Hydrocarbon Type Discrimination Using AVO analysis, Sama Field, WDDM, Nile Delta, Egypt*

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Abstract

Sama Field is one of the rare fields in the offshore Nile Delta which contain two types of hydrocarbons: gas and oil. Although Sama Field is covered by a state-of the art high density, long offset 3D dataset, the differentiation between several fluid types using the conventional stacked dataset is a big challenge. Although different fluids discrimination is difficult using post-stack seismic data, pre-stack seismic data can be the best tool of doing it. The reason can be attributed to the different amplitude change with offset behavior for each fluid type. The main aim is to find a way to map out the different reservoirs, in order to help in calculating the HIIP (Hydrocarbon Initial in Place) volumes and for optimizing the development plan. Rock physics modeling is needed to understand the AVO behaviors of oil and gas sands of the field. This understanding can be coupled with the pre-stack seismic data to produce AVO-classified seismic volumes. Hence, reservoirs of different fluid types can be identified and mapped across the study area. Rock physics modeling suggested that gas sand exhibits class 3 AVO response; however oil sand has a class 2 AVO behavior. Pre-stack seismic data needed some conditioning before the AVO classification. The conditioning workflow included: frequency filtering, time alignments, and amplitudes balancing. Finally AVO-classified seismic volumes have been produced, which enabled the lateral tracking of the different reservoir bodies away from the well. The integration of pre-stack seismic data and the understanding the AVO behavior of different fluids allows precise delineation for the different reservoirs. Which in turn promotes a better chance of success for further future development plan.

References Cited

Abdel Aal, A., A. El Barkooky, M. Gerrits, H. Meyer, M. Schwander, and H. Zaki, 2000, Tectonic Evolution of the Eastern Mediterranean Basin and Its Significance for Hydrocarbon Prospectivity in the Ultradeepwater of the Nile Delta: The Leading Edge, v. 19/10, p. 1086-1102.

Mohamed, I.A., H.Z. El-Mowafy, D. Kamel, and M. Heikal, 2014, Prestack Seismic Inversion versus Neural-Network Analysis: A Case Study in the Scarab Field Offshore Nile Delta, Egypt: The Leading Edge, v. 33/5, p. 498-506.

Reading, H.G., and M. Richards, 1994, Turbidite Systems in Deep-Water Basin Margins Classified by Grain Size and Feeder System: AAPG Bulletin, v. 78, p. 792-822.

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Outline

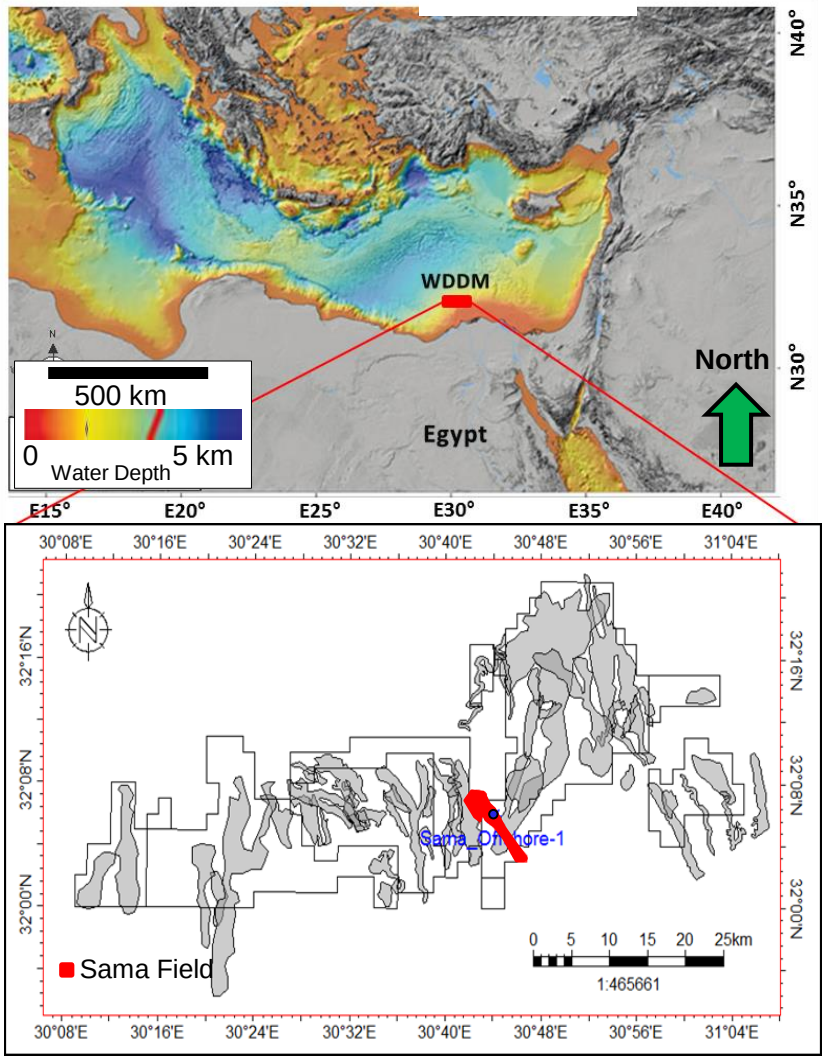
- Introduction
- Geological Setting
- Reservoir Characteristics
- AVO Modeling
- Conclusions

Introduction

- Sama offshore field is located in WDDM, offshore Nile Delta and has been discovered by Sama Offshore-1 well.
- Structurally, it is a four-way dip closure, part of a rollover due to a drag on Rosetta fault.
- Stratigraphically, it is a Pliocene slope marine channel complex consisting of four seismically resolvable architectural elements.
- Pressure data suggests the presence of two fluid gradients in the hydrocarbon bearing reservoir interval.

Area of Study

- Egypt
- Offshore Nile Delta
- West Delta Deep Marine (WDDM) leases covers 2212 km²
- The Sama offshore field is a Pliocene reservoir located 105 km off Alexandria under water depths around 450m.



(Modified from Mohamed et al., 2014)

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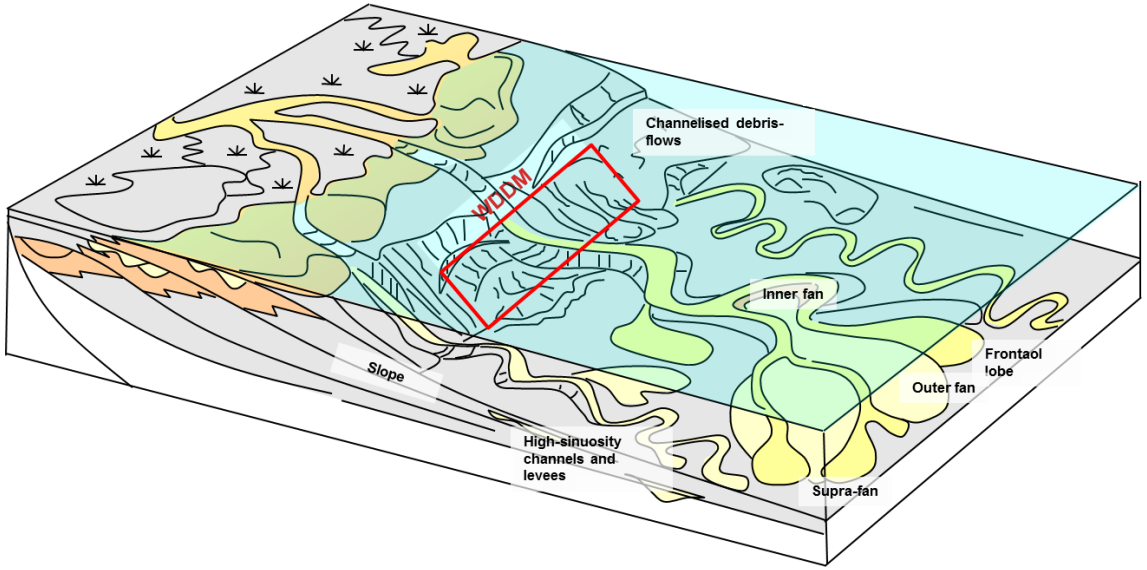
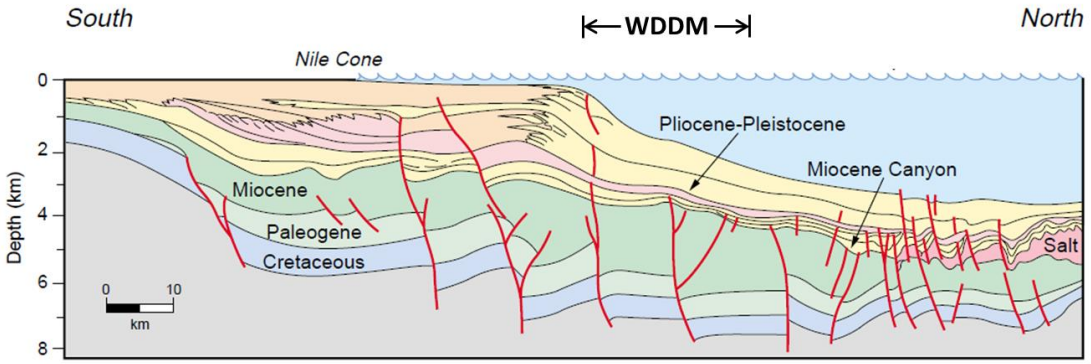
Geological Model

WDDM Simplified Model



Schematic block diagram showing that WDDM is located is aslope part of Nile Delta with turbidite depositional setting.

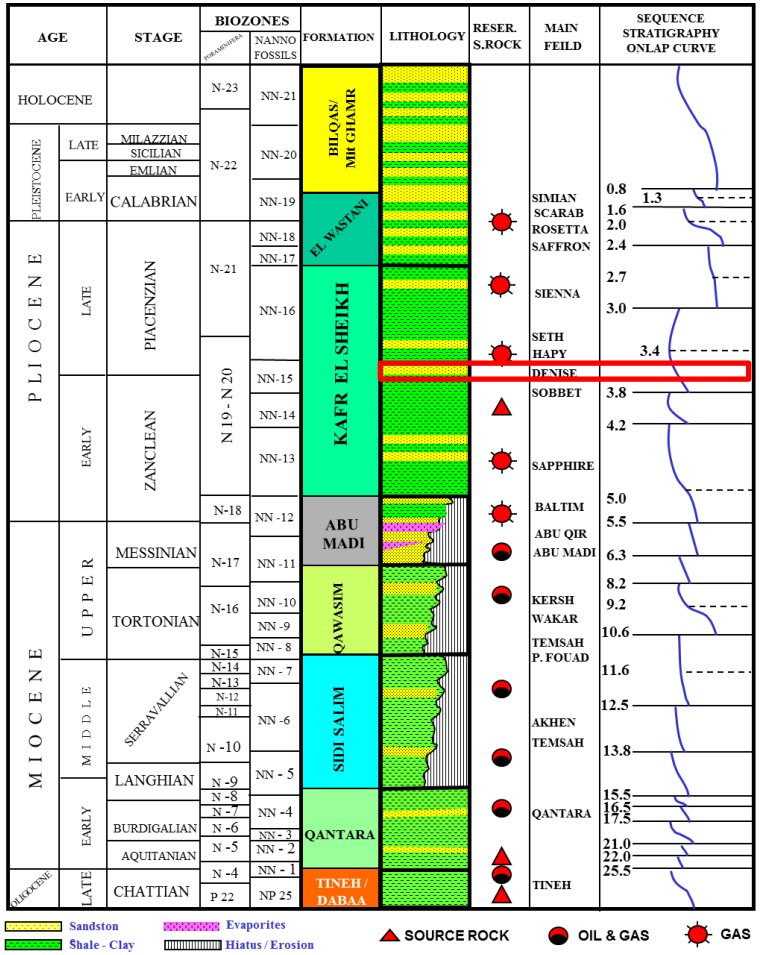
(modified from Reading and Richards, 1994)



Geological cross-sections through the Nile Cone to illustrate the Upper Miocene (Messinian) canyon and Pliocene-Pleistocene turbidite depositional sequences.

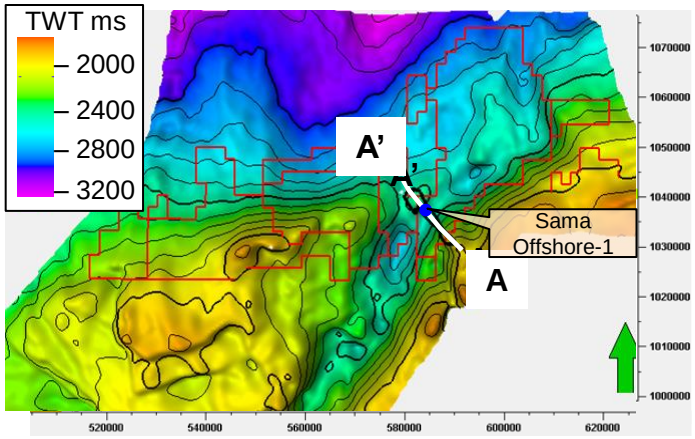
(modified from Abdel Aal et al., 2006)

Generalized Stratigraphic Column

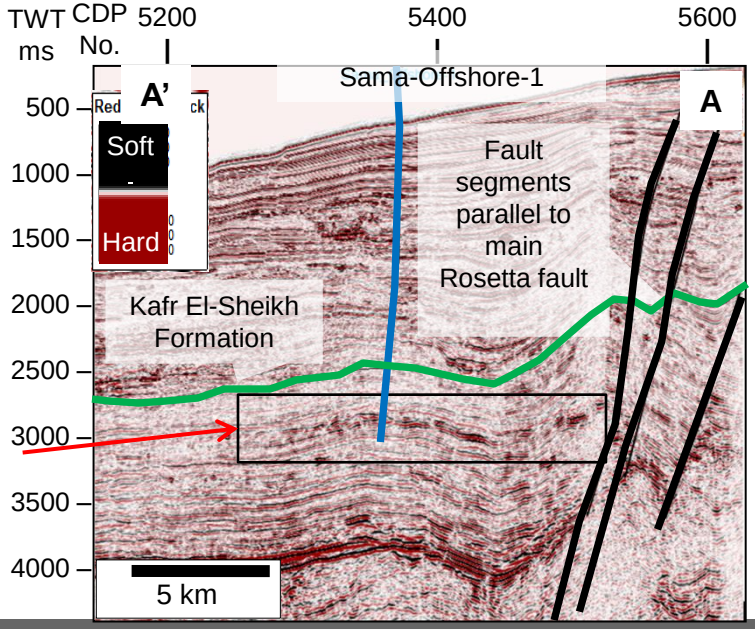


Nile Delta stratigraphic column and hydrocarbon system

Sama field: Middle to Late Pliocene, Kafr El-Sheikh Formation



Kafr El-Sheikh Formation TWT map



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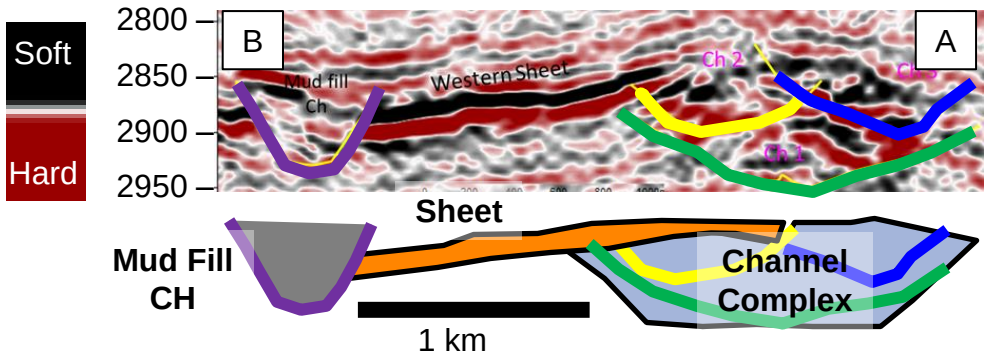
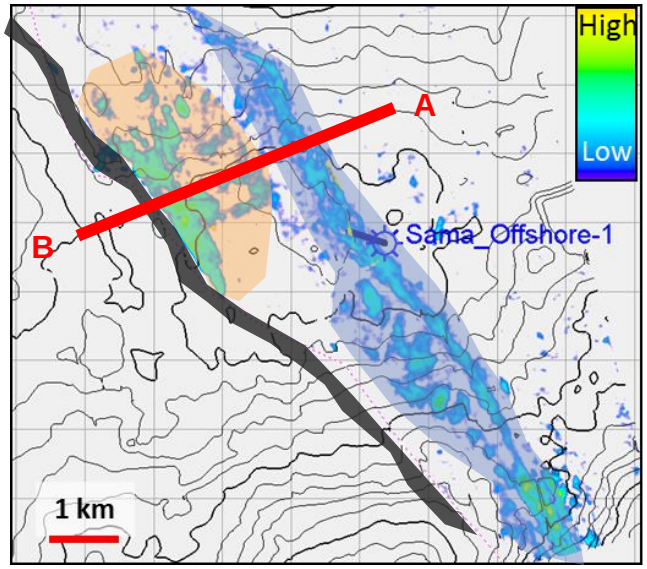
Reservoir Characteristics

- Sama-Offshore is a complex submarine channel system draped over anticlinal form
- Sama-Offshore is 10 km long and up to 2.5 km wide at its widest point

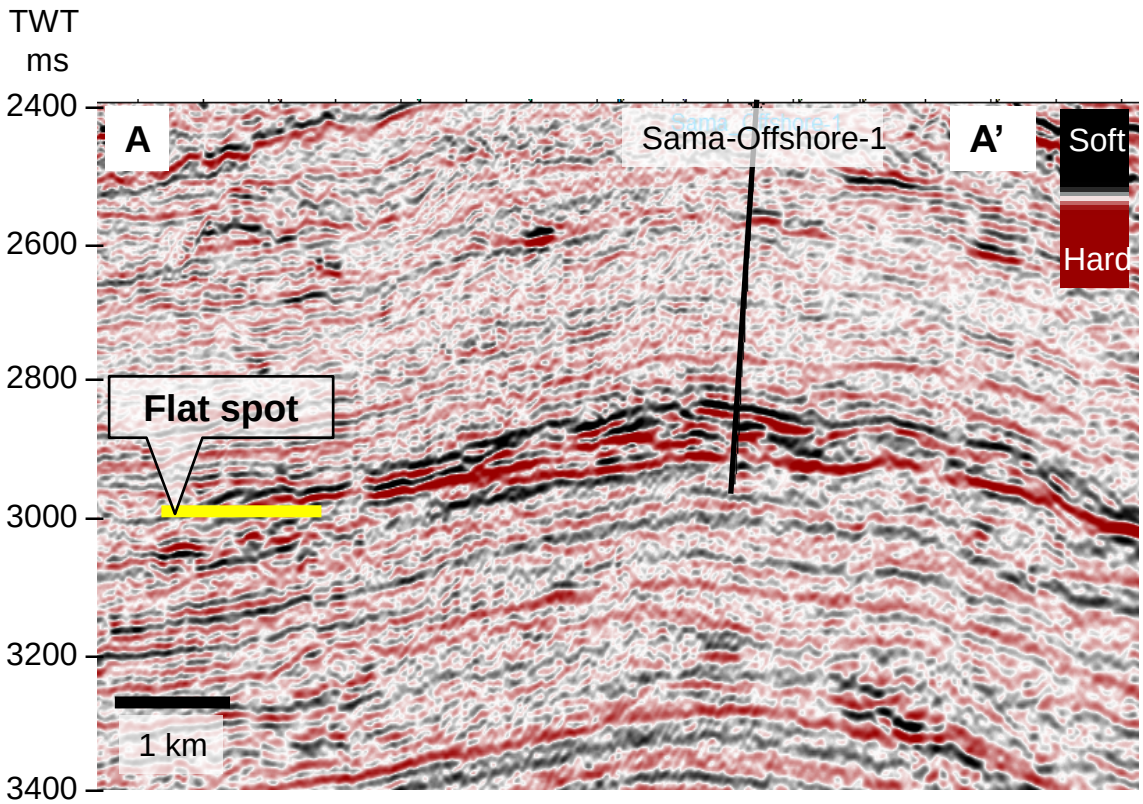


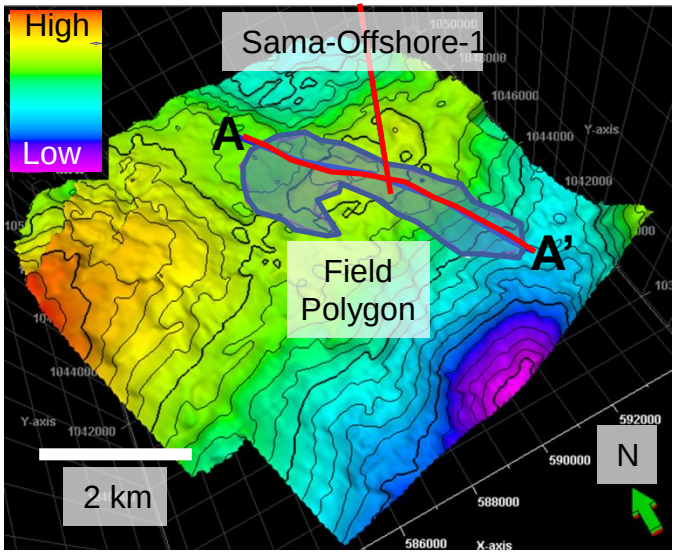
Seismic section followed by a sketch showing the multi channel phases



AAA attribute map from top to base reservoir showing the channel geometry

Reservoir Characteristics

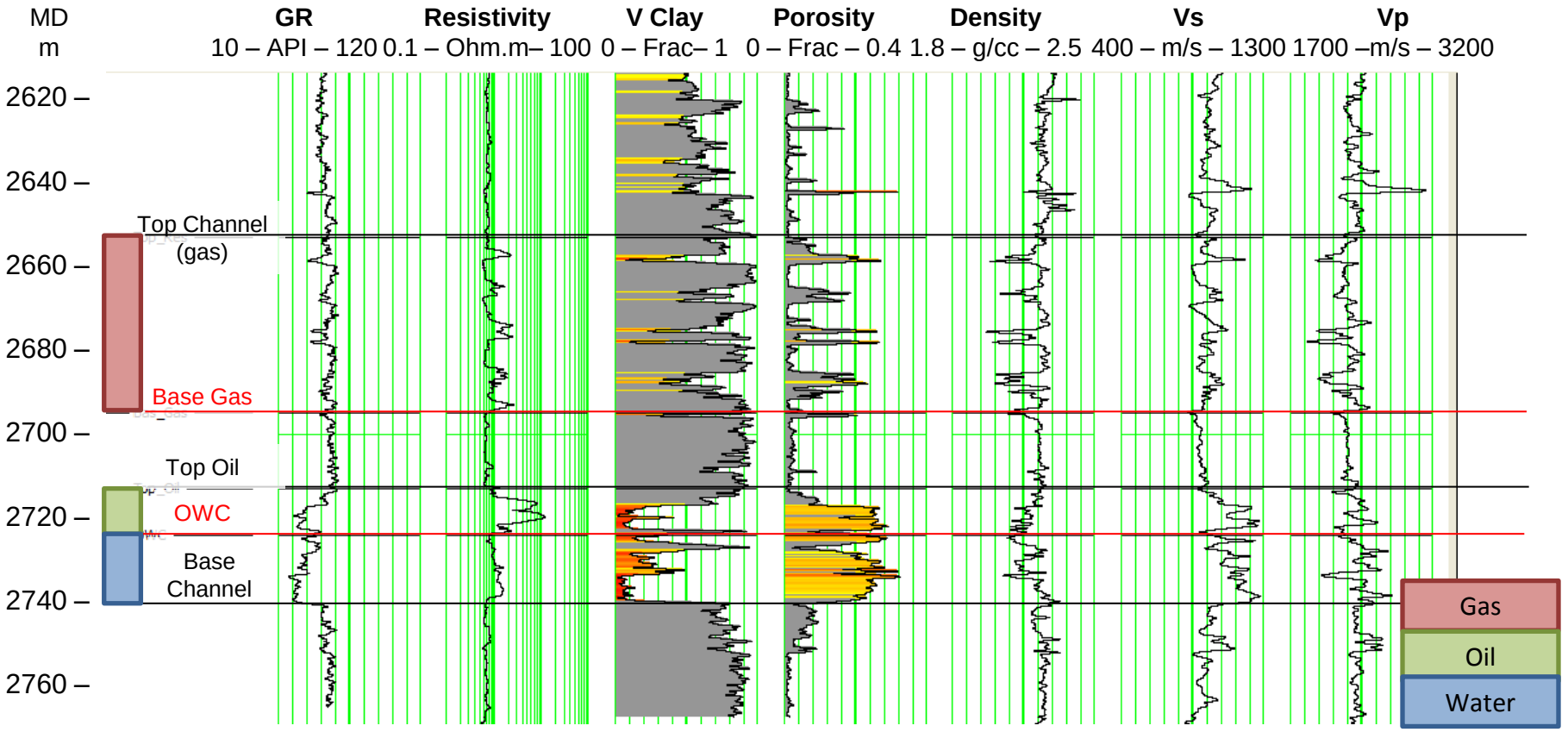




3D perspective for depth structure map of top Sama-Offshore with field polygon

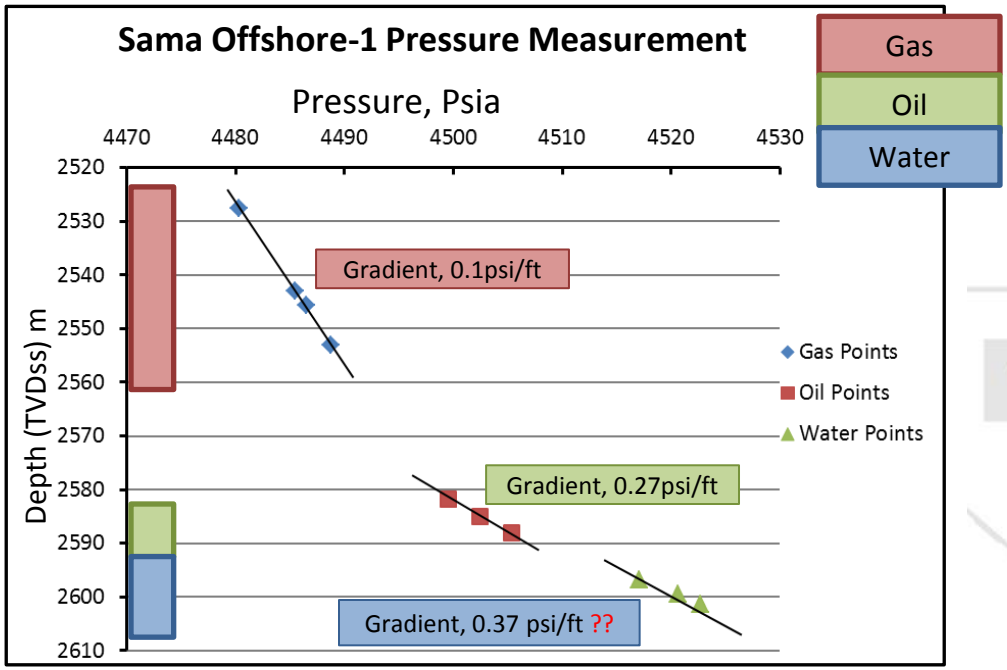
- Seismic section passing through Sama-Offshore field showing the 4-way dip closure

Reservoir Characteristics



- Sama-Offshore is a channel that are up to 100m in gross thickness, 27m of pay
- An average reservoir porosity of 18%
- An average water saturation of 38%

Reservoir Pressure Data



- MDT samples confirmed fluid types that were interpreted by test track gradients. MDT analysis confirmed the presence of gas gradient in the upper sand and oil gradient in the lower sand.
- From PVT analysis showed there is an oil zone with 38 API.

Sama PVT analysis

COREX

Table 1

Samples Listing and Validation

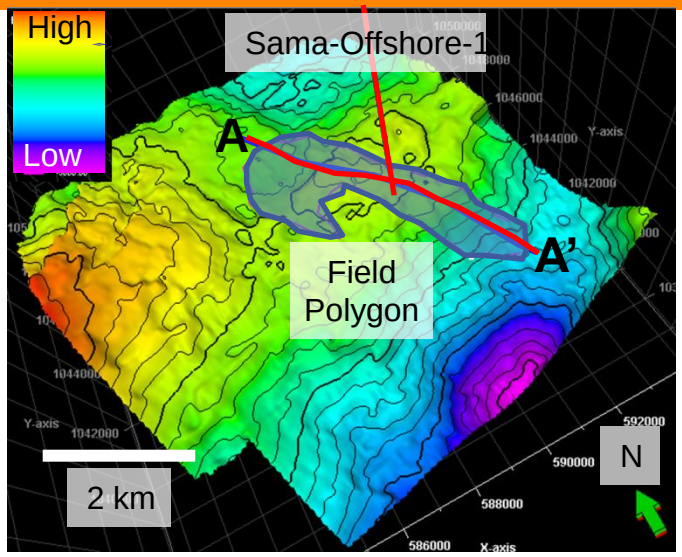
Well: Sama Offshore

Chamber Number	Depth (m)	Opening Pressure (psig)	Formation Pressure (psia)	Transferred To	Marked As
2072	2678	4485 @ 160.2 °F	4491.5 @ 160.2 °F	80017	Gas
2251*	2678	4500 @ 160.2 °F	4491.5 @ 160.2 °F	814130	Gas
3976*	2724.8	9153 @ 167.4 °F	4509.67 @ 167.4 °F	881015	Oil
4303	2724.8	8075 @ 167.4 °F	4509.67 @ 167.4 °F	890973	Oil
2512*	2738	4602 @ 169.7 °F	4506.04 @ 169.7 °F	---	Water
3001*	2738	4498 @ 169.7 °F	4506.04 @ 169.7 °F	---	Water

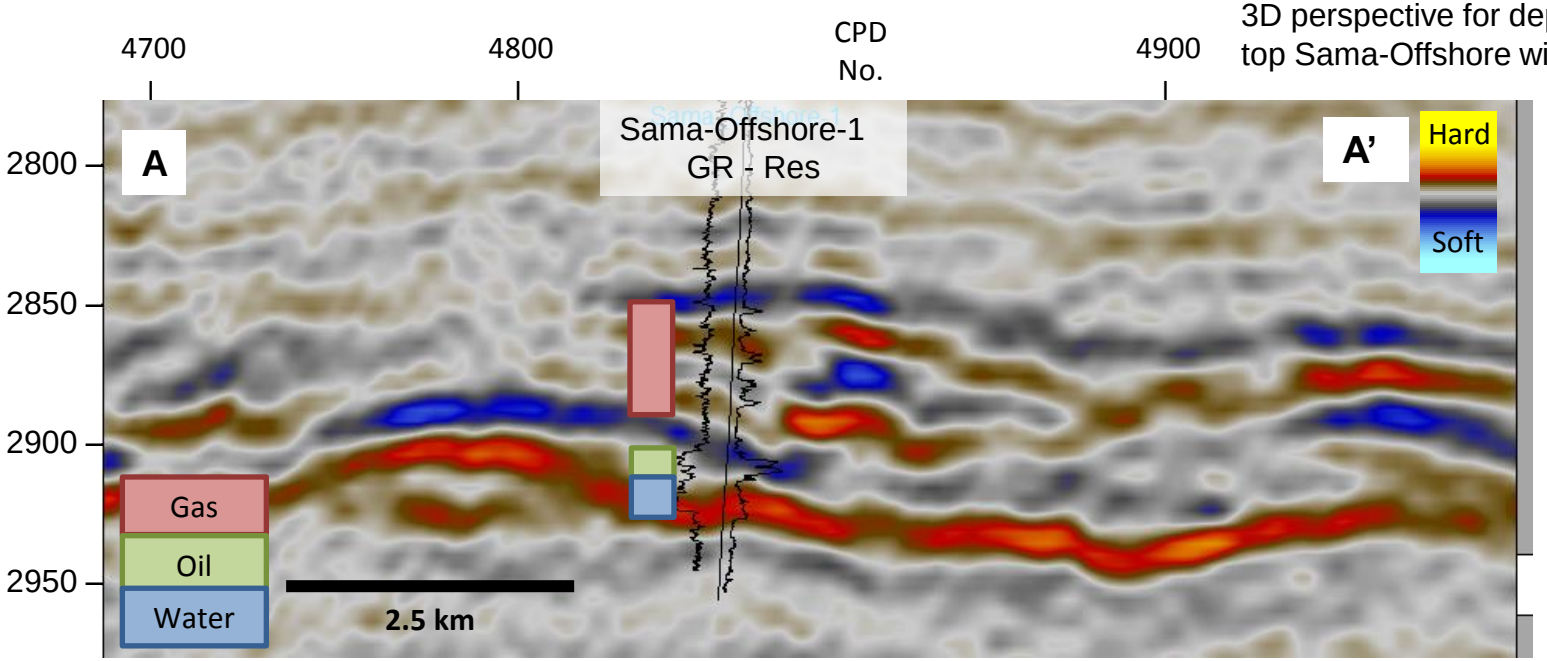
* Selected for flash test.

Chamber Number	Separator Pressure (psig)	Separator Temperature (°F)	Gas Oil Ratio (scf/stb)	Bo* (bbl/stb)	Oil Properties		Gas Properties
					Density at 60 °F (gm/cc)	°API	Gas Gravity (air=1.000)
881015	0	60	763.8	1.2381	0.8330	38	0.653

Problem Statement



3D perspective for depth structure map of top Sama-Offshore with field polygon



It is difficult to tell which is Oil and which is gas

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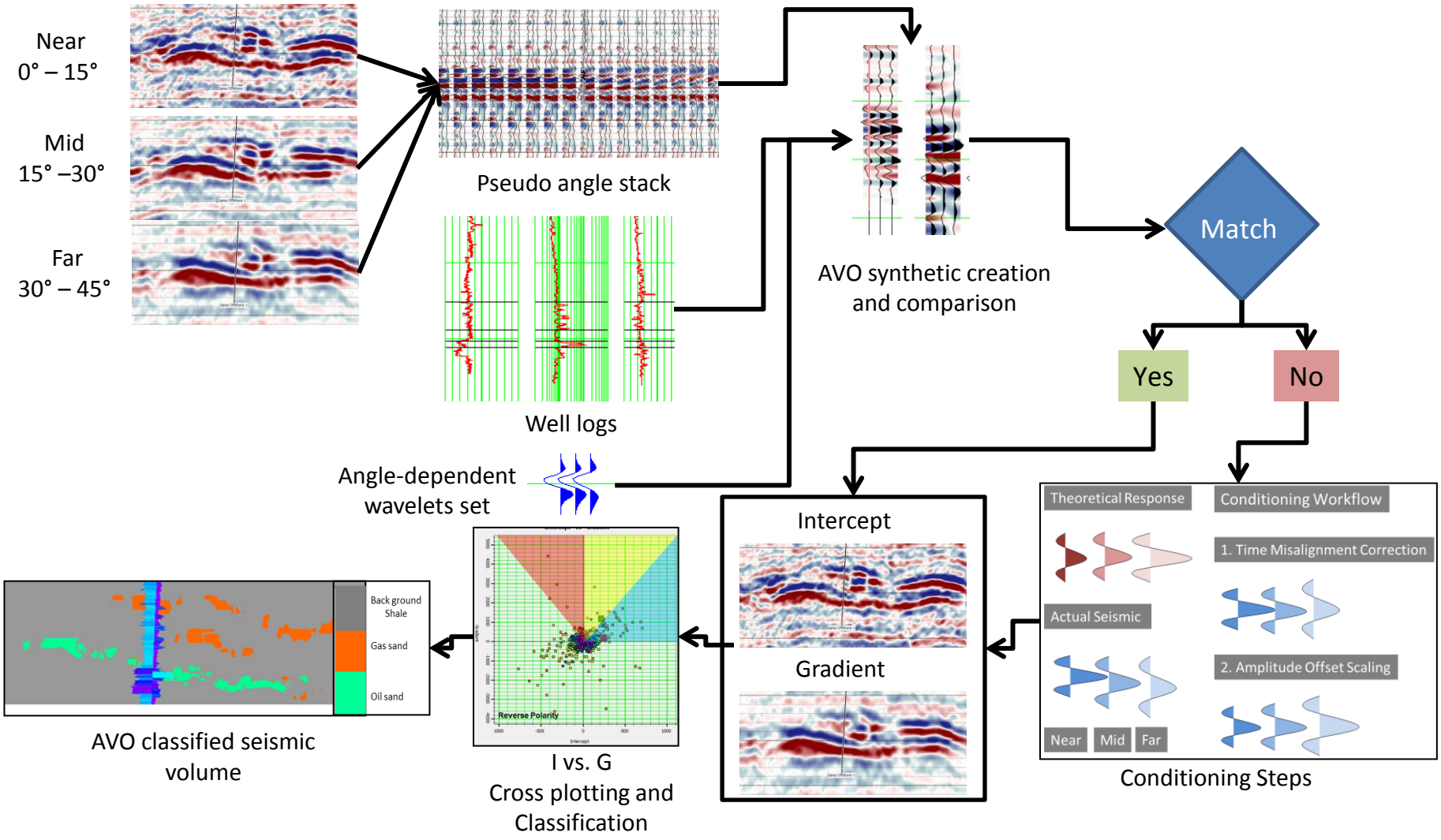
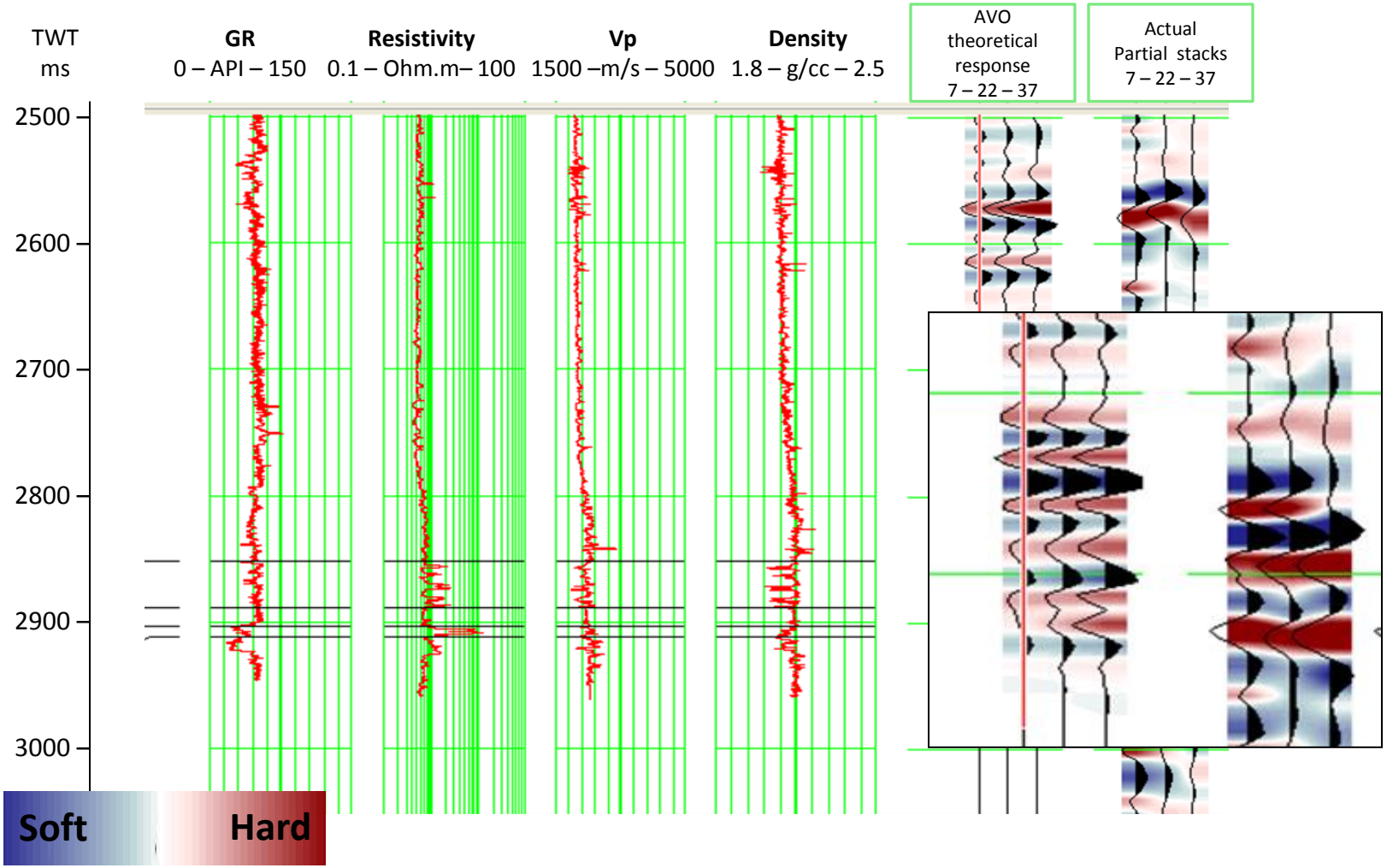
AVO Workflow

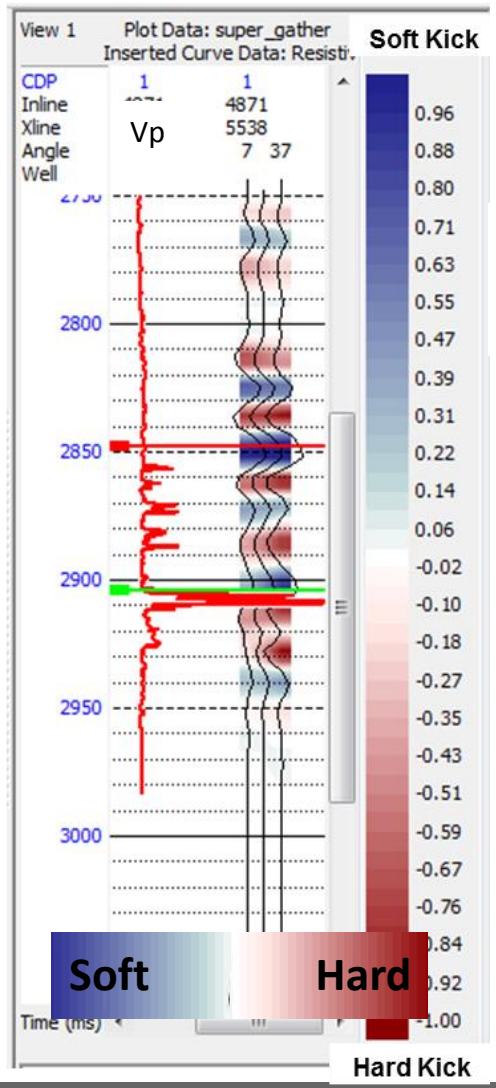


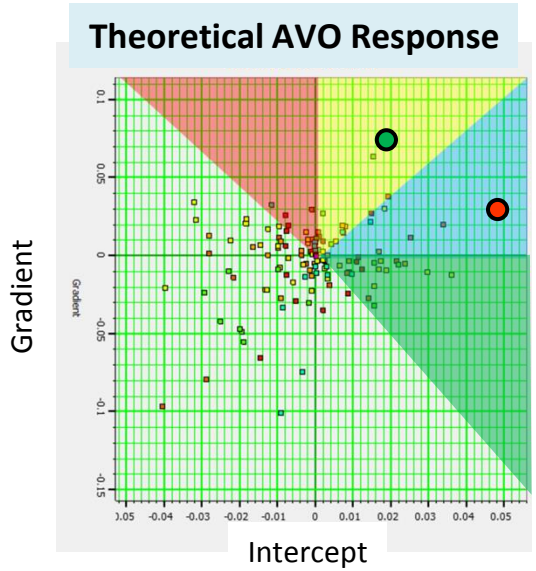
Sama-Offshore AVO Synthetic

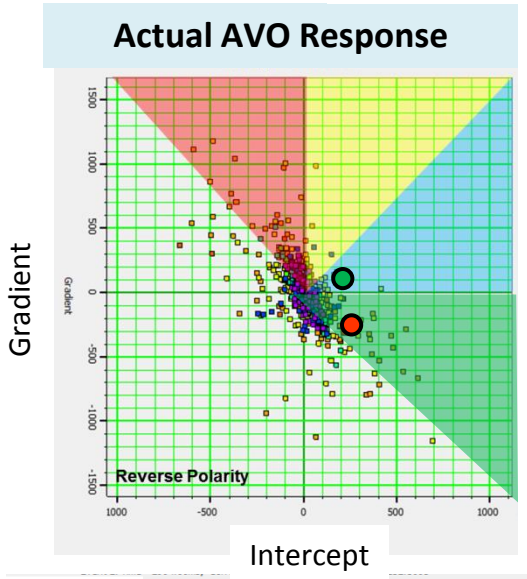


The AVO theoretical synthetic versus the angle stack.

Comparing AVO Theoretical Response with Actual Partial Angle Stacks

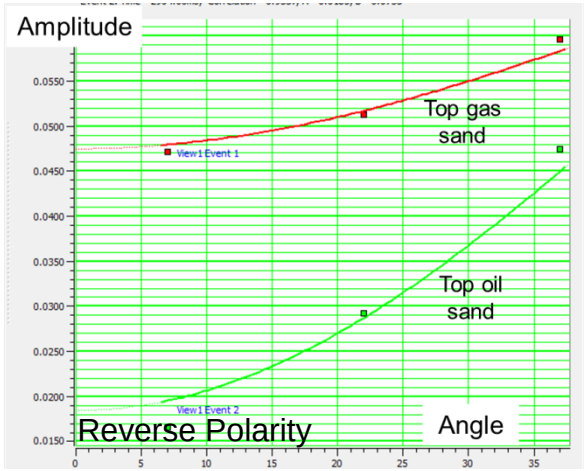


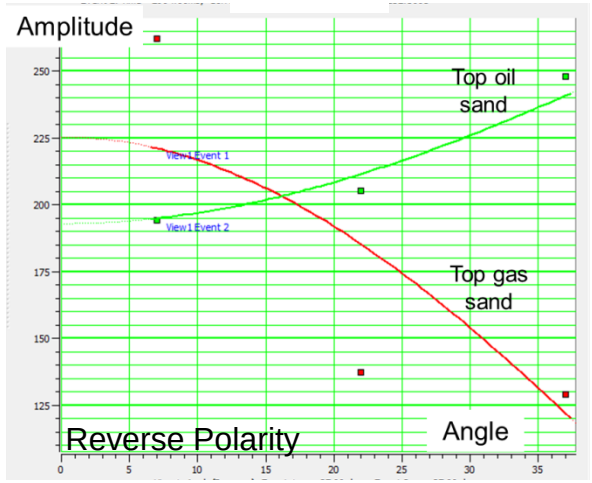




Class 2P
Class 2
Class 3
Class 4

Gas
Oil





Actual AVO response is different from theoretical one, so conditioning is required

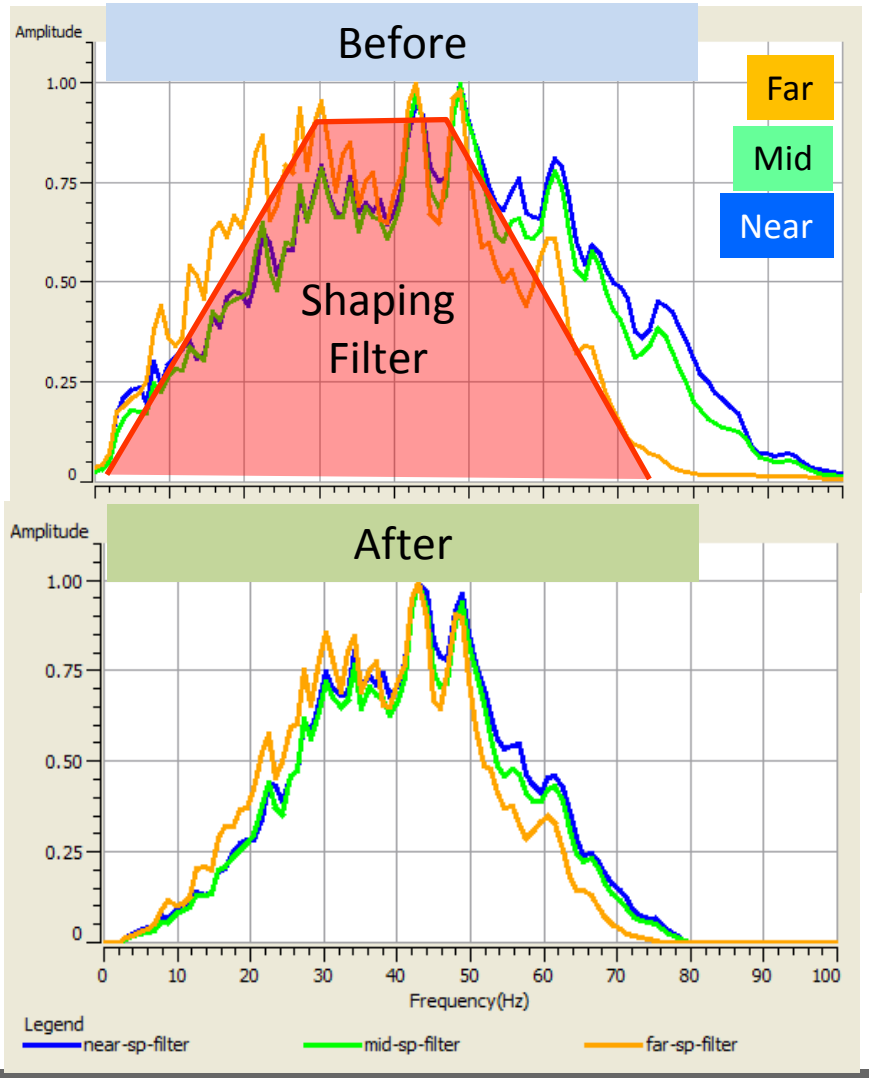
Data Conditioning

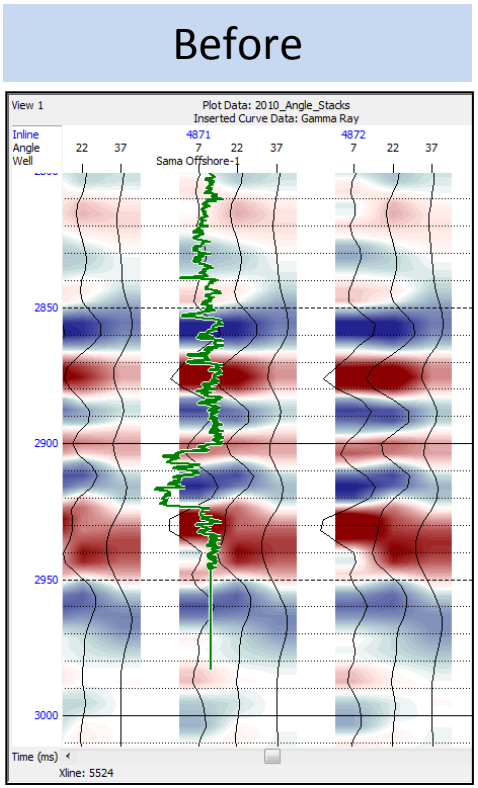
- Frequency Filtering
  (To prepare each partial stack to have nearly the same bandwidth)

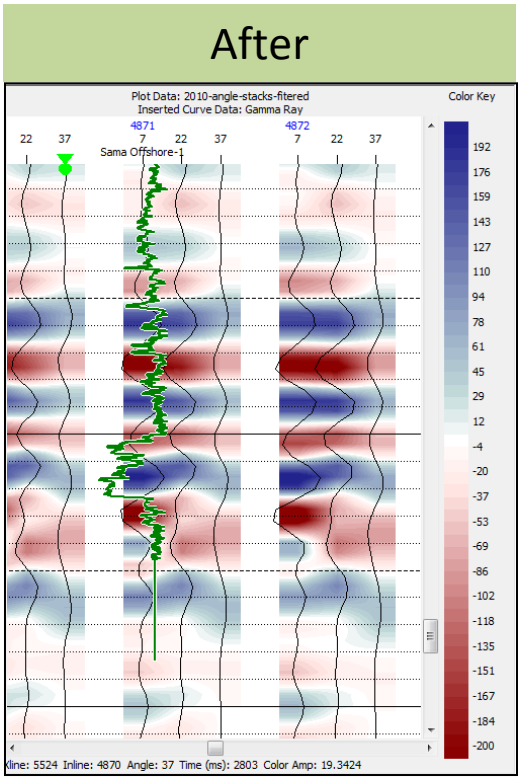
- Residual Normal Move-out Correction
  (Misalignments are corrected)

- Amplitude Scaling
  (Knowledge gained from AVO analysis of the well data is to be used to balance the offset amplitudes)

Frequency Conditioning







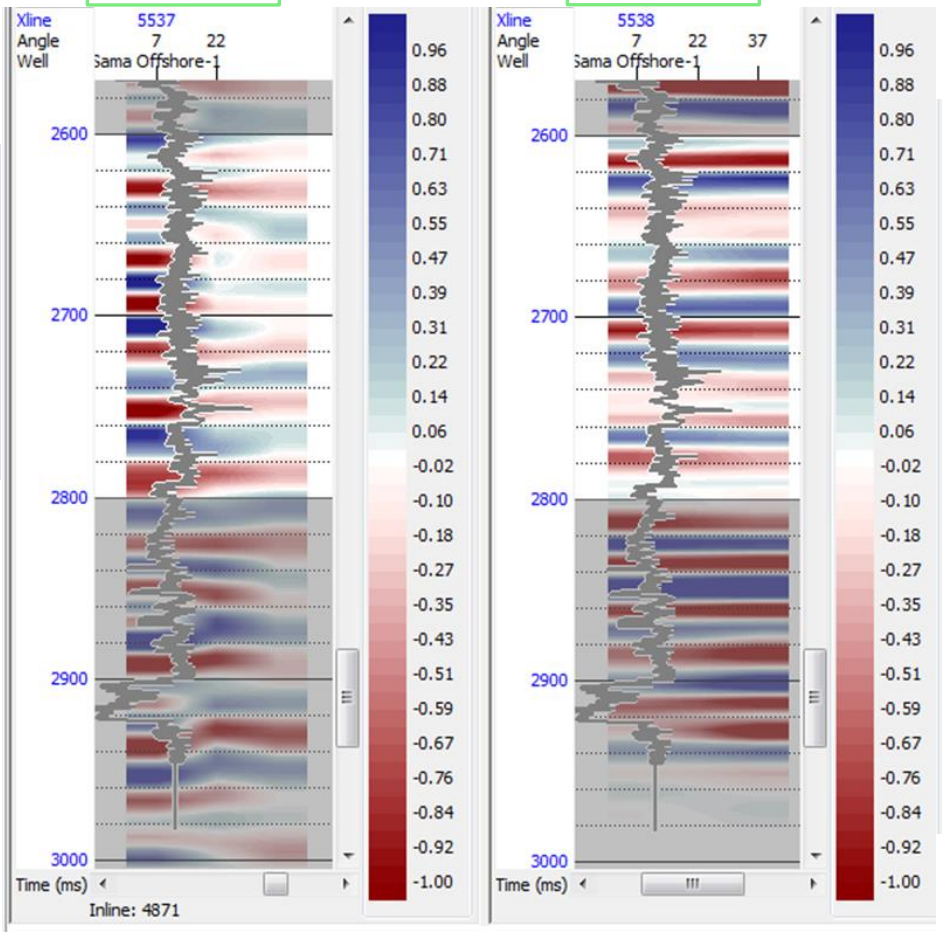
Amplitude spectrum at different angles

Amplitude Scaling analysis

Background

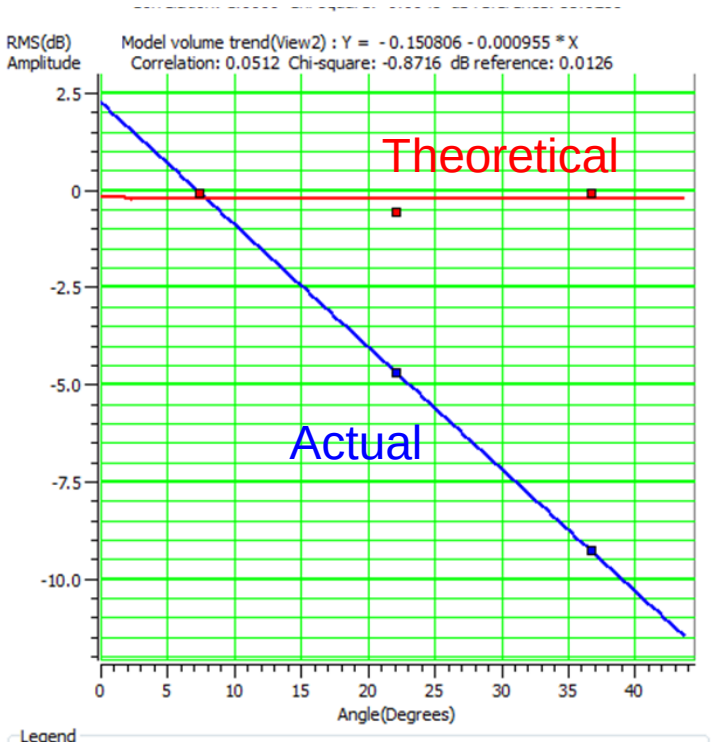
AVO theoretical response 7 – 22 – 37

Actual Partial stacks 7 – 22 – 37

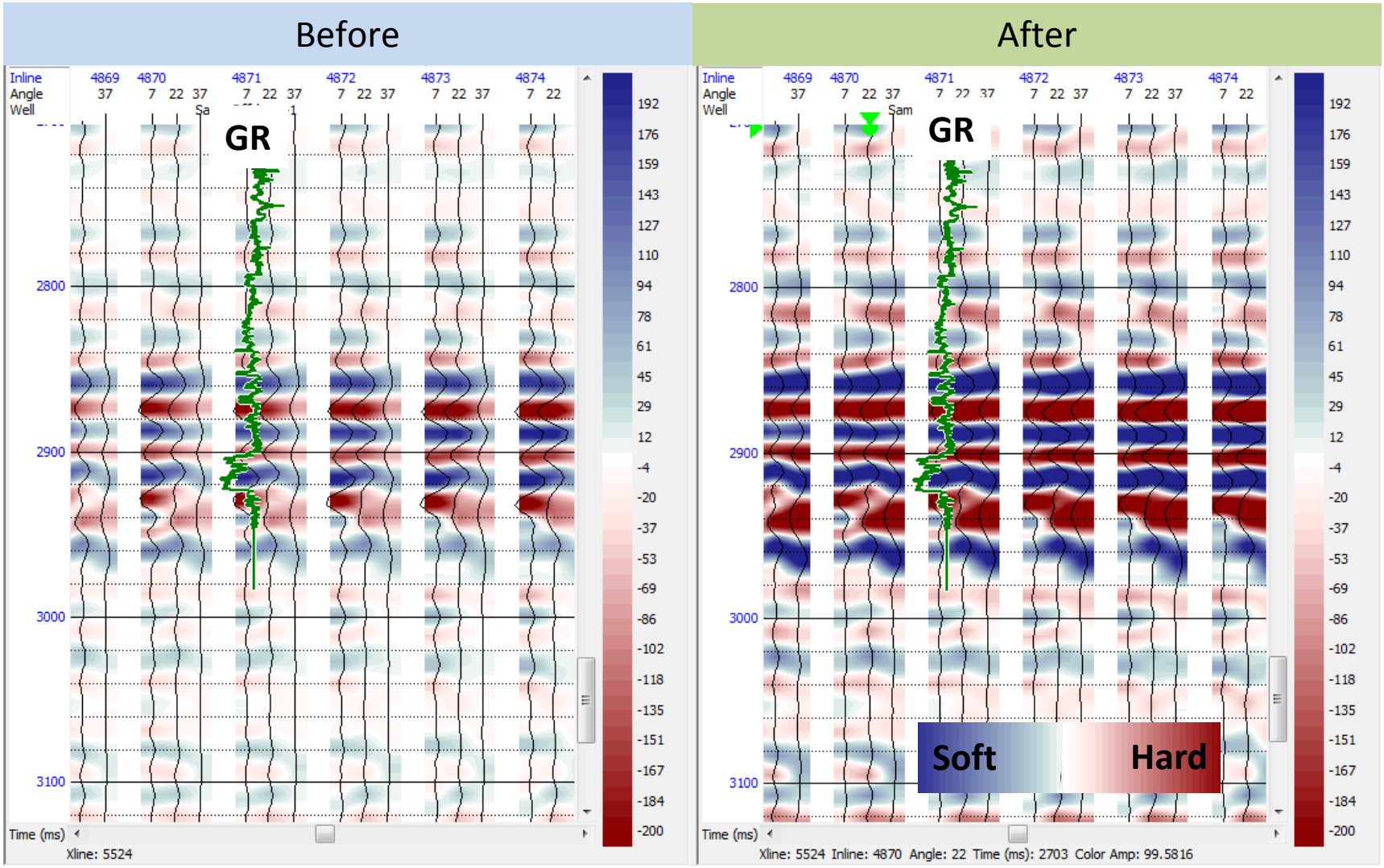


Angle stacks

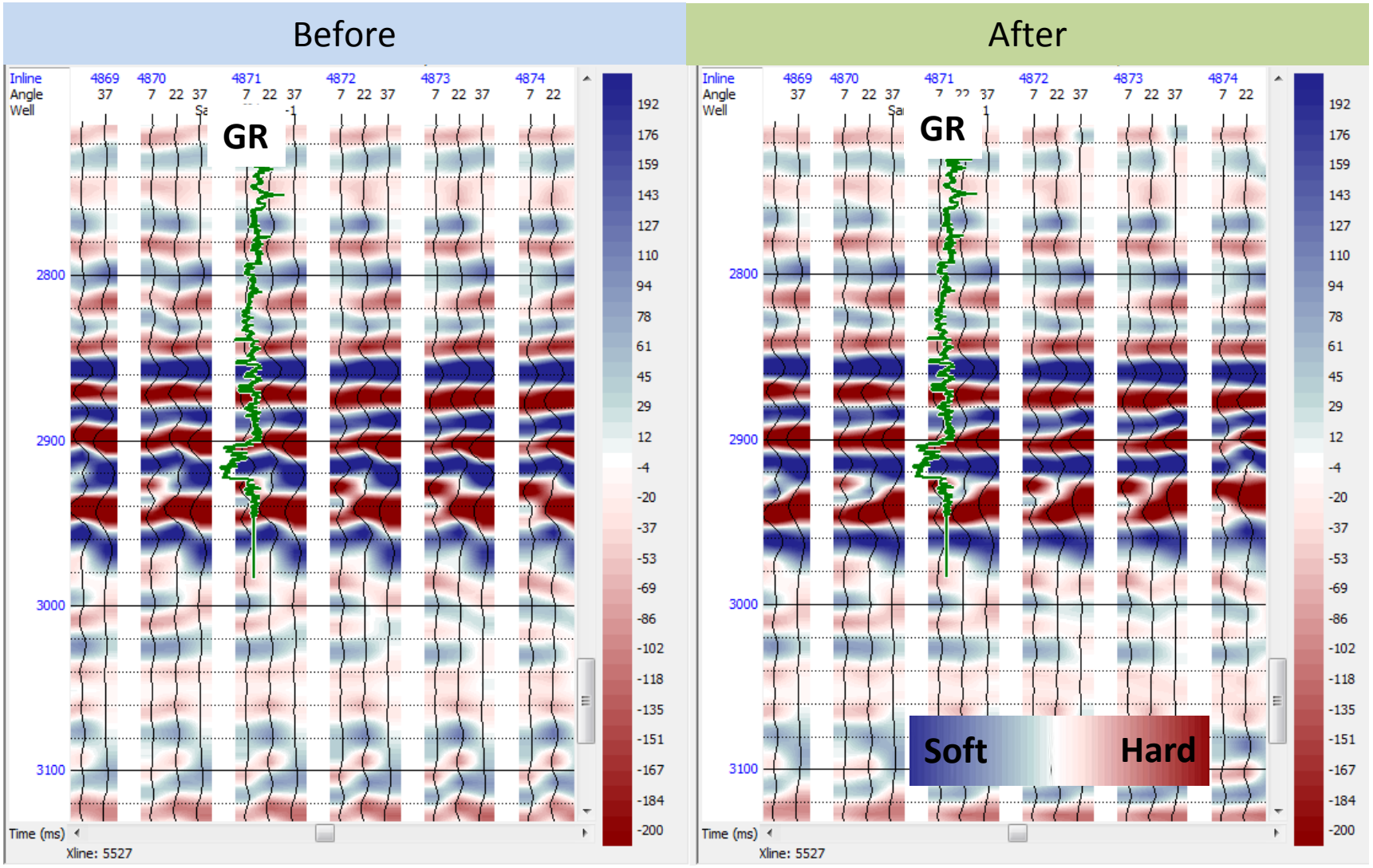
AVO Synthetic



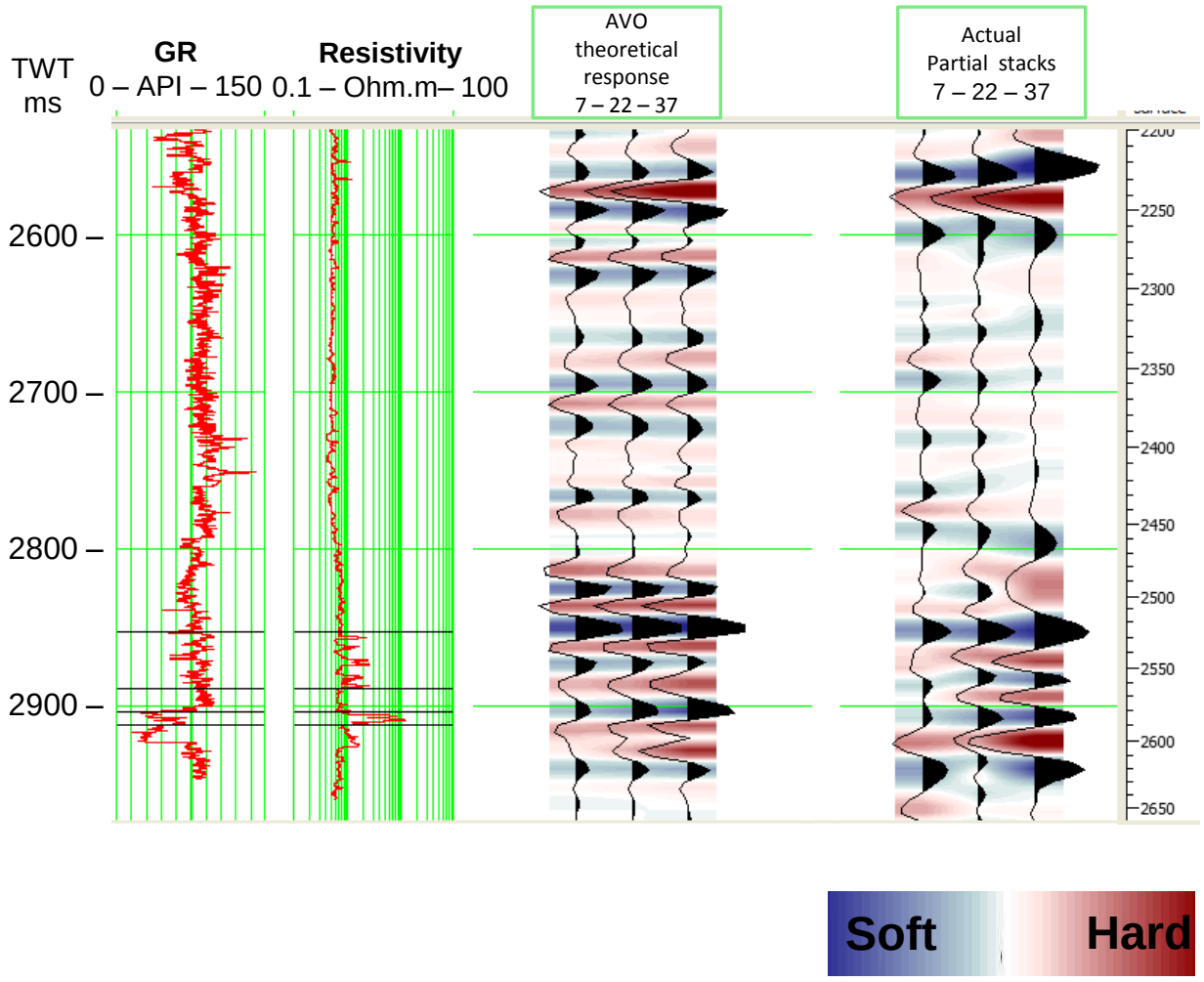
Amplitude Scaling QC



Trim Static

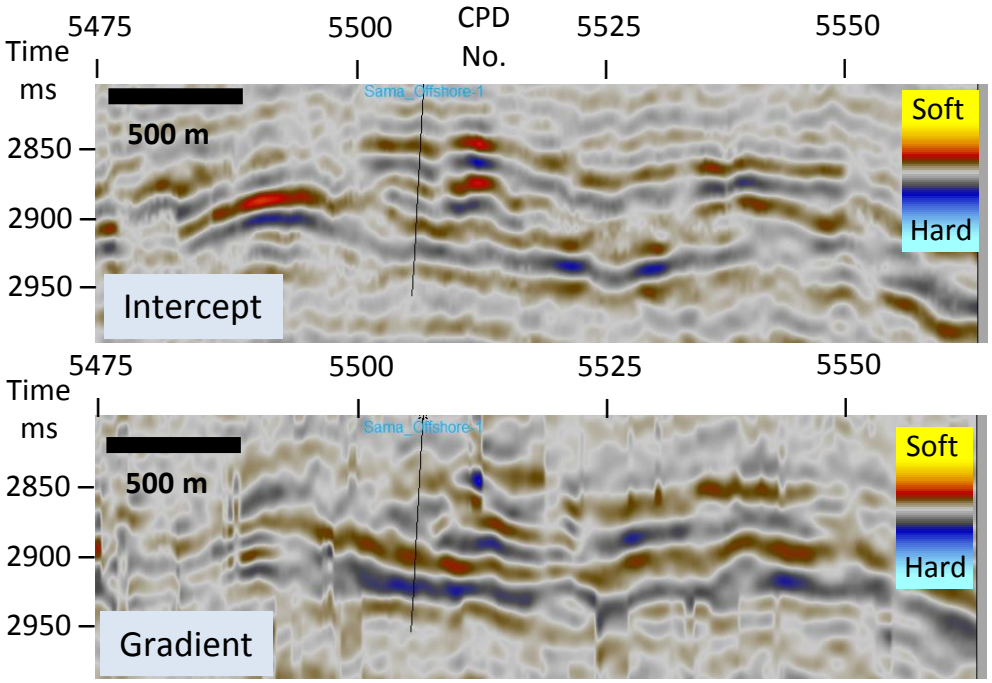

Before
After
Inline
Angle
Well
4869
4870
4871
4872
4873
4874
GR
2800
2900
3000
3100
Time (ms)
Xline: 5527
Soft
Hard

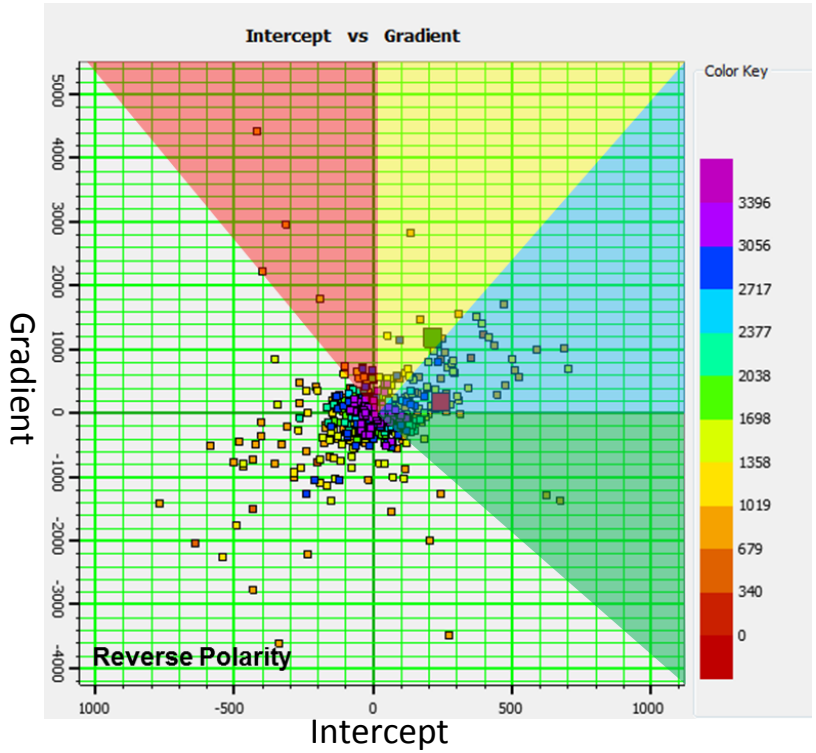
Sama-Offshore AVO Post Conditioning



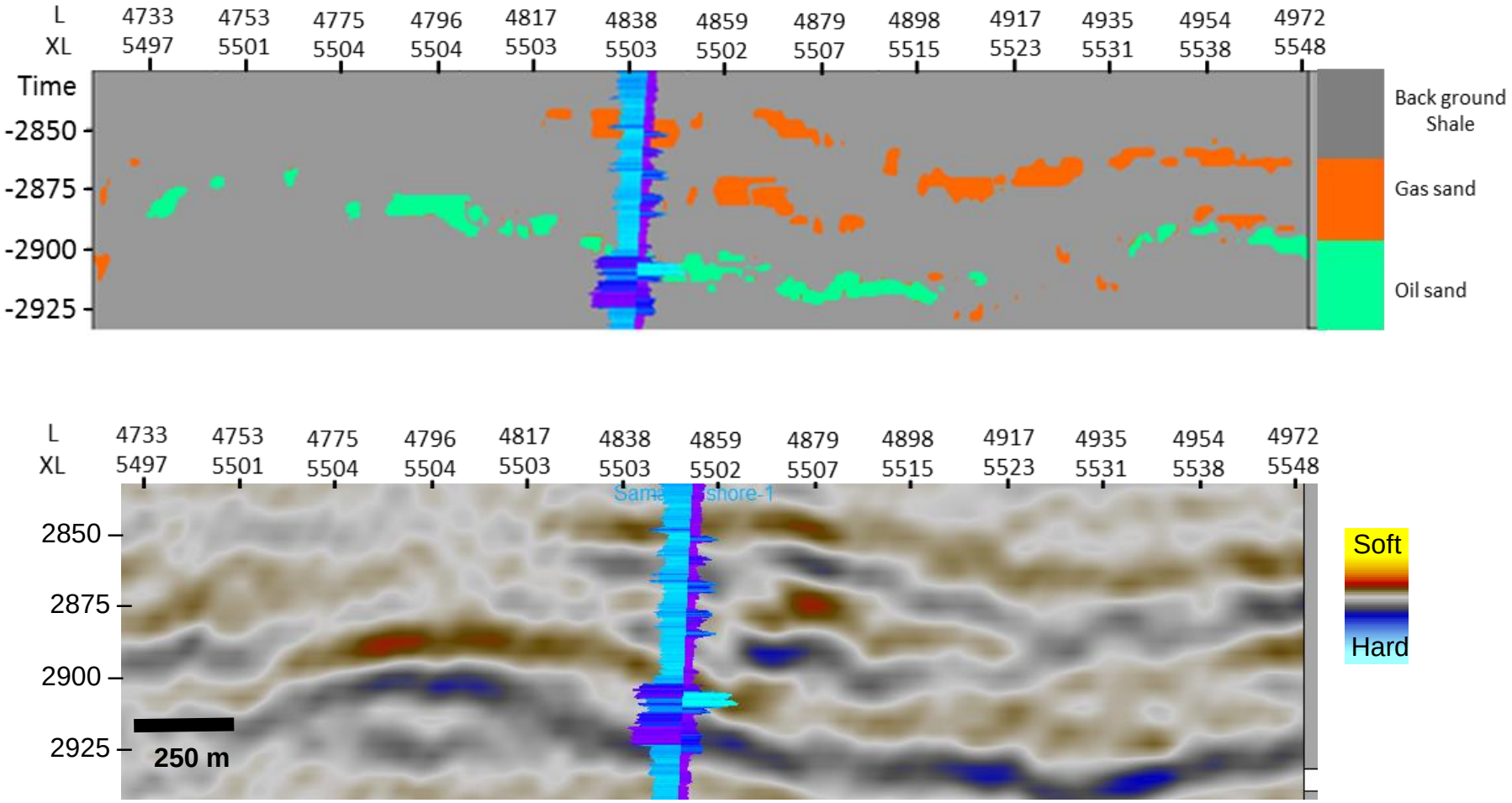
The AVO theoretical synthetic versus the angle stack

Angle stacks after Conditioning





AVO classified seismic section



AVO classified seismic section along the channel axis, showing the different fluid geobodies.

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Conclusions

- Sama-offshore well indicates that AVO signatures can be used as an integral part of seismic interpretation to predict hydrocarbon types.
- Sama- offshore well found that type 2 and 3 AVO behaviors are indicatives for the oil and gas response respectively.
- The proposed workflow is recommended to be applied in any similar geological setting.
- We can use AVO classified volume to predict the hydrocarbon geobodies which is important in volumetric calculation and in any further development wells.

Thank You