PP-PS JOINT INVERSION FEASIBILITY STUDY - APPLICATION IN OKLAHOMA UNCONVENTIONAL RESOURCE PLAY

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Marathon Oil

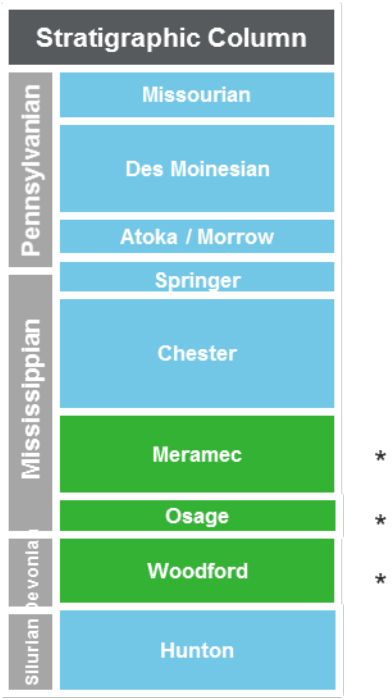
Project Objectives

Assess the efficacy of the PP-PS joint inversion compared to the PP simultaneous inversion

Interpretation of elastic properties and derivatives in a testing survey area

Estimation of reservoir properties for lithofacies distribution

Analyze the PP-PS joint inversion workflow to evaluate the applicability of the technology to unconventional resource plays



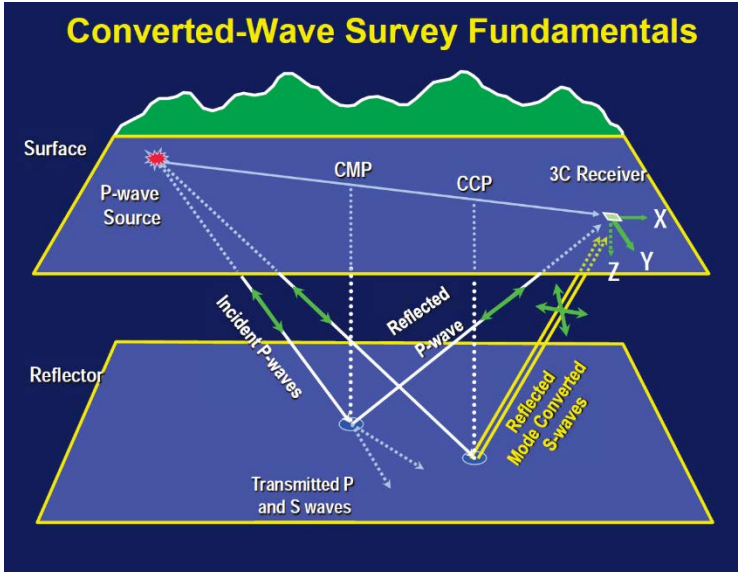
Converted waves (PS)

What are converted waves?

When the down-going P-wave (aka primary or compressive waves) hits an interface, it can reflect upwards as an S-wave (aka secondary or shear waves).

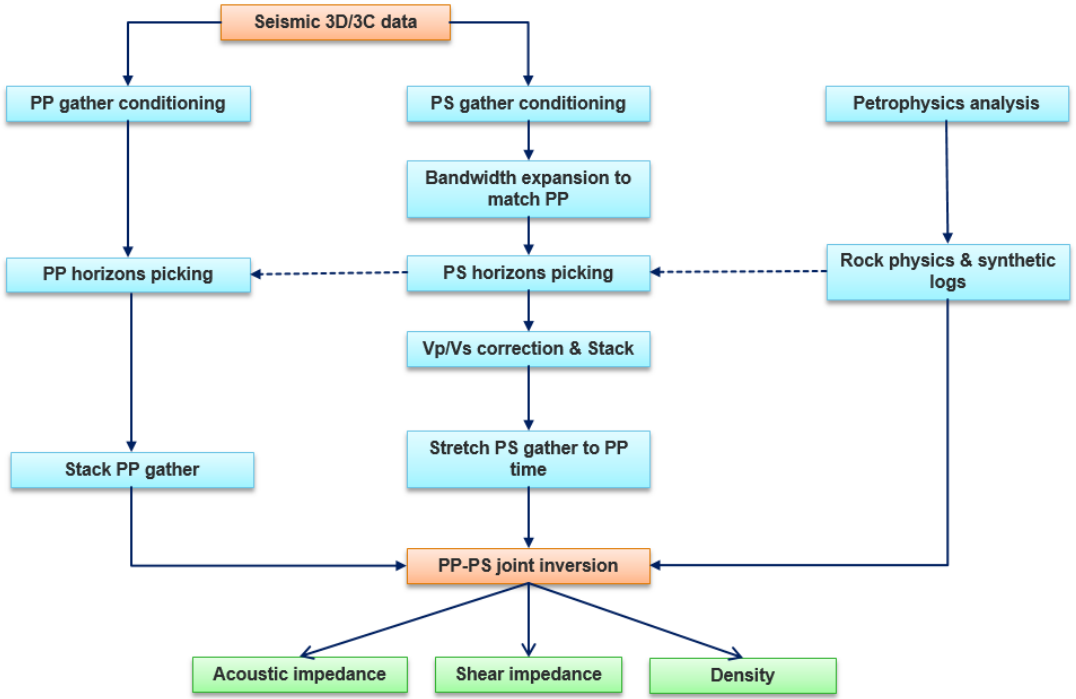
What can PS waves be used for?

- Structural image
- Rock properties
- Fracture detection



Robert R. Stewart “Application and Interpretation of Converted-waves” Class

Workflow Diagram of a PP-PS Joint Inversion



Inversion Processes

Major steps of the project included:

Evaluate the quality of PP and PS stack data including frequency contents and correlation of events between PP and PS data

Condition PP and PS azimuthal gathers to improve the data quality with reference to the synthetic PP and PS gather of well data

PP-PS joint inversion and PP-only simultaneous inversion

Data Preparation Steps

PP and PS data are high quality with comparable frequencies

The polarity convention for PS during this study is that an increase in PS impedance (at 25 degree) is represented by a peak (PS interpretation polarity)

Bandwidth matching filter was applied to match the frequency spectrum of PS and PP

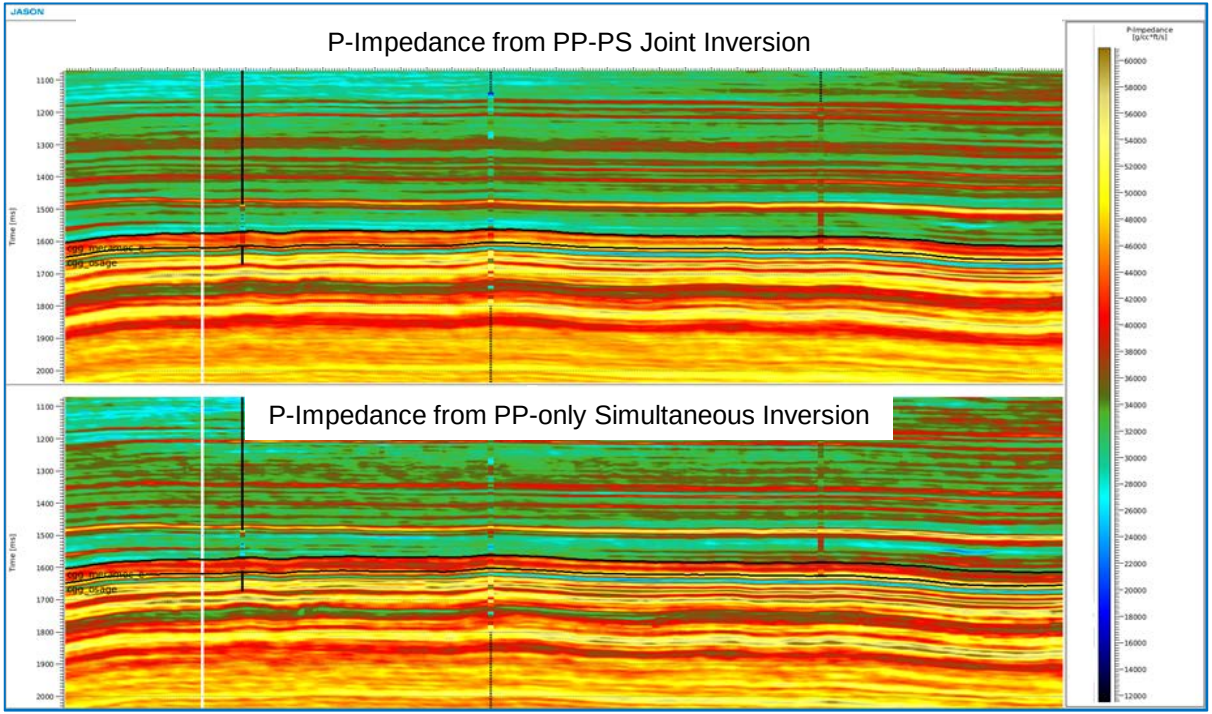
Major horizons have been picked in both PP and PS data

Registration from PS to PP time

Trim statics was applied for all azimuths per single offset stack (6 for PP and 12 for PS)

Noise attenuation was applied to reduce linear noise, PP and PS multiples

P-Impedance vs. Well Logs



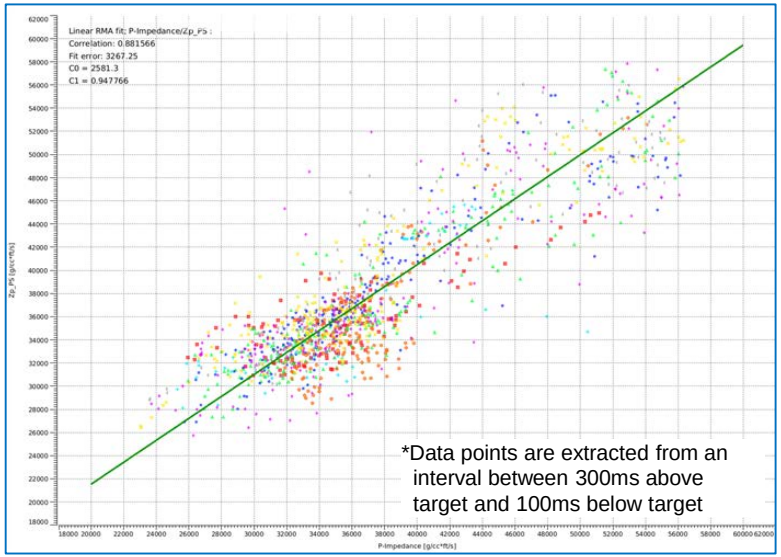
Good tie between well logs and shear impedance volumes

Similar results from the PP-PS joint inversion & PP volumes

P-Impedance vs. Well Logs

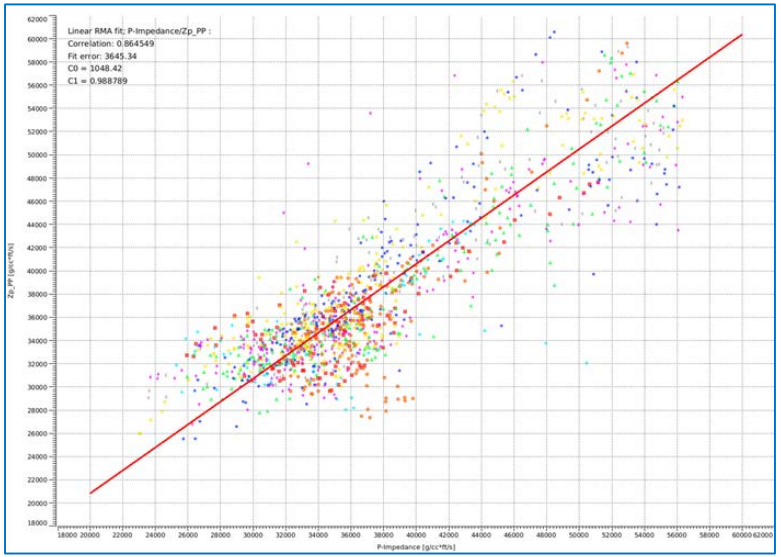
~2% Uplift From PP-PS Joint Inversion

P-Impedance of PP-PS joint inversion vs. well logs



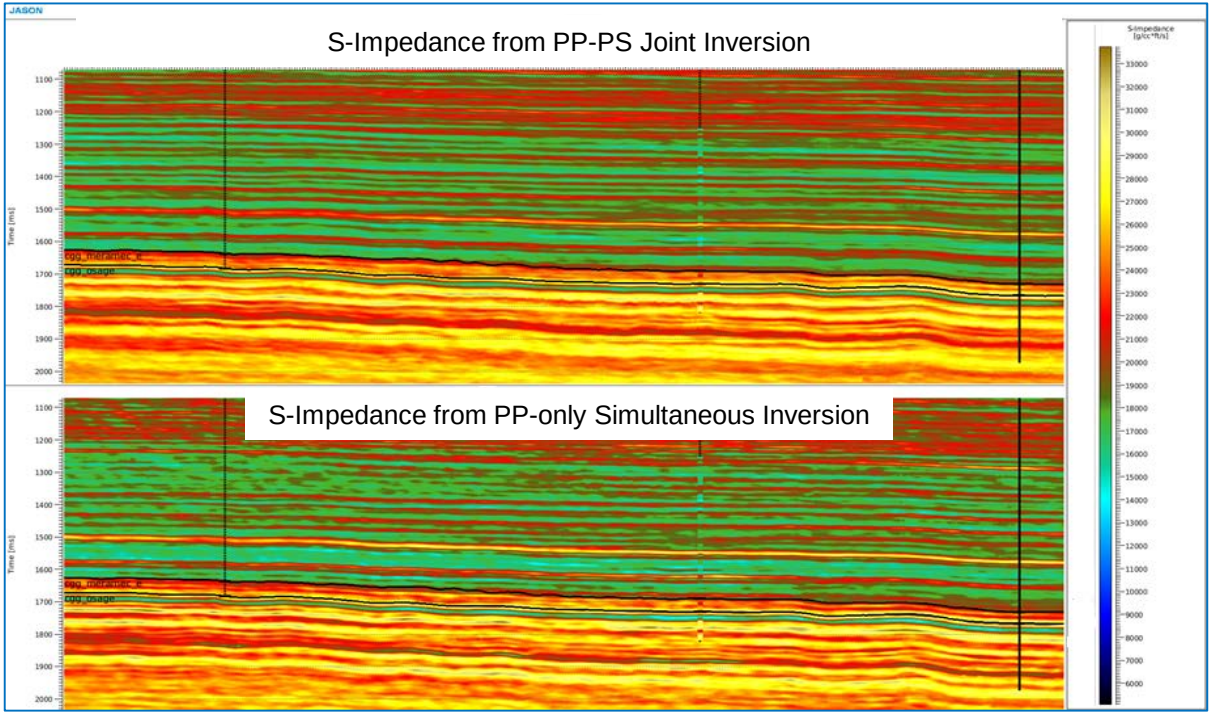
Cross correlation coefficient= 0.882

P-Impedance of PP simultaneous inversion vs. well logs



Cross correlation coefficient= 0.865

S-Impedance vs. Well Logs



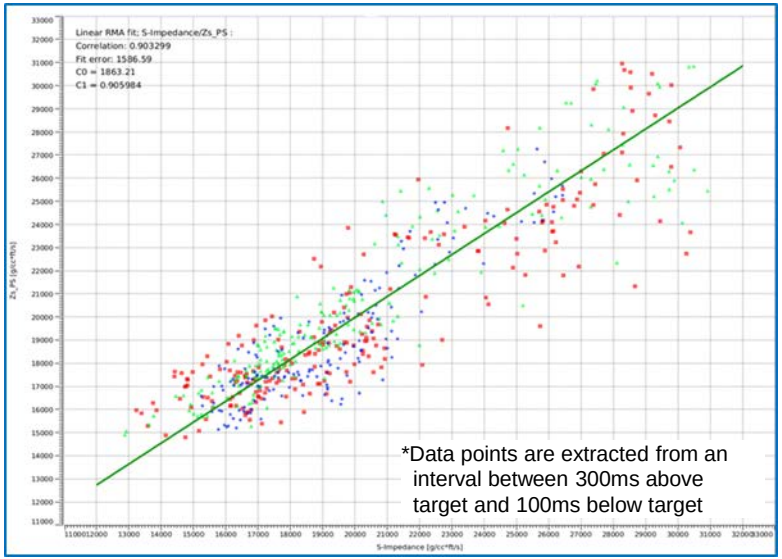
Good tie between well logs and shear impedance volumes

Better tie with the PP-PS joint inversion volume

S-Impedance vs. Well Logs

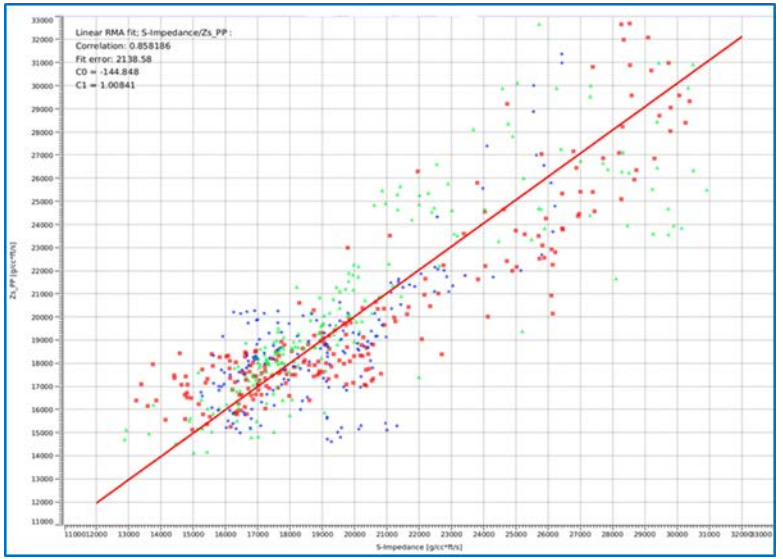
~6% Uplift From PP-PS Joint Inversion

S-Impedance of PP-PS joint inversion vs. well logs



Cross correlation coefficient= 0.903

S-Impedance of PP simultaneous inversion vs. well logs

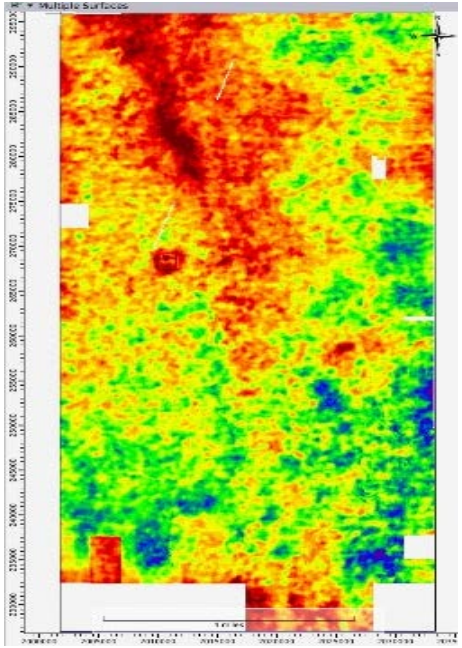


Cross correlation coefficient= 0.858

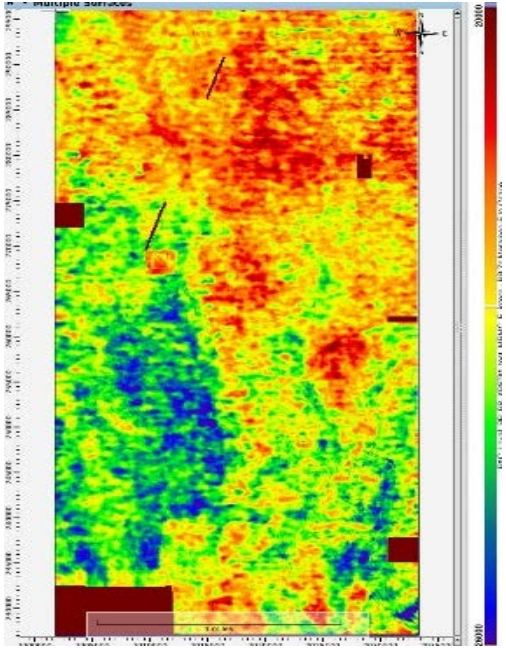
S-Impedance vs. Well Logs

~6% Uplift From PP-PS Joint Inversion

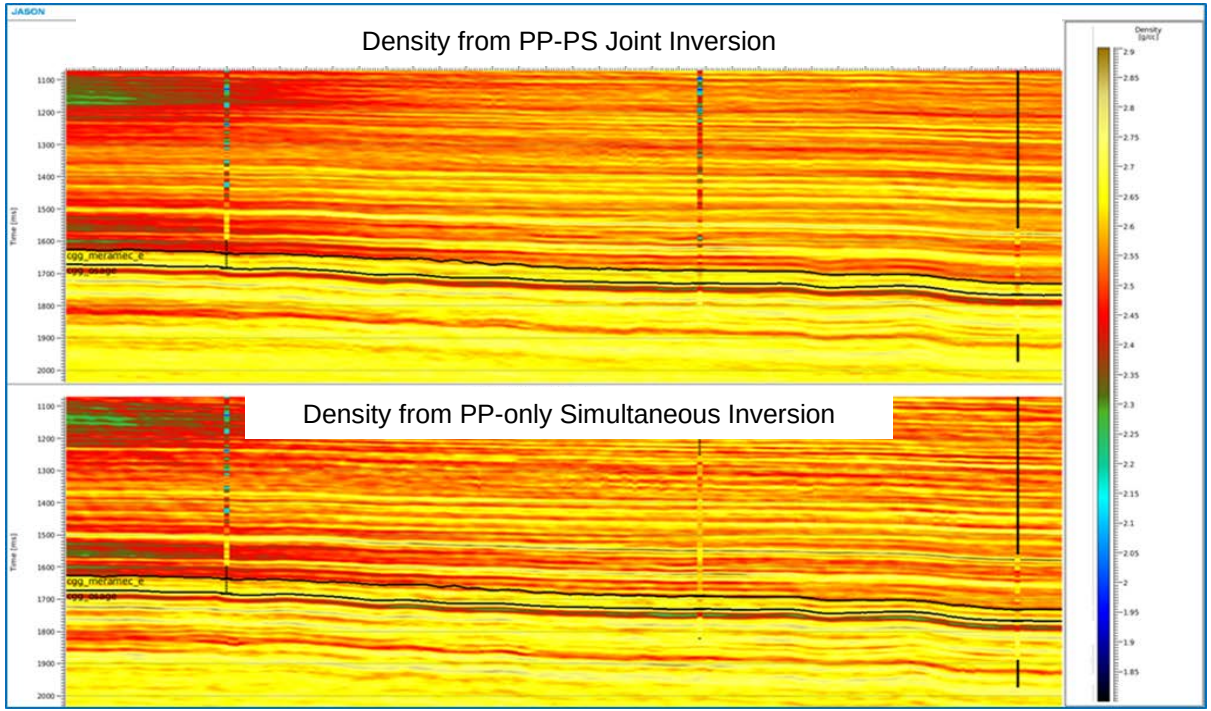
PP-PS Joint Inversion



PP Inversion



Density vs. Well Logs



Both inversions show density estimates from seismic do not match well logs in areas

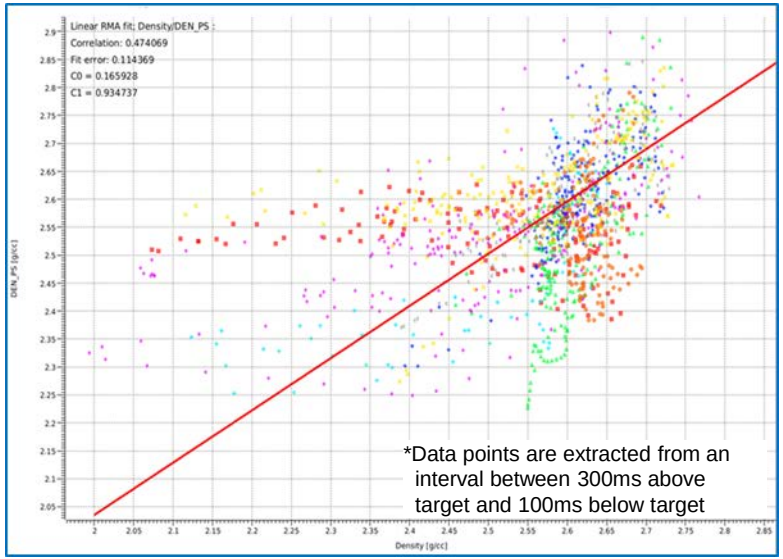
Predicting well log densities from seismic typically difficult

- Need large angles and low noise data

Density vs. Well Logs

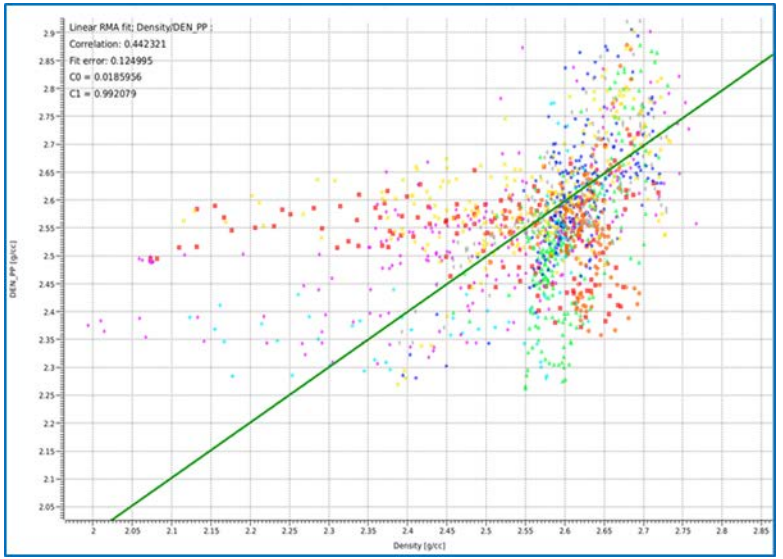
~7% Uplift From PP-PS Joint Inversion

Density of PP-PS joint inversion vs. well logs



Cross correlation coefficient= 0.474

Density of PP simultaneous inversion vs. well logs

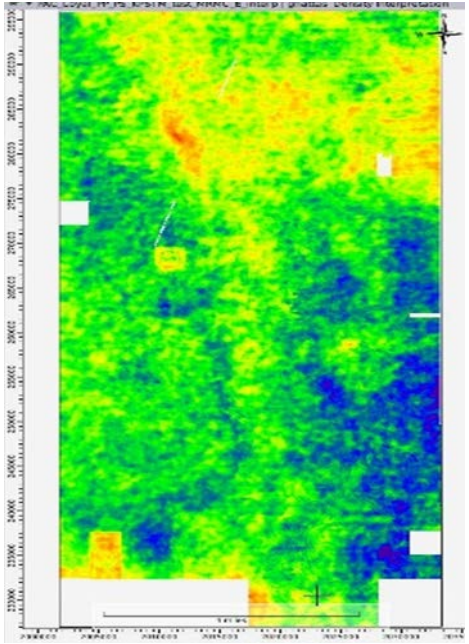


Cross correlation coefficient= 0.442

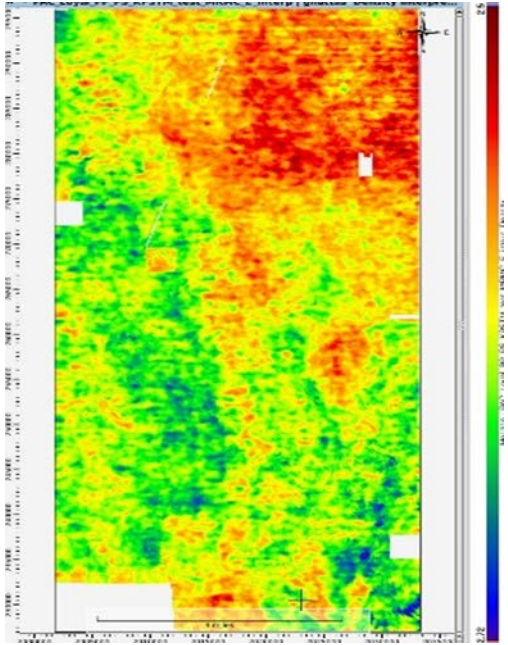
Average Density – Target

Significant Variability

PP-PS Joint Inversion



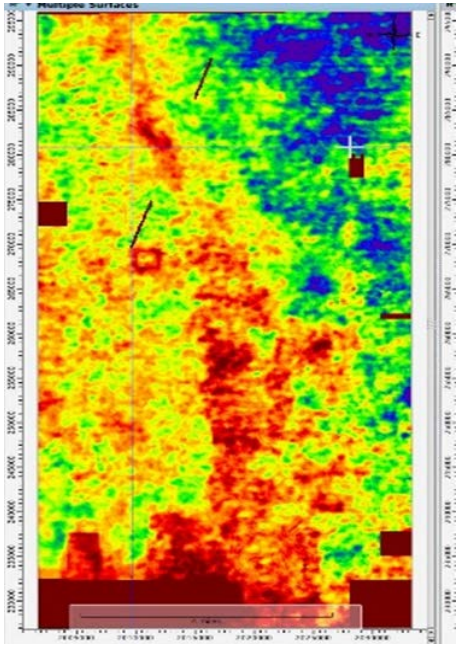
PP Inversion



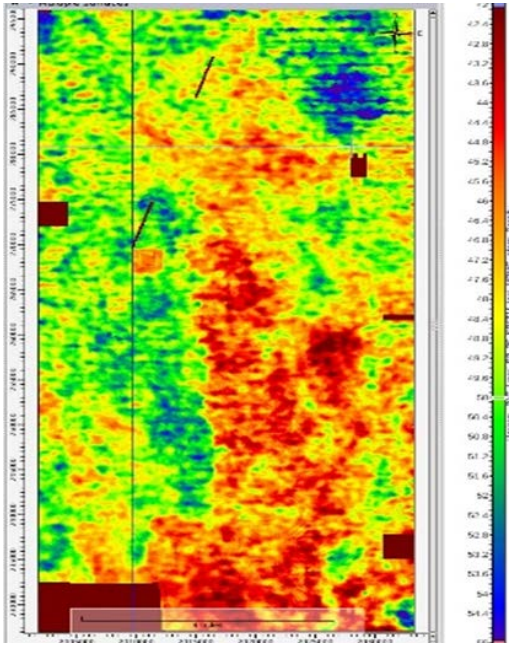
Young's Modulus – Target

Joint Inversion Fits Depositional Trends

PP-PS Joint Inversion



PP Inversion



Summary

Technical

Acquiring multicomponent seismic data allows you to measure rather than estimate shear wave properties

PP-PS joint inversion shows higher lateral consistency compared to PP-only simultaneous inversion – Fits with geologic model

Rock mechanics estimates show higher correlation coefficients when utilizing PS data in the inversion

Summary

Business Drivers

Improved geomechanical properties utilized in completions program

Better distribution of rock properties away from well control to predict well performance and geologic models

Combining PP-PS joint inversion with shear wave splitting results can predict natural fracture orientations and densities along with rock matrix properties

Potential Future Work

Continue building processes to make multicomponent data more cost effective

Acknowledgements

TGS

CGG

Marathon Oil


THANK YOU
Marathon Oil

Q&A

Marathon Oil