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1 Onboard Processing Personnel and System

Operators

Senior Processing Geophysicist

08th – 26th November 2004	:	Emma Buckingham	Multiwave

Hardware Description

1 x IBM machine, Xeon 2x3.0GHz

Machines	:	1 x SGI Octane Workstation
Monitors	:	2 x 21" LCD Monitor
Hard Disk Drives	:	1 TB External Disk
Tape Drives	:	2 x IBM 3590 tape drives
Plotters	:	1 x Isys V24 24" Thermal Plotter

Software Description

Processing software	:	ProMAX2D version 2003.3.2
Operating System	:	IRIX 6.5
Plotting software	:	ZehPlot Express 4.4

2 Objectives

2.1 Geophysical Objectives & Reference Parameters

The objective of the survey was to acquire approximately 973 line Km's of 2D seismic data in the Otway Basin, Victoria.

2.1.1 Processing Objectives

The main objective of the onboard QC processing was to assess the impact of noise in the data, to check for problems associated with acquisition and recording on a line-by-line basis and 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 to be 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 a shore or vessel based processing centre. A brute stack was produced 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. Raw shot, near trace and various RMS displays were also generated and examined to identify any noise problems.

3 Processing Sequence

3.1 Parameter Testing

Due to the high production rates expected and short survey duration, parameter testing was kept to a minimum in order that there was little time lag between production and final QC. Parameter testing was therefore limited to checking suitability of the parameters on the first sequence, along with post stack scaling for the displays.

3.2 Main Seismic Processing Parameters

Upon completion of a line, the primary SegD tape was read to confirm the integrity of the tape and to write the data to disk onto the ProMAX system. A listing of the field file (FFID) and shot point (SP) numbers was printed to clearly identify any lost shots or shots with missing navigation headers. All data, including start and end-of line noise files and auxiliary channels (-1 to –21), were input to a record length of 8000ms. An instrument delay of 50ms was applied to the data during acquisition and this was removed using a bulk shift static correction on the data.

A simple 2D geometry was merged with all the seismic trace data and offset/CDP binning calculations loaded into the seismic trace headers, before the process of 2:1 summation.

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 2:1 trace summation after differential NMO, which increased the receiver spacing from 12.5 to 25 metres. A regional velocity function was used for differential NMO prior to trace sum.

Trace editing involved killing any bad traces or shots based on Observer’s logs comments, and the results obtained during ProMAX QC analysis.

To balance the shot records, true amplitude recovery using a spherical divergence correction was used and applied to the whole shot record.

3.3 Velocity Work

A regional velocity function was available from a previous survey in the same area; this was used as an initial guide function to aid in early velocity scans.

Velocities were picked for every line at a 4 km interval using ProMAX's interactive velocity analysis package. This comprised of a semblance display with interval velocity graph, CDP super gather and a series of function stack panels. To improve the signal to noise ratio, super gathers were formed by combining fifteen adjacent CDP gathers. Stack panels were created from these 15 CDP's using 15 functions varying +/- 25% from the regional velocity function.

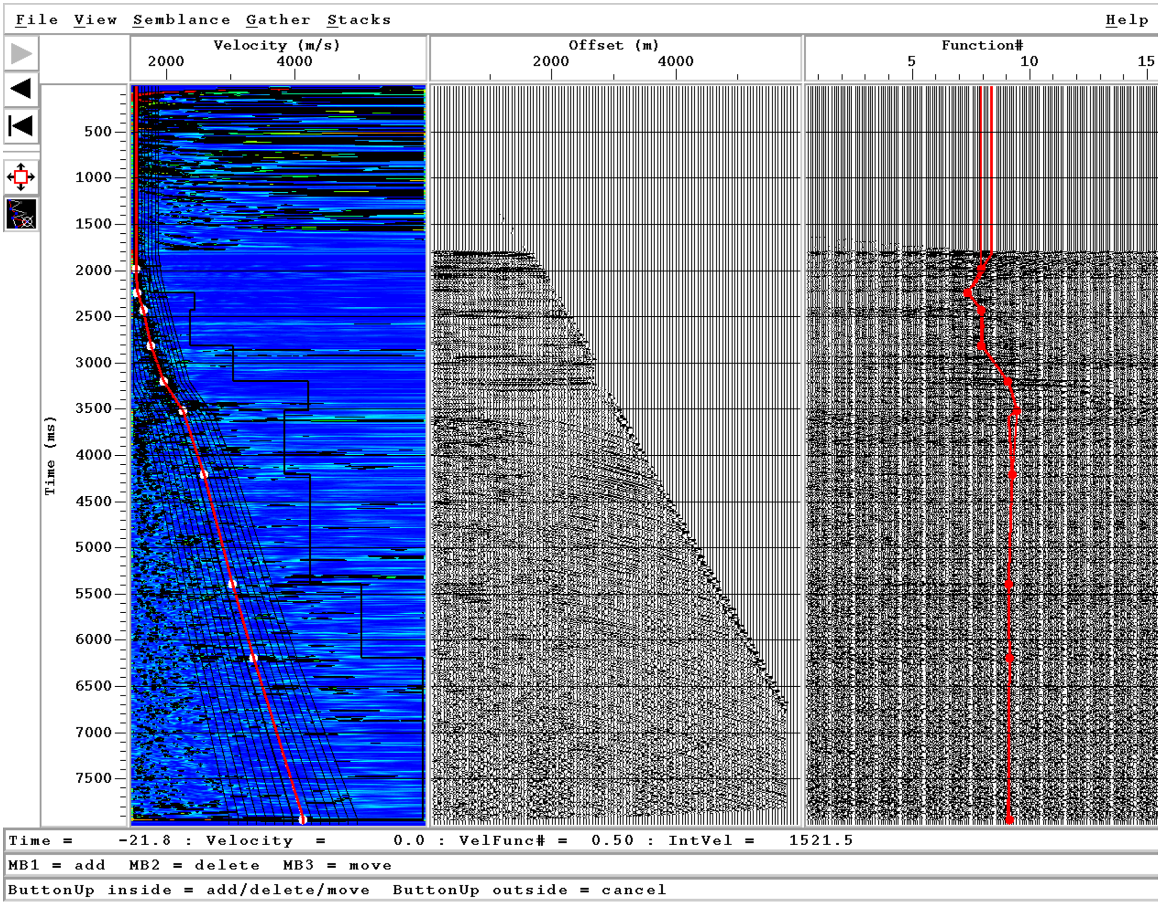

Figure 1 Velocity analysis interface with semblance, super-cdp gather and function stacks (orange - previous, red - present, yellow - next pick).

Velocities were picked using a two and three pass process due to the large variations in water bottom depth. The first pass was to pick an approximate velocity function which was input to the second pass as a central function for the stack functions.

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.

Velocities were mainly picked off the function stacks due to there being a large percentage of multiples and reverberations affecting the semblance display.

After velocity picking, velocities were viewed and QC'd on screen using the ProMAX velocity viewer module, which provided an iso-velocity display together with interval velocities. This module was most useful for editing any stray velocity picks. NMO corrected gathers were also displayed on screen both at and between velocity locations for further verification.

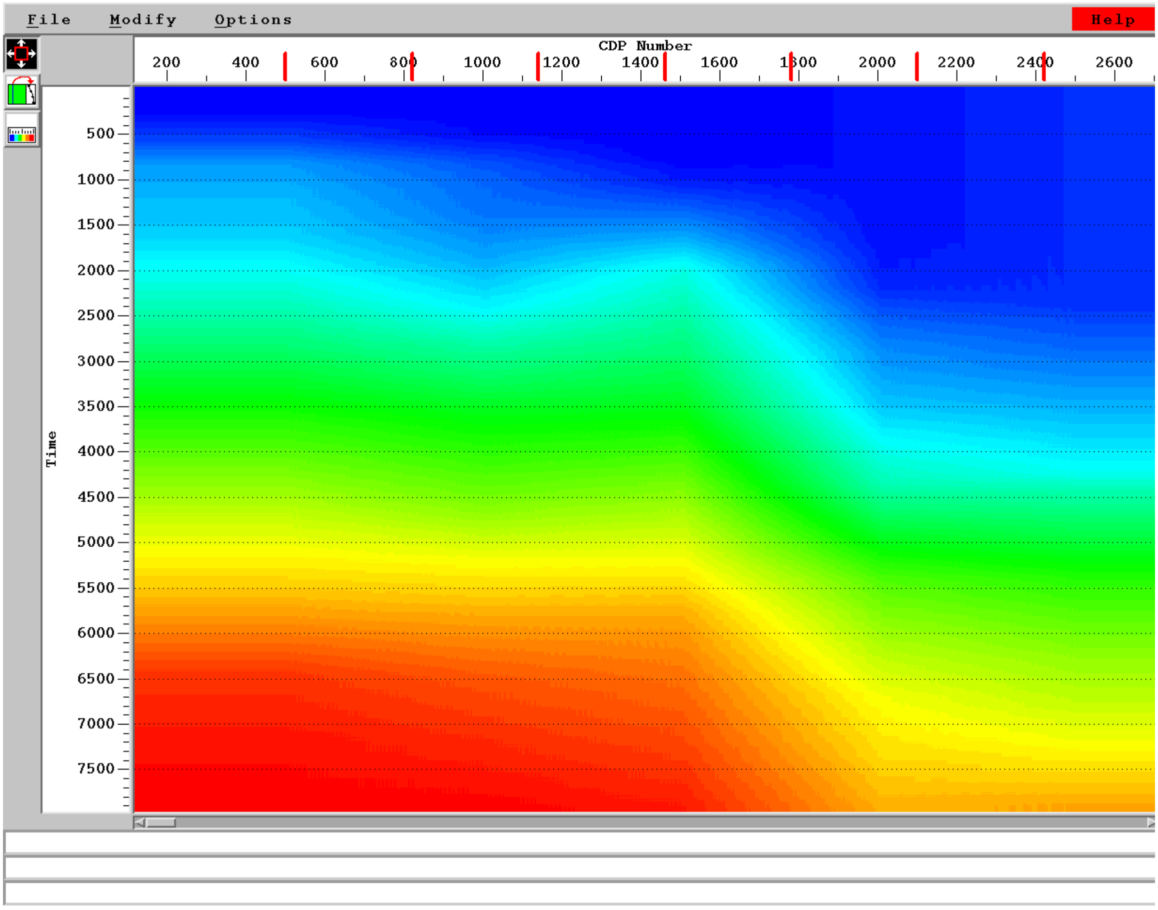

Figure 2 Iso-velocity display in ProMax velocity viewer

3.3.1 CDP Gather Displays

Gathers were regularly displayed on screen at 1 kilometre intervals to QC the velocities after NMO correction and ascertain the impact of swell noise and cable impacts on the pre-stack data. The CDP gathers were NMO corrected using the picked RMS stacking velocities, and an NMO stretch mute was picked and then applied for every line independently

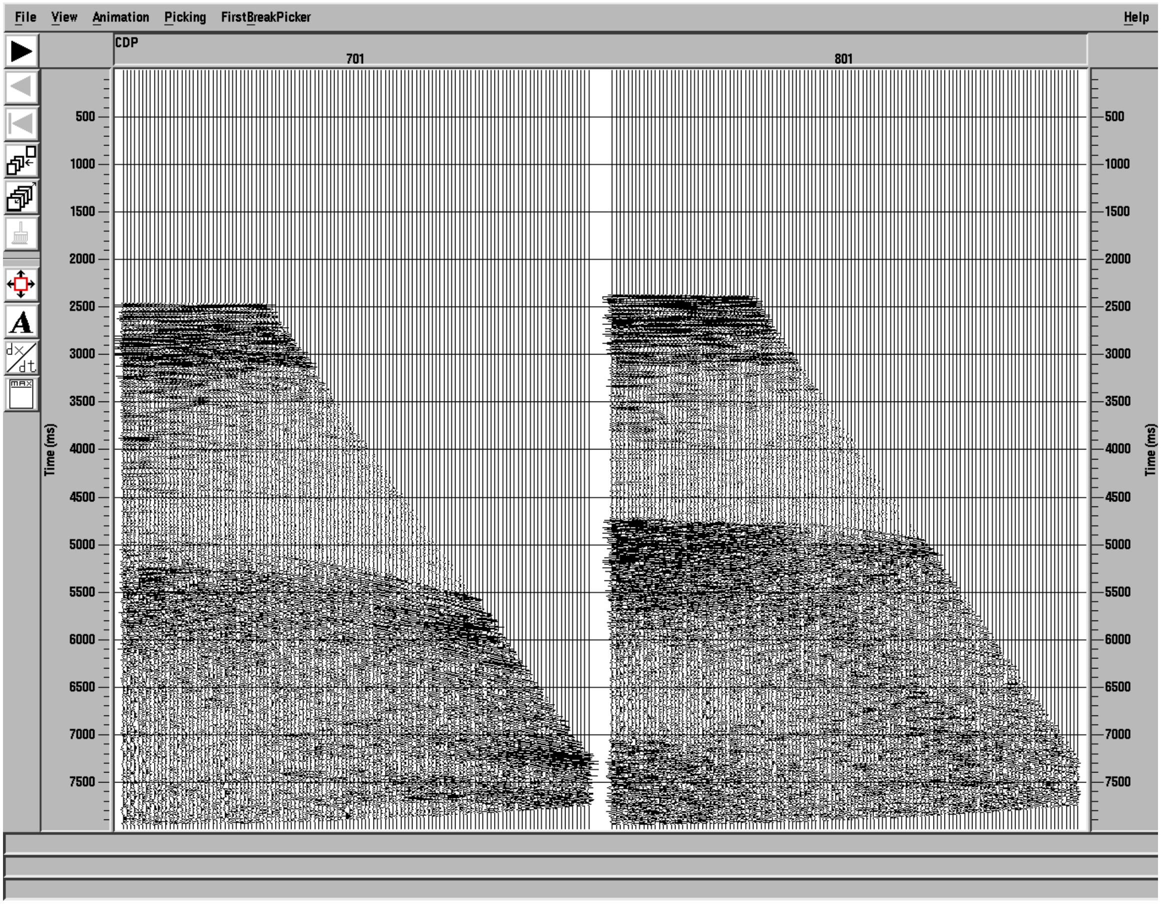

Figure 3 CDP gather to confirm the velocity picks.

3.3.2 CDP Stack

A straight mean vertical stack algorithm was used for CDP stacking, with a root power scalar for normalization of 0.5.

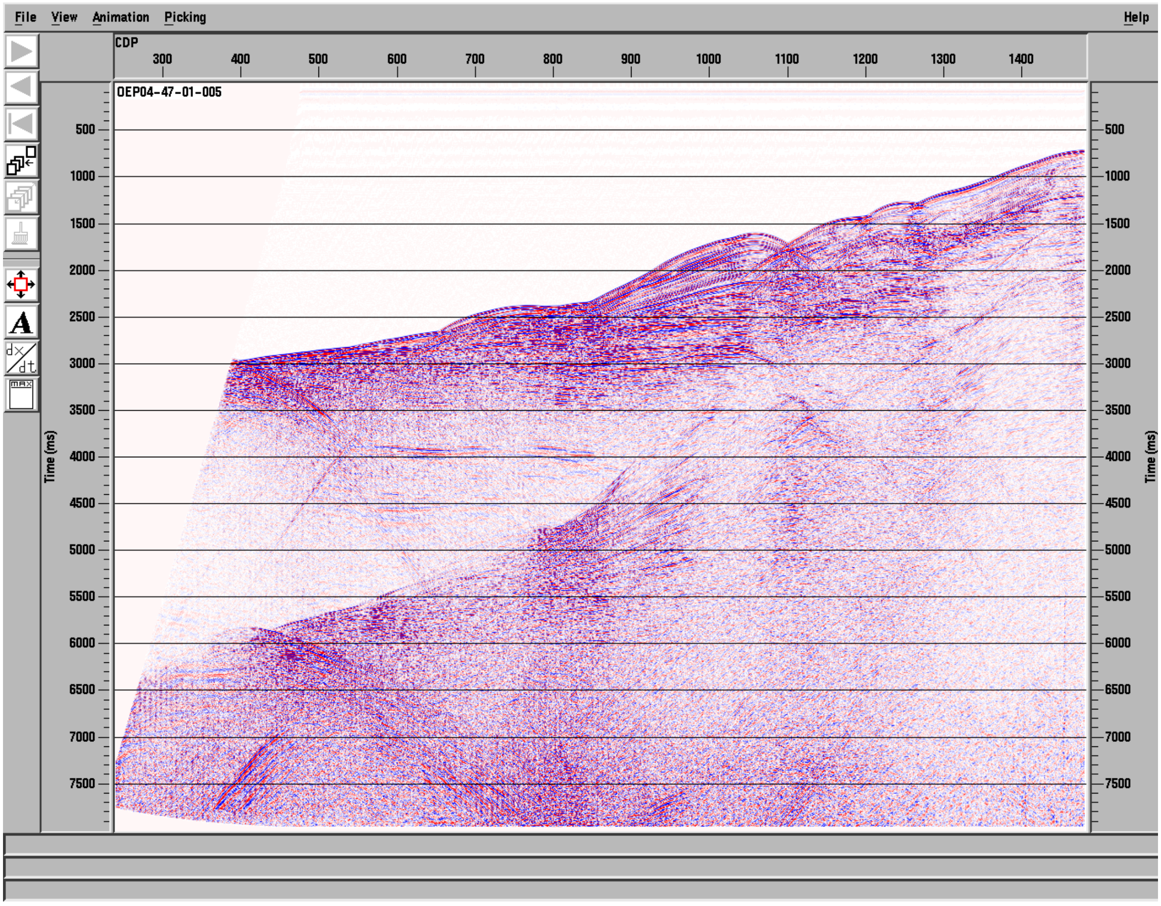

Figure 4 Brute stack

A bulk shift static correction was applied to the data after stack to correct for the gun and cable depths. Filtering was limited to a 3-90 Hz broadband filter. Since amplitudes appeared well-balanced, scaling was limited to overall scaling for the plots.

Stacks were then output to disk. All brute stacks were written to 3590 tapes in SEG-Y format for delivery to Essential Oil. The brute stack headers contain all relevant SP and CDP information.

3.4 Processing Flow & Quality Control

3.4.1 Quality Control of Processing Steps

At every stage of the processing sequence the data was QC'd on screen to ensure that there were no problems. RMS analyses were also used to check for noisy or spiking channels. The final QC involved close examination of the brute stack.

Processing Flow Chart

SEG-D Input From Tape
Resample / Desample From 2 ms to 4 ms. Hi-Fi anti-alias filter applied in module
Reformat to ProMAX internal format Input 8000ms, 480 channels + 21 auxiliary channels
↓ ——→ **Noise Record** Start and end of line, ambient rms
↓
↓ ——→ Shot Vs Chan Colour RMS Analysis Window 7500-8000ms
↓ ——→ SCREEN DISPLAY + GIF FILE
↓ ——→ **Auxiliary Channel QC** On screen QC. Aux channels 1-21
↓ ——→ Near Trace Display On screen QC
↓ ——→ Merge with P190 All 480 channels
↓ ——→ **Seismic / Nav Merge QC** On screen QC.Chan1v's predicted arrival
Marine Trace Decimation 2:1 summation using differential NMO
2D Marine Geometry 2D Geometry to trace headers
Bulk Shift Static -50ms for instrument filter delay
↓
↓ ——→ **Raw Shots Display** Every 2 km, 8000 ms, 480 channels
↓ ——→ ON SCREEN QC DISPLAY
Trace / Shot Kill Edits based on Observer's Logs
Band-pass Filter Ormsby, Minimum Phase, 3-6-90-120 Hz
True Amplitude Recovery Spherical Divergence 1/ t^*V^2 using picked velocity
↓ 2 dB/sec from water bottom to 8000 ms
Band-pass Filter Ormsby, Minimum Phase, 3-6-90-120 Hz
↓ ——→ **Velocity Analysis** Every 4 km, Semblance, Gathers, Function Stack
↓ ——→ **<u>ASCII FILE</u>**
Normal Move-out Correction
↓ ——→ **NMO Corrected Gathers** Every 1 km, 8000 ms
↓ ——→ ON SCREEN QC DISPLAY
NMO Stretch Mute Top mute picked from CDP gathers
CDP / Ensemble Stack Mean, Root power scalar for normalization 0.5
Gun and Cable Static
↓ ——→ **Plot Brute Stack** 8000ms, No Scaling
↓ ——→ BRUTE STACK to SEG-Y TAPE

3.5 Acquisition QC Processing

3.5.1 Noise Record RMS

Noise records were displayed for the start and end of line noise records for QC. RMS values were computed for all 480 channels over the entire record for noise analysis.

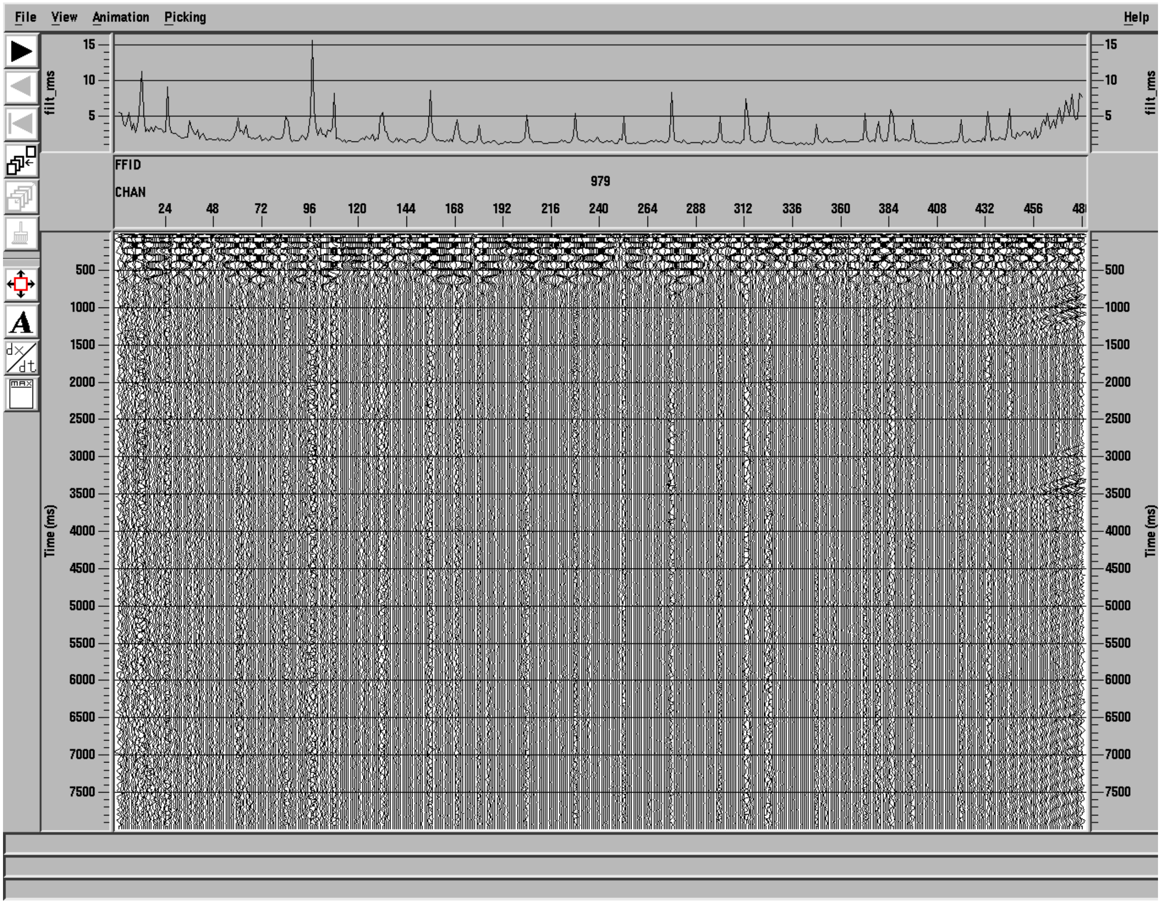

Figure 5. Noise record

3.5.2 Shot Versus Channel Colour RMS Amplitude Display

Colour displays of shot vs. channel RMS values were produced for every line. Raw data with a sample rate of 2 ms was used to calculate the RMS values for every channel on every shot. A window of 7500-8000ms was used.

The colour RMS displays were viewed on screen, and the screen images were then saved as GIF files. The displays were extremely useful in showing noise trends along the line such as bad channels, bird noise, cable tug, front end noise, cable strikes, swell noise contamination, auto-fire and misfires, multiple interference, etc. The on screen analysis also allowed the exact shot and channel location of any noise trend to be located and investigated.

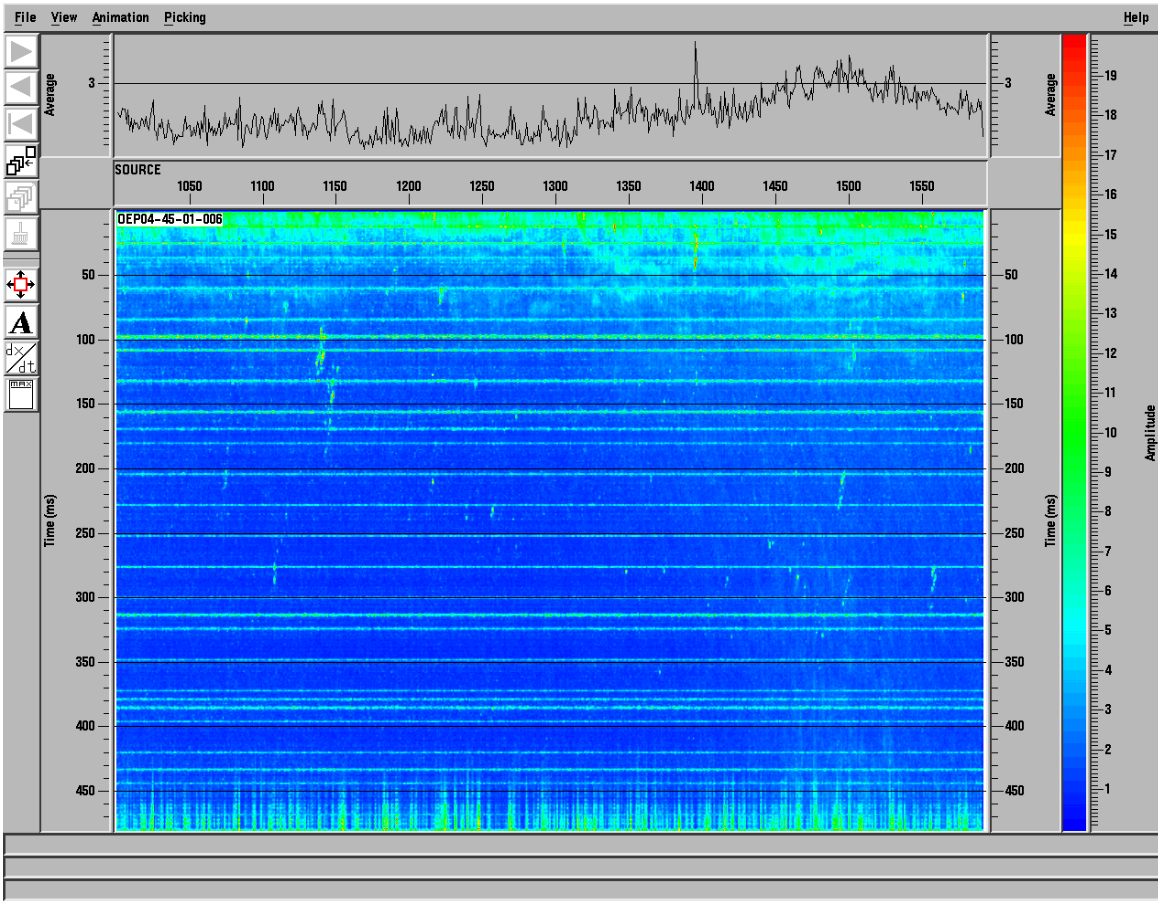

Figure 6. Ambient Noise – shot v's channel colour RMS Amplitude display. Example above of a quiet line (seq. 005)

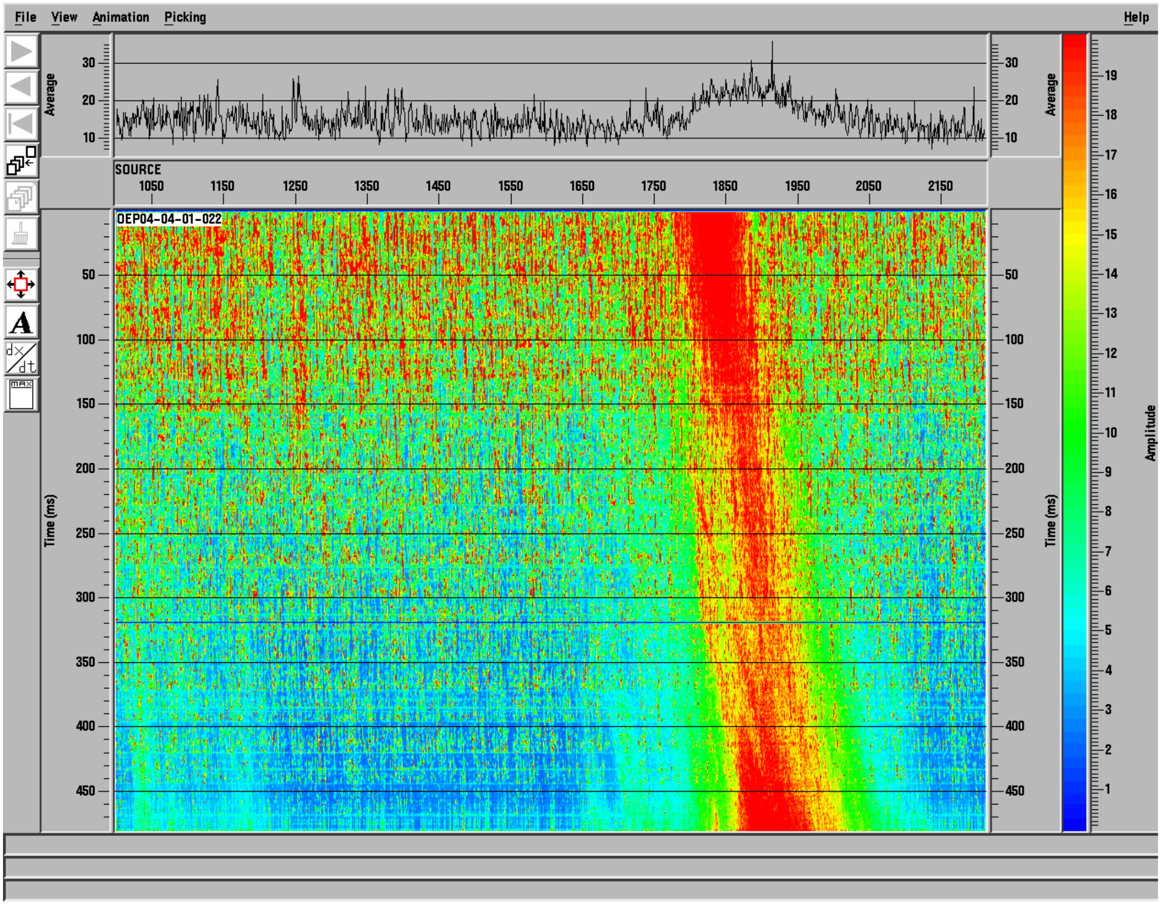

Figure 7. Ambient Noise – shot v's channel colour RMS Amplitude display. Example above of a noisy line (seq. 022)

The RMS amplitude maps were kept on disk throughout the survey and a library was built up. To investigate noise problems the colour displays from each sequence were displayed side by side. In this way it was possible to compare whether one line was noisier than the other, and identify any swell noise increases or cable deterioration. This also proved to be an extremely useful method for QC'ing any dead, noisy or spiking channels from line to line.

For all RMS computations a scaling factor of 57.1 was used to convert from millivolts to microbars.

The deep window often contained high levels of deep water multiples and reverberation energy.
A further final display was created from the RMS data: RMS HISTORY DISPLAY (Appendix 5.1)
Showing the line average RMS for each individual channel for all sequences.

3.5.3 Near Trace Display

Near traces were displayed on screen routinely at the end of each line. This proved useful in quickly determining any possible errors with acquisition. They revealed gun volume changes, bad records, time-break problems and any auto-fire 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, remnant multiple interference and swell noise contamination.

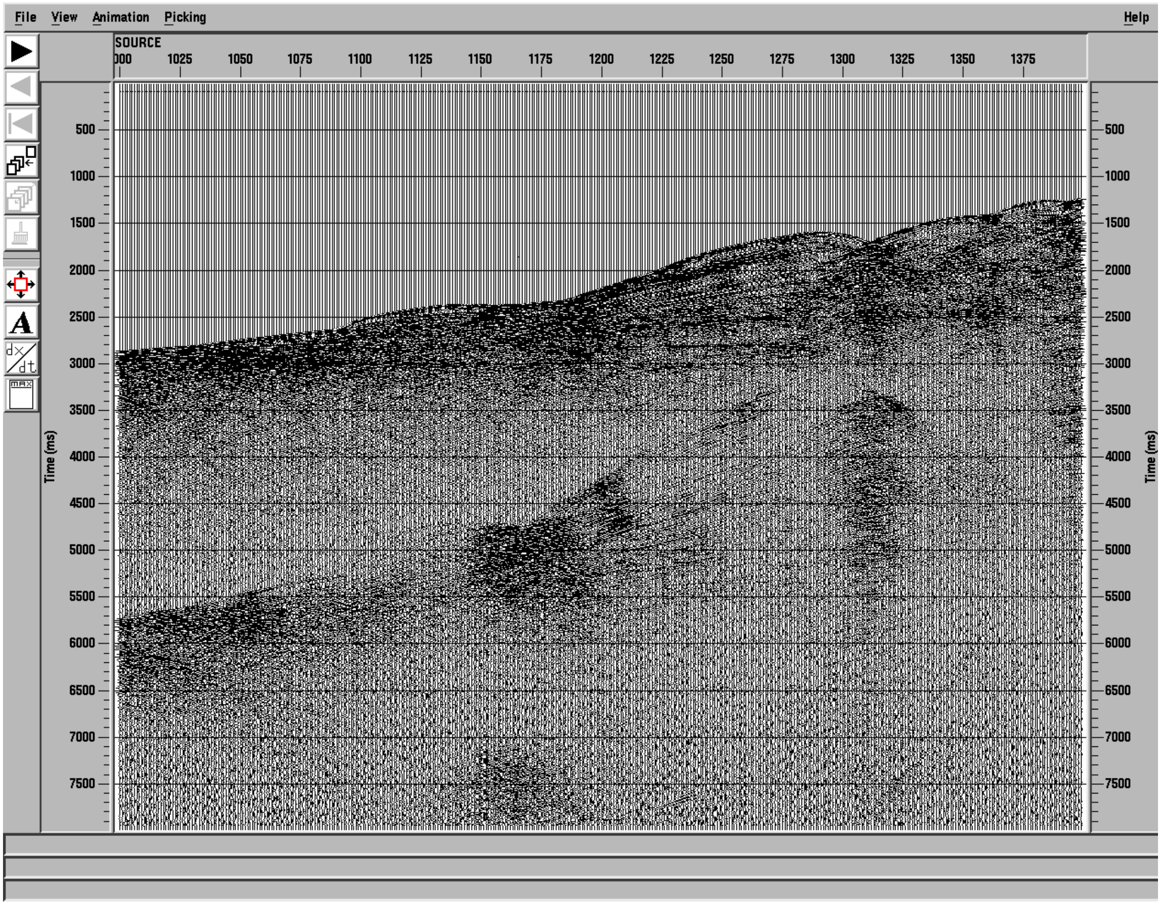

Figure 8. Near Trace display.

The near trace files were kept on disk and were available for further analysis if necessary.

3.5.4 Auxiliary Channel QC

The auxiliary channels loaded during the SEG-D read were separated from the data channels and stored in a separate data file, which was used for on screen analysis. These records consisted of the time break, the water break hydrophone, and near-field hydrophones for the three sub-arrays.

Time break and water break channels were displayed as a single trace display on screen.

Each gun hydrophone was also displayed as a single trace on screen. Additionally, the first 500ms of the 3 hydrophones from a single sub-array were stacked vertically and displayed. This proved extremely useful in determining whether spurious signals were genuine gun timing problems or just electrical noise on the signal.

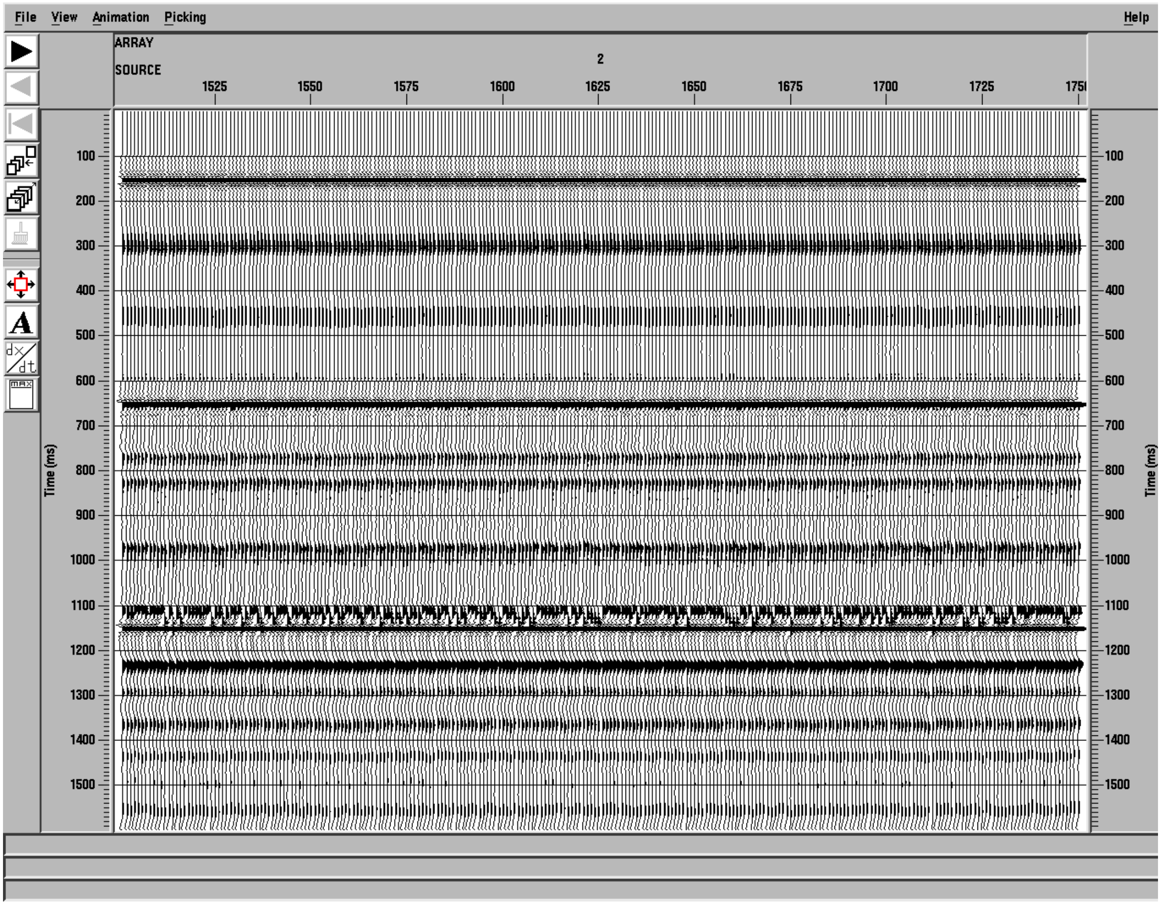

Figure 9. Auxillairy QC Display

3.5.5 Shot Record Displays

Shot records were filtered to the signal bandwidth and balanced with a true amplitude gain recovery. They were displayed on screen at 1 km intervals for each line. Individual records were examined on screen if there was felt to be a problem with acquisition, or to investigate the source of anomalous seismic energy. The colour RMS displays were frequently used to pinpoint bad shots, and these could be investigated on screen.

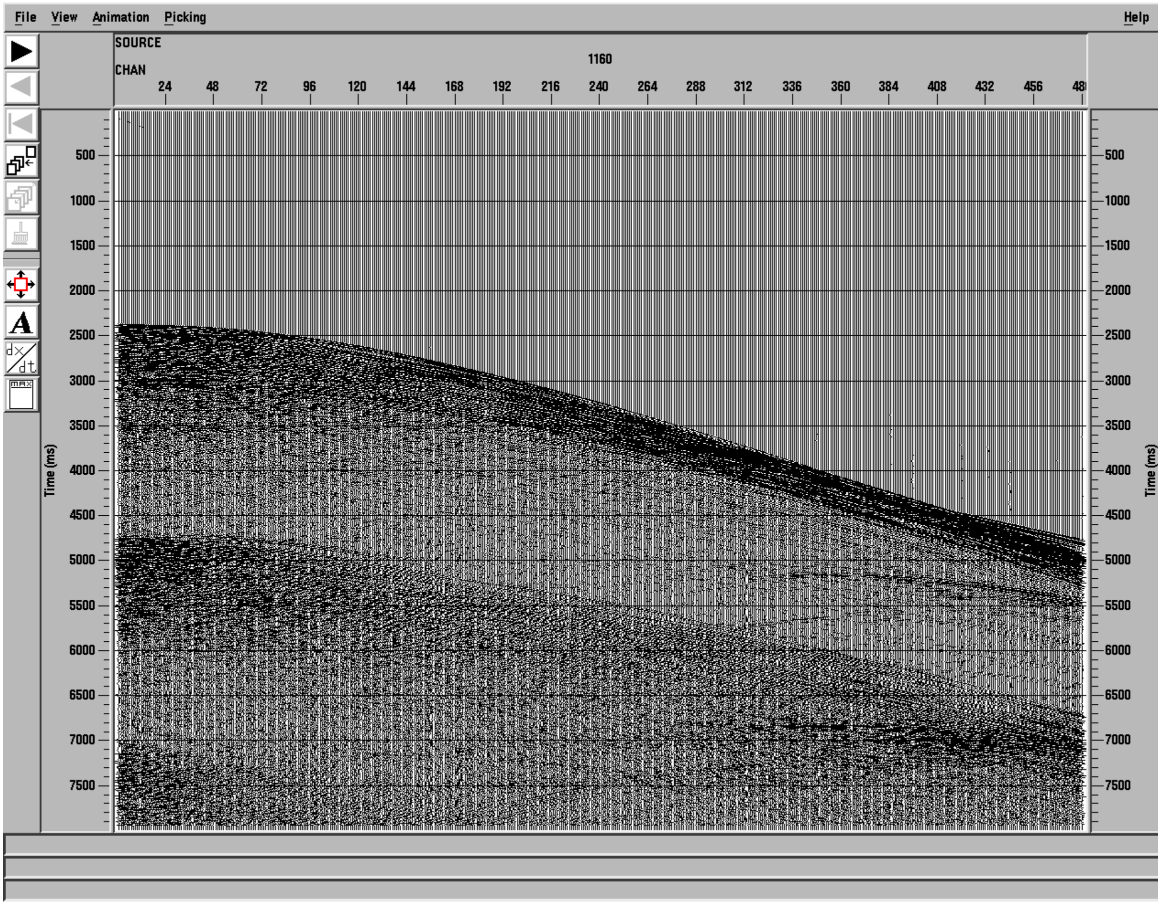

Figure 10. Shot Gather Display

The raw shot displays could also be used to estimate the amplitude and amount of any external noise on the shot records prior to further processing. Consistently noisy channels were also identified on the raw shot displays, and any edited channels on the observer's logs were verified.

3.5.6 Additional QC Displays

Spectral analysis displays were generated for occasional lines to evaluate the power and frequency content of the data and noise. FK plots and FT displays were also occasionally displayed.

3.6 Navigation Processing

In order to QC navigation data, the final processed P190 was merged with the near trace for each line. The theoretical first break time was then computed and overlaid on the near trace as seen below.

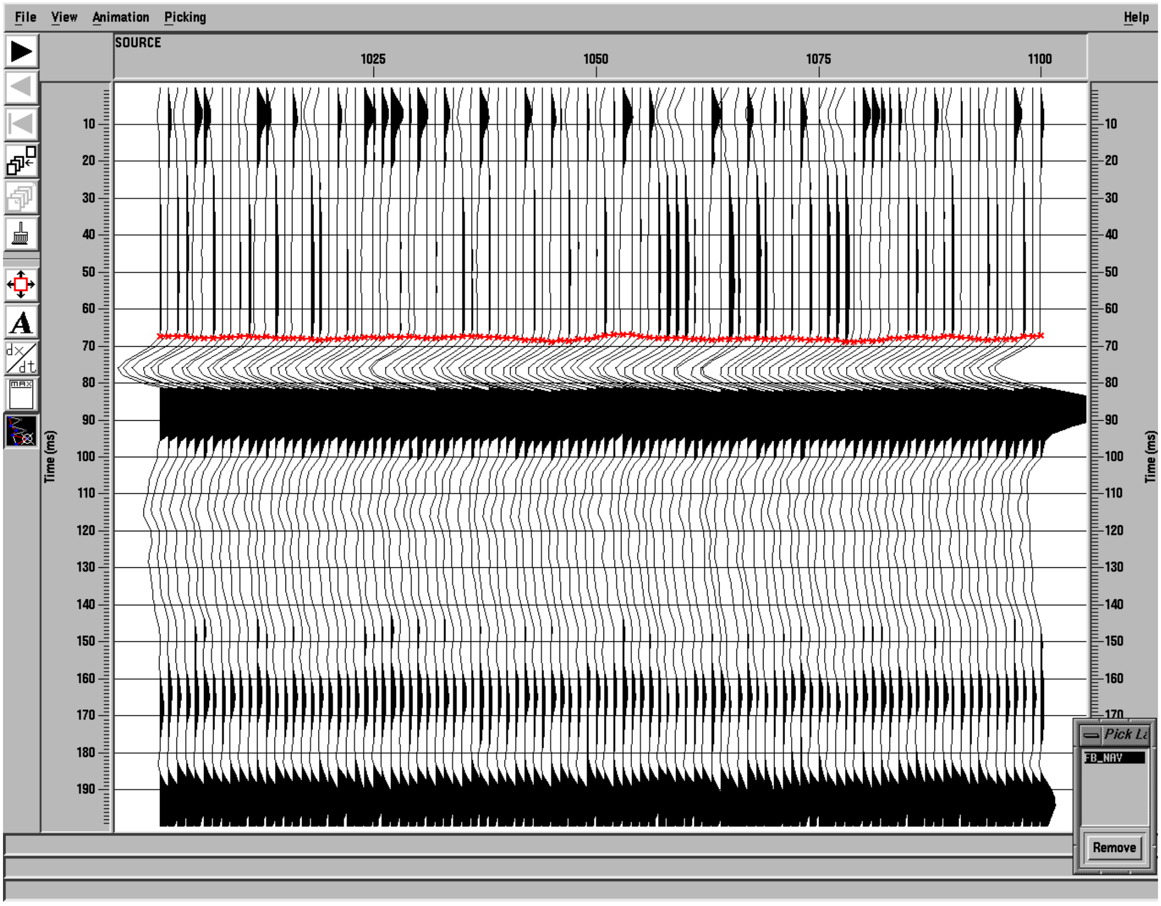

Figure 11. Navigation QC, checking the consistency between first breaks and navigation derived first breaks (red).

For the navigation-derived first break calculation a water velocity of 1508ms^{-1} was used. This being the value recorded by the TS-dip measurement

4 Summary

Throughout the survey, bad weather hampered production. On the best days, data quality was uniformly good and average noise levels were consistently of around 4-6 µbar, however most lines were still deemed acceptable with average noise levels over 12uB. The stacks of these noisier lines were surprisingly good with swell noise generally only visible below 3 seconds even for the worst cases. All brute stacks showed good data quality and contained high amounts of reverberations, strong diffractions and deep water multiples.

For sequences 031 to 032 ships noise was evident, though of minimal amplitude and showed not to have any significant impact on the quality of data. Other outside noise included sequence 004, selected shots were contaminated with down hole seismic interference from an adjacent rig.

Whale sightings within a 3km radius were to result in NTBP of 2 lines and sequences 007,038 and 043 to be terminated early. Selected shots from sequence 009 showed external noise recorded through the water column of approx 50 Hz, thought to originate from whales pinging.

A complete list of all lines is included in Appendix 5.2.

For sequences 001 to 012 the inline offset was 104m. This was changed to 114m for sequences 013 to 046 for better towing arrangement.

5 Appendices

5.1 RMS History Display

The following display shows the line average RMS for each individual channel for all sequences, calculated from RMS window 7500-8000 ms.

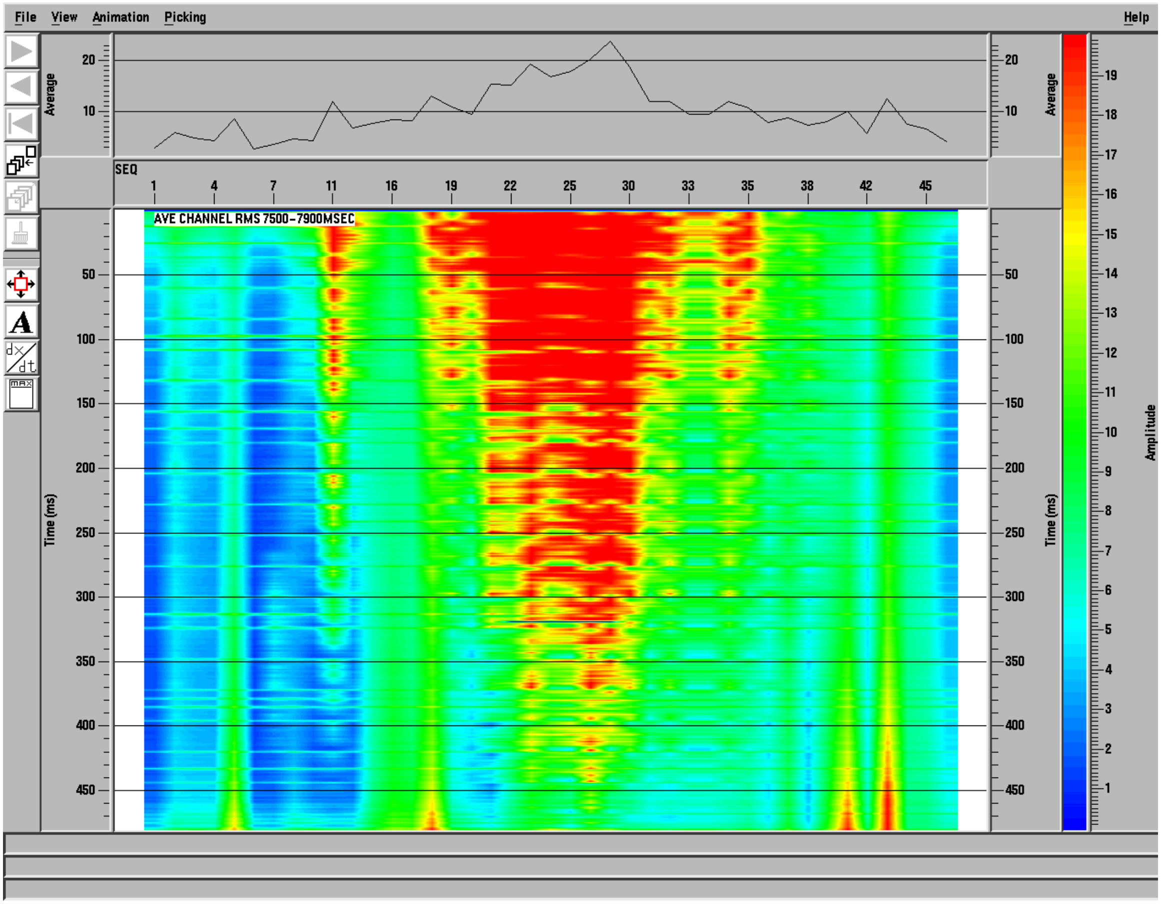

Figure 12. Final sequence vs. channel RMS display. A good tool for comparing noise levels sequence-to-sequence and identifying faulty channels.

5.2 ProMAX QC Log

Sequence	Line	Heading (°)	Date acquired	DATA QUALITY
1	26-01	129	11/09/2004	Ave shot RMS 3ub. Tail end noise evident on last 20 channels. Good stack, increased noise towards EOL d/t rig reflections.
2	59-01	211	11/10/2004	Ave shot RMS 5ub, peak rms of 20ub. Swell noise throughout line, below 4secs on stack. High diffractions and deep water multiples seen in RMS.
3	51-01	030	11/10/2004	Ave shot RMS 4ub. High RMS amplitudes d/t deep water multiples. Occasional swell bursts. Cable impacts sp: 1128 + 1316. Sp; 2760 down hole seismic.
4	57-01	211	11/10/2004	Swell noise throughout line seen on stack. Numerous shots affected by down hole seismic. SI seen from rig. Ave rms 4ub.
5	47-01	030	11/10/2004	Ave shot RMS 8ub. Good stack. Cable impact sp: 1169
6	45-01	030	11/10/2004	Ave shot RMS 2.5ub. Clean data, good stack. Some tail end noise seen
7	53-01	210	11/11/2004	Ave shot RMS 3ub. Swell noise seen on stack below 6 secs. SOL-1150 tail end of streamer still in turn causing noise.
8	53-02		NTBP	NTBP: Line stopped due to whale sighting
9	55-01	211	11/11/2004	Ave shot rms 4ub. Well head reflections SOL in stack. Occasional shots showing noise of whale pinging. Deep water multiples seen in stack as high rms amps.
10	49-01	031	11/11/2004	Ave rms 5ub, max of 10ub. AN increase in swell noise throughout line. Seen in stack below 4secs. High amp refractions seen in stack at EOL.
11	53-03		NTBP	NTBP: Line stopped due to whale sighting
12	43-01	030	11/11/2004	Ave shot RMS 11ub. High percentage of swell noise, seen below 3 secs in stack for whole of line. Max rms of 27ub.
13	53-04		NTBP	NTBP: Line terminated on run-in d/t collapsed door
14	02-01	301	11/16/04	Ave shot RMS 10ub for SOL-1950, 4ub for sp1950-EOL d/t decrease in swell. Swell seen in stack below 4 secs.
15	06-01	128	11/16/04	Ave shot rms 7ub. Occasional swell bursts seen in rms at front end of streamer. Good stack, with strong deep water bottom multiples.
16	10-01	313	11/16/04	Ave shot rms 8ub. Occasional cable impacts through out line. Overall background increase of rms d/t weather conditions. Stack contains strong diffractions and deep water bottom multiples.
17	08-01	133	11/16/04	Ave shot RMS 8ub. Good clean stack. Cable impact sp: 2015
18	41-01	006	11/16/04	Ave shot RMS 12ub. Occasional swell bursts throughout line. Seen in stack below 4 secs. Deep water multiples in stack.
19	31-01	211	11/17/04	Ave shot RMS 10ub. Swell noise increase. Seen in stack below 3secs. Stack ok. Cable impact sp: 1973
20	39-01	031	11/17/04	Ave shot RMS 9ub. Swell bursts seen on stack below 3 secs. Stack ok. Cable impacts.
21	53-05	210	11/18/04	Ave shot RMS 15ub. Increase in swell conditions. Max RMS 30ub. Swell seen on stack below 2.5 secs.
22	04-01	301	11/20/04	Ave shot RMS 15ub. Deep water multiples seen on stack and RMS. Swell bursts on stack below 3 secs. Chan 319 dead.
23	29-01	210	11/21/04	Ave shot RMS 19ub. Increase in swell. Deep water multiples on stack. Swell bursts below 4 secs on stack. Max RMS 34ub. Chan 319 dead.
24	37-01	030	11/21/04	Ave shot RMS 16ub. Swell bursts throughout stack, seen below 2 secs.
25	43-02	030	11/21/04	Ave shot RMS 18ub. Increase in swell, seen in stack below 2.5 secs.

26	33-01	211	11/21/04	Ave shot RMS 20ub. Swell below 2.5 secs in stack. Signal to noise ratio decreasing. Max RMS 40ub.
27	21-01	030	11/21/04	Ave shot RMS 24ub. Increase in swell. Max RMS 48ub. Swell below 1.5-2 secs on stack.
28	15-01		NTBP	NTBP d/t excessive swell noise
29	15-02		NTBP	NTBP d/t streamer tripped and would not reset after first few shots.
30	15-03	211	11/23/04	Ave shot RMS 18ub. Poor signal to noise ratio in shallow. Swell below 3 secs in stack.
31	19-01	211	11/23/04	Ave shot RMS 12ub. Ships noise in stack, sp 2370-2456, seen in stack below 6 secs. Swell bursts below 3 secs in stack.
32	27-01	211	11/23/04	Ave shot RMS 12ub. Swell bursts below 3 secs in stack. Deep water multiples, diffractions and reverberations seen in stack.
33	35-01	031	11/23/04	Ave shot RMS 9ub. Strong diffractions at SOL. Occasional swell bursts in stack below 3 secs.
34	25-01	211	11/24/04	Ave shot RMS 12ub. Reverberations and strong deep water multiples in stack. Swell noise below 3 secs in stack.
35	17-01	031	11/24/04	Ave shot RMS 10ub. Decrease in swell noise. Bursts below 4secs. Strong diffraction in stack.
36	23-01	211	11/24/04	Ave shot RMS 8ub. Decrease in swell noise. Occasional bursts below 4 secs in stack.
37	07-01	031	11/24/04	Ave shot RMS 8ub. Strong multiples and diffractions in rms and stack. Swell below 4 secs in stack.
38	13-01	211	11/25/04	Ave shot RMS 7ub. Good stack. Swell below 4 secs. Strong reverberations evident.
39	03-01		NTBP	NTBP d/t stopped early for missing shots and low air pressure
40	13-02	211	11/25/04	Ave shot RMS 8ub. Strong multiples and diffractions. Good stack. No swell seen.
41	05-01	031	11/25/04	Ave shot RMS 9ub. No swell evident on stack. Good clean stack.
42	11-01	211	11/25/04	Ave shot RMS 5ub. Random swell bursts in shallow water of stack below 4 secs. High energy deep water multiples.
43	03-02	024	11/26/04	Ave shot RMS 12ub. Good clean stack. No swell seen.
44	09-01	211	11/26/04	Ave shot RMS 7ub. Good clean stack. No swell seen. Strong diffractions present.
45	01-01	025	11/26/04	Ave shot RMS 6ub. Good clean stack. No swell seen. Strong diffractions present.
46	03-03	024	11/26/04	Ave shot RMS 4ub. Good clean stack.

5.3 Shipments

The Processing Data was enclosed in shipment:

Proforma Invoice & Packing List PT-2004-058 dated 04-12-2004 - Sent off on 05-12-2004.

To:

CGG Australia Services Pty Ltd
First Floor, 2 Ord Street
West Perth, WA, 6005
Australia

Consisting:

Brute stack paper plots, Sequences 001-046
CDROM containing RMS GIFs, Brute Stack GIFs for Sequences 001-046, ASCII file velocities and processing spreadsheet.
1 x 3590 cartridge tape containing: 2D SEGY brute stack datasets (UNIX tar –cvf) for sequences 001-046.

For shipment details see: Sequence 2, §5, page 15 in this report.