New insights brought by broadband seismic data on the Brazil-Angola conjugate margins

Gregor Duval, Jaswinder Mann, Lauren Houston and Steven Bowman*

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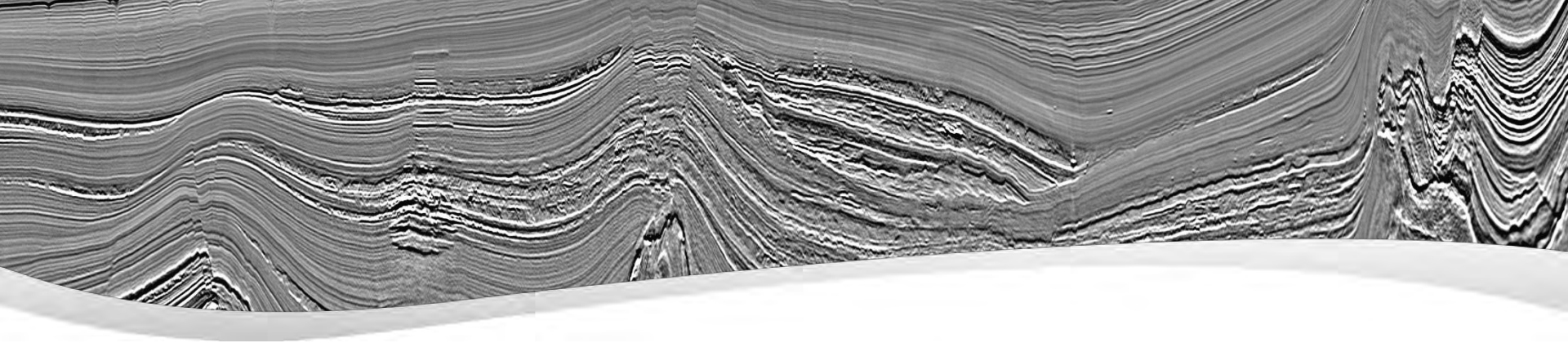
Content

- Introductory remarks: why does the seismic interpreter need broadband data?
- Seismic surveys location (South Atlantic margin equivalence) and acquisition parameters
- Pre-salt exploration and broadband seismic imaging
- Post-salt broadband seismic benefits: facies mapping and reservoir characterisation



Why does the seismic interpreter need broadband data?

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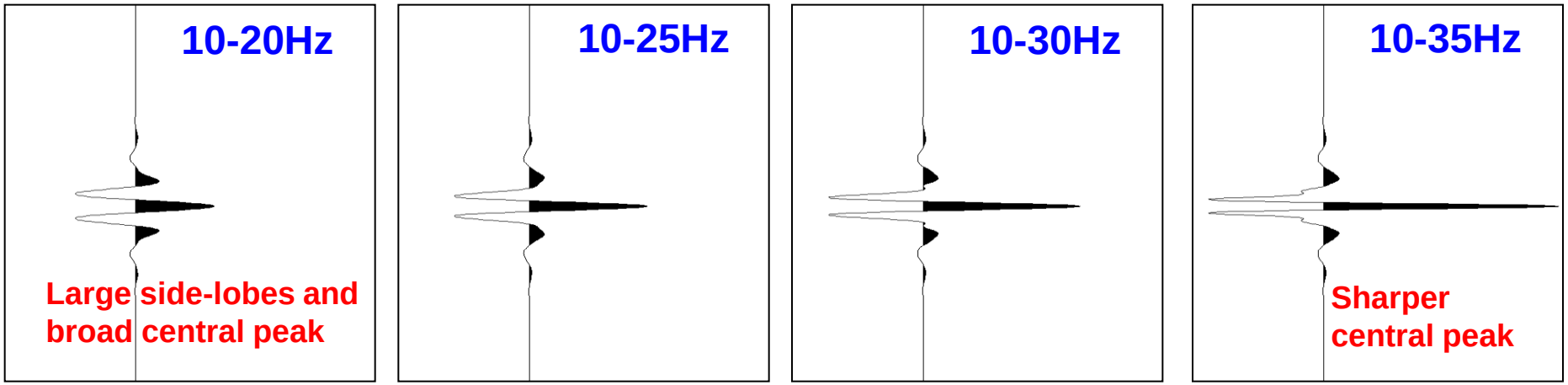
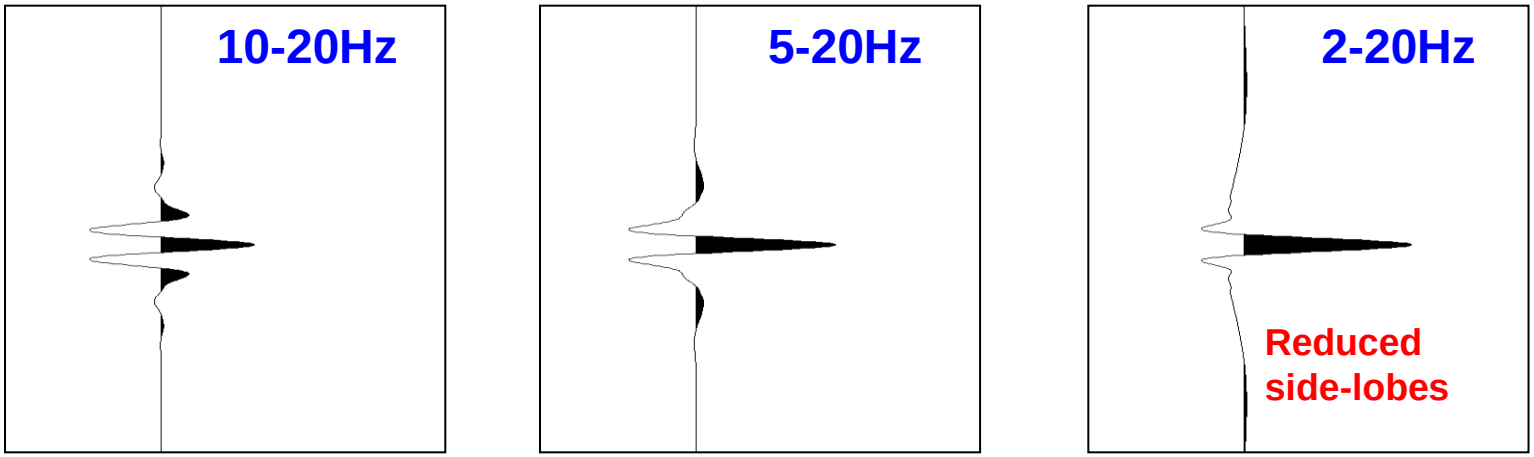
Effects and benefits of increasing the bandwidth

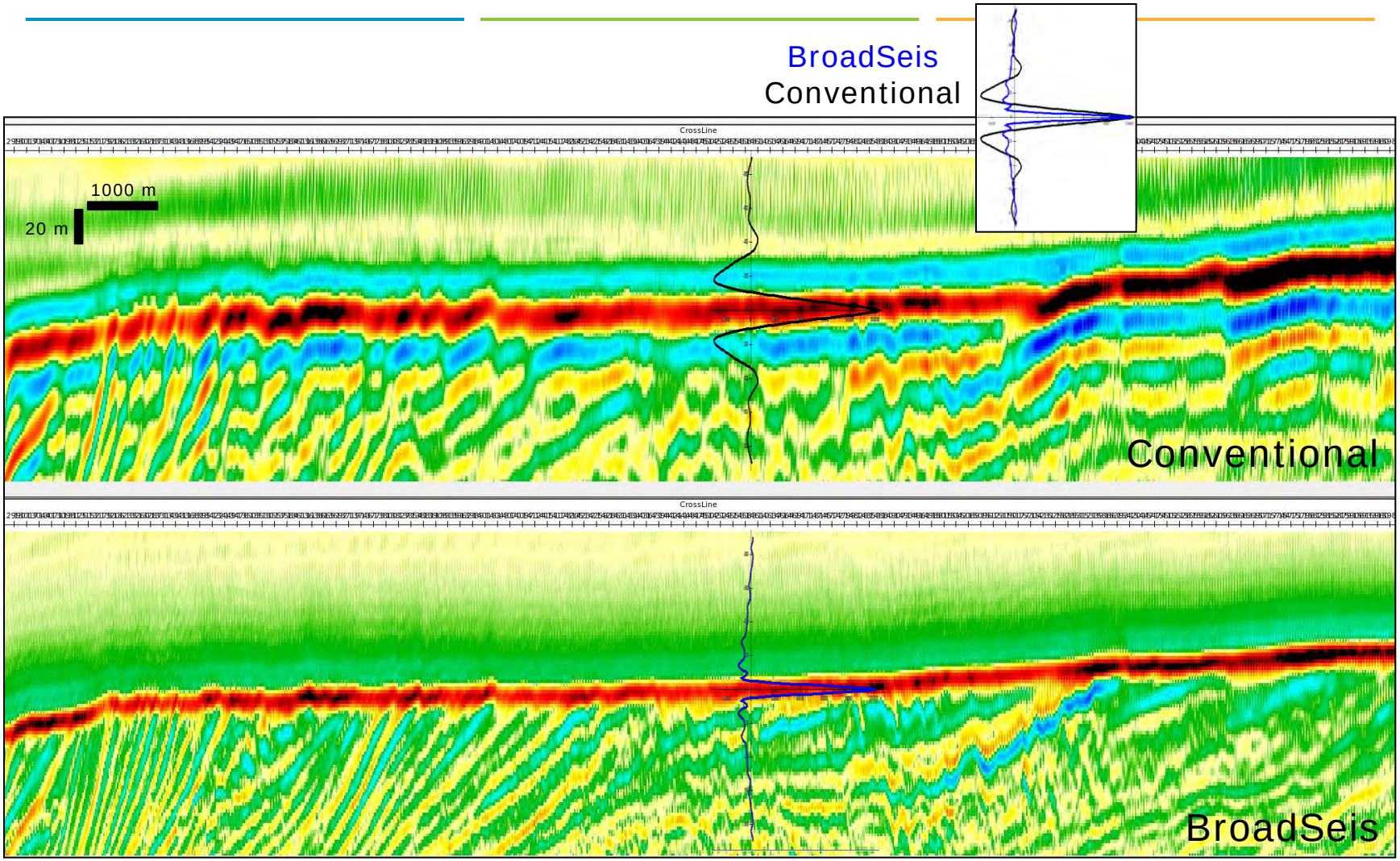


Increasing high frequencies

Increase low frequencies

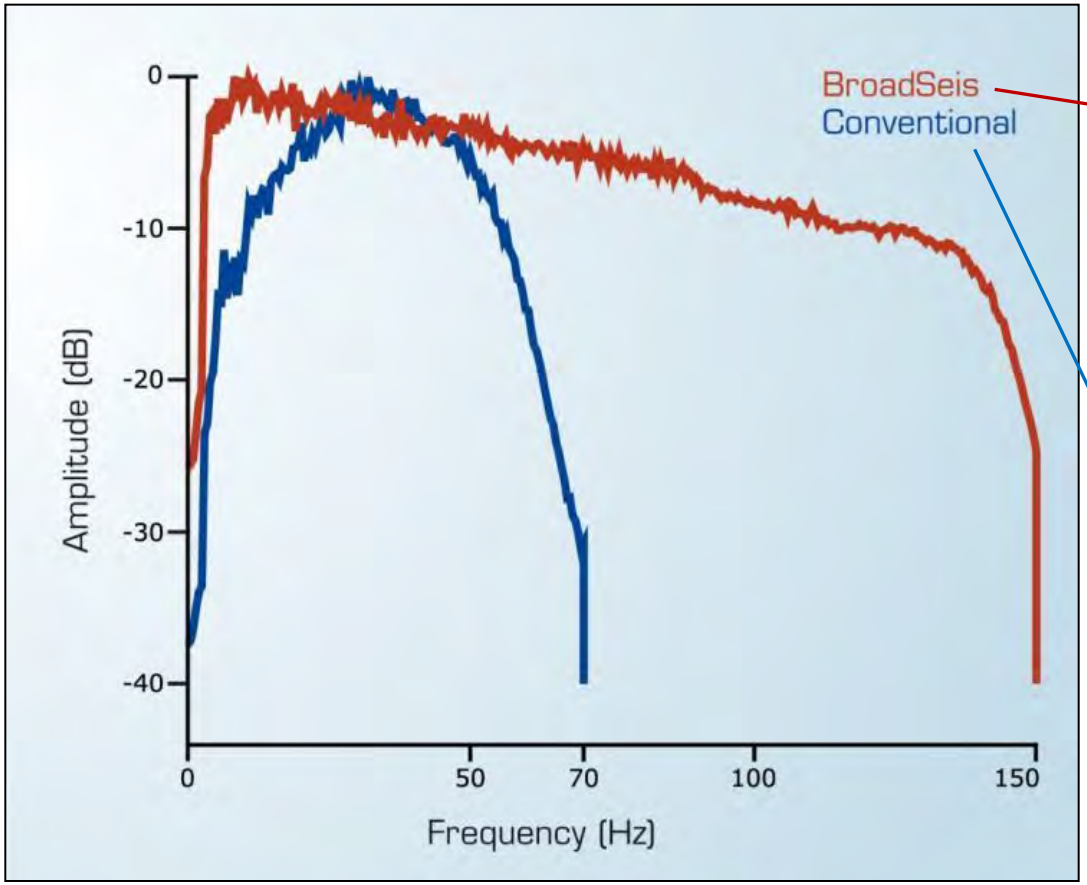


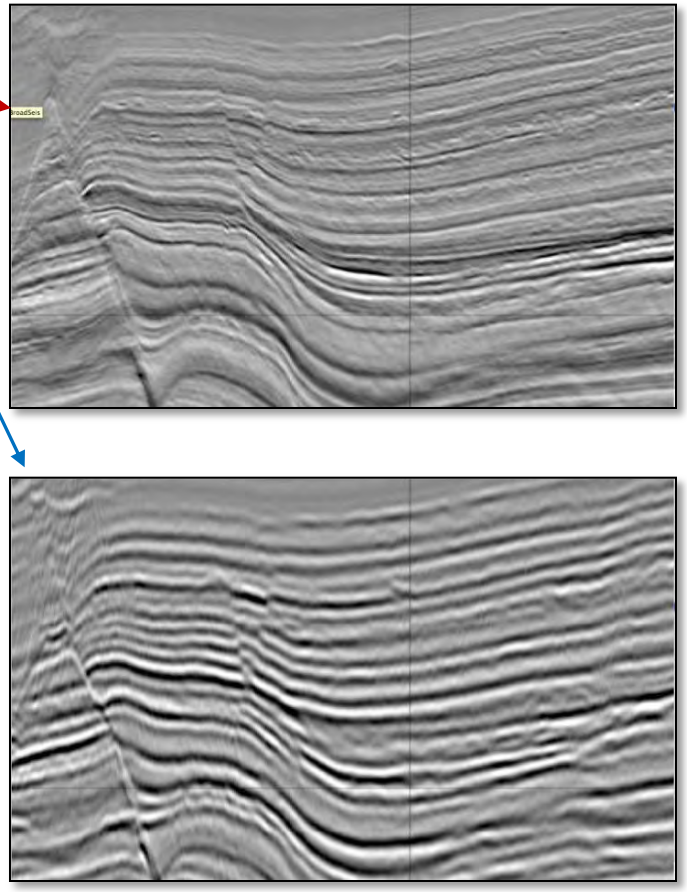
Effects and benefits of increasing the bandwidth



Courtesy of Total, Cobalt and the Republic of Gabon

Effects and benefits of increasing the bandwidth





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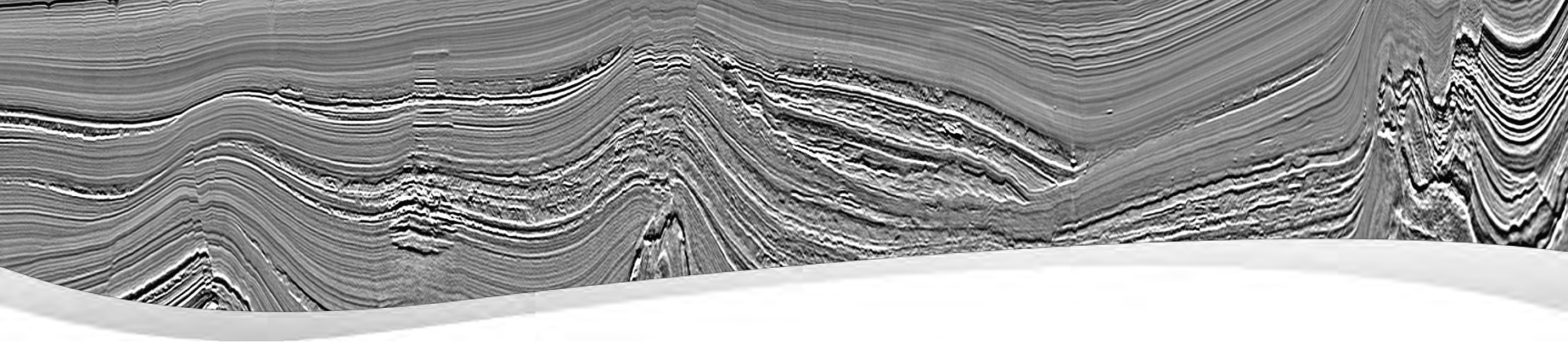

Broadband 3D seismic surveys location and parameters

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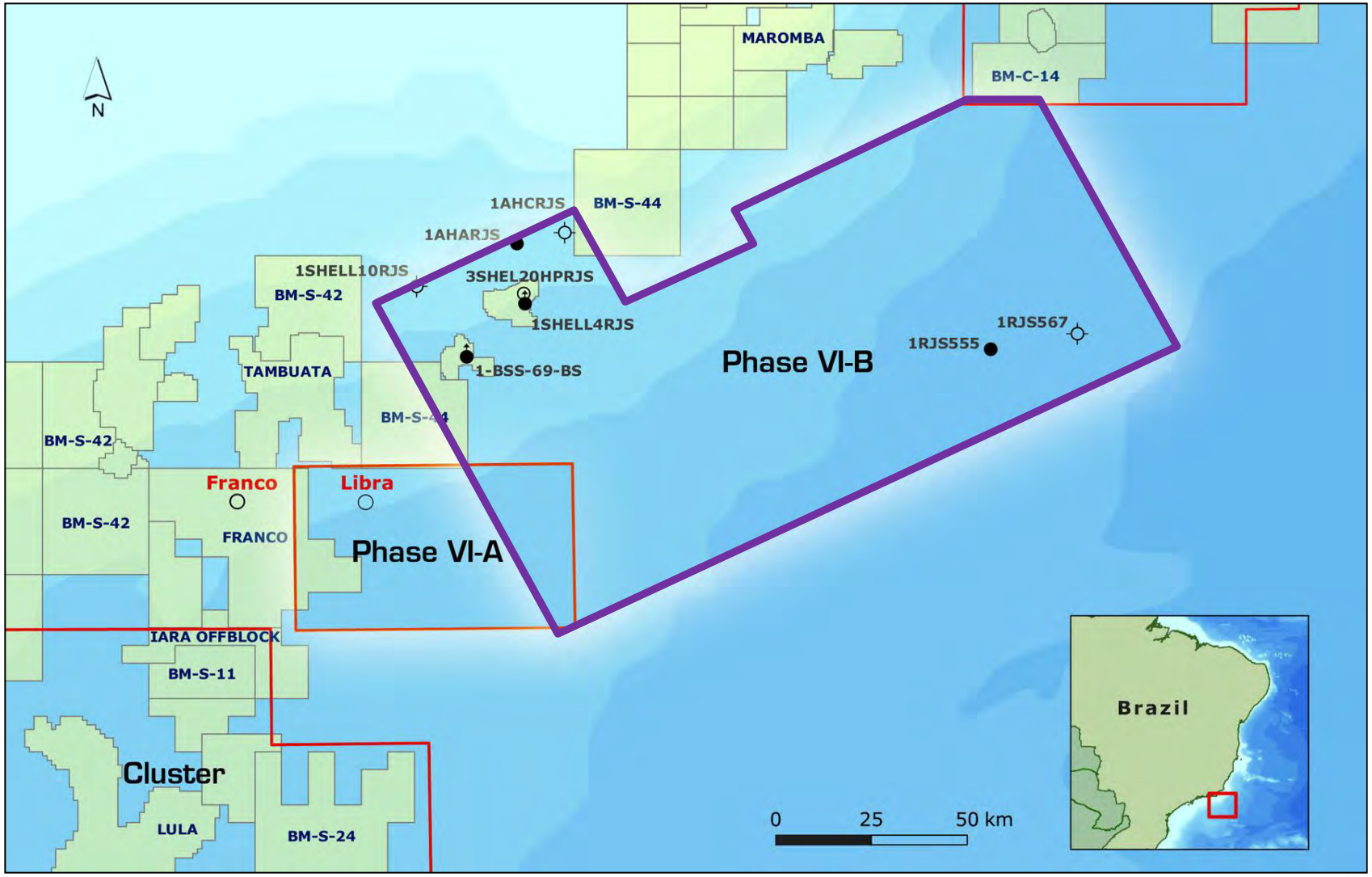
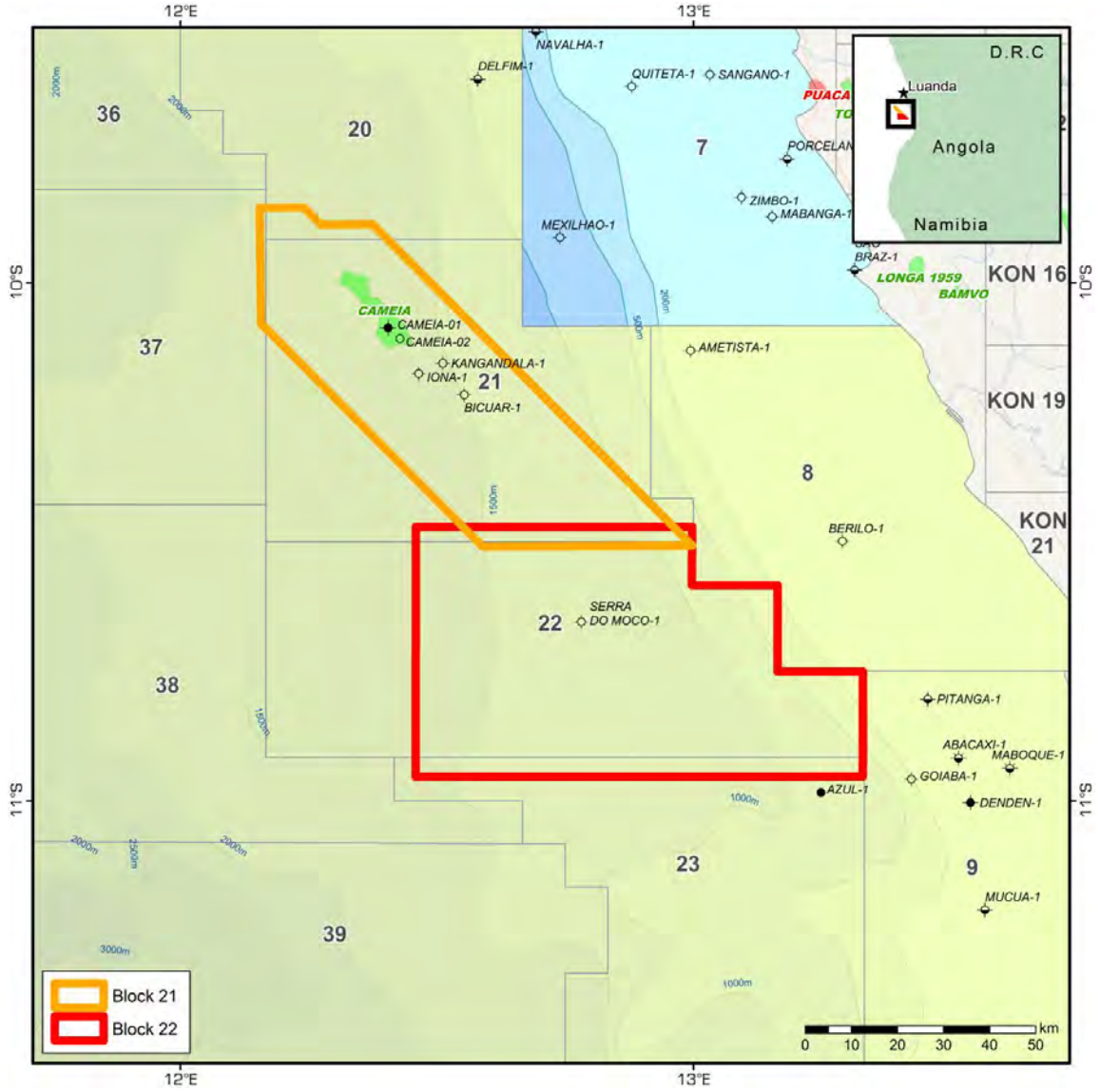
Brazil Santos Basin – Broadband 3D survey



Brazil Santos Basin – Broadband 3D survey

- Total area covered = 13,760km^2
- Streamer spread = 8000m x 10, 8100m x 12
- BroadSeis streamer profile = 10m to 50m
- Streamer separation = 100m
- Shot-point interval = 25m
- Record length = 10sec
- PreSDM algorithm = **Kirchhoff**, AP-CBM and RTM
- Max depth output 10km

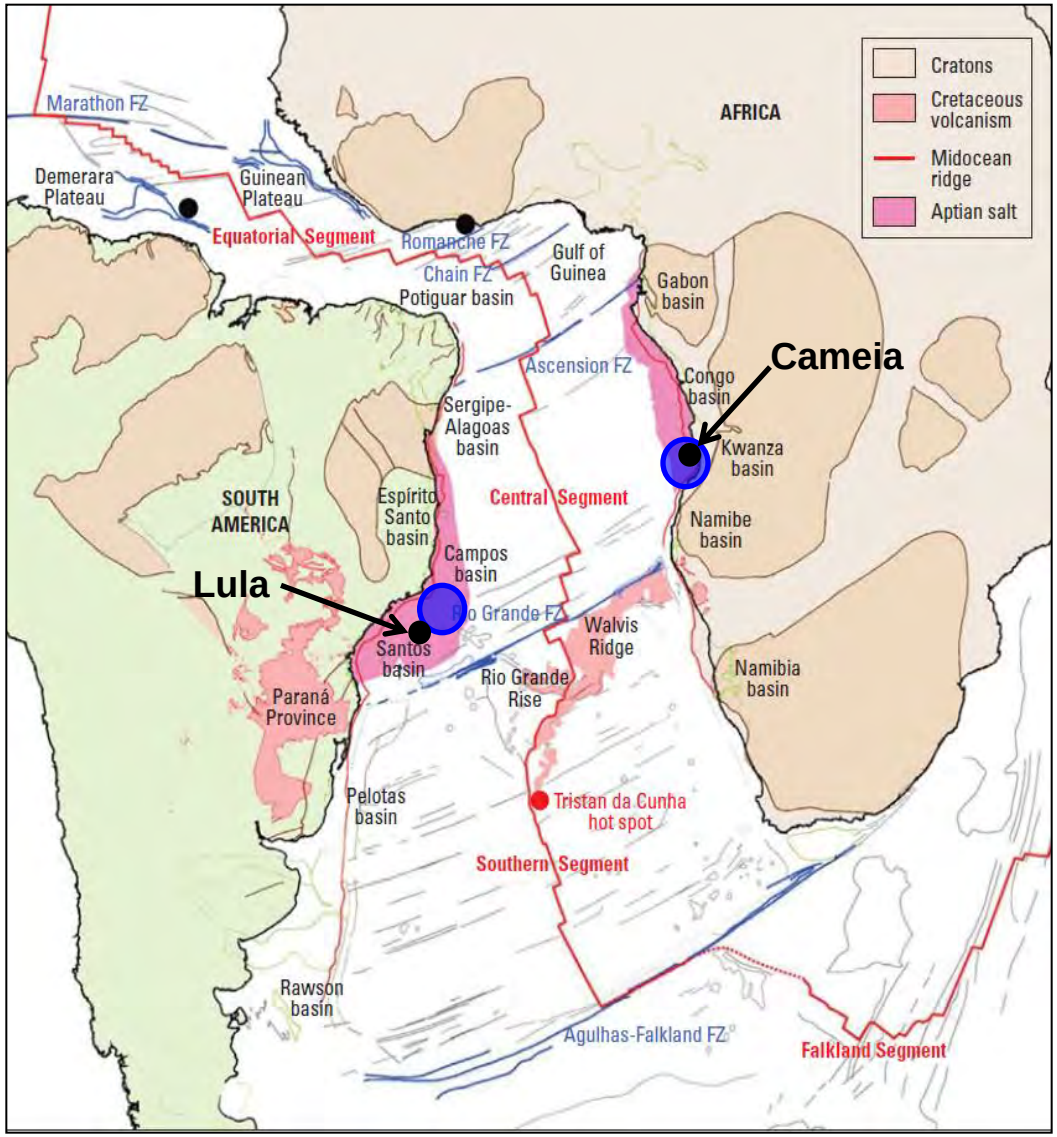
Angola Kwanza Basin - Broadband 3D surveys



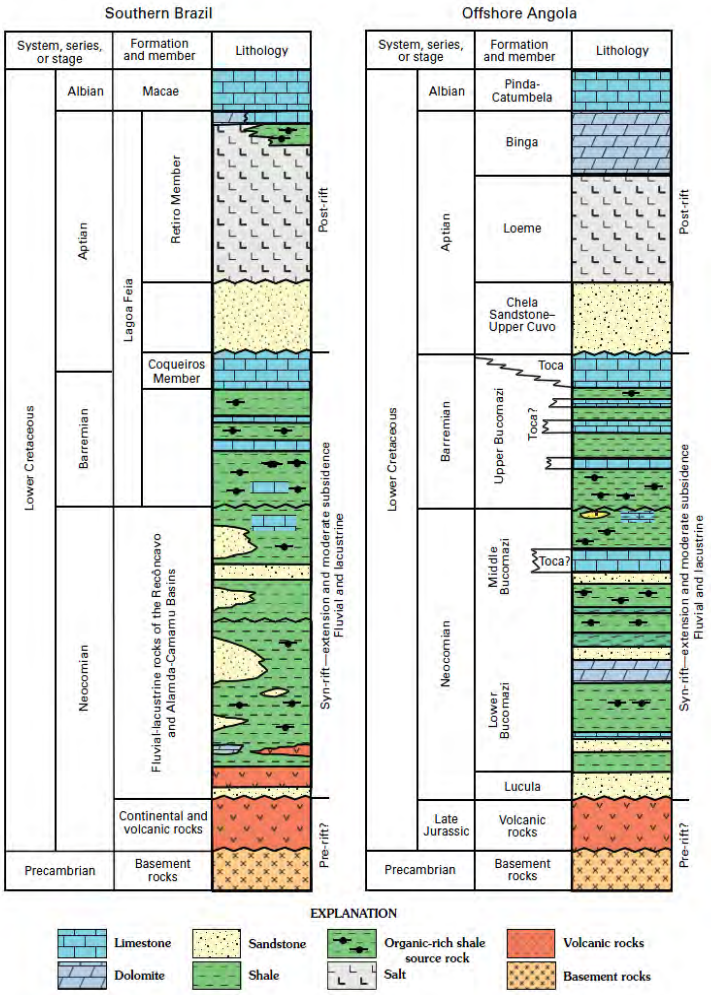
Angola Kwanza Basin – Broadband 3D surveys

Parameter	Block 21 survey	Block 22 survey
Total area	4,300km^2	2,915km^2
Streamer length	8100m	8100m
Number of streamers	12	12
BroadSeis streamer profile	8-50m	10-50m
Streamer separation	100m	100m
Shot-point interval	25m	25m
Record length	10sec	9sec
PreSDM algorithm	**CBM (fast-track)** Kirchhoff (final)	**CBM** and Kirchhoff
Max depth output	12km	10km

South Atlantic main geological features



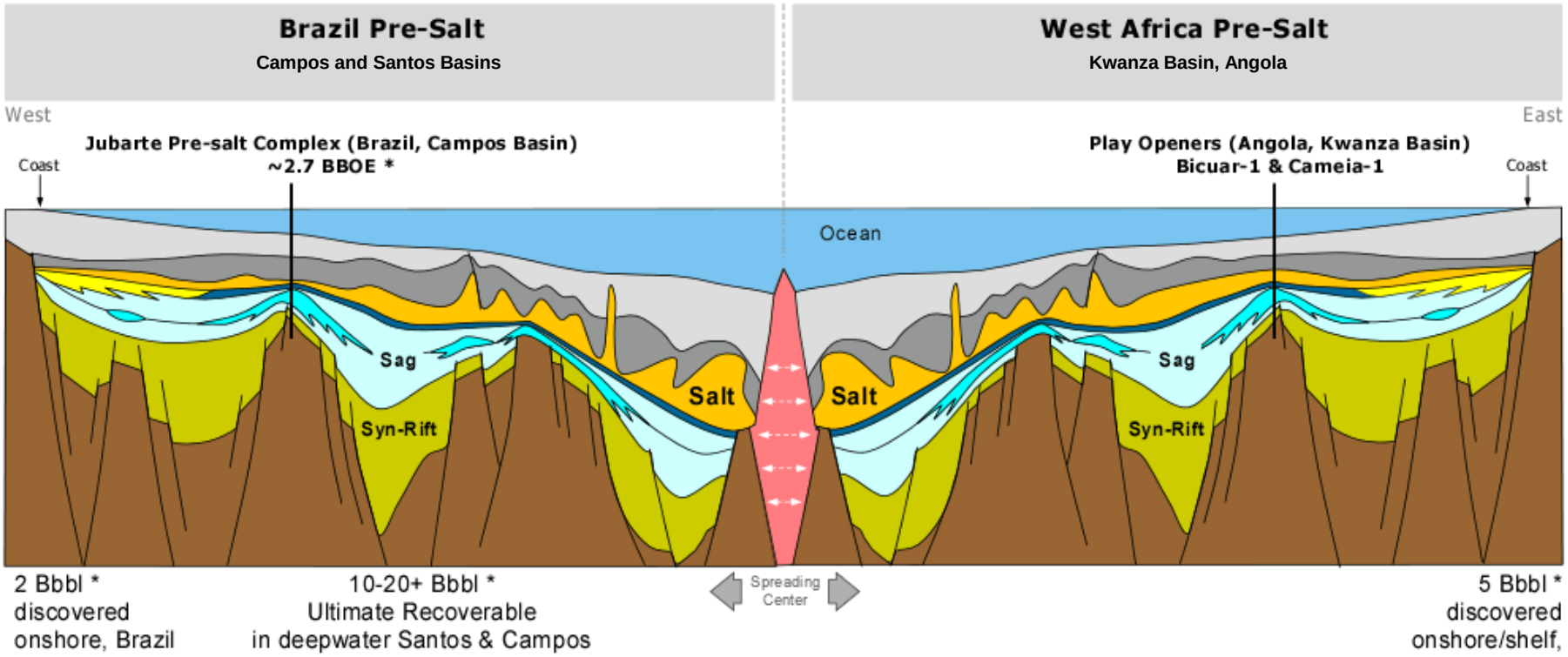
Source: Bryant et al. 2012



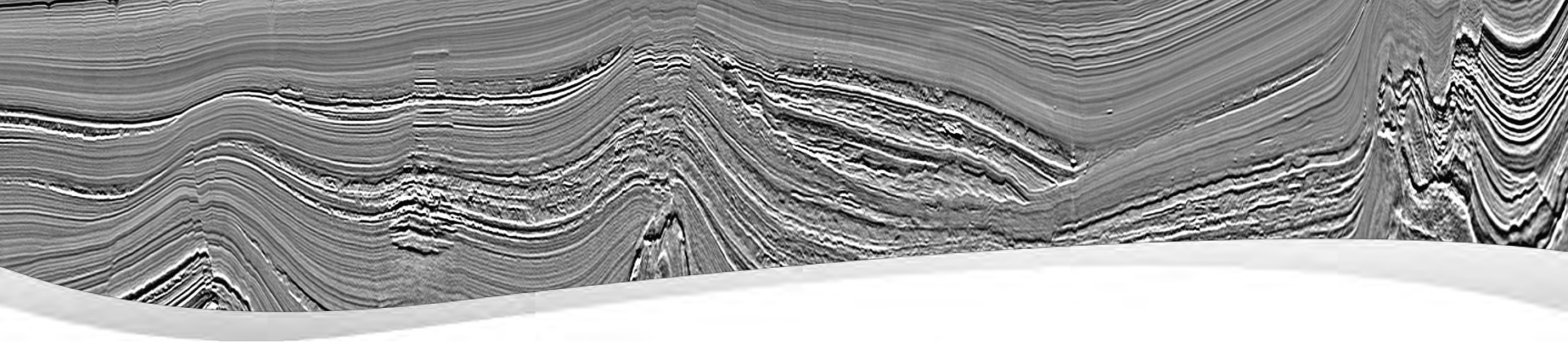
Source: USGS

BroadSeis 3D surveys

South Atlantic equivalent margins cross-section



Source: Cobalt International Energy



Pre-salt exploration and broadband seismic imaging

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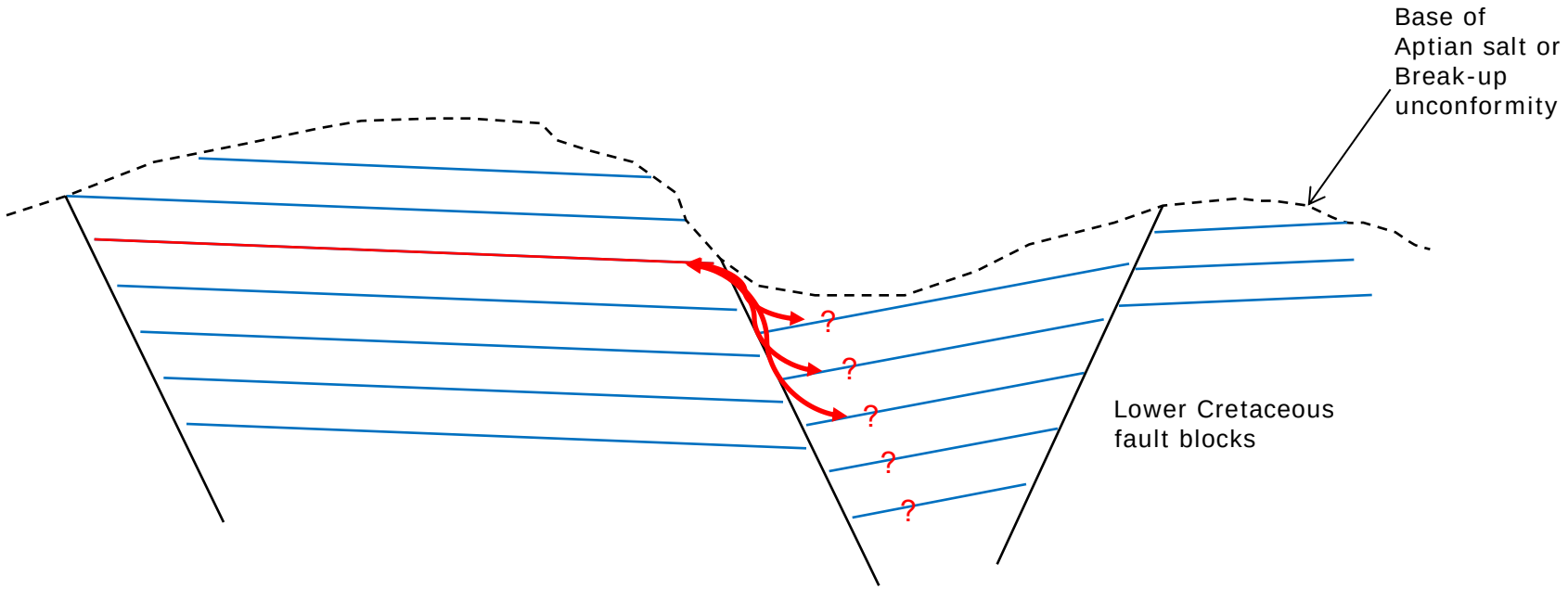
Brazil Campos/Santos Basins – Deep water pre-salt exploration history

Field	Year of discovery	Water depth (m)
Badejo	1975	100
Linguado	1978	100
Trilha	1982	100
Lula (Tupi)	2006	2100
Carioca	2007	2100
Jupiter	2008	2100
Sapinhoa	2008	2100
Guarani	2009	2100
Franco	2010	2000
Libra	2010	2000

Angola Kwanza Basin - Deep water pre-salt exploration history

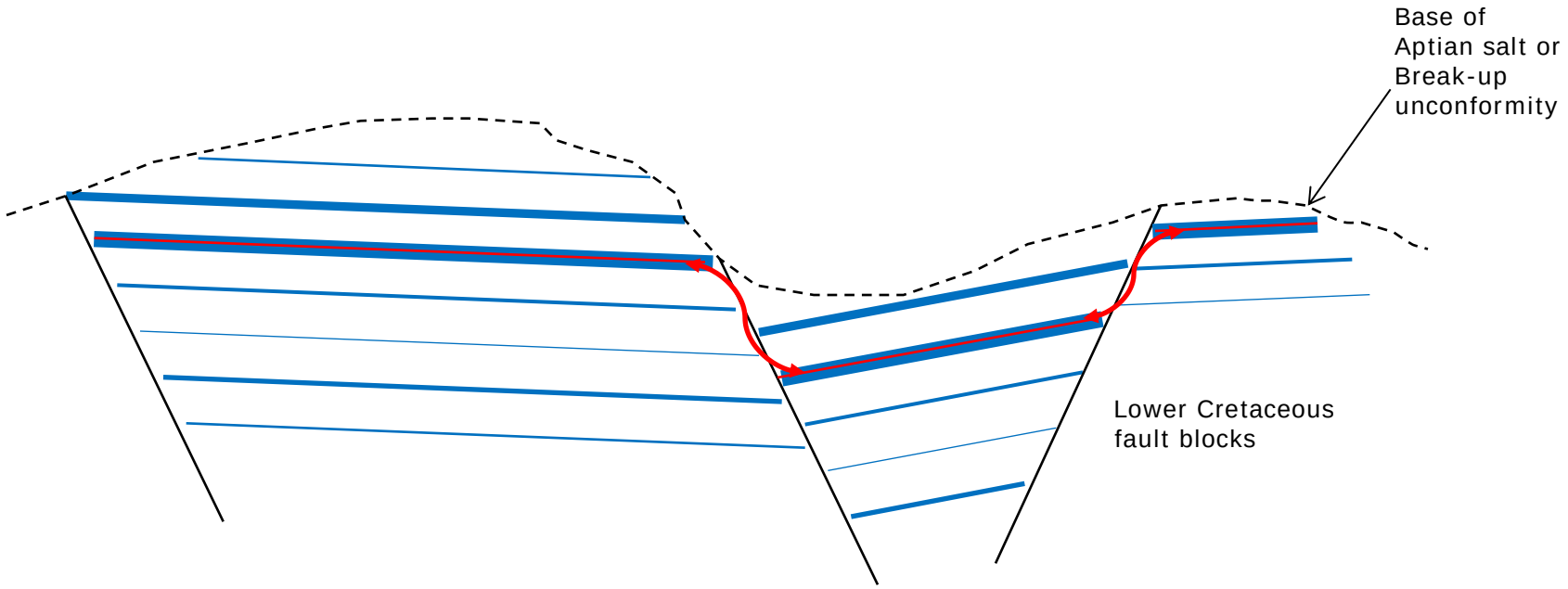
Field	Year of discovery	Water depth (m)
Mucua	1982	200
Denden	1983	200
Falcao	1992	200
Baleia	1996	800
Bicuar	2011	1500
Azul	2011	900
Cameia	2012	1700

Pre-salt seismic interpretation on conventional data



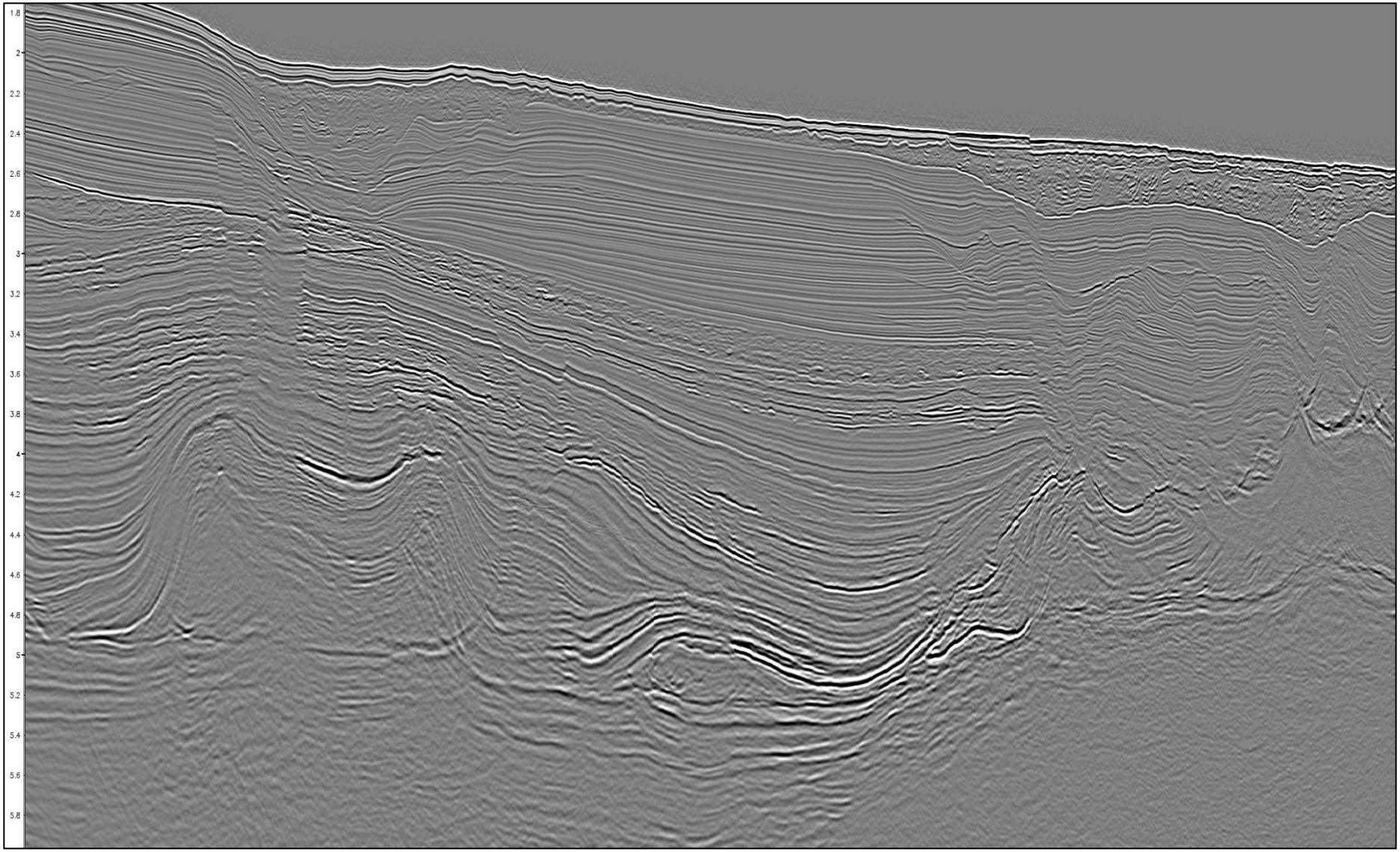
Cross fault correlation with multiple choices ??
Any reflector can be correlated through faults

Pre-salt seismic interpretation on broadband data

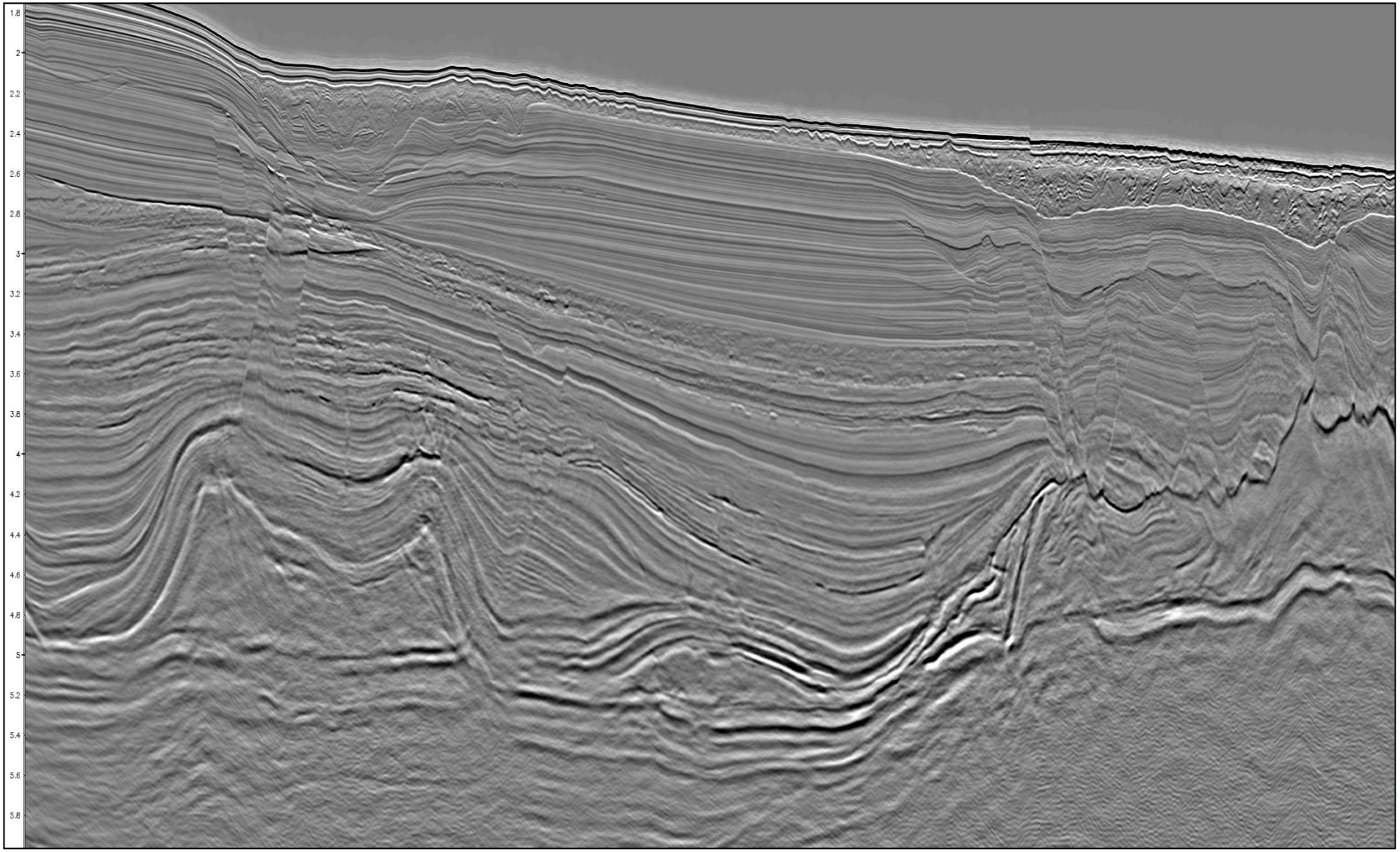


Cross fault correlation better understood
Uniqueness of the correlation through faults

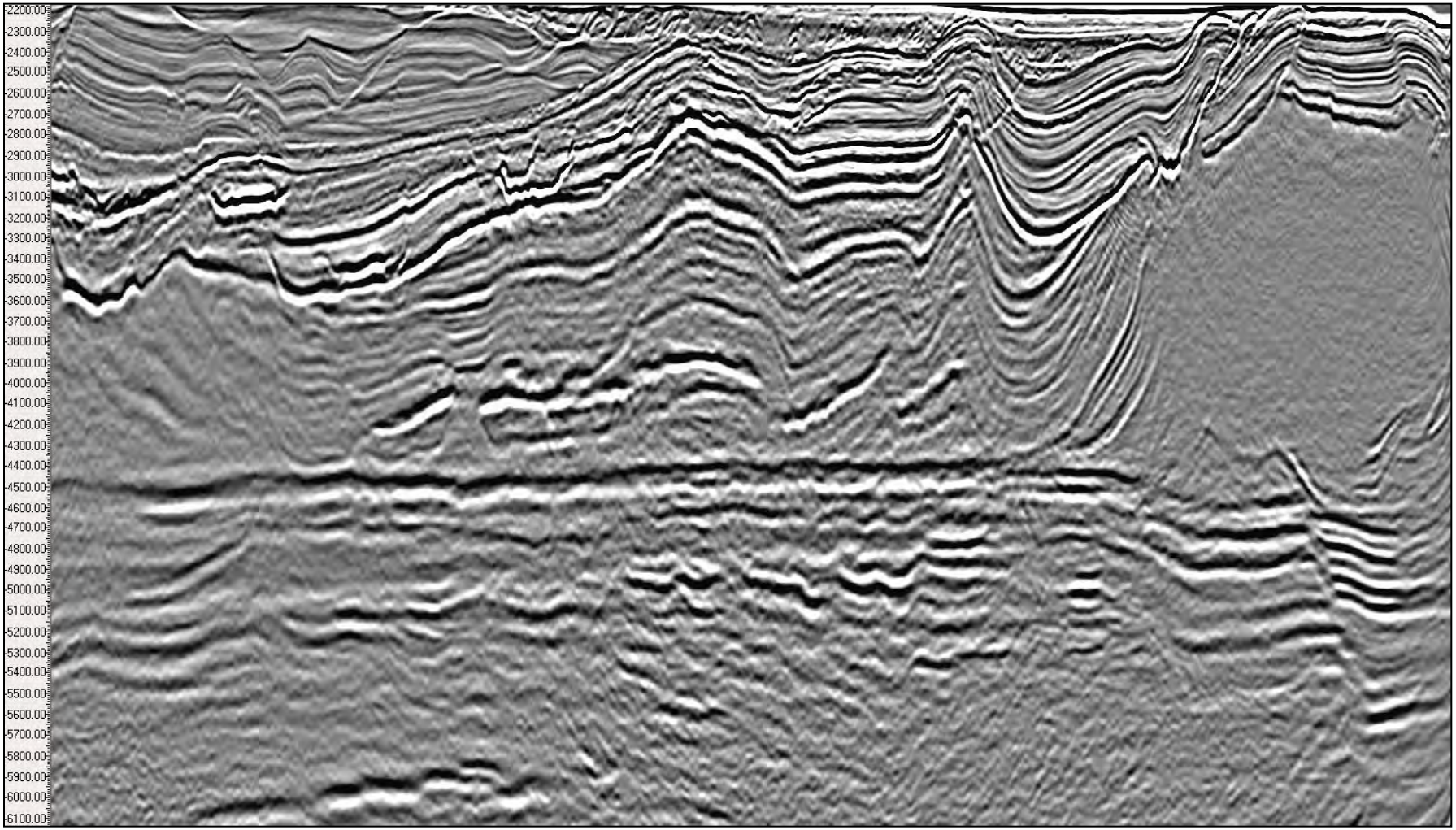
Brazil Santos Basin legacy PSTM data



Brazil Santos Basin BroadSeis PSDM stretched to time

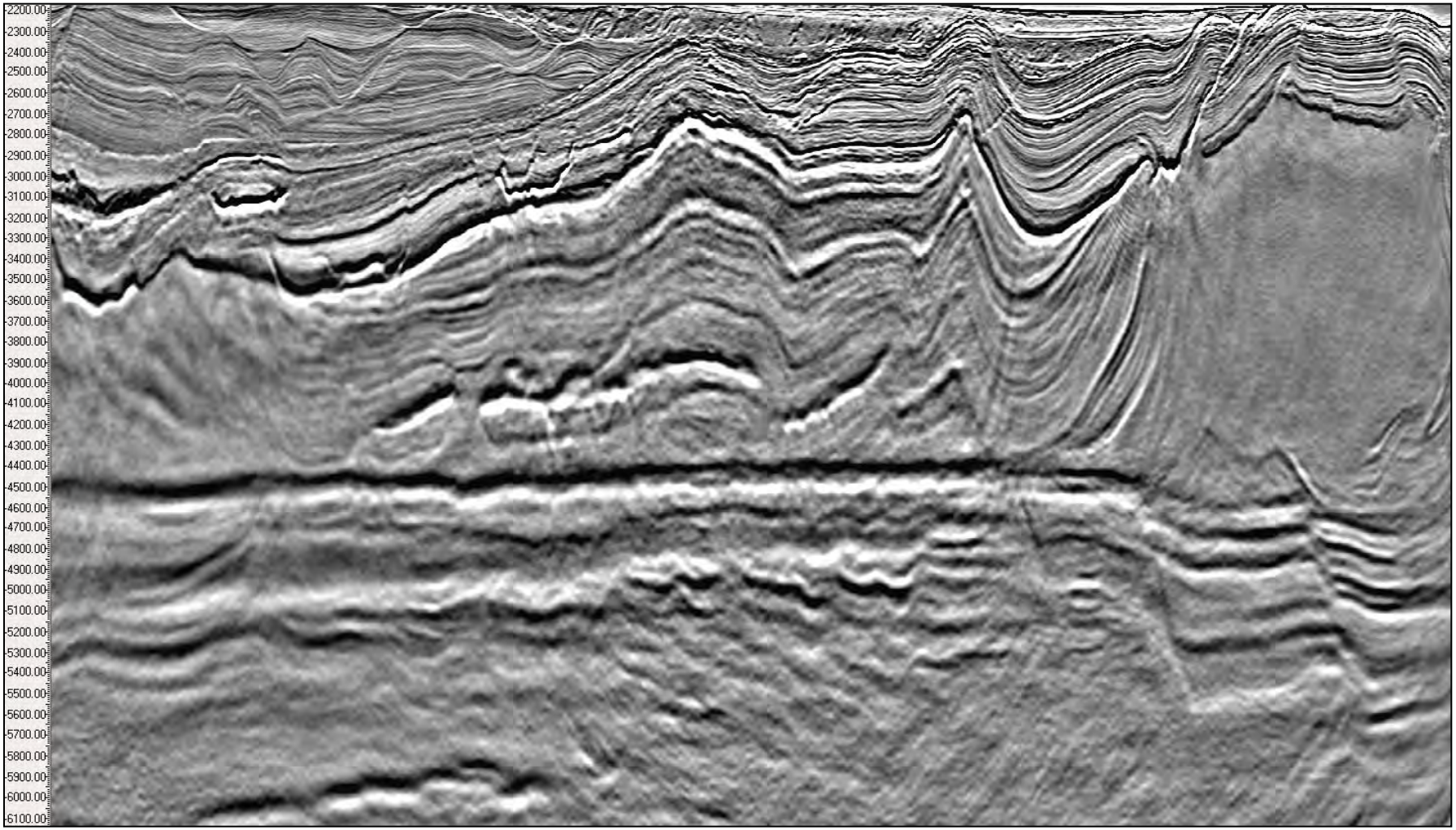


Brazil Santos Basin – BroadSeis PSDM filtered

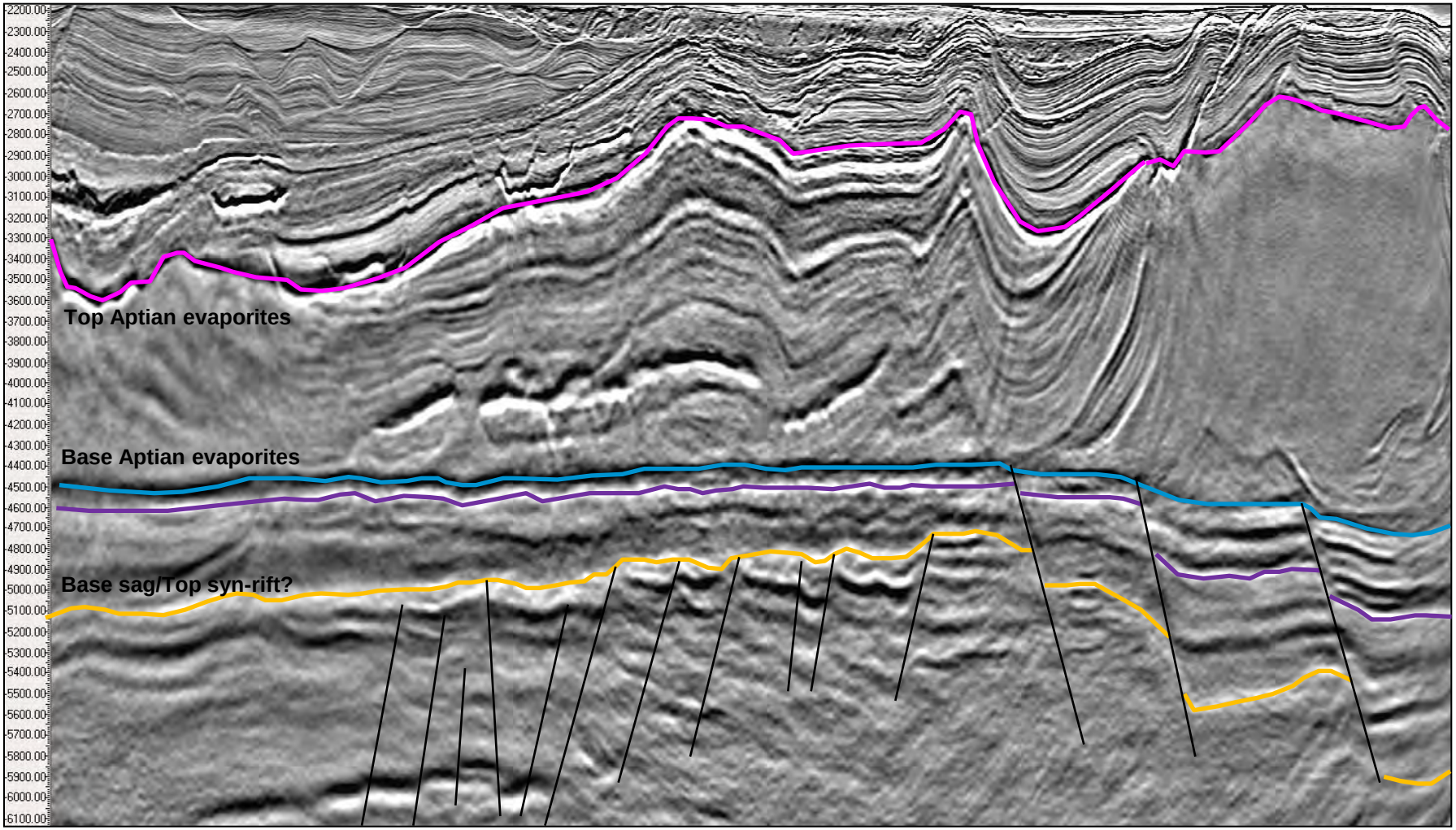


Bandpass filter applied: 2-8 / 15-50 cycles per 1000m

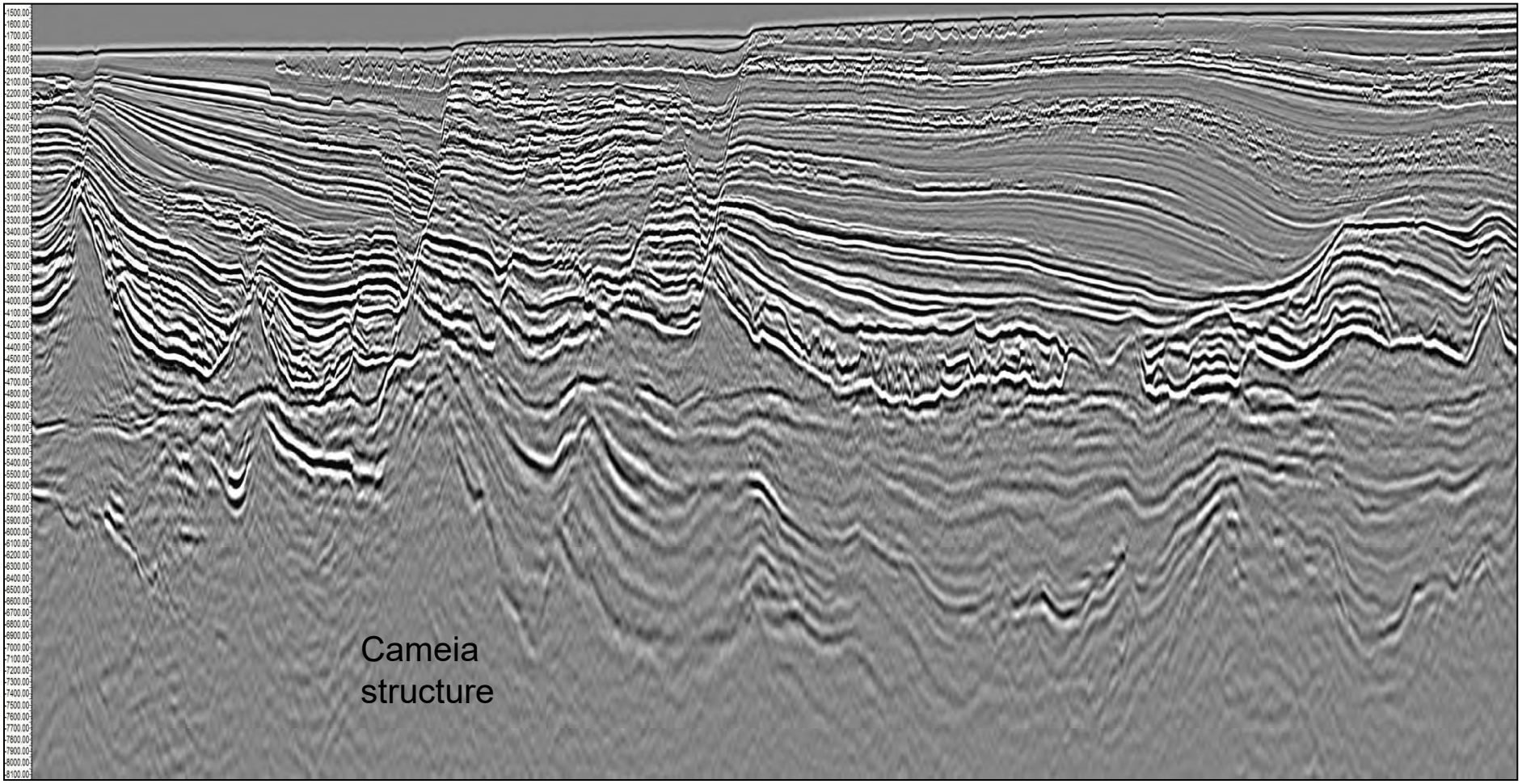
Brazil Santos Basin – BroadSeis PSDM



Brazil Santos Basin – BroadSeis PSDM interpreted



Angola Kwanza Basin – BroadSeis PSDM filtered



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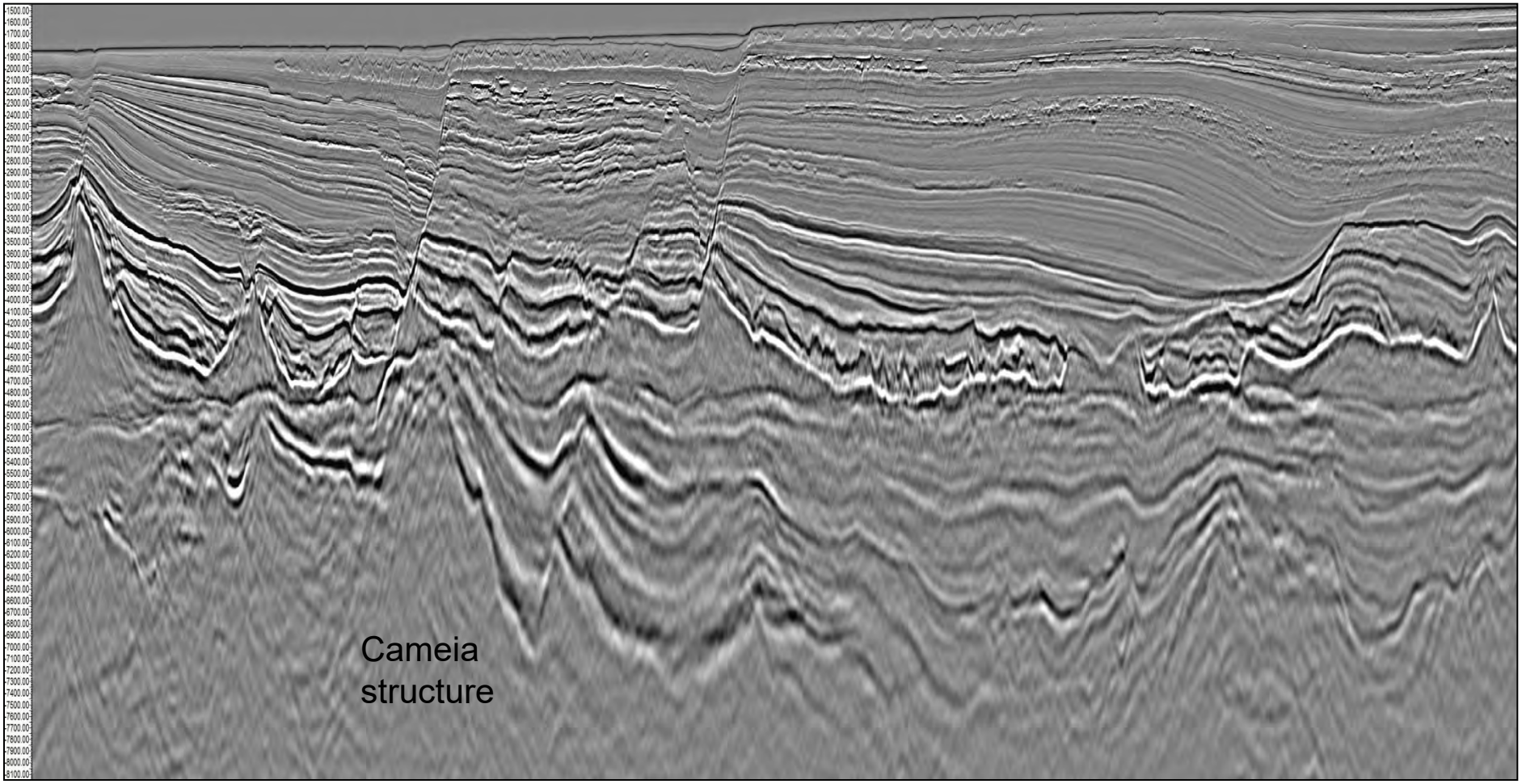
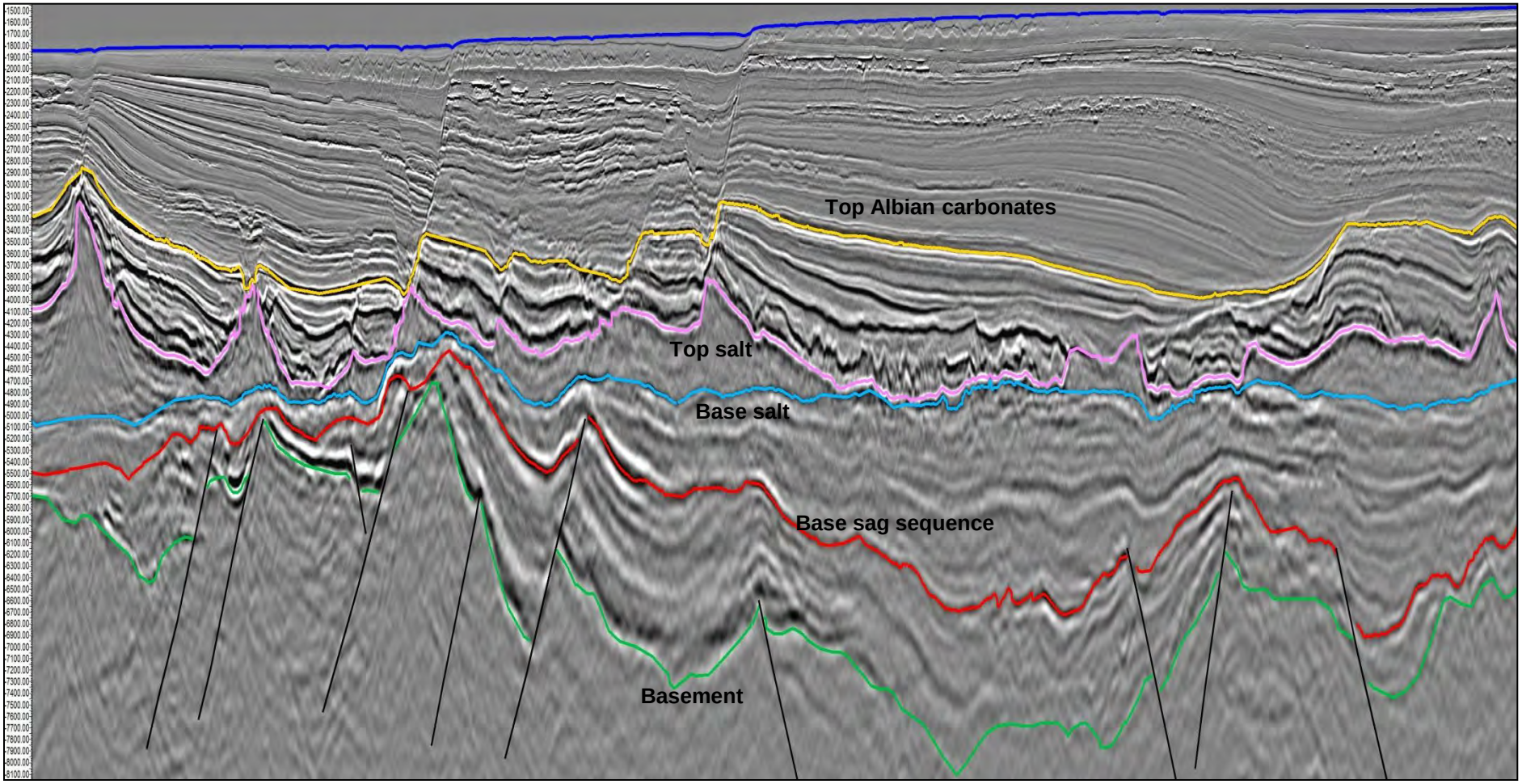
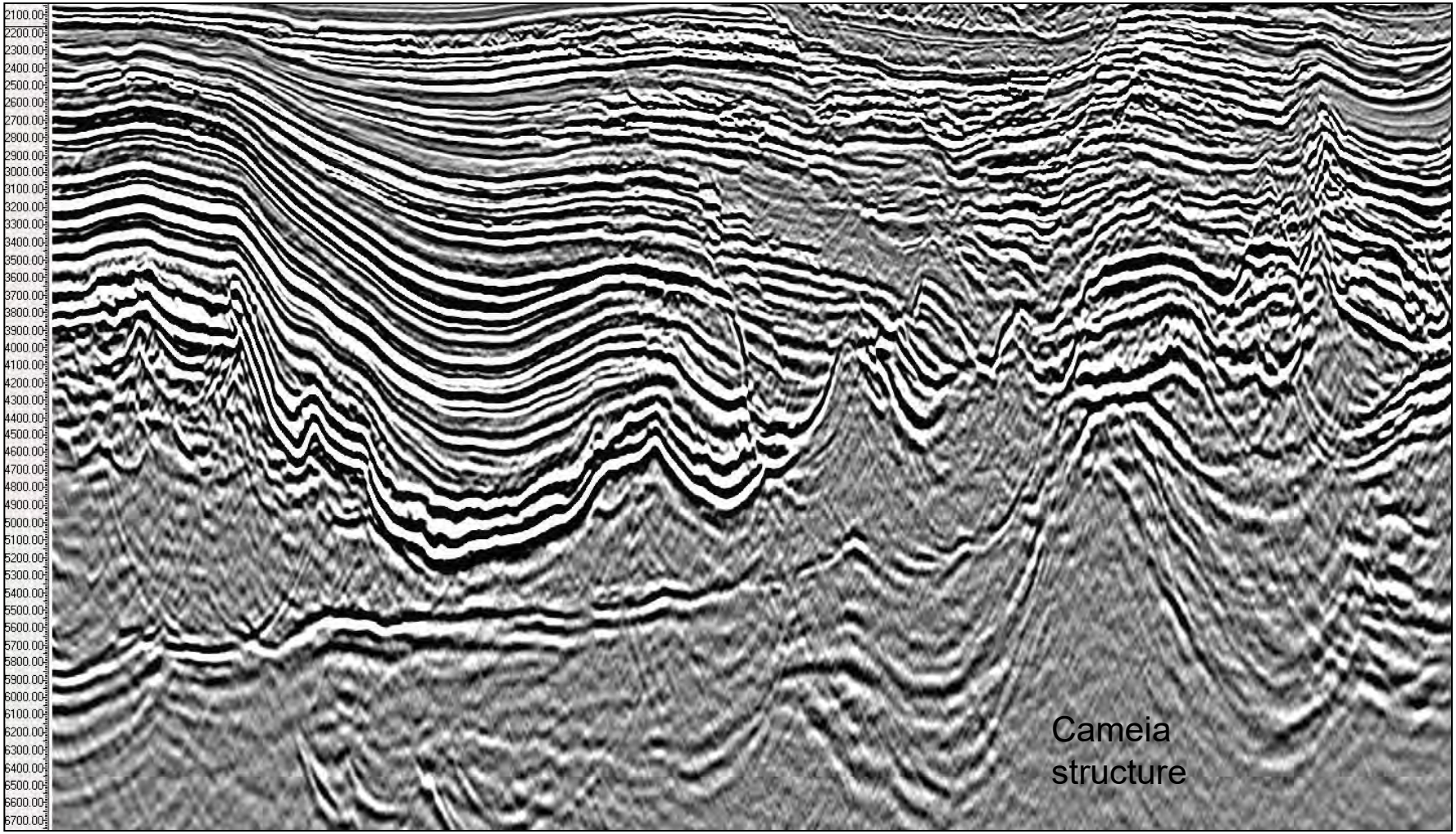
Angola Kwanza Basin – BroadSeis PSDM



Angola Kwanza Basin – BroadSeis PSDM interpreted



Angola Kwanza Basin – BroadSeis PSDM filtered



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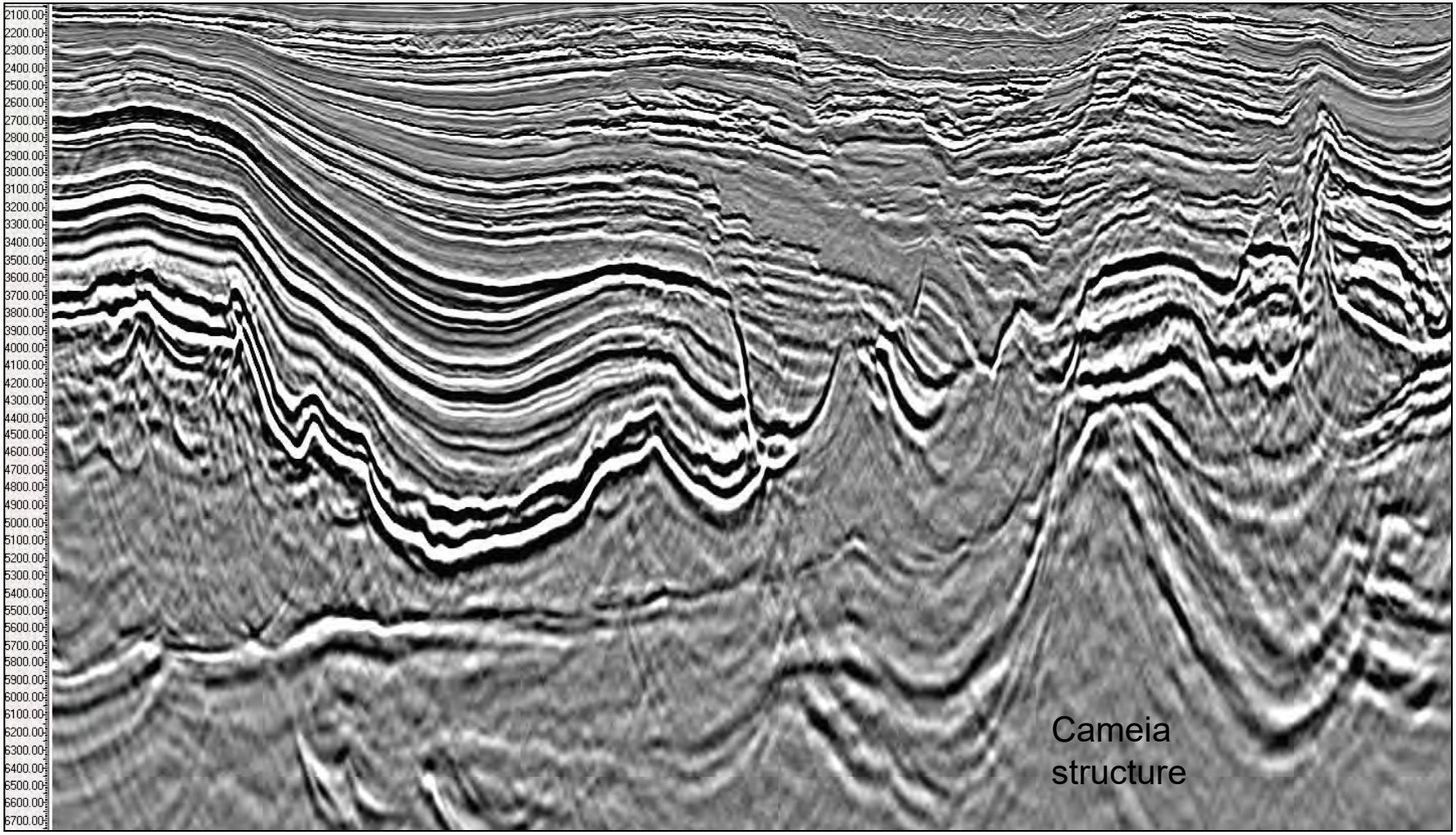
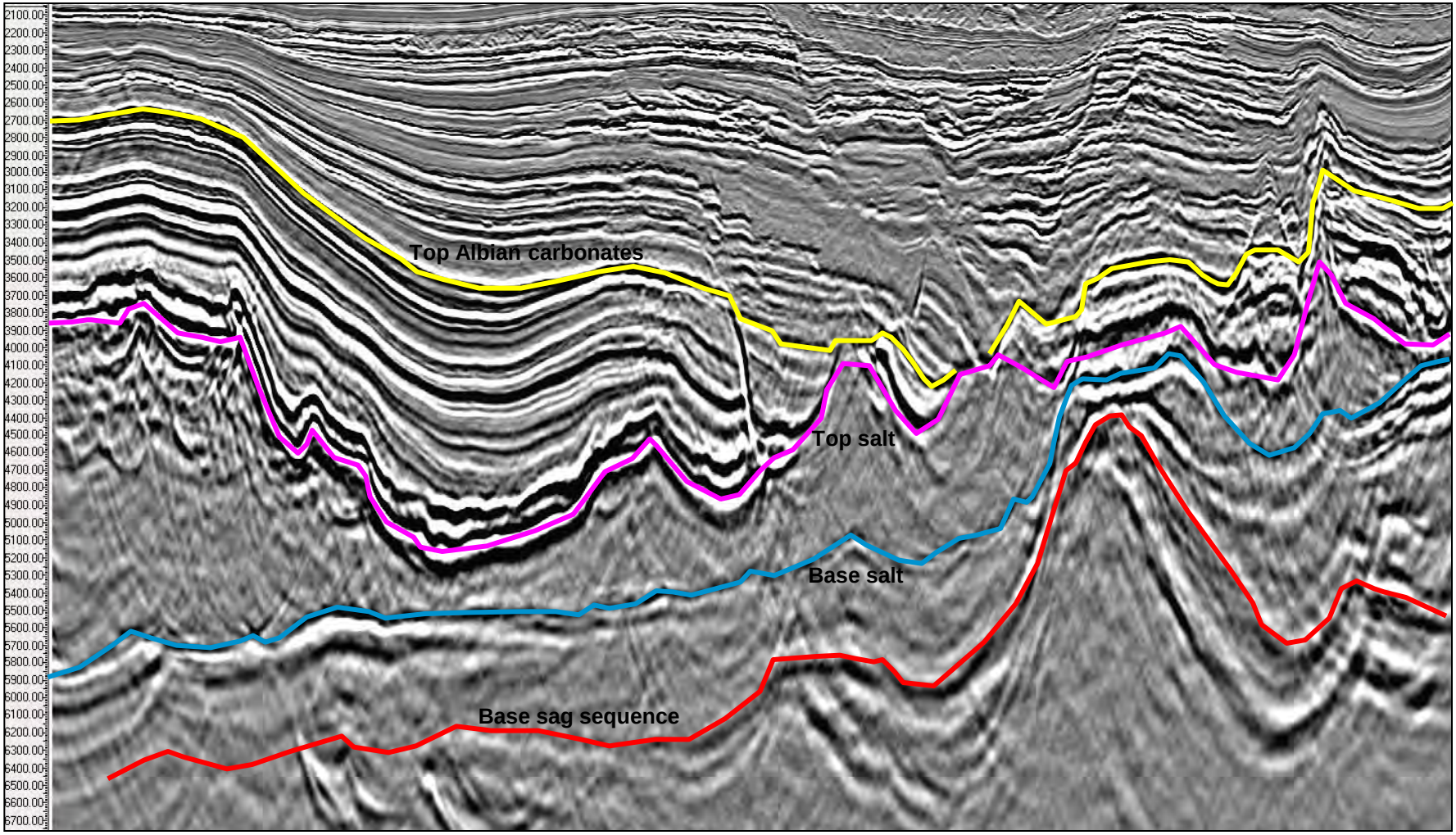
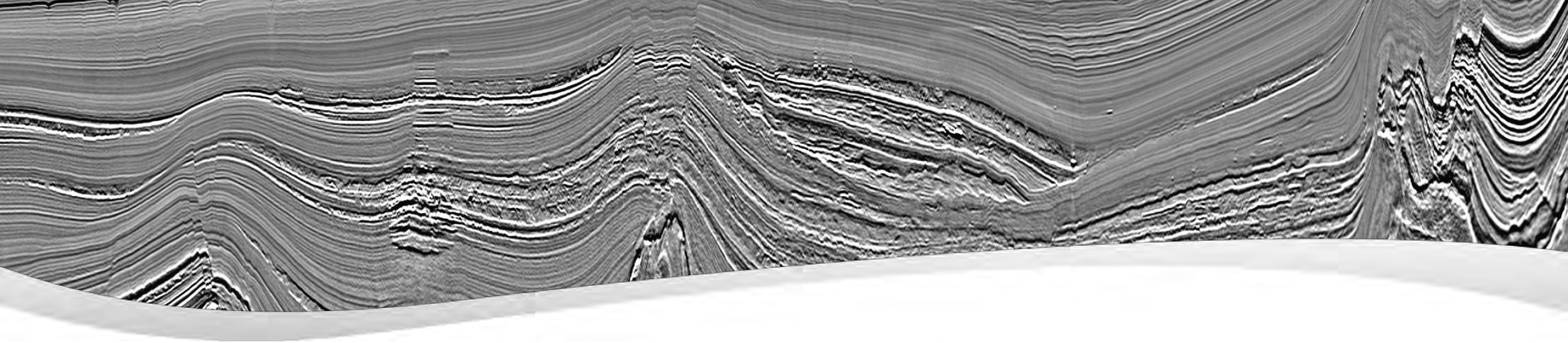
Angola Kwanza Basin – BroadSeis PSDM



Angola Kwanza Basin – BroadSeis PSDM interpreted





Post-salt broadband seismic benefits: facies mapping and reservoir characterisation

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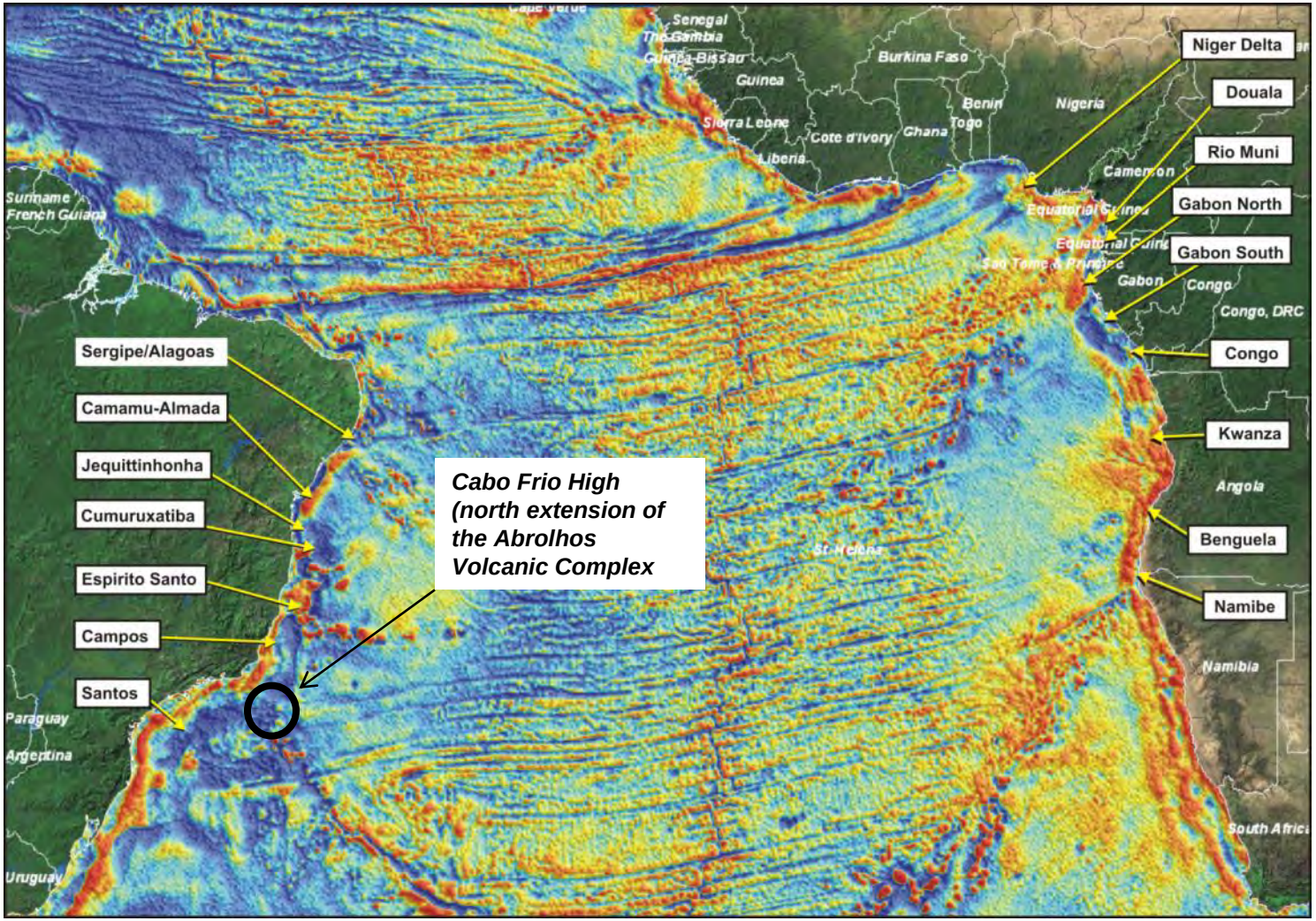
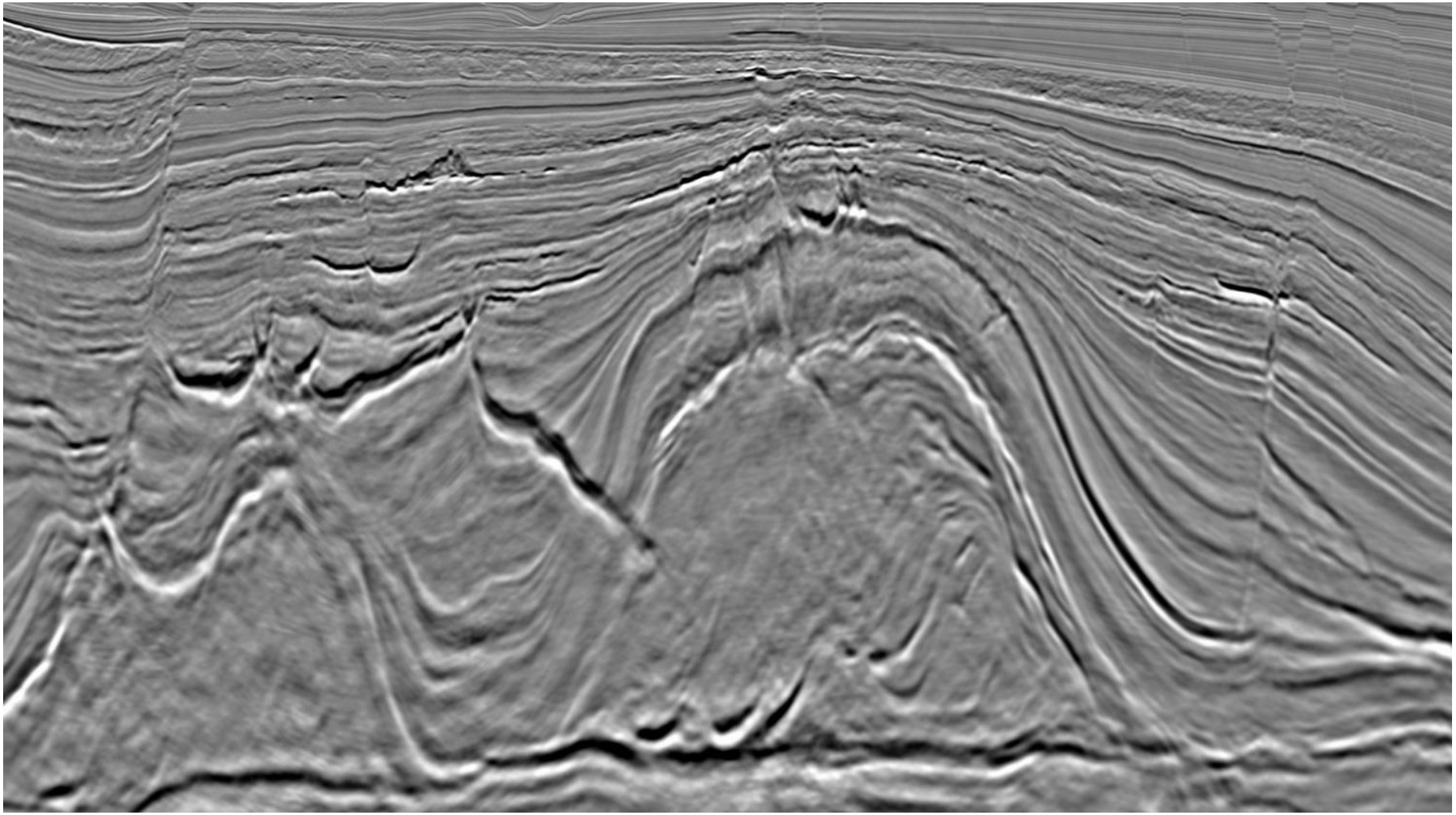
Brazil Santos Basin – Phase 6B location

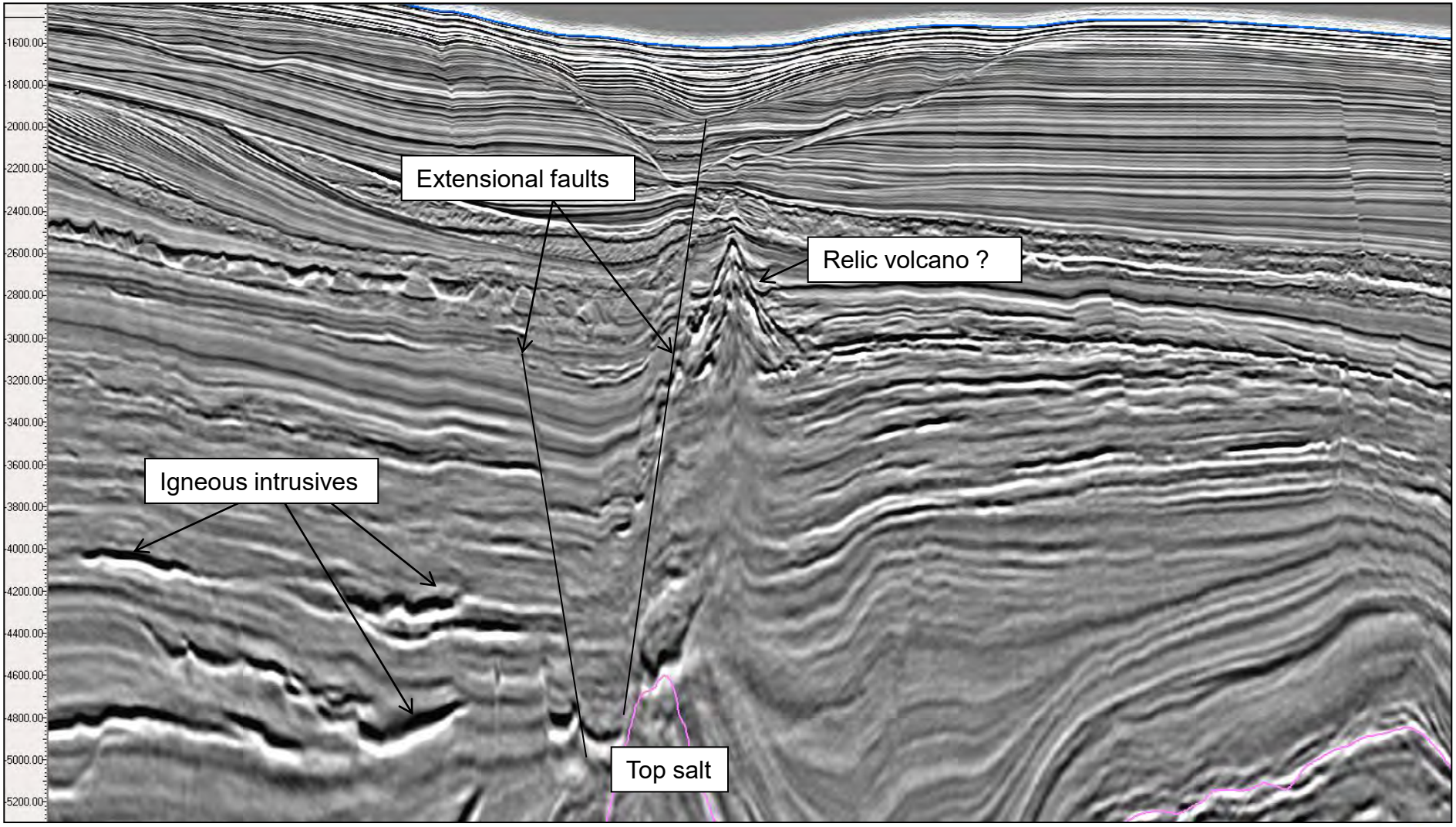


Source: Parsons et al. 2003

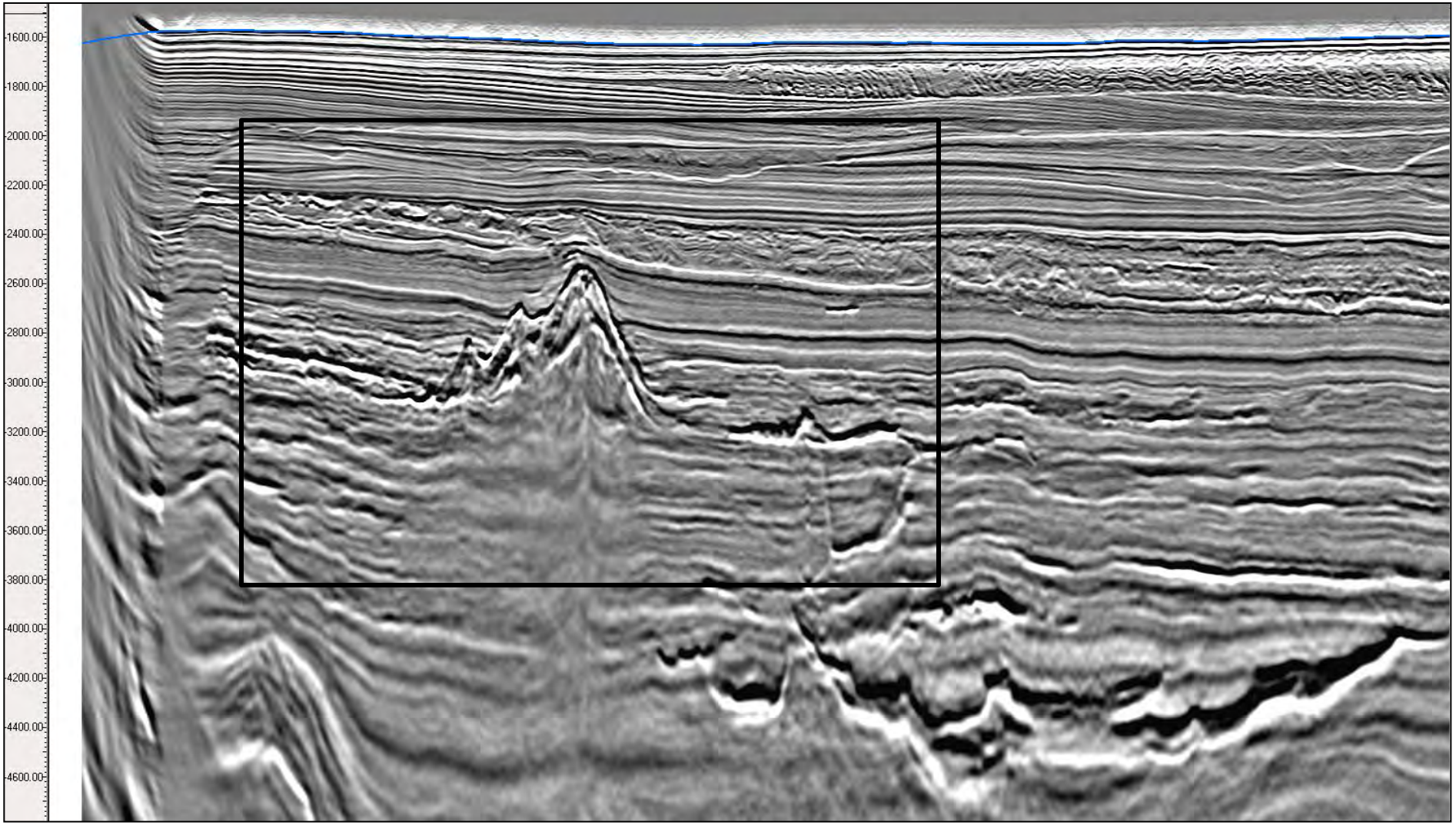
Brazil Santos Basin - Post-salt volcanics



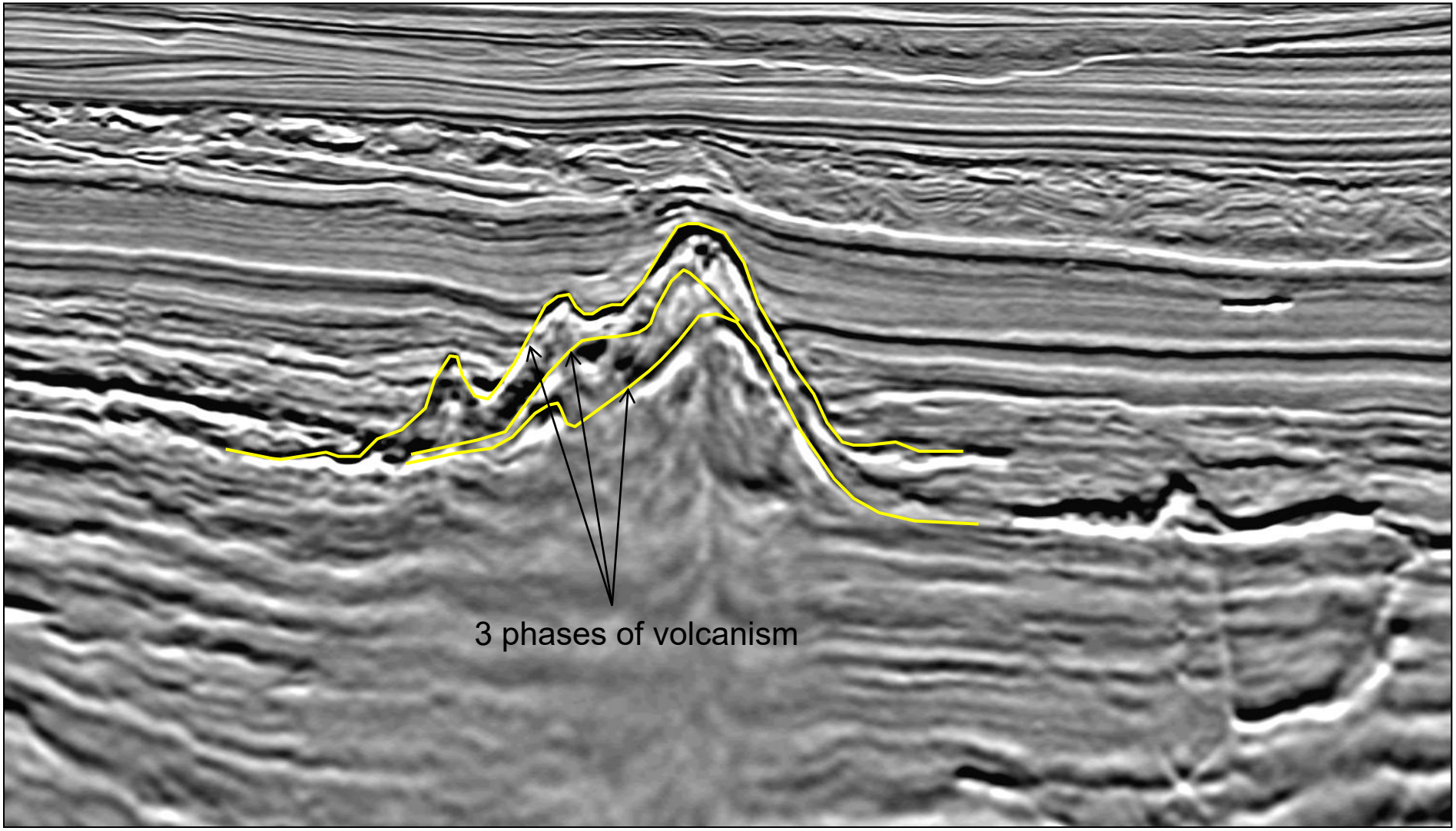
Brazil Santos Basin - Post-salt volcanics



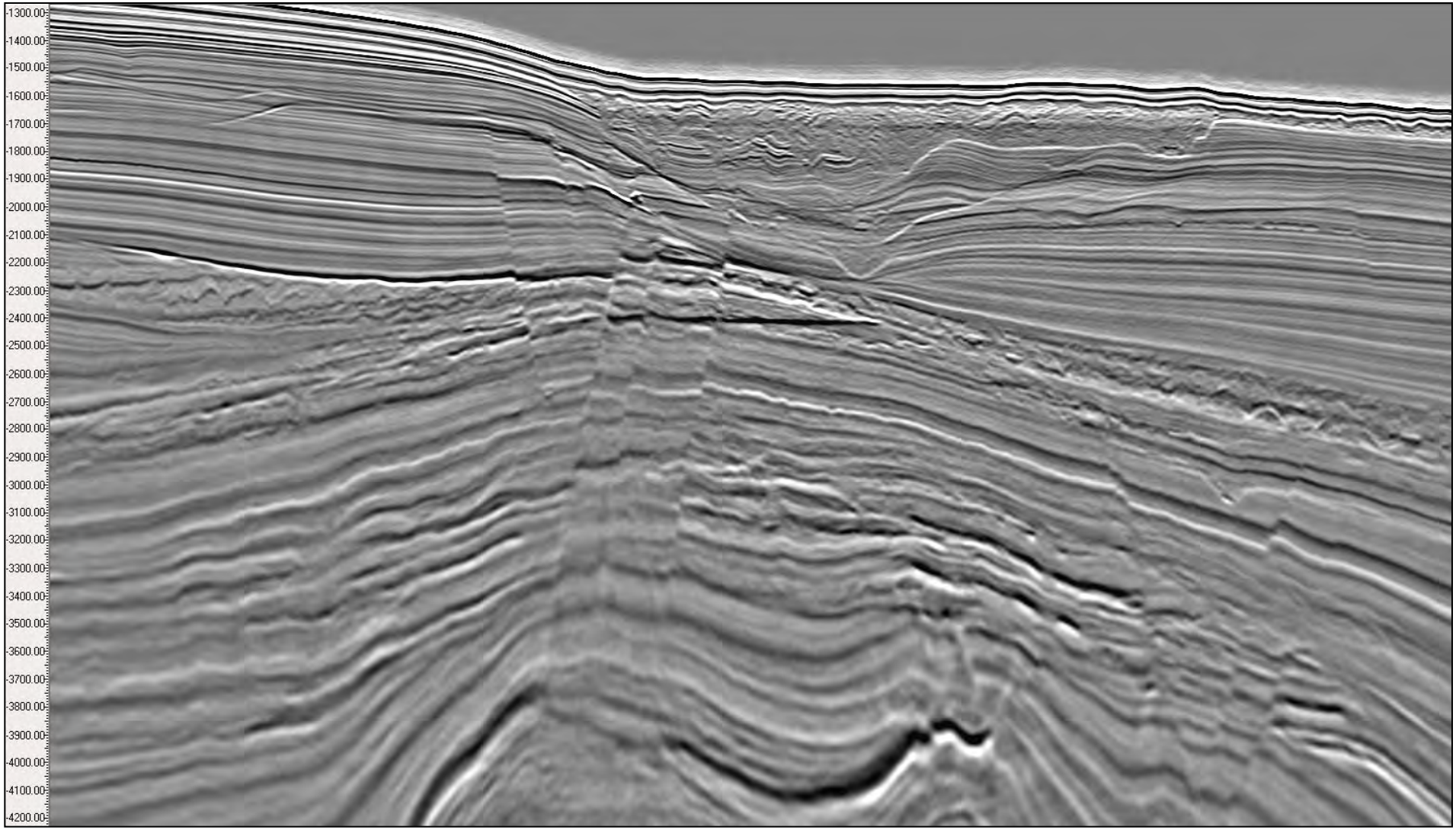
Brazil Santos Basin - Post-salt volcanics



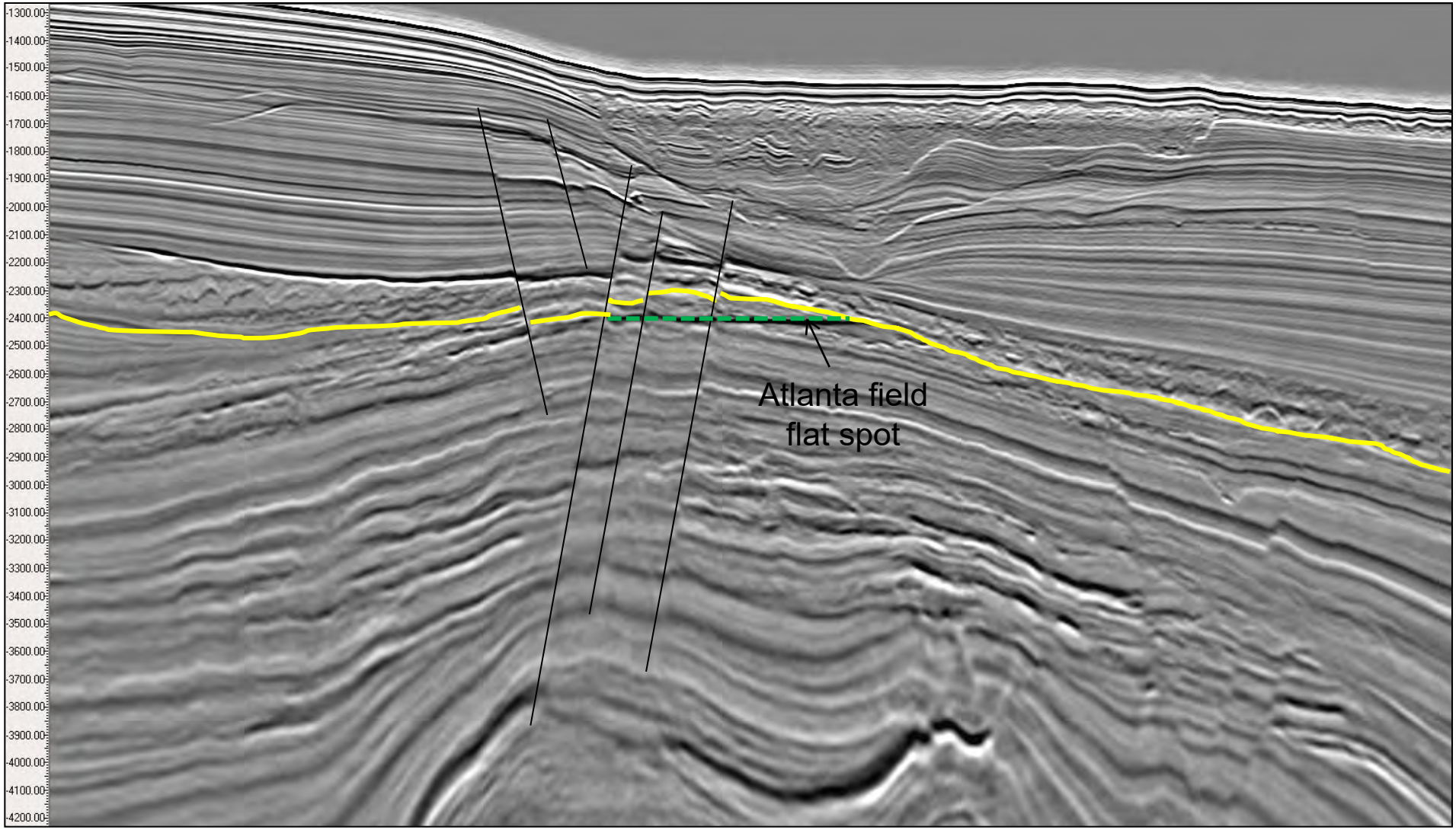
Brazil Santos Basin - Post-salt volcanics



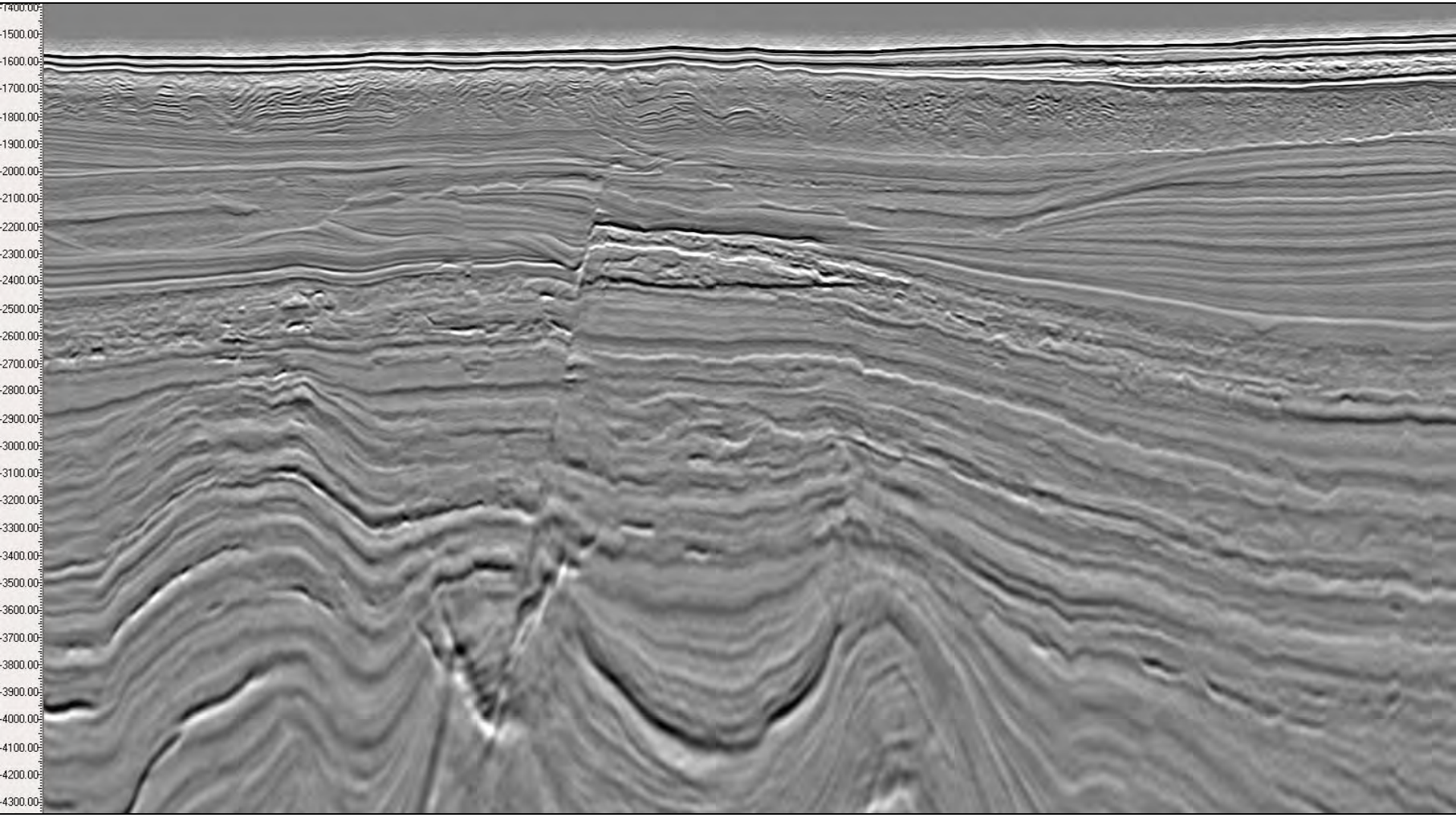
Brazil Santos Basin - Atlanta Discovery inline



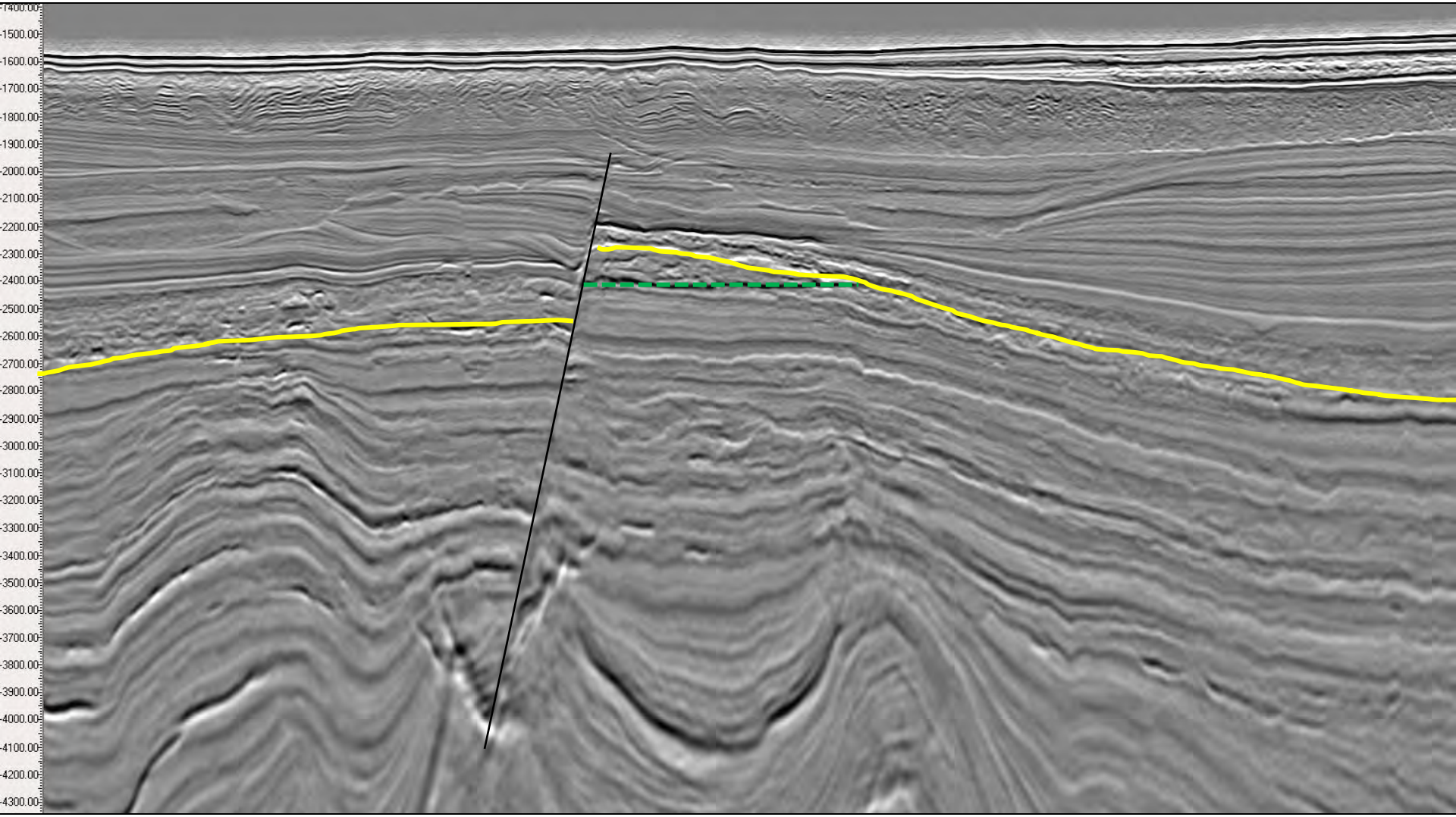
Brazil Santos Basin - Atlanta Discovery inline



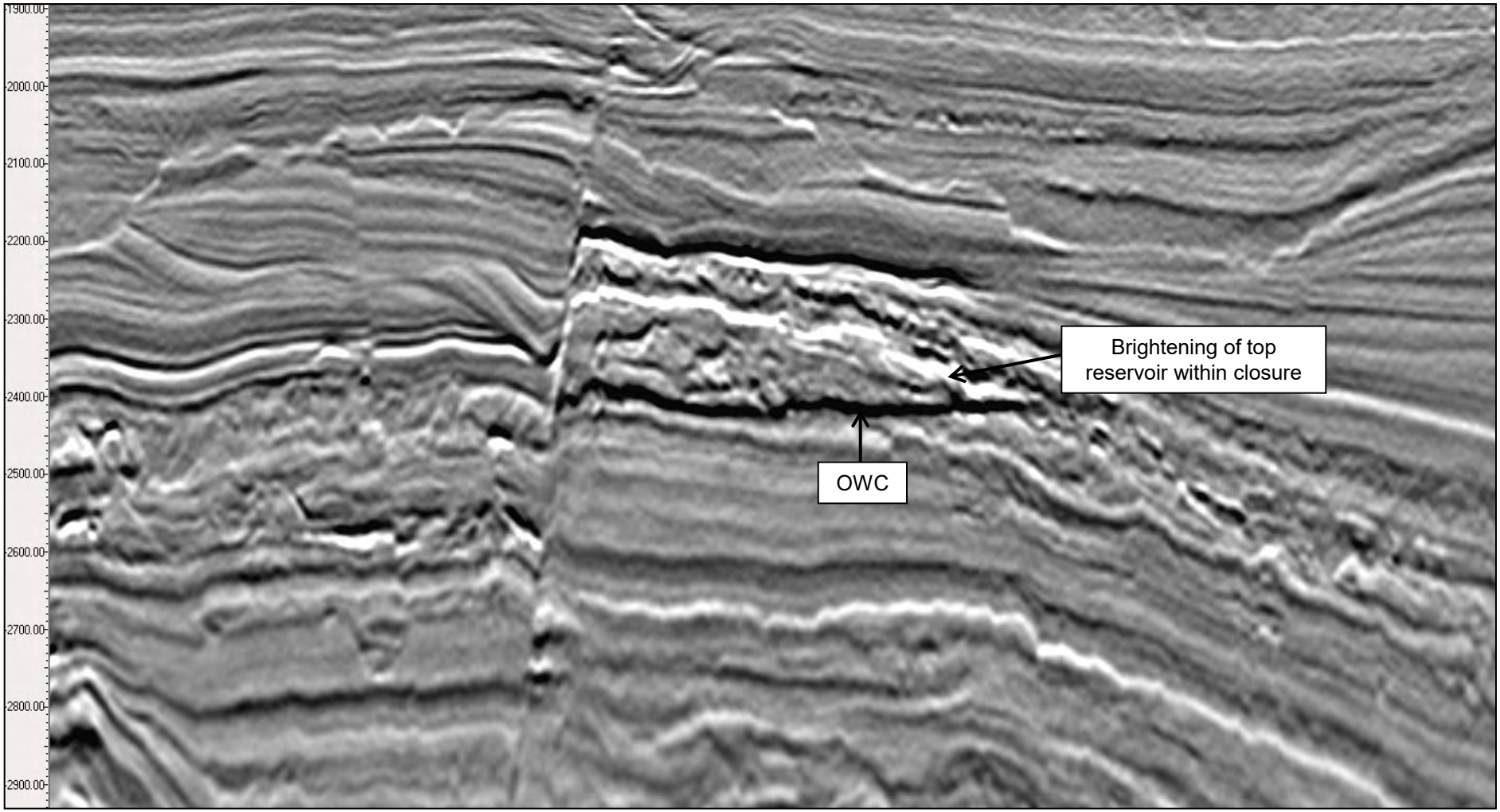
Brazil Santos Basin - Atlanta Discovery crossline



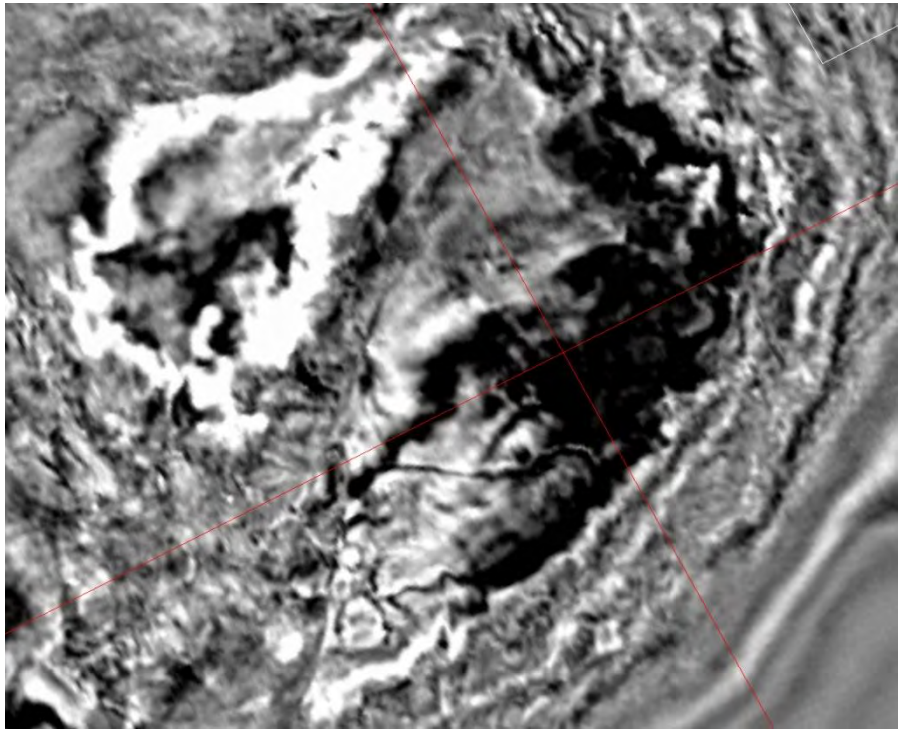
Brazil Santos Basin - Atlanta Discovery crossline



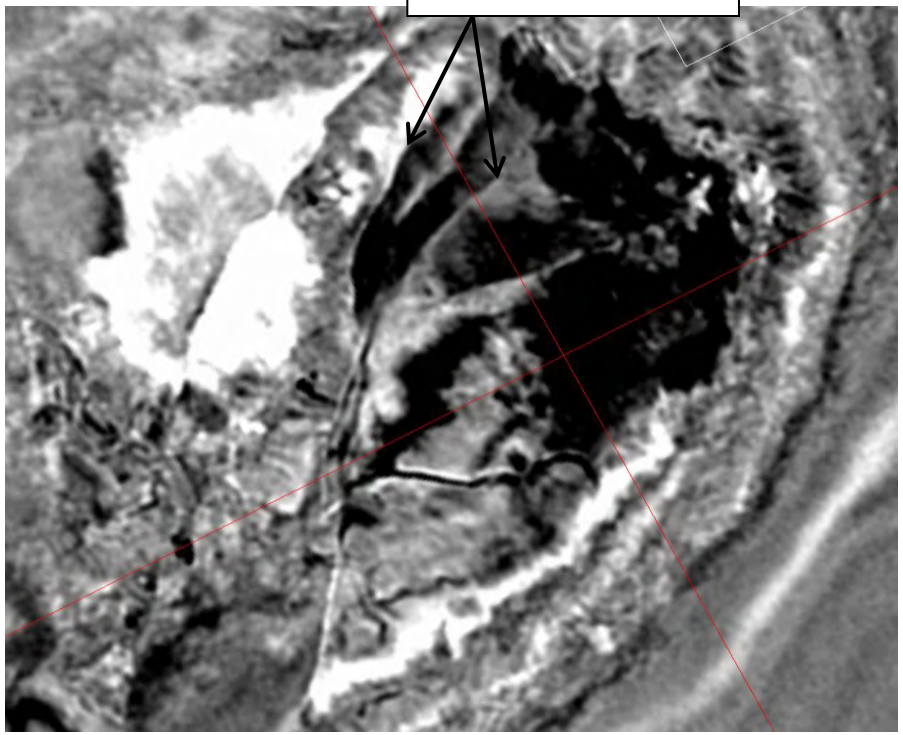
Brazil Santos Basin - Atlanta Discovery crossline (zoom)



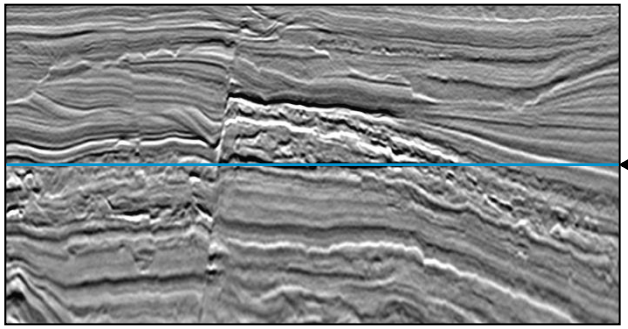
Time-slice - Conventional vs. Broadband



Conventional

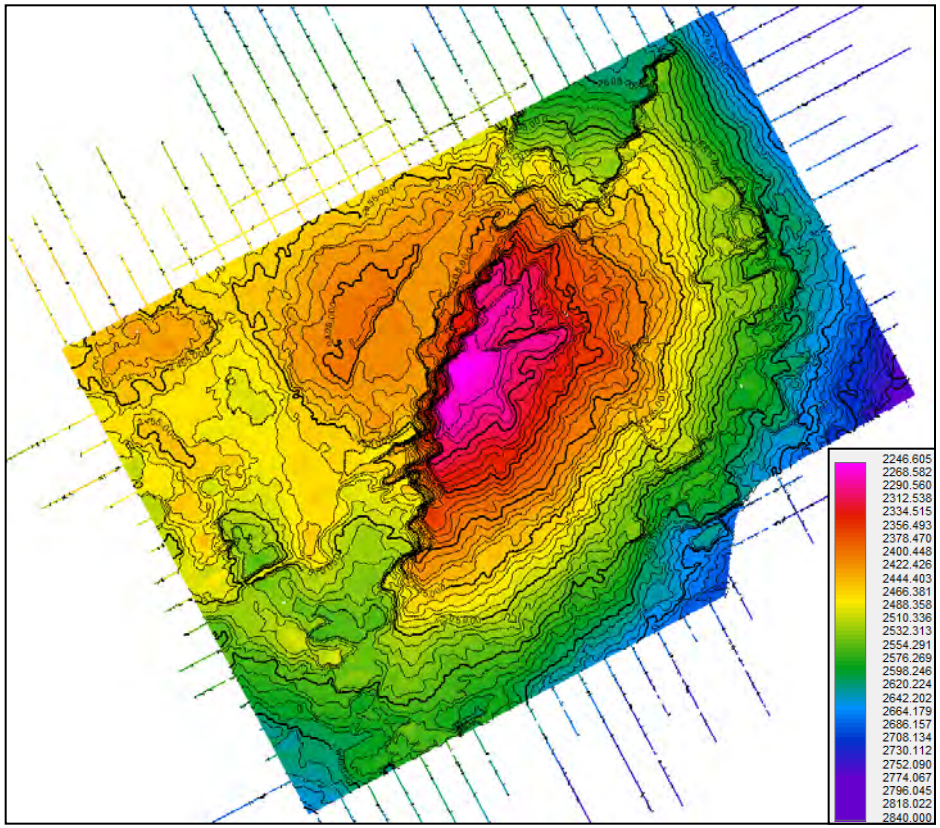


Broadband

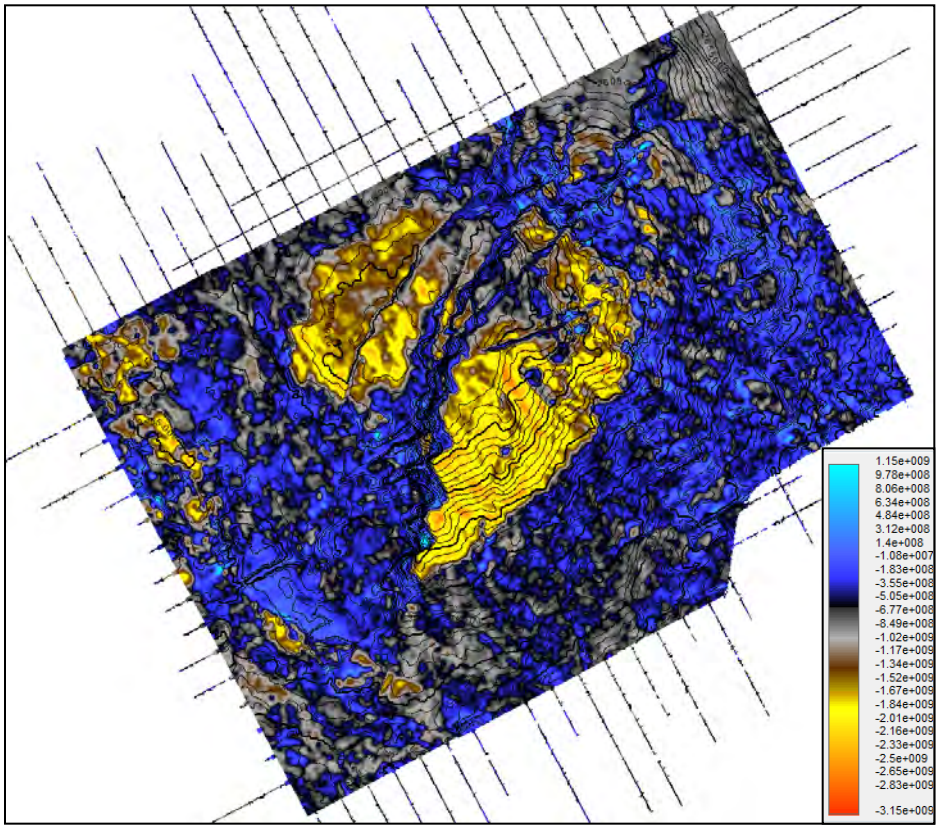


Atlanta Discovery - Top reservoir

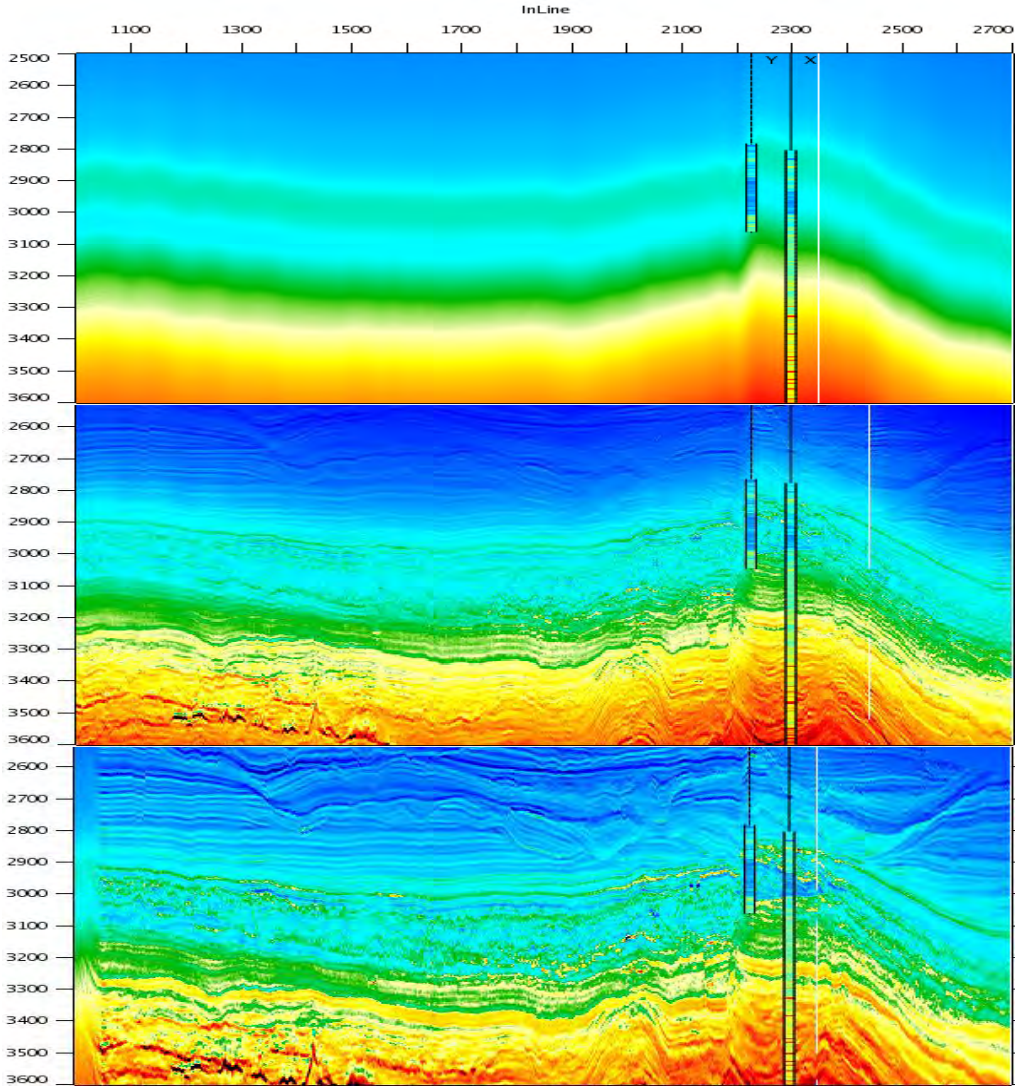
Oligocene depth structure map



Oligocene amplitude map



Atlanta Discovery - Acoustic inversion results



Initial model
Filter 2-5Hz

Conventional

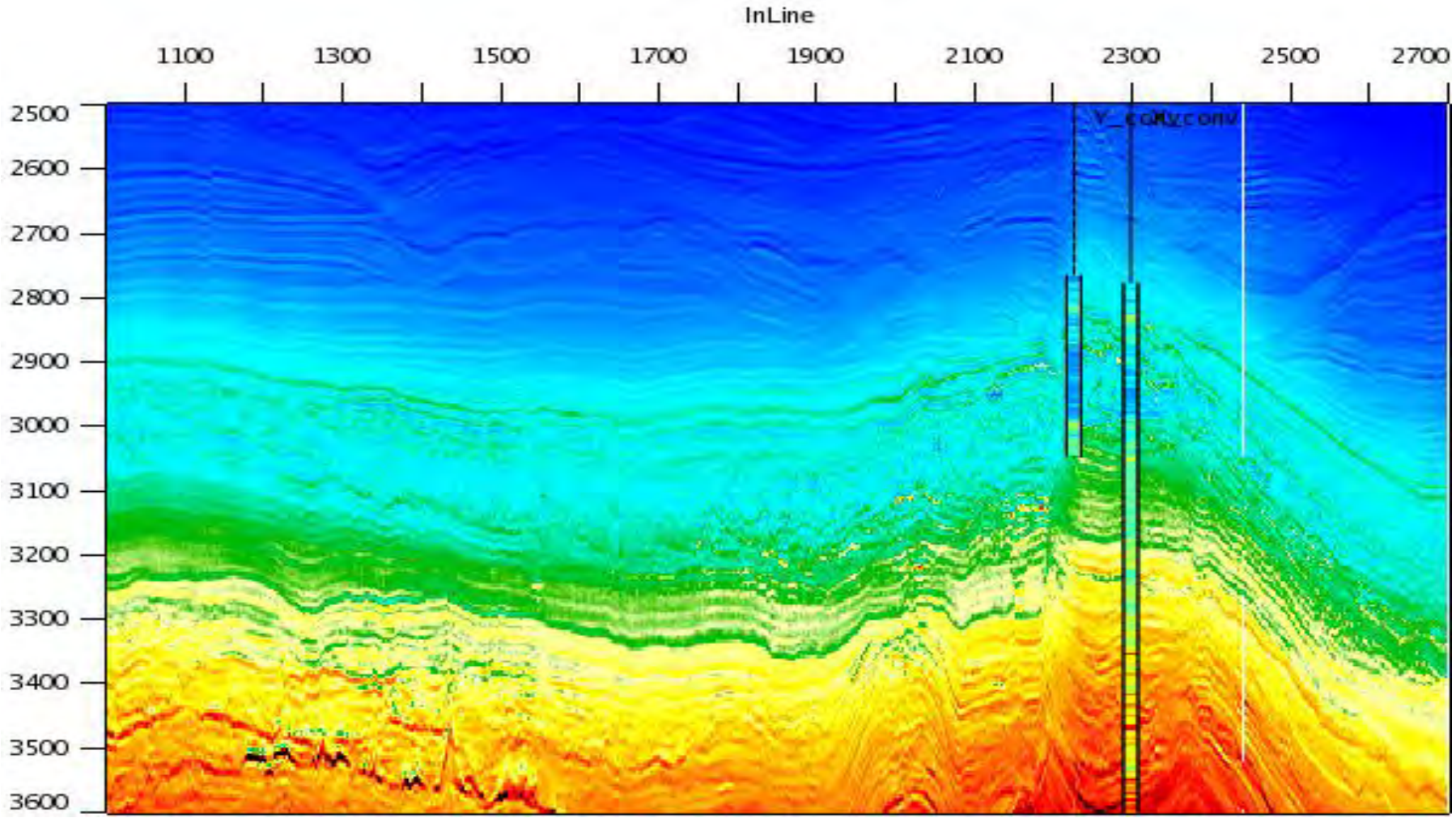
Broadband

ACOUSTIC
IMPEDANCE

HIGH

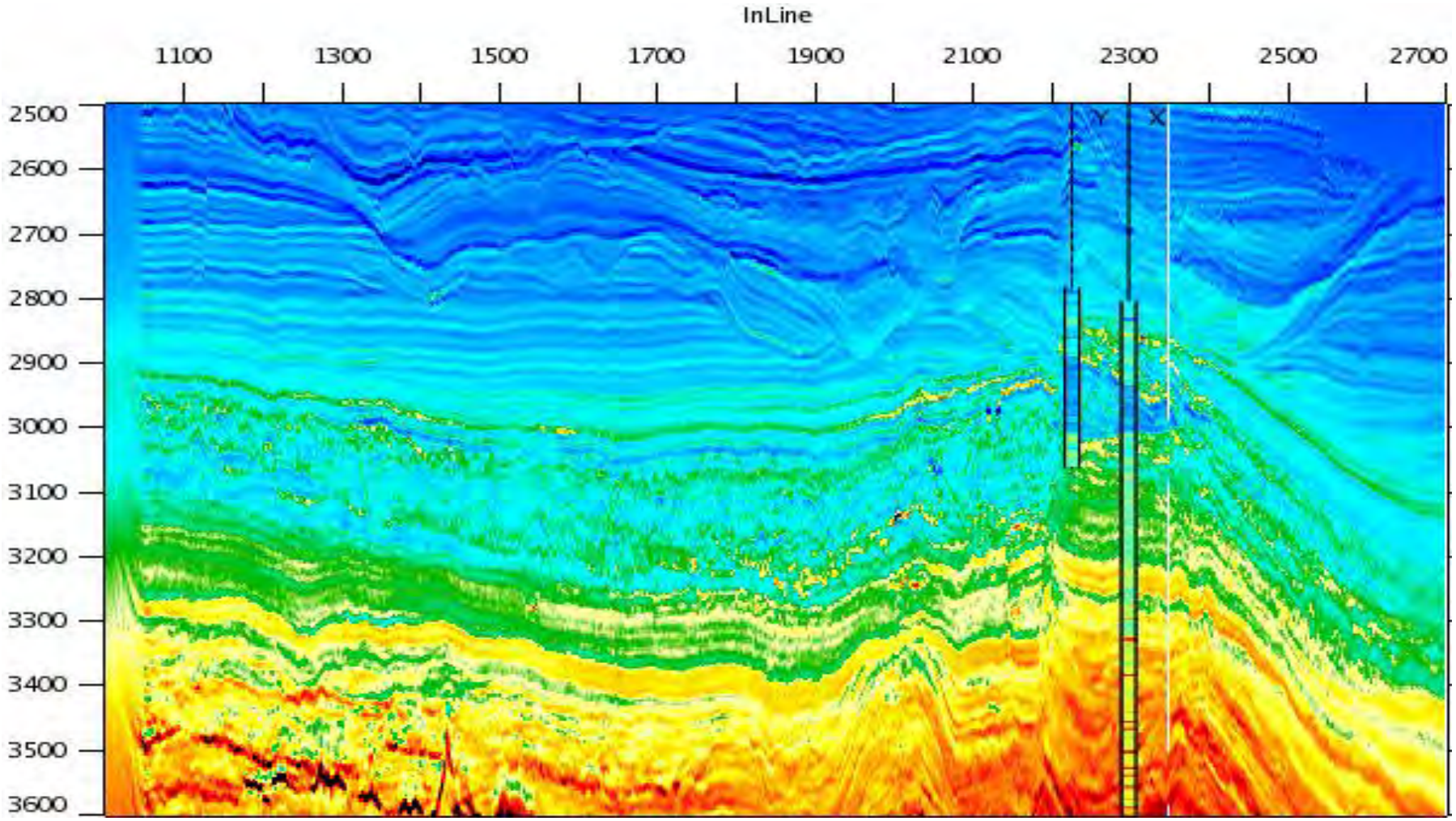
LOW

Atlanta Discovery - Acoustic inversion results



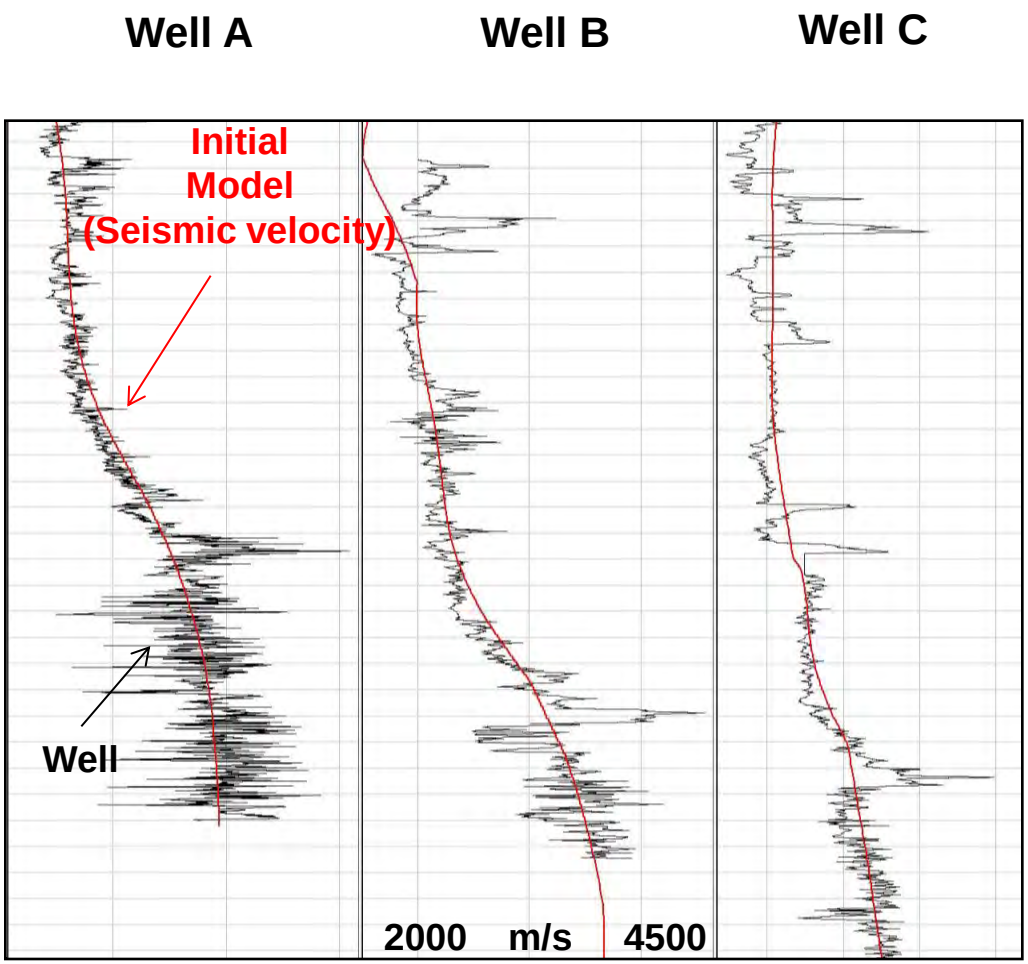
Conventional

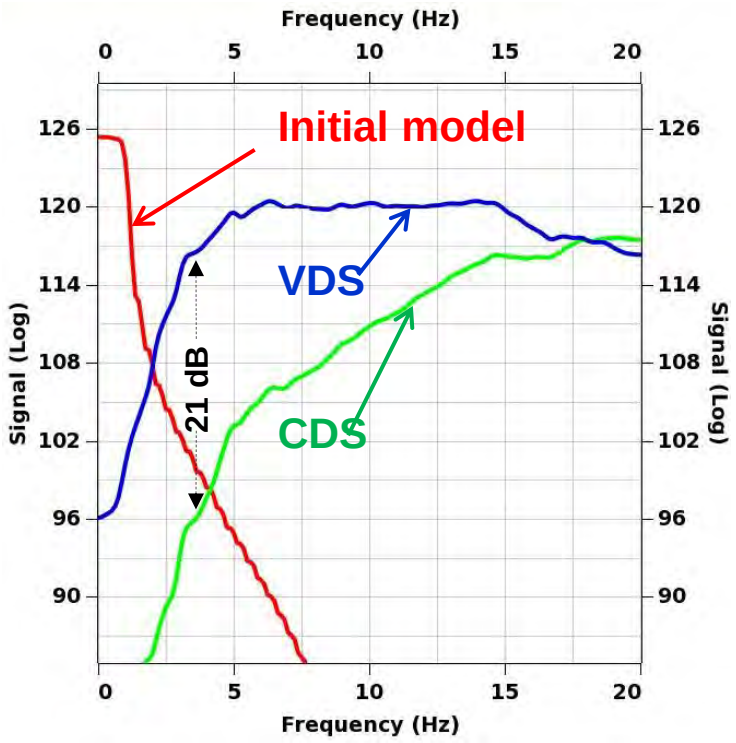
Atlanta Discovery - Acoustic inversion results



Broadband

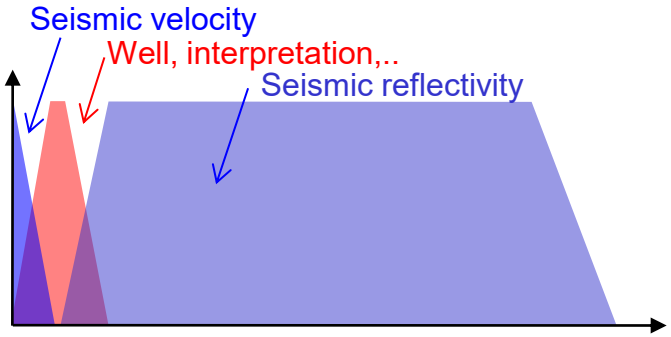
Building the initial Vp model with broadband data





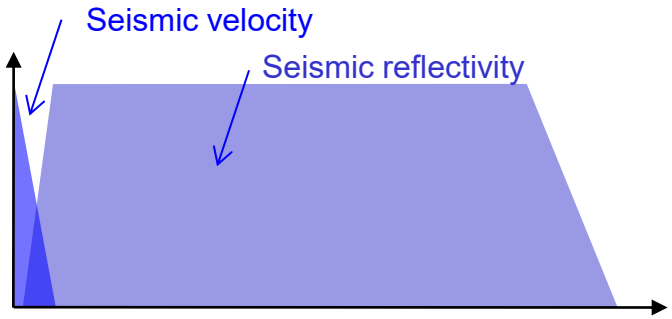
Remarks

Constant Depth Streamer



VS.

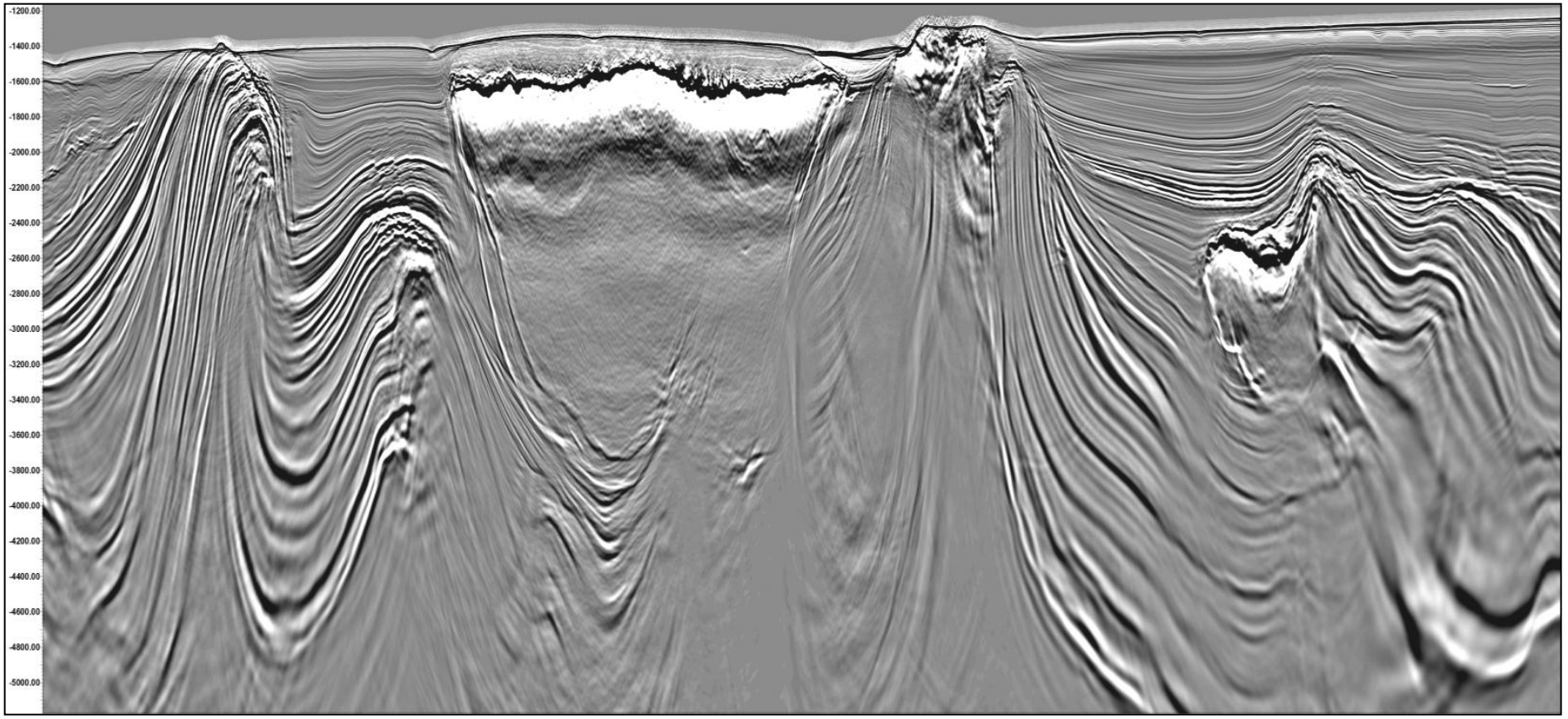
Variable Depth Streamer



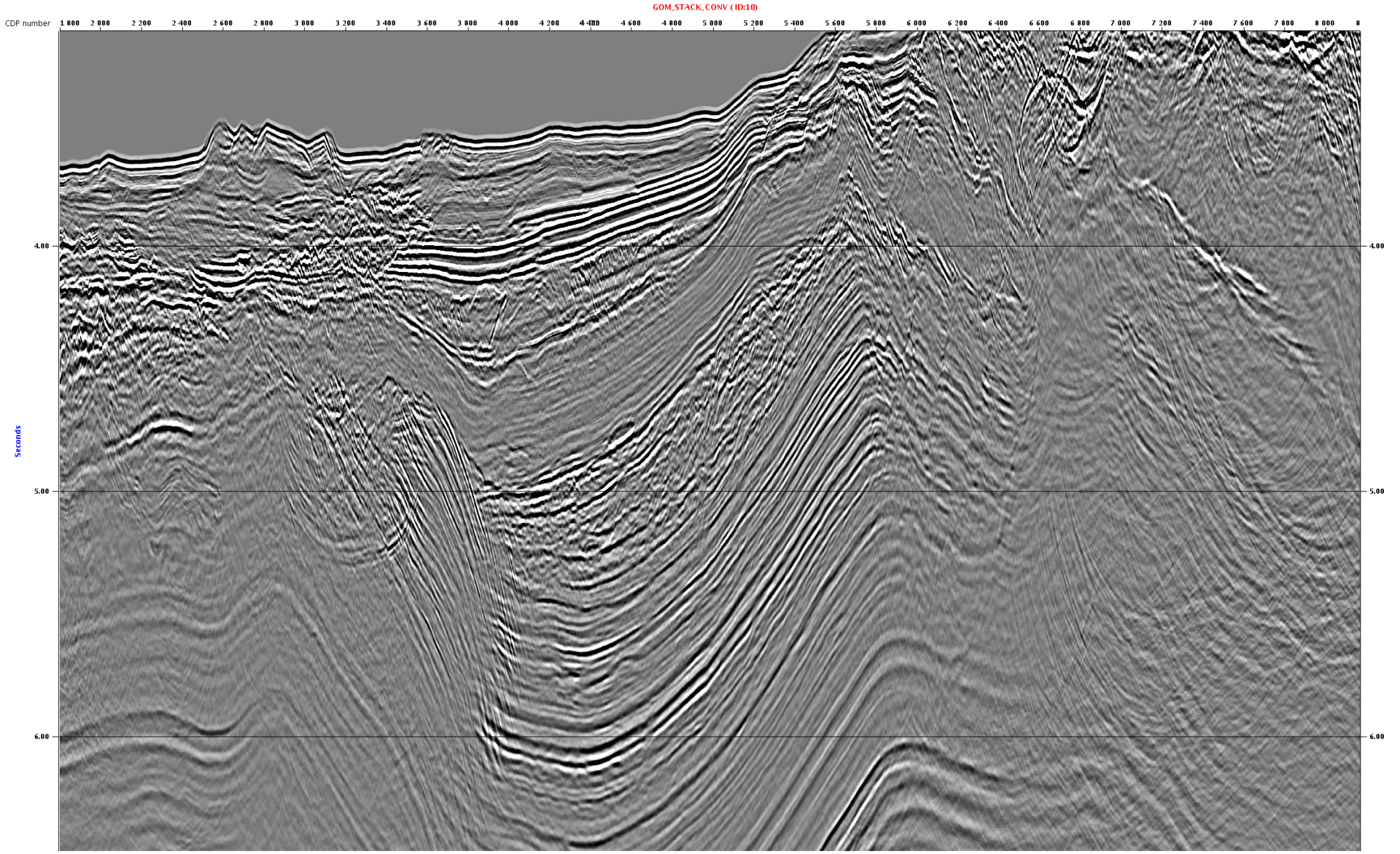
Broadband data very useful for:

- Quick look, uncalibrated inversion techniques
- Use of seismic inversion in frontier areas (no well data)

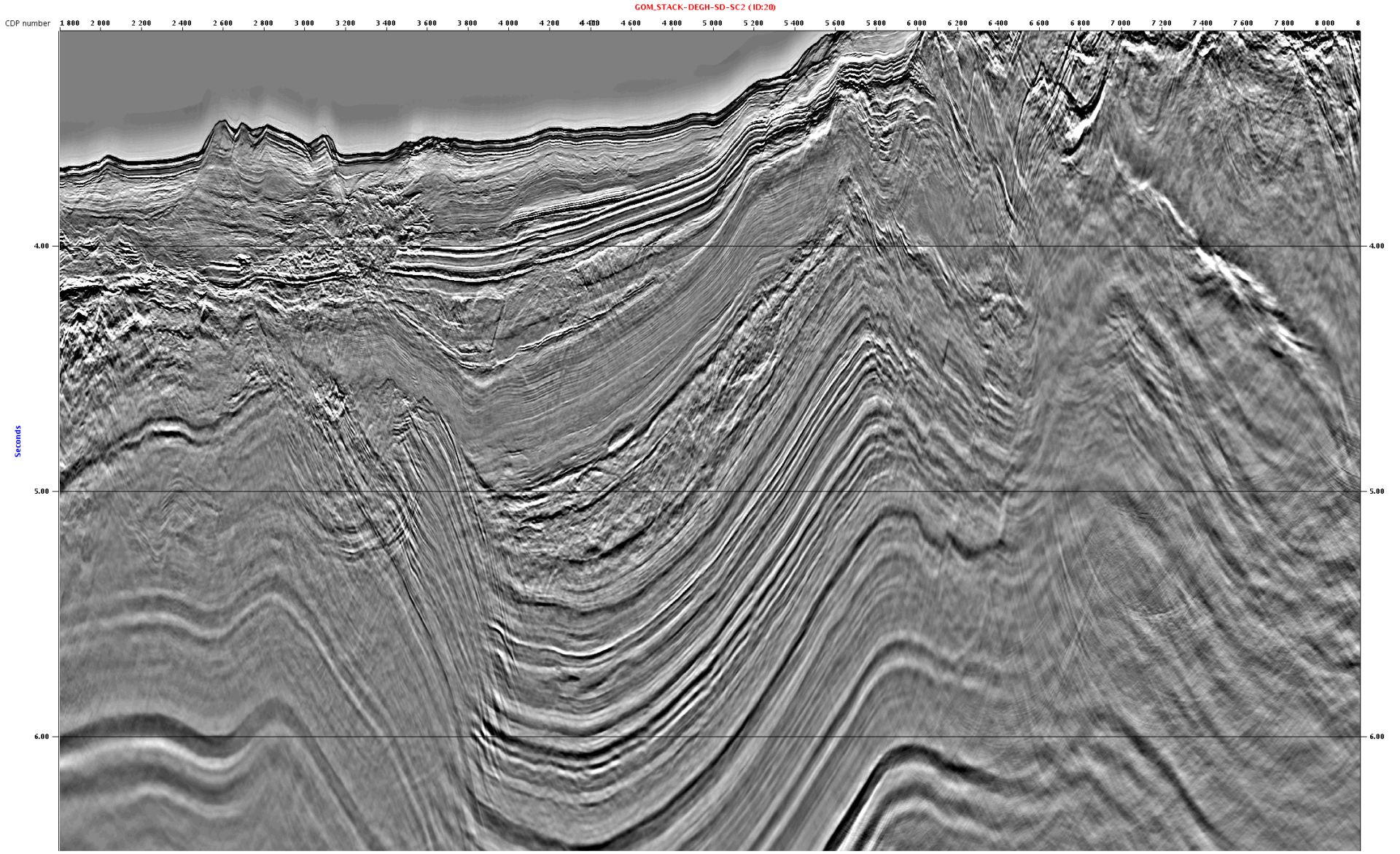
Angola Kwanza Basin – Sub-salt imaging



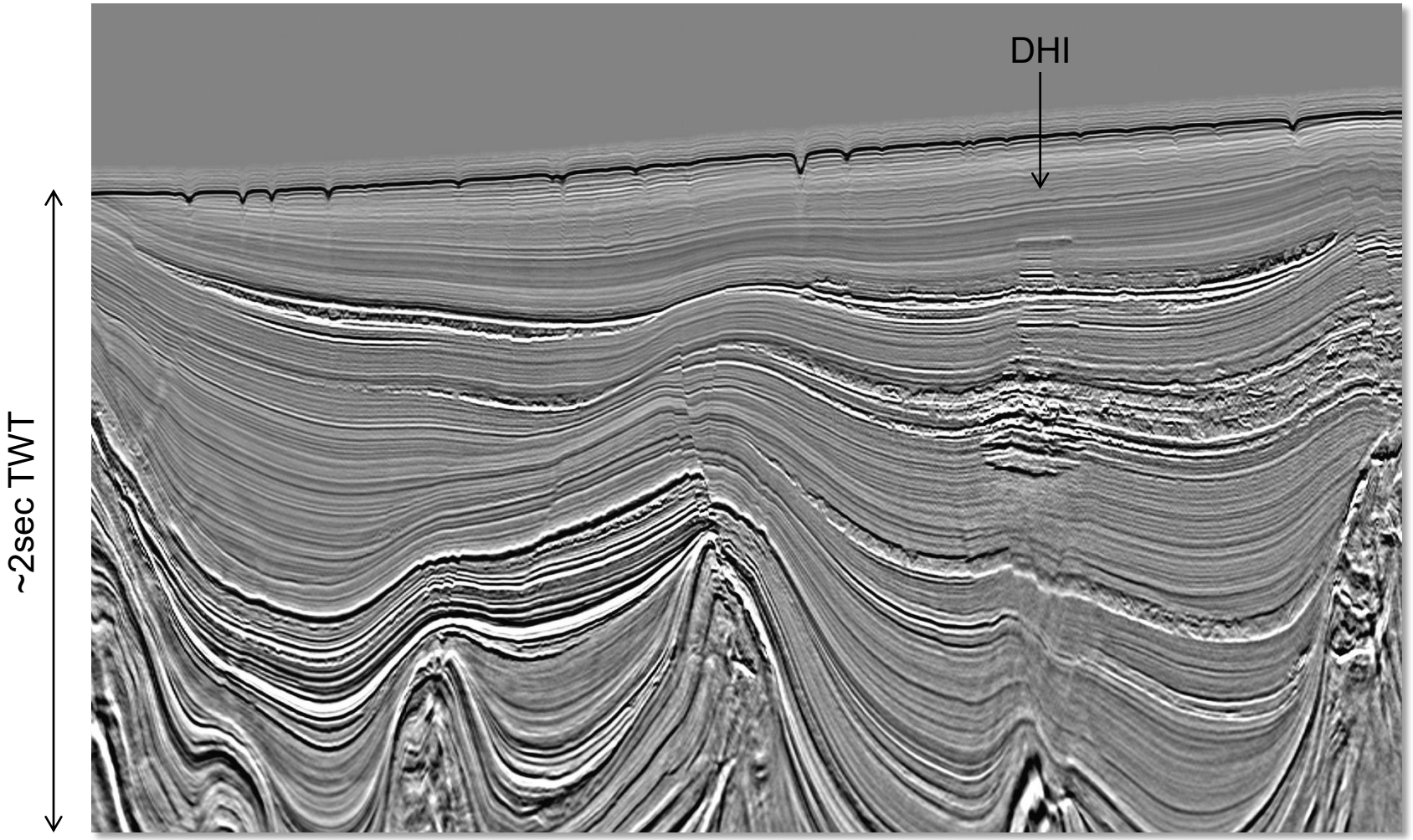
Gulf of Mexico analogy – Conventional data



Gulf of Mexico analogy – Broadband data



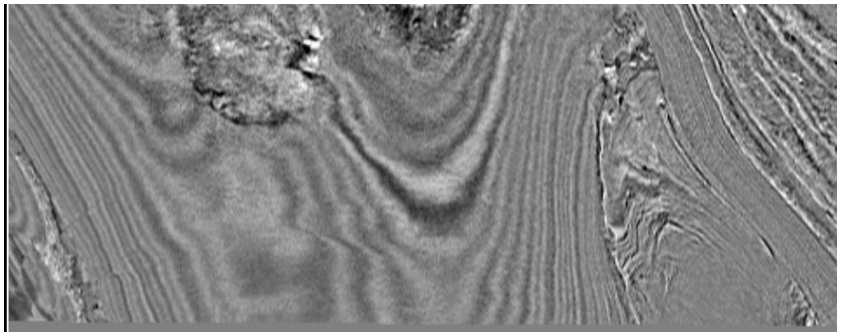
Angola Kwanza Basin – Broadband PSTM

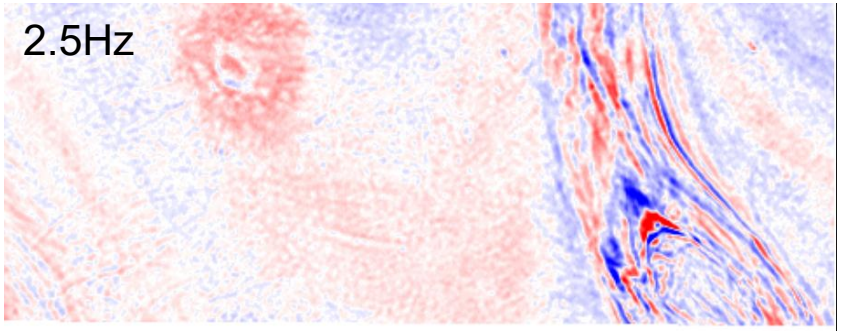


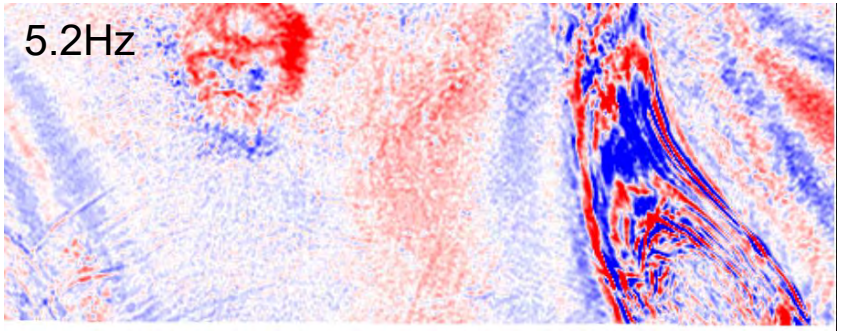
BroadSeis would give more high frequencies, as high as 250Hz, for sharp imaging of faults and small scale features

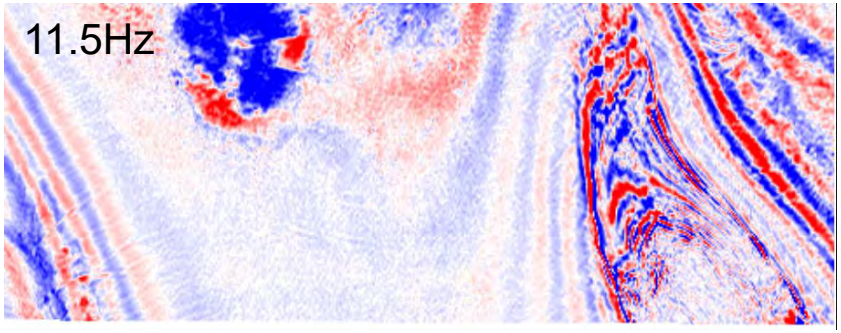
Angola Kwanza Basin - Frequency decomposition

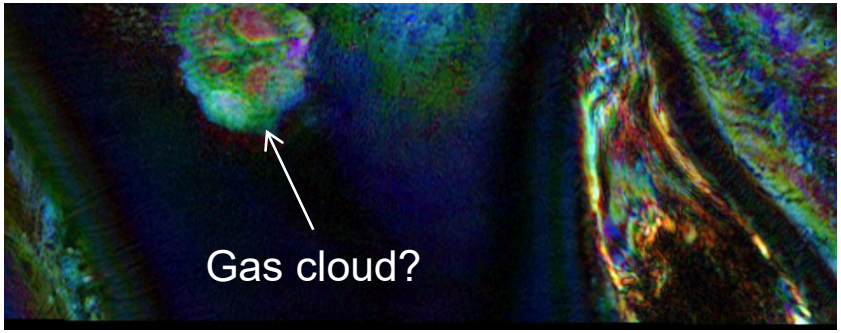
Time slice at 2844ms



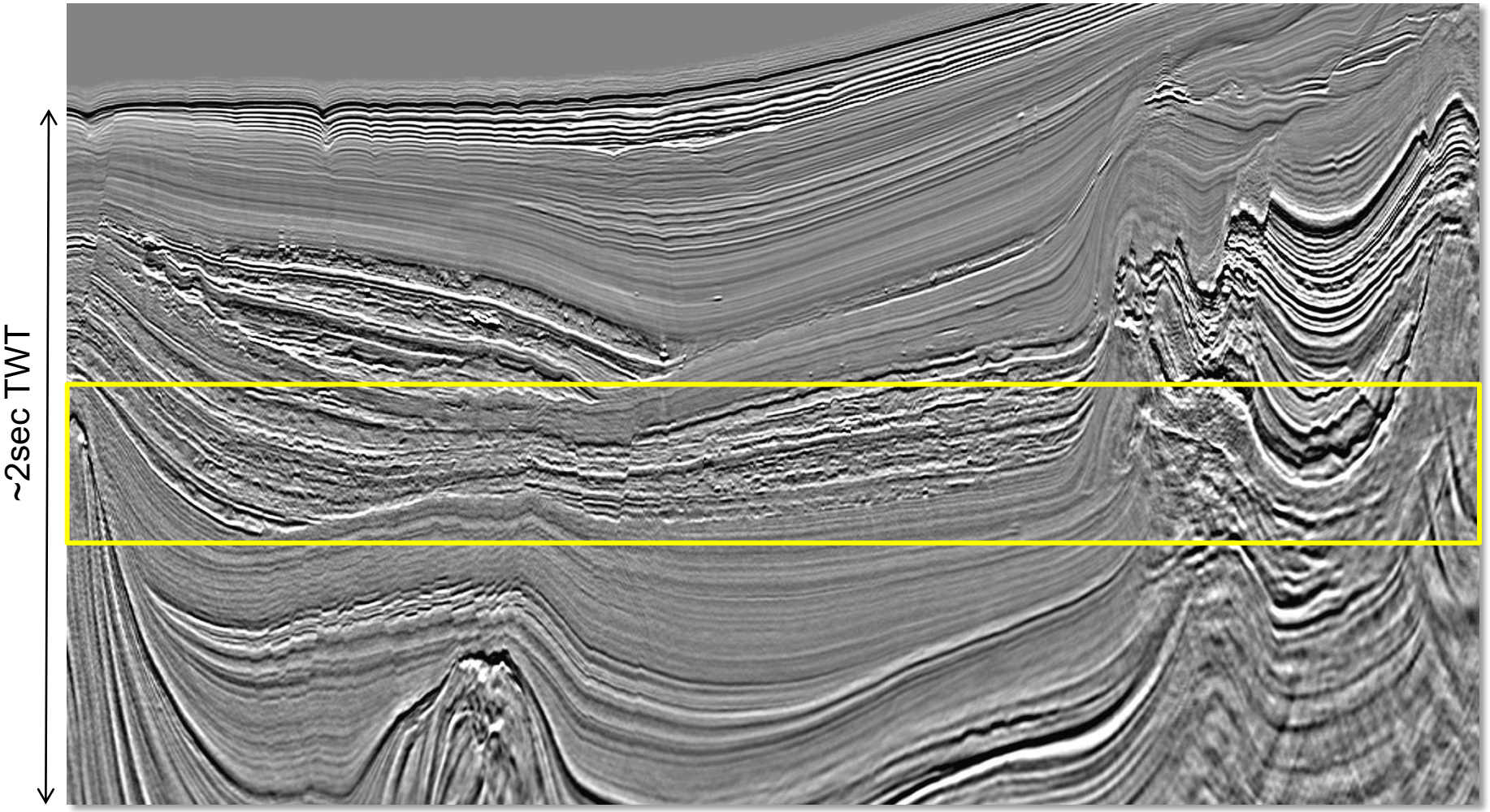








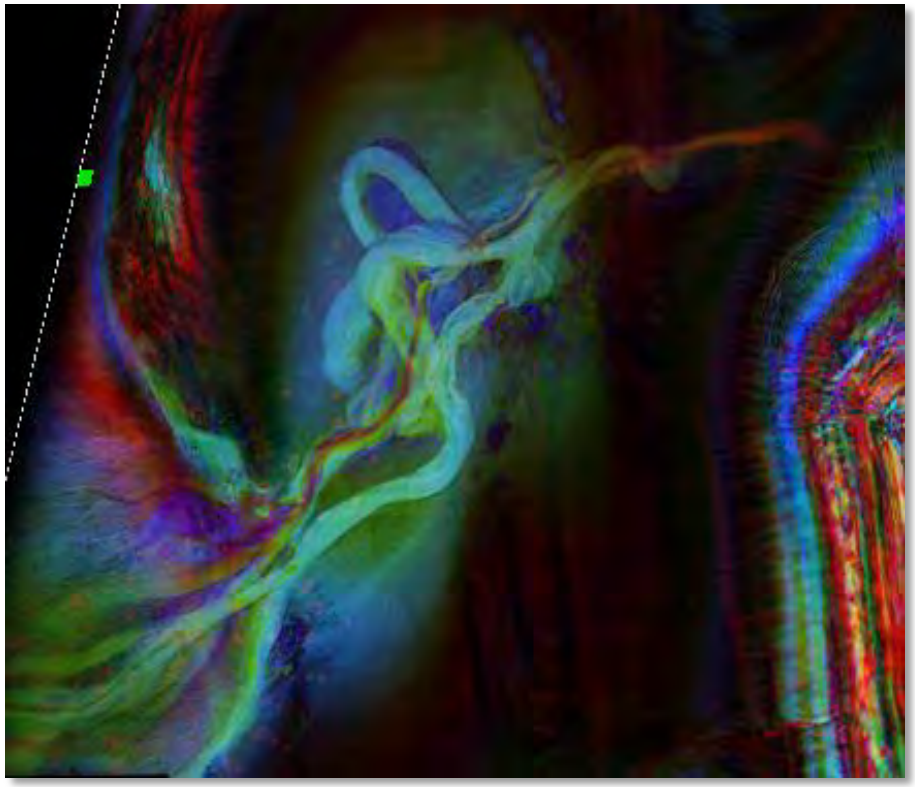
Angola Kwanza Basin – Broadband PSTM

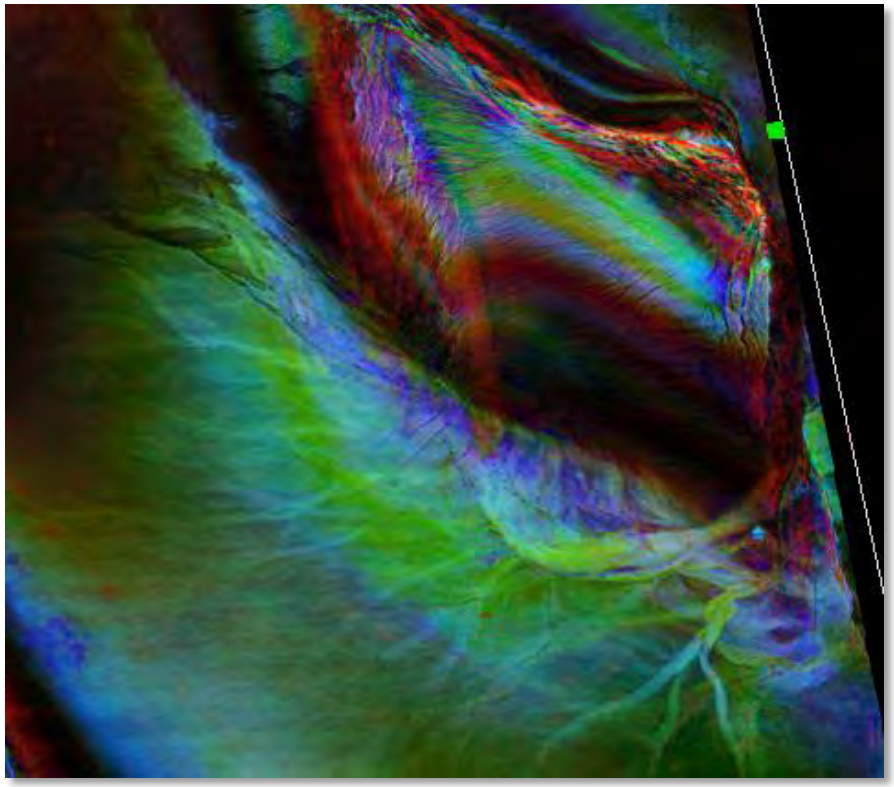


BroadSeis would give more high frequencies, as high as 250Hz, for sharp imaging of faults and small scale features

Angola Kwanza Basin – Frequency decomposition

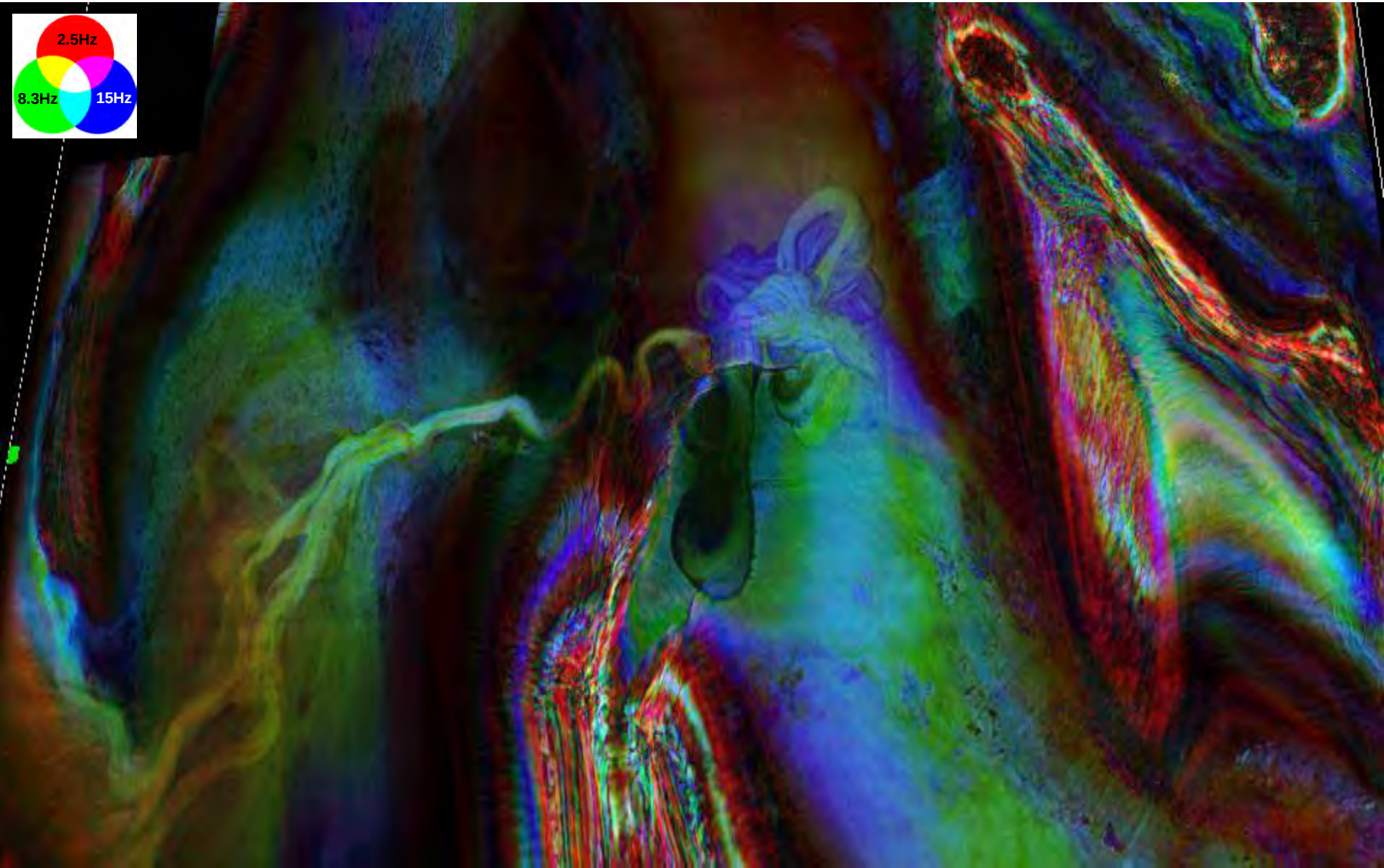
Frequency decomposition of broadband data and volume blend





The full range of frequencies offered by BroadSeis allows for highly detailed facies and structural mapping

Angola Kwanza Basin – Frequency decomposition



Conclusions

- Broadband seismic data gives the following benefits on the South Atlantic Margins
  - Overall genuine formation signature: no side-lobes and sharper central peak
  - Strong basis for reservoir characterisation and pre-stack seismic inversion
  - Low frequencies penetrate deeper to help imaging trough salt bodies and interpret deep syn-rift fault blocks to better understand sub-salt plays
  - High frequencies allow for high resolution shallow imaging and subtle facies variations in the post-salt turbidite plays

Acknowledgements

- Jaswinder Mann, Lauren Houston and Steven Bowman for their contributions to this presentation
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