Improving Static Reservoir Modelling through Integration of Quantitative Seismic Data

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Presentation Outline

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- **Objectives**
- **Introduction and Reservoir description**
- **Inversion fundamentals and Workflow**
- **Results**
  - Co-Krigging Modeling Results
  - Reservoir Property Variations (Porosity distribution) and GU/Flow Unit controls
- **Conclusion**

Objectives

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- Derive acoustic impedance and porosity relationships
- Generate a seismic-porosity model
- Construct a reservoir model with seismic-derived porosity as a secondary property

Introduction – location and geology

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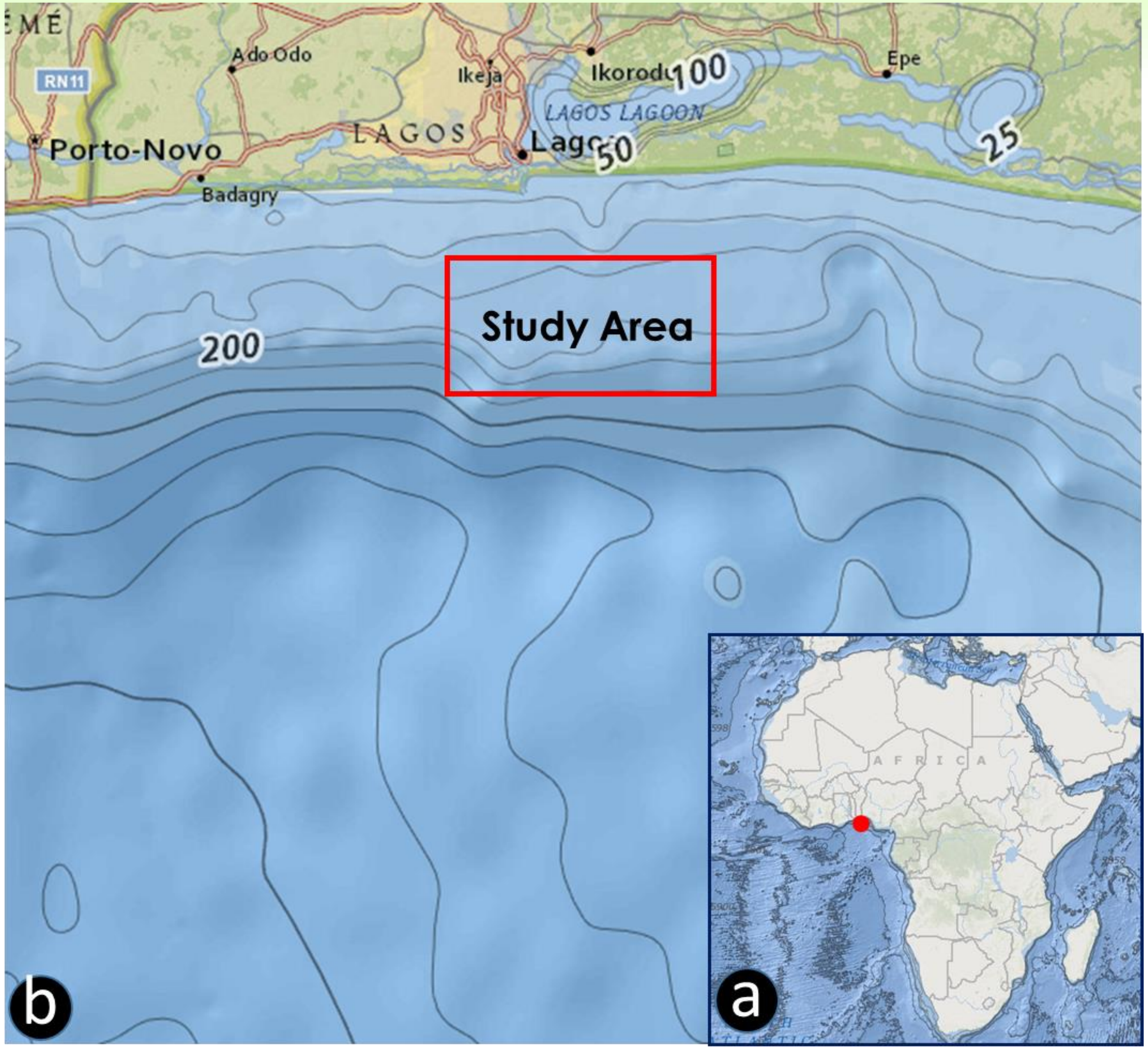
- **Located shallow offshore Dahomey Basin**
- **Rifted basin (half-graben), part of WARS**
- **Structural style: normal and strike-slip faults**
- **3 Discovery Fields**

Stratigraphy

Benin/Ijebu Fm
Afowo Fm
Oshosun Fm
Imo Fm
Araromi Fm
Awgu Fm
Abeokuta
Albian Sanstone
Ise Fm

(Franck d'Almeida, 2016)



Introduction – Depositional Envt and Facies Belts

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Fluvial-Shoreface Depositional Setting

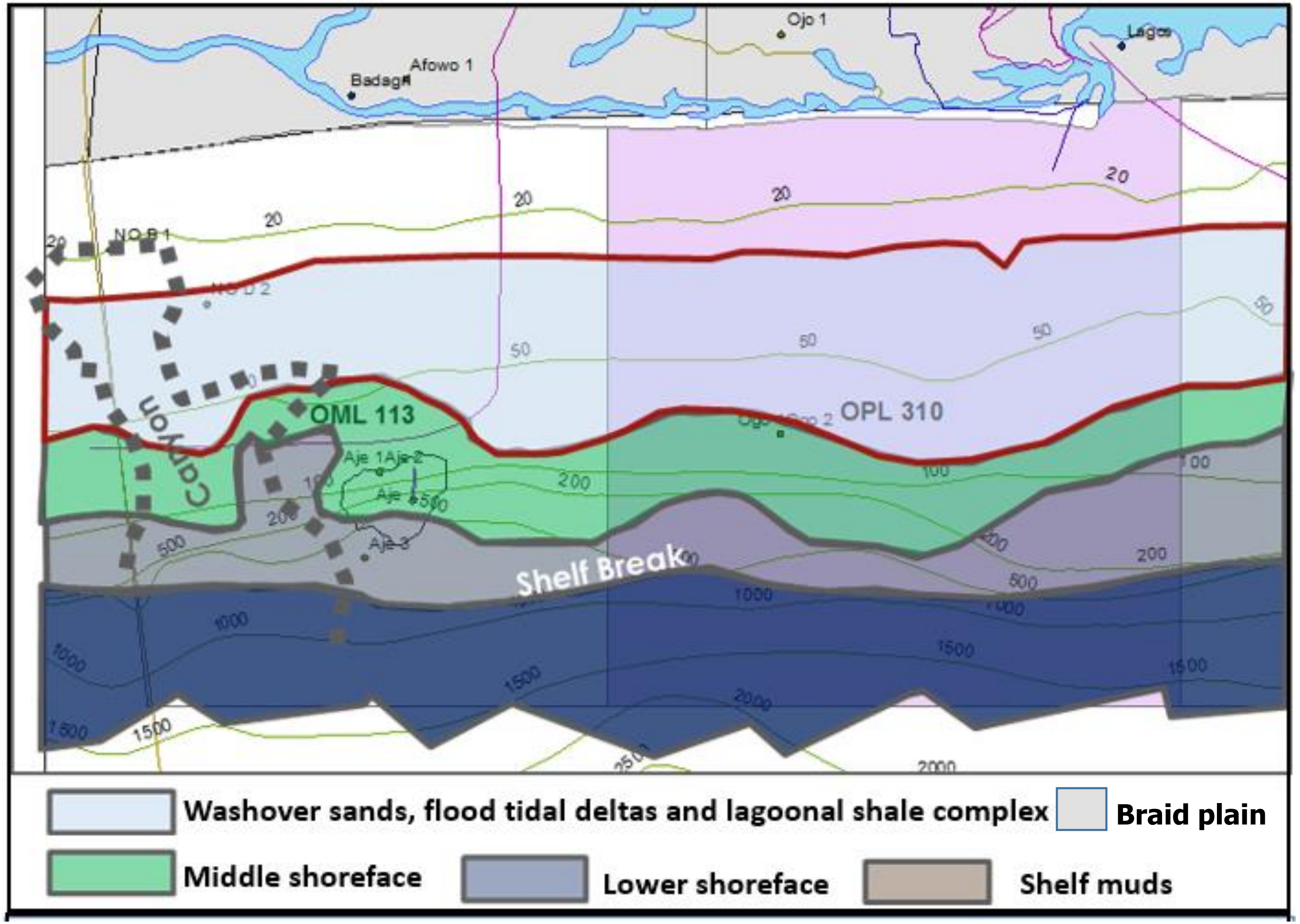
E – W Palaeo-shoreline

Depositional genetic Units

- Back barrier
- Washover sands
- Lagoons
- Tidal deltas
- Mouth bar
- Braidplain and braid bars

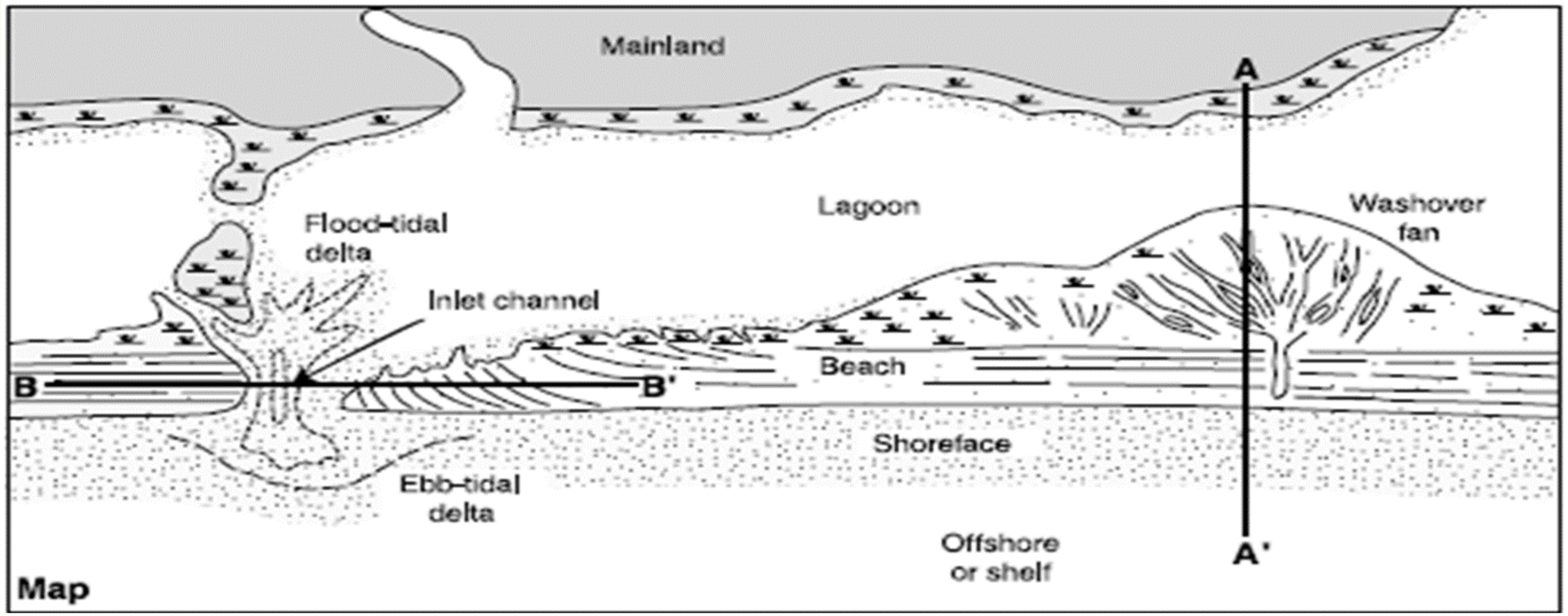
Controls on Depositional Facies and Reservoir Quality

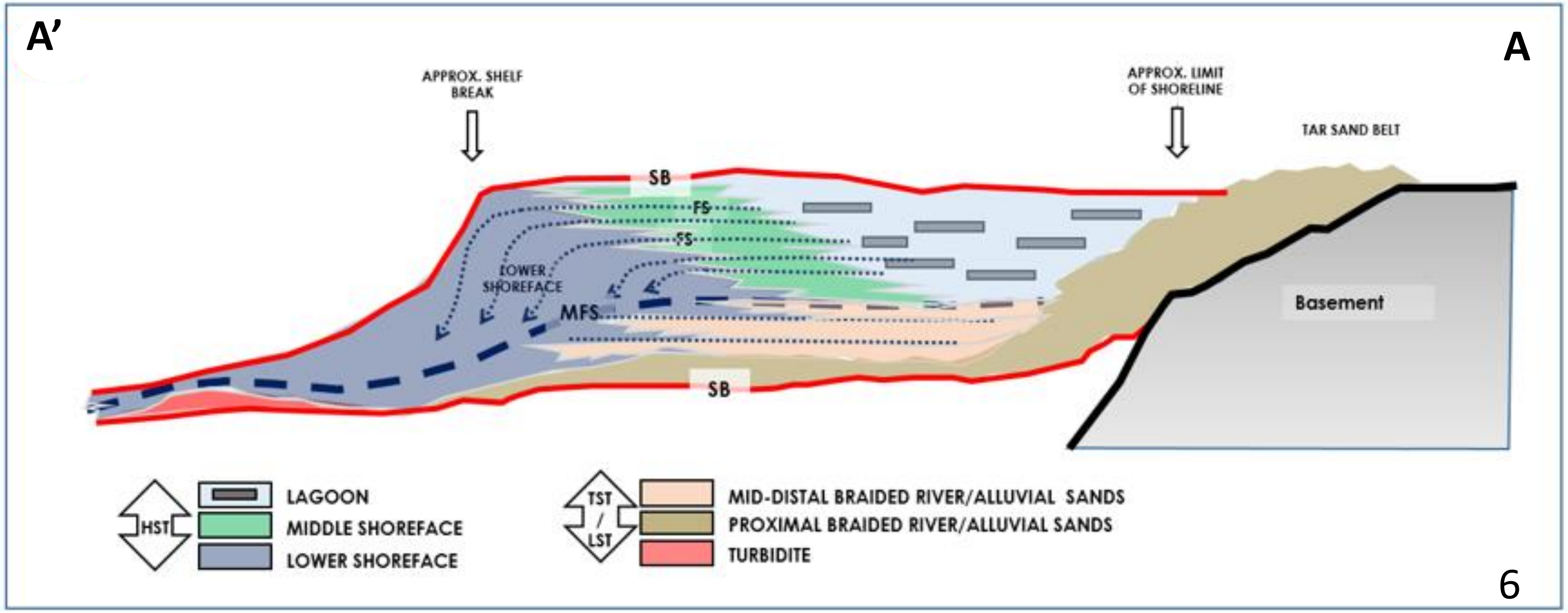
- Sea level variations
- Distance from palaeo-shoreline



Depositional Analogue and Architecture of Genetic Units

- **Facies belts are parallel to paleo-shoreline**
- **Facies Associations and Genetic Units reflects position and distance from the paleo-shoreline**
- **Reservoir quality changes basin ward of the shoreline i.e. increase authigenic carbonate cements**





Reservoir Zonation and Layering

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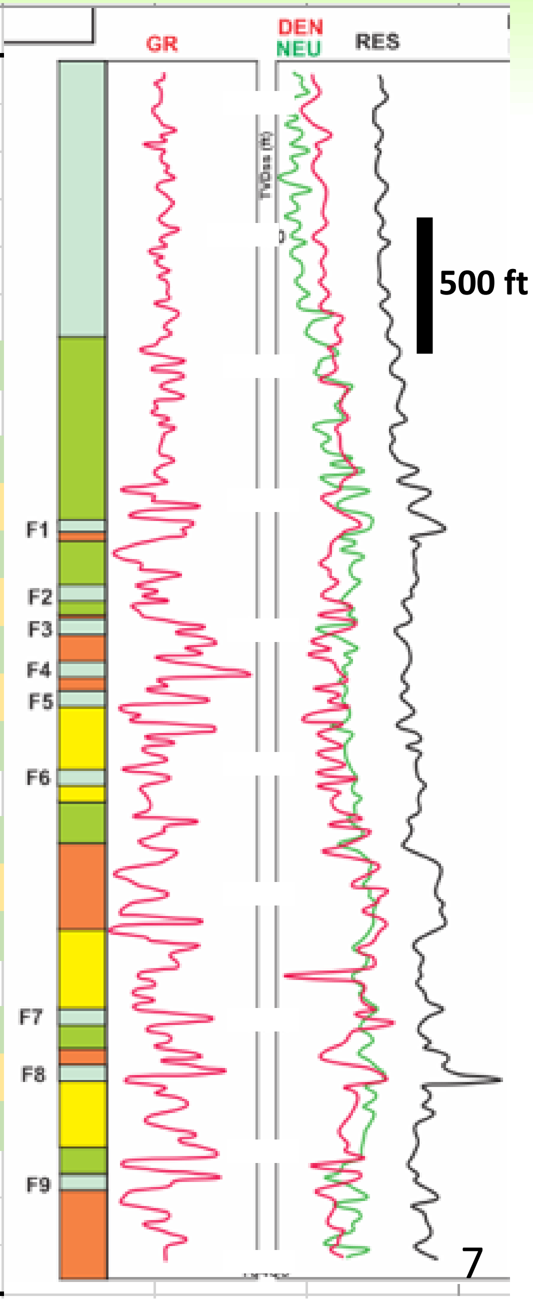
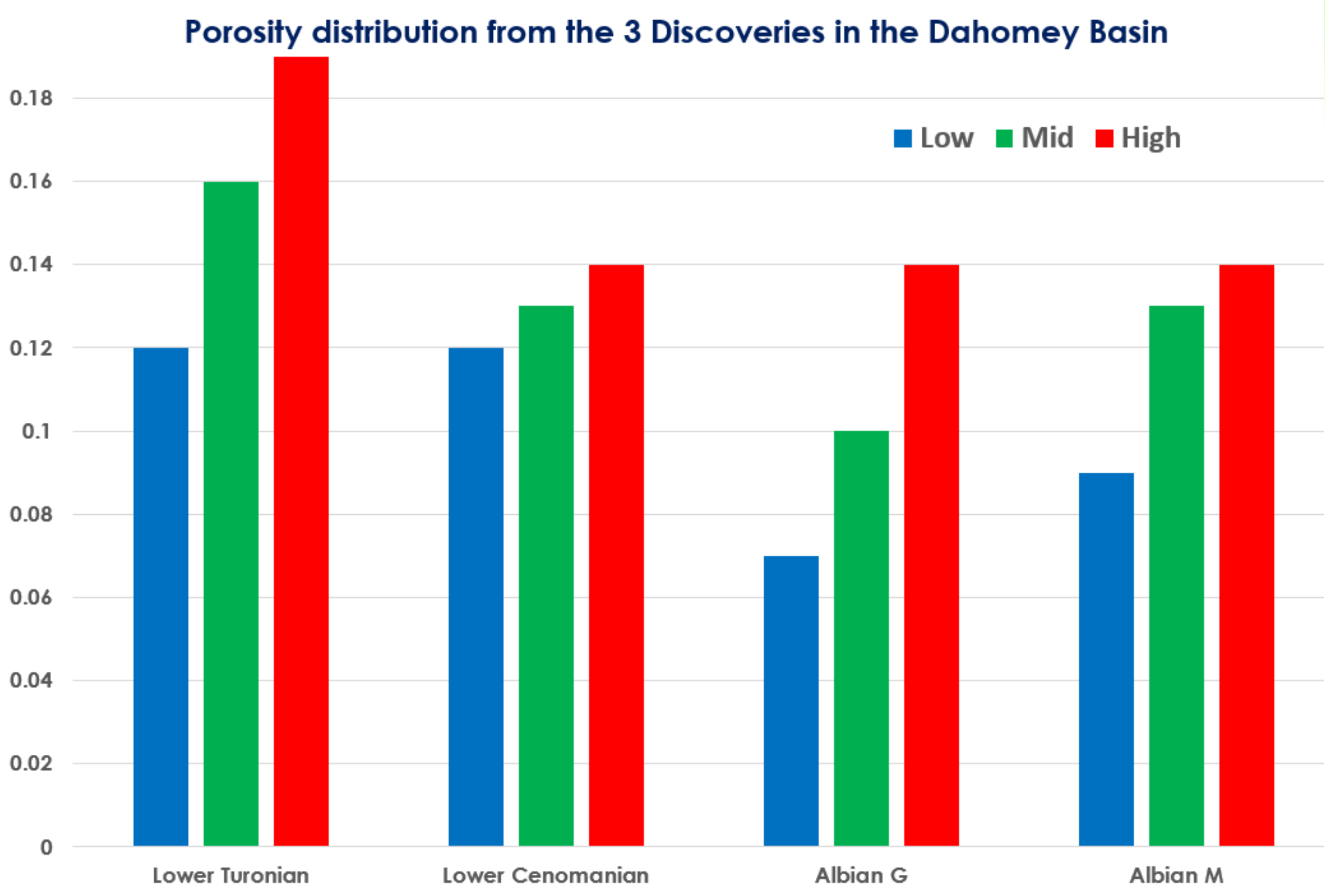
- **Key surfaces and flooding events correlated across basin (H1 to H9)**
- **Higher resolution stratigtraphic zonation achieved from stacking patterns of characteristic Genetic Units in the wells, defined by FS & SBs**
- **Reservoir Flow Units are separated from major flooding events and SBs**
  - Flooding Shales are 9 – 36 ft thick
  - SBs defined by multi-well logs breaks and seismic terminations
- **Characterization of Genetic Units is based on**
  - Higher order GUs (4th Order)
  - & Petrophysical properties

Kaki et. al. (2013)	This Study	Name
H2		Mid-Miocene Unconformity
H3		Base Miocene Unconformity
Intra-Imo FM		Eocene Unconformity
H4		Top Araromi Fm
Intra-Araromi FM		Mid-Maastrichtian Unconformity
H5		Maastrichtian Unconformity
	F1	Flooding Event
H6	SB4	Top Abeokuta Sandstone
	F2	Flooding Event
		Flow Unit
	F3	Flooding Event
		Flow Unit
	F4	Flooding Event
		Flow Unit
	F5	Flooding Event
H7	SB3	Early Cenomanian Sandstone
	F6	Flooding Event
		Flow Unit
	F7	Flooding Event
H8	SB2	Mid-Albian Unconformity
	F8	Flooding Event
		Flow Unit
	F9	Flooding Event
H9	SB1	Mid Cretaceous Unconformity
?	SB0	?
Deep Marker		Base of syn-rift Ise (?)



Petrophysical Analogues

Dahomey Basin

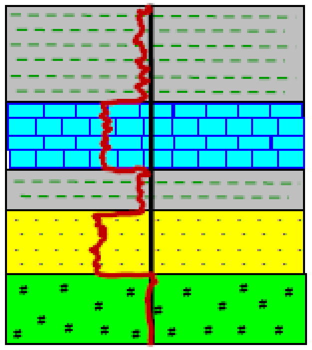


Other Basins

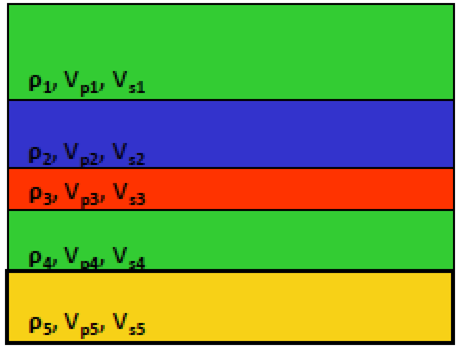
BASIN	LOCATION	BASIN TYPE	ROCK	PERIOD	PETROPHYSICAL PROPERTIES POROSITY	
					RANGE %	MEAN %
Bredasdrop Basin	South African Cretaceous Basins	RIFT	SILICICLASTIC	CRETACEOUS	11.3 - 16	13.65%
Gongola Basin	North Eastern Nigeria	RIFT	SILICICLASTIC	CRETACEOUS		25%
Tano Basin	Ghana	RIFT	SILICICLASTIC	CRETACEOUS	17 - 22	19.50%

Inversion Model: Porosity Trends

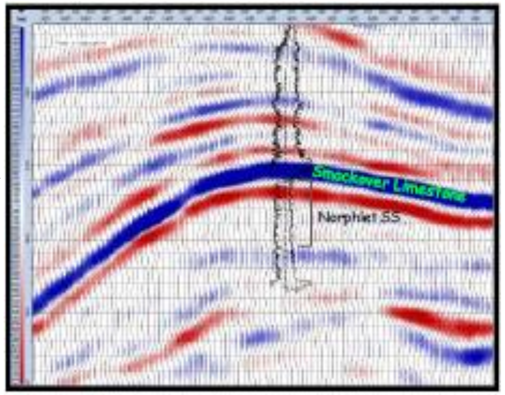
Well logs and reservoir zonation

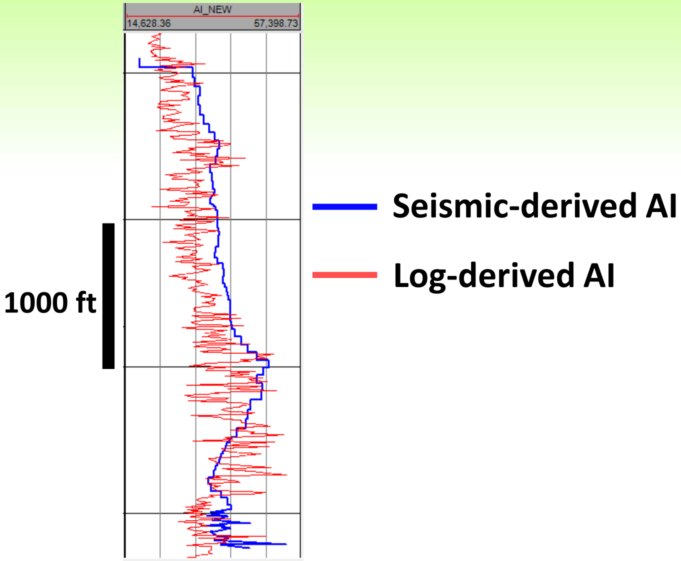


Acoustic Impedance (AI) derived from well data



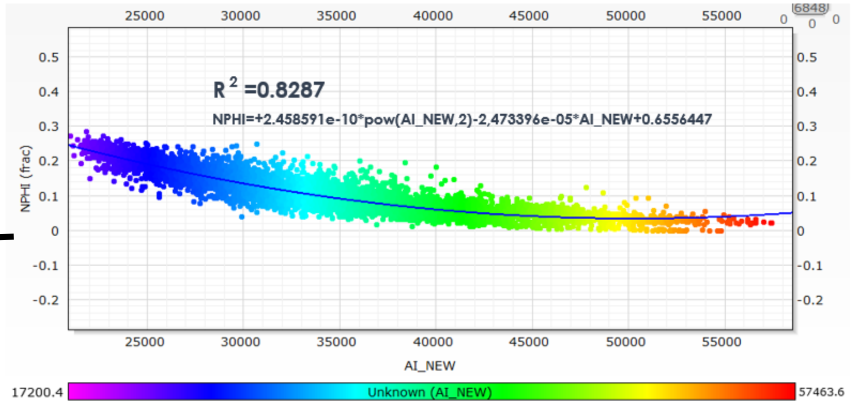
Match between AI and Seismic

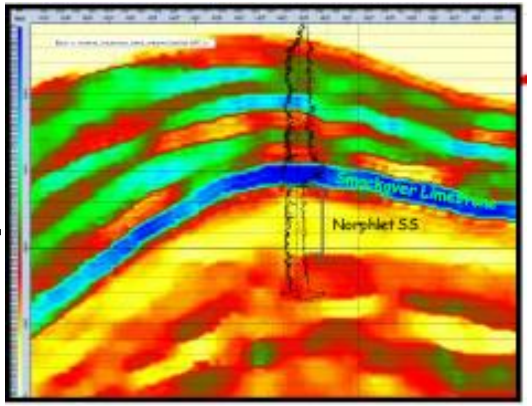




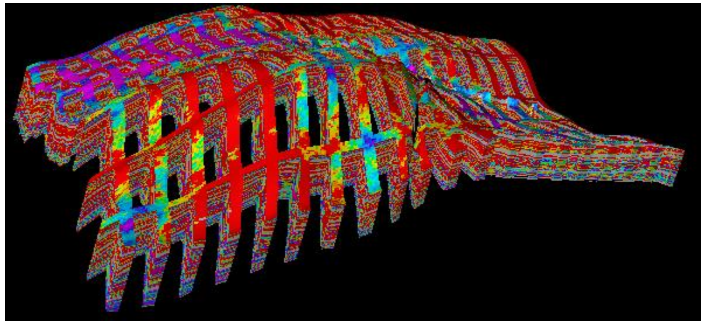
Model-based Inversion

AI vs NPHI transform for training the seismic data. One F(x) per zone.





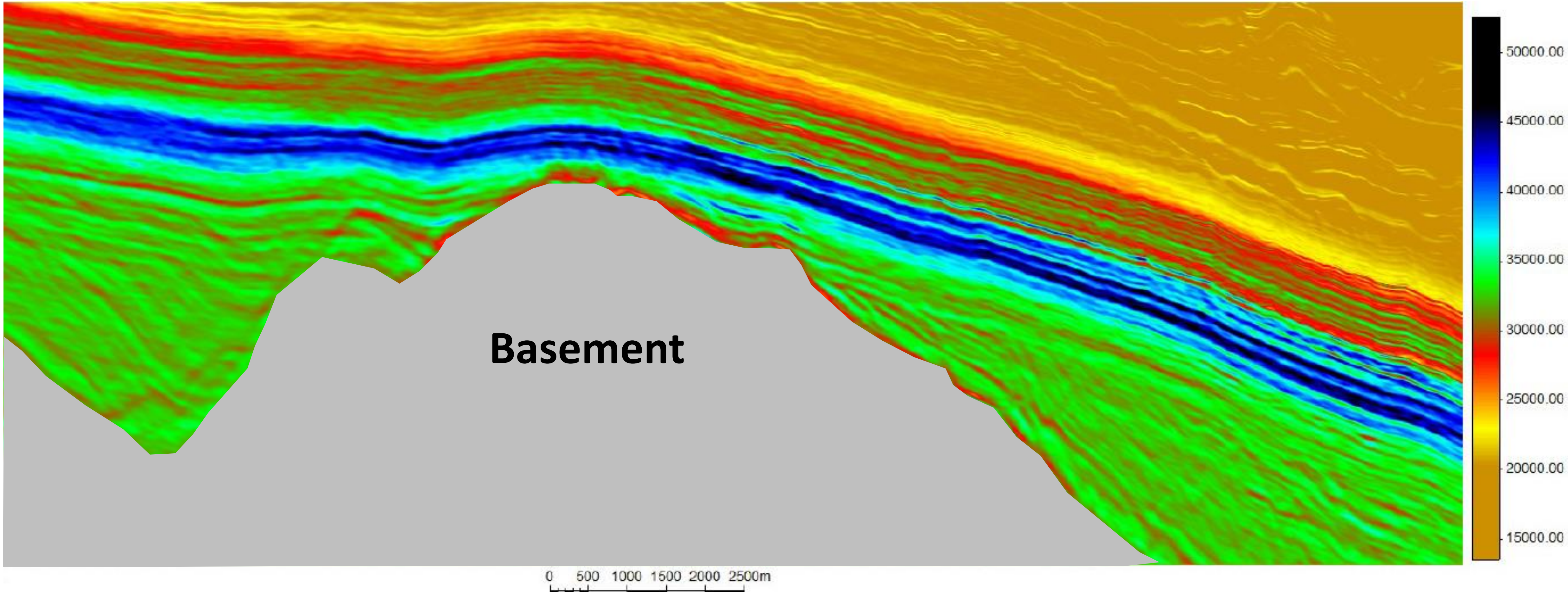
Seismic-derived porosity cube



Co-kriged RM with seismic porosity as secondary attribute

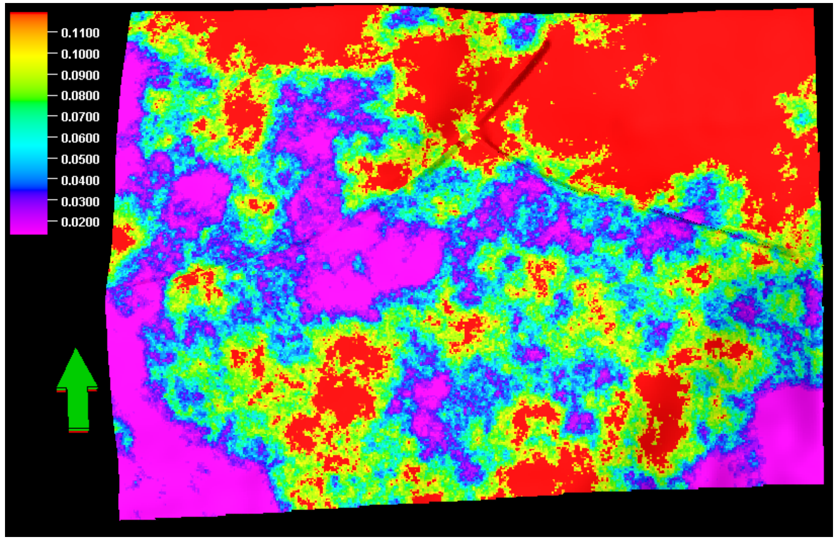
Results - 3D Reservoir Architecture and Gross Rock Property Characterization

- Low acoustic impedance (AI) indicates high porosity
- High acoustic impedance indicate of mainly shale lithology
- Low porosity may result from either tight sand (?cementation) or percentage of shale
- Lateral variations in acoustic impedance suggest proximal-distal/axial lateral variabilities in porosities

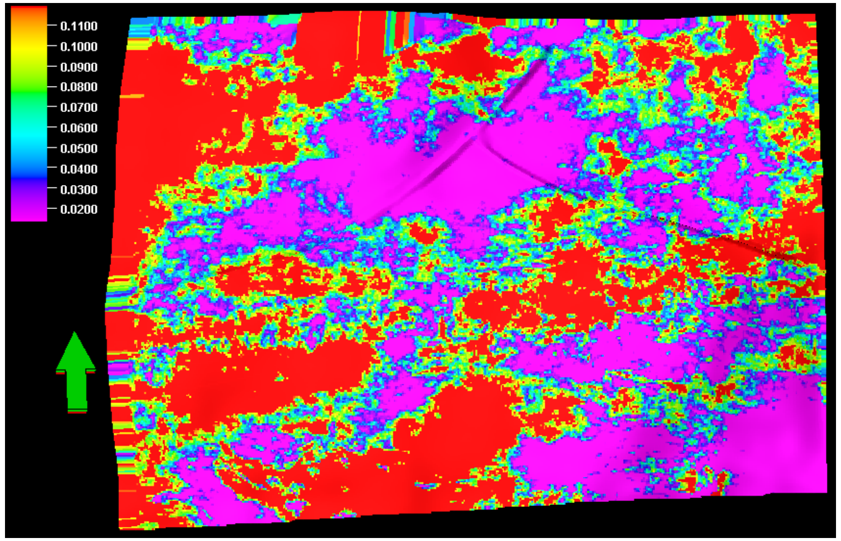


Reservoir Property Realization Models - Turonian

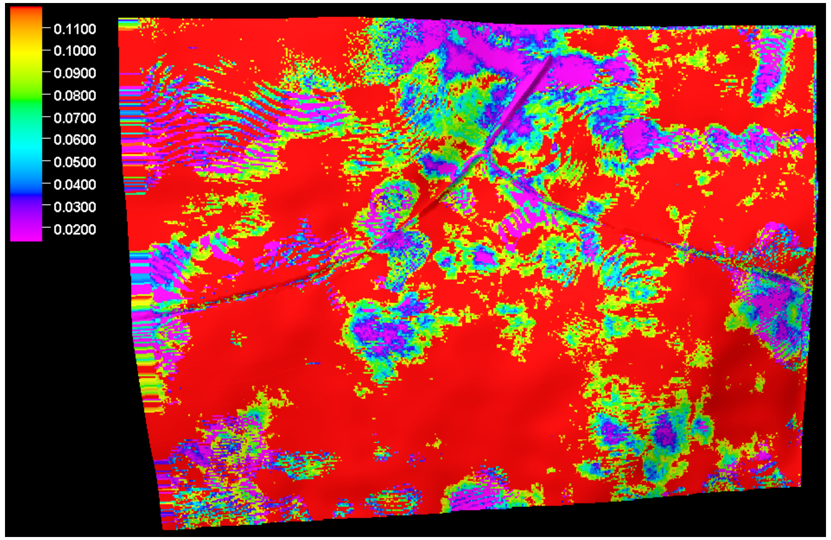
Sequential Gaussian Simulation (SGS)



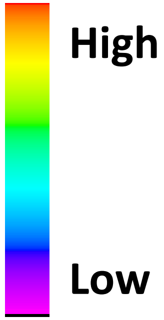
SGS co-kriged with Trend Map from Inverted QI Model



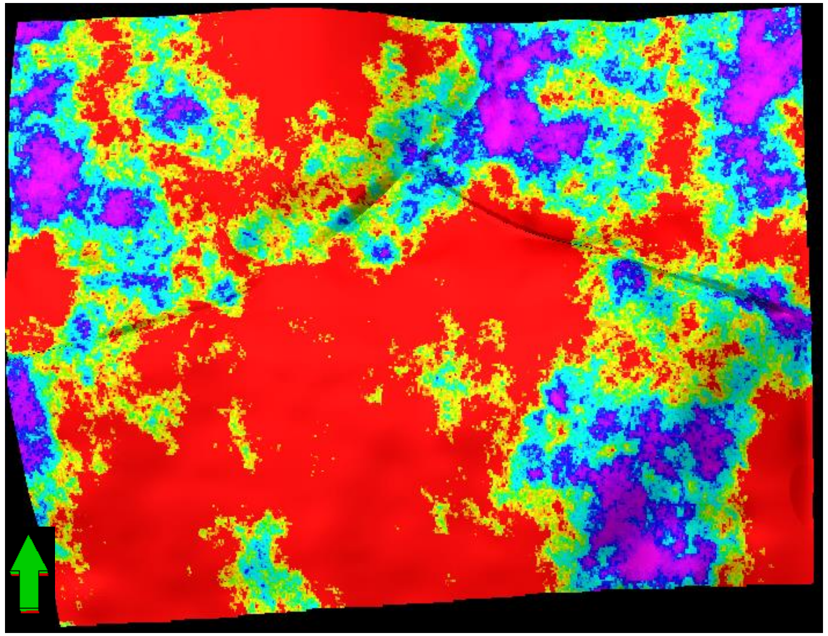
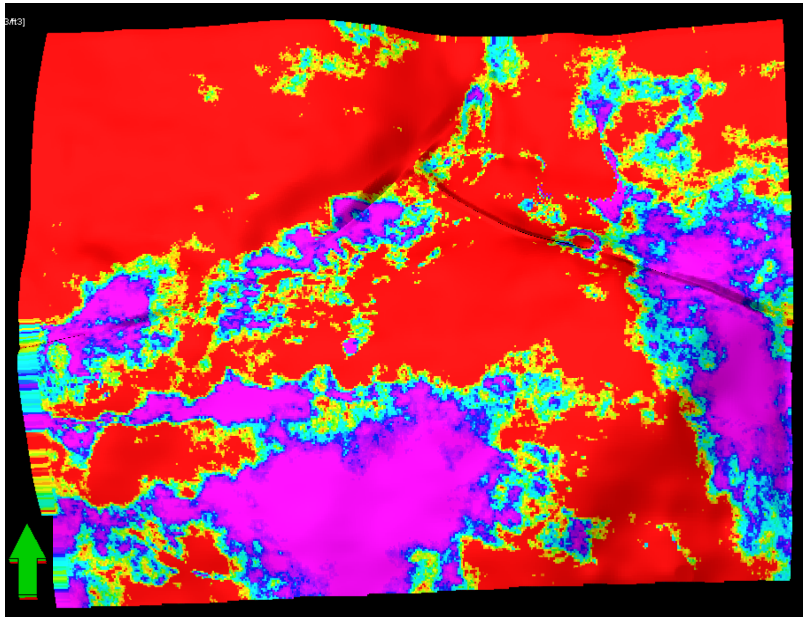
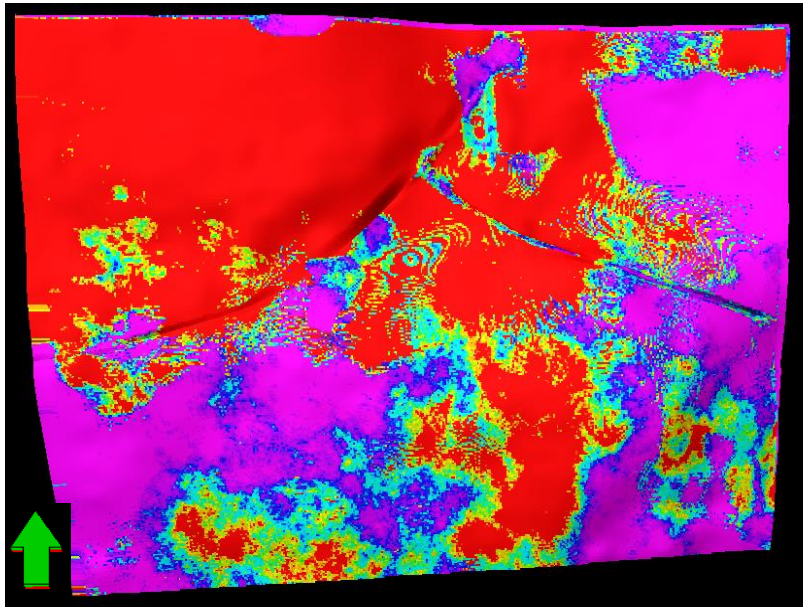
SGS co-kriged with Seismic Resampling from Inverted QI Model



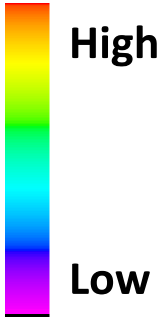
- SGS shows low porosity distribution from the centre to the southern region
- Co-kriged with Trend Map shows high variability
- Co-kriged with seismic resampling shows high porosity distribution



Reservoir Property Realization Models - Cenomanian

Sequential Gaussian Simulation (SGS)	SGS co-kriged with Trend Map from Inverted QI Model	SGS co-kriged with Seismic Resampling from Inverted QI Model
		

- Overall high porosity distribution
- Co-kriged realisations show a remarkably different distribution from SGS
- The inversion results and co-krigging of inverted data indicate higher porosity distribution around the north western part of the block.
- In southern and eastern part, the co-krigged models show more variability
- East – West facies belt is better developed with the realization from Trend Map, i.e. southern part of AOI



Reservoir Property Realization Models – Albian

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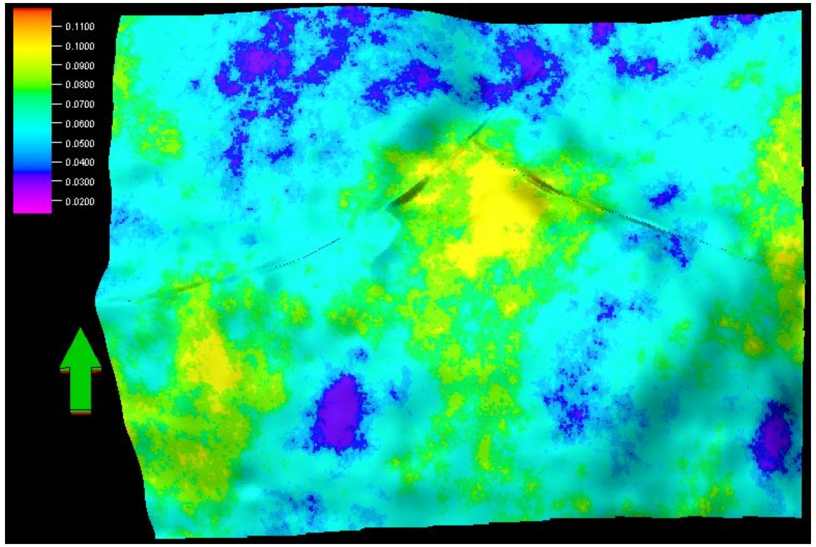
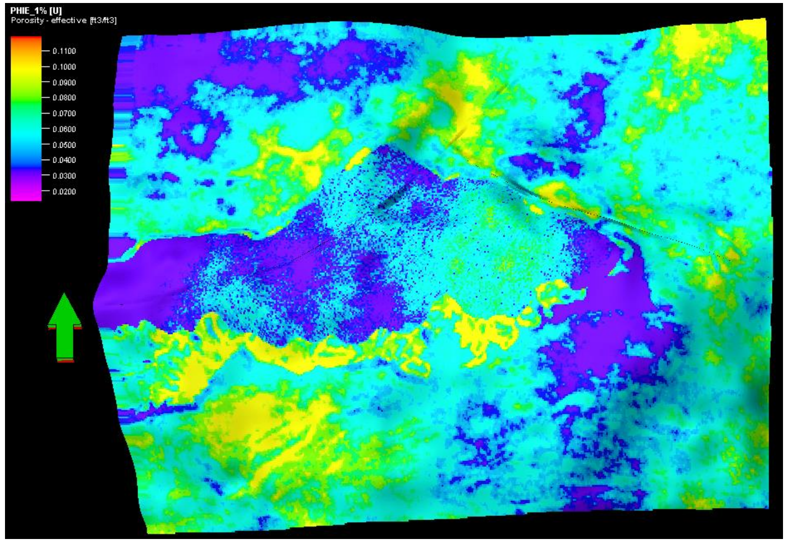
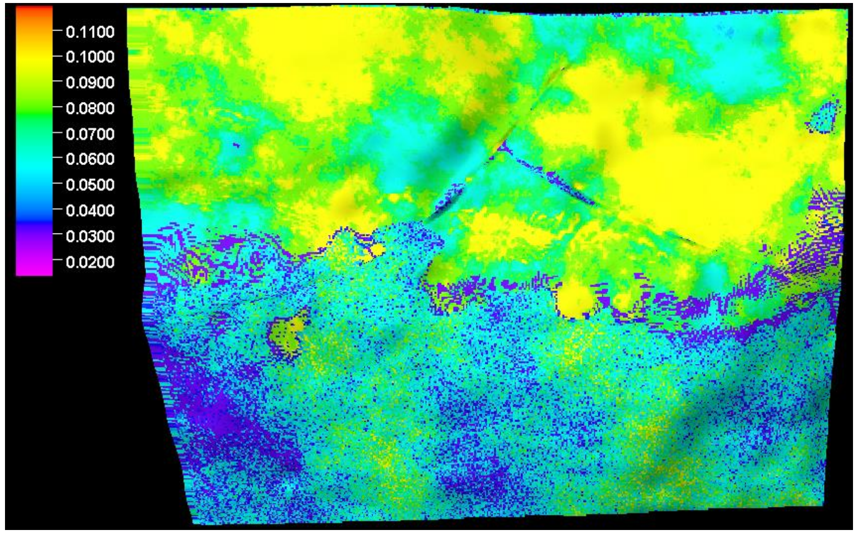
Sequential Gaussian Simulation (SGS)



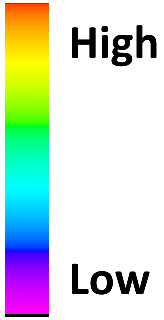
SGS co-kriged with Trend Map from Inverted QI Model



SGS co-kriged with Seismic Resampling from Inverted QI Model



- SGS shows a more even porosity distribution
- Co-kriging resulted in a porosity distribution that trends with East – West facies belt
- Co-kriged with seismic resampling shows high porosity to the north and low porosity to the south



Constraining the seismic porosity with real data

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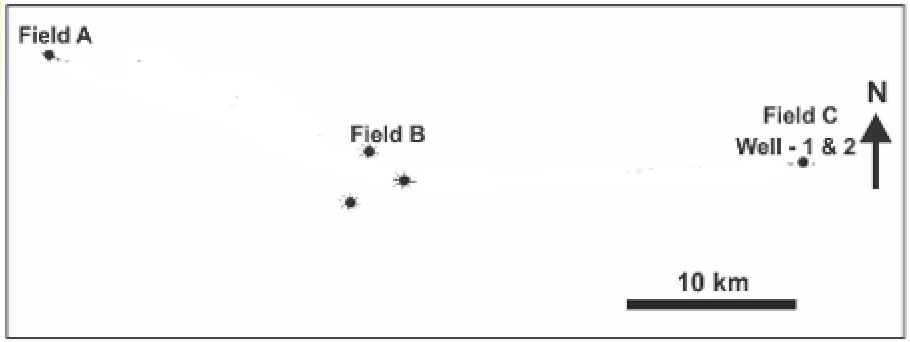
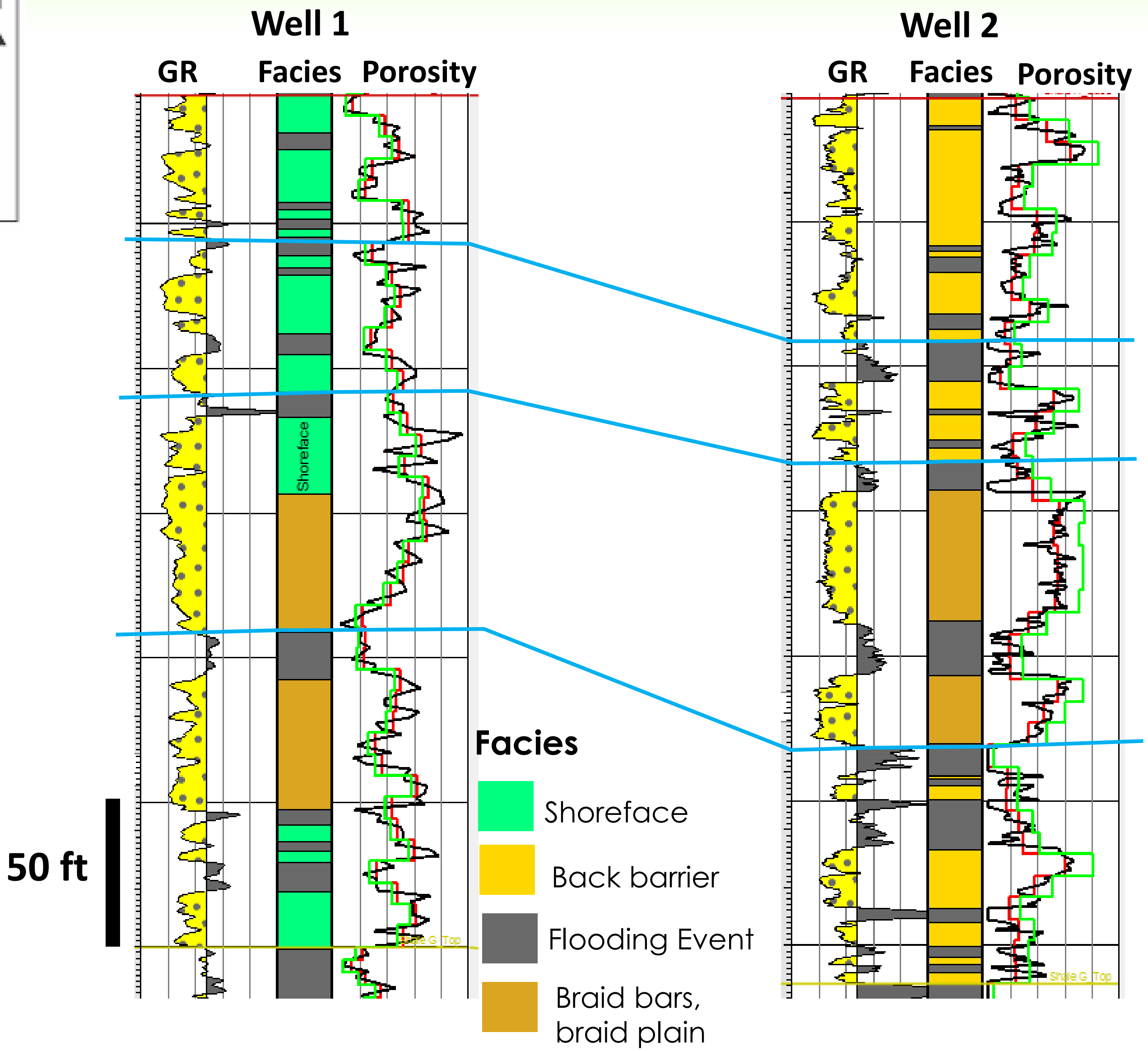


- **SGS over-estimates porosity distribution**

- **Porosity distribution from trend maps is over-estimated in shales**

- **Porosity from Co-kriging with seismic resampling is best constrained**



Log data
Sequential Guassian Simulation (SGS) and Trend Maps QI
Co-kriging with Seismic resampled QI
Trend Maps QI

Conclusion

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- Optimal use of available data
- Improved reservoir property distribution and reduced uncertainty in an area with limited data
- Observed Property distribution honours facies trend which provides confidence in inversion model output
- Results has been used to improve future development concepts and potential appraisal targets in such complex stacked reservoir GUs

Acknowledgement

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