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WELL SEISMIC PROCESSING REPORT

VSP

Beardie-1

FIELD: Offshore Exploration

COUNTRY: Australia, offshore VIC, Permit VIC/L9

COORDINATES: Latitude: 38" 15' 16.214" S
: Longitude: 147" 48' 24.643" E

DATE OF VSP SURVEY: 5-AUG-2002

REFERENCE NO: DS 0402-003

INTERVAL: 119.9-1900.0 mRT

Prepared by: Y. Solovyov

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VSP/Geogram PLOTS

1. Introduction

A borehole seismic survey was recorded in one run in vertical well Beardie-1 on 5-th of August 2002. This survey included both rig source VSP and additional checkshot measurements. The data were acquired using a Dual Combinable Seismic Acquisition Tool (CSAT-B) downhole and a cluster of 2 G-Guns suspended from the rig.

This report describes the techniques used, the parameter choices and presents the results of the checkshot and VSP data processing.

2. Data Acquisition

The data were acquired in one logging run in both open and cased hole, using the three component Dual Combinable Seismic Acquisition Tool (CSAT-B), fitted with GAC accelerometer. A cluster of 2 G-guns with 150 cu in capacity each used as the source, was fired at 2000 psi air pressure. The gun cluster was positioned 5.5 m below the SRD sea level. Hydrophone was positioned 2 m above the gun. Recording was made on the Schlumberger Maxis 500 Unit using DLIS format .
The VSP levels were acquired from 1900 mKB to 228 mKB with additional checkshot levels from 198 mKB to 123 mKB. VSP levels were recorded with 15.12 m interval. 5 shots were recorded for each VSP level and 3 shots for each checkshot level.

Table 1. Survey Parameters

Elevation of KB	25 m
Elevation of DF	25 m
Elevation of GL	-51.2 m
Well Deviation	0.58 (vertical)
Energy Source	2x150 cu in. G-guns
Source Offset	61 M
Source Depth	5.5 M below Sea Level
Reference Sensor	Hydrophone
Hydrophone Offset	61 M
Hydrophone Depth	3.5 M below Sea Level
Source & Hyd. Azimuth	104 Deg.
Tool Type	Dual CSAT-B
Tool Combination	CSAT-B+GR
De-coupled Sensors	Yes
Shaker Fitted	Yes
Number of Axis	3
Sensor Type	GAC – Geophone Accelerometer
Frequency Response (GAC)	3-200 Hz
Sampling Rate	1 ms.
Recording Time	6.0 sec.
Acquisition Unit	MAXIS
Recording Format	DLIS

3. Well Seismic Edit

The data for both VSP and the checkshot intervals were prepared using the same methods.

Each shot of the raw GAC integrated 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. The transit time of each trace was re-computed after stacking.

The following subsections describe the main aspects of the well seismic edit phase:

- Data Quality
- Transit Time Measurement
- Stacking

3.1 Data Quality

The data quality is good apart from the levels at 1596.9 mKB, 1599.9 mKB, 1642 mKB and 1654.9 mKB. Levels at 1596.9 mKB, 1599.9mKB and 1642 mKB are located below coal layers and recorded signal interfere strongly with coals. Level at 1654.9 mKB was recorded in washed out interval, no good contact with formation, interference from above coal layer is also present. These levels and double level at 1580 mKB were removed from VSP processing.

3.2 Transit Time Measurement

The transit time measured, corresponds to a difference between arrivals recorded by surface and downhole sensors. The reference time (zero time) is the physical recording of the source signal by accelerometers on the gun or sensors positioned near the source. In this case, a hydrophone positioned 3.5 m below the sea level was used as the reference. An inflection point tangent first break picking algorithm was used on both the hydrophone and the geophone data , see Attach. 1.

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 are 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 surface sensor (hydrophone) breaks are used as the zero time for stacking. The break time of each trace is recomputed after stacking. X, Y and Z component median stacks presented in Figure 2,3,4. There is a downgoing shear velocity component observable on X component.

4. VSP Processing Chain

The vertical component of the VSP data was processed using the conventional zero offset processing chain. The following subsections describe the main aspects of the processing chain:

Well Seismic Edit:

- load data
- edit bad records
- pick break time
- Z component median stack

Pre processing:

- transit time correction to datum
- spherical divergence correction
- bandpass filter
- trace normalization

VSP Processing:

- wavefield separation
- waveshaping deconvolution
- corridor stack

4.1 Pre Processing

4.1.1 Transit Time Correction to Datum

Seismic Reference Datum (SRD) is at Mean Sea Level.
The source was positioned 5.5 meters below sea surface. The reference hydrophone was located 2 meters above the G-Guns cluster, 3.5 m below sea level. Correction to SRD was calculated using a water layer velocity of 1524 m/s .

4.1.2 Spherical Divergence Correction

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

$$Gain(T) = \left(\frac{T}{T_0}\right)^{\alpha}$$

where T is the recorded time, T_0 is the first break time and a = 1 was applied.

4.1.3 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. Zero phase Butterworth Bandpass filter was applied to the data limiting the bandwidth to 5-120 Hz.

4.1.4 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 used.

4.2 VSP Processing

4.2.1 Wavefield Separation

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

The downgoing coherent compressional energy is estimated using three levels median velocity filter parallel to the direct arrival curve. The 7, 5 and 3 level velocity filter were tested. 3 level filter produced the best resolution for thin coal bed layers. The filter array is moved down one level after each computation and the process is repeated level by level over the entire dataset.
The downgoing wavefield is displayed in one way time (Figure 5).

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 (Figure 6).

4.2.2 Waveshaping Deconvolution

The waveshaping process shortens the seismic pulse within races and for zero phase 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 2 s starting 20 ms before the picked break times in order to include the wavelet precisely. The designed outputs were chosen to be zero phse with a bandwidth of 5-80 Hz. Once the design is made upon the downgoing wavefield, it is applied to the both downgoing and upgoing wavefields at the same level. The upgoing compressional wavefield is then enhanced using 5 level median coherency velocity filter as shown in Figure9. The same wavefield before enhancement displayed in Fig. 8

The downgoing wavefield is displayed in one way time (Figure 7).

4.2.3 Corridor Stack

A corridor stack was computed on the data after zero phase waveshaping deconvolution by designing a constant 100 ms timing window along the to-way time depth curve and stacking the data onto a single trace. The deepest 7 traces are stacked entirely. The resulting trace under normal circumstances satisfies the assumption of one dimentiality and provides the best seismic representation of borehole. This corridor stack is displayed in Figure 10 along with the enhanced upgoing wavefield in two way time. First track displays enhanced upgoing wavefield, second-corridor stack within 100 ms, third-the same corridor stack phase rotated by –90 degree.

5. 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 14.

6. Shear Velocities from VSP

Despite of near-vertical angle of incidence in rig source VSP, fairly strong converted wave S energy was generated from coal layers. That made possible to attempt S wave extraction in this case using the Parametric Wavefield Decomposition method.

After stacking, the X, Y and Z components need to be rotated into direction of maximum downgoing compressional energy arrival (TRY), which is very similar to vertical Z component in vertical well and maximum horizontal energy arrival (HMX). A polarization analysis using hodograms of the first arrival energy on the 3 components is used to perform these rotations.

Parametric Wavefield Decomposition is used to generate 4 wavefields: Down P, Down S, Up P and Up S. The technique of wavefield decomposition used in this module is a parametric least-squares minimization where the data are modeled locally in a given time window as a superposition of plane-wave events . The data at each depth level are modeled as superposition of down-going and up-going P waves and down-going and up-going S waves. Each wave is modeled by defining its local velocity, its angle of incidence and its waveform.

The technique was developed in Schlumberger by C. Esmersoy. More information can be found in: Inversion of P and SV waves from multicomponent offset VSP's, C. Esmersoy, Geophysics January 1990

Figure 12 shows a snapshot of resulting processing window after executing the parametric wavefield separation.

The inverted slownesses and an incidence angles have been used to produce the vertical shear and comprressional velocity logs shown in Figure 11.

A good match is achieved between P and S slowness derived from VSP and sonic slowness from DSI (Figure 13).

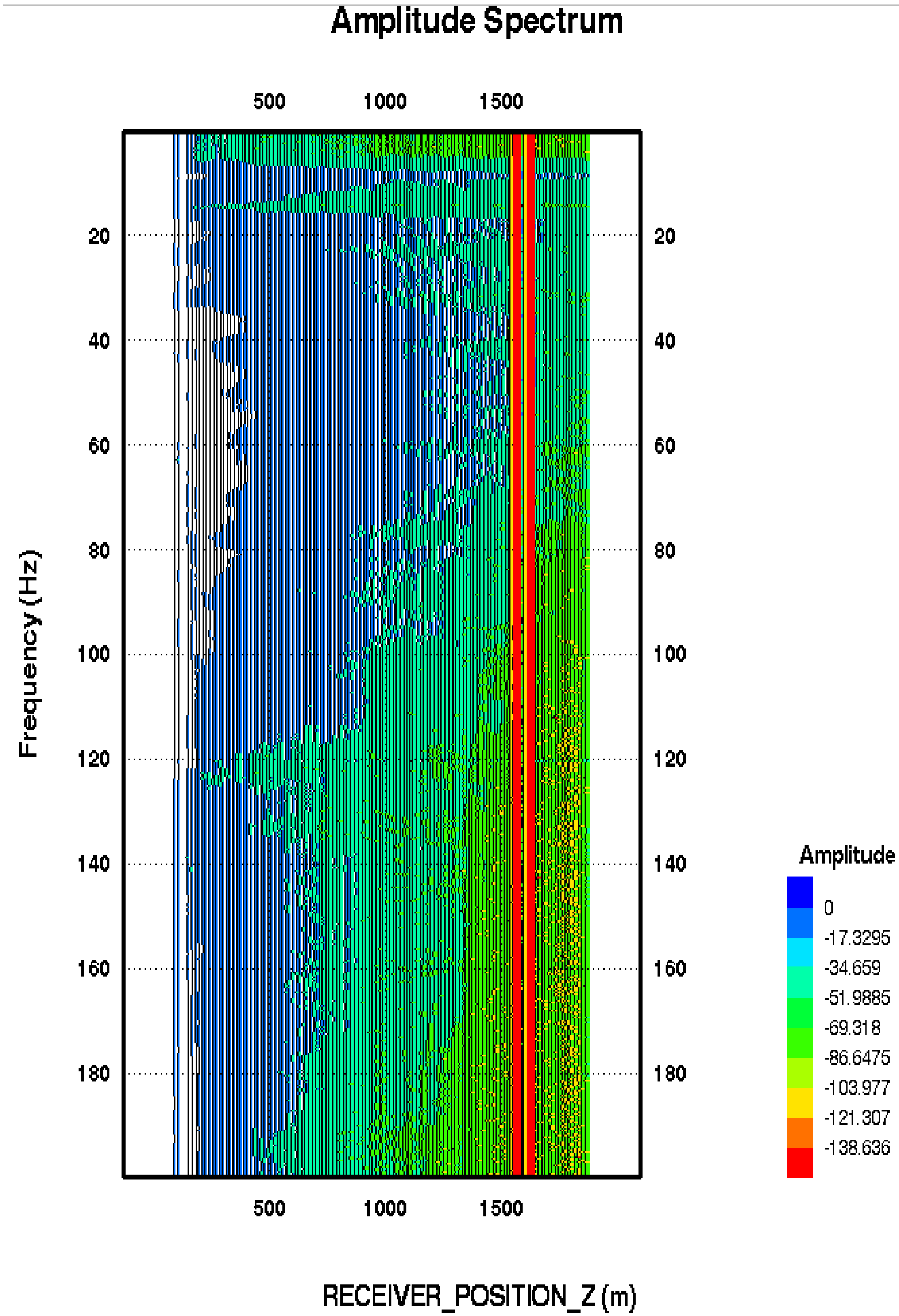

Figure 1. Amplitude Spectrum

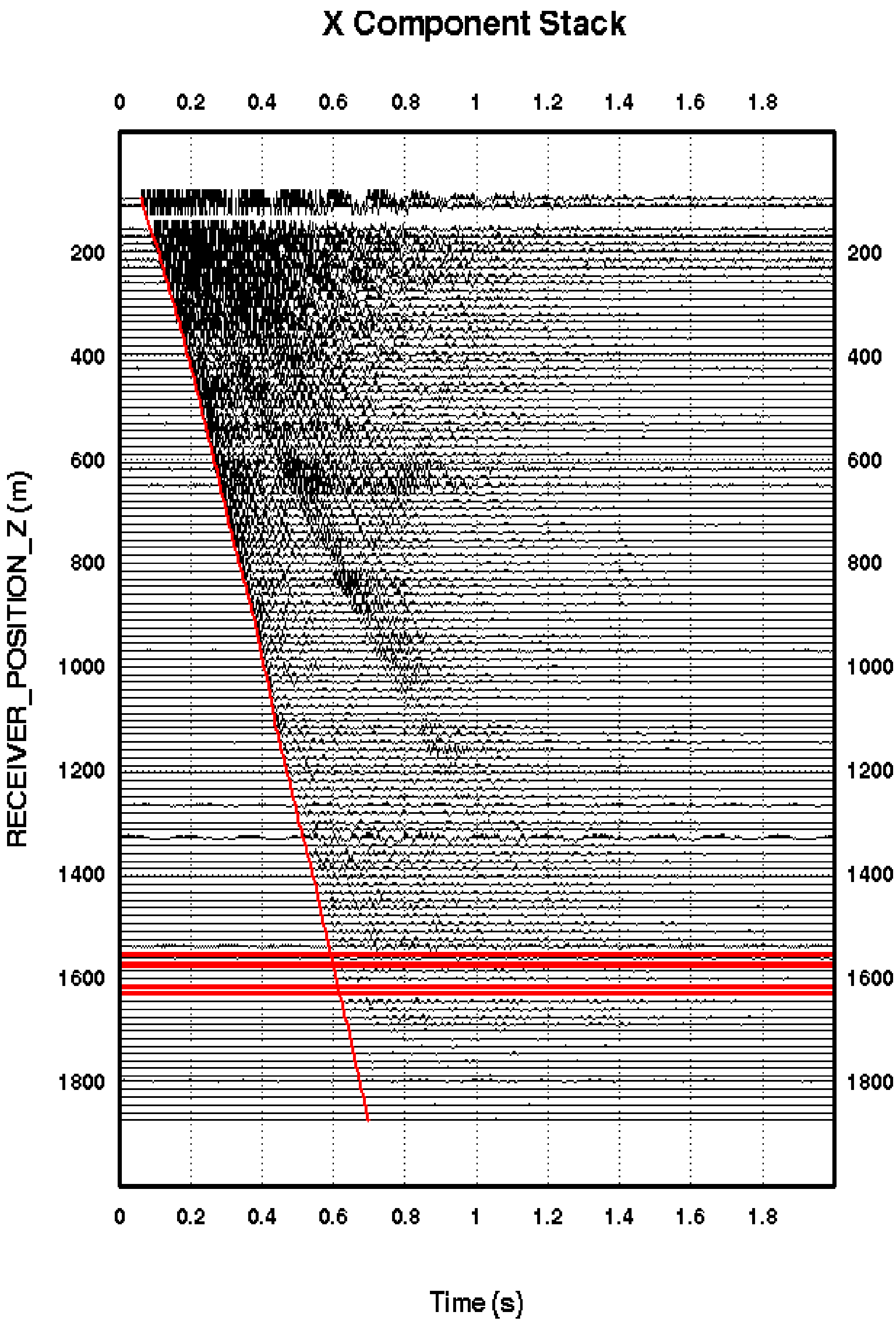

Figure 2. X Component Stack

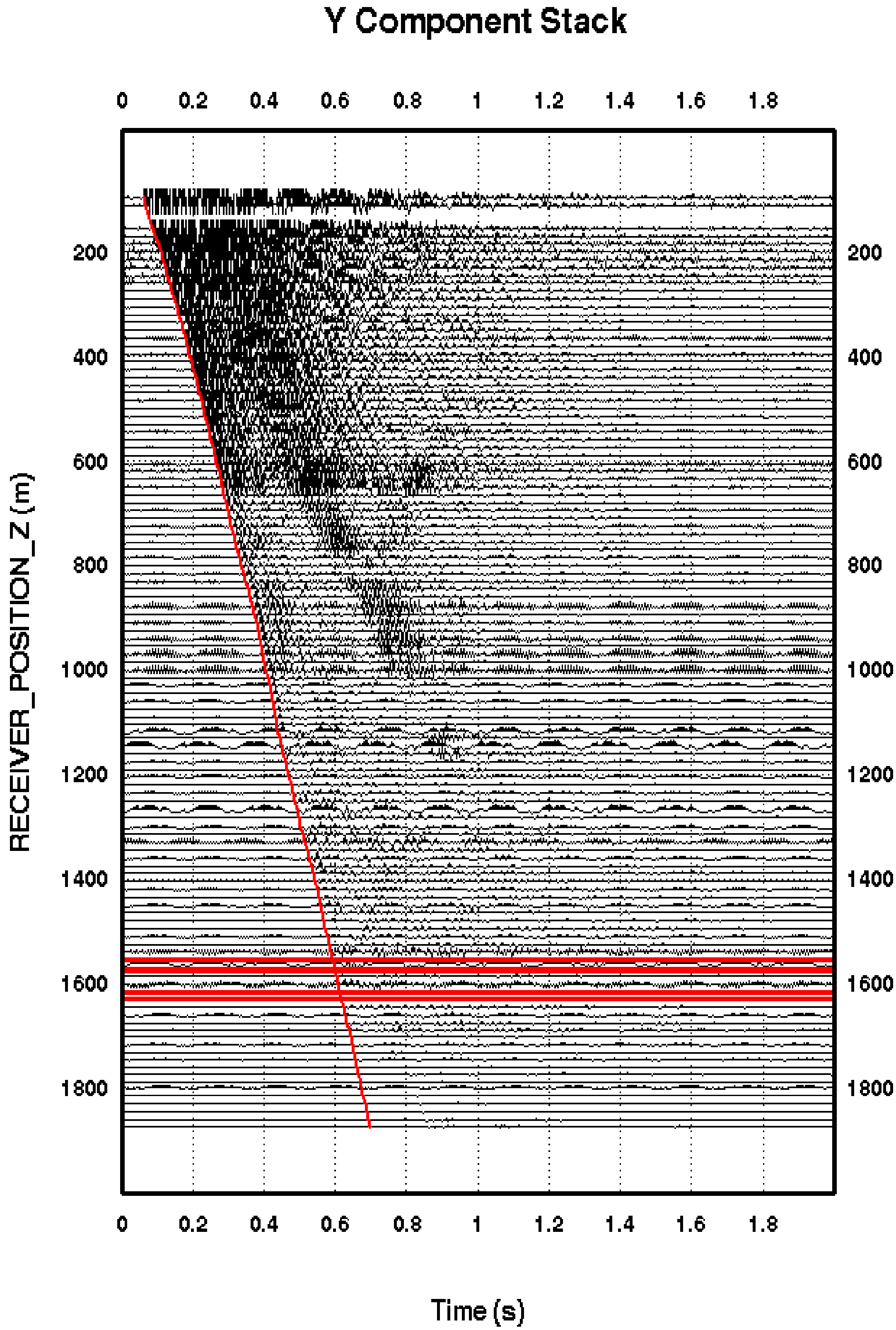

Figure 3. Y Component Stack

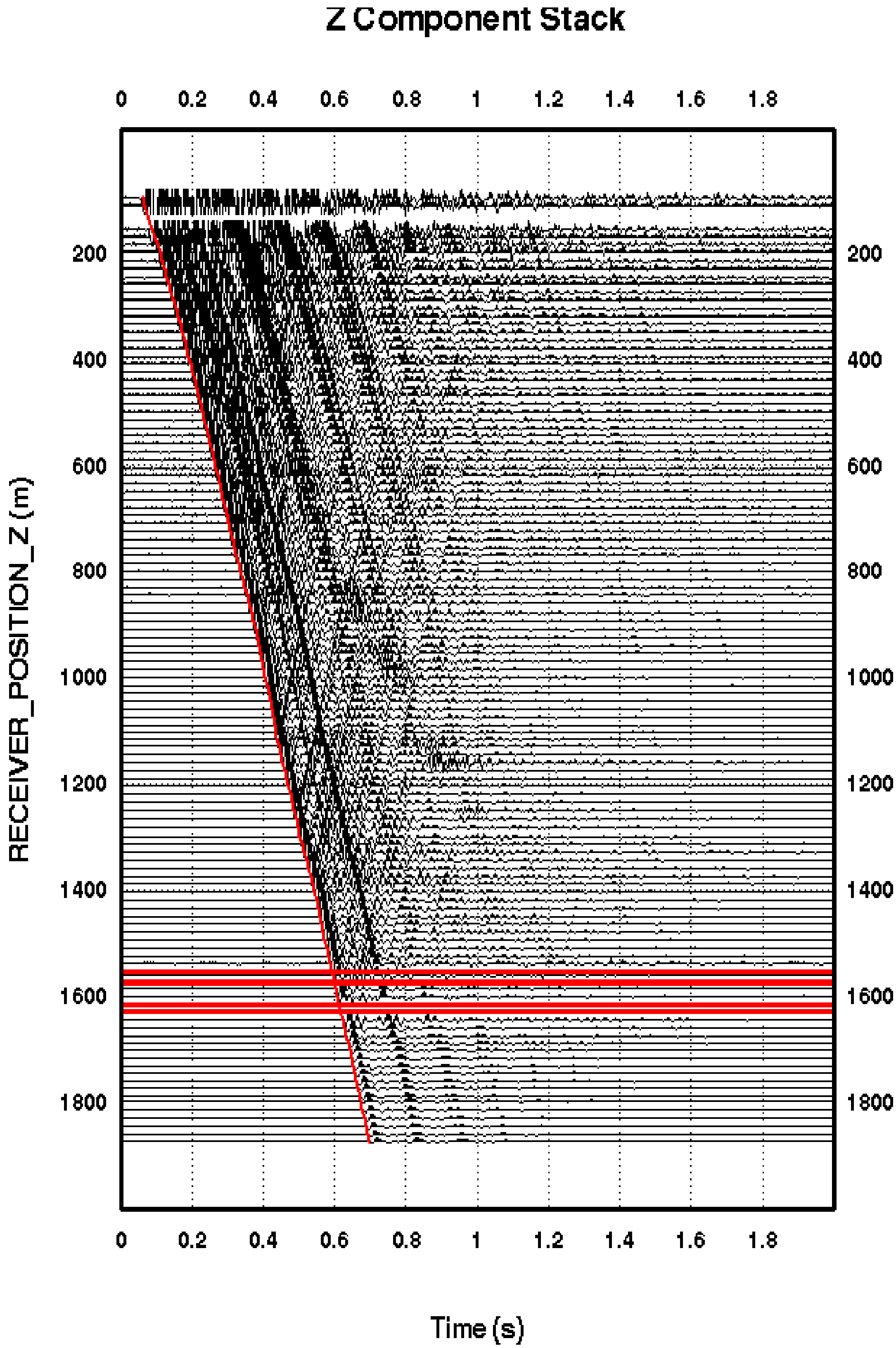

Figure 4. Z Component Stack

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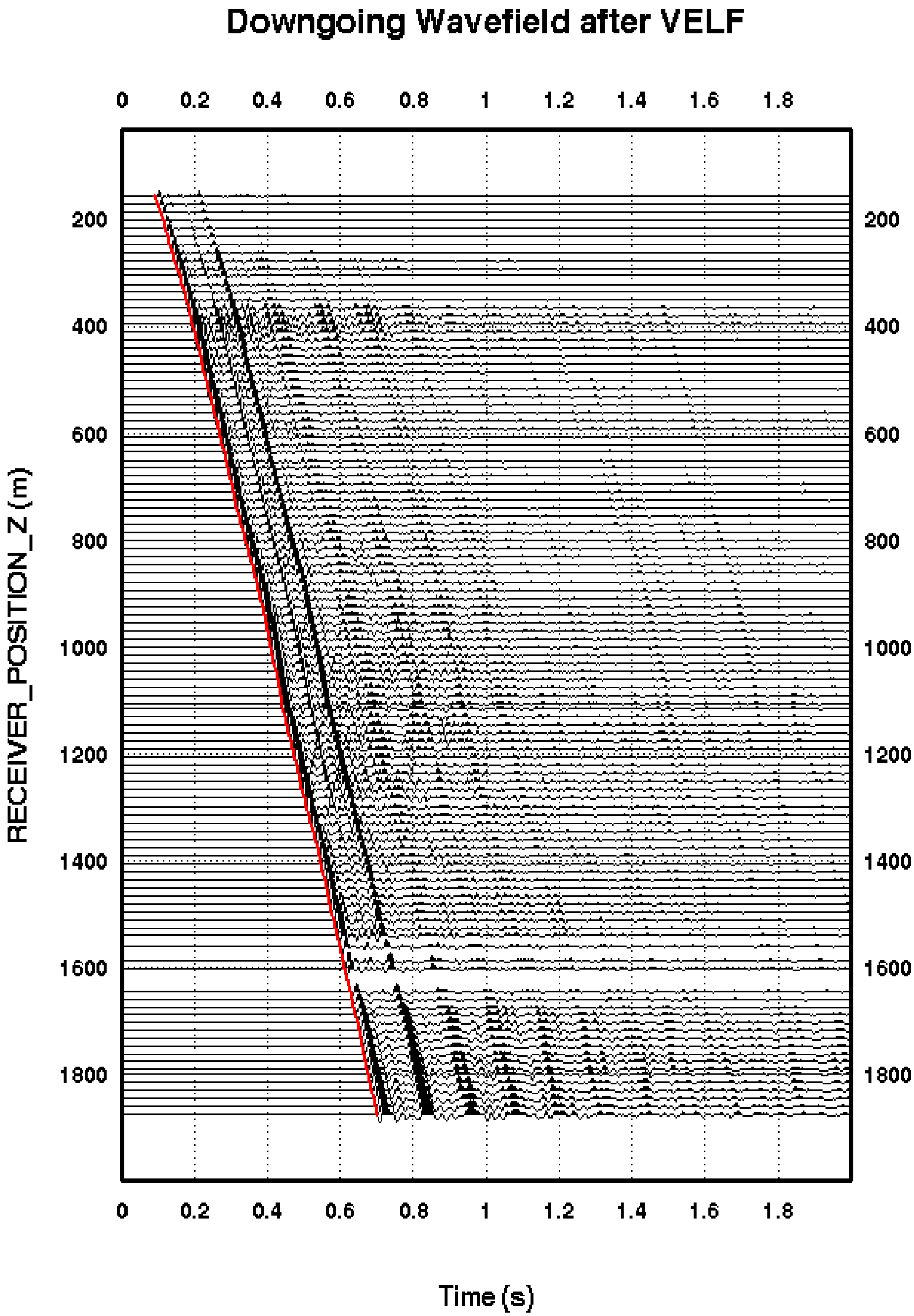

Figure 5. Downgoing Wavefield after VELF

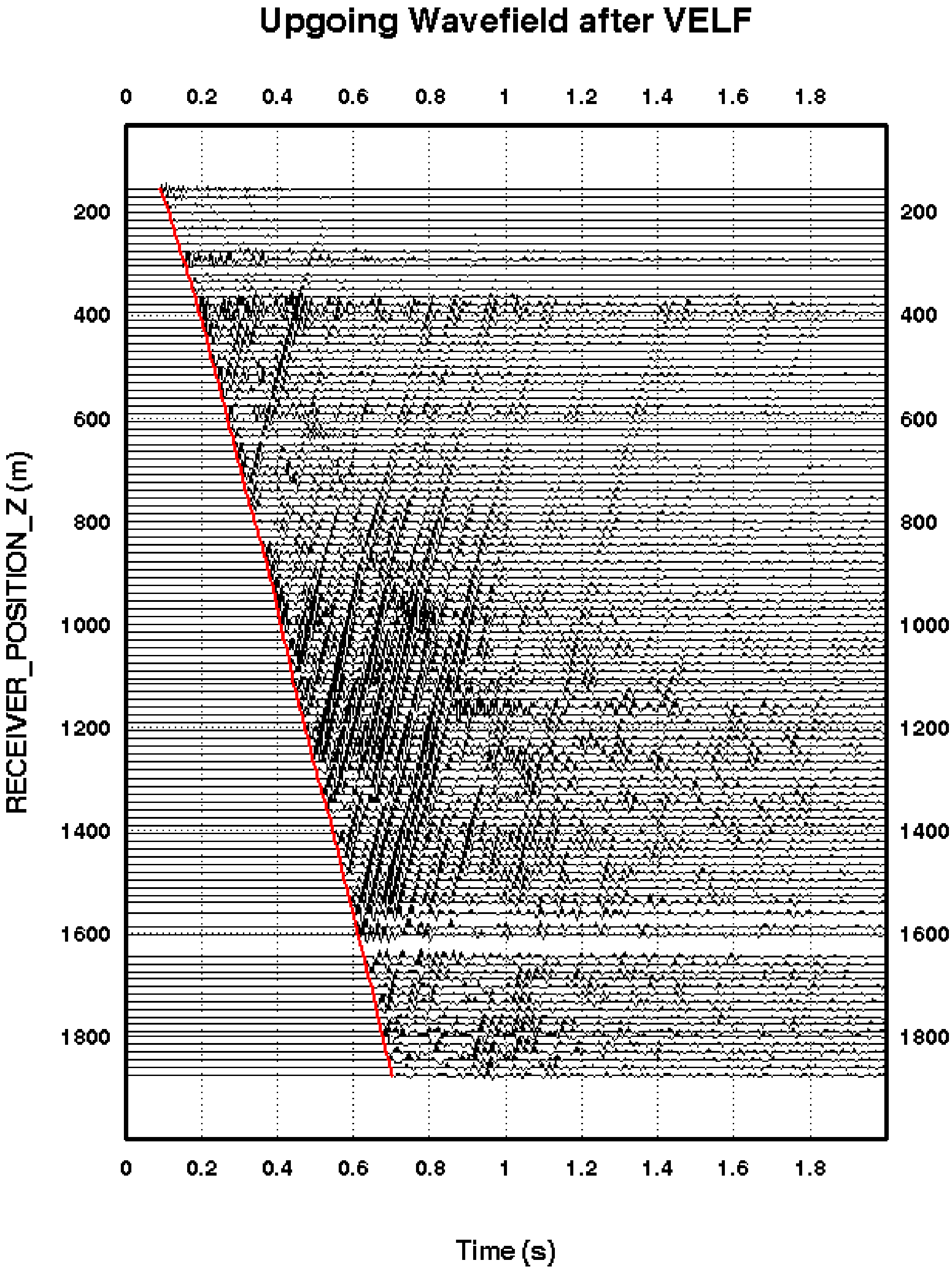

Figure 6. Upgoing Wavefield after VELF

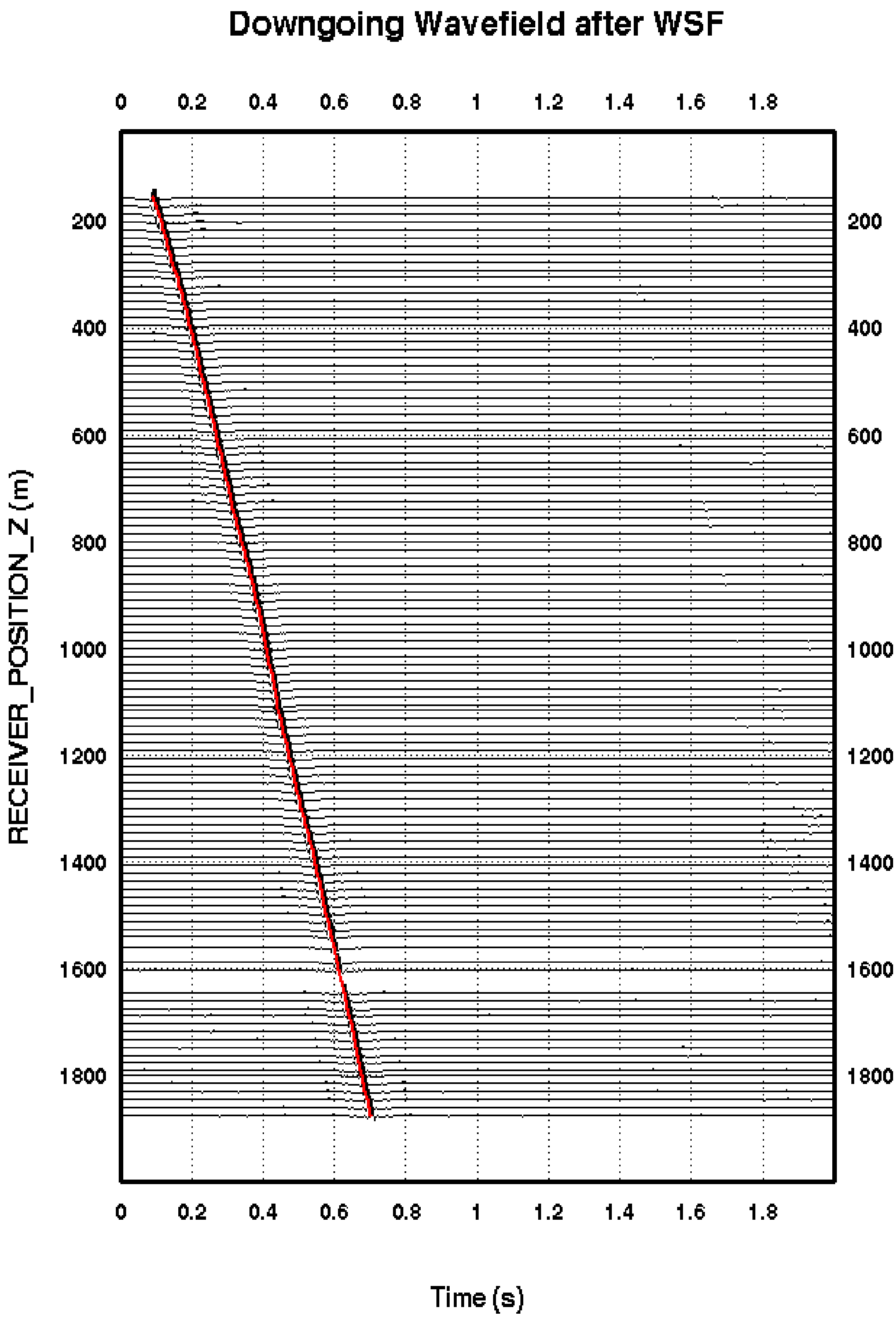

Figure 7. Downgoing Wavefield after WSF

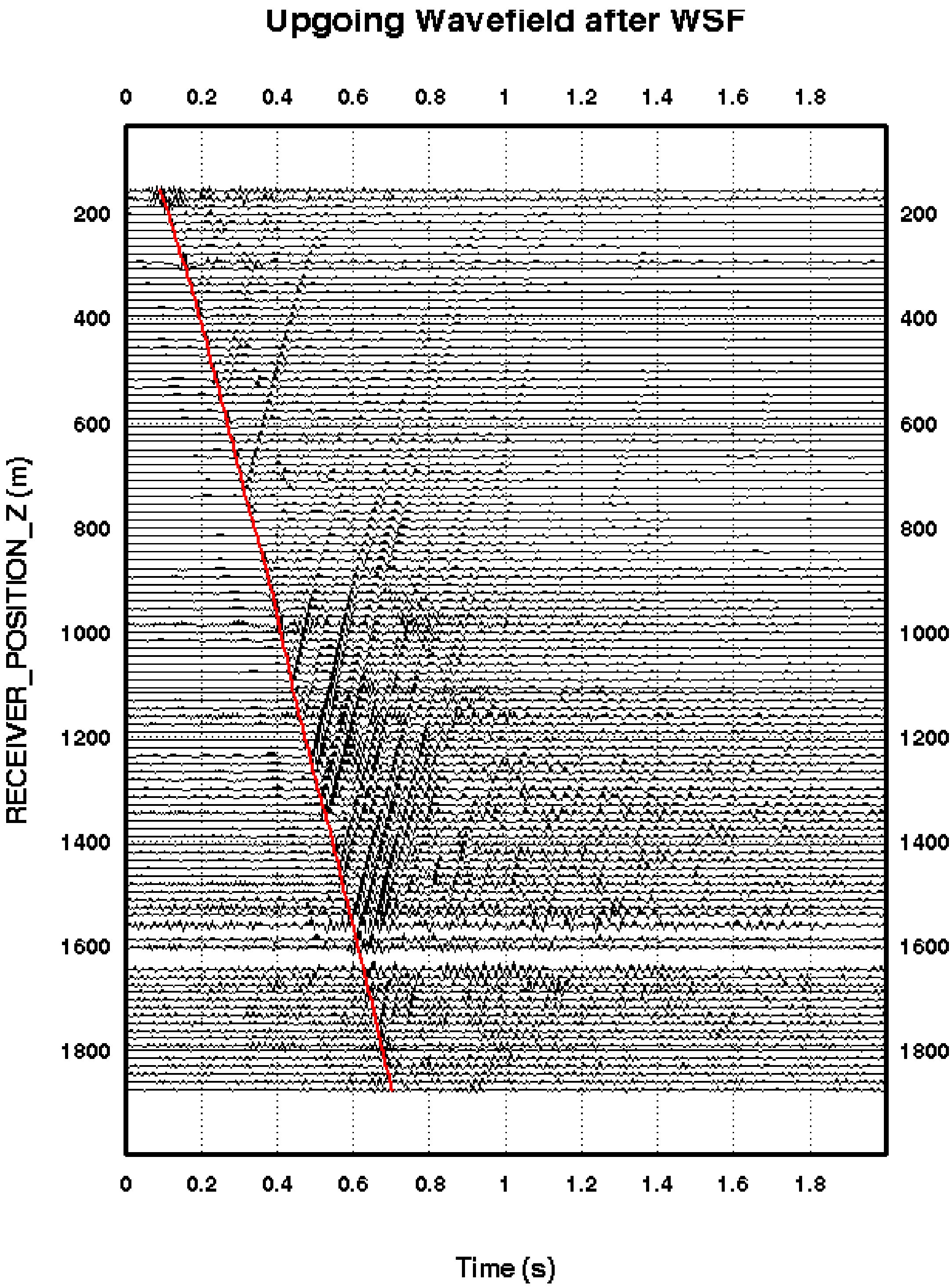

Figure 8. Upgoing Wavefield after WSF

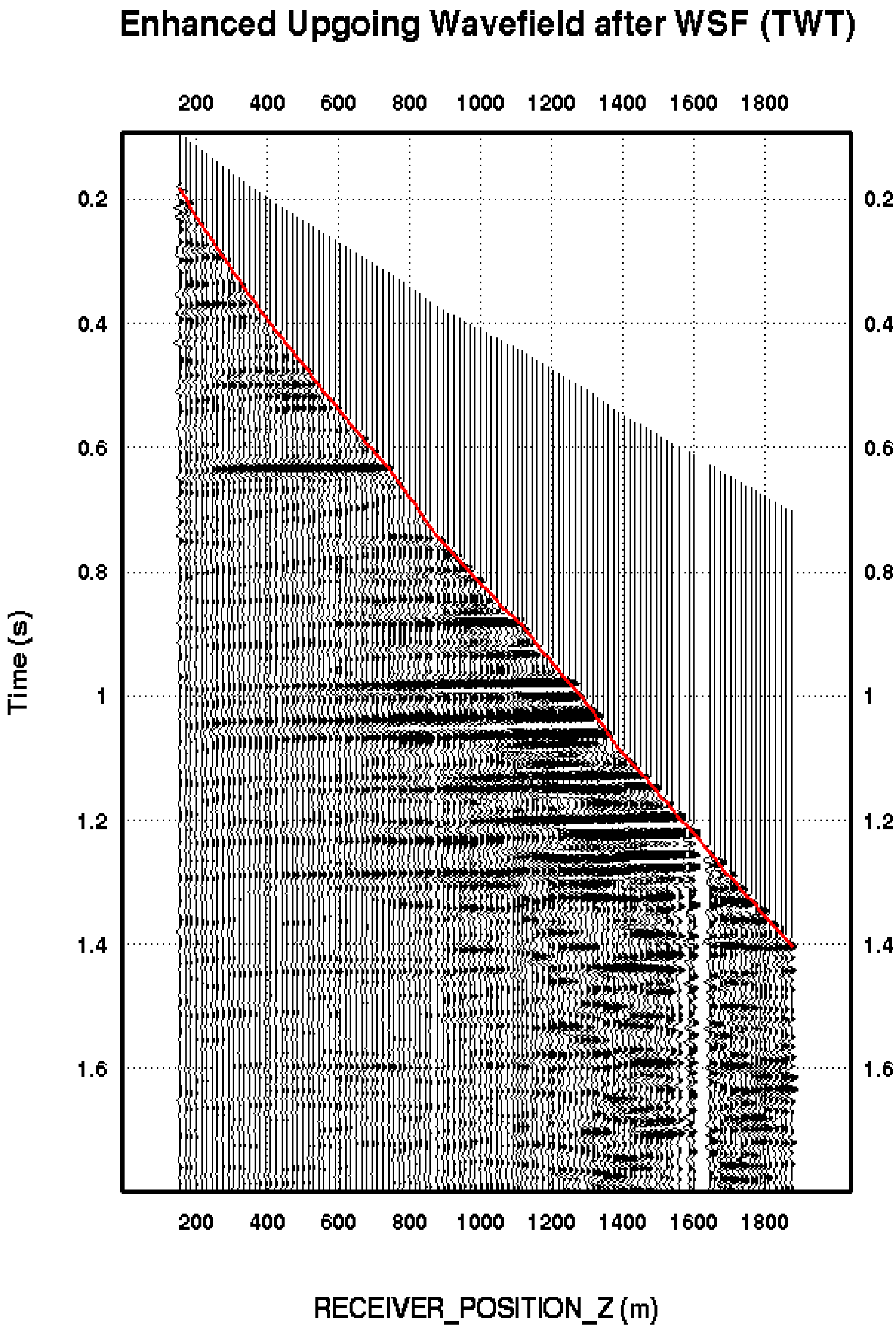

Figure9. Enhanced Upgoing Wavefield after WSF in TWT

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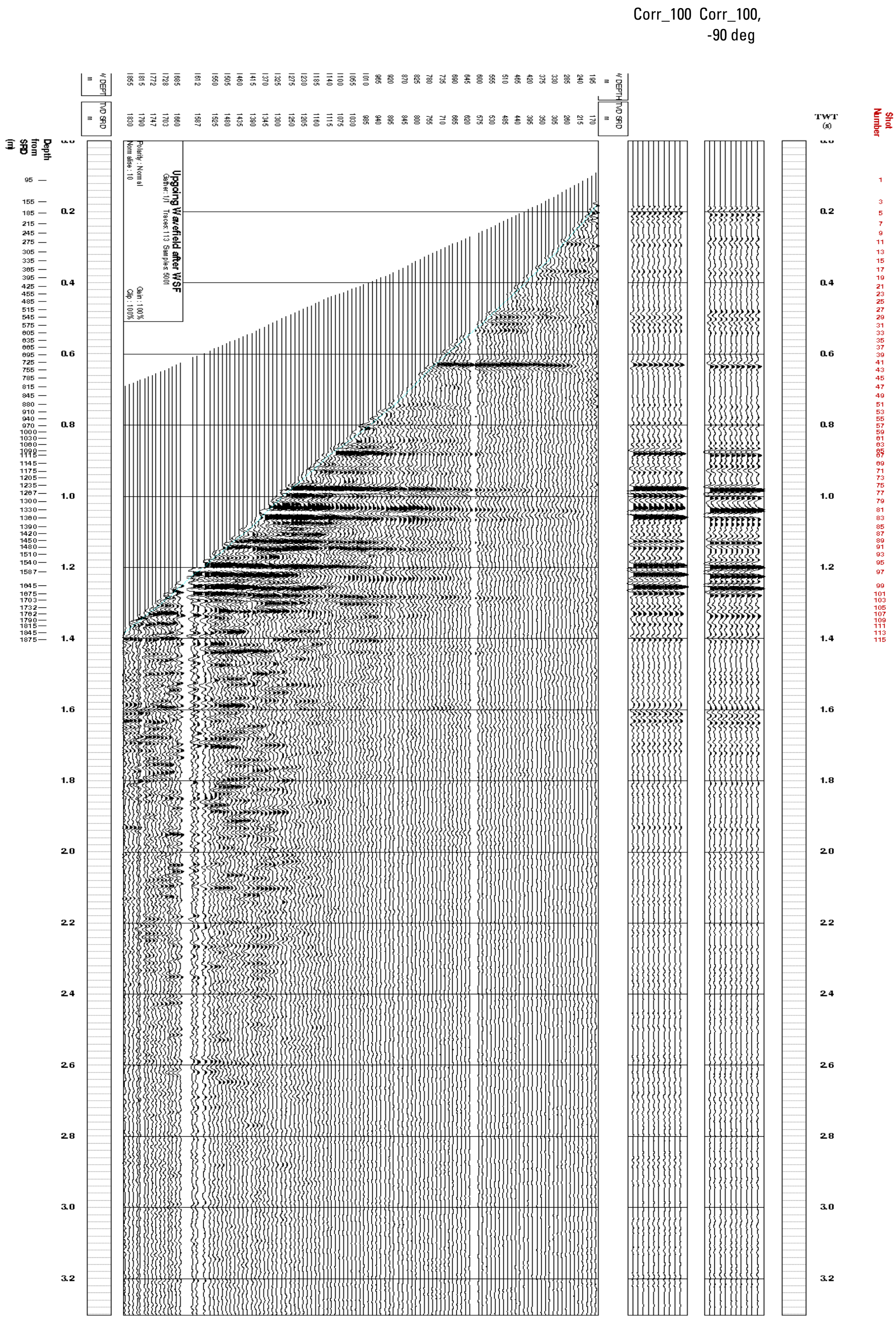

Figure 10. Composite Display

Finally, a velocity crossplot was created, using interval, average and RMS velocities, Figure 11.

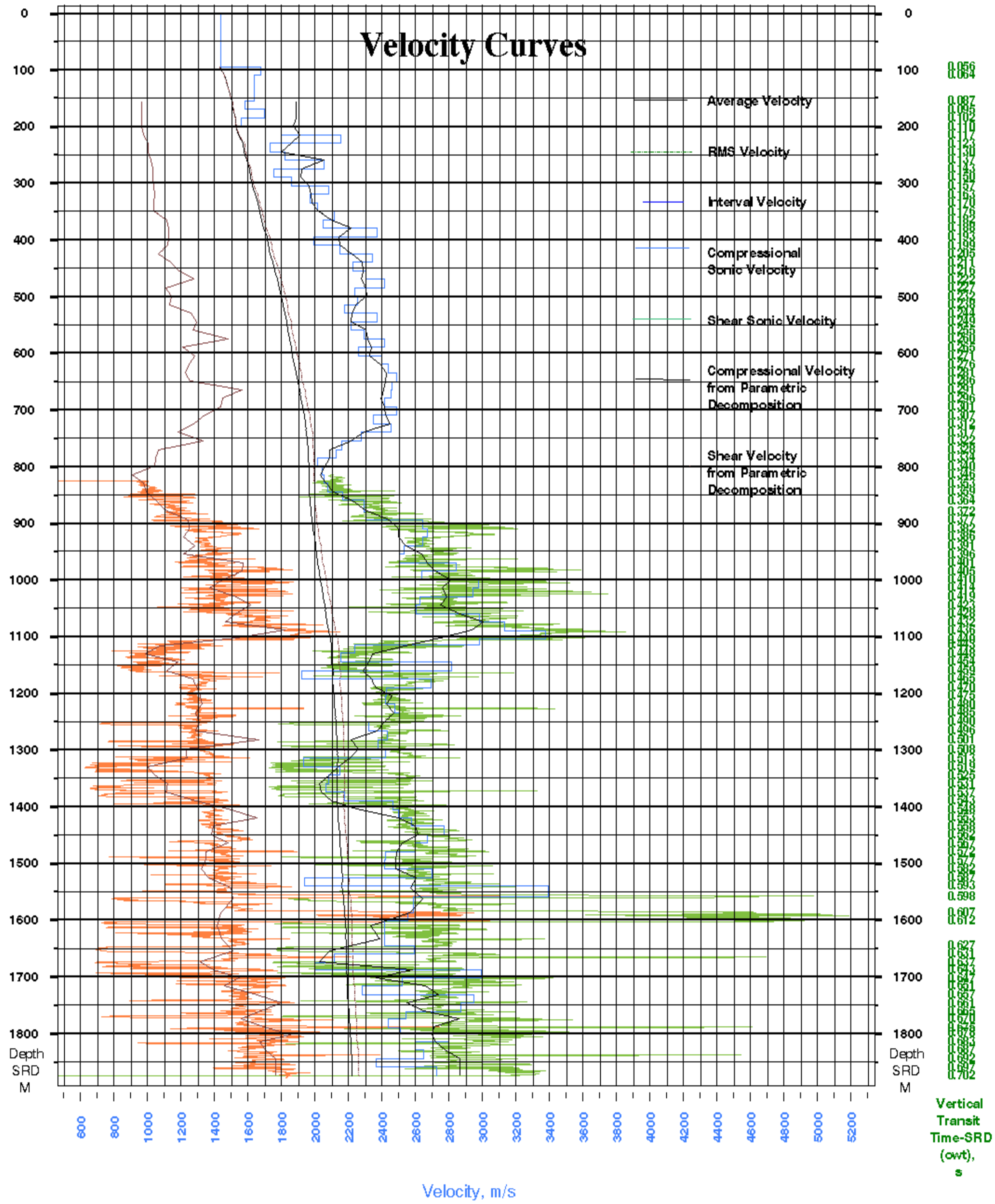

Figure 11. Velocity Crossplot

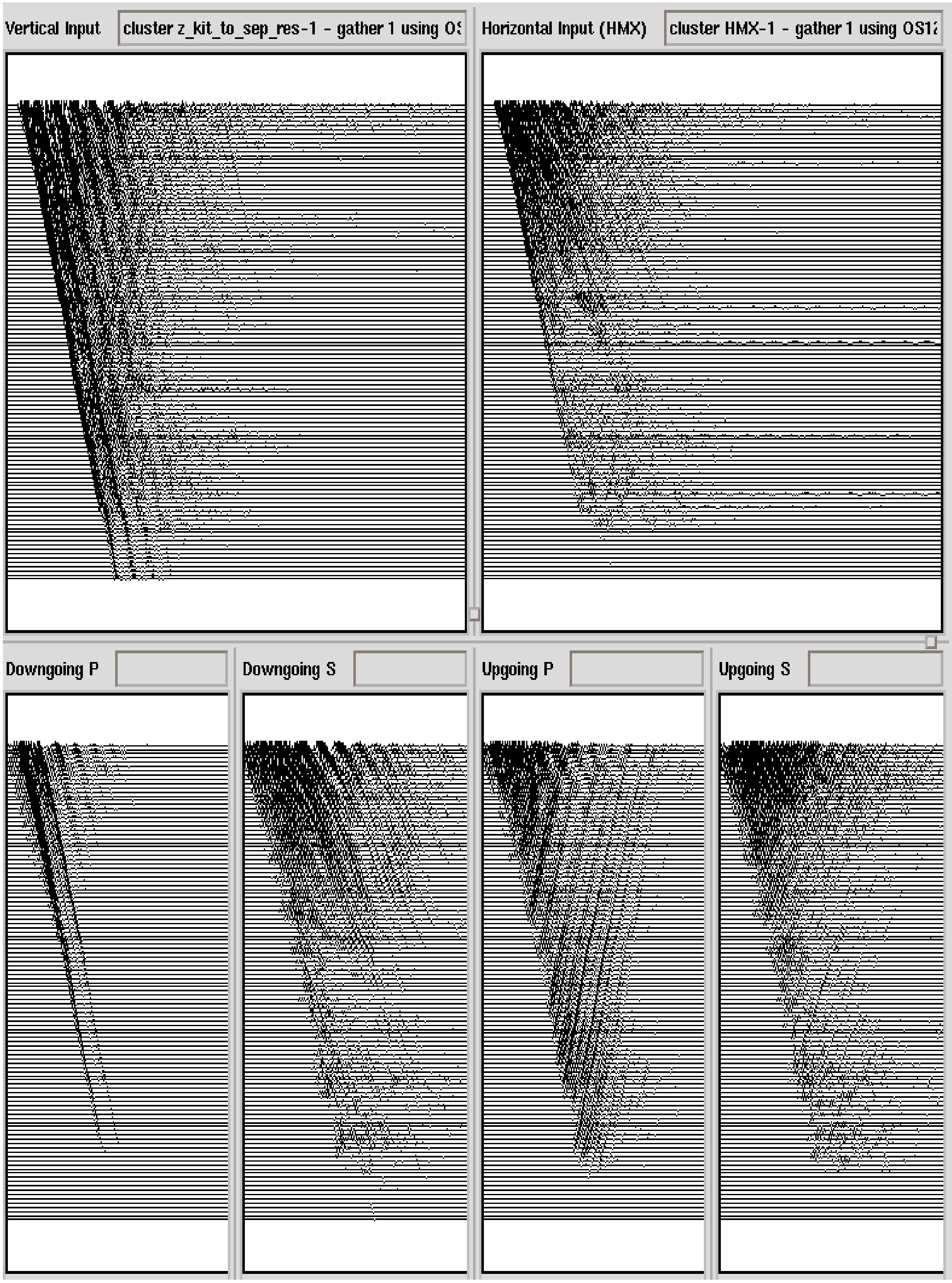

Figure 12. Parametric Wavefield Decomposition

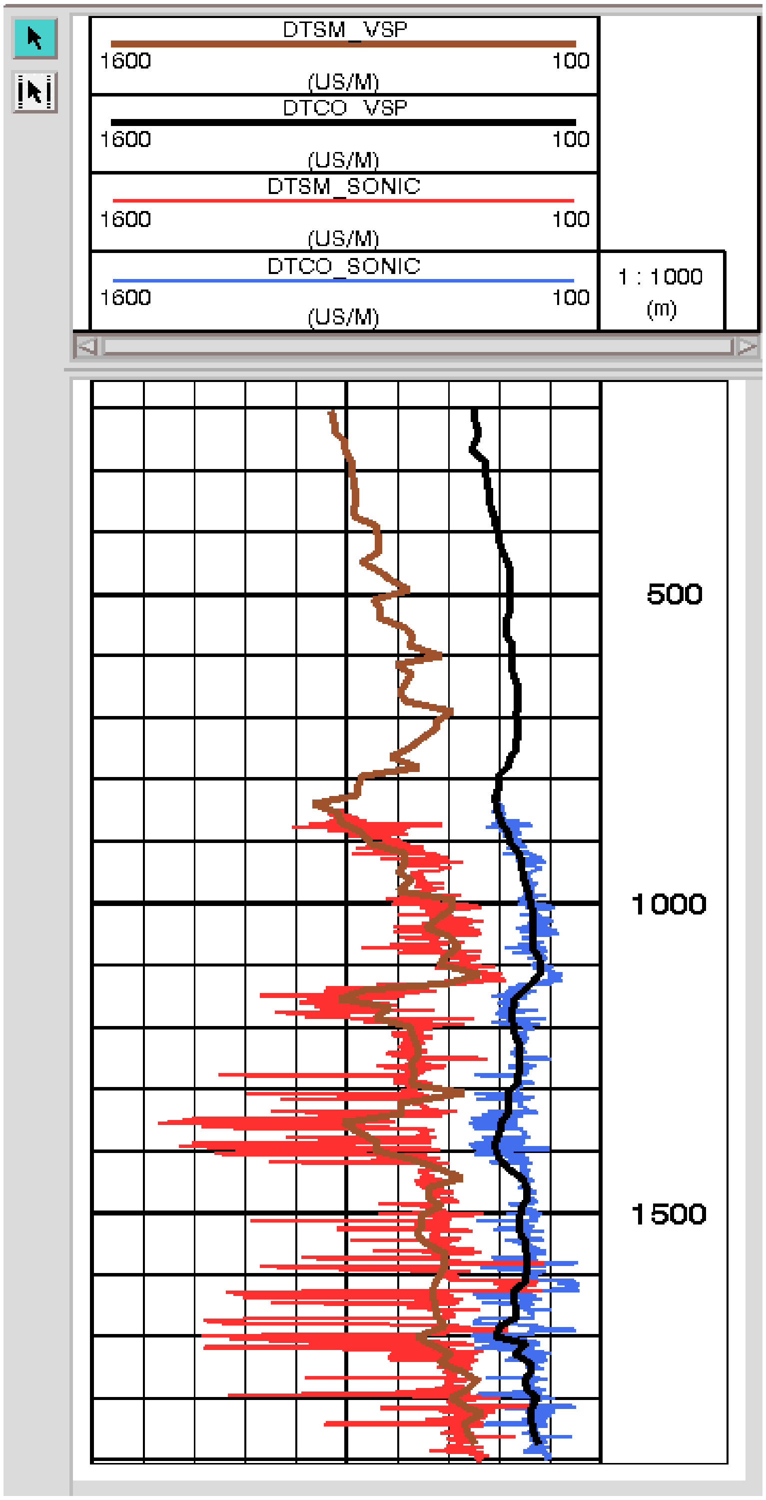

Figure 13. P and S Velocities from VSP vs. Sonic

Summary of Geophysical Listings

One geophysical data listing appended to this report. 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 metres from seismic reference datum.

3. Measured depth from KB: *dkb*, the depth in metres from kelly bushing.

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: ∆*depth*, the vertical distance between each level.

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

8. Interval velocity between shots: the average seismic velocity between each level, ∆*depth/*∆*time*

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

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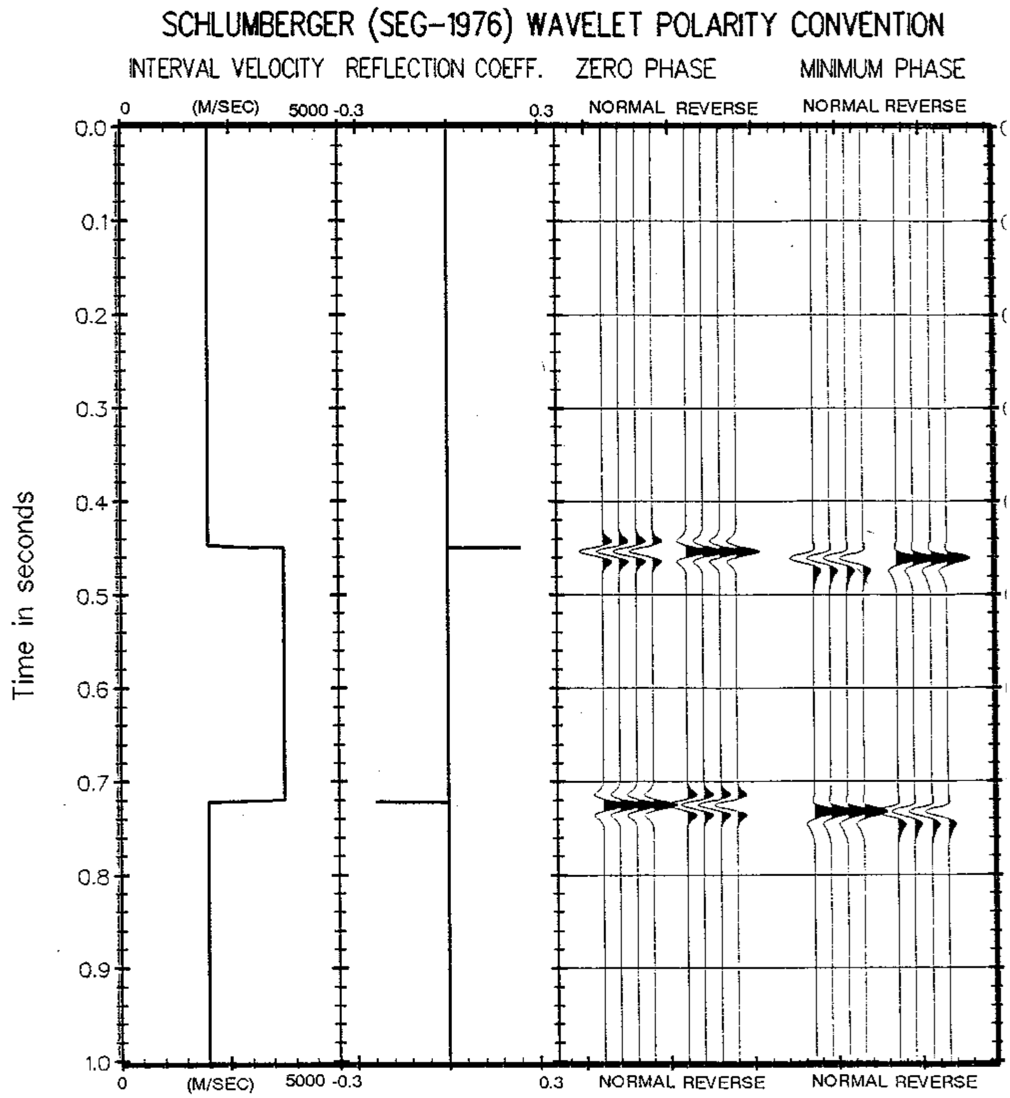

Figure 14. Schlumberger Wavelet Polarity Convention

Client and Well Information

Country	Australia
State	Victoria
Logging Date	5-Aug-2002
Company	Esso Australia Ltd.
Field	Offshore Exploration
Well	Beardie-1

Check Shot Data

LEVEL NUMBER	VERTICAL DEPTH FROM SRD m	MEASURED DEPTH FROM KB m	OBSERVED TRAVEL TIME (owt) s	Vertical Transit Time-SRD (owt) s	DELTA DEPTH m	DELTA TIME s	SEISMIC INTERVAL VELOCITY m/s	SEISMIC AVERAGE VELOCITY m/s
1	0.0			0.0000				
							1696	
2	94.9	119.9	0.0620	0.0559				1696
					15.1	0.0076	1992	
3	110.0	135.0	0.0681	0.0635				1732
					44.9	0.0231	1946	
4	154.9	179.9	0.0883	0.0866				1789
					15.1	0.0080	1877	
5	170.0	195.0	0.0958	0.0946				1796
					14.9	0.0074	2020	
6	184.9	209.9	0.1026	0.1020				1812
					15.1	0.0082	1850	
7	200.0	225.0	0.1104	0.1102				1815
					14.9	0.0070	2142	
8	214.9	239.9	0.1169	0.1171				1835
					15.1	0.0059	2580	
9	230.0	255.0	0.1224	0.1230				1870
					14.8	0.0072	2060	
10	244.8	269.8	0.1293	0.1302				1881
					15.1	0.0070	2167	
11	259.9	284.9	0.1360	0.1371				1895
					14.9	0.0061	2457	
12	274.8	299.8	0.1418	0.1432				1919
					15.1	0.0072	2090	
13	289.9	314.9	0.1488	0.1504				1927
					14.9	0.0067	2218	
14	304.8	329.8	0.1554	0.1571				1940
					15.2	0.0061	2493	
15	320.0	345.0	0.1613	0.1632				1960

					14.8	0.0063	2352	
16	334.8	359.8	0.1674	0.1695				1975
					15.2	0.0063	2409	
17	350.0	375.0	0.1736	0.1758				1990
					14.9	0.0059	2530	
18	364.9	389.9	0.1794	0.1817				2008
					15.1	0.0062	2447	
19	380.0	405.0	0.1854	0.1879				2022
					14.9	0.0052	2843	
20	394.9	419.9	0.1905	0.1931				2045
					15.1	0.0063	2380	
21	410.0	435.0	0.1968	0.1995				2055
					14.8	0.0058	2570	
22	424.8	449.8	0.2024	0.2052				2070
					15.2	0.0054	2813	
23	440.0	465.0	0.2078	0.2107				2089
					14.8	0.0055	2667	
24	454.8	479.8	0.2132	0.2162				2104
					15.1	0.0055	2766	
25	469.9	494.9	0.2186	0.2217				2120
					14.9	0.0051	2903	
26	484.8	509.8	0.2237	0.2268				2138
					15.2	0.0057	2681	
27	500.0	525.0	0.2293	0.2325				2151
					14.8	0.0055	2705	
28	514.8	539.8	0.2347	0.2379				2164
					15.2	0.0058	2610	
29	530.0	555.0	0.2405	0.2438				2174
					14.9	0.0052	2848	
30	544.9	569.9	0.2456	0.2490				2188
					15.1	0.0057	2655	
31	560.0	585.0	0.2513	0.2547				2199
					14.9	0.0054	2753	
32	574.9	599.9	0.2566	0.2601				2210
					15.1	0.0052	2901	
33	590.0	615.0	0.2618	0.2653				2224
					14.8	0.0055	2709	
34	604.8	629.8	0.2672	0.2708				2234
					15.1	0.0052	2883	
35	619.9	644.9	0.2724	0.2760				2246
					14.9	0.0051	2926	
36	634.8	659.8	0.2775	0.2811				2258
					15.2	0.0051	2989	
37	650.0	675.0	0.2825	0.2862				2271
					14.9	0.0050	2956	
38	664.9	689.9	0.2875	0.2912				2283
					15.1	0.0051	2947	
39	680.0	705.0	0.2926	0.2963				2295
					14.8	0.0051	2903	
40	694.8	719.8	0.2977	0.3014				2305
					15.2	0.0051	2990	
41	710.0	735.0	0.3027	0.3065				2316
					14.9	0.0053	2819	
42	724.9	749.9	0.3080	0.3118				2325
					15.1	0.0051	2949	
43	740.0	765.0	0.3131	0.3169				2335

					14.9	0.0055	2732	
44	754.9	779.9	0.3185	0.3224				2342
					15.1	0.0058	2587	
45	770.0	795.0	0.3243	0.3282				2346
					14.9	0.0059	2545	
46	784.9	809.9	0.3302	0.3341				2350
					15.1	0.0063	2411	
47	800.0	825.0	0.3364	0.3403				2351
					14.8	0.0061	2442	
48	814.8	839.8	0.3424	0.3464				2352
					15.2	0.0062	2454	
49	830.0	855.0	0.3486	0.3526				2354
					14.8	0.0060	2484	
50	844.8	869.8	0.3546	0.3585				2356
					15.2	0.0059	2592	
51	860.0	885.0	0.3604	0.3644				2360
					19.8	0.0072	2747	
52	879.8	904.8	0.3676	0.3716				2367
					15.2	0.0055	2768	
53	895.0	920.0	0.3731	0.3771				2373
					14.8	0.0047	3177	
54	909.8	934.8	0.3777	0.3818				2383
					15.1	0.0047	3212	
55	924.9	949.9	0.3824	0.3865				2393
					15.0	0.0047	3177	
56	939.9	964.9	0.3871	0.3912				2403
					15.1	0.0050	3047	
57	955.0	980.0	0.3920	0.3961				2411
					14.8	0.0049	3014	
58	969.8	994.8	0.3969	0.4011				2418
					15.2	0.0044	3424	
59	985.0	1010.0	0.4014	0.4055				2429
					14.8	0.0047	3176	
60	999.8	1024.8	0.4060	0.4102				2438
					15.2	0.0042	3590	
61	1015.0	1040.0	0.4102	0.4144				2449
					14.9	0.0042	3546	
62	1029.9	1054.9	0.4144	0.4186				2460
					15.1	0.0048	3161	
63	1045.0	1070.0	0.4192	0.4234				2468
					14.9	0.0048	3133	
64	1059.9	1084.9	0.4239	0.4281				2476
					15.1	0.0042	3596	
65	1075.0	1100.0	0.4281	0.4323				2487
					14.8	0.0039	3781	
66	1089.8	1114.8	0.4320	0.4362				2498
					15.1	0.0037	4086	
67	1104.9	1129.9	0.4357	0.4399				2512
					9.9	0.0028	3595	
68	1114.8	1139.8	0.4384	0.4427				2518
					15.1	0.0056	2684	
69	1129.9	1154.9	0.4440	0.4483				2520
					15.0	0.0058	2578	
70	1144.9	1169.9	0.4499	0.4541				2521
					15.1	0.0045	3393	
71	1160.0	1185.0	0.4543	0.4586				2530

					14.9	0.0065	2294	
72	1174.9	1199.9	0.4608	0.4651				2526
					15.1	0.0047	3240	
73	1190.0	1215.0	0.4654	0.4697				2533
					14.8	0.0051	2917	
74	1204.8	1229.8	0.4705	0.4748				2537
					15.2	0.0052	2904	
75	1220.0	1245.0	0.4757	0.4800				2541
					14.8	0.0050	2976	
76	1234.8	1259.8	0.4807	0.4850				2546
					15.2	0.0051	3007	
77	1250.0	1275.0	0.4857	0.4901				2551
					16.9	0.0061	2782	
78	1266.9	1291.9	0.4918	0.4961				2553
					15.1	0.0052	2926	
79	1282.0	1307.0	0.4970	0.5013				2557
					17.9	0.0063	2852	
80	1299.9	1324.9	0.5032	0.5076				2561
					15.1	0.0052	2911	
81	1315.0	1340.0	0.5084	0.5128				2564
					14.9	0.0065	2310	
82	1329.9	1354.9	0.5149	0.5192				2561
					15.1	0.0059	2569	
83	1345.0	1370.0	0.5207	0.5251				2561
					14.8	0.0059	2495	
84	1359.8	1384.8	0.5266	0.5310				2561
					15.1	0.0061	2470	
85	1374.9	1399.9	0.5328	0.5371				2560
					15.0	0.0058	2607	
86	1389.9	1414.9	0.5385	0.5429				2560
					15.1	0.0051	2960	
87	1405.0	1430.0	0.5436	0.5480				2564
					14.8	0.0049	3000	
88	1419.8	1444.8	0.5485	0.5529				2568
					15.2	0.0049	3098	
89	1435.0	1460.0	0.5534	0.5578				2572
					14.8	0.0044	3340	
90	1449.8	1474.8	0.5579	0.5623				2578
					15.2	0.0047	3217	
91	1465.0	1490.0	0.5626	0.5670				2584
					14.8	0.0047	3129	
92	1479.8	1504.8	0.5673	0.5717				2588
					15.2	0.0052	2908	
93	1495.0	1520.0	0.5725	0.5770				2591
					14.9	0.0051	2898	
94	1509.9	1534.9	0.5777	0.5821				2594
					15.1	0.0046	3249	
95	1525.0	1550.0	0.5823	0.5867				2599
					14.9	0.0064	2315	
96	1539.9	1564.9	0.5887	0.5932				2596
					19.9	0.0048	4104	
97	1559.8	1584.8	0.5936	0.5980				2608
					27.2	0.0087	3111	
98	1587.0	1612.0	0.6023	0.6068				2615
					14.8	0.0048	3073	
99	1601.8	1626.8	0.6071	0.6116				2619

					43.2	0.0149	2897	
100	1645.0	1670.0	0.6220	0.6265				2626
					14.9	0.0048	3122	
101	1659.9	1684.9	0.6268	0.6313				2629
					15.1	0.0060	2532	
102	1675.0	1700.0	0.6327	0.6372				2629
					12.8	0.0054	2385	
103	1687.8	1712.8	0.6381	0.6426				2626
					15.2	0.0042	3612	
104	1703.0	1728.0	0.6423	0.6468				2633
					13.8	0.0046	3028	
105	1716.8	1741.8	0.6469	0.6514				2636
					15.2	0.0056	2739	
106	1732.0	1757.0	0.6524	0.6569				2637
					14.8	0.0042	3558	
107	1746.8	1771.8	0.6566	0.6611				2642
					15.2	0.0044	3464	
108	1762.0	1787.0	0.6609	0.6655				2648
					12.8	0.0042	3054	
109	1774.8	1799.8	0.6651	0.6697				2650
					15.1	0.0052	2929	
110	1789.9	1814.9	0.6703	0.6748				2652
					9.9	0.0033	3018	
111	1799.8	1824.8	0.6736	0.6781				2654
					15.1	0.0045	3375	
112	1814.9	1839.9	0.6780	0.6826				2659
					14.9	0.0048	3123	
113	1829.8	1854.8	0.6828	0.6873				2662
					15.2	0.0048	3186	
114	1845.0	1870.0	0.6876	0.6921				2666
					14.8	0.0052	2842	
115	1859.8	1884.8	0.6928	0.6973				2667
					15.2	0.0046	3281	
116	1875.0	1900.0	0.6974	0.7020				2671

Listing of Deliverables

1. VSP/Geogram Processing Report in PDF format

2. Graphics in PDS format, 34" plots:

   Plot 1. Composite Display
   Plot 2. Velocity Crossplot

3. SEGY Deliverables

Corr_100_minus_90_deg_rot.sgy	Vertical_Component.sgy
Corr_100_minus_90_deg_rot.txt	Vertical_Component.txt
Corr_100_Zero_Phase.sgy	WSF_DOWN.sgy
Corr_100_Zero_Phase.txt	WSF_DOWN.txt
Downgoing_P.sgy	WSF_UP.sgy
Downgoing_P.txt	WSF_UP.txt
Downgoing_S.sgy	WSF_UP_before_enh.sgy
Downgoing_S.txt	WSF_UP_before_enh.txt
Horizontal_Component.sgy	X_Component_Stack.sgy
Horizontal_Component.txt	X_Component_Stack.txt
Surface_Hydrophone.sgy	X_Geophone.sgy
Surface_Hydrophone.txt	X_Geophone.txt
Upgoing_P.sgy	Y_Component_Stack.sgy
Upgoing_P.txt	Y_Component_Stack.txt
Upgoing_S.sgy	Y_Geophone.sgy
Upgoing_S.txt	Y_Geophone.txt
VELF_DOWN.sgy	Z_Component_Stack.sgy
VELF_DOWN.txt	Z_Component_Stack.txt
VELF_UP.sgy	Z_Geophone.sgy
VELF_UP.txt	Z_Geophone.txt

4. Listings and Logs

   Beardie_1_Checkshot_Report.xls – Checkshot Report in EXELL format.
   Beardie_1_VSP_vel_SRD.zip – P and S VSP velocities from Parametric Decomposition.

Attachment 1. Transit Time Picking Algorithms

The time picking can be broken down into several tasks:

First of all focus on the relevant parts of a data trace by selecting time intervals in form of constraints. To this end the user can select velocity, time header and/or initial guess constraints.

Detect a signal or a first break using a detection algorithm.

Tune on a particular phase of the event (e.g. zero-crossing, peak, trough, etc). It should be clear that tuning is only happening if a pick was either detected by an algorithm or retrieved from a header as initial guess.

Despike the picked transit time curve in order to eliminate mispicks either by median filtering or by cross-correlation. The cross-correlation option does not only have filtering features but also allows to pick correlated events within a section after having picked only one event.

Detection algorithm

Energy break: the algorithm determines the maximum of the so-called energy function, which is the integrated signal energy within a sliding time window normalized by the total energy accumulated since the first time of data.

For a trace S(t) an energy function F(•) is calculated with algorithm proposed by (Coppens, 1985)

Geophone break: finds the first break of a downhole sensor. The algorithm compares amplitudes and slopes in consecutive arches. Input parameters are the center frequency of the data to be picked, a linear fit gate time which should be about half a wavelet period, and a detection threshold between 0.0
and 0.5.

Hydrophone break: provides the first break of a downhole sensor. The routine finds the global minimum and maximum amplitude along a trace, takes the smaller one of the corresponding sample indices and outputs the time of the preceding zero-crossing as the first break. The zero-crossing time is determined by linear regression over a selected length (linear fit gate time).

Tuning:

Peak: finds the time of the closest local maximum amplitude in the vicinity of an input break time.

Trough: finds the time of closest local minimum amplitude in the vicinity of an input break time.

Zero-crossing: finds the time of the closest zero-crossing in the vicinity of an input break time. The routine stores the sign of the derivative at the zero-crossing which can be passed on for the tuning of the following trace. Thus artifacts created by cycle skipping can be reduced.

Inflection: finds the time of the closest inflection point in the vicinity of an input break time. The routine stores the sign of the derivative at the inflection point which can be passed on for the tuning of the following trace. Thus artifacts created by cycle skipping can be reduced.

Inflection point tangent: finds the time of the closest inflection point in the vicinity of an input break time. The tuned break time is the zero-crossing time of the corresponding tangent at this inflection point. The routine stores the sign of the derivative at the inflection point which can be passed on for the tuning of the following trace. Thus artifacts created by cycle skipping can be reduced.

Cross-correlation

This option allows to tune transit times by considering the picked phase of a selected reference trace. The cross-correlation gate in time or length units can be specified in the Motif parameter panel of this option. The default

value for the gate is three times the estimated center frequency of the first five traces of the seismic section to be picked. The window is put symmetrically around the transit times of the two traces to be cross-correlated if the option Use Existing Picks for the Gate Center Time is enabled and the
transit times are not absent.

If the option Use Existing Picks for the Gate Center Time is disabled then the cross-correlation is started with the ambient traces around the reference trace. Those two traces, in turn, will be taken to set the time gates for the following ones, and so on. Thus an automatic picking can be provided after having picked only the reference trace.

Retuning can be selected to follow the cross-correlation. In this case the cross-correlation serves as a transit time curve despiker.

The cross correlation process can be stopped automatically if the picking quality degrades. This happens if the time difference between the break of the current and the previous trace exceeds a threshold value derived from a user-specified apparent velocity.

A polynomial amplitude interpolation is proposed in order provide “real” extreme values instead of extreme values at the nearest sample. The algorithm works as follows: the global extreme values are detected with the gate together with the corresponding sample indices. A minimum and maximum amplitude tuning provides an exact time estimate of these amplitudes. Polynomial interpolation determines the amplitudes at these times which generally fall in between samples.

There are a variety of selectable and non-exclusive constraints available in order to stabilize the time picking process . The objective is to extract only the relevant part of the trace for the detection, tuning and/or cross-correlation process using.

Reference:

Coppens, F., 1985, First arrival picking on common offset trace collections for automatic estimation of static corrections, Geophys. Prosp. 33, 1212-1231.

Lee, D. and Morf, M., 1980, A novel innovations based time –domain pitch detection.

Example:¶

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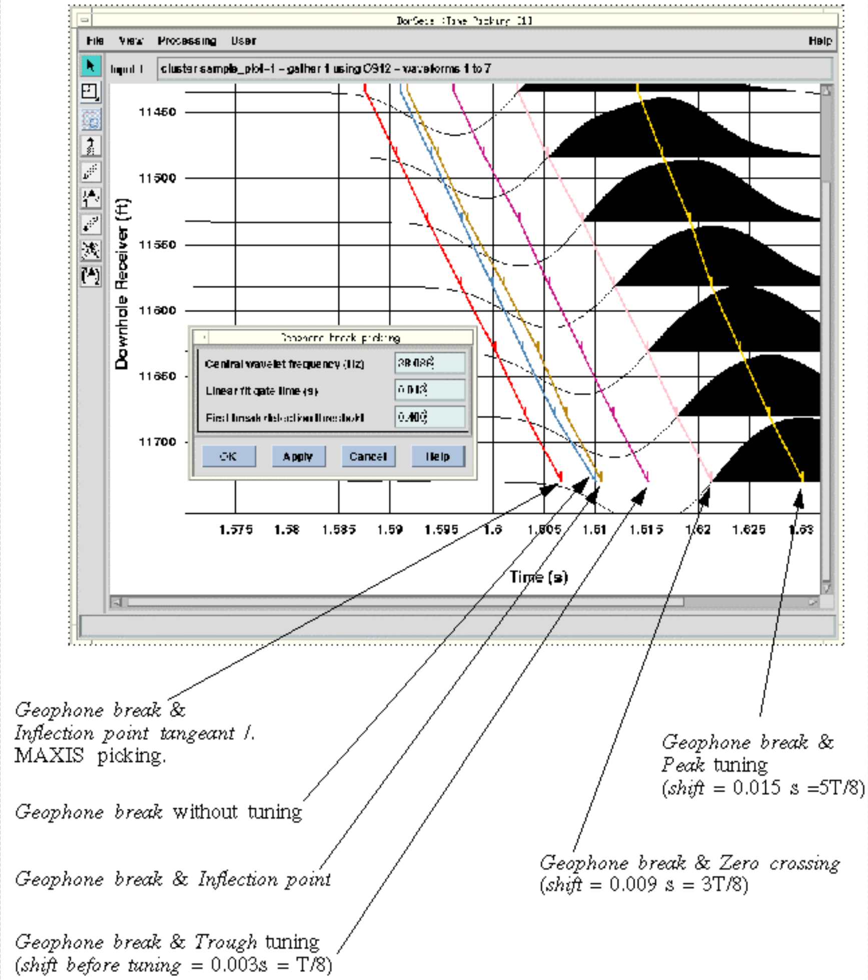

Note: the period of the signal (T) is computed from the central frequency.
the default linear fit gate time =T/2.

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