Seismic Data Processing Report

3D Land

For: ***SENEX Energy Limited***

Area: ***PEL 104 and 111, Cooper Basin***

Survey: ***Mollichuta 3D***

CGG Australia			
38 Ord Street			August 13, 2013
WEST PERTH WA 6005			
AUSTRALIA			
			Compiled by:
Tel:	(08) 9214 6200		*Min Lee Chua*
Fax:	(08) 9214 6222		*Anatoly Osadchuk*

Contents

Table of Figures

1 Introduction

1.01 Scope of report

This report describes 114 sq. km seismic data processing of Mollichuta 3D 2009 onshore survey for SENEX Energy Ltd by CGG between December 2012 and July 2013.

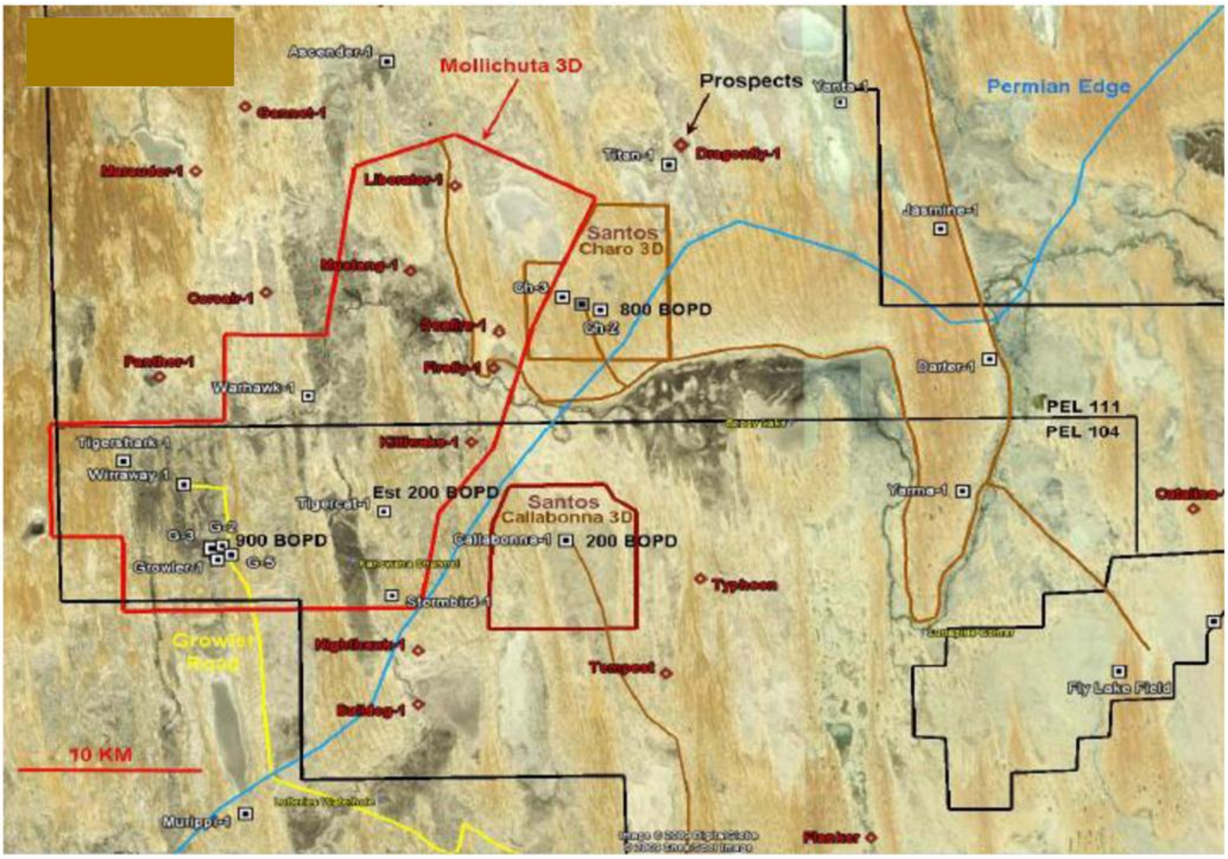


Figure 1 Mollichuta 3D in SENEX exploration campaign context

Project management and parameter testing were conducted in Perth and production was run at CGG processing hub in Singapore.

The project is registered under CGG project number ph100se.

1.02 Purpose and objectives of the processing

The processing goals were high SNR, good temporal resolution, pre-stack time migrated datasets suitable for AVO and AVAZ analyses.

1.03 Personnel

SENEX :

Irwan Djamaludin	*Geophysicist*
Cameron Belcher	*Senior Geophysicist*

For CGG:

Min Lee Chua	*Senior Geophysicist*
Marwoto	*Project Leader*
Anatoly Osadchuk	*Sr. Team Leader*
Nigel Mudge	*Centre Manager*

1.04 Acquisition Parameters

General Parameters	
Survey Name	Mollichuta 3D
Acquisition contractor	Terrex Seismic Crew 402
Year acquired	March 2009
Volume	114 km^2 processed (actual whole survey size is 268 km^2)
Correlated Record Length	5 sec
Acquisition Sample Interval	2 ms
Channels per record	960 (10 lines x 96 Channels live)
A8cquisition Filter	High: 0.8 Nyquist-Linear
Bin size	25x25m
Nominal CMP Fold	60
Source Parameters	
Source type	I/O AHV-IV
Source peg interval	50 m
Source line interval	200, 400 and 800 m
Source array	3 Vibs inline (12m pad spacing)
Sweep frequency	2-80 Hz
Sweep amplitude taper	200 ms
Sweep type	Linear
Sweep length	6 sec
Sweeps per VP	2 standing sweep
Phase Lock	N/A
Amplitude control	N/A
Receiver Parameters	
Receiver interval	50 m
Receiver line interval	400 m
Receiver array	12 geophones 2.08m apart
Receiver array dimensions	50m Centred on Station
Instrumentation	
Recorder	SERCEL SN 428
Geophone	SERCEL SG 10
Noise Editing	Div Stack
Correlation	With Pilot

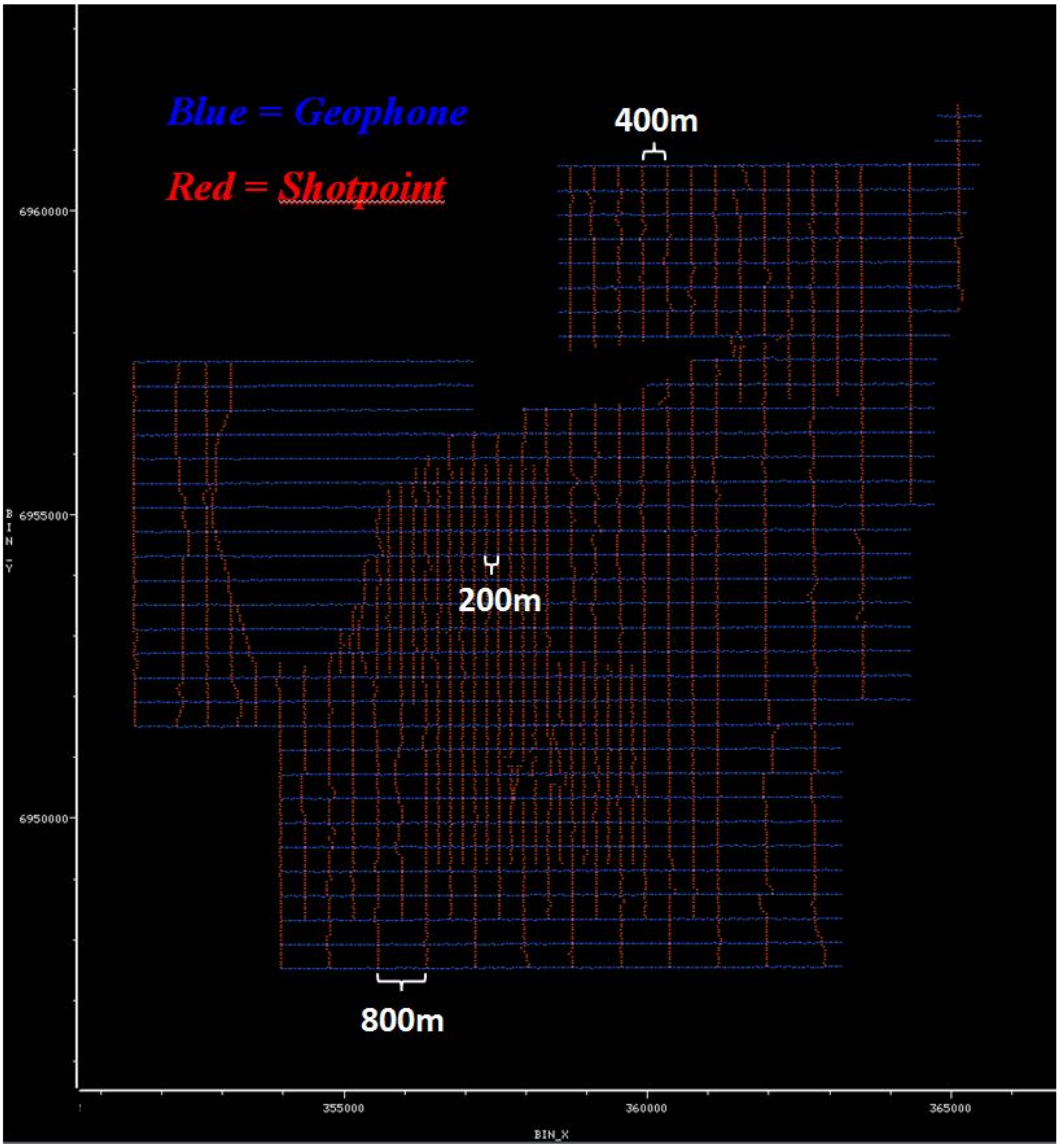


Figure 2 Acquisition Grid. RCV Line 400m, SP Line 200/400/800m. SP&RCV Interval 50m

2 Processing

2.01 Processing Sequence and Deliverables Summary

1. **SEG-D input** TL/SI=5000/2ms
2. **Nav merge and 3D gridding**
3. **First Break Picking and Tomo Statics**
4. **Conversion from Zero- to Minimum Phase**
5. **Resample** 2ms-> 4ms
6. **T^2 Spherical Amplitude Compensation**
7. **Apply Tomostatics**
8. **Anomalous Amplitude Attenuation/Despiking**
9. **Surface Consistent Deconvolution**
10. **Linear Noise/Groundroll Attenuation**
11. **VA01** 1x1km
12. **Compute/Apply Surface Consistent Residual Statics #1**
13. **Random Noise Attenuation**
14. **Surface Consistent Amplitude Correction**
15. **VA02** 1x1km
16. **Compute/Apply Surface Consistent Residual Statics #2**
17. **Residual Linear Noise/Groundroll Attenuation**
18. **Cadzow Random Noise Attenuation**
19. **3D COV Regularization**
20. **Remove T^2 Amplitude Compensation**
21. **Preliminary PSTM for velocity picking**
22. **VA03** 1x1km
23. **3D PSTM** with smoothed VA03
24. **VA04.** Dense Vstk and Eta 25x25m autopicking
25. **NMO** VA04 Vstk/Eta
26. **VA05** 25x25m Azimuthal: Vfast, Vslow, Azimuth ω
27. **AzNMO** VA05
28. **Inv-Q** Amplitude only and **Spectral Shaping Filter**
29. **Gather Flattening** (Trim)
30. **FX denoise on CDP gathers**
31. **Shift from Processing to MSL=0m Datum**
32. **Stack**
33. **Low freq dip filter**
34. **Post-stack Cadzow filtering**
35. **Time variant filter**
36. **Final PSTM Stack**

Table 1. Project Deliverables

NO	Deliverable	Filename	Format	Media	Number of Copies	Datum	Comment
		Seismic Gathers					
1	Decon gathers	PreInterpolation_CMP_Gathers.sgy	SEGY	USB#U 001	1	Float	before interpolation, No NMO
2	Raw PSTM gathers (48 fold) - 3D int	Raw_PSTM_Gathers_WithNMO.sgy	SEGY	USB#U 001	1	MSL	NMO applied, no SPARN FX denoise
3	Final PSTM gathers (48 fold) - 3D int	Final_PSTM_Gathers_WithNMO.sgy	SEGY	USB#U 001	1	MSL	NMO applied, with SPARN FX denoise
		Seismic Cubes					
9	48-fold Raw Full Stack	11A_Raw_PSTM_FullFold_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, X-T mute
11	48-fold Final Full Stack	12A_Final_PSTM_FullFold_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, X-T mute, post-stack Cadzow, TVF
13	Angle Stacks	13A_PSTM_00_15deg_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, angmute, post-stack Cadzow, TVF
	Angle Stacks	13A_PSTM_15_25deg_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, angmute, post-stack Cadzow, TVF
	Angle Stacks	13A_PSTM_25_35deg_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, angmute, post-stack Cadzow, TVF
	Angle Stacks	13A_PSTM_35_45deg_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, angmute, post-stack Cadzow, TVF
	Angle Stacks	13A_PSTM_45_55deg_Stack.sgy	SEGY	USB#U 001	1	MSL	Vnmo/Eta, AzNMO, Amp Q, Trim, angmute, post-stack Cadzow, TVF

		Kinematic Attribute Cubes					
15	HDPIC Dense 25x25m Vnmo Velocity	15A_DenseStackingVelocity_FixedDatum.sgy	SEGY	USB#U001	1	MSL	
16	HDPIC Dense 25x25m Eta	16A_DenseEffectiveEta_FixedDatum.sgy	SEGY	USB#U001	1	MSL	
		ASCII Attributes					
29	Floating Datum	Mollichuta3D_FloatingDatum.txt	ascii	USB #U001	1	N/A	IL/XL/X/Y/Static Shift
30	Tomo Statics and Residual Statics	Mollichuta3D_Tomostatics_and_Residual Statics.txt	ascii	USB #U001	1	N/A	Tomostatics and Residual Statics
31	Stacking Velocity VA02 1x1km	VA02_StackingVelocity1x1km_WesternFormat.txt	ascii	USB #U001	1	FLOAT	Last VA of un-migrated data On Processing Datum
32	Migration Velocity Smooth VA03 1x1km	VA03_MigrationVelocitySmooth1x1km_WesternFormat.txt	ascii	USB #U001	1	FLOAT	VA03 On Processing Datum
34	Post PSTM Dense VA04 extract 240x240m/50ms	VA04_PostPSTM_DenseVelocity250x250m.ascii	ascii	USB #U001	1	FLOAT	Post PSTM Velocity - Automatic Dense Velocity On Processing Datum
35	Bin Coordinates with PSTM CDP Fold	Mollichuta3D_BinCoordinat_PSTM_Fold Cover.txt	ascii	USB #U001	1	N/A	IL/XL/X/Y/Final Stack Fold
36	Processing Report		pdf	DVD #2	1		

2.02 SEG-D Input

At this step SEG-D field records 5s/2ms were converted to CGG internal format 5s/2ms.

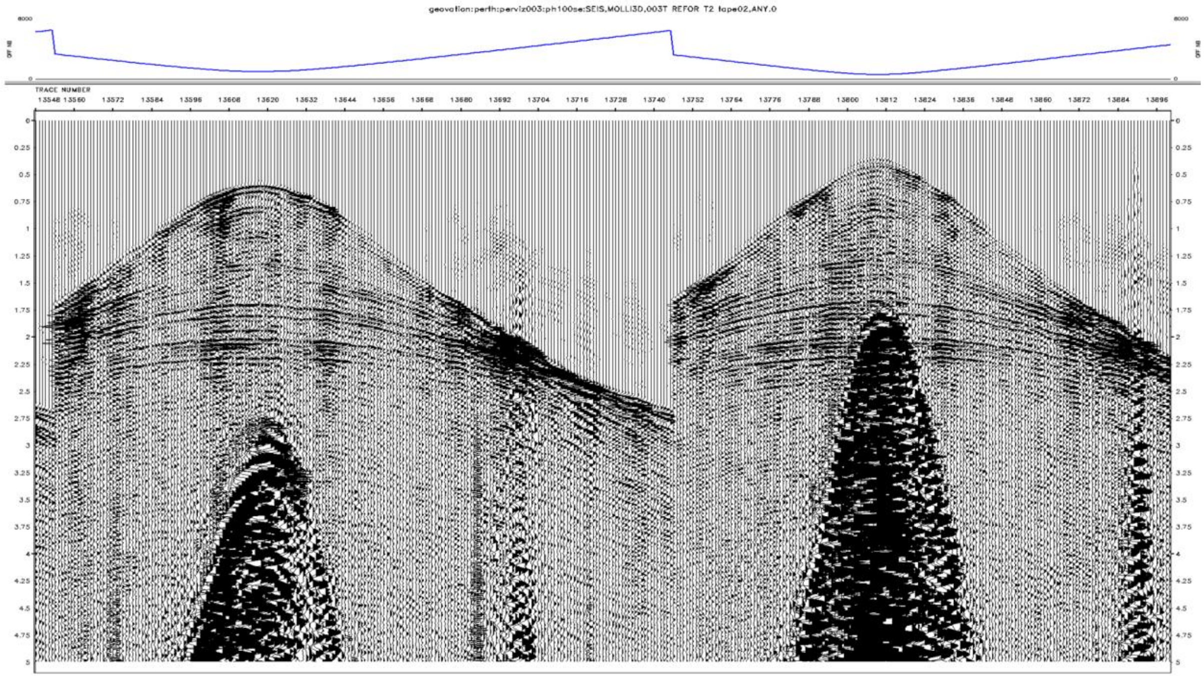


Figure 3 Mollichuta raw shot example

Data was found to be in good technical condition: no digital distortions, no corrupted headers encountered.

2.03 Geometry and Grid

Geometry database was created from SPS files, loaded to trace headers and gridded to 3D CMP as follows:

Geodetic Datum **GDA94**
Projection Zone **54S**

Grid Corners (INL/CRL) (X/Y):

CORNERS (INL/CRL) (X/Y)
(2002, 10002) (351586.29, 6947523.87)
(2533, 10002) (351539.83, 6960798.79)
(2002, 10513) (364361.22, 6947568.58)
(2533, 10513) (364314.75, 6960843.50)

INL/XL Increment 1/1
CMP Cell size 25x25m

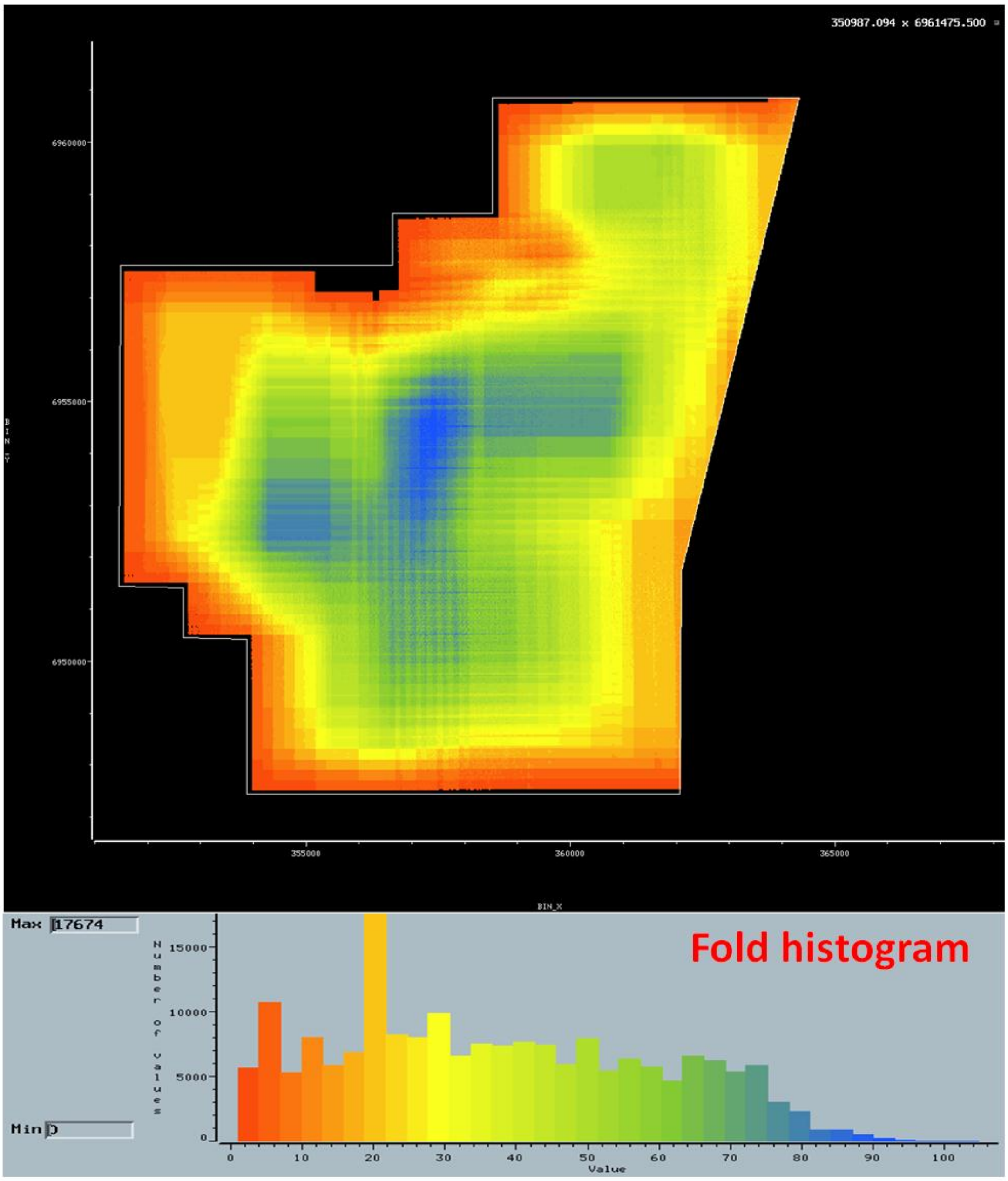


Figure 4 Raw Stack Fold Map.

Median Fold coverage = 40 (in 400x400m SL/RL area)

2.04 Conversion from Zero- to Minimum-Phase and Resampling

The minimum phase signal, required by deconvolution, is the most *front-loaded* signal possible that is both causal and has the given amplitude spectrum. Mathematically it is a signal with phase spectrum $\Phi(\omega)$ which is a Hilbert transform of amplitude spectrum $A(\omega)$

$$\Phi(\omega)=\mathrm{H}\{\ln[A(\omega)]\}$$

Mollichuta Minimum Phasing Operator was designed using Klauder wavelet extracted from a field record auxiliary channel (Fig 5).

Data resampling from 2ms to 4ms which followed, was performed without prior anti-alias filter.

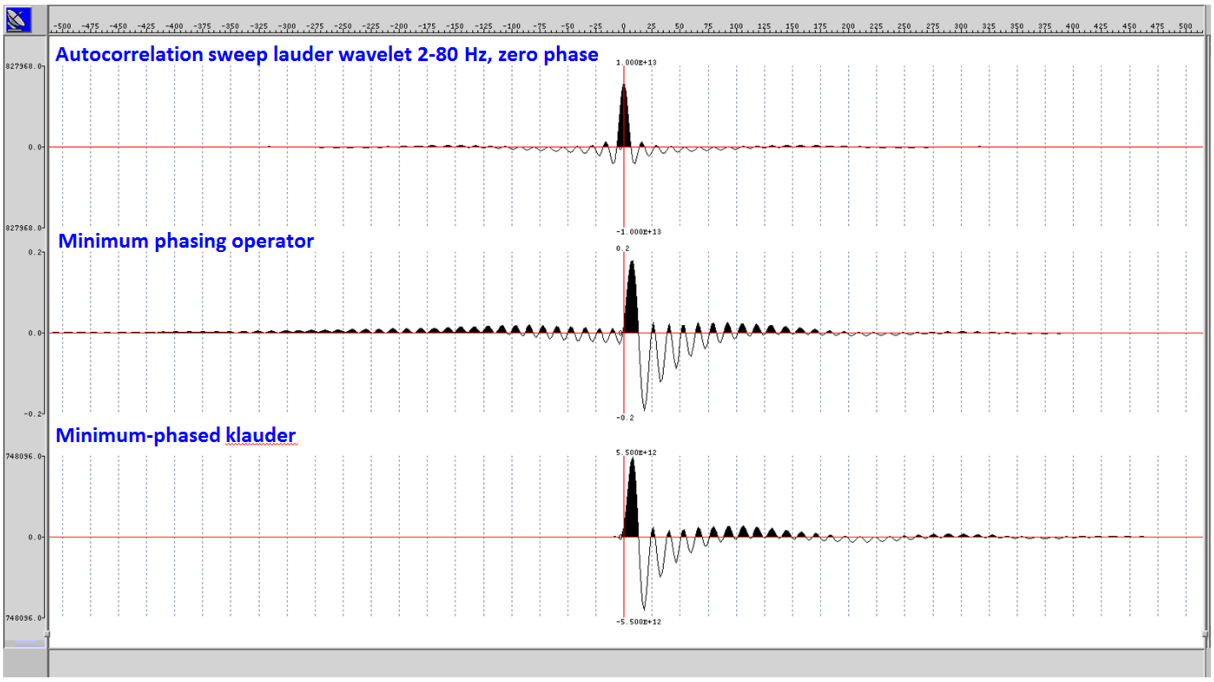


Figure 5 Minimum Phasing

2.05 First Breaks and Long Wave Statics

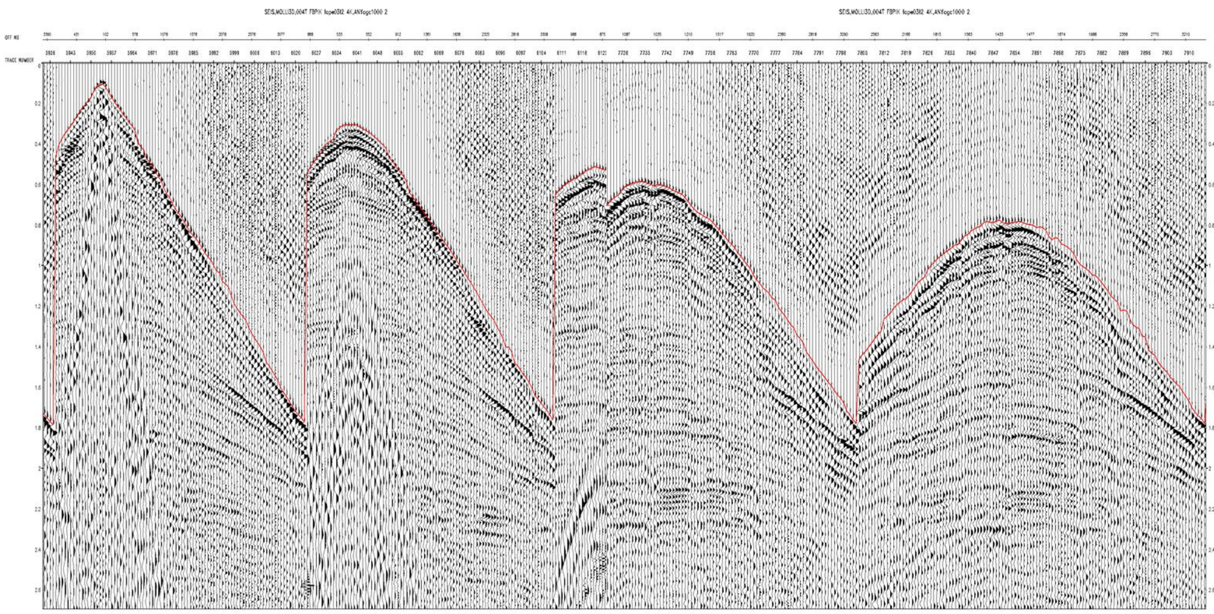


Figure 6 First Breaks QC in XSpread domain. Top right XSpreads used to QC FB picks

First breaks were auto-picked on raw shots and qc'd over the survey area on XSpread gathers.

Three different static solutions were derived and compared to ascertain the optimal statics.

An *Elevation Static* correction was based on a constant depth of weathering of 20 metres at 600 m/sec overtop of a subweathering layer of 1900 metres/second down to a datum of sea level.

This model was also input along with the first break picks and iterated to converge on an *LMI static* solution. Linear Model Inversion (LMI) uses first breaks to update the depth of weathering and subweathering velocity of initial model to fit the first breaks.

The *Tomo Statics* initial model was a simple 2 layer: thickness/Vz: 40m/1200m/s, 200m/1900m/s below.
Tomo non-linear solution treats first-breaks as diving ray events and inverts their traveltimes to V(z,x,y) tomogram by computing Vz of each cell. Model sampling used 50x50x40m

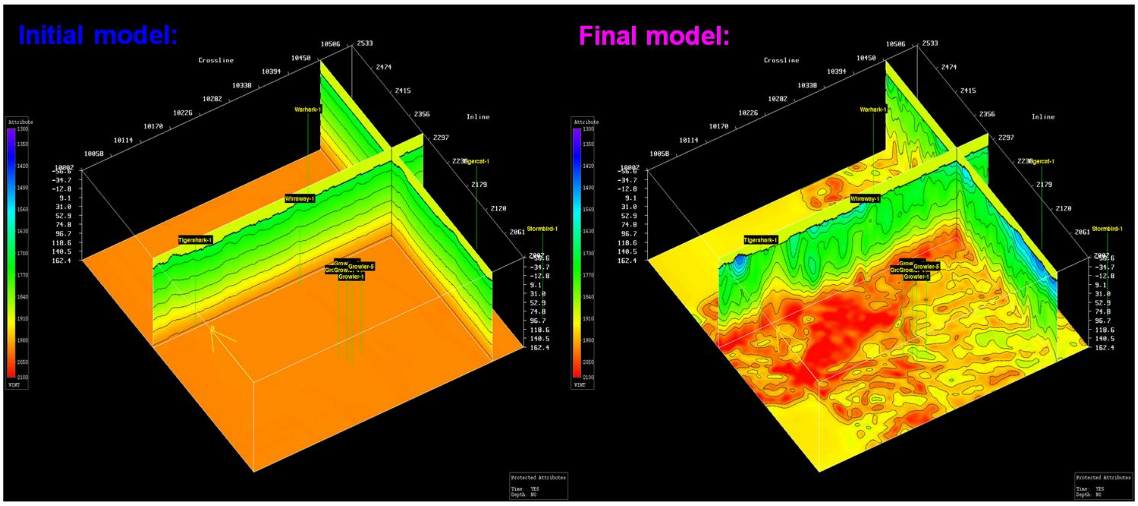


Figure 7 Tomo model before and after inversion.

After extensive qc on maps and stack cubes, SENEX approved tomostatics.

2.06 Anomalous amplitudes/noise bursts attenuation

Vibroseis data at input to processing is represented by correlograms generated in field from originally recorded vibrogram. Even if there were any spikes at a vibrogram, after correlation they are transformed to a lengthy noise trains. Such trains can be detected by comparing trace amplitudes of adjacent traces in a sliding window against their median value. Once detected, an anomalous trace fragment is scaled down by M/A, where M is median and A – anomalous amplitude.

Production Parameters:

Number of traces in sliding window:	11
Sliding window length:	300ms
Anomalous Amplitude threshold:	2.5

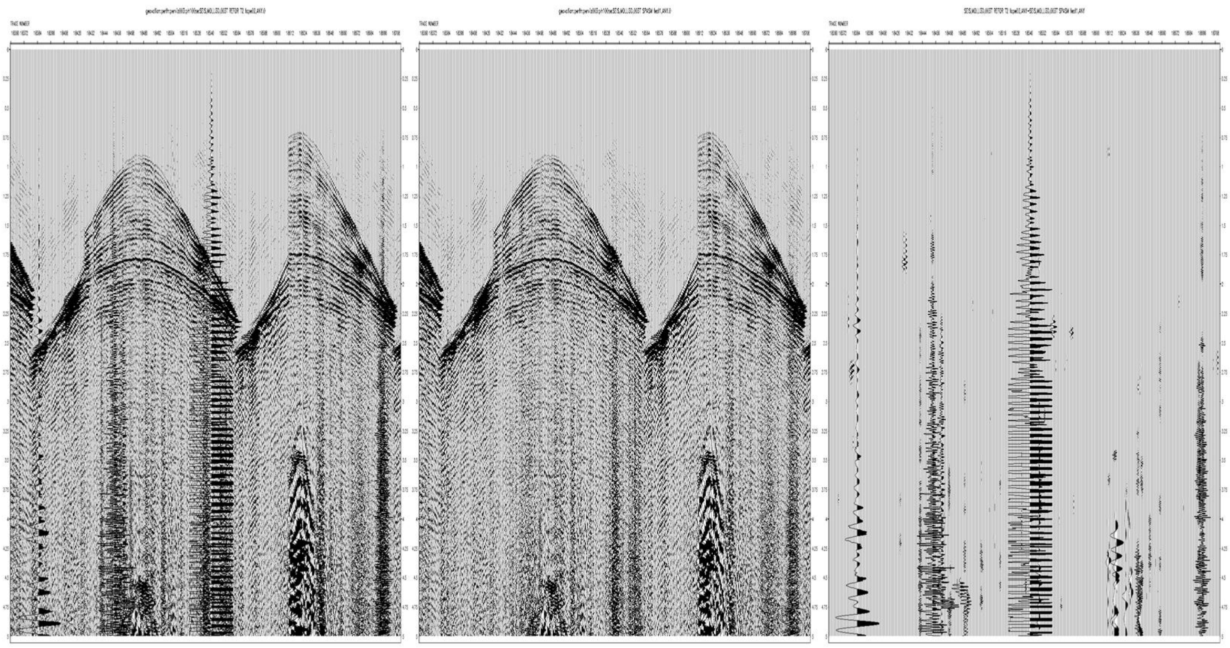


Figure 8 Noise burst example. Before, after attenuation and difference

2.07 Deconvolution

Deconvolution is carried out to reverse the effects of seismic convolution on recorded data, resulting in compression of the wavelet and increase in resolution of the data. It is also designed to remove short-period reverberations in the data.

Surface consistent deconvolution is based on the assumption that the seismic trace can be expressed mathematically as the convolution of the earth's reflectivity with the four filters, i.e. source, receiver, offset and CMP. The structural filter (CMP term) is not normally applied in this process.

SC Spiking Decon Parameters

Design window:	1000-2400ms following moveout
Operator Length:	160ms
White noise:	1%

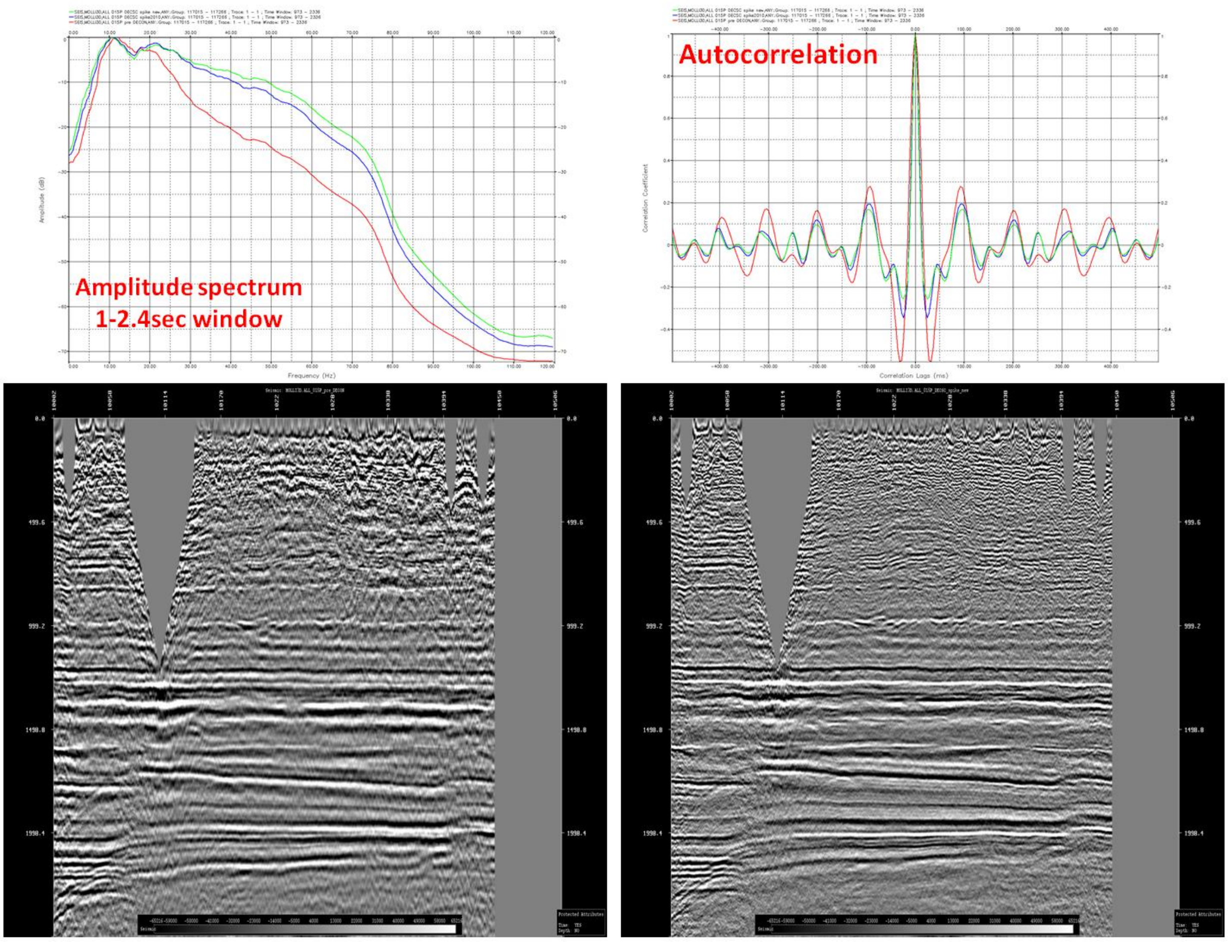


Figure 9 Before and after spiking deconvolution

Visual comparison, spectral and autocorrelation analyses demonstrated that spiking deconvolution broadened the amplitude spectrum and removed reverberation from the data resulting in noteworthy improvement in seismic resolution.

2.08 Linear Noise Attenuation

LINAT attenuates ground roll on cross spread data with orthogonal geometry. Data is first put into an orthogonal cube that is defined by two spatial attributes and time to form a T-X-Y cube and then is transformed to F-Kx-Ky domain. It is analyzed and filtered in that domain. Results are later transformed back to T-X-Y domain and are output

The following parameters are finally chosen for Mollichuta production.

LINAT Parameters:

XSpread	Domain
30-1200m/s	Vmin-Vmax range
3-35Hz	Frequency Range

After VA02 is done, a residual LINAT is applied with NMO wraparound:

LINAT Parameters:

XSpread	Domain
5-1500m/s	Vmin-Vmax range
3-40Hz	Frequency Range

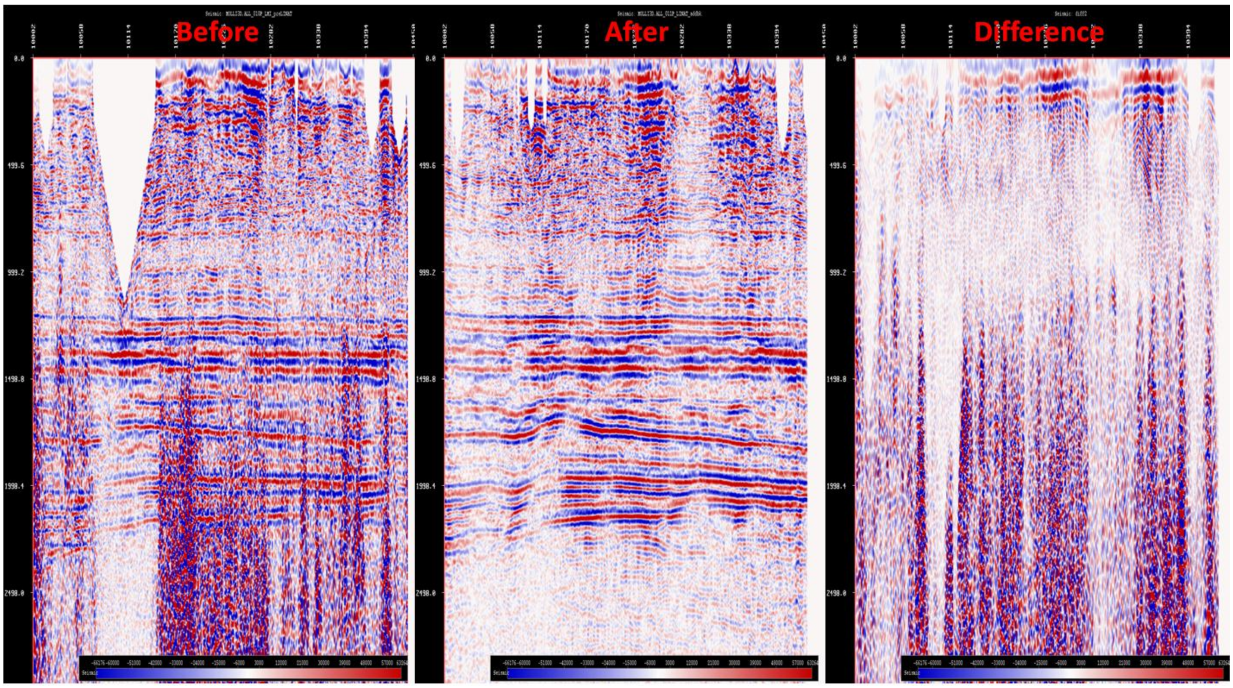


Figure 10 Stack before and after LNA LINAT

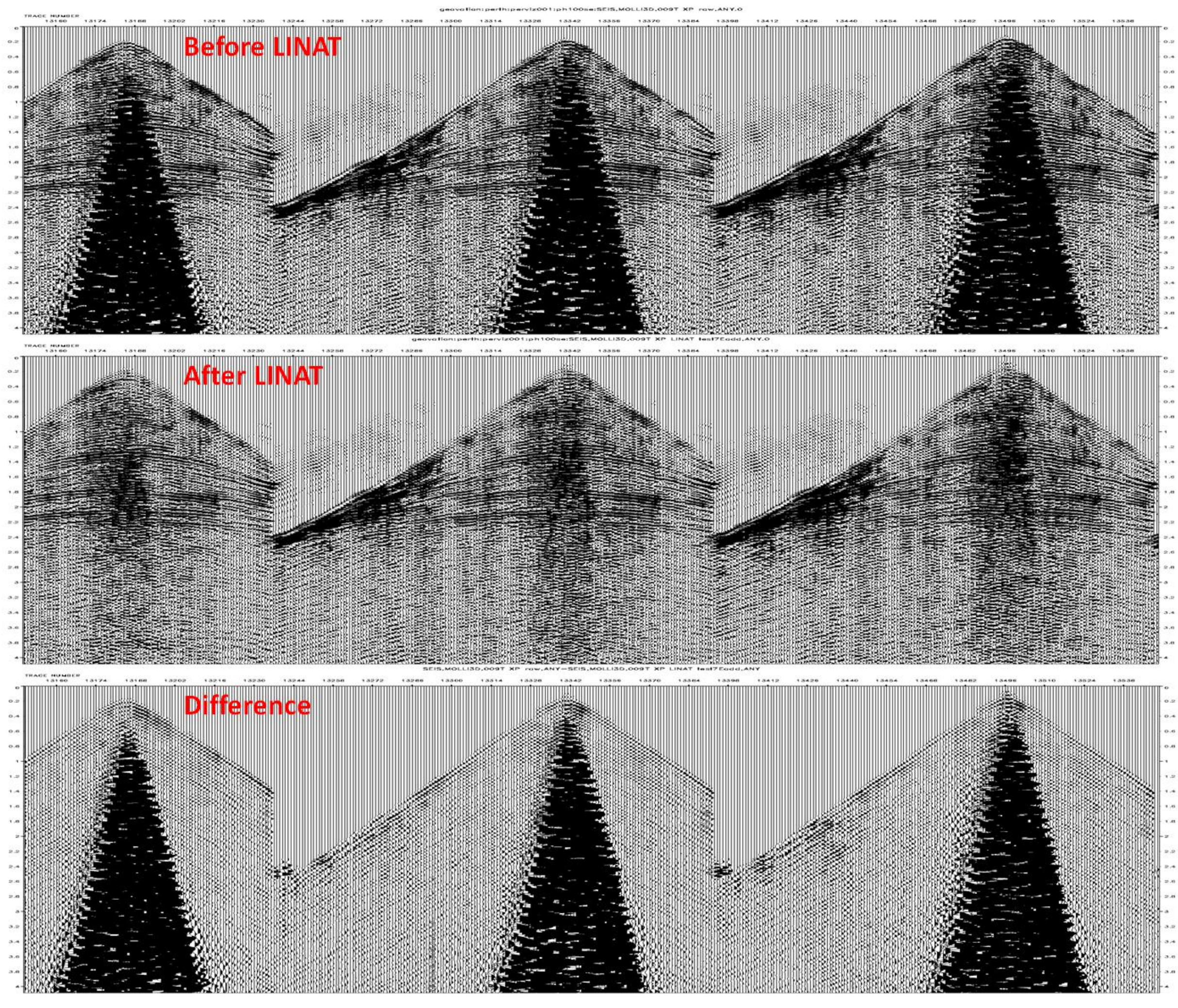


Figure 11 Shot Gathers. 3D Linear Noise Attenuation LINAT

2.09 Random Noise Attenuation FDNAT

Deconvolution has raised noise level. To suppress it, we applied 2 passes of FDNAT: in shot domain on each cable separately, then in receiver domain – separately on each shot line.

The FDNAT module attenuates high-amplitude noise in decomposed frequency bands. It uses frequency-dependent and time-variant amplitude threshold values in defined trace neighborhoods to detect and suppress noise specific to different frequency ranges and different times.

Production parameters:

NC71,	FREQ3,T0,TH3,T2600,TH3,T5000,TH1.3,
	FREQ10,T0,TH3.5,T2600,TH3.0,T5000,TH1.3,
	FREQ14,T0,TH3.5,T2600,TH3.0,T5000,TH1.3,
	FREQ30,T0,TH3.5,T2600,TH3.0,T5000,TH1.3,
	FREQ60,T0,TH3.5,T2600,TH3.0,T5000,TH1.3,
	FREQ80,T0,TH3.5,T2600,TH3.0,T5000,TH1.3,

where NC – number of traces; TH – threshold; T-TWT; FREQ – frequency.

Following VA02, a residual Random Noise Attenuation step was applied.

2.10 Surface Consistent Residual Statics

There were 2 passes of 3D Residual Static Corrections, one after VA01 and another after VA02 step. In both cases MASTT module has been used.

Modules MAST1 and MAST2 produce a surface consistent statics solution. MAST1 computes and saves the cross-correlations and other information to disk files. MAST2 uses these files to compute residual statics and outputs its database for application.

Production Parameters:

Window Horizon driven:	from 800 to 2200ms
Max shift	+-/16ms (1st pass)
Max shift	+-/12ms (2nd pass)

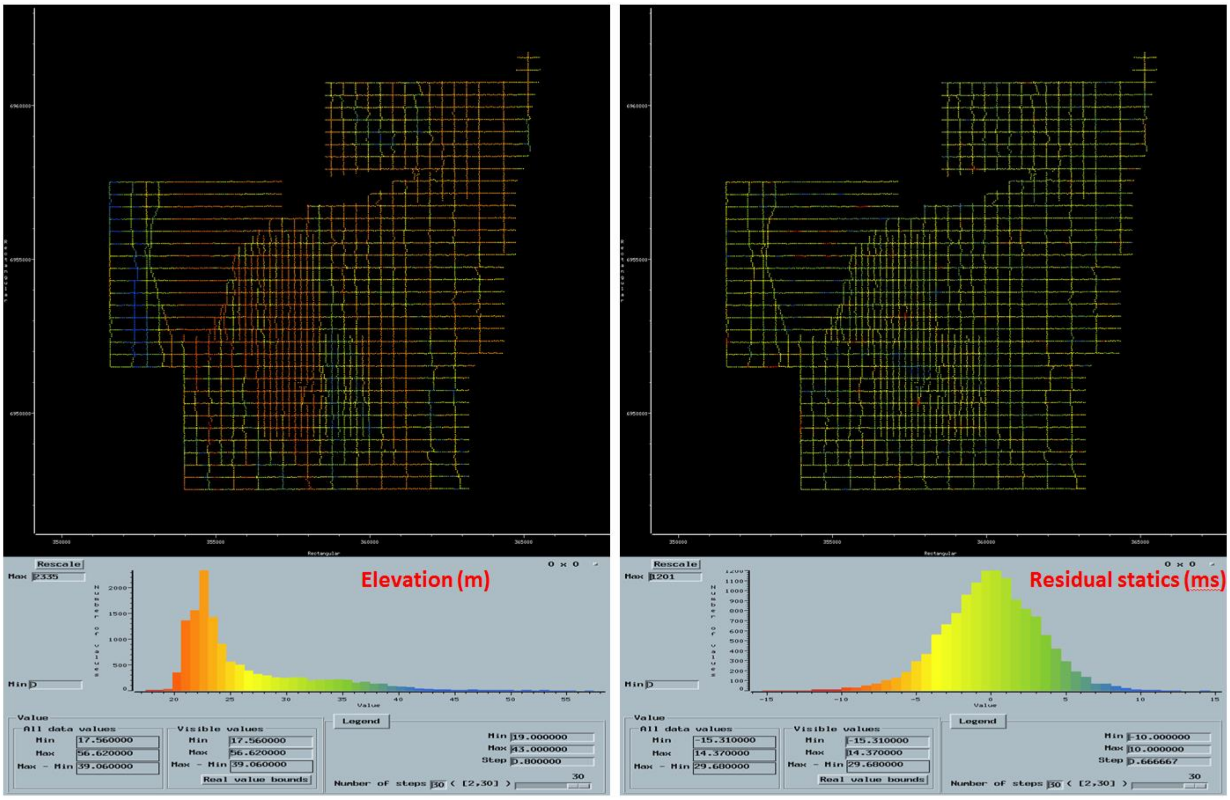


Figure 12 Sum of Residual Statics with Elevations for reference

2.11 Surface Consistent Amplitude Correction (SCAC)

SCAC attempts to compensate for source amplitude variation, receiver coupling, as well as for effect of near surface condition in a surface consistent manner. It computes shot, receiver, and offset amplitude terms, but only the shot and receiver terms are applied.

Production Parameters:

Amplitude Computation:	Window from 1000 to 2800ms
Correction Applied:	Shot and Receivers

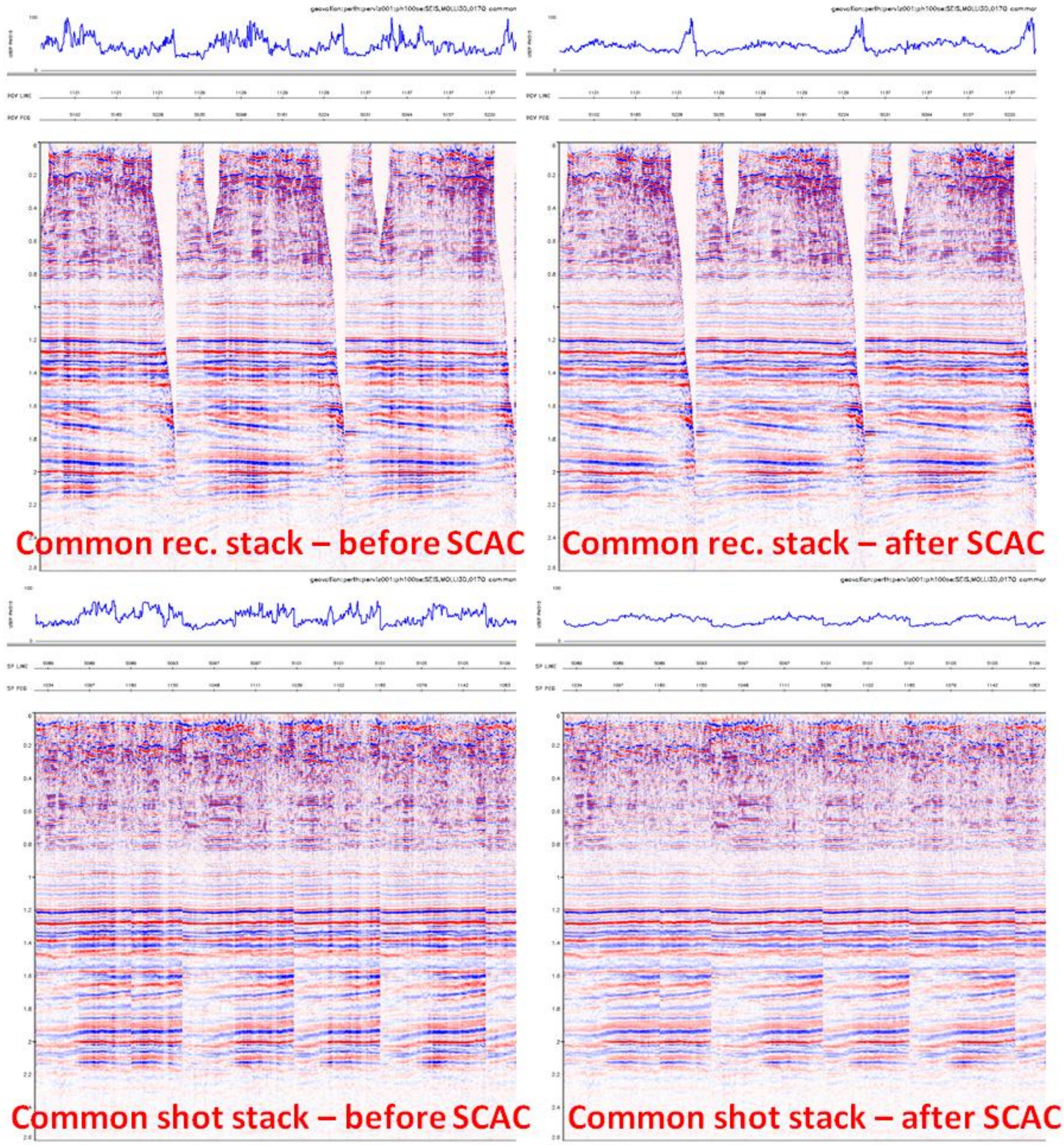


Figure 13 Surface Consistent Amplitude Correction.

2.12 Cadzow Random Noise Attenuation

In CADZO input traces are Fourier transformed to frequency domain where they form a complex Hankel matrix. Singular Value Decomposition (SVD) reduces the rank of this matrix. It is then returned to Hankel form and FFT'd to time domain.

Signal tends to span over lower ranks, random noise occupies higher. Noise is filtered out by limiting rank of the output matrix.

Production parameters:

Domain	cross-spread gathers with NMO wraparound
Mode/Rank:	Hankel/5
IL/XL block/taper:	9x9/3x3
Temporal window:	300/150ms

2.13 3D Interpolation and Regularization REG3D

Module REG3D performs 3D de-aliased Fourier data regularisation. Data is processed in overlapping spatio-temporal blocks.

After temporal FFT, each frequency slice is transformed into the spatial frequency domain with an irregular Fourier transform (similar to the anti-leakage Fourier transform). The reverse Transform reconstructs the energy to the bin centre (regularisation) or specified coordinates (mapping).

Instead of traditional radial-offset class grouping, a Common Offset Vector (COV) class grouping was performed on this survey. This method has the benefit of fulfilling minimal dataset requirements and has the characteristic advantage of featuring both group offset and group azimuth attributes. This allows for azimuthal attribute analysis and correction later.

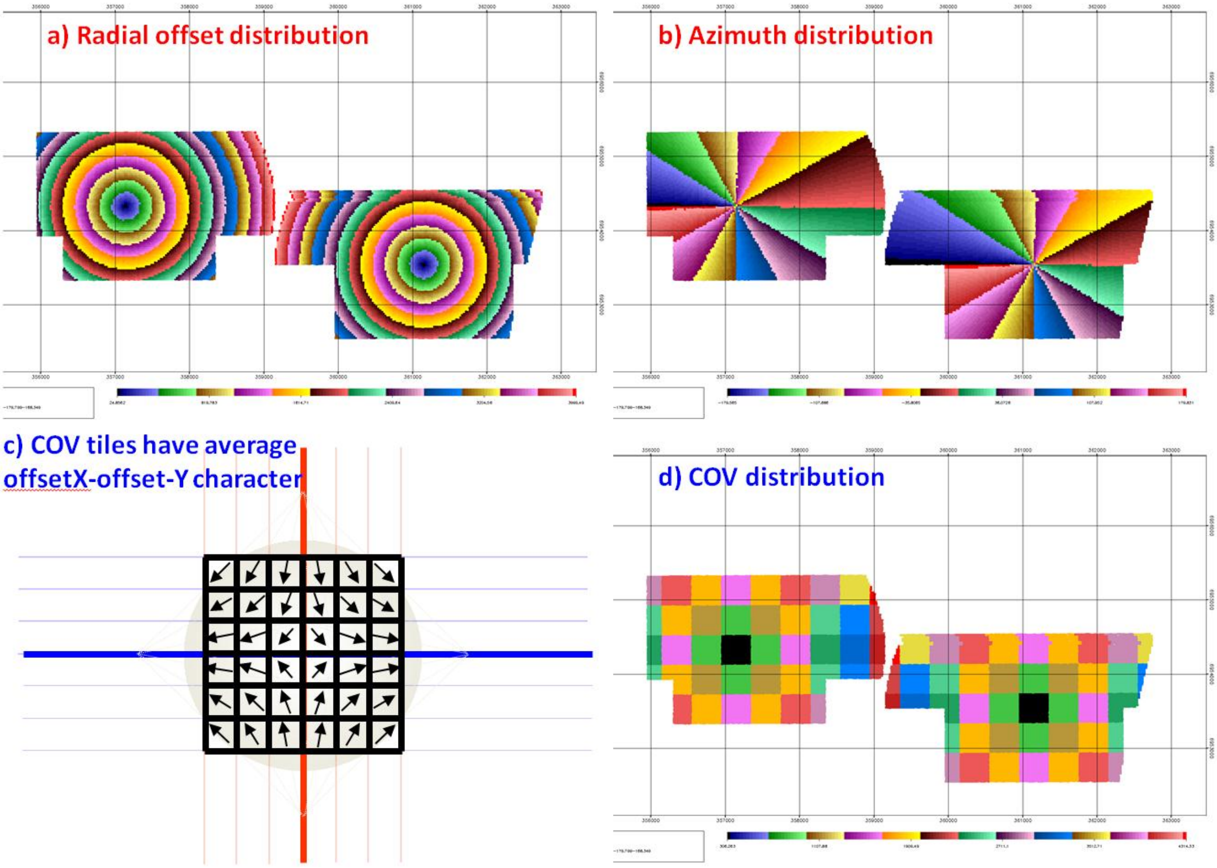


Figure 14 COV explanation

How COV binning works. The CDP distribution for two neighbouring cross-spreads are shown. Both a) and b) displays the true offset and azimuth of a trace. During COV tiling c), all traces are divided based on its offset-azimuth orientation into their COV tiles. In d) traces are now distinguished by their COV tile numbering. Each COV is then processed as just if it is an offset class.

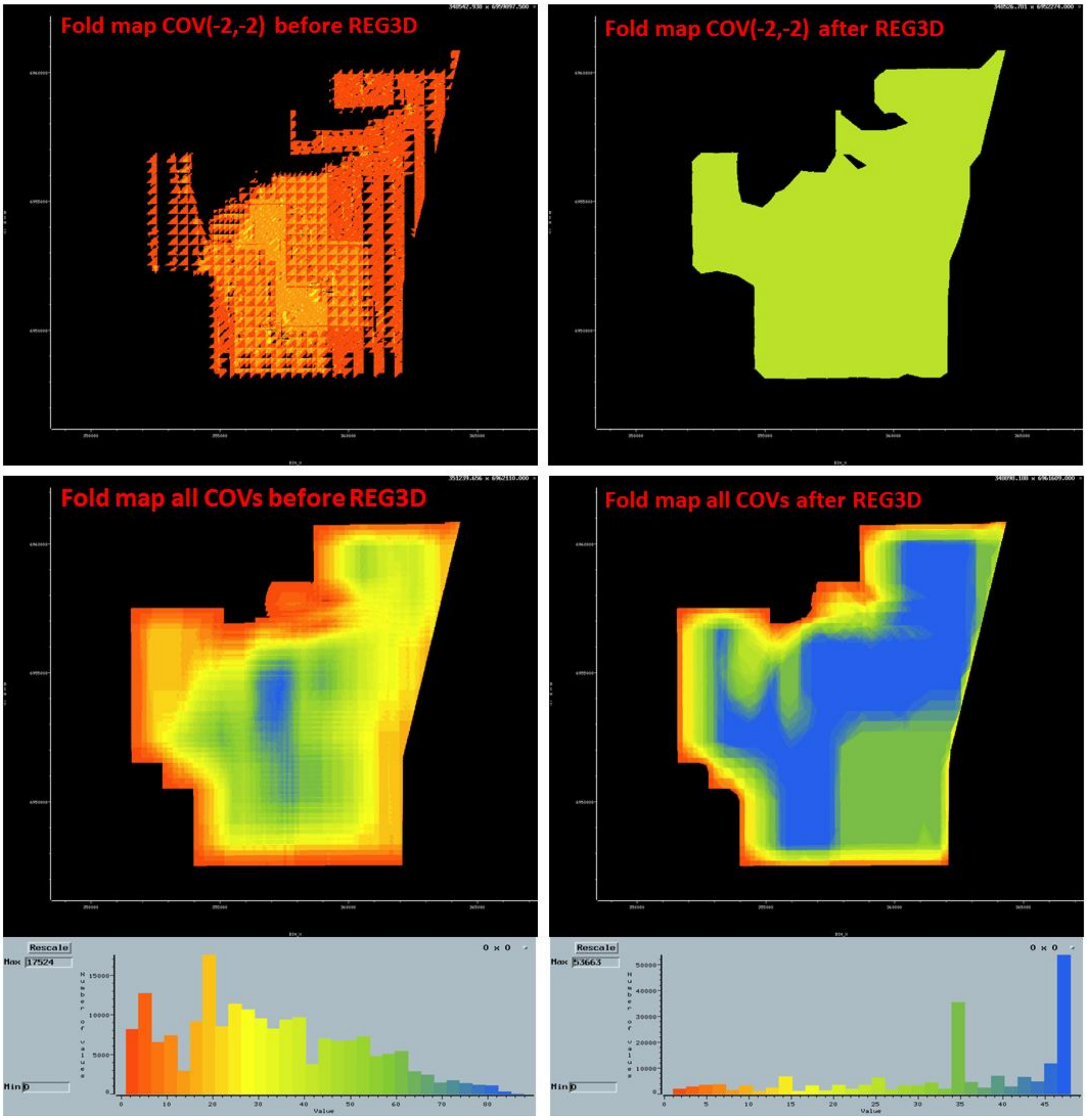


Figure 15 Fold map before and after COV interpolation.

Production Parameters:

Inline Block/Overlap Size	41
Xline Block/Overlap Size	41
Inline Offset Y spacing	800m
Xline Offset X spacing	800m
Number of COVs	48

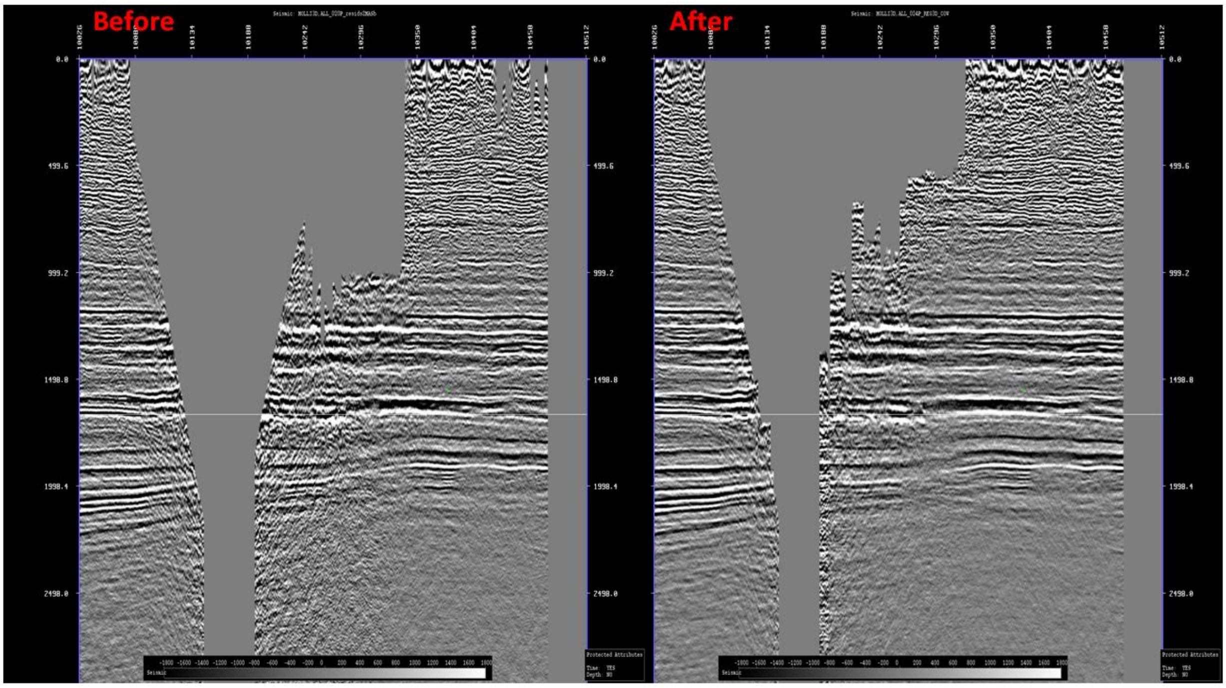


Figure 16 **Full stack before and after COV 3D interpolation**

2.14 Velocity Analyses

There were 3 passes of 1x1km manual velocity picking:

VA01 – to support Residual Statics #1
VA02 – to support Residual Statics #2
VA03 – on targeted 3D PSTMigrated lines, to create migration V-field

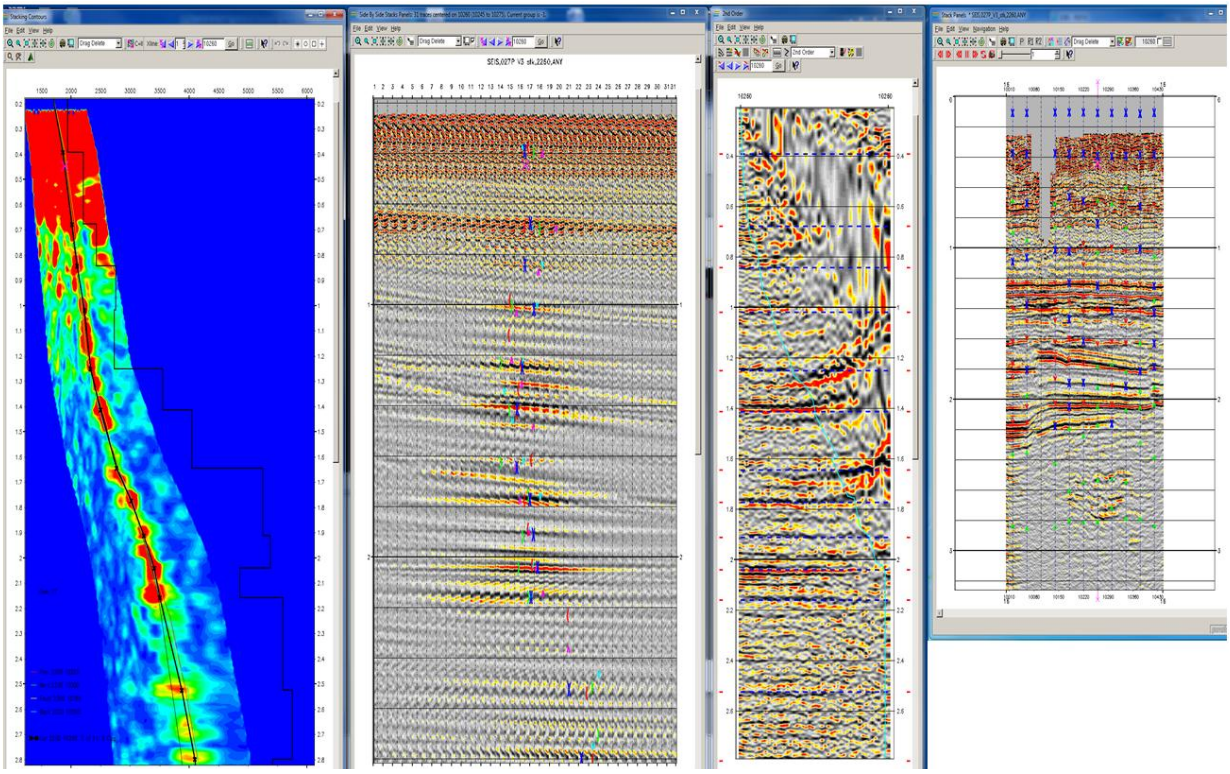


Figure 17 VA03 1x1km. Interactive Velocity Picking session example

2.15 3D Kirchhoff Pre-Stack Time Migration

Kirchhoff migration module is a trace-by-trace migration, which treats each output sample as the apex of a diffraction curve. Input samples are summed along the diffraction curve, which is characterized by a locally defined 1D RMS velocity function and raybending. The reflector image is built by constructive interference.

Geometrical spreading compensation is included into migration as amplitude terms of the Green function.

Each of 48 Single Fold cubes was migrated one by one.

Production Parameters:

Migration Velocity – smoothed VA03
Dip limit – 60°
Half-Aperture Limit – 2500m

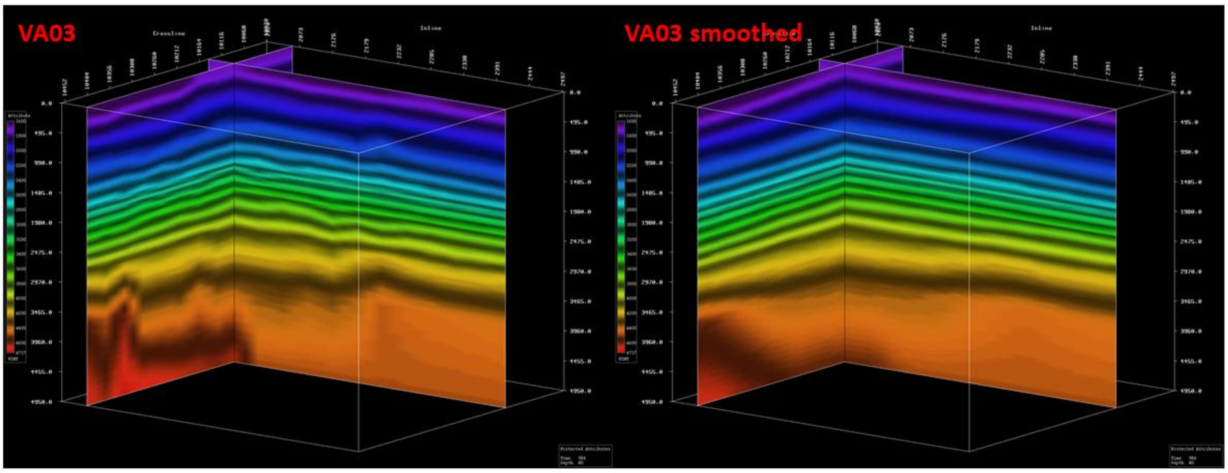


Figure 18 Migration velocity VA03 before and after smoothing

2.16 Dense VTI Analysis VA04 HDPIC

In VTI model reflections traveltime is expressed through Vnmo and effective Eta (Alkalifah & Tsvankin)

$$t_\rho^2 = t_0^2 + \frac{\rho^2}{v_{nmo}^2} - \frac{2\eta\,\rho^4}{v_{nmo}^2[t_0^2 v_{nmo}^2 + (1+2\eta)\rho^2]}$$

$$\eta = \frac{1}{2}\left\{\left(\frac{V_a}{V_{nmo}}\right)^2 - 1\right\}$$

where ρ – absolute (radial) offset and Va – anelliptical (“horizontal”) velocity.

The HDPIC module is used to generate dense volumes of velocity and anellipticity moveout parameters. It is based on an original approach of anelliptic shifted hyperbola moveout equation which corresponds to a sixth order approximation of anisotropic travel times. Both velocity and anellipticity parameters are simultaneously estimated using the full coverage of the data. The scanning of two internal uncorrelated parameters generates bispectral panels at time slices. The sampling of these parameters is directly related to the sensitivity of the normal moveout. For practical reasons, HDPIC outputs the uncorrelated parameters dtn and $\tau 0$ to help further interpolation, filtering and conversion to Vnmo and Eta (anellipticity) parameters.

A corridor, limited by the minimum and maximum values of Velocity and Eta reduces the analysis domain. Semblance maximum is used as the automatic picking criteria.

Computed effective parameters can be converted to interval ones:

Dix Inversions

$$v^2_{nmo\_int}(t_1 \rightarrow t_2) = \frac{t_2 V^2_{nmo}(t_2) - t_1 V^2_{nmo}(t_1)}{t_2 - t_1}$$ Interval nmo velocity

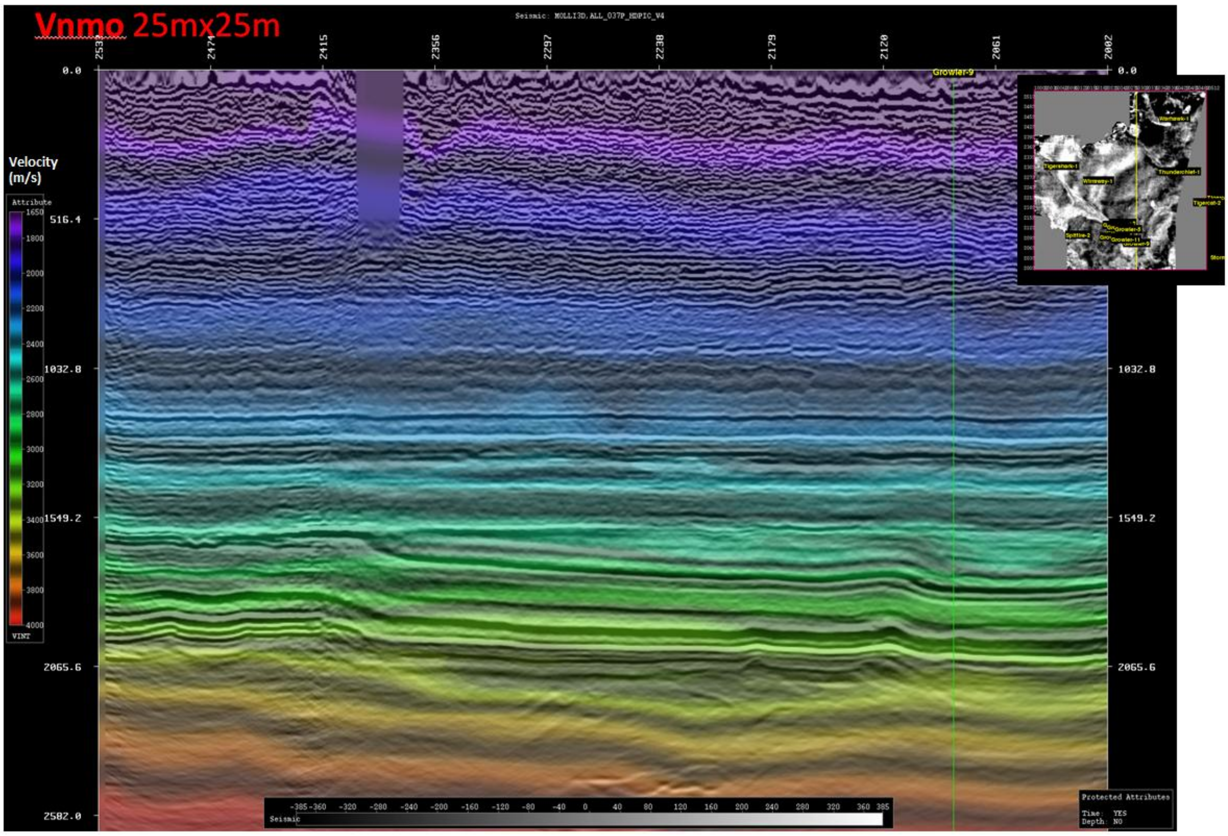
$$v^4_{a\_int}(t_1 \rightarrow t_2) = \frac{t_2 V^4_{a}(t_2) - t_1 V^4_{a}(t_1)}{t_2 - t_1}$$ Interval anelliptic velocity

$$\eta_{int}(t_1 \rightarrow t_2) = \frac{1}{8}\left(\frac{v^4_{a\_int}(t_1 \rightarrow t_2)}{v^4_{nmo\_int}(t_1 \rightarrow t_2)} - 1\right)$$ Interval anellipticity

Production Corridors:

TWT ms	0	1000	2000	3200	5000
Vnmo %	+/-3.0	+/-8.0	+/-8.0	+/-5.0	+/-5.0
η*1000	-20-20	-20-150	-10-200	0-150	0-100

The HDPIC results have been QC'd volumetrically in Tornado, on NMO'd gathers, semblances and stacks.



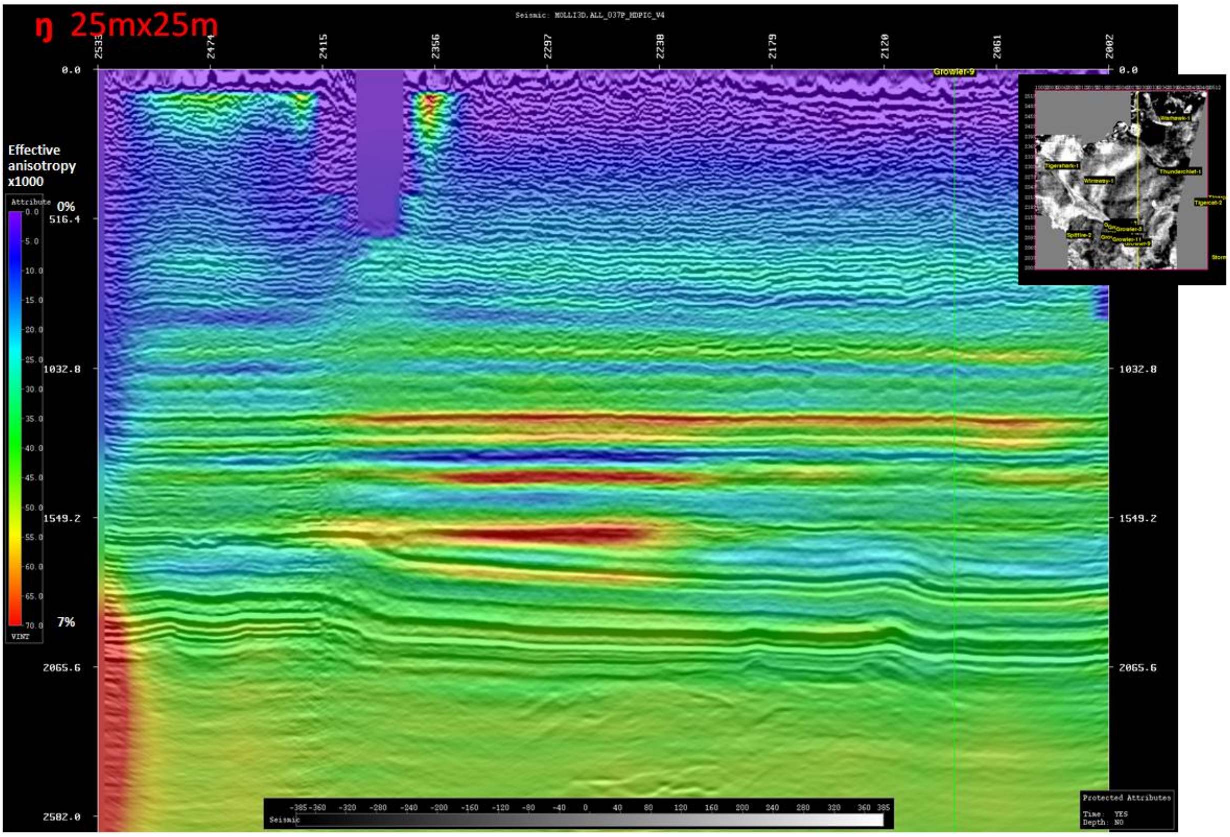


Figure 19 Dense VTI cubes generated by program HDPIC

2.17 Azimuthal Velocity Analysis VA05

Azimuthal velocity analysis purpose was two-fold:

- improve gather flattening by accounting for azimuthal NMO anomalies
- evaluate azimuthal velocity anisotropy parameters and attempt to interpret them in terms of fracture density and orientation

It is expected that fast velocity direction coincides with fracture direction and Vfast-Vslow/Vfast is proportional to fracture density.

The theory behind is based on assumption that what in an isotropic medium used to be a 3D hyperboloid is now an elliptically squeezed/stretched in horizontal plane 3D hyperboloid.

Azimuthal Traveltime

$$T = \sqrt{T_0^2 + \frac{R^2}{V_\varphi^2}}$$

where

$$\frac{1}{V_\varphi^2} = \frac{\cos^2(\varphi - \omega)}{V_{fast}^2} + \frac{\sin^2(\varphi - \omega)}{V_{slow}^2}$$

where

ω – fast velocity azimuth

φ – trace azimuth

$$k = \frac{V_{fast} - V_{slow}}{V_{fast}}$$

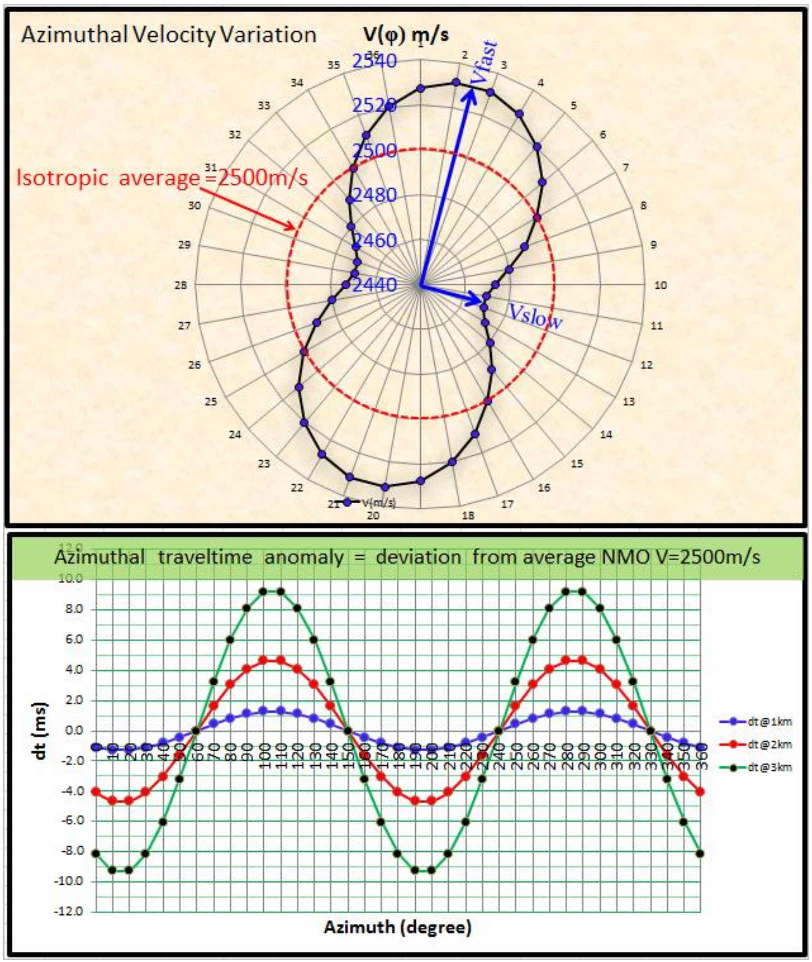


Figure 20 Azimuthal Vnmo anisotropy

ω=15deg k =2.5% and caused by it moveout anomalies at offsets 1km, 2km and 3km (TWT=1.6s)

2.18 Azimuthal NMO and Trim Statics

Azimuthal NMO has been applied using VA05 azimuthal analysis attributes – Vfast, Vslow and azimuth ω.

Time-Variant trim-statics has been computed in 400ms sliding gate from 300 to 2800ms. Max shift 10ms.

As can be seen from Fig. 24 below , the effect of AzNMO is small but positive.

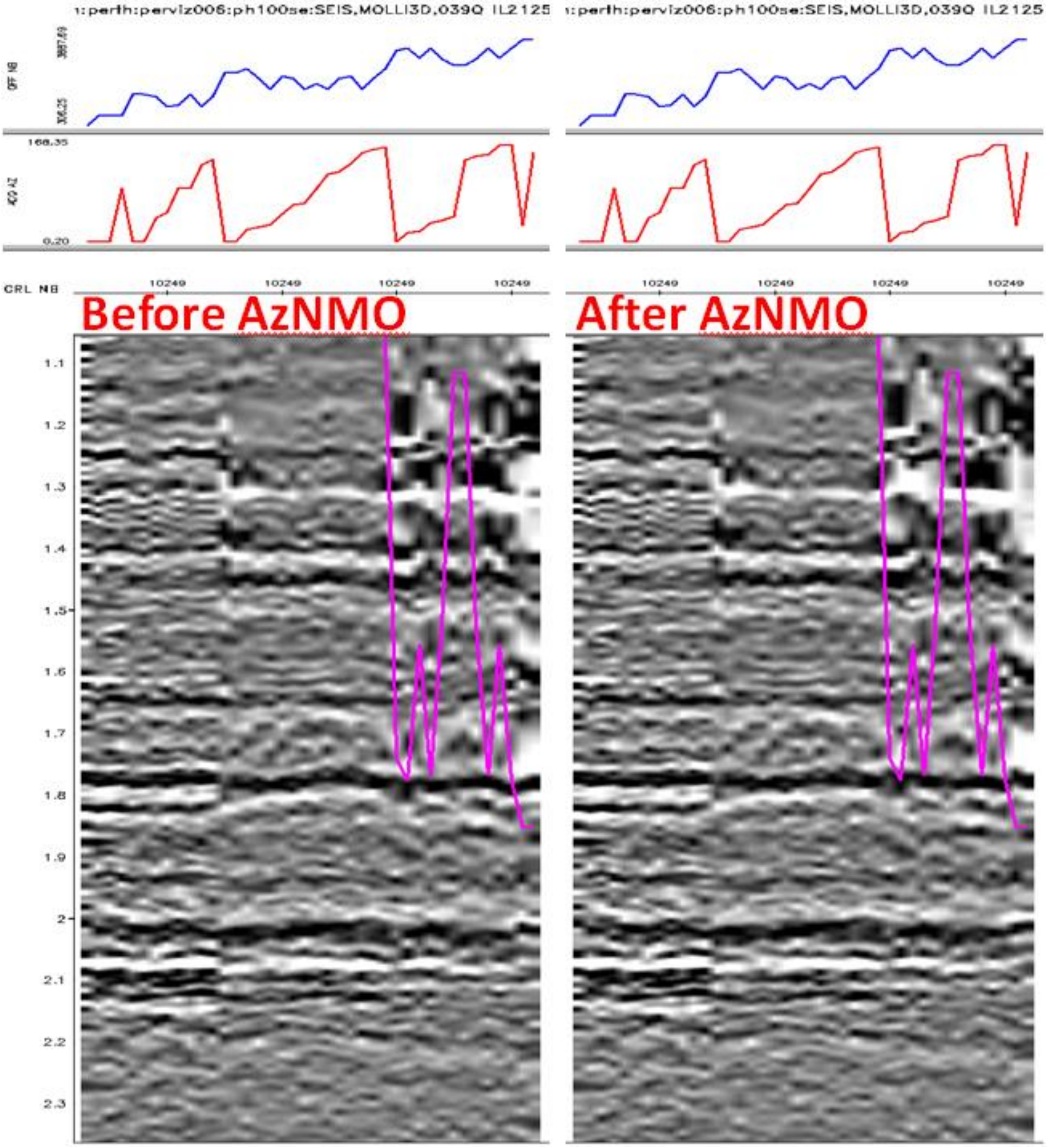


Figure 21 Gathers before and after AzNMO

2.19 Stacks

Time (ms)	Offset (m)
4	500
320	548
714	1100
1298	1611
1724	1996
2310	4000

5 Angle Stacks - using mutes

00-15deg
15-25deg
25-35deg
35-45deg
45-55deg

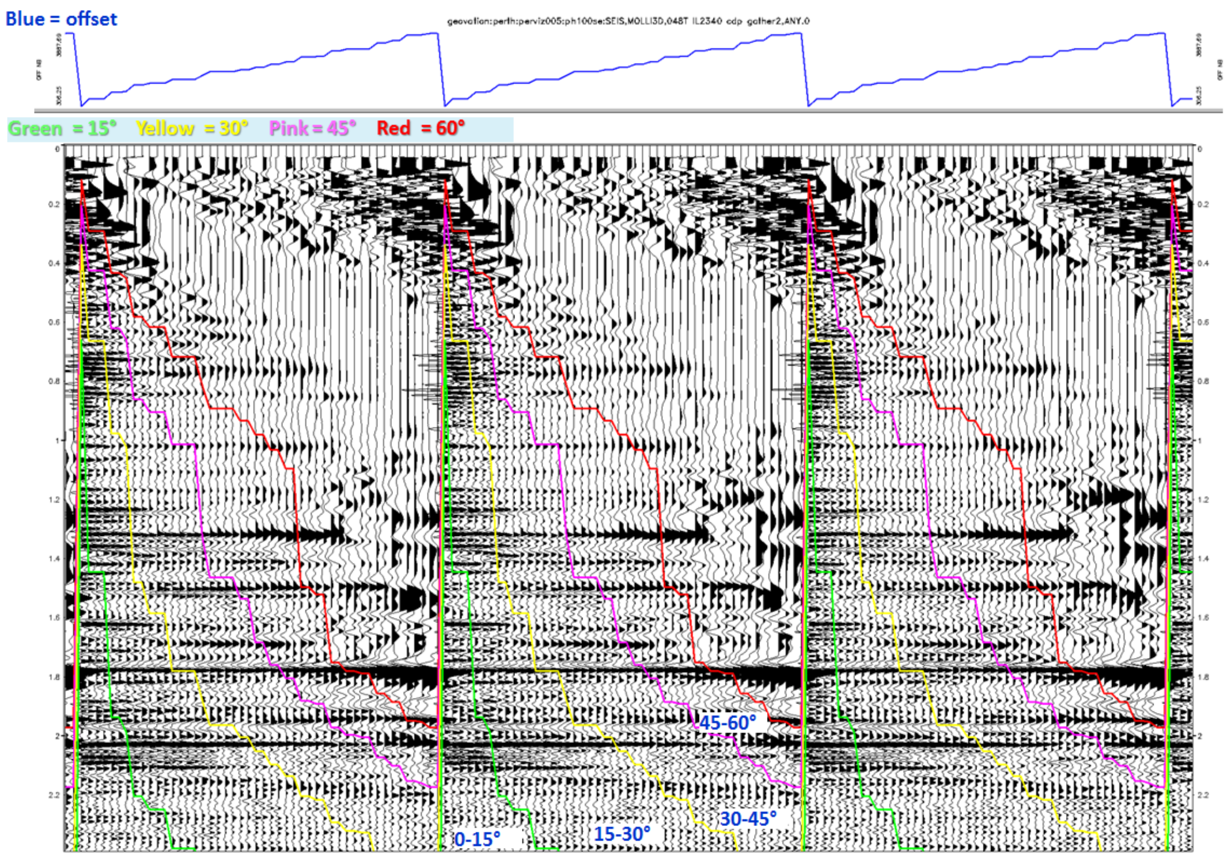


Figure 22 Angle mutes overlaying CDP gathers

2.20 Inverse Q

To compensate for amplitude absorption an inverse Q filter "Amplitude Only" has been applied on pre-stack gathers.
The Q-function below used in InvQ filtering is an edited version of Q-analysis performed on a stacked cube.

TWT	Qapply
0	133
1000	161
2000	196
3500	250
5000	300

Because of prior spiking deconvolution, these Q values do not reflect real rock Q-factors. The Inverse Q filter here is rather a convenient way of applying time-variant spectral correction.

2.21 Spectral shaping

Spectral shaping operator was computed in on stacked data in 1.1s-2.1s window and applied on the whole trace. The process boosted spectrum below 10Hz and 80Hz at high frequency.

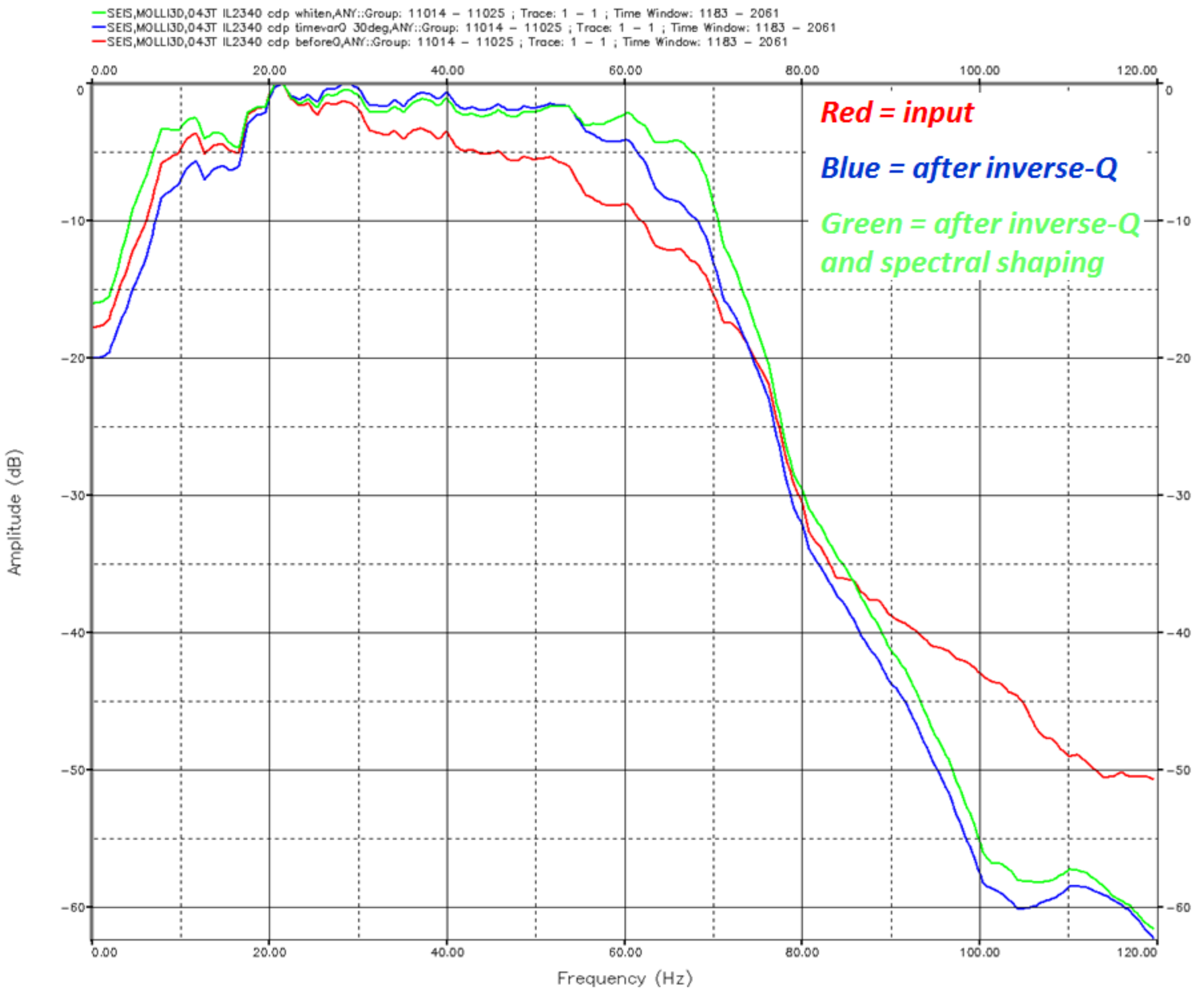


Figure 23 Amplitude spectrum before and after amplitude Q and spectral shaping.

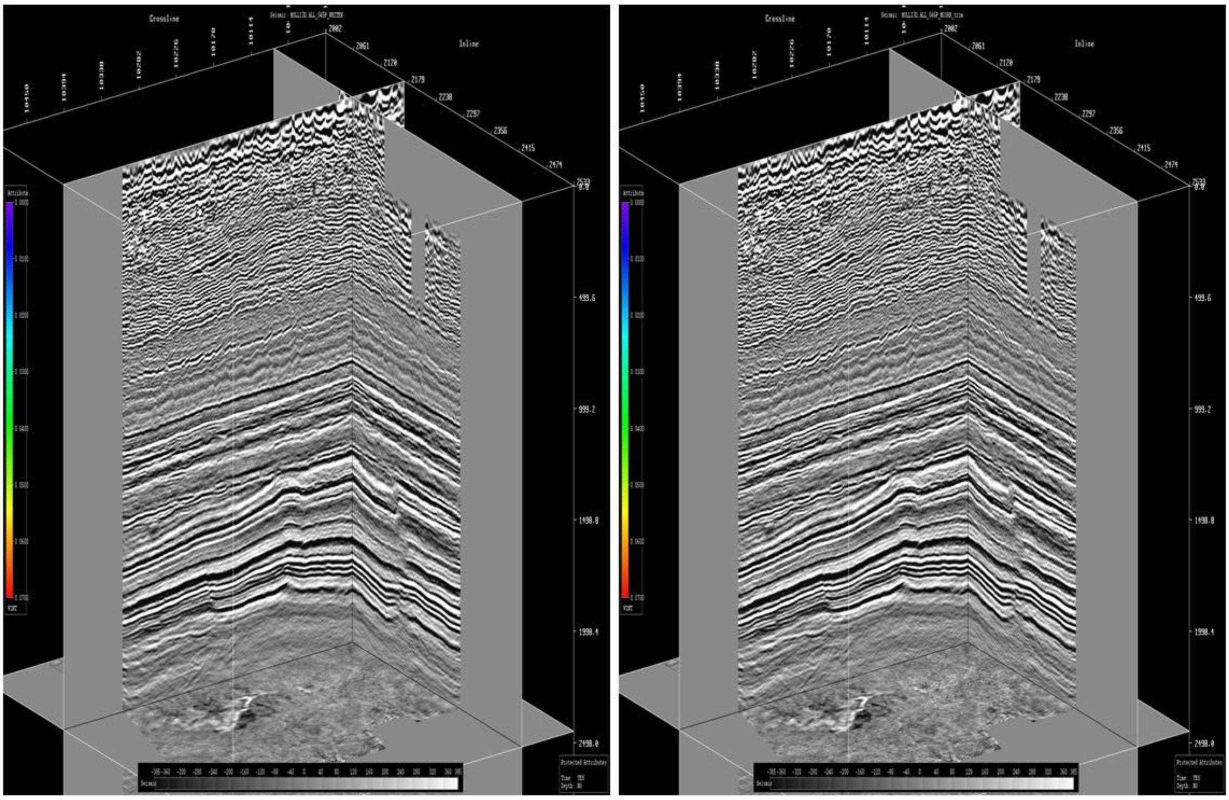


Figure 24 Stack before (left) and after (after) Spectral Correction

2.22 3D FK low frequency dip filtering

A mild 3D FK dip filtering is applied on the stack volume to remove remnant groundroll energy from the data.

Production parameters:

Domain	Post-stack 3D cube
Frequency:	2 – 10 Hz
Min/Max velocity:	300-1500 m/s

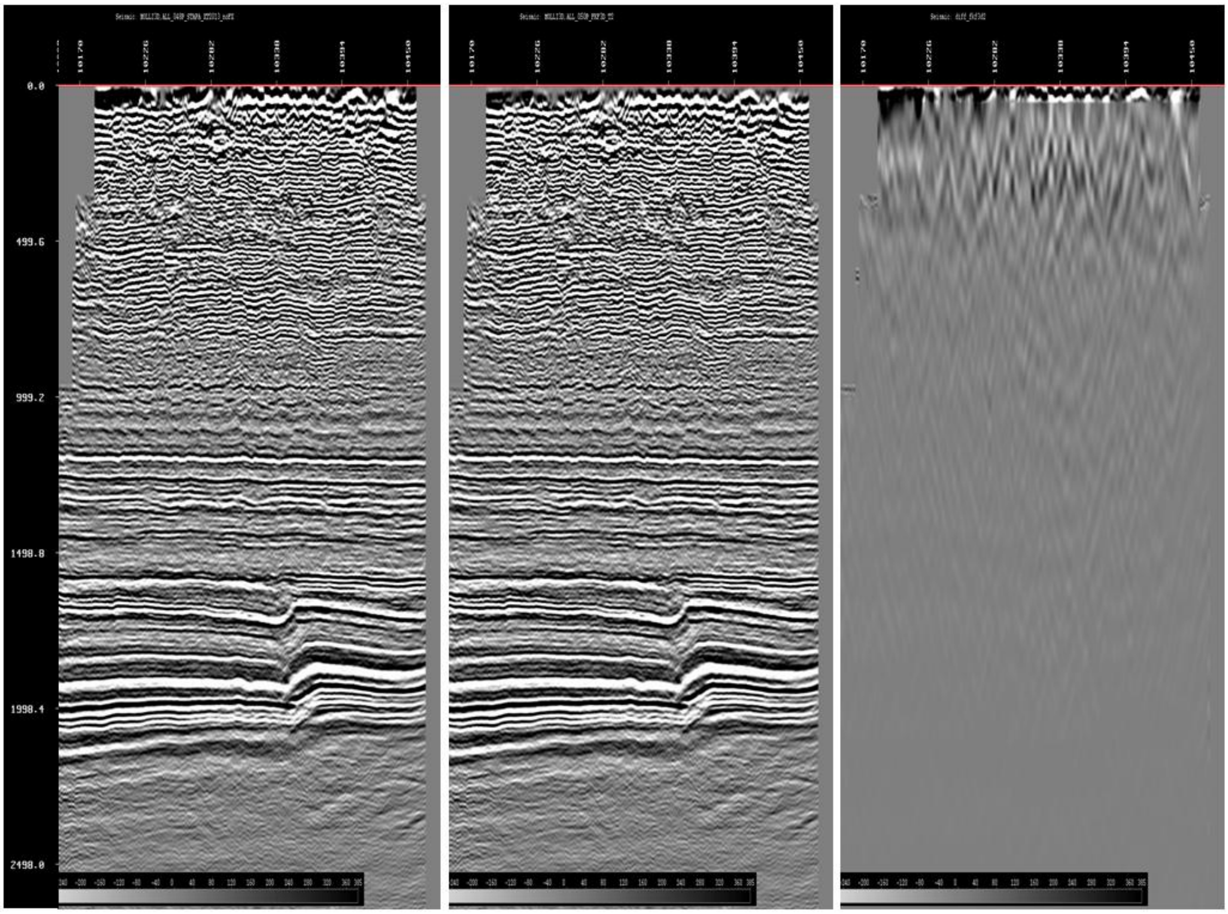


Figure 25 3D FK dip filtering.

2.23 Post-Stack De-Noise CADZO

Similar to the pre-migration Cadzow, the same process is repeated again to improve event coherency and S/N of the final stack volume.

Production parameters:

Domain	Post-stack 3D cube
Mode/Rank:	Hankel/2
IL/XL block/taper:	6x6/3x3
Temporal window:	400/200ms

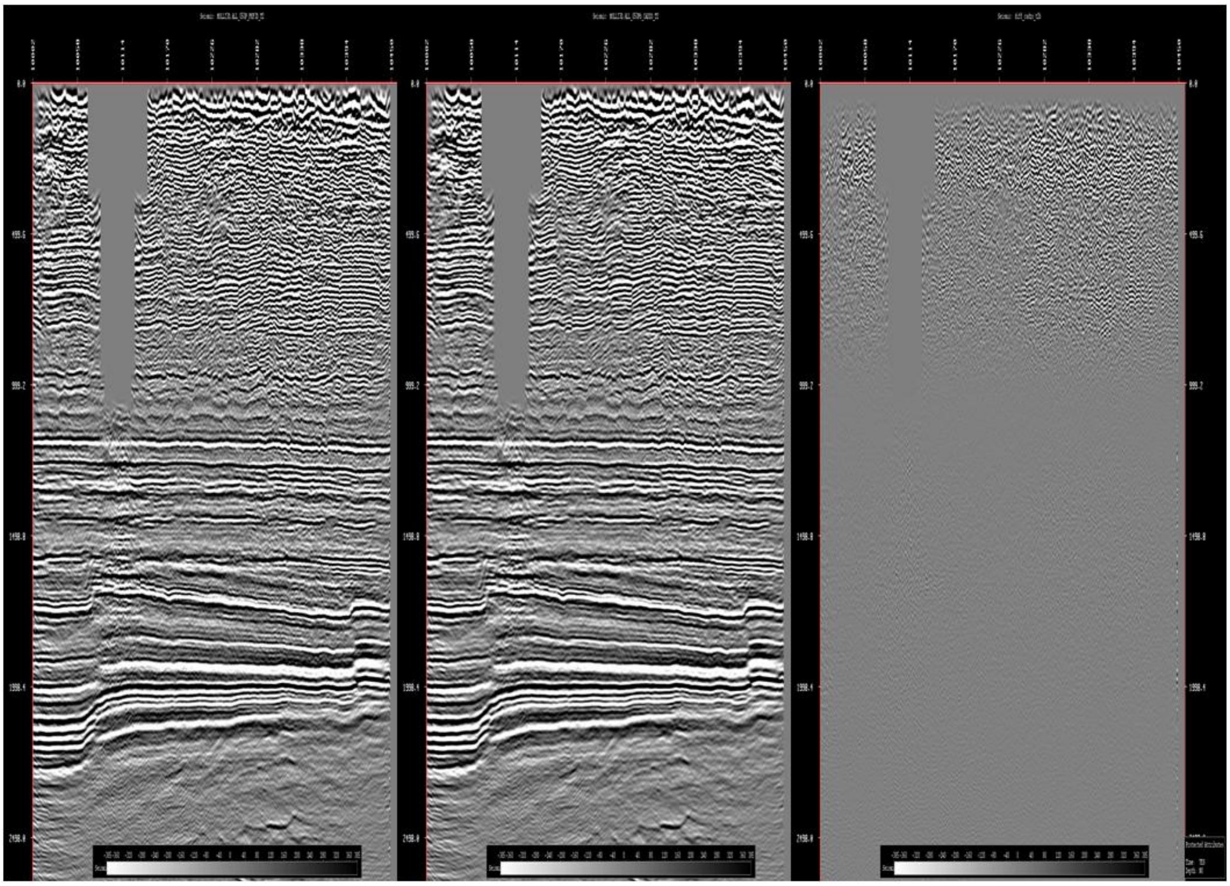


Figure 26 Post-Stack CADZO: before/after and difference. Inline 2270.

2.24 SPARN FX denoising on CDP gathers

SPARN has been applied to improve S/N on Processed Final PSTM Gathers 3 (see Deliverables Table, Chapter 2.01).

SPARN carries out projective filtering in the (f-x) domain. It separates the signal, assumed to be predictable in x, from non-predictable noise, for all the signal's component frequencies. Rather than using predictive filtering, SPARN uses projective filtering. The signal after filtering is the same as it would be after passing through a filter whose spectrum values are 0 or 1. This ensures that the signal is preserved, at the same time as optimizing the attenuation of random noise. The projective filter is calculated from an auto-deconvolved prediction error filter.

Production Parameters:

Adjacent gathers flipped to create near-to-near/ far-to-far offset sequence

Processing Block:	600ms by 100 traces
Block overlap:	200ms and 10 traces

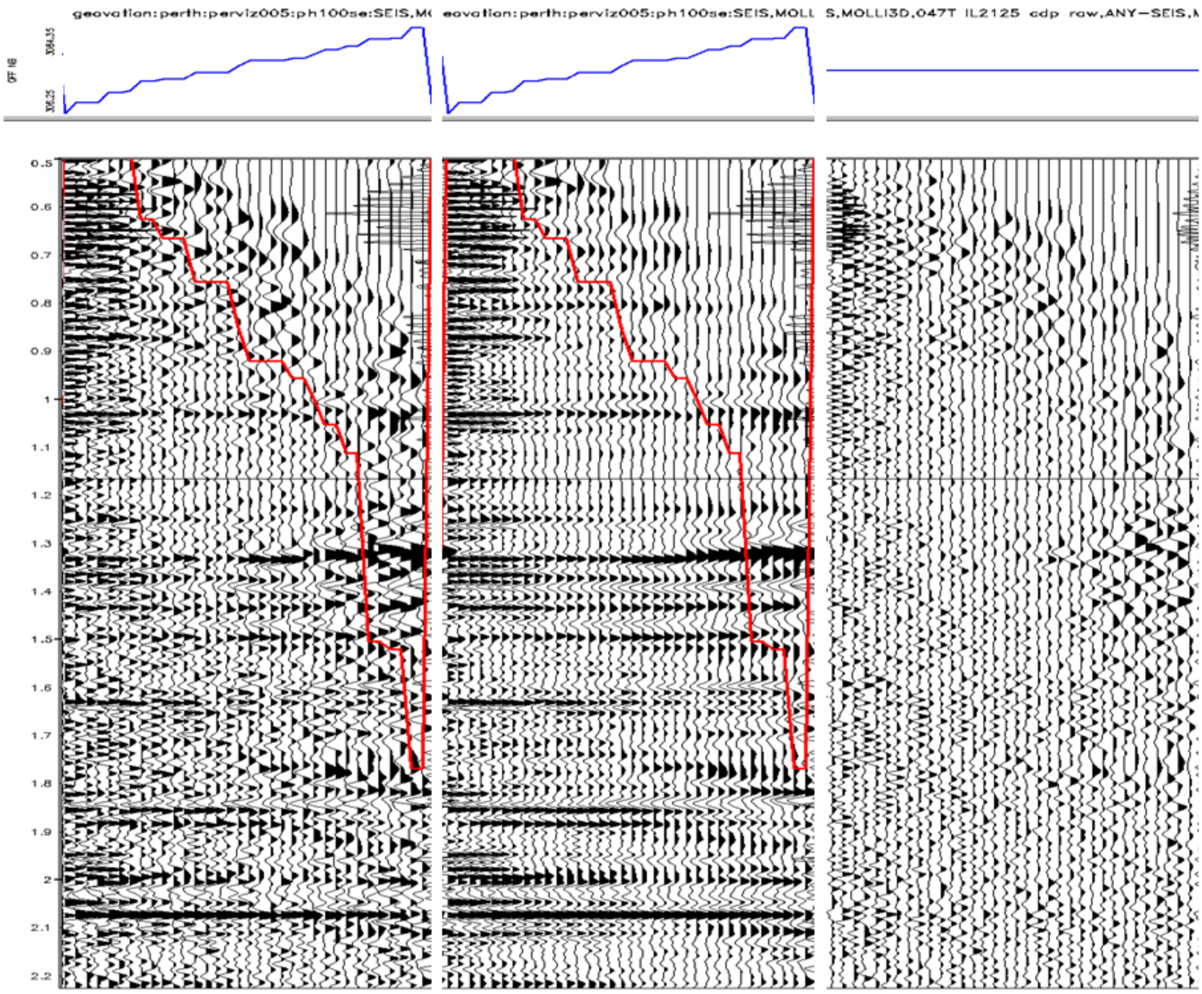


Figure 27 Sample PSTM Gathers: Input, after SPARN and difference

2.25 Conclusion

The 3D COV interpolation approach employed on the project delivered good imaging, satisfactory resolution and AVO/AVAZ compliant pre-stack data.

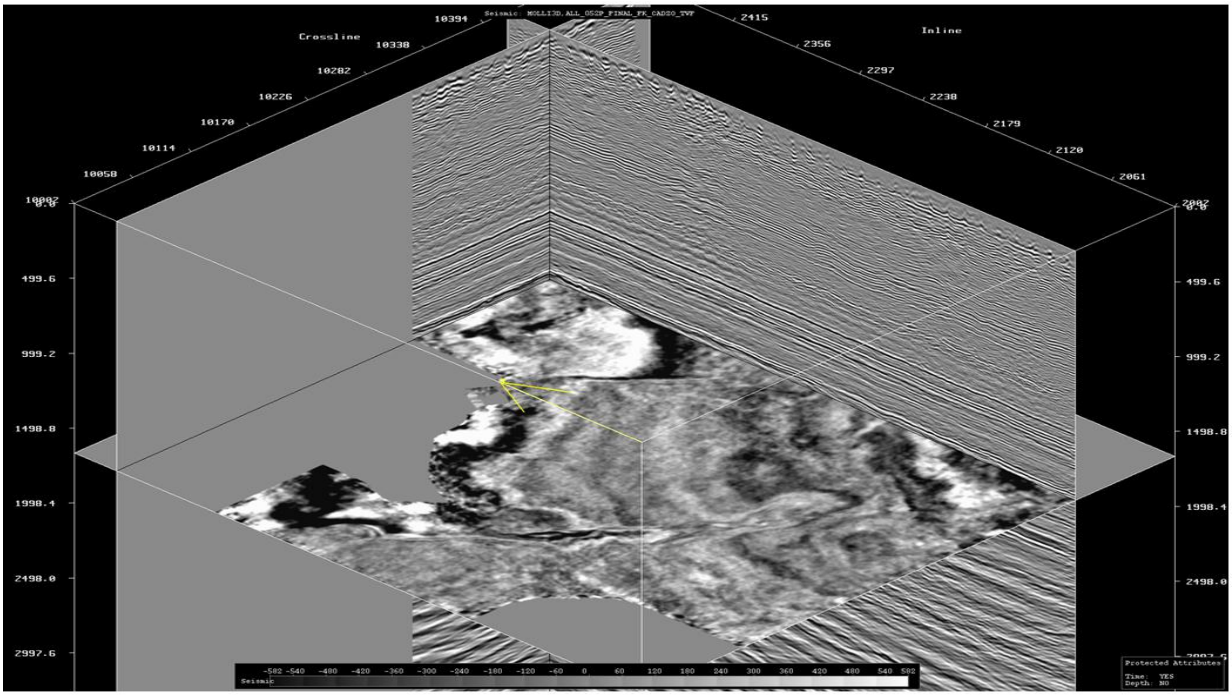


Figure 28 Final PSTM Cube

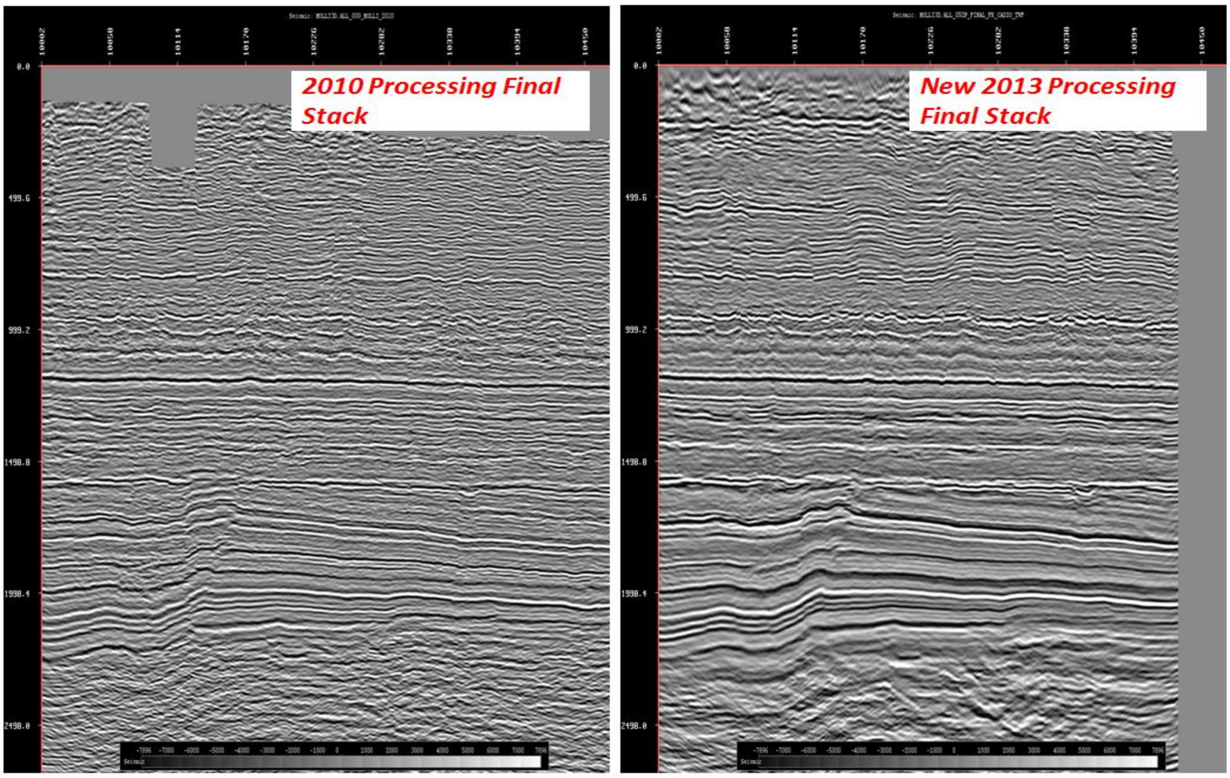


Figure 29 Current 2013 reprocessing Final Stack compared to earlier 2010 Final stack.

3 Appendices

3.01 EBCDIC and Trace Header Examples

EXAMPLE 1. **PRE-INTERPOLATION CMP GATHERS**

CLIENT : SENEX ENERGY LIMITED
DATA : PRE-INTERPOLATION CMP GATHERS (4S/4MS,ON FLOATING DATUM)
SURVEY : MOLLICHUTA 3D 2009, TERREX SEISMIC CREW 402
AREA : PEL104/PEL111/PPL15 COOPER BASIN, SOUTH AUSTRALIA
DATUM : GDA94, PROJECTION : UTM ZONE 54S, CENTRAL MEREDIAN : 141E
IL/XL RANGE : IL2002-2533, XL10002-10513 CELL SIZE: 25X25M
SAMPLE RATE : 4MS, RECORD LENGTH: 5000MS
PROCESSING GRID CORNERS (INL/CRL) (X/Y)
(2002 , 10002) (351586.29, 6947523.87) (2002 , 10513) (364361.22, 6947568.58)
(2533 , 10002) (351539.83, 6960798.79) (2533 , 10513) (364314.75, 6960843.50)
INLINE FROM SOUTH TO NORTH INC=1, XLINE FROM WEST TO EAST INC=1
SEGY HEADER BYTE POSITIONS:
BYTES 21-24 :CDP ENSEMBLE NUMBER BYTES 25-28 :BIN FOLD
BYTES 81-84 :BIN POINT EASTING BYTES 85-88 :BIN POINT NORTHING
BYTES 197-200:INLINE NUMBER BYTES 201-204:XLINE NUMBER
BYTES 233-236:PROCESSING DATUM (IBM FP) - APPLIED
PROCESSING SEQUENCE:
01. REFORMAT SEGY TO INTERNAL FORMAT (RECORD LENGTH 5000 MS).
02. TRACE EDITING, NAV-SEISMIC MERGING, 3D BINNING
03. VIBROSEIS MINIMUM PHASE CONVERSION 04. RESAMPLE 2MS TO 4MS
05. T^2 AMPLITUDE COMPENSATION, 06. APPLY REFRACTION STATICS
07. GROUNDROLL AND LINEAR NOISE ATTENUATION
08. 1ST PASS VELOCITY ANALYSIS 09. 1ST PASS RESIDUAL STATICS
10. SURFACE CONSISTENT SPIKING DECON 11. RANDOM NOISE ATTENUATION
12. S.C. AMPLITUDE CORRECTION 13. 2ND PASS VELOCITY ANALYSIS
14. 2ND PASS RESIDUAL STATICS 15. RESIDUAL LINEAR NOISE ATTN
16. CADZOW RANDOM NOISE ATTN 17.SEGY

BYTES WORD MEANING 2-D 3-D:

BYTES/FORMAT/MEANING		
9 - 12 I4 FIELD RECORD NUMBER		
13 -16 I4 TRACE NUMBER		
17 -20 I4 SP NUMBER		
21 -24 I4 CMP NUMBER		
33 -34 I4 17 STACK WORD		
37 -40 I4 SOURCE DETECOR DISTANCE		
41 -44 I4 ELEVATION RECEIVER/DETECTOR		*X10*
45 -48 I4 ELEVATION SOURCE		*X10*
49 -52 I4 13 DEPTH OF SOURCE		*X10*
61 -64 I4 6 STATION NUMBER SOURCE (PROCESSING)		*9 DIGITS* *SAME AS ACQ 209-212*
65 -68 I4 7 STATION NUMBER DETECTOR (PROCESSING)		*9 DIGITS* *SAME AS ACQ 213-216*
69 -70 I2 ELEVATION AND DEPTH SCALAR		*1*
71 -72 I2 COORDINATE SCALAR		*1*
73 -76 I4 X-COORDINATE SOURCE		
77 -80 I4 Y-COORDINATE SOURCE		
81 -84 I4 X-COORDINATE DETECTOR		
85 -88 I4 Y-COORDINATE DETECTOR		
89 -90 I2 COORDINATE UNITS		*1 (METERS)*
91 -94 I2 IBM-FP TRIM STATIC		*0*
95 -96 I2 SHOTHOLE TIME AT SOURCE		*0*
99 - 100 I2 FIELD STATIC CORRECTION AT SOURCE LOCATION		*0*
101 -102 I2 FIELD STATIC CORRECTION AT DETECTOR LOCATION		*0*

109 -110 I2TIME OF FIRST SAMPLE (TMFS)		*0*
111 -112 I4 TIME OF FIRST SAMPLE (TMFS)		*0*
113 -114 I2 FIRST LIVE SAMPLE		
115 -116 I2 NUMBER OF SAMPLES IN THIS TRACE		
117 -118 I2 SAMPLE INTERVAL IN MICROSECONDS FOR THIS TRACE		
127 -128 I2 (ACQUISITION)		*SP LINE FROM SPS*
129 -130 I2 (ACQUISITION)		*SP PEG FROM SPS*
131 -132 I2 (ACQUISITION)		*RCV LINE FROM SPS*
133 -134 I2 (ACQUISITION)		*RCV PEG FROM SPS*
135-136 I2 SURVEY NUMBER		*MOLLICHUTA =1*
141 -144 IBM-FP X-COORDINATE AT CELL CENTRE		*BIN_X*
145 -148 IBM-FP Y-COORDINATE AT CELL CENTRE		*BIN_Y*
149 -152 IBM-FP X-COORDINATE MIDPOINT		*CMP_X*
153 -156 IBM-FP Y-COORDINATE MIDPOINT		*CMP_Y*
185 -188 IBM-FP RESIDUAL STATIC CORRECTION AT SOURCE LOCATION:		*RES. 1+2*
189 -192 IBM-FP RESIDUAL STATIC CORRECTION AT DETECTOR LOCATION:		*RES. 1+2*
193 -194 I2 CMP DATUM CORRECTION APPLIED		*0*
197 -200 I4 INLINE NUMBER WITHIN 3D SURVEY IL		
201 -204 I4 CROSSLINE NUMBER WITHIN 3D SURVEY XL		
205 - 208 I4 CMP NUMBER		*IL*100000+XL*
209 - 212 I4 FIELD STATION NUMBER SOURCE **NOTE B* (ACQUISITION)		*9 DIGITS. SAME AS 61-64*
213 - 216 I4 FIELD STATION NUMBER DETECTOR **NOTE B* (ACQUISITION)		*9 DIGITS. SAME AS 65-68*
217 - 218 I2 FIELD RECORD NUMBER		*SAME AS 9-12*
221 - 222 I2 SOURCE TYPE 1=VIBROSEIS 2=DYNAMITE		
225 - 228 I4-FP RELATIVE & RESIDUAL SOURCE STATIC		*TOTAL STATICS: DS+RES1+RES2*
229 - 232 IBM-FP RELATIVE & RESIDUAL DETECTOR STATIC		*TOTAL STATICS: DS+RES1+RES2*
233 - 236 IBM-FP CDP DATUM CORRECTION		*NOT APPLIED*
237- 240 IBM-FP 3D AZIMUTH		*SOURCE-TO-RECEIVER AZIMUTH FROM NORTH, 0-360DEG RANGE, DEG.*

NOTES:

FIELD STATION NUMBER SOURCE = *SURVEY NUMBER *10^8 +SOURCE LINE*10^4+SOURCE PEG (SOURCE LINE AND SOURCE PEG AS IN SPS)*

FIELD STATION NUMBER DETECTOR = *SURVEY NUMBER *10^8 +RCV LINE*10^4+RCV PEG (RCV LINE AND RCV PEG AS IN SPS)*

EXAMPLE 2. **FINAL PSTM STACK**

CLIENT : SENEX ENERGY LIMITED
DATA : FINAL PSTM STACK
SURVEY : MOLLICHUTA 3D 2009, TERREX SEISMIC CREW 402
AREA : PEL104/PEL111/PPL15 COOPER BASIN, SOUTH AUSTRALIA
DATUM : GDA94, PROJECTION : UTM ZONE 54S, CENTRAL MEREDIAN : 141E
IL/XL RANGE : IL2002-2533, XL10002-10513 CELL SIZE: 25X25M
SAMPLE RATE : 4MS, RECORD LENGTH: 5000MS
PROCESSING GRID CORNERS (INL/CRL) (X/Y)
(2002 , 10002) (351586.29, 6947523.87) (2002 , 10513) (364361.22, 6947568.58)
(2533 , 10002) (351539.83, 6960798.79) (2533 , 10513) (364314.75, 6960843.50)
INLINE FROM SOUTH TO NORTH INC=1, XLINE FROM WEST TO EAST INC=1
SEGY HEADER BYTE POSITIONS:
BYTES 21-24 :CDP ENSEMBLE NUMBER BYTES 25-28 :BIN FOLD
BYTES 81-84 :BIN POINT EASTING BYTES 85-88 :BIN POINT NORTHING

BYTES 197-200:INLINE NUMBER BYTES 201-204:XLINE NUMBER
BYTES 233-236:PROCESSING DATUM (IBM FP) - APPLIED
PROCESSING SEQUENCE:
01. REFORMAT SEGY TO INTERNAL FORMAT (RECORD LENGTH 5000 MS).
02. TRACE EDITING, NAV-SEISMIC MERGING, 3D BINNING
03. VIBROSEIS MINIMUM PHASE CONVERSION 04. RESAMPLE 2MS TO 4MS
05. T^2 AMPLITUDE COMPENSATION, 06. APPLY REFRACTION STATICS
07. GROUNDROLL AND LINEAR NOISE ATTENUATION
08. 1ST PASS VELOCITY ANALYSIS 09. 1ST PASS RESIDUAL STATICS
10. SURFACE CONSISTENT SPIKING DECON 11. RANDOM NOISE ATTENUATION
12. S.C. AMPLITUDE CORRECTION 13. 2ND PASS VELOCITY ANALYSIS
14. 2ND PASS RESIDUAL STATICS 15. RESIDUAL LINEAR NOISE ATTN
16. CADZOW RANDOM NOISE ATTN 17. COV/REG3D AND INTERPOLATION
18. 3RD PASS 1X1KM MIGRATION VELOCITY ANALYSIS 19. 3D KIRCHHOFF PSTM
20. HD VEL CORR AFTER PSTM 21. INV-Q AMPLITUDE ONLY, SPECTRAL CORRECTION
22. AZIMUTHAL NMO VEL, TRIM STATICS, 23. XT MUTE, STACK,
24. POST STACK 3D FK FILTERING 25. POST STACK CADZOW FILTERING
26. TIME VARIANT FILTERING
27. STATICS CORRECTION FROM PROCESSING TO FIXED DATUM MSL 28.SEGY

BYTES WORD MEANING 2-D 3-D:

Bytes/Format/Meaning		
17 -20 I4 Grid Inline Number		
21 -24 I4 Grid Xline Number		
71 -72 I2 Coordinate Scalar		*1*
81 -84 I4 X-Coordinate 3D Cell Centre		
85 -88 I4 Y-Coordinate 3D Cell Centre		
89 -90 I2 Coordinate Units		*1 (meters)*
109 -110 I2Time of First Sample (TMFS)		*0*
111 -112 I4 Time of First Sample (TMFS)		*0*
113 -114 I2 First Live Sample		
115 -116 I2 Number of Samples in This Trace		
117 -118 I2 Sample Interval in Microseconds for This Trace		
141 -144 IBM-FP X-Coordinate at Cell Centre		*3D Grid Cell Centre*
145 -148 IBM-FP Y-Coordinate at Cell Centre		*3D Grid Cell Centre*
197 -200 I4 Inline Number within 3D Survey IL		
201 -204 I4 Crossline Number within 3D Survey XL		
205 - 208 I4 CMP Number		*IL*100000+XL*
233 - 236 IBM-FP CDP datum correction		
237- 240 IBM-FP 3D Azimuth		*N/A*

***EXAMPLE 3.* DENSE 25x25m Vnmo CUBE**

CLIENT : SENEX ENERGY LIMITED
DATA : DENSE STACKING VELOCITY FIXED DATUM
SURVEY : MOLLICHUTA 3D 2009, TERREX SEISMIC CREW 402
AREA : PEL104/PEL111/PPL15 COOPER BASIN, SOUTH AUSTRALIA
DATUM : GDA94, PROJECTION : UTM ZONE 54S, CENTRAL MEREDIAN : 141E
IL/XL RANGE : IL2002-2533, XL10002-10513 CELL SIZE: 25X25M
SAMPLE RATE : 4MS, RECORD LENGTH: 5000MS
PROCESSING GRID CORNERS (INL/CRL) (X/Y)
(2002 , 10002) (351586.29, 6947523.87) (2002 , 10513) (364361.22, 6947568.58)
(2533 , 10002) (351539.83, 6960798.79) (2533 , 10513) (364314.75, 6960843.50)
INLINE FROM SOUTH TO NORTH INC=1, XLINE FROM WEST TO EAST INC=1
SEGY HEADER BYTE POSITIONS:
BYTES 21-24 :CDP ENSEMBLE NUMBER BYTES 25-28 :BIN FOLD
BYTES 81-84 :BIN POINT EASTING BYTES 85-88 :BIN POINT NORTHING
BYTES 197-200:INLINE NUMBER BYTES 201-204:XLINE NUMBER
BYTES 233-236:PROCESSING DATUM (IBM FP) - APPLIED
PROCESSING SEQUENCE:
01. REFORMAT SEGY TO INTERNAL FORMAT (RECORD LENGTH 5000 MS).
02. TRACE EDITING, NAV-SEISMIC MERGING, 3D BINNING
03. VIBROSEIS MINIMUM PHASE CONVERSION 04. RESAMPLE 2MS TO 4MS
05. T^2 AMPLITUDE COMPENSATION, 06. APPLY REFRACTION STATICS

07. GROUNDROLL AND LINEAR NOISE ATTENUATION
08. 1ST PASS VELOCITY ANALYSIS 09. 1ST PASS RESIDUAL STATICS
10. SURFACE CONSISTENT SPIKING DECON 11. RANDOM NOISE ATTENUATION
12. S.C. AMPLITUDE CORRECTION 13. 2ND PASS VELOCITY ANALYSIS
14. 2ND PASS RESIDUAL STATICS 15. RESIDUAL LINEAR NOISE ATTN
16. CADZOW RANDOM NOISE ATTN 17. COV/REG3D AND INTERPOLATION
18. 3RD PASS 1X1KM MIGRATION VELOCITY ANALYSIS 19. 3D KIRCHHOFF PSTM
20. HD VEL CORR AFTER PSTM
21. STATICS CORRECTION FROM PROCESSING TO FIXED DATUM MSL 22.SEGY OUTPUT

BYTES WORD MEANING 2-D 3-D:

Bytes/Format/Meaning		
17 -20 I4 Grid Inline Number		
21 -24 I4 Grid Xline Number		
71 -72 I2 Coordinate Scalar		*1*
81 -84 I4 X-Coordinate 3D Cell Centre		
85 -88 I4 Y-Coordinate 3D Cell Centre		
89 -90 I2 Coordinate Units		*1 (meters)*
109 -110 I2Time of First Sample (TMFS)		*0*
111 -112 I4 Time of First Sample (TMFS)		*0*
113 -114 I2 First Live Sample		
115 -116 I2 Number of Samples in This Trace		
117 -118 I2 Sample Interval in Microseconds for This Trace		
141 -144 IBM-FP X-Coordinate at Cell Centre		*3D Grid Cell Centre*
145 -148 IBM-FP Y-Coordinate at Cell Centre		*3D Grid Cell Centre*
197 -200 I4 Inline Number within 3D Survey IL		
201 -204 I4 Crossline Number within 3D Survey XL		
205 - 208 I4 CMP Number		*IL*100000+XL*
233 - 236 IBM-FP CDP datum correction		
237- 240 IBM-FP 3D Azimuth		*N/A*

END OF REPORT