Advances in OBN Technology: Full Azimuth, Long Offset Illumination for Complex Reservoirs*

John Smythe[1]

Search and Discovery Article #70290 (2017)**
Posted October 2, 2017

*Adapted from oral presentation given at 2017 AAPG Latin America & Caribbean Region GTW, Optimization of E&P Projects: Integrating Geosciences and Engineering from Block Acquisition through Production, Rio De Janeiro, Brazil, August 22-23, 2017

[1]FairfieldNodal, Inc., Houston, TX, United States (jsmythe@fairfieldnodal.com)

Abstract

The advantages of full azimuth, long offset illumination, characteristic of ocean bottom node (OBN) acquisition, are shown in data examples from deep-water pre-salt fields in the Gulf of Mexico. Additionally, data examples from structurally complex, highly obstructed areas on the Continental Shelf of the Gulf of Mexico demonstrate how advances in OBN technology can rejuvenate interest in mature basins.

Reference Cited

Smit, F., C. Perkins, L. Lepre, K. Craft, and R. Woodard, 2008, Seismic data acquisition using ocean bottom seismic nodes at the Deimos Field, Gulf of Mexico: SEG Technical Program Expanded Abstracts, 2008, p. 998-1002.

AAPG Latin America & Caribbean Region
BRAZIL 2017
Geosciences Technology Workshop
Co-hosted by

Advances in OBN Technology: Full Azimuth, Long Offset Illumination for Complex Reservoirs

John Smythe
FairfieldNodal, Inc.

fairfieldnodal

Outline

- Node technology
- Node Acquisition
  - Characteristics
  - Improving productivity
  - Shallow and deep water acquisition
- Benefits of OBN acquisition
  - Gulf of Mexico examples
  - Onshore example
- Reservoir monitoring with nodes
- Conclusions

Node Technology

- Autonomous seismic recording device
- Land, deep or shallow water, reservoir monitoring (ARM) designs
- Marine node features:
  - Very accurate clock
  - 4 component geophone
  - Lithium-ion batteries
  - Data storage
- Continuous recording
- No cables or connectors

OBN Seismic Acquisition

- Deployment with ROV or passive rope
- Sources and receivers are decoupled
- Access to obstructed areas
- Shot dominated acquisition time
- Repeatable
- Multicomponent
- Improved data quality through wide azimuth, long offset, dense shot geometries
- OBN surveys are *expensive*
- ***Challenge: Improve OBN productivity and use efficient geometries***

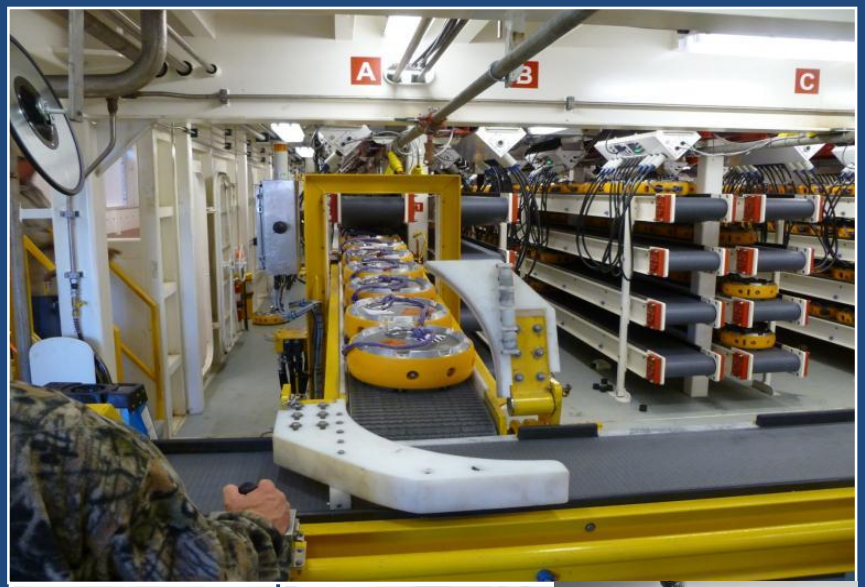
Improving OBN Productivity

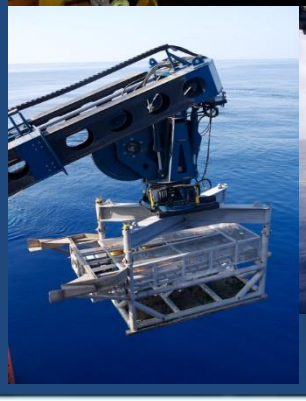
- Use large receiver spreads → 3,4, $7x10^3$ nodes
- Improve receiver efficiency
  - Fast deploy and retrieve (passive rope)
  - Minimal technical downtime
  - Long deployment life, 48 days (180 deepwater)
- Reduce shot time
  - Blended acquisition: improved data with better economics

Efficient Node Geometries

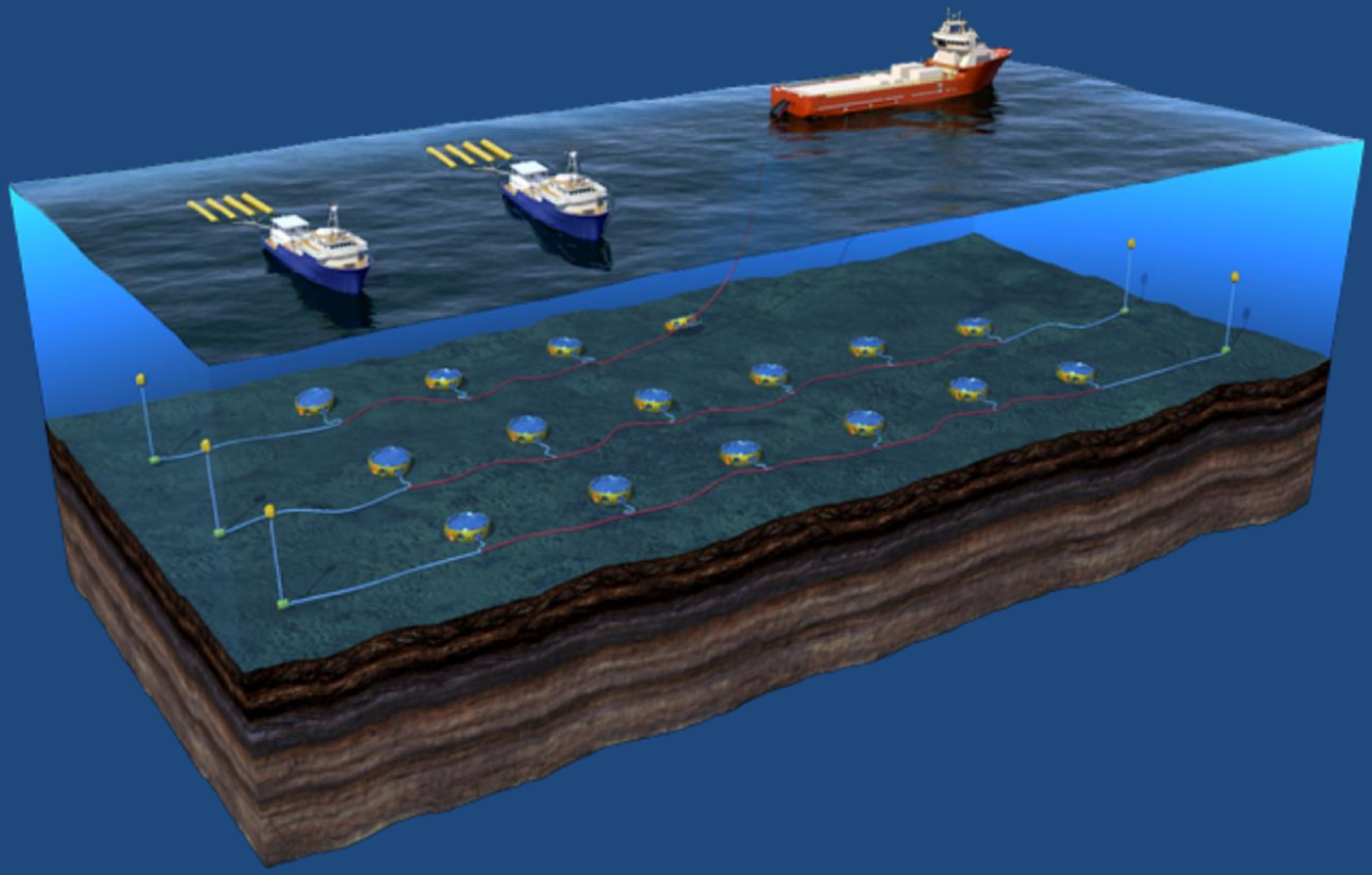
- Shooting starts when small portion of spread complete; ends shortly before last receiver is picked up
- Source and receiver lines are parallel
- Shots repeat only on “tier” roll
- Each node “sees” shots from all offset and azimuths
- Roll is continuous with no interruption of shooting
- Balances source and receiver effort
- Requires only one node handling vessel

Shallow and Deepwater OBN

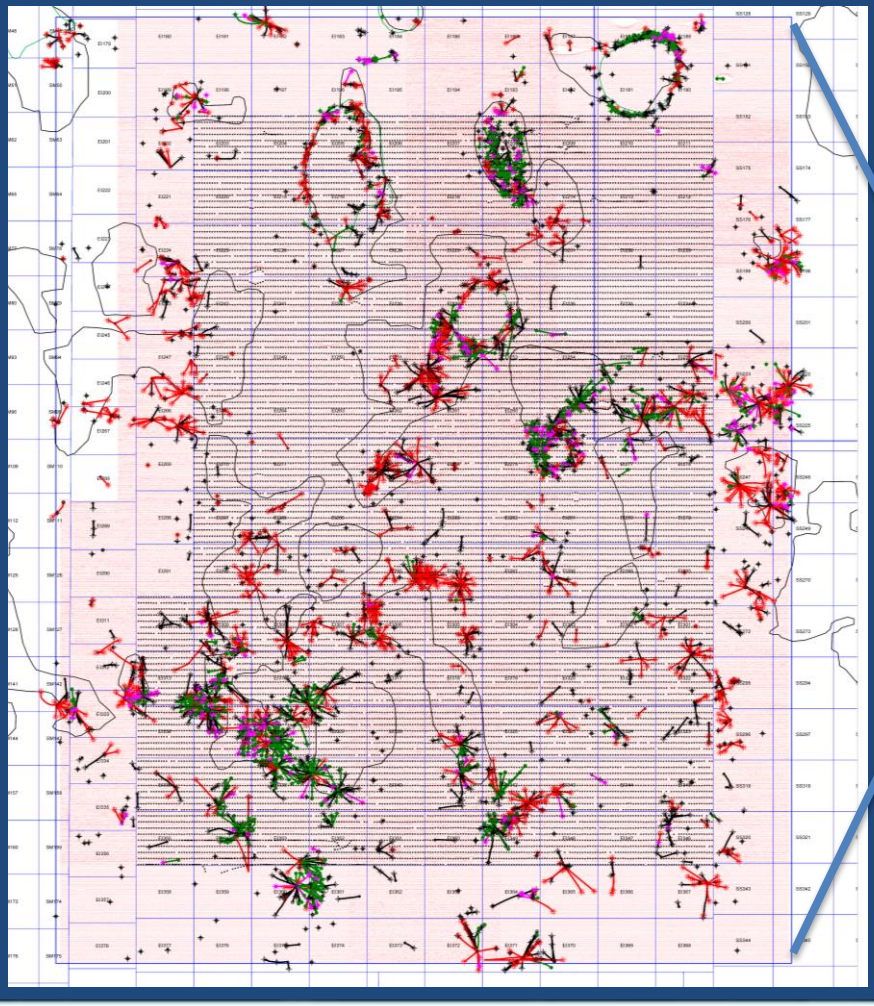


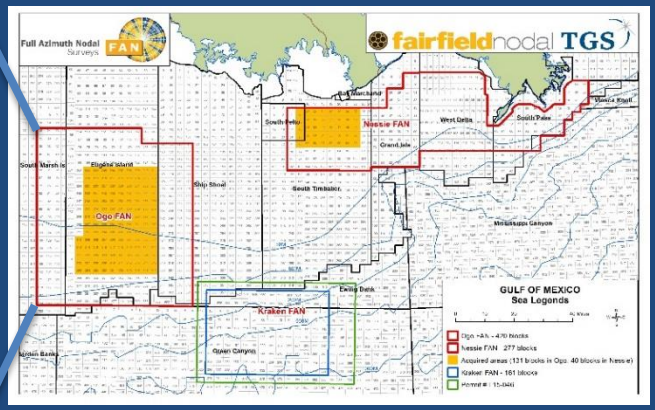


Shallow Water OBN Acquisition

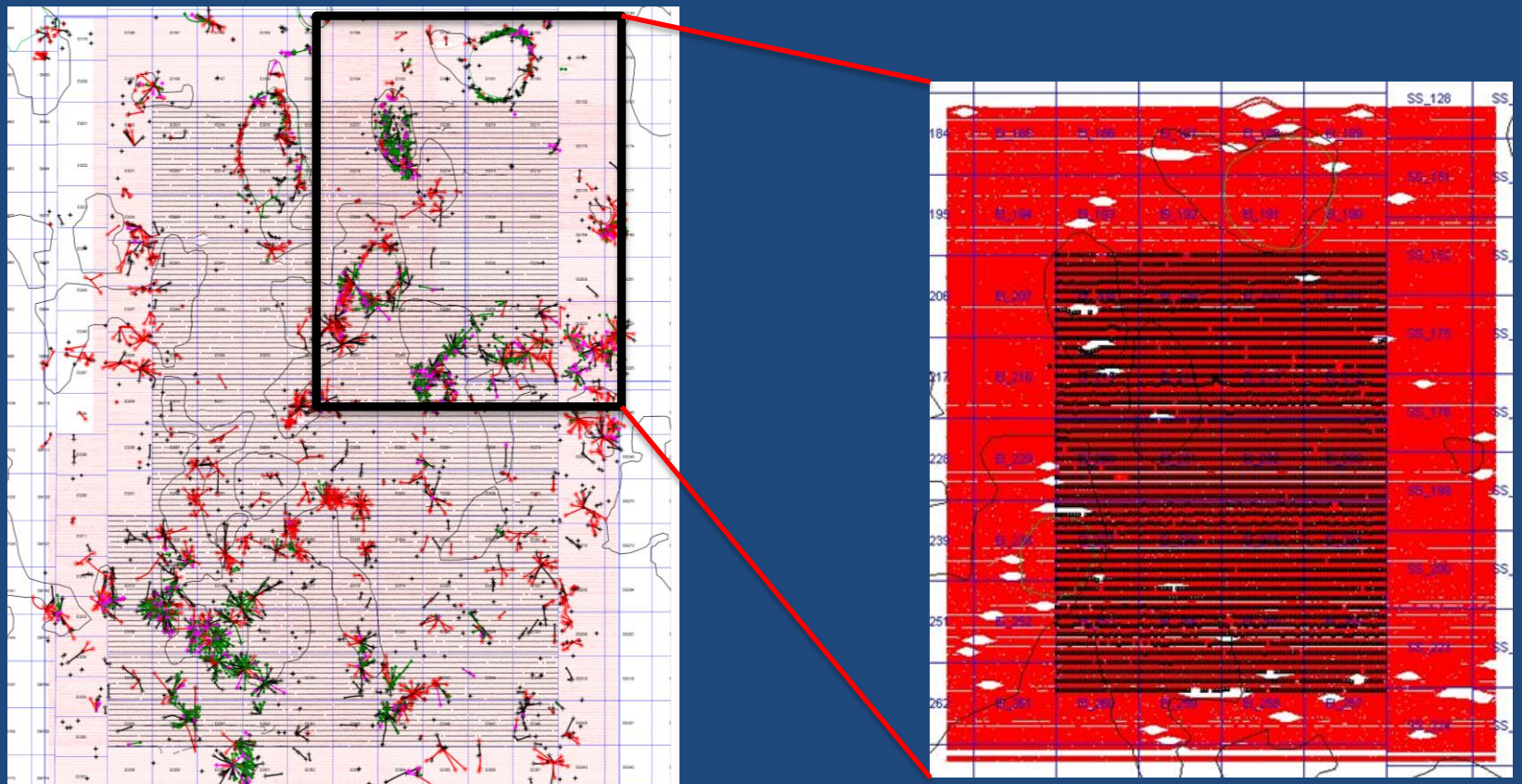


Shallow Water OBN Survey

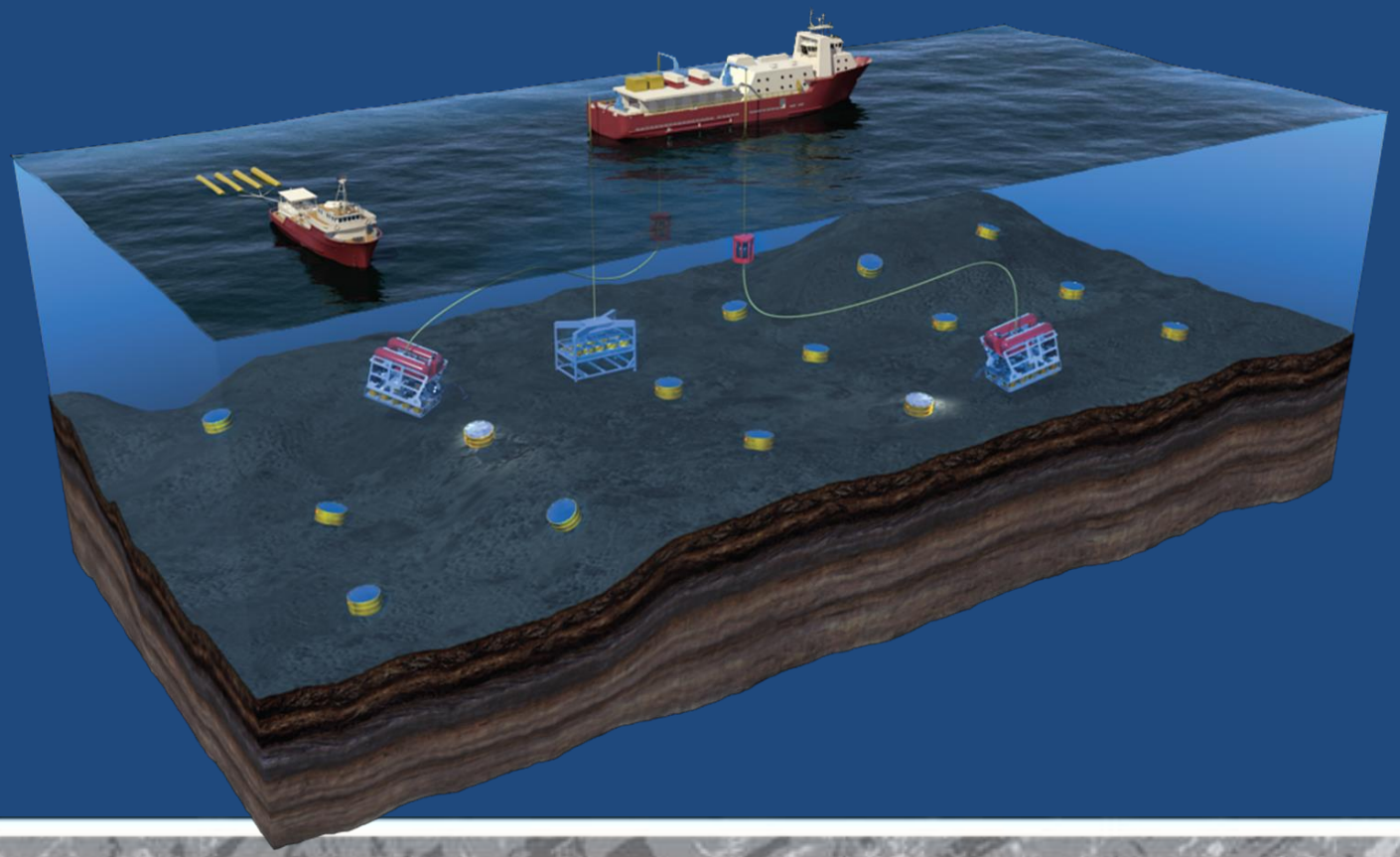




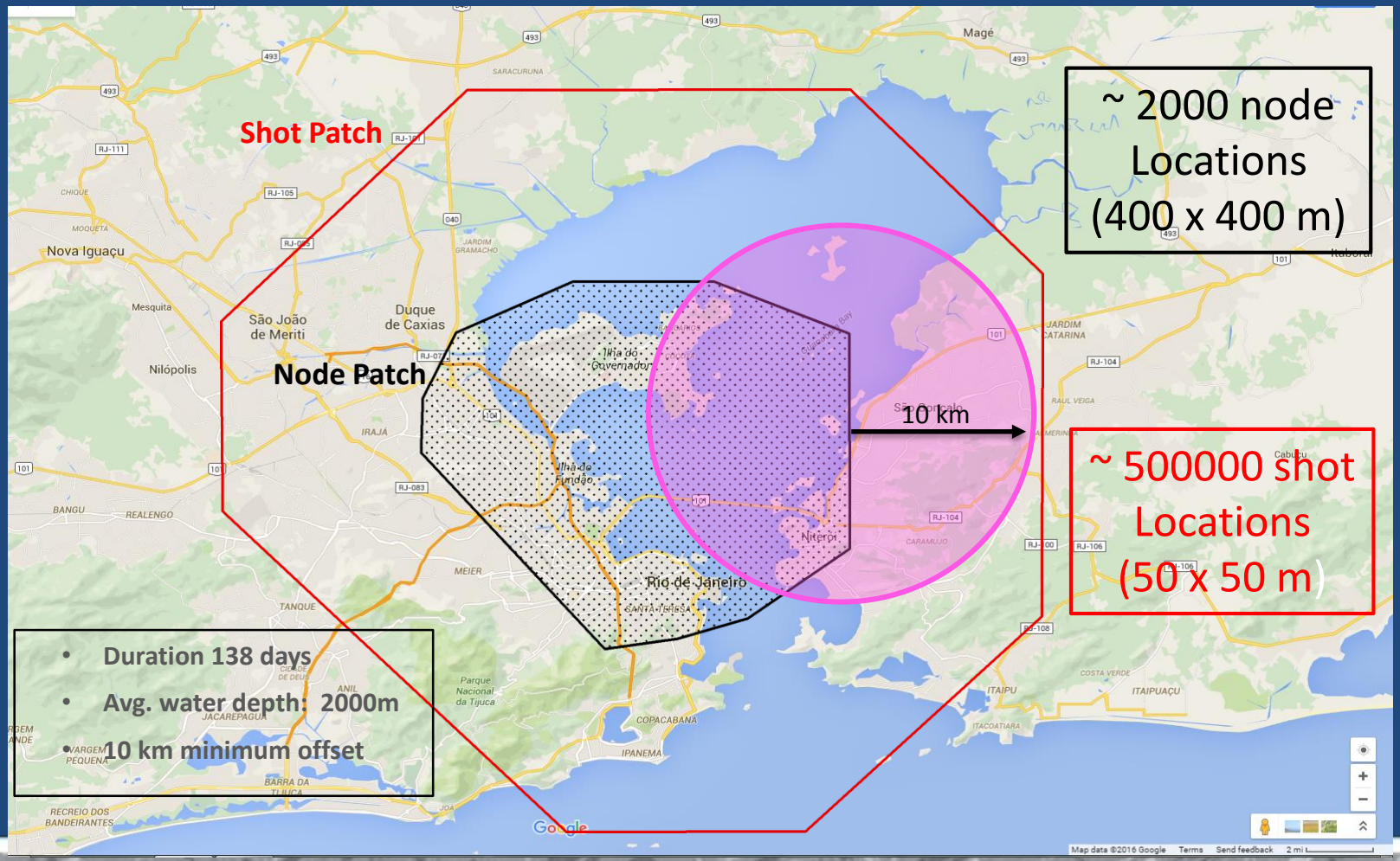
Shallow Water OBN Post-plot



Deepwater Node Acquisition



Deep Water OBN Survey

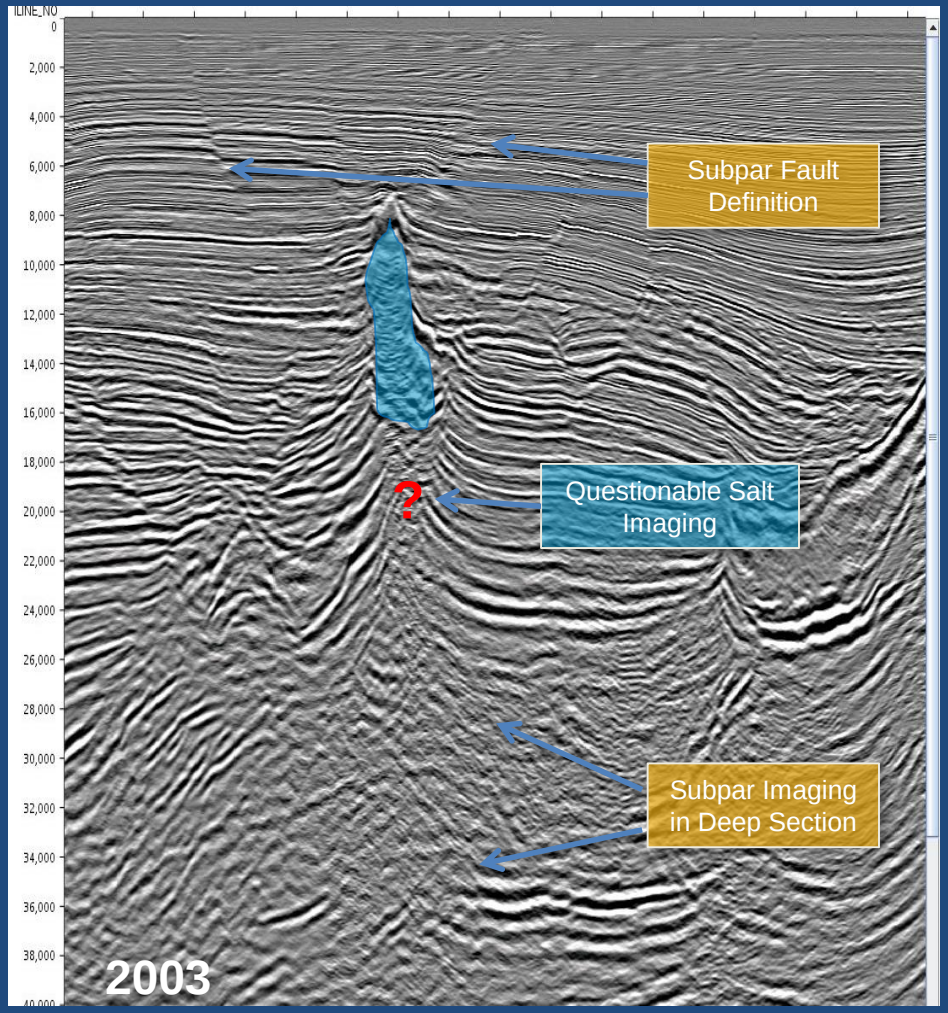


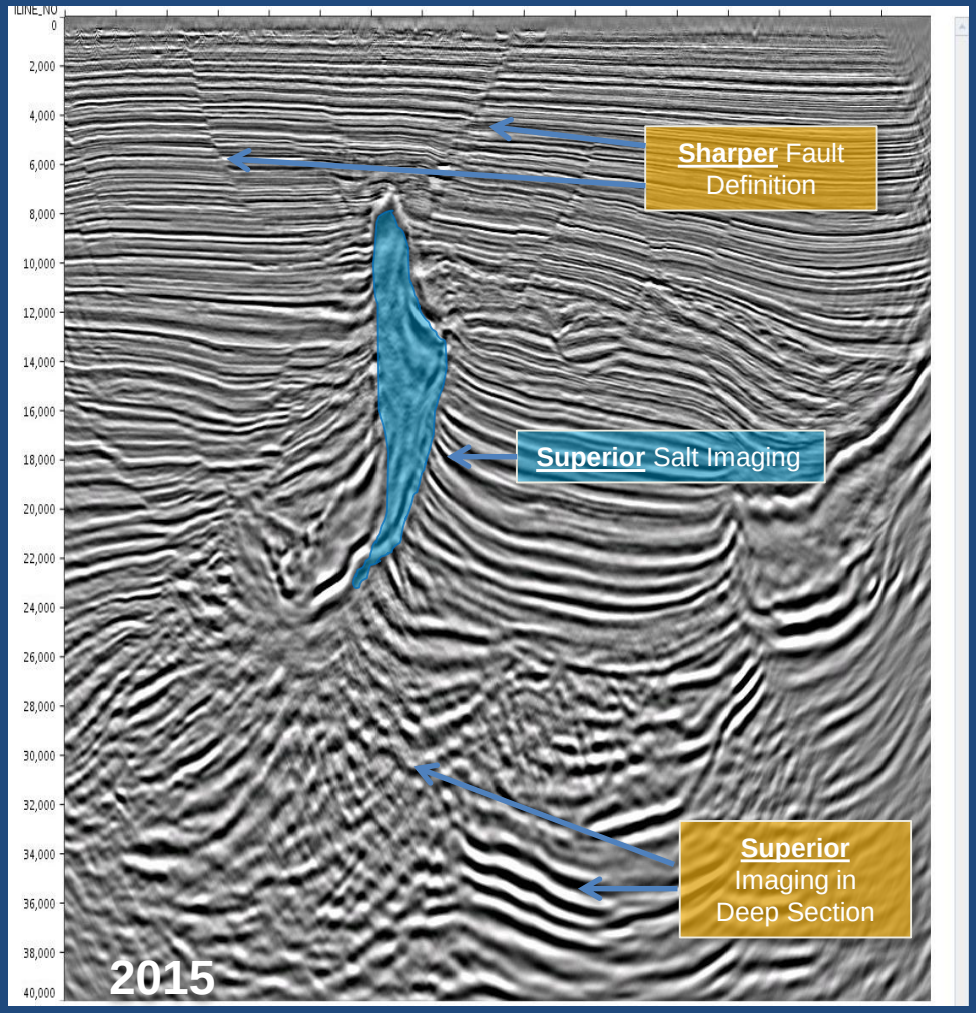
Processing Benefits of OBN Acquisition

- High density surveys unlock the power of new processing algorithms
  - Redundancy of information
  - Fine sampling of signal and noise
- Repeatability for 4D analysis
- Full azimuth
- Long offset

Processing Benefits of OBN Acquisition

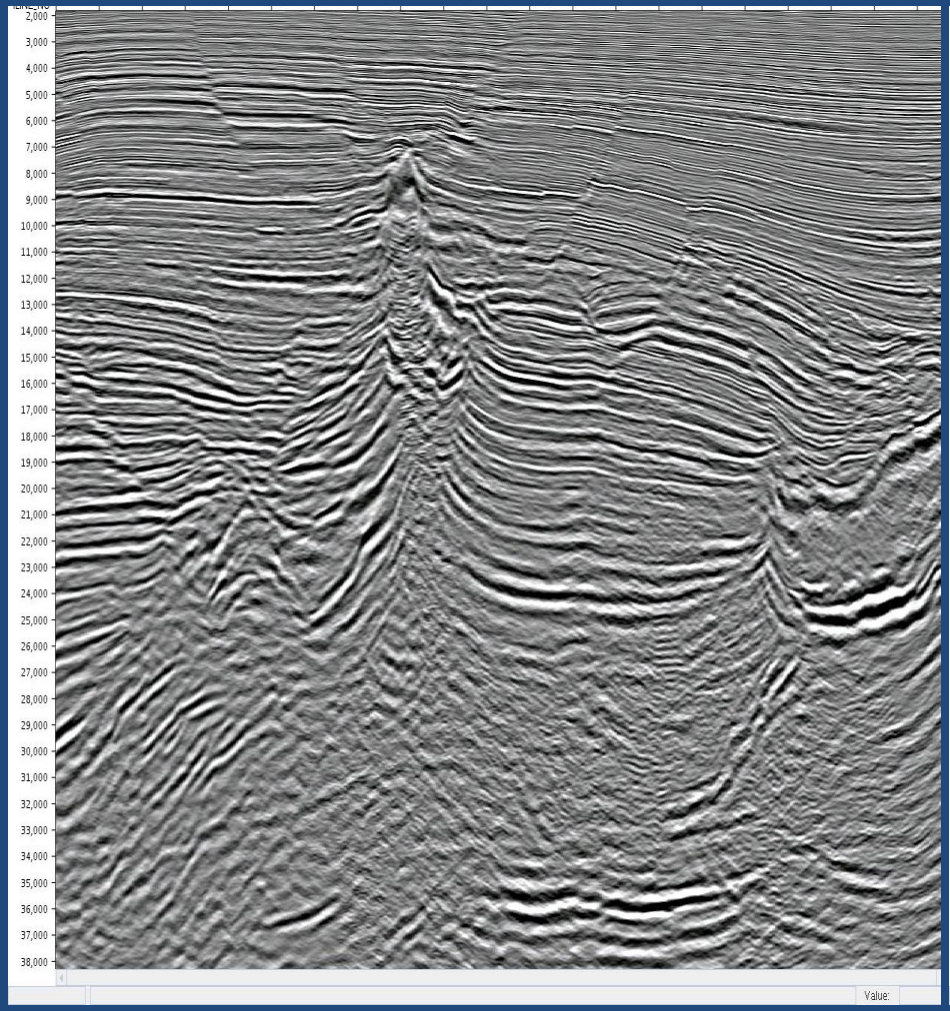
- Imaging technologies
  - Wave equation migration (TTI, VTI, orthorhombic)
  - RTM (TTI, VTI, orthorhombic)
  - Least squares RTM
  - Full waveform inversion
- Multi-dimensional interpolation
- Azimuthal velocity analysis
  - Fracture identification
- Multiple attenuation
- AVO analysis
- Inversion technologies


N
NAZ Kirchhoff
S
Subpar Fault Definition
Questionable Salt Imaging
?
Subpar Imaging in Deep Section
2003


N
Full Azimuth RTM
S
Sharper Fault Definition
Superior Salt Imaging
Superior Imaging in Deep Section
2015

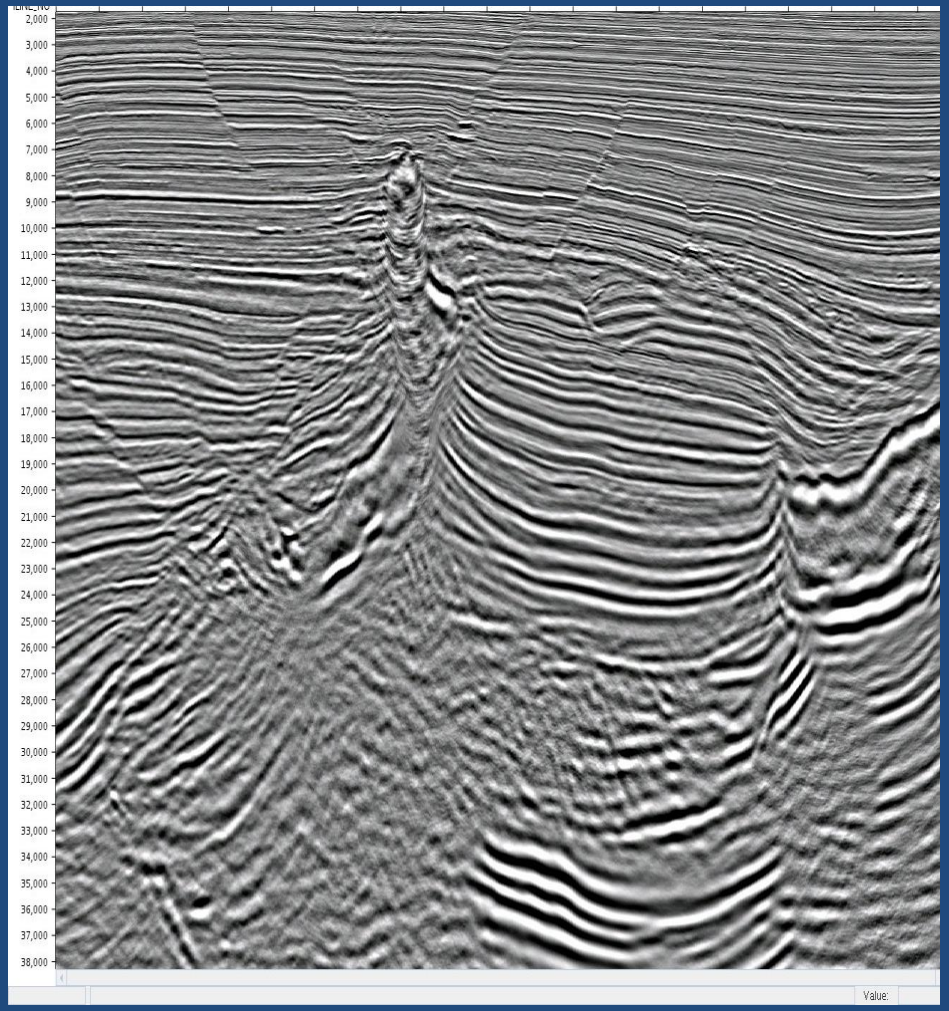
NAZ Kirchhoff

N S



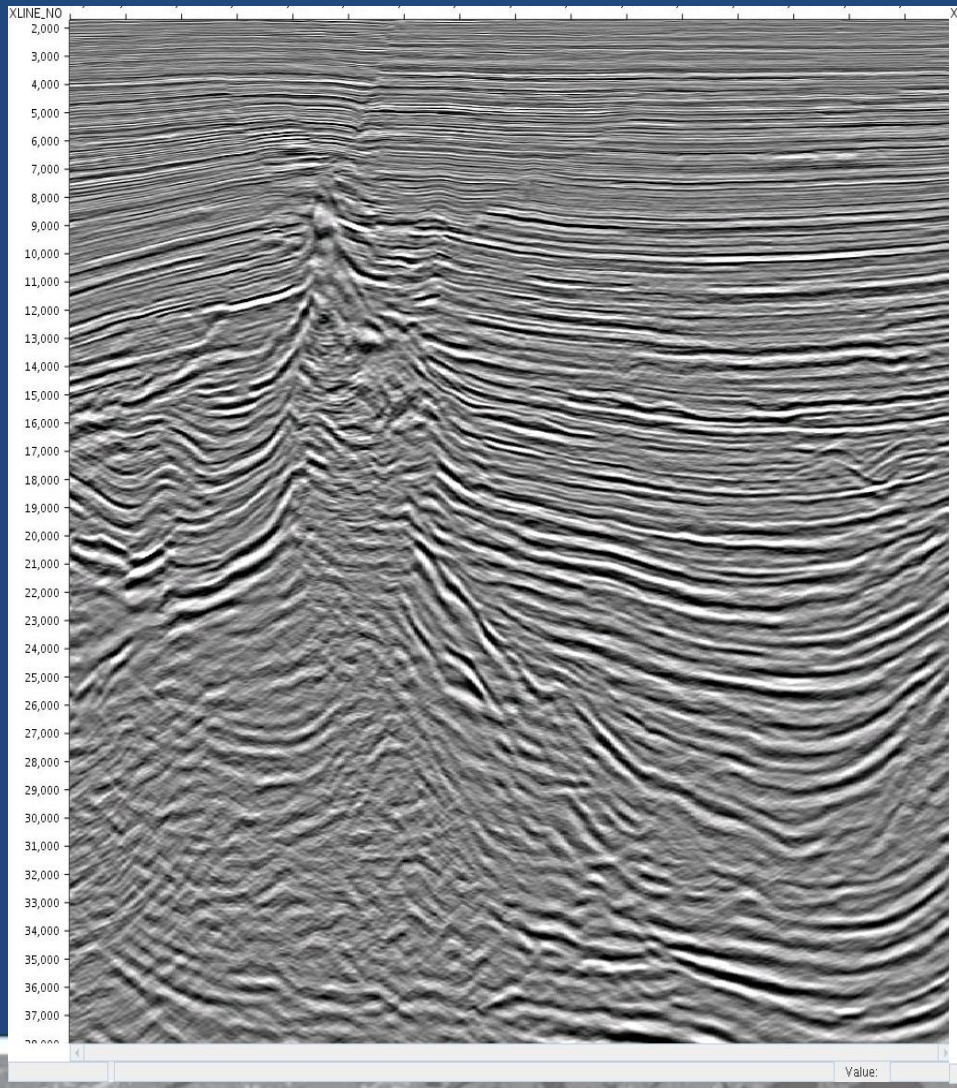
Full Azimuth Kirchhoff

N S



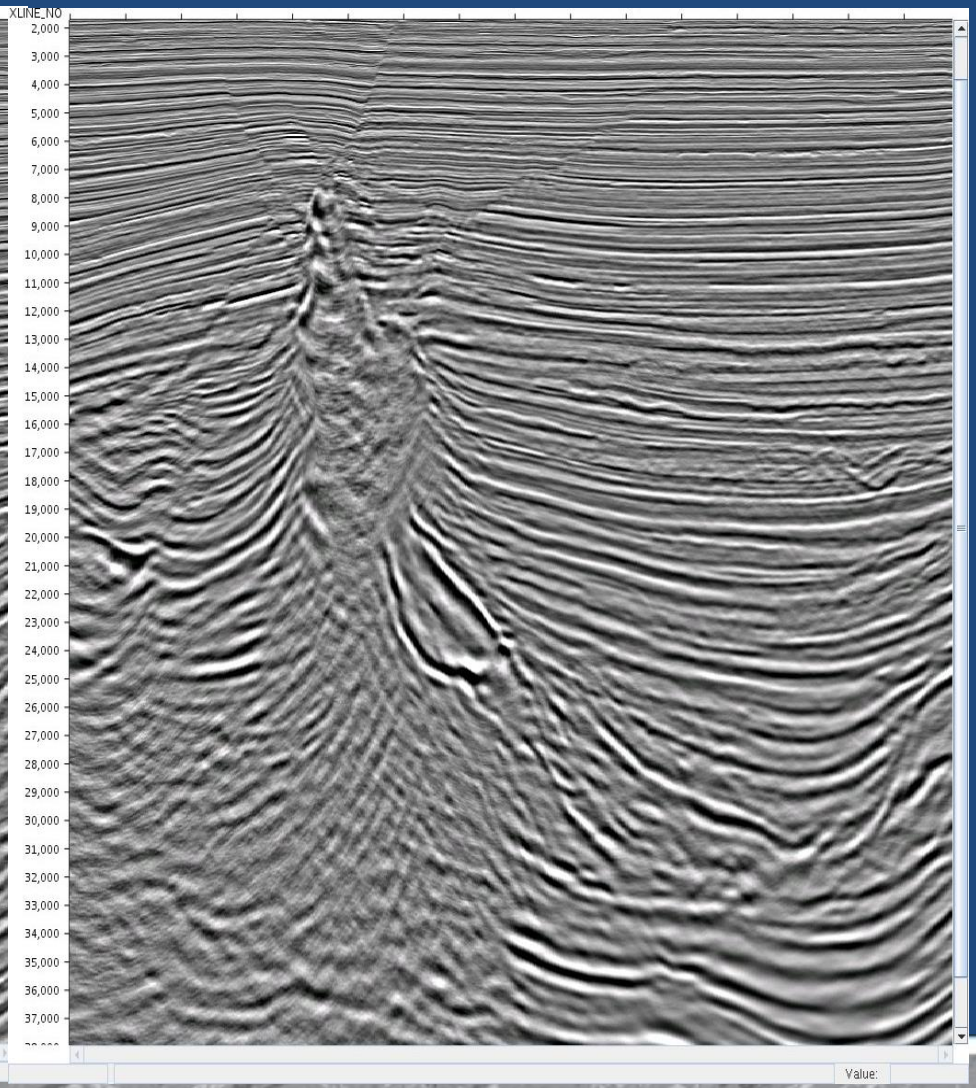
NAZ Kirchhoff

W E



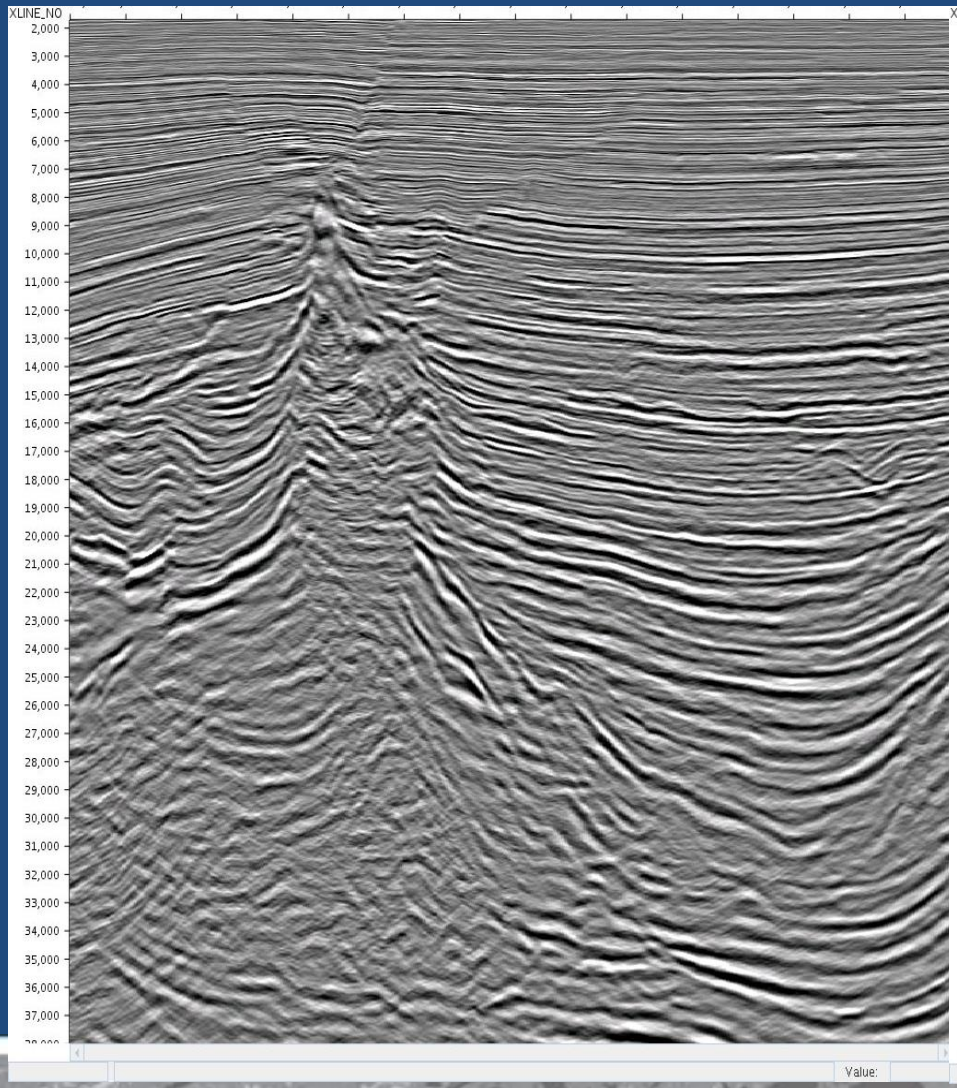
Full Azimuth Kirchhoff

W E



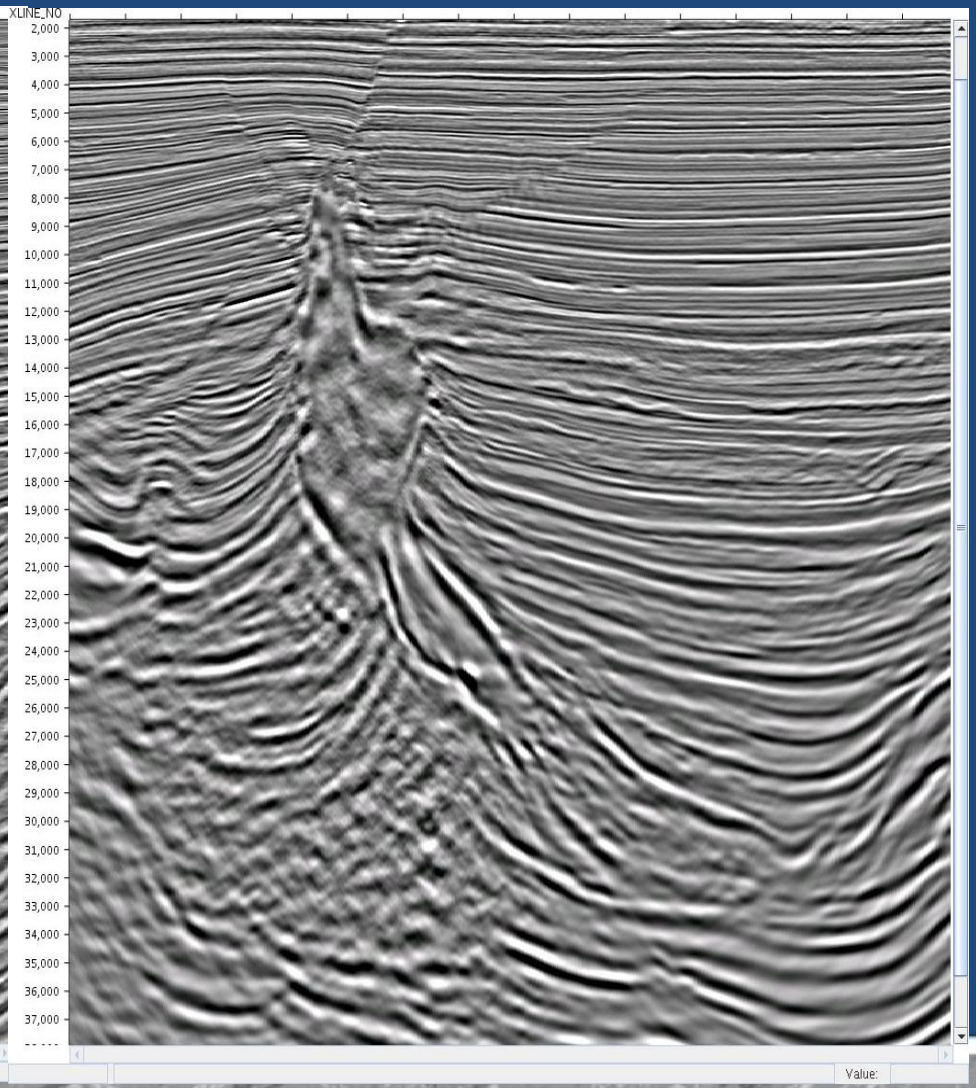
NAZ Kirchhoff

W E

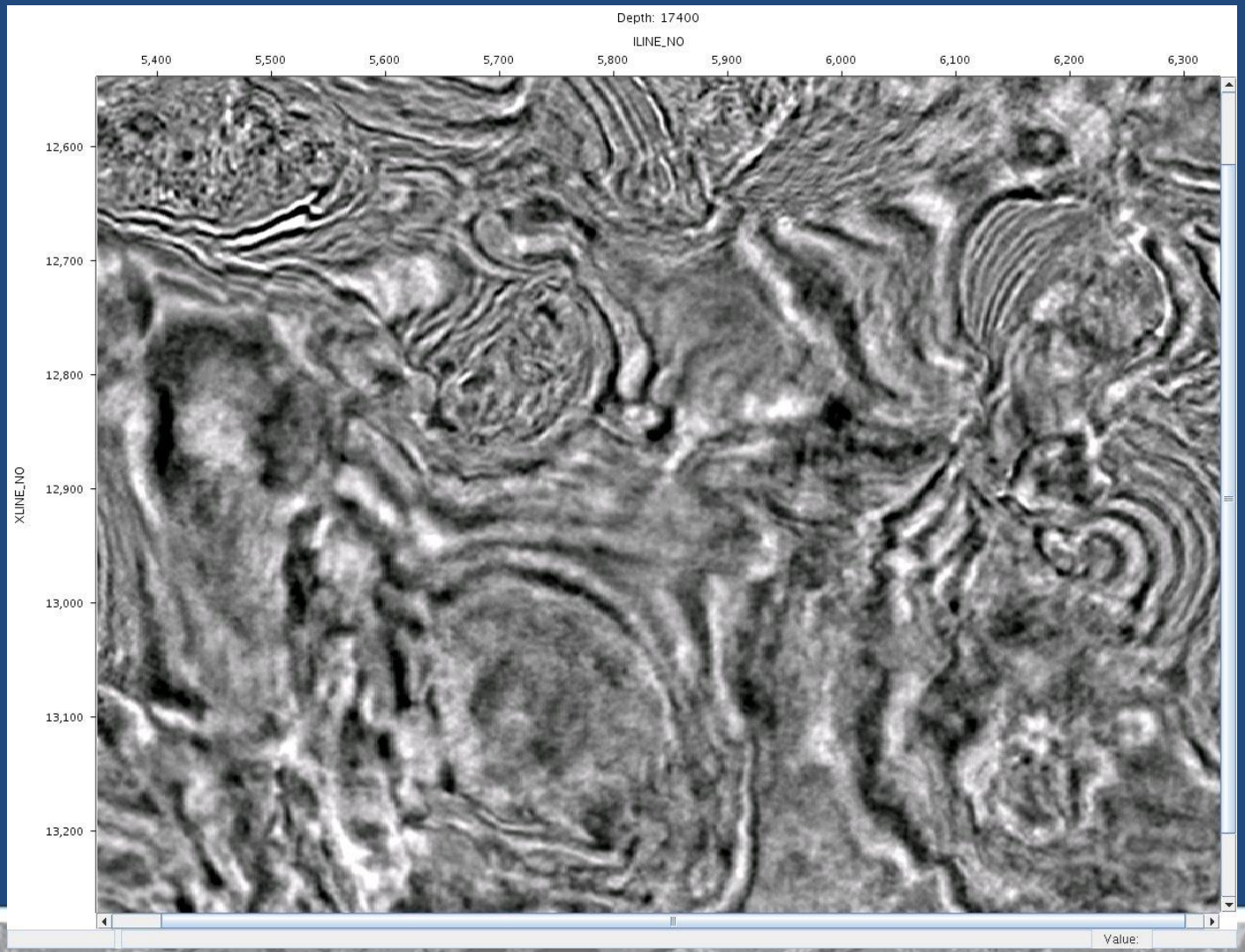


Full Azimuth RTM

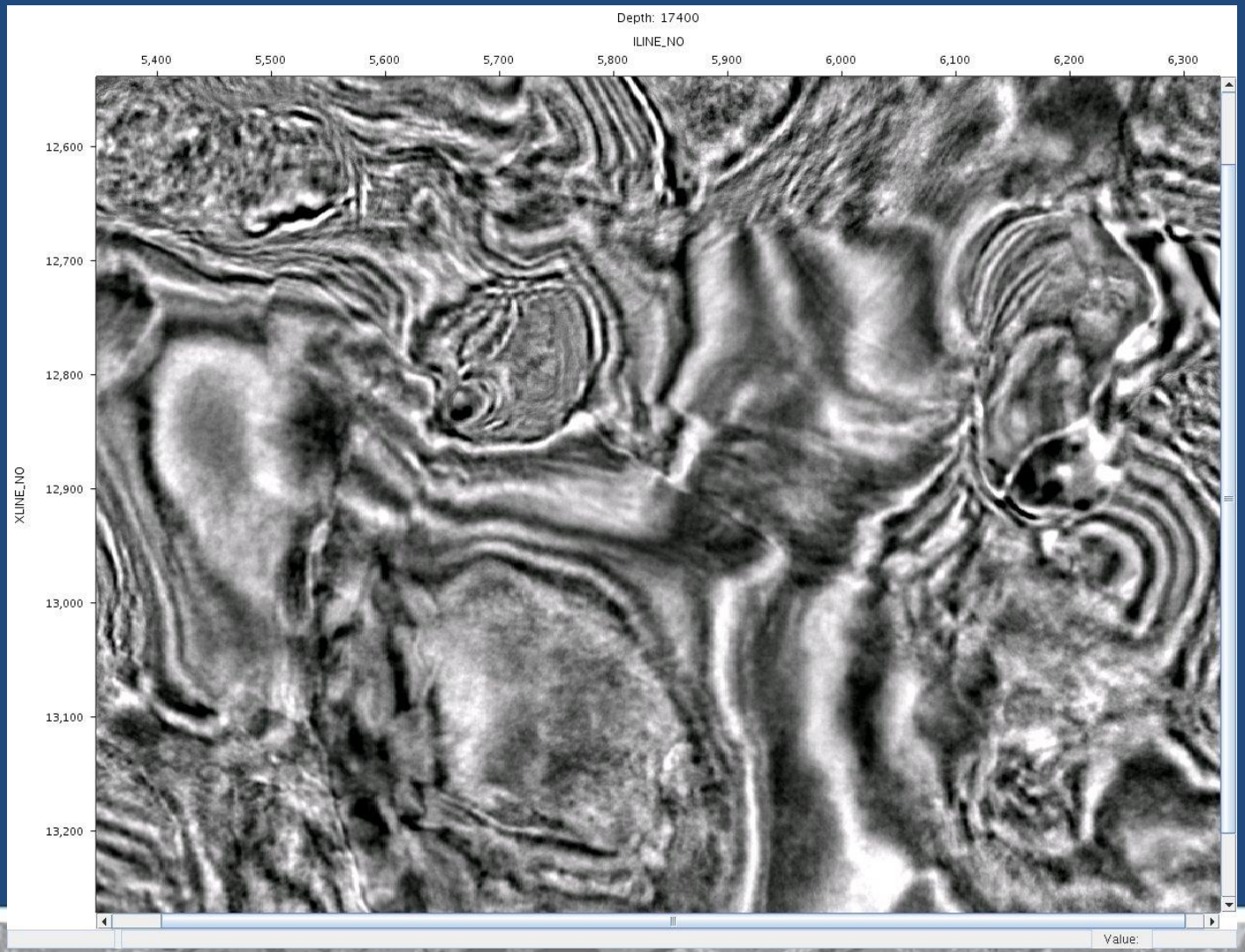
W E



NAZ Kirchhoff

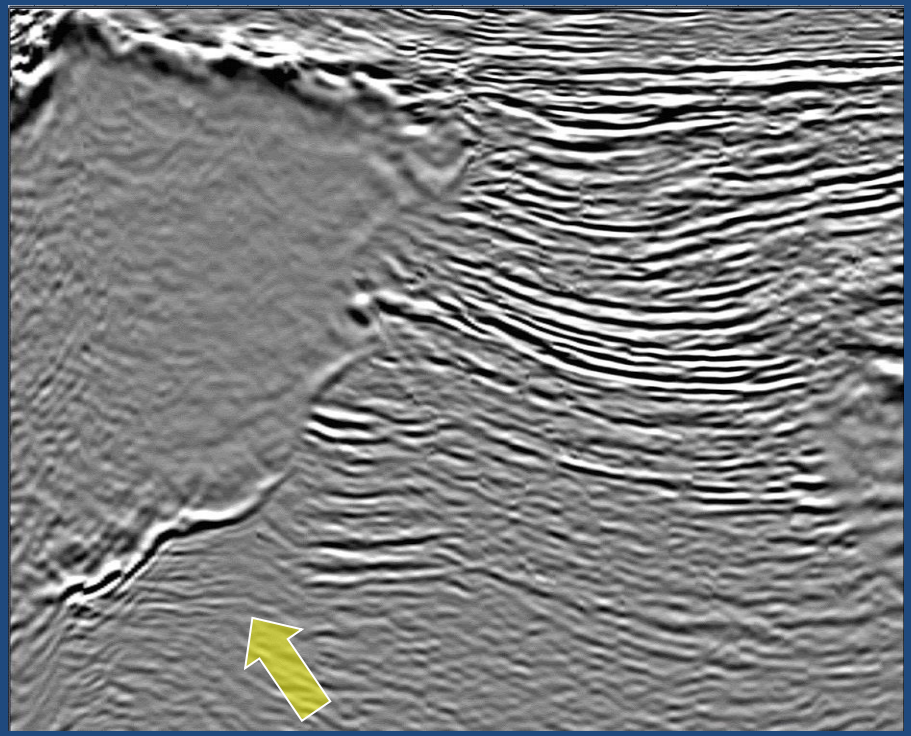


Full Azimuth Kirchhoff

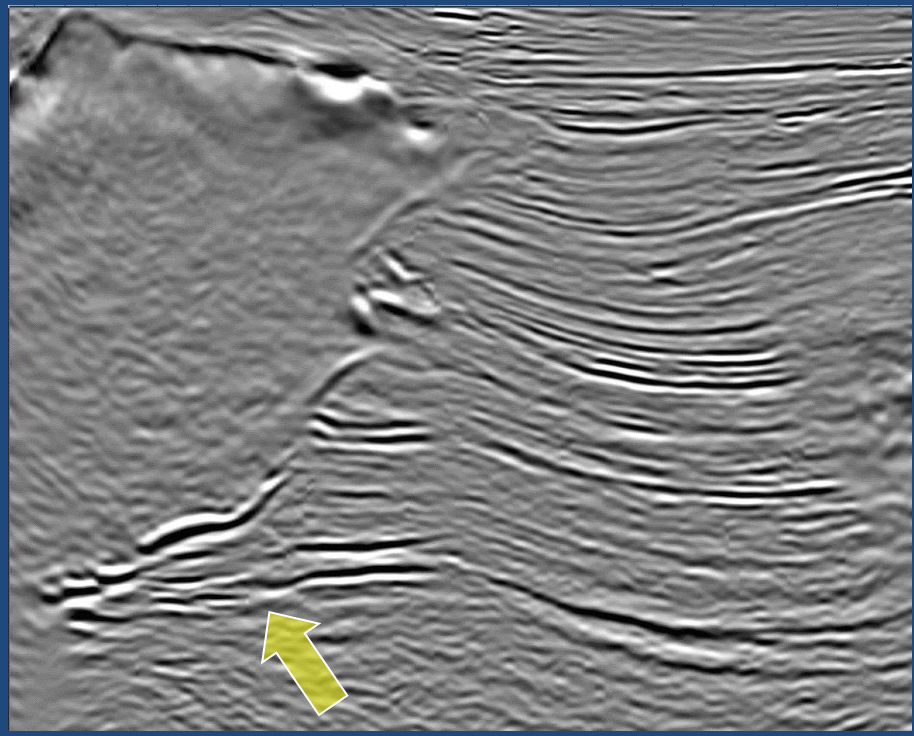


Deepwater OBN vs. NAZ Streamer

NAZ Streamer

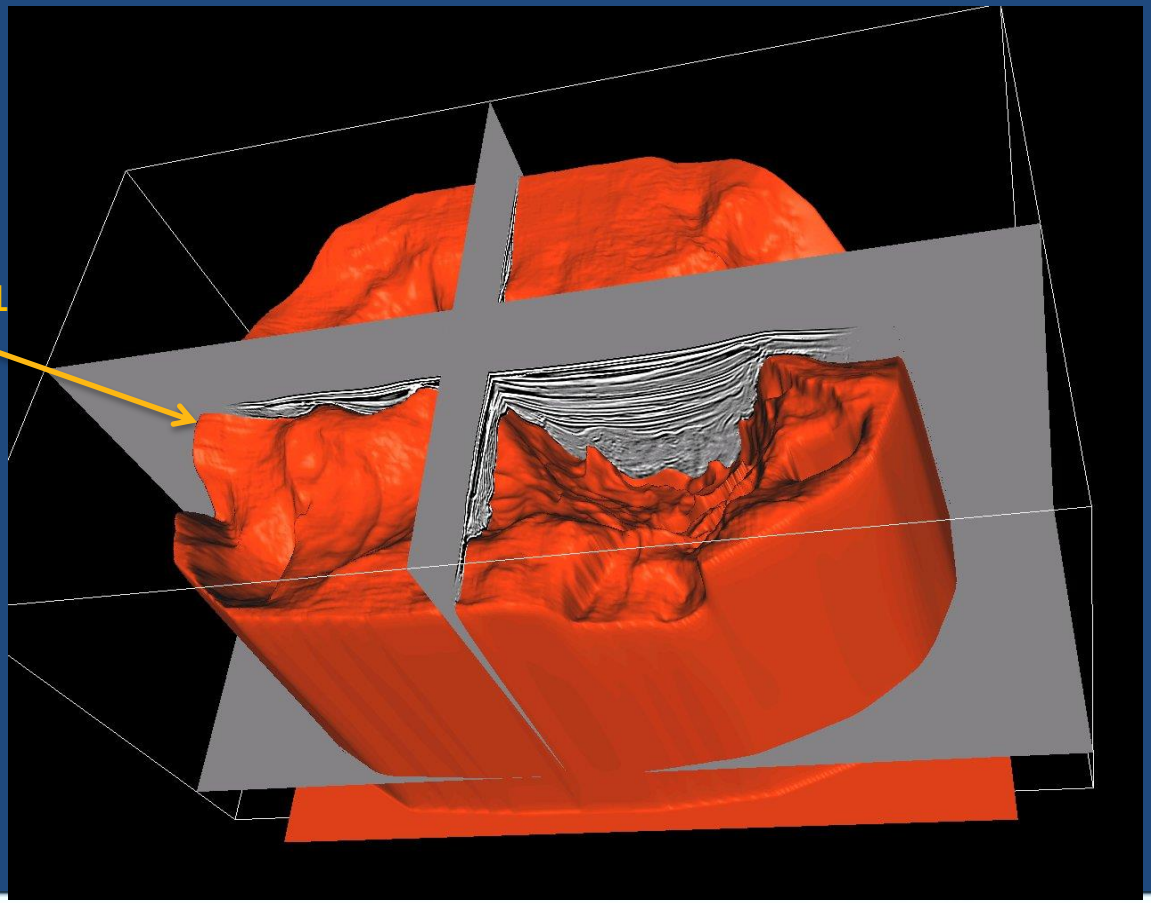


Full Azimuth OBN

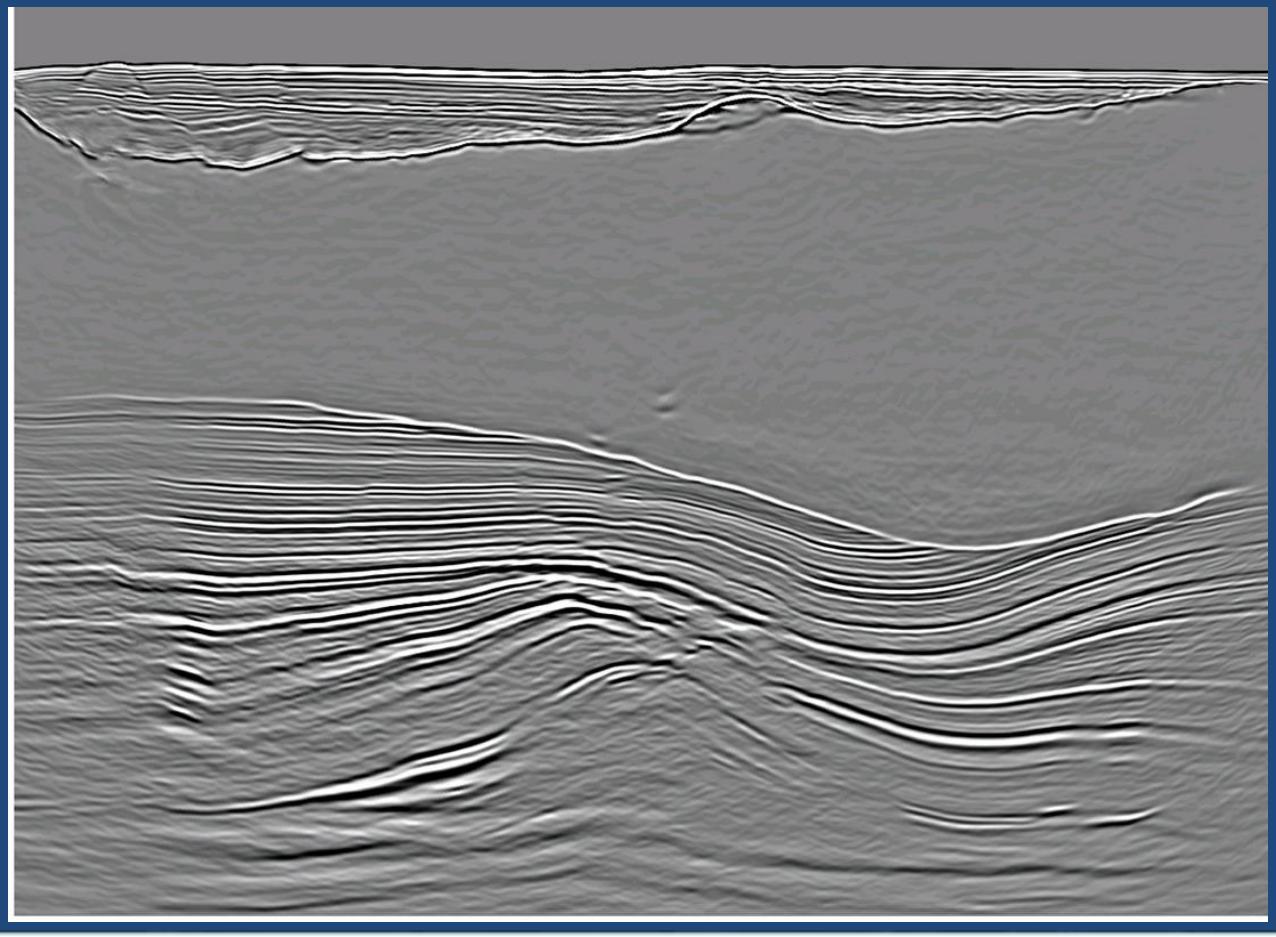


From Smit, 2008

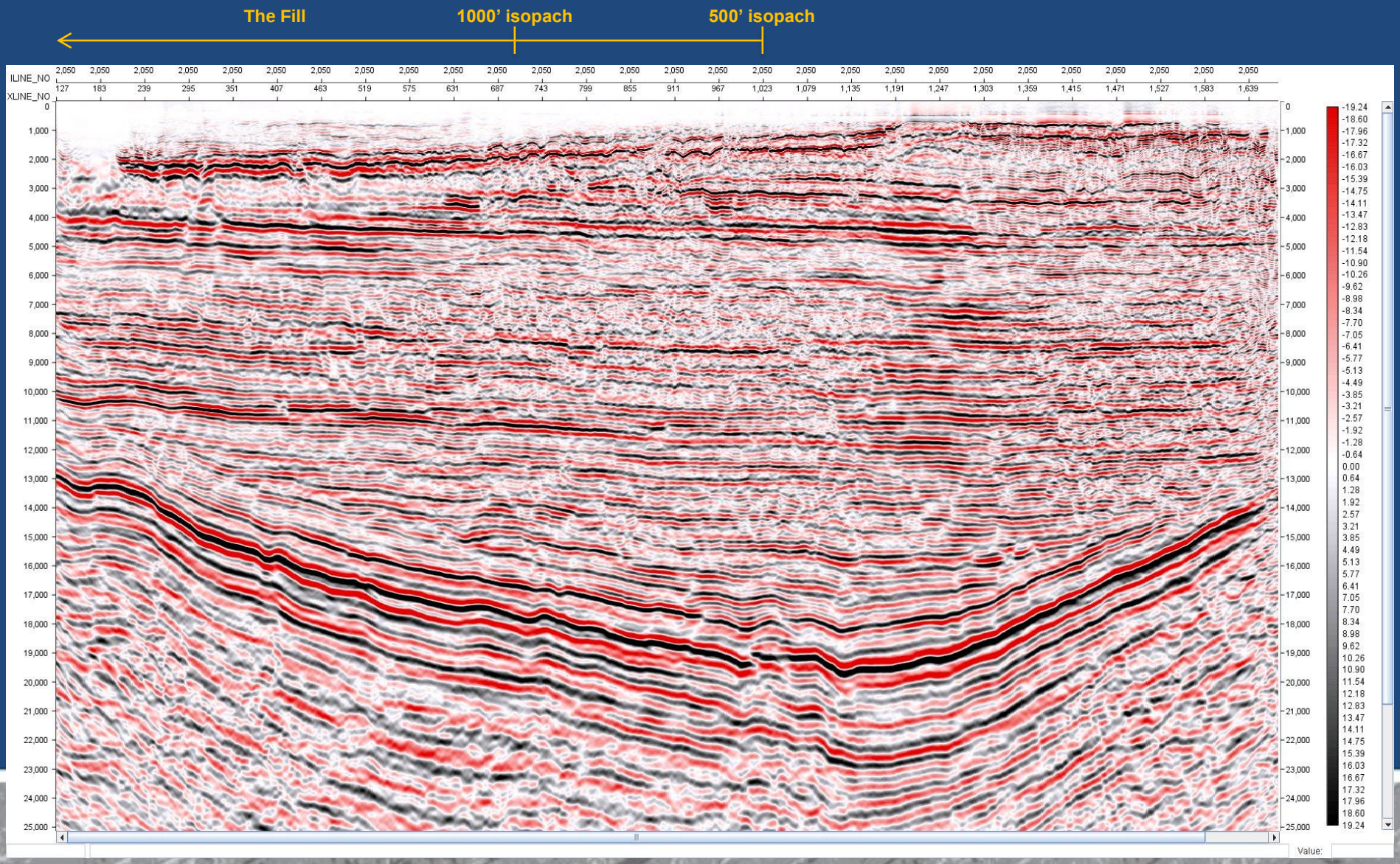
Deepwater OBN: Gulf of Mexico



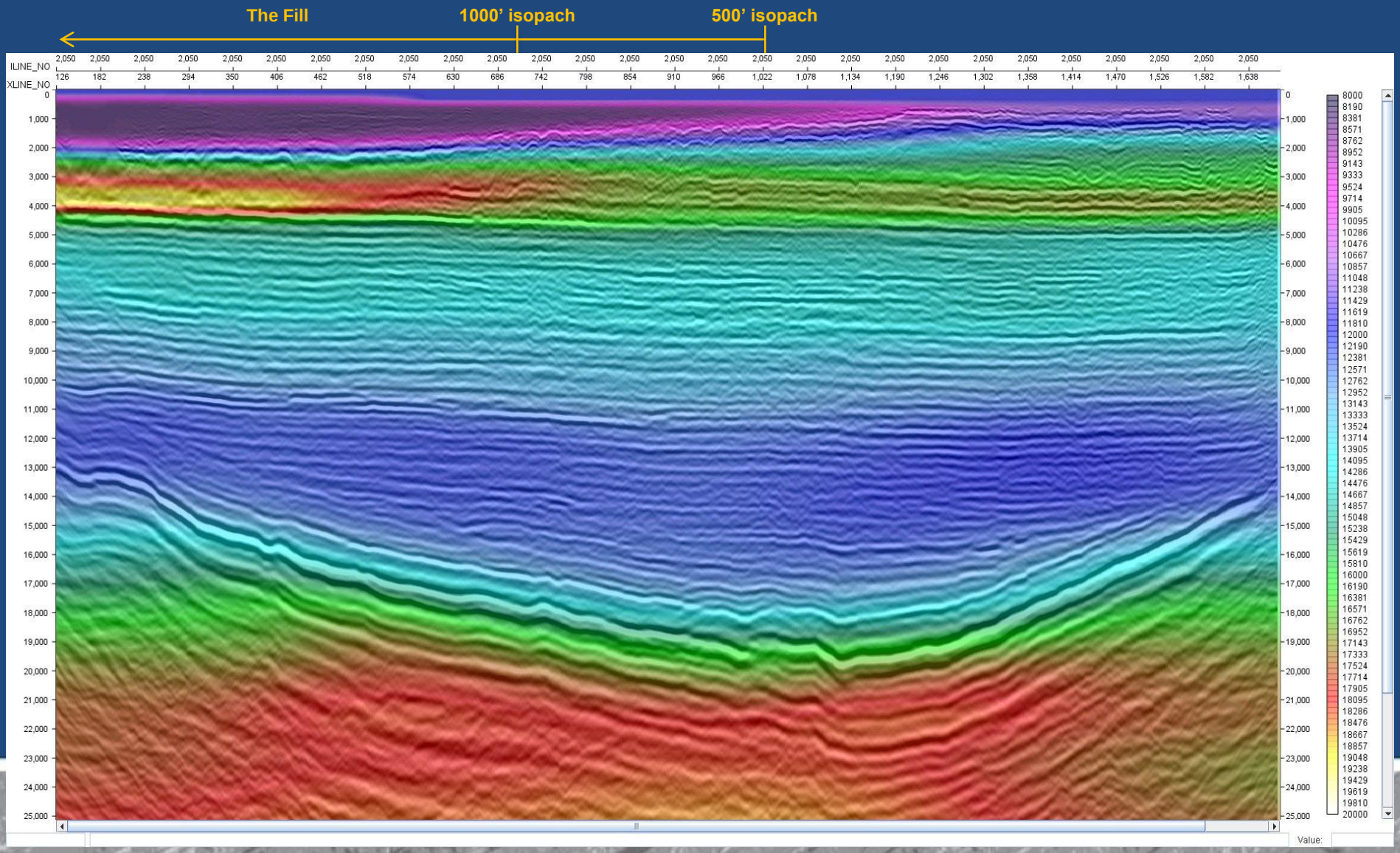
Deepwater OBN: Gulf of Mexico



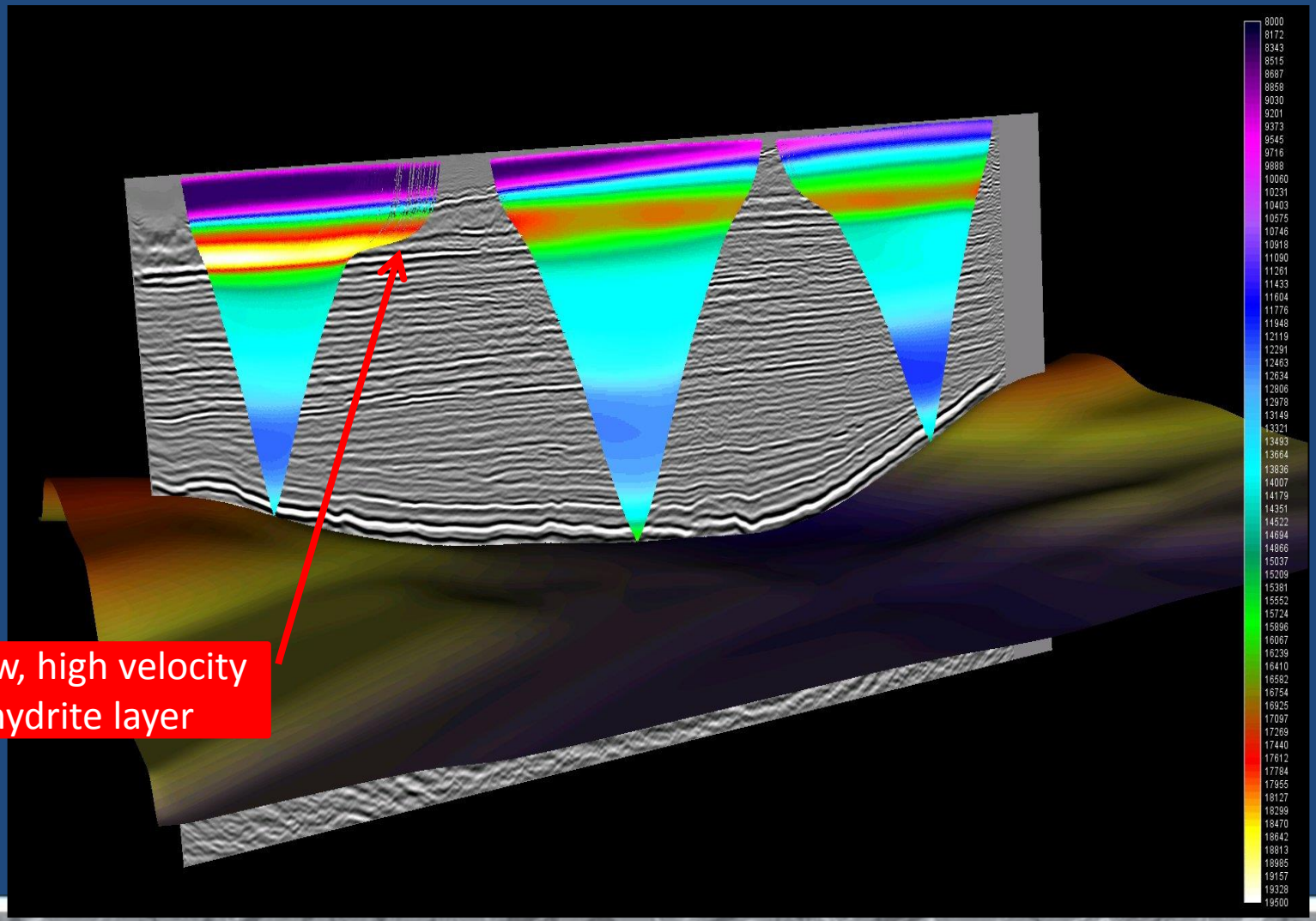
PSTM Stack: Delaware Basin, USA



Final Anisotropic PSDM stack - velocity model overlay



2D line extraction with image ray bundles

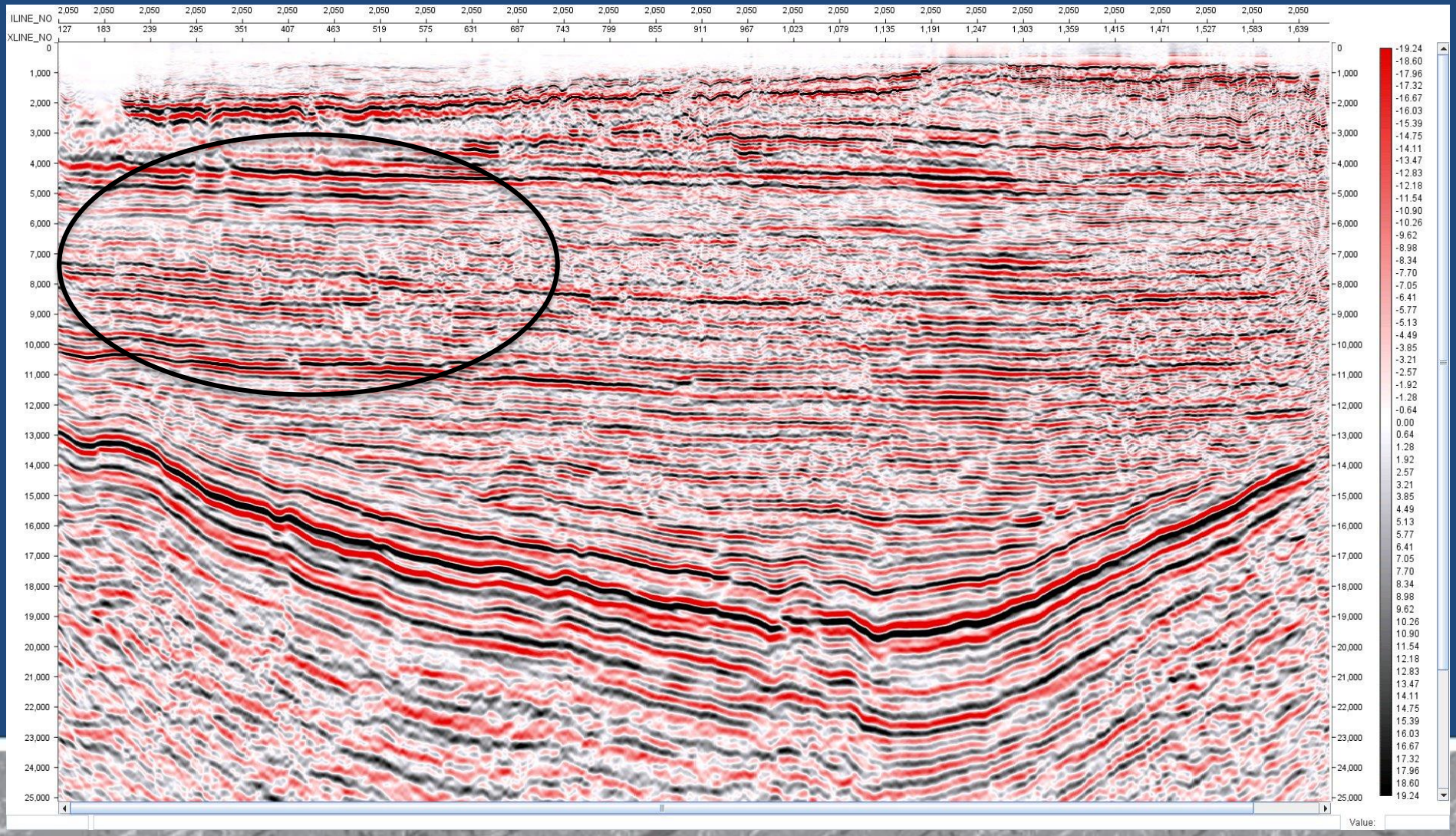


PSTM Stack

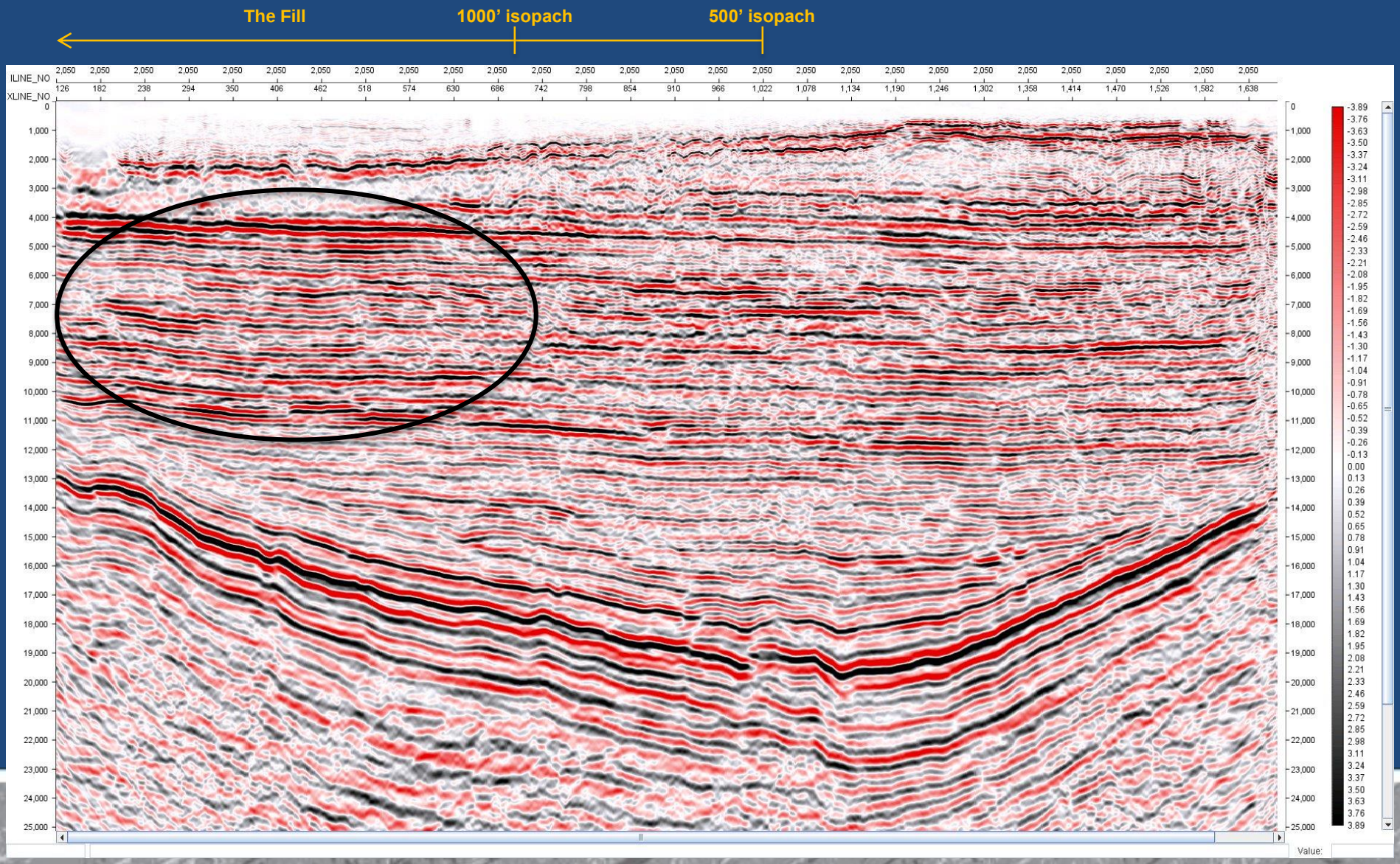
The Fill

1000’ isopach

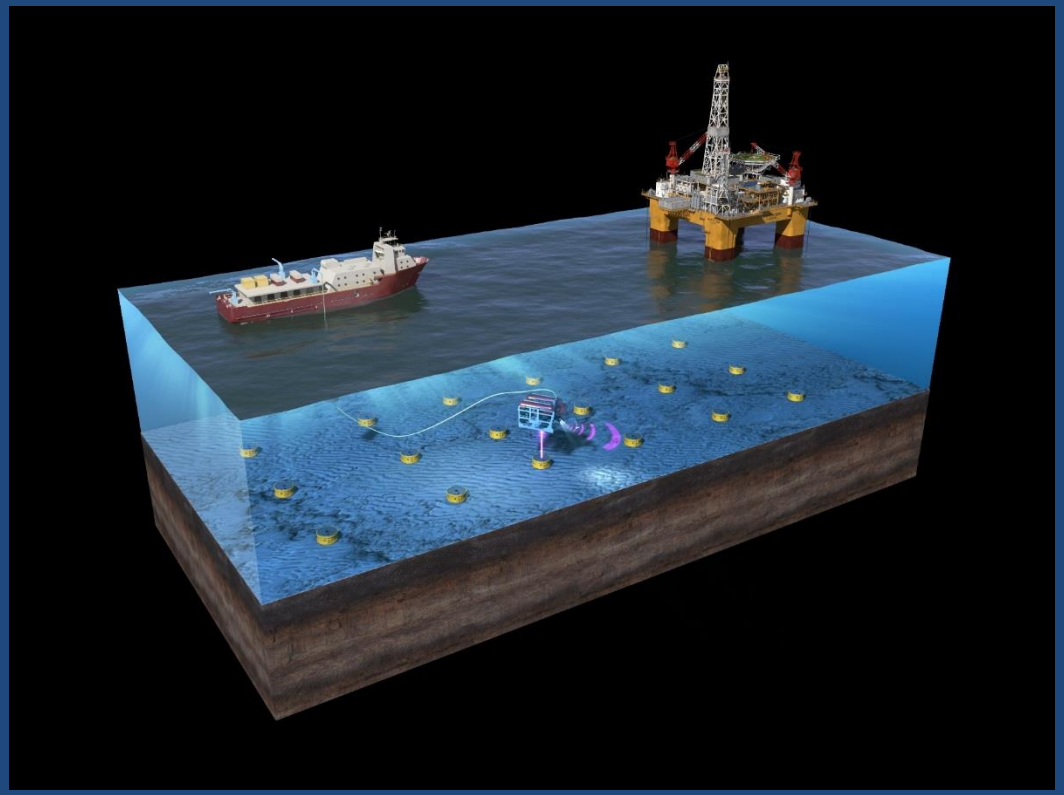
500’ isopach



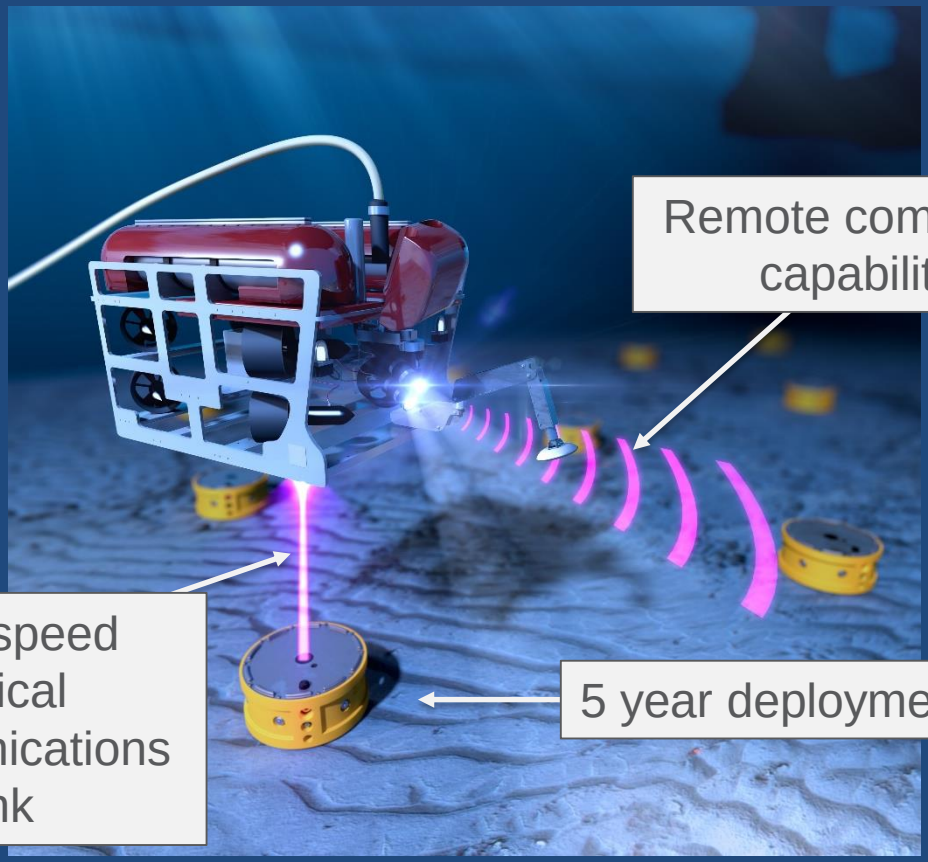
Anisotropic PSDM stack



Reservoir Monitoring with Nodes



Reservoir Monitroing with Nodes



Reservoir Monitoring with Nodes

- No cables, no pipeline crossings, no trenching
- No ties to production facilities
  - No umbilical(s)
  - No oilfield installation space
- Sparse node geometry - small environmental impact
- Installation – little technical risk, conventional node deployment (30,000 successful deployments in last 10 yr.)

Reservoir Monitoring with Nodes

- Low maintenance – nodes are reliable. If node fails status check, it's replaced with no other stations disturbed
- Flexibility– nodes can be moved or added as development plans change or reservoir knowledge evolves
- Monitor survey costs are low, single vessel operations
- Expect excellent NRMS

Conclusions

- Imaging objectives of modern seismic surveys are met by
  - Long offsets
  - Wide azimuths
  - High fold
  - Dense subsurface sampling
- Acquiring optimal data in obstructed areas requires
  - Operational efficiency
  - Flexibility
  - Accessibility
- OBN acquisition has clear advantages for seismic acquisition in each stage of field appraisal and development

Thank You

fairfieldnodal