Schlumberger

Origin Energy Resources Ltd

YOLLA-4

WELL SEISMIC PROCESSING REPORT

VI-VSP / GEOGRAM

[See also Q-Borehole Survey Report]

Q BOREHOLE

Origin energy

FIELD:	Yolla
COUNTRY:	Australia (Tasmania)
COORDINATES:	Latitude: 39 50’ 40.5920” S
:	Longitude: 145 49’ 06.0569” E
DATE OF SURVEY:	15-JUL-2004
SURVEY TYPE:	Vertical Incidence VSP, Offshore, Airgun
REFERENCE NO:	DS 0904-11

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WA 6000 Australia

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1 Introduction

A borehole seismic survey was recorded in one run in the deviated (max 25.6 deg deviation) offshore well Yolla-4 on 15 July 2004. This survey consisted of boat source Vertical Incidence VSP measurements in open and cased hole. The data were acquired using a 4 shuttle Versatile Seismic Imager Tool (VSI-4) downhole and a Parallel Dual Air gun source deployed from a crane on the boat.

Processing of the data consisted of performing VIVSP processing, Sonic calibration and Synthetic seismogram generation. This report describes the processing techniques used, the parameters chosen and presents the results of the data processing. There is a good match between Corridor Stack and Synthetic seismograms. A quick-look tie with the surface seismic data was obtained with a 29 ms bulk time shift.

2 Data Acquisition

The data were acquired in one logging run in both open and cased hole using a four shuttle three component Versatile Seismic Imager Tool (VSI-4) fitted with GAC accelerometers.

Two 150 cu in G-Gun Air guns were used as the source operating under 2000 psi. Due to rough sea conditions during the survey the guns were suspended from a buoy 6m below sea level vertically above the center of the downhole array position. Fugro provided the boat navigation service.

A reference hydrophone was positioned at 3.2 m below the guns. Recording was made with the Macha TGS-8 gun controller system and Schlumberger VSI Workbench/WAVE borehole seismic system.

Good VSP levels were acquired from 3225 m KB to 1205 m KB at 20 m intervals. A minimum of 5 good shots was recorded for each level. Above 1200 m KB more levels were acquired up to 770 m KB, but they were not used for time-depth curve or VIVSP processing because the formation first arrivals could not be reliably picked due to casing ringing.

Initial In-Field processing of the VIVSP data using Schlumberger's WAVE (Wellsite Acquisition, Validation and Evaluation) processing software was done. These results were QC'ed by the DCS Processing Center and are reported in the separate "**Q-Borehole Survey Report**".

Warning:

The acquisition experienced a problem as the bridle below the second shuttle (from top) got wrapped around the tool while running into the hole causing the depth measurements on shuttles 3 and 4 to be 5m shallow. This did have some impact on the final processed results as it increased the maximum trace spacing and made it less regular thus increasing the noise levels in the processing steps. Geometry and deviation corrections have been made to the data and now show coherent time-depth and velocity curves.

Table 1. Survey Parameters

Elevation of KB/RT/DF	43 m above MSL
Elevation of GL	81 m below MSL
Well Deviation	max 25.6 deg
Energy Source	2x 150 cu in Sodera G-Guns (Parallel Cl)
Reference Sensor	TGS-8 PTB signal (S1)
Source & Hyd. Offset	Vertically above center Downhole Array
Source Depth	6 m below MSL
Hydrophone Depth	9.2 m below MSL
Water Velocity	1524 m/s
Tool	4 Shuttle VSI-4 (20 m Spacing)
Sensor Type	3-C GAC – Geophone Accelerometer
Sampling Rate	1 ms.

3 Well Seismic Edit

The initial preparation of the data is called Well Seismic Edit and consists of:

- Load Data
- Edit bad records & Sort Data
- Pick Reference Break times
- Median stack
- Pick Break time on Stacked Data

Each shot of the raw GAC data was evaluated and edited to remove bad traces. The hydrophone data were also evaluated for signature changes and timing shifts. The good shots at each level were stacked, using a median stacking technique, to increase the signal to noise ratio of the data. For better comparison with geophone data, a transform to a 10 Hz/76% damped geophone is applied to the GAC data. This transform from acceleration to velocity is in the field approximated by integrating raw data. After stacking and transform the transit time of each trace was re-computed. The following subsections describe the main aspects of the well seismic edit phase.

3.1 Data Quality

The data quality is generally fairly good, but of limited frequency content, in particular below app 2500 m MD KB. The source signature is stable, showing little pressure and gun depth variations in spite of the rough sea surface conditions. The vertical component data shows fair continuity and some shear contamination. The horizontal components also show some converted shear energy, particularly in the deeper section of the well. All three components are used for obtaining the rotated true vertical component that will be used for the VSP processing.

3.2 Transit Time Measurement

The measured transit time corresponds to a difference between the surface reference time and arrivals recorded by the downhole sensors. The reference time is the recorded Predicted Fire signal of the TGS-8 shooting system. First break picking algorithms were applied on the transformed and filtered geophone data using an inflection point tangent algorithm.

3.3 Stacking

After reordering and selecting the raw shots, a median stack was performed on the three component data. In this method of stacking, at each sample time, the amplitudes of the input traces are read and sorted in ascending order. The output is the median amplitude value from this ordering. If an even number of traces is input, the first is dropped and a median calculated. Then the last is dropped and another median found. The final output is the average of these two median values. The reference time breaks are used as the zero time for stacking. The break time of each trace is recomputed after stacking and rotation. The X, Y and Z component stacks are presented in Figures 2a, 2b and 2c.

VIVSP Processing Chain

The vertical incidence VSP data were processed using standard VSP processing techniques.

The following subsections describe the main aspects of the VIVSP processing chain:

• Survey Geometry / Datum corrections	:	Well deviation / MSL
• Bandpass Filter	:	Butterworth Zero Phase, 5-95Hz
• Rotation to Vertical Component	:	X,Y to HMX / Z,HMX to V
• Signature Deconvolution	:	PDN, Gap 55 ms , 0.85 s
• Spherical Divergence Correction	:	Exponent $\alpha = 1.56$
• Trace Normalization	:	RMS Window 200 ms
• Wavefield Separation	:	Velocity Filter, 11x1 Tri Mean
• Waveshape Deconvolution	:	5-60 Hz Zero Phase, Window 0.5 s
• Upgoing Enhancement	:	Velocity Filter, 7x3 Tri Mean
• Corridor Stack	:	150 ms , 8 deepest traces

3.4 Survey Geometry / Datum corrections

Seismic Reference Datum (SRD) is at Mean Sea Level. A static shift of 3.9 ms was applied to the data to correct to SRD. This correction to SRD was calculated using a surface velocity of 1524 m/s. Survey geometry corrections for the lateral offset of the source position with respect to the downhole receiver in this well taking into account well deviation and recording delay corrections have been applied.

3.5 Bandpass Filter

The effective bandwidth of the recorded data is evaluated by examining the amplitude spectrum of the stacked vertical component presented in Figure 1. A wide zero phase Butterworth Bandpass filter was applied to the data limiting the bandwidth to 5-95 Hz.

3.6 Rotation to Vertical Component

Non-gimballed GAC receivers record the VSI data. When processing a vertical incidence VSP in a deviated well (Figures 19 and 20) the 3 component data need to be rotated to the vertical axis (i.e. Source-Receiver direction). This can be done by first taking the two horizontal components X and Y and determining via energy hodograms around the picked transit time the orientation of the maximum horizontal component (HMX) as shown in Figure 3. The Z and HMX components are then rotated using the well deviation angle and this is QC-ed by determining the rotation angle from the data. (Figure 21). Figure 4 shows the Vertical Component used for further processing.

3.7 Source Signature Deconvolution

Due to the interference of airgun bubble and water column multiples, a rough removal of the source signature was performed. To do this properly a calibrated far field source signature needs to be recorded. This was not available for this survey and predictive deconvolution using the near field hydrophone recording was used instead. Designature tests provided reasonably satisfactory results. The deconvolution filter is designed using a three level sliding window on the reference signal and applied on the full wavefield. The predictive distance or gap is set to 55 ms to keep the main source wavelet untouched and multiples are predicted over a window of 0.85 s. The deconvolution operator is then applied on the whole trace.

3.8 Spherical Divergence Correction

To correct the recorded amplitudes for the loss of energy due to the spherical divergence of the wave front, a time varying gain function of the exponential form:

$$Gain(T) = (T)^{\alpha}$$

where T is the recorded time and α = 1.56 was applied. This equation considers homogeneous spreading and attenuation effects within a gate starting from the shot time.

3.9 Trace Normalization

Trace equalization was applied by normalizing the RMS amplitude of the first break to correct for transmission losses of the direct wave. A normalization window of 200 milliseconds was used. The amplitude corrected vertical component wavefield is displayed in two-way time (Figure 5).

3.10 Wavefield Separation

A velocity filter (coherency) technique was used to separate upgoing and downgoing wavefields.

The downgoing coherent compressional energy is estimated using an 11x1 level tri-mean velocity filter parallel to the direct arrival curve. The filter array is moved down one level after each computation and the process is repeated level by level over the entire dataset. The first break aligned downgoing wavefield is displayed in Figure 6.

The residual wavefield is obtained by subtracting the estimated downgoing coherent energy from the total wavefield. The residual wavefield is dominated by reflected compressional events as shown in Figure 7.

3.11 Zero Phase Waveshape Deconvolution

The waveshaping process shortens the seismic pulse within traces and centers their amplitude peak on the reflector. This improves the resolution of the seismic data and helps to clarify the correlation of the seismic events. It is also applied to collapse the recorded multiples.

The waveshaping deconvolution operator is a double-sided Wiener-Levinson waveshaping filter. The operator is computed for each level of the downgoing wavefield using a design window length of 0.5 s starting 5 ms before the picked break times in order to include the wavelet precisely. The designed outputs were chosen to be zero phase with a bandwidth of 5-60 Hz. Once the design is made upon the downgoing wavefield, it is applied to the both downgoing and upgoing wavefields at the same level as displayed in Figures 8 and 9.

3.12 Upgoing Enhancement

A velocity filter (coherency) technique was used to enhance the zero phase upgoing wavefield.

The upgoing coherent compressional energy is estimated using a 7x3 level tri-mean velocity filter orthogonal to the direct arrival curve. The filter array is moved down one level after each computation and the process is repeated level by level over the entire dataset. This enhanced upgoing wavefield is displayed in two way time (TWT) in Figure 10.

3.13 Corridor Stack

A corridor stack in two way time (TWT) was computed on the enhanced zero phase upgoing wavefield by designing a constant 100 ms timing window along the two-way time depth curve and stacking the data onto a single trace. The deepest 8 traces are stacked entirely. The resulting trace provides the seismic representation of the borehole in vertical two-way time. This corridor stack is displayed in Figure 11 both as a vertical trace and along the 2D projected well path.

A snapshot of the 40 cm/s normal polarity composite display (PLOT-1) is shown in figure 12. A composite display in reverse polarity is included as well (PLOT-2). The polarity convention is explained in Figure 18.

A comparison of the VIVSP data projected onto the surface seismic section provided by Origin (Yolla2 to Yolla4) was made shown in Figures 13, 14a/b and 15a/b showing both normal and reverse polarity. To provide a Quick Look comparison with the surface seismic a constant time of +29ms was applied to the Corridor Stack. /Upgoing wavefield. The surface seismic frequency content near TD is considerably lower than that of the borehole seismic data.

Figures 16a/b show a comparison of the corridor stack with the different synthetic seismograms described in the next section. Both normal and reverse polarities are displayed in these figures.

On Plots 1 and 2 additional panels show the projected and offset regularized VIVSP corridor stack and upgoing wavefield along the surface seismic.

No migration was used as the main travel paths are more or less vertical and the ray paths just below the main fault crossing the wellbore are too complex to resolve.

4 Sonic Calibration Processing

4.1 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:

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

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

4.2 Open Hole Logs

The P&S mode compressional DT curve from the open hole DSI data was used for drift computation. The log quality ranges from fair to good and required some editing.

A density log was available over the same interval as the sonic log. Other logs included as companion curves are: Gamma Ray, Resistivity and Caliper.

4.3 Correction to Datum and Velocity Modeling

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

4.4 Sonic Calibration Results

The checkshot near the top of the sonic log (1205m MD KB) is chosen as the origin for the calibration drift curve. The compressional sonic log was extended using the checkshot data only for the generation of the velocity and time/depth listings.

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). A minimum number of knee points was used due to the increased measurement uncertainty introduced by both the well deviation and possible lateral velocity variations in the overburden.

The Velocity Crossplot is presented in Figure 17 and as a separate plot.

5 Synthetic Seismogram Processing

GEOGRAM plots were generated using three different wavelets: 25 Hz, 30 Hz and 35 Hz (Dominant Frequency) zero phase Ricker wavelets.

The presentation includes composite plots on a time scale of 40 cm/sec in both normal and reverse polarity (Plots 1 and 2). The 35 Hz Ricker Synthetics show a good match with the Corridor Stack.

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

5.1 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.

5.2 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.

5.3 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:

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

5.4 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.

5.5 Multiples Only

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

5.6 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.

5.7 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 18.

5.8 Convolution

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

FIGURES

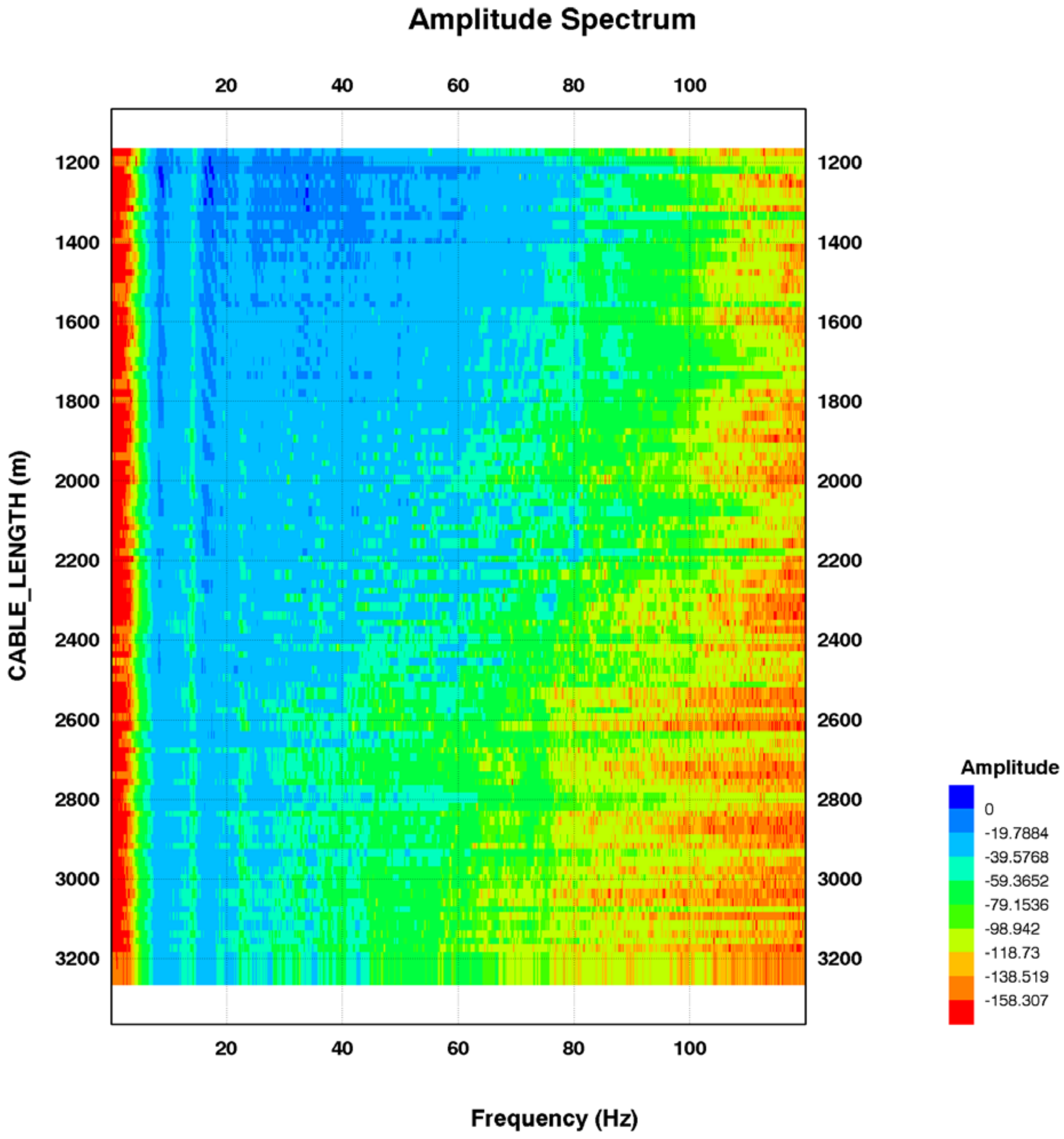

Figure 1. Amplitude Spectrum

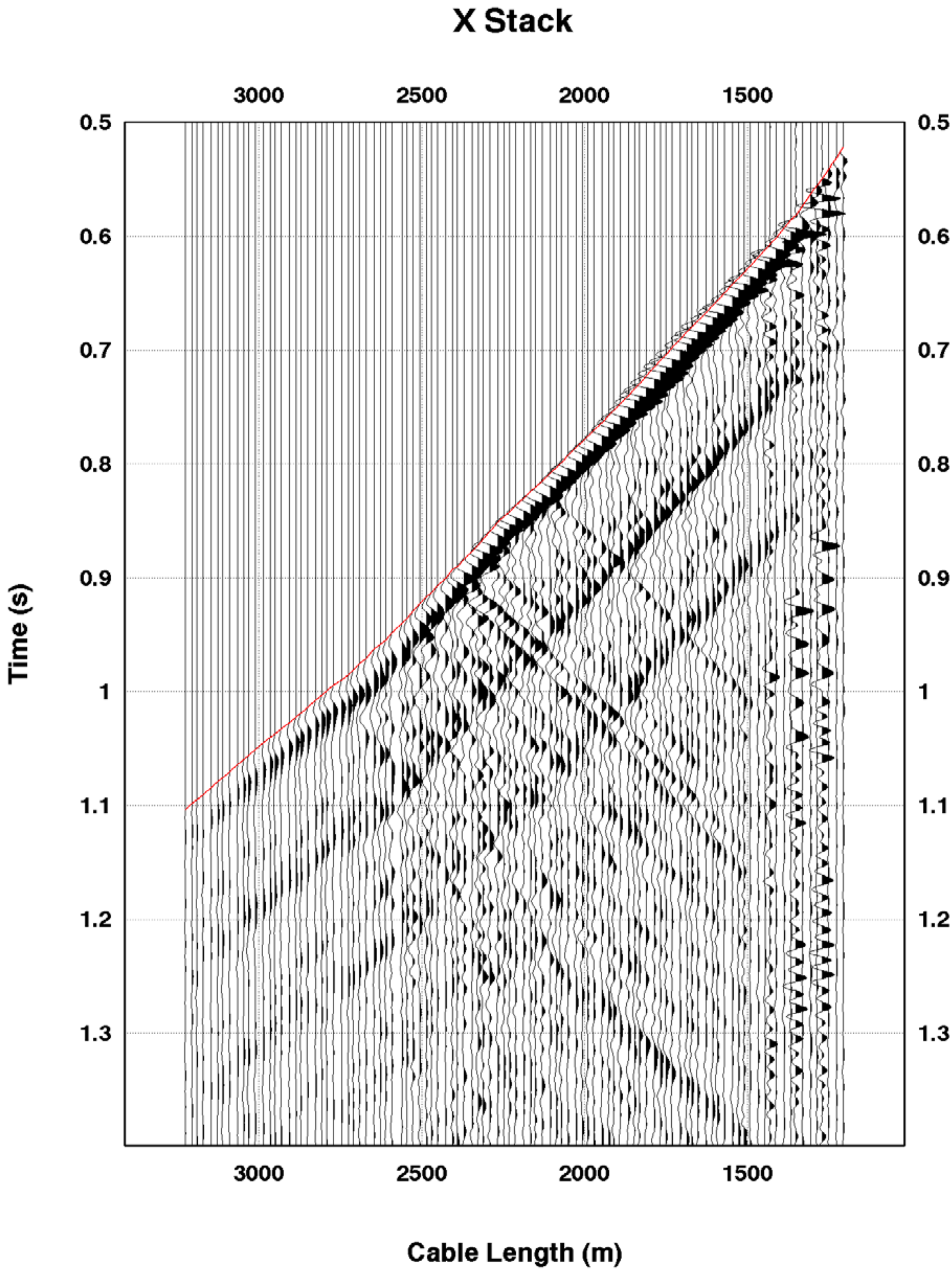

Figure 2a. X Component Stack

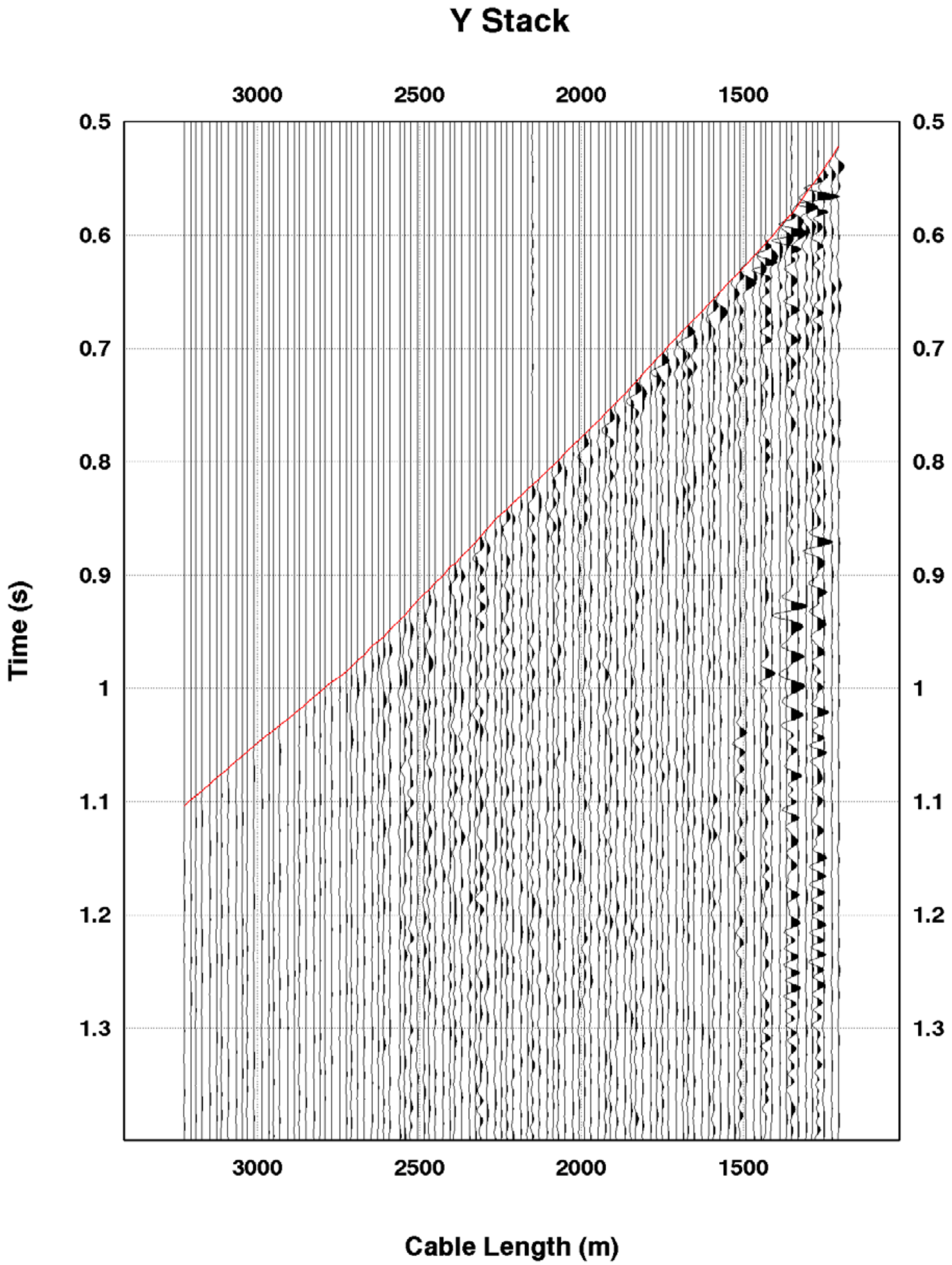

Figure 2b. Y Component Stack

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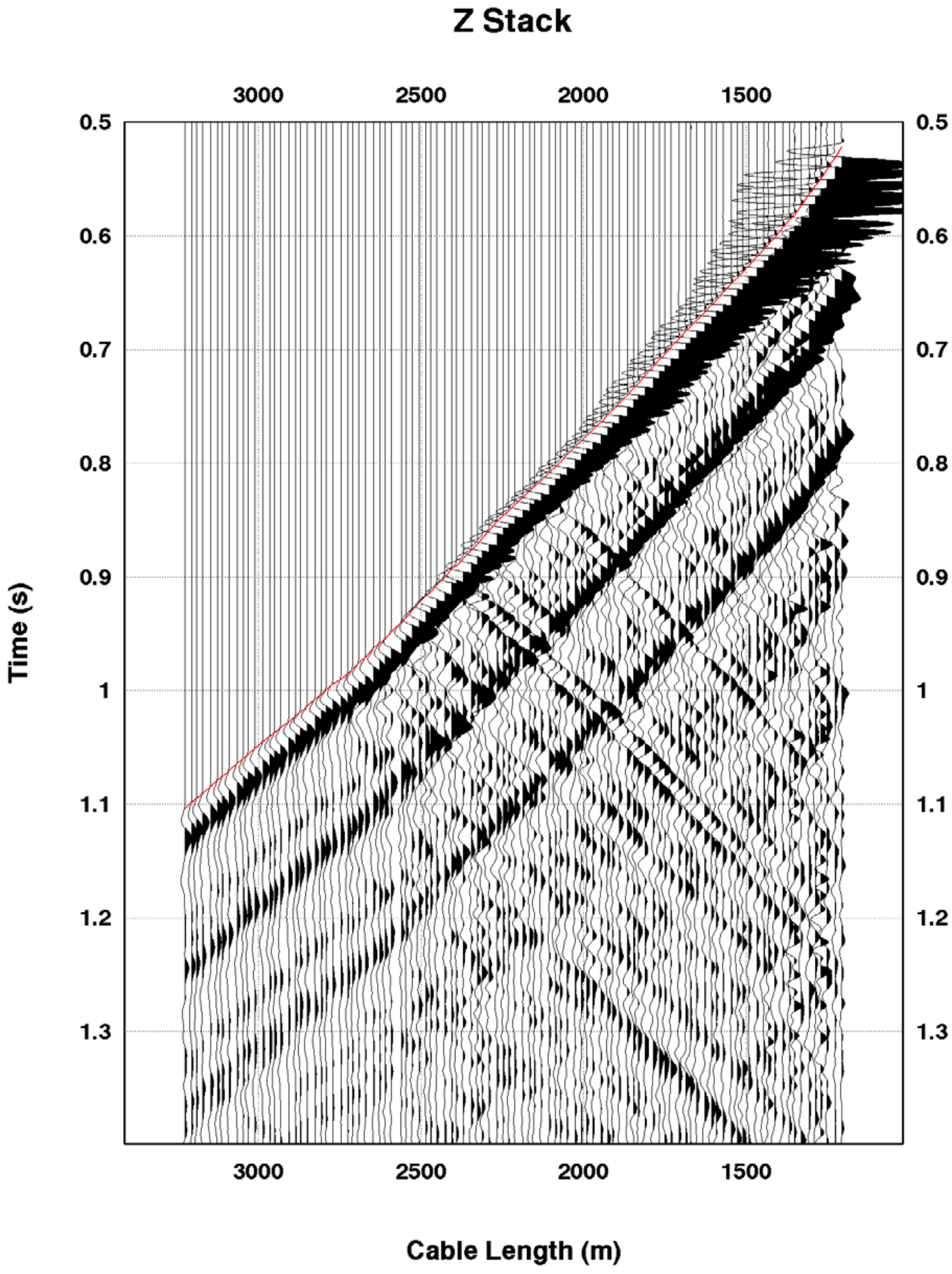


Figure 2c. Z Component Stack

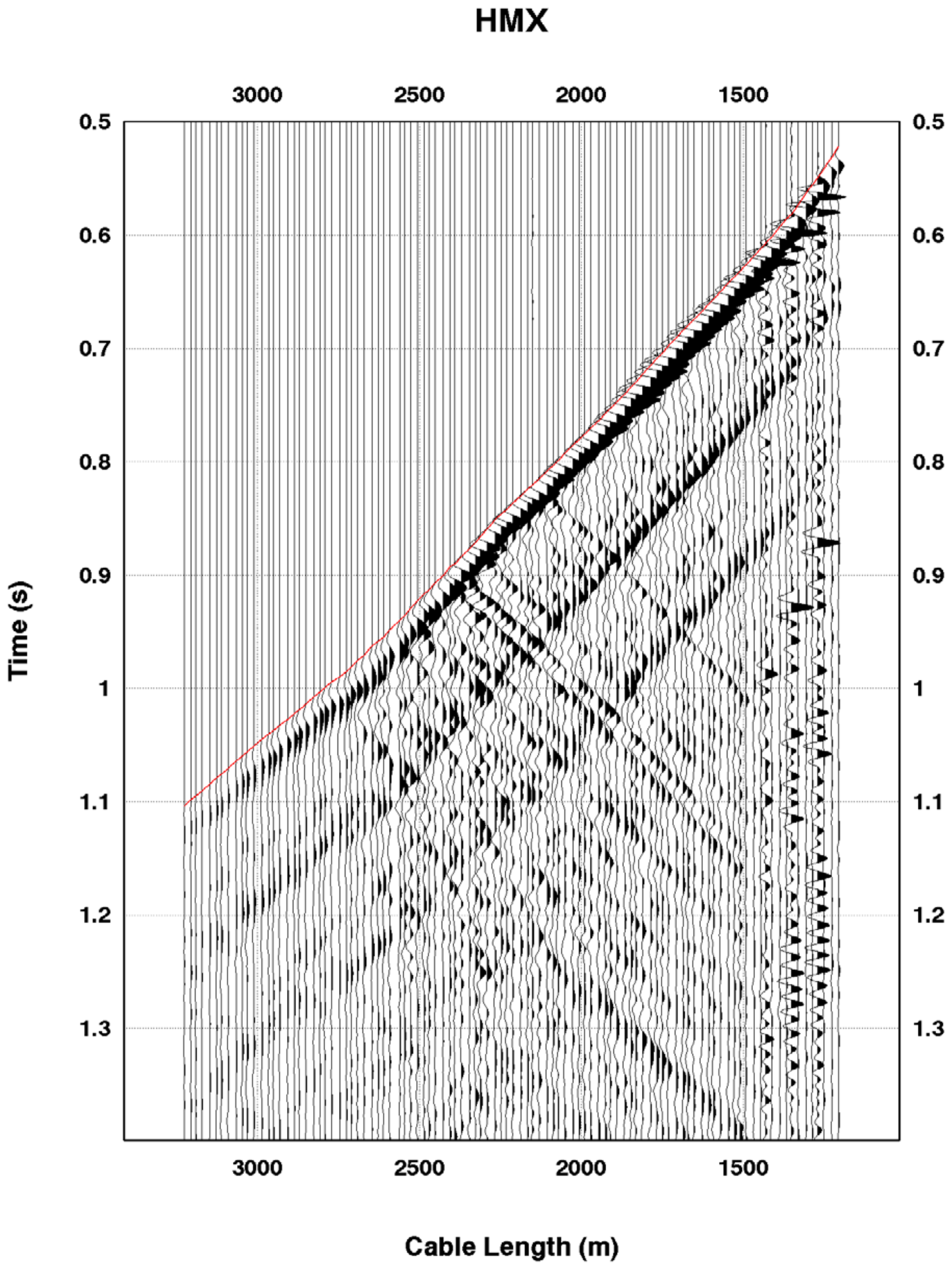


Figure 3. X,Y Components Rotated to HMX Component

Vertical Stack

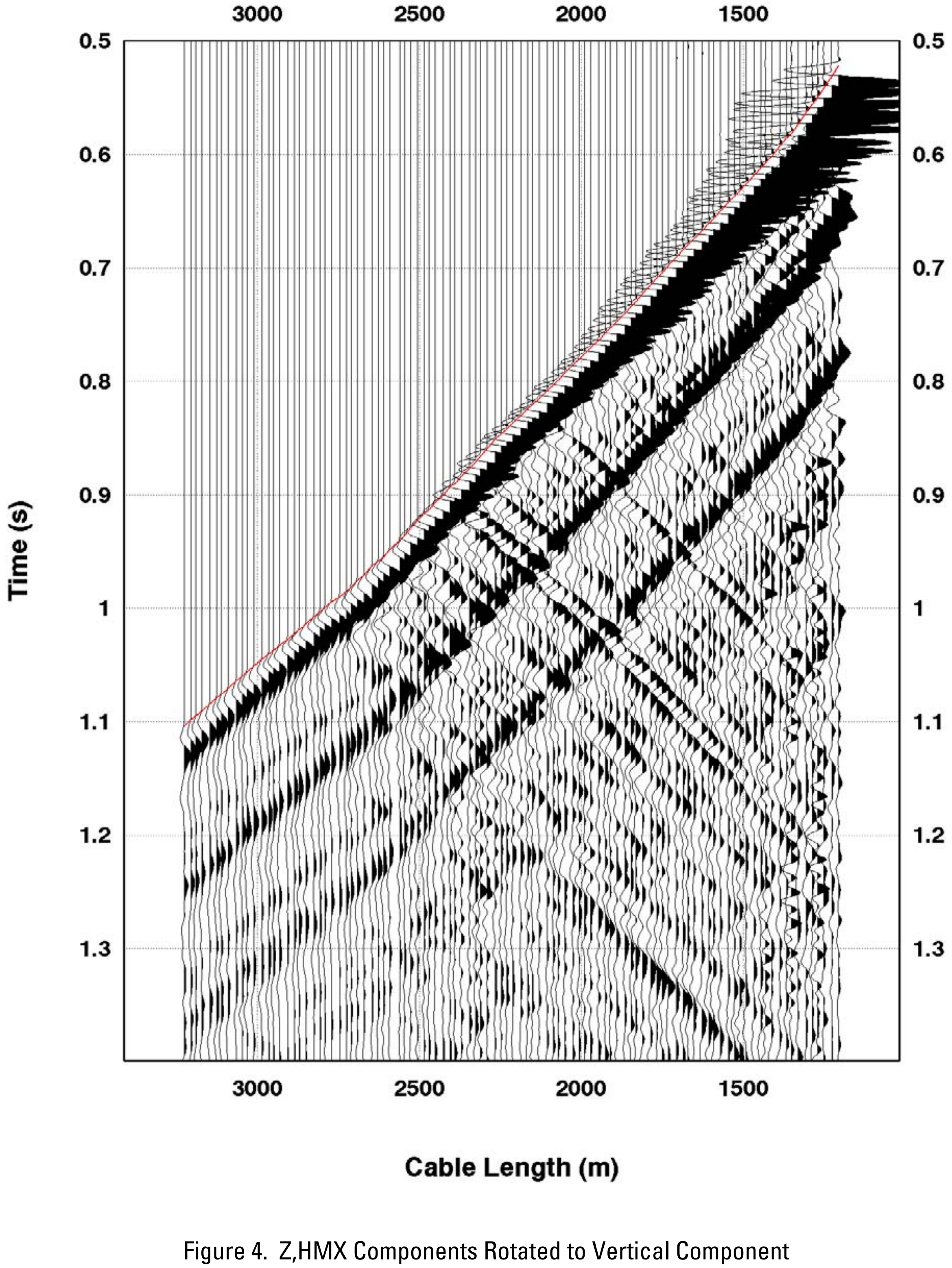


Figure 4. Z,HMX Components Rotated to Vertical Component

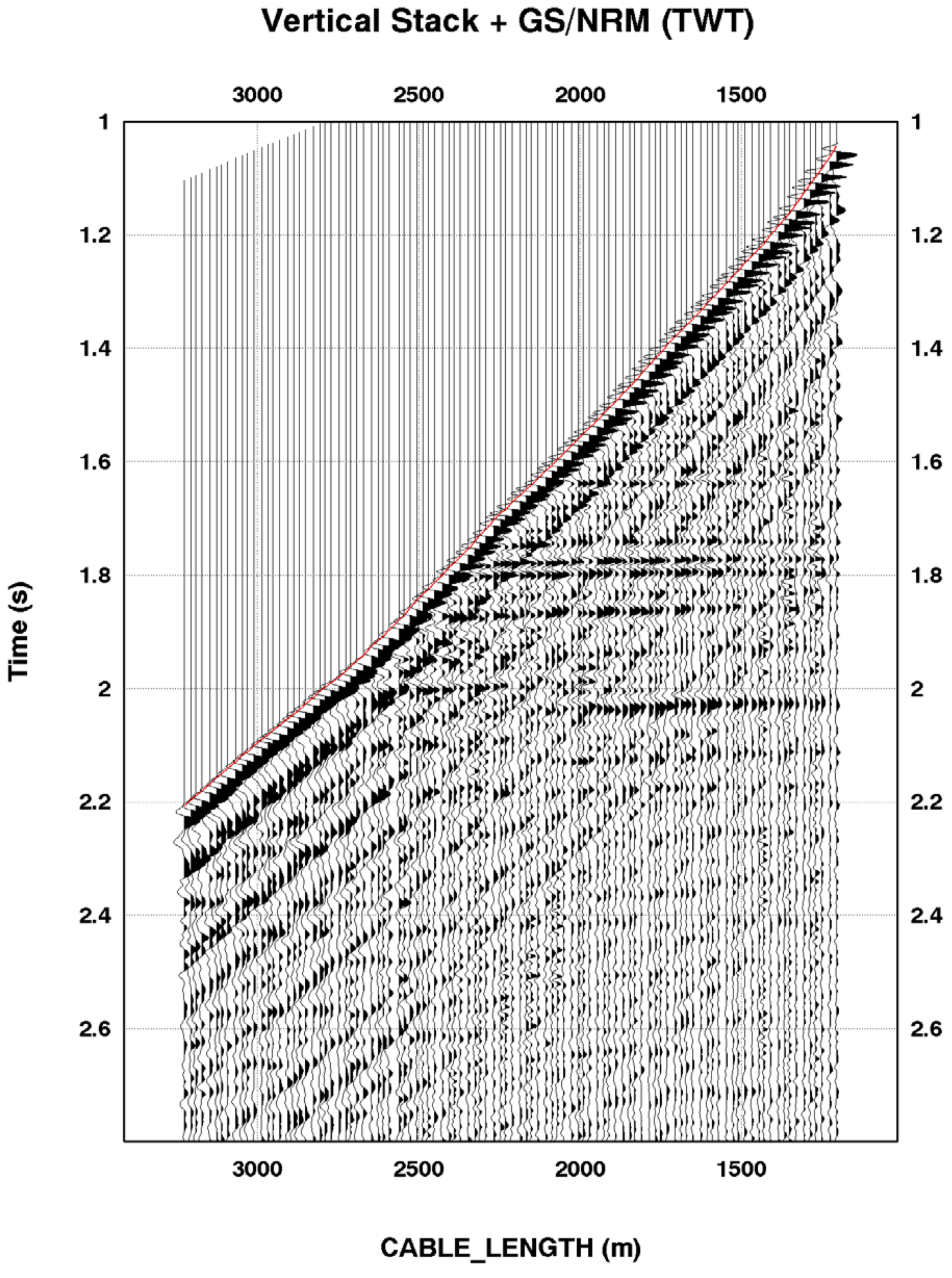


Figure 5. Z Component Stack for VSP processing

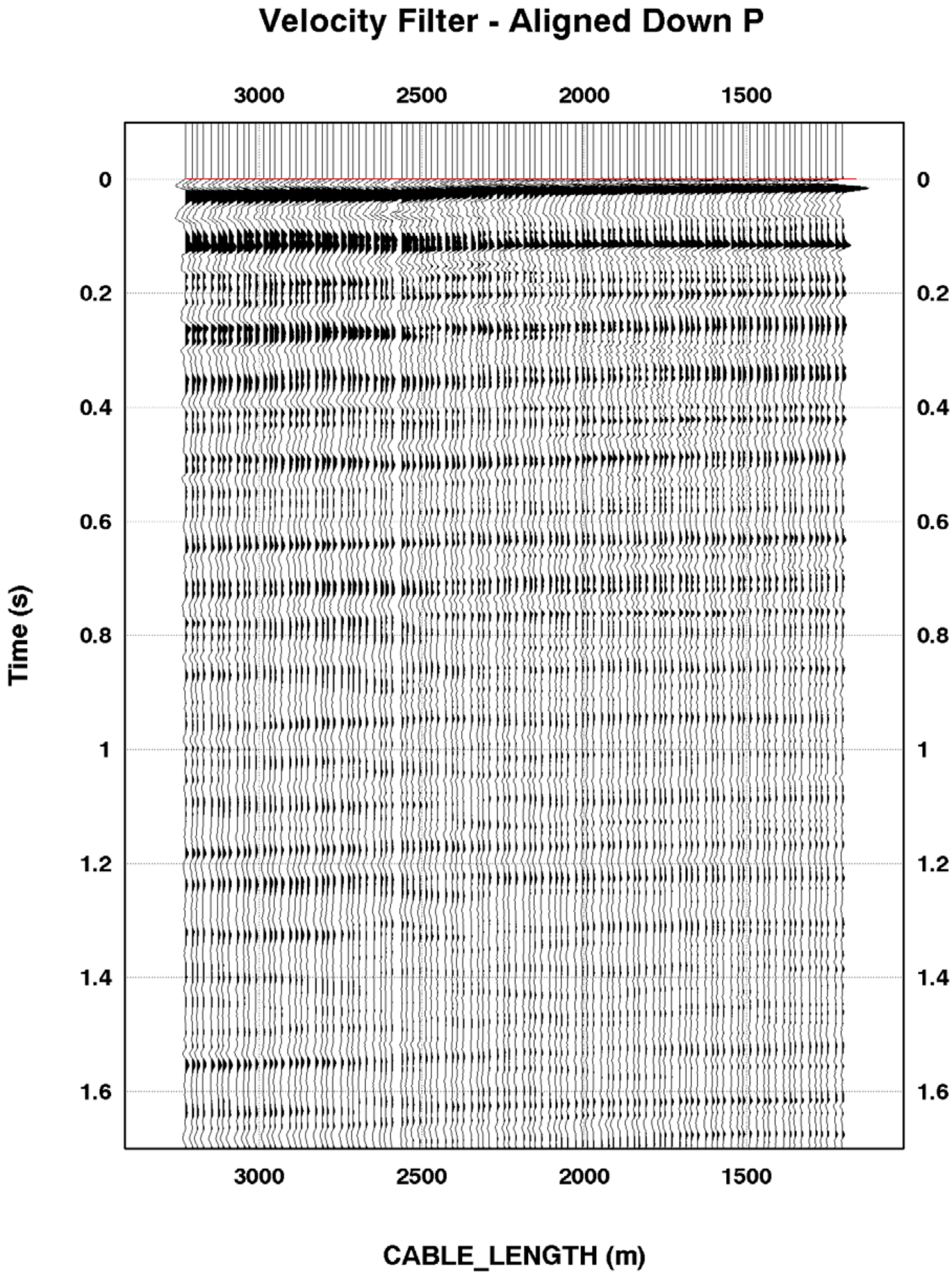


Figure 6. Downgoing Wavefield after Wavefield Separation

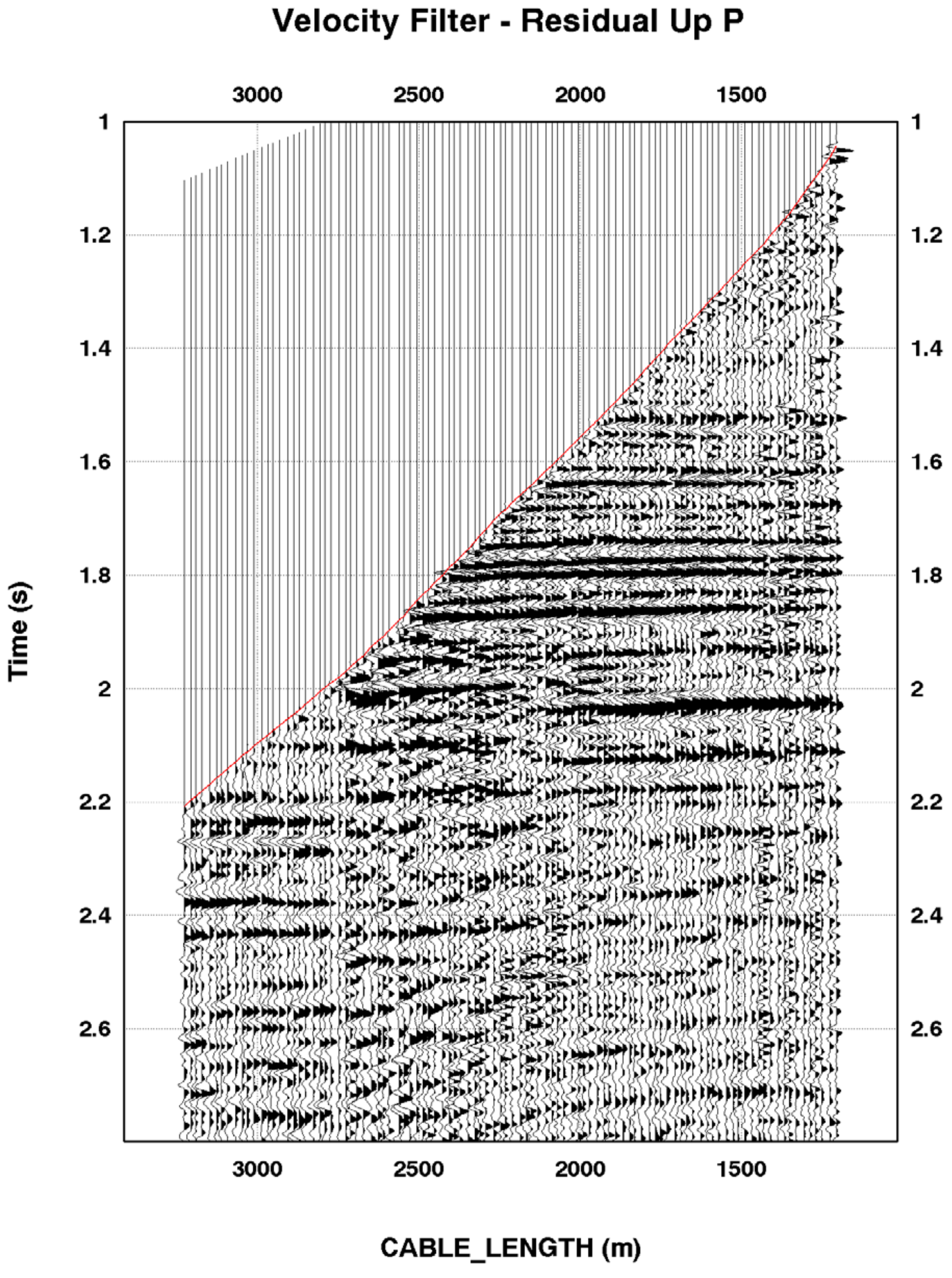


Figure 7. Upgoing Wavefield after Wavefield Separation

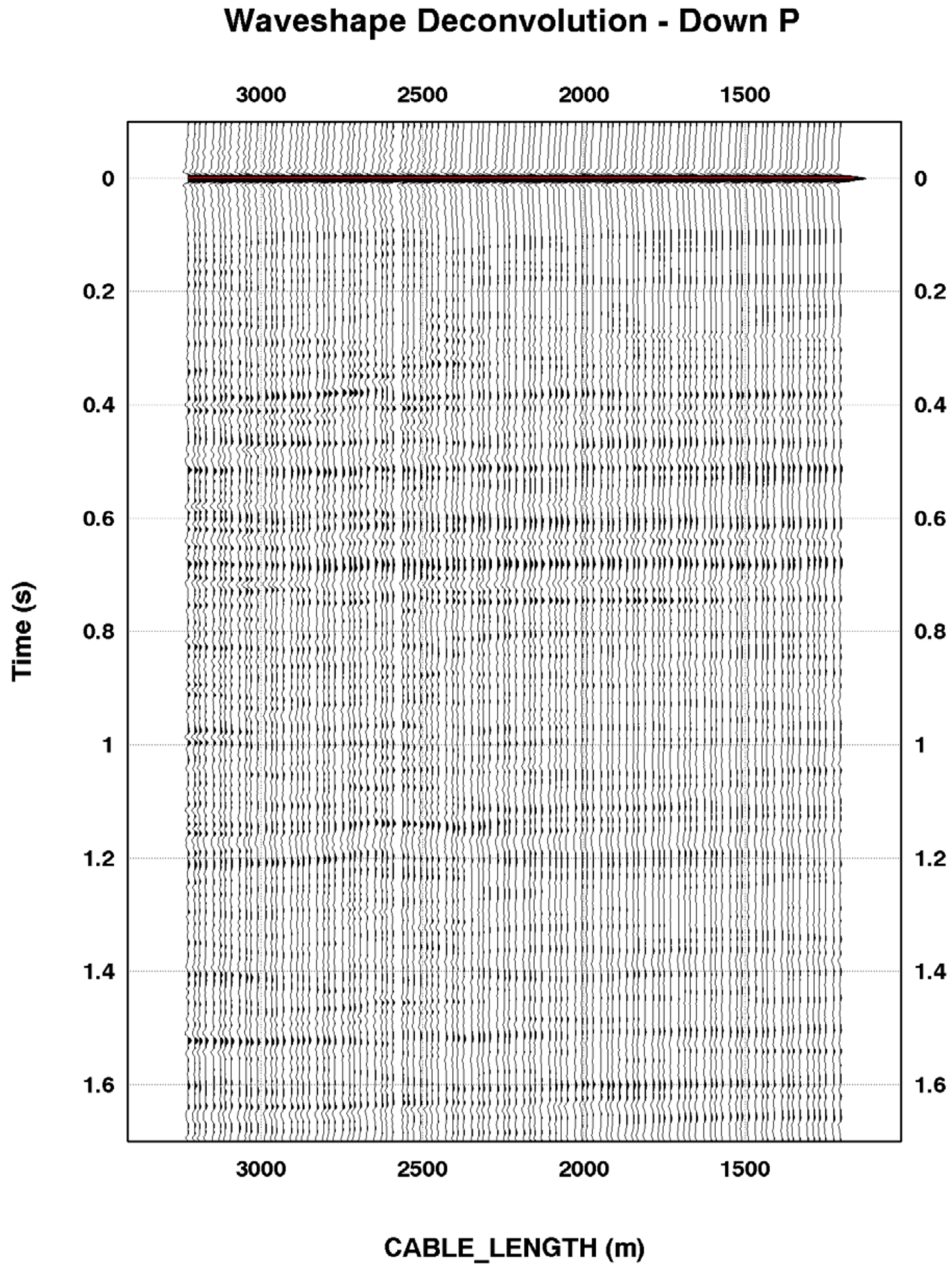


Figure 8. Downgoing Wavefield after Waveshaping Deconvolution

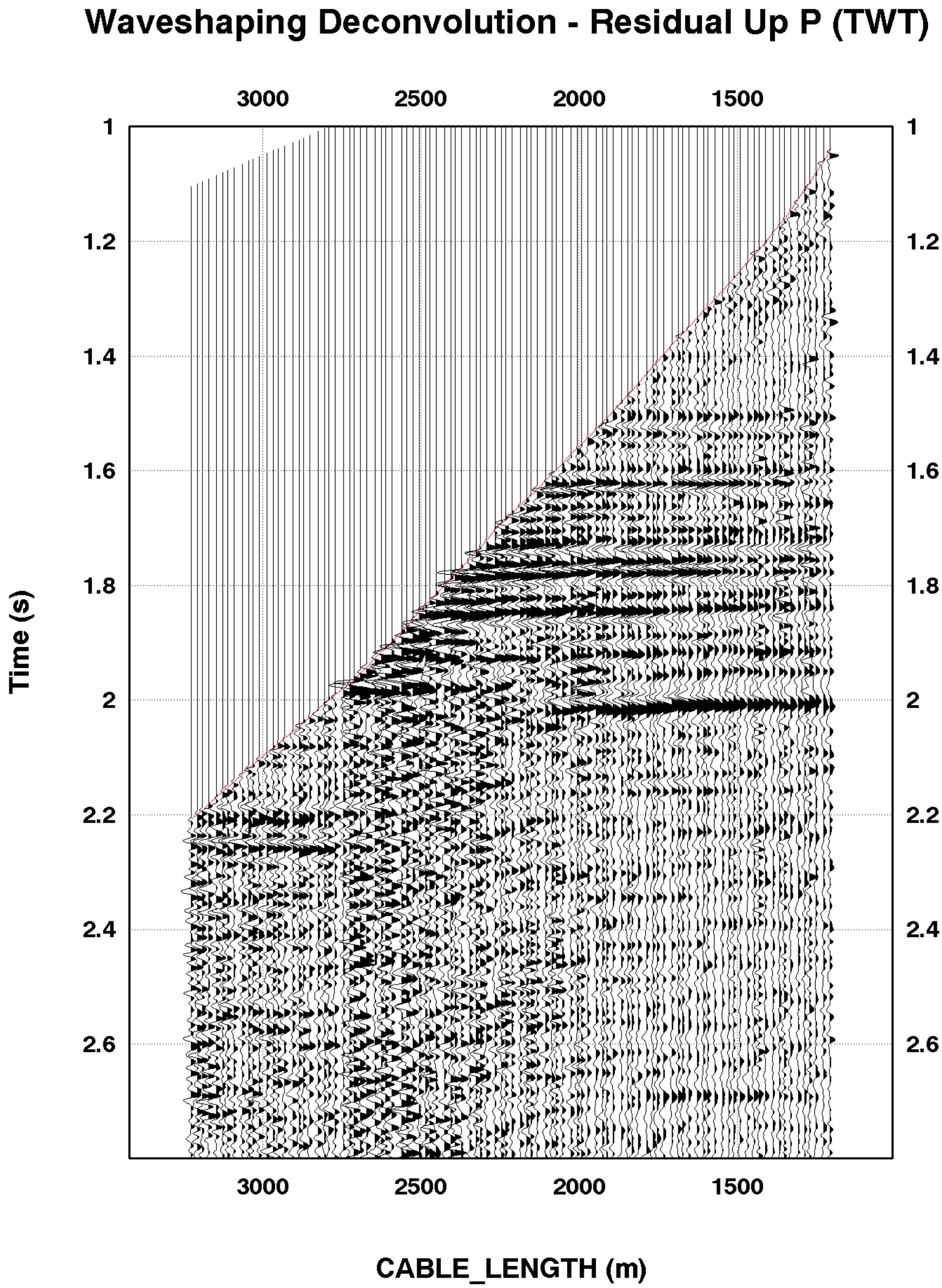


Figure 9. Upgoing Wavefield after Waveshaping Deconvolution

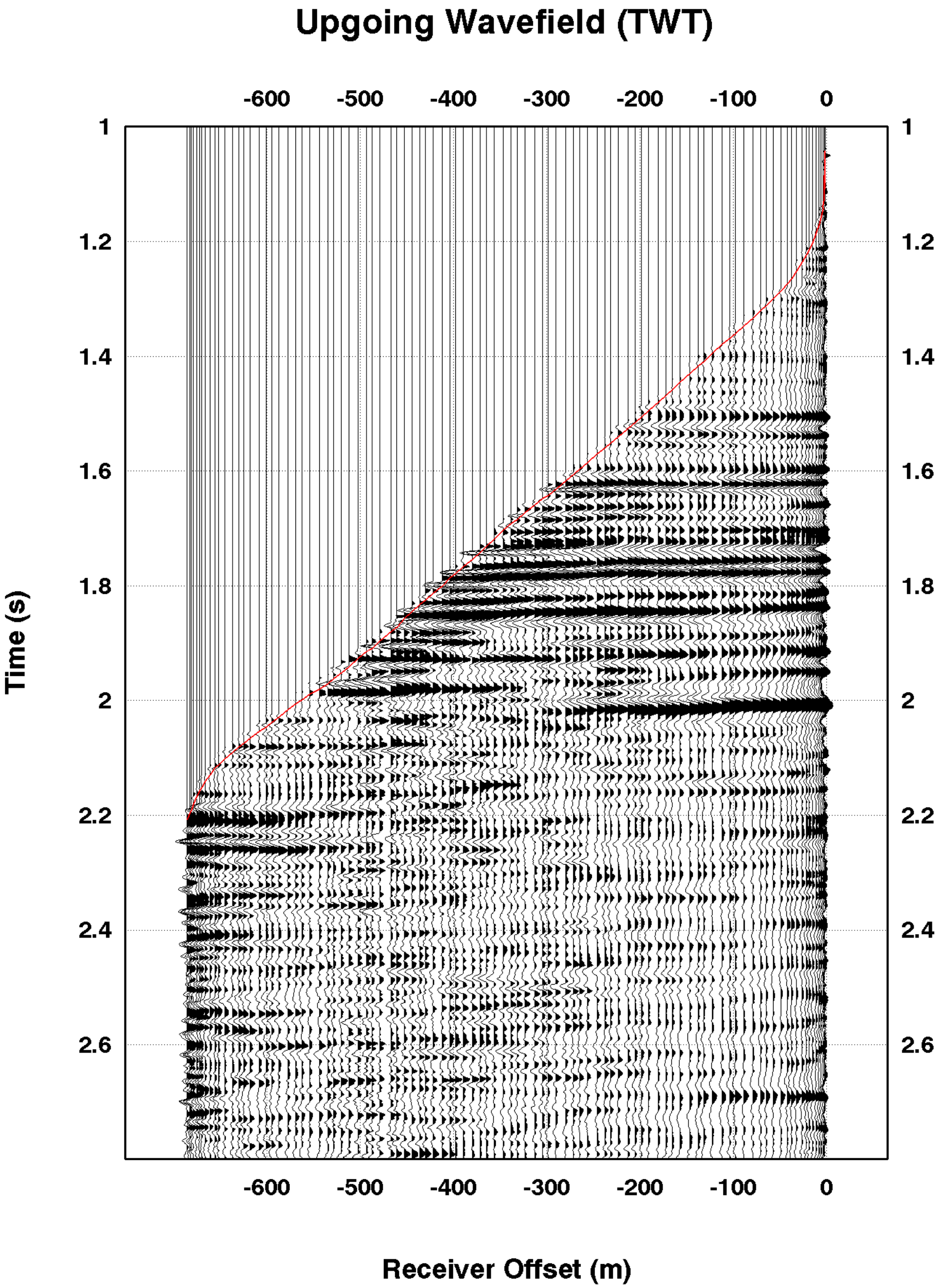


Figure 10. Enhanced Upgoing Wavefield after Waveshaping Deconvolution

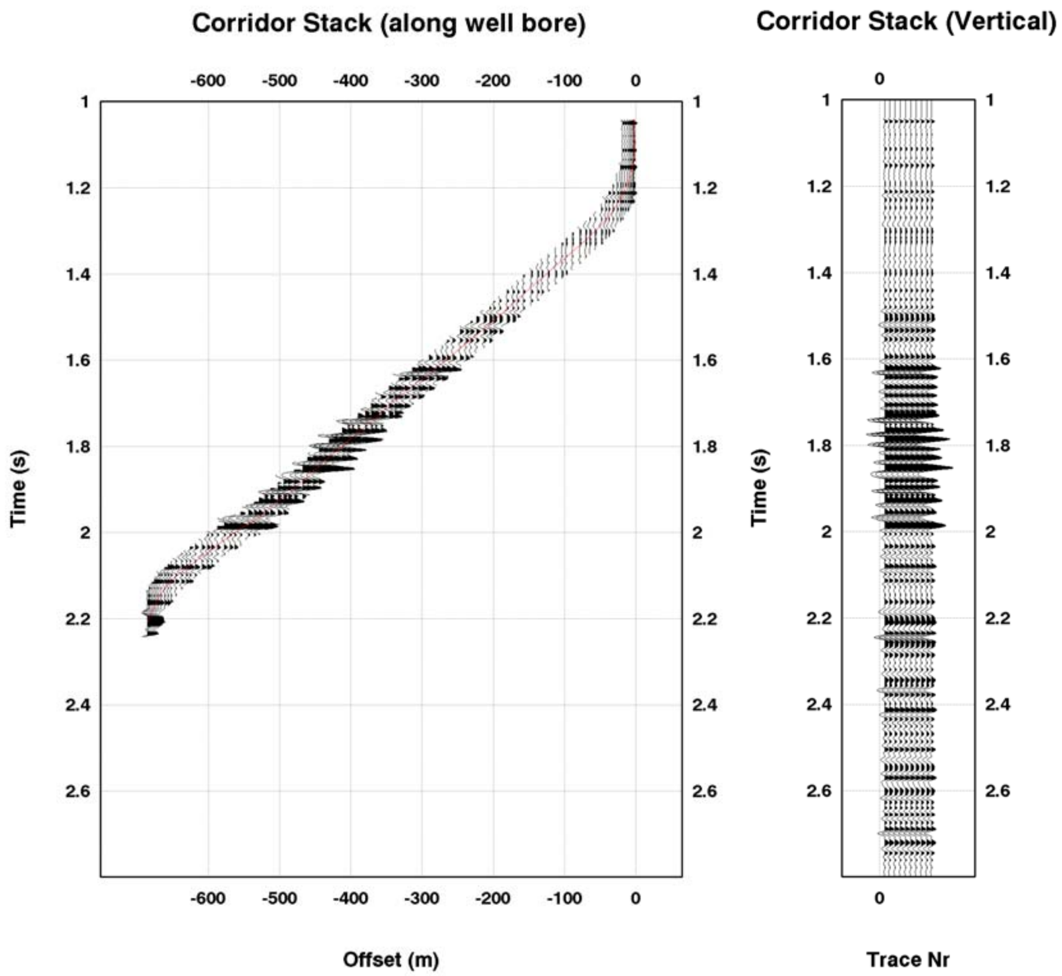


Figure 11. Corridor Stacks: along wellbore and vertical trace

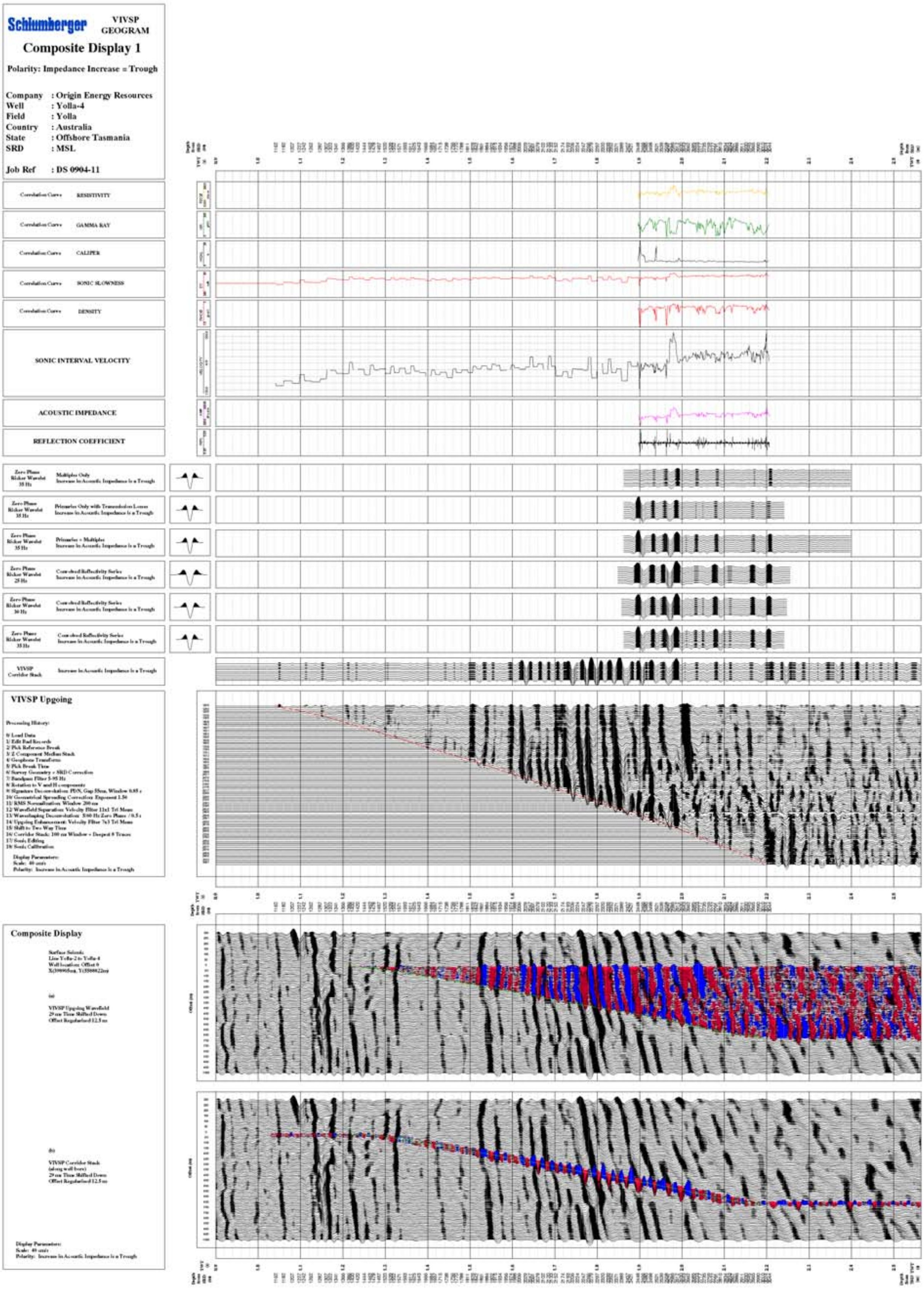


Figure 12. Composite Display (See Plots 1 and 2)

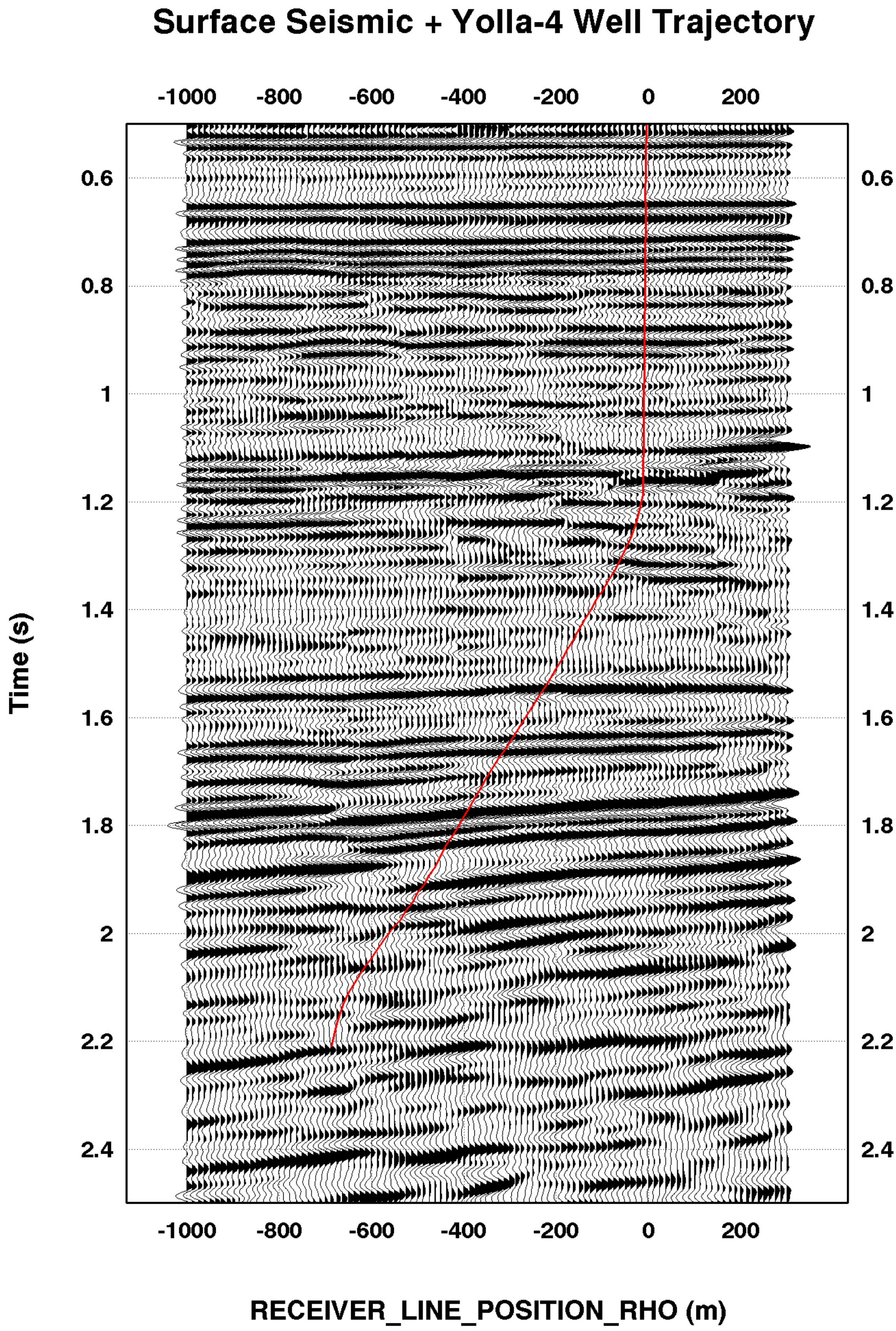


Figure 13. Composite Display of Surface Seismic and borehole track

Polarity: An increase in acoustic impedance is a peak

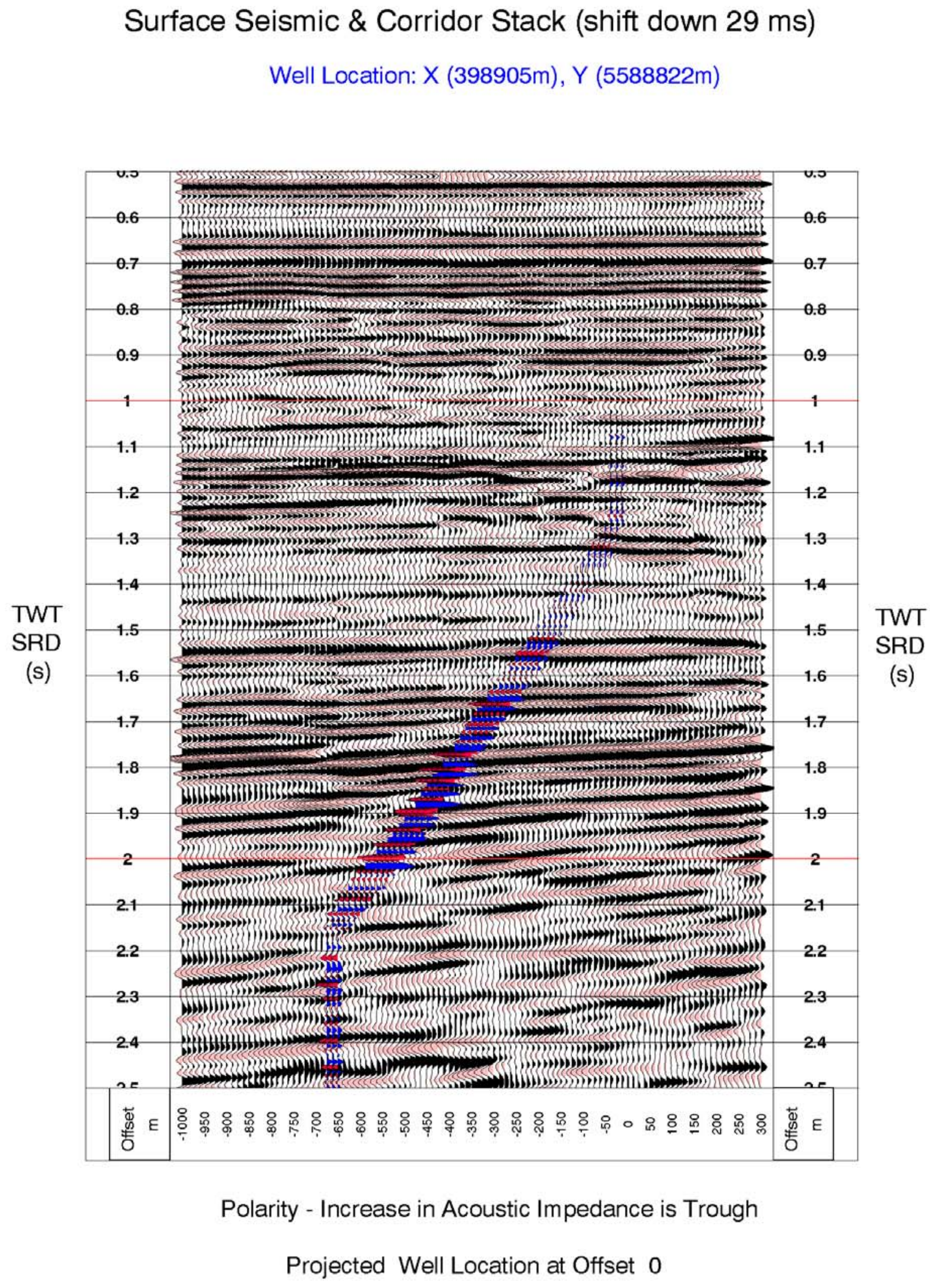
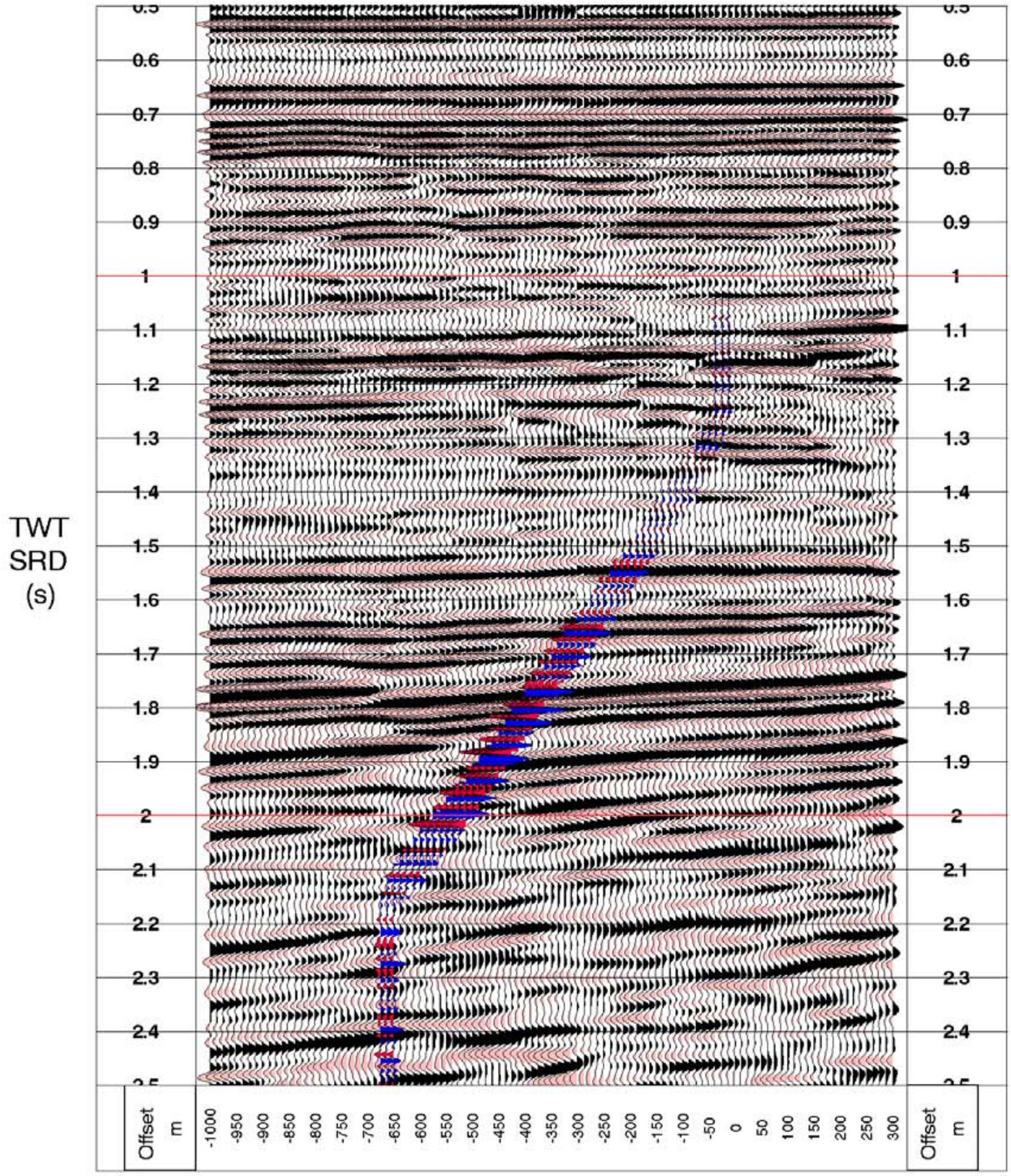


Figure 14a. Composite Display of Surface Seismic and Corridor Stack (N)

Surface Seismic & Corridor Stack (shift down 29 ms)

Well Location: X (398905m), Y (5588822m)



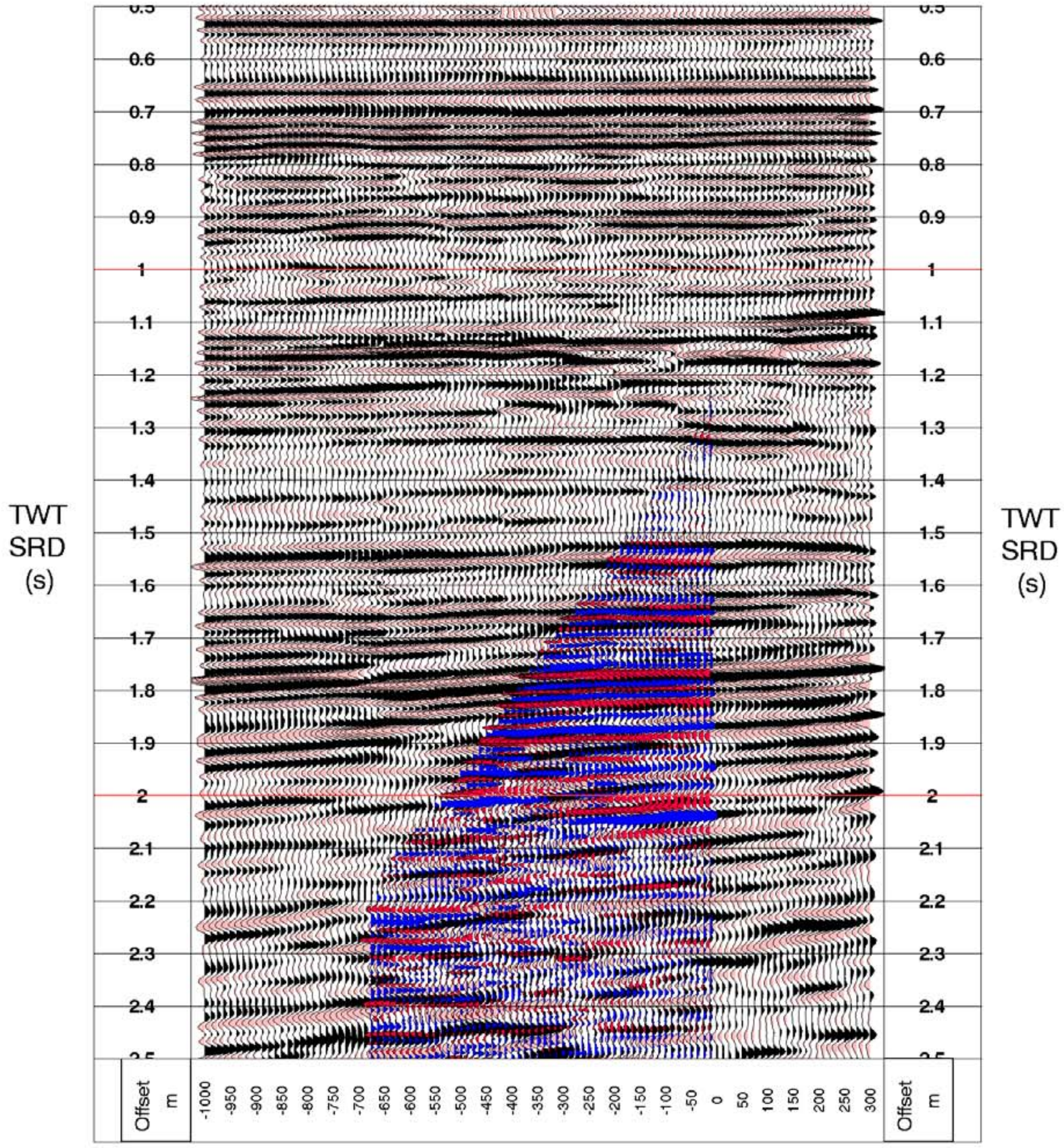
Polarity - Increase in Acoustic Impedance is Peak

Projected Well Location at Offset 0

Figure 14b. Composite Display of Surface Seismic and Corridor Stack (R)

Surface Seismic & VIVSP Upgoing Wavefield (shift down 29 ms)

Well Location: X (398905m), Y (5588822m)



Polarity - Increase in Acoustic Impedance is Trough

Projected Well Location at Offset 0

Figure 15a. Display of VIVSP Upgoing Wavefield under the wellbore and Surface Seismic (N)

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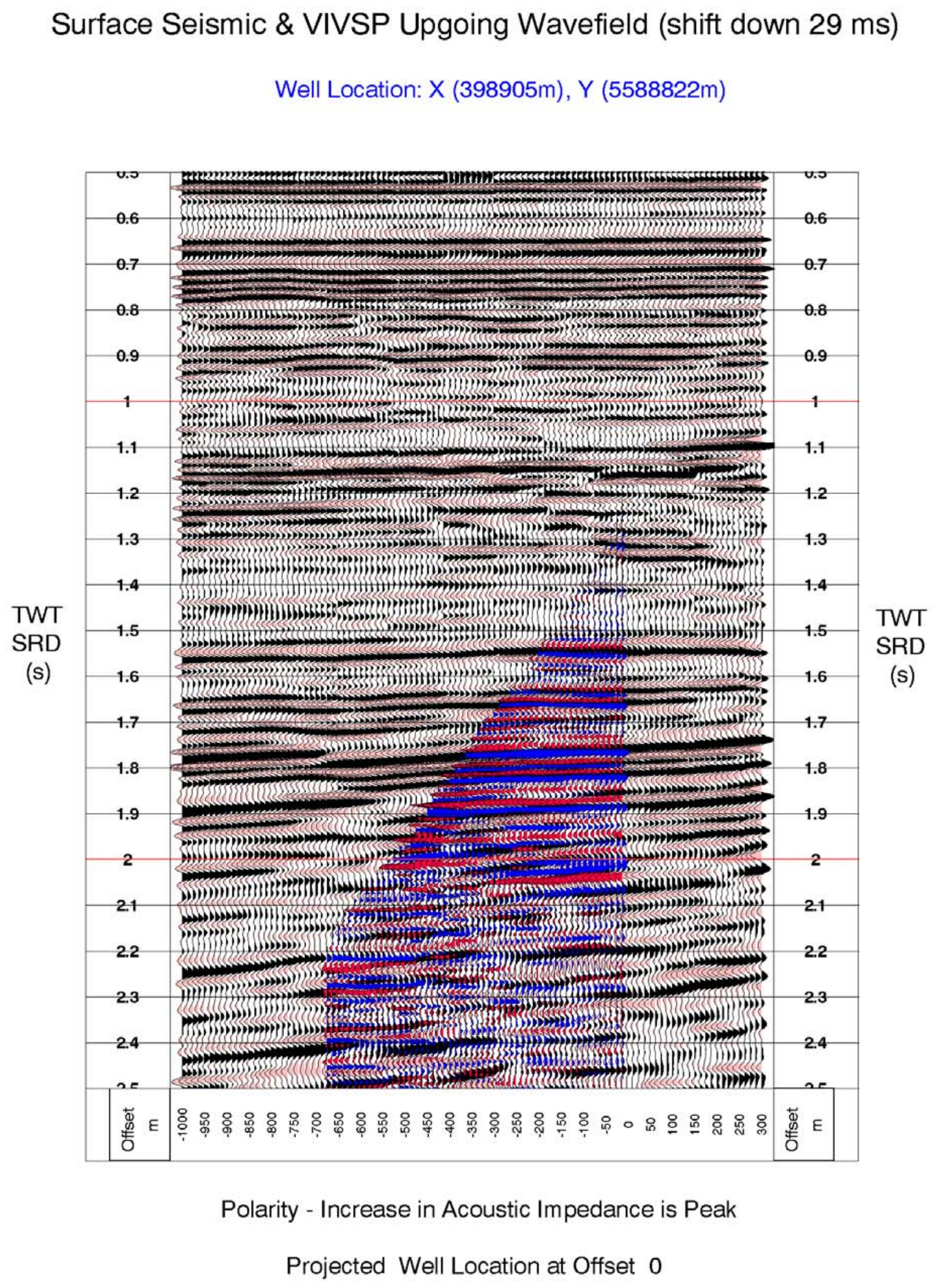

Figure 15b. Display of VIVSP Upgoing Wavefield under the wellbore and Surface Seismic (R)

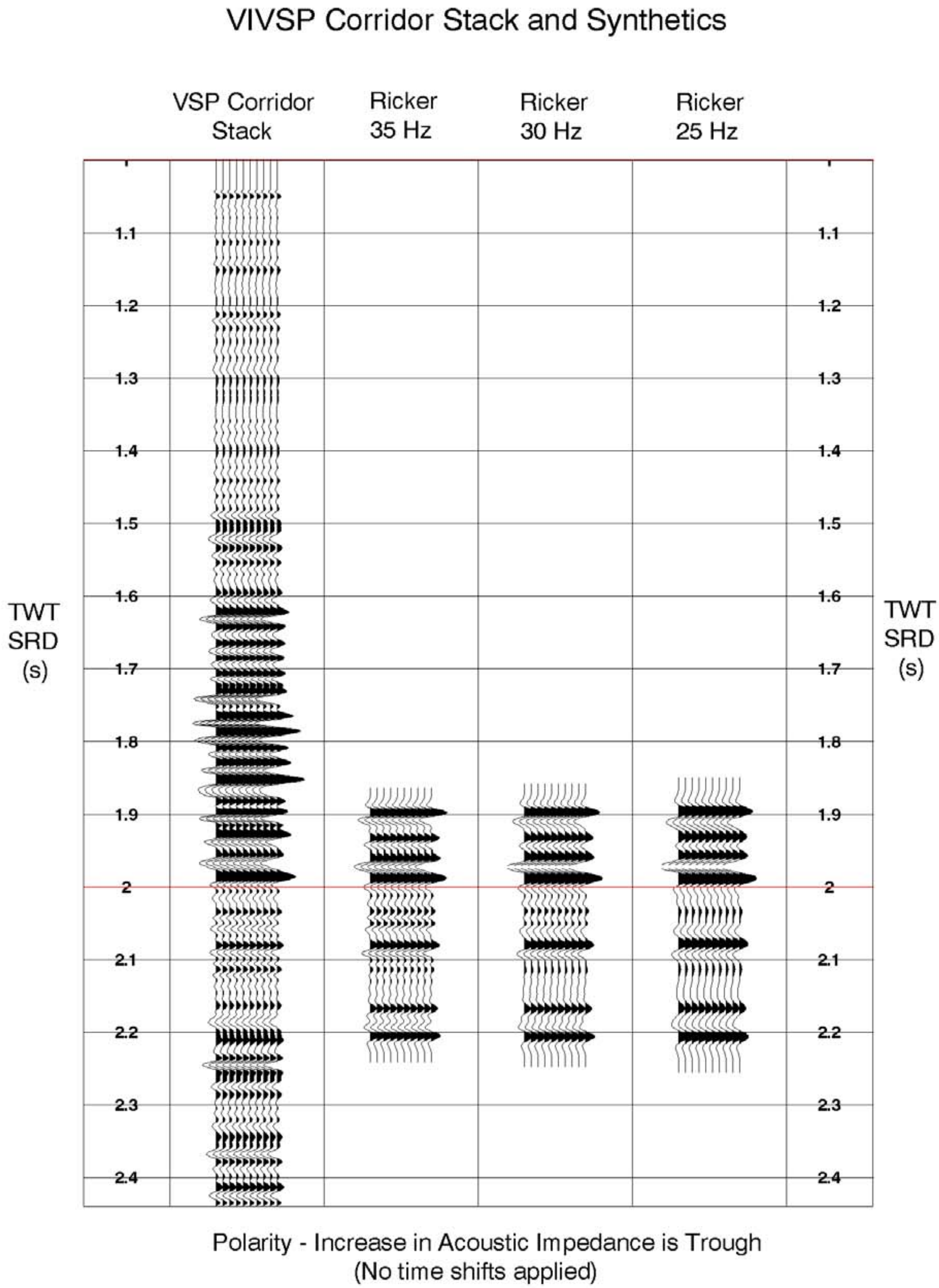

Figure 16a. Display of VIVSP Corridor Stack and Synthetics (N)

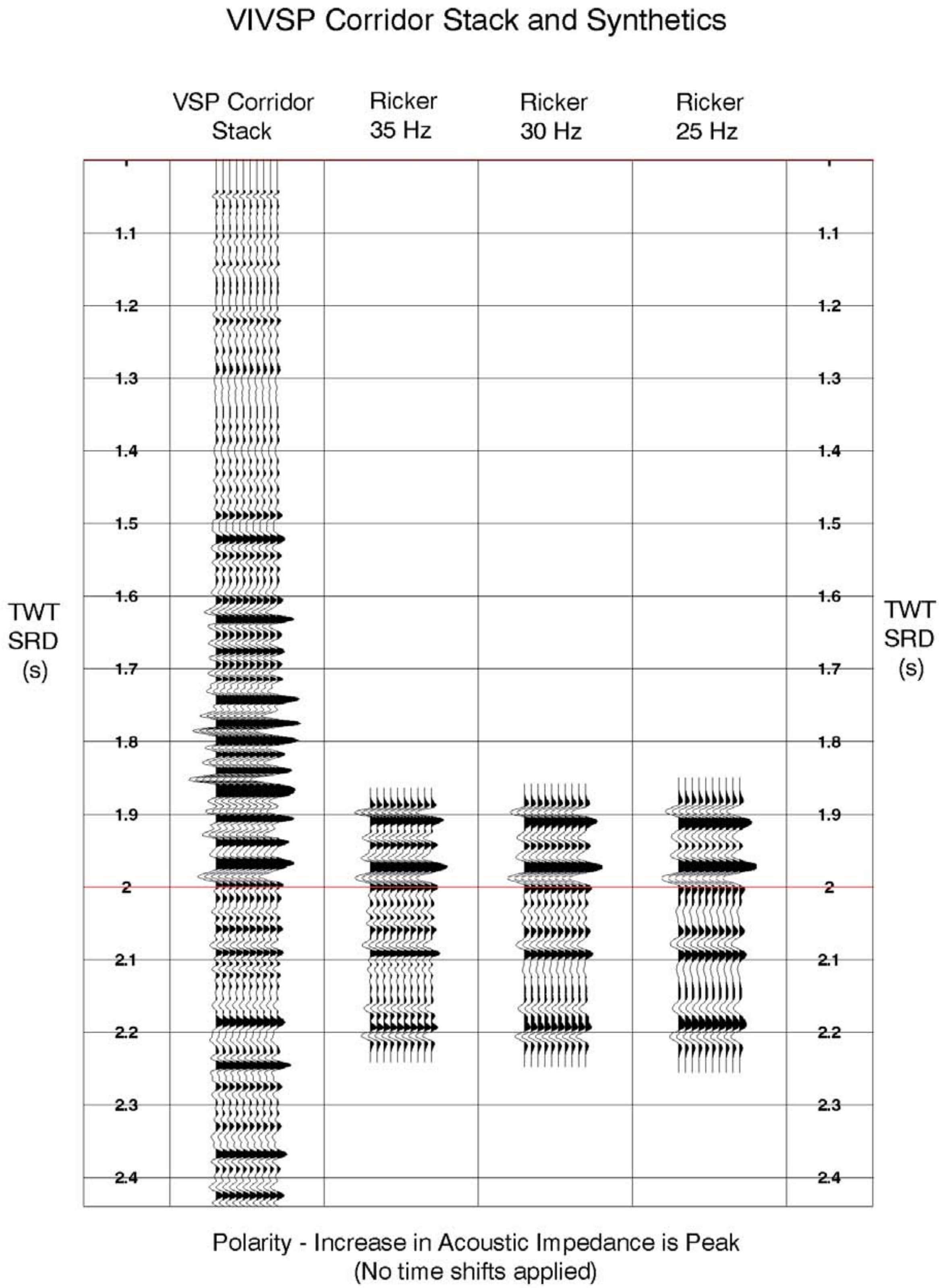

Figure 16b. Display of VIVSP Corridor Stack and Synthetics (R)

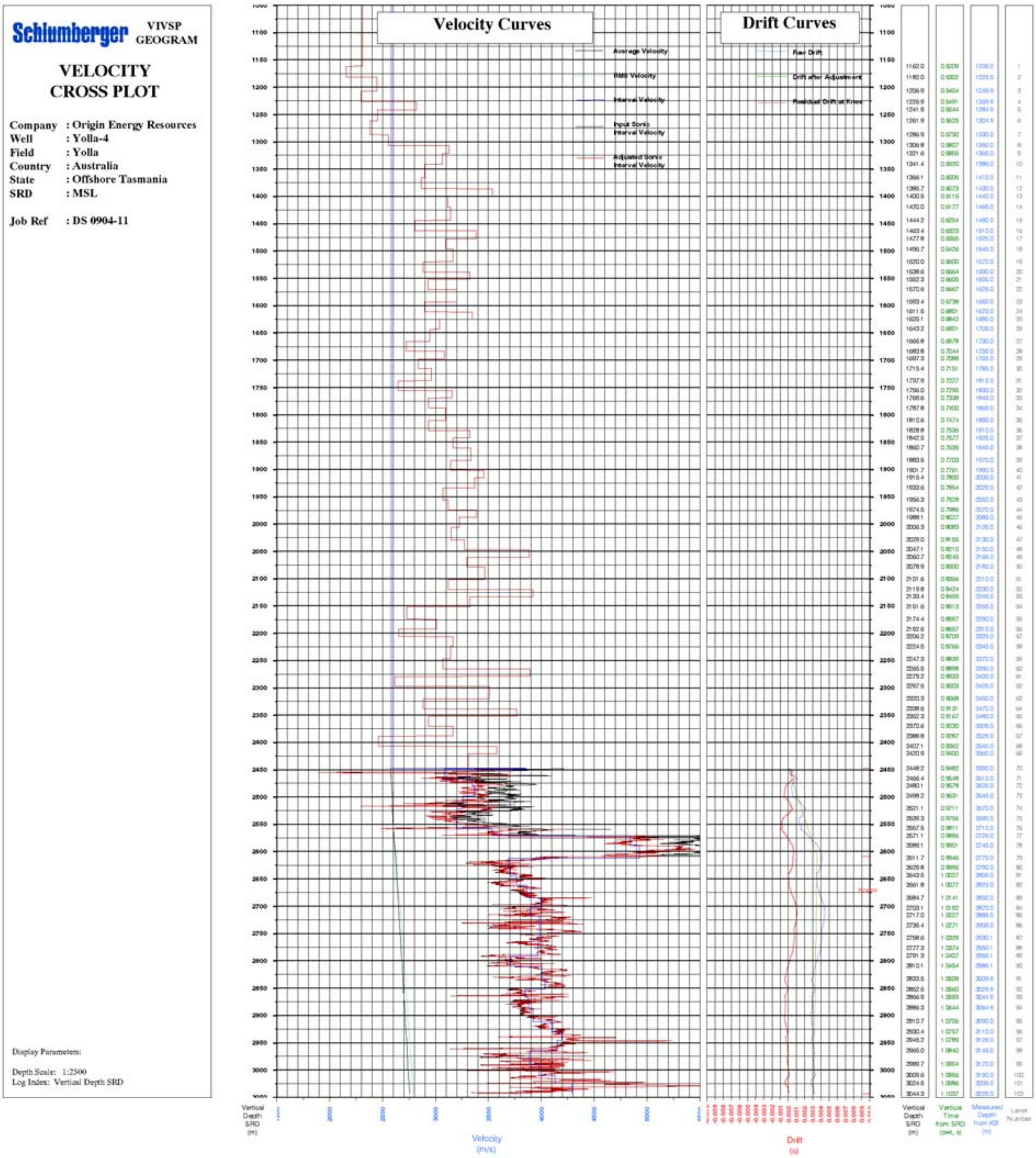

Figure 17. Velocity Crossplot (see Plot Vel 1)

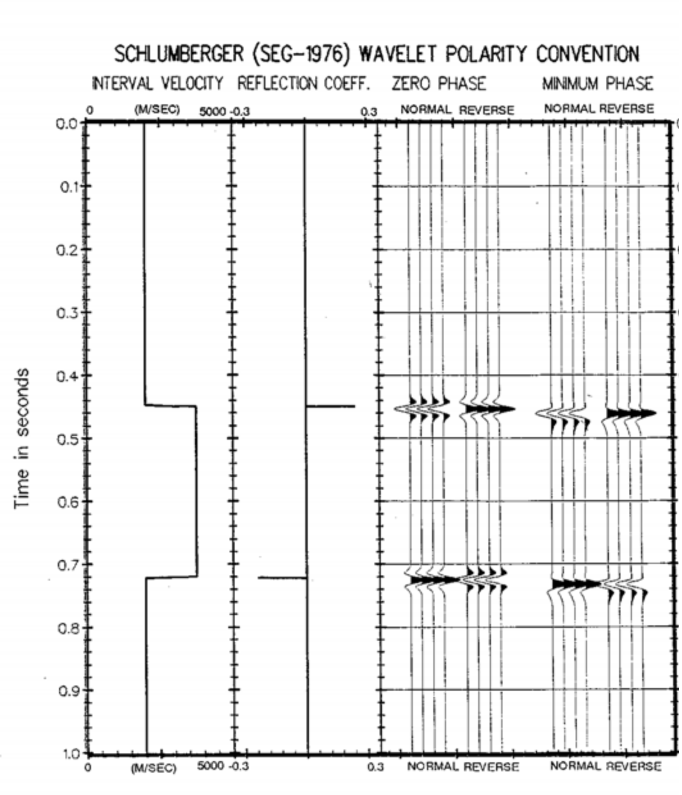

Figure 18. Schlumberger Wavelet Polarity Convention

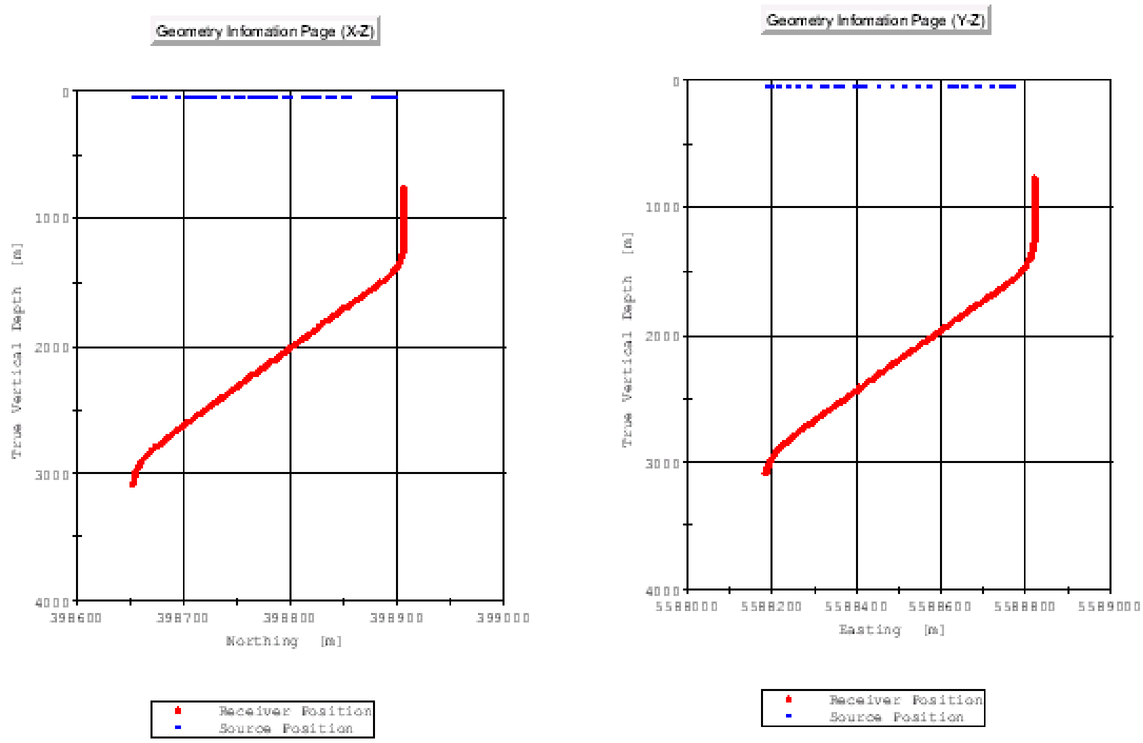

Figure 19. Yolla-4 Well Geometry

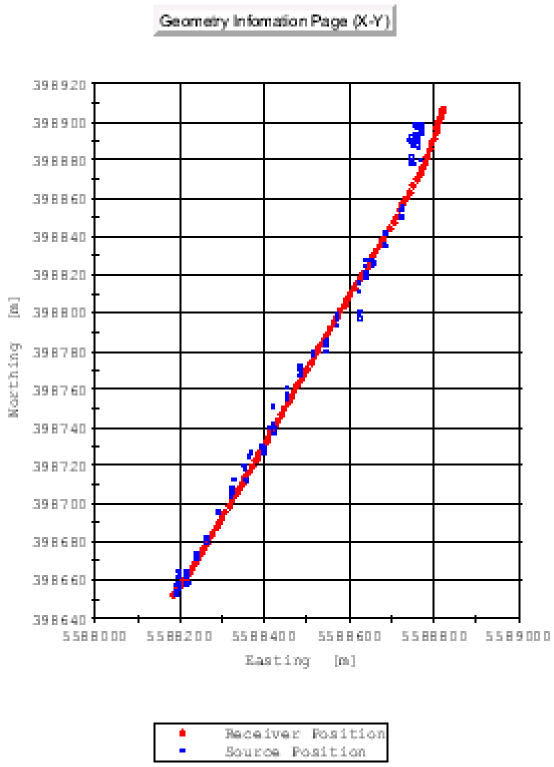

Figure 20. Yolla-4 VIVSP Source and Receiver Locations – Plan View

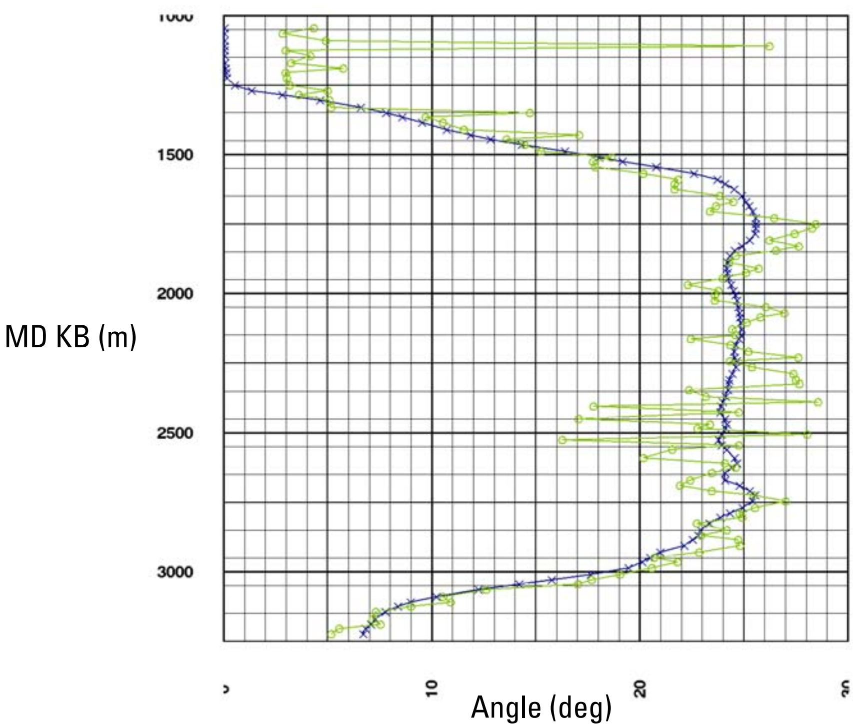

Figure 21. Rotation QC Display - Well deviation (x) vs. Polarization Angle (o)

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.

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 is reported every 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

Attachment 2: A-1 Well Seismic Report

Client and Well Information

Country	**Australia**
State	**Offshore Tasmania**
Logging Date	**15-Jul-2004**
Company	**Origin Energy**
Field	**Yolla**
Well	**Yolla-4**

Seismic Reference Datum : **MSL**

KB Elevation above MSL : 43 m

Water Velocity : 1524 m/s

Time Picking on Geophone Transformed GAC Stacks

Well deviation and Survey geometry corrections applied

Time picks above 1205 m KB are affected by casing arrivals and have been excluded from time picking

Check Shot Data

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s
1	0			0				
							2231	
2	1162	1205	0.5177	0.5209				2231
					20	0.009	2155	
3	1182	1225	0.527	0.5302				2229
					24.9	0.01	2451	
4	1206.9	1249.9	0.5372	0.5404				2234
					20	0.009	2298	
5	1226.9	1269.9	0.5459	0.5491				2235
					15	0.005	2823	
6	1241.9	1284.9	0.5512	0.5544				2240
					20	0.008	2455	

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s
7	1261.9	1304.9	0.5593	0.5625				2243
					25	0.011	2387	
8	1286.9	1330	0.5696	0.573				2246
					19.9	0.008	2561	
9	1306.8	1350	0.5773	0.5807				2250
					14.9	0.005	3130	
10	1321.6	1365	0.582	0.5855				2257
					19.8	0.007	3069	
11	1341.4	1385	0.5884	0.592				2266
					24.7	0.009	2898	
12	1366.1	1410	0.5971	0.6005				2275
					19.7	0.007	2871	
13	1385.7	1430	0.6039	0.6073				2282
					14.7	0.004	3542	
14	1400.5	1445	0.608	0.6115				2290
					19.5	0.006	3119	
15	1420	1465	0.6142	0.6177				2299
					24.2	0.008	3147	
16	1444.2	1490	0.6217	0.6254				2309
					19.2	0.007	2810	
17	1463.4	1510	0.6285	0.6323				2315
					14.3	0.004	3387	
18	1477.8	1525	0.6327	0.6365				2322
					18.9	0.006	3102	
19	1496.7	1545	0.6387	0.6426				2329
					23.4	0.007	3168	
20	1520	1570	0.6461	0.65				2339
					18.5	0.006	2886	
21	1538.6	1590	0.6525	0.6564				2344
					13.7	0.004	3327	
22	1552.3	1605	0.6566	0.6605				2350
					18.3	0.006	2933	
23	1570.6	1625	0.6628	0.6667				2356
					22.8	0.007	3206	
24	1593.4	1650	0.67	0.6738				2365
					18.1	0.006	2900	
25	1611.5	1670	0.6762	0.6801				2369
					13.6	0.004	3349	
26	1625.1	1685	0.6802	0.6842				2375

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s
					18.1	0.006	3041	
27	1643.2	1705	0.6862	0.6901				2381
					22.6	0.008	2950	
28	1665.8	1730	0.6939	0.6978				2387
					18	0.007	2728	
29	1683.8	1750	0.7005	0.7044				2390
					13.5	0.004	3085	
30	1697.3	1765	0.7048	0.7088				2395
					18	0.006	2839	
31	1715.4	1785	0.7112	0.7151				2399
					22.5	0.008	2966	
32	1737.9	1810	0.7189	0.7227				2405
					18.1	0.007	2651	
33	1756	1830	0.7256	0.7295				2407
					13.6	0.004	3159	
34	1769.6	1845	0.7299	0.7338				2411
					18.2	0.006	2935	
35	1787.8	1865	0.7361	0.74				2416
					22.8	0.007	3101	
36	1810.6	1890	0.7435	0.7474				2423
					18.2	0.006	2937	
37	1828.8	1910	0.7497	0.7536				2427
					13.7	0.004	3329	
38	1842.5	1925	0.7538	0.7577				2432
					18.2	0.006	3170	
39	1860.7	1945	0.7595	0.7635				2437
					22.8	0.007	3338	
40	1883.5	1970	0.7664	0.7703				2445
					18.2	0.006	3146	
41	1901.7	1990	0.7722	0.7761				2450
					13.7	0.004	3460	
42	1915.4	2005	0.7761	0.78				2456
					18.2	0.005	3372	
43	1933.6	2025	0.7816	0.7854				2462
					22.7	0.007	3075	
44	1956.3	2050	0.7889	0.7928				2468
					18.2	0.006	3123	
45	1974.5	2070	0.7947	0.7986				2472
					13.6	0.004	3392	

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s
46	1988.1	2085	0.7987	0.8027				2477
					18.2	0.006	3225	
47	2006.3	2105	0.8043	0.8083				2482
					22.7	0.007	3149	
48	2029	2130	0.8116	0.8155				2488
					18.1	0.006	3278	
49	2047.1	2150	0.8171	0.821				2493
					13.6	0.004	3889	
50	2060.7	2165	0.8206	0.8245				2499
					18.2	0.006	3302	
51	2078.9	2185	0.8261	0.83				2505
					22.7	0.007	3469	
52	2101.6	2210	0.8326	0.8366				2512
					18.2	0.006	3121	
53	2119.8	2230	0.8385	0.8424				2516
					13.6	0.004	3925	
54	2133.4	2245	0.8419	0.8459				2522
					18.2	0.006	3328	
55	2151.6	2265	0.8474	0.8513				2527
					22.7	0.008	2731	
56	2174.4	2290	0.8557	0.8597				2529
					18.2	0.006	3013	
57	2192.6	2310	0.8618	0.8657				2533
					13.7	0.005	2656	
58	2206.2	2325	0.8669	0.8709				2533
					18.2	0.006	3168	
59	2224.5	2345	0.8727	0.8766				2538
					22.8	0.007	3145	
60	2247.3	2370	0.8799	0.8839				2543
					18.3	0.006	3076	
61	2265.5	2390	0.8859	0.8898				2546
					13.7	0.004	3899	
62	2279.2	2405	0.8894	0.8933				2551
					18.3	0.007	2619	
63	2297.5	2425	0.8964	0.9003				2552
					22.9	0.007	3516	
64	2320.3	2450	0.9029	0.9068				2559
					18.3	0.006	2889	
65	2338.6	2470	0.9092	0.9131				2561

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s
					13.7	0.004	3769	
66	2352.3	2485	0.9128	0.9167				2566
					18.3	0.006	2934	
67	2370.6	2505	0.919	0.923				2568
					18.3	0.006	3171	
68	2388.8	2525	0.9248	0.9287				2572
					18.3	0.007	2463	
69	2407.1	2545	0.9322	0.9362				2571
					13.7	0.004	3585	
70	2420.9	2560	0.9361	0.94				2575
					27.4	0.008	3327	
71	2448.2	2590	0.9443	0.9482				2582
					18.2	0.007	2755	
72	2466.4	2610	0.9509	0.9548				2583
					13.6	0.003	4504	
73	2480.1	2625	0.9539	0.9578				2589
					18.2	0.005	3493	
74	2498.2	2645	0.9591	0.9631				2594
					22.8	0.008	2832	
75	2521.1	2670	0.9672	0.9711				2596
					18.2	0.005	4057	
76	2539.3	2690	0.9717	0.9756				2603
					18.2	0.006	3303	
77	2557.5	2710	0.9772	0.9811				2607
					13.6	0.005	3039	
78	2571.1	2725	0.9817	0.9856				2609
					18	0.005	4042	
79	2589.1	2745	0.9861	0.9901				2615
					22.6	0.005	4936	
80	2611.7	2770	0.9907	0.9946				2626
					18.1	0.005	3712	
81	2629.8	2790	0.9956	0.9995				2631
					13.6	0.003	4299	
82	2643.5	2805	0.9987	1.0027				2636
					18.3	0.005	3667	
83	2661.8	2825	1.0037	1.0077				2642
					23	0.007	3552	
84	2684.7	2850	1.0102	1.0141				2647
					18.4	0.005	3664	

LEVEL NUMBER	VERTICAL DEPTH FROM MSL m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME s	VERTICAL TRAVEL TIME MSL s	DELTA DEPTH m	DELTA TIME s	ACOUSTIC INTERVAL VELOCITY m/s	ACOUSTIC AVERAGE VELOCITY m/s
85	2703.1	2870	1.0152	1.0192				2652
					13.8	0.004	3859	
86	2717	2885	1.0188	1.0227				2657
					18.4	0.004	4203	
87	2735.4	2905	1.0232	1.0271				2663
					23.2	0.006	4023	
88	2758.6	2930.1	1.029	1.0329				2671
					18.7	0.005	4114	
89	2777.3	2950.1	1.0335	1.0374				2677
					14	0.003	4303	
90	2791.3	2965.1	1.0368	1.0407				2682
					18.8	0.005	3992	
91	2810.1	2985.1	1.0415	1.0454				2688
					23.5	0.006	4302	
92	2833.5	3009.9	1.0469	1.0508				2696
					19	0.005	3714	
93	2852.5	3029.9	1.052	1.056				2701
					14.4	0.003	4284	
94	2866.9	3044.9	1.0554	1.0593				2706
					19.4	0.005	3820	
95	2886.3	3064.9	1.0604	1.0644				2712
					24.5	0.006	3961	
96	2910.7	3090	1.0666	1.0706				2719
					19.6	0.005	3851	
97	2930.4	3110	1.0717	1.0757				2724
					14.8	0.003	4501	
98	2945.2	3125	1.075	1.0789				2730
					19.8	0.005	3953	
99	2965	3145	1.08	1.084				2735
					24.8	0.006	3865	
100	2989.7	3170	1.0864	1.0904				2742
					19.8	0.005	3822	
101	3009.6	3190	1.0916	1.0956				2747
					14.9	0.003	4900	
102	3024.5	3205	1.0947	1.0986				2753
					19.9	0.005	3920	
103	3044.3	3225	1.0997	1.1037				2758

Attachment 3: Listing of Deliverables (CD-ROM)

Report:

VIVSP_report	VIVSP/Geogram Processing Report	PDF
QBH_report	Q-Borehole Survey Report	PDF

Graphics Displays:

comp1	Plot 1. Composite Display 1– Polarity: Trough	TIF / PDF / PDS / CGM
comp2	Plot 2. Composite Display 2 – Polarity: Peak	TIF / PDF / PDS / CGM
vel1	Plot 3. Velocity Crossplot	TIF / PDF / PDS / CGM

Data files plus Verification (.txt) listings:

(Raw data is affected by cable problem as described in Chapter 2 – Data Acquisition, Field LDF only)

Y4_xstk.sgy	stacked x axis data	SEGY
Y4_ystk.sgy	stacked y axis data	SEGY
Y4_zstk.sgy	stacked z axis data	SEGY
Y4_upp.sgy	Zero Phase upgoing wavefield TWT	SEGY
Y4_corstk.sgy	Zero phase corridor stack	SEGY
Y4_upp_reg.sgy	Zero Phase upgoing wavefield TWT (Regularised Offset)	SEGY
Y4_corstk_reg.sgy	Zero phase corridor stack (Regularised Offset)	SEGY
Y4_synt_R35.sgy	Zero Phase Synthetic Seismograms – Ricker 35Hz	SEGY
Y4_synt_R30.sgy	Zero Phase Synthetic Seismograms – Ricker 30Hz	SEGY
Y4_synt_R25.sgy	Zero Phase 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)
logs_in_mdtvdtwt.xls	Corridor Stack resampled in MD, TVD, TWT (special request)	EXCEL

Listings:

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