

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Marine Multichannel Seismic Reflection Profile

Line 13 Reprocessed

Cape Hatteras to Georges Bank

By R.A. Wise¹ and H.L. Oliver²

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.

¹Cheyenne, Wyoming
²Denver, Colorado

CONTENTS

	Page
Abstract.....	1
Introduction.....	1
Operational problems.....	3
Reprocessing.....	3
Conclusions.....	23
Recommendations.....	23

ILLUSTRATIONS

Figure 1. Location map.....	2
2. Frequency spectrum of original data.....	6
3. Frequency spectrum of reprocessed data.....	7
4. Same as figure 3 with no deconvolution applied.....	8
5A,B,C. 5A is a common depth point (CDP) record without normal move-out (NMO) velocity correction. 5B has the original NMO velocity correction. 5C has the reprocessed velocity correction.....	9
6A,B,C. 6A is CDP record uncorrected. 6B is CDP record with original velocity correction. 6C is CDP record with reprocessed velocity correction.....	10
7A,B. 7A is velocity analysis showing curve of original velocities versus correct pick octagons. 7B is stacked traces of the velocity functions from figure 7A.....	11
8. Segment of original stacked data, Line 13EF.....	13
9. Same as figure 8 after reprocessing.....	14
10. Segment of original stacked data, Line 13F.....	15
11. Same as figure 10 after reprocessing.....	16
12. Original stacked segment from 13A, southern part of profile.....	17
13. Same as figure 12 after reprocessing.....	18
14. Original stacked segment from middle of profile Line 13A...	19
15. Same as figure 14 after reprocessing.....	20
16. Original stacked segment from the southeasternmost segment profile 13H.....	21
17. Same as figure 16 after reprocessing.....	22

TABLES

Table 1. Reprocessing information: compare to table 2.....	4
2. Original information label from line 13.....	5
3. A comparison of the velocities from figure 7A converted to depth.....	12

Marine Multichannel Seismic Reflection Profile Line 13 Reprocessed,

Cape Hatteras to Georges Bank

By R.A. Wise

ABSTRACT

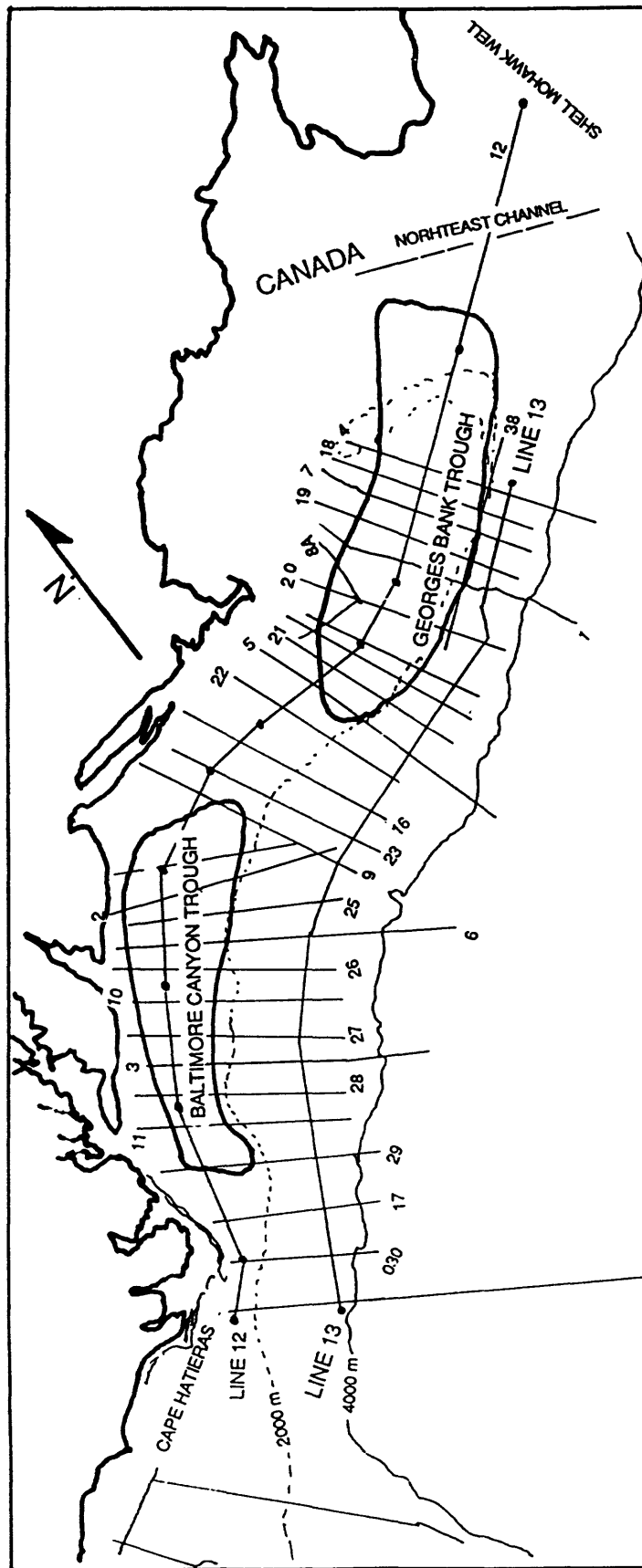
Marine multichannel seismic reflection profiles in their final presentation (stacked profiles) can present problems of concern to the scientist working with the data. Some of these problems are related to the acquisition and processing information labels that accompany the stacked profiles. The labels 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 attenuates 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.

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: 77	DEPTH OF GUNS : 9.1 METERS
ARRAY WIDTH : 1700 CU. INCHES	# OF GUNS : 7
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
◁	*	←-----	→
		3500 M	
(S2.4) <--347.5M--> (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 1.--Reprocessing information: compare to table 2.

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 X ADDITIONAL PROCESSING
— VIBROSEIS CORRELATION 9 TV-FILTER
2 VELOCITY ANALYSIS 10 AGC 11 SEC
3 NORMAL MOVEOUT 6 DISTANCE WEIGHT
— DATUM STATICS
— AUTOMATIC STATICS
7 STACK 36 FOLD
8 DECONVOLUTION
9 FILTER
4 TRACE EQUALIZATION

PROCESSING PARAMETERS

CORRECTIONS

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

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

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

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 DESEIL
GEOPHONE INTERVAL 100M AMPLIFIERS 8.6
NEAR OFFSET 340M RECORDING FILTER 8-124
FAR OFFSET 340M SAMPLE RATE 205
NUMBER TRACES 40 RECORD LENGTH 10SEC
CONFIGURATION SWEEP LENGTH
PROGRESSION SE-NH SWEEP FREQUENCY
GEOPHONES/TRACE NUMBER SWEEPS

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.

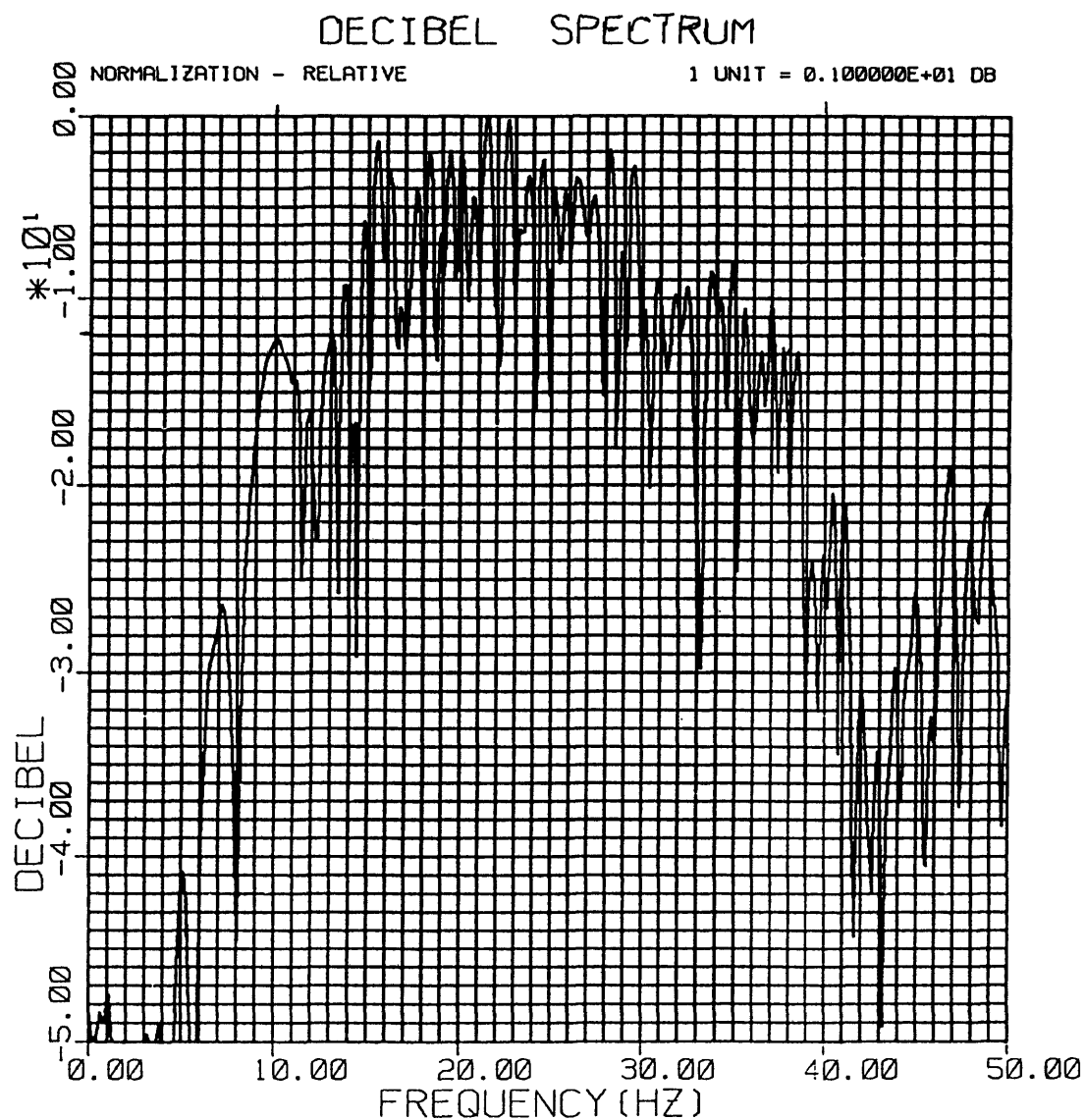


Figure 2.--Frequency spectrum of original data. Note how information label lists the first filter 15 to 55 hertz. It is doubtful that frequencies greater than 38 hertz will visually exist.

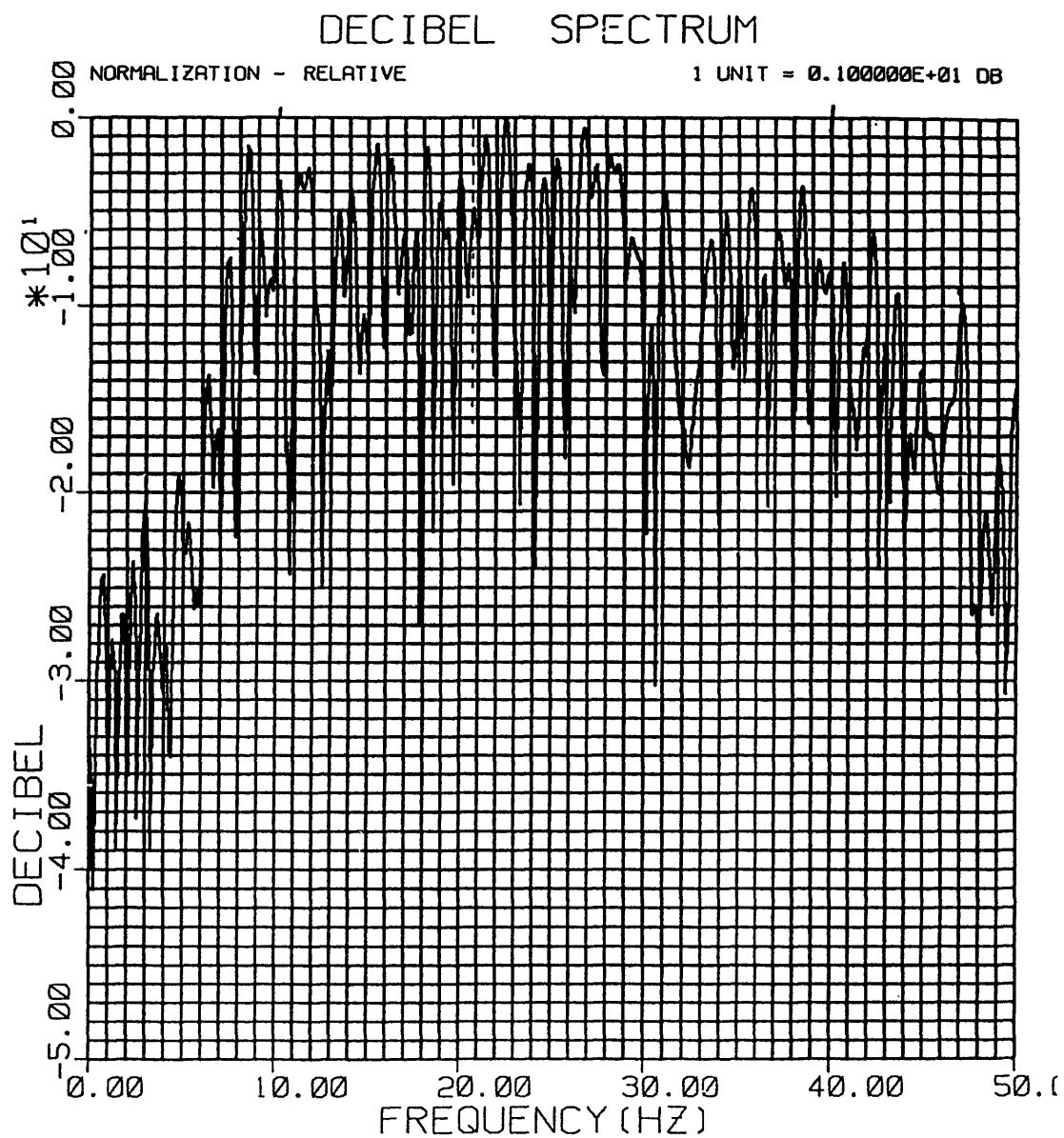


Figure 3.--Frequency spectrum of reprocessed data. Note how well balanced the spectrum is. Frequencies from 7 hertz through 47 hertz will be visually seen. This figure is taken at the same data location as figure 2.

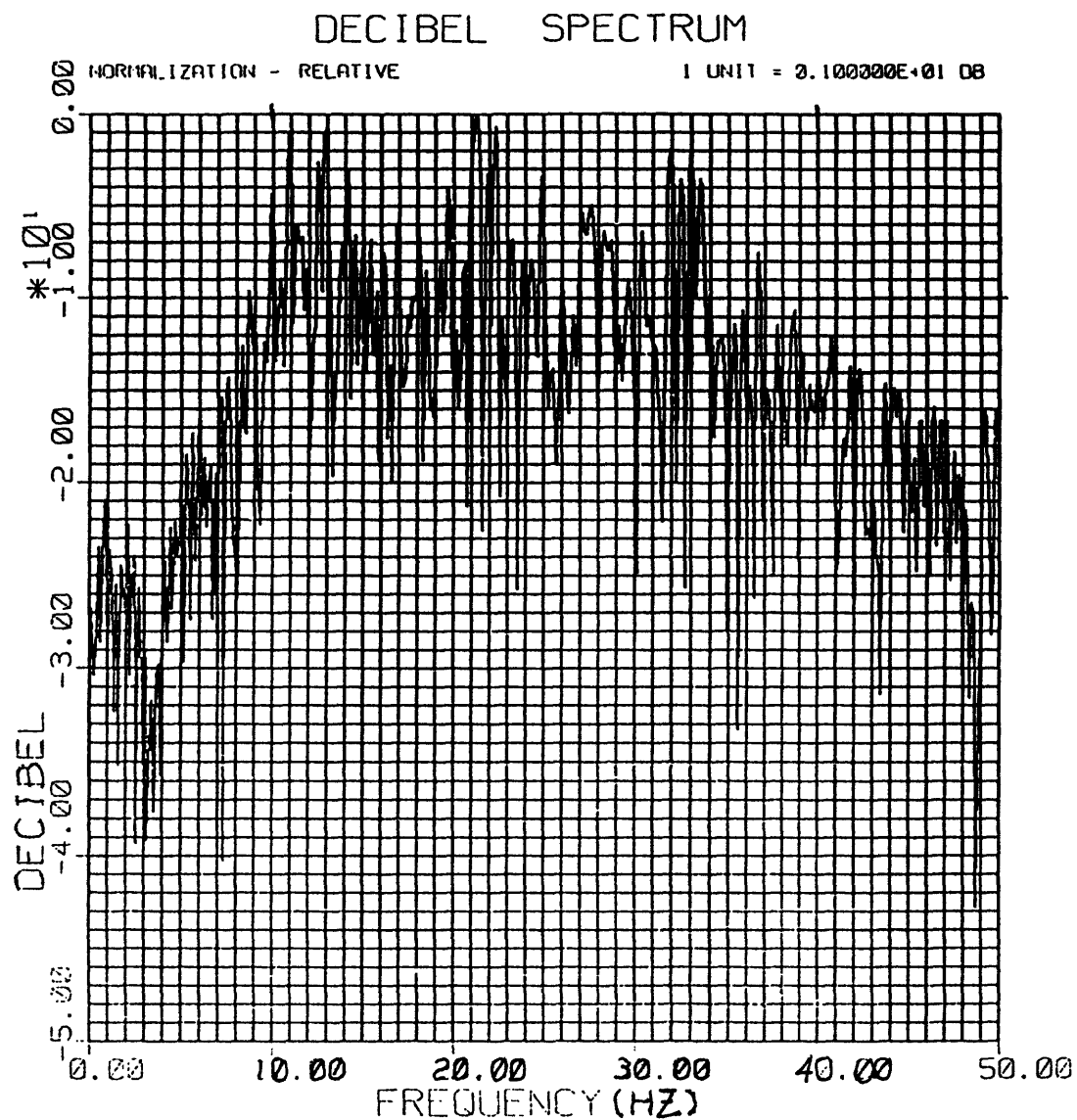
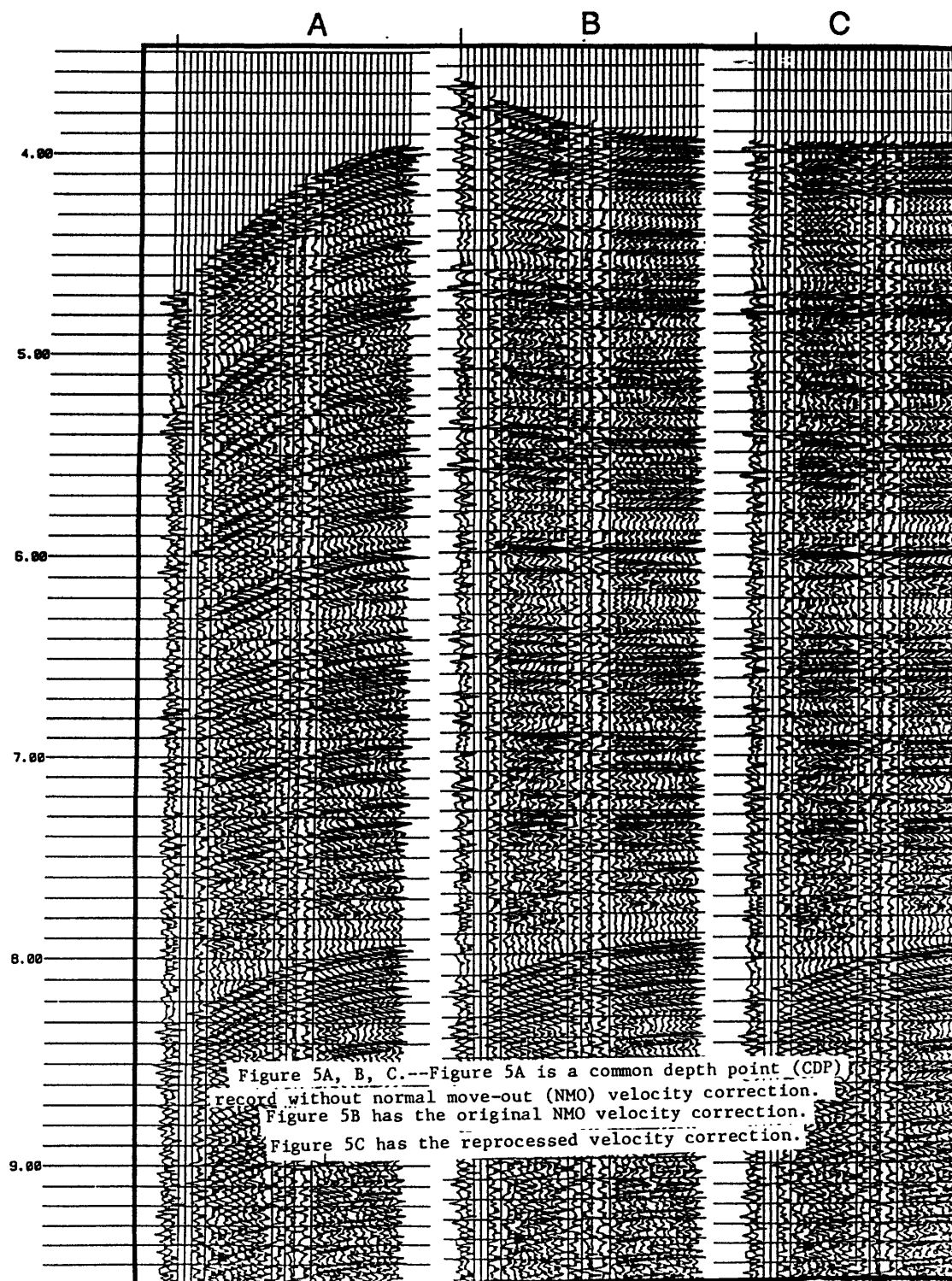


Figure 4.--This figure is exactly the same as figure 3 with the exception of no deconvolution applied. Note the difference in the balance of the spectrum.



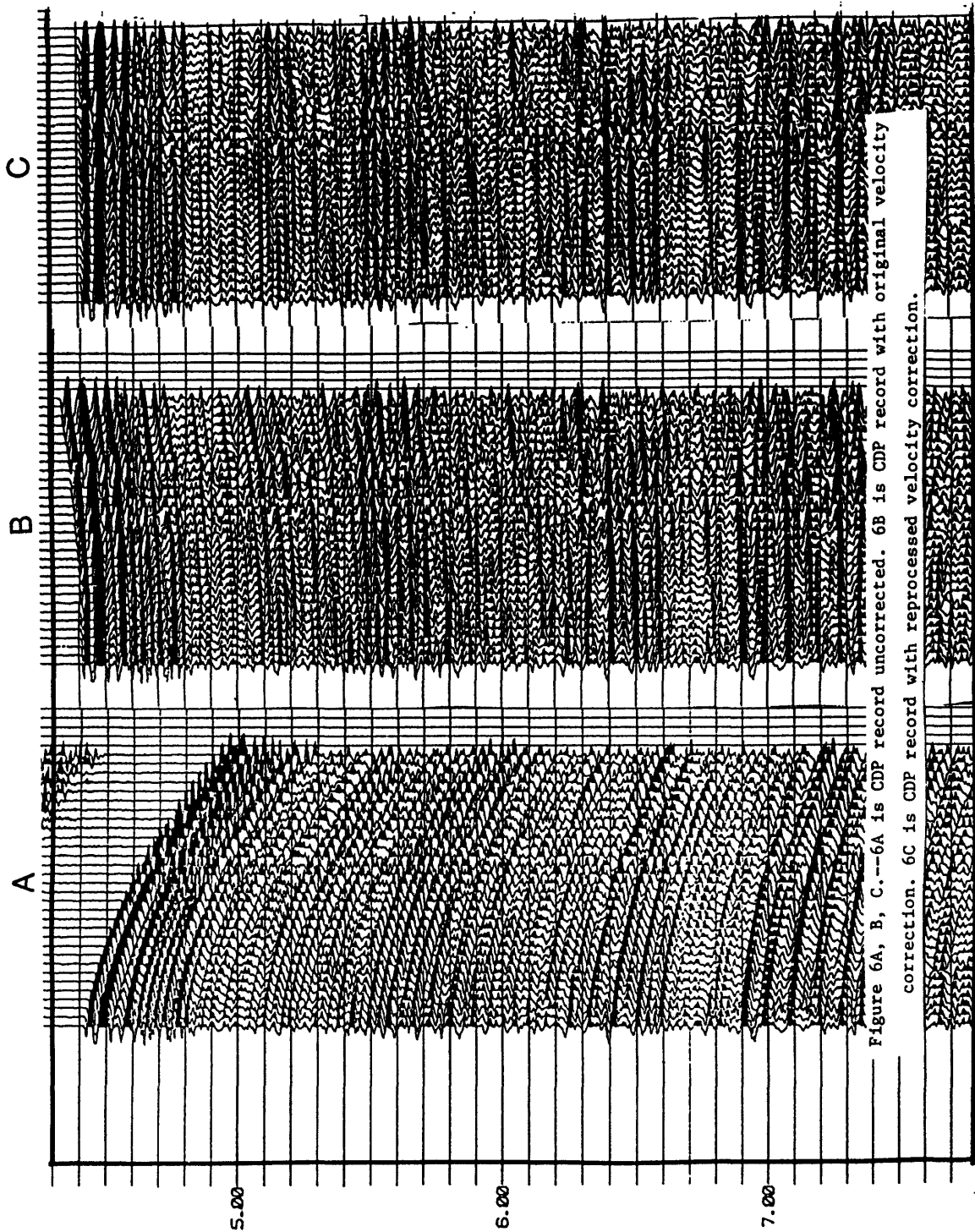


Figure 6A, B, C.--6A is CDP record uncorrected. 6B is CDP record with original velocity correction. 6C is CDP record with reprocessed velocity correction.

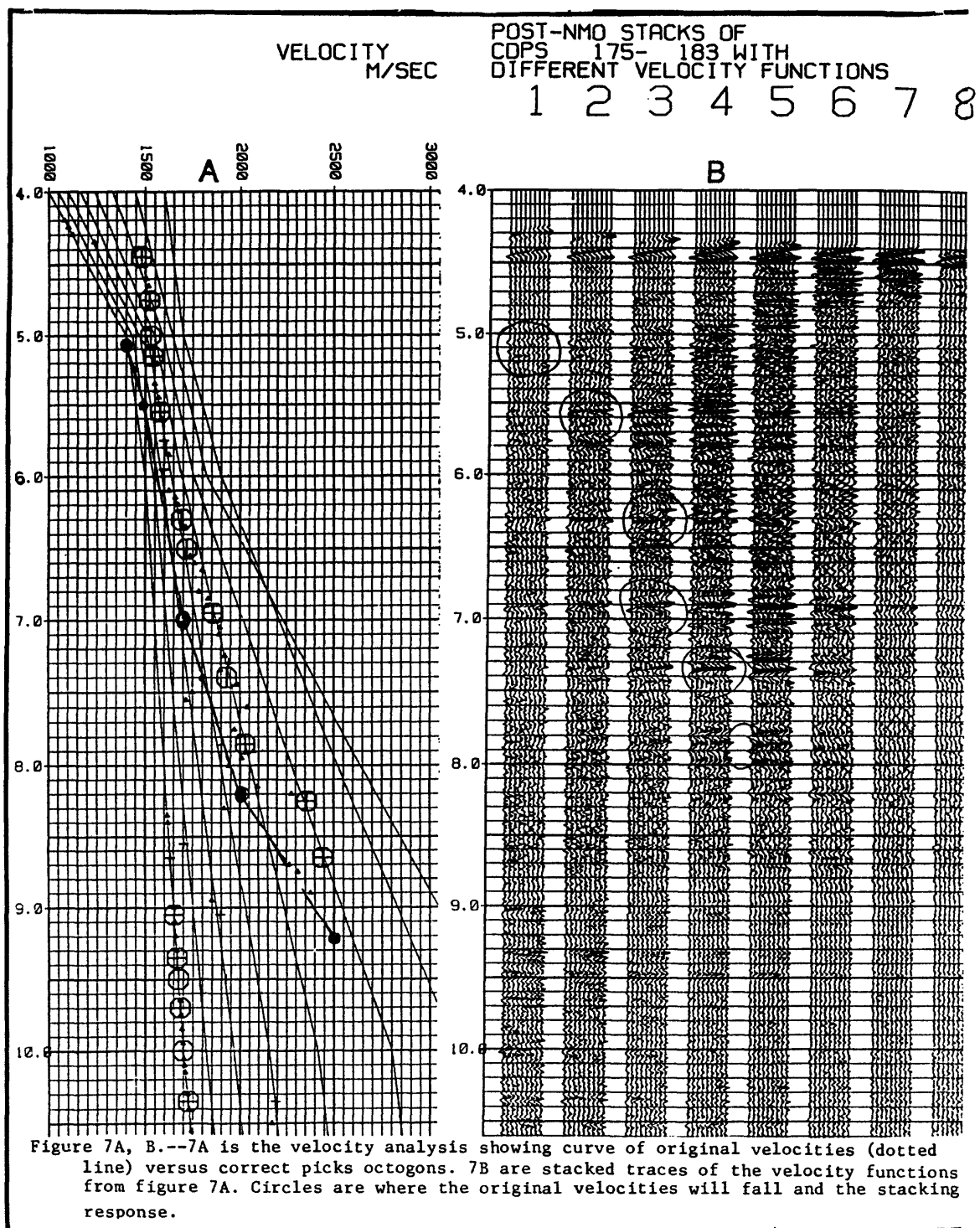
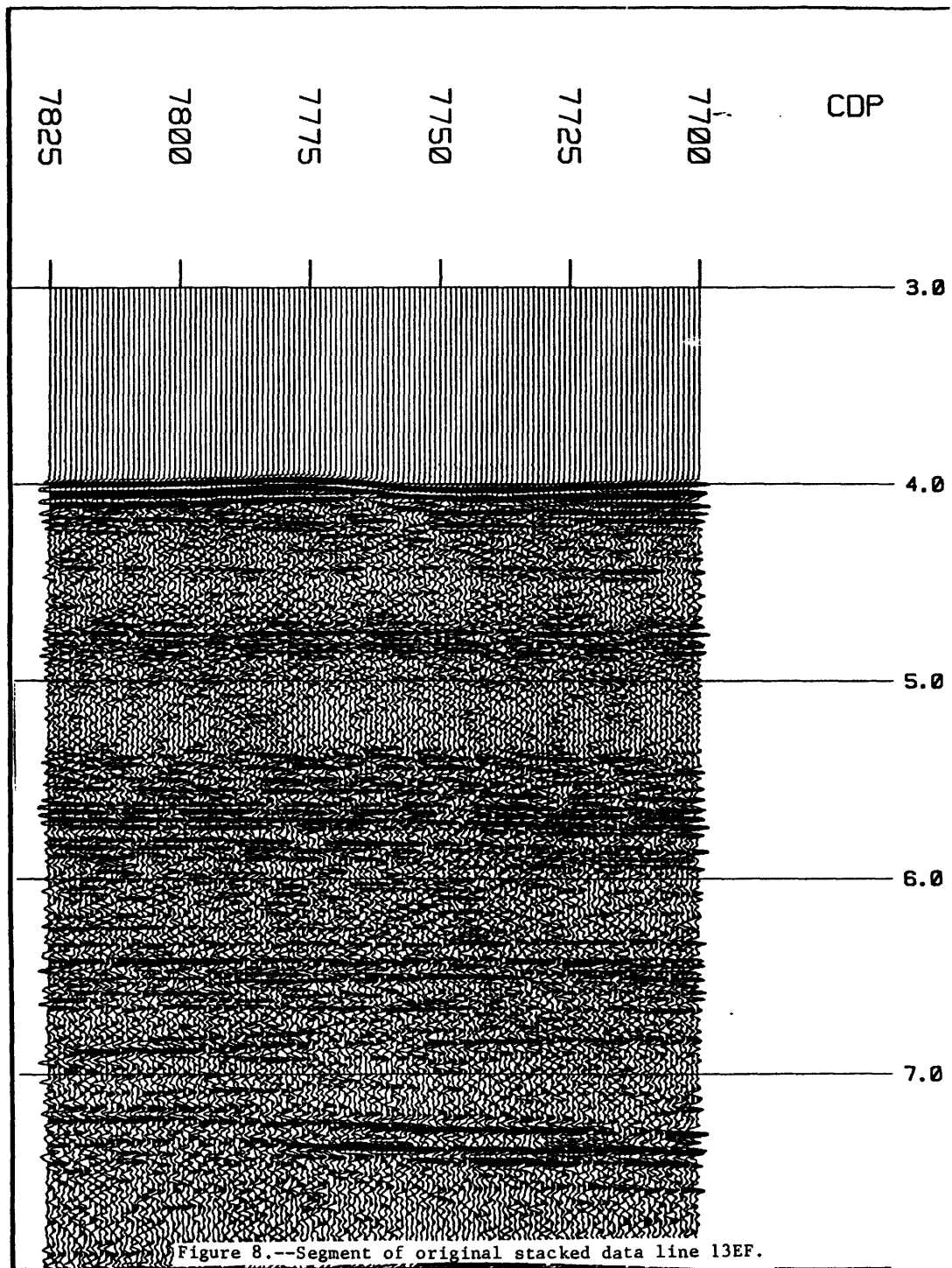


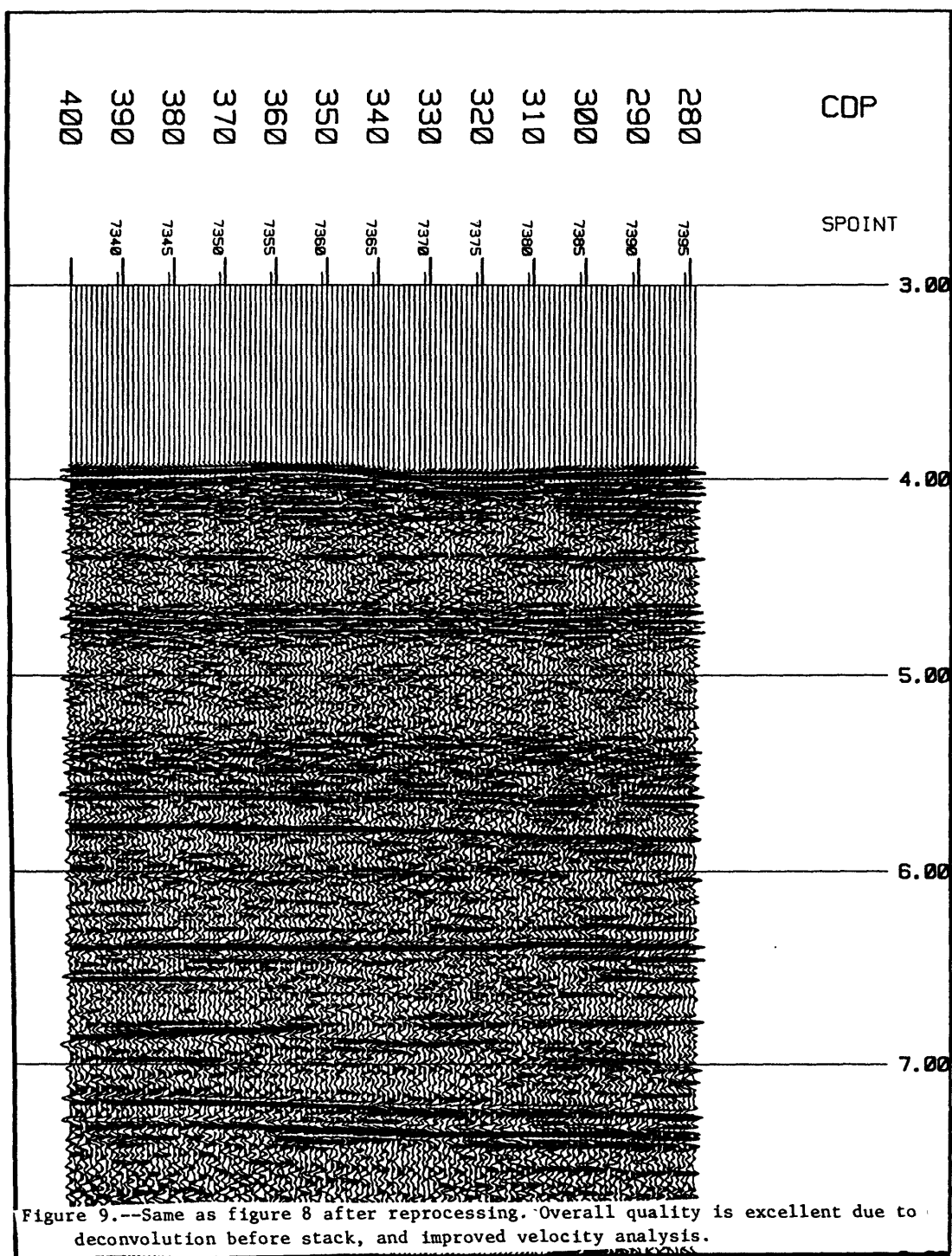
Figure 7A, B.--7A is the velocity analysis showing curve of original velocities (dotted line) versus correct picks octagons. 7B are stacked traces of the velocity functions from figure 7A. Circles are where the original velocities will fall and the stacking response.

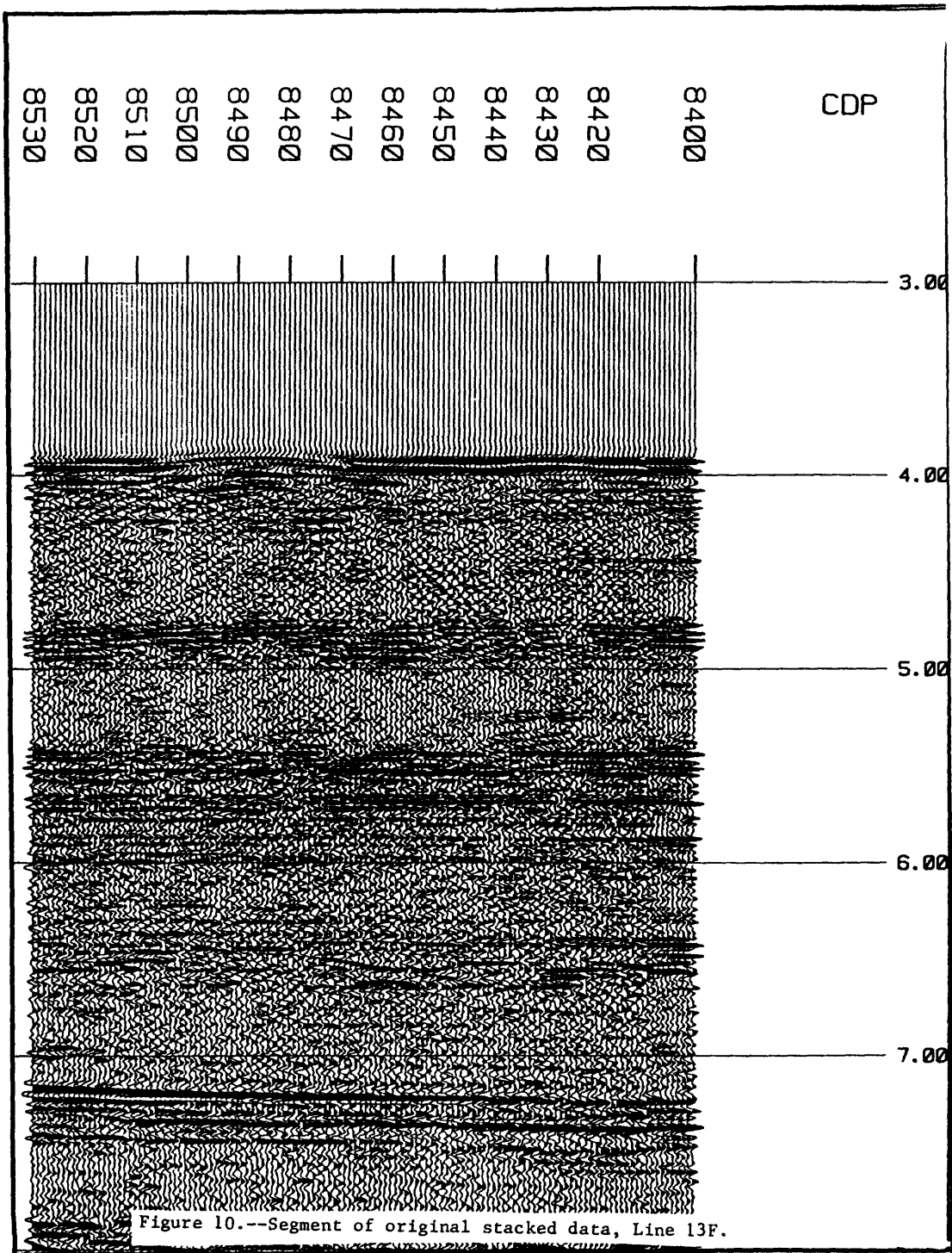
Table 3.--A comparison of the velocities from figure 7A converted to depth

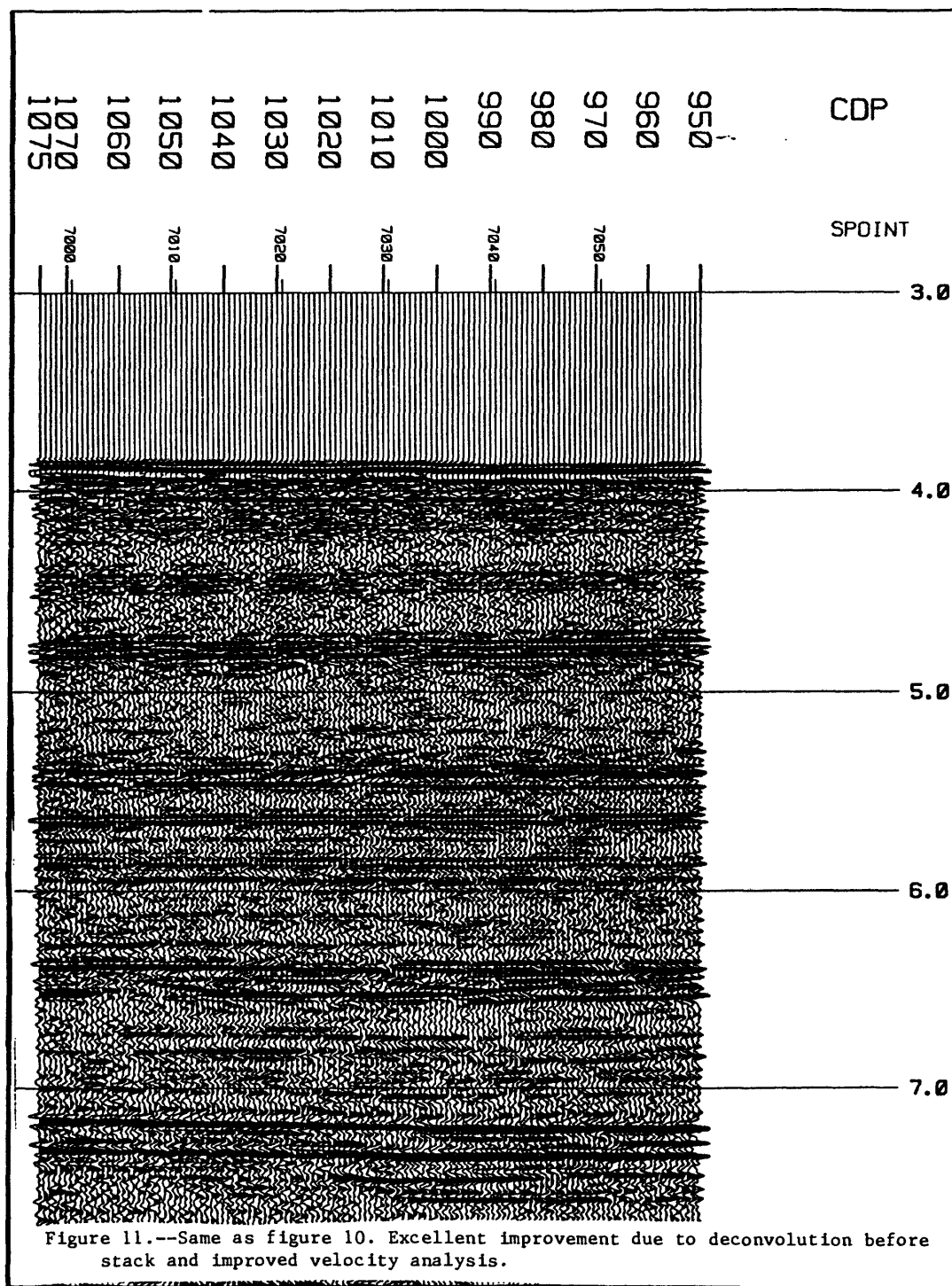
Original processing velocities		Reprocessed velocities		Original velocities converted to depth (m)	Reprocessed velocities converted to depth (m)	Difference in depths (m)
5.1	1400	WB 4.45	1480	3570	3304	+266
		5.00	1530	---	---	---
5.5	1500	5.50	1575	4058	3814	-124
6.3	1610	6.3	1690	4947	5244	-267
6.95	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.









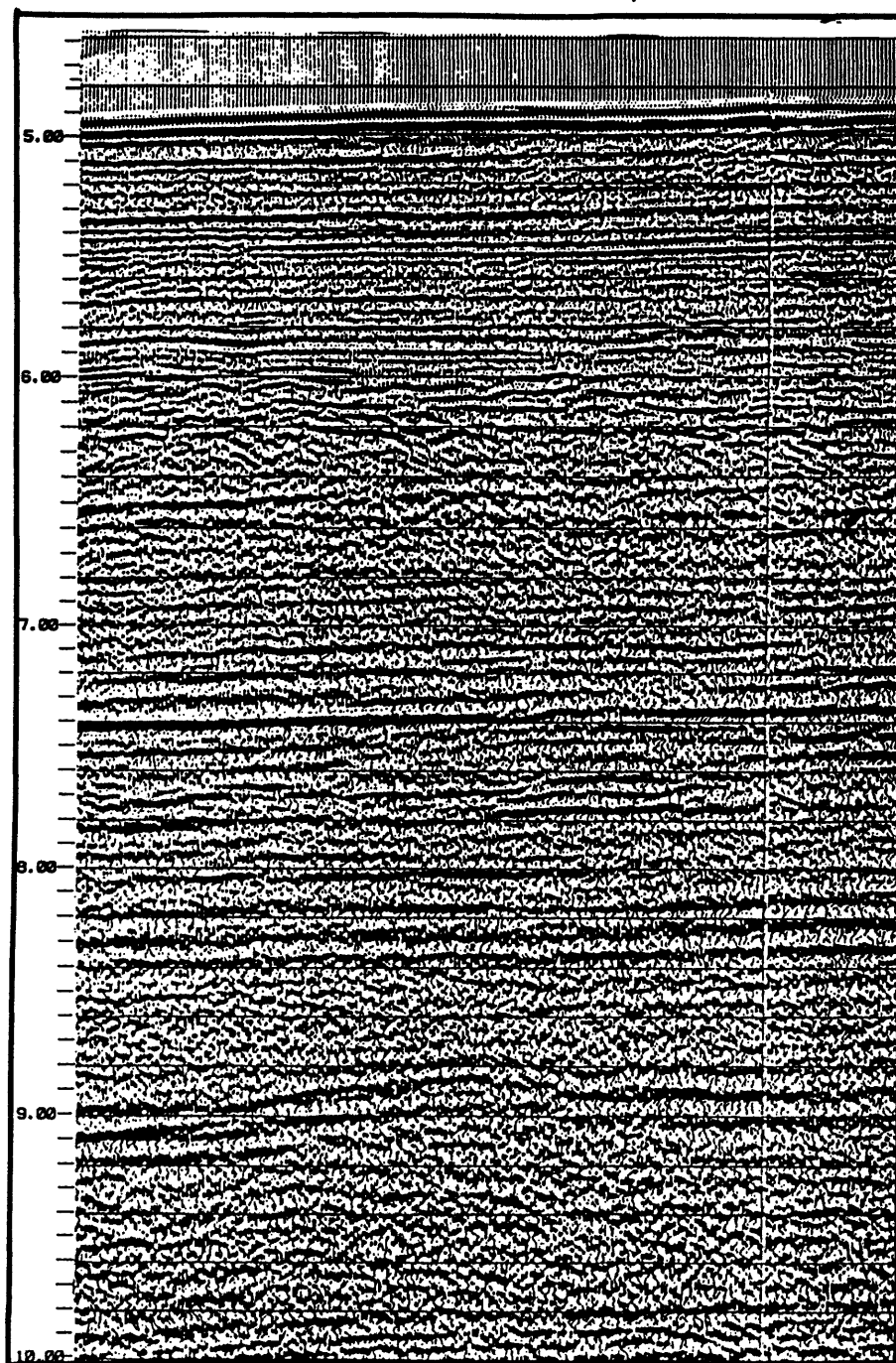


Figure 12.--Original stacked segment from 13A, the most southern part of the profile.

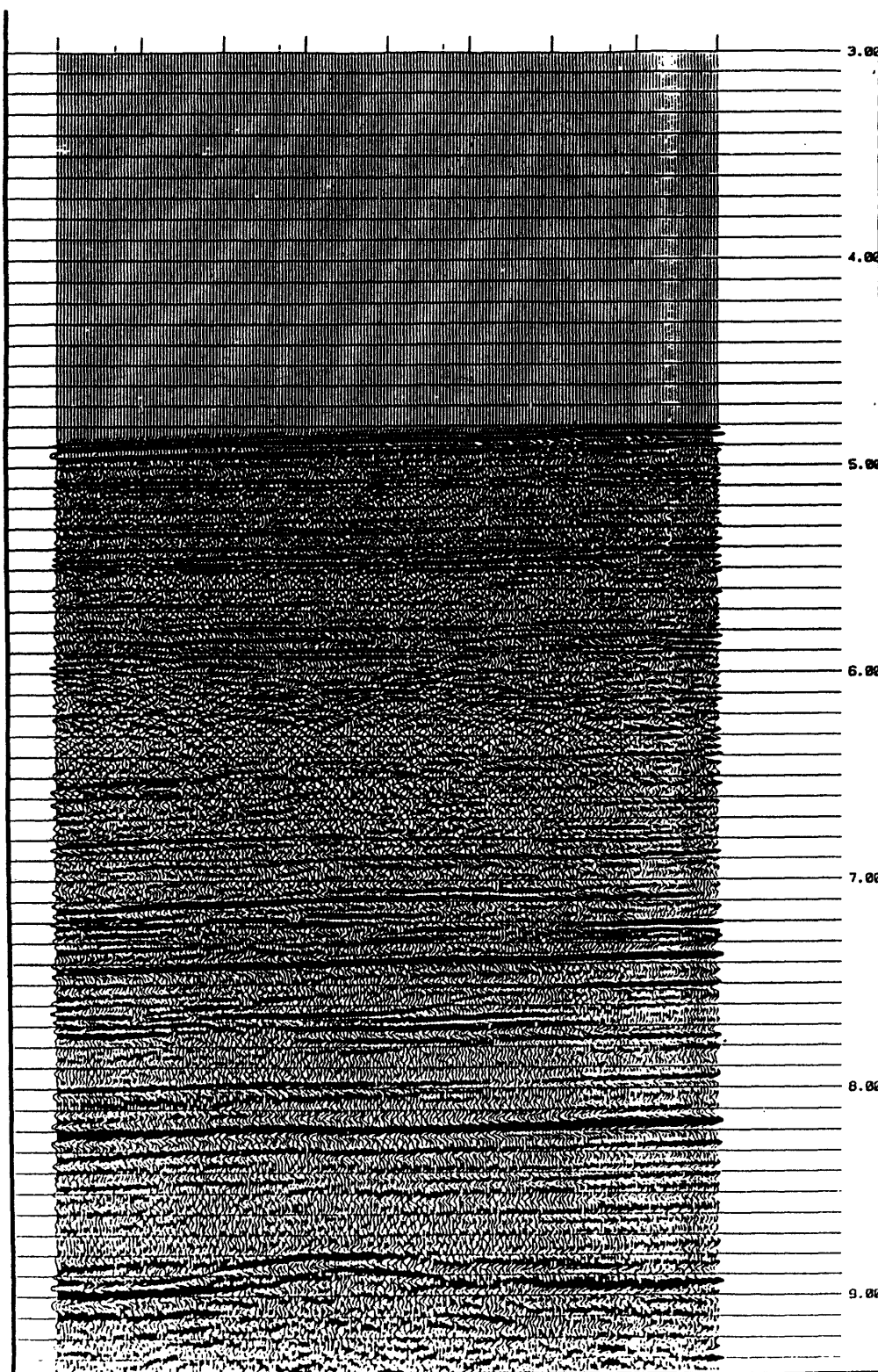


Figure 13.--Same as figure 12 after reprocessing. Overall improvement is due to deconvolution before stack and accurate regenerated velocity analysis.

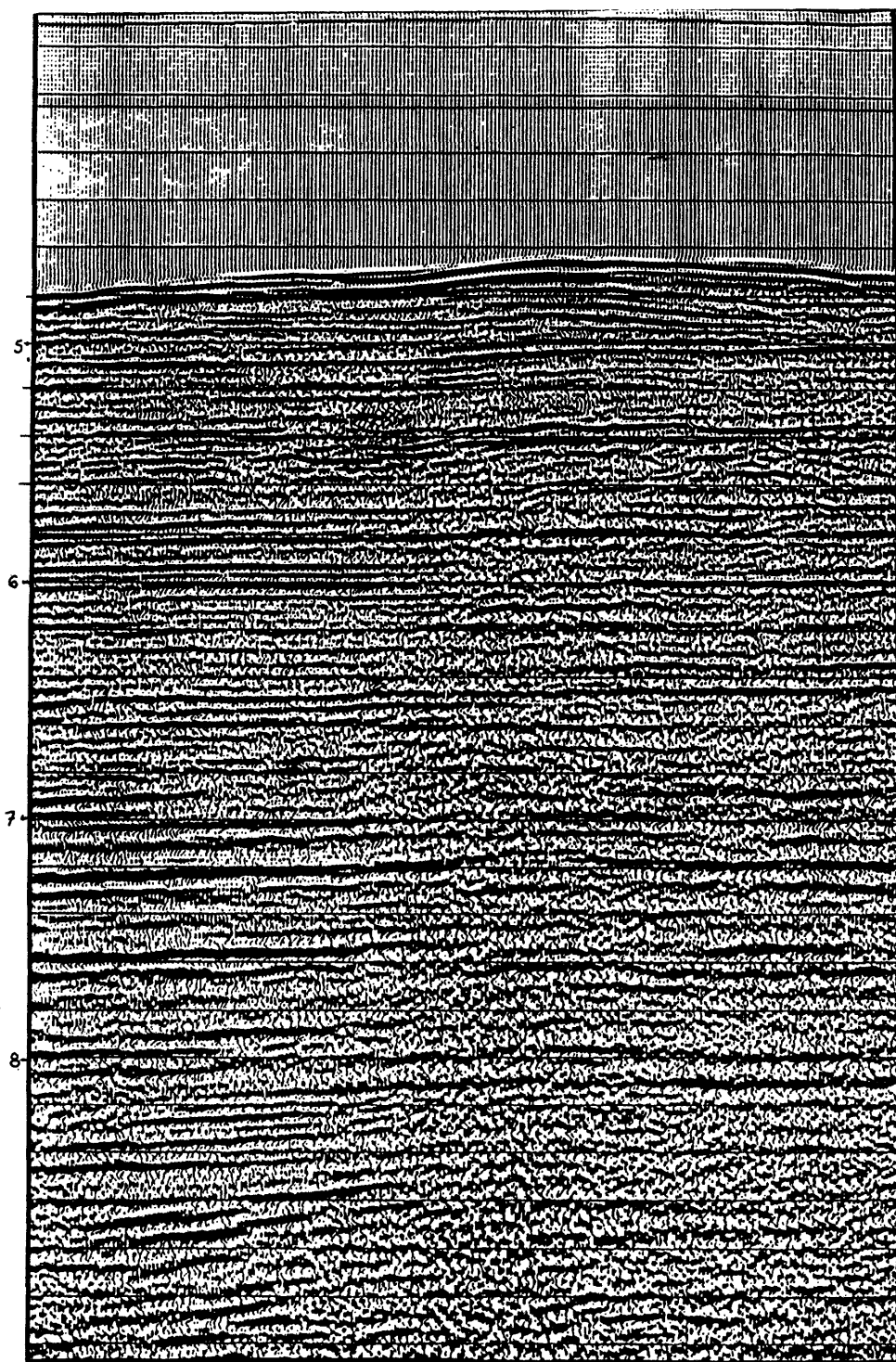


Figure 14.--Original stacked segment from middle of profile Line 13A.

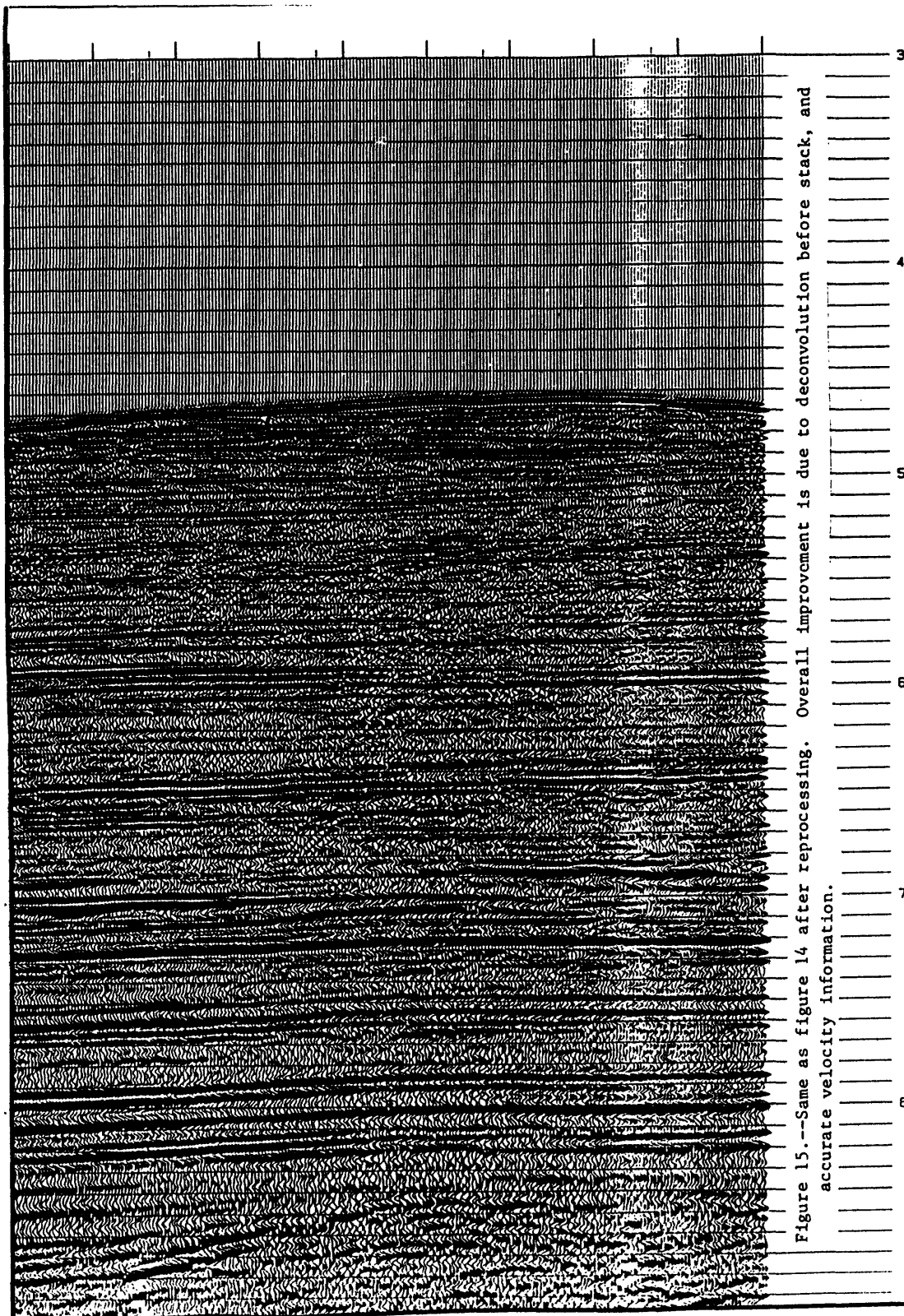
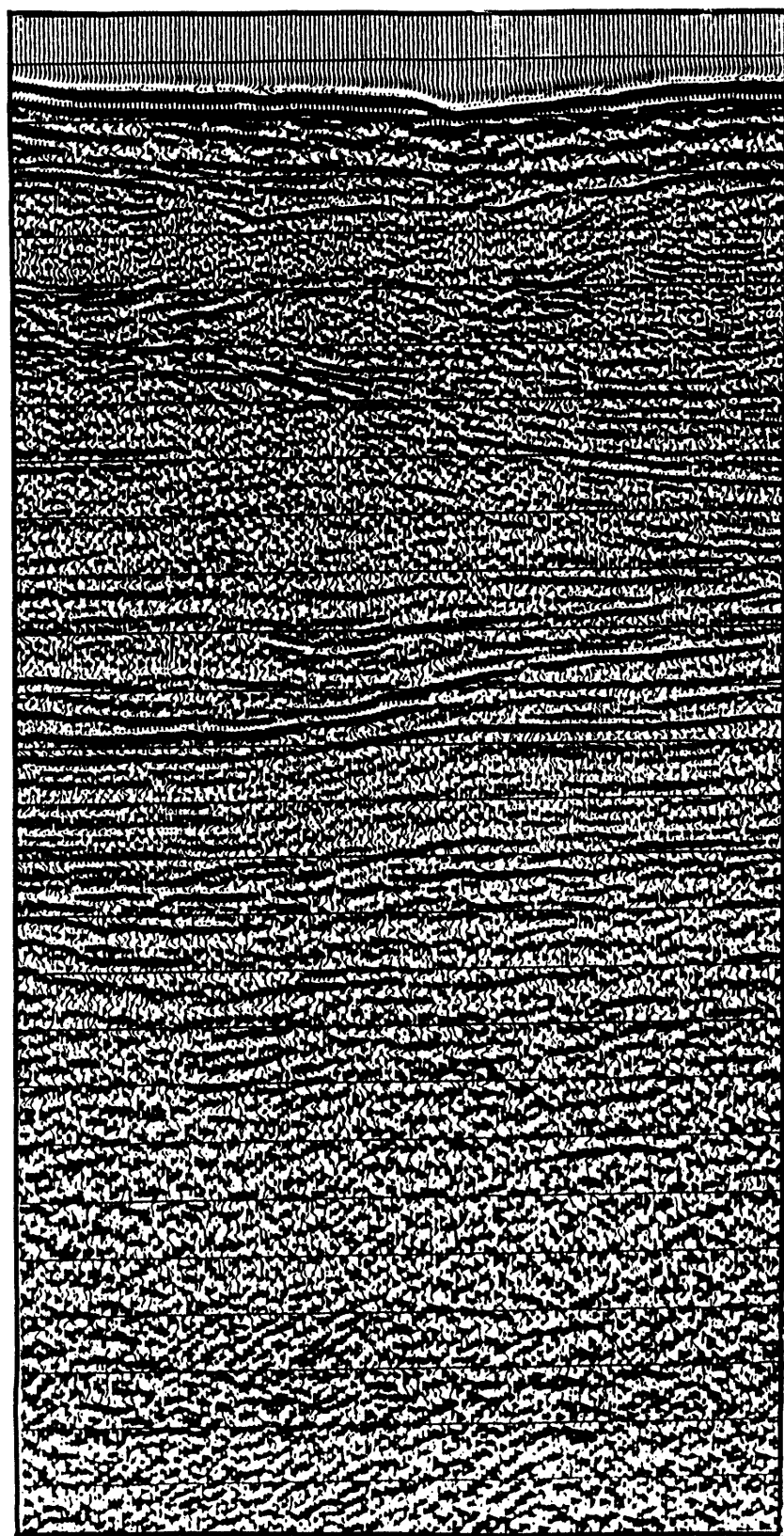
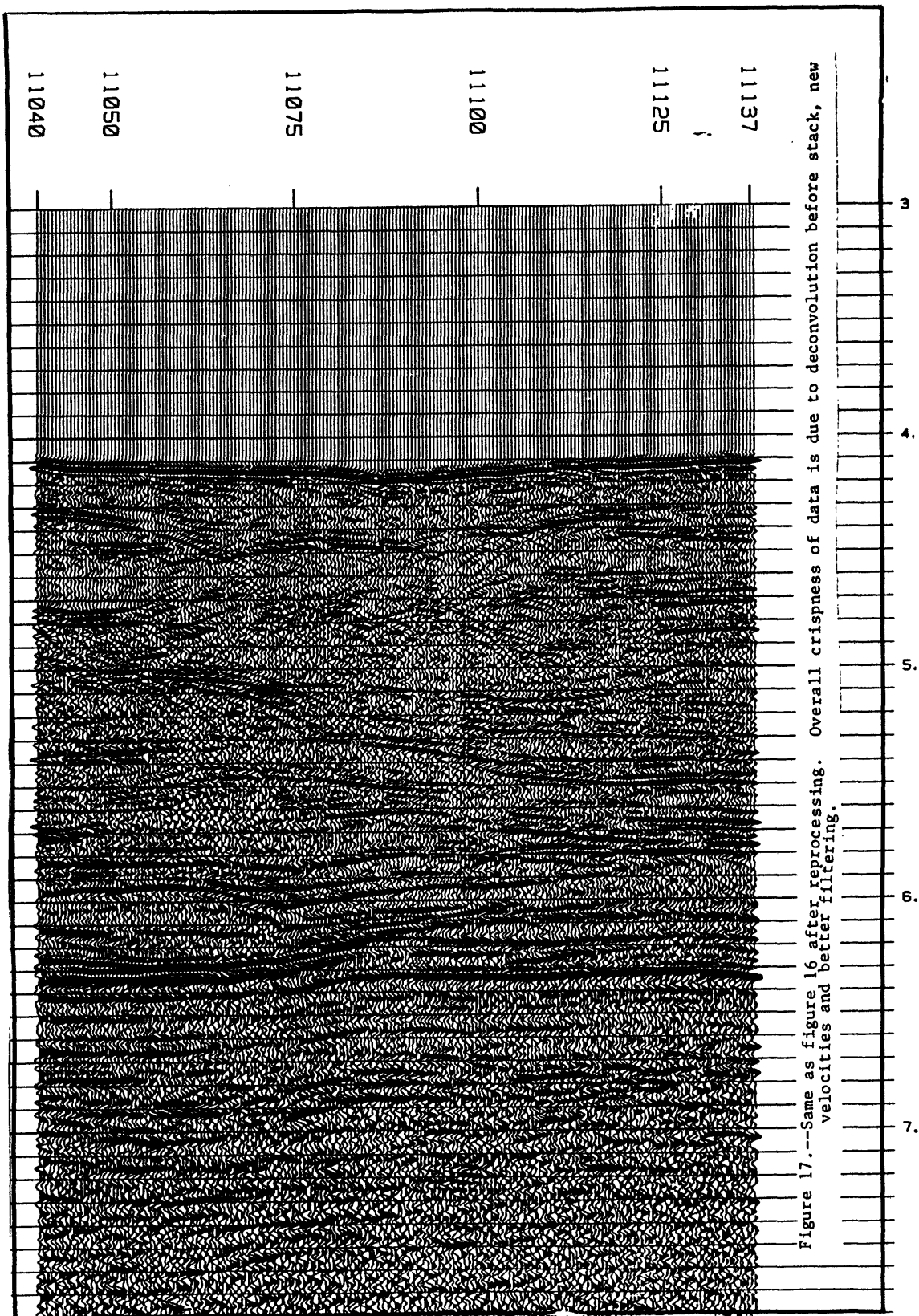


Figure 15.--Same as figure 14 after reprocessing. Overall improvement is due to deconvolution before stack, and accurate velocity information.

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





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.