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ANZON ENERGY LTD

BASKER-1

REVISED WELL SEISMIC PROCESSING REPORT

CHECKSHOT / GEOGRAM

azn

Anzon Energy LIMITED

FIELD:	Wildcat (by Shell Development Australia Ltd)
COUNTRY:	Australia
COORDINATES:	Latitude: 38 18' 26.5" S
:	Longitude: 148 41' 53.2" E
LOCATION:	Victoria, Gippsland Basin
DATE OF SURVEY:	19-May-1983 & 14-Jun-1983
DATE OF REPORT:	September 2004
SURVEY TYPE:	Rig Source Checkshot, Offshore, Airgun
REFERENCE NO:	DS 0904-10

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Index

List of Figures

Attachments

1 Introduction

A borehole seismic survey was recorded in two runs in the vertical offshore exploration well Basker-1 on 19 May and 14 June 1983. This survey included rig source checkshot measurements in both open and cased hole. The data were acquired using a single Well Seismic Tool (WST) downhole and an Air gun source deployed from a crane on the rig.

Original field prints show checkshot processing and sonic calibration was done in 1983, but this data could no longer be traced.

This re-processing of the data consisted of recalculating Checkshot corrections, Log editing, Sonic calibration and Synthetic seismogram generation. This report describes the processing techniques used, the parameters chosen and presents the results of the data processing.

2 Data Acquisition

The data were acquired in two logging runs in both open and cased hole, using a single Well Seismic Tool (WST).

One 200 cu in Airgun was used as the source. The gun was suspended 6.6 m below sea level at 57.5 and 47.3 m offset from the wellhead. Reference sensors were positioned at the guns. Recording was made on the Schlumberger CSU using DLIS format.

26 checkshot levels were acquired from 3985 m DF to 520 m DF at variable intervals. A minimum of 3 good shots was recorded for each level.

Elevation of DF	25 m above MSL
Elevation of GL	162 m below MSL
Well Deviation	Vertical
Energy Source	200 Cu In Air Gun
Source Offset	57.5 m / 47.3 m
Source Azimuth	340 deg / 360 deg
Source Depth	6.6 m below MSL
Sensor Depth	6.6 m below MSL
Water Velocity	1524 m/s
Tool	WST

Table 1. Survey Parameters

3 Well Seismic Data

The original field data was examined and showed good quality recorded seismic waveforms and well picked field data. The previously processed time-depth listings were truncated to integer millisecond values. Analysis of the time picks shows that this introduces small (< 1ms) errors. To avoid these errors the more accurate field picks were used for the subsequent processing steps.

See Appendix 2 for the Well Seismic Report with the checkshot measurements.

4 Composite Displays of Results

A snapshot of the 20 cm/s composite display (PLOT-1) of checkshot calibrated log and synthetic data is shown in figure 1.

Composite displays of the Synthetic Seismograms are shown in Figures 2 and 3. The figures show displays in both normal and reverse polarity. The polarity convention used (Normal: Increase in Acoustic Impedance is a Trough) is explained in Figure 5.

The time of the water bottom spike on the synthetic traces is based on the reported water depth and a velocity of 1524 m/s.

5 Sonic Calibration Processing

5.1 Sonic Calibration

A 'drift' curve is obtained using the sonic log and the vertical check level times. The term 'drift' is defined as the seismic time (from check shots) minus the sonic time (from integration of edited sonic). Commonly the word 'drift' is used to identify the above difference, or to identify the gradient of drift versus increasing depth, or to identify a difference of drift between two levels.

The gradient of drift, that is the slope of the drift curve, can be negative or positive.

For a negative drift (Δdrift/Δdepth < 0) the sonic time is greater than the seismic time over a certain section of the log.

For a positive drift (Δdrift/Δdepth > 0), the sonic time is less than the seismic time over a certain section of the log.

The drift curve, between two levels, is then an indication of the error on the integrated sonic or an indication of the amount of correction required on the sonic to have the TTI of the corrected sonic match the check shot times.

Two methods of correction to the sonic log are used.

1. Uniform or block shift. This method applies a uniform correction to all the sonic values over the interval. This uniform correction is applied in the case of positive drift and is the average correction represented by the drift curve gradient expressed in µsec/m .

2. ΔT Minimum. In the case of negative drift a second method is used, called Δ minimum. This applies a differential correction to the sonic log, where it is assumed that the greatest amount of transit time error is caused by the lower velocity sections of the log. Over a given interval the method will correct only Δt values which are higher than a threshold, the Δt_{min} . Values of Δwhich are lower than the threshold are not corrected. The correction is a reduction of the excess of Δt over Δt_{min}, $\Delta t - \Delta t_{min}$.

$\Delta t - \Delta t_{min}$ is reduced through multiplication by a reduction coefficient which remains constant over the interval. This reduction coefficient, named G, can be defined as:

$$G = 1 + \frac{\text{drift}}{(\Delta t - \Delta t_{min})dZ}$$

Where drift is the drift over the interval to be corrected and the value $(\Delta t - \Delta t_{min})dZ$ is the time difference between the integrals of the two curves Δt and Δt_{min}. only over the intervals where $\Delta t > \Delta t_{min}$.

Hence the corrected sonic: $\Delta t = G(\Delta t - \Delta t_{min}) + \Delta t_{min}$.

5.2 Open Hole Logs

The provided digital log data consisted of a spliced dataset that required editing. The sonic (LSS) DT curve was used for drift computation. The log quality is fair. There is one big gap between the logging of the 17.5” and the 12.25” sections from app. 1007 to 1110 m MD DF that was interpolated. Several other smaller gaps and spikes have been edited.

The density log has also been edited. In many locations big washouts and mud invasion resulted in an incorrect density curve. Other logs included as companion curves are: Gamma Ray, Neutron Porosity, Resistivity (RT, RXO) and Caliper.

5.3 Correction to Datum and Velocity Modeling

The sonic calibration processing has been referenced to Mean Sea Level, which is the seismic reference datum. Geometry corrections are applied to correct for source offset, source depth and SRD elevation.

5.4 Sonic Calibration Results

The checkshot near the top of the sonic log (520 m MD DF) is chosen as the origin for the calibration drift curve. The compressional sonic log was extended using the given water bottom depth.

The drift curve is the correction imposed upon the sonic log. The adjusted sonic curve is considered to be the best result using the available data. A list of shifts used on the sonic data is given in A2 Listing (supplied in digital form on Final Results CD-ROM). The drift curve shows a fairly smooth positive drift consistent with sonic vs seismic velocity dispersion effects.

The Velocity Cross plot is presented in Figure 4 and as a separate plot.

6 Synthetic Seismogram Processing

GEOGRAM plots were generated using four different wavelets: 25 Hz, 35 Hz (Dominant Frequency) zero phase Ricker wavelets and these two wavelets with a (+90 deg) phase rotation applied.

The presentation includes composite plots on a time scale of 20 cm/sec in both normal and reverse polarity (Plots 1 and 2).

GEOGRAM processing produces synthetic seismic traces based on reflection coefficients generated form sonic and density measurements in the wellbore. The steps in the processing chain are the following:

- Depth to time conversion
- Reflection coefficient generation
- Attenuation coefficient calculation
- Convolution
- Output

6.1 Depth to Time Conversion

Open hole logs are recorded from the bottom to top with a depth index. This data is converted to a two-way time index.

6.2 Primary Reflection Coefficients

Sonic and density data are averaged over chosen time intervals (normally 2 ms). Reflection coefficients are then computed using:

$$R = \frac{r_2.v_2 - r_1.v_1}{r_2.v_2 + r_1.v_1}$$

where:

r_1 = density of the layer above the reflection interface
r_2 = density of the layer below the reflection interface
v_1 = compressional wave velocity of the layer above the reflection interface
v_2 = compressional wave velocity of the layer below the reflection interface

This computation is done for each time interval to generate a set of primary reflection coefficients without transmission losses.

6.3 Primaries with Transmission Losses

Transmission loss on two-way attenuation coefficients is computed using:

$$A_n = (1 - R_1^2).(1 - R_2^2).(1 - R_3^2)...(1 - R_n^2)$$

A set of primary reflection coefficients with transmission loss is generated using:

$$Primary_n = R_n.A_{n-1}$$

6.4 Primaries plus Multiples

Multiples are computed from these input reflection coefficients using the transform technique from the top of the well to obtain the impulse response of the earth. The transform outputs primaries plus multiples.

6.5 Multiples Only

By subtracting previously calculated primaries form the above result we obtain multiples only.

6.6 Wavelet

A theoretical wavelet is chosen to use for convolution with the reflection coefficients previously generated. Choices available include:

Klauder wavelet
Ricker zero phase wavelet
Ricker minimum phase wavelet
Butterworth wavelet
User defined wavelet

Time variant Butterworth filtering can be applied after convolution.

6.7 Polarity Convention

An increase in acoustic impedance gives a positive reflection coefficient, is written to tape as a negative number and is displayed as a white trough under normal polarity. Polarity conventions are displayed in Figure 5.

6.8 Convolution

The standard procedure of convolving the wavelet with reflection coefficients; the output is the synthetic seismogram.

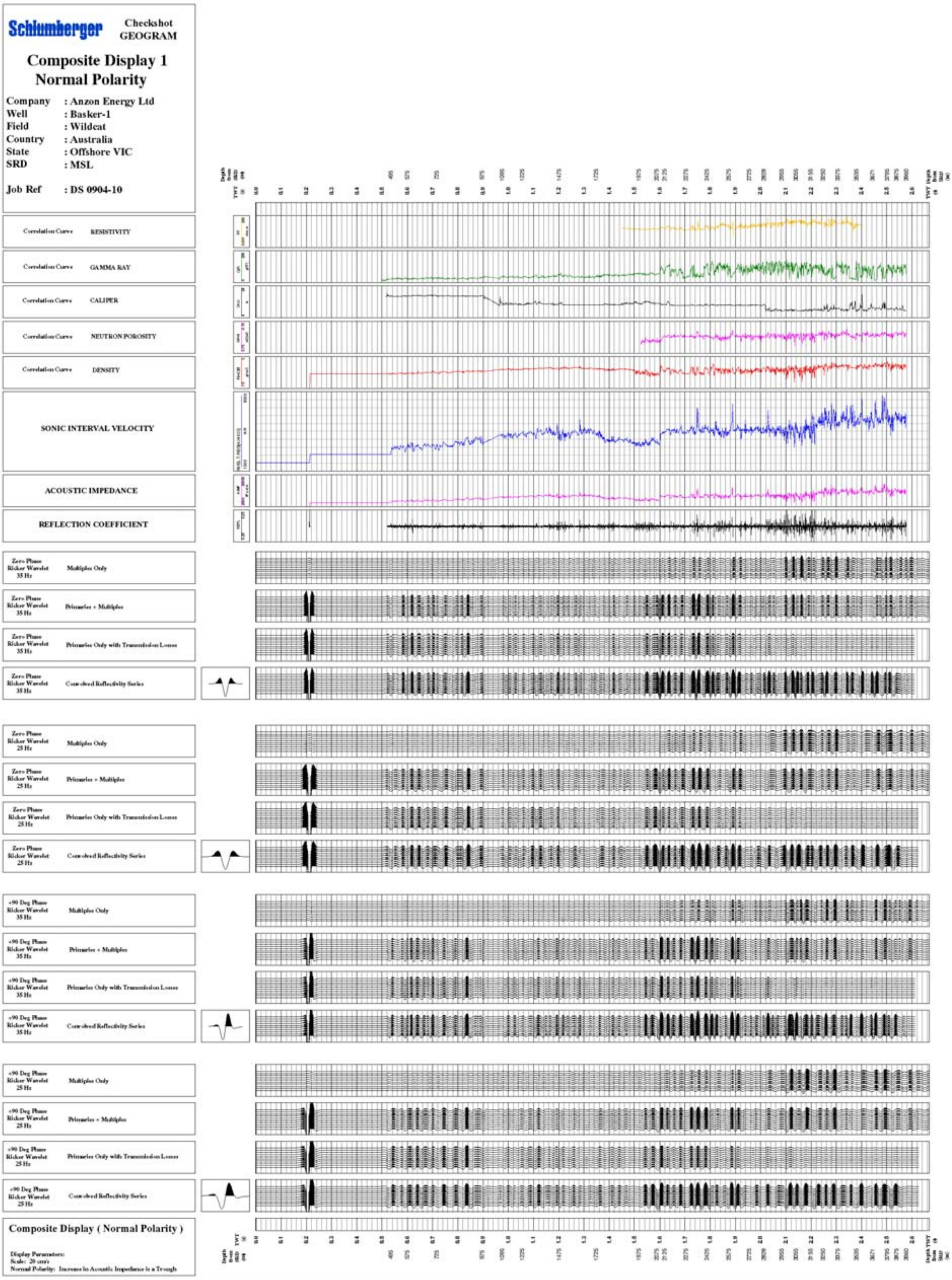

Figure 1. Composite Display (See Plot 1)

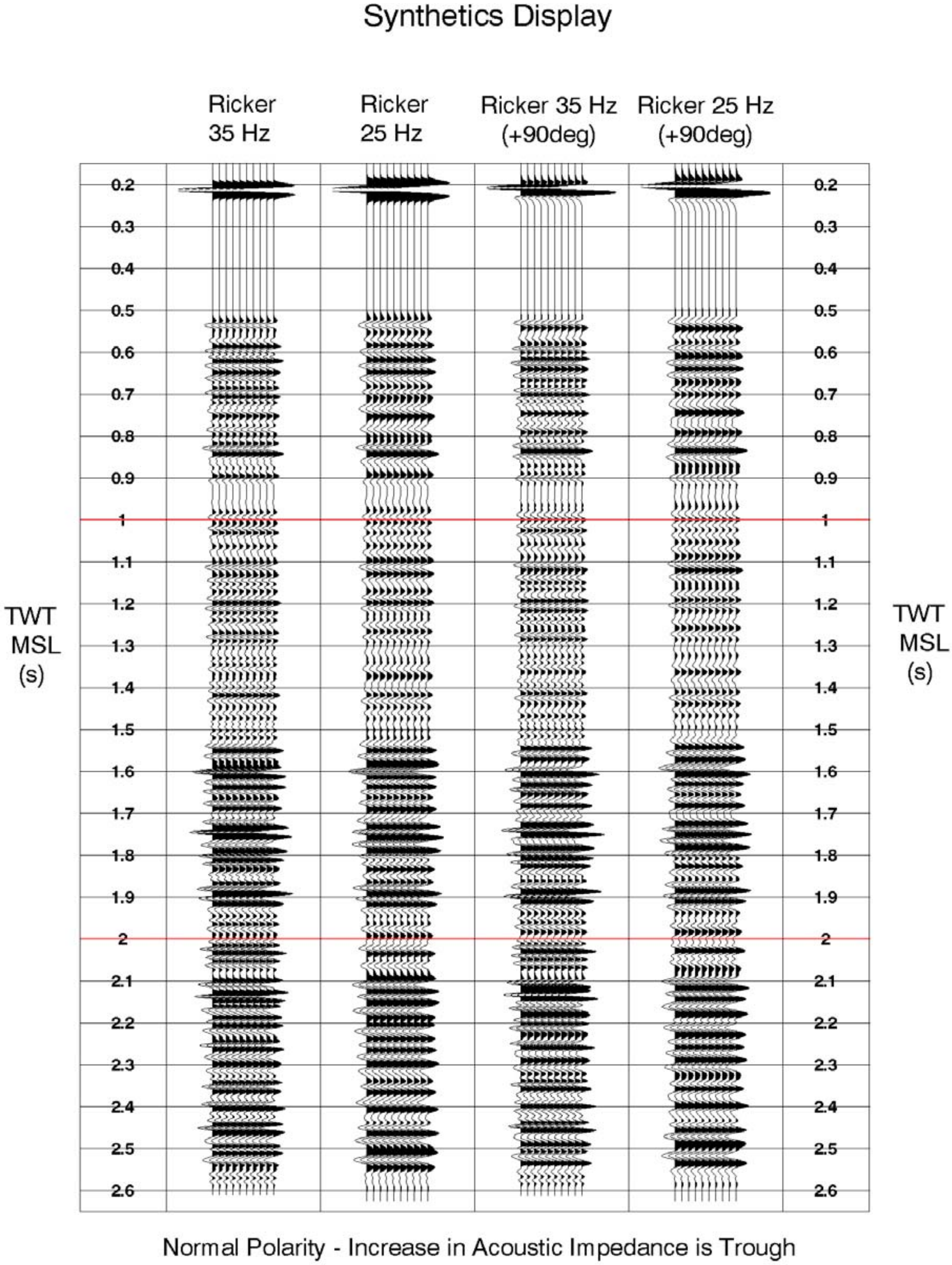

Figure 2. Composite Display of Synthetics (N)

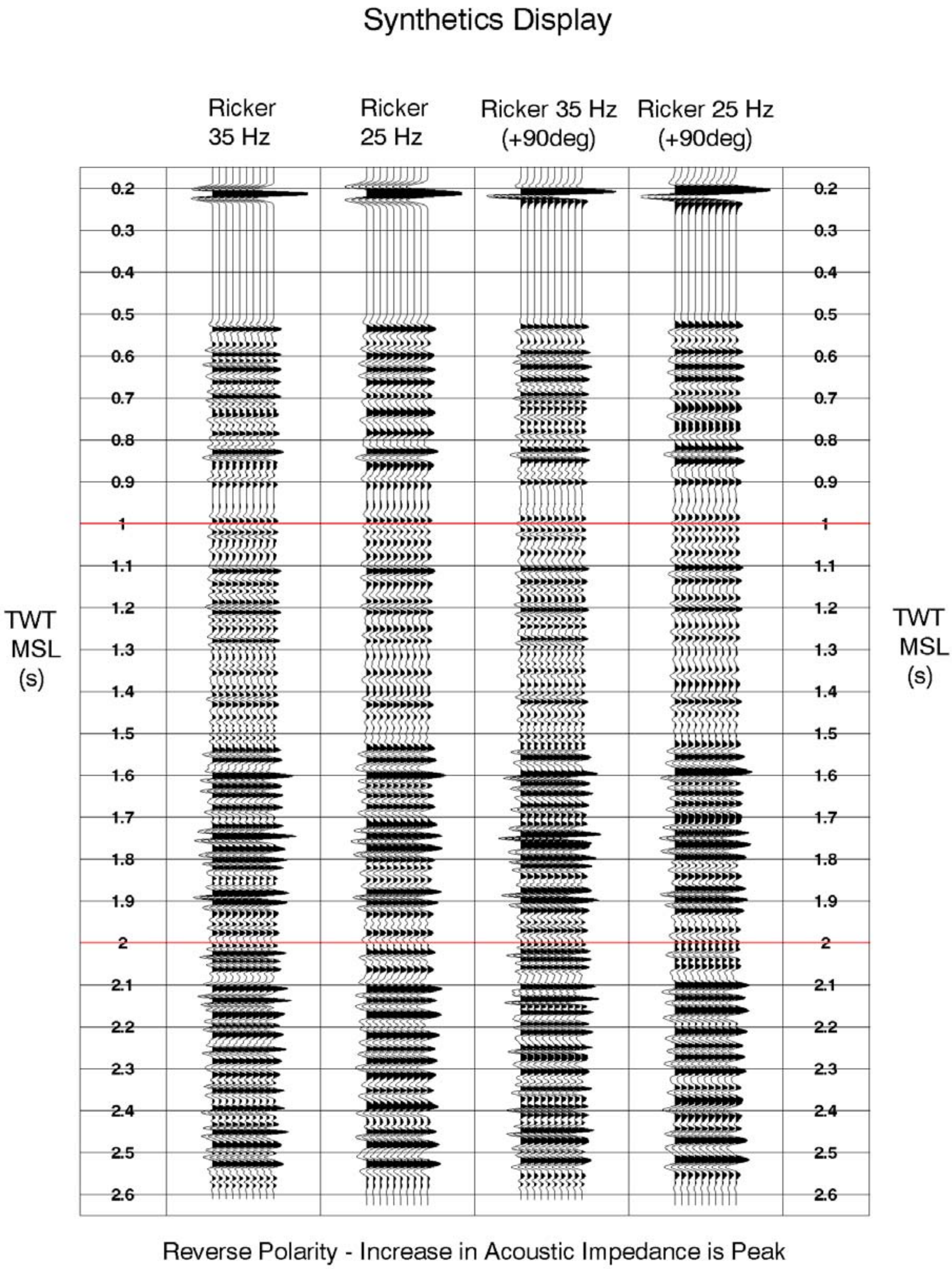

Figure 3. Composite Display of Synthetics (R)

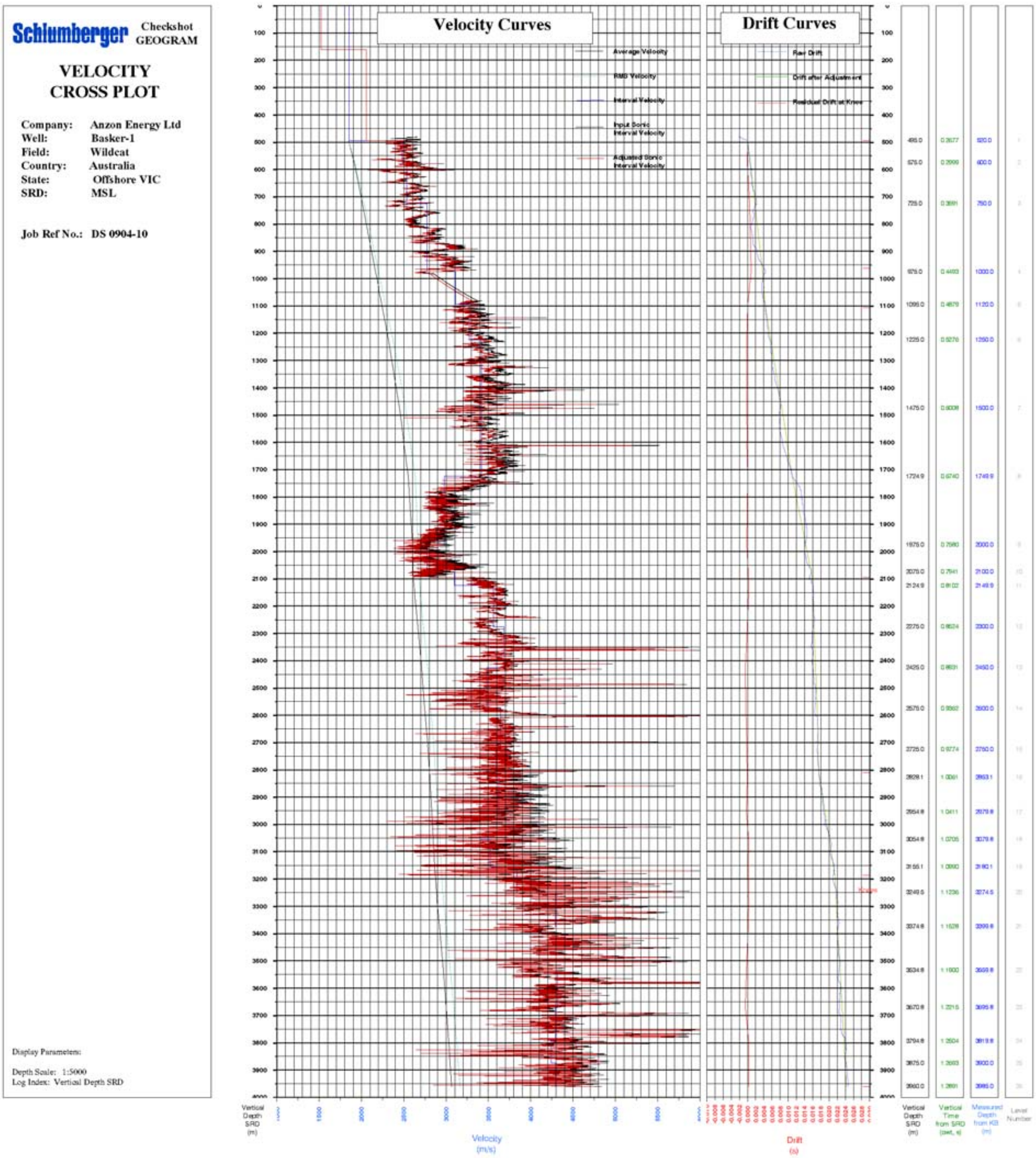

Figure 4. Velocity Cross plot (see Plot 3)

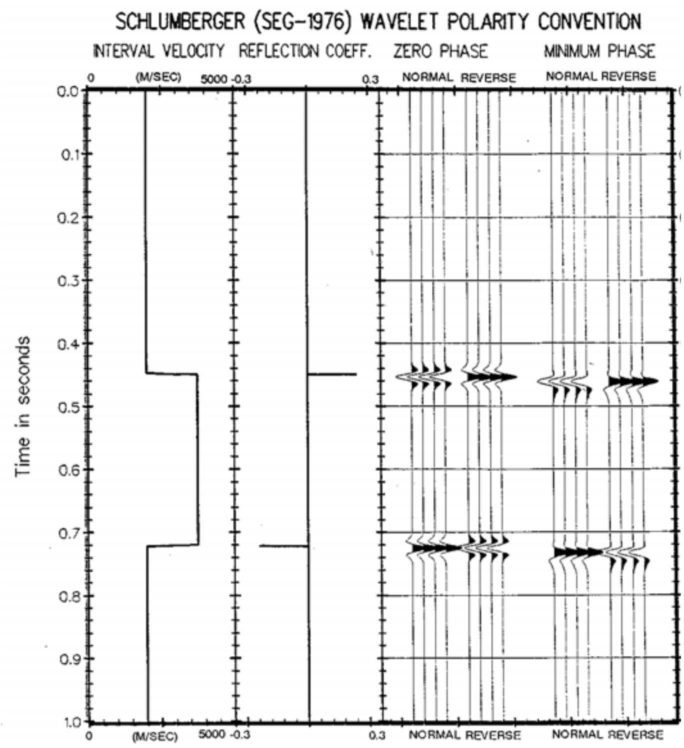

Figure 5. Schlumberger Wavelet Polarity Convention

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Attachment 1: Summary of Geophysical Listings

Four geophysical data listings are appended to this report. A1 is included in the report, A2, A3 and A4 are provided in electronic form on the CD-ROM. Following is a brief description of the format.

A1 Check Shot Data

1. Level number: the level number starting from the top level (includes any imposed shots).

2. Vertical depth form SRD: *dsrd*, the depth in meters from seismic reference datum.

3. Measured depth from KB: *dkb*, the depth in meters from KB.

4. Observed travel time HYD to GEO: *tim*0, the transit time picked form the stacked data by subtracting the surface sensor first break time from the downhole sensor first break time.

5. Vertical travel time SRD to GEO: *shtm*, is *timv* – vertical time, corrected for the vertical distance between source and datum.

6. Delta depth between shots: Δ*depth*, the vertical distance between each level.

7. Delta time between shots: Δ*time*, difference in vertical travel time (*shtm*) between each level.

8. Interval velocity between shots: average velocity between each level, Δ*depth/*Δ*time*

9. Average velocity SRD to GEO: average velocity from datum to the checkshot level, shtm/dsrd

A2 Drift & Sonic Adjustment

Zone Set Data

1. Knee number: the knee number starting from the highest knee. (The first knees listed will generally be at SRD and the top of sonic. The drift imposed at these knees will normally be zero.)

2. Measured depth from KB: the depth in meters from KB

3. Vertical depth from SRD: the depth in meters from seismic reference datum.

4. Selected Drift at knee: the value of drift imposed at each knee.

5. Shift: the change in drift divided by the change in depth between any two levels.

6. Delta-T: see section 4 of report for an explanation of Δt_{min}.

7. Reduction factor G: see section 4 of report.

8. Selected Drift Gradient: the gradient of the imposed drift curve.

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Sonic Adjustment Data

1. Measured depth from KB: the depth in meters from KB
2. Vertical depth from SRD: the depth in meters from seismic reference datum.
3. Vertical shot time SRD to GEO: the calculated vertical travel time from datum to geophone.
4. Adjusted Sonic Time.
5. Computed drift at level: the checkshot time minus the integrated raw sonic time.
6. Residual Shot Time - Adjusted Sonic Time.
7. Adjusted Interval Velocity.
8. Adjusted RMS Velocity.
9. Adjusted Average Velocity.

A3 Velocity Report

The data in this listing has been resampled in time.

1. Two way travel time from SRD: this is the index for the data in this listing. The first value is at SRD (0 ms) and the reporting interval is 10 ms.

2. Measured depth from KB: the depth from KB at each corresponding value of two way time.

3. Vertical depth from SRD: the vertical depth from SRD at each corresponding value of two way time.

4. Average velocity SRD to GEO: the vertical depth from SRD divided by half the two way time.

5. RMS velocity: the root mean square velocity from datum to the corresponding value of two way time.

$$v_{rms} = \sqrt{ (\Sigma v_i^2 t_i / \Sigma t_i) }$$

where v_i is the velocity between each 2 ms interval.

6. Interval velocity: the velocity between each sampled depth.

A4 Time to Depth

1. Two Way Sonic Time from SRD

2-11. Depth at Time, ms: times every 1 ms

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Attachment 2: A-1 Well Seismic Report

Client and Well Information

Country	**Australia**
Logging Date	**19-May-1984 & 14-Jun-1983**
Company	**Anzon Energy Ltd**
Field	**Wildcat (by Shell Development Australia Ltd)**
Well	**Basker-1**

Seismic Reference Datum : **MSL** Water Velocity : 1524 m/s

DF Elevation above MSL : 25 m

Check Shot Data

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM DF m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL (OWT) s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s	ACOUSTIC RMS VELOCITY m/s
1	0.0			0.0000					
							1849		
2	495.0	520.0	0.2654	0.2677				1849	1849
					80.0	0.0592	2484		
3	575.0	600.0	0.2973	0.2999				1917	1927
					150.0	0.0903	2534		
4	725.0	750.0	0.3561	0.3591				2019	2040
					250.0	0.0385	2772		
5	975.0	1000.0	0.4460	0.4493				2170	2206
					120.0	0.0398	3109		
6	1095.0	1120.0	0.4844	0.4879				2244	2291
					130.0	0.0731	3275		
7	1225.0	1250.0	0.5241	0.5276				2322	2379
					250.0	0.0732	3415		
8	1475.0	1500.0	0.5971	0.6008				2455	2528
					249.9	0.0841	3414		
9	1724.9	1749.9	0.6702	0.6740				2559	2639
					250.1	0.0361	2977		
10	1975.0	2000.0	0.7542	0.7580				2606	2678
					100.0	0.0161	2770		
11	2075.0	2100.0	0.7903	0.7941				2613	2683
					49.9	0.0421	3099		
12	2124.9	2149.9	0.8064	0.8102				2623	2691
					150.1	0.0407	3557		
13	2275.0	2300.0	0.8485	0.8524				2669	2741
					150.0	0.0431	3686		
14	2425.0	2450.0	0.8892	0.8931				2715	2791
					150.0	0.0412	3480		
15	2575.0	2600.0	0.9323	0.9362				2750	2826
					150.0	0.0287	3641		
16	2725.0	2750.0	0.9735	0.9774				2788	2865

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LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM DF m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL (OWT) s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s	ACOUSTIC RMS VELOCITY m/s
					103.1	0.0350	3592		
17	2828.1	2853.1	1.0021	1.0061				2811	2888
					126.7	0.0294	3620		
18	2954.8	2979.8	1.0371	1.0411				2838	2916
					100.0	0.0285	3401		
19	3054.8	3079.8	1.0665	1.0705				2854	2930
					100.3	0.0246	3519		
20	3155.1	3180.1	1.0950	1.0990				2871	2947
					94.4	0.0292	3837		
21	3249.5	3274.5	1.1196	1.1236				2892	2970
					125.3	0.0372	4291		
22	3374.8	3399.8	1.1488	1.1528				2927	3010
					160.0	0.0315	4301		
23	3534.8	3559.8	1.1860	1.1900				2970	3059
					136.0	0.0289	4317		
24	3670.8	3695.8	1.2175	1.2215				3005	3098
					124.0	0.0189	4291		
25	3794.8	3819.8	1.2464	1.2504				3035	3130
					80.2	0.0198	4243		
26	3875.0	3900.0	1.2653	1.2693				3053	3150
					85.0	0.0198	4293		
27	3960.0	3985.0	1.2851	1.2891				3072	3171

Attachment 3: Listing of Deliverables (CD-ROM)

Report:

CS_report	Checkshot/Geogram Processing Report	PDF

Graphics Displays:

comp1	Plot 1. Composite Display 1– Normal Polarity	PDF / PDS / CGM / TIF
comp2	Plot 2. Composite Display 2 – Reverse Polarity	PDF / PDS / CGM / TIF
vel1	Plot 3. Velocity Crossplot	PDF / PDS / CGM / TIF

Data files plus Verification (.txt) listings:

BA1_synt_R35.sgy	Zero Phase Synthetic Seismograms – Ricker 35Hz	SEGY
BA1_synt_R25.sgy	Zero Phase Synthetic Seismograms – Ricker 25Hz	SEGY
BA1_synt_R35Rot.sgy	(+90 deg) Rotated Synthetic Seismograms – Ricker 35Hz	SEGY
BA1_synt_R25Rot.sgy	(+90 deg) Rotated Synthetic Seismograms – Ricker 25Hz	SEGY
logs_depth.las	Depth indexed Logs	ASCII (LAS)
logs_time.las	Time indexed Logs	ASCII (LAS)
synthetics.las	Synthetic Seismograms and Corridor Stack	ASCII (LAS)

Listings:

A1	Well_Seismic_Report	EXCEL
A2	Drift_and_Sonic_Adjustment_Report	EXCEL
A3	Velocity_Report	EXCEL
A4	Time_to_Depth_Report	EXCEL