DATA PROCESSING REPORT

SCORPION SEISMIC SURVEY

GIPPSLAND BASIN

OFFSHORE VICTORIA

PREPARED FOR
EAGLE BAY RESOURCES NL
BY
VELSEIS PROCESSING

15 OCTOBER 2001

Disclaimer

This report has been prepared in good faith and with all due care and diligence. It is based on the seismic and other geophysical data presented and referred to, in combination with the author's experience with the seismic technique, and as tempered by the geological and stratigraphic evidence presented in various forms and through discussions with client representatives.

As such, the report represents a collation of opinions, conclusions and recommendations, the majority of which remain untested at the time of preparation. In the light of these facts it must be clearly understood that Velseis Processing Pty. Ltd., its proprietors and employees cannot take responsibility for any consequences arising from this report.

Table of Contents

Sections

Table of Contents 2
Introduction 3
    Line Summary 3
    Acquisition Parameters 4
Testing 5
Processing Parameters 8
    Reformat 8
    Trace Editing 8
    Geometry 8
    Statics 8
    Gain Recovery 8
    Removeable AGC 8
    F−K Filter 8
    Data Reduction 9
    Designature Deconvolution 9
    Predictive Deconvolution 9
    Velocity Analysis − 1st pass 9
    Normal Moveout Correction 10
    Multiple Attenuation−Radon 10
    Dip Moveout 10
    Stolt Pre−Stack Time Migration 10
    Velocity Analysis − 2nd pass 10
    Normal Moveout Correction 10
    Mute 11
    Amplitude Balance 11
    Stack 11
    Statics 11
    Stolt De−Migration 11
    Kirchhoff Migration 12
    Dip Filter 12
    Time−variant Mix 12
    Frequency Filter 12
    Amplitude Balance 12
    Display 12
Quality Control 13
Conclusions 14
Archiving 14
Appendix 15

Introduction

Velseis Processing Pty. Ltd. processed approximately 450km of marine seismic data from the Scorpion Seismic Survey for Eagle Bay NL from August 2001.

Line summary for processed lines

Line	First Shotpoint	Last Shotpoint	Group Interval	Length (km)
GEBR01−01	132	502	25	9.25
GEBR01−02	101	502	25	10.025
GEBR01−03	101	502	25	10.025
GEBR01−04	101	502	25	10.025
GEBR01−05	101	502	25	10.025
GEBR01−06	101	502	25	10.025
GEBR01−07	101	502	25	10.025
GEBR01−08	101	502	25	10.025
GEBR01−09	101	999	25	22.450
GEBR01−10	101	502	25	10.025
GEBR01−11B	2101	2502	25	10.025
GEBR01−12	101	502	25	10.025
GEBR01−13	101	999	25	22.450
GEBR01−14	101	502	25	10.025
GEBR01−15	101	502	25	10.025
GEBR01−16	101	502	25	10.025
GEBR01−17	101	502	25	10.025
GEBR01−18	101	994	25	22.325
GEBR01−19	101	502	25	10.025
GEBR01−20	101	502	25	10.025
GEBR01−21	101	502	25	10.025
GEBR01−22	101	502	25	10.025
GEBR01−23	101	1182	25	27.025
GEBR01−24	101	702	25	15.025
GEBR01−25	101	702	25	15.025
GEBR01−26	101	702	25	15.025
GEBR01−27	101	701	25	15.000
GEBR01−28	101	702	25	15.025
GEBR01−29	101	702	25	15.025
GEBR01−30	101	1216	25	10.025
GEBR01−31	101	442	25	8.525
GEBR01−32	101	440	25	8.475
GEBR01−33	101	442	25	8.525
GEBR01−34	101	957	25	21.400
TOTALS				448.875

Acquisition Parameters for the Scorpion Seismic Survey

Recorded By	Fugro
Vessel	R/V Geo Arctic
Date Shot	June 2001
Source	Single Array
Instruments	I/O MSX
Hydrophones	Multiplex streamer
Tape format	SEGD
Sample Rate	2 ms
Data Length	6 seconds
Filters	8/18 − 180/72 Hz/dB per octave
Source Array	3660 Cubic Inch ; 2041 Psi; Depth 9m
Group Spacing	12.5m
Shot Spacing	25m
Coverage	8000%

TESTING

Near Trace Display

Plots were produced consisting of just the near trace only of all records. These are a good quality control measure showing the time breaks of all records and the water bottom profile at a glance.

Amplitude Recovery

A series of spherical divergence and gain recovery tests were produced in order to compensate for amplitude decay due to wavefront spreading and inelastic attenuation.
The following functions were tested:

1. No Gain − Raw record
2. Spherical Divergence
3. Spherical Divergence plus 1dB/sec
4. Spherical Divergence plus 2dB/sec
5. Spherical Divergence plus 3dB/sec
6. Time * Power constant 1.6
7. Time * Power constant 2.0
8. Time * Power constant 2.4

Panel #3 was chosen to best balance amplitudes down and across the record.

F−K Filter

A raw record was filtered with various F−K velocity fan or pie−slice filters in order to attenuate the first break and reverberation energy. The following filter panels were produced:

1. No F−K filter
2. F−K Velocity Fan Filter: −1500 to −2700m/s
3. F−K Velocity Fan Filter: −1500 to −2800m/s
4. F−K Velocity Fan Filter: −1500 to −2900m/s
5. F−K Velocity Fan Filter: −1500 to −3000m/s
6. F−K Velocity Fan Filter: −1500 to −3100m/s
7. F−K Velocity Fan Filter: −1500 to −3200m/s
8. F−K Velocity Fan Filter: −1500 to −3300m/s
9. F−K Velocity Fan Filter: −1500 to −3400m/s

It was felt that panel #3 (−1500 to −2800m/s) was satisfactory in attenuating a great deal of the noise but mild enough to not harm real dipping data. It allowed data to be seen much further out in the offset direction.

Brute stacks as outlined further on were produced showing that the F−K filter was of benefit to the data.

Deconvolution Before Stack

An initial set of velocity analyses were produced following a test application of designature and predictive ensemble decon. These velocities were picked at a 2km interval then used to stack all of the following deconvolution and brute stack methods. All stacks have a bandpass display filter of 10−80Hz followed by a 500ms AGC. Line GEBR01−12 was used for all testing and the processing test sequences were as follows:

Trace Editing
Geometry Application
Amplitude Recovery: Spherical Divergence + 1dB/s

1. Raw Stack (No Deconvolution) after adjacent trace summation
2. F−K velocity filter reject −1500 to −2800m/s then adjacent trace sum
3. F−K filter, trace sum, Designature then Predictive 36ms Gap Shot Ensemble Decon
4. F−K filter, trace sum, Spiking Decon
5. F−K filter, trace sum, Shot Ensemble Spiking Decon
6. F−K filter, trace sum, 8ms Gapped Decon
7. F−K filter, trace sum, 16ms Gapped Decon
8. F−K filter, trace sum, Shot Ensemble 8ms Gapped Decon
9. No FK, trace sum, Designature then Predictive 36ms Gap Shot Ensemble Decon

All Predictive deconvolution operators are shot ensemble−averaged except for panels #4, 6 & 7 which were trace by trace deconvolutions.

Tests were primarily carried out to demonstrate the cumulative effects of adding on the extra processing steps. It was felt the Designature decon did a good job of shaping and whitening the wavelet, while producing a stack with stable phase. Events were more clearly defined and continuous. The follow−up predictive ensemble decon helped attenuate some of the multiple energy in the section.

Pre−Stack Time Migration

Three tests were performed on line GEBR01−12 to determine the best form of migration to use on this data.

Two methods of pre−stack time migration were tested. Firstly, Stolt time migrations were performed on DMO'd offset planes: after velocity analyses these data were stacked then de−migrated before a standard post−stack Kirchhoff time migration. Secondly, a full pre−stack Kirchhoff time migration was run. These sections were then compared with that resulting from a standard post−stack Kirchhoff time migration of the stacked DMO data.

From these tests it was determined that the DMO/Stolt pre−stack time migration path gave good results that were also cost−effective.

Post Stack Filter

A suite of octave filter panels were produced for a set of 100 CDP’s from line GEBR01−12. A time−variant filter was then picked from these.

Dip Filter

A series of different dip filters were run on line GEBR01−12 and compared interactively on the screen. The aim was to attenuate steeply dipping acquisition noise and migration artefacts while at the same time preserving the steeply dipping signal. From various test panels, a dip filter rejecting dips greater than +/− 6ms per trace was considered to give the best results.

Running Mix

To try and enhance the deeper data, different triangular running mixes were run on the data. However it was determined that these mixes, whilst improving the deeper data, were having a detrimental effect on the shallower data. To compensate for this, a 9 trace triangular weighted mix was run only on the deeper data.

Post−Stack Migration

5 different percentages of velocities were tested to determine the optimum migration velocity to performed on the de−migrated Pre−Stack Time Migrated data. 85, 90, 95, 100 & 105% of smoothed stacking velocities were tested and it was determined that the 100% gave the more focused Kirchhoff migration.

PROCESSING PARAMETERS

Reformat

Input is reformatted to ProMAX internal data format.

Trace Edit

Remove bad or noisy traces from shot records interactively.

Geometry

Assign geometry information to trace headers. Information assigned to each trace includes source, receiver and CDP location along with offsets and CDP fold.

Gain

Amplitude Recovery with spherical divergence based on function of travel time and velocity with a 1dB per second correction constant to 6 seconds.

Removeable AGC (AGC Wrap)

Data can have highly varying amplitudes, the highest of which will dominate the F−K spectrum. Filtering will cause artefacts of these high amplitudes to be spread to other regions of the data in the time domain. Compressing the amplitudes and saving the scalars before F−K, then decompressing or reversing the scalars afterwards, prevents these artefacts from contaminating the time domain data.

A 500ms AGC wrap was applied (and de−applied) to the shot records before and after F−K filtering.

F−K Velocity Filter

Linear noise was rejected from shot records using standard pie−slice or velocity filters. The slopes of the reject ranges of velocities were:

−1500 to −2800 m/s.

Data Reduction

Adjacent traces in shot records were summed together after normal moveout to produce a 25m group interval and a 12.5m cdp interval. This provides a degree of random noise attenuation and reduces the data volume.

Designature Deconvolution

A minimum phase estimated wavelet of the shot ensemble is calculated using the averaged power spectrum. From this an inverse filter is computed and applied to the shot ensemble removing the source signature and outputting a zero phase wavelet.

Deconvolution

As designature decon does not attenuate multiple energy, a predicitve or gap deconvolution was applied at this stage. A shot ensemble−averaged decon operator of 280ms with a gap of 36ms was employed to attenuate ringing multiple energy.
The design gate times below are referenced to the water bottom:

Offset (m)	Start (ms)	End (ms)
140	120	3600
170	120	3610
520	150	3610
890	270	3610
1370	530	3620
2120	880	3625
2770	1230	3630
4070	1620	3635

Velocity Analysis (1st Pass)

Velocities were picked using the ProMAX interactive velocity picking package (IVA). IVA uses velocity spectra, moved out gathers and stacked panels to assist in a careful interpretation of stacking velocities. As the velocity function is altered, revised gathers and stacks are produced until optimized stacking velocities are achieved.

Velocities were picked at locations at 2km intervals. Each panel consisted of 11 CDPs stacked using 11 velocity functions centred around the regional velocity function.

Multiple Attenuation

CDP data were transformed into the Radon domain and an interactive filter was designed and applied to remove multiple energy.

Dip Moveout

An F−K DMO correction or dip−dependant partial migration was applied to moved out common offset gathers transforming them from non−zero to zero offset. This allows for improved velocity estimates, lateral resolution and attenuation of coherent noise.

Stolt Pre−Stack Time Migration

Common offset planes were migrated using a stolt algorithm. Migration used 100% of the smoothed stacking velocities .

Velocity Analysis (2nd Pass)

Velocities were picked again using the interactive picking package, following the Pre−Stack Stolt Time Migrations. Velocities were picked at locations at 1km intervals.

Normal Moveout Correction

An NMO correction was applied to the data using 1st pass velocities, allowing a brute stack to be generated.

Dynamic corrections are applied to the data using the following formula.

$$TX = T0^2 + \frac{X^2}{V^2}$$

TX = time at offset X
T0 = time at zero offset
X = offset of the trace
V = velocity at time T

Mute

A front mute was applied to eliminate refractors and stretch caused by normal moveout corrections. The mute was designed interactively from common offset stacks of the lines. The mute start times as listed below are referenced to the water bottom:

Time (ms)	Offset
0	170
320	620
640	970
910	1520
1260	2120
1570	2820
2070	4120

Amplitude Balance (AGC)

Trace amplitude balancing scalars were calculated for each sample at the centre of a sliding balance window. The scaling factor is the ratio of the absolute average amplitude of the window and the average amplitude of the entire trace. Before this is calculated, the average amplitude of the entire trace is made equal to a requested value.
A scaling window of 500 ms was used.

Stack

Add traces within a common midpoint gather. The post stack trace was scaled by the square root of the sum of fold for each sample in the trace.

Static

A gun and cable depth correction static of +11ms was applied to the stacked data.

Stolt De−Migration

Pre−stack time migrated stacks were de−migrated using a stolt algorithm. The de−migration used the same velocity field as the pre−stack time migration.

Kirchhoff Migration

Stacks were migrated using a Kirchhoff algorithm. Migration used 100% of the smoothed stacking velocities.

Dip Filter

By attenuating more steeply dipping noise, coherent signal energy with dips in the range +/− 6ms per trace were enhanced.

Trace Mixing

A 9 trace weighted mix below two seconds was performed to enhance the continuity of deeper data.

Frequency Filter

The following Ormsby time variant digital Zero phase bandpass filter was applied to the data to remove high and low frequency noise.

Time (ms)	Frequency (Hz)
500	10−90
2000	10−70
3000	10−60
4500	10−50

Amplitude Balance (AGC)

A scaling window of 500 ms was used.

Display

Migrated and final stacks are displayed at a horizontal scale of 20 traces per cm and a vertical scale of 10 cm per second.
Displayed with the traces are Shotpoint and CDP annotation, line intersections, velocity information and fold.

Quality Control

The following is a summary of the quality control steps taken throughout this production project.

- Interactive Near Trace displays to QC water depth and water bottom profile
- Interactive display of all shot records for trace editing
- Geometry QC displays of cdp fold, SP/cdp relationship and water depths
- Brute stack displays with FK, decons and 2km velocities
- Stack with Radon demultiple before DMO
- PSTM stack with first pass velocities − interactive display
- PSTM stack with 1km PSTM velocities
- Final Displays with final filter and scaling

Conclusions

Overall data quality was good although frequency content was not near the upper limits of the field filters. First break noise and reverberations were attenuated reasonably well with the pre−decon F−K filtering. Multiple energy was also present but handled OK with the application of the Radon transform filter. The application of Pre−Stack Time Migration improved the continuity and interpretability of seismic events below 2 seconds TWT.

Archiving

Digital Data:
Raw and filtered−scaled final Kirchhoff migrated stacks were archived in SEGY format on an 8mm Exabyte tape #CPT367. A CD−ROM, CPCD−217, was also produced containg CGM+ display files. Western format velocities for the project were supplied to the client in text format via email.

Appendix

These data were processed by Velseis Processing Pty. Ltd., Brisbane, Australia. Client QC and liaison were provided by Powell Seismic Services.

Velseis Processing utilizes ProMAX 2D processing software. This is a totally interactive system allowing the user to view data processing at each stage, producing a final result of the highest quality.

The software executes on a dual processor Sparc 20 Sun workstation. Each processor is rated at 400 MHz and the system is configured with 1024 Mbytes of memory. Data is viewed via X terminals networked to the main system, each terminal has a high definition monitor to enable accurate representation of the digital data in pixel form.

The overall efficiency of the system enabled processing to be completed within the allotted time frame.

Plots were generated via a 300 dpi laser plotter. This was used to generate paper plots for QC purposes as well as providing final filmed copies.

Velseis Processing is committed to offering a premium product, the software development undertaken by ProMAX resulting in processing algorithms which are state of the art. Velseis Processing is not limited to 2D seismic − we have access to a full suite of 3D Algorithms via **ProMAX 3D**.