Delineating a sandstone reservoir at Pikes Peak, Saskatchewan using 3C seismic data and well logs
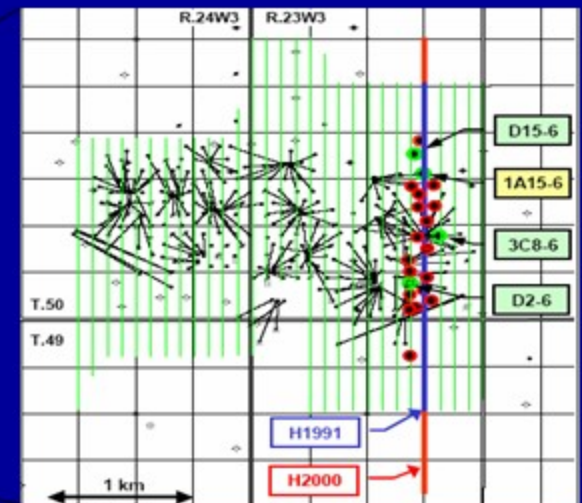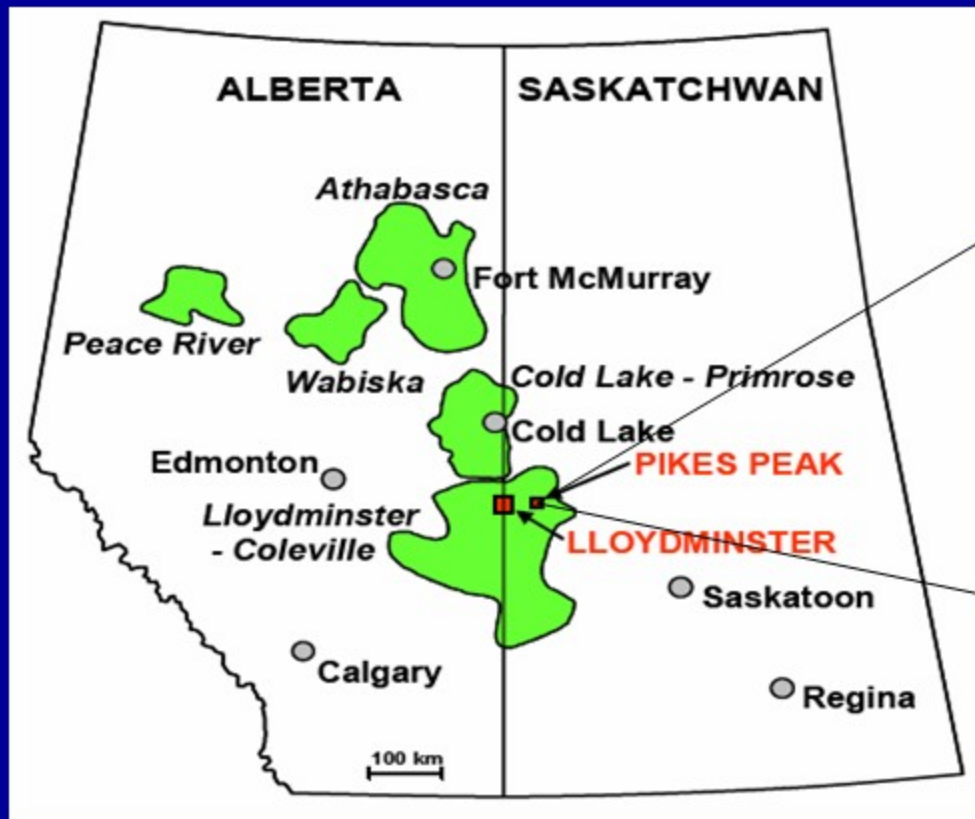
Natalia L. Soubotcheva & Robert R. Stewart
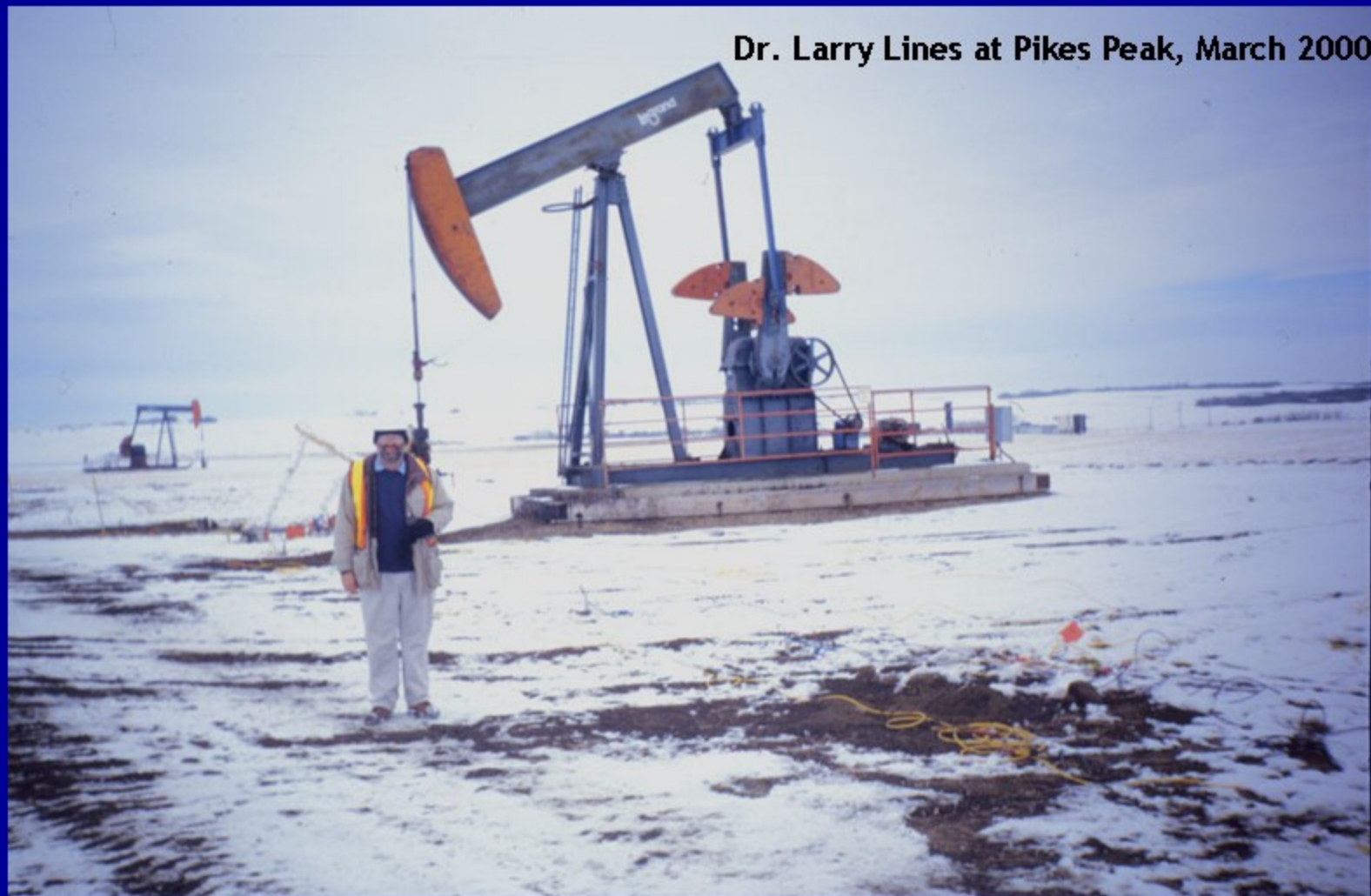University of Calgary
December 2, 2005

CREWES

Outline

- Pikes Peak oilfield - Geology & location
- Well log & synthetic correlation to seismic
- PP and PS inversions of seismic data (using Strata)
- Prediction of density and porosity using seismic attributes (using Emerge)
- Results - Imaging of anomalous zones
- Conclusions, Future work

Location of the Pikes Peak oilfield
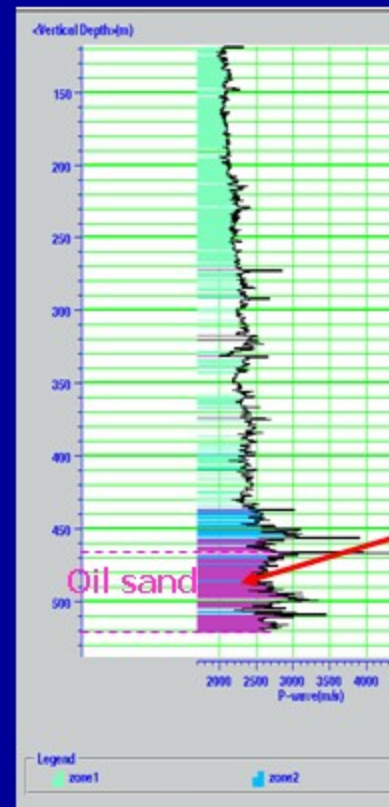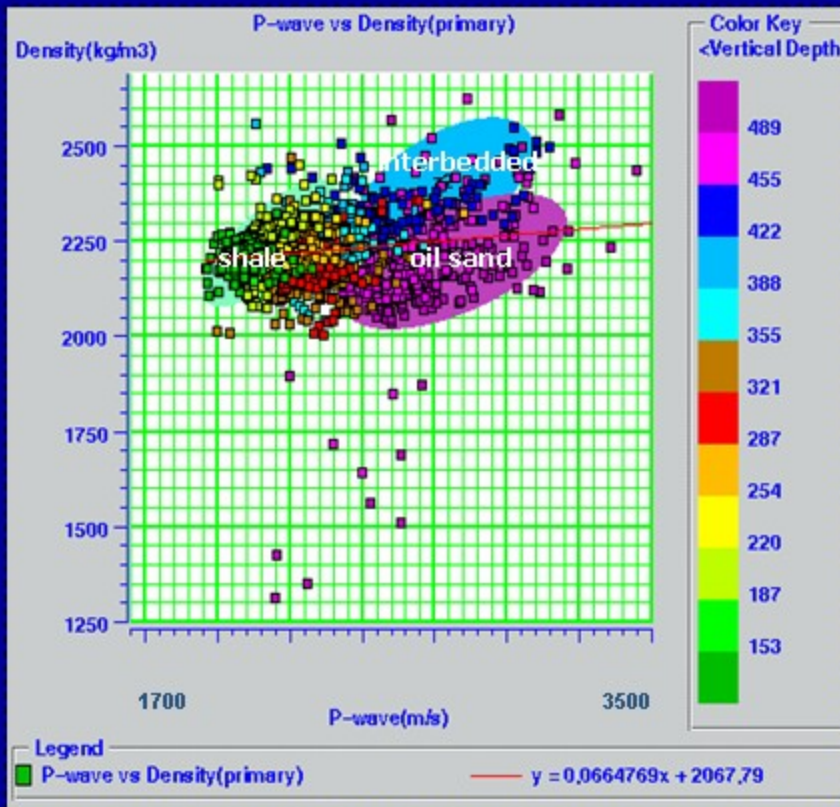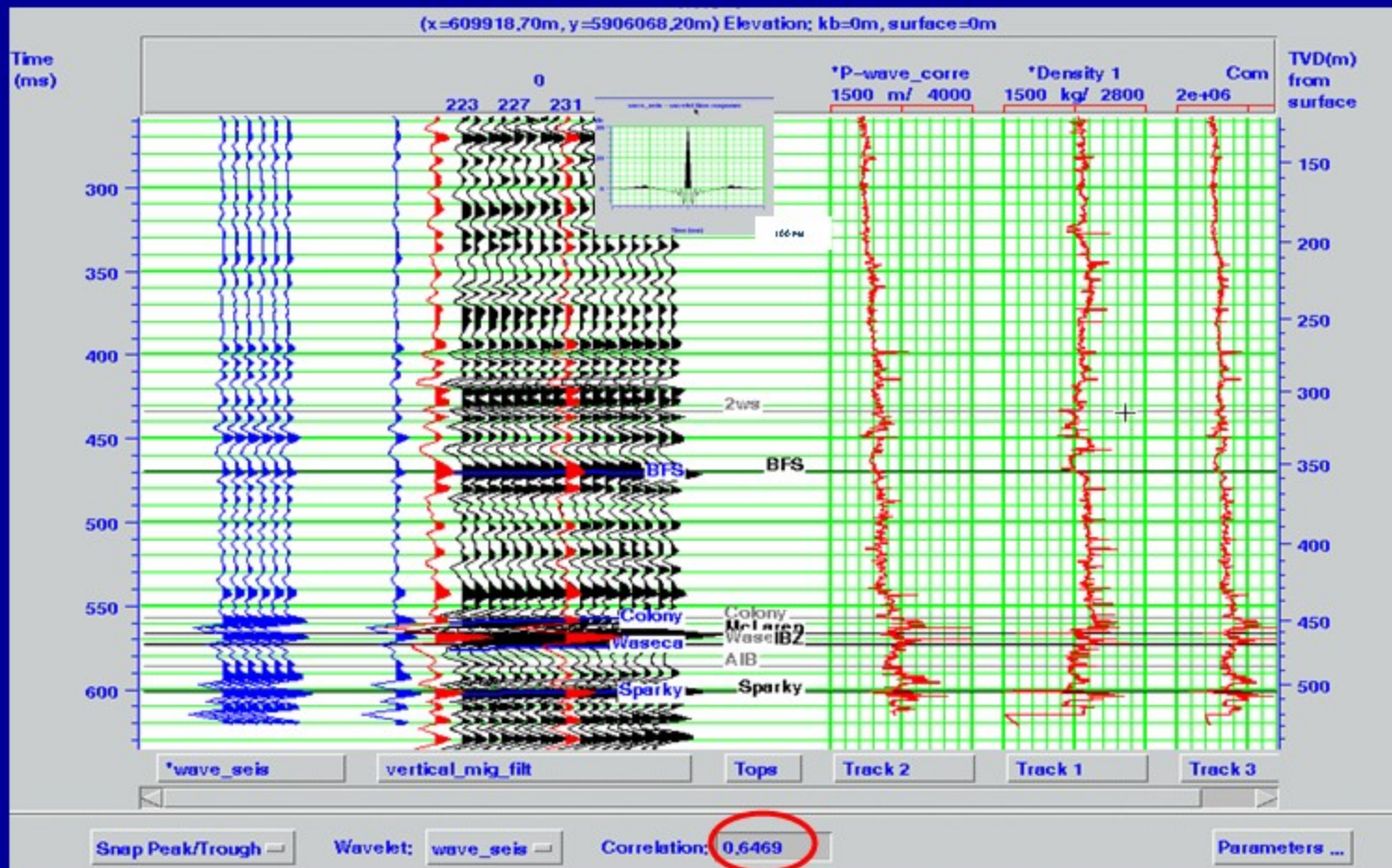## (from Watson, 2003)

Pump jacks in operation

Dr. Larry Lines at Pikes Peak, March 2000

Lithology differentiation

Well 1A15-6

(after Core Lab Stratigraphic Chart for Saskatchewan)

Synthetic, seismic, & well log correlation

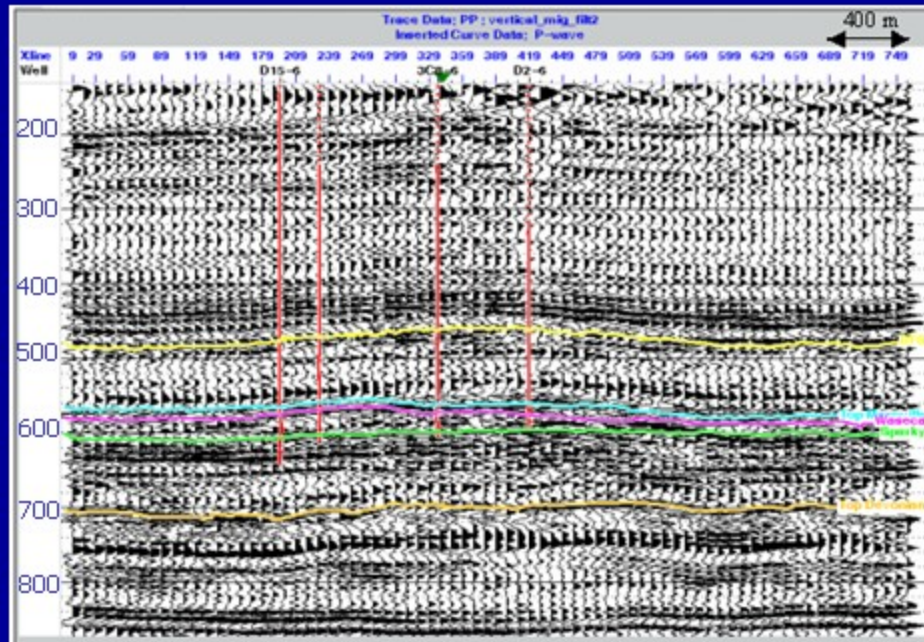# Log-seismic calibration
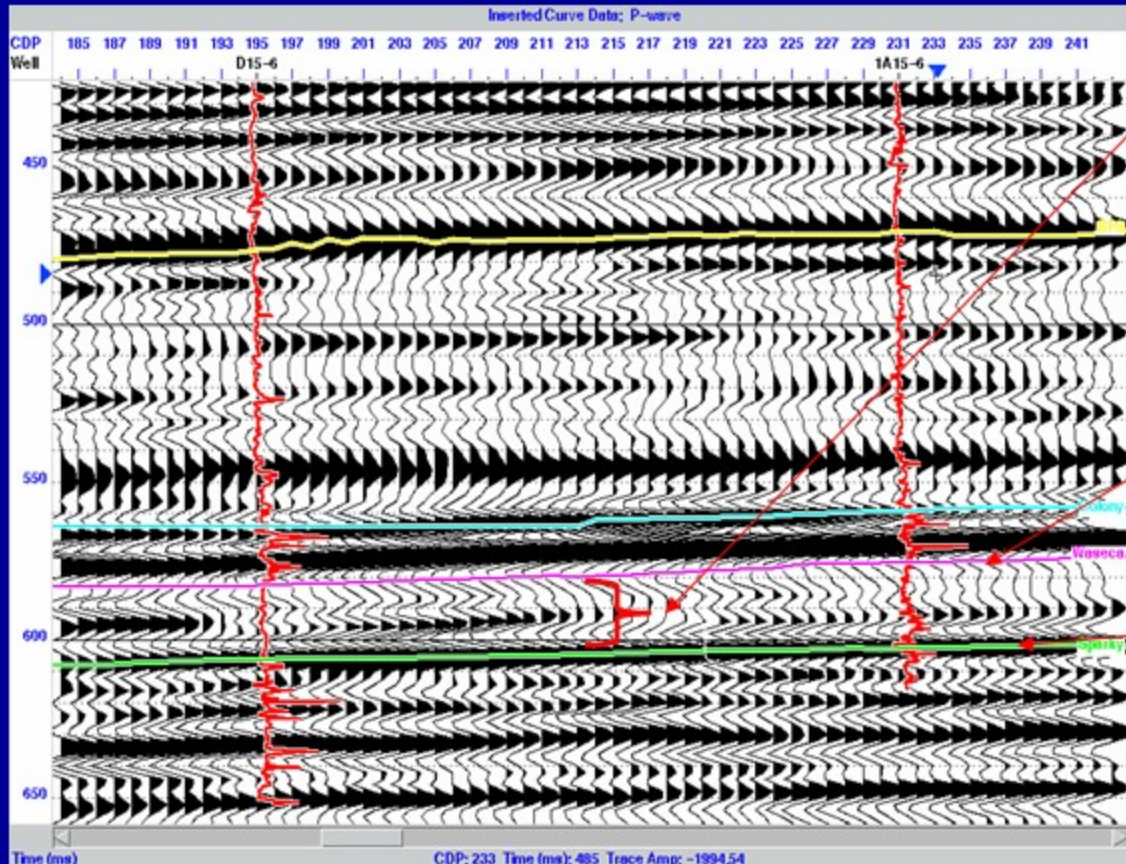
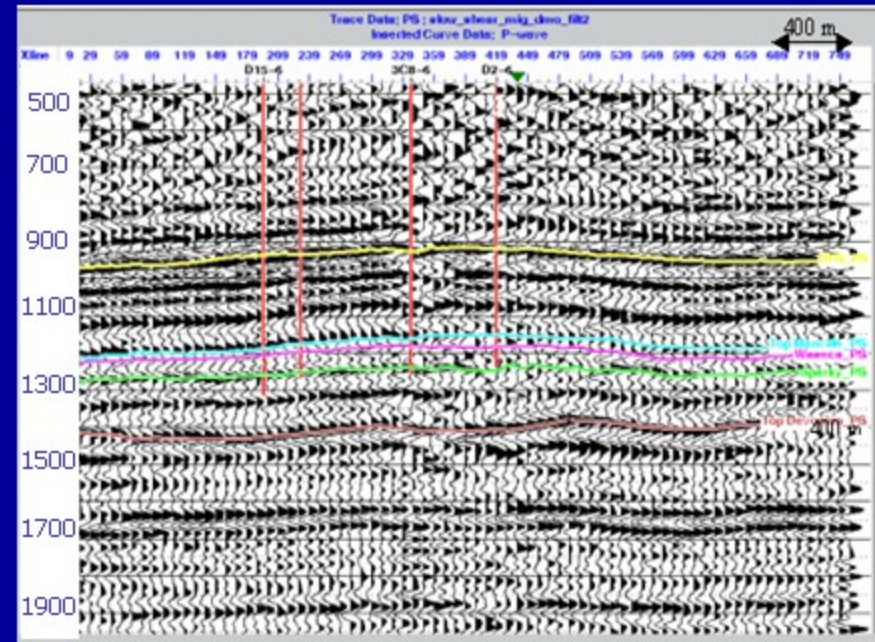Productive formation Waseca (5-30 m)

impedance ↓
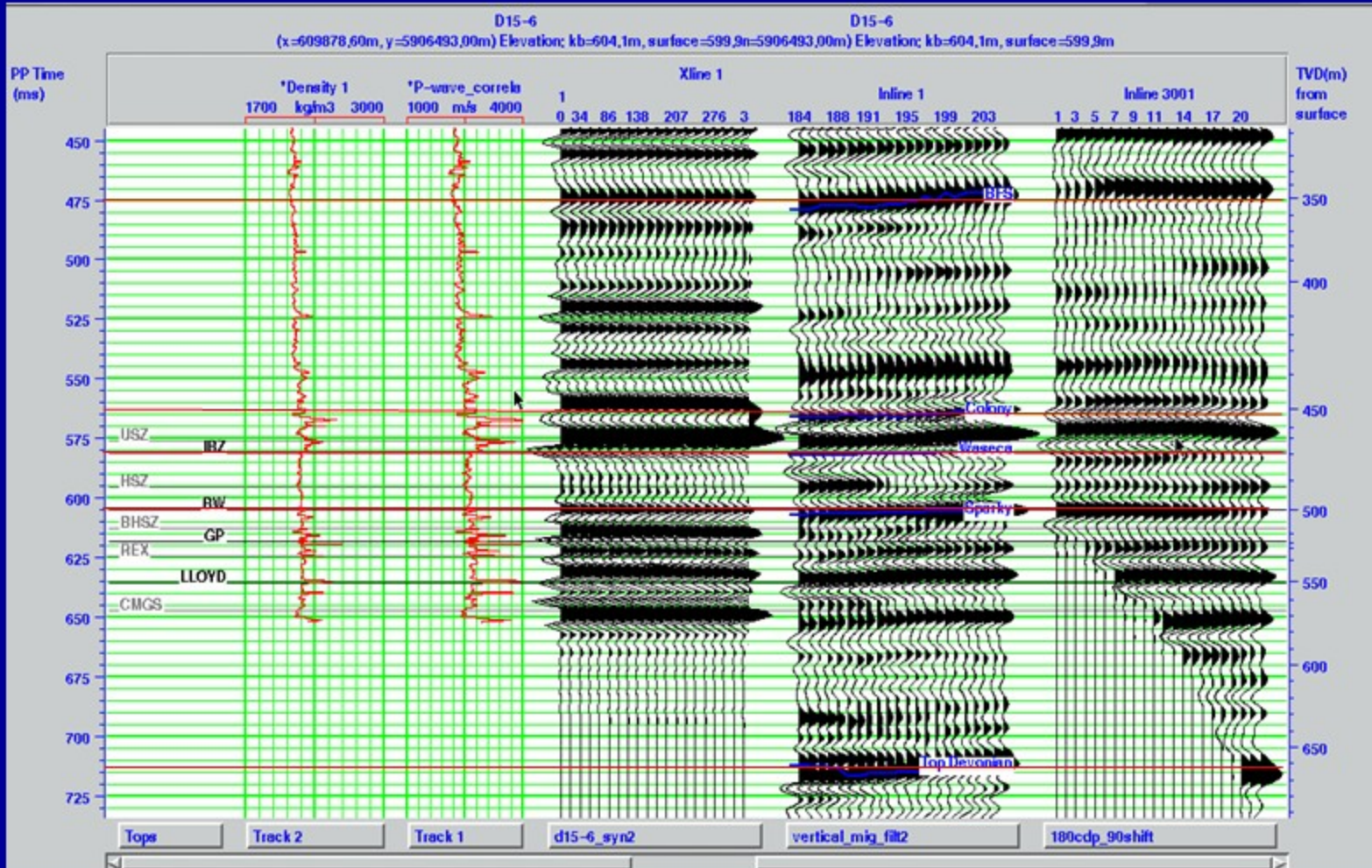
impedance ↑

Interpreted PP and PS sections

PP time, ms

PS time, ms

Composite plot

Synthetic

Surface
seismic

VSP, Offset
180 m

Inversion for P-wave impedance

Total correlation - 57%

Modifying the correlation window
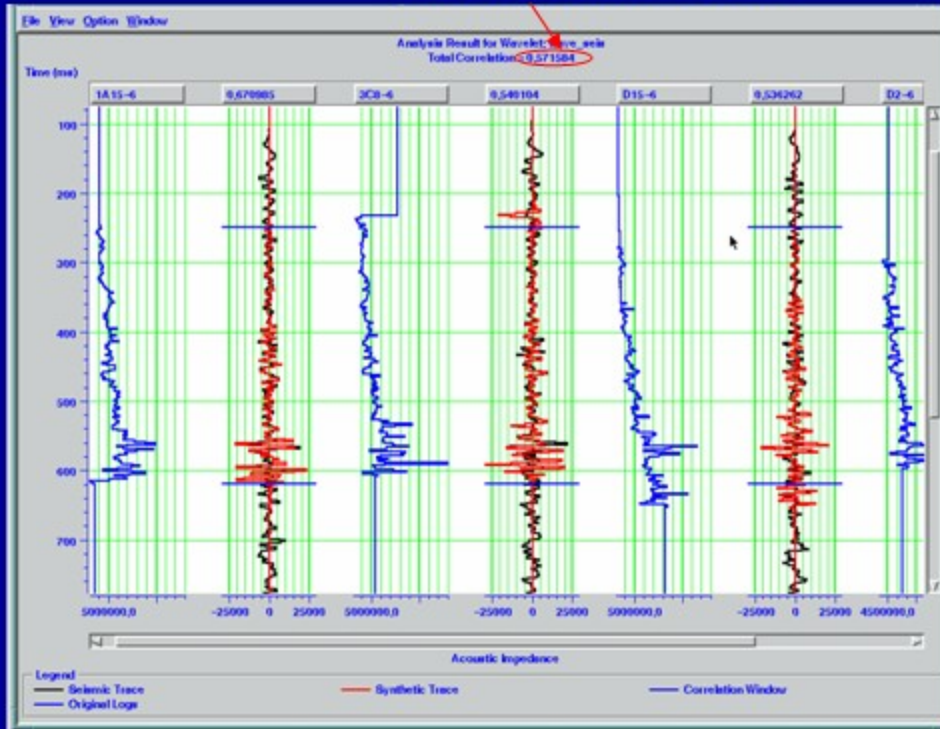
Impedance log

Seismic trace (black)

Synthetic trace (red)

Correlation plot for four wells

The initial background model
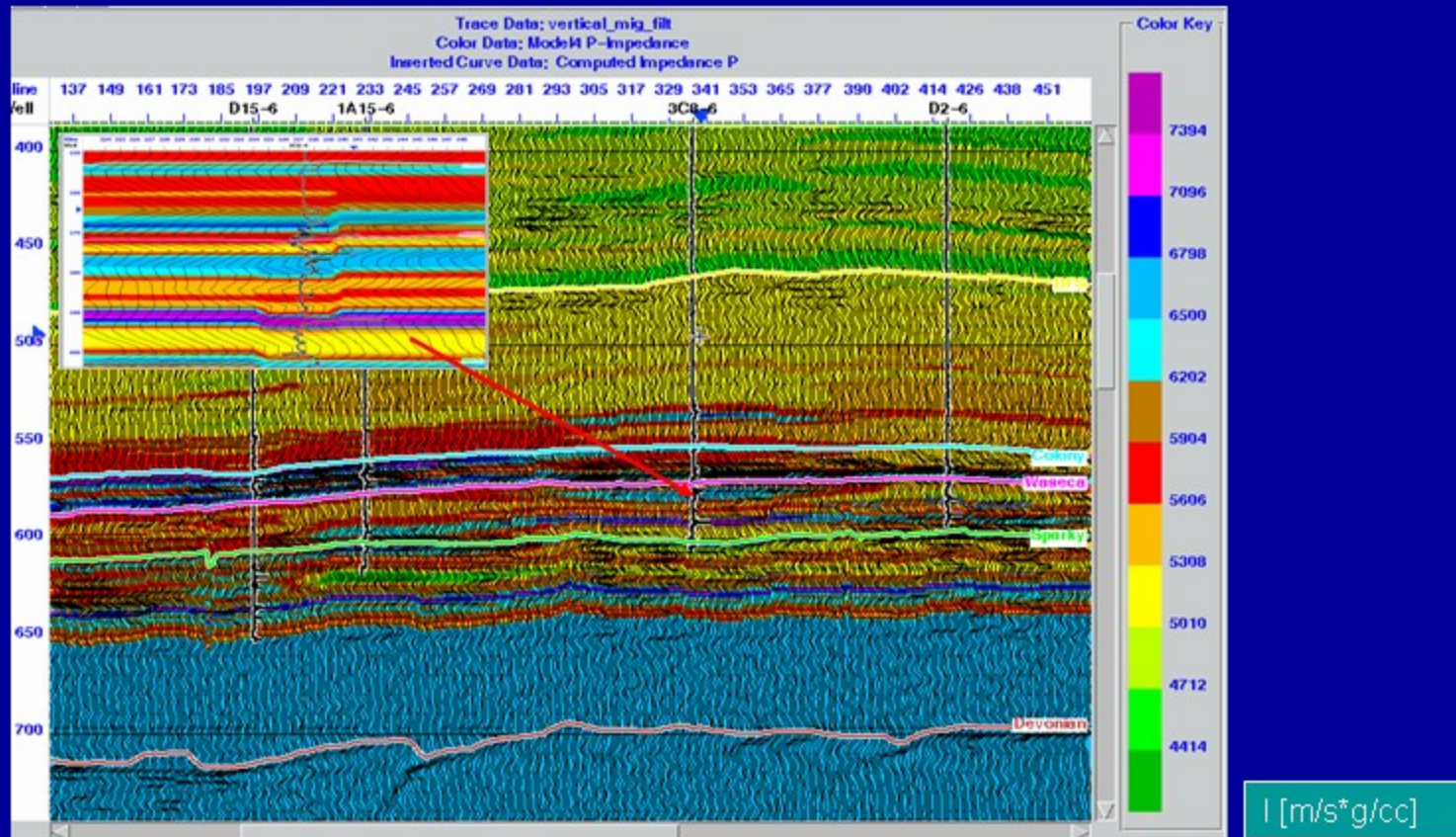
PP inversion results

Model based inversion

Impedance drop

High frequency result (frequency comes from the initial guess model)

PS inversion

The ratio of PP inversion to PS inversion in PP time
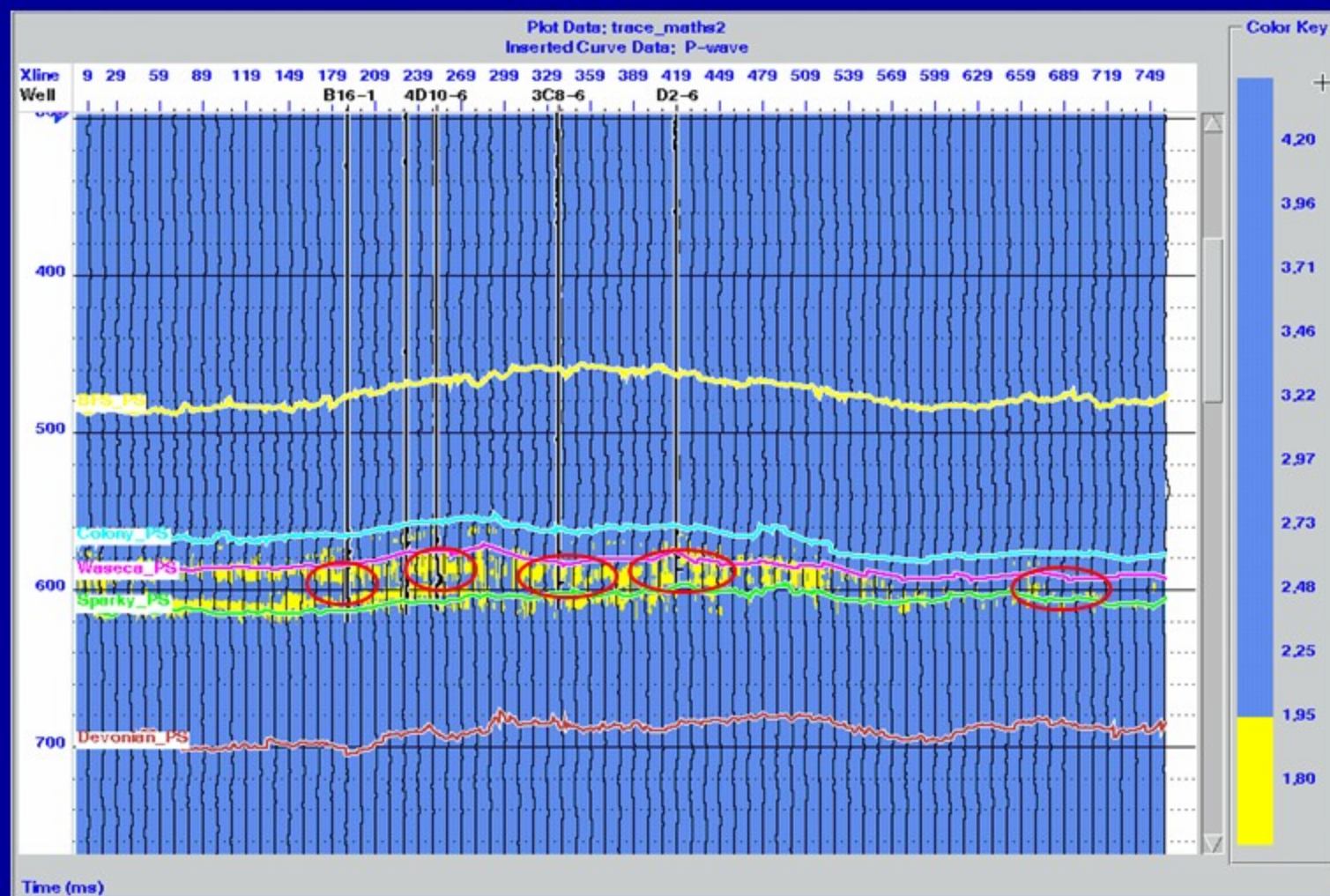
Vp/Vs from time thicknesses
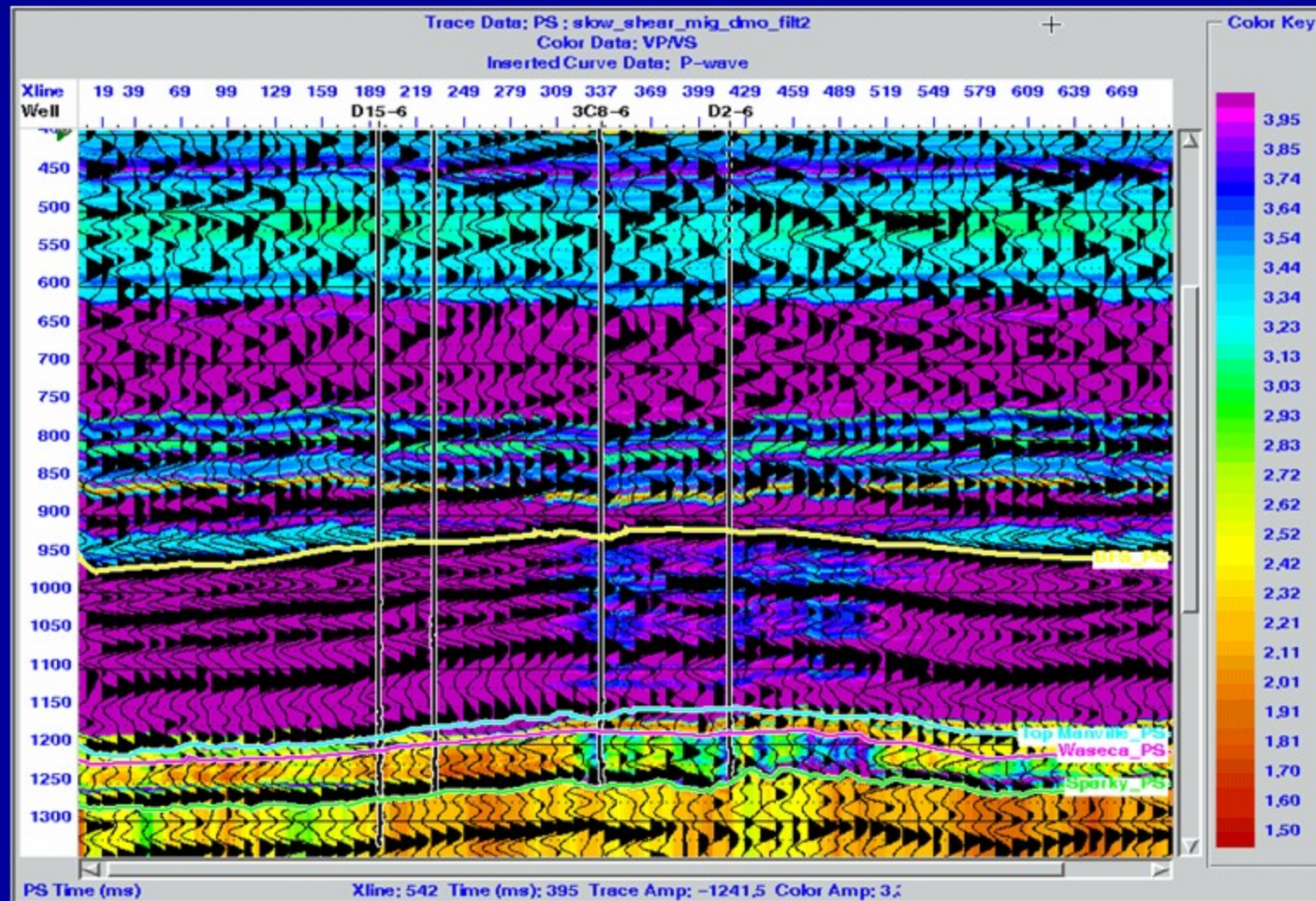
Density prediction
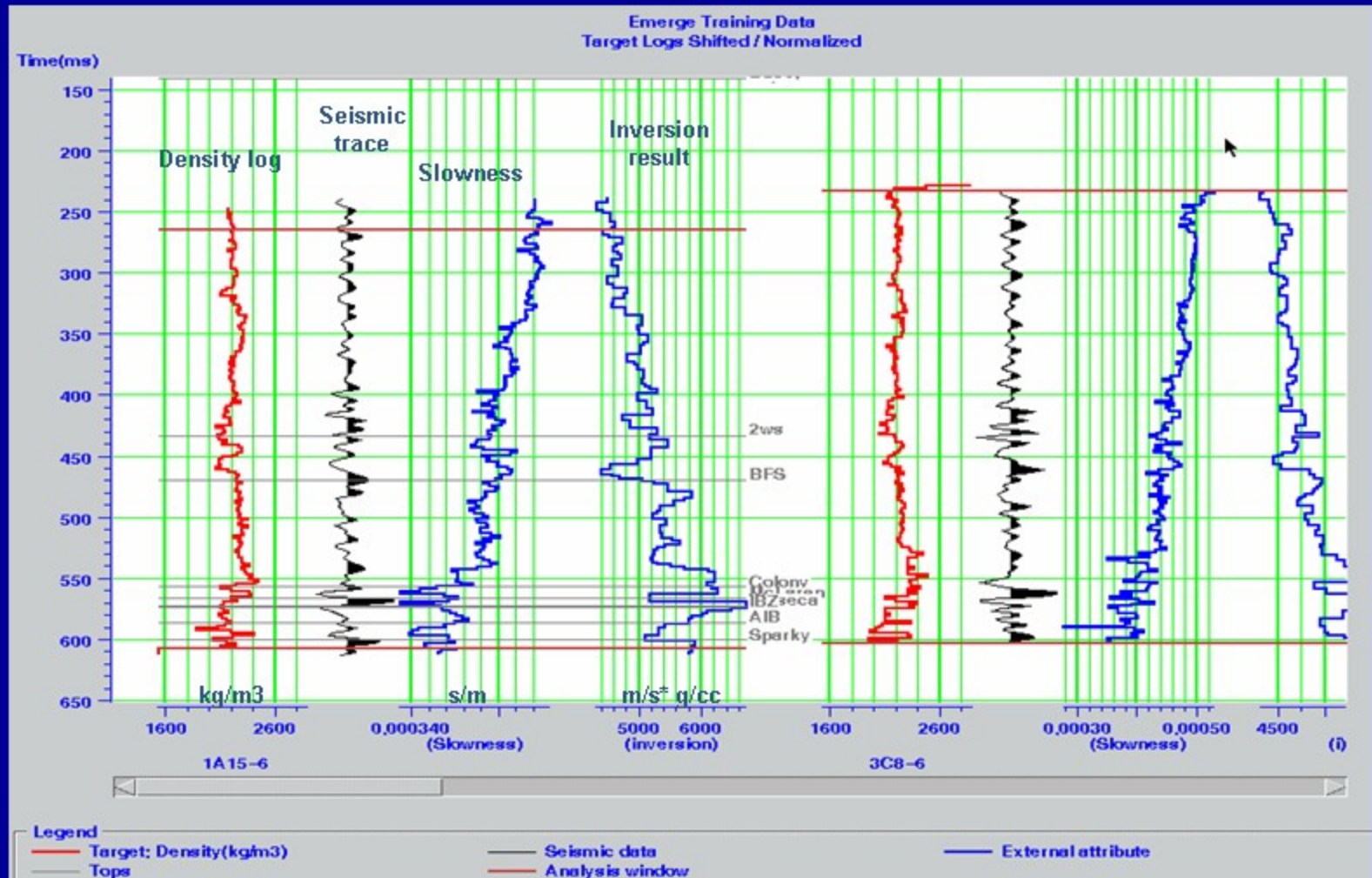
Various sample-based seismic attributes along with density log

$$\boldsymbol{\rho}(t) = w_0 + w_1 {}^* A_1(t) + w_2 {}^* A_2(t) + w_3 {}^* A_3(t) + w_4 {}^* A_4(t)$$
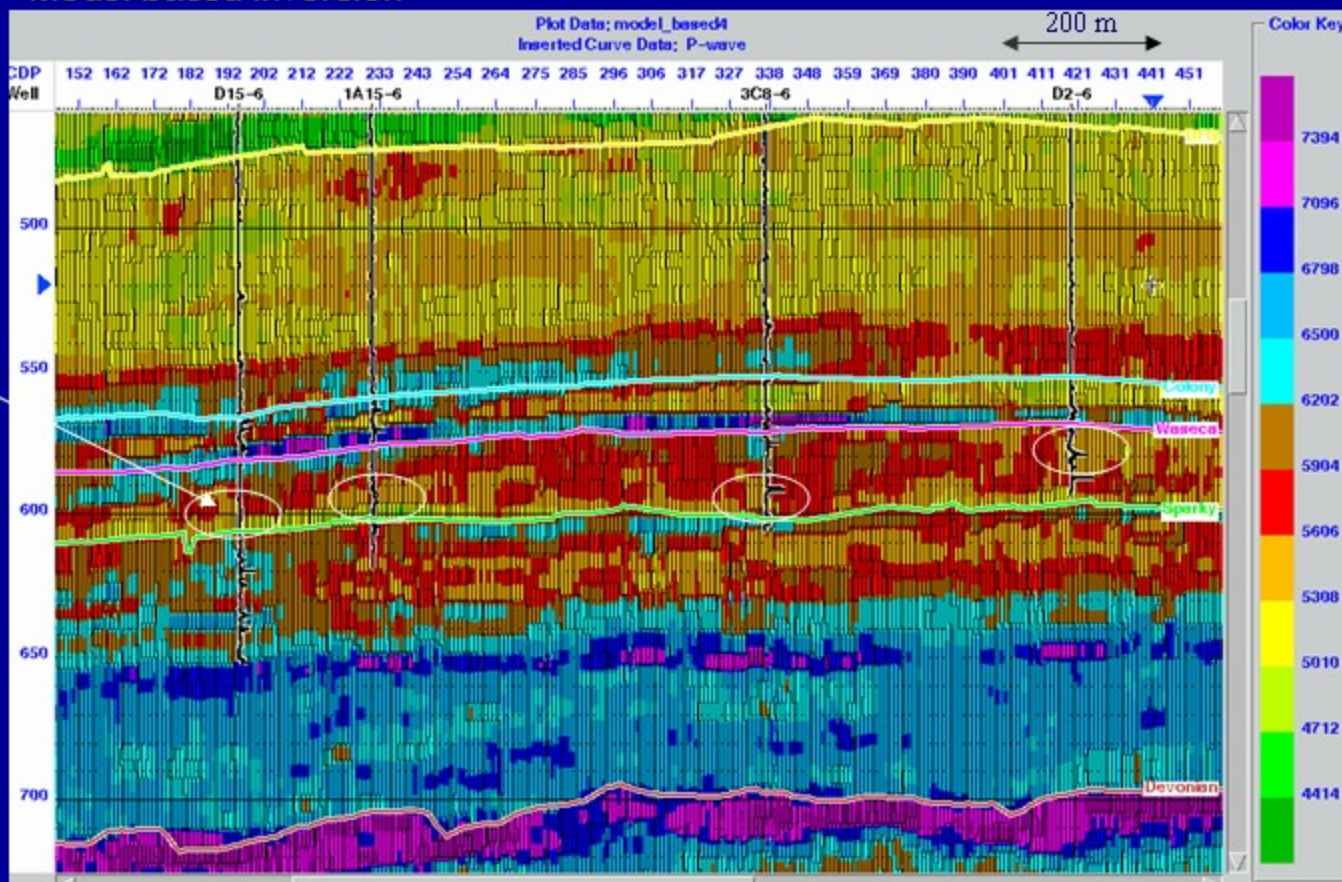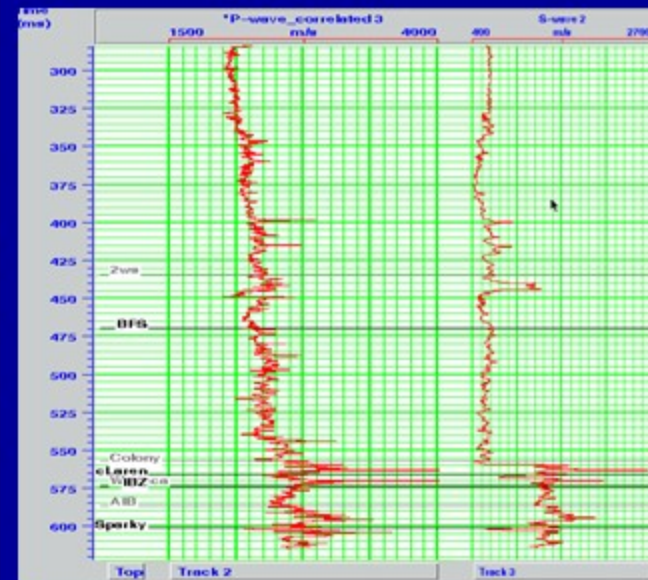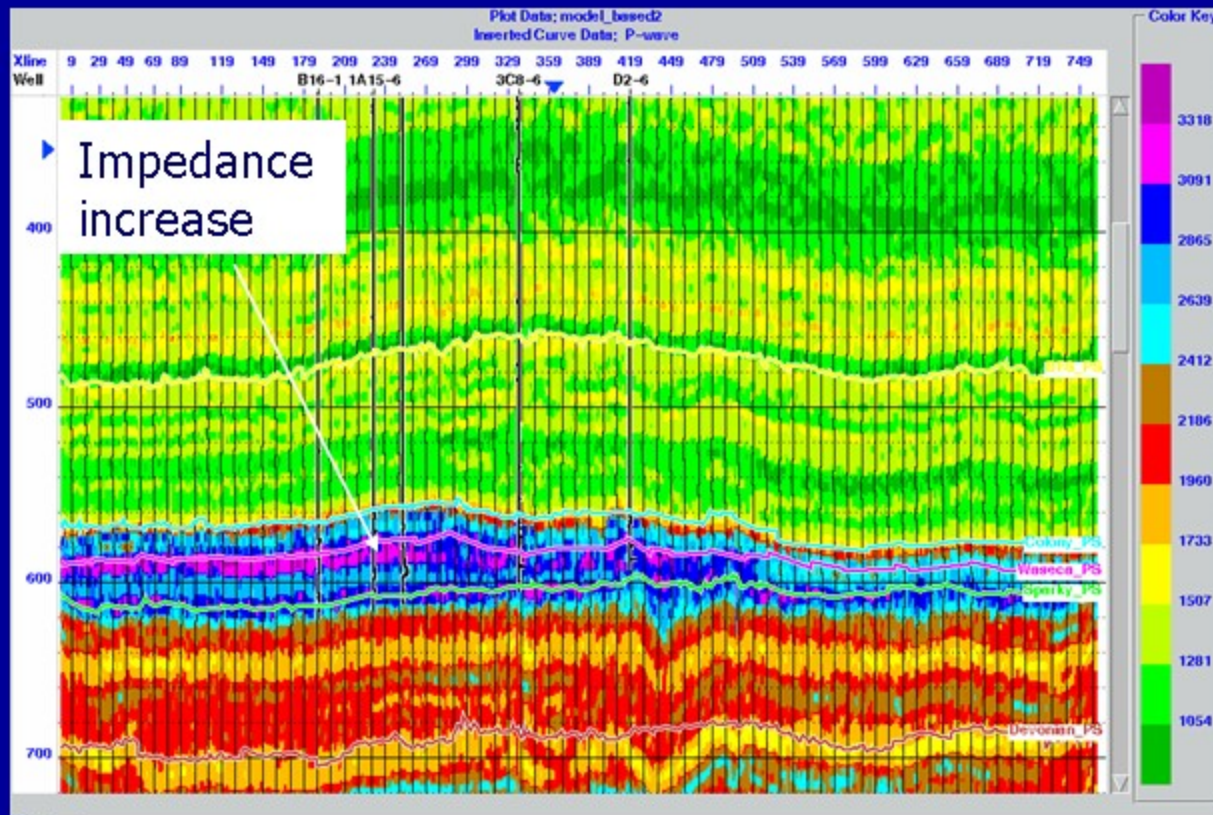
$$\boldsymbol{\rho}(t) = w_0 + w_1 A_1(t) + w_2 A_2(t) + w_3 A_3(t) + w_4 A_4(t)$$

Well: 1A15-6

Time (ms)

Group of samples
Single sample

w1   w2   w3   w4

Density 1   Raw Seismic   Amplitude Envelope   Dominant Frequency   Derivative   inv_spike

Data Curves

Legend
— Log   — Analysis Window
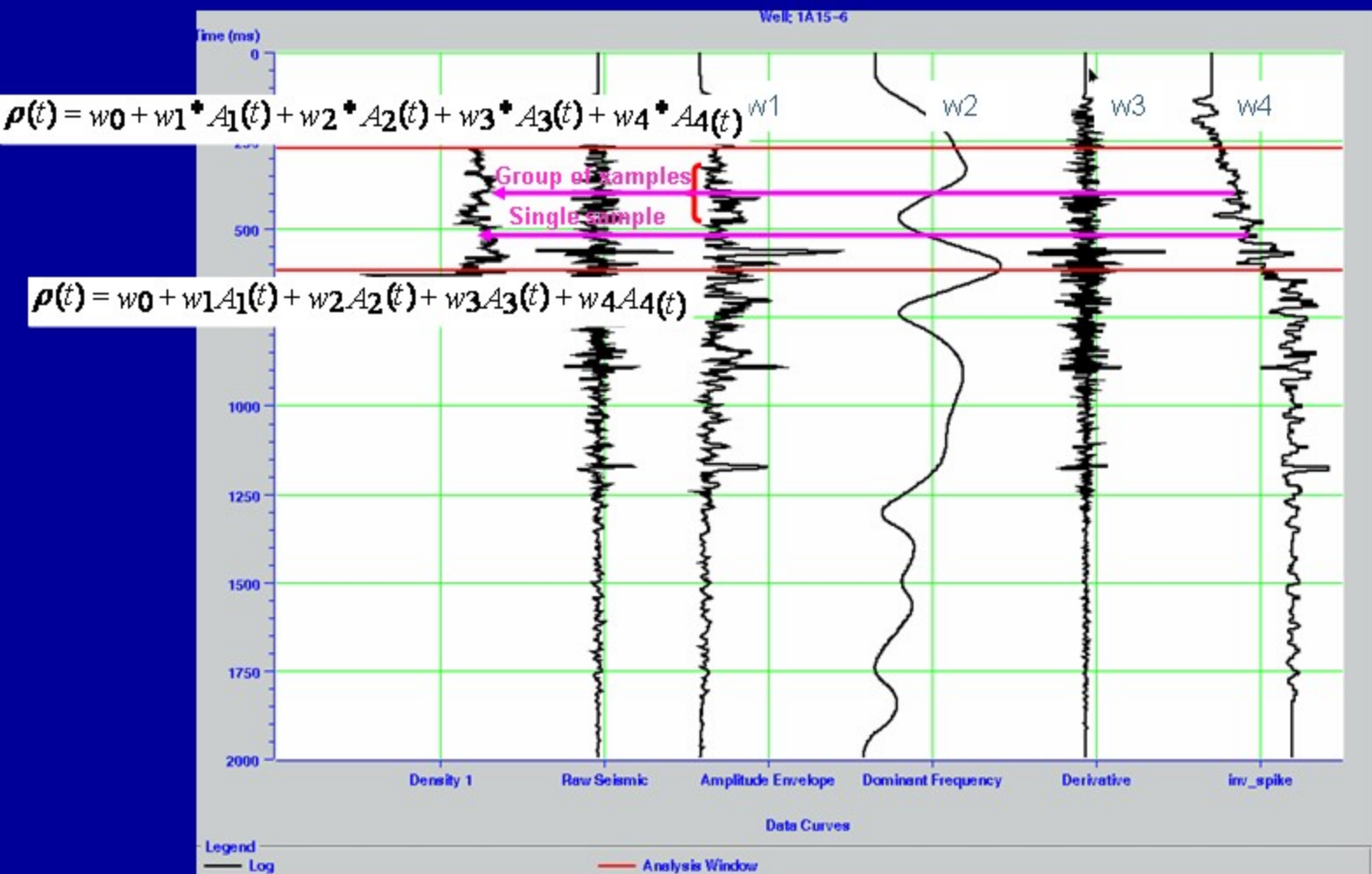
Multi attribute analysis
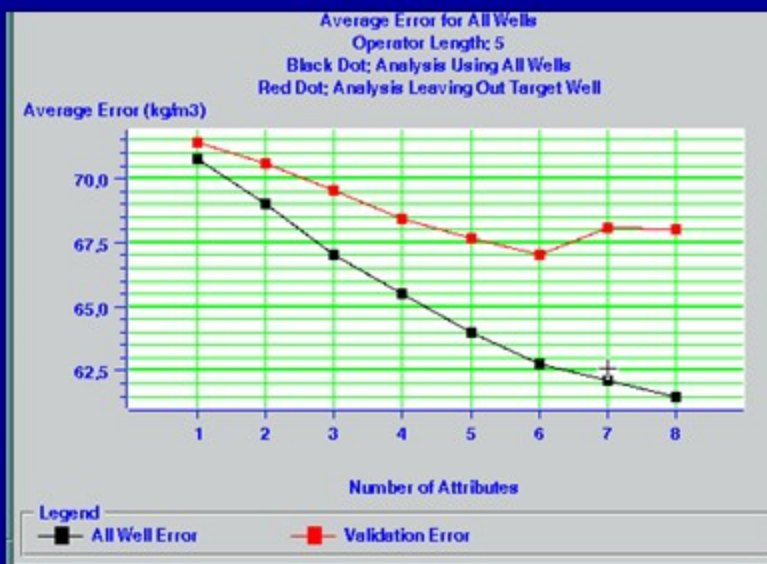
Prediction error plot

	Target	Final Attribute	Training error	Validation error
1	Density	Amplitude Weighted Cosine Phase (inversion)	70.75	71.38
2	Density	Derivative	69.01	70.60
3	Density	1/(Slowness)	67.04	69.52
4	Density	(inversion)**2	65.49	68.42
5	Density	Quadrature trace (inversion)	63.98	67.67
6	Density	Amplitude Weighted Frequency	62.75	67.02
7	Density	Integrate (inversion)	62.09	68.11
8	Density	Cosine Instantaneouse Phase (inversion)	61.50	68.04

Multi Attribute list with corresponding error

Predicted density section along the seismic line
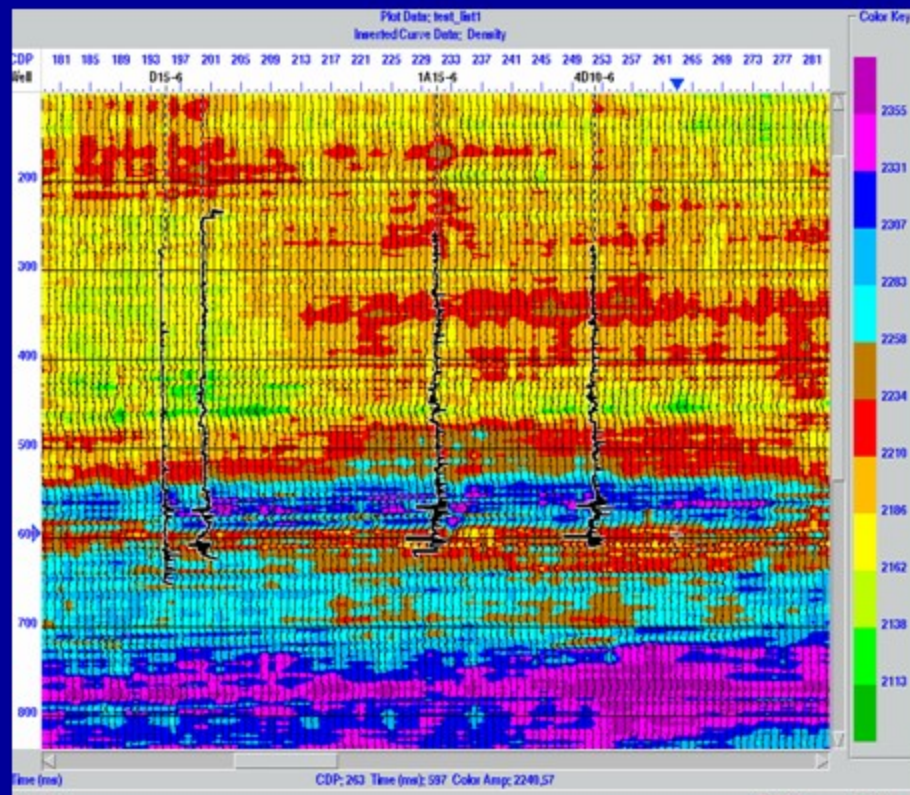
CDP 180-282
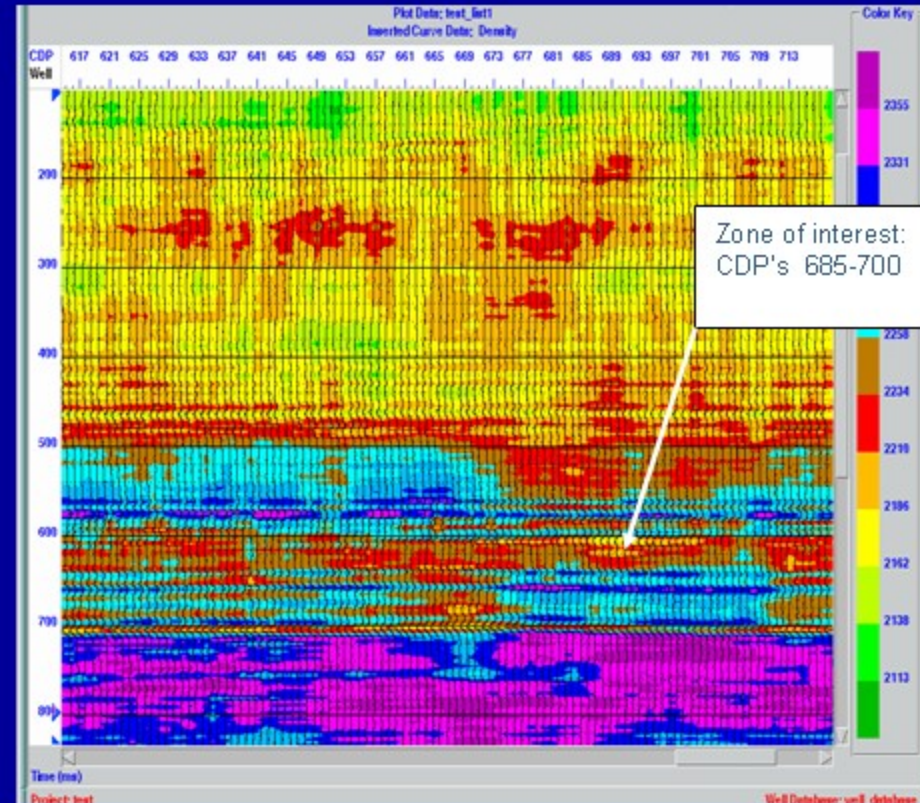
CDP 616-714

Calculated porosity logs

$$\varphi = \frac{\rho_{ma} - \rho_{obs}}{\rho_{ma} - \rho_f}$$

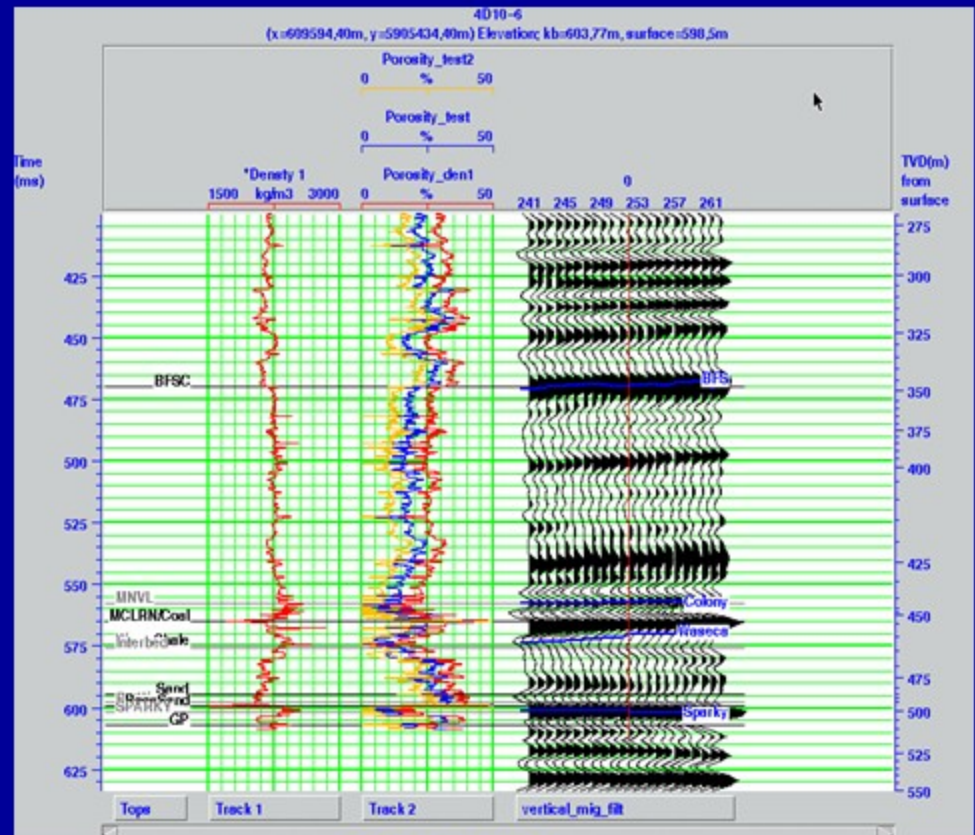ρ_{ma} — matrix density

ρ_f — fluid density
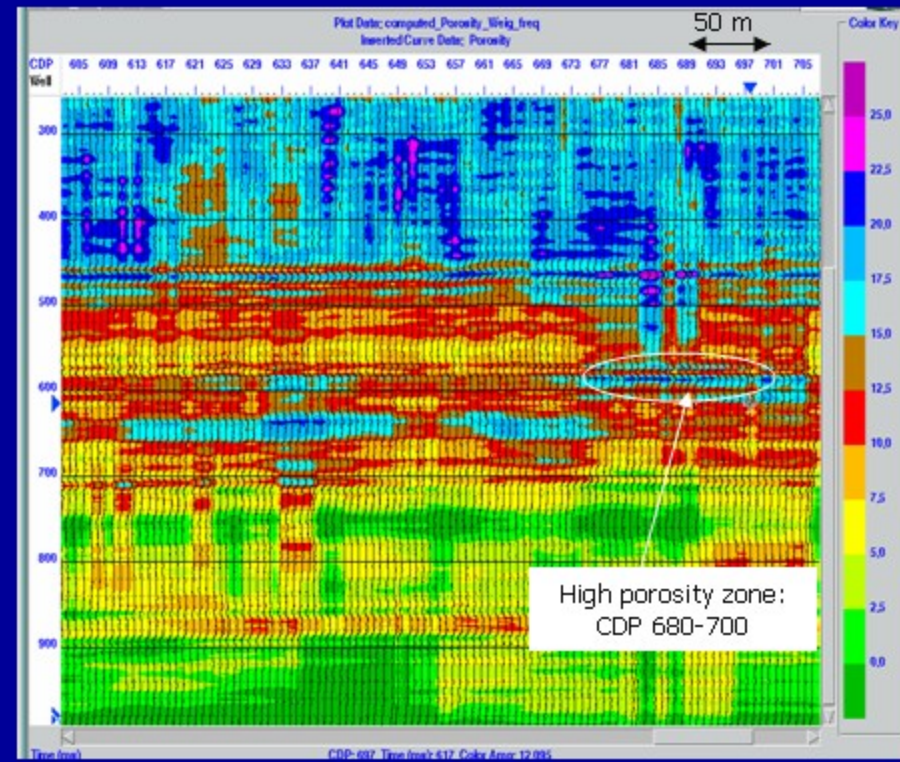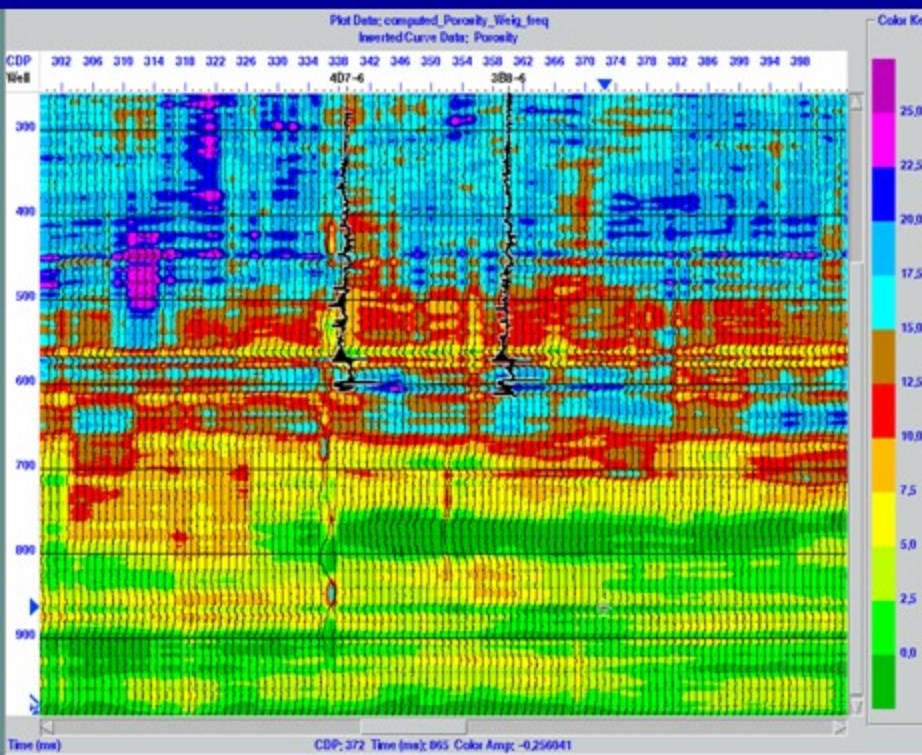
ρ_{obs} — observed density

Matrix density - 2.4 g/cc (yellow)

- 2.5 g/cc (blue)

- 2.6 g/cc (red)

Density   Calculated porosity

Predicted porosity section along the seismic line

High porosity zone: CDP 680-700

Reservoir indicators
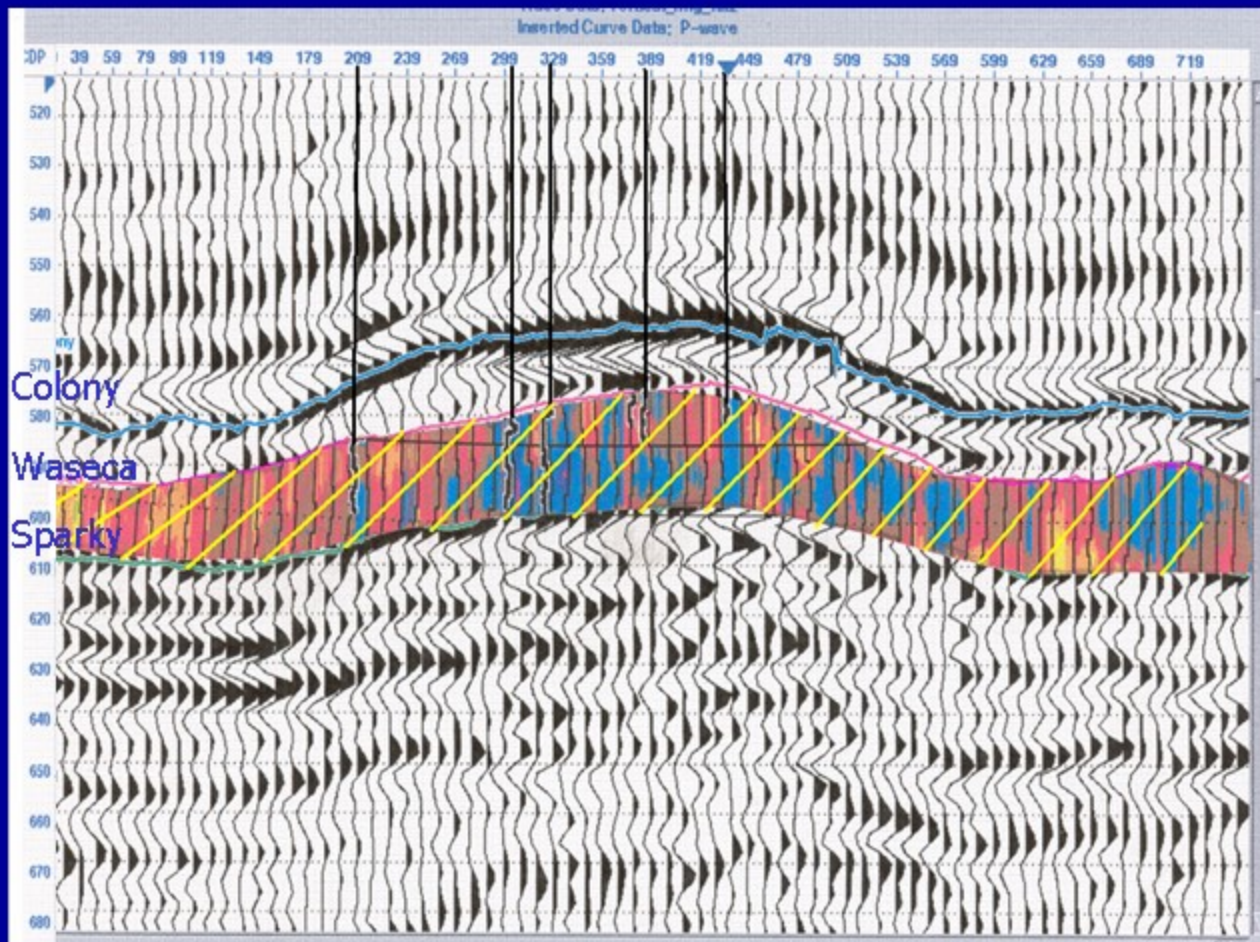
- Anomalous structure
- Low Vp/Vs
- High porosity

Conclusions

1. The main impedance changes correspond to the major lithologic boundaries.

2. The top of the productive interval is interpreted as a PP impedance drop and PS increase.

3. Inversions and other attributes have been used to predict the density and porosity along the seismic line.

4. Some previously unknown targets are identified.

Future work

1. Assess the accuracy of the results
2. Vp/Vs from amplitude inversions versus Vp/Vs from time-thicknesses
3. Estimate the original oil in place (OOIP)

Acknowledgement

- Drs. Larry Lines and Brian Russell
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- Andrew Bau (Husky)
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- CREWES sponsors