De-Risking a Gas Development Using Geophysical Methods*

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Abstract

This study investigates the optimal geophysical determination of sand distribution using seismic data for a Tertiary turbidite gas field. 625 km^2 full-fold new 3D seismic data was acquired and processed in 2001. In 2004, the 3D seismic dataset was reprocessed with the objectives of improving signal-to-noise, removing multiples and generating near/far-trace data for AVO analysis. A further reprocessing campaign was carried out in 2010 in order to improve the seismic imaging beneath the gas clouds over two different areas and to improve the frequency content of the data whilst reducing noise and multiples. Other objectives were to generate high-quality flattened gathers that can be used for pre-stack Inversion and to sharpen the image of the faults for accurate placement of development wells. It is standard industry practice to quantify reservoir property inverting seismic data usually via a model-based approach; unfortunately, the area posed several challenges to this standard approach mainly due to the lack of well controls as well as due to the uncertainties associated with wavelet extractions near the gas cloud. In order to account for the above problems it was decided to combine the benefits of an Extended Elastic Impedance (EEI) projection to maximize a particular property, such as the separation between hydrocarbon and brine sand or between sands and shale without the need of building a model or a extracting wavelet with the benefit of a model base simultaneous elastic inversion (MBEI) followed by a neural network (NN) analysis aimed at producing a seismic derived Volume of Shale (Vsh). EEI lithology volume shows an excellent match with the well data as well as a very good continuity of the sand presence both down dip of the well but also beneath the gas cloud. EEI Fluid volume amplitude extraction along the mapped top of Sand 3 show an excellent match between the Gas Water Contact (GWC) and the area characterized by highest probability of hydrocarbon bearing sand occurrence. Seismic derived Vsh volume also shows an excellent match with the well data as well as a very good continuity of the sand presence both outside and beneath the gas cloud. In light of the observations made using the latest geophysical methodologies EEI and MBEI-NN applied to the field, our confidence about the sand presence both far from well control and beneath the gas cloud has broadened.

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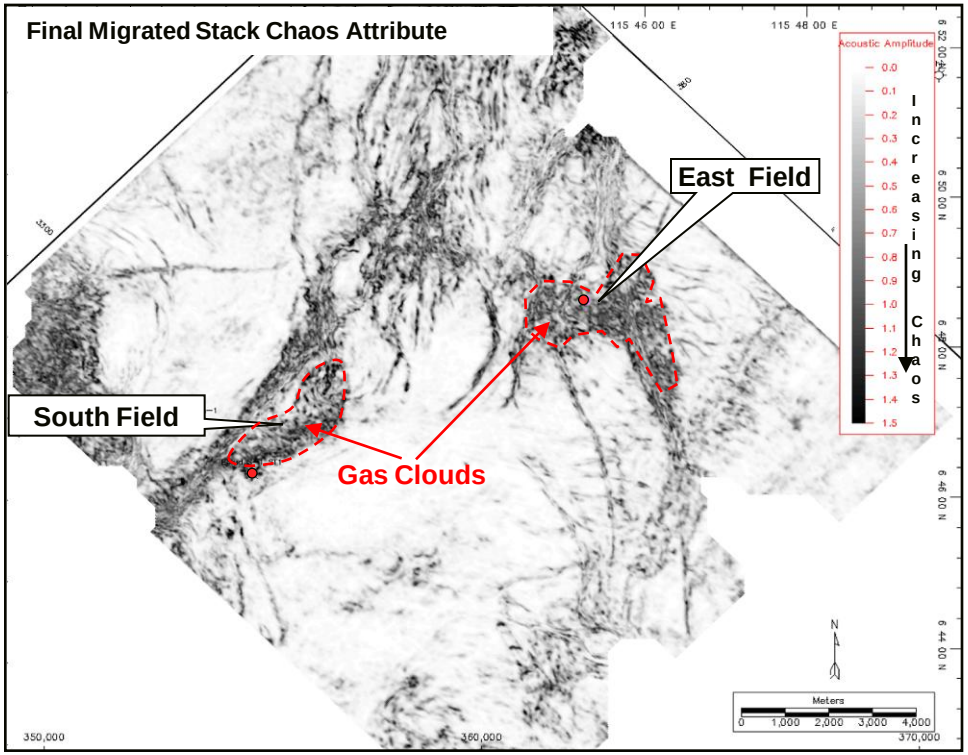
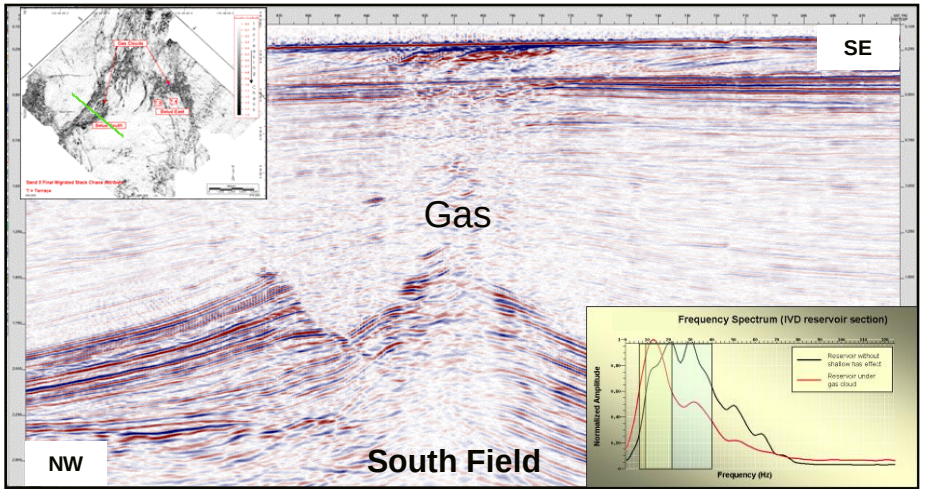
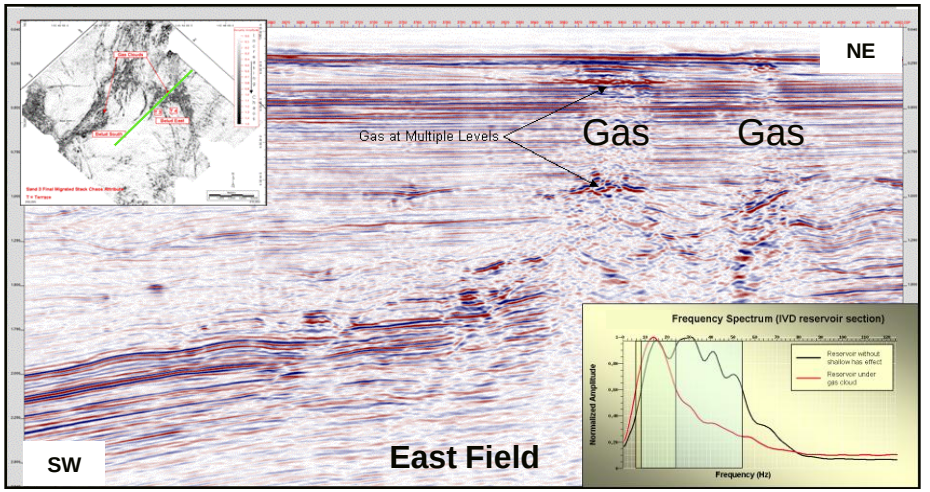
Presentation Outline

- Geophysical Challenges
- Seismic Reprocessing History
- Benefits of Latest Reprocessing Campaign
- Fluid Detection via AVO
- EEI and Simultaneous Elastic Inversion for Fluid and Lithology discrimination
- Conclusions

Geophysical Challenges







- Gas cloud covering South Field reduces data quality but does not completely mask
- Gas cloud over East Field is at multiple levels and completely masks data in places
- Only 2 wells plus 1 Side Track over the two Fields

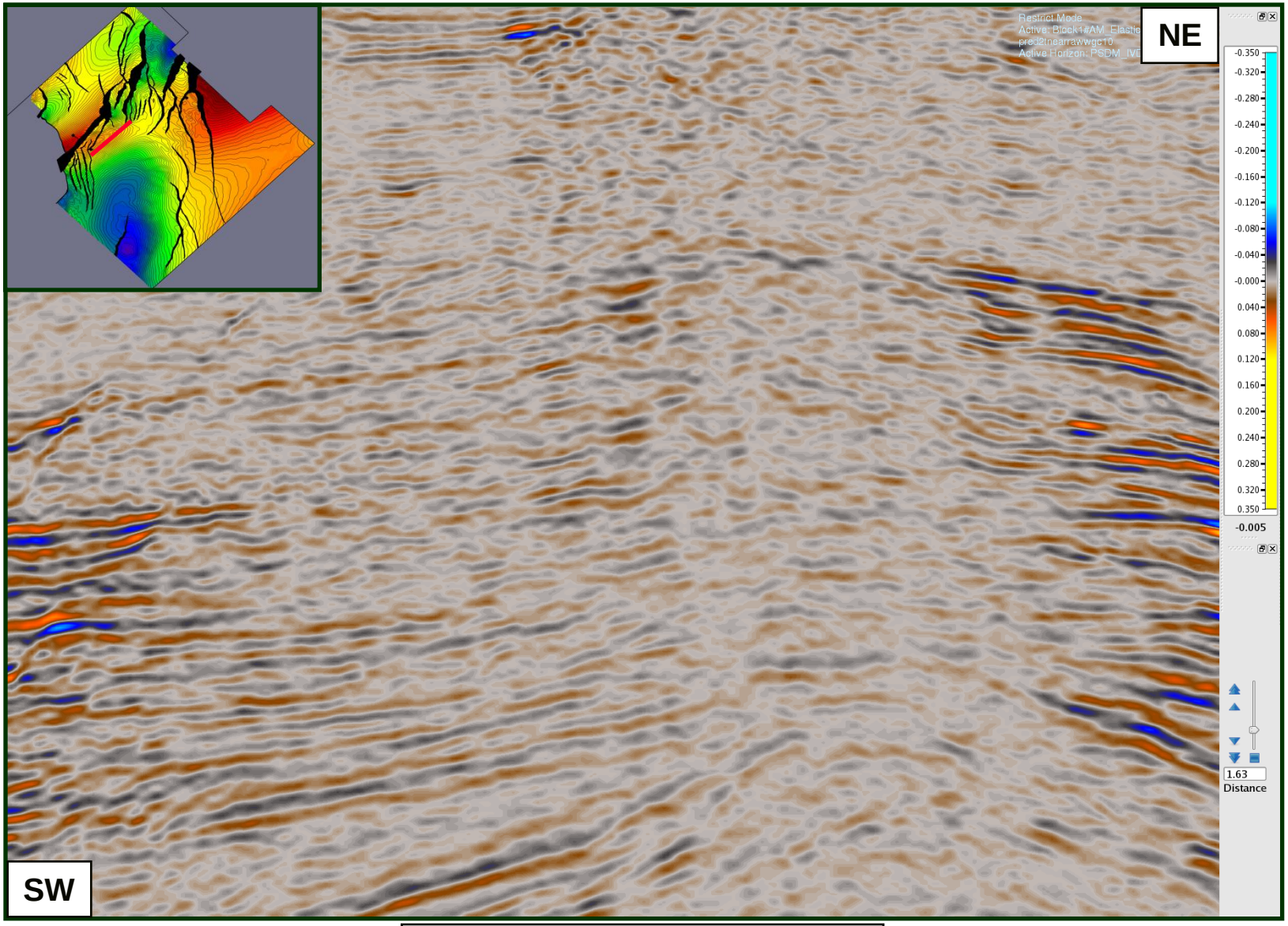
Seismic Reprocessing History

- 2001 625km^2 64 fold 3D seismic data acquired and processed using post stack time migration.

- 2004 3D data reprocessed using pre-stack time migration.

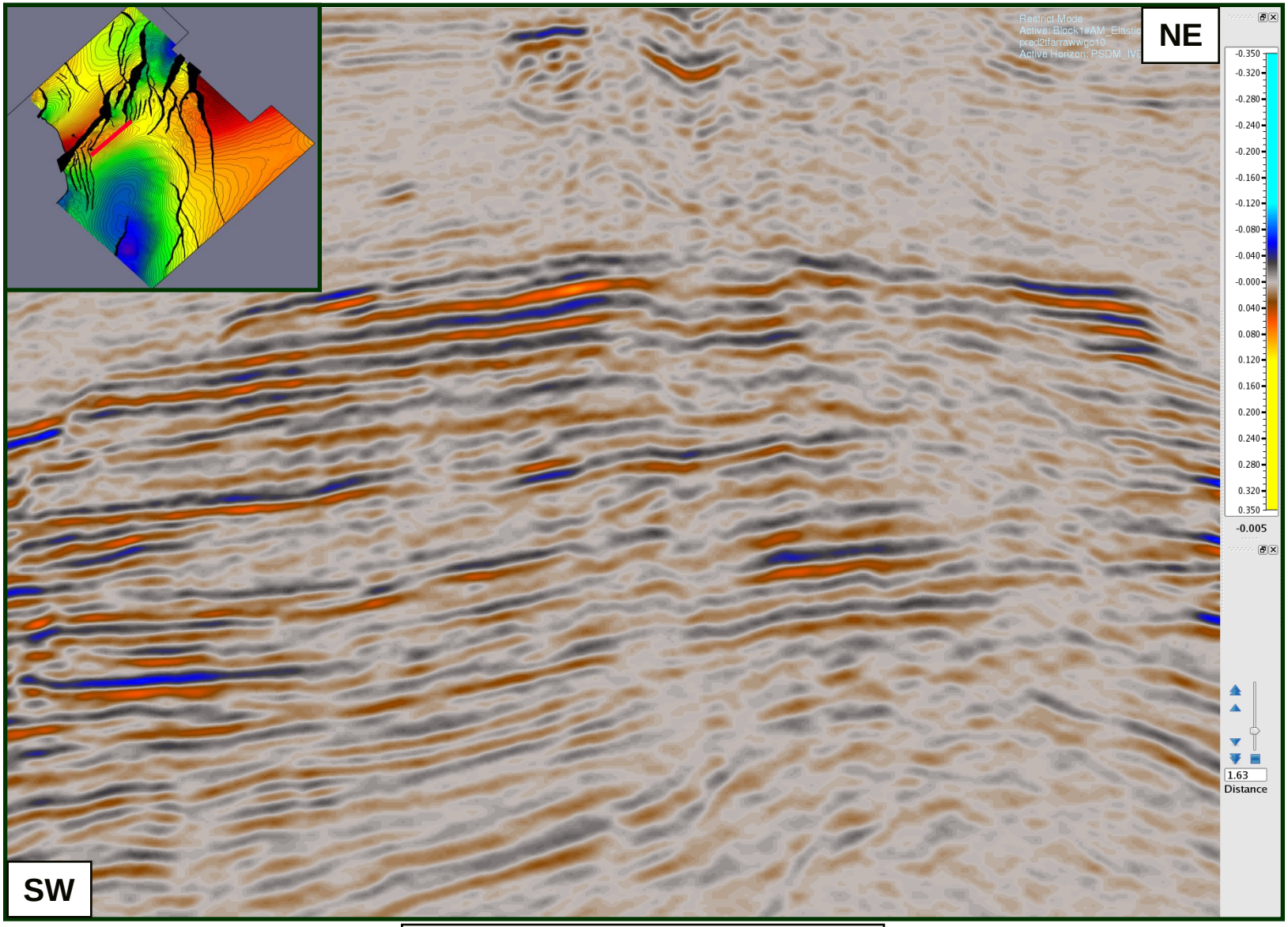
- 2010 3D data reprocessed using anisotropic pre-stack depth migration.
    - Objectives:
        - Improve imaging beneath gas clouds
        - Reduce noise and multiples
        - High quality flattened gathers for pre-stack inversion
        - Sharpen fault imaging for placement of development wells

Benefits of Latest Reprocessing Campaign



Anisotropic PreSDM Near Stack

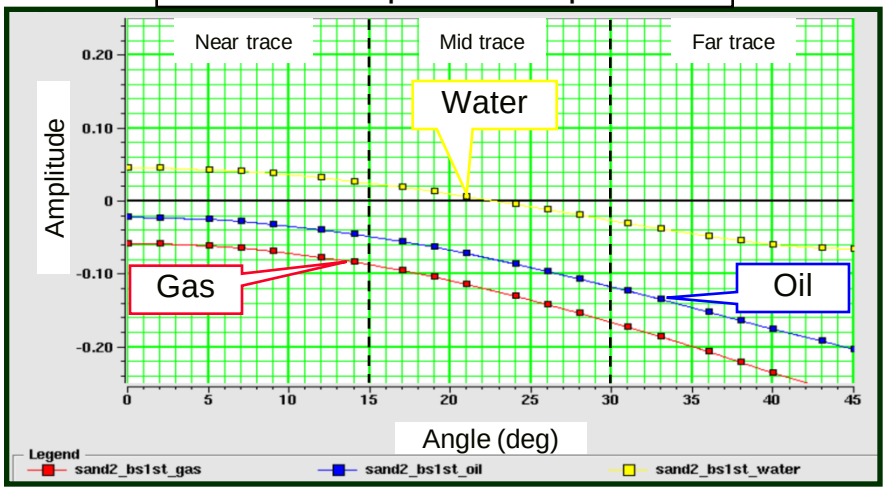
Benefits of Latest Reprocessing Campaign



Anisotropic PreSDM Far Stack

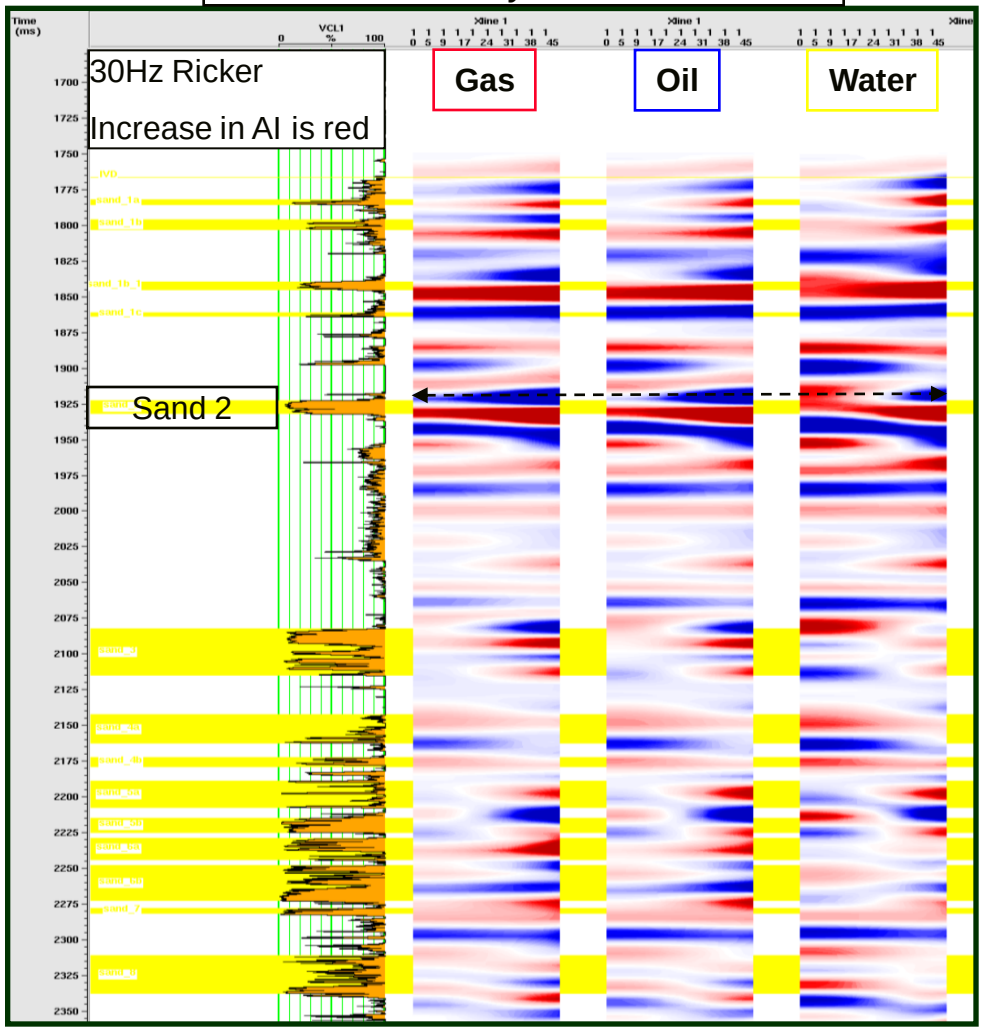
Fluid Detection via AVO – Top Sand 2 Response

Sand 2 Top AVO Response

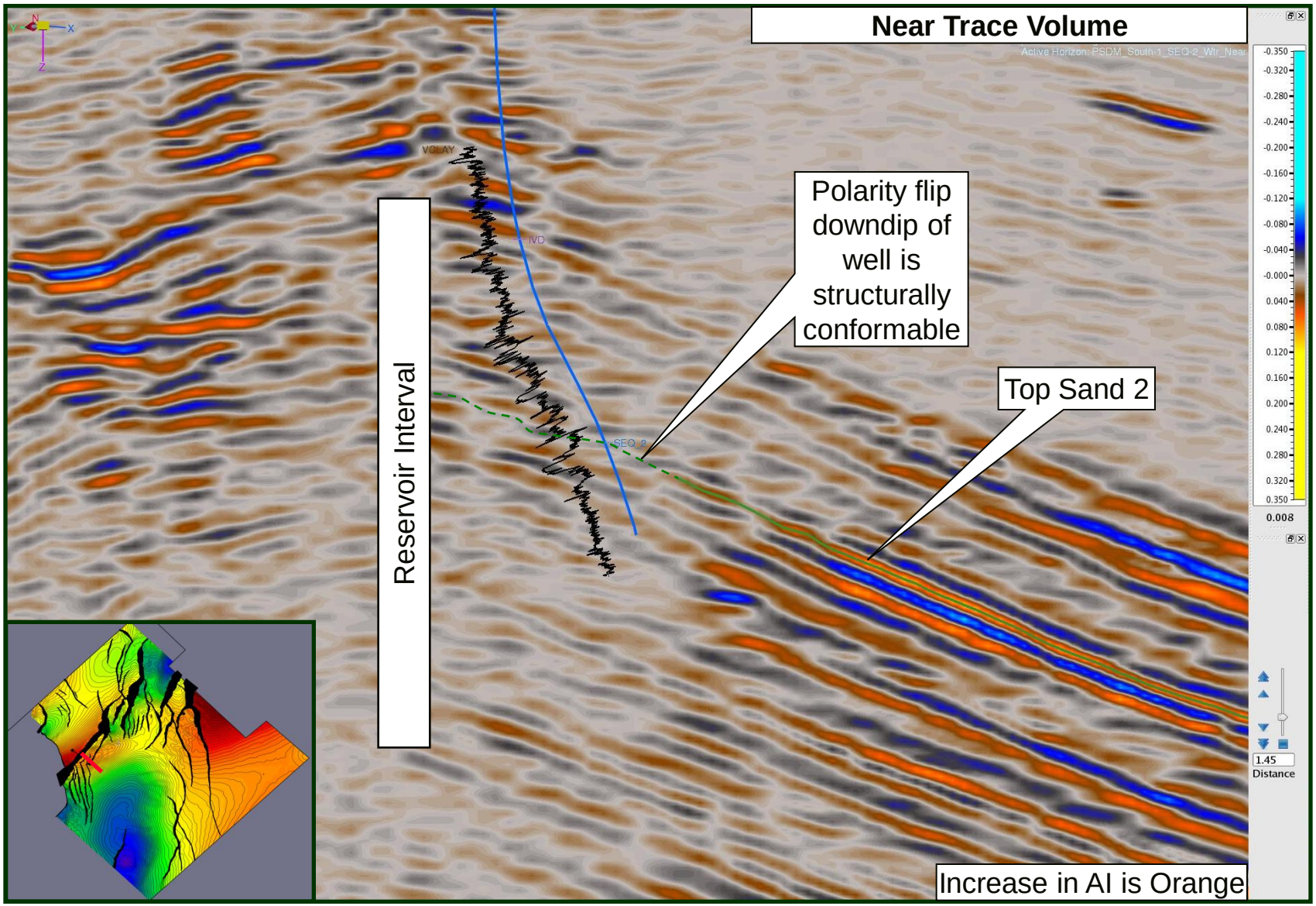


- All fluid responses are AVO class 2
- Water wet sands show a bright seismic response on the near trace or intercept volume
- Transition from hydrocarbon to water will be marked by a polarity flip at the sand top on the near trace or intercept volume

South Well - Synthetic Gathers

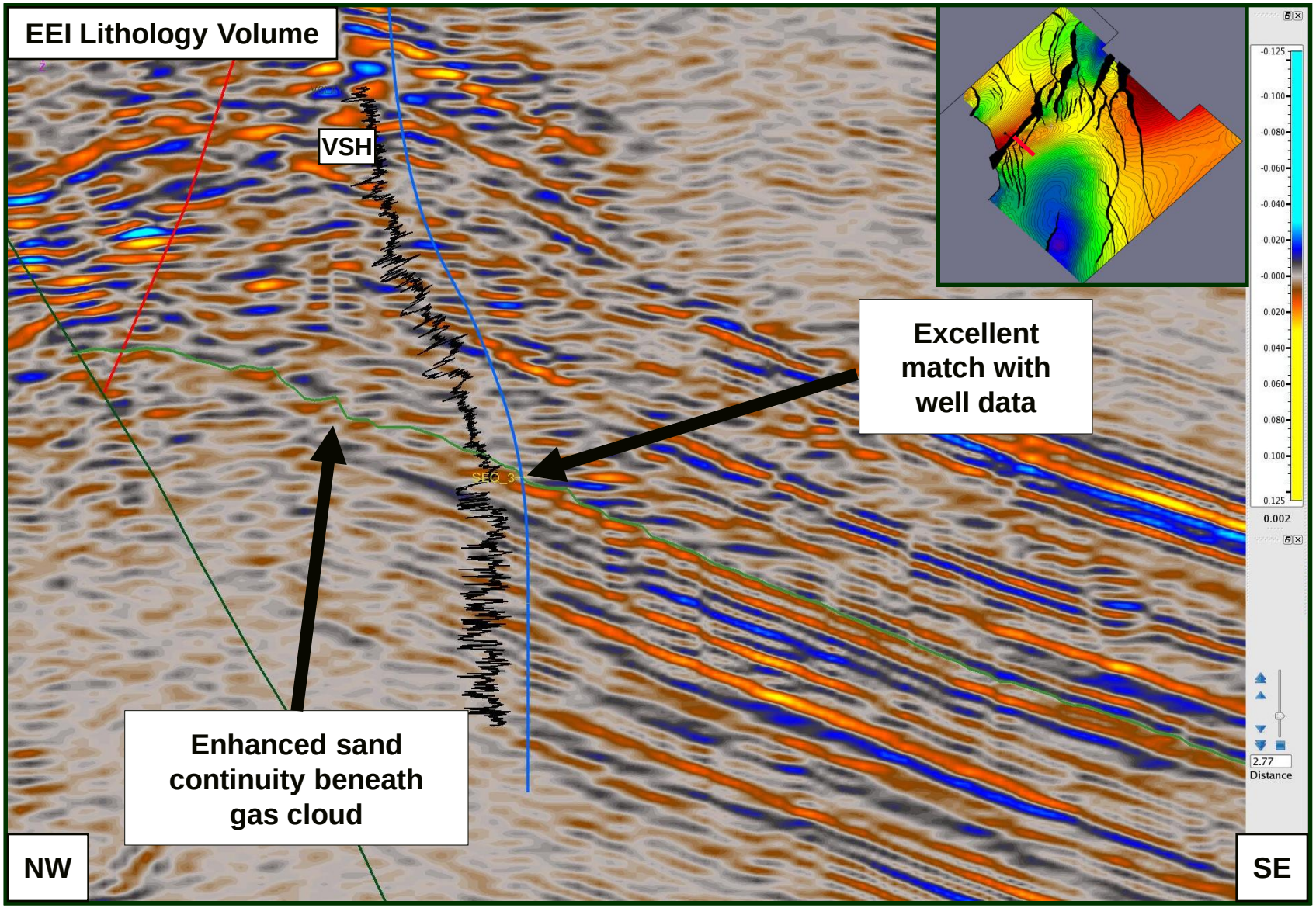


Fluid Detection via AVO – Top Sand 2 Response

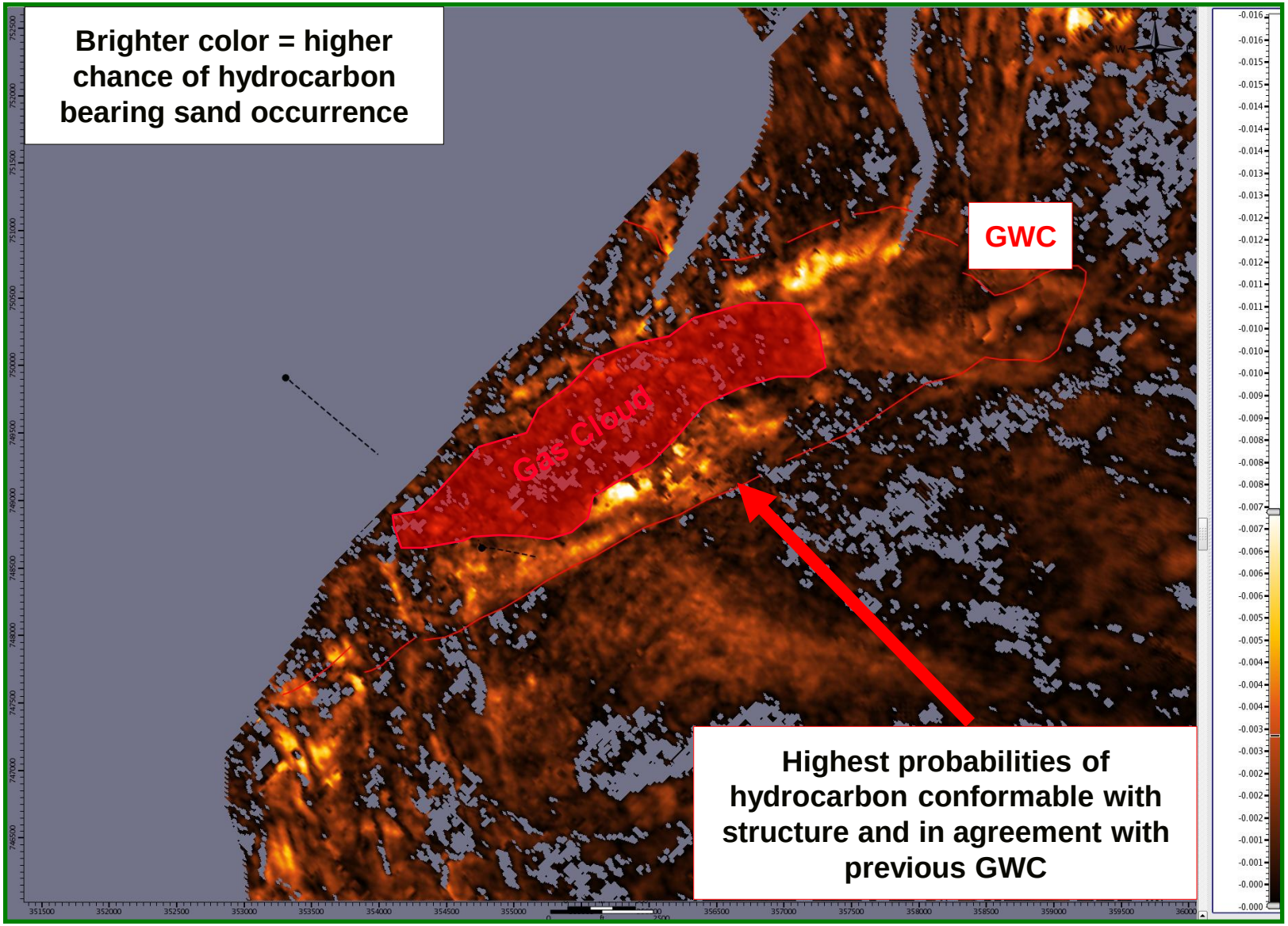


- South field shallow reservoir hydrocarbon-water contacts can be mapped using seismic data

- Next challenge to understand lithology distribution under gas cloud
  - Two methods tried:
    1. Extended Elastic Impedance (EEI)
    2. Simultaneous Model based Elastic Inversion (MBEI) combined with Neural Network Petrophysical Inversion (NN)
- By comparing results of both methods aimed to qualitatively broaden confidence in sand presence
  - Issues:
    - Gas cloud data degradation
    - Limited wells for low frequency MBEI model


EEI Lithology Volume
VSH
Excellent match with well data
Enhanced sand continuity beneath gas cloud
NW
SE
-0.125
-0.100
-0.080
-0.060
-0.040
-0.020
-0.000
0.020
0.040
0.060
0.080
0.100
0.125
0.002
2.77
Distance

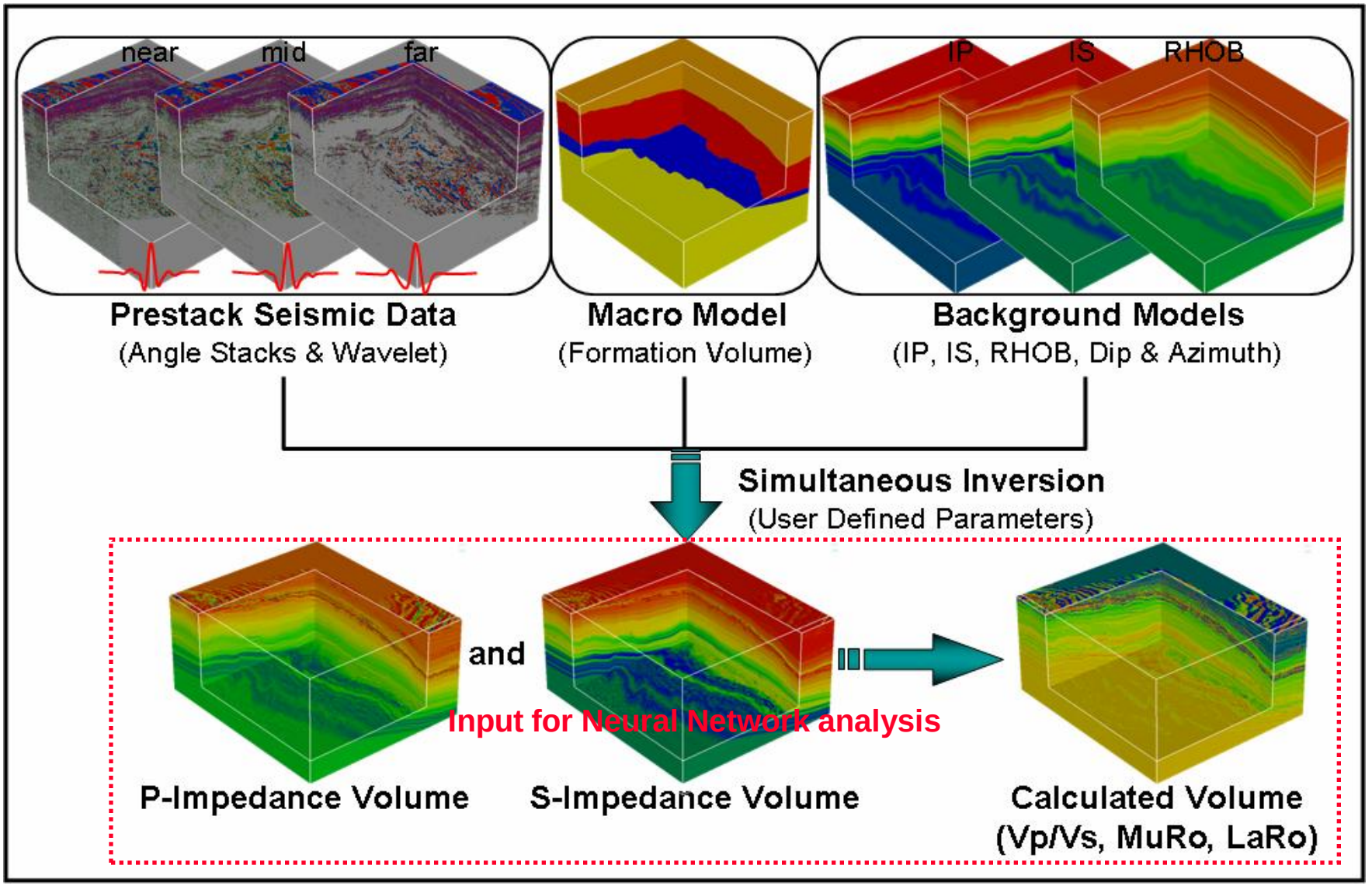
EEI and Simultaneous Elastic Inversion for Fluid and Lithology Discrimination



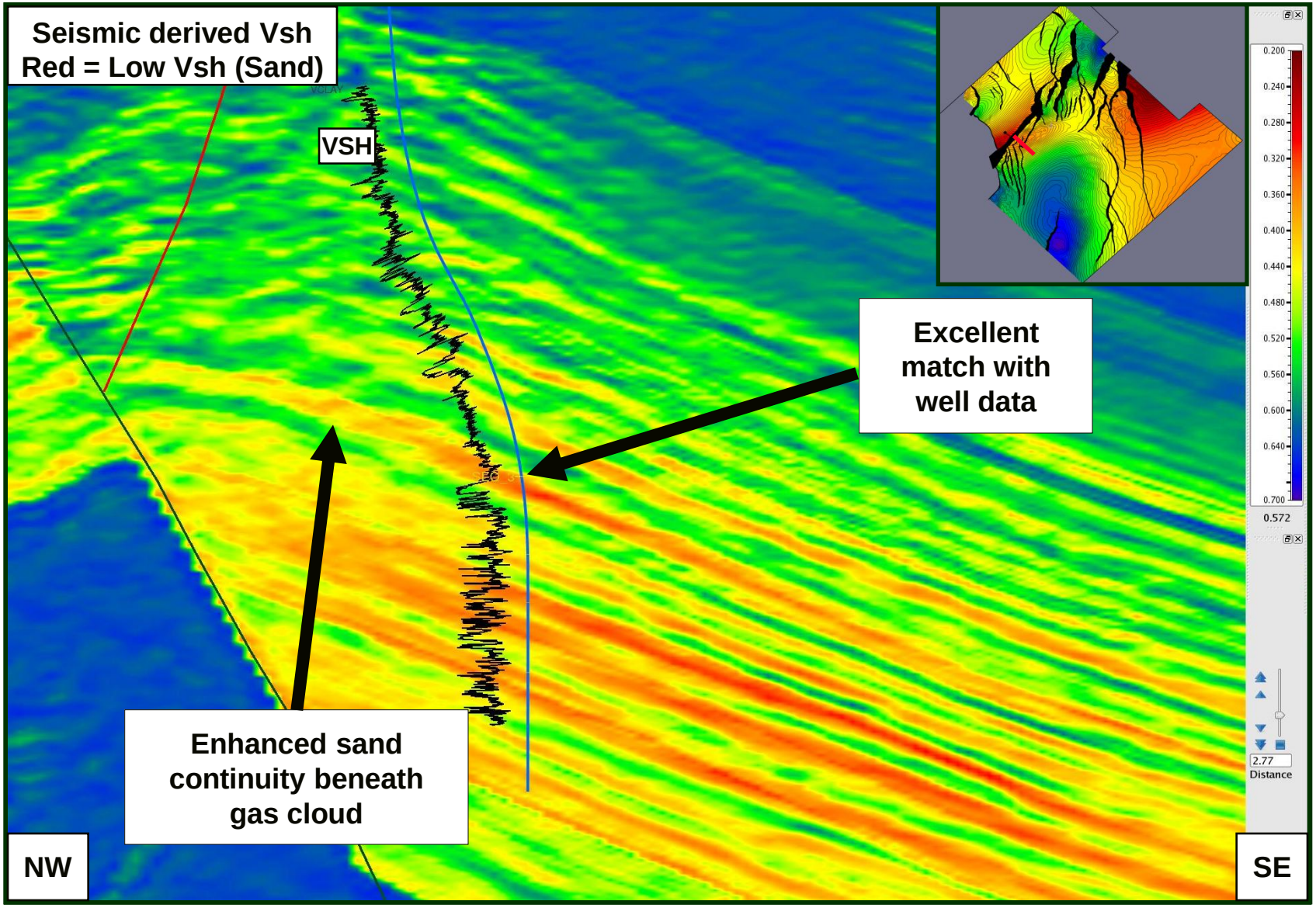
- EEI Lithology and Fluid Projections in AI-GI space were used to investigate sands presence beneath gas cloud and far from well control.

- Despite amplitude dimming associated with gas cloud, following was achieved:
  1) Seismic lithology projection showed a good match with well data and a reassuring continuity beneath gas cloud
  2) Seismic fluid projection showed an excellent match with GWC from well data

- Next challenge to validate the EEI projections using a Seismic derived Vsh.


near
mid
far
IP
IS
RHOB
Prestack Seismic Data
(Angle Stacks & Wavelet)
Macro Model
(Formation Volume)
Background Models
(IP, IS, RHOB, Dip & Azimuth)
Simultaneous Inversion
(User Defined Parameters)
and
Input for Neural Network analysis
P-Impedance Volume
S-Impedance Volume
Calculated Volume
(Vp/Vs, MuRo, LaRo)

EEI and Simultaneous Elastic Inversion for Fluid and Lithology Discrimination



Conclusions

- Project greatly benefitted from uplift in seismic imaging achieved during latest reprocessing campaign.

- Maximum information has been extracted from seismic data acquired in 2001 and reprocessed 2010.

- Anisotropic PreSDM data (gathers and partial stacks) allowed for successful Extended Elastic Impedance (EEI) projection and Model Based Simultaneous Elastic Inversion followed by a Neural Network analysis (MBEI-NN).

- Both EEI and MBEI-NN show similar results broadening our confidence in sand distribution - hydrocarbon bearing sands seem to be present all over South Field