Spectrum

Processing Report

Spectrum Final Processing Report for

EDISON S.P.A

Zappolina, Italy 2D Land

Test Line BO-371-91-V

July - September 2012

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Introduction

1.1. Description of Survey

This report covers the processing during July to September 2012 of approximately 19 kms of 2D seismic data from Zappolina, Italy. The project covers one line from vintage acquired in 1991. The source used for this line was vibroseis. The elevations ranged from 20 to 50m.

This test line was processed in Spectrum's Woking Data Processing Centre, conforming to quality assurance standard ISO9001

1.2. Objectives

The main objectives were to obtain improvements to structural imaging particularly on the south-western side of the line where the data is of poor quality.

1.3. Personnel

The following personnel were involved in this project:

Edison Representatives	Stefano Carbonara
Spectrum Representatives	Roger Oldfield Processing Manager Andy Schutz Team Leader Kirit Tailor Senior Geophysicist

2. Acquisition Parameters

2.1. Survey Parameters

Data Acquired By	Geoitalia GIT-4
Date	1991
Source – Receiver Geometry	
Geophone group spacing	40 m
Source point spacing	40 m
Nominal fold	60
Number of channels	120, split-spread
1-2360m-60-140m-VP-140m-61-2360m-120	
Source	
Source Type	vibroseis
Sweep	linear
Frequency	8-70Hz
Sweep length	12s
Receiver	
Geophone type	SM4-10Hz
Receiver pattern	80x6m
Elements per pattern	12x2
Recording	
Instrument	SN-368
Recording length	6 seconds
Sample Rate	2 milliseconds
Low Cut Filter	4Hz 18dB/Oct
High Cut Filter	87.5 72dB/Oct
Recording format	SEG-D

3. PRE-PROCESSING

3.1. Reformat

The data received was raw field data in SEGY format which was then reformatted to SeisUp internal format in the UK. Data was then electronically transferred to disk areas on the system in Houston USA.

3.2. Resample

Raw field data were re-sampled from 2ms to 4ms with a zero-phase anti-alias filter applied (90% Nyquist, 34 DB down at 125 HZ).

3.3. Geometry

Geometry information was supplied from scanned (to .pdf file) observer's reports. Navigation information was available as a tiff file.

Manual entry of co-ordinate and elevation information was necessary. This was accomplished using spread sheets in order to interpolate values. QC checks on the data were then run to identify and correct for spurious values.

Crooked line geometry was used due to the nature of acquisition in this area. The cmp traverse was set to follow the centre of gravity of the mid-point scatter. The bin shape was kept as constant as possible, i.e. square, by smoothing radii on the cmp traverse, and omitting very widely scattered mid-points. This was accomplished using spreadsheets, and moving average or exponential smoothing functions. The final results were checked using maps created from the geometry dataset.

3.4. Geometry Quality Control

After assigning the final crooked line geometry to the trace headers, LMO corrected shots were plotted and viewed to check for gross errors. A brute stack was run to view the stack result. This was checked for geometry errors, areas of noise, and any short records. The brute stack was re-run after any corrections, and again after all trace editing was completed.

3.5. Trace Editing

This line there were some raw shots were heavily contaminated with spikes and noisy traces. Manual trace editing was then employed to edit out dead / excessively noisy shots and traces. In addition, reversed polarity stations were also checked using receiver station ordered displays.

4. Refraction Statics

Initial brute stacks used an elevation correction. A replacement velocity of 2000m/sec was selected. The final processing datum was set at 0m (M.S.L.).

Comparisons of elevation statics, versus initial refraction statics showed that refraction modelling could produce some significant improvements to stack quality.

The methodology is reviewed below.

4.1. First break picking

First breaks were picked in a semi-automatic manner using the interactive display within Renegade. Both shot domain and common offset domains were used for picking, which helped to avoid cycle skips. In addition, selected common offset displays with pick times were displayed to check for consistency both within. The peak was picked to identify the first breaks.

The final set of SEG-Y shots with picked times and geometry information were transferred to the Seismic Studio statics software.

4.2. Refraction Modelling

Seismic Studio statics modelling involves 3 main stages: -

1. QC of picking and "branch point" assignment.
2. Derivation of refractor velocities and delay times.
3. Derivation of near-surface model and calculation of statics.

In practice, this tends to be an iterative process; the statics derived can be applied to the first breaks to flatten them, and this often makes it much easier to spot areas of mis-picking. Similarly, at step (2) the delay time deviation and pick-error terms can be used to identify poorly picked shots or receivers, or geometry errors, which can be corrected interactively.

Ranges of offsets were picked between 450 – 1000m, which covered the main refractor seen in the area. The main refractor was seen with a velocity 2200m/sec layer immediately below the weathered layer forming the direct arrivals. A single layer model was to be used in order to achieve a static solution.

Delay times and refractor velocities were then derived using Renegade's "Residual Velocity Correction" (RVC) option. A constant weathering velocity of 1000m/sec was used for the weathered layer. The base of weathering elevations was smoothed over 200m, and the weathering velocities were then updated. The statics are then derived as follows; Downward continue from surface to base of weathering, and then to the final datum using the replacement velocity 2000m/sec.

The static solution derived was then applied to the first-breaks in shot and common-offset domain to re-check the picking. When a satisfactory 2-D statics solution was complete, this was output, applied to the data, and stacked to compare with elevation correction statics.

The statics were applied to the data in two stages. Firstly, the static is split into two components by calculating the mean and differential static for each CMP gather. The differential statics are applied to reference the gathers to the surface. This is used for velocity analysis and NMO application. The remaining mean static value, to place the data from surface to final datum, is then applied.

5. PARAMETER TESTING

This section takes the form of a general description of the range of tests run, and then a brief discussion of the results and decisions made.

5.1. PRE-STACK PROCESSING

5.2. Gain Recovery

The purpose of gain recovery was to produce spatially and temporally balanced amplitudes on each shot record, correcting for spherical divergence and amplitude/time decay. A regional velocity function was used.

The following trials were run:

- No gain correction
- Linear T, $T^{1.5}$, T^2, VT and V^2T correction
- Spherical divergence

Overall $T^{1.5}$ was found to achieve a good amplitude balanced section.

5.3. Surface consistent Amplitude Correction

Before we can interpret amplitudes in recorded data, we have to compensate for near surface and acquisition-related effects, such as source strength and receiver coupling variations, preferably in the early stages of the processing. These variations influence all common-midpoint based processing, since traces with different sources and receivers are combined in a CMP stack. This degrades the quality of the stack and could lead to biased AVO trends, particularly when related to slowly varying near-surface conditions.

The surface consistent amplitude corrections involve three stages. In the first stage instantaneous mean amplitude is computed for each input trace within a given design window. In the second stage the amplitudes are decomposed into Source, Receiver, CMP and offset terms in a best-fit sense by using Gauss-Seidel algorithm. Two colour plots are generated outputting the average instantaneous amplitudes before and after the surface consistent solution. However, as the name “best-fit” indicates the solution is the best under the given conditions. The corrected amplitude will not be perfectly flat in general because the equation system is over-determined i.e. it is not possible to completely satisfy every point. The final stage is the application of the surface consistent gain functions. Stacks were run before and after application of the surface consistent amplitude for comparison. These showed significant improvements in correcting the amplitude anomalies due to the near surface effects.

It was decided to apply the source, receiver and offset terms.

5.4. Noise Reduction

Most shots in the area exhibited low frequency. To attenuate this noise the following were tested:

- Shot/receiver domain FK filter
- TFDNoise (Noise Suppression Using frequency bands)

The data was affected by a combination of ground roll, air bursts and refracted energy to varying degrees depending on the acquisition parameters and line location.

Various shot domain F-K filter tests were run. The filter design, shape, cut-off dB levels, and tapering were all optimised interactively. Testing of the shot F-K comprised assessing the application of various constant slope F-K dip filters to the data. The filters were applied with a wraparound NMO correction, 500ms AGC and statics. With the NMO correction applied dip filters of +/-14ms/tr could be applied without damaging any primary events, and thus remove a significant amount of noise.

Receiver domain F-K filtering was also tested and the same dip filter of +/-14ms/tr with a wraparound NMO correction, 500ms AGC and refraction statics was found to be optimal and used in production as it further attenuated the residual coherent noise.

TFDnoise module-This performs noise suppression and sub-spectral balancing using sample wise median thresholding within frequency sub-bands in the time-frequency space. There was noticeable suppression of some noisy traces in the test shots, but some of the noise bursts were across several receivers, and so the algorithm would not detect all these traces as being anomalous. This process helped in dampening the environmental noise (Air-wave, electric interference 50HZ). Therefore TFDNoise was selected and applied in shot domain.

5.5. Deconvolution

Deconvolution was used to improve temporal resolution and attenuate short period multiple energy.
Initially, deconvolution before stack (DBS) scans were run to obtain suitable parameters for operator length, and predictive lag times. Whole line CMPs were used to produce stack panels. Autocorrelations taken from the main data region were appended to the data. Results from the scans showed that some form of deconvolution was required. The amount of variation seen in the scans was minimal however. The predictive DBS approach gave a cleaner result, with the same resolution as that achieved by spiking DBS.

The difference between single trace, ensemble, and surface consistent DBS applications was also found to be minimal. Therefore, the following DBS parameters were selected for this line:

Surface Consistent, predictive DBS.

Operator length = 160 msec

Predictive gap = 24 msec.

White noise = 0.1%

5.6. First Pass Velocity Analysis

An initial pass of the velocities was carried out prior to residual statics, at 1km intervals. Statics were applied to correct the data to a near surface floating datum, and all velocities referenced to this floating datum.

A combination of constant velocity stacks, semblance displays, and gather displays were used in the analyses.

5.7. Residual Statics

Surface consistent residual statics are calculated and applied in order to remove short wavelength static anomalies. The methodology used was for statistical cross-correlation of the cmp traces to produce guide peaks. The surface consistent components are then solved for, and residual statics for source and receiver terms output.

For the initial pass of residual statics, the maximum static value was limited to 24ms. Statics values were broadly in the range of +/-10msec,. Tests were run on this line to check the 2 main input variables i.e. window length and smash rate. These tests showed that stack with smash rate of 7 traces and a window (300-5000ms), in the main area of data, gave a superior result. Graphical displays of static versus receiver source/station location were used to QC results, as well as stack displays.

5.8. Second Pass Velocity Analysis

The second pass velocity analysis was made at 500m intervals
Variable velocity stacks, semblance and gather displays were used. Velocity picks were either updated, if present from the initial pass, or inserted.

5.9. Pre-Stack Random Noise Attenuation

The data was analysed in the common offset domain to see if any further residual noise remained in the dataset or if any form of scaling is required prior to pre-stack migration it was also evident that some form of scaling was required to balance the amplitudes across the section so as to avoid migration smiles. It was decided to apply an AGC of 1000ms followed by FX-Deconvolution to remove the random noise.

5.10. Pre-Stack Time Migration & Dmo Stack

Migration is a process that attempts to reconstruct an image of the original reflecting structure from energy recorded on input seismic traces. Pre-stack migration is a direct process that moves each sample to all the possible reflection positions, and invokes the principles of constructive and destructive interference to recreate the actual image. An alternate description of the migration process starts by selecting an output migrated sample. All input traces are searched to find energy that contributes to the output sample. This second description is the basis of Kirchoff migration. This method was used for this dataset due to the algorithm's superior handling of steep dips, lateral and vertical velocity variations.

Data was initially split into common offset planes with the minimum common offset plane being 160m and the increment 80m. The PSTM was used to produce migration gathers for velocity analyses every 500m. These velocities were then picked and a final pass of PSTM was run using the PSTM picked velocities.

At this stage an additional product was generated. The PSTM was replaced by DMO and a similar processing sequence was applied.

5.11. Second Pass Velocity Analysis

Input to second pass velocity analysis were pre-stack time migration gather data at floating datum. The velocity locations were every 500m intervals.

A combination of constant velocity stacks, semblance displays, and gather displays were used in the analyses. Picks were either updated, if present from the initial pass, or inserted.

5.12. Final NMO Mute

A final NMO mute was derived by interactively picking time and space variant mute function. This was found to give optimal stack quality

5.13. Stack

The data was stacked using normalisation/compensation scaling of the form 1/SQRT(N), where N is the stacking fold.

5.14 Coherency Filtering

Coherency filtering using dip limitations of +/-6ms/tr was tested on this dataset. It effectively enhanced the coherent data . It was decided to apply this in production

5.15 Band Pass Filtering

A Band pass filter of 10-60Hz was applied to remove any excessive low and high drequency noise.

5.16 Final Scaling

A 500ms AGC was selected for final scaling. This was used to balance amplitudes across the data zone, and also reduced the amplitudes slightly at the top of the section.

6. Conclusions

This report describes the re-processing of a 2D seismic test line from the permit Zappolino in Italy.

Overall, resolution and continuity of events have been improved against the original processing. The processes having the most impact on final data quality were the Refraction statics, noise attenuation and PSTM.

7. Final Products

The following final products were produced:

Count	Version	NMO/Mute	O/P MEDIA	Format	Data Phase	Notes
PRE-STACK VOLUMES						
1	PSTM CRP Gathers	No/No	3590	SEG-Y	Zero	Raw Migrated PSTM
POST-STACK VOLUMES						
2	Raw DMO Stack		3590	SEG-Y	Zero	No post stack enhancement. No gain
3	Final DMO Stack		3590	SEG-Y	Zero	With enhancement and gain
4	Raw DMO Stack		DVD	SEG-Y	Zero	No post stack enhancement. No gain
5	Final DMO Stack		DVD	SEG-Y	Zero	With enhancement and gain
6	Raw PSTM Stack		3590	SEG-Y	Zero	No post stack enhancement. No gain
7	Final PSTM Stack		3590	SEG-Y	Zero	With enhancement and gain
8	Raw PSTM Stack		DVD	SEG-Y	Zero	No post stack enhancement. No gain

9	Final PSTM Stack		DVD	SEG-Y	Zero	With enhancement and gain
10	Final DMO Stack		DVD	CGM+	Zero	Final section with side label and graphs
11	Final PSTM Stack		DVD	CGM+	Zero	Final section with side label and graphs
VELOCITY AND ANCILLARY VOLUMES						
12	PSTM Velocities		DVD	ASCII	n/a	
13	DMO Velocities		DVD	ASCII	n/a	
14	PSTM Final mute		DVD	ASCII	n/a	
15	DMO Final mute		DVD	ASCII	n/a	
16	SPS		DVD	ASCII	n/a	With statics used in processing
17	Final Processing Report		DVD		n/a	

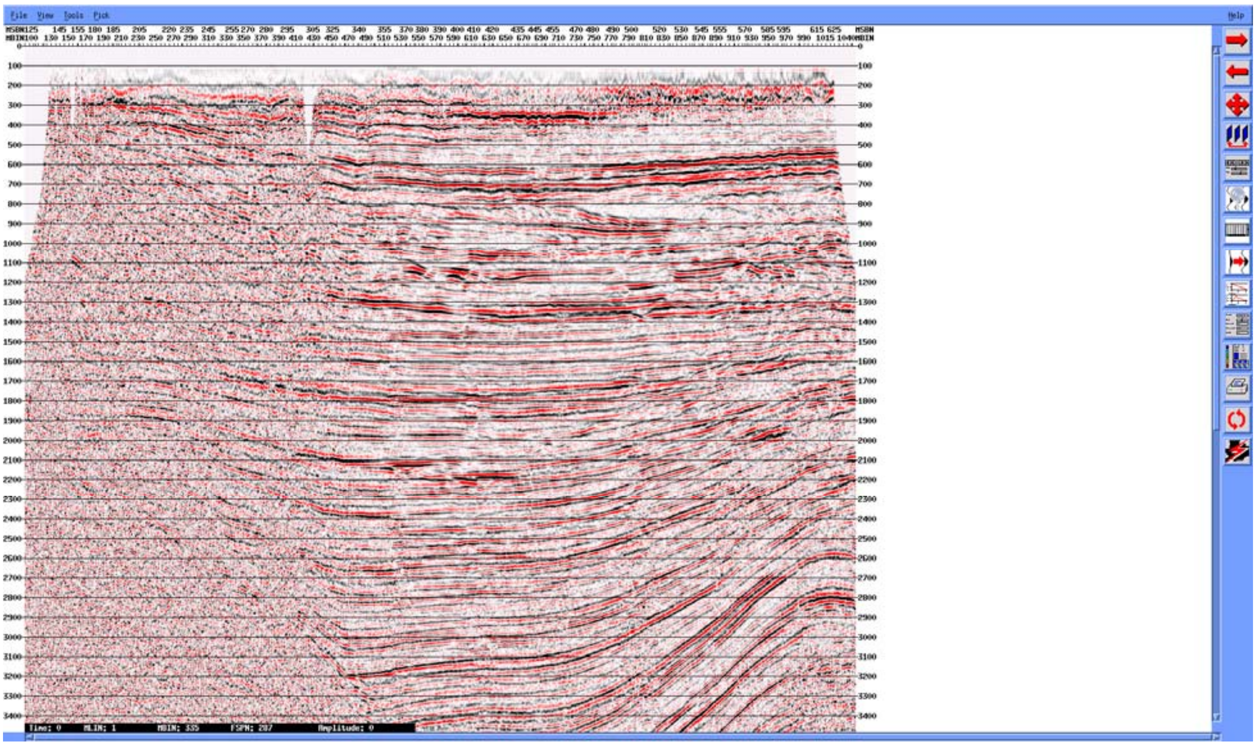
Appendices

Appendix 1 – EXAMPLE OF SEGY HEADER

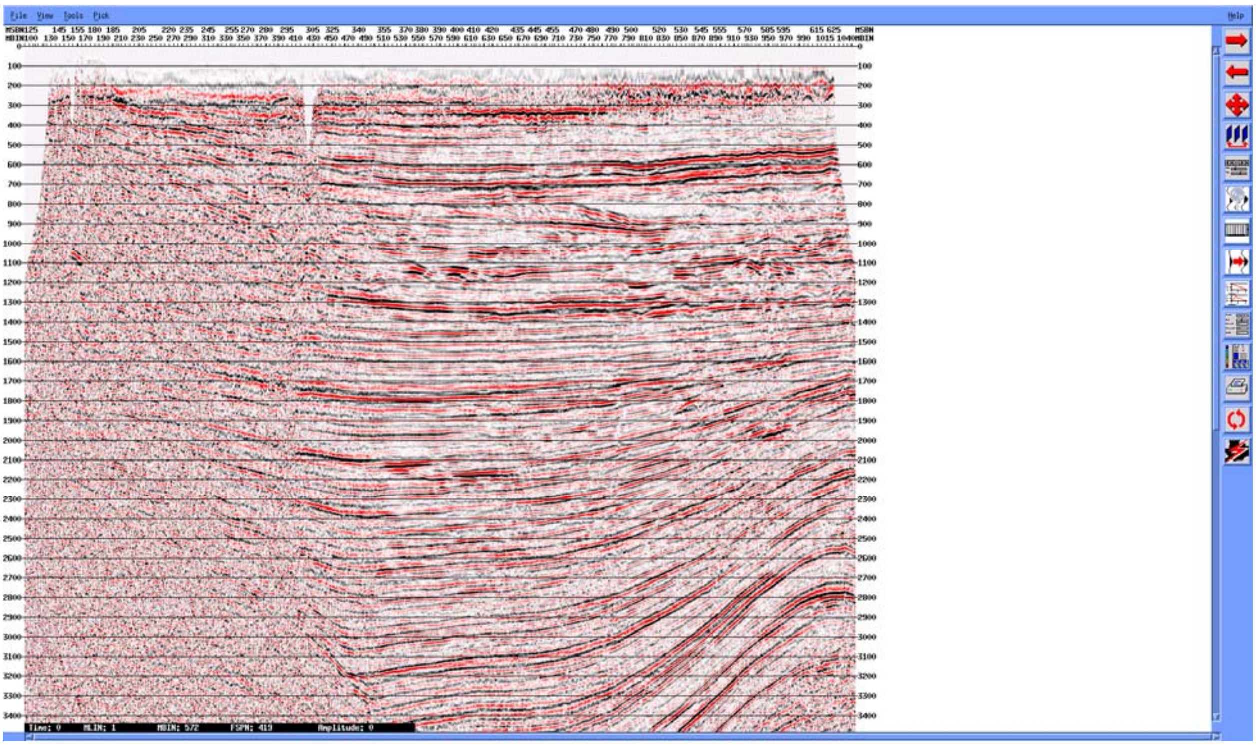
C1 CLIENT: EDISON PROCESSED BY: SPECTRUM GEO LTD.
C2 AREA: ONSHORE ITALY (ZAPPOLINO)
C3 LINE BO-371-91
C4 FINAL PSTM STACK
C5 DATA RANGE: STATION 107-654, CMP 100-1049
C6
C7 ---------------------------PROCESSING HISTORY -----------------------------
C8
C9 REFORMAT FROM SEGY TO INTERNAL FORMAT
C10 APPLY GEOMETRY, MINIMUM PHASE CONVERSION
C11 GAIN RECOVERY T**1.5
C12 REFRACTION STATICS: VW 1000M/S, VR 2000M/S, FINAL DATUM 0M
C13 SURFACE CONSISTENT GAIN S+R+O TERMS
C14 NOISE BURST SUPPRESSION
C15 DUAL F-K DIPFILTER +/- 14MS/TRACE PASS FILTER (WRAPAROUND NMO AND STATIC)
C16 SURFACE CONSISTENT DECON, 24MS GAP, 160MS OPERATOR LENGTH, 0.1% WHITENING
C17 PRELIMINARY VELOCITY ANALYSIS (1KM)
C18 SURFACE CONSISTENT RESIDUAL STATICS (1)
C19 RE-PICK VELOCITIES (500M)
C20 SURFACE CONSISTENT RESIDUAL STATICS (2)
C21 FX DECON IN COMMON-OFFSET DOMAIN, 1000MS AGC
C22 1ST PASS PSTM APPLIED WITH SMOOTHED VELOCITIES (180 CDP'S)
C23 POST PSTM (1) VELOCITY ANALYSIS
C24 2ND PASS PSTM USING PSTM(1) VELOCITIES, SMOOTHED BELOW 1600MS (180 CDP)
C25 FINAL VELOCITY ANALYSIS
C26 NMO CORRECTION, MUTE, 500MS AGC AND STACK
C27 BULK STATICS SHIFT 200MS, STATICS TO FIXED DATUM
C28 COHERENCY ENHANCE +/- 6MS/TR 25TR IN SPATIAL GATE
C29 BANDPASS FILTER 10-60HZ
C30 500MS AGC
C31 ZERO PHASE
C32
C33
C34
C35
C36 SEGY HEADERS:
C37 CDP 21-24, STATION 17-20, CDPX 181-184, CDPY 185-188, ELEVATION 221-224
C38 SEGY OUTPUT CREATED SEPTEMBER 2012

Appendix 2– Examples of Data

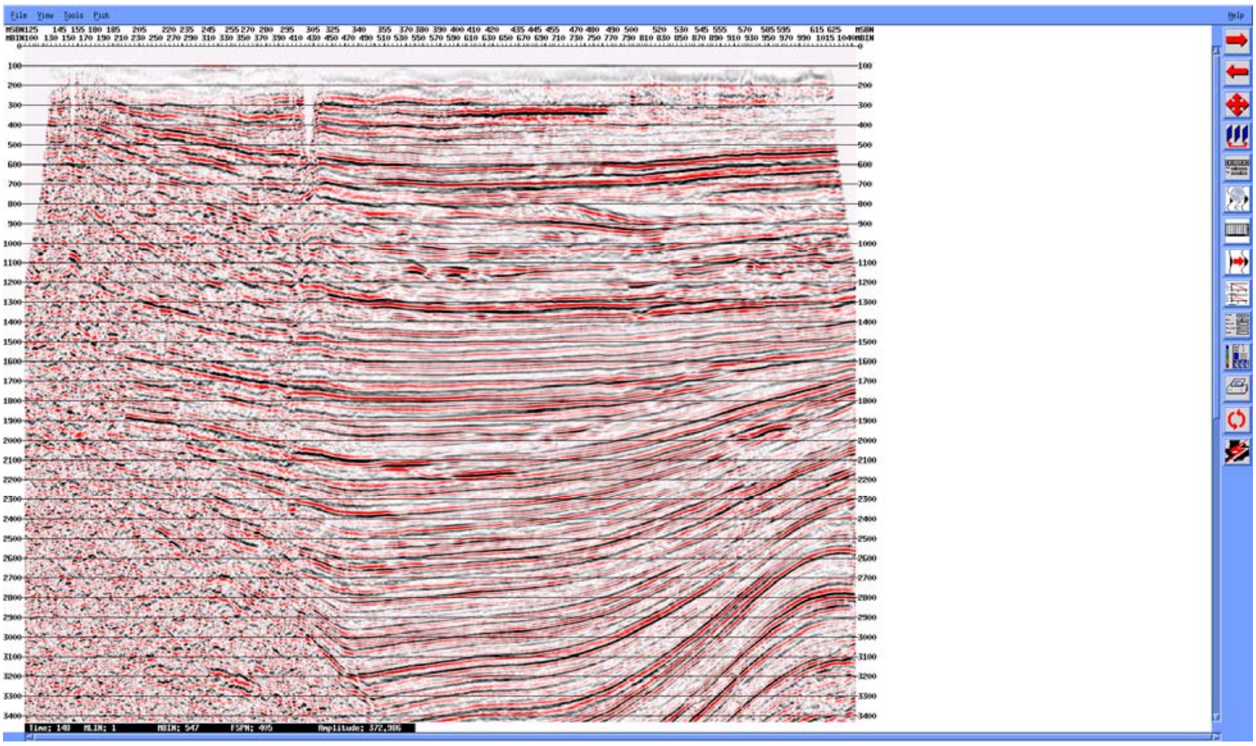
Brute Stack with Elevation Statics



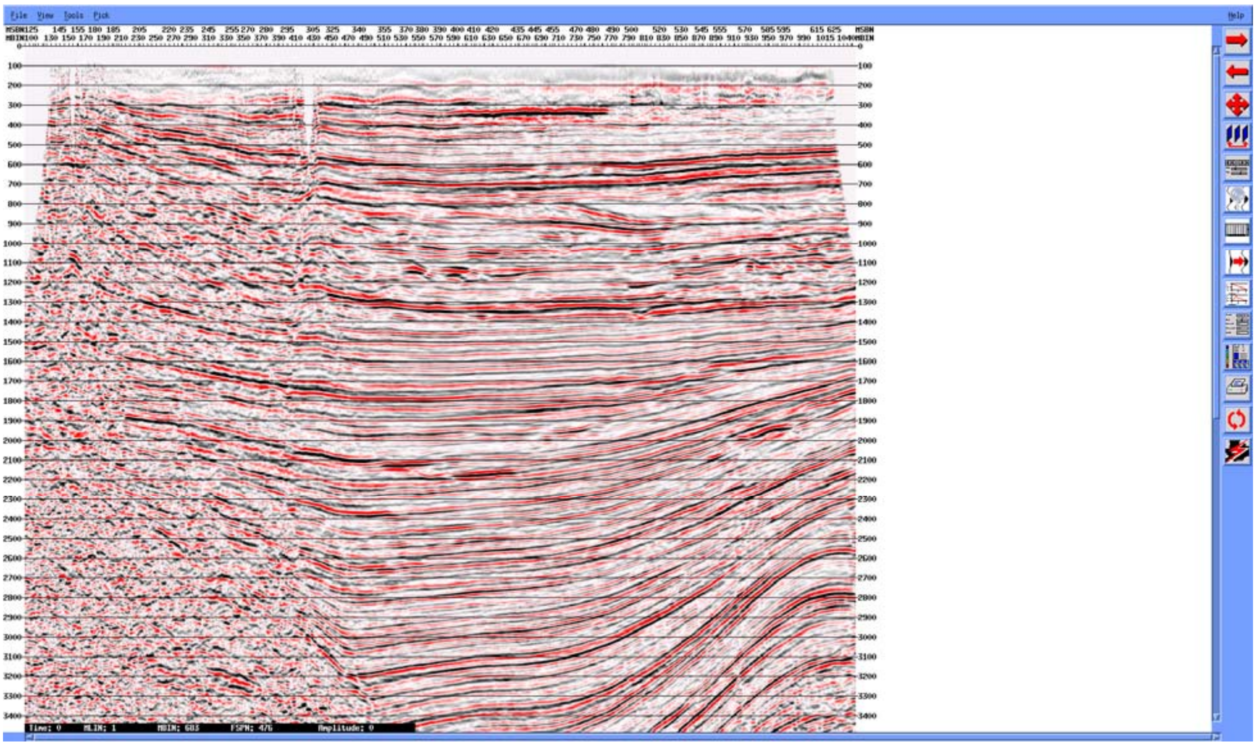
Refraction Statics Stack



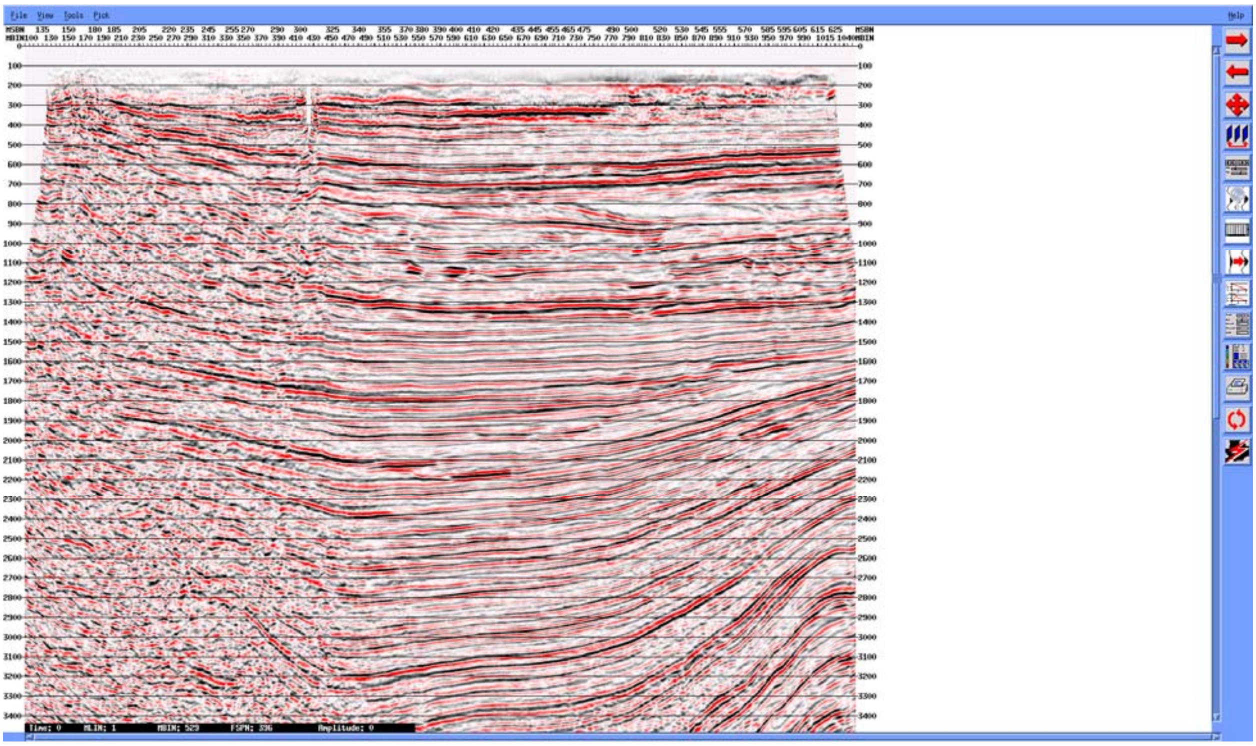
Residual Statics Stack



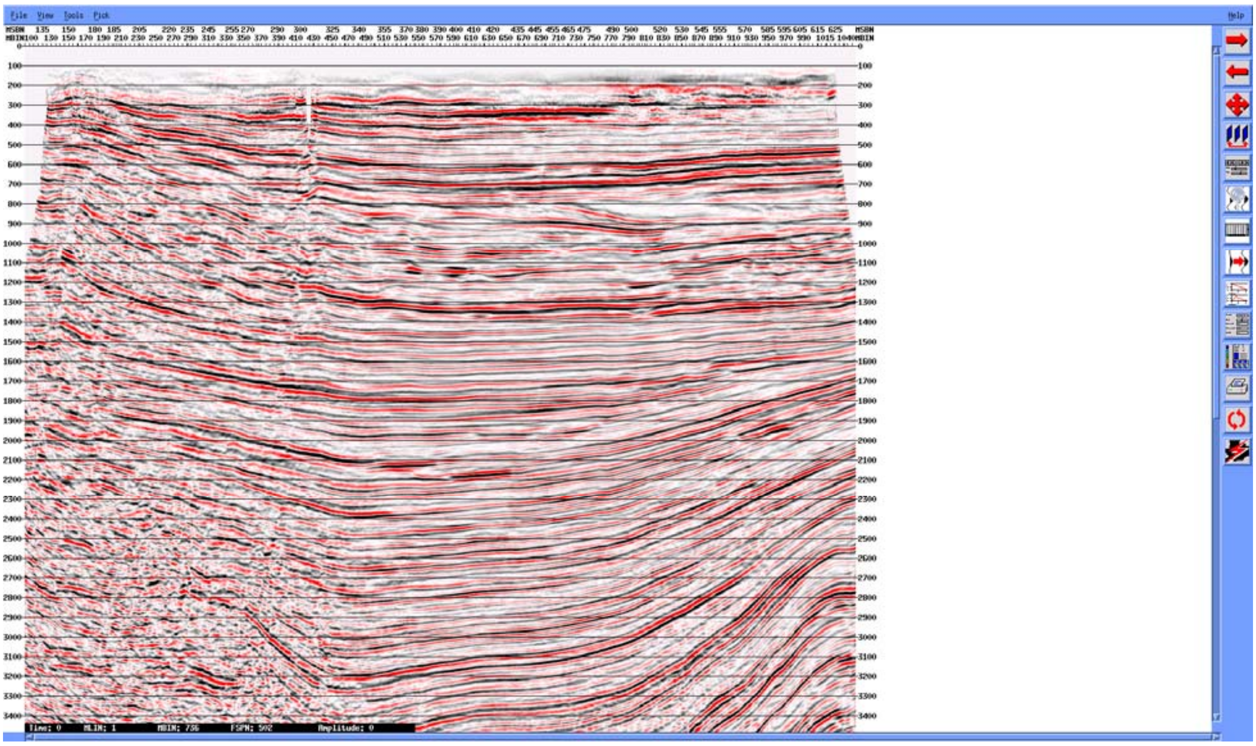
Residual Static Stack with Pre-stack Random Noise attenuation



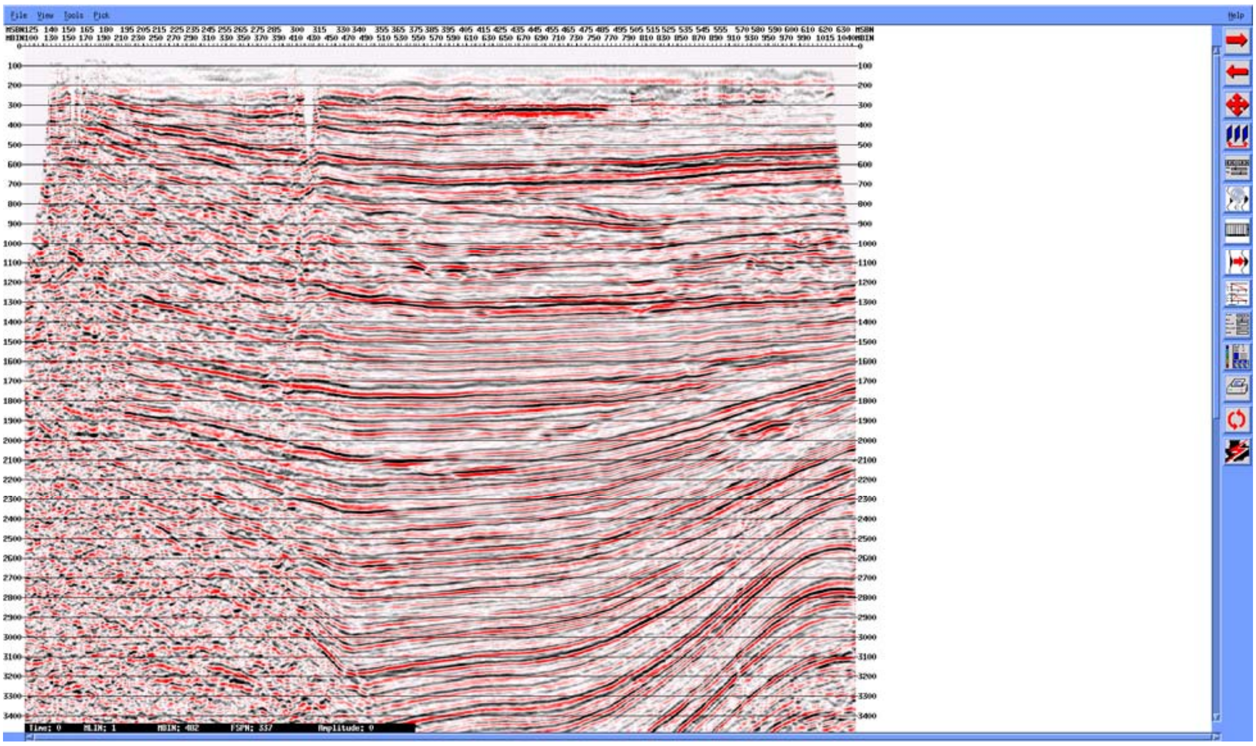
PSTM stack



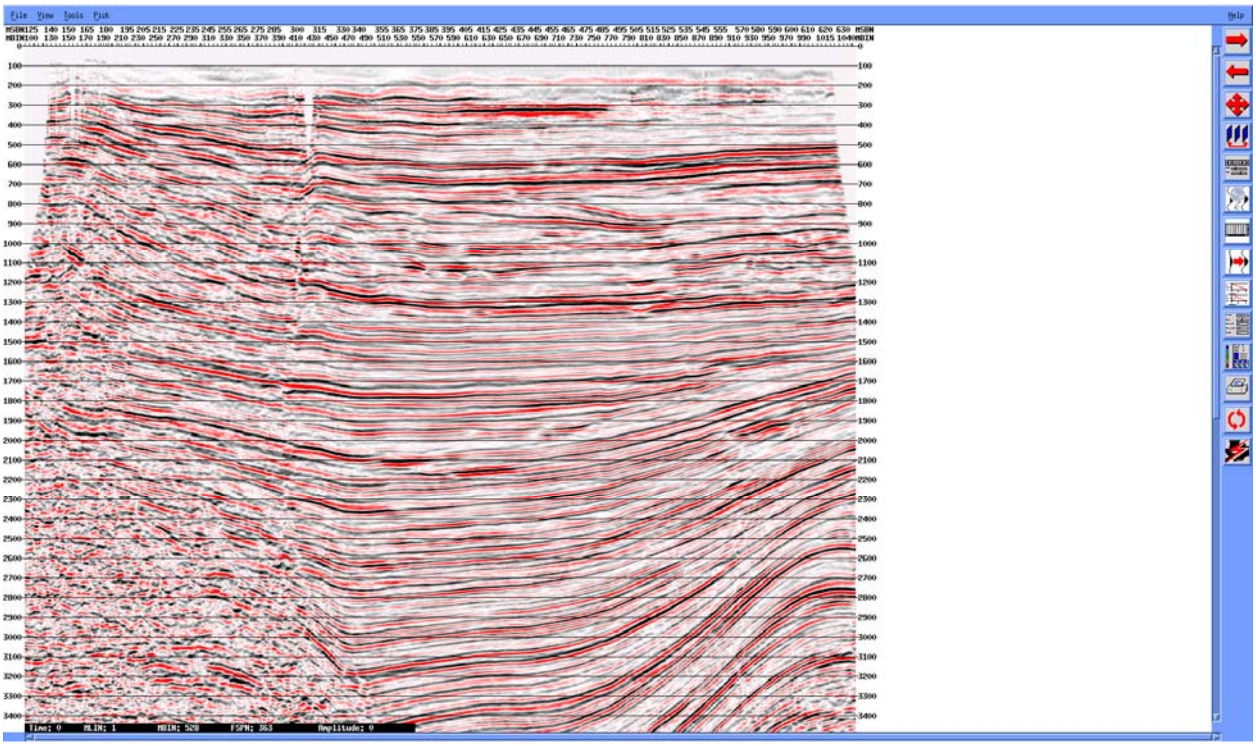
PSTM Stack with final post stack processing



DMO Stack



DMO Stack with final post stack processing



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