OFFICER BASIN SEISMIC PROCESSING REPORT

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EXECUTIVE SUMMARY

This record describes the seismic processing for the Officer Basin seismic data acquired as part of the NGMA by the Australian Geological Survey Organisation (AGSO) during the 1993. The goals of the seismic acquisition in the Officer Basin were to provide a regional network of traverses to develop a cross section and evaluate basin morphology. The acquisition was designed to image the basin fill, with the aim of extending the stratigraphic control in the eastern Officer Basin into the central portion of this basin.

The survey acquired data along five lines in the Officer Basin. Products of this survey include migrated final stack sections of the sedimentary sequence (3 seconds two way time), and final stack sections of the deeper seismic data (20 seconds two way time). The processing sequence of this data is outlined in this report.

This survey in the central Officer Basin provides data for the understanding the structure and stratigraphy of the central Officer Basin's structure, and will assist the future exploration for mineral and petroleum resources in this little known and remote region.

CONTENTS

AVAILABLE PRODUCTS

Paper or Film sections available from MPSR sales:

Migrated final stacks of the sedimentary section:

Line 1 Line 3 Line 4 Line 5 Line 6

20 s Stacks:

Line 1 Line 3 Line 4 Line 5 Line 6

Digital data available from the MPSR sales:

Edited shot gathers, migrated final stack, 20 s stack for the following lines are available in SEGY format on 3480 cartridge:

Line 1 Line 3 Line 4 Line 5 Line 6

Written reports

Pre survey reports:	BMR Record 1991/63	Proposal - Lindsay et al.
	BMR Record 1991/87	Cook Tests - Leven et al.
	AGSO Record 1992/89	Proposal - Lindsay et al.
Operations report	AGSO Record 1995/	Barton et al.
Processing report	AGSO Record this report	Leven & Owen (this report)

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1. INTRODUCTION

The Officer Basin project was a co-operative project jointly conducted by the Australian Geological Survey Organisation (AGSO) and the South Australian Department of Mines and Energy (DMESA) as part of the National Geoscience Mapping Accord (NGMA). The background and aims of this project are set out in the two Officer Basin proposals (Lindsay et al., 1991, 1992).

The goals of the seismic acquisition in the Officer Basin were to provide a regional network of traverses to develop a cross section and evaluate basin morphology. The acquisition was designed to image the basin fill, with the aim of extending the stratigraphic control in the eastern Officer Basin into the central portion of this basin.

1.1 Field Trials

Preliminary field trials were conducted in 1991 on the Nullarbor Plain (Leven & Barton, 1992) to assess the feasibility of recording seismic data. The surface cover of most of the Eucla Basin is the karstic weathered Nullarbor Limestone which presents significant technical difficulties for recording of seismic data. The results of these trials near Cook, S.A., indicated that only poor quality data would be obtained through the Nullarbor Limestone. The design of the 1993 seismic survey took into account the results of the 1991 field trials.

1.2 Operations

The line clearing operations commenced simultaneously on Line 1 and Line 5 in March 1994, and drilling and recording on Line 1 commenced on 13th May. Recording finished on Line 6 on 7th October, 1994. The remoteness of the area and the distances over poor roads to any source of supply or support infra-structure made this survey one of the most logistically difficult seismic surveys undertaken by BMR/AGSO. Further details of the operations can be found in the operations report (Barton et al., 1994).

1.3 Processing

Processing of the data acquired during the Officer Basin survey was undertaken at AGSO using Disco software on a Convex 3420 CPU from August 1993 to July 1994.

2. SURVEY PARAMETERS AND FIELD DATA

Survey parameters:

Recording unit:	Sercel SN368
Source:	Explosive ICI Powergel
Nominal shothole depth:	40 m (varied according to drilling conditions)
Average shot interval:	240 m
Geophone type:	GS20D - 8 Hz
Geophone pattern:	16 geophones at 2.5 m interval - 4 series of 4 parallel
Group interval:	40 m
Spread:	2380 - 20 : 20 - 2380 m
Recording format:	SEGD multiplexed 6250 bpi 8 inch 9 track reels
Number of channels:	120 data + 4 aux.
Fold:	10

Record Length:	20 s
Sample rate:	2 ms
Field filter:	8 Hz @ 18 dB/oct; 178 Hz @ 18 dB/oct Notch out

3. FIELD DATA PROCESSING

3.1 Demultiplexing and geometry definition

Field data recorded in SEGD format on the Sercel SN368 seismic acquisition system were demultiplexed to SEGY format in the field using the Vista PC-based seismic processing system. Header information giving geometry of the spread from the SEGD records was captured during demux, and cross-checked with the observer's and shooter's logs. Inline and perpendicular offsets were checked against field monitors and questionable offsets checked physically on the seismic traverse. Uphole times were picked in the field, and uphole velocities calculated for quality control of the data. The SEGY data were written to 9-track tape for shipment from the field back to AGSO. Four second shot records were spawned for field processing and one second shot records were spawned for translation into CPT format as input into the refraction statics Green Mountain package.

3.2 Geometry and surveying data

The cross checked SEGD header information was loaded into the SEGY trace headers, and also used as the geometry database for the Green Mountain (GMG) refraction statics program. Surveying data was loaded into the GMG package for checking and refraction statics calculation. A QC program combined data from the observer's log, the shooter's log, and the Sercel record headers to cross check these data and generates the DISCO geometry job files for direct loading into the DISCO seismic database.

3.3 Green Mountain Statics

First break picking and calculation of the refraction statics were either done in the field as time permitted by the field geophysicists (lines 1 and 5 and portion of line 3), or upon return to AGSO. The GMG refraction package had not been used for previous surveys because of a difficulty of transfering SEGY data into the CPT format.

3.4 Brute Stacks

Although brute stacks of the data were produced in the field on selected portions of the lines, this was not achieved on a production basis in the field.

3.5 Reflection signal quality

Reflection quality varied along the lines, as would be expected in such a regional survey. The best reflection events observed on the field monitors were obtained in the central portion of Line 1 and on Line 6. In most other areas the reflection events were barely visible or inconspicuous on the monitor records. Ground roll was not a significant problem, in general, due to the depth of the shots.

4. PROCESSING PARAMETER TESTING

Testing was undertaken to determine the processing sequence and the optimum parameters for processing.

4.1 Gain Correction and Trace Balancing

Spherical divergence and trace balancing equalise the seismic amplitude of the traces for subsequent processes that require normalised amplitudes. For pre-stack processes such as FK filtering and DMO that require balanced amplitudes, a removable trace scaling was used rather than spherical divergence and trace balancing, and this scaling removed upon completion of the process.

4.2 Pre-stack Filter

Tests indicated wide bandwidth of the recorded data (8 to 90 Hz), so that a broad pre-stack filter (12/20-100\124 Hz) was selected to remove any spurious low or high frequency noise. An anti-alias filter used for the resampling to 4 ms.

4.3 FK analysis

FK filtering on NMO corrected shot records was found to significantly improve the S/N ratio at the expense of some smearing which FK filtering introduces. The NMO correction was removed after the FK filtering, allowing further velocity analysis.

4.4 Deconvolution vs Spectral Whiting

Tests indicated no significant improvement in the stack produced by either spiking or gapped deconvolution. Better signal whitening was obtained by spectral whiting (SPEQ module) than by deconvolution.

4.5 Muting

The mute functions were determined by analysis of offset limited stacks. Because of the high velocities, the mute was limited by NMO stretch, rather than elimination of refraction events.

4.6 Post stack deconvolution

Again tests indicated no significant improvement in the stack with the use of deconvolution.

4.7 Filtering - post stack

Optimum filter parameters for the post stack display were determined from filter panels.

4.8 FX Deconvolution

FX deconvolution is used to enhance laterally coherent energy, and increase horizon definition. Tests indicated this process improved the display, and it was therefore applied before final display.

5. PROCESSING SEQUENCE - 3 SECOND SECTIONS

The processing sequence for the 3 second sections is outlined in Table II.

5.1 Conversion from SEGY 9 track to DISCO format 3480 cartridge

The 9-track SEGY tapes, which had been written on the Vista PC system, were read on the VAX computer using the DISCO GIN module, and transcribed to 3480 cartridges in DISCO tapout format. Seismic database entries for these tapes were then transfered to the Convex database.

5.2 QC plots & Edits

Plots of the individual shot records were inspected and acquisition problems or noise bursts edited using on, off or surgical mutes. Reverse and dead channels were edited, and these edits applied to the shots before concatenating the SEGY field tapes to produce an edited shot data set. This dataset has been archived.

5.3 Crooked line geometry

Survey information provided by the South Australian Department of Environment and Natural Resources defined the location of the seismic traverses. Further geometry information from the field QC programs defined the spread geometry of each shot. Crooked line processing was used, but as the lines were generally straight, the CMP line generally followed the seismic traverse except for bends in the direction of the line (e.g. Lines 1 & 3) or corners in the road the line was following (e.g. Line 5).

5.4 Refraction Statics - First Break picks

Refraction static corrections were essential in seismic processing of the central Officer Basin, and the Green Mountain Refraction Statics Package (GMG) was used both to pick the first breaks and to calculate the refraction statics. The interactive first break picking was done on a PC, and provided a consistent and effective technique to pick first breaks. Cross checking of the first break picks was done with the QC module of the GMG package, ensuring only valid picks were used to calculate the refraction statics. The GMG package uses a time term approach for the statics calculation.

The GMG package had not been used in AGSO before the 1993 Officer Basin field season, but should now become a standard part of the field processing. Shot and station refraction statics from GMG were directly loaded into the seismic database on the Convex computer for use in the DISCO processing.

Table I outlines the parameters used in calculating the statics. A datum of 100 m was chosen to maintain consistency with the Comalco 1986 seismic lines in the eastern Officer Basin. The choice of the correction velocity V_c for Line 1 (3800 m s^{-1}) was a compromise between the fast basement at the northern end and the slower sediments within the basin at the southern end. A correctional velocity of 3500 m s^{-1} was used on the other lines. V_0 varied along the lines and was calculated as a smoothed uphole velocity.

TABLE I
Green Mountain Refraction Statics

	Line 1	Line 3	Line 4	Line 5	Line 6
V_1 (m s^{-1})	2626	2771	1950	2999	2974
V_2	3804	3218	3333	3415	3355
V_3	5669	4172	5708	5577	4675
V_c	3800	3500	3500	3500	3500
Datum (m)	100	100	100	100	100

5.5 Muting

The mute function was determined for offset limited stacks chosen at various locations along each line. The high velocities required the stretch mute to cut below any refraction events. A typical mute function would run from 20 ms neartrace to 950 ms at 2400 m offset.

5.6 Filtering

A very open pre-stack bandpass trapezoidal filter (12/20-100\124 Hz) was employed. A 75 Hz notch filter was applied to those traces within 4 stations of the recording cab to remove generator noise.

5.7 Spectral balance

Spectral balancing procedure (SPEQ) divides the spectrum into specified bandwidths and scales the amplitude of the spectrum in each of these bandwidths by applying an AGC type operator. These spectral bandwidths are then recombined to produce a whitened spectrum. Gates from 8 to 20 Hz, 20 to 45 Hz, 45 to 65 Hz, and 65 to 120 Hz were used.

5.8 Velocity - first pass

Three different velocity analysis techniques were compared: constant velocity stacks (CVS), VELEX velocity analysis, and IVIS an interactive horizon based velocity analysis package. The CVS analysis provides less resolution than the other techniques, but is important as it allows the limits of velocities for analysis by the other techniques to be quickly determined. It is therefore useful early in the velocity analysis. IVIS provides a superior resolution of the velocities for horizons which are well defined on the stack, but was found to have poor velocity resolution for horizons which were not clearly evident on the brute stack. For this reason, VELEX was found to be the best velocity analysis technique. Unfortunately, there was no convenient way to marry the excellent results of the IVIS analysis from the better seismic horizons with the velocity functions from the VELEX analyses.

VELEX analyses were therefore used, with CVS analyses to select the envelopes and as a guide for picking in difficult areas. Careful consideration of the mute function applied prior to VELEX was required for useful velocities in the first second.

5.9 Residual statics

Surface consistent residual statics were calculated using the STATICR module. The data was gated with the PREPARE module following the structure of the events below the region where the mute reduced the fold. STATICR parameters were a max shift of 8 ms, with a seven trace smash to produce a pilot trace, and 3 iterations.

5.10 Second pass Velocity determination

A 4-fold collection (or binning) of CMP gathers was used to increase the fold for better velocity resolution in the VELEX analysis.

5.11 FK shot

FK filtering of the shot gathers was used to clean the data after the application of refraction and autostatics, and using the 2nd pass velocity for the NMO correction. A removable trace scaling was applied before this process. An FK dip filter of ±8.5 ms/trace was used

5.12 DMO - shot domain

DMO usually involves a pre-stack "partial migration" in the common offset domain. However, the low fold and irregular offset distribution of our data makes sorting the data into common offset and applying DMO in that domain very difficult, and of questionable value. The common offset DMO (the CDPDMO module) was applied to Line 6, but shot domain DMO (SHOTDMO module) was used for the other lines.

Another velocity analysis (V3) should ideally be performed post-DMO. Tests indicated that the changes in velocities post DMO were insignificant in regions of little structure. Therefore this V3 analysis was omitted for all lines except Line 3 and portion of thrusting on Line 1.

5.13 NMO

The standard normal moveout correction (NMO module) was employed.

5.14 Stack

A conventional mean stack was employed.

5.15 Migration

Migration was performed using the finite difference algorithm implemented in DISCO as the MIGRATX module. Data was scaled prior to migration with an AGC operator. Tests in which the migration velocity field was scaled from the stacking velocity indicated that a 90% scaling gave the best results.

5.16 Filter

Post stack filtering was used to enhance the display. Filter parameters were:
0 - 800 ms : 18 dB/oct below 20 Hz lowcut and 72 dB/oct above 80 Hz highcut
1000 ms and below : 18 dB/oct below 15 Hz lowcut and 72 dB/oct above 60 Hz highcut

5.16 FX deconvolution and trace mix

Both FXDECON and a mild trace mix 1-2-1 were applied to improve continuity and reduce noise.

5.17 Scaling

An AGC with a 500 ms gate was used to rescale the data before display.

5.18 Display

The standard SECPLOT module was used to display the data, with SIDELBL and TOPLBL used to append auxiliary data and information.

5.19 Archive

The shot gathers (20 s), final migrated stack (~3 s), and 20 second stack have been written to 3480 cartridges in standard SEGY format for archive. Additional header information has been added to the SEGY trace header to include the following attributes in the trace header:

cmp X and Y coordinate
aeromagnetic and gravity data

residual and refraction statics
original demux shot sequence number

6. PROCESSING SEQUENCE - 20 SECOND SECTIONS

The processing sequence for the 20 second stack broadly followed that of the 3 s stack processing, with the exception that certain of the seismic processing steps used on the 3 s were not applied to the 20 s data either for computational time or technical considerations. The same refraction and residual static corrections and velocity functions for the top 3 s were used. DMO was not applied to the deeper data as the contribution of the DMO operator diminishes with depth. The processing sequence is outlined in Table III.

7. FINAL DISPLAY PARAMETERS

The display parameters for the sedimentary sections (2 or 3 s) was 25 traces cm^{-1} (corresponding to 1:50,000 horizontal scale), and 10 cm s^{-1} (corresponding to 1:20,000 at average velocity of 4000 m s^{-1}). The display parameters for the 20 s sections was 25 traces cm^{-1} (corresponding to 1:50,000 horizontal scale), and 1.5 inch s^{-1} (3.81 cm s^{-1} corresponding to 1:78,740 at average velocity of 6000 m s^{-1}).

TABLE II

Seismic Processing sequence for sedimentary section

[1] demultiplex and load headers
[2] crooked line geometry definition
[3] quality control displays and trace edits
[4] 75 Hz notch filter on channels around cab
[5] refraction static corrections
[6] spectrum balance
[7] bandpass filter
[8] velocity analysis - Velex
[9] residual statics
[10] velocity analysis - Velex
[11] normal moveout correction
[12] post NMO mute
[13] trace scale
[14] FK filter
[15] mute
[16] shot domain DMO
[17] descale traces
[18] cmp sort
[19] trace scale
[20] cmp stack
[21] trace scale
[22] fd migration (90% stack velocity)
[23] trace mix 1-2-1
[24] bandpass filter
[25] FX deconvolution
[26] trace scale

[27] display

TABLE III

Seismic Processing sequence for 20 second section

[1] demultiplex and load headers
[2] crooked line geometry definition
[3] quality control displays and trace edits
[4] 75 Hz notch filter on channels around cab
[5] refraction static corrections
[6] residual statics corrections
[7] normal moveout correction
[8] post NMO mute
[9] trace scale
[10] FK filtering
[11] post NMO mute
[12] descale traces
[13] sort to common mid-point order
[14] trace scale
[15] common depth point stack
[16] bandpass filter
[17] trace scale
[18] display

8. CONCLUSIONS

Acquisition and processing of the seismic data from the central Officer Basin has provided a regional framework for this unexplored portion of the basin, and met the objectives of the seismic acquisition. The data shows the central portion of this basin is relatively undeformed with regional dips of less than 1°. From this work, two potential petroleum plays have been identified:

1) the thrusted northern margin, and
2) the southern hinge zone between the basin and the Nullarbor Platform and the Ammoraroodinna Ridge.

9. RECOMMENDATIONS

The following recommendations for future AGSO land seismic processing arose from this work:

a) Problems of demultiplexing the SEGD data tapes from the Sercel 368 acquisition system needs to be solved, either by moving to another recording medium, or eavesdropping and demultiplexing in real time.

b) The field processing needs to be streamlined so that brute stacks can be routinely produced. A prerequisite for this would be more automatic demultiplexing. Eavesdropping and real-time production of SEGY data would also assist this goal.

c) The Green Mountain Refraction statics package had not been used for previous surveys prior to the Officer Basin Survey. This interactive package calculated good quality static corrections, and should become a standard part of the field processing in future. A floating datum should be used where there are significant variations in elevation along a profile.

d) The comparison of the three velocity analysis techniques (CVS, VELEX, and IVIS) suggested that Velex provides greater velocity resolution, and should be the preferred technique, even in hard rock areas.

e) Reprocessing of Line 1 by Digital Exploration showed that several passes of surface consistent autostatics, and one pass of non-surface consistent statics (trim statics) produced a significantly improved stack.

Archived Tapes

Officer Basin Archived tapes Jim Leven 11/25/94
Data is in SEGY format - except for the 9 track field tapes and 93-155

Line	Data	media	tape #	to tape #	
Line 1	field tape	9 track	93-010	93-032	SEGD
	Edited shot gathers	3480	93-122	93-130	
	20 s Stack	3480	93-175		
	3.2 s Migrated stack	3480	93-180		

Line 2 does not exist

Line 3	field tape	9 track	93-055	93-088	SEGD
	Edited shot gathers	3480	93-131	93-147	
	20 s Stack	3480	93-185	93-186	
	3.2 s Migrated stack	3480	93-181		
Line 4	field tape	9 track	93-089	93-103	SEGD
	Edited shot gathers	3480	93-148	93-154	
	20 s Stack	3480	93-177		
	3.2 s Migrated stack	3480	93-182		
Line 5	field tape	9 track	93-035	93-054	SEGD
	Edited shot gathers	3480	93-156	93-165	
	20 s Stack	3480	93-178		
	3.2 s Migrated stack	3480	93-183		
Line 6	field tape	9 track	93- 104	93-121	SEGD
	Edited shot gathers	3480	93-166	93-174	
	20 s Stack	3480	93-179		
	3.2 s Migrated stack	3480	93-184		
tar archive	Processing files all lines	3480	93-176		

Serpentine Lakes

Line 1	Reprocessed	3480	93-191	
Line 2	Reprocessed	3480	93-187	
Raw transcribed shots - unorigined		3480	93-188	93-190

Digicon Reprocessing

Line 1 & 3	Reproc in TAPOUT form	3480	93-155	Disco Tapout format
Line 1	3 s Final Stack	3480	93-192	
	3 s Migrated Stack	3480	93-193	
Line 3	3 s Final Stack	3480	93-194	
	3 s Migrated Stack	3480	93-195	