Integrated Services in
Petroleum Exploration and Production

Processing Report

for

2003 Sorell Basin Processing
Survey SS03 2D

Area:
Sorrel Basin, T/35P

May 2004

Robertson Research
Australia Pty. Ltd.

69 Outram Street
West Perth WA 6005
Australia

Tel: +61 (08) 9322 2490
Fax: +61 (08) 9481 6721
E-mail: info@robres.com.au

TABLE OF CONTENTS

SECTIONS	CONTENTS	Page Numbers
1.0	INTRODUCTION	1
1.1	PERSONNEL	1
1.2	SURVEY MAP	2
2.0	PARAMETER TESTING	3
3.0	COMMENTS & CONCLUSION	4
4.0	PROCESSING SEQUENCE	5
5.0	PROCESSING TECHNIQUES	10
6.0	ACQUISITION PARAMETERS	24

APPENDICES

SECTIONS	CONTENTS	Page Numbers
A1	LINE LISTING	25
A2	PHASE MATCHING	26
A3	DELIVERABLES	27

1.0 INTRODUCTION

The 2003 SS03 2D Sorell Basin Processing consisted of 31 lines, totalling 1336 km. Water depth times varied from 300ms to 4000ms with the majority of data having water bottoms times greater than 1000 ms. Most of the dip lines had smooth water bottom profiles, however the strike lines were somewhat undulating. This caused several problems with respect to certain processing stages. All processing parameters that were applied were done so with respect to the changing water bottom. The data was recorded in November 2003 with the processing being completed in May 2004.

1.1 PERSONNEL

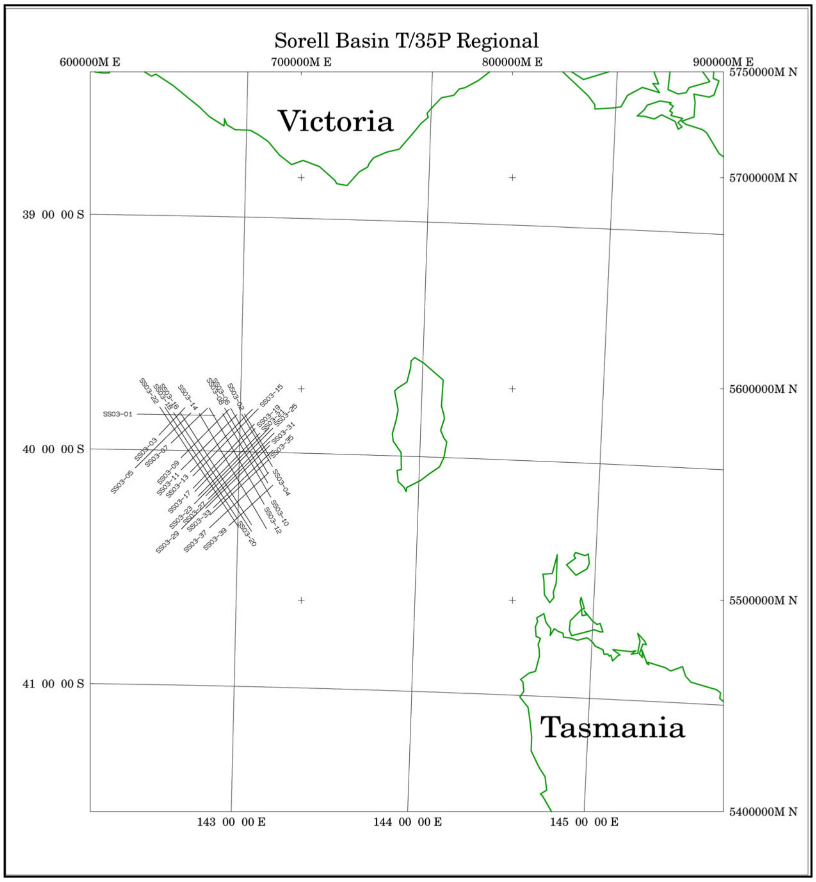
Robertson Research Australia

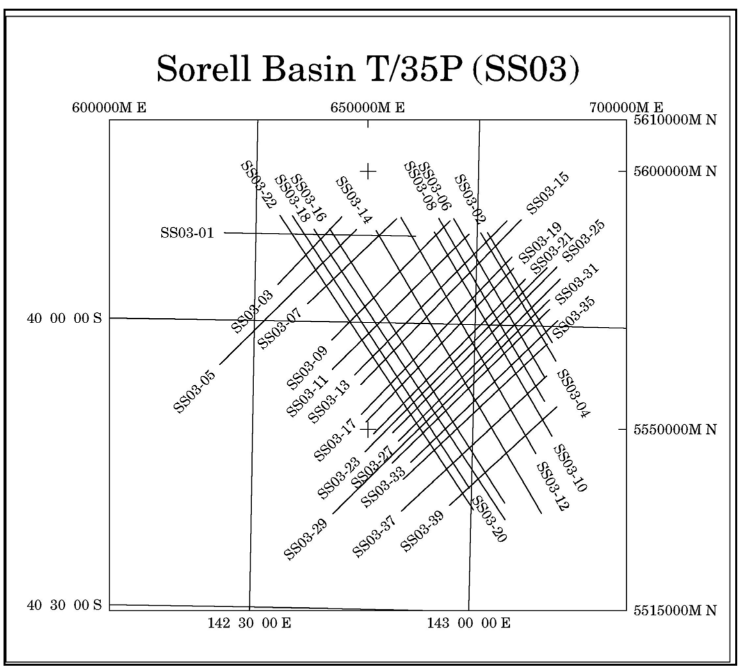
Kelly Beauglehole	Processing Manager
Simon Stewart	Marine Processing Manager
Paul Phythian	Geophysicist

Santos Limited

Stuart Brew	Senior Staff Geophysicist (Santos)
Bruce Hawkes	Geophysical Consultant

1.2 SURVEY MAP





2.0 PARAMETER TESTING

All pre and post stack testing was carried out on line SS03-21. This line was chosen since it passed through the middle of the survey area and it was typical of the dip lines of the survey. The exception to this was the tests run to try and attenuate the migration artefacts after PSTM. Since the strike lines had very undulating water bottoms compared to the dip lines, several PSTM, Movevout Equation Multiple Attenuation (MEMUL) & Offset FK tests were done on line SS03-02. These PSTM, Memul & Offset FK tests were also rum on line SS03-18 which was another strike line that displayed several migration artefacts after the PSTM.

Please refer to the table below for further details of the tests performed.

Test	Format		
	Shot Record	CDP Gather	STACK
Shot record displays	✔		
Gain recovery: Amplitude decay analysis	✔		
Gain recovery: exponential gain	✔		
F-K filter (shot domain, various cuts)	✔		✔
F-K filter with NMO (shot domain, various cuts)	✔		✔
F-K filter (shot domain)	✔		✔
Signature deconvolution	✔		✔
Tau-P Linear Noise Removal	✔		✔
Multiple attenuation: F-K method		✔	✔
Multiple attenuation: Radon method		✔	✔
Predictive deconvolution (before stack)			✔
PSTM Testing (SCAMP, MEMUL & OFFSET FK)		✔	✔
Outer and inner trace mutes		✔	✔
Bandpass filter and Post stack scaling			✔

3.0 COMMENTS & CONCLUSION

The processing was completed in May 2003. A post stack full fold fast track volume was archived and delivered via FTP on the 3rd of February to allow preliminary interpretation to begin. With the final Pre Stack Time Migrated archive (Filtered/Scaled) delivered via FTP on 2nd of April. Tape archives of the Final Filtered and Scaled PSTM and Raw PSTM (Full, Near & Far) followed. Also Pre Stack Time Migrated gathers were archived. The gathers were NMO corrected with the final 0.5km velocities. The t^2 gain recovery, that was applied at the start of processing, was removed and an Ursin spherical divergence, with dB gain, was applied. See section 5 for parameter details. The Near and Far angle stacks had the same scaling (t^2 removed and Ursin spherical divergence, with dB gain) applied.

With about half the lines in the survey having a rugged undulating water bottom, the multiples of the water bottom diffractions of these lines caused rather severe migration artefacts after PSTM. These multiples, due to their non parabolic nature, did not respond to conventional demultiple (Radon or F-K). The post stack time migration “fast-track” data didn’t suffer as badly due to the cancellation of this “noise” in the stack prior to the migration, however migration artefacts were still present on the post stack volume. These migration artefacts were especially a problem with the strike lines while the dip lines were somewhat unaffected. Even though they had quite variable water depths, their water bottom profiles were generally gently sloping which in turn didn’t pose the same problems for the PSTM.

We achieved the best attenuation of these “migration artefacts” with a Move Out Equation Multiple (MEMUL) attenuation in combination with a F-K dip filter. Both of these being applied in the common offset domain. It was however decided not to go with either of these methods due to the degradation in fault definition and attenuation of primary events.

There was no well data to tie the survey to and there was no other recent seismic to phase match this data. Instead it had the statistical minimum zero phase applied then a phase rotation only applied (no bulk shift) to produce the best looking “zero phase SEG negative” response at the water bottom.

4.0 PROCESSING SEQUENCE

4.1 POST STACK TIME MIGRATION

TRANSCRIPTION
|
LOW CUT FILTER
|
GAIN RECOVERY (t^2)
|
SWELL NOISE ATTENUATION
|
F-K FILTER (shot & receiver domain +/- 2000 m/s)
|
ADJACENT TRACE SUM
|
CDP GATHER
|
FIRST PASS VELOCITY ANALYSIS (2 km intervals)
|
TRACE INTERPOLATION (Receiver Domain)
|
MULTIPLE ATTENUATION (F-K & Radon)
|
DROP INTERPOLATED TRACES
|
DMO
|
SECOND PASS VELOCITY ANALYSIS (1 km intervals)
|
NMO CORRECTION & MUTES
|
CDP STACK
|
GUN & CABLE STATIC CORRECTIONS
|
FINITE DIFFERENCE MIGRATION
|
BAND-PASS FILTER
|
POST STACK SCALING (+)

(+) Final Filtered and Scaled Post Stack Migration. See section 5 for parameter details.

4.2 PRE STACK TIME MIGRATION (FILTERED & SCALED)

TRANSCRIPTION
|
LOW CUT FILTER
|
GAIN RECOVERY (t^2)
|
SWELL NOISE ATTENUATION
|
F-K FILTER (shot & receiver domain +/- 2000 m/s)
|
ADJACENT TRACE SUM
|
CDP GATHER
|
FIRST PASS VELOCITY ANALYSIS (2 km intervals)
|
TRACE INTERPOLATION (Receiver Domain)
|
MULTIPLE ATTENUATION (FK & Radon)
|
DROP INTERPOLATED TRACES
|
SECOND PASS (PSTM) VELOCITY ANALYSIS (1 km intervals)
|
RESAMPLE
|
KIRCHHOFF PRE-STACK TIME MIGRATION (*)
|
THIRD PASS VELOCITY ANALYSIS (0.5 km intervals) (+)
|
REVERSE t^2 GAIN RECOVERY
|
NMO CORRECTION
|
SPHERICAL DIVERGENCE (URSIN & GAIN)
|
OUTER TRACE MUTE / PRE STACK SCALING / INNER TRACE MUTE
|
CDP STACK
|
GUN & CABLE STATIC CORRECTIONS
|
ZERO PHASING / PHASE ROTATION
|
BAND-PASS FILTER
|
POST STACK SCALING (&)

(*) Pre Stack Time Migration gather archive. FK/Radon combination demultiple applied and NMO corrected with the final 0.5km velocities. T squared scaling backed off and Ursin spherical divergence, with a water bottom dependent gain, applied. See section 5 for parameter details.

(+) Final 0.5km velocities (Western format)

(&) Final Filtered and Scaled Pre Stack Time Migration. See section 5 for parameter details.

4.3 PRE STACK TIME MIGRATED ANGLE STACKS (FILTERED / SCALED)

TRANSCRIPTION
|
LOW CUT FILTER
|
GAIN RECOVERY (t^2)
|
SWELL NOISE ATTENUATION
|
F-K FILTER (shot domain +/- 2000 m/s)
|
SIGNATURE DECONVOLUTION (6/12-75/72, Hz/dB/Octave)
|
TAU-P LINEAR NOISE REMOVAL
|
ADJACENT TRACE SUM
|
CDP GATHER
|
FIRST PASS VELOCITY ANALYSIS (2 km intervals)
|
TRACE INTERPOLATION (Receiver Domain)
|
MULTIPLE ATTENUATION (F-K & Radon)
|
SECOND PASS (PSTM) VELOCITY ANALYSIS (1 km intervals)
|
RESAMPLE
|
KIRCHHOFF PRE-STACK TIME MIGRATION
|
THIRD PASS VELOCITY ANALYSIS (0.5 km intervals)
|
REVERSE GAIN RECOVERY (t^2)
|
NMO CORRECTION (*)
|
SPHERICAL DIVERGENCE (URSIN & GAIN)
|
OUTER / PRE STACK SCALING / INNER TRACE MUTES
|
CDP STACK (Near & Far)
|
GUN & CABLE STATIC CORRECTIONS
|
ZERO PHASING / PHASE ROTATION
|
BAND-PASS FILTER
|
POST STACK SCALING

4.4 PRE STACK TIME MIGRATION (RAW)

TRANSCRIPTION
|
LOW CUT FILTER
|
GAIN RECOVERY (t^2)
|
SWELL NOISE ATTENUATION
|
F-K FILTER (shot & receiver domain +/- 2000 m/s)
|
ADJACENT TRACE SUM
|
CDP GATHER
|
FIRST PASS VELOCITY ANALYSIS (2 km intervals)
|
TRACE INTERPOLATION (Receiver Domain)
|
MULTIPLE ATTENUATION (FK & Radon)
|
DROP INTERPOLATED TRACES
|
SECOND PASS (PSTM) VELOCITY ANALYSIS (1 km intervals)
|
RESAMPLE
|
KIRCHHOFF PRE-STACK TIME MIGRATION
|
THIRD PASS VELOCITY ANALYSIS (0.5 km intervals)
|
REVERSE t^2 GAIN RECOVERY
|
NMO CORRECTION
|
SPHERICAL DIVERGENCE (URSIN & GAIN)
|
OUTER / INNER TRACE MUTE
|
CDP STACK
|
GUN & CABLE STATIC CORRECTIONS
|
ZERO PHASING

4.5 PRE STACK TIME MIGRATED ANGLE STACKS (RAW)

TRANSCRIPTION
|
LOW CUT FILTER
|
GAIN RECOVERY (t^2)
|
SWELL NOISE ATTENUATION
|
F-K FILTER (shot & receiver domain +/- 2000 m/s)
|
ADJACENT TRACE SUM
|
CDP GATHER
|
FIRST PASS VELOCITY ANALYSIS (2 km intervals)
|
TRACE INTERPOLATION (Receiver Domain)
|
MULTIPLE ATTENUATION (F-K & Radon)
|
DROP INTERPOLATED TRACES
|
SECOND PASS (PSTM) VELOCITY ANALYSIS (1 km intervals)
|
RESAMPLE
|
KIRCHHOFF PRE-STACK TIME MIGRATION
|
THIRD PASS VELOCITY ANALYSIS (0.5 km intervals)
|
REVERSE GAIN RECOVERY (t^2)
|
NMO CORRECTION
|
SPHERICAL DIVERGENCE (URSIN & GAIN)
|
OUTER / INNER TRACE MUTES
|
CDP STACK (Near & Far)
|
GUN & CABLE STATIC CORRECTIONS
|
ZERO PHASING

5.0 PROCESSING TECHNIQUES

A brief description of each of the processes used in the processing sequence follows:

5.1 TRANSCRIPTION

Field data were converted to Robertson's internal format for processing. RRA's internal processing format is trace sequential, with samples in 32 bit IEEE floating point. At intermediate processing stages the data is stored on magnetic tape in sixteen-bit integer with a gain ranging scalar for each trace.

5.2 GAIN RECOVERY

A gain function was applied to the data set to compensate for inelastic attenuation and spherical divergence losses.

Gain functions applied were as follows :

Survey	Gain Function (dB)
All	t^2

where t = two way travel time in milliseconds.

5.3 STATICS

Applied –120ms static shift to compensate for recording delay.

5.4 LOW-CUT FILTER

A low-cut filter of 4/12 Hz/dB/Octave was applied to the shot records.

5.5 SWELL NOISE ATTENUATION

A symmetrical "velocity" filter was designed in the F-K domain to preserve the Swell noise attenuation is achieved by normalization of the amplitude spectra of selected "swell" traces.

To determine which traces are affected by swell noise the shot record is passed through an fx transform after an appropriate gain function has been applied to the data. Although swell noise is predominantly low frequency it also has a significant proportion of high frequency energy which can be more successfully predicted. The user can limit the range of frequencies they wish to perform analysis on by defining a low cut frequency with the upper limit being restricted to 3/4 of the nyquist frequency. For this data a low cut of 32 hz was defined and analysis performed up to 187.5 hz.

Swell traces are then chosen as those whose amplitude are greater than double a user defined percentile less the minimum amplitude. For this data a value of 30% was used for the user defined percentile. A scalar is then computed to normalize frequencies of the "swell" traces to the mean of the "non swell" traces. None of the calculated scalars are allowed to exceed 1 and they are smoothed with a user defined n point filter before application. For these data a nine point filter was used. The scalar is then fully applied to the amplitude spectra of the "swell" trace up to 1/2 of the user defined low cut frequency. For these data the scalar was fully applied from 0 to 16 hz. The scalar is then tapered to no scaling at the cut off frequency (32hz). The data is then passed on for further processing.

For data that exhibits strong swell noise the scalar values applied will be small, significantly changing the low frequency end of the amplitude spectra for the selected "swell" traces. For data with minimal swell noise the scalars will be close to 1 and result in little change to the low frequency end of the amplitude spectra for the selected "swell" traces. Only the selected "swell" traces are altered, all other traces are passed on for further processing unchanged.

5.6 MULTI CHANNEL FILTER (SHOT & RECEIVER DOMAIN)

A symmetrical “velocity” filter was designed in the F-K domain to preserve the primary reflection signal and to discriminate against coherent dipping noise trains. The filter employs a cosine-squared taper from k = 0 to the velocity intercept at each frequency. Filtering was applied in both the shot and receiver domains. The input data was conditioned with a 300 ms AGC, and the scalars preserved for removal subsequent to the application of the F-K filter. A cut off velocity of 2000 m/sec was used for both the shot and receiver F-K in the filter design and NMO was applied before and removed after the filter.

5.7 ADJACENT TRACE SUM

A 2:1 adjacent trace sum was applied to form a 25m / 25m shot/group interval geometry. This was applied after NMO correcting the shots with a water bottom dependent regional velocity function. A trace mix was also applied during the summation process:

Trace Mix Details :

Time (ms)	Trace Mix
0	1 - 2 - 1
5000	1 - 2 - 1
8000	1 - 2 - 3 - 2 - 1

Summation Details :

Input Traces	Input Trace Interval	Output Traces	Output Trace Interval
480	12.5m	240	25m

5.8 CDP GATHER

The shot records were sorted into common depth point gathers. Nominal fold is 120.

5.9 FIRST PASS VELOCITY ANALYSIS

First pass velocities were determined using Robertson's "MGIVA" interactive velocity analysis program. Each velocity analysis comprised a semblance display, a 30 CDP stacked panel repeated 14 times with a suite of velocity functions, and a central CDP gather. The suite of functions were generated using 0%, +/-4 %, +/-8%, +/-13%, +/-19 %, +/-25%, +/-32%, and +40% increments from a central velocity function. The central function was derived from a brute velocity that varied according to water depth.

A mild F-K multiple attenuation was applied to enhance the primary energy of the data before the analyses using the following percentages of the brute velocity function: -8% at 0ms, -10% at 800ms, -12% at 2500, -18% at 4500 and -25% at 10000ms. This was applied for the purpose of the analyses only.

The velocity analysis incorporated a map of all velocity locations, and the semblance display included functions from proximate lines. This enabled the velocities to be picked with knowledge of areal velocity trends. Velocity QC could be performed more effectively when discordant velocities could be recognised on the map.

5.10 DEMULTIPLE (F-K and Radon)

The F-K demultiple, using scaled final velocities derived in 5.9, was applied in the shallow portion of data with respect to the water bottom where the fold of the data was much lower. The F-K demultiple application times were:

WB Time (ms)	*Full Application (ms)*	*No Application (ms)*
100	0-900	1400 – Tmax
500	0-1000	1500 – Tmax
1000	0-1500	2000 – Tmax
2000	0-2500	3000 – Tmax
5000	0-5500	6000 – Tmax

The percentage scaling applied to the final velocities used in the F-K demultiple were:

Time (ms)	*% of velocity*
0	94
800	94
3500	90
6000	86
TMAX	86

Radon demultiple, using 100% final velocities derived in 5.9, was applied in the deeper portion of data using 450p values between maximum offset delta t values of –1000ms and 3500ms. Move-outs greater than those listed below were modelled and subtracted from the data.

WB Time (ms)	*Time (ms) / Moveout (ms) Pairs*
0	0/200, 1000/200, 2000/75, 8192/50
1000	0/200, 2000/200, 3000/75, 8192/50
4000	0/200, 5000/200, 6000/75, 8192/50
5000	0/200, 6000/200, 7000/75, 8192/50

Reference Offset = 6120m

The Radon demultiple application times were:

WB Time (ms)	*Full Application (ms)*
100	900 – Tmax
500	1000 – Tmax
1000	1500 – Tmax
2000	2500 – Tmax
4000	4500 – Tmax

5.11 DIP MOVEOUT (Fast Track Only)

Robertson Research's DMO program applies 2D convolution operators to map the data accurately from non-zero to zero offset in the manner described by Deregowski and Rocca (1981). The convolution is conveniently implemented by the summation method, and applied to traces in common offset order. This procedure achieves the desirable partial migration, whereby traces with common mid-points, but different source-receiver offsets, relate to the same sub-surface locations after DMO, for all dips. After DMO all reflection events appear, for the purposes of normal moveout correction, to have originated from horizontal reflectors. Therefore, optimum stack response for all reflector dips can be obtained from conventional moveout corrections based on velocity functions undistorted by reflector dips.

The number of common offset planes used in DMO was equivalent to the maximum fold of the data, in this case 120.

5.12 SECOND PASS VELOCITY ANALYSIS (Fast Track Only)

The second pass of velocities were picked at 1km intervals on DMO gathers using Robertson's "MGIVA" interactive velocity analysis program. Each velocity analysis comprised a semblance display, a 25 CDP stacked panel repeated 13 times with a suite of velocity functions, and a central CDP gather. The suite of functions were generated using 0%, +/-2 %, +/-4%, +/-7%, +/-11 %, +/-15% and +/-20% increments from a central velocity function. The first pass of velocities were used as the central function for this suite of velocity variant functions.

5.13 NMO CORRECTION (Fast Track Only)

Fourth order NMO correction was performed using the final picked 1km DMO velocity functions.

5.14 OUTER TRACE MUTE (Fast Track Only)

A post-NMO outer trace mute was applied for two main reasons :

- to remove any coherent noise on the outer traces and
- to reduce contamination from the effect of NMO stretch on the far offsets.

Water Bottom Time: 100 ms		**Water Bottom Time: 500 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
280	0	130	200
330	200	400	200
640	600	640	600
2400	1775	2400	1775
4200	2975	4200	2975
6150	4300	6150	4300
7150	4900	7150	4900
Water Bottom Time: 1000 ms		**Water Bottom Time: 2000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
130	800	130	1800
640	800	872	1800
997	1600	1197	2600
2597	2500	2647	3500
4172	3750	4148	4350
6150	4900	6150	5600
7150	5500	7150	6000
Water Bottom Time: 3000 ms		**Water Bottom Time: 5000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
130	2800	130	4800
1200	2800	1800	4800
1572	3500	2200	5700
3297	4400	3297	6200
4497	5000	4522	7000
6150	6300	6150	7850
7150	6800	7150	7950

5.15 PRE-STACK SCALING (Fast Track Only)

General Parameter Summary
Window lengths of 1200 ms and 400 ms
Equalisation applied : 60
Short window stopped 8000 ms

5.16 INNER TRACE MUTE (Fast Track Only)

A post NMO inner trace mute was applied to help remove remnant multiple energy still apparent on the inner traces following the demultiple.

Water Bottom Time: 100 ms		**Water Bottom Time: 500 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
135	900-8192	135	1300-8192
650	1800-8192	850	2000-8192
800	2100-8192	1100	2500-8192
Water Bottom Time: 1000 ms		**Water Bottom Time: 2000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
135	1800-8192	135	3000-8192
1050	2400-8192	1150	3900-8192
1300	3000-8192	1400	4200-8192
Water Bottom Time: 3000 ms		**Water Bottom Time: 4000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
135	4200-8192	135	5200-8192
1200	5100-8192	1200	6100-8192
1600	5400-8192	1600	6400-8192

5.17 COMMON DEPTH POINT STACK (Fast Track Only)

The traces within each common depth point gather were summed using 1/root(N) stack compensation. Nominal fold is 120.

5.18 STATICS (Fast Track Only)

A static compensation for gun and cable depths was applied. The static value applied was calculated using average gun and cable depths supplied in the observer's reports. A 10ms static correction was applied to all lines.

5.19 WAVE EQUATION MIGRATION (Fast Track Only)

A third order 65 degree finite difference migration scheme was used. The migration model velocities were based on laterally smoothed stacking velocities with the following percentages of reduction.

Time (ms)	*% of velocity*
0	100
WB+2500	100
WB+5000	96
WB+10000	85

5.20 BAND PASS FILTER (Fast Track Only)

Unwanted noise that lay outside the frequency range of the desired reflection and diffraction data was removed by the application of a series of zero phase time variant cosine squared tapered filters.
General parameter summary:

Water Bottom Time: 1000 ms	
Time (ms)	***Frequency limits (Hz/dB/Oct)***
1000	6/10-80/96
1800	6/10-70/84
2600	6/10-60/72
3400	6/10-50/60
4200	6/10-40/50
5000	6/10-30/40
5800	6/10-25/35
6500	6/10-20/30
7500	6/10-15/25
Water Bottom Time: 1600 ms	
Time (ms)	***Frequency limits (Hz/dB/Oct)***
1600	6/10-80/96
2300	6/10-70/84
3000	6/10-60/72
3700	6/10-50/60
4400	6/10-40/50
5100	6/10-30/40
5800	6/10-25/35
6500	6/10-20/30
7500	6/10-15/25
Water Bottom Time: 2500 ms	
Time (ms)	***Frequency limits (Hz/dB/Oct)***
2500	6/10-80/96
3200	6/10-70/84
3900	6/10-60/72
4600	6/10-50/60
5300	6/10-40/50
6000	6/10-30/40
6700	6/10-25/35
7400	6/10-20/30
8000	6/10-15/25

5.21 POST STACK SCALING (Fast Track Only)

A dual window, time variant AGC method was used for post stack scaling. The negative effects normally associated with AGC are avoided by employing two different length windows to determine the amplitude model (using the minimum of the two mean amplitudes determined at each sample), then conditioning the model by a weighted mix with the amplitude model derived from a single window per trace.

General parameter summary

Window lengths of 1200 ms and 400 ms
Equalisation applied : 60
Short window stopped 5000 ms

5.22 SECOND PASS VELOCITY ANALYSIS (Flow continued from 5.10)

The second pass of velocities, picked at 1km intervals on the Pre-stack Time Migrated gathers were again determined using Robertson's "MGIVA" interactive velocity analysis program. Each velocity analysis comprised a semblance display, a 25 CDP stacked panel repeated 13 times with a suite of velocity functions, and a central CDP gather. The suite of functions were generated using 0%, +/-2 %, +/-4%, +/-7%, +/-11 %, +/-15% and +/-20% increments from a central velocity function. The central function was derived from the second pass velocities picked earlier.

5.23 RESAMPLE

Data was resampled from 2msec to 4msec.

5.24 PRE-STACK TIME MIGRATION

Kirchhoff PreSTM was applied using a maximum half aperture of 600 traces (7500m). Apertures were muted with a 50% stretch mute to avoid operator aliasing. Smoothed third pass velocities were scaled (see table below) and used in the migration. Migration was performed on all 120 offset planes.

Time (ms)	*% of velocity*
WB	100
WB+2500	100
WB+5000	96
WB+10000	85

5.25 THIRD PASS VELOCITY ANALYSIS

The third and final pass of velocities, picked at 0.5km intervals on the final Pre-stack Time Migrated gathers were again determined using Robertson's "MGIVA" interactive velocity analysis program. Each velocity analysis comprised a semblance display, a 25 CDP stacked panel repeated 13 times with a suite of velocity functions, and a central CDP gather. The suite of functions were generated using 0%, +/-2 %, +/-4%, +/-7%, +/-11 %, +/-15% and +/-20% increments from a central velocity function. The central function was derived from the second pass velocities picked earlier.

5.26 REVERSE GAIN RECOVERY

Backed off t^2 scaling that was applied at the start of processing.

5.27 NMO CORRECTION

Fourth order NMO correction was performed using the final picked 0.5km PSTM velocity functions.

5.28 SPHERICAL DIVERGENCE CORRECTION

With the previously applied t^2 gain function removed, it was then replaced with an offset and velocity dependent spherical divergence approximation as described by Bjorn Ursin (GEOPHYSICS Vol.55 No.4, pp492-496 1990).

$$\sqrt{\frac{T0\times V^4}{V0^2}+\left(2\times\left(\frac{V}{V0}\right)^2-1\right)\times X^2+\frac{X^4\times\left(\frac{1}{V0^2}-\frac{1}{V^2}\right)}{t0^2}}$$

Where T0 is the two way travel time, V is the RMS velocity at T0, and V0 is the velocity in the first layer. Although this method is applicable to uncorrected data as a moveout tracking divergence correction, for algorithmic ease it is applied to NMO corrected CDP gathers.

Along with the URSIN spherical divergence, water bottom dependent dB scaling was also applied. Scaling was as follows:

Time (ms)	*Scalar (dB)*
WB	0
WB+1000	0
WB+2000	8
WB+8000	8

5.29 DEMULTIPLE (Hi Resolution Radon)

This second pass of demultiple was only applied to the NMO corrected (final 0.5km velocity) Kirchhoff PreSTM gathers that were archived.

Radon demultiple, using 100% final velocities derived in 5.25, was applied in the deeper portion of data using 250p values between maximum offset delta t values of –500ms and 2000ms. Move-outs greater than those listed below were modelled and subtracted from the data. The Radon demultiple application times were:

WB Time (ms)	*Time (ms) / Moveout (ms) Pairs*
100	0/250, 1000/100, 2000/75, 8192/35
500	0/250, 1500/100, 2500/75, 8192/35
1000	0/250, 2000/100, 3000/75, 8192/35
3000	0/250, 4000/100, 5000/75, 8192/35
5000	0/250, 6000/100, 7000/75, 8192/35

Reference Offset = 6120m

The Radon demultiple application times were:

WB Time (ms)	*Full Application (ms)*
100	500 – Tmax
500	900 – Tmax
1000	1500 – Tmax
3000	3500 – Tmax
5000	5500 – Tmax

5.30 OUTER TRACE MUTE

A post-NMO outer trace mute was applied for two main reasons :

- to remove any coherent noise on the outer traces and
- to reduce contamination from the effect of NMO stretch on the far offsets.

Water Bottom Time: 100 ms		**Water Bottom Time: 500 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
280	0	130	200
330	200	400	200
640	600	640	600
2400	1775	2400	1775
4200	2975	4200	2975
6150	4300	6150	4300
7150	4900	7150	4900

Water Bottom Time: 1000 ms		Water Bottom Time: 2000 ms	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
130	800	130	1800
640	800	872	1800
997	1600	1197	2600
2597	2500	2647	3500
4172	3750	4148	4350
6150	4900	6150	5600
7150	5500	7150	6000
Water Bottom Time: 3000 ms		**Water Bottom Time: 5000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
130	2800	130	4800
1200	2800	1800	4800
1572	3500	2200	5700
3297	4400	3297	6200
4497	5000	4522	7000
6150	6300	6150	7850
7150	6800	7150	7950

5.31 PRE-STACK SCALING

General Parameter Summary:
Window lengths of 1200 ms and 400 ms
Equalization applied : 60
Short window stopped 8000 ms
Note: Scaling only applied to the Final Filtered and Scaled Pre Stack Time Migrated dataset.

5.32 INNER TRACE MUTE

A post NMO inner trace mute was applied to help remove remnant multiple energy still apparent on the inner traces following the demultiple.

Water Bottom Time: 100 ms		Water Bottom Time: 500 ms	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
135	900-8192	135	1300-8192
650	1800-8192	850	2000-8192
800	2100-8192	1100	2500-8192
Water Bottom Time: 1000 ms		**Water Bottom Time: 2000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
135	1800-8192	135	3000-8192
1050	2400-8192	1150	3900-8192
1300	3000-8192	1400	4200-8192

Water Bottom Time: 3000 ms		**Water Bottom Time: 4000 ms**	
Offset (m)	***Application times (ms)***	***Offset (m)***	***Application times (ms)***
135	4200-8192	135	5200-8192
1200	5100-8192	1200	6100-8192
1600	5400-8192	1600	6400-8192

5.33 COMMON DEPTH POINT STACK

The traces within each common depth point gather were summed using 1/root(N) stack compensation. Nominal fold is 120.

5.34 STATICS

A static compensation for gun and cable depths was applied. The static value applied was calculated using average gun and cable depths supplied in the observer's reports. A static correction between 9 and 11ms was applied depending on the cable depth used for that particular line.

5.35 ZERO PHASE CONVERSION / PHASE MATCHING

Data were converted from minimum phase to zero phase. The spectral estimate was made using the Wiener-Levinson double inverse method.

All lines were then phase rotated –150 degrees to produce the best looking zero phase (SEG Negative) water bottom.

5.36 BAND PASS FILTER

Unwanted noise that lay outside the frequency range of the desired reflection and diffraction data was removed by the application of a series of zero phase time variant cosine squared tapered filters.

General parameter summary:

Water Bottom Time: 1000 ms	
Time (ms)	***Frequency limits (Hz/dB/Oct)***
1000	6/10-80/96
1800	6/10-70/84
2600	6/10-60/72
3400	6/10-50/60
4200	6/10-40/50
5000	6/10-30/40
5800	6/10-25/35
6500	6/10-20/30
7500	6/10-15/25

Water Bottom Time: 1600 ms	
Time (ms)	***Frequency limits (Hz/dB/Oct)***
1600	6/10-80/96
2300	6/10-70/84
3000	6/10-60/72
3700	6/10-50/60
4400	6/10-40/50
5100	6/10-30/40
5800	6/10-25/35
6500	6/10-20/30
7500	6/10-15/25
Water Bottom Time: 2500 ms	
Time (ms)	***Frequency limits (Hz/dB/Oct)***
2500	6/10-80/96
3200	6/10-70/84
3900	6/10-60/72
4600	6/10-50/60
5300	6/10-40/50
6000	6/10-30/40
6700	6/10-25/35
7400	6/10-20/30
8000	6/10-15/25

5.37 POST STACK SCALING

A dual window, time variant AGC method was used for post stack scaling. The negative effects normally associated with AGC are avoided by employing two different length windows to determine the amplitude model (using the minimum of the two mean amplitudes determined at each sample), then conditioning the model by a weighted mix with the amplitude model derived from a single window per trace.

General parameter summary

Window lengths of 1200 ms and 400 ms
Equalisation applied : 60
Short window stopped 5000 ms
Note: Scaling only applied to the Final Filtered and Scaling Pre Stack Time Migrated dataset.

5.38 ANGLE STACKS

Using the full fold inner and outer trace mutes, the remaining “live” data was split (equal fold) to produce near and far angle stack datasets. The T squared scaling was backed off (prior to NMO correction) and an Ursin spherical divergence, with water bottom dependent scaling, was applied. Scaling was as follows:

Time (ms)	*Scalar (dB)*
WB	0
WB+1000	0
WB+2000	8
WB+8000	8

6.0 ACQUISITION PARAMETERS

Data recorded by:	PGS Exploration A/S
Date recorded:	2003
Vessel:	Orient Explorer
Seismic Source:	
Type:	Sleeve Airgun
Pressure/Volume:	1800 psi / 2500 cu.in.
Depth:	6m
Shot interval:	25m
Gun delay:	0
Recording System:	
Record length:	8 s
Sample interval:	2 ms
Filters:Low	3 Hz - 12 dB / Octave
:High	206 Hz – 276 dB / Octave
Recording Delay	120 ms
Streamer:	
Streamer length:	6000 m
Streamer depth:	8 – 10 m
No. of groups:	480
Near group no:	480
Group interval:	12.5 m
Near group offset:	95 m
Antenna-source:	180 m
SP annotation:	SHOTPOINT

APPENDICES

A.1 LINE LISTING

Line	1st SP	Lst SP	SP Int	Kms
SS03-01	1000	2477	25	36.95
SS03-02	1000	1989	25	24.75
SS03-03	1000	1720	25	18.03
SS03-04	1000	2152	25	28.83
SS03-05	1000	2486	25	37.18
SS03-06	1000	2420	25	35.53
SS03-07	1000	1953	25	23.85
SS03-08	1000	2634	25	40.88
SS03-09	1000	2301	25	32.55
SS03-10	1000	2826	25	45.68
SS03-11	1000	2487	25	37.20
SS03-12	1000	3104	25	52.63
SS03-13	1000	2676	25	41.93
SS03-14	1000	3537	25	63.45
SS03-15	1000	2781	25	44.55
SS03-16	1000	3519	25	63.00
SS03-17	1000	2684	25	42.13
SS03-18	1000	3688	25	67.23
SS03-19	1000	2647	25	41.20
SS03-20	1000	3514	25	62.88
SS03-21	1000	2676	25	41.93
SS03-22	1000	3726	25	68.18
SS03-23	1000	3004	25	50.13
SS03-25	1000	2805	25	45.15
SS03-27	1000	2770	25	44.28
SS03-29	1000	3359	25	59.00
SS03-31	1000	2702	25	42.58
SS03-33	1000	2579	25	39.50
SS03-35	1000	2530	25	38.28
SS03-37	1000	2537	25	38.45
SS03-39	1000	2129	25	28.25
			Total Kms	1336.08

A.2 PHASE MATCHING

All data was zero phased with the spectral estimate made using the Wiener-Levinson double inverse method. The data was then phase rotated –150 degrees to produce the best looking zero phase (SEG Negative) water bottom response.

A.3 DELIVERABLES

Item	Format	Media	Tape No.
Whale Analysis Raw Field Data (Single Channel)	SEGY	Exabyte	306RS001E
Final Filtered/Scaled Migrations (Original) Zero Phase & Phase Matched Full, Near and Far Datasets	SEGY	Exabyte	306FM002E
Final Filtered/Scaled Migrations (Copy1) Zero Phase & Phase Matched Full, Near and Far Datasets	SEGY	Exabyte	306FM003E
Final Filtered/Scaled Migrations (Copy2) Zero Phase & Phase Matched Full Dataset only	SEGY	Exabyte	306FM004E
Raw Migrations (Original) Full, Near and Far Datasets	SEGY	Exabyte	306RM005E
Raw Pre-Stack Time Migration gathers (Original)	SEGY	3590	306GA006L – 306GA009L
Final Stacking Velocities (PSTM) 0.5km Intervals	Western	CD	306FV013CD
Final Processing Report (Original)	PDF	CD	306FR014CD
Final Processing Report (Copy1)	PDF	CD	306FR015CD
Final Processing Report (Copy2)	PDF	CD	306FR016CD
CDP End-Point Co-ordinates	ASCII	CD	306XY017CD
Final Processing Report	Paper Copy		