PROCESSING REPORT

FOR

GREAT SOUTH LAND MINERALS LIMITED

TASMANIAN BASIN
TASMANIA
SEL 13/98

2001 SEISMIC DATA PROCESSING

COMPILED BY: -

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1.0   INTRODUCTION

The 2001 Tasmanian processing project involved the processing of 662.5 km of seismic data recorded by Trace Terracorp over the period of March to August 2001.

Processing was performed over the same period and into September.

No seismic data had been acquired in this area previously. The data was recorded as 240 trace off road and 360 trace on road. In June, the off road acquisition was cancelled due to the rain flooding off road access and the project was finally halted just short of the target due to snow.

Processing of the data was delayed due to the final survey not being made available until approximately two weeks after the final line was recorded.

2.0 ACQUISITION PARAMETERS

DESCRIPTION	DETAILS
Data recorded by:	Trace Terracorp
Date recorded:	March to August 2001
Seismic source:-	Vibroseis Litton LRS-15
Sweep length:	8 seconds
Sweep frequency:	6 - 80 Hz
No of sweeps/VP	2
VP interval	25 m
Vibe spacing	12.5m
Source array length	37.5m
Sweep type	Linear
Recording system:-	I/O System Two
Format:	IEEE SEGD
Record length:	14 secs
Sample interval:	2 ms
Low cut filter	5.5 Hz
High cut filter	Out
Receivers:-	
Geophone type:	SENSOR SM4 10 Hz
Geophone array:	12 phones inline over 25 m
Group interval	25 m
Number of groups:	240 or 360
Spread type	Split spread
Spread 360 channel	4487.5-12.5-x-12.5-4487.5 m
Spread 240 channel	2987.5-12.5-x-12.5-2987.5 m

The field data were supplied to Robertson Research Australia as SEGD format accompanied by observers' logs and field survey on floppy disk.

3.0   SURVEY MAP

4.0 LIST OF PROCESSED LINES

Line	SP Range	Length (Km)
TB01-PG	101- 2382	59.65
TB01-PB	100- 3816	92.925
TB01-TB	100- 1877	44.45
TB01-PA	106- 344	6.225
TB01-PD	142- 620	11.975
TB01-PC	100- 562	11.575
TB01-PF	155- 1526	34.30
TB01-PJ	100- 1000	22.525
TB01-PM	101- 1036	26.40
TB01-PT	101- 1030	23.875
TB01-PU	355- 1512	29.475
TB01-PW	370- 1059	18.525
TB01-ST	100- 2500	60.025
TB01-TA	101- 570	11.775
TB01-TC	100- 1484	34.625
TB01-TD	107- 712	15.325
TB01-TE	100- 1120	25.525
TB01-SC	140- 396	7.325
TB01-SD	110- 420	7.775
TB01-SA	100- 842	18.575
TB01-SB	146- 700	13.875
TB01-TH	100- 2810	67.775
TB01-TI	100- 820	18.025

Total: 662.525

5.0   PARAMETER TESTING

An overall test sequence was established during the processing of lines TB01-PA because it was the first line in and later on line TB01-PB as the data quality there ranged from good to fair. A comprehensive suite of tests was conducted which included true amplitude recovery, deconvolution, D.M.O., mutes, noise attenuation, migration, taup, fxdcn, spectral balance and post-stack filter and scaling.

The adjustment and finetuning of the parameters to achieve the final processing sequence was discussed between Mike Swift representing Great South land Minerals and Mick Curran representing Robertson Research Australia.

These parameters were designed to provide the best possible result in relation to continuity and signal to noise.

6.0   PROCESSING DESCRIPTION

6.1   PROCESSING SEQUENCE DIAGRAM

TRANSCRIPTION OF SEGD DATA TO ROBERTSON INTERNAL FORMAT

CONVERSION TO MINIMUM PHASE

AMPLITUDE RECOVERY

GREEN MOUNTAIN REFRACTION STATICS FLOATING DATUM CORRECTION

CDP SORT

16 MSEC GAPPED DECONVOLUTION

PRELIMINARY VELOCITY ANALYSIS

SURFACE CONSISTENT RESIDUAL STATICS

SECONDARY VELOCITY ANALYSIS

DMO

FINAL VELOCITY ANALYSIS

NMO CORRECTIONS

MUTE

FLOATING DATUM TO DATUM CORRECTION

TRACE SCALING

CDP CONSISTENT RESIDUAL STATICS

CDP STACK

SPECTRAL BALANCE

FINITE DIFFERENCE MIGRATION

BAND PASS FILTER

SCALING

TAUP

6.2   TRANSCRIPTION

Field data was received on cartridge tapes in correlated Trace SEGD demultiplexed format. This was transcribed to Robertson's internal trace sequential 16 bit integer format. The sample interval remained unchanged at 2 ms.

6.3   GAIN RECOVERY

Gain recovery is used to compensate for spherical divergence and absorption losses. A gain curve of 3.0t + 26 log (t) was chosen and applied to all traces from 0 to 6 seconds.

6.4   REFRACTION STATICS

Refraction statics are used to help reduce the structural biases introduced by weathering anomalies. Here refraction breaks were picked using the "Green Mountain" refraction statics package. The "Green Mountain" package then used the measured travel time from shot to receiver to extract information about the near surface layer. Over many shots and many receivers, it is determined whether the ray paths are direct arrivals or refracted along one of the layers modelled by the package. The STV solution was used here. A model is developed to estimate the velocities and the delay times for each refractor under each source and each station.

The Green Mountain STV solution is summarised by the following paragraph from the Green Mountain manual.

"STV is based on the Hollingshead technique of refraction statics. Extended delay time curves are calculated for each refractor for both the shots and receivers. In essence, the receiver delay time curve is a single source gather whose first arrivals are all from a single refractor. Correspondingly, the resultant shot delay curve is a single receiver gather whose first arrivals are from sources transmitting energy in that refractor. From these extended delay time curves, a midpoint curve between the source and receiver delay time curves is extracted. The slope of the midpoint curve measures the relative velocity variations and sufficient fold for overlapping arrivals, STV produces excellent results."

On this data set a one-layer model was used with a constant weathering velocity of 1800 m/s. There was a variable sub weathering velocity of between 3000 and 6000 m/sec and a weathering depth up to 100 m

All statics were tied at intersections within this project and indeed, in nearly all cases, the differences were very small which indicates the reliability of the refraction static solution.

6.5   CDP GATHER

Traces from common depth points were collated.
All of the lines were processed as crooked.

Robertson uses the "Radar" method to bin the midpoints and construct the resultant CMP line. The CMP line is steered through the densest concentration of midpoints with controls over the relative contributions of near and far offsets. The CMP line is then divided into equally sized bins (12.5 m bins in our case) being the new CMP interval. Binning results in individual midpoints being assigned to their nearest bin. Midpoints outside specified maximum distances from the bin centres can be dropped. Where the seismic line is crooked the resultant best fit CMP line will not necessarily be a vertical cross section of the ground because in the shallow data the midpoints that contribute to it will have come from nearer the seismic line than with deeper far offset contributions. This will make it difficult to tie with intersecting lines. Also because the actual midpoint locations are distributed over an area they contain information about dip outside the plane of the CMP line.

As this is an area that is very prone to flooding, there were numerous occasions when the shot points had to be offset from the line or even skipped. The vibrators were laterally offset from the line by up to 100 m due to obstructions such as streams, rivers, and soft ground.

6.6   DECONVOLUTION

Testing of deconvolution parameters was conducted on line TB01-PG. To obtain the optimum stack response one pass of velocity analysis and residual statics were first applied to the line prior to testing. Various gaps were tested along with single window and two window trace-by-trace deconvolution. Surface consistent deconvolution was tested for comparison. Deconvolution derivation and application windows were designed from shot records. Stack panels and their autocorrelations were displayed both unfiltered and filtered (filtered to the source bandwidth).

We felt that there was not much between 8 msec and 16 msec gap deconvolutions. The client selected a 16 msec gap with two design windows. There was not enough improvement in the surface consistent deconvolution to warrant its use.

Robertson's deconvolution routine is based on the conventional Wiener-Levinson least squares minimum phase inverse filter method. For trace by trace deconvolution a unique operator was designed from the autocorrelation of each trace and applied to each trace.

Bandlimited deconvolution and minimum phase
One of the requirements for Wiener-Levinson deconvolution is for the input data to be minimum phase. With vibroseis data the effective source pulse that is sent into the earth is the zero-phase autocorrelation of the sweep. After convolution with the earth's reflectivity series and recording equipment, the phase of the recorded data is mixed phase.
To precondition vibroseis data for deconvolution the data is resampled in the frequency domain over the sweep bandwidth. The deconvolution thus sees only the frequencies present in the sweep. This solves the problem of the bandlimited nature of vibroseis data and what to do with frequencies that are outside of the sweep bandwidth. The wavelet now becomes causal with minimum phase properties and thus satisfies the conditions of deconvolution. After deconvolution the data is resampled back to its original frequency range.

Parameters used throughout were 120 msec operator, 16 msec gap and 1.0% white noise.

6.7   PRELIMINARY VELOCITY ANALYSIS

Preliminary velocity analysis was performed at approximately 2 km intervals. The CVS stack panels were run over 20 cdps with a constant velocity ranging from 1500 to 8000 m/sec at 100 msec intervals.

6.8   RESIDUAL STATICS

Robertson's "NEBULA" package was used to determine surface-consistent residual statics. The following is a brief description of how NEBULA works:
A pilot trace is constructed at each CMP using a tapered mix of adjacent stacked traces from within a selected time window. The pilot trace is then cross-correlated with individual traces within each CMP over the specified time window. To decompose the static errors into their source and receiver components the cross-correlation functions for each trace are summed for each source and receiver component. The resultant cross-correlation function is then resampled to 0.25 ms. The peak of each summed cross-correlation is used to determine the static for each source and receiver. Shifts from anomalous cross-correlations outside of a specified maximum time shift are given low weighting in the decomposition but are still time shifted. If there is more than one valid peak, the peak with the smallest static shift is chosen.

Three iteration passes were used with statics generated in previous iterations being applied to the data for the current iteration. The pilot trace correlation was started from alternate ends of the line on successive iterations in order to ensure penetration of a reasonable pilot trace into poor signal-to-noise areas.

The derivation widow chosen was based on geological structure, area of interest and signal to noise ratio. In our case the window length varied from line to line. The traces were given the following weighting: 85-90-95-100-95-90-85 %. Maximum static time shift was set at $\pm$ 25ms. Traces with correlation peaks outside this range were given a weighting of 25% although still included in the iteration process. Where there were problems with resolving short wavelength anomalies a larger pilot was tried, often including up to 15 traces in the pilot.

The distribution of the total source and receiver residual statics was displayed above the data on the section. Analysis of the residual static profiles provides several important quality control checks:
- Accuracy of picking the Green Mountain refraction statics.
- Checking for cycle skips. These were most likely to occur where there were large source point skips and the residuals followed the wrong trend. These can be seen by the residual profiles departing from the mean and then aliasing. A dislocation in the main horizons can usually be seen.
- Checking for incorrect recording geometry used in the field (different to that stated in the observers' logs). In this case the source and receiver residual statics would be separated. Checking the coupling between the geophones and the ground. Poorly planted geophones or geophones subjected to excessive noise will display erroneous residual static values vastly greater than surrounding values. Stations displaying excessive residual statics were flagged dead.

Parameter summary:

Correlation pilot	7 CDP sum
Number of iterations	3
Analysis window	varied from line to line
Maximum allowable static	30 ms

6.9   SECONDARY VELOCITY ANALYSIS

Secondary velocity analysis was performed at approximately 1 km intervals. The CVS stack panels were run over 20 cdps with a constant velocity ranging from 1500 to 8000 m/sec at 100 msec intervals.

6.10   DIP MOVEOUT

Dip Moveout is a partial pre-stack migration which moves reflectiion points to their zero offset positions. It is used to correct for moveout caused by structural dip as opposed to NMO which assumes flat horizons and corrects for moveout due to offset. Steeply dipping data and fault planes are better imaged after DMO.

Input to DMO on this project was NMO corrected CMP gathers using second pass velocities and with oness of residual statics applied. A mild mute and a 800ms removable AGC (to equalise the traces) were also applied before DMO.

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 velocity functions derived from analyses of data processed through DMO are essentially independent of structure and are therefore well suited to direct utilisation in processes such as migration, depth conversion and interpretative studies.

DMO was tested on line TB01-PG. Gathers were first sorted into 120 or 180 offset ranges in increments of 25 m. New offsets corresponding to bin centres from 12.5m to 2987.5 m (240 trace) or 4487.5 m (360 trace) in increments of 25 m were assigned. This involved a partial stacking of 2 for each offset range. Partial stacking of 2:1 is often advisable with land data due to the non-uniform range of offsets and azimuths due to crooked line binning, shot skips and offset shots.

Two methods of DMO were tested, the Deregowski (Kirchhoff) method and the Hale method. Deregowski DMO uses integral (Kirchhoff) methods by integrating along diffraction curves in the time domain, each element of a reflection being treated as a portion of a diffraction. This option is basically a low dip correction. It ensures that the amplitudes of horizontal events are preserved. The Hale method is recommended for data that contains steeply dipping complex structures and areas of complex faulting. It is better at preserving the amplitudes of steeply dipping events and is performed in the FK domain.
Deregowski DMO was chosen in preference to the Hale DMO because, although the datasets looked similar, the Deregowski algorithm produced less noisy data at deeper times.

A useful by-product of DMO is its ability to attenuate steeply dipping noise trains such as residual ground roll and out-of-the-plane diffractions. A cut-off velocity of 1800 m/s was used to define the reject zone. This amounted to an attenuation of noise trains with dips greater than ± 8 ms/trace.

6.11 FINAL VELOCITY ANALYSIS

Final velocity analysis was performed at approximately 0.5 km intervals. The CVS stack panels were run over 20 cdps with a constant velocity ranging from 1500 to 8000 m/sec at 100 msec intervals.

Velocities in this survey were found to vary quite significantly along the lines. Hence there was a need to sample them every 500 m for the final velocity appraisal.

6.12 NMO CORRECTION

NMO correction was performed using the picked final velocity functions.

6.13 PRE-STACK SCALING

Traces need to be equalised prior to stack to compensate for the loss of amplitude with distance from the source point and for variable ground conditions that result in weak signals being detected at the geophones. The same pre-stack equalisation using 500ms AGC (derived below the mute zone)

6.14 MUTE

A post-NMO outer trace mute was applied to remove any coherent noise on the gathers and to reduce contamination by the stretching effect of NMO on the far offsets. They were spatially variant.

Outer trace mute:	offset (m):	200	300	1200	4000
	time (ms):	0	100	450	1000

The above mute was used for most of the survey. In really poor data regions, the mute was opened up at the far offsets to allow more data in. This proved most effective in some regions.

6.15   CORRECTION TO DATUM

Refraction statics are applied just prior to stack. This corrects the data from floating datum to final mean sea level datum. To avoid losing data above datum all datasets were time shifted by 700 ms prior to static correction to datum. A new time origin of -700 ms was established.

6.16   CDP TRIM STATICS

CDP Trim Statics were run to optimise trace alignments within a CDP gather. The traces within a CDP gather are cross-correlated against a smoothed version of the corresponding pilot trace. The smoothed pilot trace is the sum of the smash number of traces (7). The cross-correlations are used to pick time shifts which will best align the CDP gather traces with the reference stack trace.

6.17   COMMON DEPTH POINT STACK

The traces within each common depth point gather were summed using 1/(sqrt n) stack fold compensation.

Nominal recording fold was 120 or 180. This was reduced where there were shot skips and where erroneous residual static values cast into doubt the validity of certain receiver stations and source profiles. Increased fold occurred during crooked line binning around the points of maximum curvature.

6.18   SPECTRAL BALANCE

Spectral balance is a zero phase deconvolution after stack. The frequencies for the desired output were 10 - 60 Hz. This proved very effective in equalising the vast contrast between the good and poor data regions.

6.19   MIGRATION

The Finite Difference method of wave equation migration was used to migrate the datasets. This method uses the downward continuation technique to map the reflectors to their true time position. With downward continuation the geophones are effectively lowered gradually downward through the earth in a series of depth steps. It is performed in the time domain. As there were steep dips of diffraction curves in the data the 65 degree second order solution was used. This is used where there is good signal to noise and reflection continuity and if steep dip response is important. The depth step used was 20 ms.

Migration was tested on lines TB01-PG. Migrations using varying percentages of the smoothed stacking velocities were tested. Velocities tested were 80%, 90%, 100%, and 110%. A final migration velocity of 90 % from zero to one second, slowing to 80% at 2 seconds and continuing at 80% to six seconds was chosen.

6.20 BAND PASS FILTER

Unwanted noise that lay outside the frequency range of the desired reflection and diffraction data were removed by the application of a zero phase time variant Ormsby filter. A final time variant filter was selected from stack panel bandpass filter tests carried out on raw stacks on lines TB01-PG, TB01-PB and TB01-PA.

Filters used were   10 to 70 Hz   at   700 ms
                                              10 to 60 Hz   at 1300 ms
                                              10 to 40 Hz   at 3700 ms

6.21 SCALING

Dual window AGC with gate lengths of 1000 and 400 msec performing a 50% application was chosen for this data. The dual window AGCworks by employing the following method:
For each sample a model is derived for both long and short windows. A model amplitude scalar is then derived from whichever of the above models gives the greater mean. A percentage of this scaling is used in application to preserve some of the original amplitude trends in the data.

6.22 TAUP FILTER

This is a time and space variant multichannel dip and coherency filter. It attenuates the random noise and enhances coherent signal within a range of specified dip angles. Filtering is done in the Taup domain. There is also an option of a mix back, where a percentage of the   unfiltered input is mixed with the output data. A mix back of 70% was chosen for this data.

7.0   FINAL DATA DISPLAYS & ARCHIVES

7.1   ARCHIVES

The final migrations and final stacks for each line were written to CD in SEGY format for workstation interpretation and archival.

7.2   FINAL DISPLAYS

Hard copy displays of final stacks and final migrations were produced as follows:

Horizontal Scale:	40.64 TPI	1:20000
Vertical Scale:	10 cm / sec	
Horizontal Scale:	40.64 TPI	1:40000
Vertical Scale:	10 cm / sec	alternate traces plotted

Plotting polarity : a negative number on tape was represented by a trough.

7.3   DATA DISPOSITION

To GSLM and Applied Geothermex (Mike Swift)

1. Paper prints of final stacks and final migrations 1: 20000 and 1: 40000
2. CD archives of final stacks and final migrations
3. Processing report

Line summary sheets and chaining maps were sent to Trace Terracorp in Perth.
At the time that this report was written, the field tapes, observers logs and support data have yet to be returned to GSLM.

8.0   CONCLUSIONS

After initial delays with survey information, the processing was completed without too many complications. The crookedness of some of the lines made it a little more difficult to place the cdp tracks for sorting and the picking of the first breaks for the static solutions. Once this was achieved, processing continued relatively smoothly.

Being a new area with no previous seismic, there was little experience to draw upon and the advice from Mike Swift was most helpful. The geology in the area is quite diverse and resulted in varying levels of data quality from line to line.

Processing of the project commenced in April 2001 and final displays were produced in September 2001.

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