Midland Basin Spraberry Exploration Using High Resolution Elastic Inversion*

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Abstract

Bandwidth extension and seismic inversion have aided in the exploration for and development of Spraberry sands in the Permian Basin. In this study, we investigate the prospectivity and connectivity of a submarine fan system covering an area of 145 sq. km. in the Midland Basin. The sandstone reservoirs are divided into five genetic sequences of Permian age; Upper Spraberry, Middle Spraberry, Lower Spraberry, Jo-Mill, and Dean. They are highly compacted and tightly cemented, low porosity, and have an average recovery efficiency of only 15 percent. Hydrocarbons are trapped by up-dip pinch outs and facies changes at depths of 6,800 to 7,100 feet. Detecting or mapping the lateral continuity of the channel sands is difficult because they are below seismic resolution in conventional seismic data. Sparse-layer reflectivity inversion was applied to the original 3D pre-stack data increasing the 7-50 Hz bandwidth of the input seismic data to 7-100 Hz through the inversion process. The results were validated using well log data. Rock physics analysis of the well logs suggests that clean porous reservoir intervals exhibit abnormally low impedance and compressional-to-shear-wave velocity ratio if the layer can be resolved. Simultaneous elastic inversion run on bandwidth extended prestack gathers revealed impedance and velocity-ratio anomalies in structurally advantageous positions that were later verified by drilling as being productive reservoirs. Overall, the new dataset improved detectability and resolution that contributed to greater understanding of the lateral connectivity of lower Spraberry channel sands, and enabled geobody extraction for reservoir static modelling.

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May 1st 2017

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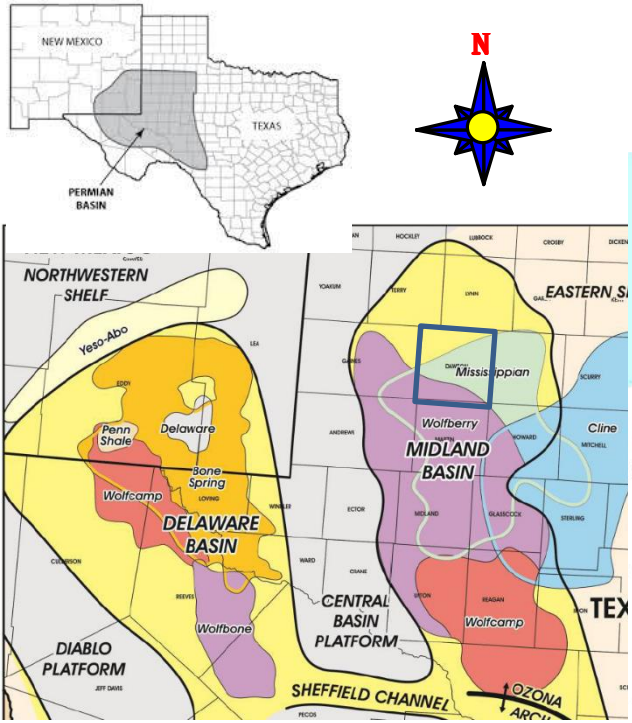
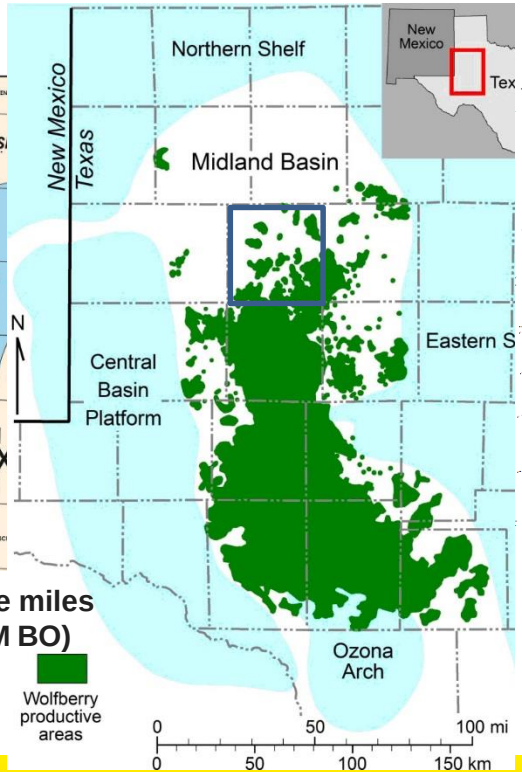
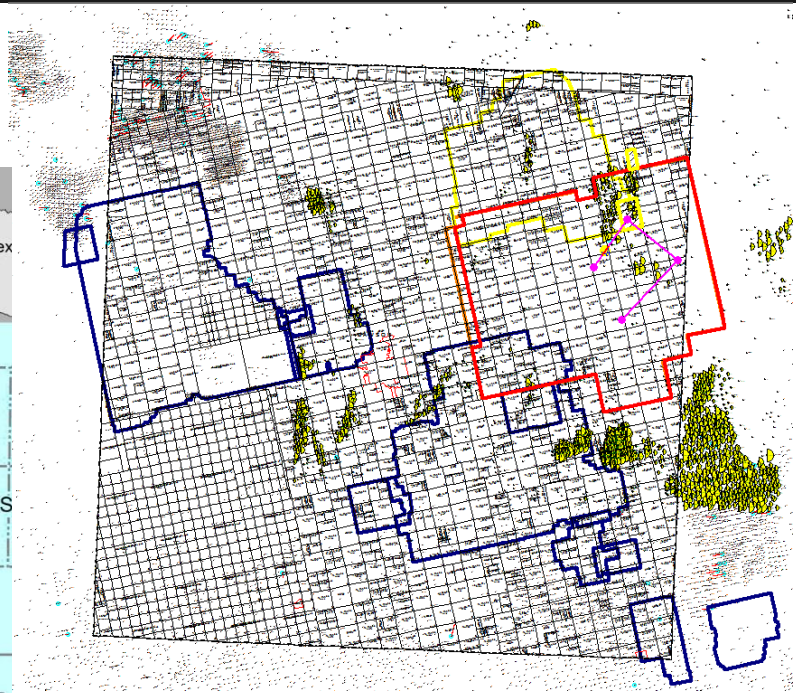


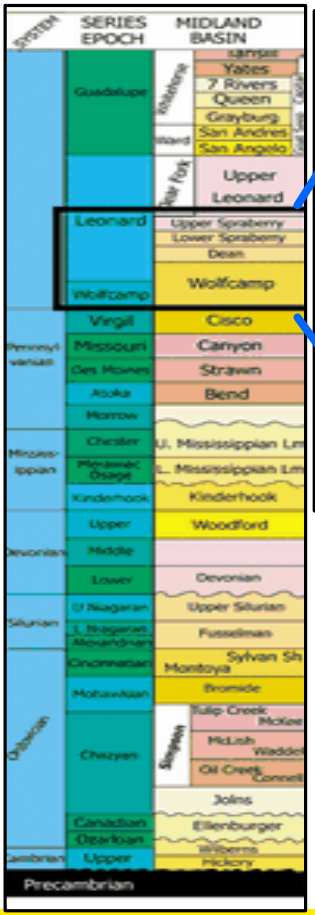


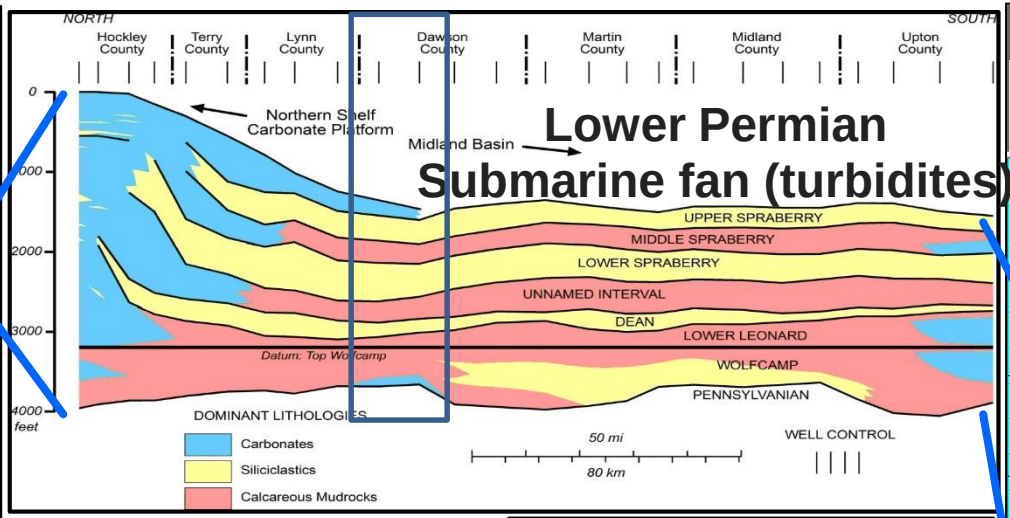


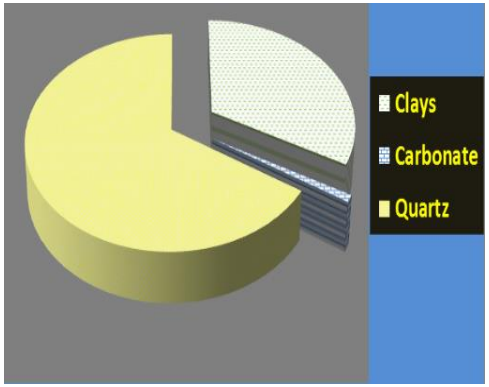
Wolfberry production covers ~2,500 square miles
3rd in USA by total proved reserves (10MMM BO)
7th In USA by production (295 MBOPD)

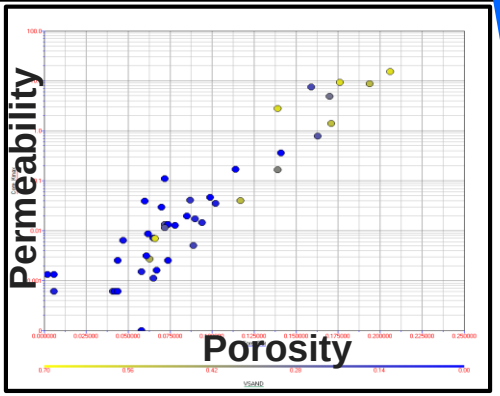
Study area ~ 50 mile²

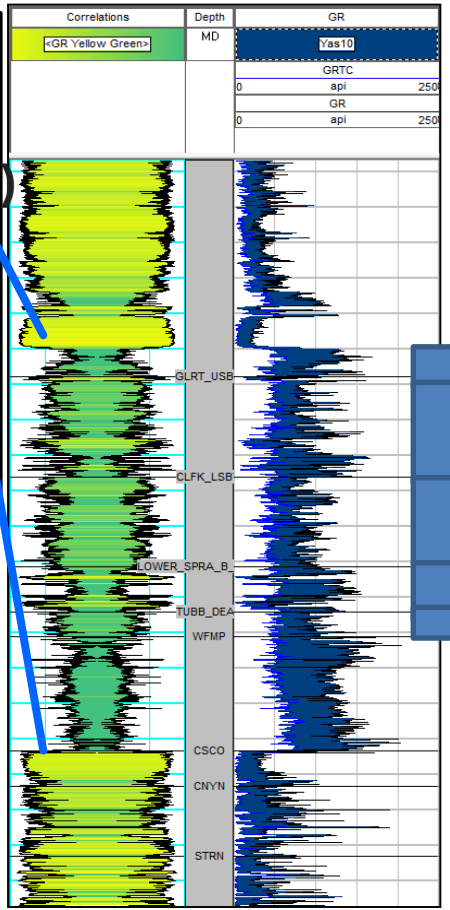
1. Introduction: Geology Background











Upper

Middle

Lower

Jo-Mill

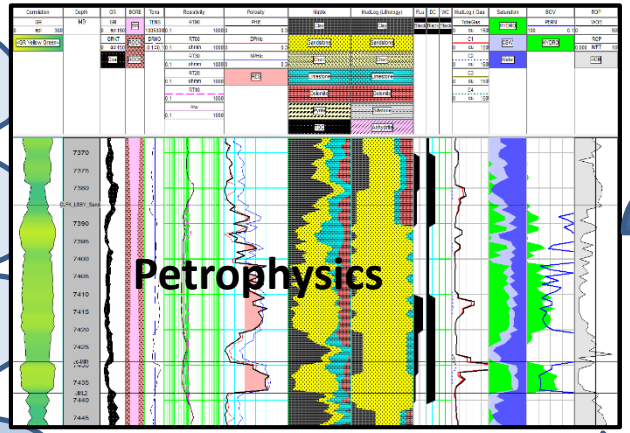
Dean

1. Introduction: Reservoir Characterization Workflow

Core data

Wireline data

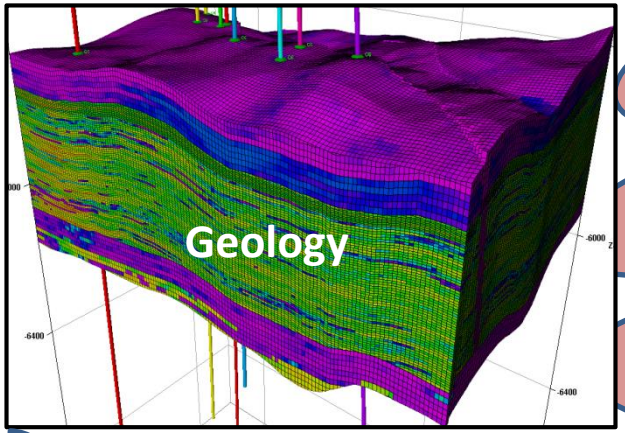
Saturation & Flow



Petrology

Stratigraphy

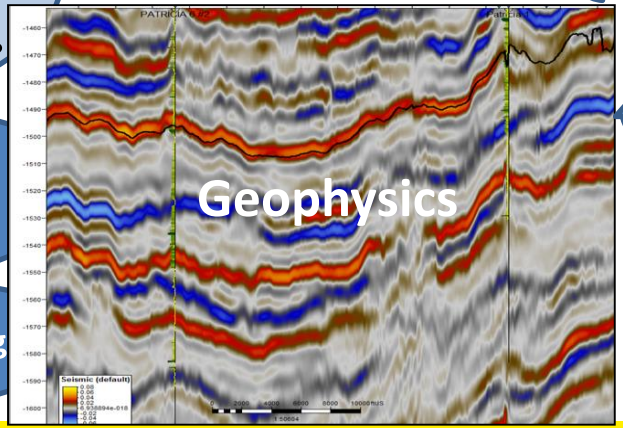
Structure



Well tie & Seismic Modeling

Seismic Data

Prospecting



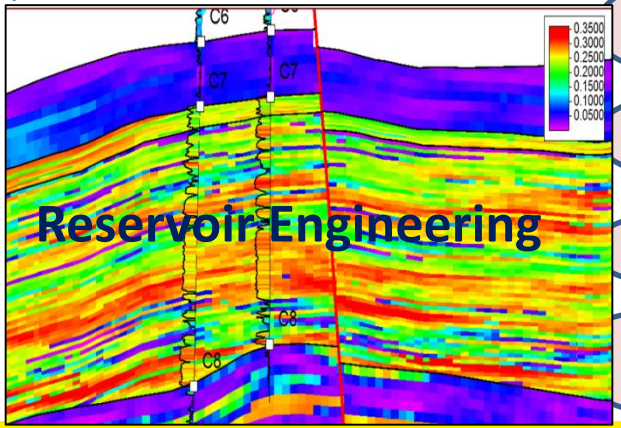
INTEGRATION

Production data

Pressure Data

History Match

Flow simulation



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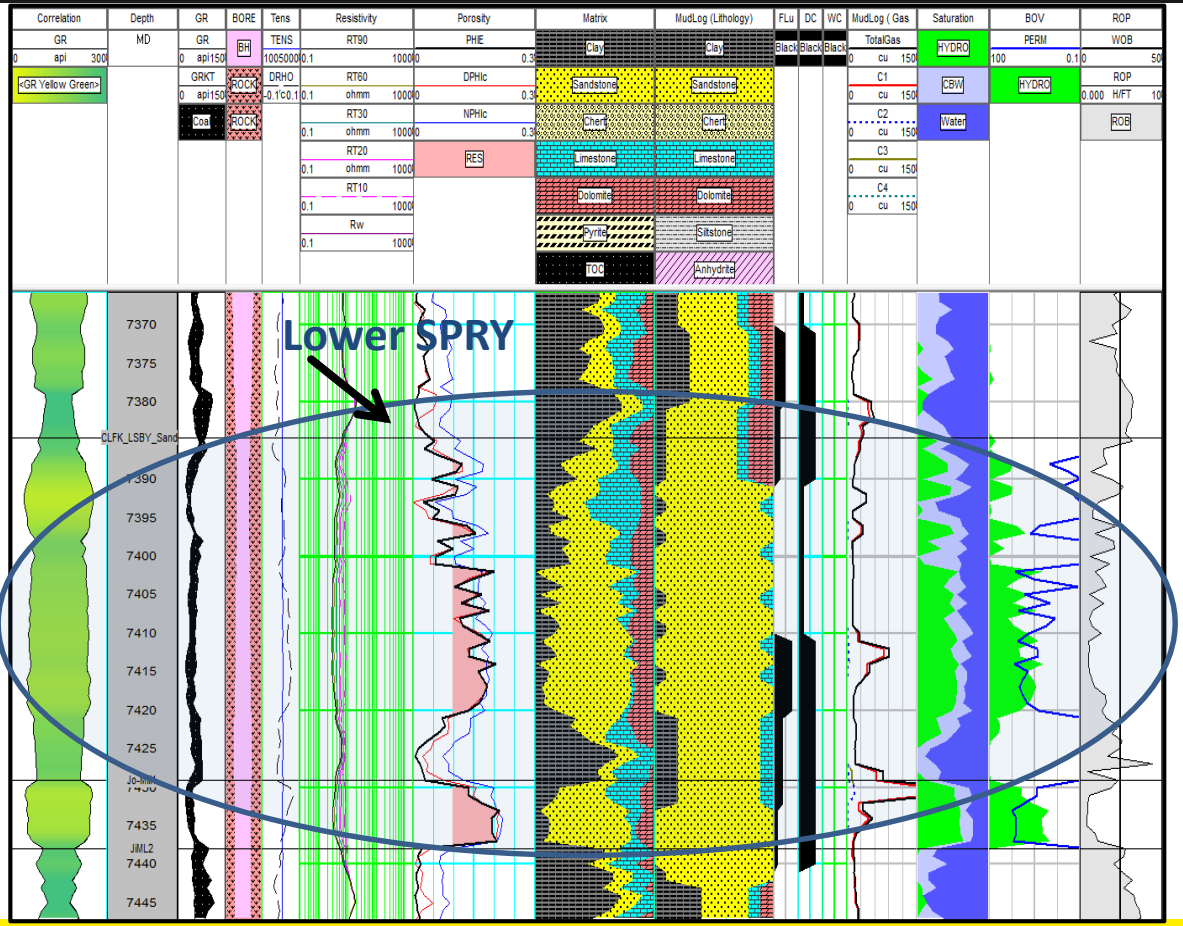
2. Well Analysis: Petrophysical Evaluation

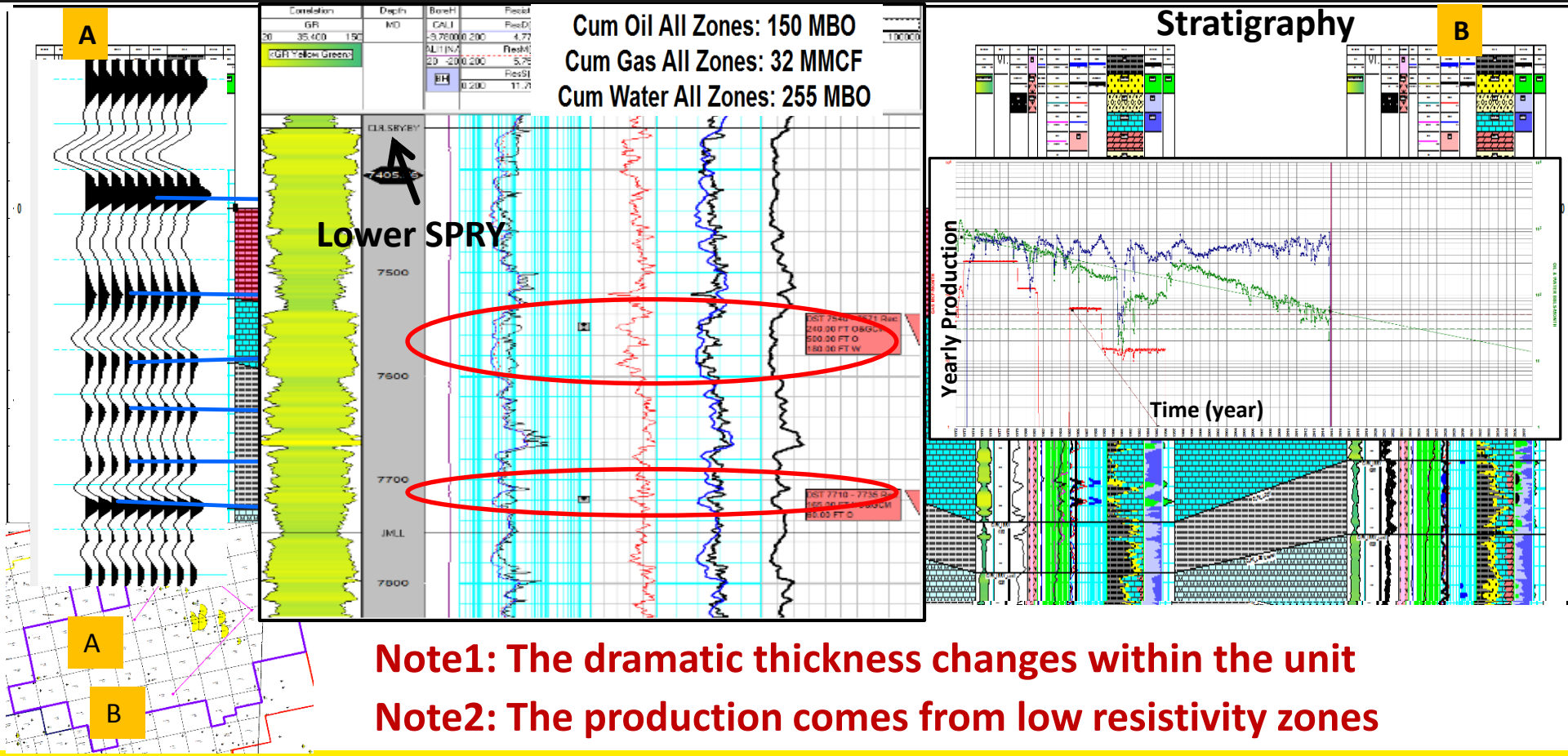


From top of Lower SPRY (Sand3)

Thickness (FT)	53.45
Bo	1.31
PERM (mD)	3.92
RT (ohm-m)	1.91
Reservoir (FT)	46.00
Net Reservoir (FT)	33.00
Pay Thickness (FT)	33.00
PHIE-Pay (v/v)	0.16
VSH-Pay (v/v)	0.16
SW-Pay (v/v)	0.46
SO*PHI*Pay (FT)	2.79

Good florescence, good gas shows and good porosity with 33 ft of Pay

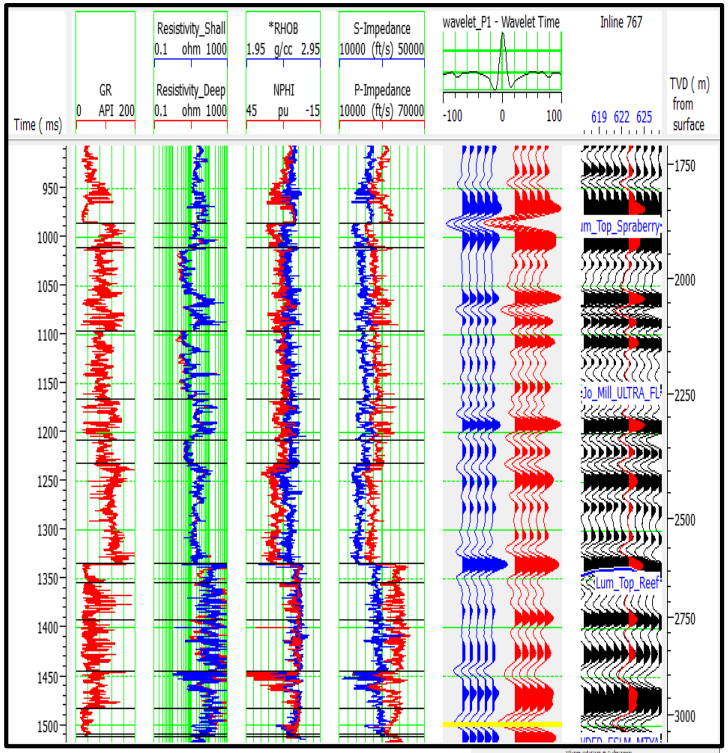
2. Well Analysis: Cross Sections



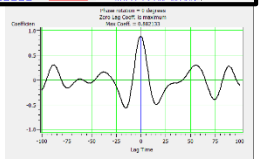
Note1: The dramatic thickness changes within the unit

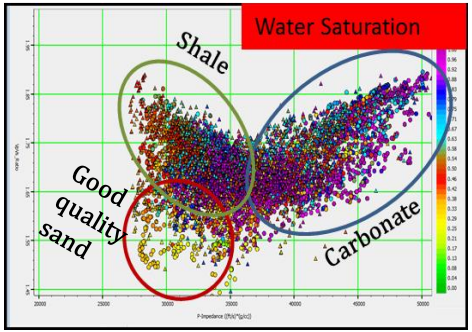
Note2: The production comes from low resistivity zones

2. Well Analysis: Rock Physics Modelling



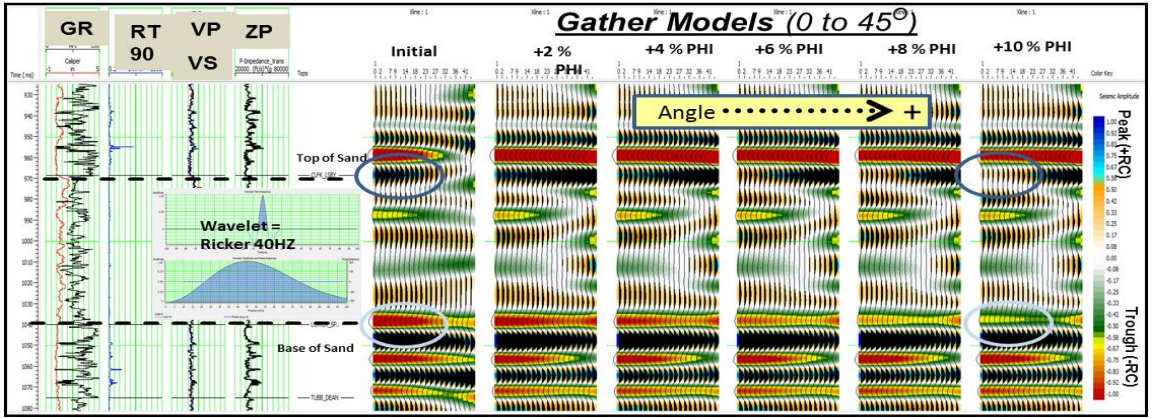
Well to seismic time depth Curve





P-Impedance vs VPVS Ratio cross plot

Note :The separation between water saturation and hydrocarbon saturation. The hydrocarbon saturated sand has low impedance and low VPVS ratio.



Porosity change models: Increasing porosity reduces the amplitude variations at LSBY Top and Bottom especially for near offsets

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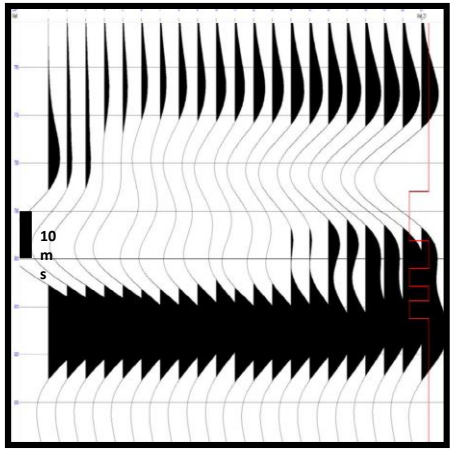
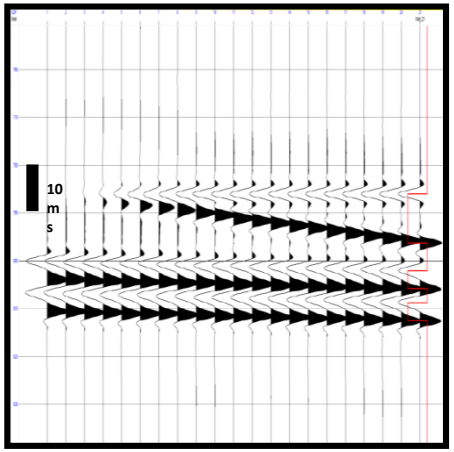
3. Seismic Bandwidth Extension

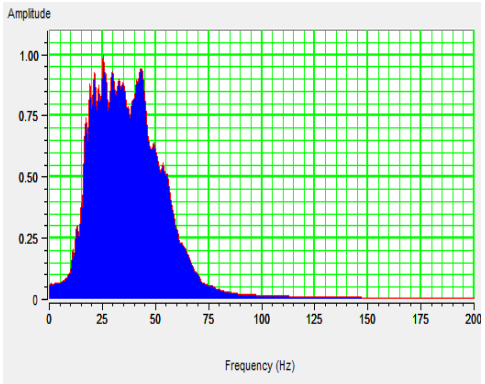
The seismic bandwidth extension is done using Ultra™ which is a spectral inversion based on a proprietary high resolution spectral decomposition that uses a multi-channel operator determined from well data (reference wavelet from well ties). The inversion algorithm does not use well data for the prediction of the high frequencies. This process is a trace by trace process.



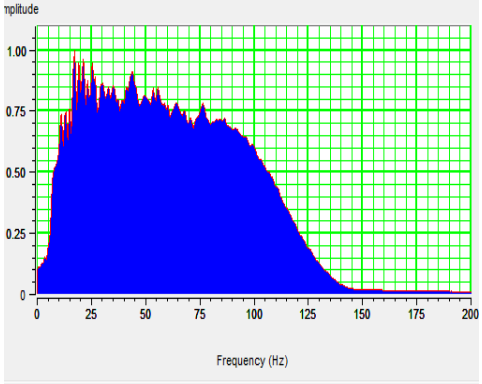
Seismic resolution ~ 20ms



Ultra(TM) resolution ~ 4ms

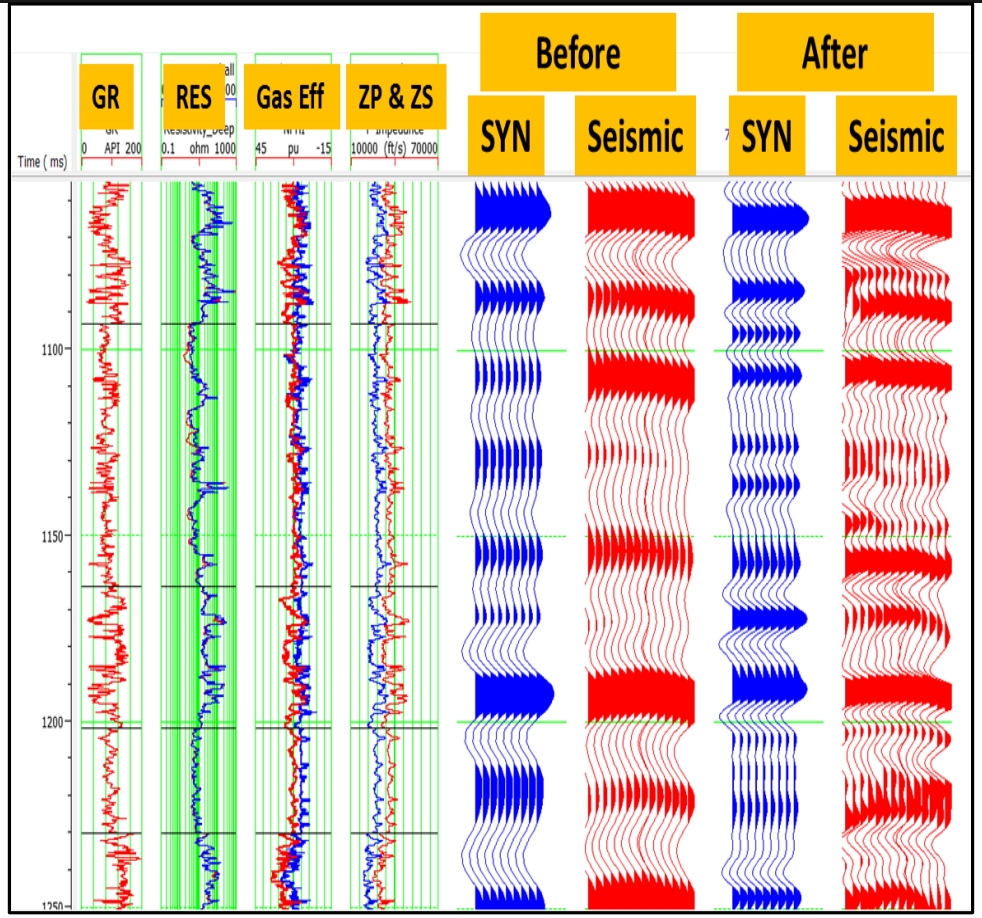


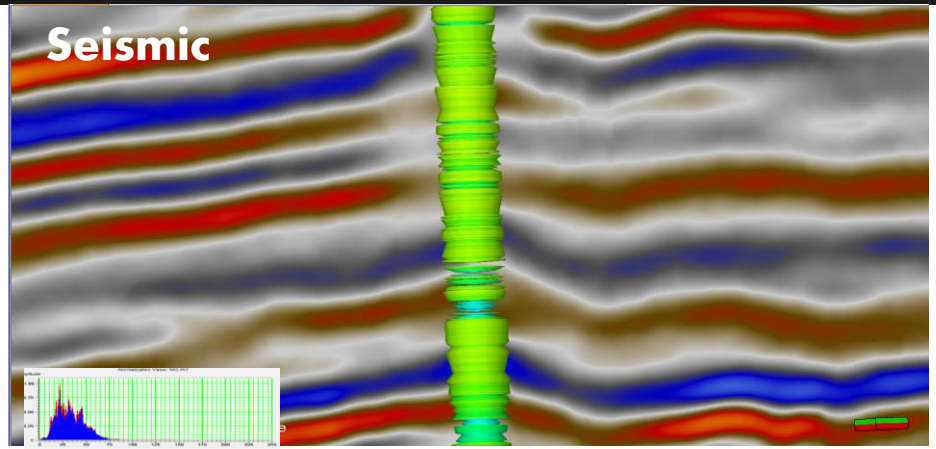
Before

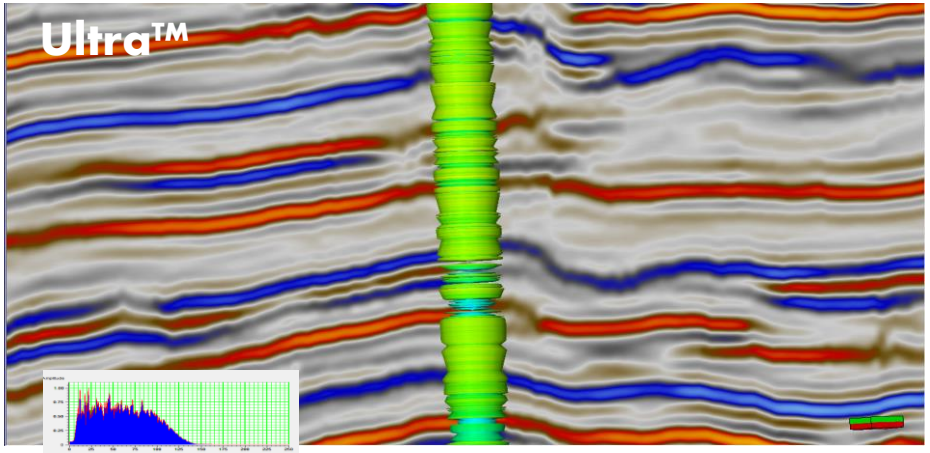


After

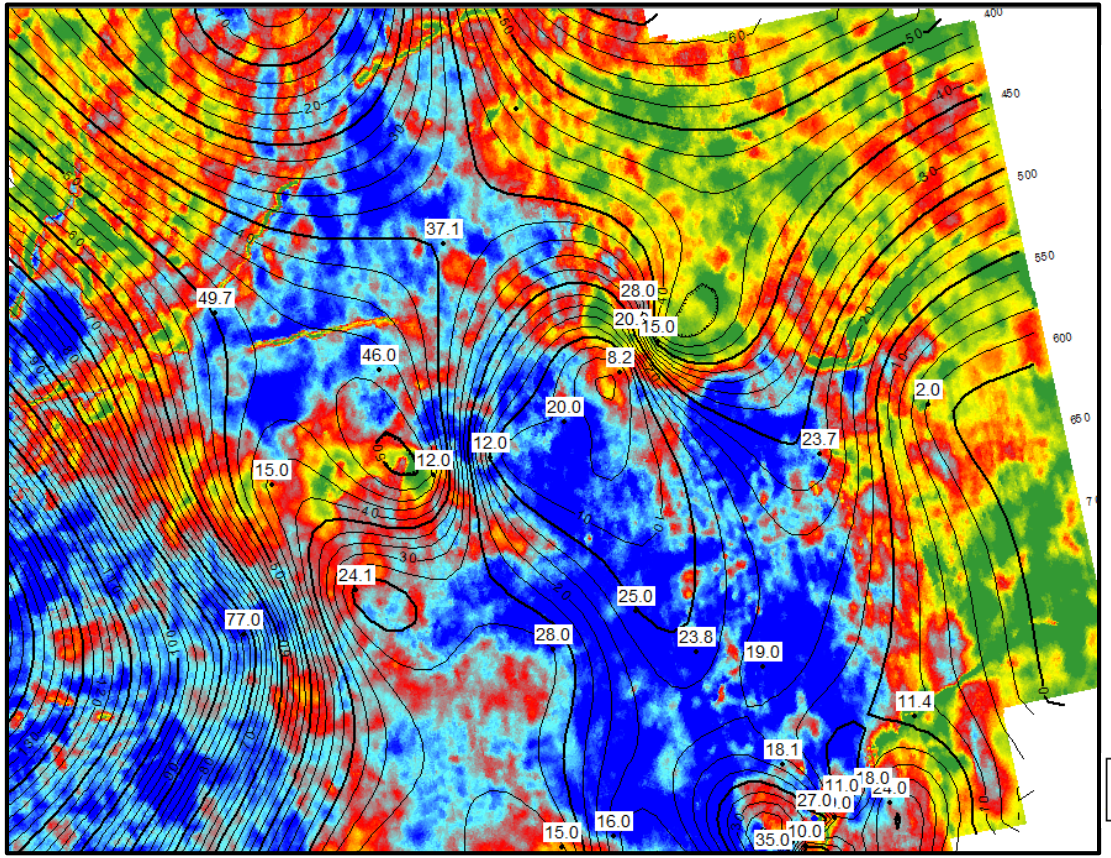
3. Seismic Bandwidth Extension





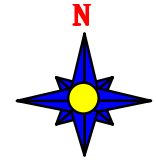


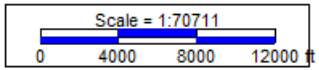
3. Seismic Bandwidth Extension- X level Pinch out

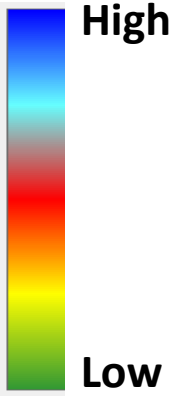


Contour Lines were created using TVD thickness interpolation of X level (Well Data).

The RMS seismic amplitude for 15 ms window for the X Level horizon

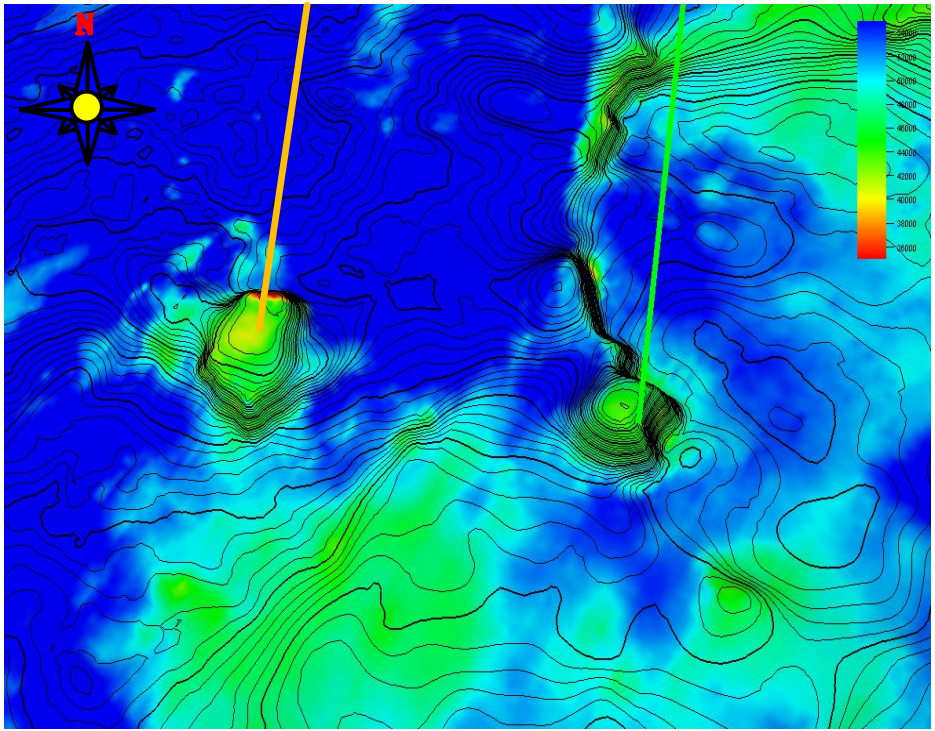


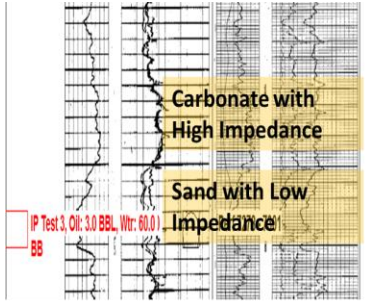


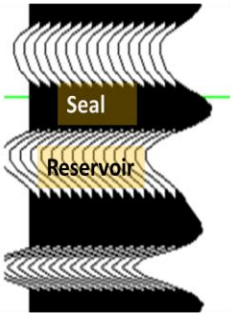


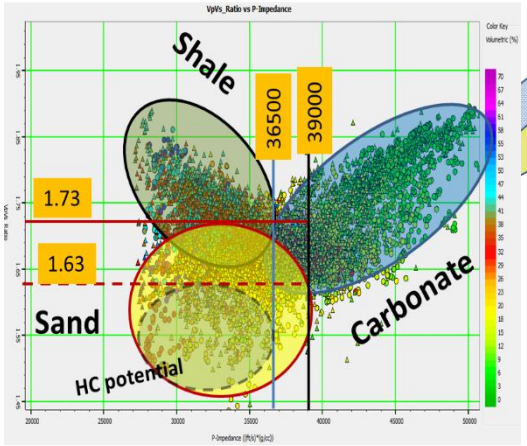
Well data shows thickness changes from 100 ft to less than 2 ft

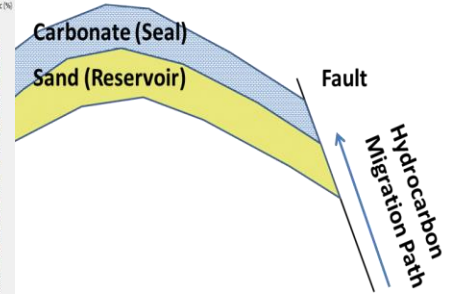
High Resolution Elastic Inversion is needed to identify the reservoir











Many wells located on structural highs or stratigraphic traps but lack reservoir were dry

Reservoir Model (SPRY)

There is a need for elastic inversion

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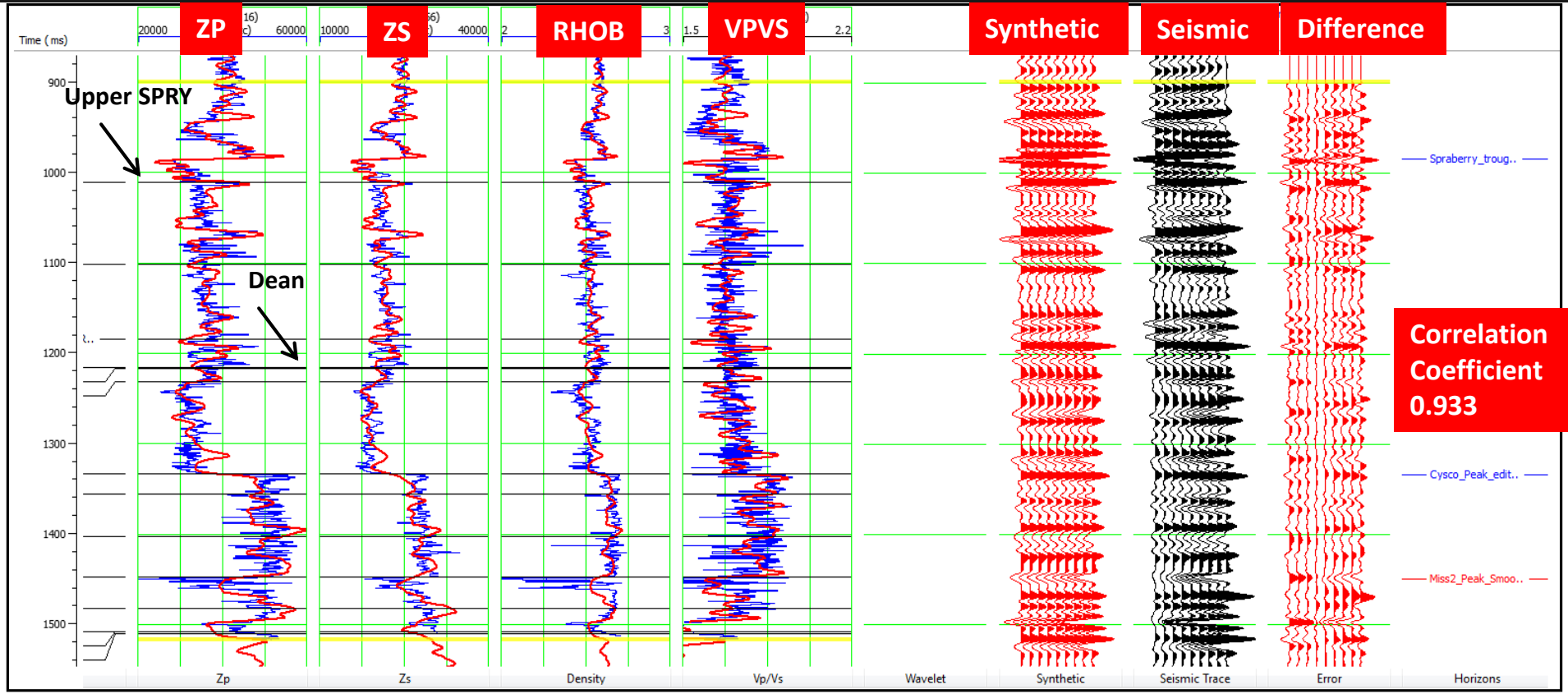
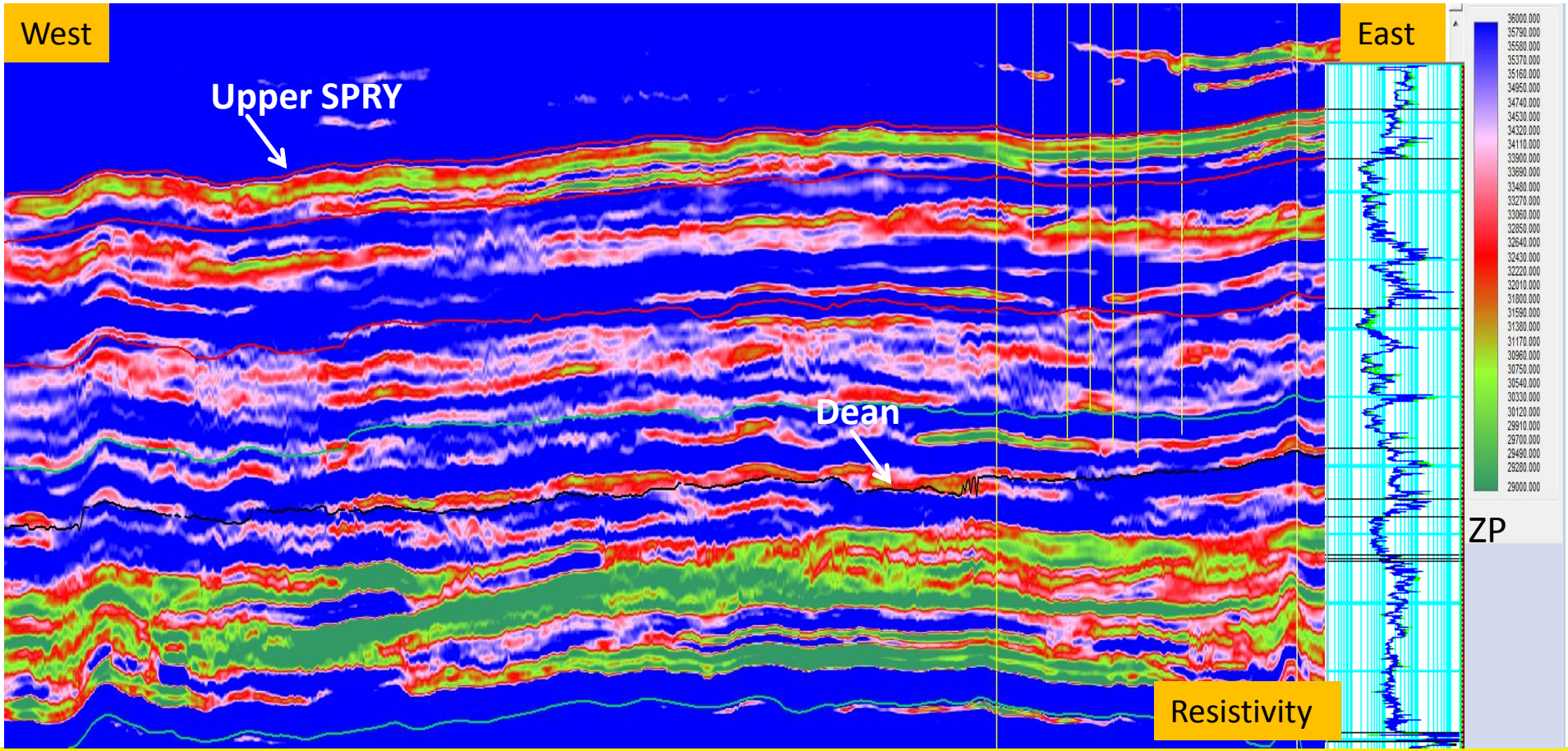
4. Rock Physics Guided Elastic Inversion

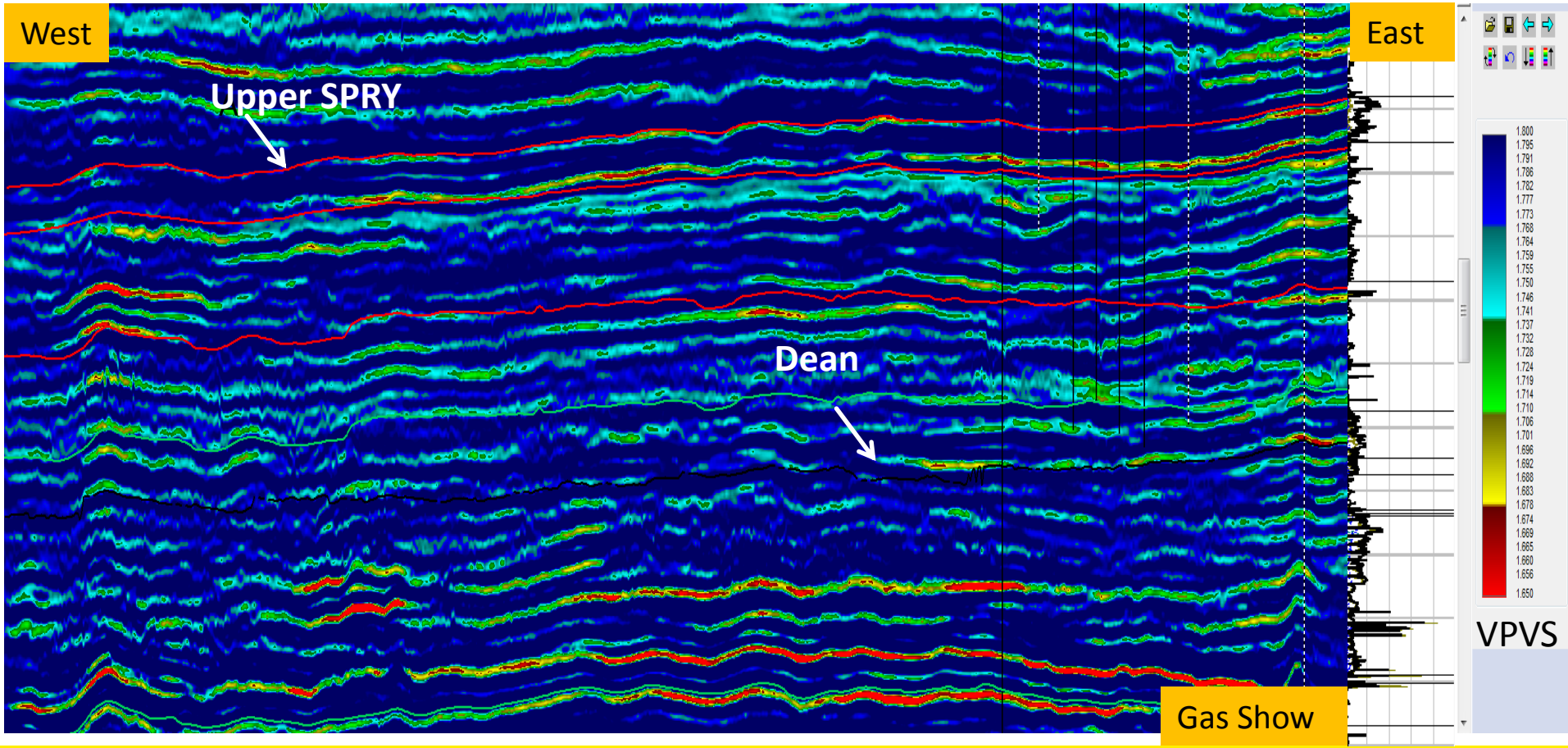


Synthetic Traces were built using absolute ZP, ZS and Density that were obtained from elastic inversion

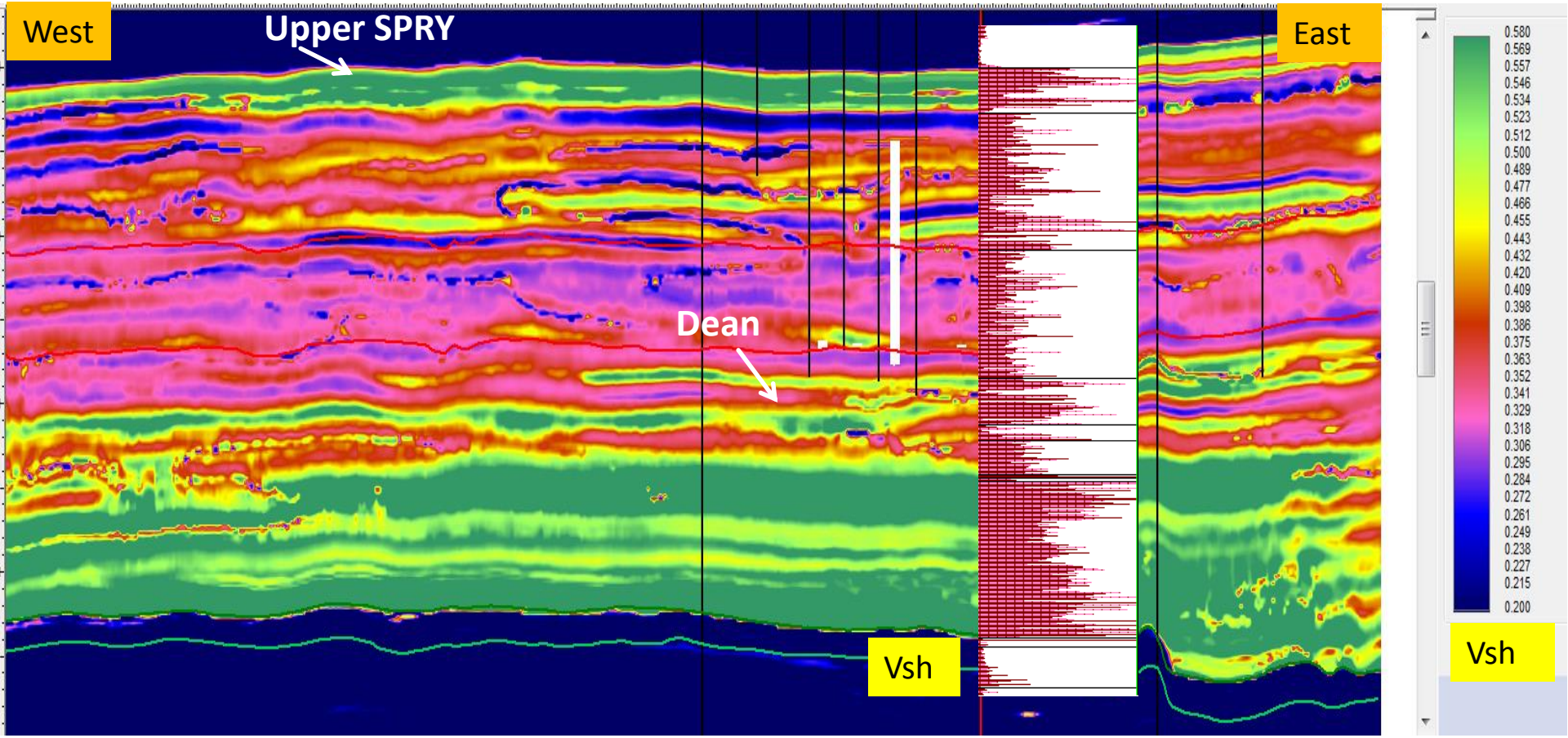
4. Elastic Inversion: P-Impedance



4. Elastic Inversion: VPVS



4. Elastic Inversion : Volume of Shale (Vsh) (Multi-Attribute)



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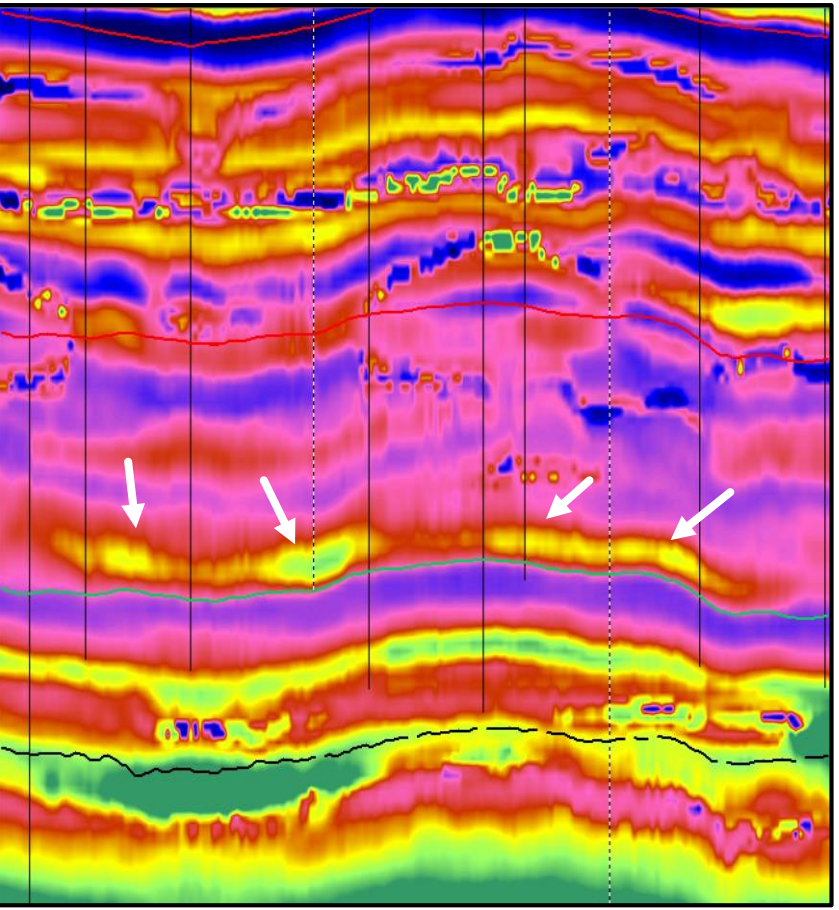
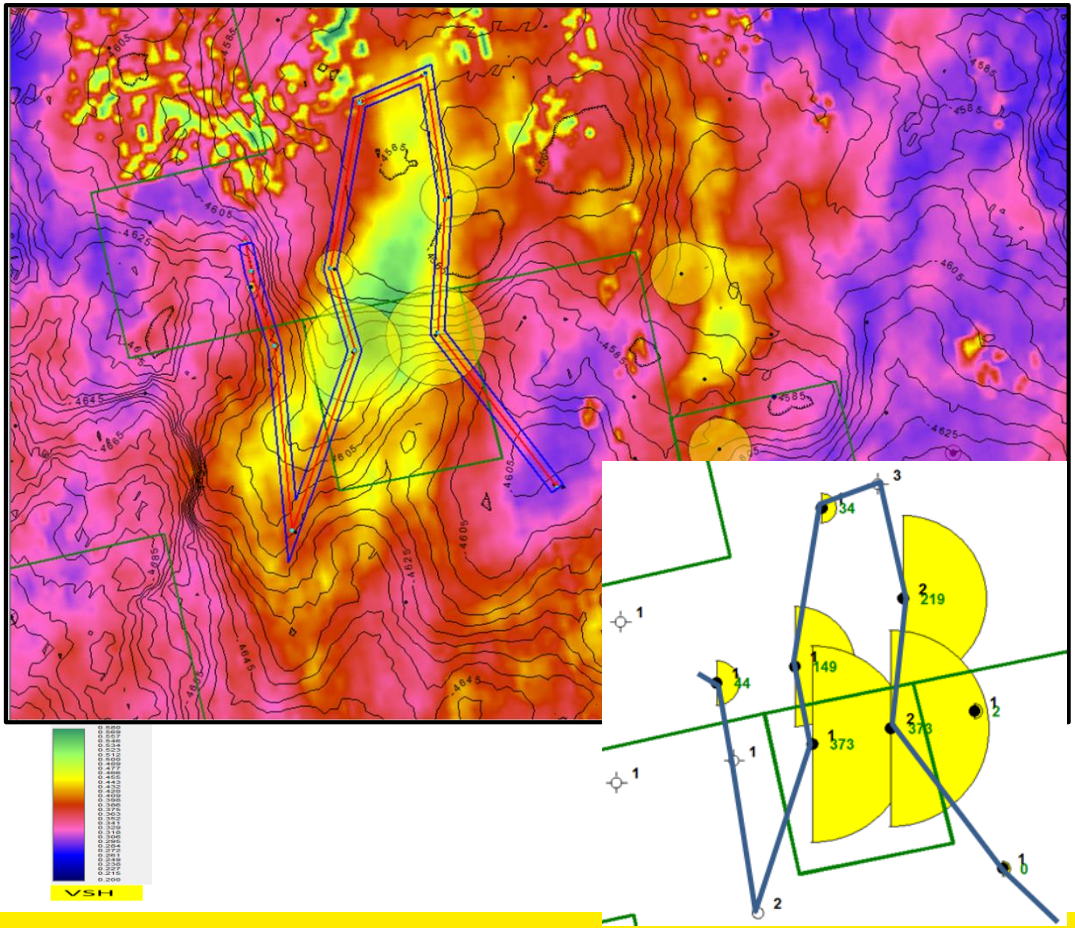
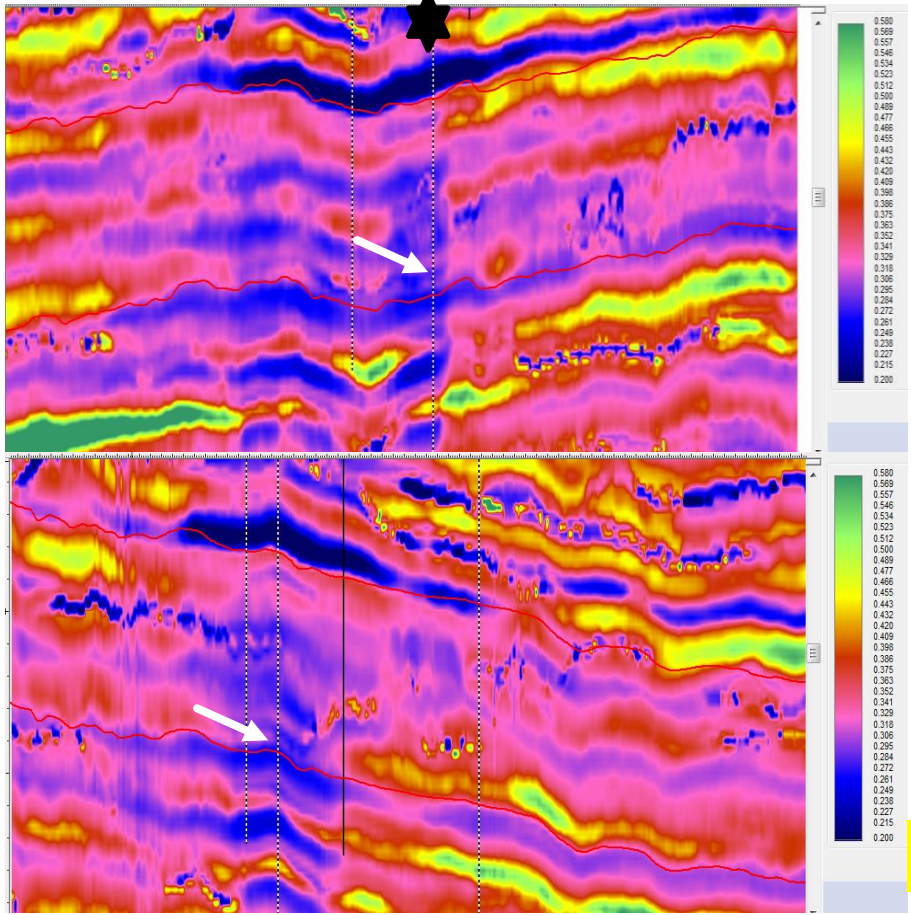
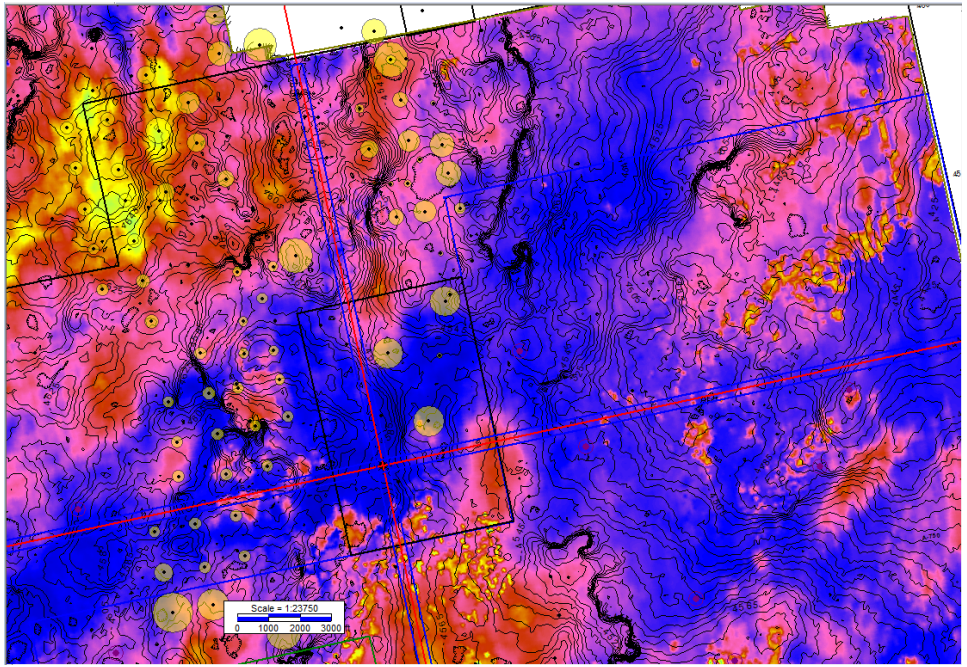
5. Results: Analogue Comparison (Vsh)





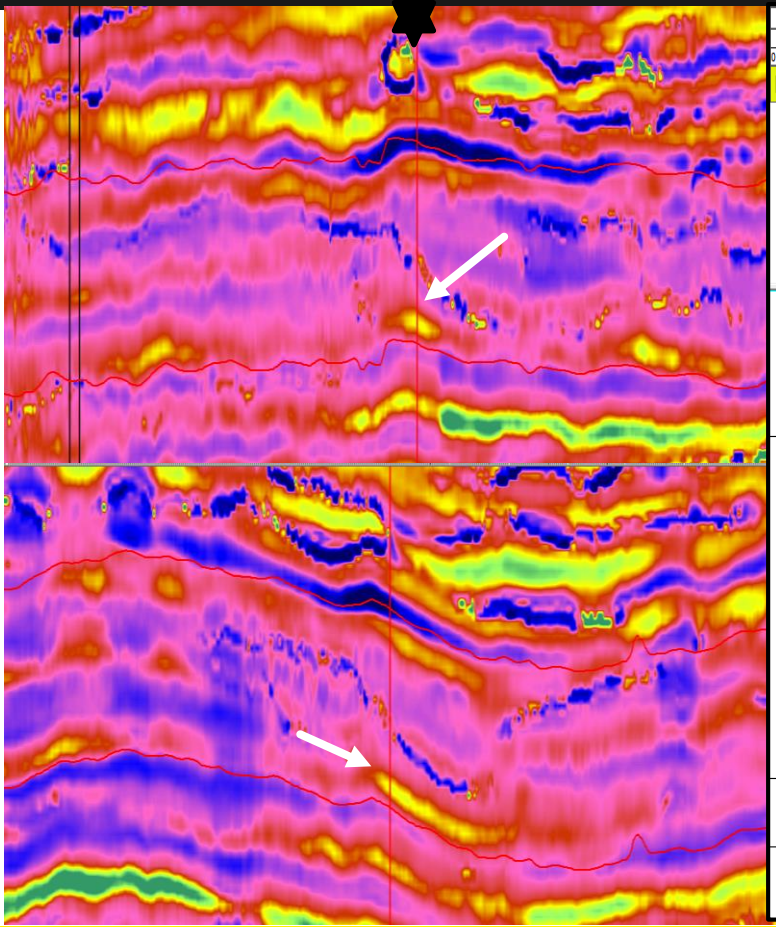
5. Results: Dry holes – did not encounter reservoir (Vsh)

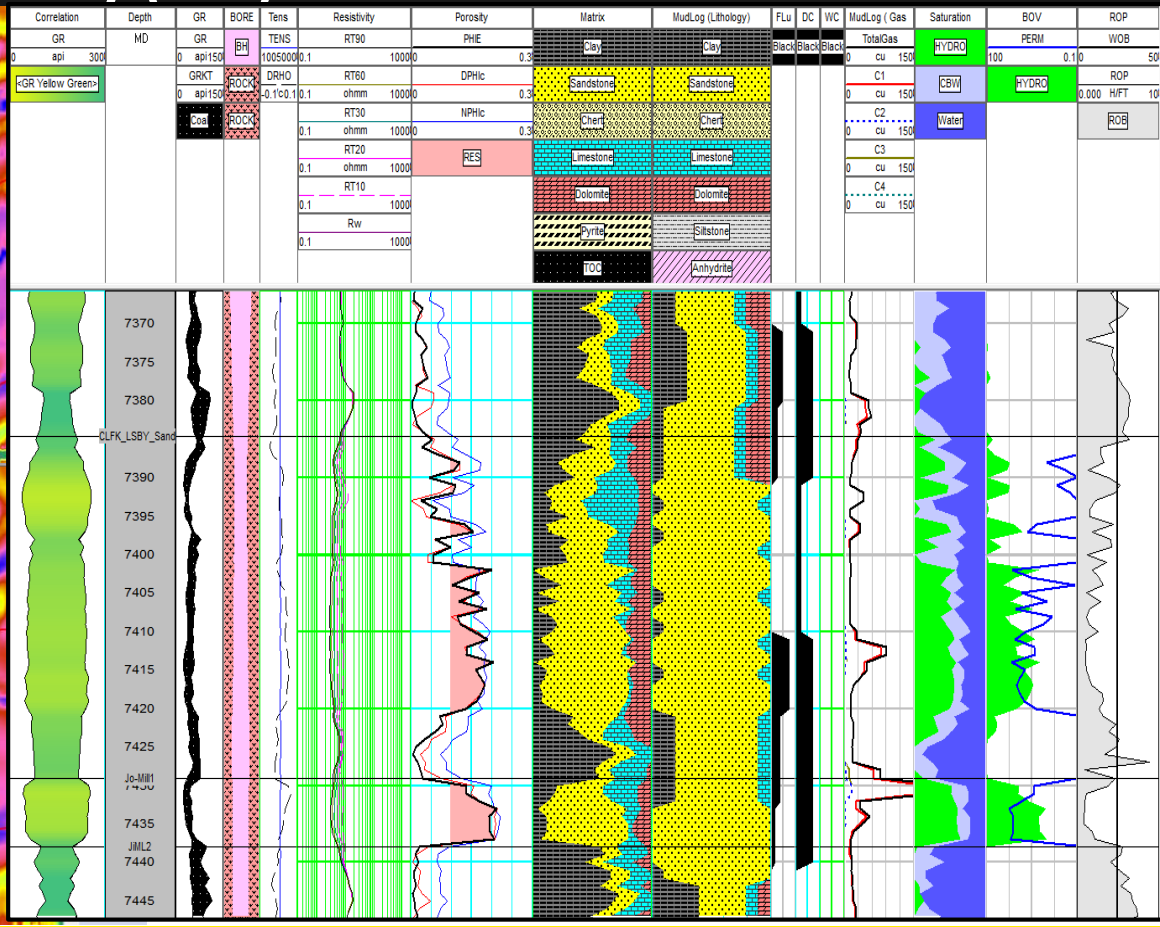




VSH

5. Results: New well – Discovery (Vsh)





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6. Conclusions

- The clean porous reservoir intervals exhibit low Resistivity, low impedance and low VPVS ratio.
- The bandwidth extension technique improved resolution and detectability that contributed to greater understanding of the lateral connectivity of lower Spraberry channel sands.
- Elastic inversion run on high frequency gathers revealed impedance, velocity-ratio and Vsh anomalies in stratigraphically/structurally advantageous locations.
- Two discovery wells were drilled using the current data set and we plan to drill more in the near future.

Thank You
Question???