KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 93-57

Feasibility of Sesimic Reflection to Image the Top
and Bottom of an 80 to 150 Ft. Deep Clay Layer
at the Memphis Defense Depot

by

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FEASIBILITY OF SEISMIC REFLECTION TO IMAGE THE TOP AND BOTTOM OF AN 80 TO 150 FT DEEP CLAY LAYER AT THE MEMPHIS DEFENSE DEPOT

By
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A high resolution seismic survey was proposed at the Memphis Defense Depot to image the subsurface along an approximately 2000 ft line. The primary geologic targets were the top and bottom of a drill confirmed clay layer between 80 and 150 ft, any acoustically significant interfaces between the ground surface and the top of the clay, and if possible the base of the Memphis sand. The thickness and integrity of the clay were the pieces of data necessary to determine the quality of the seal between fluids above and the aquifer below the clay.

To determine the clay thickness it was necessary for the data to be high frequency and broadband. The dominant frequency of the recorded data was very near 125 Hz. Assuming an average velocity in this area of around 2000 to 3000 ft/sec the maximum resolution potential of a seismic survey using the equipment available would have been about 7 ft.

Proven high resolution techniques (Steeples and Miller, 1990) were to be used to insure the highest quality (both resolving power and signal-to-noise ratio) recorded data. The walkaway noise testing completed at this site was designed to determine the feasibility of acquiring data in a standard CDP format (Mayne, 1962) using roll-along type acquisition techniques similar to conventional petroleum exploration data acquisition. The geophone spacing, analog filtering, seismic source, geophone type, spread geometry, sampling interval, total samples, shots/pt, and acquisition philosophy are all normally determined during pre-production tests.

The project was designed to consist of two major phases: testing and production. The testing phase consisted of two days of walkaway noise surveys at three places along planned survey line. The walkaway noise tests were gathered according to common shot station and receiver offset and separated into distinct groups according to recording parameters. The quality and potential of the test data were used to determine whether the production portion of the project was feasible and should be undertaken. It was determined after careful consideration of both the data quality requirements and the necessary effort with the existing equipment to produce a meaningful stacked section that the survey should not go onto the production phase.

EXPERIMENTAL (TESTING) PHASE

The testing phase began on September 14, 1993 and consisted of a series of walkaway noise tests at three different locations east of MW-19 and west of MW-18 (figure 1). The first test line was oriented north/south and located in the grassy area immediately west of the north gate entrance and south of MW-34. The second test line was situated about half way between the west fence and the north gate entrance in a gravel area about 100 ft north of a railroad spur. The third and final test area was in a saturated gravel area directly north of the second test line and about four feet south of the asphalt road just inside the north fence. The test data set should be representative of overall data quality that could be expected from a CDP survey in this area with the available equipment.

Testing at this site included evaluation of both P- and S-waves. The data were acquired on a 15-bit EG&G Geometrics 2401 seismograph sampling at 1/5 ms, no or 50 Hz analog low-cut filters (18 dB/octave rolloff from their indicated -3 dB point), and 500 Hz analog high-cut filters. The dynamic range of the seismograph was more than adequate to record high-quality reflection information at this site in the presence of source-generated and cultural noise.

The degree to which various source configurations and types and receivers could be tested during the walkaway portion the P-wave surveys was limited by availability and near-surface conditions. The gravel covered near-surface limited source testing to the sledge hammer impacting a steel plate. Each record represents the summation of between 5 and 30 single impacts repeated at each shot station. The relatively thick gravel cover would have made downhole placement of an explosive source extremely difficult, possibly compromised safety with the available equipment and supplies. The receiver array consisted of single Mark Products L28E 40-Hz geophones with approximately 9 cm spikes centered at each station. All applicable acquisition parameters and available equipment that could be safely tested at this site were tested to determine feasibility of the technique under existing conditions.

With the drill defined geologic setting and proposed target a downhole explosive source would probably have been the source of choice for the P-wave survey. Most of the energy produced by the hammer source at this site seemed to propagate horizontally with limited vertical or near vertical components. This predominant horizontal energy travel resulted in extremely high amounts of recorded direct wave, ground roll (surface wave), and air coupled wave. The spectral and total energy characteristics of a downhole seismic source (Miller et al., 1992) in this geologic setting would have had a greater chance of imagining reflectors at depths between 80 and 250 ft.

S-wave testing was only performed at test area #3. The single horizontal geophones of unknown natural frequency were oriented to preferentially record the SH component of source generated shear wave energy. The source for the testing was a wood plank impacted perpendicular to the survey line with a sledge hammer. To maximize source coupling a vehicle was parked on the wood plank. The plank was struck with the sledge hammer from both north-to-south and south-to-north. The polarized nature of SH waves allows for qualitative comparisons and signal enhancement during analysis by simply reversing the sign of the data from one direction. The S-wave data at test area #3 was only recorded with analog low cut filters out.

The spreads used for testing were generally end-on with source-to-receiver-offsets that ranged from 4 ft to as much as 386 ft. The large range of source-to-receiver offsets allowed for definitive determination of the optimum recording window (Hunter et al. 1984). The tight receiver spacing (4 ft) was used to improve the coherency of recorded data within the optimum window. The cable, roll switch, seismograph combination allowed a maximum of 48 channels to be recorded from one source location and therefore due to multiple shot locations on some gathers, slight time mis-ties (shot static) can be observed on shot gathers with more than 48 traces. Equivalent shots recorded from both ends of the spread allowed evaluation of the consistency in energy arrivals independent of localized near-surface conditions. The spread used during testing was designed to facilitate the recording of reflected energy from depths between 10 and 400 ft assuming a velocity structure consistent with the drill reported lithology and geologic setting.

Critical data collected during the testing phase of this survey were reduced to the appropriate display format on site. The on-site data reduction and associated analysis allowed confident decisions concerning the feasibility of the technique to image the proposed target. All single shot gathers were displayed in raw, AGC, and digital filtered format at the time of recording . Walkaway noise tests for this report are displayed according to source-to-receiver offset with separate displays for each source, receiver type, and low cut filter tested. Data displayed in this report have been trace balanced and/or digitally filtered and displayed in a variable-area wiggle trace format.

TEST AREA #1

The grassy area between two sets of railroad tracks just west of the north guard house appeared to be an ideal place to get good geophone plants and source couple. During the planting of geophones it was determined that the near-surface was fill with a grass veneer. The resulting data acquired at this location was relatively low energy with excessive amounts of wind noise (figure 2). After digital filtering only subtle indications of potential reflecting events can be interpreted ahead of the air wave and just after the refracted arrival. Little body wave energy can be interpreted beyond about 24 channels even with the 5 shot stacks. The dominant frequency of the recorded body wave energy was in excess of 125 Hz. This higher than expected frequency speaks well for the potential resolution in this area. With the extremely low level of recorded body waves at this location it was determined necessary to move on to another site with potentially greater energy propagation.

TEST AREA #2

Data recorded in this gravel covered area seemed to have potential to produce meaningful reflected energy (figure 3 to 8). The ground roll, direct wave, and air couple wave are easily identifiable. The refracted arrival possessing a linear velocity of about 4000 ft/sec seemed to be converging with an arrival with apparent hyperbolic curvature. This event arrives between 90 and 110 msec on the longer offsets (figure 3). The asymptotic nature of these two arrivals is very diagnostic of reflection/refraction interaction at longer offsets. The NMO curve for this apparent reflection suggested a NMO velocity of about 2600 ft/sec and therefore a depth to reflector of about 100 ft. Well within the target depth window. At this point the only aspect of the data that was a cause of some skepticism was the apparent drop in NMO velocity of curved arrivals appearing later in time (ie 110 msec to 120 msec at longer offset before air coupled wave). The data recorded at site #2 seemed to have the potential for a very focused but meaningful CDP stacked section.

Longer offset data were acquired to determine if a refraction arrivals could be interpreted at offsets greater than 200 ft (figure 5). The site was sufficiently attenuative to high frequency body wave energy that for longer offset records as many as 30 impacts were summed to form a single record. The arrivals at longer offsets were not conclusive but did not refute the suggestion that the 90 msec event was a primary reflection event. Some indication at offsets greater than 200 ft of relatively flat (high velocity) deeper (400 ft plus) events might be interpretable.

To insure that the recorded data was representative and not the result of localized near-surface conditions, the source location was moved to the east end of the line (figure 6 and 7). From the opposite end of the line consistency should be the primary focus of data analysis. The arrivals were expected to be very consistent with those from the west with only subtle difference associated with potential dip on the refracting interface. The resulting sections were the first indication that the majority of the recorded energy was propagating horizontally and very little had a strong vertical component. The apparent reflection at 90 msec became an obvious refraction especially at longer offsets. The origin time of the event changed from about 85 msec to about 60 msec. The reflector dip necessary for this event to be a reflection is unrealistic. The lack of any arrival earlier in time at offsets greater than 200 ft represents the most conclusive evidence to suggest this event is a refraction. Deeper in the record the characteristic ring associated with large acoustic contrasts at shallow depths can be easily interpreted. The characteristics of the seismograms from the east are not encouraging for a reflection profile.

On previous surveys, in areas with poor source couple occasionally using an asphalt area as the source contact point has improved total recorded energy without sacrificing ground roll/direct wave verses body wave ratios. The asphalt road boarding the site was 67 ft away and was used to test this principle at this site (figure 8). The seismograms recorded with the source contacting the asphalt seem to possess a broader bandwidth and a greater signal-to-noise ratio. Therefore the next day's test area was proposed to be in a saturated area close enough to the asphalt road and perpendicular to that road to allow source locations on the asphalt.

TEST AREA #3

As a rule, saturated material improves the propagation of high frequency acoustic energy. With the less than encouraging results of previous testing an attempt was made to locate the third and final test line in an area of the gravel yard with the highest potential for recording meaningful information. The site was about 4 ft from the asphalt road in a muddy low area within about 30 ft of the main east/west road along the north end of the facility.

The initial testing at this site placed the source on the west end of the line and did not produce any arrivals that were conclusive (figure 9 and 10). The first arrivals were consistent with what was recorded at test site #2. The close proximity of the road is evident in terms of recorded background noise from vehicular traffic. A very low amplitude high frequency and high velocity arrival can be interpreted on close offsets and early time unique to this site. This arrival is interpreted to be associated with the asphalt. It presents no problem to the interpretation of acoustic energy significant to this survey.

Reversing the shot direction produced unique arrivals that were similar to those from site #2 but possessed greater bandwidth and apparent depth of penetration (figure 11 and 12). The previous interpreted 90 msec event identified as a refraction on records with the source on east end at test area#2, is present and clearly fits the model of a refracted arrival. A unique event deeper in time (approximately 110 to 140 msec) at longer offsets is set apart from the refraction but possesses a hyperbolic slope inconsistent with expectation and reasonable models. It does have the potential to be a mode converted S-wave. If the S-wave interpretation is correct, S-wave surveying might have a greater potential at this site than P-wave profiling.

Prior to ending the P-wave portion of the study data were recorded in a 48 channel split spread format to determine consistency of energy propagation at the closer offsets (figure 13). The test suggests subtle differences in arrival patterns which seem to be dependent on line orientation. This difference is most likely related to dipping layers and localized near-surface anomalies.

The S-wave survey was undertaken based on the possible interpretation of the mode converted wave on previous P-wave surveys. The recorded data possesses many of the same problems the P-wave data encountered. There seems to be significant amounts of horizontally travelling energy but only limited amounts of energy with a vertical component. The direct and refracted arrivals can easily be interpreted on unfiltered files (figure 14 to 16). Some arrivals deeper in time appear to have curvature. The velocity is unrealistic and does not properly fit any idealized curve representative of a reflection. These arrivals are most likely Love Wave. Filtering enhances these arrivals and allows clear inspection of their varying curvatures with depth. Longer offset data were recorded to allow a better interpretation of arrivals at offsets between 100 and 200 ft. These longer offset records required two source location and resulted in the apparent static mis-tie (figure 17, 19, and 21). The longer offset data confirms that no confidently interpretable S-wave reflection energy has been recorded at this site.

To insure that energy recorded on an S-wave record is real polarized shear wave, data recorded with opposite polarity but identical parameters and equipment can be reversed (sign) and display according to offset. The resulting section should have all S-wave data in-phase with all compressional or surface wave data 180 degrees out of phase. The displays of the S-wave data from this survey in that format is conclusive evidence that all the coherent arrivals are shear waves (16 and 21).

CONCLUSION

The final decision concerning the feasibility of seismic reflection surveying at this site were made at the completion of testing. The data used to make the final determination had been sorted, bandpass filtered, AGC scaled, and displayed in wiggle trace format. These plots possessed sufficient information and detail for a qualitative judgment concerning the feasibility of shallow high resolution CDP seismic reflection methods to delineate the structural and stratigraphic features of interest in this area. The CDP seismic reflection method does have the potential to produce meaningful information at this site, but the specialized equipment, significant site preparation, and rigorous data reduction requirements of this site made continuation to the production stage not a cost effective choice.

Quality Assurance and Quality Control During Acquisition of High Resolution Seismic Reflection Test Data

The most important part of any seismic survey is the initial walkaway testing necessary to properly set recording parameters. During this phase, all available parameters significant to the geologic setting need to be tested. In-field analysis should be focused on significant and influential parameter settings. The flow of in-field testing and analysis will vary with near-surface conditions. Some level of experience and technical expertise is necessary and critical at this stage of data acquisition to insure optimization of parameters. Improperly collected data will be of limited or no use. It is not possible to extract signal during processing if signal was not recorded during acquisition.

Several seemingly insignificant physical conditions can drastically effect the quality of the recorded seismic data. The most obvious will be poor geophone plants. The geophones need to be firmly planted and vertical to insure acceptable data quality. Degradation in signal associated with inadequate geophone plants occurs as the cosine of the angle away from vertical. Uniform energy levels from one shot to the next and from one trace to the next is critical for generation of meaningful CDP stacked sections. As might be imagined, when traces are gathered according to a common midpoint, corrected for offset, and stacked, amplitudes of individual wavelets are indicative of their relative weighting with respect to other traces in a particular gather.

The most productive QC and QA result from continuous monitoring and analysis of recorded data. Reflection events should be identified and their physical properties monitored throughout the data acquisition. Simple calculations of NMO velocity, depth, and time intercept for the most important reflections enable quick detection of changes in the subsurface or in acquisition techniques that may warrant further investigation. Attention to detail will generally detour most problems associated with improper or ineffective acquisition settings and techniques.

CONCLUSION

It is essential that the highest level of quality control be maintained at all stages of a shallow seismic reflection survey. During acquisition geophone plants were to be vertical with each undergoing a modified tap and twist test. No data were recorded unless background noise levels with the 50 Hz analog low cut filters were less than 0.5 mV. Only clean vertical impacts on the ground surface or steel plate were recorded as a good shot. Initial identification of all recorded energy on raw field data was necessary to determine next step and effectiveness of previous parameter change. Critical to the processing flow of any seismic data is confident interpretation of stacked reflection arrivals based on interpretations of unstacked reflection arrivals.

The QA/QC for the seismic reflection testing at the Defense Depot in Memphis was based on well documented and proven techniques of verification and cross-checking. This kind of thoroughness is essential to avoid the many pitfalls that can lead to incorrect interpretations. The methodology is sound as well the calculations and interpretations of QC data. The correlation of geology based on borehole data and the walkaways is essential for proceeding to the production phase of any seismic survey.

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Steeples, D.W., and Miller, R.D., 1990, Seismic-reflection methods applied to engineering, environmental, and ground-water problems: Soc. Explor. Geophys. Investigations in Geophysics no. 5, volume on Environmental Geophysics, S. Ward, ed., 1-30.

FIGURE CAPTIONS

Figure 1 Site map locating the three test areas.

Figure 2) Test site #1, analog low cut filter 50 Hz, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off north end.

Figure 3) Test site #2, analog low cut filter 50 Hz, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off west end.

Figure 4) Test site #2, analog low cut filters out, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off west end.

Figure 5) Test site #2, analog low cut filters 50 Hz, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off west end.

Figure 6) Test site #2, analog low cut filters out, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off east end.

Figure 7) Test site #2, analog low cut filters 50 Hz, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off east end.

Figure 8) Test site #2, asphalt surface for source 67 ft away from line, (A1) low cut 50 Hz and 50 msec AGC scale, (A2) low cut out and 50 msec AGC scale, (B1) low cut 50 Hz and bandpass filtered 50-100--300-450.

Figure 9) Test site #3, analog low cut filters 50 Hz, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off west end.

Figure 10)Test site #3, analog low cut filters out, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off west end.

Figure 11) Test site #3, analog low cut filters out, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off east end.

Figure 12) Test site #3, analog low cut filters 50 Hz, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, source off east end.

Figure 13) Test site #3, analog low cut filters out, receiver spacing 4 ft, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450, split spread.

Figure 14) Test site#3, S-wave survey, low cut out, source direction north to south off the west end, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450.

Figure 15) Test site#3, S-wave survey, low cut out, source direction south to north off the west end, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450.

Figure 16) Test site#3, figure 14 polarity reversed and combined with figure 15 effective south to north and 2 ft between traces, (A) AGC scale 50 msec, (B) digital bandpass filter 50-100--300-450.

Figure 17) Test site# 3, south to north, low cut filter out, off east end, AGC scaled 50 msec.

Figure 18) Figure 17 band pass filtered 50-100--300-450.

Figure 19) Same as figure 17 except source direction from north to south.

Figure 20) Figure 19 band pass filtered 50-100--300-450.

Figure 21) Figure 17 added to a reversed figure 19 to simulate south to north polarity with effective 2 ft trace spacing.

Figure 22) Figure 18 added to a reversed figure 20 to simulate south to north polarity with effective 2 ft trace spacing.

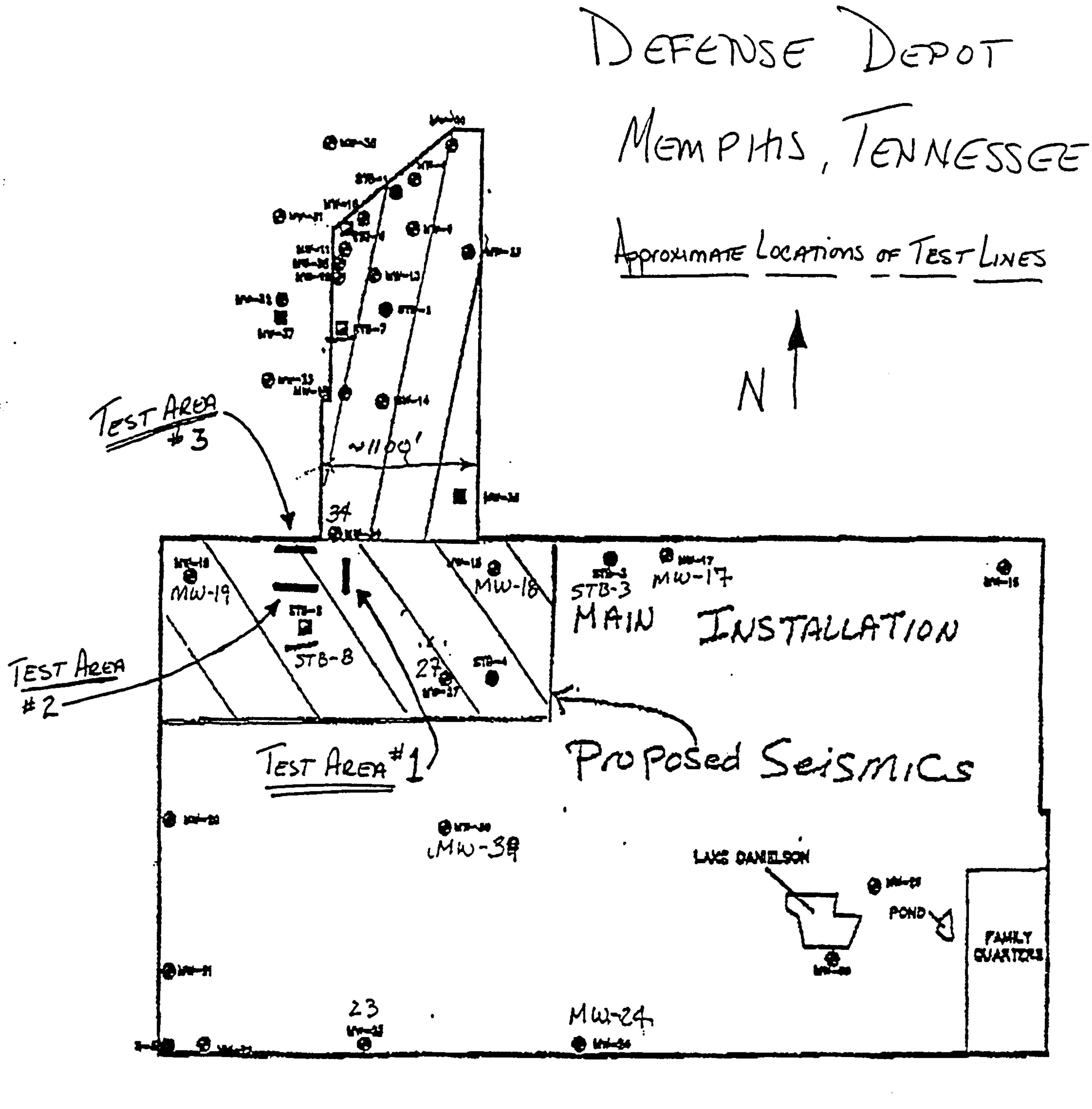


FIGURE.1 SITE MAP WITH TEST LINE LOCATIONS AND MONITOR WELL LOCATIONS.

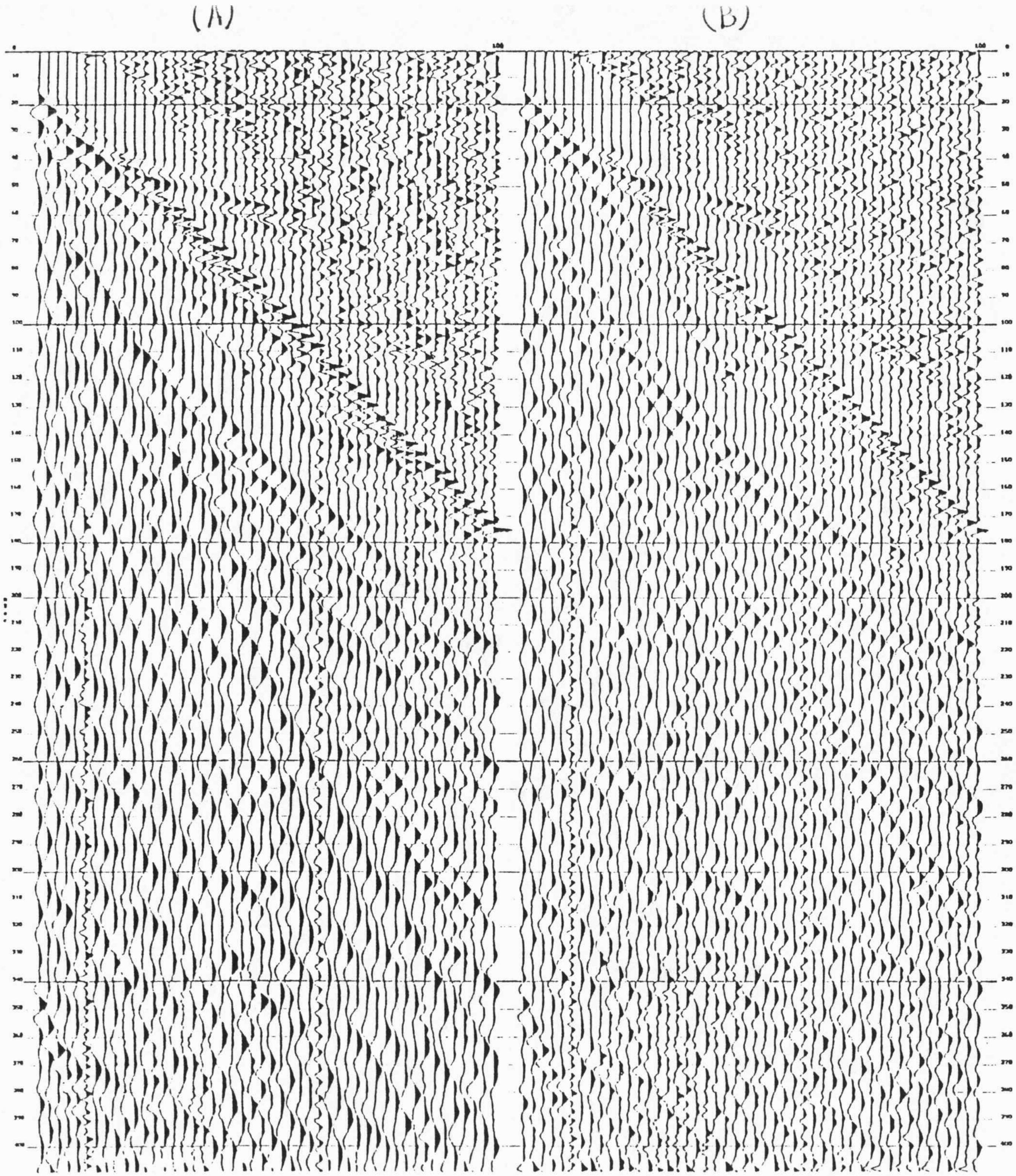


FIGURE 2

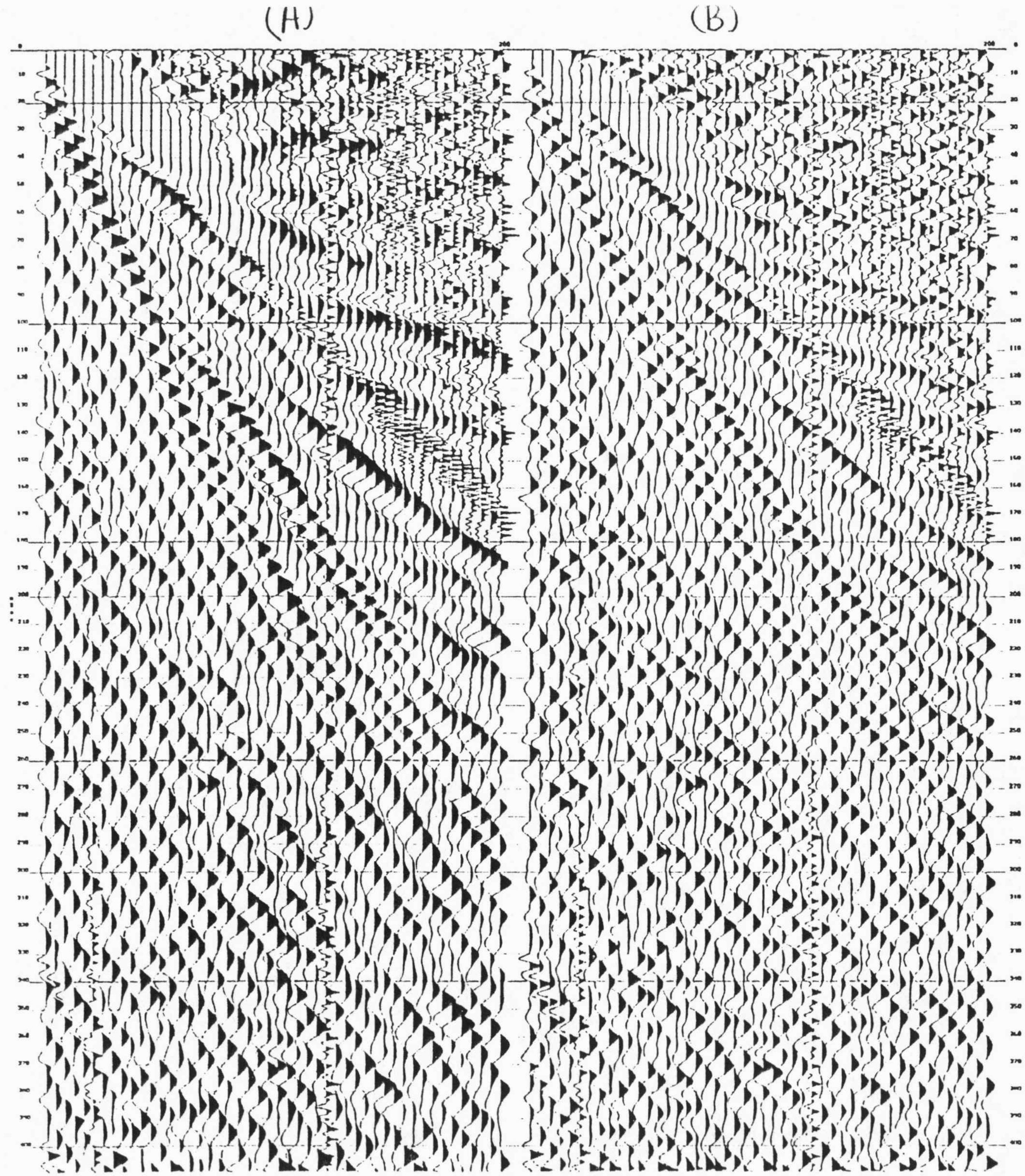


FIGURE 3

(A) (B)

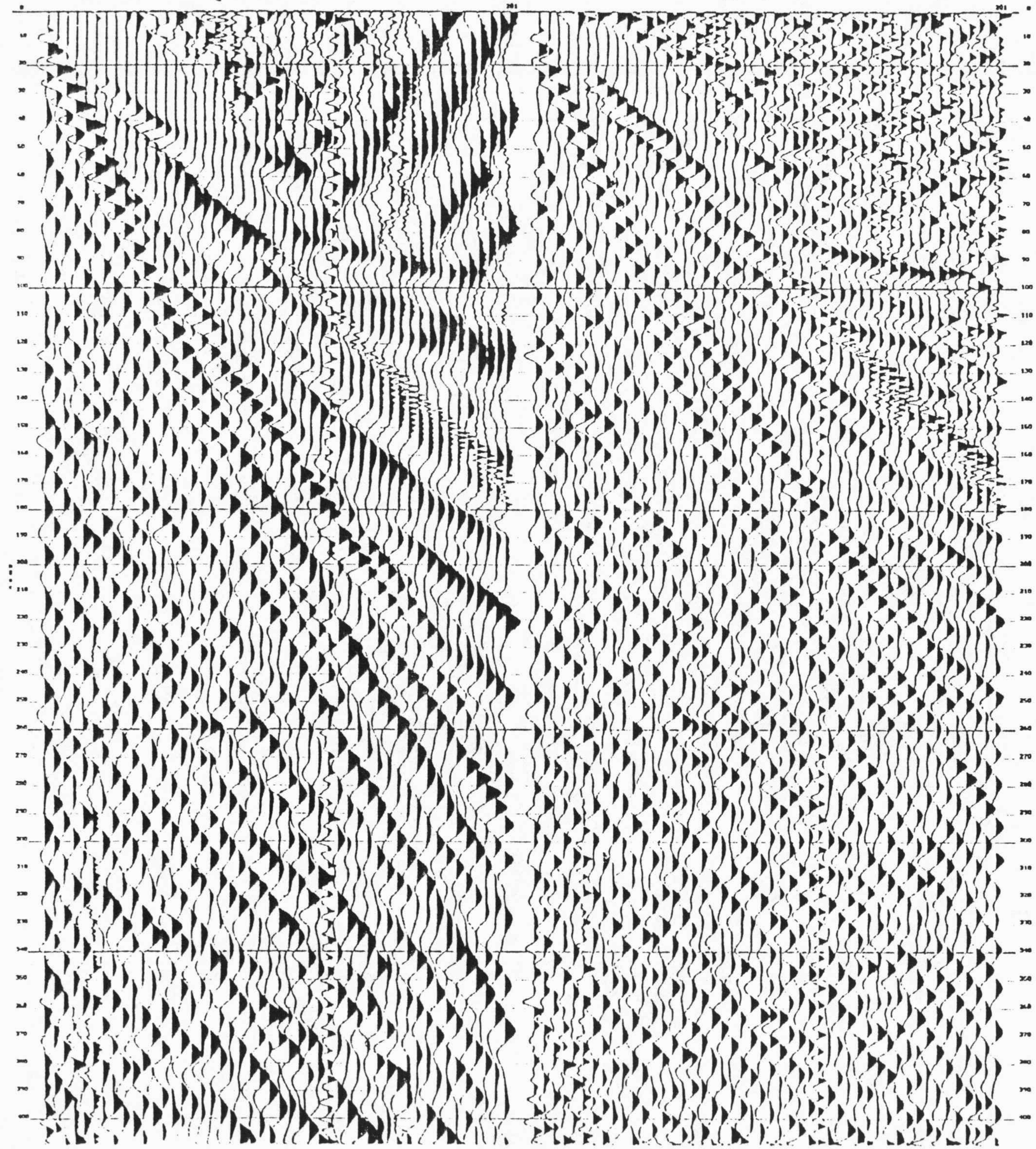


FIGURE 4

(A)

(B)

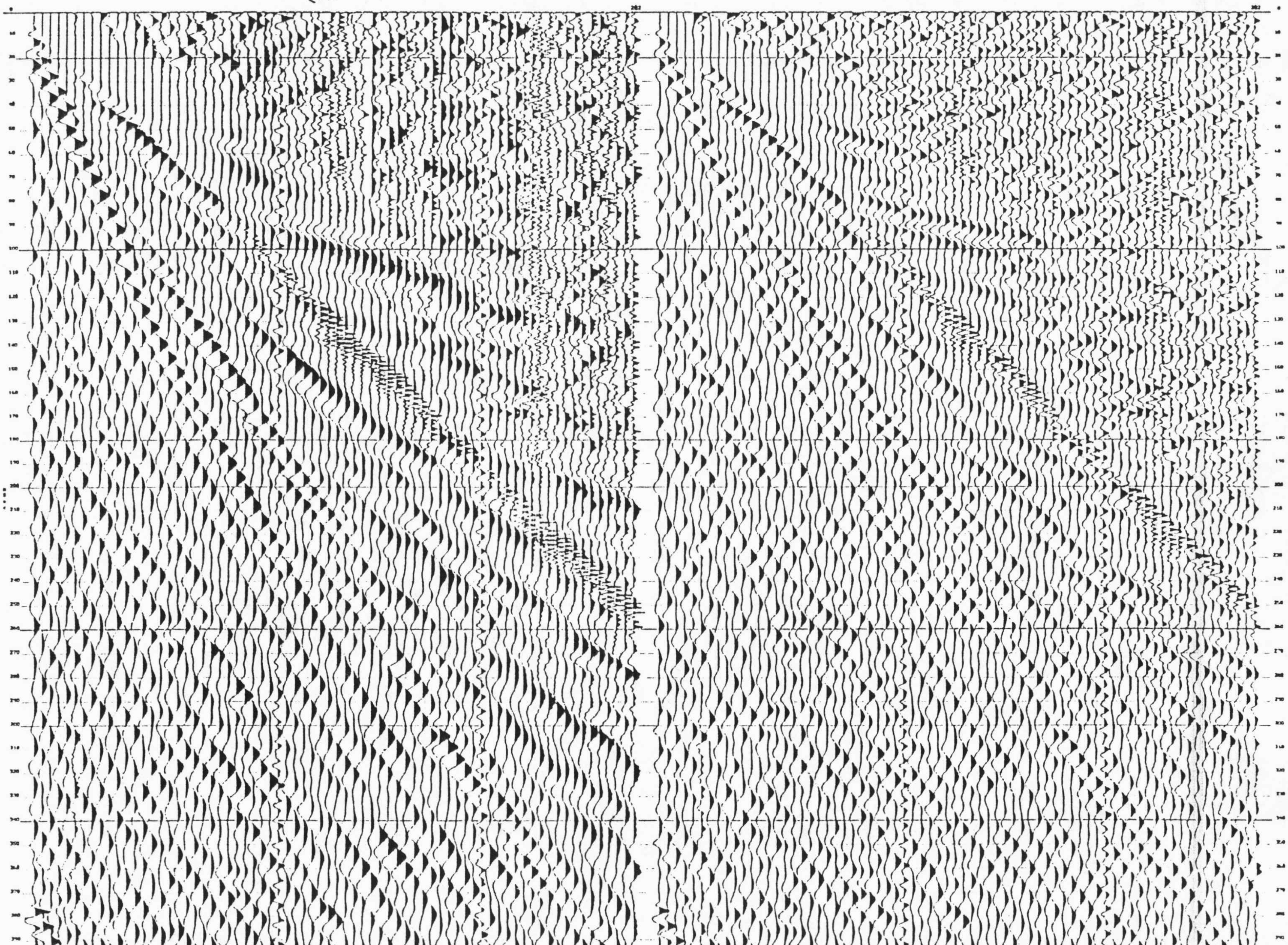


FIGURE 5

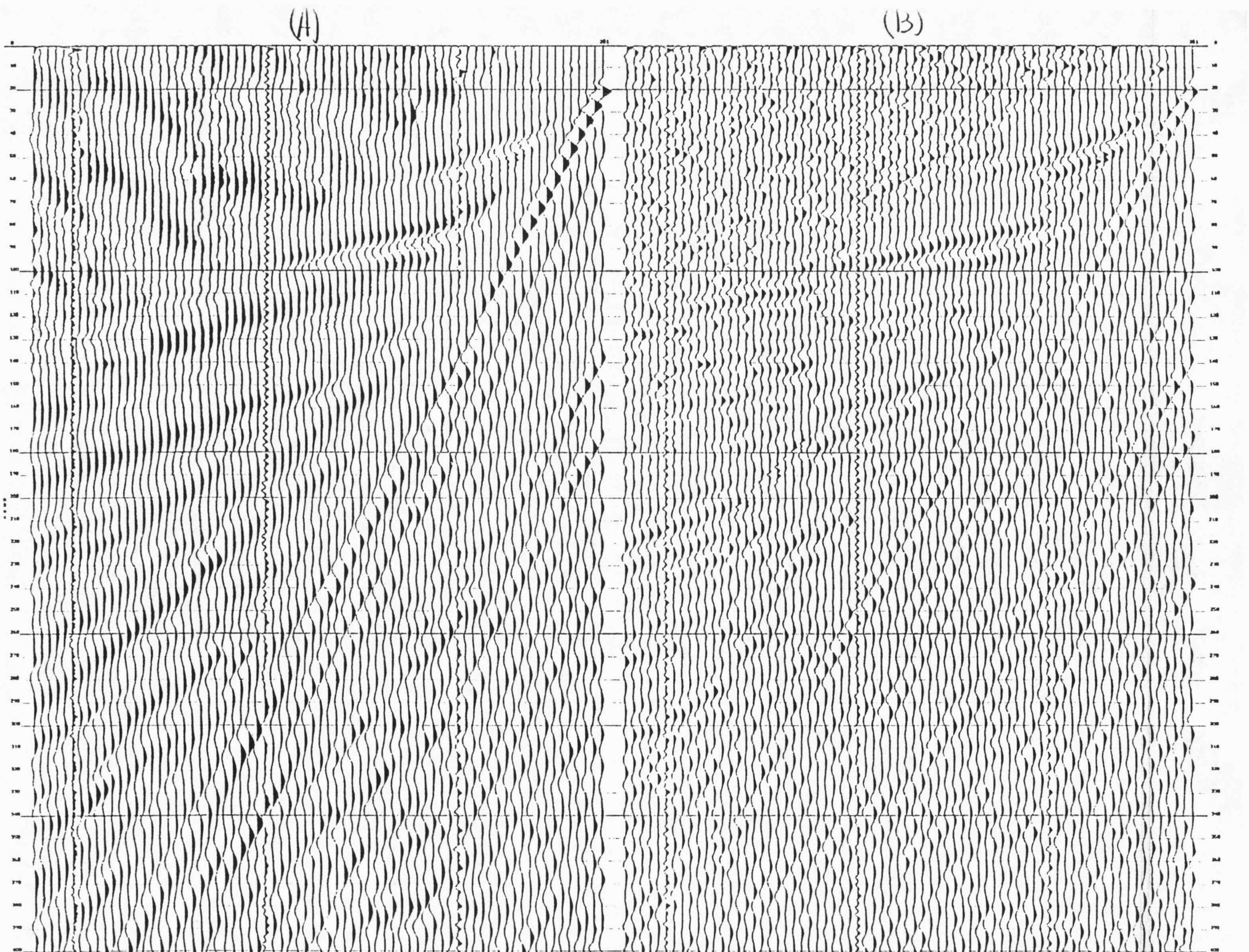


FIGURE 6

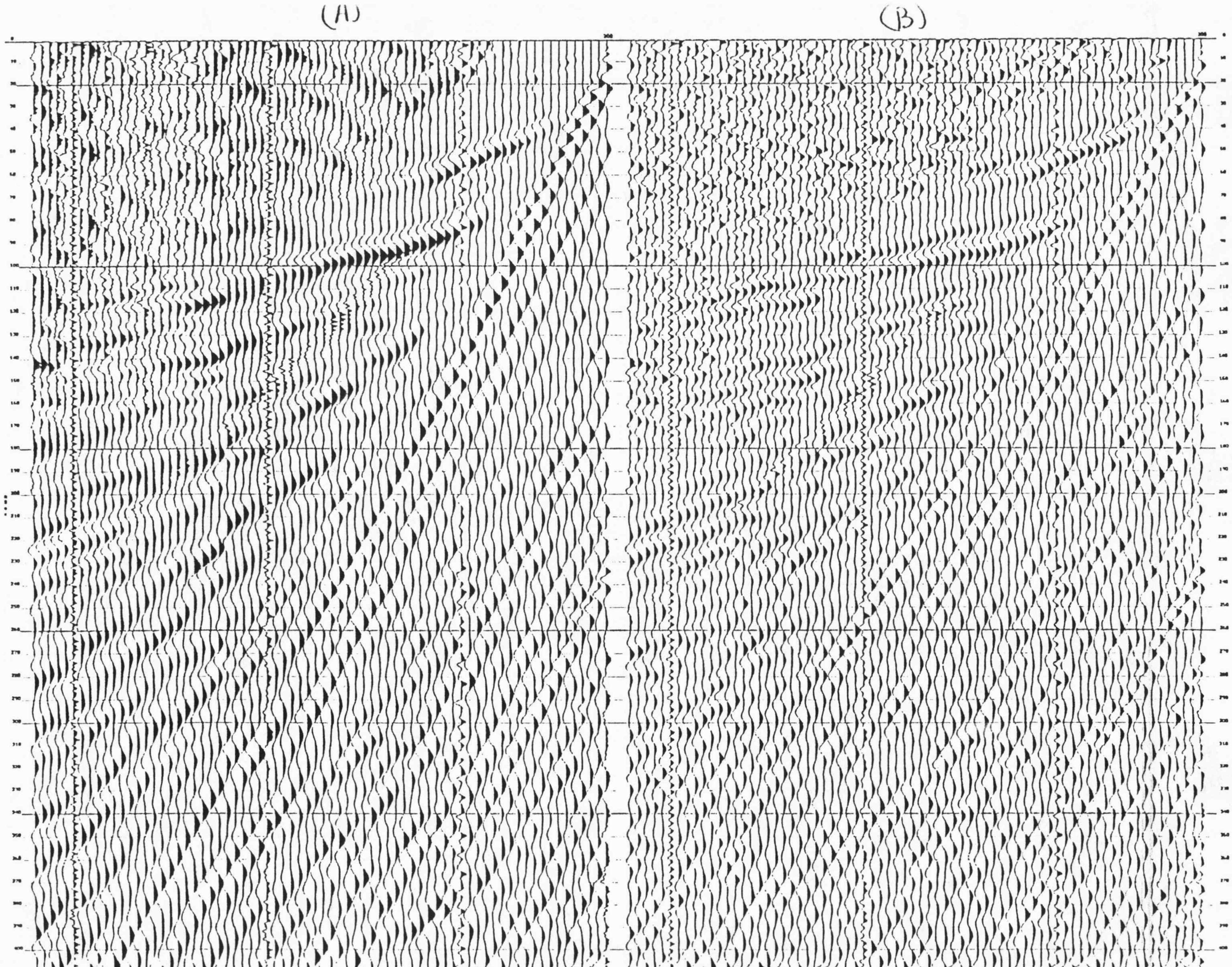


FIGURE 7

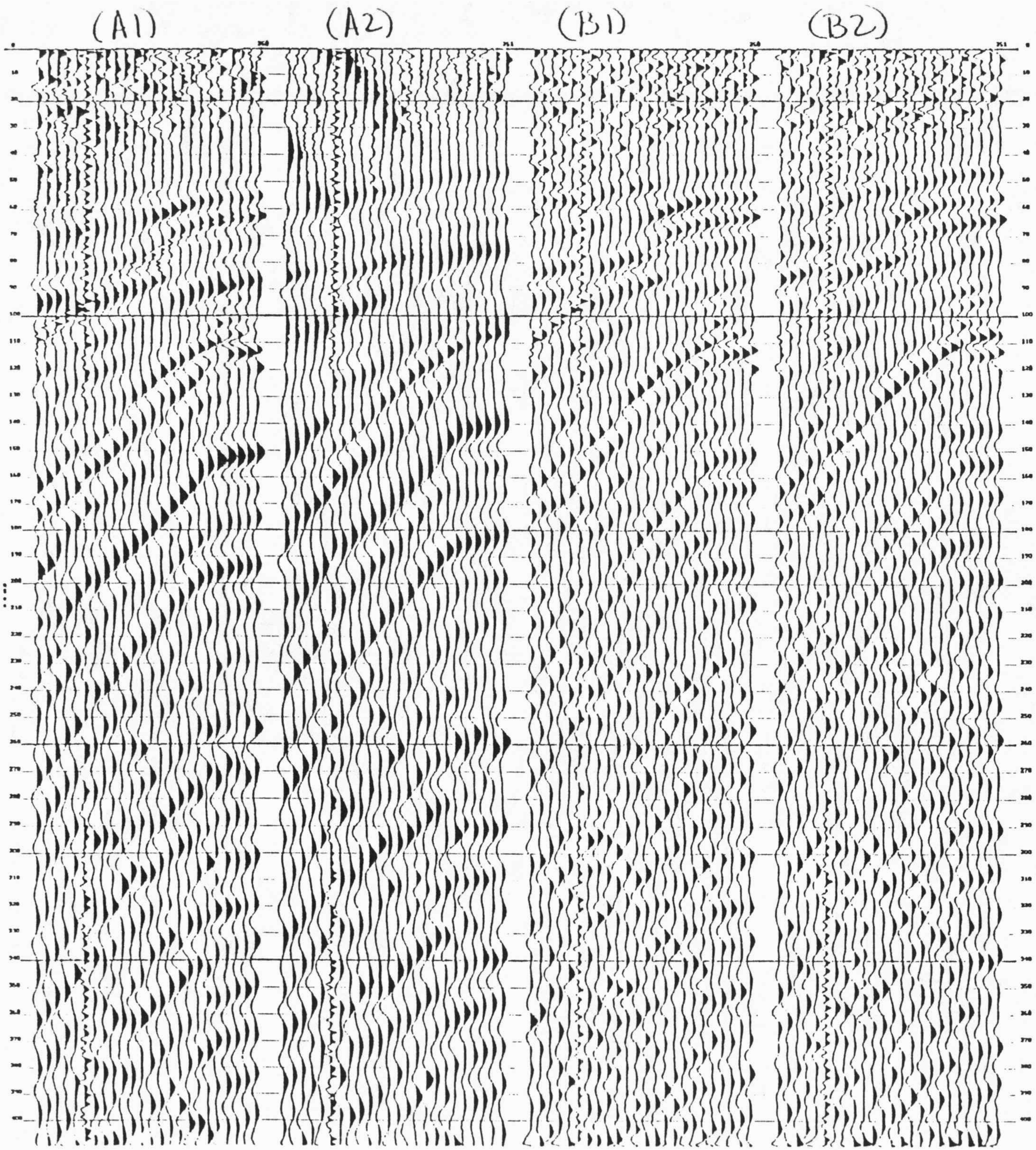


FIGURE 8

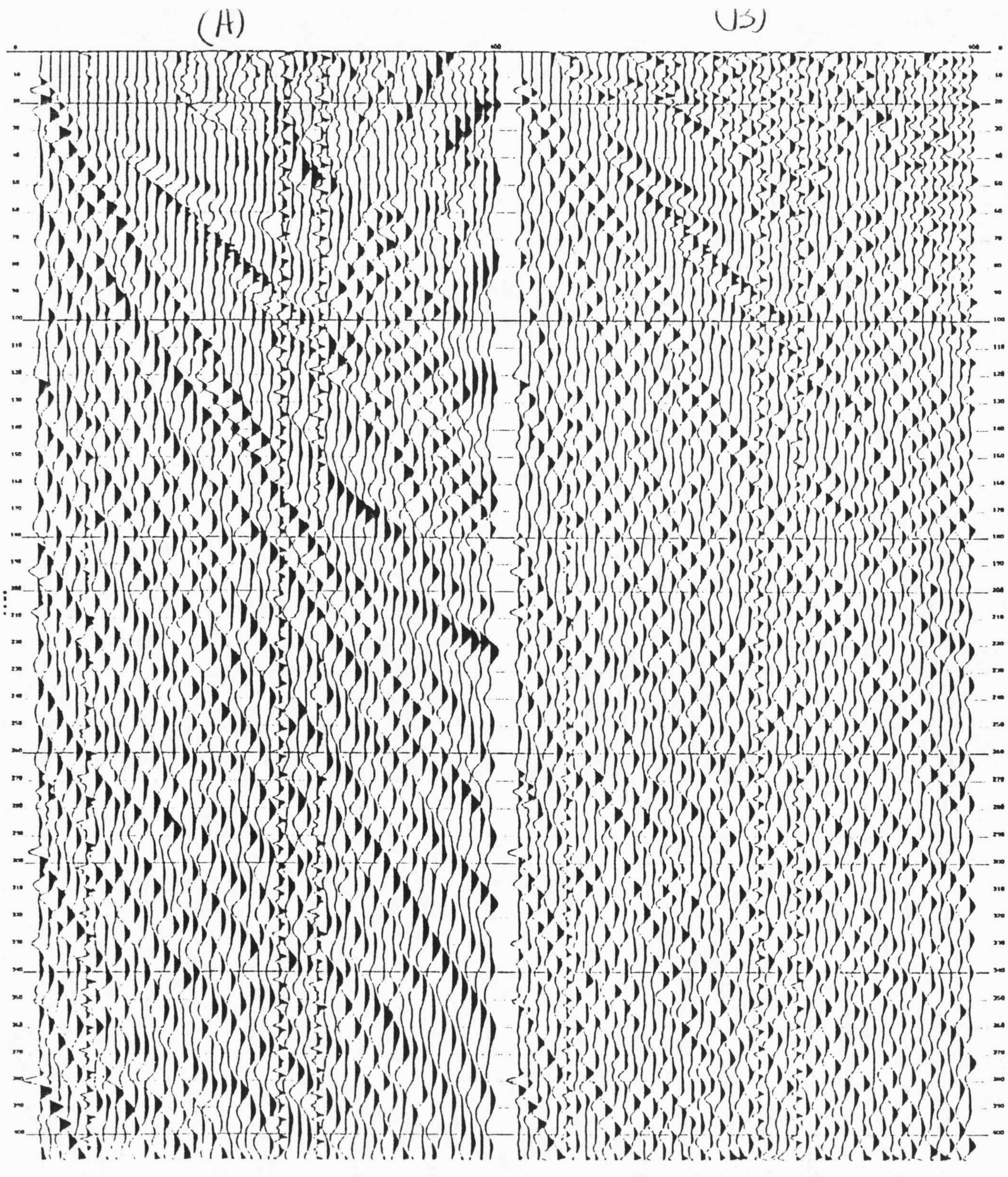


FIGURE 9

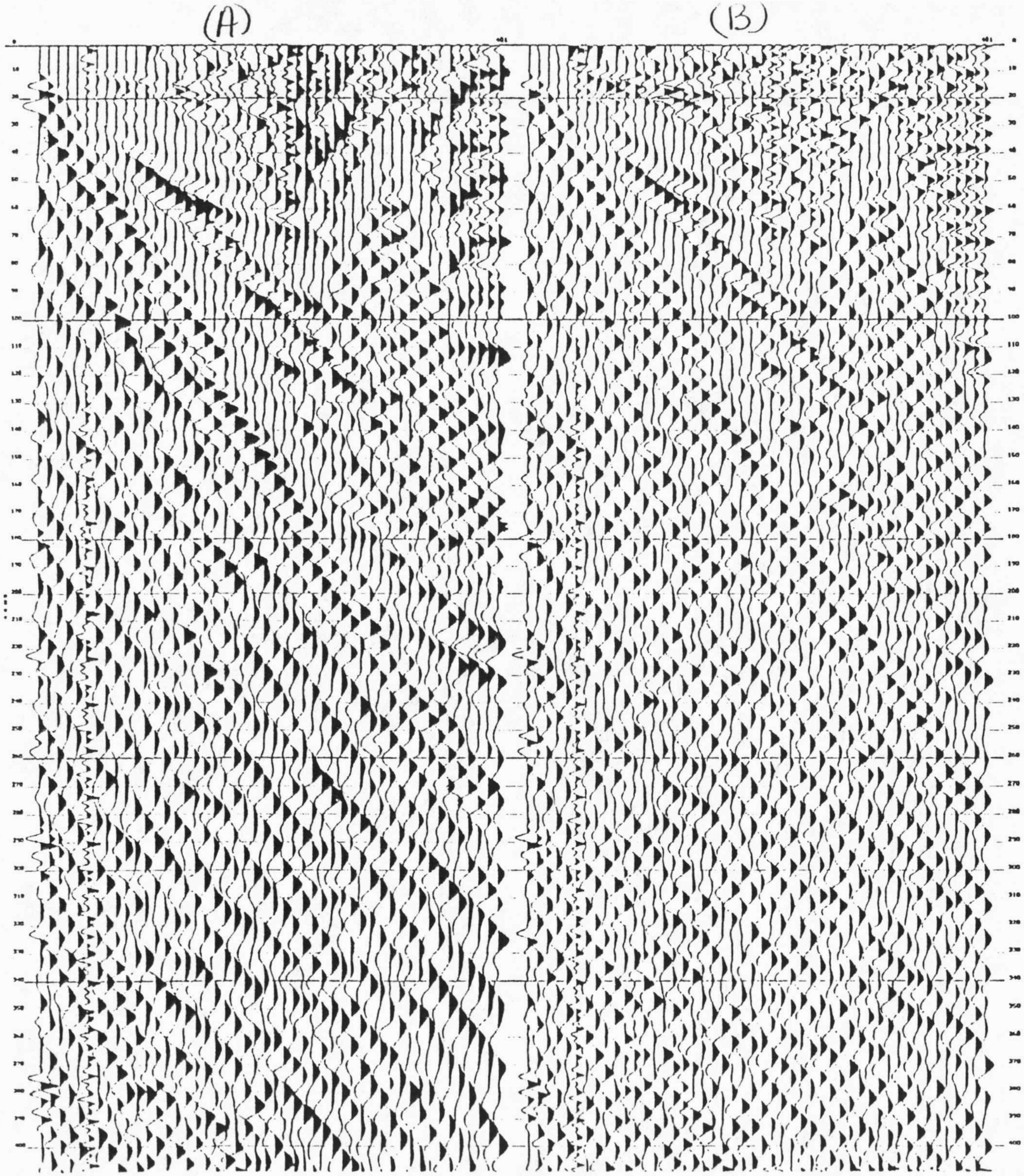


FIGURE 10

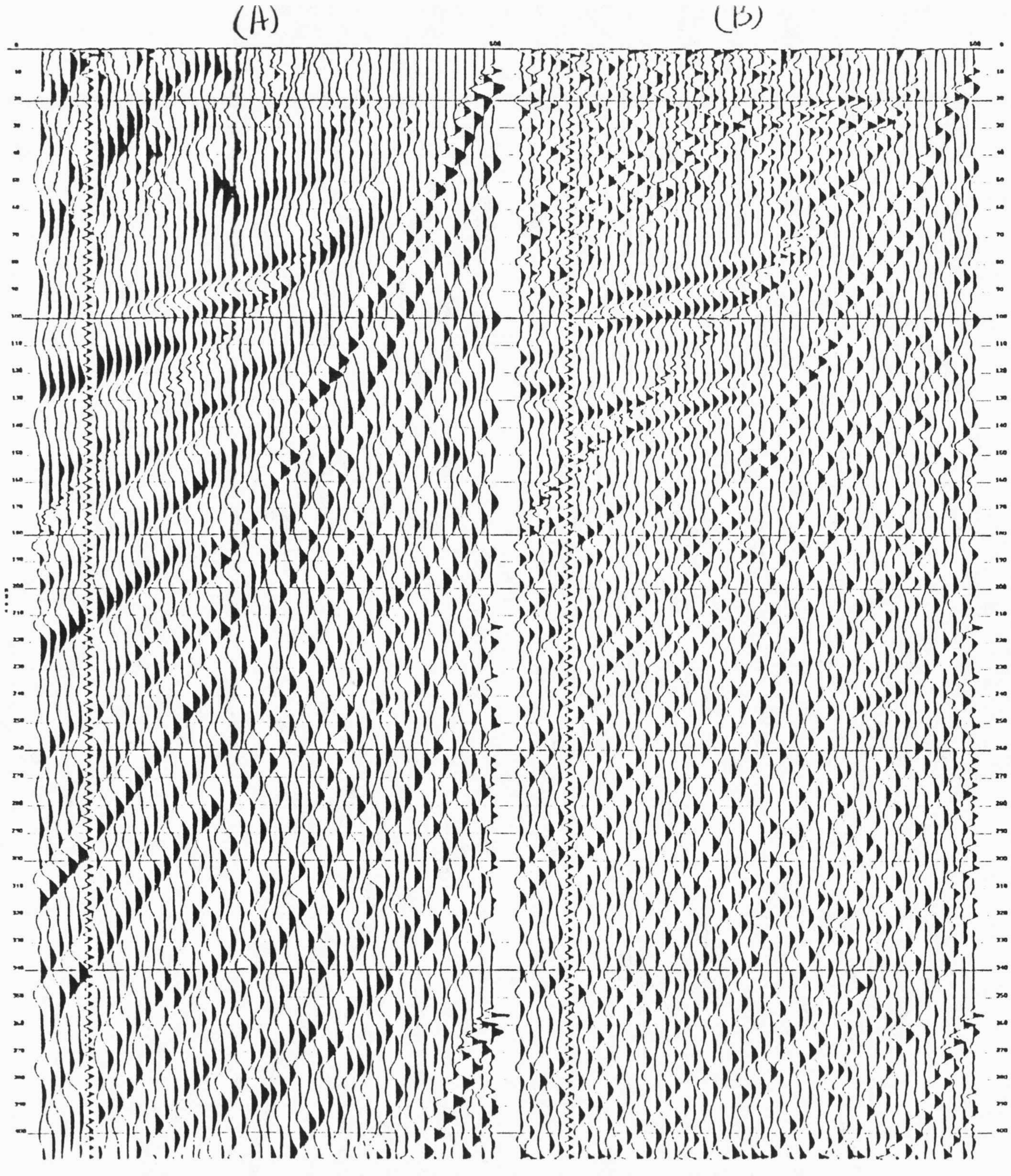


FIGURE 11

(A) (B)

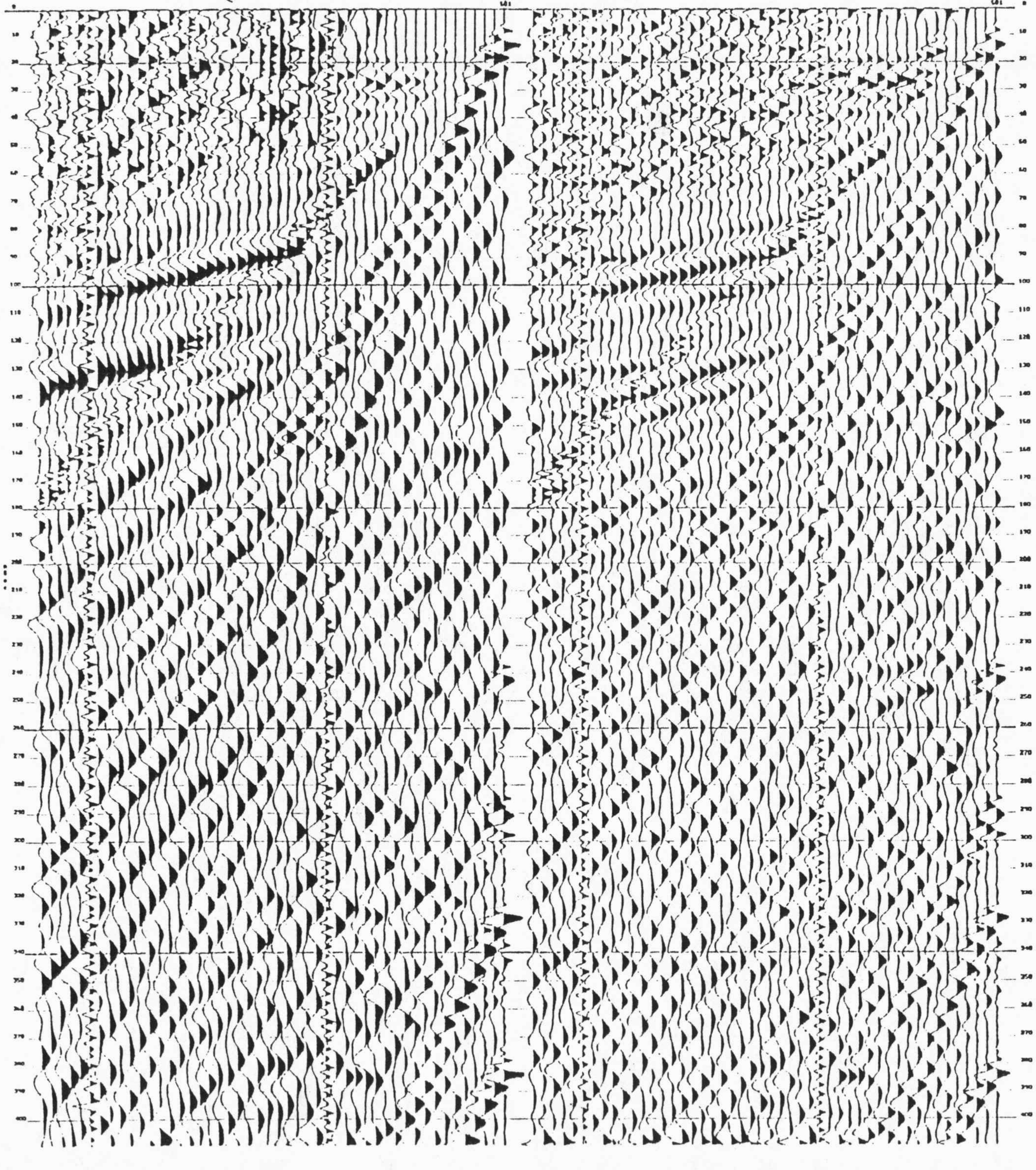


FIGURE 12

(A) (B)

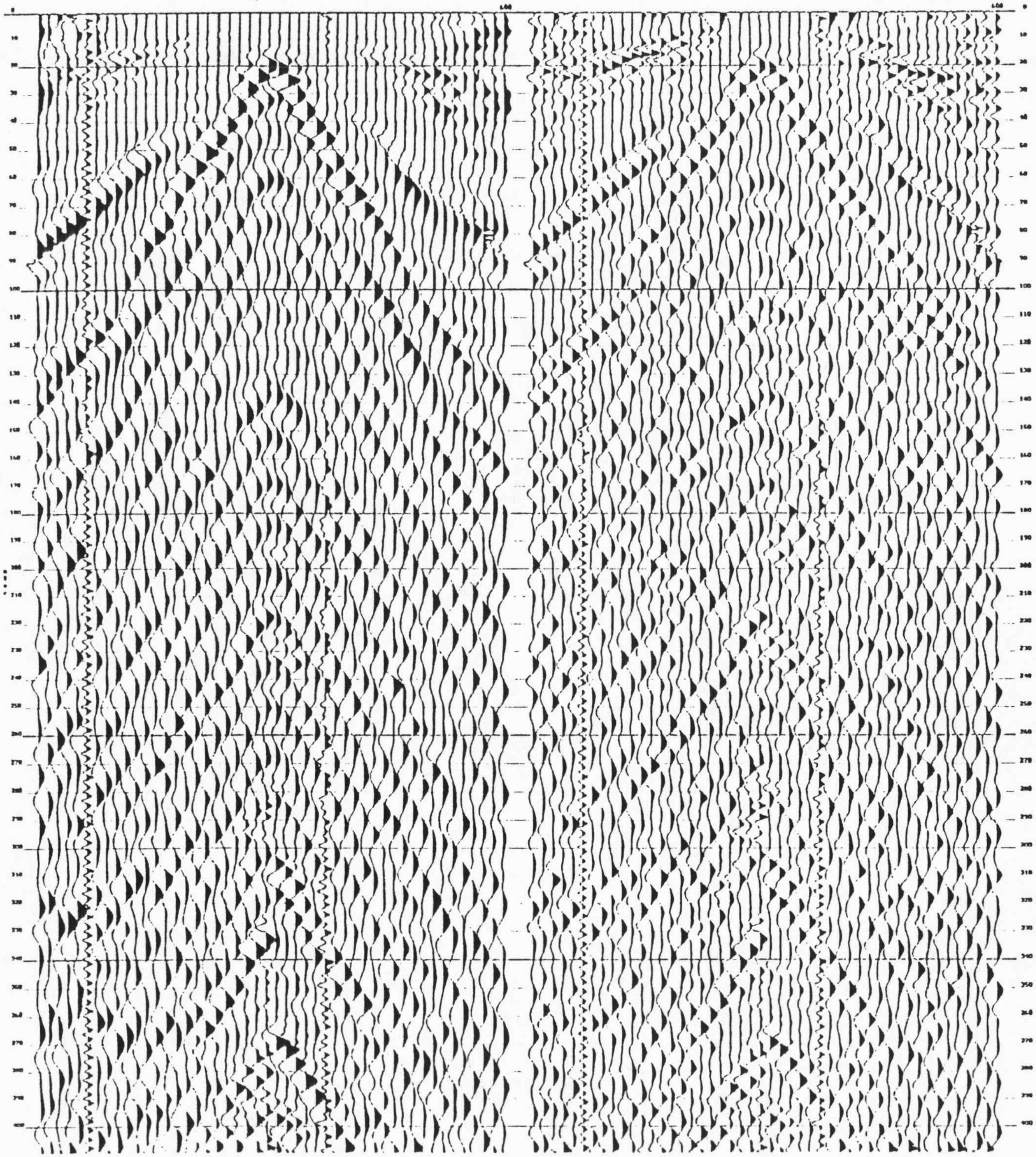


FIGURE 13

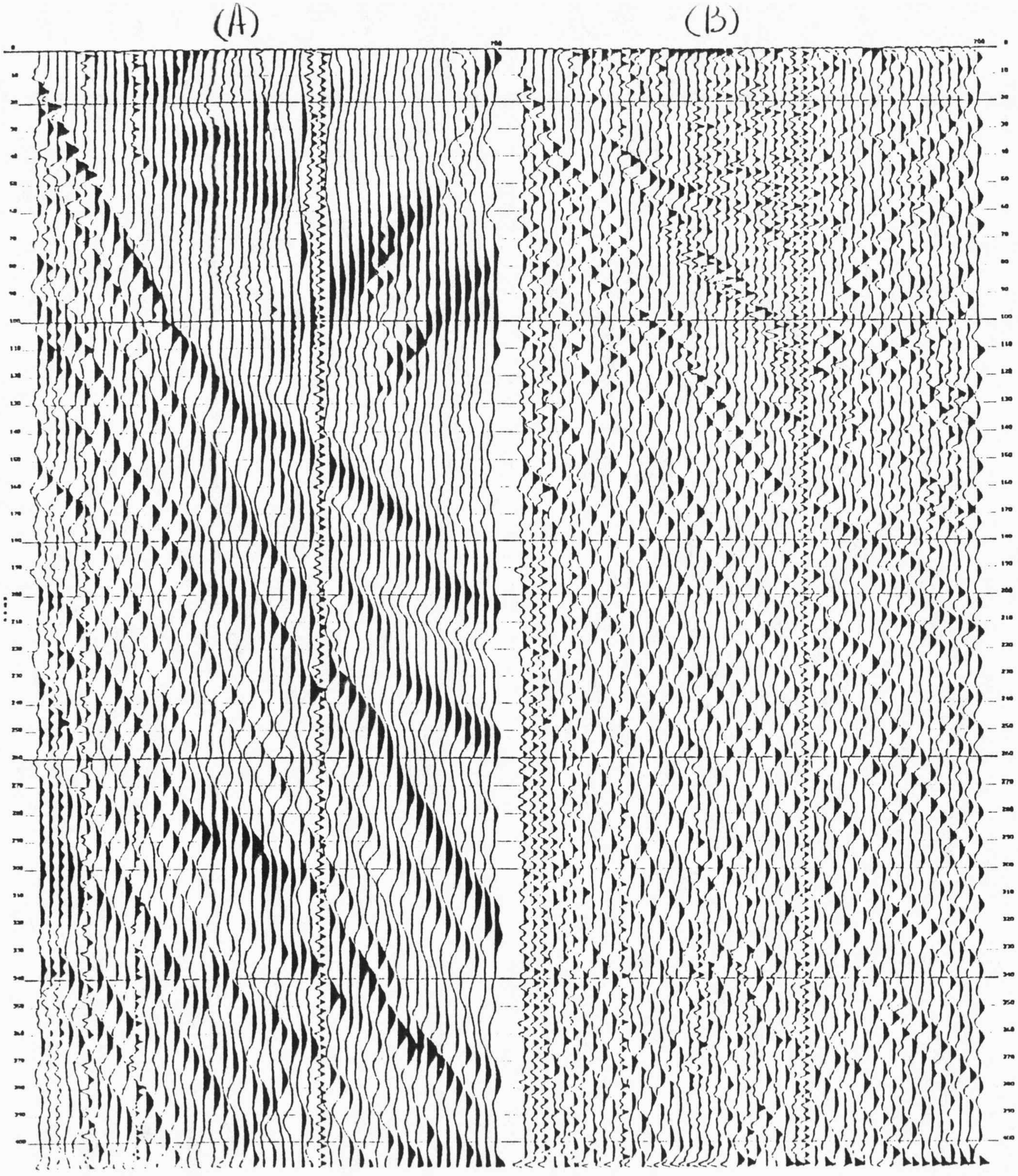


FIGURE 14

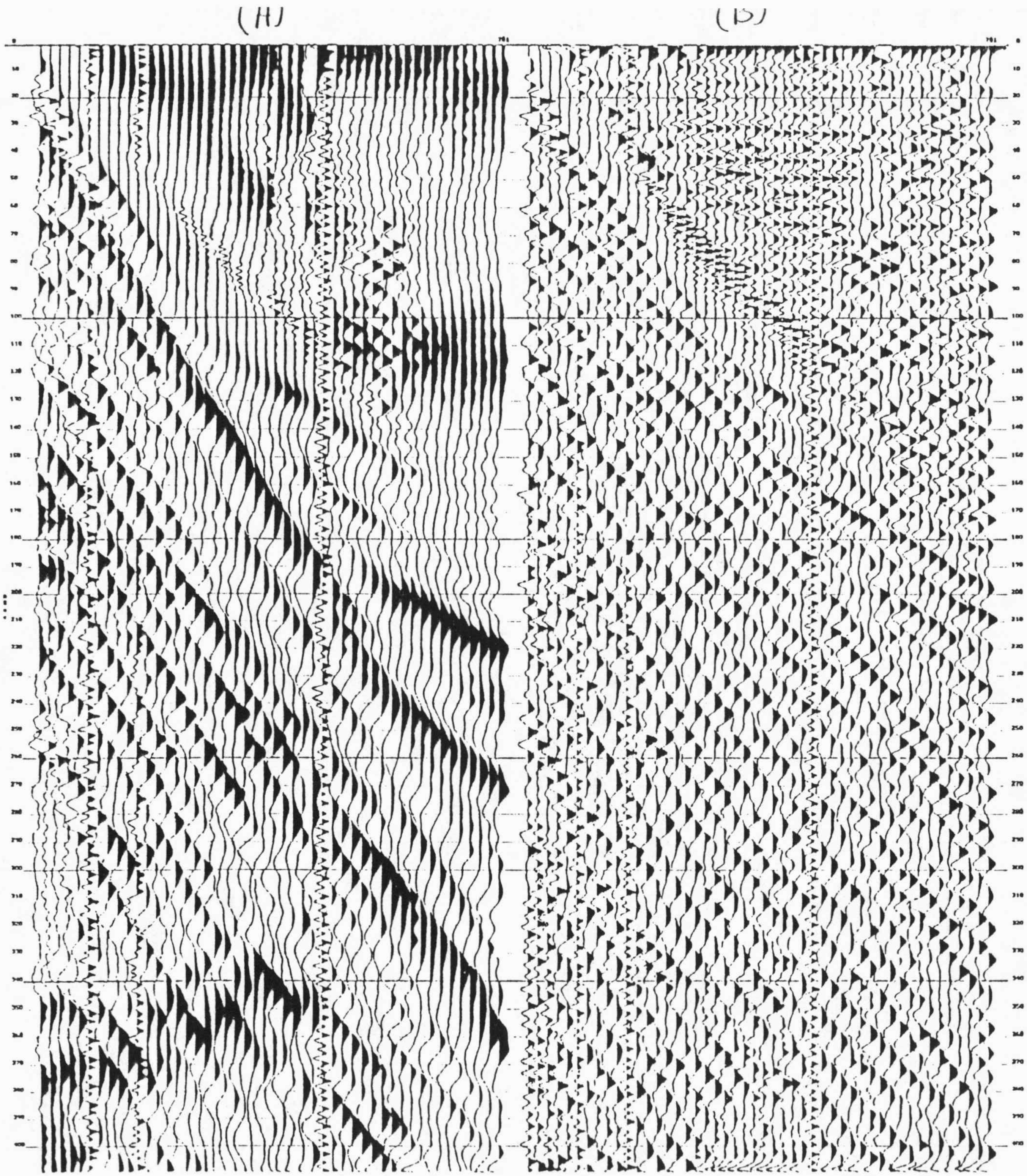


FIGURE 15

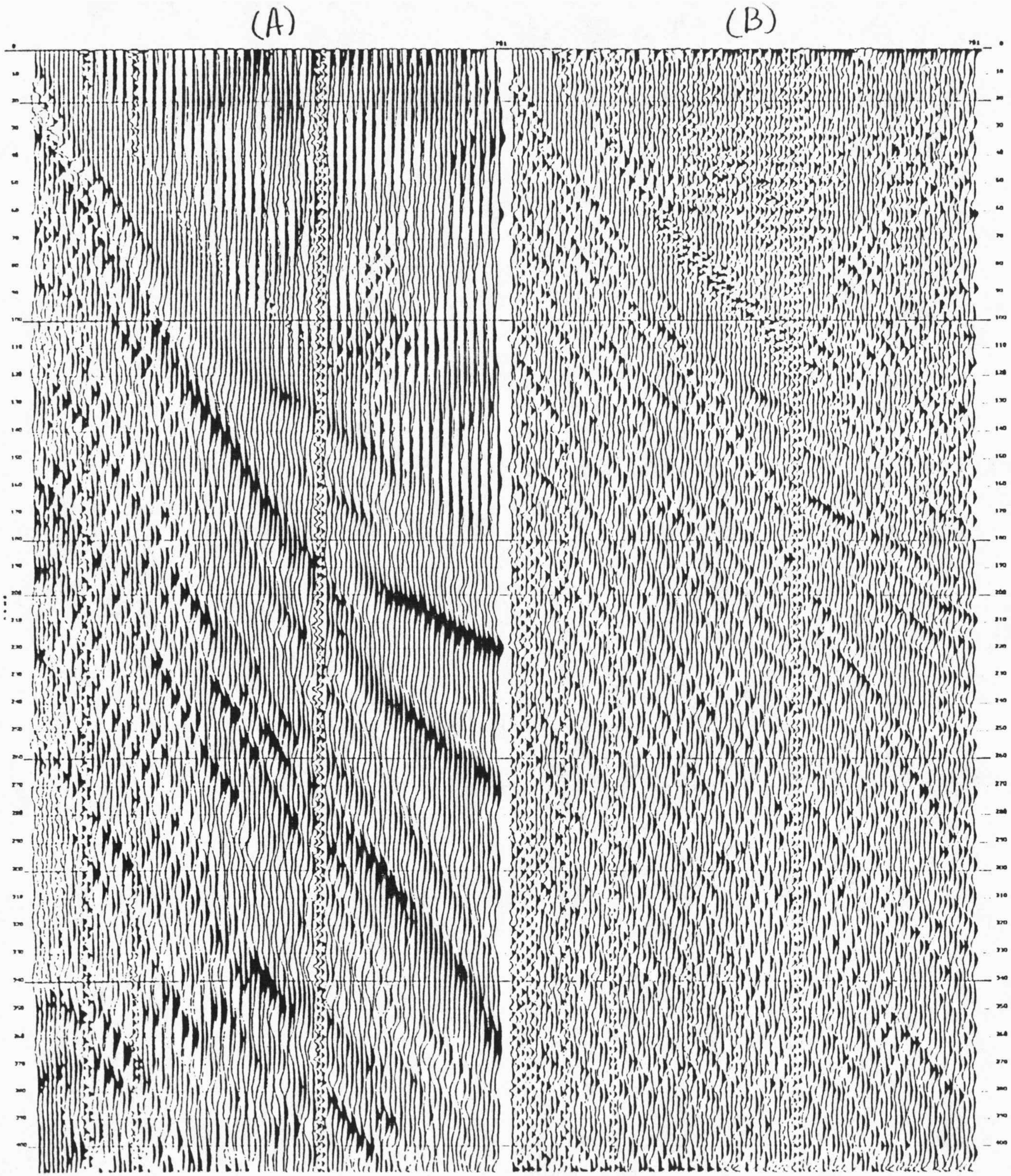


FIGURE 16

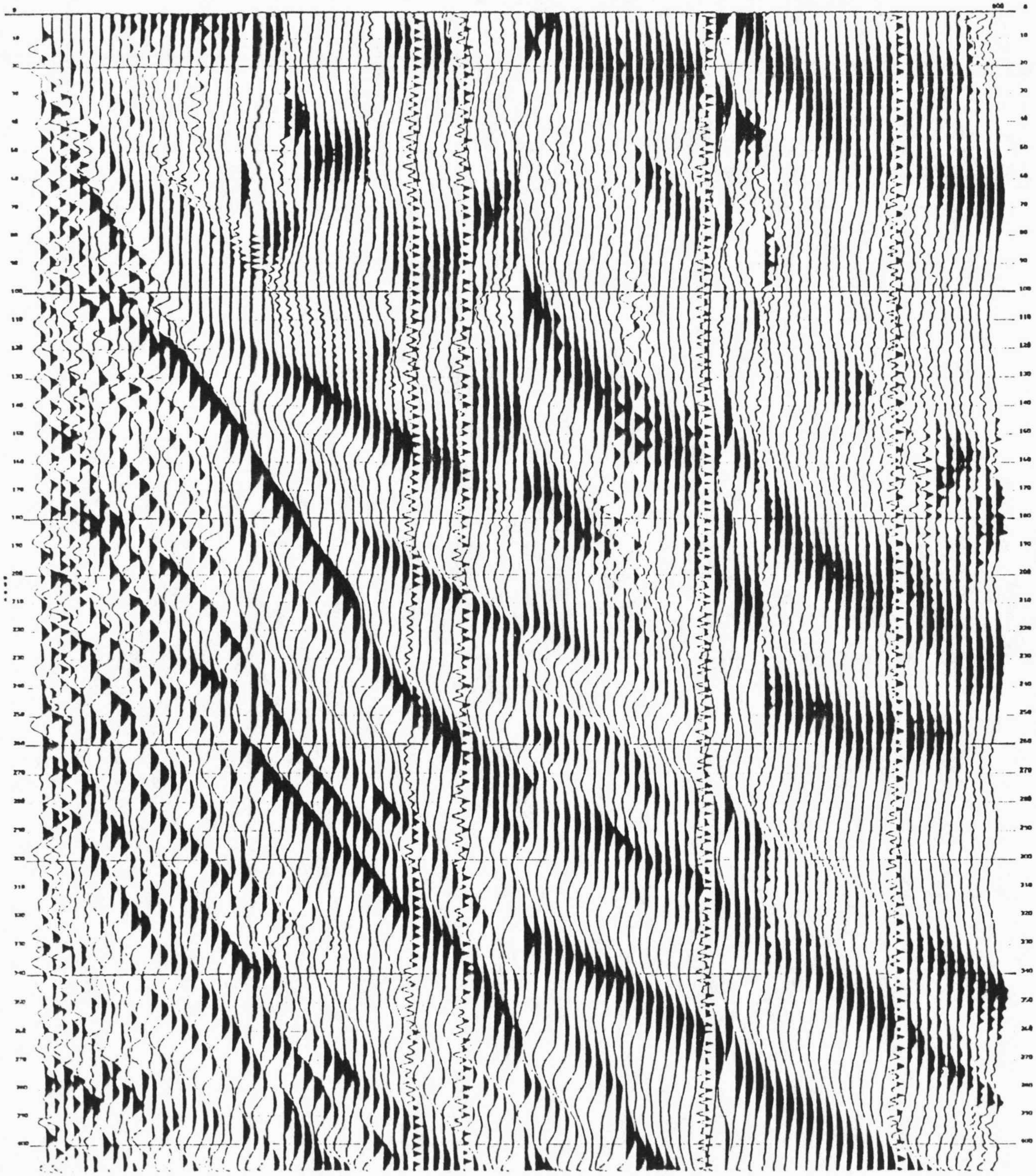


FIGURE 17

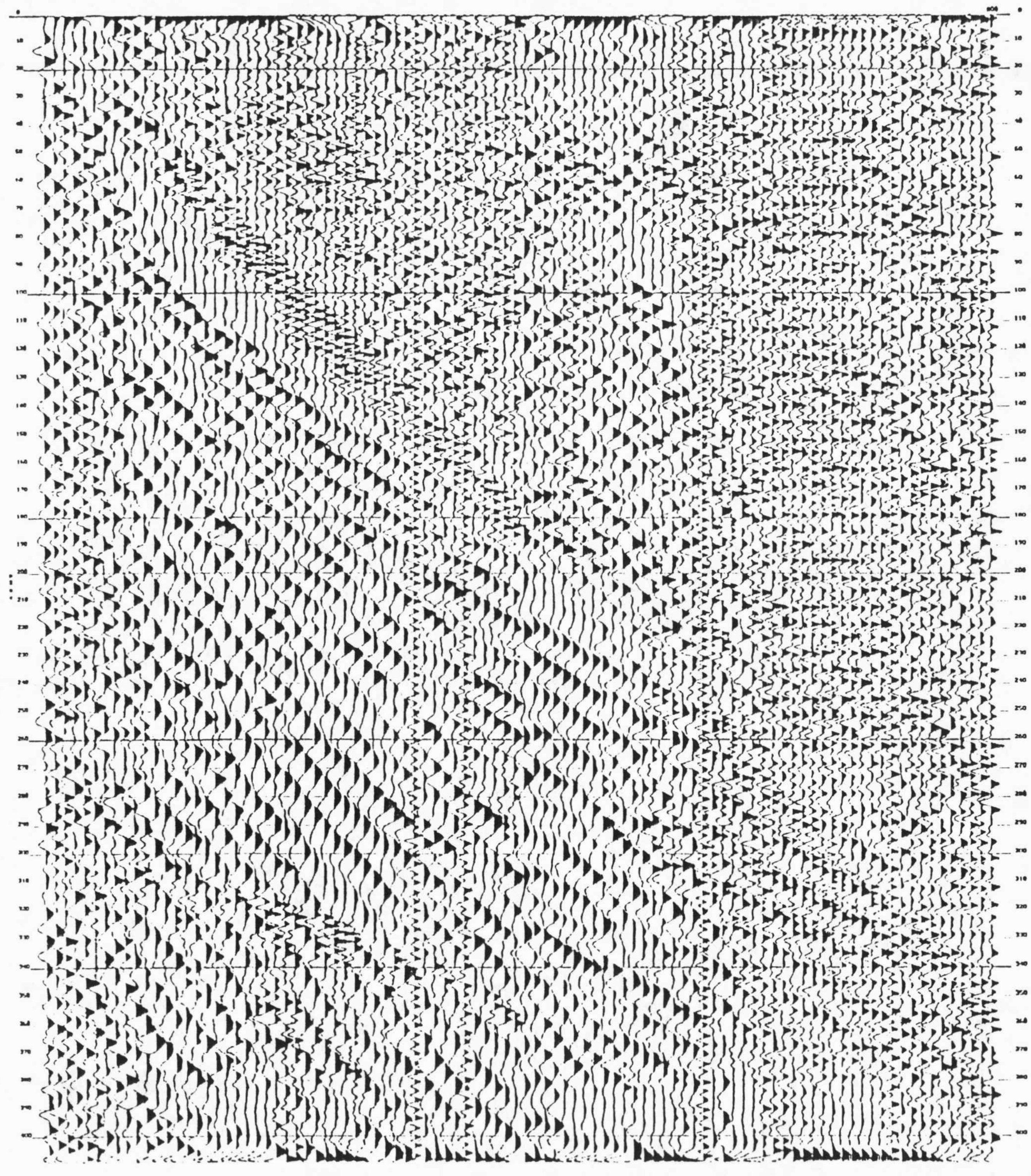


FIGURE 18

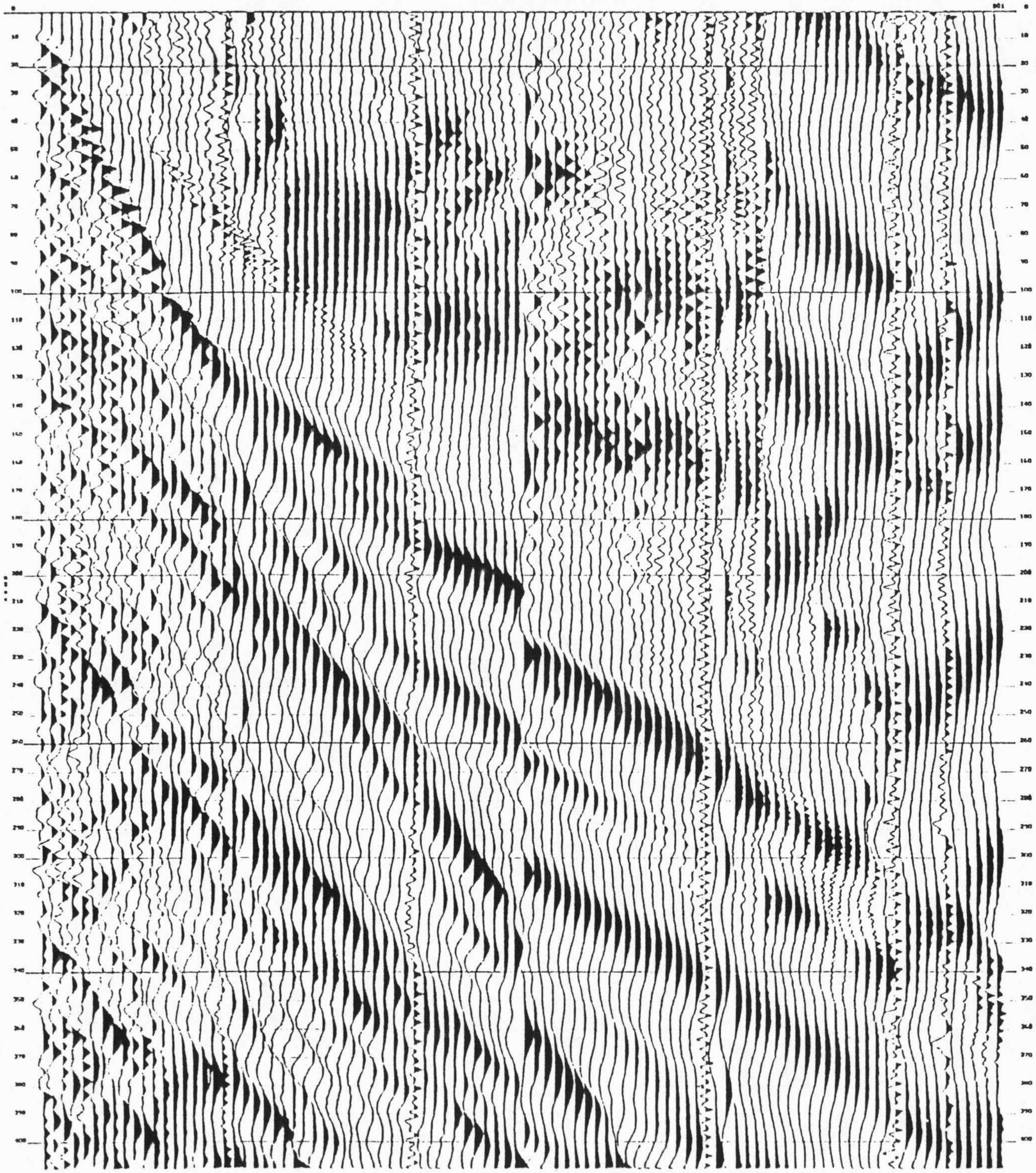


FIGURE 19

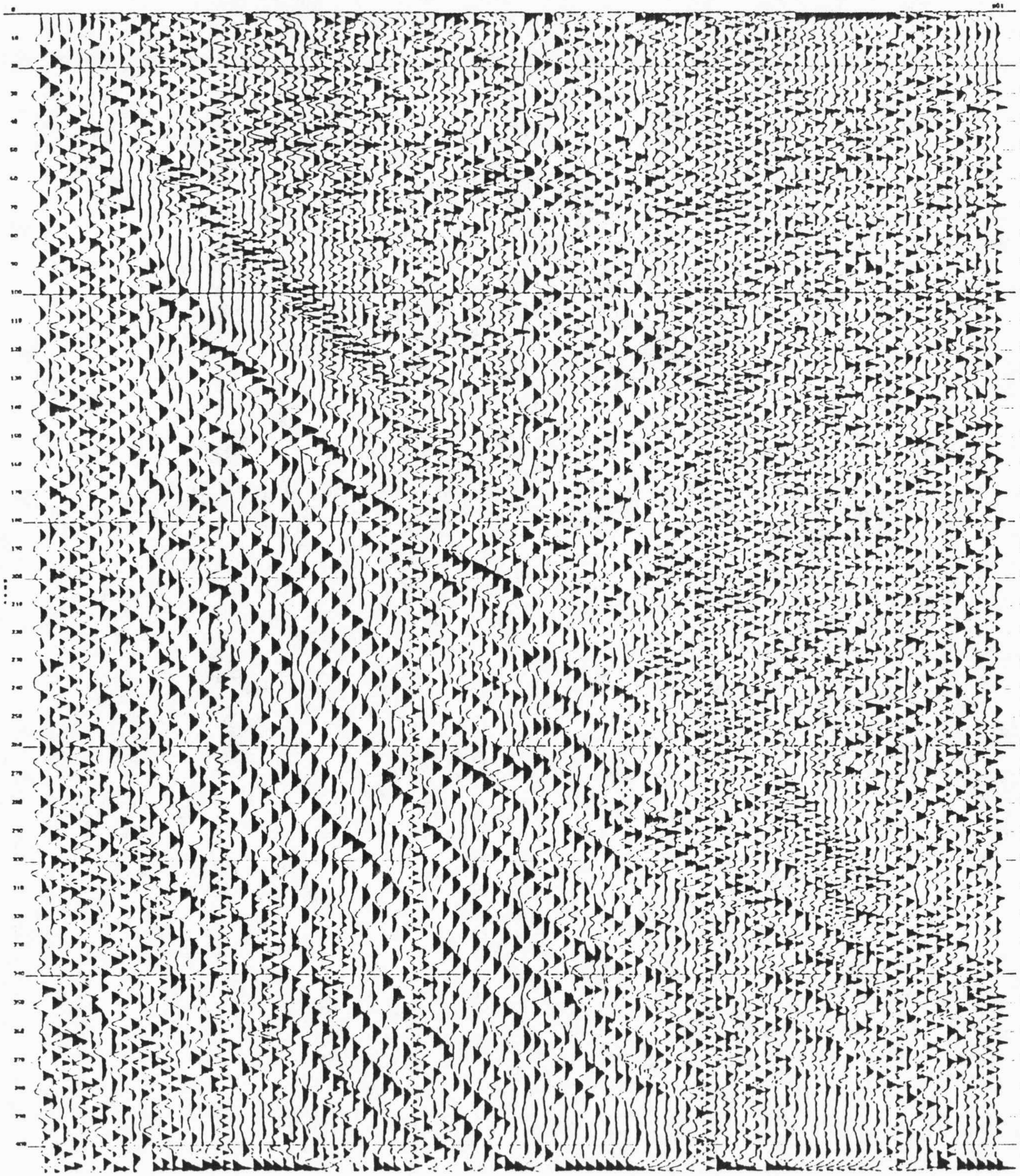


FIGURE 20

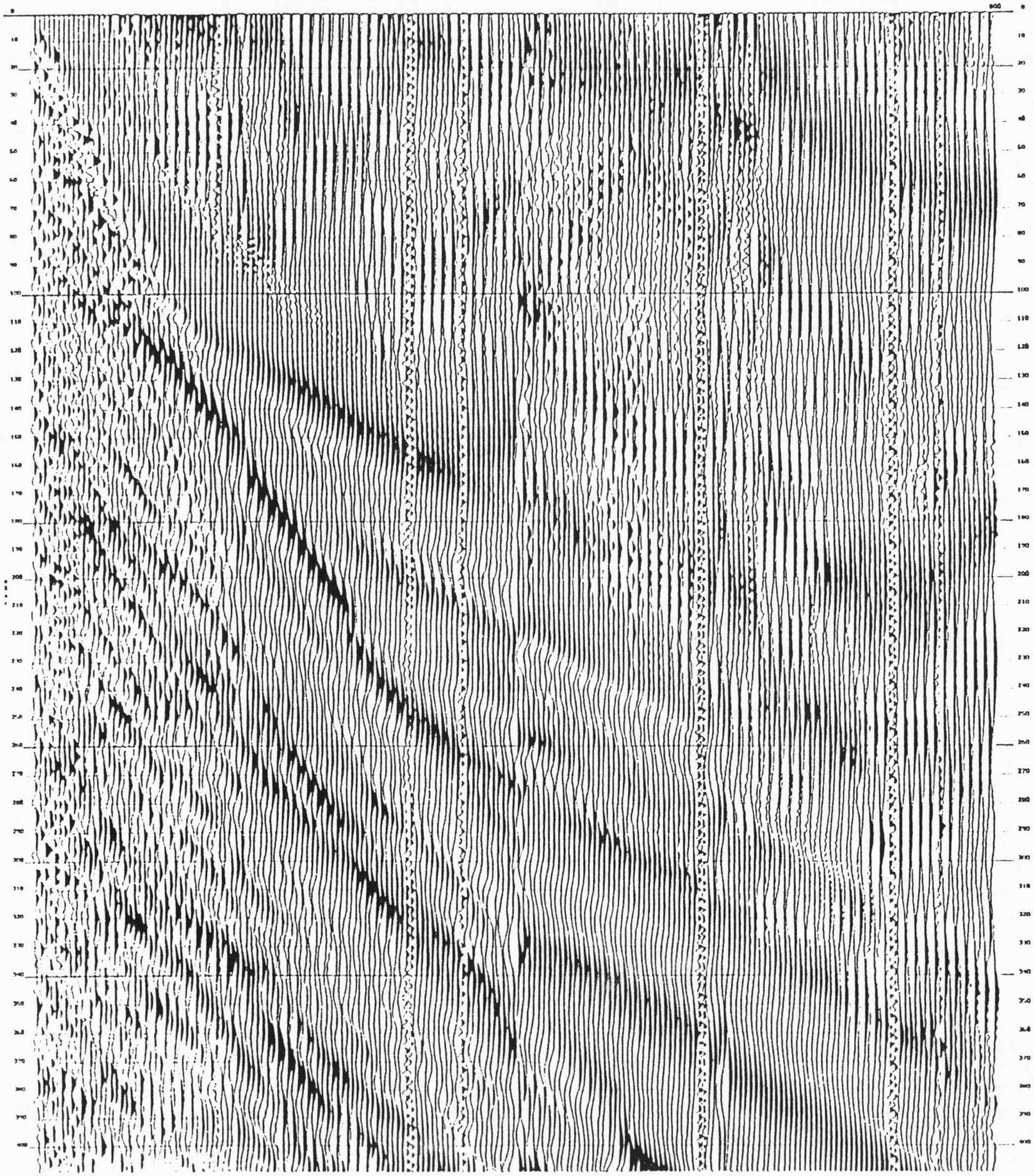


FIGURE 21

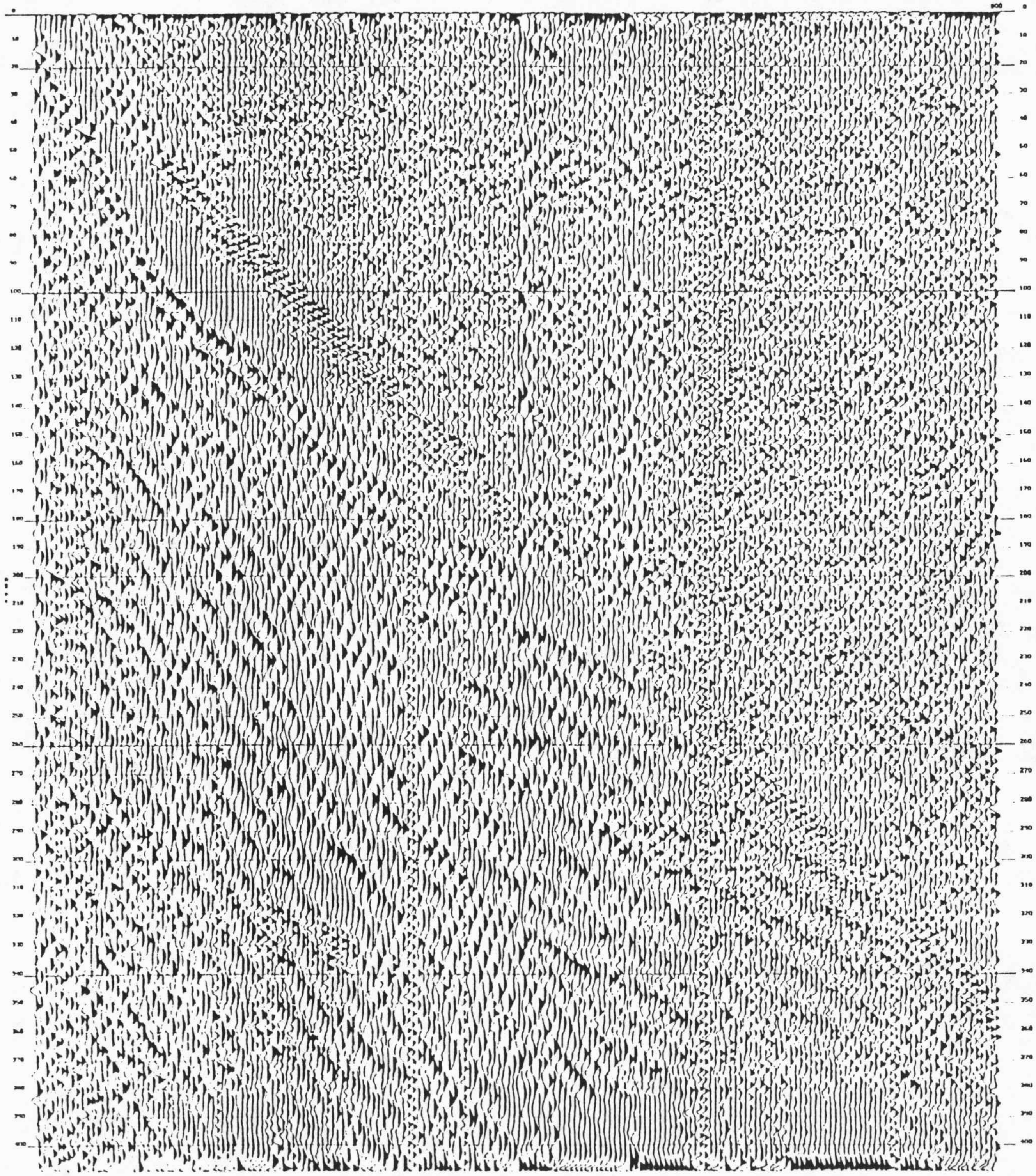


FIGURE 22

Appendix A: Field Notes

USAE WATERWAYS EXPERIMENT STATION // Land Seismic Recording

Client HUNTSVILLE DIV.	Prospect MEMPHIS, TN	Area DDMT	Line No.
Instrument Engineer RICK MILLER		MO 9 DAY 14 YEAR 93	
Instrument Type ES2401	Serial No.	No. of Channels 24	
Tape/Storage Format SEG-1 on Floppy Disk		HARD DRIVE AS INITIAL STORAGE	
Parameters Rec. Length 409 sec	Sample Rate 0.2 msec	LoCut VARIABLE HiCut 500 Notch In ✓ Out __	
Display AGC ✓ Fixed __ Other __		Var. Area ✓ Wiggle TRace ✓	
Source TYPE: 12 lb sledge hammer	Pattern __	Size __ Depth __ Stacks VARIABLE	
Receiver TYPE: MARK	Freq. 40 Hz Pattern SINGLE		
Spread No. Groups __ Offset Gr.1 __ Gr. Interval 4 ft	Offset Gr. __ : __ Offset Gr. __ : __	SP interval 4 ft Max. Fold __	Direction of Progresssion __

Diagrams/Misc.

North * 1 CLOSE 24 25 FAR 48 — SPREAD #1 (GRASSY AREA NEAR GAURD HOUSE)

100W * W * 1 CLOSE 24 25 FAR 48 * E *E 100 — SPREAD #2 — BETW RR + ROAD ON GRAVEL

11:10 →

SPREAD #1 (1001 + 1002 100 ms record length)

NEW SITE on GRAVEL — SPREAD #2

5:00pm →

Shotpoint	Disk ID	REC#	Offset/STACK	~~CDP SW~~ FILTER	Line Groups	Comments
4' N	CLOSE 24	1001	5 shot	LC OUT	grassy area with fill	100 msec record length
4' N	FAR 24	1002	5 shots	LC out	beneath / wind noise bad.	100 msec record length
4' N	FAR 24	1003	6 shots	LC out	not much energy / impact	409 msec record length
4' N	CLOSE 24	1004 ✓	8 shots	LC 50	AIR WAVE BAD → VERY LITTLE ENERGY	4 ft spacing
4' N	FAR 24	1005 ✓	8 shots	LC 50	Geophone plants marginal grass	~~pl~~ picking up some phones!
XXX	WENT TO LUNCH + THEN CHANGED TO GRAVEL AREA TO GET MORE ENERGY TRANSMITTED →					
4' W.	CLOSE 24	1006 ✓	8 shot	LC 50	GRAVEL SITE DIFFICULT GEOPHONE PLANTS. SPREAD	
4' W	FAR 24	1007 ✓	8 shot	LC 50	SET-UP WITH ~~HALF~~ HALF SPREAD OVER LIGHT COLORED	
4' W	CLOSE 24	1008 ✓	8 shot	LC OUT	GRAVEL AND HALF OVER DARKER GRAVEL →	
4' W	FAR 24	1009 ✓	8 shot	LC OUT	TRAFFIC NOISE SIGNIFICANT PROBLEM - 409 ms —	
4' W	FAR 24	1010	2 shot	LC 50	HAMMER HITTING GROUND (DIFFICULTY TRIGGERING) NO PLATE	
4' W	FAR 24	NO RECORD	↗	LC 50	DEAD BLOW HAMMER NOT IMPULSIVE ENOUGH TO TRIG	
4' W	FAR 24	1011	25 shot	LC 50	MAXIMIZE IMPACTS TO CLEAR ESTABLISH REFRACTION	
4' W	CLOSE 24	1012	15 shot	LC 50	BASE IMPACT # ON RECORDED FIRST ARRIVAL	
100' W	CLOSE 24	1013	25 shot	LC 50	INCREASED OFFSET TO DETERMINE WIDE ANGLE EFFECTS	
100' W	FAR 24	1014	31 shots	LC 50	LONGEST OFFSET FROM W OF SPREAD NEED MORE ENERGY	

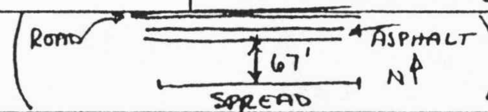
PAGE #2

USAE WATERWAYS EXPERIMENT STATION // Land Seismic Recording

SAME AS PAGE #1

Client HUNTSVILLE DIV.	Prospect MEMPHIS, TN	Area DDMT	Line No.
Instrument Engineer		MO____ DAY_____ YEAR_____	
Instrument	Type ES2401	Serial No.	No. of Channels 24
Tape/Storage	Format SEG-1 on Floppy Disk		
Parameters	Rec. Length ___ sec	Sample Rate __ msec	LoCut__ HiCut__ Notch In__ Out__
Display	AGC___ Fixed____ Other___	Var. Area ___ Wiggle TRace ___.	
Source	TYPE:__________________	Pattern____	Size___ Depth___ Stacks___
Receiver	TYPE:_____	Freq.___Hz Pattern______________________	
Spread	No. Groups__ Offset Gr.1 ___ Gr. Interval __ Offset Gr.__ : ____ Offset Gr.__ : ____	SP Interval___ Max. Fold____ Direction of Progresssion ________	

Diagrams/Misc. W 1 CLOSE 24 | 25 FAR | 48 E SPREAD #2 N



SHOTS ⇒ (1022 1023)

Shotpoint	Disk ID	REC#	Offset	CDP SW	Line Groups	Comments
4'E	FAR 24	1015 ✓	9 shot	LC 50	REVERSE SHOT DIRECTION TO	VERIFY ARRIVALS
4'E	CLOSE 24	1016 ✓	8 shot	LC 50	INCREASED RECORDED E	NERGY FROM EAST
4'E	CLOSE 24	1017 ✓	9 shot	LC OUT	→ INCREASE MAYBE RELATED TO	DIFFERENT GRAVEL TYPE
4'E	FAR 24	1018/1019 ✓	8 shot	LC OUT	& COMPACTION "RINGER"	⟨DOUBLE SAVE⟩ 5:20
100'E	CLOSE 24	1020 ✓	25 shot	LC OUT	INCREASED STACK COUNT TO	ALLOW EQUIVALENT
100'E	CLOSE 24	1021 ✓	25 shot	LC 50	COMPARISON WITH STACKS FR	OM W END.
HAMMER ON	CLOSE 24	1022 ✓	8 shot	LC 50	ESTIMATE EFFECT OF ASPHALT	TO INCREASE BANDWIDTH
STEEL PLATE	CLOSE 24	1023 ✓	8 shot	LC OUT	AND ENERGY ⇒ HOPE TO INC	REASE COUPLING SOURCE
ON ASPHALT	⟨NO TRI	GGER DIREC	TLY ON A	SPHALT⟩	CURVED ARRIVAL DUE TO	OFFLINE OFF-SET.
		END OF	DAY #1		5:50 PM	

67' NORTH OF REC #24

USAE WATERWAYS EXPERIMENT STATION // Land Seismic Recording

Client HUNTSVILLE DIV.	Prospect MEMPHIS, TN	Area DDMT	Line No.
Instrument Engineer		MO 9 DAY 15 YEAR 93	
Instrument	Type ES2401	Serial No.	No. of Channels 24
Tape/Storage	Format SEG-1 on Floppy Disk	TEMPORARY STORAGE ON HARD DRIVE	
Parameters	Rec. Length 409 sec	Sample Rate __ msec	LoCut VARY HiCut 500 Notch In ✓ Out __
Display	AGC ✓ Fixed ___ Other ___ 40msec	Var. Area ✓	Wiggle TRace ✓
Source	TYPE: SLEDGE HAMMER	Pattern ✓	Size 12lb Depth ✓ Stacks ✓ VARY
Receiver	TYPE: MARK	Freq. 40 Hz	Pattern SINGLE (I THINK)
Spread 4 ft spacing	No. Groups __ Offset Gr.1 __ Gr. Interval __ Offset Gr. __ : ___ Offset Gr. __ : ___	SP interval 4 ft Max. Fold ___	Direction of Progresssion ________

Diagrams/Misc. W * ASPHALT * E ← ROAD CLOSE 24 25 FAR 48 N ↑ <SOURCE HAMMER/STEEL PLATE ON ASPHALT>
PLANTS IN MOIST GRAVEL ≃ 4-6' from EDGE OF ASPHALT

Shotpoint	Disk ID	REC#	Offset	CDP SW	Line Groups	Comments
4'W	CLOSE 24	1024 ✓	8 SHOT	LC OUT	SOURCE ON ASPHALT TO TRY TO	IMPROVE COUPLE
4'W	FAR 24	1025 ✓	8 SHOT	LC OUT	— PLATE BOUNCE — TRAFFIC	DIFFICULT TO SHOOT —
4'W	FAR 24	1026 ✓	13 SHOT	LC 50	HAMMER SWITCH INTERMITTANT	REPLACED WITH DIFF.
4'W	CLOSE 24	1027 ✓	8 SHOT	LC 50	— GEOPHONES MOST PLANTED	WITHOUT PUNCH —
4'E	CLOSE 24	1028 ✓	10 SHOT	LC 50	BOUNCE REAL BAD ENERGY	LEVEL INCREASED
4'E	FAR 24	1029 ✓	8 SHOT	LC 50	PLATE MOVED TO EDGE J	UST OFF ASPHALT
4'E	FAR 24	1030 ✓	8 SHOT	LC 50	SAME PARAMETERS AS 1029 to	compare WITH 1029
4'E	FAR 24	1031 ✓	8 SHOT	LC OUT	PLATE BACK ON ROAD — SEEMS TO	COUPLE BETTER
4'E	CLOSE 24	1032 ✓	10 SHOT	LC OUT	HIGHER RECORDED AMPLITU	DES FROM EAST (TRAFFIC)
SPLIT-SPREAD	~~NEAR~~ CLOSE 24	1033 ✓	8 SHOT	LC OUT	— LOOK AT SYMMETRY BETW	TWO DIRECTION
SPLIT-SPREAD	FAR 24	1034 ✓	9 SHOT	LC OUT	— VERIFY SHOT CONSISTENCY	→ MOVE ON TO S-WAVE
	<END OF P-WAVE PORTION OF SURVEY>					

USAE WATERWAYS EXPERIMENT STATION // Land Seismic Recording

Client HUNTSVILLE DIV.	Prospect MEMPHIS, TN	Area DDMT	Line No.
Instrument Engineer		MO 9 DAY 15 YEAR 93	
Instrument	Type ES2401	Serial No.	No. of Channels 24
Tape/Storage	Format SEG-1 on Floppy Disk	TEMPORARY STORAGE ON HARD DRIVE	
Parameters	Rec. Length 409 sec	Sample Rate 0.2 msec	LoCut OUT HiCut 500 Notch In ✓ Out__
Display	AGC ✓ Fixed___ Other___ 40msec	Var. Area ✓ Wiggle TRace ✓	
Source	TYPE: PLANK UNDER CAR/SLEDGE	Pattern___	Size 12lb Depth___ Stacks___ 8'-4x4 POST
Receiver	TYPE: MARK	Freq. 40 Hz	Pattern S-WAVE PHONES ⇒ ORANGE TO NORTH
Spread	No. Groups___ Offset Gr.1___ Gr. Interval 4'	Offset Gr.__ : ___ Offset Gr.__ : ___	SP Interval 4' Max. Fold___ Direction of Progresssion ________

Diagrams/Misc. 

SPREAD EXACTLY THE SAME AS PREVIOUS P-WAVE
⇒ USED SAME HOLES TO PLANT PHONES INTO

& Rw

Shotpoint	Disk ID	REC#	Offset	CDP SW	Line Groups	Comments
4W'	FAR 24	1035 ✓	5 SHOT	LC OUT	SWAVE SURVEY W/SH ORIE	NTATION IMPACT N→S
4'W	CLOSE 24	1036 ✓	5 SHOT		CONTACT ON END OF PLANK	WITH SLEDGE N→S
4'W	CLOSE 24	1037 ✓	5 SHOT		PLANK SLIDING A LITTLE	WITH EACH HIT S→N
4'W	FAR 24	1038 ✓	5 SHOT		EVENTS CAN BE INTERPRE	TED THAT HAVE S→N
4'E	FAR 24	1039	5 SHOT		CURVATURE AS EXPECTED	FROM REFLECTION S→N
4'E	CLOSE 24	1040/1041	5 SHOT		THE CURVATURE SUGGEST	A VELOCITY & S→N
4'E	CLOSE 24	1042	5 SHOT		ARRIVAL PATTERN NOT	CONSISTENT WITH N→S
4'E	FAR 24	1043	5 SHOT		THE REFRACTION & DIRE	CT WAVE. N→S
192'E	FAR 24	1044	10 SHOT		- USE A RAILROAD TIE	FOR SOURCE N→S
192'E	CLOSE 24	1045	15 SHOT		LONG OFF NECESSARY TO	SEE PATTERN N→S
192'E	CLOSE 24	1046	15 SHOT		OF COHERENT EVENTS AT LO	NGER OFFSET S→N
192'E	FAR 24	1047	15 SHOT	LC OUT	NO CONCLUSIVE IDENTIFICA	TIONS POSSIBLE S→N
		END	OF DAY	&	SURVEY AT MEMPHIS	DEPOT.
		WENT TO	LUNCH	TO DISCUSS @	1:10	