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DATA PROCESSING REPORT

1989 BUNDEY RIVER SEISMIC SURVEY

JULY - AUGUST 1989

GEORGINA BASIN EP10 N.T.

AUSTRALIA

for

PACIFIC OIL AND GAS PTY LTD

826 WHITEHORSE ROAD

BOX HILL VIC 3128

by

DIGITAL EXPLORATION LIMITED

(A DIGICON COMPANY)

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ALLEN GELL: LAND PROCESSING SUPERVISOR

FEBRUARY 1990

DPR018B:KJF

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INTRODUCTION

During July - August, 1989 Pacific Oil and Gas Pty Ltd carried out a seismic reflection survey in lease EP10 of the Georgina Basin in the Northern Territory.

Approximately 40 kilometres of 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 Geosystems and the acquisition parameters used.

LEASE	LINE	SHOTPOINTS	KMS
EP10	89-102	100-684	7.008
	89-104	100-1266	13.992
	89-105	100-1684	18.756
			39.756

ACQUISITION PARAMETERS

Recording

Recorded By:	Geo Systems Pty. Ltd., Party GSC No. 205
Date:	July - August 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:	8 Varisweeps
Sweep Length:	5982 msecs.
Sweep Frequency:	Varisweep bandwidth 10 - 40, 14 - 56, 28 - 72, 36 - 76, 40 - 76, 32 - 74, 16 - 64, 10 - 50
Sweep Type:	Linear
Source Array:	12 m. spacing, 0 m. moveup, array centred on peg:
Source Interval:	12 m.

Spread

Number Of Groups:	300
Group Interval:	12 m.
Geophone Array:	6 phones over 12 m. (2.4 m. spacing)
Spread Pattern:	1794 m. - 6 m. - 0 - 6 m. - 1794 m.
Coverage:	15000%

PRODUCTION PROCESSING SEQUENCE

1. Reformat
2. Resample
3. True Amplitude Recovery
4. Trace Editing
5. F-K Filter
6. Deconvolution
7. Common Depth Point Gather
8. Datum Static Computation and Application (SRD = 400 metres above sea level)
9. Velocity Analysis
10. Automatic Residual Static Computation and Application
11. Velocity Analysis
12. Normal Moveout Correction
13. Pre-stack Muting
14. Time Variant Scaling
15. Automatic Residual Static Computation and Application
16. Common Depth Point Stack
17. Tau-P Filtering
18. Migration
19. Digital Bandpass Filtering
20. Time Variant Scaling
21. Datum Correction

PROCESSING

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 msec. to 4 msec. 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 the absorption of energy due to inelastic attenuation of the earth which is experimentally shown to be linear and frequency dependent, i.e. increasingly greater losses of higher frequencies with record time.

   To correct for these effects each trace is multiplied by a gain function (normally expressed in decibels per second) which usually remains constant for the prospect and brings the records to a readable level. An exponential gain function of 0db at 500 ms. to 10db at 1500 ms. was found to be adequate for the entire survey.

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 ± 4124 m/sec. A 241 msec. filter with a 24 db/octave roll-off and 21 msec. taper was used.

6. 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. The deconvolution is accomplished by the application of one or more whitening filters designed from the auto-correlation of the data trace of the input records.

The filter is designed to whiten or broaden the frequency spectrum within a band pass having an allowable signal-to-noise ratio. By whitening the pass-band, the time transient is collapsed into a shorter interval thus providing finer delineation of the reflecting horizons.

On the subject data a gapped deconvolution filter of 20 msec. with an operator of 161 milliseconds was designed on data within the windows defined by the following offset-time pairs:

Gate 1:	6 m. - 200 msec,	1794 m. - 3000 msecs
	6 m. - 600 msec,	1794 m. - 3000 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:-

$$Tg = -\frac{E}{Vr} + KTd$$

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:-

$$Wx = \left[\frac{Td \times Vo}{\cos\left(\arcsin \frac{Vo}{Vr}\right)}\right]$$

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 seismic datum of 400 metres.

9. VELOCITY ANALYIS (SVELFAN)

SVELFAN 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 SVELFAN 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. <u>RESIDUAL STATICS</u>

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 ($\pm$ 4 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.

Final mute values were taken from the 1988 Bundey River Survey.

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. 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 40%.

16. 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 76Hz. was used.

Final time variant filters applied to lines are noted in Appendix 1.

17. POST STACK SCALING

A multi-gated balance was applied to the data after final filtering to bring the data to the desired amplitude level. The average absolute value (AABS) of the gate is computed and a scalar is applied to the centre point of the gate. This is repeated for each gate with the scalar interpolated between the gate centres.

18. MIGRATION (FINITE DIFFERENCE METHOD)

The lines were migrated using the finite difference method with a layer thickness of 40 ms from 0.0 secs. to 4.0 secs. and migration velocity of 90% of the smoothed stacking velocities.

19. DISPLAY

The final display films were of a horizontal scale of 10 traces per cm (1:12,000) with the trace interval representing 12 metres on the ground, ie. only every second trace displayed. 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 final and 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 one Digital Equipment Corporation VAX 11/780 computer and one VAX 8650 computer, 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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LAND PROCESSING SUPERVISOR

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GENERAL MANAGER

DPR001B:MEB

APPENDIX 1

PROCESSING PARAMETER TESTS

A. PRE-STACK TESTING:

Pre-stack tests were performed at two locations within the survey: VP298 of line 89-102, and VP700 of line 89-105.

(1) GAIN

The two shot records were measured for db level over 100 msec. time gates from time 0.10 sec. to 4.00 sec. From the resultant displays an exponential gain of 0 to +10db from 0.5 sec. to 1.5 sec. 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 two shot records were tested using velocity cuts of 3000 m/s, and 4125 m/s after the application of the exponential gain function. The 4125 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 - 3000 msec
far trace: 600 msec - 3000 msec
operator length 161 msec

(b) Spike; 0.1% white noise, operator length 121 msec.

(c) Spike; 0.1% white noise, operator length 201 msec.

(d) Spike; 0.5% white noise, operator length 161 msec.

(e) Spike; 2.0% white nosie, operator length 161 msec.

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

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

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

(j) Wavelet deconvolution (DEFLAT)

Filtered and unfiltered displays with autocorrelation appended were produced.

B. STACK PANEL TESTS

Three panels of data from line, 89-102, VP150-250, and VP100-400 and VP200-400 were 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)	288	384	672	1056	1824
TIME (msec)	0	200	325	475	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 an exponential gain function of 12 db 500-2500 msec applied and were resampled to 4 msec after the application of an anti-alias filter.

The following pre-stack tests were performed on line 89-102, VP200-400.

(1) F-K +2.91 msec. per trace (vel. 4124 m/s), spiking deconvolution, 0.5% white noise, operator length 161 msec. Display every second trace.

(2) F-K +4.0 msec. per trace (vel. 3000 m/s), spiking deconvolution, 0.5% white noise, operator length 161 msec. Display every second trace.

(3) F-K +2.91 msec. per trace (vel. 4124 m/s), predictive deconvolution, 0.5% white noise, operator length 161 msec., gap 20 msec. display every second trace.

Post stack tests were performed on line 89-102, VP150-250 and VP100-400.

(1) Filter test - VP150-250; Octave width bandpass filters were tested from 0-7.5 Hz to 90 - 180 Hz.

The following filter was used on all lines:

Time - msec	Low - (Hz/Db per Octave) - High	
0	15/30	75/60
600	15/30	70/60
1500	12.5/30	65/60
2000	10/30	60/60

(2) Tau-P Filter Test VP150-250;
unfiltered addback of 40%, 50%, 60% were tested. From this test the 40% unfiltered addback was chosen.

(3) Spectral Equalization VP150-250;
Spectral equalization using a passband of 15-70 Hz after the application of Tau-P filtering was tested. It was decided to use this sequence on all lines.

(4) Migration test VP100-400;
Finite difference migration after stack using layers of 20 msec, 40 msec and 60 msec were tested.

On line 89-105 VP600-800 the following pre-stack tests were performed.

(1) F - K ± 2.91 msec per trace (vel 4124 m/s), spiking deconvoluting 0.1% white noise, operator length 161 msec. All traces displayed.

(2) F - K ± 2.91 msec, per trace (vel 4124 m/s), refraction statics, spiking deconvolution, 0.1% white noise, operator length 161 msec. All traces displayed.

(3) F - K ± 2.91 msec, per trace (vel 4124 m/s), spiking deconvolution 0.1% white noise, operator length 161 msec. Display every second trace.

(4) As for 3 using refraction statics.

(5) F - K ± 4.0 msec, per trace (vel 3000 m/s), spiking deconvolution, 0.1% white noise, operator length 161 msec. display every second trace.

(6) F - K ± 2.91 msec per trace (vel 4124 m/s), 2:1 sum, spiking deconvolution, 0.1% white noise, operator length 161 msec. Display all traces.

(7) F - K ± 2.91 msec per trace (vel 4124 m/s) predictive deconvolution, gap 20 msec, 0.1% white noise, operator length 161 msec. Display every second trace.

(8) No F - K, spiking deconvolution, 0.1% white noise, operator length 161 msec. Display every second trace.

(9) No F - K, band limited minimum phase deconvolution using a band pass of 12 to 70 Hz. Display every second trace.

APPENDIX 2
TAPE LOG

REL NO.	LINE	DATA SET	FIRST REC.	LAST REC.	REMARKS
CPT-1198	89-102	UNFILTERED	201	1367	3.0 SEC DATA
CPT-1198	89-104	MIGRATED	201	2531	4.0 MSEC
CPT-1198	89-105	STACK	201	3367	SAMPLE RATE
					SEGY FORMAT
CPT-1201	89-102	UNFILTERED	201	1367	
CPT-1201	89-104	FINAL STACK	201	2531	
CPT-1201	89-105		201	3367	