Three and Five Source Towed Streamer Acquisition Techniques

Philip Fontana – Polarcus
Howard Davies - DownUnder GeoSolution

Symposium Reflections on Seismic Acquisition
Utrecht, NL
February 23, 2017

DownUnder GeoSolutions

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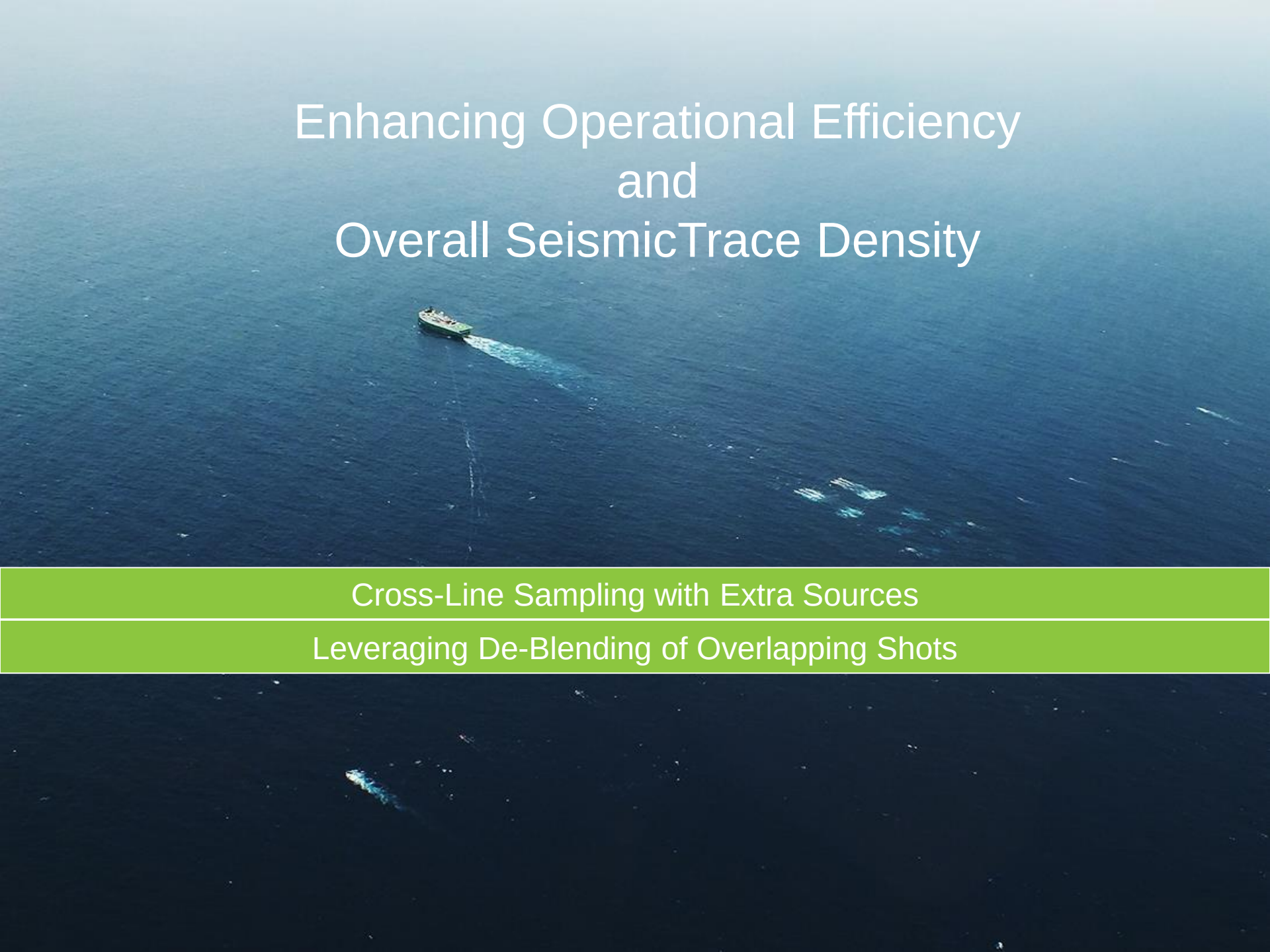


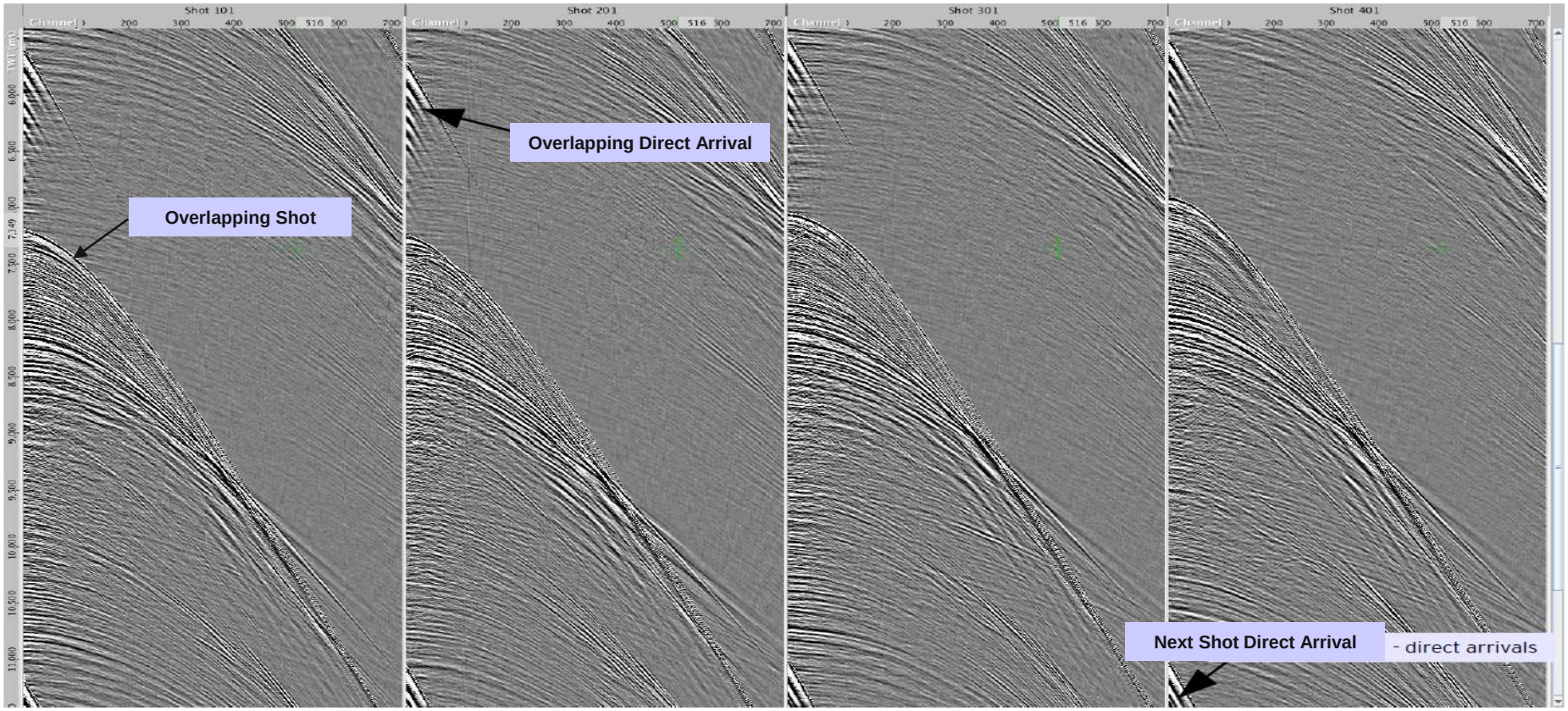
Enhancing Operational Efficiency and Overall SeismicTrace Density

Cross-Line Sampling with Extra Sources

Leveraging De-Blending of Overlapping Shots

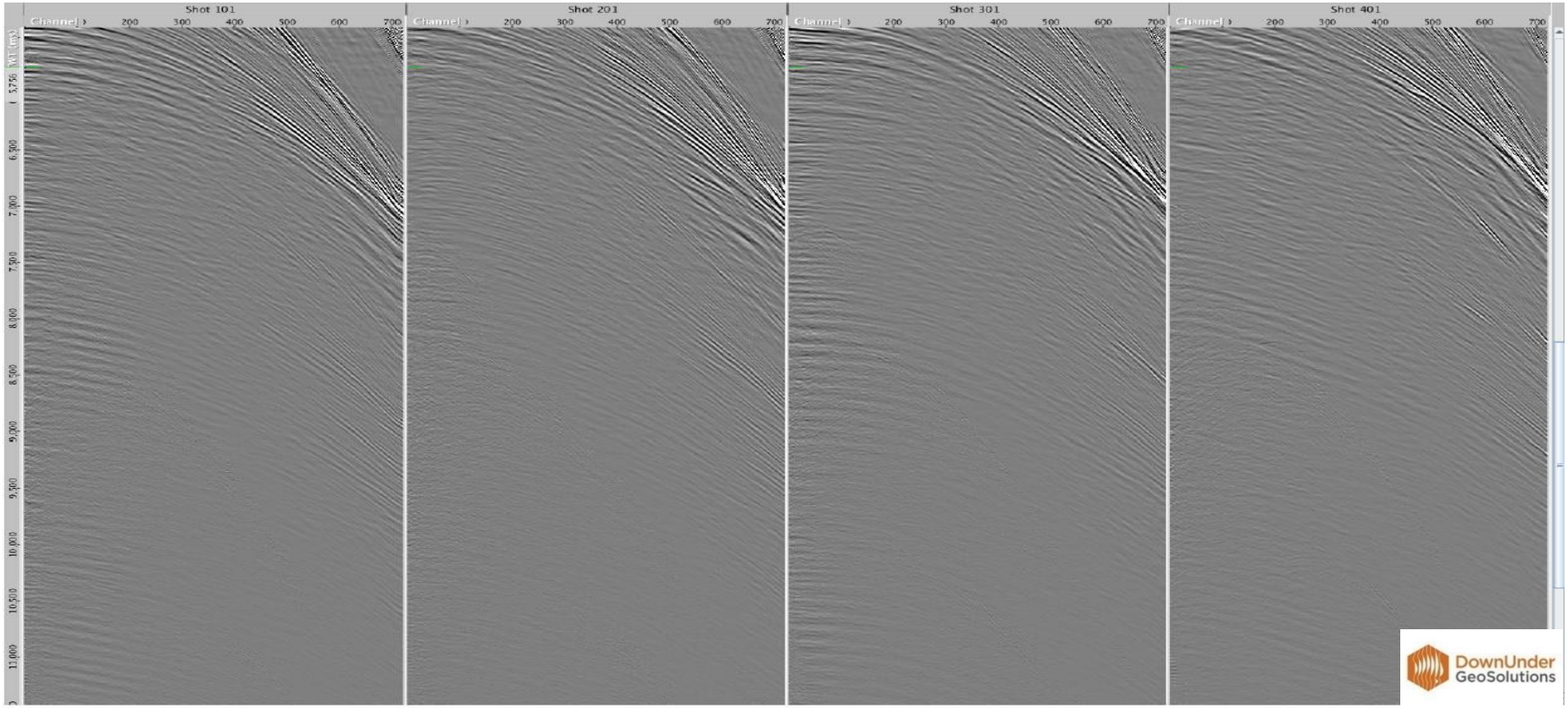
Overlapping Shot Records

Raw 12-second Shot Records



Overlapping Shot Records

Deblended 12-second Shot Records



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De-Blending Technology

2016 Session at SEG

- **- SPNA 1 - Deblending and Marine Noise Attenuation**

Inversion-based 3D deblending of towed-streamer simultaneous source data using sparse Taup and wavelet transforms
Can Peng, Jie Meng
pp. 4607-4611 (5 pages)
http://dx.doi.org/10.1190/segam2016-13866688.1
Abstract | References | PDF (5234 KB) | PDF w/Links (1511 KB) | Permissions

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Focal deblending using smart subsets of towed streamer 5D data
Apostolos Kontakis, Dirk Verschuur
pp. 4612-4617 (6 pages)
http://dx.doi.org/10.1190/segam2016-13945960.1
Abstract | References | PDF (1221 KB) | PDF w/Links (1228 KB) | Supplemental Material | Permissions

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Towards better deblending: Application of wave equation based demigration
Chao Peng, Yuan Yao
pp. 4618-4622 (5 pages)
http://dx.doi.org/10.1190/segam2016-13872538.1
Abstract | References | PDF (5953 KB) | PDF w/Links (5954 KB) | Permissions

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Data studies of simultaneous source separation using robust linear algebra
Ian Moore, Robin Fletcher, Craig Beasley, Clara Castellanos
pp. 4623-4627 (5 pages)
http://dx.doi.org/10.1190/segam2016-13779503.1
Abstract | References | PDF (1521 KB) | PDF w/Links (1525 KB) | Permissions

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Rank-reduction deblending for record length extension: The example of the Carnarvon basin
Margherita Maraschini, Audrey Kielius, Sergio Grion
pp. 4628-4632 (5 pages)
http://dx.doi.org/10.1190/segam2016-13685251.1
Abstract | References | PDF (1683 KB) | PDF w/Links (1687 KB) | Permissions

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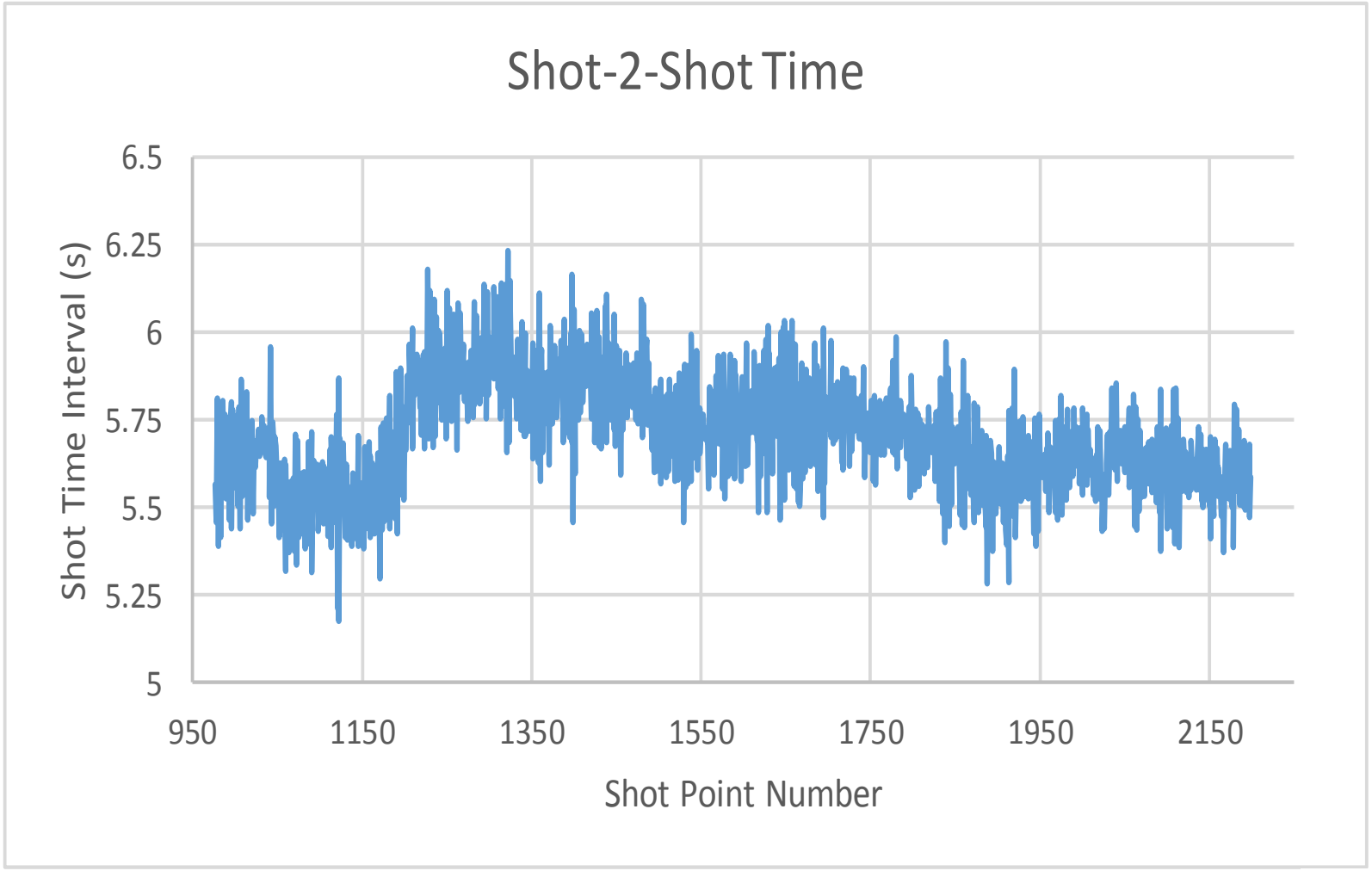
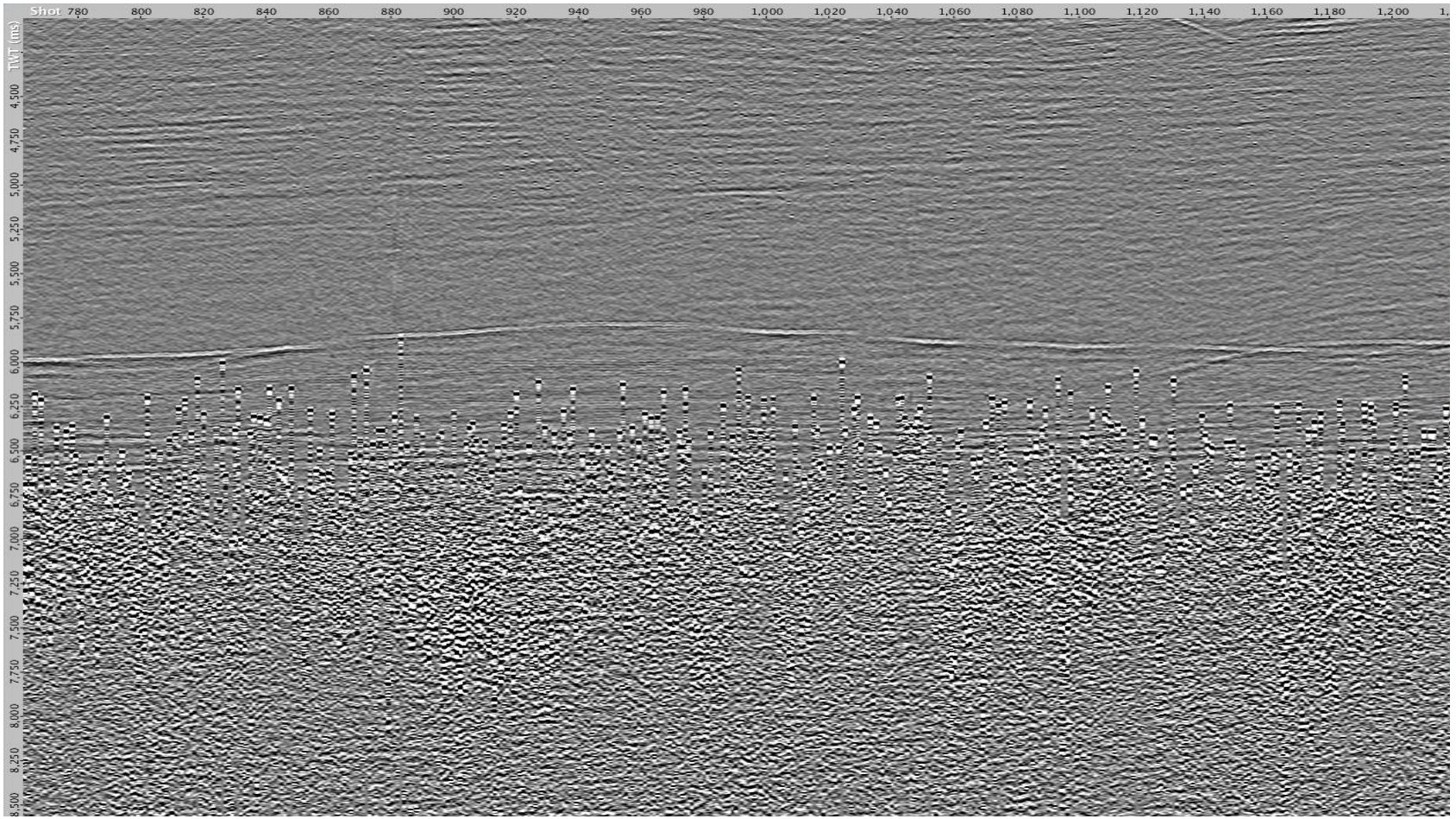
Shot-to-Shot Time Variations



Overlapping Shot Records

Channel Display : Input Channel 130

4.2s

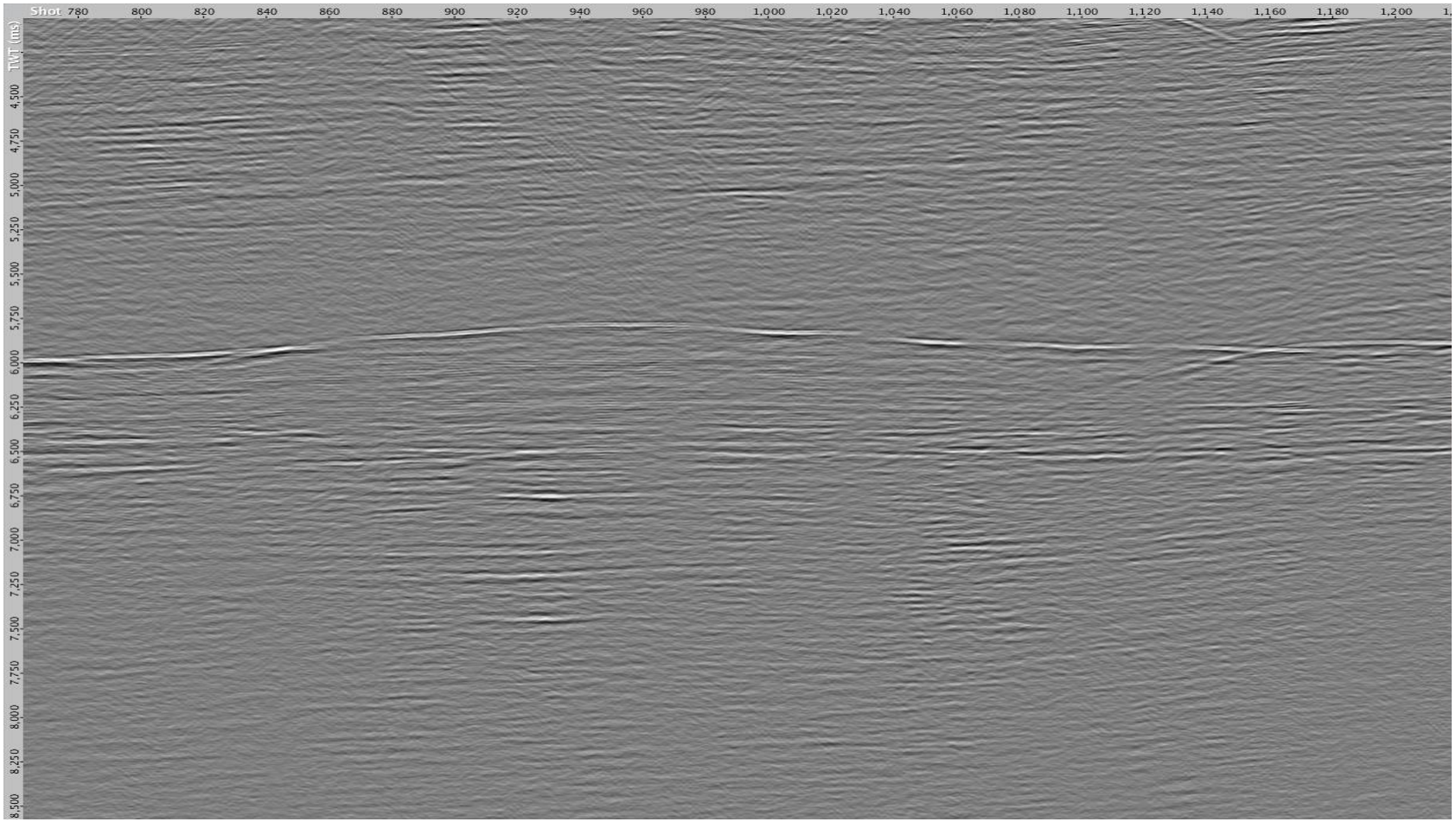


8.7s

Overlapping Shot Records

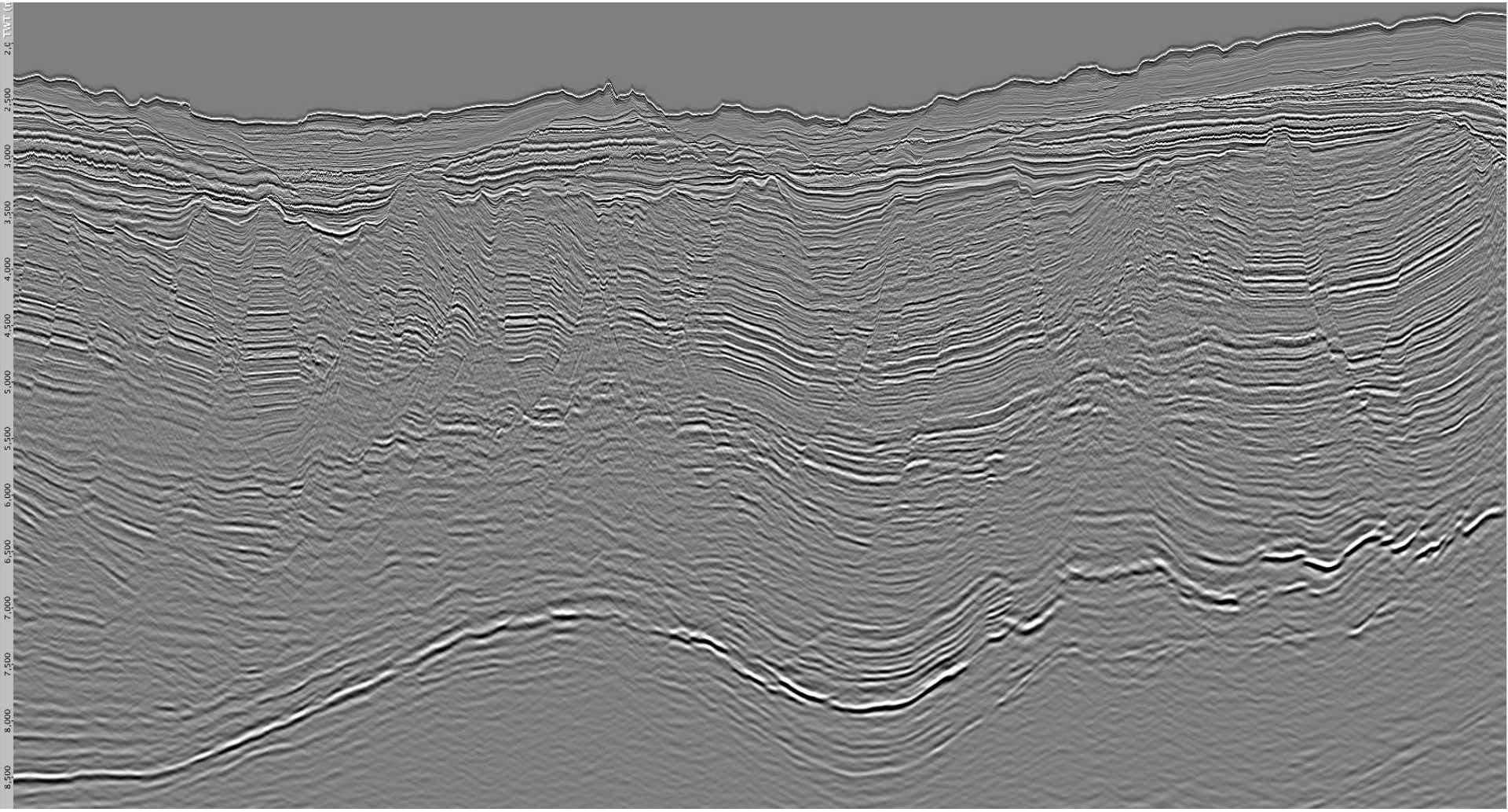
Channel Display : After Deblending Channel 130

4.2s



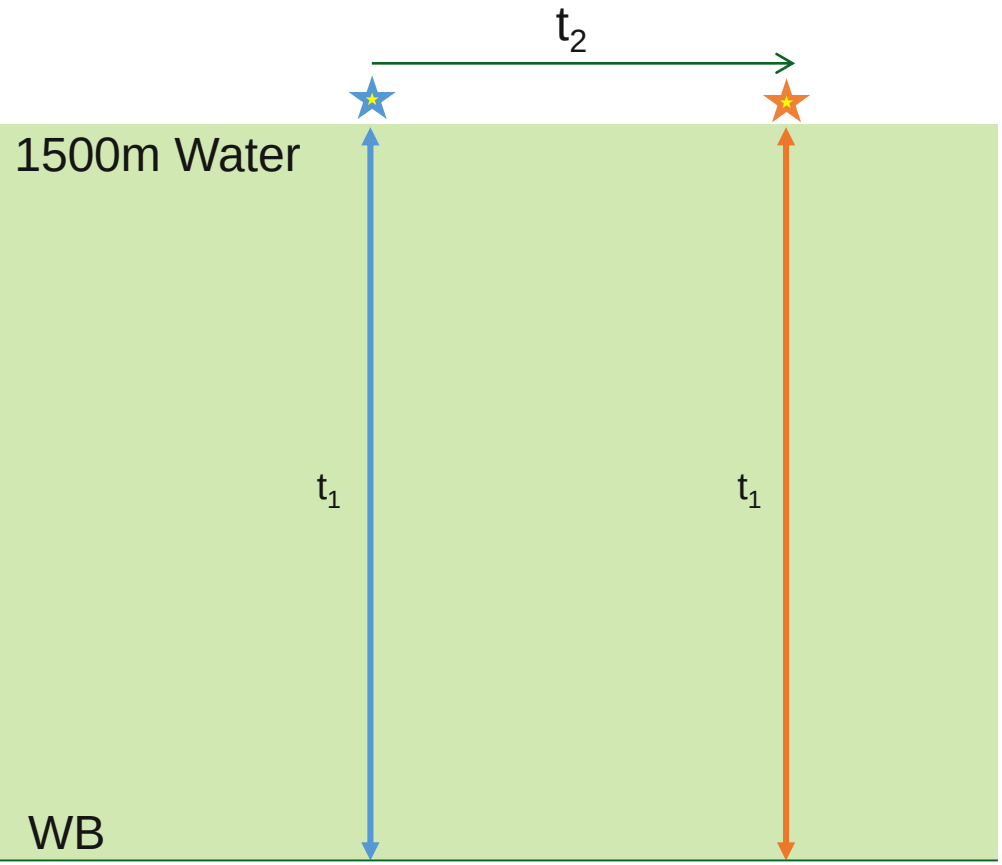
8.7s

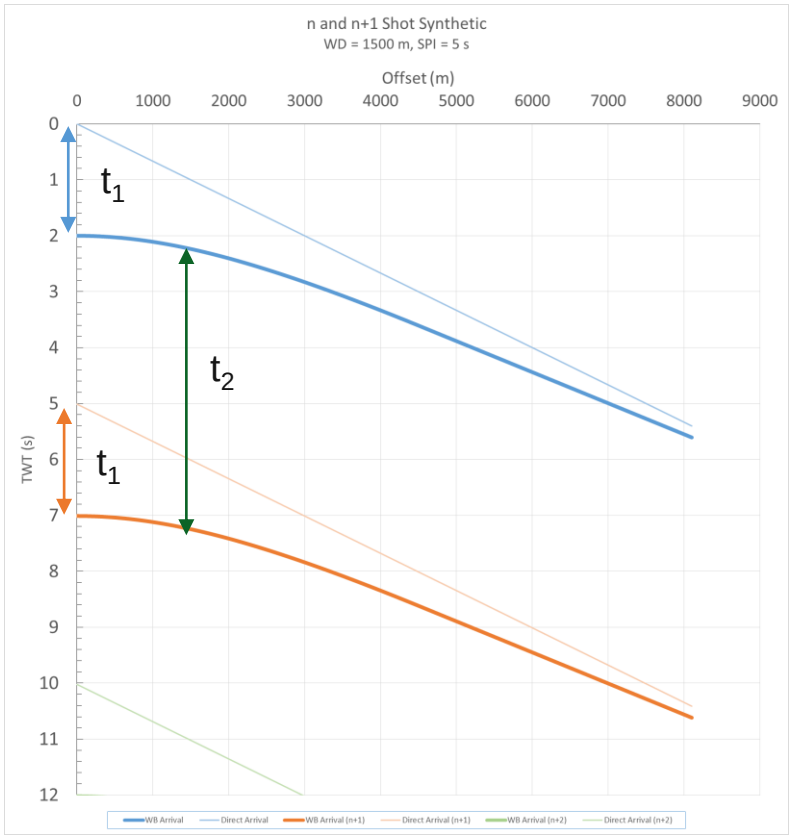
De-Blended Migrated Section



Shotpoint Interval and Overlap

1500 m water depth, 5 s shot interval time





t_2 = shot interval time = “unblended” zone = SPI / vessel speed

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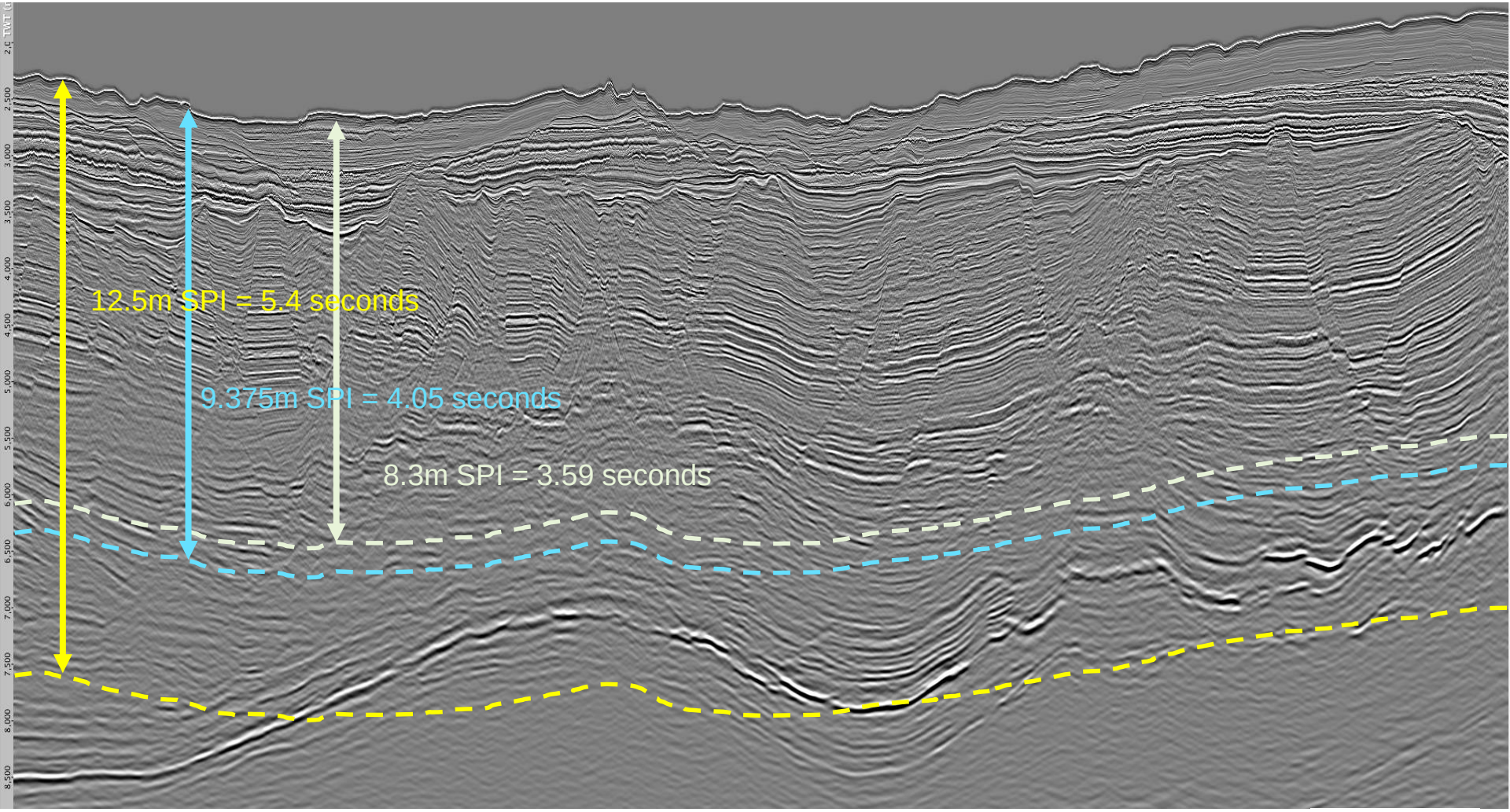
Deblended Migrated Section

Shot Record Overlap Determined by Shot Point Interval

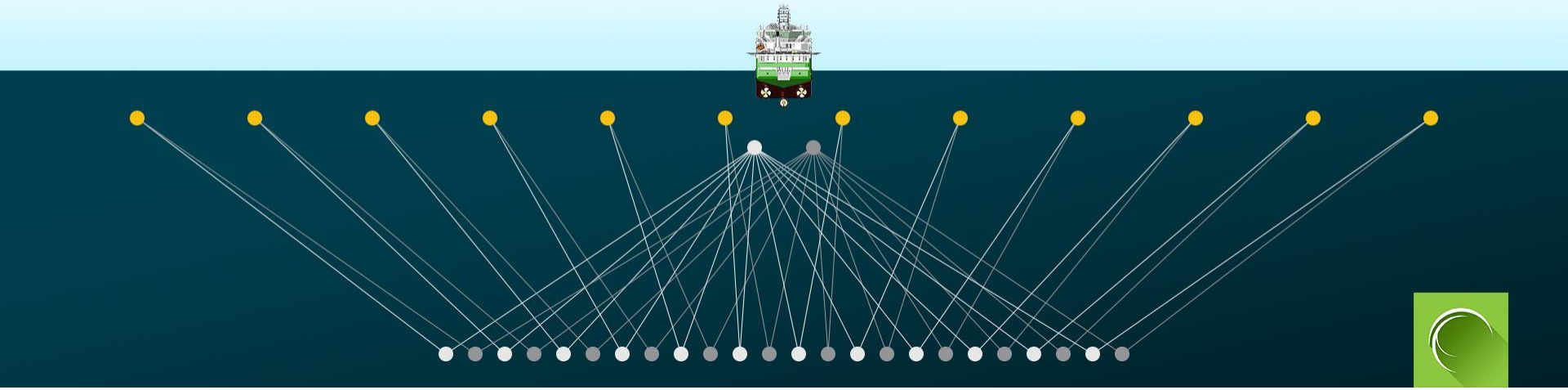


Dual-Source

Multi-Source Acquisition : Higher Geophysical Fidelity

- Designed to provide closer cross-line sampling and more unique ray-paths than dual sources on the same streamer configurations
- Dual-source cross-line sampling = 1/4 of streamer separation
- Triple-source cross-line sampling = 1/6 of streamer separation

Dual-Source Configuration



Triple-Source

Multi-Source Acquisition : Higher Geophysical Fidelity

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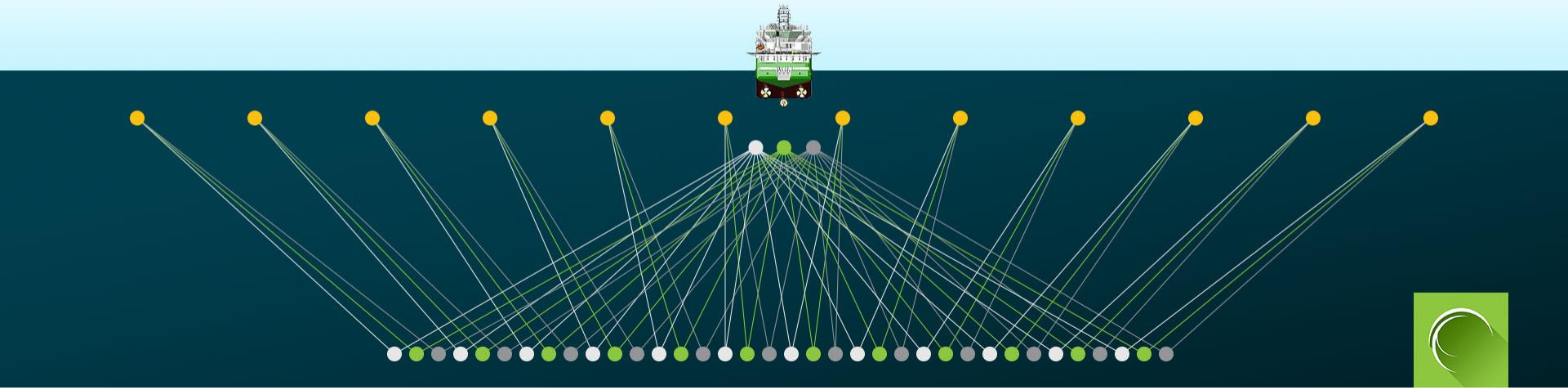
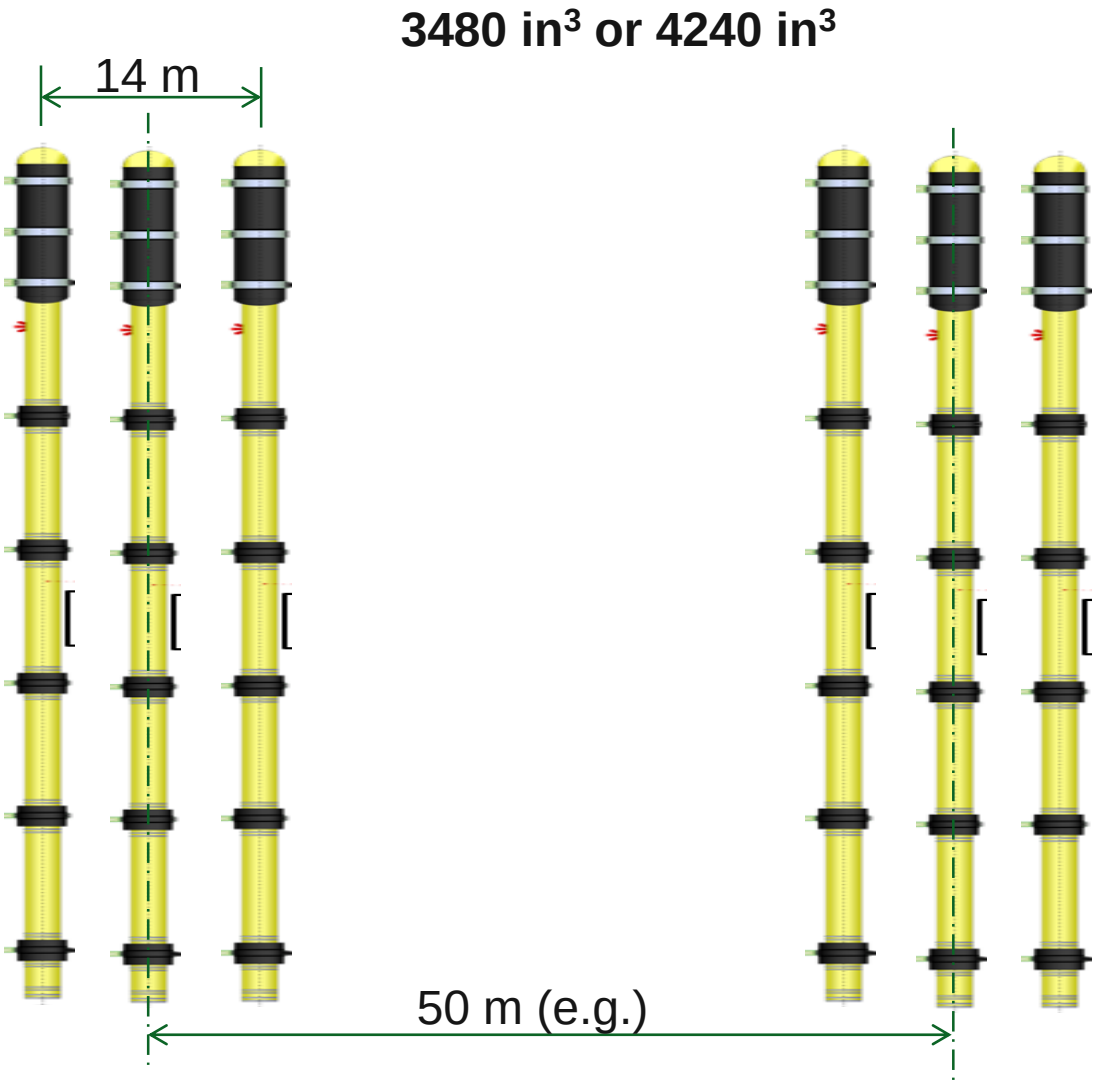
Triple-Source Configuration

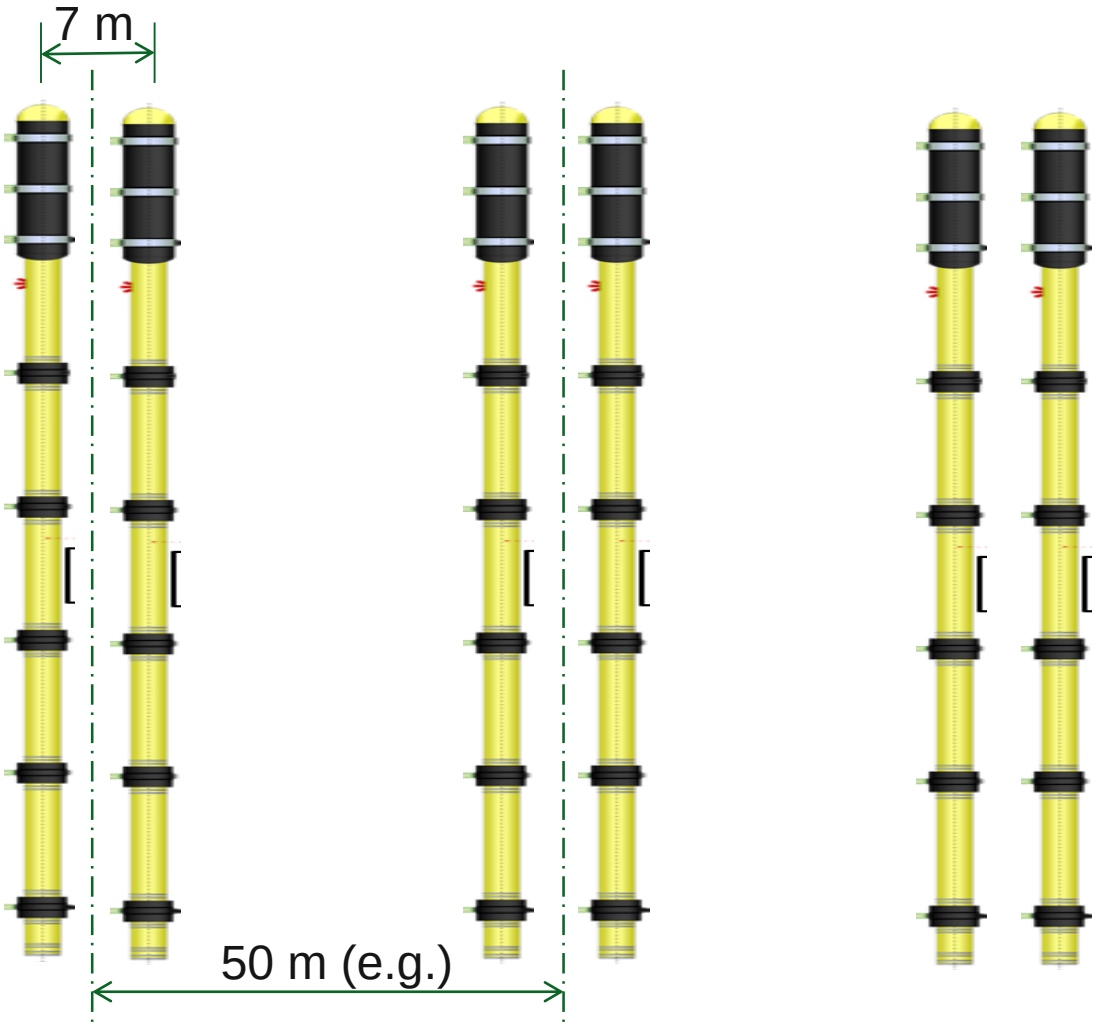


Dual-Source Array Configuration

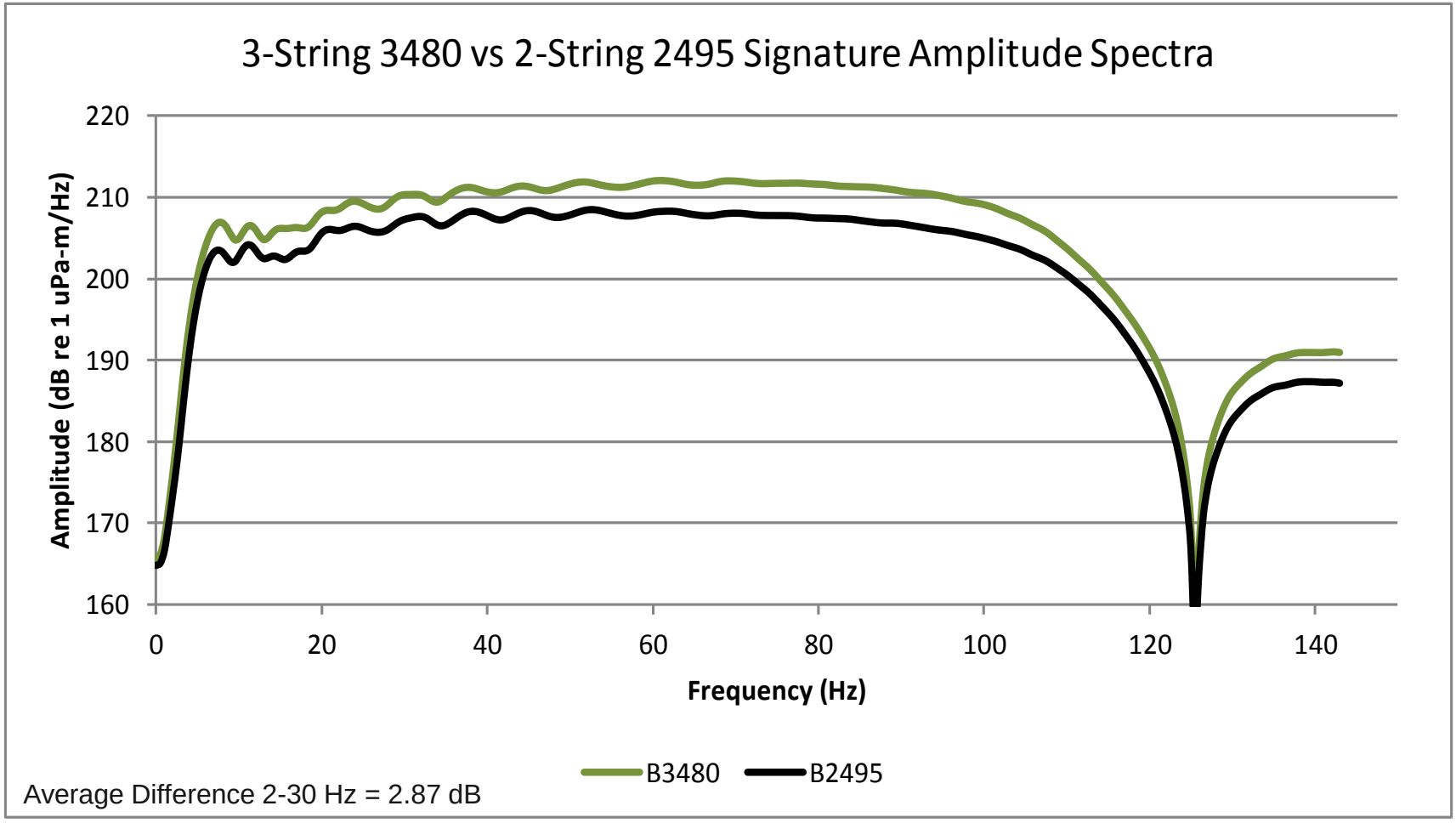


Triple-Source Array Configuration

2495 in^3 or 3090 in^3



Bolt 3480 vs Bolt 2495 Signature Amplitude Spectra
6m Tow Depth and DFS-V Filter



Dual vs Triple Sources

MADRID 2015
1-4 June 2015 I IFEMA Madrid

We N101 06

Triple-Source Simultaneous Shooting (TS3), A Future for Higher Density Seismic?

J. Langhammer* (TGS) & P. Bennion (TGS)

SUMMARY

The use of triple-sources in marine seismic streamer acquisition has been tested in the past, but with no significant commercial success compared to dual-source acquisition. With the introduction of new and better low noise streamers, in addition to the ability to record and deblend simultaneous source data, it is time to revisit the use of triple-sources in marine seismic exploration for decreased crossline bin-size leading to better spatial resolution. The data from the triple-source configuration flip-flop-flap sequential firing mode, is similar in quality compared to flip-flop conventional dual-source acquisition mode. When firing off the triple-sources in simultaneous mode, giving reduced shot-point interval, the results appear to be better than for dual-source flip-flop mode mainly due to increased fold and less aliasing of pre-stack gathers. A triple-source configuration can find its application in shallow and deeper water areas for imaging of targets where reduced crossline spacing and higher fold may be required.

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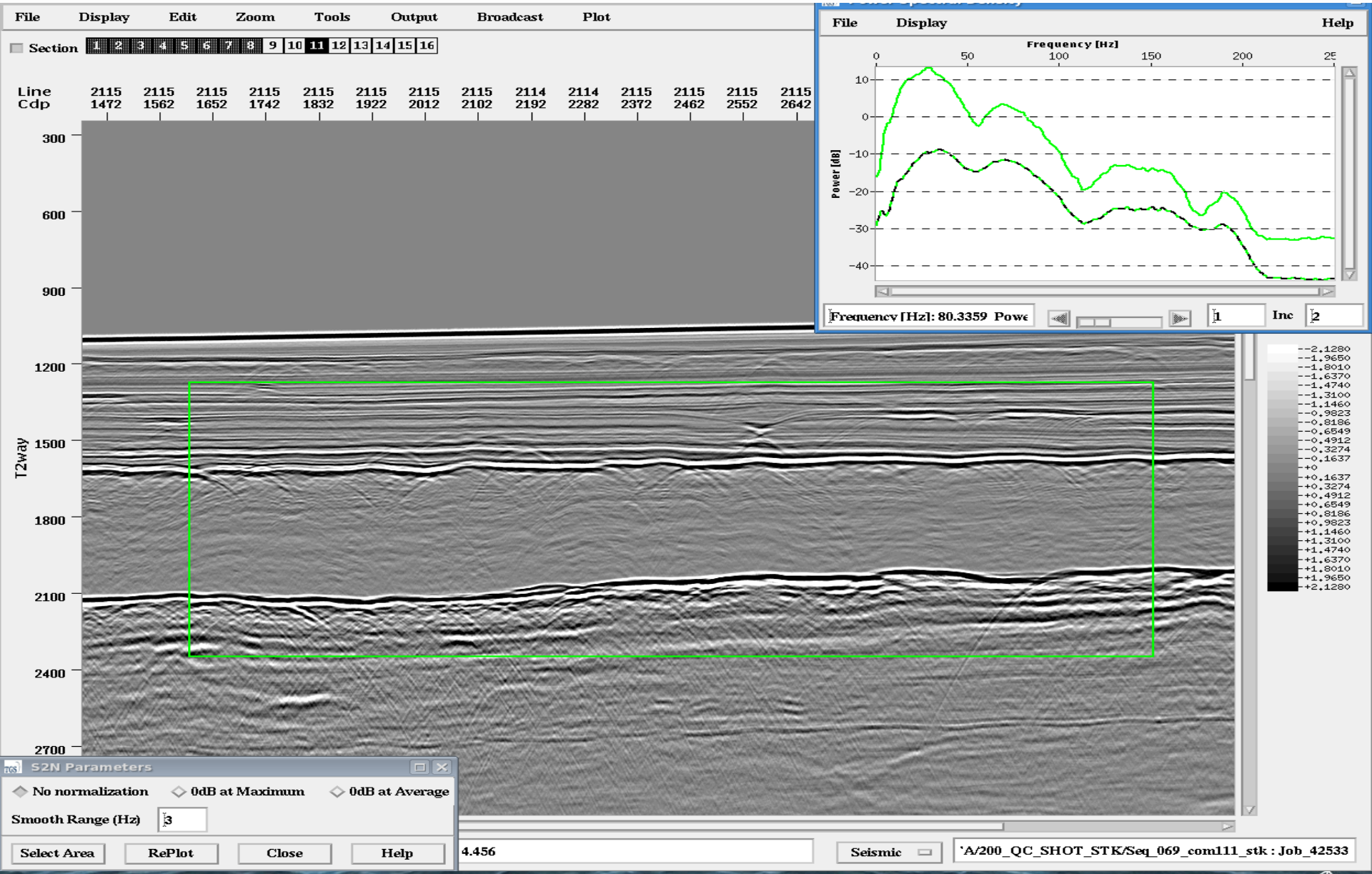
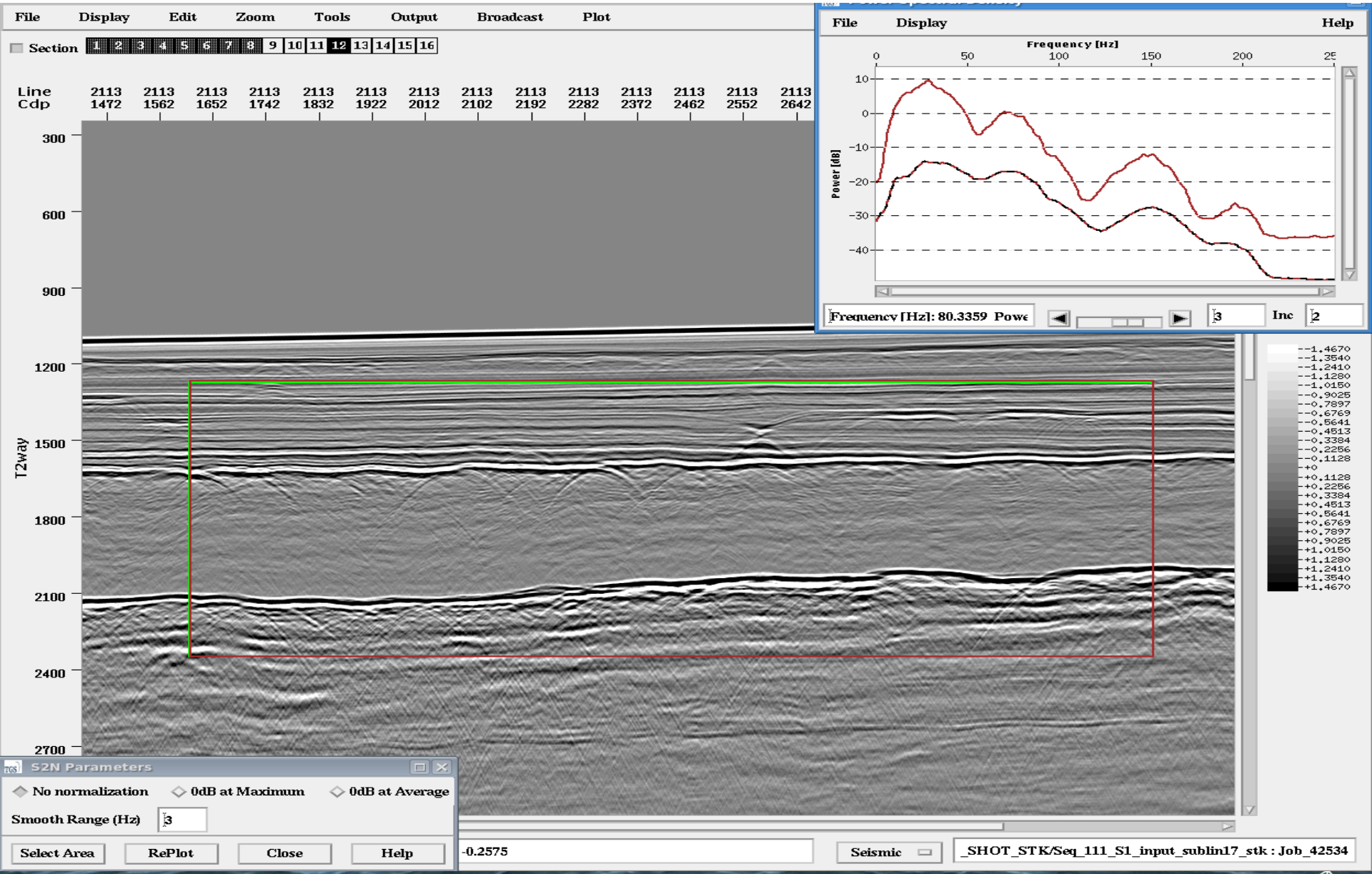
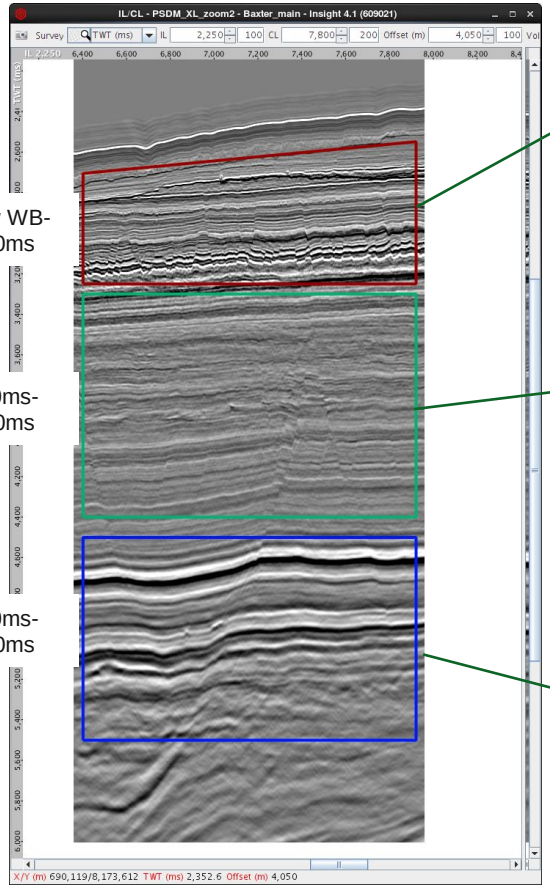
Seq 069: Stack Dual-Source Flip-Flop Sequential

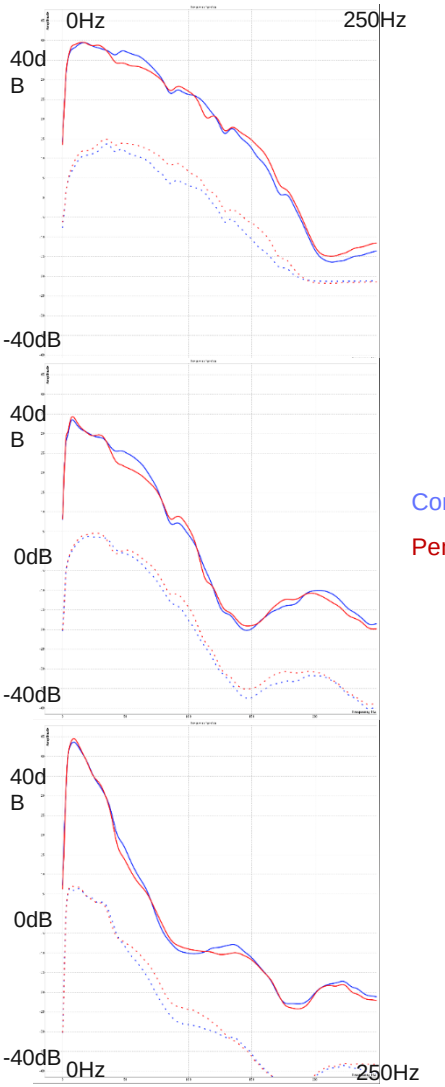


Seq. 111: Stack Triple-Source Flop-Flop-Flap Sequential



Estimated S/N PSDM processing

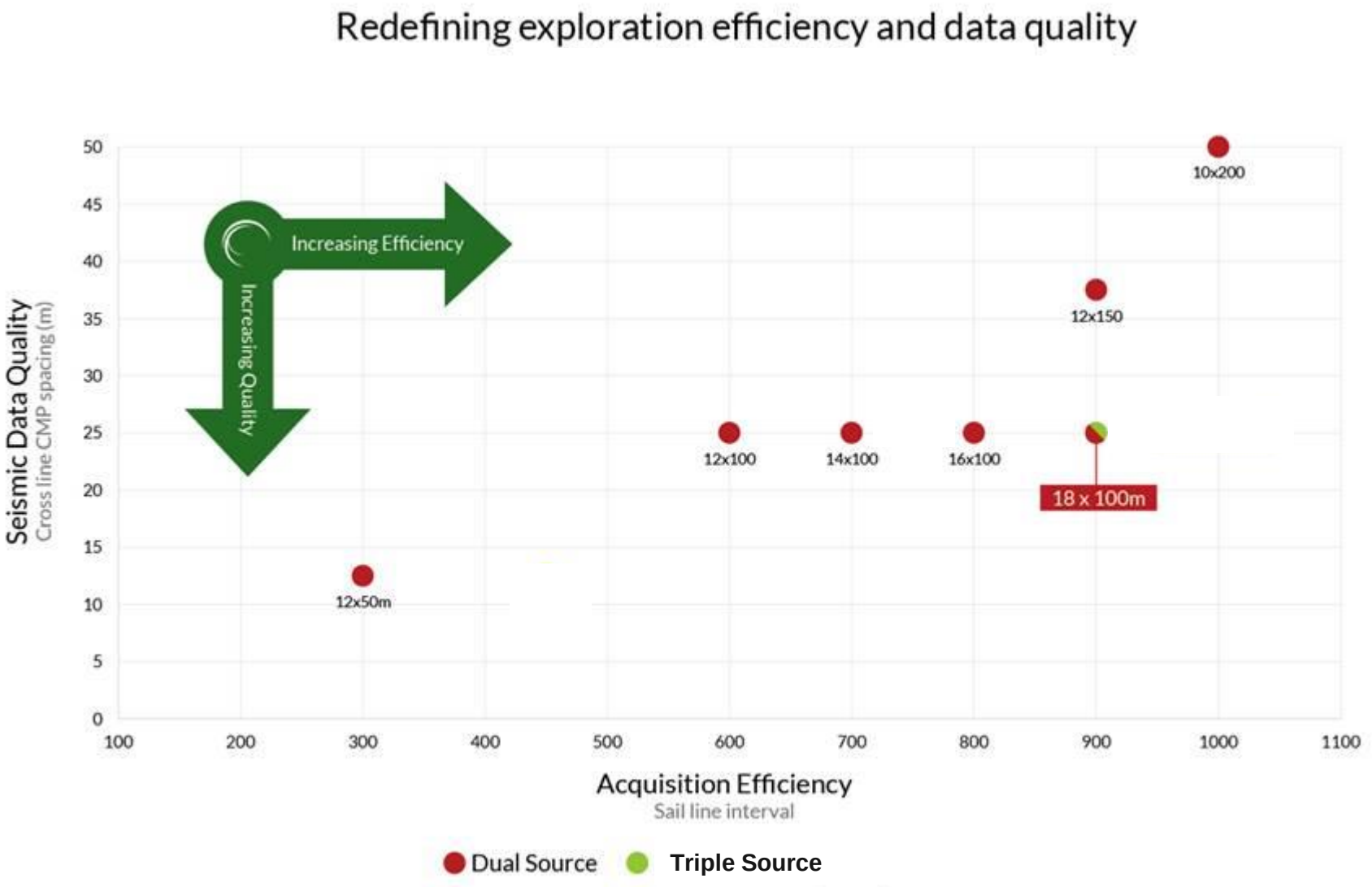




Conventional

Penta Source

Triple Source Efficiencies



Triple Source Efficiencies

Reduced Operational Risk and HSE Exposure

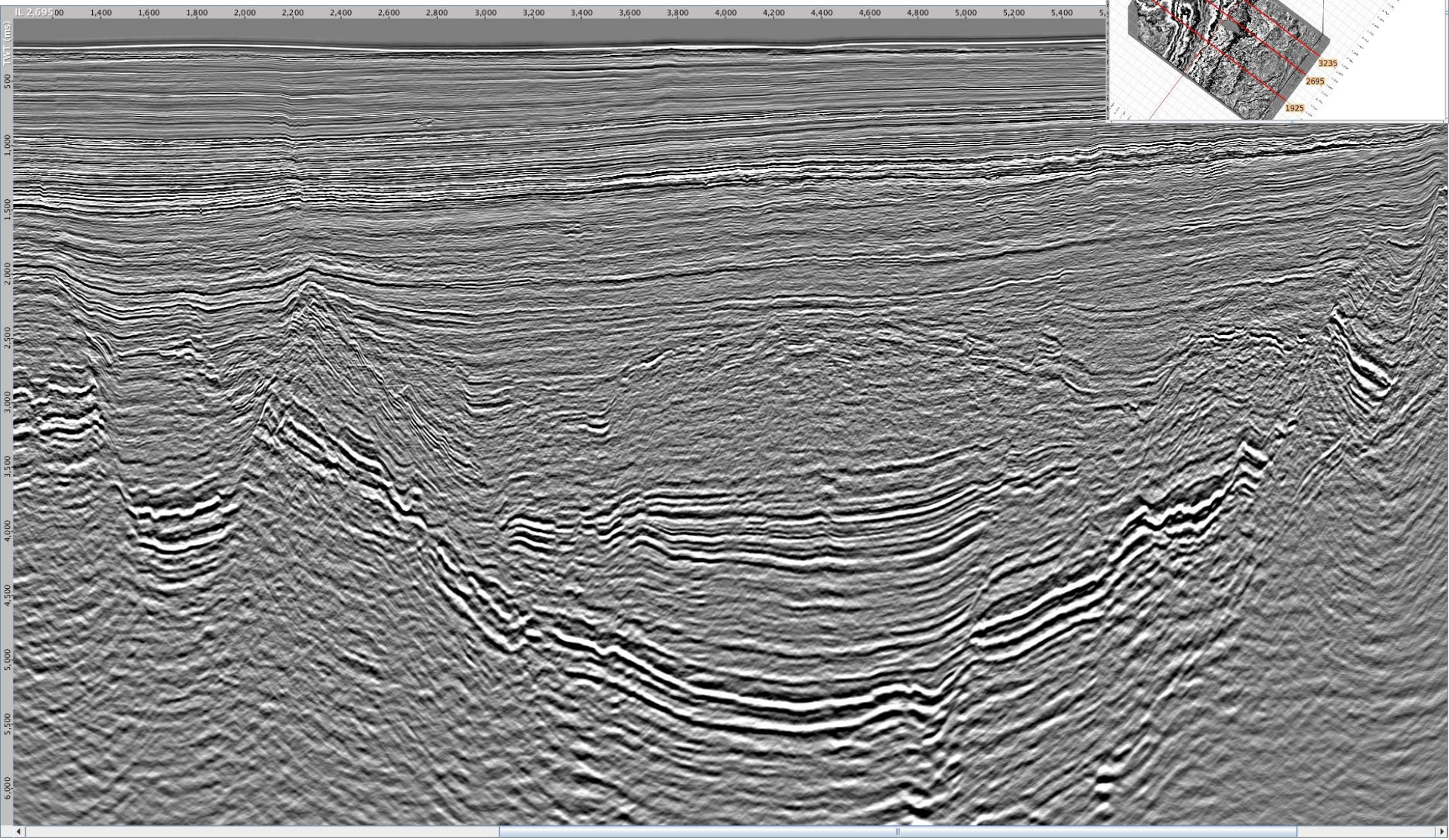
Shot Interval vs Overlap Time vs Trace Density
14x100 Dual Source vs 10x150 Triple Source

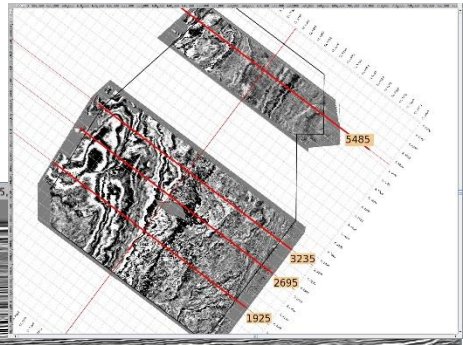
Streamer Spread	Number of sources	Source Separation (m)	Cross-line CMP (m)	Shot Interval (m)	Source Interval (m)	Nominal Bin Fold*	Shot Overlap Time (s)**	Sail-Line Interval (m)	Trace Density (traces/sq km)
Dual Source									
14x100	2	50	25	25.000	50.00	81	10.80	700	518,200
16x100	2	50	25	25.000	50.00	81	10.80	800	518,400
Triple Source									
10x150	3	50	25	12.500	37.50	108	5.40	750	691,028
10x150	3	50	25	9.375	28.13	144	4.05	750	921,371
10x150	3	50	25	8.300	24.90	163	3.59	750	1,036,957

Nominal Bin Fold*	Based upon 8100m streamer length and 12.5m group interval
Shot Overlap Time (s)**	Shot interfernce occurs at this time below mud-line for 4.5kt vessel ground speed

Trace Density = Num of Streamer Channels x Num of Inline shots/km x Num of Crossline sail line/km

Final PreSDM, Inline 2695
Cygnus Triple Source Survey





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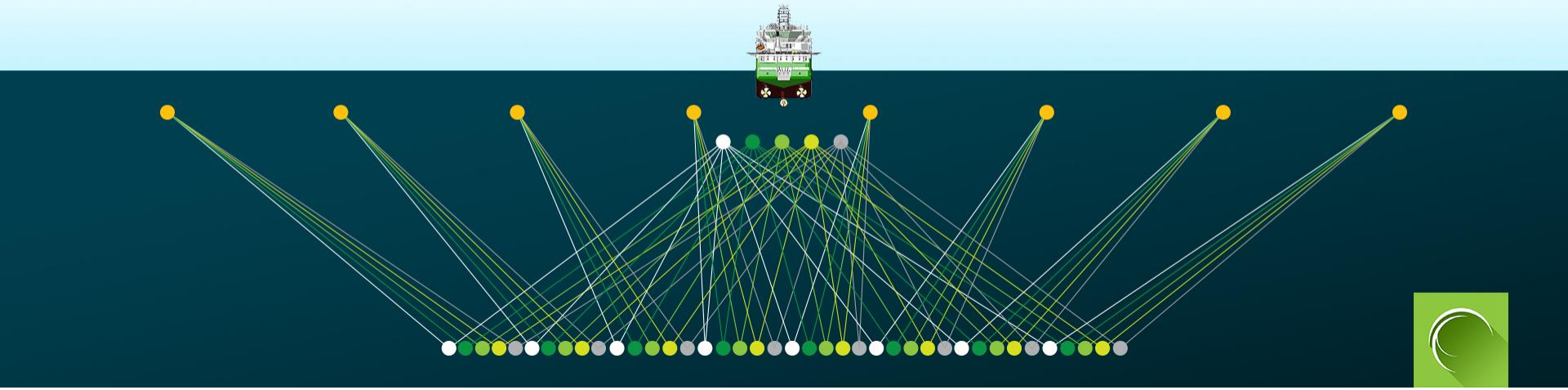
Penta-Source

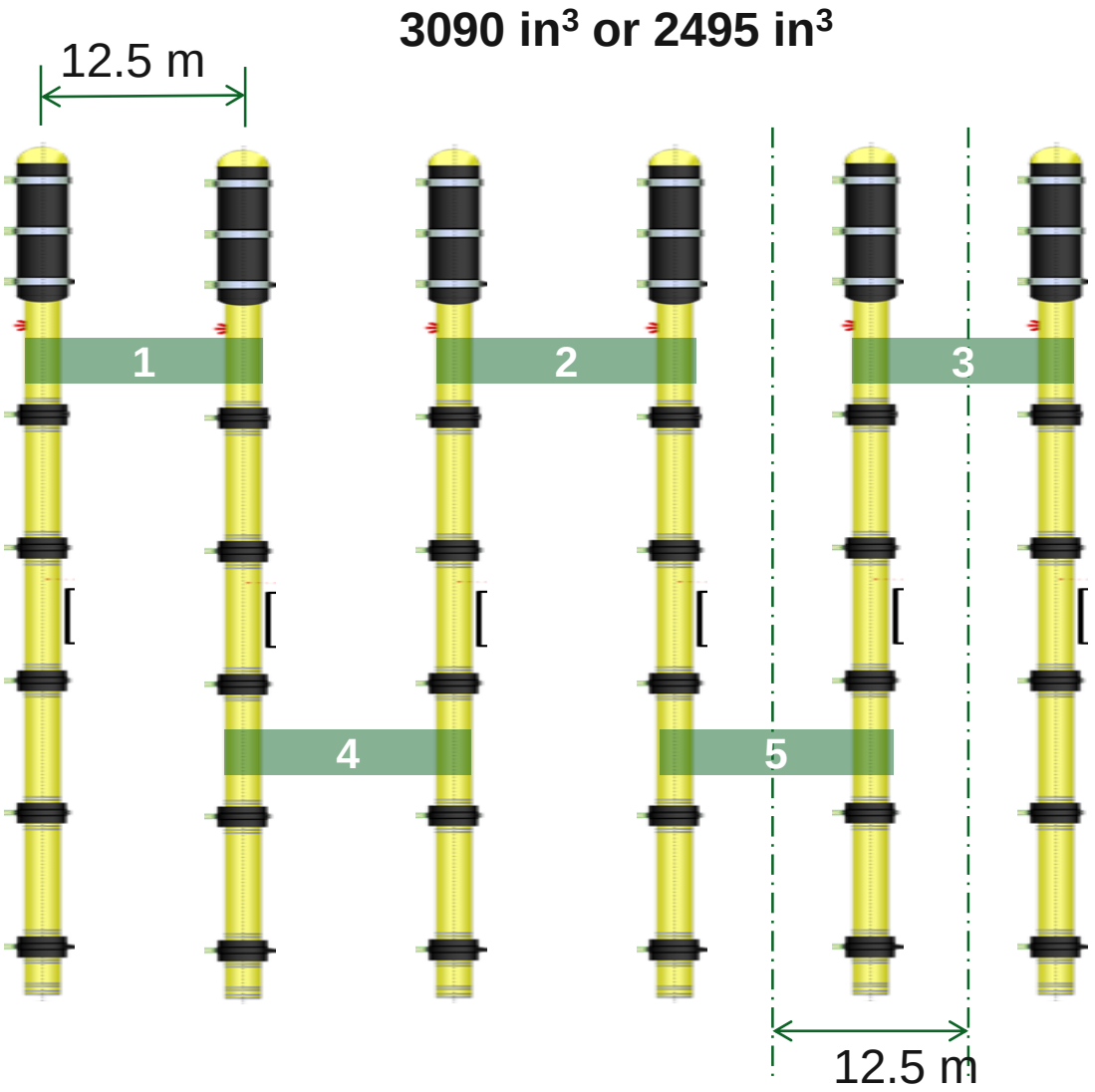
Multi-Source Acquisition : Higher Geophysical Fidelity

- Designed to provide 6.25-meter cross-line sampling with real data using conventional streamers

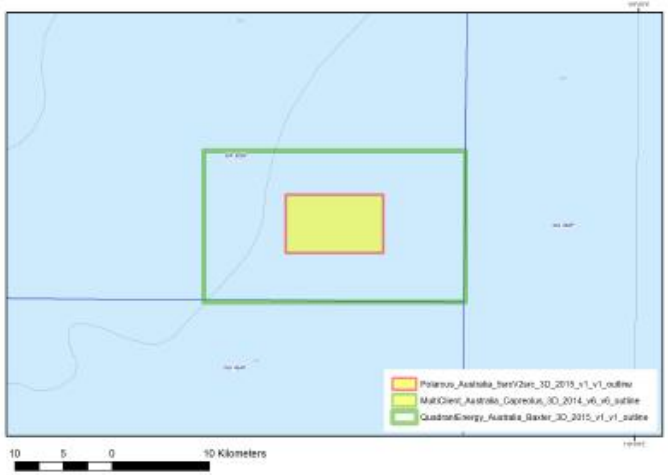
Penta-Source Configuration



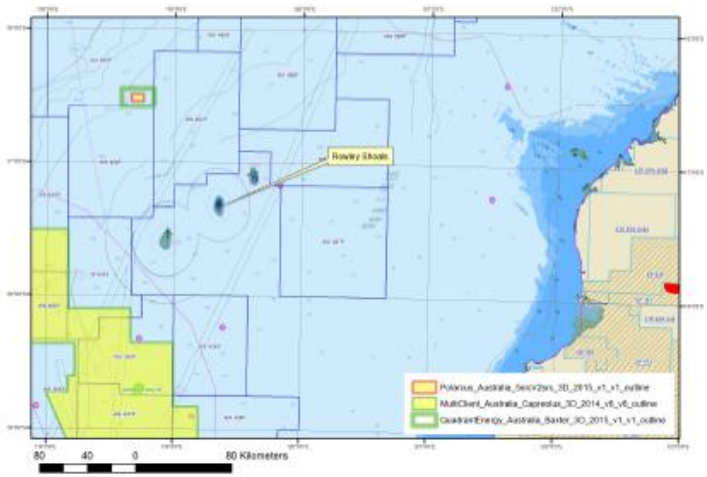
Penta-Source Array Configuration



Baxter Five-Source Survey



Test Area



Main Area in Green = 417 km^2
Acquired with Penta-Source configuration for 6.25m cross-line with 9,000m streamers

Conventional “Control Area” in yellow = 60 km^2
Acquired with 10 x 100 x 9,000m and dual 3-string source arrays

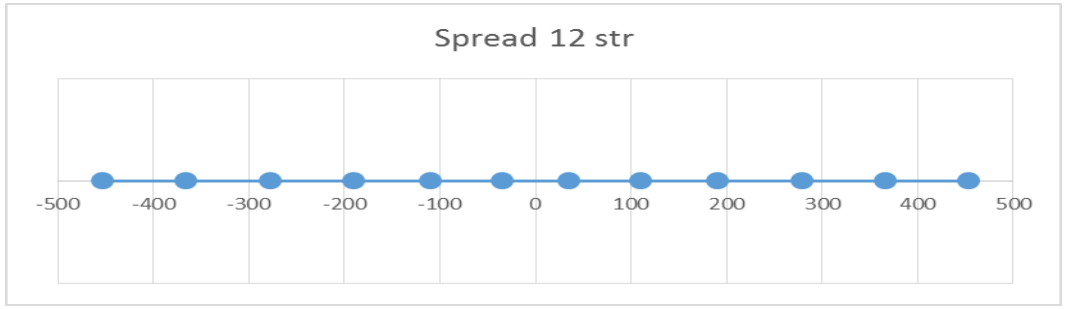
SEG 2016 - Dallas

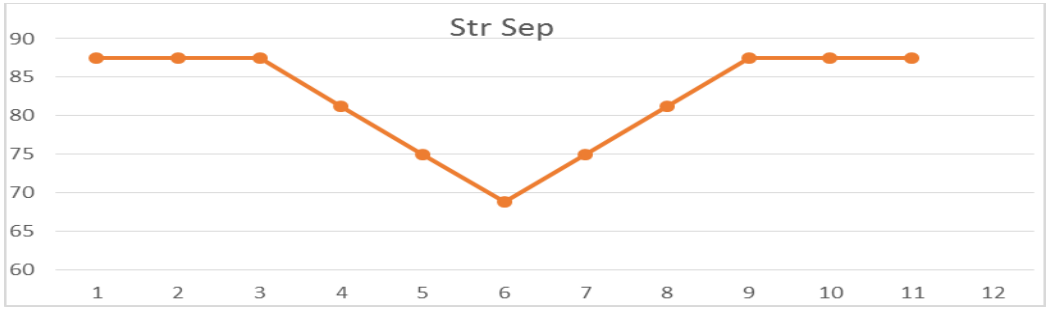
Baxter: a high-resolution penta-source marine 3D seismic acquisition

Ed Hager, Polarcus; Rob Kneale, Laurence Hansen, Quadrant Energy; Troy Thompson, DownUnder GeoSolutions

Streamer Separation

- Efficiency gained by hit-5 miss-2 sub-surface lines
- Closer separation on the inner cables, use wider on outer to give reasonably even coverage with fan





Streamer	Sep	#column (@6.25)
1		
	87.5	14
2		
	87.5	14
3		
	87.5	14
4		
	81.25	13
5		
	75	12
6		
	68.75	11
7		
	75	12
8		
	81.25	13
9		
	87.5	14
10		
	87.5	14
11		
	87.5	14
12		

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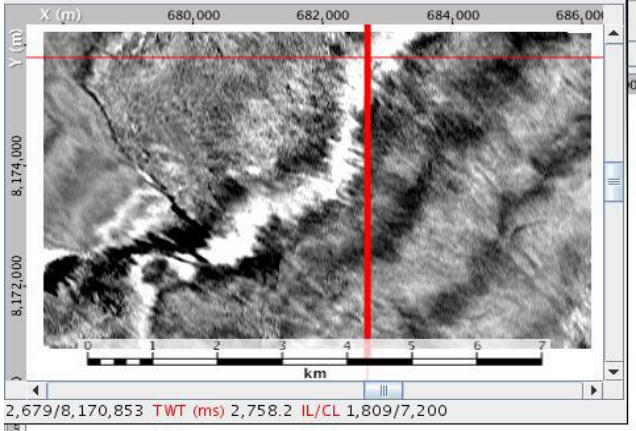
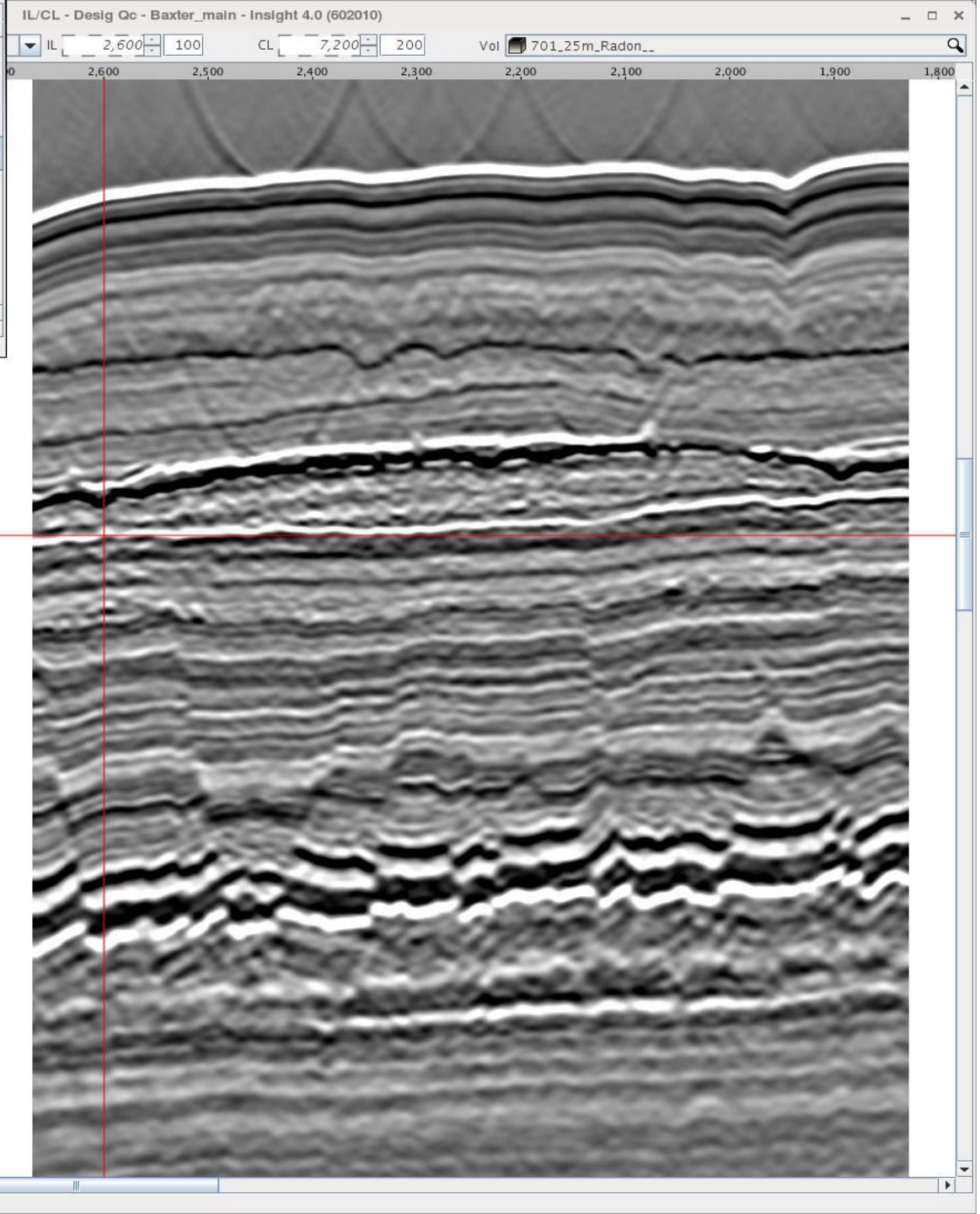
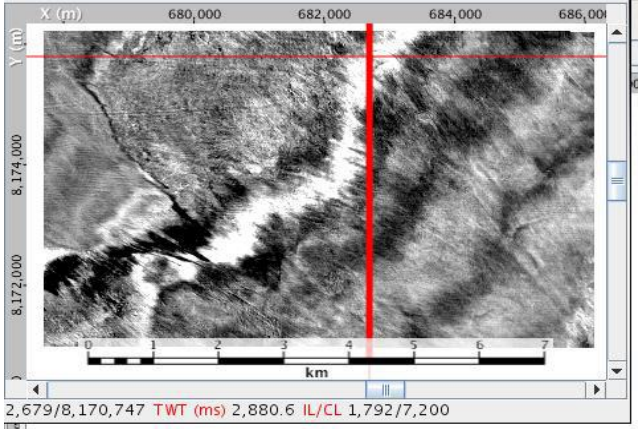


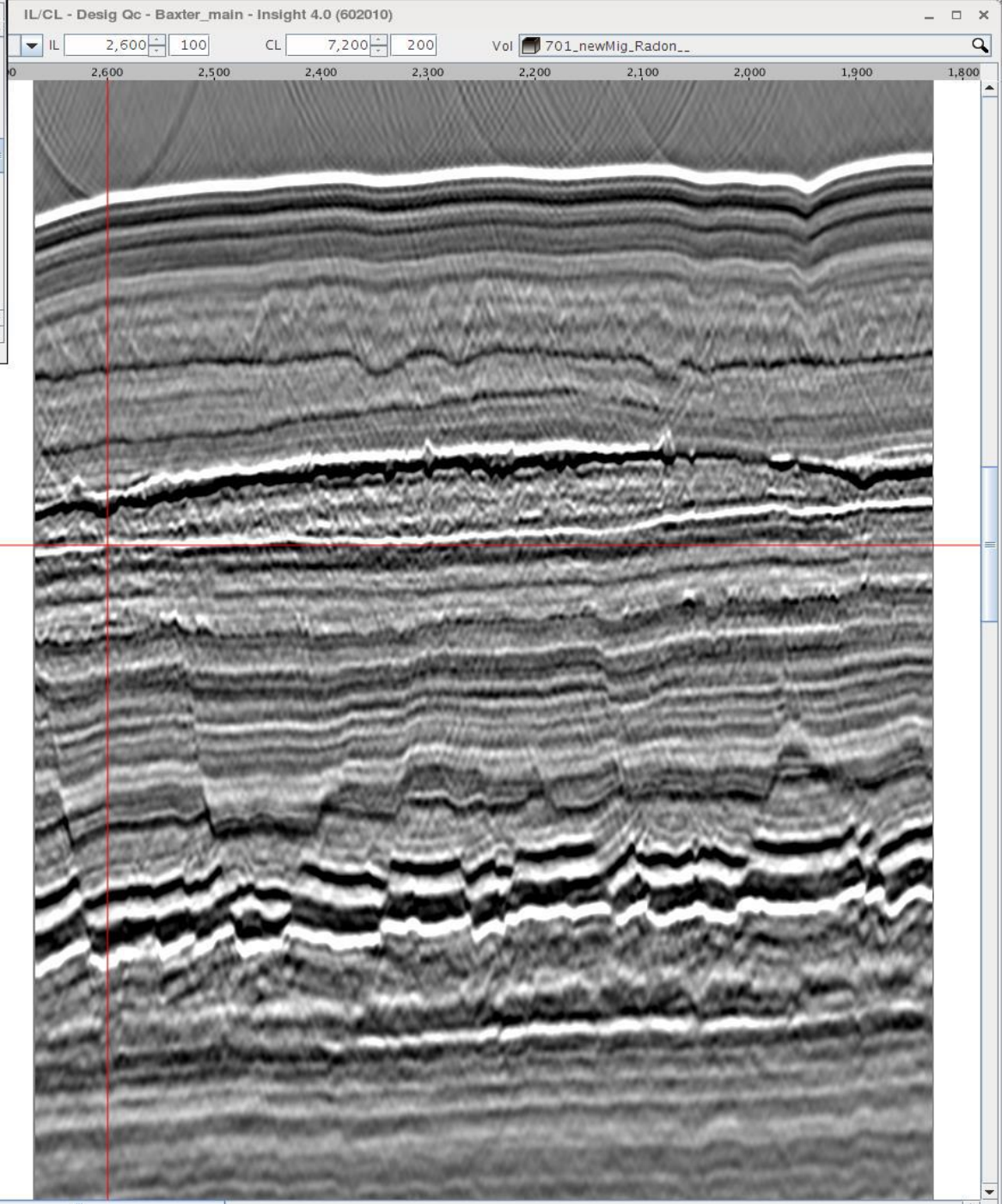


Penta-Source
Case Study

Preliminary PSTM
X-line 7200, Conventional

Quadrant Energy



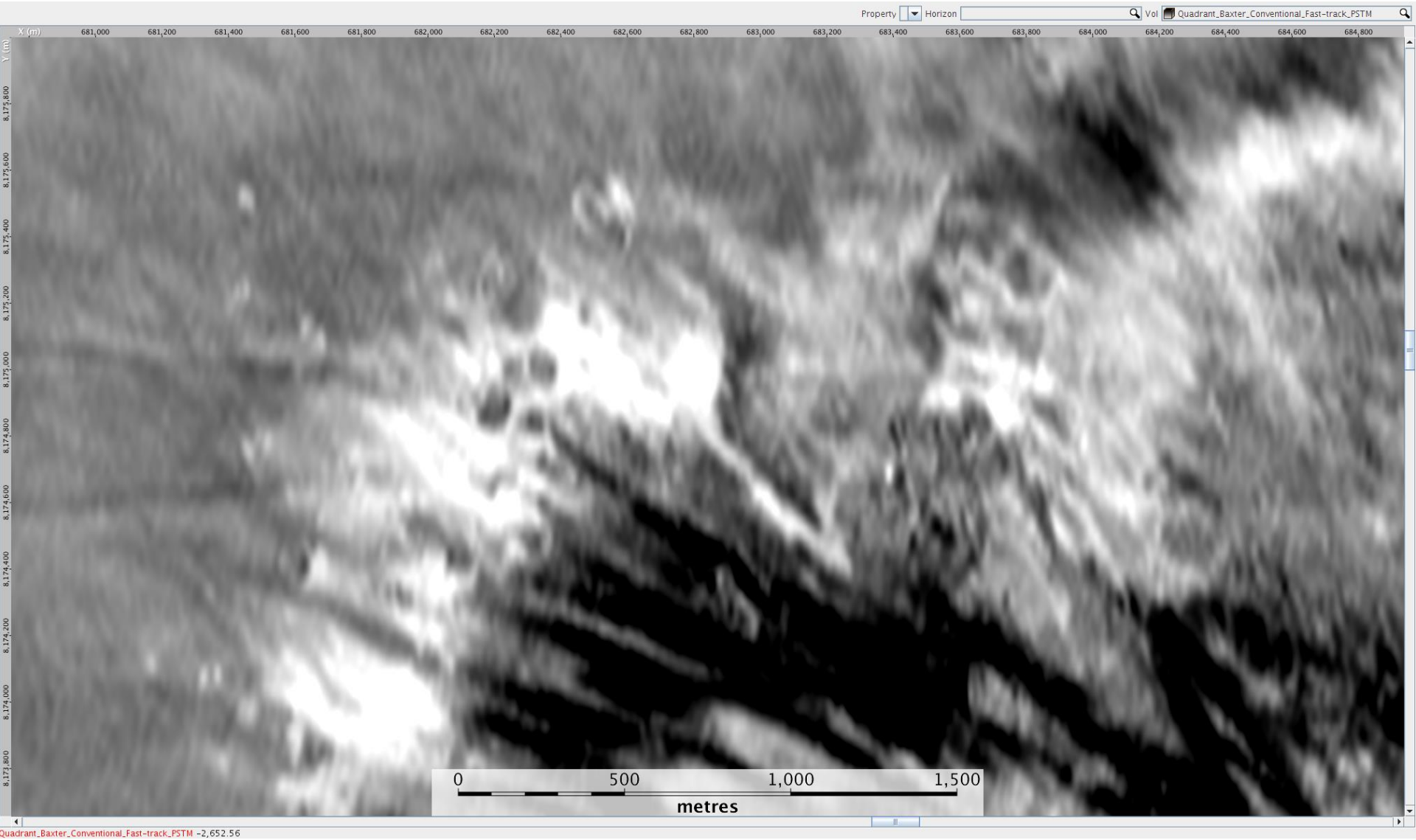


Penta-Source
Case Study

Preliminary PSTM
X-line 7200, Penta

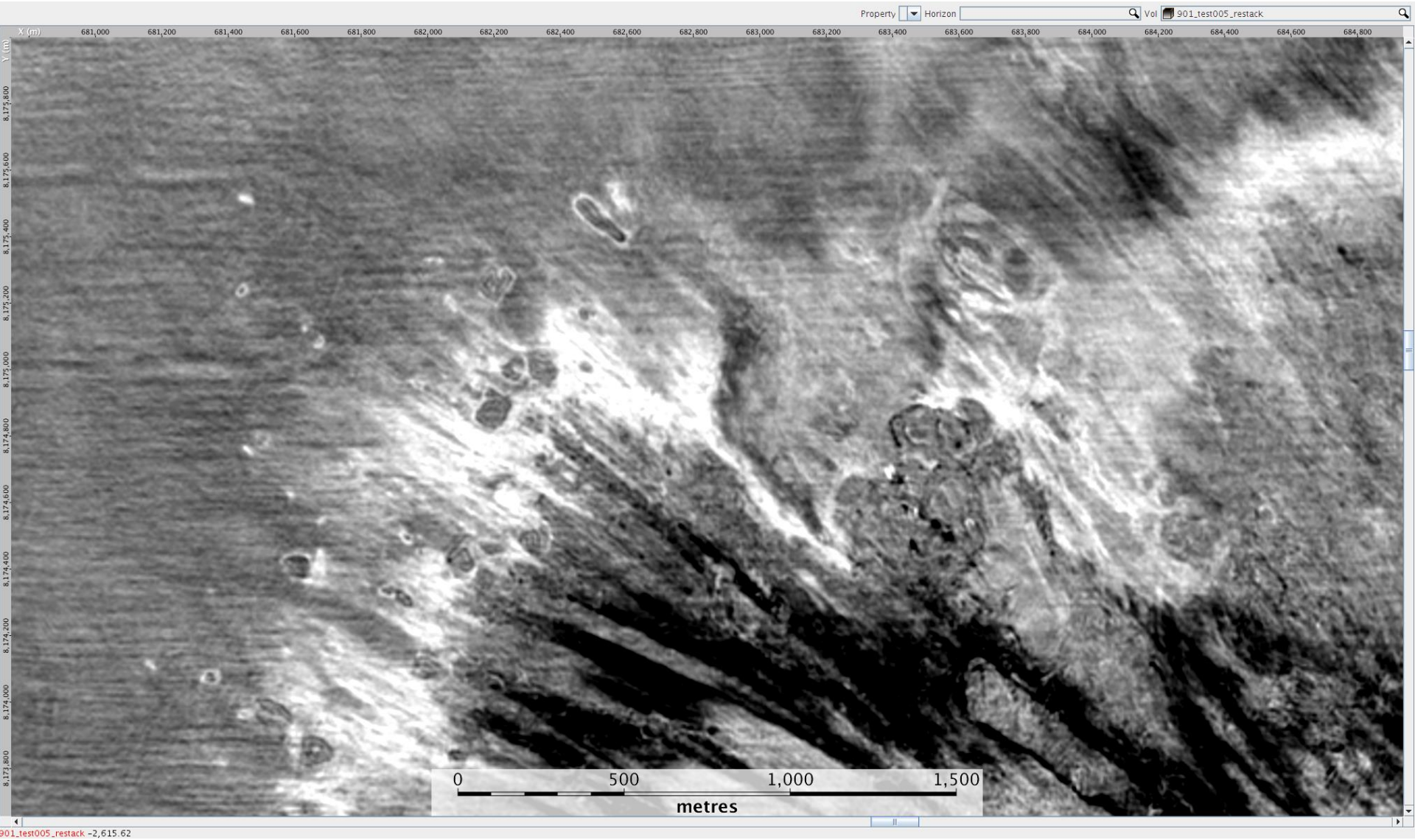
Quadrant Energy

Penta-Source : Case Study : Time Slice 2720 ms, Conventional



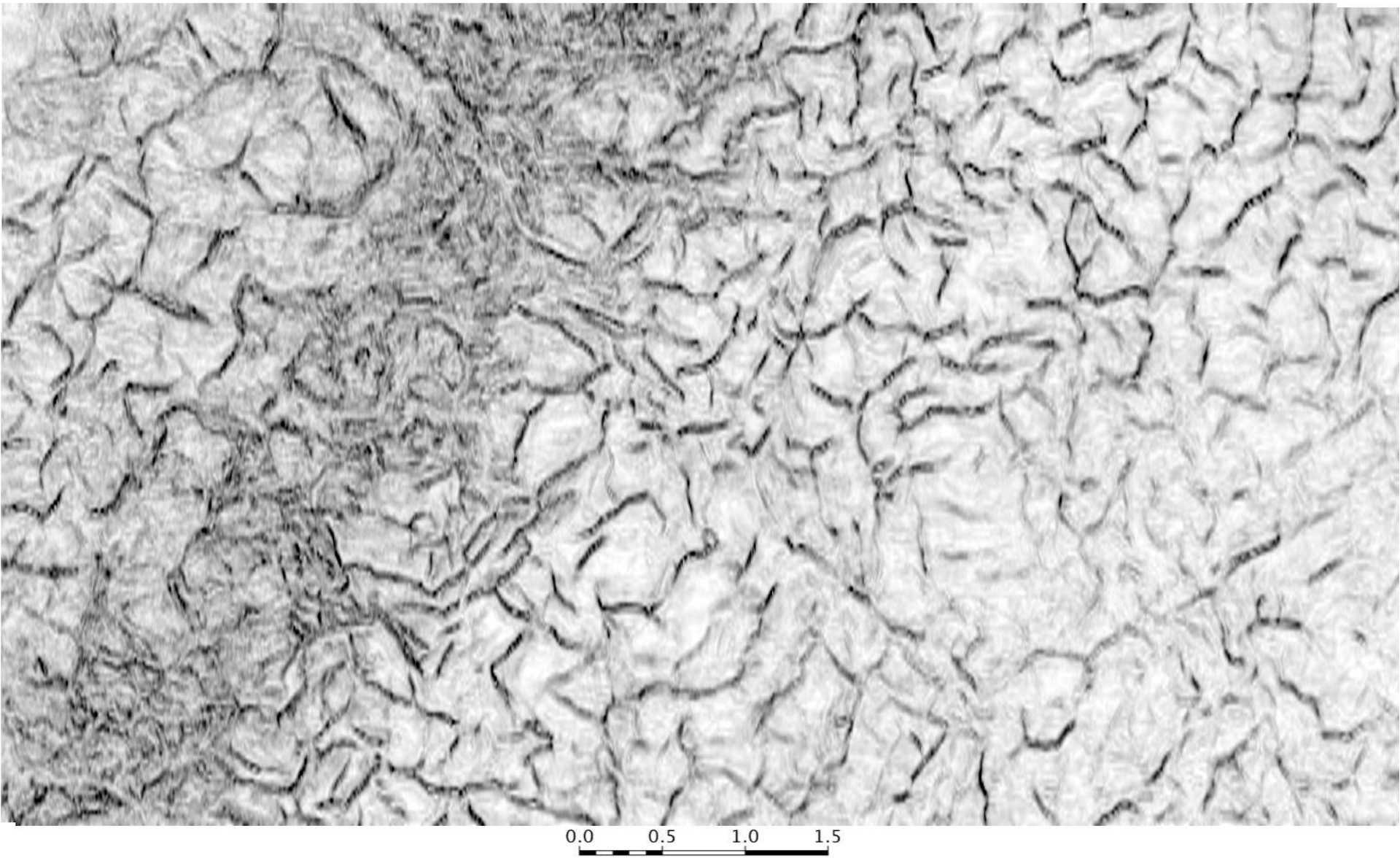
Quadrant Energy

Penta-Source : Case Study : Time Slice 2730 ms, Penta-Source



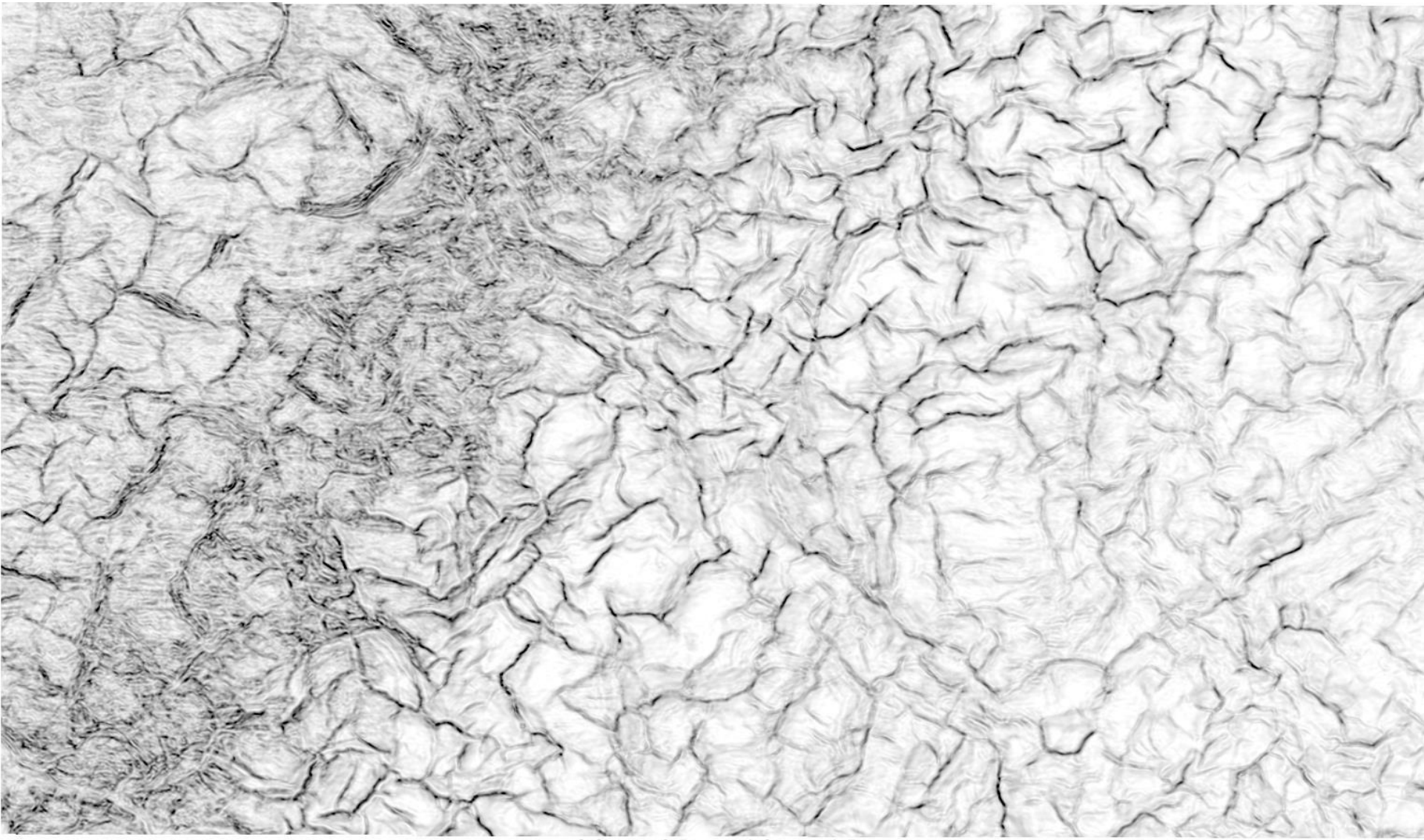
Quadrant Energy

Penta-Source : Case Study : Coherency 3100 ms, Conventional

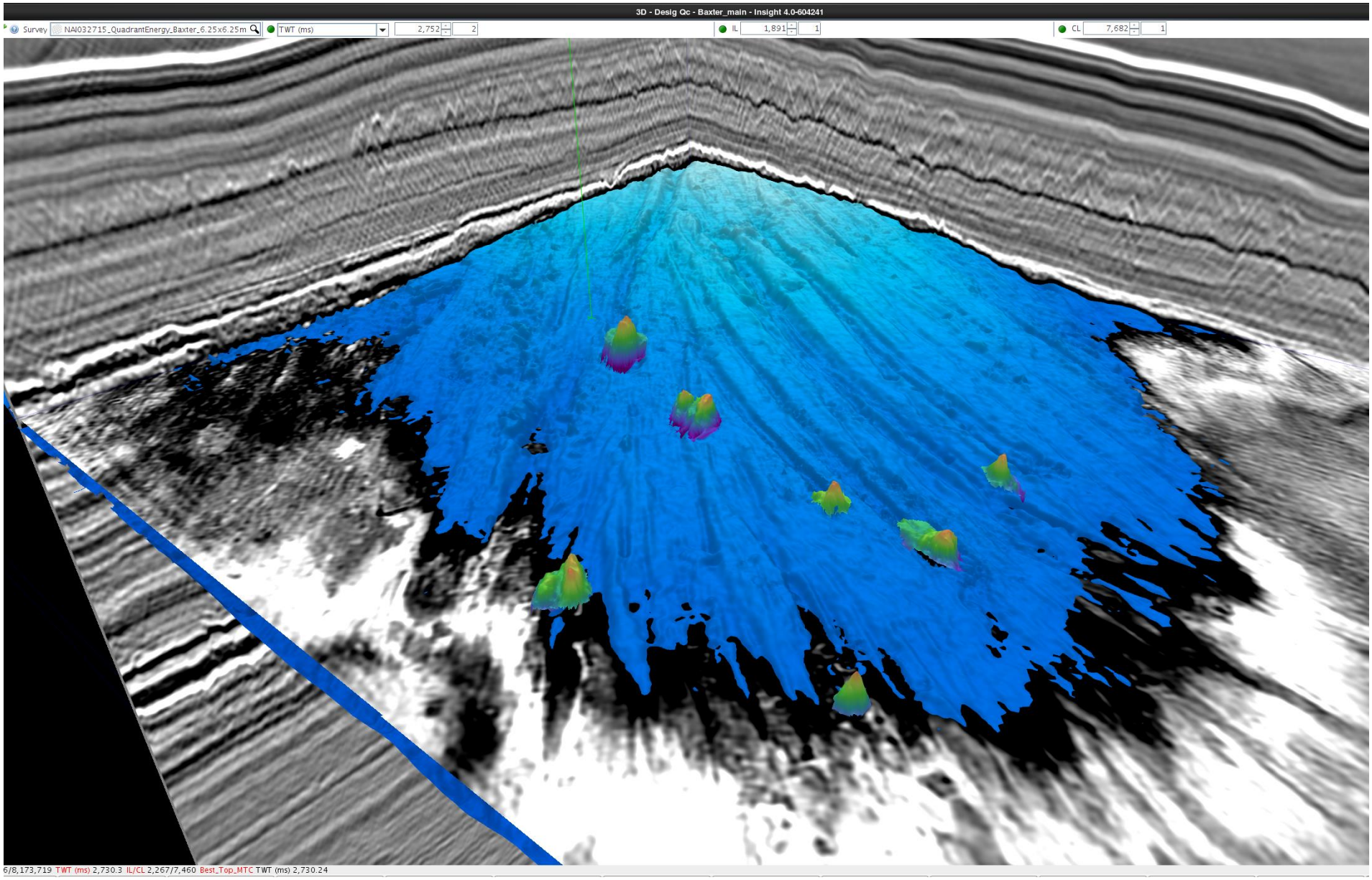


Quadrant Energy

Penta-Source : Case Study : Coherency 3100 ms, Penta-Source



Quadrant Energy


3D - Desig Qc - Baxter_main - Insight 4.0-604241
Survey
NAI032715_QuadrantEnergy_Baxter_6.25x6.25m
TWT (ms)
2,752
2
IL
1,891
1
CL
7,682
1
6/8,173,719 TWT (ms) 2,730.3 IL/CL 2,267/7,460 Best_Top_MTC TWT (ms) 2,730.24

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Conclusions

- Leveraging de-blending of overlapping shots provides the opportunity to sample 3D towed streamer seismic data with more sources and less streamers.
- Sources can be used to increase overall efficiency and/or increase inline and crossline trace sampling density.
- The reduction of the number of streamers provides a significant reduction in capital costs and risks, operational risks, and HSE exposure during deployment, retrieval, and daily streamer maintenance.
- Result - More, better, quicker!

Acknowledgements

- Management of Polarcus
- Management of DownUnder GeoSolutions
- Quadrant Energy for permission to show examples from the Baxter survey.

DownUnder GeoSolutions

Polarcus

Thank you for your time and attention

@Polarcus