DATA PROCESSING REPORT

1989 MURPHY'S RANGE SEISMIC SURVEY

DECEMBER 1989

AMADEUS BASIN EP26 N.T.

AUSTRALIA

for

PACIFIC OIL AND GAS PTY LTD

2/10 WILKINSON STREET

ALICE SPRINGS N.T. 0870

by

DIGITAL EXPLORATION LIMITED

(A DIGICON COMPANY)

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ON STEWART: GEOPHYSICIST

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INTRODUCTION

During December, 1989 Pacific Oil and Gas Pty Ltd conducted the Murphy's Range seismic reflection survey in lease EP 26 of the Amadeus Basin, Northern Territory.

Approximately 48.5 kilometres of sign-bit vibroseis data were acquired by Geo-Systems Pty Ltd party GSC#205 and processed by Digital Exploration Limited in their Brisbane centre.

Following is a list of the lines acquired by Geo-Systems and the acquisition parameters used.

LEASE	LINE	SHOTPOINTS	KMS
EP26	MR89-102	100 - 1102	12.024
	MR89-104	1600 - 102	17.976
	MR89-105	100 - 1018	11.016
	MR89-107	883 - 259	7.488
			48.504

ACQUISITION PARAMETERS

Recording

Recorded By:	Geo Systems Pty. Ltd., Party GSC No. 205
Date:	December 1989
Instruments:	Geocor IV (sign bit recording)
Tape Format:	SEGY correlated sum
Tape Density:	1600 BPI
Sample Rate:	2 msecs.
Record Length:	4 secs.
Recording Filter:	None

Source

Energy Source:	Vibroseis X 4 (Litton, LRS-311, truck-mounted)
Sweep/VP:	6 Varisweeps
Sweep Length:	5982 msecs.
Sweep Frequency:	Varisweep bandwidth 10-44, 16-64, 44-84, 40-84, 18-70 10-50
Sweep Type:	Linear
Source Array:	12 m. spacing, 6 m. moveup. 66 m. source array/centred on peg:
Source Interval:	36 m.

Spread

Number Of Groups:	360
Group Interval:	12 m.
Geophone Array:	6 phones over 36 m. (7.2 m. spacing)
Spread Pattern:	2166 m. - 6 m. - 0 - 6 m. - 2142 m.
Coverage:	6000%

PRODUCTION PROCESSING SEQUENCE

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PROCESSING

A conventional assembly of processing operations was performed on the subject data. Except for some proprietary programs, those used form part of Digicon's basic "Disco" seismic processing system developed for use with the Digital Equipment Corporation's VAX computers.

1. REFORMAT

   The data from the field tapes were decoded and converted to Digicon's internal 9 track, trace sequential format for subsequent processing.

2. RESAMPLE

   The data were resampled from 2 millisecond to 4 millisecond sampling interval. A 90 Hz. high cut anti-alias filter of the Butterworth type was applied prior to resampling.

3. TRUE AMPLITUDE RECOVERY

   True amplitude recovery phase of seismic data processing consists of the following steps:-

   a. Removal of binary gain (non-linear) which is applied to the data during recording.

   b. Correction for amplitude loss due to spherical spreading of the wave-front as it is propagated downwards through the earth and reflected back to the surface (spherical divergence). To correct for this each trace is multiplied by VT, where V is the seismic wave velocity and T is the two-way recorded time.

   The velocity table used for the spherical divergence correction of this data is listed below:-

TIME (MS)	:	0	400	770	1250	2000	4000
VELOCITY (M/S)	:	3260	3450	4080	4700	5200	5500

4. TRACE EDIT

   This option is used on some records to zero noisy or wild traces which would not make a useful contribution to the stack. Information from the displayed reformatted field records, field monitor records and observer's logs is combined to determine the editing table.

5. F-K FILTER

This process applies to shot data, a zero phase F-K filter in the F-K domain using straight forward design principles. Reflections are separated from interfering noise on the basis of differences in apparent horizontal velocity. Events which are slower than the specified velocity cut are rejected. Amplitude and phase of the signal in the accept zone are preserved. The velocity cut used was ± 3000 m/sec. A 241 msec. filter with a 24 db/octave roll-off and 21 msec. taper was used.

6. SIGNATURE DECONVOLUTION

Deconvolution is the process of designing and applying an inverse filter to remove the effects on the recorded data of the earth's filtering and distortion of the source wavelet characteristics.

Signature Deconvolution applies a single wavelet shaping filter to each field record in turn.

An estimate of the source wavelet is made after compensation for instrument, geophone and truncation effects. A filter is then designed, using a Homomorphic approach, to shape this source wavelet to a specified desired output wavelet.

The major advantage of this process over more conventional deconvolution operators is the replacement of each variable source wavelet with a stable, predictable output wavelet. This results in an overall improvement in character and continuity on the stacked seismic section.

On these data a wavelet deconvolution filter was designed within the windows defined by the following offset-time pars:-

Gate 1:	6 m. - 200 msec,	2166 m. - 800 msecs
	6 m. - 2100 msec,	2166 m. - 2300 msecs

7. COMMON DEPTH POINT GATHER

The seismic traces along a line are gathered into data sets on the basis of common reflection point. The offsets, surface and sub-surface co-ordinates and shot sequence numbers are annotated in the trace headers for use in the subsequent processing.

8. DATUM STATICS COMPUTATION

Initial static corrections were computed using a refraction static technique.

The input is digitised first breaks from the production records. Geometry information is drawn from the database and used with the input elevation listings to fully define the profile. Details of shot and receiver offsets, instrument delay correction, weathering velocity (Vo), and selected datum elevation are also provided.

The routine is iterative, and progressively adjusted first break times are submitted for updating of sub-weathering velocities (Vr) and delay times (Td) at each group location. Both of these are constrained by suitable smoothing filters to inhibit erratic variation.

After the final iteration, usually 5, the geophone static (Tg) is computed as an elevation correction plus a weathering correction as follows:-

$$Tg = -\left[\frac{E}{Vr} + KTd\right]$$

where $$K = \sqrt{\frac{Vr - Vo}{Vr + Vo}}$$

and E = elevation above datum

The shot correction (Ts) is obtained from:-

$$Ts = Tg + Tuh$$

The weathering thickness (Wx) is computed as:-

$$Wx = \frac{Td \times Vo}{\text{Cos}\left[\text{arc Sin } \frac{Vo}{Vr}\right]}$$

After calculation, the shot and receiver statics are averaged to produce a mean static and a residual shot and receiver static, which is usually quite small. Subsequent processing is performed on data with only the residual components applied. Effectively the data is referenced to surface.

The mean static is applied to the data after the final filtering process to correct the data to the selected processing datum of 400 metres. An adjustment of -34 ms to the data is applied to correct back to the seismic datum of 350 metres.

9. VELOCITY ANALYSIS (VELFAN)

VELFAN Velocity Analysis is an automatic production orientated technique designed to obtain RMS velocity information from seismic data in CDP gather form.

Based on pre-determined knowledge of the stacking velocities which might be expected in an area, a set of velocity ranges versus two-way reflection time is input to the program together with a number of consecutive CDP gathers, for each location where a velocity study is required. Also input is a number, N, (usually 9 - 11), of velocity functions to be applied to the gathers.

The program takes the maximum and minimum functions as specified by the ranges and times above and evenly intersperses N-2 other functions between them. It then applies these functions, stacks and filters the data.

The VELFAN display consists of six parts:

a. The uncorrected central gather of the input group.
b. The central gather NMO corrected by the central velocity function.
c. The stacks formed by NMO correcting, stacking and filtering the set of CDP gathers using the N functions.
d. A display of velocity versus reflection time showing the N functions and points of high coherence at preselected intervals, e.g. 50 milliseconds.
e. A plot of relative coherence amplitude versus time.
f. A listing of velocities versus time of up to three velocities at any time level, based on coherence measurements.

For this survey the analyses were run over 21 depth points with 11 velocity functions forming the fan, and were run at approximately 2 km. intervals before automatic residual statics and 1 km. intervals after automatic residual statics.

10. RESIDUAL STATICS

The routine assumes that the static variation from trace to trace is caused by velocity and thickness variations in the low-velocity weathering layer. It further assumes that refined static corrections, based on statics computed from the reflection data itself, are desirable.

The automated statics analysis routine is conducted on NMO corrected gather records by utilizing all possible cross correlations between traces within and from adjacent depth points.

A dip model, representing the observed structure on one or more events within a specified gate or gates, is input to the program to facilitate dip correction within the set of CDP gathers being operated on. The model is interpreted from the previous stacked section in the processing sequence.

The process iterates automatically and makes separate estimations of residual normal moveout and dip, then computes a set of surface consistent residual statics for all shot and receiver locations. The appropriate residuals may be output on tape for application at a later stage, or stored in the data-base.

The following correlation processing controls are generally followed while estimating residual statics and have some data dependence:

a. Static limits (± 20 msec. for these data).
b. Damping factor to prevent matrix instability.
c. Number of iterations (3 for these data).
d. The number of depth-points in the cross correlations. This was constant at 11, 9 and 7 through iterations 1, 2 and 3.

Residual geophone statics are applied in accordance with receiver surface location and residual shot statics with record or shot input sequence. Both are recorded in the appropriate trace headers.

For the 2nd pass automatic residual statics calculation a non surface consistent solution was determined. The following correlation processing controls were used:

a. Static limits (± 5 msec.)
b. Number of iterations (1 for these data)
c. Number of depth-points used in the cross correlations (5 for these data)

11. NORMAL MOVEOUT (NMO) CORRECTION

This operation is performed assuming that the energy travels in a straight ray path and utilizes the following equation:

$$T^2 \text{ (recorded)} = T^2 \text{ (corrected)} + \left[\frac{X \times 1000}{VRMS}\right]^2$$

A space varying velocity function is utilized and the program computes a new space-varying function for each trace, by making floating point cubic interpolations between input control points, to produce a high fidelity NMO output.

12. PRESTACK MUTING

The function of this process is to mute the very shallow long offset traces where the signal to noise ratio is extremely poor.

In particular, the disproportionate stretching of traces with decreasing velocity and increasing offset, by NMO correction, contributes significantly to the poor S/N ratio.

To design the optimum parameters, NMO corrected CDP data sets may be output and displayed or sets of stacked data panels, having varying offset distances eliminated from the input gathers, may be used. By examining these displays the optimum muting time related to a particular offset distance can be derived. The offset time table used to determine the muting for these data is given below:

OFFSET (M)	288	384	672	1056	2200
TIME (MS)	0	200	325	475	800

13. PRE-STACK SCALING

At this final stage of preparation of the trace it is assumed that each has been statics and NMO corrected to a simulated zero offset condition, on the datum plane, for the particular CDP. So that each may contribute equally over its full length, to the summed trace, a short gate (500 milliseconds) Automatic Gain Control was applied, before stacking, to ensure that all were at optimum level.

14. COMMON DEPTH POINT STACK

After the completion of prestack muting and balancing the CDP data sets, which are corrected for the final velocity and residual statics, are summed algebraically. The resultant amplitude is divided by the number of live samples contributing to the summation to produce the final unfiltered stacked sample.

15. PHASE SHIFT FILTER

After the completion of the stacking process, a constant phase shift filter of -135 degrees was applied to the data. This enabled the data to be tied back to previously recorded seismic data in the survey area.

16. TAU-P FILTER

The stacked data is input to the program which is a 2-D time space dip filter that has two non-linear signal estimation options available, coherence masking and dip balancing. The dip pass region given was ± 3.0 msec per trace and the unfiltered addback was 50%.

17. FILTERING

Zero-phase digital filters were used in the filtering of stacked data. For intermediate processing, a time constant band-pass filter having a low-cut of 10Hz. and a high-cut of 90Hz. was used.

18. POST STACK SCALING

A long gate automatic gain control (1000 milliseconds was used to equalise trace amplitude after final stack.

19. MIGRATION (FINITE DIFFERENCE METHOD)

In this process events in the stacked seismic section are migrated to more correct spatial locations using a finite difference method migration algorithm. The input parameters to the migration program consist of smoothed stacking velocities, sub-surface trace interval and layer thickness. The effects of migration on the stack are:-

a. Lateral displacement of dipping events.
b. Collapsing of diffraction patterns.
c. More distinct fault resolution.
d. Signal-to-noise ratio improvement.

The data were migrated using the finite difference method with a layer thickness of 7 ms. at 0 ms., 20 ms at 2000 ms, 40 ms. at 3000 ms. to 3994 ms. and migration velocity of 100% of the smoothed stacked velocities.

20. DISPLAY

The final display films were of a horizontal scale of 20 traces per cm (1:12,000) with the trace interval representing 6 metres on the ground. The vertical scale was 12.7 cm per second.

The films were fitted with a side panel on the right hand side with a comprehensive tabulation of line, field and processing information. Along the top of the films data relating to actual location along the line is displayed. This includes datum statics and residual statics, line intersection details, well locations, surface elevation and R.M.S. velocity tables with their points of application. All films were in the wiggle trace-variable area mode, with timing lines every 100 milliseconds.

Reduced scale films of all migrated stacks were produced with a horizontal scale of 1:48,000 (every fourth trace displayed at a scale of 20 live traces per cm) and vertical scale of 12.7 cms per second.

THE DATA PROCESSING SYSTEM

Digicon's installation in Brisbane is based on two Digital Equipment Corporation VAX 8650 computers, coupled with Digicon's Disco Seismic Data Processing System.

The hardware configuration is extremely flexible, with the Brisbane installation being one of many possible alternatives. Included in this establishment are twenty-five tri-density tape drives, disk storage of 6 gigabytes, five FPS array processors, two Numerix Vector processors, three Benson and one Versatic Electrostatic Plotters and twenty-six remote input/output terminals allowing multi-user, multi-functional interactive capability.

The 32-bit central processing unit and a 16 mega-byte main memory capacity enhances the scientific application of the VAX computers.

Plotting in a variety of modes is available through the on-line Benson plotters and a Geospace film plotter. Off-line a Regma A170 Ammonia paper printer enables high quality reproductions of paper and filmed sections.

The Disco System (Digicon's Interactive Seismic Computer) is an extension of the Digicon Modular Seismic Data Processing System developed over many years. Being modular, the system is completely flexible allowing complete user control of the number and sequence of operations performed in any job. The Disco Seismic monitor assembles the selected modules in the specified order and controls the processing run.

Respectfully submitted,

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APPENDIX 1

PROCESSING PARAMETER TESTS

A. PRE-STACK TESTING:

Pre-stack tests were performed at one location within the survey: VP1215 of line MR89-104.

(1) GAIN

The shot record was measured for db level over 100 msec. time gates from time 0.10 sec. to 4.00 sec. From the resultant displays, spherical divergence gain was chosen and applied to the data. The db level was again measured and displayed.

(2) FILTER

Octave width bandpass filters were tested from 0-7.5 Hz to 90-180 Hz.

(3) F-K

The shot record was tested using velocity cuts ranging from 600 to 4000 m/s after the application of spherical divergence gain function. The 3000 m/s velocity cut was chosen as this effectively removed the majority of reverberated refractions from the data without interfering with the reflection signal.

(4) DECONVOLUTION BEFORE STACK

The following combination of parameters were tested.

(a) Spike; 0.1% white noise:
near trace: 200 msec - 1500 msec
far trace: 800 msec - 1700 msec
operator length 121 msec

(b) Spike; 0.1% white noise, operator length 161 msec.

(c) Spike; 2.0% white noise, operator length 161 msec.

(d) Spike; 0.1% white noise, operator length 161 msec, 2 gates

(e) Predictive; 0.5% white noise, operator length 161 msec, gap 16 ms.

(f) Predictive; 0.5% white noise, operator length 161 msec, gap 20 msec.

(g) Predictive; 0.5% white noise, operator length 161 msec, gap 20 msec, 2 gates

(h) Predictive; 0.5% white noise, operator length 161 msec, gap 24 msec.

(i) Predictive; 0.5 white noise operator length 161 msec, gap 32 msec.

(j) Wavelet deconvolution (SIGDCN)

Filtered and unfiltered displays with autocorrelation appended were produced.

B. STACK PANEL TESTS

One panel of data from line, MR89-104, VP1150-1250, was selected to perform stack tests using parameters chosen from the shot record tests. Each test panel was full fold and each had a single velocity analysis performed using Digicon's VELFAN routine.

The following mute function was determined and applied to each test panel following normal moveout correction of the data.

OFFSET (m)	245	440	1030	1420	1600	1800	2166
TIME (msec)	0	200	310	380	400	500	600

A pre-stack 500 msec gated scaling function was applied to the data pre-stack followed by a 1000 msec gated function post stack. No frequency filtering was applied to the stacked data.

All panels had a spherical divergence gain function applied and were resampled to 4 msec after the application of an anti-alias filter.

The following pre-stack tests were performed:

(1) F-K ± 4.0 msec. per trace (vel. 3000 m/s), spiking deconvolution, 0.5% white noise, operator length 161 msec, 2 gates.

(2) As above display decimated

(3) F-K ± 5.5 msec. per trace (vel. 2181 m/s), spiking deconvolution, 0.5% white noise, operator length 161 msec., 2 gates.

(4) F-K ±4.0 msec. per trace (vel. 3000 m/s), spiking deconvolution, 0.5% white noise, operator length 161 msec.

(5) F-K ± 4.0 msec. per trace (vel 3000 m/s), predictive deconvolution, 0.5% white noise, operator length 161 msec, gap 20 msec. 2 gates.

(6) No F-K, spiking deconvolution, 0.5% white noise, operator length 161 msec.

(7) No F-K, signature deconvolution

(8) F-K ± 4.0 msec, per trace (vel 3000 m/s), signature deconvolution

POST STACK TESTS

The following set of tests were performed on line MR89-104

(A) Phase shift filter tests (-180, -135, -90, -45, 0, 45, 90, 135, 180) degress of rotation were conducted on VP 1150-1250

(B) Filter test VP 1150-1250; octave width bandpass filters were tested from 0.75 Hz to 90-180 Hz

(C) Migration test were performed on VP 300-700

(1) Finite Difference, 90% smoothed velocities, 20 ms layer
(2) Finite Difference, 90% smoothed velocities, 40 ms layer
(3) Finite Difference, 90% smoothed velocities, 60 ms layer
(4) Finite Difference, 100% smoothed velocities, 40 ms layer
(5) Finite Difference, 110% smoothed velocities, 40 ms layer
(6) Finite Difference, 120% smoothed velocities, 40 ms layer
(7) Finite Difference, 100% smoothed velocities, 7 ms layer
(8) Finite Difference, 110% smoothed velocities, 7 ms layer
(9) Finite Difference, 120% smoothed velocities, 7 ms layer
(10) F-K migration 100% smoothed velocities
(11) Wide aperture method 100% smoothed velocities

Additional pre-stack and post stack tests were conducted on line MR89-102.

(A) 2nd pass residual statics test VP 100-350

(B) Tau-p filter addback test VP 200-300
Dip : ± 3.0 ms/trace
Addback: 80%, 70%, 60%, 50%, 40%

(C) Deconvolution after stack VP 200-300
5 panels
gap deconvolution : 32ms, 24ms, 16ms gap
DECONZ: frequency range 15-75 Hz
frequency range 15-84 Hz

(D) Filter test - VP 200-300; Octave width bandpass
Filters were tested from 0-7.5 Hz to 90-180 Hz

APPENDIX II

SEGY ARCHIVE TAPE LISTING

CLIENT : PACIFIC OIL AND GAS
SURVEY : MURPHY'S RANGE
DATA LENGTH : 4.0 SEC.
SAMPLE RATE : 4 MS
FORMAT : SEGY

LINE	STATION RANGE	DATA TYPE	INPUT CDPS	OUTPUT CDPS	TAPE NO.
MR89-102	100 - 1102	UNFILTERED	200 - 2205	1 - 2006	CPT-1533
MR89-104	1600 - 102	FINAL	8199 - 200	2007 - 5006	
MR89-107	883 - 259	STACK	1769 - 337	5007 - 6439	
MR89-105	100 - 1018		200 - 2037	6440 - 8277	
MR89-102	100 - 1102	UNFILTERED	200 - 2205	1 - 2006	CPT-1532
MR89-104	1600 - 102	TAU-P	8199 - 200	2007 - 5006	
MR89-107	883 - 259	STACK	1769 - 337	5007 - 6439	
MR89-105	100 - 1018		200 - 2037	6440 - 8277	
MR89-102	100 - 1102	UNFILTERED	200 - 2205	1 - 2006	CPT-1531
MR89-104	1600 - 102	MIGRATED	8199 - 200	2007 - 5005	
MR89-107	883 - 259	STACK	1769 - 337	5006 - 6437	
MR89-105	100 - 1018		200 - 2037	6438 - 8275	

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