Searching for sand in Saskatchewan: Manitou Lake 3C-3D Project

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Outline

- Location and Geology
- Lithology differentiation
- Acquisition geometry
- Well production
- PP Interpretation
- PS Interpretation, PP-PS Registration
- Inversions, attributes
- Imaging of sand channels
- Conclusions

What are we trying to do?

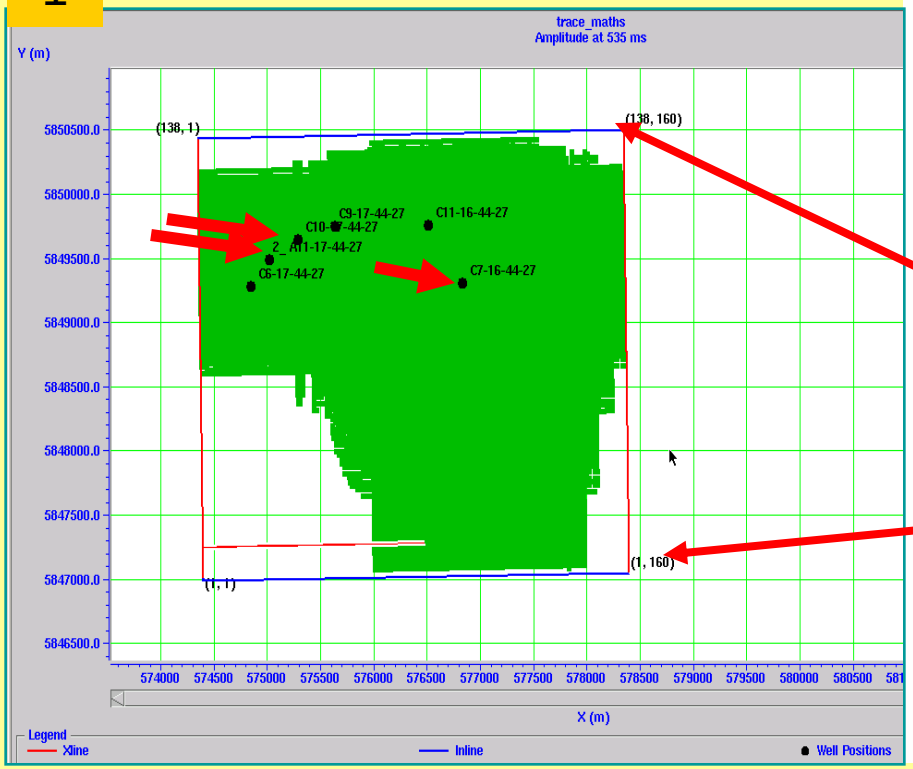
- **Find Colony and Sparky sand channels (especially channel edges & water zones)**
- **PP data alone cannot solve the problem**
- **Can PS data give us more information?**

Multicomponent seismic workflow

- **Create PP and PS synthetics**
- **Find and interpret geologic horizons**
- **Register data: PP and PS seismic responses (reflection amplitude, phase and frequency could be different)**
- **Calculate and compare the PP and PS attributes**
- **Correlate Vp/Vs with productive zones**

Location of Manitou Lake

1



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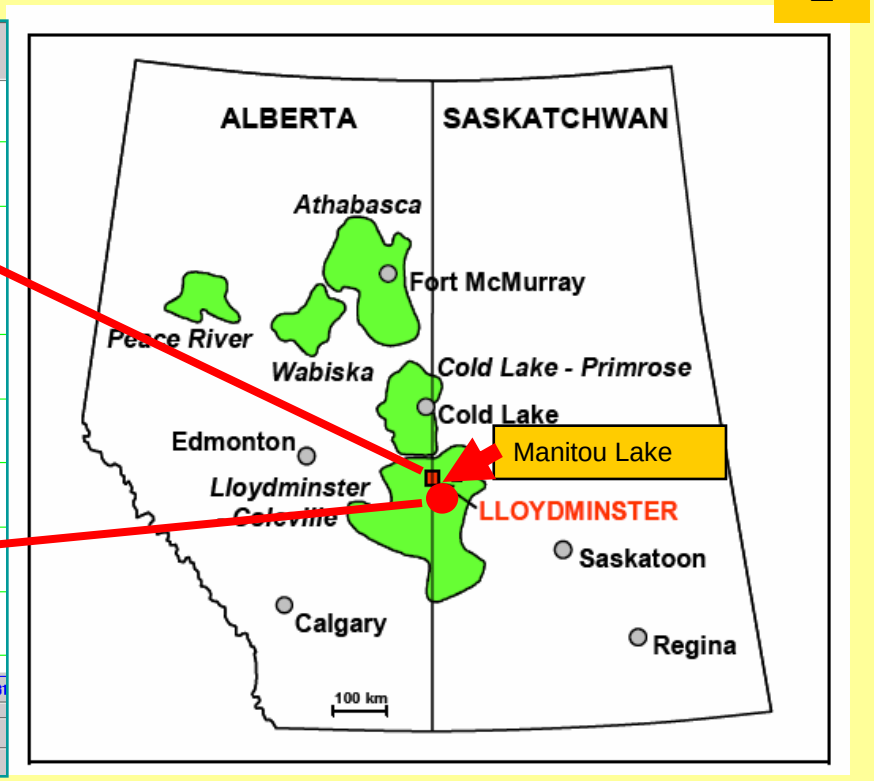


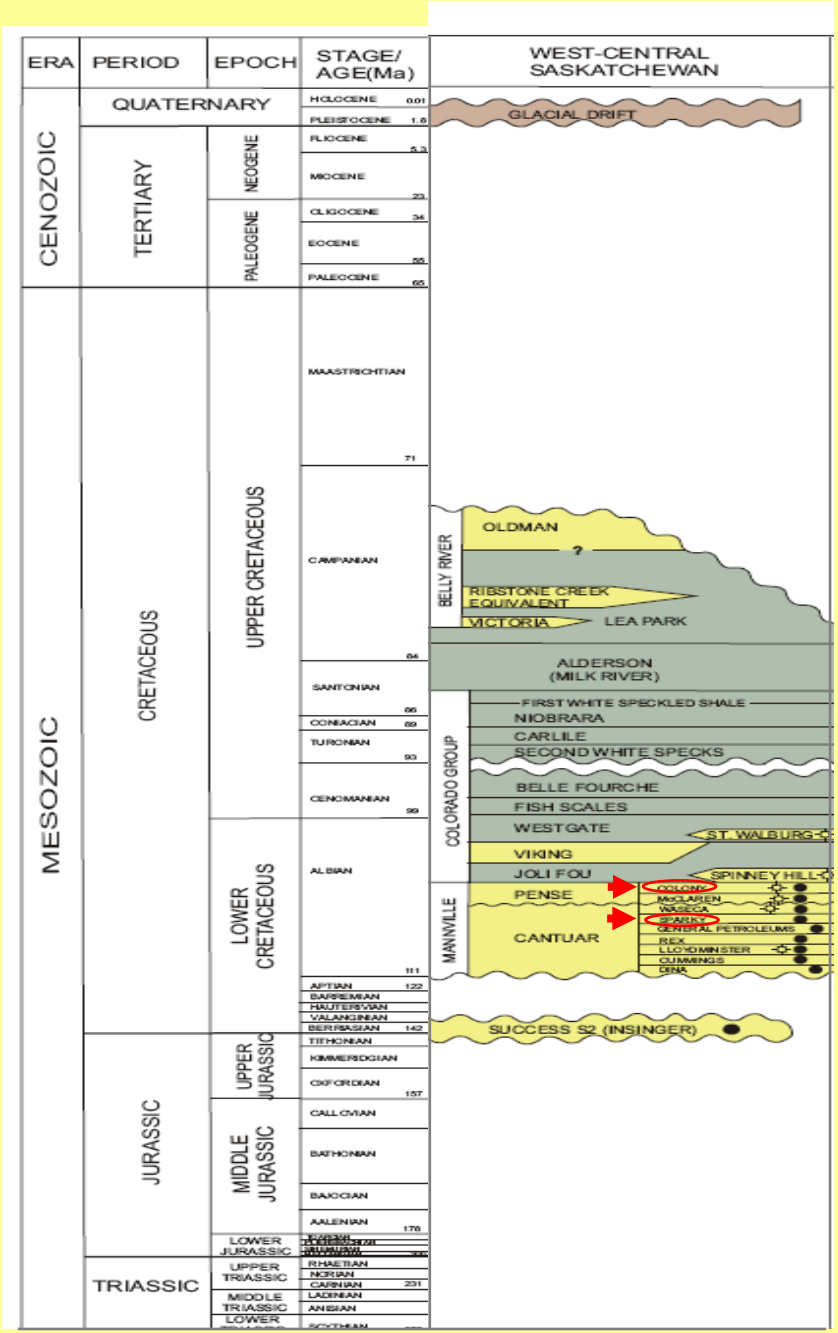
Map of the 3D-3C Manitou survey

Map of major heavy-oil deposits of Alberta and Saskatchewan, and location of the study area (after Watson, 2004)

Stratigraphic column for west central Saskatchewan (From Saskatchewan Industry and Resources, 2006)

Producing zones : Colony and Sparky formations of the Cretaceous Manville group

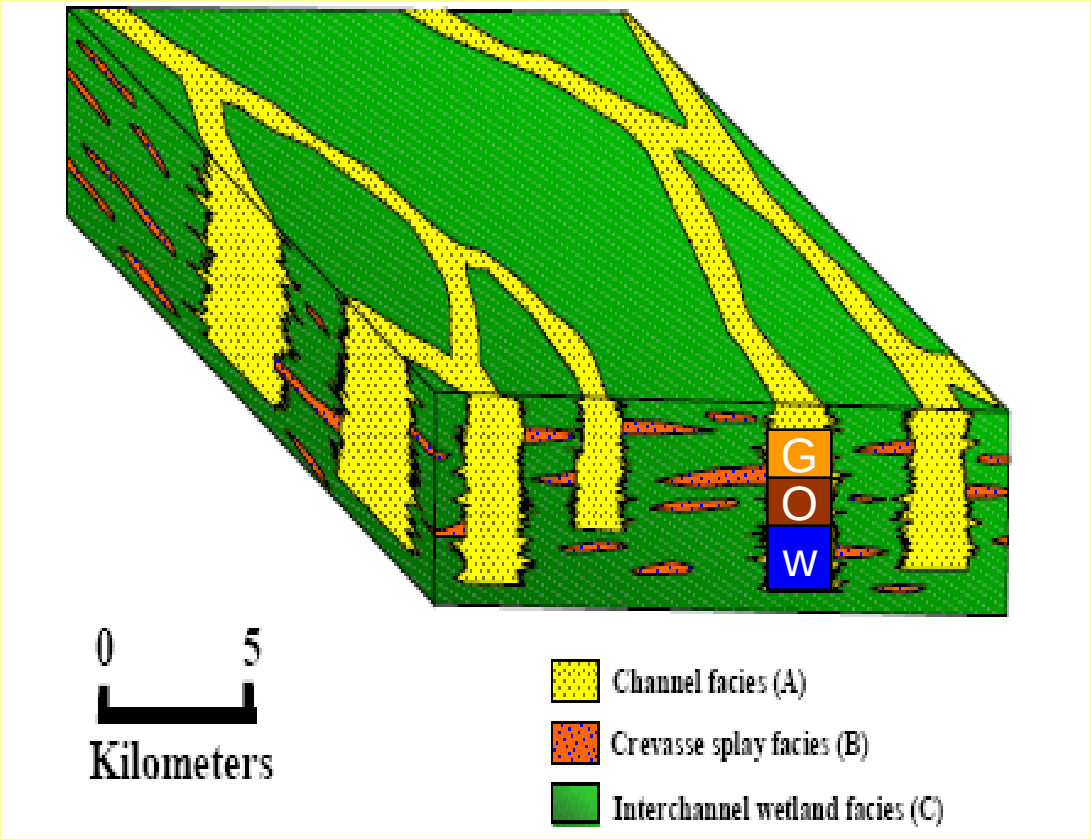
Manville marks a clear separation between the predominant sands and the overlaying marine shales of the Colorado and Belly River Group.



Colony sands channels

Consists of shales, siltstones, coals and sandstones.
Deposition of this member occurred in an extensive complex of anastomosing channels sandstones, encased within siltstones, shales, coals and thin sheet sandstones (Putnam and Oliver, 1980).

Figure shows a schematic depositional model for the Colony sands, including the three distinct facies:
A channel,
B crevasse splay and
C interchannel wetlands.



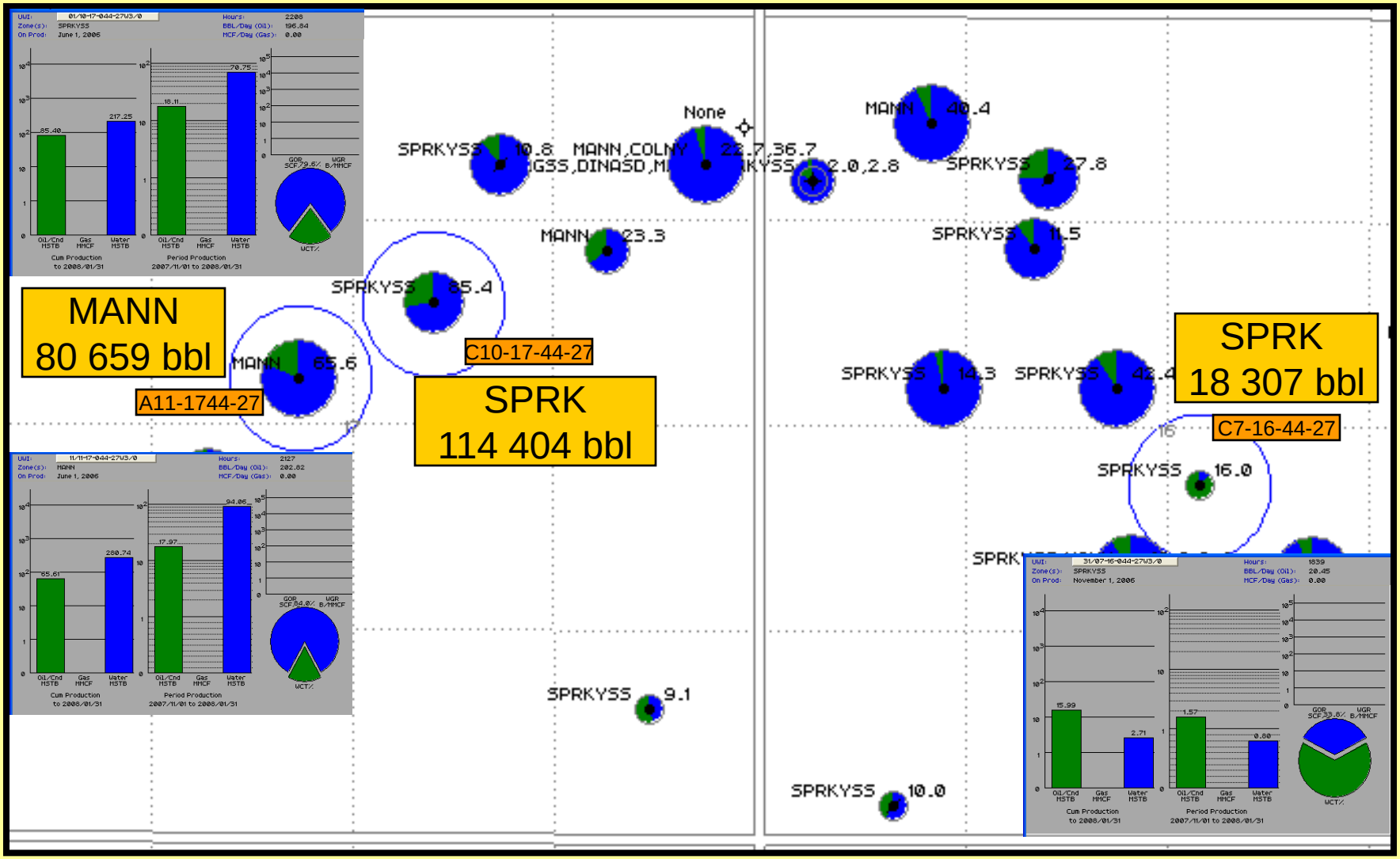
Depositional model for the Colony sand member after Putnam and Oliver (1980)

Sparky member

Dominated by sheet sandstone development, with narrow, channel sandstones and shales also present (Putnam, 1982).

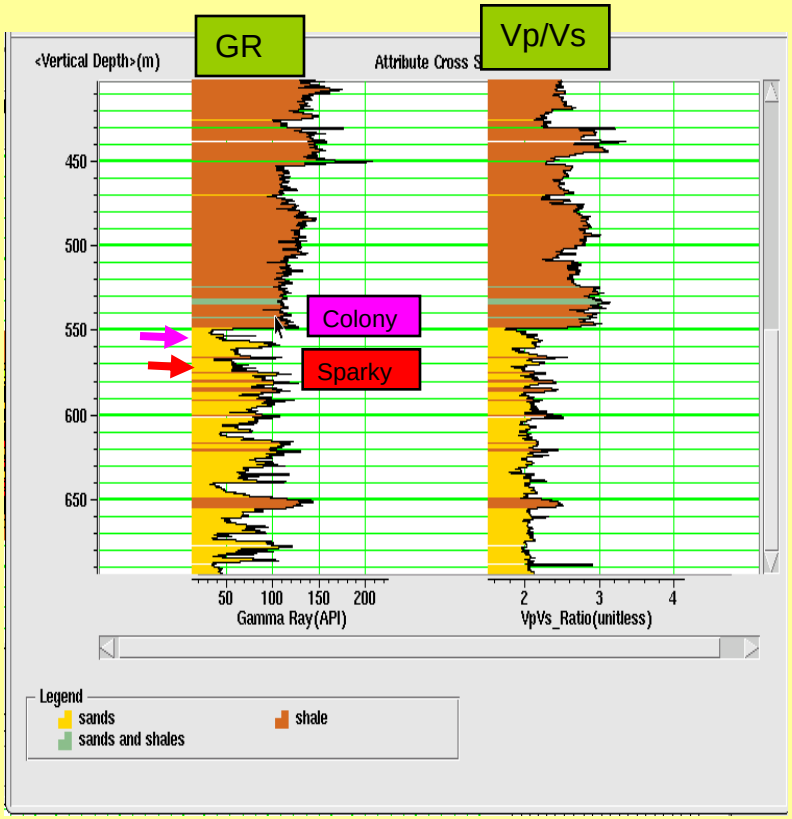
The sheet sandstones in Sparky can be traced laterally for several tens of kilometers; however, they are commonly broken by thick ribbon-shaped deposits or sandstone pinchouts (Putnam, 1982).

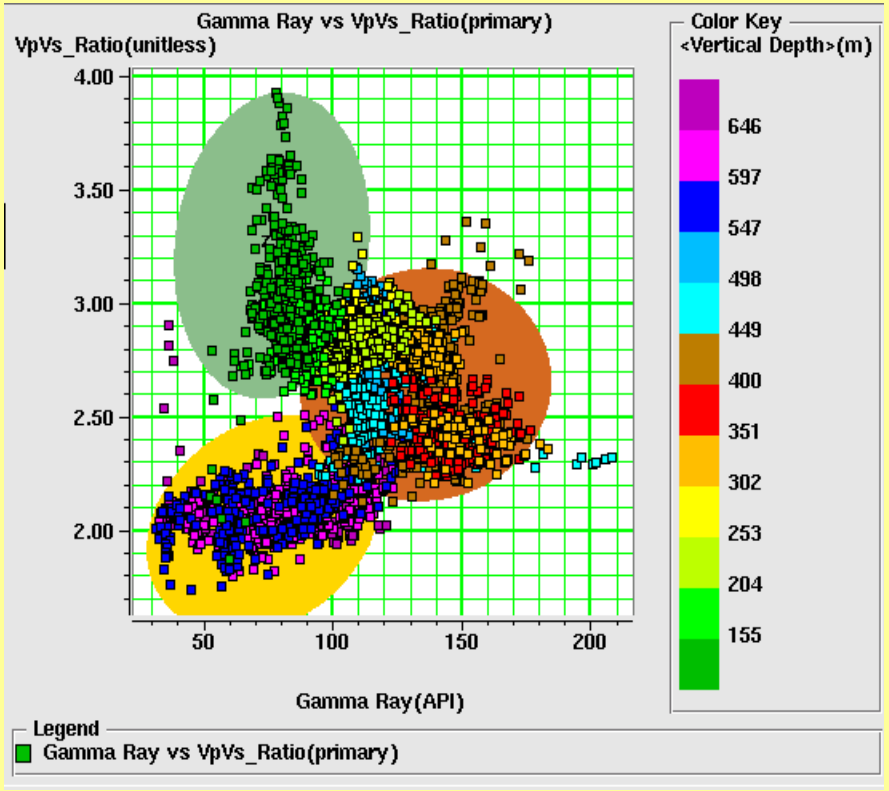
Oil Production (Accumap)



Lithology differentiation

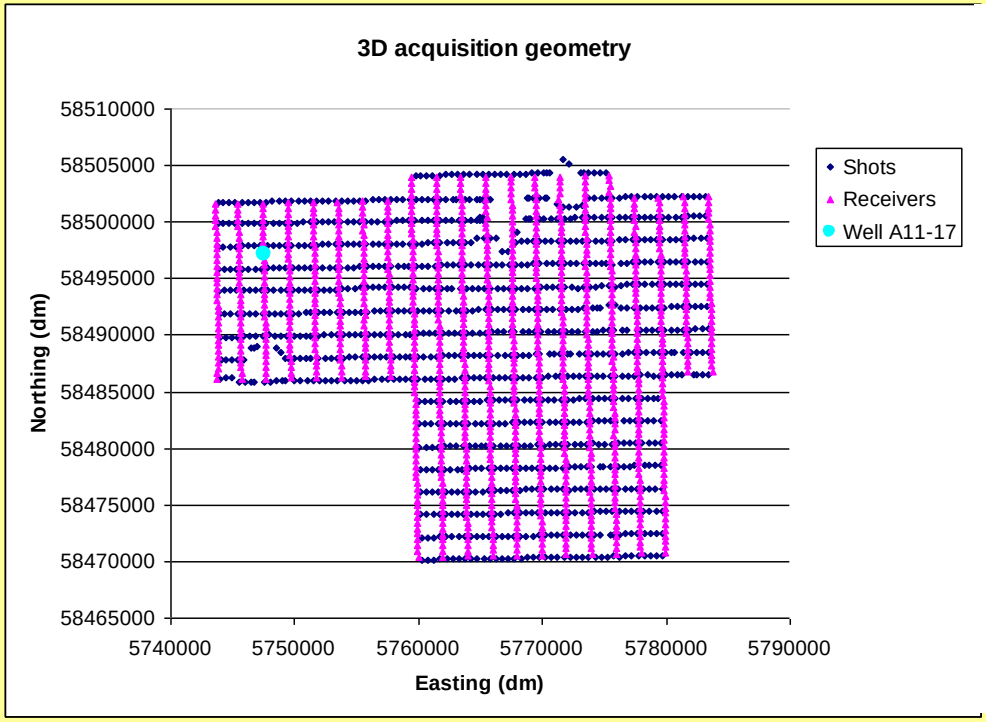
well A11-17





Vp/Vs versus gamma ray for the well A11-17. a) Three major types of lithology were selected: sands (yellow), shales (brown) and sand/shales (olive), b) Cross-section for well A11-17 delineating the zones with different lithology. Low values in gamma ray log indicates permeable sand interval with high porosities.

Acquisition geometry of the Manitou Lake survey

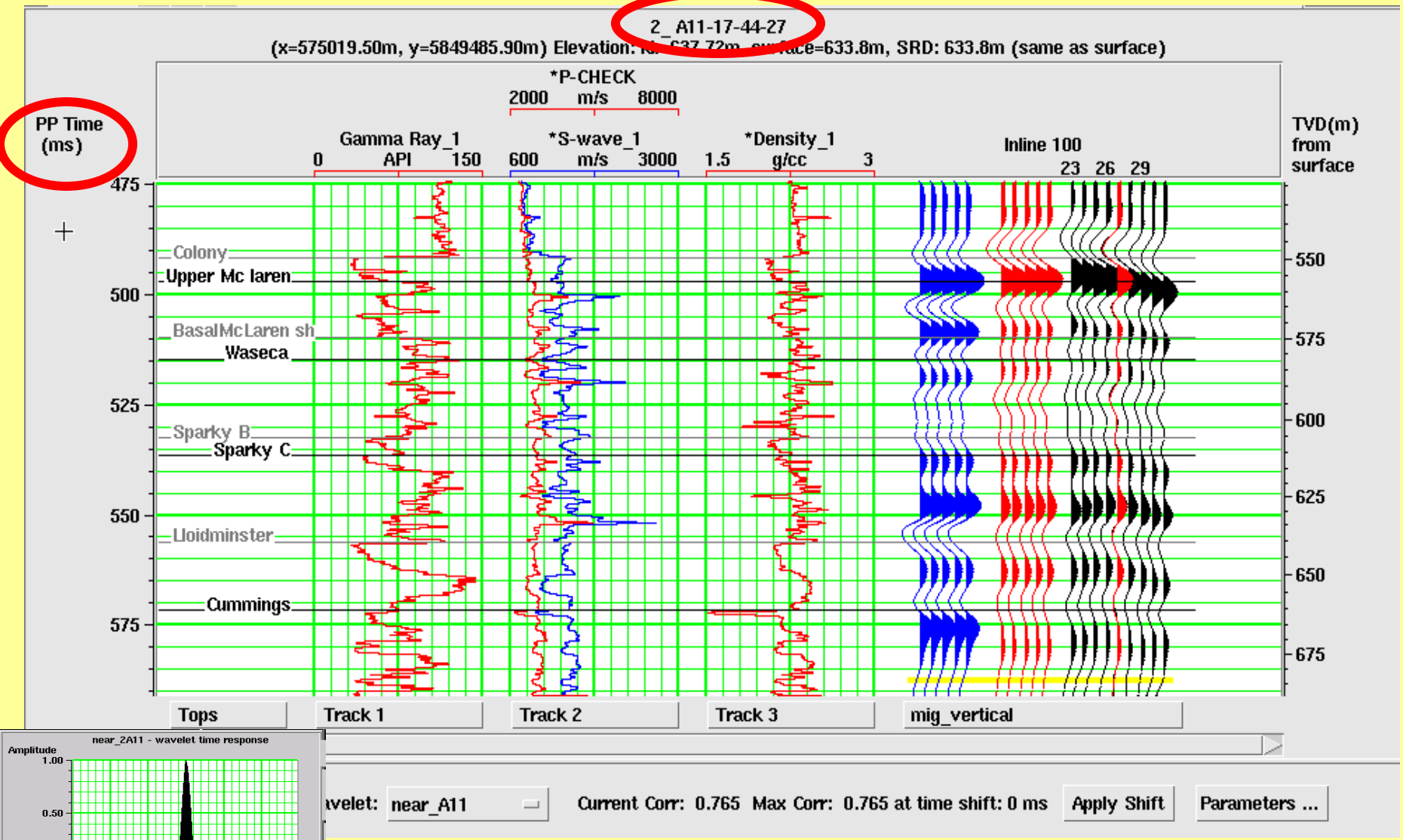


Recording System	I/O System 4
Source	Two vertical vibrators (IVI Y2400)
Source Array	16 m dragged array, 8 sweeps per VP, 1.14 m move-up per sweep. Diversity stacked in the field.
Sweep	8-144 Hz over 10 s with 5 s listen time
Receiver	I/O VectorSeis SVSM
Receiver Array	Single sensor per station
Station spacing	50 m source and receiver station spacing
Line spacing	200 m source and receiver line interval
Receiver lines	21 lines, total length 51.93 km
Source lines	18 lines, total length 53.89 km
Total area	~10 km^2

Acquisition parameters (Kinetex Inc.)

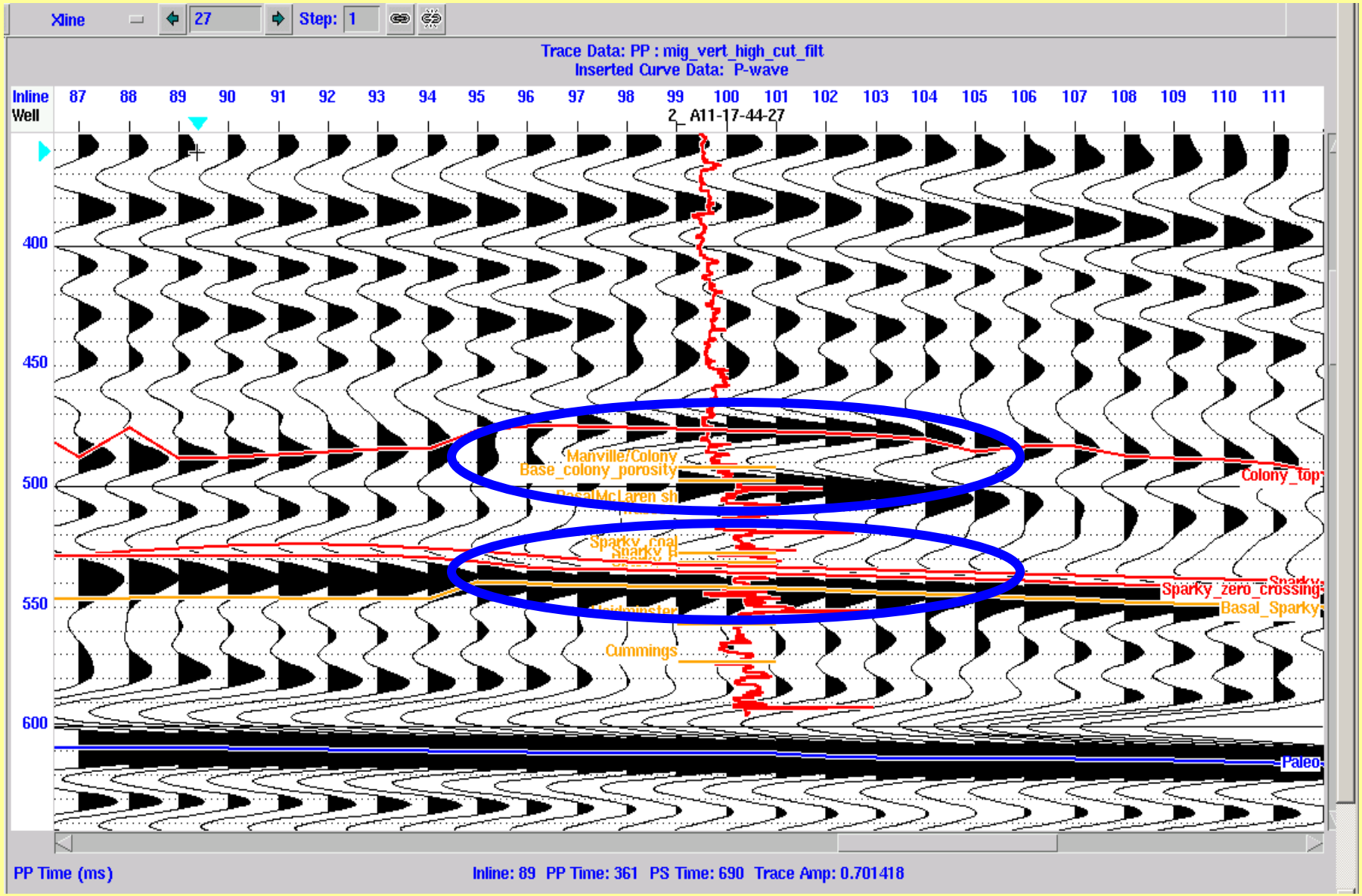
Survey acquired for Calroc Energy in 2005. 21 SN receiver lines and 18 source WE lines. Shots are in blue, Receivers in purple

PP Interpretation

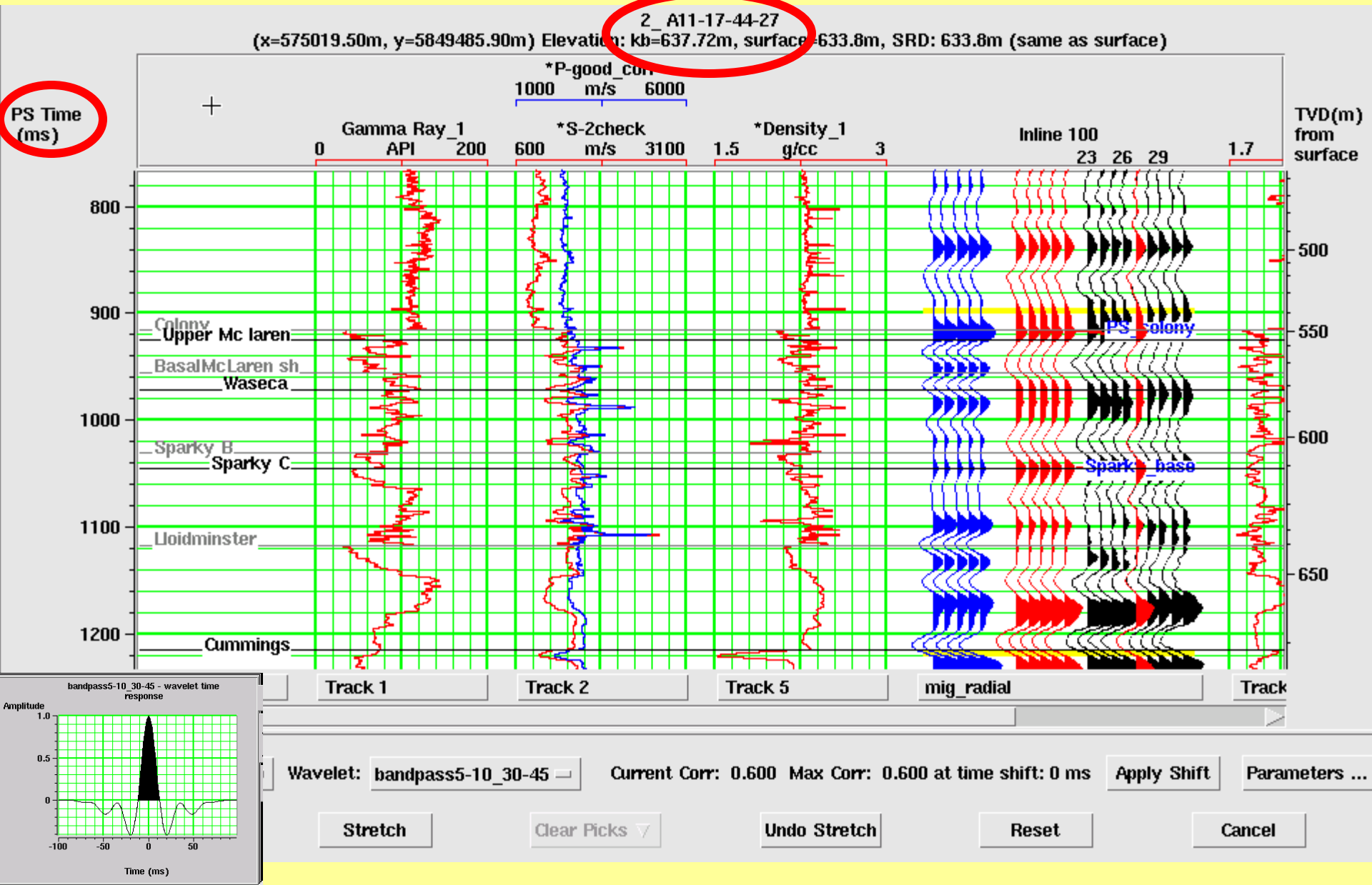


Synthetic, Seismic and well log correlation - PP time

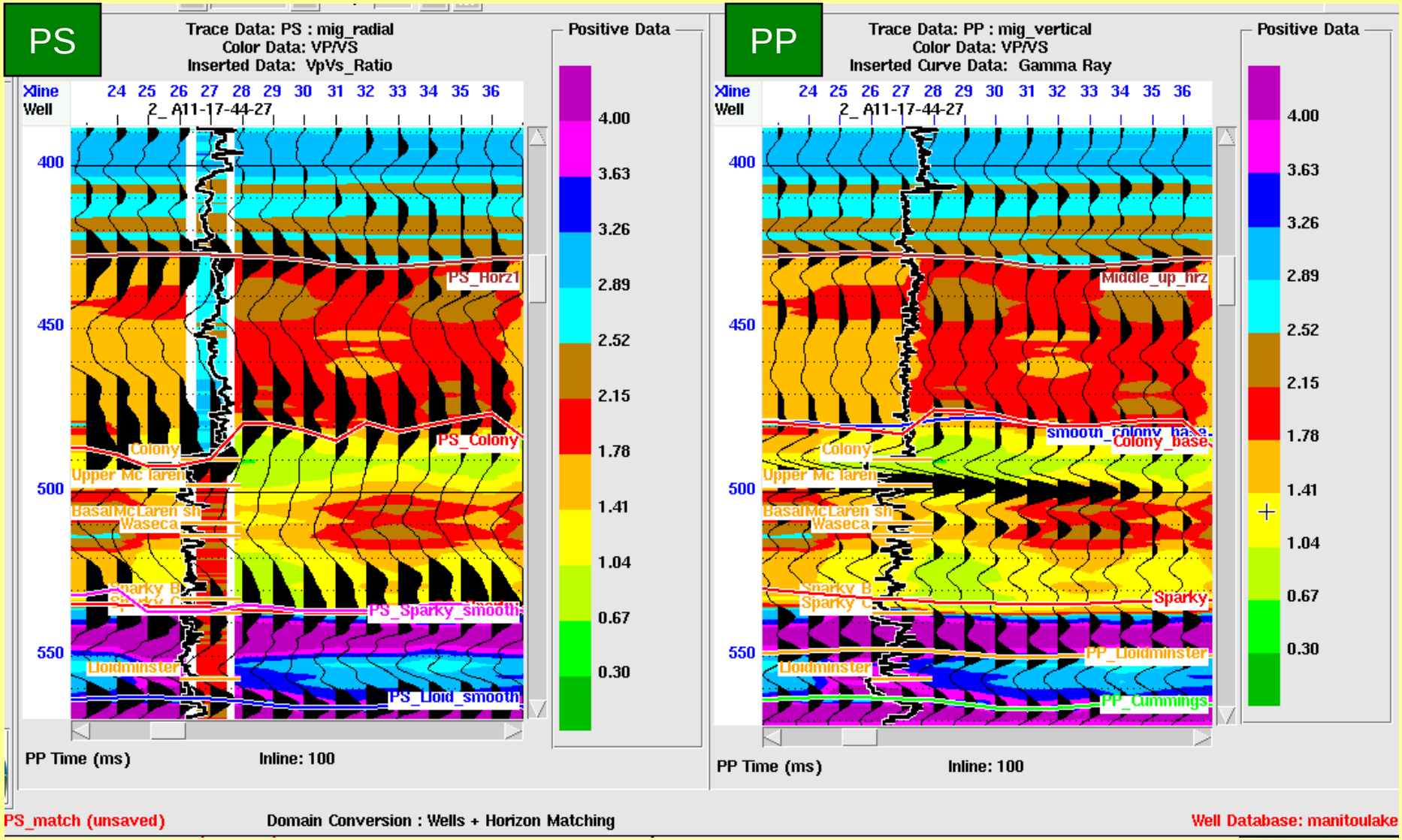
PP interpretation



PS interpretation



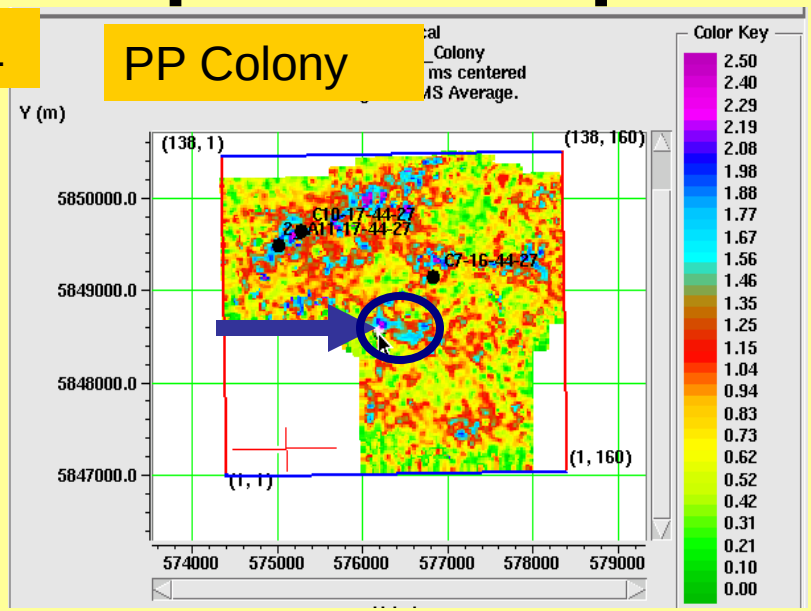
PP and PS Interpretation



Amplitude maps for Colony and Sparky

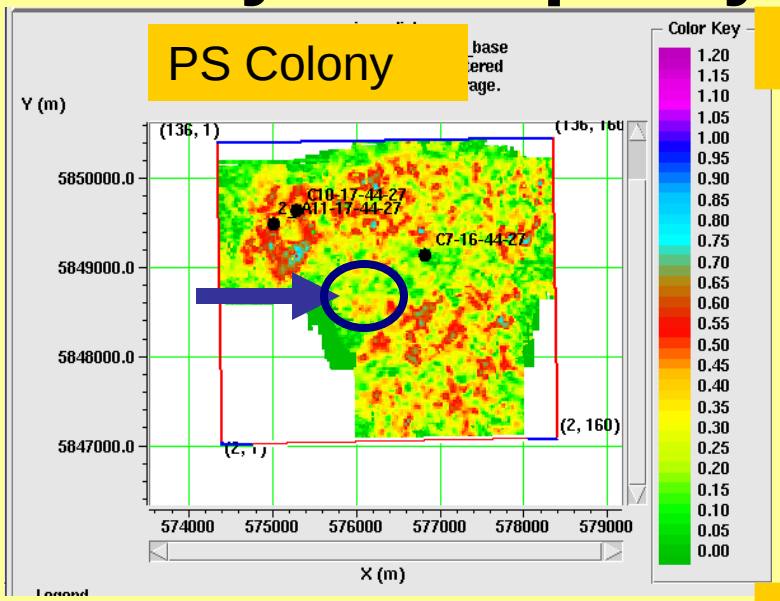
1

PP Colony



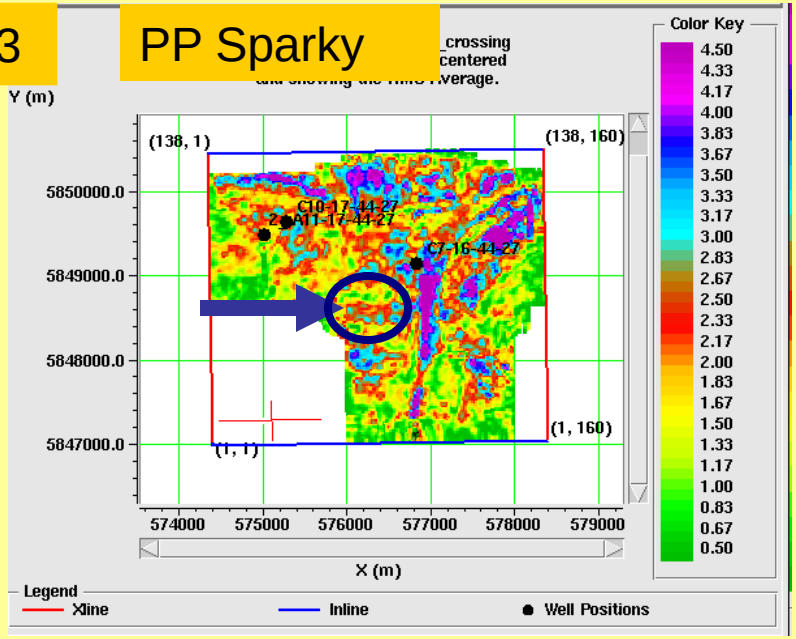
PS Colony

2



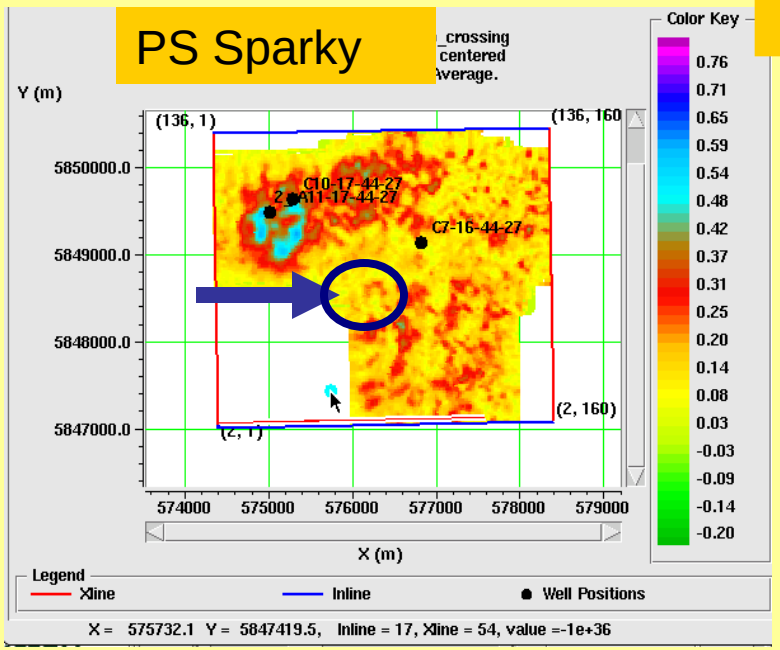
3

PP Sparky

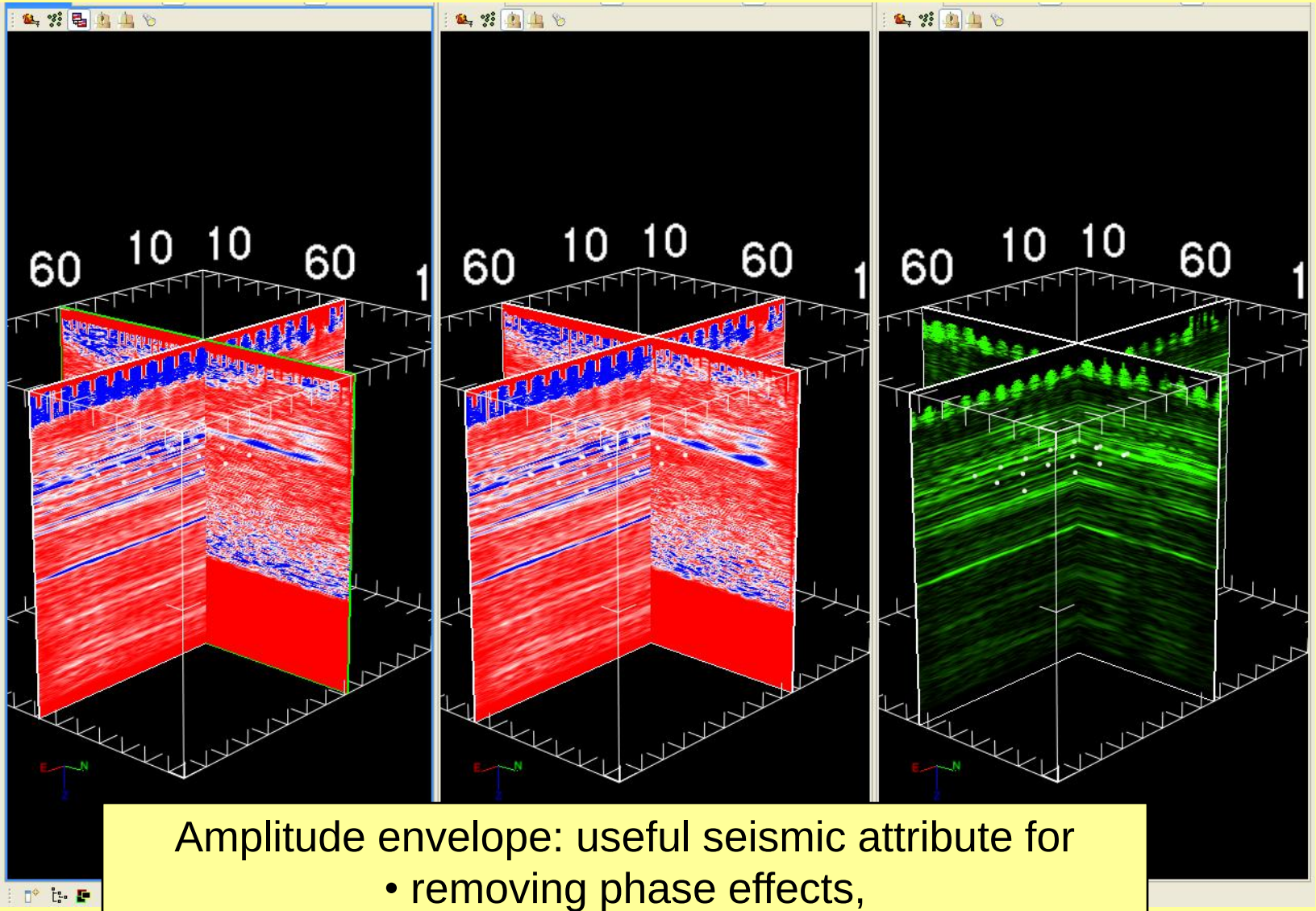


4

PS Sparky

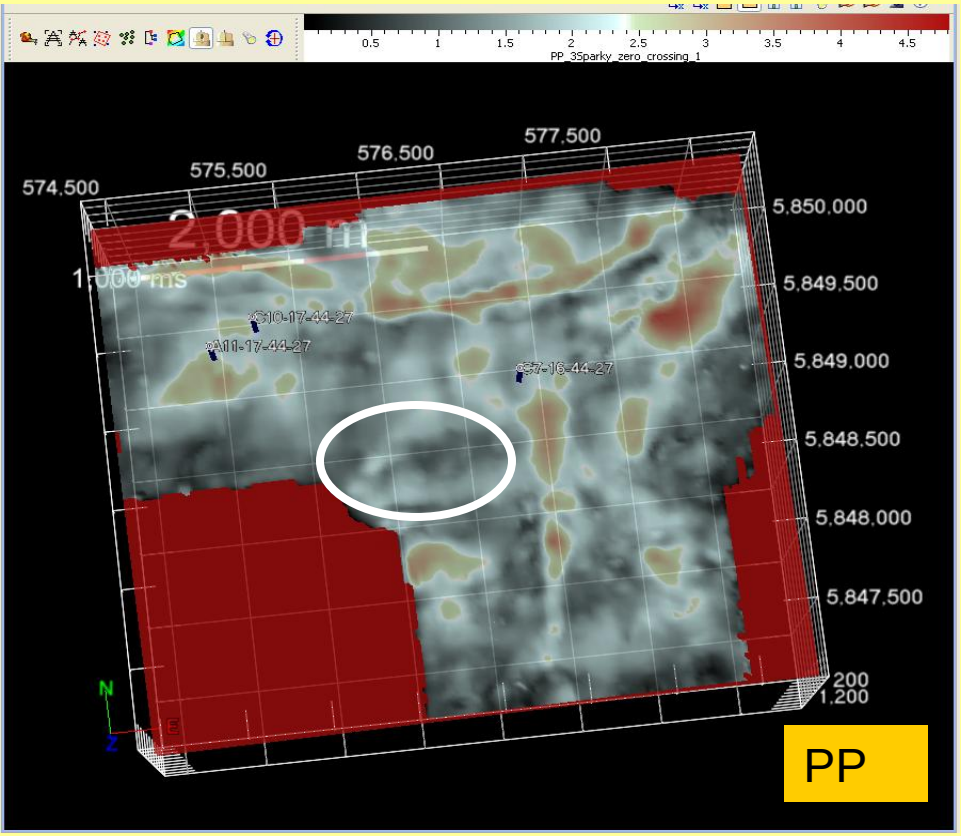


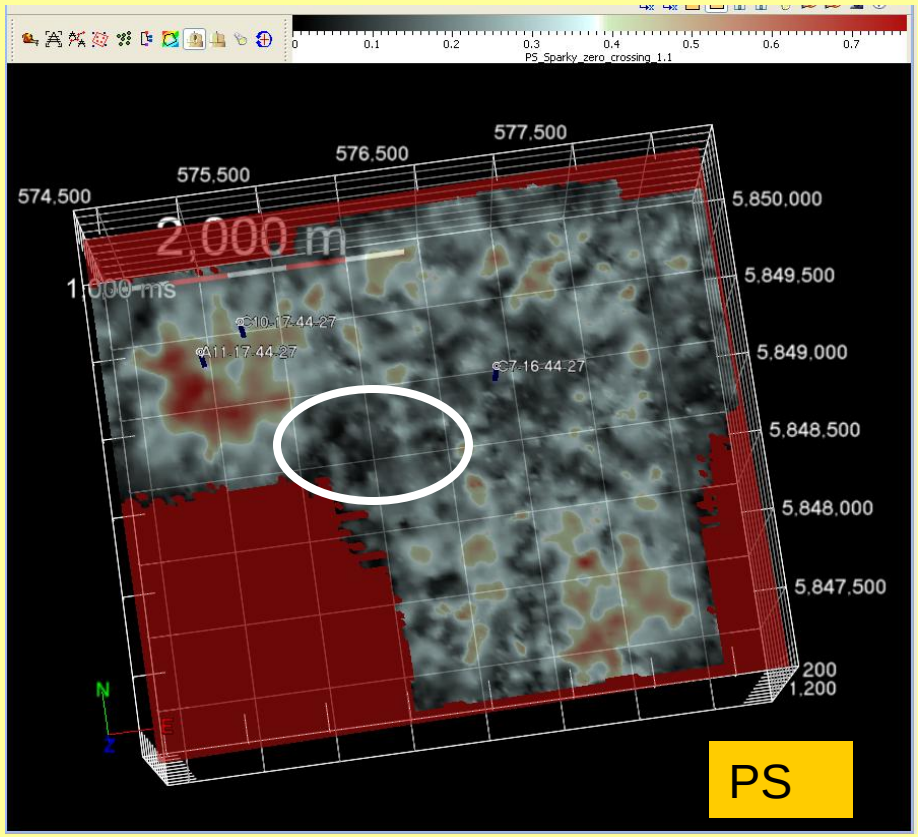
Registration using Amplitude Envelope



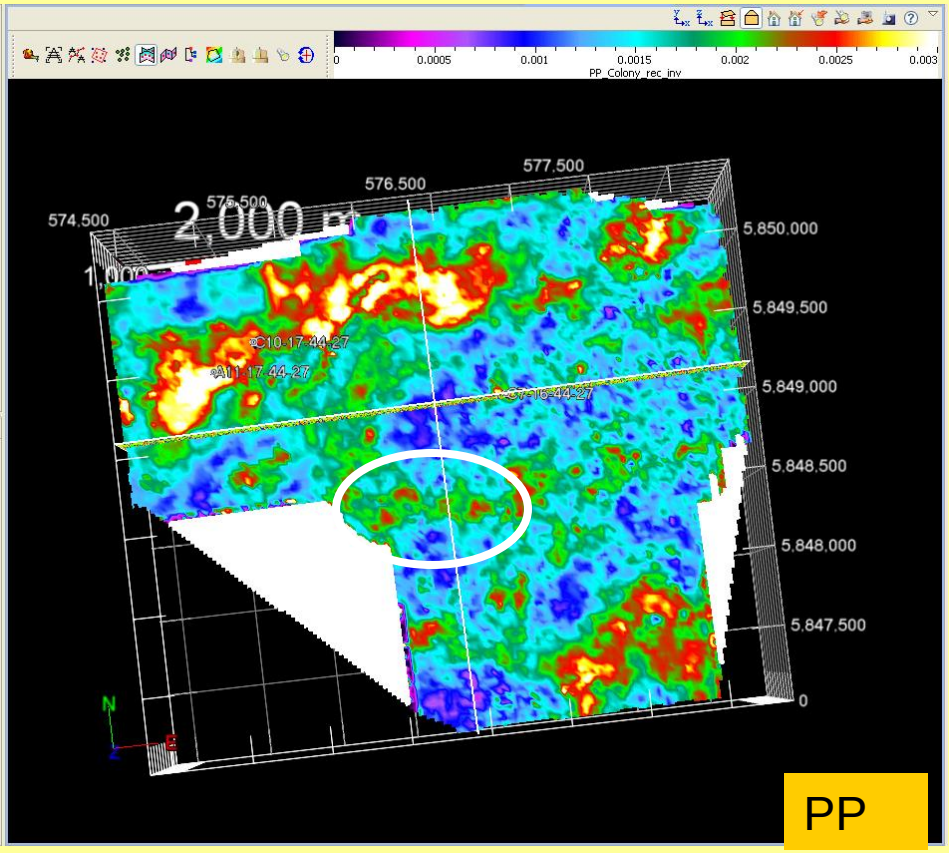
Amplitude envelope: useful seismic attribute for
- removing phase effects,
- reducing frequency effects and
- highlighting high and low energy zones

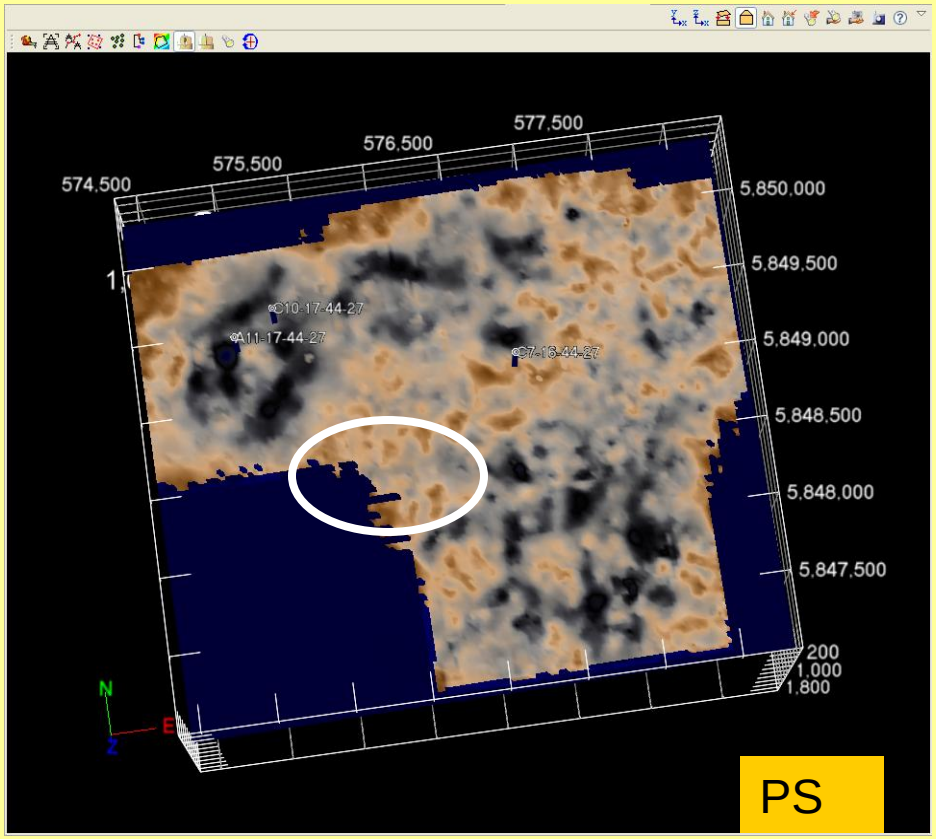
PP and PS Amplitudes on Sparky horizon





Colony horizon

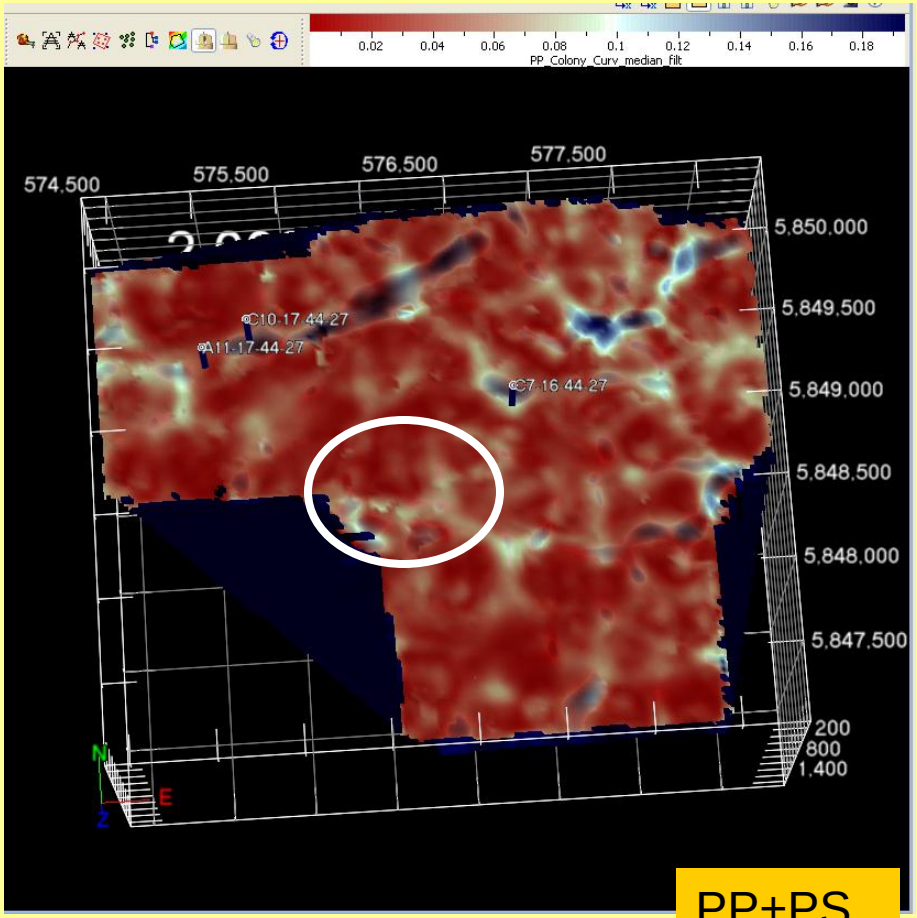




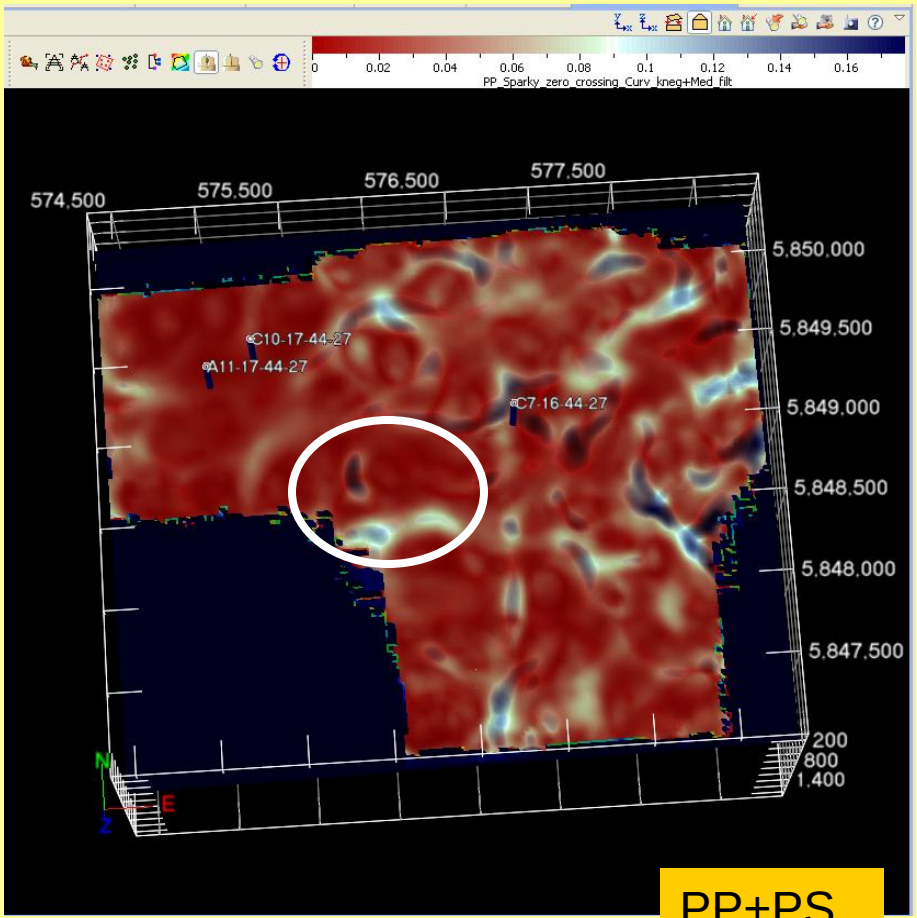
PP: Max Curvature co-rendered with Inversion

PS: Amplitude envelope co-rendered with Inversion

Colony and Sparky horizons Curvature

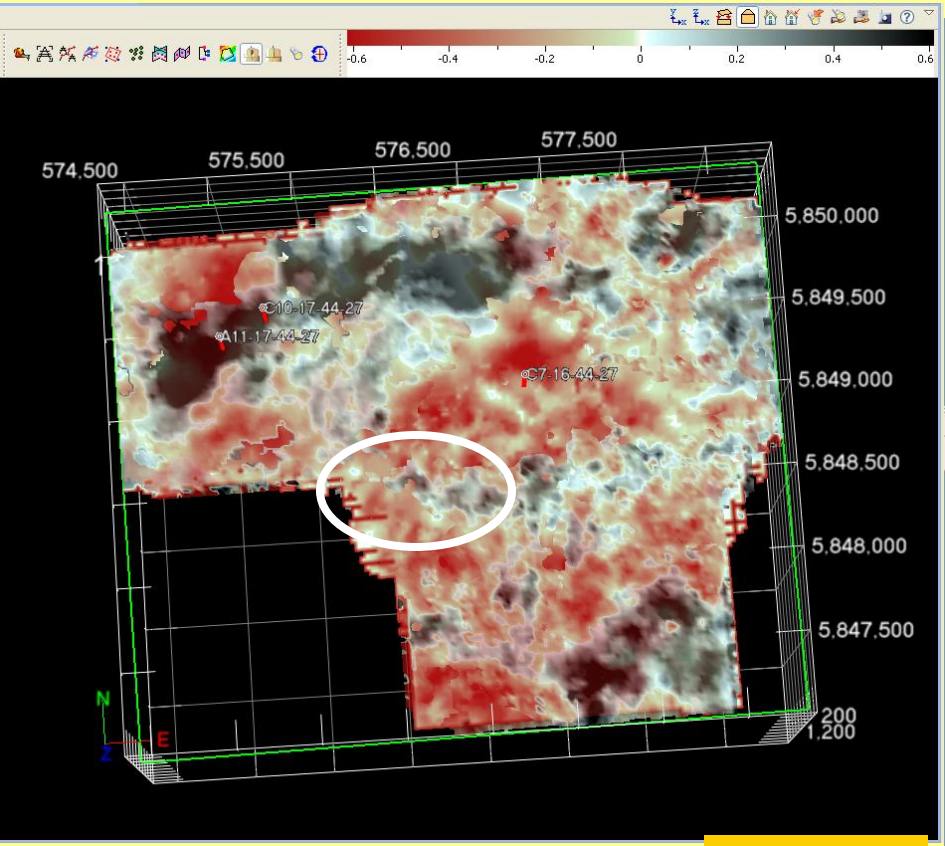


Colony

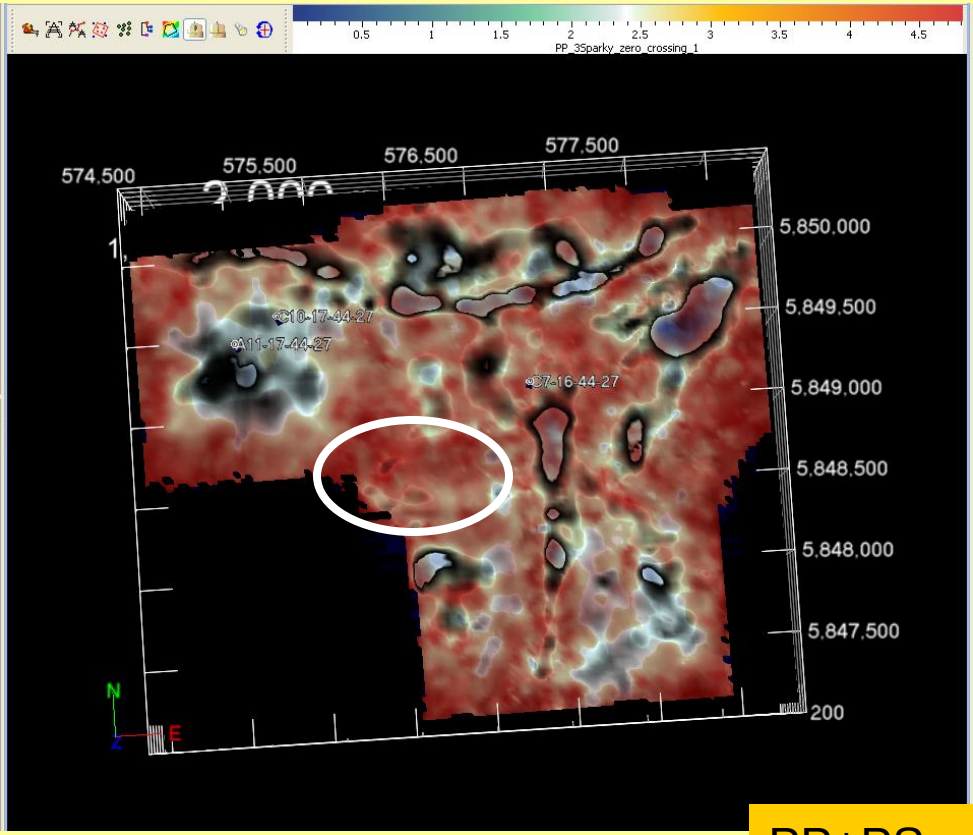


Sparky

Colony and Sparky Inversion



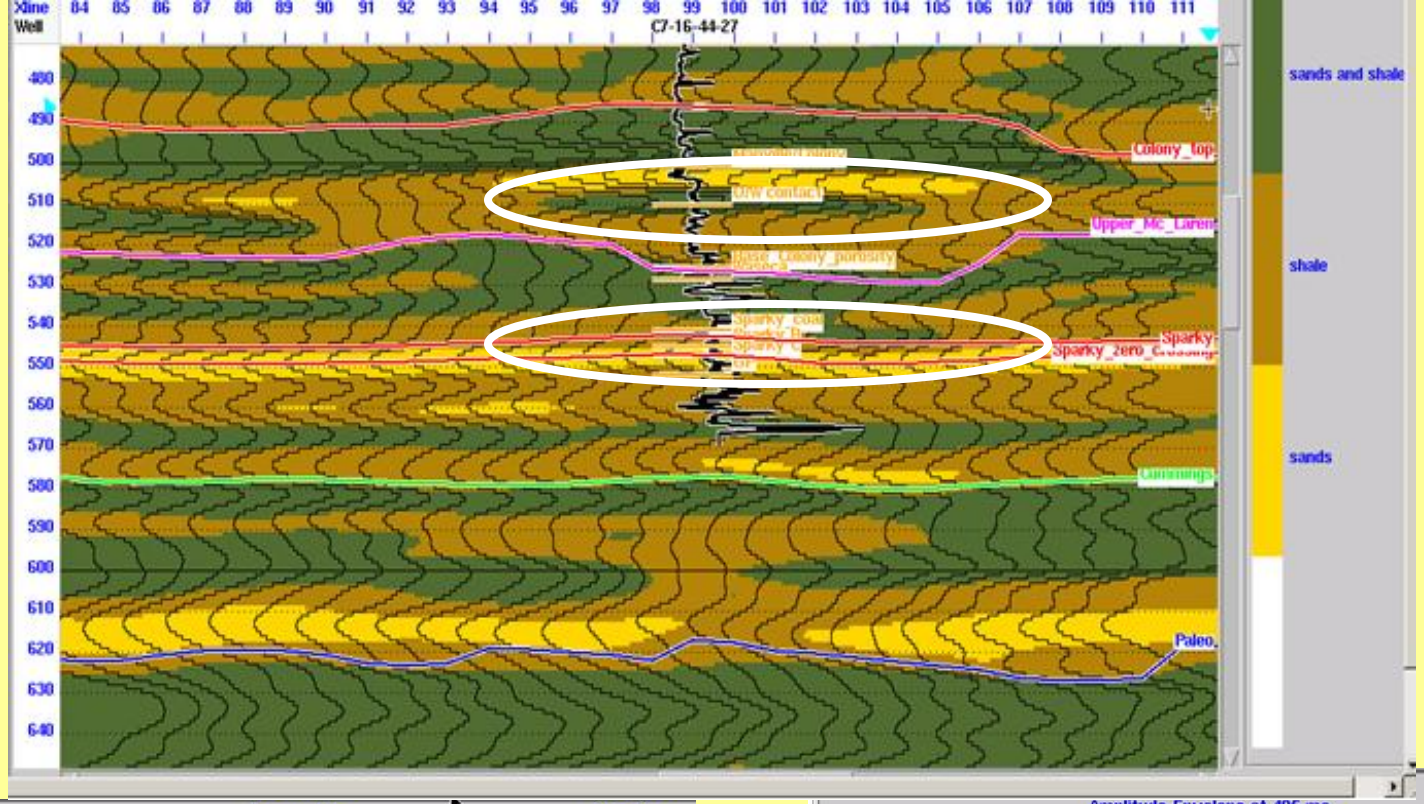
PP+PS



PP+PS

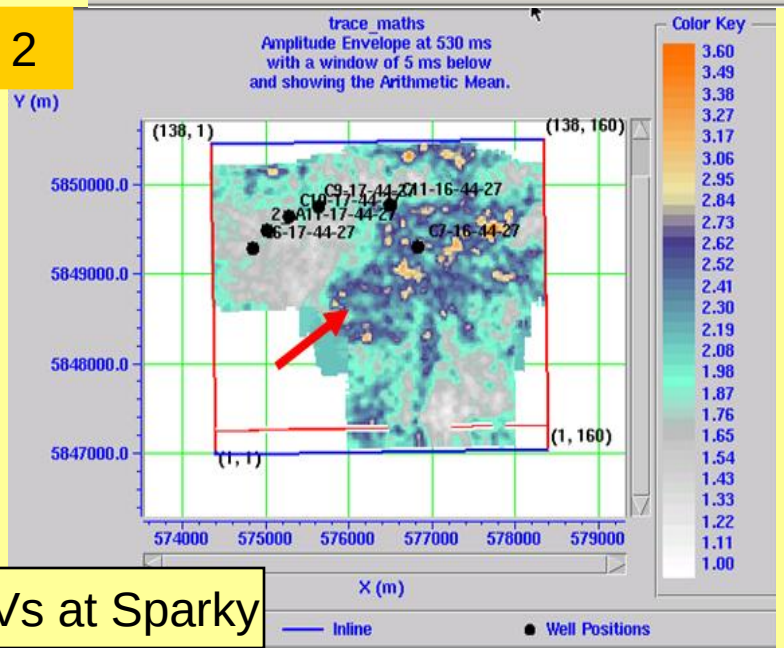
zero-decon-median filter-applied

1



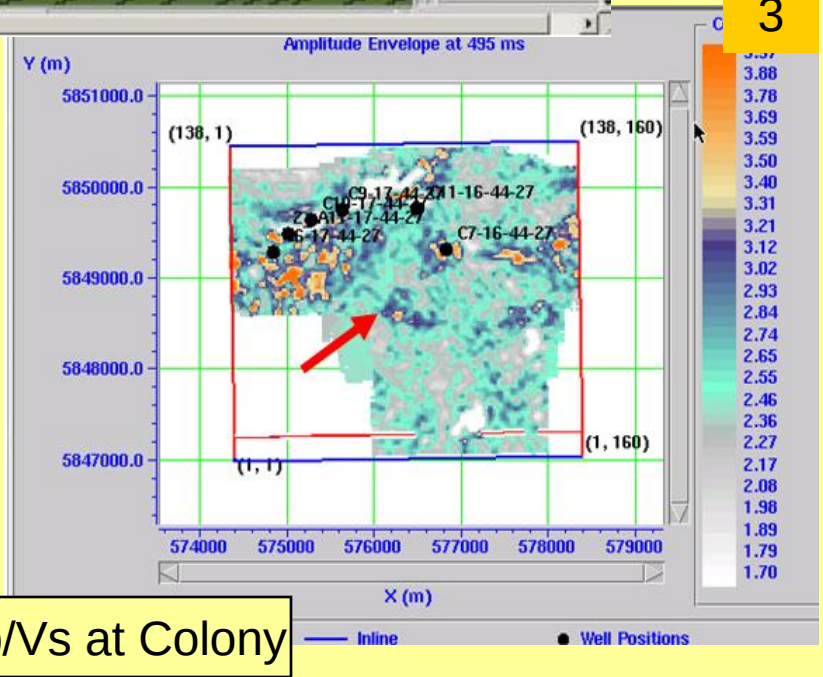
Vp/Vs ratio
from Inversion

2



Vp/Vs at Sparky

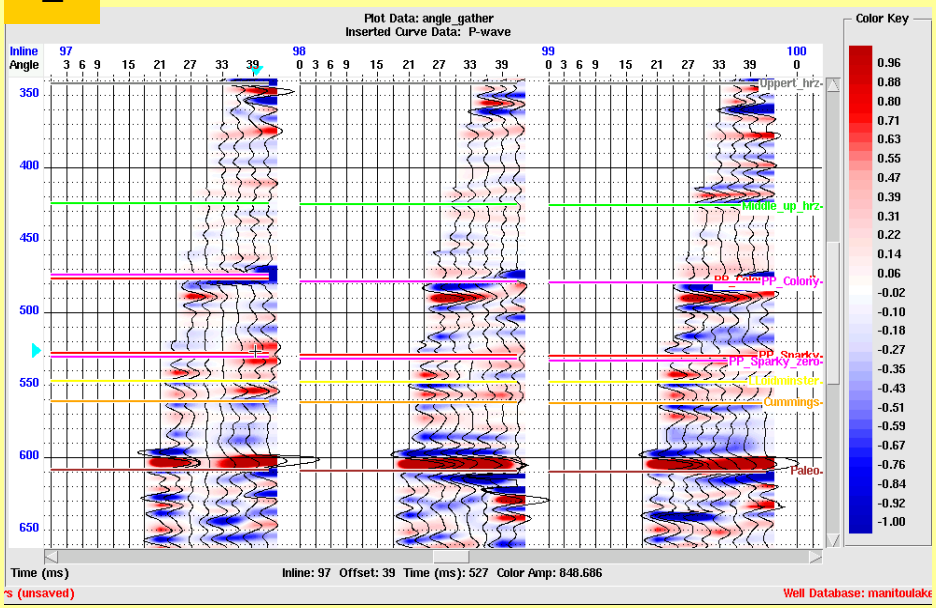
3



Vp/Vs at Colony

Prestack Inversion

1



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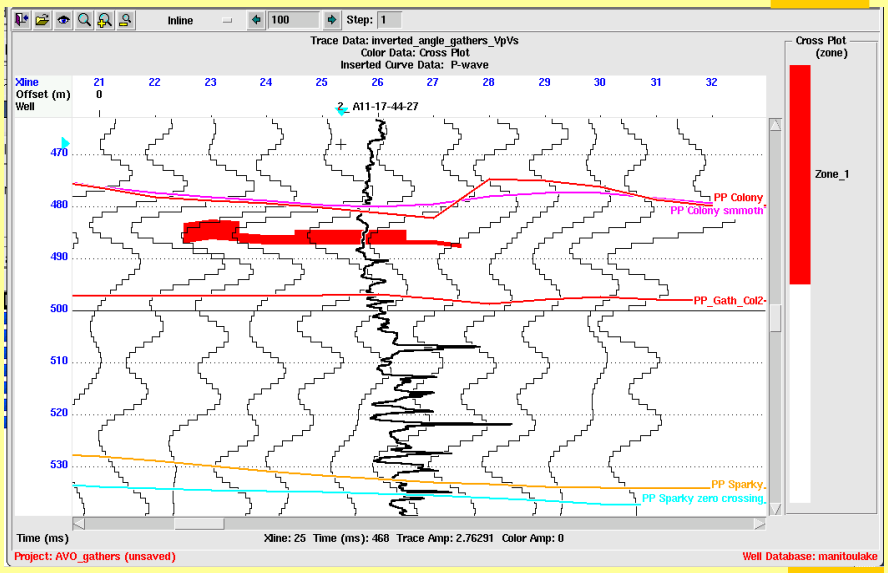

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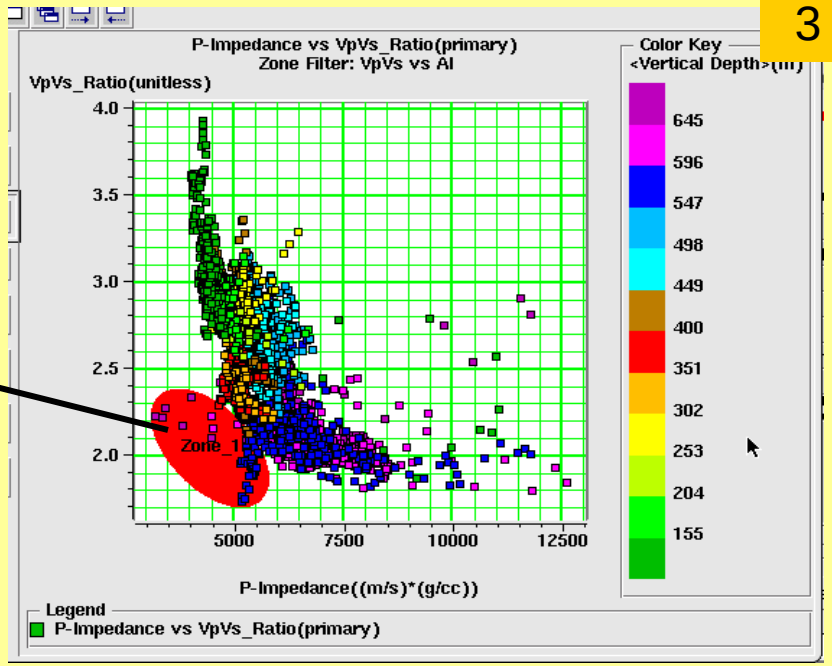

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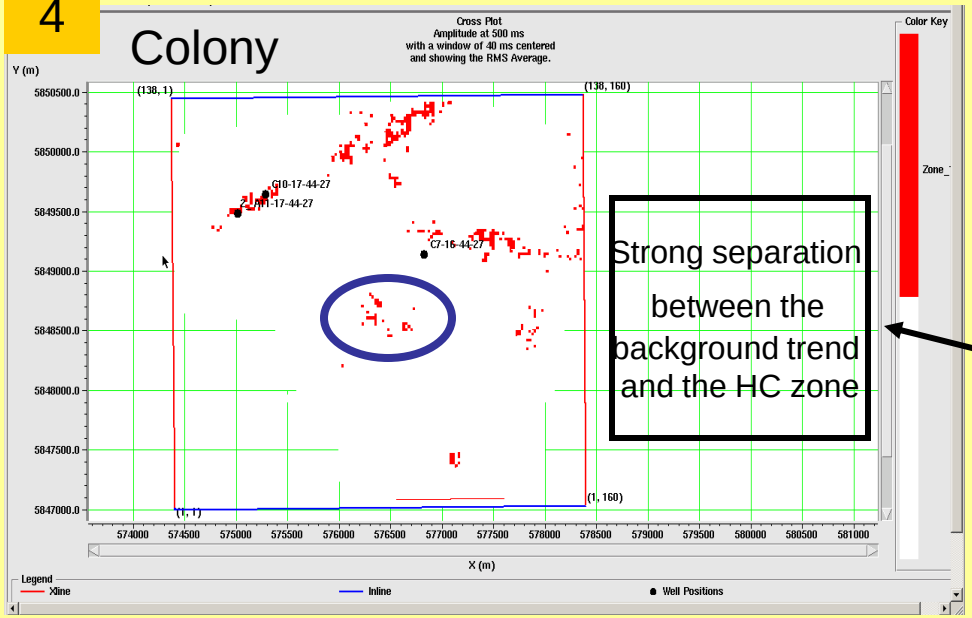
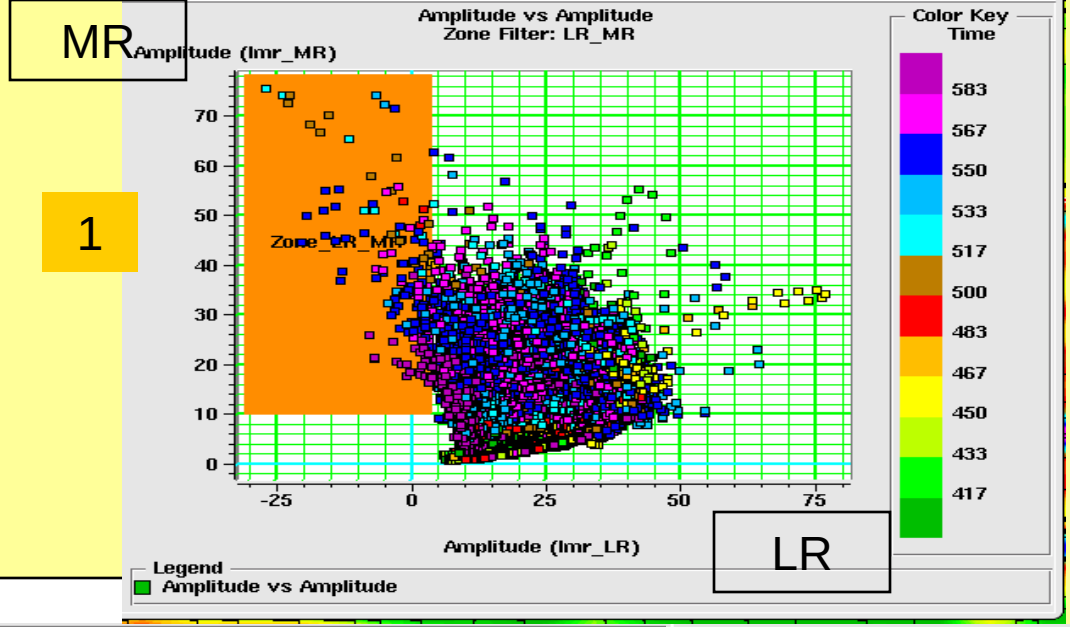
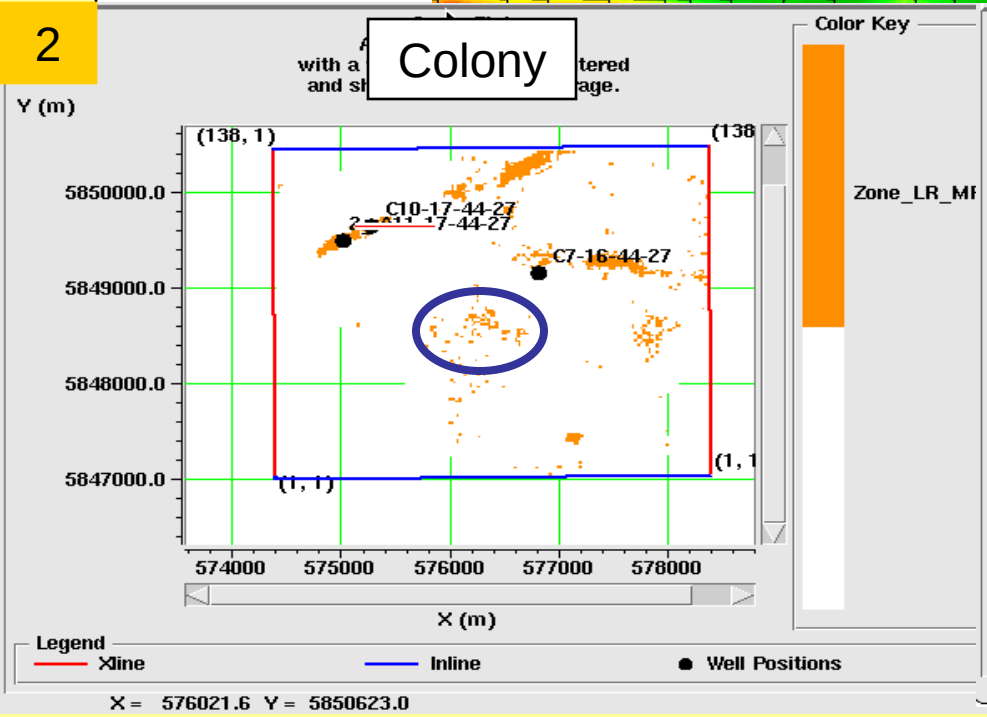


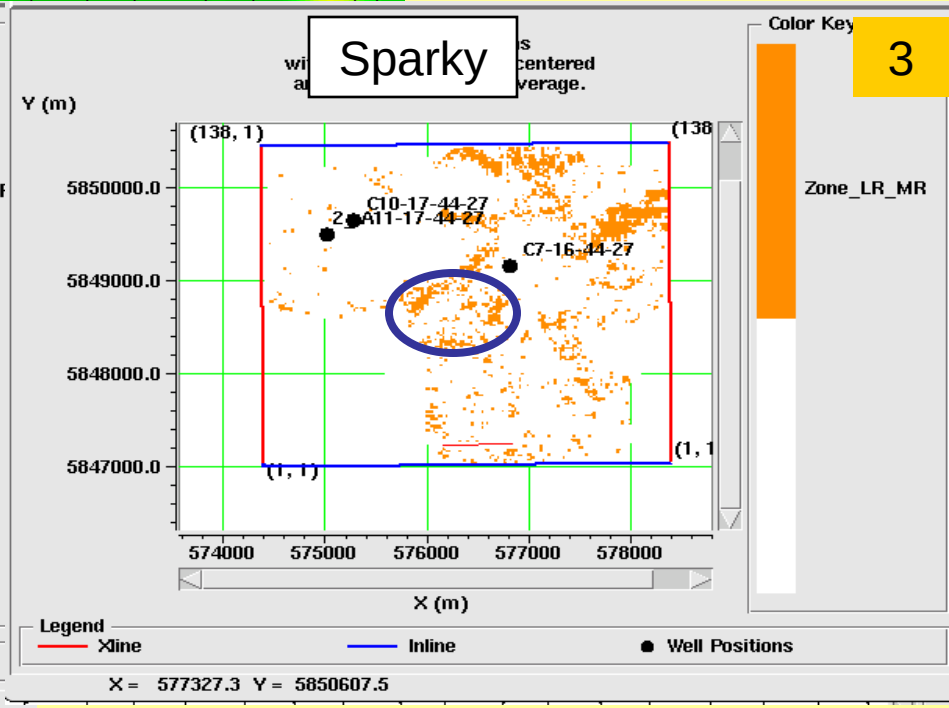
Strong separation between the background trend and the HC zone



1

2





3

λ – sensitive from shale to gas sands (Goodway 1997)

Conclusions and future work

- PP+PS attributes to help analyze channel morphology
- The productive interval is interpreted as a PP impedance drop and a PS increase
- The main impedance changes correspond to the major lithologic boundaries
- The ratio of PP inversion to PS inversion (Vp/Vs from amplitudes) in PP time is useful
- PP and PS amplitude maps are different, this can help avoid erroneous drilling locations
- Fluid substitution is the next step in this work

Acknowledgements

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