Discriminating Gas Bearing Sands from Shale Using Rock Physics Guided Inversion*

Ahmed W. Daghistani[1], Aiman M. Bakhorji[2], and Husam M. Al-Mustafa[2]

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Abstract

Seismic properties such as compressional and shear wave velocities, bulk density, impedance, and Vp/Vs ratio are key elements in seismic reservoir characterization. It is very important to understand the physical link between seismic properties and reservoir properties (e.g., lithology, porosity, pore type, clay content, fluid type, and saturation), and rock physics provides such a link. Rock physics, along with the inverted seismic data, can be used to detect the presence of hydrocarbon bearing rocks and forecast their performance during production. Rock physics models and template can be used to predict reservoir properties from the observed seismic properties, to interpret the seismic response away from the well.

This study is carried out over a field in Saudi Arabia that has a gas bearing clastic reservoir that ranges in age from the Late to Middle Triassic. Two wells "A" and "B" have been drilled targeting this reservoir. Well "A" has an average porosity greater than 10% and produced gas; whereas the equivalent formation in well "B" proved to be tight shale with an average porosity of approximately 1%. The main objective of the study was to predict the gas bearing sands using seismic inversion with the help of rock physics.

A feasibility study was conducted to determine the type of seismic attributes that would be suitable for discriminating between gas bearing sands and wet shale. Rock physics cross-plots between various elastic moduli showed that the Vp/Vs ratio versus acoustic impedance (AI) plane showed the best discrimination between the two lithofacies. Moreover, AVO analysis suggested that the gas bearing sand in well "A" exhibits a class 4 AVO response. The tight shale in well "B" shows a class 1 AVO response. These observations indicated that pre-stack inversion and AVO analysis must be jointly conducted to predict changes in lithofacies from the seismic data between the two wells. The elastic properties inverted from seismic data were interpreted using the modeled rock physics template, which in turn was used to predict the lithology and fluid saturation between the two wells.

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Saudi Aramco

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March, 2012

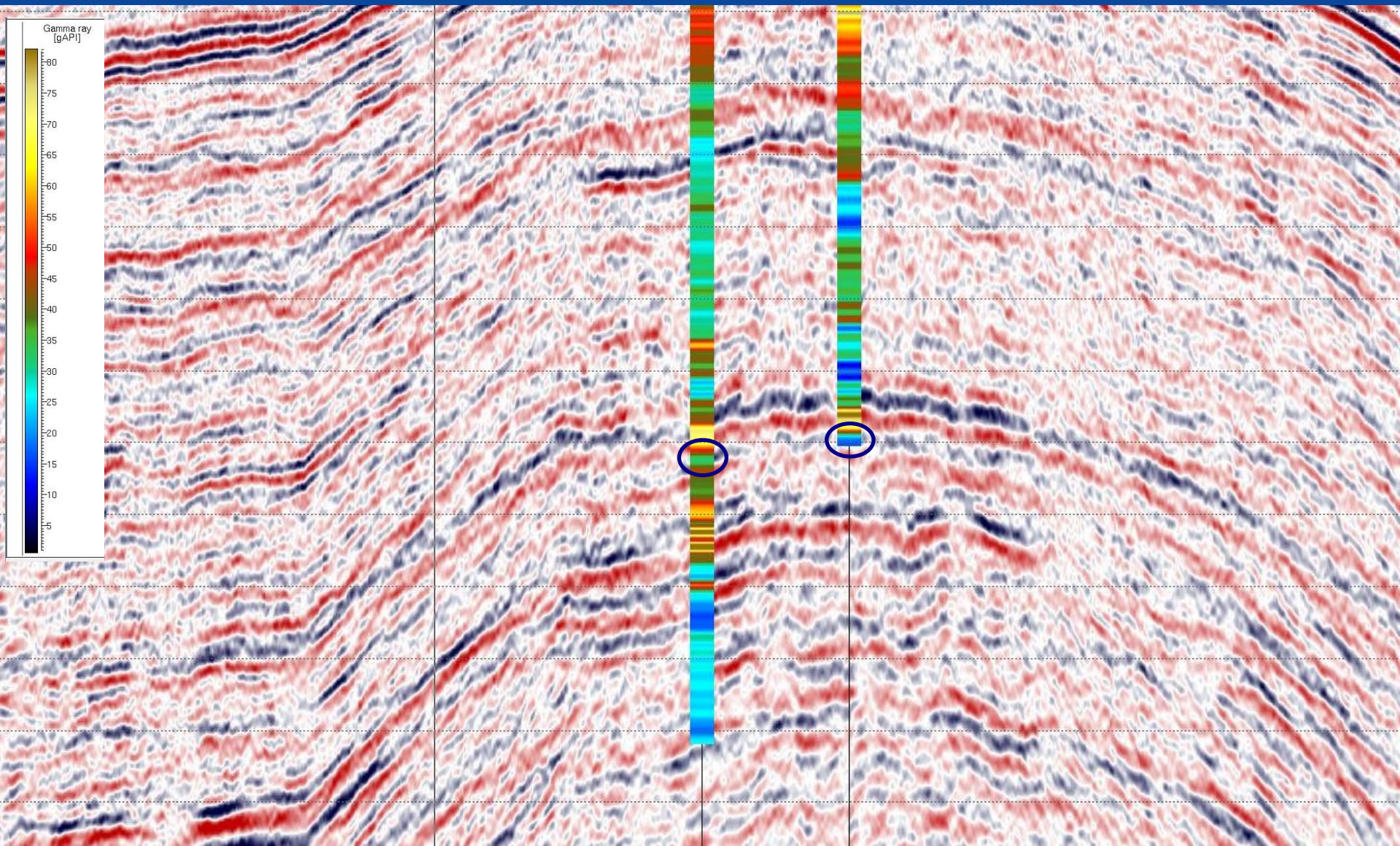
Outline

- Objective
- Rock physics role in seismic interpretation
- Rock physics feasibility analysis
- AVA analysis
- Inversion results
- Conclusion

Objective

The objective of this study is to discriminate between shale and sand using rock physics multi-attribute approach.

Objective


Well#1
Well#2
Gamma ray
[gAPI]
80
75
70
65
60
55
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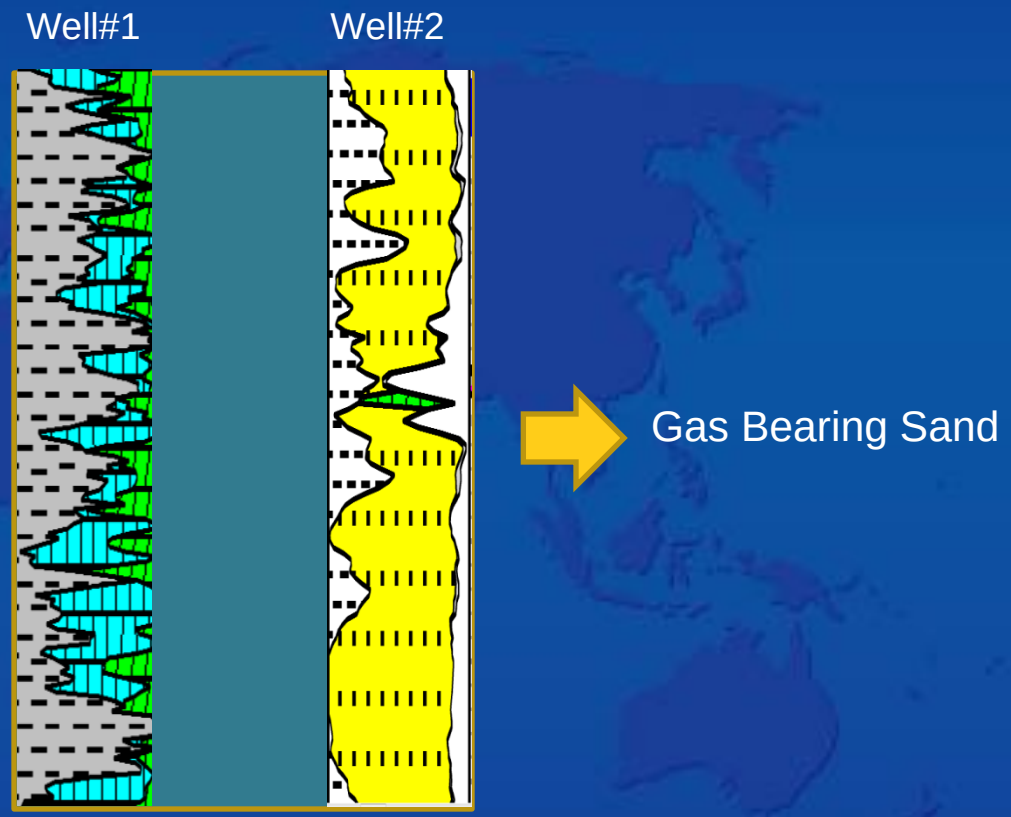
5

Objective

- **Well #1** is tight shale with some carbonate. This well has been drilled with no production.

- **Well #2** is Gas-bearing sand. It has produced gas.



Legend

Limestone
Shale
Dolomite
Sandstone

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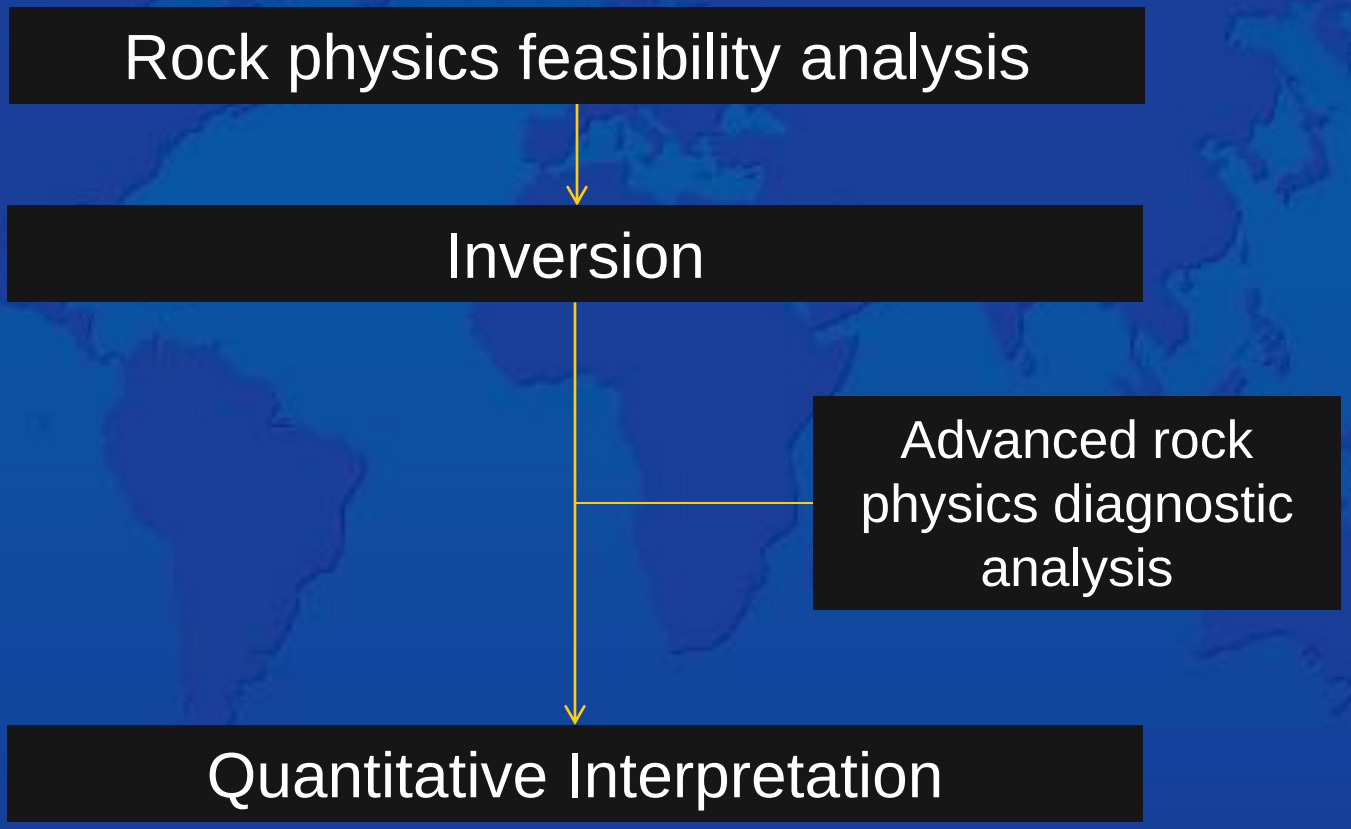
Rock physics role in seismic interpretation



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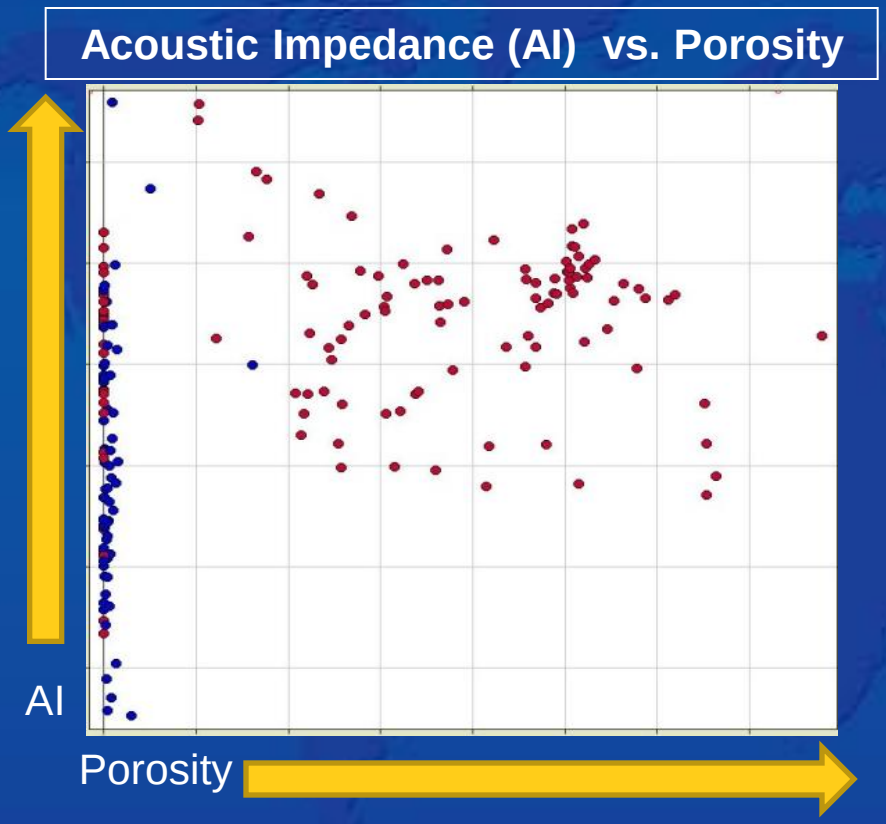
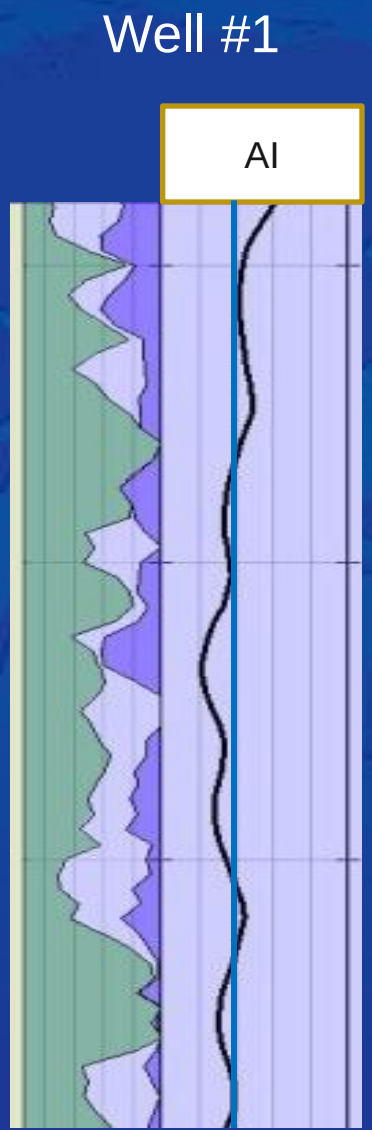
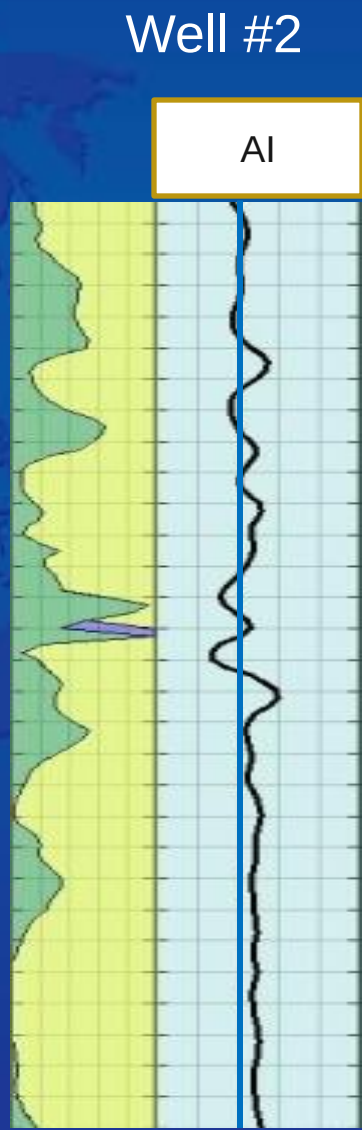
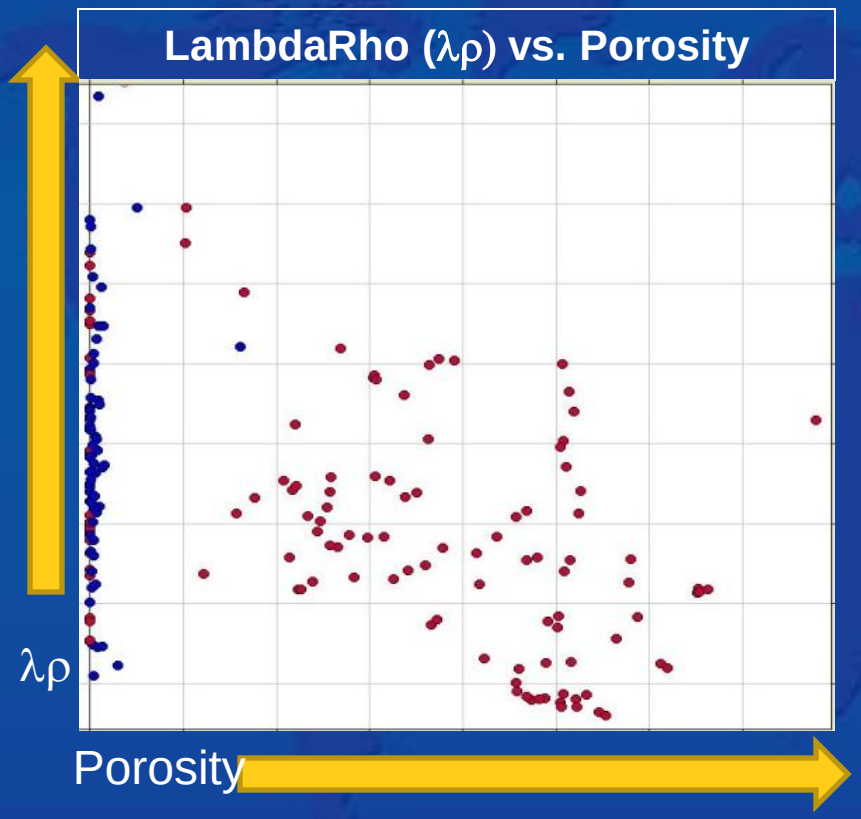
Rock physics feasibility analysis





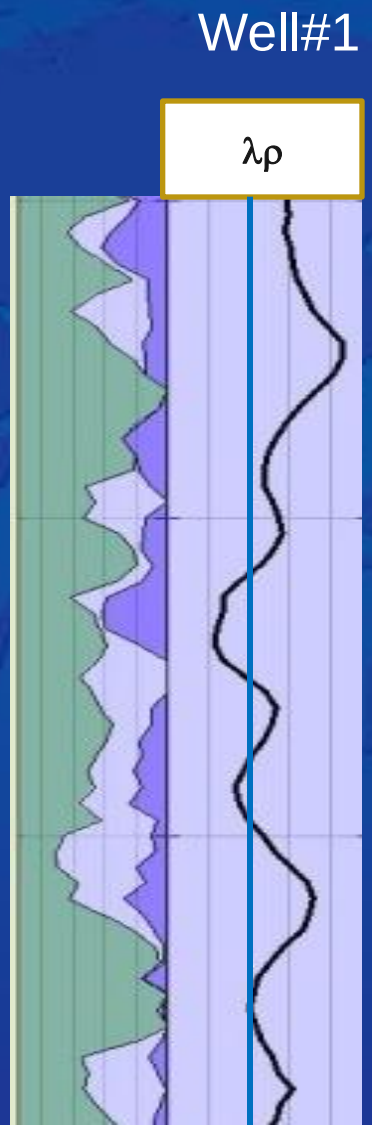


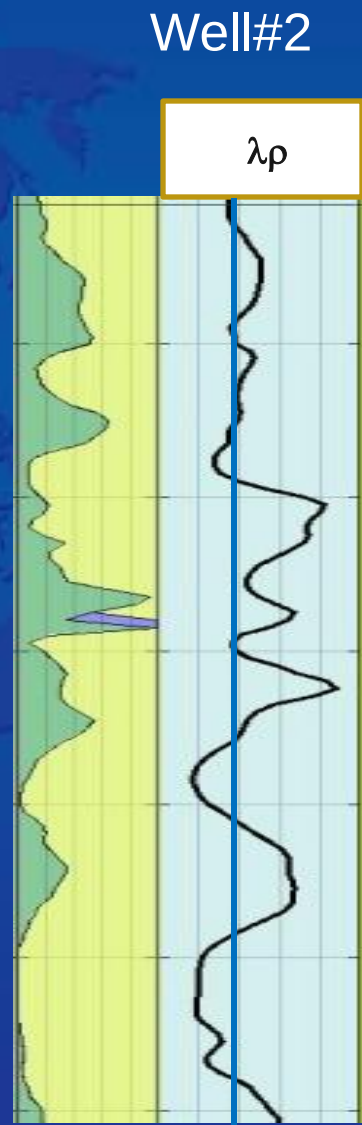
Rock physics feasibility analysis



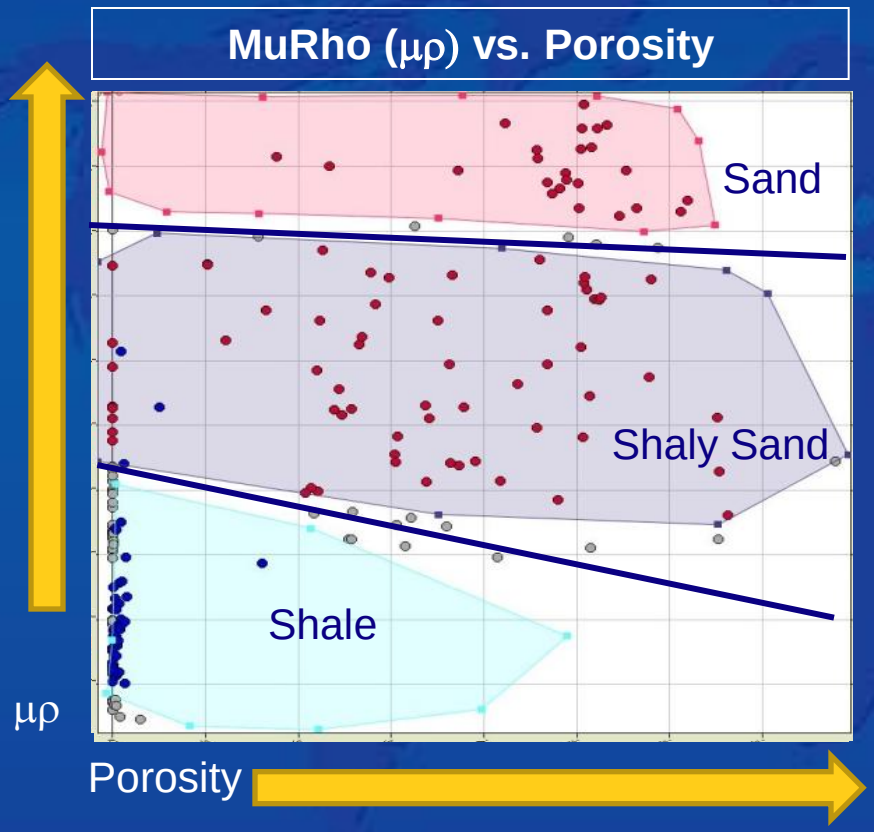
Well # 1

Well # 2



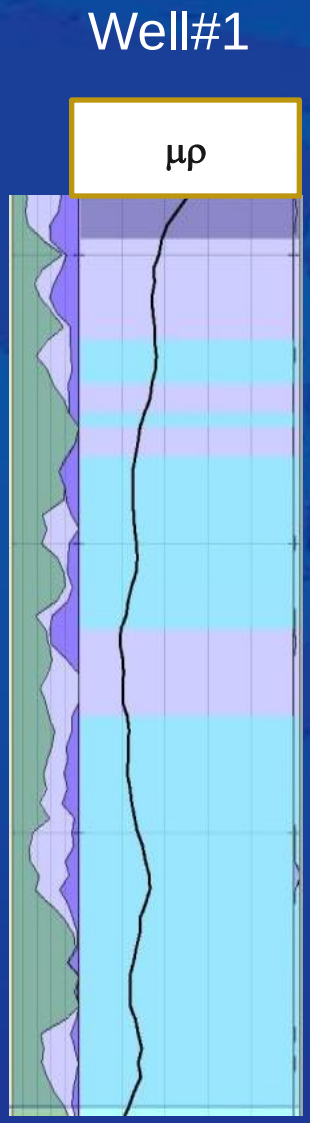


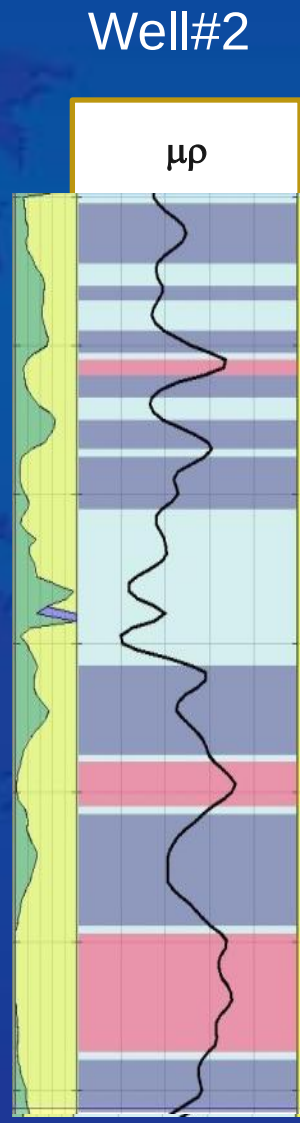
Rock physics feasibility analysis



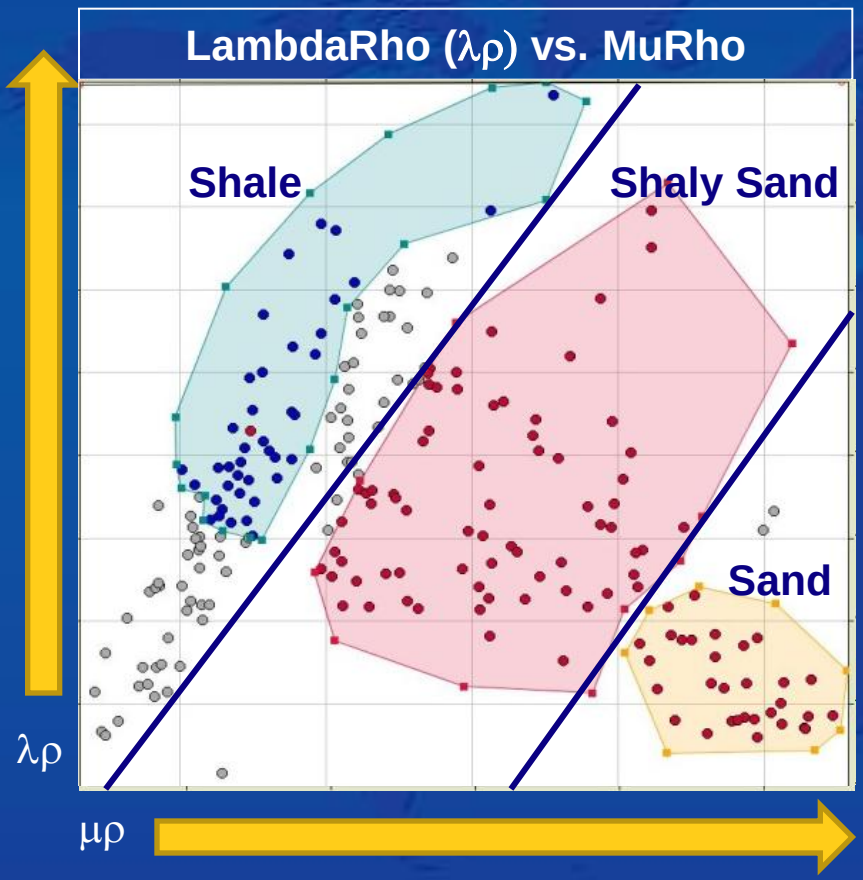
Well # 1

Well # 2



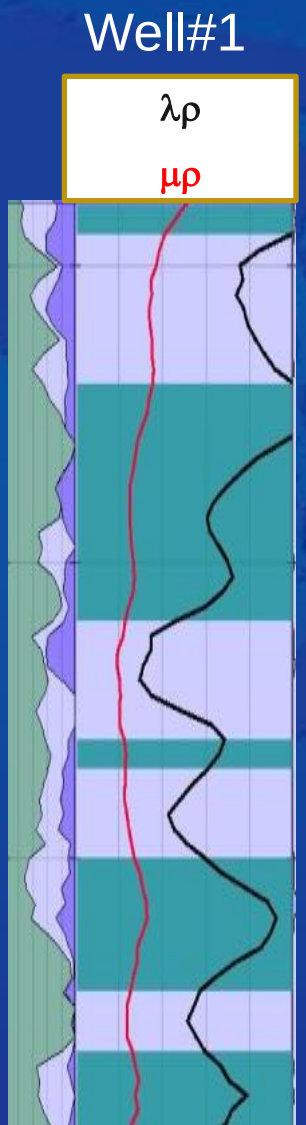


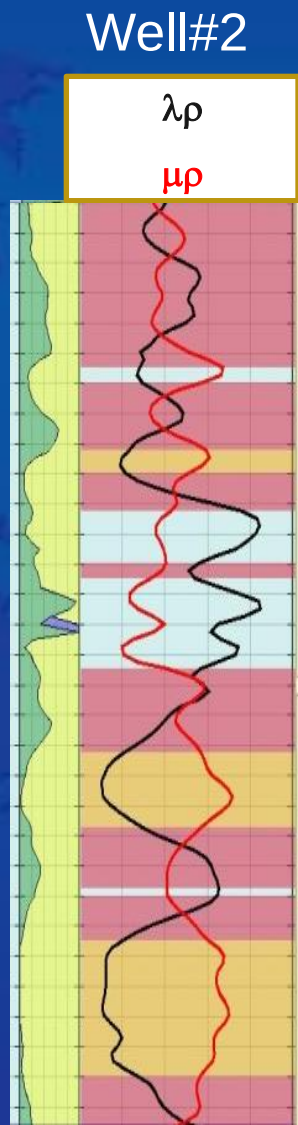
Rock physics feasibility analysis



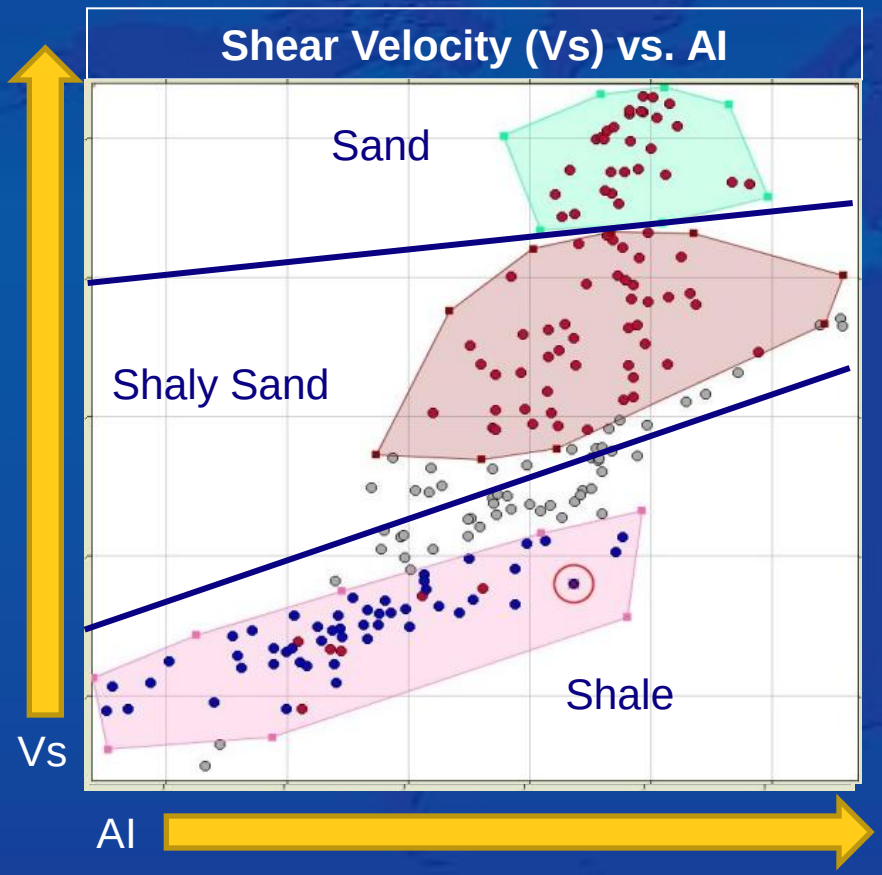
Well # 1

Well # 2





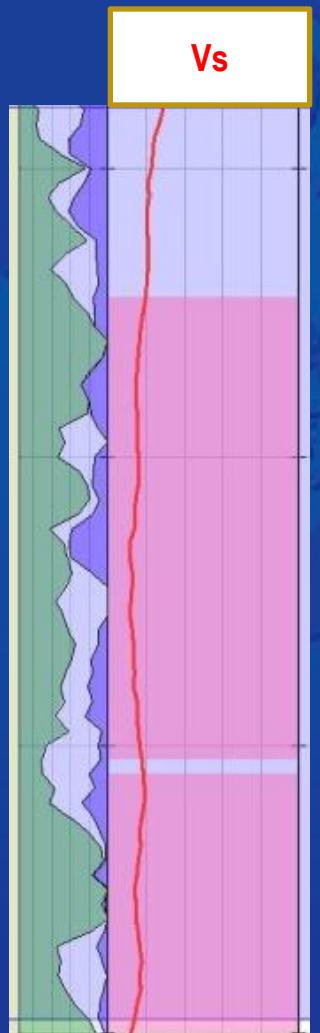
Rock physics feasibility analysis



Well # 1

Well # 2

Well#1



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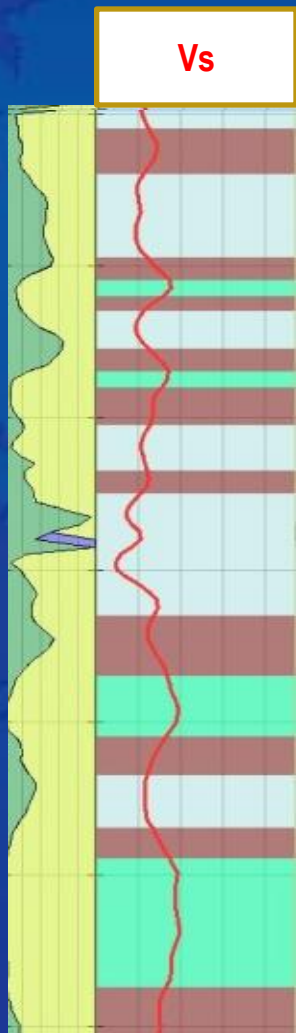
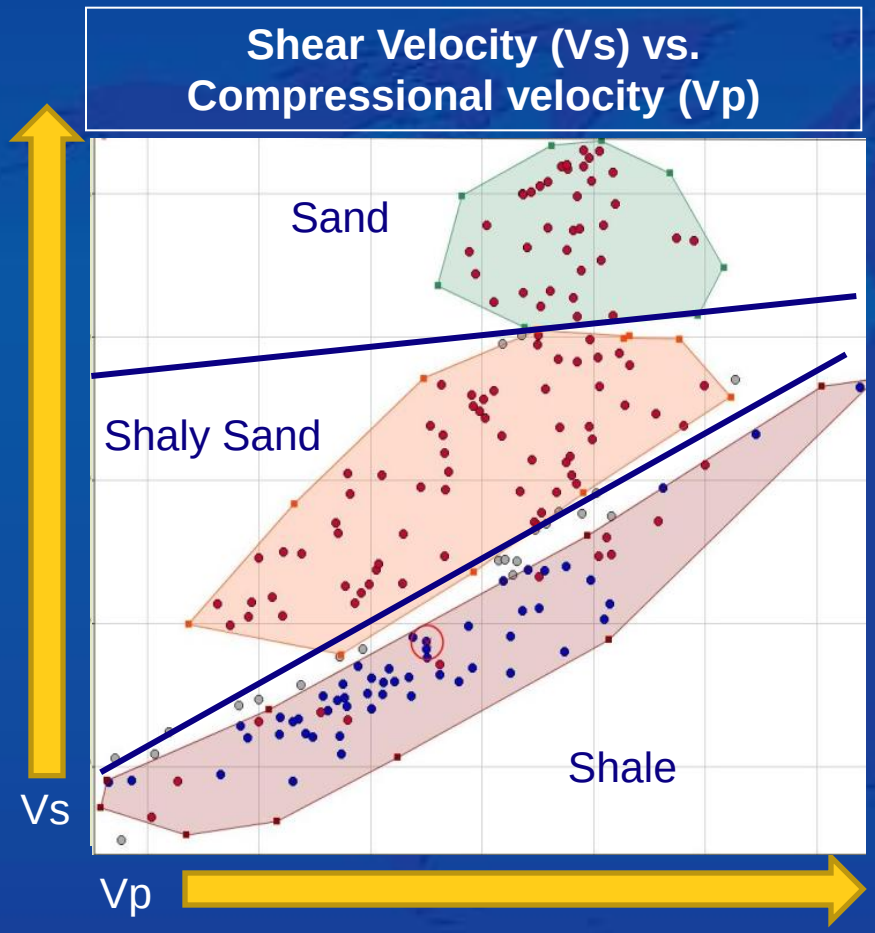
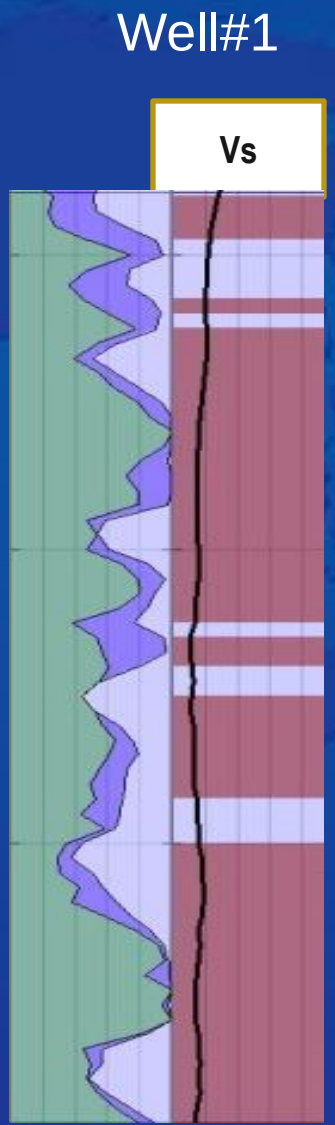
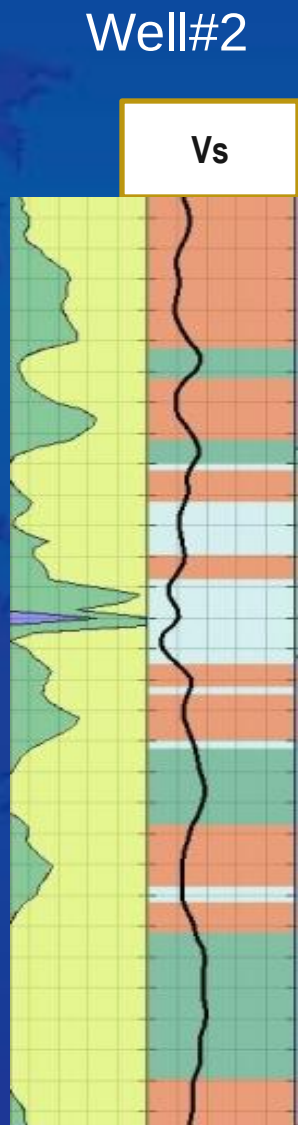


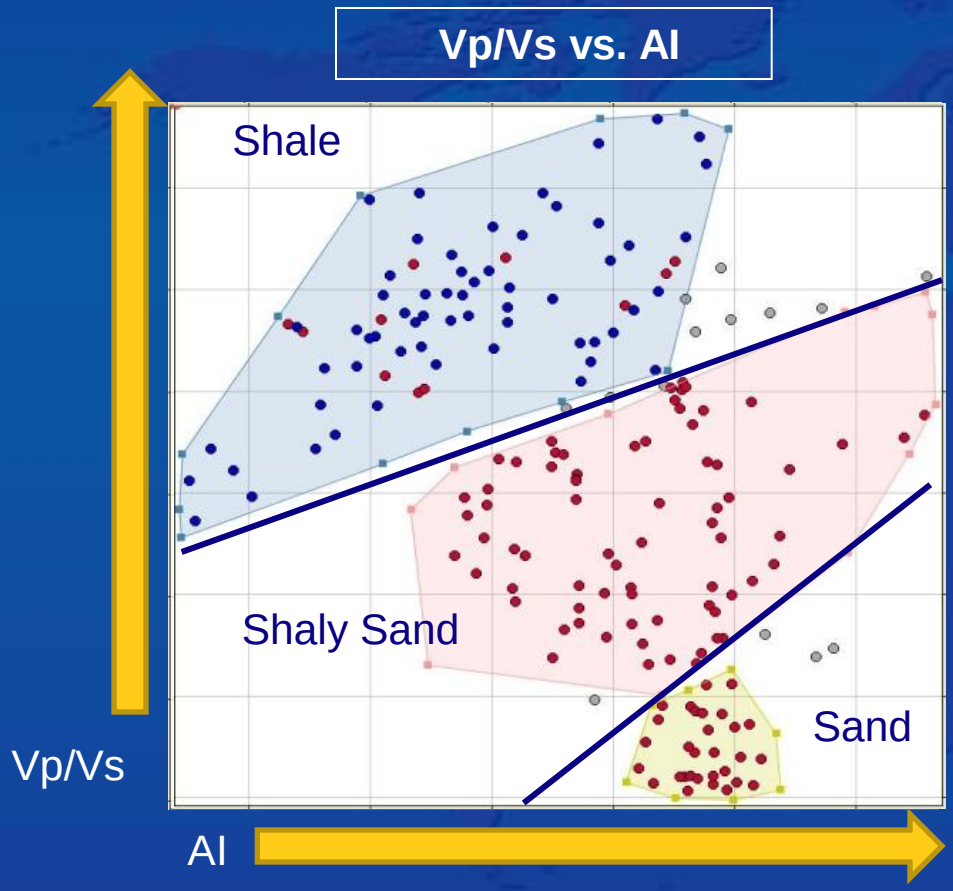
Rock physics feasibility analysis

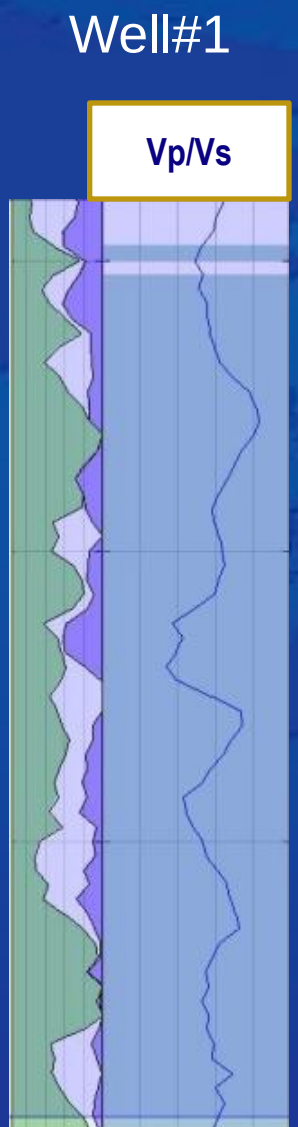


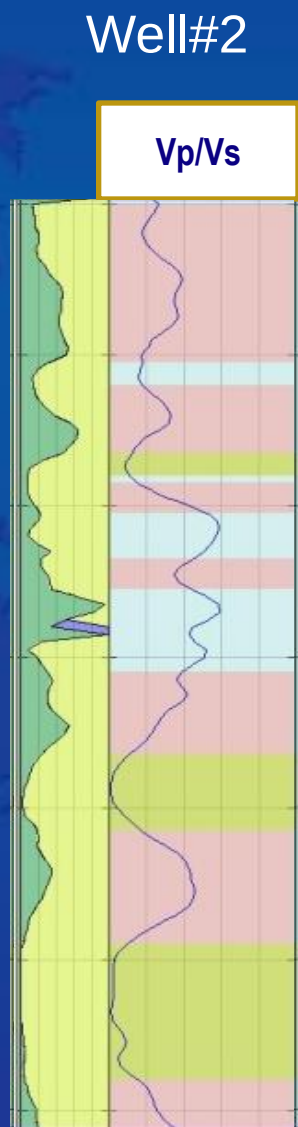




Rock physics feasibility analysis







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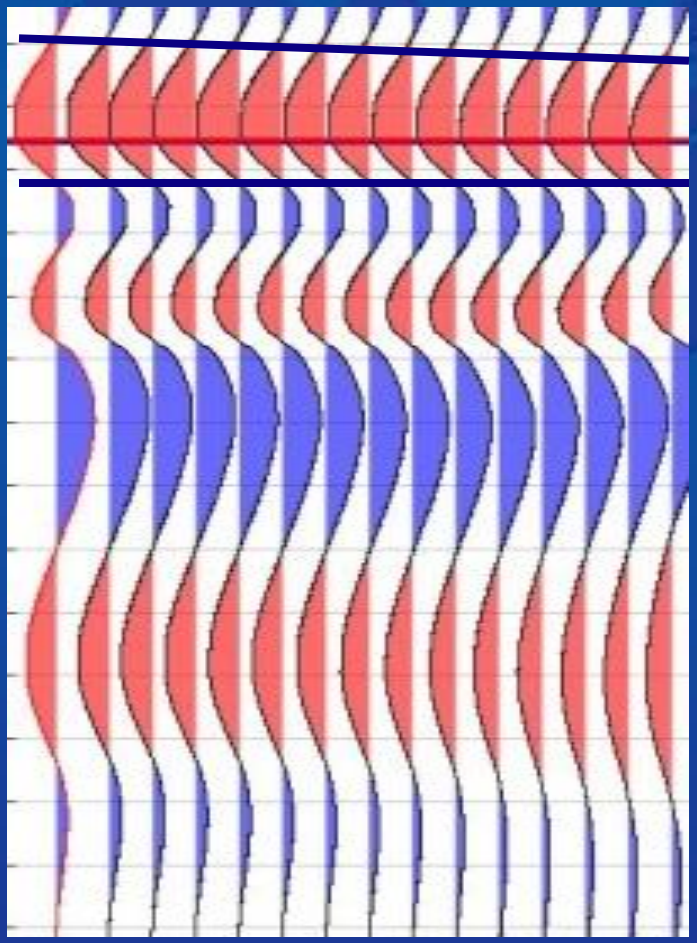
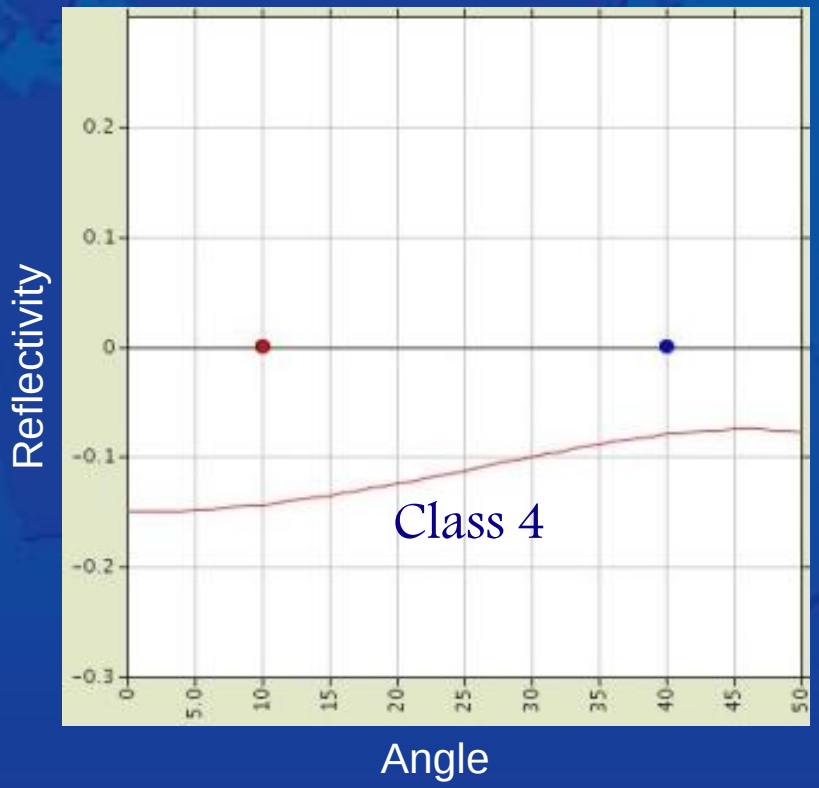
AVA analysis

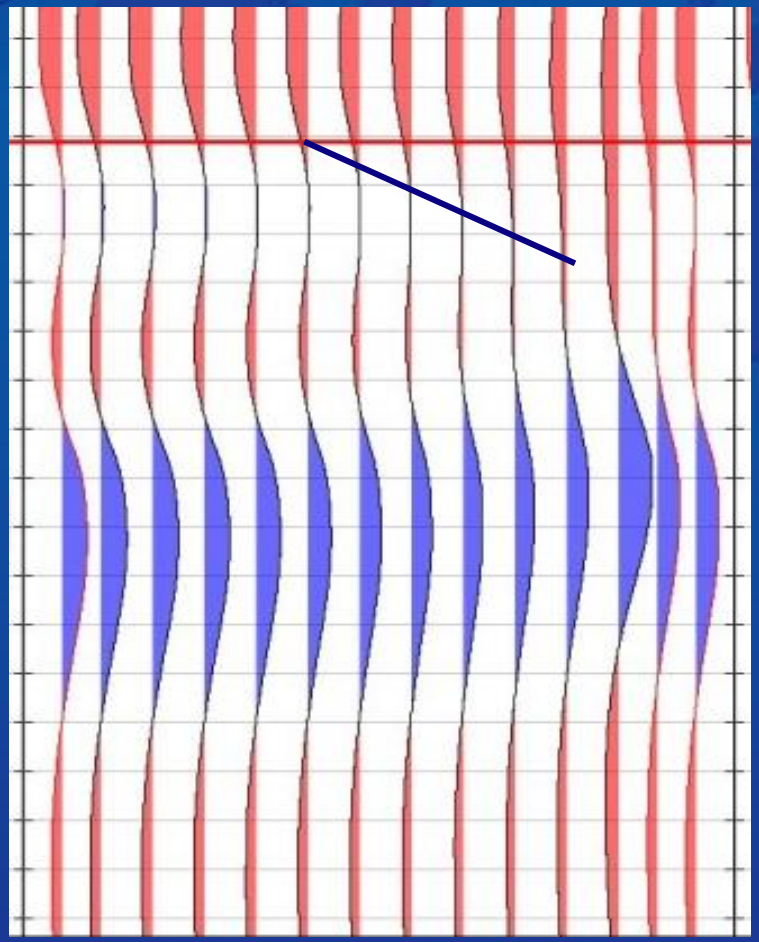
CDP Gather: Well # 1

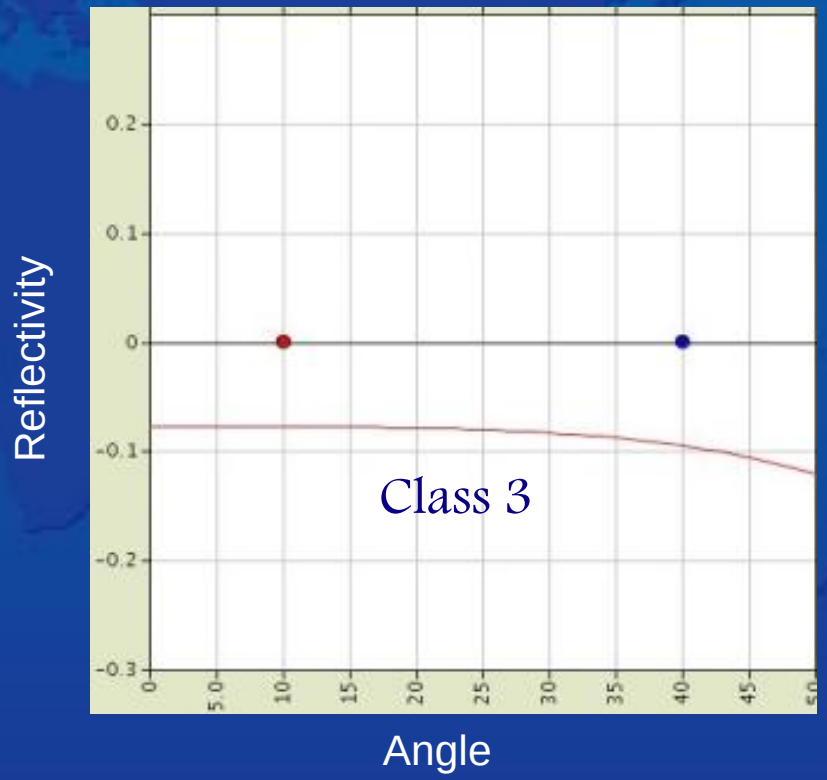




AVA analysis

CDP Gather: Well # 2





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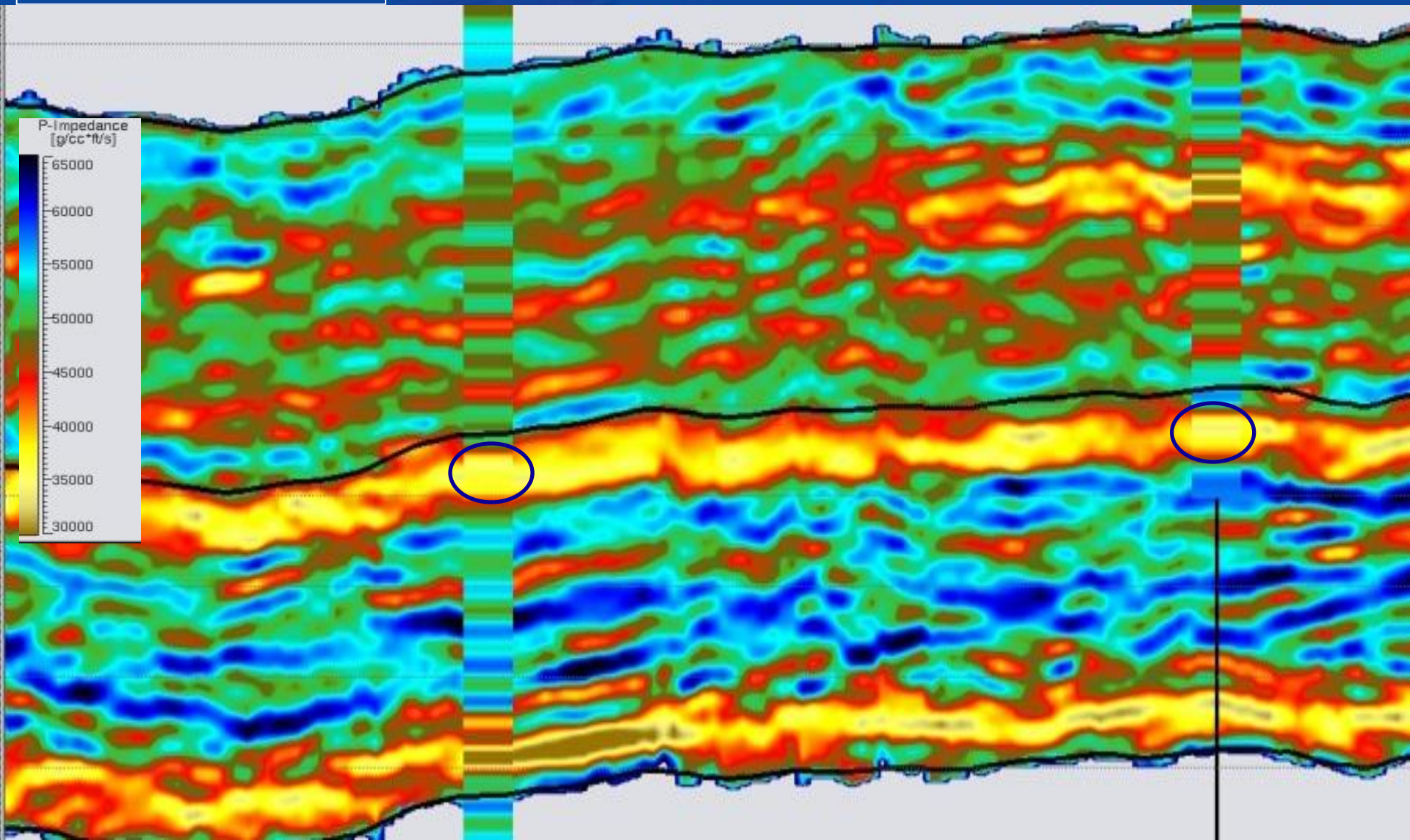
Inversion results

Inverted Impedance

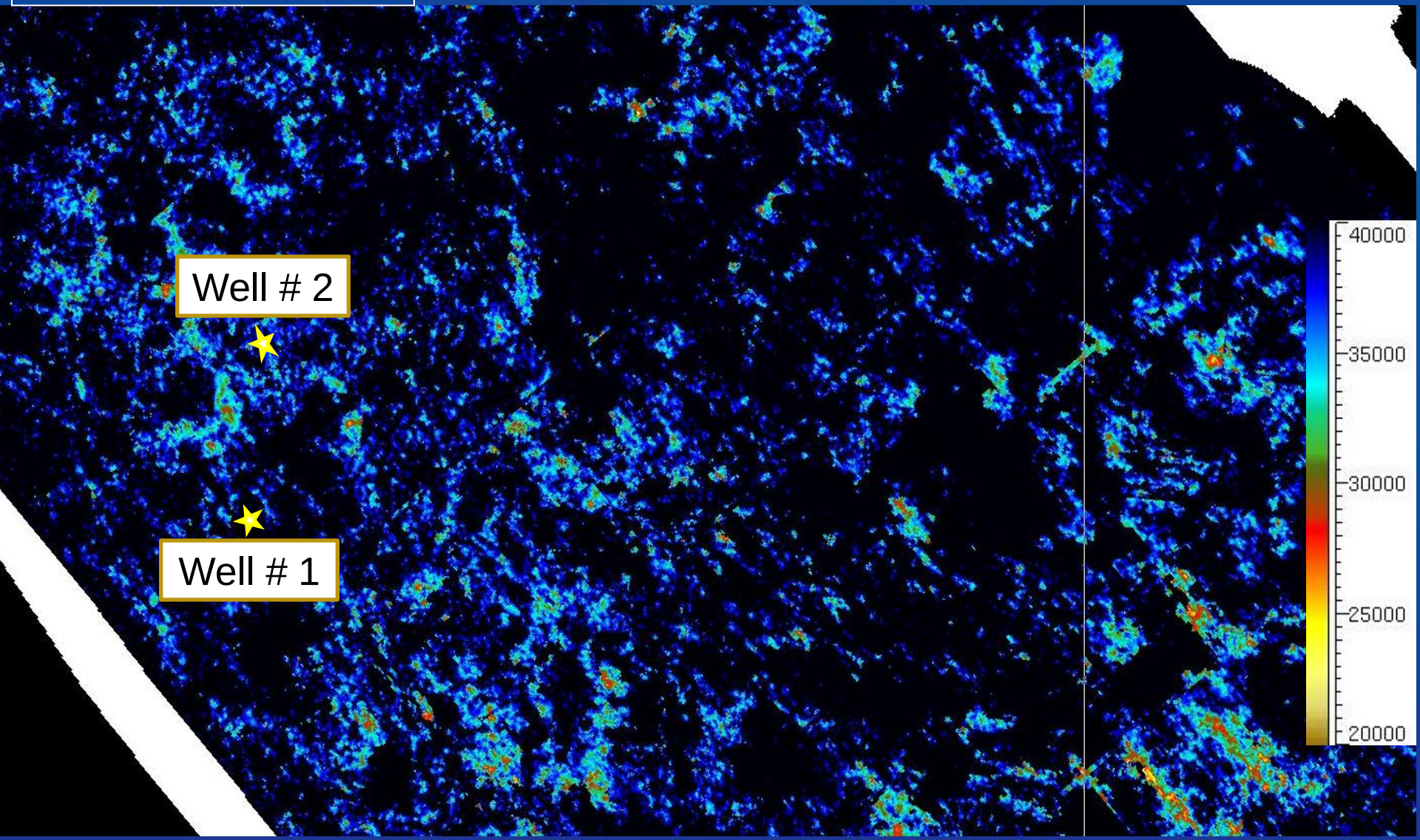
Well #1

Well #2

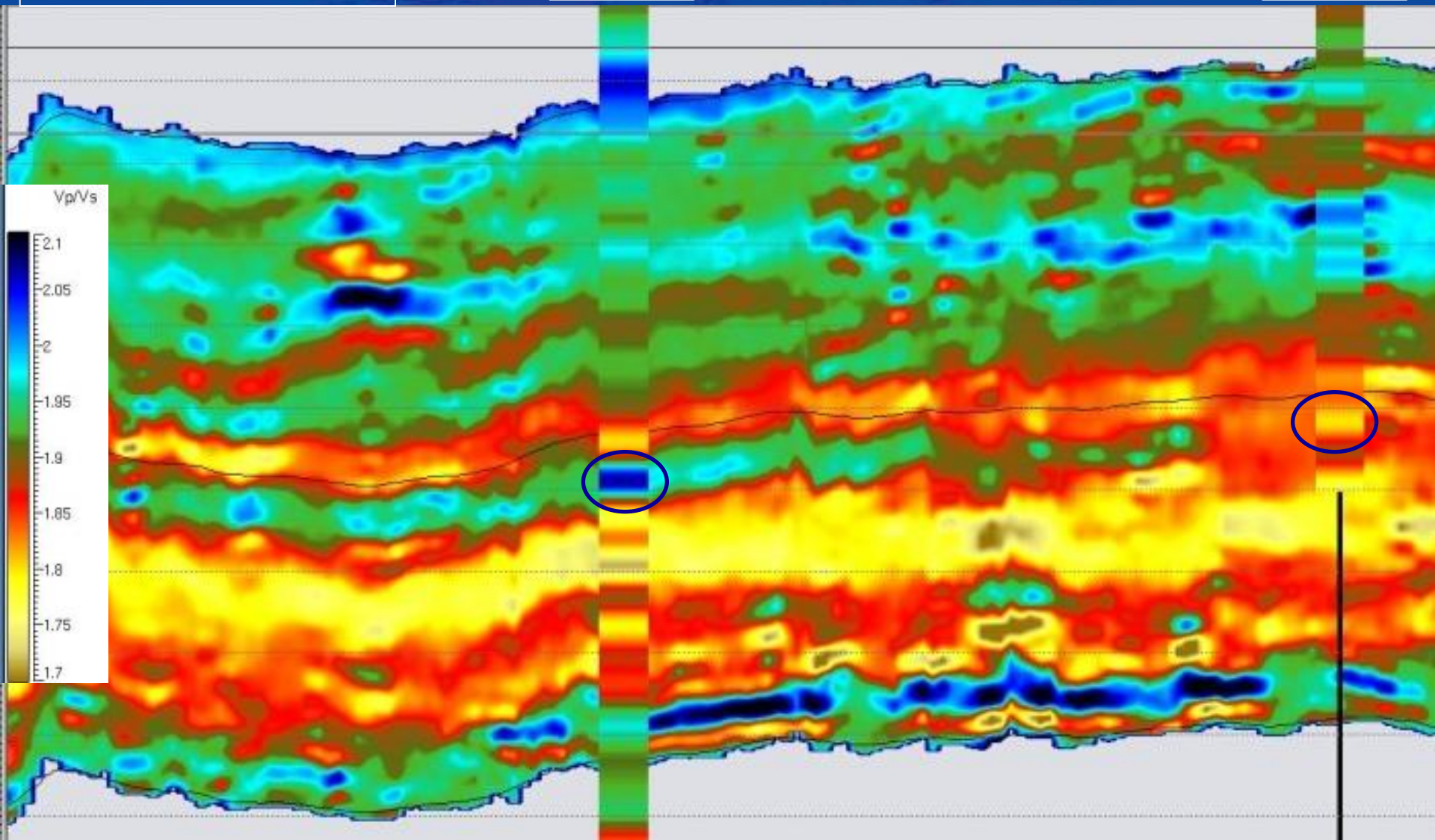


Inversion results

Impedance Time slice

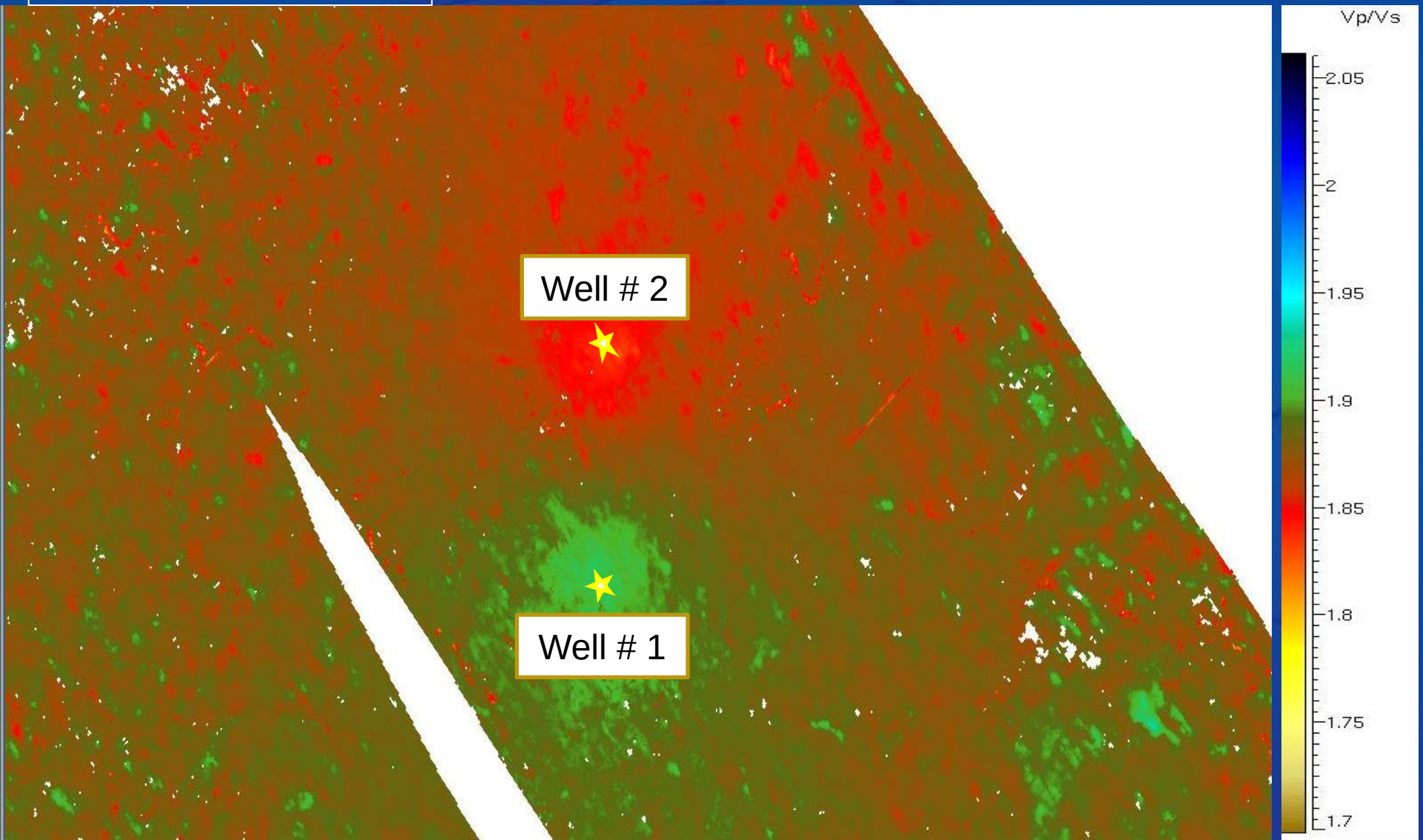


Inversion results

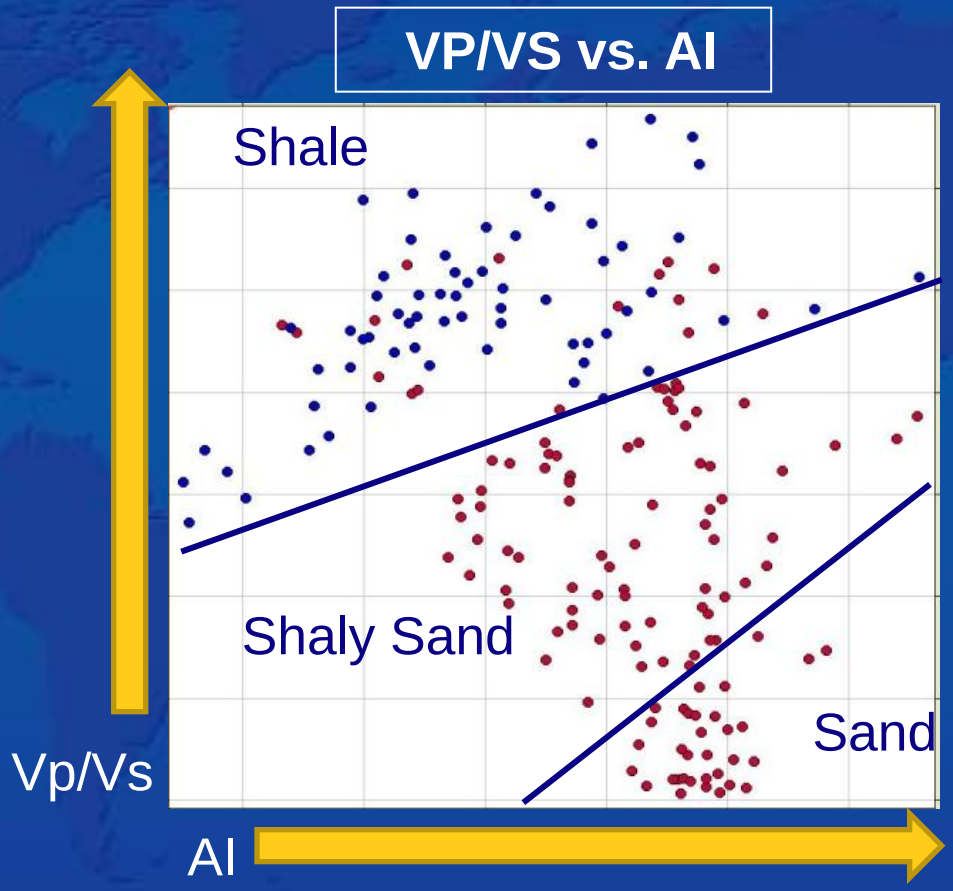


Inversion results

Vp/Vs Time slice

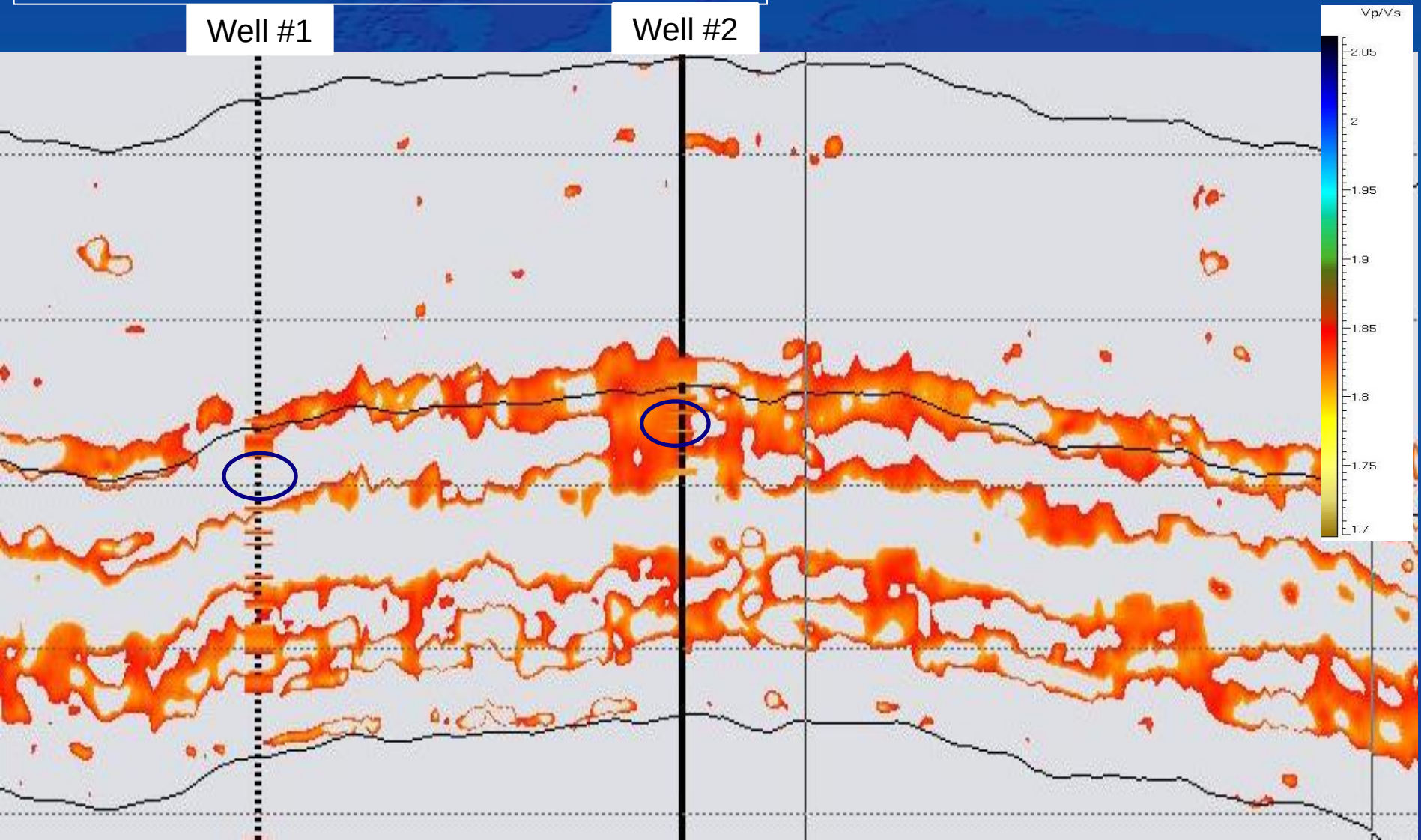


Inversion results



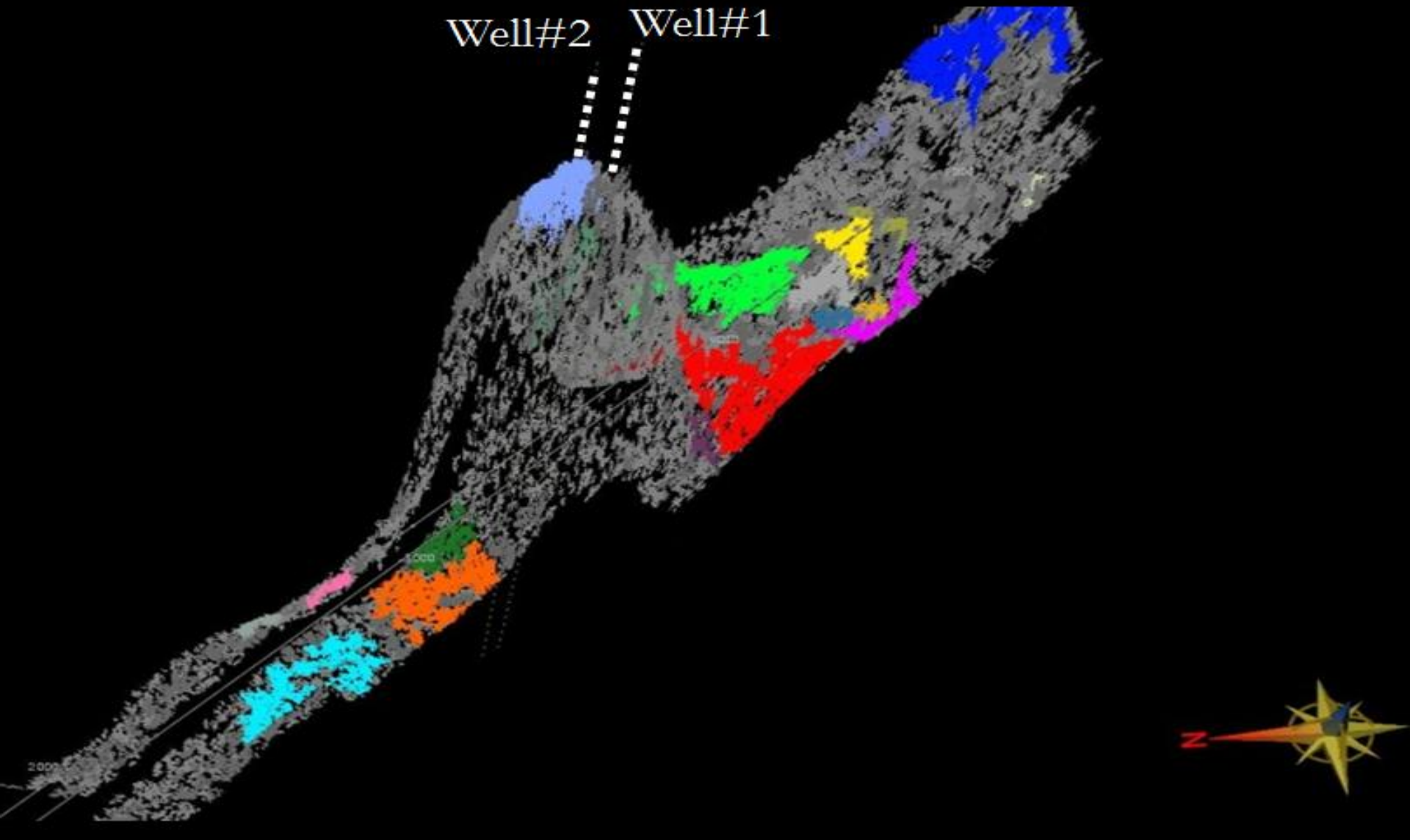
Inversion results

Inverted Vp/Vs: Highlighted Sand



Inversion results

Geobodies



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Conclusion

- Rock physics feasibility study helps in indicating whether separation of the desired lithology can be achieved with P-impedance alone or whether S-impedance is also required
- Rock physics guided inversion helps in predicting sand bodies
- Using multi-attribute technique shows promising results in identifying lithology changes
- Simultaneous inversion products are quantitatively integrated with rock physics for quantifying the elastic rock properties

Acknowledgement

We would like to thank Saudi Aramco for giving us this opportunity to publish this work in GEO2012.

Thank you