DATA PROCESSING REPORT

IMPERIAL OIL & GAS PTY LTD

2019 BROADMERE 2D SEISMIC SURVEY
EP187
NORTHERN TERRITORY

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Integrated Seismic Technologies

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.

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INTRODUCTION

Velseis Processing processed 223.24km of seismic data for Imperial Oil and Gas Pty Ltd from their Broadmere 2D Seismic Survey in the Northern Territory. The processing was undertaken during November and December 2019 and were processed through a standard Trim Stack/FD Migration sequence as well as a Pre-stack Time Migration(PSTM) sequence.

Due to the complex geological structures these data were processed in order to determine the extent and size of both structures and faulting within the area covered by these six lines. Through the use of the heavy Renegade vibrators, sufficient seismic energy penetration allowed the investigation of these structures both spatially and temporally.

Line Summary

Line	First SP	Last SP	GI (m)	Line length (km)
2019-01	100	1778	20	33.56
2019-02	100	1378	20	25.56
2019-03	100	2559	20	49.18
2019-04	100	1763	20	33.26
2019-05	100	1828	20	34.56
2019-06	295	2651	20	47.12

Acquisition Parameters

Sample Rate	2ms
Record Length	6000ms
No. of Channels	560
Source Array	2 Vibes, 1x 16s 5-80Hz sweep, 6s listen
Spread	5590m-10m-x-10m-5590m
Group Spacing	20m
VP Spacing	20m

TESTING

TAR Test

Several different amplitude recoveries were tested on line 2019-06. After testing it was decided to proceed with a time raised to a power of 1.2.

Deconvolution

Several different deconvolutions were tested on line 2019-06. After testing, it was decided to apply a double window, surface consistent spiking deconvolution using 160ms operators.

Linear Noise Removal

Linear noise removal was tested on line 2019-06. The order in which Fan Filter was applied was tested, and it was decided to apply the linear noise removal in the Shot domain before Deconvolution.

Random Noise Removal

A common offset FX deconvolution (COSFXD) was applied to the data pre-PSTM in an attempt to remove residual random noise from the CDP gathers. Since it did remove noise from the gathers, it was decided to proceed with its use in production.

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 locations along with offsets, elevations, and CDP fold.

Minimum Phase Conversion

The data were converted from zero-phase to minimum-phase.

Gain

In addition to an offset amplitude correction – determined from a regional velocity – a time/power constant of 1.2 was applied to the data

Static Computation

Tomographic statics were calculated utilising first breaks picked on refractors corresponding to the base of weathering.

Replacement Velocity	Final Datum
4500 m/s	300 m

Linear Noise Attenuation in Shot Domain

Fan Filter applies a spatial filter in the F-X domain to remove linear coherent noise from 2D or 3D ensembles. During the initialisation phase, Fan Filter builds a table of fan-reject or fan-pass filter weights as a function of frequency and offset. During the execution phase, it Fourier transforms all traces in the input ensemble to the f-x domain. For each trace, it builds a model of the reject or pass region via a weighted stack of neighbouring traces. Weights are a function of frequency and offset and come from the table of filter weights. Output, depending upon choice of parameters, is either the model of the reject or pass region, or the input minus the model. Residual linear noise was removed up to linear velocities of 3000m/s.

Deconvolution

Whitening of the spectrum to enhance signal resolution was achieved using a 2 window Surface Consistent Spiking Deconvolution with 160ms operators. The parameters were picked from test stacks.

The windows are as follows:

Offset	Window 1 Start	Window 1 End	Window 2 Start	Window 2 End
70m	140ms	2980ms	2750ms	5460ms
200m	180ms	2990ms	2760ms	5460ms
2610m	960ms	3140ms	2950ms	5520ms
5590m	1760ms	3320ms	3190ms	5600ms

Surface Wave Noise Attenuation – Receiver Domain

Surface wave noise was attenuated in the Shot domain by the formation of low-frequency arrays. Given the surface velocity and the frequency cutoff of the noise, Surface Wave Noise Attenuation transforms the data from the time-space domain to the frequency-space domain, where it performs a frequency dependent mix of adjacent traces. At each frequency the number of traces to mix is determined by the relation:

mix = velocity / (frequency * trace spacing)

Frequency components higher than the cutoff frequency remain unchanged. Finally, the data are transformed back to the time-space domain. Filtering with a velocity of 3000m/s over a frequency range of 0-60Hz, blend width 5Hz, removed the most linear noise.

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 optimised stacking velocities are achieved.

Velocities were picked at locations 1000m apart. The regional velocity was used as the guide function and 15 velocity panels covering 85% to 115% of the guide velocities for every location. Each panel consisted of 49 trace CDP stacked sections using the 11 differing velocities.

Residual Statics Calculation and Application

Surface consistent residual statics were calculated and applied using Maximum Power Autostatics.

Pilot or reference traces were formed for a 1000ms time gate following structure by flattening all traces along the autostatics horizon over 21 CDP's.

These traces are summed to form a single pilot trace. Each trace from the active CDP is time shifted relative to the pilot trace and summed with it. The power of the stack is measured for each time shift. This shift-power trace is then summed with other traces having the same shot and receiver in their respective domains.

After the shift spectra has been calculated for the entire line and summed in the Receiver/Shot domains, time shifts are picked at the maximum of the power shift spectra and stored as Static Values.

The pilot stack is updated and the process repeated for a number of iterations.

In this case, calculations were conducted for at least 8 iterations or until the RMS of the change in the computed statics was less than .05.

Velocity Analysis (2nd 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 optimised stacking velocities are achieved.

Velocities were picked at locations 500m apart. The first pass velocity was used as the guide function and 15 velocity panels covering 90% to 110% of the guide velocities for every location. Each panel consisted of 49 trace CDP stacked sections using the 11 differing velocities.

Residual Statics Calculation and Application

Surface consistent residual statics were calculated and applied using Maximum Power Autostatics.

Pilot or reference traces were formed for a 1000ms time gate following structure by flattening all traces along the autostatics horizon over 21 CDP's.

These traces are summed to form a single pilot trace. Each trace from the active CDP is time shifted relative to the pilot trace and summed with it. The power of the stack is measured for each time shift. This shift-power trace is then summed with other traces having the same shot and receiver in their respective domains.

After the shift spectra has been calculated for the entire line and summed in the Receiver/Shot domains, time shifts are picked at the maximum of the power shift spectra and stored as Static Values.

The pilot stack is updated and the process repeated for a number of iterations.

In this case, calculations were conducted for at least 8 iterations or until the RMS of the change in the computed statics was less than .05.

Trim Statics Calculation and Application

CDP consistent residual statics were calculated and applied. Pilot or reference traces were formed for a 1000ms time gate following structure by flattening all traces along the autostatics horizon over 11 CDP's.

FX Deconvolution

Data was sorted to common offset domain and an FX Deconvolution was run on the offset planes. This data was then used in the DMO thread and the Pre-Stack Time Migrated (PSTM) thread.

Pre-stack Scaling

A 500ms AGC was applied to the data.

Kirchhoff Pre-stack Time Migration

A Kirchhoff Pre-stack Time Migration was used to move data to their correct subsurface locations. Stacking velocities were smoothed for PSTM. The migration aperture was 4000m, there was no migration operator stretch mute applied and a migration angle taper of 90 degrees was used.

Velocity Analysis (3rd 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 optimised stacking velocities are achieved.

Velocities were picked at locations 500m apart. The second pass velocity was used as the guide function and 15 velocity panels covering 90% to 110% of the guide velocities for every location. Each panel consisted of 49 trace CDP stacked sections using the 11 differing velocities.

Kirchhoff Pre-stack Time Migration

A Kirchhoff Pre-stack Time Migration was used to move data to their correct subsurface locations. The original PSTM stacking velocities were smoothed for this new run of PSTM. The migration aperture was 4000m, there was no migration operator stretch mute applied and a migration angle taper of 90 degrees was used.

Velocity Analysis (4th 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 optimised stacking velocities are achieved.

Velocities were picked at locations 500m apart. The second pass velocity was used as the guide function and 11 velocity panels covering 90% to 110% of the guide velocities for every location. Each panel consisted of 49 trace CDP stacked sections using the 11 differing velocities.

Normal Moveout Correction

An NMO correction was applied to the data using the velocities determined in the 4th pass of Velocity Analyses. Dynamic corrections are applied to the data using the following formula.

$$TX^2 = T0^2 + X^2/V^2$$

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

Scaling

The data were scaled using a 500ms AGC.

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 Shift

The data were shifted to the final datum of 300m.

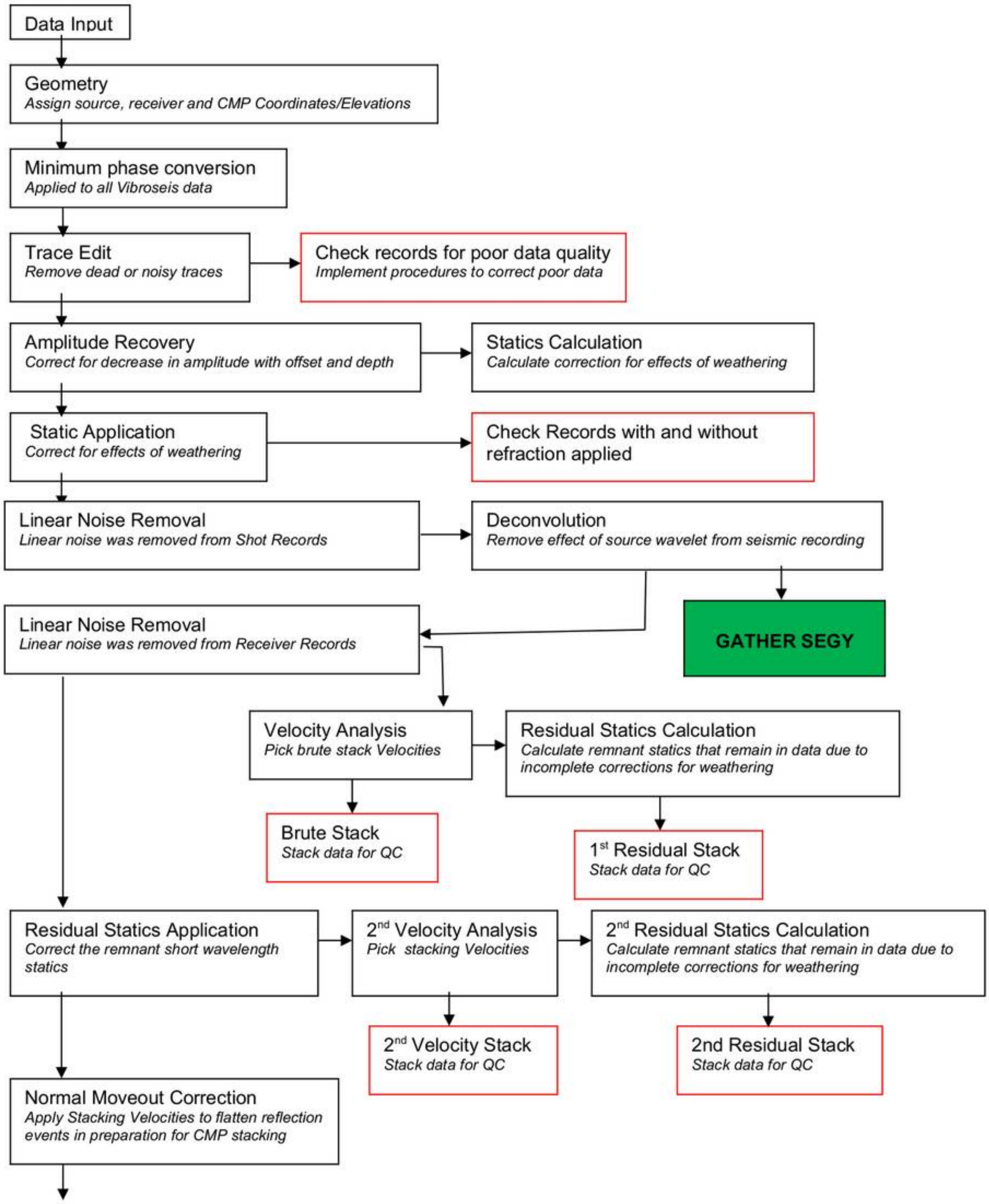
Bandpass Filter

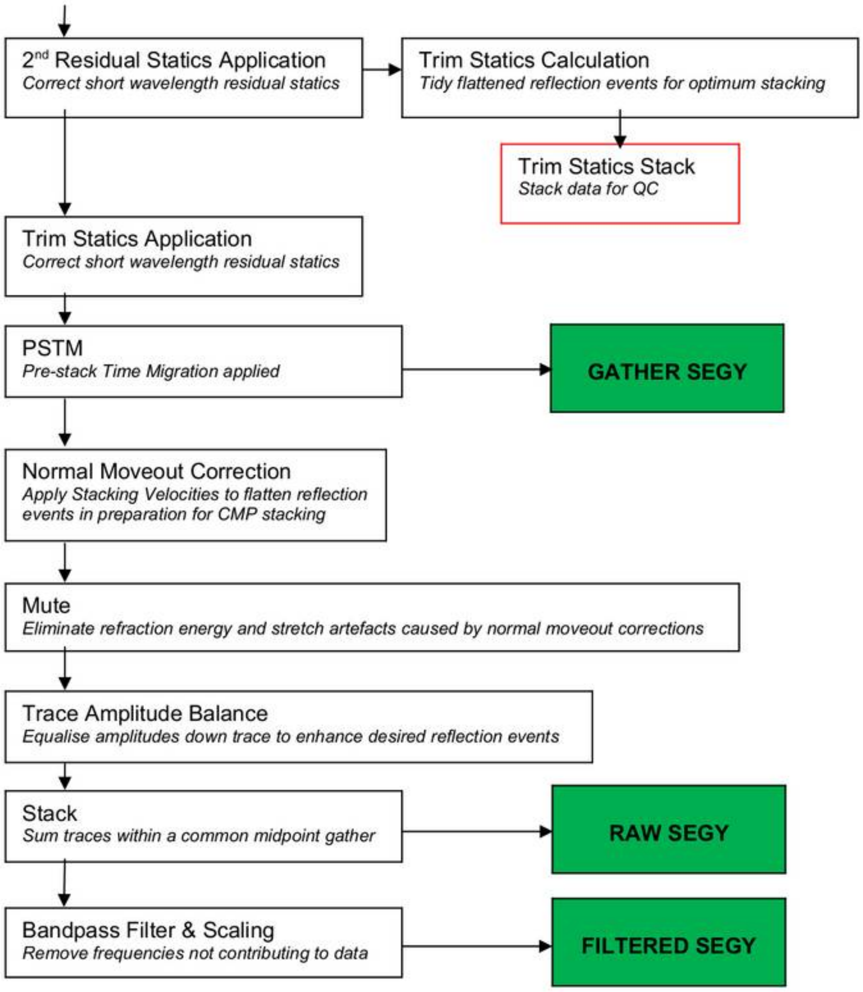
A time-variant bandpass filter was applied to the data.

Scaling

Scaling was performed in 1000ms windows which had a 10% overlap.

PROCESSING FLOWCHART




2nd Residual Statics Application
Correct short wavelength residual statics
Trim Statics Calculation
Tidy flattened reflection events for optimum stacking
Trim Statics Stack
Stack data for QC
Trim Statics Application
Correct short wavelength residual statics
PSTM
Pre-stack Time Migration applied
GATHER SEGY
Normal Moveout Correction
Apply Stacking Velocities to flatten reflection events in preparation for CMP stacking
Mute
Eliminate refraction energy and stretch artefacts caused by normal moveout corrections
Trace Amplitude Balance
Equalise amplitudes down trace to enhance desired reflection events
Stack
Sum traces within a common midpoint gather
RAW SEGY
Bandpass Filter & Scaling
Remove frequencies not contributing to data
FILTERED SEGY

ARCHIVING

An archive hard-drive, PHD/C-333, contains the following processing files: segy files of raw and filtered PSTM Stacks, Deconvolved and PSTM Gathers, ascii files of the static values, CDP-Station relationship, velocity files and a copy of this report. A complete list of digital computer files delivered is provided in the Appendix of this report. The CDP ranges, and corresponding station ranges, are listed below. Note the CDP-STATION relationship in which the CDP value is double the station value.

Line	CDP Range	Station Range
2019-01	200-3555	100-1777.5
2019-02	200-2755	100-1377.5
2019-03	200-5117	100-2558.5
2019-04	200-3525	100-1762.5
2019-05	200-3655	100-1827.5
2019-06	590-5301	295-2650.5

CONCLUSION AND RECOMMENDATIONS

The seismic data of the 2019 Broadmere Seismic Survey recorded in EP187 for Imperial Oil was of a high quality. This was most likely due to the use of Velseis' 80,000lb Renegade vibrators which provided sufficient power for deep signal penetration. While random noise was kept to a minimum, the linear noise present within the shot records was easily removed using linear noise removal in both the shot and receiver domains. The use of Prestack Time Migration (PSTM) was beneficial in providing a good image of very complex geological data.

Should future surveys in such complex data require a more rigorous determination of structure location and depth, it is suggested that Prestack Depth Migration (PSDM) be applied to the seismic data. While PSDM is specifically designed to account for complex seismic raypaths, it is more expensive than PSTM. However, PSDM has been demonstrated to provide a better focused image of complex structures, especially at depth.

APPENDICES

These data were processed by Velseis Processing Pty. Ltd., Brisbane, Australia .

Velseis Processing utilizes ProMAX 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 multi-CPU linux cluster. Data is viewed via X terminals networked to the main system, each terminal has two high definition monitors to enable accurate representation of the digital data in pixel form.

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.