Reservoir Characterization of a Basin Floor Fan System Using Rock Physics to Integrate Seismic Amplitude and Well Data, Offshore Block 9, South Africa*

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Abstract

An extensive technical review in recent years involving well and seismic data on development areas off the southern coast of South Africa has been carried out. The area is covered by the late Jurassic to early Cretaceous fluvial to shallow marine rift fill to a succession of deep marine channel complex drift Albian sequence. The aim of this study is to identify potential infill targets, which will ultimately improve the reservoir sweep efficiency and ultimate recovery.

The focus of this paper is the 14A deposits, described as a third order sequence of Albian age submarine fan complex that includes channel and fan lobe sandstones and overbank fines encased in deep-marine shales. The 14A sand has proved to be the most productive and economic oil play in the basin to date.

The reservoir characterization is executed by integrating seismic amplitude and well data using rock physics modelling to demonstrate the reliability on pre-stack data to resolve hydrocarbon presence. The workflow implemented is based on two phases: (a) A forward model (AVO modelling) to investigate changes in seismic response due to reservoir quality facies (fluid content, porosity, shaliness) away from well control, and (b) to conduct an AVO analysis (I-G attributes cross-plot) to characterize rock properties based on seismic response. This workflow seeks to assist in identifying other hydrocarbon accumulations in the area of interest (upswept or prospective), and to mitigate the uncertainty that affects expected reservoir performance.

The integration process show that AVO modelling is good in discrimination between oil and brine in the reservoir, especially when the porosity is high, because the fluid occupies a higher percentage of the bulk rock.

Similarly, AVO Gradient attribute in the interval of interest shows a strong response that coincide with the discovered hydrocarbon and new potential upswept area or production accumulations. On the other hand, porosity models show a very strong effect on the acoustic impedance

response than fluid. In addition, an increase in clay content leads to an extreme decrease in acoustic impedance and a slight increase in Poisson's ratio.

Selected Reference

Avseth, P., T. Mukerji, and G. Mavko, 2005, Quantitative Seismic Interpretation. Applying Rock Physics Tools to Reduce Interpretation Risk: Cambridge University Press. doi:10.1017/CBO9780511600074

ICE2018 International Conference & Exhibition

Reservoir characterization of a basin floor fan system using rock physics to integrate seismic and well data, offshore Block 9, South Africa.

Authors: M.M Mmema, J.I Adrian

Content

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❑Problem statement and approach
❑Methodology & Results
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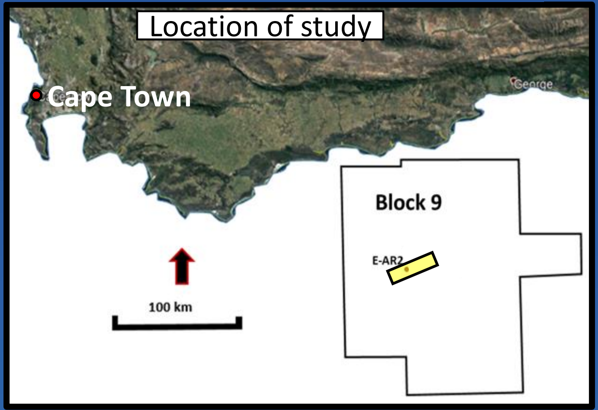
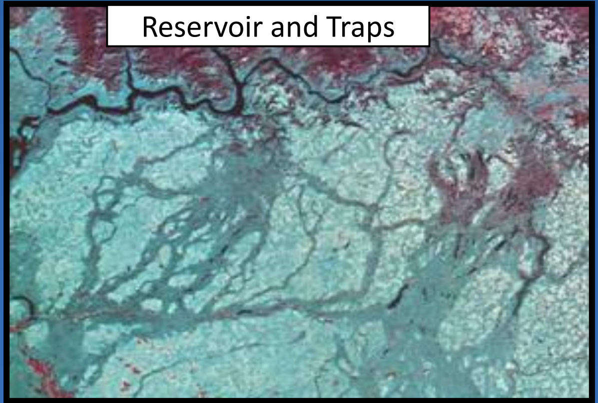
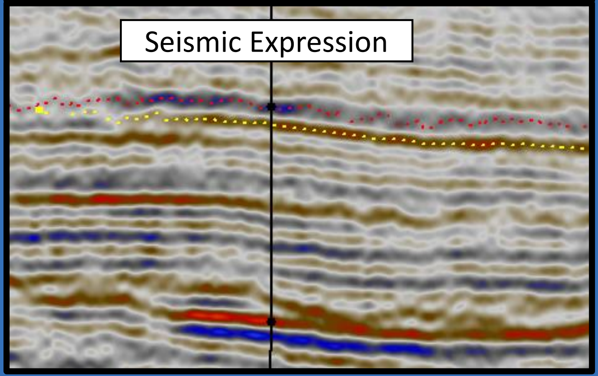
Background & Geological Setting







- ❑ Block 9 Offshore, South Africa, Bredasdorp Basin, a sub basin of the Outeniqua Basin.
- ❑ One Pilot well has been used in this study; E-AR2. An oil discovered well within the 14A drift sequence.
- ❑ The sequence of interest is described as deep-marine fan complex and fan lobes sandstones containing hydrocarbons- Albian and Aptian geological period.
- ❑ Mainly stratigraphic traps.
- ❑ Porosity with values range from 13 to 21%.
- ❑ Permeability average 250 mD.
- ❑ The target reservoirs are within 2350- 2750 m below MSL.

Problem statement and approach

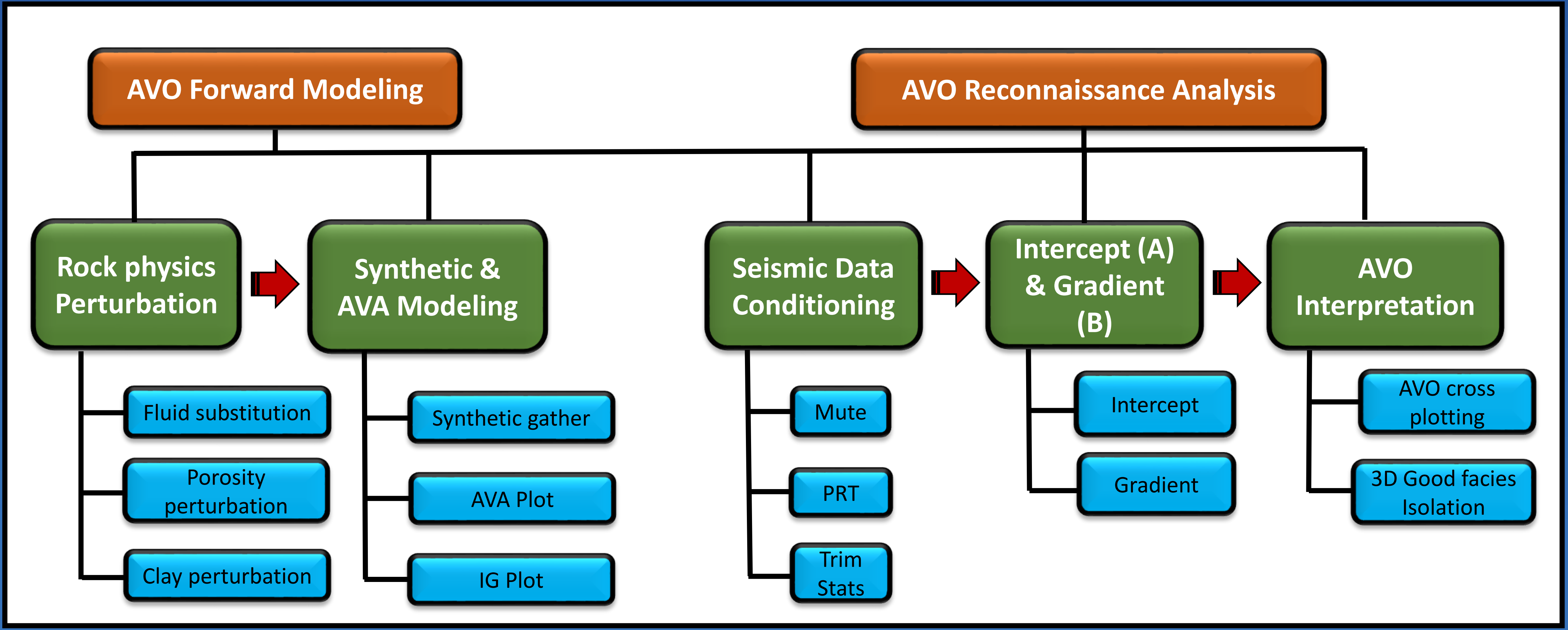
Problem

To understand the relationships between rock properties and the observed seismic response in order to investigate the feasibility of using the seismic as a Direct hydrocarbon Indicator (DHI) tool.

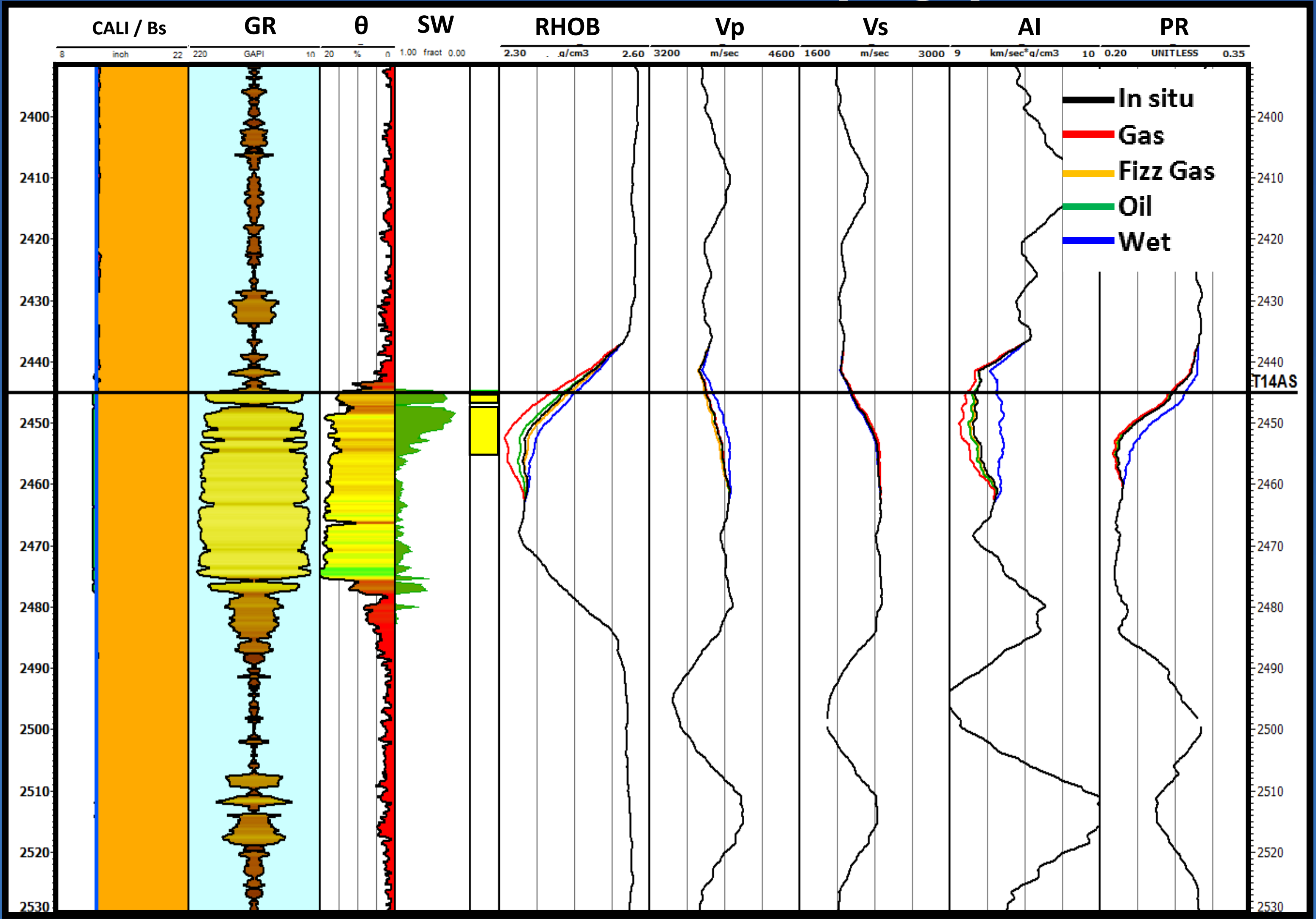
Approach

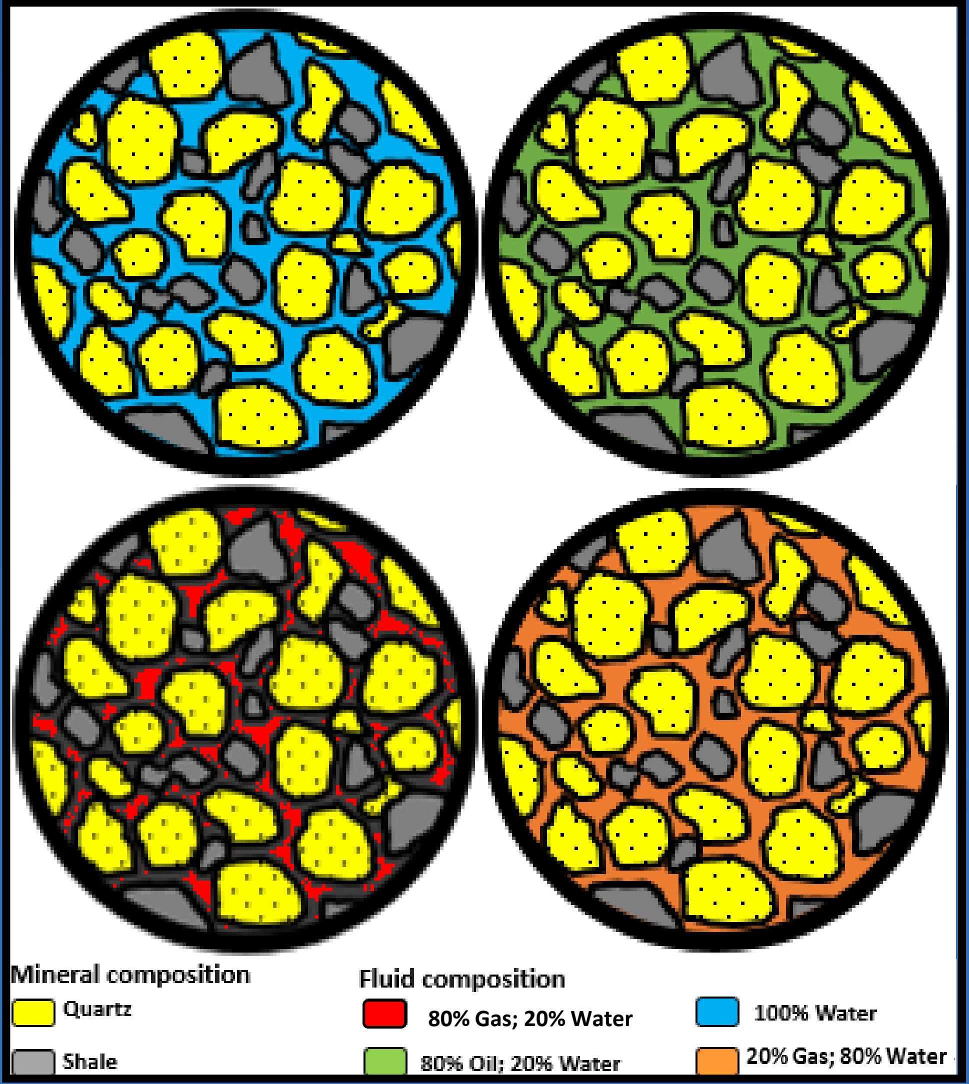
To implement a reservoir characterization workflow using rock physics modeling to demonstrate the reliability of pre-stack data to resolve hydrocarbon presence and rock properties (porosity, clay volume) in the reservoir sandstones.

Workflow

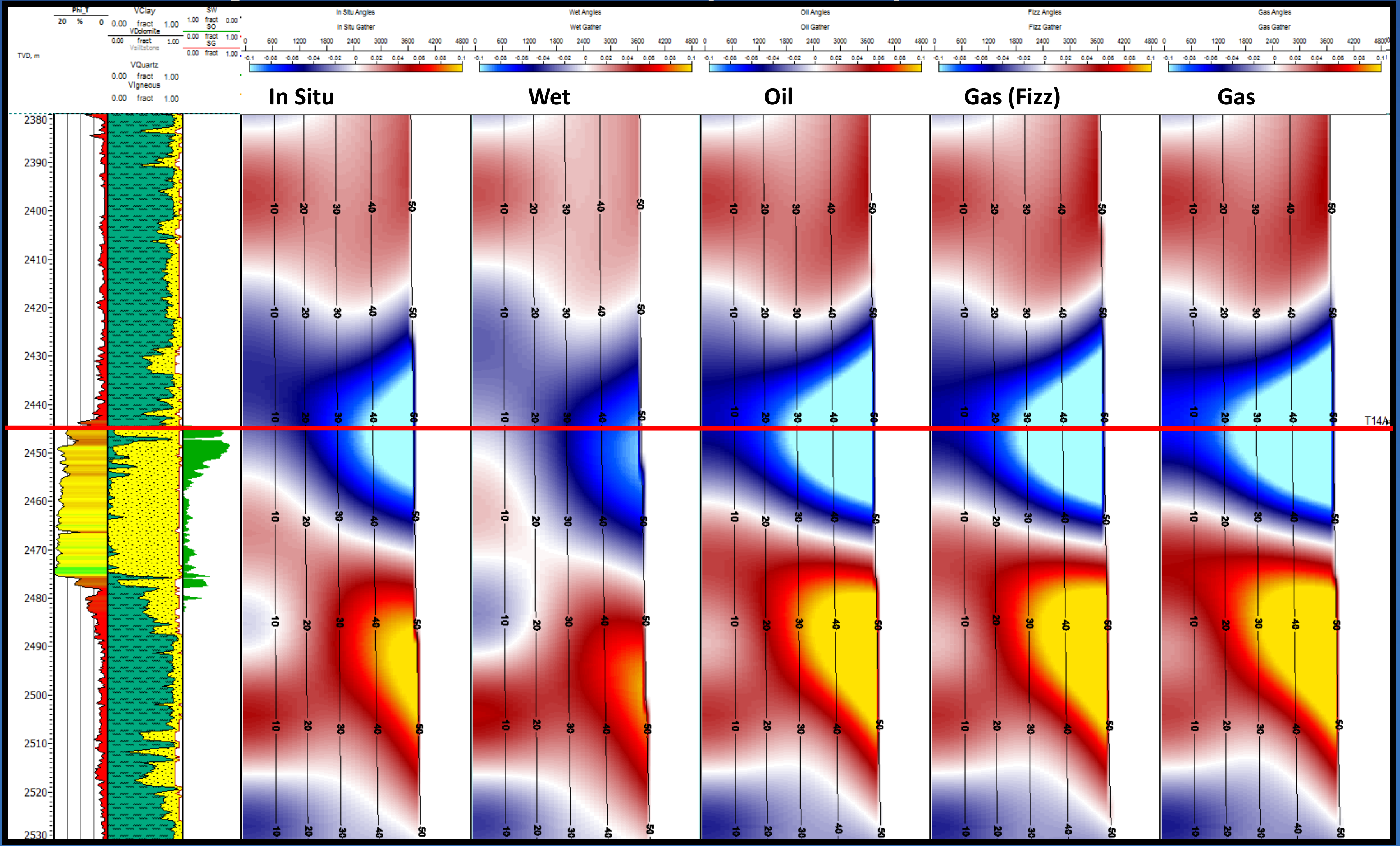

AVO Forward Modeling
AVO Reconnaissance Analysis
Rock physics Perturbation
Synthetic & AVA Modeling
Seismic Data Conditioning
Intercept (A) & Gradient (B)
AVO Interpretation
Fluid substitution
Porosity perturbation
Clay perturbation
Synthetic gather
AVA Plot
IG Plot
Mute
PRT
Trim Stats
Intercept
Gradient
AVO cross plotting
3D Good facies Isolation

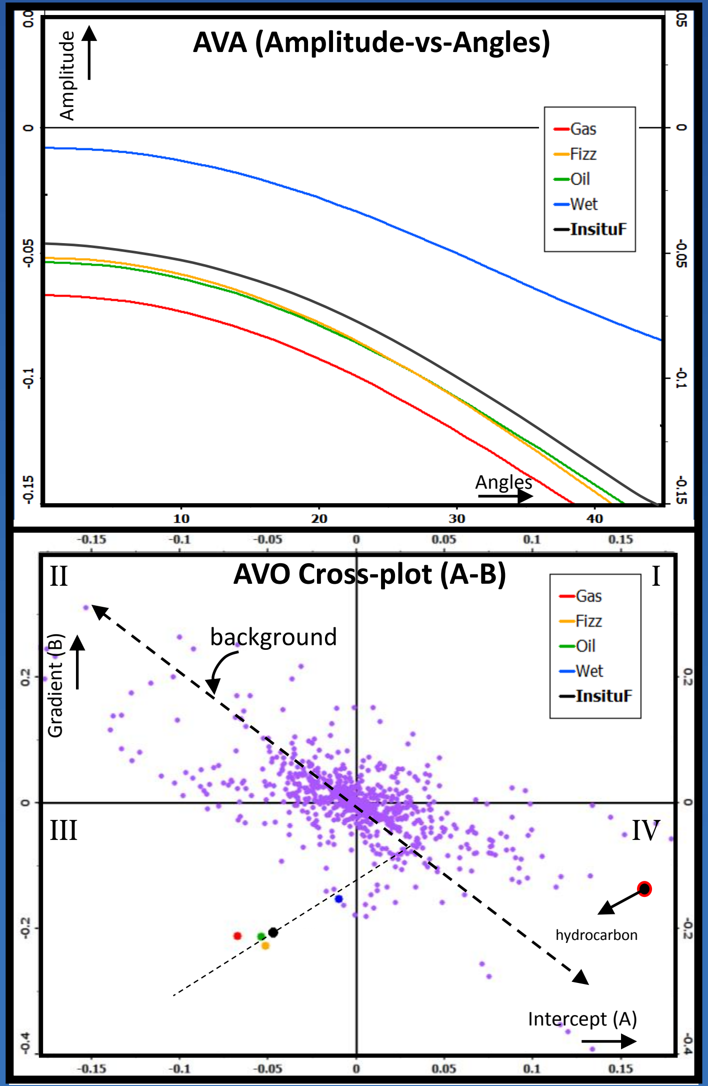
Fluid Substitution_E-AR2 (log-plot)



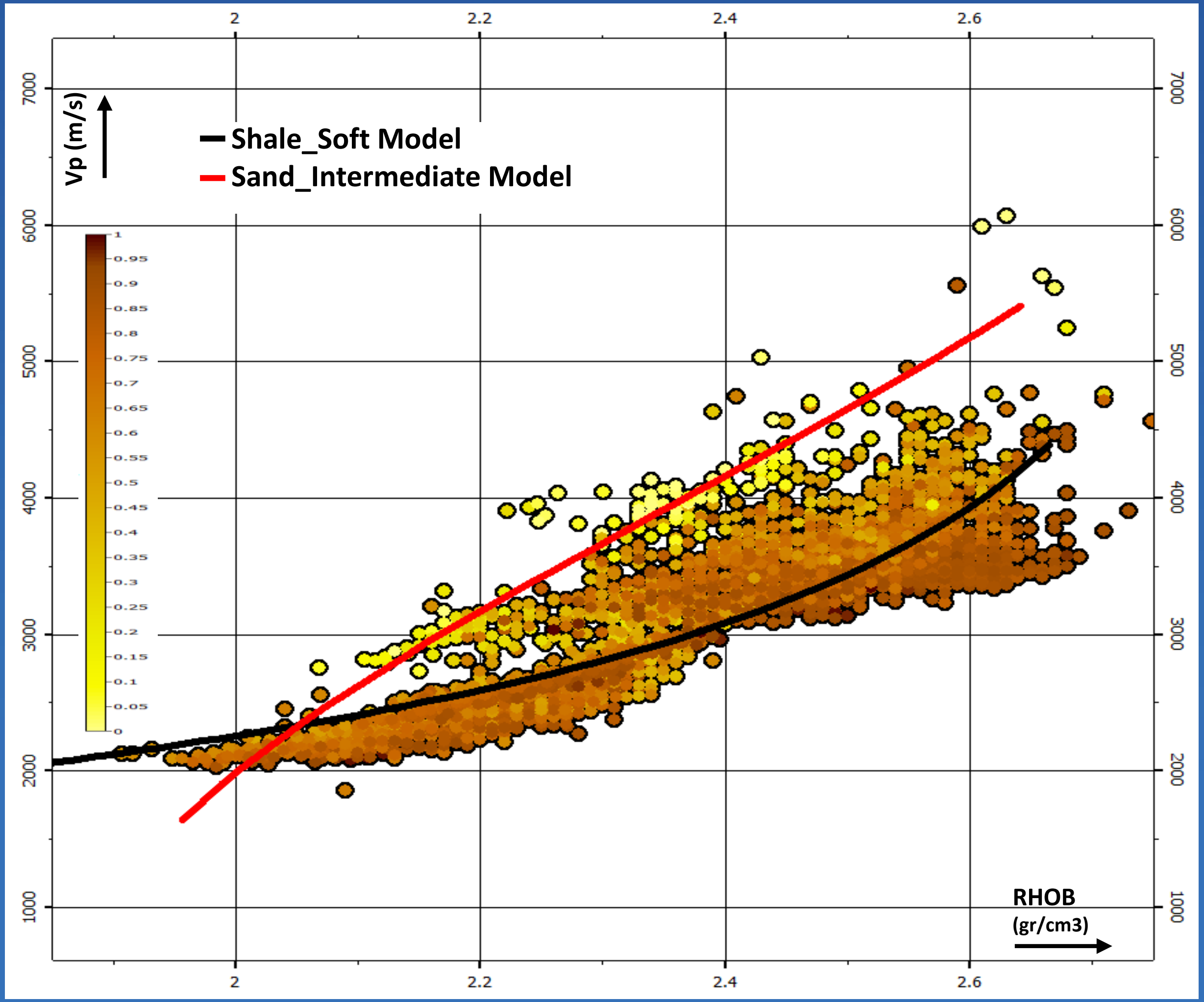


AVA analysis-Fluid Models (T14AS) :E-AR2 Seismic Gather





Porosity perturbation_E-AR2(log-plot)



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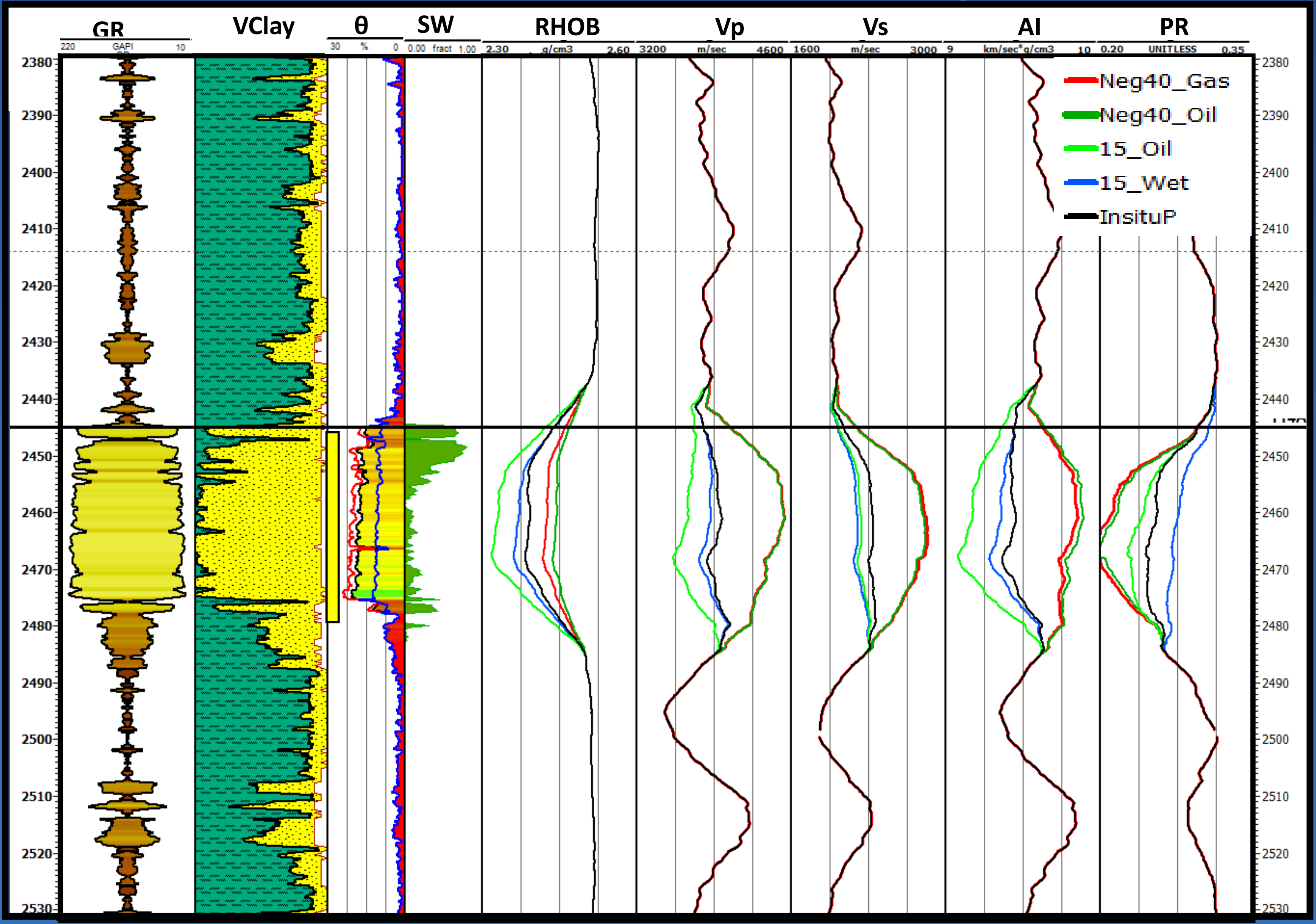
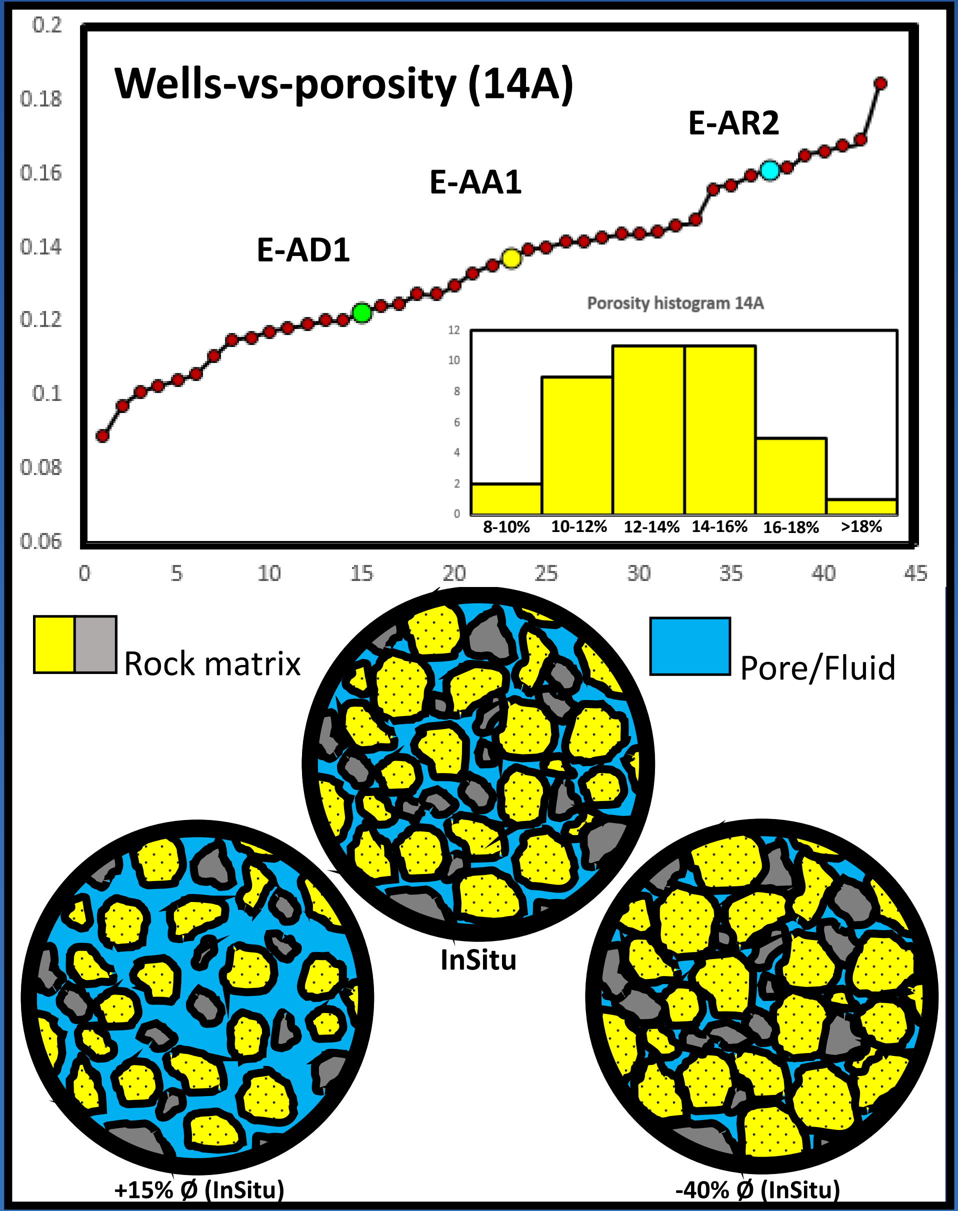
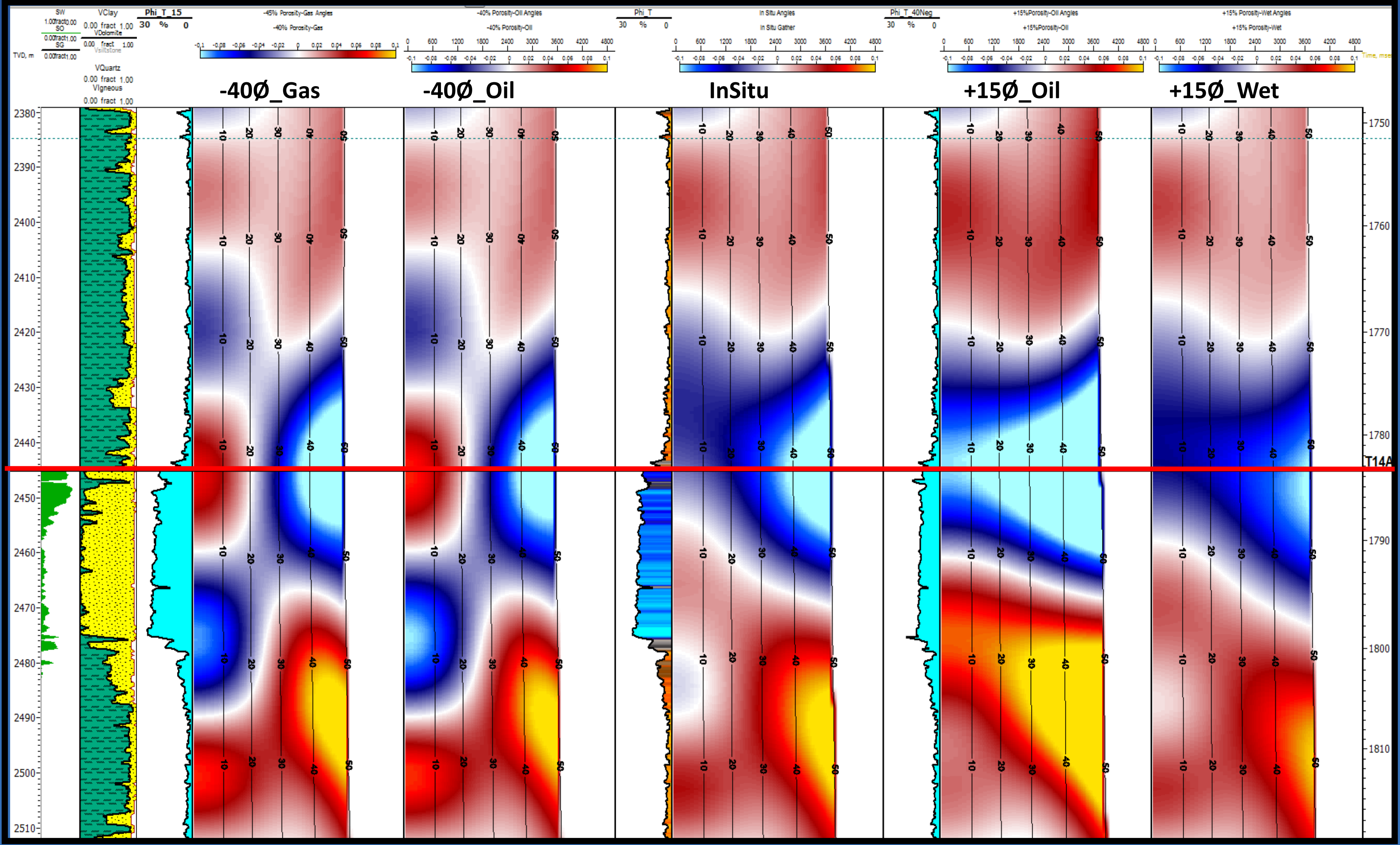
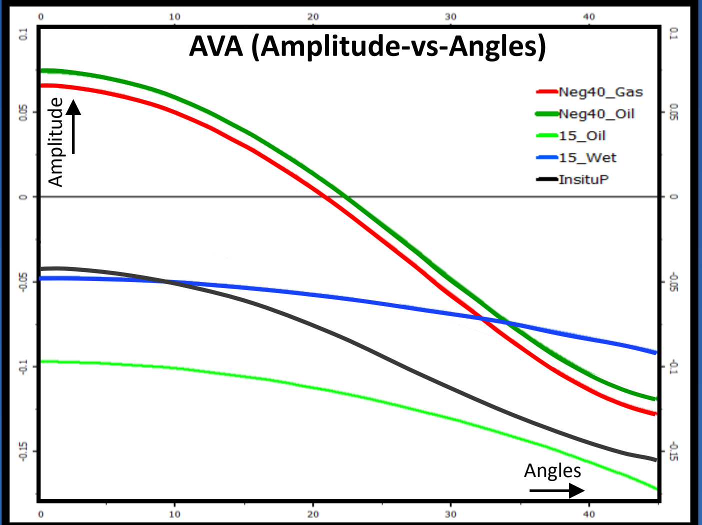
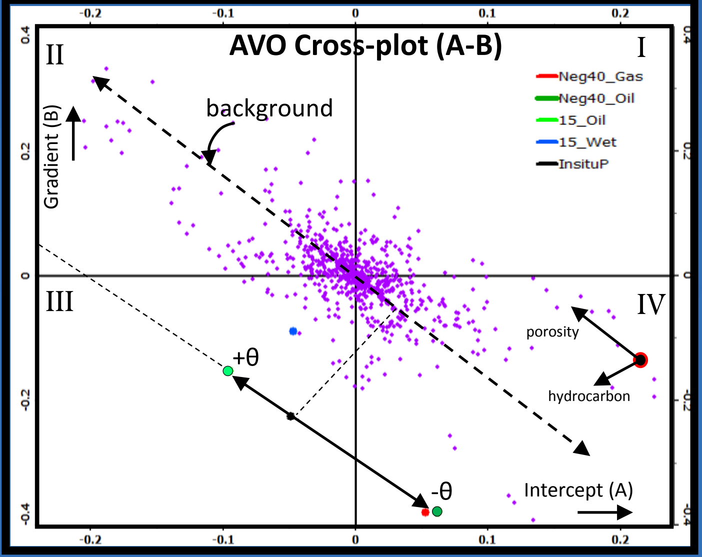




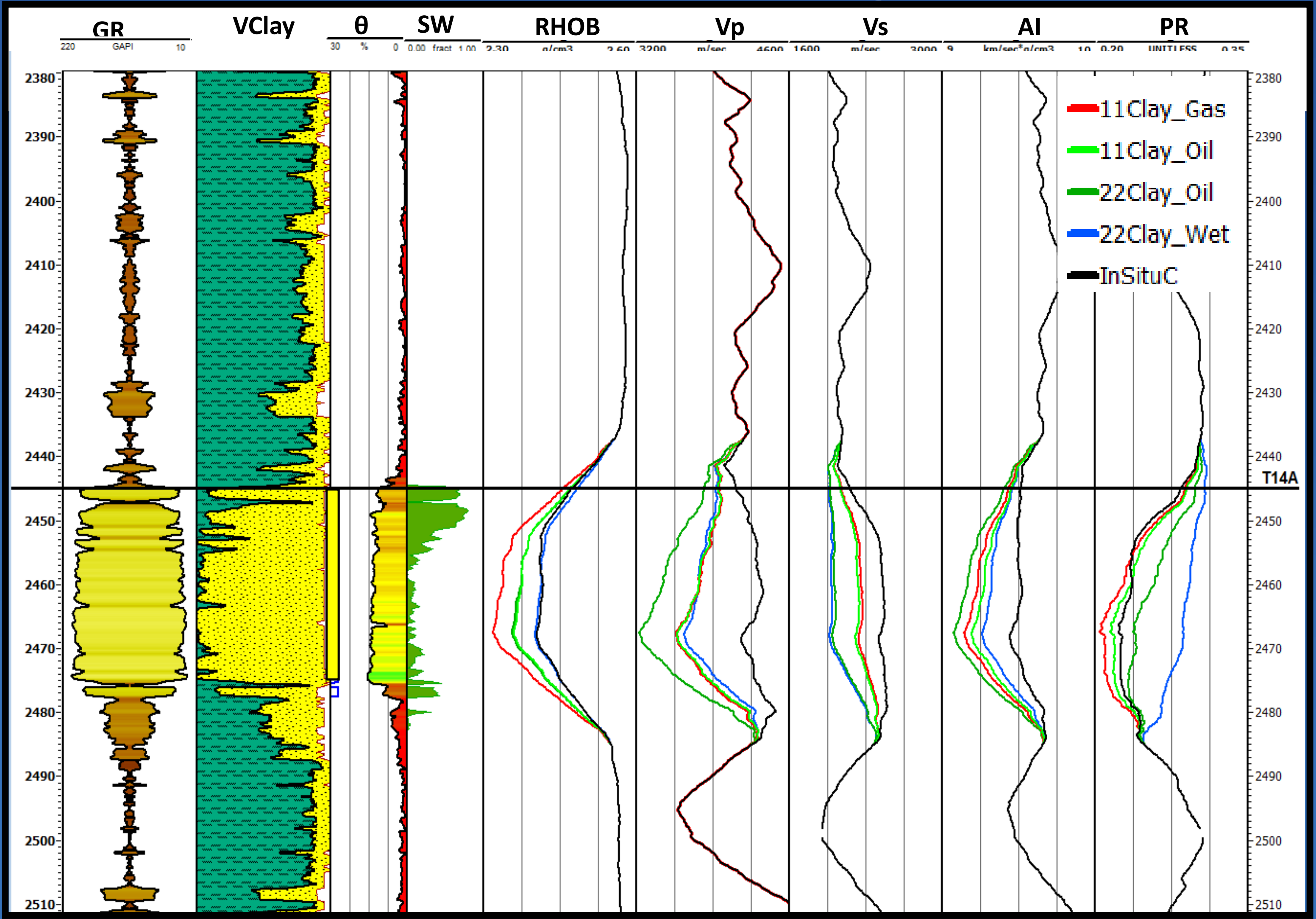
AVA analysis-Porosity Models (T14AS) :E-AR2 Seismic Gather

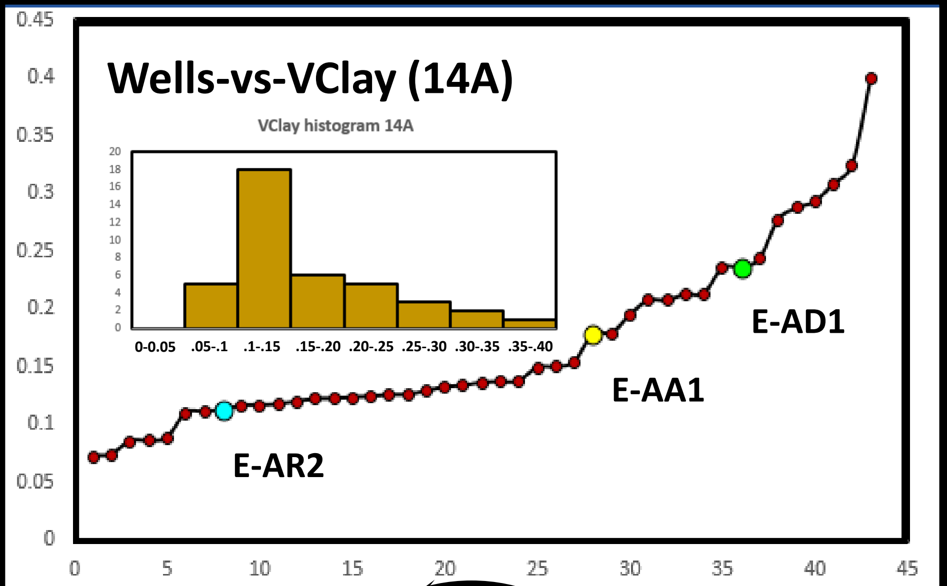


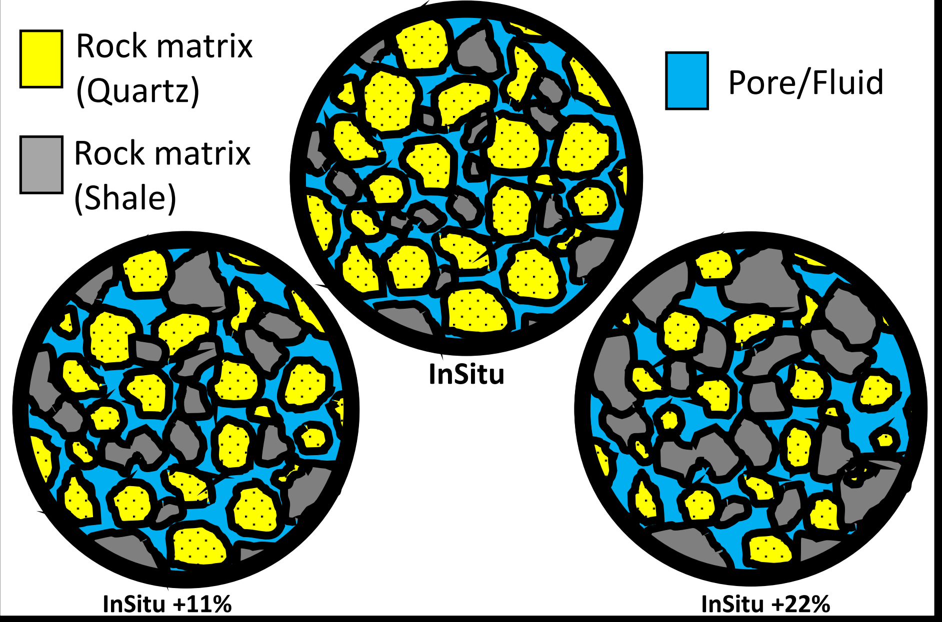




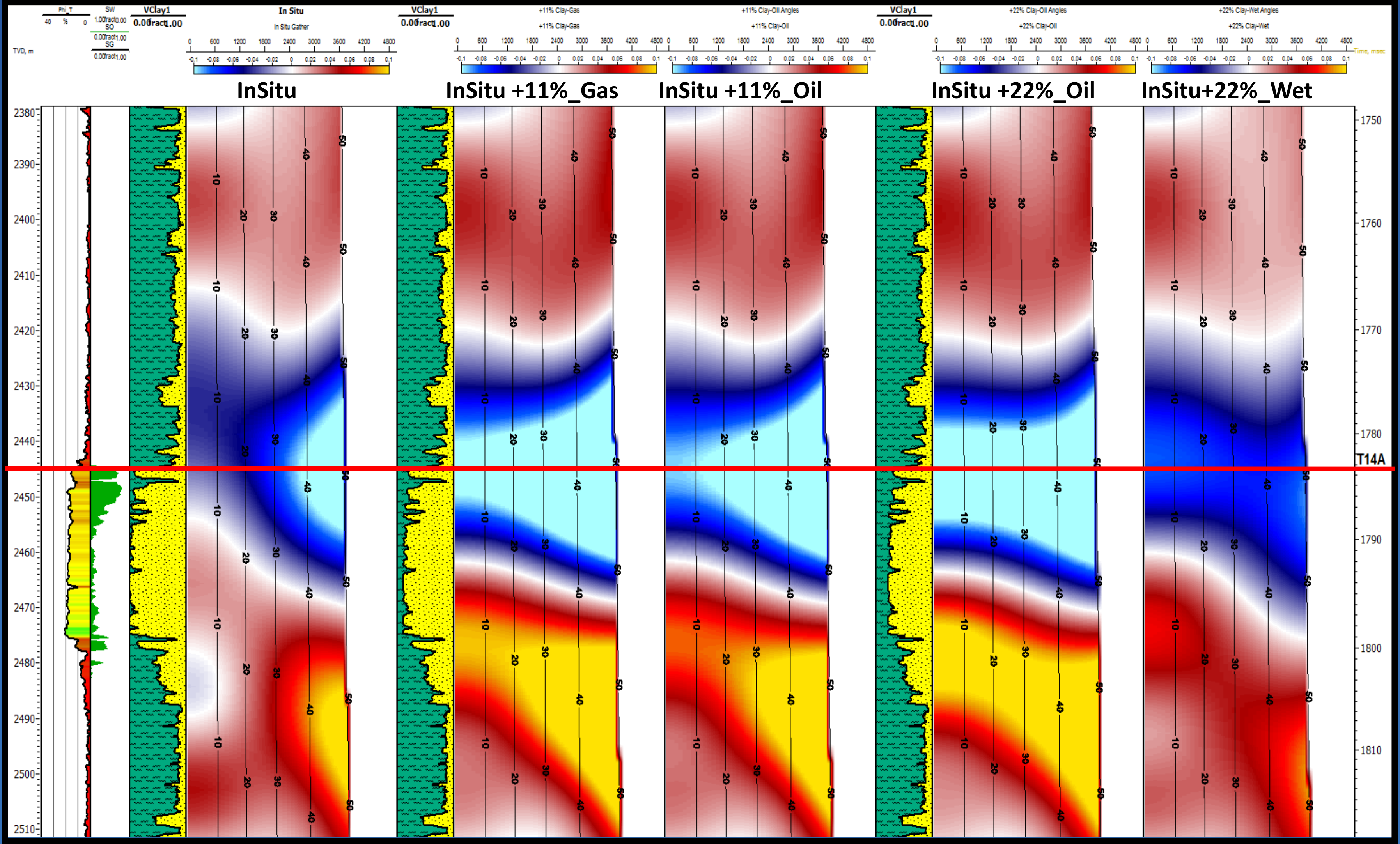
Shale perturbation_E-AR2(log-plot)

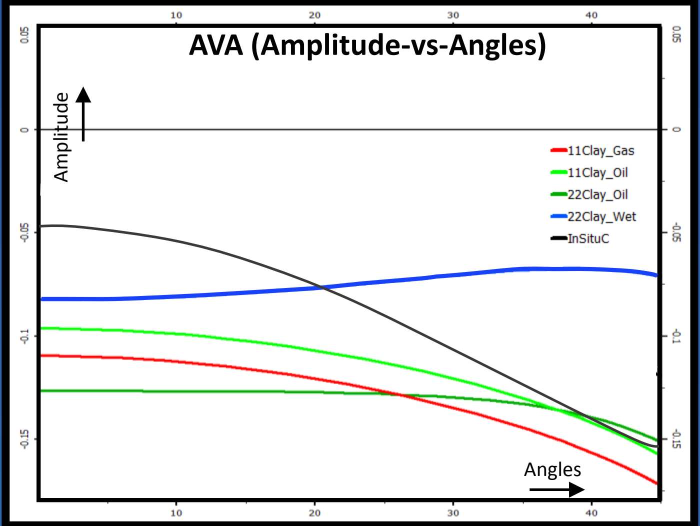


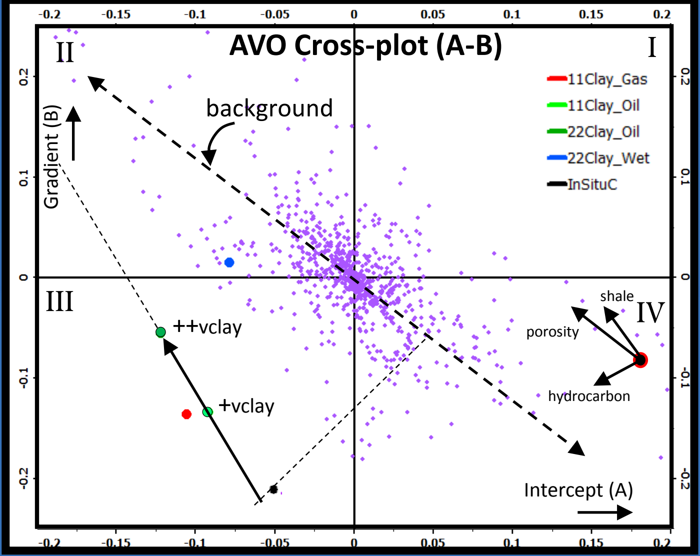




AVA analysis-VClay Models (T14AS) :E-AR2 Seismic Gather

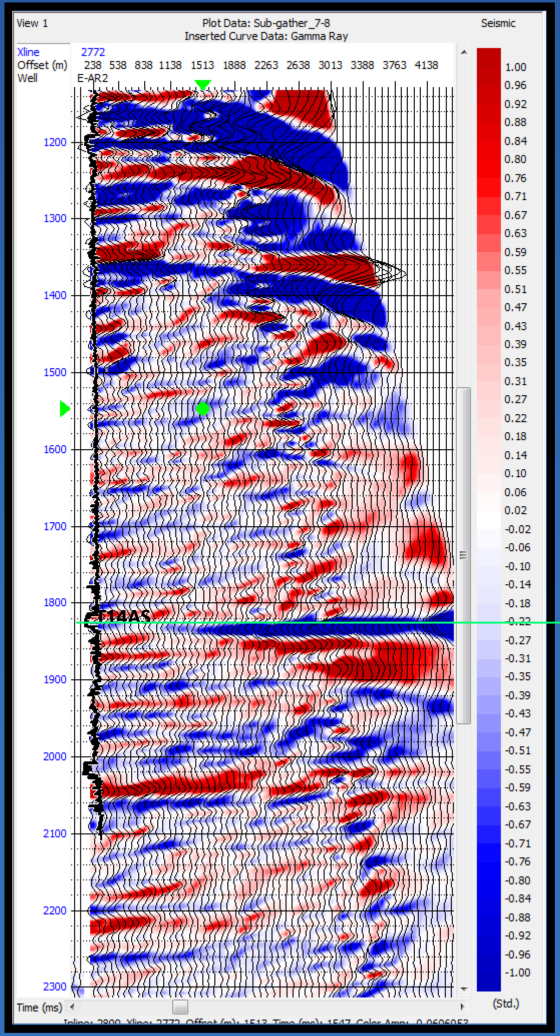




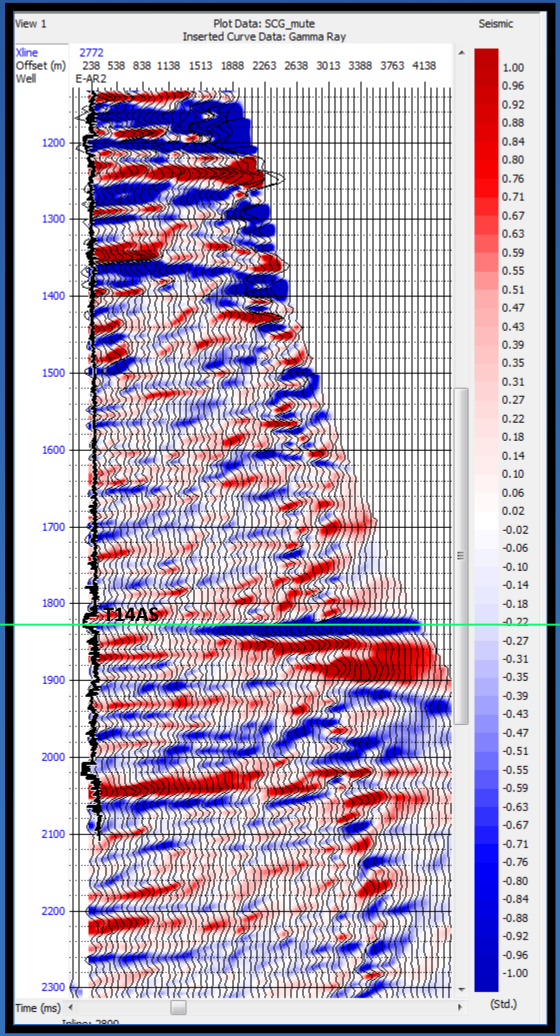


Seismic Conditioning

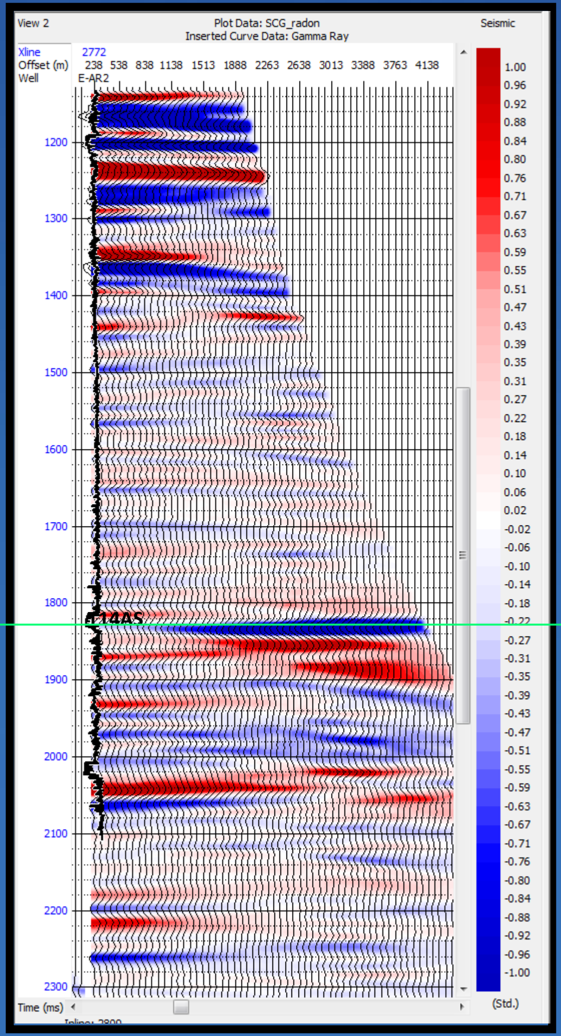
Original Gather



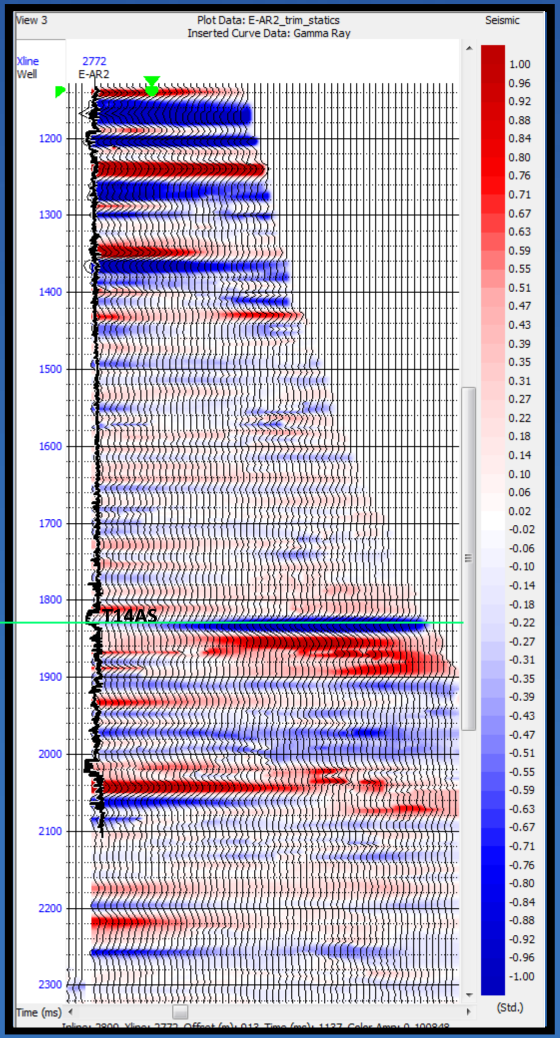
Mute



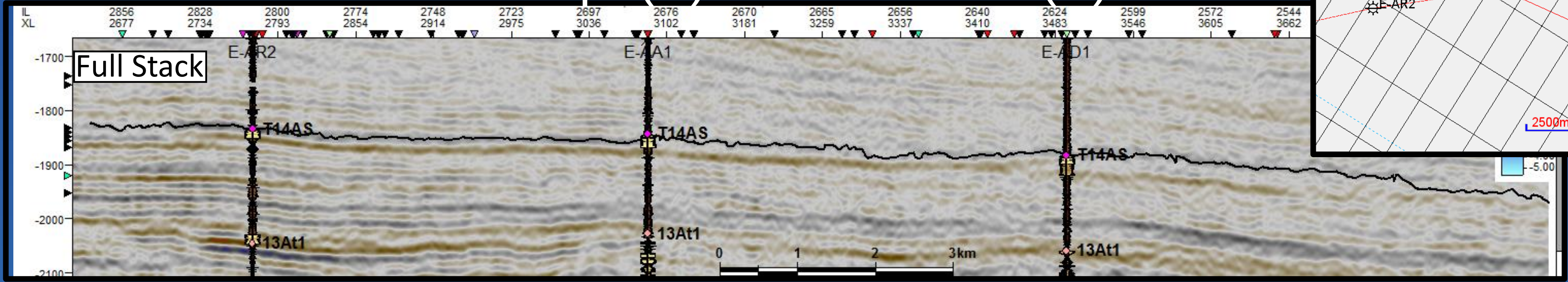
Parabolic Transform

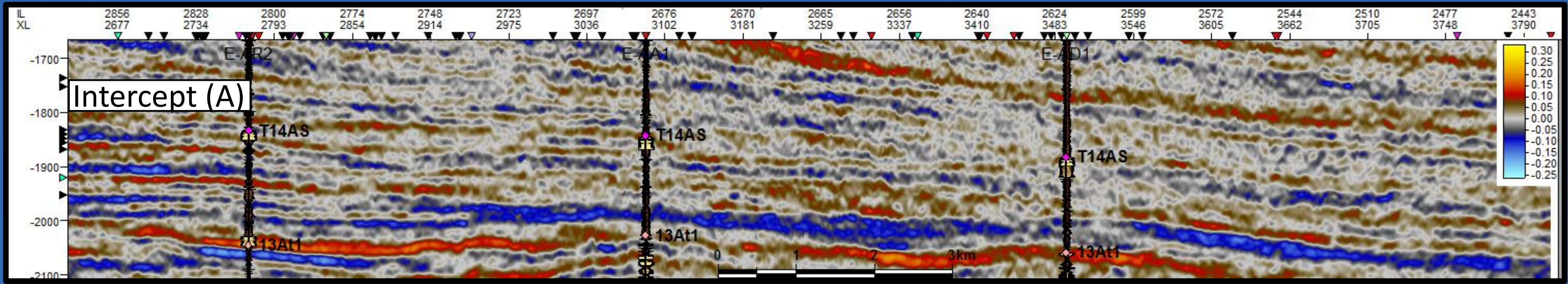


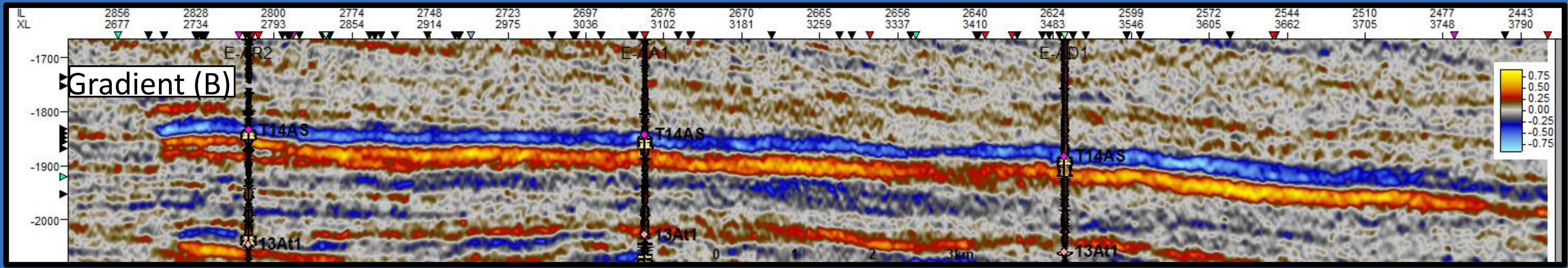
Trim Static

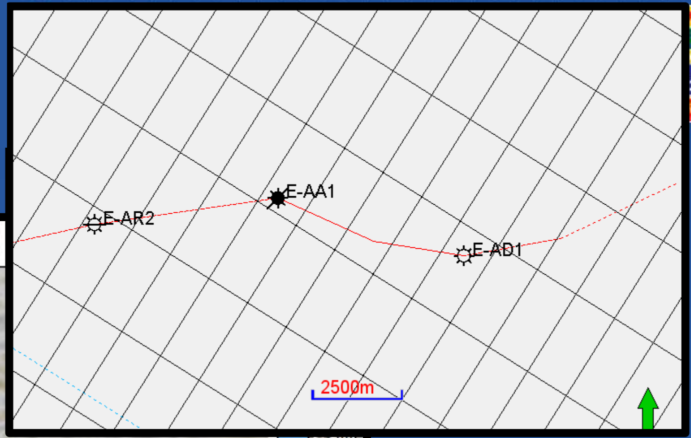


AVO Attributes: Intercept (A) and Gradient (B)

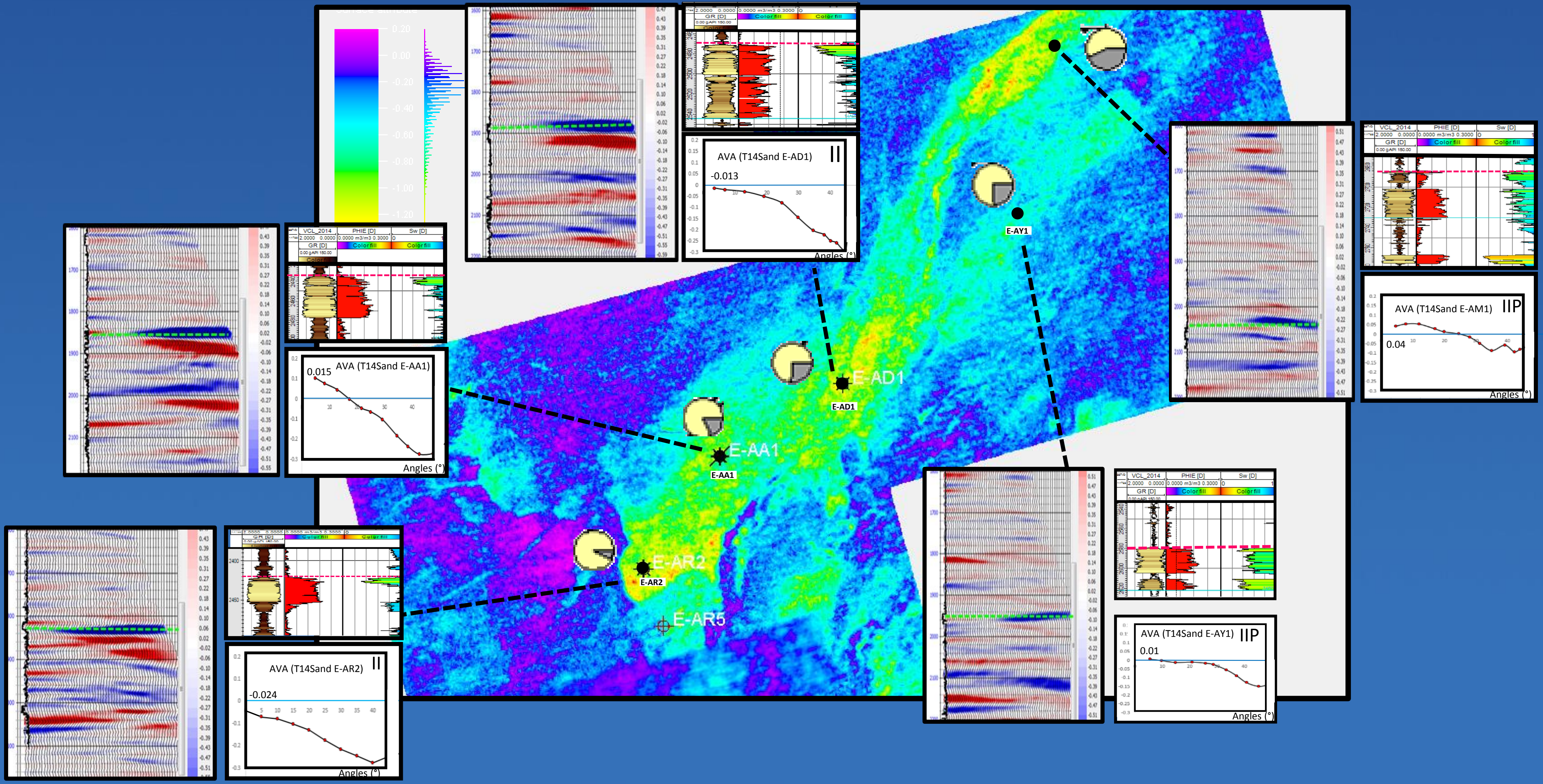




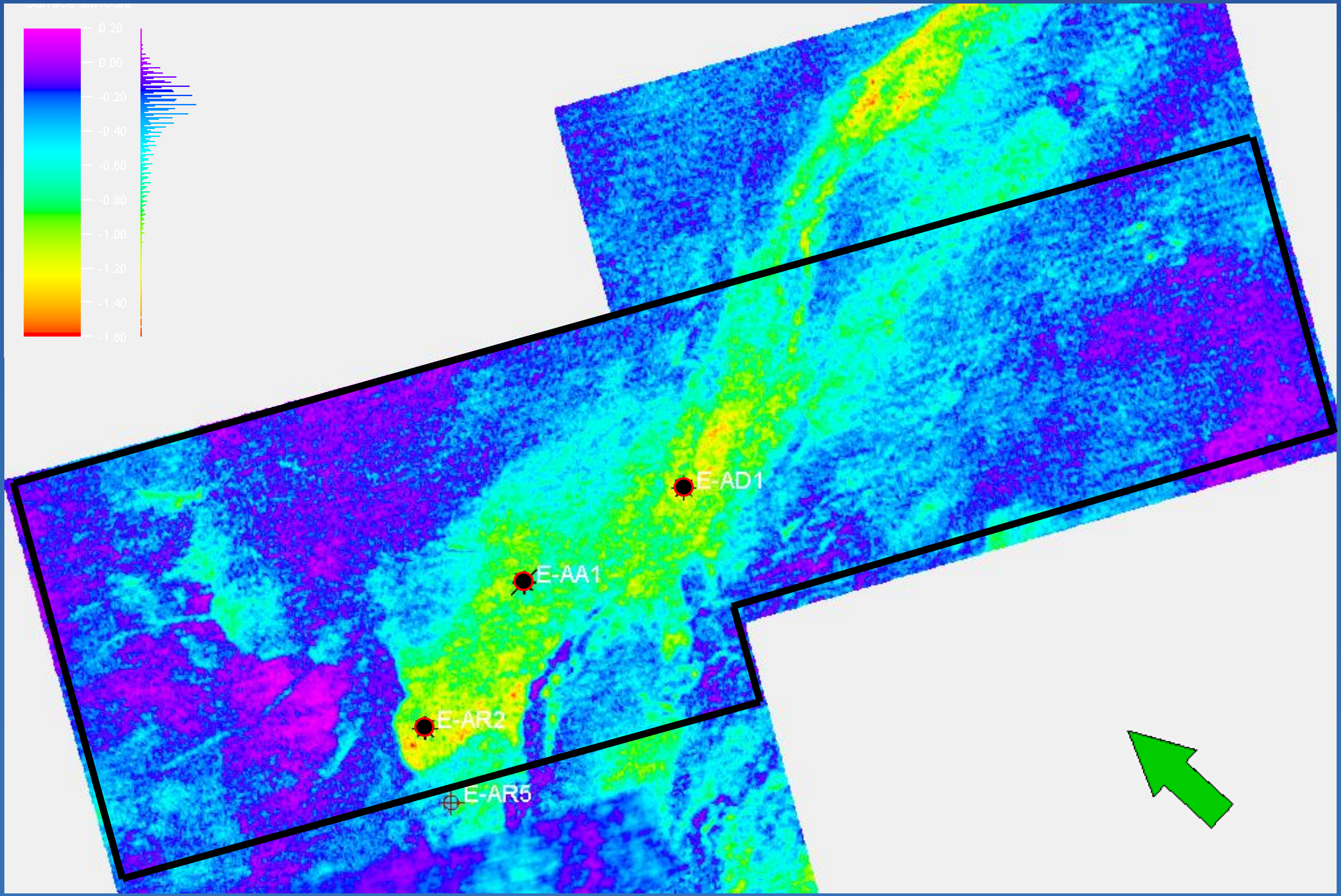




AVA class vs seismic response

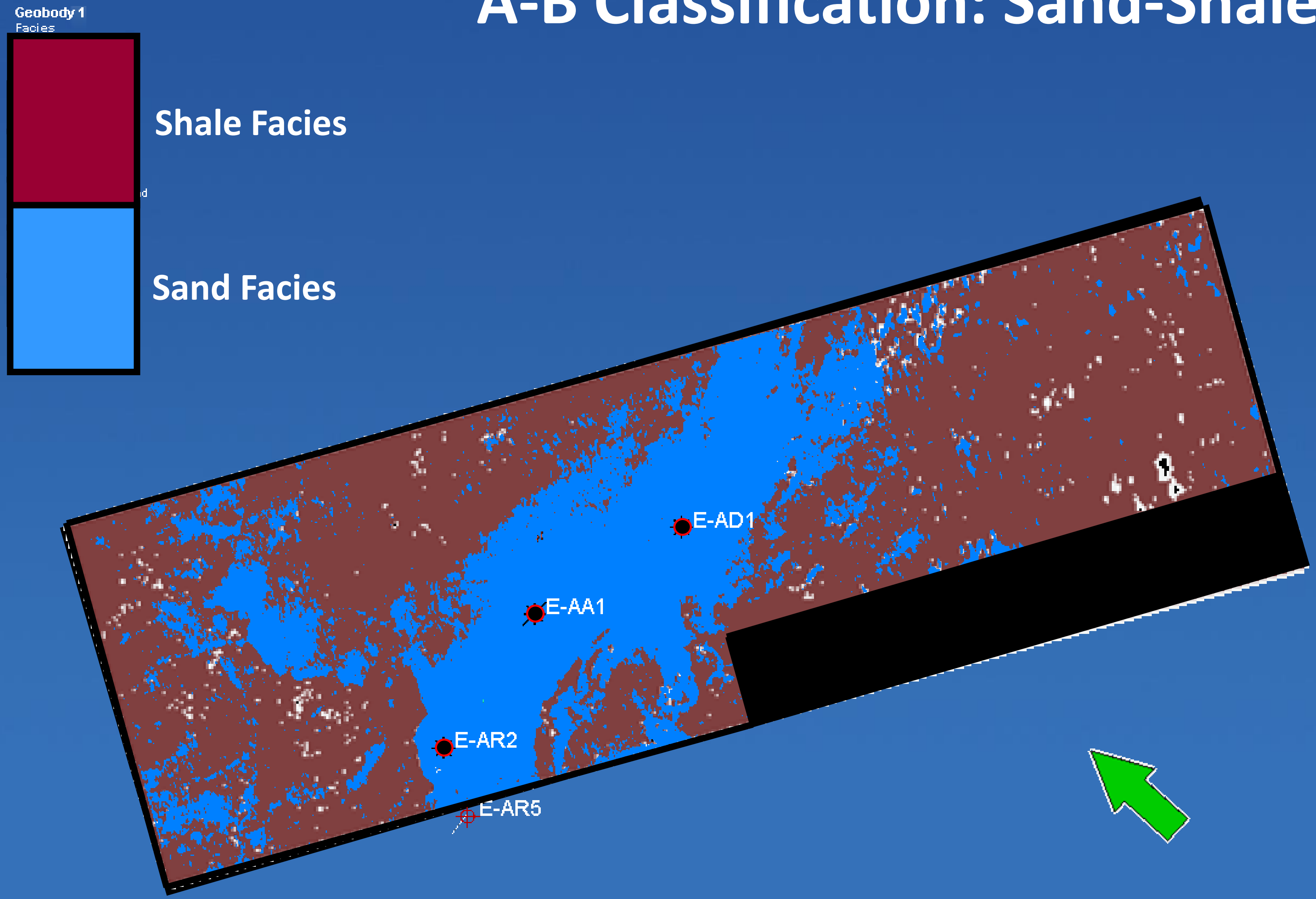


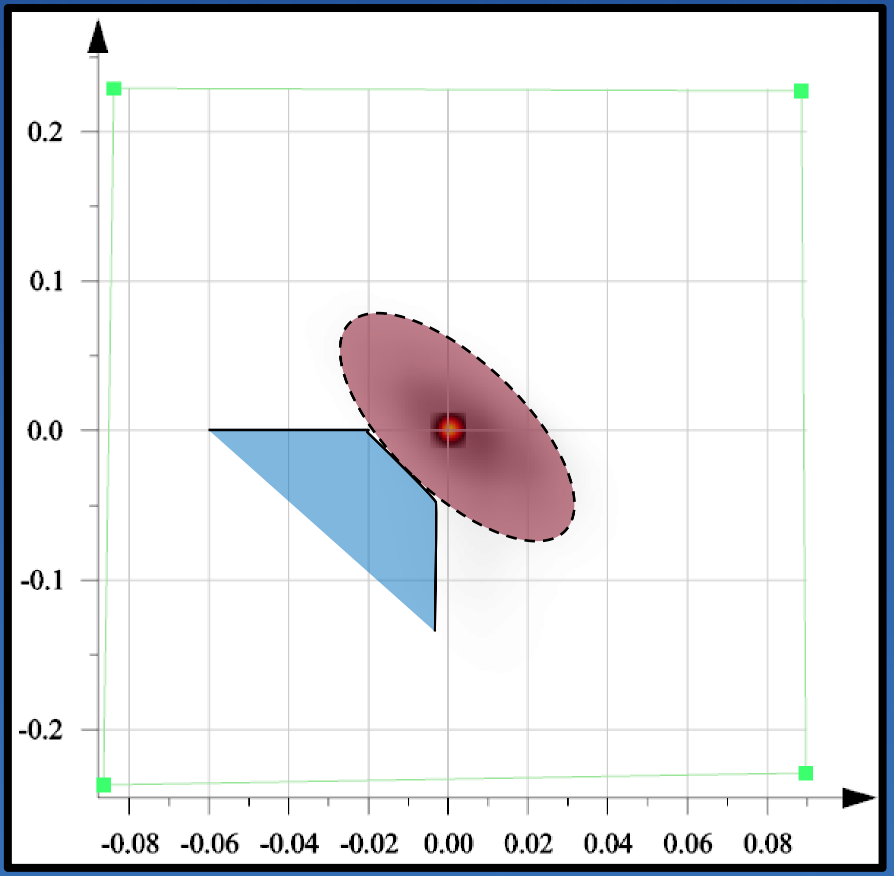
Window-attribute generation



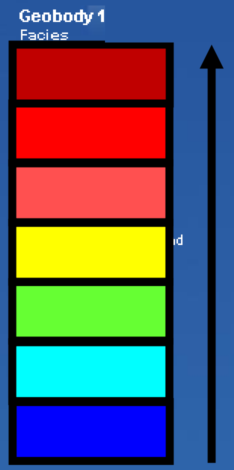
14At1 + 30 ms Minimum amplitude attribute (Far Stack-36-54°)

A-B Classification: Sand-Shale

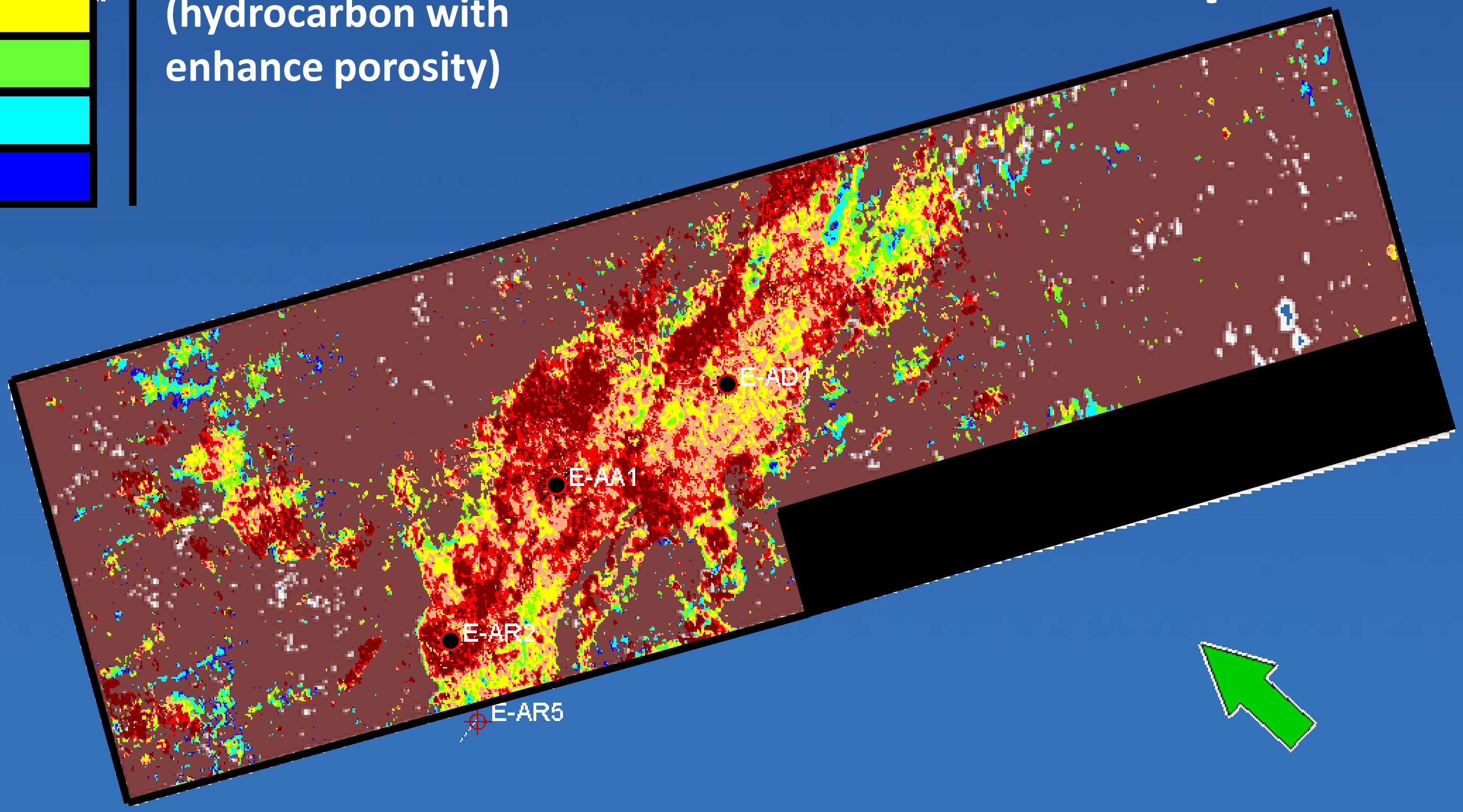


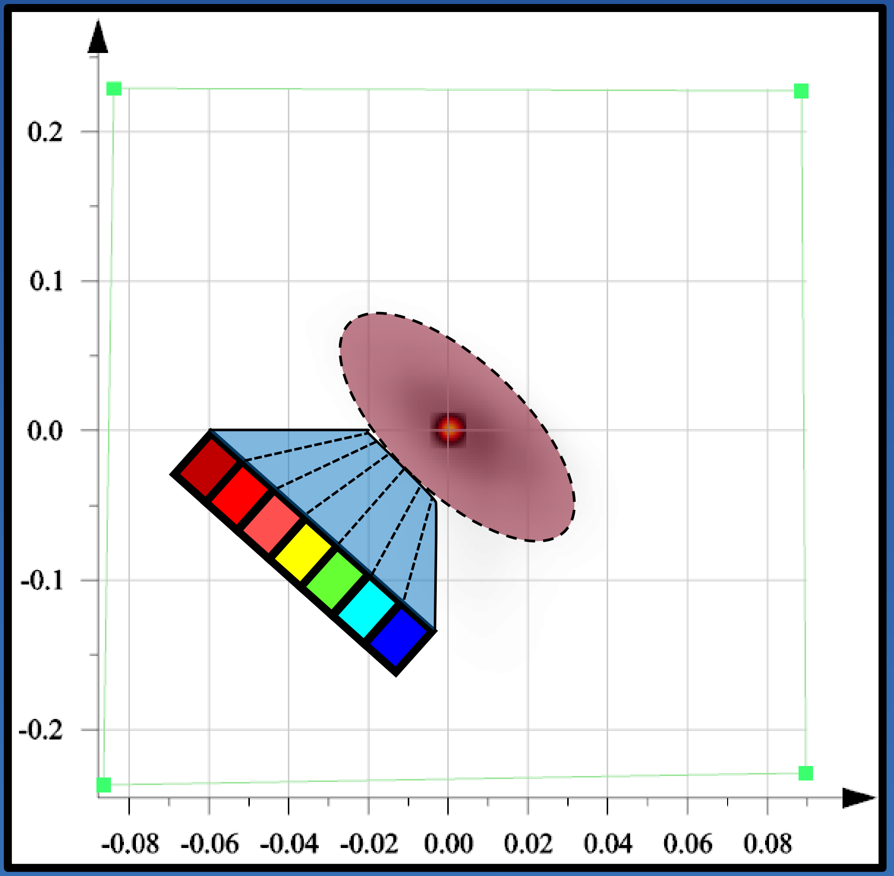


A-B Classification:
Sand internal architecture
Map View

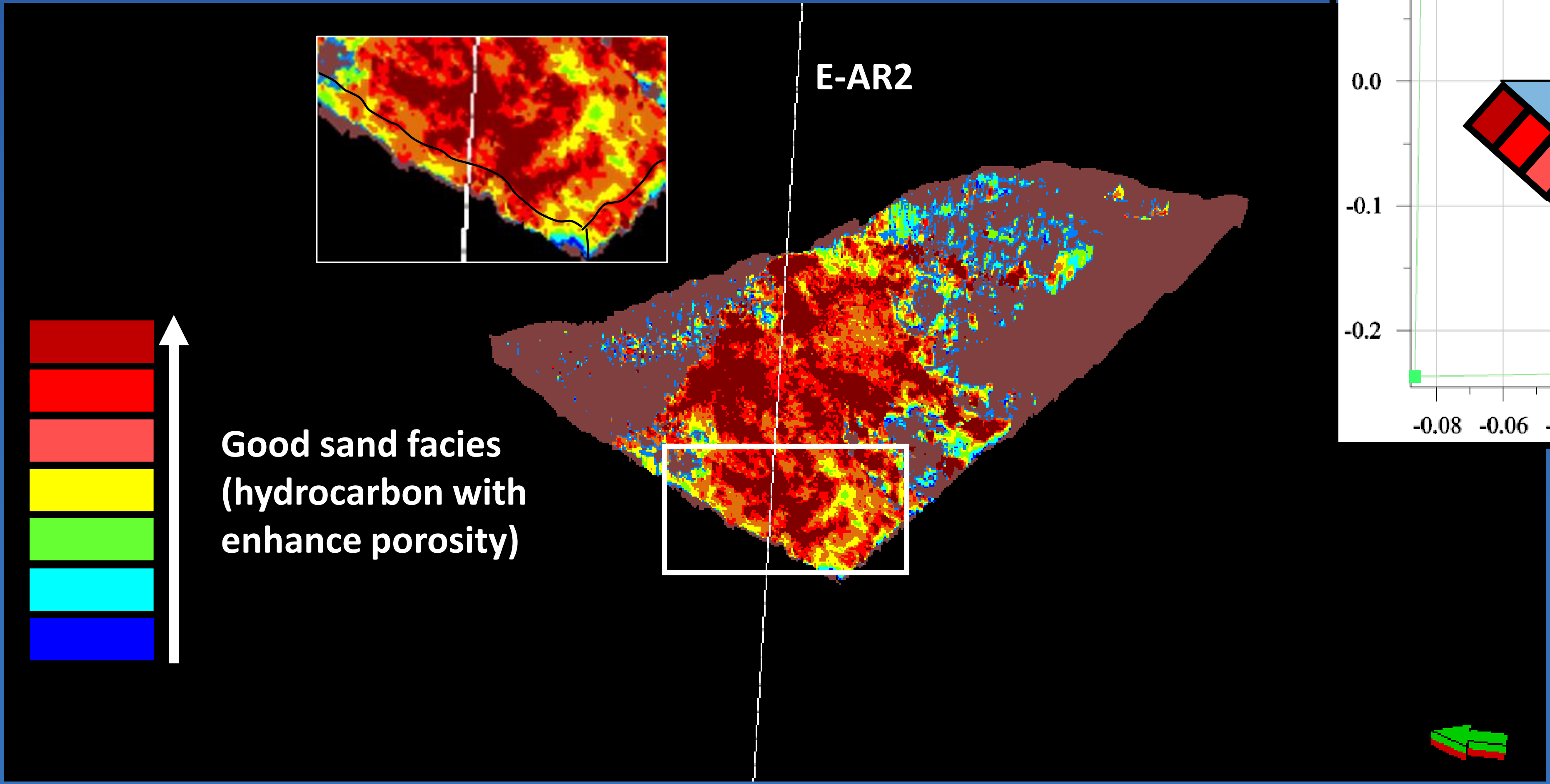


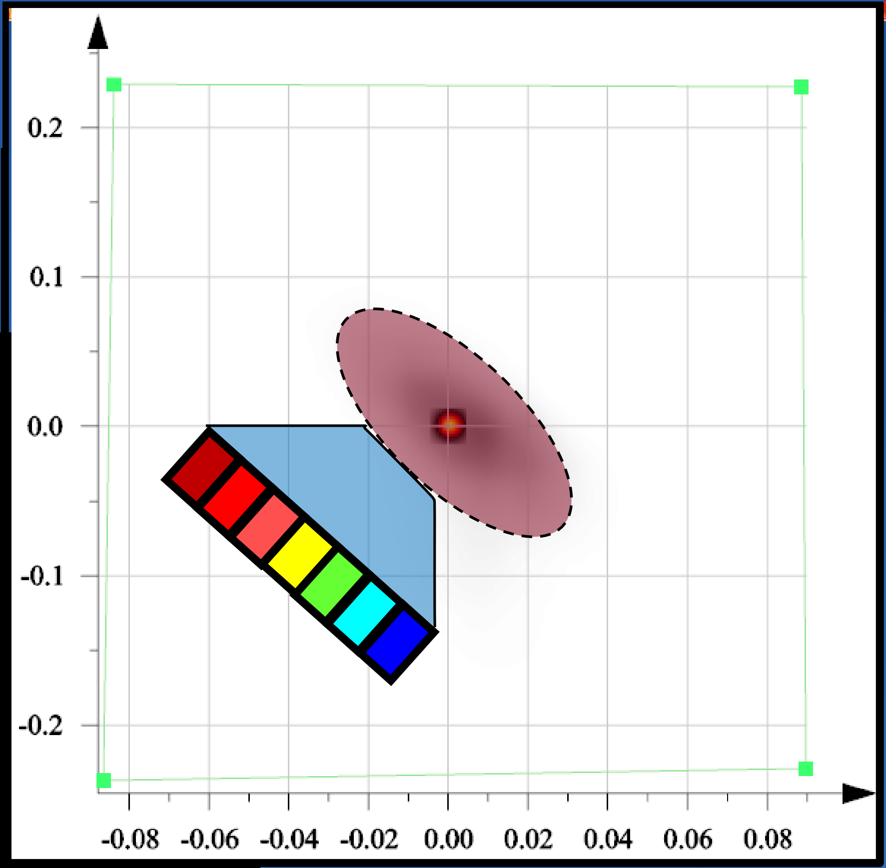
Good sand facies (hydrocarbon with enhance porosity)





A-B Classification: Sand internal architecture 3D View





Observations & Conclusions

- Measured well data overall very good, so no log conditioning was necessary. However, gather were conditioned to remove multiples and improve signal-to-noise.
- A soft sediment model for shales and intermediate stiff sediment for sand were sufficient to build the different litho-**substitutions** (porosity, clay volume).
- Fluid substitution modelling shows good discrimination between oil and brine in the reservoir, but negligible between hydrocarbon cases (oil, gas, fizz gas).
- When porosity increases acoustic impedance dramatically decreases, and when porosity decreases acoustic impedance increases. This behaviour does lead to a greater sensitivity to fluid changes, because there is a higher percentage of the bulk rock that is fluid.
- Increasing clay similarly leads to a dramatic decrease in acoustic impedance and increase to Poisson's ratio. It also reduce the fluid sensitivity, most likely due to the fact that there is less reservoir available for substitution.
- AVO 3D attributes (A-B) domain technique proved successful in the area of interest to isolate good facies from shales, but as well to characterize with certain accuracy the internal architecture of the reservoir for geo-modeling purposes, taking into consideration the ambiguities the technique suffers caused by lithology effects, tuning effects, and overburden effects.
- With the knowledge of the relationships between seismic response and pore fluids properties from rock physics modeling one can use this AVO technique as a DHI tool to a curtain extent despite the ambiguities.

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  Co-Author