IGU Committee Meeting

Rio de Janeiro – 2013

HALLIBURTON

Applied Technologies for Tight and Shale Projects Exploration and Development

García Mariano Nicolás

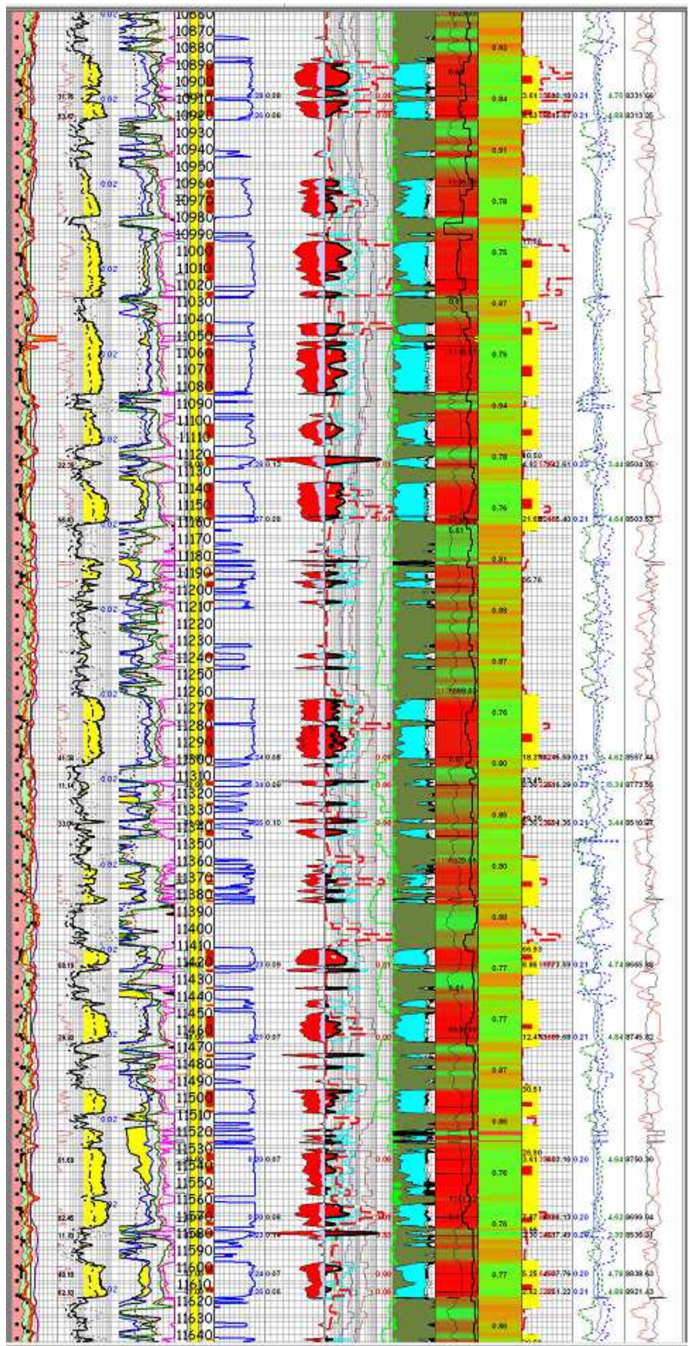
Agenda

What technologies and techniques are being applied for Tight Gas and Shale Gas Exploration and Development?

- Pin Point completions
- Microseismic
- Clay Sensitivity
- Water Management
- Stimulation Equipment Improvements

Applied PinPoint Technologies

Stage	ZnTop	ZnBtm	ZnThk	NPAY	Phie	PhiH
	ft	ft		ft		
26	10790.0	10824.5	27.2	27.9	0.1	3.1
25	10843.5	10856.3	9.5	10.2	0.1	1.1
24	10890.1	10923.2	30.5	30.2	0.1	4.0
23	10958.7	10981.0	22.31	22.64	0.13	3.02
22	10995.4	11028.5	29.86	30.19	0.16	4.47
21	11043.6	11085.6	38.39	37.73	0.14	5.50
20	11101.4	11115.8	14.44	14.76	0.13	1.86
19	11137.8	11156.5	18.70	19.03	0.17	3.27
18	11265.8	11300.5	31.83	32.49	0.14	4.39
17	11368.8	11380.2	11.48	9.84	0.15	1.44
16	11416.7	11422.6	5.91	6.23	0.16	1.02
15	11443.6	11467.8	21.00	21.66	0.12	3.01
14	11496.4	11509.8	13.45	13.78	0.14	1.94
13	11523.3	11576.8	42.64	42.00	0.13	5.43
12	11598.4	11619.4	21.00	20.34	0.14	2.88
11	11645.3	11653.5	8.2	8.5	0.118	1.00
10	11698.8	11721.5	20.3	21.0	0.128	2.54
9	11736.9	11775.3	36.1	35.4	0.092	3.53
8	11957.7	12013.5	43.6	43.6	0.139	6.17
7	12042.3	12060.7	14.1	13.8	0.135	1.78
6	12091.5	12112.5	21.0	20.3	0.098	1.99
5	12209.7	12238.5	24.0	24.6	0.086	2.10
4	12274.3	12293.0	16.4	17.1	0.091	1.54
3	12316.6	12331.0	14.4	14.1	0.080	1.12
2	12415.4	12523.0	66.9	77.4	0.068	4.51
2 Bis	12415.4	12523.0	66.9	77.4	0.068	4.51
1	12599.7	12698.5	95.2	91.2	0.072	6.54
1 Bis	12599.7	12698.5	95.2	91.2	0.072	6.54



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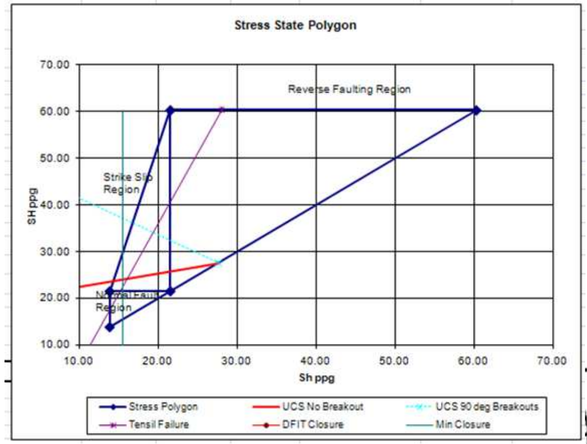
Nowadays Stress State

Main Conclusions

- Constant Stress orientation
- Strike Slipe Regime: Sh<Sv<SH
- Big difference in between the three principal stresses.



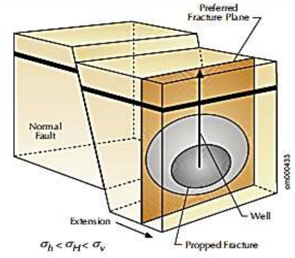


Figure 3.3—Formation stresses and preferred fracture plane in the vicinity of a normal fault.

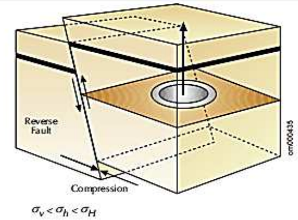


Figure 3.5—Formation stresses and preferred fracture plane in the vicinity of a reverse fault.

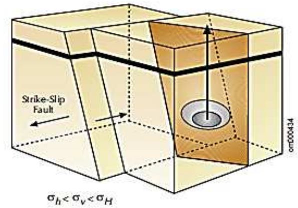


Figure 3.4—Formation stresses and preferred fracture plane in the vicinity of a strike-slip fault.

The principal stresses will determine the general direction of an induced hydraulic fracture. Away from the wellbore, a hydraulically induced fracture will propagate perpendicular to the minimum principal formation stress in a plane defined by the maximum and intermediate principal stress directions. For example, if the minimum principal formation stress direction is horizontal, the preferred fracture plane is vertical (Figures 3.3 and 3.4). If the overburden is the least principal formation stress, horizontal fractures can be expected (Figure 3.5).

The original relationship between the formation stresses can be altered by fluid injection and withdrawal. An example of this is the diatomite formation in California's South Belridge field, which is being actively water-flooded with a line-drive injector arrangement. The formation is extremely tight, and water injection has significantly increased the pore pressure in the immediate vicinity of hydraulically fractured injectors. This pore-pressure increase, which is limited to the injector rows,

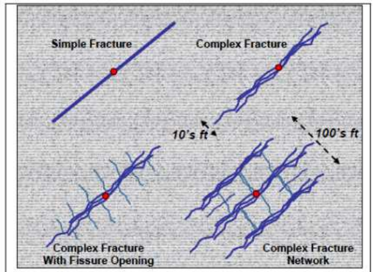
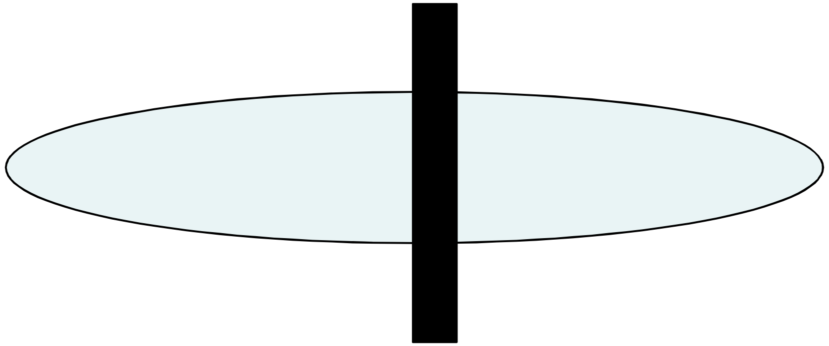
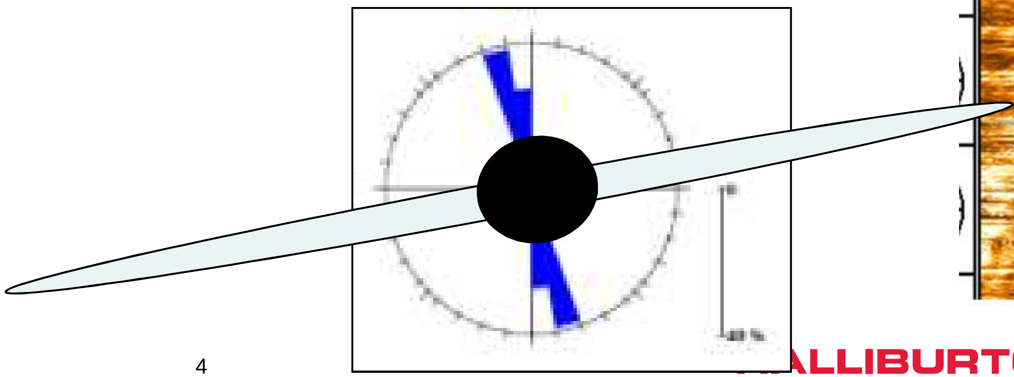
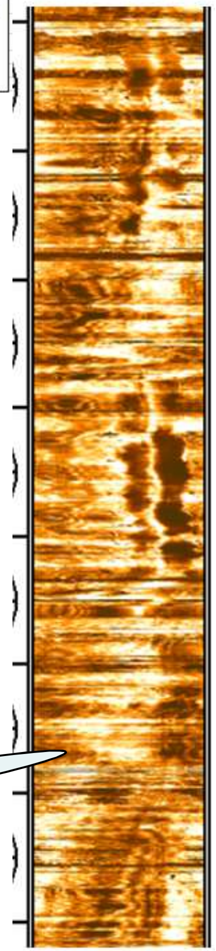


Figure 1 – Fracture growth and complexity

Most Probable Situation
Simple Planar Fractures







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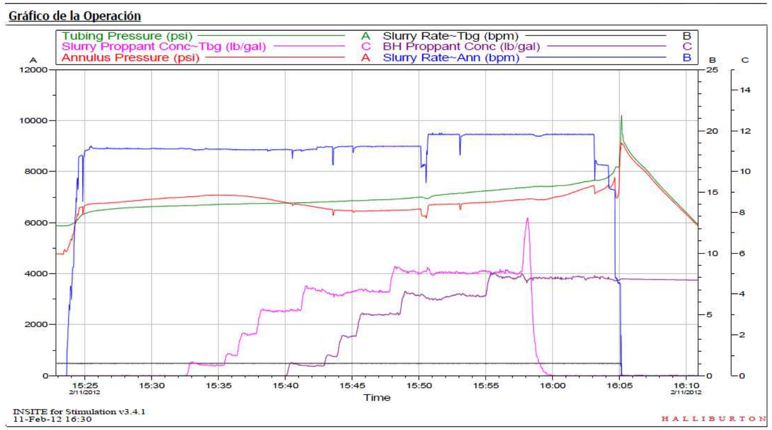
Stimulation Techniques

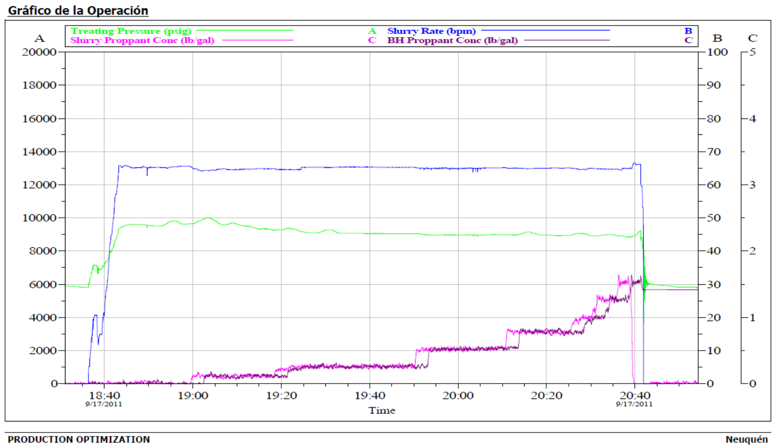
Pin Point Completions

Perf & Plug

XL Fluid – Low Rate



SlickWater – High Rate

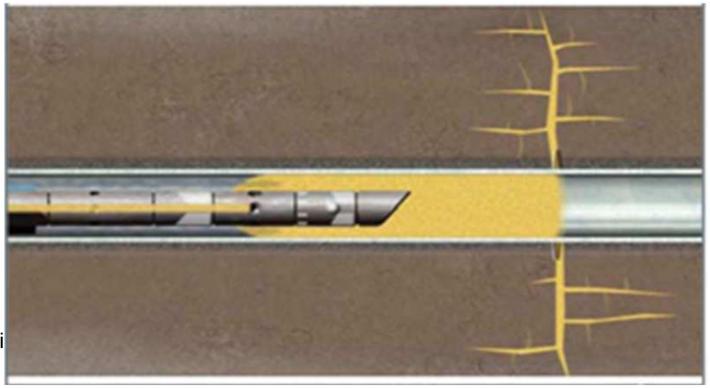


Coil Tubing Assited PinPoint Technologies

CobraMax℠ H Fracturing Service

CobraMax® DM Service

Enables HighIntensity Multistage Fracturing with Proppant Concentration Control



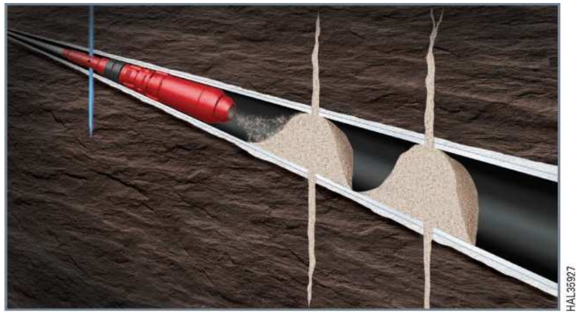
CobraMax® HJA Service

New Tool Technolgy Improves the Efficiency of Proven CobraMax Service

CobraMax® HJA service improves the efficiency of CobraMax® technology in several ways:

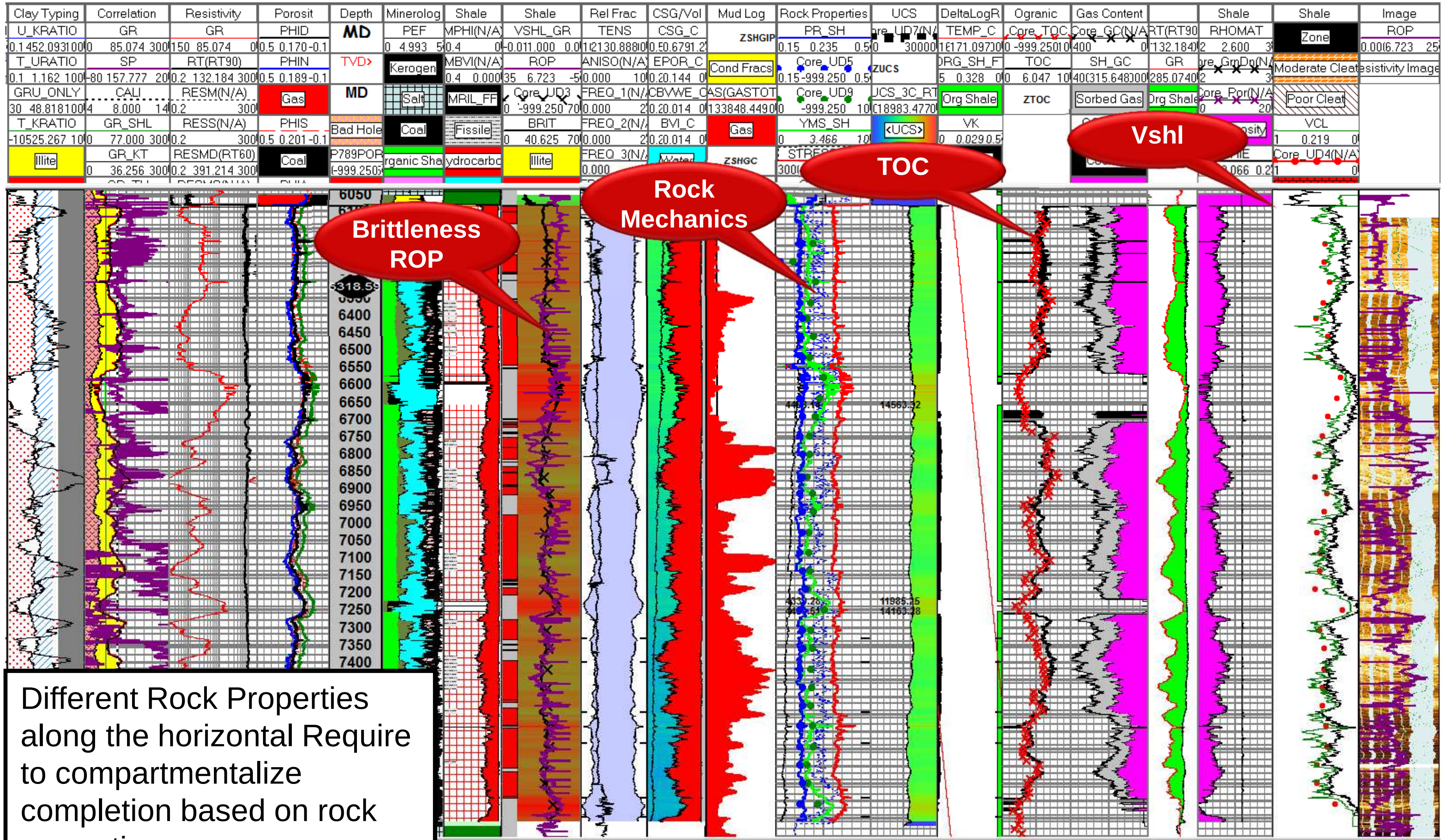
•Improves the process of setting proppant plugs to isolate intervals

•Reduces the time between intervals of a multi-stage fracturing treatment



The CobraMax HJA process helps achieve a very reliable proppant plug for interval isolation and speeds up the overall procedure by enabling the proppant plug to be augmented while perforating another interval.

Horizontal Shale Exploration



Different Rock Properties along the horizontal Require to compartmentalize completion based on rock properties

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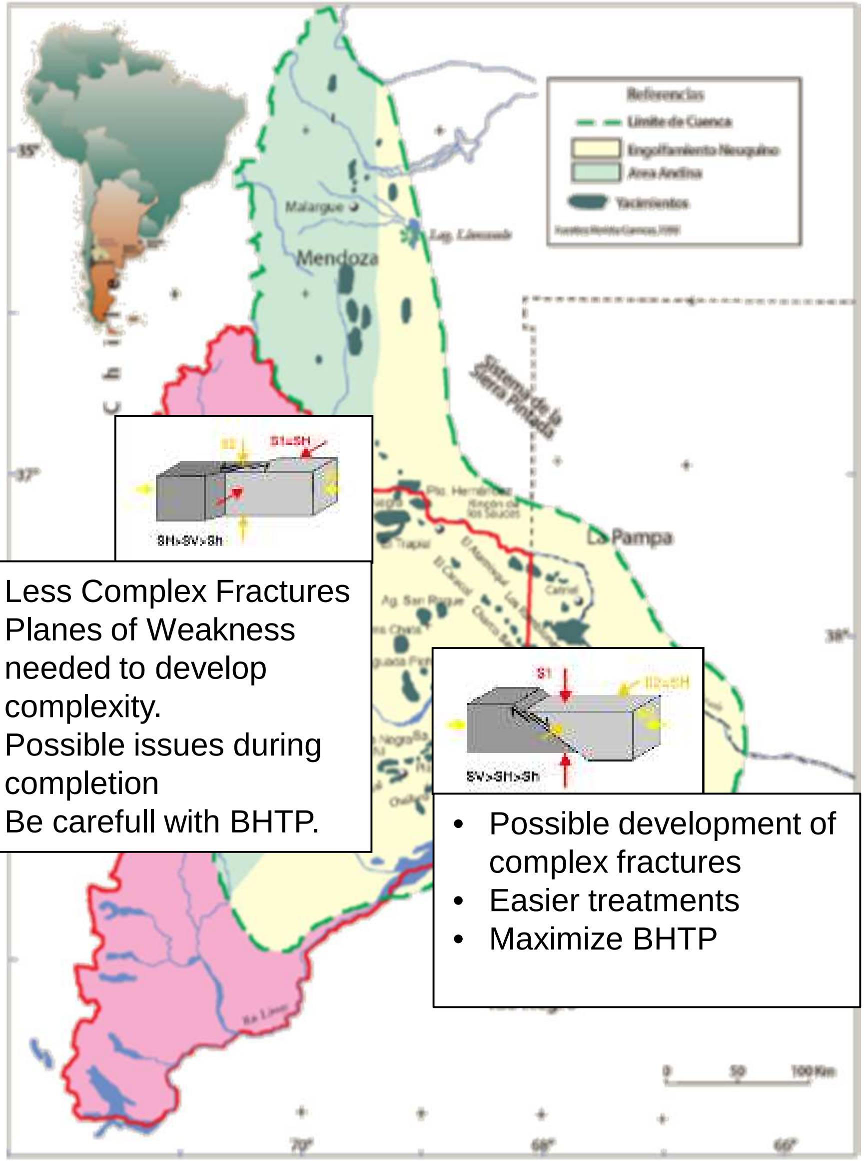
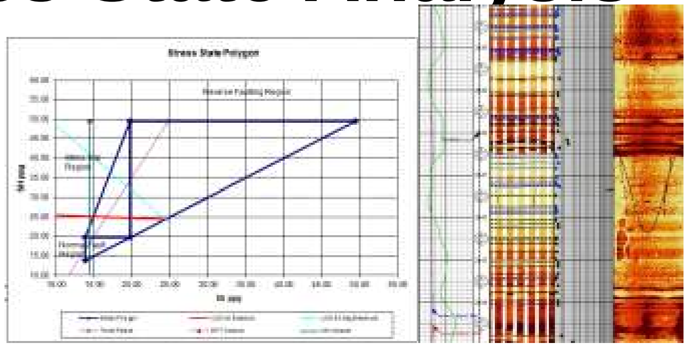
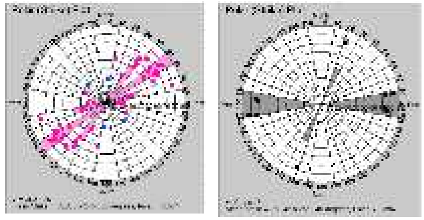
Regional and local Stress State Analysis

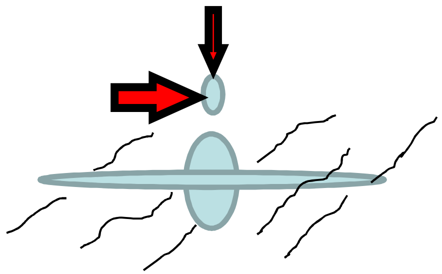


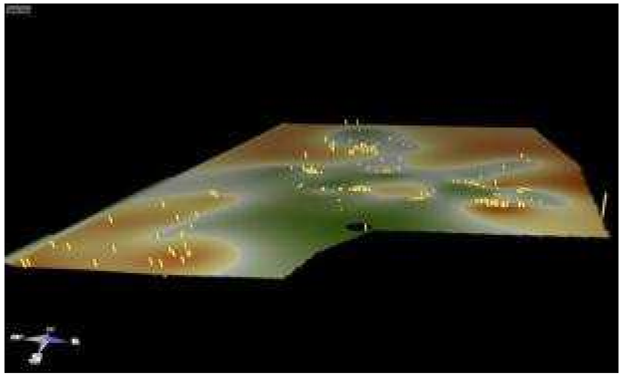
- Less Complex Fractures
- Planes of Weakness needed to develop complexity.
- Possible issues during completion
- Be carefull with BHTP.

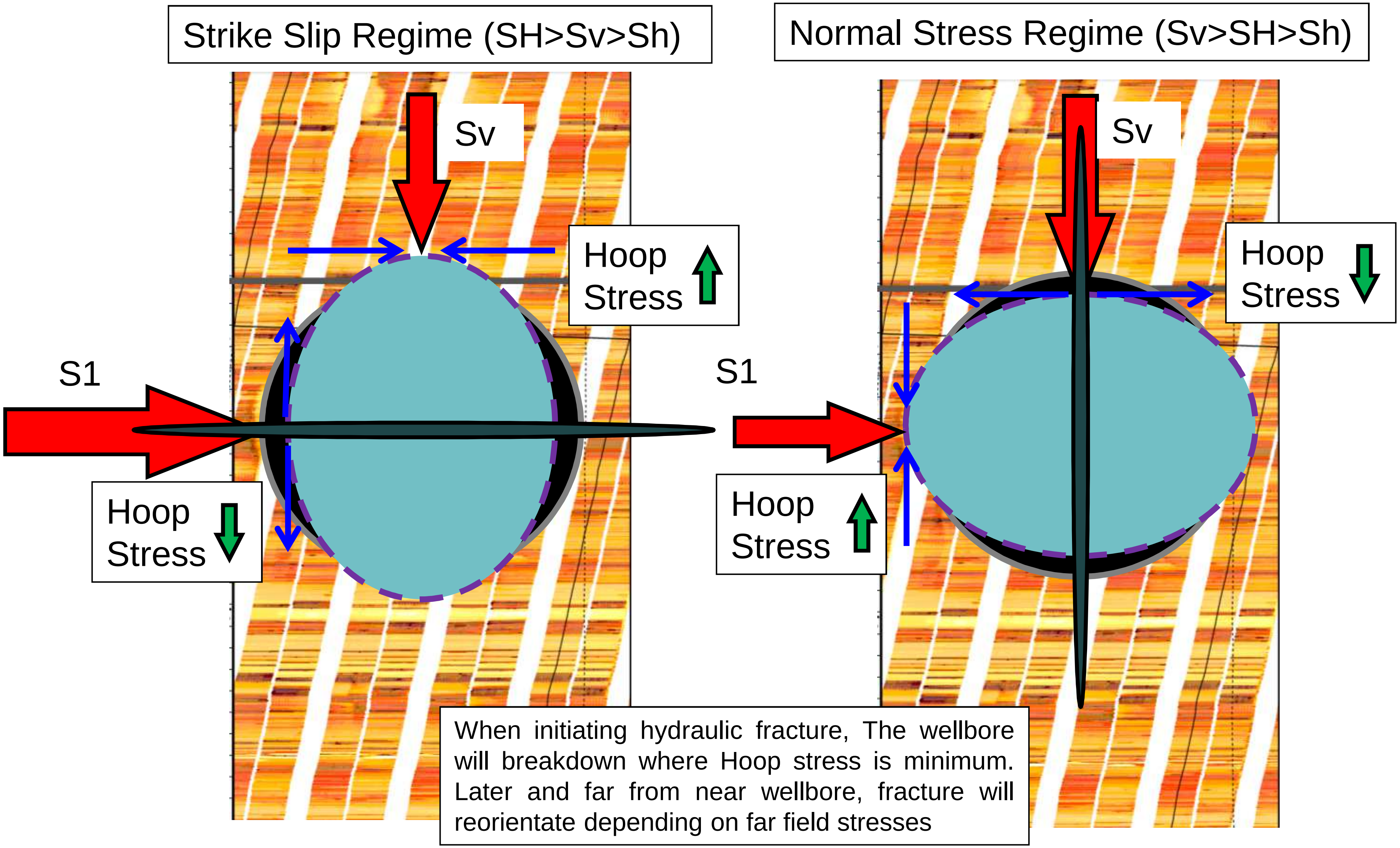
- Possible development of complex fractures
- Easier treatments
- Maximize BHTP











So, reservoir contact along the horizontal may end up having a strong influence on productivity as well as near wellbore conductivity.

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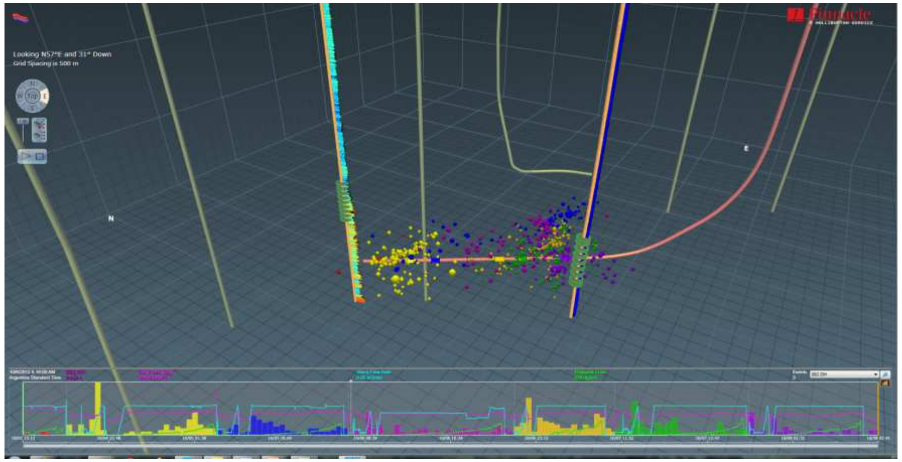
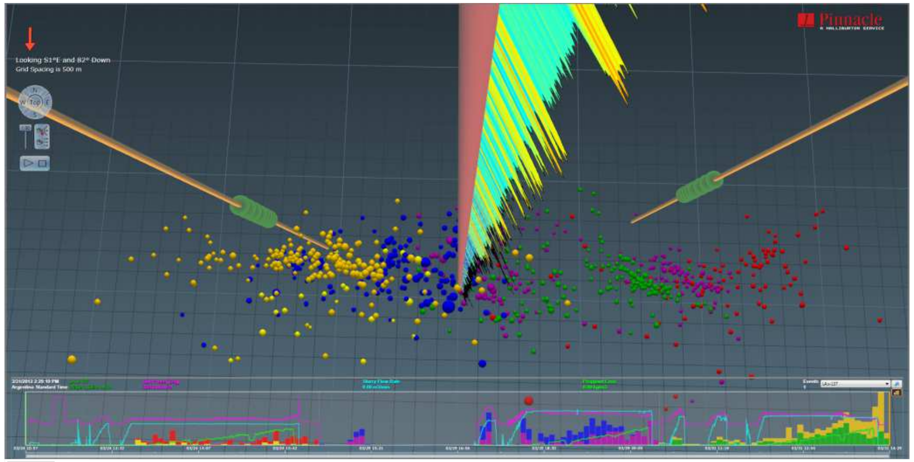
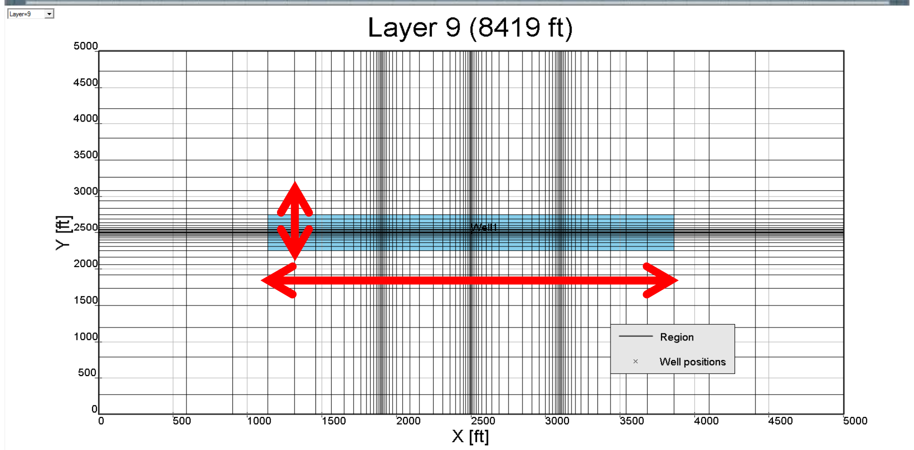
Shale Projects - Microseismic Inputs







- Compare Frac Azimuth to image logs Shmin and SHmax azimuth
- Analyze Frac Complexity
- Analyze SRV to
  - Frac Volume
  - Rate
  - Frac Fluid Viscosity
  - Identify Frac Barriers

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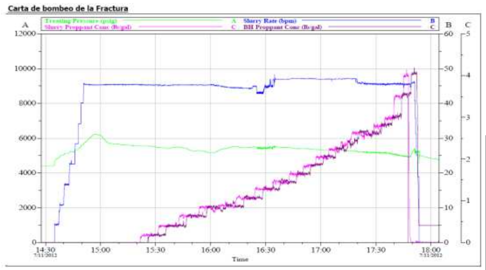
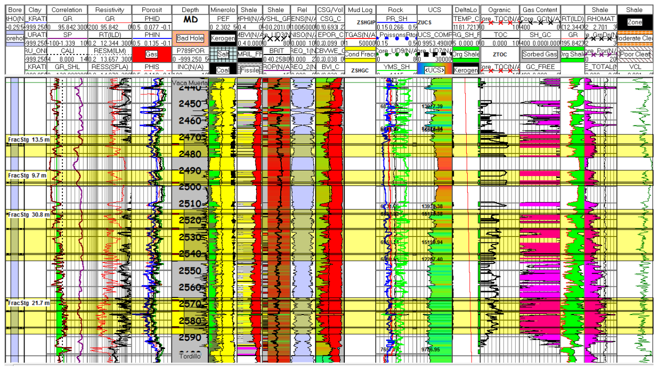
Production History Match

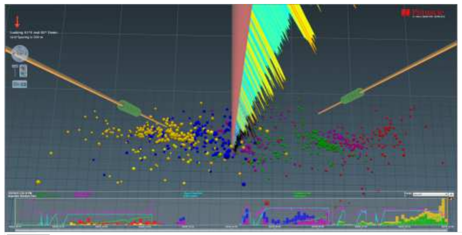
- The model is based on core data and more than 15 wells with lab data to calibrate the petrophysical model.
- Frac geometry was defined based on microseismic, tagged proppant and temperature logs.

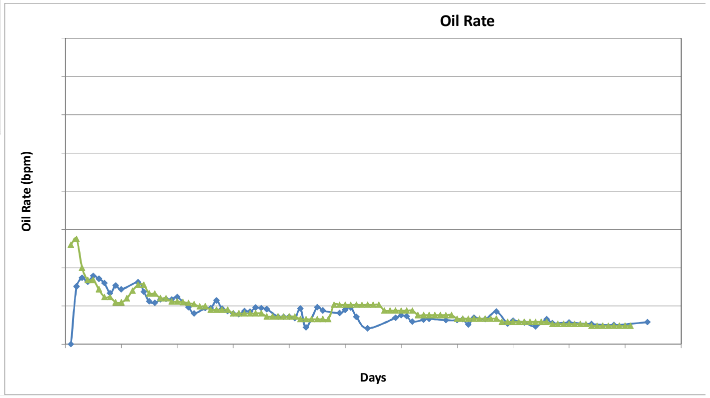
SPE 120271

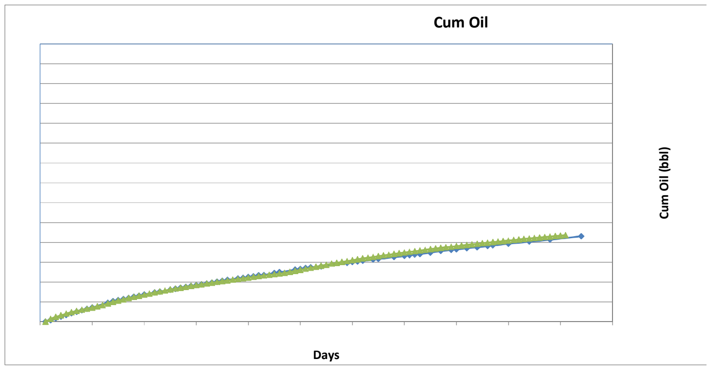
Predicting Production Outcome From Multi-Stage, Horizontal Barnett Completions
Bill Grieser, Bob Shelley, and Mohamed Soliman, Halliburton

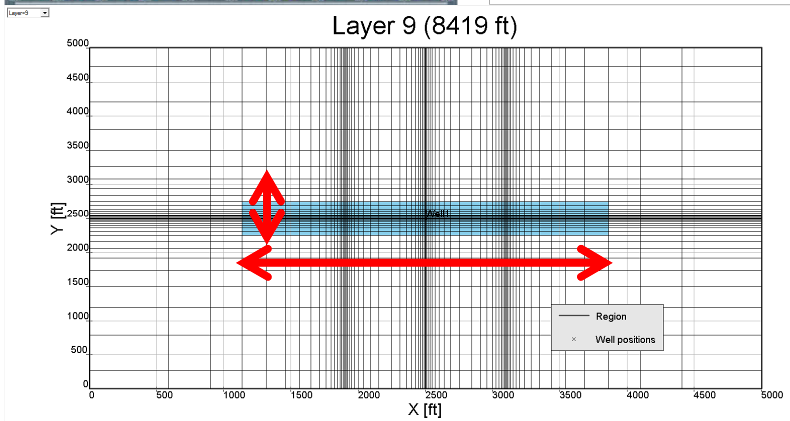




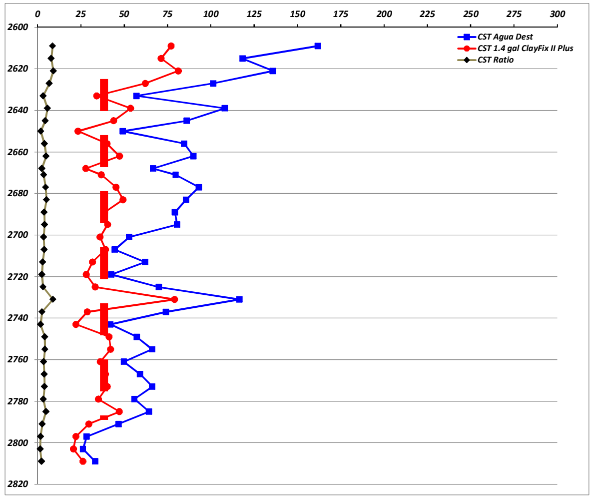


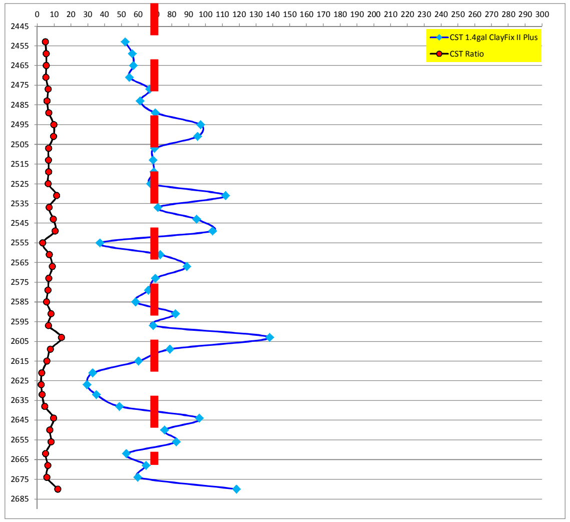


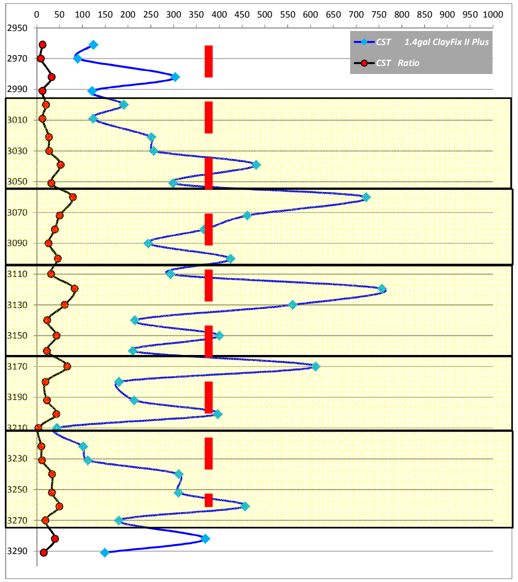


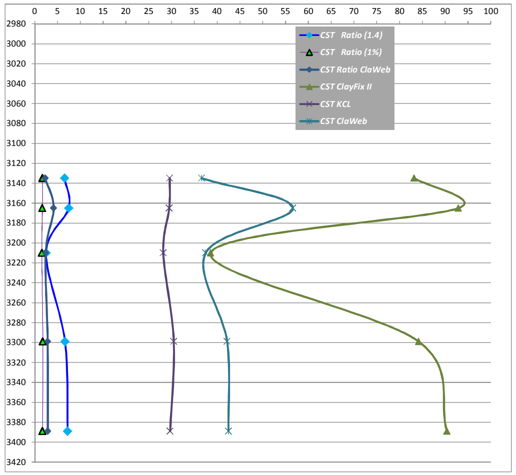


Clay Sensitivity in Shale Formations









SPE 115258

A Practical Use of Shale Petrophysics for Stimulation Design Optimization: All Shale Plays Are Not Clones of the Barnett Shale

Rick Rickman, Mike Mullen, Erik Petre, Bill Grieser, and Donald Kundert, SPE, Halliburton

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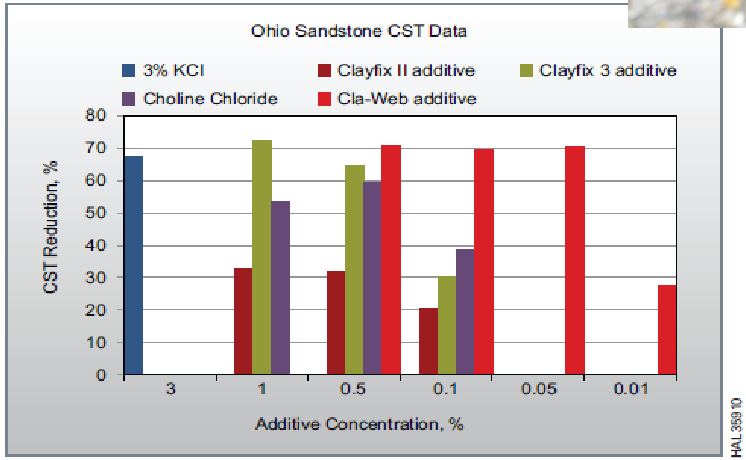
Cla-Web℠ Clay Damage Control Additive for Low Permeability Formations

Provides Improved Clay Damage Protection and Enhanced Environmental Performance

Clay swelling, dispersion and migration due to water-sensitive clay minerals in the producing formation can substantially reduce permeability of formation sands and proppant packs resulting in greatly reduced well productivity.

New Cla-Web™ agent is a liquid clay stabilization additive that can be applied in hydraulic fracturing treatments. It offers a highly effective alternative to common KCl (potassium chloride) substitutes.



Customized for Low Permeability Formations

In addition to temporary clay stabilization during the treatment, Cla-Web agent provides long-lasting clay stabilization in low permeability formations. The Cla-Web agent molecule is very small and is able to enter the matrix of low permeability formations like tight sand and shale. The molecule is ion-exchange resistant rendering treated clay minerals insensitive to water, preventing clay swelling and dispersion.

Water Logistics for Unconventional

- Reduce
  - Fresh Water usage
  - Transportation Time and Costs
  - Re-use water costs
  - Completion Time

CleanStream Service & CleanWave™

- Halliburton-integrated process; Full frac solution
- On-the-fly bacteria treatment at rates up to 100 bbl/min
- Minimize environmental footprint with the reduction or complete elimination of environmentally unfriendly biocide
- Minimize exposure to hazardous biocides
- Water recycling

Equipment Innovation

Q10™ Pumping Unit

Advanced Design Helps Reduce Nonproductive Time During Fracturing Treatments

- Reduce NPT
- Reduce Enviromental Foot Print
- Cleaner energy (Natural Gas)
- New Sand Castle Units

Summary

What technologies and techniques are being applied for Tight Gas and Shale Gas Exploration and Development?

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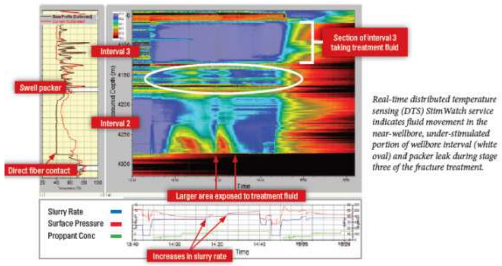

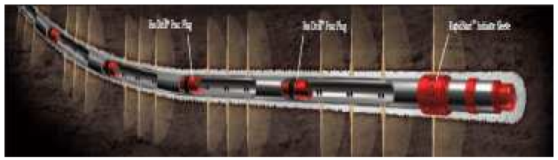

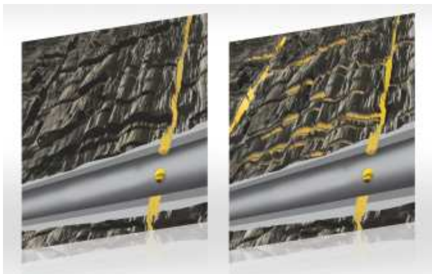

Thank You