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REPORT ON
WEATHERING-LAYER STATICS
1988 ROPER VALLEY SEISMIC SURVEY
EP5
McARTHUR BASIN, NORTHERN TERRITORY

Author: R. H. Castleden
Date: December, 1989

Submitted to: 

Copies to: Central Information Services, Canberra
N.T. Dept. Mines & Energy, Darwin
Pacific Oil & Gas Pty Limited, Box Hill (2)

Submitted by: 

Accepted by: 

ONSHORE

Report No. 303853

PR89/014 F
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1 CONCLUSIONS

This note demonstrates that the non-application of delay-time statics to the processed 1988 Roper Valley Seismic Survey seismic data has had no major effect on the integrity of the structural interpretation in CRAE Report No. 303598.

The application of delay time statics to the data would have the effect of systematically varying the datum level by $16 \pm 5$ milliseconds two-way-time. With an actual error level of $\pm 5$ milliseconds (ie. one standard deviation), there would be little variation in interpreted structures.

Elevation statics are an order of magnitude greater than the delay time statics. As a result, the elevation statics have more influence on subsurface structures. Since the differential in the delay times is small in magnitude, the application of delay times statics will have minimal effect on the robust structural leads and prospects interpreted to exist in EP5 (Castleden, 1989).
2. INTRODUCTION

The Northern Territory Department of Mines and Energy (NTDME) raised a query concerning the statics model used in the processing of data from the 1988 Roper Valley Seismic Survey after receiving the Interpretation Report (Castleden, 1989) for this survey.

Although a weathering survey was part of the seismic survey, the results were not incorporated into the processing seismic data. The reasons for this were not given in the above report.

This note sets out in some detail the reason for omitting to apply long-wavelength delay time statics to the 1988 Roper Valley Seismic Survey seismic data during the processing of the data.
3. DISCUSSION

During acquisition of the 1988 Roper Valley Seismic Survey, Geo Systems Pty Limited, the acquisition contractor, also recorded a 57-hole uphole weathering survey (Appendix 1). Results of the uphole survey are shown as one-way-time versus depth plots in Appendix 2. The holes were drilled to an average depth of 30 metres, with charges spaced at five metre intervals (Appendix 3). Instrument malfunction and unexpectedly slow drilling conditions (Appendix 3) meant a delay was experienced at the seismic processing centre for receiving the results of the uphole survey. A decision was made to review the results of the uphole survey, and either apply, or not apply, the resultant long-wavelength weathering-layer-model static at the "final stack" stage of seismic data processing.

An examination of the delay times (Table 1) shows a tight distribution around 8 milliseconds one-way-time (standard deviation is only 2.5 milliseconds one-way-time). This means that there is, on average, a range of ± 5 milliseconds two-way-time around a central value of 16 milliseconds. The latter value may be regarded as a systematic, or datum, shift to be applied to the data, and to have no effect on interpreted structures. The maximum 10 milliseconds of deviation, applied as a differential static to the seismic data, would have a negligible effect on the interpreted structures, since all identified leads and prospects of interest have between 50 to 100 milliseconds or more of closure (Castleden 1989, Enclosures 22, 25 and 28). All the structures of 10 milliseconds closure, or less, were so small in area as to warrant no further interest.

A test of this theory is to be found in comparing the Final Stack for Line 88-301 to be found in CRAE Report No. 303557 (part of which report is included here as Appendix 4) with the Final Stack for the same line to be found in CRAE Report No. 303598 (Raw Data). Both Final Stacks show the seismic data in similar structural disposition. There is a difference in the datum, only part of which is due to weathering-layer-model statics being applied to the former, but not the latter.

The elevation statics are an order of magnitude greater than the differential (ie. ± 5 milliseconds) delay time static, as an inspection of the datum statics header displays on each of the above Final Stacks will show. Appendix 4, page 7, states that "static corrections were generally not a major problem, with only minor variations occurring along the line, apart from a large escarpment occurring at VP400...". A look at the chaining notes for this part of line 88-301, included in Appendix 4, will show the reason for the application of or elevation static corrections as being critical the correct interpretation of seismically imaged structures.

In a seismic sense, the weathering layer may be regarded as being uniformly thin over the survey area, and thus has negligible effect on the interpreted structures.
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REFERENCES

Castleden, R. H. 1989 'Interpretation Report for the Roper Valley Seismic Survey'. CRAE Report No: 303598
APPENDIX 1
ROPER VALLEY SEISMIC SURVEY

EP 4 & EP 5, MCARTHRU BASIN NORTHERN TERRITORY

FINAL REPORT - OPERATIONS

by

F.R. O'SULLIVAN, B. MATTHES and S.P.C. TOBIN

of

GEO SYSTEMS PTY LTD

A wholly owned subsidiary of
Geophysical Systems Corporation
Pasadena, California, U.S.A.

for

PACIFIC OIL & GAS PTY LIMITED
826 Whitehorse Road
Box Hill
Victoria
6. WEATHERING CONTROL

Weathering recording started on the 9th June and ended on the 17th July 1988. A total of 61 valid upholes were recorded.

Upholes were recorded at start, finish and intersections along the lines. Upole depth varied. Holes were loaded with Anzomex "A" primers and No8 submarine detonators, supported by a harness of twin twist blasting circuit wire.

6.1 Recording

Upole weathering was recorded using a 24-channel OYO McSEIS 1500 Upole Refraction System and 6 x 8 Hz geophones over a spread length of three (3) metres. Charges were set at 5 metre intervals to a depth of 12 to 80 metres.

6.2 Drilling

The upole drilling was carried out by Bennett Drilling of Warmambool, Victoria.
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6.3 Uphole Summary

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<td><em>REPLACES HOLE AT 403 VP 240, NO RIG ACCESS.</em></td>
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6.3 Uphole Summary

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\[ n = 57, \overline{x} = 29.0 \text{ m}, \sigma_x = 10.0 \text{ m} \]
APPENDIX 2
**UPHOLE SUMMARY**

- **D1**: 16 m
- **V1**: 7.50 m/s
- **D2**: 24.40 m/s
- **VSUB**: 3500 m/s
- **VREP**: 3500 m/s
- **COEFF**:
- **Q.C.**: Jane
Client: PACIFIC
Survey: NEMPHYS
Line: 100
S.P.: 415
Date: 14/1/88
Terrain:
Notes:

UPHOLE SUMMARY
D1: 18.5 m
V1: 800 m/s
D2:
V2: 2414 m/s
VSUB:
VREP:
COEFF:
Q.C. Jane
UPHOLE SUMMARY

D1: 6.5m
V1: 667 m/s
D2: 
V2: 2087 m/s

COEFF: 
Q.C.: done
UPHOLE SURVEY

Client: PIAERL
Survey: LADY RENAISSANCE
Line: 100/101
S.P.: Interception
Date: 14/6/98
Terrain: 
Notes: 

UPHOLE SUMMARY
D1: 13 m
V1: 800 ms⁻¹
D2: 
V2: 1832 ms⁻¹
VSUB: 
VREP: 3500 ms⁻¹
COEFF: 
Q.C.: June
Client: PACIFIC
Survey: LADY PENNYP
Line: 10Z
S.P.: WF 200
Date: 14/5/82
Terrain:
Notes:

UPHOLE SUMMARY
D1: 13 m
V1: 1200 m/s
D2: 
V2: 30 55 m/s
VSUB:
 VREP:
COEFF:
QC: Jane
**UPHOLE SUMMARY**

- **D1**: 18 m
- **V1**: 10.37 m/sec
- **D2**: 18 m
- **V2**: 2.564 m/s
- **V_SUB**:
- **V_REP**:
- **COEFF**:
- **Q.C.**
UPHOLE SURVEY

Client: Pacific
Survey: Borrowdale
Line: 240
S.P.: 252
Date: 13/4/88
Terrain:
Notes:

UPHOLE SUMMARY
D1: 8 m
V1: 750 m/s
D2:
V2: 2667 m/s
VSUB:
VREP:
COEFF:
Q.C.: Jane

\( V_1 = 750 \text{ m/s} \)
\( V_2 = 2667 \text{ m/s} \)
Client: INCITS
Survey: BORROWDALE
Line: 201/200
S.P.: 201/1825, 200/1574
Date: 12/4/98
Terrain:
Notes:

UPHOLE SUMMARY
D1: 17 m
V1: 909 m/s
D2:
V2: 2727 m/s
VSUB: 
VREP: 
COEFF: 
Q.C.: clean.
UPHOLE SURVEY

Client: PACIFIC
Survey: 12/6/88
Line: 201
S.P.: 232
Terrain:
Notes: 303375

UPHOLE SUMMARY
D1:
V1:
D2:
V2:
VSUB:
VREP:
COEFF:
Q.C.
Uphole Survey

Client: Pacific Oil
Survey: Malwok Cr
Line: 300
S.P.: 588
Date: 2-7-88
Terrain:
Notes:

25 m
50 m

UPHOLE SUMMARY
D1:
V1:
D2:
V2:
VSUB:
VREP:
COEFF:
Q.C.
UPHOLE SURVEY

Client: Pacific Oil
Survey: Maurox UK
Line: 300
S.P.: 1230
Date: 17/88
Terrain:
Notes:
Casing in hole to 2.5m

UPHOLE SUMMARY
D1:
V1:
D2:
V2:
VSUB:
VREP:
COEFF:
Q.C.
UPHOLE SURVEY

Client: [Handwritten]
Survey: Maiwok CK
Line: 300
S.P.: 1550
Date: 1.7.88
Terrain:
Notes:
30m hole

UPHOLE SUMMARY
D1: [Handwritten]
V1: [Handwritten]
D2: [Handwritten]
V2: [Handwritten]
VSUB: [Handwritten]
VREP: [Handwritten]
COEFF: [Handwritten]
Q.C.: [Handwritten]
UPHOLE SURVEY

Time (msec)

Drill Log

Client: Pacific
Survey: Main Creek
Line: 300 / 301
S.P.: 1824 / 1933
Date: 1.7.88
Terrain:
Notes:
35m Hole

UPHOLE SUMMARY
D1: 9 m
V1: 750 m/s
D2:
V2: 2553 m/s
VSUB:
VREP:
COEFF:
Q.C.
UPHOLE SURVEY

Client: PACIFIC
Survey: MAWOK
Line: 301
S.P.: 1040
Date: 29.6.08
Terrain:
Notes:
25m Hole
30337

UPHOLE SUMMAR
D1: 10m
V1: 1383
D2:
V2: 5263 m/s
VSUB:
VREP:
COEFF:
Q.C.
Client: PACIFIC
Survey: MAHWOOK CRK
Line: 303
S.P.: 240
Date:
Terrain:
Notes:

UPHOLE SUMMARY
D1: 14 m
V1: ?
D2: 
V2: 5600 m/s
VSUB:
VREP:
COEFF:
Q.C.
Drill Log

Client: Pacific Oil

Survey: Mawok Creek

Line: 88-303

S.P.: 600

Date: 26-6-88

Terrain:

Notes:

303374

Uphole Summary

D1: 14 m

V1: 1100 m/s

D2:

V2: 2745 m/s

V SUB:

V REP:

COEFF:

Q.C.
AGE [m] 10 15 20 25 30 35 40 45 50

Client: 
Survey: 
Line: 303 
S.P.: 956 
Date: 
Terrain: 
Notes: 

25m, m/c 

VMO: 3.640 

UPHOLE SUMMARY 
D1: 
V1: 
D2: 
V2: 
VSUB: 
VREP: 
COEFF: 
Q.C.
UPHOLE SURVEY

Client: [Name]
Survey: MAWOK Ck
Line: 307
S.P.: 1596
Date: 6.7.88
Terrain:
Notes: 35 m X 400

UPHOLE SUMMARY
D1:
V1:
D2:
V2:
VSUB:
VREP:
COEFF:
QC: [Name]
U. WOLL SURVEY

Client: Pacific
Survey: Mainex CC
Line: 307
S.P.: 778
Date: 7-7-88
Terrain:
Notes:

30 m holes

\[ 80 \, \text{m} \]

UPHOLE SUMMARY

D1: 8 m
V1: 1234 m/sec

D2:
V2: 3085 m/sec

VSUB:
VREP:
COEFF:
QC:_-
Client: Pacific
Survey: Flying Fox
Line: 600
S.P.: 204
Date: 12.7.86
Terrain:
Notes:

280 m lost
12.5 m
100% correl
300 37

UPHOLE SUMMARY
D1: 3.5
V1: 3200
D2
V2: 2600
VSUB
VREP
COEFF:
Q.C. John
UPHOLE SURVEY

Client: Pacific Co.
Survey: Fiting Fox
Line: 400
S.P.: 1280
Date: 6.7.93
Terrain:
Notes:
25x X axis

UPHOLE SUMMARY
D1: 11m
V1: 1000 m/s
D2
V2: 3095 m/s
Vsub:
Vrep:
Coeff:
Q.C.: Jane
UPHOLE SURVEY

Client: Pacific Oil
Survey: Flying Fox
Line: 400/401
S.P.: INT
Date: 11-7-78
Terrain:
Notes:
25m hole

UPHOLE SUMMARY

D1: 12 m
V1: 176 m/sec
D2:
V2: 3533 m/sec
VSB:
VRE:
COEF:
Q.C. Dave
APPENDIX 3
SEISMIC SUPERVISION REPORT


FOR

PACIFIC OIL & GAS PTY LTD

JUNE 4TH TO JULY 16TH, 1988

M. Small
ECL Australia Pty Ltd
19 Colin Street
West Perth 6005
WESTERN AUSTRALIA
3.2 Geophones and Cables

Mark Products L21, 10 Hz spiked geophones were used in conjunction with Geospace coaxial cables.

An above contract number of cables and geophone strings were provided (900 phones and 100 cables) of which 60 relatively new cables were received from a stacked crew in China.

The Mark Products geophones used in this survey have a noted tendency for the case to become brittle with age and for the geophone spike to break away at the base. The crew was reasonably diligent in detecting phones with missing spikes and flagging them for repair. All geophone strings were fairly old and extensively repaired, it was evident that many elements were "tired" and in need of replacing. A geophone tester such as the GS 900, employed on Geosystems other crew have assisted the detection of faulty elements. Most strings were ready for overhaul or replacement and many also contained several splices. Although no quantitative studies have been performed on signal attenuation through leakage on a "sign bit" system, it would seem likely that data quality would be optimised in the absence of leakage.

3.3 Source

Five truck mounted LRS 311 vibrators were used, with three/four on line and one spare.

These units were serviceable and accounted for little down time, however the fifth vibrator was down and unavailable as a spare for most of the survey.

A Pelton Vibracheck was provided at the start of operations, however insufficient paper was provided to perform any useful tests. This instrument should be available on crew at all times to provide independent vibe Q.C. and amplitude information.

3.4 Surveying

Surveying was relatively straight forward with horizontal and vertical control being maintained. The survey was tied to Trig Stations.

3.5 Weathering Crew

The weathering crew consisted of an OYO McSeis refraction recording system carried in a Toyota 4x4. The uphole survey was performed by loading the drilled hole with a prepared charge harness, with charges set at varying depths. Each charge was shot individually and recorded by geophones offset from the hole.
Drilling was performed by a subcontractor, Bennett Drilling, using a Midway 10M and support equipment.

The recording system is a standard system widely used by the industry, a common weakness with the system seems to be that the printer is prone to malfunction and failure. Service and repair facilities in Australia for the OYO printer are often slow and unreliable, this was again demonstrated during this survey with the instrument being down for a number of days causing a backlog of holes to be shot. This is a common fault with an otherwise reliable instrument.

Bennett's equipment was in good order and well suited to seismic upheole drilling. The rig experienced some downtime due to mechanical breakdown, but was otherwise reliable. Initially the contract was accepted on a meterage basis, however this was later changed to an hourly basis due to unexpected slow drilling conditions. Bennett, although relatively inexperienced, displayed a positive attitude to be able to come to terms with the demands of the survey. Although the rig was equipped with an adequate 600 CFM compressor and hammer bits it was necessary to change to mud injection drilling in the vicinity of river where shallow ground water was encountered. The author feels that many of the problems encountered with Bennett stem from the operators inexperience in both bidding and drilling unknown conditions.

3.6 Line Clearing

Line clearing was performed by Kentworth Pty Ltd on a turnkey basis, using two Caterpillar D7G dozers, John Deere grader, Mack truck, float, camp and support equipment.

Dozing lead was adequate at all times, however the standard of cutting was very average. This was caused by frequent breakdowns of the John Deere grader and environmental requirements. Support from the base in Toowoomba was poor in respect to supply of necessary parts for repair. Parts were often sent road freight rather than air despite the required urgency. The poor performance of the grader and the unnecessary delays in repair detract from an otherwise competent service.

3.7 Permitting

Permitting was performed by Craig Gumley of Pacific Oil and Gas with an on-going liaison by the author.
according to ground conditions and sweep parameters it may not be possible to always achieve 80% accelerometer similarity e.g. low frequency sweeps on hard ground. In these circumstances vibrators are expected to be consistent to each other.

The Geocor IV similarity tests, being "sign bit" provide no amplitude information which may be useful in the setting of vibrator drive levels to optimise energy in the desired band widths. Also these tests have to be performed in a non-production mode so no check can be made during the day on individual vibrators without halting production. Geosystems will in the future be providing a Pelton "Vibracheck" which will elevate both these shortcomings.

Vibrator downtime was acceptable due to normal operational occurrences. The units, although six years old, were well maintained and in good operational order.

4.4 Surveying

Surveying was accomplished using the following equipment:

Two (2) Wild T1/T16 Theodolites
Two (2) Sokkisha EDM's
Two (2) HP-41CX Programmable Calculators
One (1) Steel Chain marked at Group Interval

All lines were set off from Trig stations and Bench marks and double run due to lack of further control. Permanent markers consisting of metal star pickets with a steel tag with details inscribed were set next to the survey dumpy at all intersections, start and five Km intervals.

No major problems were encountered during the survey despite the lack of control points and difficult access. (Loop closure maps in appendix).

4.5 Weathering Crew

The weathering crew consisted of a 4x4 Toyota pick-up in which was carried a 24 channel OYO McSeis refraction recording system and necessary peripheral equipment. Charge harnesses were prepared at the hole by the weathering observer while drilling was performed. Holes were drilled to an average depth of 30 metres with charges spaced at five metre intervals.

Performance of the weathering crew and drilling crew was satisfactory.
SEISMIC DATA PROCESSING REPORT

TEST REPROCESSING OF LINE 88-301

FROM 1988 ROPER VALLEY SEISMIC SURVEY

FOR PACIFIC OIL & GAS PTY. LTD.

BY

HORIZON SEISMIC AUSTRALIA PTY. LTD.

PERTH WESTERN AUSTRALIA
PROCESSING PARAMETER DETERMINATION

Extensive testing was employed to determine the optimum processing sequence and parameters for this data set. These can be summarised as follows:-

1. Amplitude compensation - a gain curve was applied to compensate for spherical divergence and transmission losses with increasing two way travel time. This was determined by testing various gain curves on raw field records until a balanced distribution of amplitudes with time could be observed.

2. Static corrections - time corrections to a fixed datum of mean sea level were computed from picked first arrival times from production field records tied down to absolute values computed at deep uphole observations located at various places along the line. A portion of the line (VP 1759-2100) was stacked with computed first break statics and compared with the same line portion stacked with a simple elevation static model with interpolated weathering delay times between deep uphole locations. (See enclosures 8 and 9)

3. F-K Filtering - Examination of field records along the line allowed identification of various noise trains caused by surface waves. The velocities of these arrivals ranged from 330m/s for a direct air wave through at least three readily identifiable ground roll trains with propagation velocities of approximately 1800 m/s, 2400 m/s and 3000 m/s to a very strong refraction with a velocity of around 4200 m/s. These noise trains were mapped into F-K space where a free format filter was designed to attenuate as much noise as possible whilst retaining valid reflection data. The filter was applied separately to the two halves of the spread. (See enclosures 1 to 5)

4. Array Simulation - Further noise attenuation was achieved by time variant long receiver array simulation. Down to a time of 700ms a three element array weighted 1-2-1 was used then a gradual increase in array size was used down to 3000 ms where a seven element array weighted 1-2-3.5-5-3.5-2-1 was used. The arrays were constructed by summing the elements along NMO curves at each time sample. The NMO curves used were computed using a single regional velocity function. Following array simulation, the data were decimated by dropping alternate traces in each record to leave 275 channel data with a 12m CDP interval.
1. TRANSCRIPTION
   USING GCORMIX

2. GAIN RECOVERY
   GAIN (dB) = 0.8t + 20.0Log(t)
   TIME (MS) AFTER WHICH GAIN LEVEL WAS HELD CONSTANT 2500

3. MULTI-CHANNEL FILTER
   FILTER DESIGN PARAMETERS:
   SHADED AREA ON PLOT REPRESENTS REJECT ZONE
   RESPONSE TAPERS 12.50 CYCLES/KM. AND 15.00 Hz.

   Wavenumber (Cycles/Km)

   Frequency (Hz)
   -41.67 0.00 41.67
   0.00 62.50 125.00

   Operator dimensions: 21 traces and 4000ms
   Removable A.G.C. Window length 200 (MS)

4. RECEIVER ARRAY SIMULATION
   Differential N.M.O. Applied
   Number of traces output = 275
   Time MS. Trace Heights
     0 1 2 1

5. COP GATHER
   Maximum fold 89
1 TRANSCRIPTION
  USING GCOMX

2 GAIN RECOVERY
  GAIN (dB) = 0.8t + 0.8Log(t)
  TIME (HS) AFTER WHICH GAIN LEVEL WAS HELD CONSTANT 2500

3 MULTI-CHANNEL FILTER
  FILTER DESIGN PARAMETERS:
  SHADeD AREA ON PLOT REPRESENTS REJECT ZONE
  RESPONSE TAPERS: 12.50 CYCLES/KM. AND 15.00 Hz.

4 RECEIVER ARRAY SIMULATION
  DIFFERENTIAL N.M.O. APPLIED
  NUMBER OF TRACES OUTPUT: 275
  TIME MS.: TRACE HEIGHTS 0 1 2 3
10. Final velocity analysis by OMNIVELS every 1km and final NMO application.

11. Initial trace muting

12. Pre-stack scaling using 400ms fixed windows

13. Final correction to datum - mean CDP statics applied.

14. CDP stack

15. Band pass filter

16. Post stack scaling using 800ms fixed windows.

17. Tau-p filter - 24 trace transform. 80ms semblance window.

18. Migration - 2nd order finite difference solution using 40ms steps.

19. Display on film the final stacked and migrated data at a horizontal scale of 1:12,000 and 10cm/s.

CONCLUSIONS

The data was mostly of good quality with continuous and readily identifiable reflectors evident down to about 1.3s T.W.T. and other more broken deeper reflectors down to 4.0s. Static corrections were generally not a major problem with only minor variations occurring along the line, apart from a large escarpment occurring at VP400. Although refraction statics generally had a beneficial effect, it is likely that a combination of model statics and residual statics would give equivalent results. Stacking velocities were quite high with 4000 m/s being realised by a two way time of 500ms. Although the raw field data exhibited a fair amount of coherent source generated noise, this was easily attenuated by F-K filtering, receiver array simulation, dip moveout and finally post stack tau-p filtering.

Unfortunately the complex faulted parts of the line (VP360-660 and VP1860-1980) still appeared somewhat confused after the application of DMO and migration, probably indicating that there is a good deal of energy coming from out of the plane of the section in these areas.
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CHAINING MAP

LINE 88 - 291

PROSPECT: Salmon Valley
CLIENT: Pacific Oil & Gas
PARTY: COMPLETED BY: Howe
DATE: 12-6-88

DIRECTION: N:5
STATION SPACING: 12M
VP SPACING: 14M

SAND + CLAY

PH 100, 50
120
140
160
180
200

SAND + CLAY

200
240
260
280
300

LOOSE SCATTERED ROCK

300
320
340
360
380
400

SHEER DROP

GO AROUND
ROCKY OUTCROP

FORM CP163