February 13, 2014

3D seismic proves its value in Bakken geosteering

Angie Southcott

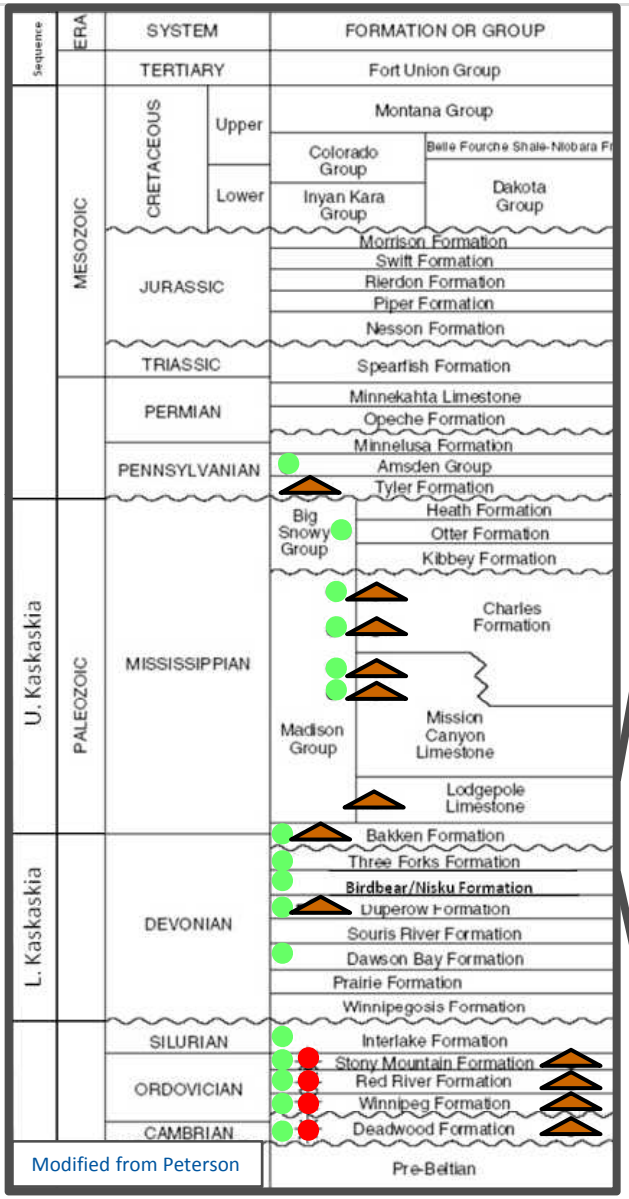
WPXENERGY

Outline

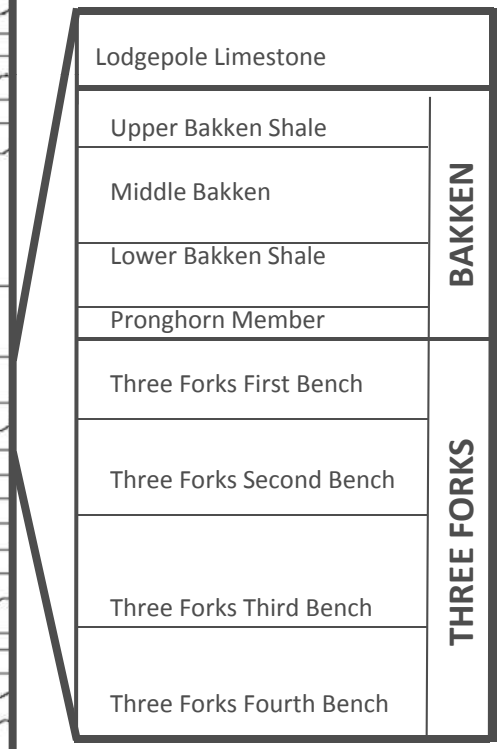
- **Introduction to the Williston Basin**
- Background and motivation for the talk
- 3D processing history
- Converting time to depth
- Conclusions

Williston Basin stratigraphic column

Modified from LeFever



Modified from Peterson



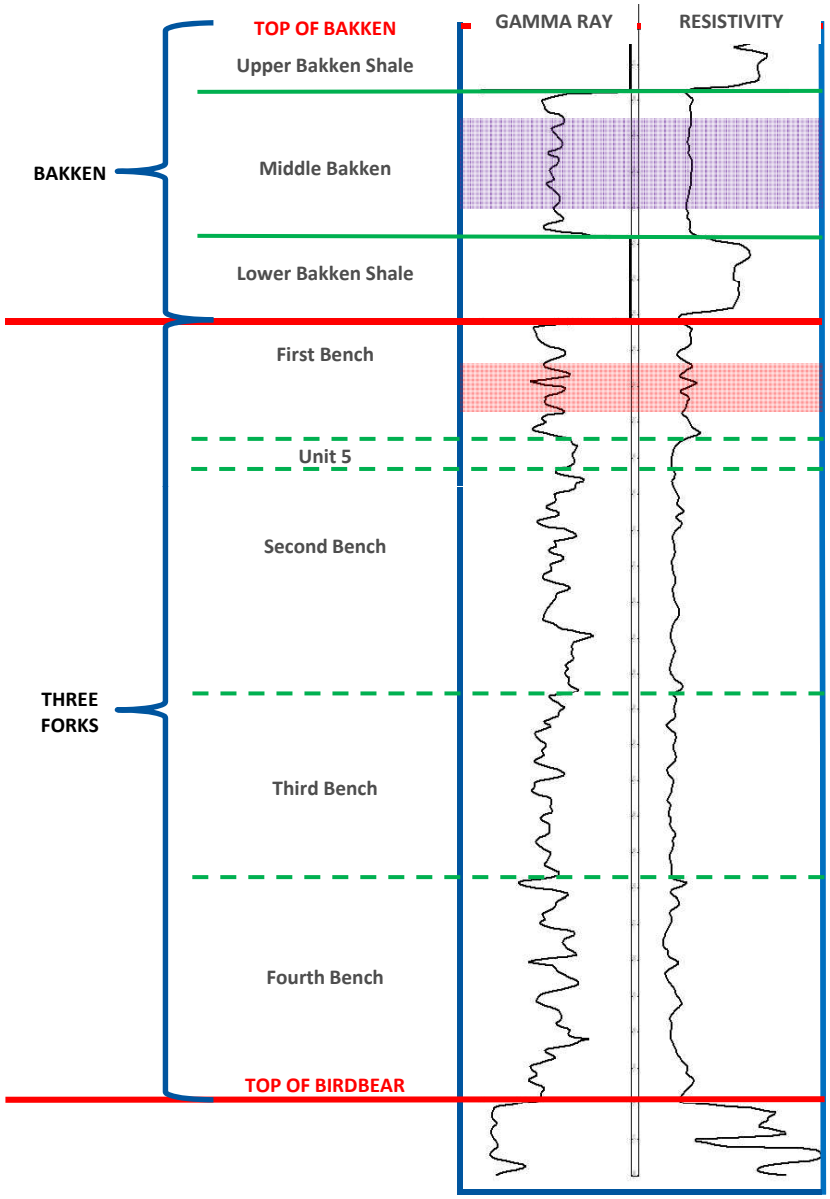
Not to scale

Oil producer

Gas producer

Source rock

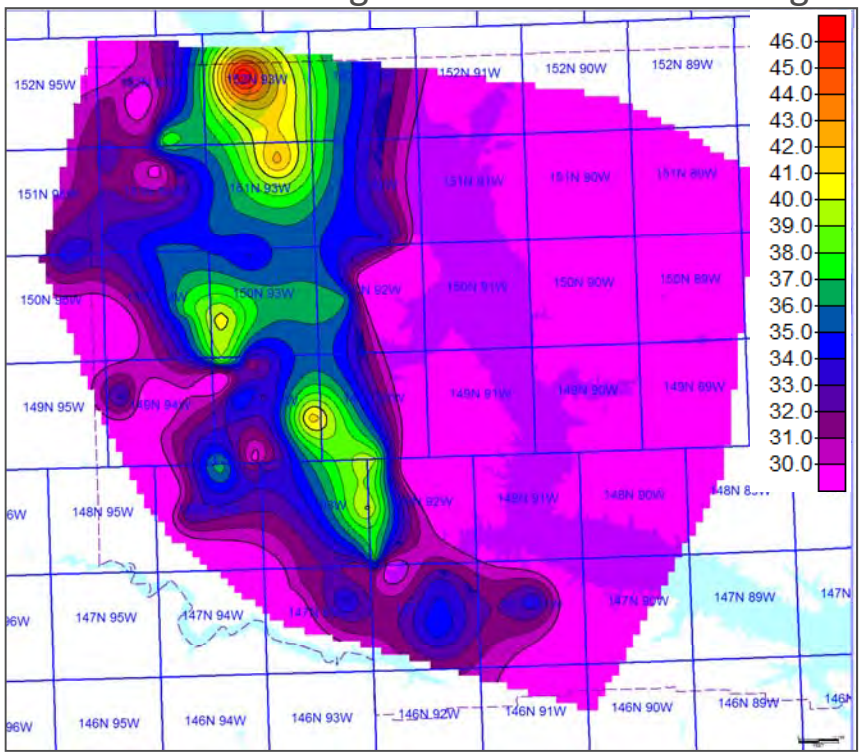
Williston Basin stratigraphic column



target zone for geosteering

target zone for geosteering

Middle Bakken target zone isochore from logs



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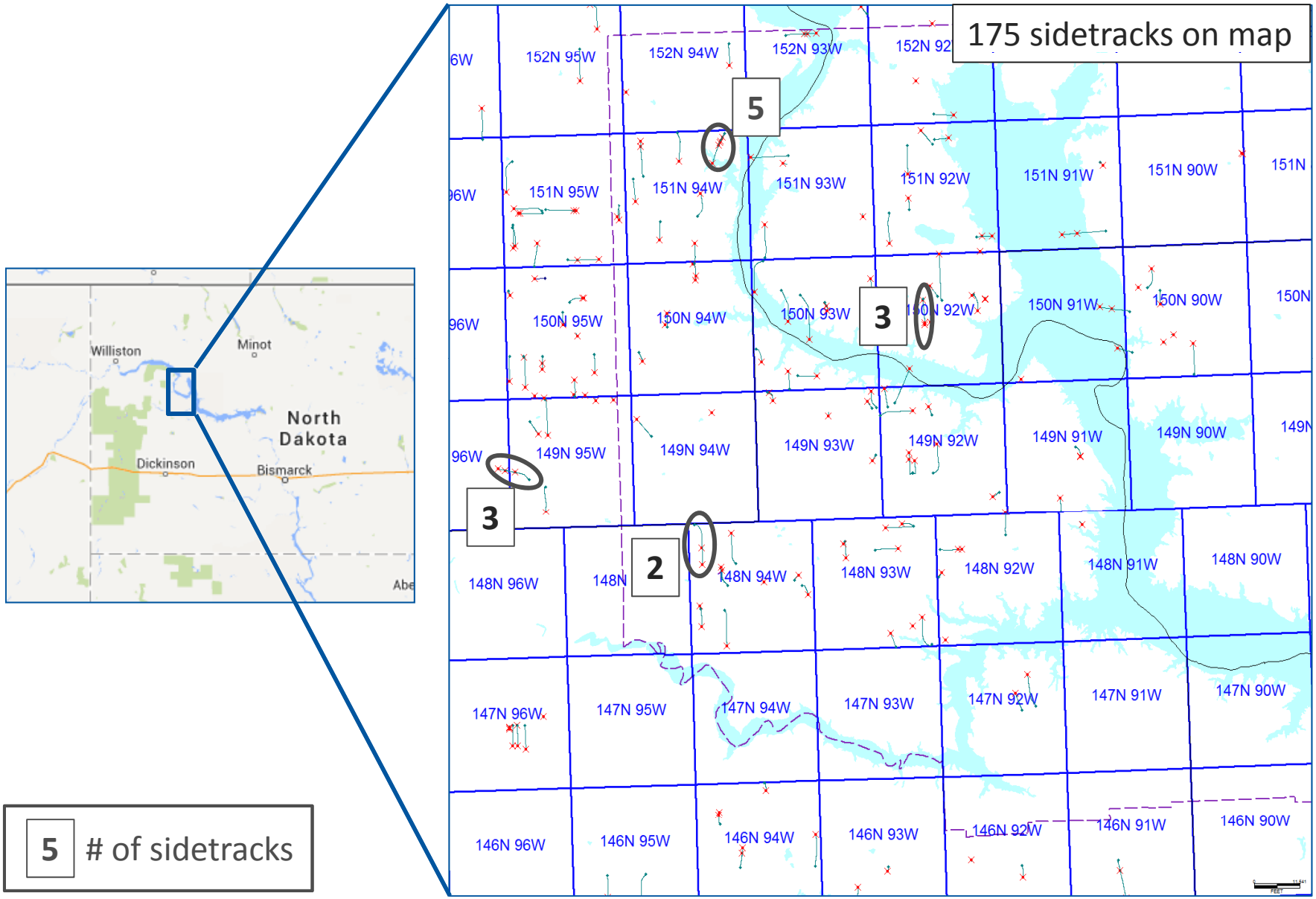
Shale strikes not just a WPX problem

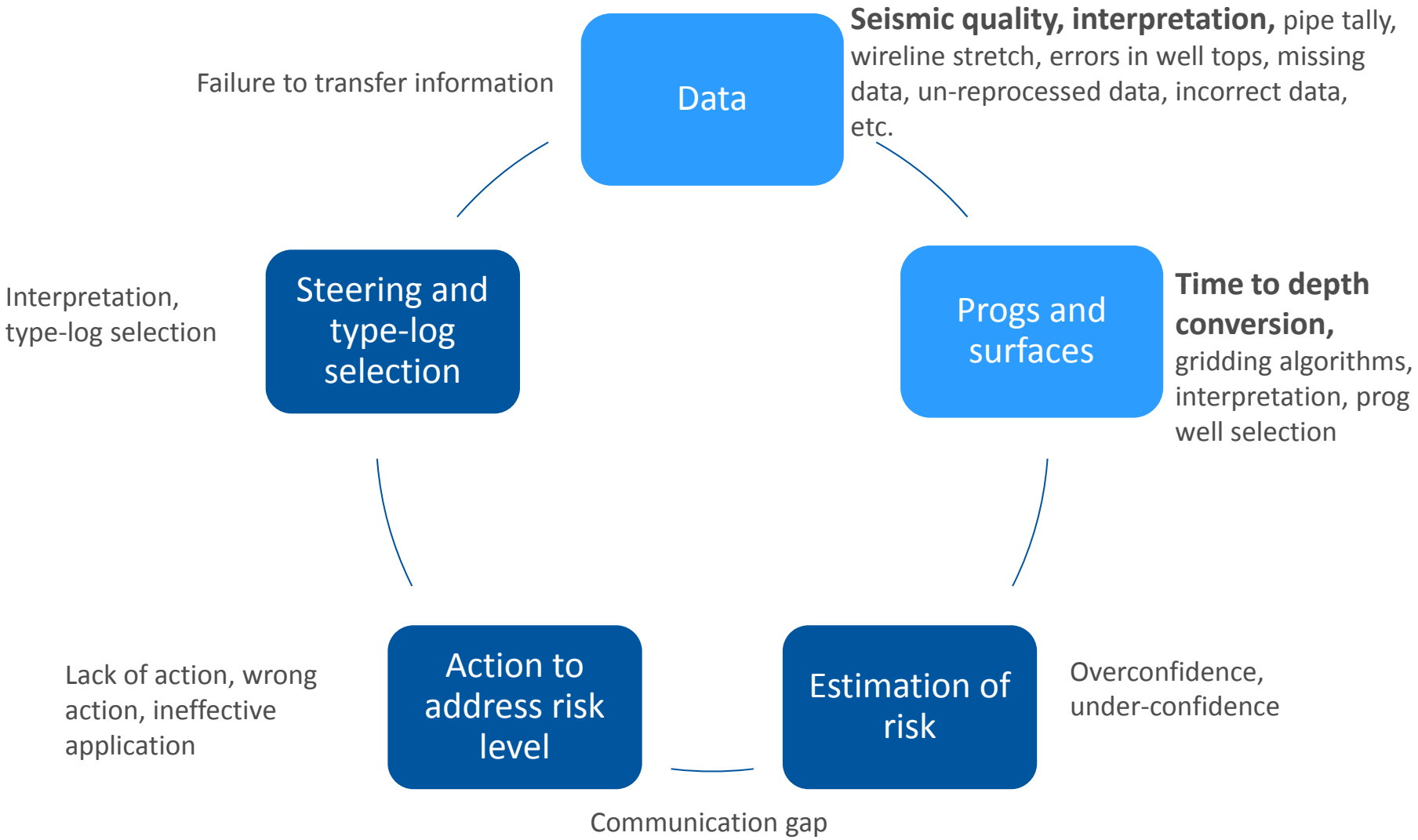


5 # of sidetracks


Republic Plaza is 2 miles from where this photo was taken
Middle Bakken is about four stories thick (yellow bar)
Bryant
STOP

How did we get the 90% reduction in geosteering errors?

Cycle of Learning



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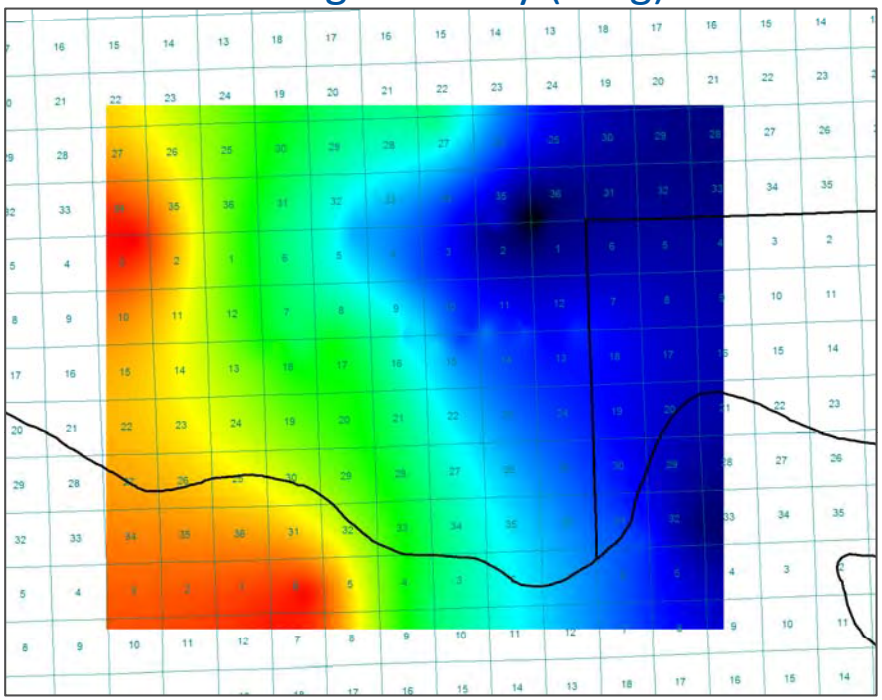
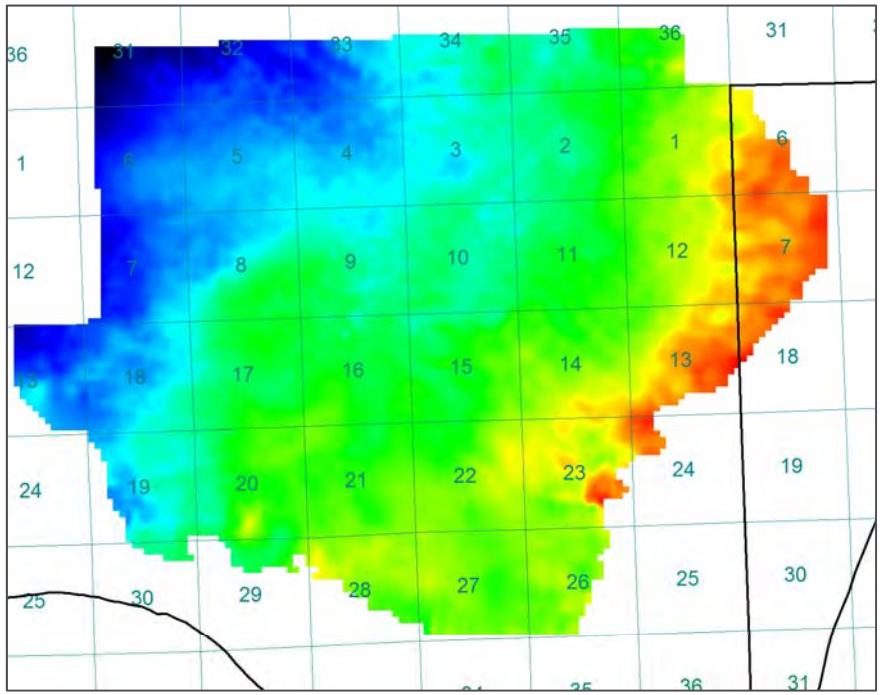
3D processing history: Converting to depth for geosteering

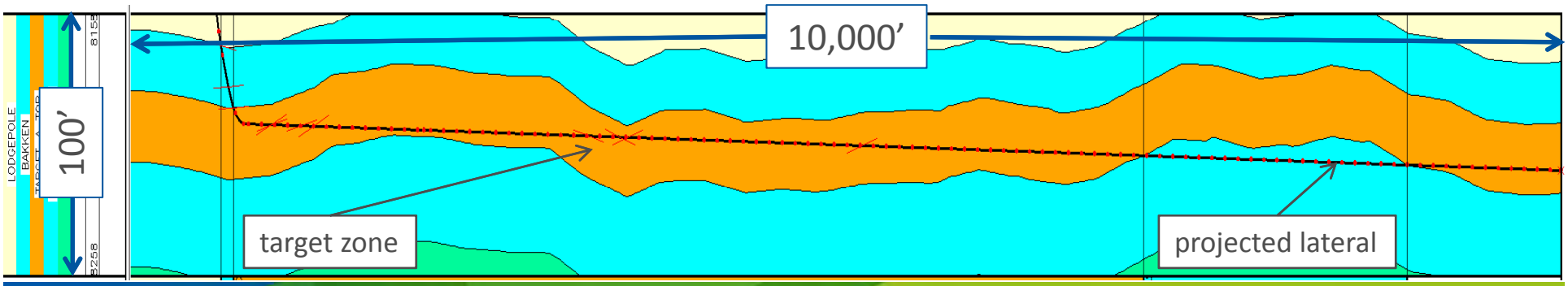
Average Velocity (Vavg)



Time



(Vavg*Time)/2=Depth



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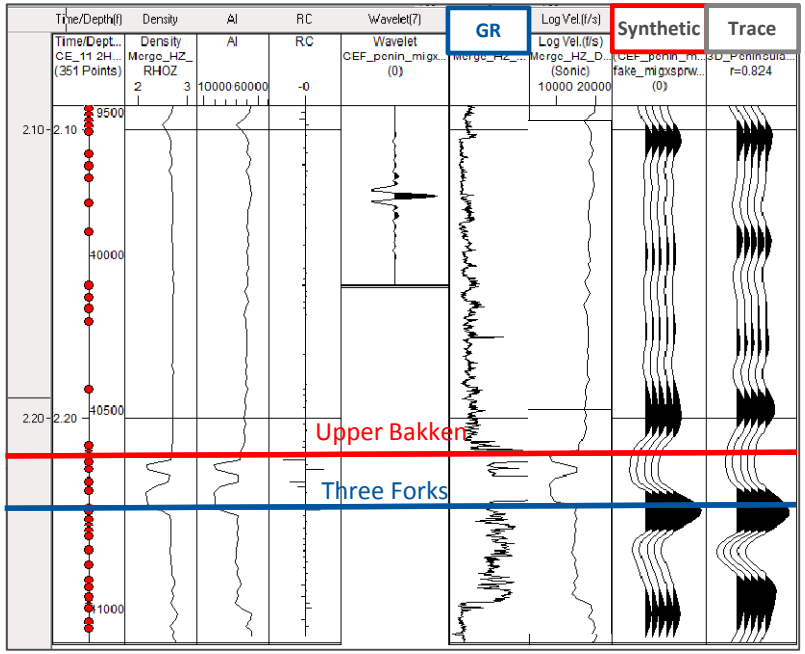
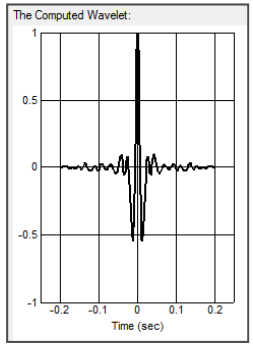
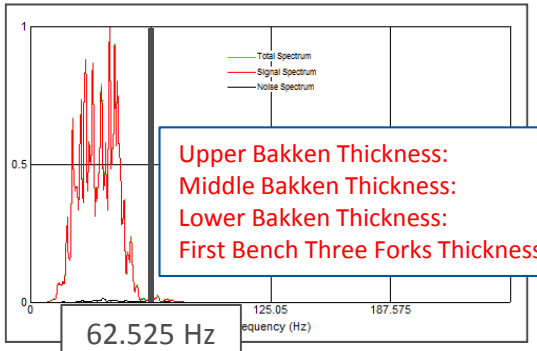
3D processing history: Processing progression - Post Stack



- Basic processing flow
- Spectral Whitening 6-84Hz
- Post Stack Spectral Balancing

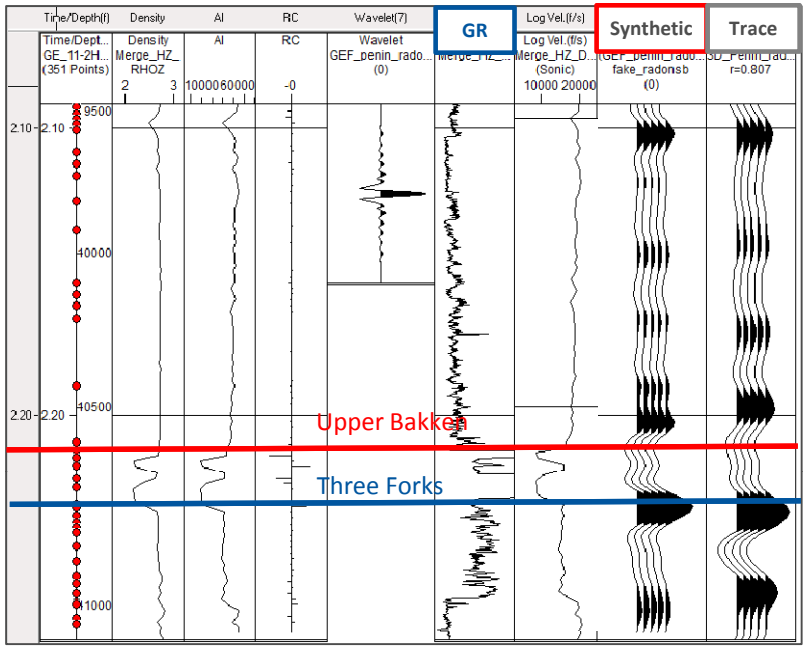




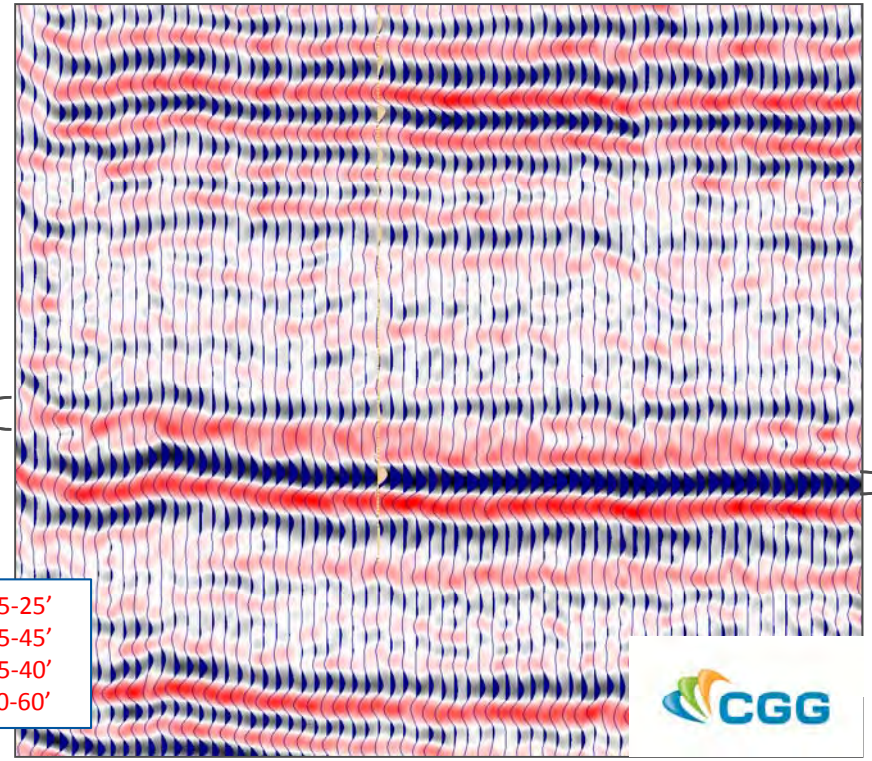
62.525 Hz

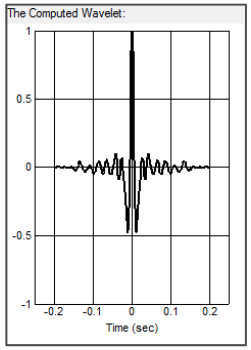
Upper Bakken Thickness:	15-25’
Middle Bakken Thickness:	25-45’
Lower Bakken Thickness:	25-40’
First Bench Three Forks Thickness:	40-60’

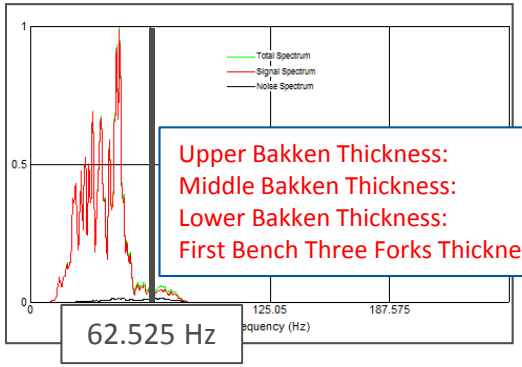
3D processing history: Processing progression - Pre Stack Time Migration



- Spectral Whitening 6-84Hz
- PSTM Kirchhoff Migration
- Residual Velocity Analysis
- Radon Filter, Horizon Based
- Post Stack Spectral Balancing

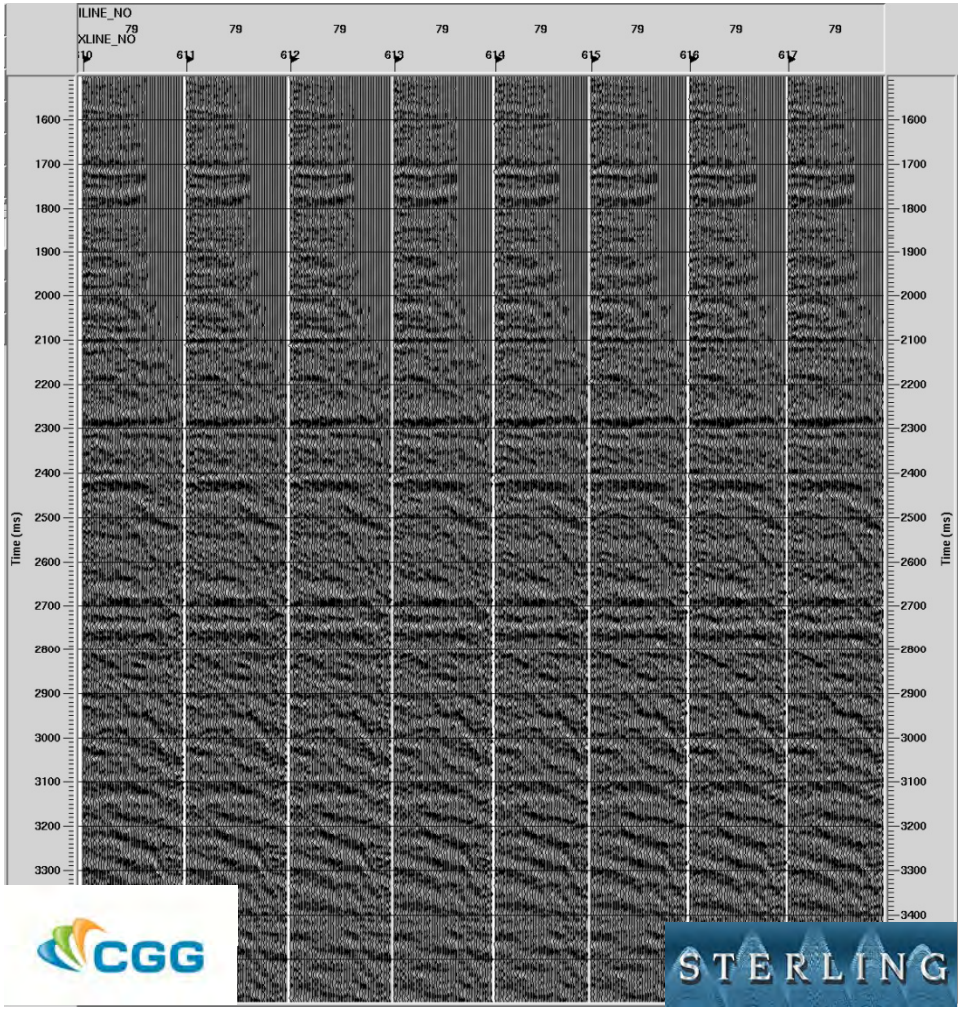




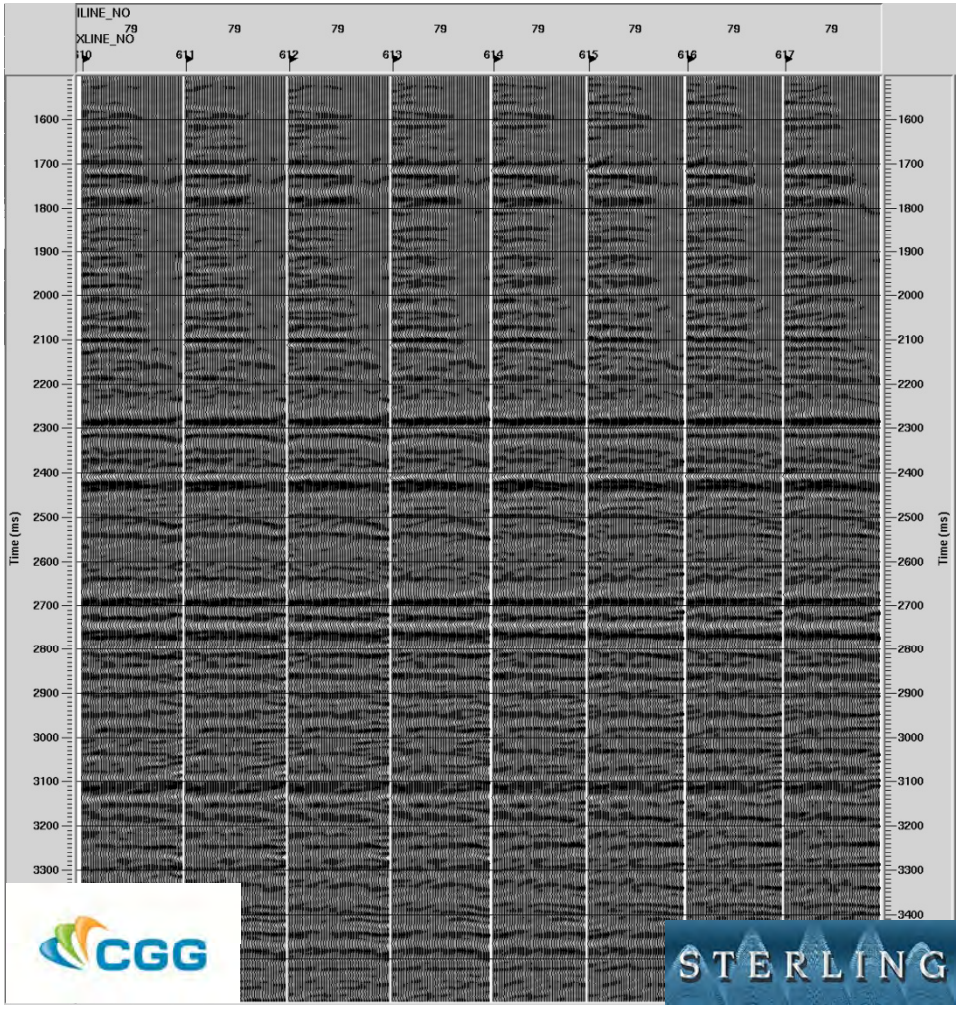


Upper Bakken Thickness:	15-25’
Middle Bakken Thickness:	25-45’
Lower Bakken Thickness:	25-40’
First Bench Three Forks Thickness:	40-60’

3D processing history: Gather panels



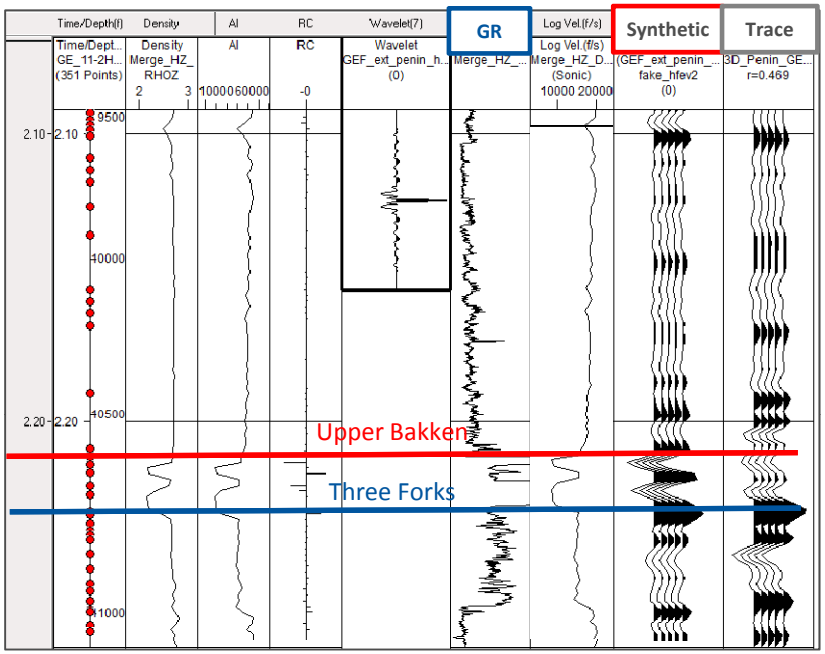
Before radon

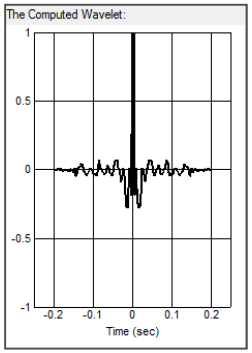


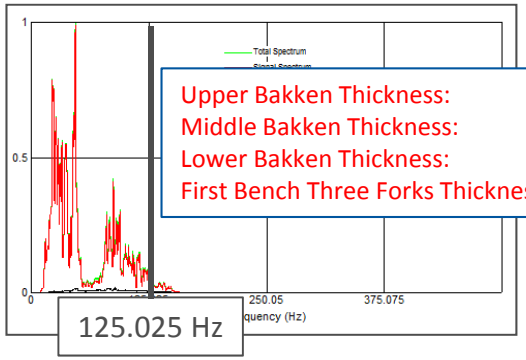
After radon

Processing progression: Pre Stack Time Migration High Frequency Extender

- Spectral Whitening 6-84Hz
- PSTM Kirchhoff Migration
- Residual Velocity Analysis
- Radon Filter, Horizon Based
- High Frequency Enhancement







Upper Bakken Thickness: 15-25'
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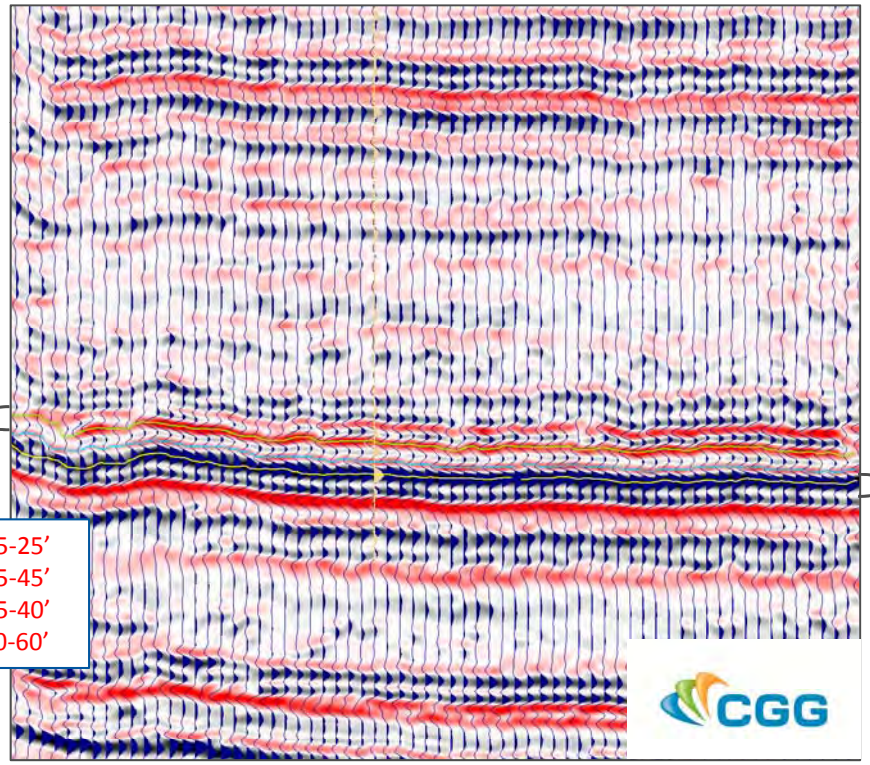
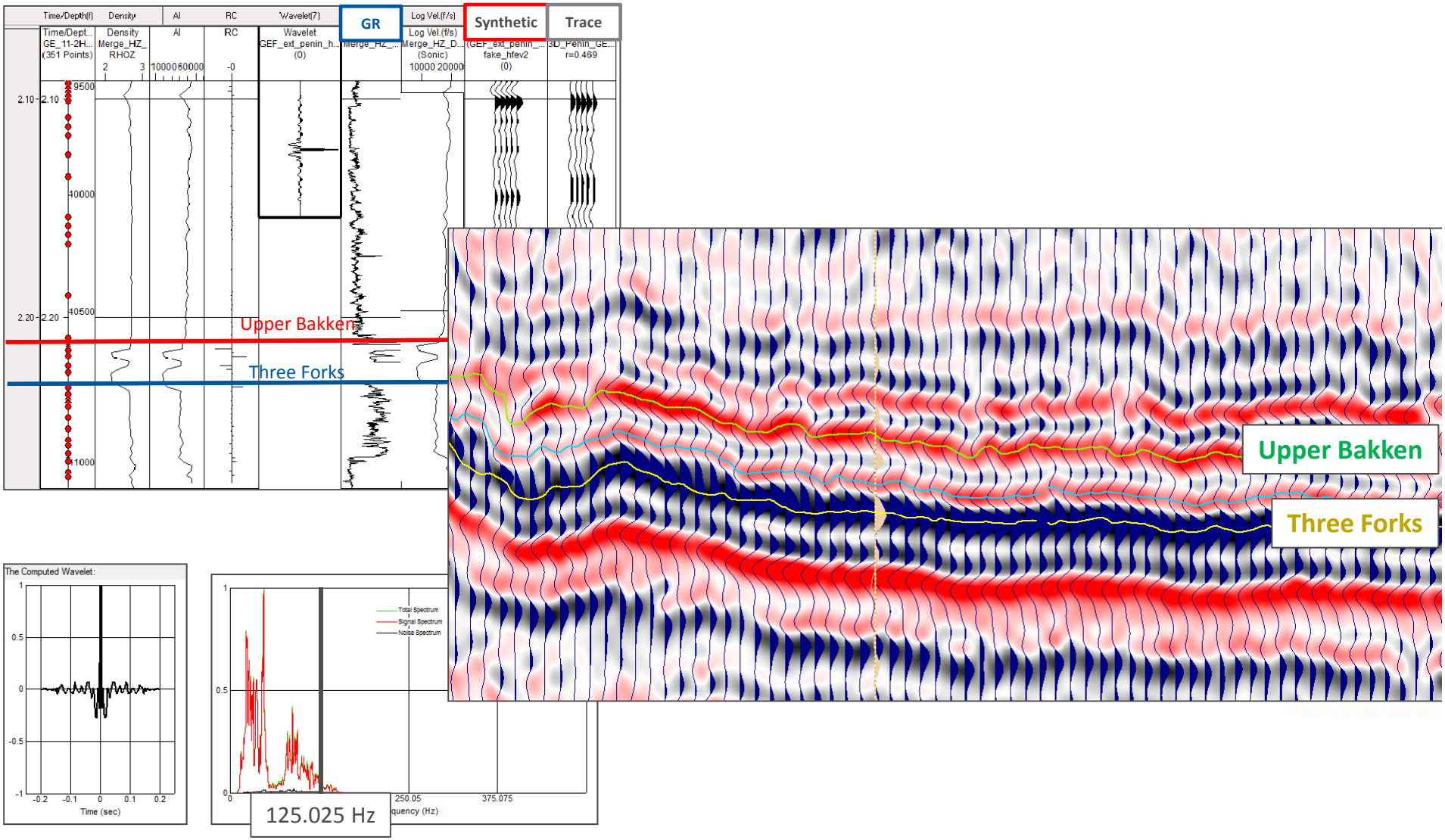
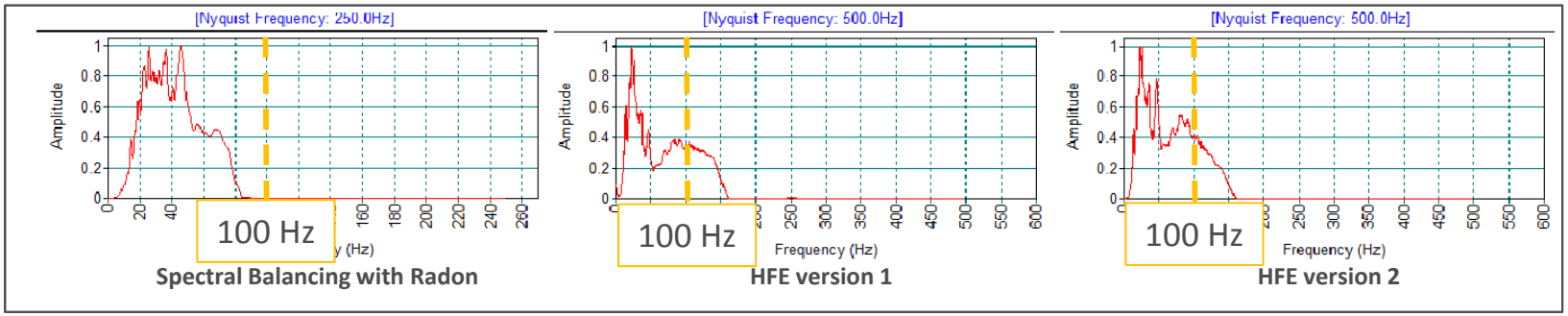
Lower Bakken Thickness: 25-40'
First Bench Three Forks Thickness: 40-60'

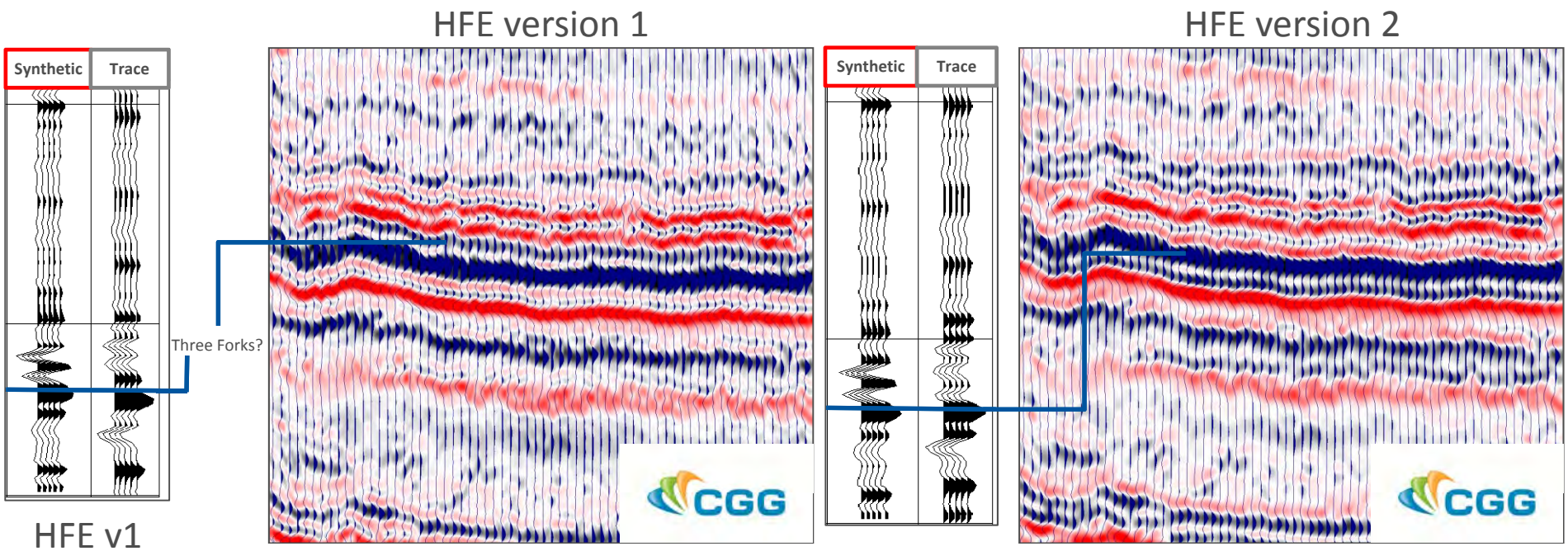


Processing progression: Pre Stack Time Migration HFE

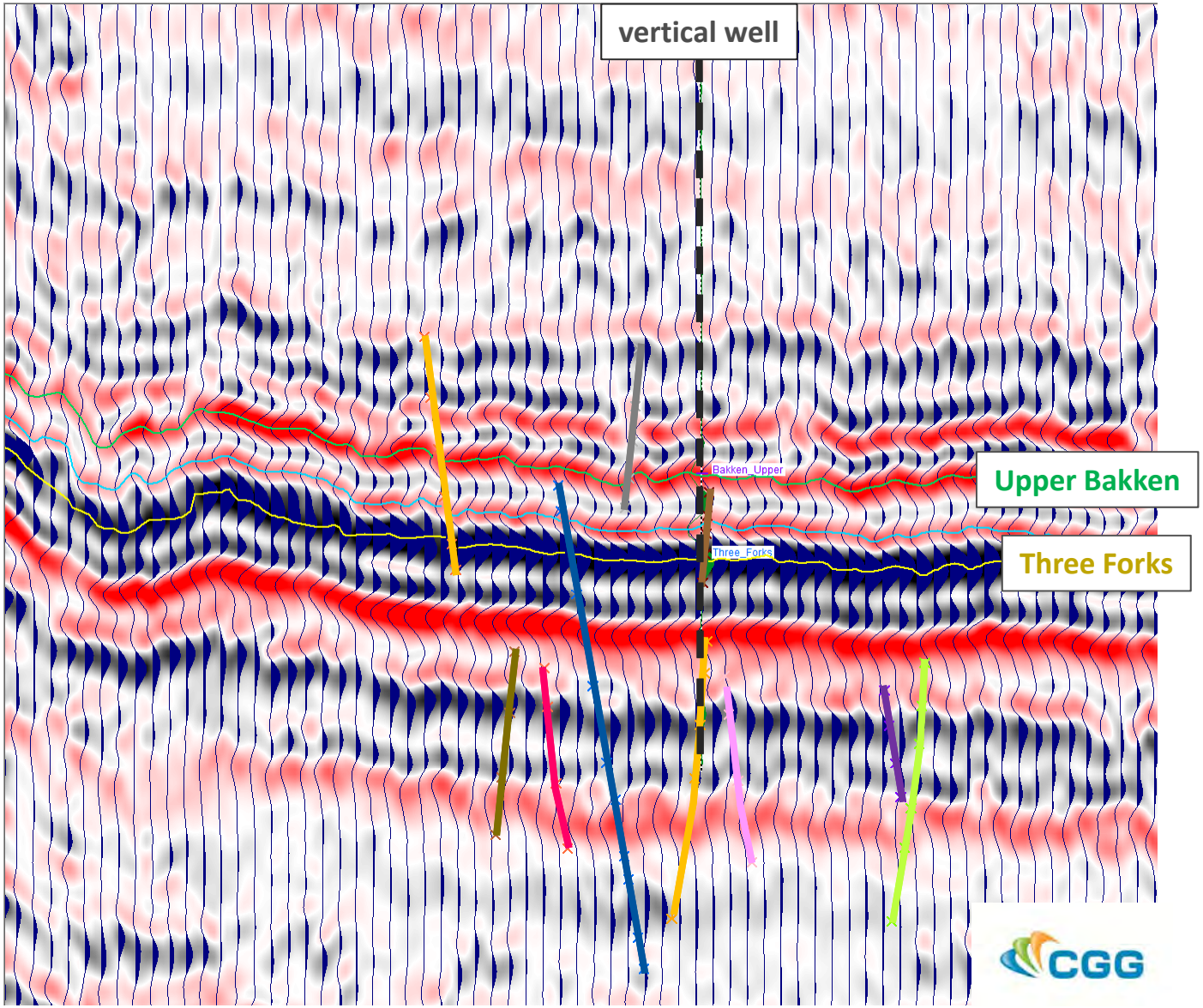


3D processing history: refining HFE volume

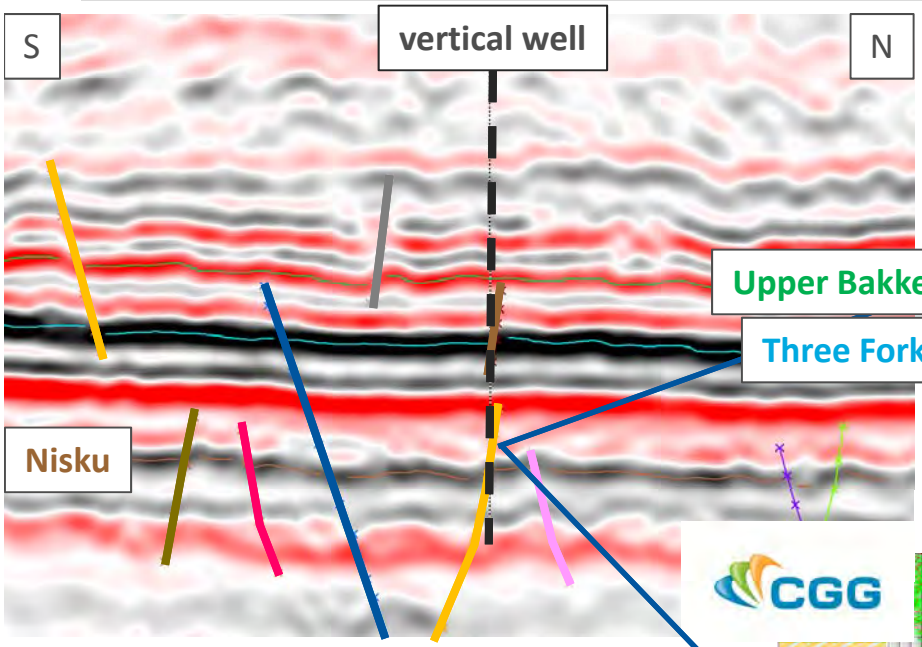


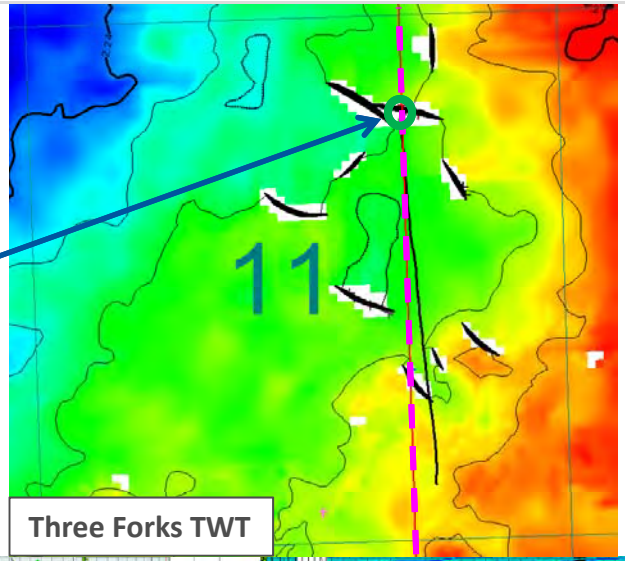


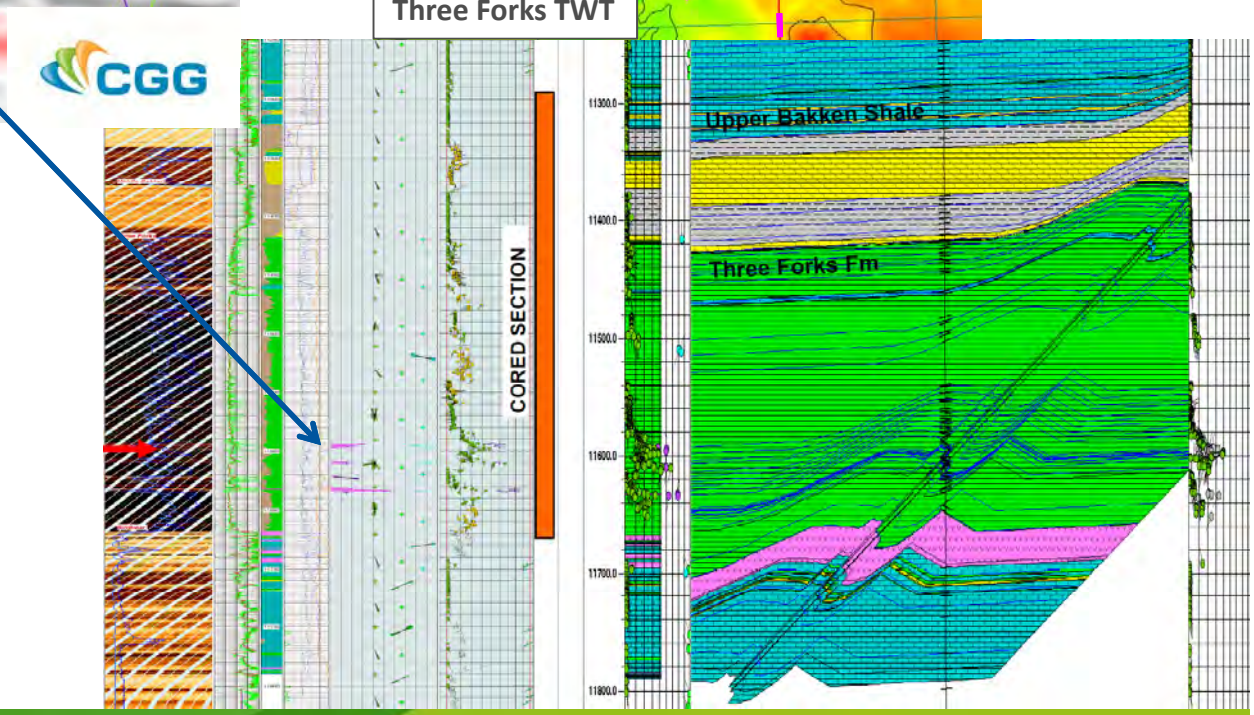
3D processing history: HFE



3D processing history: HFE







- Well logs and core verify fault interpretation not seen until this HFE volume

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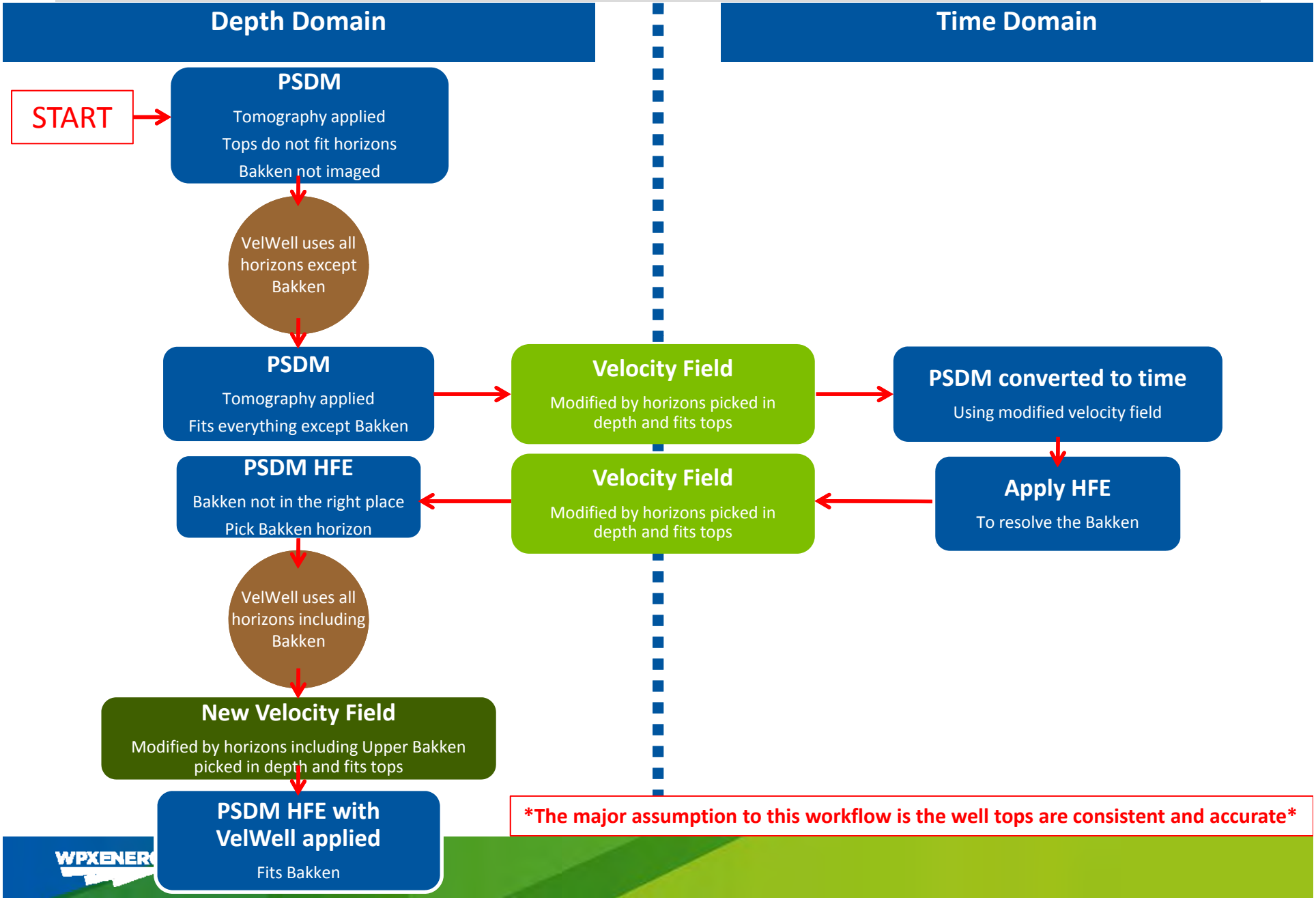
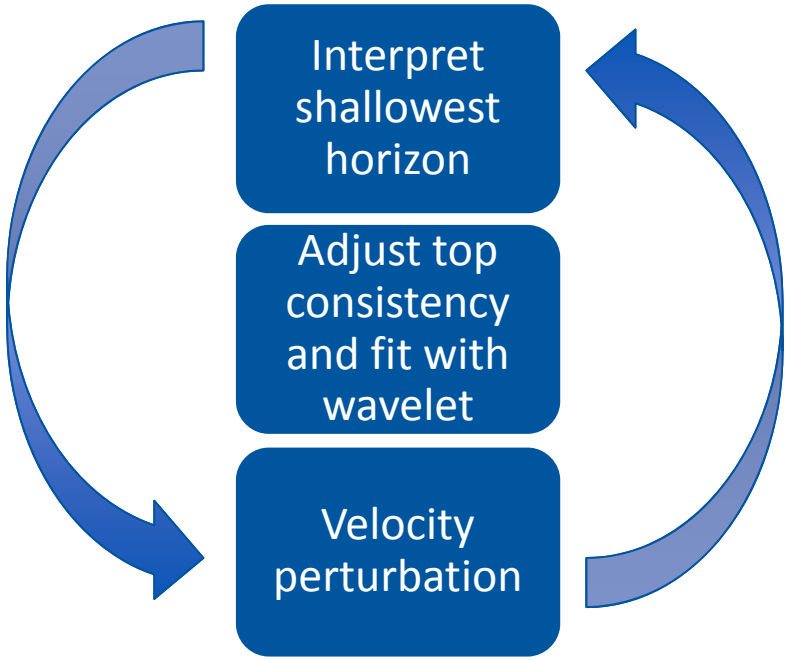
  - **PSDM workflow**
  - Well tops and their accuracy
  - Depth calibration of CBL and MWD/LWD logs
- Conclusions

Converting time to depth: Isotropic Depth Conversion



Converting time to depth

- After the tomo passes have converged on an answer the PSDM volume is interpreted at key horizons



- Go to second shallowest surface and repeat process of comparison to tops
- And so on down to last surface
- Provide fixed tops and interpreted horizons to processor

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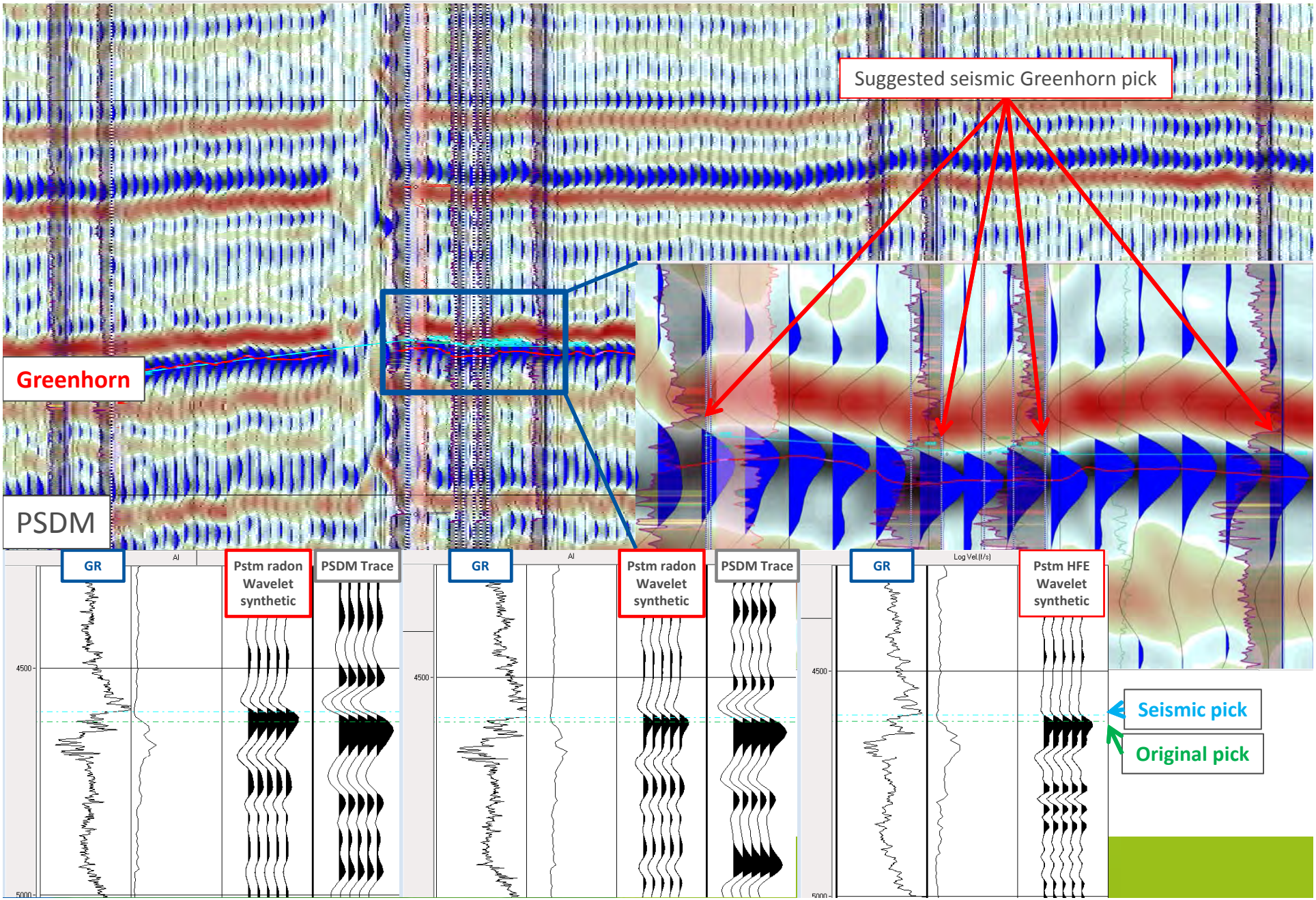
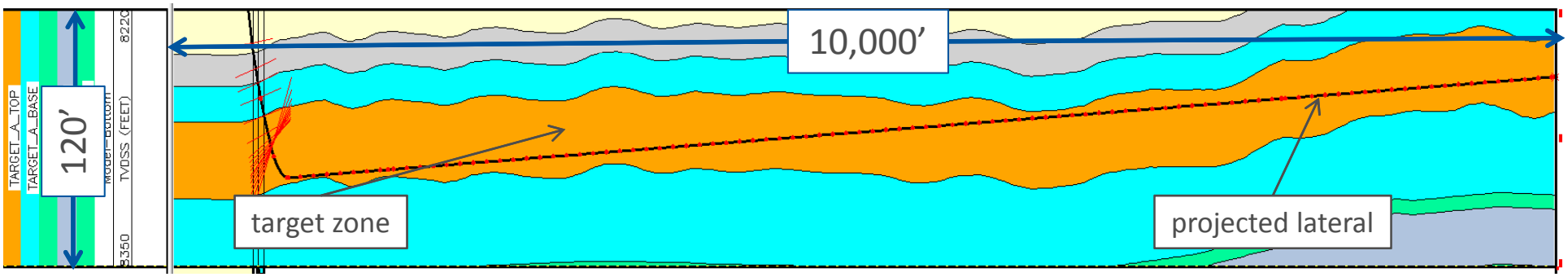
Well tops and their accuracy

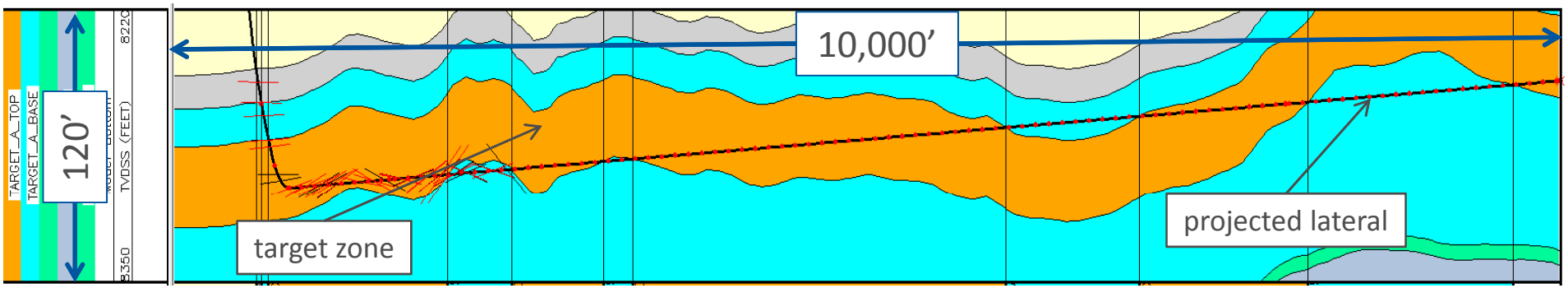


Well tops and their accuracy

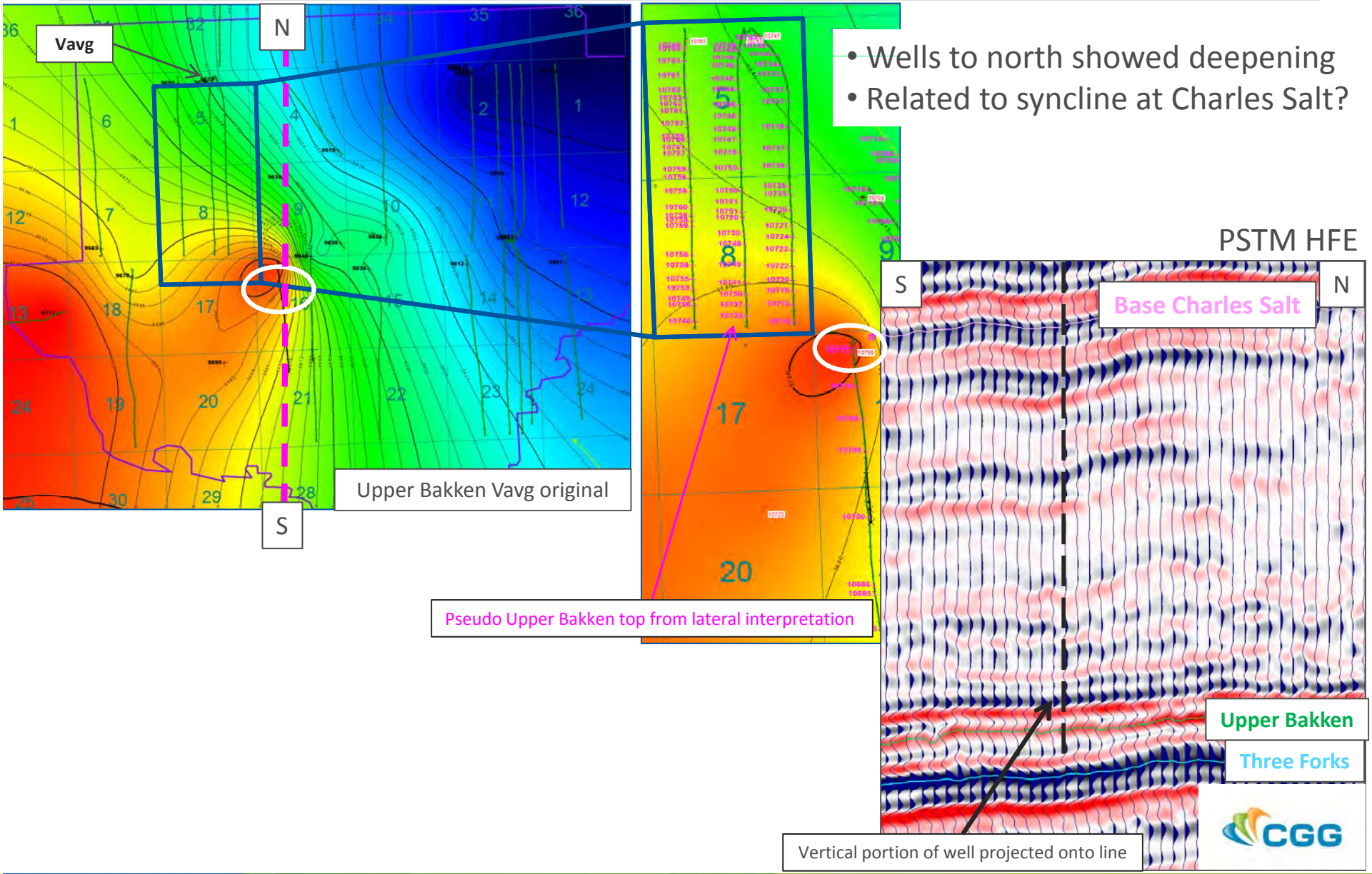
PSTM HFE



PSDM

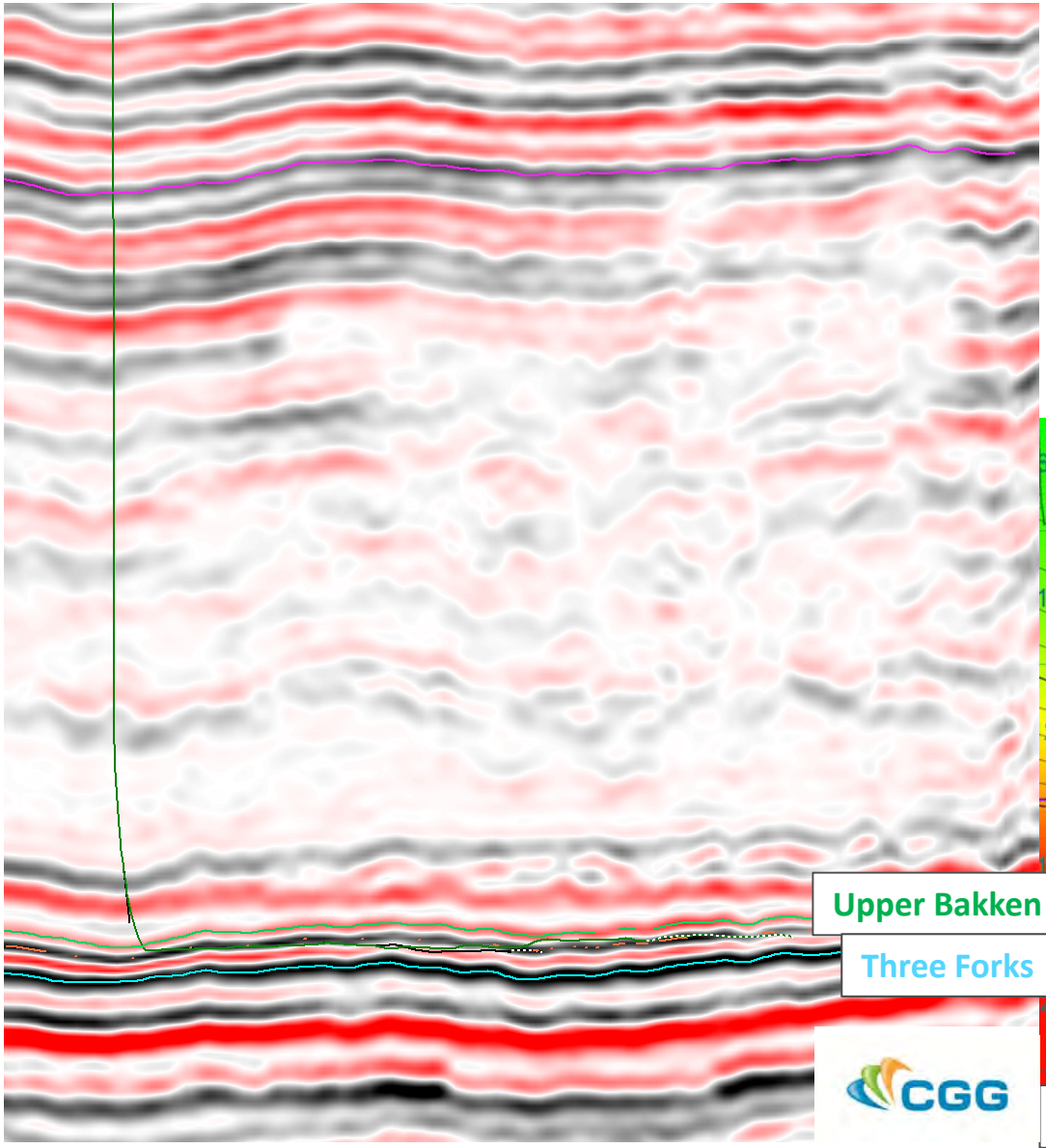


Well tops and their accuracy

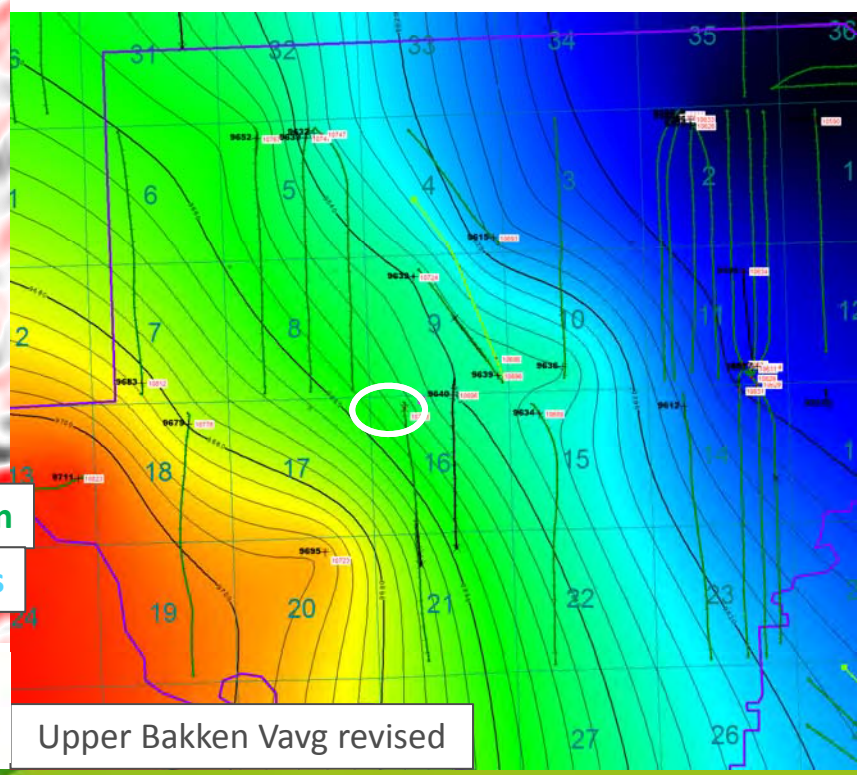


- Wells to north showed deepening
- Related to syncline at Charles Salt?

Well tops and their accuracy



- Error of 40 ft/sec is only 0.4%
- Puts the lateral in the Upper Bakken shale



Upper Bakken Vavg revised

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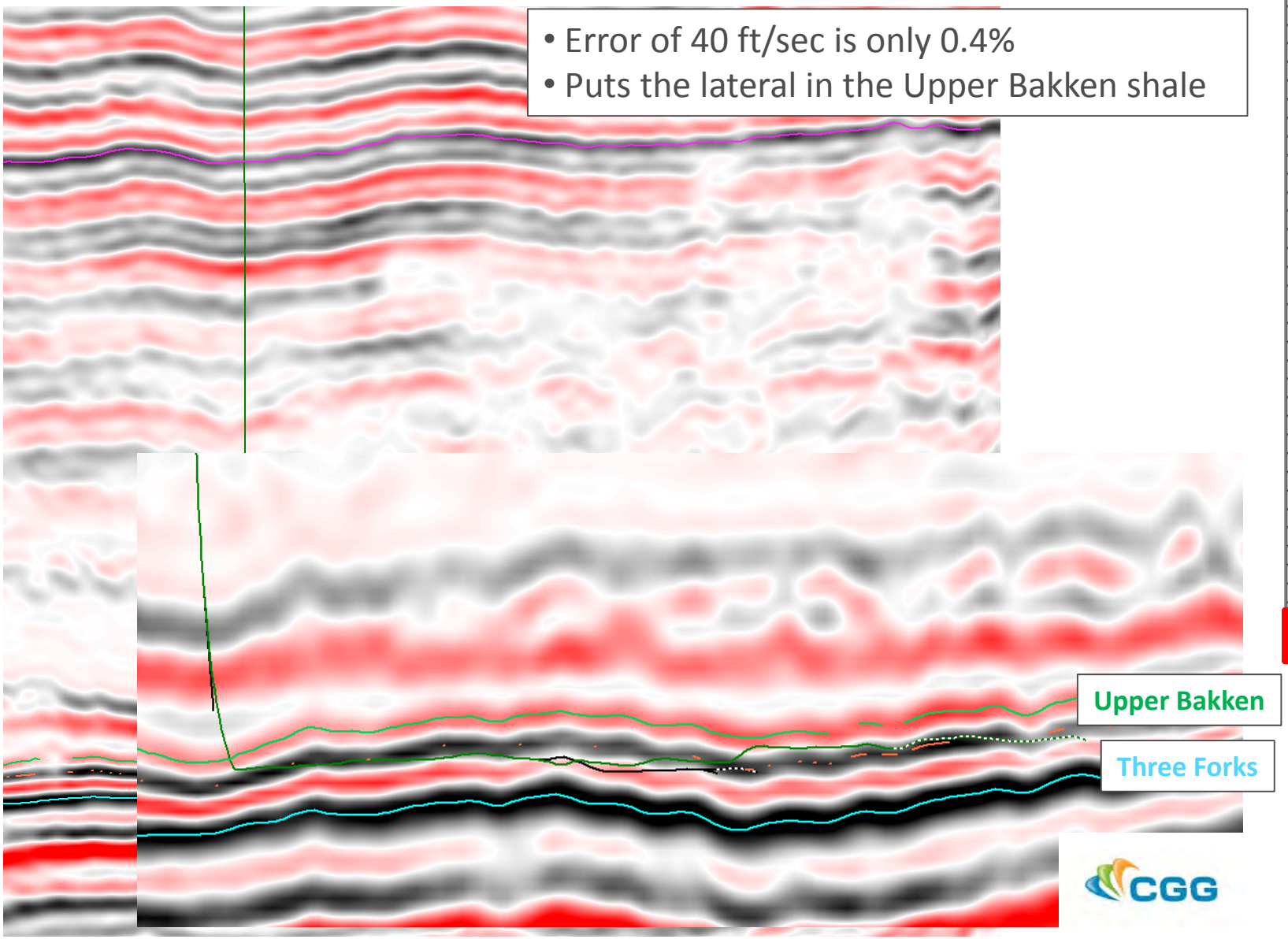
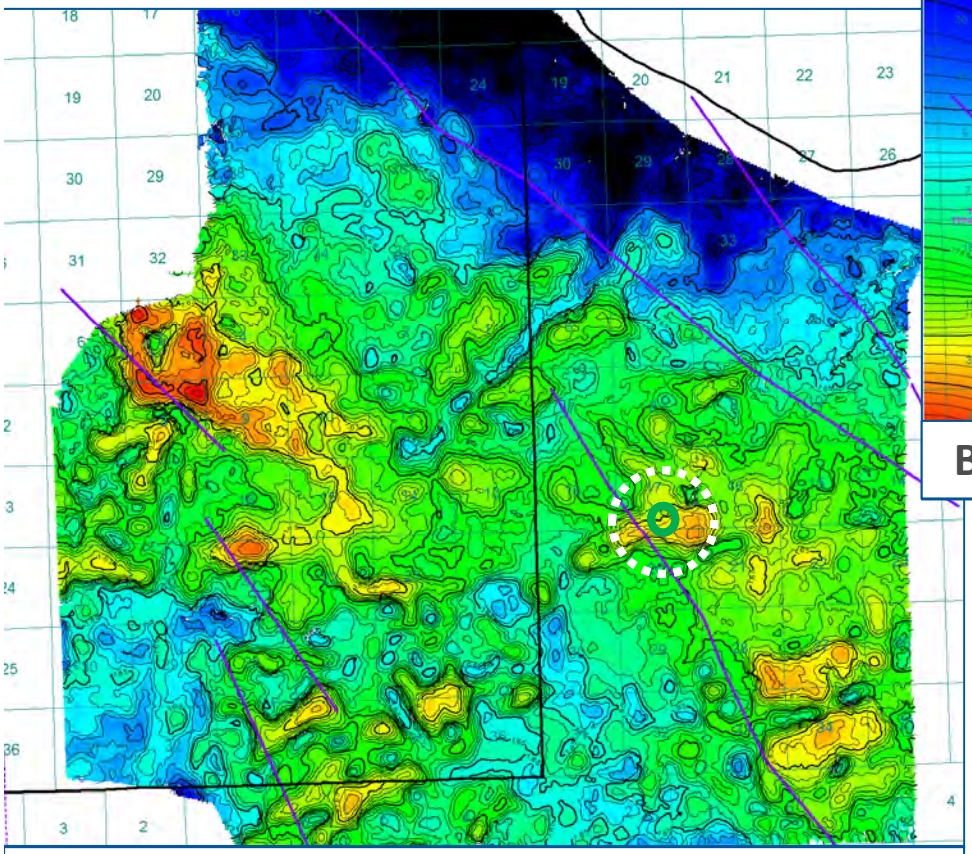
Well tops and their accuracy

- Error of 40 ft/sec is only 0.4%
- Puts the lateral in the Upper Bakken shale

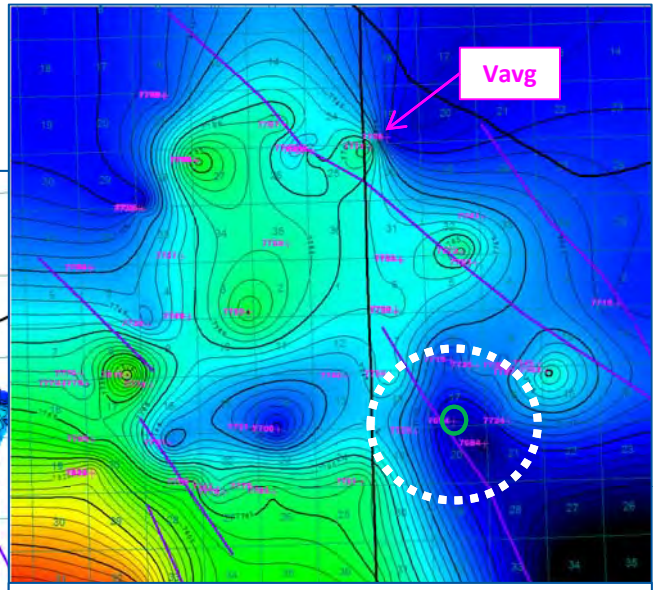


	MD(Feet	Incline(	Azimuth
71	7920.00	0.87	89.67
72	8010.00	0.78	88.30
73	8100.00	0.78	87.95
74	8190.00	0.79	95.40
75	8280.00	0.82	99.55
76	8370.00	0.77	102.99
77	8460.00	0.75	107.73
78	8550.00	0.74	115.03
79	8640.00	0.69	115.25
80	8730.00	0.71	116.00
81	8820.00	0.67	116.54
82	8910.00	0.62	111.41
83	9000.00	0.66	113.26
84	9090.00	0.63	113.69
85	9180.00	0.57	110.53
86	9270.00	0.56	97.81
87	9360.00	0.56	99.68
88	9450.00	0.57	101.94
89	9540.00	0.49	91.91
90	9630.00	0.44	85.15
91	9647.00	0.28	49.26
92	9681.00	0.94	159.45
93	9713.00	4.43	173.32
94	9744.00	7.39	175.63
95	9776.00	10.18	176.85
96	9808.00	13.45	176.97
97	9839.00	16.89	176.78
98	9871.00	20.30	177.92
99	9902.00	22.80	179.97
10	9934.00	25.47	181.59
10	9965.00	28.54	183.83
10	9997.00	31.80	184.81
10	10060.0	38.67	185.56
10	10228.0	38.67	185.56

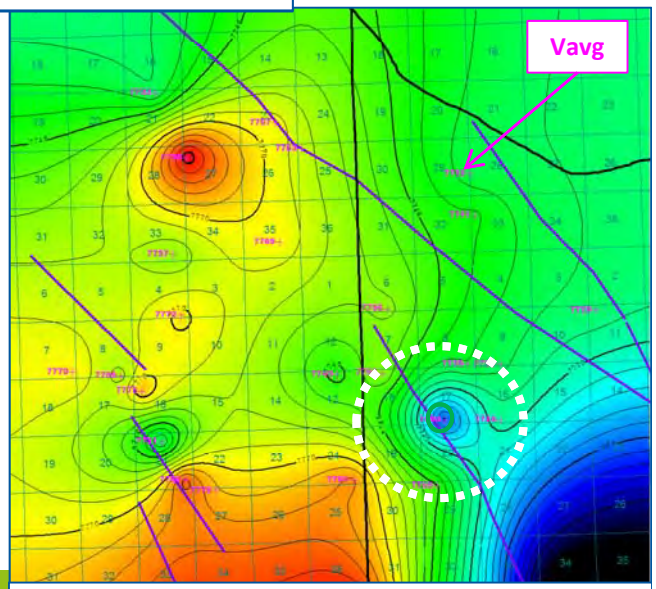
Well tops and their accuracy



Base of Rierdon TWT



Base of Rierdon Vavg original



Base of Rierdon Vavg revised

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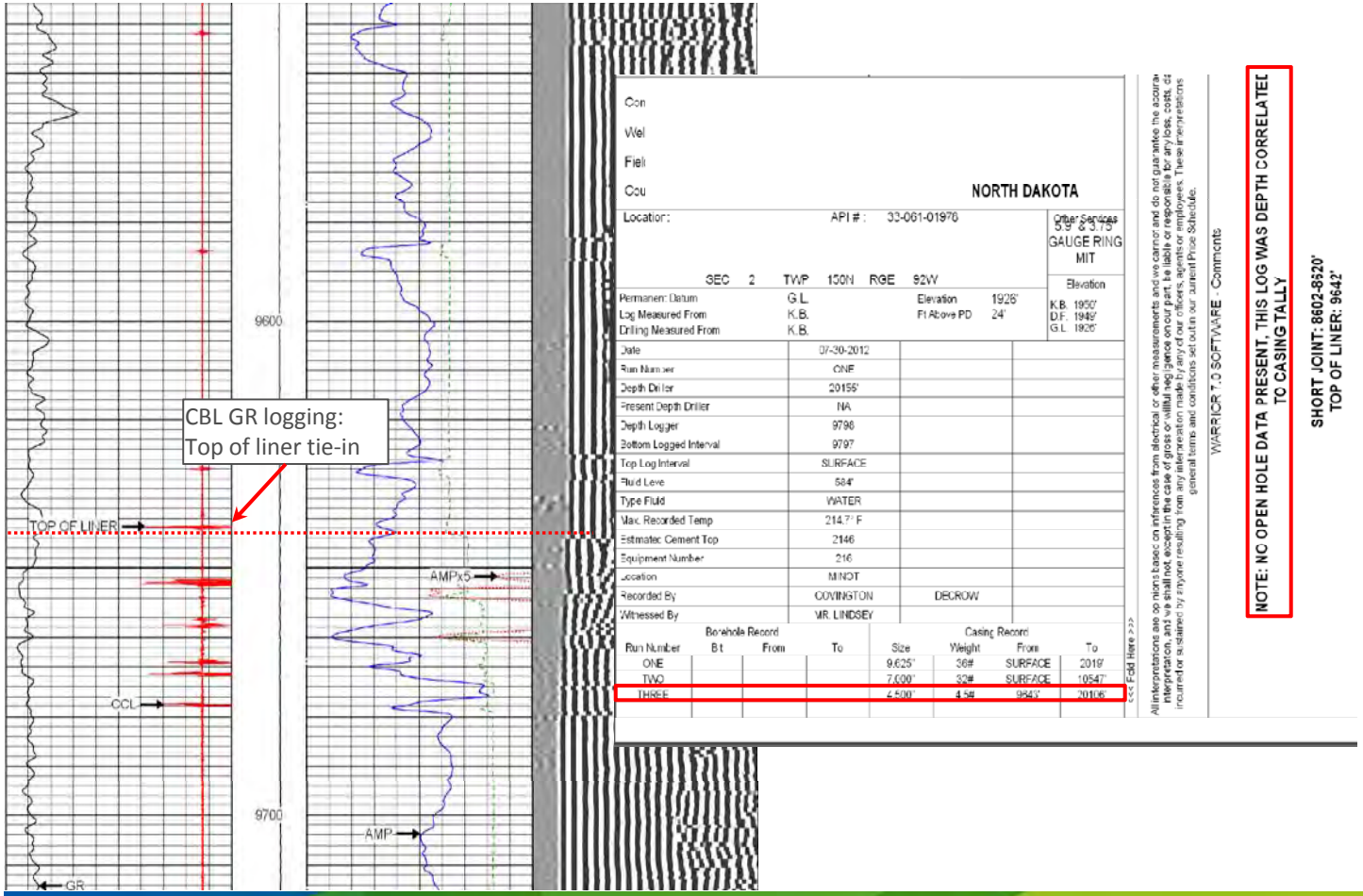
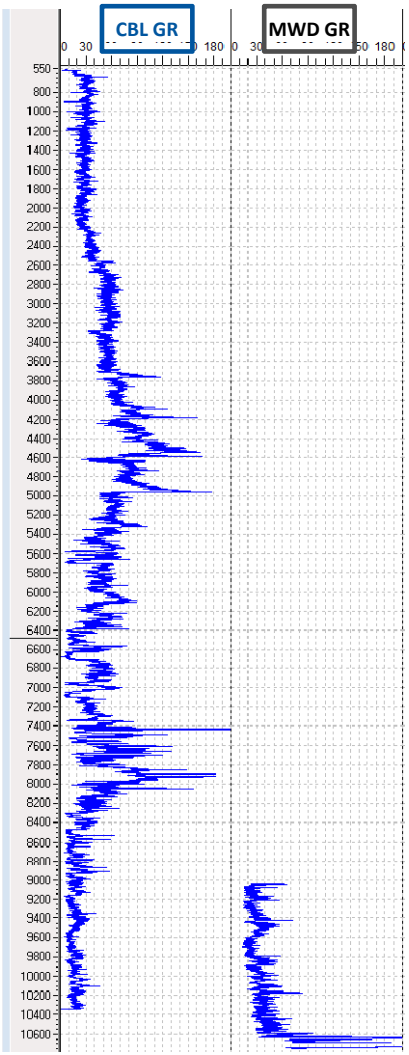
- Conclusions

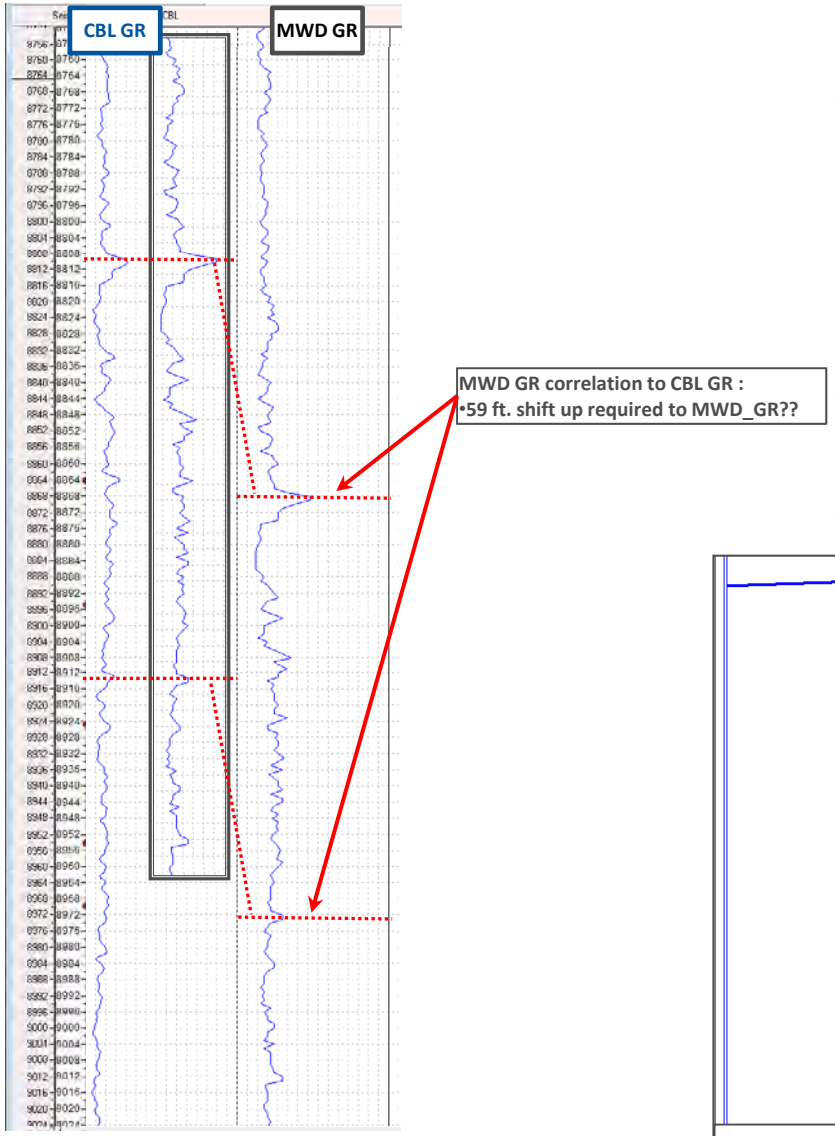
Depth calibration of wireline/CBL and MWD/LWD logs

- MWD GR logs turned on in Lodgepole due to time and cost constraints
- CBL GR run from KOP to surface usually months later





Depth calibration of wireline/CBL and MWD/LWD logs



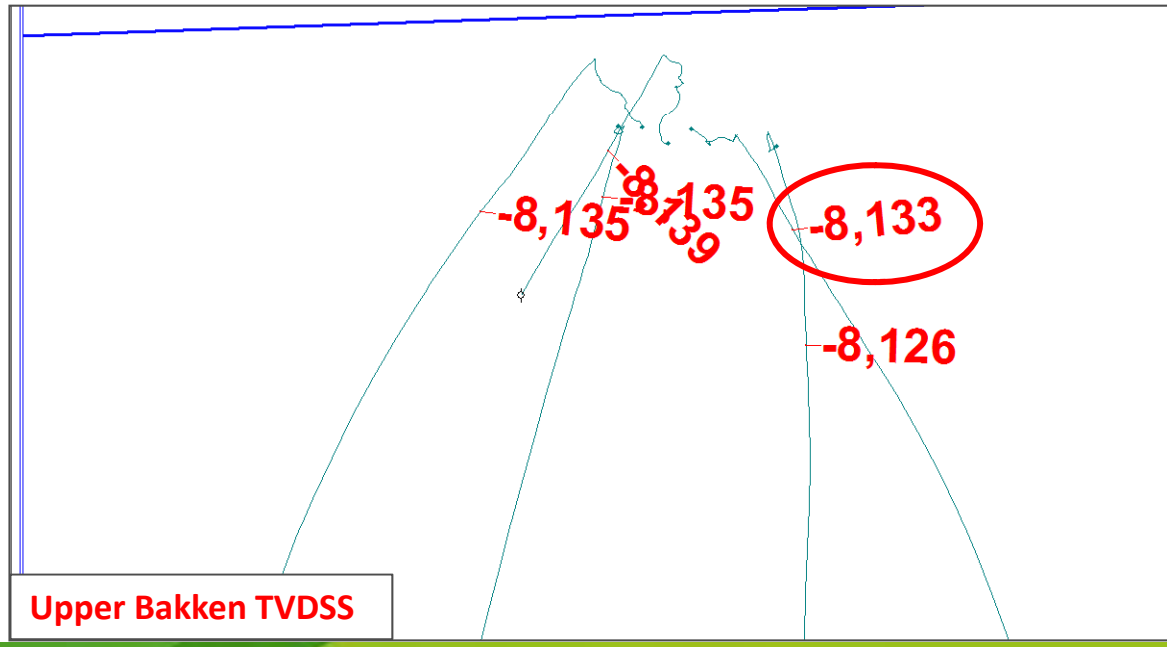
CBL has opportunity to be tied in with different markers at different depths

SHORT JOINT: 8602-8620'
TOP OF LINER: 9642'

One choice was to shift MWD GR to CBL GR

Posting TVDSS depths of Upper Bakken top does not suggest that MWD should be shifted to CBL

Shift CBL GR to MWD GR and shift all shallow tops!



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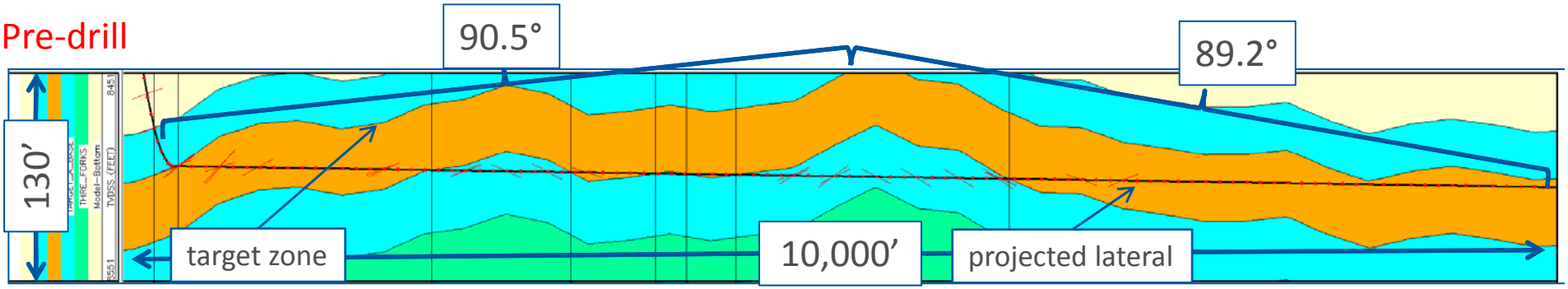
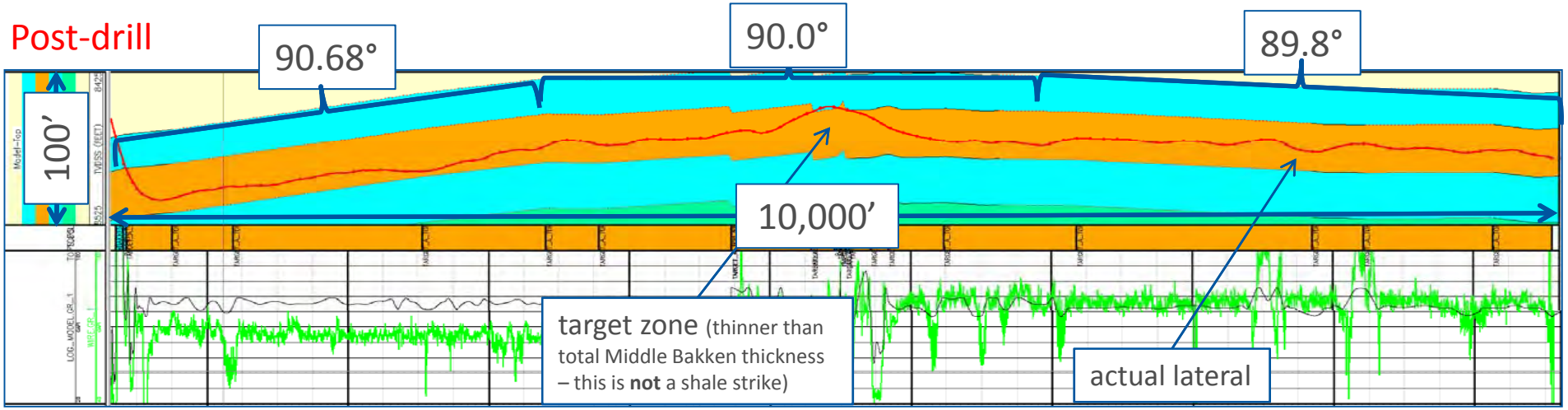
Conclusions

Pre-drill



Post-drill



- Post drill surfaces modified by lateral GR interpretation

Thank you

WPX Energy

Hal Harper
Lee Steinke
Laura Wray
Jason A. Harms
John Frame
Simon Cole

STERLING

Rus Kappius
Steve Saindon

CGG

Rick Trevino