U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Report of Reprocessing of Reflection Seismic Profile X-5 Waste Isolation Pilot Plant Site, Eddy County, New Mexico

By

John J. Miller[1]

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[1]U.S. Geological Survey, Box 25046, Denver Federal Center, Denver, Colorado 80225

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ABSTRACT

Seismic reflection profile X-5 exhibits a 7,700 ft long anomalous zone of poor quality to nonexistent reflections between shotpoints 100 and 170, compared to the high-quality, flat-lying, coherent reflections on either side. Results from drill holes in the area suggest "layer cake" geology with no detectable abnormalities such as faults present.

In an attempt to determine whether the anomalous zone of the seismic profile is an artifact or actually indicates a geologic condition, the data were extensively reprocessed using state-of-the-art processing techniques and the following conclusions were made:

1. The field-recorded data in the anomalous zone are of poor quality due to surface conditions and recording parameters used.
2. Reprocessing shows reflectors throughout the anomalous zone at all levels. However, it cannot prove that the reflectors are continuous throughout the anomalous zone.
3. Significant improvement in data quality may be achieved if the line is reshot using carefully determined recording parameters.

INTRODUCTION

In October 1977, at the Waste Isolation Pilot Plant (WIPP) site, Eddy County, New Mexico, line X-5 was recorded and processed by Dresser Olympic, Inc. (Hern and Powers, 1978).

The 1977 X-line Vibroseis® lines (X-5 being one of these) were designed to cover areas of the WIPP site, New Mexico, where anomalies were noted on the 1976 SAN line series. The anomalies could be interpreted as faults in the shallow (<2,000 ft) rocks at the WIPP site. The purpose of the study was to delineate the subsurface geology for use as a repository for nuclear waste isolation. The rocks consist of Permian evaporites (Salado and Rustler Formations) and overlying younger sediments (Permian Dewey Lake Red Beds and Triassic Santa Rosa Sandstone). The surface is covered by sand, sand dunes, and caliche totaling 5-20 ft thick. Further information on the geology and geophysical studies of the WIPP site and background may be obtained in Powers and others (1978). Hern and Elliot (1978) presented a paper on geophysical investigations of the WIPP site. Interpretation of the profile X-5 (fig. 1) showed an anomalous zone in reflector continuity between shotpoints 100 and 170. However, the geology of the area, as known from drill holes and surface studies, does not show an anomalous situation other than small variations in bed thickness. There is no evidence of faulting. Therefore, the seismic profile should appear "layer cake" in style. To either side of the anomalous zone, good-quality, flat-lying, continuous reflections appear as expected. The surface between shotpoints 100 and 170 consists of uncompacted sand of varying thickness which can give rise to static errors. In the Dresser Olympic processing flow, residual static corrections were not applied. It was hoped that they might be the key to the solution in this anomalous zone and so the profile was reprocessed between shotpoints 60 and 200 using state-of-the-art processing techniques on the USGS Phoenix I Seismic Data Processing System with the hope of answering the following questions:

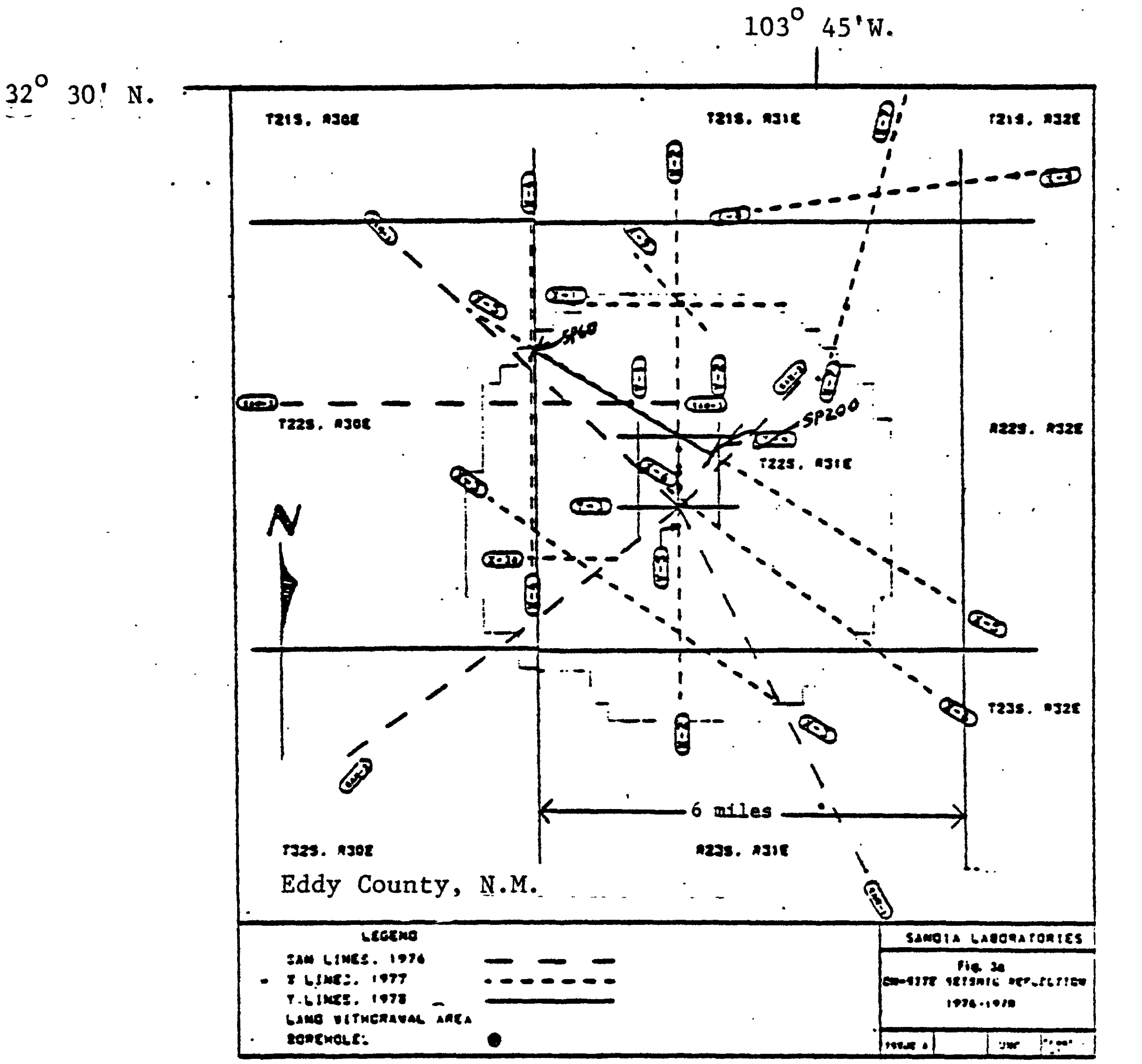

Figure 1: WIPP Site study area showing seismic track lines including portion of line X-5 reprocessed (after Hern and Powers, 1978)

├──────────┤ -Portion of line X-5 reprocessed.

1. Does the anomalous portion of the seismic line indicate a geologic anomaly, and if so, what is causing it?
2. If the anomaly is not geologically real, can reprocessing improve the data enough to show that reflectors are continuous between shotpoints 100 and 170?
3. If one or both of the above questions cannot be answered satisfactorily, can suggestions be made for additional techniques which might be performed in order to solve the problem?

FIELD RECORDING PARAMETERS

The following parameters obtained from the side label attached to Dresser Olympic's final stacked section were used to record line X-5:

Instrument type:	CFS I - DFS IV
Filter:	18-36/124 Hz
Notch filter:	In
Source type:	Vibroseis
Sweep length:	12 s
Sweep frequency:	25-100 Hz
Sample interval:	2 ms
Record length:	16 s
Group interval:	110 ft
Source interval:	110 ft
Number of groups:	24
Geophones per group:	6
Geophone type:	GSC-200
Geophone array:	Inline
Maximum fold:	12
Spread type:	Split straddle, 880 ft gap across source

REPROCESSING THE SEISMIC DATA

The first step in reprocessing the data was to attempt to duplicate the cross section processed by Dresser Olympic. The parameters used were as similar to theirs as possible and the resulting cross section (fig. 2) appears nearly identical to the Dresser result. A comparison of the processing flow and parameters used by Dresser Olympic and the USGS is shown in table 1.

The second step was an attempt to improve upon the original processing by including residual statics application. A residual statics solution program was run on the data shown in figure 2. This processing step was performed between steps 8 and 9 in table 1. Because the geology in the area is believed to be "layer cake" in style, it was hoped that the continuous reflectors on the right and left side of the section would appear to be continuous across the entire section. Some improvement in reflector quality can be seen on figure 3 especially in the shallow section. However, overall data quality must still be considered poor.

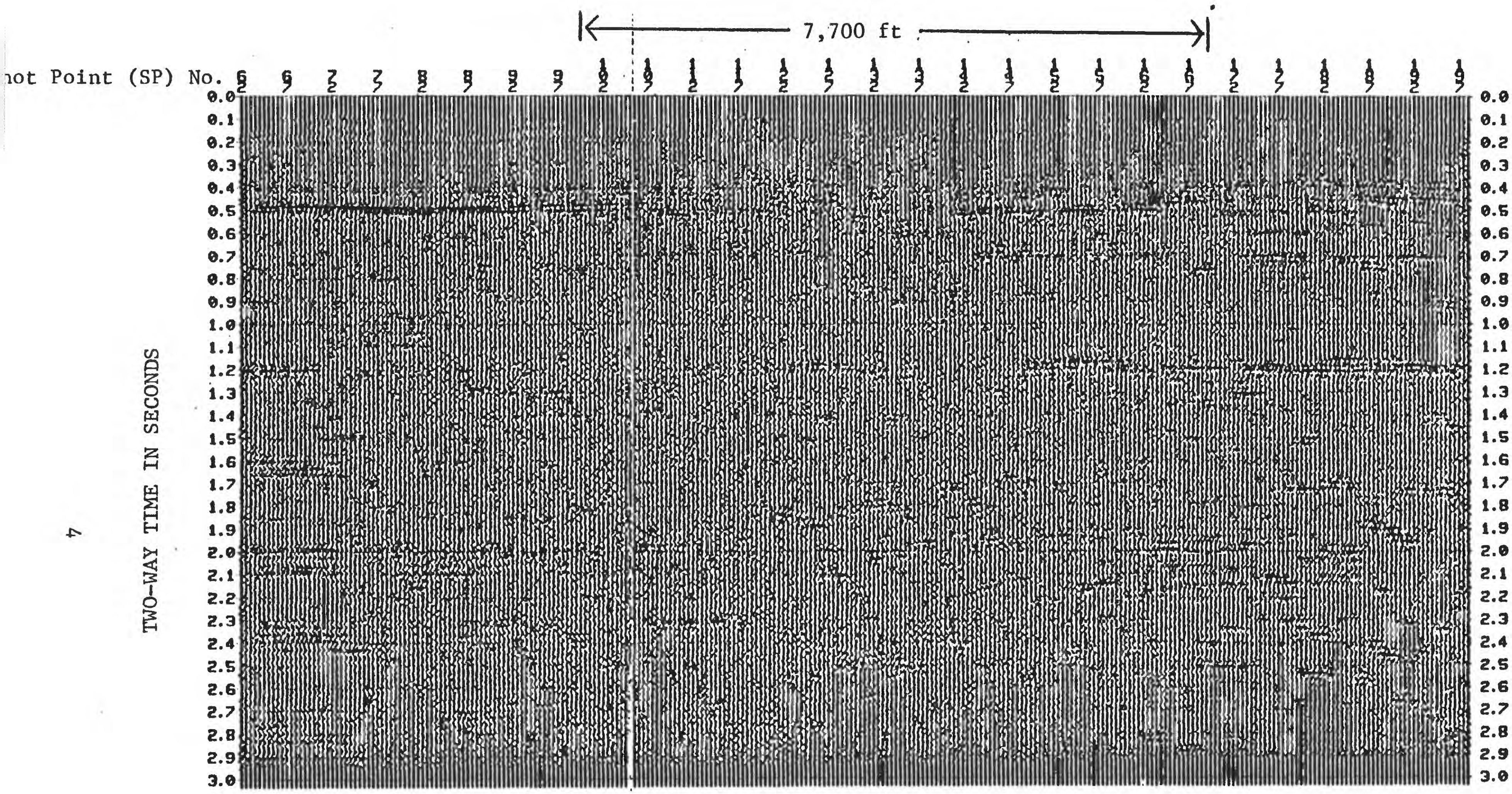

Figure 2. Line X-5 processed by USGS using parameters as similar to those used by Dresser Olympic as possible.

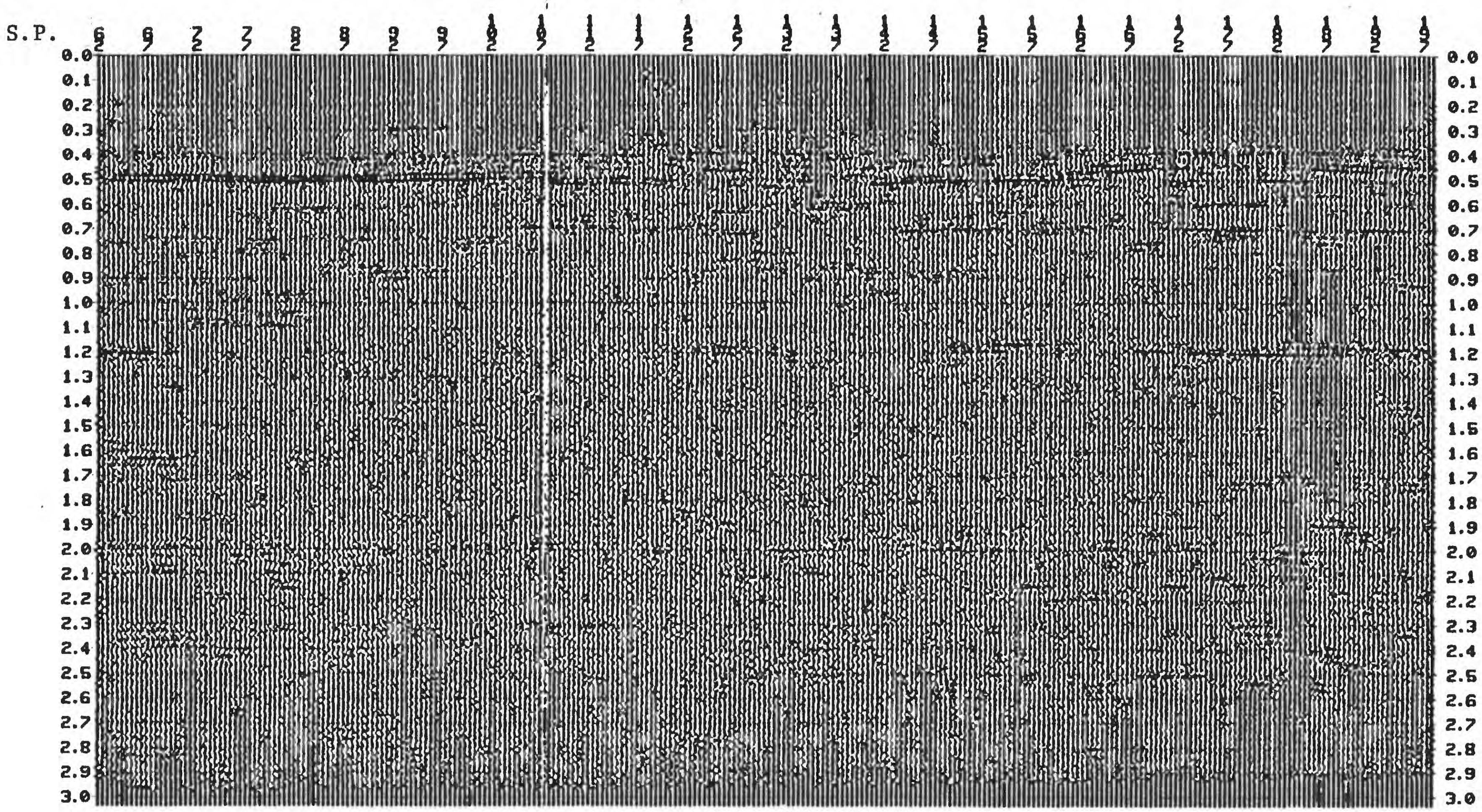

Figure 3. Line from figure 2 after application of residual statics.

Table 1.--Processing flow and parameters used by Dresser Olympic vs. those used by the USGS

DRESSER OLYMPIC	USGS
1. Demultiplex	Vibroseis correlated tape received as input.
2. Binary gain recovery	1. CDP gathers
3. Vibroseis correlation	2. Datum statics +3,200 ft, Vc=6,000 ft/s.
4. CDP gathers	3. T**2 gain recovery
5. Deconvolution filter 140 ms, predictive distance (P.D.) = 2nd zero crossing, design window unknown.	4. Deconvolution filter 140 ms, P.D.=2nd zero crossing, design window .18-2.5 s.
6. Band-pass filter 25/80 Hz.	5. Band-pass filter 15-25/70-90 Hz.
7. Datum statics +3,200 ft, Vc=6,000 ft/s.	6. Velocity analysis
8. Velocity analysis	7. Normal moveout
9. Normal moveout corrections	8. Mute
10. Mute (First break suppression)	9. CDP stack
11. CDP stack	10. AGC 500 ms sliding window.
12. Band-pass filter 25/80 Hz.	
13. AGC window length unknown.	

The original premise that residual statics application might solve the bad data zone was now proven to be in error. Therefore, an analysis of the raw data was made. Figure 4 shows a sampling of some of the records across the line. It can be seen that signal-to-noise (S/N) ratio is poor. Also, those reflectors which are continuous and of high amplitude on the right and left side of the cross section (SP's 62 and 180, for example) are weak or entirely absent in the center (e.g., SP 114).

It was decided that S/N ratio must be improved in order to have any chance of solving the problem. A frequency analysis showed that the noise on the records is essentially of the same frequency band as the data, so band-pass filtering was eliminated as a method to improve S/N ratio.

A second attempt to improve S/N ratio was to perform a three-shot running sum [e.g., the corresponding traces from SP(N) = those from SP(N-1) + SP(N) + SP(N+1)]. This is a fairly common technique (sometimes called "mixing") used especially in areas where reflectors are known to be relatively flat lying with little structure and S/N ratio is poor. Figure 5 shows examples of these summed records corresponding to figure 4. The S/N ratio is clearly improved, especially in areas where the reflectors are weak but still present.

Next, it was noted that the data exhibit a very reverberative character especially in the deeper reflectors. Predictive and spiking deconvolution were performed to try to remove these reverberations but they were not successful. This is due in part to the excessively narrow band width of the data. Analysis of the data in figure 5 showed that the period of the reverberations was about 28 hertz. Figure 6 shows amplitude spectra for some of the traces in figure 5. To remove these reverberations, a bandstop filter was applied to the data. The frequency pass band of this filter is shown in figure 7.

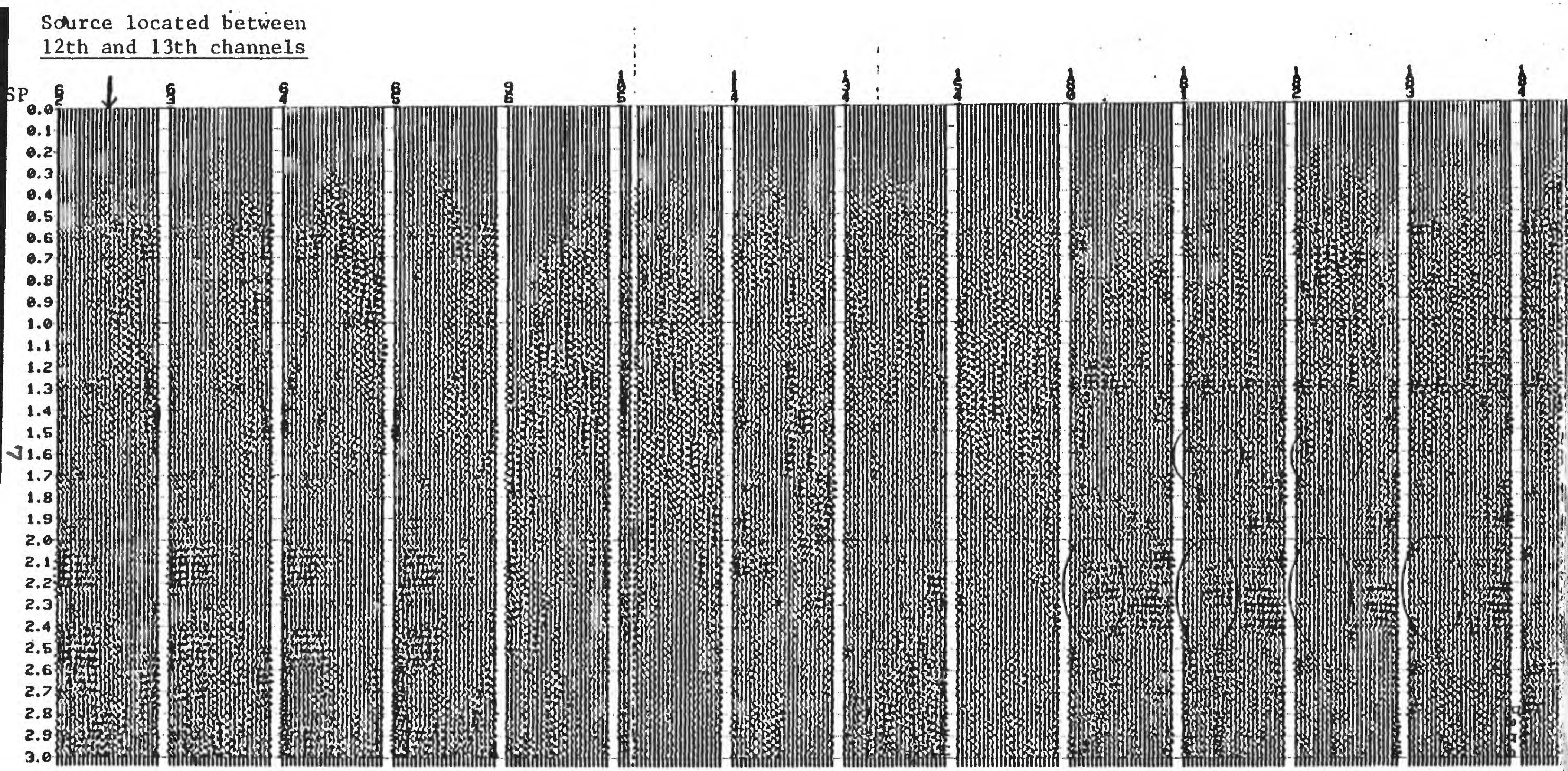

Figure 4. A sampling of raw field recorded records. Circles indicate areas of varying reflection strength on adjacent shots.

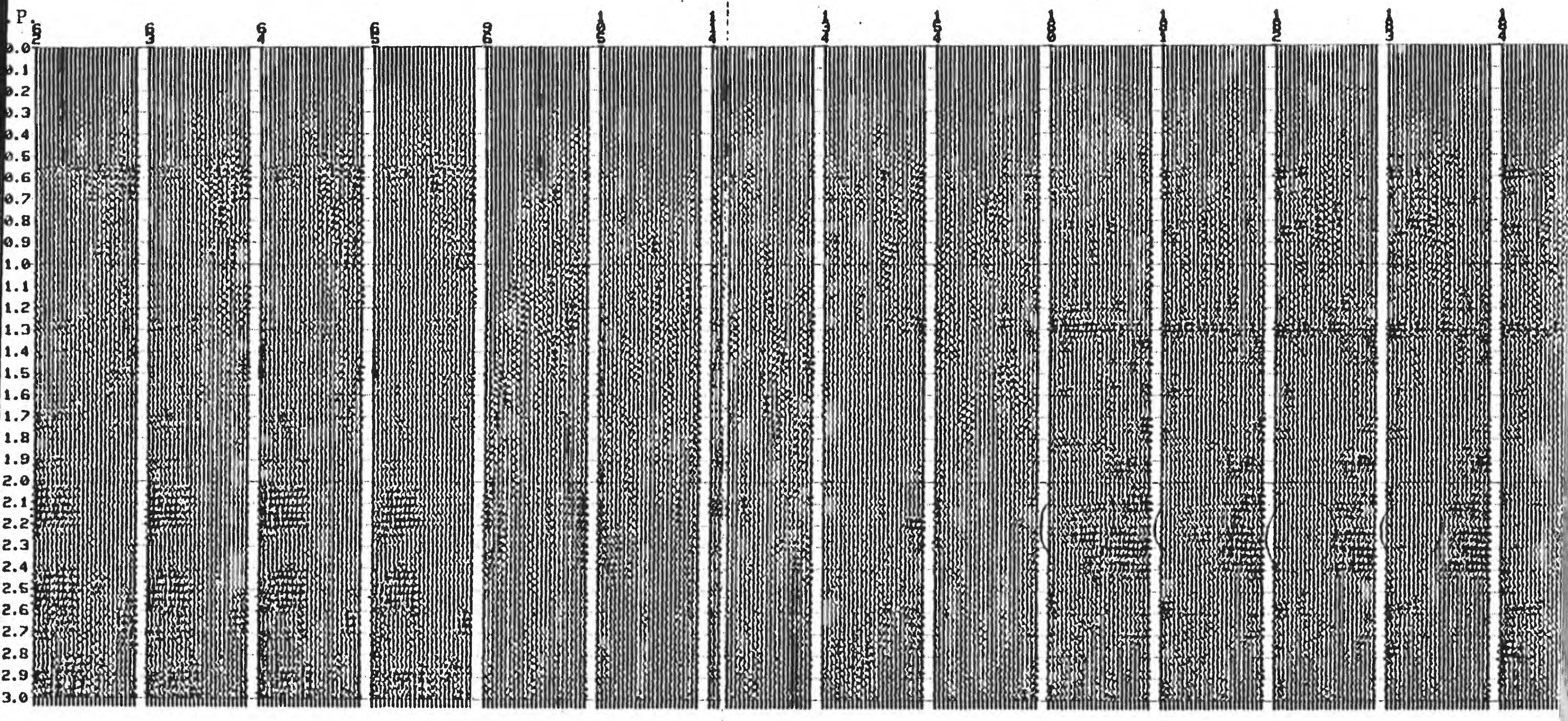

Figure 5. Records from figure 4 after 3-shot sum process.

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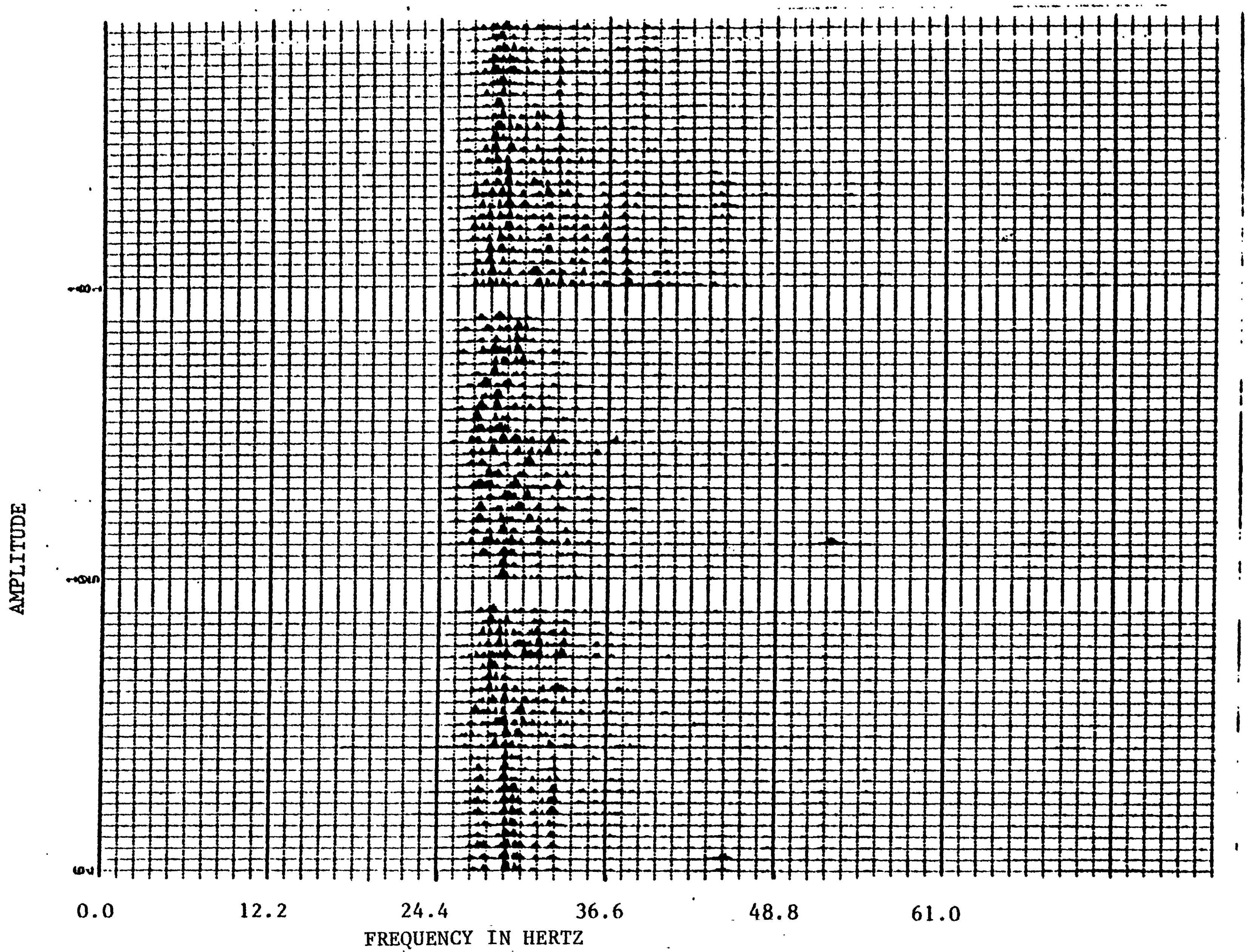

Figure 6. Amplitude spectra for some traces from figure 5.

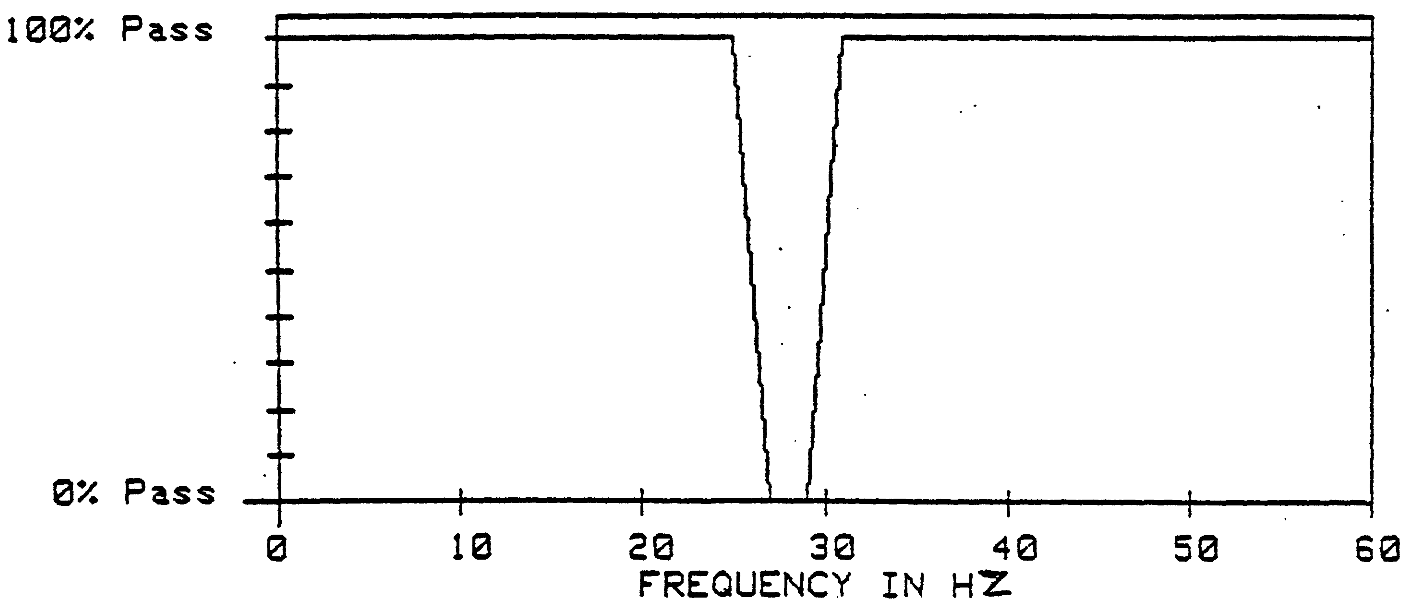

Figure 7. Bandstop filter pass band applied to data.

Stacked cross sections were created from the 3-shot, summed, bandstop filtered data. Figure 8 is a cross section which has had no residual statics applied. Figure 9 shows the result of residual statics corrections applied to figure 8 before stacking. Table 2 shows the processing flow for these cross sections.

Although figure 9 exhibits a mixed appearance due to the three-shot sum process, reflectors can be seen to be somewhat more continuous across the section. Nevertheless the section does not satisfactorily answer the question as to whether the subsurface geology is continuous. It is believed that further processing will not further improve the data.

Table 2. Processing flow and parameters for data shown in figures 8 and 9

1. T**2 gain recovery
2. Base-level scale
3. 3-shot running sum
4. CDP gathers
5. Datum statics +3,200 ft, Vc = 6,000 ft/s
6. Bandstop filter 0-25/27-28/30-OUT
7. Velocity analysis
8. NMO application
9. Mute
10. Residual statics (for data in figure 9 only)
11. CDP stack
12. AGC 500 ms sliding window

CONCLUSIONS

From all previous studies, there is no evidence that the geology in this area is anything other than "layer cake" in style. Also, reflectors are seen at all levels throughout the anomalous zone but are quite inconsistent from shot to shot. Thus, I conclude that the apparent disruption in the continuity of layers is an artifact of the data and not due to subsurface geologic phenomenon.

It is believed that the failure of reprocessing to resolve the reflectors is due to inadequate field acquisition procedures. The reasons are as follows:

1. The surface conditions between shotpoints 100 and 170 are loosely compacted sand of varying thickness. This type of condition will always result in problems with ground coupling of sources and receivers. Also, high-frequency energy is attenuated much faster in this type of condition than in solid rock or highly compacted soil.
2. Reflectors are inconsistent from shot to shot. Throughout the anomalous zone, strong reflectors present on some shots may be absent on the adjacent shots recorded only 110 ft away. For example, note the circled areas on figure 5, SP's 180 through 183. This erratic apppearance and disappearance cannot be accepted at face value.
3. The vibrator sweep used as an energy source was composed of frequencies varying from 25 to 100 Hz over a period of 12 seconds. Most of the high frequency energy was attenuated by the near surface and thus never recorded. This is supported by the observation that the shallow reflector at about 500 ms is resolved quite well as compared to deeper reflectors showing that high frequencies are being

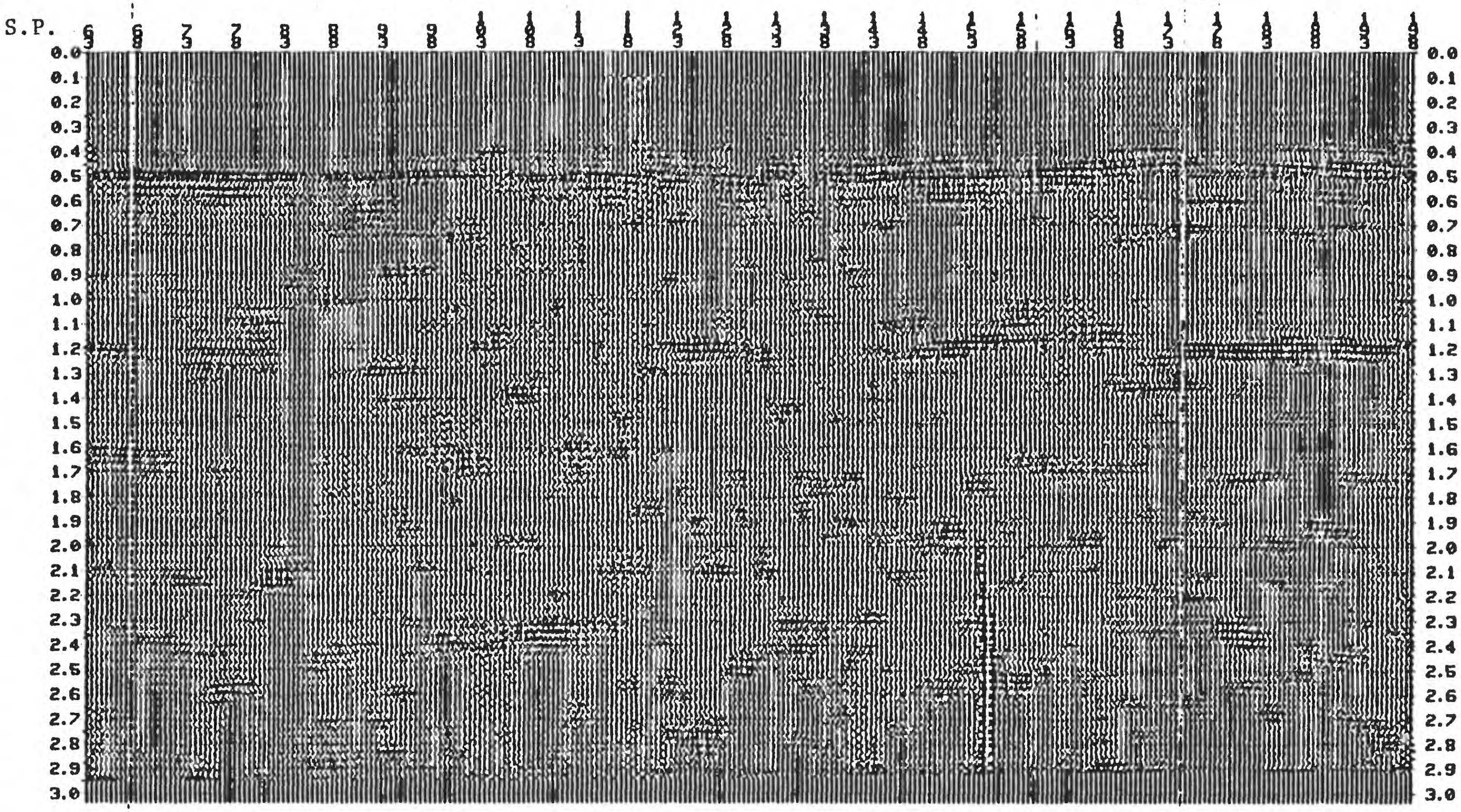

Figure 8. Cross section created from 3-shot summed, bandstop filtered data with no residual statics.

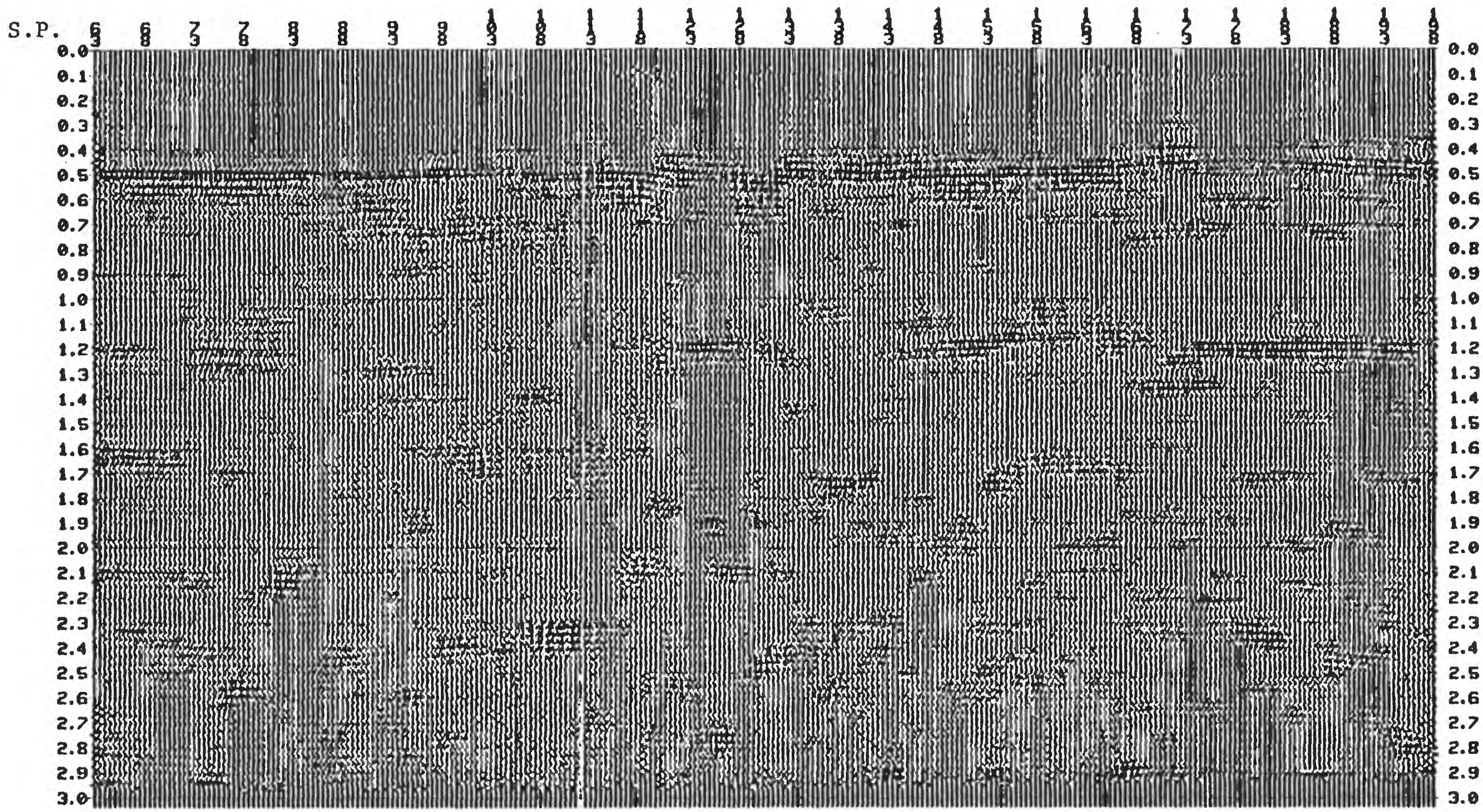

Figure 9. Cross section as in figure 8 with residual statics applied.

attenuated with depth. Therefore, when using the sweep signal in cross-correlation to recover the wavelet, the correlation either failed completely as in the case of missing reflectors, or the low frequencies correlated in a reverberatory manner since they occupy only a small amount of time within the total sweep length.

SUGGESTIONS FOR FURTHER WORK

The line should be reshot in the vicinity of the anomalous zone. Careful attention should be given to selection of recording parameters. A lower frequency sweep is suggested with the frequencies varying over as long a time as possible. For example, an 8 to 48 Hz sweep over a 14 second period might be appropriate. Extensive tests should be performed using a variety of recording parameters (such as sweep frequencies, group intervals, geophone spread lengths) until successful ones are found before the entire line is reshot.

REFERENCES

Hern, J. L., and Elliot, C. L., 1978, Geophysical Investigations for a Nuclear Waste Isolation Pilot Plant in Southeastern New Mexico: Abstract, Society of Exploration Geophysicists, 48th Annual International Meeting.

Hern, J. L., and Powers, L. J. B., 1978, Seismic reflection data report Waste Isolation Pilot Plant (WIPP) Site, southeastern New Mexico: Sandia Laboratories, SAND79-0264, Unlimited Release, v. 1, 27 p.

Powers, D. W., Lambert, S. J., Shaffer, S-E., Hill, L. R., and Weart, W. D., editors, 1978, Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, southeastern New Mexico: Sandia Laboratories, SAND78-1596, 2 volumes.