Slocombe-Rood #1-19

Results from a Hunton Horizontal Well

Unger Field, Marion County

Enhancing Oil Recovery from Mature Reservoirs Using a Lateral with Gamma Ray Sensor, Drillpipe Conveyed Well Logging Including Micro Resistivity Imaging

Lynn Watney, Jason Rush, Saibal Bhattacharya,
John Doveton, David Newell
Kansas Geological Survey
Lawrence, KS 66006

Alan DeGood & Doug Davis
American Energy Corporation
Wichita, KS

RPSEA
Research Partnership to Secure Energy for America

Small Producer Project #07123-04

KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

American Energies Corporation

NETL

Outline

- **Background**
- Rig visit
- Pre-spud analysis
  - Stratigraphy, mapping
  - Well planning
- Actual well results
- 3D Visualization
- Concluding Remarks

Project Start: August 25, 2008
Project End: August 24, 2011
DOE Contribution: $248,385
Performer Contribution: $271,056
Contact Information:
RPSEA – Martha Cather (prrc.nmt.edu or 575-835-5685)
NETL – Chandra Nautiyal (Chandra.Nautiyal@netl.doe.gov or 281-494-2488)
University of Kansas – W. Lynn Watney (lwatney@ku.edu or 785-864-2184)

RPSEA
Research Partnership to Secure Energy for America

Small Producer
Project #07123-04

Background

- **Objective** –
  - Drill 1000 to 1500 ft lateral through porous Hunton dolomite residing at roughly 2800 ft MD
  - Section 19-Range 21 South- Range 4 East of Unger Field in Marion County, Kansas

- **Unger Field** –
  - Discovered in 1955 has produced 8.6 million barrels
  - 17 wells produced 16,191 bbls. in 2009, 2.6 BOPD per well

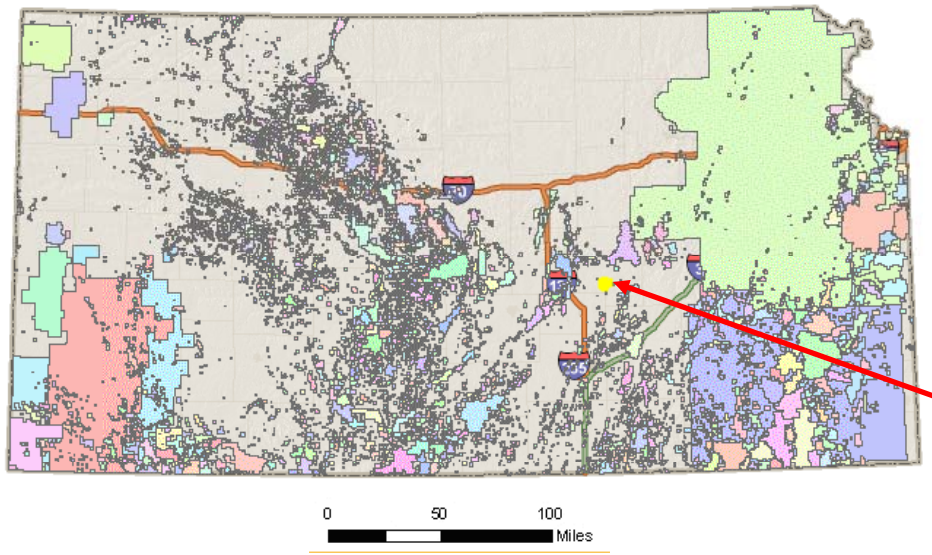
- **Wells on the Section 19 anticline originally produced several 1000's of barrels of oil per day**
  - Wells average 2.6 bbls/day with high water cut (strong water drive)
  - Oil production can increase as wells pumped off suggesting oil still being drained outside of cone of depression

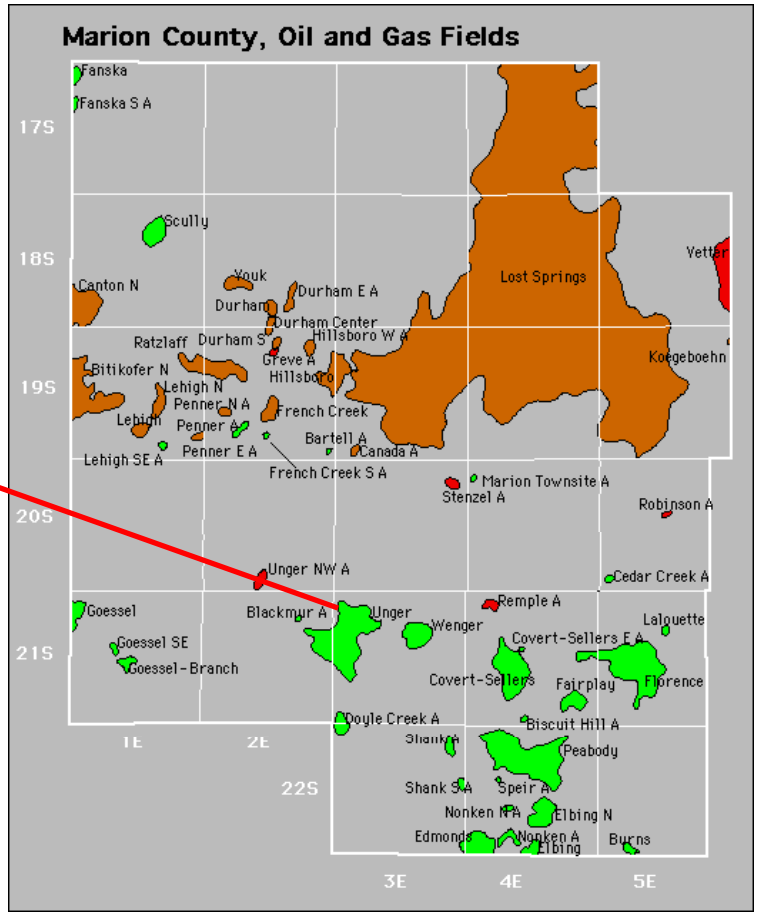
- **Lateral paralleled east flank of ¾ mile long northwest-trending anticline**
  - Local structural relief is 30 ft
  - Original oil column around 40 ft.

- **Porous Hunton reservoir**
  - Thickness ranges = 11-25 ft
  - Lithology – Dolomite - fractured, vuggy, intercrystalline Ø
  - Tight caprock above reservoir = 0-10 ft thick

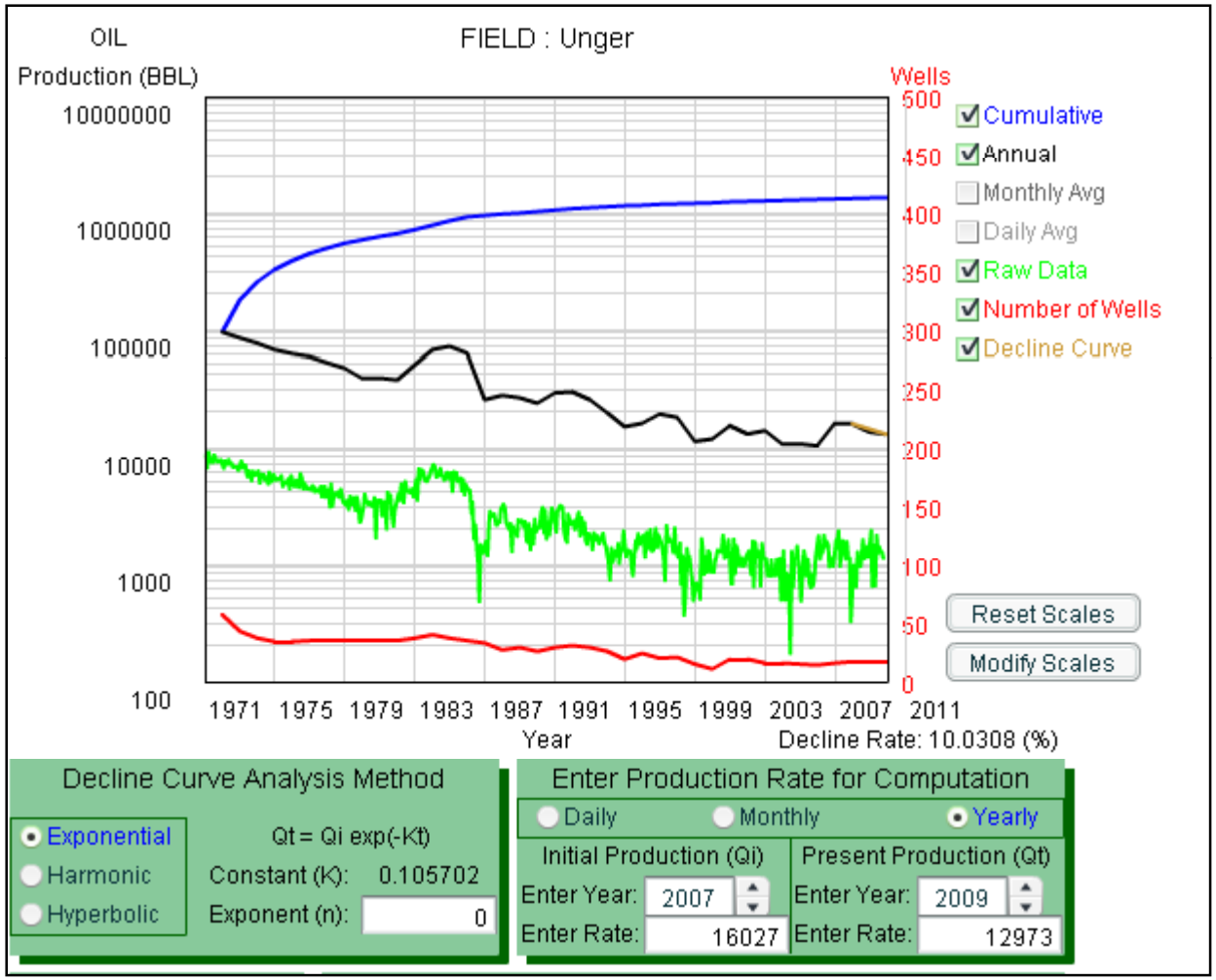
- **The Hunton dolomite is overlain by a thick (~130 ft), relatively hard Kinderhook-Chattanooga Shale.**
  - Sufficiently hard rock for making turn of the lateral.

Horizontal Well
American Energies Corporation
Slocombe-Rood #1-19
Unger Field
Marion County, Kansas





Unger Field Production



Field discovery: 1955

Cum. 8.6 million bbls.

2009: 16,191 bbls.,
17 wells
2.6 BOPD/well

Producing zones:
Hunton dolomite
~2800 ft (md)
Locally Misener Ss.

Partners in Unger Field Drilling

TRES

Tres Management, Inc.
providing outstanding personnel for all your energy projects

Design and well site supervision on over 300 horizontal wells drilled including multi-laterals in Oklahoma Hunton, Arbuckle, Barnett Shale and others – up to 8,000' lateral displacement

Pan American
DRILLING SERVICES L.L.C.

Focus Gamma (sensor)
-- To avoid shale caprock above reservoir

<u>Post Drill</u> - Compact Micro Imager (CMI) & Triple Combo (Gr, N-D Ø, Array Induction, Pe)

Weatherford®

Use of modern to optimize selection of the completion interval
- **Log-derived lithology, pore type,**
- **oil saturation, and fracture detection.**

Project Website

http://www.kgs.ku.edu/PRS/Unger/index.html

Info from Wichita Eagle — January 2011

Video from the Wichita Eagle on the American Energies well in the Unger field

Article from the Wichita Eagle--Wichita driller hopes new technique opens oil fields

American Energies "Slocombe-Rood 1-19" — January 2011

KGS database page for this well

Revised Intent (Acrobat PDF, 462 kB)

Project Info — December 2010

About...

The Unger field horizontal well is a RPSEA-funded project of the Kansas Geological Survey and American Energies Corp.
More ...

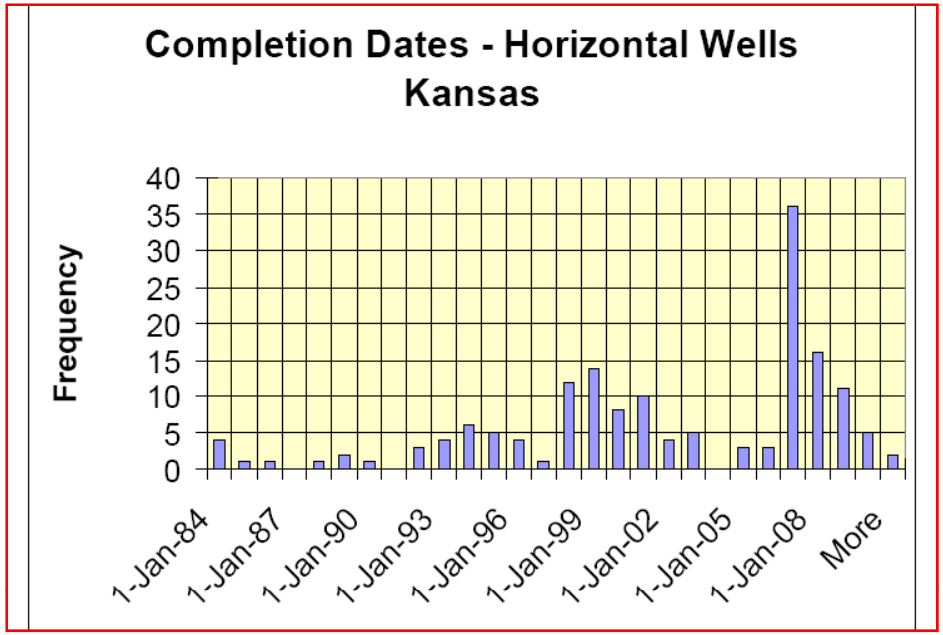
Topics...

Home

Partners

Reports

Video in the making by Jeremy Viscomi, TORP



Presentation on horizontal wells to Fall Continuing Education Seminar, KBA-KIOGA:

http://www.kgs.ku.edu/PRS/Unger/Watney-KBA-KIOGA--Horizontal_Drilling.pdf

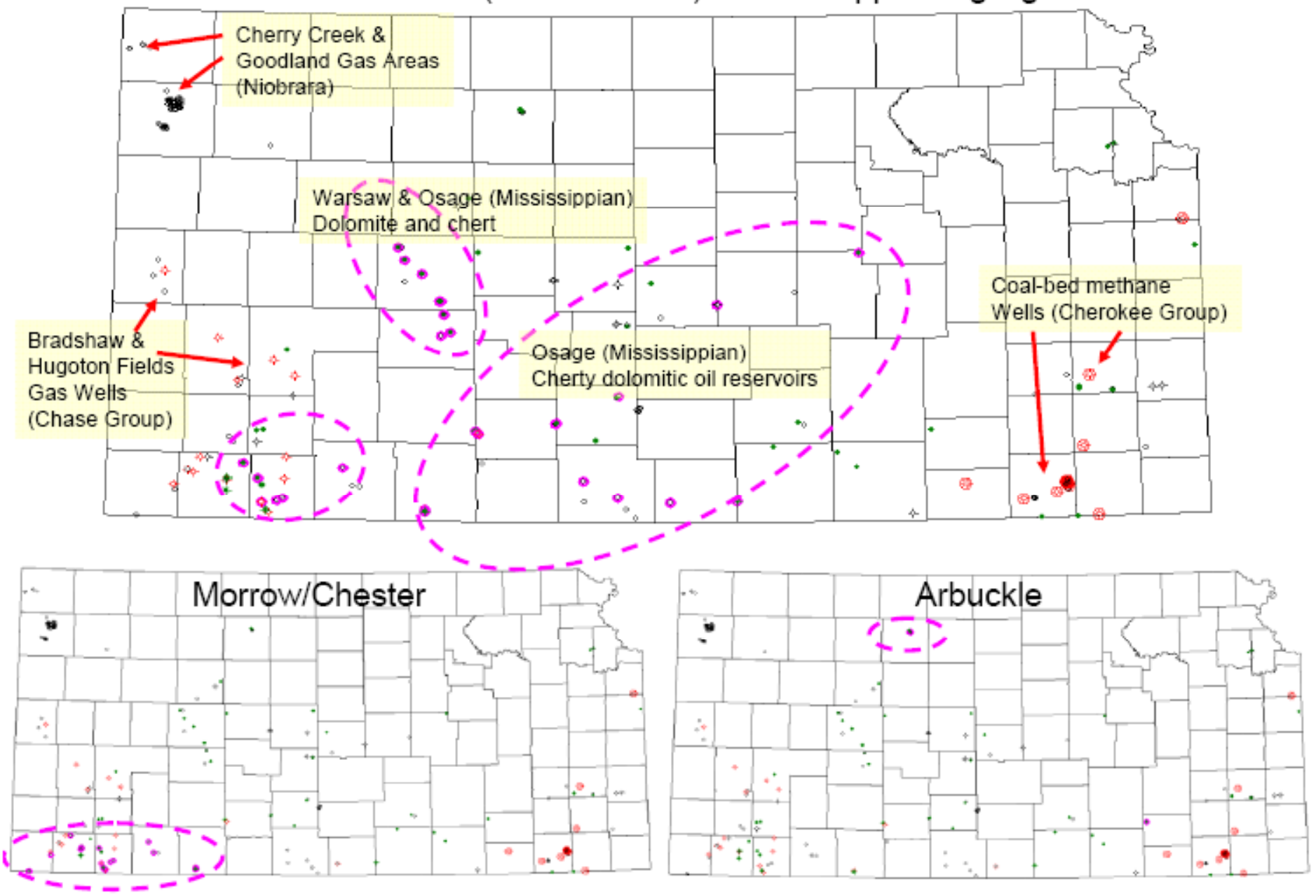
15-103-20433-0100

Code on API number for horizontal & slant wells

HORIZONTAL WELLS IN KANSAS — **October 2010**

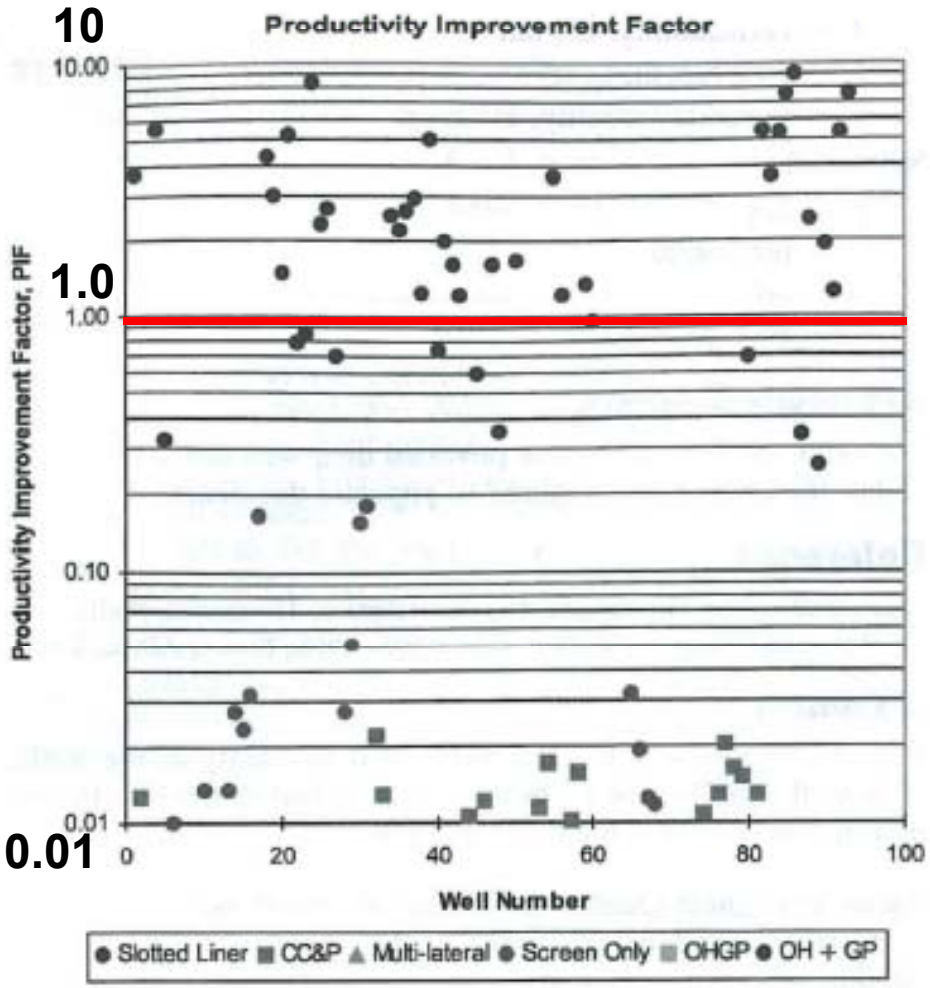
		Wells with oil production
Total producing oil wells	238	
	20	
Success rate (%)	8.4	
Niobrara chalk shallow gas	61	
Chase-Council Grove	10	
Lansing-Kansas City	2	0
Cherokee CBM	15	
McLouth Sandstone	9	0
Morrow-Chester	16	4
Mississippian carbonates	22	6
Viola	7	0
Arbuckle	8	3

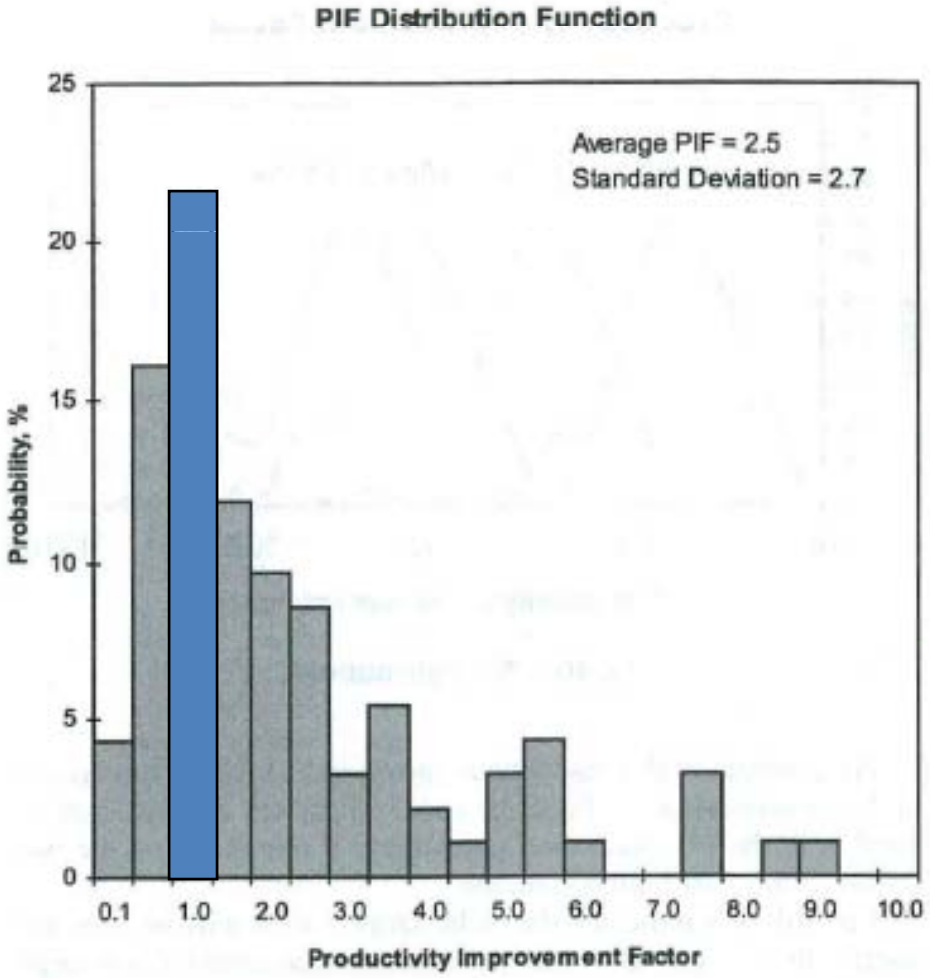
Horizontal Wells in Kansas (October 2010) – Mississippian highlighted



Productivity Improvement Factor

Distribution of Productivity in 96 horizontal wells

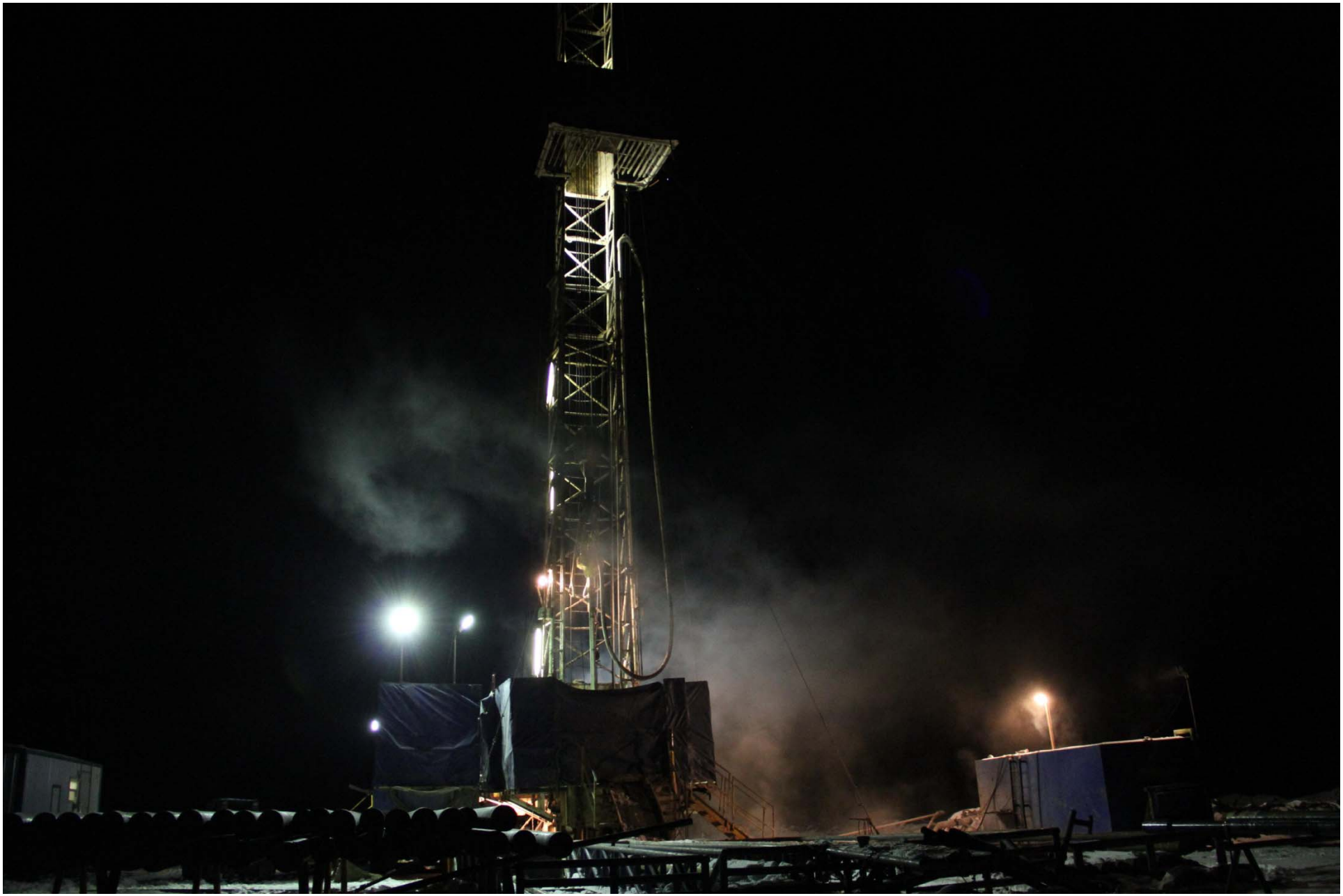




PIF

Joshi Technologies International, Inc.

C&G Drilling Rig, Eureka KS



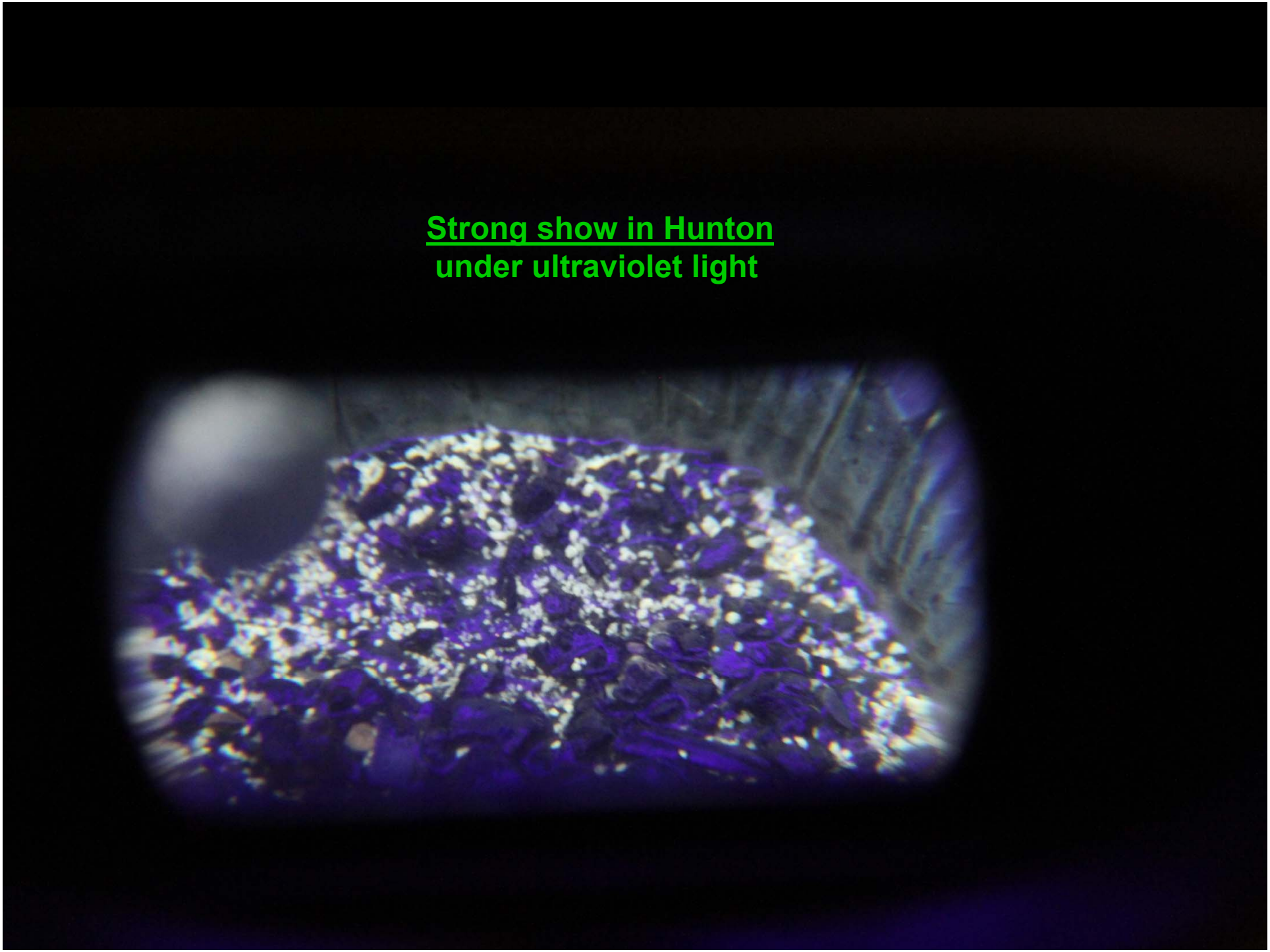
C&G Drilling Rig #2, Geo trailer, Tres Management, Pan American Directional Drilling and MWD

January Field trip for students and industry with the boss
Alan DeGood, American Energies Corporation
John discussing MWD- azimuthal gamma ray tool

KGS colleagues and co-authors Jason Rush and Saibal Bhattacharya with KGS Interim Director Rex Buchanan and DOE's Brian Dressel

Geologist Doug Davis hard at work running samples

Strong show in Hunton - sucrosic, fine intercrystalline Ø dolomite with light brown spotty stain, free oil, fluorescence, cut, odor

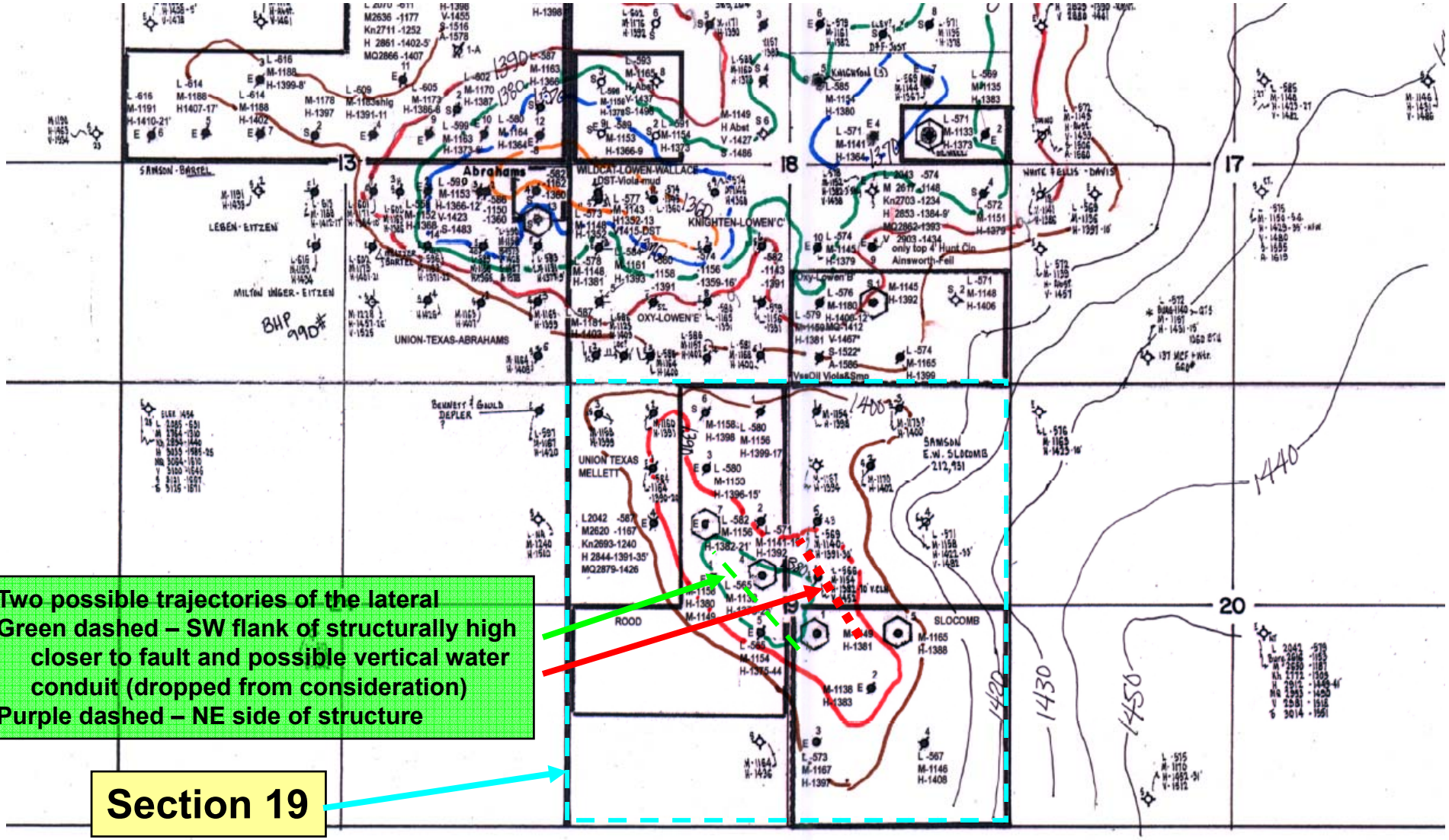

Strong show in Hunton
under ultraviolet light

Outline

- Rig visit
- **Pre-spud analysis**
  - **Stratigraphy, mapping**
  - **Well planning**
- Actual well results
- 3D Visualization
- Concluding Remarks

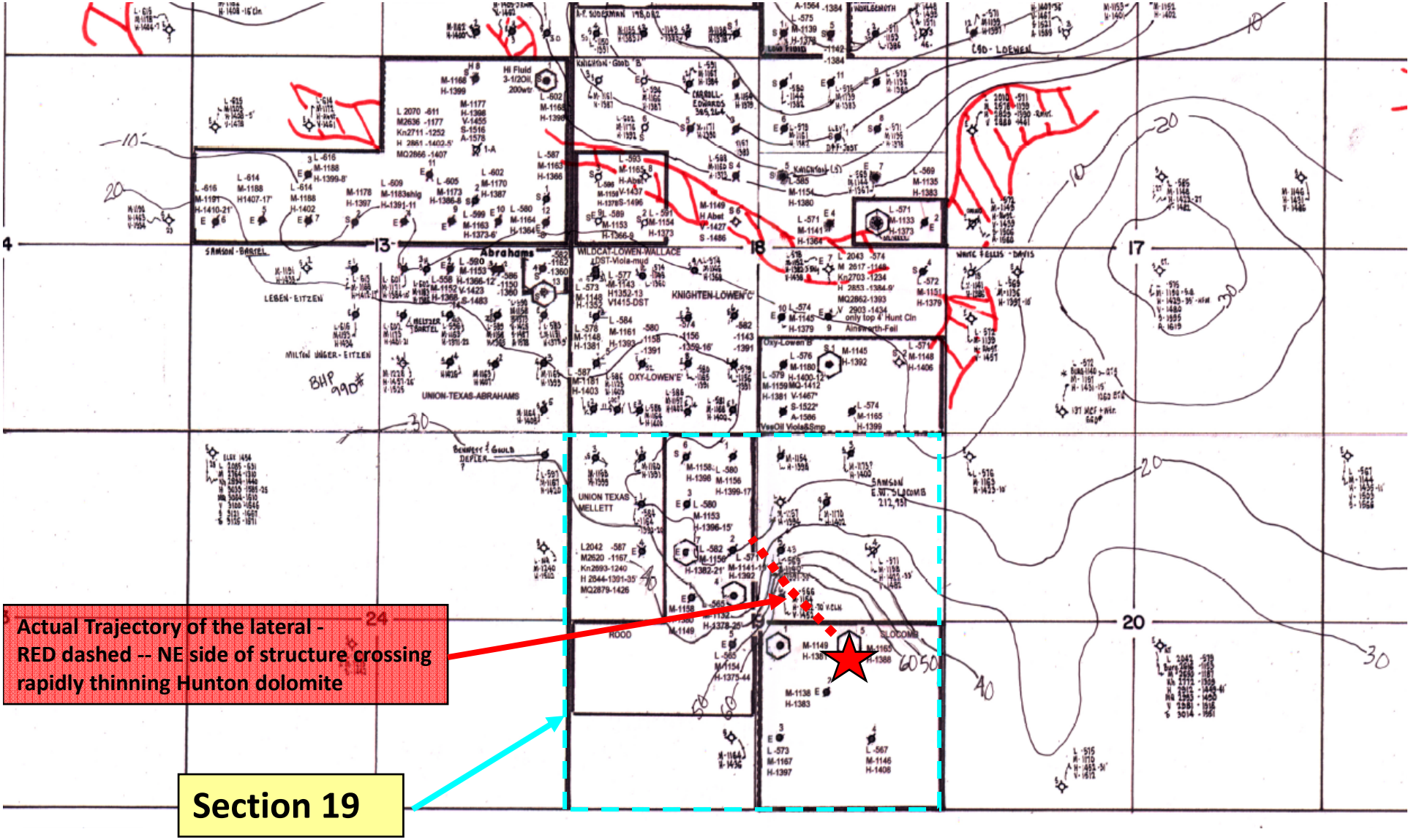
Hunton Structure – south Unger Field

Geology by Gerry Honas

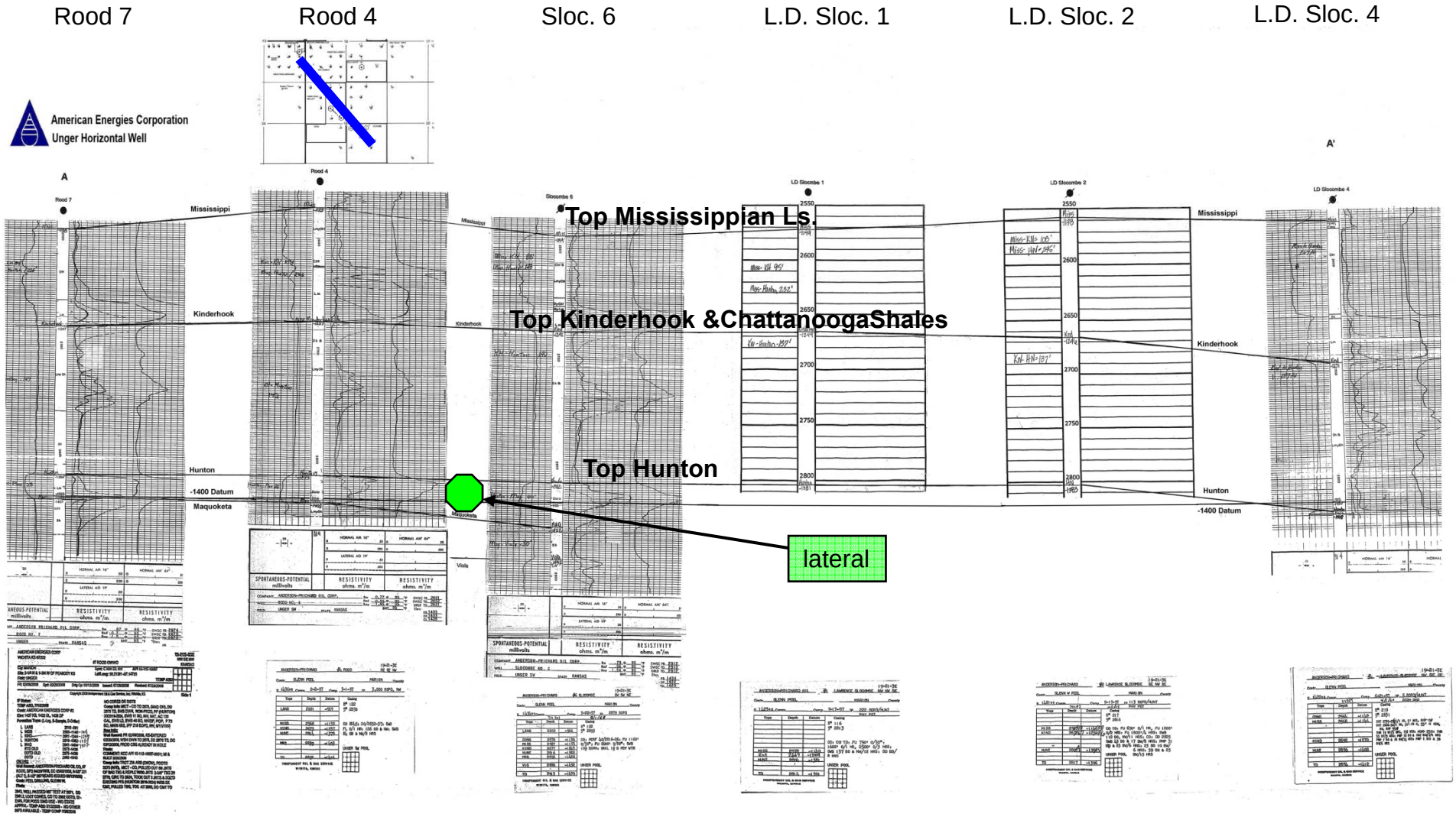


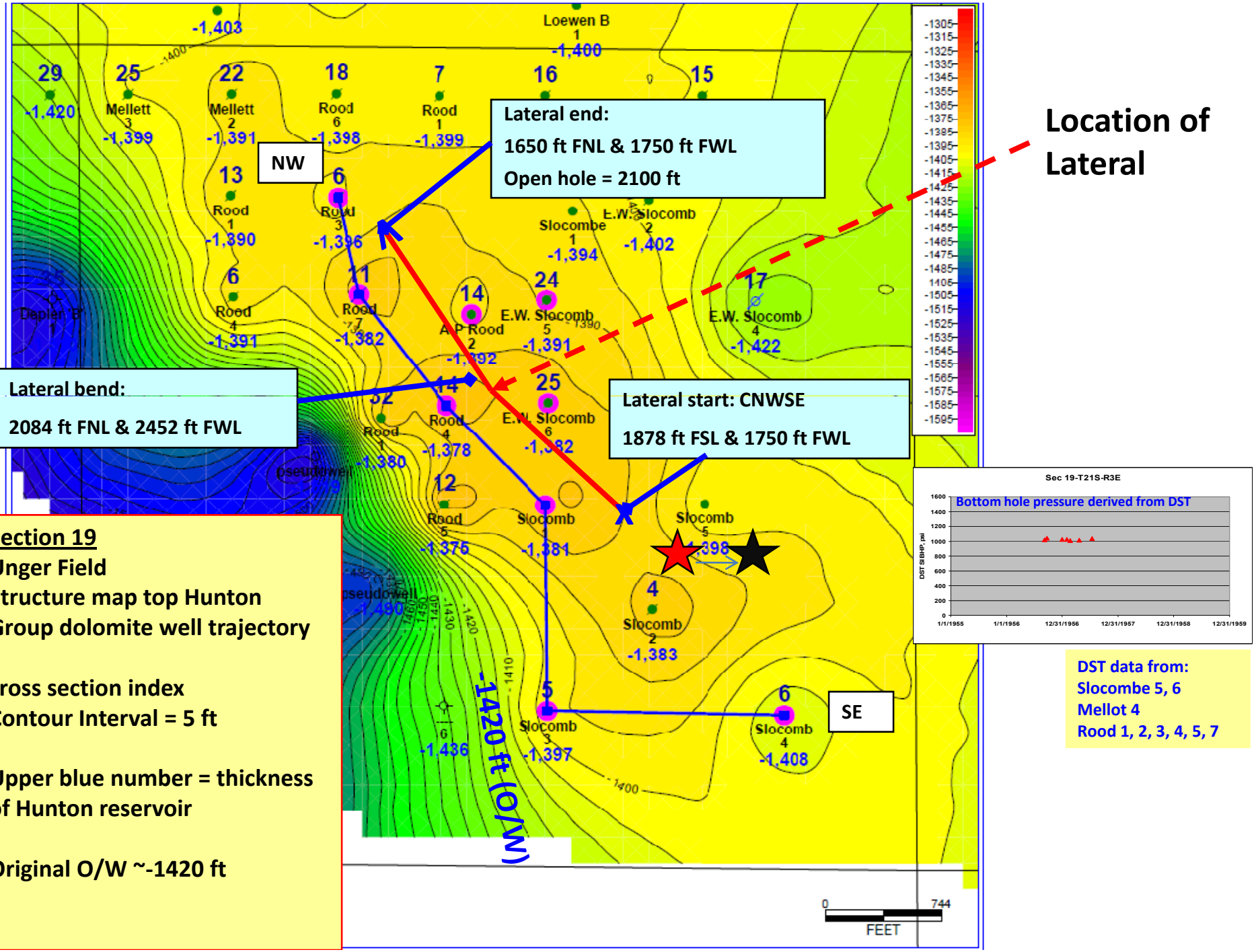
Hunton isopach – south Unger Field

Geology by Gerry Honas

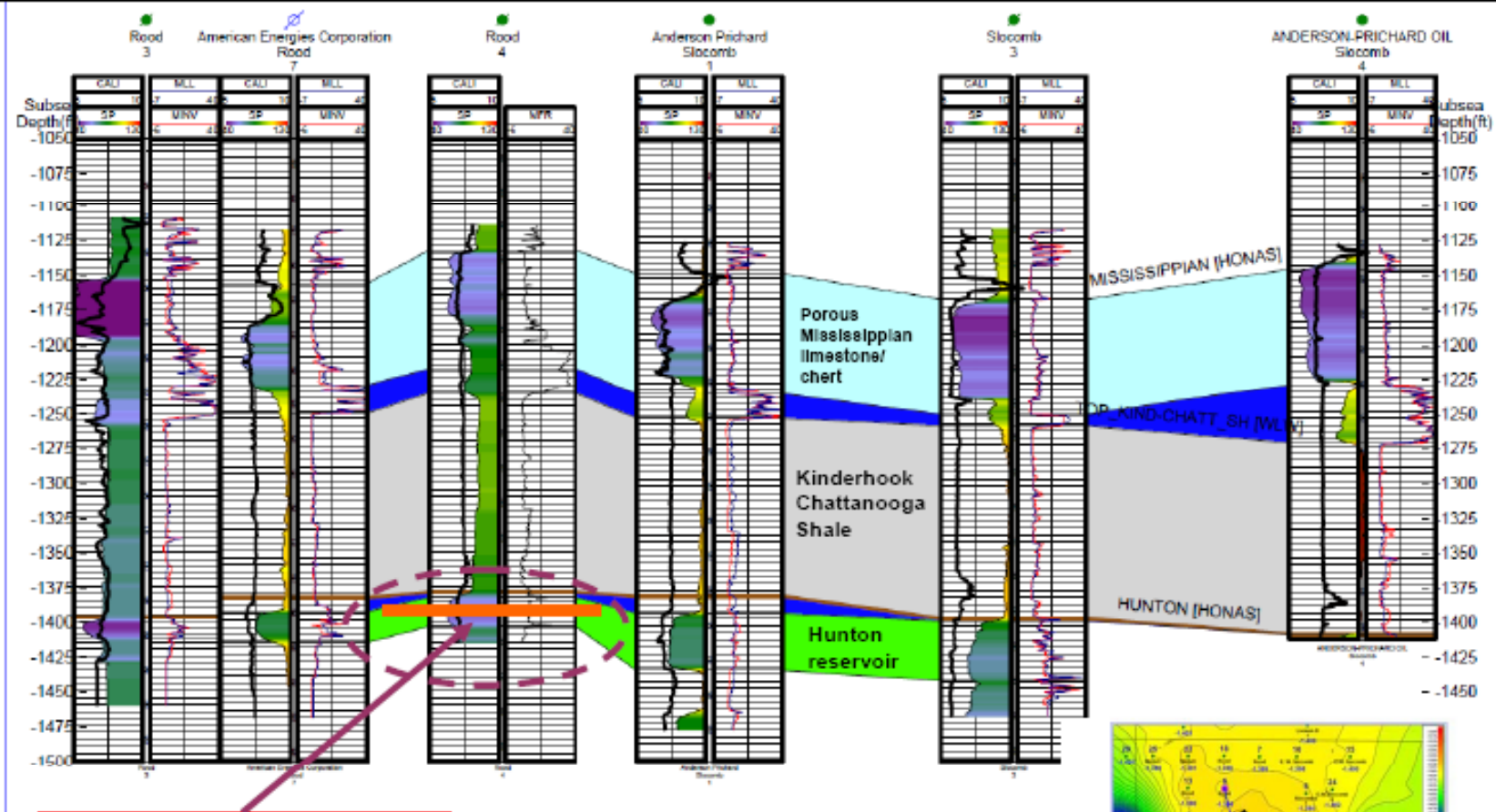


NW-SE structural cross section with scanned wells in sec. 19-21s-3w, Unger Field

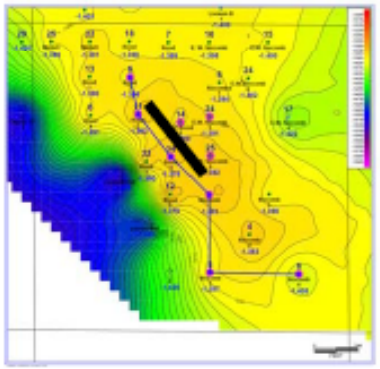



Location of Lateral
Lateral end:
1650 ft FNL & 1750 ft FWL
Open hole = 2100 ft
Lateral bend:
2084 ft FNL & 2452 ft FWL
Lateral start: CNWSE
1878 ft FSL & 1750 ft FWL
NW
SE
-1420 ft (O/W)
Loewen B 1 -1,400
Mellett 3 -1,399
Mellett 2 -1,391
Rood 6 -1,398
Rood 1 -1,399
Rood 1 -1,390
Rood 3 -1,396
Rood 4 -1,391
Rood 7 -1,382
Rood 2 -1,392
Rood 4 -1,378
Rood 1 -1,380
Rood 5 -1,375
Slocombe 1 -1,394
E.W. Slocomb 2 -1,402
E.W. Slocomb 5 -1,391
E.W. Slocomb 4 -1,422
E.W. Slocomb 6 -1,382
Slocomb 1 -1,381
Slocomb 5 -1,398
Slocomb 2 -1,383
Slocomb 3 -1,397
Slocomb 4 -1,408
Sec 19-T21S-R3E
Bottom hole pressure derived from DST
DST SIBHP, psi
DST data from:
Slocombe 5, 6
Mellot 4
Rood 1, 2, 3, 4, 5, 7
Section 19
Unger Field
Structure map top Hunton Group dolomite well trajectory
cross section index
Contour Interval = 5 ft
Upper blue number = thickness of Hunton reservoir
Original O/W ~-1420 ft
0
744
FEET

NW-SE Structural Cross Section #1

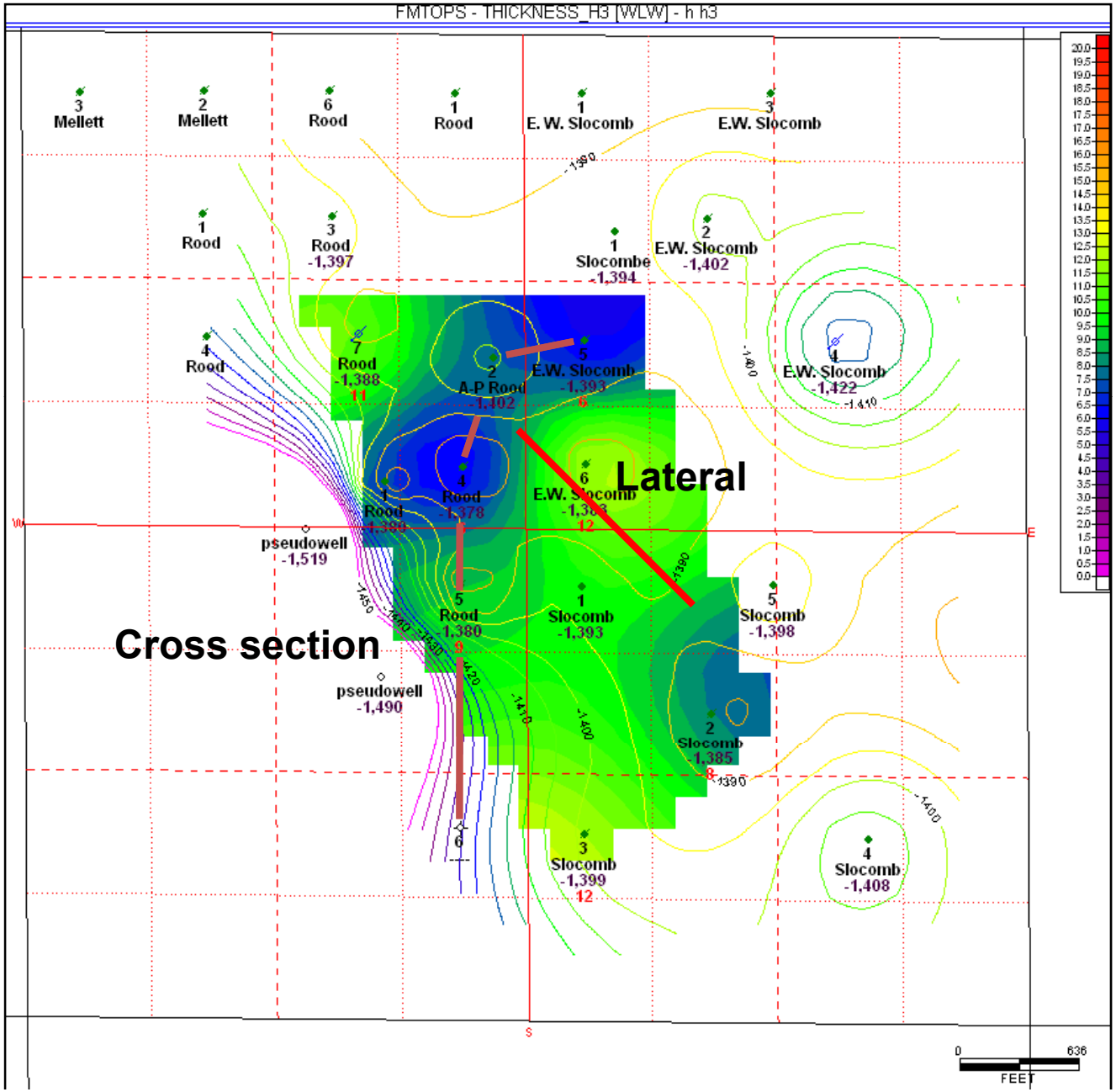


Target zone for lateral Paralleling cross section



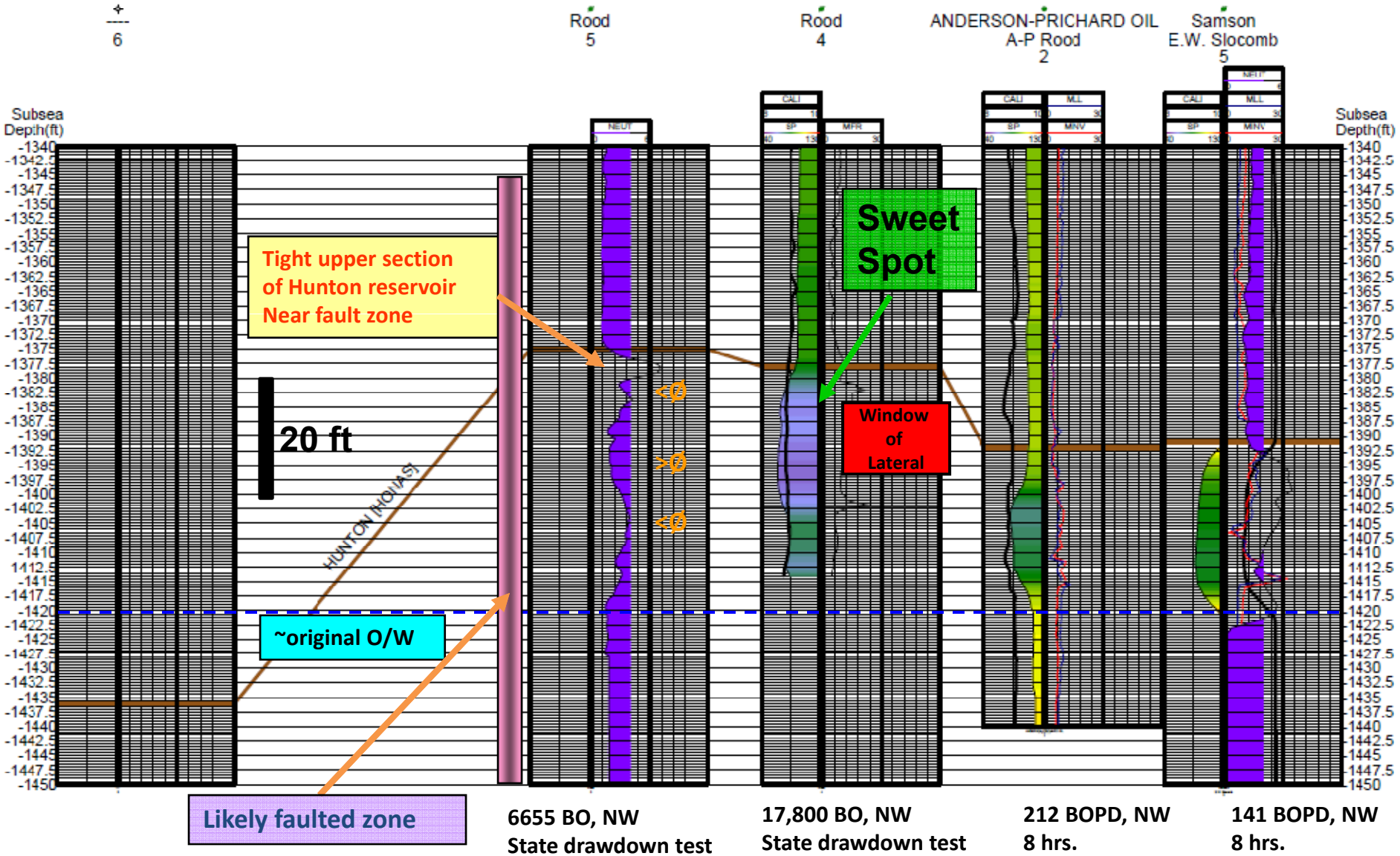
SP-Caliper-Microlog curves shown – SP depicted in color delimiting magnitude

Thickness of H3 layer with structure top of pay zone as contours



South to Northeast Structural Cross Section

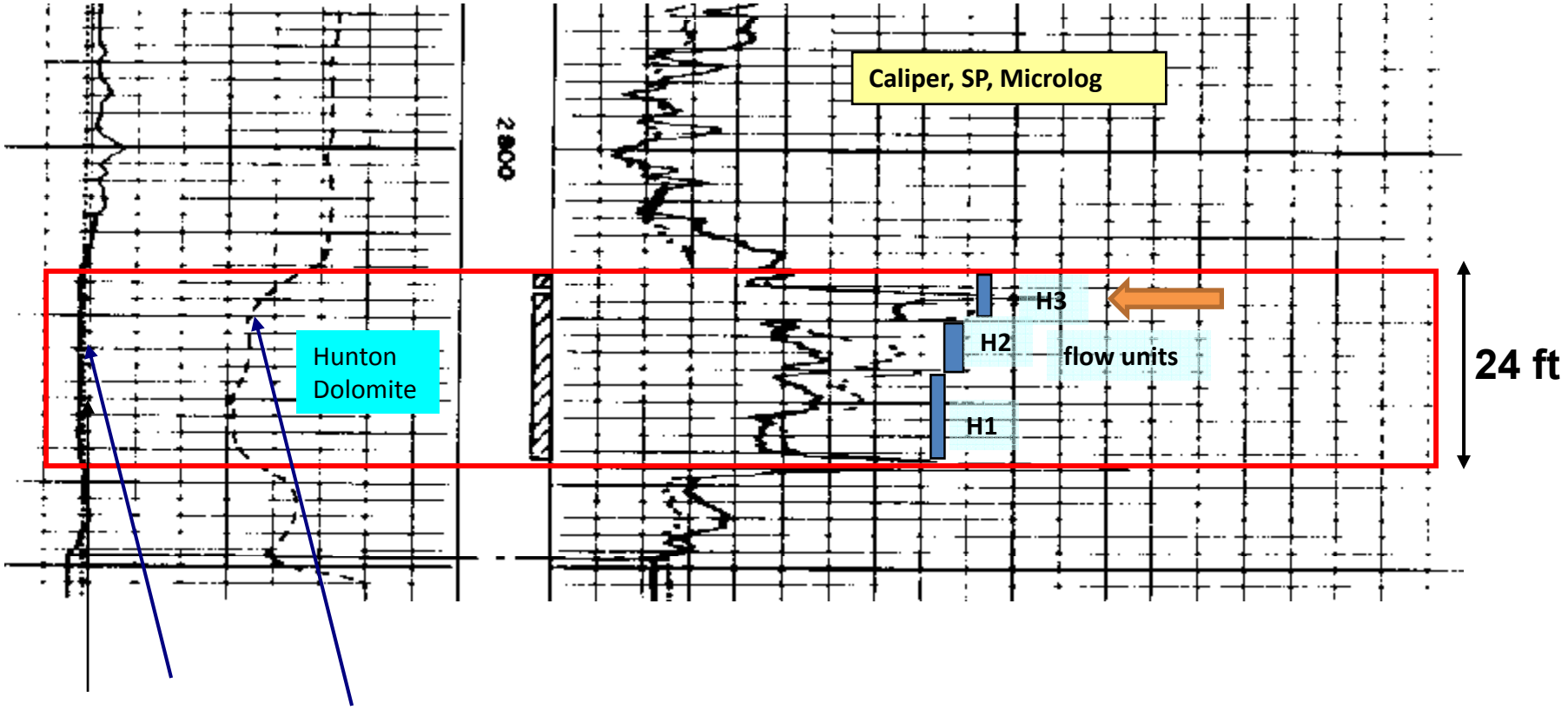
- **SP-Caliper-Microlog, neutron curves shown – SP (variable color) and neutron (all purple)**
- **Lateral passes through this cross section east of Rood #4**



Vertical Exaggeration = 3x

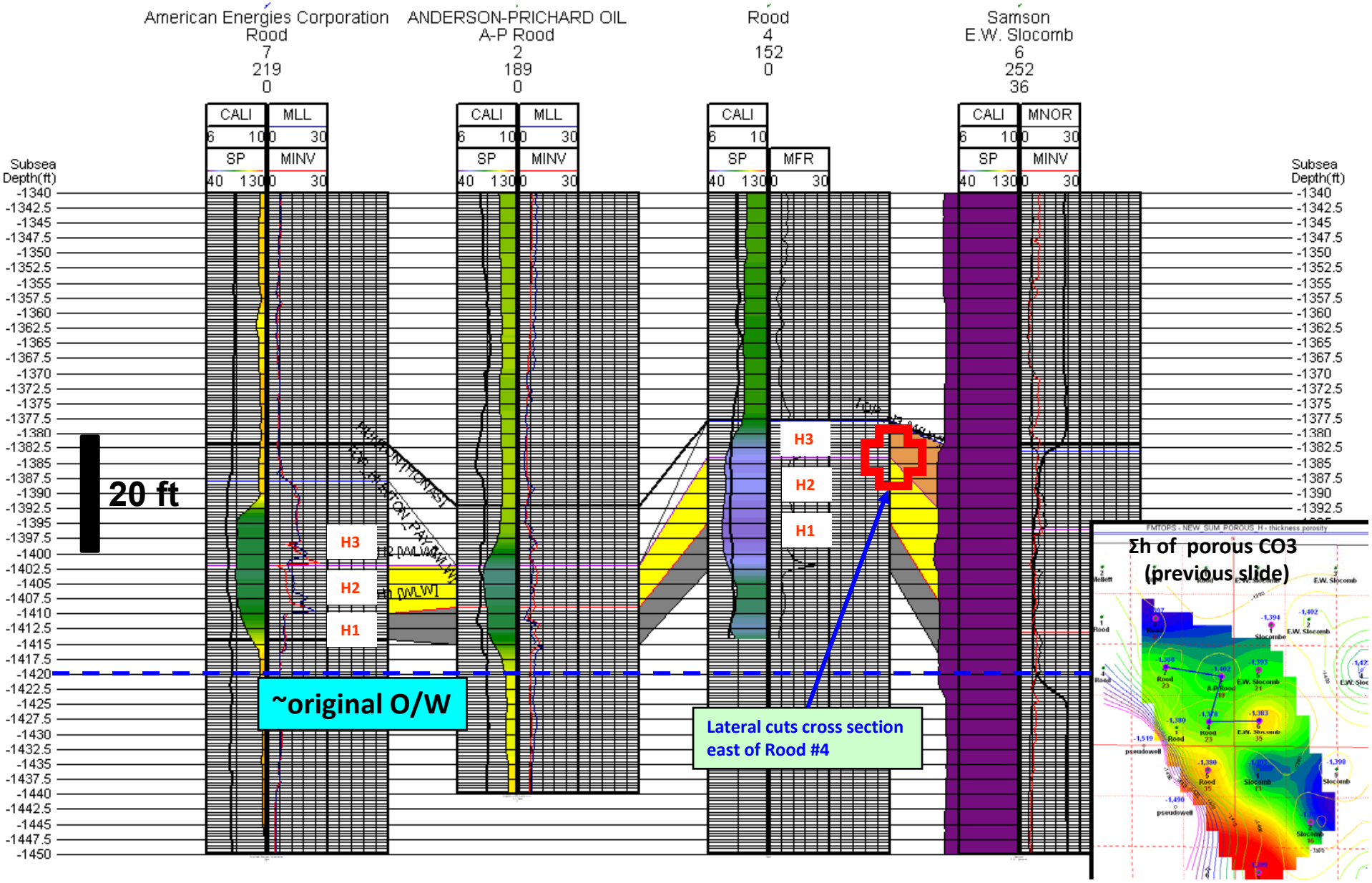
Rood #4 se se nw 19 CAL-SP-Microlog
Effective ~14 ft.
Upper zone ~6 ft.

key well immediately west of lateral



Good SP deflection (dashed line)
and mudcake (positive deflection of caliper – solid line)
suggest matrix permeablematrix porosity

NW-SE Structural Cross Section
with flow units (H1, H2, H3) of Hunton dolomite reservoir



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Horizontal Drilling Plan – Unger Field, Marion County, Kansas

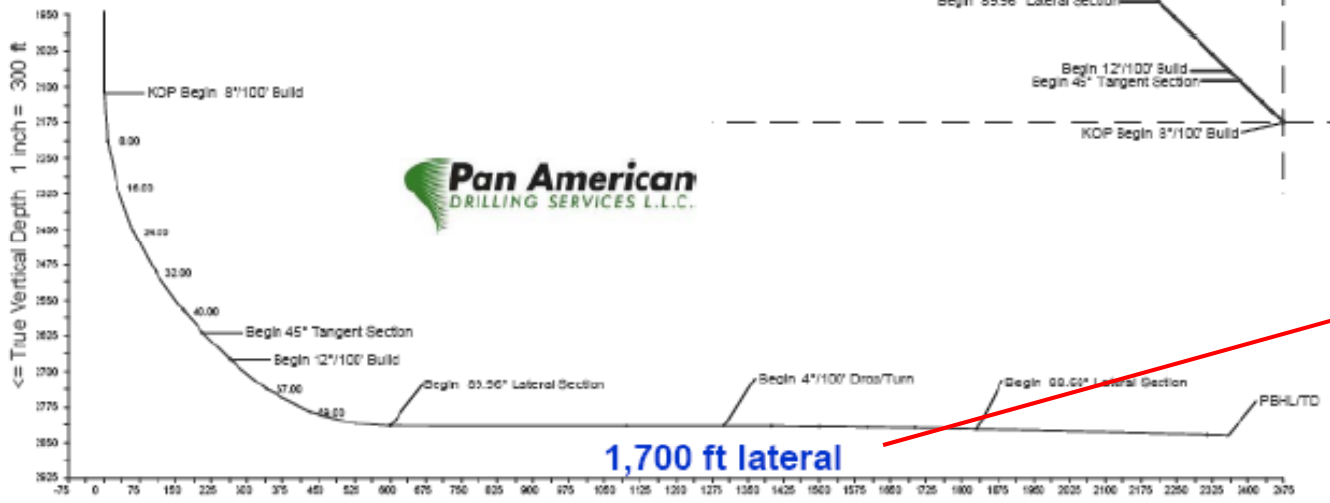
American Energy Corporation

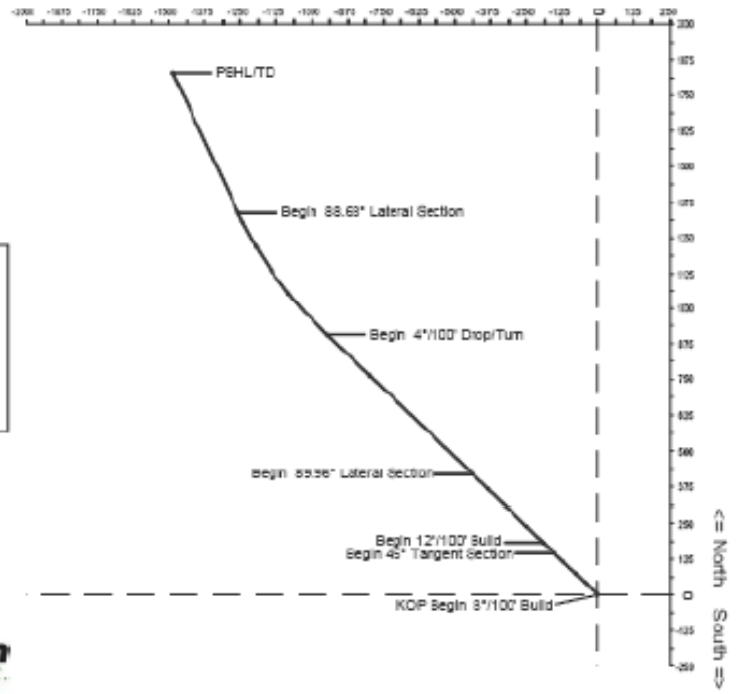
Unger Field

1 inch = 500 ft <= West East =>

WELL PROFILE DATA rev0

MD	Inc.	Azi.	TVD	N/-S	E/-W	DLS	Comment 09-19-2010
2113	0.00	313.70	2113	0	0	0.00	KOP Begin 8°/100' Build
2675	45.00	313.70	2619	145	-152	8.00	Begin 45° Tangent Section
2755	45.00	313.70	2676	184	-193	0.00	Begin 12°/100' Build
3130	89.96	313.70	2815	417	-436	11.00	Begin 89.96° Lateral Section
3887	89.96	313.70	2816	906	-948	0.00	Begin 4°/100' Drop/Turn
4371	88.68	305.00	2822	1330	-1237	4.00	Begin 88.68° Lateral Section
4915	88.68	305.00	2835	1830	-1417	0.00	PBHL/TD





Pan American DRILLING SERVICES L.L.C.

actual 1137 ft.

Azimuthal Gamma Ray

ran while drilling to assist geosteering

Pan American DRILLING SERVICES L.L.C.

Focus/azimuthal Gamma (sensor)
-- To avoid shale caprock above reservoir and shale below reservoir

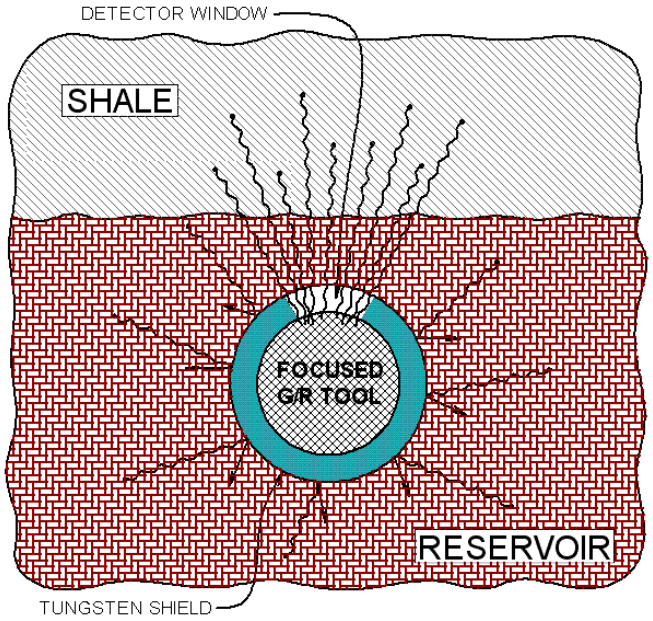
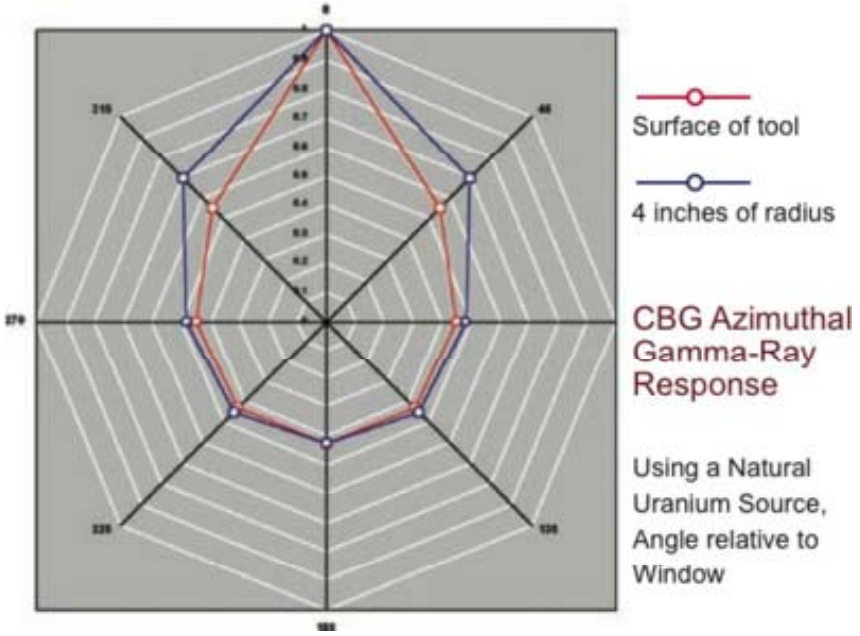


FIG. 1



Drilling is paused while detector window on azimuthal gamma ray tool is rotated and measurements taken every 45 degrees through 360 degree rotation.

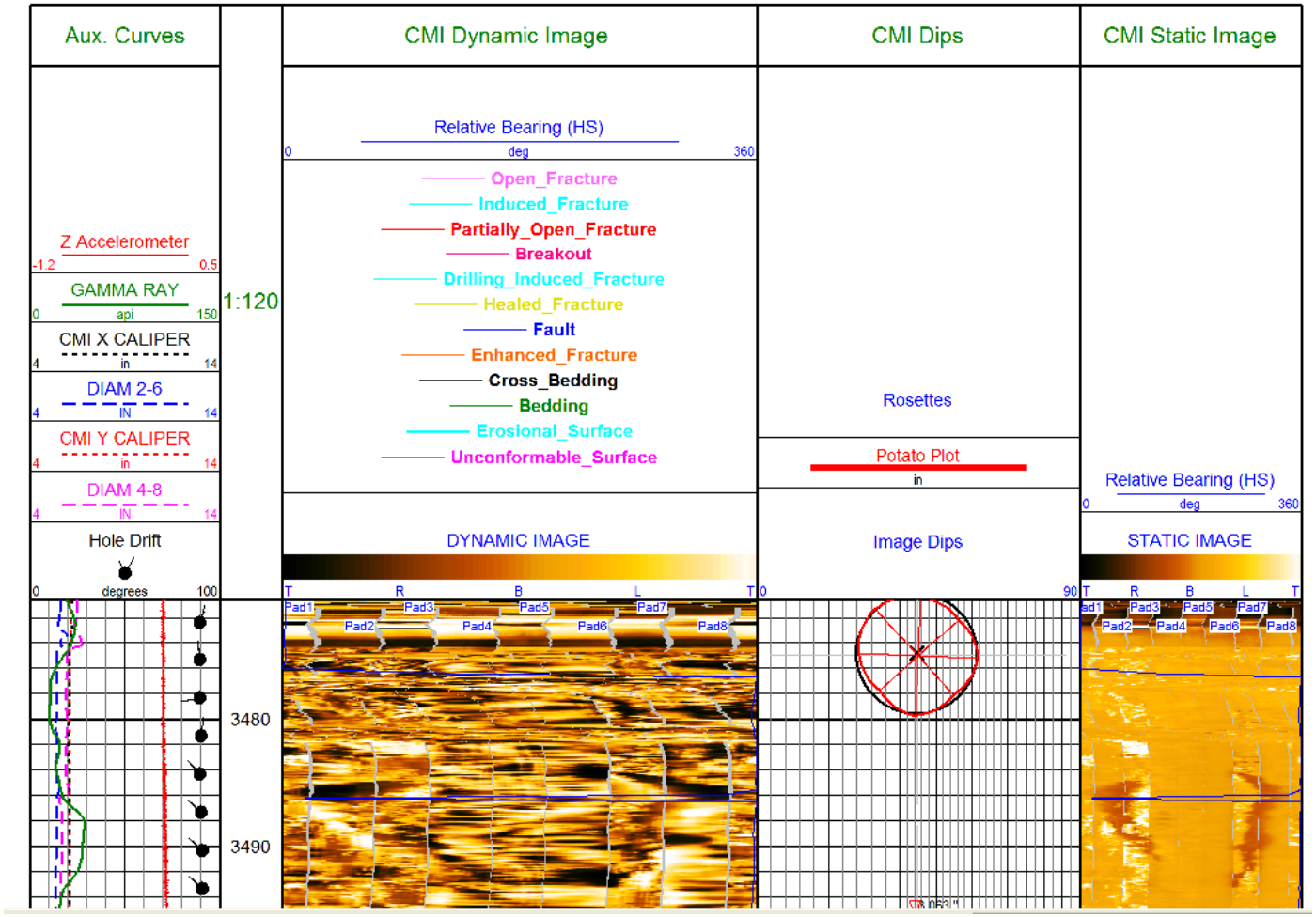
Ran Post-drill (drill pipe conveyed)

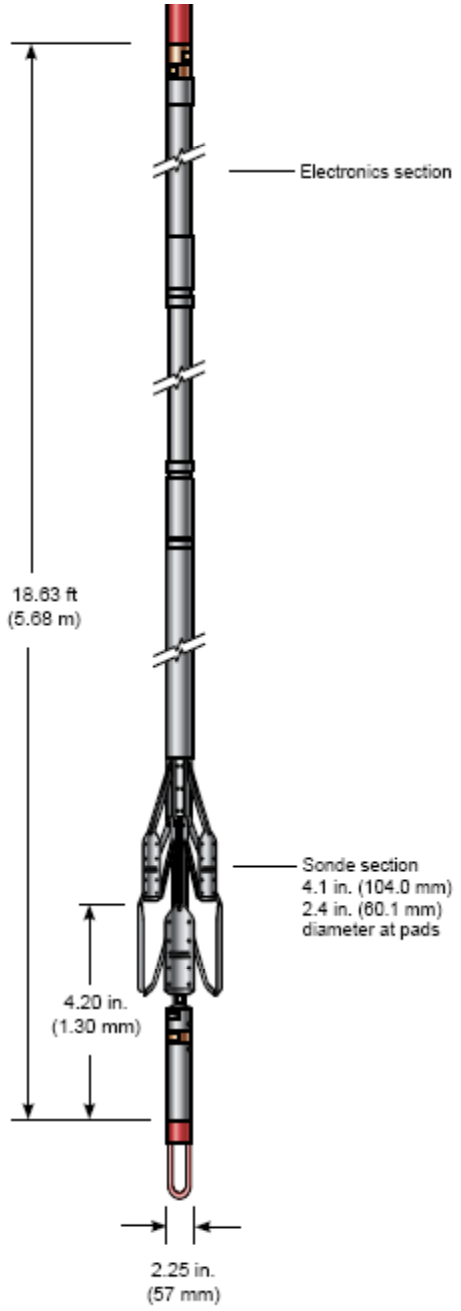
Weatherford®

Wireline Services

Open Hole | Formation Imaging

Compact™ Microimager (CMI)





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American Energies
Corporation

155 N. Market, Suite 710, Wichita, KS
316-263-5785, 316-263-1851 fax

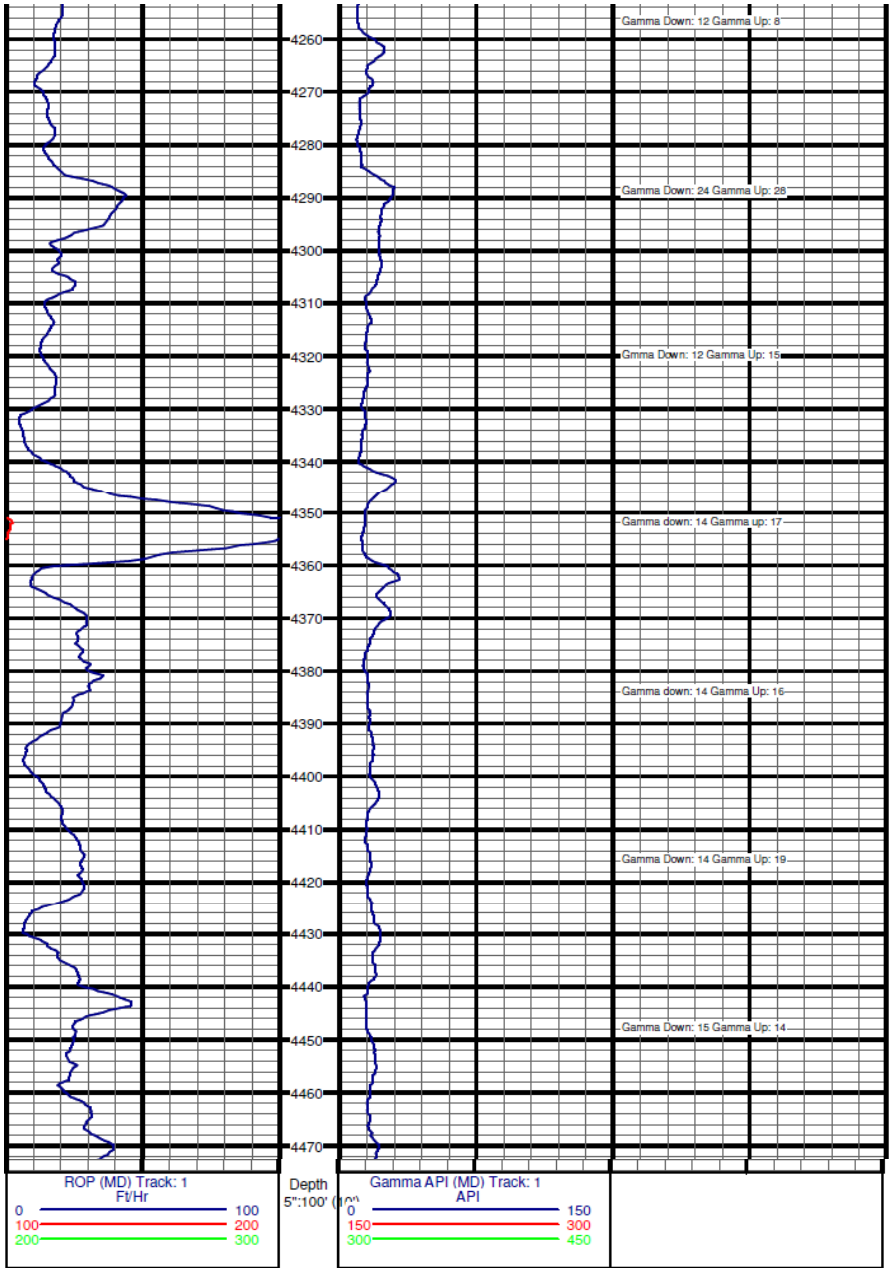
AMERICAN ENERGIES CORPORATION
COMPLETION RECOMMENDATION
Slocombe-Rood #1-19

LOCATION: NE SE NW SE Sec. 19-T21S-R3E
COUNTY: Marion
API: 15-115-21419-01-00
CONTRACTOR: C & G Drilling, Inc.
GEOLOGIST: Doug Davis

DST'S: None Taken
SAMPLE TOPS: None Taken
LOG TOPS: None Taken
LTD: **4613'**

SURFACE CASING: 6 jts 9 5/8" set @ 256.01'
PRODUCTION CASING: 78 jts 7" set @ 3470'
PROJECTED RTD: 2815', TVD: 4617'
G.L.: 1421' **K.B.: 1430'**
SPUD DATE: 01/06/11
COMPLETION DATE:
TOTAL VERTICAL DEPTH: **2820'**
TOTAL LATERAL DEPTH: **1137'**
TOTAL HORIZONTAL DEPTH: **4613'**

Azimuthal Gamma ray with ROP



Directional Drilling Survey
MD, Inclination, Azimuth, TVD
Build & Turn

Pan American Drilling Services
Well Report

Company : American energies corp
Well : slocombe rood #1-19
Location : Marion County
Reference : GRIDNORTH

Date : 1/21/2011
File :OK11002

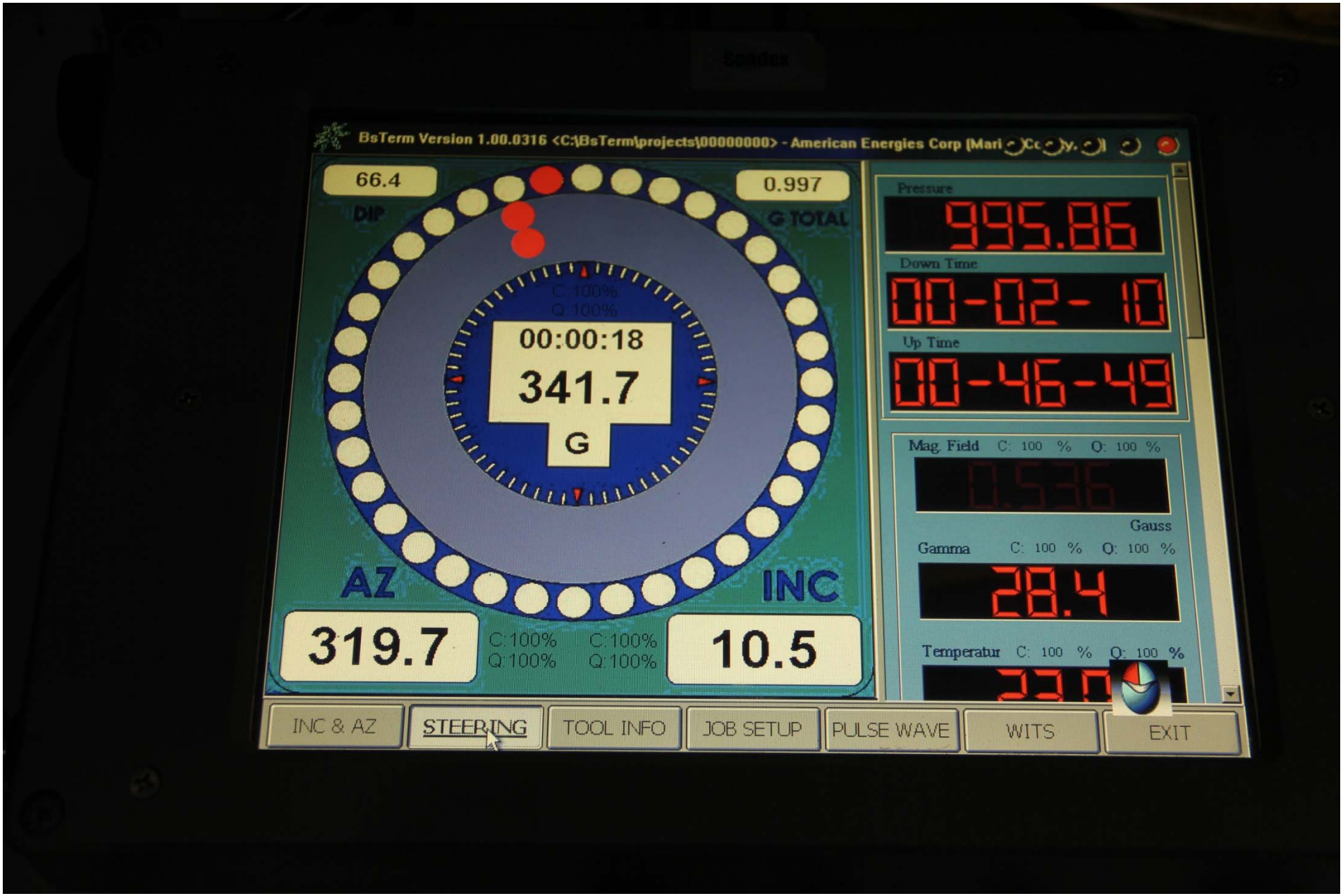
KB Elevation : 0
License :

Gr Elevation : 0.00
UWI :

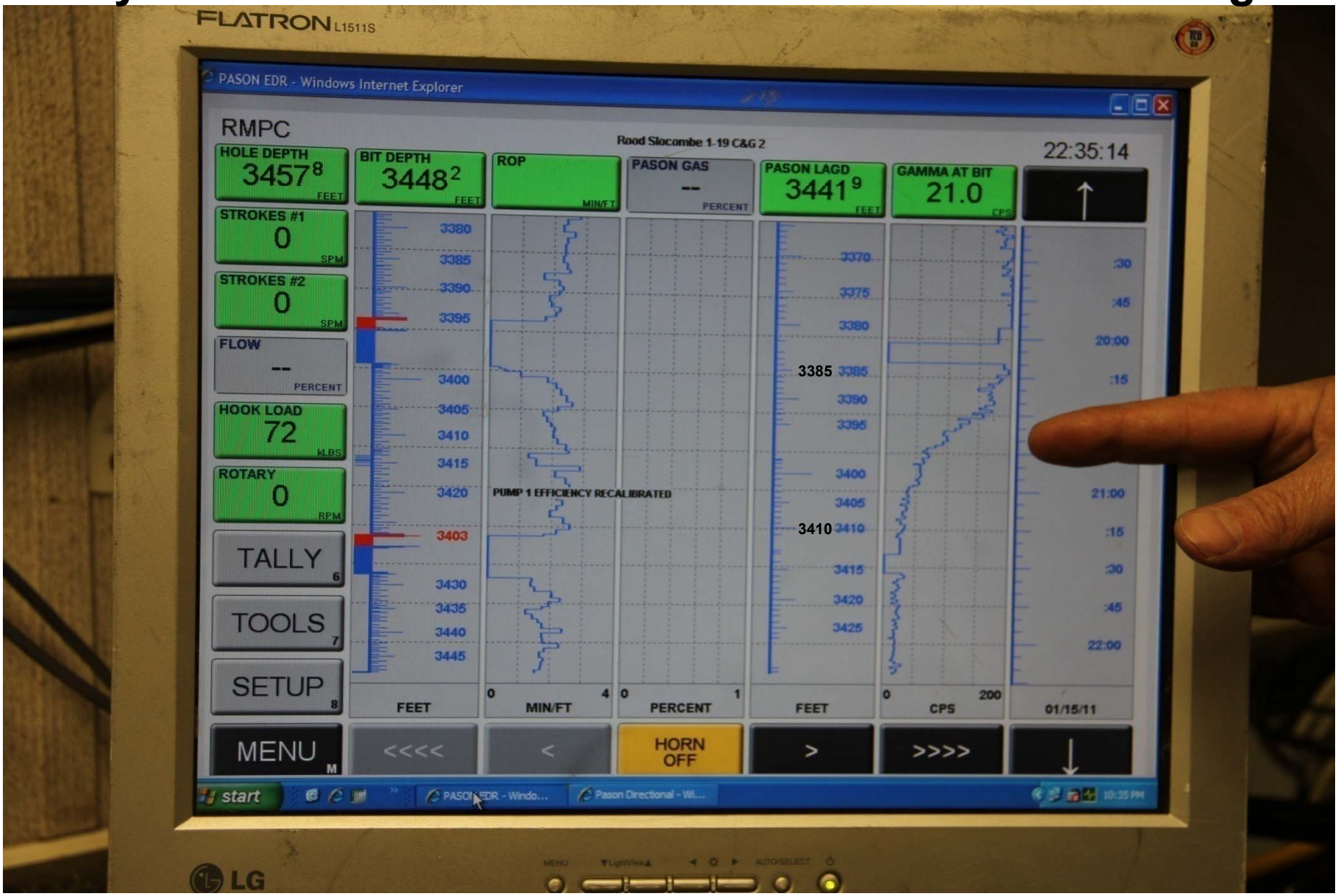
Vertical Section Calculated Along Azimuth 319.44°

MD ft	Inc deg	Azi deg	TVD ft	North ft	East ft	V'Sect ft	D'Leg °/100	Build °/100	Turn °/100
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2067.00	0.10	288.70	2067.00	0.58	-1.71	1.55	0.00	0.00	-3.45
2099.00	0.90	324.60	2099.00	0.79	-1.88	1.82	2.57	2.50	112.19
2130.00	3.50	322.70	2129.97	1.74	-2.60	3.01	8.39	8.39	-6.13
2161.00	6.60	319.80	2160.85	3.86	-4.32	5.74	10.03	10.00	-9.35
2191.00	10.50	319.70	2190.51	7.26	-7.20	10.20	13.00	13.00	-0.33
2222.00	14.70	318.90	2220.76	12.38	-11.62	16.96	13.56	13.55	-2.58
2253.00	18.70	317.20	2250.44	18.99	-17.58	25.86	13.00	12.90	-5.48
2284.00	22.50	316.30	2279.45	26.93	-25.06	36.75	12.30	12.26	-2.90
2315.00	26.40	315.70	2307.67	36.16	-33.97	49.56	12.61	12.58	-1.94
2346.00	29.30	314.90	2335.08	46.44	-44.16	64.00	9.43	9.35	-2.58
2378.00	30.20	314.60	2362.86	57.62	-55.44	79.83	2.85	2.81	-0.94
2409.00	30.10	314.60	2389.66	68.56	-66.52	95.34	0.32	-0.32	0.00
2440.00	34.20	314.60	2415.90	80.14	-78.27	111.77	13.23	13.23	0.00
2471.00	35.70	314.50	2441.31	92.59	-90.92	129.47	4.84	4.84	-0.32
2502.00	37.30	314.10	2466.23	105.47	-104.12	147.83	5.22	5.16	-1.29
2534.00	38.50	314.10	2491.48	119.15	-118.24	167.40	3.75	3.75	0.00
2565.00	39.70	314.20	2515.54	132.77	-132.26	186.87	3.88	3.87	0.32
2596.00	40.70	314.00	2539.22	146.69	-146.63	206.79	3.25	3.23	-0.65
2627.00	42.00	313.40	2562.49	160.84	-161.44	227.17	4.38	4.19	-1.94
2659.00	42.70	313.40	2586.14	175.65	-177.10	248.61	2.19	2.19	0.00
2690.00	43.00	313.30	2608.86	190.12	-192.43	269.57	0.99	0.97	-0.32
2721.00	43.70	313.50	2631.41	204.75	-207.90	290.73	2.30	2.26	0.65
2752.00	44.50	314.00	2653.67	219.66	-223.48	312.20	2.81	2.58	1.61
2783.00	46.60	314.60	2675.38	235.12	-239.31	334.24	6.91	6.77	1.94
2814.00	50.20	315.50	2695.95	251.53	-255.68	357.35	11.81	11.61	2.90
2845.00	53.30	316.40	2715.14	269.02	-272.61	381.65	10.26	10.00	2.90
2876.00	56.00	317.20	2733.08	287.46	-289.91	406.90	8.96	8.71	2.58
2907.00	60.50	318.80	2749.39	307.05	-307.54	433.25	15.16	14.52	5.16
2939.00	65.20	319.70	2763.99	328.61	-326.12	461.71	14.90	14.69	2.81
2971.00	69.10	319.10	2776.41	351.00	-345.30	491.19	12.31	12.19	-1.88
3000.00	71.80	317.40	2786.11	371.38	-363.50	518.51	10.83	9.31	-5.86
3032.00	74.50	315.70	2795.39	393.61	-384.56	549.10	9.85	8.44	-5.31
3064.00	77.50	314.60	2803.13	415.62	-406.46	580.05	9.95	9.37	-3.44

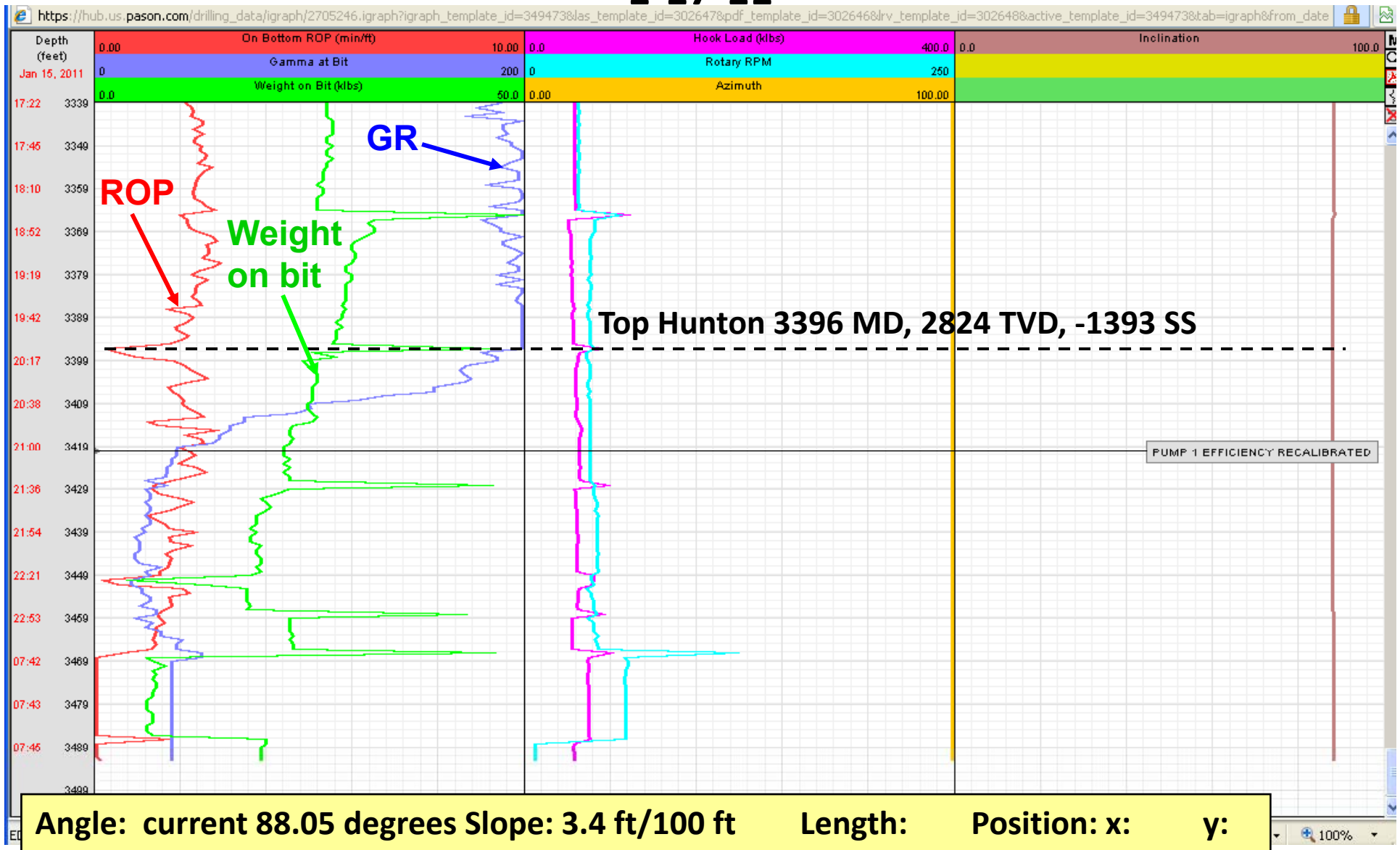
Directional drilling with Pason controls



Pason recording of drilling progress including gamma ray at bit at time enter Hunton dolomite in soft landing

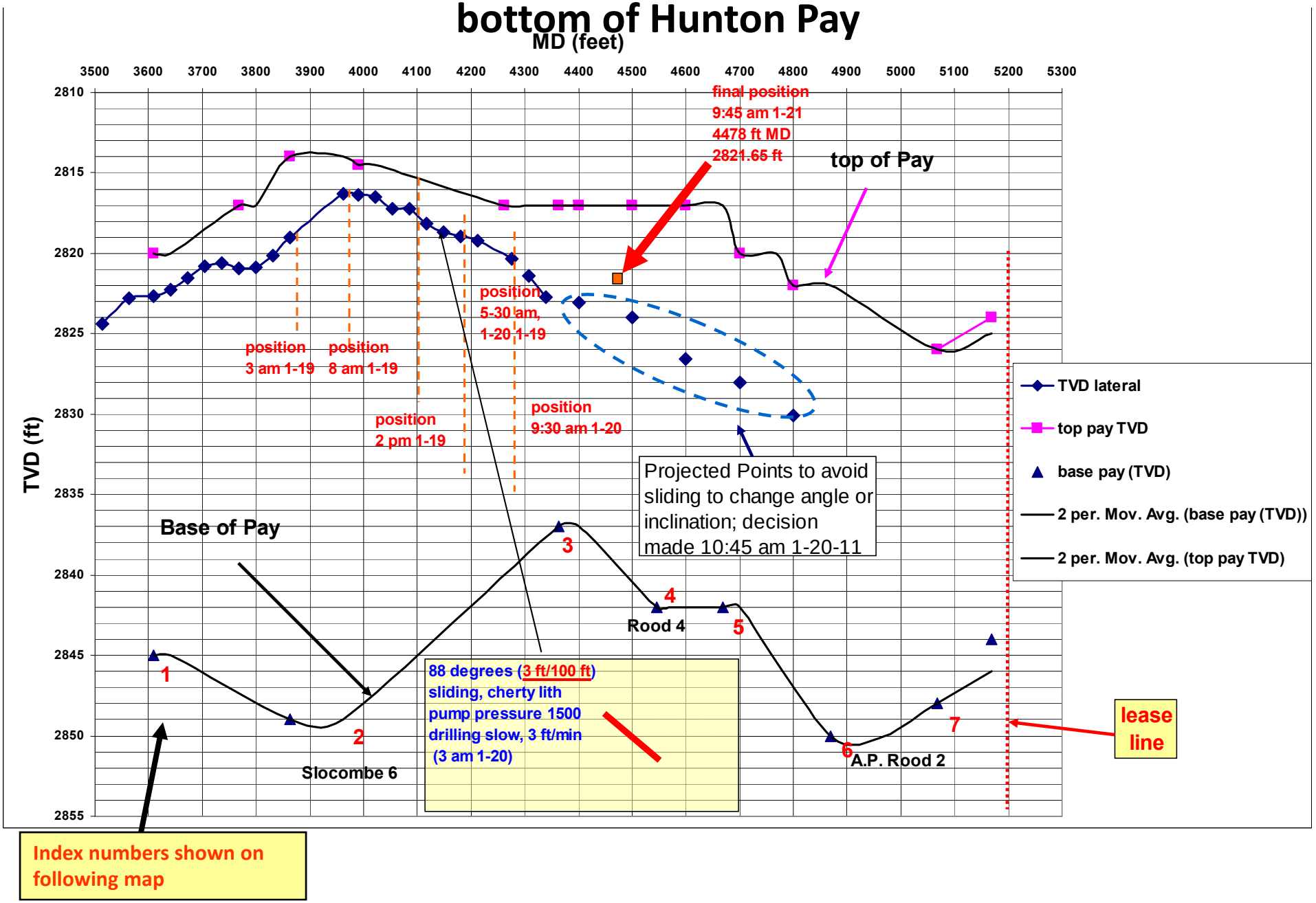


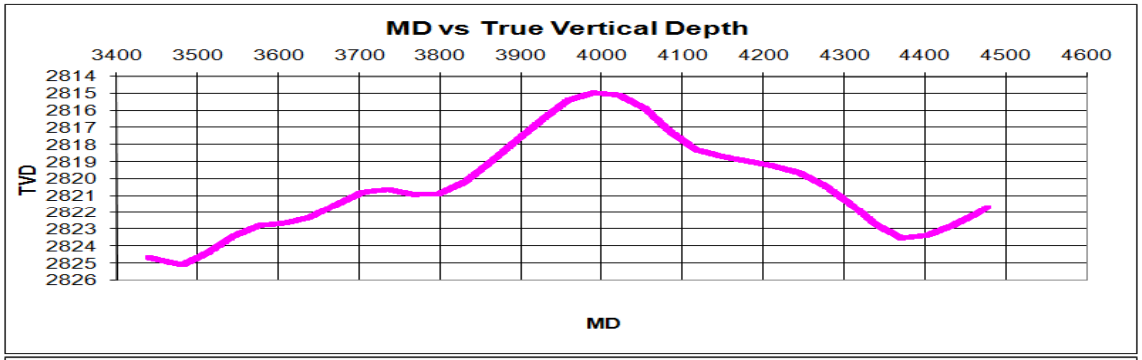
Pason's Real Time Drilling Data at Soft Landing In Hunton Dolomite 1-17-11

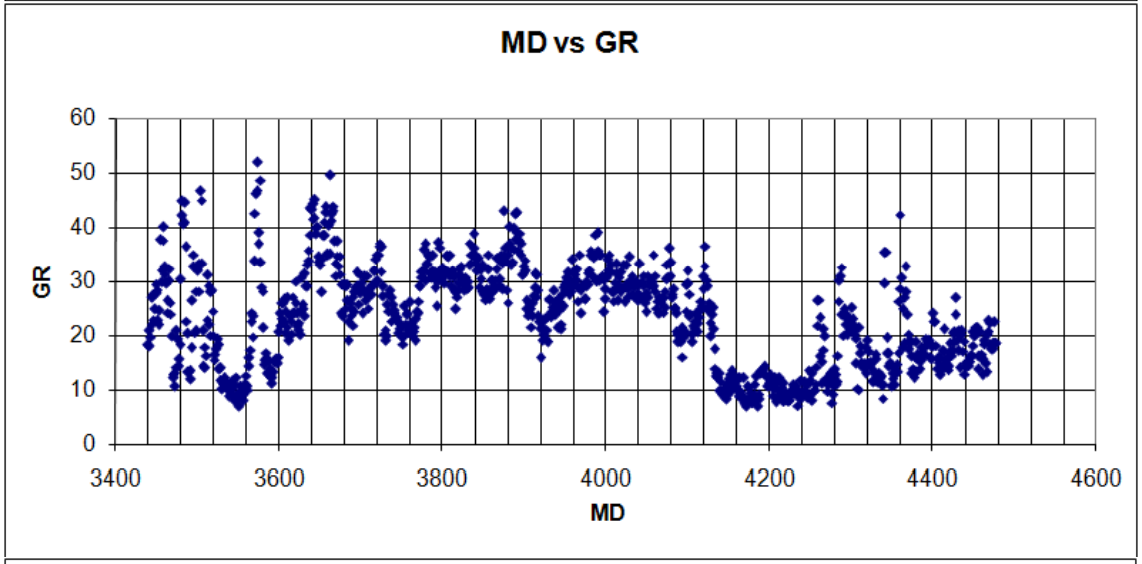


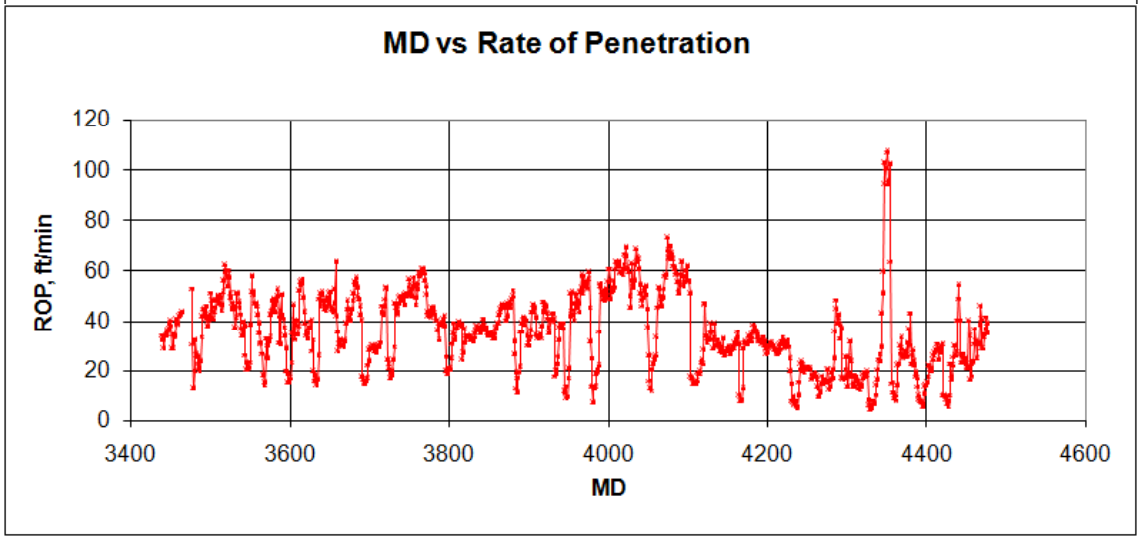
Angle: current 88.05 degrees Slope: 3.4 ft/100 ft Length: Position: x: y:
89 degrees (1.75 ft/100 ft)

MD vs TVD with location of lateral with respect to top and bottom of Hunton Pay

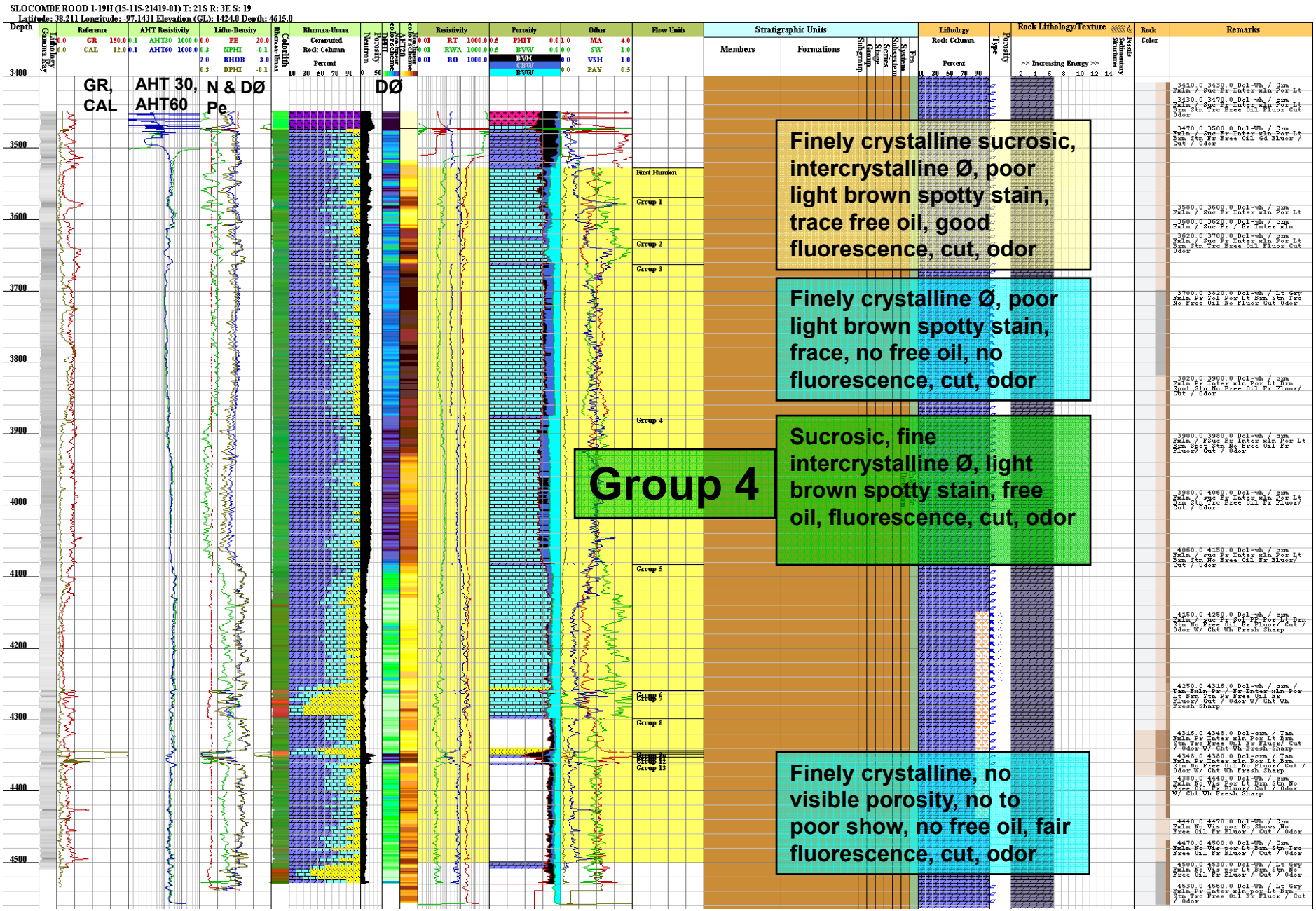



MD vs True Vertical Depth
3400 3500 3600 3700 3800 3900 4000 4100 4200 4300 4400 4500 4600
2814 2815 2816 2817 2818 2819 2820 2821 2822 2823 2824 2825 2826
TVD
MD

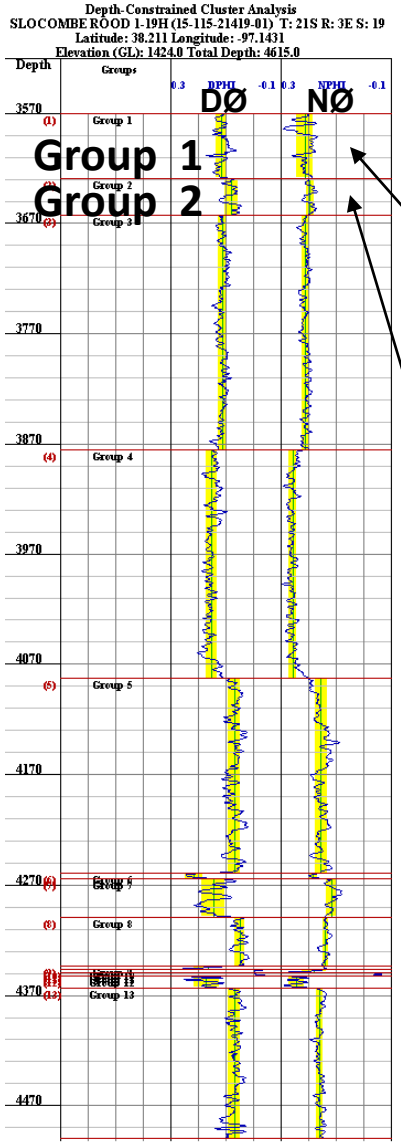

MD vs GR
60 50 40 30 20 10 0
GR
3400 3600 3800 4000 4200 4400 4600
MD


MD vs Rate of Penetration
120 100 80 60 40 20 0
ROP, ft/min
3400 3600 3800 4000 4200 4400 4600
MD

KGS Well Viewer



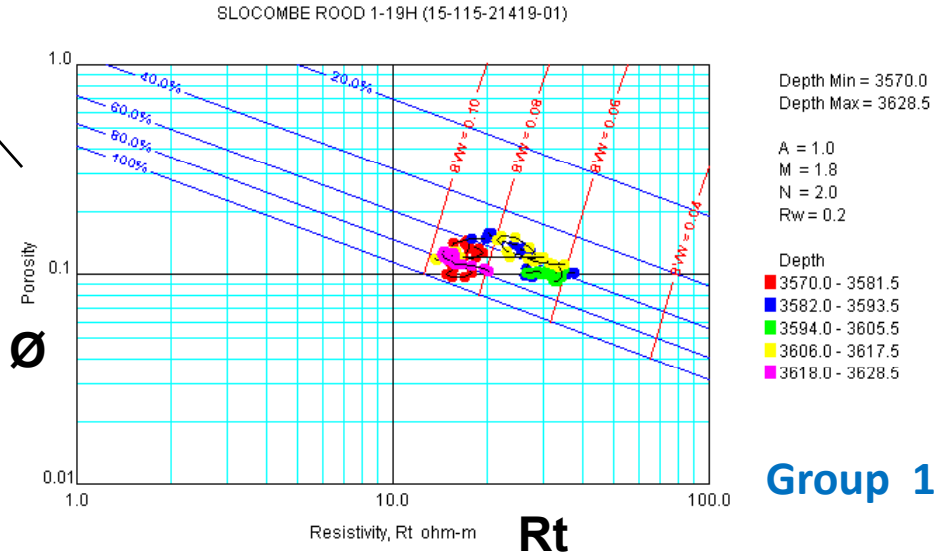
Depth-Constrained Clustering (*Density and Neutron Φ*) & Pickett Plots (*log Rw vs. Φ*)



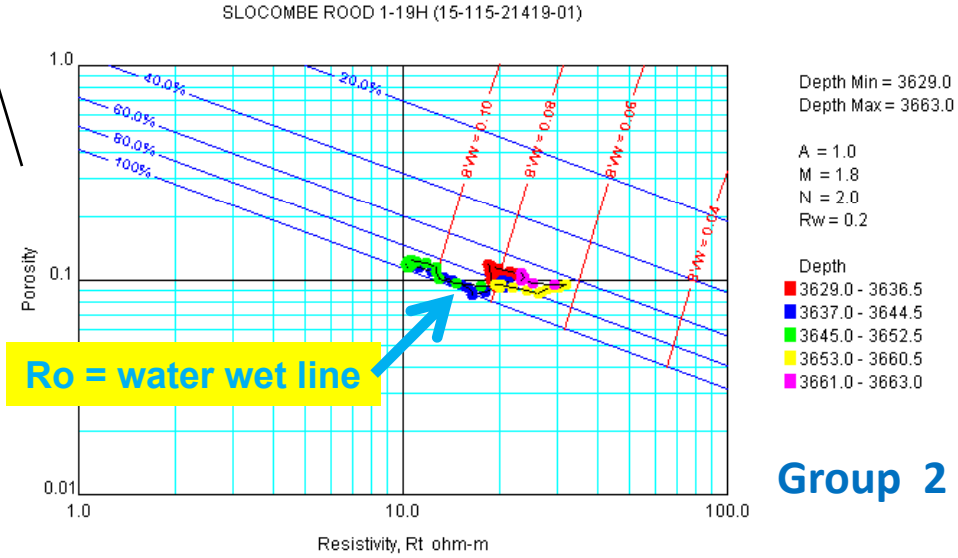
Cluster Analysis - Group Means
Number of Clusters = 13 R-squared = 16.84 %

Start	End	Group (edit)	DPHI	NPHI
3570.0	3628.5	Group 1	0.113	0.211
3629.0	3663.0	Group 2	0.077	0.192
3663.5	3875.0	Group 3	0.111	0.209
3875.5	4083.0	Group 4	0.15	0.255
4083.5	4259.0	Group 5	0.067	0.152
4259.5	4264.0	Group 6	0.214	0.18
4264.5	4298.5	Group 7	0.142	0.113
4299.0	4343.0	Group 8	0.047	0.136
4343.5	4345.5	Group 9	0.163	0.141
4346.0	4348.5	Group 10	0.37	0.176
4349.0	4352.0	Group 11	0.384	0.337
4352.5	4362.5	Group 12	0.168	0.241
4363.0	4500.0	Group 13	0.067	0.156

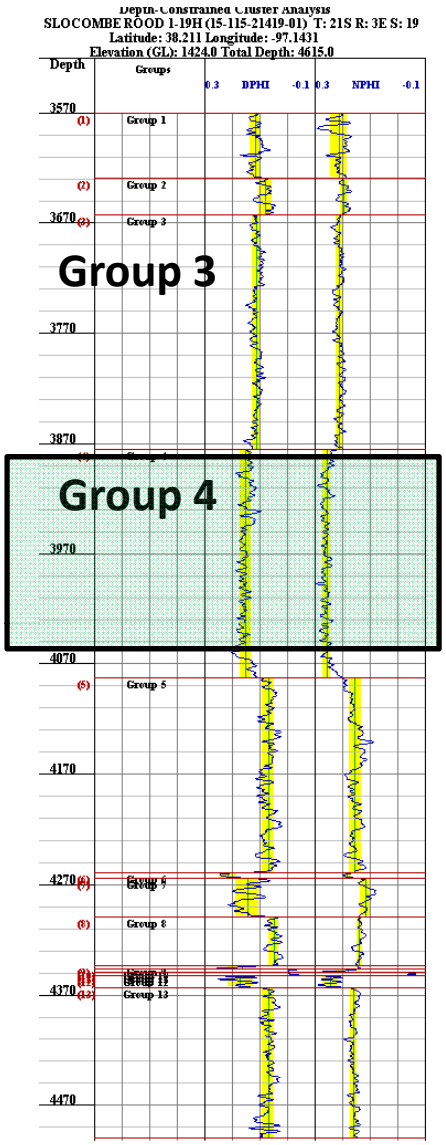
DPHI Density porosity
NPHI Neutron porosity



Group 1



Group 2



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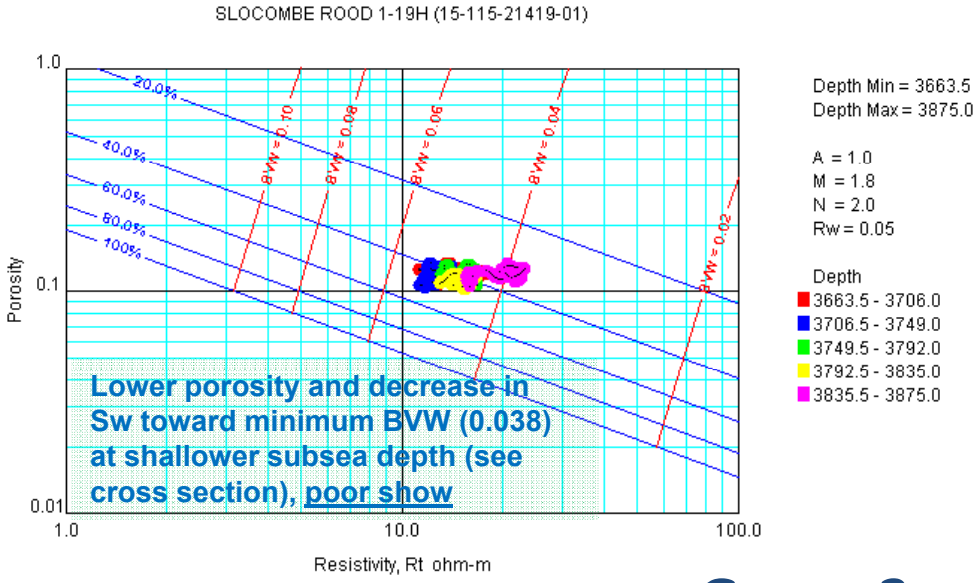
4352.5	4362.5	Group 12	0.168	0.241
4363.0	4500.0	Group 13	0.067	0.156

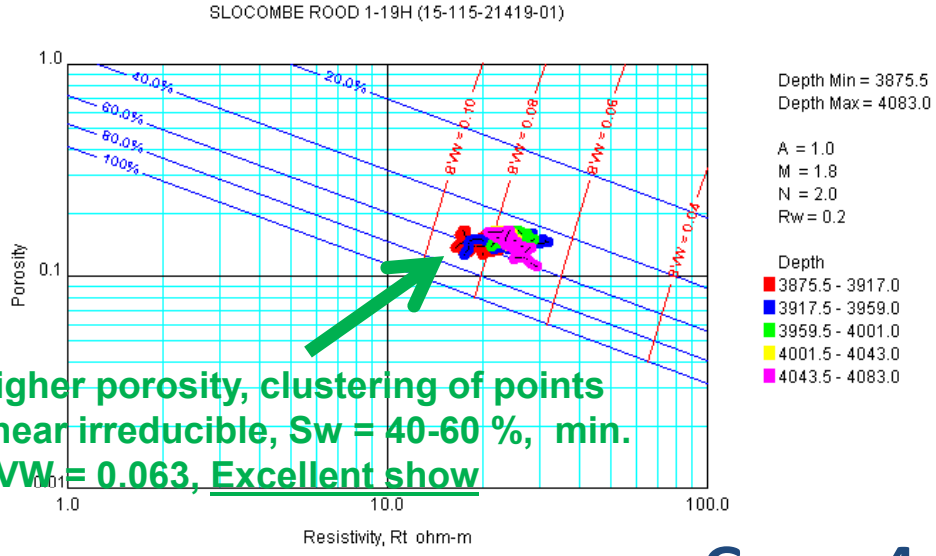
DPHI Density porosity
NPHI Neutron porosity

Likely pay

Run 4.5” tubing with slotted liner, set packers to produce between 3880 – 4060’

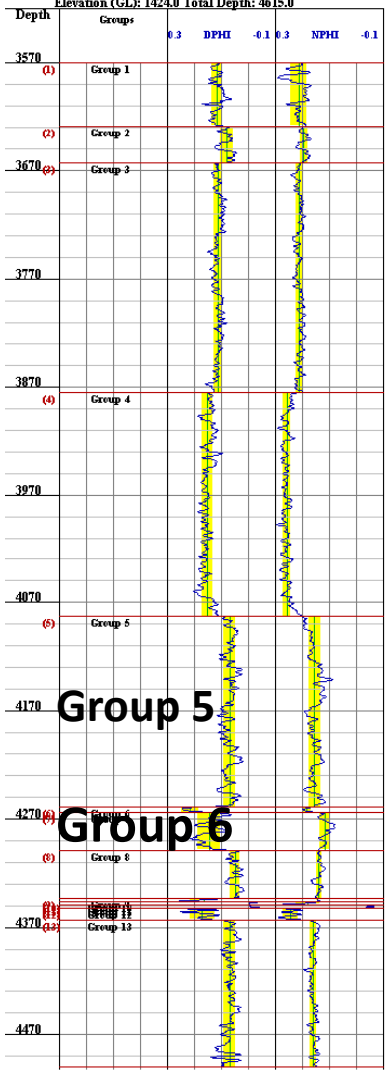


Group 3



Group 4

Depth-Constrained Cluster Analysis
SLOCOMBE ROOD 1-19H (15-115-21419-01) T: 21S R: 3E S: 19
Latitude: 38.211 Longitude: -97.1431
Elevation (GL): 1424.0 Total Depth: 4615.0



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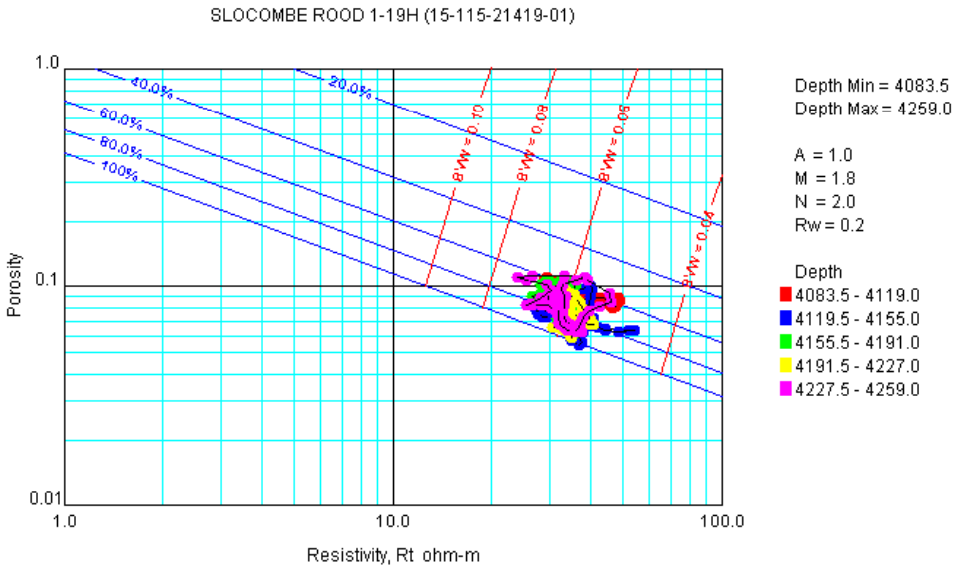
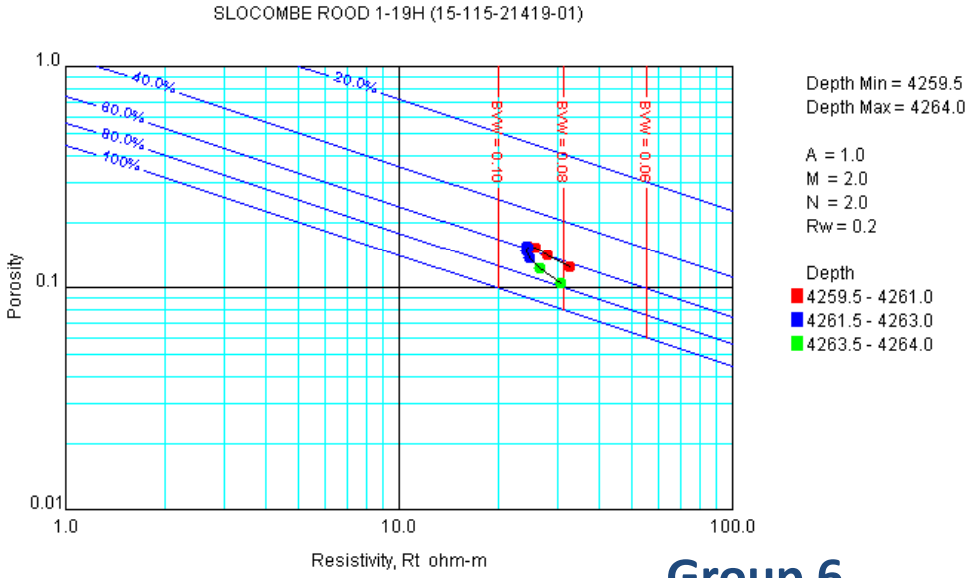
4346.0	4348.5	Group 10	0.37	0.176
4349.0	4352.0	Group 11	0.384	0.337
4352.5	4362.5	Group 12	0.168	0.241
4363.0	4500.0	Group 13	0.067	0.156

DPHI Density porosity
NPHI Neutron porosity

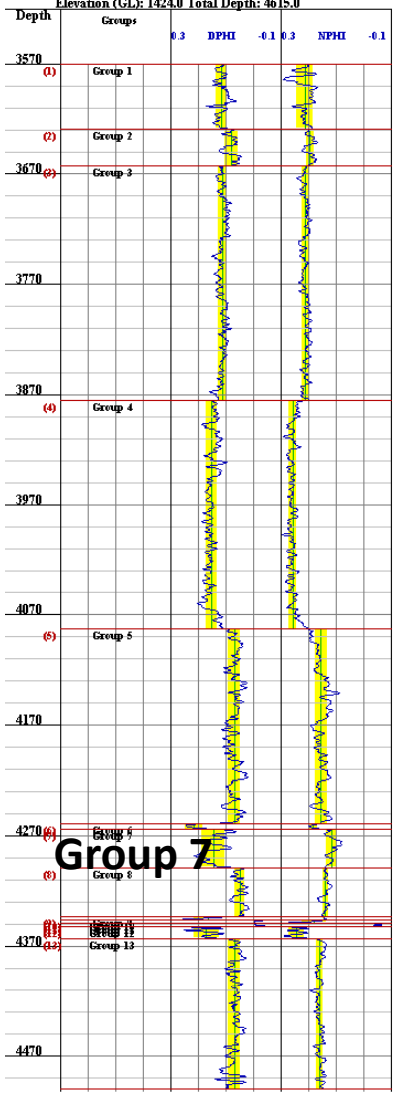


Group 5



Group 6

Depth-Constrained Cluster Analysis
SLOCOMBE ROOD 1-19H (15-115-21419-01) T: 21S R: 3E S: 19
Latitude: 38.211 Longitude: -97.1431
Elevation (GL): 1424.0 Total Depth: 4615.0



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Number of Clusters = 13 R-squared = 16.84 %

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3570.0	3628.5	Group 1	0.113	0.211
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4346.0	4348.5	Group 10	0.37	0.176
4349.0	4352.0	Group 11	0.384	0.337
4352.5	4362.5	Group 12	0.168	0.241
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DPHI Density porosity
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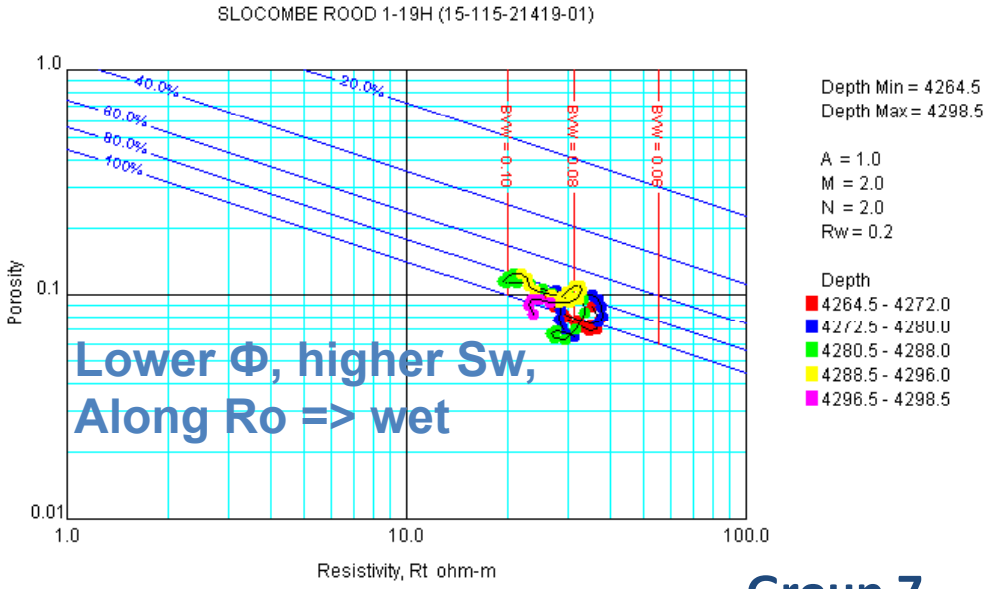
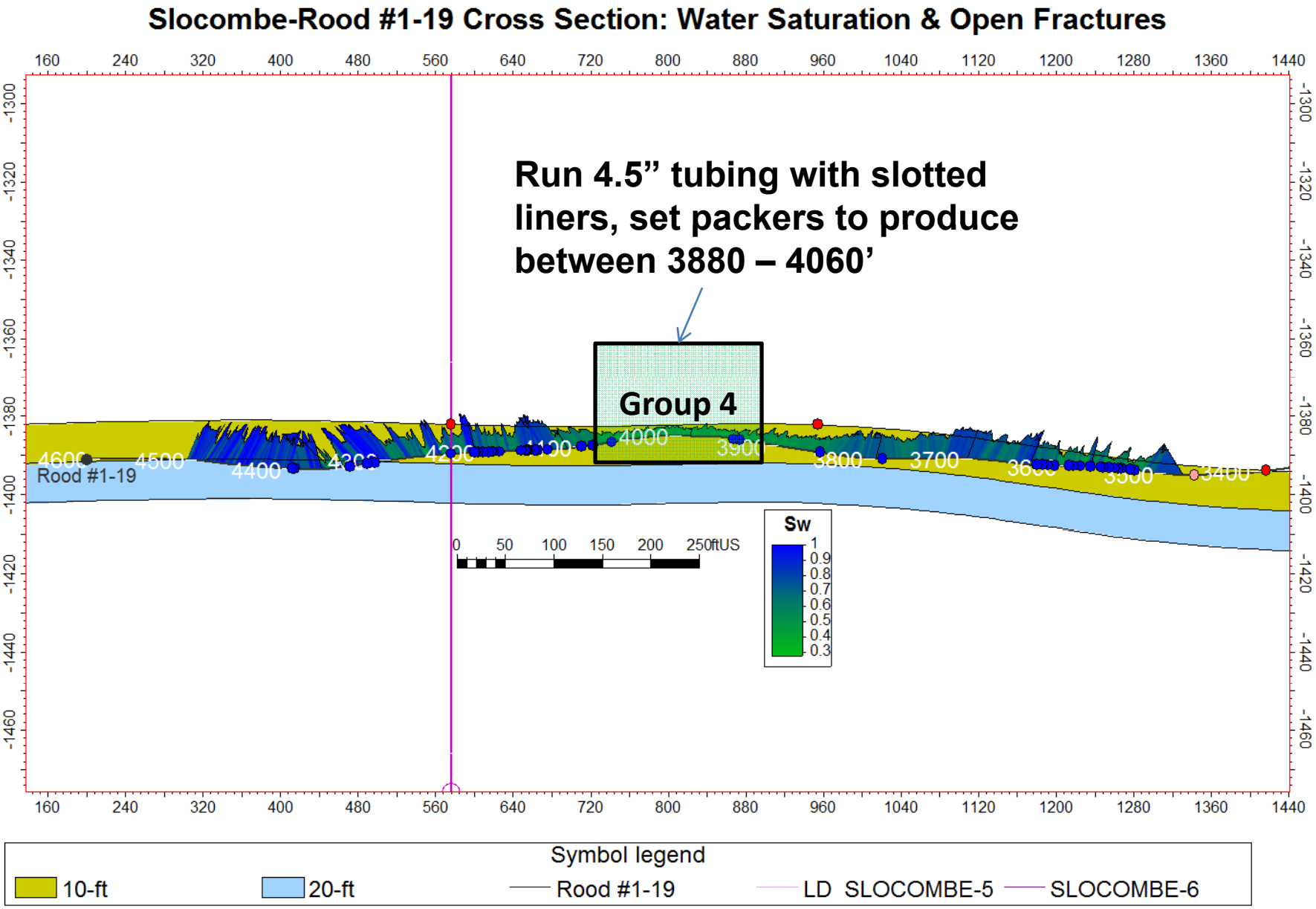
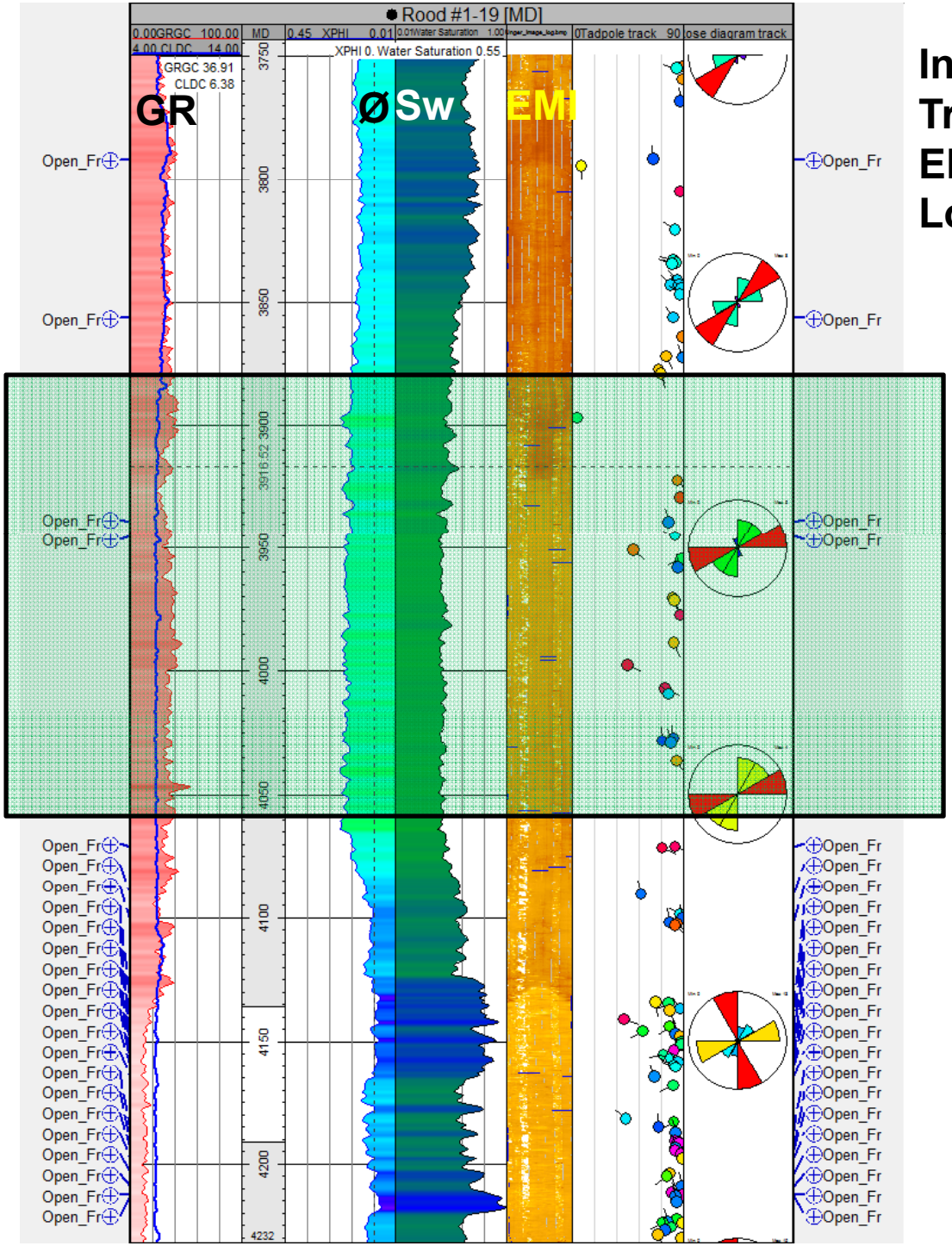


Group 7



Petrel presentation of lateral in subsea

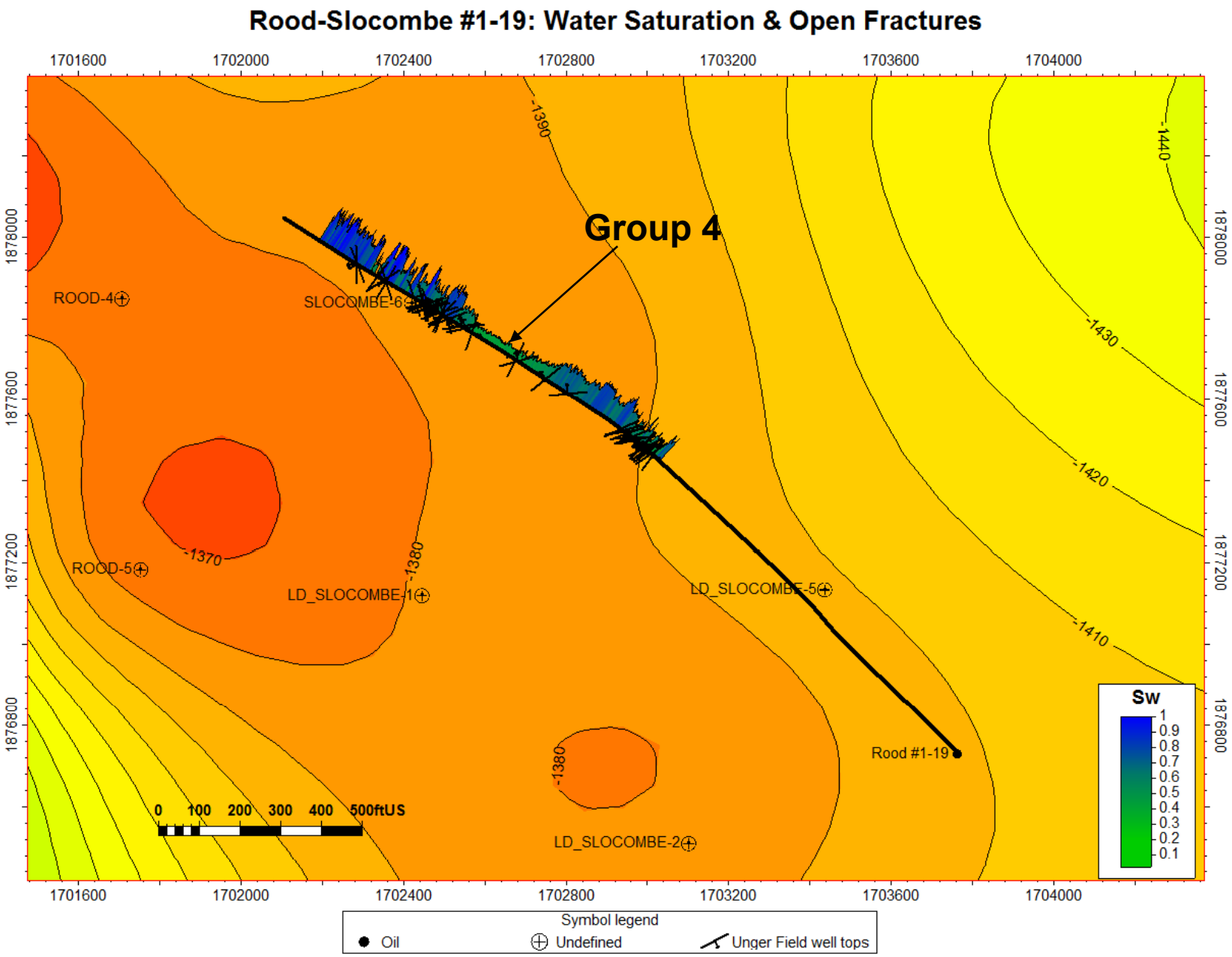


Interpretation of Weatherford's Triple Combo and Electrical Micro Imaging (EMI) Log (*fracture log*)

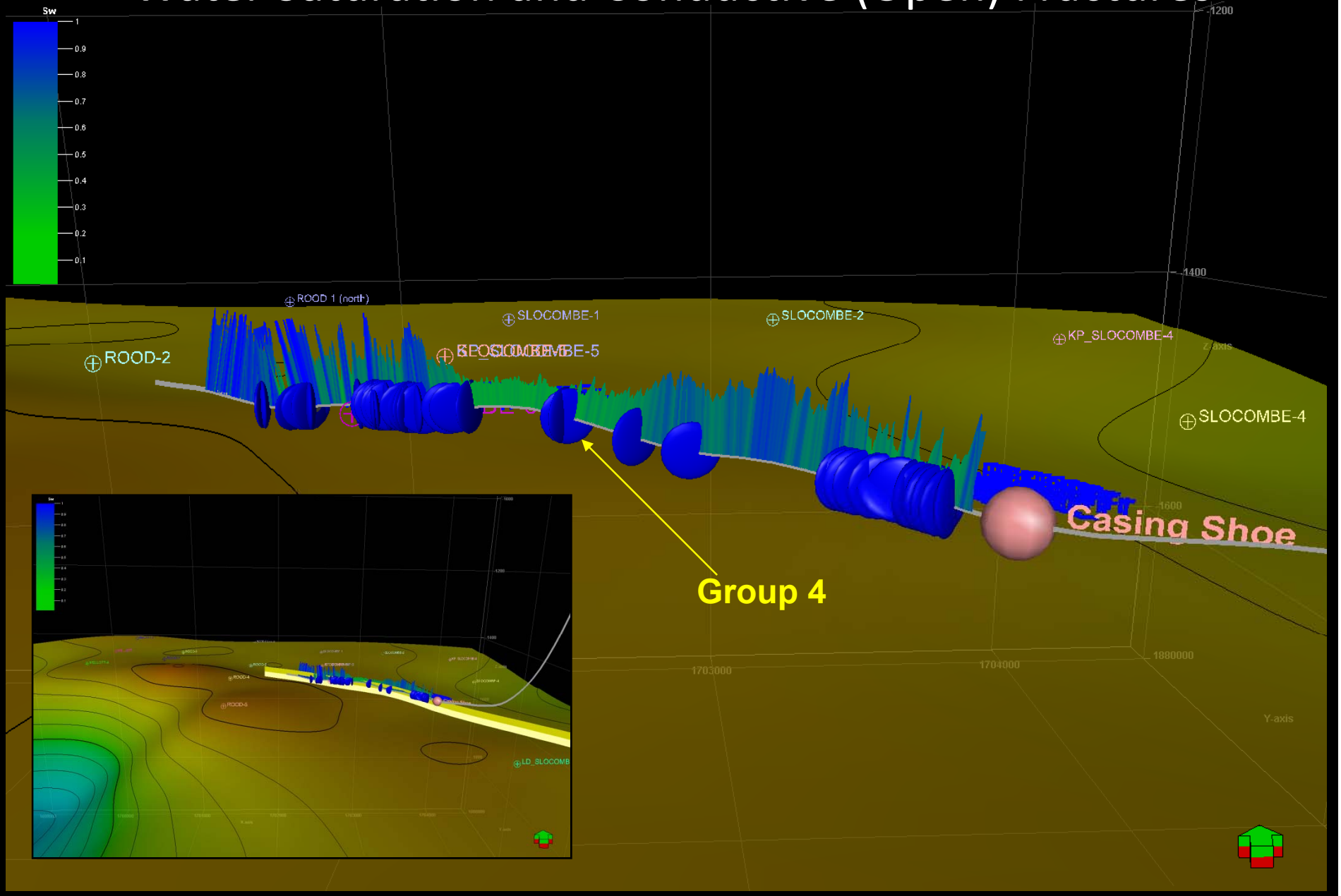
Run 4.5" tubing with slotted liners, set packers to produce between 3880 – 4060'

Group 4

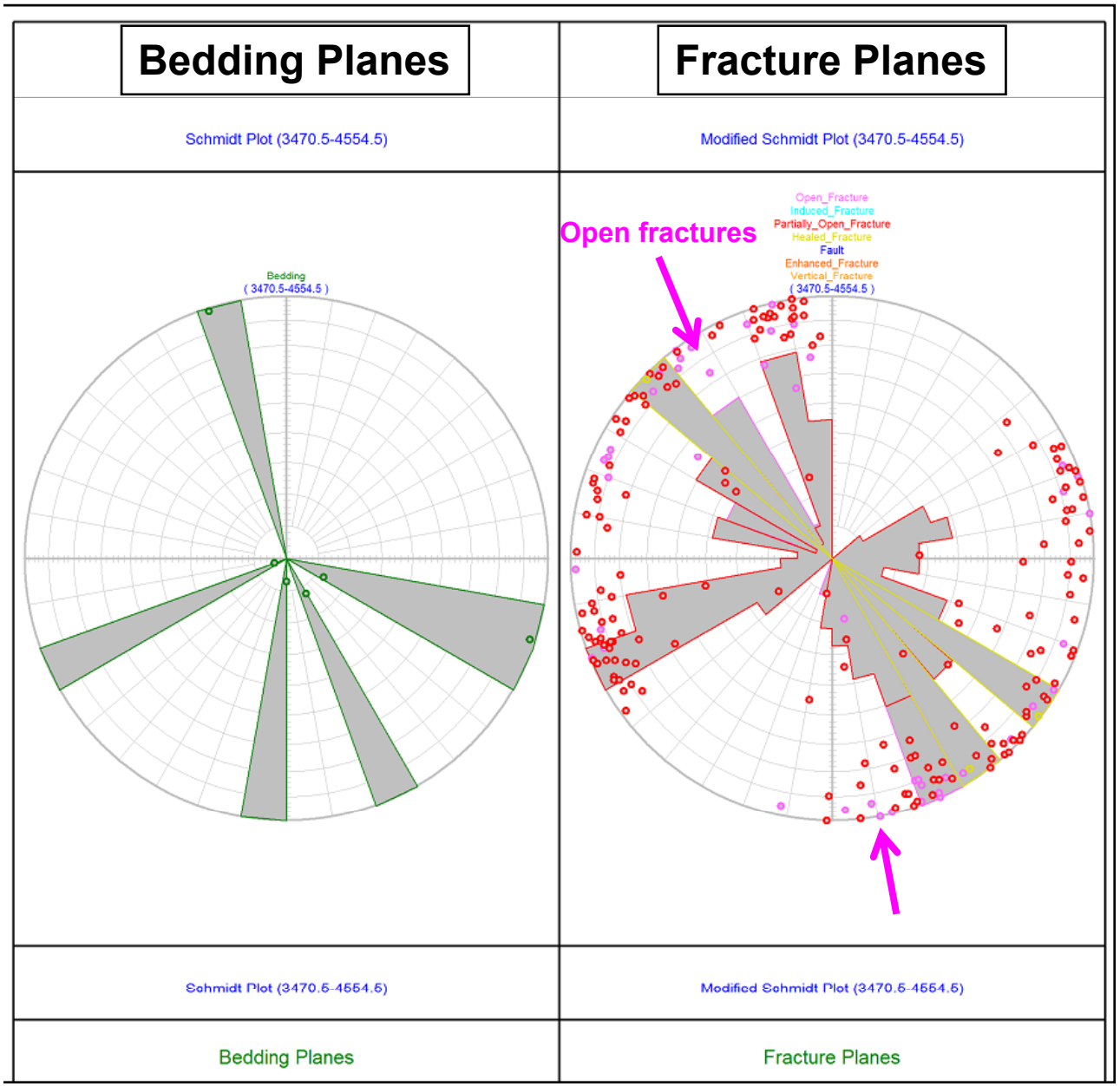
Dominate fracture set oriented NE


Rood-Slocombe #1-19: Water Saturation & Open Fractures
1701600
1702000
1702400
1702800
1703200
1703600
1704000
1878000
1877600
1877200
1876800
-1390
-1440
-1430
-1420
-1410
-1380
-1370
Group 4
ROOD-4
SLOCOMBE-6
ROOD-5
LD_SLOCOMBE-1
LD_SLOCOMBE-5
LD_SLOCOMBE-2
Rood #1-19
0 100 200 300 400 500ftUS
Sw
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Symbol legend
Oil
Undefined
Unger Field well tops

Water Saturation and Conductive (Open) Fractures



Pole Plot

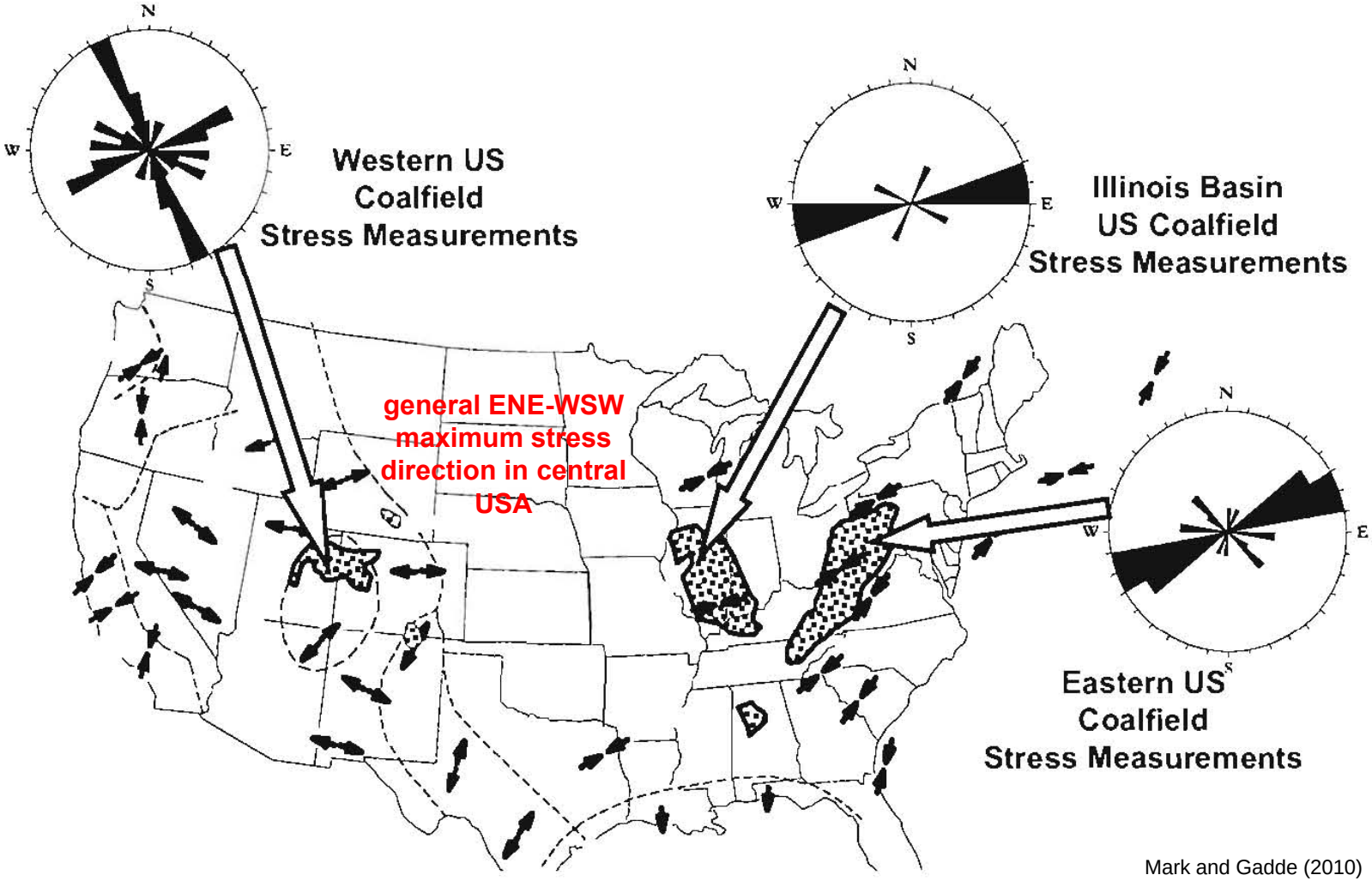


CMI log
Pole plot of fractures and bedding plans

Pole is perpendicular to plan that it is describing

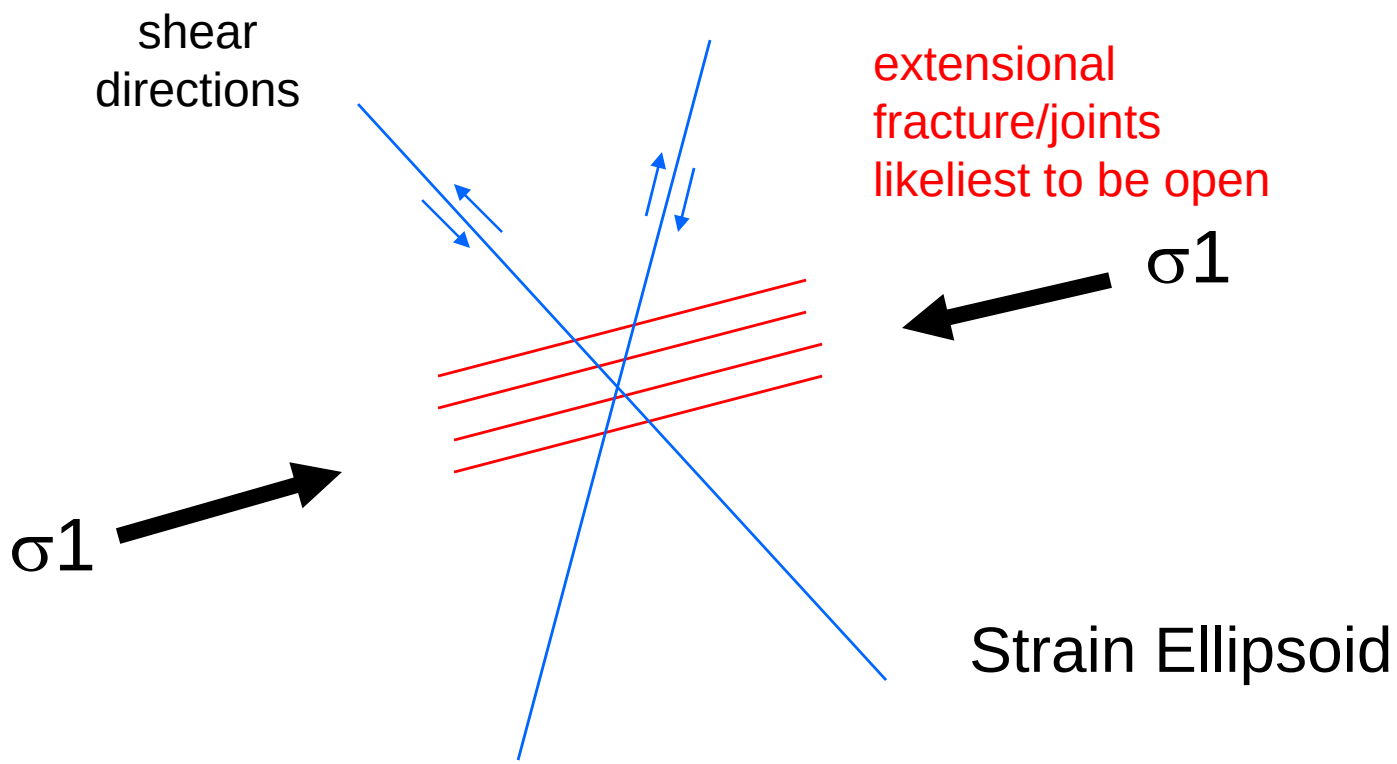
Open fractures primarily oriented E-NE

Maximum Horizontal Stress



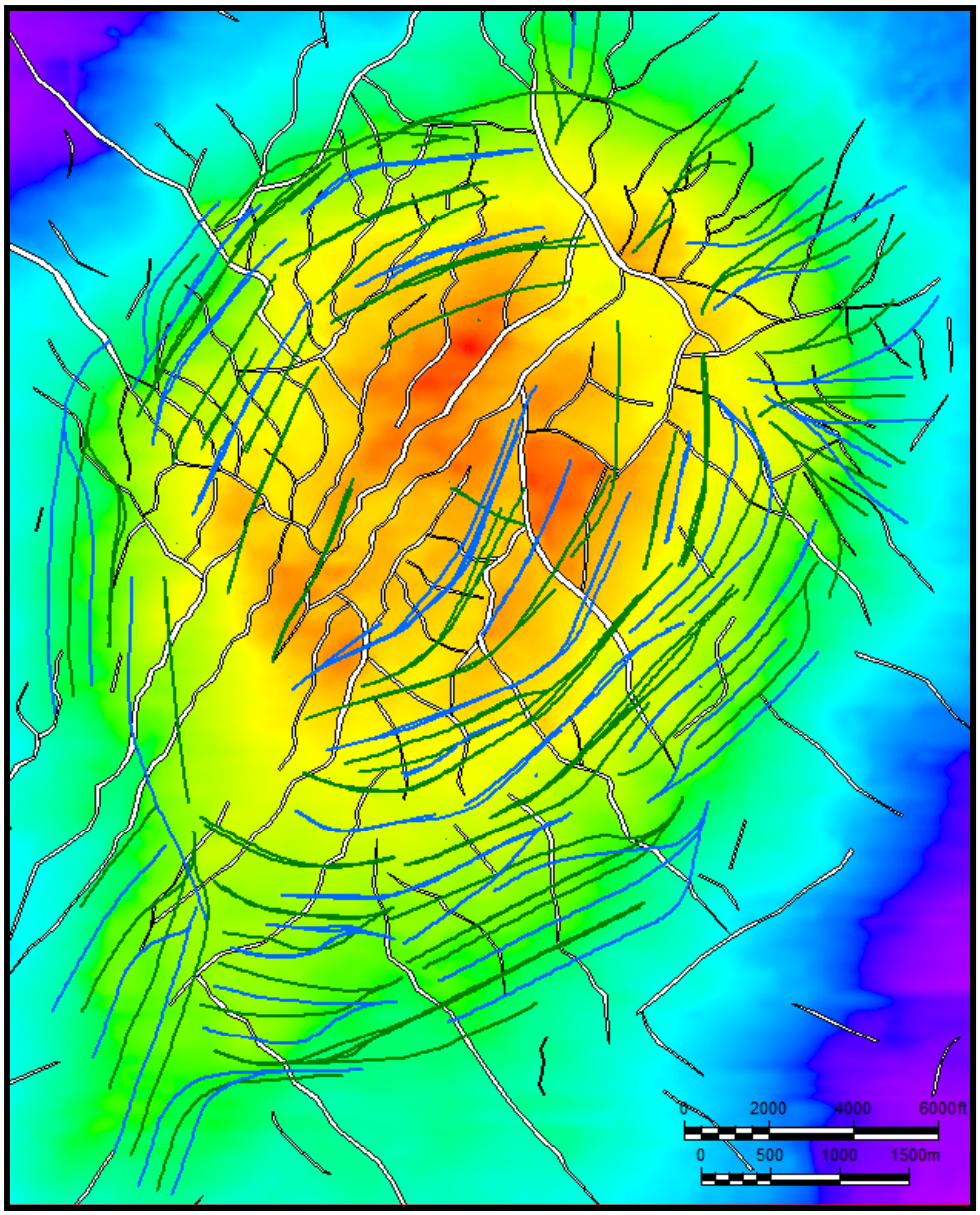
Mark and Gadde (2010)

Maximum horizontal stress
expected fracture directions

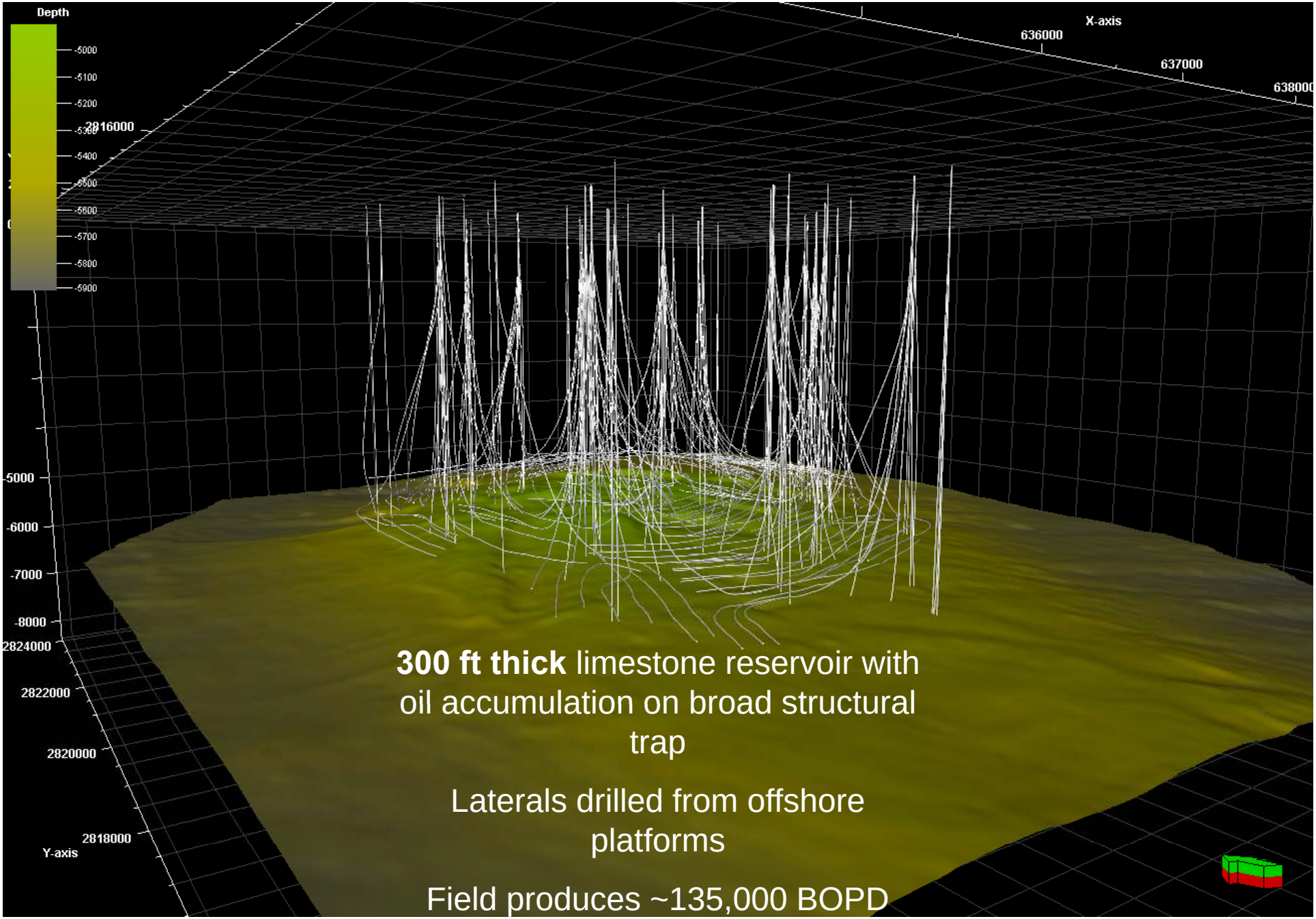


σ1 is maximum horizontal stress direction

Horizontal Wells in a Fractured Reservoir
Idd El Shargi, Offshore Qatar



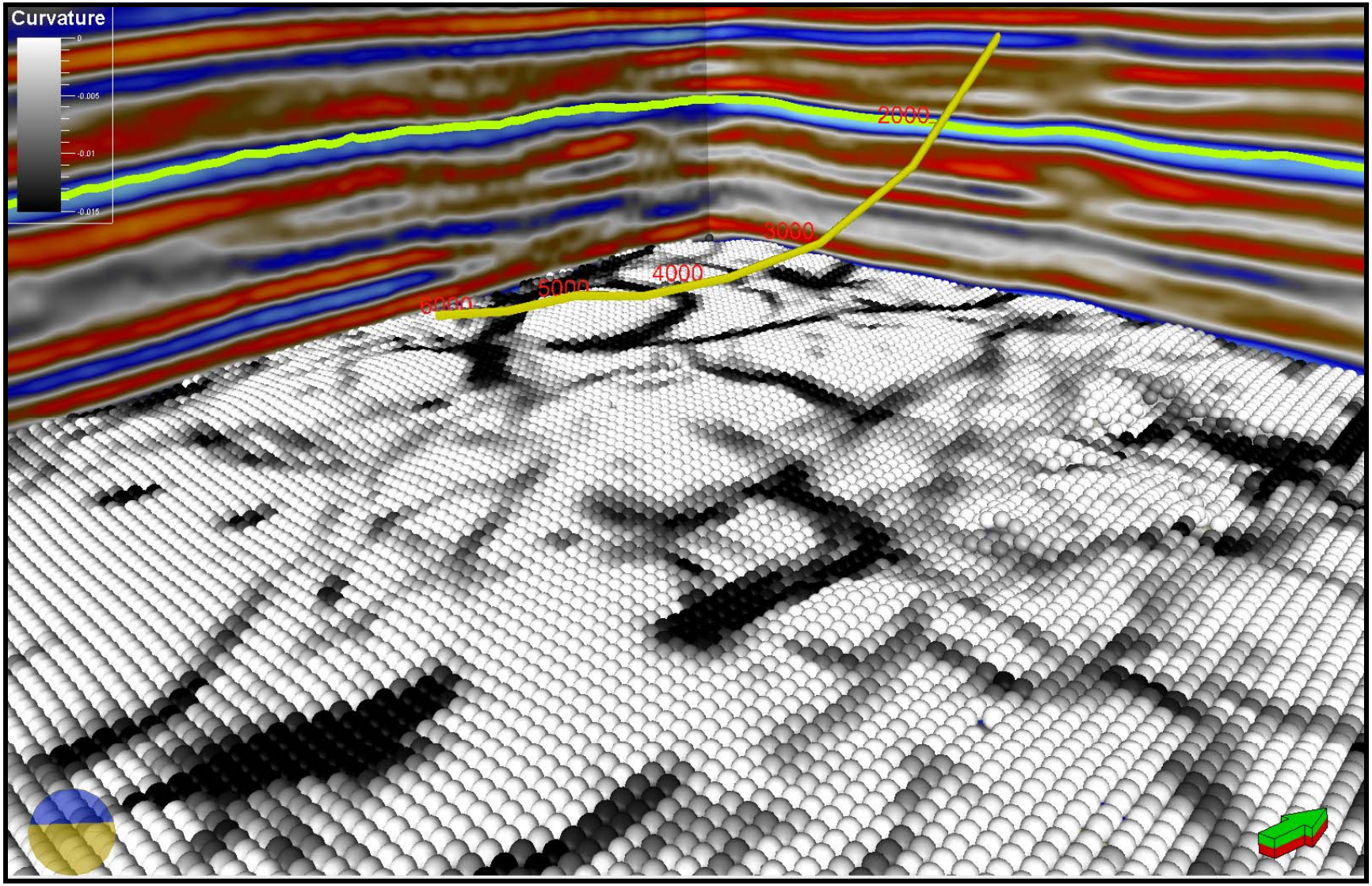
J. Rush, KGS



Idd El Shargi, J. Rush, KGS

Horizontal Targeting Arbuckle Paleokarst
Wellington Field Data

Concept for Upcoming Bemis-Shutts Lateral



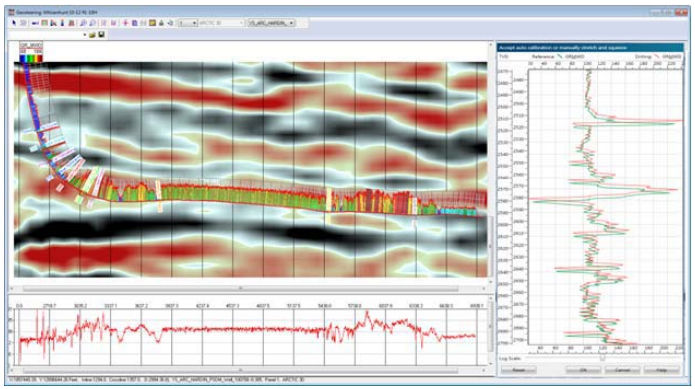
Outline

- Rig visit
- Pre-spud analysis
  - Stratigraphy, mapping
  - Well planning
- Actual well results
- 3D Visualization
- **Concluding Remarks**

Conclusions

- Slocombe-Rood 1-19 a technical success
- Logging program permits optimization of completion design
  - *Selectively isolate high Sw zones/fractures*
- More experience = greater success
- Additional opportunities including horizontal injectors, multi-laterals, …use of integrative technologies

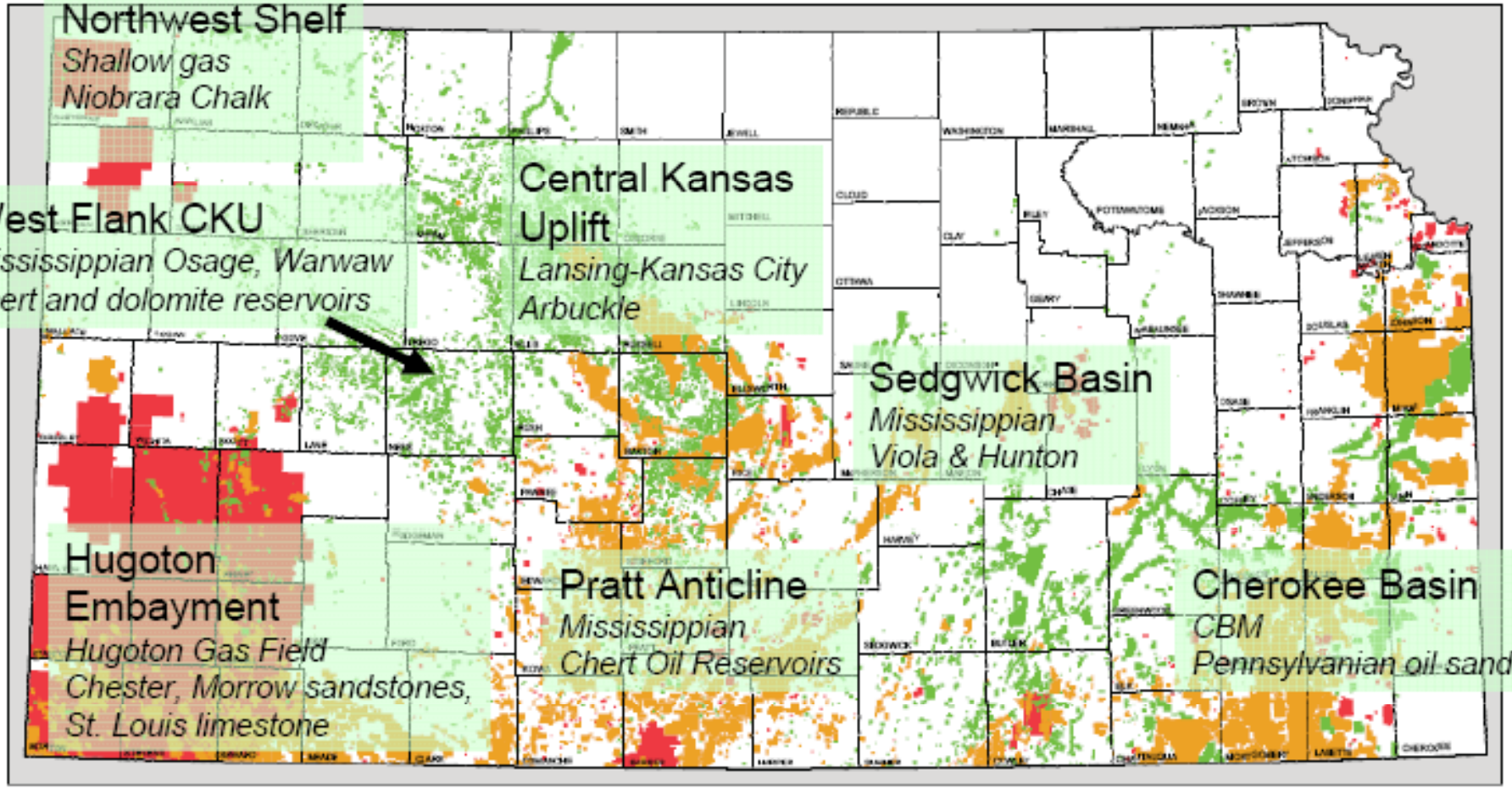
Kingdom Suite new release



KANSAS GEOLOGICAL SURVEY
The University of Kansas

OIL AND GAS FIELDS OF KANSAS

2009



This map was prepared by the staff of the Kansas Geological Survey and is based on Oil and Gas Fields in Kansas (1967) and subsequent revisions with the same name (1975, 1989, 1990, and 1995). Fields are represented according to their status as of June 1, 2009. Listings of fields by location, name, and cumulative production are found in the Survey's interactive oil and gas map viewer located at http://maps.kgs.ku.edu/oilgas/index.cfm. For viewer instructions, click on the "Help" tab at the top of the page. Due to frequent data updates, field and production area boundaries may differ slightly from those shown on this map. All fields are shown without differentiation between active and inactive. Areas of natural gas production from coal are not included on this map.

As set forth in Kansas Administrative Rule 82-3-102, field boundaries are determined by the Kansas Corporation Commission after considering the recommendations of the Conservation Division, Kansas Corporation Commission, and the Nomenclature Committee, Kansas Geological Society.

SCALE 1:2 600 000

LAMBERT CONFORMAL CONIC PROJECTION
WITH STANDARD PARALLELS AT 33° AND 45°N
CENTRAL MERIDIAN 98° 30' W
NORTH AMERICAN DATUM OF 1983

Named Fields

- Oil field
- Gas field
- Oil and gas field

Completion – In Process

1. Rig up AEC's Workover Rig #2.
2. Pick up 3 ½" tubing and reamer – ream to 4250'.
3. Come out of hole, lay down tubing and reamer.
4. Rig up and run 4 ½" LTC 11.6# new tubing with packers and slotted liners.
5. Set bottom packer with 30,000 lbs.
6. Pump fluid with ball to activate second packer to produce interval between 3880 – 4060'.
7. Set liner in 7" casing @ 2900', 4 ½" is between 2900' and 4060'. PBTD: 4060'.
8. Fluid needed to set packer:
   - 3 ½" tubing @ 2900' @ .0090 bbls/foot = 26.1 bbls
   - 4 ½" LTC, 11.6#, 1260' @ .0155 bbls/foot = 19.53 bbls

     Total 45.63 bbls KCL Water
   - 45.63 bbls of KCL water
9. Weight of tubing:
   - 4 ½" @ 11.60 lbs/foot X 1260' = 14,616 lbs
   - 3 ½" @ 8.50 lbs/foot X 2,900 = 24,650 lbs

     39,266 lbs
10. We will need 30,000# to set the bottom packer.

Information for Galen:

1. We will need pipe racks or sill to put 4 ½" casing and 3 ½" tubing on.
2. We will need to haul 4,300' 3 ½" tubing to location.
3. Backhoe with forklifts to unload tubing.
4. 3 ½" tubing from AEC's yard and 4 ½" casing from Midwest
5. Weatherford packer assembly (Monday @ 8:00 a.m.) Will require backhoe and forks.
6. Will probably require extra hand to help Travis's crew run casing.

Weatherford Completion team to run and set the packers and the liner.

- **Isolate the 3880' to 4060'**
- **Pump until turns to a high water cut, then drop a ball to shutoff the first section**
- **Produce the second section from 3515' to 3880'.**
- **When this turns to a watercut similar to the first section, drill the ball out and produce the entire section 3515' to 4060'.**

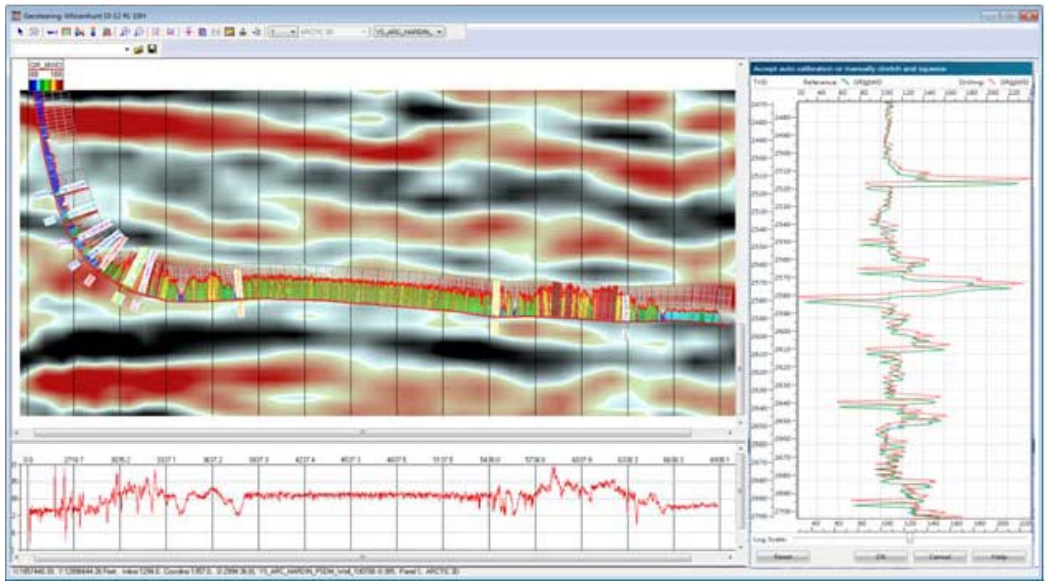
•The liner will only be set to 4280' so this will be our plugged back TD.

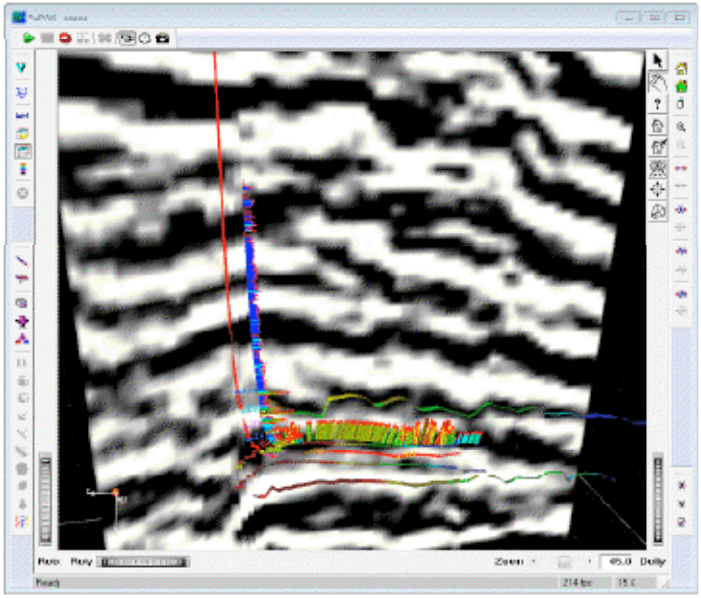
•The hanger for the 4 ½" liner will be at 2900' in the 7" production casing, meaning the 4 ½"' liner will be set from 2900' to 4280'.

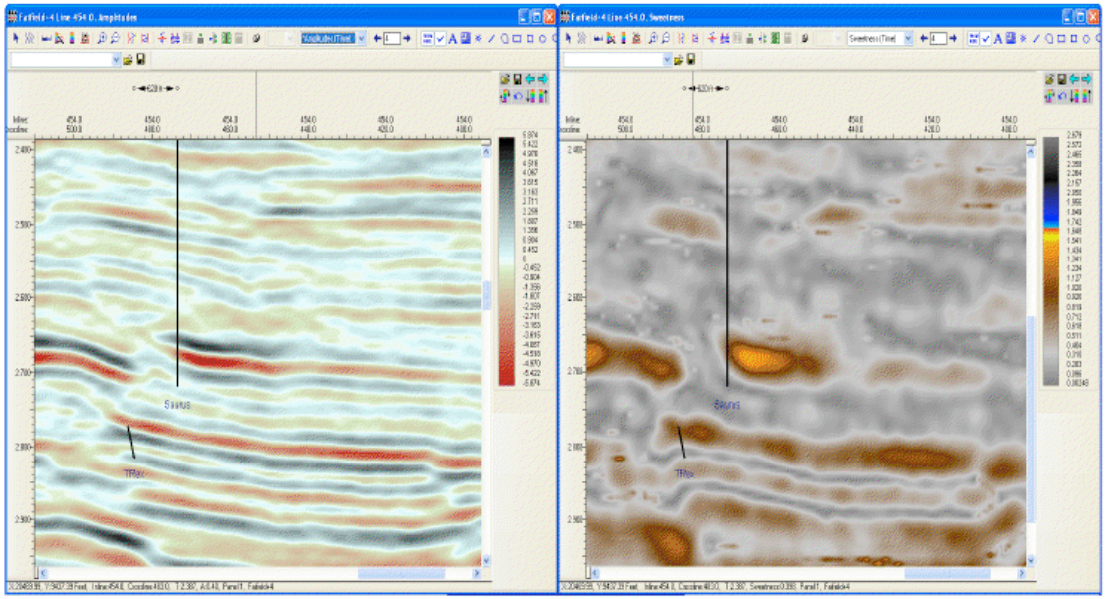
•After the liner is set we will remove the 3 ½' tubing above the liner and run 2 7/8' tubing to 1500' and install beam pump and pump from 1500'.

Producibility problems addressed with horizontal wells

- **Mature fields – often have high water cut, strong water drive**
- **Current production practice – use conventional vertical wells**
- **Limited lateral drainage in vertical well**
- **Significant variation in producibility between adjacent wells**
- **Residual pockets of oil possibly located in the interwell areas outside the drainage reach of vertical wells**
- **Often reservoirs are compartmentalized (*karstification and subcropping strata*)**
  - Wells located in small compartment have short production life, uneconomic cumulative volumes
  - Wells located (by chance) in large compartments – long production life
- **Effective pay zones in Kansas are thin (*less than 20 ft*)**
- **Limited resource-reach of operators – financial and technical**






Fairfield-4 Line 454.0, Amplitudes
Fairfield-4 Line 454.0, Sweetness
Saurus
TPlio
Saurus
TPlio

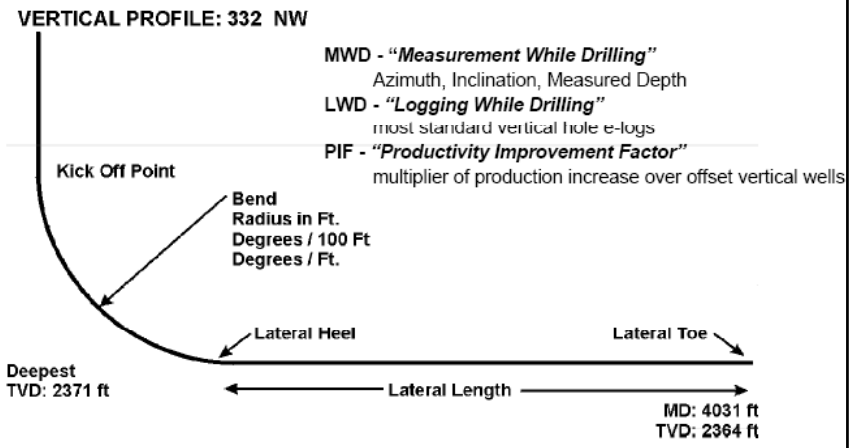
History of Horizontal Wells

- Short Radius
- Medium radius, downhole motors, 1985
- Re-entry drilling, 1995
- Coil tubing drilling – underbalanced
- Rotary steerable system
- Fracture stimulation of horizontal wells

Horizontal Drilling in Kansas

Definitions & Terms

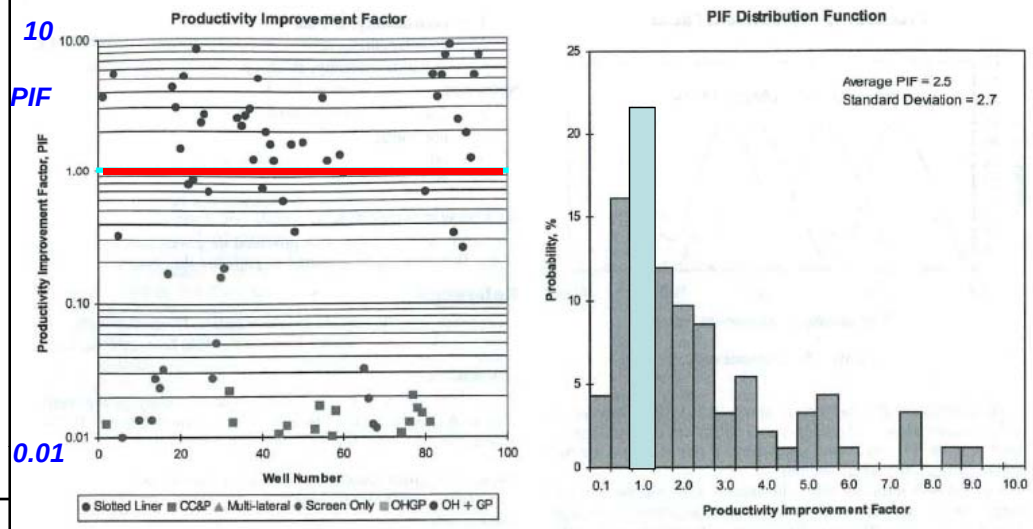
Common terms used to describe horizontal wells



Gerlach (2000)

Productivity Improvement Factor

Distribution of Productivity in 96 horizontal wells



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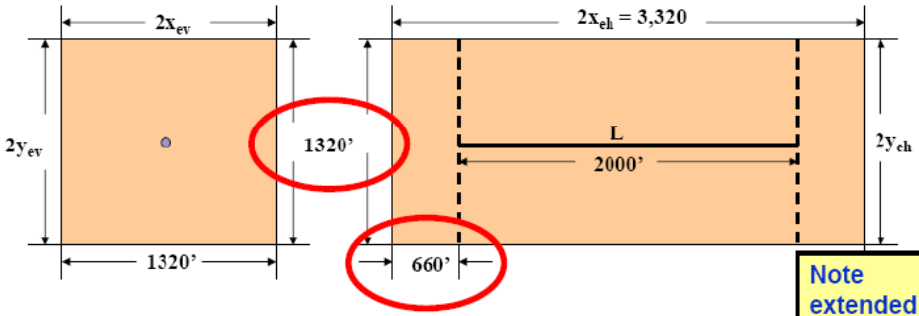
Reservoir with Uniform Horizontal Permeability ($k_y/k_x = 1$)



Vertical Well
Drainage Area = 40 Acres
$x_{ev}/y_{ev} = 1$

Horizontal Well
Drainage Area = 100 Acres
$x_{eh}/y_{eh} = 2.5$

Note extended drainage area off ends of the lateral

JTI

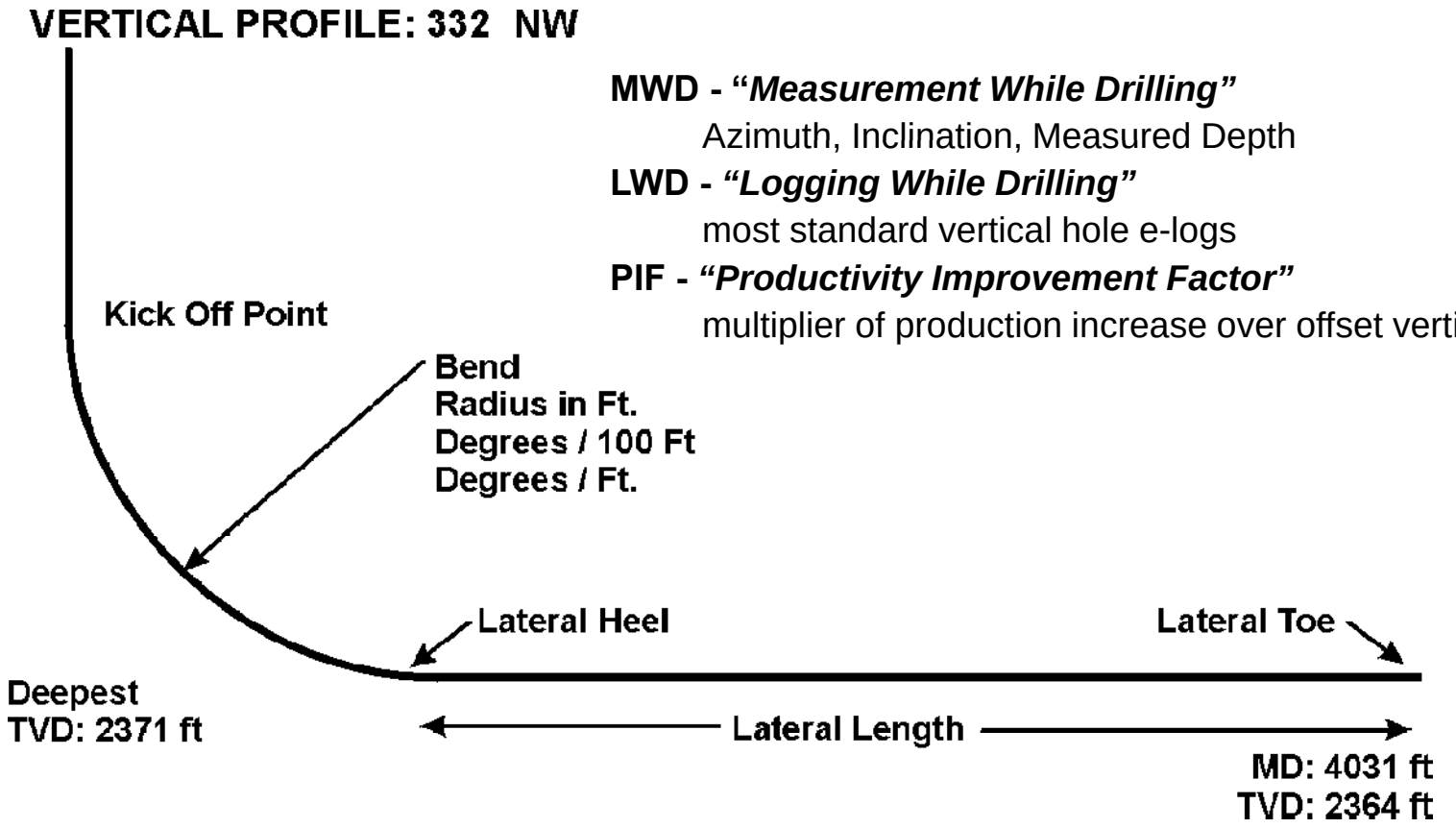
Joshi Technologies International, Inc.

Joshi --

Horizontal Drilling in Kansas

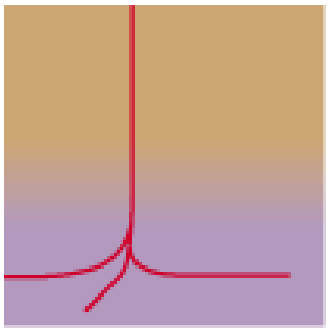
Definitions & Terms

Common terms used to describe horizontal wells

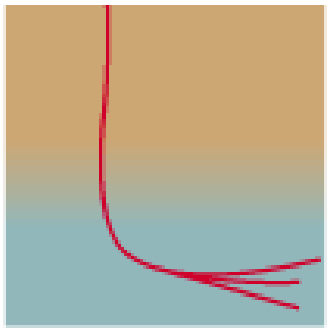


Gerlach (2000)

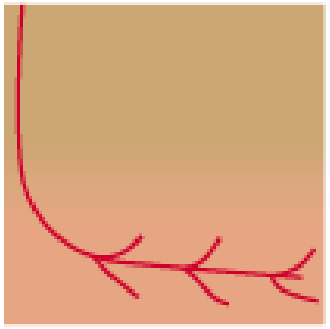
Multilaterals with conventional horizontal drilling technology



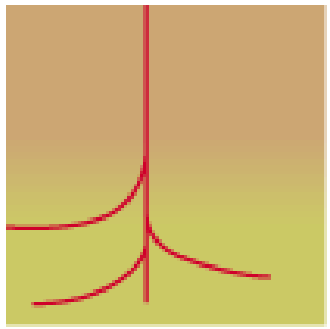
Multibranched



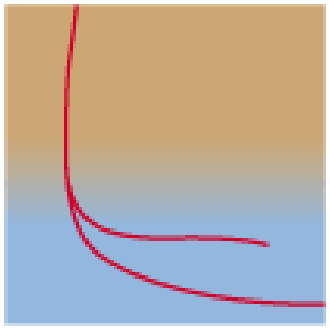
Forked



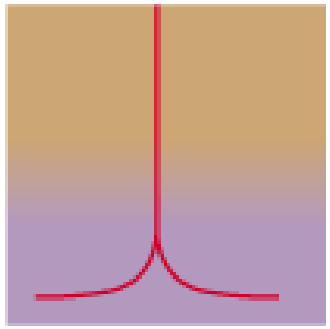
Laterals into horizontal hole



Laterals into vertical hole



Stacked laterals

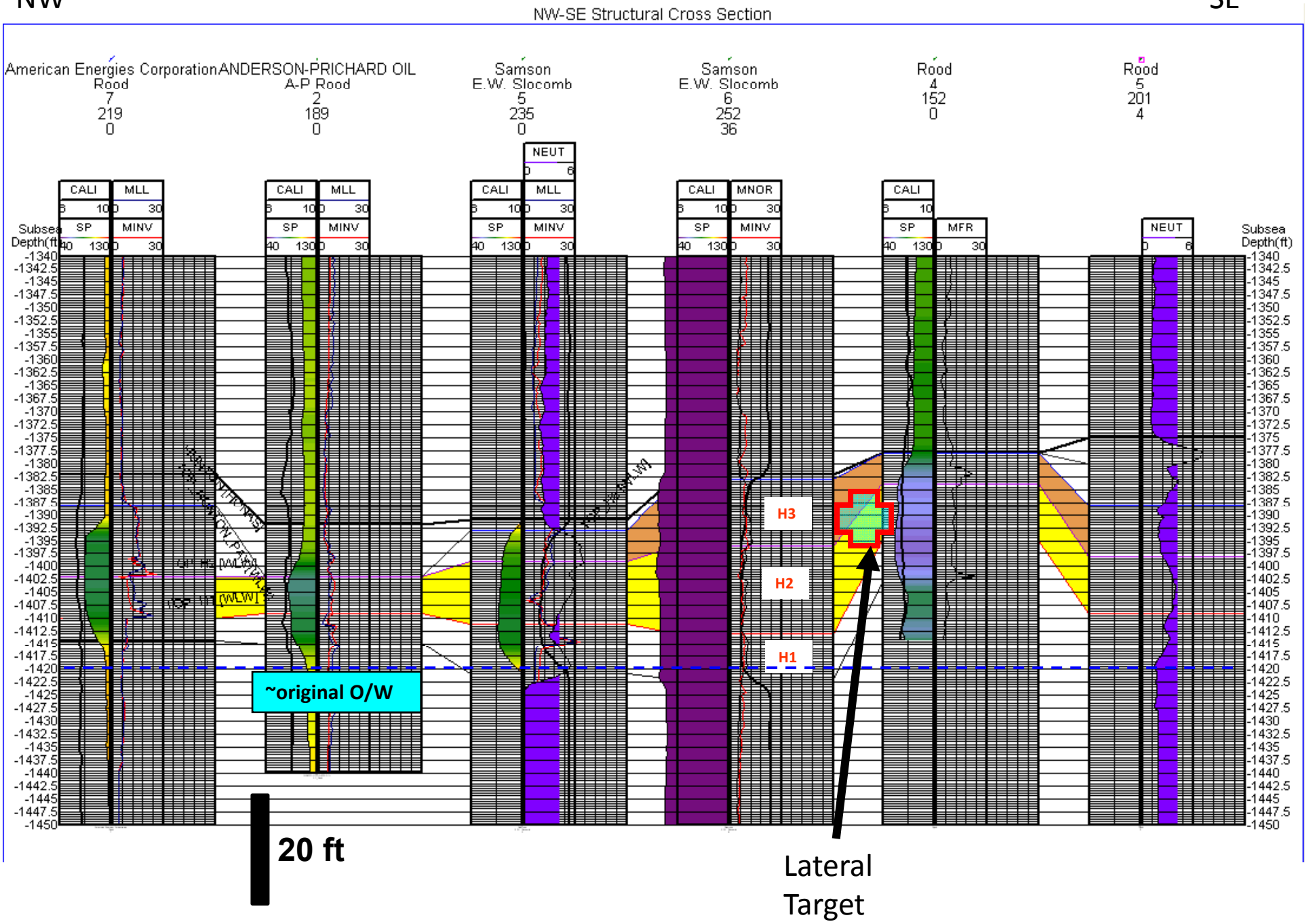


Dual-opposing laterals

Additional cross section similar to section in previous slide

NW

SE



Well Placement