Seismic Attributes and Probability Property Modeling of Turbidites and Channel Sands*

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Abstract

Facies correlated seismic attributes (RMS amplitude, instantaneous amplitude) were combined with rock physics parameters, for probability property modeling of Turbidites and channel sands. The aim is to reduce geologic uncertainties inherent in well log correlation, and facies modeling of characteristic deepwater environments. This is critical for inter-well petrophysical property distribution, reservoir characterization, field development strategy, and predictability of future field performance. An integrated approach using litho-sensitive seismic attributes, rock physics, facies log, artificial neural network and variogram analyses; was used within a geostatistical framework to model rock facies and related petrophysical properties. This study has revealed, discrete facies classes that can be linked to the architectural facies pattern of turbidites and channel sands. These facies are characterized by high output probability properties. The modeled reservoir bulk volume from the integrated approach is observed to be relatively lower, when compared with the result of the traditional log-based correlation and structural modeling. Consequently, this over estimation of bulk volume, characteristic of the sequential indicator simulation modeling of upscaled log facies alone, have resulted to high static and volumetric uncertanties. The application of seismic attributes to probability property modeling of turbidites and channel sands, has improved inter-well facies distribution in the study area. This implies, better property distribution, better reservoir characterization, reduced uncertainties in static reservoir properties and volumetric estimation of hydrocarbon in-place. Also, the combination of seismic attributes and well logs in the sequential indicator simulation has led to drilling recommendation for optimal well placements, as driver for increased future production and reduced dynamic uncertainties.

References Cited

Corredor, F., J.H. Shaw, and F. Bilotti, 2005, Structural styles in the deep-water fold and thrust belts of the Niger Delta: AAPG Bulletin, v. 89, p. 753-780.

Doust,H., and E. Omatsola, 1990. Niger Delta, *in* Divergent/Passive Margin Basins, D. Edwards and P.A. Santagrossi, eds.: AAPG Memoir 45, p. 201-238.

Tyler, N., and R.J. Finley, 1991, Architectural controls on the recovery of hydrocarbons from sandstone reservoirs: Concepts in Sedimentology and Paleontology, v. 3; p. 1-5.

Seismic Attributes and Probability Property Modeling of Turbidites and Channel Sands, Offshore Niger Delta

By

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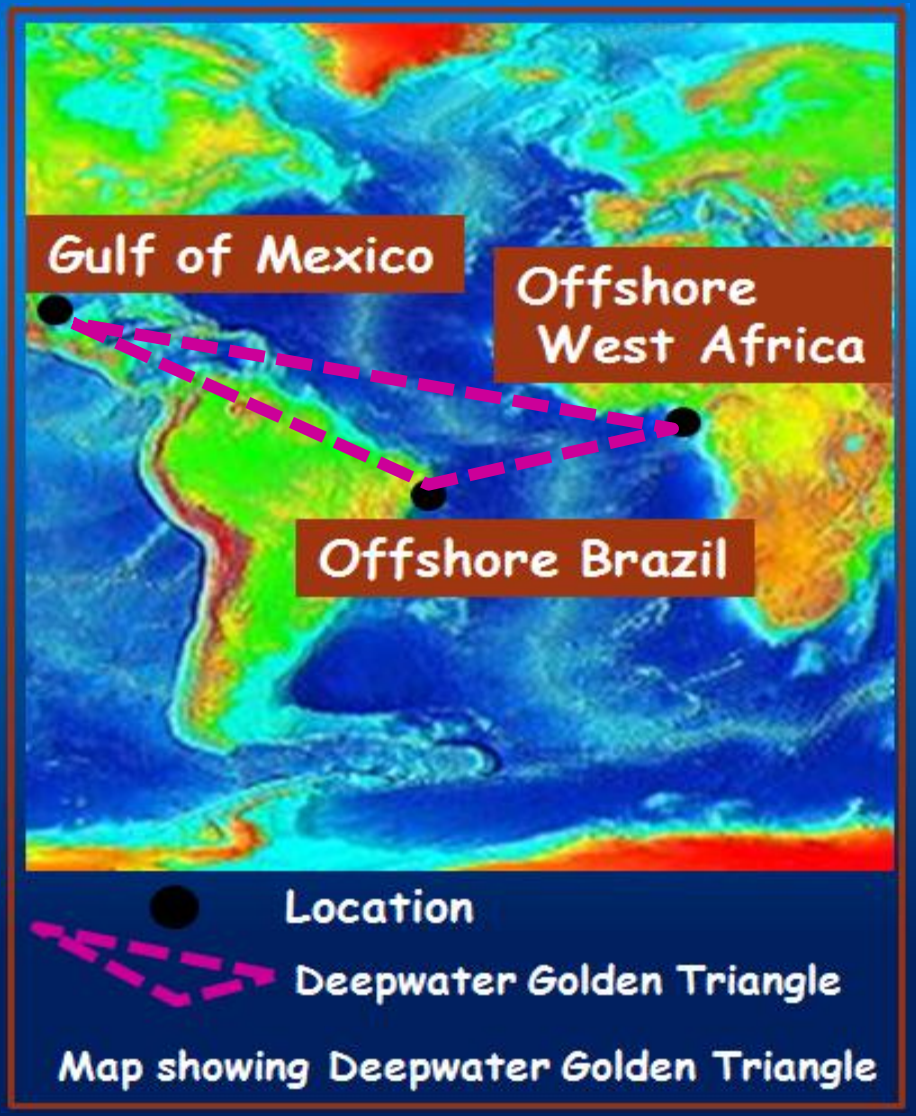
Presentation outline

- Introduction
- Aim and objectives of study
- Location of study area and geology setting
- Methodology and interpretation workflow
- Results and discussion
  - Well log analysis and rock physics characterization
  - Post-stack seismic attribute analysis
  - Variogram analysis and trend modeling
  - Seismic probability property modeling of turbidites and channel sand
- Summary and Conclusion

Introduction

The Deepwater Golden Triangle Discoveries

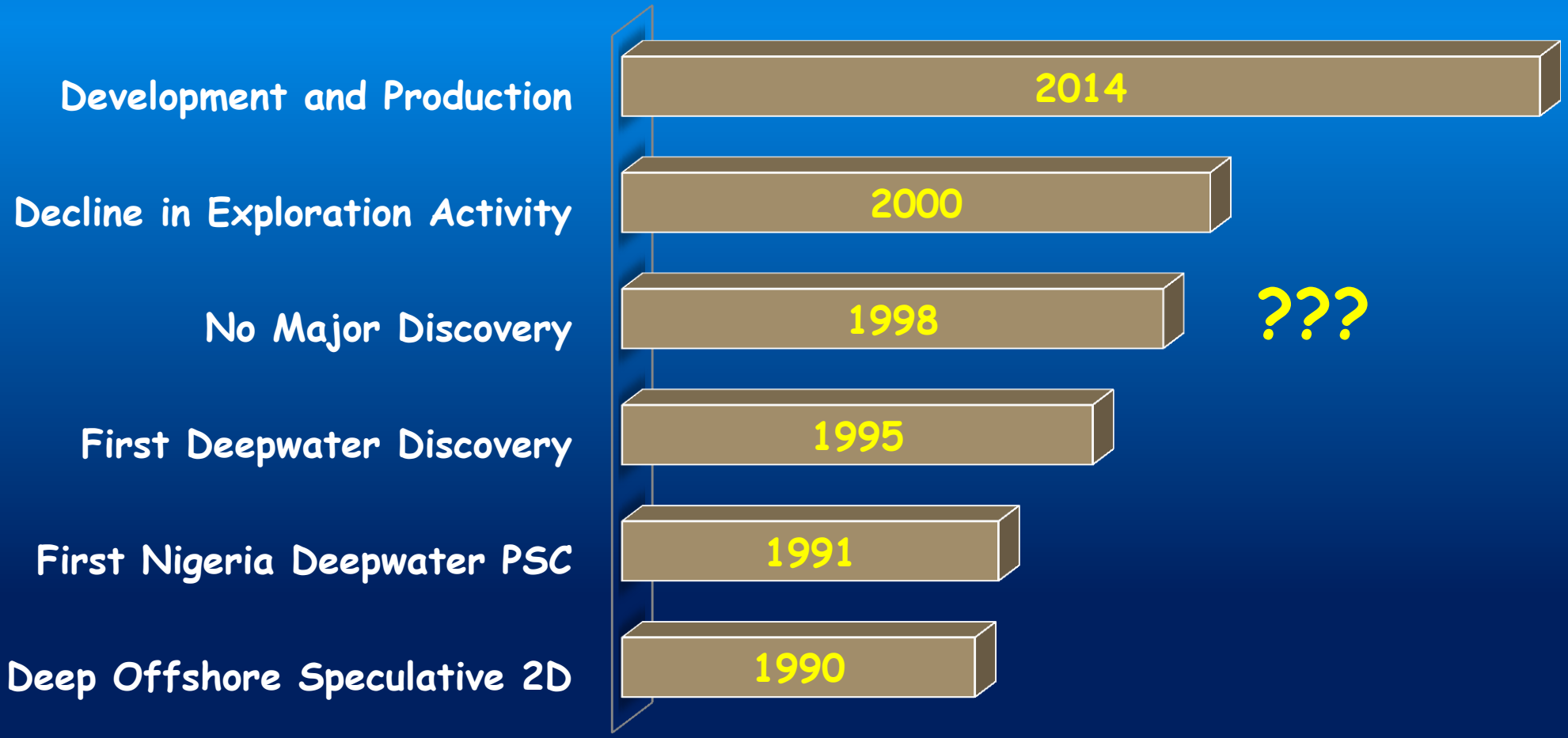
- 1975: First Gulf of Mexico discovery
- 1984: Brazil Campos Basin
- 1994: West African Angola discovery
- 1995: Nigeria Niger Delta discovery



Map showing Deepwater Golden Triangle

Introduction

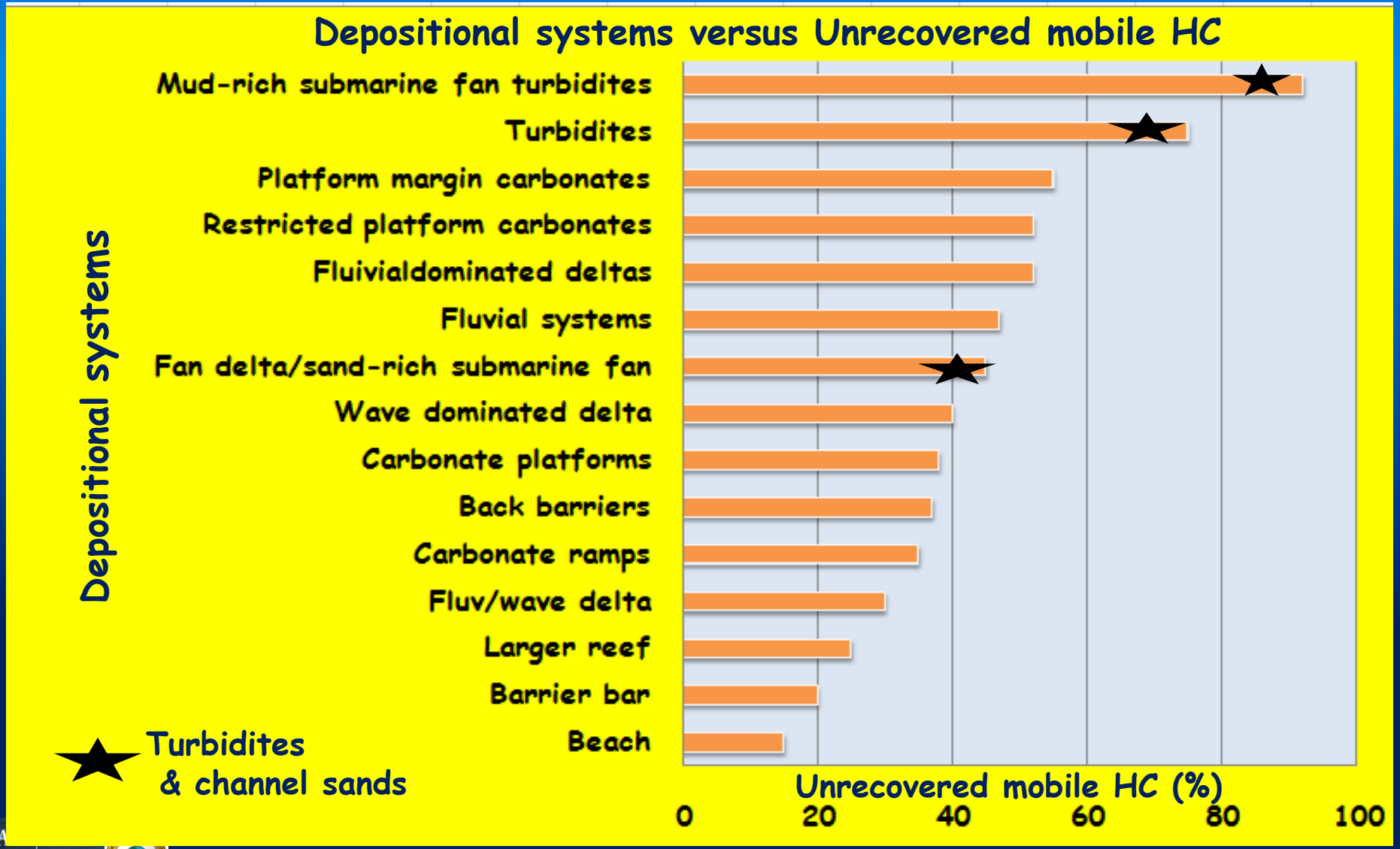
Niger Delta Deepwater Exploration History



Introduction

- Turbidites & channel systems are typical of deepwater Niger Delta

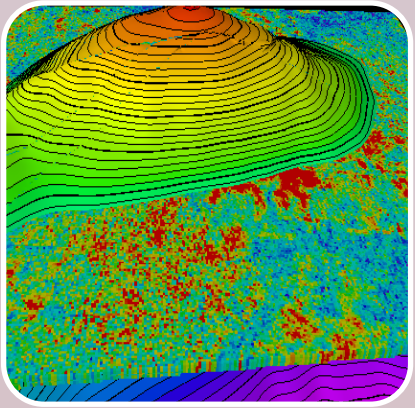
- More than 70% of unrecovered HC in turbidites & channel systems



(Modified from Tyler & Finley, 1991)

Introduction

Exploration/Production Uncertainties in Deepwater Turbidites & Channel Sands



Exploration

Uncertainties

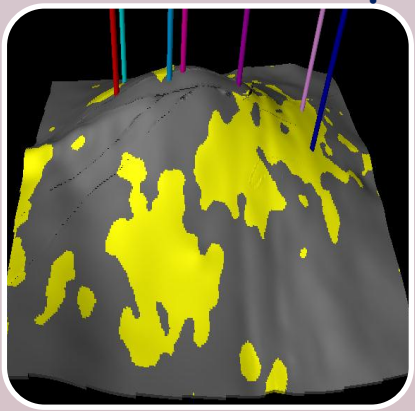
Reservoir presence

In-place oil & gas

Risk

Dry hole

Low discovery rate



Appraisal

Uncertainties

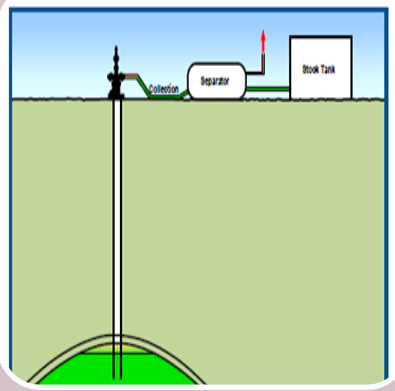
Resource size

Well location

Static RX

Risk

Poor development strategy



Development

Uncertainties

Dynamic RX

Drillability

Field performance

Risk

Cost escalation

Production

Production

Uncertainties

Optimal reserve

Field rate

Risks

Reserve replacement

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  - Seismic probability property modeling of turbidites and channel sand
-

Aim and objectives of study

- Aim of study
  - Reduce geologic uncertainty in deepwater environments
    - Well log correlation & reservoir prediction
    - Facies modeling of turbidites & channel sands
- Study objectives
  - Seismic characterization of turbidites & channel sands
  - Integrate neural network & seismic probability for robust reservoir modeling
  - Compare seismic probability property modeling and the use of variogram

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  - [illegible]
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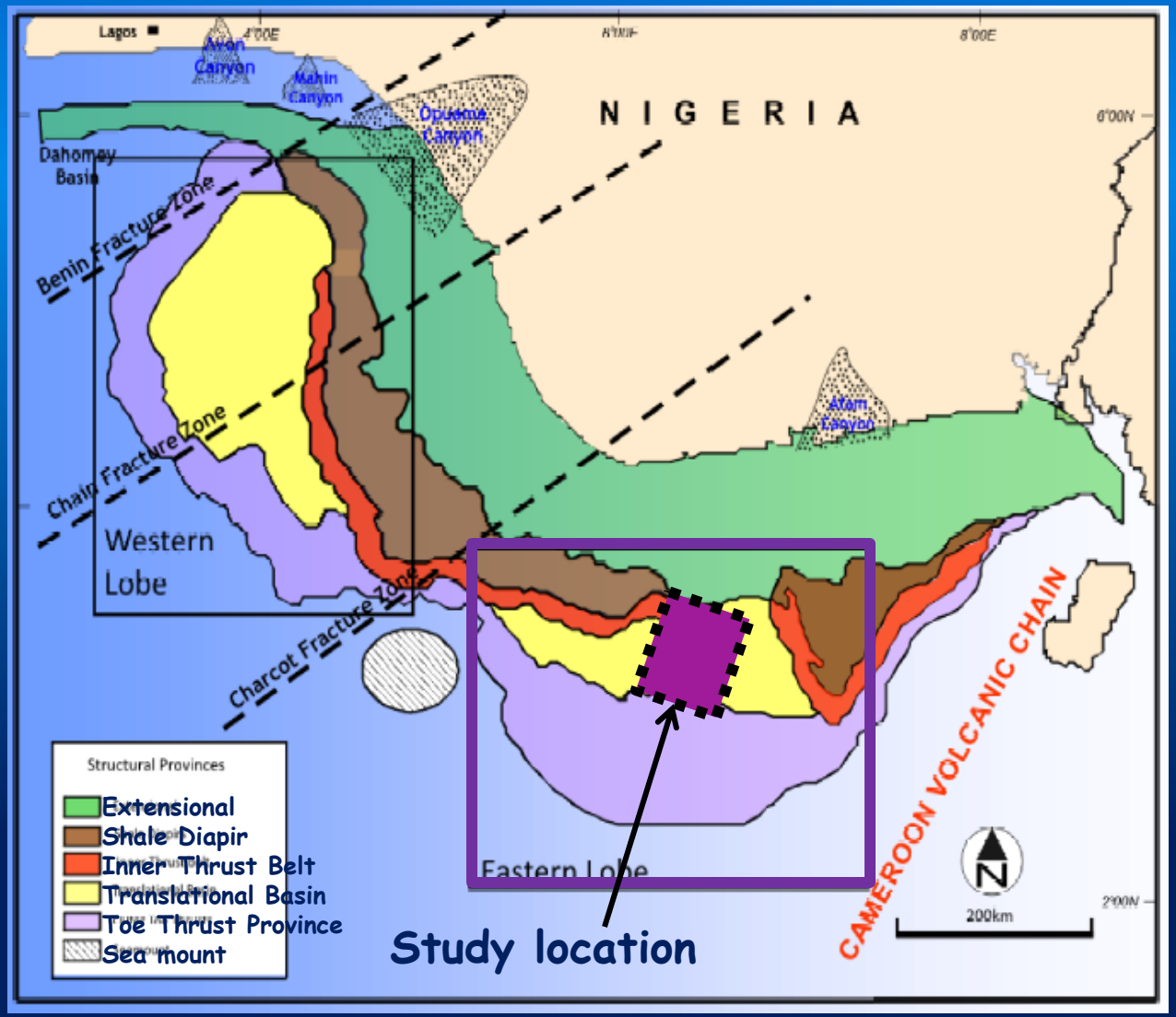
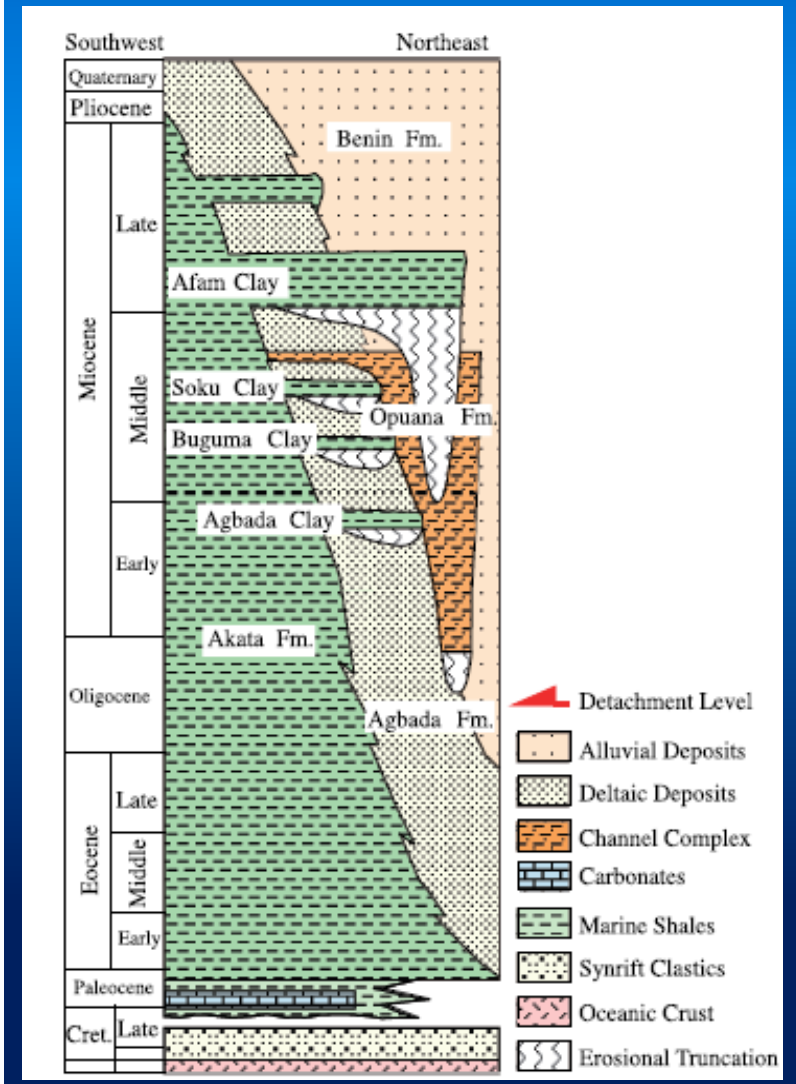
Location of study area & geology setting





Niger Delta map showing study location & Stratigraphic column (After Corredor et al., 2005; Doust & Omastola, 1990)

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  - [illegible]
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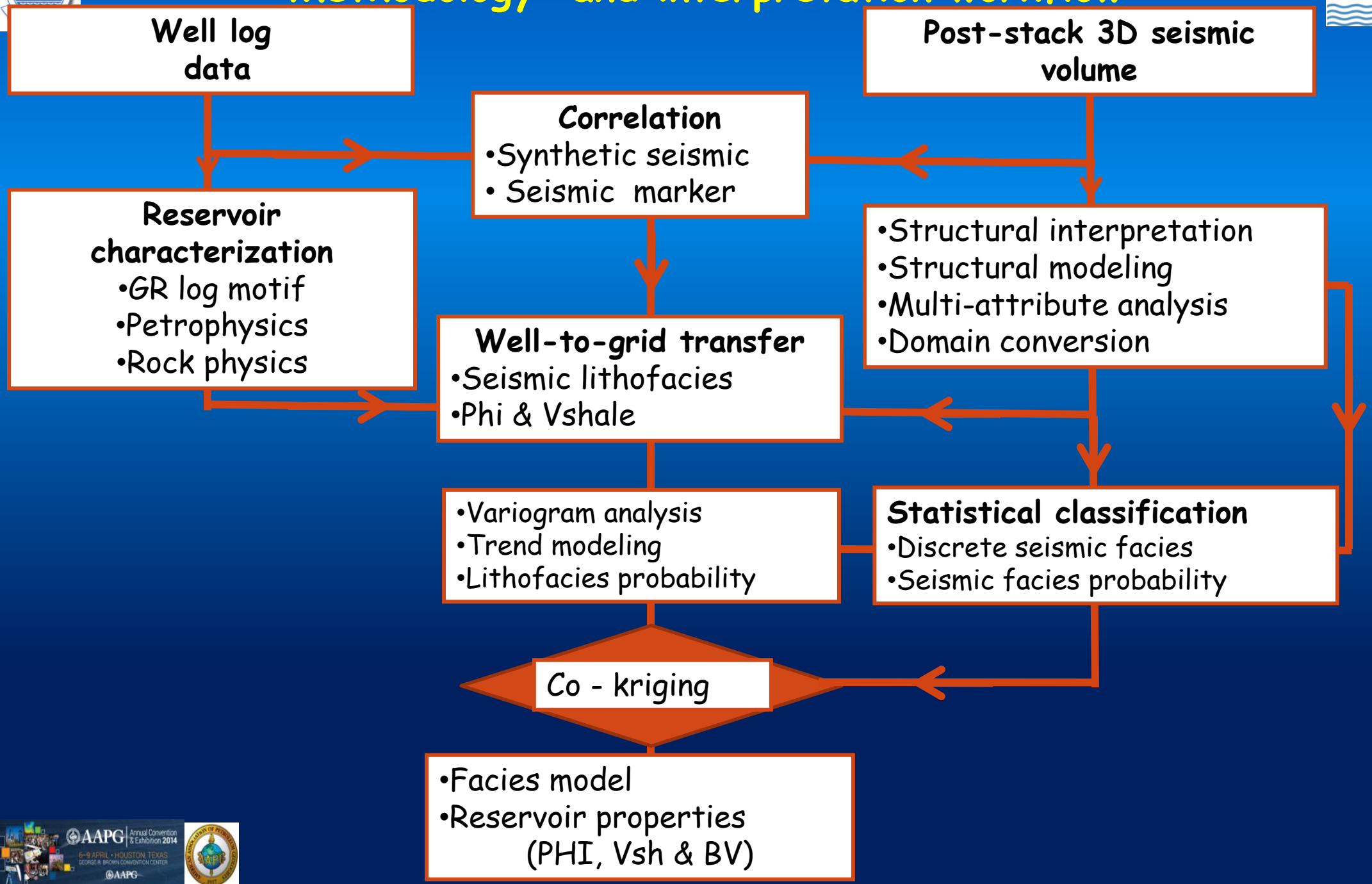
Methodology and interpretation workflow



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  - Probability property modeling of turbidites and channel sand
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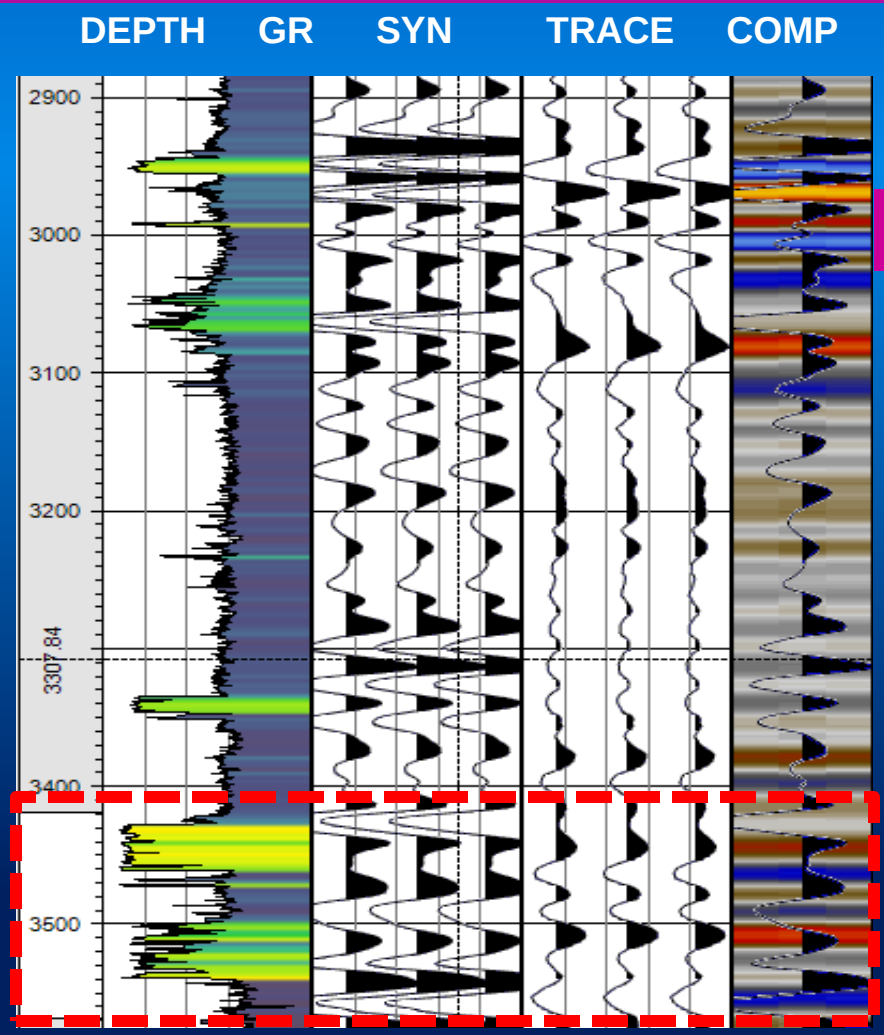
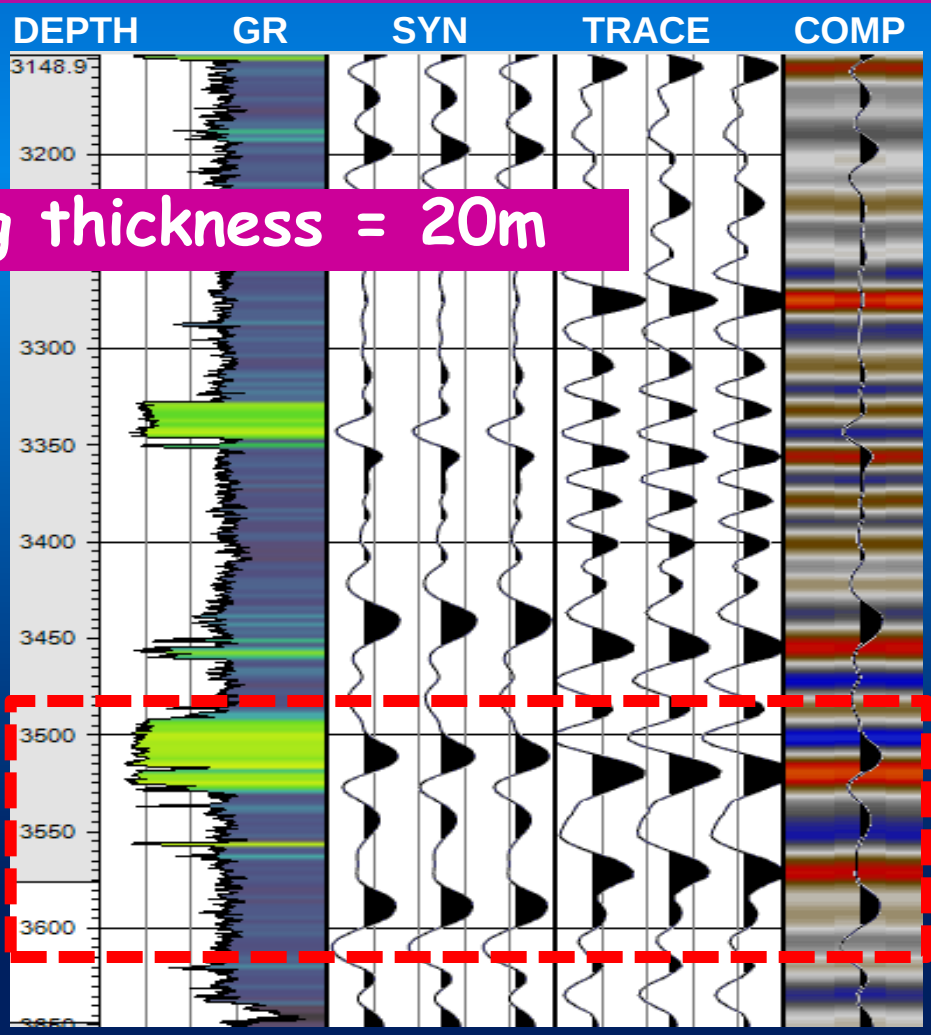
Well log analysis and rock physics characterization

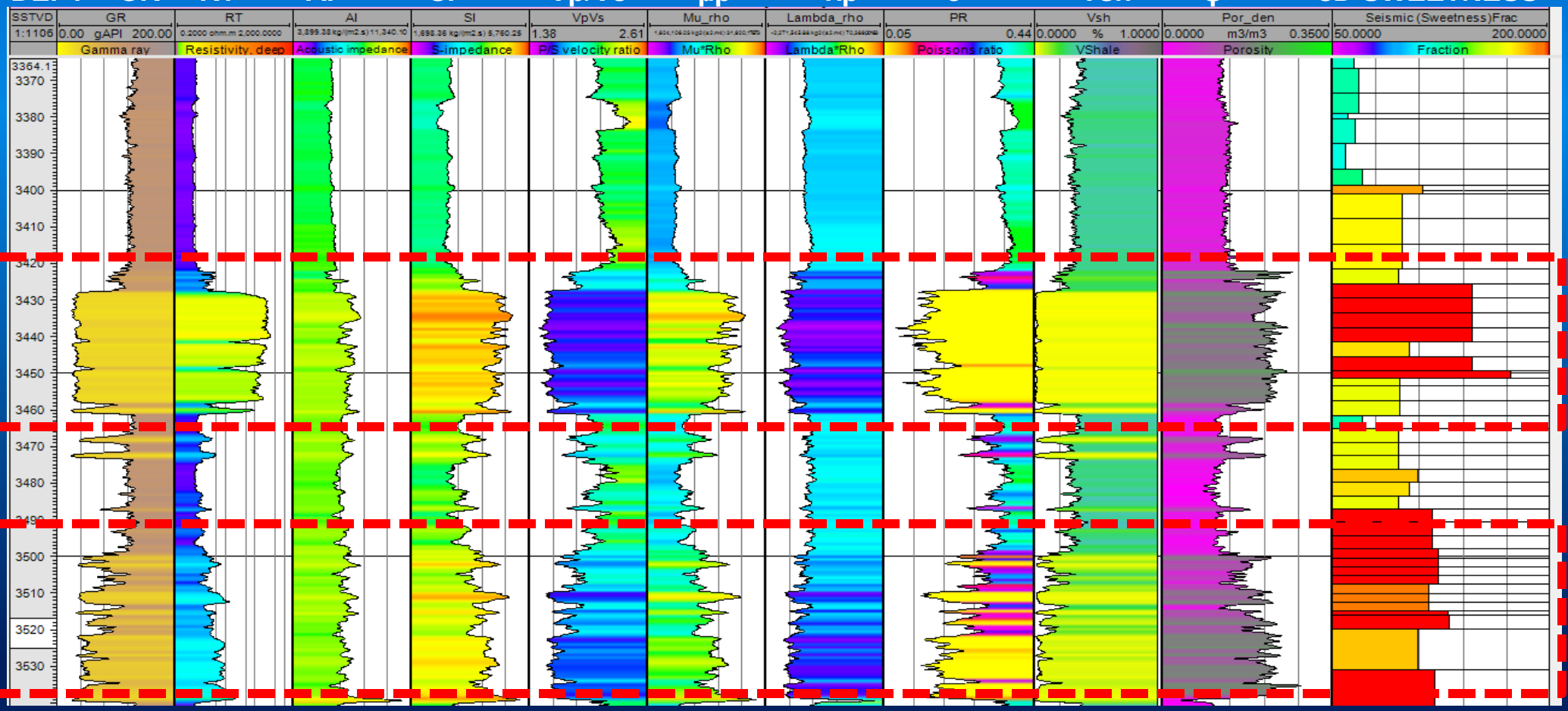


Tuning thickness = 20m



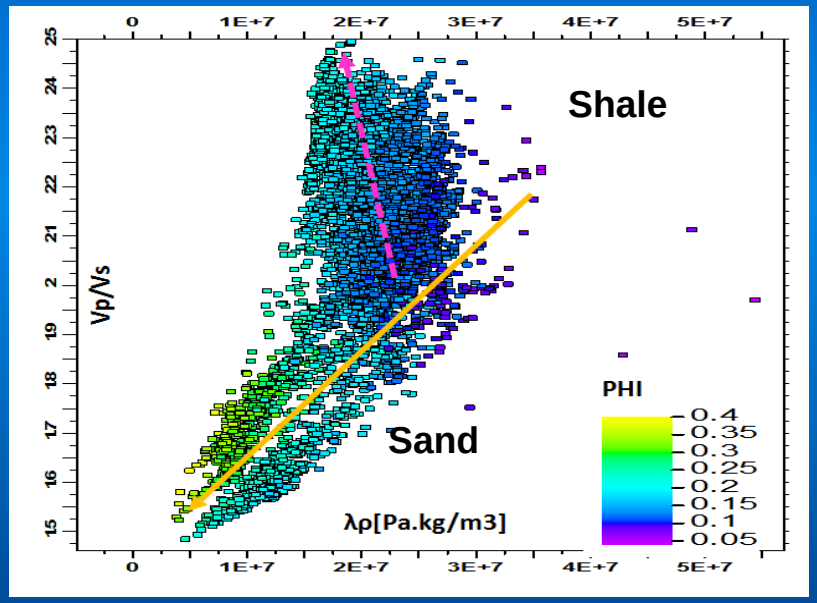
- Synthetic to seismic correlation across 2 wells

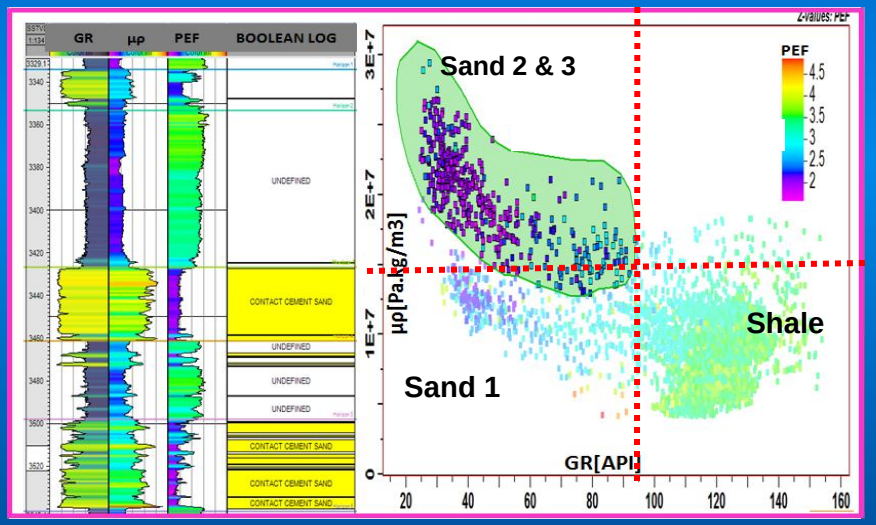
Well log analysis and rock physics characterization

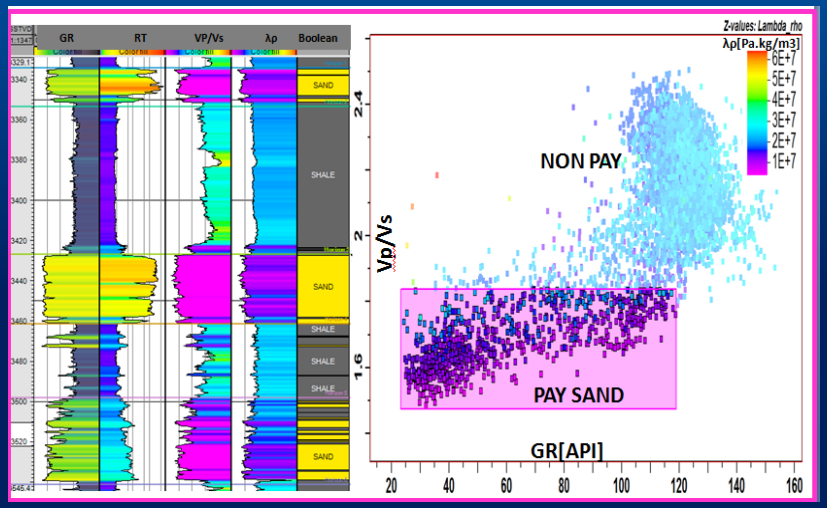


- Sand facies give relatively high sweetness & disctinct rock physics properties

Well log analysis and rock physics characterization



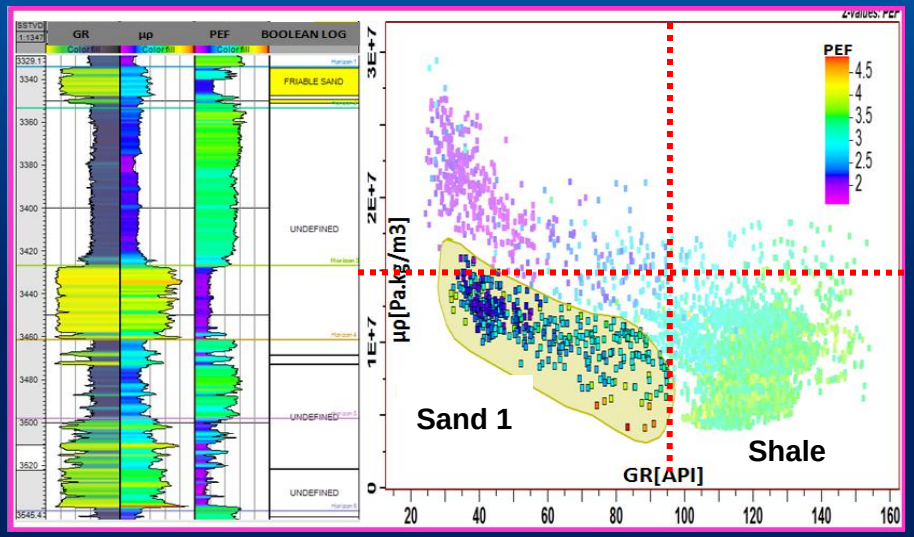




Sand 1
17m

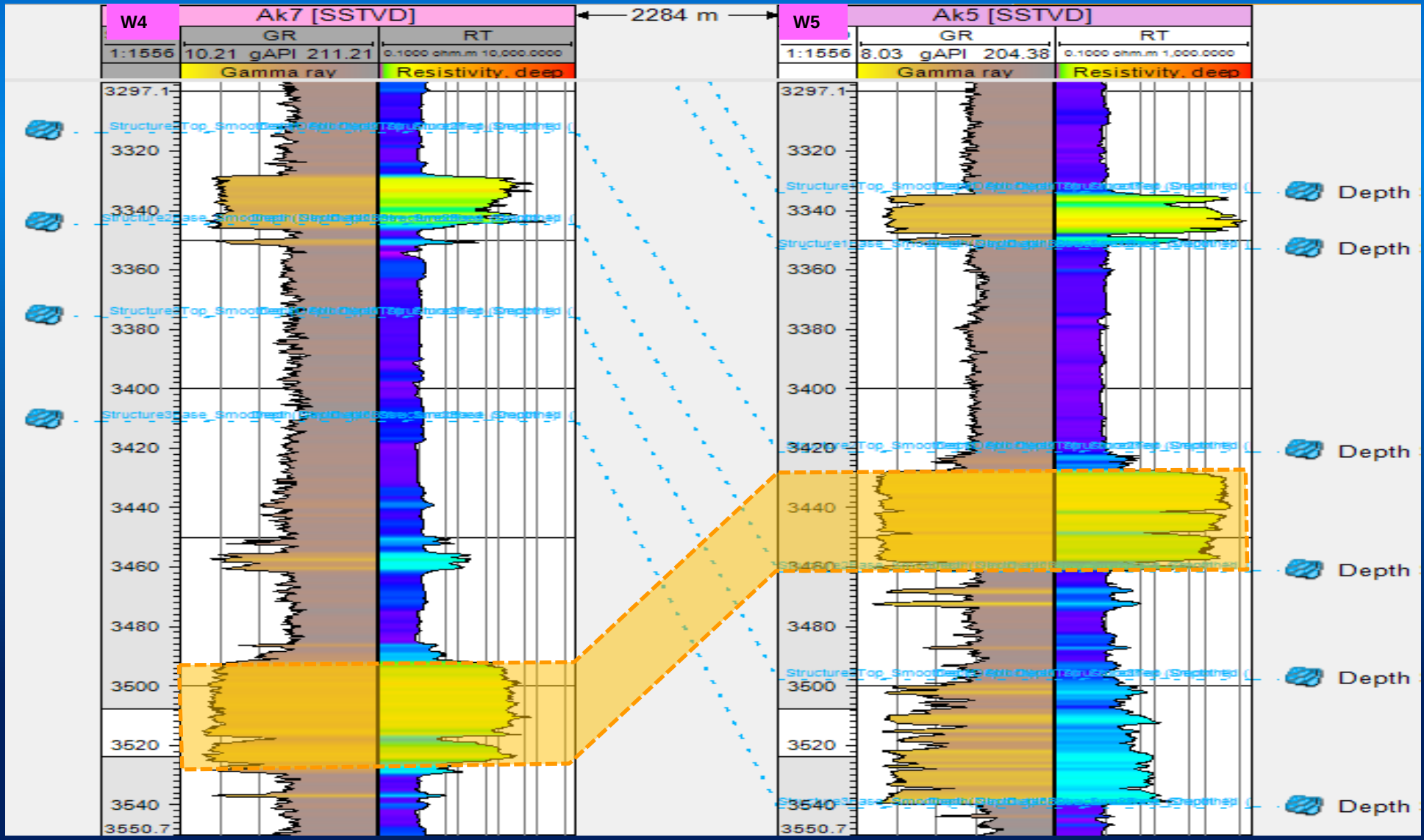
Sand 2
34m

Sand 3
40m



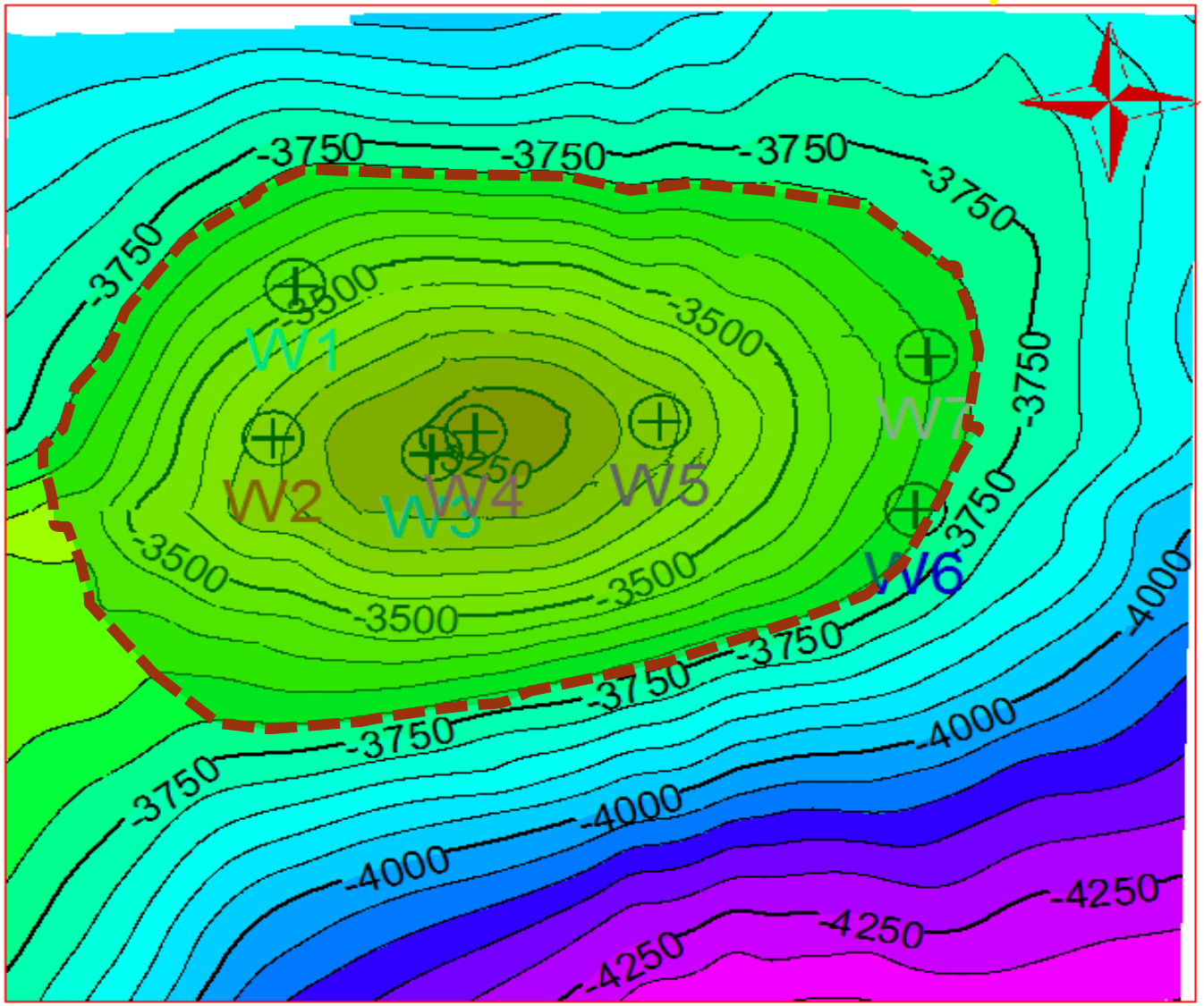
Rock physics properties characterization of lithofacies

Well log analysis and rock physics characterization



Diachronous surfaces across wells

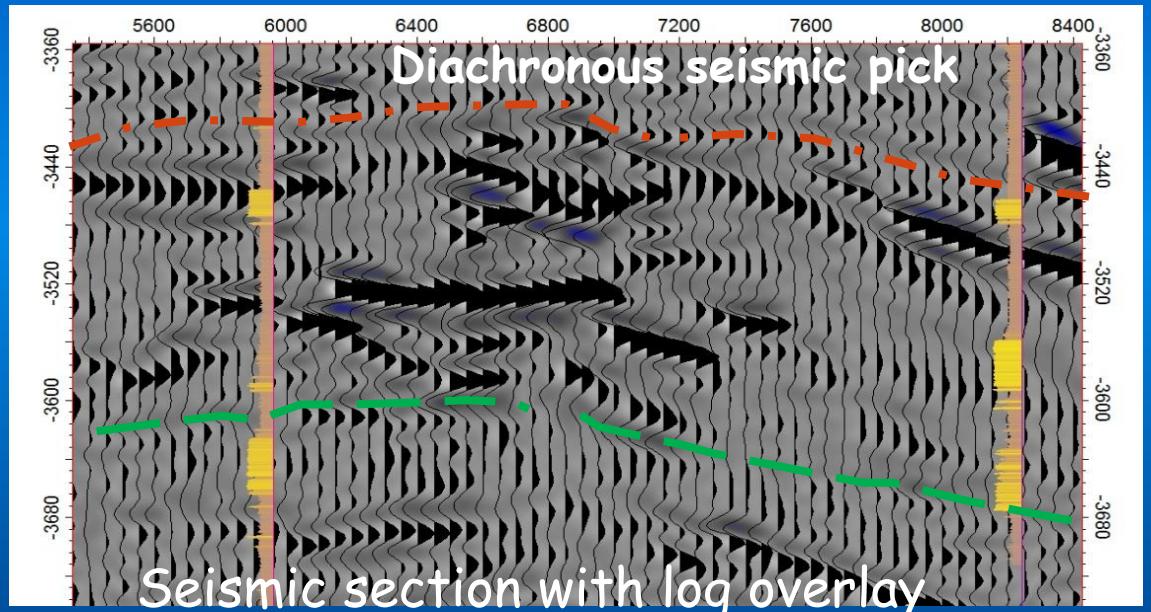
Post-stack seismic attributes analysis



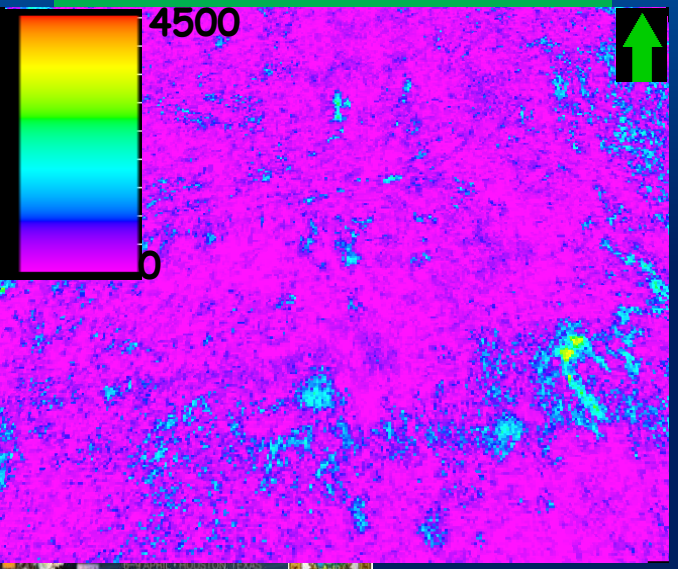
Structural map

Post-stack seismic attributes analysis

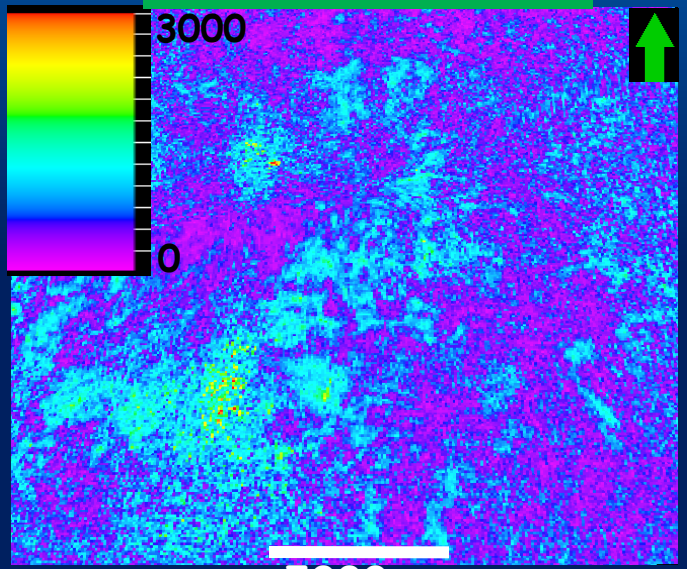
- Multi-attribute analysis
  - Attribute contrast
  - Seismic facies trend
  - Architectural pattern



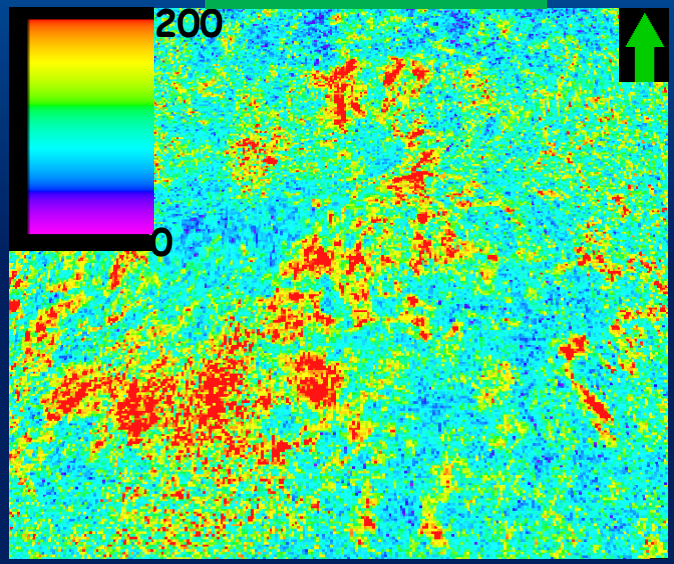
ACOUSTIC IMPEDANCE



RMS AMPLITUDE

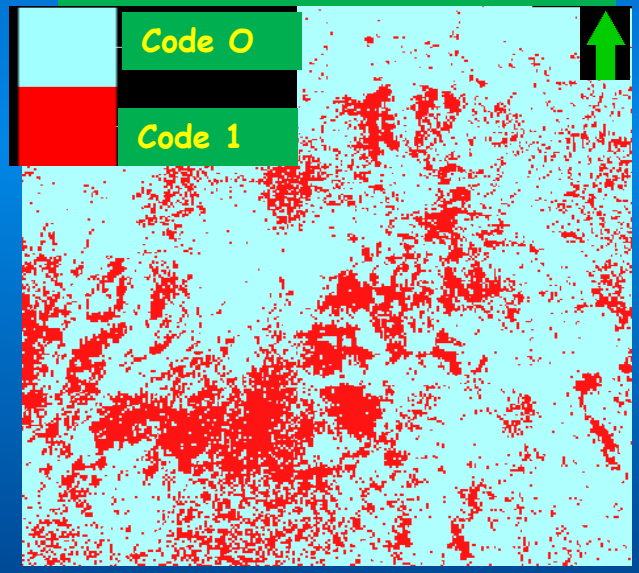


SWEETNESS

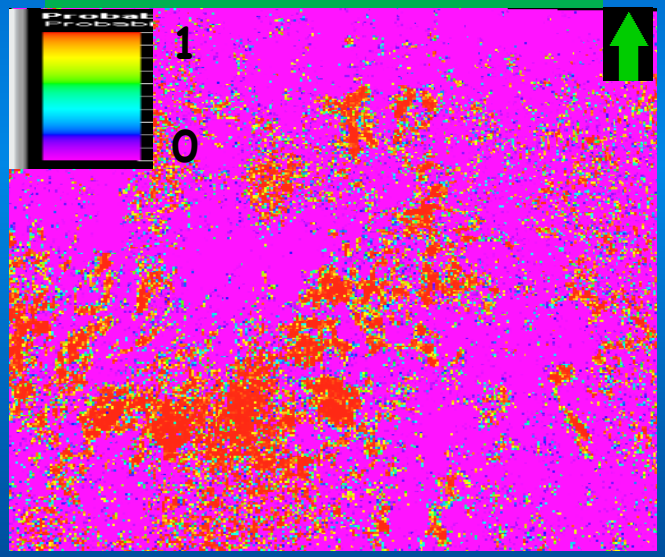


Variogram analysis and trend modeling

DISCRETE FACIES



Code 1 PROBABILITY



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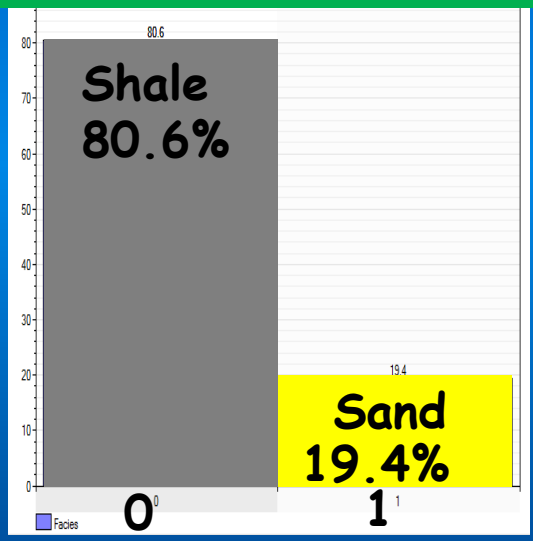
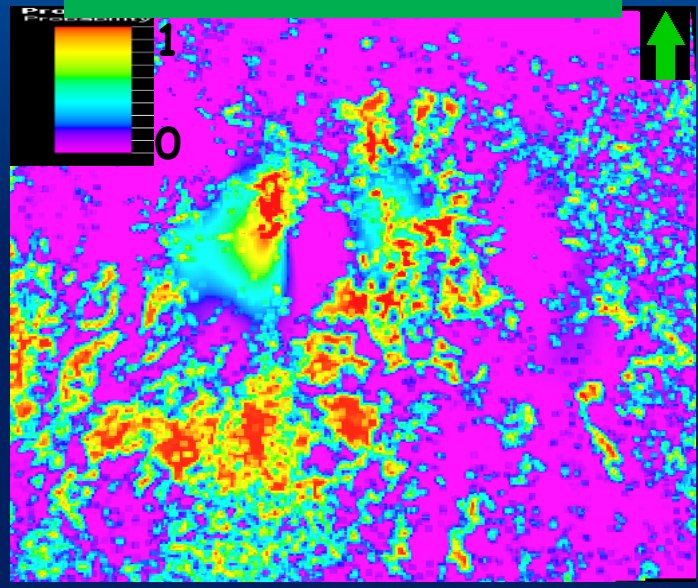
UPSCALED LOG FACIES



- Variogram analysis & kriging of seismic lithofacies
  - Sand & shale probability output
  - Omni-directional variogram for shale
  - Anisotropic variogram for sand

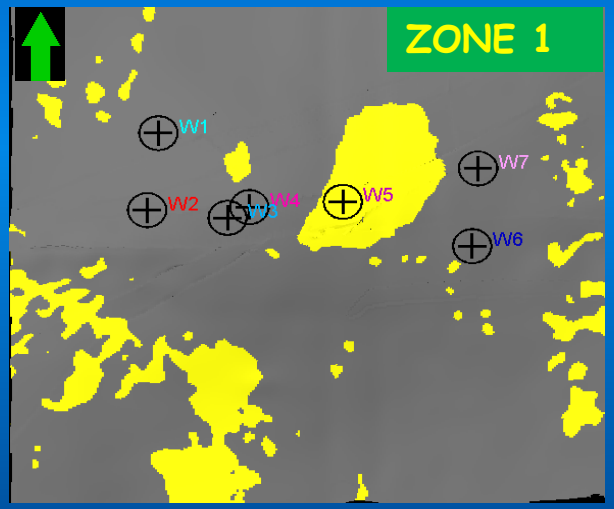
=

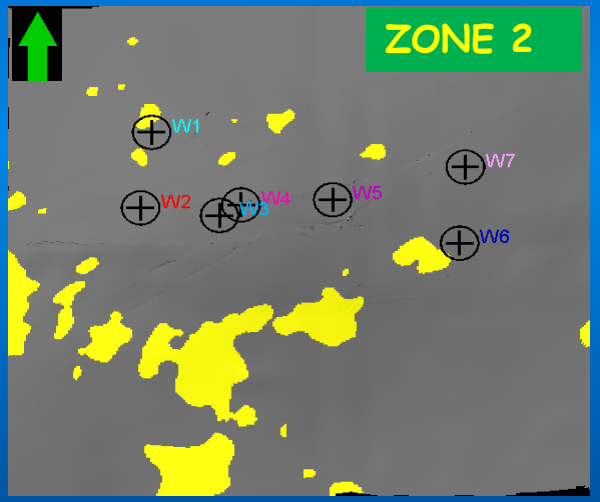
SAND PROBABILITY

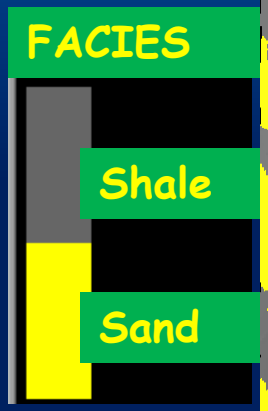


Probability property modeling of turbidites and channel sand

- Turbidites & channel sand
  - Seismic lithofacies
  - Sand probability
  - Assign value
  - Facies model

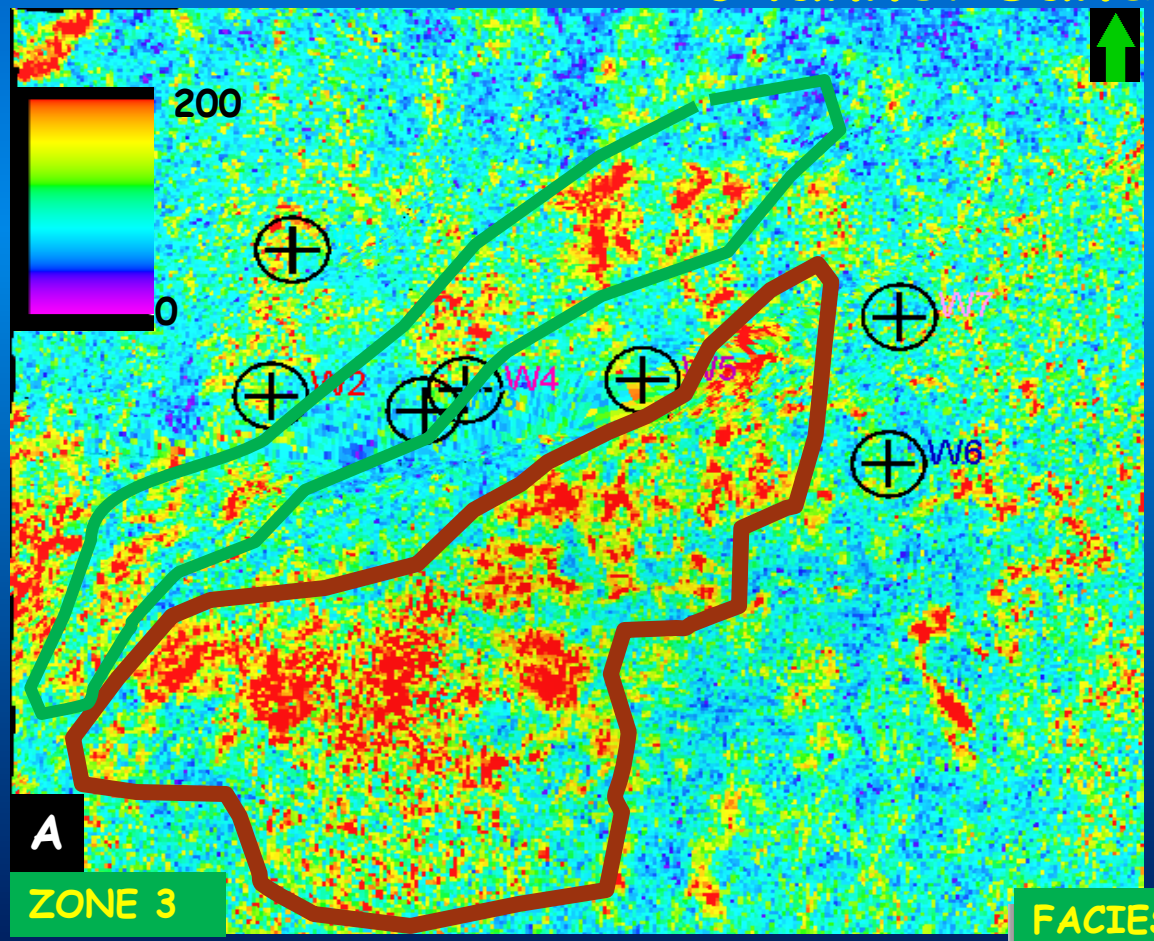


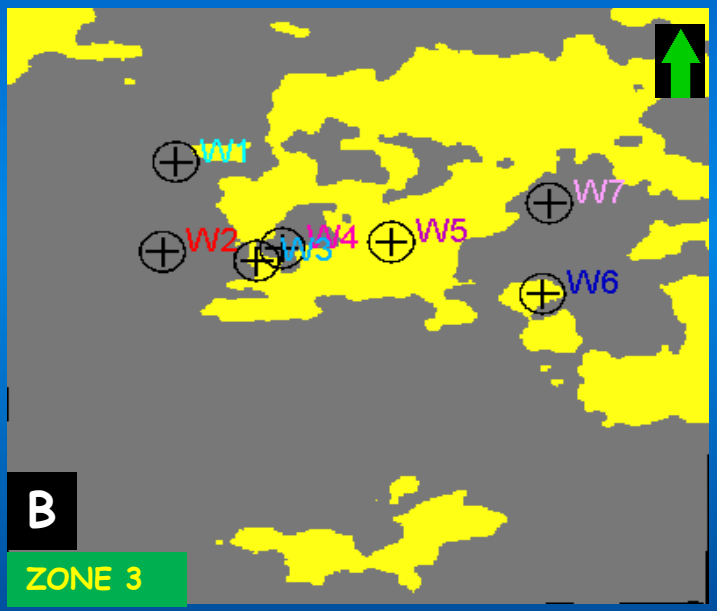


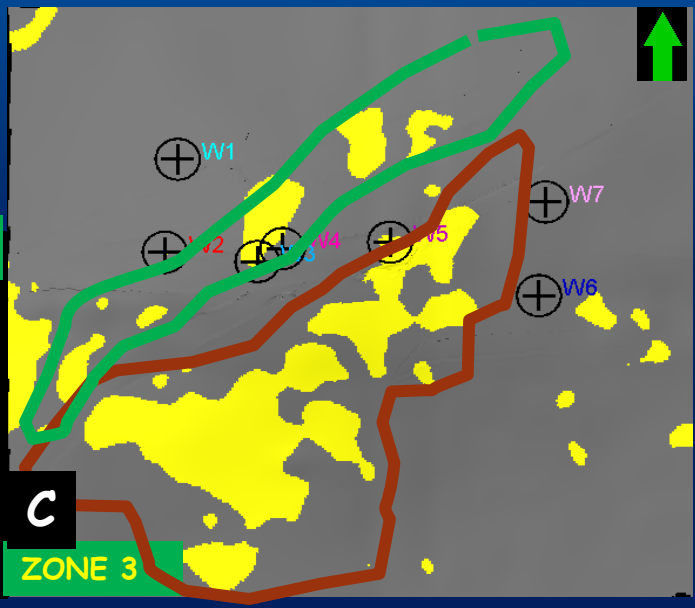


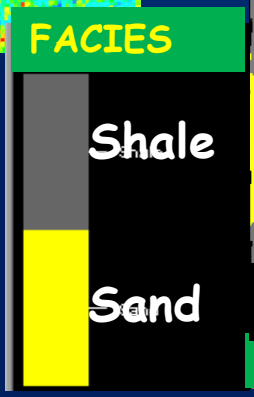
5000m

Probability property modeling of turbidites and channel sand







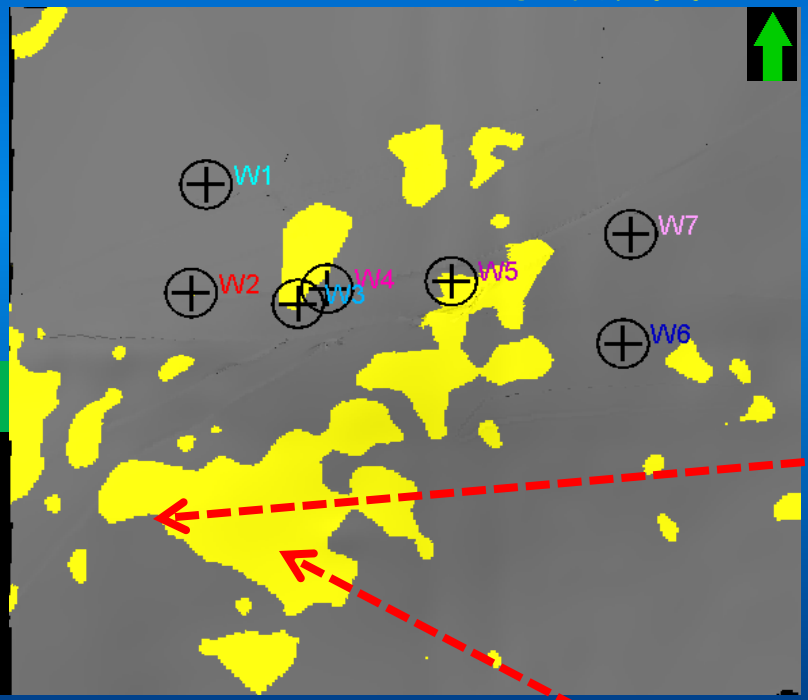


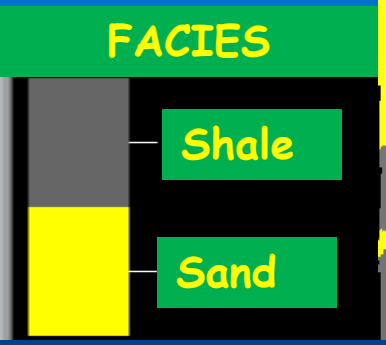
A. Seismic attributes AF pattern

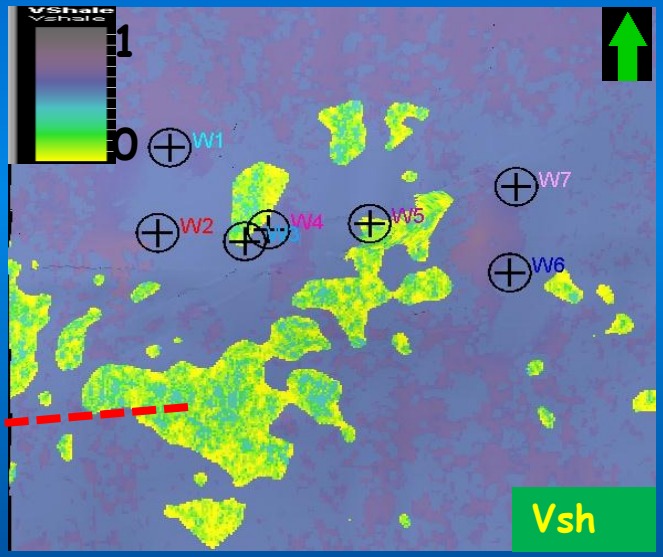
B. Variogram-based facies model (SGS)

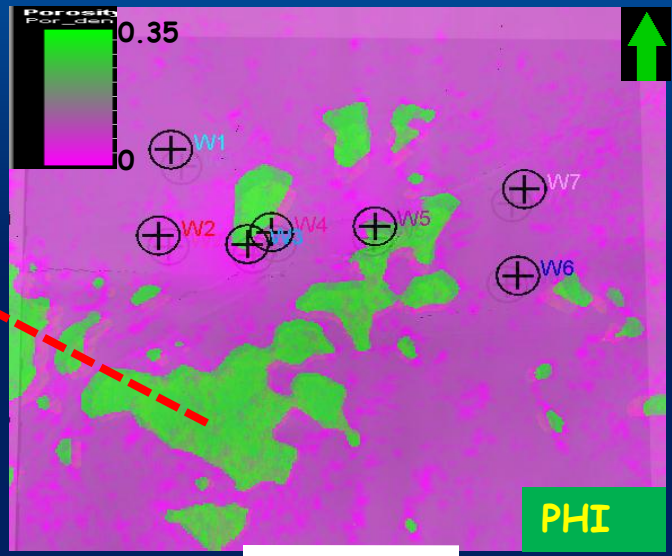
C. Seismic probability-based facies model

Probability property modeling of turbidites and channel sand





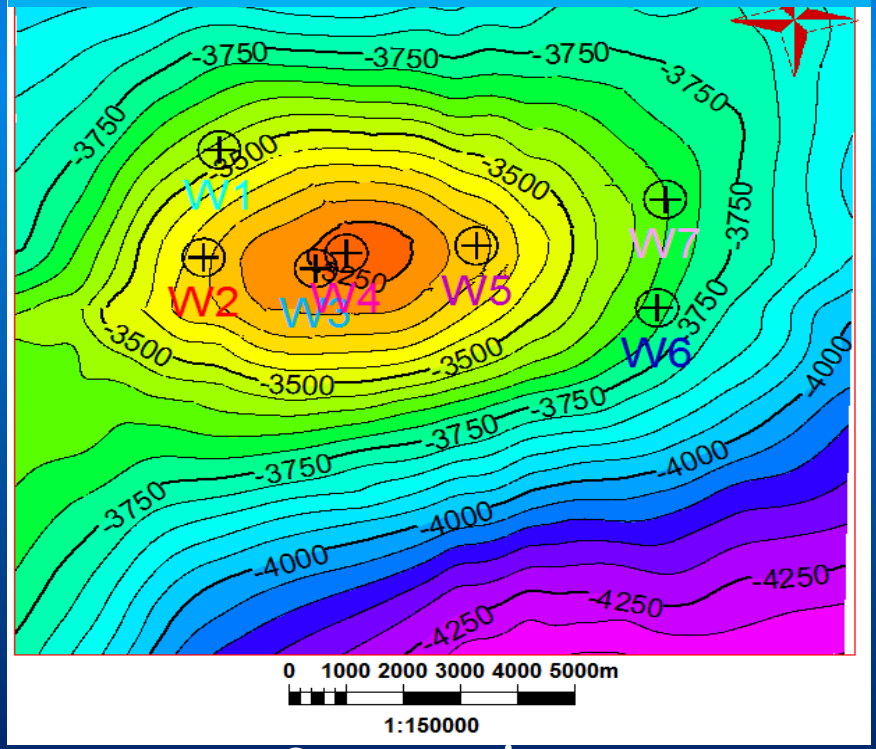




- Turbidites & channel sands facies
  - SGS of petrophysical inputs
  - Anisotropic variogram model
  - Co-kriging with sand probability
- Good correlation of Vsh & Phi with facies

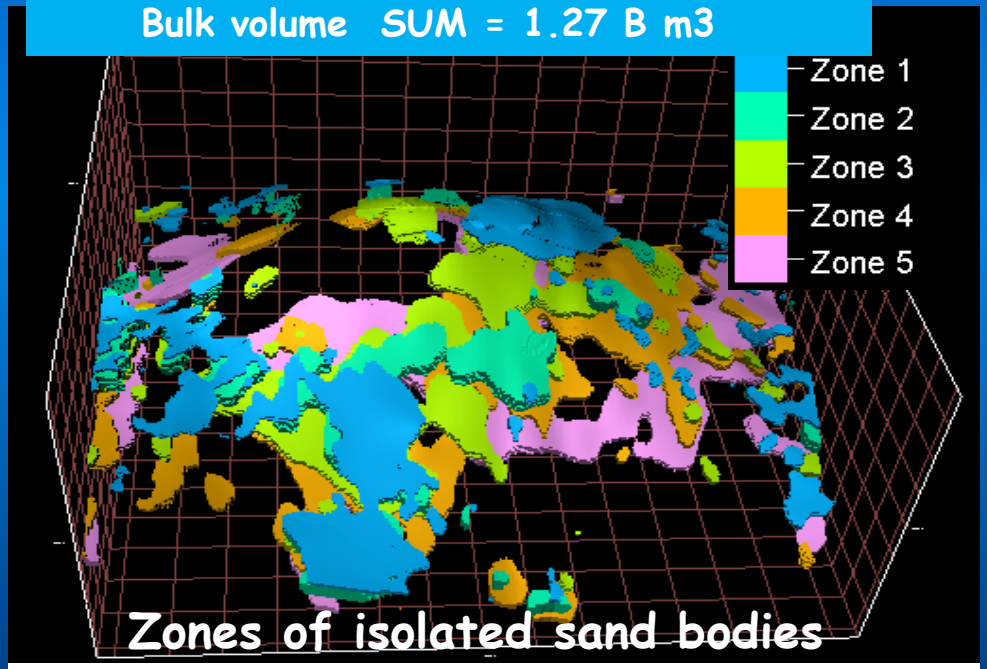
Probability property modeling of turbidites and channel sand

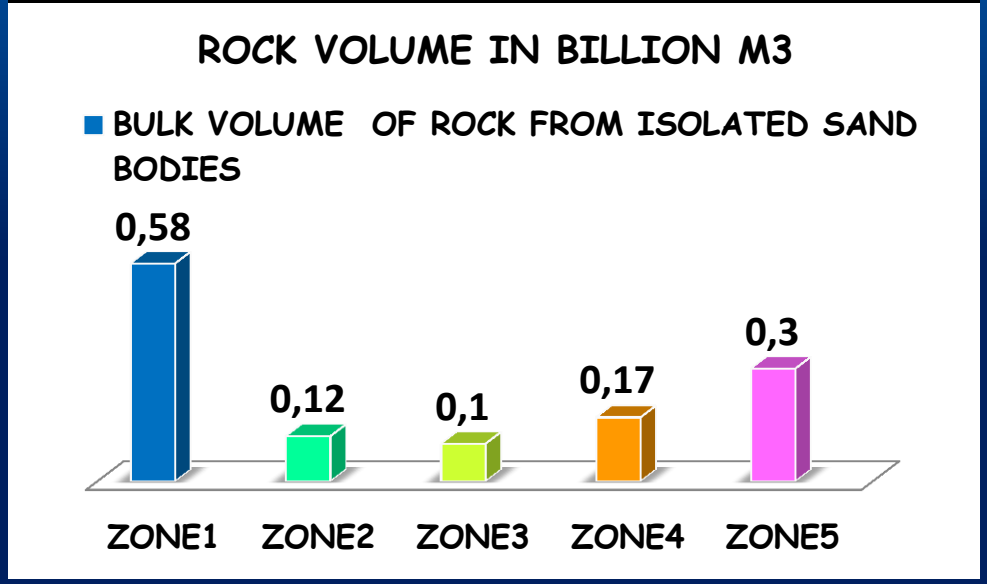
Pre-drilled Bulk volume @ 3560m= 5.9 B m3



Structural map

Bulk volume SUM = 1.27 B m3





- Reduction in volumetric uncertainty

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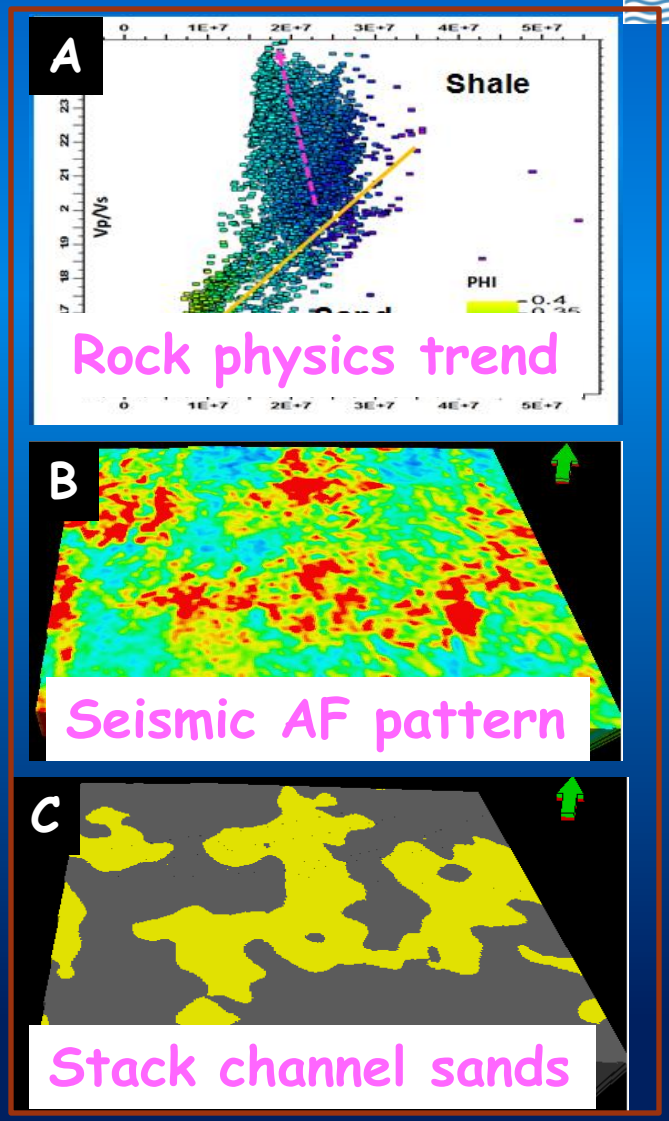
  - [illegible]
- Summary and Conclusion

Summary and conclusion

- Robust characterization & prediction of facies
  - High mu-rho & SI, low PR & Vp/Vs
  - High instantaneous attribute responses
- Litho-seismic attributes
  - RMS amplitude & instantaneous amplitude
  - Sweetness & reflection strength
- Reduce uncertainty in pre-drill volumetrics
- Reduce uncertainty in the geologic model
  - Reservoir characterization
  - Inter-well petrophysical modeling
- Robust field development strategy
- Seismic resolution, tuning-bed thickness, Vsh, burial history



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- AAPG

- SAPETRO, Total and partner companies including, CNOOC, PETROBRAS, NNPC and DPR

Thank you for listening

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