DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Marine Multichannel Seismic Reflection Profile

Line 13 Reprocessed

Cape Hatteras to Georges Bank

By R.A. Wise[1] and H.L. Oliver[2]

Open-File Report 89-572

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

[1] Cheyenne, Wyoming
[2] Denver, Colorado

1989

CONTENTS

ILLUSTRATIONS

TABLES

Marine Multichannel Seismic Reflection Profile Line 13 Reprocessed, Cape Hatteras to Georges Bank

By R.A. Wise

ABSTRACT

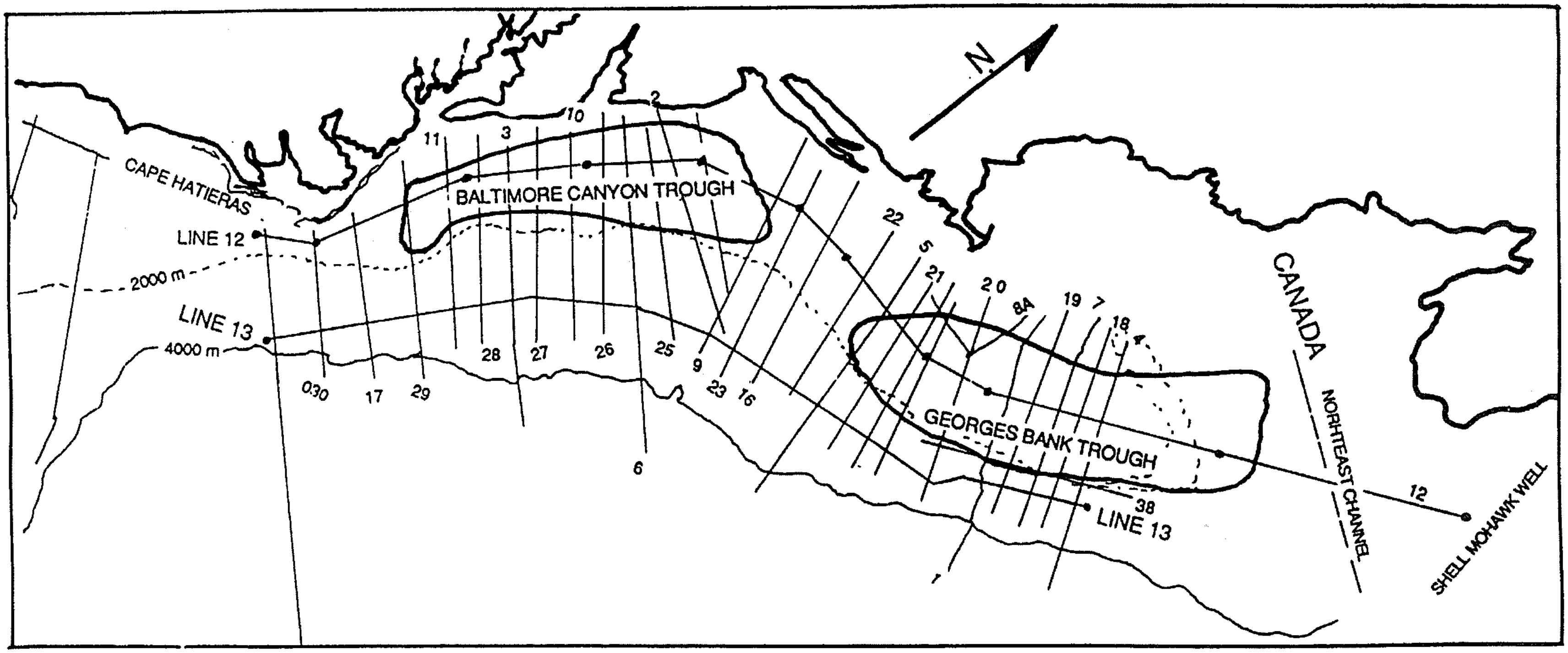
Marine multichannel seismic reflection profiles in their final presentation (stacked profiles) can present problems of concern to the scientist working with the data. Some of these problems are related to the acquisition and processing information labels that accompany the stacked profiles. The labels are supposed to contain the correct information as to how the data were collected and how the data were processed. It is necessary to be able to determine with some degree of certainty whether the labels are correct or not. Marine multichannel reflection profile Line 13 is an example of finding wrong information in the information labels of the original processed data and finding errors in the original processing of the data itself.

INTRODUCTION

U.S. Geological Survey marine multichannel seismic reflection profile Line 13 was collected in 1975 as part of a project to give the U.S.G.S. its first deep look at the arrangement of sedimentary rock layers in the mid to North Atlantic basins (fig. 1). Seismic reflection profile Line 13 is a regional strike profile that tracks from Cape Hatteras in the southwest to Georges Bank in the northeast along the continental slope in water depths greater than 2,500 meters. The data were collected by Digicon Inc. using their vessel, the Gulf Seal. The data were recorded using a DFS III system and 48-channel, 3,500 meter, nonlinear streamer. The streamer was divided into two parts. The nearest section of 24 hydrophones was spaced at 100-meter intervals. The second 24-channels were spaced at 50-meter intervals. These two different groupings were separated between channel 24 and 25 with a 75-meter interval. The final geometric configuration of the streamer and the source interval was designed for 36-fold processing. Data were recorded to 10 seconds using a system delay for a total length of up to 14 seconds, where necessary. Recording was done using a 2-millisecond sampling rate.

Reprocessing was done for the following reasons:

1. To eliminate multiples and data ringing that dominated the original profile causing unreliable primary reflections.
2. To reveal and enhance primary reflections that were not seen in the original processed profile or were highly contaminated by multiples, ringing or random noise.
3. To provide accurate velocity information along the profile.
4. To accurately tie intersection profiles.



ATLANTIC CONTINENTAL MARGIN

Figure 1.-- Location map.

OPERATIONAL PROBLEMS

The demultiplexing of marine seismic multichannel reflection profile Line 13 revealed several operational problems. These problems relate entirely to the original field tapes. The major problem with these field tapes is the problem of tape skew. This condition occurred during original recording of the data. Previously, experience with this problem (Open File Report 88-51) allowed us to improve on the number of shots lost, and to cut the amount of time necessary to complete the demultiplexing process. In this case, 25-30 percent of the time previously used was saved.

REPROCESSING

Reprocessing of marine seismic multichannel reflection profile Line 13 was done on a VAX-11-780 computer, using "Disco" (seismic software package provided by Digicon Geophysical Inc.). A standard processing sequence was used in reprocessing the data (table 1). After completing the reprocessing, the stacked profiles were compared with the original stacked profiles to determine the differences in quality and processing accuracy. Table 2 is the information label from the original processing. Several errors were found in the original information label. The most difficult error to correct relates to the filtering information. The original input parameters (Table 2) listed a first filter of 15 to 55 Hertz; however, it is doubtful that frequencies greater than 38 Hertz appear in the records. Figure 2 is a spectral analysis of a segment of original stacked data. The strongest frequencies seen are 13 to 30 Hertz followed by 31 through 38 Hertz. Table 1 shows the reprocessing filter parameters. Figure 3 is a spectral analysis of the same segment of the filtered reprocessed stack. Frequencies from 7 through 48 Hertz are well balanced and less than 12 db down in signal strength.

Figure 4 is the exact spectrum without deconvolution. Deconvolution is an important process that was not used during the original processing. This process not only attentuates multiples and data ring but also balances and enhances the frequency spectrum. Original stacked data have a low frequency appearance due to lack of deconvolution prior to the stacking. Errors in velocity information used in the original stacked data are the most serious of the errors found. Figure 5A is a common depth point (CDP) record without normal move-out (NMO) velocity correction. Figure 5B has the original NMO correction applied. The flatter the data, the more accurate the stack. Figures 6A through 6C are another set of CDP's from another part of the seismic profile showing again the NMO velocity analysis generated during reprocessing. The water-bottom sediment interface is at a time of 4.45 seconds with a velocity of 1,485 meters per second. Two velocity curves are shown (left side of figure 7). The curve connected by dots is the original velocity pick; the circles to the right show the stacking response to the original velocities input. Table 3 gives the velocities shown in figure 7 converted to depth. Errors in the original velocities exist throughout the entire profile. Figures 8 through 17 are examples of original stacked segments compared to reprocessed segments. Improvements result from deconvolution before stack, better filter choices, and accurate velocity information.

Table 1.--Reprocessing information: compare to table 2.

RECORDING PARAMETERS

RECORDED BY	DIGICON GEOPH.	DATE RECORDED	11-18-75
VESSEL	GULF SEAL	PARTY #	511
PRIMARY NAV.	SAT-LORAN-C	SECONDARY NAV.	
INSTRUMENT TYPE	DFS III	SAMPLE RATE	2.0 MS
# OF GUN ARRAYS	??	DEPTH OF GUNS	9.1 METERS
ARRAY WIDTH		# OF GUNS	?
TOT. GUN VOL.	1700 CU. INCHES	TYPE GAIN	BG
TAPE FORMAT	SEG-A 800 BPI	SYSTEM DELAY	VARIED
NO. OF CHANNELS	48	SOURCE INTERVAL	50.0 METERS
RECORD LENGTH	10 SECONDS	STREAMER	NON-LINEAR
TRACE INTERVAL	48 TO 25=100 METERS 25 TO 24=75 METERS 24 TO 1=50 METERS		
RECORD FILTER		CABLE TYPE	48T COLD:
LOCUT	8.0 HZ.	POSITIONING	SAT/SONAR
SLOPE	18 DB/OCTAVE	LINE STARTS AT	SOUTHWEST.
HICUT	124 HZ.	NEAR TRACE #	48
SLOPE	72 DB/OCTAVE	FOLD	36
60 HZ NOTCH	OUT		

SPREAD CONFIGURATION:

```
SHIP      SOURCE      TR-48                                                TR-1
 <>         *         +--------------------------------------------------------+
<52.4><--347.5M-->    <----------------------3500 M ------------------------->
 (SP'S 1127-083)
```

PROCESSING SEQUENCE

1 DEMULTIPLEX
2 RECORDING GAIN REMOVAL
3 GEOMETRY DEFINITION
4 TRACE EDITING
5 RESAMPLE TO 4.0 MS
6 COMPRESS TO 36 TRACE 100 METER RECORDS
7 CDP SORT 36 FOLD
8 VELOCITY ANALYSIS
9 AUTOMATIC GAIN CONTROL
   GATE LENGTH: 1000 MS
10 PRE-STACK DECONVOLUTION
   TYPE : SPIKING
   OPERATOR LENGTH: 81 POINTS
   TIME WINDOW : 4600-8000
   TYPE: SPIKING
   OPERATOR LENGTH: 81 POINTS
   TIME WINDOW : 7000-14000
11 NORMAL MOVEOUT CORRECTION
12 FIRST BREAK NOISE SUPPRESSION (MUTE)
13 STACK 36 FOLD
14 POST-STACK DECONVOLUTION
   TYPE : 2ND ZERO CROSSING
   OPERATOR LENGTH: 41 POINTS
   TIME WINDOW : 4275-6000
   TYPE : 2ND ZERO CROSSING
   OPERATOR LENGTH: 41 POINTS
   TIME WINDOW : 5500-8500
   TYPE : 2ND ZERO CROSSING
   OPERATOR LENGTH: 41 POINTS
   TIME WINDOW : 8500-12000
15 BANDPASS FILTER

TIME:	BANDPASS:
4000-5500 MS	8:10 - 40:45
6500-7500 MS	4:8 - 30:40
8500-14000 MS	3:5 - 20:30

16 MUTE ALONG WATER BOTTOM
17 DISPLAY
   SHOT POINTS ADJUSTED TO ACTUAL ANTENNA POSITION

Table 2.--Original information label from Line 13. Note in processing sequence there is no deconvolution before stack. Note #7:36-fold stack; this is incorrect as original computer records indicate data was stacked 48-fold. Note recording parameters: the shot interval is 50 meters, not 100 meters as shown. The geophone interval is both 100 and 50 meter intervals. Information on this label is wrong in many entries.

AREA ATLANTIC OFFSHORE

FOR MAR GEO WOODS HOLE

BY U.S. GEOLOGICAL SURVEY
BR. OF OIL + GAS - DENVER

JOB NUMBER 13000
DATE 011977

PROC. ON THE PHOENIX I

PROCESSING SEQUENCE

1 DEMULTIPLEX-EDIT-SUM
__ VIBROSEIS CORRELATION
2 VELOCITY ANALYSIS
3 NORMAL MOVEOUT
__ DATUM STATICS
__ AUTOMATIC STATICS
7 STACK 36 FOLD
8 DECONVOLUTION
5 FILTER
4 TRACE EQUALIZATION

X ADDITIONAL PROCESSING
9 TV-FILTER
10 AGC 11 SEC)
6 DISTANCE WEIGHT

PROCESSING PARAMETERS

CORRECTIONS

DATUM SEA LEVEL
VE ______ VW ______
AUTOMATIC STATICS WINDOW ______ TO ______ SEC
ADDITIONAL DEEP WATER DELAY APPLIED

	LENGTH (MS)	WINDOW (SEC)	PREDICTION (MS)
DECONVOLUTION BEFORE STACK			
DECONVOLUTION AFTER STACK	240	4.0-7.0	50

	BAND PASS	APPL. (SEC)	OVERLAP (SEC)
BAND PASS FILTERS	15-55HZ	0.0-5.0	.5
	10-40HZ	5.0-8.0	.5
	6-25HZ	8.0-14.0	

SAMPLE RATE 4 MS
ONE INCH 24 TRACES
ONE SECOND 2.5 INCHES
PLAYBACK GAIN 9 DB DB
MEAN VALUE 7200

RECORDING PARAMETERS

RECORDED BY DIGICON INC.
CONTRACT ______ PARTY 511 DATE RECORDED 11-75
SP/VP INTERVAL 100M INSTRUMENT TYPE DFSIII
GEOPHONE INTERVAL 100M AMPLIFIERS B.G.
NEAR OFFSET 340M RECORDING FILTER 8-124
FAR OFFSET 5140M SAMPLE RATE 2MS
NUMBER TRACES 48 RECORD LENGTH 10SEC
CONFIGURATION ______ SWEEP LENGTH ______
PROGRESSION SE-NW SWEEP FREQUENCY ______
GEOPHONES/TRACE ______ NUMBER SWEEPS ______

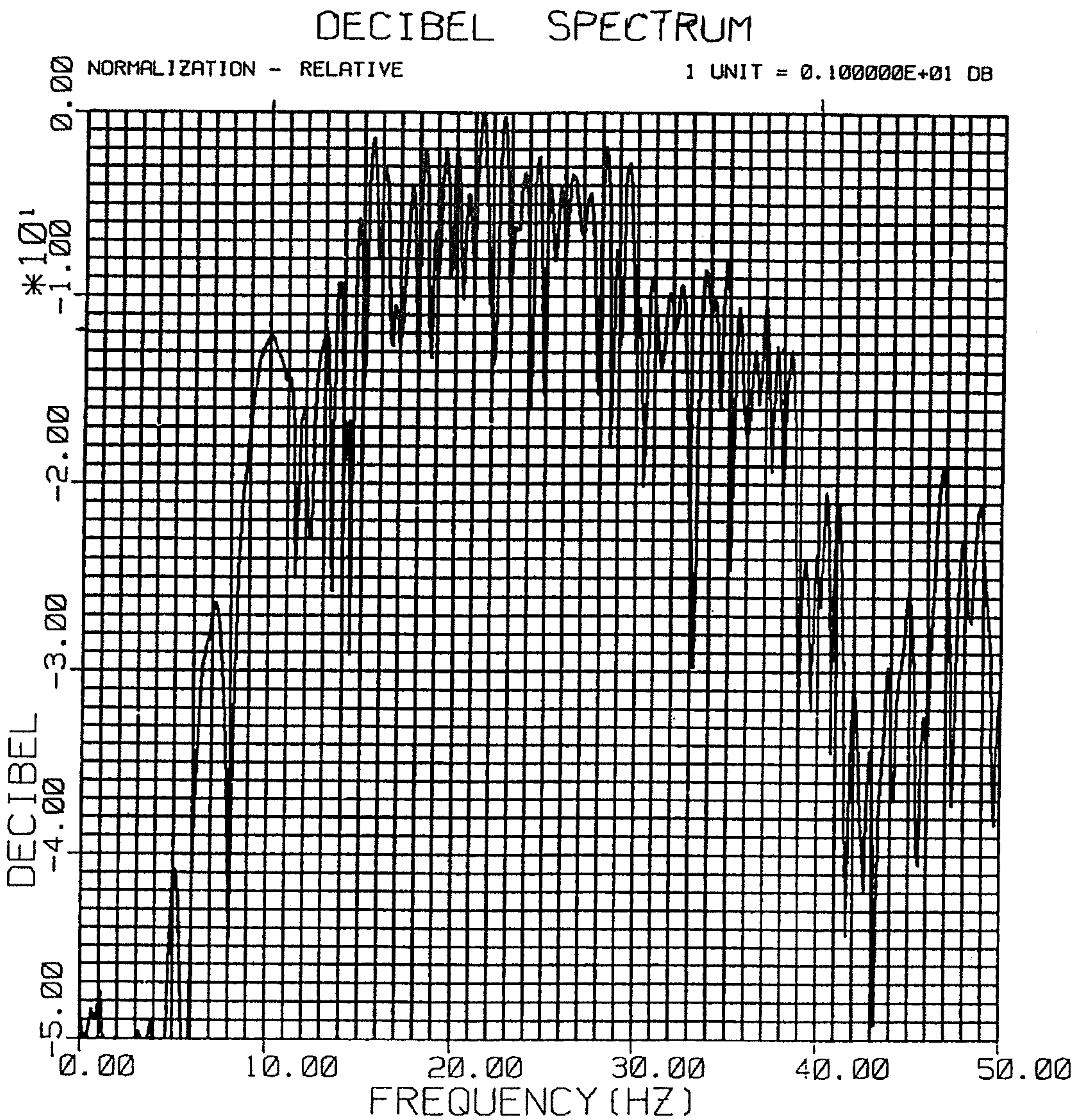


Figure 2.--Frequency spectrum of original data. Note how information label lists the first filter 15 to 55 hertz. It is doubtful that frequencies greater than 38 hertz will visually exist.

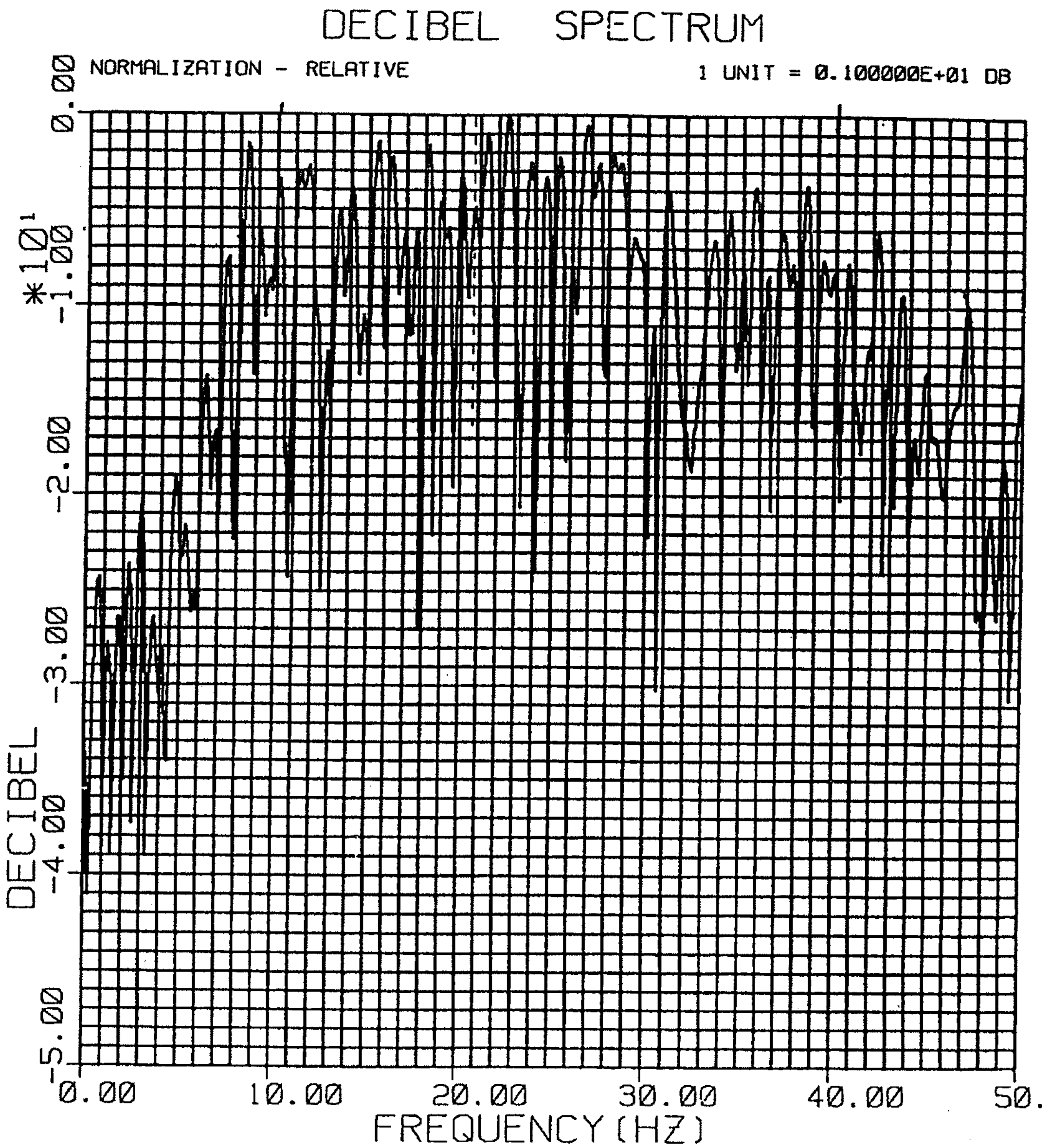


Figure 3.--Frequency spectrum of reprocessed data. Note how well balanced the spectrum is. Frequencies from 7 hertz through 47 hertz will be visually seen. This figure is taken at the same data location as figure 2.

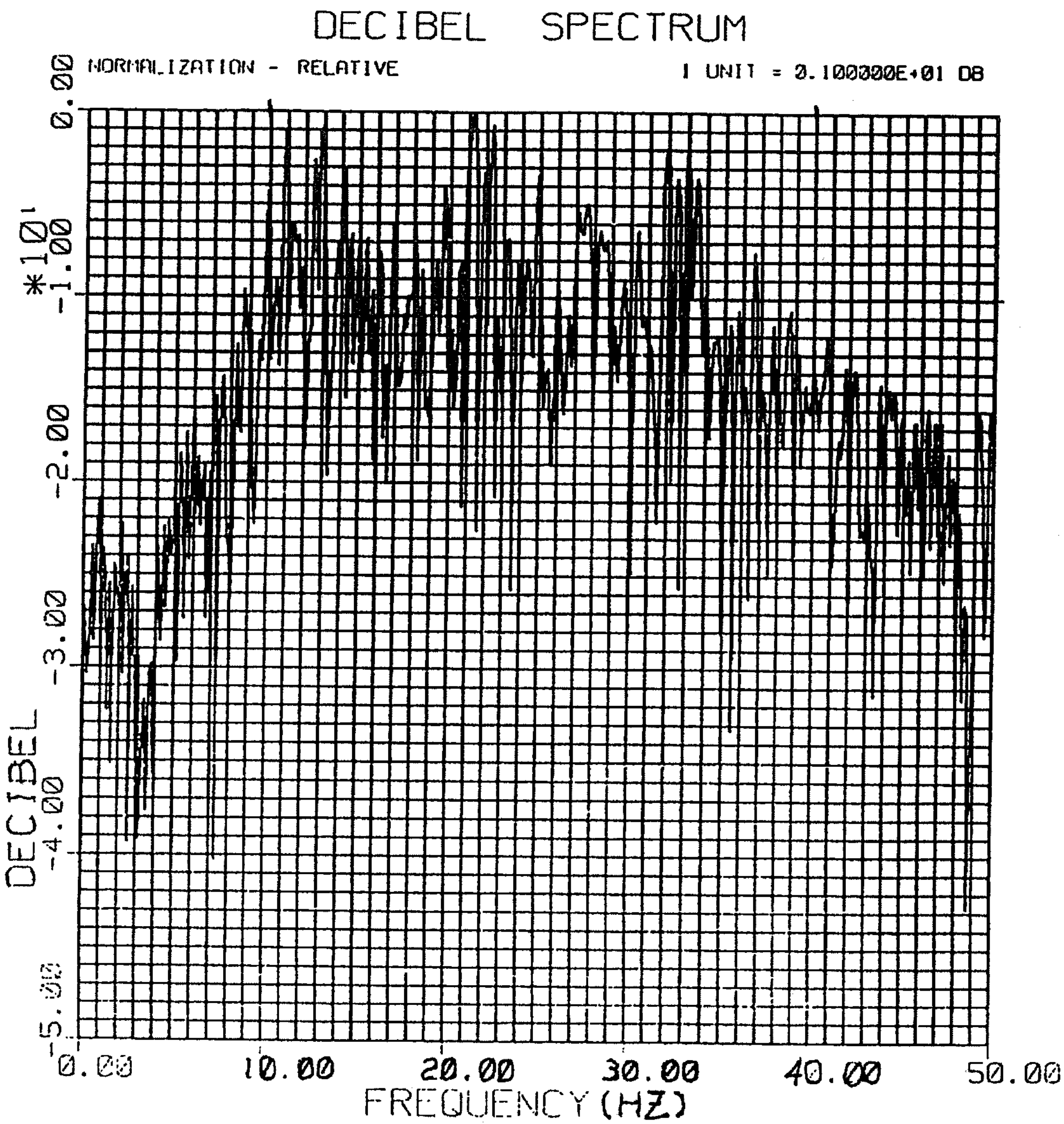


Figure 4.--This figure is exactly the same as figure 3 with the exception of no deconvolution applied. Note the difference in the balance of the spectrum.

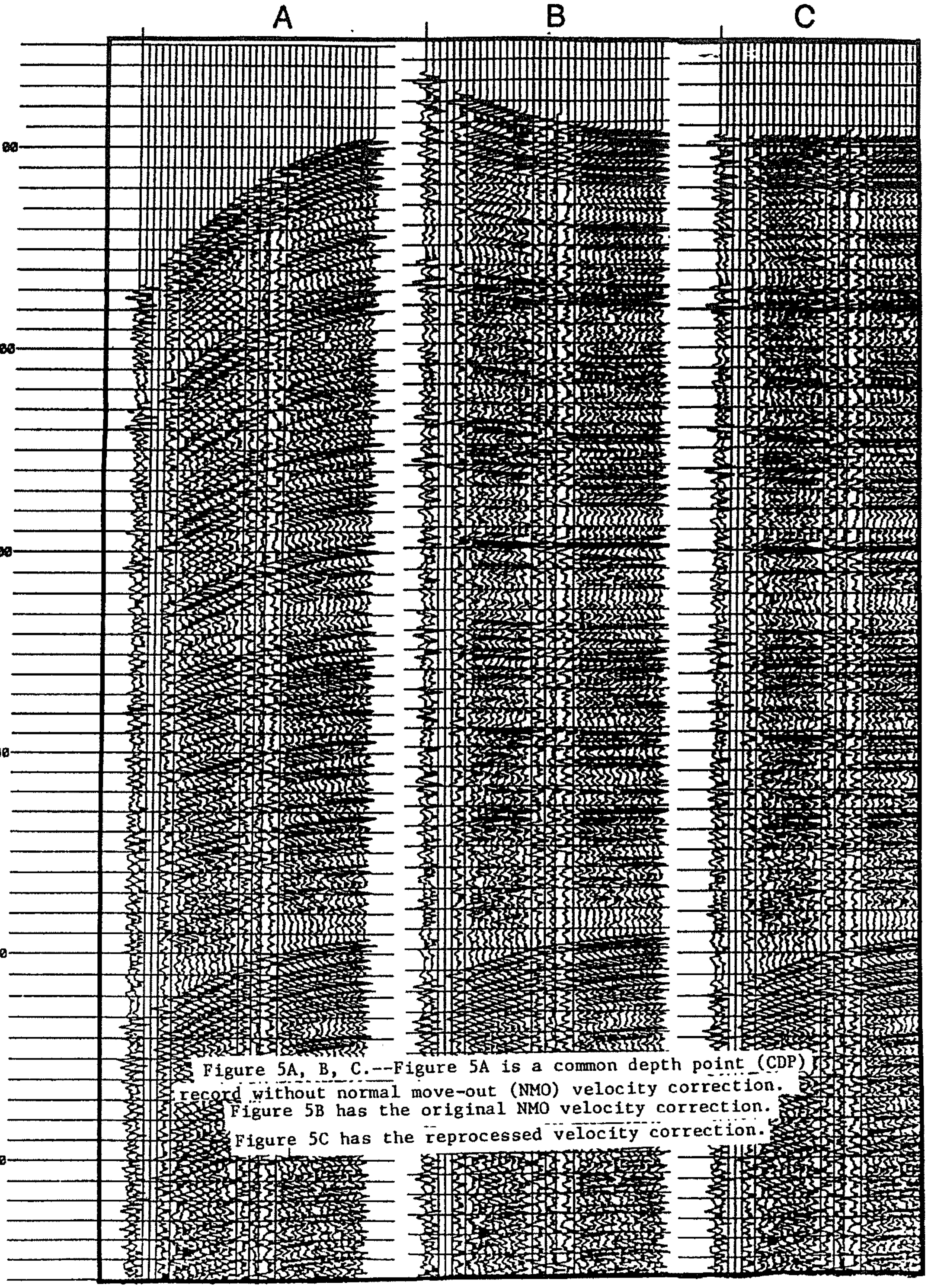


Figure 5A, B, C.--Figure 5A is a common depth point (CDP) record without normal move-out (NMO) velocity correction. Figure 5B has the original NMO velocity correction. Figure 5C has the reprocessed velocity correction.

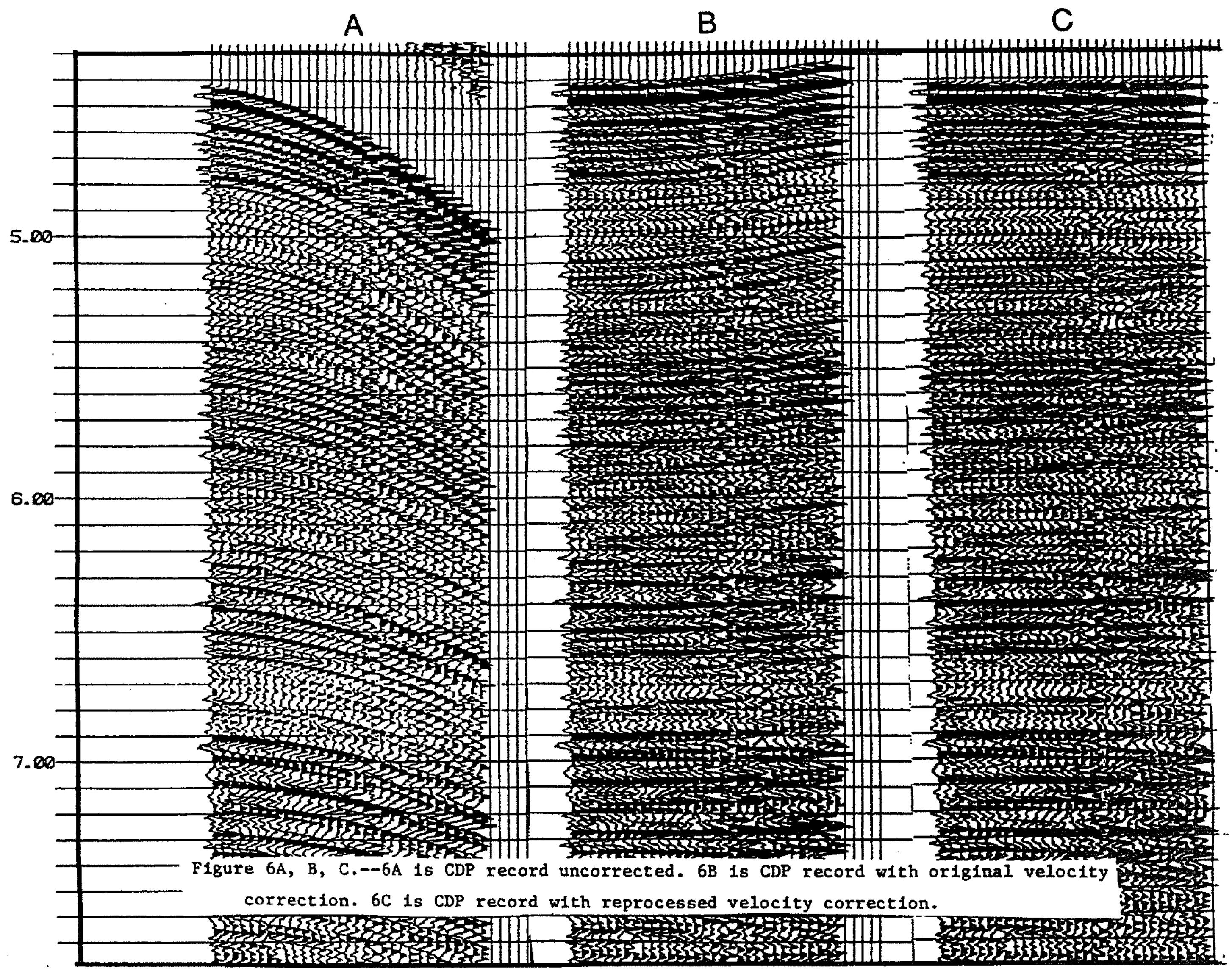


Figure 6A, B, C.--6A is CDP record uncorrected. 6B is CDP record with original velocity correction. 6C is CDP record with reprocessed velocity correction.

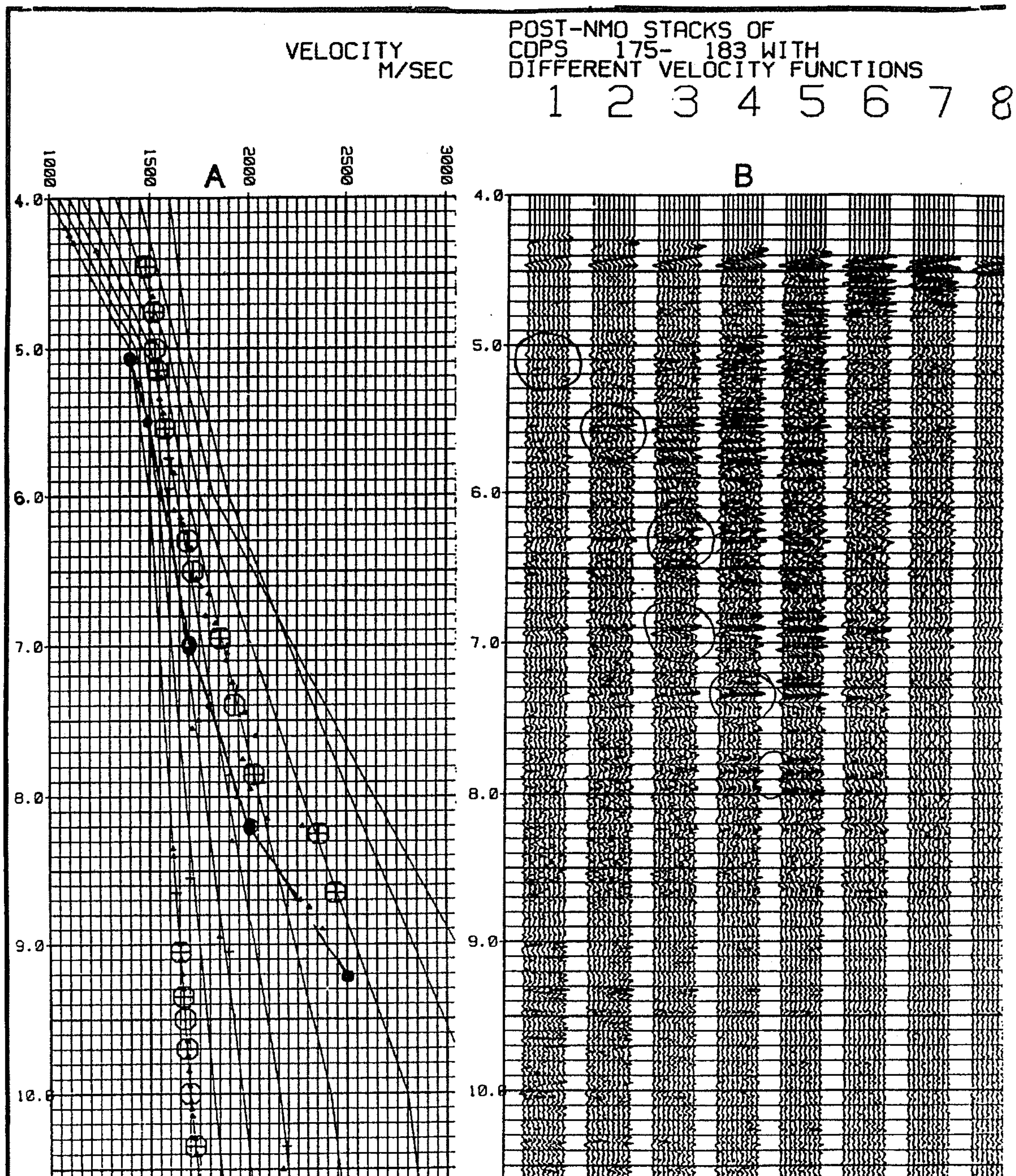


Figure 7A, B.--7A is the velocity analysis showing curve of original velocities (dotted line) versus correct picks octogons. 7B are stacked traces of the velocity functions from figure 7A. Circles are where the original velocities will fall and the stacking response.

Table 3.--A comparison of the velocities from figure 7A converted to depth

Original processing velocities		Reprocessed velocities		Original velocities converted to depth (m)	Reprocessed velocities converted to depth (m)	Difference in depths (m)
5.1	1400	WB 4.45	1480	3570	3304	+266
		5.00	1530	---	---	---
5.5	1500	5.50	1575	4058	3814	-124
6.3	1610	6.3	1690	4947	5244	-267
6.95	1700	6.95	1855	5728	6225	-497
7.85	1900	7.85	2030	7091	7602	-511

The true waterbottom interface is at 4.45 seconds. Reprocessed velocities are very accurate. Original velocities for the entire profile are in error.

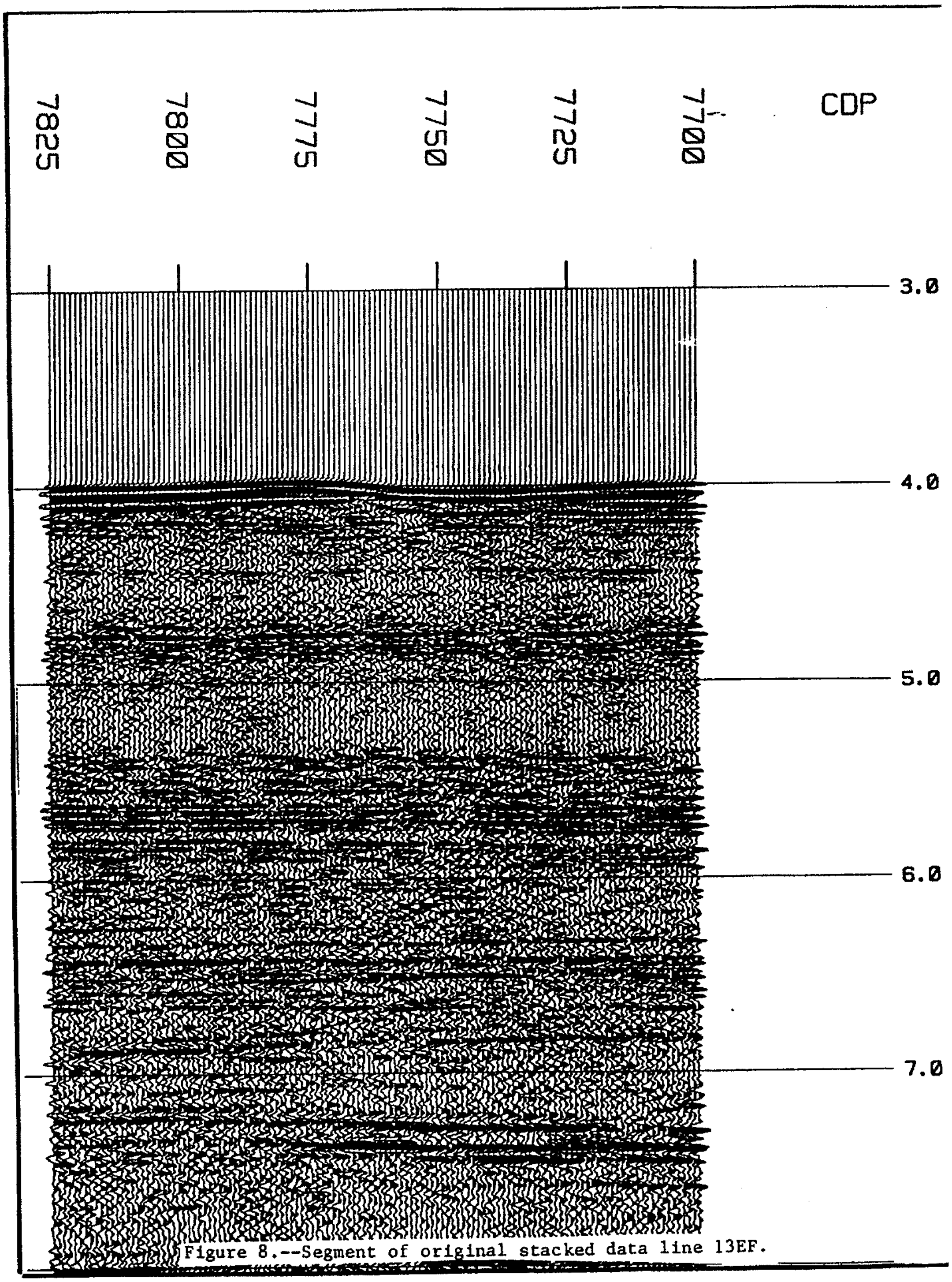


Figure 8.--Segment of original stacked data line 13EF.

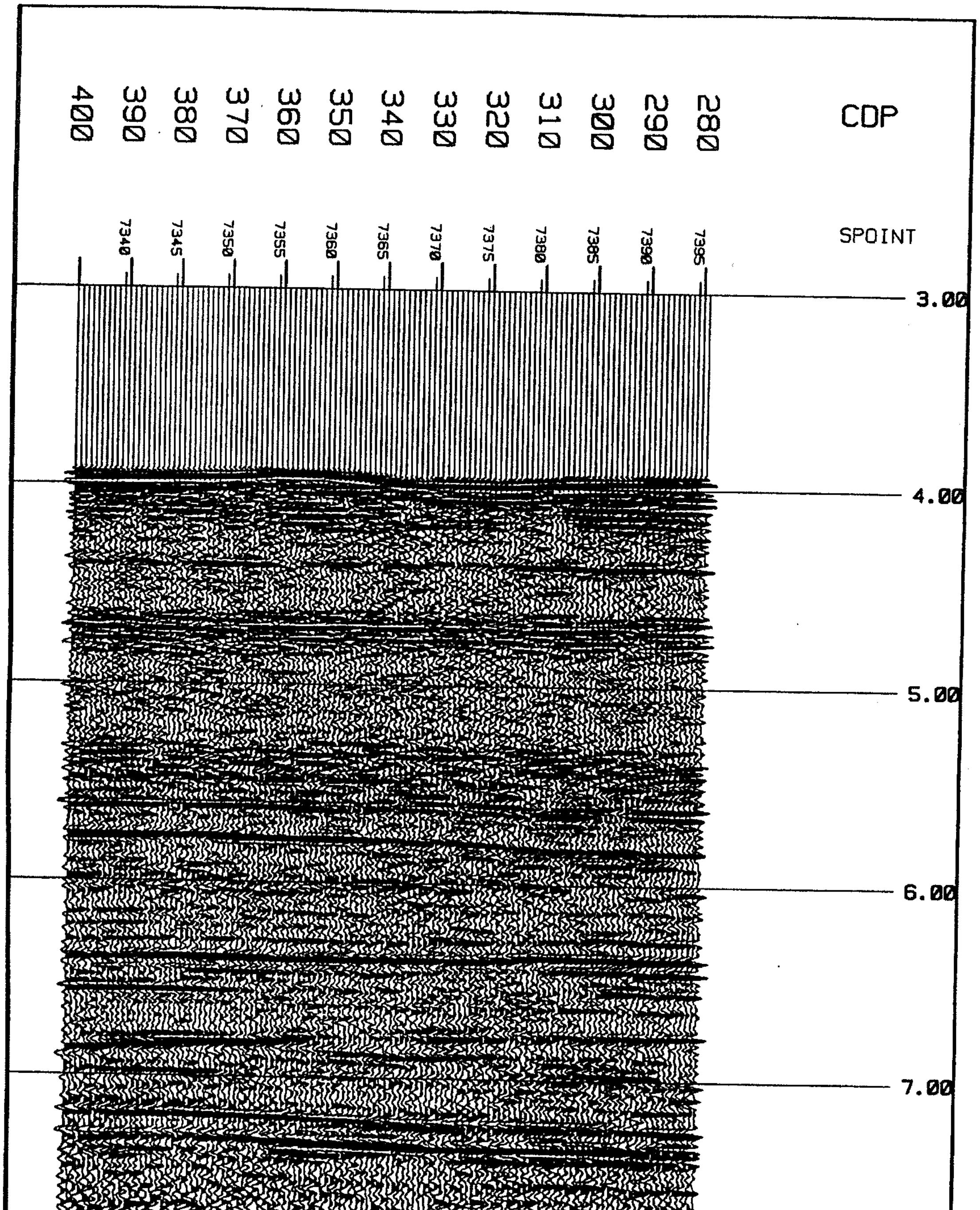


Figure 9.--Same as figure 8 after reprocessing. Overall quality is excellent due to deconvolution before stack, and improved velocity analysis.

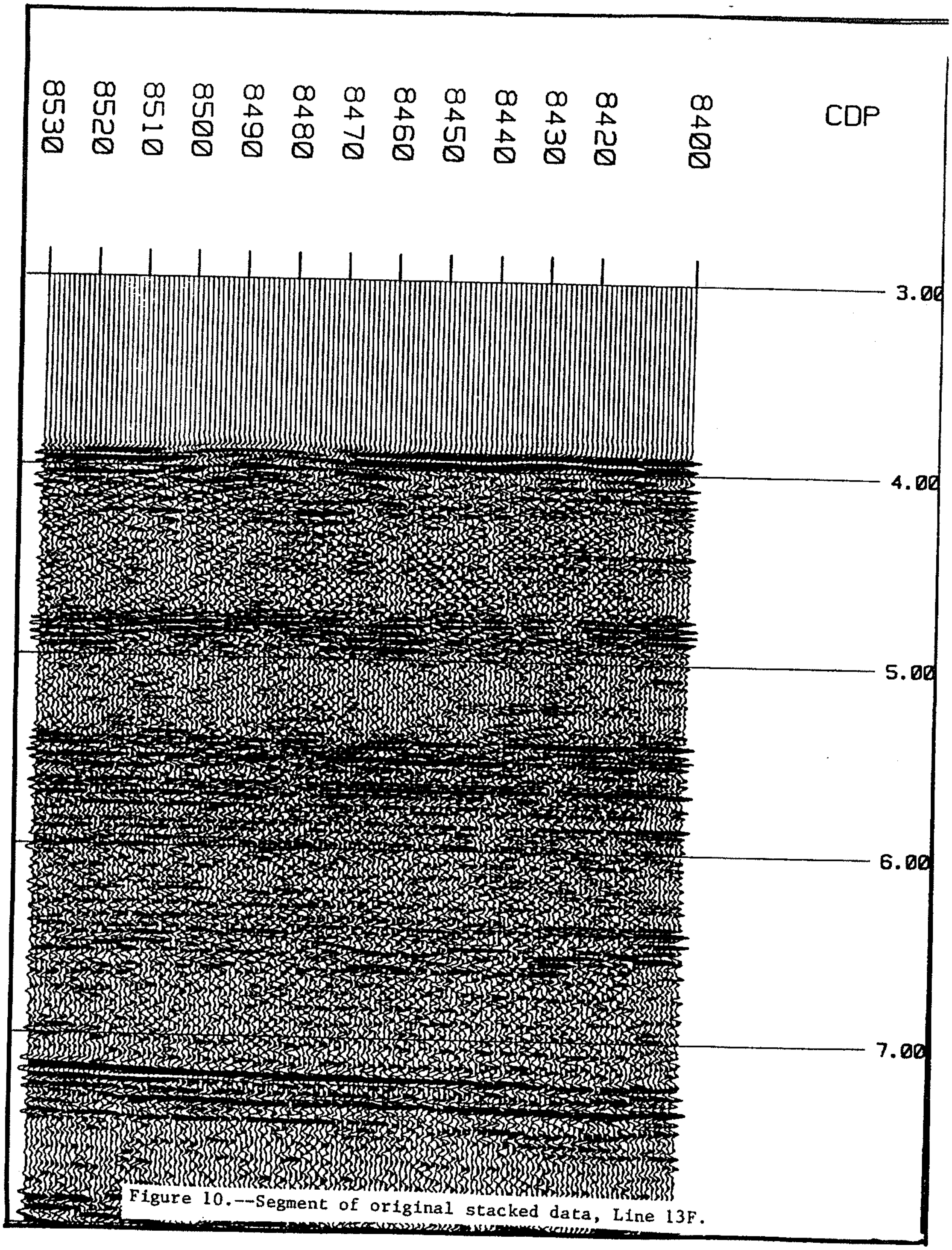


Figure 10.--Segment of original stacked data, Line 13F.

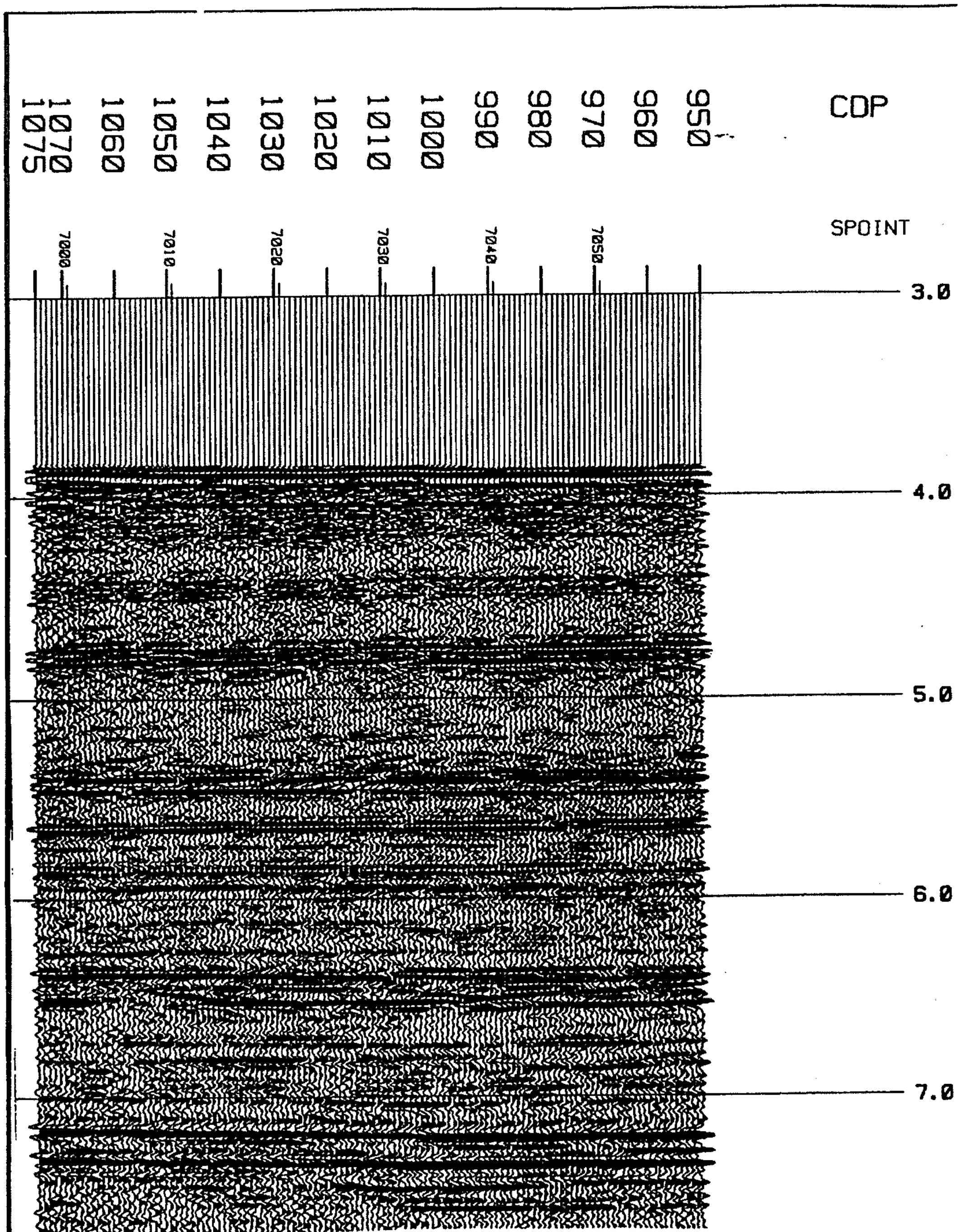


Figure 11.--Same as figure 10. Excellent improvement due to deconvolution before stack and improved velocity analysis.

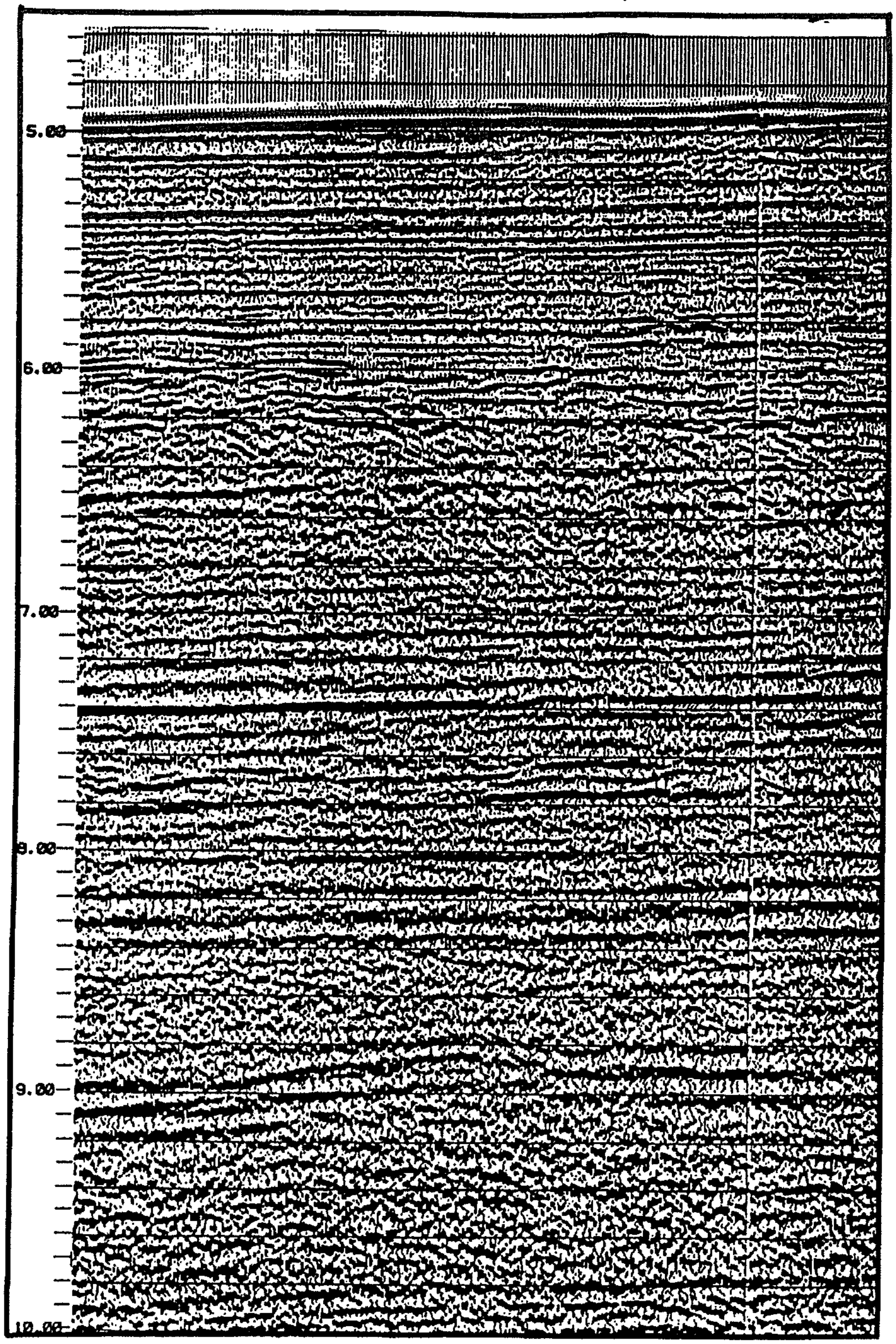


Figure 12.--Original stacked segment from 13A, the most southern part of the profile.

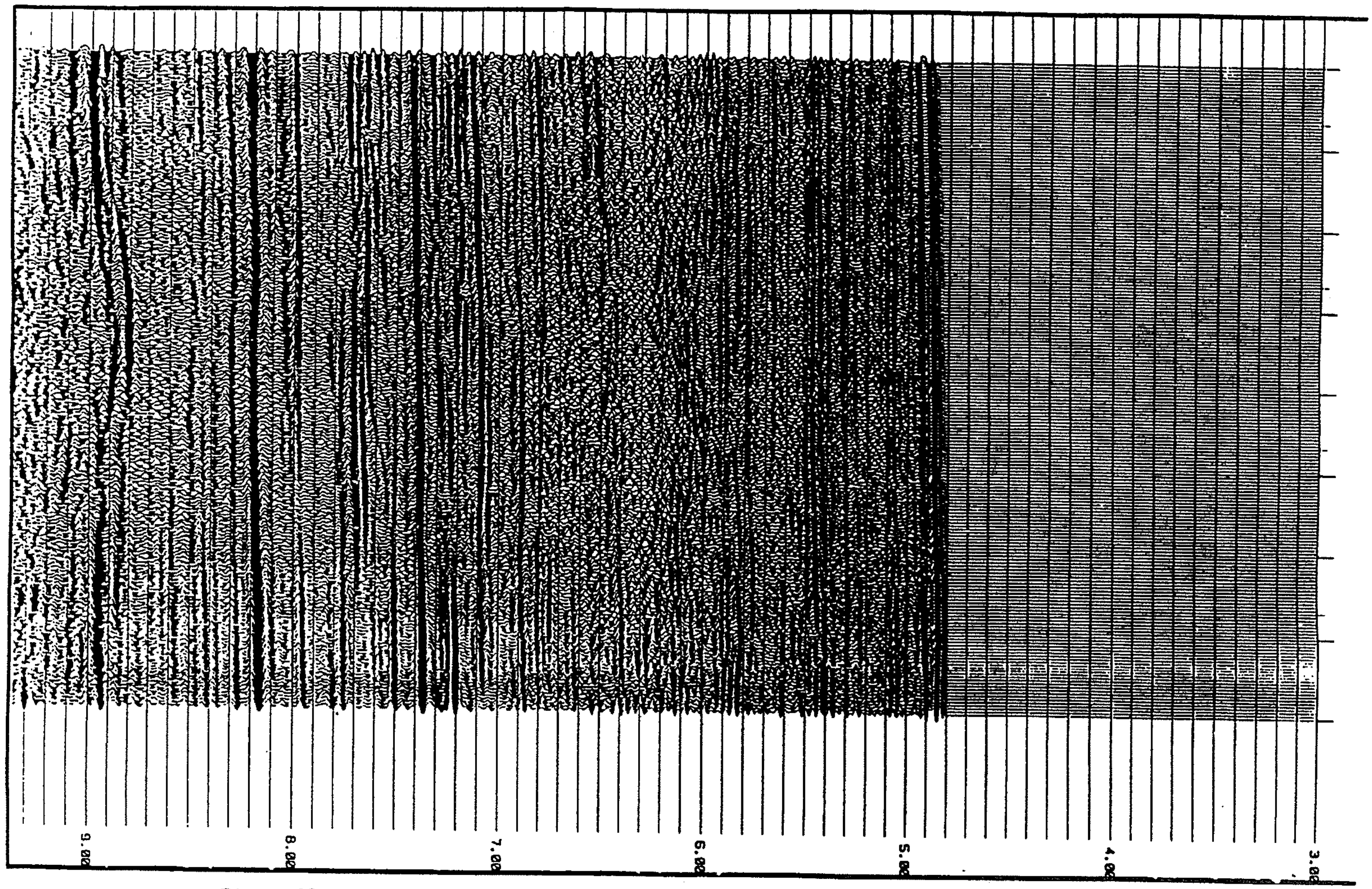


Figure 13.--Same as figure 12 after reprocessing. Overall improvement is due to deconvolution before stack and accurate regenerated velocity analysis.

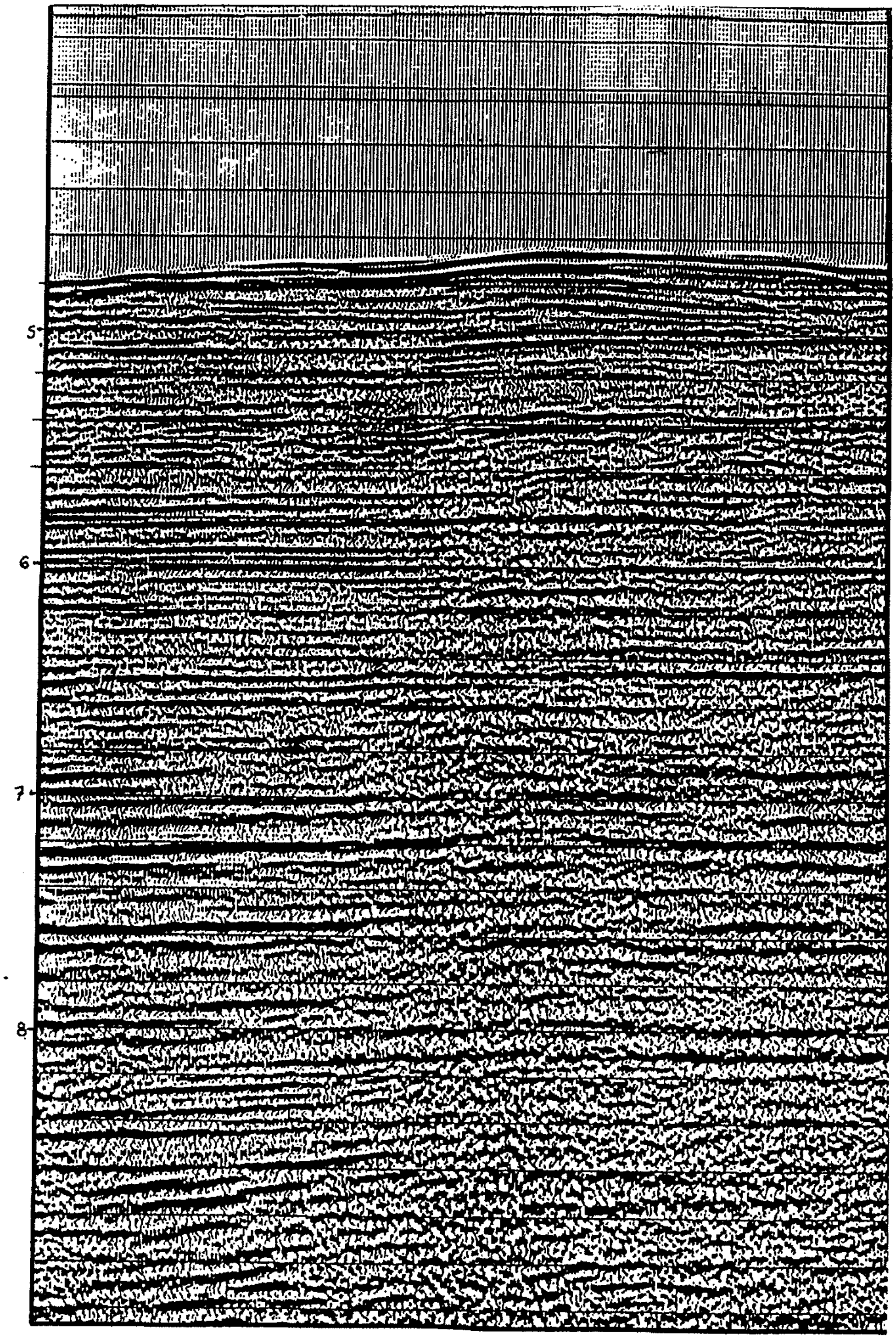


Figure 14.--Original stacked segment from middle of profile Line 13A.

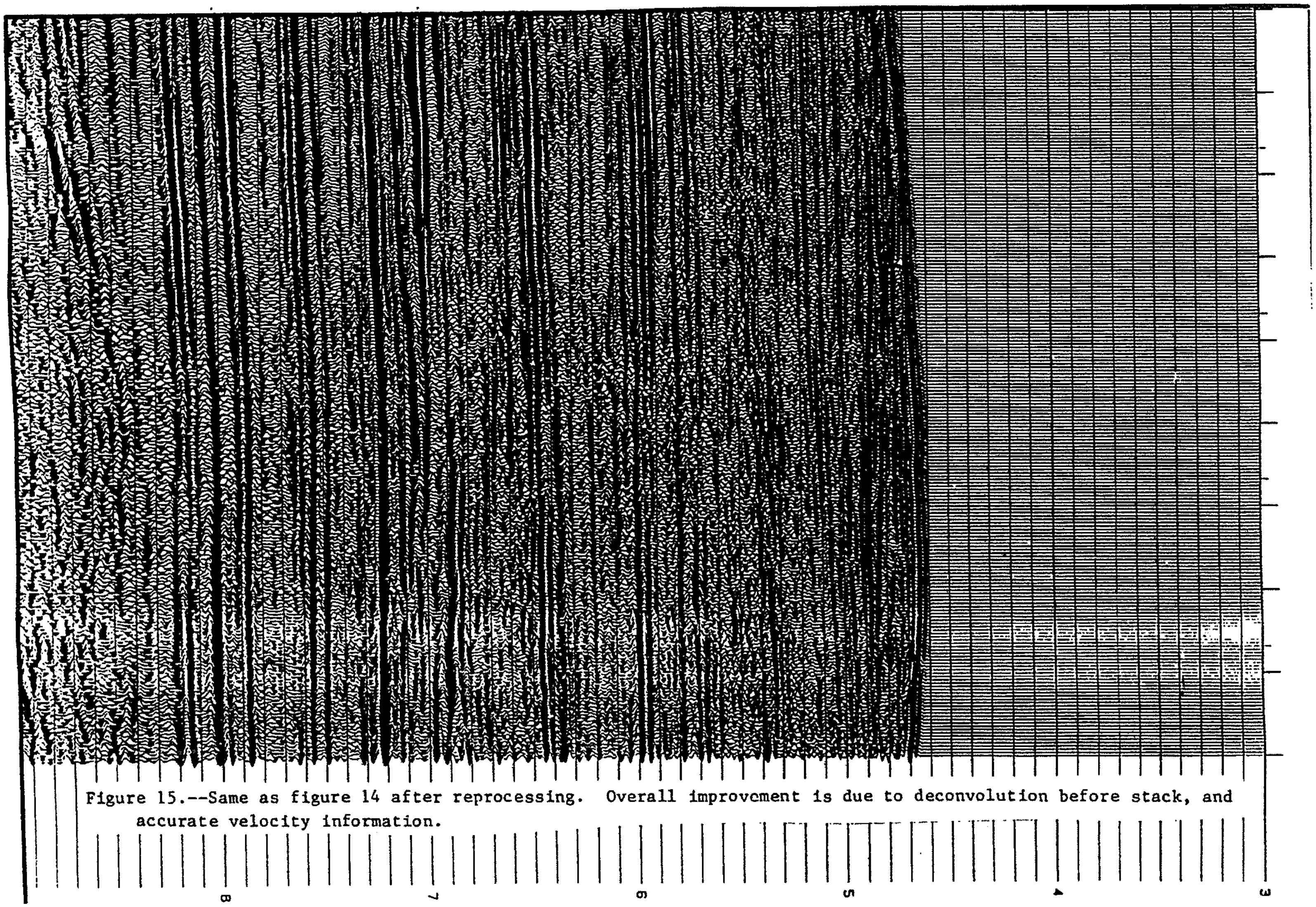
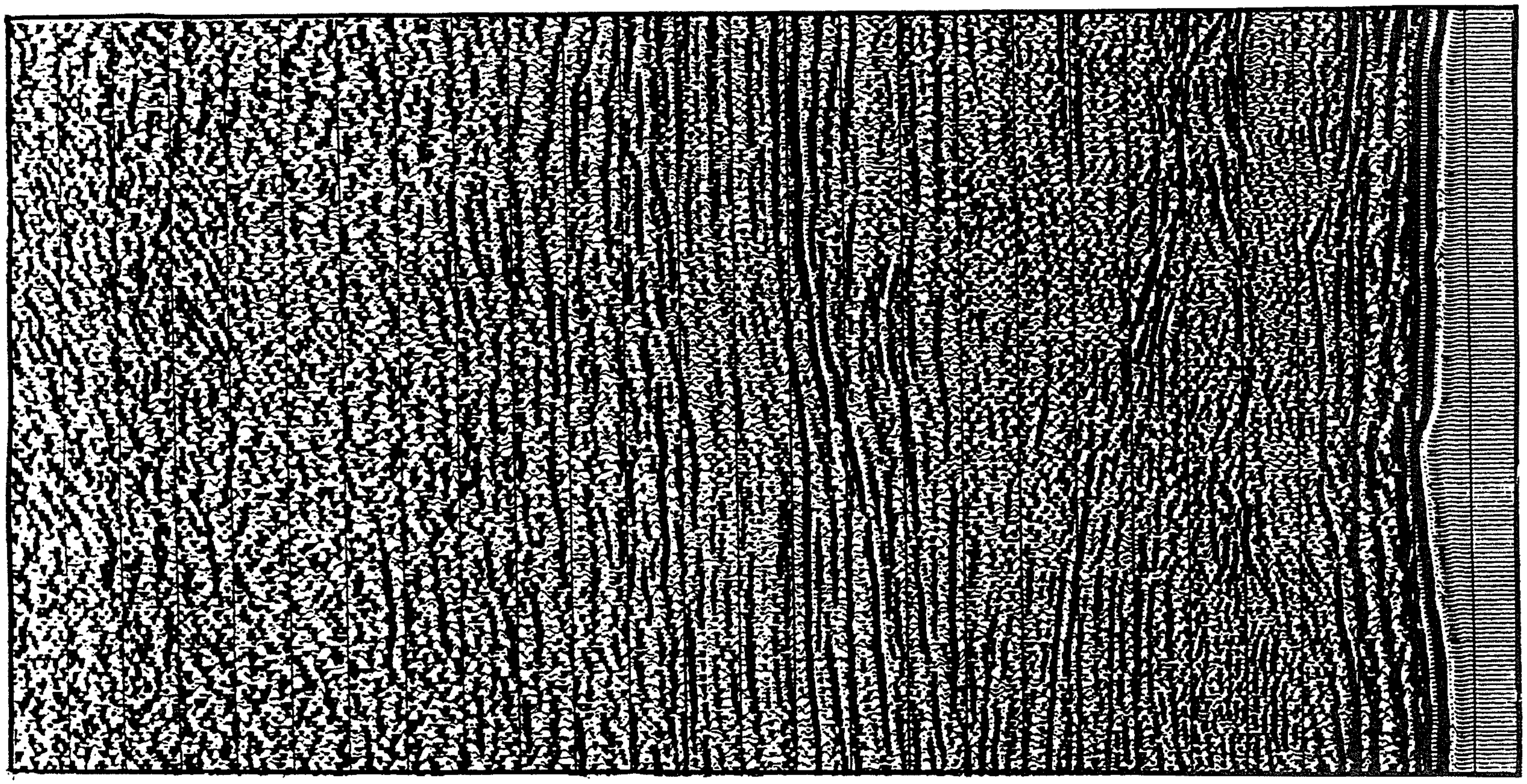


Figure 15.--Same as figure 14 after reprocessing. Overall improvement is due to deconvolution before stack, and accurate velocity information.

Figure 16.--Original stacked segment from the most southeastern segment of profile 13H.



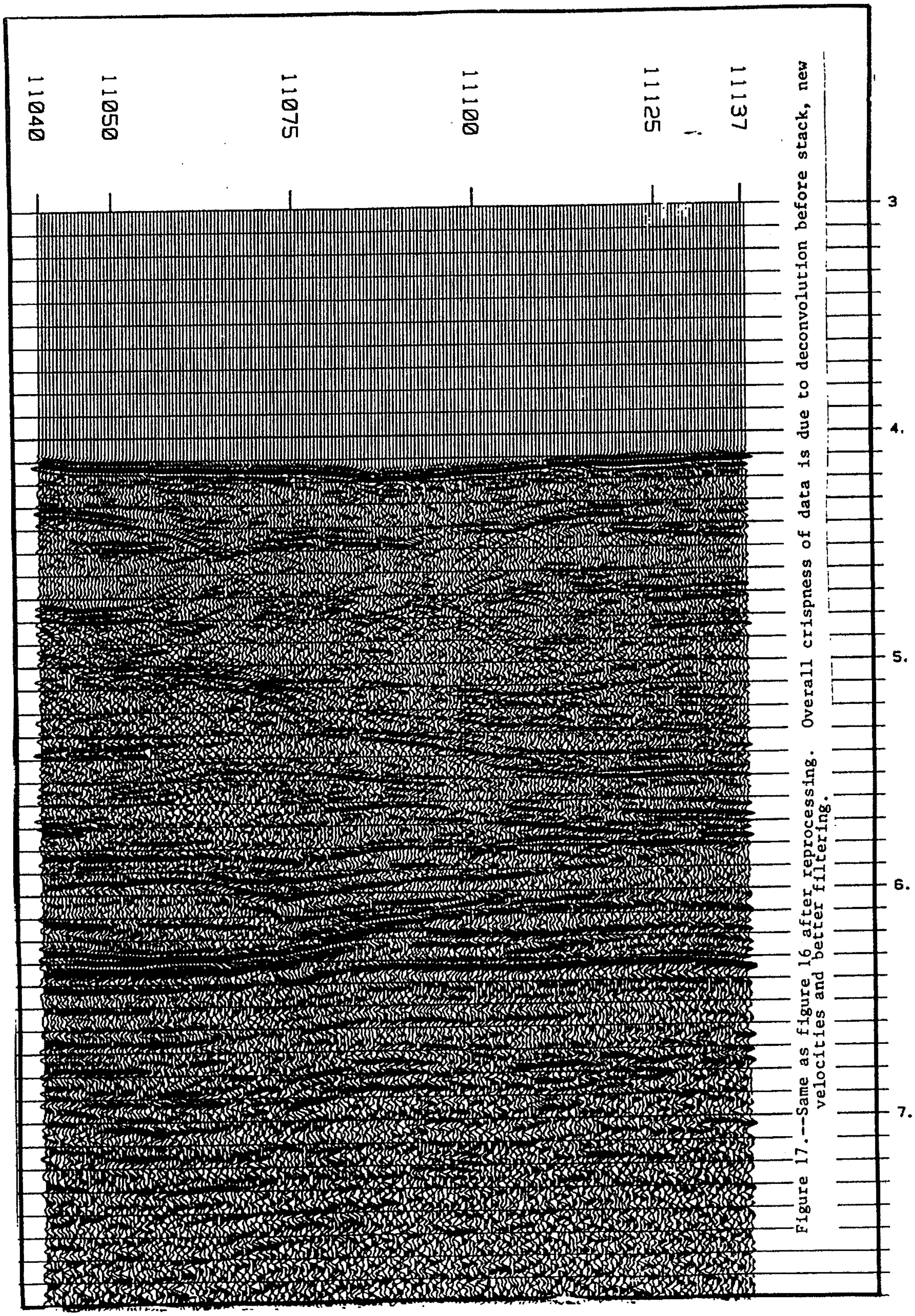


Figure 17.--Same as figure 16 after reprocessing. Overall crispness of data is due to deconvolution before stack, new velocities and better filtering.

CONCLUSIONS

Multichannel seismic reflection profile Line 13 was substantially improved through reprocessing. Errors found in the original processing were corrected during the reprocessing. Accurate velocity information was applied to the reprocessed data. The original velocity work was inaccurate throughout the profile. As depth conversion is based on accurate velocity information, it is extremely important to obtain the best possible velocity information. Deconvolution before stack, a very important pre-stack process, was not used during the original processing. By not using this process, the original data were affected in several ways. Original data lacked high frequencies. If the original data had been deconvolved before stack (spiked and whitened), the higher frequencies would have been balanced and preserved. More structure is visible in the reprocessed data due to the process of weighting the stack (giving more power to the farther traces in the CDP). With bad velocity input (see figure 5), the far traces can cause timing errors and create false structure. Tremendous improvements were realized during reprocessing resulting in increased information and accuracy in the seismic profile.

It is suggested that data processed prior to 1980 be thoroughly checked for accurate velocity analysis and proper processing procedure. Seismic profile Line 13 is a prime example of the types of problems that develop when seismic data are processed incorrectly.