Should Horizontal Wellbores be Logged?

An analytical approach to hydraulic fracturing entry positioning and completion equipment selection

Weatherford®

ICoTA

Agenda

- Existing horizontal well completion techniques
  - Multi “port” completions systems
  - Wireline pumpdown plug and shoot
  - Coil plug and shoot
  - Abrasive jet perforating
- Value of micro-seismic data
- Horizontal well logging technology

Completion Techniques

- Multi-port completion systems
  - Hydraulically Isolated Frac Entry Systems
  - Often engineered prior to well being drilled and more geared towards spacing than reservoir characteristics.
  - Service provider supplies entire horizontal completion system

Weatherford®

Customer ZoneSelect Installation - 11 Zones SUMMARY SHEET

Final Installation Report

ZoneSelect Fracturing Systems

Company	Mr Good Customer	Reference	MZ Sum Template
Location		Page	1
Prepared for		Phone	
Prepared by	Cal Lawton (403) 693-7529	Sales Rep	Cal Lawton
Service Center	Edmonton HO 1-800-661-6922	Drawn by	Cal Lawton
		Date	14 Jan 2009

Tubular	Size (mm)	Weight (kg/m)	Grade	Thread	Top Depth (mKB)	Bottom Depth (mKB)
Casing 1	177.8	34.23	J-55	LT-C	0	1695.00
Liner 1	114.3	17.26	P-110	LT-C	1514.50	3079.43

Zone	Length (m)	Sleeve	Seat Size (in)	Seat Size (mm)	Ball Size (in)	Ball Size (mm)	Displacement (m³)
1	119.88	1	n/a	n/a	n/a	n/a	
2	111.97	2	1.28	32.51	1.50	38.10	
3	124.36	3	1.53	38.86	1.75	44.45	
4	89.05	4	1.78	45.21	2.00	50.80	
5	113.88	5	2.03	51.56	2.25	57.15	
6	101.97	6	2.28	57.91	2.50	63.50	
7	111.94	7	2.53	64.26	2.75	69.85	
8	101.04	8	2.78	70.61	3.00	76.20	
9	112.44	9	3.03	76.96	3.25	82.55	
10	100.81	10	3.28	83.31	3.50	88.90	
11	112.55	11	3.53	89.66	3.75	95.25	
12							

Notes

All depths given in the item description table are tops, and the depths given on the packers in the tool string illustration below are center elements.

Zone lengths are calculated from packer center element to packer center element.

Item	Description	I.D. (mm)	O.D. (mm)	Length (m)	Depth (m)
	114.3 mm, P-110, 17.26 kg/m, Weatherford Float Shoe	98.43	126.00	0.47	3078.96
	114.3 mm, P-110, 17.26 kg/m, KLC Ball Locking Landing Collar	98.43	126.00	0.27	3078.04
	114.3 mm, P-110, 20.09 kg/m, ZoneSelect Frac Sleeve ZTA Toe Sleeve	99.57	140.00	1.03	3030.00
	114.3 mm, P-110, 20.09 kg/m ARES™ Hydraulic Open Hole Packer	98.43	147.00	5.12	1919.75
	114.3 mm, P-110, 20.09 kg/m ZoneSelect Frac Sleeve	98.43	140.00	1.25	1871.29
	114.3 mm, P-110, 17.26 kg/m NTD Permanent Liner Top Packer	109.00	151.00	1.86	1514.50

Notes

Well Specific

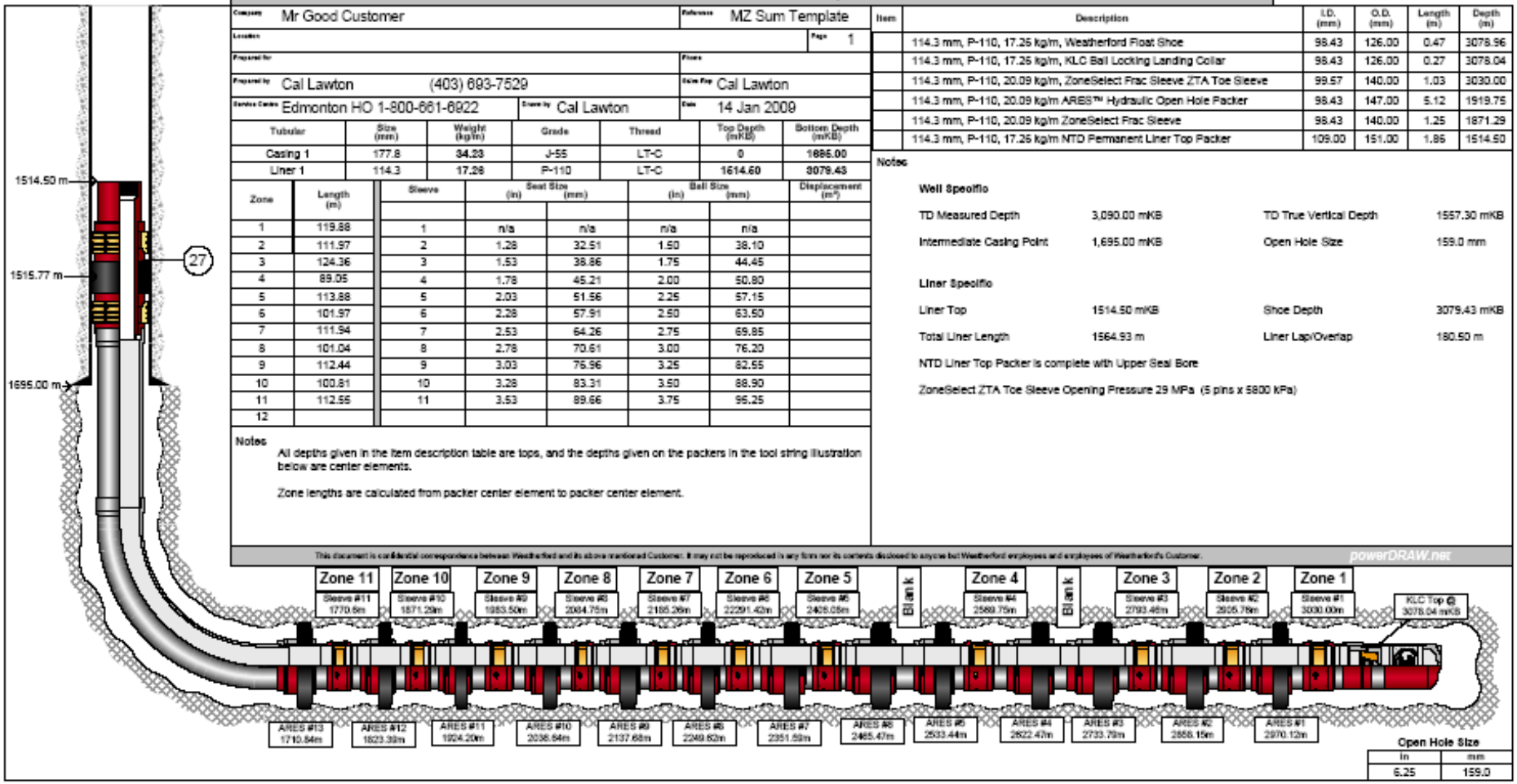
TD Measured Depth	3,090.00 mKB	TD True Vertical Depth	1557.30 mKB
Intermediate Casing Point	1,695.00 mKB	Open Hole Size	159.0 mm

Liner Specific

Liner Top	1514.50 mKB	Shoe Depth	3079.43 mKB
Total Liner Length	1564.93 m	Liner Lap/Overlap	180.50 m

NTD Liner Top Packer is complete with Upper Seal Bore

ZoneSelect ZTA Toe Sleeve Opening Pressure 29 MPa (5 pins x 5800 kPa)



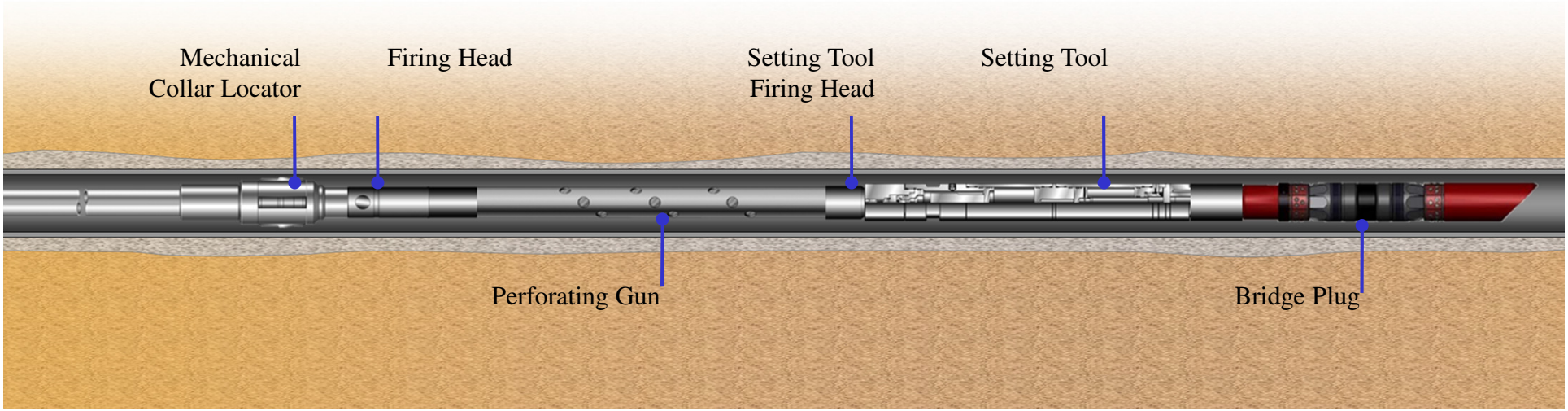
ICoTA

Completion Techniques

- Wireline Plug and Shoot Completion
  - Pumpdown or tractor conveyed
  - Equipment is conveyed into the horizontal, with traditional electric line plug setting and select fire perforating procedures

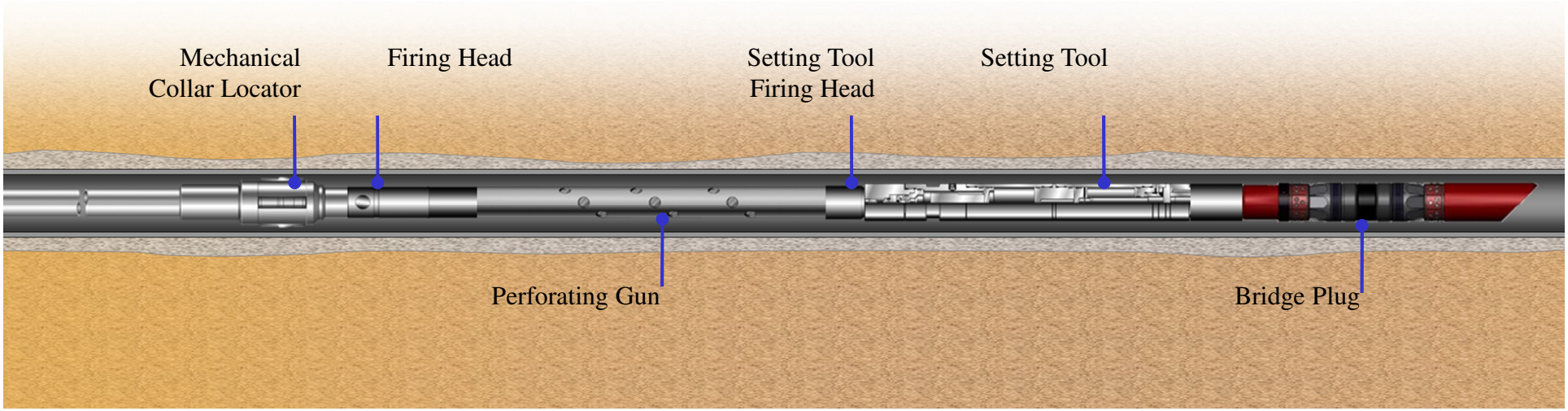
Completion Techniques

- Coiled Tubing Plug and Shoot
  - Assembly conveyed on coiled tubing – plug and perforating gun(s) are actuated using pressure
  - Typically the bridge plug is set utilizing tubing pressure and perforating guns by annular pressure
  - Time delays may be used to permit perforating of multiple intervals



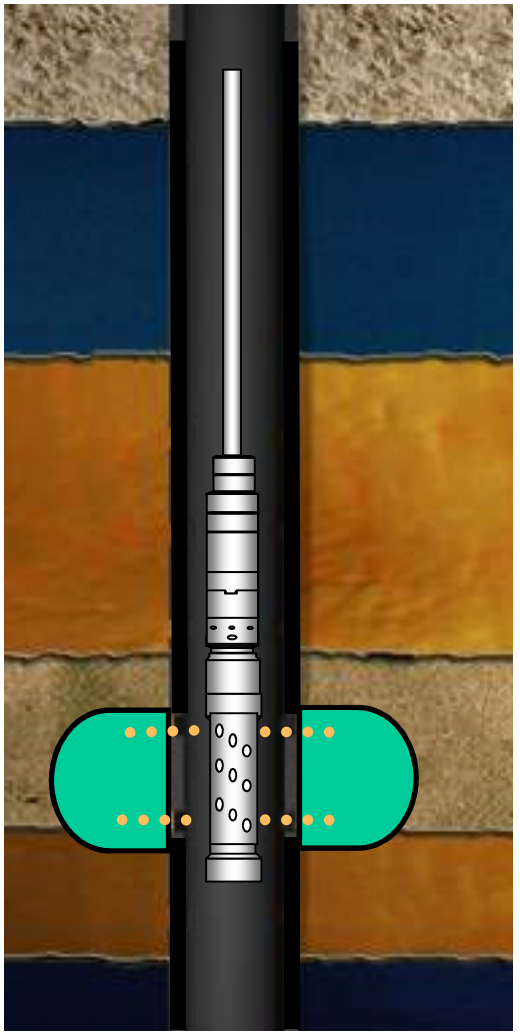
Completion Techniques

- Other options include running the assembly on coiled tubing and using pressure to set the bridge plug and/or fire the perforating gun
  - Coil Tubing pressure actuated plug and shoot method
  - Coil Tubing time delay select fire method



Completion Techniques

- Abrasive Jet Perforating
  - Used not only on new wells but in re-perforating zones that have reduced production due to the build up of sediment by flowing oil.
  - No explosives are necessary.
  - Run with either jointed tubing or coiled tubing.
  - No temperature limitations
  - Perforate zones from 1’ to 10’ and 4 to 20 holes at a time.
  - Tools can be customized for specific phasing.
  - Plug and shoot applications can be performed using sand jet perforators.



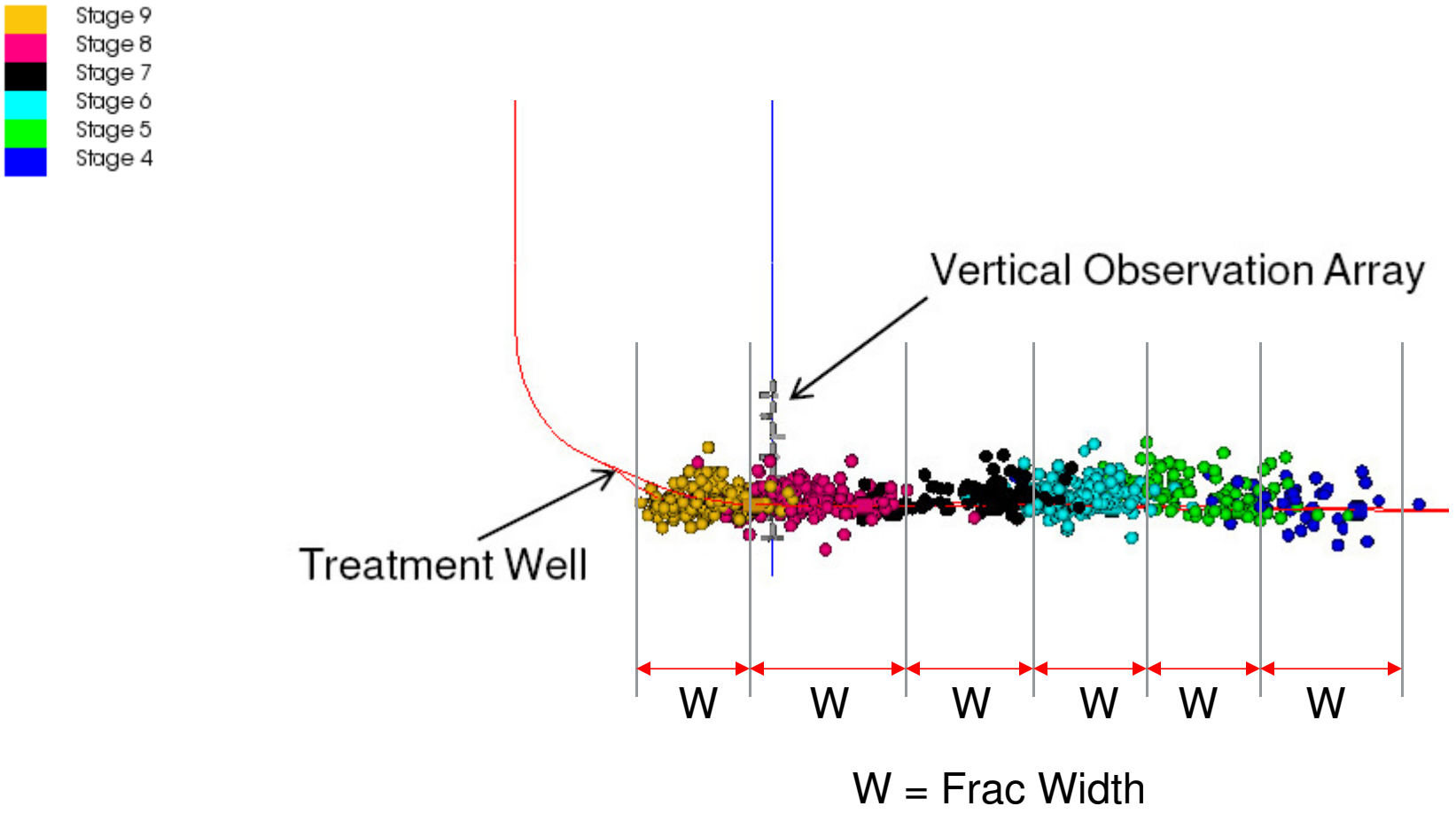
Microseismic Fracture Monitoring

- Fracturing process creates mini-earthquakes in the formation
- String of geophones used to listen for and then pinpoint the location of these mini-earthquakes in 3D space

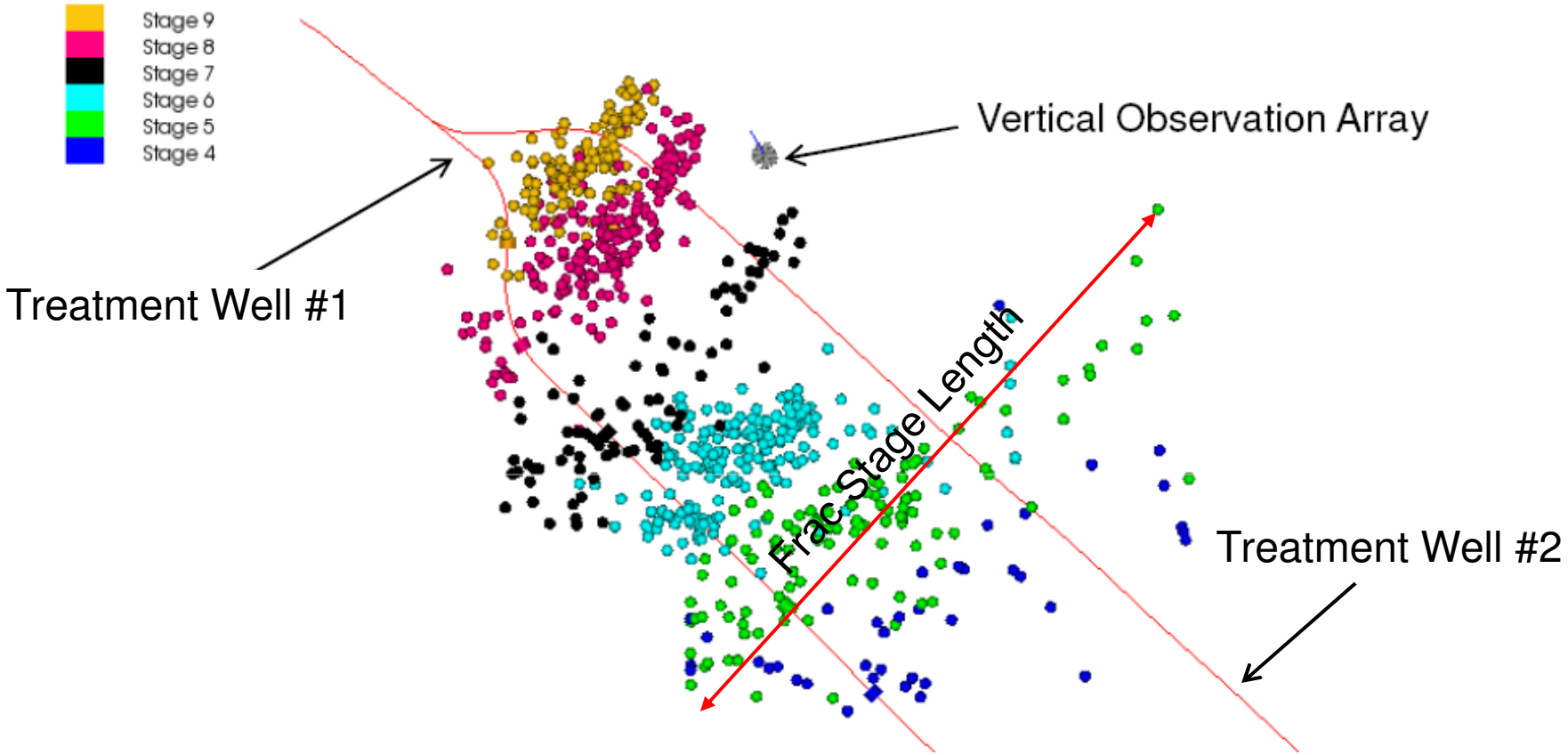
Microseismic Fracture Monitoring

- Fracture Dimensions (Width, Length, Height, Azimuth)
- Frac Width -> Packer / Perf Placement
- Frac Length -> Interwell Spacing
- Frac Height -> Borehole Placement in Section
- Frac Azimuth -> Ideal Wellbore Azimuth

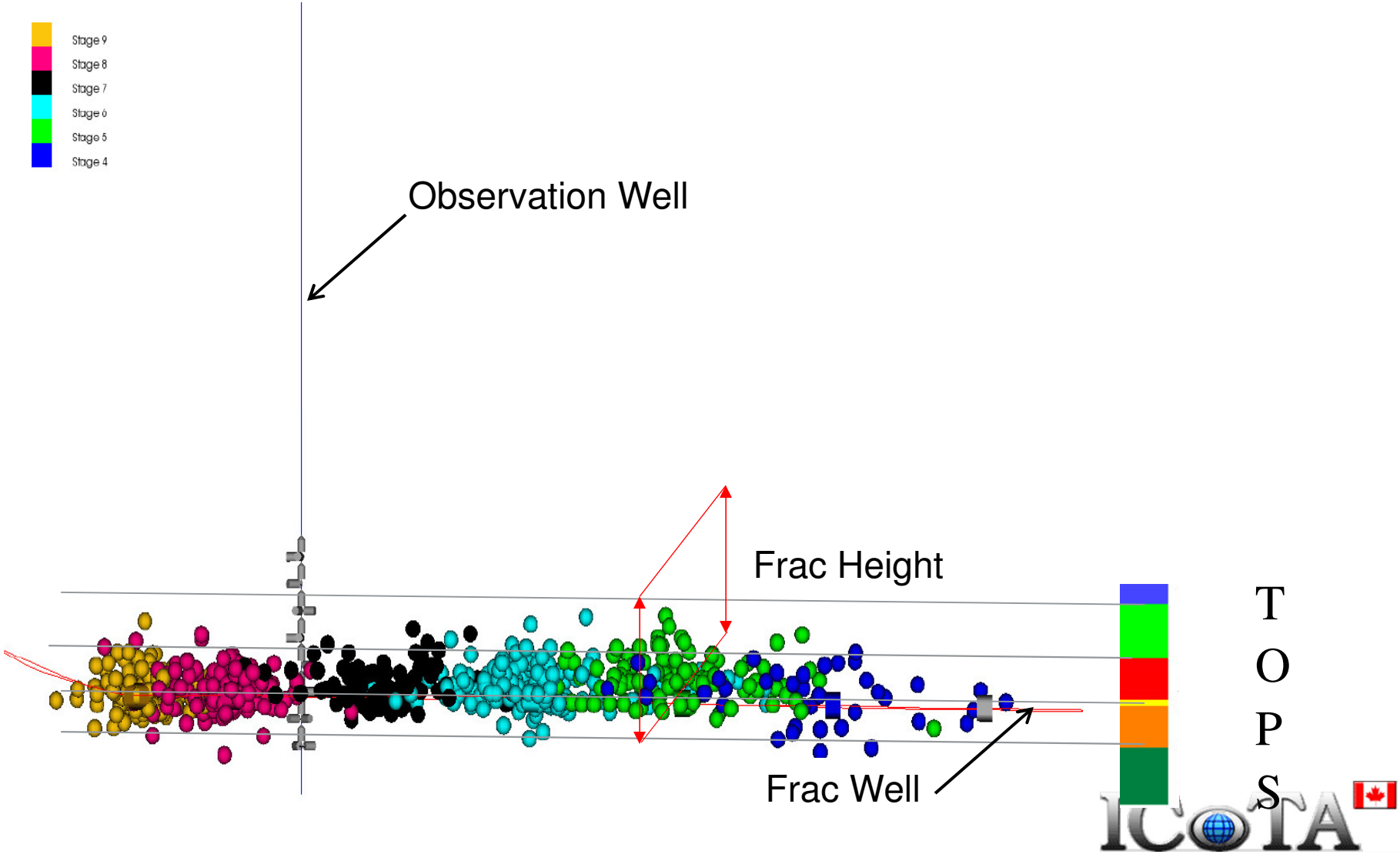
Packer / Perf Placement



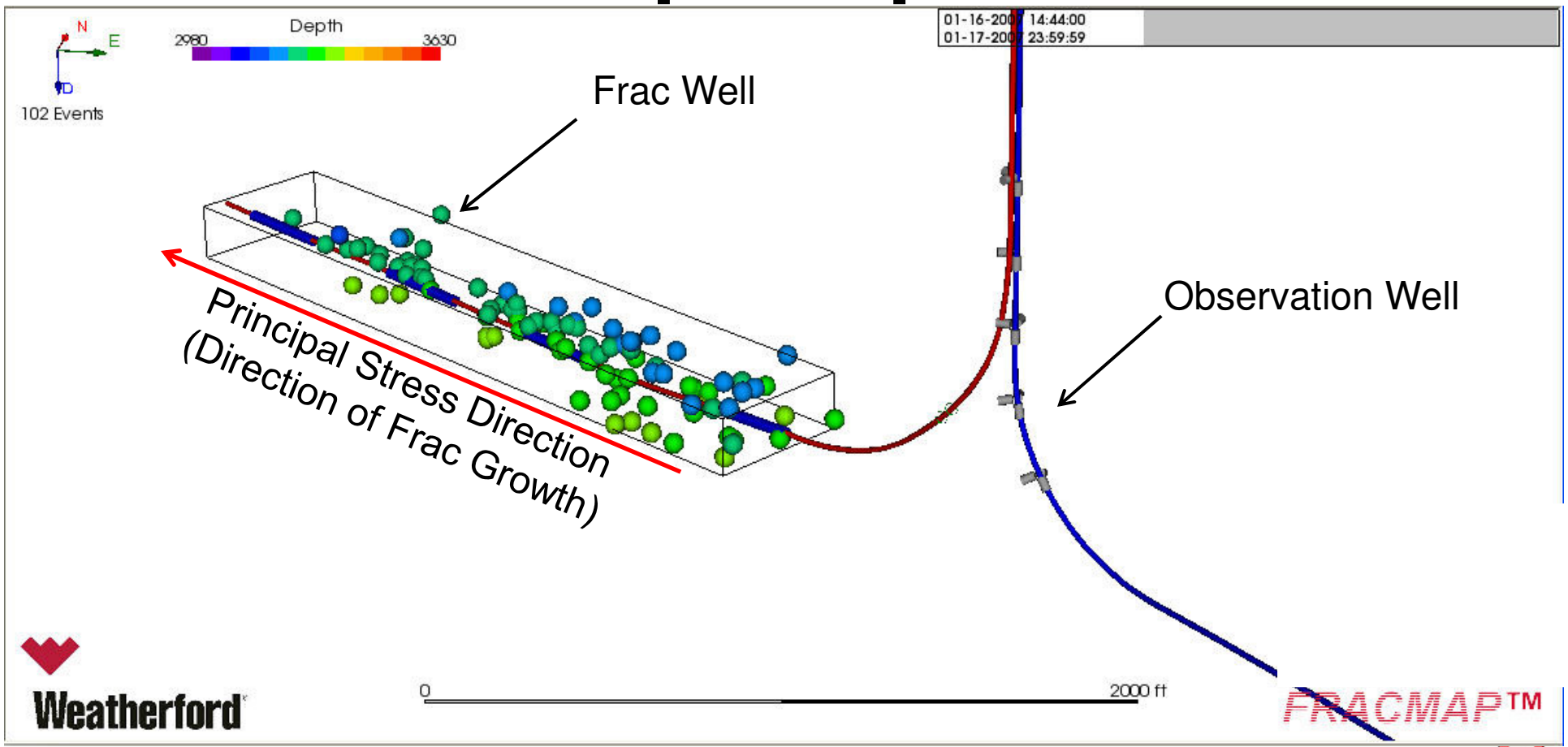
Frac Length – Offset Well Placement



Frac Height: is your horizontal well at the correct depth?



Frac Azimuth – is your well drilled in the proper direction to benefit from principal stresses?



(Limited Frac Growth - well drilled in Principal Stress Direction)

ICoTA

OPEN HOLE LOGGING IN HORIZONTAL WELLS

- Why Run Open Hole Logs?
  - It's all the same stuff. Right?
  - We will just frac every 100m.
- Coil Tubing Conveyance Options for Open Hole Logging.

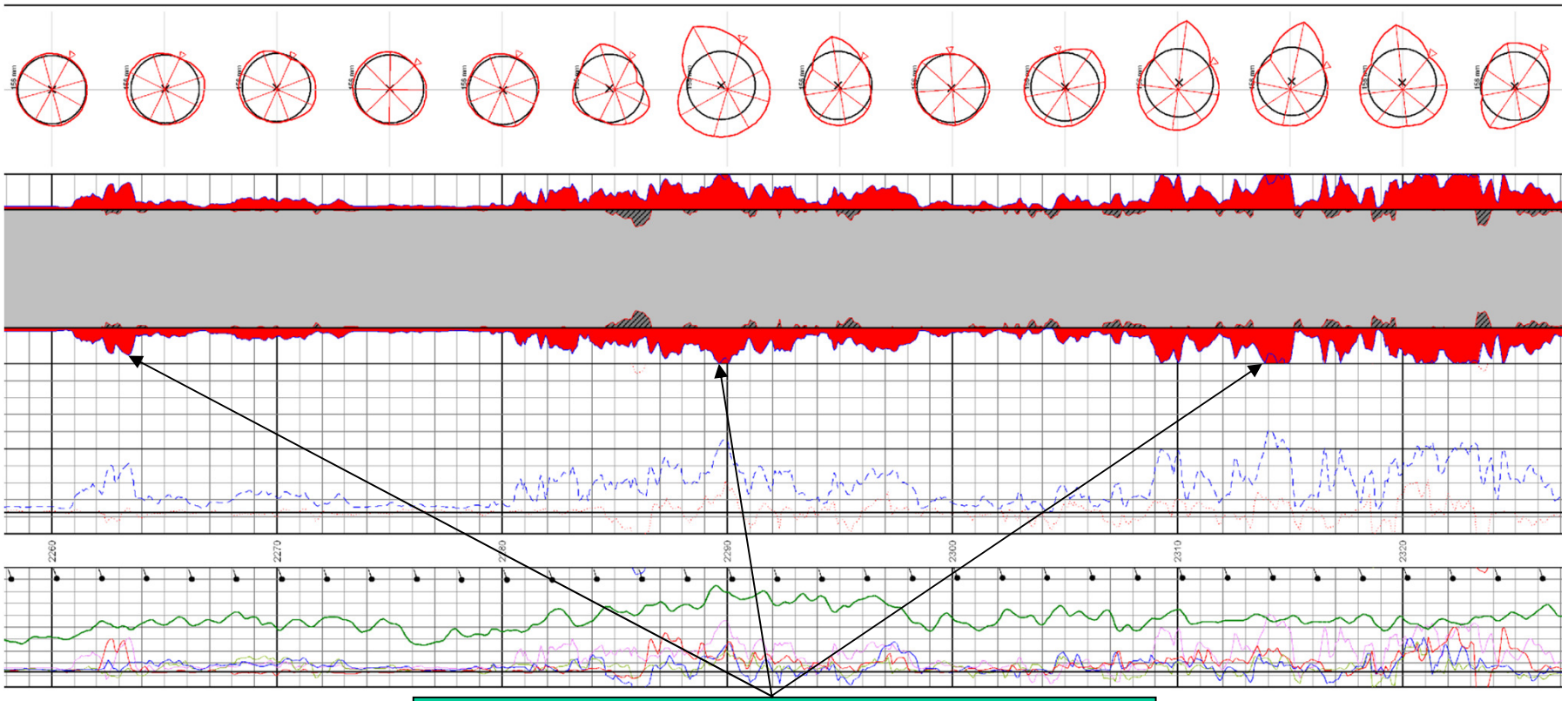
Typical Open Hole Logging Services For HZ Wells

- GR
- Caliper
- Resistivity (Induction or Laterolog)
- Density/Neutron Porosity
- Sonic
- Imaging

Why Run Open Hole Logs?

- Evaluate hole conditions for multi-stage frac packer positioning (eliminate wasted frac $$$)
- Evaluate reservoir quality for better placement of acid or frac stimulation (eliminated wasted $$$ putting expensive treatments in the wrong place).
- Locating water production (fractures? or high water saturation?)
- Understand your reservoir (is this well performing better/worse because of your completion technique or the reservoir quality?)

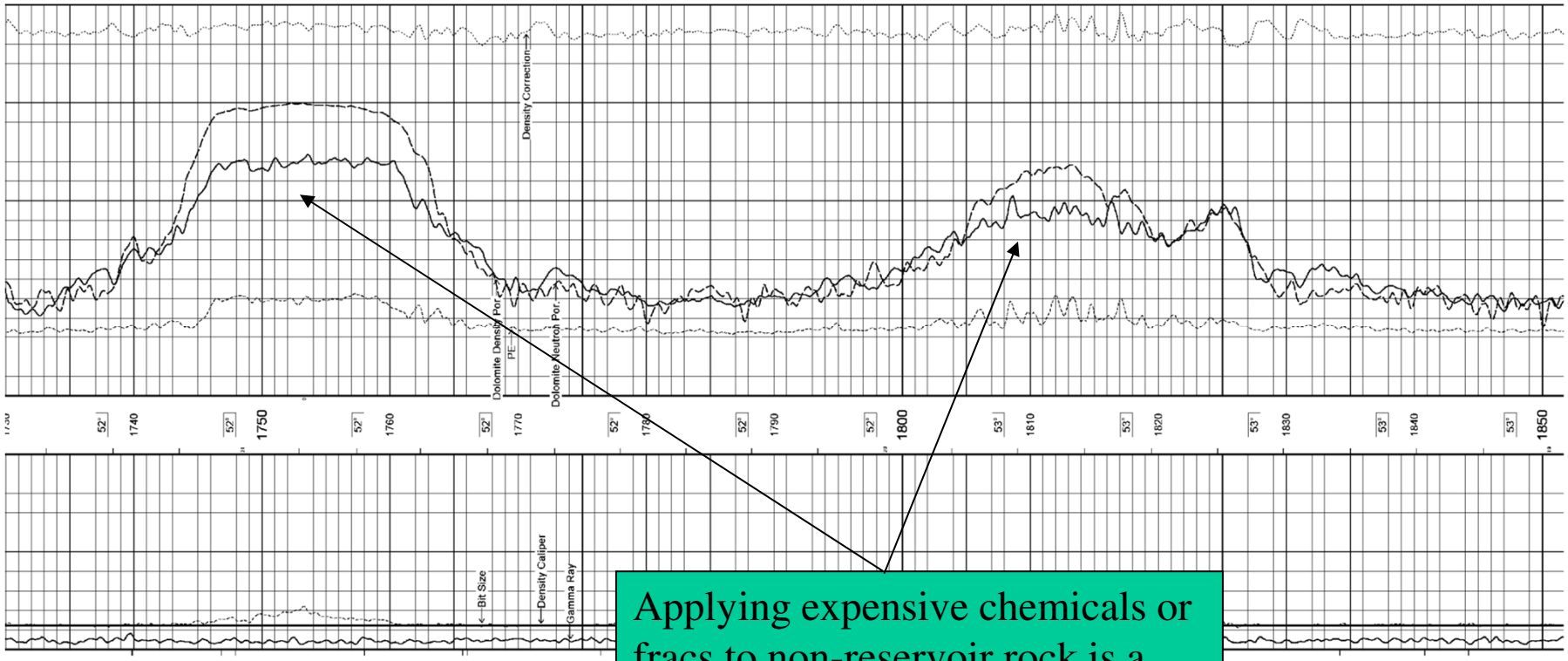
Using Caliper Logs To Optimize Packer Positioning For Multizone Frac



Packers set in washed-out hole may fail, resulting in an ineffective frac operation.

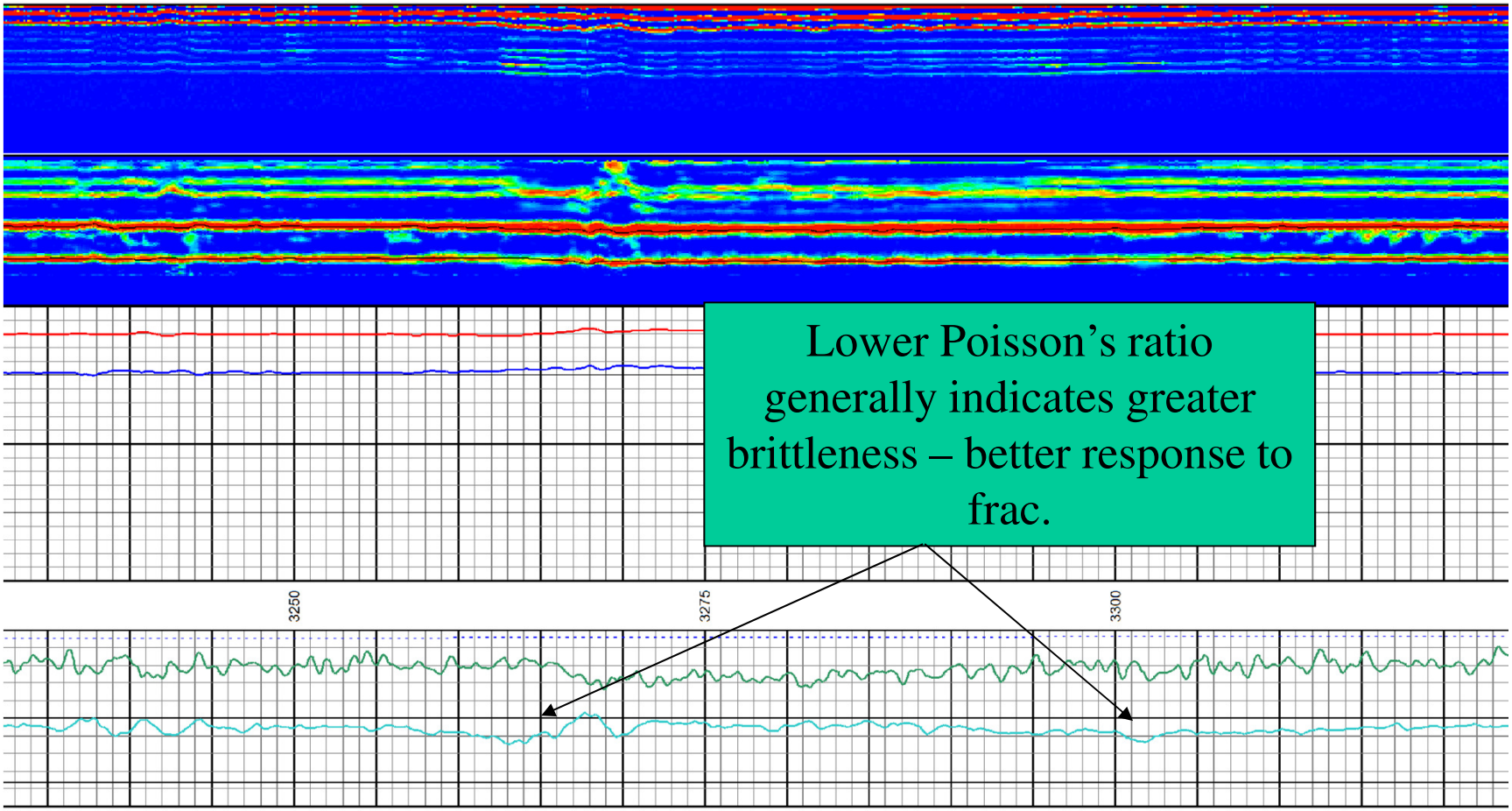
ICoTA

Using Porosity Logs To Optimize Stimulation

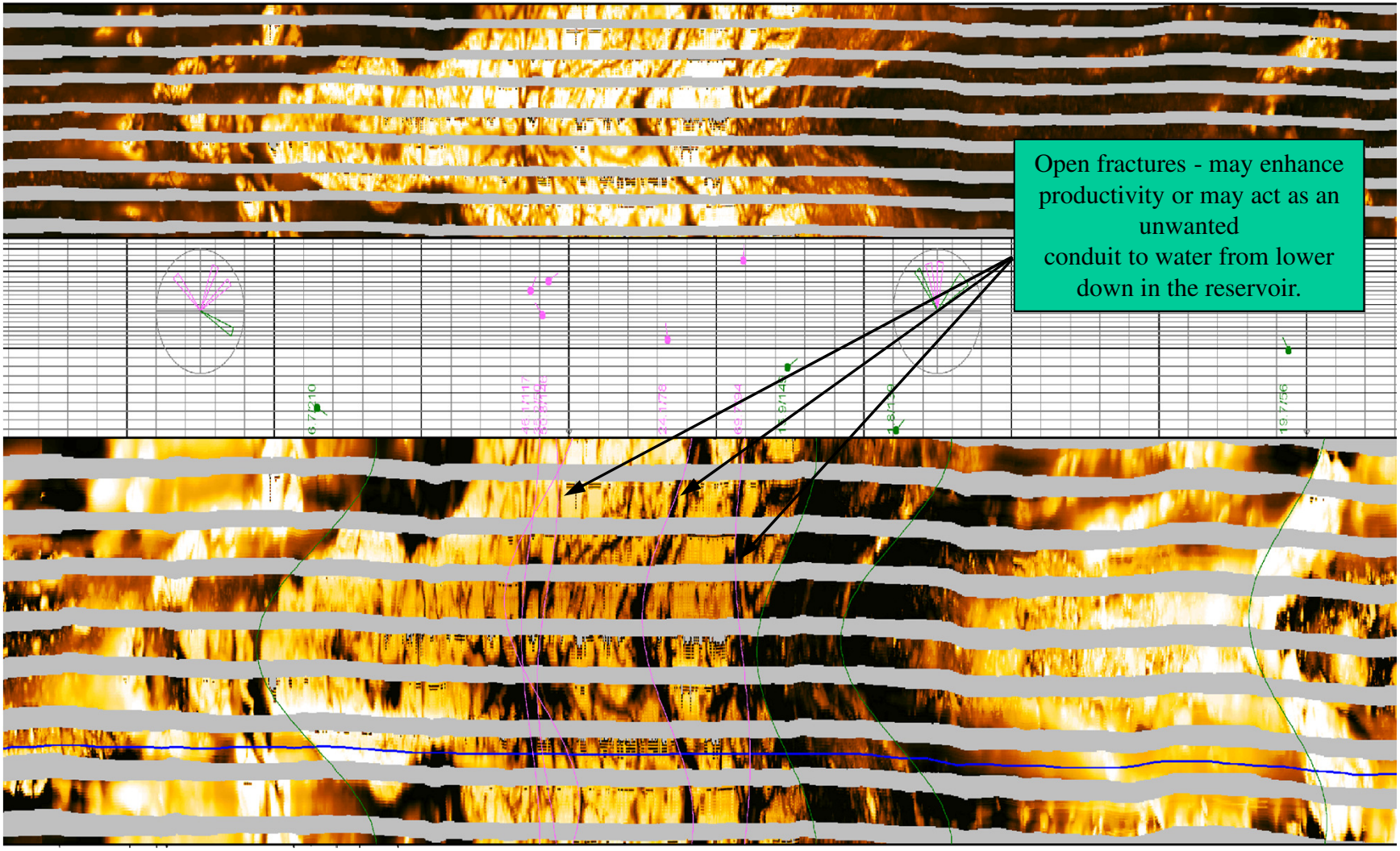


Applying expensive chemicals or fracs to non-reservoir rock is a waste of money.

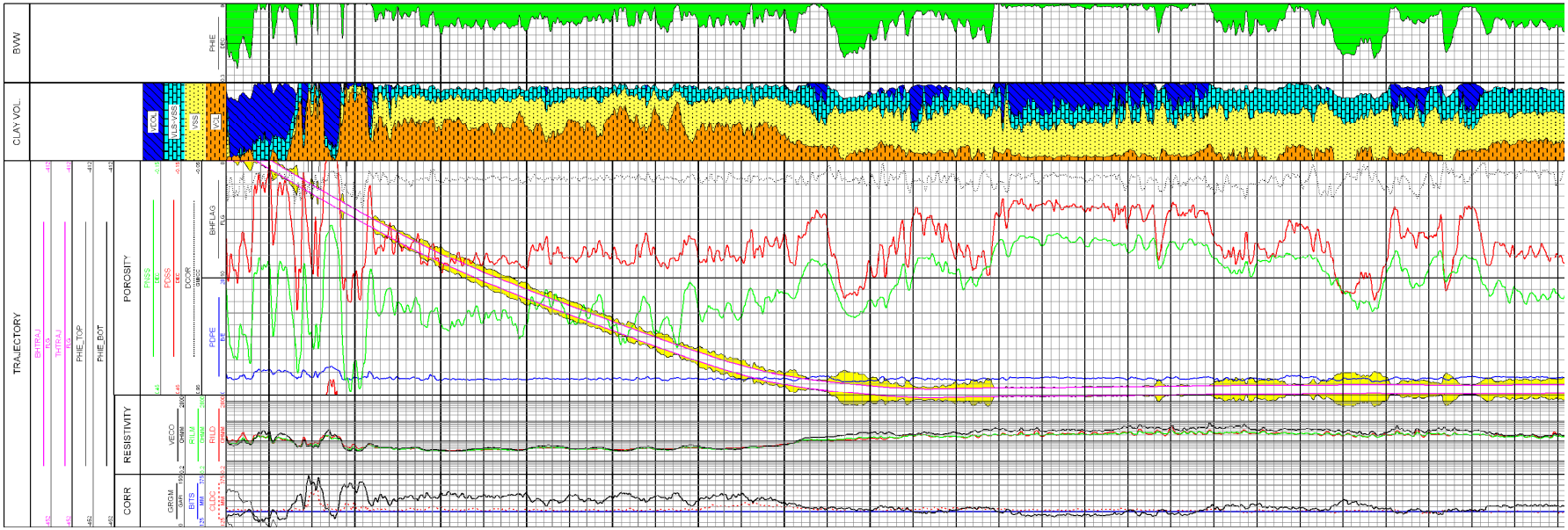
Using Sonic Data To Evaluate Mechanical Rock Properties



Using Resistivity Image Logs To Locate Existing Fractures

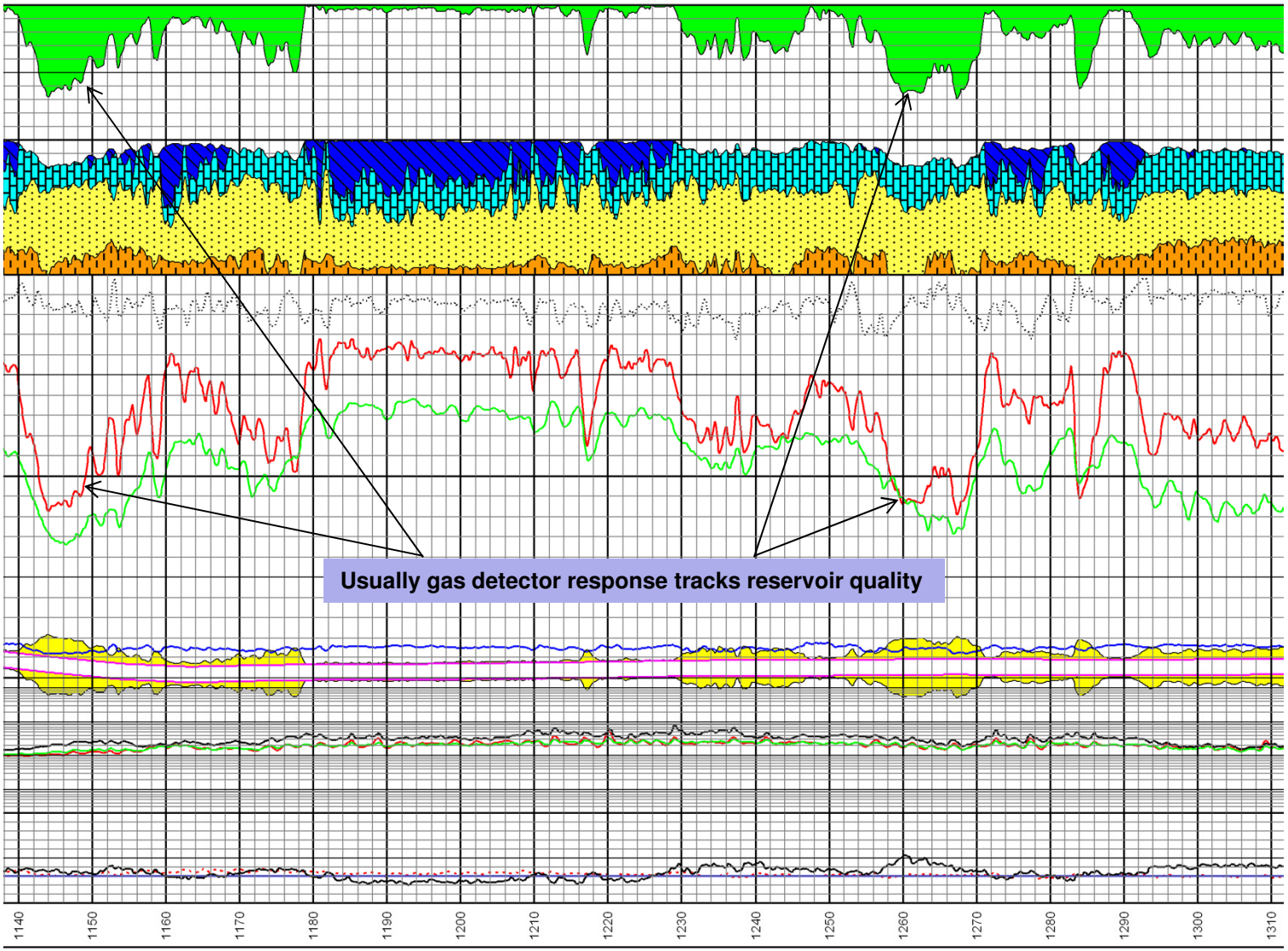


Combining Resistivity & Porosity Data to Evaluate Reservoir

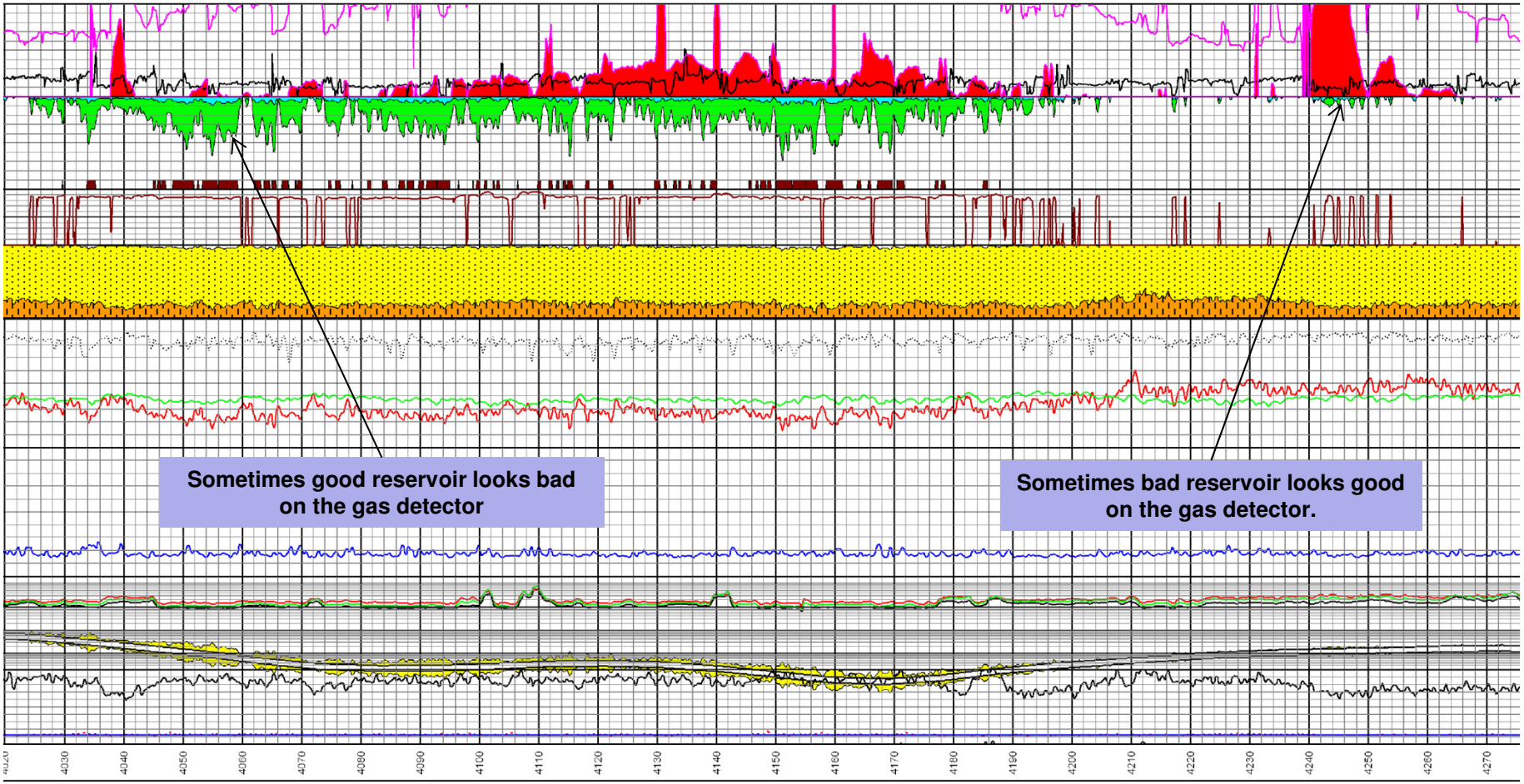


ICoTA

Combining Resistivity & Porosity Data to Evaluate Reservoir



Combining Resistivity & Porosity Data to Evaluate Reservoir



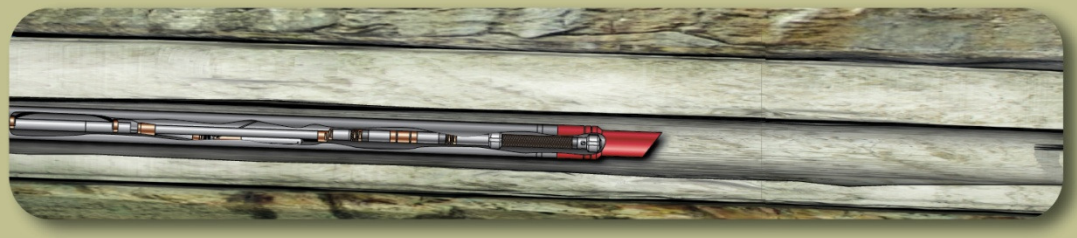
ICoTA

Coil Tubing Conveyance Options for Open Hole Logging

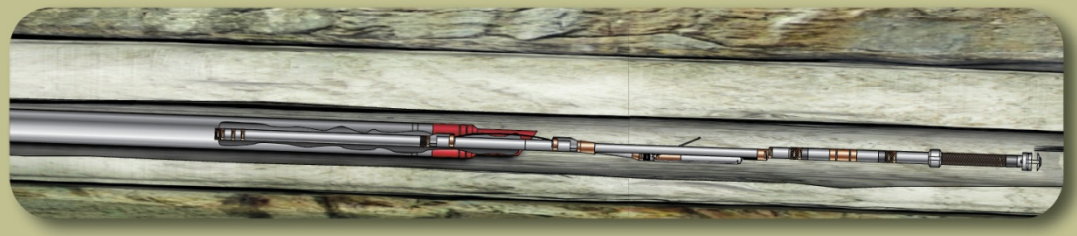
- Wireline threaded through coil (logging tools exposed).
- Memory system (logging tools exposed).
- Shuttle deployment system (logging tools housed within joints of drillpipe – pressure activated release).

Compact Well Shuttle Service (CWS)

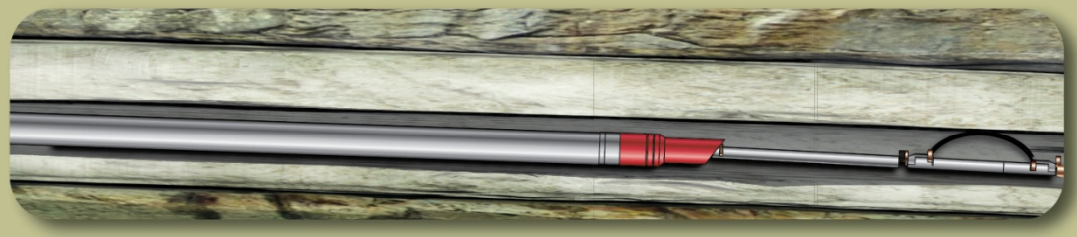
Well Shuttle Operations



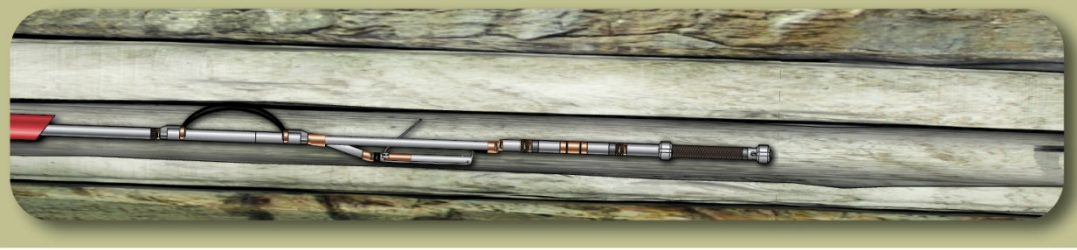
1. *Compact* tools protected inside the drillpipe while being tripped into the wellbore.



2. Tools being “pumped” out of drillpipe into open hole by messenger dart or impulse system.



3. Tools latched into position. Drillpipe is free to rotate and reciprocate.



4. Drillpipe is tripped out of well. *Compact* tools acquire data in memory mode.

Other Logging Technologies Pertinent to the Horizontal Wellbore

- Cement Bond Log
- Production Logging

Questions ???