



TopSeis – Shooting over the seismic spread ... with examples from the Barents Sea

Rose Seminar, April 2018

cgg.com



TopSeis

Shooting over the seismic spread



Artist's impression
August 2016

TopSeis

Geo Caspian

Shooting over the seismic spread

TopSeis full-scale real acquisition
August 2017

Geo Coral

Drone photo

TopSeis

Full-scale real acquisition
August 2017

Geo Coral

Geo Caspian

Jan Erik Lie Chief Geo in Lundin
Geo Coral, September 2017



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TopSeis



Barents Sea

September 2017

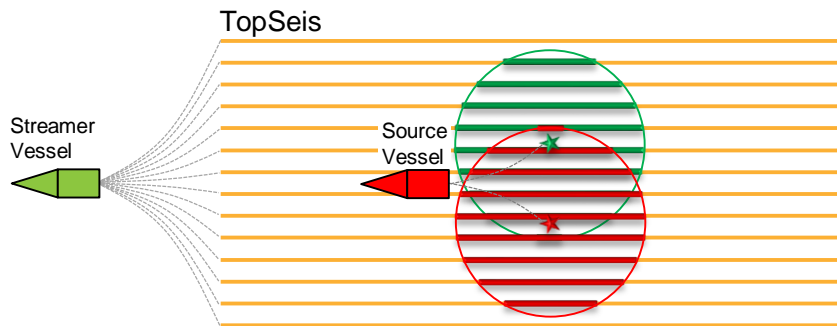
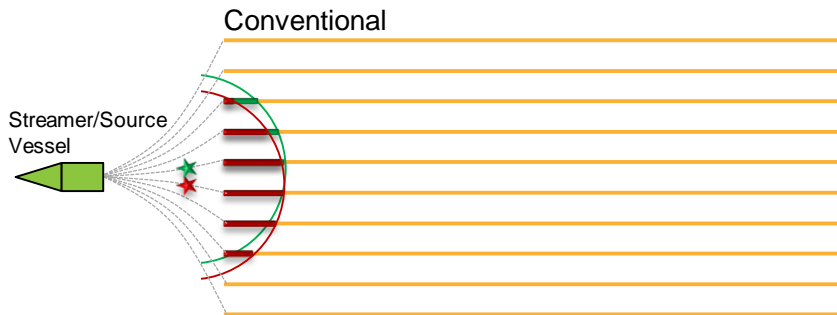


Rowing on the Barents Sea
Geo Coral, September 2017





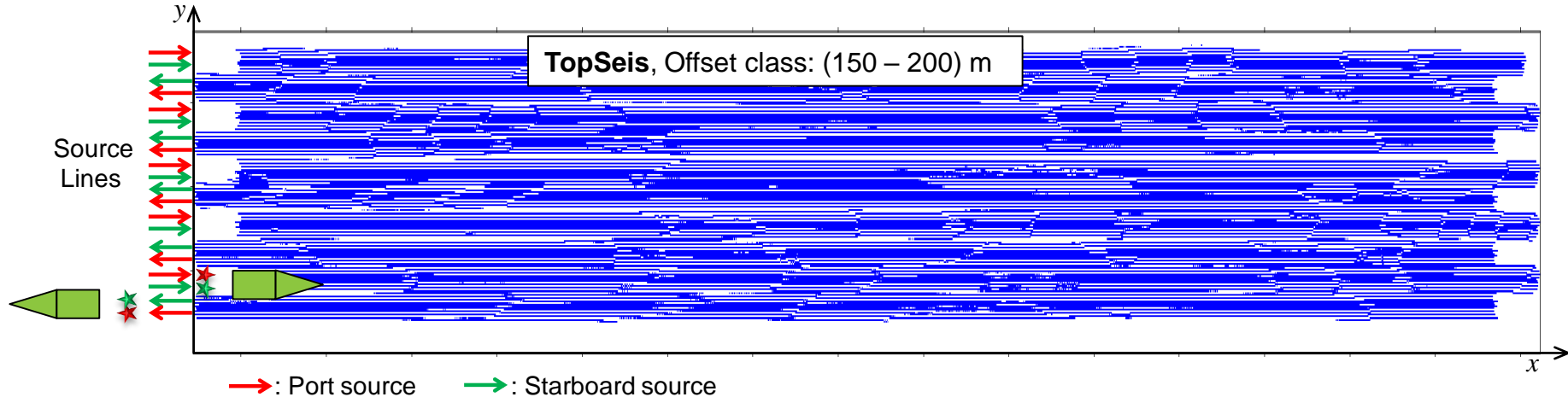
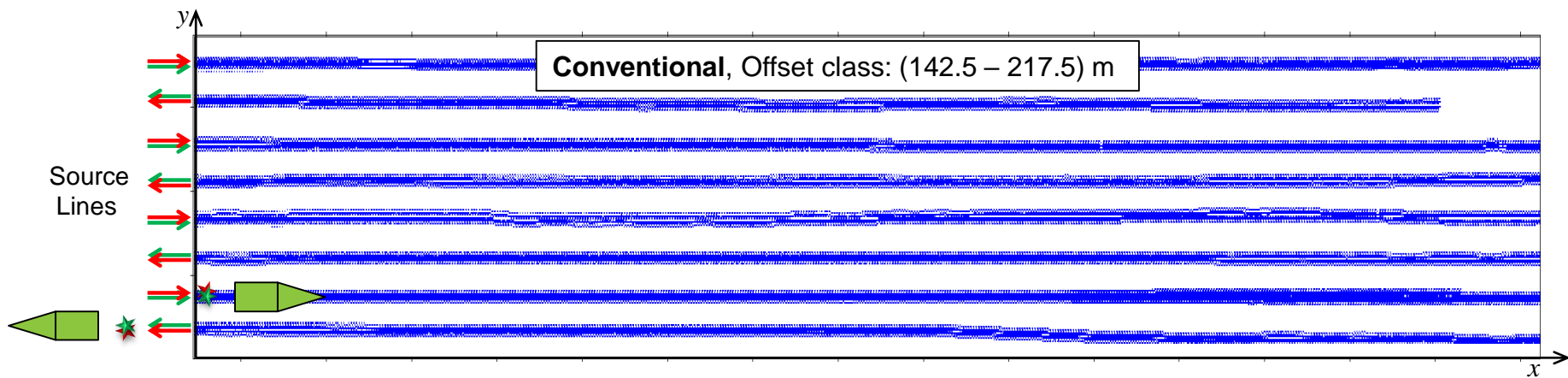
What is TopSeis?



- Sources on top of the spread
...for zero-offsets and split spread
- Wide towed sources
...to reduce the minimum offset
- Dense spatial sampling
...to increase subsurface illumination

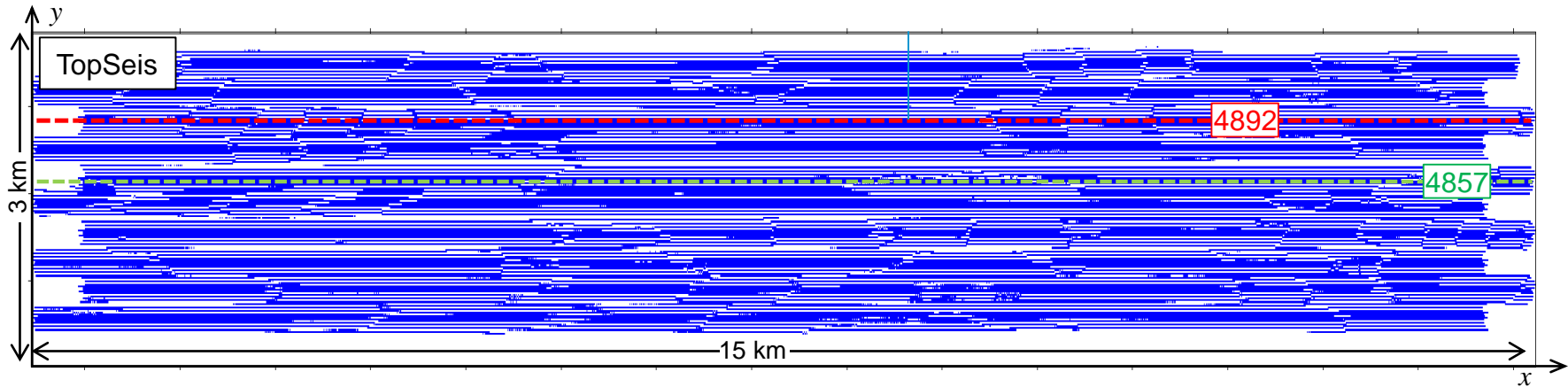
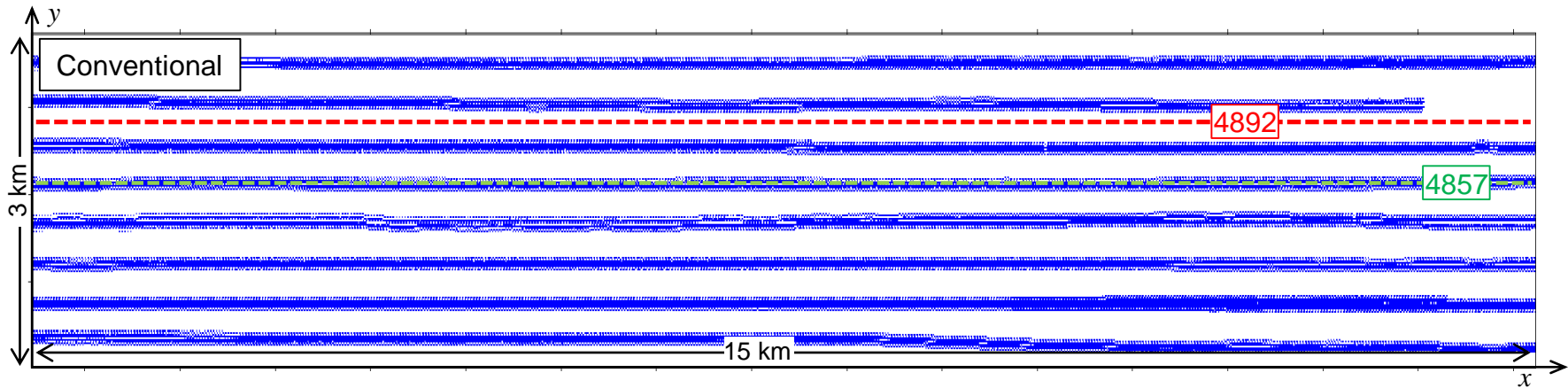


Near offset CMP coverage on a field test

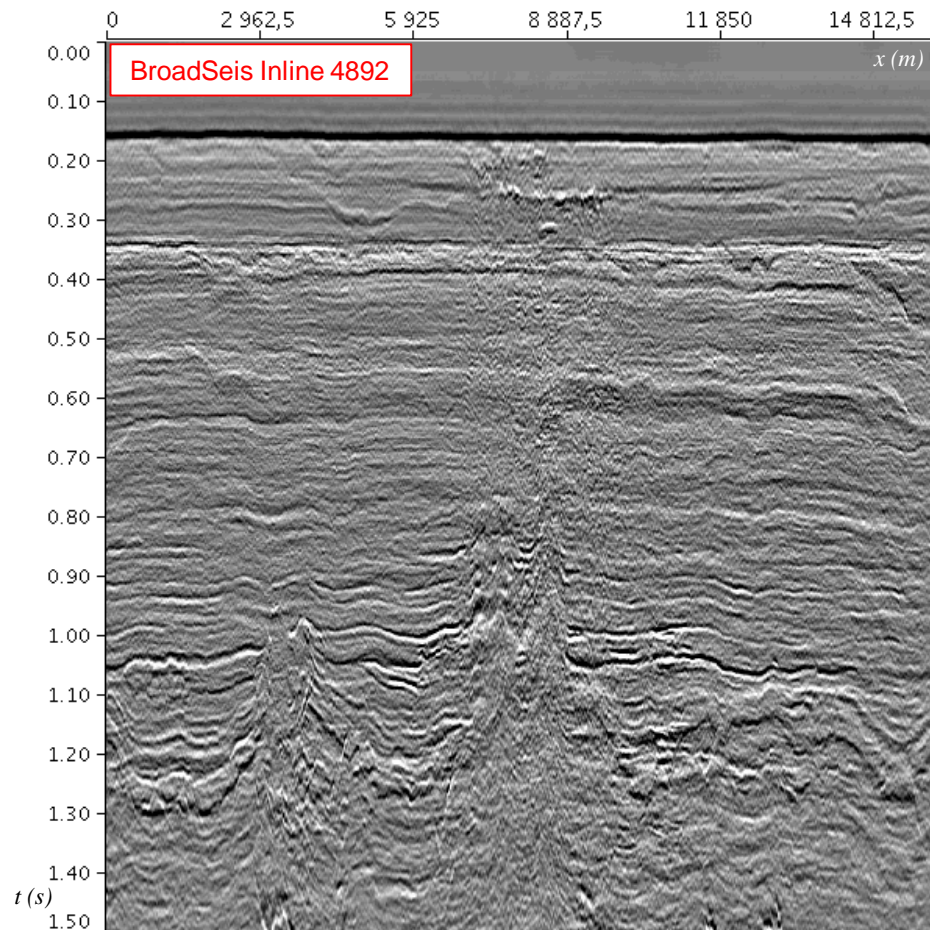
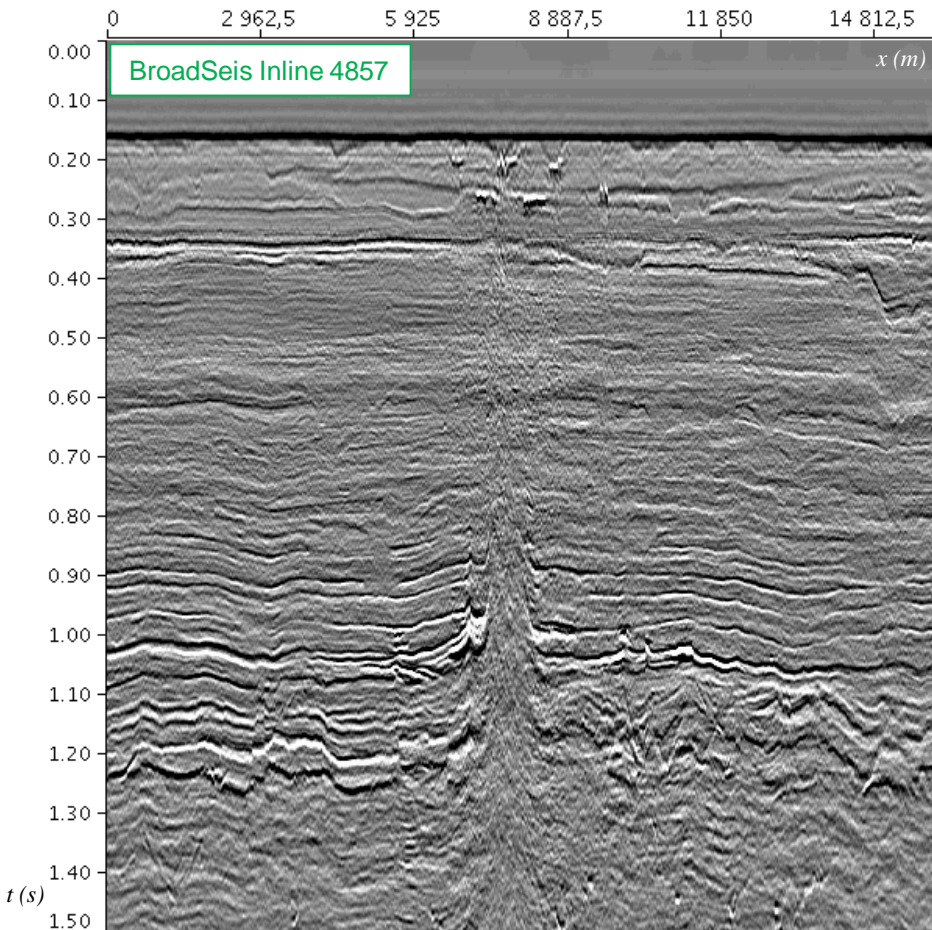




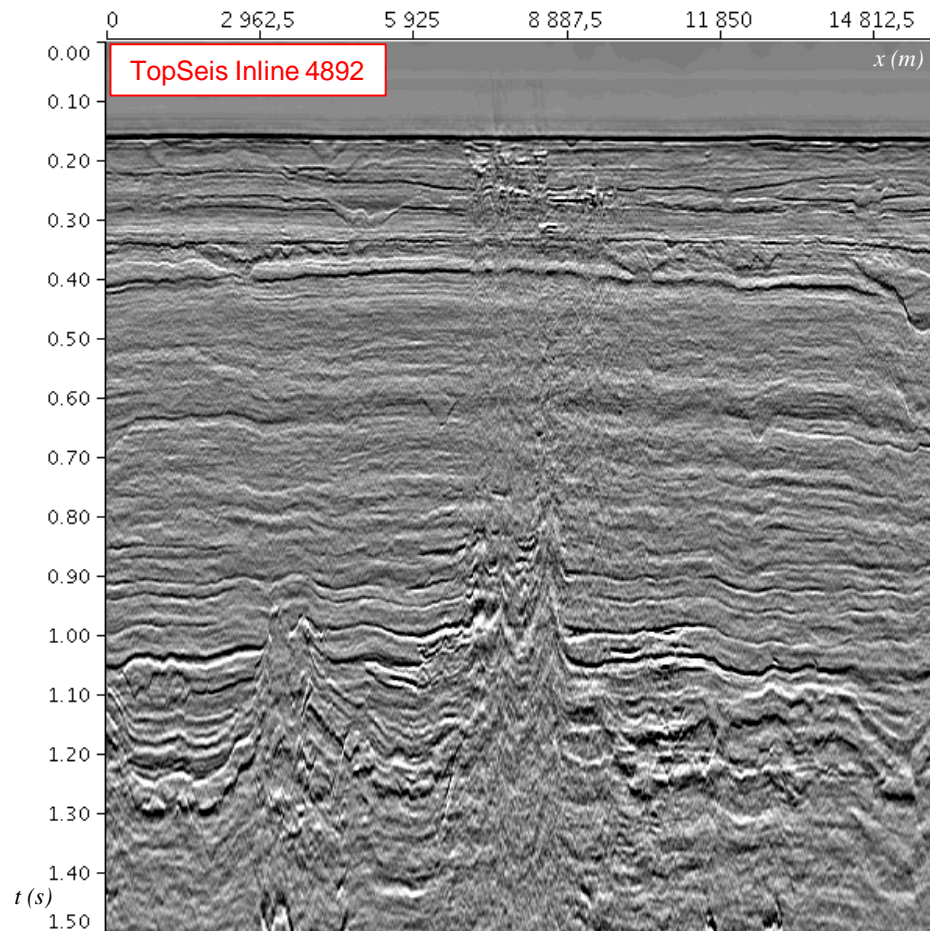
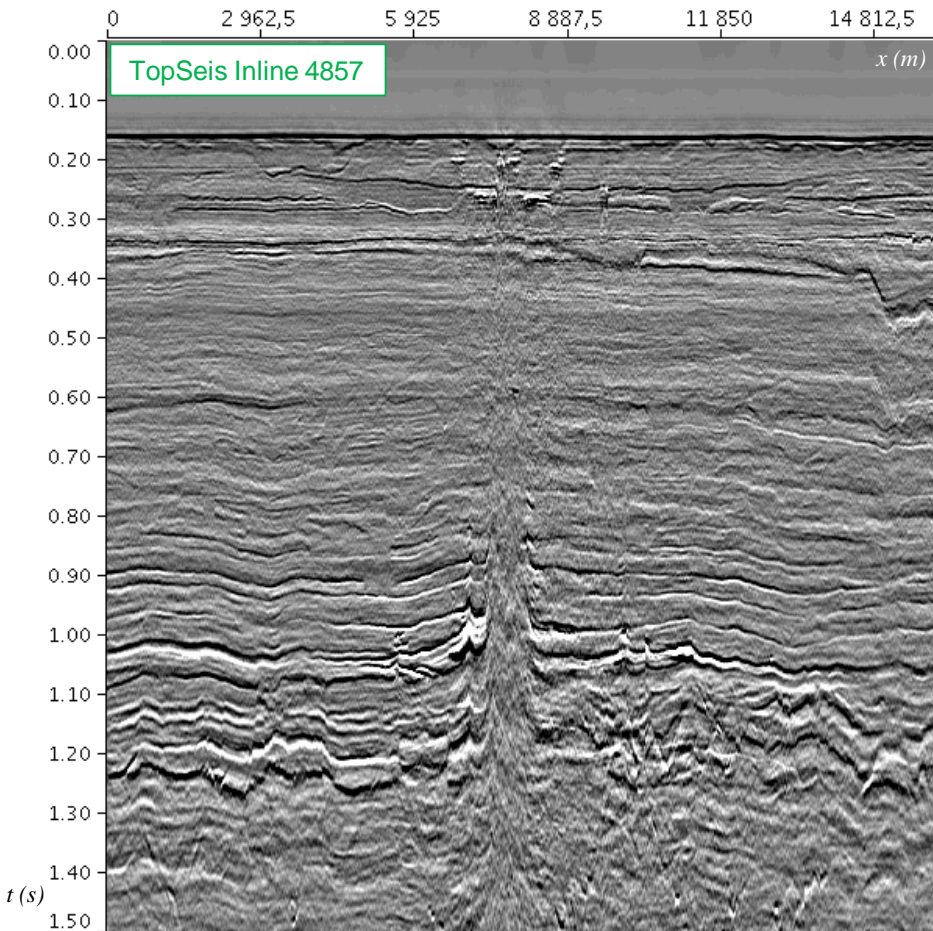
The Good Lines and the Not-So-Good lines on Conventional



Conventional Inlines – down to 1.5 s

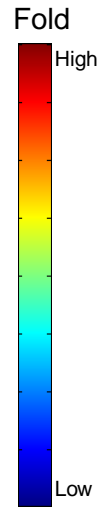
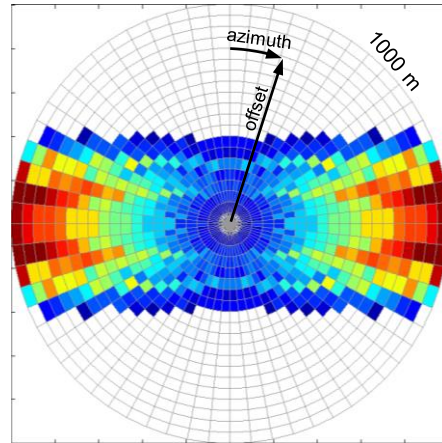
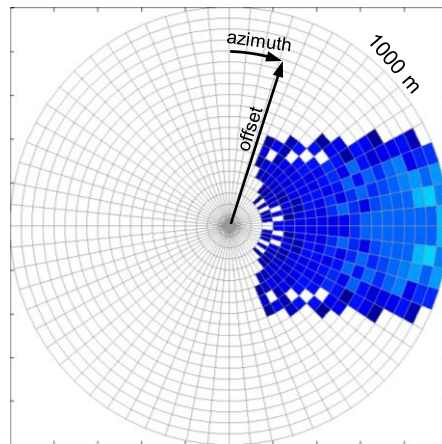
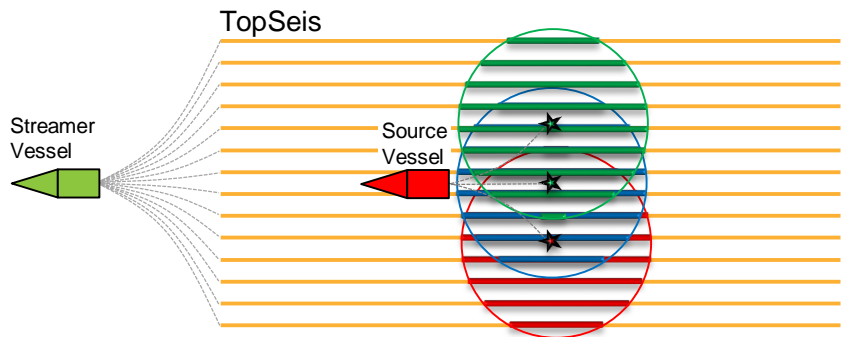
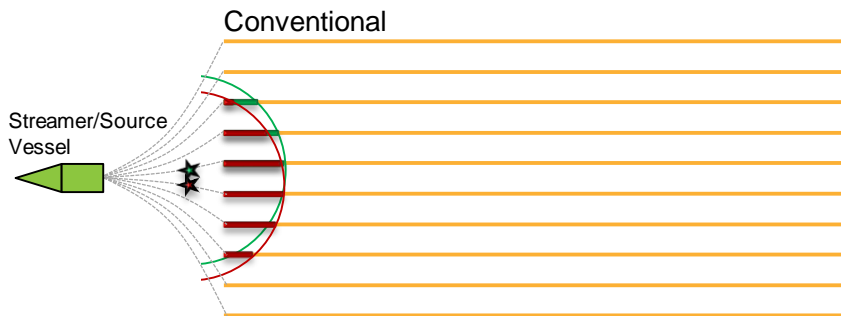


TopSeis Inlines – down to 1.5 s



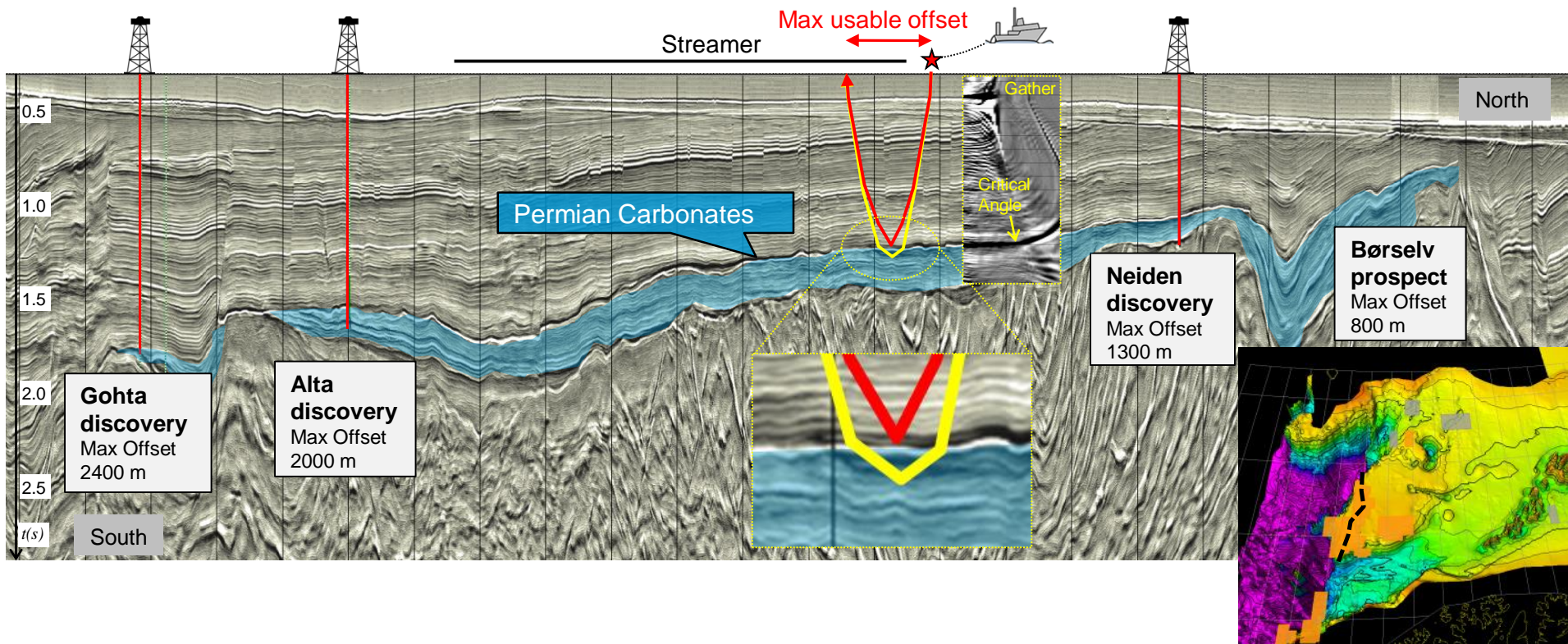


TopSeis with triple source for denser crossline sampling



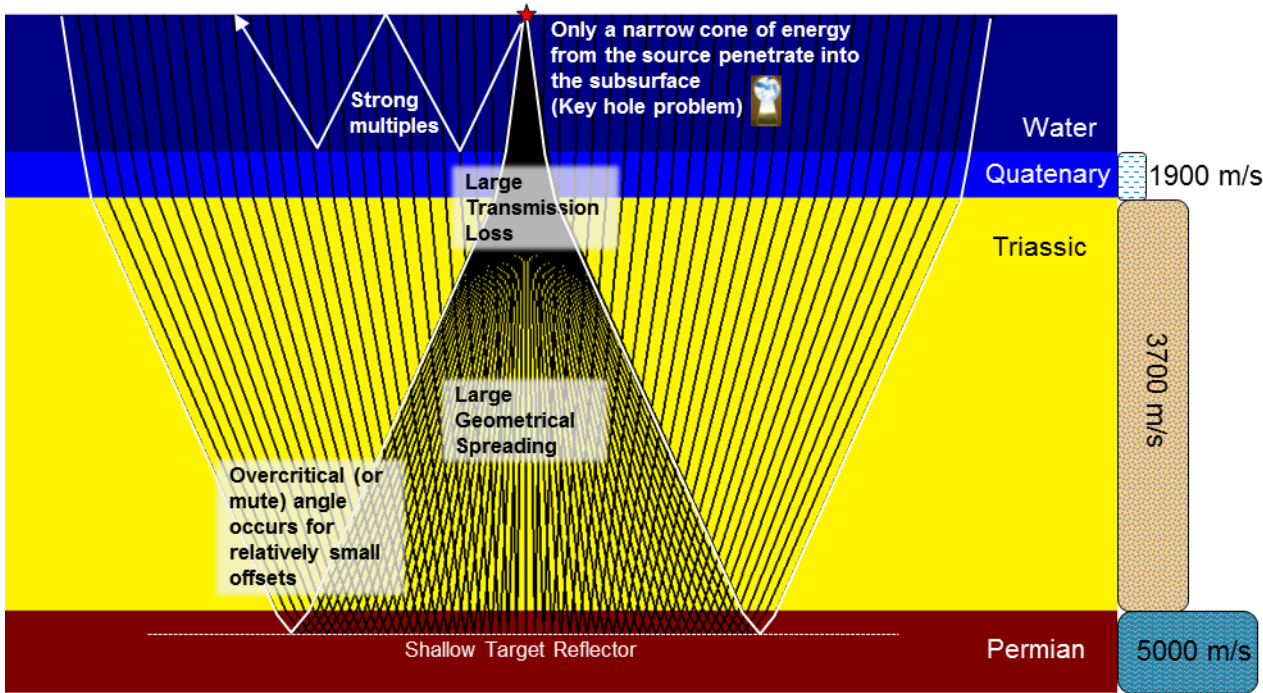


Motivation – Better imaging in the Barents Sea

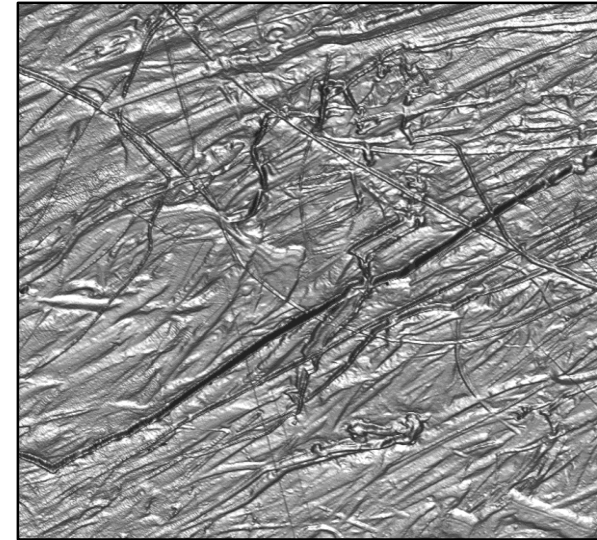




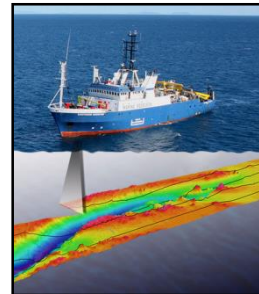
The imaging problems in the Barents Sea



Arch-typical, simplistic geology in the Loppa High area in the Barents Sea

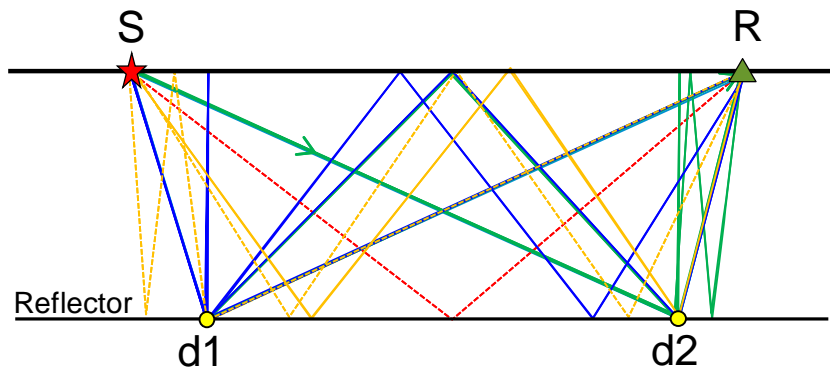


Alta-Gotha water bottom, Multi-Beam sonar





Multiples can be complicated



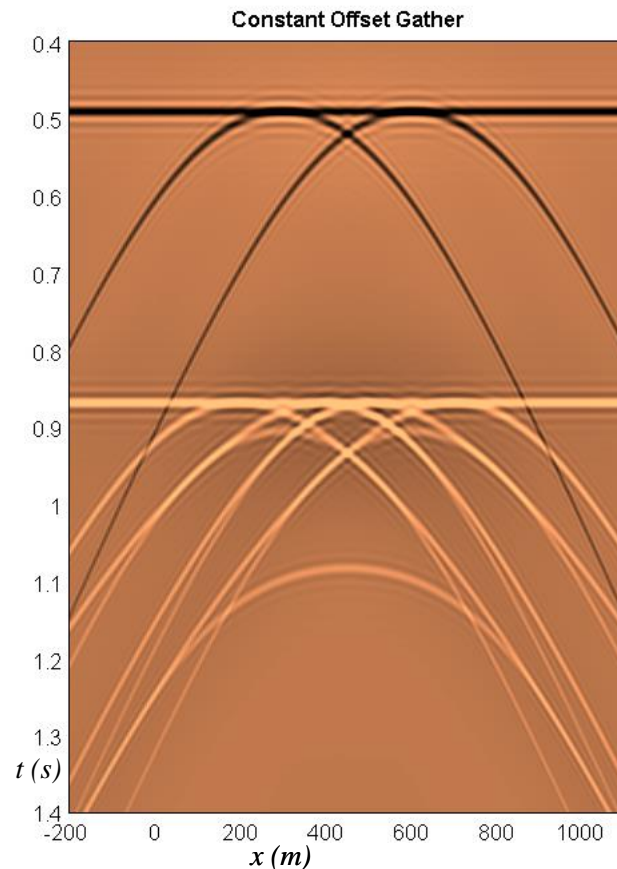
Primaries
reflection
d1
d2
1st order multiples
reflection – reflection
reflection – d1
reflection - d2
d1- reflection
d1 – d1
d1 – d2
d2 – reflection
d2 – d1
d2 – d2

Model:

One reflector and two diffractors giving 3 primary events

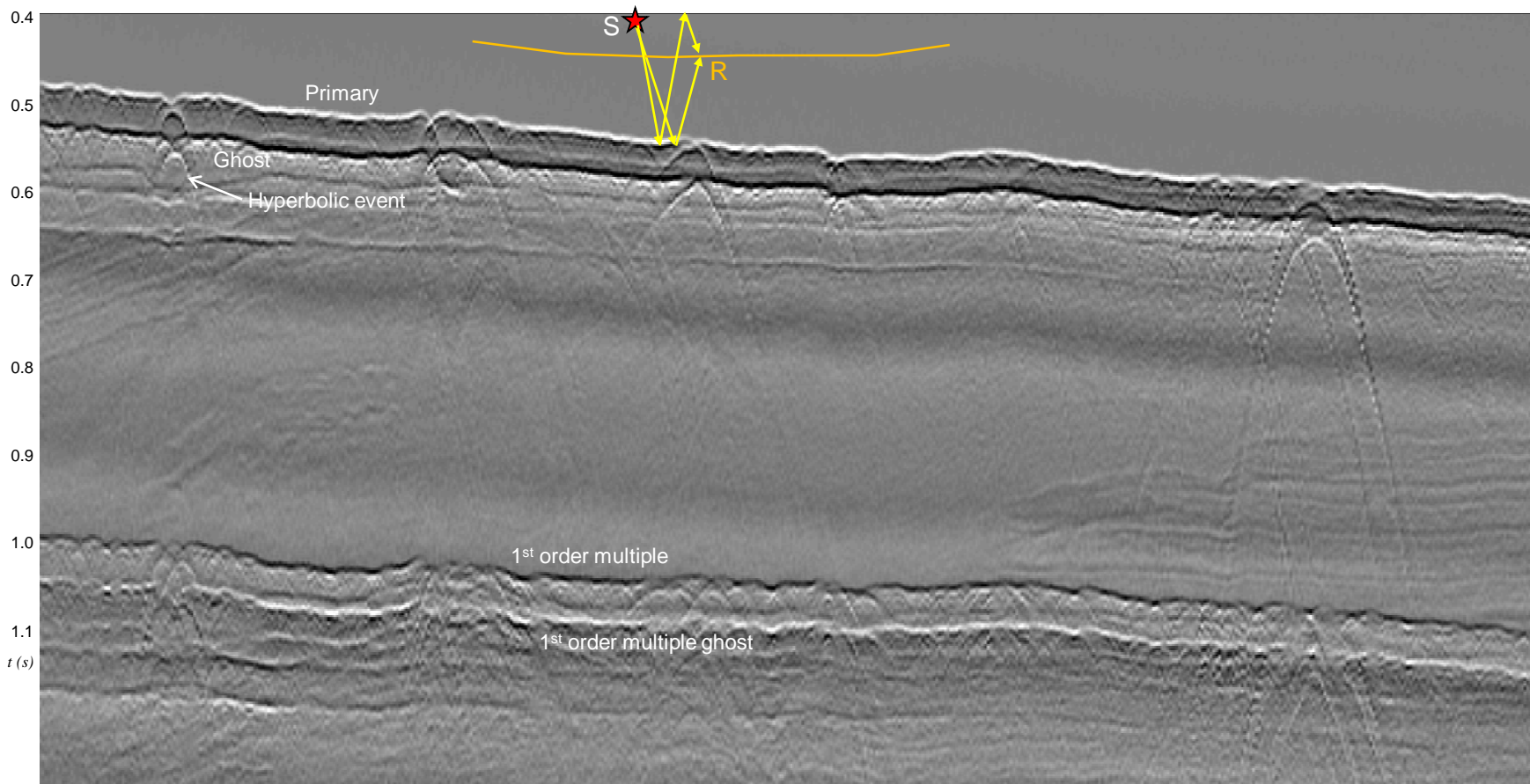
1st order multiple events:

$3^2 = 9$ multiple events

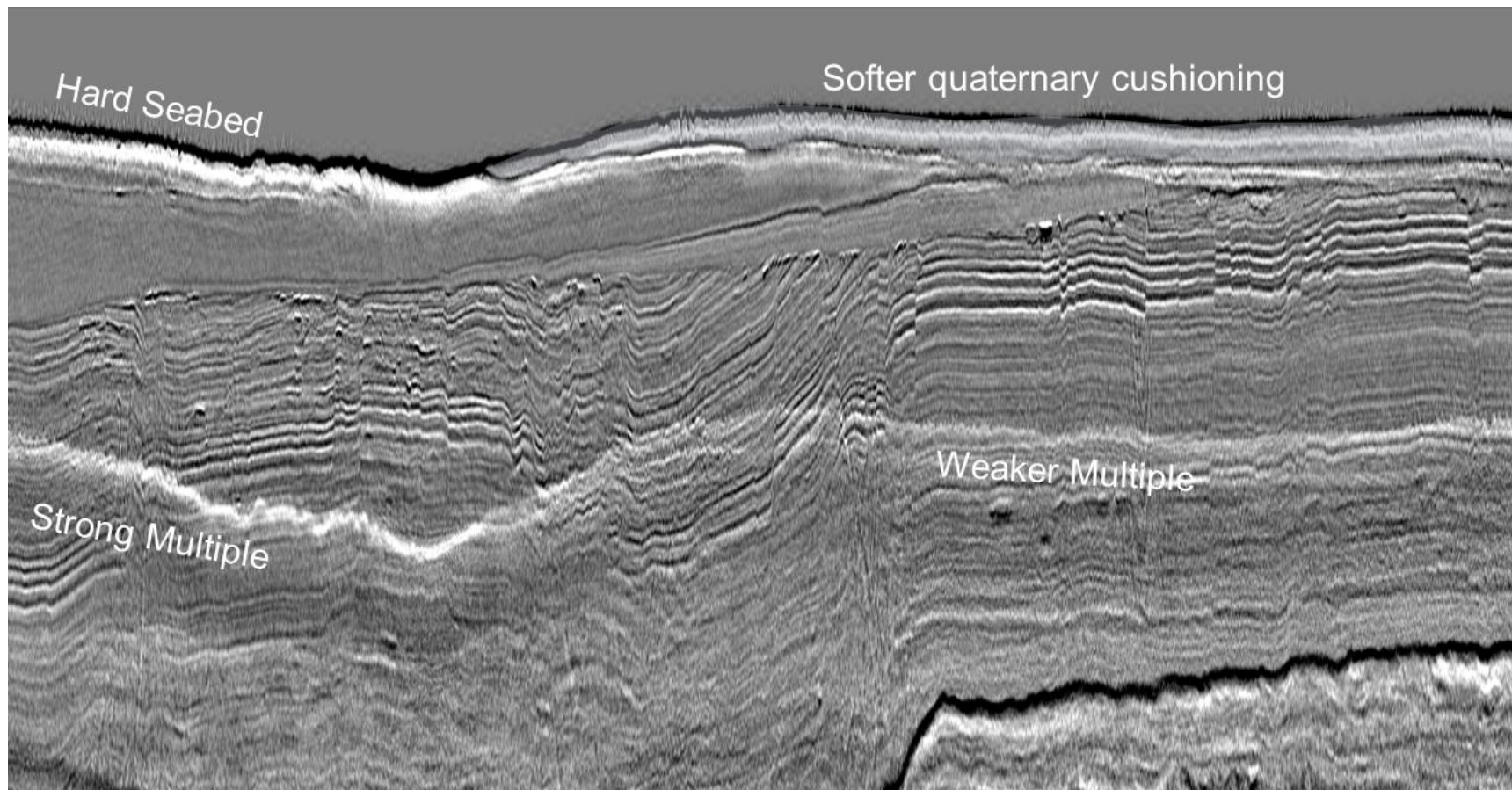




Barents Sea; Complex primary and even more complex multiples



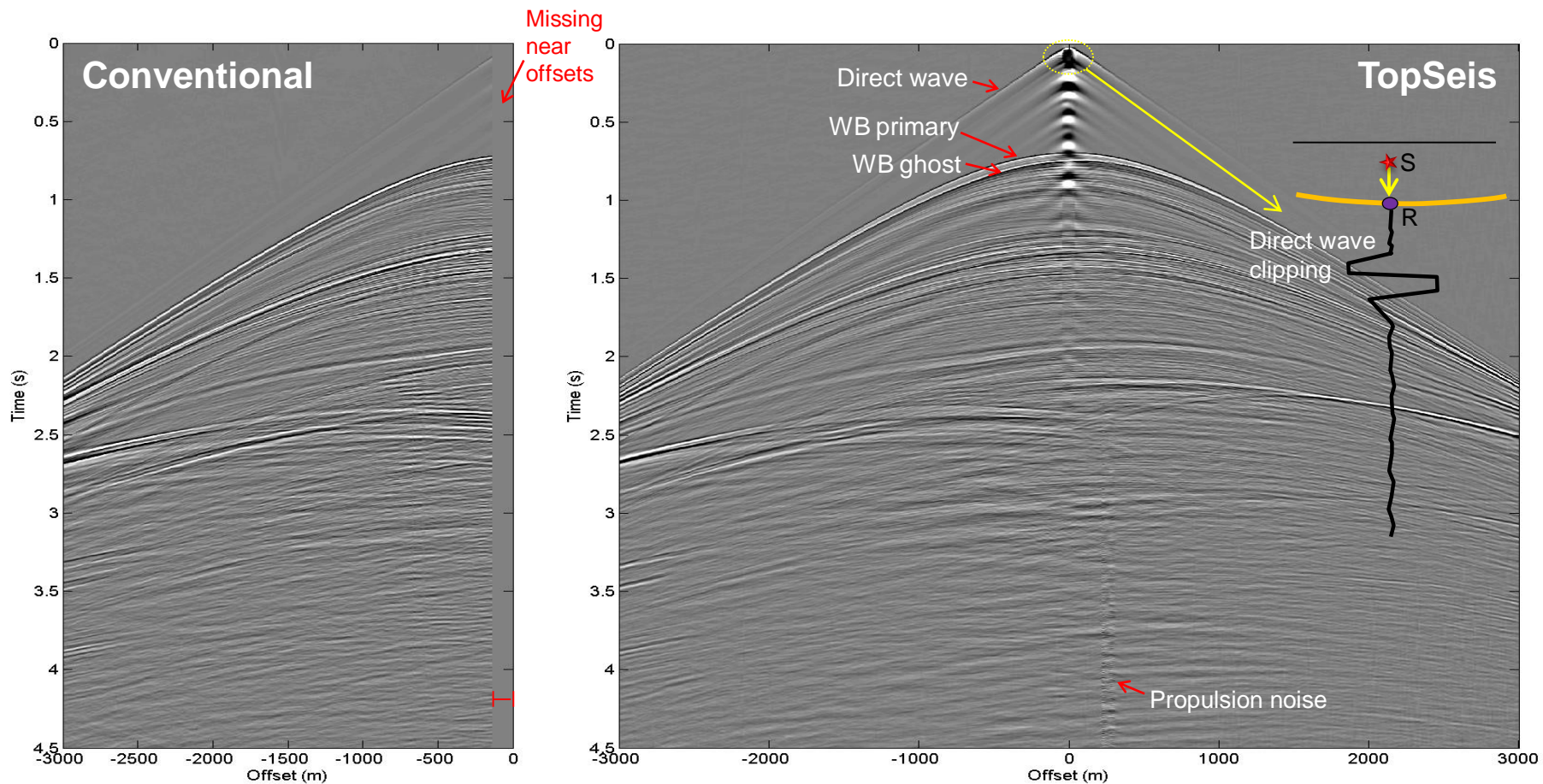
Constant Channel Gather, from TopSeis over Alta-Gotha , 2017



Seismic image with residual multiples, from conventional acquisition



Shot Gathers – Example from 2D test offshore Gabon





2014 - 2015

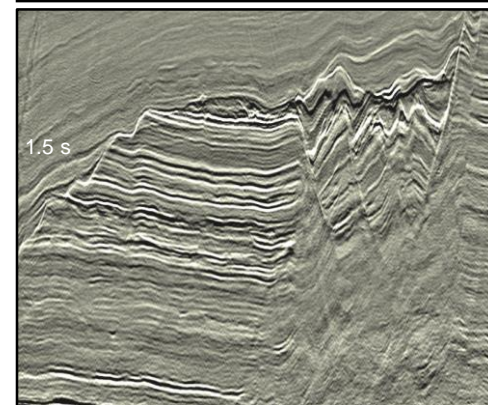
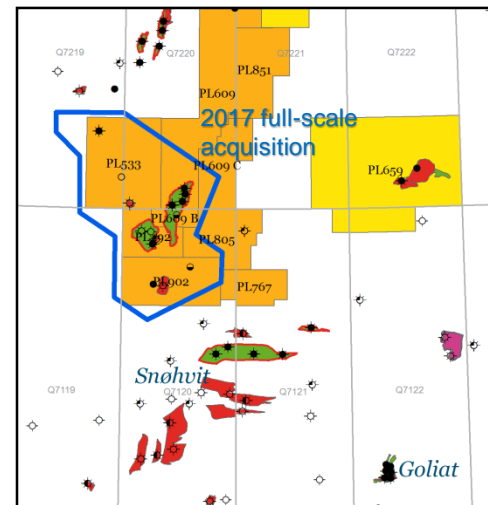
- Comprehensive modelling program
- Geowave Voyager shooting over the spread of Endeavour
- Geowave Voyager with wide-towed source to assess the wide-tow limits

2016

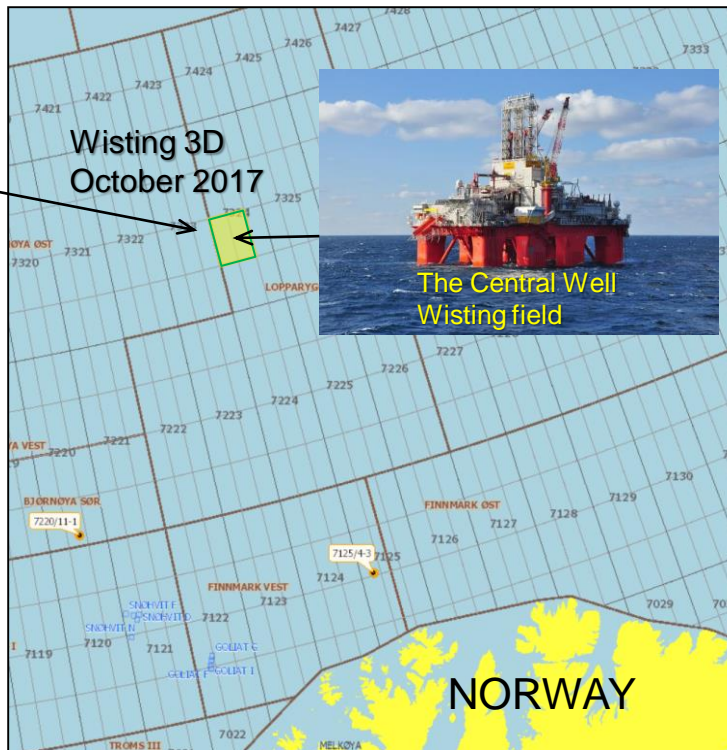
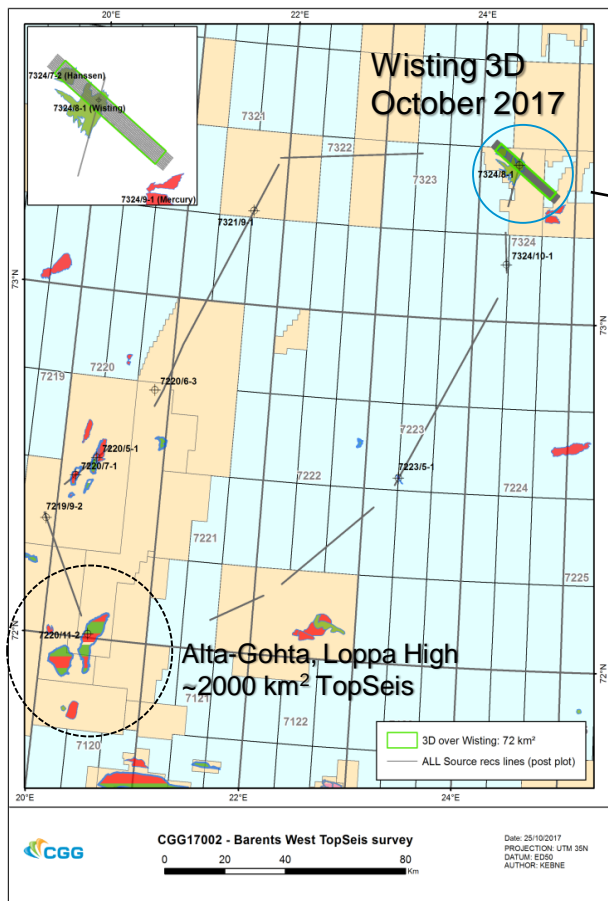
- 2D line (30 km) of TopSeis vs BroadSeis offshore Gabon
- 3D TopSeis on Frigg-Gamma in the North Sea (15 x 3) km

2017 – Barents Sea

- Full-scale ~2000 km² over Loppa High
- “Tour” of 2D lines
- 3D on Wisting (24 x 3) km



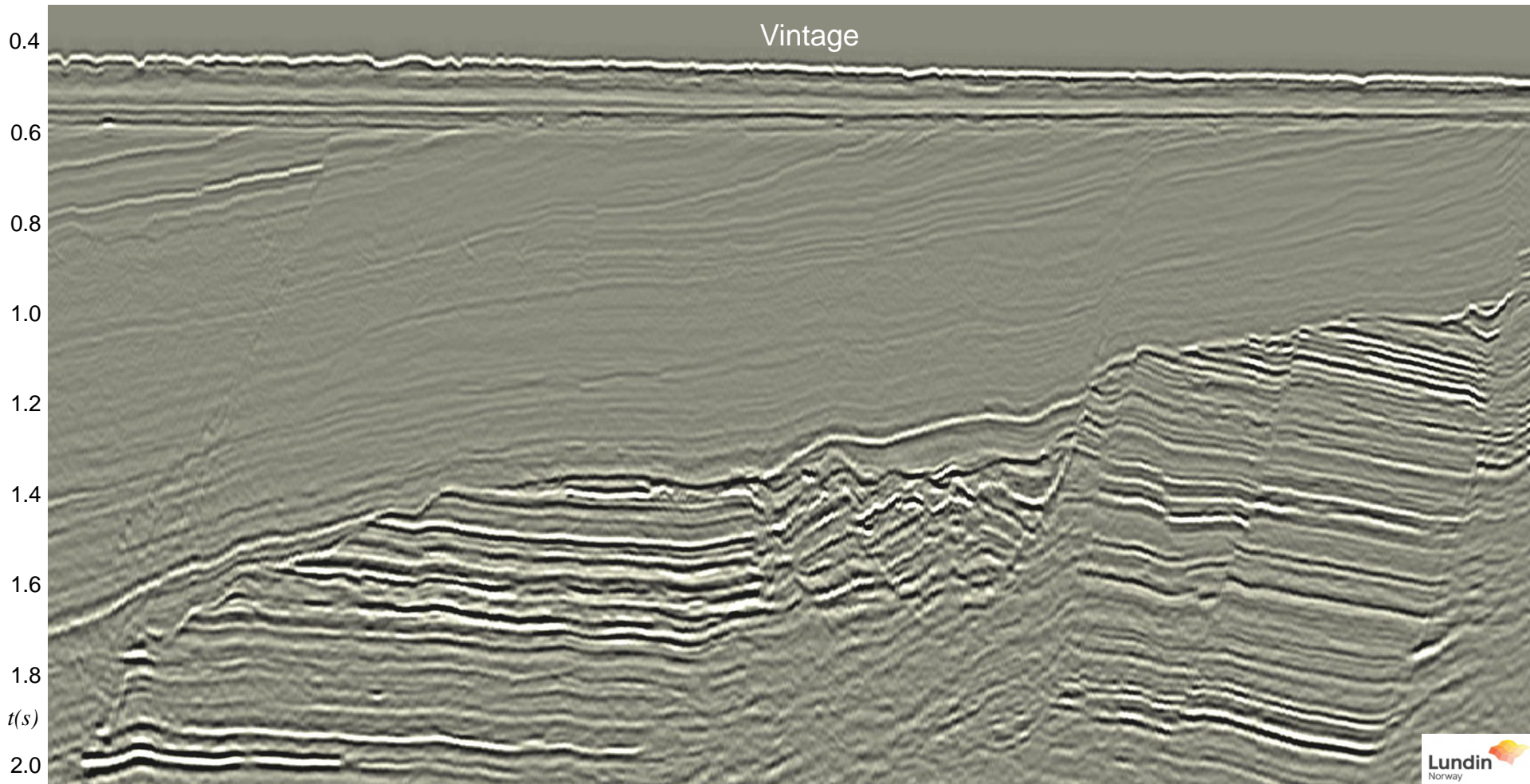
Preliminary TopSeis data, Barents Sea

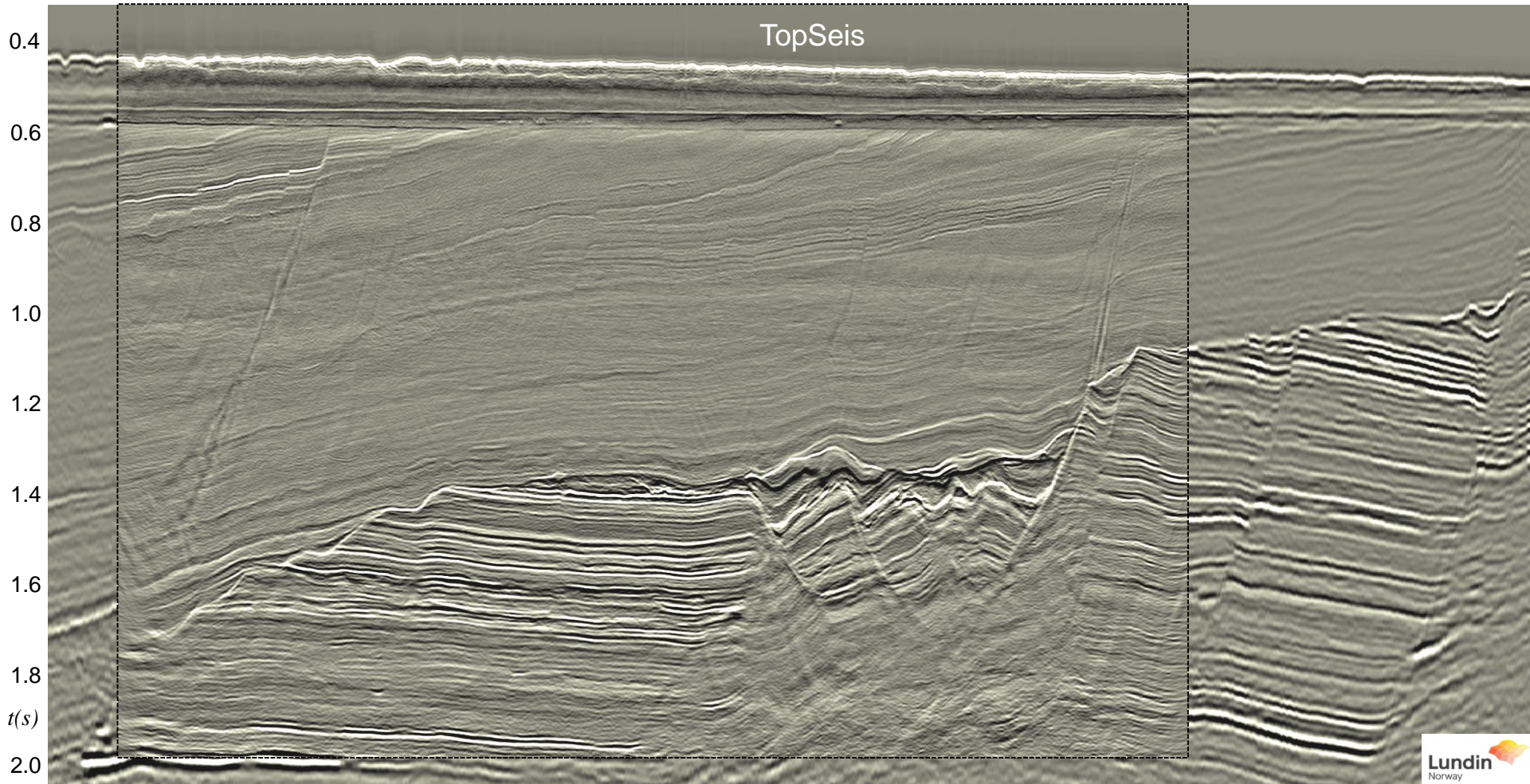


CGG Multi-Client data

TopSeis in the Barents Sea 2017

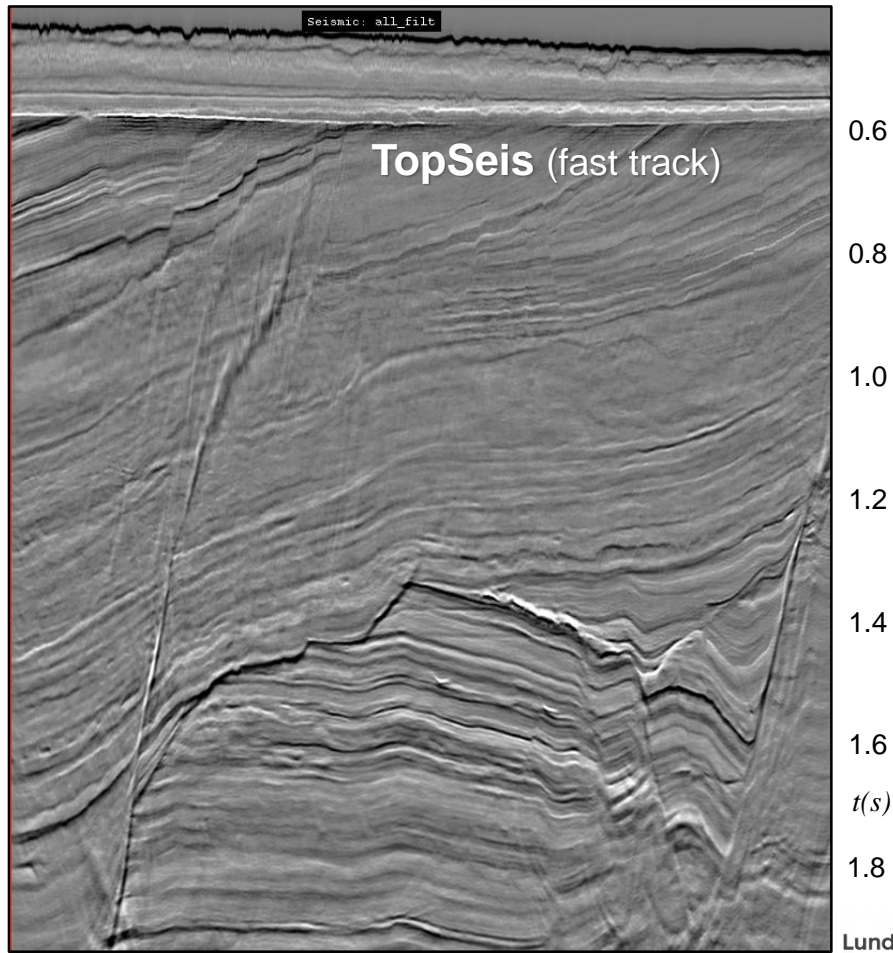
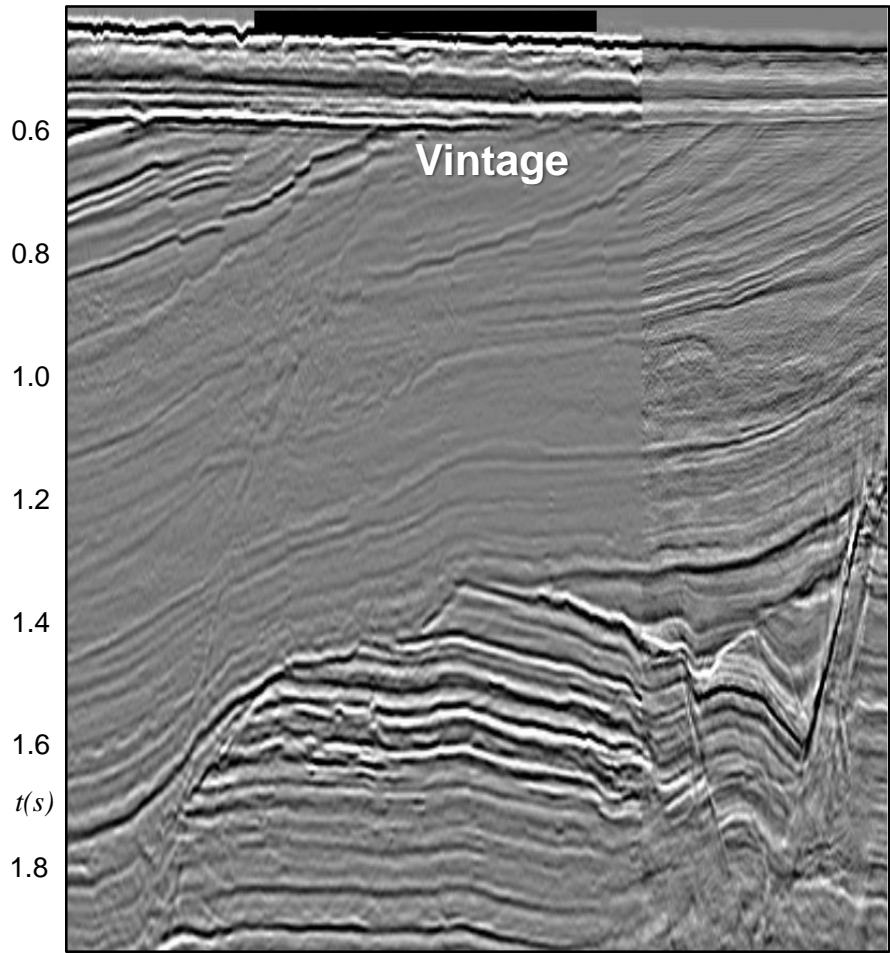
- Aug-Oct** : Loppa High ~1900 km²
- October** : field tests, 2D lines
- October** : Mini-3D on Wisting

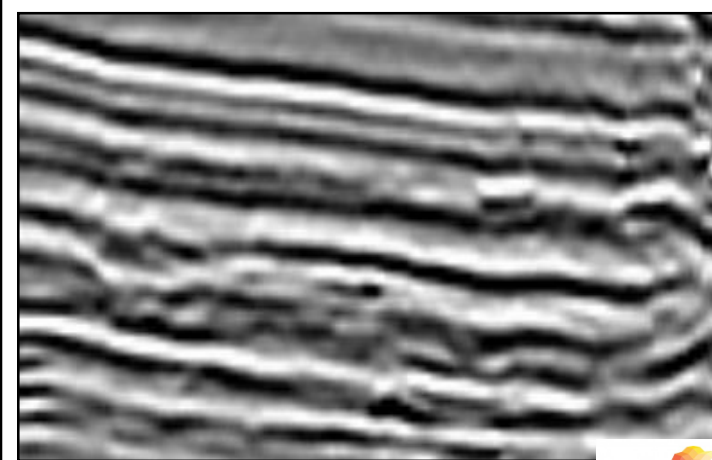
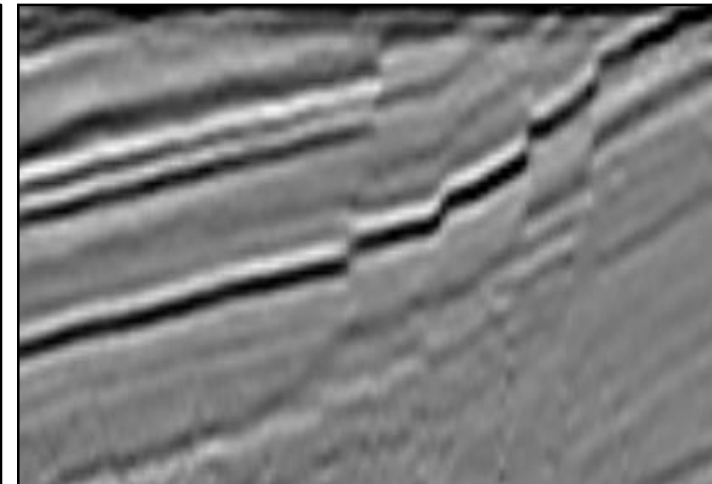
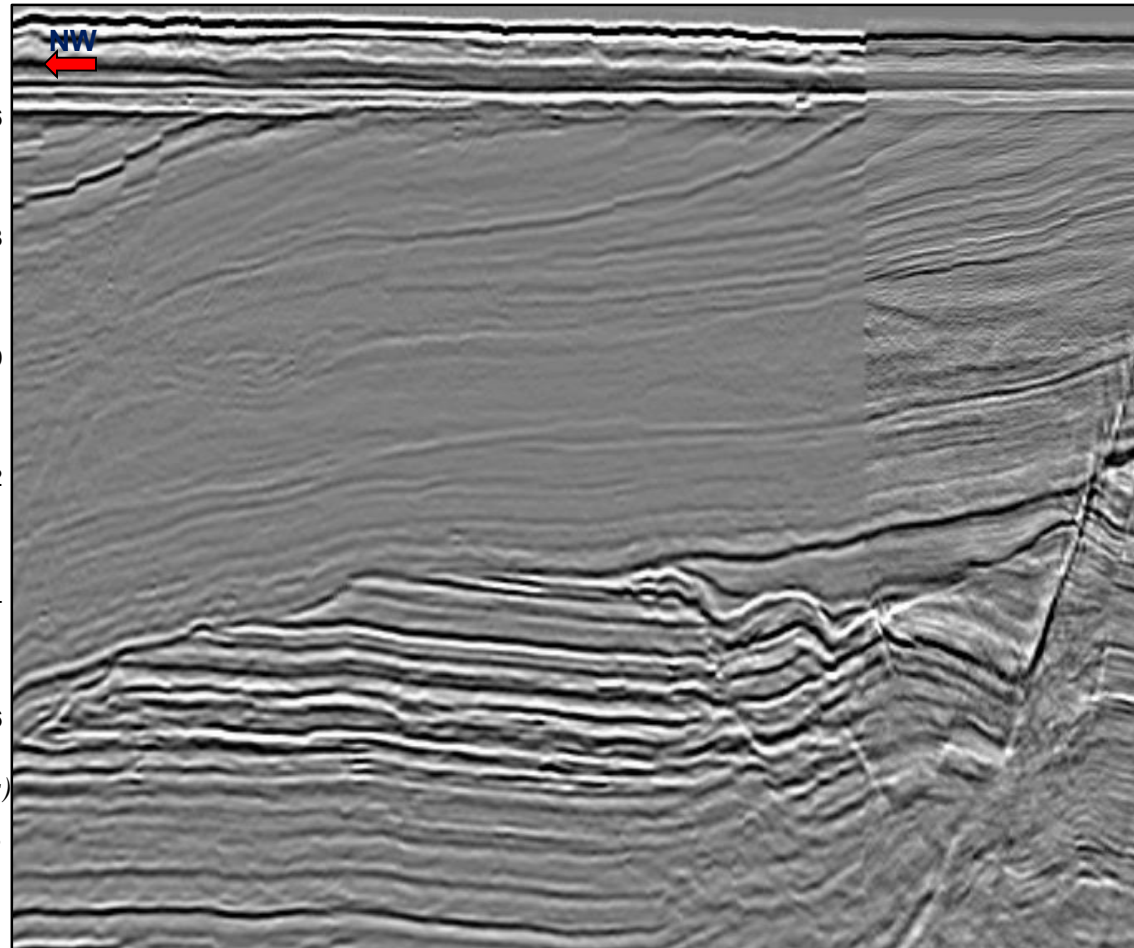






TopSeis in Barents Sea

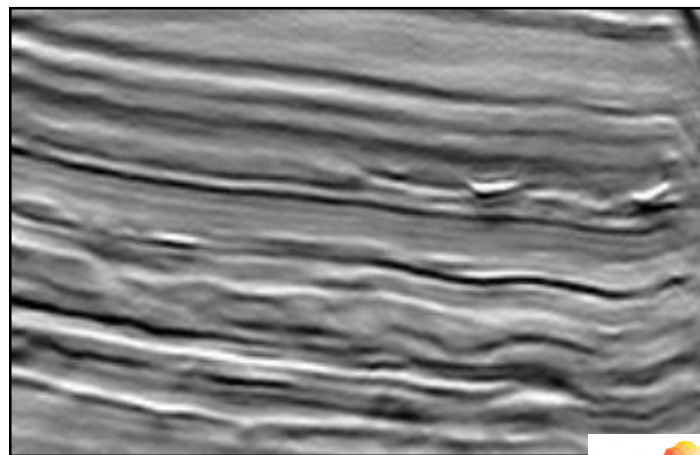
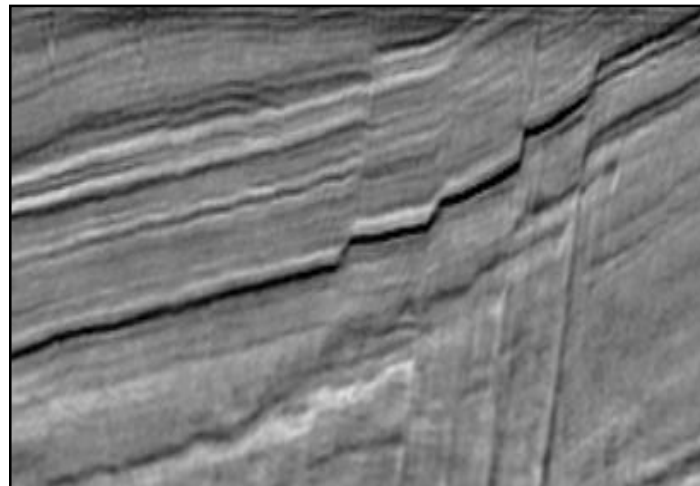
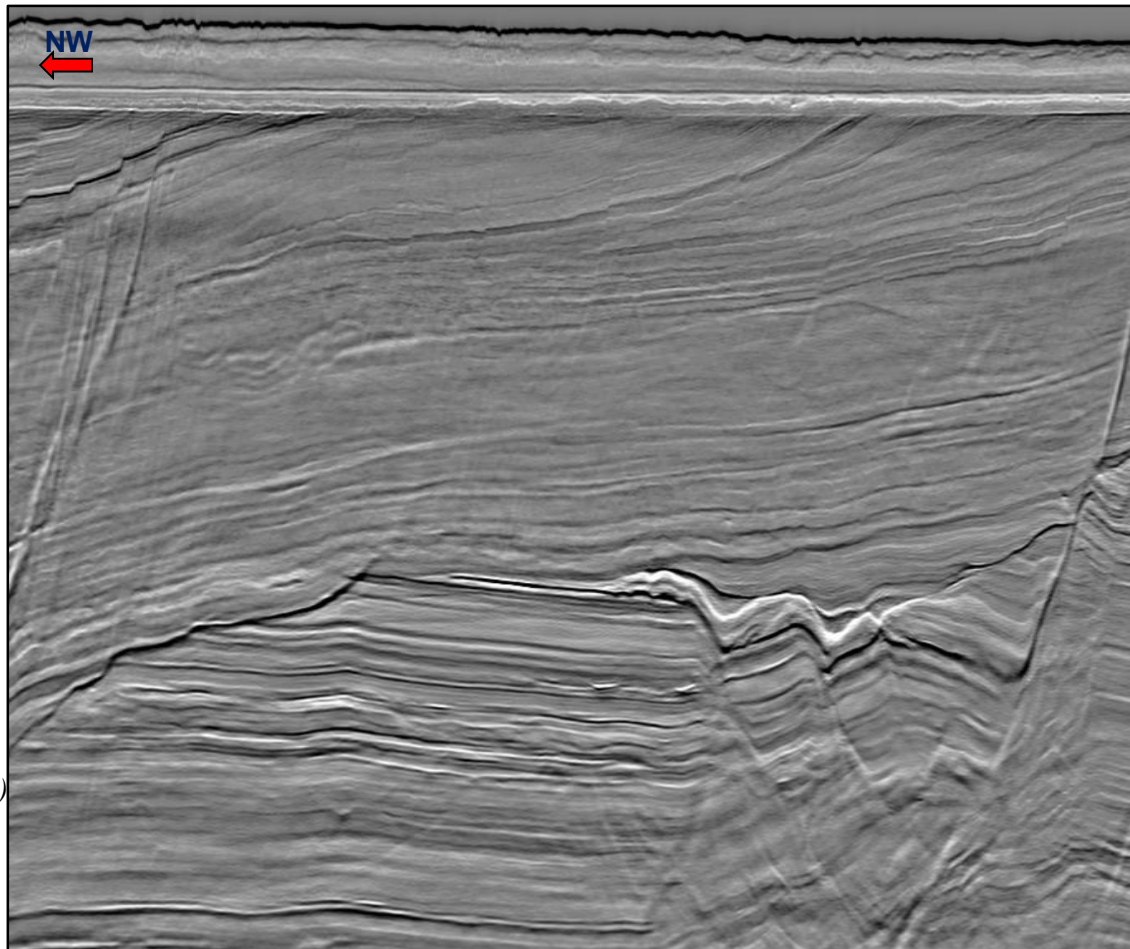


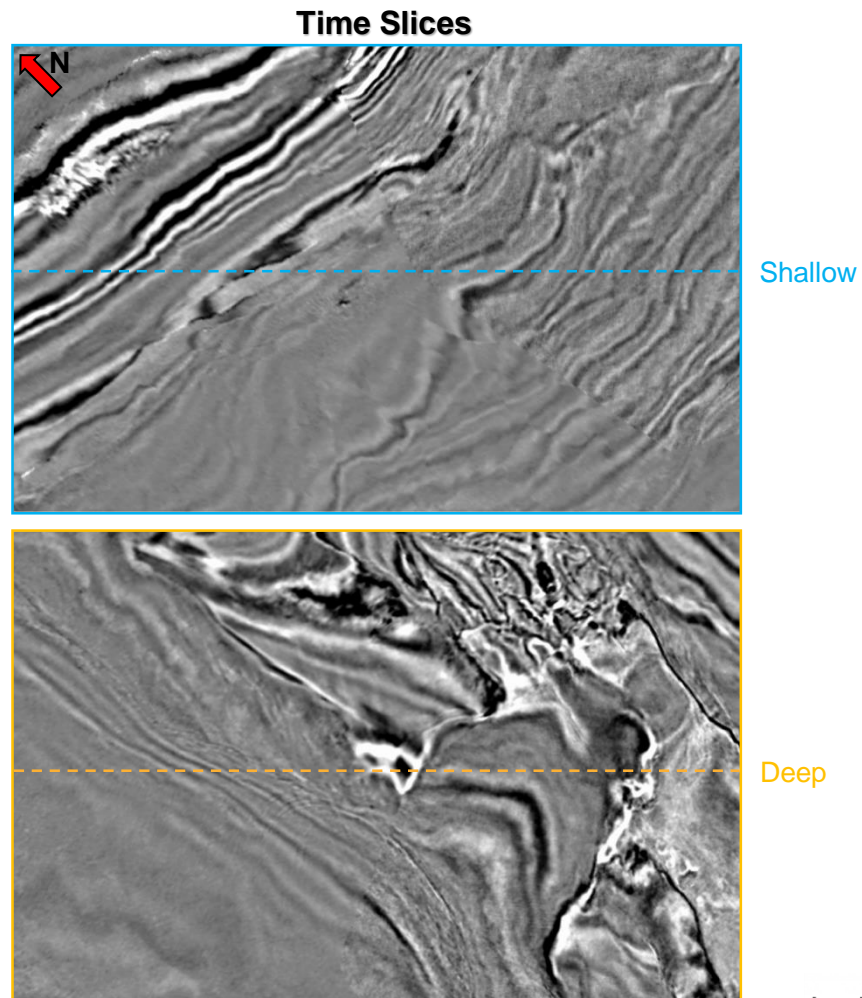
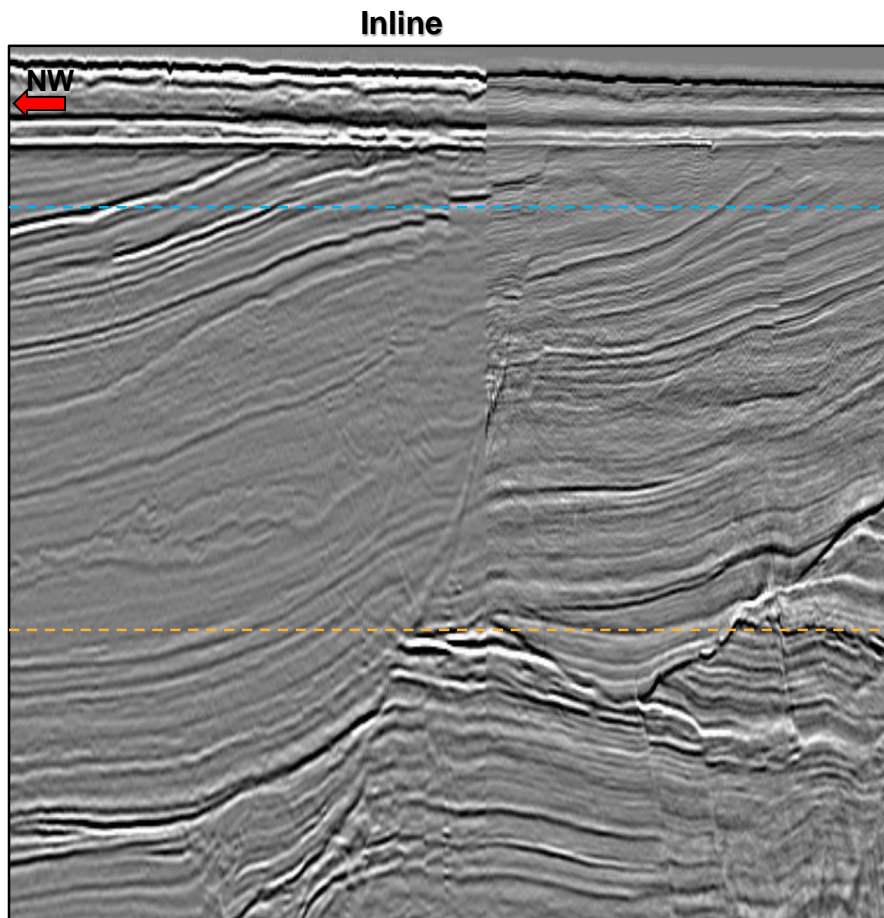




TopSeis (fast track) Inline

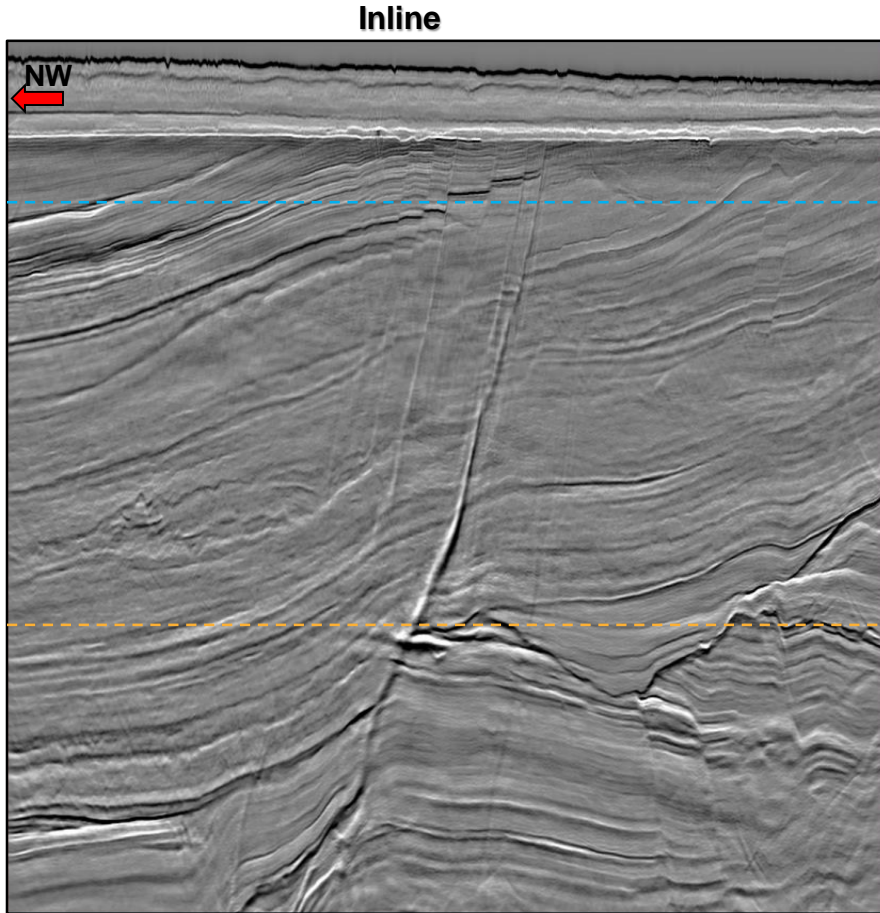
Zooms



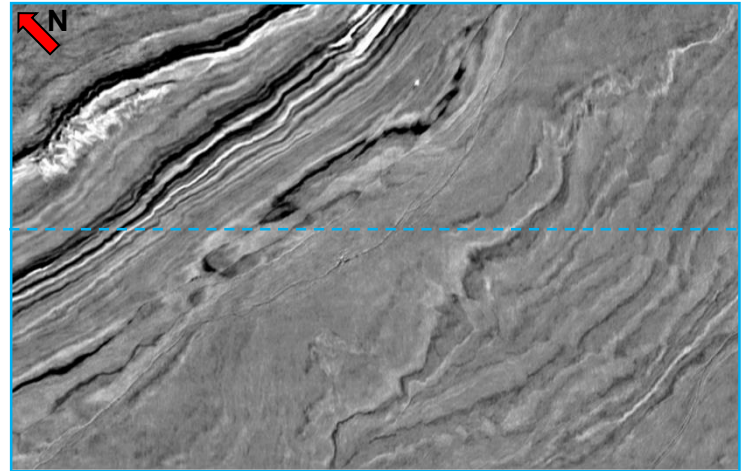




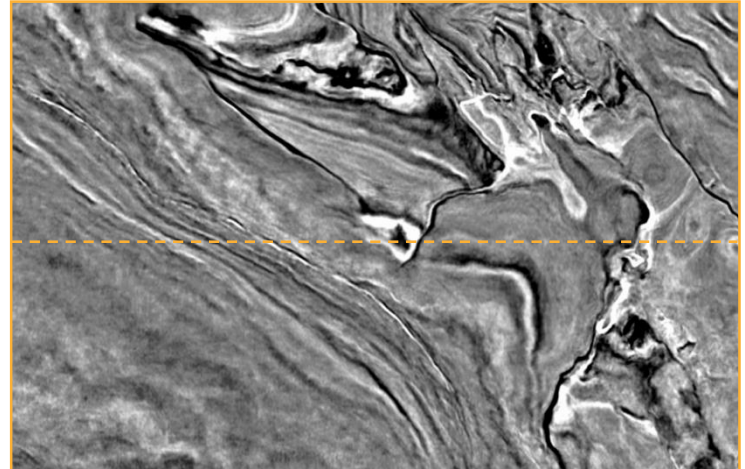
TopSeis (fast track)



Time Slices

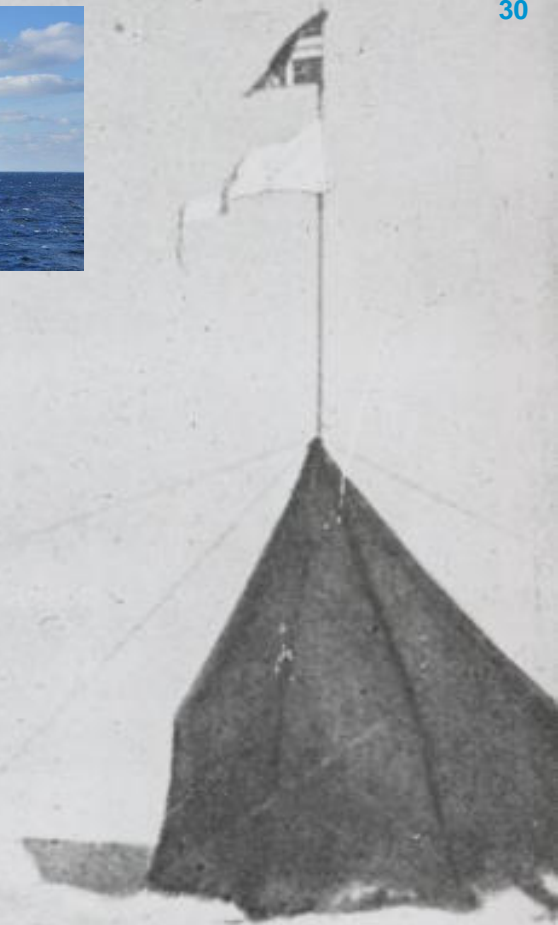
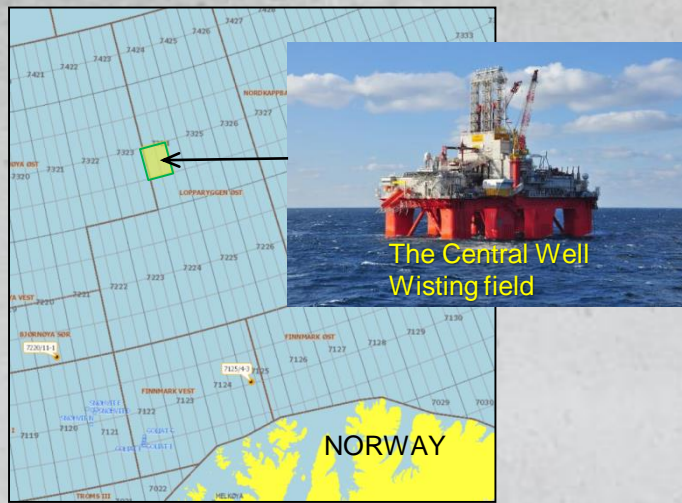


Shallow



Deep

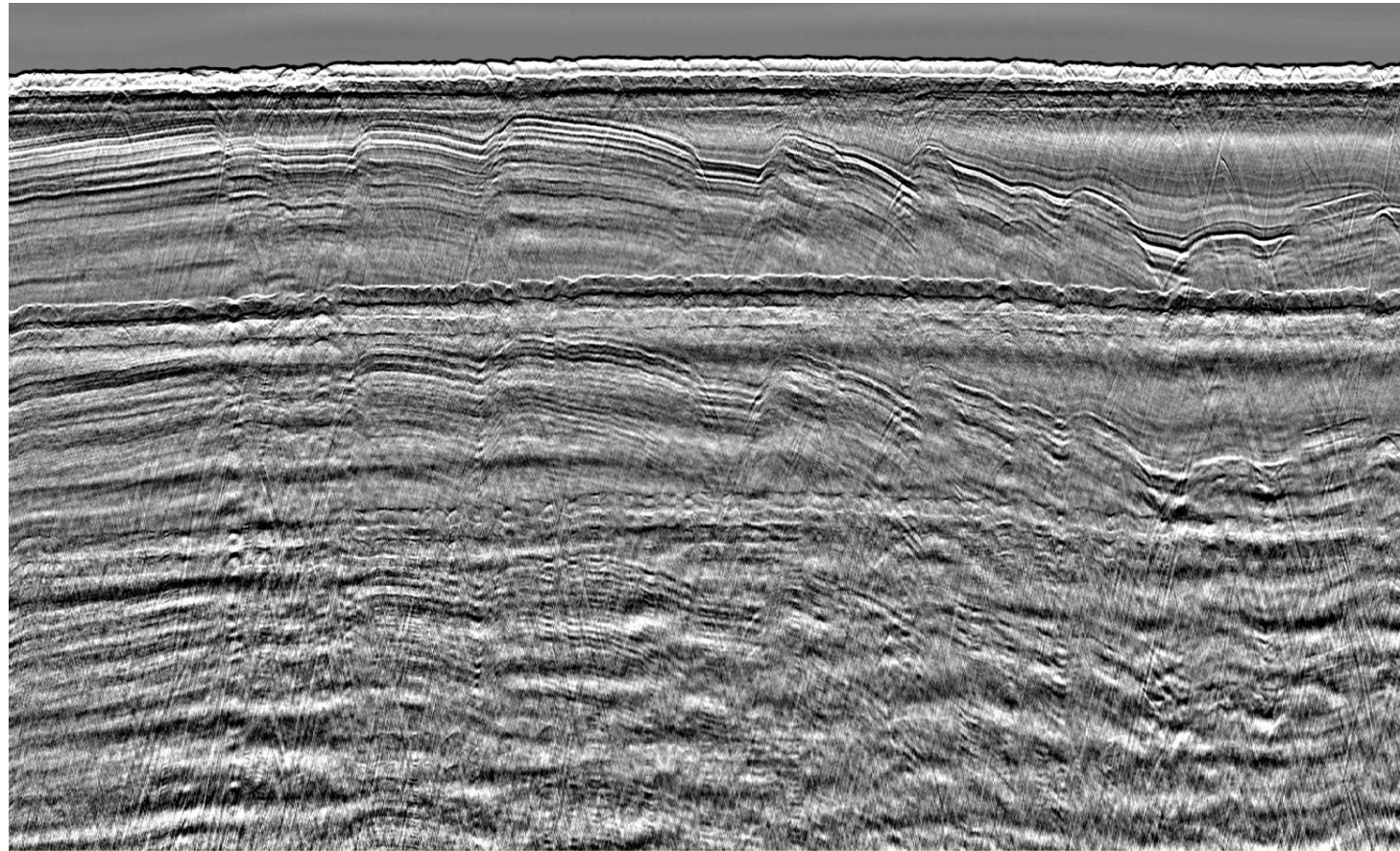
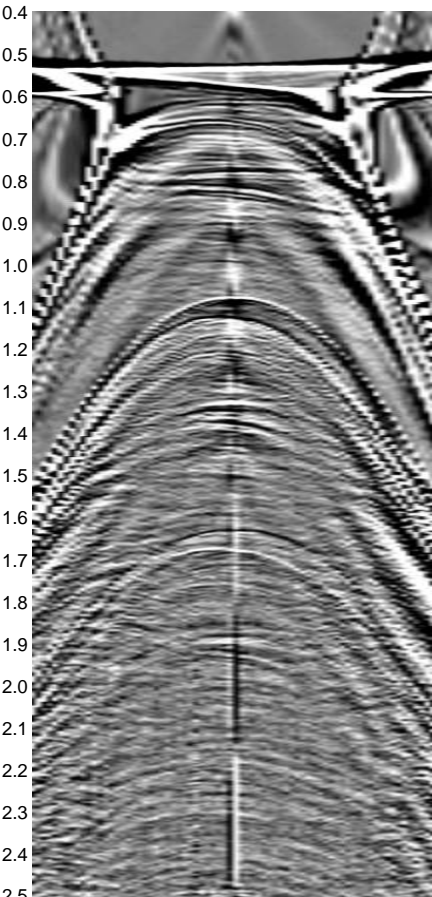
Wisting 3D TopSeis test October 2017



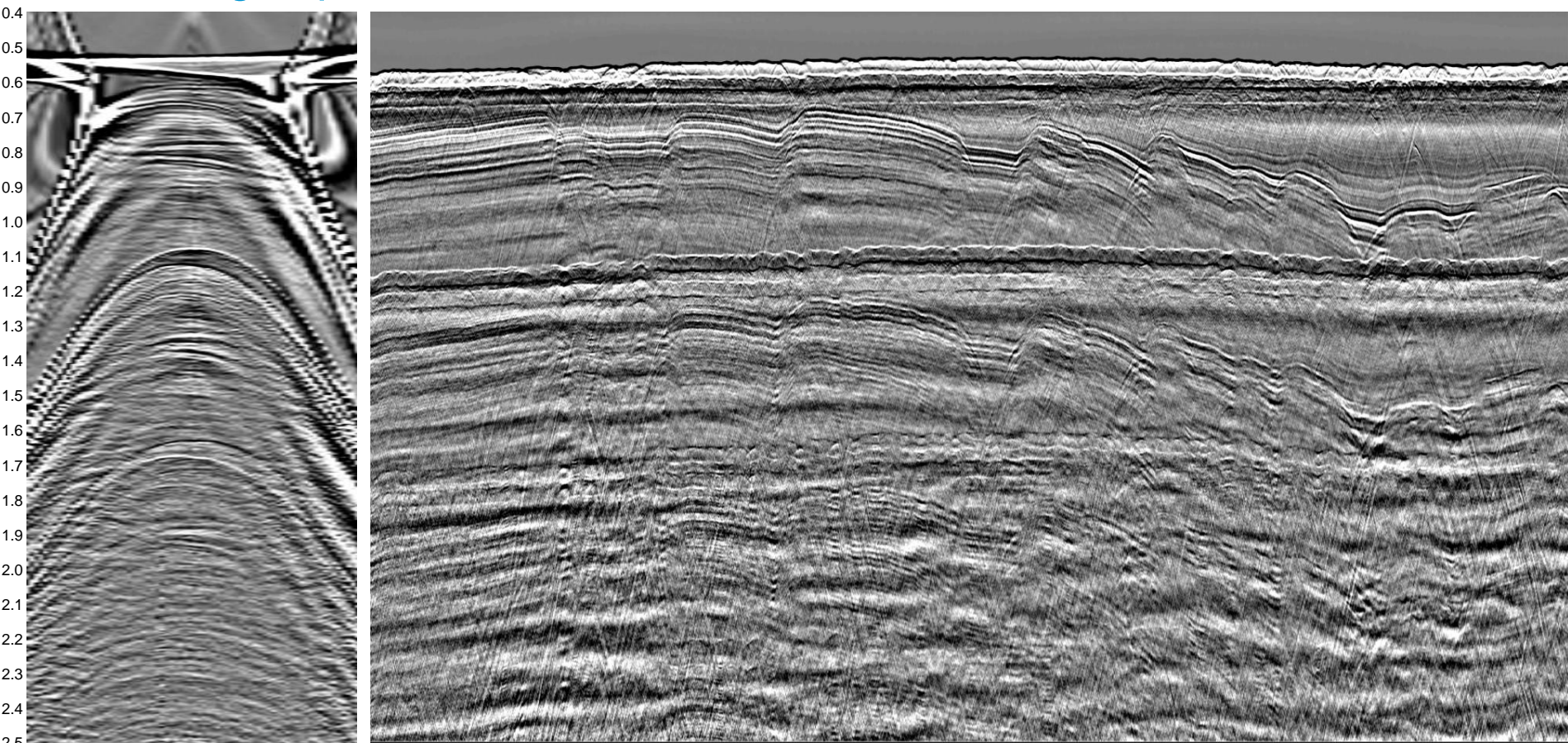
South Pole, 14th December 1911
Amundsen, Bjaaland, Hanssen, Hassel, Wisting



Wisting TopSeis: Input



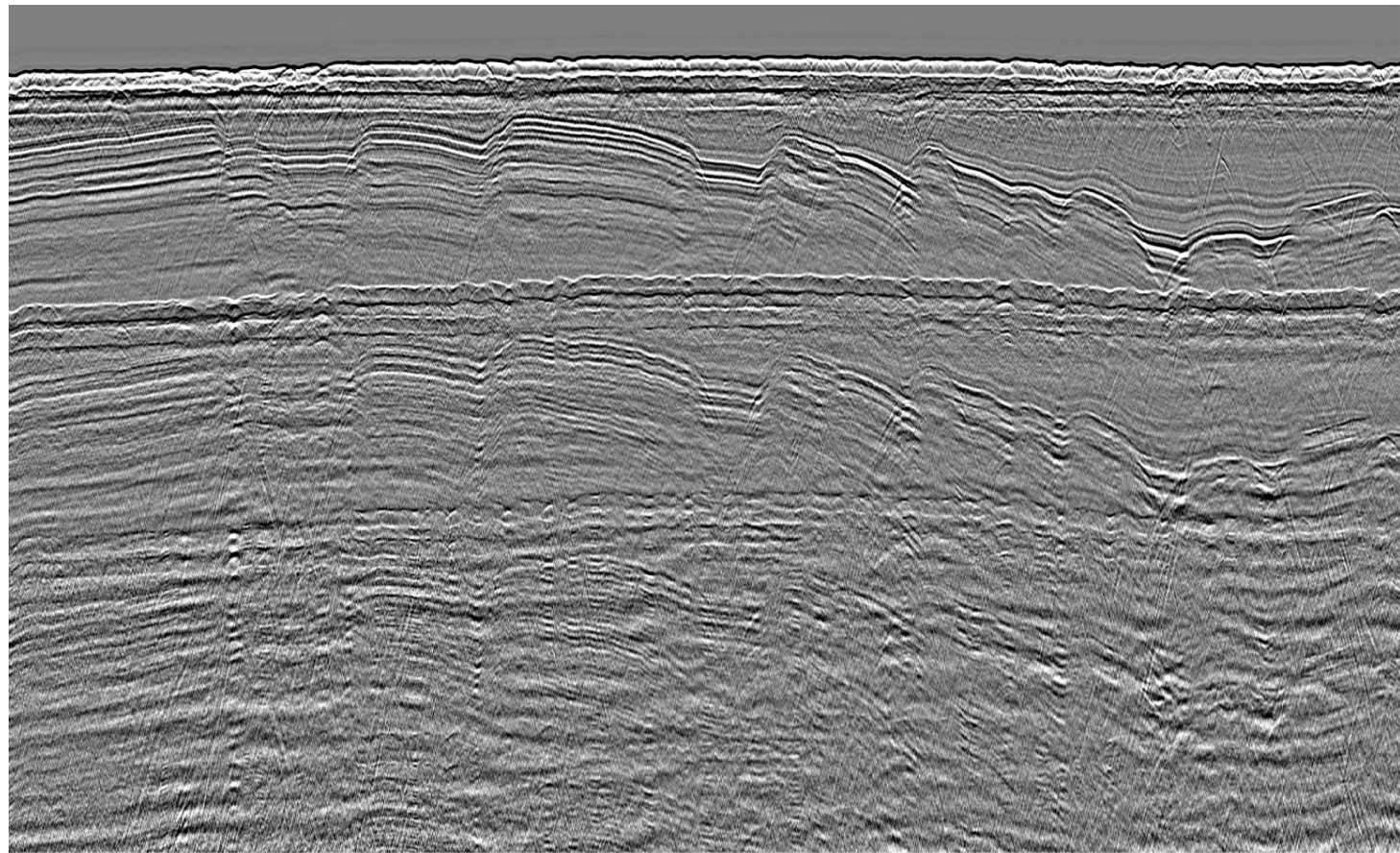
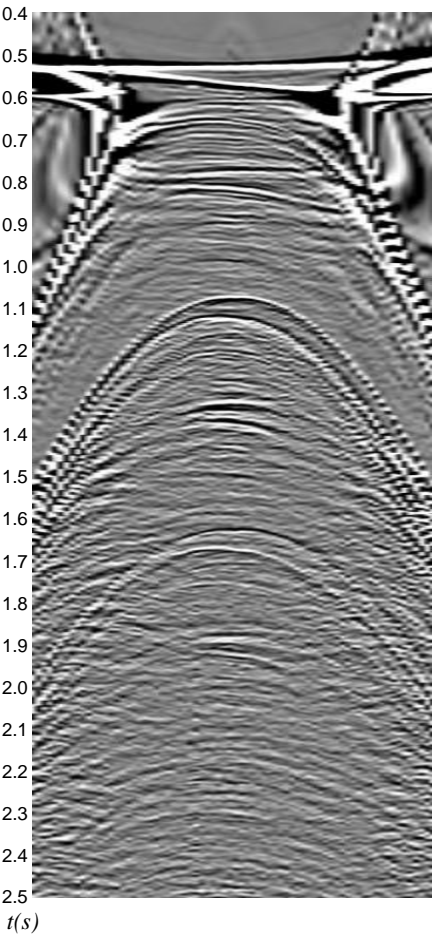
$t(s)$

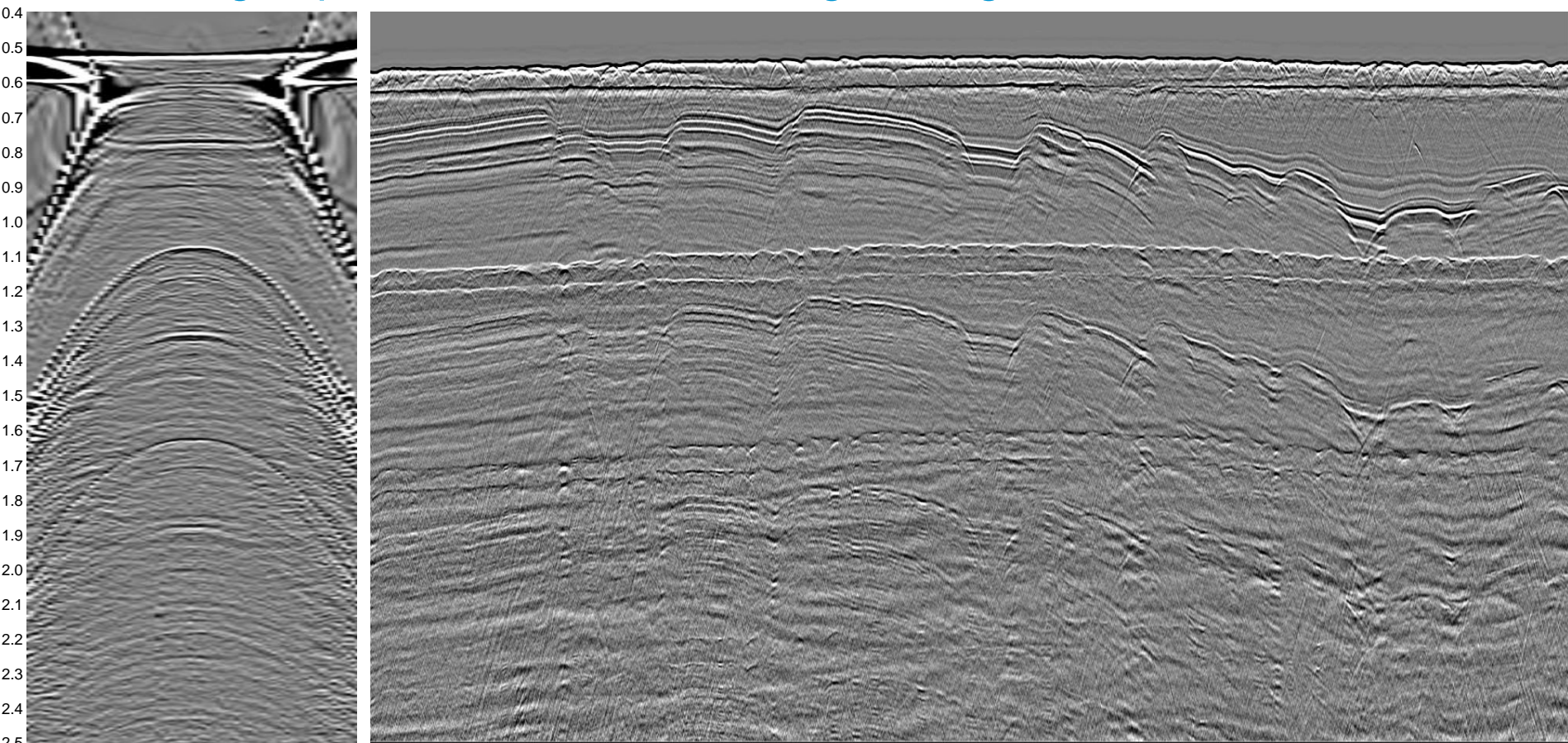


- Adaptive subtraction of direct arrival model from notional source data

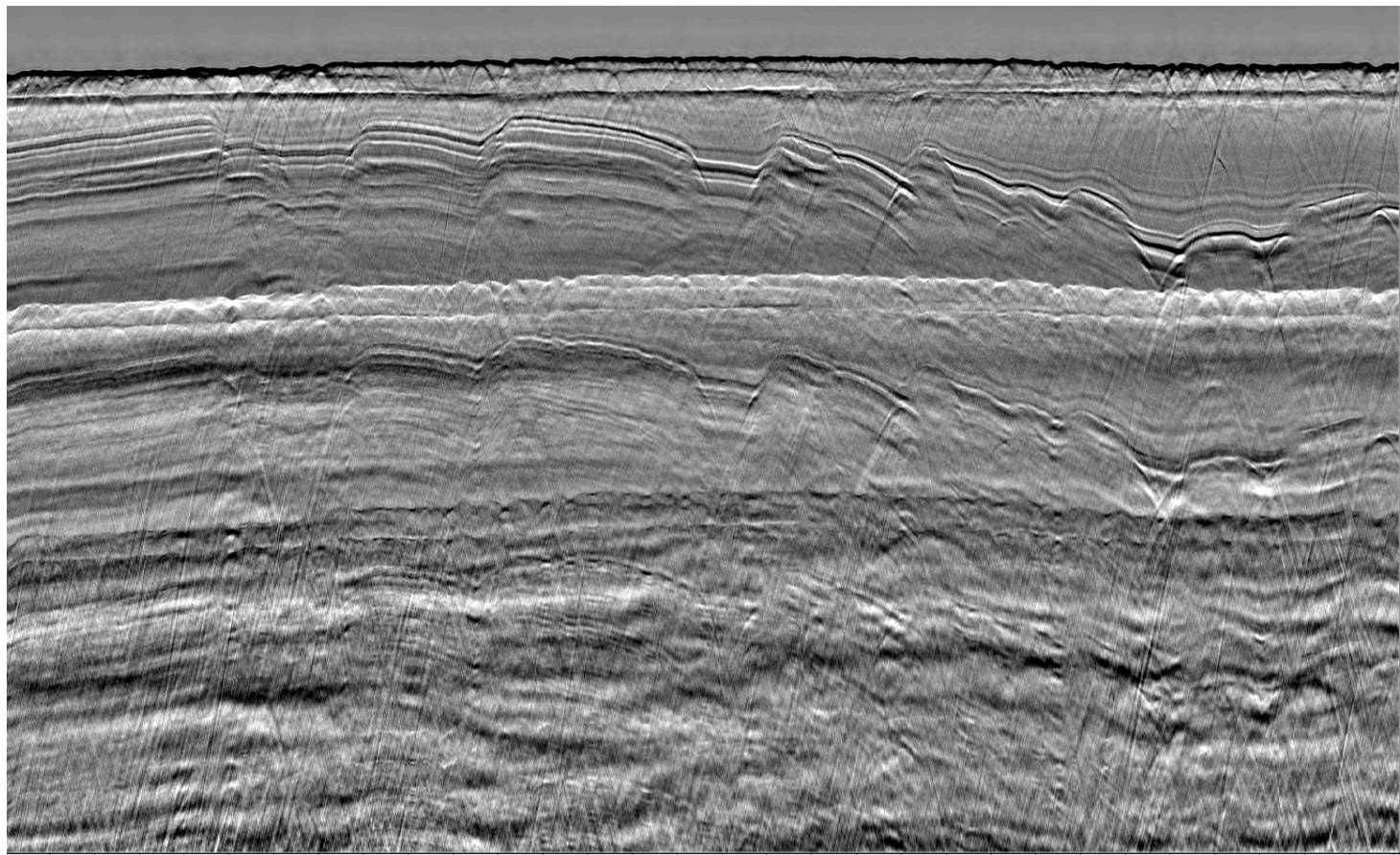
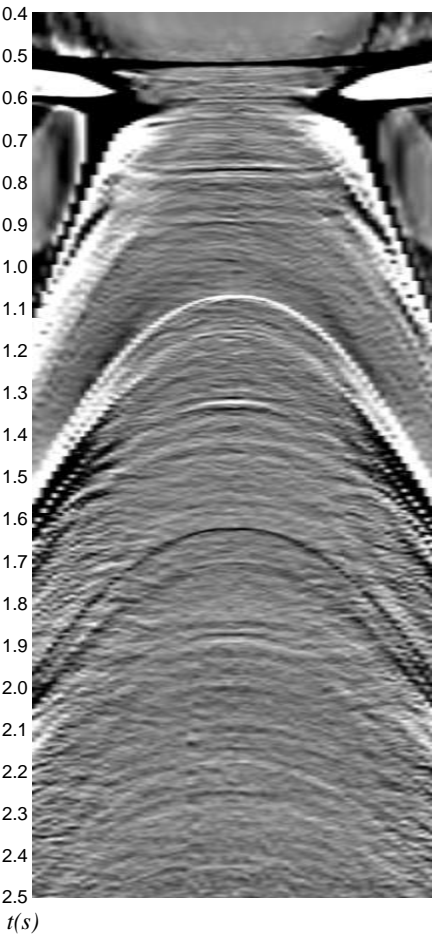


Wisting TopSeis: After source debubble and zero-phase

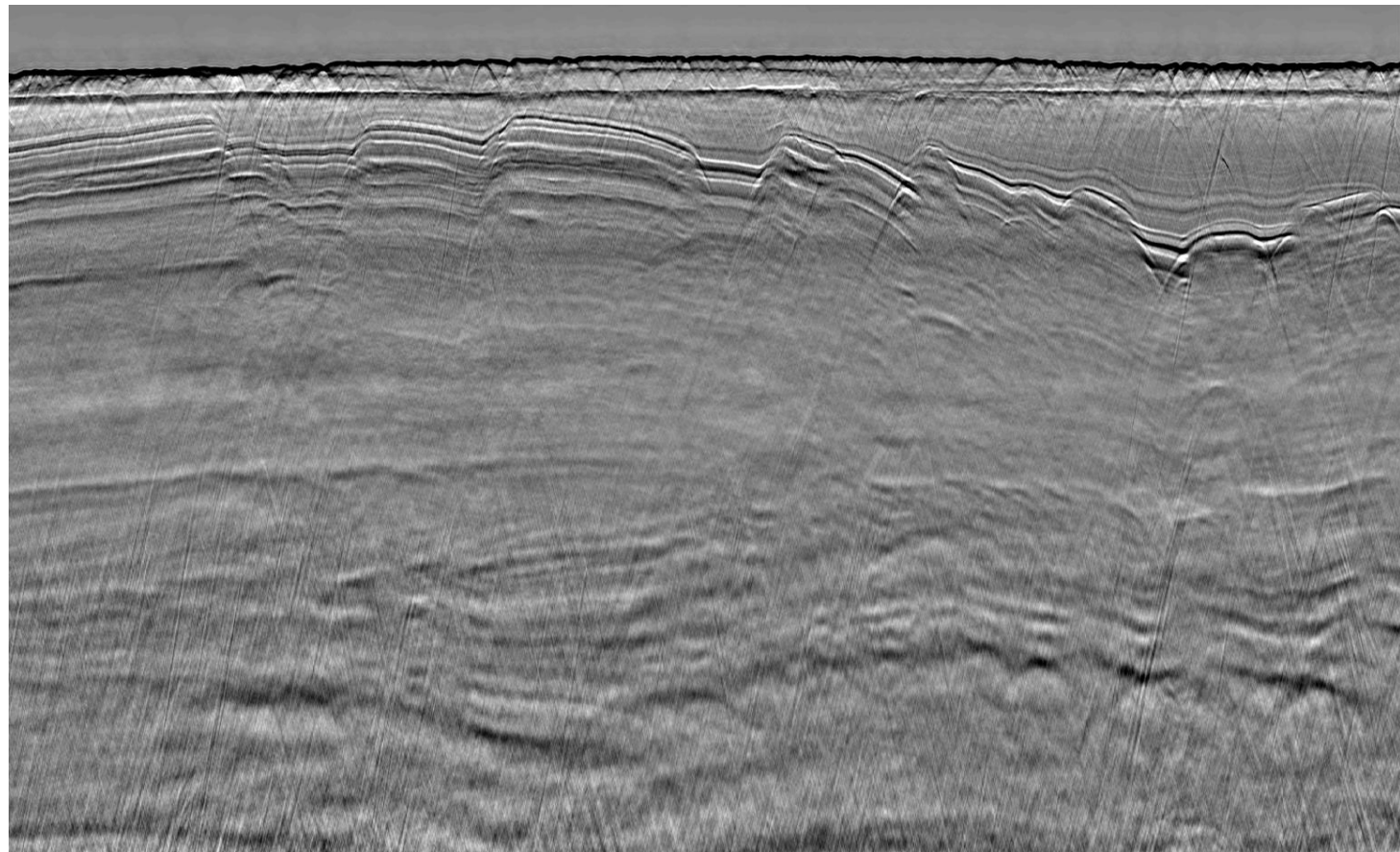
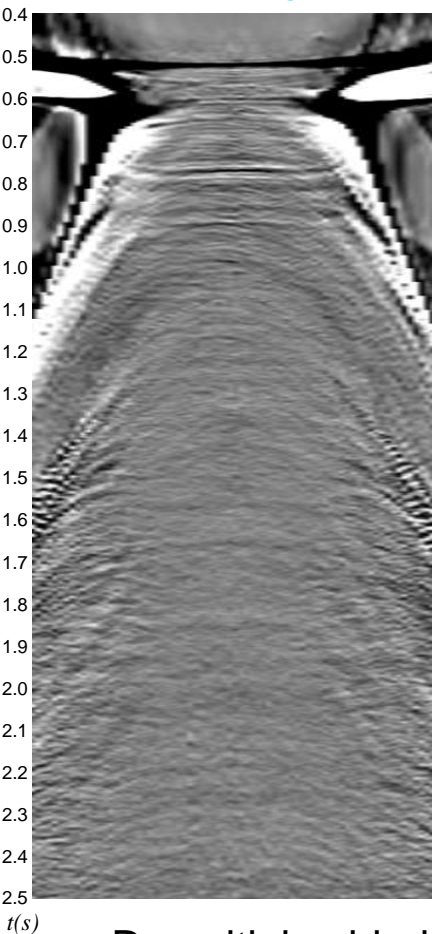




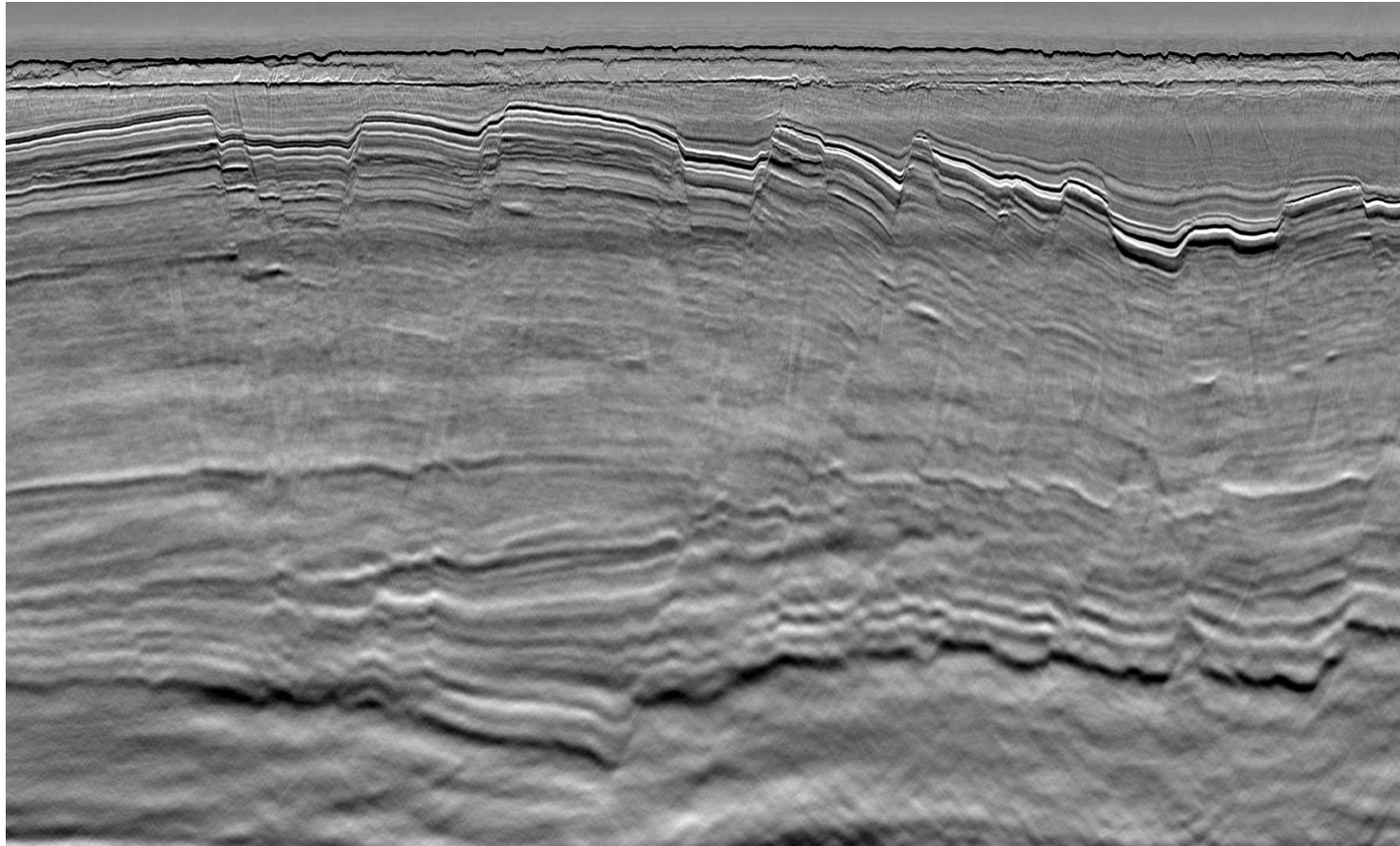
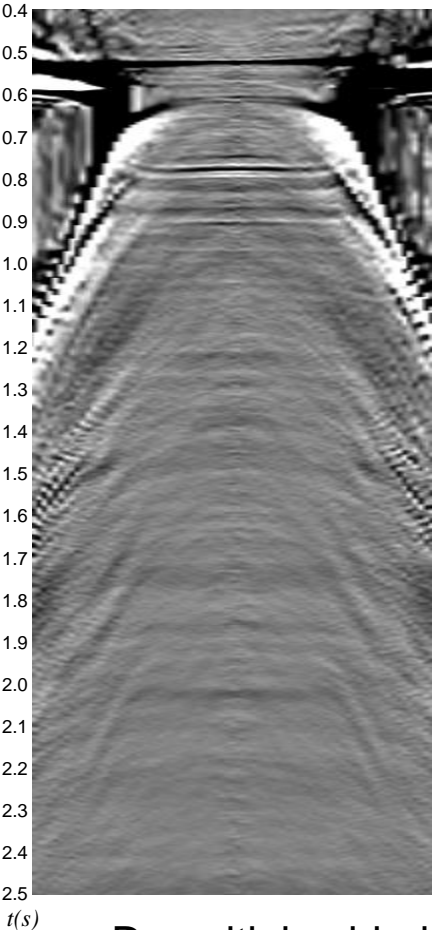
- Tilted hyperbolic deghosting; developed to respect highly non-linear kinematics at short offsets



$t(s)$



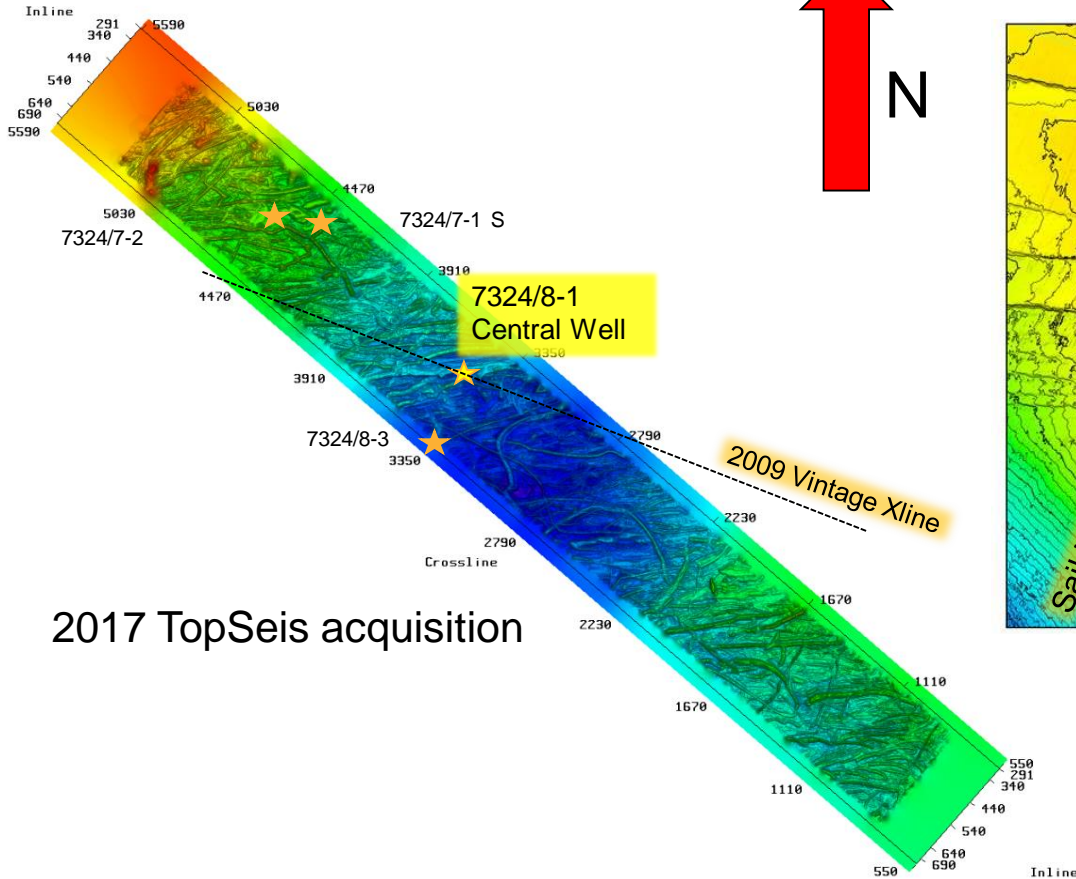
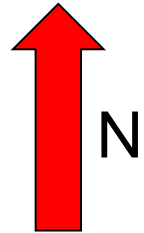
- Demultiple aided through the recording of multiple generator at short offsets



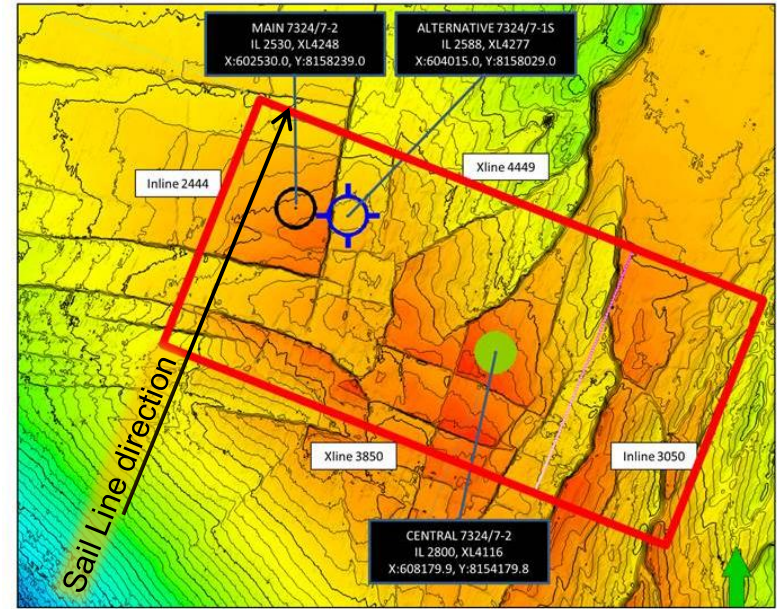
- Demultiple aided through the recording of multiple generator at short offsets



TopSeis 2017 vs Vintage 2009 acquisition



2017 TopSeis acquisition

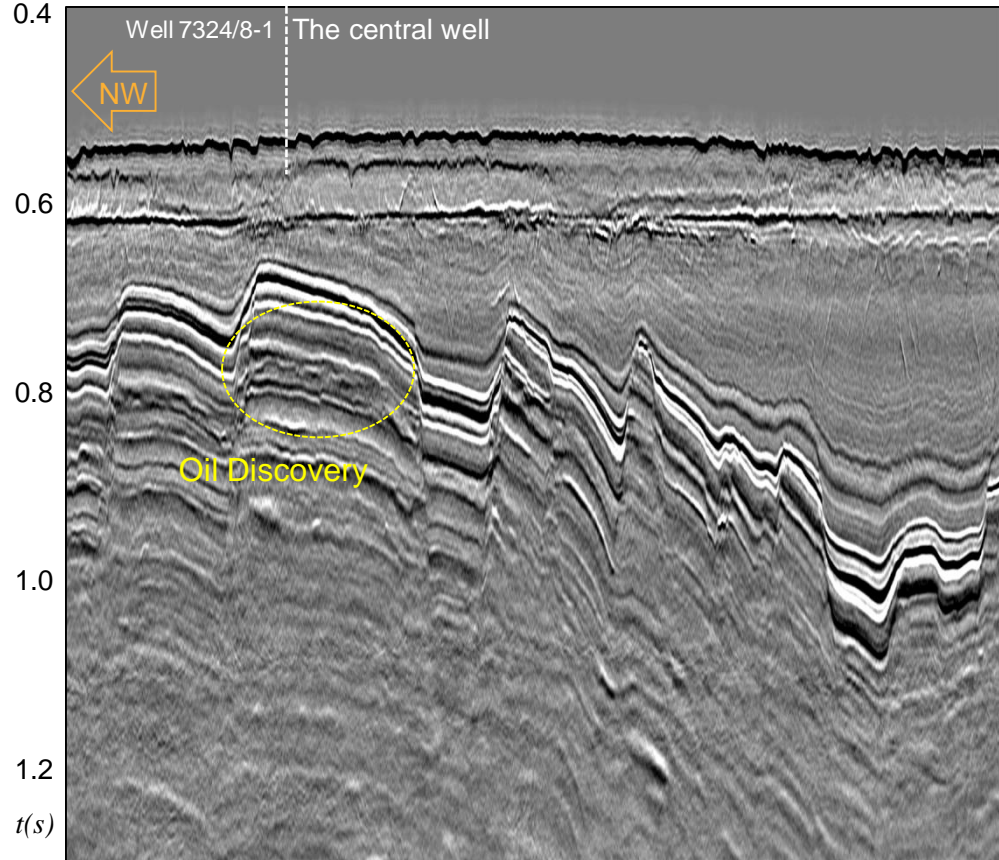


2009 Vintage acquisition

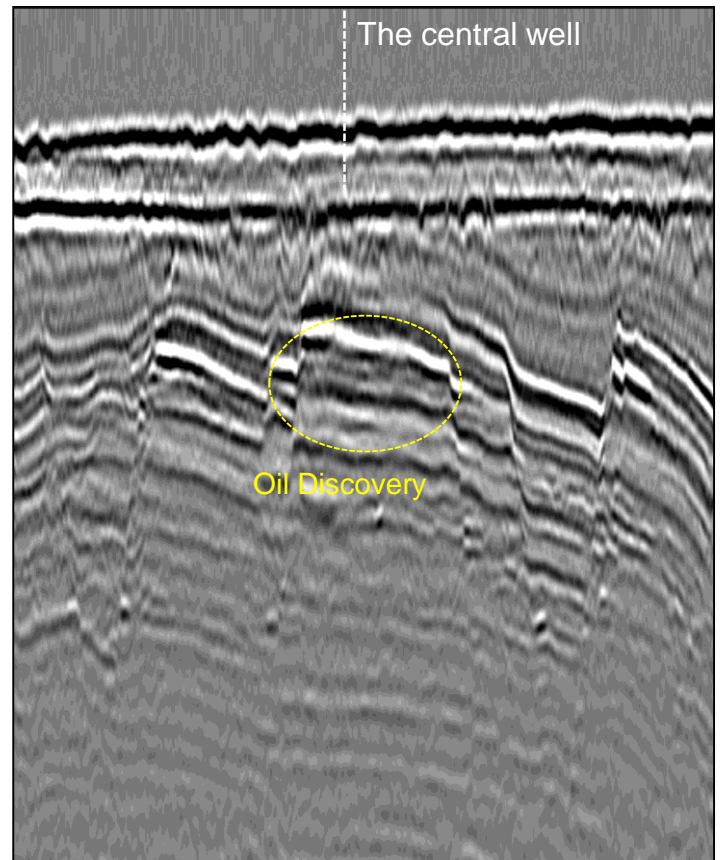


TopSeis vs Vintage through Central Well - @@

TopSeis 2017 – preliminary image (Inline)

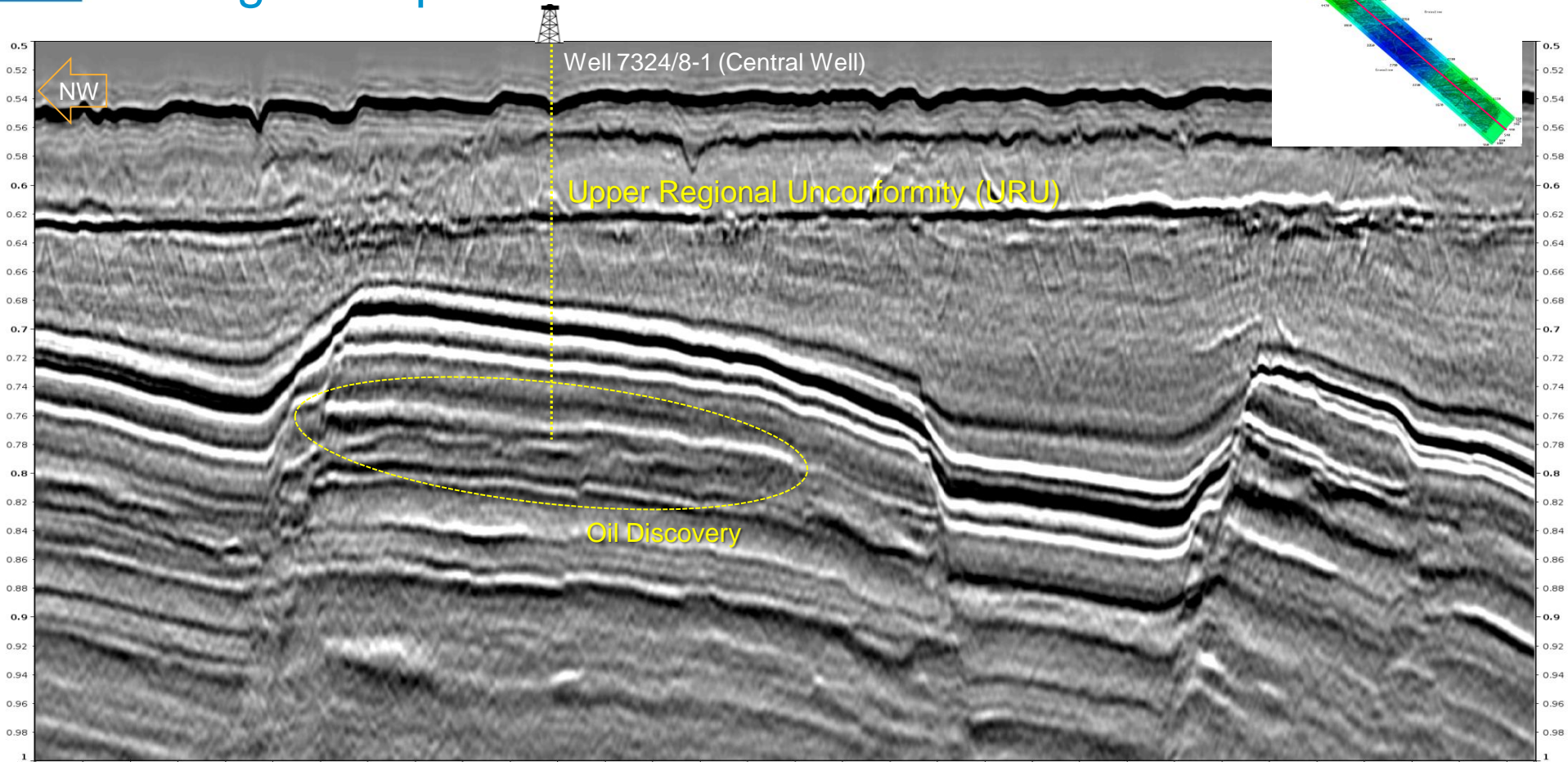


Vintage 2009 (Xline)



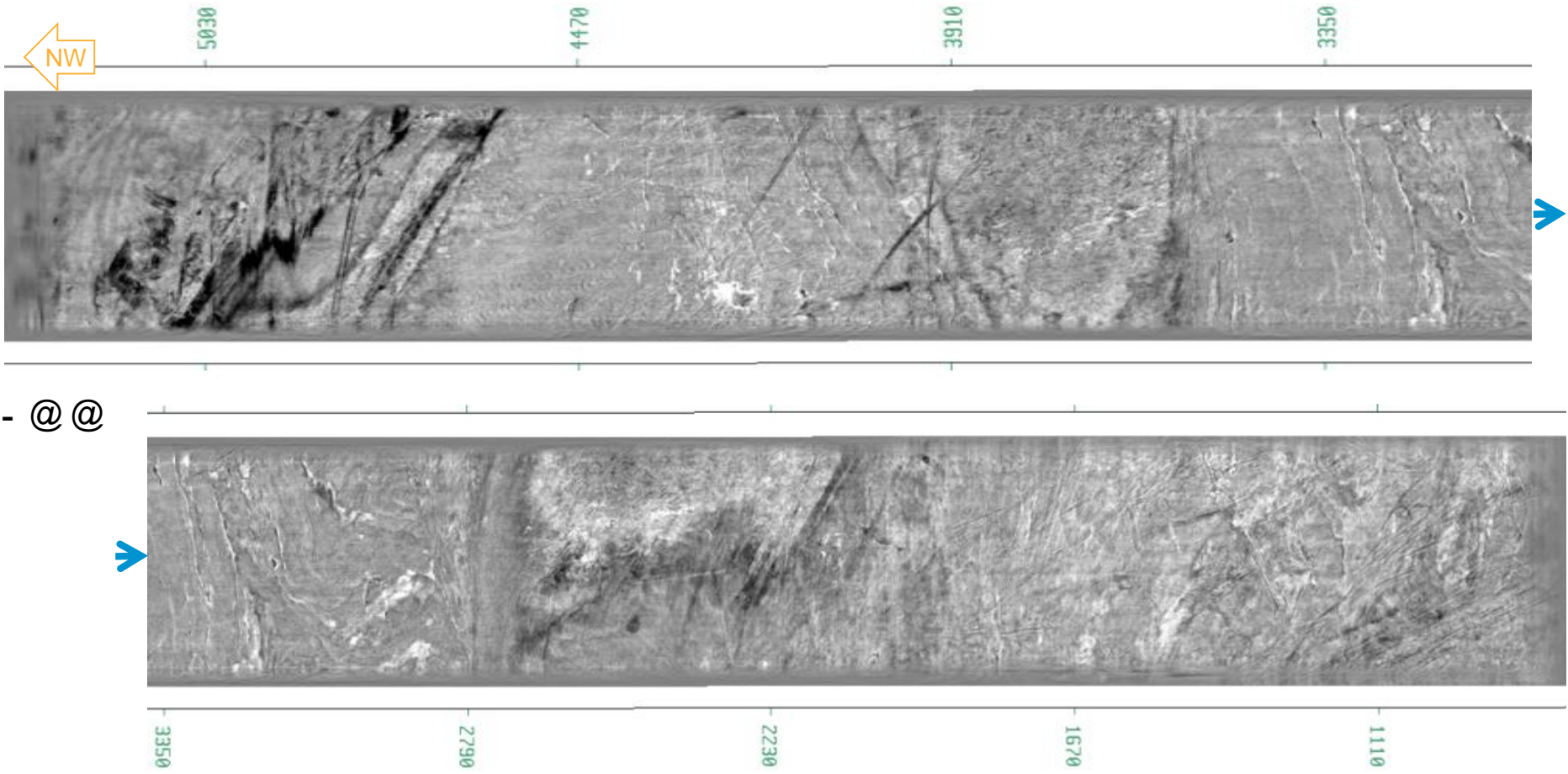
NOTE: The two data sets have been acquired in different directions

Wisting 3D TopSeis IL475 – ZOOM - @@

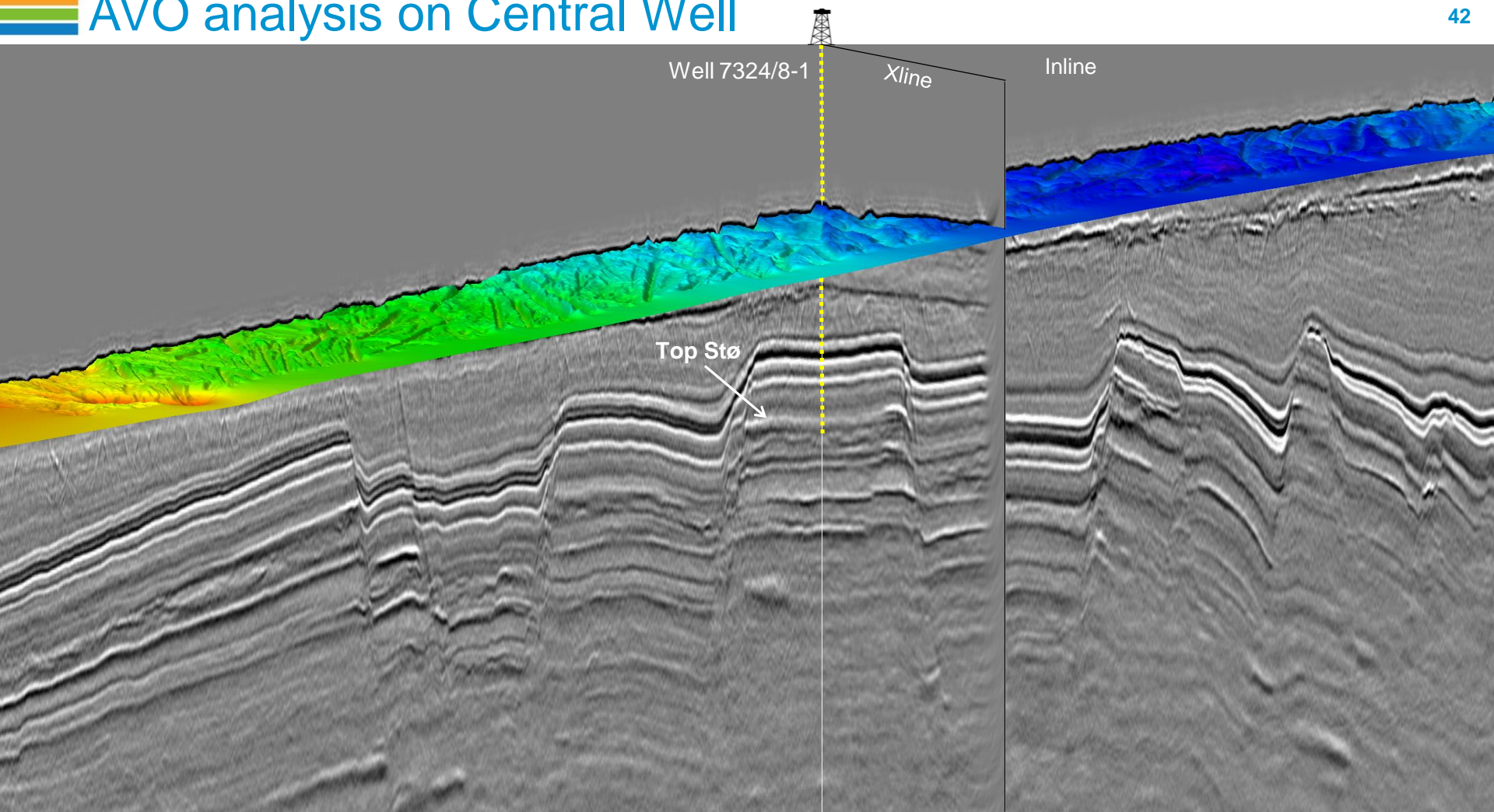




Wisting 3D TopSeis time slice at 600ms (above URU)

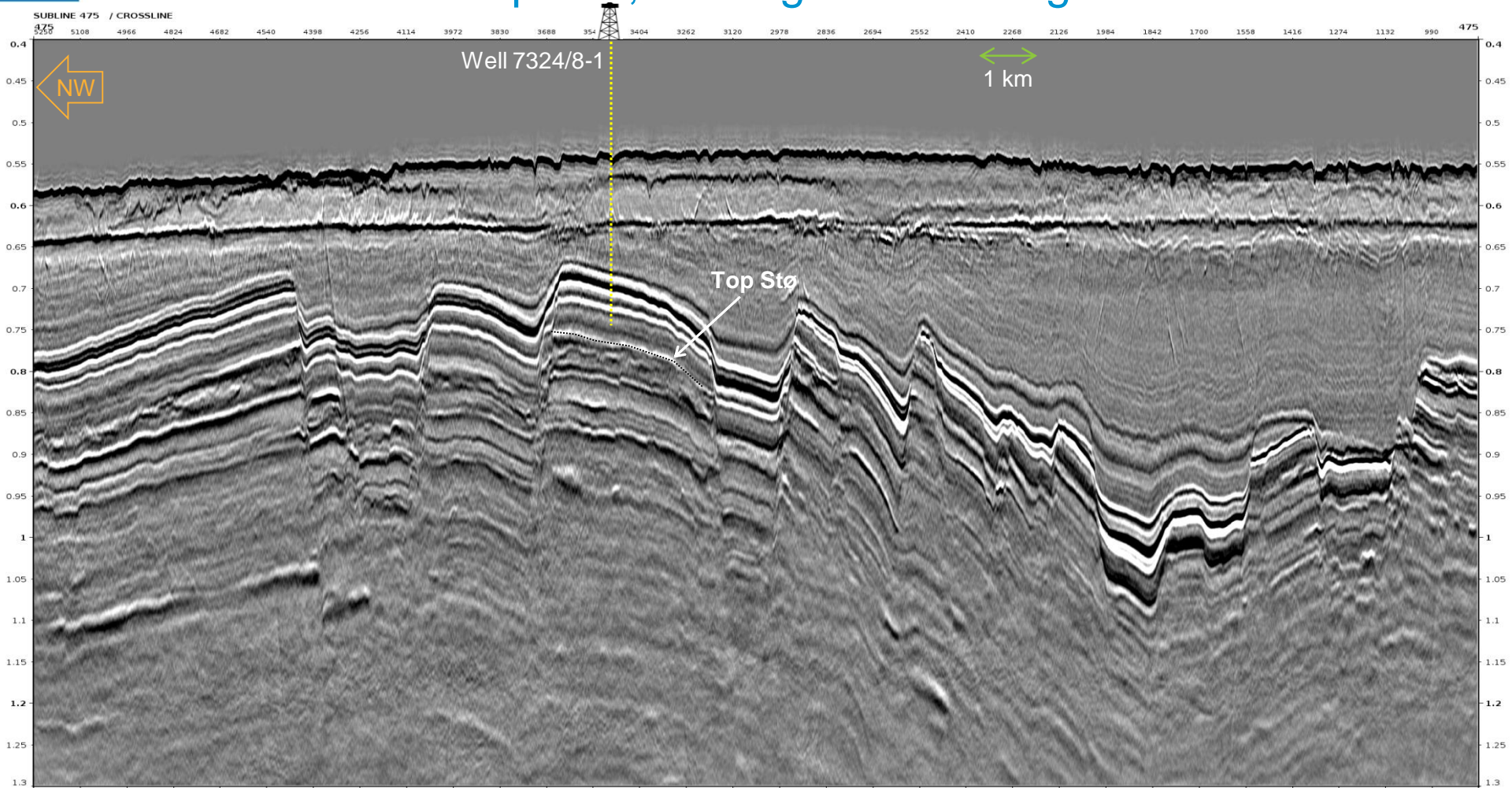


AVO analysis on Central Well



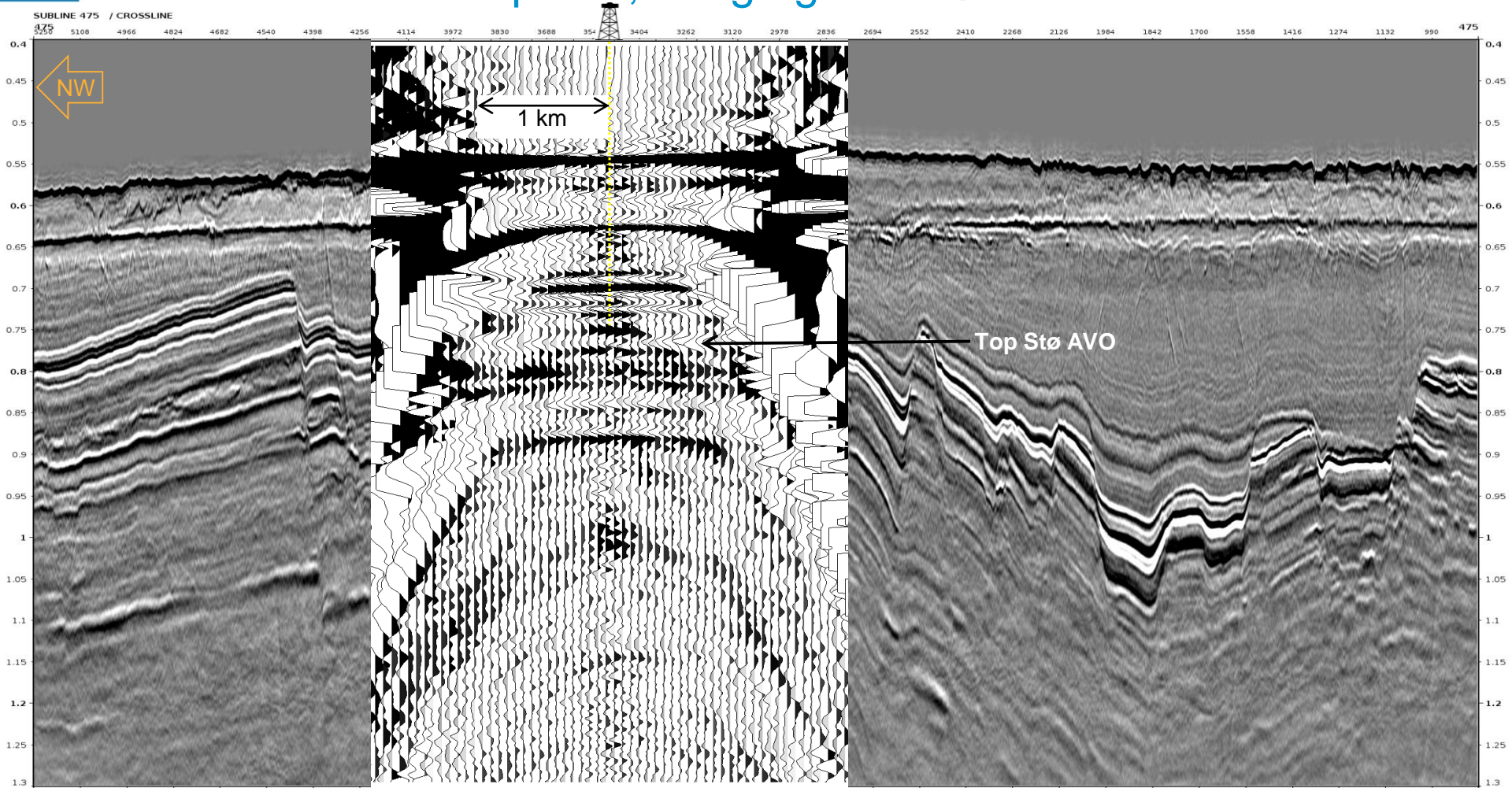


Shallow AVO with TopSeis; Wisting Inline through central well



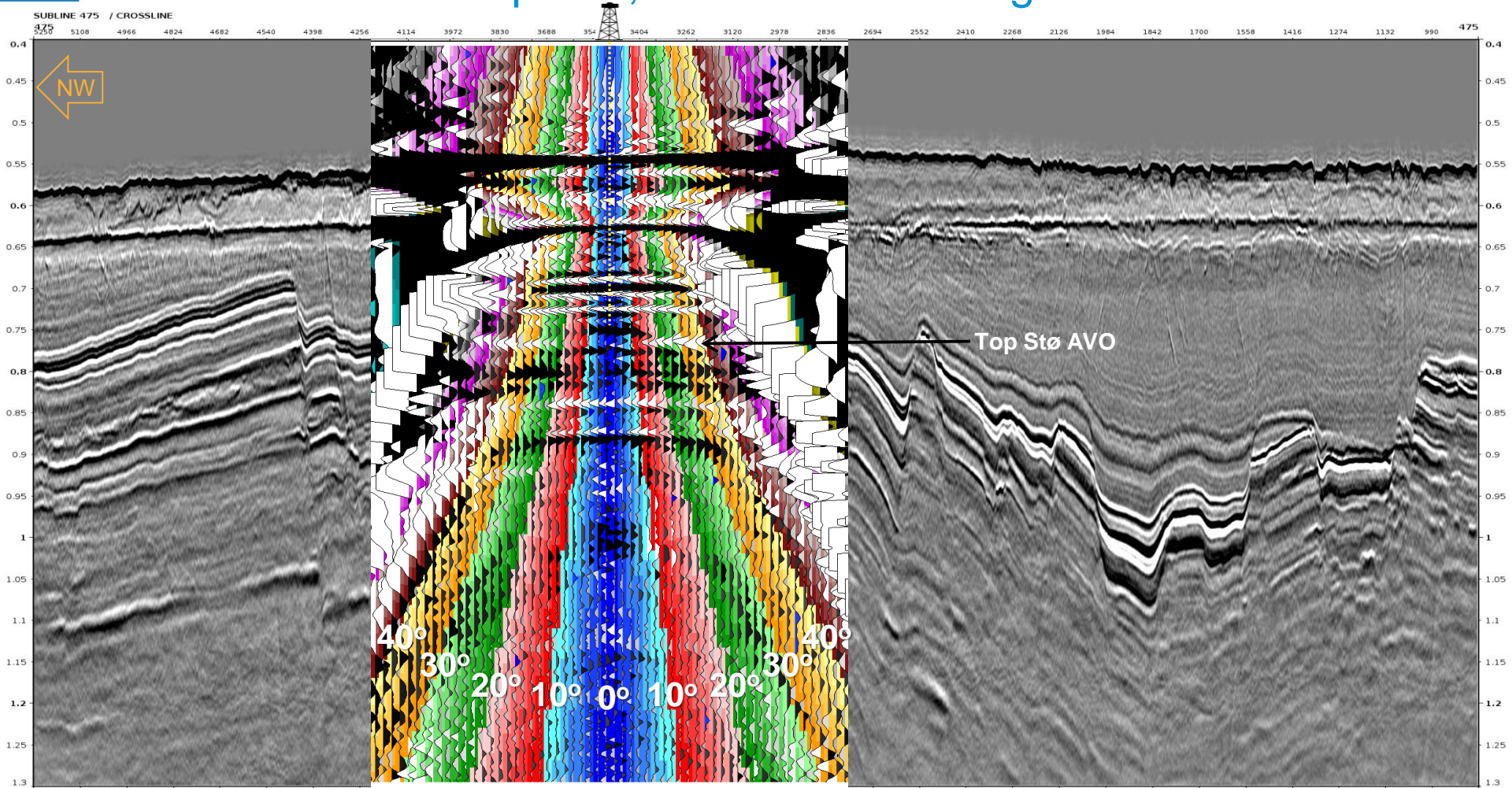


Shallow AVO with TopSeis; Image gather @ Central Well

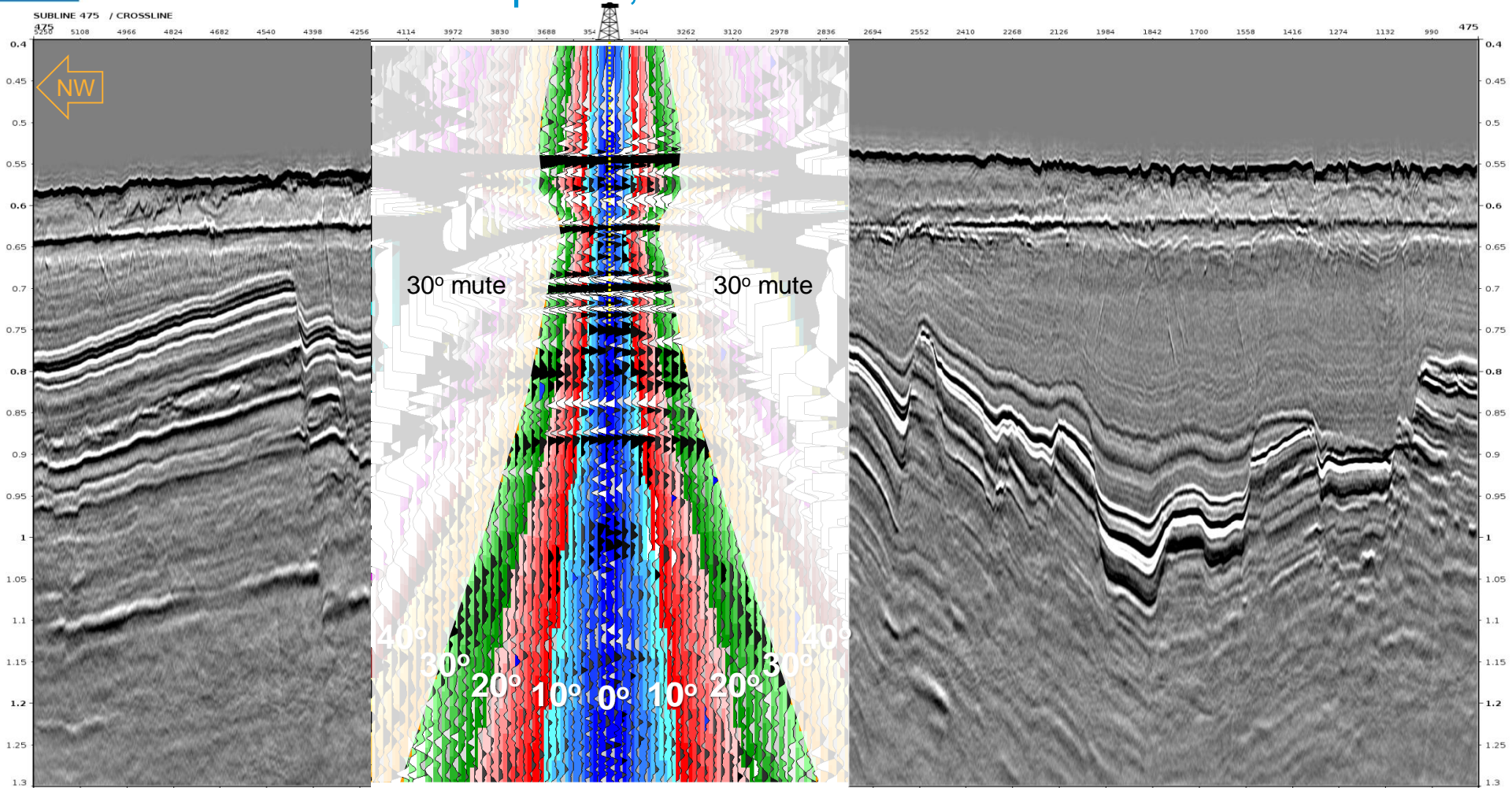




Shallow AVO with TopSeis; With reflection angle

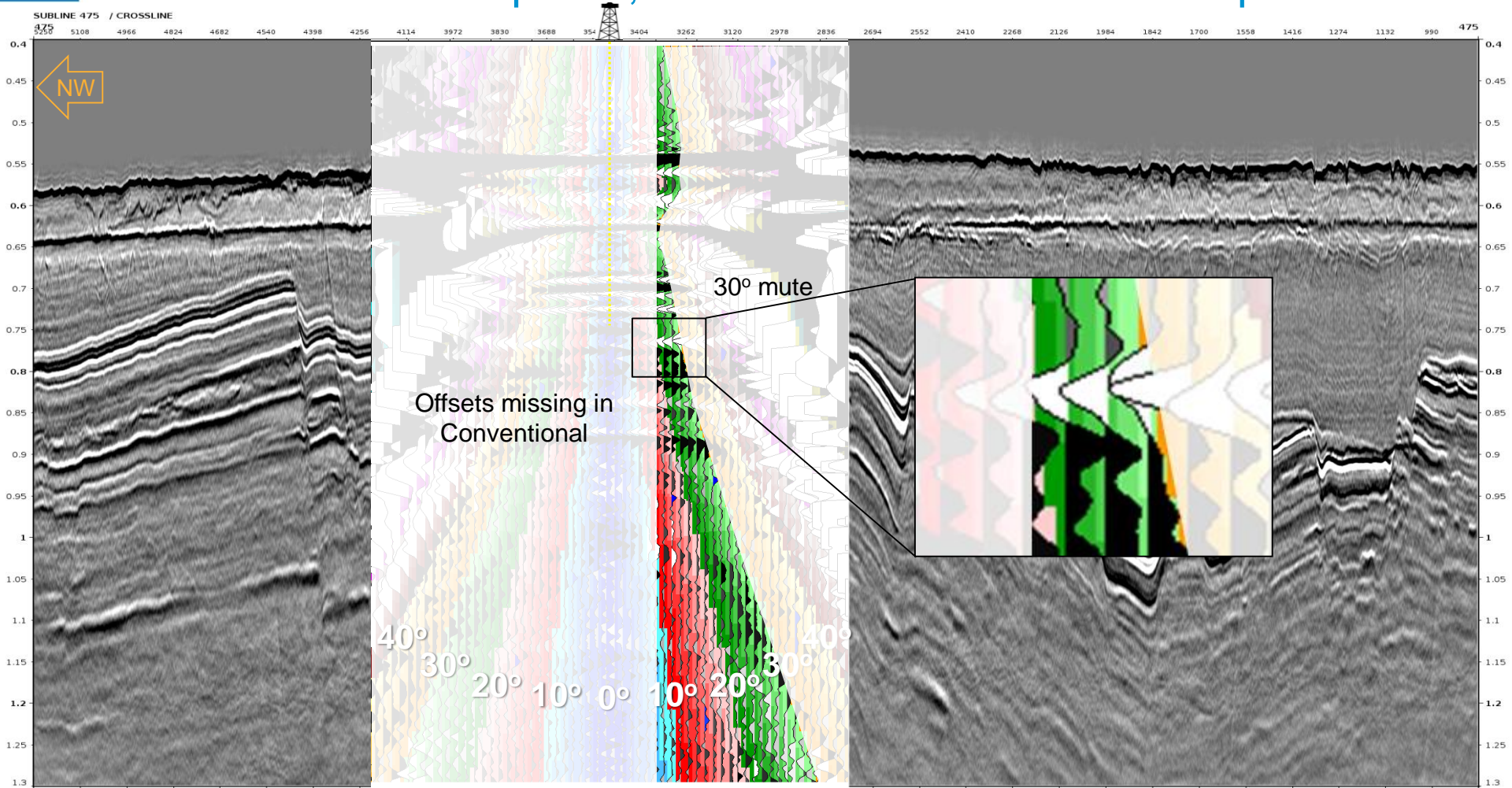


Shallow AVO with TopSeis; Stack mute



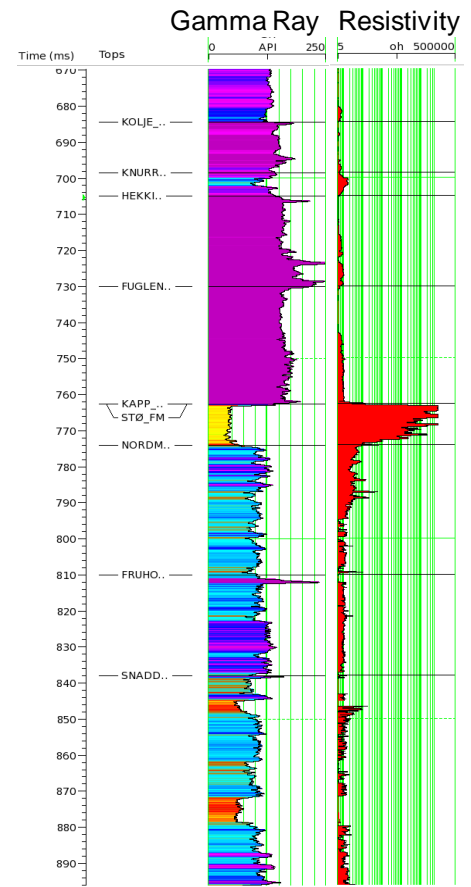
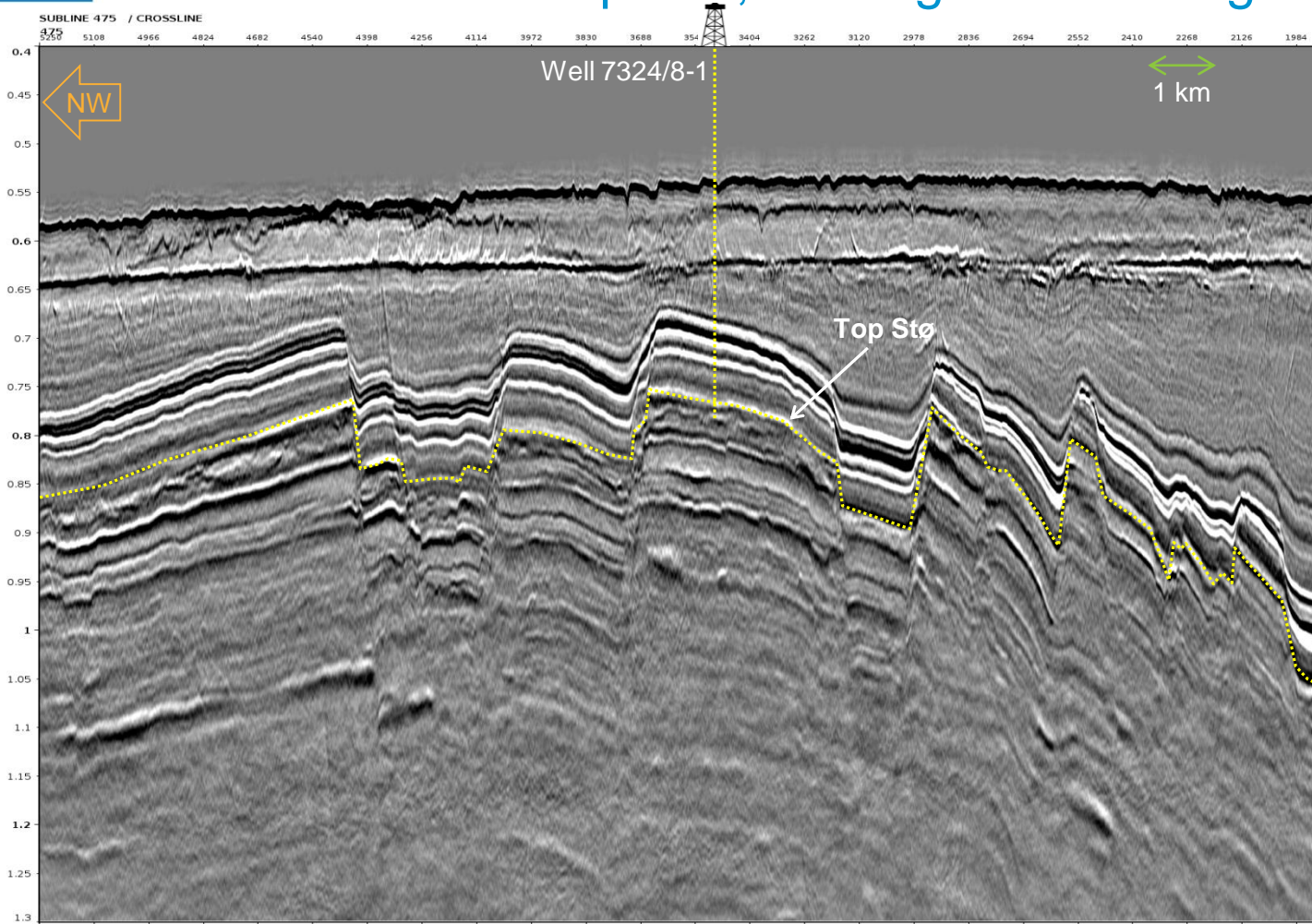


Shallow AVO with TopSeis; Conventional offsets for comparison



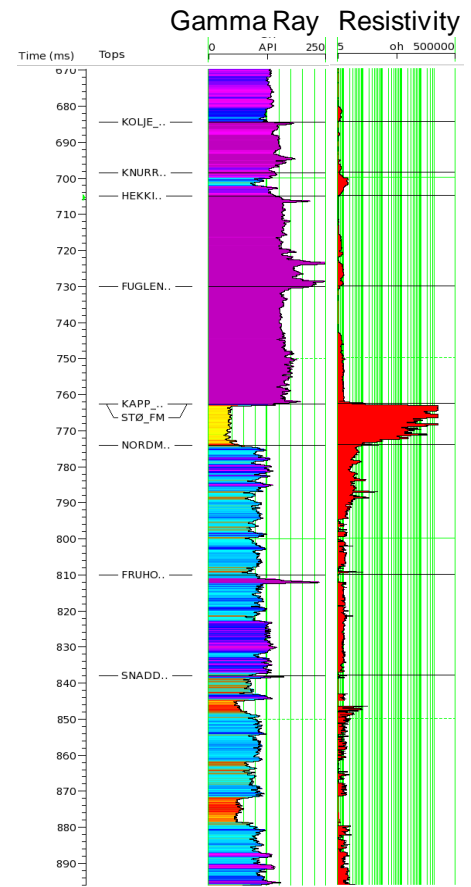
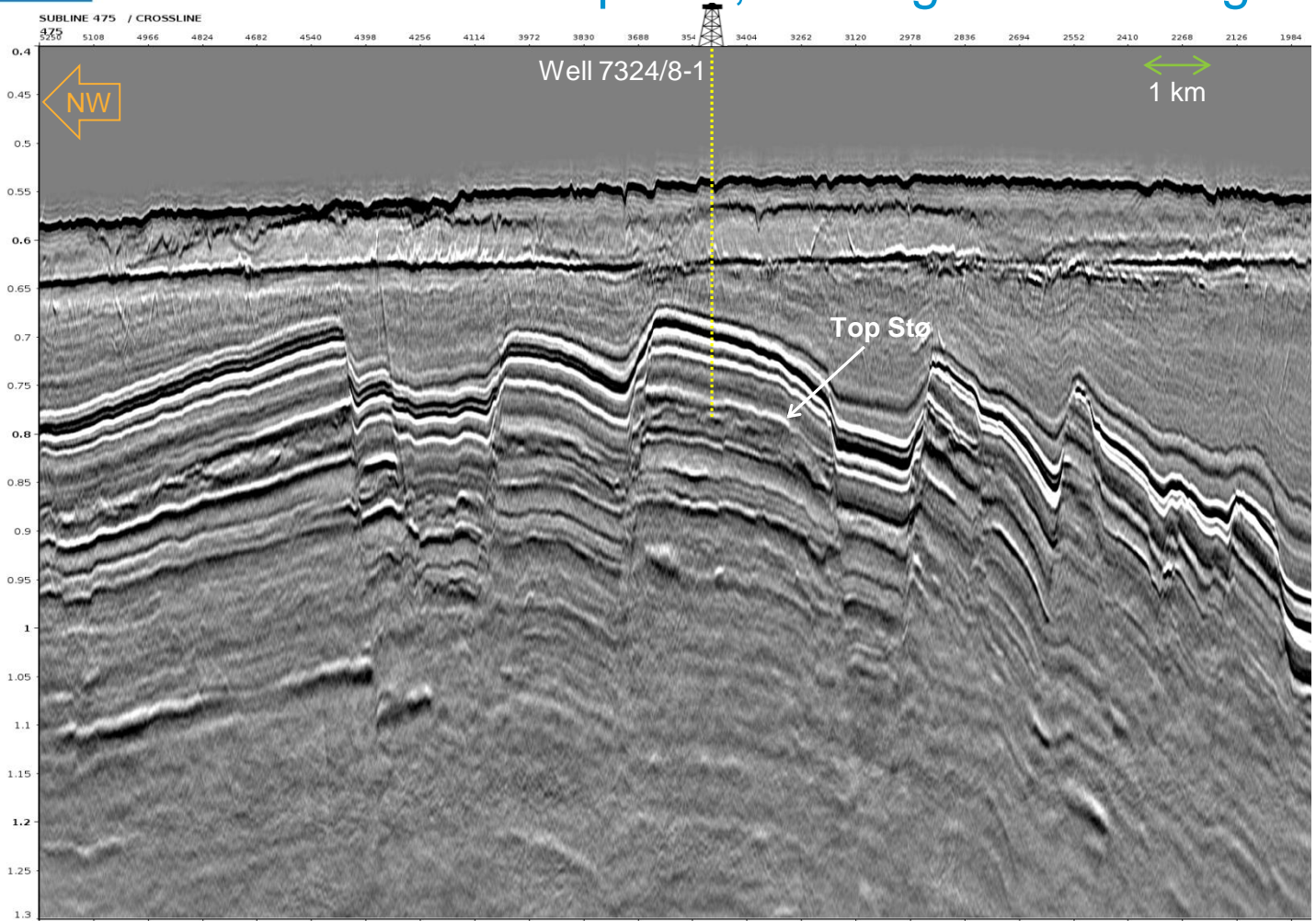


Shallow AVO with TopSeis; Wisting Inline through central well



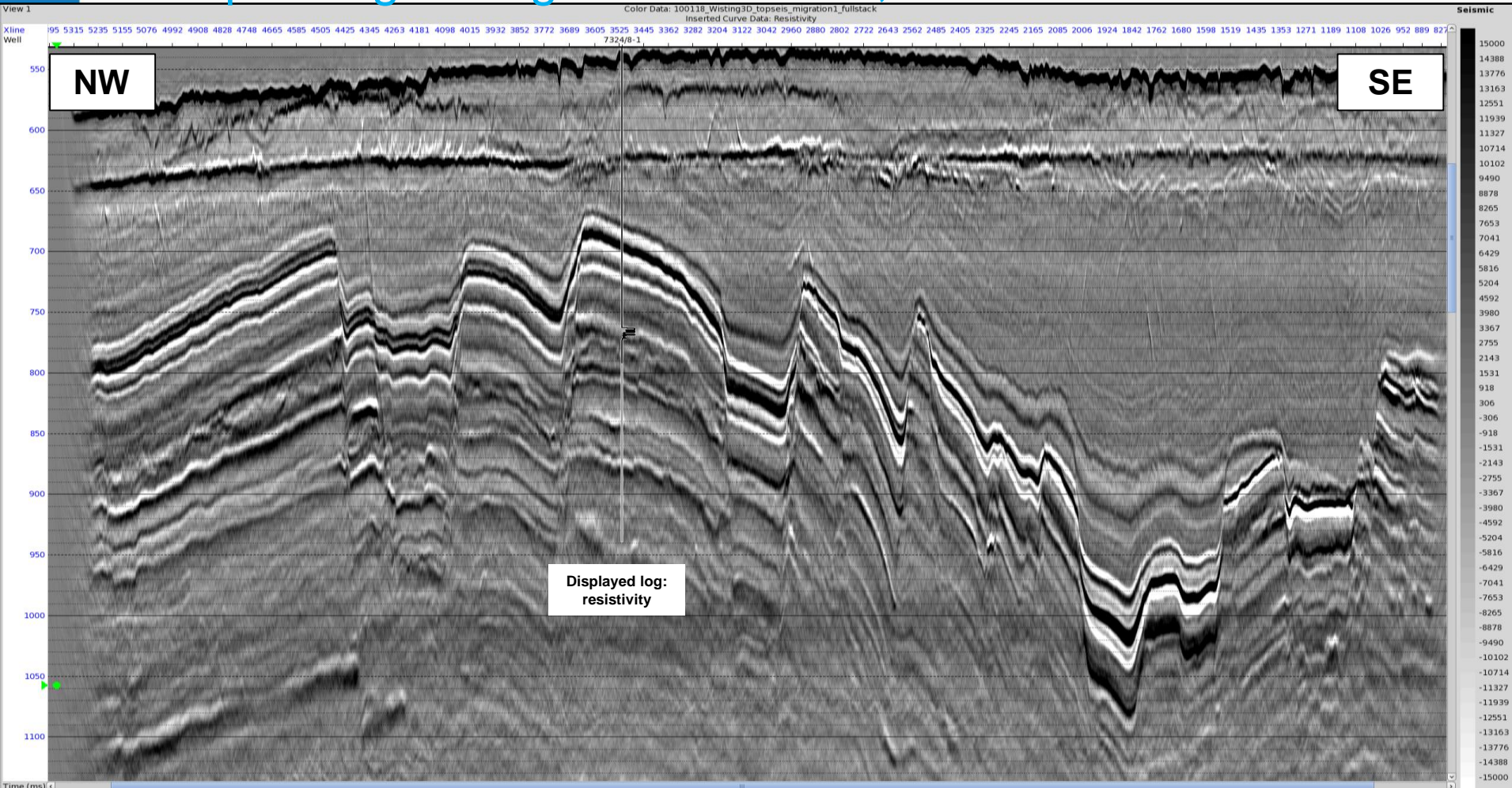


Shallow AVO with TopSeis; Wisting Inline through central well

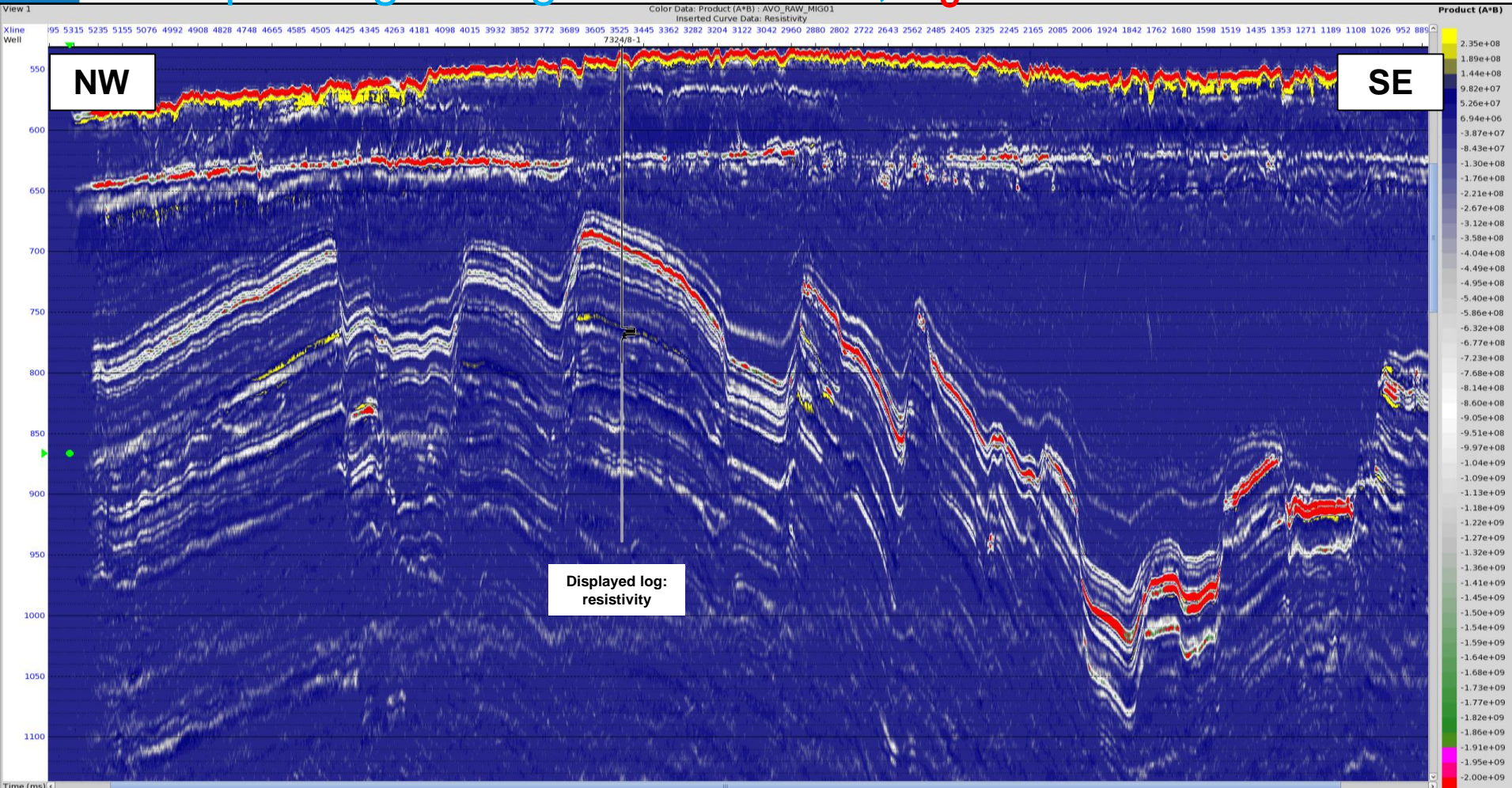




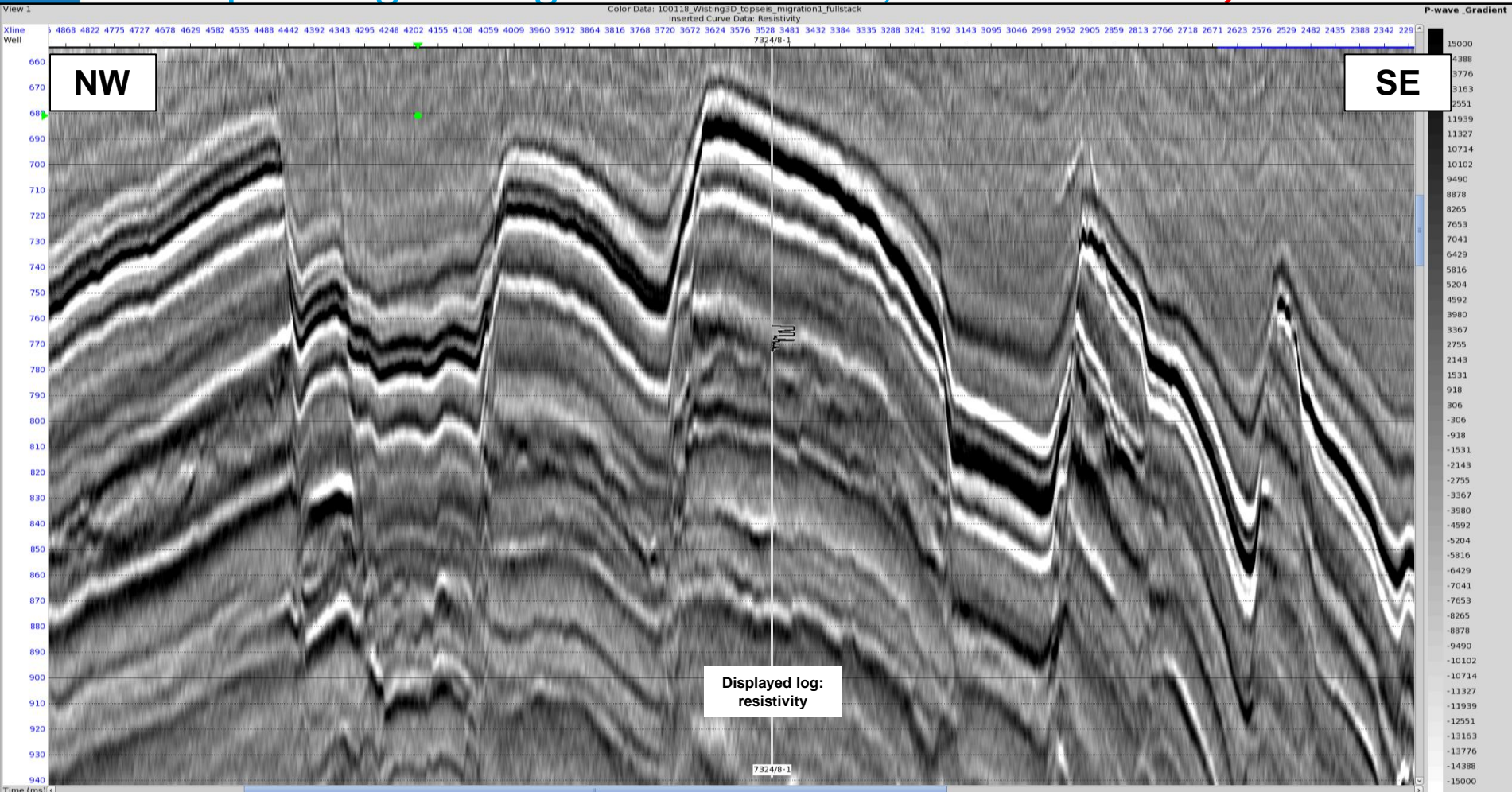
Inline passing through Central Well, FULL STACK



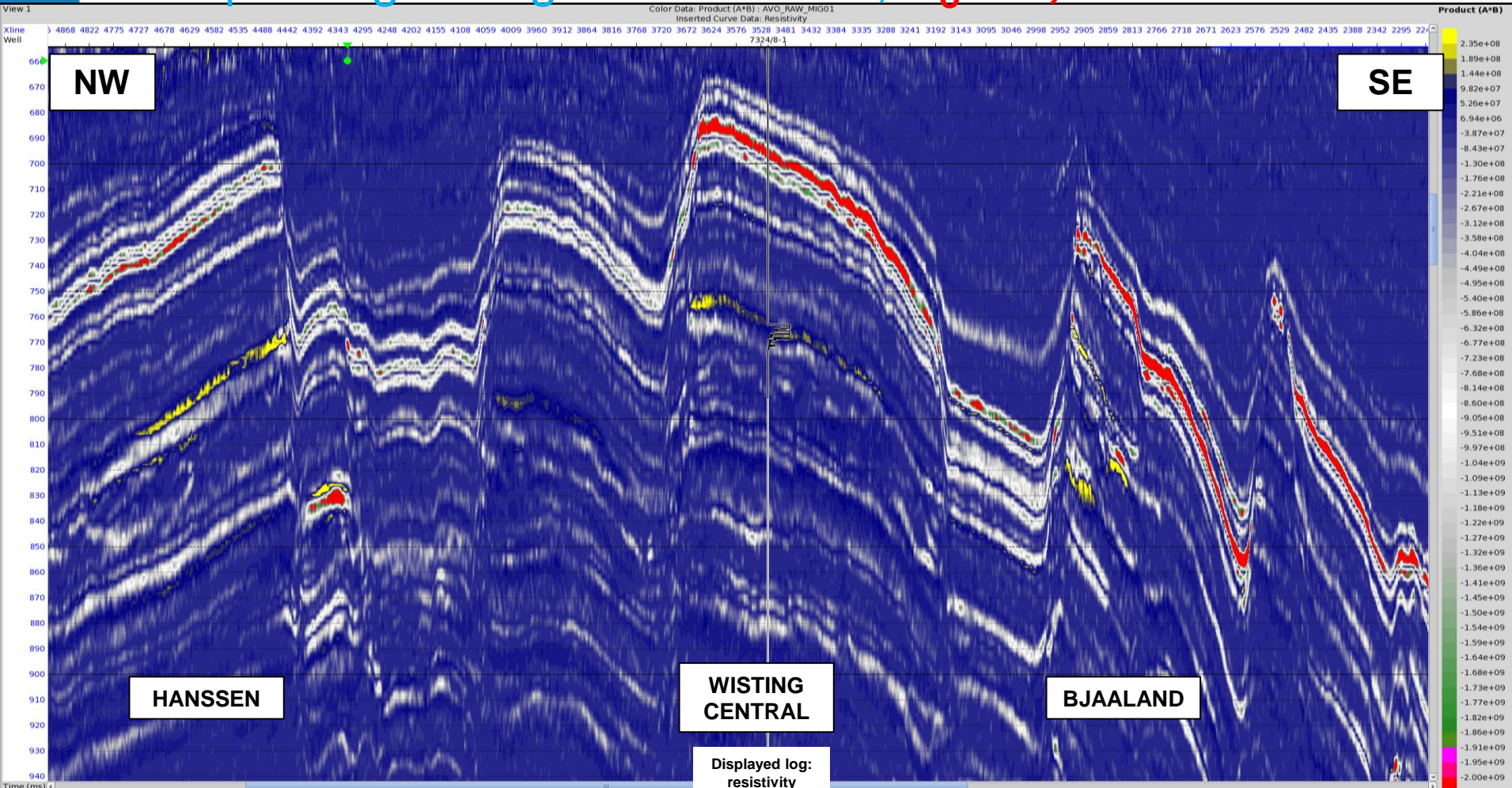
Inline passing through Central Well, $R_o * G$



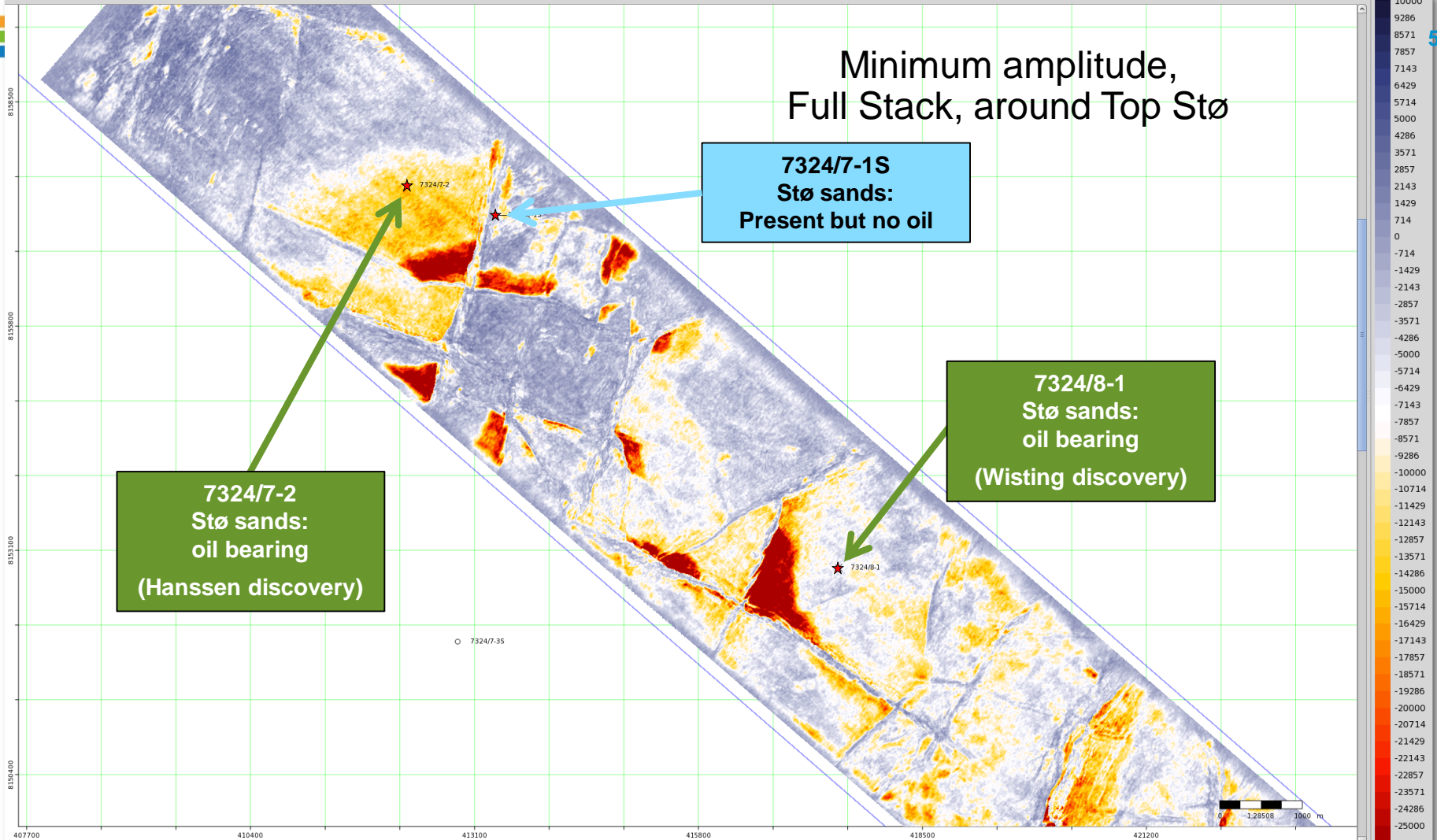
Inline passing through Central Well, FULL STACK, ZOOM



Inline passing through Central Well, $R_o * G$, ZOOM



Minimum amplitude, Full Stack, around Top Stø



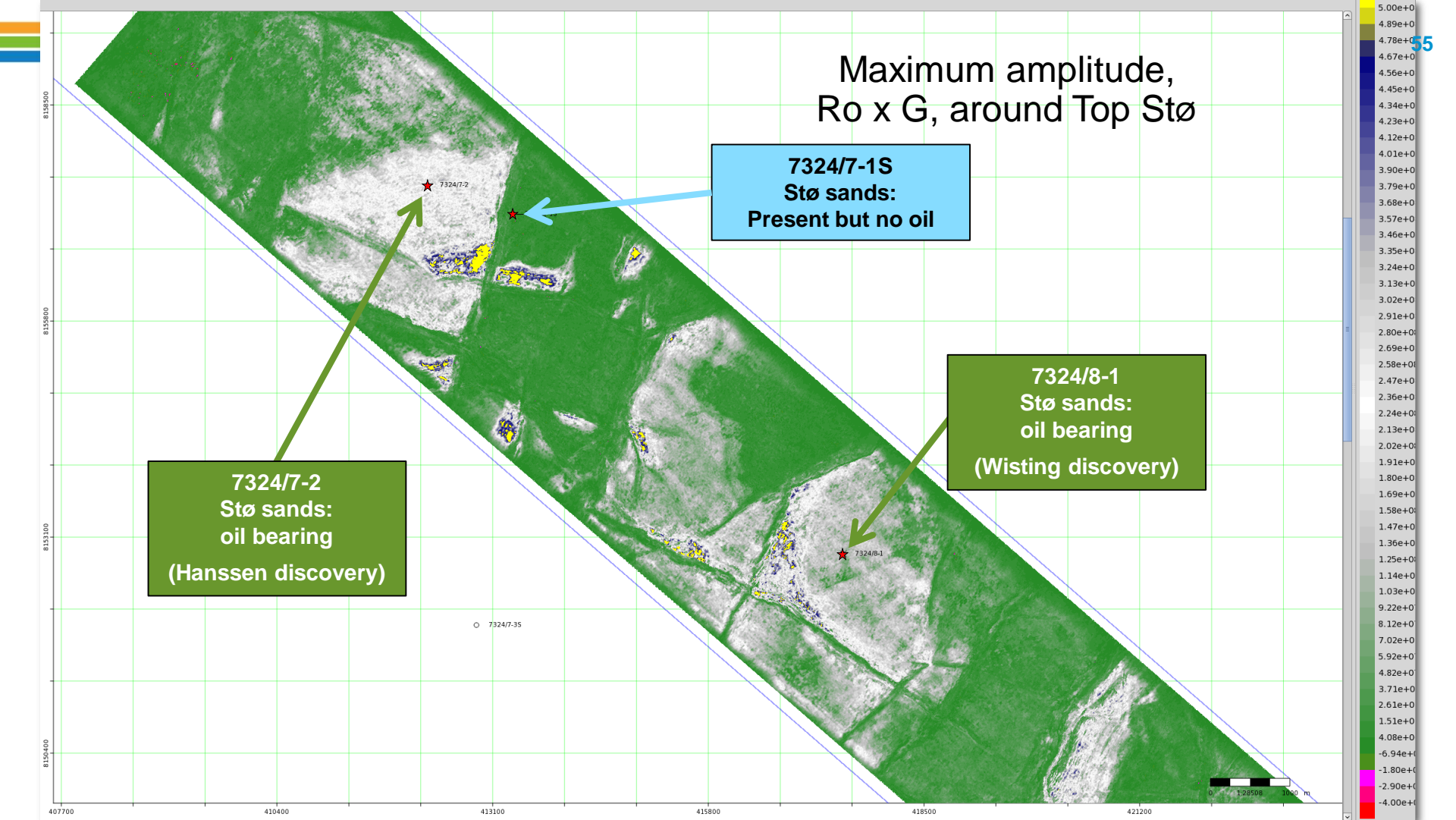
7324/7-1S
Stø sands:
Present but no oil

7324/7-2
Stø sands:
oil bearing
(Hanssen discovery)

7324/8-1
Stø sands:
oil bearing
(Wisting discovery)

○ 7324/7-35

0 128508 1000 m



Maximum amplitude, Ro x G, around Top Stø

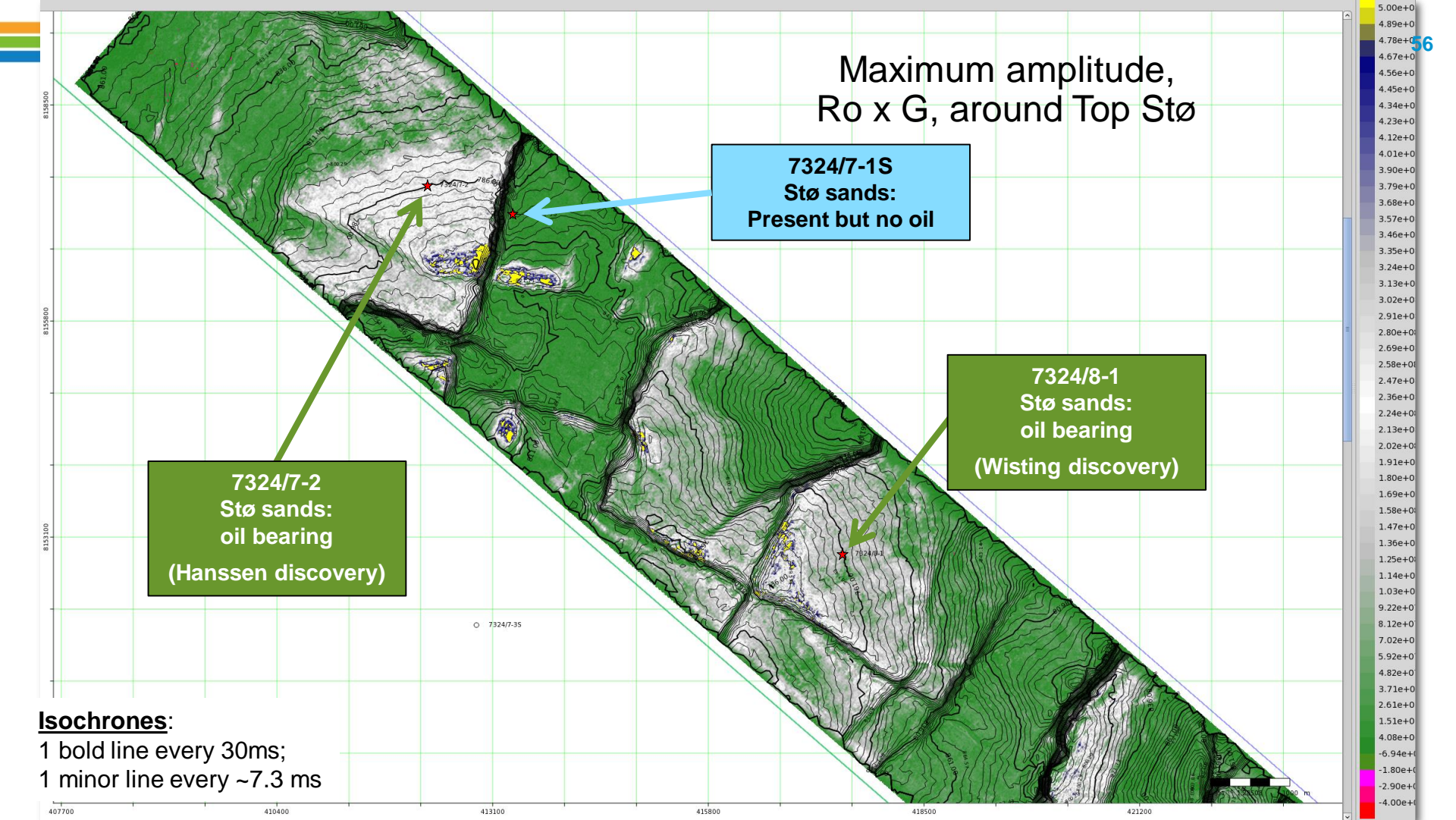
7324/7-1S
Stø sands:
Present but no oil

7324/7-2
Stø sands:
oil bearing
(Hanssen discovery)

7324/8-1
Stø sands:
oil bearing
(Wisting discovery)

○ 7324/7-35

0 128508 257016 m



Maximum amplitude, $R_o \times G$, around Top Stø

7324/7-1S
Stø sands:
Present but no oil

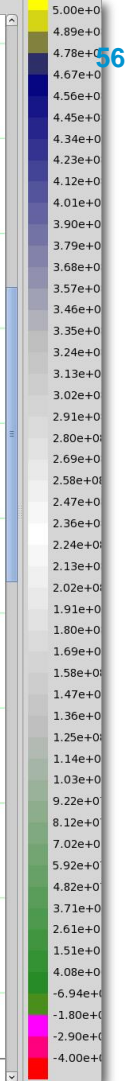
7324/7-2
Stø sands:
oil bearing
(Hanssen discovery)

7324/8-1
Stø sands:
oil bearing
(Wisting discovery)

Isochrones:

1 bold line every 30ms;

1 minor line every ~7.3 ms



8158000
8158000
8153100
407700
410400
413100
415800
418500
421200

○ 7324/7-35



TopSeis - Conclusions

- ✓ Provides unique illumination and fold for improved imaging and reservoir characterization
- ✓ Complete top-to-bottom solution (when also shooting from the front)
- ✓ Has been verified in a comprehensive modelling and field test program
- ✓ First commercial survey was done in 2017 in the Barents Sea



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