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20. Onboard QC Personnel and System

20.1. Onboard QC Processing Geophysicists

17th March to 2nd April 2008	Steffi Schwarz	CGGVeritas, Chief Field Geophysicist
	Dennis Jerome Aquino	CGGVeritas, Field Geophysicist
2nd to 18th April 2008	Tommy Timenes	CGGVeritas, Chief Field Geophysicist
	Isabel Adjani Nicolas	CGGVeritas, Field Geophysicist

20.2. Onshore QC Processing Support

Ronny Tømmerbakke	Support Geophysicist
Cathrine Myrmehl	Support Geophysicist
Christophe Massacand	Chief Operations Geophysicist

20.3. Seismic Processing Hardware Description

Machines	:	1 x Supermicro, built on SC833T-R760 Chassis (Dual Core Xenon 2x3.2GHz CPU, 8Gb RAM) 1 x Win XP SP2 PC
Hard Disk Drive	:	1.6Tb Disk
Monitors	:	4 x 19in LCD Monitors
Tape Drives	:	2 x IBM 3590 tape drives
Plotter	:	1 x Isys V24 24in Thermal Plotter (B&W)

20.4. Seismic Processing Software Description

Processing software	:	ProMAX 2D version 2003.12.1.1
Operating System	:	LINUX Red Hat Enterprise WS 3.0 Update 6
Plotting software	:	ZehPlot Express 4.7.0

21. Acquisition Quality Control

21.1. Introduction

This report provides a summary of the steps taken for the onboard seismic data QC for this survey. Information important for the onshore processing of this data is either contained within this document, or its location is referenced.

The SEBOA survey is comprised of several 2D seismic surveys for the SEBOA consortium (Santos, 3D Oil, Bass Straits Oil Company, Cue Energy Resources, Eagle Bay Resources, Exoil and Tap Oil). The survey sites are located offshore South East Basin and Bass Strait Basin in Australia and cover around 10,900 km.

This report covers the CUE survey of blocks T37P and T38P.

Acquisition parameters for the project are the following:

- 1 Streamer x 6000m
- Single source
- 25 m SP interval
- 6 seconds record length

21.2. QC Processing Objectives

The main objective of the onboard QC processing was to identify problems associated with the data acquisition and recording. This included the assessment of noise in the data on a line by line basis in order to give an overall impression of the data quality.

Various QC methods, including RMS noise displays, single and multi-trace displays, gun hydrophone channels and stacks were used to assess compliance with various acceptance criteria and to isolate any other acquisition issues.

The general aim of the QC processing was not to attenuate noise but to show the data as it was recorded, or how it would be presented to the processing centre.

A brute stack was produced for every line with minimal processing to enable a thorough QC of the data onboard. In addition to brute stack processing, gun hydrophone channels were checked to QC the performance of the source, near trace and Shot vs. Channel RMS displays were generated and examined to identify any noise problems.

21.3. Parameter Testing

Parameter testing consisted of choosing suitable parameters on the first sequence, along with NMO mutes, and post stack scaling for the displays, and checking that these parameters remained appropriate throughout the survey. Testing was kept to a minimum due to the high acquisition rate and resulting workload.

After initial cable deployment and after each subsequent redeployment, a near-offset test was performed using the gun closest to the centre of the source to ascertain the actual distance from the source to the centre of the first receiver group.

21.4. QC Processing Sequence

Data was recorded by the Observer department in duplicate onto 3590 tape cartridges (10Gb capacity). One 'primary' tape set and one 'copy' tape sets were generated. Upon completion of a line, the ‘original’ (or ‘primary’) tape was read to confirm the integrity of the data on tape. All SEG-D data on the primary tape was extracted and written to the ProMAX system disk. A listing of the field files (FFID), shot point numbers (SP) and number of channels was printed to clearly identify any lost shots or shots with missing navigation headers.

The data included 480 seismic channels and 30 auxiliary channels (-1 to -30). Informative auxiliary channels are Aux1 - System Start, Aux2 - Time Break, Aux4 - Water break, Aux13 to Aux30 - Gun Near Field Hydrophones. Also recorded were the start of line (SOL) and end of line (EOL) noise records.

Seismic data, noise records and auxiliary channels were input with a record length of 6000ms, and a 2ms sample interval was used in the acquisition. The cable length was 6000 meters with hydrophone group separation of 12.5 meters, and shot points were recorded at 25m intervals.

A bulk shift static correction was applied to the data to correct for the 50ms instrument delay of the recording system.

For QC purposes a nominal 2D geometry was applied to all the seismic trace data. The resulting offset / CDP binning information calculated was then loaded into the seismic trace headers. The data was re-sampled from 2 ms to 4 ms using a minimum phase, high fidelity anti-alias filter applied prior to resample. Further data reduction involved 2-to-1 Marine Trace Decimation after differential NMO, which increased the receiver spacing from 12.5 to 25 meters.

To balance the amplitudes of the shot record, true amplitude recovery using a spherical divergence correction was used and applied to the whole shot record, based on a brute velocity function picked for the area. Band pass filtering (Ormsby 6-8-90-120) was also applied to the data, prior to NMO and stacking.

Water bottom picks were automatically generated and manually QC’ed for the near channel.

Trace editing involved killing any bad traces or shots based on Observer log comments and results of the QC.

21.5. Velocity Analysis

Velocities were picked for every line at a 4 km interval using ProMAX interactive velocity analysis package. This comprised of a semblance display with RMS stacking velocity graph and interval velocity graph, CDP super gather panel and function stack panels.

To improve the signal to noise ratio, super gathers were formed by combining 15 adjacent CDP gathers. Stack panels were created from these 15 CDPs using 31 functions varying +/- 35% from the regional velocity function of the first two sequences. Thereafter, the velocity functions of the nearest adjacent line shot in the same direction, were used as a guide.

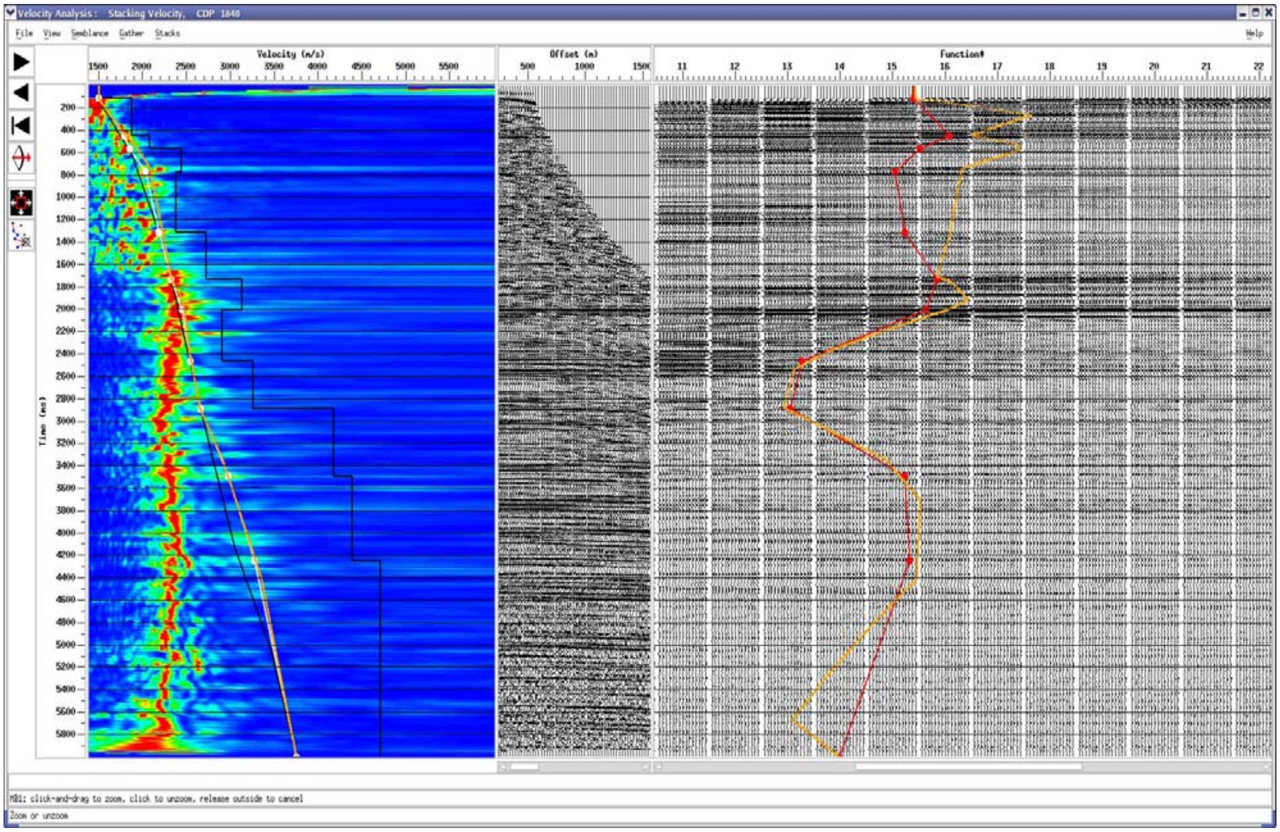

Figure 21-1: Velocity analysis for sequence 072. Graphical user interface with semblance, super-CDP gather and function stacks.

To speed up the on-screen velocity picking procedure, the velocity analysis displays were pre-computed. Normal move-out was applied to the gather to check that the events were lining up well.
NMO corrected gathers were also displayed onscreen: both, at and between velocity locations, for further verification.

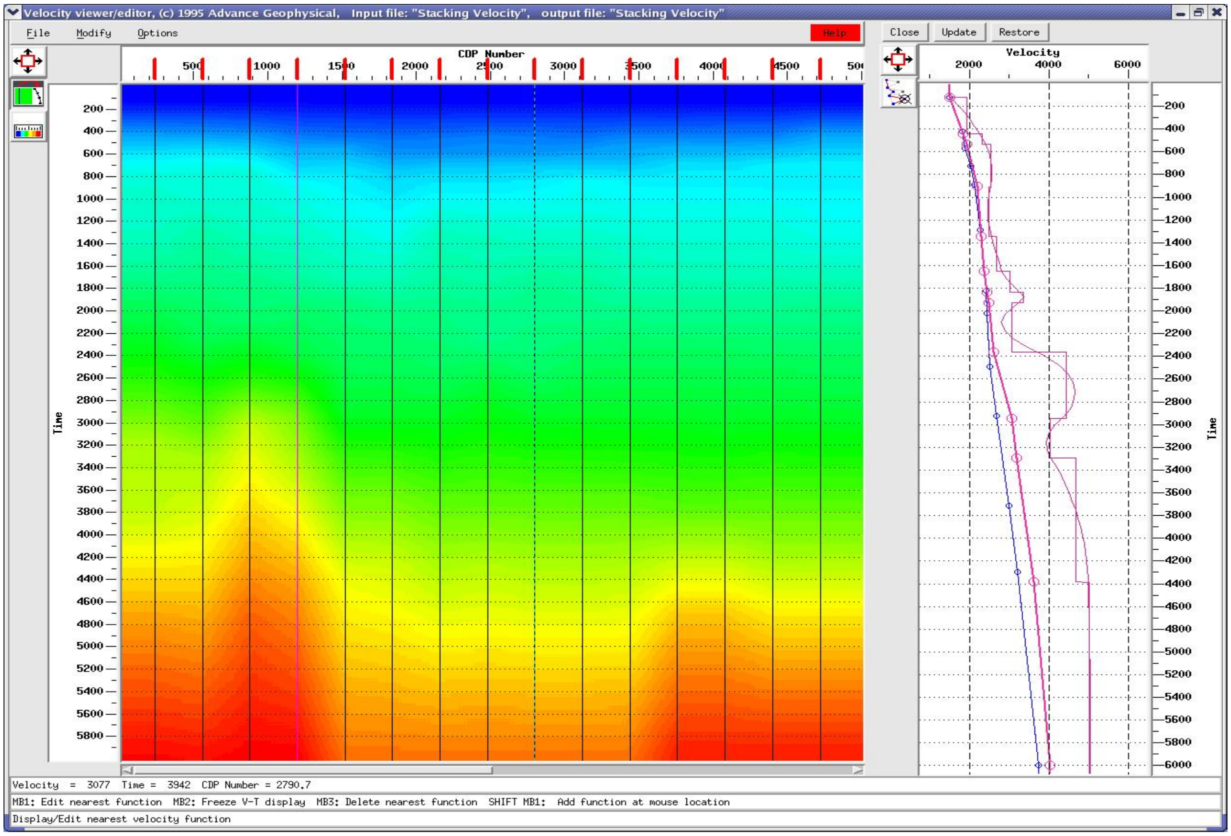

Figure 21.2: Velocity QC for sequence 072 using the Velocity Viewer/Point Editor to check for any errant picks.

Velocity table for each sequence was exported to ASCII format.

21.6. Brute Stack

Brute stacks were produced as soon as possible after each line and presented to the onboard client to assess the noise impact on the data.

A straight mean vertical stack algorithm was used for CDP stacking, with a root power scalar for normalization of 0.5. A bulk shift static correction was applied post-stack to correct for the gun and cable depths. Filtering was limited to a 6-8-90-120 Hz Ormsby band-pass filter. The raw brute stacks were captured to jpg and plotted to paper.

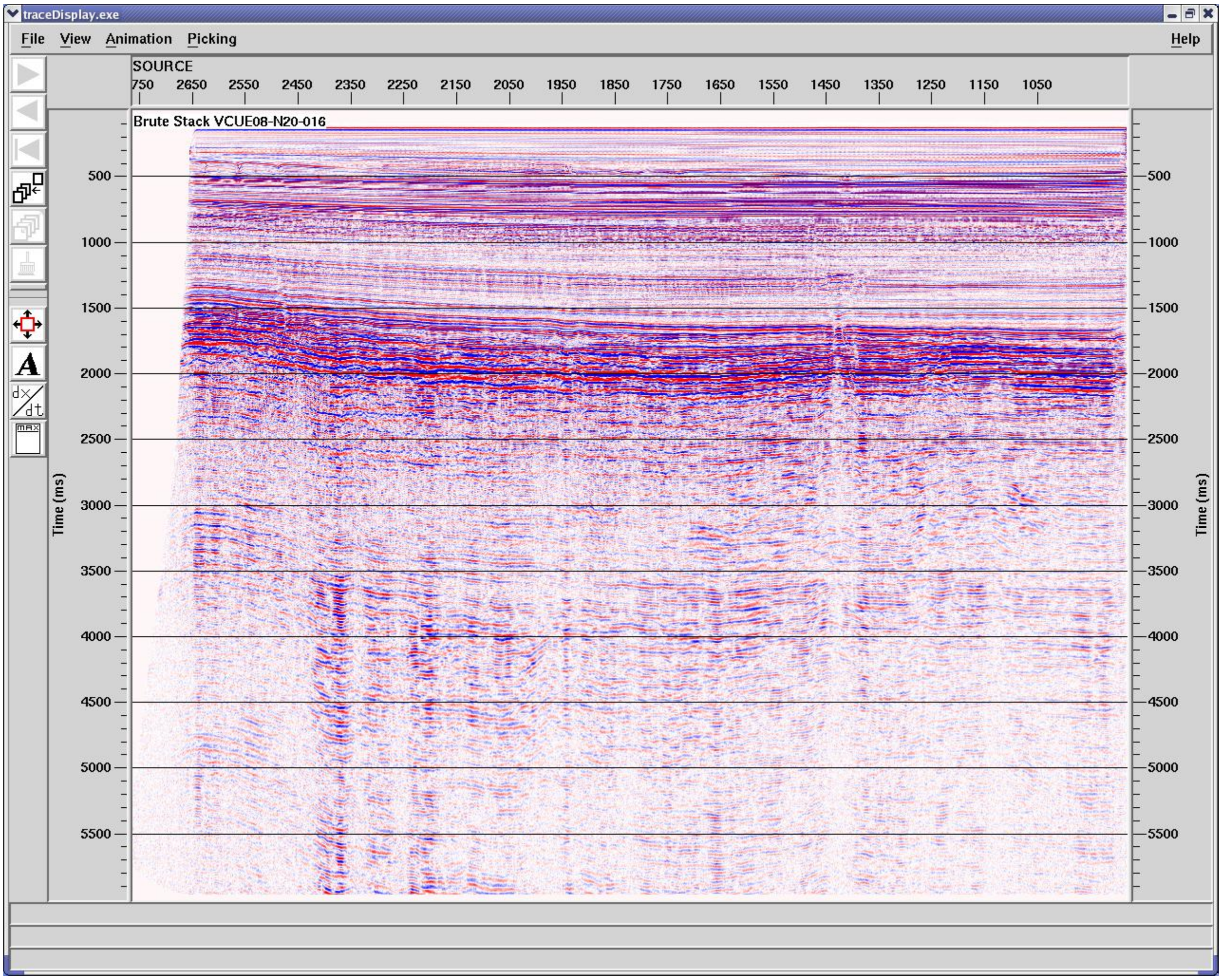

Figure 21-3: Brute stack for sequence 016. Note string ringing.

21.7. QC Workflows

This section describes the quality control steps that were taken. This acquisition QC allows for the onboard processors to find, log and analyse any potential problems with data acquisition. These were done in conjunction with the other onboard departments so as to maintain the highest possible standards of acquisition.

The onboard QC workflows include a full set of quality controls used to detect seismic and positioning problems.

STEP	DETAILS	QC PROCEDURE/PRODUCT
Reformat to ProMAX internal format	Input full length record - 6000ms, 480 channels + 30 auxiliary channels	Check Job Listing for FFID/Shot numbering, Gun Seq, Main headers. Check for missing data
Noise Record	Start And End Of Line. Ambient RMS Calculation	Check screen display and noise level Screen capture SOL & EOL records
Noise History	Append Noise Calculation to History	Screen capture Noise History – single display for entire project
Raw Shots Display	Every 1025m, 480 channels 6000ms	Check Channel Edits Check Data Quality
Auxiliary Channel QC	Create Aux Channel Gathers Vertical Stack Gun Hydrophones for each Gun string	QC of Aux Channels Check for autofires, gun timing, air leaks
Near Trace Display	Select First Channel and Display	Check record length, data quality Screen capture
Shot vs Chan RMS Analysis	• Ormsby, Zero Phase, 4-8-90-120 Hz BPF applied. • 2 Windows: 50-500ms & 5450-5950ms. • Shot by shot Average Noise Calculation.	Check levels against job specs Check for bad channels Screen capture for both displays
RMS History	Calculate Average for Sequence and append to RMS History File	Screen capture RMS History – single display for entire project
Trace Decimation Flow	• Input Raw Shots • Apply Shot and Channel Edits based on Observer Logs and QC • -50ms static shift for Instrument Filter Delay • Ormsby, Minimum Phase, 4-8-90-120 Hz Band Pass Filter • Apply 2D Nominal Marine Geometry	
Decimated shot display	Every 1250 m shot display on screen	Check shots
Velocity Analysis	Every 4 km, Semblance, Gathers, Variable Velocity Percentage Stack Panels	Pick velocities every 4km
Velocity QC	Start ProMAX Interactive Velocity QC and Editing tool.	Check velocity Field for Spikes and Picking errors. Display as Interval Velocities for additional QC
NMO gathers	Every 2km NMO CMP gathers on screen	Check moveout of primaries.
Export Vels	Export Velocity Table to ASCII	Save ASCII Vel file

STEP	DETAILS	QC PROCEDURE/PRODUCT
Stack RMS Flow	Calculate water column RMS value for posting on top of the stack	
Shot Stack Flow	Calculate average RMS level of each shot over entire line, measured within a 5450-5950 window. Post in ProMAX database	QC for anomalous values Screen capture
Channel Stack Flow	Calculate average RMS level of each channel over entire line, measured within a 5450-5950 window. Post in ProMAX database	QC for anomalous values Screen capture
Stack Flow	• Input Decimated Shots • Sort to CMP order • Moveout with picked Velocity Field • Surgical NMO mute • 1/sqrt(n) fold compensated stack • Apply Gun and Cable Statics • $1/tv^2$ • amplitude recovery • Ormsby, Minimum Phase, 4-8-90-120 Hz Band Pass Filter	Check quality of stack Check completeness of Stack and corresponding SPs, FFIDs and CDPs Screen capture
Stack Plot	Time Variable Amplitude Compensation	QC of stack
SEG-Y stack	Write to SEG-Y & QC	Save deliverable file
Nav Merge QC	Merge lead trace of each cable with P190. Calculate direct arrival time and display over Seismic Near Trace Gather.	Check that predicted Direct Arrival Time closely follows the seismic data. Check that all traces have merged successfully. End of Job

21.8. Noise Record and Channel RMS graph

The noise records were recorded at the start and end of every line, and displayed for QC. Channel RMS values were computed for all 480 channels over the entire record for noise analysis, and graphed above the display. For every sequence the noise record at SOL and EOL was displayed on screen and archived to GIF format.

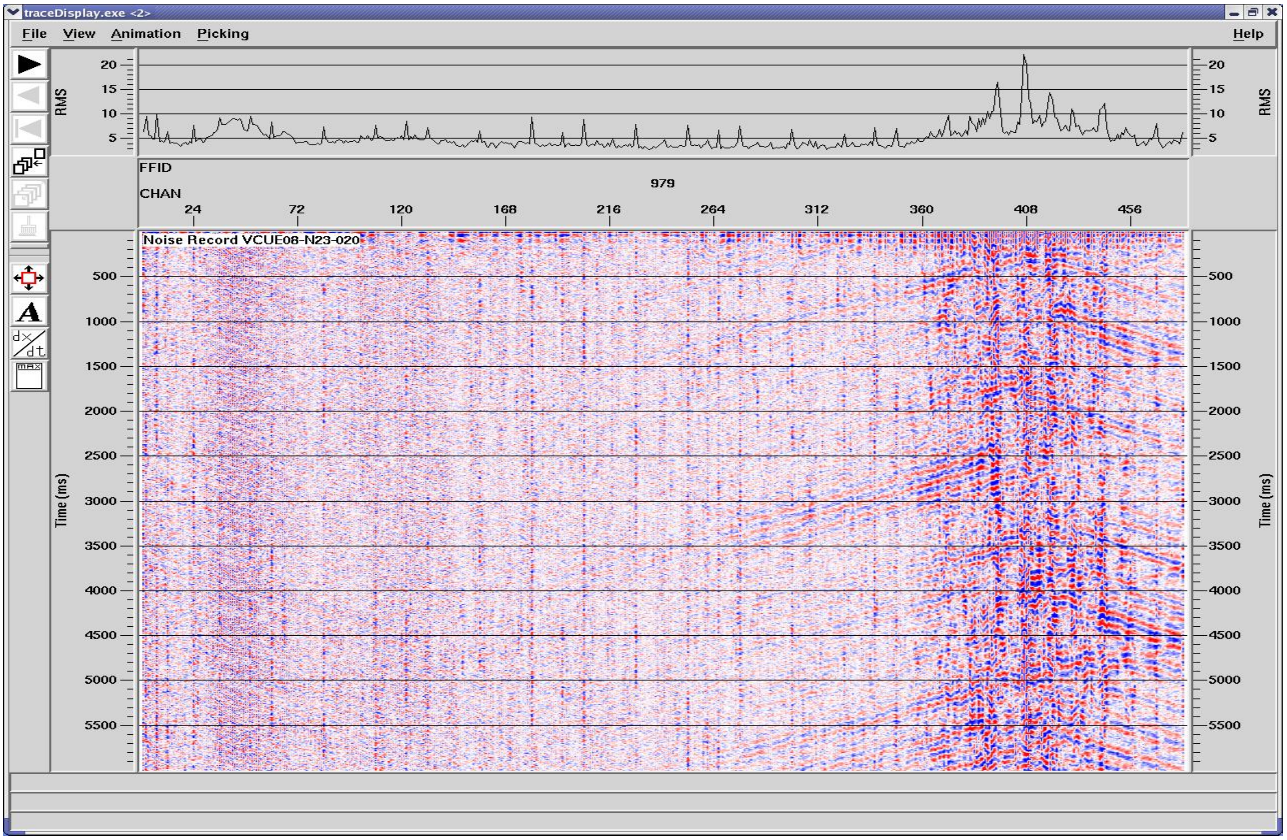

Figure 21-4: Example Noise Record with Channel RMS levels annotated, sequence 020. Note slightly noisy bird channels, and bend noise towards the tail of the streamer.

For each noise record a noise analysis is performed. The average ambient noise encountered in the noise records is recorded in the QC log.

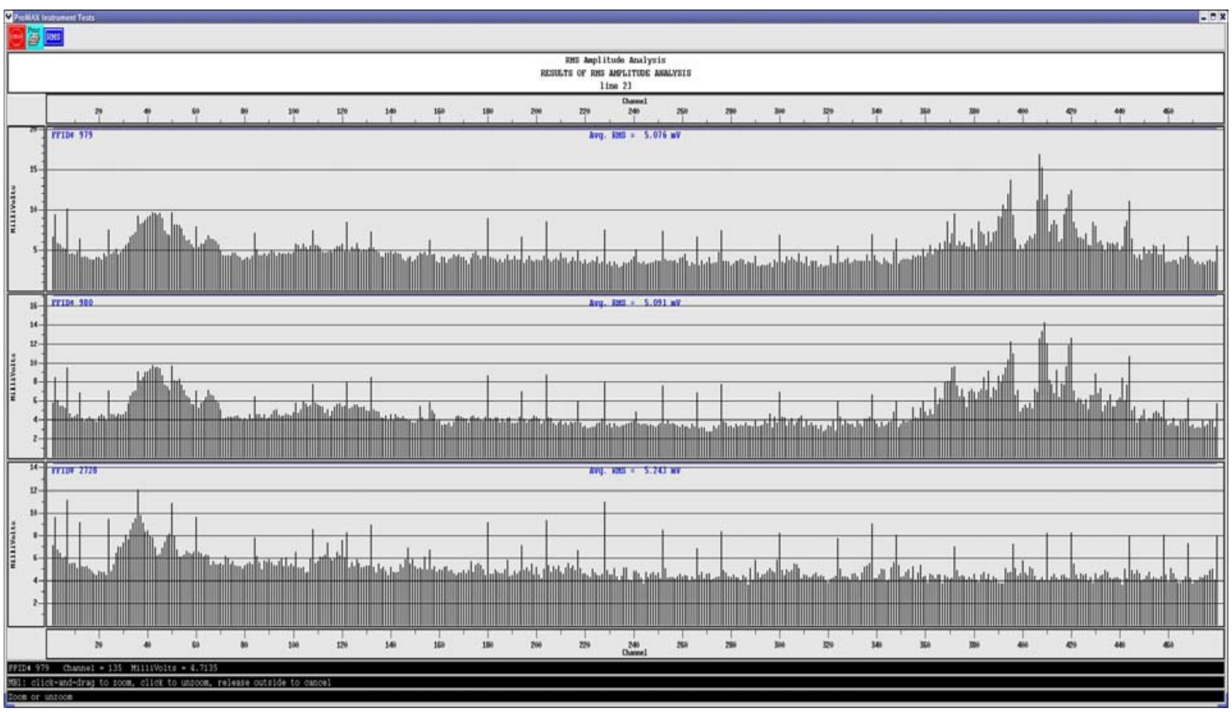

Figure 21-5: Example of analysis of Noise Records for sequence 020. Average Ambient RMS: 5.1µb. Tail end of cable still in turn during the SOL.

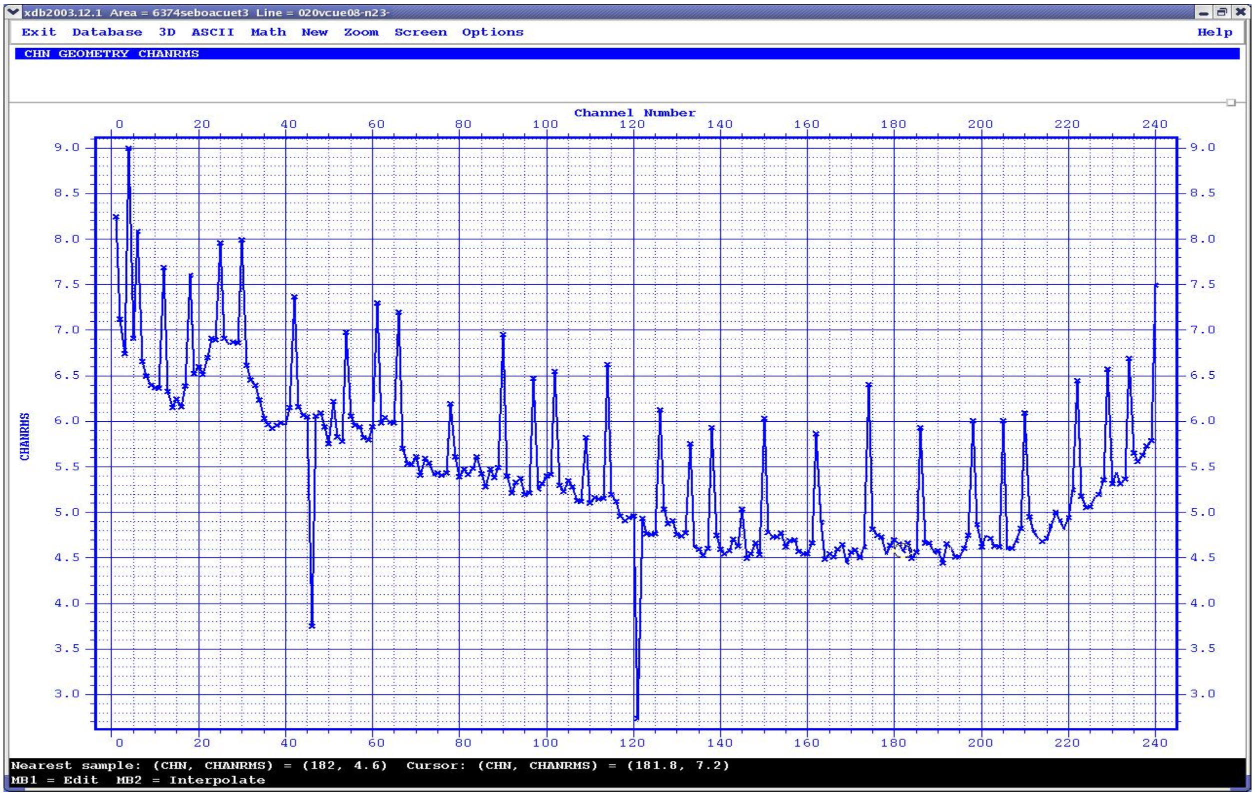

Figure 21-6: Channel stack sequence 020. The display computes the average RMS of the last 500ms of each channel and writes it to database.

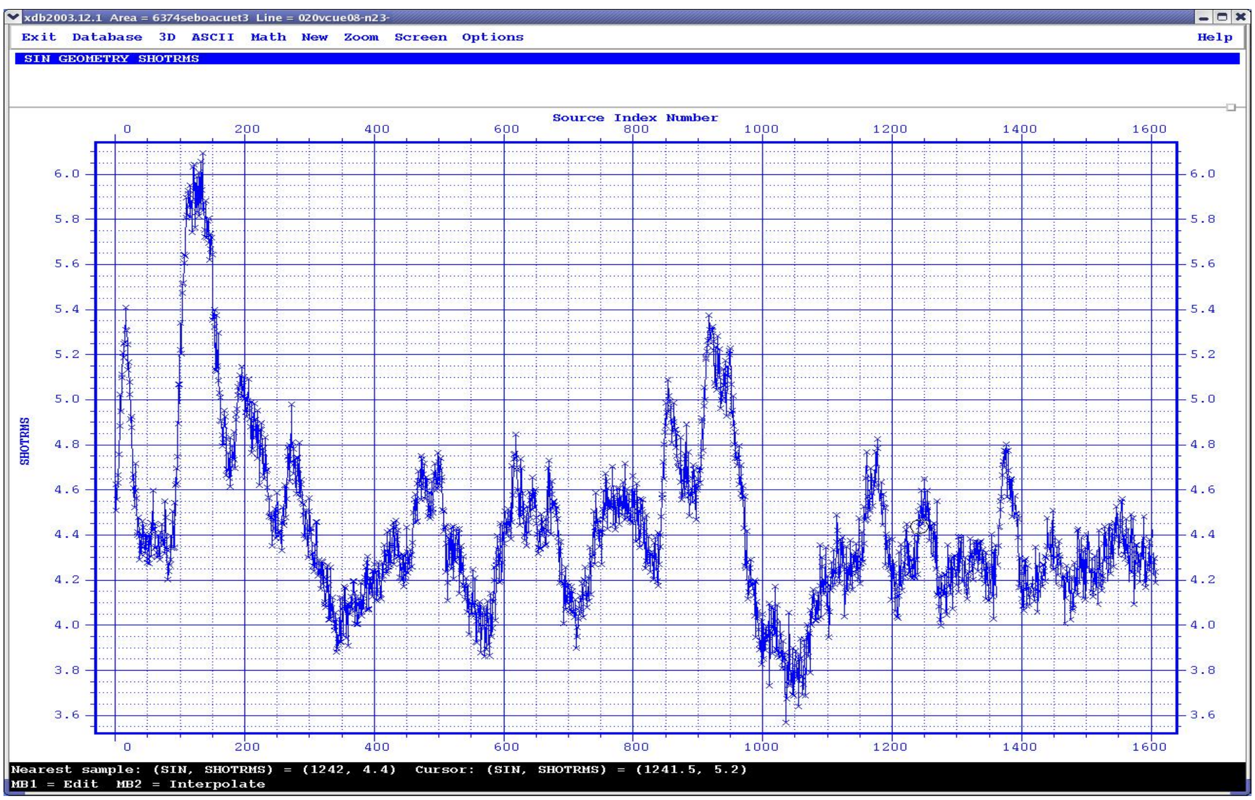

Figure 21-7: Shot stack sequence 020. The display computes the average RMS of the last 500ms of each shot and writes it to database.

21.9. Ambiant noise - Shoot Vs Channel RMS Display

Colour displays of Shot vs. Channel RMS values were produced for the whole cable for every line to assess the ambient noise level and the channel quality. Raw data with a sample rate of 1 ms was used to calculate the RMS values for every channel on every shot.

RMS values were calculated from two windows, a shallow window of 50-500ms at the start of the record, and a deep window of 5450-5950ms at the end of the record. RMS values from all channels were averaged for each shot. They were displayed on the graph.

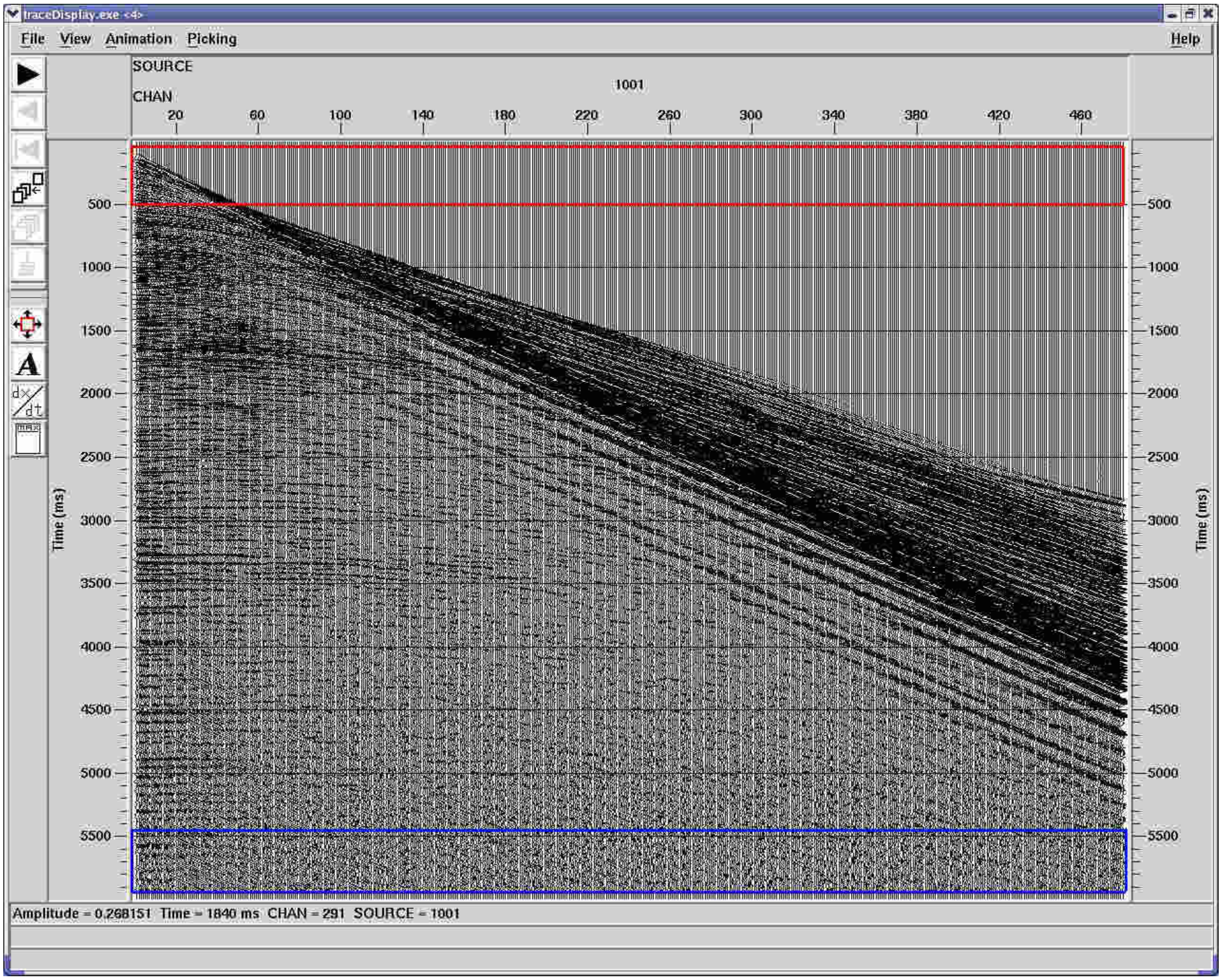

Figure 21-8: Shot gather with shallow and deep RMS analysis windows annotated.

For all RMS computations a scaling factor of 46.5 was used to convert from millivolts to microbars, the instrument sensitivity being 21.5 Volts/Bar.

The shallow and deep colour RMS displays were viewed on screen, and screen images were then saved as JPG files. The displays were used to show noise trends along the line such as swell noise, noisy/bad channels, bird noise, cable tug, front end noise, cable strikes, auto-fires and misfires, multiple interference, etc. Noisy channels could be clearly identified and deteriorating channels could be spotted using this display. The on screen analysis also allowed the exact shot and channel location of any noise trend to be located and investigated. All suspicious shots were then examined in the raw shot display to find and edit noisy shot records.

The shallow window was overdriven for the first 50 channels and the deep window was overdriven from time to time, as can be seen on the plot below (red bar at top of display). This is due to the water depth of the survey area, and the impossibility of finding an adequate water column window at the top of the trace, free from the seismic impulse. Therefore it was impossible to determine average values of ambient noise from the rms displays.

At the end of the survey a composite display was created showing average RMS values per channel on a sequence-by-sequence basis.

ASCII format files of the ambient RMS can be found on the Deliverables CD as well as the QC log for the survey area.

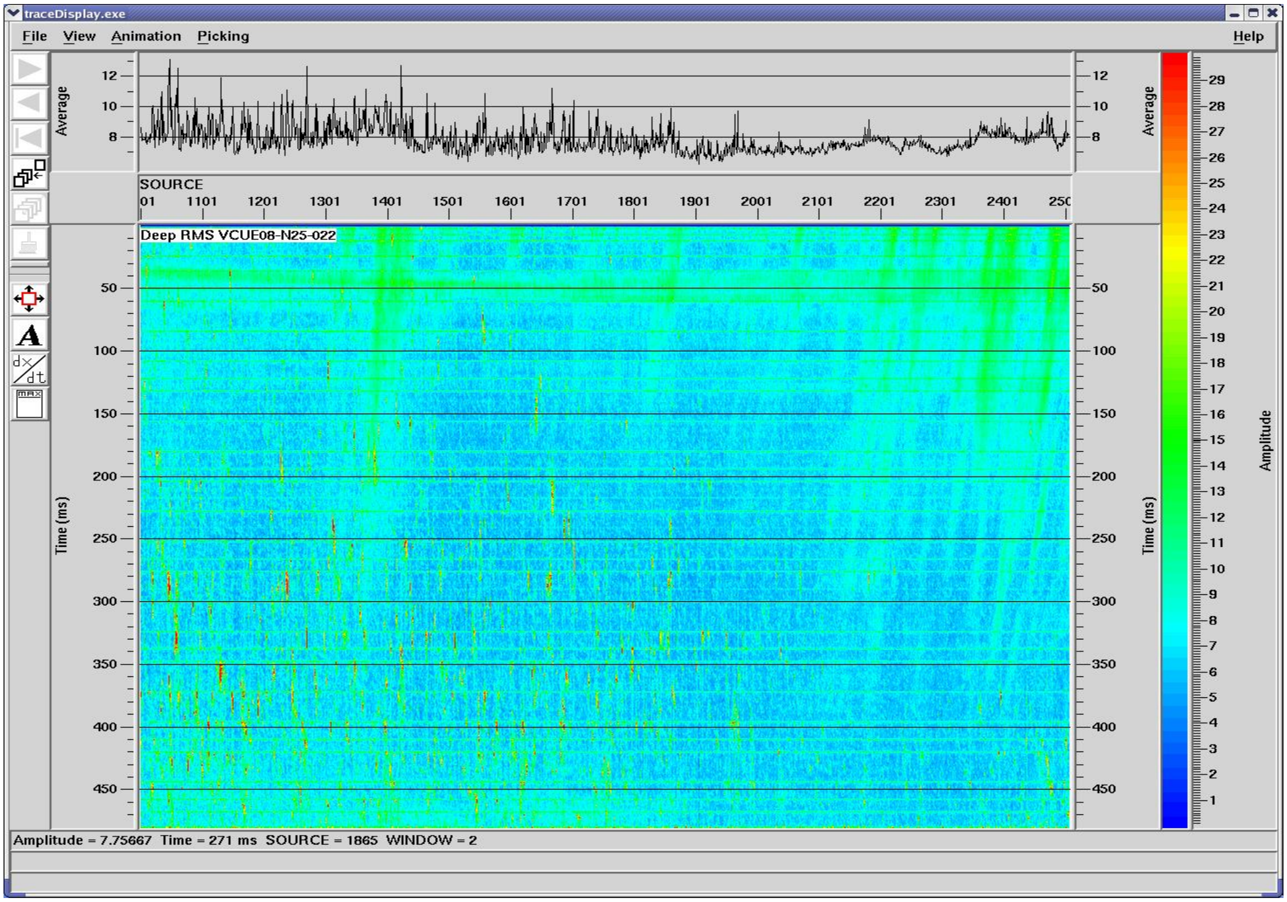

Figure 21-9: Deep RMS window for sequence 022. Note some swell bursts and noise on channels 25-40.

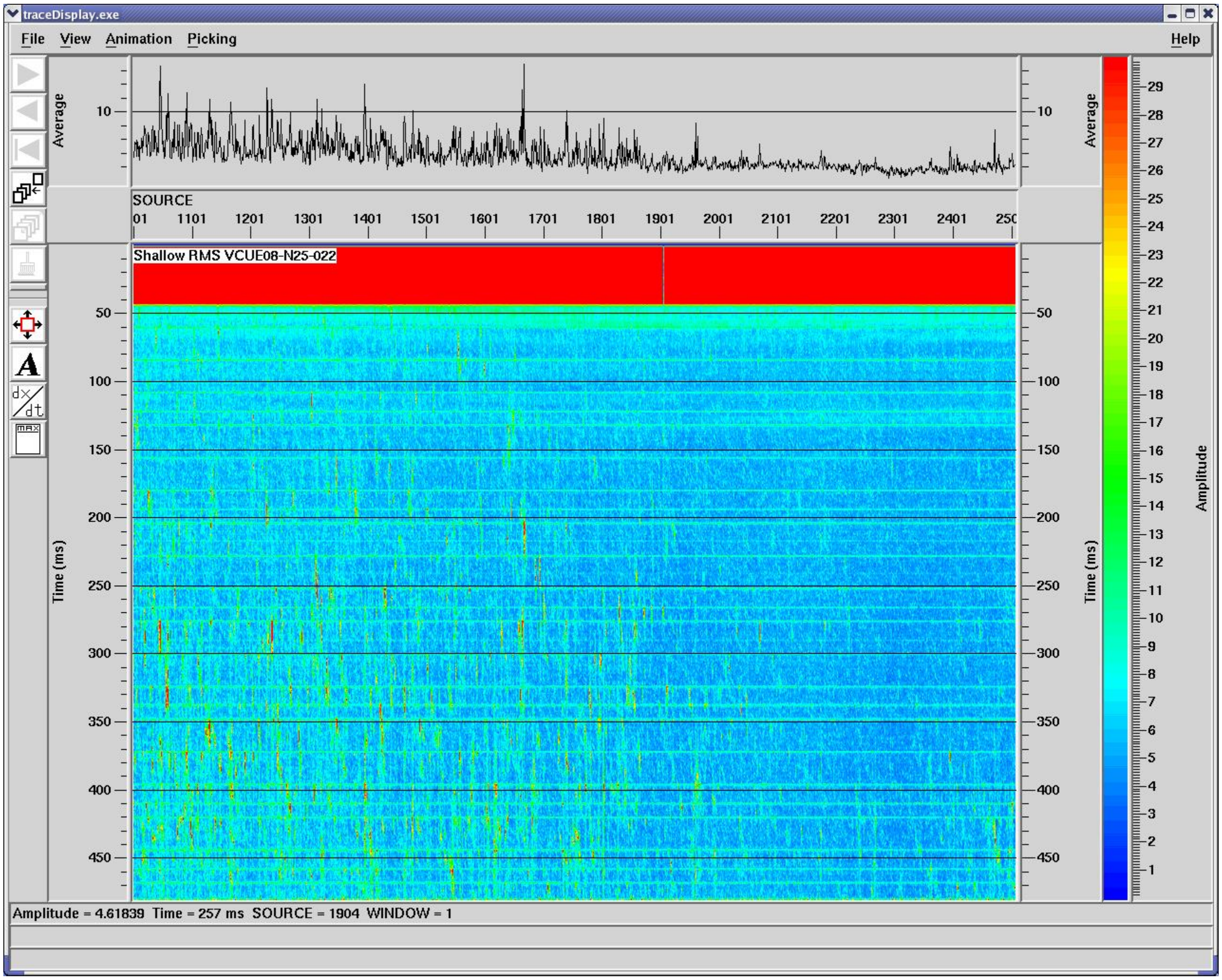

Figure 21-10: Examples of Shallow rms window QC from sequence 022. The first 50 channels are dominated by direct arrival energy. Some swell noise is evident.

21.10. Near Trace Display

The near traces were displayed on screen for every line in order to quickly determine any possible errors with acquisition, e.g. gun volume changes, bad records, time-break problems and any auto-fires not reported by the recording system. The near traces also provided a good indication of the geological conditions, including strength of the water bottom multiples, residual seismic multiple energy and swell noise contamination.

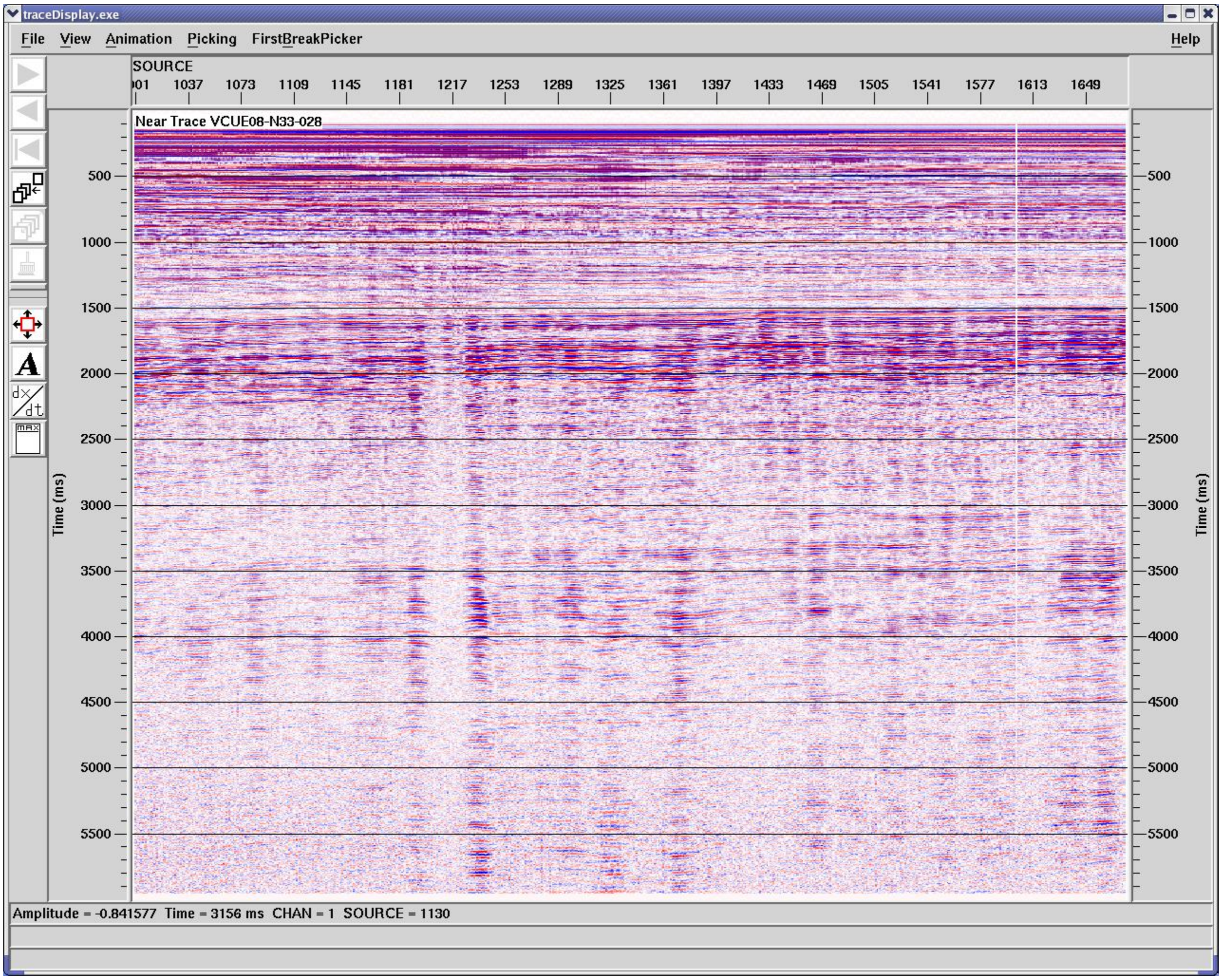

Figure 21-11: Near trace display, sequence 028. Note missed SP 1602.

21.11. Auxiliary Channel QC

The 30 auxiliary channels (-1 to -30) loaded during the SEG-D read, were separated from the 480 data channels, stored in a separate data file, and used for on screen analysis. These records consisted of the time break, the water break, and 6 near-field hydrophones for each of the 3 sub-arrays.

Time break and water break channels were displayed as a single trace display on screen. The first 500ms from all 6 hydrophones within each sub-array were stacked vertically and displayed in order to evaluate the performance of the guns. This proved useful in distinguishing genuine gun problems from noise on the trace. The auxiliary channel displays were used to locate air leaks and autofires.

Hydrophones 20 and 21 (gun string 2) were dead for all sequences.

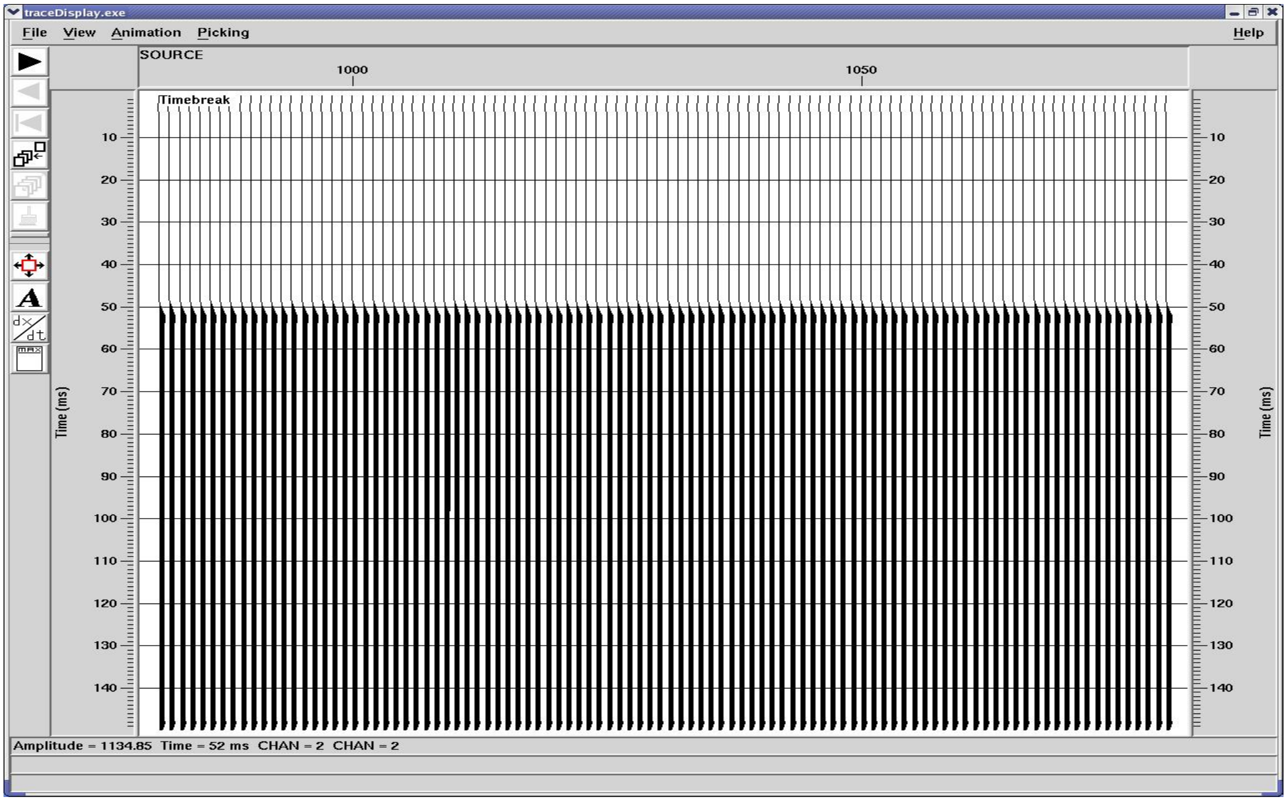

Figure 21-12: Timebreak QC (Auxiliary channel 1).

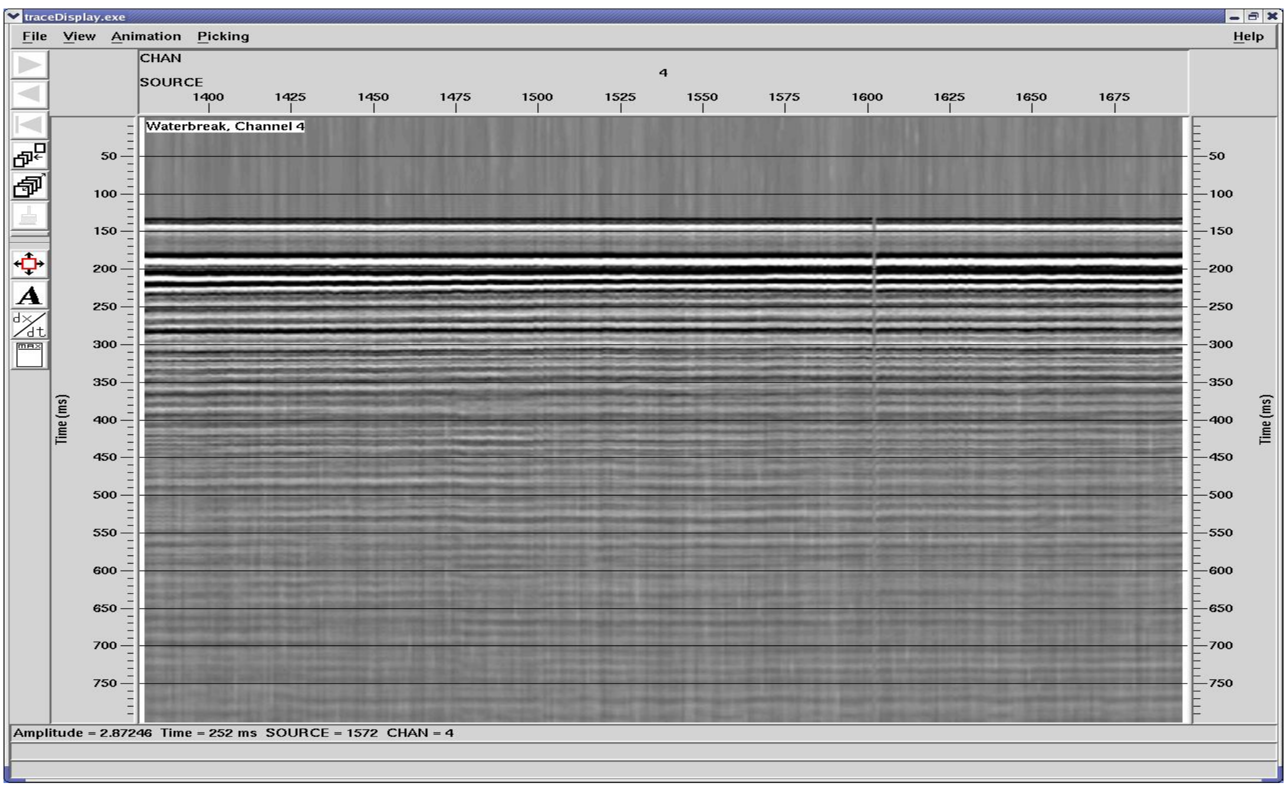

Figure 21-13: Waterbreak hydrophone QC (Auxiliary channel 4). Note missed SP 1602.

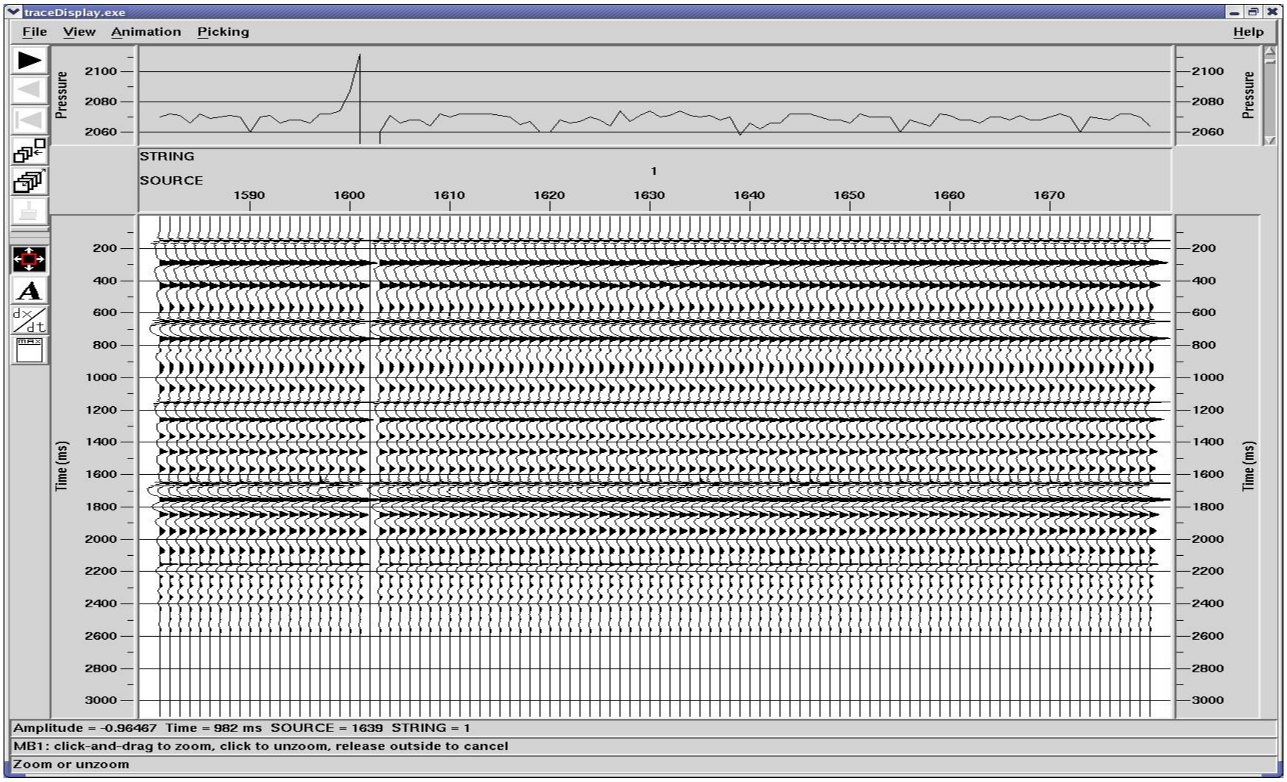

Figure 21-14: QC of vertically stacked near field hydrophones 1 to 6 on gunstring 1 (Auxiliary channels 13 to 18). Note annotation of gun pressures, dead hydrophone 6 and missed SP 1602.

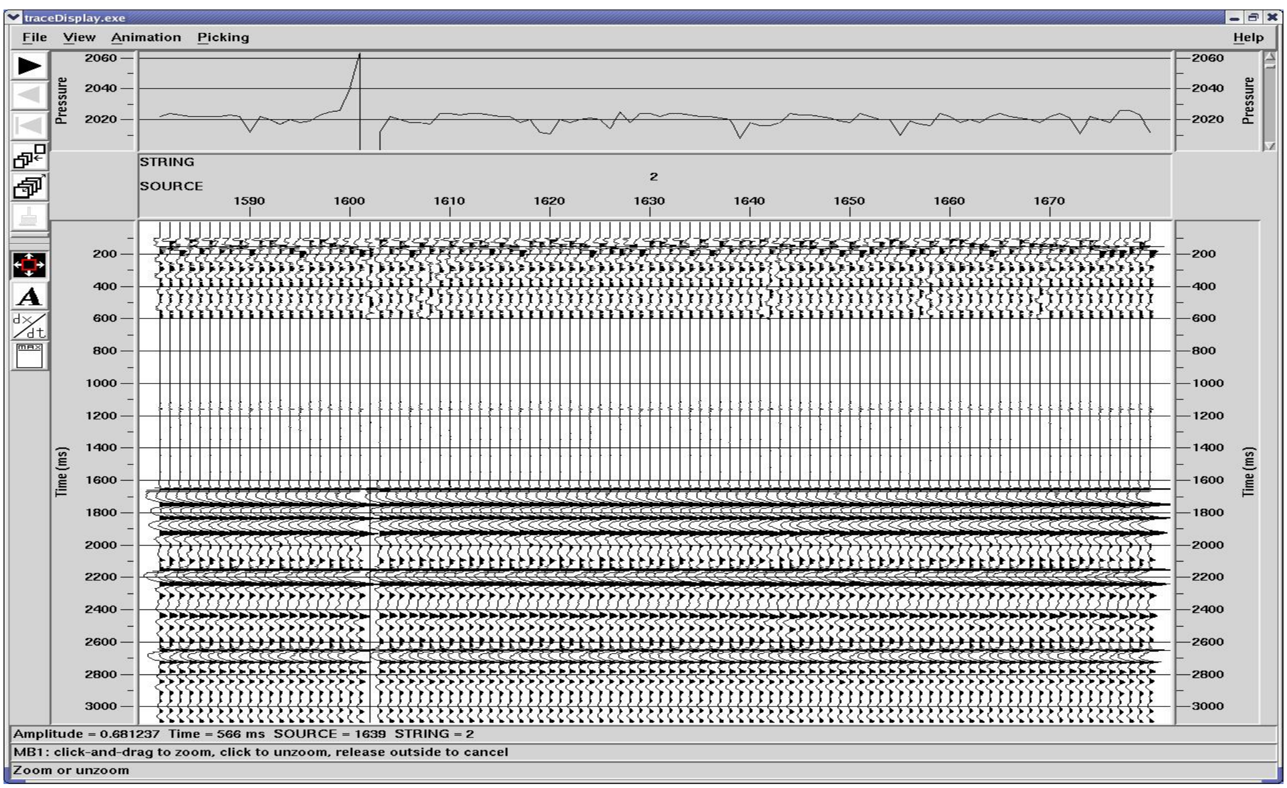

Figure 21-15: QC of vertically stacked near field hydrophones 1 to 6 on gunstring 2 (Auxiliary channels 19 to 24). Note annotation of gun pressures, dead hydrophones 2 and 3 and missed SP 1602.

21.12. Shot Record Displays

Shot records were band pass filtered (Ormsby 6-8-90-120) and balanced with a true amplitude gain recovery. They were displayed every 500m for each line.

Additional records were also examined on screen if an issue with acquisition was suspected, such as noise, residual seismic energy or auto-fires. The colour RMS displays were frequently used to pinpoint bad/suspicious shots, the shot gathers of which were subsequently investigated onscreen.

Consistently noisy channels were also identified on the raw shot displays, and cross checked against the Observer Logs, which were modified if necessary.

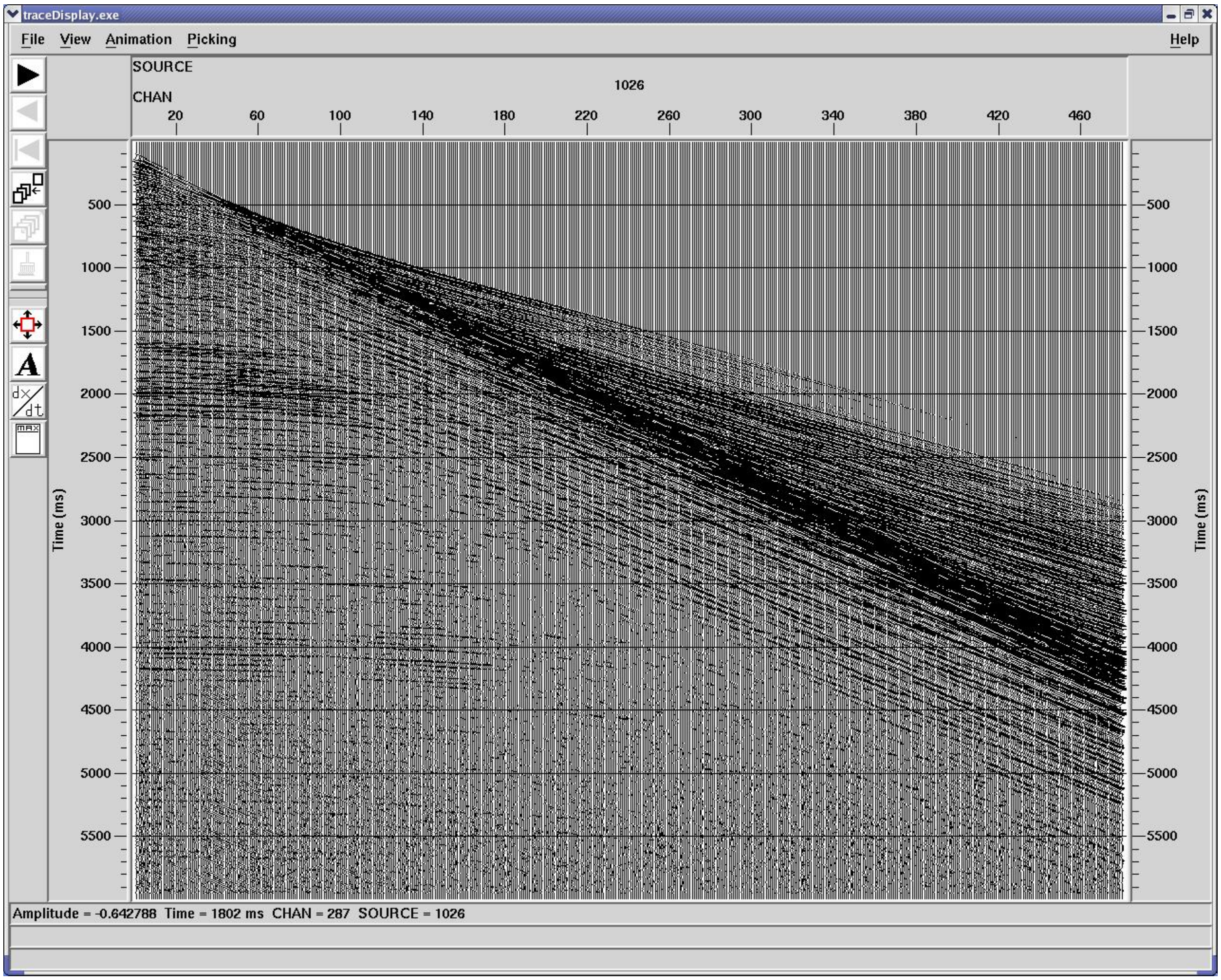

Figure 21-16: Raw shots display on SP 1026 of sequence 028. Note "mudroll", "ringing" and refraction multiples on the longer offsets.

21.13. Navigation Processing

In order to QC the navigation data, the final processed P190 navigation files were merged with the near traces for each line. The predicted first break time was computed using the water velocity. This was displayed overlaid on the near trace as seen below (in red), to enable QC of the consistency between the predicted and the recorded first breaks.

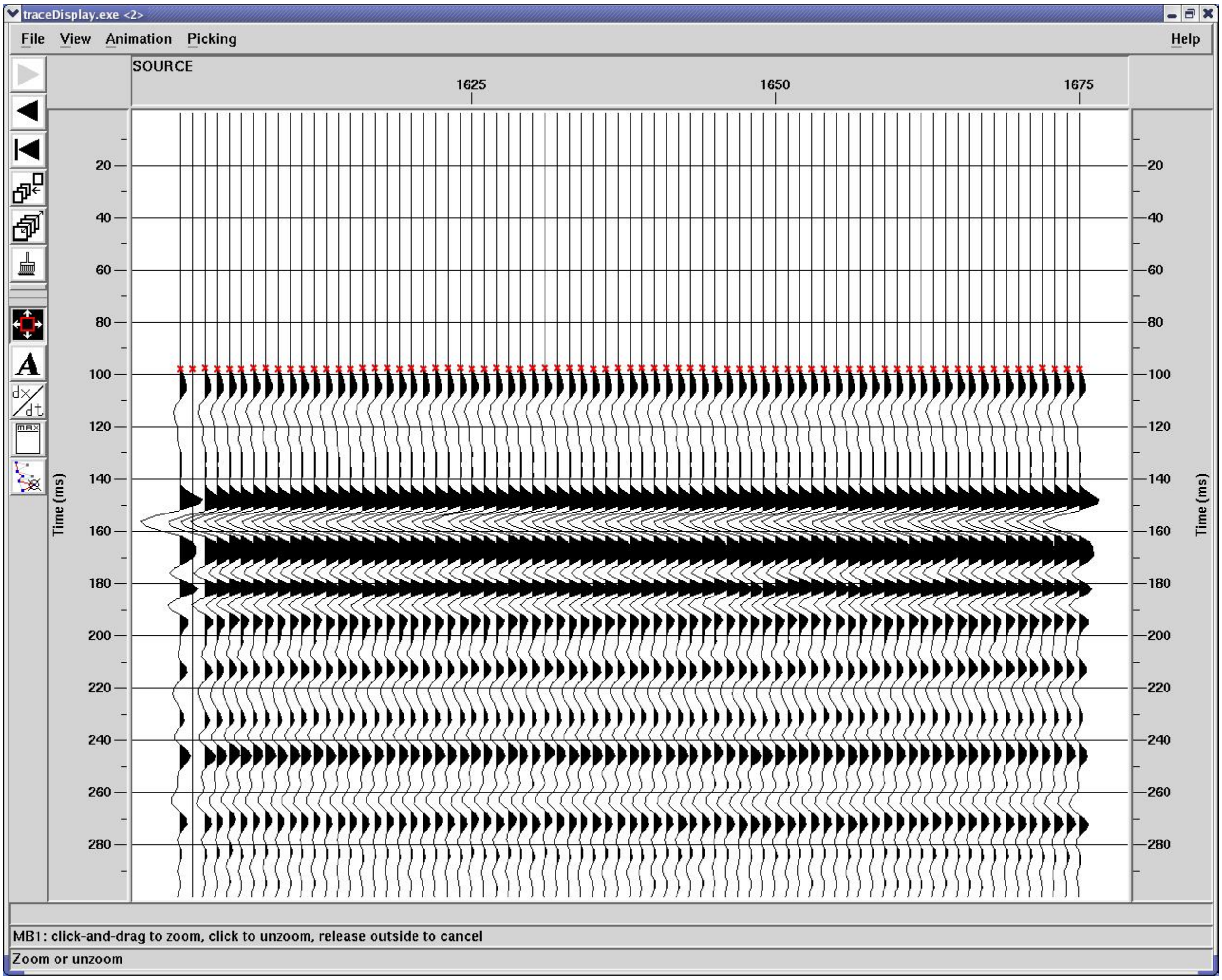

Figure 21-17: Navigation QC display.