ANALYSIS OF ZERO PHASE DECONVOLUTION

BY

Muhammad Asif
(M.Sc Geophysics)

DEPARTMENT OF EARTH SCIENCES
QUAID-I-AZAM UNIVERSITY
ISLAMABAD
JANUARY 2000

IN THE NAME OF ALLAH,
THE MOST BENEFICENT,
THE MOST MERCIFUL.

QAUID – I – AZAM UNIVERSITY
DEPARTMENT OF EARTH SCIENCES
ISLAMABAD

Date ------------------

CERTIFICATE

This thesis is submitted by Mr. Muhammad Asif to the department of Earth Sciences as a partial fulfillment of the requirement for the award of degree of M.S.c in Geophysics.

Recommended by

EXTERNAL
EXAMINAR...

Dr. MUBARIK ALI...
(Supervisor & Chairman)
Department of Earth Sciences.

DEDICATED TO
MY GRAND FATHER

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References

ACNOWLEDGEMENT

All praises for ALLAH, Who guides us in darkness and helps us in difficulties and all my respect for His Holy Prophet (PBUH).

I pay my deepest gratitude to Dr. Mubarik Ali for his skilled guidance, full cooperation and encouragement, which lead me to successful completion of this dissertation.

I am also deeply grateful to teachers of the department for their valuable advice and sympathetic attitude throughout M.Sc.

I pay my appreciation to Mr. Shujaat Ali for his generous help and cooperation during this work. He really is a very nice, cooperative and dedicated person.

Very special thanks to my friend Aamir Rashid for his inspirational help in thesis manuscript writing and cooperation at every step during my study in University.

I would also like to acknowledge the cooperation of my friends Muhammad Rafique, Muhammad Abid, Attiqu-ur-Rehman and Muhammad Ramzan.

At last, but certainly not the least, I take this opportunity to pay my thanks to all my family members, whose prayers and advice always kept alive my spirit for knowledge.

ABSTRACT

Deconvolution applies a linear filter to a to a time function, to cancel undesired effects produced by the earth. In this report the focused objective is to check Zero-phase Deconvolution of Zero-phase wavelet. Spiking Deconvolution when applied on Zero-phase data produced phase distortions in Zero-phase data. But the Zero-phase Deconvolution Produced good results causing no phase distortion. In Zero-phase Deconvolution, the output is symmetric, whose length has been decreased optimally with respect to the input. After cross-correlation of vibroseis data a Zero-phased output is produced. Spiking Deconvolution of that data produces phase distortions, therefore, Zero-phase Deconvolution is more appropriate for vibroseis data.

INTRODUCTION

Seismic reflection processing results depend upon the processes used for the processing. Deconvolution is one of the fundamental processes. It often improves temporal resolution by collapsing the seismic wavelet into a spike and suppressing reverberations.

A wavelet is usually a transient signal. To shape a wavelet, digital filters are computed whose functions are to transform the input wavelet into a sharp wavelet. The wiener filter converts the seismic wavelet into any desired shape.

When wavelet is zero phase, the spiking deconvolution produces phase distortion. Zero phase deconvolution produce better result than spiking deconvolution. It is commonly applied on vibroseis data. In zero phase deconvolution two parameters are considered.

- Operator length
- Prewhitening

Short operators yield spikes with small amplitude and relatively high frequency tail. Long operators whiten the spectrum further bringing it closer to the spectrum of the impulse response.

Prewhitening is achieved by adding an artificial level of noise in data before deconvolution. Prewhitening is an essential parameter used in deconvolution to escape the drawback of Wiener Levinson algorithm.

By using above two parameters, a zero phase wavelet is designed, to interpret the data.

Chapter 1

Seismic Exploration

SEISMIC EXPLORATION

1.1 INTRODUCTION

Before 1920, some oil fields were discovered by chance or by looking at surface such as seeps or surface geological manifestation of surface traps. In 1930's and later gravity, magnetic and seismic methods were used for discovering oil fields. In recent years the introduction of electronic computers in oil industry has brought about a tremendous revolution in exploration technology.

Now a days seismic reflection seismology is widely used to map the structures of the subsurface formations by measuring the time required for the seismic wave, generated in the earth by a near surface source, to return to the surface after reflection from interfaces. This method provides a structural picture of surface comparable to obtained from several boreholes.

Seismic exploration technique consists of three main stages

1) Data Acquisition

2) Data Processing

3) Interpretation

Here we will discuss only data processing

1.2 Seismic Data Processing

Seismic data processing is a sequence of operations, those are carried out according to pre-defined program to extract useful informations from a set of raw data obtained in the field using CDP technique (Mayne, 1962).

The data are usually contaminated with different kind of noise. The processing sequence consisting of corrections and adjustments is meant to correct the data for various physical processes and then to suppress that noise which obscures the desired geological information of seismic data (Yilmaz, 1987).

There are three primary stages for processing the data.

1) Deconvolution.
2) Stacking
3) Migration

All other processing techniques may be considered secondary in that they help to improve the effectiveness of primary processing. A brief description of data processing sequence is given below.

1.3 PRE- PROCESSIING

1.3.1 DEMULTIPLEXING

Unscrambling a multiplexed array into a trace sequential array is called demultiplexing and it is accomplished by using specific computer program.

Multiplexed data is in time sequential format and demultiplexed data is in trace sequential format. The seismic data is recorded on magnetic taps using any of the formats such as

SEG-A, SEG-B, SEG-C (Record the data in multiplexed form)

SEG-D (Record the data in multiplexed and demultiplexed form)

SEG-Y (Used in processing center to record data in demultiplexed form)

Mathematically demultiplexing is to transpose the field packed data into a matrix that can be read in a trace sequence order related with a common shot point.(Yilmaz, 1987)

1.3.2 EDITIG

Data editing is the process of removing or correcting any trace partially or completely that may cause a deterioration of stack.

Muting is accomplished by zeroing the amplitude values of that particular trace that has a recognizable noise (Al-Sadi, 1980)

1.3.3 VIBROSEIS CORRELATION

All reflected and refracted signals in a vibroseis seismogram overlap in such way that the traces are not readable. To make them readable the procedure used is called "Vibroseis Correlation". This is done by cross correlating the data with original input sweep, each reflection is compressed into a wavelet which can be used directly to examine sub surface structure (Badley, 1985)

1.3.4 GAIN APPLICATION

A gain recovery function is applied on the data to correct for amplitude decay. Gain is also time variant scale derived from the data used mostly for display purposes. Automatic gain control (AGC) brings out the weak reflection zone of seismic data, but destroys the signal character during processing (Yilmaz, 1987)

1.4 DECONVOUTION

Deconvolution is performed along time axis to improve the temporal resolution of seismic trace through compressing the basic seismic wavelets to approximately the spikes and suppressing the reverberating noise. (Yilmaz, 1987).

Deconvolution is of two types.

1 Deterministic Deconvolution.

2 Predictive Deconvolution.

Deterministic deconvolution is capable of producing a pulse of any designed shape with an approximate band-width.

Predictive deconvolution attempts to predict event shapes obtained by statistical studies of the seismic traces (Badley, 1985)

1.5 CDP SORTING

Each trace to be included in a CDP stack comes from different sources and is related with a common reflection point. The set of traces "Sorted" for a particular CDP stack is called a "CDP gather"

When reflector is horizontal and velocities do not vary, the CDP Gather is equivalent to CMP gather. But when the reflector is dipping these two gather should never be equivalent (Yimaz, 1987)

1.6 VELOCITY ANAYSIS

In addition to providing an improved S/N ratio, multifold coverage with non-zero-offset recording yields velocity information about the subsurface. Velocity analysis is performed on selected CDP gathers or group of gathers. The output from one type of velocity analysis is a table of numbers as a function of velocity versus two way zero-off set time. These numbers represents some measures of signal coherency along the hyperbolic trajectories governed by velocity, offset and travel time. From the velocity spectra of a CDP location, the velocity time pair are selected from these spectra based on maximum coherency peaks. These velocity functions are spatially interpolated between the analysis points across the profile to supply a velocity function for each CDP gather along the profile.

The estimation of velocities from the seismic data requires the data recorded at nonzero off sets provided by common depth point (CDP) recording. Normal move is the basis for determining the velocity from the seismic data. Where the "Normal move out" (NMO) is the time difference between travel time at a given offset and at zero offset. The method of constant velocity scans of a CDP gather is important technique for velocity analysis. The NMO corrected CDP gathers are displayed side by side in the form of panel using a range of constant velocity. Now any event on the NMO corrected CDP gather is observed to be flat, corresponding to velocity. This will be the "stacking velocity". By proceeding in this way, we can build up a velocity function that is appropriate for the NMO correction of this gather.

The most important reason to obtain reliable velocity function is to get the best quality of the signal. Therefore stacking velocities often are estimated from data, stacked with a range of constant velocities on the basis of stacked event amplitude and continuity. Hence the stacking velocities are picked directly from the constant velocity stack panel by choosing the velocity that yields the best stack response at a selected event time.

The constant velocities used in this method should be chosen with care. There are two issues to consider besides the expected range of actual velocities in the subsurface.

1) The range of velocities needed to stack the data.
2) Spacing between the trial stacking velocities.

In choosing the range, consideration should be given to the fact that dipping events and out of plane reflections may have anomalously high stacking velocity. In choosing the spacing of constant velocities keep in the mind that it is move out not velocity. That is basis for velocity estimation.

1.7 NORMAL MOVE OUT (NMO)

NMO correction or dynamic correction is applied to reflection times to remove the effect of NMO. It is a function of offset, velocity, reflector depth and is derived from the velocity time function. (Robinson, 1988)

The formula for NMO correction is

$$T= (X^2/ V^2+t^2_o)^{½}-t \text{---------} (1.1)$$

Where

T= Normal Move Out

X= offset Distance

V= Stacking Velocity

t_o = Two way velocity Time

t= Delay in two-way vertical time.

The dynamically corrected traces are stacked.

1.8 STACKING

Stacking compresses the offset dimension, reducing the seismic data volume to the plane of the zero offset seismic section and increasing signal-to-noise ratio (Yilmaz, 1987)

Stacking is done by simple summing of traces in a CMP gather to produce a single trace. In stacking process the multiples surface wave refractions, etc. are attenuated where as primary reflections are enhanced.

1.9 RESIDUAL STATIC CORRECTIONS

To improve the stacking quality, residual static corrections are performed on NMO corrected CMP gathers. (Yilmaz,1987)

1.10 FILTERING

It is an operation by which the amplitude and phase spectra of a time signal or are emended.

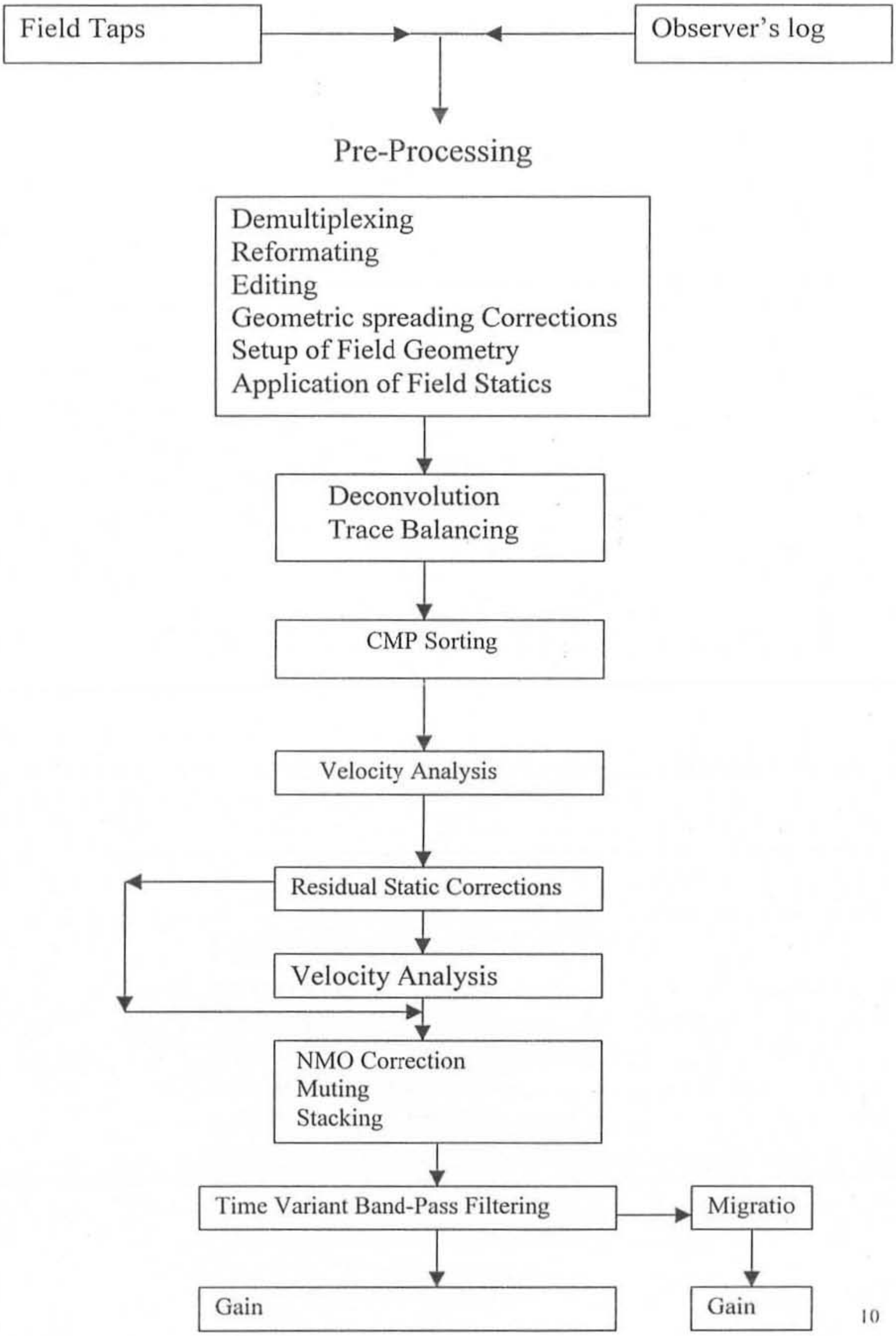
There are several filters such as low-pass, high-pass, band-pass which are used to improve the signal-to-noise ratio. Commonly, frequency filters are used, which discriminate against selected frequency range. Notch-filter, inverse of band-pass filters, are used to remove specific frequency or frequencies such as 60 Hz frequency introduce in field data by power lines. (Yilmaz, 1987)

1.11 MIGRATION

It is performed on zero-offset stacked section to increase the lateral resolution by collapsing diffractions and moving dipping events to their true subsurface positions.(Yilmaz,1987) The methods, which generally adopted for migration are

- Kirchoff's Migration
- Wave-Equation Migration
- Frequency-Domain Technique
- Finite-Difference Migration

A PROCESSING FLOW CHART



Chapter 2

Deconvolution

DECONVOLUTION

Deconvolution is a process that improves temporal resolution of seismic data by compressing the basic seismic wavelet, to approximately a spike.

Deconvolution is normally applied before stacking. The process some times does more than just wavelet compression. It can remove a significant part of the multiple energy from the section. To understand the deconvolution, first we need to examine the building block of a recorded seismic record.

The earth is composed of layers of rocks with different lithology and physical properties. Seismically, rock layers are defined by the densities and velocities, and the product of density and velocity is called the acoustic impedence. The impedence contrast between adjacent rock layers causes the reflections that are recorded along a surface profile. Thus the recorded seismogram can be modeled as a convolution of the earth's impulse response with the seismic wavelet. This wavelet has many components including source signature, recording filter, surface reflection and geophone response. The earth's impulse response is what would be recorded if the wavelet were just the spike. (Yilmaz, 1987)

Thus, the goal of deconvolution filtering is to return from the recorded seismogram to the ground response function. If, however, the signal waveform changes shape due to attenuation or scattering of the signal energy, a suitable deconvolution filter is necessarily time-variable, and becomes more complicated. The time-invariant deconvolution problem is frequently regarded as a special case of optimum waveshaping, where the filter input is a known waveform with noise and the desired output is a spike like function. Upon application of the Wiener filter theory, the time-invariant property of the filter follows directly from the assumed stationary of the input process. If the input signal waveform is thought to change shape as it propagates, the filter input must be treated as a non-stationary random process, that is, a random process that requires a time-dependent statistical description. (Clarke, 1968)

2.1 THE CONVOLUTION MODEL

A seismometer at the surface detects arrivals at times governed by two way transit time for various layers and with amplitudes related to the reflection coefficients between layers. The train of impulses observed at the surface is called the ground response function g(t). If the input signal waveshape at the surface is s(t), then observed surface disturbance is

$$r(t) = s(t) * g(t). \text{-------------------}(2.1)$$

This is the expression for an idealized reflection seismogram in the absence of noise. The aim of deconvolution filtering is to obtain the ground response function g(t) from the recorded seismogram r(t), and therefore to eliminate the effect of the signal waveshape s(t).

The situation is greatly complicated when the layers have attenuation. If we again assume a discretely layered, laterally homogeneous half space, each layer alters the pulse shape as well as contributes a time delay. The character of the observed impulse like disturbance will depend on the path taken through the layered attenuating medium. To simplify the analysis we consider the attenuation to be constant over the entire section. In this case the change of signal waveform due to attenuation by the layers is independent of its path and depends only on its age, that is, how long it has been propagating through attenuating medium. (Clark, 1968)

Let us now consider the auto correlation function of impulse response, a wavelet and seismogram. The auto correlation function of basic wavelet and seismogram are also similar. Mathematically the similarity between the auto correlation function of the wavelet and seismogram suggest that the impulse response has an auto correlation function that is small at all lags expect the Zero lag. (Yilmaz, 1987)

2.2 INVERSE FILTERING

If a filter operator is defined such that convolution with known seismogram $x(t)$, yields an estimate of the earth's response $e(t)$, then

$$e(t) = a(t) * x(t) \text{--------------------} (2.2)$$

Where

$x(t)$ = Recorded seismogram,

$a(t)$ = filter operator

$$\delta(t) = w(t) * a(t) \text{------------------} (2.3)$$

Where $\delta(t)$ is the kronecker delta function.

$\delta(t) = 1$ when $t= 0$

$= 0$ else where

Solving the (2.3) for the filter operator $a(t)$

$$a(t) = \delta(t) * w'(t) \text{-------------------} (2.4)$$

Where $w'(t)$ inverse of the seismic wavelet. This equation implies that the inverse filter converts the basic wavelet to a spike at $t = 0$. Likewise the inverse filter converts the seismogram to a series of spikes that define the earth's impulse response. (Yilmaz, 1987)

2.3 PHASE OF A WAVELET

The angle of sine wave with respect to a reference is called a phase. The phase carries the time information of a seismogram and proper phase presentation is important.

Let us consider three wavelets with the same amplitude spectrum, but with different phase lag spectra. As a result, their shapes differ,

I) A minimum phase wavelet that has more energy concentrated at the onset (figure 2.1).

II) The mixed phase wavelet that has energy concentrated in the center (figure 2.2).

III) Also the maximum phase wavelet having the most of its energy concentrated at the end (figure 2.3).

A symmetric wavelet that has peak amplitude at t = o is a zero phase wavelet (figure 2.4). Most stratigraphic goals can best be met when output seismic data is zero-phase, that is, when each primary reflection event is marked by a well-compressed symmetric wavelet of proper polarity.

But prior to processing the favourable seismic reflections are minimum phase wavelet. For proper treatment of phase it is important to

Figure 2.1 Minimum phase wavelet

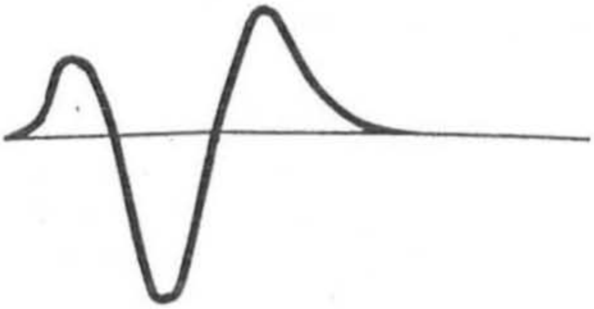


Figure 2.2 Mixed phase wavelet

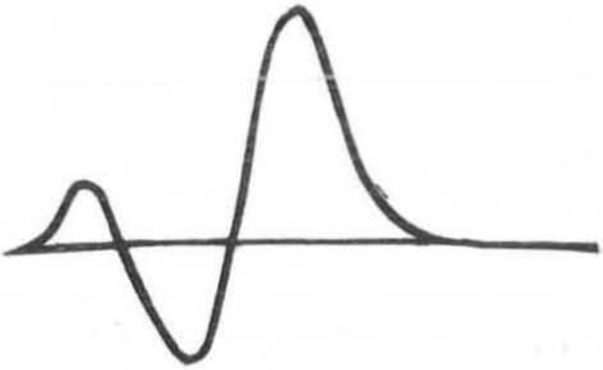


Figure 2.3 Maximum phase wavelet

Figure 2.4 Zero phase wavelet

remove the effect of filters for which the responses are known. (Berkhout, 1977)

2.4 SPIKING DECONVOLUTION

The process by which the seismic wavelet is compressed into zero lag spike is called the spiking deconvolution. This goal is achieved by making use of various filters. Their performance depends upon the filter length but also on whether the input wavelet is minimum phase.

The amplitude spectrum of the operator is the inverse of the amplitude spectrum of minimum phase. Therefore one way to extract the seismic wavelet, is to provide the minimum phase to compute the spiking deconvolution operator and find its inverse. In conclusion, if the input wavelet is not minimum phase then spiking deconvolution can not convert it to a perfect zero lag spike. (Yilmaz, 1987)

2.5 PREDICTIVE DECONVOLUTION

Predictive deconvolution is the processing technique by far most commonly used to increase the resolution of seismic data because some form of predictive deconvolution will make almost any data more interpretable. While noise typically limits the potential increase of resolution, the parameters of predictive deconvolution (specifically, prediction distance and added white noise) can be adjusted to give an optimal balance between increasing the signal bandwidth and limiting the noise amplification. This adaptability in the presence of noise is a prime reason for the popularity of the process. (Gibson and Larner, 1984)

Chapter 3

Zero Phase Deconvolution

ZERO PHASE DECONVOLUTION

Zero phase deconvolution or spectral flattening is a technique, which can be implemented in various ways, but its distinguishing characteristic is that attenuated (usually higher) frequencies are amplified without any adjustment of the phase spectrum. This simple balancing or flattening of the trace amplitude spectrum is exactly what one would choose to do if the embedded wavelet were zero-phase.

At first thought, zero-phase deconvolution seems particularly well suited to treating the problem of vibroseis data, because that source pulse is nominally zero-phase. Some of filters may indeed be close to zero-phase. For instance, a symmetric source or receiver array will act as a zero-phase high-cut filter to energy arriving at non-normal angles of incidence. Earth filtering effects are distinctly not zero-phase. Therefore the validity of zero-phase assumption will depend upon what types of filter effects dominate a particular reflection event. Obviously, the assumption can not hold over an entire trace, and it is certainly suspect at late reflection times.(Gibson and Larner, 1984)

3.1 ZERO-PHASE LEAST-SQUARE INVERSE FILTERING

Causal least-square inverse filter $f_n(t)$ is represented as (Robinson and Wold, 1963)

$$f_n(t) * R_\Delta(t) = \delta(t) \quad \text{for } 0 <= t <= N\Delta \quad \text{-----------(3.1)}$$

And

$$R_\Delta(t) = S'_\Delta(t) * S_\Delta(t)$$

Where $R_\Delta(t)$ is auto-correlation function of signal $S_\Delta(t)$ is a minimum-phase filter for any energy bounded $S_\Delta(t)$. This means that if $S_\Delta(t)$ represents a minimum-phase signal, $f_n(t)$ will have desirable phase spectrum. The output of $f_n(t)$ will be again a minimum-phase signal whose length has been decreased optimally with respect to input. However, if $S_\Delta(t)$ has not minimum phase property, the phase spectrum of $f_n(t)$ is not corrected and $f_n(t)$ will not be the optimum least-square for $S_\Delta(t)$.

In the special case where $S_\Delta(t)$ represents a zero-phase signal it is obvious that the desirable phase of the inverse filter-should be zero, since any other phase spectrum would increase the length of the output. Hence the optimum least-square inverse filter can be obtained by computing the zero-phase correspondent of $f_n(t)$.

Now

$$g_N(t) * g_N(t) = f_n(t) \quad \text{for } t <= N\Delta \quad \text{--------------}(3.2)$$

and $g_N(t)$ that converges to a minimum-phase signal for increasing N.

$$h_{N,N}(t) = g'(-t) * g(t) \quad \text{-------------------}(3.3)$$

Therefore, if the input of the zero-phase least-square inverse filter $h_{N,N}(t)$ is a zero-phase signal, the output will be again zero-phase signal with optimally decreased length with respect to the input.

The minimum phase signals of figure 3.1(a) has been filtered with its minimum phase and zero-phase least-square inverse filters. The filters were computed following the equations (3.1), (3.2) and (3.3). The lengths of the signal for both outputs indicate clearly that zero-phase inverse filtering is to be preferred (figure 3.1(d), 3.1(e)). (Berkhout, 1974)

3.2 VIBROSEIS DECONVOLUTION

In deconvolution the linear filter is applied to time function to cancel undesired affects of convolution (the transfer function of the earth). Frequently the unwanted convolution output is of minimum phase and minimum phase method such as Wiener-Levinson spiking algorithm (Robinson, 1967) can be used to determine the inverse filter.

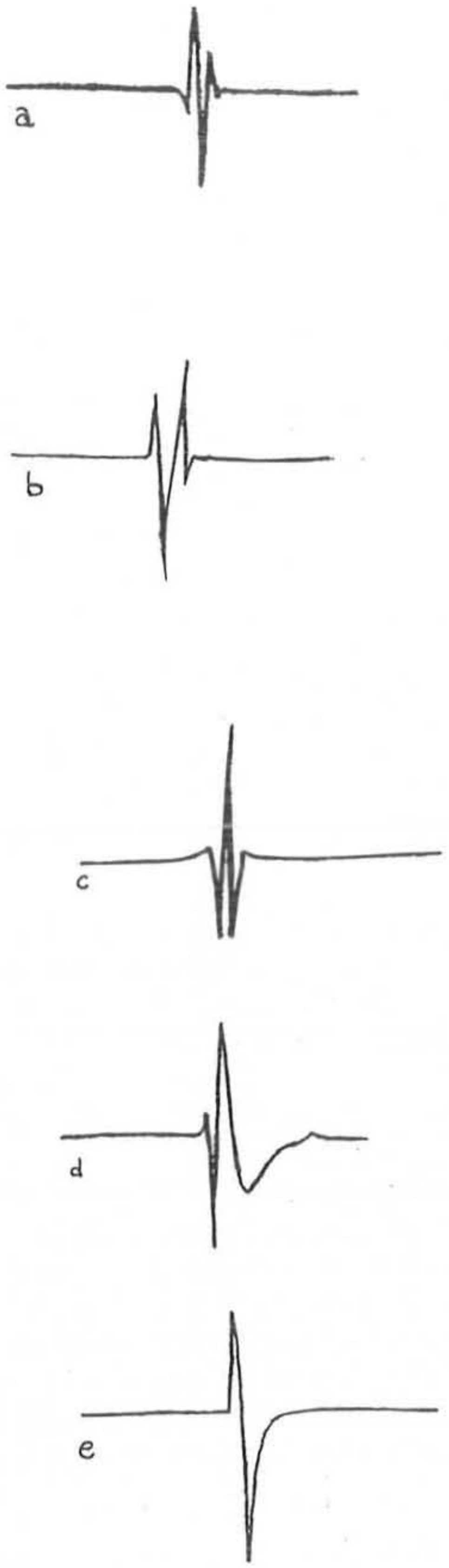


Figure 3.1 a) signal under investigation, b) minimum phase c) zero phase d)output of minimum phase least-square inverse filter e) output of zero phase least-square inverse filter

Ristow and Jurczyk (1975), Lines and Clayton (1977) pointed out that in the case of vibroseis signals, the minimum phase methods do not yields the correct inverse operator. This is because the vibroseis wavelet (Klauder,1960) is the autocorrelation of the sweep and is therefore zero phase.

Another reason of not applying spiking deconvolution is that the vibroseis signal approximates a band-limited signal. Thus, one goal of vibroseis deconvolution is to design a linear (possibly time–varying) filter to cancel the effects of the earth with in the frequency band of the vibroseis signal. (Bickel, 1982)

For vibroseis deconvolution there is two possibilities, the deconvolution process can be carried out before correlation or after correlation. At each stage of the deconvolution, it increases resolution of the vibroseis trace at the expense of increasing the high frequency noise.

The convolution model of vibroseis seismogram

$$x(t) = s(t) * w(t) * e(t) \qquad \text{-----------------}(3.4)$$

Where x(t) is the recorded seismogram , s(t) is the sweep signal, w(t) is the seismic wavelet and e(t) is the earth's impulse response.

Equivalent of equation (3.4) in frequency domain is multiplication

$$X(w) = s(w) * W(w) * E(w) \text{-----------------}(3.5)$$

In terms of amplitude A(w) and phase ϕ(w) spectra,

$$A_X(w)=A_S(w) * A_W(w)* A_E(w) \text{ ---------------(3.6)}$$

And

$$\phi_x(w) = \phi_s(w) + \phi_W(w) + \phi_e(w) \quad \text{--------------(3.7)}$$

Cross correlation of the recorded seismogram x(t) with the sweep signal S(t) is equivalent to multiplying equation (3.6) by $A_s(w)$ and subtracting $\phi_s(w)$ from equation (3.7) .

The correlated seismogram x'(t) , therefore , describes the amplitude a phase spectra

$$A'(w) = A_s^2(w) A_w(w) A_e(w) \quad \text{---------------(3.8)}$$

And

$$\phi'(w) = \phi_N(w) + \phi_e(w) \quad \text{-----------------(3.9)}$$

Applying inverse Fourier transform of $A_s^2(w)$ produces autocorrelation of the sweep signal, which is called Klauder wavelet K(t). Time domain conversion of equations (3.8) and (3.9) is

$$X'(t) = K(t) * w(t) * e(t) \quad \text{-----------------(3.10)}$$

Here K(t) is Klauder wavelet of zero phase.

One approach to deconvolve vibroseis data is to apply a zero-phase inverse filter to remove K(t), followed by a minimum phase deconvolution to remove w(t).(Yilmaz, 1987)

3.3 PHASE COMPENSATION OF DECONVOLVE VIBROSEIS SIGNALS

The of measure trace (Ristow and Jurczyk, 1975) is

$$T = E_O * W * R \text{ ----------------(3.11)}$$

Where E_O = Earth's filter (assume to be minimum phase)

W = Zero-phase vibroseis wavelet, and

R = Reflectivity function.

Common deconvolution goal is to eliminate the effects of the earth's filter and there by estimate the band-limited reflectivity function.

$$\overline{R} = W * R \text{ ----------------------------(3.12)}$$

To reach this goal, it is common practice to first to deconvolve the data with the Wiener-Levinson Spiking deconvolution operator. The deconvolved output is then filtered by a zero-phase band–pass filter, which is matched to the passband of the vibroseis signal. In other words, the commonly estimated reflectivity function is given by

$$R = W * D * T \text{------------------}(3.13)$$

Where D is the Spiking deconvolution operator. According to Ristow and Jurczyk (1975), the deconvolve trace should be convolved with the minimum-phase equivalent of the vibroseis trace, hence

$$\overline{R} = W_O * D * T \text{------------------}(3.14)$$

Where W_O denotes a minimum–phase wavelet, which has the same amplitude spectrum as the correlated vibroseis wavelet W. In equation (3.14), one must over look the fact that vibroseis wavelet approaches a band–limited signal and therefore W_O may not exist. A comparison of equation (3.13) with equation (3.14) shows that they differ only in their phase spectra and that equation (3.14) can be regarded as phase compensated version of equation (3.13).

In order to show equation (3.14) yields the desired estimate, we will assume that reflectivity sequence in equation (3.11) is white and once again neglect the problems associated with band–limited signal. Hence with the trace desired by equation (3.11) as the input to the minimum phase deconvolution process, the deconvolution operator is found to be

$$D = E'_O * W'_O \text{----------------------}(3.15)$$

If we substitute equation (3.15) into equation (3.14) we find that

$$\overline{R} = \hat{R} \qquad \text{------------------------}(3.16)$$

Where $\overline{R}$ is the desired band–limited reflectivity function given by equation (3.12).(Bickel, 1982)

3.4 ZERO PHASE AND MINIMUM PHASE

Figure (3.2a) shows the model of simple gas reservoir and figure (3.2b) gives its primary synthetic.

In figures (3.3a), (3.3b) and (3.3c) the primary synthetic has been convolved with signal of figure (3.1a), its minimum-phase correspondent and zero phase correspondent are shown in figures (3.3d) and (3.3e).

Finally in figures (3.3d) and (3.3e) the reservoir response of figure (3.3a) has been deconvolved with its minimum–phase least-square inverse filter respectively. It is clearly visible that after minimum phase least–square inverse filtering the resolving power has been decreased seriously. (Berkhout, 1974)

It is therefore concluded that zero-phase length signal has better length properties than minimum phase signal. Like minimum-phase signals, zero phase signals have, in addition to the minimum–length property, the advantage that perfect deconvolution is feasible by knowing the auto correlation function only. The zero-phase investigation scheme

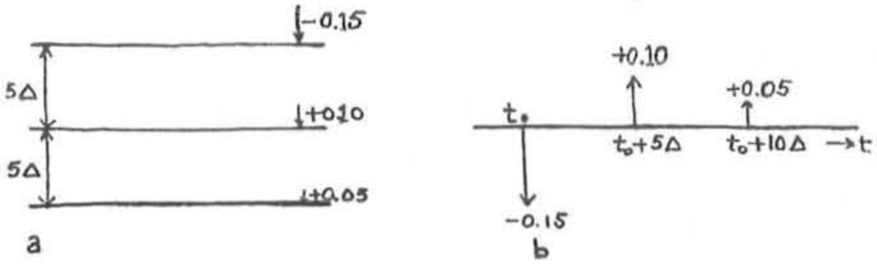


Figure 3.2 a) model of simple gas reservoir b) primary synthetic of reservoir

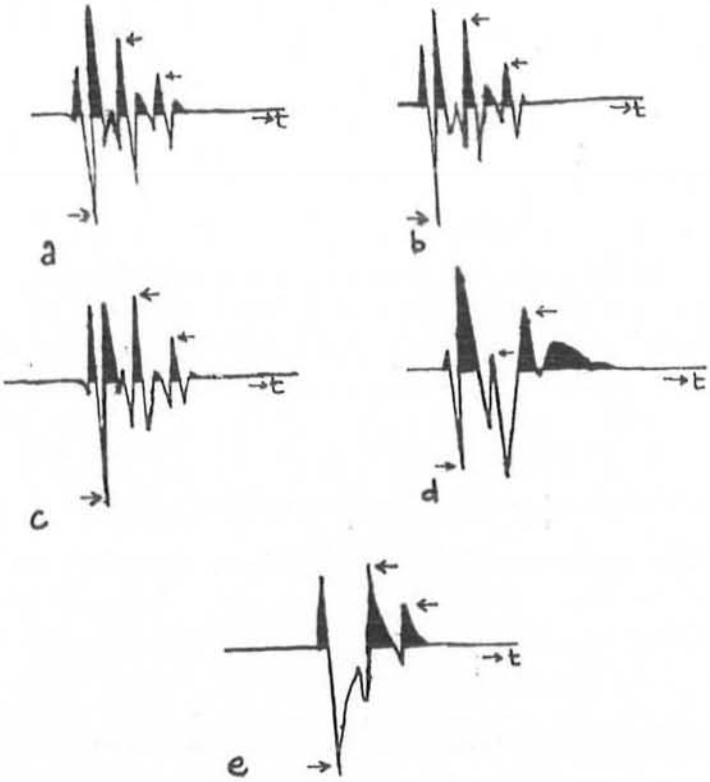


Figure 3.3 a) reservoir response using wavelet 1a b) reservoir response using minimum phase 1b c) reservoir response using zero phase 1c d) reservoir response using minimum phase filter output 1d e) reservoir response using zero phase filter output 1e

determines whether a symmetric signal has the zero-phase property. (Berkhout, 1974)

3.5 ZERO PHASE DECONVOLUTION AND PREDICTIVE DECONVOLUTION

Zero-phase deconvolution does have one interesting characteristic in comparison predictive deconvolution. As noted earlier (Berkhout, 1977), the presence of noise on trace strongly affects the phase treatment produced by predictive deconvolution. In unstacked field data, noise condition can vary drastically form one trace to another with in any gather and from one shot to another along a line. For instance, low–velocity ground roll might be present only at near and intermediate offsets such variation will mean that traces stacked together after predictive deconvolution can receive irregular phase treatment. The phase treatment of zero-phase deconvolution however, although generally incorrect, is assuredly stable, it is identical from trace to trace. Therefore the stacked section may show better continuity of events than one processed conventionally with predictive deconvolution. Attaining a high-quality stack may will be the primary goal in the deconvolution of unstacked data, whether or not the phase treatment is correct. (Gibson and Larner, 1984)

Chapter 4

Practical Aspects

PRACTICAL ASPECTS

The SAP program is basically designed for training purposes and provides several processing facilities, such as deconvolution, filtering, gain applications and array simulations.

There are three types of deconvolution available in this program,

- Spiking deconvolution.
- Predictive deconvolution.
- Zero-Phase deconvolution.

The seismic section W85-8.sgy (figure 4.1) is sampled at 2ms interval and total length of data is about 1.5 Second, starting from 200ms. 101 traces starting from trace No. 1360 have been selected for experiment work. From the figure (4.1) it is observed that there are six strong reflectors, i.e. at 290ms, 545ms 650ms, 1115ms, 1130ms, and 1460ms. In Zero-phase deconvolution, the important parameters are,

- Operator length.
- Prewhitening.

4.1 OPERATOR LENGTH

Operator length is changed by keeping prewhitening constant at 1%.

1) When fig.(4.1) is processed with operator length of 200ms, it is observed in fig.(4.2) that amplitude of traces is decreased and even strong reflectors at 1460ms are disturbed. The reflector at 650ms is almost disappeared and similar is case with the reflector at 1460ms. Further observation of amplitude spectrum (figure 4.3) suggests that flattening is not good.
2) When operator length is increased to 250ms, the results are slightly improved (figure 4.4), however, the overall impact declares that the amplitudes of the traces are decreased in strong reflections. Comparing the figure (4.2) with the figure (4.4), it appears that at 1215ms there is faint reflector in the figure (4.2), which is slightly enhanced in the figure (4.4). The amplitude spectrum (figure 4.5) is improved.
3) By increasing the operator length upto 300ms, it is observed that amplitude has decreased exceptionally. The strong reflectors at 1115ms and at 1130ms in the figure (4.6) are disturbed and loosing their sharpness considerably. The amplitude spectrum given in the figure (4.7) is not flat.

CONCLUSION

The compression of figures (4.2), (4.4) and (4.6) suggest that the operator length 250ms give better result.

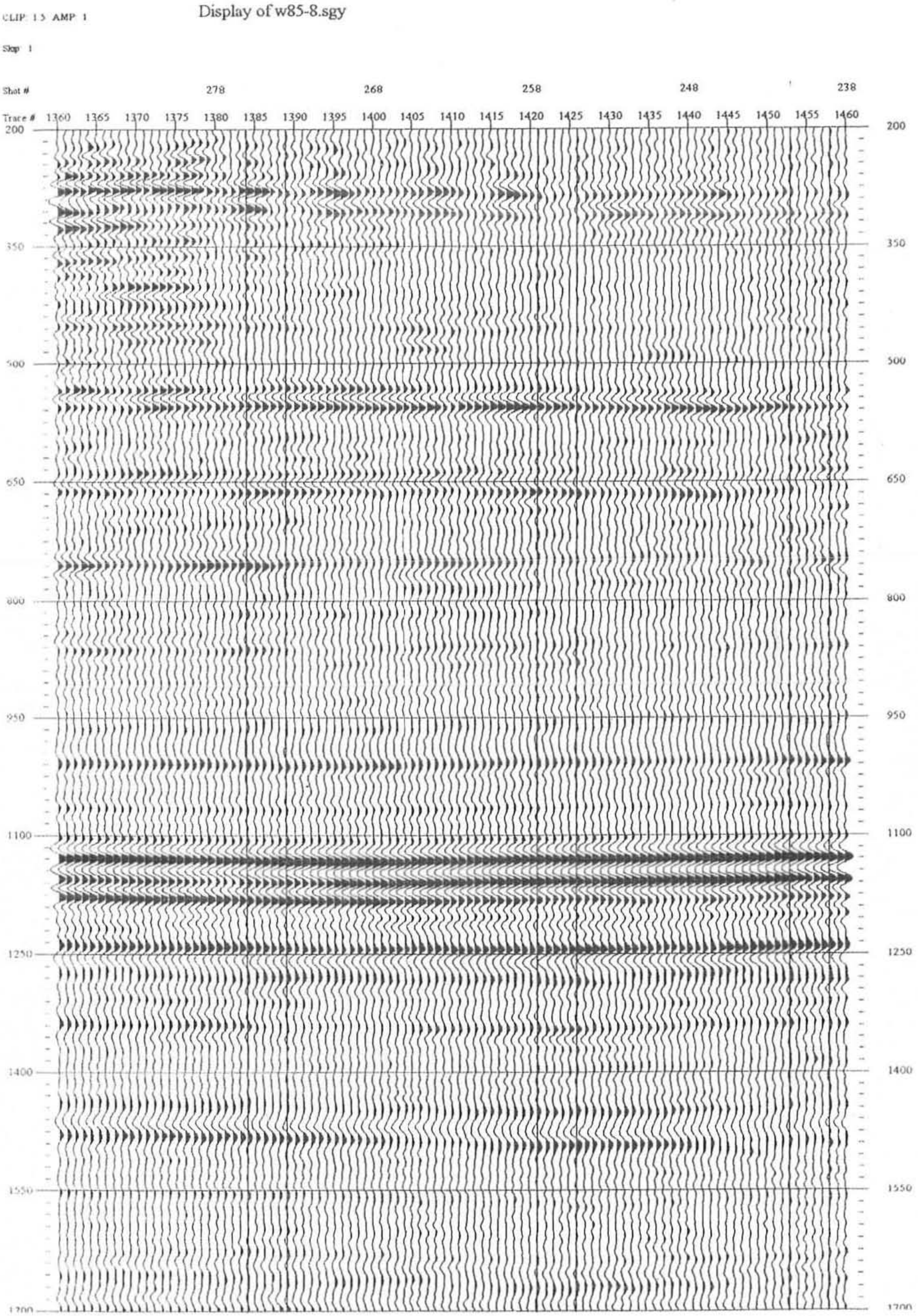

CLIP: 1.5 AMP: 1
Display of w85-8.sgy
Skip: 1
Shot #
278
268
258
248
238
Trace #
1360
1365
1370
1375
1380
1385
1390
1395
1400
1405
1410
1415
1420
1425
1430
1435
1440
1445
1450
1455
1460
200
350
500
650
800
950
1100
1250
1400
1550
1700

Figure 4.1

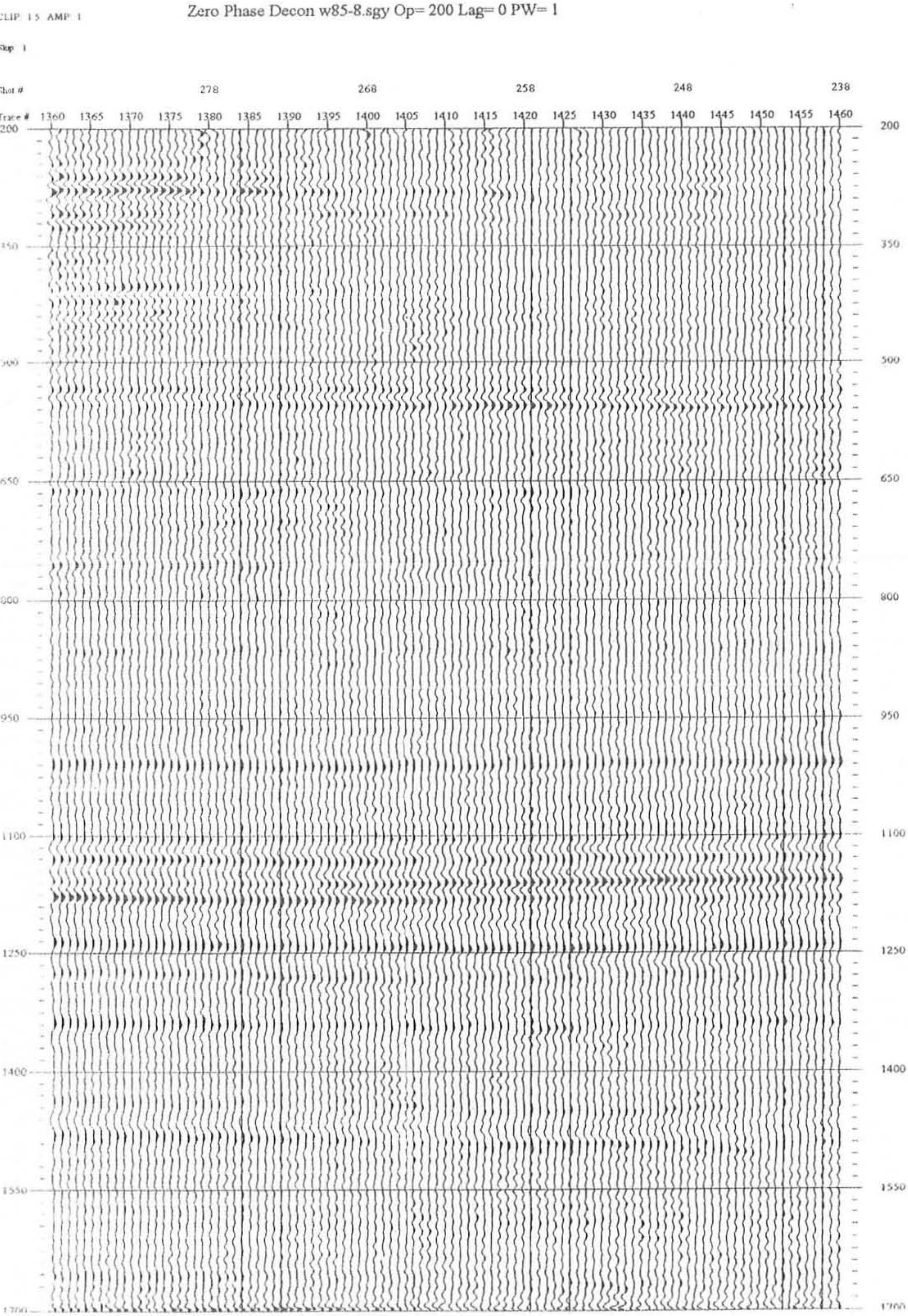
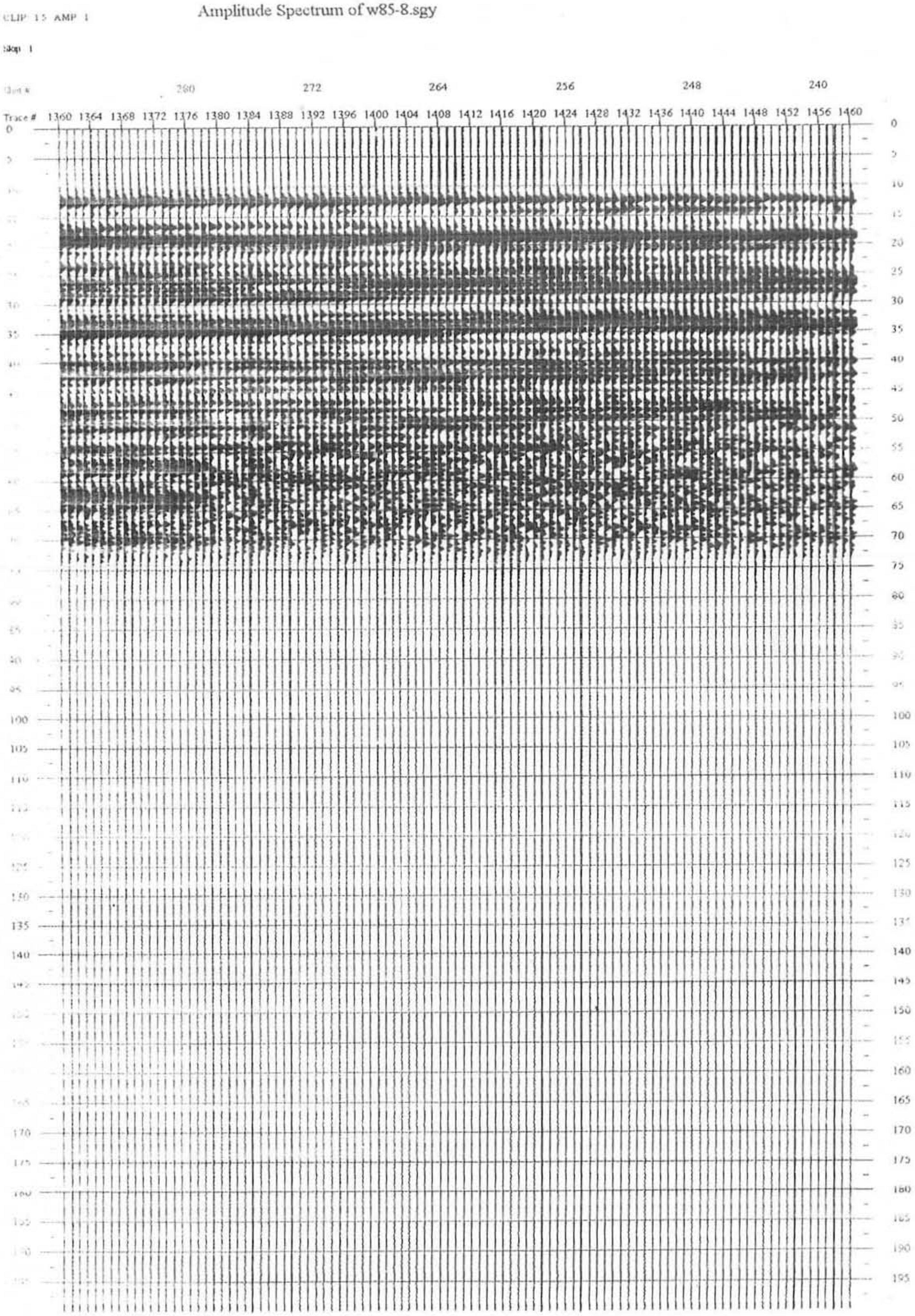

Zero Phase Decon w85-8.sgy Op= 200 Lag= 0 PW= 1
CLIP 1.5 AMP 1
Skip 1
Shot #
278
268
258
248
238
Trace #
1360
1365
1370
1375
1380
1385
1390
1395
1400
1405
1410
1415
1420
1425
1430
1435
1440
1445
1450
1455
1460
200
350
500
650
800
950
1100
1250
1400
1550
1700

Figure 4.2



Amplitude Spectrum of w85-8.sgy

Figure 4.3 OPERATOR LENGTH = 200ms PREWHITENING = 1%

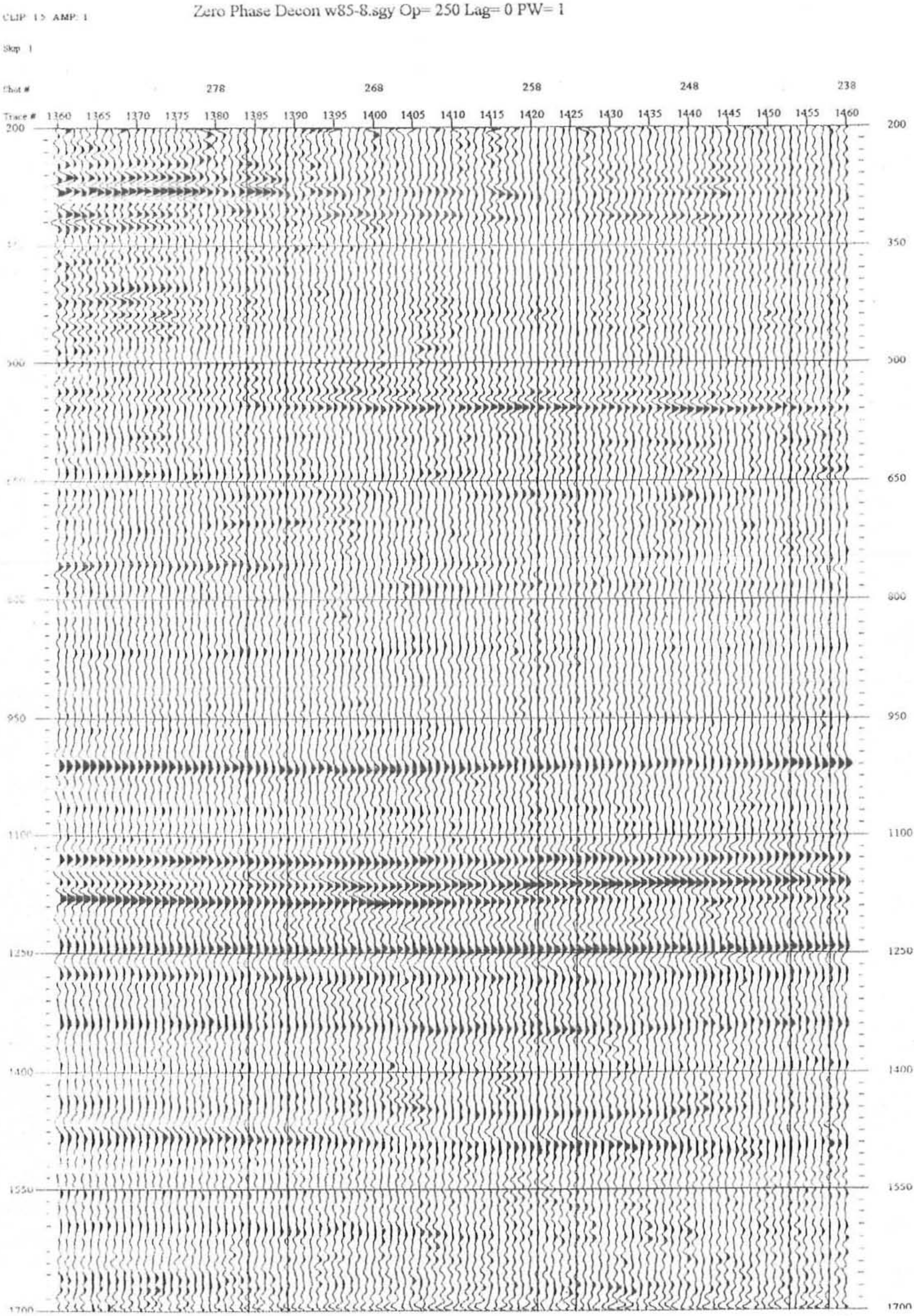

CLIP: 15 AMP: 1
Zero Phase Decon w85-8.sgy Op= 250 Lag= 0 PW= 1
Skip 1
Shot #
278
268
258
248
238
Trace #
1360
1365
1370
1375
1380
1385
1390
1395
1400
1405
1410
1415
1420
1425
1430
1435
1440
1445
1450
1455
1460
200
350
500
650
800
950
1100
1250
1400
1550
1700

Figure 4.4

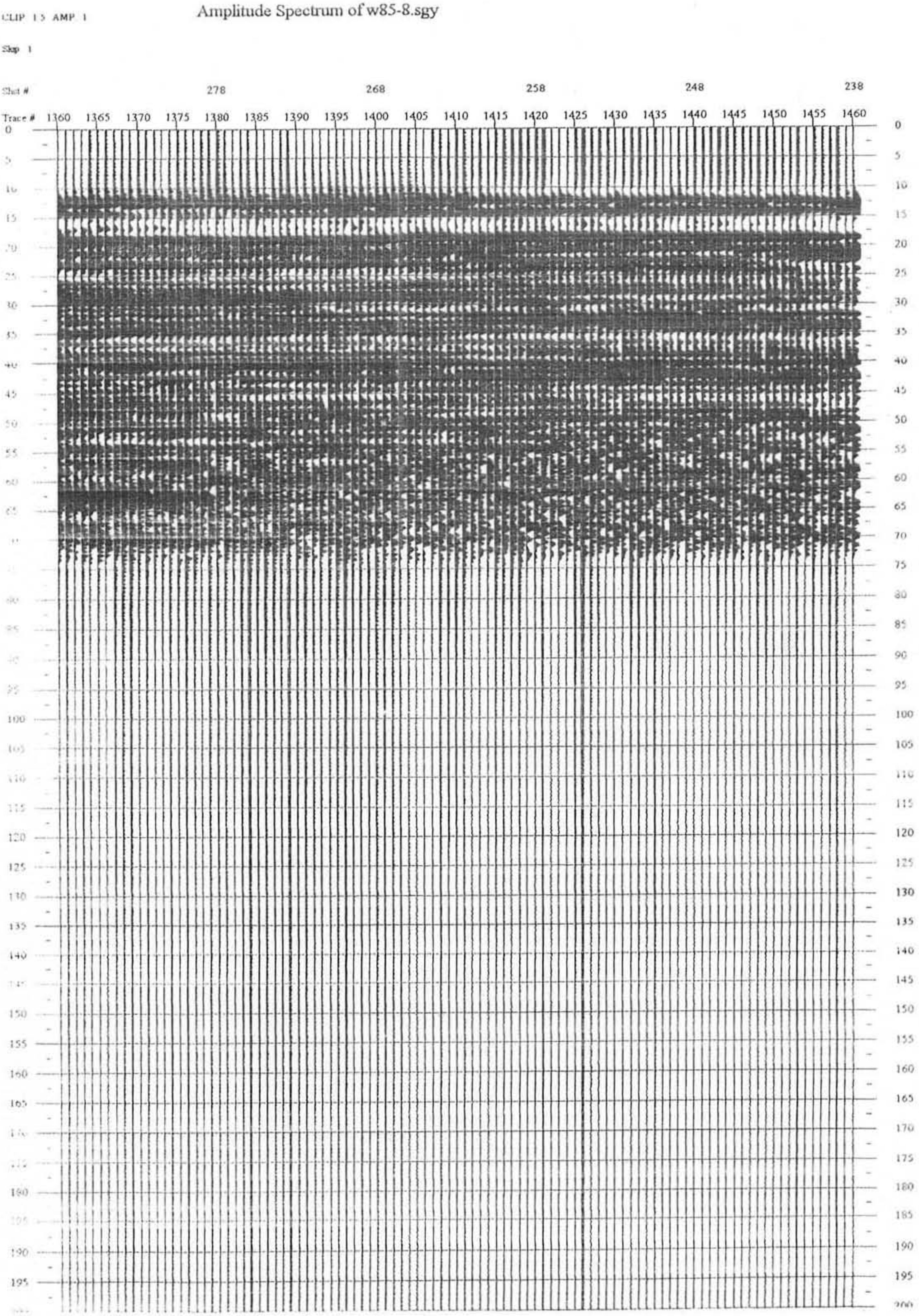


Figure 4.5 OPERATOR LENGTH=250ms PREWHITENING=1%

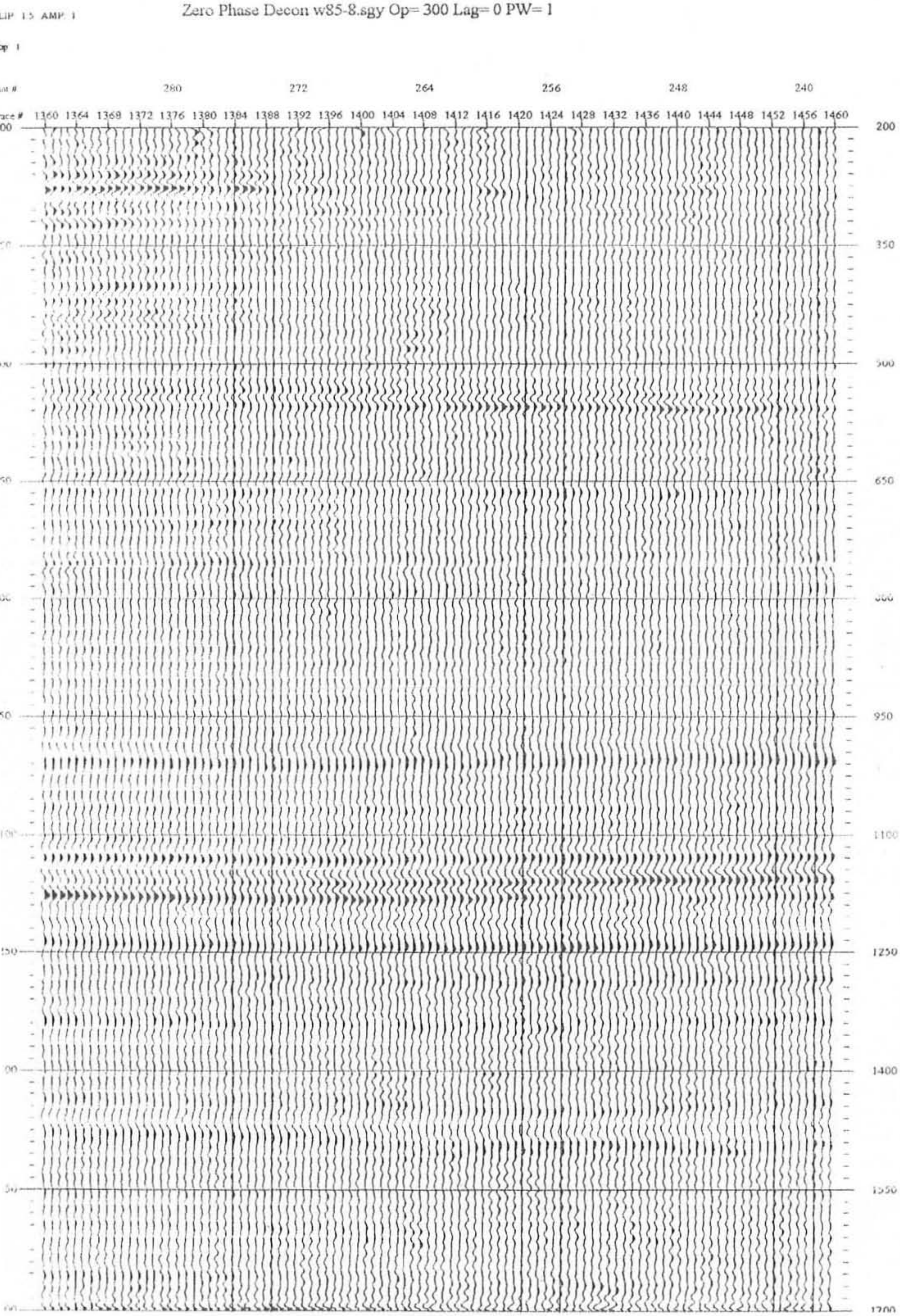

Zero Phase Decon w85-8.sgy Op= 300 Lag= 0 PW= 1
LIP 15 AMP 1
op 1
at #
280
272
264
256
248
240
race #
1360 1364 1368 1372 1376 1380 1384 1388 1392 1396 1400 1404 1408 1412 1416 1420 1424 1428 1432 1436 1440 1444 1448 1452 1456 1460
200
350
500
650
800
950
1100
1250
1400
1550
1700

Figure 4.6

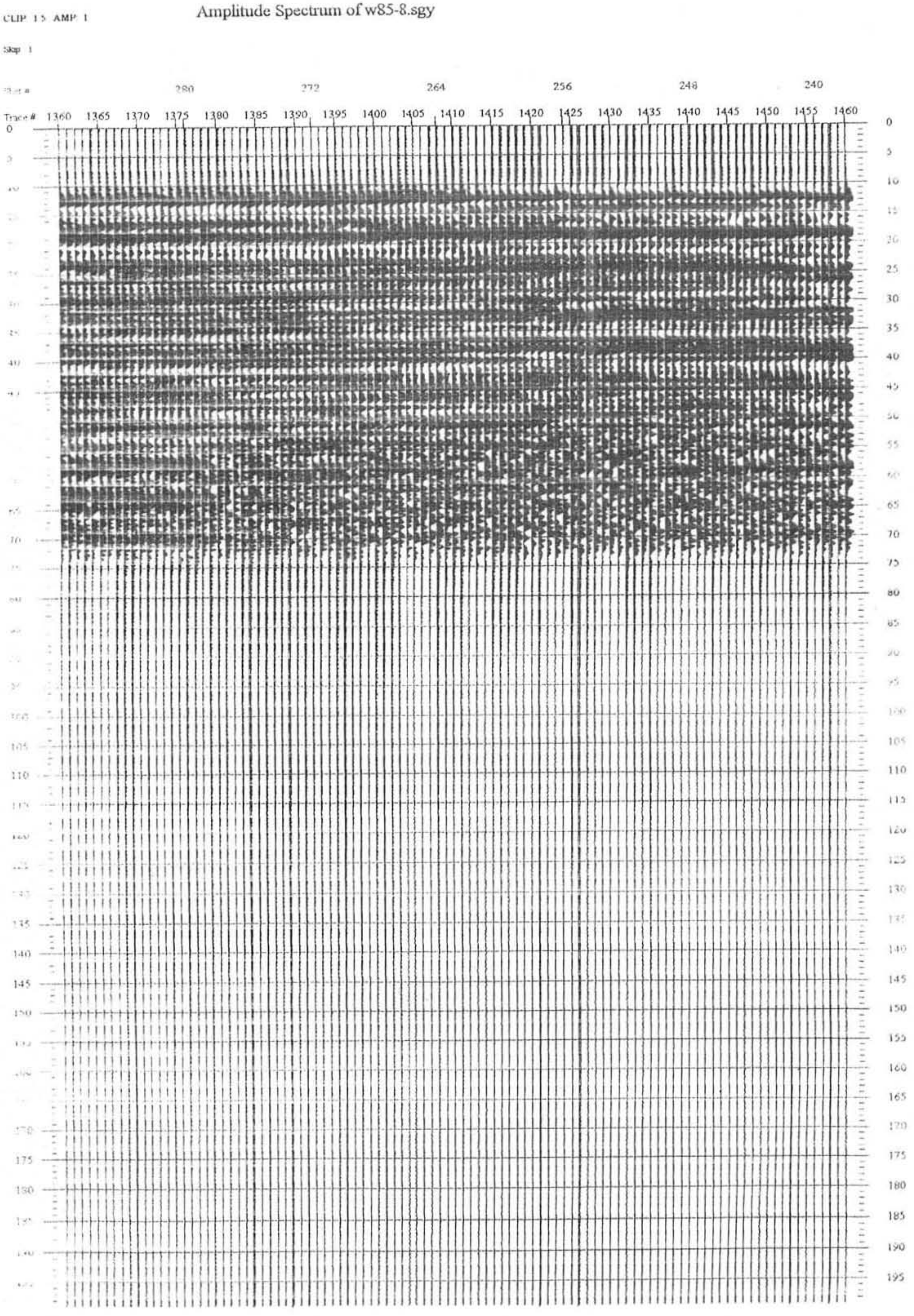


Figure 4.7 OPERATOR LENGTH=300ms PREWHITENING=1%

4.2 PREWHITENING

Now keeping the operator length constant at 250ms changes the prewhitenig.

1) When prewhitening is 0.1%, small amount of noise is added, the amplitude of reflections are reduced greatly (figure 4.8). Similarly the amplitude spectrum (figure 4.9) is not flat.
2) By increasing the prewhitening upto 0.5% (figure 4.10), it is observed that there is considerable increased in amplitudes of the traces. The amplitude spectrum (figure 4.11) is still not flat.
3) At 1% prewhitening (figure 4.3) a lot of improvement in amplitudes is visible, good reflectors can be observed from the figure (4.3). The amplitude spectrum (figure 4.4) is also improved.
4) When prewhitening is 2% (figure 4.12), some weak reflectors also becomes stronger, and some phase distortions in the seismic traces are also observed. The amplitude spectrum (figure 4.13) is also not flat one.

CONCLUSION

Addition of prewhitening upto 1% improves the result, but beyond that quality is deteriorated.

R

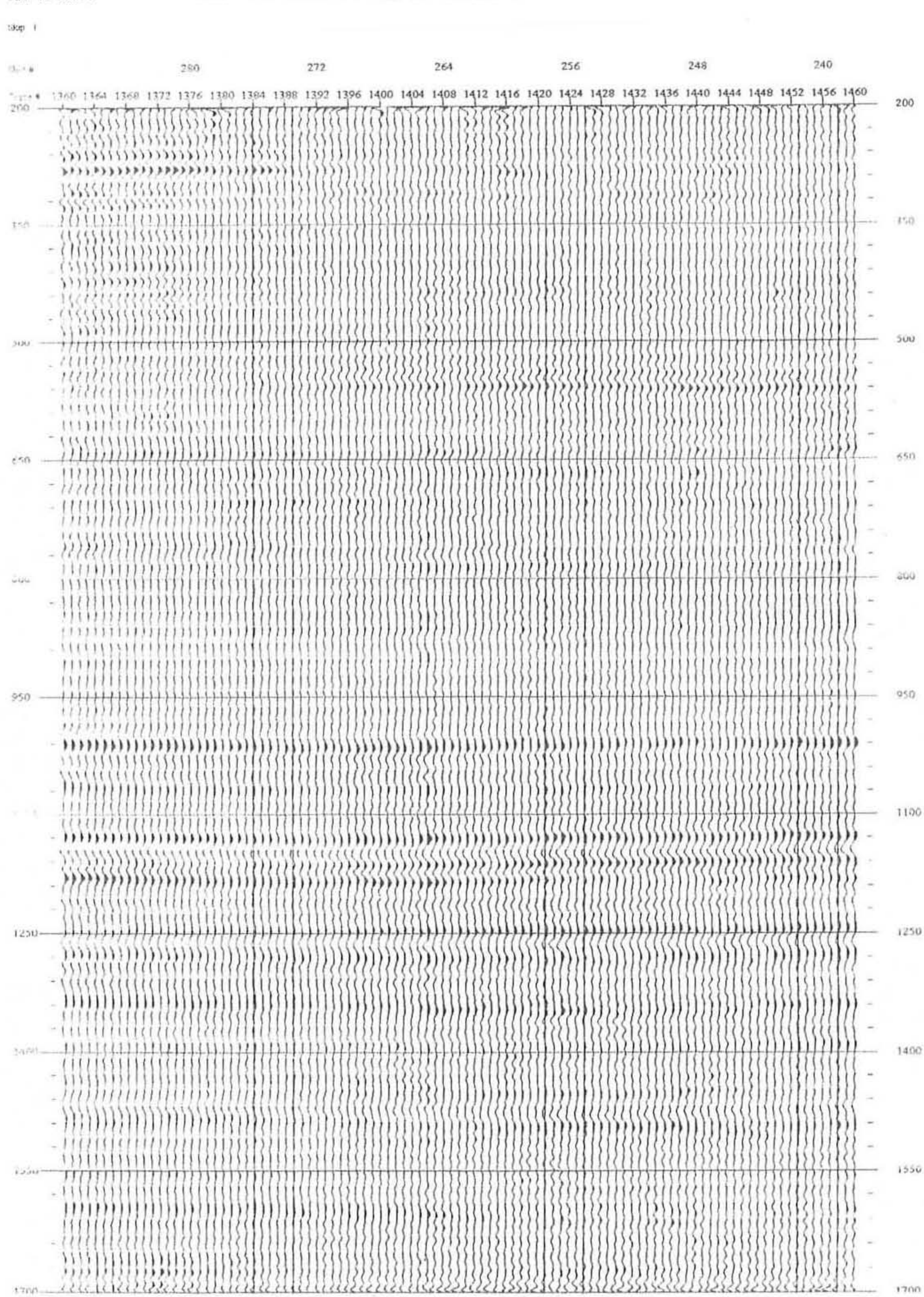

CLIP 15 AMP 1
Zero Phase Decon w85-8.sgy Op= 250 Lag= 0 PW= .1
Skip 1
280
272
264
256
248
240
1360 1364 1368 1372 1376 1380 1384 1388 1392 1396 1400 1404 1408 1412 1416 1420 1424 1428 1432 1436 1440 1444 1448 1452 1456 1460
200
350
500
650
800
950
1100
1250
1400
1550
1700

Figure 4.8

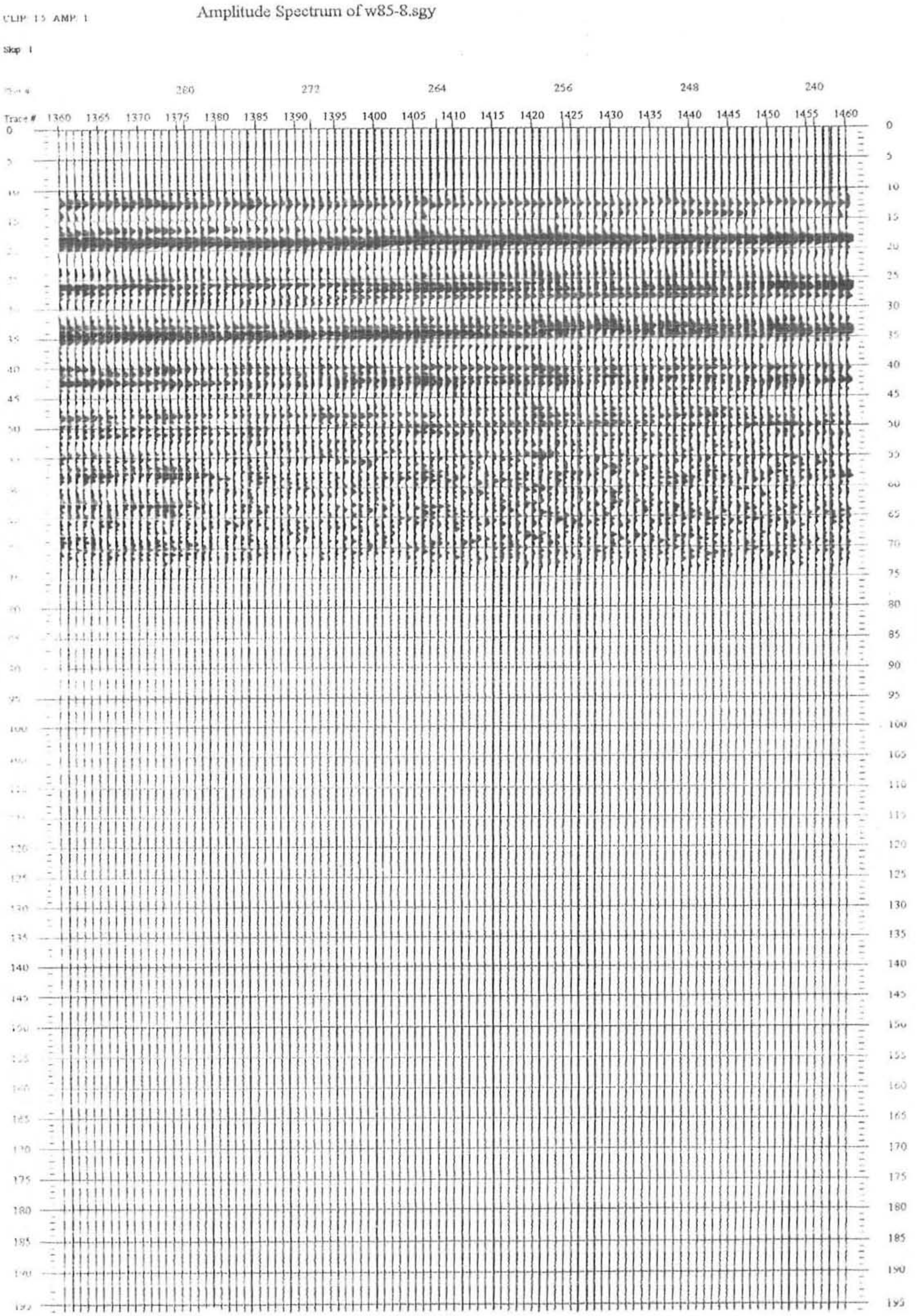


Figure 4.9 OPERATOR LENGTH=250ms PREWHITENING=0.1%

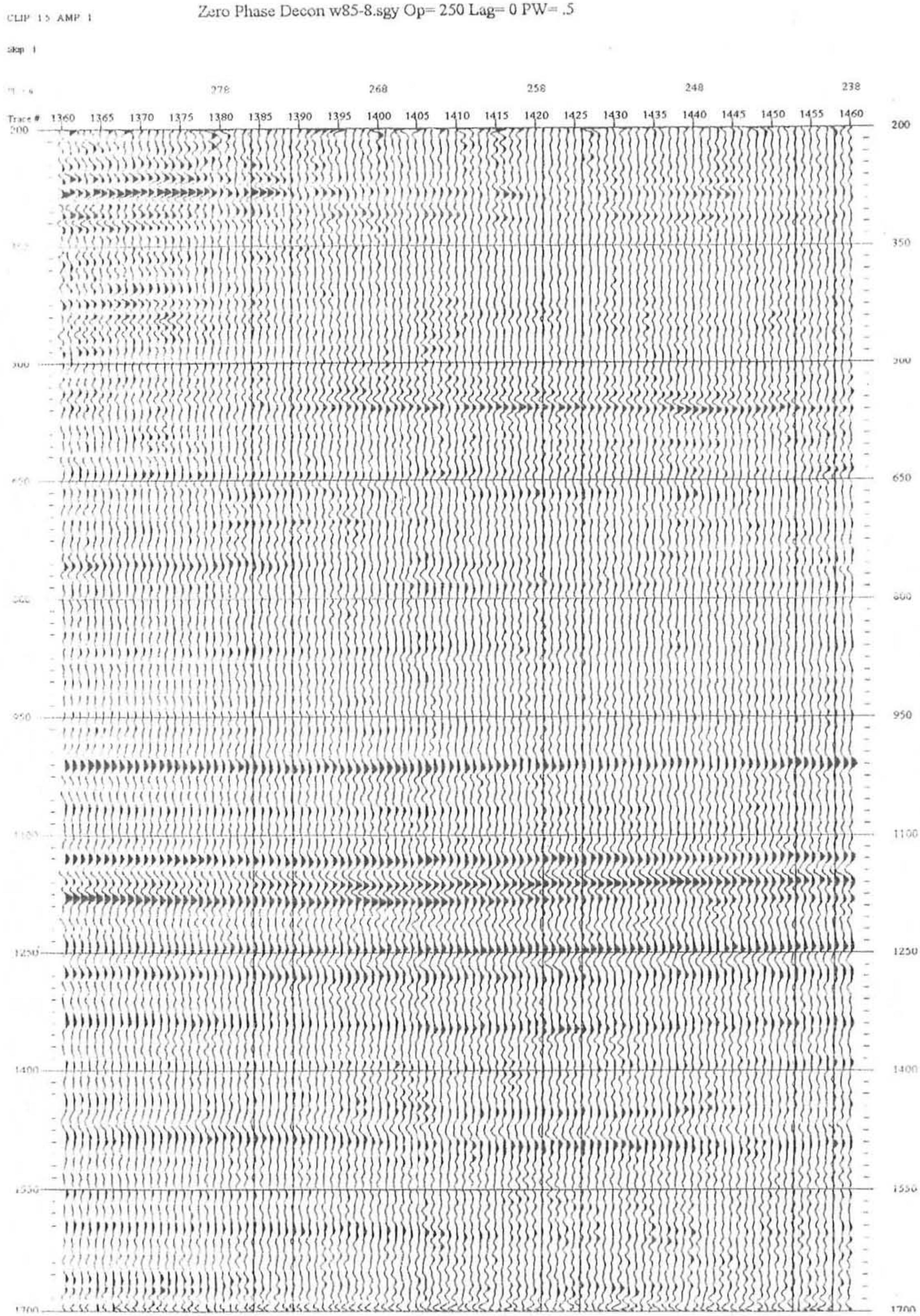

CLIP 15 AMP 1
Zero Phase Decon w85-8.sgy Op= 250 Lag= 0 PW= .5
skip 1
278
268
258
248
238
Trace #
1360
1365
1370
1375
1380
1385
1390
1395
1400
1405
1410
1415
1420
1425
1430
1435
1440
1445
1450
1455
1460
200
350
500
650
800
950
1100
1250
1400
1550
1700

Figure 4.10

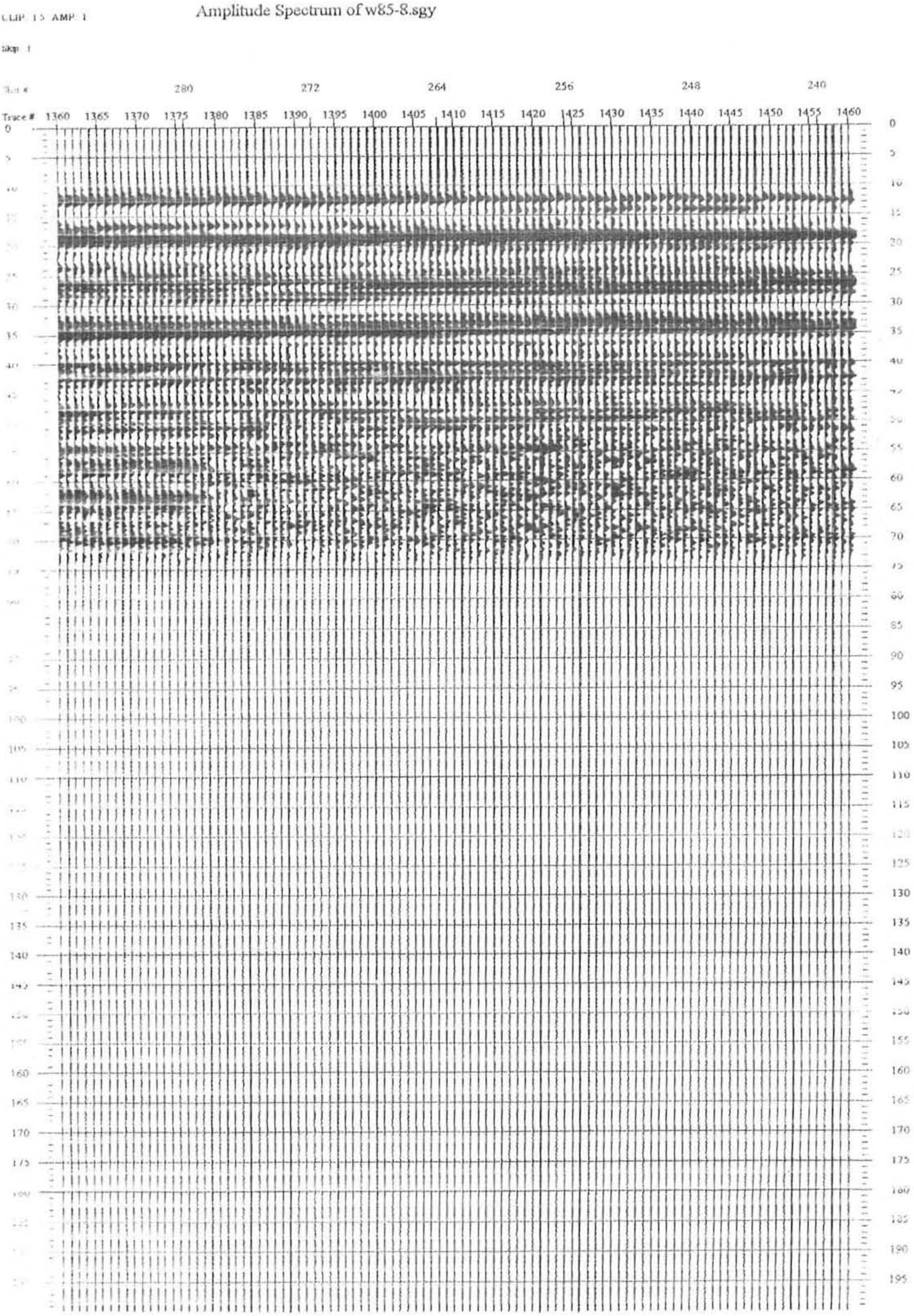


Figure 4.11 OPERATOR LENGTH=250ms PREWHITENING=0.5%

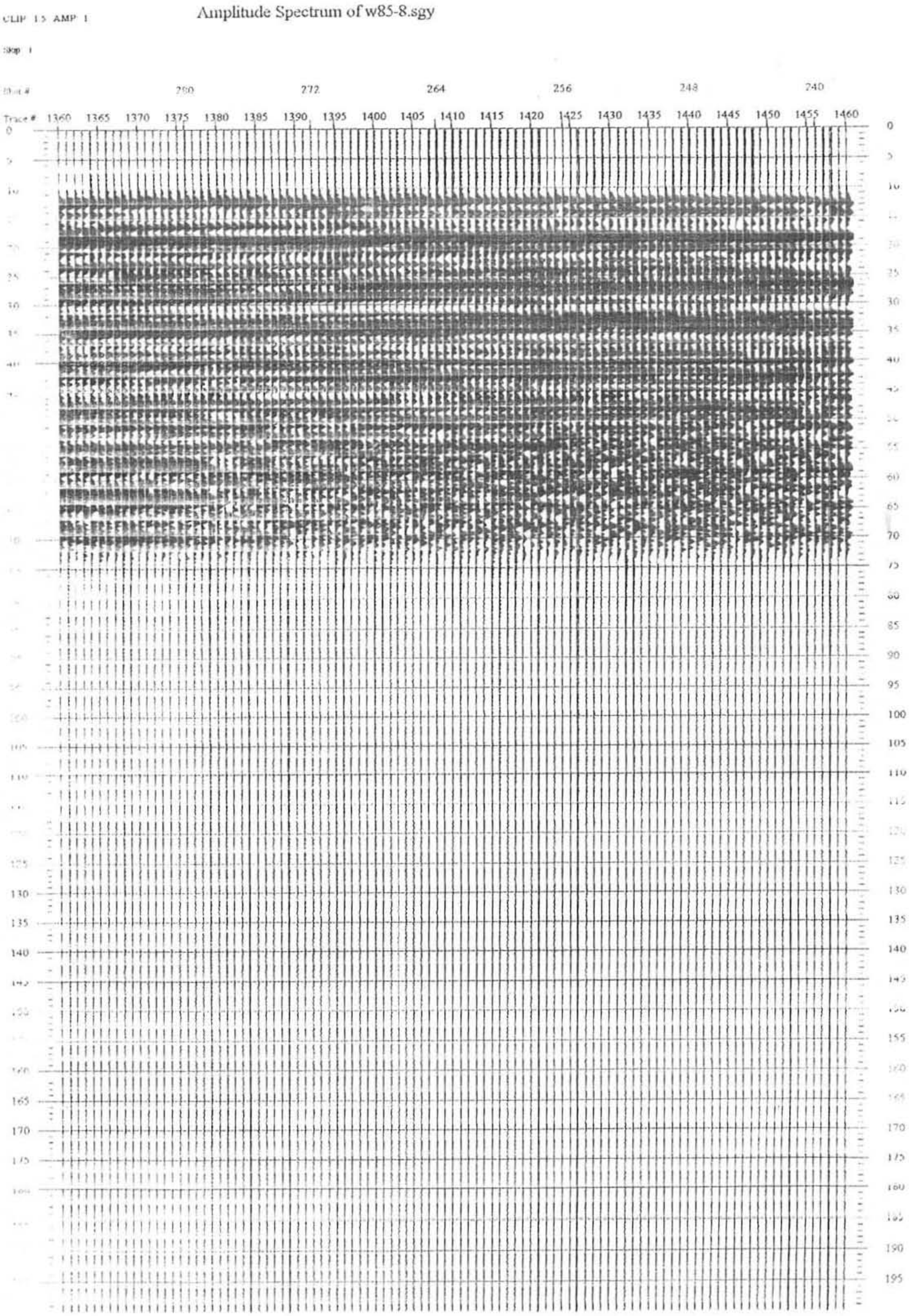


Figure 4.13 OPERATOR LENGTH=250ms PREWHITENING=2%