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REPORT FOR EXPLOSION AND EARTHQUAKE DATA ACQUIRED IN THE 1999 SEISMIC HAZARDS INVESTIGATION OF PUGET SOUND (SHIPS), WASHINGTON

By Thomas M. Brocher[1], Thomas L. Pratt[2], Kate C. Miller[3], Anne M. Trehu[4], Catherine M. Snelson[3], Craig S. Weaver[5], Ken C. Creager[6], Robert S. Crosson[6], Uri S. ten Brink[7], Marcos G. Alvarez[8], Steven H. Harder[3], and Isa Asudeh[9]

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[1] U.S. Geological Survey, 345 Middlefield Road, M/S 977, Menlo Park, CA 94025
[2] U.S. Geological Survey, School of Oceanography, Box 357940, Univ. Washington, Seattle, WA 98195
[3] Dept. of Geol. Sci., Univ. Texas, El Paso, TX 79968
[4] College of Oceanic and Atmospheric Sci., Oregon State Univ., Corvallis, OR 97331
[5] U.S. Geological Survey, Geophysics, Box 351650, Univ. of Washington, Seattle, WA 98195
[6] Geophysics, Box 351650, Univ. of Washington, Seattle, WA 98195
[7] U.S. Geological Survey, Woods Hole, MA 02543
[8] PASSCAL Instrument Center, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801
[9] Geological Survey of Canada, 615 Booth St.., Ottawa, Ontario, K1A 0E9, Canada

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ABSTRACT

This report describes the acquisition, processing, and quality of seismic reflection and refraction data obtained in the Seattle basin, central Puget Lowland, western Washington, in September 1999 during the Seismic Hazards Investigation of Puget Sound (SHIPS). As a sequel to the 1998 SHIPS air gun experiment (also known as "Wet SHIPS"), the 1999 experiment, nicknamed "Dry SHIPS", acquired a 112-km-long east-west trending multichannel seismic-reflection and refraction line in the Seattle basin. One thousand and eight seismographs were deployed at a nominal spacing of 100 meters and 29 shot points were detonated at approximately 4 km intervals along the seismic line. The wide-angle seismic profile was designed to (1) determine the E-W geometry of Seattle basin, (2) measure the seismic velocities within the basin, and (3) define the basement structure underlying the Seattle basin. In this report, we describe the acquisition of these data, discuss the processing and merging of the data into common shot gathers, and illustrate the acquired profiles. We also describe the format and content of the archival tapes containing the SEGY-formatted, common-shot gathers. Data quality is variable but useful data were acquired from all 29 shot points fired along the Dry SHIPS seismic line. The data show pronounced travel time delays associated with the low velocity sedimentary rocks filling the Seattle basin.

Thirty-five REFTEK stations, deployed at 4 km intervals along the Dry SHIPS line, recorded 26 regional earthquakes and blasts and 17 teleseismic events, including the main shock and several aftershocks of the M_w = 7.6 Chi-Chi (Taiwan) earthquake of 9/20/1999. The teleseismic recordings of the Chi-Chi (Taiwan) mainshock provide useful signals down to 10 second periods. They document a significant (factor between 5 and 10) focusing of compressional- and shear-wave energy by the Seattle basin at periods between 1 and 2 seconds relative to "bedrock" sites east and west of the basin. Signal durations in the Seattle basin were also substantially increased relative to "bedrock" sites in the Olympic peninsula and Cascade foothills.

INTRODUCTION

In the past decade three major seismic hazards to western Washington and British Columbia have been recognized. Large (M~9) magnitude earthquakes along the Cascadia subduction zone megathrust have been proposed and documented in the geological record (Heaton and Kanamori, 1984; Atwater, 1987; Heaton and Hartzell, 1987; Hyndman et al., 1990; Hyndman and Wang, 1993; Atwater, 1996; Atwater and Hempill-Haley, 1997). Earthquakes within the subducting Juan de Fuca plate also represent significant seismic hazards (Weaver and Baker, 1988). Finally, crustal faults capable of large (M~7) magnitude earthquakes within the Puget Lowland have been inferred and mapped using a variety of methods including paleoseismicity, seismicity, seismic reflection, gravity and aeromagnetics (Atwater and Moore, 1992; Bucknam et al., 1992; Johnson et al., 1994, 1996, 1999; Pratt et al., 1997; Wells et al., 1998).

A March 1998 survey known as "Wet SHIPS (Seismic Hazards Investigation in Puget Sound)" performed a large scale investigation of the regional crustal structure of the Puget Lowland using airgun sources and land recorders during March 1998 (Brocher et al., 1999; Fisher et al., 1999). The purpose of Wet SHIPS was to obtain new, three-dimensional structural control on the seismogenic structures and Cenozoic basins in western Washington and southwestern British Columbia.

In this report we describe data obtained in September 1999 during a focused seismic investigation of the crustal structure in central Puget Sound, in an experiment nicknamed "Dry SHIPS". During Dry SHIPS we recorded 38 shots using 1008 portable seismic stations at offsets up to 112 km. A primary goal of Dry SHIPS was to provide compressional and shear wave velocity information for the sedimentary basin fill of the Seattle basin to allow better forecasts of strong ground motion focusing in the Seattle area (Figure 1). The new 3-D models developed from Dry SHIPS will be used to calculate synthetic seismograms to help understand the lateral variations of strong ground motions in the Seattle area.

DATA ACQUISITION

Experiment Design

The Dry SHIPS seismic survey was designed to provide low-fold reflection coverage and high-fold refraction coverage along an east-west line through the center of the Seattle basin. The average shot spacing of 4 km was chosen to provide complete subsurface coverage beginning at about 2 seconds two-way travel time (above the base of the thickest part of the Seattle basin). The line orientation was selected to cross the thickest part of the Seattle basin (Finn et al., 1991) in an east-west direction. The line location was determined by the geometry of the local waterways and public lands. Because a true east-west line could not be fit through the study area, the line was broken into two line segments, lines 1 and 2, which overlap for 12 km on Kitsap Peninsula (Fig. 1). The overlap of the ends of lines 1 and 2 was designed to provide full-fold reflection coverage along the combined seismic line. Four shorter N-S trending fan lines, lines 3 to 6, were designed to provide three-dimensional control on the geometry of the eastern end of the Seattle basin. The nominal seismograph spacing along the fan lines was 1 km (Figure 1).

Station and shotpoint numbers increase from west to east (Figure 1). Line 1, 39 km long, started near the eastern end of Olympic National Park at Station 1000 and ended at the eastern end of Kitsap Peninsula at Station 1390. Line 2 was 87.8 km long and started at the western end of Kitsap Peninsula at Station 2000 and ended to the east along the north fork of the Snoqualmie River in the western foothills of the Cascade Mountains at Station 2878. Line 3, 22 km long, trended north along Bainbridge Island (Stations 3000 to 3210). Line 4, 25 km long, trended north along the western shore of Lake Washington (Stations 4010 to 4250). Line 5, 22 km long, trended north along the western shore of Lake Sammamish (Stations 5000 to 5210). Line 6, 25 km long, trended north to the east of Lake Sammamish (Stations 6000 to 6240). Station numbers for Lines 3 to 6 increase from north to south (Figure 1).

Seismographs

Five different types of portable seismographs were used during Dry SHIPS (Table 1). The 1008 recorders were deployed at a nominal station spacing of 100 m, except for the ends of the lines, where a nominal station spacing of 200 m was used. The five types of recorders included: Texans (440 units), REFTEKs (231 units), Portable Refraction Seismographs (PRS-1's and PRS-4's; 200 units), Seismic Group Recorders (SGR-III's; 129 units), and USGS Ocean bottom seismometers ("OBS's"; 8 units). The different types of land seismographs were interspersed uniformly along the line to provide a uniform instrument types along the line. Because the Texan units were completely buried, they were used in city parks and public areas to minimize vandalism

or theft of the instruments. As a rule, the seismographs were programmed to record only 72 planned shot windows. Thirty-five REFTEKs, however, each having a 1-GByte hard-disk drive, were programmed to record continuously during their deployment to obtain records for local earthquakes and teleseisms occurring during Dry SHIPS. These 35 REFTEKs were deployed at about 4 km intervals along the seismic line and are annotated in Table 2. The Reftek model type, geophone type, and gains used for the continuously recorded REFTEKs were identical.

The Texans are single-component digital seismographs that record the signal from a single Mark Products® l-10B vertical-component 4.5-Hz geophone. The main operational problems encountered with the Texans were (1) a shorter than anticipated battery life for some units and (2) a software glitch that resulted in the failure to download the complete recording program into 5 to 10% of the Texans.

The REFTEKs are described by PASSCAL (1991) and Brocher et al. (1999). For this experiment, the REFTEKs recorded signals from Mark Products® L-28 three-component 4.5-Hz geophones. The 3-component sensors were oriented with compasses such that the N-S component was directed to **magnetic north**. Almost all the REFTEKs were equipped with Global Positioning System (GPS) receivers to synchronize the internal timing on the individual REFTEKs to satellite timing. The main operational problem encountered during the deployment of the REFTEKs was a difficulty in obtaining a lock on the GPS satellites in forested areas.

The Portable Refraction Seismographs (PRS-1s and PRS-4s) used during Dry SHIPS have been described by Asudeh et al. (1992, 1998) and Luetgert et al. (1993). A single component from a Mark Products® L4A 2-Hz vertical component geophone was recorded. All 200 PRSs deployed yielded useful data apart from two that were stolen: one at Station 5100 was recovered but had been powered down causing the data from it to be lost. The other PRS stolen was deployed at Station 2143 and was never recovered.

The Seismic Group Recorders (SGR-III's) were described by Luetgert et al. (1993). The SGR-III's recorded the vertical component from Mark Products® L4A 2-Hz geophones. The 129 SGR's were programmed to record 24 different shot windows for each of the three nights of shooting. SGR tapes were changed after each night of shooting, yielding a set of three SGR tapes per seismograph. The main operational problem for the SGR's was a shortage of new batteries, requiring the reuse of old batteries. The use of old batteries and lack of maintenance of the SGR's contributed to many of the failures of the SGR's.

The 8 USGS OBS's used in Dry SHIPS were described by Brocher et al. (1999). All the OBS's (OBS1 through OBS8) were deployed in Puget Sound between Bainbridge Island and Seattle (Station 2190-2232; Figure 1, Table 2) and were programmed to record continuously. OBS locations were determined using differential GPS navigation and are believed to be accurate to within 10-20 meters. Depths were determined using available bathymetric maps and are believed to

be accurate to within 10 meters. The OBS locations and water depths are provided in Table 4. Four channels were recorded by the OBS's, including three from a gimbaled, 3-component 4.5 Hz Mark Products® L15B seismometer and one from an OAS® E-2S hydrophone. OBS horizontal seismometer orientations were not recorded. All the OBS's were equipped with Seascan® clocks with accuracy of $1x10^{-8}$ sec^{-1} that have a clock drift of ~1 msec per day. A linear drift rate was assumed for the duration of the experiment and times were corrected accordingly.

Seismograph Deployment

The 231 Reftek recorders were deployed during a two-day period from Julian Day (JD) 261 to JD 262 (September 18th to September 19th). The remaining 769 land seismographs were deployed on JD 262 (September 19th). All the land seismographs were retrieved on JD 265 (September 22nd). Only three instruments (two PRSs and one OBS) were lost or stolen, and only a few other seismographs were tampered with.

The OBS's were deployed on JD 258 (September 15) and were programmed to start recording continuous data at 0800 UTC on JD 260 (September 17). Recording by the OBS's ended upon recovery of the OBS's on JD 265 (September 22nd). OBS D9 (Station 2190) used a 1 Hz geophone, and as expected, the signals for it are smaller than for the other OBS's, which used 4.5 Hz geophones.

Detonation of Shot points

Shot hole loading began on September 9th and was completed on September 21st, the last evening of shooting. The shots were detonated on three consecutive evenings, generally under still and warm conditions.

A total of 38 shots were detonated at 29 different shot points, numbered 1 to 35, from west to east (Fig. 1; Table 3). At nine shot points, shots were repeated to allow stacking of the shots to increase data quality. The shot sizes ranged from 25 lbs (11.4 kg) to 2500 lbs (1136.4 kg) of ammonium nitrate emulsion. The main charge was detonated using 1 lb boosters ignited by Primacord® detonating cord. The detonating cord was ignited by an electrical blasting cap using shot systems whose clocks were set to a GPS master clock accurate to within a millisecond. The clock drift of each shot system was measured to determine whether correction to the shot time was necessary. Table 3 presents this shotpoint data in the chronological order that the shots were fired. Latitudes and longitudes of the shot points are given in WGS 1984 datum and in UTM eastings and northings (Zone 10). Table 4 summarizes the shot information in geographical order from west to east, and, in addition, provides the name of the lead shooter for the shot.

Several of the largest shots triggered the Pacific Northwest Seismic Network (PNSN). Table 5a identifies shots that triggered the PNSN. Hypocentral locations of the shots in Table 5a are those determined by the PNSN. Errors in these locations determined from their measured GPS locations are tabulated in Table 5b. The average error in latitude is 0.9 km; the average error in longitude is 1.6 km; the average total distance error in location is 2.0 km; the average depth error is 2.1 km. The errors are systematic in that they are smaller, on average, in the middle of the seismic line, between SP 17 and 22 (Bainbridge Island to Redmond), than on either end of the seismic line (Figure 1).

Earthquakes:

Thirty-five continuously recording REFTEK stations and the 8 OBS's, deployed at 4 km intervals along the Dry SHIPS line, recorded 26 local earthquakes and quarry blasts having magnitudes between –0.1 and 3.2 (Table 6a). The REFTEK stations that recorded continuously are shown in Figure 48 (and marked with dots in the second column of Table 4). Events 3, 6, 11 to 13, and 21 to 22 occurred closest to the seismic line (Figure 48).

Seventeen teleseisms, including the mainshock of the M_w 7.6 Chi-Chi (Taiwan) earthquake (Shin et al., 2000) (Event 4) and 10 of its aftershocks, were recorded during Dry SHIPS as determined by the USGS National Earthquake Information Center at Golden, Colorado (Table 6b).

Data Downloading

Data recorded by the Texans, REFTEK's, and PRS's were downloaded in the field at the Kitsap County Fairgrounds, Washington on the day of instrument pickup, JD 265 (September 22nd, 1999). The OBS data were downloaded after the experiment (by October 27, 1999) at Woods Hole, Massachusetts. Data recorded on cassette tape by the SGR's were downloaded at Menlo Park, California on JD 361 (December 27nd, 1999) and were reduced there on January 5, 2000.

Station and Shotpoint Locations:

Shotpoint and seismograph locations and elevations provided in Tables 2 and 3 are based on differential GPS measurements, using the World Geodetic System (WGS) 1984 datum. The roving GPS receiver occupied each station for about 2 minutes, yielding a nominal differential accuracy (standard deviation) of about 1 meter, in the horizontal. The nominal vertical accuracy of these determinations is lower, being about 2 meters (standard deviation), although this nominal accuracy seems unlikely and is demonstrably larger for many stations. The locations for 10 stations were not

determined using differential GPS; for these stations the locations and elevations (WGS 1984 datum) were picked from digital USGS 7-1/2 minute topographic maps on a TOPO® CD-Rom. These stations are annotated on Table 2.

SEGY DATA MERGING

Station numbers

To avoid letters of the alphabet appearing in the shotpoint and receiver station names, all names were changed using numerals only. The shot points (SP1 - SP35) are multiplied by 10, with 1 added for an 'a' and 2 for a 'b'. Thus, shot point SP5a becomes shotpoint number 51 and SP5b becomes shot point number 52. The USGS OBS stations (OBS1 - OBS8) were numbered as Station 2190, 2196, 2202, etc. Only one land station, Station 1148a, had a letter in its name; it lies between 1148 and 1149 and is renumbered as Station 0148. Stations 1300, 1387, and 2283 are listed twice in Table 2: two different instruments were accidentally placed at each of these locations. Station 2057 is the location of the instrument center at Kitsap Fairgrounds (Figure 1). Station 5007 was an extra seismograph deployed at a participant's house located just east of the northern end of line 5.

Instrument numbers

The instrument numbers have been changed as follows

PRS Axxx are changed to PRS 1xxx (1000-1999); these are the PRS-1's
PRS Oxxx are changed to PRS 2xxx (2000-2999); these are the PRS-4's
OBS A3 changed to 3003 (etc. for all OBS's) (3001-3009)

Conversion to UTM coordinates

The WGS 1984 coordinates were converted to UTM zone 10 North coordinates in NAD83 using the National Geophysical Data Center's UTM algorithm UTMS (http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml).

Reftek and Texan data processing

Clock drift correction: previously made during preprocessing of Reftek and Texan data
Debias by subtracting the mean trace amplitude from every sample
Increase trace length to 62 seconds by adding 2 seconds of zero values to the beginning of the traces (recorded traces start at the shot time)
Put UTM geometry into SEGY headers

PRS data processing

Clock drift correction: static shift using values in headers
Debias by subtracting the mean trace amplitude from every sample

Resample to 4 msec sample interval from 8 msec sample interval (125 samples/sec) using RESAMP in the seismic reflection processing software package SU
Increase trace length to 62 seconds from 57 seconds by adding 5 seconds of zero values to the end of the traces (recorded traces start 2 seconds prior to the shot time)
Put UTM geometry into SEGY headers

SGR data processing

Clock drift correction: previously made during preprocessing of SGR data
Debias by subtracting the mean trace amplitude from every sample
Resample to 4 msec sample interval from 2 msec sample interval (500 samples/sec) using RESAMP in the seismic reflection processing software package SU
Increase trace length to 62 seconds from 31 seconds by adding 31 seconds of zero values to the end of the traces (recorded traces start 2 seconds prior to the shot time)
Put UTM geometry into SEGY headers

OBS data processing

Clock drift correction: previously made during preprocessing of OBS data
Resample to 4 msec sample interval from 10 msec sample interval (100 samples/sec) using RESAMP in the seismic reflection processing software package SU
Shift start of trace to 2 seconds by adding 2 seconds of zero values to the beginning of the traces (recorded traces start at the shot time)
Truncate trace length to 62 seconds from 79 seconds
Debias by subtracting the mean trace amplitude from every sample
Put UTM geometry into SEGY headers

SEGY Trace Format

The merged common shot gathers generated by combining all of the data from the 5 types of seismographs were written in an unreduced travel-time format. Sixty-two seconds of data were saved for each trace, starting two seconds before the shot time. At a sample rate of 4 ms, there are 15500 samples per trace, for a block length, including header, of 62240 bytes per trace.

SEGY trace header formats described by Barry et al. (1975) were modified slightly, as described in Table 7. Each merged record consists of a 240-byte header and a 62000 -byte data trace. All of the data trace values are written as 32 bit, IBM floating-point numbers (SEGY standard).

There are approximately 1400 total traces per common-shot gather. Of these, around 950 traces were recorded using vertical seismometers and the remaining 450 or so traces represent the horizontal geophone components recorded by the REFTEK's.

Earthquakes

The standard programs **ref2segy**, **refrate**, and **segymerge** were obtained from the PASSCAL Instrument Center and used to convert the REFTEK data to SEGY format, correct the clock drift, and make separate traces for these events (http://www.passcal.nmt.edu/software.shtml). (Events 17-19 represent three of our own shots.) These events were stored in SEGY format and archived to exabyte tape using unix tape-and-recovery (**tar**) commands. The local earthquakes and blasts archived to tape are listed in Table 6a.

These local earthquake data were archived in two exabyte tape formats. In the first format, the data are in PASSCAL segy format, generally with 600 seconds of data retained. On this archive tape there is a directory for each event, with each trace in a separate file named with the instrument and component of motion. The data values for each trace are preceded by a 240 byte header. The format of the header is given Table 7. All integer values are stored with the most significant byte first. Data values are 16 or 32 bit integers depending upon byte 206 of the header. Although there is a SEGY trace header for each trace, there are no IBM SEGY tape or binary headers.

In the second archival format for the local earthquakes, 120 seconds of unreduced SEGY data were saved for each event in the same format as the shot records (described below). The sample rate is 4 msec. The windows for this second format start either at the origin time, 15 seconds after the origin time, or 30 seconds after the origin time, increasing with epicentral distance. The data values for each trace are preceded by a 240 byte header that contains full geometry information in both latitude/longitude and UTM coordinates using the same header values as the shot records (described below).

Processing for the teleseismic events was similar to that used for the local events. The teleseism data were also archived in two exabyte tape formats. In the first tape format, the data are written in PASSCAL segy format with time windows from 10 minutes to 2 hours long (no geometry information has been placed into these headers). In the second tape format, the data were resampled to 80 msec (12.5 samples/sec) and 42 minutes of unreduced data were saved for each event. In this second format, the headers contain the latitude and longitude of the source and receiver, the UTM coordinates for the receiver, but do not contain the source UTM coordinates or the source-receiver distance (offset). In the headers the sample rate is given as 8 msec due to limitations in segy format for sample rate (a short integer limits the largest sample rate to 32.767 milliseconds). Thus the sample rate is a factor of ten too small, so that a 600 second trace (10 minutes) will appear to be 60 seconds long according to the header values.

DATA QUALITY

The seismic reflection/refraction data recorded during SHIPS are plotted in Figures 2 to 39. Data quality is variable; we found large variations in shotpoint efficiency. Eleven of the larger shots that triggered the Pacific Northwest Seismic Network (PNSN) had network magnitudes between 1.0 and 2.7 (Table 3). Probably due to their location within the water table, shots in Seattle carried to much greater ranges than anticipated. In the following table, we briefly describe each shot.

SP	Shot size (lbs)	Data Quality (A Qualitative Assessment)
SP1	2800	SP1a yielded strong first arrivals that carried to the far eastern end of the line and provided useful data along entire line through Seattle. SP1b, 46 m from SP1a, yielded much poorer quality data that are traceable only about 15 km from the shot.
SP2	250	Weak shot that yielded faint first arrivals for 10 km
SP4	250	Shot yielded useful first arrivals for 20 km.
SP5	2000	Both SP5a and SP5b, 169 m apart, yielded high-amplitude first arrivals that carried the far eastern end of line: arrivals recorded in Seattle are faint.
SP6	50	Fair shot that yielded first arrivals detected for ±8 km on either side of the source.
SP8	250	Shot yielded useful data for 25 km.
SP9	50	Shot yielded high-quality first arrivals for 25 km.
SP10	150	Weak shot yielded observable first arrivals out to ±7 km.
SP11	500	Both SP11a and SP11b, 29 m apart, were strong shots yielding arrivals can be followed to the far eastern end of the line. Data recorded in Seattle are faint. Data recorded from SP11b are slightly higher in quality than those recorded from SP11a.
SP12	500	SP12a yielded poor arrivals. SP12b, 30 m from SP12a, yielded higher quality data observed for ±20 km from the shotpoint.
SP13	125	Strong shot, yielded arrivals to nearly the eastern end of the line.
SP14	50	Fair shot, yielded arrivals for about 10 km from the shotpoint.
SP15	50	Strong shot, yielded useful arrivals as far as 30 km from the shotpoint.
SP17	375	Strong shot, yielded useful arrivals to both ends of the line and possibly traceable in Seattle.
SP18	325	Strong shot, yielded useful arrivals traceable through Seattle and out to both ends of the line.
SP19	25	Both SP19a and 19b, 18 m apart, yielded very faint arrivals, traceable only near the shotpoint.
SP20	125	Strong shot, yielded useful arrivals out to both ends of the line. The arrivals have a lower frequency character than most of the other shots along the line.
SP21	400	Both SP21a and SP21b, 45 m apart, yielded large arrivals traceable through Seattle and out to both ends of the line.
SP22	400	SP22 yielded large arrivals traceable throughout Seattle and out to the ends of the line.
SP24	500	Weak shots at both SP24a and SP24b, 30 m apart, because the main charge failed to detonate.

		Both shots yielded few useful arrivals.
SP26	500	Both shots yielded comparable data quality. Both SP26a and SP26b, 46 m apart, produced arrivals all along the eastern end of the line.
SP27	250	Shot yielded useful first arrivals for at least 10 km on both sides of the shotpoint.
SP29	800	Shot yielded useful first arrivals for ±20 km of the shot.
SP30	250	Strong shot yielded arrivals throughout the western end of the line. The arrivals in Seattle are faint.
SP31	250	Weak shot yielded arrivals for ±6 km.
SP32	2000	Both SP32a and SP32b, 30 m apart, yielded strong first arrivals seen to the far western end of the line. Data are traceable through Seattle.
SP33	250	Strong shot yielded first arrivals detected for 15 km.
SP34	250	Fair shot yielded first arrivals detected for 6 km.
SP35	2400	Strong shot yielded which large first arrivals that are traceable through Seattle and to the far western end of the line.

Record sections for local earthquake 11 (Table 6a), a M2.8, 17-km deep event occurring near the eastern end of the line (Figure 48), are shown in Figures 40 to 42. The vertical channel is aligned on the predicted P-wave arrival time (Figure 40; dotted line) with no filtering. The North component (Figure 41) and East component (Figure 42) are aligned on the predicted S-wave arrival time and have been low-pass filtered with a corner at 3 Hz. Times are calculated for the iasp91 model that has P and S velocities of 5.8 and 3.36 km/s above 20 km depth and 6.5 and 3.75 km/s velocities below. Note the large travel time delays in both P-wave and S-wave arrivals in Seattle (Station 2262) associated with lower velocity sedimentary rocks in the Seattle basin.

Figures 43 to 47 present record sections showing 3-component recordings for the M_w = 7.6 Chi-Chi (Taiwan) main shock of September 20, 1999 (Shin et al., 2000). In these figures, waveforms are aligned on the iasp91 predicted time for the P- and S-wave arrivals and are shifted using cross correlation for optimal alignment of the waveforms. The time shifts (relative travel-time residuals in seconds) are shown as the last numbers in the station labels. Labels show station number, epicentral distance (degrees), and azimuth (degrees). Traces are shown in true relative amplitude. In Figure 43, the P-wave arrivals have been low-pass filtered with a corner at 1 Hz (1 second period). Figure 44 shows the P-wave record section that has been low pass filtered with a corner at 0.25 Hz (4 second period). Note the large (factor between 5 and 10) amplification of the signal at Station 2262, located in Seattle, in the middle of the Seattle basin, relative to Stations 1002 to 1082 in the Olympic Mountains west of Hood Canal and to Station 2768, in the Cascade foothills, outside of the Seattle basin (Figure 48). Similar results are seen in the shear wave arrivals, displayed in Figures 45 to 47. Note that with the 89˚ azimuth of propagation of these arrivals, the E-W horizontal component is nearly radial and the N-S horizontal component is nearly transverse to the direction of propagation. The locations of these recordings (Figure 48) reveal strong relative

amplification of the P- and S-wave arrivals in the Seattle basin (Figure 49). The duration of large arrivals in the Seattle basin is also significantly longer than for stations located outside of the Seattle basin, approaching 100 seconds in the vicinity of Seattle (Figures 43-47).

DATA AVAILABILITY

Tape copies of the SEGY seismic data may be ordered via the World Wide Web from the IRIS/PASSCAL Data Management Center (DMC) in Seattle, Washington. The current Web site address of the Incorporated Research Institutions for Seismology (IRIS) Consortium is: http://www.iris.edu. The current general email address for the IRIS DMC is webmaster@iris.washington.edu.

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Table 1. Recording Parameters Used by the Five Different Types of Seismographs

Instrument Type	Number of Units	Record Length (seconds)	Recording Start Time (seconds before shottime)	Sample Rate (Hz)	No. of Geophone Components	Natural Frequency Geophone (Hz)	Internal Timing
Reftek 06, 07	231	62	2	250	3	4.5	GPS
PRS-1, PRS-4	200	58	2	125	1 (Vertical)	2	Pulsed
Texan	440	60	0	250	1 (Vertical)	4.5	Pulsed
SGR-III	129	31	2	500	1 (Vertical)	2	Pulsed
OBS	8	Continuous	Continuous	100	3	4.5	Pulsed

Two different types of REFTEKs were deployed; REFTEK Model 06's and 07's. REFTEK Models 06s (DAS No. 6000-6999) are 16-bit, 3-component recorders. REFTEK Models 07s (DAS No. 7000-7999) are 24-bit, 3-component recorders. The two different models of REFTEKs recorded channels 1 to 3. Channel 1 was used for the vertical geophone component, channel 2 was used for the N-S oriented horizontal geophone component, and channel 3 was used for the E-W oriented horizontal geophone component. Eighty-five REFTEK Model 06's and 146 REFTEK Model 07's were deployed.

One hundred seventy-three PRS-I's and 27 PRS-4's were deployed. Only the vertical geophone component was used for the 3-component PRS-4 recorders.

Internal timing of the seismographs was synchronized to Universal Time either by using an internal GPS receiver to continuously record UTC (for the REFTEKS) or by setting the internal time from a master clock at the time of deployment and using this master clock to note the clock drift at the time that the receiver was retrieved (pulsed).

Table 2. Receiver Station List (WGS 1984 Datum).

Stake	Unit No.	Latitude	Longitude	UTM Easting	UTM Northing	Elev m
1000	*501	47.729631	-123.135968	489805	5286259	435
1002	•7283	47.730413	-123.133018	490026	5286346	411
1004	A066	47.730737	-123.130403	490222	5286382	383
1006	38	47.730517	-123.127582	490434	5286357	364
1008	6096	47.730625	-123.124675	490651	5286369	359
1010	∗503	47.730128	-123.122729	490797	5286313	368
1012	∗504	47.730119	-123.119628	491030	5286312	346
1014	∗505	47.729801	-123.118080	491146	5286276	329
1016	6118	47.729201	-123.113740	491471	5286209	347
1018	46	47.728836	-123.111405	491646	5286168	308
♦1020	∗506	47.728850	-123.109020	491825	5286169	336
♦1022	43	47.728780	-123.106330	492027	5286161	350
♦1024	6038	47.728780	-123.103920	492207	5286161	324
♦1026	A065	47.729000	-123.101340	492401	5286185	314
♦1028	40	47.729270	-123.098260	492632	5286215	301
♦1030	6061	47.730410	-123.095180	492863	5286342	250
♦1032	∗508	47.731210	-123.092320	493078	5286430	226
1034	41	47.730944	-123.089770	493269	5286400	218
1036	A067	47.734213	-123.085712	493573	5286763	202
1038	•7443	47.735803	-123.082747	493796	5286940	232
1040	37	47.736645	-123.080211	493986	5287033	229
1042	∗509	47.737734	-123.076317	494278	5287154	203
1044	A068	47.738925	-123.073318	494503	5287286	174
1046	6128	47.739471	-123.070344	494726	5287347	225
1048	A069	47.740054	-123.067513	494939	5287411	198
1050	36	47.740320	-123.064485	495166	5287441	196
1052	∗510	47.740858	-123.061857	495363	5287500	175
1054	6047	47.741457	-123.058983	495578	5287567	212
1056	35	47.741650	-123.056059	495797	5287588	171
1058	A070	47.741715	-123.054349	495926	5287595	176
1060	34	47.742000	-123.051776	496119	5287627	161
1062	6071	47.741646	-123.049106	496319	5287587	144
1064	∗511	47.741347	-123.046546	496511	5287554	156
1066	33	47.741225	-123.043788	496717	5287540	142
1068	A071	47.741412	-123.040554	496960	5287561	142
1070	6019	47.740922	-123.038002	497151	5287506	140
1072	30	47.740086	-123.035594	497332	5287413	137
1074	∗512	47.739453	-123.033163	497514	5287343	148
1076	32	47.739184	-123.028264	497881	5287313	136
1078	6062	47.737804	-123.026426	498019	5287159	124
1080	A072	47.736077	-123.024298	498178	5286967	125
1082	•7613	47.735042	-123.022541	498310	5286852	124
1084	∗513	47.733350	-123.020359	498474	5286664	146
1086	6109	47.731373	-123.018147	498639	5286444	103
1088	A023	47.729293	-123.016684	498749	5286213	107
1090	6003	47.727969	-123.014414	498919	5286066	104
1092	A025	47.727476	-123.012544	499059	5286011	104
1094	6080	47.725689	-123.010093	499243	5285812	105
1096	∗635	47.725811	-123.007254	499456	5285826	105
1098	6125	47.725306	-123.004269	499680	5285770	115
1100	A026	47.724611	-123.002509	499812	5285693	109
1101	6056	47.724208	-123.001318	499901	5285648	116
1102	31	47.723773	-123.000205	499985	5285599	125
1102	6110	47.723773	-123.000205	499985	5285599	125
1103	∗515	47.723268	-122.999018	500074	5285543	132
1104	A027	47.722828	-122.997814	500164	5285494	113
1105	6100	47.722433	-122.996036	500297	5285451	129
1106	A028	47.721720	-122.994475	500414	5285371	122
1107	A029	47.721618	-122.993066	500520	5285360	116
1108	∗659	47.721477	-122.991750	500619	5285344	113
1109	6055	47.721320	-122.990409	500719	5285327	96
1110	27	47.720978	-122.989183	500811	5285289	82
1111	A056	47.720748	-122.987720	500921	5285263	82
1112	∗518	47.720241	-122.986688	500998	5285207	75
1113	6119	47.720155	-122.985359	501098	5285197	74
1114	∗520	47.720170	-122.984000	501200	5285199	70
1115	26	47.720425	-122.982724	501296	5285228	65
1116	A057	47.720646	-122.981338	501400	5285252	61
1117	6052	47.720705	-122.979817	501514	5285259	99
1118	29	47.720484	-122.978471	501615	5285234	65
1119	∗521	47.720235	-122.977161	501713	5285207	60
1120	28	47.720008	-122.975799	501815	5285181	72
1121	6099	47.719939	-122.974499	501913	5285174	76
1122	A058	47.719887	-122.973288	502003	5285168	75
1123	∗522	47.719560	-122.971951	502104	5285132	62
1124	25	47.719168	-122.970438	502217	5285088	70
1125	6025	47.719315	-122.969120	502316	5285104	69
1126	643	47.719304	-122.967687	502423	5285103	96
1127	A059	47.719422	-122.966352	502524	5285116	74
1128	∗523	47.719393	-122.965027	502623	5285113	58
1129	•7593	47.719386	-122.963720	502721	5285113	72
1130	73	47.719459	-122.962370	502822	5285121	66
1131	642	47.719513	-122.961034	502922	5285127	67

1132	A060	47.719333	-122.959456	503041	5285107	70
1133	6035	47.719266	-122.958270	503130	5285099	55
1134	A061	47.719249	-122.956941	503229	5285098	57
1135	∗524	47.719194	-122.955566	503333	5285092	57
1136	A062	47.719239	-122.954259	503431	5285097	50
1137	6092	47.719285	-122.952892	503533	5285102	55
1138	A063	47.719180	-122.951557	503633	5285090	52
1139	72	47.719035	-122.950269	503730	5285074	58
1140	∗525	47.718689	-122.948936	503830	5285036	60
1141	6034	47.718707	-122.947605	503930	5285038	47
1142	74	47.718835	-122.946165	504038	5285052	46
1143	A064	47.718827	-122.944910	504132	5285051	48
1144	∗526	47.718854	-122.943645	504227	5285054	46
1145	6125	47.718446	-122.942270	504330	5285009	44
1146	∗527	47.717754	-122.941314	504402	5284932	47
1147	70	47.715987	-122.940348	504474	5284736	56
1148	A030	47.713573	-122.939833	504513	5284468	83
♦0148	6065	47.712817	-122.939354	504549	5284384	82
1149	6020	47.712062	-122.938875	504585	5284300	81
1150	∗528	47.711711	-122.937468	504691	5284261	81
1151	69	47.711681	-122.936206	504785	5284258	97
1152	A050	47.710785	-122.935185	504862	5284158	71
1153	6050	47.710346	-122.933889	504959	5284109	67
1154	68	47.709547	-122.932708	505048	5284021	56
1155	∗529	47.708758	-122.931535	505136	5283933	59
1156	A049	47.708032	-122.930351	505225	5283852	47
1157	6029	47.707381	-122.929248	505308	5283780	40
1158	A051	47.707031	-122.928002	505401	5283741	41
1159	67	47.706766	-122.926726	505497	5283712	40
1160	∗531	47.706449	-122.925415	505595	5283677	44
1161	6101	47.705991	-122.924179	505688	5283626	42
1162	A031	47.705567	-122.923024	505775	5283579	42
1163	A033	47.705129	-122.921855	505862	5283530	50
1164	∗532	47.704825	-122.920605	505956	5283497	66
1165	6057	47.704641	-122.919006	506076	5283476	70
1166	653	47.704455	-122.917548	506186	5283456	72
1167	66	47.704377	-122.916251	506283	5283447	79
1168	∗534	47.704403	-122.914883	506386	5283450	71
1169	A032	47.704397	-122.913529	506487	5283450	76
1170	65	47.704292	-122.912337	506577	5283438	91
1171	A034	47.703627	-122.910962	506680	5283364	82
1172	∗535	47.702583	-122.909846	506764	5283248	64
1173	•7623	47.701483	-122.908979	506829	5283126	58
1174	A048	47.699906	-122.907999	506903	5282951	54
1175	6043	47.698272	-122.907183	506964	5282769	49
1176	∗536	47.697426	-122.906123	507044	5282676	61
1177	A047	47.697548	-122.904800	507143	5282689	18
1178	A046	47.697756	-122.903430	507246	5282712	47
1179	64	47.697706	-122.902157	507341	5282707	15
1180	63	47.697588	-122.900821	507441	5282694	6
1181	A045	47.697490	-122.899421	507546	5282683	22
1182	62	47.697906	-122.898015	507652	5282730	6
1183	∗507	47.698414	-122.896314	507779	5282786	6
1233	59	47.693356	-122.829128	512822	5282233	104
1234	57	47.692614	-122.828646	512858	5282151	109
1235	51	47.692462	-122.827438	512949	5282134	108
1236	54	47.692575	-122.826048	513053	5282147	122
1237	6095	47.692792	-122.824795	513147	5282171	129
1238	A189	47.692401	-122.823661	513232	5282128	120
1239	53	47.691973	-122.822665	513307	5282080	119
1240	∗537	47.691487	-122.820555	513465	5282027	101
1241	6027	47.690660	-122.820162	513495	5281935	88
1242	56	47.689353	-122.818594	513613	5281790	71
1243	A125	47.689166	-122.817657	513683	5281769	62
1244	6081	47.689273	-122.816540	513767	5281781	61
1245	58	47.689407	-122.815286	513861	5281797	66
1246	52	47.689389	-122.813945	513962	5281795	67
1247	60	47.689456	-122.812374	514080	5281803	61
1248	55	47.689923	-122.810569	514215	5281855	50
1249	A126	47.691198	-122.808154	514396	5281997	40
1250	∗538	47.690385	-122.807048	514479	5281907	26
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1252	61	47.690420	-122.804494	514671	5281911	30
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1255	6113	47.695567	-122.798995	515082	5282484	82
1256	∗539	47.695594	-122.797358	515205	5282488	78
1257	48	47.695602	-122.795983	515308	5282489	87
1258	6129	47.695581	-122.794790	515398	5282487	90
1259	∗540	47.695587	-122.793195	515517	5282488	92
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1261	6040	47.695472	-122.790414	515726	5282475	99
1262	47	47.695446	-122.789310	515809	5282473	101
1263	6046	47.695462	-122.787939	515912	5282475	92
1264	42	47.695401	-122.786556	516015	5282468	93
1265	44	47.695249	-122.785059	516128	5282452	86
1266	∗541	47.695103	-122.783713	516229	5282436	82
1268	49	47.694881	-122.781550	516391	5282412	106
1269	∗542	47.694671	-122.779971	516510	5282389	106
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1273	A129	47.693879	-122.774456	516924	5282302	44
1274	A130	47.693457	-122.773502	516996	5282255	47
1275	A131	47.693390	-122.772608	517063	5282248	28
1293	∗543	47.689534	-122.745028	519134	5281826	42
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1316	82	47.678869	-122.715280	521370	5280648	107
1317	81	47.678156	-122.713612	521496	5280569	93
1318	7343	47.678365	-122.712447	521583	5280593	90
1319	80	47.678747	-122.711151	521680	5280636	85
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1322	7322	47.679361	-122.707245	521973	5280705	81
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1325	A053	47.678757	-122.703391	522263	5280639	55
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1333	640	47.678429	-122.692968	523045	5280606	51
1335	7075	47.678520	-122.690236	523250	5280617	42
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1348	107	47.677493	-122.672975	524546	5280508	93
1349	∗554	47.677395	-122.671458	524660	5280497	123
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1351	105	47.677288	-122.668541	524879	5280486	129
1352	104	47.676463	-122.666301	525048	5280395	121
1353	103	47.677995	-122.665454	525111	5280566	117
1354	102	47.677686	-122.664201	525205	5280532	104
1355	∗555	47.678154	-122.663237	525277	5280584	89
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1358	A055	47.678308	-122.658161	525658	5280603	75
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1362	98	47.679466	-122.653529	526005	5280733	110
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1366	97	47.677609	-122.648229	526404	5280529	97
1367	∗556	47.677597	-122.646949	526500	5280528	97
1368	96	47.677637	-122.645947	526575	5280533	93
1370	7070	47.676864	-122.643560	526754	5280448	80
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1387	90	47.670922	-122.620981	528452	5279795	81
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1390	88	47.666933	-122.617090	528747	5279353	68
2000	A039	47.666250	-122.750040	518766	5279237	35
2002	112	47.666111	-122.746938	518999	5279222	67
2004	113	47.665376	-122.743843	519231	5279141	93
2006	114	47.665122	-122.741302	519422	5279113	110
2008	A038	47.664817	-122.738633	519623	5279080	131
2010	7342	47.664895	-122.735853	519831	5279090	150
2012	115	47.664859	-122.733519	520007	5279086	145
2014	∗549	47.663542	-122.730849	520208	5278941	126
2016	7629	47.662724	-122.728201	520407	5278850	108
2018	116	47.662284	-122.725651	520598	5278802	94
2020	A040	47.661682	-122.722659	520823	5278736	101
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2024	∗638	47.660431	-122.718093	521167	5278598	91
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2041	120	47.665502	-122.695525	522859	5279168	43
2043	A052	47.665478	-122.693173	523035	5279166	31
2045	6122	47.665059	-122.690114	523265	5279121	17
2048	∗561	47.665020	-122.684871	523659	5279118	14
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2058	∗560	47.667404	-122.671440	524666	5279387	96
2060	A042	47.667526	-122.668890	524858	5279401	116
2062	634	47.668602	-122.667220	524982	5279521	120
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2069	635	47.666845	-122.657631	525703	5279329	57
2071	6048	47.666791	-122.655036	525898	5279324	65
2073	∗559	47.666781	-122.652497	526089	5279324	64
2075	125	47.667708	-122.650242	526257	5279428	55
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2083	∗558	47.666806	-122.639312	527078	5279331	52
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2097	132	47.664678	-122.620815	528468	5279101	87
2100	133	47.664364	-122.615558	528863	5279068	56
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2122	∗639	47.663558	-122.588002	530932	5278989	36
2123	135	47.663765	-122.586630	531035	5279013	52
2124	A151	47.663750	-122.585273	531137	5279012	14
2125	136	47.664839	-122.583286	531286	5279134	19
2126	7271	47.665216	-122.582848	531318	5279176	33
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2128	636	47.665407	-122.579609	531561	5279198	42
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2130	137	47.665512	-122.577065	531752	5279211	42
2131	138	47.665092	-122.575804	531847	5279165	42
2132	∗562	47.665803	-122.574594	531938	5279244	43
2133	139	47.665914	-122.573135	532047	5279257	48
2134	140	47.665840	-122.571794	532148	5279250	26
2138	A152	47.664806	-122.566915	532515	5279137	19
2139	141	47.664782	-122.565446	532625	5279135	24
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2141	∗649	47.664855	-122.562678	532833	5279144	69
2142	142	47.664887	-122.561387	532930	5279148	53
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2144	•7268	47.664950	-122.558336	533159	5279156	81
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2146	143	47.664889	-122.555713	533356	5279151	51
2147	144	47.664870	-122.554377	533456	5279149	69
2148	145	47.664846	-122.553020	533558	5279147	77
2149	146	47.664847	-122.551693	533658	5279148	86
2150	147	47.664874	-122.550346	533759	5279151	84
2151	148	47.664873	-122.548962	533863	5279152	85
2152	149	47.664875	-122.547653	533961	5279153	83
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2154	151	47.664880	-122.544890	534168	5279154	78
2155	152	47.664893	-122.543551	534269	5279156	79
2156	153	47.664901	-122.542206	534370	5279158	67
2157	154	47.664918	-122.540862	534471	5279160	69
2158	155	47.664900	-122.539502	534573	5279159	70
2159	156	47.664866	-122.538192	534671	5279156	74
2160	157	47.664853	-122.536870	534771	5279155	67
2161	158	47.664849	-122.535503	534873	5279155	54
2162	159	47.664885	-122.534213	534970	5279160	63

2163	160	47.664841	-122.532886	535070	5279155	43
2164	161	47.664812	-122.531556	535170	5279153	26
2165	162	47.664802	-122.530238	535268	5279152	16
2166	163	47.664856	-122.528757	535380	5279159	17
2167	164	47.664721	-122.527595	535467	5279145	33
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2169	∗566	47.664794	-122.524960	535665	5279154	54
2170	A150	47.664743	-122.523726	535757	5279149	58
2171	A155	47.664768	-122.522385	535858	5279152	68
2172	A153	47.664658	-122.520841	535974	5279141	79
2173	166	47.664692	-122.519668	536062	5279145	78
2174	167	47.664733	-122.518217	536171	5279150	58
2175	168	47.664725	-122.516972	536265	5279150	47
2176	169	47.664671	-122.515771	536355	5279144	52
2177	170	47.664725	-122.514345	536462	5279151	49
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2179	172	47.664690	-122.511692	536661	5279148	49
2180	173	47.664690	-122.510191	536774	5279149	52
2181	174	47.664697	-122.508906	536870	5279151	54
2182	175	47.664697	-122.507599	536968	5279151	53
2183	176	47.664717	-122.506398	537058	5279154	49
2184	177	47.663493	-122.504801	537179	5279019	35
2185	178	47.663201	-122.503579	537271	5278987	39
2186	179	47.662621	-122.501926	537396	5278923	38
2187	180	47.662742	-122.500548	537499	5278937	15
2190	D9	47.665783	-122.493217	538047	5279279	-56
2196	C1	47.666000	-122.485667	538614	5279307	-232
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2208	C3	47.666500	-122.470667	539740	5279370	-225
2214	B2	47.666167	-122.463833	540253	5279336	-228
2220	D4	47.665833	-122.455833	540854	5279303	-247
2226	D1	47.666500	-122.440833	541979	5279386	-70
2232	A8	47.666333	-122.436667	542292	5279369	-54
2238	187	47.661433	-122.433998	542497	5278826	1
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2242	191	47.660040	-122.427862	542958	5278675	42
2243	192	47.660154	-122.426521	543059	5278688	48
2244	193	47.661002	-122.425378	543144	5278783	53
2245	194	47.661594	-122.424012	543246	5278850	78
2246	195	47.662134	-122.422356	543370	5278911	78
2247	196	47.663190	-122.421253	543452	5279029	67
2248	197	47.663784	-122.420007	543545	5279095	83
2249	198	47.666042	-122.419325	543594	5279347	68
2250	199	47.666498	-122.417672	543718	5279398	40
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2252	390	47.665755	-122.414611	543949	5279317	41
2253	391	47.665357	-122.413117	544061	5279274	50
2254	392	47.665074	-122.411718	544166	5279243	41
2255	393	47.664804	-122.410142	544285	5279214	52
2256	394	47.664432	-122.408669	544396	5279174	46
2257	395	47.664150	-122.407260	544502	5279143	38
2258	396	47.663957	-122.406176	544583	5279122	42
2259	397	47.663769	-122.404900	544679	5279102	44
2260	398	47.670031	-122.403968	544744	5279799	21
2261	O312	47.670146	-122.402791	544832	5279812	19
2262	•7595	47.670294	-122.401406	544936	5279829	31
2263	212	47.670249	-122.399812	545056	5279825	36
2264	∗573	47.670499	-122.398666	545142	5279854	40
2265	7619	47.670661	-122.397478	545231	5279872	39
2266	7316	47.670967	-122.396260	545322	5279907	31
2267	O271	47.671102	-122.394909	545423	5279923	30
2268	7355	47.671029	-122.393237	545549	5279916	20
2269	∗642	47.670808	-122.392004	545641	5279892	22
2270	7292	47.670808	-122.390831	545730	5279893	20
2271	213	47.671154	-122.389451	545833	5279932	27
2272	7303	47.670511	-122.388182	545929	5279861	25
2273	214	47.670790	-122.388197	545927	5279892	33
2274	O275	47.671284	-122.386340	546066	5279948	26
2275	∗654	47.670567	-122.384207	546227	5279870	29
2276	7351	47.670762	-122.382568	546350	5279892	28
2277	7352	47.671287	-122.380764	546485	5279952	32
2278	O281	47.671573	-122.379765	546560	5279984	35
2279	∗646	47.670650	-122.378245	546674	5279883	32
2280	7598	47.670820	-122.377386	546739	5279902	33
2281	O262	47.670975	-122.375812	546857	5279920	30
2283	7332	47.670845	-122.373118	547059	5279907	25
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2284	∗661	47.670787	-122.371884	547152	5279902	23
2285	216	47.670843	-122.370493	547256	5279909	22
2286	7430	47.670584	-122.369432	547336	5279881	22
2287	O311	47.670792	-122.367961	547446	5279905	23
2288	7434	47.670703	-122.366609	547548	5279896	31
2289	217	47.670601	-122.365336	547644	5279885	34
2290	7330	47.670799	-122.363628	547772	5279908	33
2291	∗660	47.671151	-122.362382	547865	5279948	38
2292	O288	47.670758	-122.360993	547969	5279905	56
2293	O317	47.671301	-122.360115	548035	5279966	72
2294	7347	47.671330	-122.358488	548157	5279970	98

2295	∗572	47.671281	-122.357425	548237	5279965	91
2296	•7618	47.671045	-122.355792	548360	5279940	104
2297	218	47.670273	-122.354099	548487	5279856	105
2298	219	47.670341	-122.353079	548564	5279864	119
2299	220	47.670654	-122.351442	548687	5279900	118
2300	223	47.670955	-122.350338	548769	5279934	98
2301	222	47.671218	-122.349491	548832	5279963	104
2302	224	47.670803	-122.348017	548944	5279918	85
2303	O258	47.670587	-122.347127	549011	5279895	87
2304	201	47.670587	-122.346034	549093	5279896	79
2305	200	47.670636	-122.345093	549163	5279902	73
2306	O305	47.671562	-122.342893	549327	5280006	55
2307	202	47.670148	-122.342097	549389	5279849	63
2308	O257	47.670090	-122.340082	549540	5279844	57
2309	203	47.668732	-122.338660	549648	5279694	72
2310	7087	47.668525	-122.337407	549742	5279672	68
2311	∗575	47.668973	-122.336217	549831	5279722	71
2312	7043	47.668595	-122.334842	549935	5279681	75
2313	O274	47.669014	-122.333798	550013	5279729	87
2314	O067	47.668431	-122.331974	550150	5279665	88
2315	7048	47.669415	-122.330721	550243	5279775	82
2316	∗578	47.669280	-122.329152	550361	5279761	88
2317	204	47.669224	-122.327879	550457	5279756	92
2318	7101	47.669650	-122.326693	550545	5279804	91
2319	O304	47.669633	-122.325401	550642	5279803	96
2320	7060	47.669127	-122.324313	550725	5279747	83
2321	O306	47.669121	-122.323020	550822	5279747	70
2322		47.669215	-122.321182	550960	5279759	65
2323	∗579	47.669439	-122.319747	551067	5279785	58
2324	O277	47.669145	-122.318568	551156	5279753	63
2325	O278	47.669352	-122.317073	551268	5279777	60
2326	7104	47.669168	-122.315911	551355	5279757	60
2327	205	47.669609	-122.314763	551441	5279807	71
2328	7444	47.669573	-122.313652	551524	5279804	65
2329	O280	47.669835	-122.312372	551620	5279834	76
2330	∗580	47.669288	-122.310928	551729	5279774	84
2331	206	47.669336	-122.309725	551819	5279780	79
2332	7044	47.669536	-122.307943	551953	5279804	70
2333	O273	47.669448	-122.306654	552050	5279795	58
2334	7107	47.670195	-122.305666	552123	5279878	48
2335	207	47.669979	-122.304164	552236	5279855	45
2336	208	47.670631	-122.302829	552336	5279929	53
2337	O272	47.672017	-122.301748	552416	5280083	53
2338	•7610	47.672049	-122.300207	552531	5280088	49
2339	∗581	47.672045	-122.298882	552631	5280089	53
2340	O263	47.672202	-122.297637	552724	5280107	61
2341	∗582	47.671953	-122.296071	552842	5280080	70
2342	7077	47.672292	-122.294847	552933	5280119	81
2343	∗583	47.672127	-122.293566	553030	5280101	109
2344	7058	47.672212	-122.292537	553107	5280111	92
2345	O318	47.671834	-122.290934	553228	5280070	80
2346	7045	47.672247	-122.289497	553335	5280117	73
2347	209	47.672257	-122.288531	553408	5280119	68
2348	∗584	47.672222	-122.287306	553500	5280116	64
2349	210	47.672209	-122.285638	553625	5280116	47
2350	7100	47.672030	-122.284203	553733	5280097	49
2351	O308	47.672347	-122.282914	553829	5280133	59
2352	7068	47.672013	-122.281295	553951	5280097	64
2353	∗586	47.671963	-122.280250	554029	5280092	52
2354	7085	47.671969	-122.278931	554128	5280094	55
2355	∗587	47.672001	-122.277699	554221	5280098	76
2356	O286	47.672244	-122.276164	554336	5280126	78
2357	211	47.671663	-122.274716	554445	5280063	81
2358	7112	47.672043	-122.273702	554521	5280106	78
2359	∗588	47.671958	-122.272162	554637	5280097	52
2360	•7626	47.671987	-122.270937	554729	5280101	39
2361	407	47.672196	-122.269970	554801	5280125	45
2362	408	47.671942	-122.268751	554893	5280098	36
2363	7109	47.672702	-122.266721	555044	5280184	37
2364	∗590	47.673117	-122.265778	555115	5280231	37
2365	O285	47.672951	-122.264601	555203	5280213	40
2366	7064	47.672612	-122.263393	555294	5280176	41
2367	O310	47.672744	-122.262067	555394	5280192	41
2368	7061	47.672801	-122.260491	555512	5280199	70
2369	∗591	47.672717	-122.259389	555595	5280191	40
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2371	∗592	47.672973	-122.256860	555784	5280221	38
2372	7074	47.672797	-122.255241	555906	5280203	33
2373	O307	47.673944	-122.253273	556052	5280332	29
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2376	406	47.677825	-122.249057	556365	5280766	8
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2409	∗644	47.661072	-122.206006	559615	5278936	11
2410	•7601	47.661199	-122.204631	559718	5278951	23
2411	A132	47.660904	-122.203322	559817	5278920	36
2412	7336	47.660968	-122.201947	559920	5278928	60
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2414	∗604	47.660898	-122.199466	560106	5278922	65

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2416	7287	47.661423	-122.196727	560311	5278982	84
2417	A134	47.660932	-122.195546	560401	5278929	89
2418	7306	47.660907	-122.193955	560520	5278927	93
2419	∗602	47.661041	-122.192379	560638	5278943	96
2420	7296	47.661292	-122.191358	560715	5278972	102
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2423	417	47.661041	-122.187654	560993	5278947	139
2424	418	47.661114	-122.186185	561103	5278956	148
2425	419	47.660994	-122.184961	561195	5278944	135
2426	416	47.660962	-122.183590	561298	5278941	138
2427	415	47.660917	-122.182338	561392	5278937	142
2428	414	47.660884	-122.181033	561490	5278935	166
2429	444	47.660120	-122.179312	561620	5278851	160
2430	443	47.660151	-122.178014	561718	5278856	163
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2432	440	47.660725	-122.175019	561942	5278922	157
2433	439	47.660670	-122.173254	562075	5278917	168
2434	445	47.660668	-122.172179	562155	5278918	164
2435	442	47.659862	-122.171153	562233	5278829	163
2436	438	47.659792	-122.169845	562332	5278822	141
2437	434	47.660706	-122.168410	562438	5278925	174
2438	437	47.660771	-122.167133	562534	5278933	157
2439	428	47.660772	-122.165783	562635	5278935	156
2440	431	47.660712	-122.164452	562735	5278929	153
2441	A136	47.661654	-122.163515	562805	5279034	146
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2444	∗603	47.665269	-122.158743	563159	5279440	140
2445	427	47.667272	-122.157827	563225	5279663	139
2446	A140	47.667358	-122.156610	563316	5279674	138
2447	7357	47.667278	-122.155403	563407	5279666	117
2448	432	47.666636	-122.153872	563523	5279596	121
2449	∗600	47.665551	-122.152273	563644	5279477	122
2450	433	47.665727	-122.150621	563768	5279498	109
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2454	∗599	47.666506	-122.145909	564121	5279588	94
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2465	∗657	47.664036	-122.131329	565218	5279326	65
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2467	7338	47.663118	-122.127877	565479	5279227	73
2468	A102	47.661607	-122.126252	565603	5279060	22
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2470	491	47.662372	-122.123893	565779	5279147	22
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2479	482	47.663916	-122.112388	566641	5279329	8
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2485	476	47.663709	-122.104323	567246	5279313	15
2486	452	47.663919	-122.103027	567343	5279337	12
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2488	454	47.663923	-122.100470	567535	5279340	14
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2493	463	47.660536	-122.094525	567986	5278968	41
2494	7108	47.659494	-122.093438	568069	5278854	35
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2497	A100	47.657601	-122.089321	568381	5278647	45
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2503	A106	47.656055	-122.081140	568997	5278482	20
2504	460	47.655915	-122.079932	569088	5278468	26

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2507	458	47.655302	-122.076160	569372	5278403	21
2508	A105	47.655158	-122.074752	569478	5278388	26
2509	457	47.655072	-122.073296	569587	5278380	33
2510	7277	47.655643	-122.072147	569673	5278445	17
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2513	A103	47.660367	-122.068665	569928	5278973	108
2514	7321	47.660264	-122.067149	570042	5278963	94
2515	A104	47.660268	-122.065748	570147	5278964	94
2516	548	47.660704	-122.064311	570254	5279014	95
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2519	496	47.671372	-122.060139	570553	5280203	115
2520	A116	47.671333	-122.058828	570652	5280200	122
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2522	7462	47.671109	-122.056029	570862	5280178	117
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2528	465	47.668690	-122.048101	571461	5279916	148
2529	466	47.668416	-122.046623	571572	5279887	153
2530	510	47.668137	-122.045291	571672	5279858	146
2531	513	47.667940	-122.043939	571774	5279837	139
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2534	446	47.667183	-122.039964	572073	5279756	141
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2569	625	47.673595	-121.992979	575591	5280514	193
2570	•7289	47.673382	-121.991437	575708	5280492	201
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2584	512	47.673428	-121.973462	577057	5280515	15
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2597	7327	47.678363	-121.955863	578370	5281081	32
2598	A111	47.677919	-121.954704	578458	5281032	25
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2614	535	47.671804	-121.933984	580023	5280374	24
2615	618	47.671778	-121.932660	580122	5280373	22
2616	A161	47.671751	-121.931299	580224	5280371	22
2617	7326	47.671454	-121.930061	580318	5280339	25
2618	A091	47.670306	-121.928781	580415	5280213	21
2619	533	47.668459	-121.927638	580504	5280009	36
2620	619	47.666032	-121.925512	580667	5279741	21
2621	7275	47.665716	-121.924361	580754	5279707	17
2622	532	47.665365	-121.923458	580823	5279669	13
2623	534	47.664970	-121.922059	580928	5279627	20
2624	A092	47.664612	-121.920714	581030	5279589	22
2625	7063	47.664238	-121.919348	581133	5279548	21
2626	620	47.663873	-121.917974	581237	5279509	14
2627	530	47.663492	-121.916631	581338	5279468	16
2628	529	47.663146	-121.915252	581442	5279431	21
2629	531	47.662773	-121.913891	581545	5279391	26
2630	526	47.662485	-121.912759	581630	5279360	19
2631	621	47.662313	-121.911047	581759	5279343	18
2632	A122	47.659960	-121.910095	581834	5279083	20
2633	7039	47.658847	-121.909164	581906	5278960	26
2634	A163	47.658843	-121.907792	582009	5278961	16
2635	537	47.658764	-121.906501	582106	5278954	16
2636	622	47.658770	-121.905138	582208	5278956	18
2637	6044	47.658744	-121.903793	582309	5278954	20
2638	536	47.658772	-121.902469	582409	5278959	22
2639	A162	47.658776	-121.901242	582501	5278960	19
2640	623	47.658671	-121.899814	582608	5278950	28
2641	6053	47.658602	-121.898534	582705	5278944	57
2642	624	47.658569	-121.897234	582802	5278942	73
2643	528	47.660254	-121.895340	582942	5279131	76
2644	A181	47.662018	-121.894255	583020	5279328	87
2645	•7612	47.661531	-121.892645	583142	5279276	96
2646	527	47.659843	-121.891621	583222	5279089	141
2647	593	47.659111	-121.889867	583355	5279010	145
2648	A183	47.659585	-121.888343	583468	5279064	165
2657	538	47.647934	-121.882707	583910	5277775	56
2663	605	47.651471	-121.868223	584992	5278184	128
2664	604	47.652329	-121.867514	585044	5278280	139
2665	598	47.653125	-121.866097	585149	5278370	137
2666	597	47.653768	-121.864726	585251	5278443	131
2667	596	47.654282	-121.863272	585359	5278502	129
2668	595	47.654881	-121.862024	585452	5278570	148
2669	594	47.655762	-121.860669	585552	5278669	136
2670	A178	47.655770	-121.859452	585644	5278672	202
2671	A124	47.654197	-121.857890	585764	5278499	53
2672	A180	47.651282	-121.856713	585857	5278176	197
2673	A123	47.650742	-121.855172	585973	5278118	172
2674	A188	47.650284	-121.853616	586091	5278068	160
2675	A187	47.649870	-121.852300	586190	5278024	159
2676	A172	47.648977	-121.851194	586275	5277926	168
2677	A171	47.648118	-121.849917	586372	5277832	181
2678	7047	47.653340	-121.848626	586461	5278414	183
2679	566	47.653525	-121.847205	586567	5278436	182
2680	7081	47.655000	-121.845771	586672	5278601	192
2681	7038	47.655773	-121.844283	586783	5278689	201
2682	567	47.656038	-121.842940	586883	5278720	207
2683	A168	47.656342	-121.841525	586989	5278755	203
2684	568	47.656596	-121.840110	587095	5278785	196
2685	7098	47.656841	-121.838817	587191	5278814	204
2686	7088	47.657022	-121.837514	587289	5278835	193
2687	7082	47.657019	-121.836258	587383	5278836	193
2688	A166	47.657250	-121.835230	587460	5278863	194
2689	•7597	47.657022	-121.833829	587566	5278839	206
2690	569	47.656418	-121.832669	587654	5278774	214
2691	7071	47.656234	-121.831359	587752	5278755	210
2692	6111	47.656668	-121.829996	587854	5278804	208
2693	6087	47.657113	-121.828651	587954	5278855	201
2694	A165	47.657187	-121.827331	588053	5278865	186
2695	∗607	47.657377	-121.826011	588152	5278888	177
2696	∗608	47.657025	-121.824710	588250	5278850	180
2697	6060	47.656213	-121.823272	588360	5278762	178
2698	570	47.657679	-121.821953	588456	5278926	167
2699	A164	47.658198	-121.820481	588566	5278985	197
2700	571	47.657857	-121.819190	588663	5278949	184
2701	6107	47.658426	-121.817573	588784	5279014	189
2702	∗609	47.659135	-121.816442	588868	5279094	203
2703	572	47.659837	-121.815298	588952	5279173	202
2704	6039	47.661242	-121.813890	589056	5279331	193
2705	A177	47.660156	-121.812291	589177	5279212	221
2706	A175	47.657341	-121.810796	589295	5278901	248

2709	573	47.655458	-121.808745	589452	5278694	295
2710	574	47.657140	-121.806679	589604	5278884	297
2711	576	47.660330	-121.805165	589712	5279240	281
2712	577	47.658795	-121.803742	589822	5279071	280
2714	578	47.658077	-121.801181	590015	5278994	284
2715	579	47.660226	-121.799334	590150	5279235	296
2716	580	47.659817	-121.798151	590240	5279191	309
2717	581	47.659094	-121.796820	590341	5279112	317
2718	A174	47.656990	-121.794637	590508	5278881	400
2719	6088	47.656850	-121.793610	590586	5278867	397
2720	6041	47.657462	-121.792525	590666	5278936	402
2721	∗610	47.657128	-121.791456	590747	5278900	394
2722	582	47.656159	-121.789071	590928	5278795	380
2723	A173	47.654967	-121.788038	591007	5278664	383
2724	6093	47.652522	-121.787032	591087	5278393	401
2725	583	47.654276	-121.785226	591220	5278590	442
2726	∗611	47.653614	-121.783857	591324	5278518	444
2727	A186	47.651723	-121.782602	591421	5278310	440
2728	A185	47.649945	-121.781396	591515	5278114	439
2729	•7299	47.650062	-121.779661	591645	5278129	435
2730	∗612	47.650760	-121.778314	591745	5278208	426
2731	∗613	47.652190	-121.777329	591816	5278368	435
2732	6124	47.653961	-121.776127	591904	5278566	451
2733	585	47.653751	-121.774808	592003	5278544	450
2734	A169	47.653399	-121.773420	592108	5278507	450
2735	586	47.653656	-121.771750	592233	5278537	435
2736	6083	47.645152	-121.773442	592121	5277590	394
2737	6084	47.648165	-121.771004	592299	5277928	356
2738	6097	47.651319	-121.769000	592443	5278281	360
2743	A022	47.651750	-121.761676	592993	5278338	342
2744	6004	47.653103	-121.759716	593137	5278490	344
2745	587	47.655185	-121.759213	593172	5278722	358
2746	∗614	47.657986	-121.757789	593273	5279035	362
2747	6132	47.656163	-121.756555	593369	5278834	363
2748	6069	47.655884	-121.755298	593464	5278805	375
2749	591	47.655527	-121.754009	593562	5278767	363
2750	A010	47.653845	-121.752976	593642	5278581	355
2751	A009	47.654176	-121.752070	593710	5278619	361
2752	A017	47.653581	-121.750918	593797	5278554	360
2753	∗615	47.656970	-121.748365	593983	5278934	370
2754	6037	47.654614	-121.747091	594083	5278674	383
2755	588	47.654078	-121.745678	594190	5278616	391
2756	6021	47.654172	-121.744319	594292	5278628	385
2757	∗616	47.654034	-121.742940	594396	5278614	381
2758	589	47.653399	-121.741685	594491	5278545	388
2759	A012	47.651757	-121.740785	594561	5278364	378
2760	6001	47.650874	-121.739156	594685	5278268	379
2761	A011	47.650322	-121.737701	594796	5278208	377
2762	∗617	47.650075	-121.736247	594905	5278182	381
2763	590	47.650130	-121.734911	595006	5278190	391
2764	6090	47.650222	-121.733582	595105	5278202	391
2765	A019	47.650223	-121.732231	595207	5278204	393
2766	592	47.650106	-121.730934	595304	5278192	400
2767	∗618	47.650059	-121.729534	595409	5278189	407
2768	•7278	47.649907	-121.728250	595506	5278173	413
2769	551	47.649545	-121.726997	595601	5278135	433
2770	A020	47.649120	-121.725884	595685	5278089	427
2771	∗619	47.648515	-121.724746	595772	5278023	439
2772	6103	47.647830	-121.723819	595843	5277948	435
2773	A021	47.647838	-121.722631	595932	5277950	445
2774	552	47.648508	-121.721288	596032	5278027	463
2775	A005	47.652054	-121.718763	596215	5278424	387
2776	6085	47.651251	-121.717872	596283	5278336	416
2777	∗620	47.651576	-121.716490	596386	5278373	389
2778	6114	47.651935	-121.715299	596475	5278415	404
2779	A006	47.652242	-121.713967	596574	5278451	393
2780	6127	47.652574	-121.712484	596685	5278489	399
2782	553	47.652628	-121.709770	596889	5278499	410
2784	∗621	47.652243	-121.707183	597084	5278459	442
2786	554	47.652234	-121.704542	597282	5278462	457
2788	6018	47.652821	-121.701996	597472	5278530	469
2790	A007	47.652071	-121.699236	597681	5278450	491
2792	6148	47.650604	-121.696718	597873	5278290	523
2794	∗622	47.649603	-121.694204	598063	5278182	551
2796	6024	47.648860	-121.691735	598250	5278103	567
2798	555	47.646930	-121.688667	598484	5277892	607
2800	A008	47.645337	-121.686108	598680	5277718	592
2802	556	47.649339	-121.682661	598931	5278167	559
2804	6026	47.649702	-121.679566	599163	5278212	552
2806	∗623	47.649322	-121.677042	599353	5278173	539
2808	•7606	47.650020	-121.674419	599549	5278254	531
2810	A001	47.651144	-121.672067	599723	5278382	522
2812	6031	47.644887	-121.670108	599882	5277689	469
2814	557	47.645826	-121.667434	600081	5277797	487
2816	∗624	47.648105	-121.664725	600280	5278053	471
2818	A014	47.648906	-121.662096	600476	5278146	487
2820	6058	47.648648	-121.659483	600673	5278121	500
2822	A002	47.648704	-121.656771	600876	5278130	484
2824	558	47.649133	-121.653914	601090	5278182	499
2826	∗625	47.649317	-121.651467	601273	5278205	492

2828	6064	47.649740	-121.648916	601464	5278256	475
2830	559	47.649525	-121.646096	601676	5278235	472
2832	A003	47.652893	-121.643773	601844	5278613	461
2834	∗633	47.654633	-121.641428	602017	5278809	448
2836	6102	47.655811	-121.637942	602277	5278945	467
2838	A004	47.656472	-121.635042	602493	5279022	474
2840	6049	47.657277	-121.632201	602705	5279115	472
2842	A016	47.658218	-121.630134	602858	5279223	472
2844	6120	47.659352	-121.627383	603062	5279352	473
2846	560	47.659900	-121.624924	603246	5279416	479
2848	∗627	47.659888	-121.622236	603448	5279419	473
2850	561	47.660349	-121.619462	603655	5279474	472
2852	•7295	47.660831	-121.616803	603854	5279531	473
2854	A015	47.661508	-121.614231	604046	5279610	483
2856	6091	47.661211	-121.611443	604256	5279580	488
2858	∗628	47.660963	-121.608646	604466	5279556	475
2860	6022	47.661748	-121.606206	604648	5279647	480
2862	562	47.662314	-121.603055	604883	5279714	494
2864	∗629	47.662834	-121.600687	605060	5279775	481
2866	∗630	47.662558	-121.598284	605241	5279748	479
2868	6098	47.662255	-121.595676	605437	5279718	477
2870	∗631	47.662538	-121.593159	605626	5279752	495
2872	563	47.661514	-121.590316	605841	5279643	487
♦2874	6067	47.661480	-121.587590	606046	5279643	475
2876	∗647	47.660204	-121.584919	606249	5279504	479
3000	∗568	47.770907	-122.560200	532952	5290932	9
3010	633	47.761683	-122.562165	532811	5289906	19
3020	•7270	47.751751	-122.562810	532769	5288802	27
3030	A147	47.744252	-122.557281	533188	5287970	41
3060	632	47.717401	-122.563909	532708	5284983	20
3070	7272	47.707286	-122.558568	533115	5283861	89
3080	A146	47.698554	-122.556450	533279	5282892	58
3090	186	47.688561	-122.549072	533839	5281784	40
3100	∗567	47.679835	-122.547586	533956	5280815	37
3110	7041	47.672146	-122.545819	534094	5279962	37
3130	A145	47.652648	-122.547791	533959	5277794	98
3140	185	47.644169	-122.547732	533968	5276851	81
3150	A144	47.637097	-122.542416	534372	5276068	57
3160	∗565	47.626707	-122.539348	534610	5274914	5
3170	184	47.618284	-122.540878	534500	5273978	47
3180	A143	47.609079	-122.537934	534728	5272956	86
3190	182	47.600762	-122.536062	534874	5272032	58
3200	A142	47.590285	-122.532582	535142	5270870	17
3210	181	47.581409	-122.523350	535843	5269887	51
4010	∗594	47.769787	-122.279394	553993	5290965	159
4020	•7628	47.760269	-122.283096	553725	5289905	48
4030	413	47.751691	-122.283011	553740	5288951	27
4040	A141	47.744134	-122.285645	553550	5288110	30
4050	410	47.733745	-122.285617	553563	5286955	57
4060	∗595	47.725890	-122.286187	553529	5286081	96
4070	7062	47.715949	-122.284378	553674	5284978	73
4080	411	47.706263	-122.277835	554175	5283906	40
4090	A133	47.697771	-122.277982	554173	5282962	18
4100	412	47.689782	-122.266566	555038	5282082	9
4120	∗593	47.670141	-122.263580	555283	5279901	57
4130	409	47.661560	-122.268960	554888	5278944	29
4140	A160	47.653243	-122.277716	554239	5278013	32
4150	7096	47.642621	-122.283589	553809	5276829	11
4160	7054	47.634141	-122.277663	554263	5275891	13
4170	∗596	47.624242	-122.284633	553749	5274786	30
4180	403	47.617674	-122.280780	554046	5274058	22
4190	•7608	47.607015	-122.283886	553823	5272871	18
4200	∗597	47.598029	-122.287299	553576	5271870	23
4210	425	47.577076	-122.283127	553911	5269545	35
4220	A088	47.577076	-122.283092	553914	5269545	14
4230	424	47.570580	-122.280101	554145	5268825	18
4240	423	47.562719	-122.268274	555043	5267960	15
4250	A089	47.551721	-122.257064	555898	5266745	9
5000	•7284	47.743521	-122.115097	566336	5288173	168
♦5007	A090	47.737830	-122.090310	568202	5287562	56
5010	475	47.733483	-122.115281	566335	5287058	156
5020	A083	47.724798	-122.115530	566327	5286092	111
5030	474	47.716496	-122.110415	566722	5285174	95
5040	A082	47.706801	-122.110743	566709	5284096	97
5050	400	47.698347	-122.111830	566639	5283156	89
5060	473	47.689297	-122.111918	566643	5282150	114
5070	631	47.679995	-122.112257	566630	5281116	97
5080	472	47.672674	-122.109195	566869	5280305	14
5100	A087	47.650098	-122.113634	566565	5277792	24
5110	467	47.643675	-122.110954	566774	5277080	49
5120	7442	47.633964	-122.110881	566792	5276001	87
5130	628	47.626225	-122.111714	566739	5275140	121
5140	468	47.616819	-122.109937	566885	5274096	99
5150	A086	47.606878	-122.113345	566641	5272989	25
5160	469	47.598921	-122.110714	566849	5272107	42
5170	A085	47.588874	-122.111797	566780	5270989	35
5180	470	47.580880	-122.112732	566720	5270100	20
5190	471	47.572253	-122.112679	566735	5269141	77
5200	A084	47.563102	-122.115117	566563	5268122	209
5210	•7617	47.548523	-122.115515	566552	5266501	346

6000	499	47.772532	-122.036566	572183	5291468	160
6010	545	47.765382	-122.037146	572149	5290673	167
6020	A148	47.754949	-122.033128	572465	5289517	183
6030	541	47.745169	-122.029438	572755	5288434	163
6040	•7614	47.735483	-122.028715	572823	5287358	173
6050	544	47.726627	-122.035069	572359	5286368	144
6060	610	47.718595	-122.034551	572409	5285475	144
6070	7057	47.709162	-122.027062	572983	5284434	192
6080	A093	47.701041	-122.024352	573198	5283534	172
6110	609	47.672486	-122.032888	572597	5280352	167
6120	547	47.663192	-122.034009	572526	5279318	161
6130	540	47.654609	-122.035262	572444	5278363	89
6140	7094	47.645970	-122.035318	572452	5277403	53
6150	A080	47.635009	-122.037361	572313	5276183	124
6160	543	47.627059	-122.035524	572462	5275301	127
6170	A079	47.618507	-122.035432	572481	5274351	131
6180	•7340	47.610177	-122.035534	572485	5273425	113
6190	546	47.601140	-122.035578	572494	5272421	165
6200	A078	47.591894	-122.035579	572507	5271393	137
6210	•7605	47.581374	-122.035659	572515	5270224	138
6220	542	47.574246	-122.035839	572512	5269432	123
6230	607	47.573470	-122.036040	572497	5269345	126
6240	539	47.559137	-122.035911	572527	5267752	153

♦ Station location determined from a digital USGS topographic map.
•Continuously recording REFTEK Model 07.
∗SGR-III

Notes: Unit numbers Axxx correspond to PRS-1's; Oxxx correspond to PRS-4's.
Unit numbers 6001-6148 correspond to REFTEK Model O6's.
Unit numbers 7038-7629 correspond to REFTEK Model 07's.
Unit numbers 1-660 are Texans.

SGR units at Stations 1000, 1084, 1103, 1114, 2024, 2295, 2359, 2695, 2870, 4010 and 4120 failed to record useful data. SGR Station 2878 was not deployed.

PRS 9900 was located at the Kitsap County Fairgrounds, near the Presidents Hall (at Station 2057).

OBS A4 (Station 2202) was not recovered. OBS A8 (Station 2232) did not record data. OBS D4 (Station 2220) accidentally released prematurely during the experiment between shot 24 and 25.

Note: The UTM coordinates in the tape headers for the OBS's (stations 2190 to 2232) are incorrect. Use the UTM coordinates from Table 2.

Table 3. Shot list ordered chronologically by shot time.

Shot No.	Shot Point No.	Shot Time (JD:Hr:Mn:S) UTC	Shot Point Latitude	Shot Point Longitude	UTM Easting (m)	UTM Northing (m)	Shot Elev. (m)	Shot Depth (m)	Trace Header Stat.	Shot Size (lbs)	Shot Size (kgs)
1	SP02	263:08:00:00	47.741223	-123.056398	495772	5287540	155	23	20	250	113
2	SP06	263:08:02:00	47.707970	-122.892340	508076	5283849	5	15	60	50	23
3	SP30	263:08:04:00	47.660151	-121.812390	589170	5279212	224	23	300	250	113
4	SP31	263:08:06:00	47.655139	-121.758625	593216	5278718	355	23	310	250	113
5	SP34	263:08:08:00	47.653562	-121.642726	601922	5278689	467	23	340	250	113
6	SP01	263:09:30:00	47.729520	-123.086529	493512	5286242	238	37	10	2800	1267
7	SP05	263:09:32:00	47.730716	-122.947215	503958	5286372	414	30	51	2000	905
8	SP29	263:09:34:00	47.657893	-121.860752	585543	5278906	129	27	291	800	362
9	SP32	263:09:36:00	47.651181	-121.717902	596281	5278328	389	30	320	2000	905
10	SP35	263:11:08:00	47.660939	-121.616558	603872	5279543	468	27	350	2400	1086
11	SP04	264:08:00:00	47.716137	-122.991552	500634	5284751	136	23	40	250	113
12	SP09	264:08:02:00	47.693580	-122.779130	516573	5282267	86	15	90	50	23
13	SP33	264:08:06:00	47.652125	-121.672736	599671	5278490	526	23	330	250	113
14	SP10	264:08:10:00	47.699421	-122.724739	520652	5282930	121	23	100	150	68
15	SP11	264:08:12:00	47.680029	-122.718209	521150	5280776	117	24	111	500	226
16	SP24	264:08:14:00	47.682420	-122.022710	573347	5281466	171	24	240	500	226
17	SP01	264:09:30:00	47.729520	-123.086529	493512	5286242	238	37	10	2800	1267
18	SP08	264:09:32:00	47.705836	-122.801583	514885	5283625	44	23	80	250	113
19	SP05	264:09:34:00	47.729511	-122.945819	504063	5286239	404	30	52	2000	905
20	SP32	264:09:36:00	47.651181	-121.717902	596281	5278328	389	30	320	2000	905
21	SP12	264:09:38:00	47.675732	-122.740495	519479	5280293	84	24	120	500	226
22	SP11	264:09:42:00	47.679773	-122.718313	521142	5280748	117	24	112	500	226
23	SP24	264:09:44:00	47.682420	-122.022710	573347	5281466	171	24	240	500	226
24	SP12	264:11:08:00	47.675732	-122.740495	519479	5280293	84	24	120	500	226
25	SP21	265:08:00:00	47.682904	-122.249409	556333	5281330	17	24	211	400	181
26	SP27	265:08:04:00	47.672020	-121.930550	580280	5280402	9	23	270	250	113
27	SP26	265:08:06:00	47.644160	-121.946420	579131	5277289	158	21	260	500	226
28	SP14	265:08:08:00	47.677027	-122.631557	527655	5280470	73	18	140	50	23
29	SP15	265:08:10:00	47.661350	-122.578149	531674	5278748	45	18	150	50	23
30	SP19	265:08:12:00	47.668744	-122.345883	549106	5279691	79	18	190	25	11
31	SP18	265:08:14:00	47.664491	-122.419736	543565	5279174	73	23	180	325	147
32	SP21	265:09:30:00	47.682955	-122.248809	556378	5281336	16	24	212	400	181
33	SP22	265:09:34:00	47.651400	-122.174900	561962	5277886	155	26	220	400	181
34	SP26	265:09:36:00	47.644160	-121.946420	579131	5277289	158	21	260	500	226
35	SP13	265:09:38:00	47.672731	-122.687674	523445	5279974	12	15	130	125	57
36	SP17	265:09:40:00	47.654140	-122.548039	533939	5277959	85	26	170	375	170
37	SP20	265:09:44:00	47.650912	-122.298710	552665	5277740	4	14	200	125	57
38	SP19	265:11:12:00	47.668744	-122.345883	549106	5279691	79	18	190	25	11

Table 4. Shot list ordered by geographic shotpoint location (west to east). Note that shotpoints are numbered from west to east, beginning with SP01 (Figure 1).

Shot No.	SP No.	Shottime UTC (JD:Hr:Min:S)	Latitude	Longitude	Ele. (m)	Shot size (lbs)	Lead Shooter
6	SP01	263:09:30:00	47.729520	-123.086529	238	2800	Reneau
17	SP01	264:09:30:00	47.729520	-123.086529	238	2800	Reneau
1	SP02	263:08:00:00	47.741223	-123.056398	155	250	Reneau
11	SP04	264:08:00:00	47.716137	-122.991552	136	250	Reneau
7	SP05	263:09:32:00	47.730716	-122.947215	414	2000	Benz
19	SP05	264:09:34:00	47.729511	-122.945819	404	2000	Burdette
2	SP06	263:08:02:00	47.707970	-122.892340	5	50	Benz
18	SP08	264:09:32:00	47.705836	-122.801583	44	250	Benz
12	SP09	264:08:02:00	47.693580	-122.779130	86	50	Benz
14	SP10	264:08:10:00	47.699421	-122.724739	121	150	Harder
15	SP11	264:08:12:00	47.680029	-122.718209	117	500	Kaderabek
22	SP11	264:09:42:00	47.679773	-122.718313	117	500	Kaderabek
21	SP12	264:09:38:00	47.675732	-122.740495	84	500	Criley
24	SP12	264:11:08:00	47.675732	-122.740495	84	500	Criley
35	SP13	265:09:38:00	47.672731	-122.687674	12	125	Criley
28	SP14	265:08:08:00	47.677027	-122.631557	73	50	Criley
29	SP15	265:08:10:00	47.661350	-122.578149	45	50	Harder
36	SP17	265:09:40:00	47.654140	-122.548039	85	375	Harder
31	SP18	265:08:14:00	47.664491	-122.419736	73	325	Van Schaack
30	SP19	265:08:12:00	47.668744	-122.345883	79	25	Kaderabek
38	SP19	265:11:12:00	47.668744	-122.345883	79	25	Kaderabek
37	SP20	265:09:44:00	47.650912	-122.298710	4	125	Van Schaack
25	SP21	265:08:00:00	47.682904	-122.249409	17	400	Reneau
32	SP21	265:09:30:00	47.682955	-122.248809	16	400	Reneau
33	SP22	265:09:34:00	47.651400	-122.174900	155	400	Burdette
16	SP24	264:08:14:00	47.682420	-122.022710	171	500	Van Schaack
23	SP24	264:09:44:00	47.682420	-122.022710	171	500	Van Schaack
27	SP26	265:08:06:00	47.644160	-121.946420	158	500	Croker
34	SP26	265:09:36:00	47.644160	-121.946420	158	500	Croker
26	SP27	265:08:04:00	47.672020	-121.930550	9	250	Burdette
8	SP29	263:09:34:00	47.657893	-121.860752	129	800	Burdette
3	SP30	263:08:04:00	47.660151	-121.812390	224	250	Burdette
4	SP31	263:08:06:00	47.655139	-121.758625	355	250	Croker
9	SP32	263:09:36:00	47.651181	-121.717902	389	2000	Croker
20	SP32	264:09:36:00	47.651181	-121.717902	389	2000	Croker
13	SP33	264:08:06:00	47.652125	-121.672736	526	250	Croker
5	SP34	263:08:08:00	47.653562	-121.642726	467	250	Criley
10	SP35	263:11:08:00	47.660939	-121.616558	468	2400	Criley

Shotpoints 3, 7, 16, 23, 25, and 28 were not used.

Shots were repeated at SP01, SP05, SP11, SP12, SP19, SP21, SP24, SP26, and SP32.

Table 5a. Shotpoints which triggered the Pacific Northwest Seismic Network (PNSN). Event times, locations, and depths are those reported by the PNSN.

SP No.	DATE yy/mm/dd	Time (UT(hh:mm:ss	Latitude	Longitude	Depth (km)	Mag	Qual.	Comment				
SP30	99/09/20	08:04:00	47.66300	121.83933	0.0	1.2	BC	5.9	km	ENE	of	Carnation
SP1a	99/09/20	09:30:00	47.70833	123.04433	1.4	1.5	BB	30.1	km	W	of	Poulsbo
SP5a	99/09/20	09:31:59	47.72867	123.02650	15.4	1.1	AD	28.6	km	W	of	Poulsbo
SP32a	99/09/20	09:36:00	47.65367	121.70950	0.0	1.6	BA	15.5	km	E	of	Carnation
SP35	99/09/20	11:08:00	47.66417	121.61150	4.3	2.7	BB	19.2	km	WSW	of	Skykomish
SP11a	99/09/21	08:12:01	47.70833	122.76467	4.1	1.4	DC	8.4	km	W	of	Poulsbo
SP5b	99/09/21	09:34:00	47.71833	122.92883	0.1	1.6	BC	21.4	km	W	of	Poulsbo
SP32b	99/09/21	09:36:00	47.65183	121.71633	4.0	1.7	CB	14.9	km	E	of	Carnation
SP11b	99/09/21	09:42:01	47.67933	122.73200	1.3	1.6	AC	9.0	km	SW	of	Poulsbo
SP21a	99/09/22	08:00:01	47.67400	122.25317	0.0	1.3	BA	3.5	km	WSW	of	Kirkland
SP18	99/09/22	08:14:02	47.66467	122.43150	0.0	1.9	BB	10.7	km	NW	of	Seattle
SP21b	99/09/22	09:30:01	47.68150	122.24617	0.0	1.7	BA	2.9	km	W	of	Kirkland
SP22	99/09/22	09:34:01	47.63767	122.17383	0.0	1.0	BC	3.6	km	NNE	of	Bellevue
SP13	99/09/22	09:38:01	47.68367	122.72117	0.7	1.3	AD	8.1	km	SW	of	Poulsbo
SP17	99/09/22	09:40:02	47.66067	122.56617	2.9	1.2	AC	10.2	km	SE	of	Poulsbo
SP20	99/09/22	09:44:02	47.63517	122.30333	0.0	1.9	DB	4.7	km	NNE	of	Seattle

Table 5b. Position errors of shots located by the PNSN in Table 5a.

SP No.	Error Latitude (km)	Error Longitude (km)	Total Range Error (km)	Depth Error (km)	Magni-tude
SP1a	2.35	3.31	4.06	1.4	1.5
SP5a	0.23	6.22	6.22	15.4	1.1
SP5b	1.24	1.33	1.82	0.1	1.6
SP11a	3.14	3.64	4.81	4.1	1.4
SP11b	0.05	1.07	1.07	1.3	1.6
SP13	1.21	2.63	2.89	0.7	1.3
SP17	0.72	1.42	1.60	2.9	1.2
SP18	0.02	0.92	0.92	0	1.9
SP20	1.75	0.36	1.78	0	1.9
SP21a	0.99	0.29	1.03	0	1.3
SP21b	0.16	0.21	0.26	0	1.7
SP22	1.52	0.08	1.53	0	1.0
SP30	0.32	2.11	2.14	0	1.2
SP32a	0.28	0.66	0.71	0	1.6
SP32b	0.07	0.12	0.14	4	1.7
SP35	0.36	0.40	0.53	4.3	2.7
Average	0.90	1.55	1.97	2.1	1.5

TABLE 6a. Earthquakes (and Blasts) in Western Washington, September 19-22, 1999[1]

Event Number	Origin Time (UTC) Yr:JD:Hr:Min:Sec	Latitude	Longitude	Depth (km)	Mag.	Window start Yr:JD:Hr:Min	Window stop Yr:JD:Hr:Min
1	1999:262:04:21:44.4	46.440	-119.620	19.9	3.1	99:262:04:21	99:262:04:31
2	1999:262:05:07:56.3	46.449	-119.636	15.8	0.0	99:262:05:07	99:262:05:17
3	1999:262:06:29:41.1	47.575	-121.768	10.2	1.3	99:262:06:29	99:262:06:39
4	1999:262:11:11:52.9	46.390	-120.100	12.4	3.2	99:262:11:11	99:262:11:21
5	1999:262:11:58:21.1	46.460	-120.083	12.6	1.0	99:262:11:58	99:262:12:08
6	1999:262:17:25:35.2	47.964	-121.931	13.0	0.8	99:262:17:25	99:262:17:35
7	1999:262:18:35:08.6	47.268	-123.969	25.3	0.6	99:262:18:35	99:262:18:45
8	1999:262:19:39:57.6	47.815	-119.504	0.0	1.8	99:262:19:39	99:262:19:49
9	1999:262:23:34:26.0	46.448	-119.636	16.6	1.5	99:262:23:34	99:262:23:44
10	1999:263:06:29:22.8	46.383	-120.115	6.9	1.3	99:263:06:29	99:263:06:39
11	1999:263:11:16:54.1	47.600	-121.760	16.9	2.8	99:263:11:16	99:263:11:26
12	1999:263:11:31:24.9	47.605	-121.773	16.1	1.7	99:263:11:31	99:263:11:41
13	1999:263:12:00:52.1	47.600	-121.760	15.9	2.1	99:263:12:00	99:263:12:10
14	1999:263:12:46:21.7	46.389	-120.106	7.7	1.6	99:263:12:46	99:263:12:56
15	1999:263:22:26:02.3	46.460	-119.608	19.4	-0.1	99:263:22:26	99:263:22:36
16	1999:263:23:50:32.8	46.398	-120.092	9.7	0.9	99:263:23:50	99:264:00:00
17	1999:264:09:34:00.5	47.718	-122.928	0.0	1.6	99:264:09:34	99:264:09:44
18	1999:264:09:36:00.6	47.652	-121.430	4.0	1.7	99:264:09:36	99:264:09:46
19	1999:264:09:42:01.4	47.679	-122.732	1.3	1.6	99:264:09:42	99:264:09:52
20	1999:264:13:09:17.2	40.619	-124.291	23.0	3.1	99:264:13:09	99:264:13:19
21	1999:264:21:27:29.4	48.085	-121.928	0.0	0.9	99:264:21:17	99:264:21:27
22	1999:265:02:06:33.6	47.349	-122.315	13.5	1.3	99:265:02:06	99:265:02:16
23	1999:265:02:32:41.3	47.643	-120.222	0.7	1.7	99:265:02:32	99:265:02:42
24	1999:265:09:56:16.7	47.640	-127.193	10.0	0.0	99:265:09:56	99:265:10:06
25	1999:265:10:01:20.5	48.612	-122.170	3.0	0.7	99:265:10:01	99:265:10:11
26	1999:265:10:21:52.2	45.890	-118.190	5.2	2.3	99:265:10:21	99:265:10:31

[1]http://www.geophys.washington.edu/SEIS/PNSN/CATALOG_SEARCH/cat.search.html

Note: Events 17-19 on the archival tapes correspond to Dry SHIPS shots SP05b, SP32b, and SP11.

The correct range to station 2144 for events 11 and 13 is 60.436 km, and is given incorrectly in the tape header.

TABLE 6b. Teleseisms recorded September 19-22, 1999

Event Number	Event Window	Origin Time (UTC) Yr:JD:Hr:Min:Sec	Latitude	Longitude	Depth (km)	Mag.	Window start Yr:JD:Hr:Min	Window stop Yr:JD:Hr:Min
1	1	1999:261:21:28:33.1	51.207	157.556	60	6.2	99:261:21:30	99:261:22:30
2	2	1999:261:23:51:30.4	-19.713	169.205	103	5.9	99:262:00:00	99:262:01:00
3	3	1999:262:03:18:54.5	-3.624	150.875	431	5.9	99:262:03:25	99:262:04:25
4	4	1999:263:17:47:18.4	23.772	120.982	33	7.7	99:263:17:50	99:263:19:50
5		*1999:263:17:57:16.0	23.785	121.202	33	6.1		
6		*1999:263:18:03:44.2	23.570	121.299	33	6.3		
7		*1999:263:18:11:53.6	23.746	121.189	33	6.1		
8		*1999:263:18:16:18.5	23.756	121.246	33	6.2		
9		*1999:263:19:40:36.4	23.408	120.768	33	5.0		
10	5	1999:263:21:46:42.8	23.390	120.964	33	6.5	99:263:21:50	99:263:22:50
11		*1999:263:21:54:49.4	23.584	120.950	33	5.3		
12	6	1999:264:11:49:46.4	44.715	149.898	33	5.7	99:264:11:55	99:264:12:55
13	7	1999:264:17:38:36.8	23.810	121.320	14	5.2	99:264:17:51	99:264:18:01
14	8	1999:265:00:14:39.1	23.729	121.167	26	6.4	99:265:00:20	99:265:01:20
15		*1999:265:00:49:42.7	23.642	121.136	33	5.9		
16	9	1999:265:07:17:44.9	43.572	146.785	33	4.8	99:265:07:25	99:265:07:45
17	10	1999:265:22:27:13.1	38.393	-122.633	10	4.2	99:265:22:27	99:265:22:37

*multiple event in window

Table 7. SEGY trace header values used for Dry SHIPS SEGY Tapes

Bytes	Format	SEGY name	SHIPS header
9-12	integer	field file number (FFID)	shot sequence number (1-38)
13-16	integer	trace within field record	receiver station number
17-20	integer	source point number	shot station number
31-32	integer	vertical traces summed	instrument type: 1,2,3 - Reftek vertical, N-S, E-W 4 - Texan vertical 5 - PRS vertical 6 - SGR vertical 7 - OBS vertical 8 - OBS horizontal 1 9 - OBS horizontal 2 10 - OBS hydrophone
37-40	integer	offset	source-receiver distance (m) (negative = west of shot)
41-44	integer	receiver elevation	receiver elevation (m)
45-48	integer	source elevation	elevation at top of shot hole (m)
49-52	integer	shot depth	depth of charge below surface (m)
65-68	integer	water depth at receiver	water depth at receiver (OBS only)
73-76	integer	source – x	x coordinate at source (m, UTM)
77-80	integer	source – y	y coordinate at source (m, UTM)
81-84	integer	receiver – x	x coordinate at receiver (m, UTM)
85-88	integer	receiver – y	y coordinate at receiver (m, UTM)
103-104	int*2	total static correction	PRS: clock drift correction (msec) Reftek, Texan: 2000 msec time shift
105-106	int*2	lag time A to time break	PRS drift correction
115-116	int*2	samples per trace	samples per trace
117-118	int*2	sample rate (microsec)	sample rate (microsec)
157-158	int*2	year	year
159-160	int*2	day	day
161-162	int*2	hour	hour at start of trace
163-164	int*2	minute	minute at start of trace
165-166	int*2	second	second at start of trace
167-168	int*2	time basis	time basis (2=GMT)
173-174	int*2	Instrument number	See note below
181-184	Float	Shot latitude	Decimal degrees
185-188	float	Shot Longitude	Decimal degrees
189-192	float	Receiver latitude	Decimal degrees
193-196	float	Receiver longitude	Decimal degrees

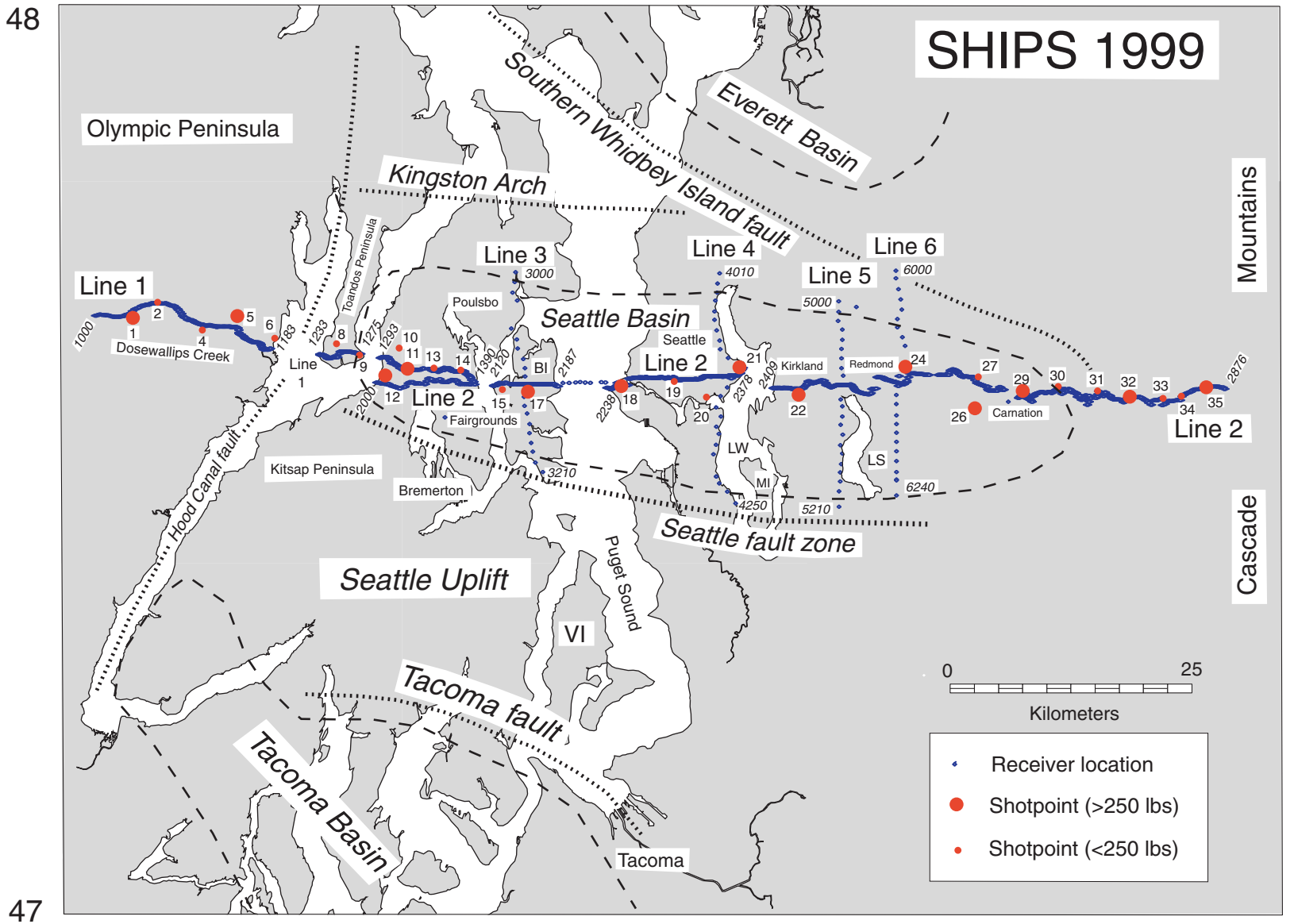

Figure 1. Map showing locations of Dry SHIP seismic shots and recorders in the Puget Lowland. Abbreviations: BI-Bainbridge Island, LS-Lake Sammamish, LW-Lake Washington, MI-Mercer Island, VI-Vashion Island.

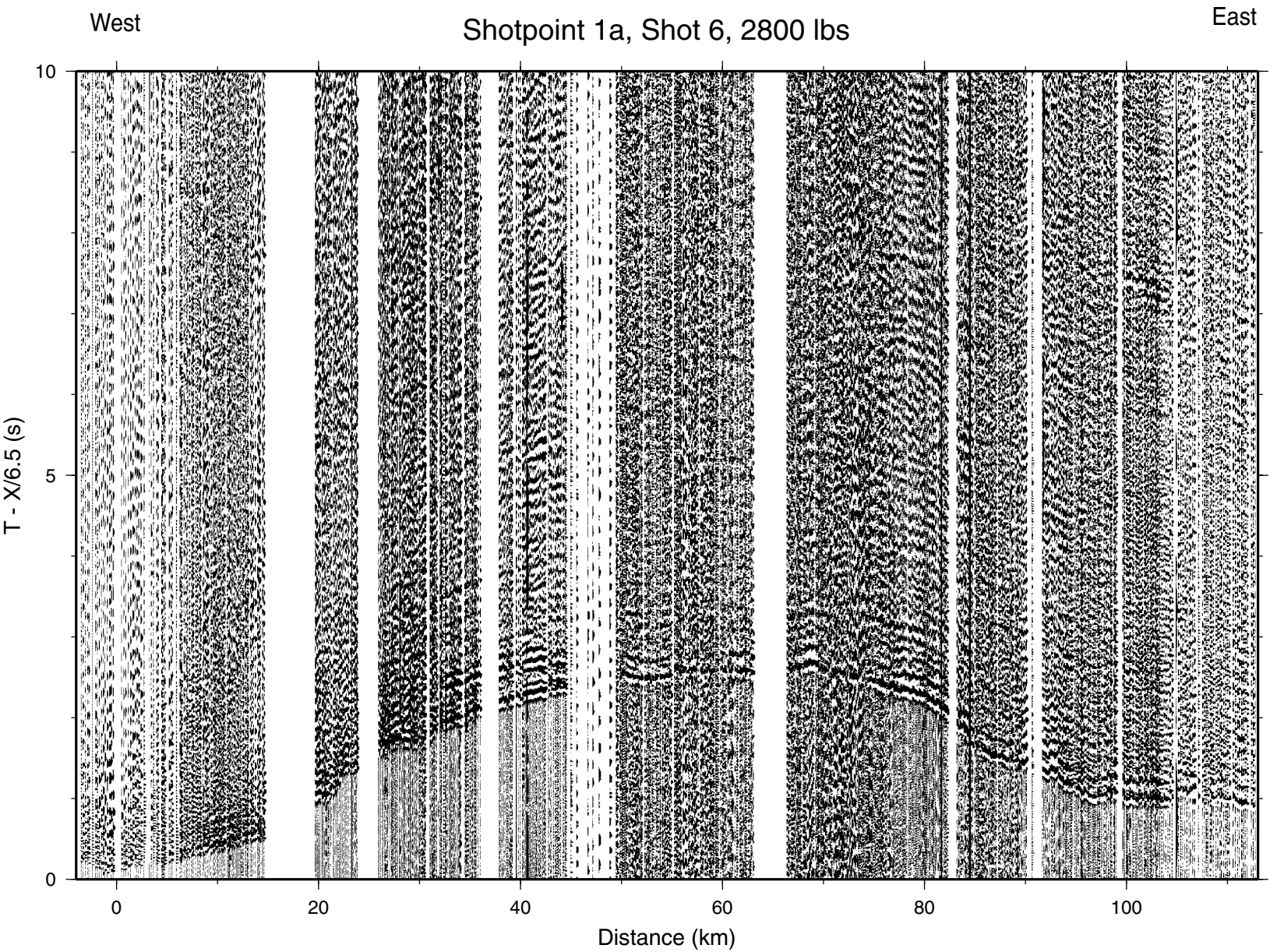

Figure 2. Reduced record section for Shotpoint 1a, vertical component only, for Lines 1 and 2.

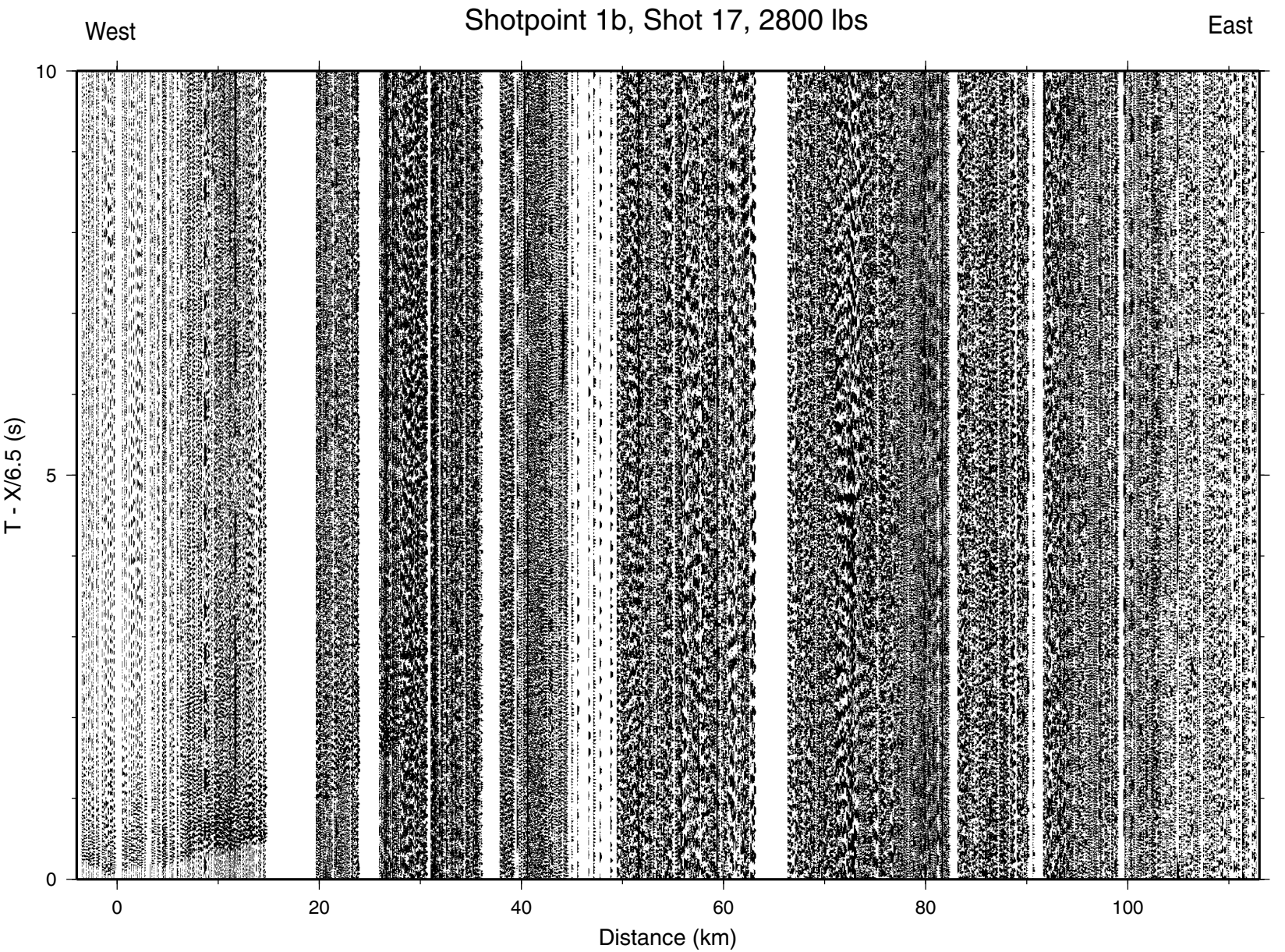

Figure 3. Reduced record section for Shotpoint 1b, vertical component only, for Lines 1 and 2.

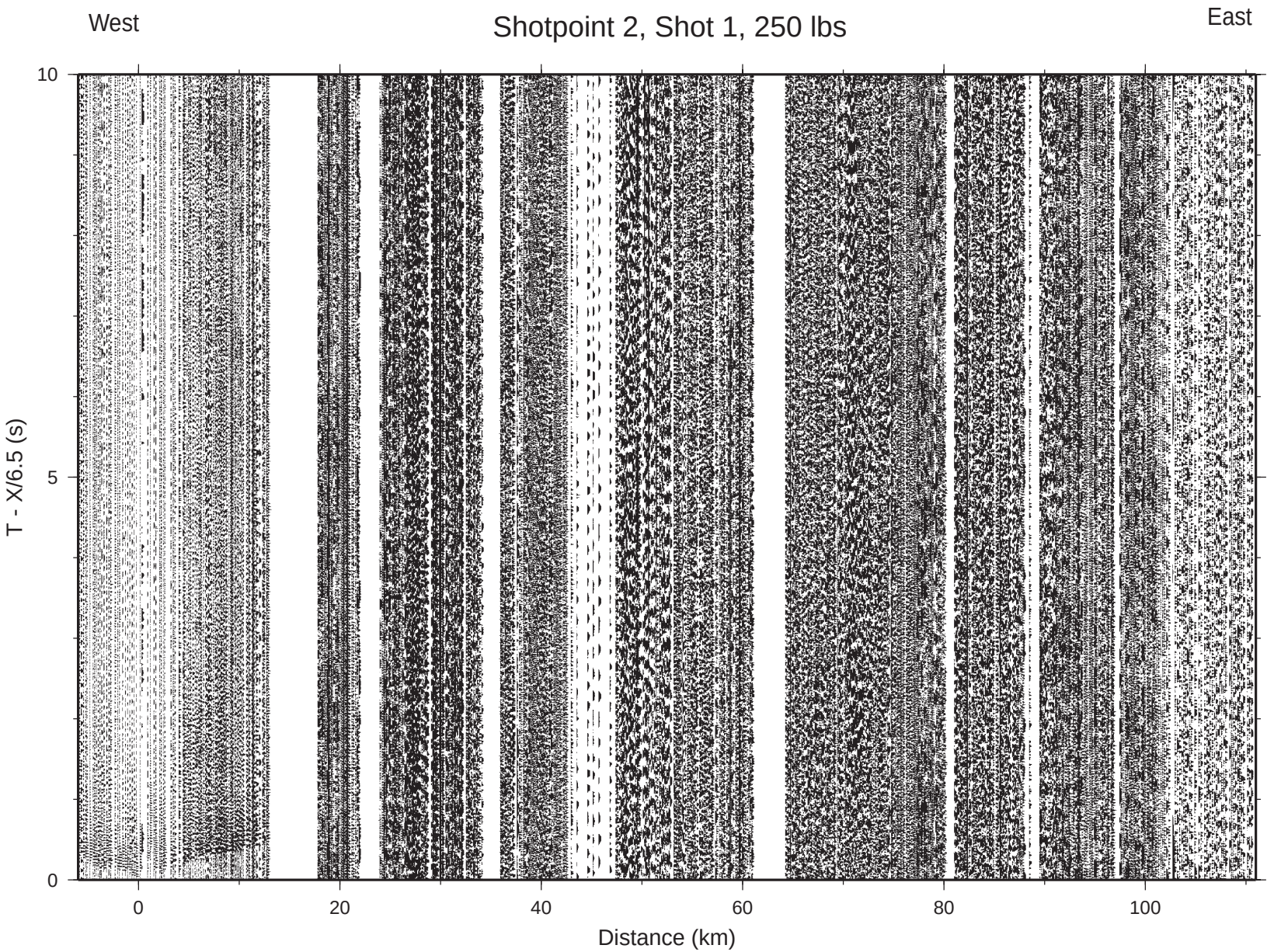

Figure 4. Reduced record section for Shotpoint 2, vertical component only, for Lines 1 and 2.

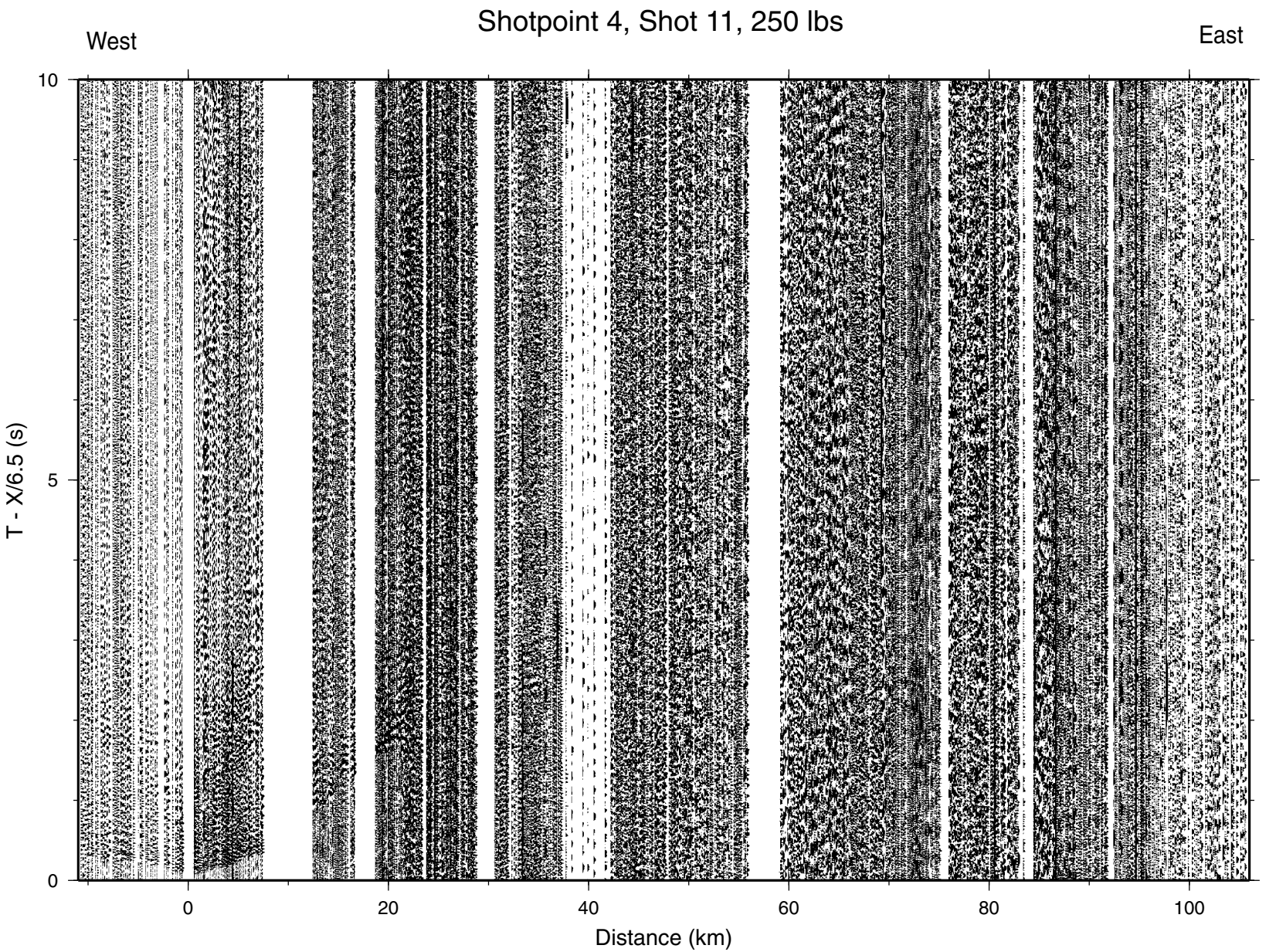

Figure 5. Reduced record section for Shotpoint 4, vertical component only, for Lines 1 and 2.

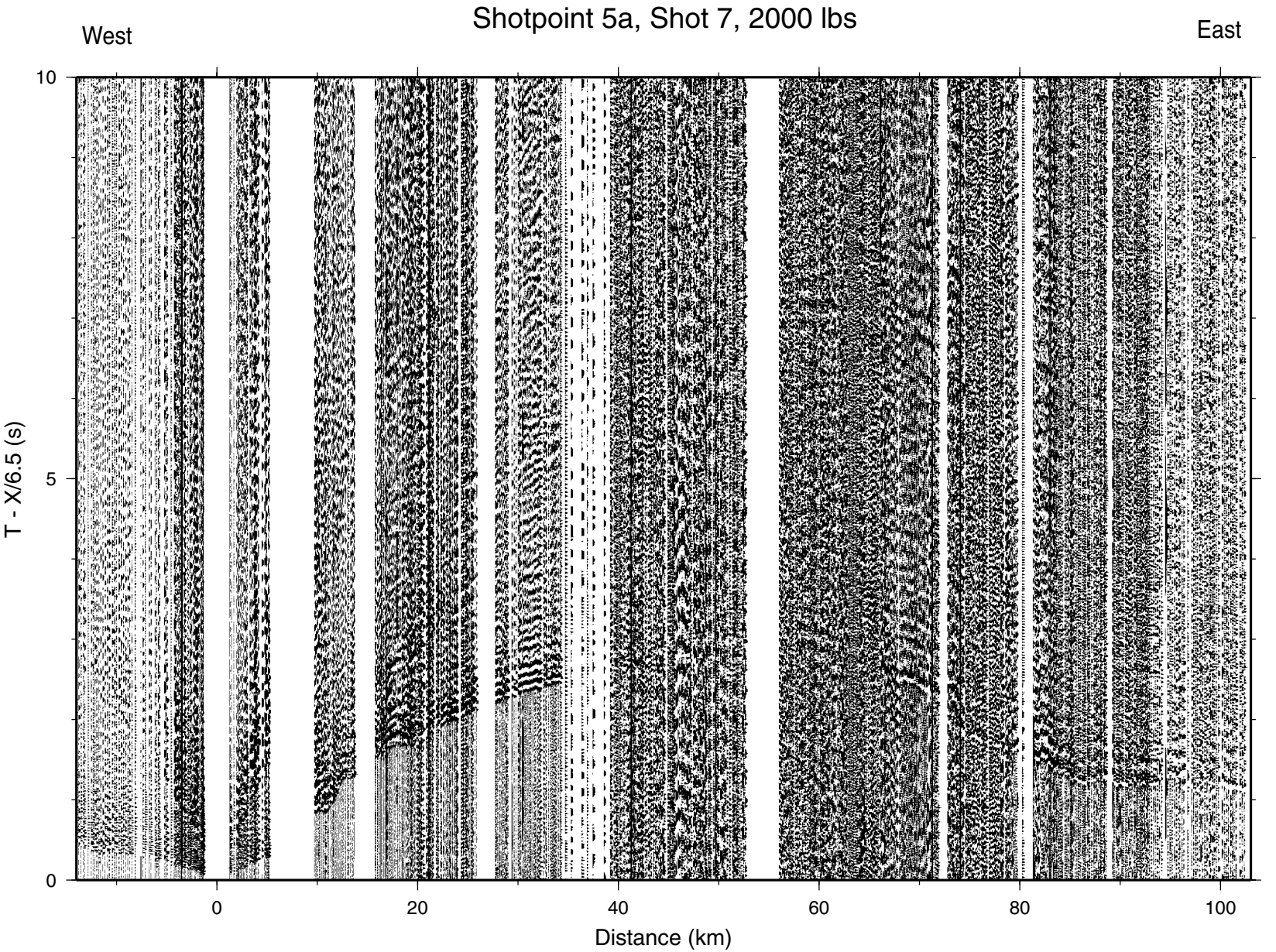

Figure 6. Reduced record section for Shotpoint 5a, vertical component only, for Lines 1 and 2.

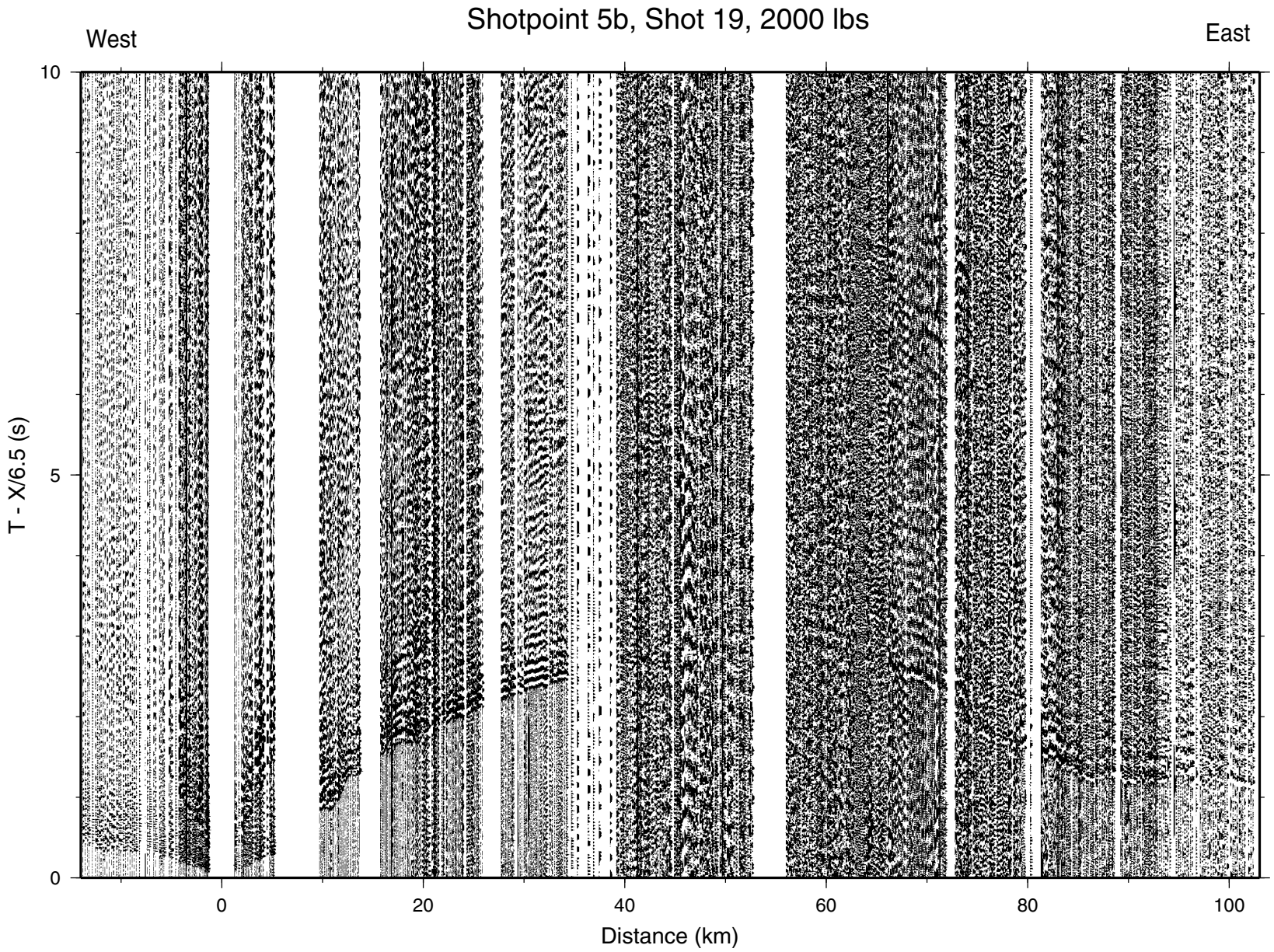

Figure 7. Reduced record section for Shotpoint 5b, vertical component only, for Lines 1 and 2.

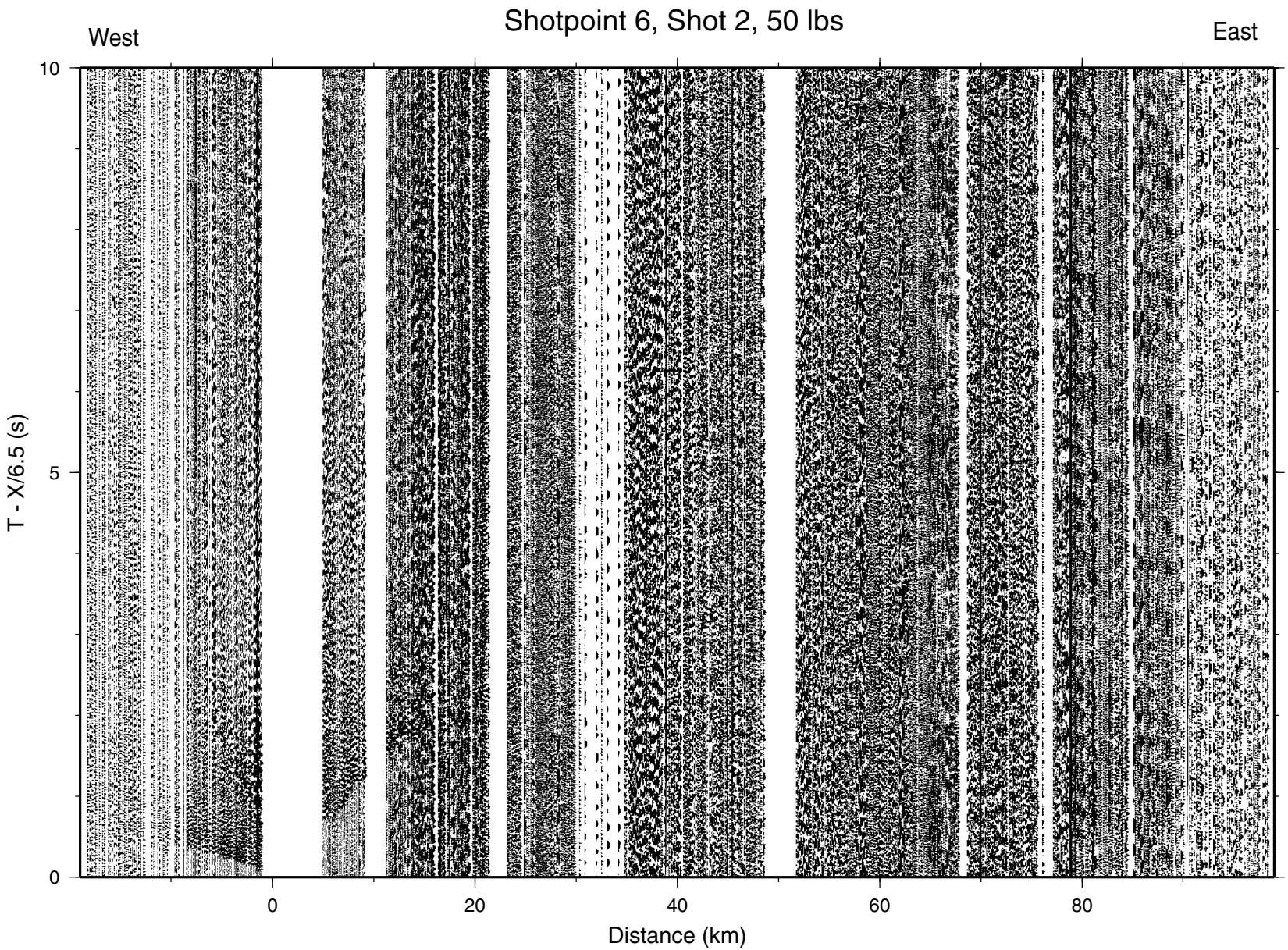

Figure 8. Reduced record section for Shotpoint 6, vertical component only, for Lines 1 and 2.

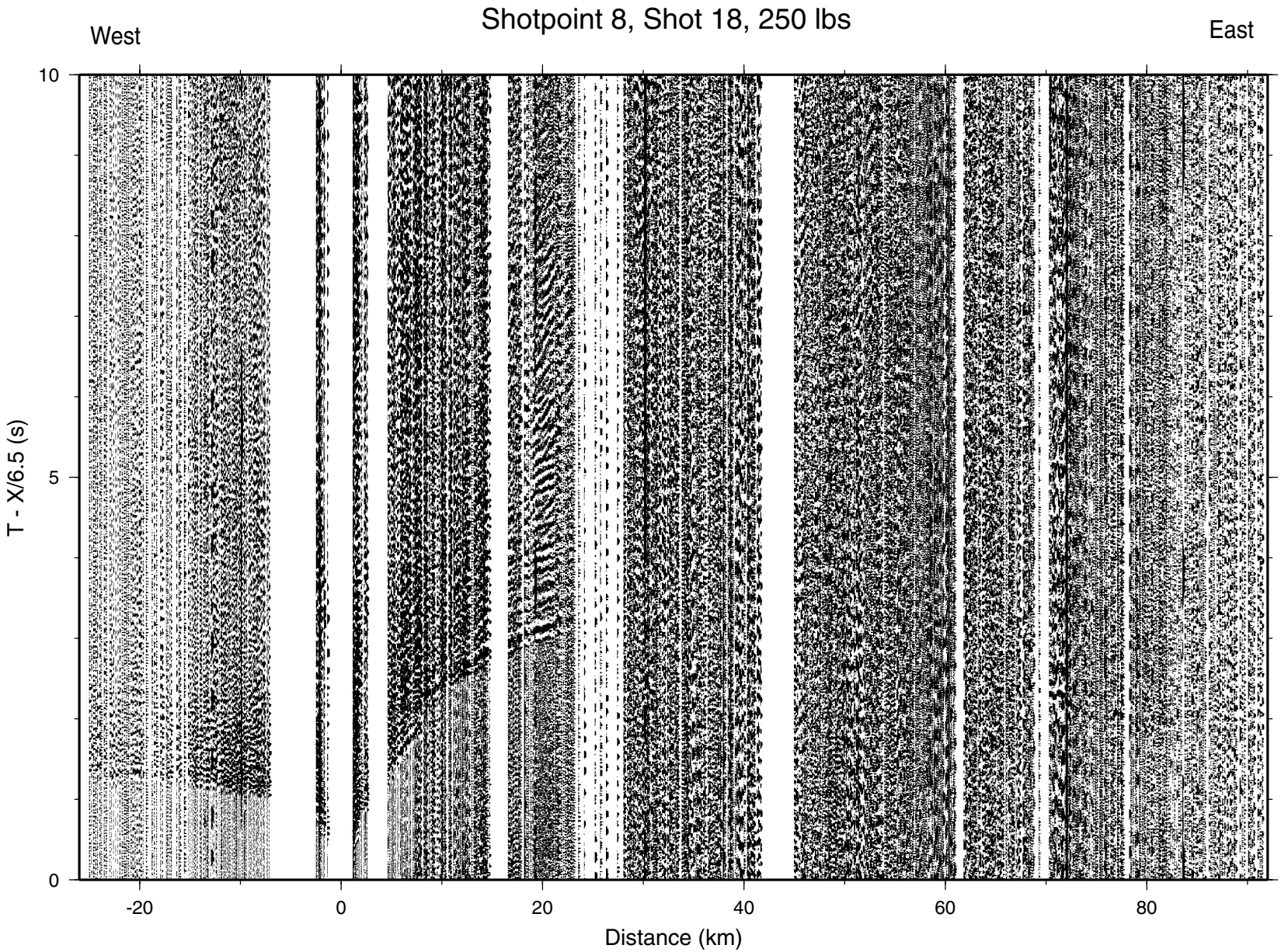

Figure 9. Reduced record section for Shotpoint 8, vertical component only, for Lines 1 and 2.

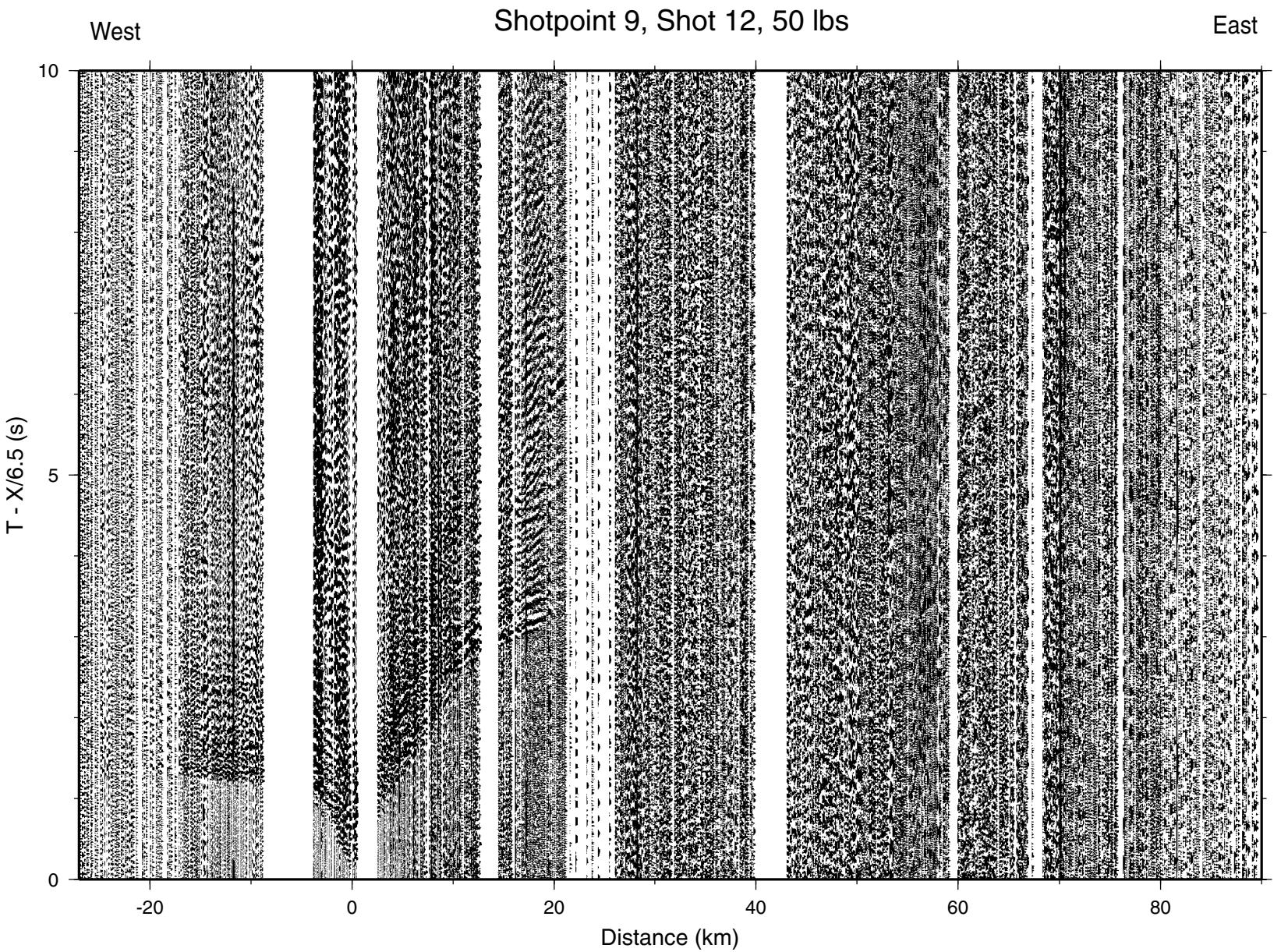

Figure 10. Reduced record section for Shotpoint 9, vertical component only, for Lines 1 and 2.

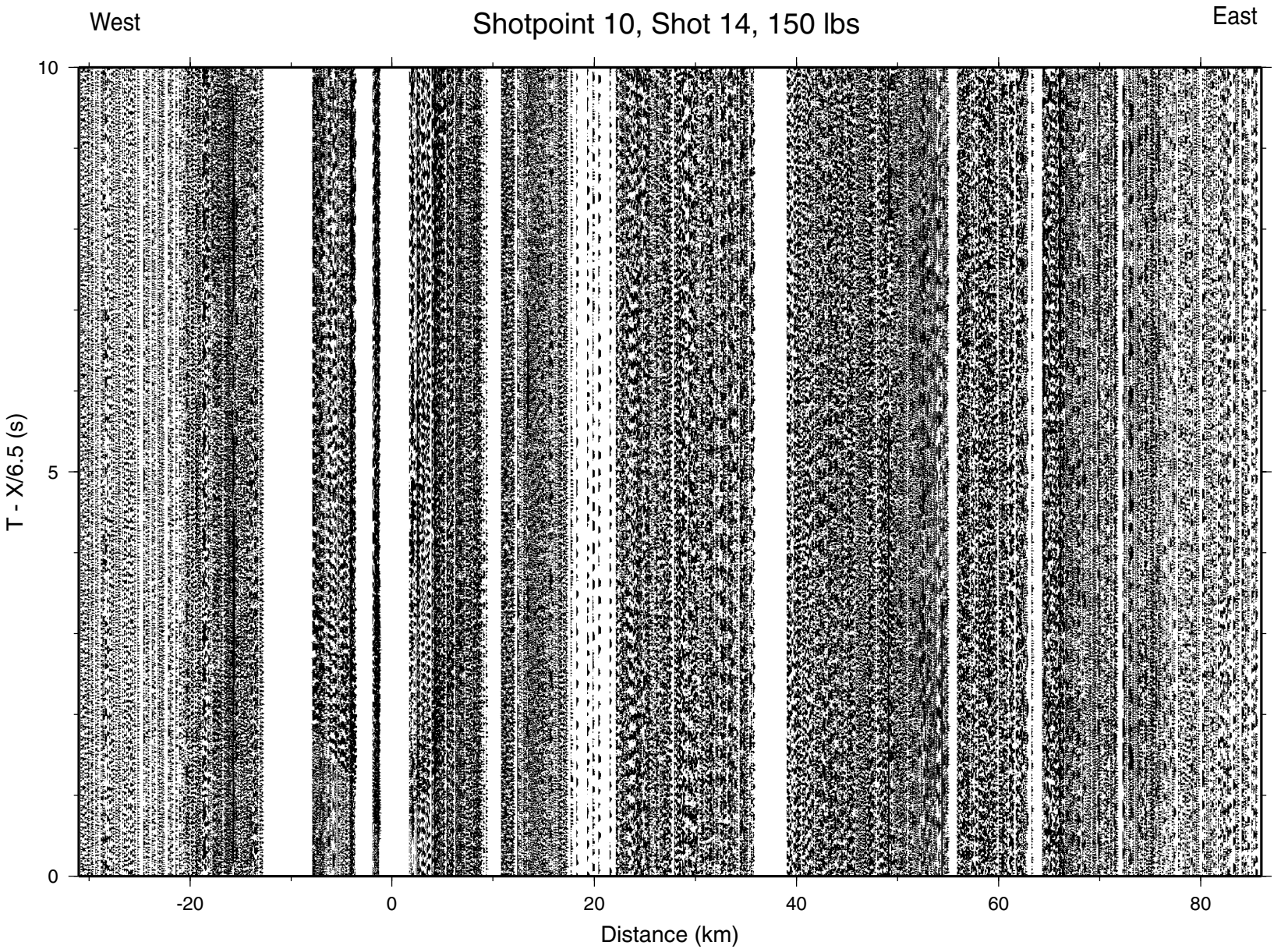

Figure 11. Reduced record section for Shotpoint 10, vertical component only, for Lines 1 and 2.

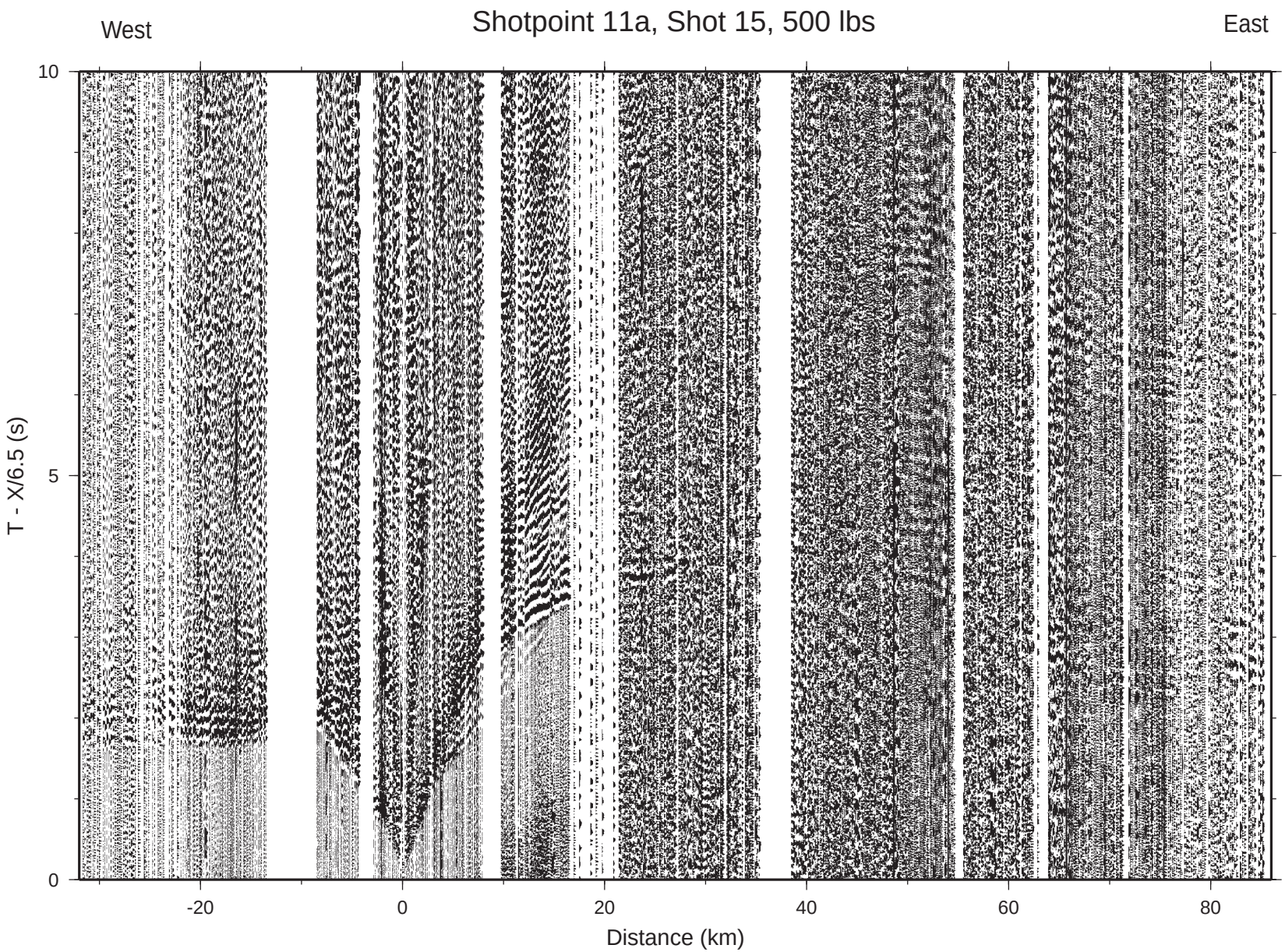

Figure 12. Reduced record section for Shotpoint 11a, vertical component only, for Lines 1 and 2.

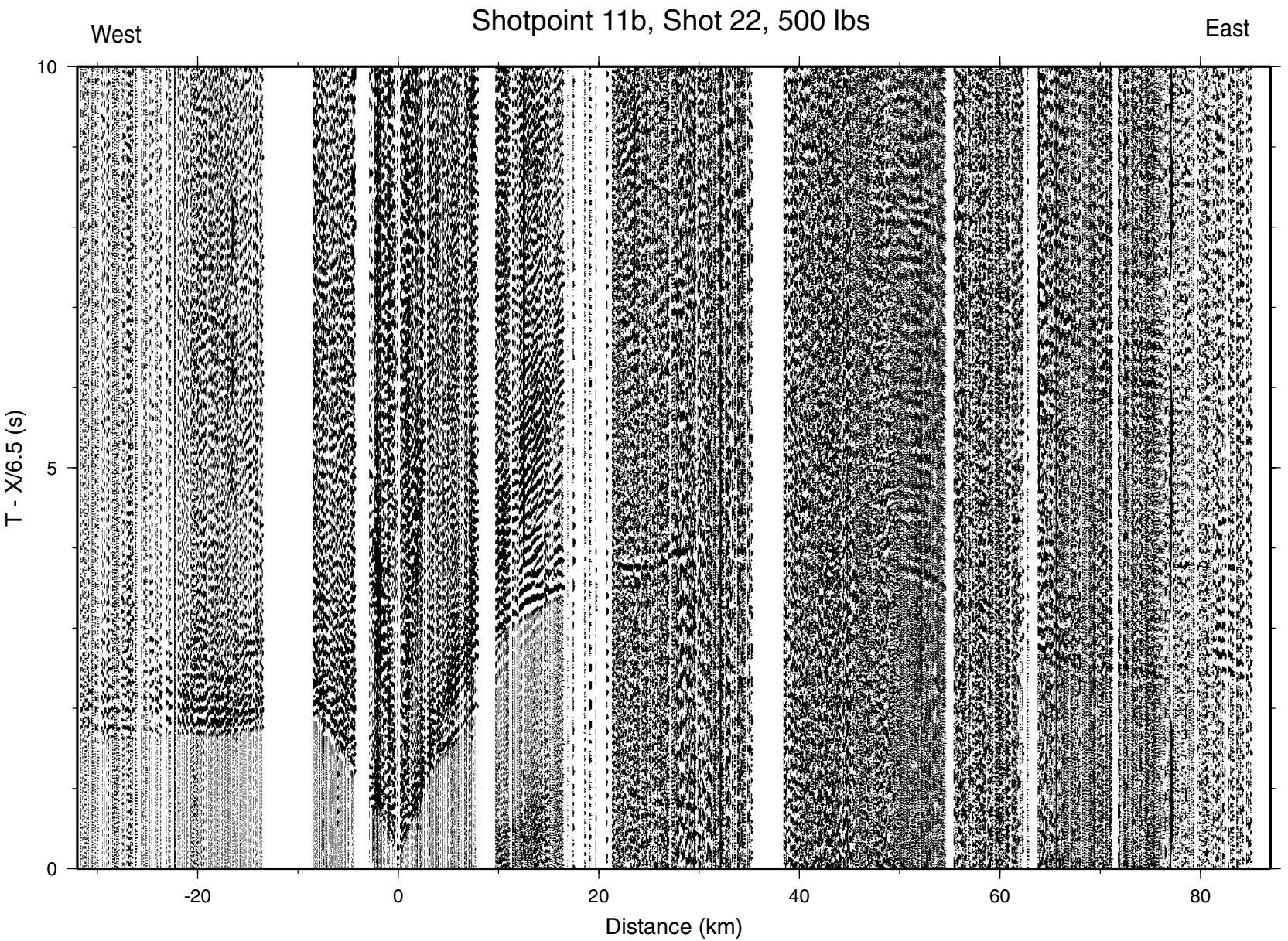

Figure 13. Reduced record section for Shotpoint 11b, vertical component only, for Lines 1 and 2.

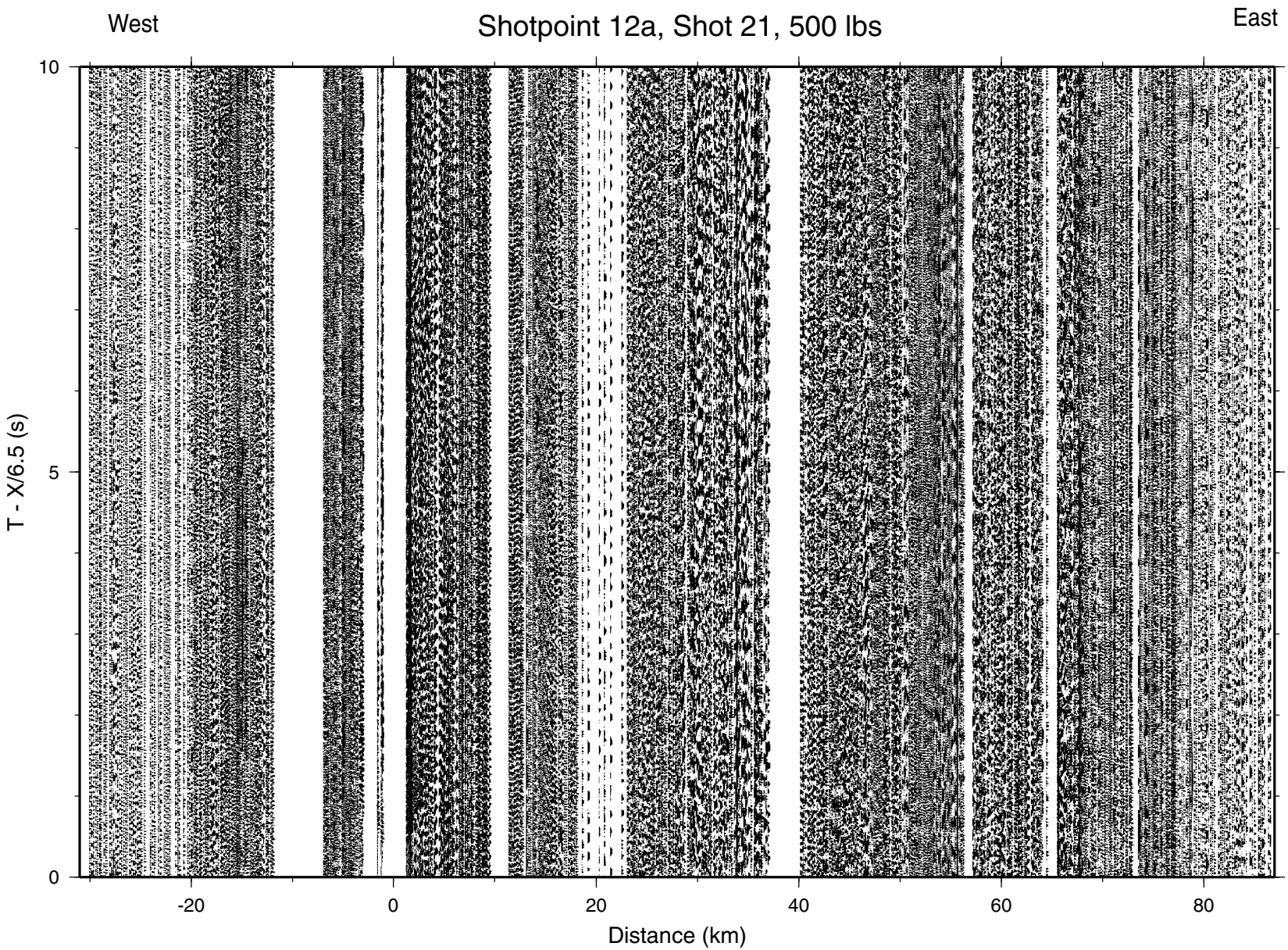

Figure 14. Reduced record section for Shotpoint 12a, vertical component only, for Lines 1 and 2.

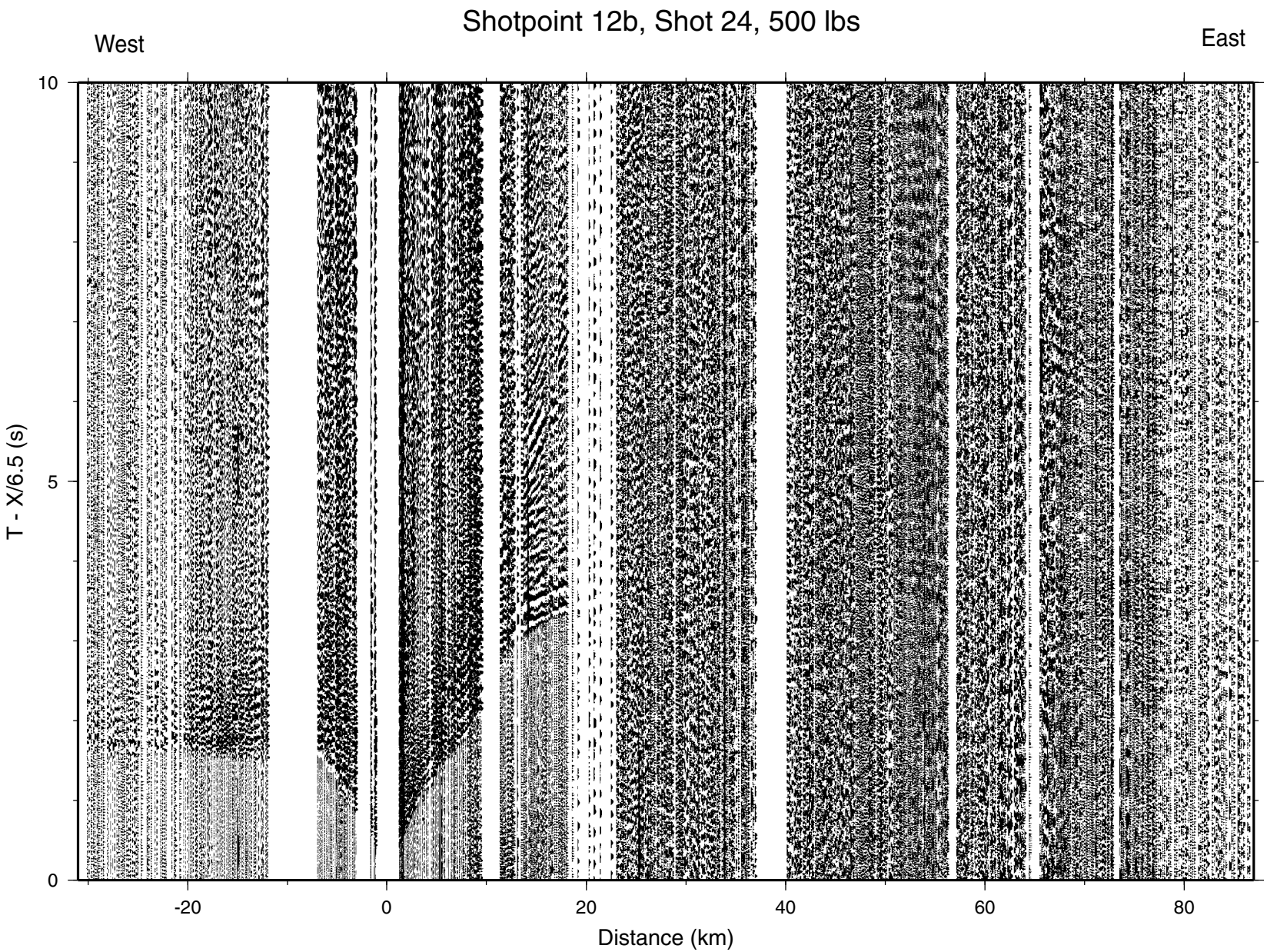

Figure 15. Reduced record section for Shotpoint 12b, vertical component only, for Lines 1 and 2.

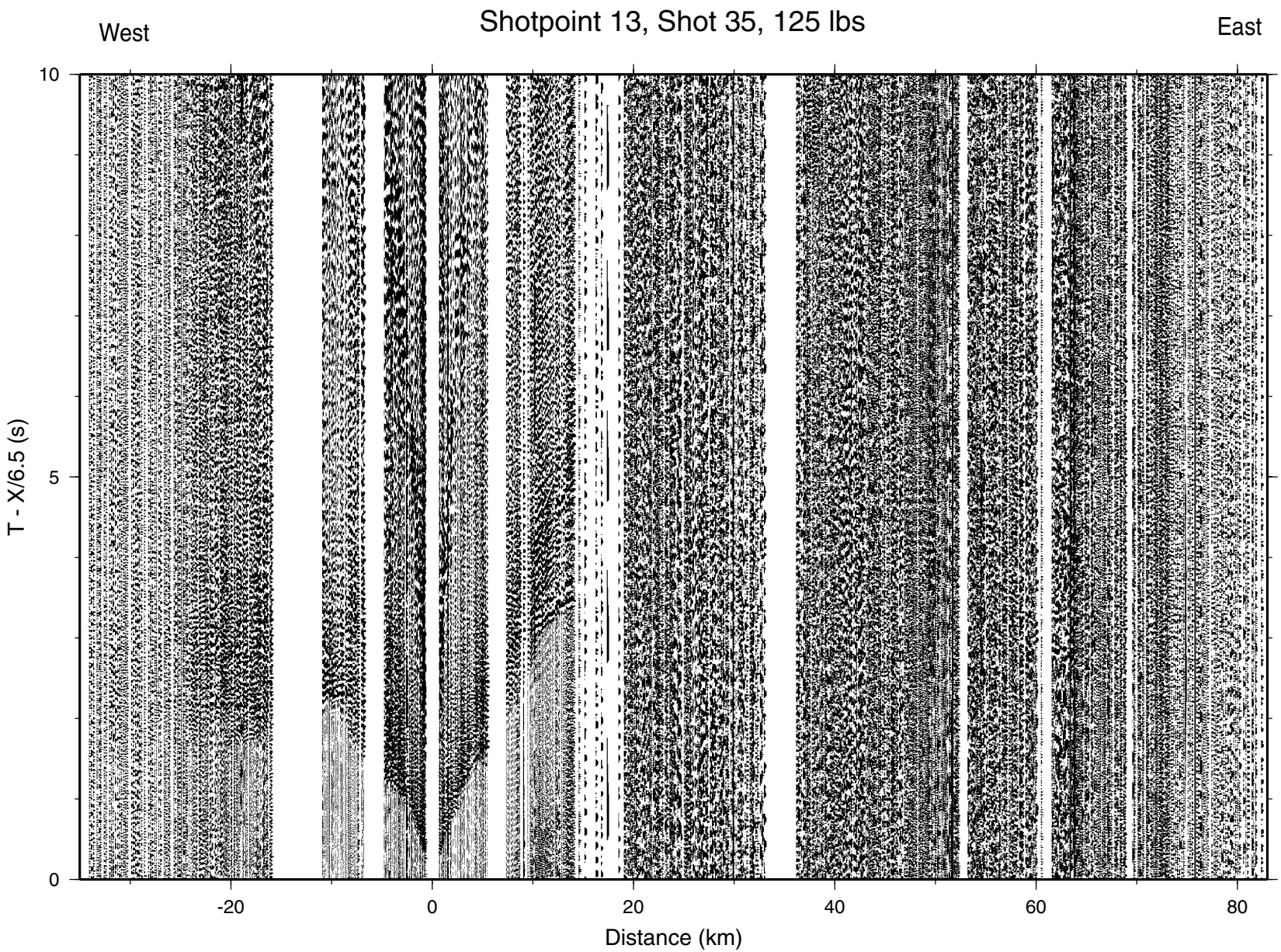

Figure 16. Reduced record section for Shotpoint 13, vertical component only, for Lines 1 and 2.

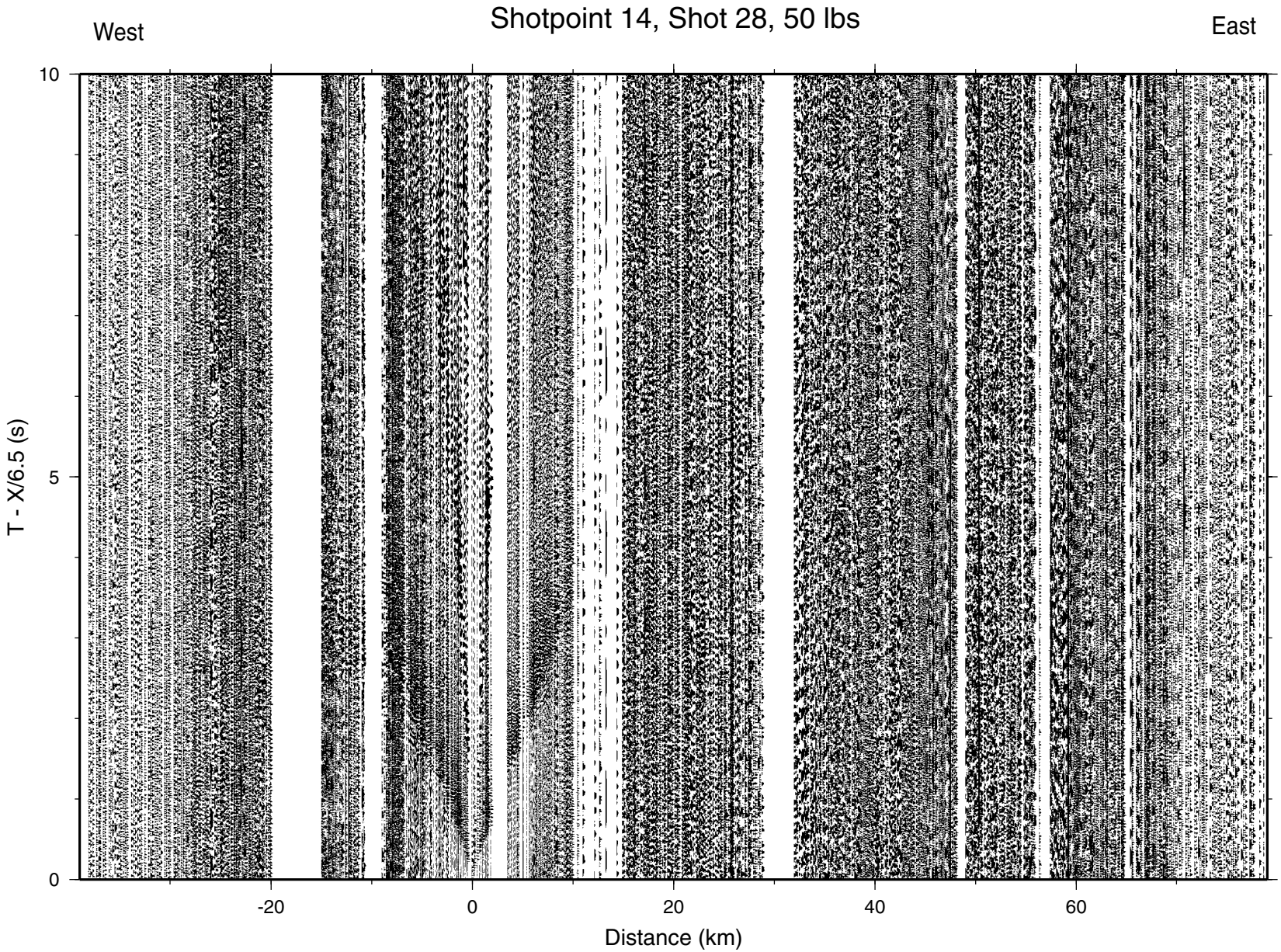

Figure 17. Reduced record section for Shotpoint 14, vertical component only, for Lines 1 and 2.

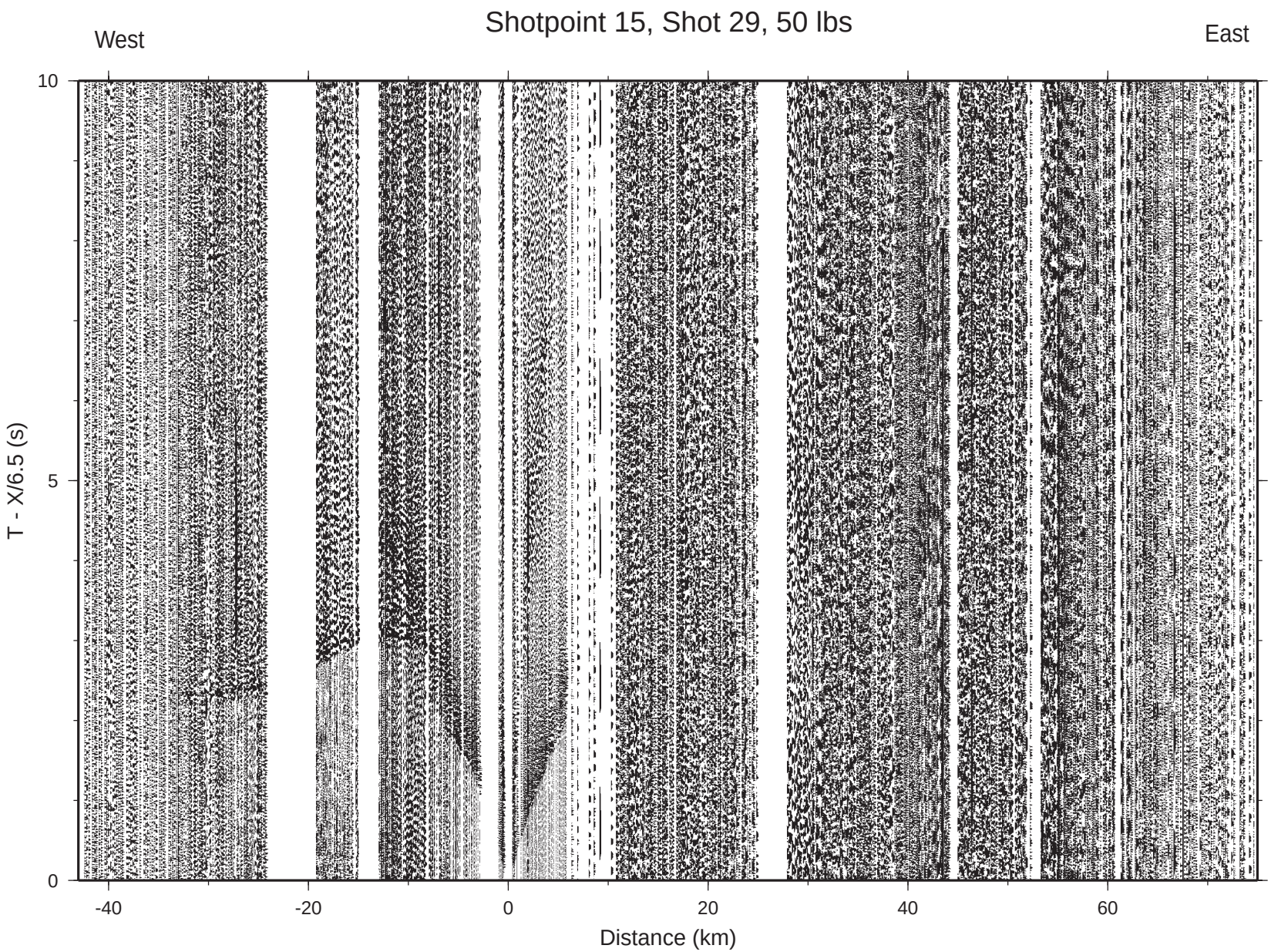

Figure 18. Reduced record section for Shotpoint 15, vertical component only, for Lines 1 and 2.

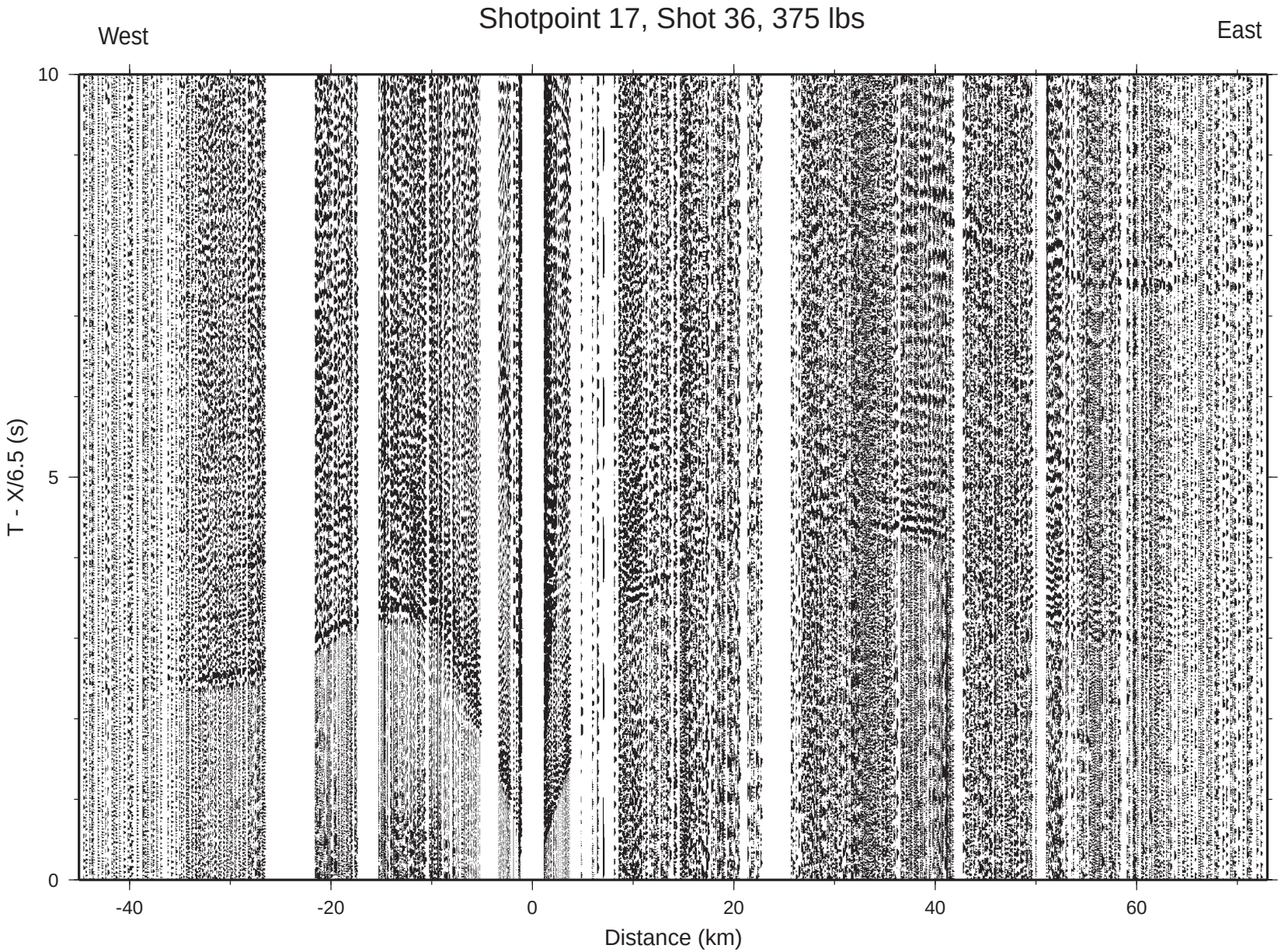

Figure 19. Reduced record section for Shotpoint 17, vertical component only, for Lines 1 and 2.

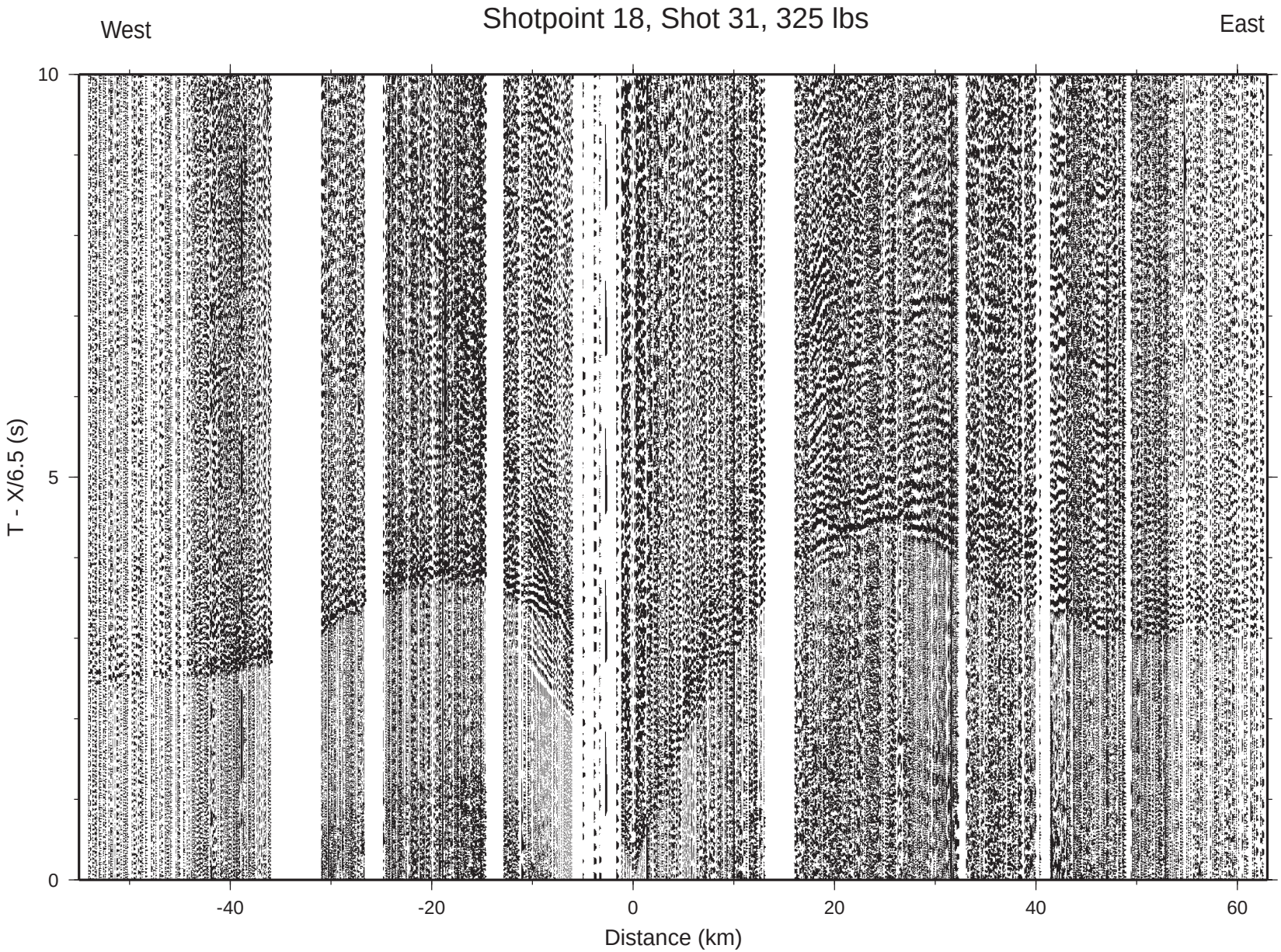

Figure 20. Reduced record section for Shotpoint 18, vertical component only, for Lines 1 and 2.

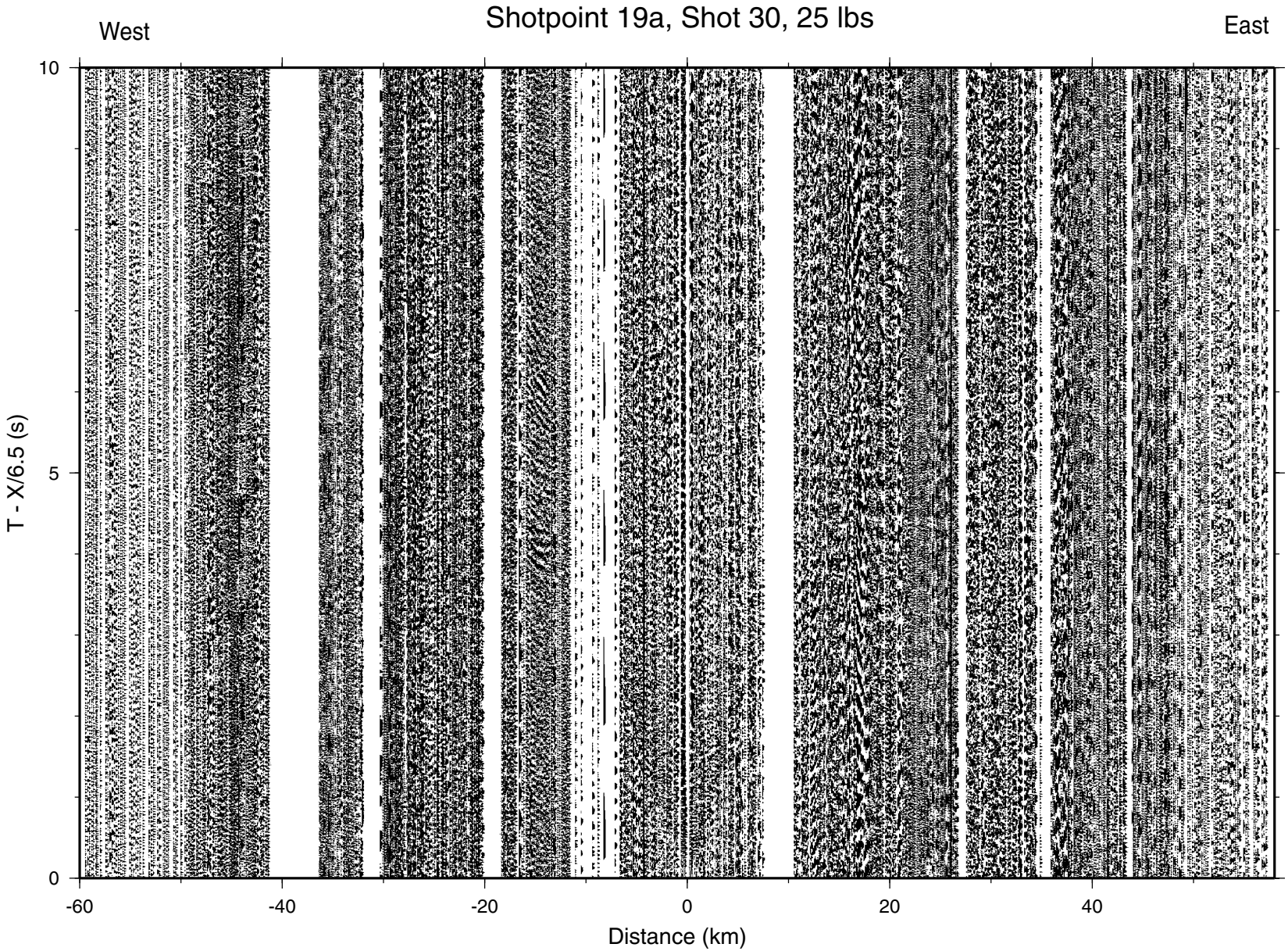

Figure 21. Reduced record section for Shotpoint 19a, vertical component only, for Lines 1 and 2.

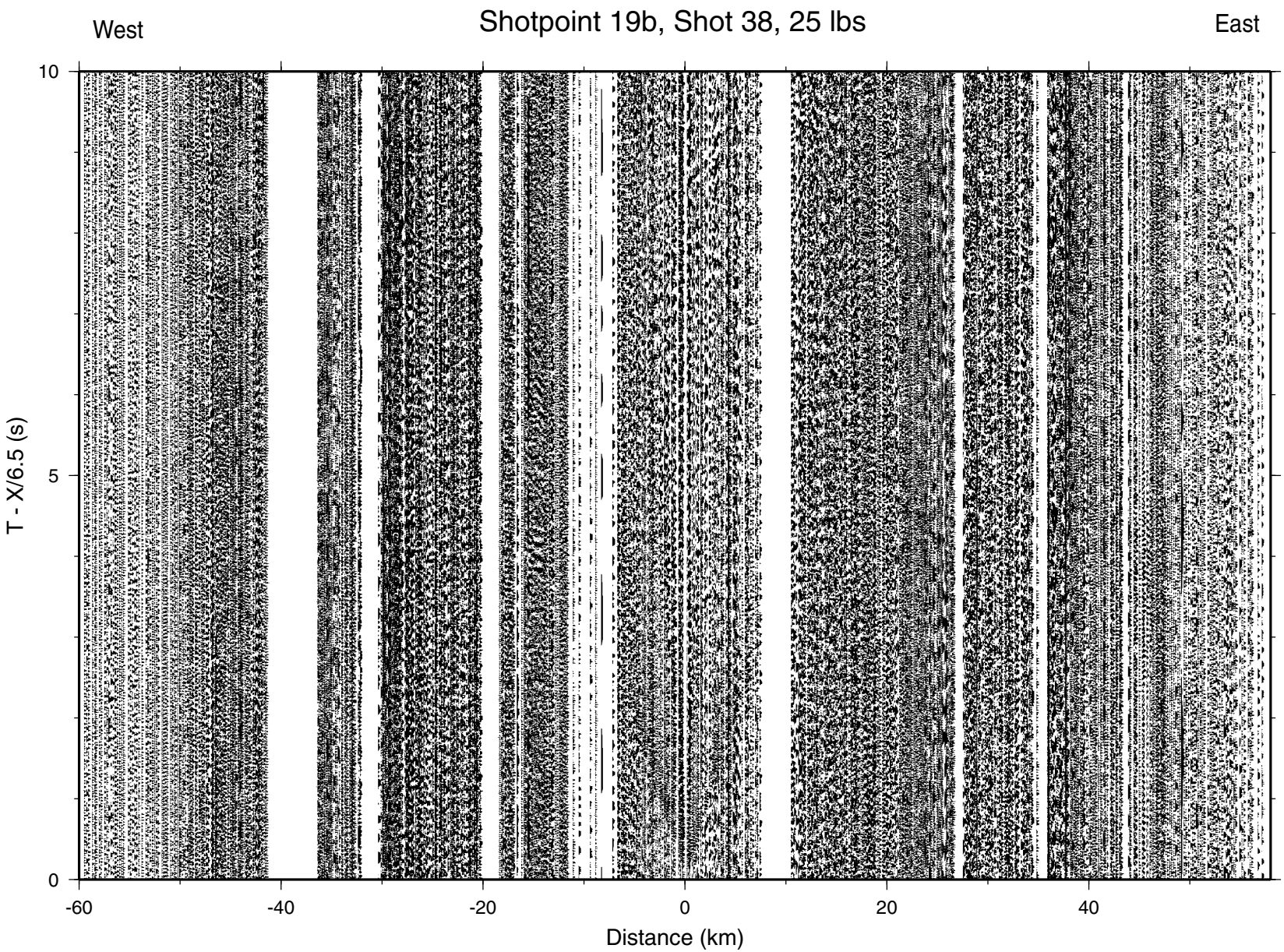

Figure 22. Reduced record section for Shotpoint 19b, vertical component only, for Lines 1 and 2.

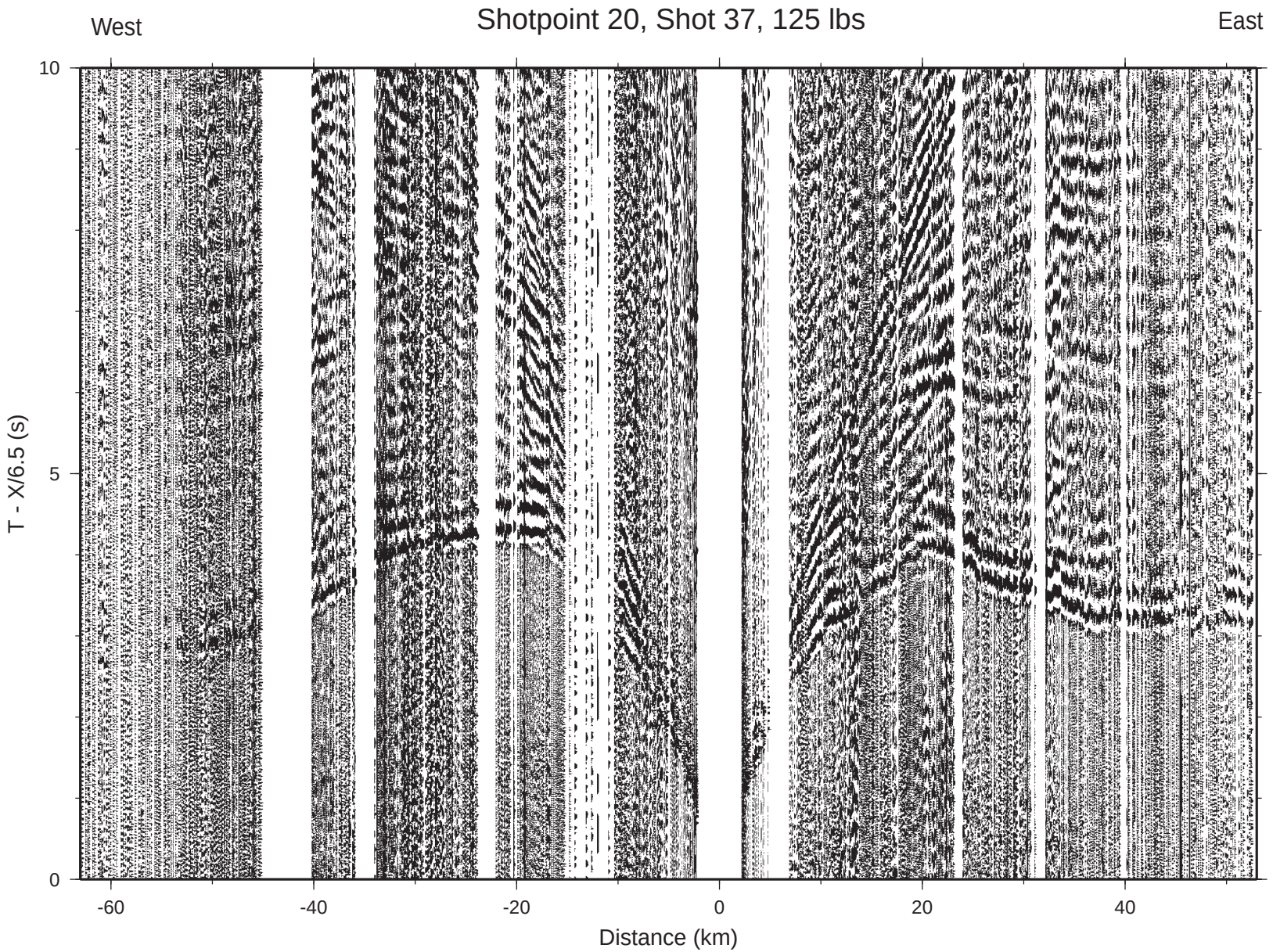

Figure 23. Reduced record section for Shotpoint 20, vertical component only, for Lines 1 and 2.

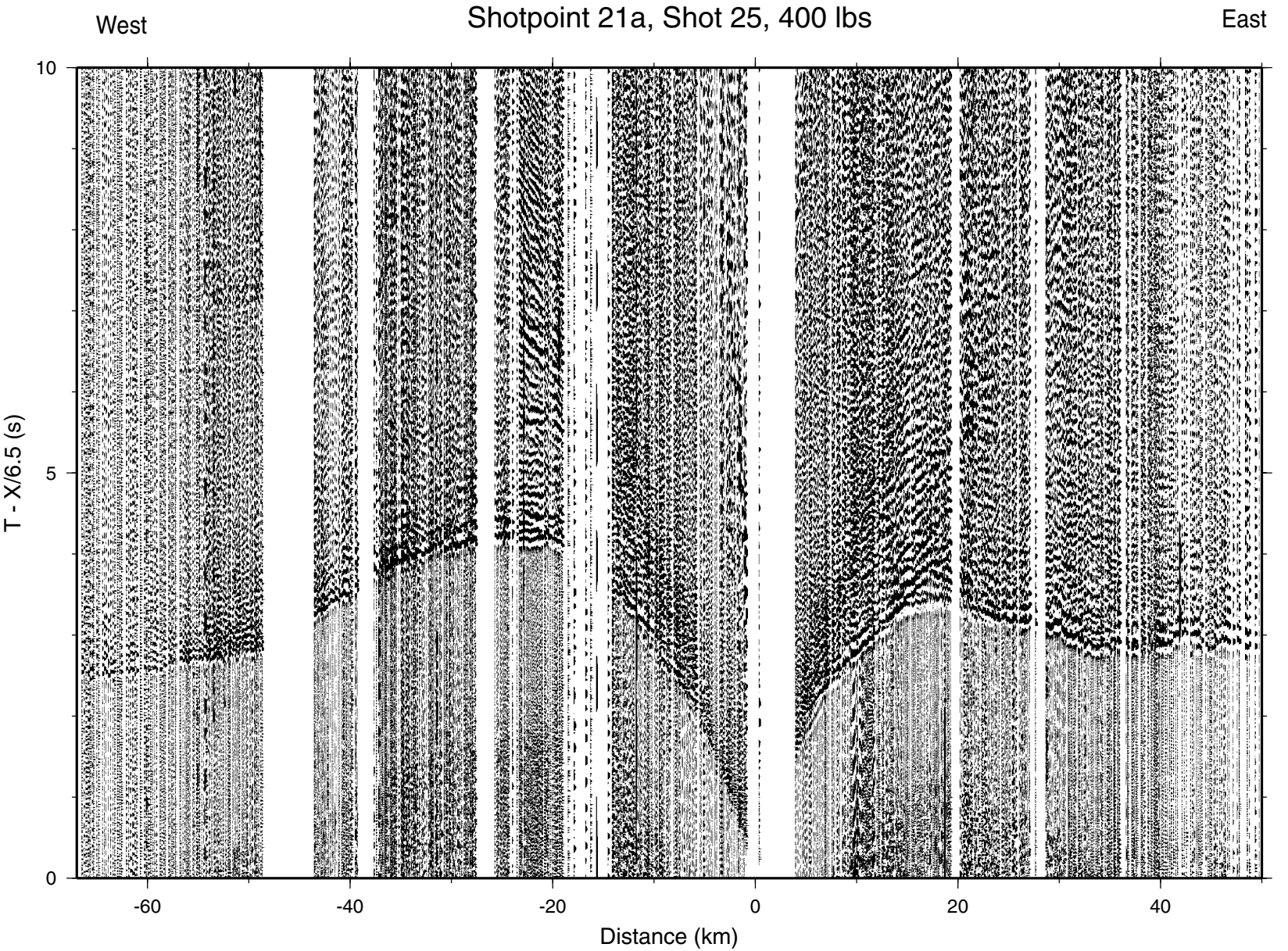

Figure 24. Reduced record section for Shotpoint 21a, vertical component only, for Lines 1 and 2.

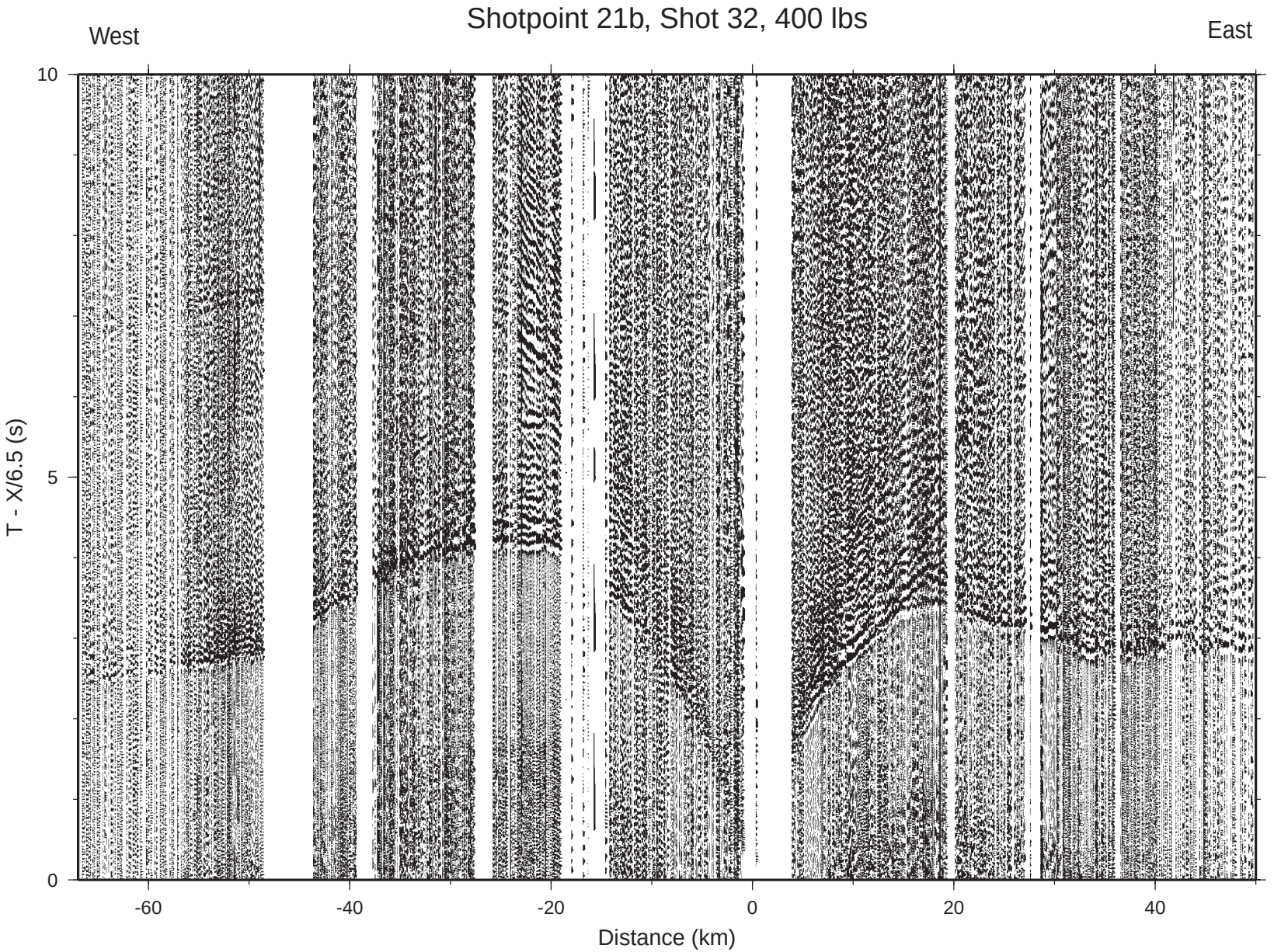

Figure 25. Reduced record section for Shotpoint 21b, vertical component only, for Lines 1 and 2.

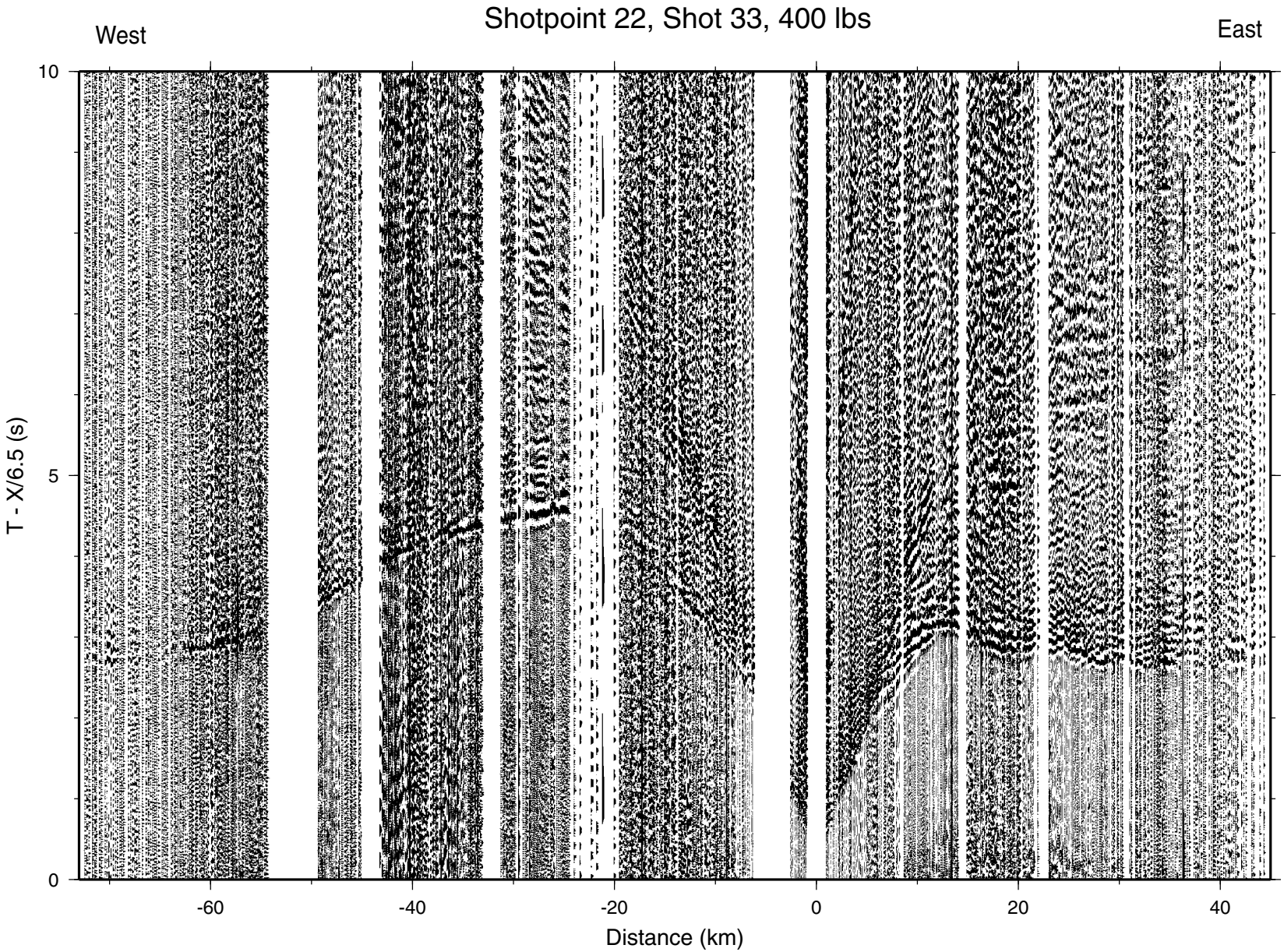

Figure 26. Reduced record section for Shotpoint 22, vertical component only, for Lines 1 and 2.

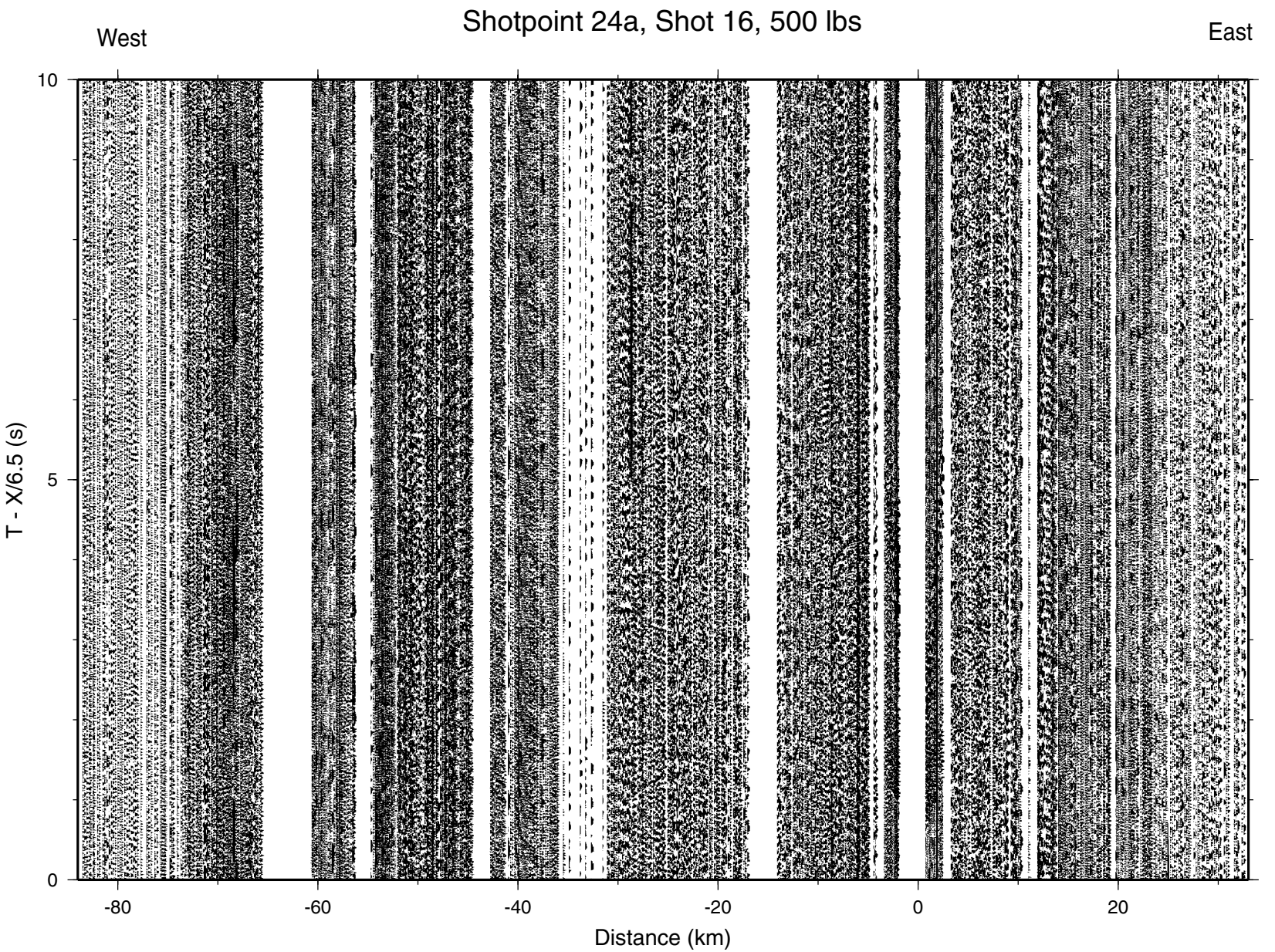

Figure 27. Reduced record section for Shotpoint 24a, vertical component only, for Lines 1 and 2.

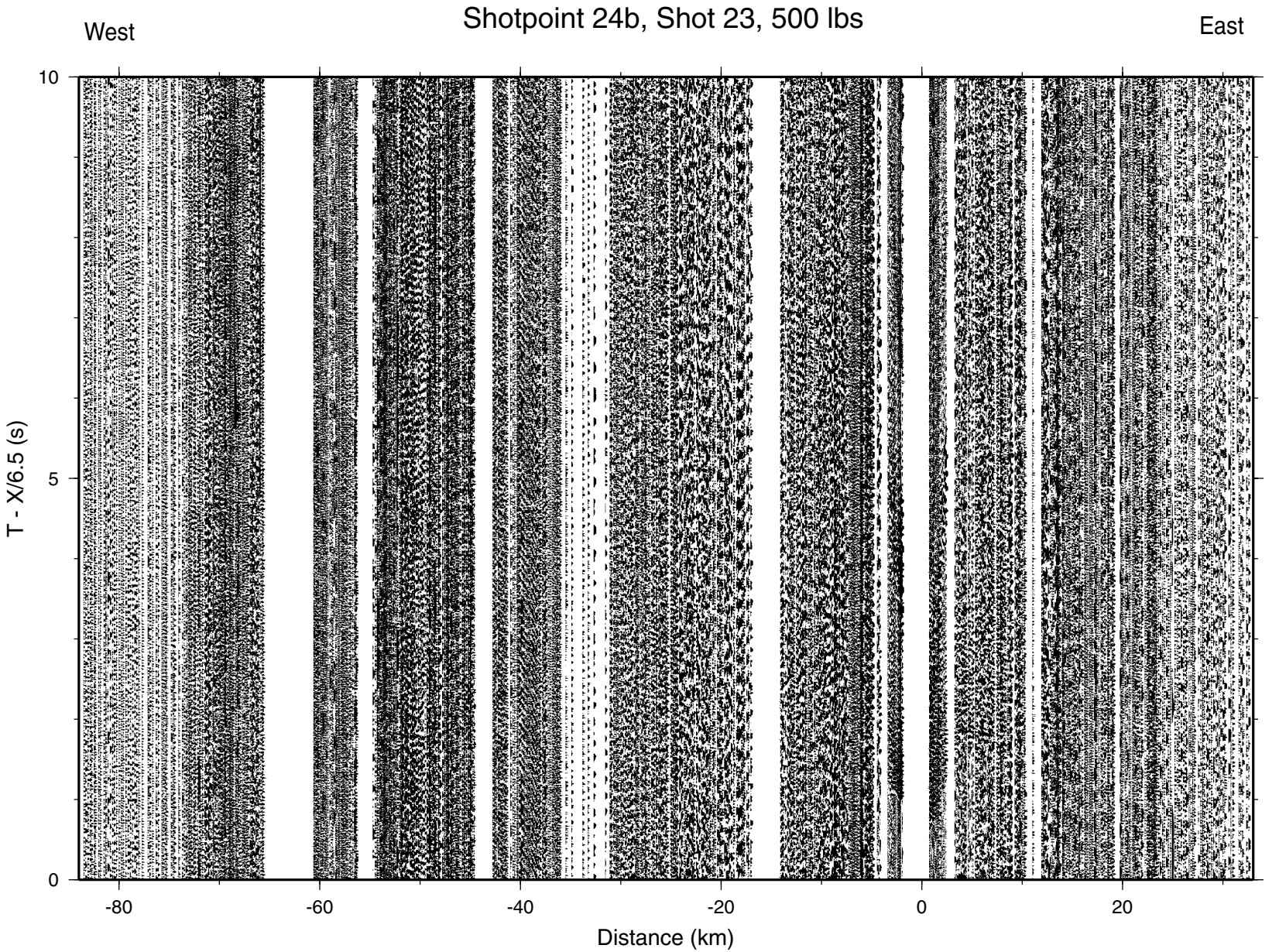

Figure 28. Reduced record section for Shotpoint 24b, vertical component only, for Lines 1 and 2.

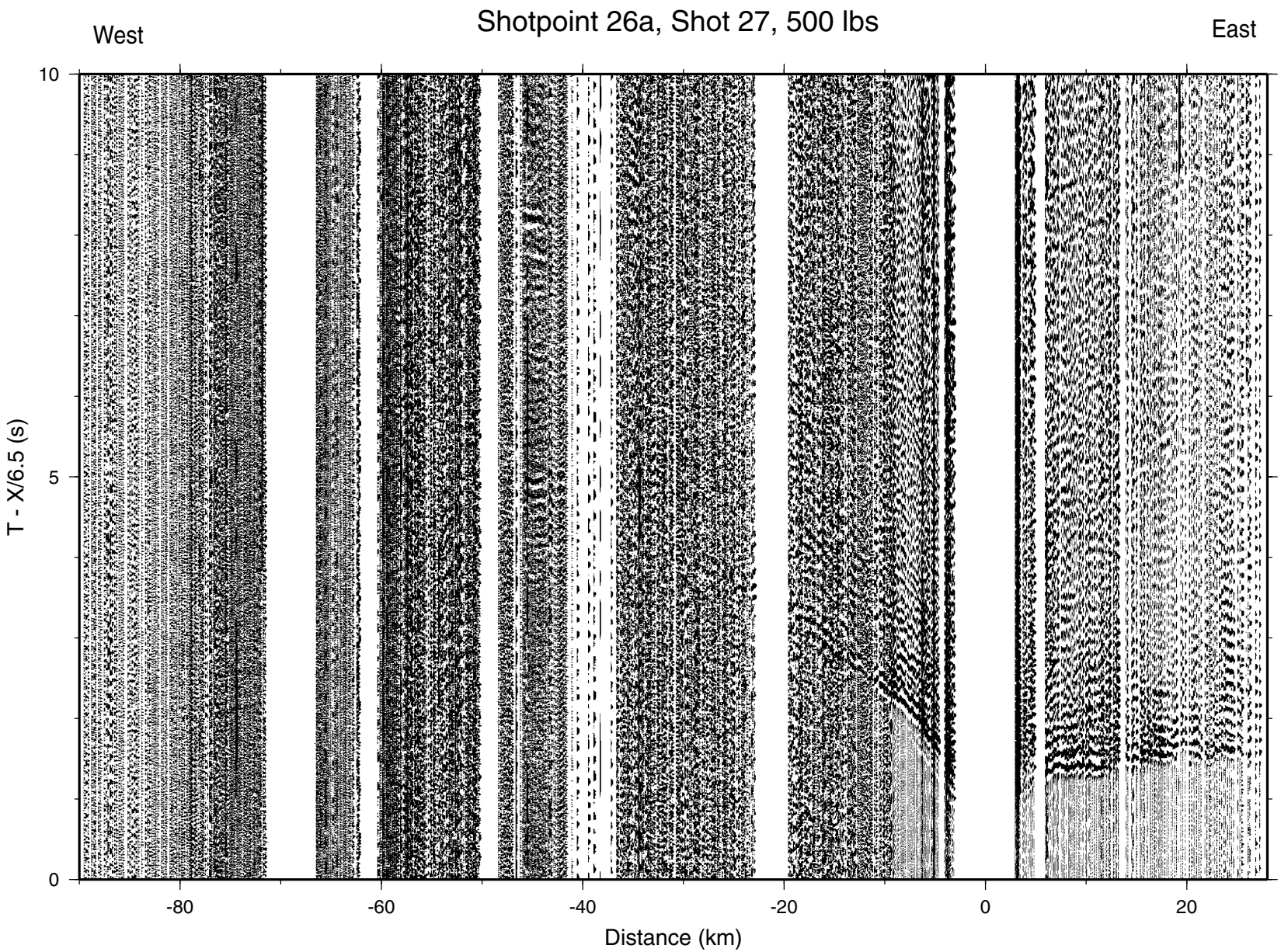

Figure 29. Reduced record section for Shotpoint 26a, vertical component only, for Lines 1 and 2.

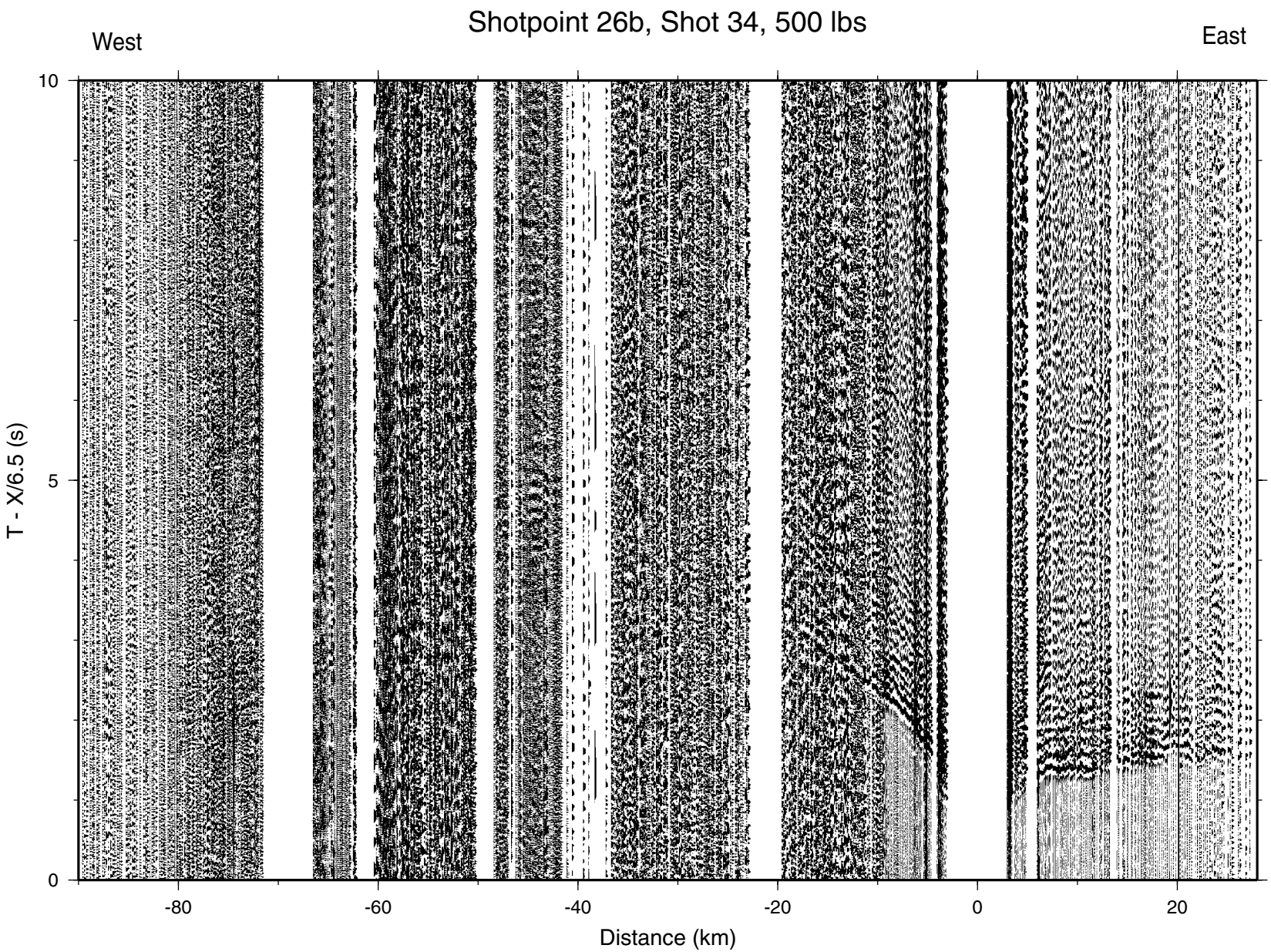

Figure 30. Reduced record section for Shotpoint 26b, vertical component only, for Lines 1 and 2.

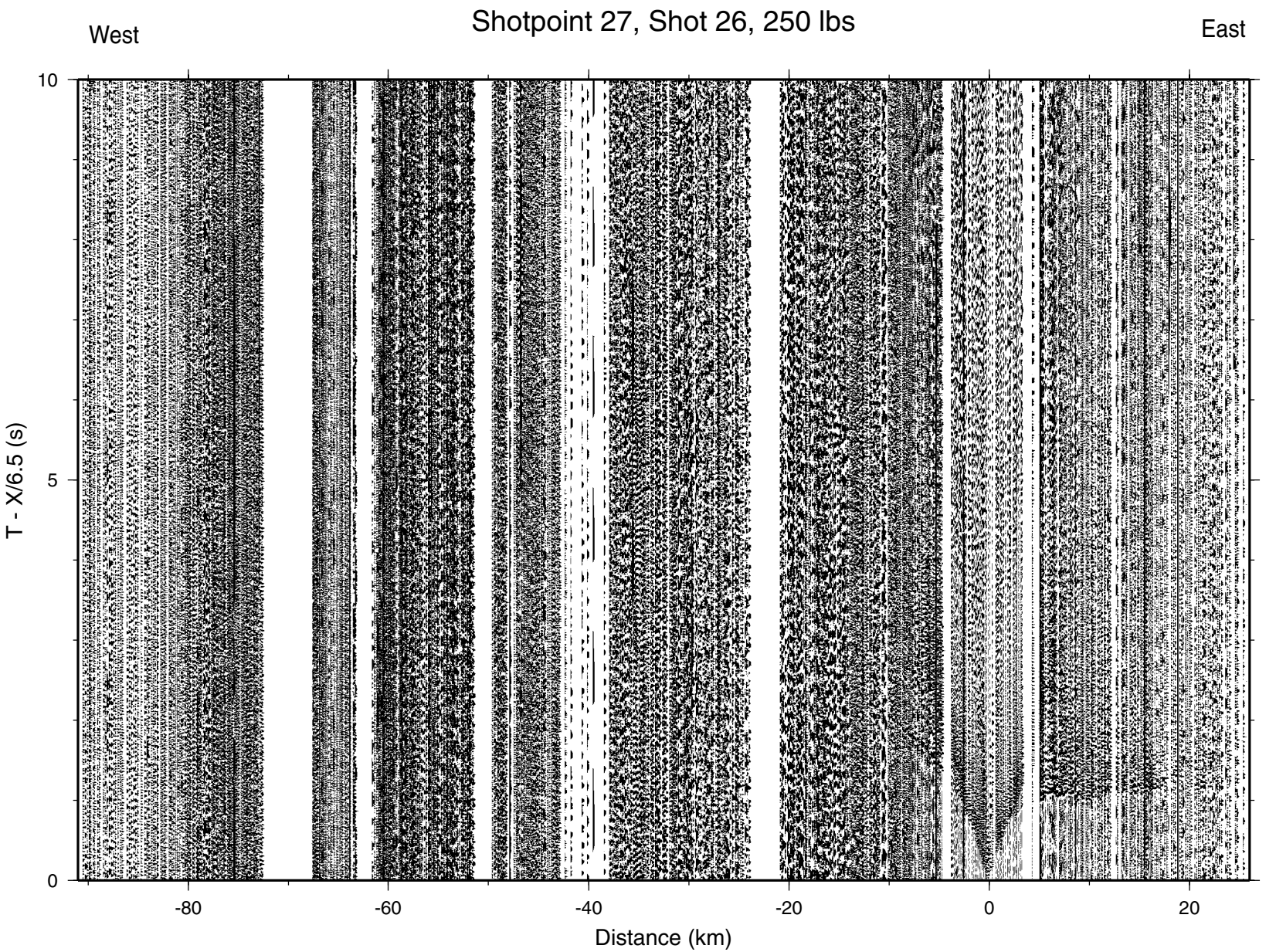

Figure 31. Reduced record section for Shotpoint 27, vertical component only, for Lines 1 and 2.

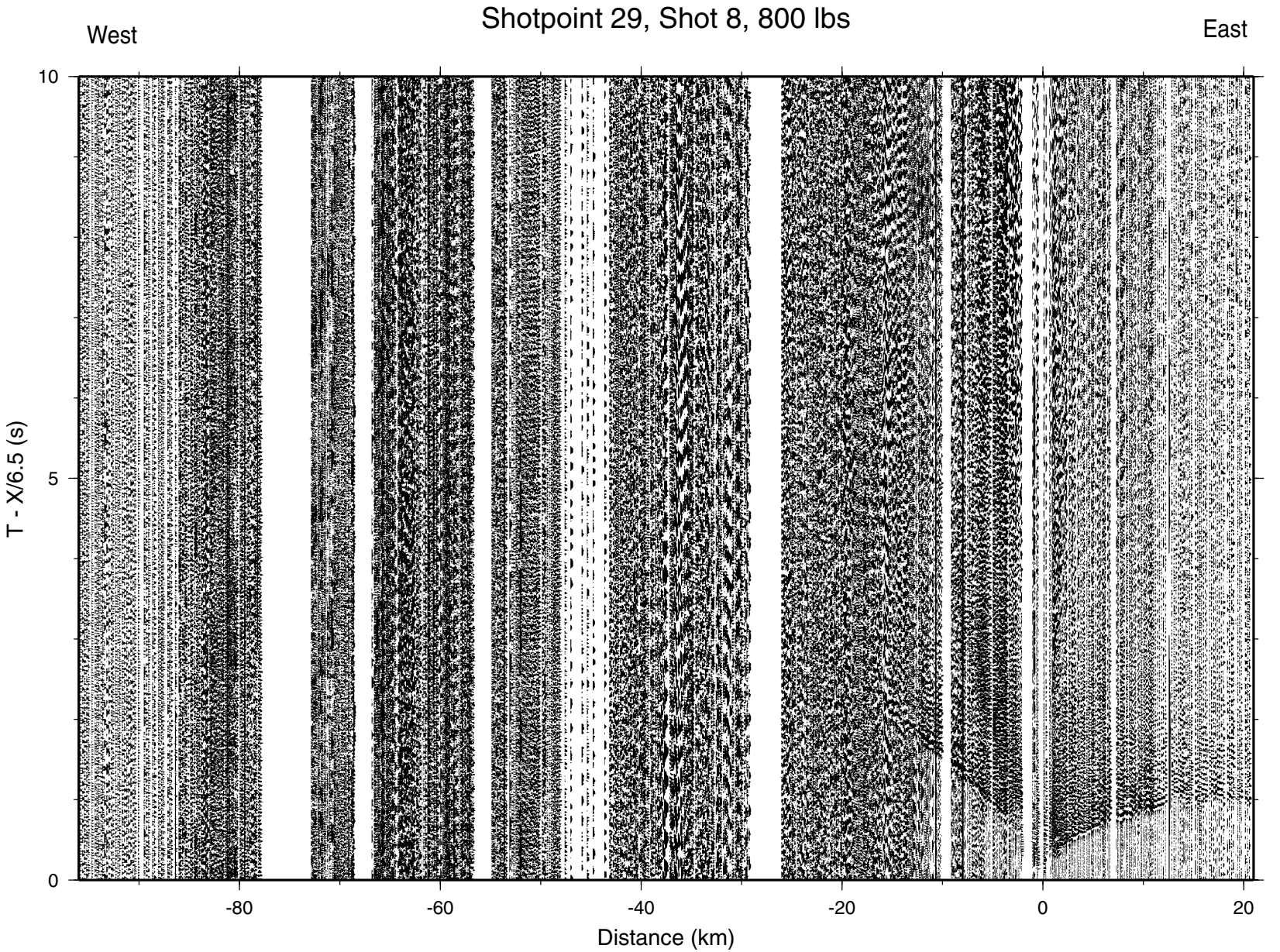

Figure 32. Reduced record section for Shotpoint 29, vertical component only, for Lines 1 and 2.

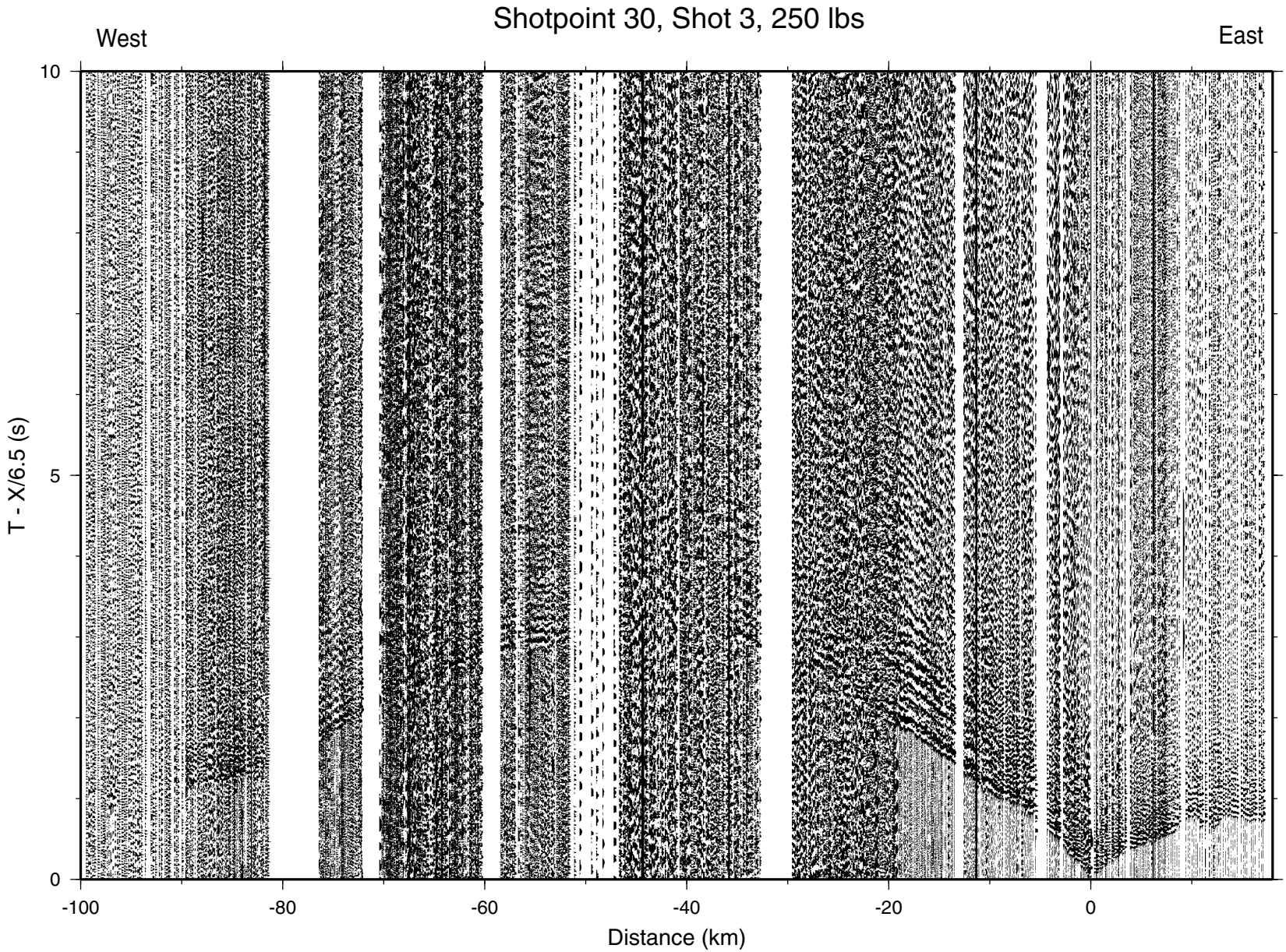

Figure 33. Reduced record section for Shotpoint 30, vertical component only, for Lines 1 and 2.

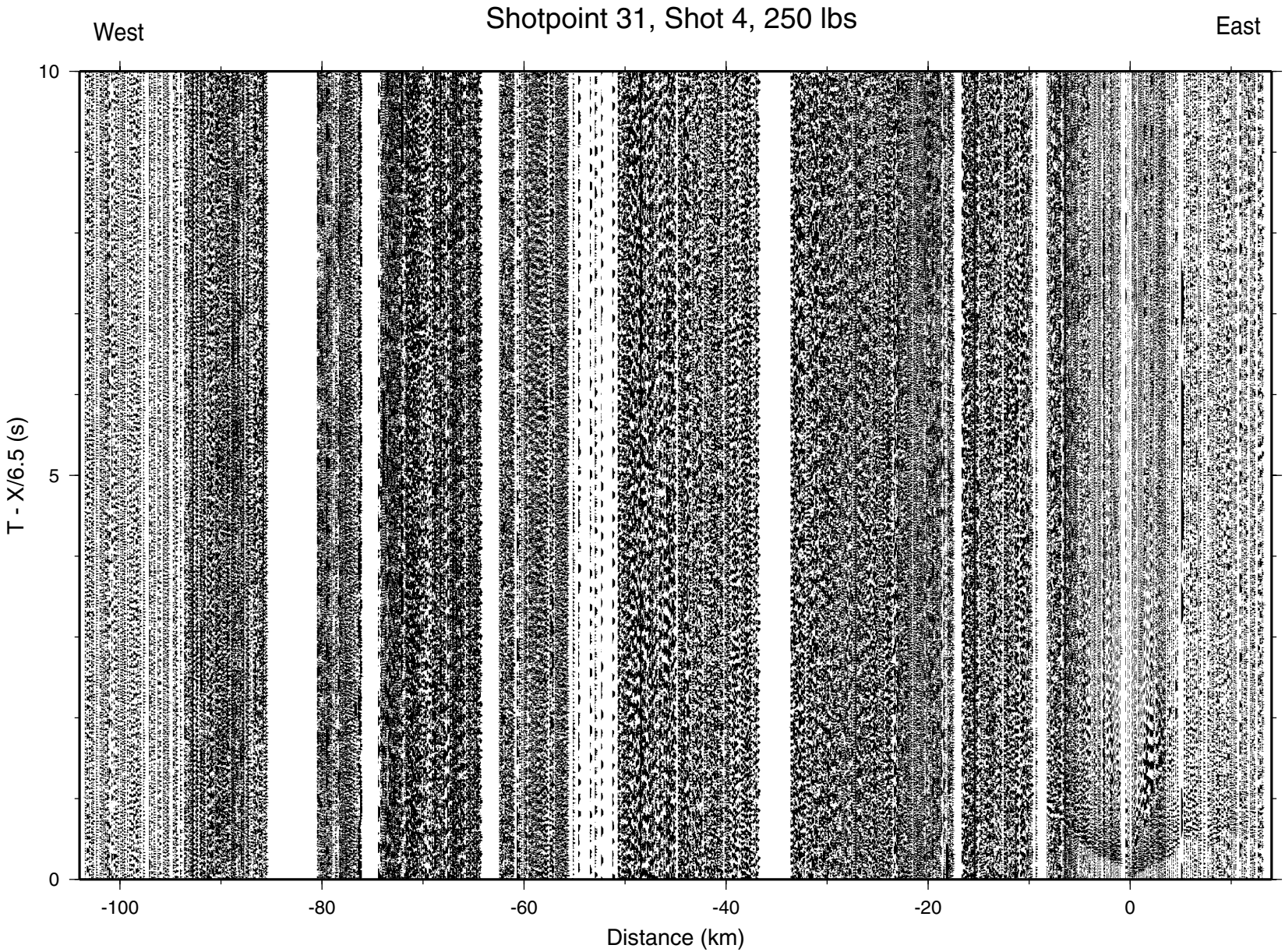

Figure 34. Reduced record section for Shotpoint 31, vertical component only, for Lines 1 and 2.

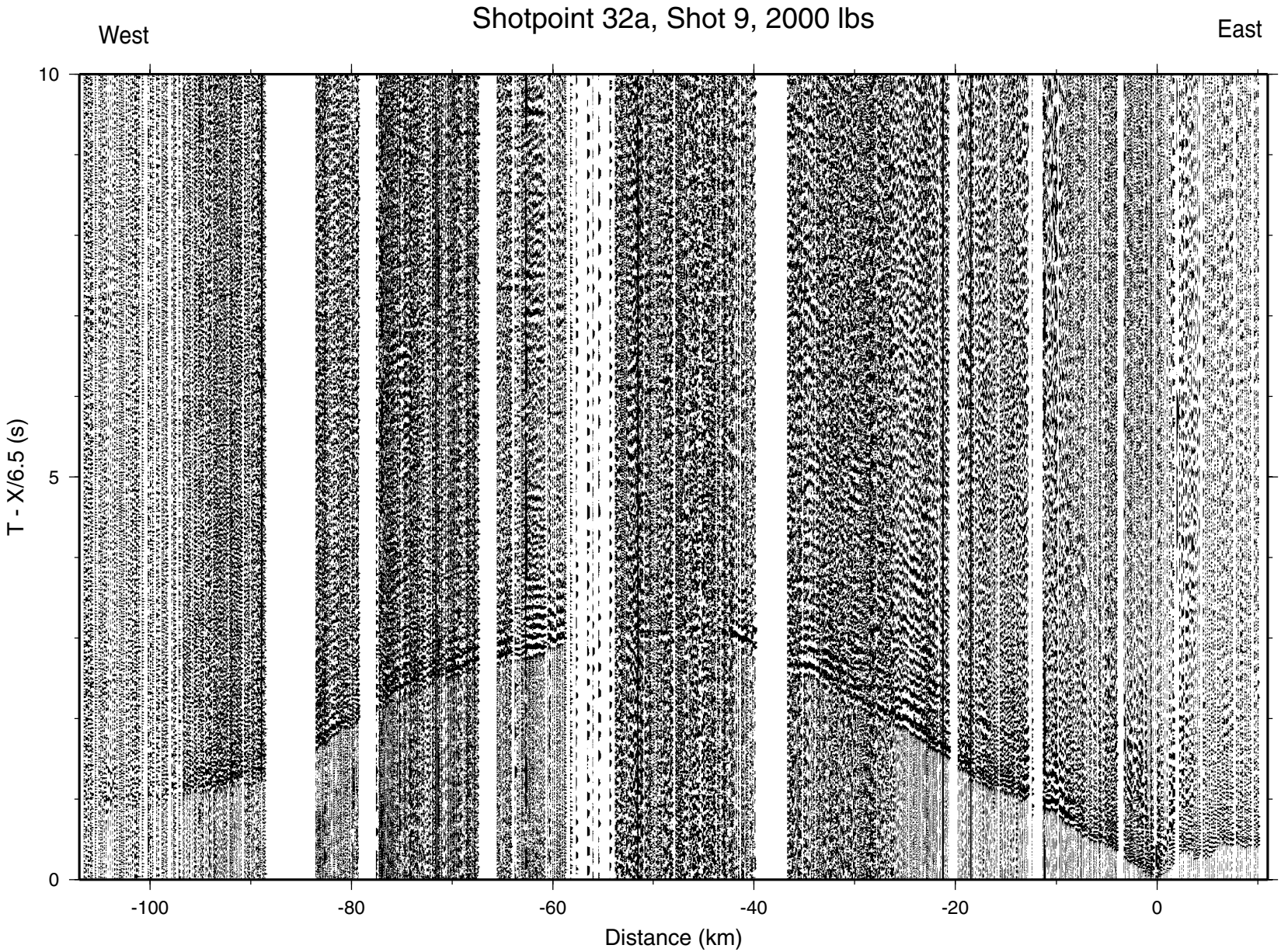

Figure 35. Reduced record section for Shotpoint 32a, vertical component only, for Lines 1 and 2.

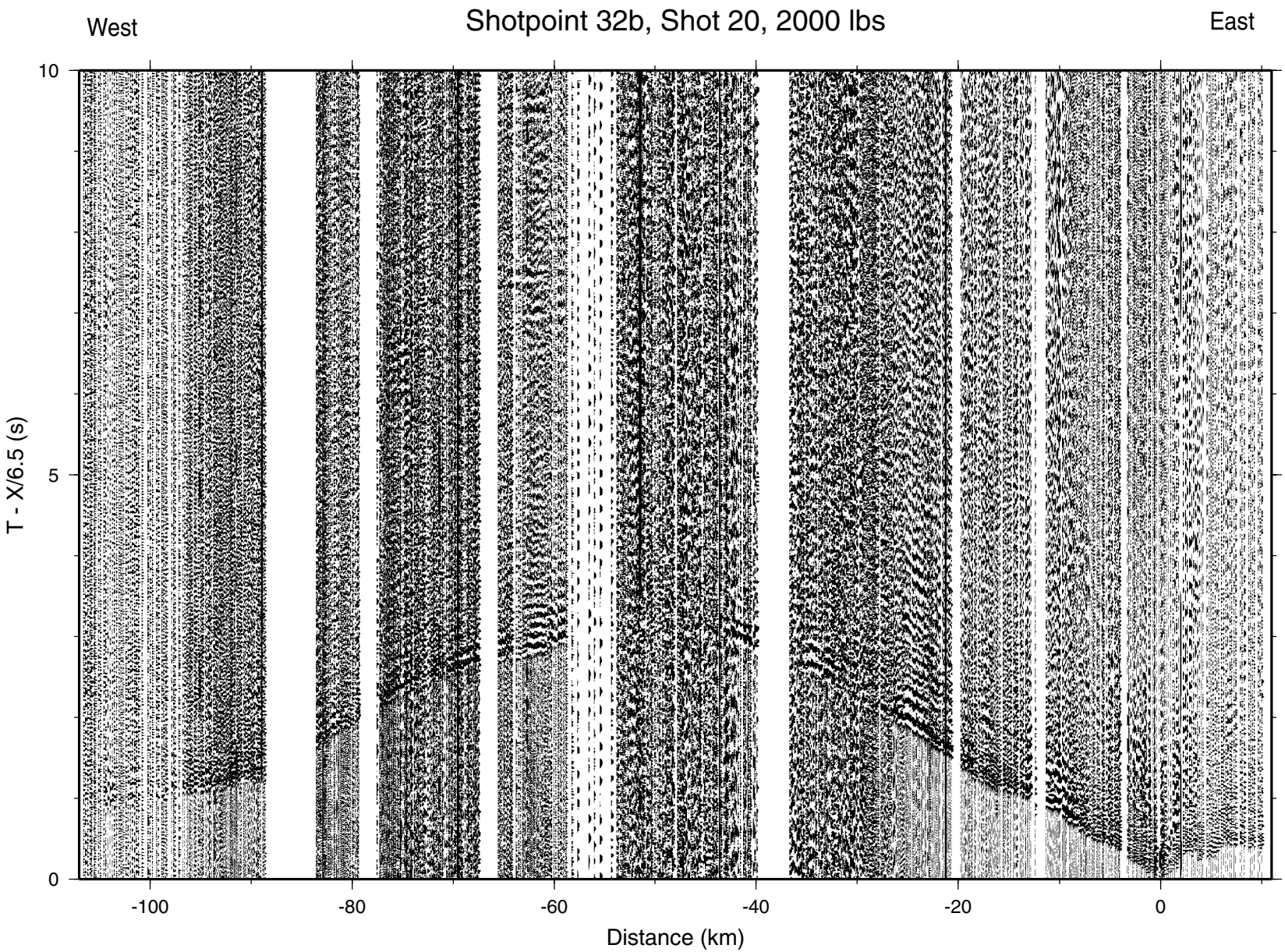

Figure 36. Reduced record section for Shotpoint 32b, vertical component only, for Lines 1 and 2.

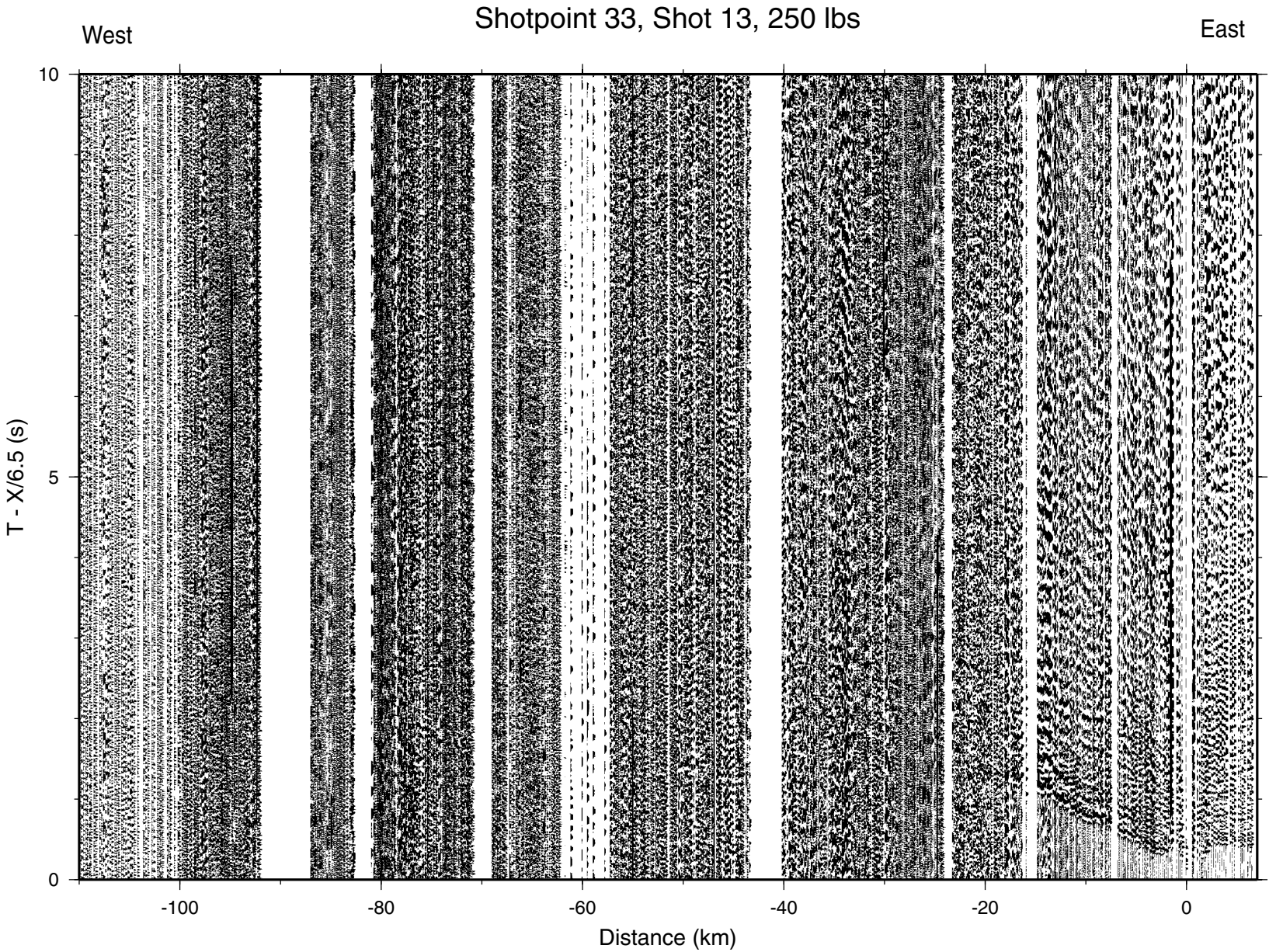

Figure 37. Reduced record section for Shotpoint 33, vertical component only, for Lines 1 and 2.

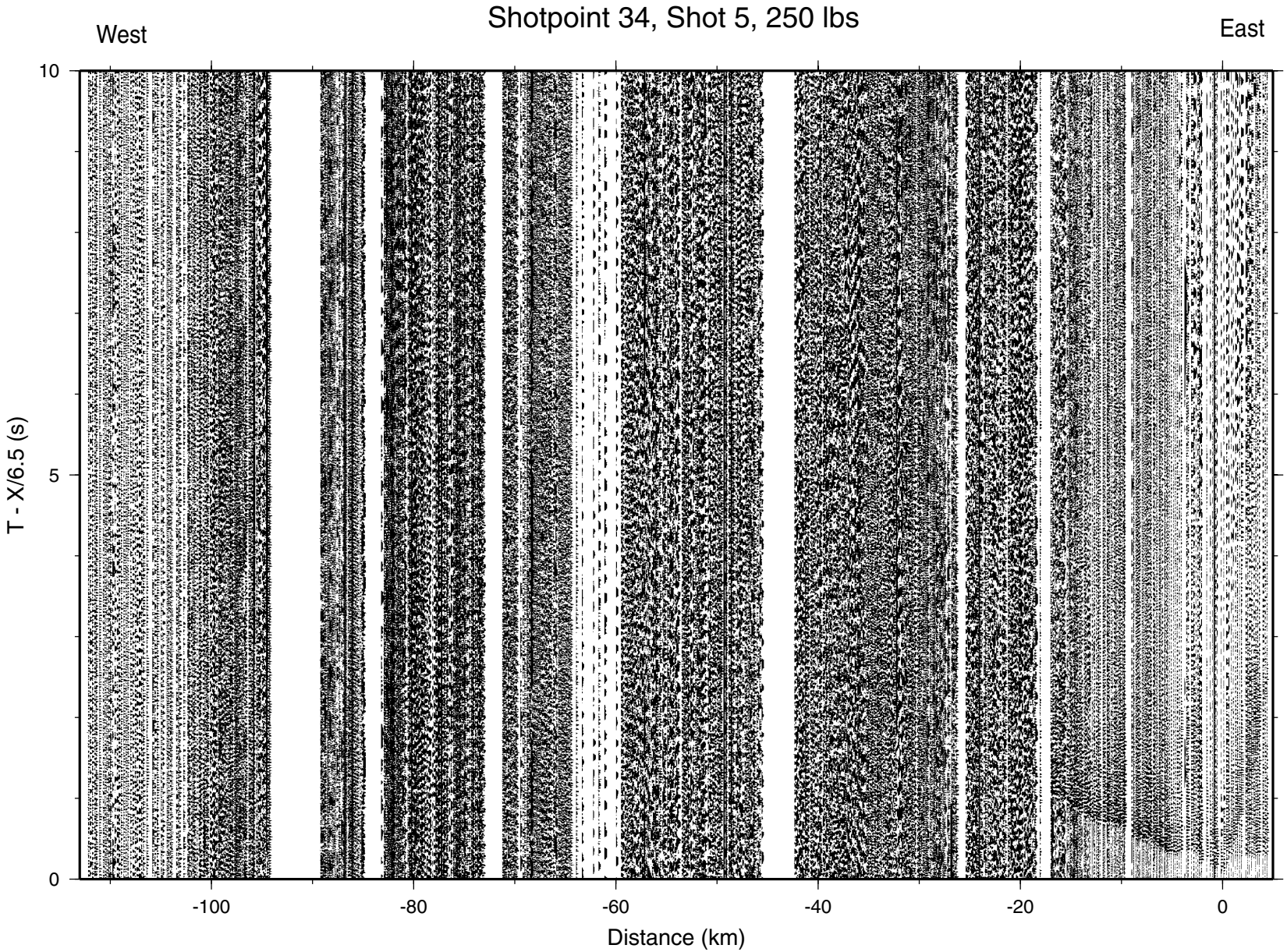

Figure 38. Reduced record section for Shotpoint 34, vertical component only, for Lines 1 and 2.

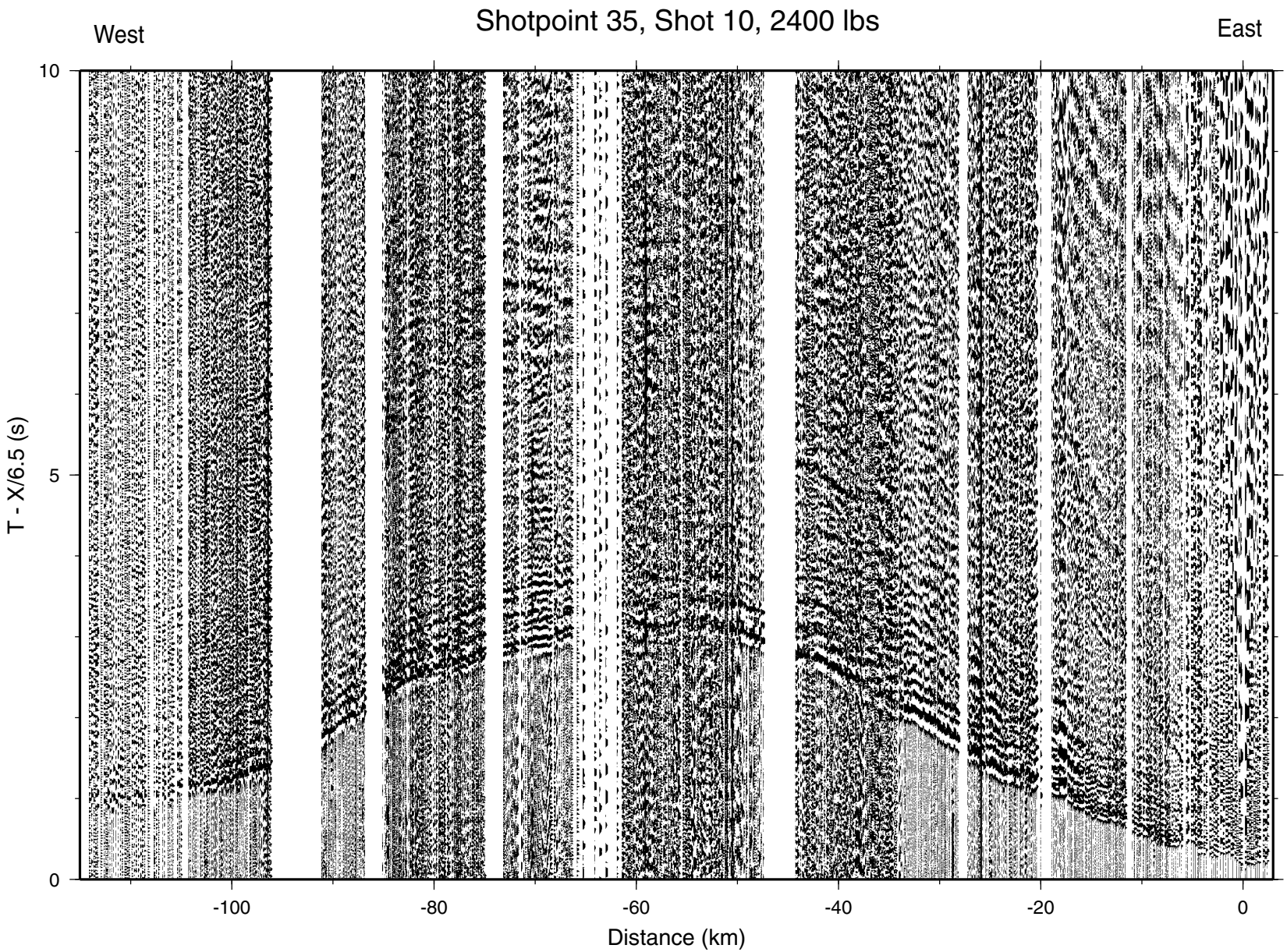

Figure 39. Reduced record section for Shotpoint 35, vertical component only, for Lines 1 and 2.

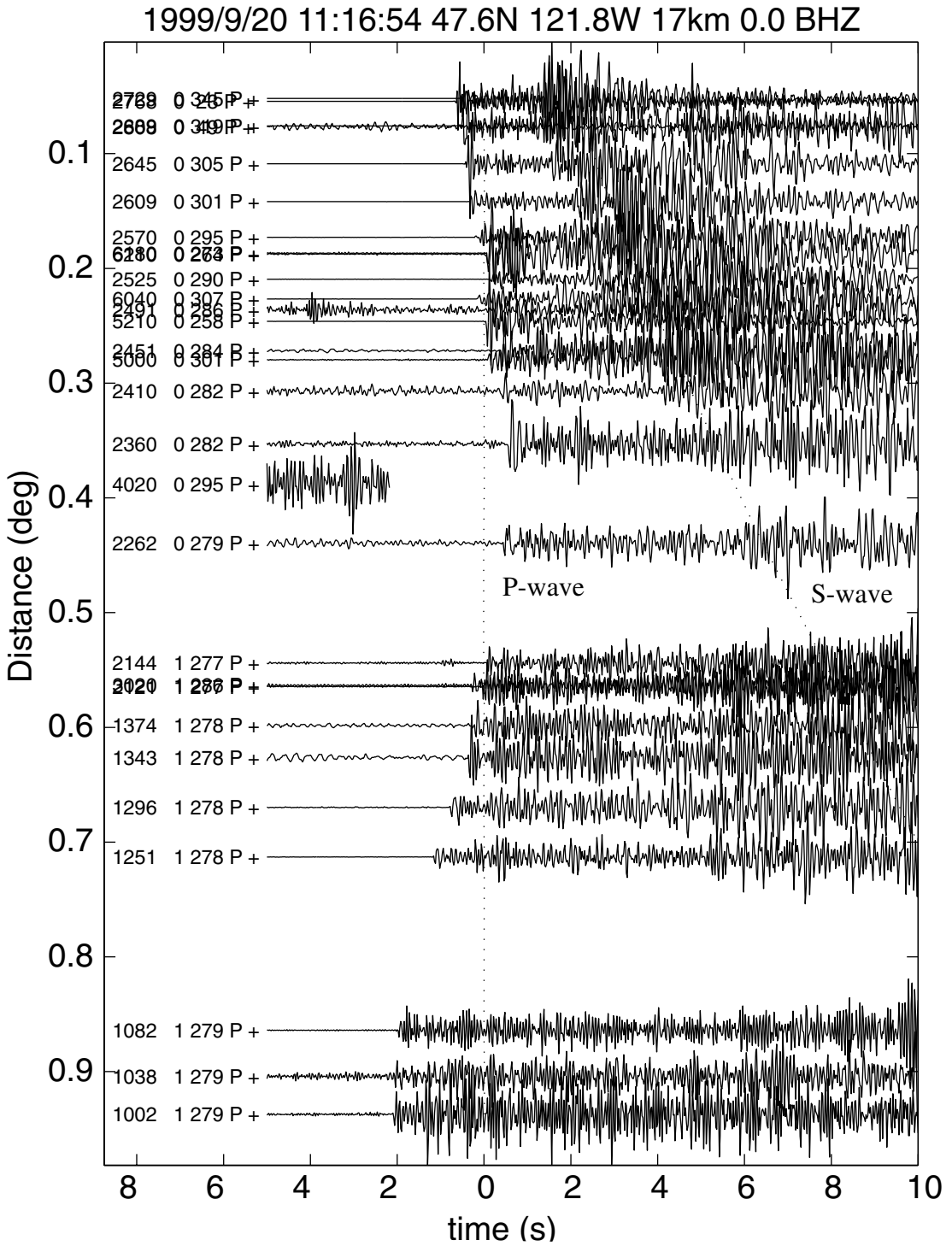

Figure 40. Vertical component REFTEK recordings of a local M2.8 earthquake on 9/20/1999 at 17 km depth (event 11 on Table 6a). Numbers on left side of traces show station numbers of the receivers; numbers between 279 and 305 show azimuth between the earthquake and the receiver. Dotted lines show locations of P- and S-wave arrivals calculated from the iasp91 earth model.

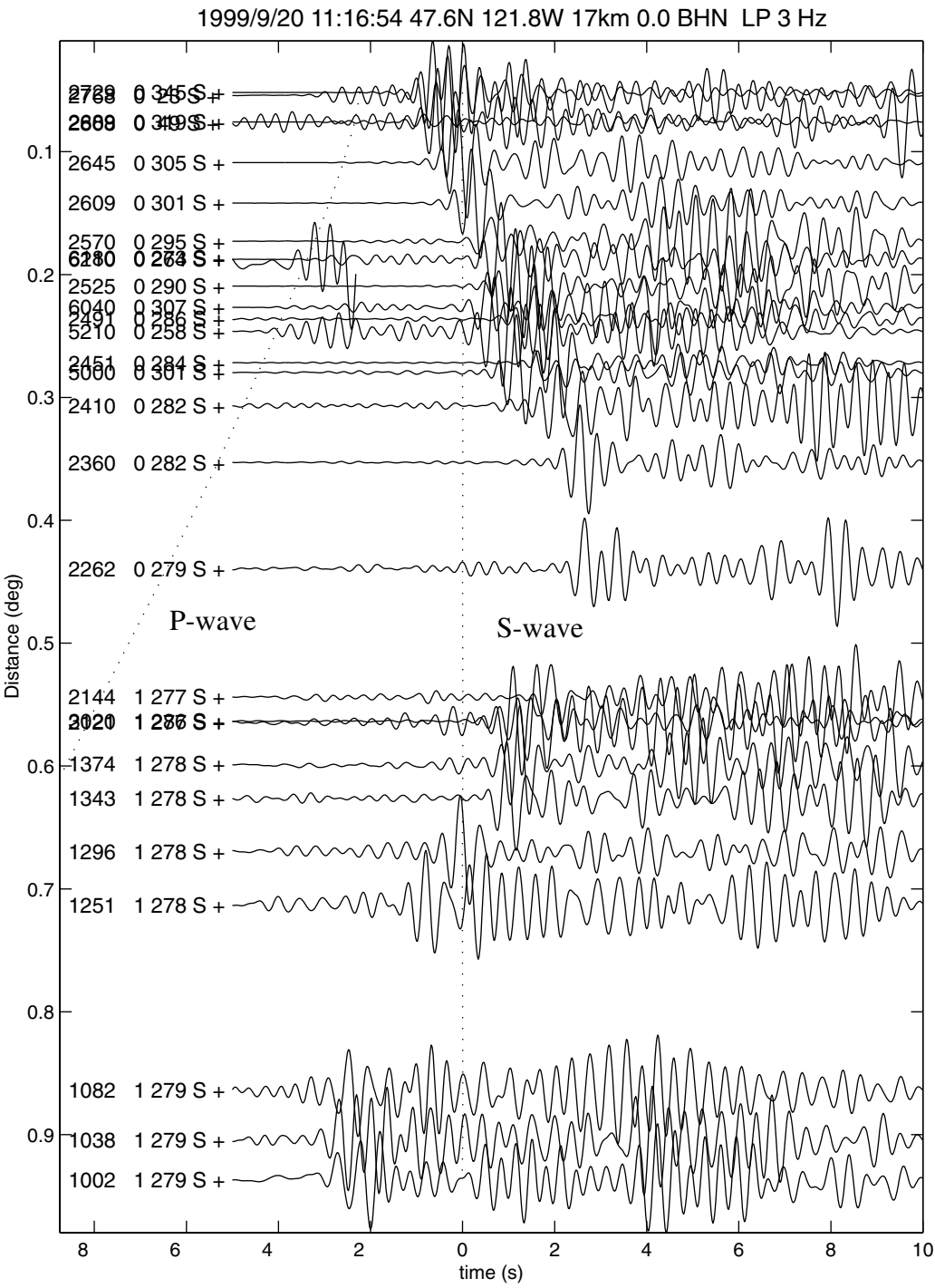

Figure 41. Horizontal component (N-S) REFTEK recordings of a local M2.8 earthquake on 9/20/1999 at 17 km depth (event 11 on Table 6a). Numbers on left side of traces show station numbers of the receivers; numbers between 279 and 305 show azimuth between the earthquake and the receiver. Dotted lines show locations of P- and S-wave arrivals calculated from the iasp91 earth model.

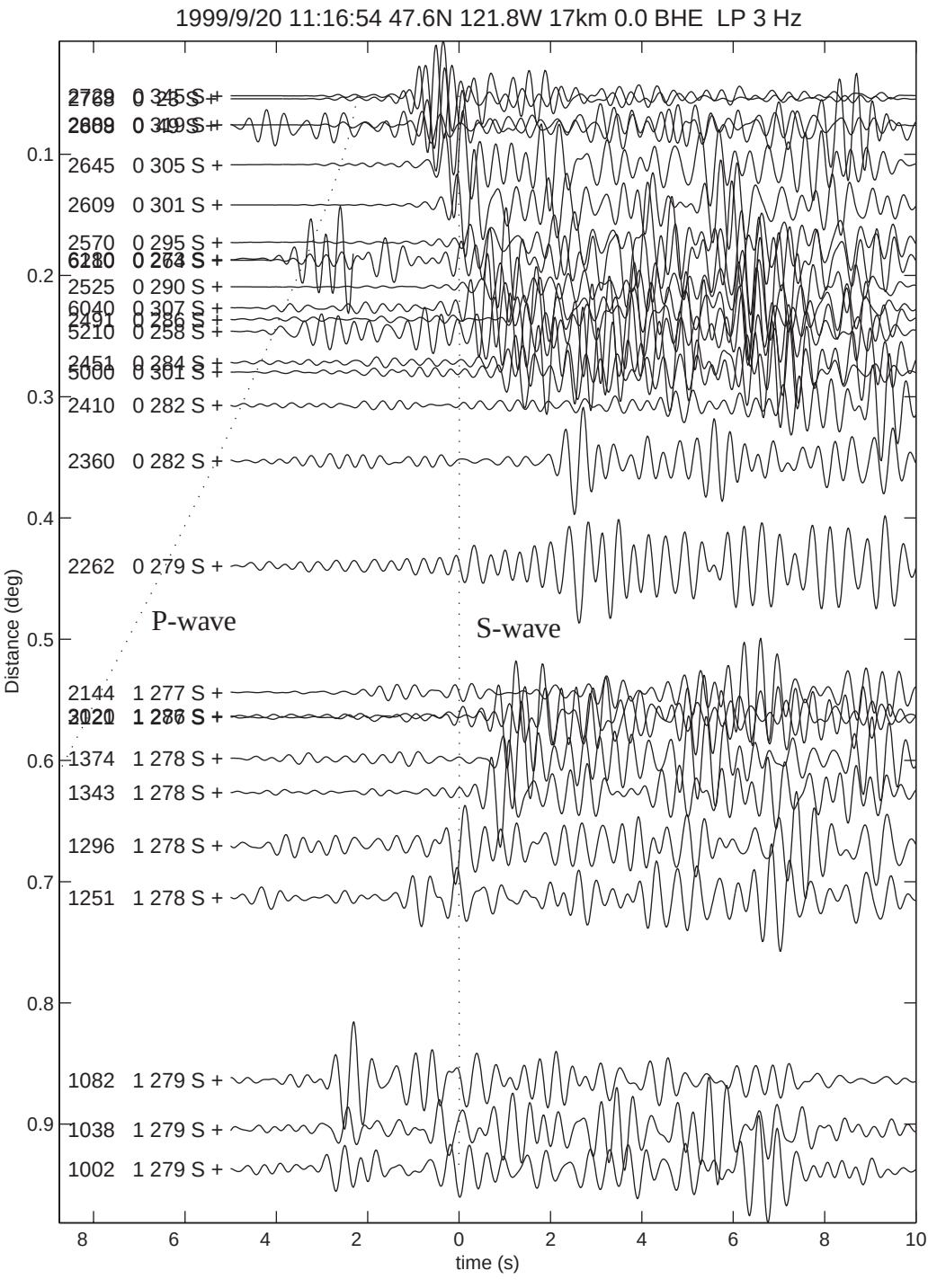

Figure 42. Horizontal component (E-W) REFTEK recordings of a local M2.8 earthquake on 9/20/1999 at 17 km depth (event 11 on Table 6a). Numbers on left side of traces show station numbers of the receivers; numbers between 279 and 305 show azimuth between the earthquake and the receiver. Dotted lines show locations of P- and S-wave arrivals calculated from the iasp91 earth model.

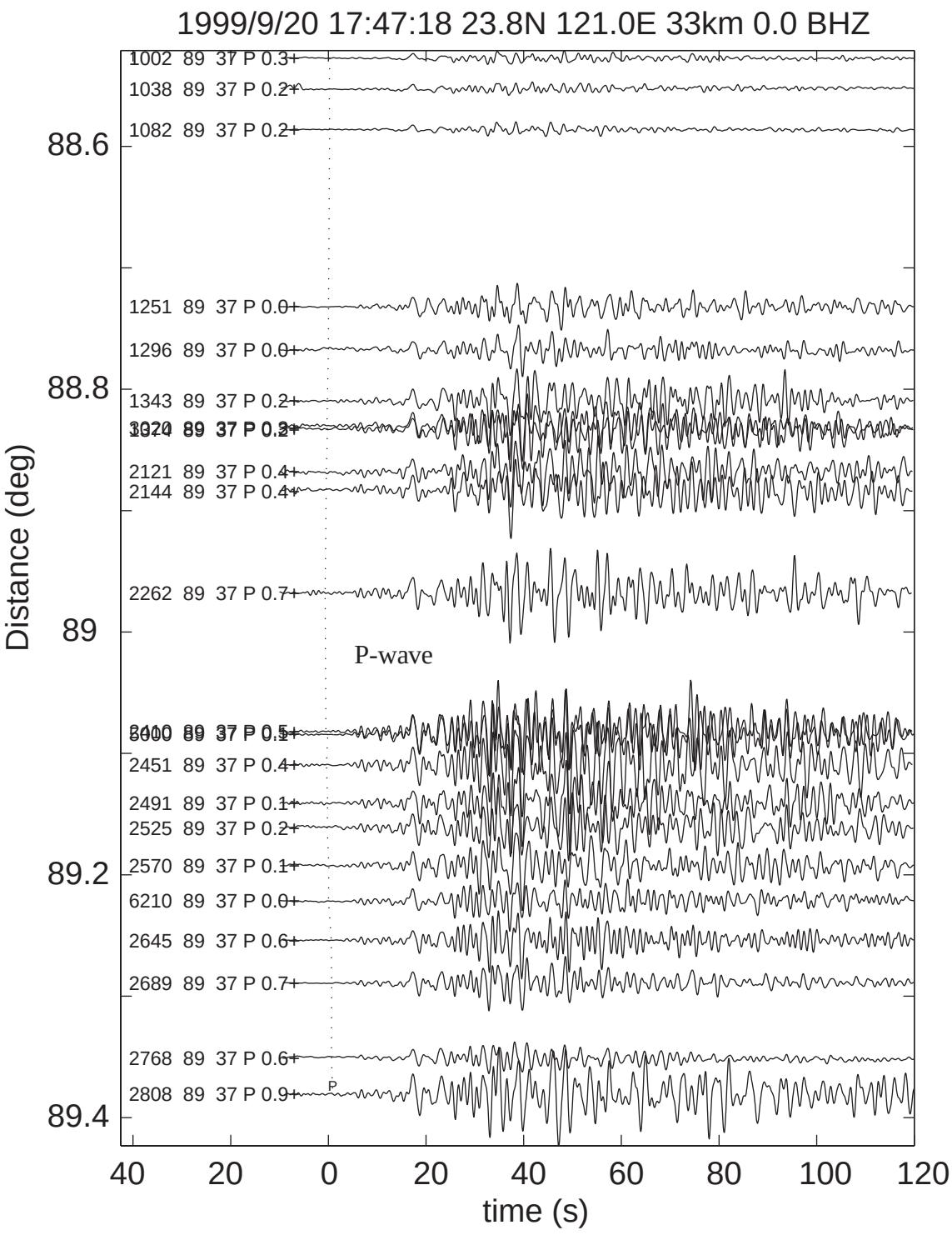

Figure 43. Vertical component REFTEK recordings of the M7.6 Chi Chi earthquake on 9/20/1999. Numbers on left side of traces show station numbers of the receivers; numbers between 0.0 and 0.9+ show shift applied to the trace. Dotted line shows locations of P-wave arrival calculated from the iasp91 earth model.

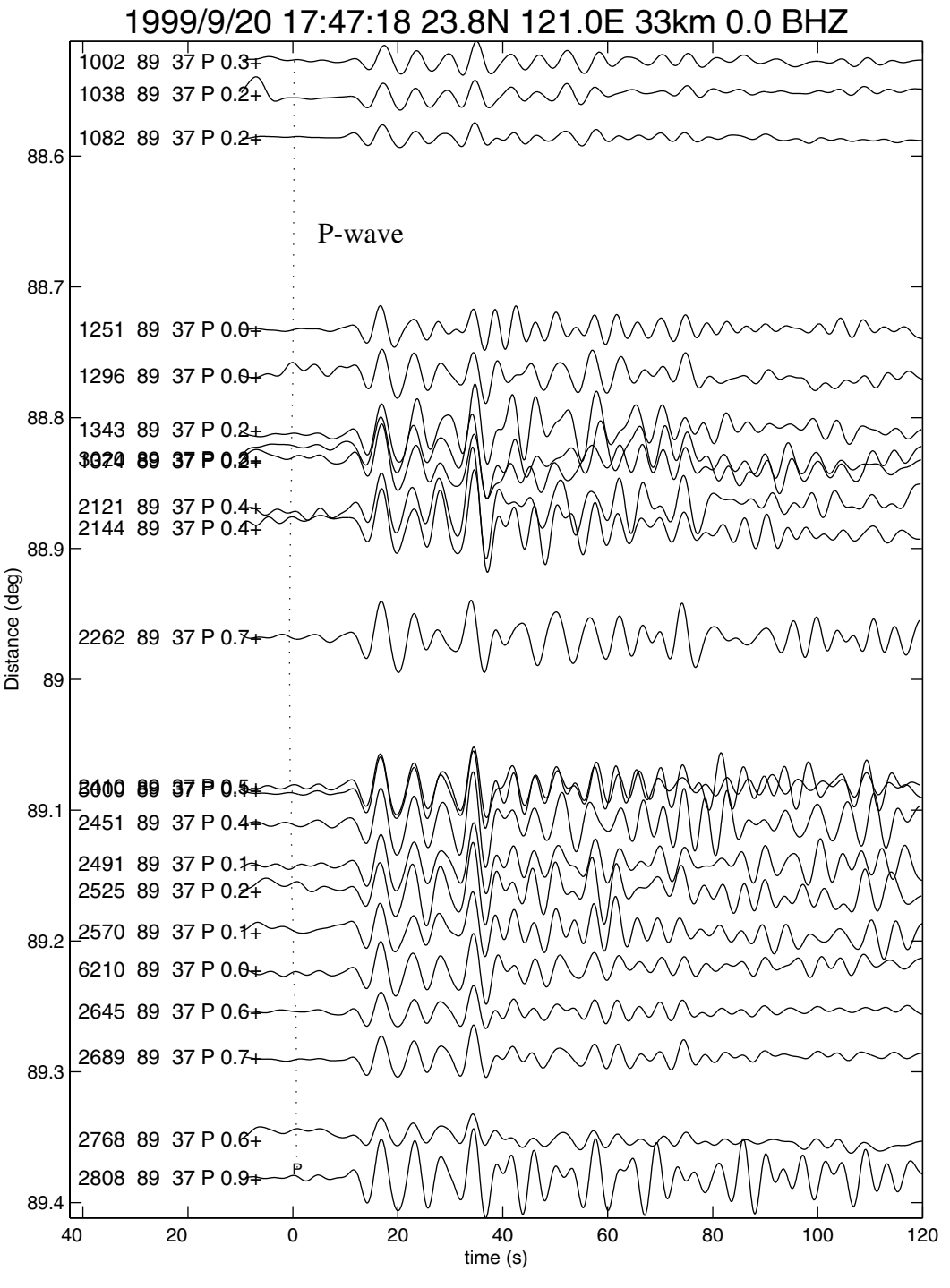

Figure 44. Vertical component REFTEK recordings of the M7.6 Chi Chi earthquake on 9/20/1999. Numbers on left side of traces show station numbers of the receivers; numbers between 0.0 and 0.9+ show shift applied to the trace. Dotted line shows locations of P-wave arrival calculated from the iasp91 earth model. Data have been low pass filtered with an upper corner at 0.25 Hz.

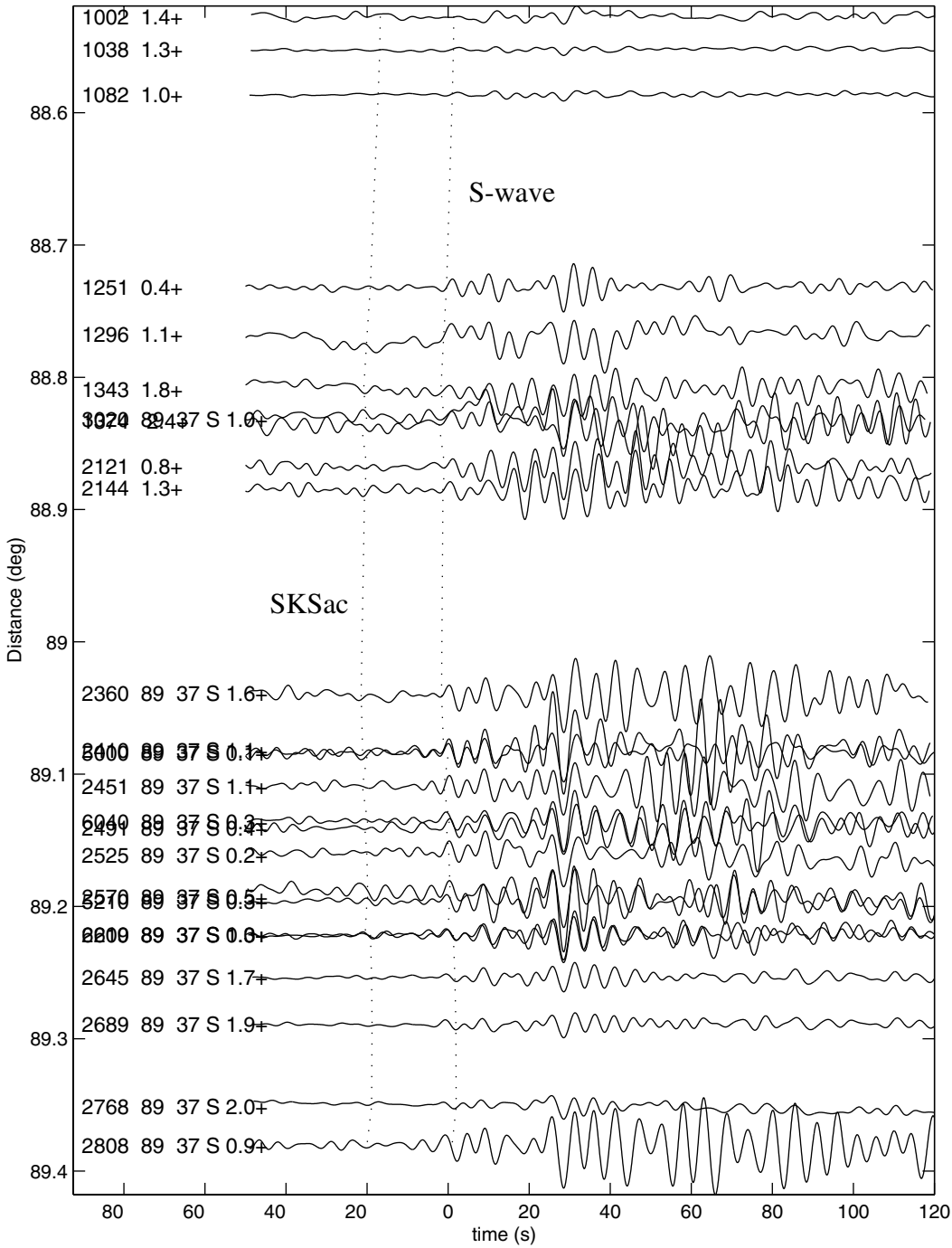

Figure 45. East-west horizontal component REFTEK recordings of the M7.6 Chi Chi earthquake on 9/20/1999. Numbers on left side of traces show station numbers of the receivers; numbers between 0.0 and 2.0+ show shift applied to the trace. Dotted line shows locations of SKS and S-wave arrivals calculated from the iasp91 earth model. Data have been low pass filtered with an upper corner at 0.25 Hz.

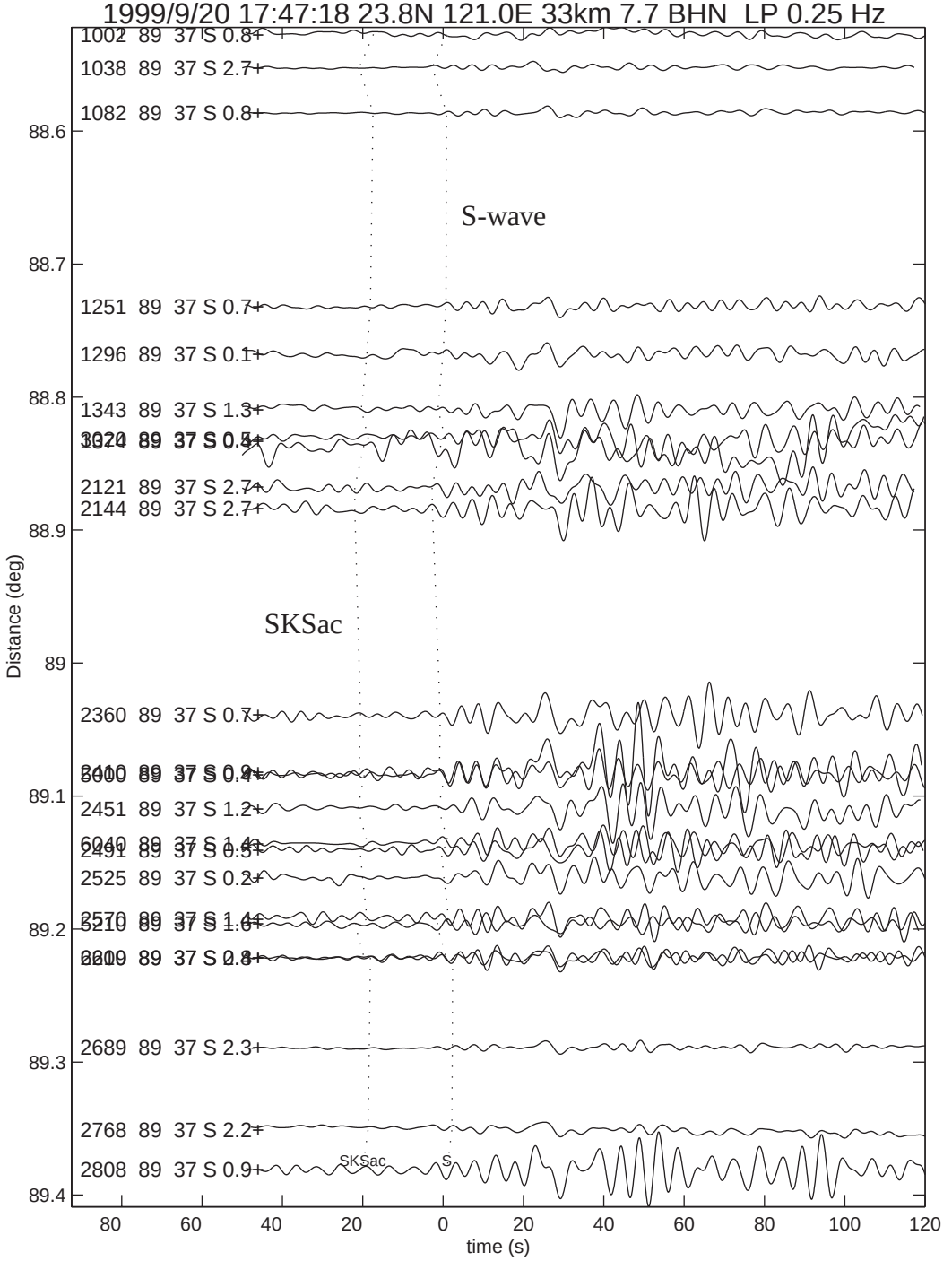

Figure 46. North-south horizontal component REFTEK recordings of the M7.6 Chi Chi earthquake on 9/20/1999. Numbers on left side of traces show station numbers of the receivers; numbers between 0.0 and 2.7+ show shift applied to the trace. Dotted line shows locations of SKS and S-wave arrivals calculated from the iasp91 earth model. Data have been low pass filtered with an upper corner at 0.25 Hz.

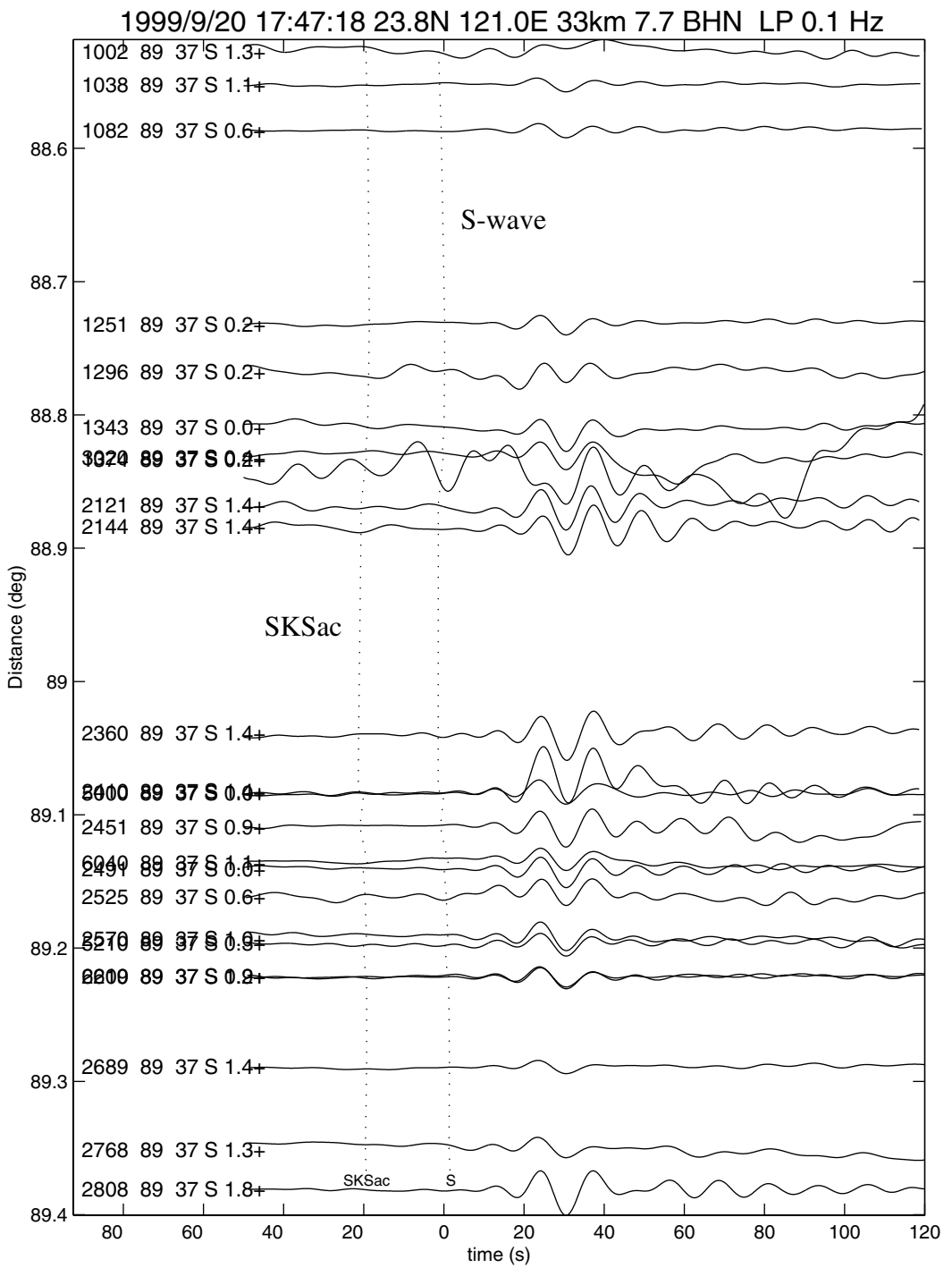

Figure 47. North-south horizontal component REFTEK recordings of the M7.6 Chi Chi earthquake on 9/20/1999. Numbers on left side of traces show station numbers of the receivers; numbers between 0.0 and 1.8+ show shift applied to the trace. Dotted line shows locations of SKS and S-wave arrivals calculated from the iasp91 earth model. Data have been low pass filtered with an upper corner at 0.1 Hz.

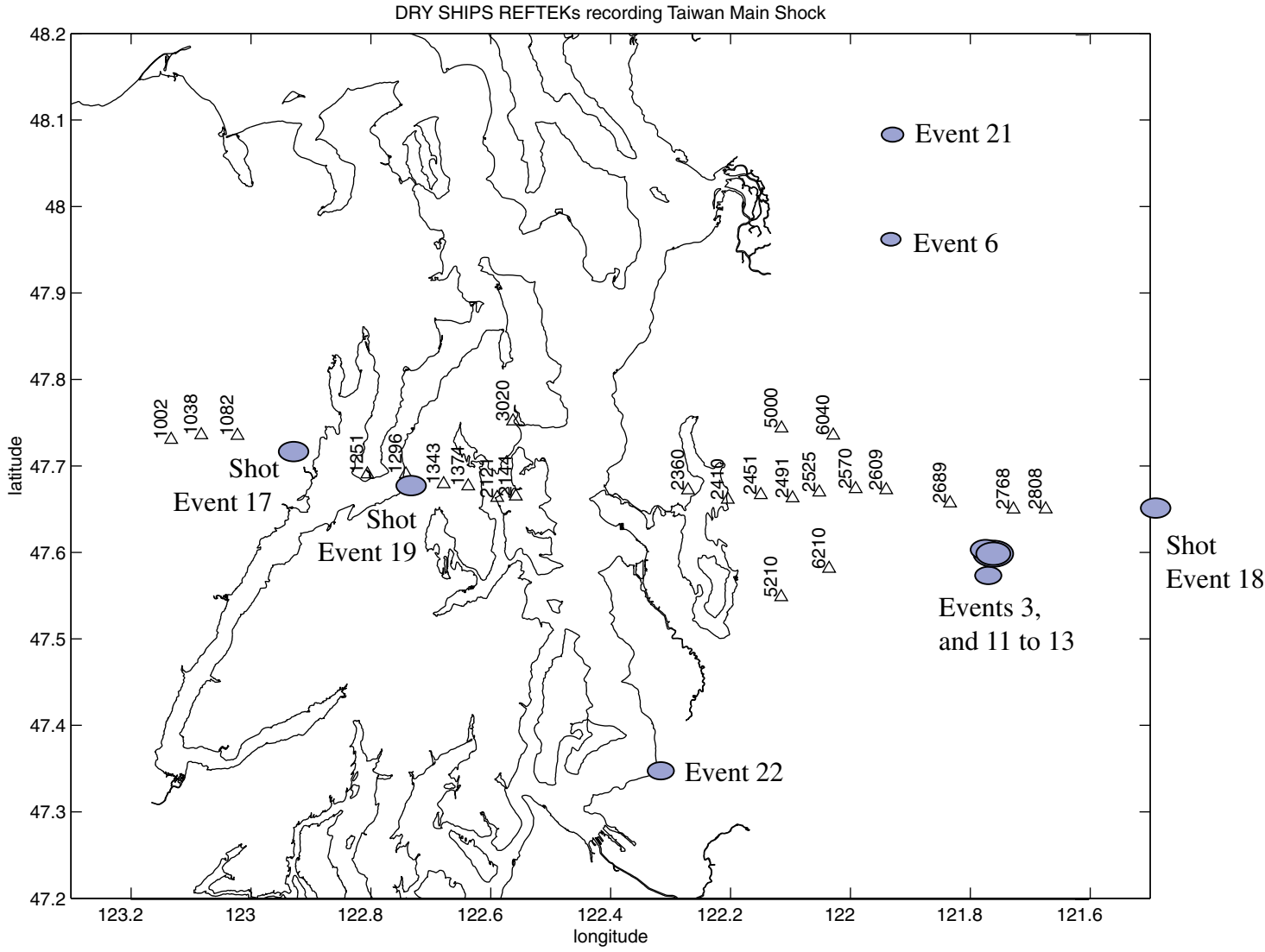

Figure 48. Map showing locations of Refteks that recorded the M7.6 Chi Chi mainshock. Ellipses show locations of local earthquakes that were also recorded by these Refteks (see Table 6a). Events 17 to 19 correspond to our own shots.

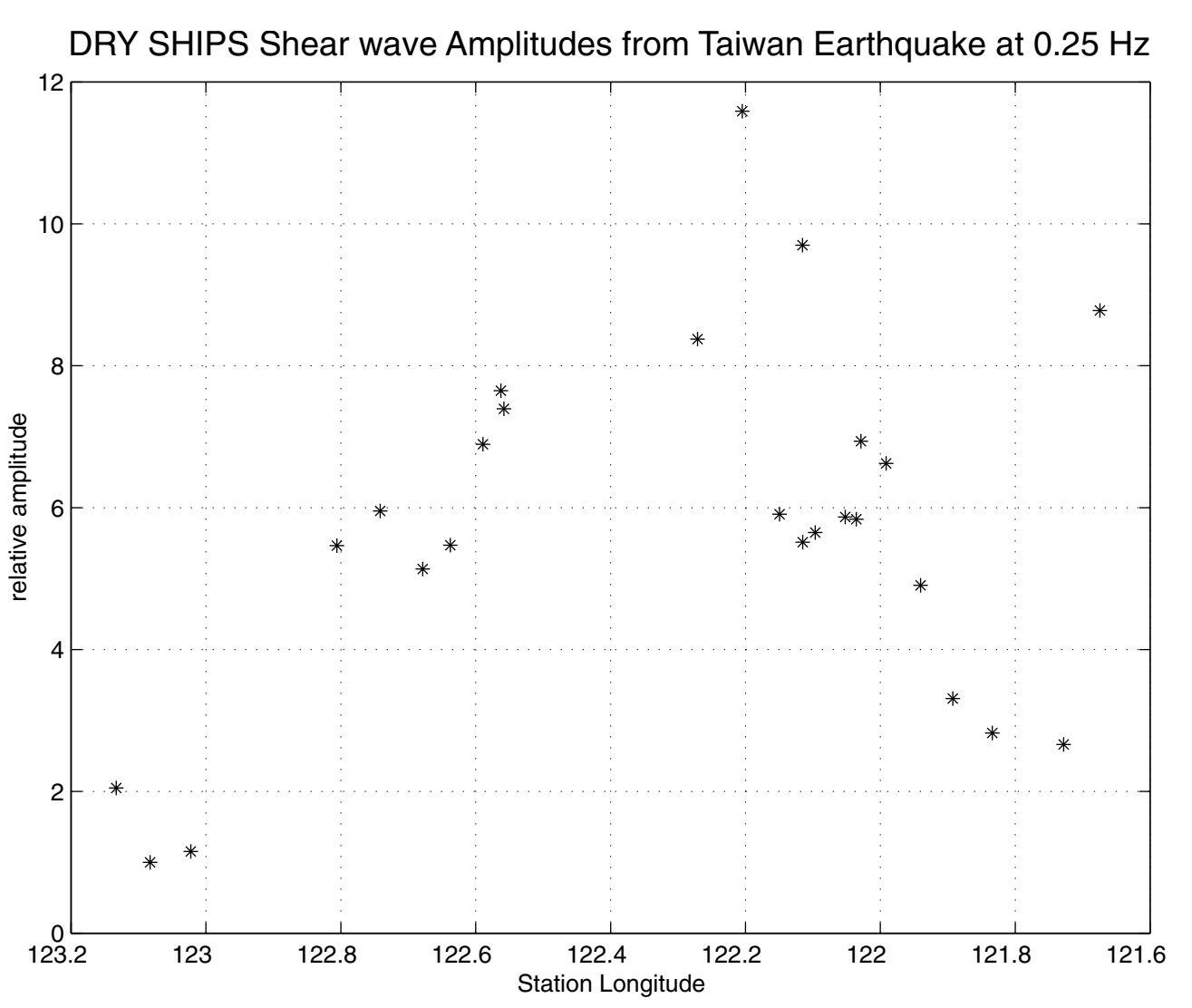

Figure 49. Relative amplitudes of shear wave arrivals from the M7.6 Chi Chi earthquake. These amplitudes represent the relative amplitudes of the east-west horizontal (nearly radial) component. The data were first low pass filtered with an upper corner of 0.25 Hz.