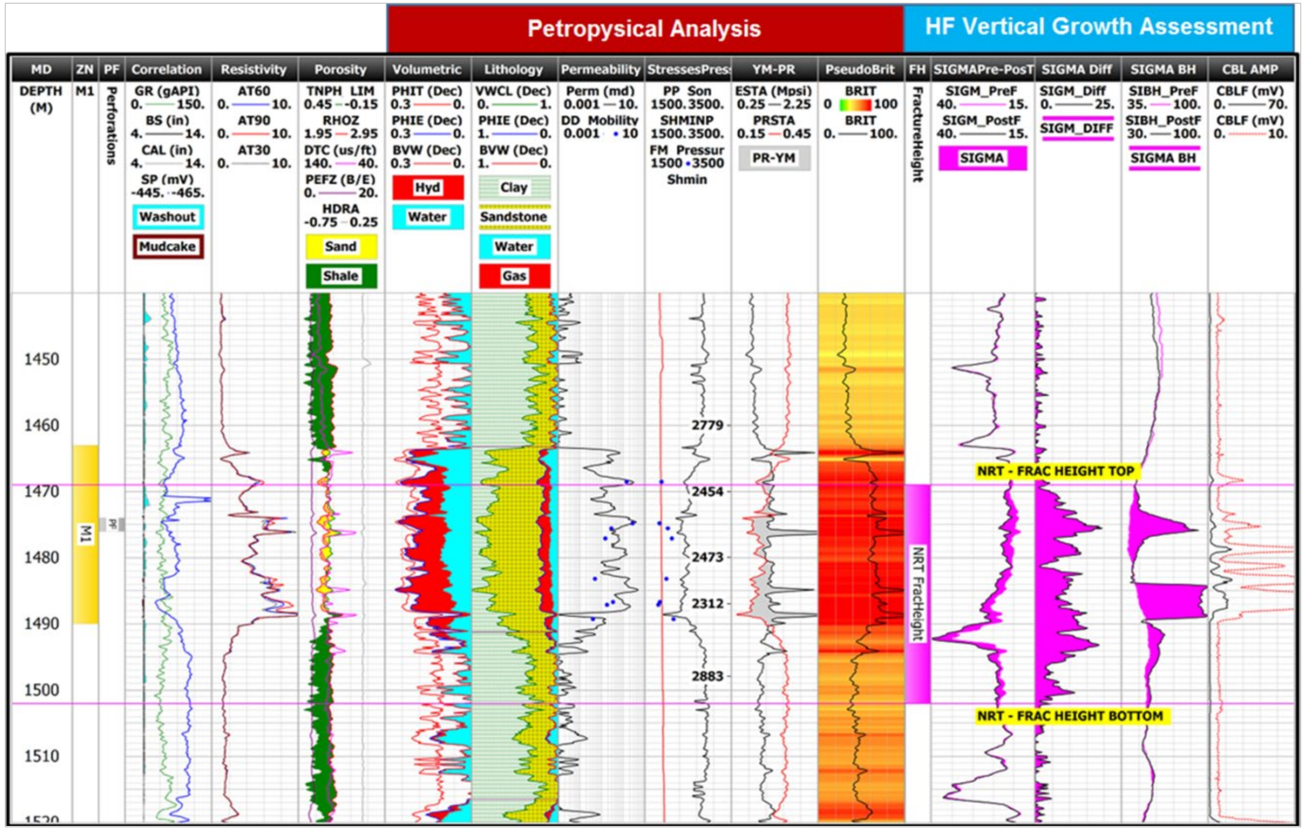
Hydraulic Stimulation Treatment - Well CI-88										
Stage	Fluid System	Rate	Volume	Concentration		Proppant			Cumulative	
		bpm	gal	ppg	ppg	Type		Sacks	Sacks	gal
Previous Tests										**5240**
					Treatment					
PrePad	**Linear gel**	**4**	**1500**							**6740**
PrePad	**Linear gel**	**8**	**1500**							**8240**
Pad	**XL gel**	**12**	**2000**							**10240**
Pad	**XL gel**	**18**	**13000**							**23240**
Proppant	**XL gel**	**18**	**1500**	**1**	**1**	**Ceramic 20/40**		**15**	**15**	**24740**
Proppant	**XL gel**	**18**	**3000**	**2**	**2**	**Ceramic 20/40**		**60**	**75**	**27740**
Proppant	**XL gel**	**18**	**4000**	**3**	**3**	**Ceramic 20/40**		**120**	**195**	**31740**
Proppant	**XL gel**	**18**	**6000**	**4**	**4**	**Ceramic 20/40**		**240**	**435**	**37740**
Proppant	**XL gel**	**18**	**11000**	**4**	**6**	**Ceramic 20/40**		**550**	**985**	**48740**
Proppant	**XL gel**	**18**	**19000**	**6**	**6**	**Ceramic 20/40**		**1140**	**2125**	**67740**
Proppant	**XL gel**	**18**	**9700**	**6**	**6**	**Ceramic 20/40**	C.E.*	**582**	**2707**	**77440**
Proppant	**XL gel**	**18**	**4000**	**6**	**7**	**NRT 20/40**	C.E.*	**260**	**2967**	**81440**
Proppant	**XL gel**	**18**	**1500**	**7**	**8**	**NRT 20/40**	C.E.*	**113**	**3080**	**82940**
Displacement	**Linear gel**	**18**	**1141**							**84081**

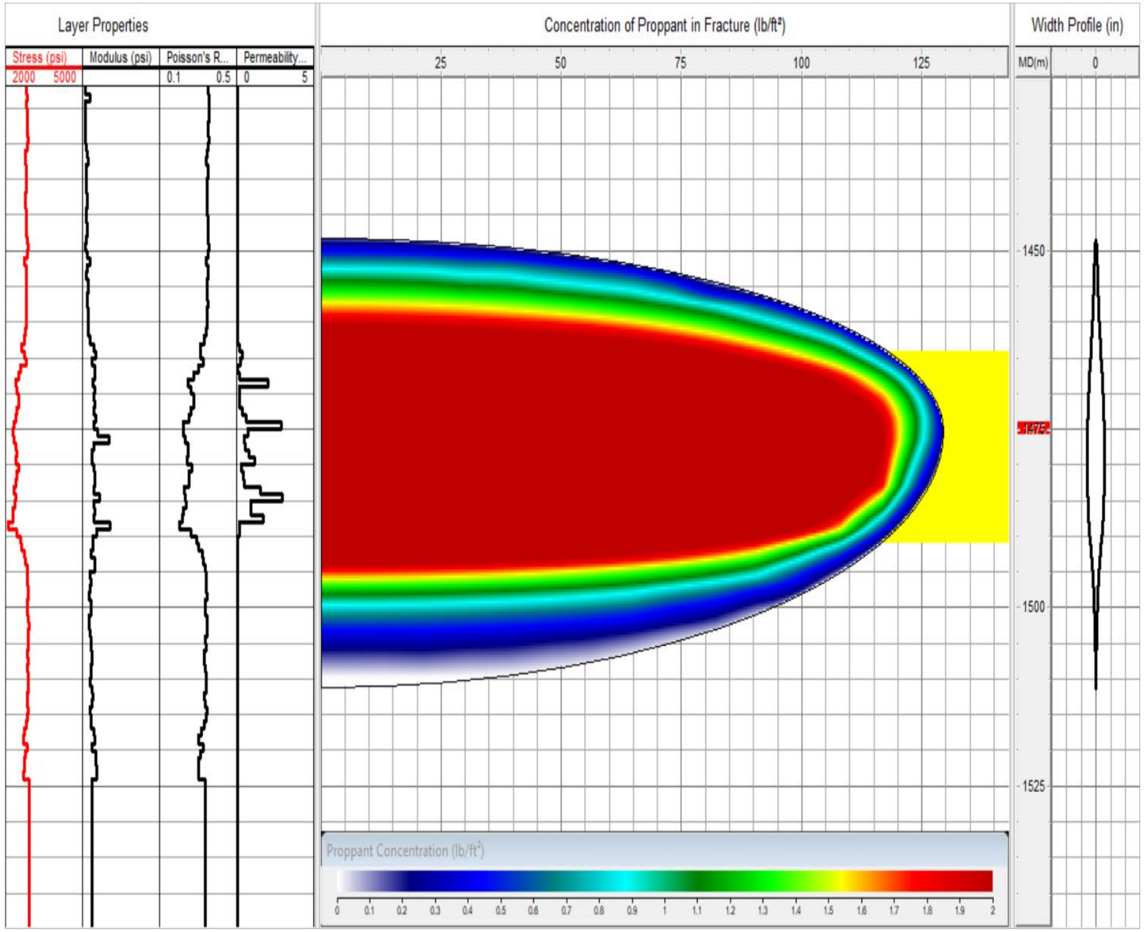
*C.E. - Conductivity enhancer

7-Design

Reservoir and Fracture Parameters - Design					
Reservoir	**Well CI-69(d)**	**Well CI-88**	**Fracture**	**Well CI-69(d)**	**Well CI-88**
Reservoir pressure	1930 psi	1,650 psi	Fracture length	134.50 m	122.60 m
Reservoir pressure gradient	0.41 psi/ft	0.35 psi/ft	Proppant length	102.90 m	108.50 m
Total compressibility	1.39E-4 1/psi	2.60E-4 1/psi	Total fracture height	65.32 m	57.21 m
Permeability	0.01 – 0.10 mD	0.01 – 0.10 mD	Total proppant height	49.89 m	50.63 m
Closure stress pressure	2420 psi	2575 psi	Average fracture width	0.292 in	0.305 in
Closure stress gradient	0.512 psi/ft	0.55 psi/ft	Proppant concentration	2.346 lb/ft^2	2.623 lb/ft^2

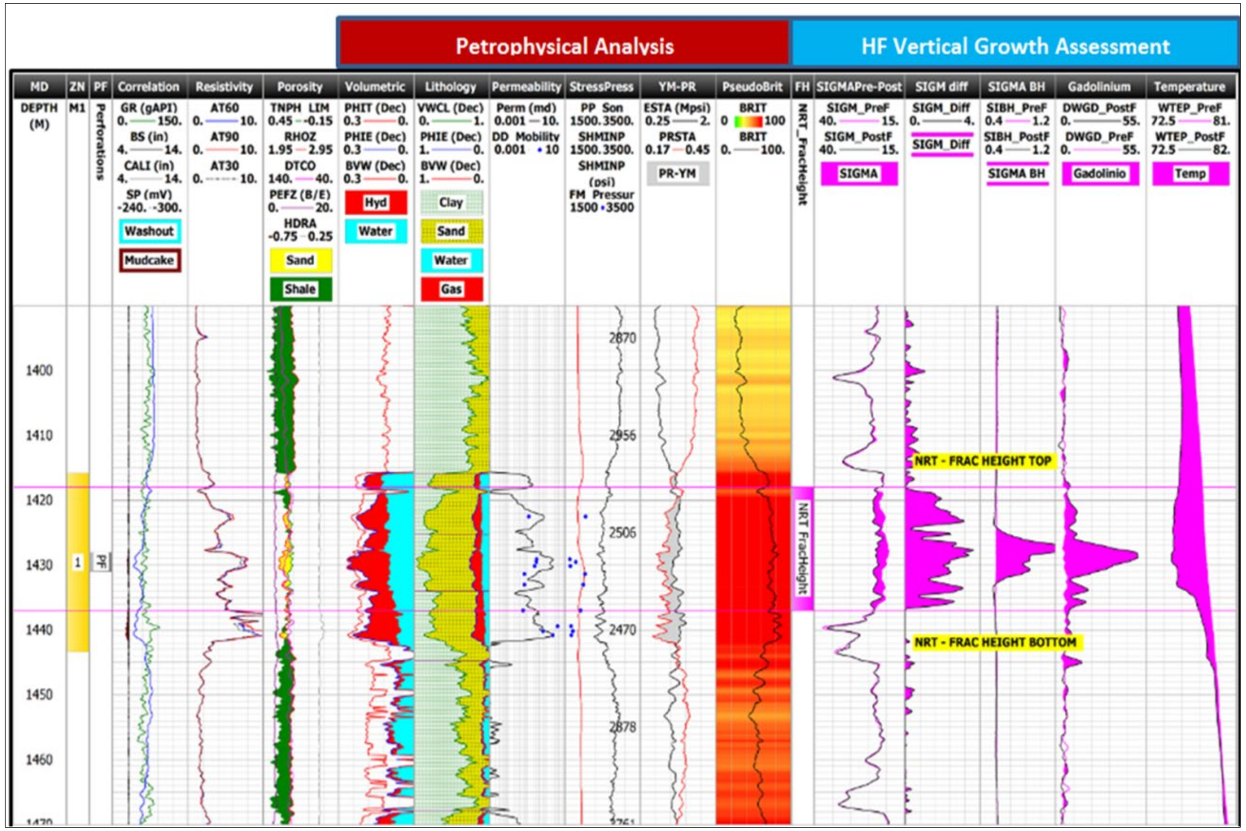
8-Fracture Height Assessment and HF Simulator Matching – Well CI-69(d)



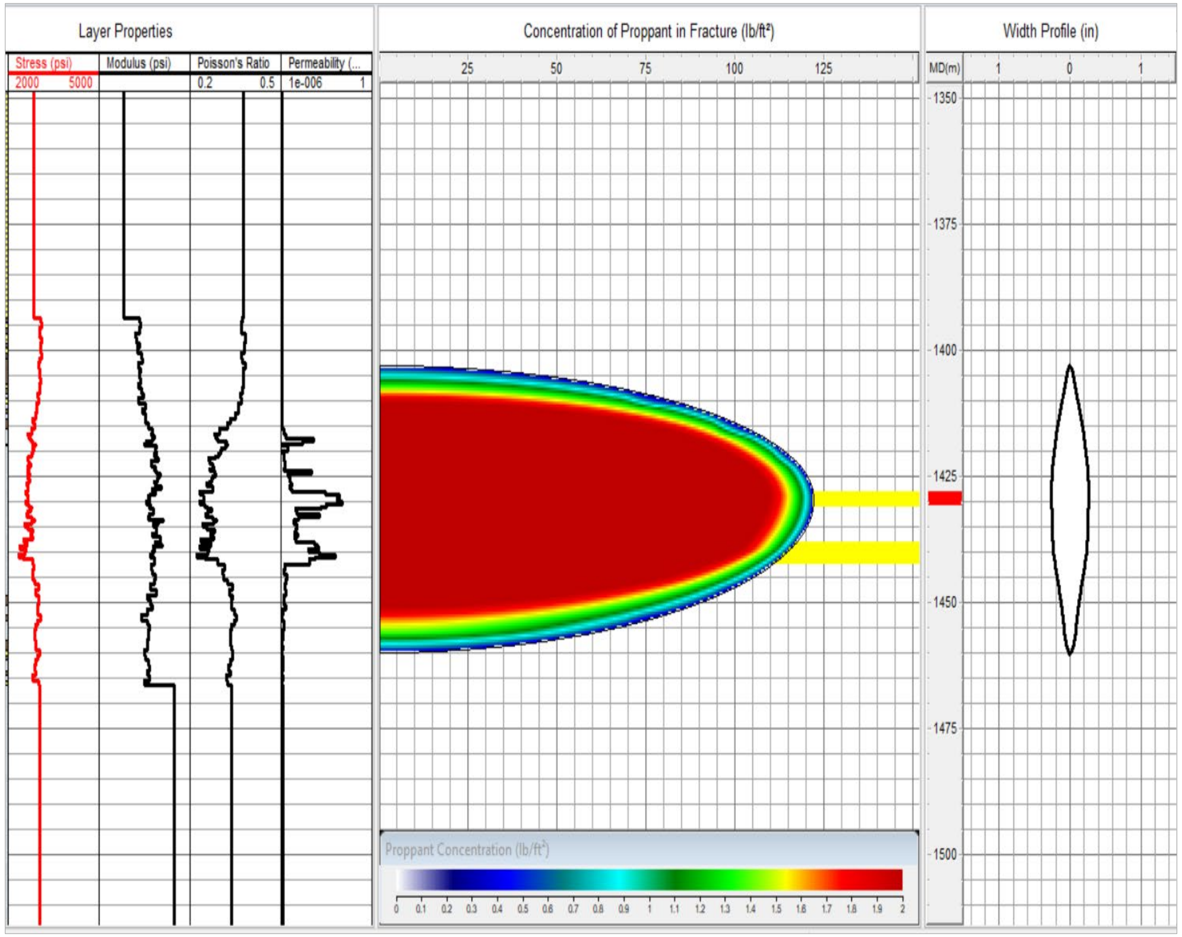


HF Stimulation Treatment Matching - Well CI-69(d)							
M1 Gross Interval (mMD)		Perforated Interval (mMD)		Interval w/NRT (mMD)		HF Simulator Matching (mMD)	
1463.5	1492.5	1474.0	1476.0	1470.0	1502.0	1469.0	1504.0

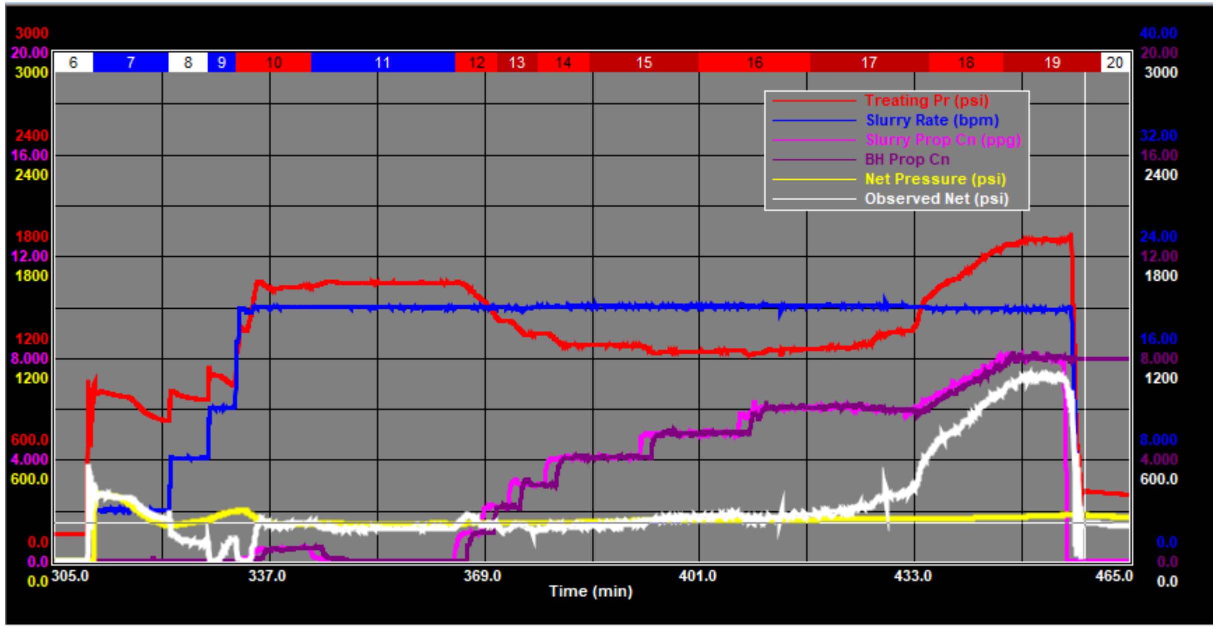
8-Fracture Height Assessment and HF Simulator Matching – Well CI-88

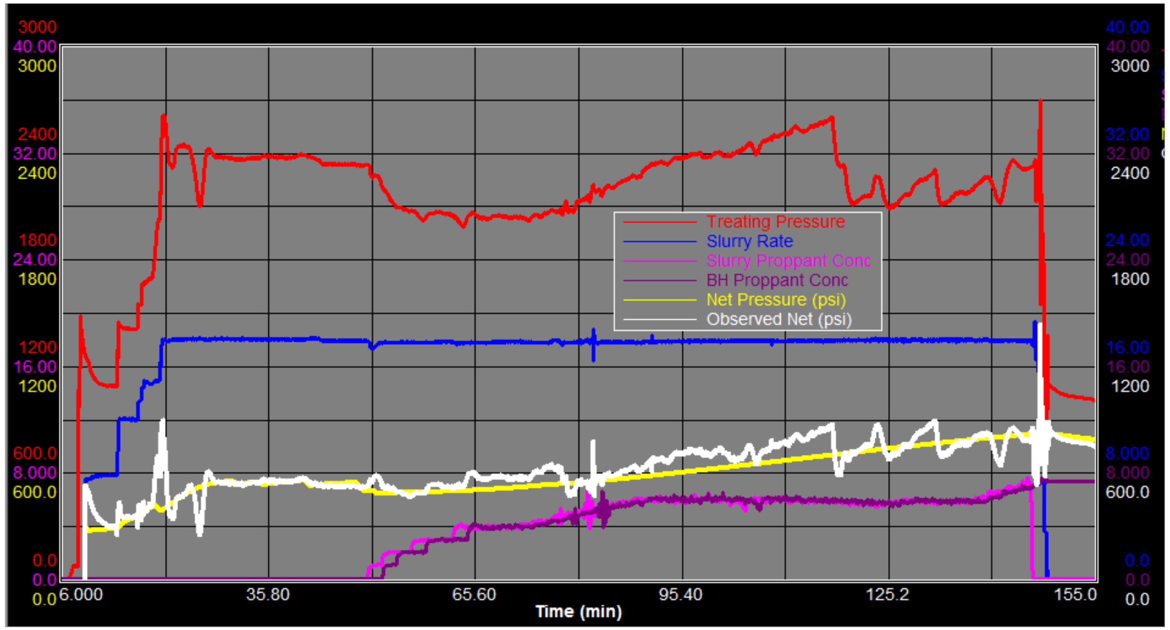


HF Stimulation Treatment Matching Well CI-88							
M1 Gross Interval (mMD)		Perforated Interval (mMD)		Interval w/NRT (mMD)		HF Simulator Matching (mMD)	
1416.0	1445.0	1428.0	1431.0	1418.7	1436.7	1406.0	1456.0



9-Fracture Simulation Results





Pre- and Post-HF Treatment Parameters Comparison - Wells CI-69(d) and CI-88								
Well	Rate (bpm)	Proppant (sacks)	ISIP Prefrac (psi)	Initial Fracture Gradient (psi/ft)	ISIP Post-frac (psi)	Final Fracture Gradient (psi/ft)	ISIP Variation (psi)	ISIP Variation (%)
CI-69(d)	20	3,303	660	0.58	415	0.52	-245	-37%
CI-88	18	3,044	590	0.56	1,095	0.67	505	86%

10-Conclusions

- The difference in the ISIPs explains the observed results in terms of the extension of the vertical growth.
- The use of a low density ceramic proppant contributed to the expected production.
- The cement quality condition is believed to be the cause of the difference observed between the vertical growths of both HF stimulations.
- The results indicate that the rock properties, low density ceramic proppant, and the cement conditions affect the final geometry registered in the appropriate profiles.

Questions?