



Seismic Data Processing Report

**MCSAN19 McArthur Basin 2D
Seismic Survey**

**EP161, McArthur Basin,
Northern Territory, Australia**



Date Processed: August 2019
Date Compiled: August 2019
Report Number: VP19-960
Compiled By: Mario Vecchi

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1. Introduction

This report describes the processing of a single 2D land seismic line for *Santos Ltd.* The project was situated within the McArthur Basin, Northern Territory, Australia and the data were acquired in 2019.

The processing consists of 1 line for a total of 9.51 km.

The data were processed by *Velseis Processing Pty Ltd.* in Brisbane, Australia from August 1-30 2019.

The objectives of the processing project were as follows:-

Achieve good imaging of the geological units with good reflector continuity in order to aid in the location for a well.

2.Data Acquisition

2.1. Data Acquisition Parameters.

The data were recorded by Velseis Pty Ltd during July and August 2019.

Source:	Vibroseis
System:	Sercel e-428
Filter:	0.8 Nyquist (at 2ms = 200 Hz)
Sample Rate:	2 ms
Trace Length:	4000 ms
Group Interval:	5 m
Shot Interval:	10 m
Vibrator:	INOVA-Renegade
Number of Vibes:	2 vibrators
Sweep Frequency:	5 – 85 Hz, 0.3 Cosine Taper, Linear Gain
Sweep Length:	16 s
Spread:	Symmetrical Split Spread
Number of Channels:	1902
Near Offset:	2.5 m
Far Offset:	4752.5 m
Array:	3 inline, 1 m interval

2.2. List of Lines Processed

One line totalling 9.51 km was processed.

Line	First Receiver	Last Receiver	Receiver interval(m)	Km
MCSAN19-01	150	2051	5	9.51
				9.51

2.3. Data Quality

The data quality for this area is relatively good although the shot records are contaminated with linear noise artefacts. The quality of first arrivals is generally good and is indicative of a fairly consistent weathering profile.

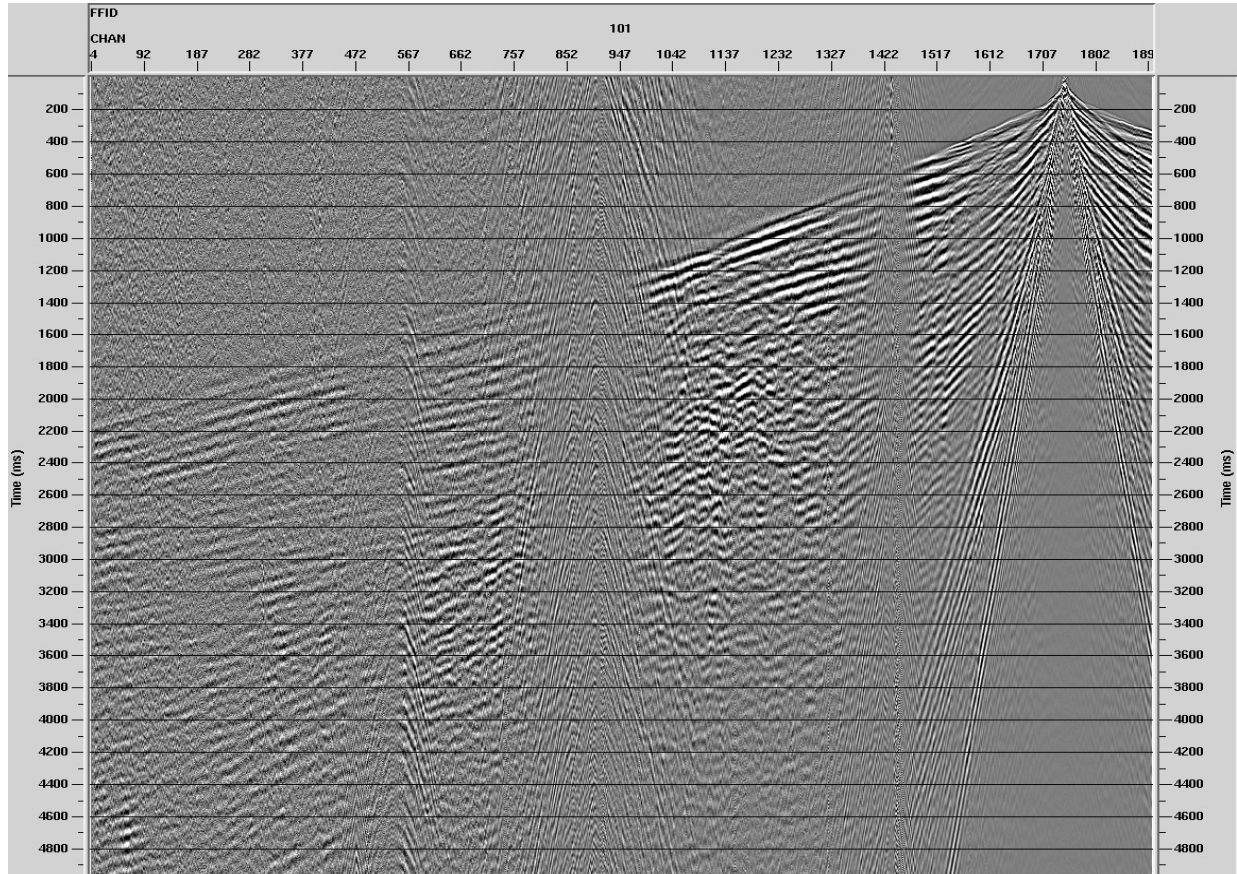


Figure 1. Typical Raw Shot Record

3. Processing Sequence

3.1. Basic Flow Chart

- 1 SEG D Input
- 2 Geometry and Navigation merge
- 3 Trace Edits
- 4 First Break Picking
- 5 Tomographic Statics Datum: 300m Replacement Velocity: 4500m/s
- 6 Minimum Phase Filter
- 7 True Amplitude Recovery: 1/TV2 Spherical Divergence
- 8 1st pass Velocity Analysis: 1km
- 9 1st pass Residual Statics
- 10 Surface Wave Noise Attenuation: 3000 m/s
- 11 Surface Consistent Deconvolution: 120ms operator, double gate window
- 12 2nd pass Velocity Analysis: 0.5km
- 13 AGC: 500ms
- 14 NMO
- 15 Time/Offset Inner and Outer Mute
- 16 Stack
- 17 FX Deconvolution
- 18 Move to final datum
- 19 Kirchhoff time migration using 100% of smoothed stacking velocities
- 20 Time-variant bandpass filter
- 21 AGC: 1000ms

3.2. Parameters

The line was processed with the following parameters:

Sample Rate:	2 ms
Trace Length:	4000 ms
Datum:	300 m

Field polarity has been maintained throughout sequence. Positive amplitude equals an increase in acoustic impedance.

3.3. Details

Reformat

Input data were reformatted to ProMAX internal data format.

Geometry

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

The coordinates are referenced to GDA94 Zone 53.

Trace Edit

Bad and noisy traces were removed from shot records interactively.

First Break Picking

First breaks were picked on offsets up to 1000m.

Tomographic Statics

Tomography was modelled on offsets 0-1000 m to a depth of 300 m with 40 m node spacing and a velocity range of 300 – 6000 m/s. Statics were calculated to a 300 m final datum with Replacement Velocity of 4500 m/s.

Minimum Phase Filter

A filter was created to convert the data from zero to minimum phase. The additive noise factor used in deriving the filter was 0.1%.

Gain Recovery

A spherical divergence correction with spreading factor $1/TV^2$ was applied to all records. The regional velocity function was:-

0 ms – 2800 m/s ; 500ms – 3500m/s ; 1000ms – 4000m/s ; 2000ms – 4500m/s ; 4000ms – 5000m/s

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 1000 m intervals using constant velocity panels. An initial guide function was used to aid picking. The guide function taken from the velocities used on original processing.

Spiking Deconvolution was applied prior to velocity picking and 1st pass residual statics calculation.

Residual Static Calculation and Application (1st Pass)

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

Pilot or reference traces were formed for a time gate following structure by flattening all traces along the autostatics horizon over a smash of 11 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 0.05 ms. The maximum permitted absolute static value was 20 ms.

Linear Noise Attenuation

Surface Wave Noise Attenuation was applied to attenuate ground roll up to 3000 m/s.

Deconvolution

Surface consistent spiking deconvolution was applied. The following parameters were used:

Operator length: 120 ms
 White noise level: 0.1%.
 Number of iterations: 3
 Design Window: Double gate

Velocity Analysis (2nd Pass)

Velocities were picked at intervals of 500 m. Each panel consisted of 13 CDP's stacked over 15 velocity functions varied by percentage, centred around the 1st pass velocity function.

Normal Moveout

An NMO correction was applied to the data using the post migration velocities. 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

Trace Mute

Time/offset inner and outer mute was applied, equivalent to angles of 5 to 35 degrees.

Gain

500ms AGC scaling was applied.

CDP 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; scalar normalisation factor 1.

Shift to Final Datum

The data were shifted from surface to the final datum of 300m

FX Deconvolution

FX Deconvolution was applied to the data in order to remove random noise prior to migration

Kirchhoff Time Migration

The data were migrated using a kirchhoff Time Migration algorithm with 100% of smoothed stacking velocities

Bandpass Filter

A time variant Ormsby zero phase bandpass filter was applied to remove high and low frequency noise. The filter frequencies were:-

Time (ms)	Filter (Hz)
0-400	8-12-70-80
600-2200	8-12-50-60
2400-4000	10-15-50-60

Scaling

A 1000ms AGC scalar was applied to the data

SEG Y Output

Two versions of Migrated Stacks were output to SEG Y: Raw and Filtered.

Archived stacks are maintained at original field polarity and are at final datum with an additional bulk shift of 100ms applied.

3.4. Geometry & Navigation Trace Headers

The navigation coordinates were provided by Santos Ltd. These XY coordinates have been loaded to the SEG Y trace headers of the final stacked data and the archived gathers.

Additionally, CDP coordinates were output to Ascii format, including CDP/SP relationship.

GDA94 Geodetic Datum. Zone 53

Stack Bytes locations

SP:	17 (4 byte integer)
CDP X (m):	73 (4 byte integer)
CDP Y (m):	77 (4 byte integer)
CDP Elevation (m):	221 (2 byte integer)
Final Datum Static (ms):	233 (4 byte floating point)

3.5. Quality Control

CDP stacks were produced and quality control was carried out after each stage of processing for the line using interactive trace display.

3.6. Conclusions

Statics proved to be vital to the improvement in the seismic section obtained during the processing. The near surface geology required the use of Tomographic Statics to resolve structure more accurately.

Velocity picking was also of vital importance during processing – the shallow velocity gradient in this area results in the data being very sensitive to RMS stacking velocities.

There was good signal present within the data and any future processing should concentrate on noise attenuation, testing new processing techniques as they become available.

4. Final Archive

The following final products have been produced:

On a Thumb-drive (USB/C-317) the following:

1. Segy Migrated Raw Stack
2. Segy Migrated Filtered Stack
3. Segy RMS velocities at surface datum
4. ASCII files of the above Velocity fields
5. ASCII Statics
6. ASCII CDP Co-ordinates
7. Processing Report in pdf format.

Archive data were delivered to :

Kristina Dukic
Santos Ltd.
Level 1
60 Flinders Street
Adelaide
SA 5000

5. Appendices

5.1. Typical Seismic Section Display

Line MCSAN19-01 before and after processing.

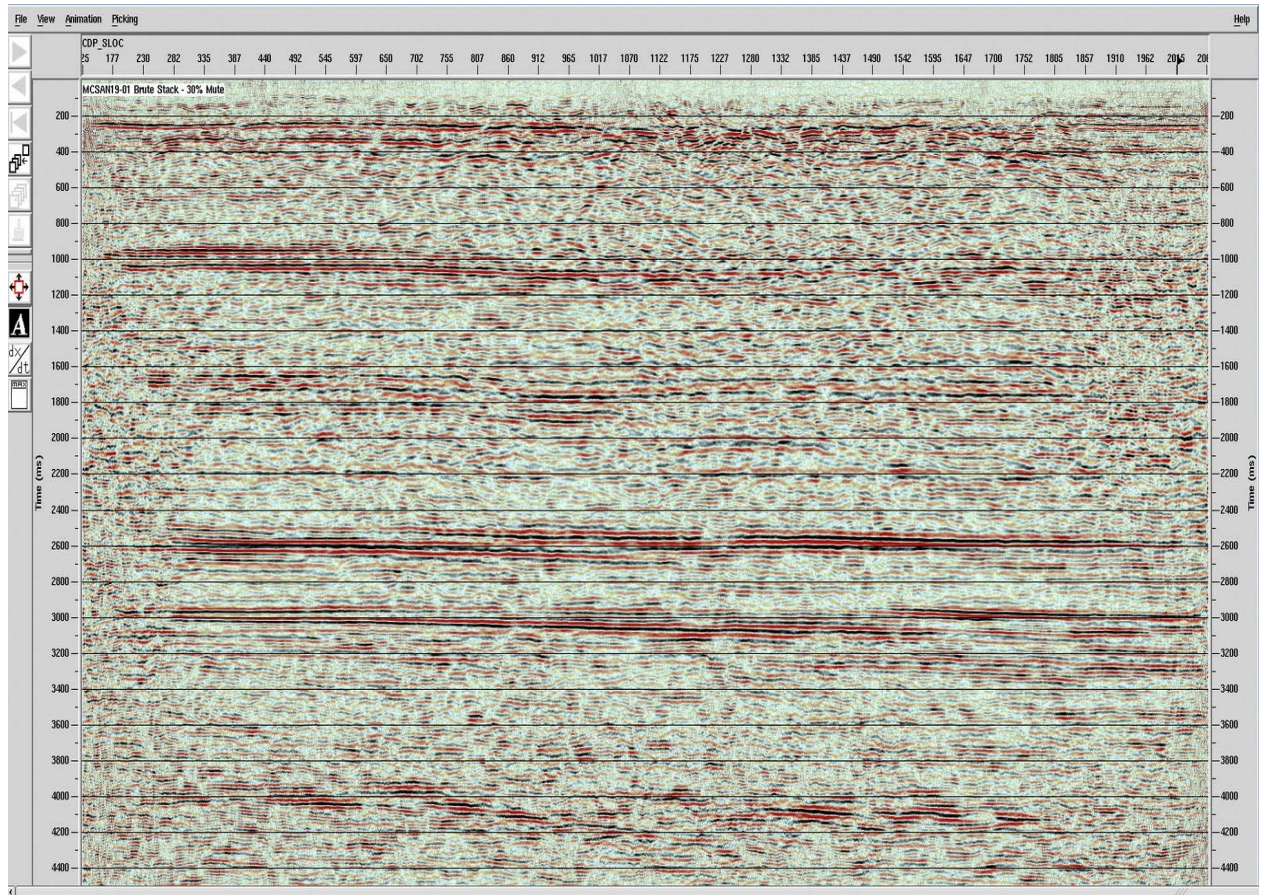


Figure 2. Brute Stack.

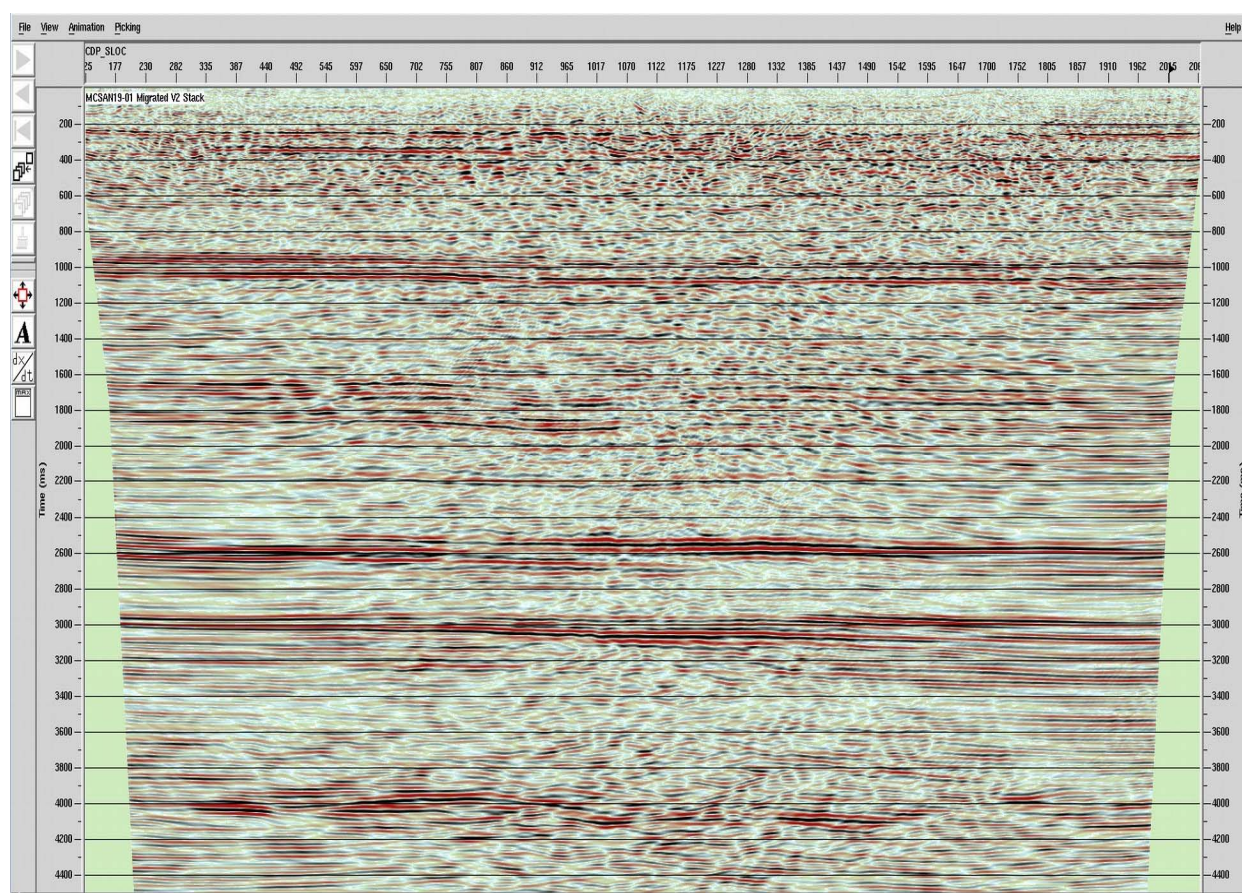


Figure 3. Filtered Migrated Stack.

5.2. Segy EBCDIC trace header

Final Migrated Stack:

C 1 SANTOS LTD. VOLUME: MIGRATED V2 STACK - TOMOSTAT, MUTE, FILTERED & SCALED
C 2 SURVEY: 2019 McARTHUR 2D AREA: McARTHUR BASIN
C 3 LINE: MCSAN19-01
C 4 CDP: 250-4137 STATION: 125-2068.5
C 5 BYTES: STN 17, CDP 21;CDPX 73,CDPY 77(4I),CDP ELEV 221(2I),DTM STAT 233(4R)
C 6 SAMPLE INTERNAL: 2ms DATA LENGTH: 4800 ms
C 7 PROCESSING DATUM: 300M. SURVEY DATUM: GDA94 ZONE 53
C 8 PROCESSING: VELSEIS PROCESSING BRISBANE AUSTRALIA, AUGUST 2019
C10 INPUT TO INTERNAL PROMAX FORMAT 2MS 5S
C11 EDIT NOISY TRACES AND BAD RECORDS
C12 GEOMETRY APPLICATION: ASSIGN SHOT AND RECEIVER COORDINATES
C13 MINIMUM PHASE FILTER
C14 GAIN RECOVERY: SPHERICAL DIVERGENCE CORRECTION $1/(TIME*VEL**2)$
C15 TOMOGRAPHIC STATICS STATICS, 300M DATUM 4500M/S REPLACEMENT VELOCITY
C16 VELOCITY ANALYSIS: 1.0 KM
C17
C18 SWNA
C19 SURFACE CONSISTENT DECON, DOUBLE WINDOW
C20 RESIDUAL STATICS
C21 VELOCITY ANALYSIS: 0.5 KM
C22 NMO. HAND PICKED OUTSIDE AND INSIDE TRACE MUTE
C23 AGC 500ms
C24 STACK; FX DECONVOLUTION; 500MS AGC; KIRCHHOFF MIGRATION
C25 TIME VARIANT BANDPASS FILTER
C26 AGC 1000 MS
C27
C28
C29
C30
C31
C32
C33
C34
C35
C36 SHIFT TO FINAL DATUM + BULK SHIFT 100 MS (TIME ZERO = -100)
C37 SEG Y OUT BYTES:
C38 STATION 17; CDP 21, CDPX 73,CDPY 77 (4I)
C39 CDP ELEV 221(2I) DATUM STAT 233(4R), TIME ZERO 105 (2I)
C40 END EBCDIC

5.3. Personnel involved in processing

The data were processed by *Velseis Processing Pty. Ltd.*, Brisbane, Australia, August 2019

Mario Vecchi	Processing Manager – New Ventures
Natascha Rahn	Technical Assistant

<http://www.velseis.com/>

Santos Ltd. personnel:

Kristina Dukic	Senior Geophysicist
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<http://www.santos.com/>

5.4. Software

Velseis Processing utilizes ProMAX 2D processing software. This is an interactive system allowing the user to view data processing at each stage, producing a final result of the highest quality. ProMAX version 5000.10.0.2 was used for this data processing.

The software executes on a multiple node Linux cluster.

Velseis Processing is committed to offering a premium product. The software development undertaken by ProMAX results in processing algorithms which are state of the art.

For Pre-stack time migration, *Velseis* uses *Tsunami* software.

<http://www.tsunamidevelopment.com/index.php>

5.5. 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.

