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PEDIRKA PETROLEUM N.L.

~~PR88/054~~ E

ONSHORE

DUNE SEISMIC SURVEY
SEISMIC PROCESSING REPORT
PEDIRKA BASIN EP-2, NORTHERN TERRITORY
JANUARY 1988

Prepared by: Nicholas Blake/Sedapro Consulting January 1988

Approved by: .... Management Date: 27.1.88

.... Geology Date: ....

.... Geophysics Date: 27.1.88

CONTENTS

APPENDICES AND ENCLOSURES

1. INTRODUCTION

The Pedirka Petroleum N.L., Dune Seismic Survey was recorded in the Pedirka Basin of S.E. Northern Territory, during September 1987. The data was recorded using a vibroseis source with uphole control by Norpac crew 287. Data processing was performed by Hoskings Geophysical initially in their Sydney based processing centre and subsequently in their Perth offices. Project monitoring was performed by the author of this report, Mr Nicholas Blake of Sedapro Consulting of Sydney.

This survey was conducted in the south-eastern corner of the permit EP-2 which lies in the middle of the Simpson Desert. The area is covered with sand dunes trending approximately NNW/SSE with elevations ranging from 125m ASL at dune peaks to 90m ASL between dunes. The wavelength of the dunes vary but is most commonly around 600m, with a receiver spread of between 105-1875m. This represents a fairly short period static disturbance which was observed throughout the area.

This type of terrain made acquisition difficult, especially for the uphole drill crew as their water supply lines became extremely long. As a result of this some of the upholes were cancelled.

This survey was aimed at the further detailing of potential leads developed from the 1986 Mooney Seismic Survey. The lines from this 1987 survey being designed as infill lines over areas of poor coverage (See Appendix 1).

This survey consisted of the following lines:

Line	Range	Dir	Km	Field Reels
S87-DU-01	100-487	NE	11.65	5015
S87-DU-02	100-350	NW	7.5	5018
S87-DU-03	100-500	NE	12	5016
S87-DU-04	100-350	SE	7.5	5017
S87-DU-05	100-500	NE	12.0	5011
S87-DU-06	100-550	NW	13.5	5014

S87-DU-07	100-415	NE	9.45	5019
S87-DU-08	100-550	SE	13.5	5013
S87-DU-09	100-415	NE	9.45	5020
S87-DU-10	100-565	NW	13.95	5012
			111.50	

Thus the project consisted of 111.5km of seismic data which were recorded using 120 channel DFSV instruments, to obtain 1200% subsurface coverage using a group interval of 30m and a vibroseis source spacing of 150m.

The data was recorded to 4 seconds using a sample rate of 2 msec, and processed to 3 seconds using a sample rate of 4 msec.

The results of the survey were good with all lines ranging in data quality from good to excellent.

2. PROCESS SEQUENCE INITIALISATION

2.1 Gain Recovery

The records were output onto tape in both uncorrelated SEGB format and correlated SEGY format by the field crew.

The SEGY tapes were transcribed into Hoskings in-house format of Phoenix I and resampled at the same time from 2 to 4 msec sample rate.

A theoretical spherical divergence correction was applied to the data to help balance the effective energy return level down the record in time.

The optimum gain curve was found to relate to an α = 0.2 function over the record length. This output a well balanced record suffering neither under nor over modulation problems, and was used for the entire survey.

2.2 Deconvolution

At this stage testing was performed to optimise the deconvolution to be applied. The following deconvolution operators were tested (see encl.1) by comparing their response on brute stack panels:-

Panel #	Type	
1	No deconvolution	
2	Predictive operator of 120 msec length, 8 msec gap.	1% WNL
3	Predictive operator of 120 msec length, 16 msec gap.	1% WNL
4A	Predictive operator of 120 msec length, 20 msec gap.	1% WNL
4B	Predictive operator of 120 msec length, 24 msec gap.	1% WNL
5	Predictive operator of 120 msec length, 32 msec gap.	1% WNL
6	Predictive operator of 120 msec length, 48 msec gap.	1% WNL
7	Predictive operator of 100 msec length, 16 msec gap.	1% WNL
8	Predictive operator of 200 msec length, 16 msec gap.	1% WNL
9	Predictive operator of 250 msec length, 16 msec gap.	1% WNL
10	Predictive operator of 300 msec length, 16 msec gap.	1% WNL
11	Spiking operator 120 msec length	2% WNL
12	Surface consistent spiking 120 msec operator length	2% WNL

All operators except the long 48 msec gap (panel 6) were superior to the undeconvolved (panel 1) section, which was dominated by low frequency components and short period multiples.

Each operator showed a good increase in the high frequency signal content and good control of the short period multiple or reverberation.

The undeconvolved auto-correlation display (encl.2, panel 1) showed the period of the main reverberation or sidelobe to be approximately 60 msec. This was well collapsed by all of the operators tested. The longer operators (shown on panels 8 to 10) demonstrated slightly better attenuation of the second sidelobe, but on the stack panels were seen to attenuate the steeply dipping data below 1.8 seconds.

Although the previously used 20 msec gapped operator did a good job it was felt that the shorter gapped operator of 8 msec (panel 2) showed much better resolution and high frequency content without adversely effecting the low frequency continuity. This is very apparent at between 0.4 and 0.7 seconds and also between 0.9 and 1.4 seconds.

The spiking operator (panel 11) was no better than the 8 msec gap, while the surface consistent spiking operator panel showed an excess of high frequency noise. It also failed to deal adequately with the noise trains in the first 0.5 second of the data.

It was decided upon these results to select the predictive 120 msec, 8 msec gapped operator with 1% white noise level. The design gates were 0.6 - 2.6 seconds on the near trace and 1.3 - 2.9 seconds on the far trace. A single gate was used as two gates could not be fitted into the relevant 'low noise' portion of the section while observing the 10:1 ratio, design gate to operator length rule of thumb.

2.3 Filter Tests

After the deconvolution tests a filter analysis was performed on a field record (see encl.3). Discrete 10 Hz passband filters were used ranging from 0-80 Hz. These panels were followed by a low cut sweep of 10, 15, 17, 20, 25 and 30 Hz while keeping the high side constant at 80 Hz.

Good signal content was observed at all frequencies between 10 and 60 Hz. Little signal was observed above 60 Hz and none at all over 70 Hz. The low frequency noise was dealt with effectively by using a 10 Hz low cut filter.

A filter of 10-80 Hz, similar to the sweep frequency range was implemented after the deconvolution as part of the production mainstream.

2.4 Spectral Balancing

A spectral balancing operator was applied both separately and in conjunction with the deconvolution operator. Although the results were interesting in that some areas responded to its application by an increase in resolution, the introduction at depth of a high frequency noise overlay distracted from the overall effectiveness of this processing option.

It was decided not to use this option in a noisy pre-stack mode, but to try the same technique as a post stack test later on in the processing sequence.

2.5 F-K Filtering

After review of the filter analysis, whereby the only noticable coherent noise train was effectively reduced by a low cut filter, the single fold shot records from a number of lines were inspected. No serious noise trains were observed. All of the brute stacks showed complete cancellation of all noise trains due to the stack fold cancellation.

In view of the foregoing it was decided not to use an F-K filter as its application was essentially redundant.

2.6 Amplitude Scalar

After deconvolution and filtering were performed a simple whole trace scalar was applied to bring all the traces and shots up to the same average power. This was a precaution against suspect geophone locations, differences in shot environment, offset - power deterioration and near surface changes.

Unfortunately, the zones between approximately 0.6 - 1.0 sec and 1.1 - 1.3 seconds remained at a very low amplitude level compared to the high amplitude events at 0.5 and 1.0 seconds.

The only satisfactory way to resolve this unacceptable contrast level was to use an AGC scalar. This was kept as long as possible at 800 msec, enabling the most relevant amplitude differentials to remain while increasing the amplitude of the events from the 'dead zones' just enough for them to be readily seen.

This also matched the previous processing in the area and would help a good character tie between the vintages of data to be made.

2.7 Display

The single fold records were then played out for quality control purposes and to aid the trace/record edit procedure. Cable configuration, offsets and slipped shots were also checked at this juncture.

2.8 Brute Stack

A brute stack was generated for each line using a previously determined velocity function from this area. This was used as a quality control measure and also to assist in the detailed positioning of the velocity analysis sets on the data. This stack was also used to check the provisional tie information at intersections.

2.9 Weathering Statics

As previously mentioned, the uphole drilling crew had logistical support problems and was running behind. This and the fact that the survey computations and base maps were late in arriving led to some delays in being able to come up with a weathering model for the area based on uphole coverage. To enable the new data to tie the old data, both the new and old upholes needed to be used in the generation of such a model.

In the meantime a trial was run comparing brute stacks with the following statics computed and applied:-

a) Brute Stack, Elevation statics only (encl.4)

b) Brute Stack, Uphole statics only (encl.5)

c) Brute Stack, refraction statics from first breaks calibrated to spacial uphole control (encl.6)

As can be seen from the referenced enclosures the stack relating to item c) above is clearly better in terms of its static solution. The stack response particularly at the marker horizons at approx. 1.0 and 1.4 seconds is far superior on encl.6 for instance than on enclosure 5 (upholes only). Shotpoints 160/170, 345 and 410 are dramatic examples of its success. At SP 305 there is some limited disruption but it is still superior to the elevation statics only stack (enclosure 4).

For the short period static resolution, the first break refraction method, is obviously preferrable in terms of its stack response and would be a distinct advantage in subsequent processing stages. Control of the long wavelength was assured by way of the uphole control that was available.

To marry the two solution together we calculated both refractions statics and uphole statics. The computed refraction static at any particular uphole location was forced to equal the static determined from that uphole, thus preventing any drift.

It was essential however for the success of this static solution and for the structural integrity of the final sections that the new and old upholes be consistent. A detailed study comparing the two sets of upholes determined that the observed results were good enough for this method to work. Although the layer thickness and velocities were not necessarily consistent the total delay time of weathering unit was (see Appendix 1 for details).

Delay times were computed for all lines to a datum of 91m ASL using a replacement velocity of 2200 m/sec. The integrated technique of using first break refraction statics calibrated to the uphole control was implemented are providing very good results.

2.10 Residual Statics (Surface Consistent)

The fully corrected unstacked data was input to the surface consistent static routine.

A design window was used that encompassed all of the main reflection sequence. This ran from 0.8 to 1.8 secs. A maximum static of ±30 msecs was allowed in the computation. The resulting stack was a clear improvement over the Brute Stacks.

The resolution of the reflection sequence was greatly improved with fine high frequency data segments becoming apparent. Even the design excluded shallower data between 0.3 and 0.7 seconds was greatly improved.

2.11 Velocity Analysis

A velocity analysis package was used on this project which output Constant Velocity Gathers (CVG's), Constant Velocity Stacks (CVS) each power picked automatically and posted on an accompanying 'scattergram' plot. The data was also NMO corrected, by using this machine picked function, and displayed next to the actual analysis. This function was not necessarily the function to be used as its results depend entirely on a power pick, which may not be the optimum geophysical velocity.

The input to this processing routine was sets of twelve adjacent CDP's at discrete locations, approximately 0.75km apart, along each of the lines.

Time-velocity pair co-ordinates of the optimised stack responses were hand-picked and compiled into a velocity function at the appropriate shotpoint location. This was checked against the associated CVG output to optimise the degree of flatness achieved. Adjustments were made to the selected velocities as required.

The resulting velocity functions were used to correct the data for normal moveout corrections (NMO).

2.12 First Break Mutes

These were originally determined from the single fold records and applied in the Brute Stack and Velocity Analysis. The final mute applied on the subsequent stacked outputs were determined from an inside/outside stack offset mute test and the common offset stacks (see next section) and was as follows:

Offset (m)	Time (msec)
375	0
675	650
975	1150
1875	1400

2.13 Common Offset Stacks (COS)

As well as checking the accuracy of the velocities and statics application this output was used to aid in the design of the first break schedule.

These were run at velocity analysis locations. The degree of flatness observed on the corrected COS was an indication of the accuracy of the velocity picks. While the degree of smoothness indicated the accuracy of the statics applied.

Fine tuning of the velocity functions at each COS location was performed when inaccuracies were found. Generally the statics looked good but there were some exceptions.

The COS were rerun with the revised velocity function and then used to select first break mute schedule. These were applied prior to stacking, and optimised the signal in the shallow section by eliminating first break noise by selective editing.

2.14 Residual Statics (Surface Consistent)

At this stage of the processing sequence a second surface consistent residual static calculation was made. This time we used a routine option which also gave common shot and receiver stacks. This was a very valuable quality control tool.

The statics calculated in this pass were small ($\pm$ 4 msec) and did not change the stacks noticably. In several locations in this prospect, where observation of the stacks and COS had brought attention to apparent static anomalies, hand-picked correlation statics were used. These were picked directly from common shot/receiver stacks. In all cases this technique solved the observed anomalies.

2.15 Residual Static (CDP Consistent)

The alternative and sometime complement to surface consistent statics is CDP consistent residual statics.

The CDP consistent residual static routine statically measures and removes the small remnant statics apparent between adjacent CDP's. These corrections are intrinsically small. This routine used a 5 trace pilot, a maximum allowable static of ± 12 msec (actual statics picked were ± 3 msec) and a design gateover the entire section of interest between 0.3 and 1.8 seconds.

The output was a further processing improvement to the section.

2.16 Final Stack

The final stacks produced by this processing job stream were of good to very good quality with sporadic but well defined segments of events between 0.1 to 0.9 sec. Between 1.0 to 1.5 seconds a strong sequence of high resolution continuous events was evident. At the base of this sequence there were some strong buried focus diffraction patterns. This sequence of events were generally flat with gentle undulations over most of the area but with up to a dramatic 100 msecs of structure in other parts.

3. POST STACK PROCESSING

3.1 Filter and Frequency Balancing (Post Stack)

Two zones of unfiltered stack data were filtered using a suite of high-low bandpass filters. An optimum filter was selected by comparing the data from each of the panels (see enclosure 7).

In this test the limit of the effective amplitude diminished over 40 Hz and little signal was seen above 60 Hz. This was somewhat of a concern as the sweep frequency went up to 80 Hz.

To investigate this further a power spectrum was performed on a raw field record (enclosure 8) and the same record after deconvolution was applied (enclosure 9). On enclosure 8, using the 'DB Power Spectrum' plot, the lack of any frequency content can be seen from above the 50 Hz level. Frequencies between 60 and 80 Hz are some 10 or 16 dB's down on the energy level observed at 50 Hz.

The same graph on enclosure 9 shows that the deconvolution operator is doing a very good job at reconstructing the frequency bandwidth, with apparent frequencies between 10-80 Hz becoming evident. This covers the whole range of the vibroseis input source. However, it is still noticable that the average amplitude level between 60 to 80 Hz is some 4 dB's down on the level observed between 40 to 60 Hzs which is itself 4 dB below the average level between 10 and 40 Hz.

Obviously some further amplitude shaping could be attempted here.

A spectral whitening operator showed some interesting results earlier on in the test sequence, at the deconvolution stages, but was not used. This time the technique was optimised in a series of tests using the raw stack data as input. The output stacks from this routine showed a good improvement over the original input stacks. There was a good increase in the resolution of the data and of course the high frequency content. The general wavelet character remained fairly consistent and still allowed a good tie to be made with the older vintage sections.

A further filter test (enclosure 10) run on the spectrally balanced data shows an increased level of amplitude from the 40 to 50 Hz range and the 50 to 60 Hz range. No response was forthcoming in the ranges over 60 Hz.

A low cut filter test (enclosure 11) was used to determine the final frequency passbands to use. In this test the highside was kept at 60 Hz, being the maximum high frequency contribution of signal to the data. No high frequency noise overlay was observed either shallower or at depth.

The low cut was selected to enhance the resolution of the data without effecting the continuity of the lower frequencies.

They were as follows:-

Time (sec)	Frequency Bandpass (Hz)
0	16-60
0.5	16-60
1.3	14-60
2.3	10-60
3.0	10-60

The resulting section looked clean and well presented with no ringing.

3.2 Trace Scaling

A final trace sector of 0 - 3.0 secs was applied to the output in order to evenly modulate all of the project data prior to filming.

3.3 TAU-P and Coherence Scaling

Both of these routines were attempted but neither added to the resultant sections without detracting an equal amount. That is, the increased continuity was achieved but at the expense of the signal characters. These techniques were not subsequently used in the processing sequence.

3.4 Migration

Migration of the final stacks was recommended due to the fractured nature and accompanying diffractions patterns, of the strong basement feature.

Migration velocity percentage tests were run. As a result of these 100% of stacking velocities were used. This gave the best contraction of the diffractions arcs.

Some of the more highly structured areas of the project benefited greatly from the use of this migration with an increase in the clarity of the transition zones and a minimising of the 'clutter'.

The result of this wave equation finite difference migrations were good for all lines of the project.

3.5 Display

Film modulation level tests were peformed and a value of 74 dB's was used.

Film sections for both the final stack and the migrated stack were displayed on film at normal polarity. The top label consisted of the following annotation:-

Velocity function boxes
Elevation and datum plot
Shot/Receiver static plot
Residual static plot
CDP fold counter
Shotpoint numbers and line ties.

A scale of 26 tpi (10 tpc) and 5 ins/sec (12.7 cm/sec) was used on both outputs.

4. PROCESSING MAINSTREAM

All of the lines recorded in this project ranged between good and very good in data quality. No major problems were encountered with the recording crew and the geometries/co-ordinates of the lines were relatively simple.

All of the lines followed a standard job flow.

Some of the lines had static anomalies and cycle skips but these were solved by using a combination of additional velocity analyses and hand-picked correlation statics as previously discussed.

The new data tied well in time and character to the older data and was in general of the same quality as the previous processing but with perhaps a little better resolution of the high frequencies.

Only two problems existed in tieing the data. One was due to an anomalous uphole at the intersection of S87-DU-04 and 86-MY-1. This new uphole showed a large pocket of weathering which failed to be apparent on surrounding upholes (new uphole control in this area was not good with several locations not recorded). It was ignored and an interpolated value used instead.

The second problem was at the intersection of S87 DU-06 and S87 DU-01. Line DU-06 ran between and closely parallel to the dunes whereas DU-04 traversed over them. A mistie of 10 msec in the data sets were observed due mainly to residual static mean shifts. An adjustment of 5 msec was made to each line to help compensate for this problem.

5. CONCLUSIONS

The project was finished in early December 1987 for interpretative purposes and completed in January 1988 with delivery of the final films.

The processing of this project progressed well with some delays due to problems in the field with the uphole control, with the survey calculations of intersections and the production of a base map in the Sydney office.

A good improvement was observed at all stages of the processing sequence. Good structural control was maintained by the use of uphole statics. The data tied well with previous data recorded in the area.

I wish to extend thanks to the Hoskings Processing staff and to Darryl Kingsley of GUMLU Pty Limited for their advice and co-operation throughout the processing phase of this project.

Respectfully submitted.

Mr N. Blake
SEDAPRO CONSULTANTS

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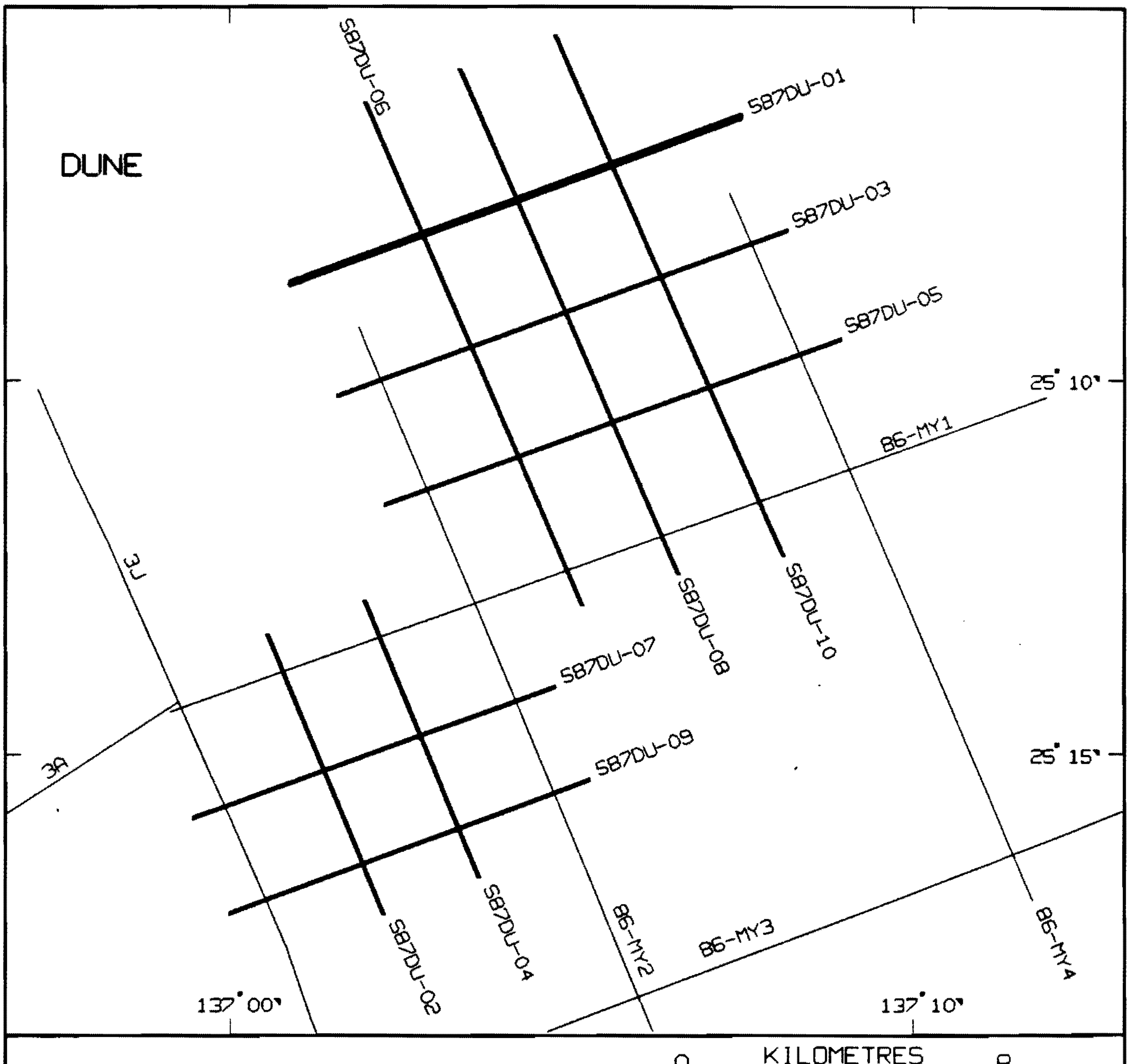
APPENDIX 1



LINE INDEX MAP

APPENDIX 2

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INCORPORATED IN N.S.W.

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44 MARGARET ST.
SYDNEY 2000, AUSTRALIA.
TELEPHONE: (02) 29 8061
TELEX: 72094 (SOCSYD)

OUR REF.
YOUR REF.

MEMORANDUM

TO: HOSKINGS GEOPHYSICAL, PERTH

ATTENTION: PETE SCRUTON, MICK CURRAN

CC: R SCHRODER, S MUNRO

FROM: NICK BLAKE S.O.C.

DATE: 23 OCTOBER 1987

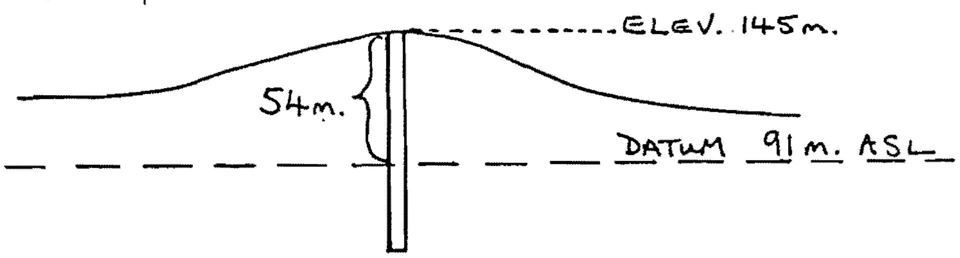
SUBJECT: DUNE, SIMPSON UPHOLE SURVEYS

Dear Pete and Mick

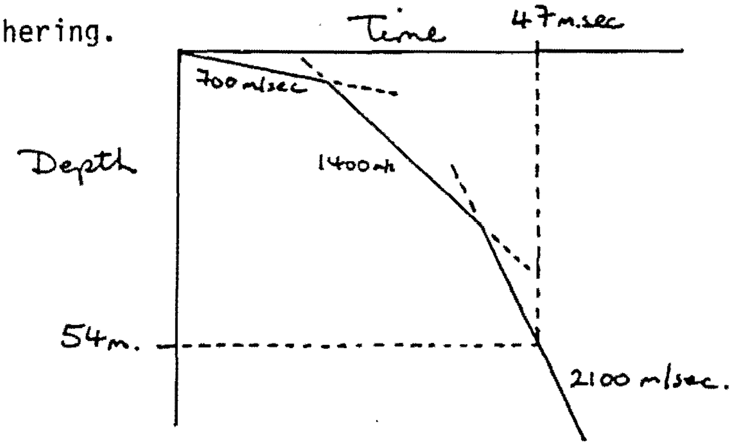
Sending you today by courier photocopies of the upholes recorded for the following seismic lines:- S86MT-01, 02, 04, 06, 08,
S86MY-01, 02, 03, 04,
S86BT-01, 02, 03, 04, 05

One way of using these and the newly acquired upholes would be to;

a) Subtract the processing datum (91m ASL) from the elevation of the uphole to get the depth in the hole that relates to the datum level.



b) In this example scan across from the 54m hole depth to where it intersects the plotted velocity lines. This will correspond to the delay time due to weathering.



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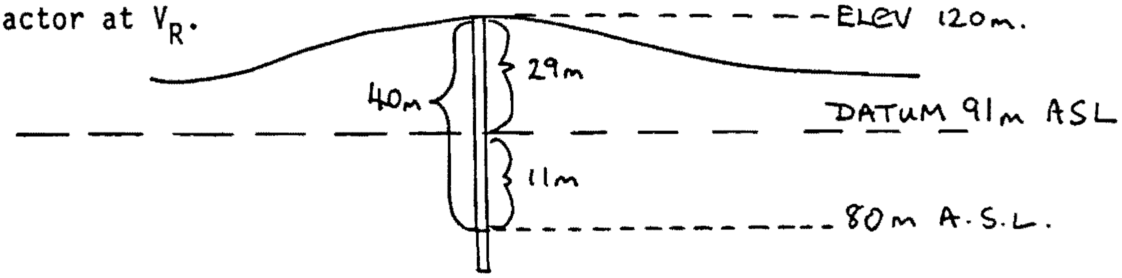
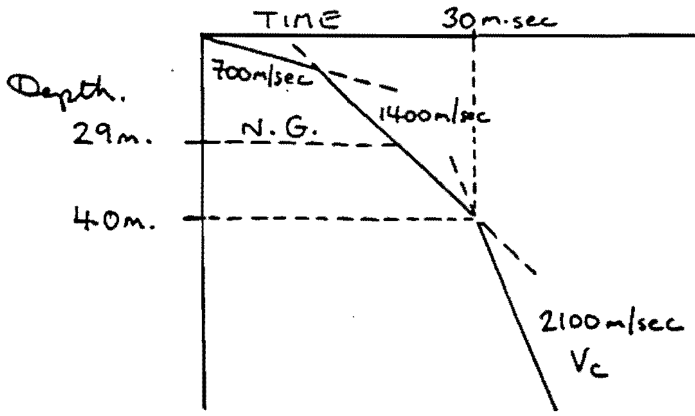
c) This assumes that the hole goes to a level below datum and that at the depth we are checking the delay time for will be in the sub-weathering or consolidated layer ie. approx 1800 m/sec upward.

Upholes outside of this criterion can be used but you must add back a factor at V_R.





Any depth less than 40m will not mesure all the delay. Use start V_C as minimum depth.

$$\therefore \text{Static} = \text{Delay Time} + \text{correction factor}$$
$$= -30 + \frac{(91 - 80)}{V_R} = -30 + \frac{11}{2.4} = -30 + 5$$
$$= -25 \text{ msec}$$

Any uphole that does not penetrate the sub-weathering you should ignore.

d) For every uphole location, the static developed by either b) or c) above should correspond to the total one way static you have calculated at that shotpoint, due to both elevation and refraction study components.

Although they should be the same I'm sure that they won't be as most things never seem to work out that well in practice. More important however, is that the differential observed between two particular upholes, of say x msecs should also be the differential of your calculated weathering (elevation and refraction) statics at the same locations. If this is so then we can feel fairly comfortable that we have modelled the weathering correctly and any structure observed on the section will be real or relate to changes in the Sub-weathering/consolidated layers that are too subtle for our velocity analysis techniques to measure, and too deep to be near surface static effects.

I have completed an analysis of the upholes, both new and old, in the area and most are fairly stable with respect to delay times. They are not stable with respect to observed layer thickness's or interval velocities. Hence I have given up trying to come up with a meaningful detailed layer model.

These are just some thoughts I have had on the weathering here. Maybe your calibration method does the same thing. Anyway your comments on this would be appreciated. The main thing is that we use both the new and old upholes to their maximum effect to ensure the best quality stacking statics and a structually sound final section that ties the old data.

Thanks for all the brutes.

Regards

Nick Blake.

NICK BLAKE

APPENDIX 3

SEQUENCE	PROCESSING PARAMETERS
TRANSCRIPTION	SEGY TO PHOENIX 1 FORMAT RESAMPLED FROM 2 TO 4 MSEC
GAIN RECOVERY	ALPHA : 0.2
DECONVOLUTION	PREDICTIVE DECONVOLUTION - 120 MSEC OPERATOR 1% WHITE NOISE - 1 DESIGN GATE - 8 MSEC GAP DESIGN: NEAR 600 2600 msec FAR 1300 2900 msec
FILTER	10 - 80 HZ
TRACE SCALING	800 MSEC AGC
STATICS	FLOATING DATUM CORRECTION. TIED TO UPHOLES HOSKING 1ST BREAK STATICS. 2200 M/SEC CONSTANT Vr
RESIDUAL STATICS	1ST PASS SURFACE CONSISTENT USING BRUTE VELOCITY MAX STATIC ALLOWED 30 MS (GATE 900 - 1800 MSEC)
NMO CORRECTIONS	REFERENCED TO SURFACE CDP MEAN STATIC ANNOTATED UNDER VELOCITY BOXES
INITIAL MUTE	OFFSET : 375 675 975 1875 M TIME : 0 650 1150 1400 MSEC
STATICS	FLOATING DATUM TO DATUM (DATUM : 91 M ABOVE MEAN SEA LEVEL)
RESIDUAL STATICS	2ND PASS SURFACE CONSISTENT AND CDP TRIM STATICS MAX STATIC ALLOWED 12 MS (GATE 200 - 1800 MSEC)
STACK	12 FOLD CDP STACK
BALANCE	SPECTRAL AND AMPLITUDE
FILTER	0.0 0.5 1.3 2.3 SEC 16-60 16-60 14-60 10-60 HZ
SCALING	1 GATE 0 - 3000 MSEC