SEISMIC STUDY OF CHEROKEE GROUP BARTLESVILLE SANDS,

WILSON COUNTY, KANSAS:

Stroud Lines 1 and 2

final report to

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INTRODUCTION

A CMP (common mid-point, i.e., CDP, common depth point) seismic reflection study was conducted on the Timmons lease, SW 1/4, Section 19, T 28 S, R 15 E, Wilson County, Kansas (Figure 1), to determine the feasibility of the seismic method to see potentially oil-producing Bartlesville fluvial sandstone facies (point bar deposits) within the Cherokee Group. Two short, east-west lines (470-m [1,542 ft] length) were shot (Figure 2). Line #1 crosses a producing well (Timmons #1), and line 2 crosses a dry hole (Timmons #2). The purpose was to recognize the reflection response of the reservoir seen on line #1 that was absent under the dry hole on line #2.

ACQUISITION

Forty-eight stations were laid on each line at 10-m [32.8 ft] intervals (Figure 2). On line #1, station position #120 corresponds with the location of Timmons #1. On line #2, station position #244 corresponds to the location of Timmons #2. The lines were laid such that geophone line passed 5 m [16.4 ft] south of the well locations and the shot line passed 5 m [16.4 ft] north. Thus there was a lateral shot offset of 10 m [32.8 ft] north, and the subsurface reflection points (CMP locations) passed in an east-west line directly under the wells. Shots were placed on the half-interval, i.e., between station locations. This method of acquisition is slightly unconventional, but it helps subsequent processing to reduce groundroll noise (Knapp, 1985). The shots were offset laterally so that the CMP points could fall directly under the wells (rather than moving a single line around the wells) and so that all geophones could be kept alive throughout the shooting. If the shots had been on the same line as the geophones, stations immediately adjacent to the shot would have been disconnected to avoid over-driving the geophone receivers and to avoid cross-talk contamination of the over-driven signal.

Two EG&G ES-2401 seismographs were used to record the data, giving 48-channel capability. Despite this, cable limitations restricted the number of live geophones to 36. This restriction was not detrimental, however, because the long offsets that would have resulted from using more live stations were so great that the data would not have had value in the final stacked section. Half of the line was shot with the first 36 stations live and the other half of the line was shot with the last 36 stations live. Maximum CMP redundancy was 26-fold, i.e, the final stacked trace is the result of averaging up to 26 field traces. Figure 3 is a section of stacking fold in both time and space.

The seismic source used was the "auger gun" designed by the Kansas Geological Survey (Healy, et al., 1991). It fires a 12-guage shotgun blank at the tip of an auger screwed about 1 m [3 ft] into the ground. This gun is a modification of the "buffalo gun" in common use. The "buffalo gun" fires the shotgun blank on the end of a rod placed in a previously augured shothole. The "auger gun" is an improvement for several reasons. A hole is not augured, so less damage is done. The bit is screwed into the ground and unscrewed out. No cuttings are dug up. The action is one step rather than two. Drilling and firing is done at one time. The flighting of the bit of the "auger gun" firmly secures the shot to the ground. This results in greater safety, less air blast noise (sound from the shot), and slightly greater utilization of the energy of the shot, as no gases escape upward.

PROCESSING

Processing of CMP data has a multitude of purposes: First, the data are converted into a cross-sectional display that represents the subsurface. The subsurface is sampled at a spacing equal to half that of the surface. That is, the subsurface is sampled at points under the surface stations and at a point half-way in between. CMP point numbers are equal to twice the corresponding surface station number. The Timmons #1 well corresponds to CMP 240, and Timmons #2 corresponds to CMP 488.

CMP stacking averages of traces that share a common source-receiver midpoint; that is, these traces are sampling the same profile in the ground. The purpose of stacking is to derive an average response for each subsurface point that is skewed toward the best of the data. Toward this means, a correlation stack was used rather than a straight averaging stack. Correlation stack weights each data sample in the stack according to its quality, i.e, agreement with a pilot trace which is the average of all traces of the CMP gather and adjacent CMP points. The process enhances the contribution of high-quality data in the stack.

Data are enhanced to have maximum resolution through frequency filtering. The second derivative filter is a 12 dB/octave high-pass filter that helps compensate for the low-pass character of the earth. Post-stack spectral balancing is a final step designed to complete the shaping of the signal spectrum so that the data have maximum resolution and minimum noise.

Principles of the stackarray (Morse and Hildebrandt, 1989) were followed both in acquisition and processing to enhance the reduction of noise on the final stacked section.

The following processing steps were followed:

1. Preprocessing to add geometry information to trace headers.
2. Spike edit to remove air-coupled wave noise and spurious spikes.
3. Two trace running mix of moved-out data. [part of stackarray]
4. 2nd derivative filter
5. High-cut filter to remove high-frequency noise amplified by step 4.
6. Deconvolution: length = 20 ms; prediction dist. = 5 ms; prewhitening = 5%, to remove periodic noise. This is a rather gentle deconvolution.
7. Spike edit to remove noise amplified by frequency enhancement.
8. CMP sort.
9. Velocity analysis.
10. Automatic surface-consistent statics.
11. Residual statics.
12. Correlation stack and residual NMO correction.
13. Post-stack spectral shaping.

RESULTS

Figures 4 and 5 are the processed sections from lines #1 and #2, respectively. Trace spacing is 5 m [16.4 ft]. The production zone is at about 275 ms. Production is found to correspond to the seismic response of the combination of a strong trough followed by a strong peak (Figure 4, 271 to 281 ms, CMP's 240-255). This is found to correspond to entry into the porous sand, a negative-polarity reflection due to decrease in velocity and density, followed by the positive reflection due to exiting the sand. Synthetic seismogram modeling (Figures 6 and 7) substantiate the interpretation. Figure 6 is a model derived from the density log of the Timmons #1 well which demonstrates the response. Figure 7 is the same model with the values of the porous sand replaced with values that correspond to denser shale. The characteristic response also disappears.

On line #2, under the dry hole of Timmons #2, the seismic response corresponds to the response of the model without porous sand (Figure 7); however, between CMP's 430 and 455 the response characteristic of porous sand is seen. The response in this interval does not have the same magnitude as the response seen on line #1 under Timmons #1. This suggests one of two possibilities. Either the sand is slightly thinner (to perhaps about 2 m [about 5-7 ft]) or the porosity development is not as good. It is difficult to distinguish which, because the response is a thin-bed response, and apparent time-thickness is independent of actual bed thickness.

The seismic response of the seismic sections west of CMP 240 (line #1) and CMP 435 (line #2) is subject to suspicion due to reduction of CMP fold off the end of the line. The apparent westward fading of the seismic response characteristic of a reservoir does not necessarily mean that the reservoir terminates. It may terminate or it may extend westward under the section line road.

RECOMMENDATIONS

On line #1 the reservoir sand is seen as a well-developed trough followed by a strong peak between CMP 236 and 257 in the time interval 270 to 280 ms. This is a width of about 105 m [354 ft]. On line #2 a similar response is found between CMP 432 and CMP 456, a reservoir about the same size. Because the amplitude response of the reservoir is less on line #2, the indication is that the reservoir may have less well-developed porosity or may be a thinner zone of sand. We do not expect it to be as good a well as Timmons #1, but it should be productive. We would like to see the location drilled and recommend it.

REFERENCES CITED

Healy, J., Anderson, J., Miller, R., Keiswetter, D., and Steeples, D., 1991, *Improved shallow seismic-reflection source: Building a better buffalo*: Society of Exploration Geophysicists Annual Meeting and Exposition, Houston.

Knapp, R.W., 1985, *Using half-interger source offset with split-spread CDP seismic data*: The Leading Edge, vol. 4, no. 10, p. 66-69.

Morse, P.F. and Hildebrandt, G.F, 1989, *Groundroll suppression by the stackarray*: Geophysics, vol. 54, p. 290-301.

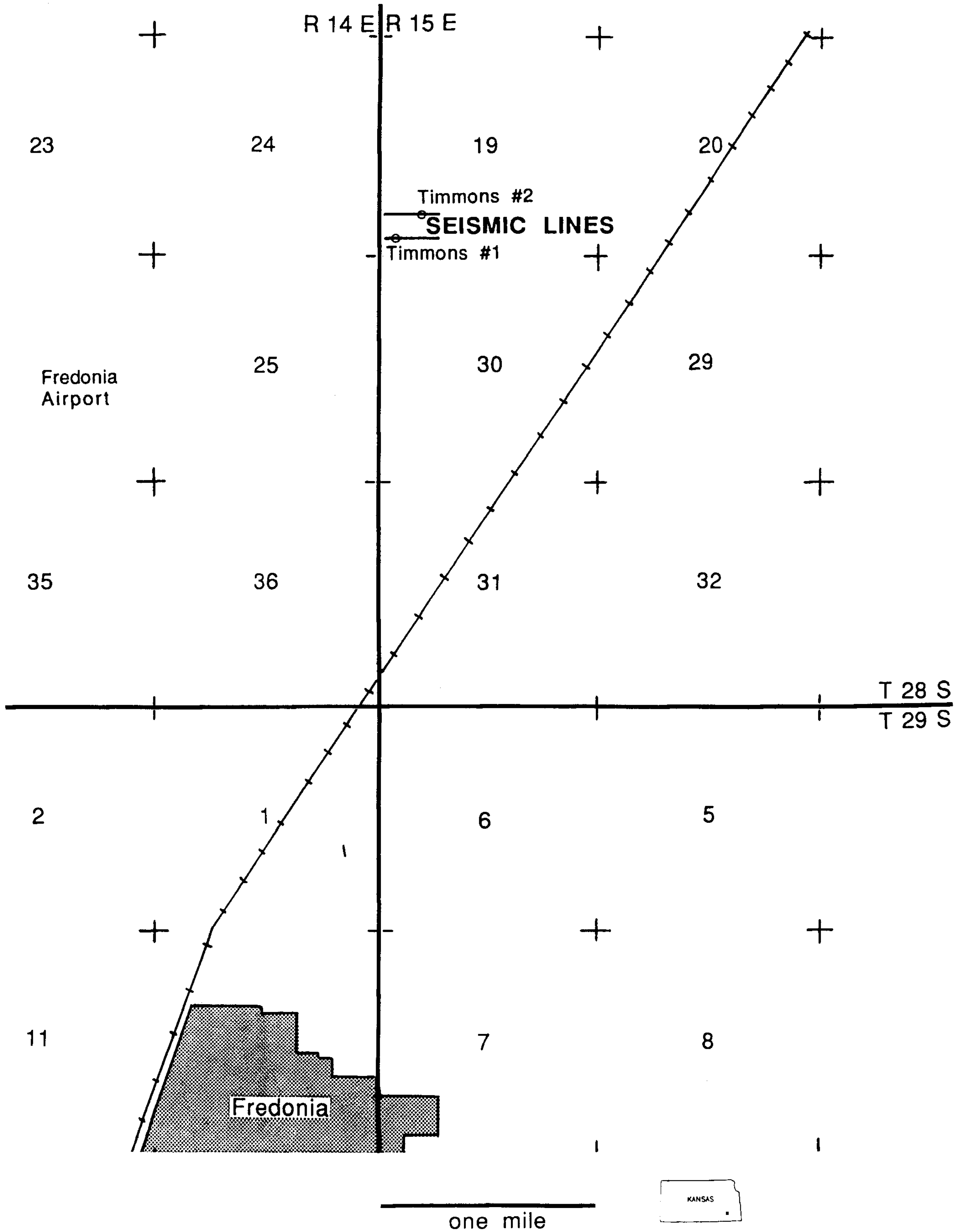

Figure 1. Index map of Fredonia area showing location of seismic work.

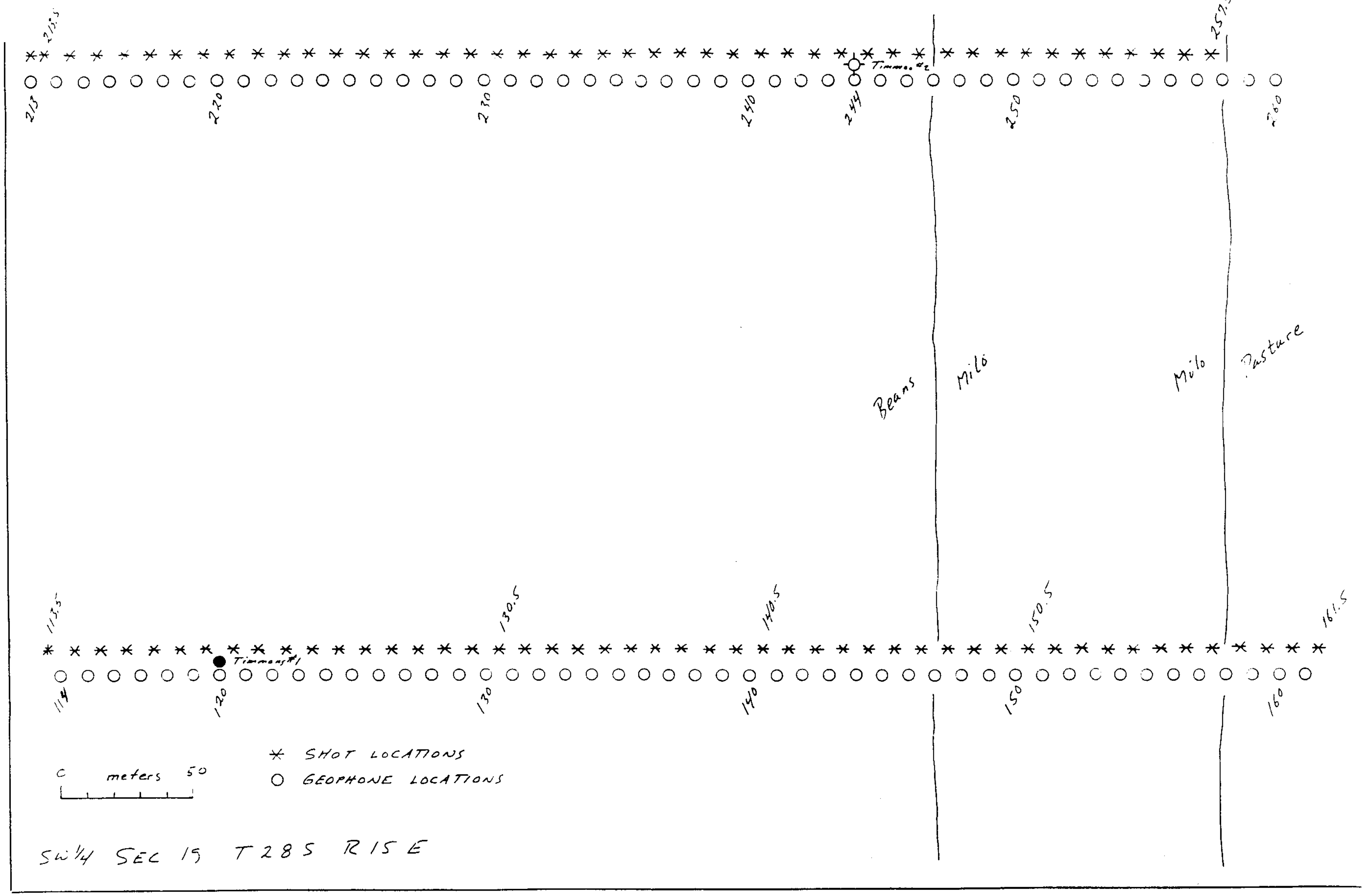

Figure 2. Surface point map. Note that CMP positions will be double in value.

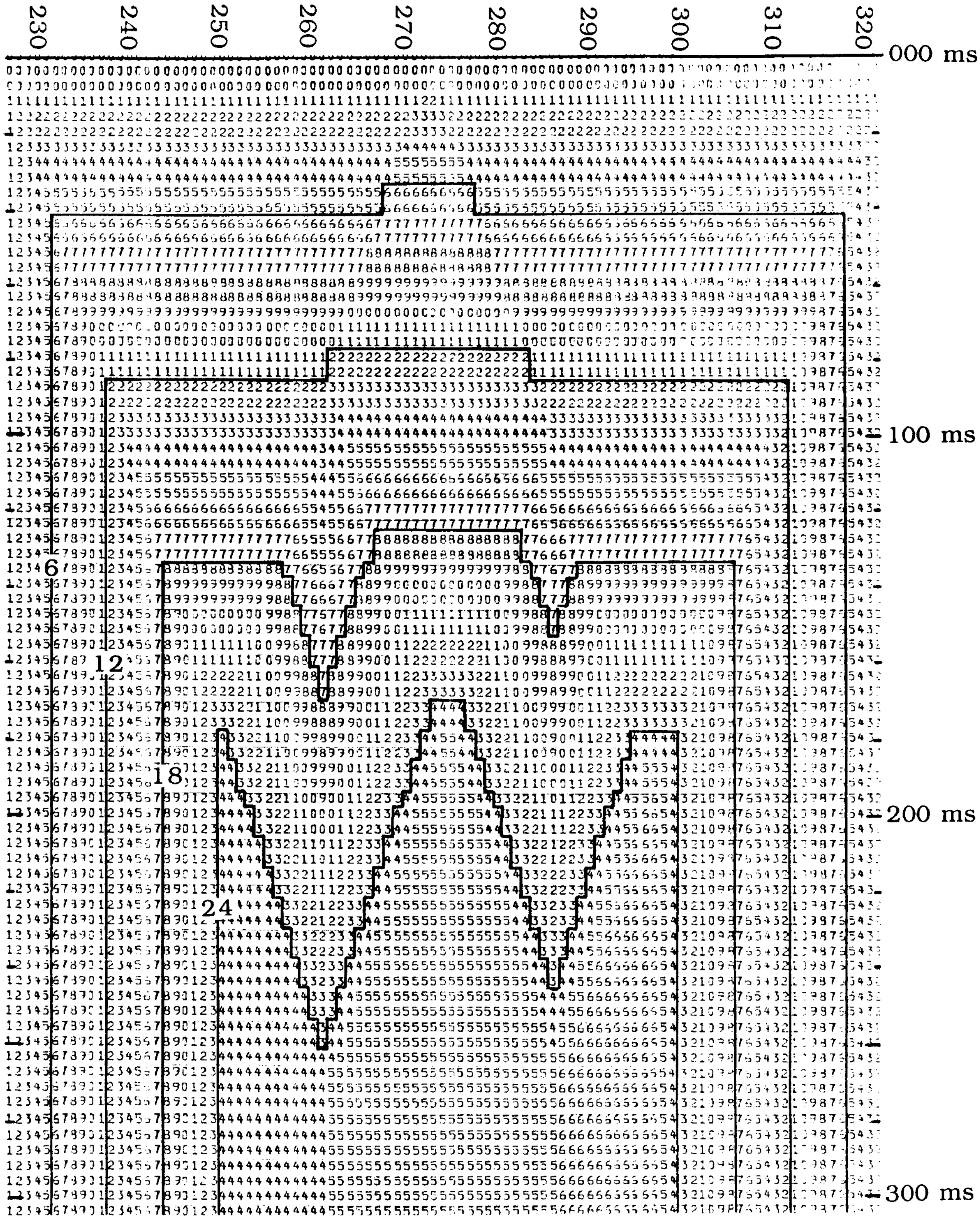

Figure 3a. Stack chart section of line #1.

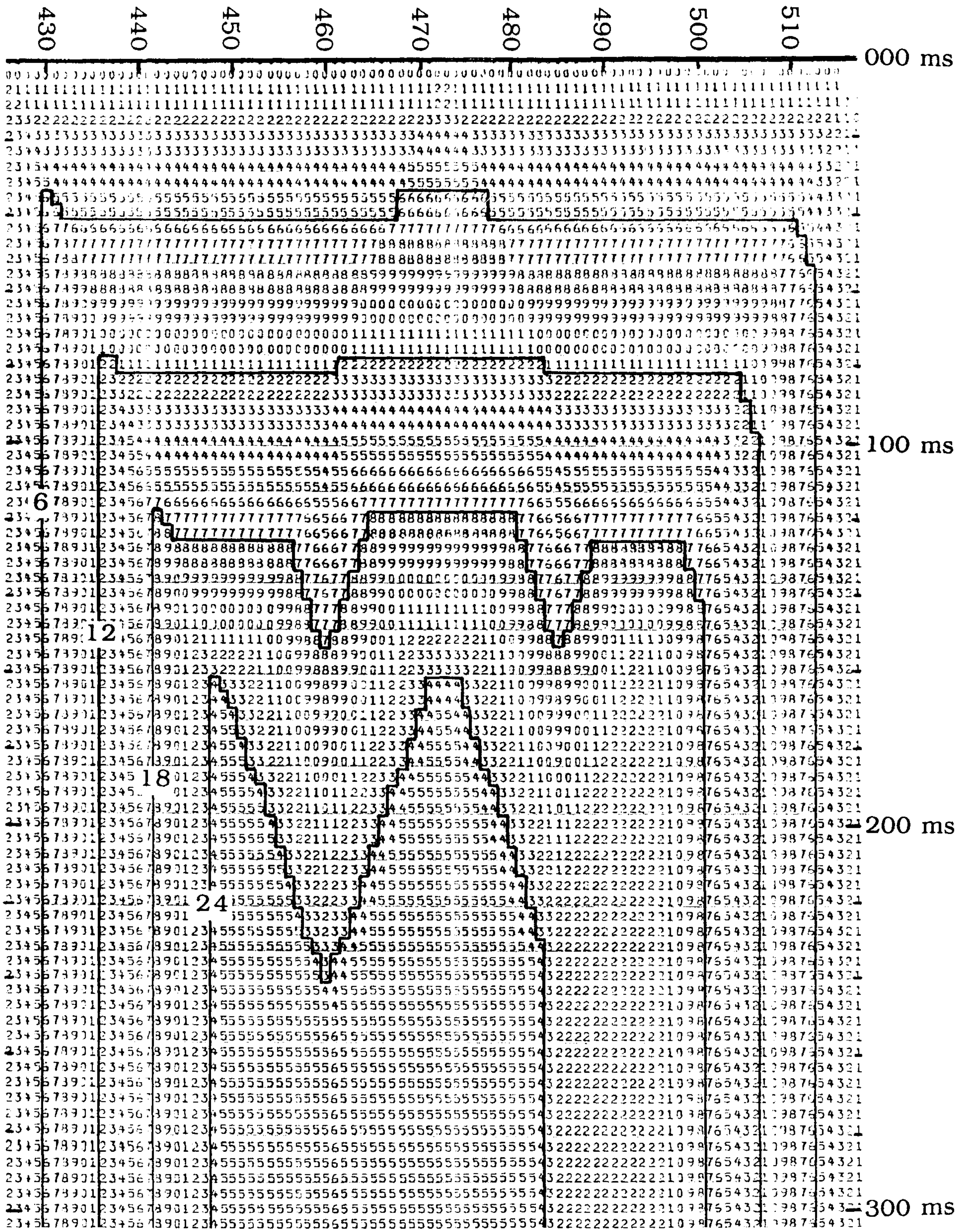

Figure 3b. Stack chart section of line #2.

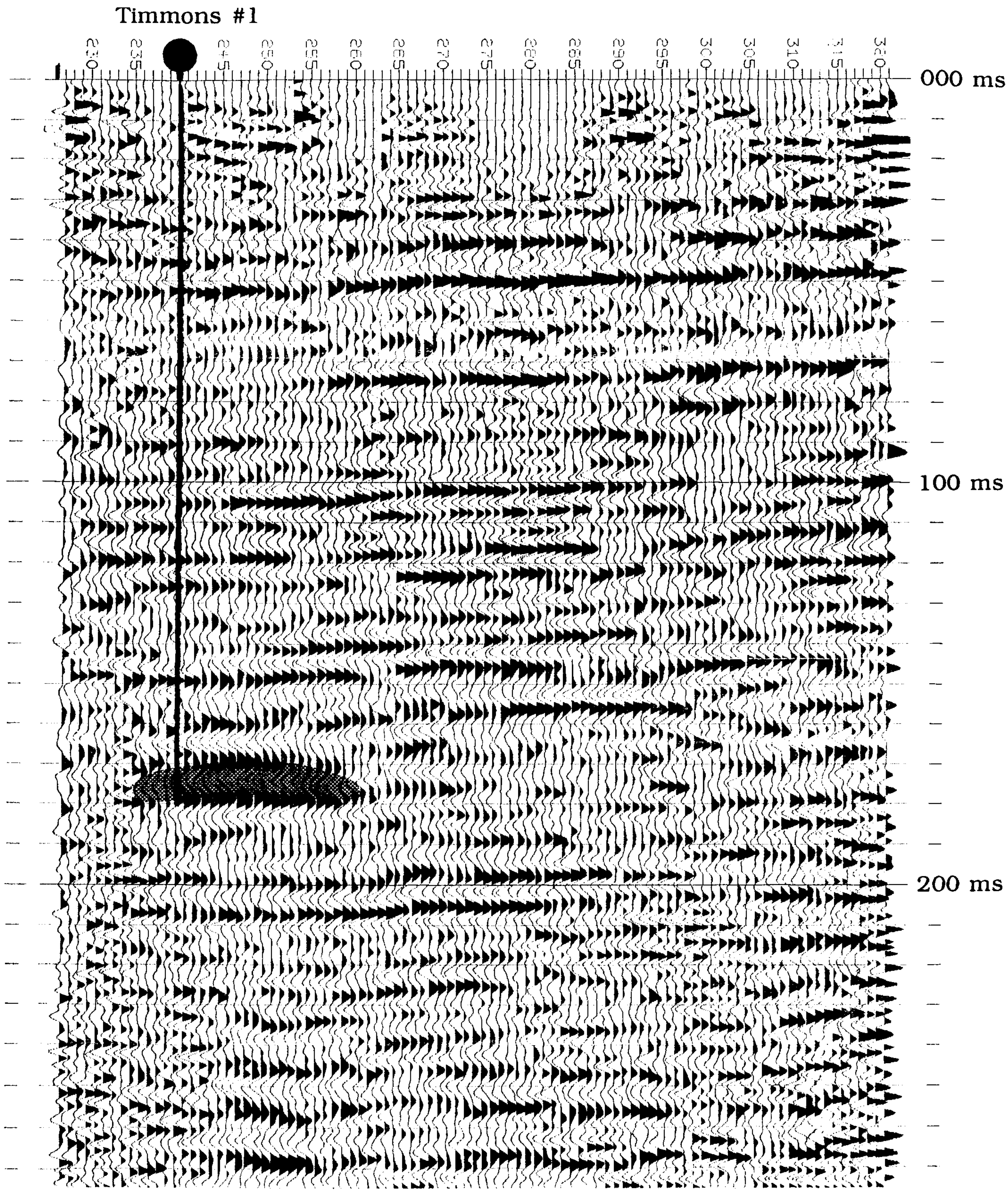

Figure 4. Final section of line #1. Note that CMP numbers are double the surface position numbers of Figure 2.

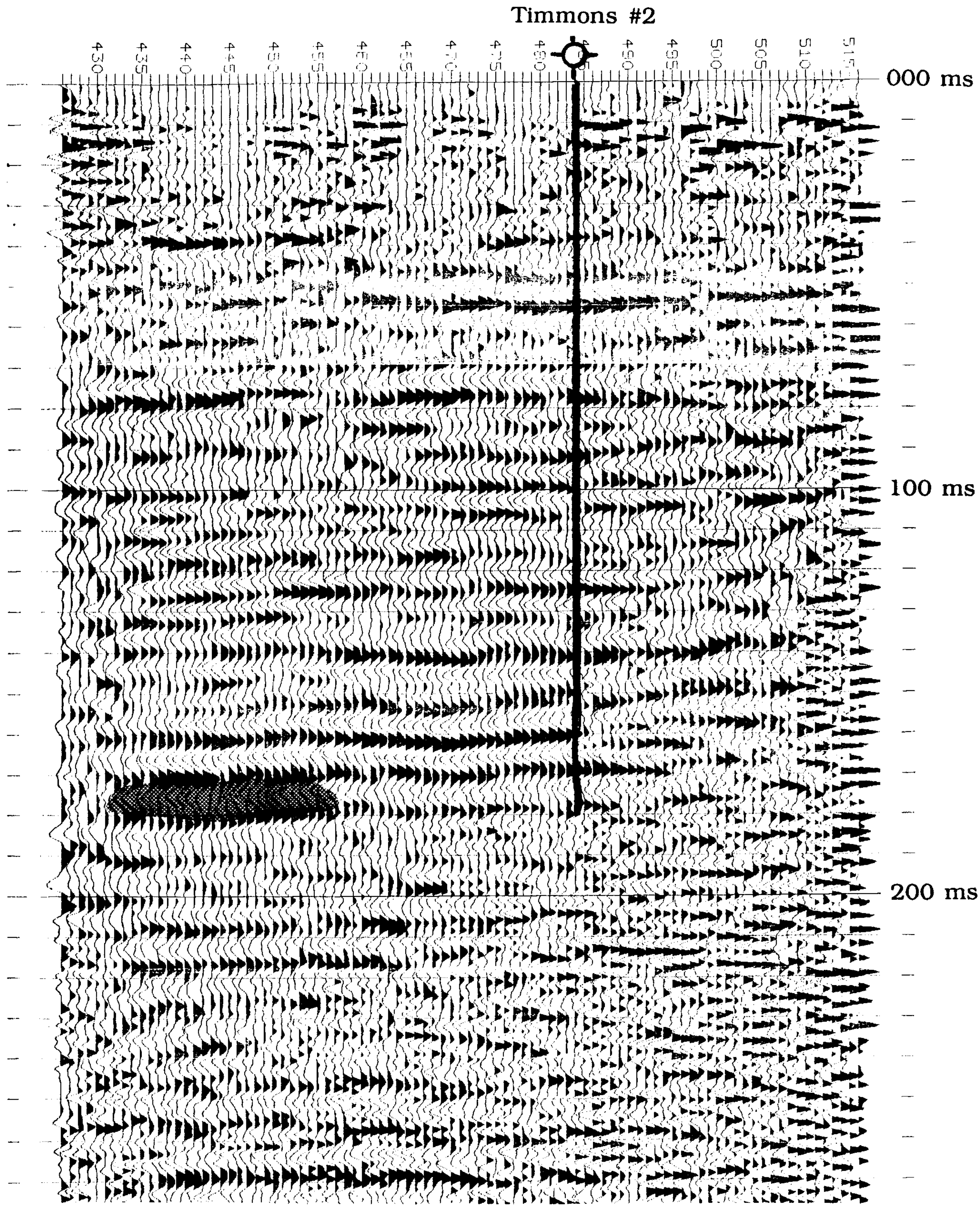

Figure 5. Final section of line #2. Note that CMP numbers are double the surface position numbers of Figure 2.

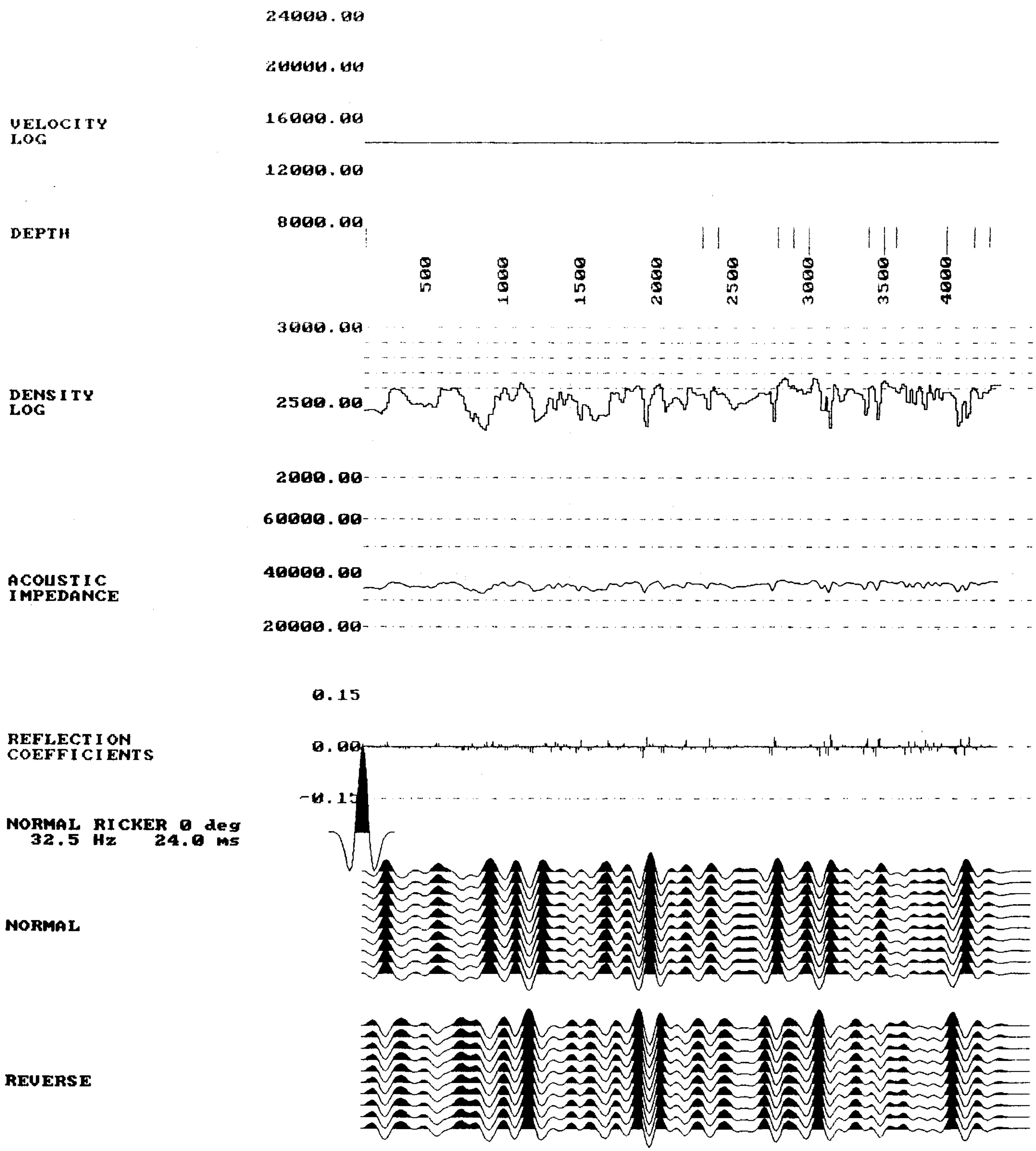

Figure 6. Synthetic seismogram from Timmons #1. Note that reflection coefficients are derived solely from density.

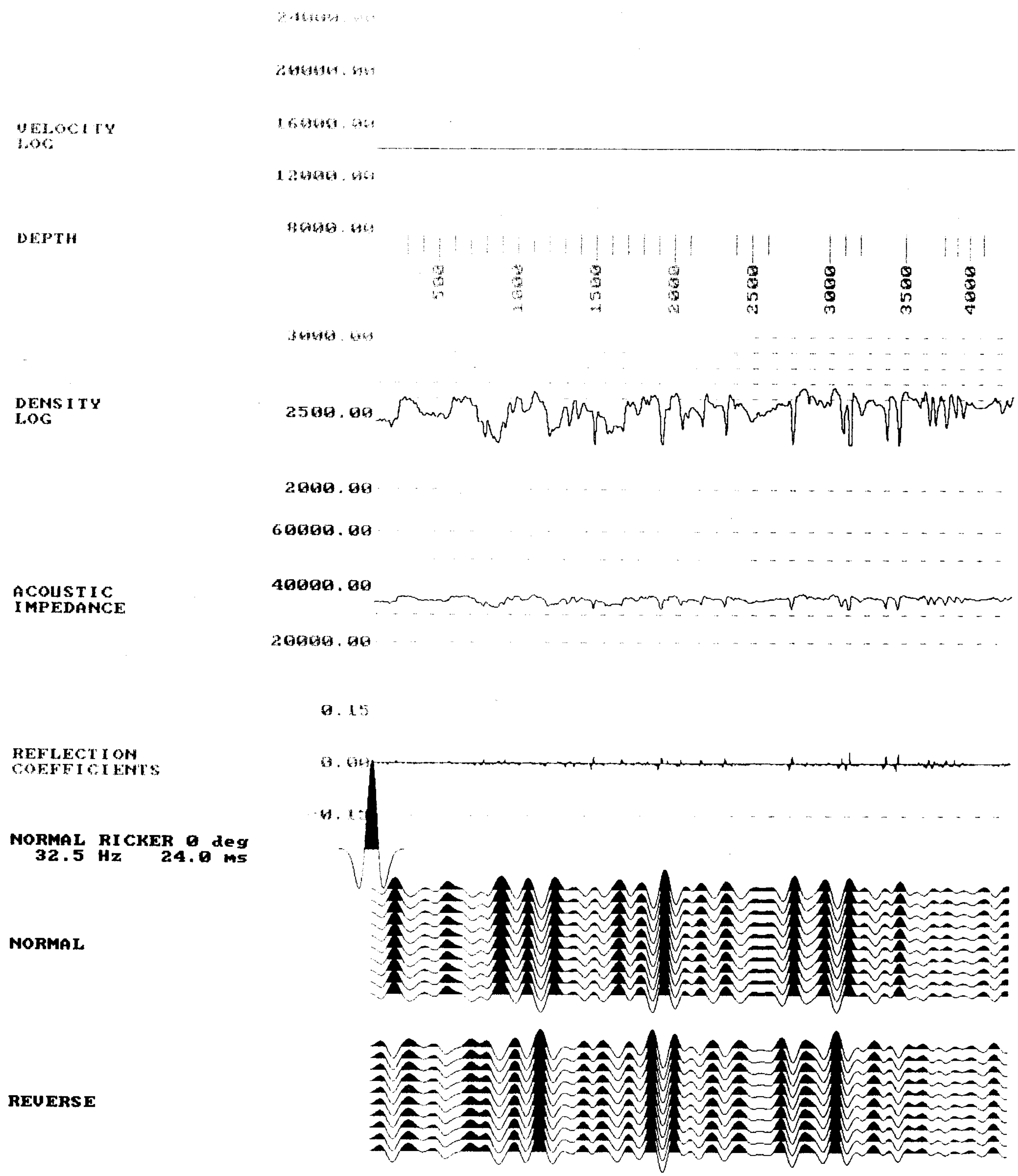

Figure 7. Synthetic seismogram from Timmons #1 with sandstone porosity replaced with higher density shale.