ICE2018
International Conference & Exhibition

AAPG

Rock Property Prediction From Model-Based Inversion F-A gas Field Bredasdorp Basin Offshore South Africa

Sbonelo Ngcongo (PetroSA, PhD Candidate in Reservoir Geophysics)

November 2018

MAIN TASKS

- The main tasks in this inversion study were:

- To invert the 3D seismic data over F-A gas field into absolute acoustic impedance using preferred seismic inversion method.

- To predict reservoir properties such volume of clay (VCL),water saturation (SW) and effective porosity (PHIE) from inverted acoustic impedance in order to assist in building a new static reservoir model.

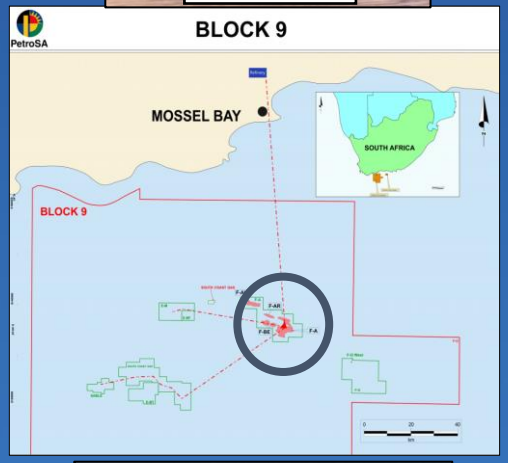
OUTLINE

- F-A FIELD LOCATION MAP AND GEOLOGY
- STUDY WORK-FLOW AND RESULTS
- VALIDATION OF PREDICTED EFFECTIVE POROSITY
- SUMMARY

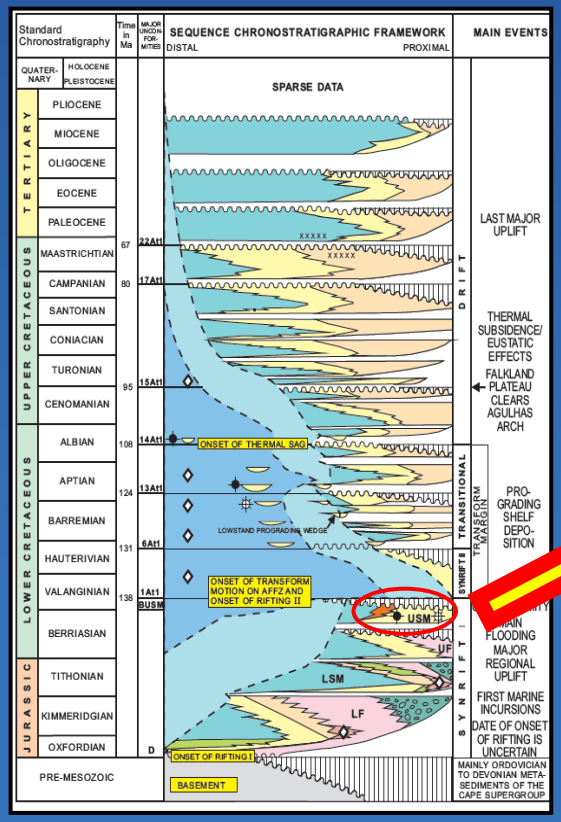
ICE2018
International Conference & Exhibition

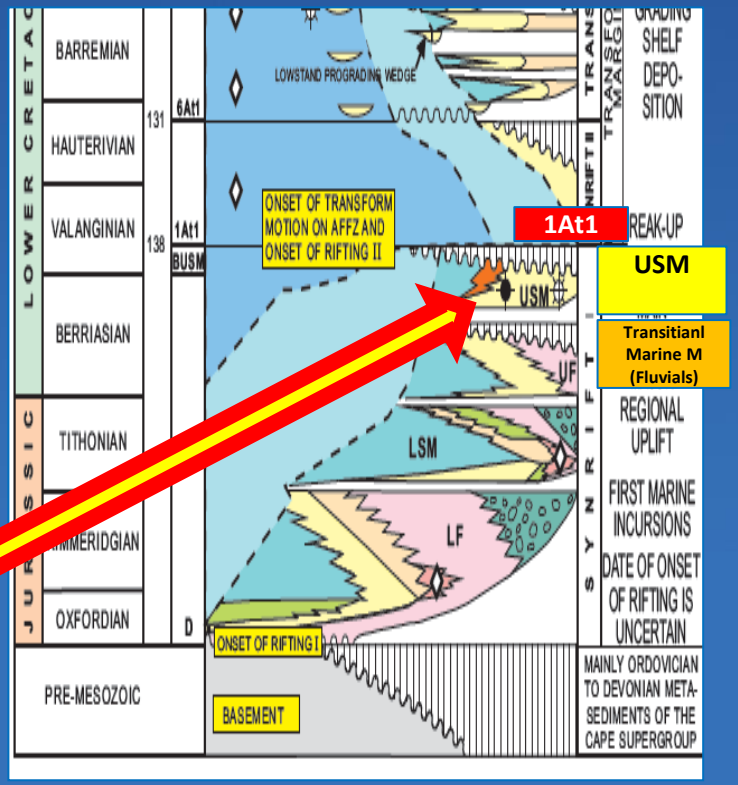
F-A FIELD LOCATION MAP AND GEOLOGY


GTL Refinery



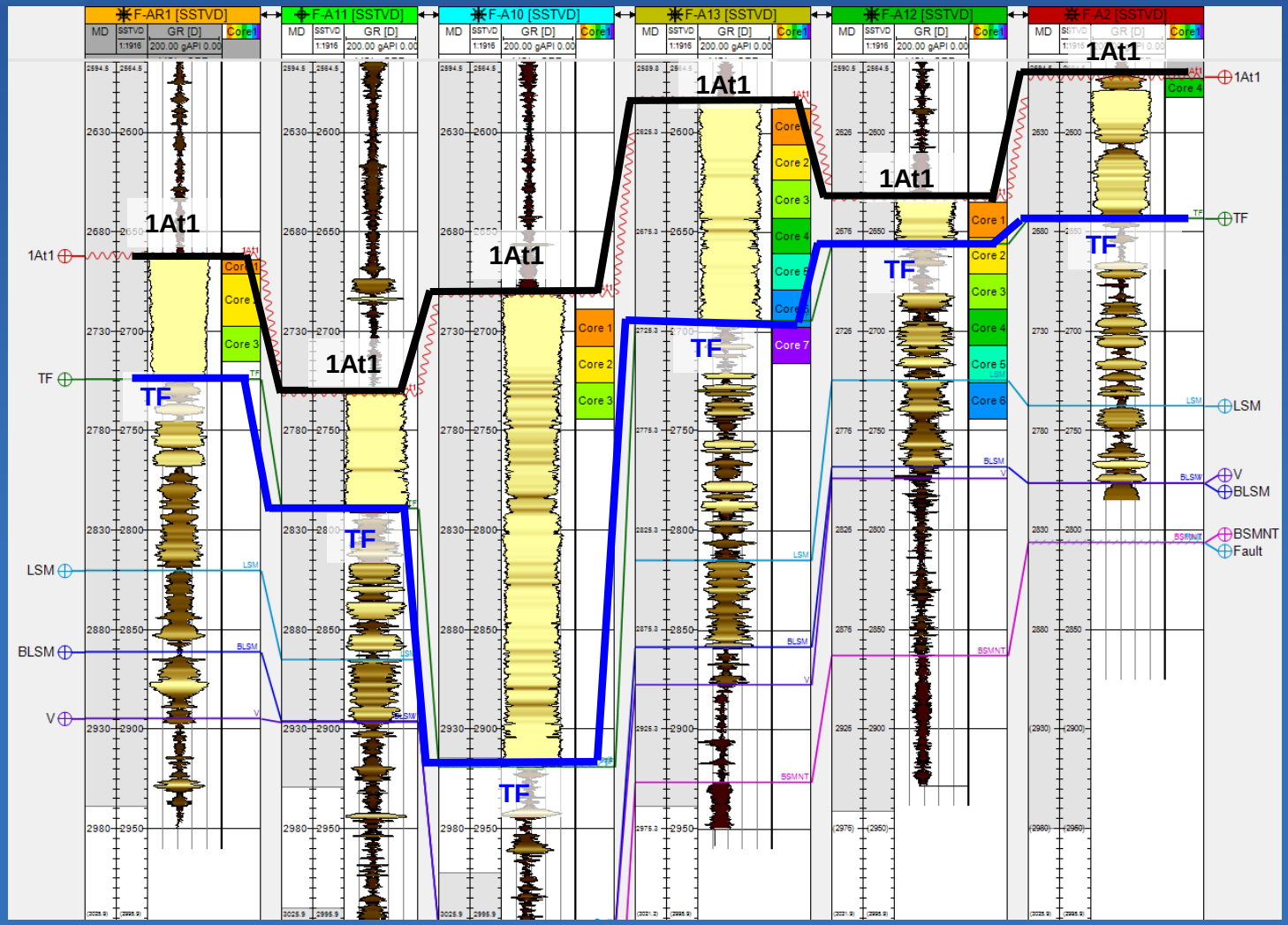

F-A Platform





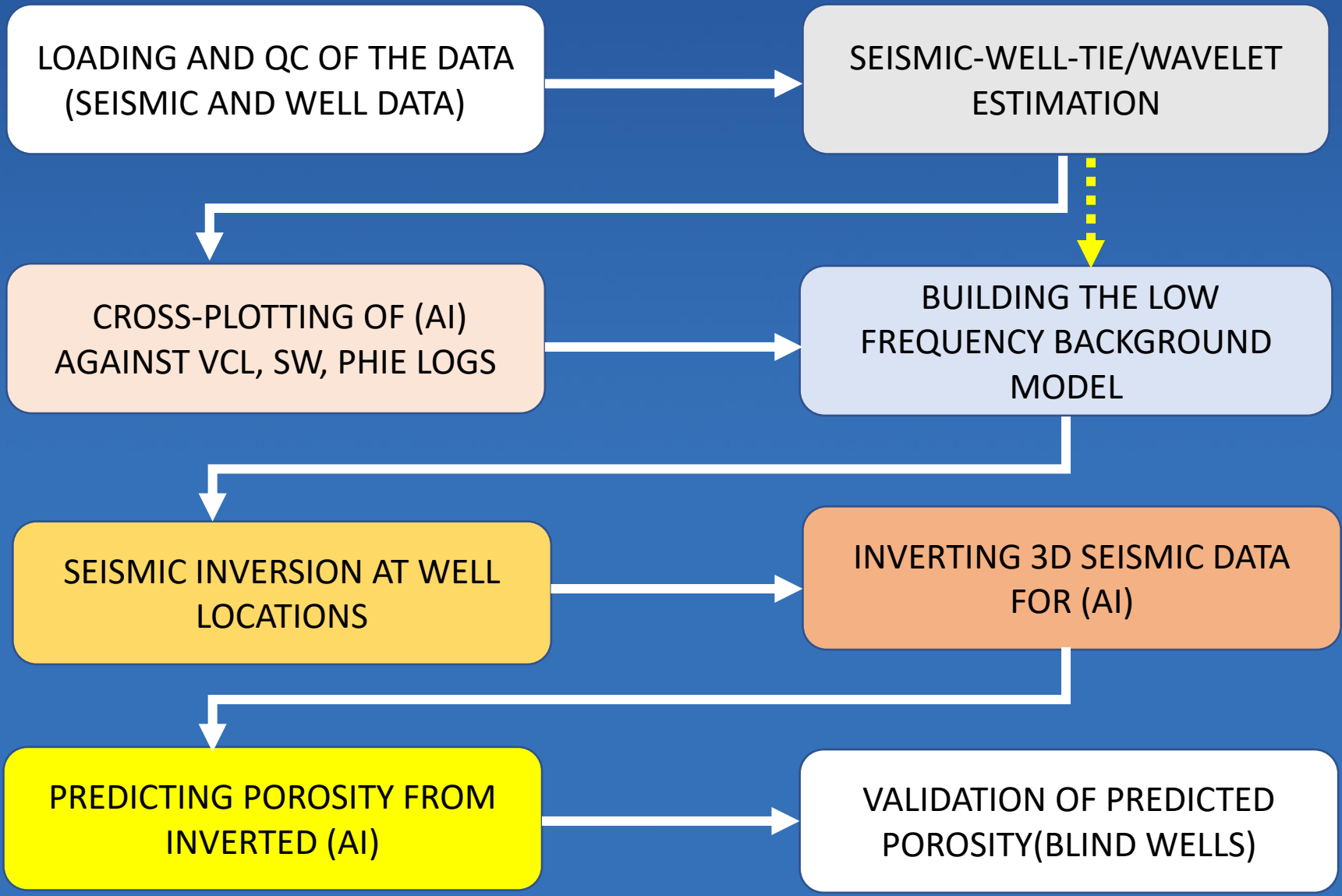
- F-A field is located in the northern part of the Bredasdorp basin within Block 9, offshore South Africa.
- The field is one of the main gas producers feeding the PetroSA's GTL Refinery.
- It was discovered in 1980 and has been producing gas since 1992 from the syn-rift Upper Shallow Marine (USM) sandstone of Valanginian age.
- Upper shallow Marine is the main target in this part of the basin and occurred below 1At1 unconformity.

CORRELATION SECTION THROUGH KEY F-A WELLS



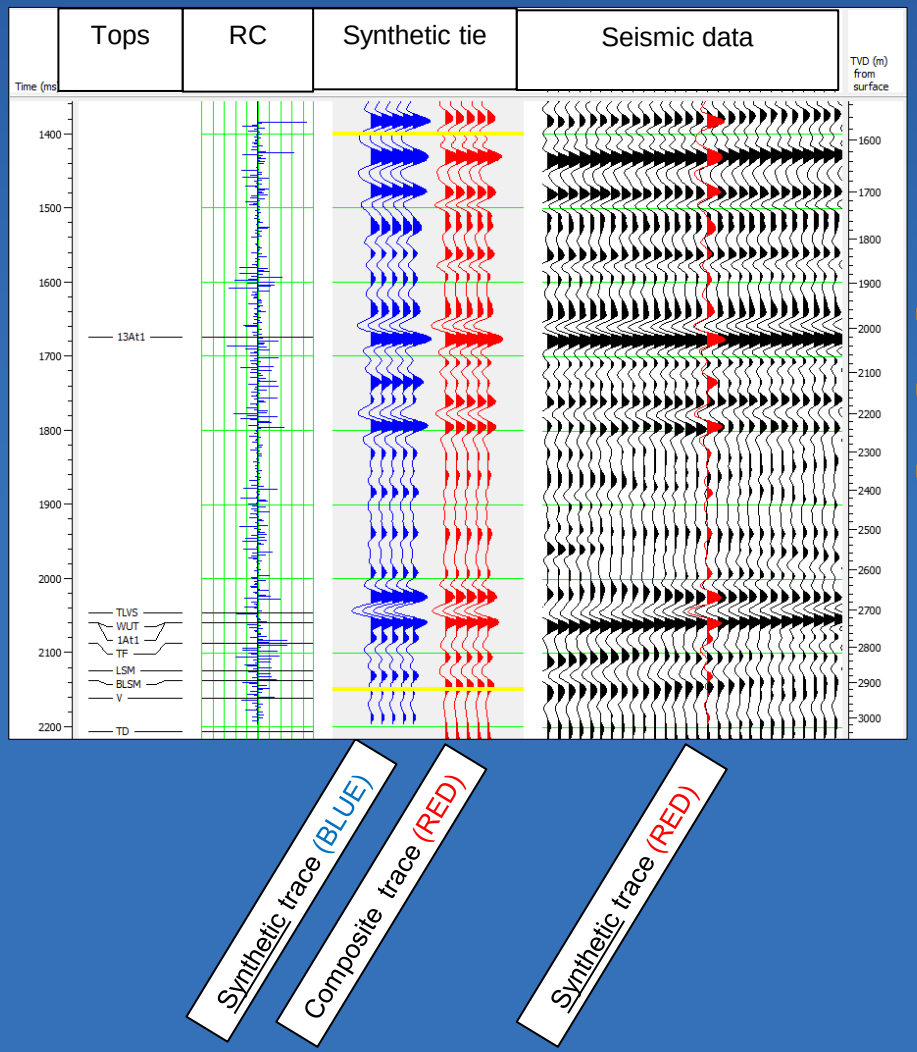
- Main reservoir: USM has a varying thickness of approx. 25-250 m across the F-A field.

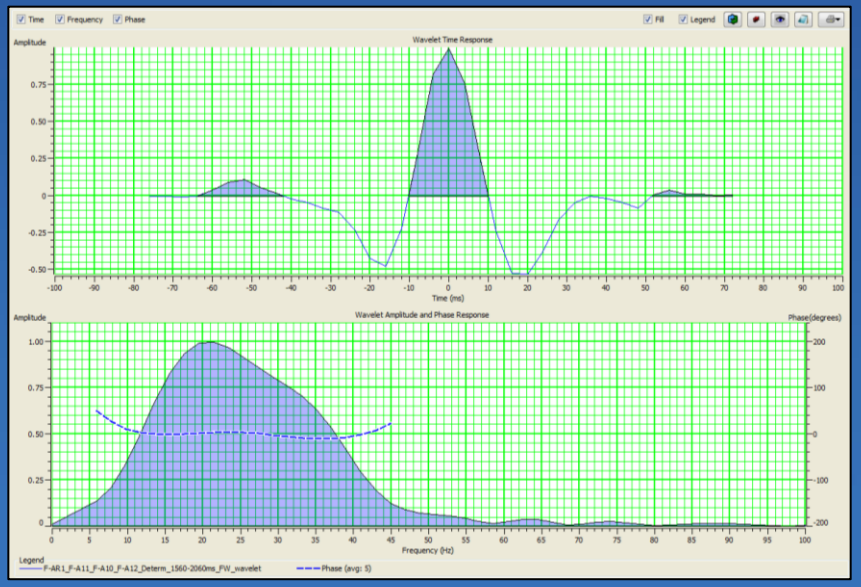
INVERSION STUDY WORKFLOW



ICE2018
International Conference & Exhibition

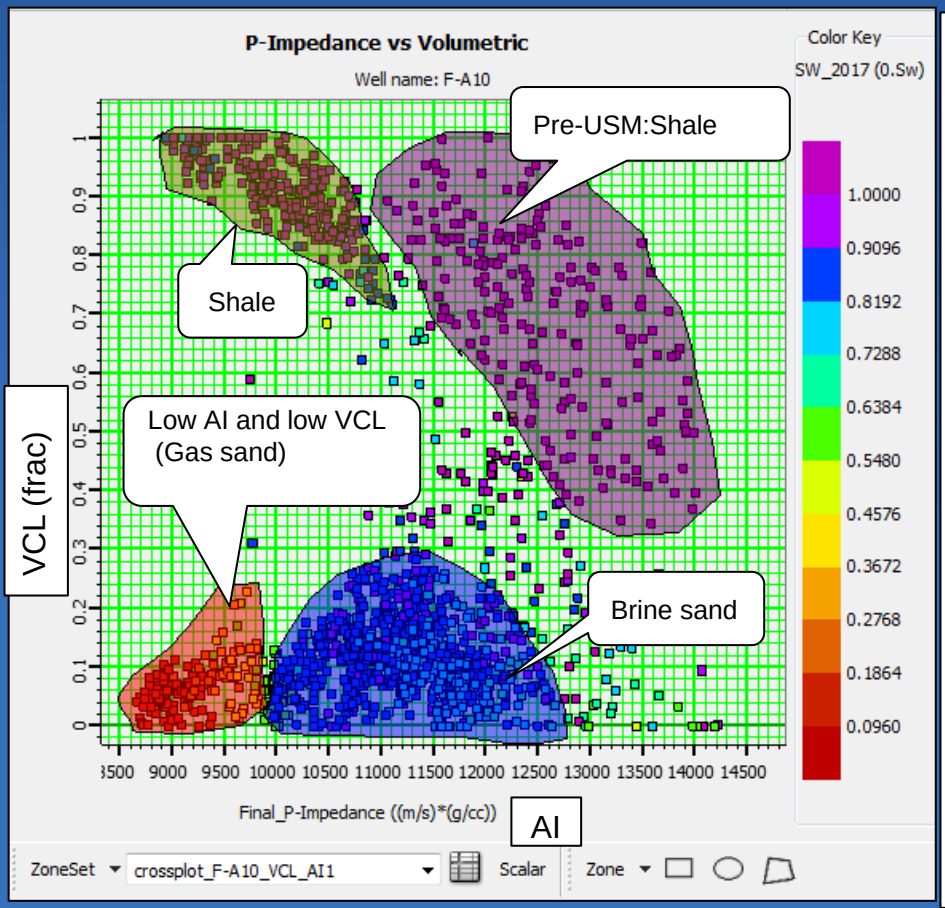
SEISMIC-TO-WELL TIE AND WAVELET ESTIMATION

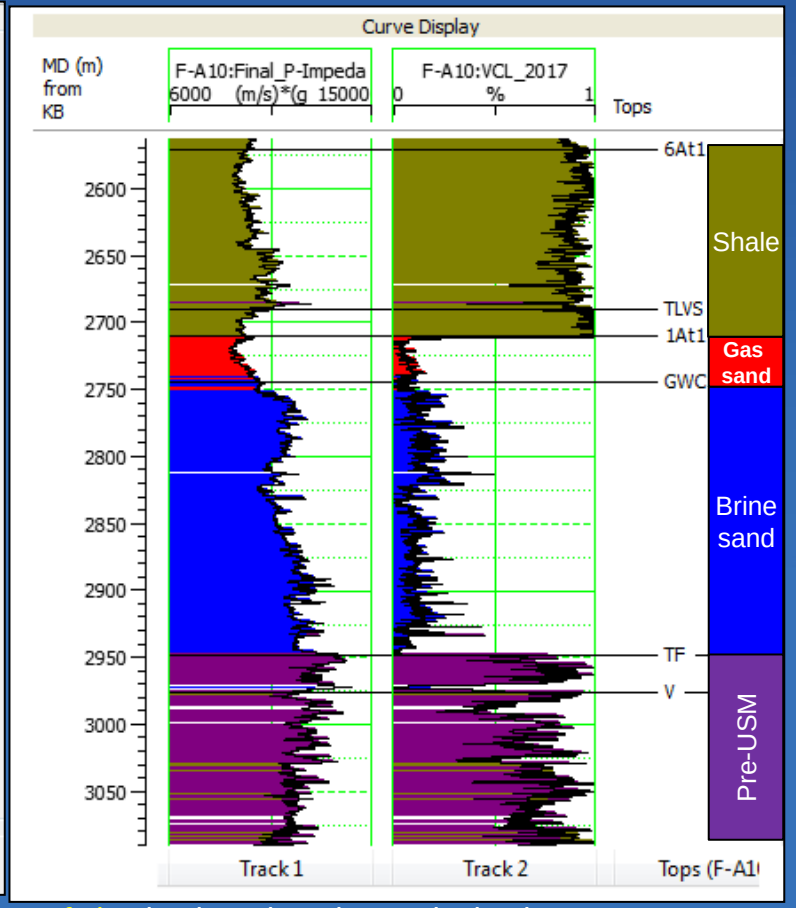




- Seismic-well tie is the critical factor of achieving good seismic inversion results.
- Accurate wavelet is the core for seismic inversion.

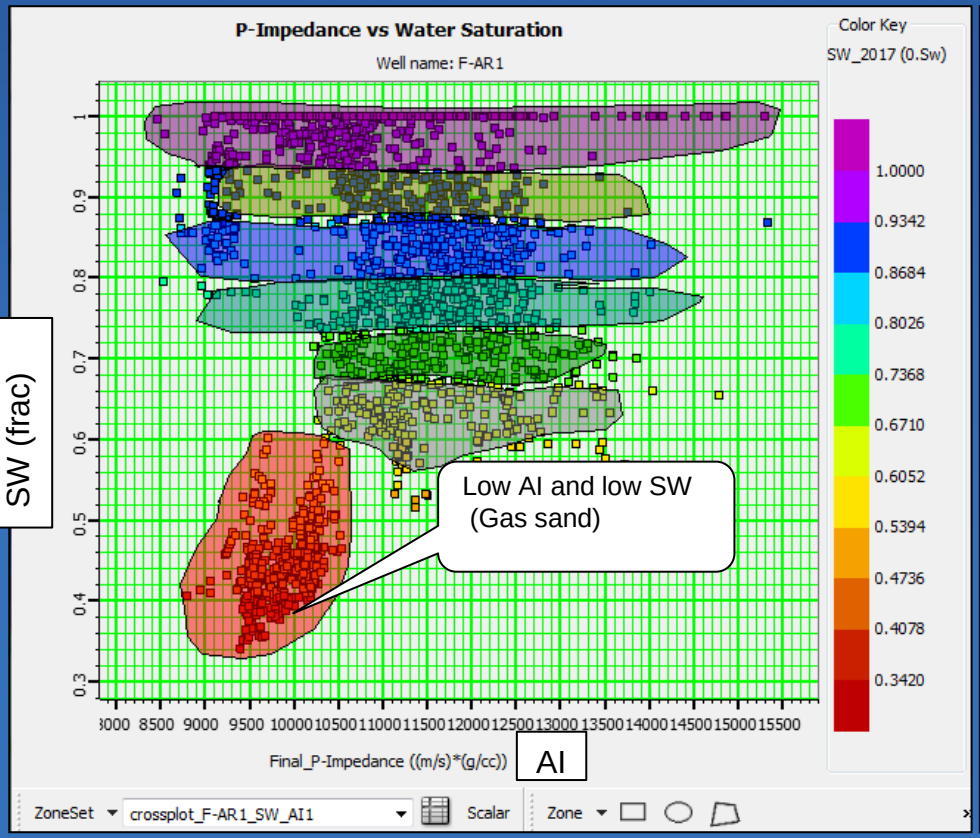
AI vs VCL EXAMPLE: F-A10 (Data color coded by SW)

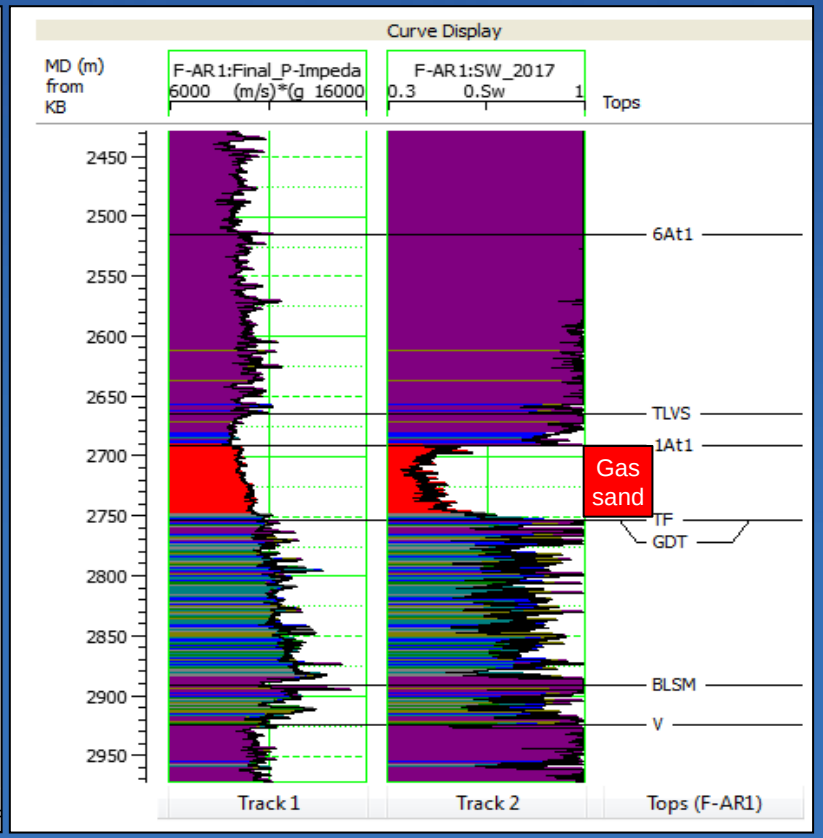




- Acoustic impedance is plotted on the horizontal axis, and volume of clay is plotted on the vertical axis.
- Gas cluster of points are highlighted in red and brine in blue.
- In this cross-plot shows that acoustic impedance cannot be used to discriminate lithology.
- There is NO CORRELATION between AI and VCL.

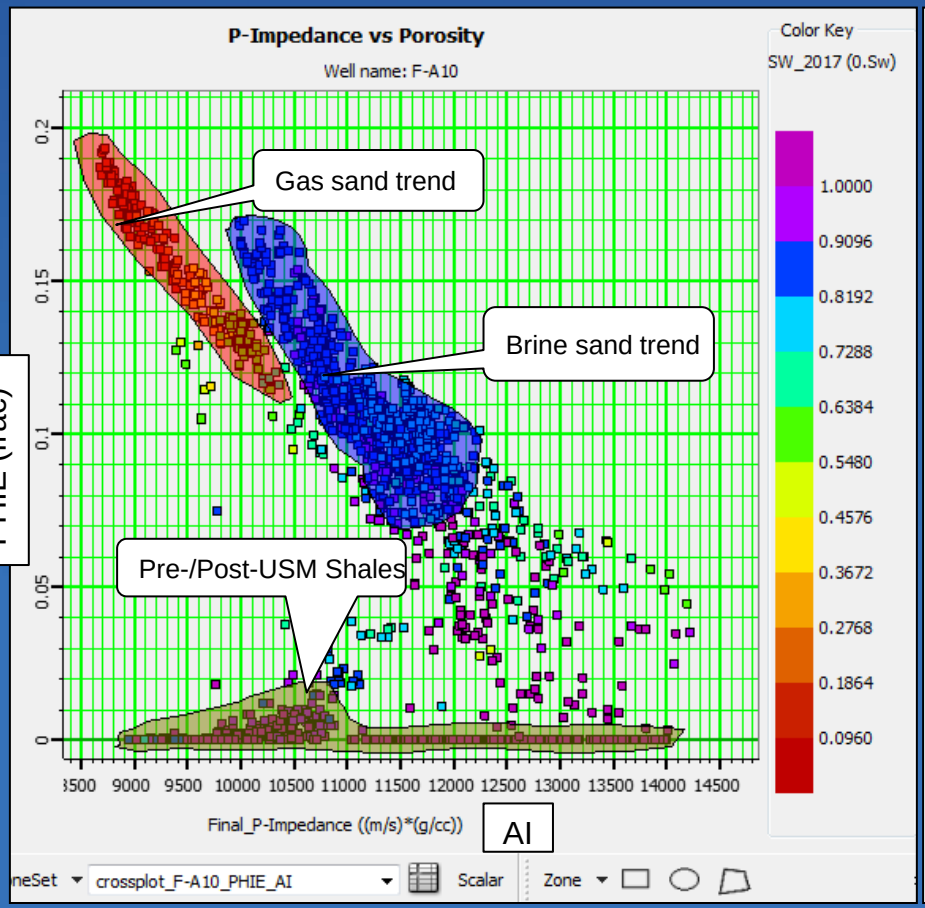
AI vs SW EXAMPLE: F-AR1 (Data color coded by SW)

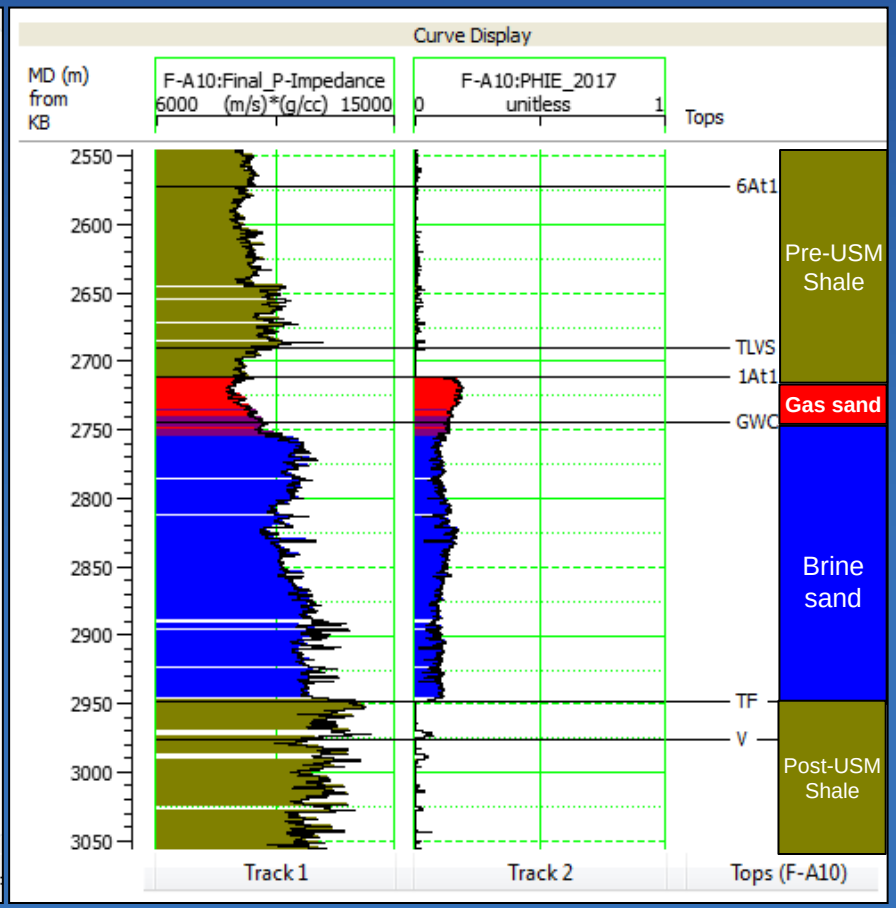




- Gas sand cluster of points are highlighted in red (low SW and AI values).
- Acoustic impedance cannot be used to discriminate pore fluid content.

AI vs PHIE EXAMPLE: F-A10 (Data color coded by SW)

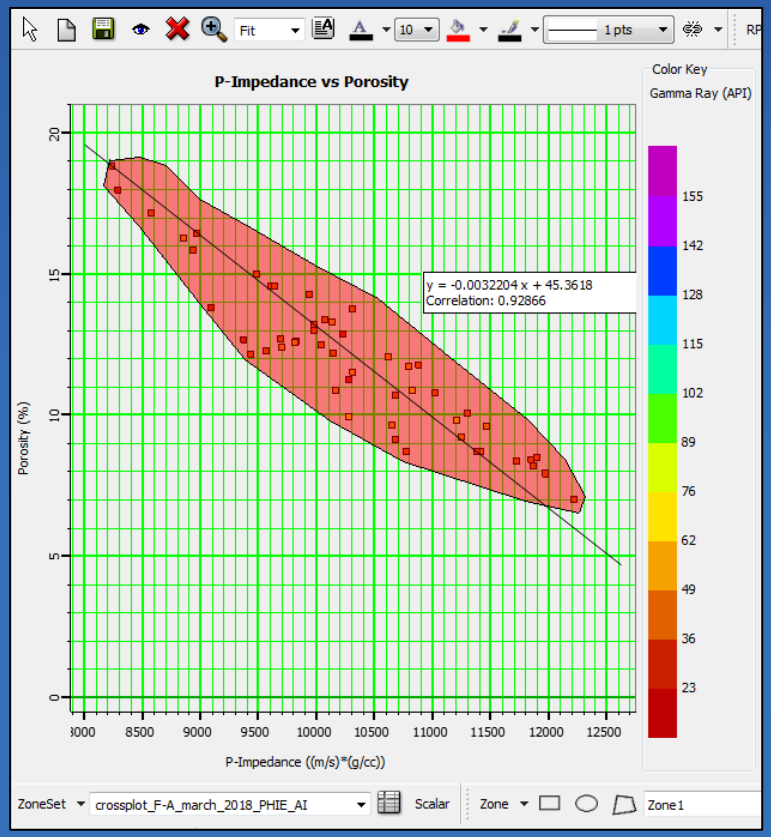


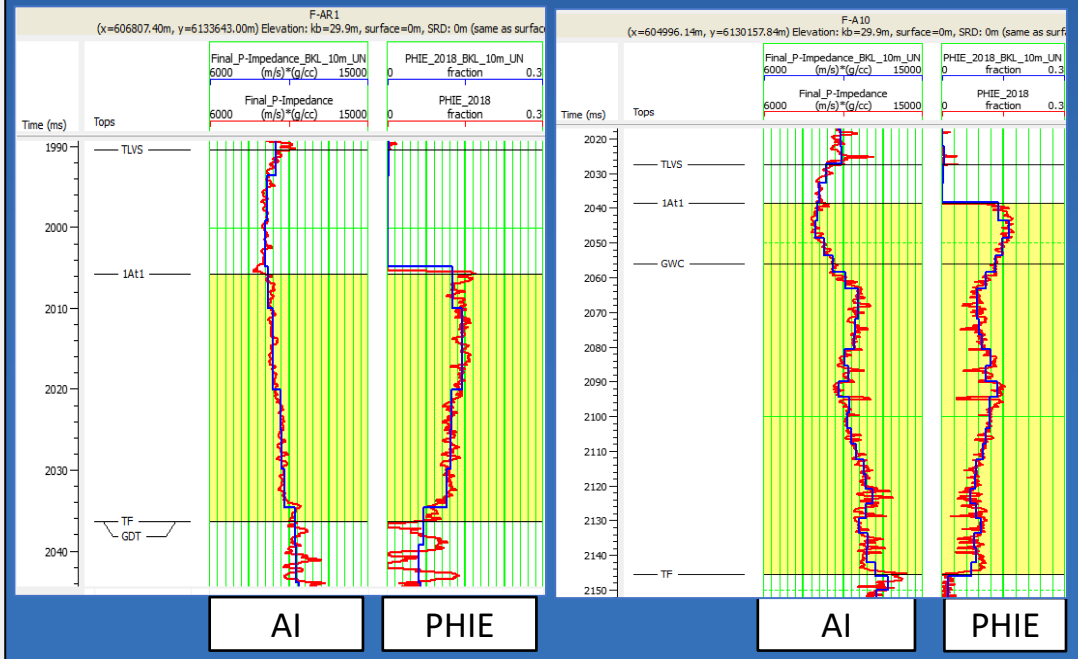


- There exists a good linear relationship between effective porosity and acoustic impedance in sandstone **(at LOG SCALE).**
- Gas and brine sand have different trends.

AI vs PHIE EXAMPLE: 6 WELLS (UPSCALED LOGS)

PHIE-AI TRANSFORM USING 6 WELLS (SEISMIC SCALE)

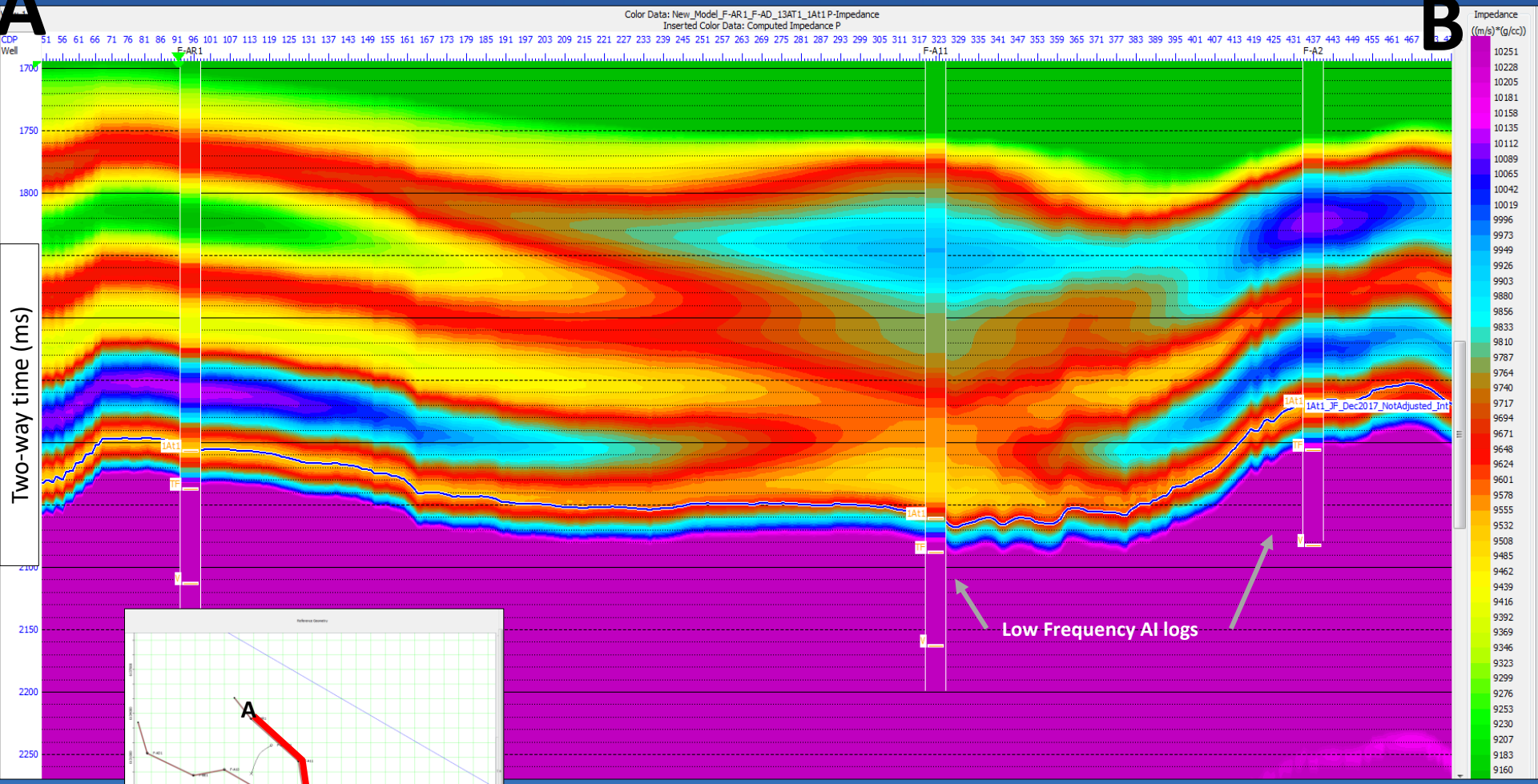




= USM Interval (1At1-TF)

- Acoustic impedance logs and effective porosity logs were upscaled to seismic scale by blocking.
- Acoustic impedance – effective porosity relationship is preserved after upscaling the logs.
- Good linear relationship still exist between acoustic impedance and porosity after blocking.

BUILDING A LOW FREQUENCY BACKGROUND MODEL

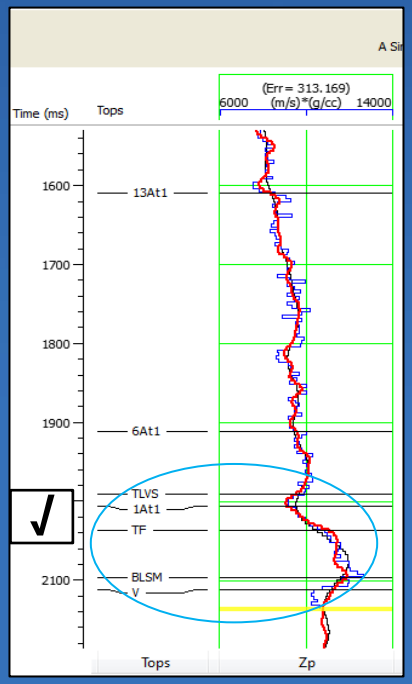


- Low frequency background model was built using interpreted horizons and acoustic impedance logs.
- Interpolation was applied using inverse distance weighting (IDW) in between the wells .The low pass filter was then applied to the AI model to only supply the missing low frequency components from seismic data.

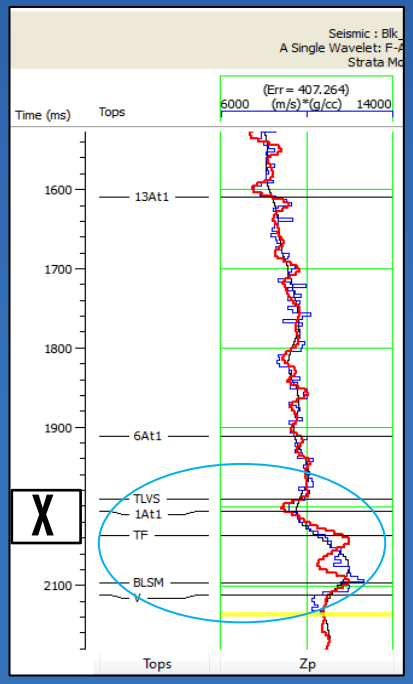
ICE2018
International Conference & Exhibition

TESTING VARIOUS SEISMIC INVERSION METHODS (INVERSION ANALYSIS AT WELL LOCATIONS)

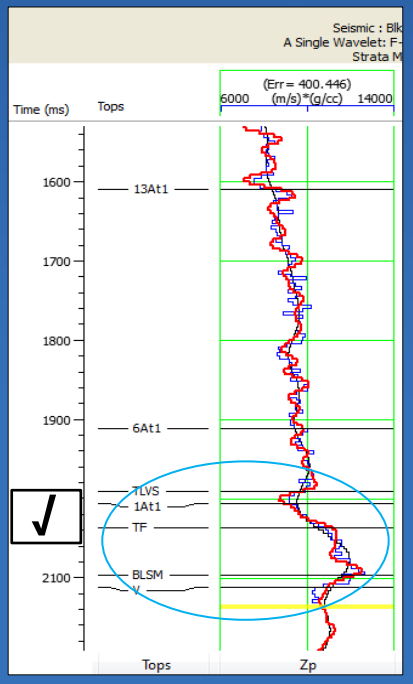
Model-Based



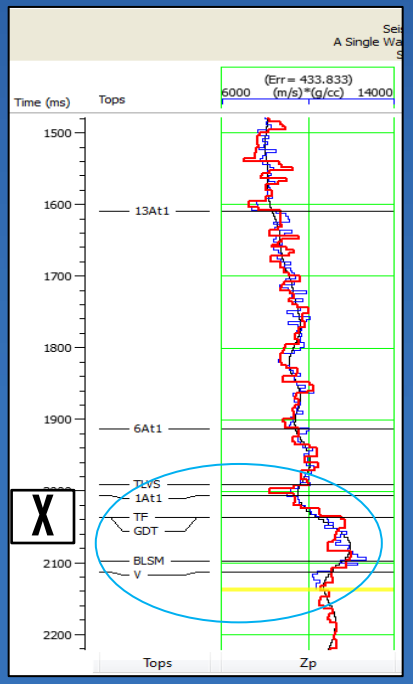
Band-Limited with LFM added



Coloured Inversion with LFM added



LP Sparse Spike



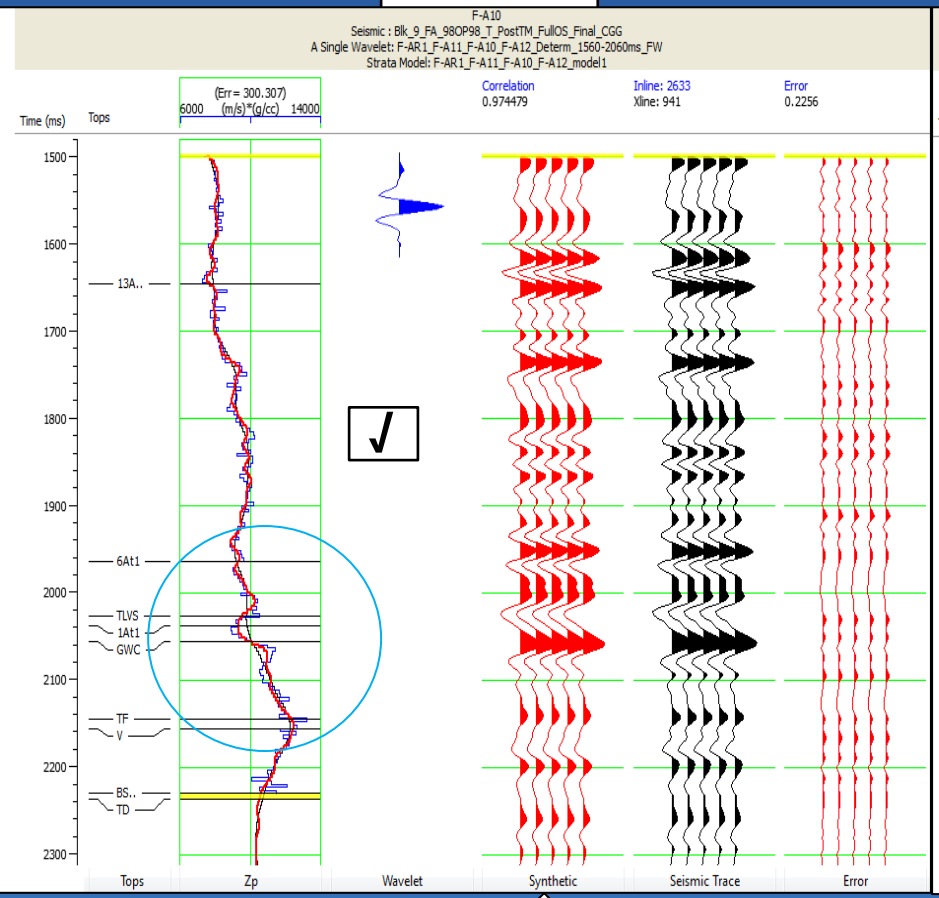
Inversion results

Original acoustic impedance log

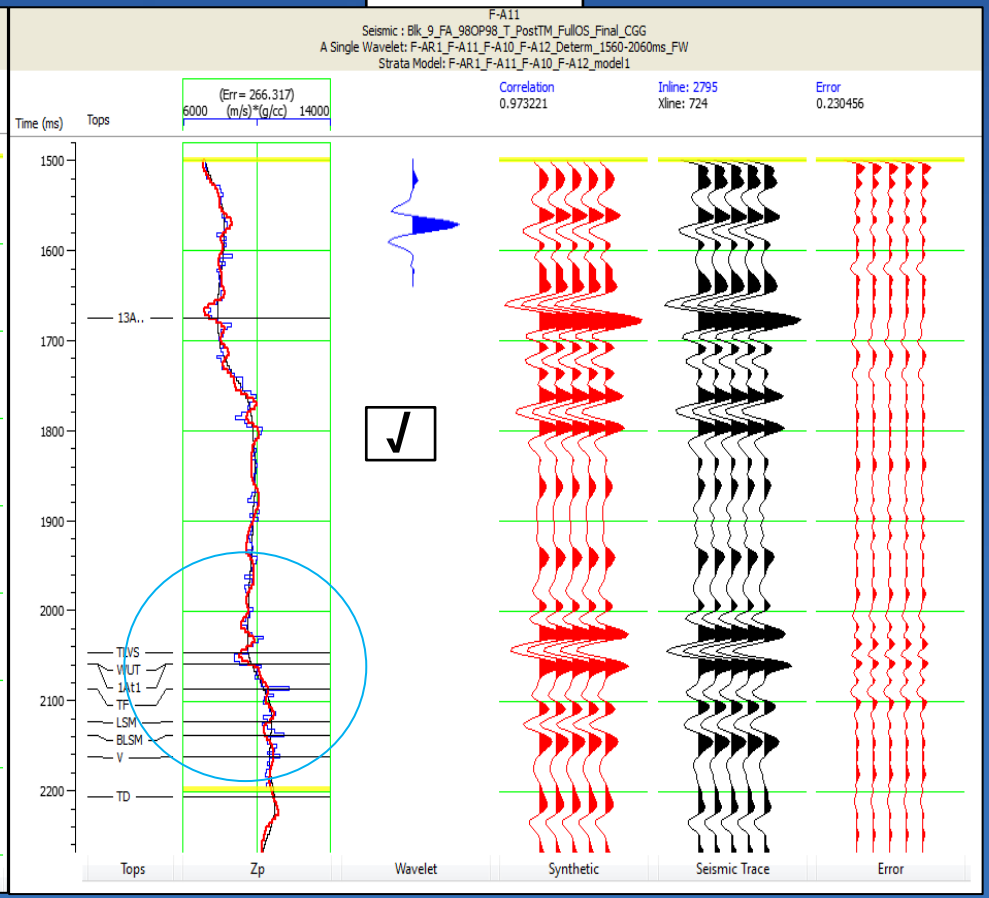
Low frequency model trend

INVERSION ANALYSIS (FROM MODEL-BASED SEISMIC INVERSION)

F-A10



F-A11



Inverted trace (RED)

Composite Trace

Error Trace

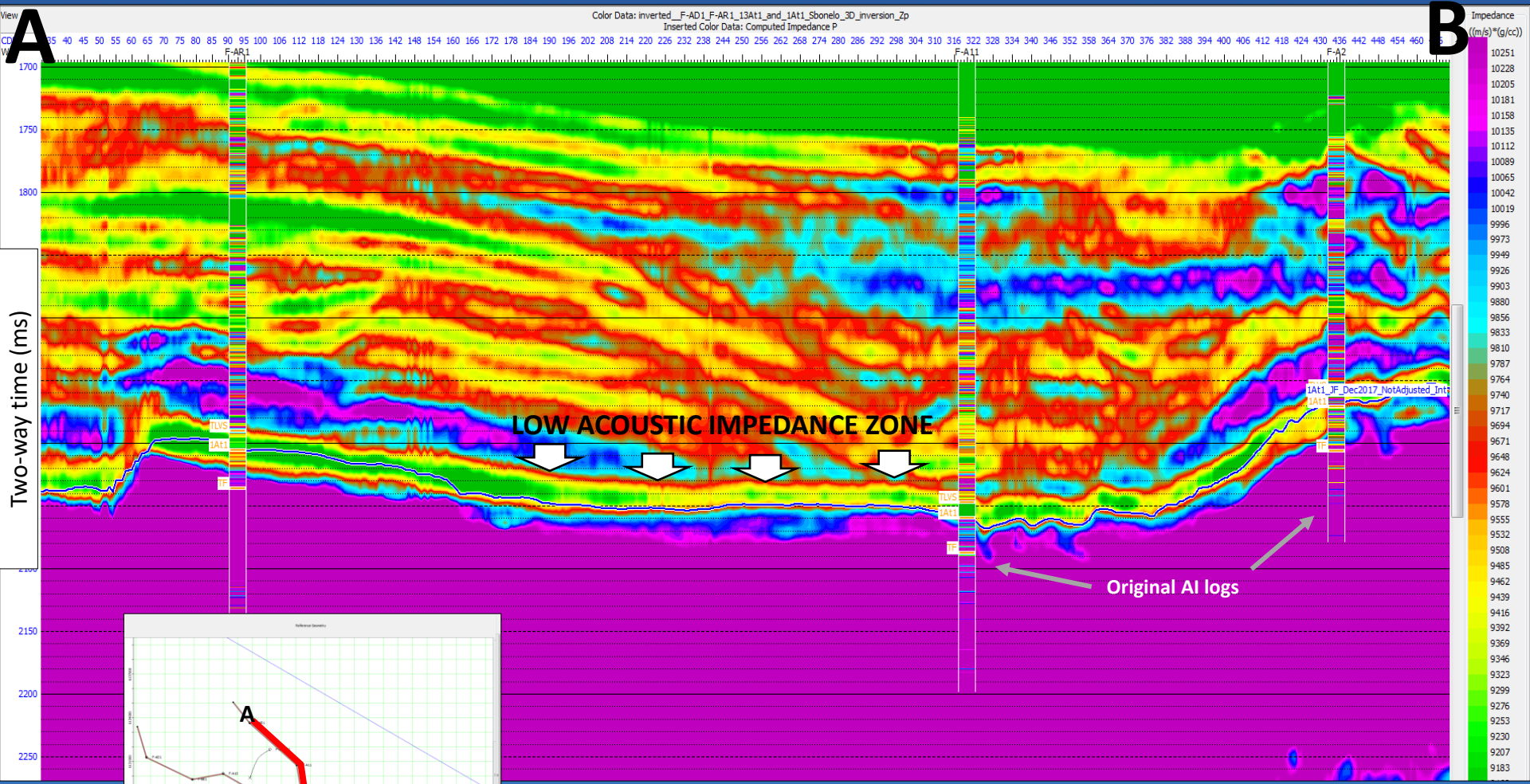
Inversion results

Original impedance log

Low frequency model tren

ICE2018
International Conference & Exhibition

AI CROSS-SECION SHOWING (LAZ) FROM FINAL MODEL



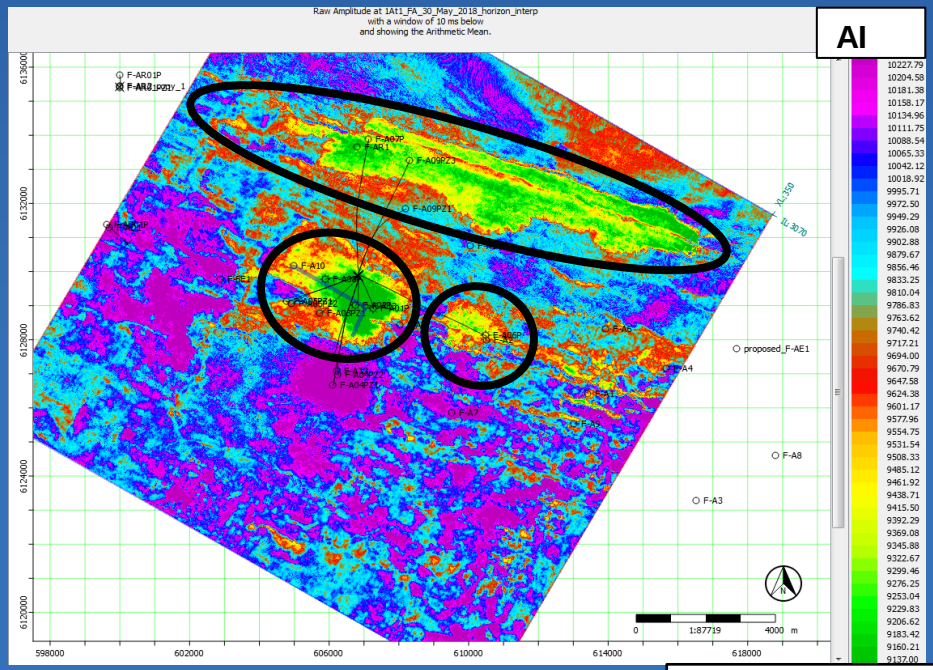
- Acoustic impedance cross-section reveals low acoustic impedance zone (LAZ).
- LAZ is made of low velocity shale and gas USM at and around F-AR1 and F-A2 wells is thicker.
- The zone is thinner at and around F-A11 (dry well) since made of only low velocity shale.

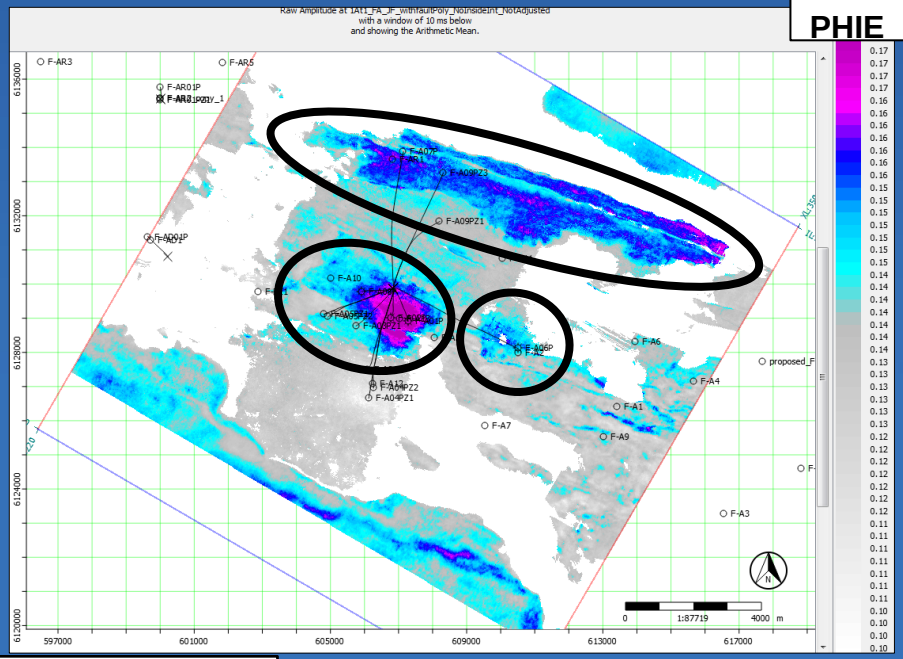
APPLYING THE TRANSFORM TO (AI) VOLUME

Average Acoustic Impedance Map
USM Reservoir in 10ms Window below 1At1

Transform: PHIE=-0.0032204*AI + 45.36

Average PHIE Map
USM Reservoir in 10ms Window below 1At1





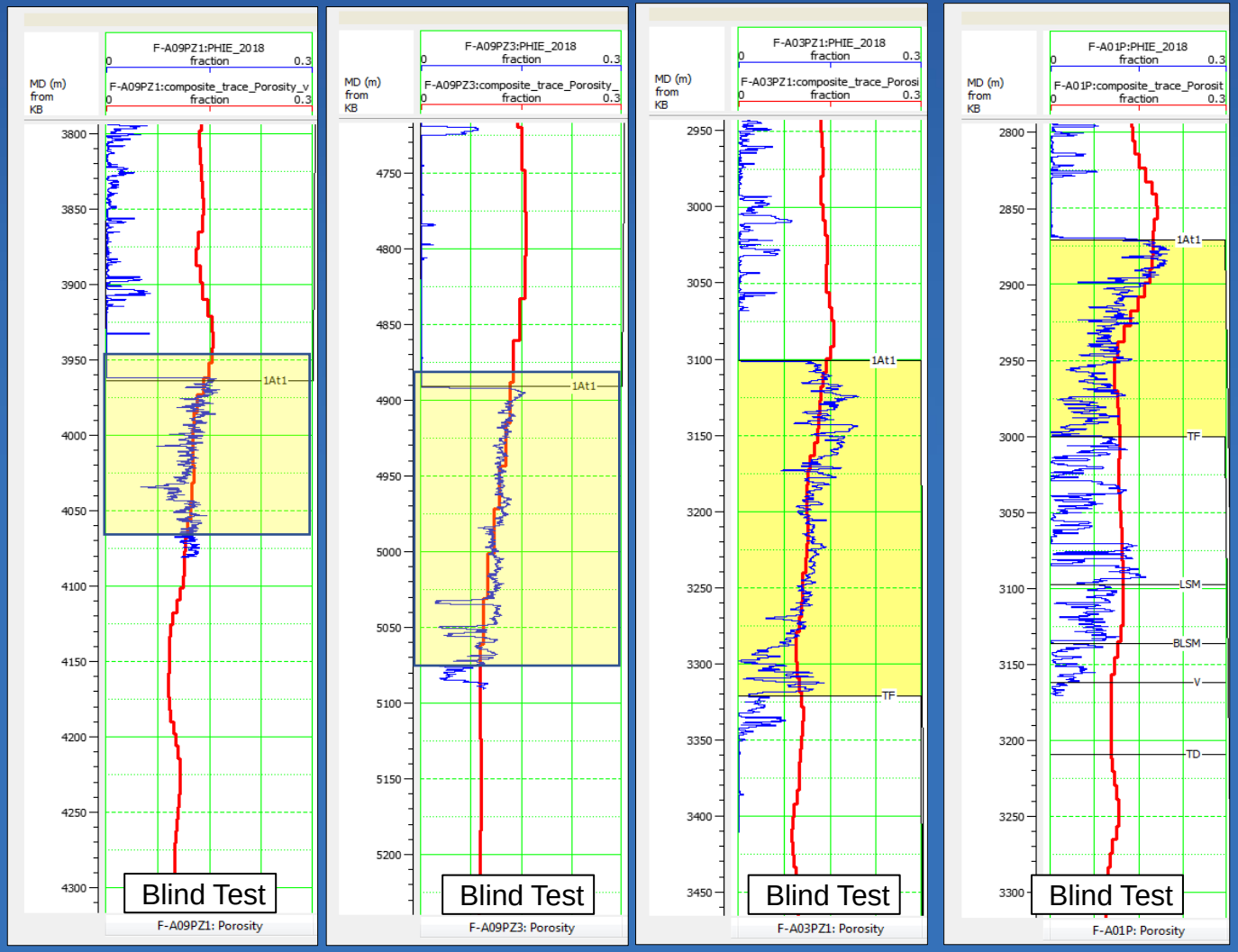
10ms below 1At1 = (10ms time window)

LEGEND

areas of low acoustic impedance and high porous zones

- Acoustic Impedance has captured gas filled sand and high porous zones in the reservoir.

VALIDATION OF THE PREDICTED EFFECTIVE POROSITY



- *Blind Test Analysis for gas producers and deviated wells that were not used during inversion in building the model.*
- ***Blind wells effective porosity logs matched the predicted porosity trend in USM sandstone.***

measured porosity

predicted porosity

SUMMARY

- Seismic inversion has converted seismic from interface property into rock layer property (acoustic impedance).
- There exist a good linear relationship between acoustic impedance and effective porosity in the Upper shallow marine sandstone.
- Model-based inversion was the preferred approach because it has produced convincing inversion results.
- Blind wells matched the predicted effective porosity trend quite well, thus justifying the use of inverted acoustic impedance as an input in modelling effective porosity distribution over F-A static reservoir model.

ICE2018
International Conference & Exhibition

Thank you