U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

DATA REPORT FOR THE PACE 1989 SEISMIC REFRACTION SURVEY, NORTHERN ARIZONA

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OPEN-FILE REPORT 94-138

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1994

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INTRODUCTION

In 1985 the U.S. Geological Survey (USGS) initiated a multi-disciplinary program to study the geologic and tectonic evolution of the southwestern United States. This study, referred to as the Pacific to Arizona Crustal Experiment (PACE), extends from San Diego, California, to Flagstaff, Arizona, and includes a wide range of geophysical and geologic studies such as gravity, magnetics, geochronology, tomography, field mapping, and paleomagnetics. Central to the PACE program has been the use of seismic refraction methods to constrain crustal thickness, rock composition, and crustal structure. The seismic refraction studies were initiated in 1985 mid-way along the PACE transect (Wilson and Fuis, 1987) and were extended to the northeast across the Transition Zone in 1987 (Larkin and others, 1988). The results of these studies have been integrated into a model of the crustal structure from the unextended Colorado Plateau to the highly extended metamorphic core complex belt (McCarthy and others, 1991; Wilson and others, 1991).

In September of 1989 the USGS, in conjunction with the University of Texas at El Paso, the University of Saskatchewan, the University of Arizona, the Air Force Geophysics Laboratory, Stanford University, and the Geological Survey of Canada, conducted a third seismic refraction experiment across the northeastern Transition Zone and the southwestern margin of the Colorado Plateau. When merged with the earlier PACE refraction profiles, the combined data set provides a complete transect from the highly extended metamorphic core complexes to the unextended Colorado Plateau (Fig. 1). This report describes the field operations for this 1989 PACE experiment and the types of data acquired.

GEOLOGIC BACKGROUND

The Colorado Plateau is a major tectonic and physiographic province in the southwestern United States that has behaved as a relatively stable, coherent block during much of the Phanerozoic (e.g., Lucchitta, 1989). A site of marine deposition during the Cretaceous, the Colorado Plateau now stands about 2 km above sea level and is actively deforming, as evidenced by earthquakes along its margins. Unlike the Basin and Range province and Rio Grande rift which have experienced approximately 1 km of uplift while simultaneously undergoing horizontal extension and internal deformation, the Plateau has remained a relatively rigid block, resistant to faulting and deformation. The greatest amount of uplift has been along the southwestern margin of the Plateau, where elevations are often 0.5 km greater than in the center.

Several mechanisms have been proposed to account for the recent uplift of the Colorado Plateau, including thermal expansion, crustal thickening, and delamination of the lithosphere. In order to evaluate each of these processes, however, the structure and thickness of the crust beneath the Plateau and the velocity structure of the upper mantle must be determined. The surface elevation is dependent on both the density and the thickness of the lithosphere, of which the crust is the buoyant component (e.g., Lachenbruch and Morgan, 1990). The thickness and average density (estimated from the average velocity) of the Plateau crust must thus be known in order to evaluate the thickness of the mantle portion of the lithosphere. Furthermore, because thermal expansion and crustal thickening via magmatism may

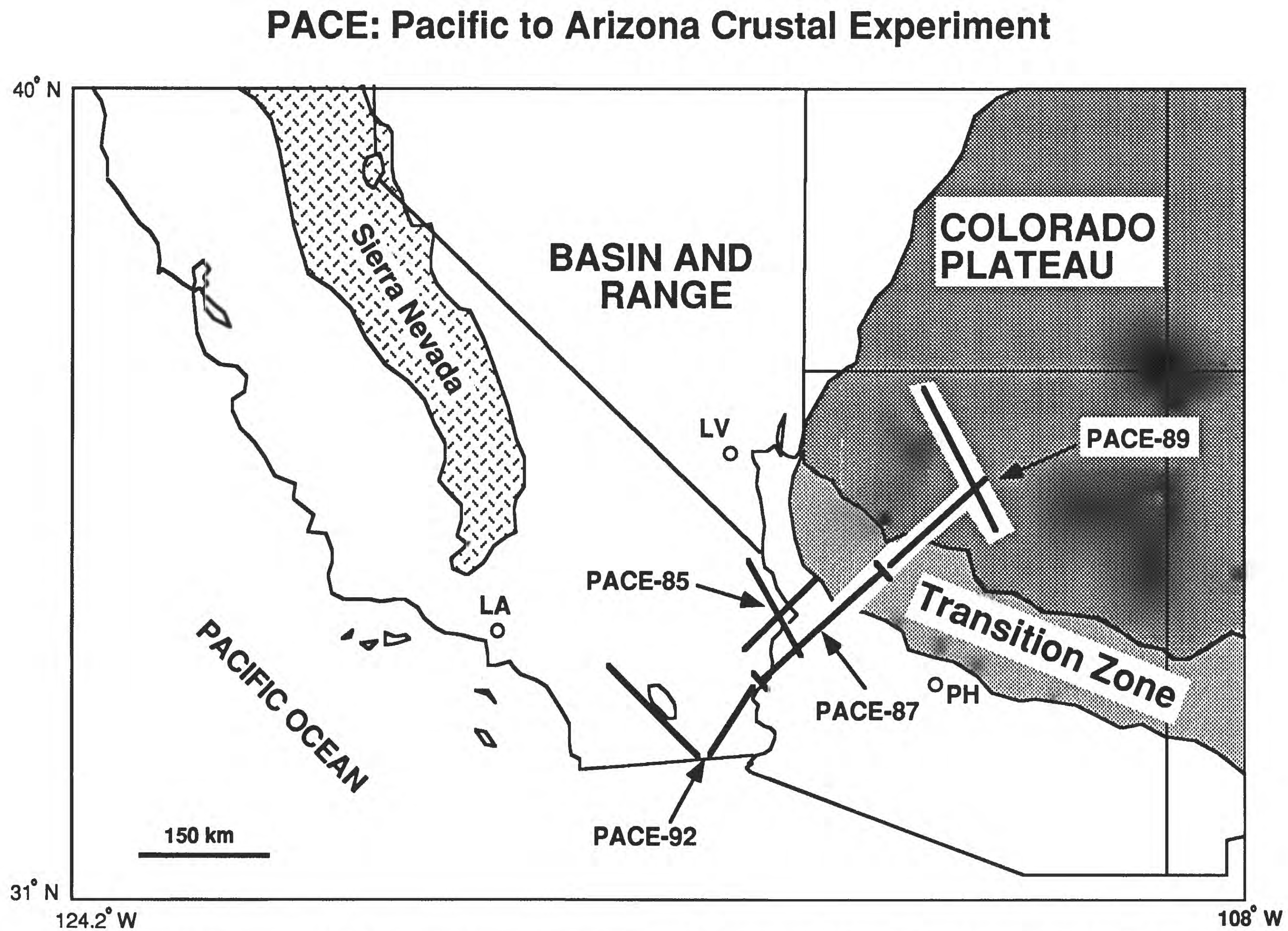

Figure 1. Location of the various PACE refraction experiments in southern California and Arizona. Two perpendicular profiles were collected in 1985 in southeastern most California, a single profile was collected in 1987 across western Arizona, and two perpendicular profiles were collected in both 1989 and 1992 to extend the transect northeast across the Colorado Plateau and southwest to the Salton Sea, respectively. Symbols used: LA, Los Angeles; LV, Los Vegas; PH, Phoenix.

contribute to the present elevations, the temperature conditions in the upper mantle must also be evaluated. The Pn velocity structure, obtained from refraction studies and from teleseismic studies (Beghoul and Barazangi, 1989), will bear directly on the question of the thermal state of the upper mantle and will permit a direct comparison between the upper-mantle lithosphere beneath the Basin and Range province, the Colorado Plateau, and the Great Plains.

The 1989 PACE seismic refraction experiment was designed to measure the crustal thickness at the southwestern margin of the Colorado Plateau. When combined with topography, gravity, heat flow, and seismicity, these results can then be used to constrain the mechanisms responsible for uplift. The seismic data acquired in this study are currently being analyzed. For initial results the reader is referred to: Benz and others (1990); Benz and McCarthy (in press); Howie (1991); Howie and others (1991); Parsons and others (1992); Johnson and Hartman (1991); Kohler and McCarthy (1990); McCarthy and Parsons (in press); Parsons and McCarthy (submitted), and Wolf and Cipar (1993).

DESCRIPTION OF SURVEY

Two refraction/wide-angle reflection profiles were acquired during the 1989 PACE experiment. The first profile, referred to as the Colorado Plateau profile (Fig. 2), was oriented NE-SW and extended 150 km from the northeastern end of the 1987 PACE study across Chino Valley, Arizona, to the western edge of the Navajo Indian Reservation, near Cameron, Arizona. This profile crossed the northeastern half of the Transition Zone and the southwestern margin of the Colorado Plateau. In addition to constraining crustal thickness and upper-mantle velocity, the study was designed to delineate structures in the crust associated with the transition from the unextended Colorado Plateau to the extended Basin and Range province.

The second refraction profile, referred to as the Grand Canyon profile (Fig. 3), was oriented NW-SE and was situated strictly within the Colorado Plateau physiographic province. This profile was positioned as far inboard into the Plateau as possible so as to constrain crustal thickness while avoiding the Plateau margin, where extensional processes may have modified crustal structure. The Grand Canyon profile also intersects the northeastern portion of the Colorado Plateau profile and thus provides axial control to the northeastern portion of this line.

In addition to the two main refraction profiles, a suite of independent "piggyback" studies were conducted by several investigators. Each of these studies is described later in this report.

The PACE 1989 experiment was unusual in terms of the collaborative nature of the study. Funding was provided by five principal organizations: the U.S. Geological Survey's Deep Continental Studies Program, the Air Force Geophysics Laboratory (AFGL), the University of Texas at El Paso (through a grant from the AFGL), the Gas Research Institute, and the National Science Foundation. The USGS, AFGL, and the University of Texas at El Paso provided primary funding for the two refraction/wide-angle reflection profiles. The Gas Research Institute, Arco Oil and Gas, and Amoco Production Company provided financial and field support for Stanford during the acquisition phase of the study, while the National Science Foundation provided data analysis support. The National Science Foundation also provided primary support for the acquisition and analysis of the University of Arizona's piggyback study.

COLORADO PLATEAU PROFILE

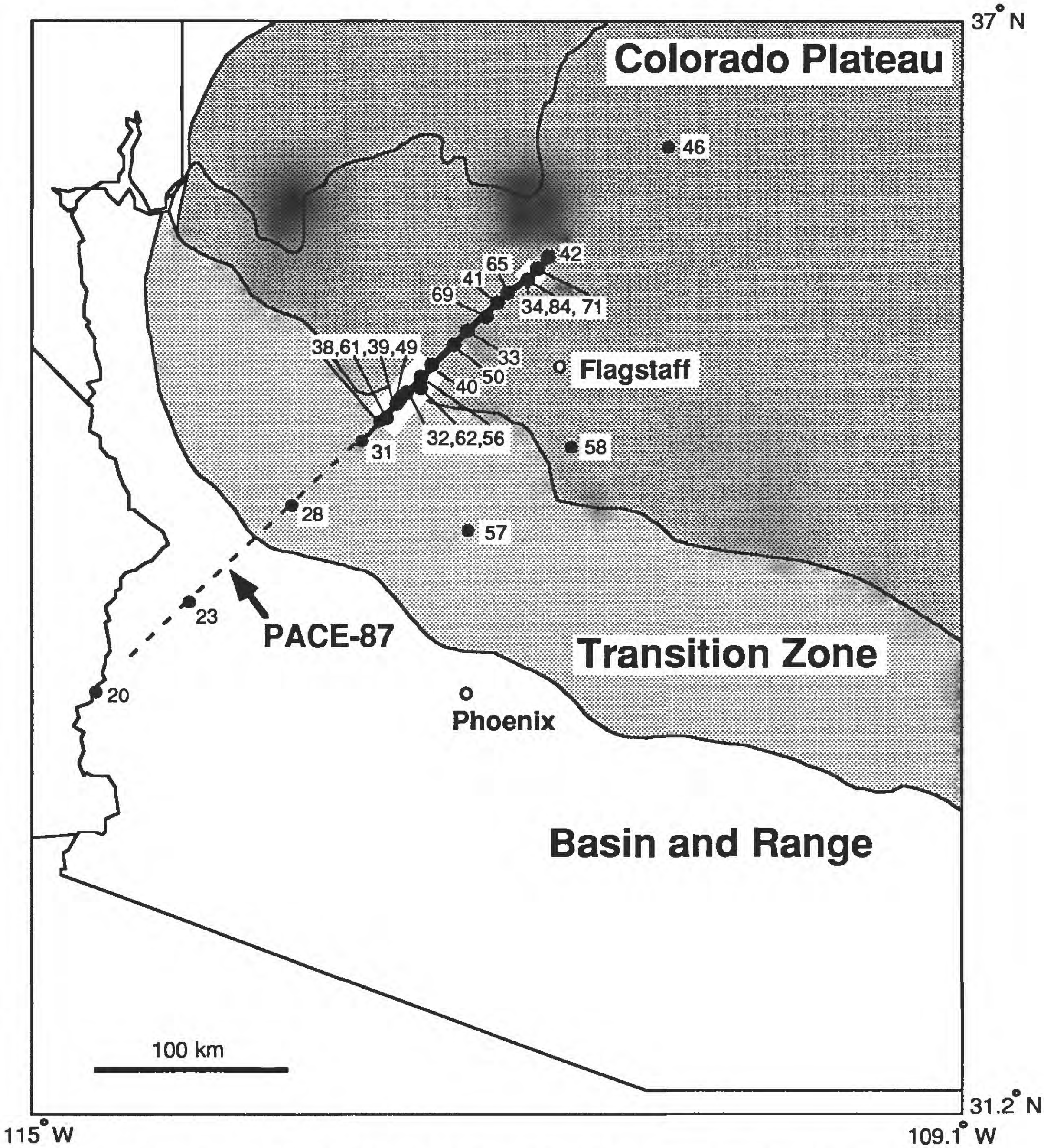

Figure 2a. Location of the PACE 1989Colorado Plateau profile. Black circles mark shotpoint locations; solid black line represents instrument deployment. Dashed line corresponds to location of 1987 PACE instrument deployment. White boxes denote the location of the Stanford (big box) and University of Arizona (small box) piggyback experiments.

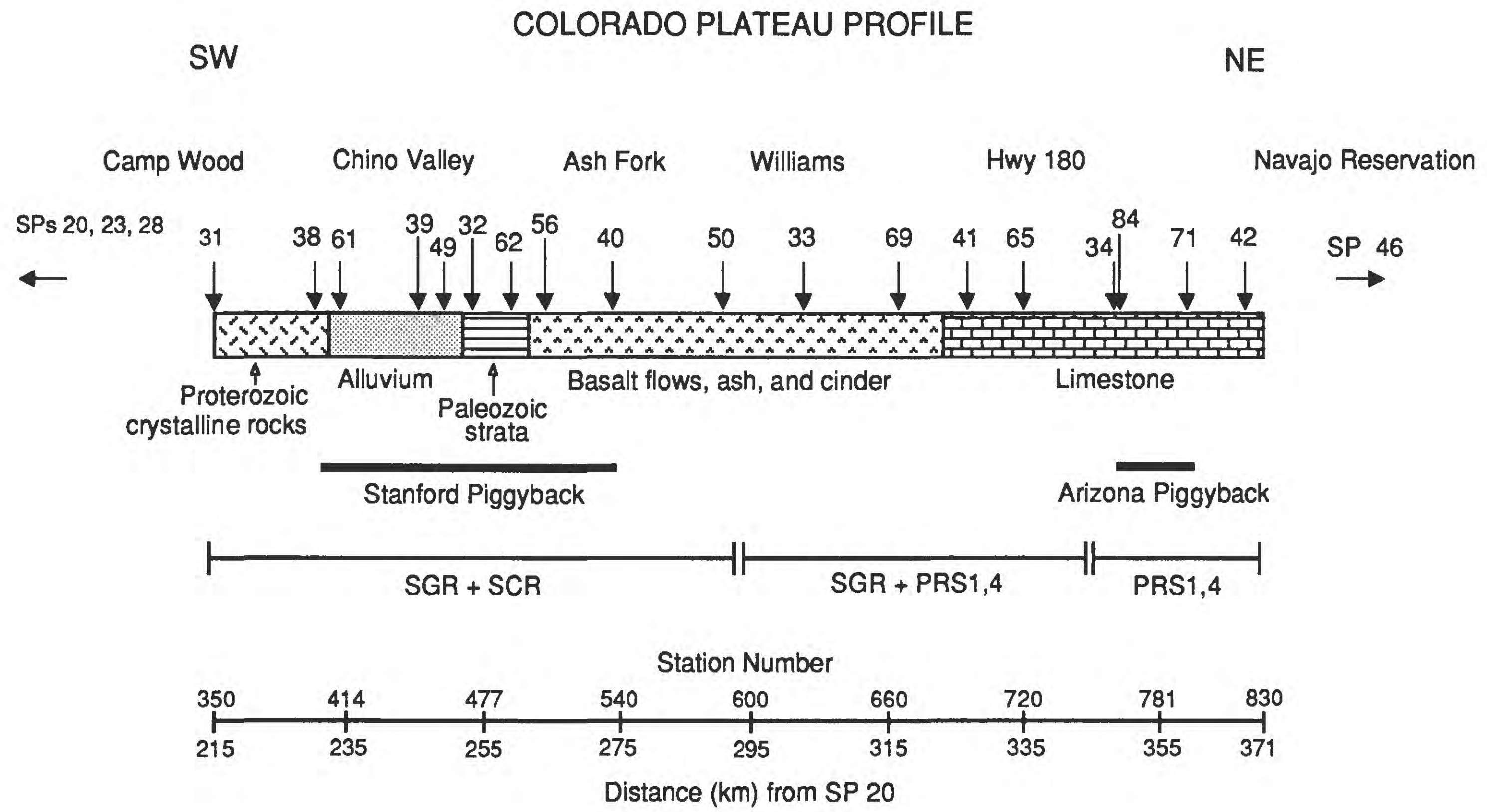

Figure 2b. Schematic diagram showing location of shotpoints (arrows), rock type (patterened squares), and receiver types on the PACE-89 Colorado Plateau Profile. Offset shotpoints are not plotted to scale. Receiver spacing is constant at 0.33 km . SGRs were interleaved with SCRs, PRS1s, and PRS4s to prevent large data gaps in the event of instrument failure. Data quality is affected by both receiver type and local surface geology (see text for more detailed discussion). The Grand Canyon profile intersects the Colorado Plateau profile on the northeast end of the line at SP 71, and the PACE-87 profile intersects the Colorado Plateau profile to the southwest, at SP 31. Location of Stanford University and University of Arizona piggybacks are shown.

The 1989 PACE experiment was also unusual in terms of the number of receiver channels deployed in the field. The USGS provided 120 analog seismic cassette recorders (SCRs), Stanford contributed 192 digital seismic group recorders (SGRs), the University of Texas, in conjunction with the University of Saskatchewan and the Geological Survey of Canada, provided 150 Canadian PRS1s and 13 PRS4s, and the Air Force Geophysics Lab contributed 30 DCS-302 Terra Technology digital cassette seismographs (the latter were deployed in-line on the Grand Canyon Profile only). All totaled, 462 receivers were used to record the Colorado Plateau profile and 490 stations recorded the Grand Canyon profile.

The Colorado Plateau Profile

The Colorado Plateau profile began at the northeastern end of the 1987 PACE profile and continued for 150 km across the northeastern half of the Transition Zone and the southwestern margin of the Colorado Plateau. The average instrument spacing along this profile was 333 m, and the average shot spacing was 10 km. A total of 24 shots were recorded; three of these shots were offset to the southwest of the recording line, one was offset to the northeast, and two were fan shots displaced approximately 80 km southeast of the receiver array (Fig. 2). The shots were detonated over a three-evening period. Locations of shot and receiver sites are listed in Appendixes A and B and are shown in Figure 2. Record-section plots are displayed in Appendix D.

The Grand Canyon Profile

The second refraction profile, referred to as the Grand Canyon profile, was oriented NW-SE and extended 150 km from just north of Flagstaff, Arizona, across the Grand Canyon, to Jacob Lake, Arizona (Fig. 3). This profile was designed both as a reflection profile with tight instrument and shot spacing, and a wide-angle profile with long receiver arrays and large shot-geophone offsets. To accomplish both of these objectives with a limited number of instruments, recorder spacing was varied along the length of the profile (Fig. 3b). At the southeast end of the line instrument spacing was 0.5 km for the first 20 km of the profile and then decreased to 0.1 km. The tight 0.1 km spacing was continued northwest for 35 km, before instrument spacing returned to 0.5 km for an additional 20 km. Across the Canyon, instrument spacing was further increased to 1.5 km. Seven backpackers deployed one instrument each down the south side of the Grand Canyon, while mules were used by the Air Force Geophysics Laboratory to deploy 15 instruments down the north rim. North of the Grand Canyon, 30 instruments were deployed by AFGL personnel at an average spacing of 1.2 km to Jacob Lake.

Shot spacing was also varied along the Grand Canyon profile (Fig. 3). Seven small shots were positioned within the 35-km-long dense, 0.1-km-spaced receiver grid, and an eighth fan shot was located approximately 10 km southwest of the line at the tie with the Colorado Plateau profile. The small, closely spaced shots provided near-vertical-incidence reflection data within the higher-resolution portion of the receiver array. Three larger explosive shots were also fired. Two of these were positioned on the north rim of the Grand Canyon -- one was located at the NW-end of the profile at Jacob Lake, and the other was located just north of the boundary of the Grand Canyon National Park. The third large shot was offset 75 km SE of the profile near Meteor Crater. These three large (3000-4000 lbs.) in-line shots provided the necessary shot-geophone offsets to record refractions and wide-angle reflections

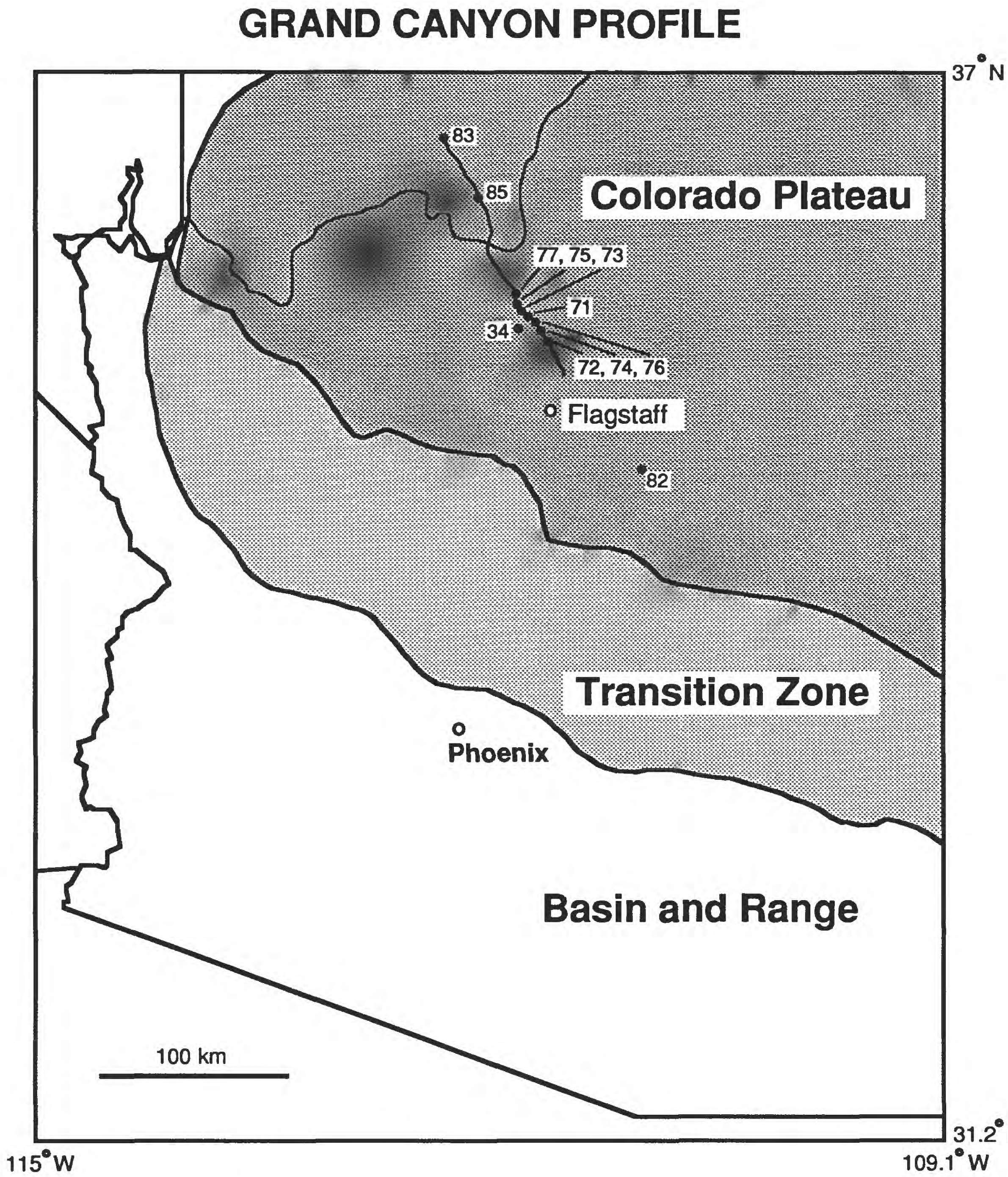

Figure 3a. Location of the PACE 1989 Grand Canyon profile. Black circles mark shotpoint locations (numbered); solid black line connecting shotpoints represents the approximate location of the receivers along the profile.

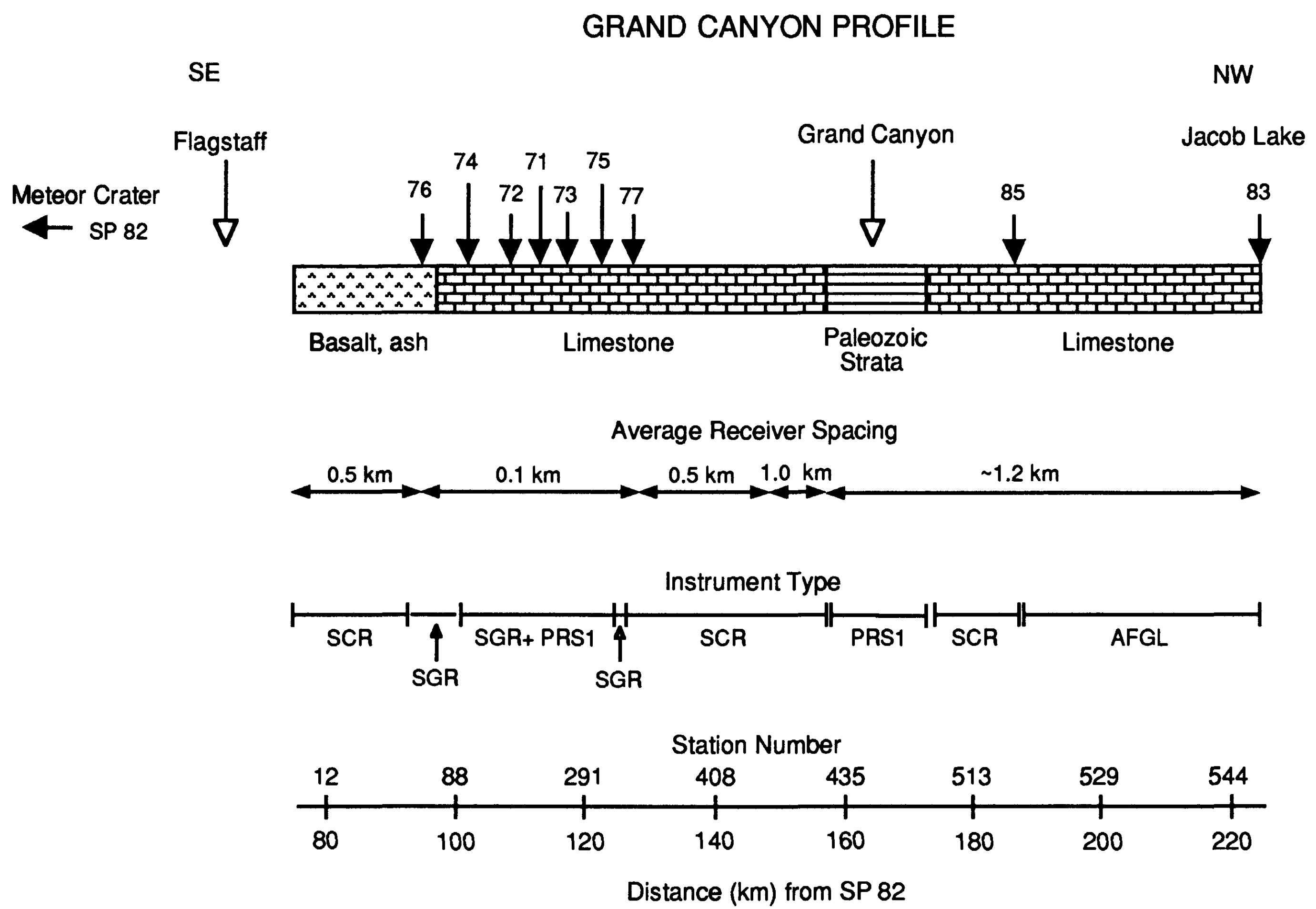

Figure 3b. Schematic diagram showing location of shotpoints (arrows), rock type (patterned squares), and instrument type along the Grand Canyon profile. Variation in receiver spacing is also shown. Note that instruments are spaced every 100 meters between SPs 76 and 77, and every to 1 to 2 km along the remainder of the profile. The location of SP 82 is not shown to scale. The Grand Canyon profile intersects the Colorado Plateau profile at SP 71. See text for details.

from structures deep in the crust. Locations of shot and receiver sites are listed in Appendixes A and B and are shown in Figure 3. Record-section plots are displayed in Appendix D.

A quarry blast from the Peabody Coal Company's Black Mesa mine, located ~150 km northeast of the recording array, was also recorded as a fan by the receiver array. Although energy carried from the shotpoint to the receiver array, the detonation time was not adequately determined, and thus these data have not been included in the data release, nor is the shot listed in the master shot list (Appendix A).

FIELD OPERATIONS

Drilling. Drilling commenced several months prior to the experiment so that the holes would be completed well before the experiment was to begin, and so that all the holes could be loaded in sequence. A total of 53 holes were drilled by Arizona Beeman Drilling Company between May and August of 1989. The holes were 8 inches in diameter and ranged between 100-200 feet in depth. Multiple holes were drilled at locations where larger shots were to be fired. At those sites the holes were perpendicular to the deployment line and spaced approximately 60 feet apart. Casing was necessary at several sites in order to keep the holes from caving in prior to loading.

Loading. Loading began two weeks prior to the experiment. Shot sizes ranged from 1000 to 8000 lbs. of explosives, and no more than 3000 pounds were loaded into an individual hole. Multiple holes were drilled where larger shots were desired. An Alpha Explosive pump truck from Lincoln, California, was used to load most of the holes. Several holes across the Kaibab Plateau were drilled into cavernous limestone and had to be loaded with bagged material from the pump truck to prevent loss through seepage and ground water circulation. A length of 50-grain primer cord with 1-pound cast boosters spaced at 8-foot intervals was lowered to the bottom of the hole. The pump truck pumped the material from the bottom of the hole up until the predetermined amount of explosive was in the hole, usually about 60 feet from the top. The remaining 60 feet was then filled with cuttings from the hole.

Shooting. After each hole was loaded, the primer cord was tied off inside a metal cap that fit over the top of the casing. This cap was then locked onto the casing via steel pipe through holes in the cap and top of the casing. The hole caps secured the hole until the shot was ready to be fired. A few minutes before shot time, an instantaneous detonator (cap) was attached to the primer cord and then to the shot line, which was wired to the shooting system about 500 feet away. The heart of the shooting system was the master clock, which had a minimal drift (< 4 milliseconds per day) and provided the time reference for the entire experiment. (In addition to the shots, the master clocks were also used to time the recording instruments.) Just before the shot time, the shooter charged up the blaster and pushed the fire button. At the shot instant, the master clock sent a pulse that fired the electronic cap and sequentially caused the primer cord, boosters, and blasting agent to detonate. The shot origin time, defined as the time that the cap fired; was typically 6 ms after the desired shot time, due to delays in the electronics. The shot times and charge sizes are listed in Appendix A and shot-hole information can be found in Appendix C. The reported shot times are accurate to within ± 1 ms.

Surveying. Two Global Positioning System (GPS) receivers (Trimble Navigation Path Finders) were used to determine locations and elevations for all receiver stations and most shotpoint sites. The GPS receivers were used in differential mode and provided horizontal locations accurate to within approximately 5 m and vertical positions accurate to within 10 m. PACE 1987 locations were used for those shots that were reoccupied from the earlier study (SPs 20, 28, 31, 32, 33, and 34). These 1987 locations were determined from 1:24,000 topographic maps and are accurate to within 50 m. For SP 23, two separate sites were used during the two studies. The 1989 site was located 0.5 miles to the east of the 1987 site in order to accommodate a much larger shot (6000 lbs. versus the 3000 lbs.) without damaging existing structures in the area. Because the 1989 site for SP 23 was displaced in a direction perpendicular to the receiver array, and because the shotpoint was offset a minimum of 135 km from the receiver array, the 1987 coordinates were used for the 1989 site. This then allowed the data from both studies to be merged into a composite record section with only a minimal (<100 ms) timing shift.

Instrument Recording. PACE 1989 was the first experiment to use the SGRs in a delay-turn-on programmable mode. For this reason the instruments were interleaved with SCRs and PRS1s on the Colorado Plateau profile to minimize the potential impact if the new turn-on method were to fail catastrophically. The SGRs were thus deployed every other station, beginning at the southwest end of the profile where they were interleaved with SCRs (Fig. 2b). Once all 120 of the SCRs were deployed, the PRS1s were inserted in the array, and they then alternated with the SGRs until finally only PRS1 instruments remained. The final 25 km of the Colorado Plateau profile consisted entirely of PRS1 instruments deployed every 333 m. Although this approach was adopted because it provided a minimum-risk approach to data acquisition, it did degrade the lateral trace-to-trace continuity of wide-angle reflections and refractions. This effect is evident in the record section plots (Figs. 8 to 31) and results from contrasting geophone and instrument responses (see discussion of data quality below).

On the Colorado Plateau profile the SGRs were programmed to record for 99 s with no turn-on delays. A maximum of 14 records could be written to the shorter (400-ft) cassette tapes given this record length and the 0.002-s sample rate. Other recording systems also had limitations. The Stanford piggyback effort utilized a recording system provided by Arco Oil and Gas Co. which required 2 to 3 minutes between shots to down-load its 800 channels of data to tape. The SCRs, on the other hand, recorded continuously in three 10-minute windows, and thus were better suited for short time intervals between shots. Given these various instrument restrictions and the large number of shots (24) on the Colorado Plateau Profile, the line was divided into three separate nights of recording, with tape swaps for the SCR and SGRs occurring each day following shooting. Even with 3 nights of shooting, not every instrument group was able to record all of the shots. The SCRs did not record SP 61, for example, which was a small shot added to the experiment by Stanford — fortunately, the dense Stanford array in the vicinity of this shot overlapped the SCRs and minimized the impact of this data loss. Similarly, the Stanford piggyback did not record several of the shots northeast of their receiver array, but they were able to record all of the shots within and southwest of Chino Valley.

Unlike the Colorado Plateau profile, the Grand Canyon profile was recorded in a single 24-hour period. The 12 shots on this profile (some with 60-s versus 99-s record lengths) could easily be recorded on a single SGR cassette tape. In addition, Stanford did not participate in this portion of the PACE study, and thus the limitations of the Arco recording system were not a factor. The only shotpoint that could not be recorded by all instrument types on the Grand Canyon profile was the Peabody Coal Company quarry blast. The SCRs did not have a sufficient number of recording windows to accommodate this daytime shot. The Terra Technology seismographs on the north rim of the Grand Canyon also did not record the quarry blast.

The instrument deployment strategy used on the Grand Canyon profile (Fig. 3b) contrasted somewhat with that described above for the Colorado Plateau profile. The SCRs and Terra Technology seismographs were deployed primarily at the southern and northern ends of the profile respectively, where instrument spacing averaged 0.5-1.2 km. The SGRs and PRS1s, in contrast, were deployed in the central 35-km-long higher-resolution portion of the study. As before, the SGRs and PRS1s were interleaved, although there were fewer PRS1s than SGRs and thus the southernmost 5 km of this dense array consisted entirely of SGRs. Because of their compact size and overall reliability, 15 of the PRS1s were also used in the ~15-km-long backpacker/mule deployment across the Grand Canyon.

INSTRUMENTATION

Five different types of recording instruments were used during this experiment: USGS's Seismic Cassette Recorders (SCR), Geological Survey of Canada's PRS1s and PRS4s, Stanford's Seismic Group Recorders (SGR), and the Air Force Geophysics Laboratory's DCS-302 Terra Technology seismographs. A general description of all but the DCS-302 TERATEKs is given here. For more detailed descriptions see Murphy (1988) regarding the SCRs and Asudeh and others (1992) regarding the PRS1s and PRS4s.

The SCRs are a six-chanel, single-component instrument consisting of a Mark Products L-4C 2-Hz vertical geophone, a set of three parallel amplifier boards with adjustable gain settings, a clock (temperature-compensated oscillator, TCXO) a VCO (voltage controlled oscillator), and a cassette recorder (Murphy, 1988; Fig. 4). The use of three parallel amplifier boards with gains set so that the dynamic ranges of the amplifiers overlap, affords a variable total dynamic range. The three data carrier frequencies, the clock carrier frequency, and a tape-speed compensation carrier frequency are summed and recorded on cassette tape. All three data channels and the time code signal (IRIG E) are frequency modulated. During the digitizing process, the cassette tapes are played back and the signals are demultiplexed and demodulated. To prevent accidental shifting of the data-carrier frequencies, the tape-speed compensation carrier frequency matches a locally generated reference frequency. A 12-bit analog-to-digital (A/D) converter converts the signals to digital data; the data are then sampled at 200 samples per second and are stored on optical disks. The amplitude response is roughly flat between 2 and 30 Hz (Fig. 5), and the approximate ground motion, $A_g(t)$, in cm/s, for this frequency range can be calculated from the following expression:

$$A_g(t) = 1.541 * 10^{-8} * 10^{(a/20)} D_m$$

where a = attenuation setting of the pre-amplifier (usually 12, 30, or 48); D_m = measured peak-to-peak amplitude in digital counts (Kohler and Fuis, 1989).

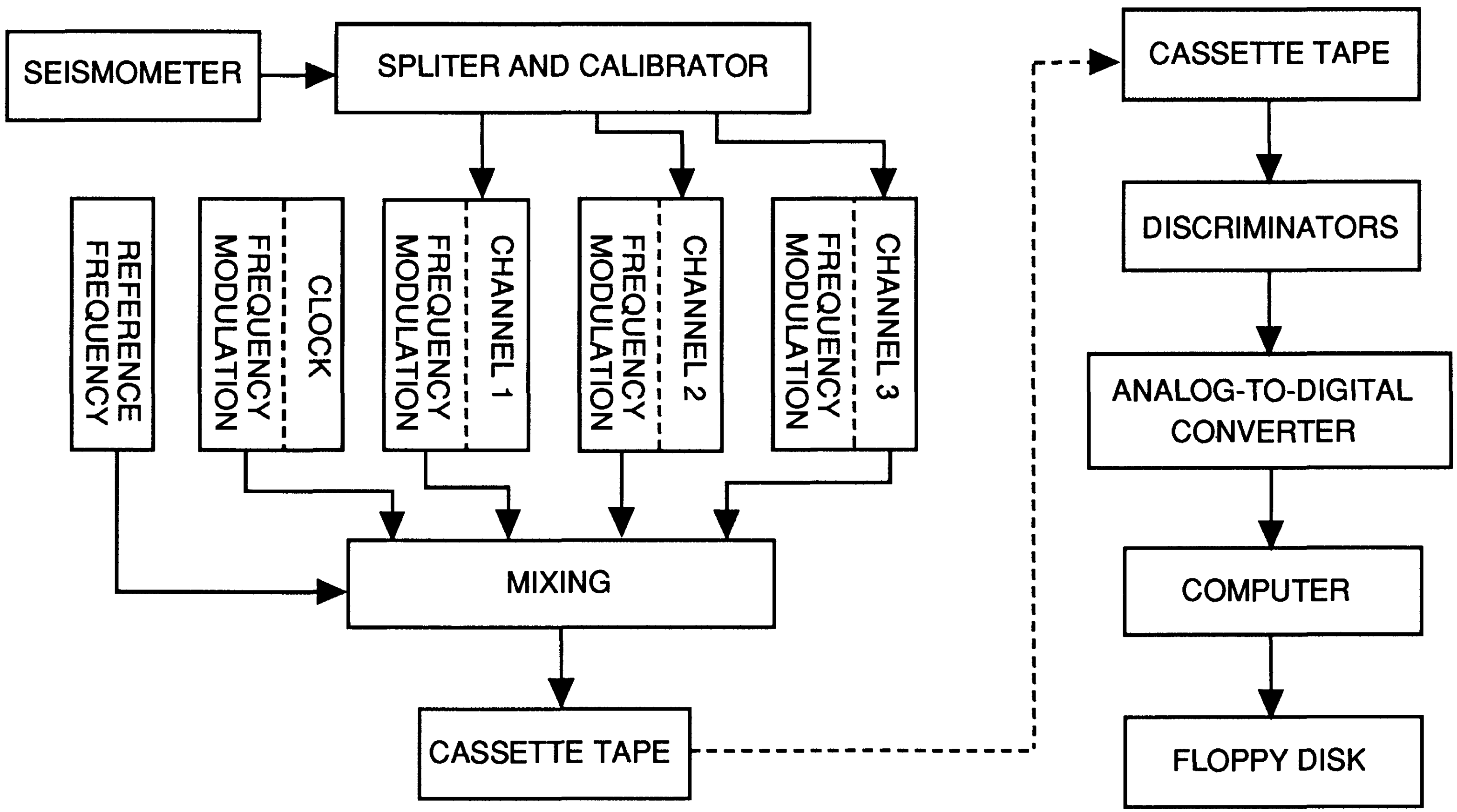

Figure 4. Schematic diagram of the Seismic Casette Recorder (SCR) data acquisition and processing system. Figure from Murphy and others (1993).

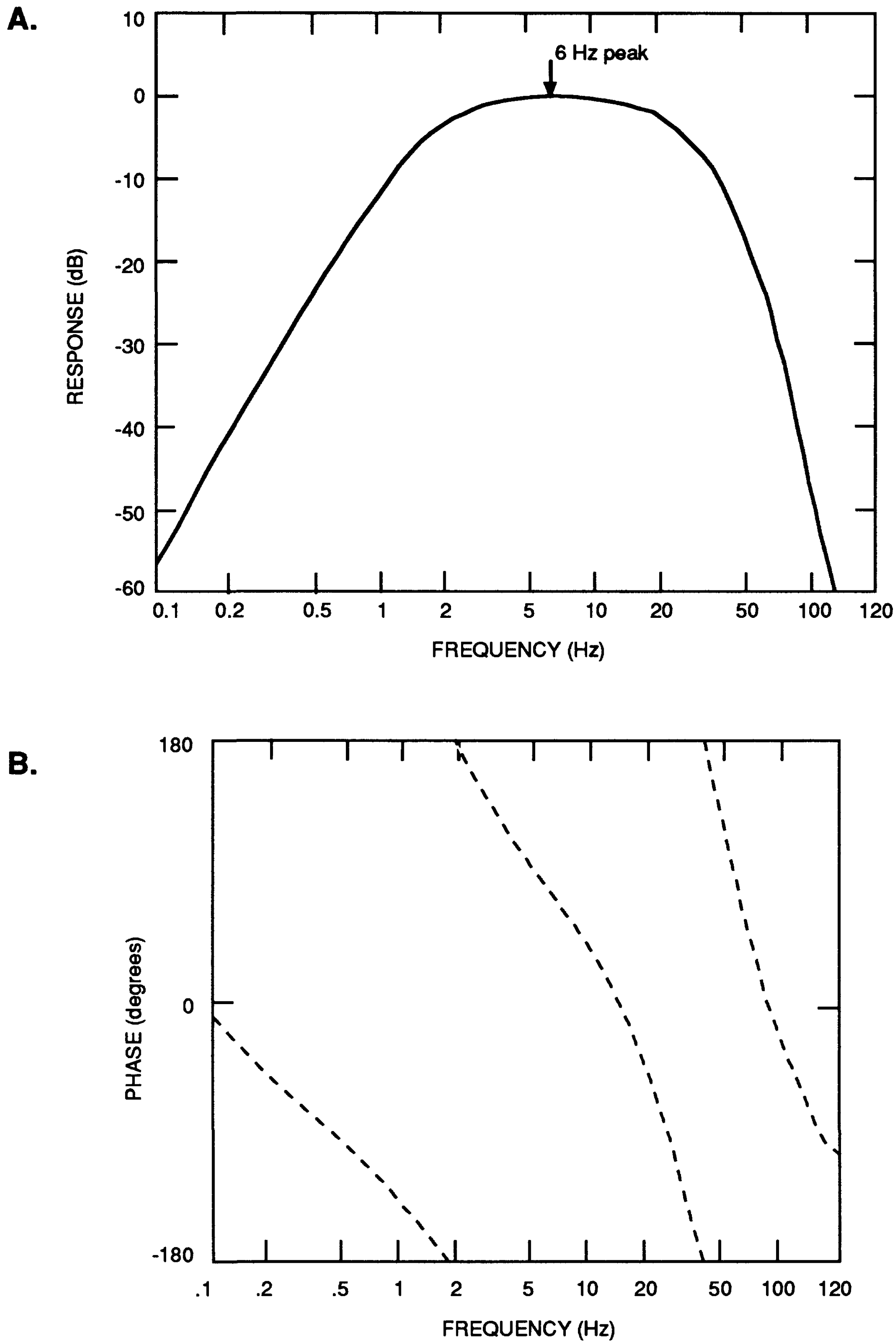

Figure 5. Theoretical amplitude (A) and phase (B) response for the USGS seismic cassette recorder (SCR) and digitizing system with a Mark Products L-4C geophone (2 Hz). (From Dawson and Stauber, 1986).

Phase characteristics are shown in Figure 5b. Prior to deployment, the clock in each unit is synchronized to a USGS master clock which drifts approximately 1 ms per day and is checked periodically against satellite clocks. When the cassette recorders are retrieved, a clock drift is measured and these data are used to calculate chronometer corrections at shot time (assuming linear drifts). Most clocks drift less than 20 ms during a 24-hour period.

The PRS1s (Asudeh and others, 1992) are also single-channel instruments that use a Mark Products L-4C 2-Hz vertical-component geophone. Automatic gain-ranging from 1 to 1024 in binary steps allows a total dynamic range for these instruments of 132 dB. Seismic data are sampled at 120 samples per second by a 12-bit A/D board and stored in memory (DRAM) until the data are uploaded to a PC. The response curves for the overall system are shown in Figure 6. The amplitude response peaks about 5 Hz. Timing is provided for each unit by a temperature-compensated oscillator (TCXO) that is synchronized to VCT via satellite during the programming (or downloading) process. After retrieval of the instruments, the clock drift is measured for each instrument and clock corrections are made assuming linear drift rates. Most clocks drift less than 20 ms during a 24-hour period. The PRS1s were designed by the Geological Survey of Canada and built by EDA Instruments Ltd. (now Scintrex Limited of Toronto). The PRS4s are similar but permit 3-channel recording capabilities.

The SGR III recorders were designed by Amoco Production Company, built by Globe Universal Sciences, Inc., and modified by the USGS. The seismograph is a single-channel digital seismic recorder with a theoretical dynamic range of 156 dB. Data are sampled at 500 samples per second by a 12-bit A/D board with gain ranging from 0-90 dB in 6 dB steps. The Stanford SGRs have been modified to turn on at pre-set times instead of using the standard radio turn on. Timing is provided by a temperature-compensated internal oscillator (TCXO) that is synchronized to a USGS master clock prior to deployment. Like the SCRs and PRS1s, most SGR clocks drift less than 20 ms during a 24-hour period. The digital data and the clock drift at the time of instrument retrieval are recorded on cartridge tape. The drift rates (assumed to be linear) are used to calculate chronometer corrections at shot time. For this experiment, the SGR III pre-amplifier was set to 50 mV, the low-cut filter was "out", and the 60-Hz notch filter was "in". Figure 7b shows the phase characteristics associated with these filter settings.

Three different geophone types were used in conjunction with the SGRs on the PACE-89 experiment. One hundred and seventy modified 6-phone (connected in-series) strings of Mark Products L-10B vertical-component phones (8 Hz) were the primary geophone used in the study. The total system response for this configuration is shown in Figure 7. In addition, 20 single Mark Products 8-Hz phones and 2 Mark Products L-4C 2-Hz vertical-component geophones were deployed. Although the single-phone 8-Hz strings were much simpler and faster to deploy, they produced about one-half the signal strength and are thus not recommended for future use. The L-4C 2-Hz phones were the most compatible with the SCR and PRS1 recorders. For this reason, the phones have since been used on several long-offset refraction experiments in conjunction with these other instruments. Because of the three types of geophone configurations used with the SGRs in the PACE 1989 study, amplitudes had to be corrected for geophone type (empirically-determined scalars of 4, 9, and 19 were applied for L-4C, single, and 6-string geophones, respectively). Co-location studies were also conducted following the experiment to derive an empirical scalar of

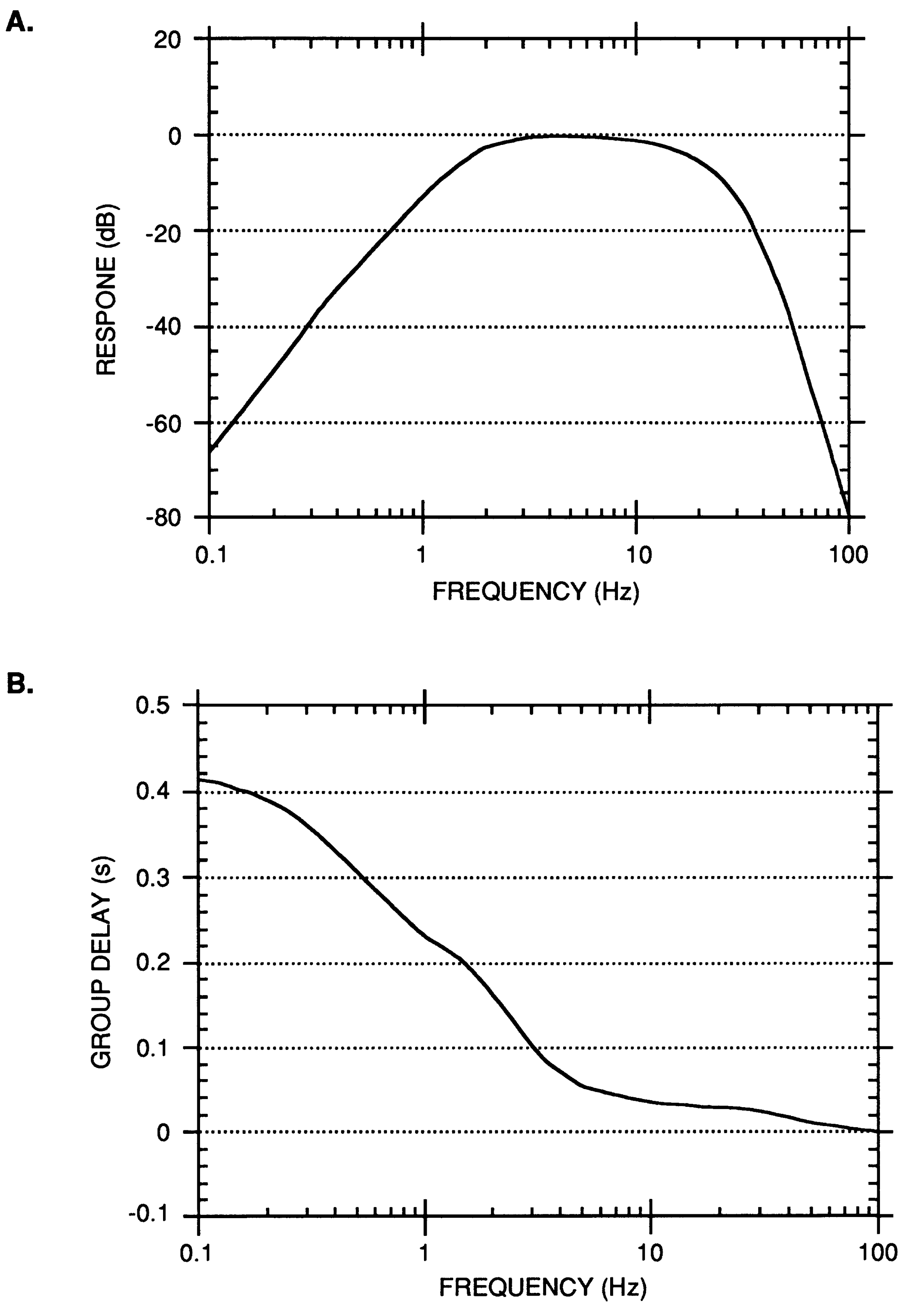

Figure 6. The amplitude (A) and phase (B) response for the PRS1 with the Mark Products L4-C geophone (2-Hz). Figure from Murphy and others (1993).

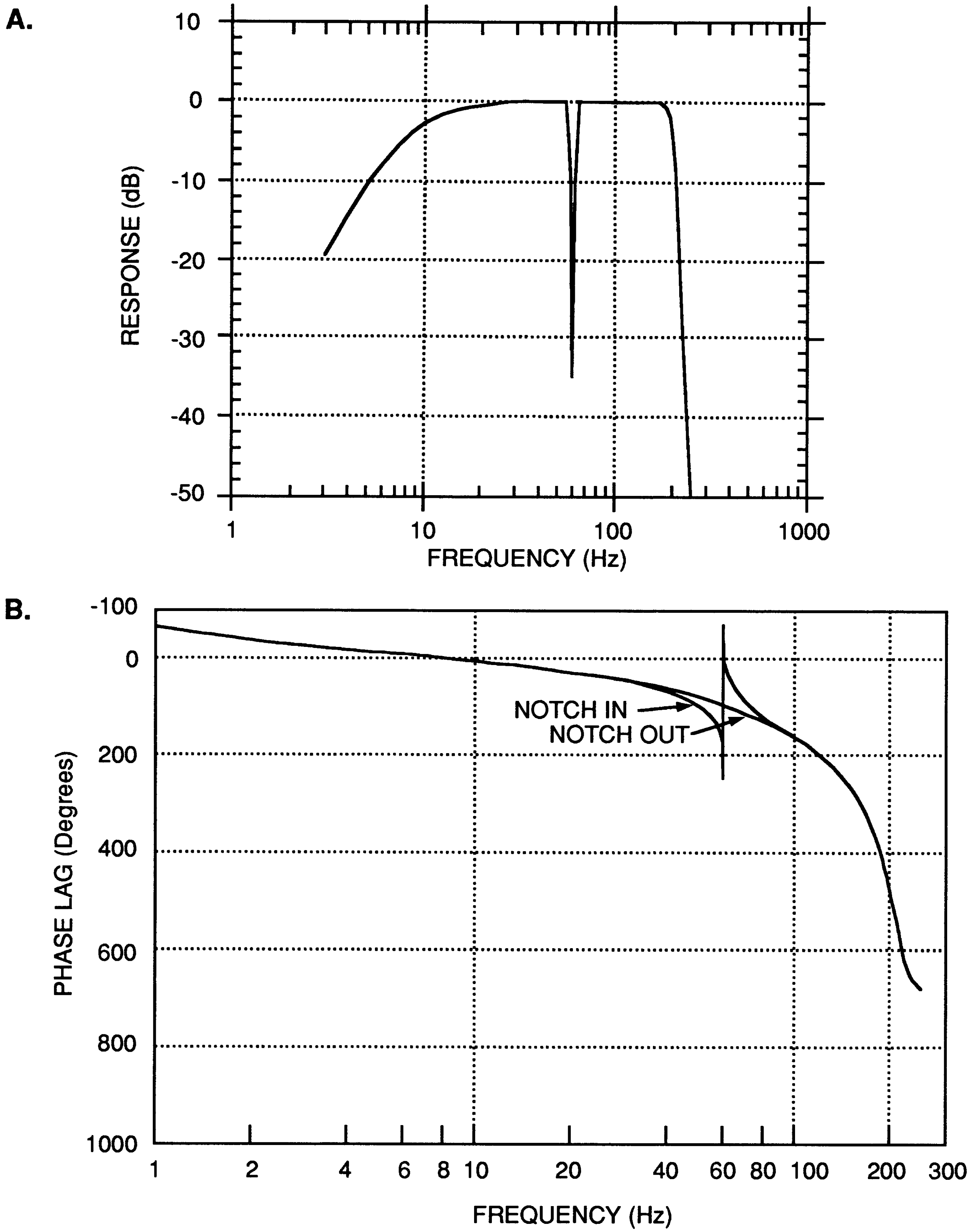

Figure 7. The amplitude response (A) and phase characteistics (B) of the SGR IIIs with filters as described in the text. The effect of the Mark Products L10-B geophone string is included in (A) but not in (B). Figure from Murphy and others (1993).

595200 which, when applied to the data, normalizes amplitudes to be approximately equivalent to SCR and PRS1 values (nm/sec/digital_count).

Many of the connectors used to link the geophones and SGR IIIs were wired incorrectly and yielded negative polarities for over half the SGRs. The SGR data were thus visually inspected for polarity reversals, and trace polarities were modified accordingly.

PIGGYBACK STUDIES

There were several smaller "piggyback" studies conducted during the 1989 PACE study. Each of these studies is described briefly below. Note that the data acquired in these piggyback studies is not included in the data release available through the National Geophysical Data Center.

Stanford. Stanford University deployed a 45-km-long recording array centered about Chino Valley, Arizona, to record the 24 shots of the Colorado Plateau profile. This piggyback study utilized an 800-channel GUS-1000 cable system provided by Arco Oil and Gas Co., and 210 two-channel SGR-IVs combined with 458 SGR-IIIs provided by Amoco Production Company and operated by Grant Norpac Inc. A total of 1678 channels were recorded at 924 stations with an average station spacing of 50 m. Areas with sensitive upper-crustal targets had station spacings of 25 m. Several short (1-5 km) 3-component arrays were positioned strategically along the 45-km reflection spread. Intermittent, short, closely spaced 3-component arrays were chosen over widely spaced 3-component stations covering the entire line so that P- and S-wave data could be compared at the same, close station spacing. Twenty-four large explosions were shot into the spread at offsets ranging from 0 to 250+ km. The Stanford reflection spread constitutes a 45-km-long high-resolution "window" embedded in the larger regional refraction array and has been used to assess the structural transition at the southwest physiographic margin of the Colorado Plateau (Howie and others, 1991; Howie, 1991; Parsons and others, 1992).

Arizona. The University of Arizona deployed a 192-channel, 9.6-km-long recording spread between shotpoints 84 and 71 along the azimuth of the Colorado Plateau profile (Johnson and Hartman, 1991). Station spacing was 50 m, with vertical- and horizontal-component geophones interleaved at alternating stations. This Arizona spread remained fixed during the course of the experiment, and thus this spread recorded in-line data during the shooting of the Colorado Plateau profile and fan data during the recording of the Grand Canyon profile. Multielement, 20-m geophone arrays were aligned along a NE azimuth; within the horizontal-component geophone arrays, elements were oriented parallel to the azimuth of the Colorado Plateau profile. Individual and composite shot records generally exhibit very high signal-to-noise ratios (S/N) for both P- and S-wave reflected and refracted arrivals. Although weak shear-wave arrivals are recorded on the vertical-component geophones, deployment of horizontal-component geophones resulted in much higher S/N for shear arrivals than would have been possible with the deployment of vertical-component geophones alone.

Williams Array. During the 1989 PACE experiment, the Solid Earth Geophysics Branch of the Geophysics Laboratory of the US Air Force, in conjunction with Weston Observatory of Boston College, operated a small aperture seismic array near the center of the NE-SW Colorado Plateau profile at Williams, Arizona, approximately 30 km west of Flagstaff (Battis, 1990). The 16-elements of the array were distributed along two cross arms of 435 and 350 m in length with the greater arm aligned with the trend of the main shot line. Data quality from this piggyback was only marginal due to the highly attenuating volcanic ash and cinder that blanketed the surface in the region.

North Rim Fan. The Air Force Geophysics Laboratory deployed 30 instruments from the north rim of the Grand Canyon to Jacob Lake, ~40 km to the NW (Wolf and Cipar, 1993). This spread remained approximately stationary during the shooting of the two PACE refraction profiles (some instruments were repositioned to different stations within the north rim array; see Appendix B). As a result, the shots from the Colorado Plateau profile were recorded as fans into the AFGL array, while the shots from the Grand Canyon profile were recorded in-line and extended this profile by 40 km. Only the AFGL data recorded in-line have been merged with the SCR-SGR-PRS1 data and are available through the National Geophysical Data Center.

Flagstaff Peaks. The University of Texas at El Paso, in conjunction with Texas A&M, deployed 27 PRS4 instruments in the vicinity of the San Francisco Peaks, parallel to, but off-axis from, the main Colorado Plateau profile. This spread is only 55 km long, but provides three-dimensional control to the structures determined from the Colorado Plateau profile (Durrani and others, 1992).

Meteor Crater Array. Following the recording of the two PACE refraction profiles, the PRS1 instruments were redeployed at 0.1-km-spacing in the vicinity of Meteor crater, 35 miles east-southeast of Flagstaff. Two small shots were fired into this array, which was located near the southern margin of the Colorado Plateau. These shots were co-located and were all approximately 100 lbs. each. The goal of this study was to try to image the deep reflections (16 s two-way traveltime) described by COCORP (Hauser and Lundy, 1989) with an explosive instead of a Vibroseis source.

Three-Component Recording. A limited number of three-component instruments were deployed at 2 km station spacing on both of the wide-angle reflection/refraction profiles. Ten of these instruments were GEOS and 18 were PRS4s (13 from the GSC and 5 from the USGS). These instruments were deployed across the northeastern portion of the Colorado Plateau profile (southwest of the tie with the NW-SE line) and the central portion of the Grand Canyon profile (centered about the tie with the NE-SW line). The vertical-component data from the PRS4s have been merged with the other vertical-component SCR, SGR, and PRS1 data and are available through the National Geophysical Data Center.

DATA QUALITY

Displays of the in-line shots recorded during the 1989 PACE experiment are presented in Figures 8 to 42. The data are reduced at 6 km/s (except for SP 20, which is reduced at 8 km/s) and are bandpass filtered from 7-35 Hz. The plots are pseudo-true amplitude: amplitudes are normalized within each trace and are laterally balanced to correct for the loss of energy with increasing distance away from the shot. Because of the difficulty in generating high-quality record-section displays when data are recorded at dramatically different trace spacings along a single profile, the cross-line plots, Figures 32 to 42 have been subsampled to a minimum trace spacing of 500 m. Thus, within the tightly spaced 0.1-km spaced portion of the receiver array, only one out of every five traces is plotted.

The record sections have several general characteristics that can be attributed to variations in the regional geology from the Arizona Transition Zone across the Colorado Plateau. In general, the first-arrival times are approximately flat (compare to the PACE 1985 and 1987 studies across the southern Basin and Range province), indicating only minor amounts of structural disruption of the upper crust. Two exceptions to this general rule are evident. On the Colorado Plateau profile, first arrivals are delayed approximately 0.2 s across Chino Valley due to the increase in slow-velocity sediments (e.g., see SP 31 between 35 and 50 km offset, Fig. 11). The opposite effect is seen on the Grand Canyon profile across the Grand Canyon. Here travel times are advanced 0.25 s due to the removal of slower-velocity Paleozoic strata (e.g., see SP 75 between 35 and 45 km offset, Fig. 37).

The single most important factor controlling data quality is the rock type at both the source and the receiver (see summary of lithologies and wet/dry conditions for each shotpoint in Figs. 2 and 3 and in Table C; see also Kohler and Fuis, 1992 for summary of relationship between shotpoint site condition and recording distance). Wet sources (e.g., SP 20, Fig. 8) produced the strongest seismic source. Shots located in hard rock sites such as granite (e.g., SP 31, Fig. 11) also produced good seismic energy. Shots fired in either dry alluvium (e.g., SP 61, Fig. 26) or volcanic cinder (e.g., SP 50, Fig. 22) were the least efficient. Limestone shotpoints were also not as effective as crystalline rock or saturated alluvium, due to the cavernous conditions at many of the shotpoints. Data recorded from limestone shotpoints typically have lower signal-to-noise ratios and are highly reverberatory (e.g., SP 77, Fig. 39).

Because rock type varies systematically across the PACE 1989 study area, there is a strong regional variation in data quality. The greatest signal-to-noise ratios were consistently recorded across the Arizona Transition Zone, where Precambrian crystalline rocks are exposed at the surface (Fig. 2b). Data quality decreases dramatically across the Colorado Plateau (between SPs 32 and 42, Fig. 2), where volcanic ash and cinder deposits of the Flagstaff volcanic field predominate. Similarly, because the shots of the Grand Canyon profile were situated almost exclusively within the limestone of the Kaibab Plateau (Fig. 3b), which is cavernous and elevated well above the regional water table, many of the recorded arrivals are reverberatory in nature and secondary reflections are rare.

One final factor that has affected phase correlation and data quality is instrument type. The different recording instruments each have a unique instrument response, and when these instruments are interleaved, the resulting waveforms have different phase and frequency characteristics. In the absence of any post-experiment wavelet processing, this results in a degradation in the trace-to-trace phase coherency. The SGRs were interleaved with SCR and PRS1 recorders across most of the Colorado Plateau profile. However, PRS1 instruments are deployed exclusively along the northeast 25 km of the profile (Fig. 2b), resulting in improved trace-to-trace coherence (e.g., see the improved data quality northeast of 130 km offset on SP 31, Fig. 11). Thus in the future, we recommend not interleaving different instrument types.

DATA REDUCTION

The raw data recorded by the SGRs, SCRs, PRS1, PRS4, and Terra Technology seismographs all had different sample rates, trace lengths, reduction velocities, instrument responses, and data-tape formats. Prior to merging these different data sets, the following data reductions steps were applied.

- Resample data to 8 ms

- Update miscellaneous headers
  Write SP to bytes 17-20 (INT format) and to bytes 225 (ASCII format)
  Write Shot to bytes 9-12
  Write FFID to bytes 233-236 (ASCII format)
  Write shot charge size to CHARGE, bytes 179-180.
  Write azimuth (in degrees) to AZIMUTH, bytes 219-220
  Write original offsets (SCR and PRS instruments) to XOFFSET, bytes 237-240.

- Write instrument type into header INSTRU (bytes 215-216)
  1=SCR
  2=SGR
  3=PRS1
  4=PRS4
  5=AFGL

- Modify CHAN in trace header (bytes 13-16)
  CHAN = station number for Colorado Plateau profile
  CHAN = (station number-2000) for Grand Canyon profile

- Apply DISCO geometry and write values into trace headers
  Soffset (bytes 37-40)
  Relev (bytes 41-44)
  Selev (bytes 45-48)
  Sdepth (bytes 49-52)
  Sdatum (bytes 53-56)
  Rdatum (bytes 57-60)
  Sht-X (bytes 73-76)
  Sht-Y (bytes 77-80)
  Rec-X (bytes 81-84)
  Rec-Y (bytes 85-88)
  CDP-X (bytes 61-64)
  CDP-Y (bytes 65-68)
  CDP-Stat (bytes 181-182)
  Sht-Stat (bytes183-184)
  Rec-Stat (bytes 185-186)

- Apply Geophone gain corrections. Amplitudes converted to nm/s/digital_count.
  Original gain corrections copied into header GAIN (bytes 177-178).
  Once applied, INGCONST (bytes 121-122) reset to 1.
  Gain correction information not available for AFGL seismographs.

- Apply drift corrections for SGR, PRS1, PRS4, and AFGL seismographs only.
  Drift corrections already applied to SCRs during digitizing process.
  Original drift values copied into header DRIFT (bytes 175-176).
  Once applied, drift values reset to zero (header COR, bytes 217-218).

- Correct shot timing errors for SGRs and AFGL seismographs (shot timing errors were previously applied to SCRs, PRS1s, and PRS4s).
  Shot timing errors ranged between 6 ms and 2132 ms.

- Reduce all data to 8 km/s, with each trace beginning at -1 s.
  Store reduction time plus -1s time shift in TTRACE (bytes 209-212).
  Create header TAPPLY (bytes 213-214) and set equal to 1.
  To unreduce data, apply values in TTRACE (ms).
  Sort data by shotpoint and offset.

- Update shot and receiver turn-on times in headers.
  Adjust shot times to reflect ideal detonation times (no delays).
  (SHOUR, bytes 191-192; SMINUTE, bytes 193-194; SSEC, bytes 195-196)
  Adjust receiver turn-on times to equal ideal shot times (no delays or drifts).
  (HOUR, bytes 161-162; MINUTE, bytes 163-1164; SECOND bytes 165-166).

- Additional corrections for the SGRs included:
  Omit dead traces generated by transcriber.
  Flip polarities on reversed geophone cables.
  Correct amplitudes for different geophone types.
  Edit data and delete bad traces.
  Reset TRACEID header to 1 (bytes 29-30).

Forty-two seconds of data sampled at 8 ms were output to 8 mm Exabyte tapes in 32-byte IBM float format following the Geological Survey of Canada's Lithoseis 3.00 SEGY refraction format. These data are reduced at 8 km/s and begin at -1 s. Trace start times were modified to equal shot times; <u>these trace start times have not been adjusted to account for the 8 km/s reduced times or the -1 trace start time</u>. To unreduce the data, apply the times stored in the header "TTRACE" (bytes 209-212). Receiver and shot static corrections were computed and stored in the trace headers but were not applied to the data.

ARCHIVE DATA TAPE FORMAT

The Pace-89 data tape is written in standard SEG-Y 32-bit IBM floating point format (Barry and others, 1975). The data are written to 1600-bpi Exabyte tapes and each tape has the standard SEG-Y EBCDIC reel header. Minor modifications to the trace headers allow refraction data to be archived in this format. A list of the header fields used for this data set is shown below.

Trace Identification Header (total of 240 bytes)

Bytes	Header	Explanation	Length:	Type:
9 - 12	SHOT	Shot number	4	INT
13 - 16	CHAN	Channel	4	INT
17 - 20	SP	Shotpoint number	4	INT
21 - 24	CDP	Common depth point number	4	INT
29 - 30	TRACEID	Trace ID code (=1, seismic)	2	INT
25-29	SEQNO	Sequential trace number in gather	4	INT
37 - 40	SOFFSET	Signed shot-receiver offset	4	INT
41 - 44	RELEV	Receiver elevation (m)	4	INT
45 - 48	SELEV	Shot elevation (m)	4	INT
49 - 52	SDEPTH	Shot depth (m)	4	INT
53 - 56	RDATUM	Receiver datum statics	4	INT
57 - 60	SDATUM	Shot datum statics	4	INT
61 - 64	CDP-X	X coordinate of CDP (m)	4	FLT
65 - 68	CDP-Y	Y coordinate of CDP (m)	4	FLT
71-72	CO-SCAL	Scalar for all coordinates in bytes 41-68	2	INT
73 - 76	SHT-X	X coordinate of shot (m)	4	FLT
77 - 80	SHT-Y	Y coordinate of shot (m)	4	FLT
81 - 84	REC-X	X coordinate of receiver (m)	4	FLT
85 - 88	REC-Y	Y coordinate of receiver (m)	4	FLT
89 - 90	COORUNIT	Coordinate units (=1, meters)	2	INT
91-92	WVEL	Weathering velocity	2	INT
93 - 94	SUBWVEL	Subweathering vel (=6000 m/sec)	2	INT
109-110	DELAY		2	INT
115 - 116	NSAMPLES	Number of Samples (=5250)	2	INT
117 - 118	SRATE	Sample rate (=8 milliseconds/smp)	2	INT
119 - 120	GAINTYPE	Gain type	2	INT
121 - 122	INGCONST	Gain constant (=1)	2	INT
123 - 124	INITGAIN	Initial gain (=1)	2	INT
133 - 134	TSTYPE	Source type (5=borehole)	2	INT
157 - 158	YEAR	Receiver turn-on time, year	2	INT
159 - 160	DAY	Receiver turn-on time, day	2	INT
161 - 162	HOUR	Receiver turn-on time, hour	2	INT
163 - 164	MINUTE	Receiver turn-on time, minute	2	INT
165 - 166	SECOND	Receiver turn-on time, second	2	INT
175 - 176	DRIFT	Original drift values	2	INT
177 - 178	GAIN	Original gain constant	2	INT

179 - 180	CHARGE	Shot charge size (kg)	2	INT
181 -182	CDP-STAT	Surface station nearest to CDP	2	INT
183 - 184	SHT-STAT	Surface station nearest to shot	2	INT
185 - 186	REC-STAT	Surface station nearest to receiver	2	INT
187 - 188	SYEAR	Shot turn-on time, year	2	INT
189 - 190	SDAY	Shot turn-on time, day	2	INT
191 - 192	SHOUR	Shot turn-on time, hour	2	INT
193 - 194	SMINUTE	Shot turn-on time, minute	2	INT
195 - 196	SSEC	Shot turn-on time, second	2	INT
209 - 212	TTRACE	Time shift to unreduce trace	4	INT
213 - 214	TAPPLY	Flag (=1 since TTRACE in use)	2	INT
215 - 216	INSTRU	Instrument type	2	INT
217 - 218	COR	Drift values (reset to 0)	2	INT
219 - 220	AZIMUTH	shot-receiver azimuth (deg)	2	INT
221 - 222	BOX	Box number	2	ASCII
225 - 228	SP	Shotpoint number	4	ASCII
233 - 236	FFID	Field file identification number	4	ASCII
237 - 240	XOFFSET	Original SCR, PRS1 offset	4	INT

To obtain a copy of the PACE 1989 seismic data on SEG-Y Exabyte tape contact either of the following:

National Geophysical Data Center
NOAA E/GCI
325 Broadway
Boulder, CO 80303
Telephone: (303) 497-6123

or:

IRIS Data Management Center
1408 NE 45th Street
Seattle, WA 98105
Telephone: (206) 547-0393

ACKNOWLEDGMENTS

Field Operations. The authors wish to express their appreciation to Beate Aichroth, Isa Asudeh, Mark Baker, Jonathan Begay, Harley Benz, Tim Cartwright, John Cipar, Tim Coté, Joseph Cotton, Coyn Criley, Chris Dietel, Lynn Dietz, Diane Doser, Don Farrell, Gary Fuis, Don Geddes, Chuck Gilbert, Mark Goldman, Greg Hajic, Zoli Hajnal and University of Saskatchewan students, Steve Harder, Pat Hart, Gordon Haxel, John Hendricks, Steve Hughes, Craig Jarchow, Gray Jensen, Klaus Joehnk, Ron Kaderabek, Uwe Kaestner, Werner Kaminski, Randy Keller, Jim Luetgert, Rob Luzitano, Carlos Montana, Walter Mooney, Mike Moses, Brennan O'Neil, Sue Priest, Dave Reneau, John Sass, Bob Schiemann, Raimund Stangl, Jean Taylor, George Thompson, Alan Walter, Theresa Williams, and Lorraine Wolf for their assistance in the field.

Instrument Development, Repair, and Data Reduction. Fred Fischer, Grey Jensen, and Reese Cutler adapted the SGRs for programable recording. Craig Jarchow assisted in SGR maintenance, modification, and development. Dale Richards and Janice Murphy assisted in data reduction and report preparation.

Pre-experiment Planning: Steve Larkin was responsible for much of the shotpoint permitting. George Billinsley, Phil Gans, and Gordon Haxel provided assistance in shotpoint site selection. Iris Barton, Jonathan Begay, and Jane Gray assisted in permitting SP 46 on the Navajo Indian Reservation. Helen Fairley and Barbara Phillips conducted the archeological and botanical studies the Navajo shotpoint.

Navajo and Hopi Indian Reservations: We would like to express a special thanks to the Navajo and Hopi Nations for providing access to Indian Lands. We are particularly grateful to the following individuals for their assistance: George Abe, Edward Begay, Irving Billy, Leonard Haskie, Byron Huskon, Richard Koch, Vernon Masayesva, Roger Paul, Patrick Ryan, Leroy Shingoitewa, Ivan Sidney, and Akhtar Zaman.

Access: Permission to record and shoot on private lands was graciously granted by: David Blair, William Cadasco (C.O. Bar Ranch), Merwin Davis (Chino Valley Land and Cattle Company), John and Linda Harper Jr. (Juniper Wood Ranch, Inc), Victor Howell (Babbitt Ranches), Kenneth Johnson, G.O. and Anita Lawdon, Lilo Perrin, Gene Polk (Kieckhefer Enterprises), Steve Powers, Roy Rager, and Terri Walker. Permission to record and shoot on public lands was granted by: Mike Howard, Coconino National Forest, Emilio Lujan and Dick Streeper, Prescott National Forest, Peter Kahon and Carey Price, Kaibab National Forest, John Davis, Grand Canyon National Park, and William Childress, Sue Richardson, and Roger Taylor, Bureau of Land Management.

Funding: The PACE 1992 seismic experiment was funded by five principal organizations: the U.S. Geological Survey's Deep Continental Studies Program, the Air Force Geophysics Laboratory (AFGL), the University of Texas at El Paso, the Gas Research Institute, and the National Science Foundation. Field support was provided by Arco Oil and Gas Company and the Peabody Coal Company. Instrumentation was provided by the Amoco Production Company and the University of Wyoming.

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APPENDIX A
PACE 1989 SHOTPOINT TIMES AND LOCATIONS

NE-SWCOLORADO PLATEAU PROFILE:

Shot	SP	FFID	Shot Time (local)	Shot Time (GMT)	Size (lbs)	Latitude	Longitude	Elev. (m)
1	31	2	10:00: 00.006pm	264: 5:00: 00.006	6000	34.80750	-112.89526	1782
2	69	3	10:02: 00.006pm	264: 5:02: 00.006	1500	35.47128	-112.11308	1945
3	57	4	10:04: 00.006pm	264: 5:04: 00.006	3000	34.33624	-112.19632	1242
4	41	5	10:06: 00.357pm	264: 5:06: 00.357	2000	35.53923	-112.03919	1926
5	58	6	12:00: 00.006pm	264: 7:00: 00.006	3000	34.76962	-111.58221	1890
6	38	8	12:40: 00.006pm	264: 7:04: 00.006	3000	34.91387	-112.78526	1579
7	33	11	02:30: 00.006am	264: 9:30: 00.006	3000	35.39258	-112.23602	1890
8	65	12	02:32: 02.132am	264: 9:32: 02.132	1500	35.58877	-111.97673	1926
9	20	13	02:33: 59.988am	264: 9:33: 59.988	8000	33.48602	-114.59665	76
10	61	15	02:39: 00.006am	264: 9:39: 00.006	1500	34.93577	-112.75211	1536
11	28	16	09:59: 59.975pm	265: 4:59: 59.975	8000	34.46483	-113.34579	927
12	32	18	10:04: 00.006pm	265: 5:40: 00.006	6001	35.08242	-112.62252	1530
13	71	19	10:06: 00.006pm	265: 5:06: 00.006	1500	35.73218	-111.79832	1946
14	50	20	10:08: 00.006pm	265: 5:08: 00.006	1000	35.30530	-112.32095	1921
15	42	21	12:30: 00.006pm	265: 7:30: 00.006	4000	35.79195	-111.71616	1988
16	84	22	12:32: 00.006pm	265: 7:32: 00.006	3000	35.67413	-111.86812	1987
17	46	23	12:34: 00.006pm	265: 7:34: 00.006	6000	36.34528	-110.95360	1704
18	23	28	02:29: 59.972am	265: 9:29: 59.972	6000	33.95883	-113.99655	305
19	39	35	10:00: 00.006pm	266: 5:00: 00.006	1000	35.02592	-112.68044	1393
20	62	37	10:04: 00.006pm	266: 5:04: 00.006	1500	35.10162	-112.56271	1707
21	34	39	10:08: 00.006pm	266: 5:08: 00.006	3000	35.65362	-111.85947	1972
22	49	41	12:00: 00.006pm	266: 7:00: 00.006	1000	35.04912	-112.65518	1405
23	56	43	12:04: 00.006pm	266: 7:04: 00.006	1500	35.13340	-112.51860	1600
24	40	45	12:08: 00.006pm	266: 7:08: 00.006	2000	35.20783	-112.45451	1579

APPENDIX A, Continued
PACE 1989 SHOTPOINT TIMES AND LOCATIONS

NW-SEGRAND CANYON PROFILE:

Shot	SP	FFID	Shot Time (local)	Shot Time (GMT)	Size (lbs)	Latitude	Longitude	Elev. (m)
25	77	6	10:01: 00.006pm	270: 5:00: 00.006	1500	35.84287	-111.89008	1819
26	76	7	10:01: 00.006pm	270: 5:01: 00.006	1500	35.60582	-111.66332	1803
27	71	8	10:04: 00.006pm	270: 5:04: 00.006	1500	35.73218	-111.79832	1946
28	83	9	10:07: 00.006pm	270: 5:07: 00.006	6000	36.65550	-112.32557	2402
29	75	11	11:30: 00.006pm	270: 6:30: 00.006	1000	35.79215	-111.88108	1997
30	74	12	11:31: 00.006pm	270: 6:31: 00.006	1000	35.65163	-111.72020	1823
31	72	13	11:34: 00.006pm	270: 6:34: 00.006	1000	35.70277	-111.75770	1901
32	82	14	11:37: 00.006pm	270: 6:37: 00.006	6000	34.90805	-111.05608	1753
33	73	16	01:00: 00.006am	270: 8:00: 00.006	1000	35.75739	-111.83242	2204
34	34	17	01:01: 00.006am	270: 8:01: 00.006	1000	35.65362	-111.85947	1972
35	85	18	01:04: 00.006am	270: 8:04: 00.006	3000	36.35262	-112.12965	2768

APPENDIX B
LOCATION OF PACE 1989 RECEIVERS

Colorado Plateau NE-SW Main Line

Station	Latitude	Longitude	Elevation (m)	Instrument type
350	34.80761	-112.89669	1792	SCR-001
352	34.80676	-112.89056	1768	SGR-500
353	34.80639	-112.88553	1756	SCR-002
354	34.80497	-112.87845	1731	SGR-501
355	34.80759	-112.87578	1719	SCR-003
356	34.81090	-112.87468	1719	SGR-502
357	34.81482	-112.87459	1707	SCR-004
358	34.81836	-112.87338	1707	SGR-503
359	34.82151	-112.87189	1701	SCR-005
360	34.82336	-112.86919	1701	SGR-504
361	34.82493	-112.86596	1658	SCR-006
362	34.82716	-112.86392	1646	SGR-505
363	34.83075	-112.86282	1646	SCR-007
364	34.83459	-112.86261	1634	SGR-506
365	34.83813	-112.86172	1658	SCR-008
366	34.83959	-112.85894	1670	SGR-507
367	34.84026	-112.85440	1682	SCR-009
368	34.84032	-112.84902	1670	SGR-508
369	34.84123	-112.84574	1658	SCR-010
370	34.84323	-112.84280	1646	SGR-509
371	34.84594	-112.84049	1634	SCR-011
372	34.84867	-112.83853	1622	SGR-510
373	34.85121	-112.83680	1622	SCR-012
374	34.85375	-112.83431	1585	SGR-511
375	34.85783	-112.83345	1609	SCR-013
376	34.86004	-112.83134	1609	SGR-512
377	34.86232	-112.82892	1609	SCR-014
378	34.86410	-112.82602	1597	SGR-513
379	34.86653	-112.82378	1585	SCR-015
380	34.86889	-112.82278	1585	SGR-514
381	34.87407	-112.82294	1573	SCR-016
382	34.88171	-112.82682	1646	SGR-515
383	34.88927	-112.83126	1664	SCR-017
384	34.89412	-112.83228	1658	SGR-516
385	34.89725	-112.83084	1634	SCR-018
386	34.89977	-112.82878	1634	SGR-517
387	34.90241	-112.82695	1634	-----
388	34.91126	-112.83271	1646	SCR-019
389	34.91314	-112.82991	1634	SGR-518
390	34.91406	-112.82581	1622	SCR-020
391	34.91656	-112.82338	1609	SGR-520
392	34.91873	-112.82121	1585	SCR-021
393	34.92183	-112.81991	1573	SGR-521
394	34.92535	-112.81898	1573	SCR-022
395	34.92728	-112.81610	1573	-----
396	34.91289	-112.79281	158	SGR-522
397	34.91329	-112.78875	1597	SCR-023
398	34.91494	-112.78577	1585	SGR-523
399	34.91759	-112.78343	1573	SCR-024

Station	Latitude	Longitude	Elevation (m)	Instrument Type
400	34.91966	-112.78092	1573	SGR-524
401	34.92138	-112.77800	1561	SCR-025
402	34.92267	-112.77431	1561	SGR-525
403	34.92338	-112.77000	1548	SCR-026
404	34.92676	-112.76885	1561	SGR-526
405	34.92911	-112.76656	1561	SCR-027
406	34.93080	-112.76319	1561	SGR-527
407	34.93211	-112.75984	1548	SCR-028
408	34.93316	-112.75569	1548	SGR-528
409	34.93426	-112.75417	1536	SCR-029
410	34.93500	-112.75315	1536	SGR-529
411	34.93632	-112.74969	1530	SCR-030
412	34.93725	-112.74532	1524	SGR-530
413	34.93778	-112.74098	1518	SCR-031
414	34.93657	-112.73363	1506	SGR-531
415	34.93620	-112.72887	1500	SCR-032
416	34.93713	-112.72498	1494	SGR-532
417	34.93837	-112.72117	1487	SCR-033
418	34.93878	-112.71596	1481	SGR-533
419	34.95942	-112.73613	1469	-----
420	34.96007	-112.73179	1469	SCR-034
421	34.96220	-112.72960	1475	SGR-534
422	34.96362	-112.72589	1475	SCR-035
423	34.96505	-112.72271	1469	SGR-535
424	34.96616	-112.71892	1463	SCR-036
425	34.96820	-112.71624	1463	SGR-542
426	34.96993	-112.71311	1463	SCR-037
427	34.97329	-112.71214	1475	SGR-543
428	34.97672	-112.71148	1487	SCR-038
429	34.97863	-112.70856	1481	SGR-544
430	34.98026	-112.70531	1481	SCR-039
431	34.98171	-112.70195	1481	SGR-545
432	34.98397	-112.69926	1481	SCR-040
433	34.98759	-112.69809	1475	SGR-546
434	34.99112	-112.69760	1463	SCR-041
435	34.99383	-112.69580	1463	-----
436	35.00433	-112.70403	1415	SGR-547
437	35.00640	-112.70121	1415	SCR-042
438	35.00878	-112.69842	1412	SGR-548
439	35.01090	-112.69615	1412	SCR-043
440	35.01391	-112.69434	1412	SGR-549
441	35.01609	-112.69186	1409	SCR-044
442	35.01753	-112.68847	1409	SGR-550
443	35.01815	-112.68421	1402	SCR-045
444	35.02049	-112.68176	1396	SGR-551
445	35.02331	-112.68184	1399	SCR-046
446	35.02563	-112.68049	1396	SGR-552
447	35.02701	-112.67972	1393	SCR-047
448	35.02926	-112.67716	1387	SGR-553
449	35.03324	-112.67725	1381	-----
450	35.03411	-112.67289	1378	SCR-048
451	35.03599	-112.67052	1375	SGR-554
452	35.03772	-112.66791	1375	SCR-049
453	35.03990	-112.66436	1381	-----
454	35.04250	-112.66193	1387	SGR-555
455	35.04497	-112.66042	1393	SCR-050
456	35.04732	-112.65799	1399	SGR-556

Station	Latitude	Longitude	Elevation (m)	Instrument Type
457	35.04918	-112.65588	1402	SCR-051
458	35.05055	-112.65414	1406	SGR-557
459	35.05171	-112.65287	1409	SCR-052
460	35.05403	-112.65071	1415	SGR-558
461	35.05637	-112.64833	1424	SCR-053
462	35.05907	-112.64603	1430	SGR-559
463	35.06126	-112.64400	1436	SCR-054
464	35.06353	-112.64180	1442	SGR-560
465	35.06584	-112.63955	1451	SCR-055
466	35.06841	-112.63727	1470	SGR-561
467	35.07096	-112.63544	1491	SCR-056
468	35.07329	-112.63303	1503	SGR-562
469	35.07543	-112.63044	1509	SCR-057
470	35.07761	-112.62783	1515	SGR-563
471	35.08009	-112.62594	1521	SCR-058
472	35.08141	-112.62374	1524	SGR-564
473	35.08180	-112.62280	1530	SCR-059
474	35.08415	-112.62080	1536	SGR-565
475	35.08343	-112.61448	1554	SCR-060
476	35.08269	-112.60835	1574	SGR-567
477	35.08269	-112.60300	1592	SCR-061
478	35.08256	-112.59803	1610	SGR-568
479	35.08072	-112.59055	1634	SCR-062
480	35.08179	-112.58681	1652	-----
481	35.08414	-112.58427	1677	SGR-569
482	35.08646	-112.58182	1689	SCR-063
483	35.08818	-112.57893	1701	SGR-570
484	35.08990	-112.57589	1731	SCR-064
485	35.07610	-112.55452	1787	SGR-571
486	35.07749	-112.55071	1778	-----
487	35.08166	-112.55092	1769	SCR-065
488	35.08572	-112.55058	1763	SGR-572
489	35.10081	-112.56316	1710	SCR-066
490	35.10128	-112.56255	1704	SGR-583
491	35.10127	-112.55885	1698	SCR-067
492	35.10036	-112.55275	1692	SGR-584
493	35.10247	-112.54997	1683	SCR-068
494	35.10471	-112.54763	1677	SGR-585
495	35.10986	-112.54916	1671	SCR-069
496	35.11522	-112.55003	1655	SGR-586
497	35.11733	-112.54772	1646	SCR-070
498	35.11874	-112.54460	1643	SGR-587
499	35.12079	-112.54261	1640	SCR-071
500	35.12298	-112.54086	1634	SGR-588
501	35.12162	-112.53464	1637	SCR-072
502	35.12388	-112.53209	1634	SGR-589
503	35.12750	-112.53123	1616	SCR-073
504	35.12926	-112.52813	1613	SGR-590
505	35.13081	-112.52480	1610	SCR-074
506	35.13245	-112.52167	1607	SGR-591
507	35.13360	-112.51860	1601	SCR-075
508	35.13452	-112.51418	1598	SGR-592
509	35.13842	-112.51364	1592	SCR-076
510	35.13971	-112.51015	1586	SGR-593
511	35.14114	-112.50679	1580	SCR-077
512	35.14338	-112.50530	1577	------
513	35.14345	-112.49912	1580	SGR-594

Station	Latitude	Longitude	Elevation (m)	Instrument Type
514	35.14665	-112.49848	1577	SCR-078
515	35.15047	-112.49800	1577	SGR-595
516	35.15489	-112.49730	1574	SCR-079
517	35.15876	-112.49701	1571	SGR-596
518	35.16261	-112.49645	1574	SCR-080
519	35.16547	-112.49499	1571	SGR-597
520	35.16856	-112.49323	1571	SCR-081
521	35.17191	-112.49139	1571	SGR-598
522	35.17485	-112.48988	1574	SCR-082
523	35.17724	-112.48758	1574	SGR-599
524	35.18055	-112.48619	1574	SCR-083
525	35.18272	-112.48368	1580	SGR-600
526	35.18483	-112.48141	1580	SCR-084
527	35.18711	-112.47890	1580	SGR-601
528	35.18915	-112.47638	1580	SCR-085
529	35.18978	-112.47144	1583	SGR-602
530	35.19176	-112.46925	1583	SCR-086
531	35.19344	-112.46609	1583	SGR-603
532	35.19287	-112.46043	1583	SCR-087
533	35.19712	-112.45999	1583	SGR-604
534	35.20095	-112.45970	1592	SCR-088
535	35.20510	-112.45934	1592	SGR-605
536	35.20612	-112.45521	1577	SCR-089
537	35.20761	-112.45383	1586	SGR-606
538	35.20850	-112.45250	1586	SCR-090
539	35.21243	-112.45285	1586	SGR-607
540	35.21346	-112.44913	1592	SCR-091
541	35.21410	-112.44462	1595	SGR-608
542	35.21457	-112.43991	1598	SCR-092
543	35.21457	-112.43488	1604	SGR-609
544	35.21695	-112.43307	1607	-----
545	35.21900	-112.42996	1628	SCR-093
546	35.22101	-112.42689	1643	SGR-610
547	35.22294	-112.42410	1662	SCR-094
548	35.22481	-112.42142	1658	SGR-611
549	35.22675	-112.41830	1668	SCR-095
550	35.22829	-112.41504	1677	SGR-612
551	35.22978	-112.41184	1695	SCR-096
552	35.23289	-112.41039	1707	SGR-624
553	35.23447	-112.40725	1719	SCR-097
554	35.23585	-112.40353	1719	SGR-625
555	35.23760	-112.40025	1713	SCR-098
556	35.23913	-112.39708	1753	SGR-626
557	35.24058	-112.39381	1763	SCR-099
558	35.24169	-112.39004	1759	SGR-627
559	35.24313	-112.38679	1759	SCR-100
560	35.24462	-112.38344	1759	SGR-629
561	35.24615	-112.38027	1769	SCR-101
562	35.24833	-112.37730	1787	SGR-630
563	35.25040	-112.37599	1780	SCR-102
564	35.25074	-112.37015	1811	SGR-631
565	35.25168	-112.36624	1835	SCR-103
566	35.25279	-112.36266	1853	SGR-632
567	35.25604	-112.36124	1853	SCR-104
568	35.25708	-112.35750	1859	SGR-633
569	35.25968	-112.35542	1865	SCR-105
570	35.25966	-112.35014	1896	SGR-634

Station	Latitude	Longitude	Elevation (m)	Instrument Type
571	35.26114	-112.34684	1914	SCR-106
572	35.26439	-112.34548	1878	SGR-635
573	35.27347	-112.35138	1893	SCR-107
574	35.27763	-112.35113	1871	SGR-636
575	35.28563	-112.35566	1817	SCR-108
576	35.29069	-112.35646	1804	SGR-637
577	35.28757	-112.34771	1868	SCR-109
578	35.28909	-112.34450	1878	SGR-638
579	35.29184	-112.34252	1878	SCR-110
580	35.29195	-112.33732	1905	SGR-639
581	35.29639	-112.33788	1890	SCR-111
582	35.29886	-112.33578	1902	SGR-640
583	35.30090	-112.33297	1905	SCR-112
584	35.30296	-112.33022	1908	SGR-641
585	35.30480	-112.32724	1902	SCR-113
586	35.30550	-112.32278	1914	SGR-642
587	35.30729	-112.32017	1914	SCR-114
588	35.30963	-112.31774	1920	SGR-643
589	35.31191	-112.31518	1923	SCR-115
590	35.31414	-112.31278	1939	SGR-644
591	35.31914	-112.31366	1942	SCR-116
592	35.32117	-112.31081	1972	SGR-645
593	35.32351	-112.30868	1981	SCR-117
594	35.32555	-112.30604	1984	SGR-646
595	35.32798	-112.30367	2006	SCR-118
596	35.33014	-112.30129	1978	SGR-647
597	35.33227	-112.29921	1975	PRS1
598	35.33463	-112.29644	1969	SGR-648
599	35.33686	-112.29391	1954	PRS1
600	35.33698	-112.28906	1954	SGR-649
601	35.33917	-112.28623	1957	PRS1
602	35.34146	-112.28422	1957	SGR-651
603	35.34370	-112.28157	1951	PRS1
604	35.34651	-112.27866	1958	SGR-536
605	35.34816	-112.27670	1939	PRS1
606	35.35084	-112.27478	1940	SGR-537
607	35.35319	-112.27228	1926	PRS1
608	35.35541	-112.26966	1939	SGR-538
609	35.35787	-112.26763	1917	PRS1
610	35.35996	-112.26515	1944	SGR-539
611	35.36233	-112.26267	1890	PRS1
612	35.36583	-112.26142	1929	SGR-540
613	35.36766	-112.25872	1884	-----
614	35.36941	-112.25565	1926	PRS1
615	35.37198	-112.25234	1936	SGR-541
616	35.37348	-112.25014	1948	PRS1
617	35.37544	-112.24757	1941	SGR-573
618	35.37818	-112.24566	1945	PRS1
619	35.38129	-112.24520	1918	SGR-574
620	35.38461	-112.24323	1902	PRS1
621	35.38462	-112.23863	1897	SGR-575
622	35.38732	-112.23611	1902	PRS1
623	35.39134	-112.23629	2065	SGR-576
624	35.39182	-112.23103	1887	PRS4
625	35.39393	-112.22882	1878	SGR-577
626	35.39617	-112.22601	1881	PRS1
627	35.39931	-112.22459	1902	-----

Station	Latitude	Longitude	Elevation (m)	Instrument Type
628	35.40148	-112.22227	1914	SGR-578
629	35.40288	-112.21897	1926	PRS1
630	35.40546	-112.21658	1926	SGR-579
631	35.40768	-112.21428	1923	PRS4
632	35.40988	-112.21157	1920	SGR-580
633	35.41231	-112.20928	1917	PRS1
634	35.41455	-112.20685	1908	SGR-581
635	35.41694	-112.20472	1917	PRS1
636	35.41924	-112.20206	1914	SGR-582
637	35.42148	-112.19982	1914	-----
638	35.42361	-112.19749	1902	SGR-613
639	35.42647	-112.19526	1878	PRS1
640	35.42906	-112.19339	1878	SGR-614
641	35.42950	-112.18900	1902	PRS1
642	35.43166	-112.18628	1896	SGR-615
643	35.43335	-112.18316	1896	-----
644	35.43230	-112.17702	1905	PRS4
645	35.43439	-112.17378	1914	SGR-616
646	35.43766	-112.17284	1917	PRS1
647	35.44009	-112.17084	1908	SGR-617
648	35.44289	-112.16883	1899	PRS1
649	35.44389	-112.16481	1902	SGR-618
650	35.44574	-112.16213	1902	PRS4
651	35.44767	-112.15901	1908	SGR-619
652	35.44928	-112.15572	1917	PRS1
653	35.45139	-112.15331	1917	SGR-620
654	35.45486	-112.15215	1911	PRS1
655	35.45340	-112.14518	1929	SGR-621
656	35.45320	-112.14014	1928	PRS4
657	35.45513	-112.13693	1925	SGR-622
658	35.45642	-112.13330	1926	PRS1
659	35.45770	-112.13002	1932	SGR-623
660	35.45905	-112.12631	1928	PRS1
661	35.46047	-112.12259	1939	SGR-652
662	35.46224	-112.12006	1939	-----
663	35.46479	-112.11738	1942	SGR-653
664	35.46554	-112.11284	1951	PRS1
665	35.47000	-112.11345	1942	SGR-654
666	35.47111	-112.11246	1942	PRS1
667	35.47265	-112.11143	1942	SGR-655
668	35.47496	-112.10894	1945	PRS4
669	35.47768	-112.10740	1954	SGR-656
670	35.48139	-112.10662	1951	PRS1
671	35.48602	-112.10668	1943	SGR-657
672	35.48748	-112.10319	1948	PRS1
673	35.48921	-112.10035	1951	SGR-659
674	35.49137	-112.09767	1951	PRS4
675	35.49310	-112.09469	1939	SGR-660
676	35.49101	-112.08721	1935	PRS1
677	35.49395	-112.08538	1926	SGR-661
678	35.49727	-112.08382	1935	PRS1
679	35.50011	-112.08256	1935	SGR-662
680	35.50284	-112.08072	1940	PRS4
681	35.50538	-112.07861	1939	SGR-663
682	35.50767	-112.07644	1934	PRS1
683	35.50993	-112.07356	1935	SGR-664
684	35.51038	-112.06921	1937	PRS1

APPENDIX B, Continued. Station Locations for the Colorado Plateau NE-SW Main Line

Station	Latitude	Longitude	Elevation (m)	Instrument Type
685	35.51251	-112.06686	1942	SGR-665
686	35.51539	-112.06485	1942	-----
687	35.51746	-112.06202	1940	SGR-666
688	35.51876	-112.05872	1942	PRS1
689	35.51945	-112.05416	1943	SGR-667
690	35.52019	-112.04984	1954	PRS1
691	35.52158	-112.04617	1958	SGR-668
692	35.52353	-112.04325	1955	PRS4
693	35.52745	-112.04287	1946	SGR-669
694	35.53089	-112.04193	1940	PRS1
695	35.53477	-112.04133	1935	SGR-670
696	35.53770	-112.03968	1929	PRS1
697	35.53999	-112.03733	1926	SGR-671
698	35.54272	-112.03550	1925	PRS4
699	35.54684	-112.03494	1919	SGR-672
700	35.54874	-112.03237	1920	PRS1
701	35.55046	-112.02930	1929	SGR-673
702	35.55251	-112.02681	1931	PRS1
703	35.55364	-112.02295	1940	SGR-674
704	35.55514	-112.01967	1939	PRS4
705	35.55724	-112.01694	1932	SGR-676
706	35.55945	-112.01456	1931	PRS1
707	35.56214	-112.01238	1935	SGR-677
708	35.56300	-112.00819	1929	PRS1
709	35.56478	-112.00517	1943	SGR-678
710	35.56926	-112.00535	1932	-----
711	35.57318	-112.00469	1920	SGR-679
712	35.57588	-112.00302	1916	PRS1
713	35.58026	-112.00307	1913	SGR-680
714	35.58118	-111.99912	1920	PRS1
715	35.70691	-111.99582	1923	SGR-681
716	35.70783	-111.99280	1926	PRS4
717	35.58540	-111.98880	1926	SGR-682
718	35.58450	-111.98237	1932	PRS1
719	35.58443	-111.97754	1932	SGR-683
720	35.58906	-111.97789	1926	PRS1
721	35.58976	-111.97322	1939	SGR-684
722	35.59090	-111.96967	1939	-----
723	35.59210	-111.96587	1945	-----
724	35.59328	-111.96176	1951	SGR-685
725	35.59446	-111.95832	1963	PRS1
726	35.59596	-111.95487	1960	SGR-686
727	35.59731	-111.95118	1960	PRS1
728	35.59854	-111.94786	1966	SGR-687
729	35.59698	-111.94087	1972	PRS4
730	35.60165	-111.94101	1978	SGR-689
731	35.60539	-111.94042	1975	PRS1
732	35.60870	-111.93928	1978	SGR-690
733	35.60772	-111.93295	1972	PRS1
734	35.61234	-111.93317	1969	SGR-691
735	35.61411	-111.92990	1972	PRS1
736	35.61535	-111.92639	1975	SGR-692
737	35.61761	-111.92403	1978	PRS1
738	35.61996	-111.92126	1978	SGR-693
739	35.62194	-111.91884	1981	PRS1
740	35.62409	-111.91632	1981	SGR-694
741	35.62623	-111.91390	1981	PRS1

APPENDIX B, Continued. Station Locations for the Colorado Plateau NE-SW Main Line

Station	Latitude	Longitude	Elevation (m)	Instrument Type
742	35.62794	-111.91100	1984	SGR-695
743	35.63614	-111.91569	1996	PRS1
744	35.64431	-111.91989	1999	SGR-696
745	35.64454	-111.91533	2018	PRS1
746	35.64614	-111.91222	2030	SGR-697
747	35.64747	-111.90819	2021	PRS1
748	35.64785	-111.90389	1999	SGR-698
749	35.64823	-111.89914	1993	PRS1
750	35.64888	-111.89447	1987	SGR-699
751	35.64941	-111.89003	1981	PRS1
752	35.65079	-111.88634	1981	-----
753	35.65306	-111.88421	1981	PRS1
754	35.65549	-111.88178	1978	PRS1
755	35.65788	-111.87971	1978	PRS1
756	35.66109	-111.87831	1987	PRS1
757	35.66102	-111.87157	1981	-----
758	35.66402	-111.87317	1975	PRS1
759	35.66595	-111.87411	1980	PRS1
760	35.66824	-111.87163	1981	PRS1
761	35.67056	-111.86920	1994	PRS1
762	35.67168	-111.86578	1987	PRS1
763	35.67723	-111.86667	1989	PRS1
764	35.68086	-111.86611	1987	PRS1
765	35.68441	-111.86518	1988	PRS1
766	35.68761	-111.86365	1987	PRS1
767	35.68983	-111.86141	1987	PRS1
768	35.69223	-111.85879	1987	PRS1
769	35.69487	-111.85687	1986	PRS1
770	35.69783	-111.85538	1986	PRS1
771	35.70020	-111.85277	1984	PRS1
772	35.69914	-111.84598	1983	PRS1
773	35.70180	-111.84403	1982	PRS1
774	35.70420	-111.84198	1981	PRS1
775	35.70526	-111.83856	1980	PRS1
776	35.70850	-111.83720	1978	PRS1
777	35.71119	-111.83475	1977	PRS1
778	35.71426	-111.83327	1974	PRS1
779	35.71653	-111.83094	1972	PRS1
780	35.71753	-111.82671	1969	PRS1
781	35.71781	-111.82176	1967	PRS1
782	35.71921	-111.81852	1966	PRS1
783	35.72146	-111.81619	1963	PRS1
784	35.72282	-111.81295	1959	PRS1
785	35.72410	-111.80726	2113	PRS1
786	35.72667	-111.80667	2045	PRS1
787	35.72745	-111.80275	2045	PRS1
788	35.72800	-111.79826	2011	PRS1
789	35.73188	-111.79777	1979	PRS1
790	35.72998	-111.78906	1948	PRS1
791	35.73118	-111.79290	1995	PRS1
792	35.72995	-111.78513	1968	PRS1
793	35.73126	-111.78177	1981	PRS1
794	35.73293	-111.77860	1974	-----
795	35.73515	-111.77608	1994	PRS1
796	35.73703	-111.77323	2005	PRS1
797	35.73901	-111.76914	1966	PRS1
798	35.73966	-111.76588	1974	PRS1

APPENDIX B, Continued. Station Locations for the Colorado Plateau NE-SW Main Line

Station	Latitude	Longitude	Elevation (m)	Instrument Type
799	35.74556	-111.76787	1987	PRS1
800	35.74814	-111.76556	1968	PRS1
801	35.75177	-111.76535	1968	PRS1
802	35.75347	-111.76181	1966	----
803	35.75444	-111.75779	1963	PRS1
804	35.75380	-111.75211	1978	PRS1
805	35.75587	-111.75076	1975	PRS1
806	35.75842	-111.74726	1975	PRS1
807	35.76235	-111.74664	1981	PRS1
808	35.76637	-111.74577	1984	PRS1
809	35.76980	-111.74491	1984	PRS1
810	35.76578	-111.73524	1984	PRS1
811	35.76915	-111.73371	1990	PRS1
812	35.77215	-111.73258	1996	PRS1
813	35.77538	-111.73127	2003	PRS1
814	35.77859	-111.72982	2006	PRS1
815	35.78150	-111.72854	2006	PRS1
816	35.78493	-111.72717	2009	PRS1
817	35.78819	-111.72580	2006	PRS1
818	35.79129	-111.72454	2003	PRS1
819	35.79162	-111.71996	1996	PRS1
820	35.79177	-111.71532	1990	PRS1
821	35.79889	-111.71866	1975	PRS1
822	35.80358	-111.71804	2003	PRS1
823	35.80493	-111.71494	2009	----
824	35.80710	-111.71262	2009	PRS1
825	35.80961	-111.70997	2003	PRS1
826	35.81089	-111.70685	1999	PRS1
827	35.81304	-111.70352	1993	----
828	35.81436	-111.70105	1987	PRS1
829	35.81586	-111.69711	1981	----
830	35.81735	-111.69363	1978	PRS1

APPENDIX B, Continued
LOCATION OF PACE 1989 RECEIVERS

Grand Canyon NW-SE Cross Line

Station	Latitude	Longitude	Elevation (m)	Instrument type
2001	35.43045	-111.57039	1979	SCR 001
2002	35.43432	-111.57349	1973	SCR 002
2003	35.43806	-111.57641	1967	SCR 003
2004	35.44184	-111.57939	1967	SCR 004
2005	35.44573	-111.58250	1970	SCR 005
2006	35.44889	-111.58644	1979	SCR 006
2007	35.45179	-111.59131	1997	SCR 007
2008	35.45594	-111.59361	1997	SCR 008
2009	35.46223	-111.59138	1997	SCR 009
2010	35.46834	-111.58994	1997	SCR 010
2011	35.47286	-111.59149	1982	SCR 011
2012	35.47645	-111.59480	1979	SCR 012
2013	35.47980	-111.59840	1979	SCR 013
2014	35.48300	-111.60311	1988	SCR 014
2015	35.48601	-111.60777	1997	SCR 015
2016	35.48886	-111.61270	2009	SCR 016
2017	35.49180	-111.61696	2012	SCR 017
2018	35.49643	-111.61889	2018	SCR 018
2019	35.50124	-111.62078	2024	SCR 019
2020	35.50582	-111.62135	2024	SCR 020
2021	35.51125	-111.62267	2024	SCR 021
2022	35.51560	-111.62386	2021	SCR 022
2023	35.51936	-111.62685	2012	SCR 023
2024	35.52227	-111.63068	1988	SCR 024
2025	35.52758	-111.63056	1982	SCR 025
2026	35.53611	-111.62556	1970	SCR 026
2027	35.54289	-111.62225	1967	SCR 027
2028	35.54714	-111.62351	1960	SCR 028
2029	35.55187	-111.62566	1954	SCR 029
2030	35.55451	-111.63122	1945	SCR 030
2031	35.55721	-111.63644	1933	SCR 031
2032	35.55962	-111.64159	1927	SCR 032
2033	35.56232	-111.64708	1924	SCR 033
2034	35.56546	-111.65125	1921	SCR 034
2035	35.56958	-111.65405	1903	SCR 035
2036	35.57416	-111.65433	1896	SCR 036
2037	35.58059	-111.65410	1878	SCR 037
2038	35.58484	-111.65626	1878	SCR 038
2039	35.58919	-111.65730	1859	SCR 039
2040	35.59411	-111.65841	1847	SCR 040
2041	35.59730	-111.66009	1787	SGR 500
2042	35.60091	-111.66158	1780	SGR 501
2043	35.60558	-111.66316	1778	SGR 502
2044	35.60675	-111.66384	1778	SGR 503
2045	35.60769	-111.66424	1777	SGR 504
2046	35.60872	-111.66458	1773	SGR 505
2047	35.60987	-111.66503	1774	SGR 506
2048	35.61084	-111.66547	1776	SGR 507
2049	35.61175	-111.66586	1778	SGR 508
2050	35.61276	-111.66620	1777	SGR 509

APPENDIX B, Continued. Station Locations for the Grand Canyon NW-SE Cross Line

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2051	35.61389	-111.66664	1774	SGR 510
2052	35.61487	-111.66709	1775	SGR 511
2053	35.61571	-111.66735	1803	SGR 512
2054	35.61641	-111.66777	1782	SGR 513
2055	35.61760	-111.66863	1798	SGR 514
2056	35.61829	-111.67098	1765	SGR 515
2057	35.61958	-111.67136	1771	SGR 516
2058	35.62056	-111.67153	1777	SGR 517
2059	35.62161	-111.67160	1768	SGR 518
2060	35.62270	-111.67180	1764	SGR 520
2061	35.62361	-111.67247	1764	SGR 521
2062	35.62455	-111.67325	1762	SGR 522
2063	35.62550	-111.67408	1765	SGR 523
2064	35.62655	-111.67491	1759	SGR 524
2065	35.62737	-111.67561	1762	SGR 525
2066	35.62834	-111.67636	1751	SGR 526
2067	35.62913	-111.67711	1760	SGR 527
2068	35.63023	-111.67776	1748	SGR 528
2069	35.63108	-111.67822	1751	SGR 529
2070	35.63250	-111.67787	1751	SGR 530
2071	35.63319	-111.67778	1766	SGR 531
2072	35.63190	-111.68473	1717	SGR 532
2073	35.63309	-111.68500	1719	SGR 533
2074	35.63275	-111.69025	1723	SGR 534
2075	35.63215	-111.69298	1721	SGR 535
2076	35.63045	-111.69714	1732	SGR 536
2077	35.63039	-111.69899	1736	SGR 538
2078	35.62967	-111.70147	1736	SGR 539
2079	35.62989	-111.70276	1740	SGR 540
2080	35.62765	-111.70670	1749	SGR 541
2081	35.62714	-111.70778	1748	SGR 542
2082	35.62744	-111.70850	1746	SGR 543
2083	35.62827	-111.70962	1744	SGR 544
2084	35.62913	-111.70997	1748	SGR 545
2085	35.63000	-111.71039	1752	SGR 546
2086	35.63087	-111.71082	1757	SGR 547
2087	35.63168	-111.71128	1758	SGR 548
2088	35.63249	-111.71174	1759	SGR 549
2089	35.63331	-111.71223	1760	SGR 550
2090	35.63414	-111.71273	1760	SGR 551
2091	35.63498	-111.71318	1755	SGR 552
2092	35.63582	-111.71363	1749	SGR 553
2093	35.63663	-111.71409	1752	SGR 554
2094	35.63745	-111.71456	1755	PRS1
2095	35.63833	-111.71501	1759	SGR 555
2096	35.63910	-111.71545	1763	PRS1
2097	35.63996	-111.71586	1760	SGR 556
2098	35.64082	-111.71627	1757	PRS1
2099	35.64168	-111.71659	1754	SGR 557
2100	35.64253	-111.71692	1752	PRS1
2101	35.64341	-111.71729	1751	SGR 558
2102	35.64430	-111.71767	1750	PRS1
2103	35.64516	-111.71794	18	SGR 559
2104	35.64602	-111.71822	1755	PRS1
2105	35.64688	-111.71851	1758	SGR 560
2106	35.64775	-111.71881	1791	PRS1
2107	35.64863	-111.71913	1757	SGR 561

APPENDIX B, Continued. Station Locations for the Grand Canyon NW-SE Cross Line

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2108	35.64952	-111.71946	1758	PRS1
2109	35.65038	-111.71982	1762	SGR 562
2110	35.65123	-111.72018	1765	PRS1
2111	35.65205	-111.72054	1764	SGR 563
2112	35.65296	-111.72086	1769	PRS1
2113	35.65363	-111.72172	1779	SGR 564
2114	35.65431	-111.72259	1789	PRS1
2115	35.65505	-111.72308	1792	SGR 566
2116	35.65579	-111.72358	1796	PRS1
2117	35.65664	-111.72404	1792	SGR 567
2118	35.65750	-111.72449	1787	PRS1
2119	35.65829	-111.72509	1794	SGR 568
2120	35.65907	-111.72569	1800	PRS1
2121	35.65984	-111.72627	1802	SGR 569
2122	35.66061	-111.72686	1803	PRS1
2123	35.66147	-111.72706	1829	SGR 570
2124	35.66239	-111.72720	1802	PRS1
2125	35.66338	-111.72725	1827	SGR 571
2126	35.66413	-111.72737	1800	PRS1
2127	35.66578	-111.72753	1828	SGR 572
2128	35.66624	-111.72766	1810	PRS1
2129	35.66720	-111.72776	1827	SGR 573
2130	35.66808	-111.72794	1813	PRS1
2131	35.66907	-111.72807	1830	SGR 574
2132	35.66989	-111.72820	1804	PRS1
2133	35.67104	-111.72842	1808	SGR 575
2134	35.67219	-111.72823	1814	PRS1
2135	35.67294	-111.72878	1817	SGR 576
2136	35.67375	-111.72886	1807	PRS1
2137	35.67487	-111.72896	1810	SGR 577
2138	35.67574	-111.72892	1829	PRS1
2139	35.67671	-111.72927	1809	SGR 578
2140	35.67764	-111.72931	1831	PRS1
2141	35.67866	-111.72957	1811	SGR 579
2142	35.67946	-111.72956	1832	PRS1
2143	35.68058	-111.73008	1812	SGR 580
2144	35.68127	-111.73085	1834	PRS1
2145	35.68168	-111.73288	1817	SGR 581
2146	35.68275	-111.73315	1847	PRS1
2147	35.68345	-111.73316	1825	SGR 582
2148	35.68431	-111.73365	1841	PRS1
2149	35.68503	-111.73398	1824	SGR 583
2150	35.68564	-111.73445	1838	PRS1
2151	35.68661	-111.73630	1825	SGR 584
2152	35.68741	-111.73714	1833	PRS1
2153	35.68843	-111.73846	1832	SGR 585
2154	35.68928	-111.73922	1833	PRS1
2155	35.68987	-111.74005	1834	SGR 586
2156	35.69037	-111.74072	1838	PRS1
2157	35.69216	-111.74336	1842	SGR 587
2158	35.69159	-111.74249	1837	PRS1
2159	35.69216	-111.74336	1842	SGR 588
2160	35.69275	-111.74421	1846	PRS1
2161	35.69349	-111.74740	1842	SGR 589
2162	35.69328	-111.74849	1848	PRS1
2163	35.69350	-111.74971	1856	SGR 590
2164	35.69410	-111.75032	1845	PRS1

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2165	35.69464	-111.75145	1845	SGR 591
2166	35.69508	-111.75177	1863	PRS1
2167	35.69557	-111.75234	1846	SGR 592
2168	35.69612	-111.75268	1861	PRS1
2169	35.69687	-111.75329	1841	SGR 593
2170	35.69756	-111.75379	1861	PRS1
2171	35.69830	-111.75440	1864	SGR 594
2172	35.69907	-111.75499	1868	PRS1
2173	35.69982	-111.75559	1868	SGR 595
2174	35.70059	-111.75617	1869	PRS1
2175	35.70136	-111.75677	1871	SGR 596
2176	35.70215	-111.75735	1874	PRS1
2177	35.70344	-111.75870	1858	SGR 597
2178	35.70408	-111.75926	1876	PRS1
2179	35.70479	-111.76014	1860	SGR 598
2180	35.70540	-111.76073	1880	PRS1
2181	35.70603	-111.76153	1888	SGR 599
2182	35.70666	-111.76232	1877	PRS1
2183	35.70733	-111.76307	1879	SGR 600
2184	35.70800	-111.76380	1881	PRS1
2185	35.70864	-111.76460	1882	SGR 601
2186	35.70928	-111.76538	1884	PRS1
2187	35.70996	-111.76617	1886	SGR 602
2188	35.71065	-111.76695	1891	PRS1
2189	35.71124	-111.76774	1888	SGR 603
2190	35.71183	-111.76853	1885	PRS1
2191	35.71251	-111.76928	1892	SGR 604
2192	35.71319	-111.77003	1900	PRS1
2193	35.71385	-111.77079	1902	SGR 605
2194	35.71450	-111.77155	1905	PRS1
2195	35.71512	-111.77234	1904	SGR 606
2196	35.71575	-111.77314	1904	PRS1
2197	35.71626	-111.77404	1905	SGR 607
2198	35.71680	-111.77493	1905	PRS1
2199	35.70071	-111.77578	1906	SGR 608
2200	35.71795	-111.77662	1908	PRS1
2201	35.71852	-111.77749	1909	SGR 609
2202	35.71909	-111.77835	1911	PRS1
2203	35.71970	-111.77919	1910	SGR 610
2204	35.72032	-111.78003	1910	PRS1
2205	35.72096	-111.78080	1909	SGR 611
2206	35.72159	-111.78158	1909	PRS1
2207	35.72225	-111.78233	1908	SGR 612
2208	35.72290	-111.78307	1908	PRS1
2209	35.72350	-111.78392	1910	SGR 613
2210	35.72411	-111.78475	1912	PRS1
2211	35.72476	-111.78551	1913	SGR 614
2212	35.72540	-111.78627	1914	PRS1
2213	35.72596	-111.78718	1915	SGR 615
2214	35.72651	-111.78808	1916	PRS1
2215	35.72704	-111.78897	1917	SGR 616
2216	35.72759	-111.78988	1919	PRS1
2217	35.72788	-111.79089	1919	SGR 617
2218	35.72819	-111.79195	1919	PRS1
2219	35.72870	-111.79300	1910	SGR 618
2220	35.72923	-111.79406	1901	PRS1
2221	35.72970	-111.79507	1903	SGR 619

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2222	35.73019	-111.79607	1906	PRS1
2223	35.73089	-111.79677	1908	SGR 620
2224	35.73162	-111.79746	1911	PRS1
2225	35.73190	-111.79837	1913	SGR 621
2226	35.73213	-111.79943	1918	PRS1
2227	35.73278	-111.80097	1908	SGR 622
2228	35.73327	-111.80164	1922	PRS1
2229	35.73422	-111.80185	1923	SGR 623
2230	35.73493	-111.80247	1922	PRS1
2231	35.73573	-111.80335	1915	SGR 624
2232	35.73644	-111.80425	1928	PRS1
2233	35.73702	-111.80486	1921	SGR 625
2234	35.73775	-111.80555	1933	PRS1
2235	35.73838	-111.80651	1920	SGR 626
2236	35.73872	-111.80733	1929	PRS1
2237	35.73934	-111.80838	1917	SGR 627
2238	35.73994	-111.80911	1942	PRS1
2239	35.74046	-111.81001	1920	SGR 629
2240	35.74093	-111.81095	1984	PRS1
2241	35.74177	-111.81178	1918	SGR 630
2242	35.74226	-111.81238	1954	PRS1
2243	35.74294	-111.81341	1929	SGR 631
2244	35.74345	-111.81410	1928	PRS1
2245	35.74413	-111.81504	1927	SGR 632
2246	35.74459	-111.81562	1927	PRS1
2247	35.74534	-111.81644	1927	SGR 633
2248	35.74581	-111.81727	1929	PRS1
2249	35.74646	-111.81821	1929	SGR 634
2250	35.74702	-111.81901	1928	PRS1
2251	35.74762	-111.81991	1928	SGR 635
2252	35.74817	-111.82060	1930	PRS1
2253	35.74890	-111.82160	1932	SGR 636
2254	35.74949	-111.82232	1930	PRS1
2255	35.74996	-111.82299	1936	SGR 637
2256	35.75070	-111.82401	1938	PRS1
2257	35.75134	-111.82489	1936	SGR 638
2258	35.75192	-111.82574	1940	PRS1
2259	35.75251	-111.82658	1944	SGR 639
2260	35.75311	-111.82739	1948	PRS1
2261	35.75363	-111.82810	1951	SGR 640
2262	35.75439	-111.82914	1952	PRS1
2263	35.75477	-111.82969	1966	SGR 641
2264	35.75535	-111.83057	1958	PRS1
2265	35.75591	-111.83146	1959	SGR 642
2266	35.75631	-111.83210	1956	PRS1
2267	35.75705	-111.83315	1958	SGR 643
2268	35.75741	-111.83392	1963	PRS1
2269	35.75800	-111.83489	1956	SGR 644
2270	35.75841	-111.83562	1961	PRS1
2271	35.75897	-111.83649	1963	SGR 645
2272	35.75953	-111.83732	1953	PRS1
2273	35.76012	-111.83831	1959	SGR 646
2274	35.76058	-111.83905	1970	PRS1
2275	35.76121	-111.83999	1970	SGR 647
2276	35.76185	-111.84079	1982	PRS1
2277	35.76240	-111.84168	1963	SGR 648
2278	35.76307	-111.84259	1984	PRS1

APPENDIX B, Continued. Station Locations for the Grand Canyon NW-SE Cross Line

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2279	35.76342	-111.84360	1971	SGR 649
2280	35.76374	-111.84461	1985	PRS1
2281	35.76413	-111.84562	1989	SGR 651
2282	35.76463	-111.84634	1988	PRS1
2283	35.76546	-111.84743	1996	SGR 652
2284	35.76604	-111.84789	1990	PRS1
2285	35.76660	-111.84870	2004	SGR 653
2286	35.75082	-111.84940	1989	PRS1
2287	35.76800	-111.85015	1998	SGR 654
2288	35.76886	-111.85071	1986	PRS1
2289	35.76960	-111.85153	1989	SGR 655
2290	35.77050	-111.85209	1981	PRS1
2291	35.77119	-111.85292	1984	SGR 656
2292	35.77206	-111.85351	1975	PRS1
2293	35.77207	-111.85480	1993	SGR 657
2294	35.77196	-111.85590	1976	PRS1
2295	35.77255	-111.85718	1980	SGR 659
2296	35.77327	-111.85769	1973	PRS1
2297	35.77391	-111.85858	1981	SGR 660
2298	35.77477	-111.85918	1973	PRS1
2299	35.77544	-111.86009	1984	SGR 661
2300	35.77607	-111.86047	1968	PRS1
2301	35.77687	-111.86154	1975	SGR 662
2302	35.77750	-111.86187	1972	PRS1
2303	35.77817	-111.86317	1985	SGR 663
2304	35.77868	-111.86371	1971	PRS1
2305	35.77925	-111.86495	1981	SGR 664
2306	35.77977	-111.86546	1963	PRS1
2307	35.78022	-111.86661	1984	SGR 665
2308	35.78087	-111.86725	1958	PRS1
2309	35.78132	-111.86846	1982	SGR 666
2310	35.78188	-111.86890	1955	PRS1
2311	35.78231	-111.87012	1990	SGR 667
2312	35.78274	-111.87082	2015	PRS1
2313	35.78340	-111.87191	2017	SGR 668
2314	35.78391	-111.87275	2014	PRS1
2315	35.78450	-111.87368	2009	SGR 669
2316	35.78502	-111.87455	2005	PRS1
2317	35.78550	-111.87526	2003	SGR 670
2318	35.78612	-111.87631	2006	PRS1
2319	35.78658	-111.87721	2000	SGR 671
2320	35.78680	-111.87847	1994	PRS1
2321	35.78724	-111.87953	1988	SGR 672
2322	35.78787	-111.88012	2009	PRS1
2323	35.78881	-111.88039	1995	SGR 673
2324	35.79012	-111.88071	1977	PRS1
2325	35.79165	-111.88114	1998	SGR 674
2326	35.79300	-111.88180	1995	PRS1
2327	35.79398	-111.88121	1998	SGR 676
2328	35.79455	-111.88069	1996	PRS1
2329	35.79534	-111.87989	1996	SGR 677
2330	35.79576	-111.87891	1984	PRS1
2331	35.79670	-111.87863	1998	SGR 678
2332	35.79723	-111.87779	1993	PRS1
2333	35.79822	-111.87797	1997	SGR 679
2334	35.79907	-111.87735	1963	PRS1
2335	35.80049	-111.87640	2000	SGR 680

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2336	35.80135	-111.87622	1998	PRS1
2337	35.80225	-111.87661	2013	SGR 681
2338	35.80298	-111.87702	2004	PRS1
2339	35.80386	-111.87759	1963	SGR 682
2340	35.80455	-111.87780	2000	PRS1
2341	35.80526	-111.87816	1972	SGR 683
2342	35.80627	-111.87836	2000	PRS1
2343	35.80742	-111.87902	1967	SGR 684
2344	35.80798	-111.87943	1997	PRS1
2345	35.80894	-111.87990	1964	SGR 685
2346	35.80975	-111.87989	1991	PRS1
2347	35.81080	-111.88056	1974	SGR 686
2348	35.81107	-111.88010	1855	PRS1
2349	35.81256	-111.88143	1976	SGR 687
2350	35.81340	-111.88157	1980	PRS1
2351	35.81423	-111.88155	1980	SGR 689
2352	35.81505	-111.88136	1999	PRS1
2353	35.81609	-111.88134	1981	SGR 690
2354	35.81704	-111.88117	1979	PRS1
2355	35.81782	-111.88123	1977	SGR 691
2356	35.81872	-111.88167	1977	PRS1
2357	35.81963	-111.88211	1977	SGR 692
2358	35.82050	-111.88221	1998	PRS1
2359	35.82154	-111.88249	1989	SGR 693
2360	35.82217	-111.88325	1993	PRS1
2361	35.82307	-111.88369	2025	SGR 694
2362	35.82377	-111.88447	2023	SGR 695
2363	35.82446	-111.88521	2033	SGR 696
2364	35.82510	-111.88626	2027	SGR 697
2365	35.82597	-111.88711	2030	SGR 698
2366	35.82700	-111.88839	2028	SCR 041
2367	35.82797	-111.88967	2011	SCR 042
2368	35.82906	-111.89067	2010	SCR 043
2369	35.83004	-111.89065	2031	SCR 044
2370	35.83073	-111.88958	2006	SCR 045
2371	35.83161	-111.88890	2025	SCR 046
2372	35.83252	-111.88860	2030	SCR 047
2373	35.83342	-111.88829	2042	SCR 048
2374	35.83434	-111.88852	2070	SCR 049
2375	35.83509	-111.88802	2028	SCR 050
2376	35.83602	-111.88788	2022	SCR 051
2377	35.83702	-111.88806	2008	SCR 052
2378	35.83798	-111.88786	2015	SCR 053
2379	35.83905	-111.88764	2047	SCR 054
2380	35.84011	-111.88800	2266	SCR 055
2381	35.84090	-111.88816	2105	SCR 056
2382	35.84184	-111.88878	1676	SCR 057
2383	35.84277	-111.88948	1726	SCR 058
2384	35.84371	-111.89017	1776	SCR 059
2385	35.84654	-111.89271	2055	SCR 060
2386	35.85096	-111.89537	2061	SCR 061
2387	35.85459	-111.89920	2067	SCR 062
2388	35.85777	-111.90268	2079	SCR 063
2389	35.86101	-111.90589	2085	SCR 064
2390	35.86453	-111.90979	2091	SCR 065
2391	35.86793	-111.91417	2103	SCR 066
2392	35.87076	-111.91918	2115	SCR 067

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2393	35.87348	-111.92391	2115	SCR 068
2394	35.87648	-111.92848	2115	SCR 069
2395	35.87999	-111.93253	2127	SCR 070
2396	35.88254	-111.93775	2142	SCR 071
2397	35.88600	-111.94110	2145	SCR 072
2398	35.88941	-111.94453	2158	SCR 073
2399	35.89173	-111.95043	2179	SCR 074
2400	35.89645	-111.95138	2188	SCR 075
2401	35.90180	-111.95116	2194	SCR 076
2402	35.90893	-111.94688	2200	SCR 077
2403	35.91439	-111.94742	2206	SCR 078
2404	35.92117	-111.94410	2221	SCR 079
2405	35.92743	-111.94237	2239	SCR 080
2406	35.93399	-111.93967	2258	SCR 081
2407	35.93922	-111.94076	2261	SCR 082
2408	35.94302	-111.94357	2270	SCR 083
2409	35.94620	-111.94782	2273	SCR 084
2410	35.94932	-111.95173	2273	SCR 085
2411	35.95352	-111.95364	2276	SCR 086
2412	35.95835	-111.95514	2282	SCR 087
2413	35.96196	-111.95898	2279	SCR 088
2414	35.96399	-111.96495	2261	SCR 089
2415	35.96693	-111.96996	2264	SCR 090
2416	35.96925	-111.97538	2264	SCR 091
2417	35.97219	-111.97998	2264	SCR 092
2418	35.97628	-111.98300	2267	SCR 093
2419	35.97905	-111.98773	2267	SCR 094
2420	35.98383	-111.98889	2270	SCR 095
2421	35.98804	-111.99032	2270	SCR 096
2422	35.99172	-111.99431	2270	SCR 097
2423	35.99412	-112.00028	2278	SCR 098
2424	35.99381	-112.02238	2235	SCR 099
2425	35.99848	-112.03411	2213	SCR 100
2426	36.00439	-112.04366	2197	SCR 101
2427	36.00991	-112.05479	2176	SCR 102
2428	36.01487	-112.06516	2158	SCR 103
2429	36.02584	-112.06414	2194	SCR 104
2430	36.03473	-112.06784	2182	SCR 105
2431	36.04076	-112.07661	2179	SCR 106
2432	36.04718	-112.08548	2176	SCR 107
2433	36.05848	-112.08252	2194	SCR 108
2434	36.06543	-112.08967	1853	PRS1
2435	36.07450	-112.09158	1617	PRS1
2436	36.08100	-112.09028	1584	PRS1
2437	36.09087	-112.08781	1218	PRS1
2438	36.10105	-112.09088	777	PRS1
2439	36.11038	-112.09118	805	PRS1
2440	36.12120	-112.07832	909	PRS1
2441	36.13358	-112.07197	985	PRS1
2442	36.14392	-112.06255	1067	PRS1
2443	36.15457	-112.05373	1113	PRS1
2444	36.16765	-112.04425	1174	PRS1
2445	36.17742	-112.03388	1348	PRS1
2506	36.20221	-112.05536	2512	PRS1
2507	36.21617	-112.06033	2539	PRS1
2508	36.22687	-112.06456	2512	PRS1
2509	36.23926	-112.07473	2560	PRS1

APPENDIX B, Continued. *Station Locations for the Grand Canyon NW-SE Cross Line*

Station	Latitude	Longitude	Elevation (m)	Instrument Type
2510	36.25201	-112.07561	2579	SCR 109
2511	36.26448	-112.07840	2591	SCR 110
2512	36.27675	-112.08039	2633	SCR 111
2513	36.28901	-112.08224	2682	SCR 112
2514	36.29957	-112.08578	2658	SCR 113
2515	36.30863	-112.09546	2701	SCR 114
2516	36.31780	-112.10490	2682	SCR 115
2517	36.33192	-112.11464	2688	SCR 116
2518	36.34495	-112.12430	2739	SCR 117
2519	36.35204	-112.12929	2765	SCR 118
2520	36.36197	-112.13357	2768	"AFGL1,2*"
2521	36.37063	-112.13992	2783	AFGL2
2522	36.38027	-112.14193	2793	"AFGL1,2"
2523	36.39002	-112.14511	2792	AFGL2
2524	36.39930	-112.15185	2795	"AFGL1,2"
2525	36.41329	-112.14801	2792	AFGL2
2526	36.42657	-112.15521	2792	"AFGL1,2"
2527	36.43824	-112.15989	2795	AFGL2
2528	36.45229	-112.15515	2774	"AFGL1,2"
2529	36.47328	-112.15443	2749	AFGL2
2530	36.48341	-112.16368	2749	"AFGL1,2"
2531	36.49746	-112.18092	2694	AFGL2
2532	36.50520	-112.19241	2674	"AFGL1,2"
2533	36.51367	-112.20100	2664	------
2534	36.52276	-112.20624	2646	"AFGL1,2"
2535	36.53272	-112.21204	2628	AFGL2
2536	36.54413	-112.21914	2634	"AFGL1,2"
2537	36.55386	-112.22276	2597	AFGL2
2538	36.56484	-112.22665	2582	"AFGL1,2"
2539	36.57444	-112.23382	2574	AFGL2
2540	36.58046	-112.24609	2569	"AFGL1,2"
2541	36.58855	-112.25841	2506	AFGL2
2542	36.59865	-112.26872	2536	"AFGL1,2"
2543	36.61245	-112.26789	2513	AFGL2
2544	36.62250	-112.27480	2499	"AFGL1,2"
2545	36.62808	-112.28661	2475	AFGL2
2546	36.63757	-112.29304	2451	"AFGL1,2"
2547	36.64363	-112.30412	2438	AFGL2
2548	36.64821	-112.32264	2402	"AFGL1,2"
2549	36.65731	-112.32977	2396	AFGL1
2550	36.68084	-112.34648	1987	AFGL1
2551	36.70290	-112.34773	1960	AFGL1
2552	36.72618	-112.33830	1984	AFGL1
2553	36.74844	-112.35703	1879	AFGL1
2554	36.76010	-112.37969	1811	AFGL1
2555	36.77560	-112.40312	1750	AFGL1
2556	36.79433	-112.41905	1710	AFGL1
2557	36.81697	-112.42290	1672	AFGL1
2558	36.83875	-112.43277	1622	AFGL1
2559	36.85805	-112.44774	1547	AFGL1
2560	36.87957	-112.46351	1506	AFGL1
2561	36.89308	-112.47968	1451	AFGL1
2562	36.91331	-112.49392	1451	AFGL1
2563	36.92984	-112.50257	1445	AFGL1
2564	36.65532	-112.32637	2402	AFGL2

*AFGL1,2 = Site occupied by AFGL instrument for the Colorado Plateau (1) and/or Grand Canyon (2) profile.

APPENDIX C
PACE 1989 SHOTPOINT INFORMATION

NE-SW COLORADO PLATEAU PROFILE:

SP	No. Holes	Hole Depth (ft)				Casing Depth (ft)				Size (lbs)	Rock Type	Wet?
		(#1	#2	#3	#4)	(#1	#2	#3	#4)			
20	4	163	165	167	169	163	165	167	169	8000	Alluvium	Y
23	2	165	175			20	15.6			6000	Basalt	Y
28	3	165	160	161		17	15	18		8000	Granite	N
31	3	163	163	160		22	22	18		6000	Granite	Y
32	2	175	175			20	23			6000	Quartsite	Y
33	1	175				14				3000	Limestone	N
34	1	170				6				3000	Limestone	N
38	1	175				22				3000	Granite	N
39	1	110				108				1000	Alluvium	Y
40	1	50				50				2000	Alluvium	Y
41	1	105				36				2000	Limestone	N
42	2	140	140			5	5			4000	Limestone	N
46	2	170	170			14	10			6000	Sandstone	Y
49	1	110				108				1000	Alluvium	Y
50	1	100				5				1000	Cinder/Ash	N
56	1	150				16				1500	Basalt	N
57	1	204				35				3000	Schist	Y
58	1	174				17				3000	Basalt	N
61	1	130				22				1500	Alluvium	N
62	1	90				14				1500	Limestone	N
65	1	105				8				1500	Limestone	N
69	1	100				8				1500	Basalt/Alluvium	Y
71	1	63				44				1500	Limestone	N
84	1	170				~20				3000	Limestone	N

APPENDIX C, Continued
PACE 1989 SHOTPOINT INFORMATION

NW-SE GRAND CANYON PROFILE:

SP	No. Holes	Hole Depth (ft)				Casing Depth (ft)				Size (lbs)	Rock Type	Wet?
		(#1	#2	#3	#4)	(#1	#2	#3	#4)			
34	0	170				0				~1500	Limestone	N
71	1	110				22				1500	Limestone	N
72	1	101				19				500	Limestone	N
73	1	100				17				500	Limestone	N
74	1	110				7				1000	Limestone	N
75	1	120				8				1000	Limestone	N
76	2	85	115			15	11			1500	Basalt	N
77	1	120				20				1500	Limestone	N
82	2	170	175			3	4			6000	Limestone	N
83	2	175	175			12	5			6000	Limestone	N
85	1	175				16				3000	Limestone	N

APPENDIX D
RECORD SECTIONS

The record sections presented on the following pages are plotted as follows. Reduction velocity is 6.0 km/s except for SP 20, which is reduced at 8.0 km/s. The data are bandpass filtered (7-22 Hz) and are displayed in pseudo true-amplitude format: first amplitudes are normalized within a trace using a full-trace automatic gain control (AGC), then a lateral trace balance is applied in order to correct for increased energy attenuation with offset. Fan shots are displayed in reduced format but are plotted trace sequentially, rather than being scaled by offset (see SPs 57, 58, and 34, Figs. 24, 25, and 32, respectively). For these three shots, channel number, rather than offset, is displayed on the horizontal plot axis. Because of the 0.1-km trace spacing between SPs 76 and 77 on the Grand Canyon profile (see Fig. 3b for location), only one out of every 5 traces is plotted from this 35-km-wide dense array. All seismic traces, however, are included in the archived data set on Exabyte tape.

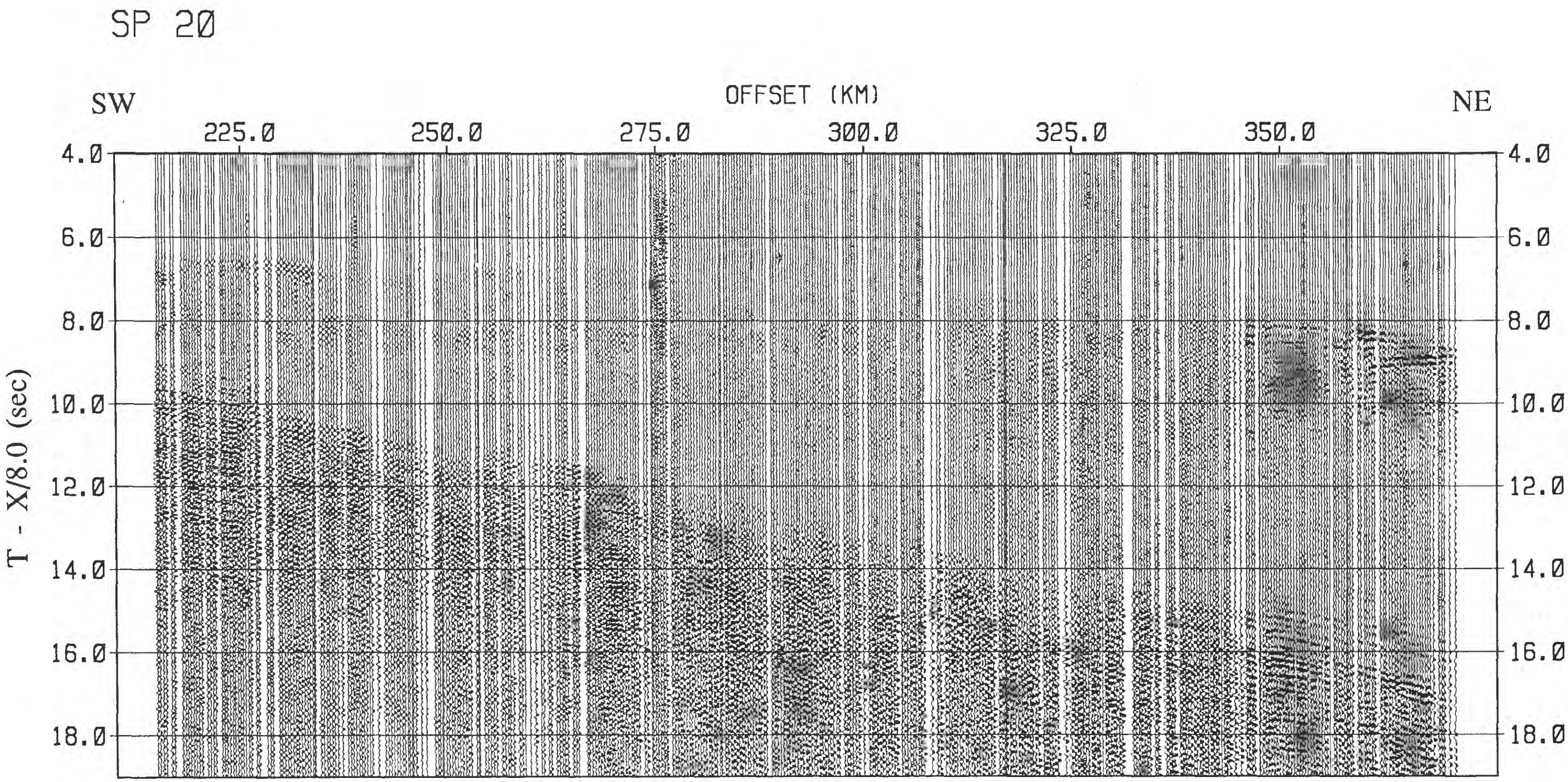

Figure 8. Reduced record-section plot of SP 20, Shot 9.

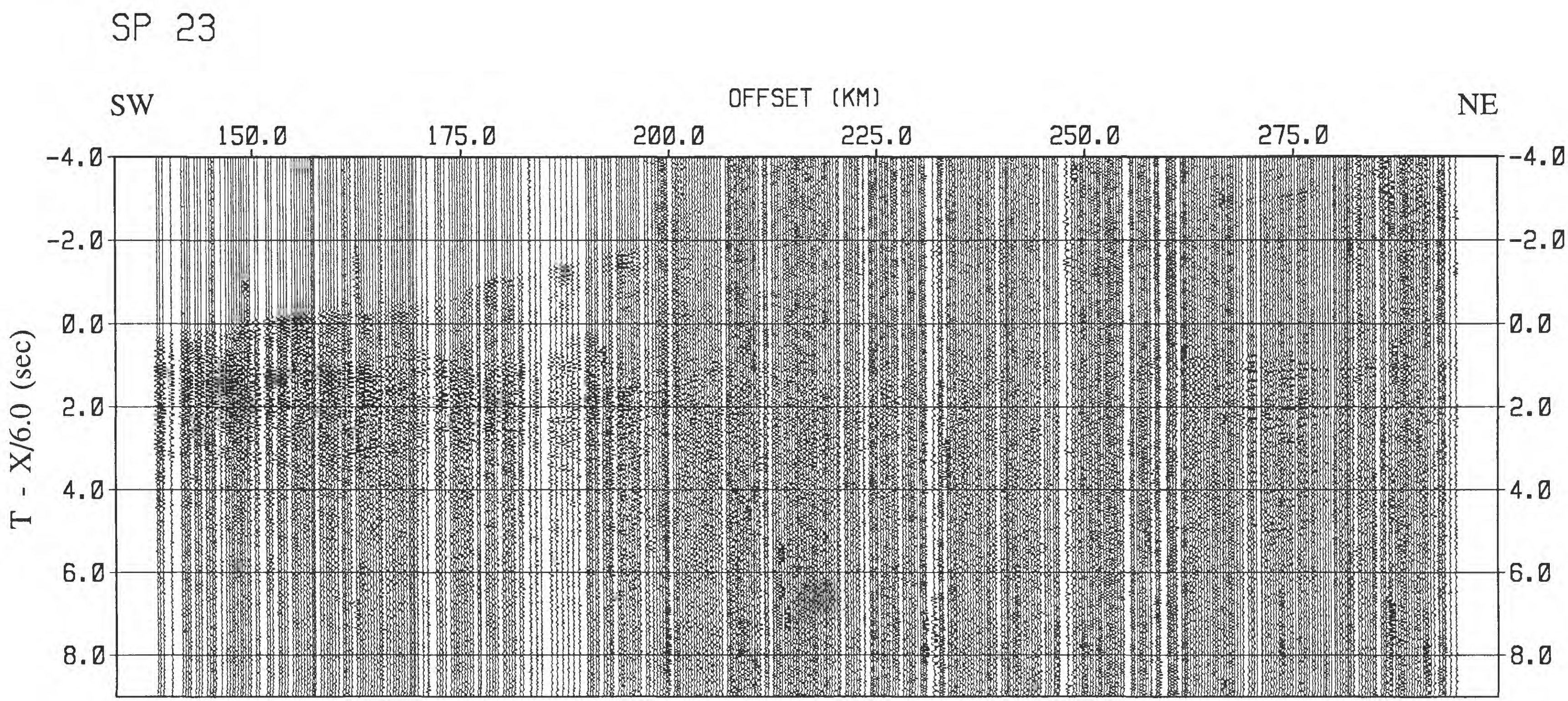

Figure 9. Reduced record-section plot of SP 23, Shot 18.

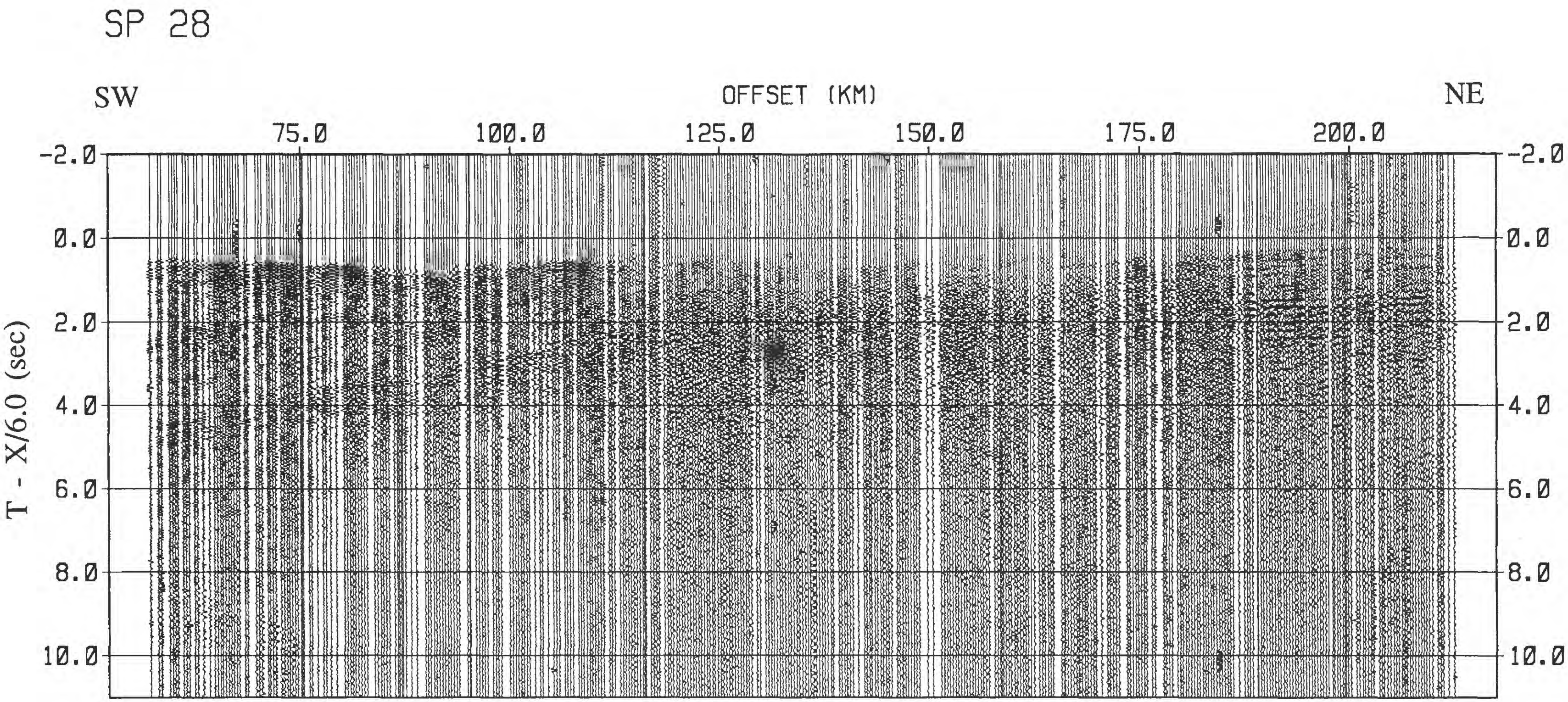

Figure 10. Reduced record-section plot of SP 28, Shot 11.

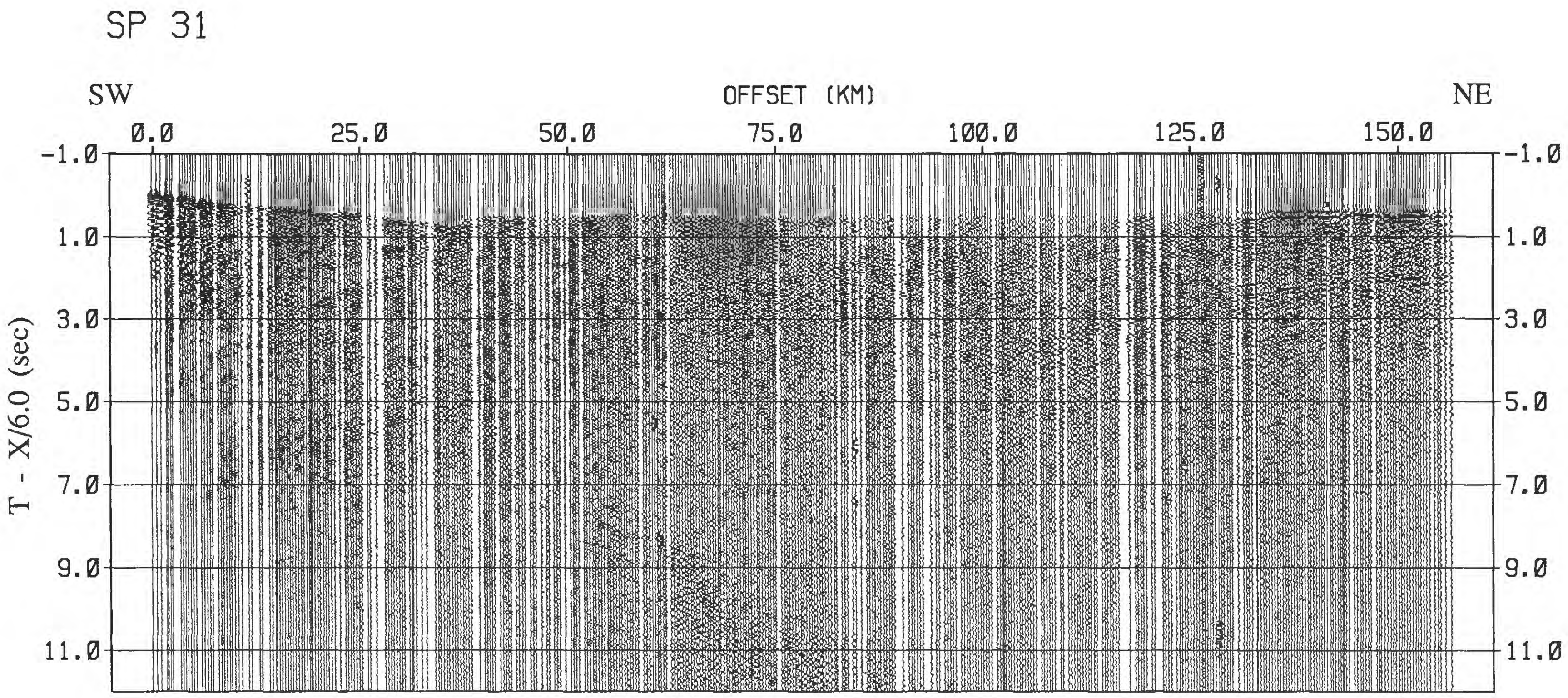

Figure 11. Reduced record-section plot of SP 31, Shot 1.

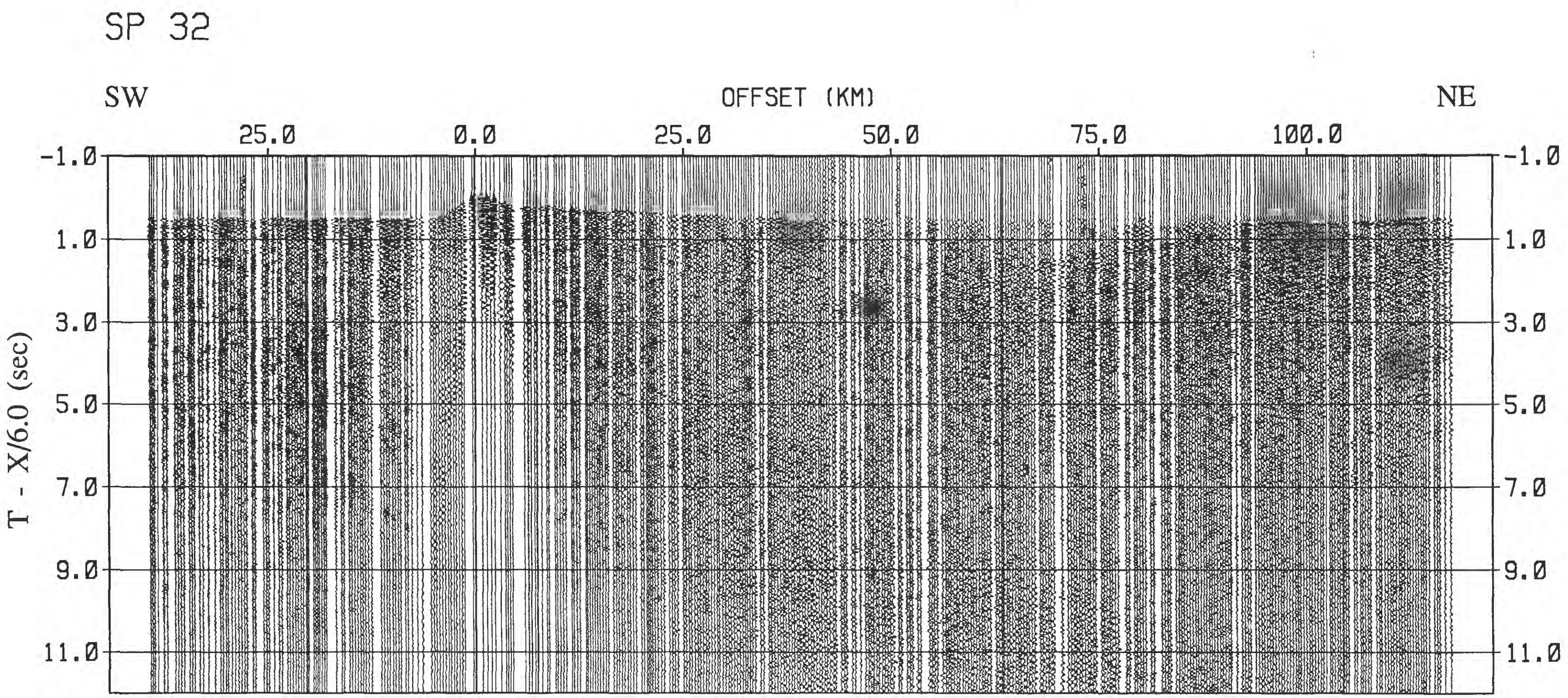

Figure 12. Reduced record-section plot of SP 32, Shot 12.

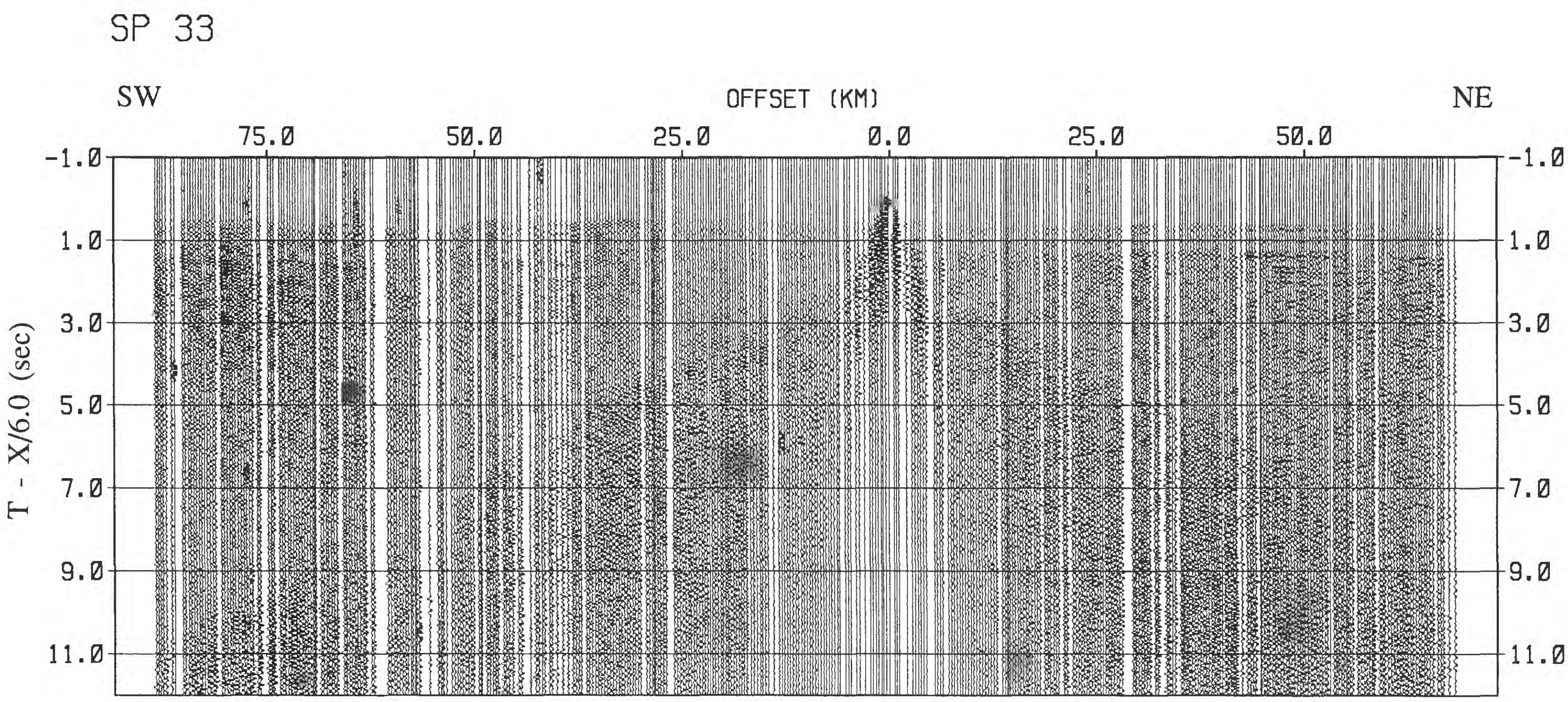

Figure 13. Reduced record-section plot of SP 33, Shot 7.

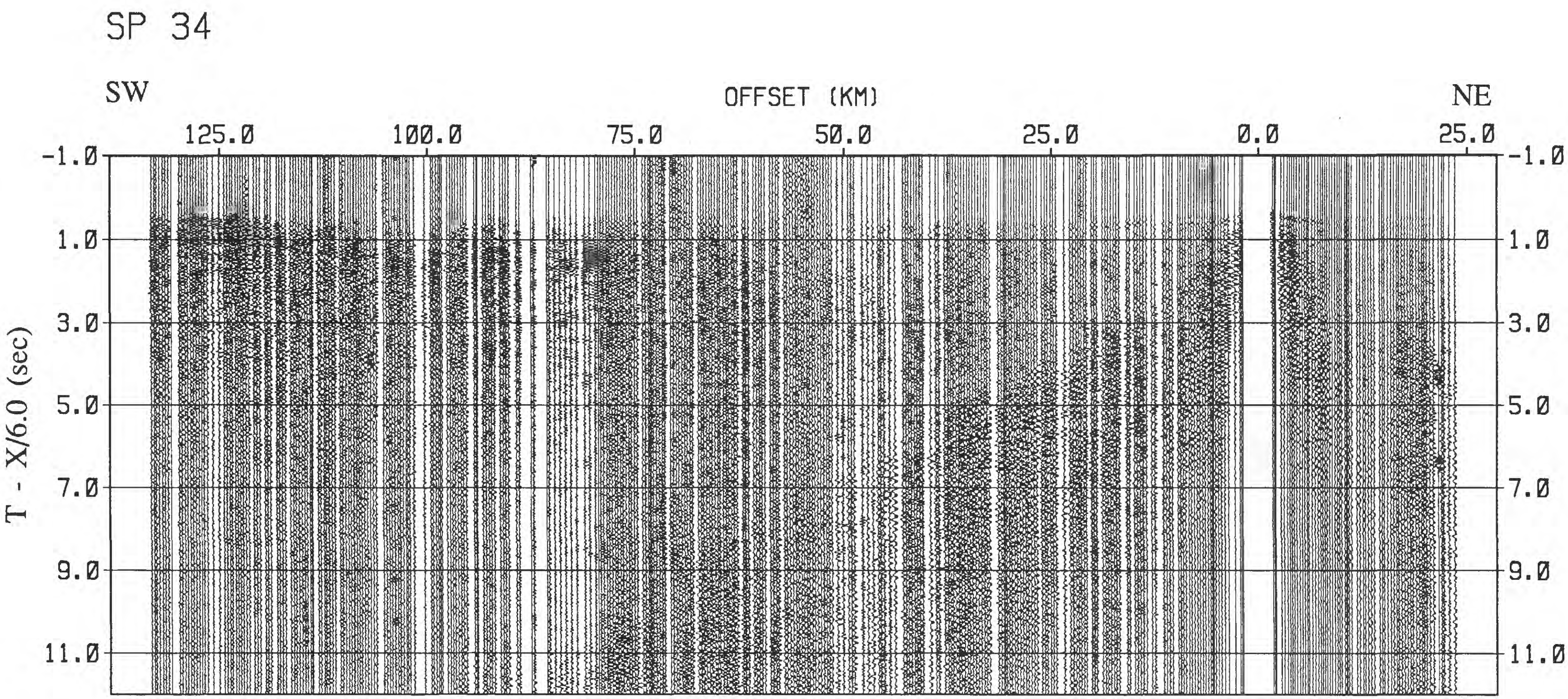

Figure 14. Reduced record-section plot of SP 34, Shot 21.

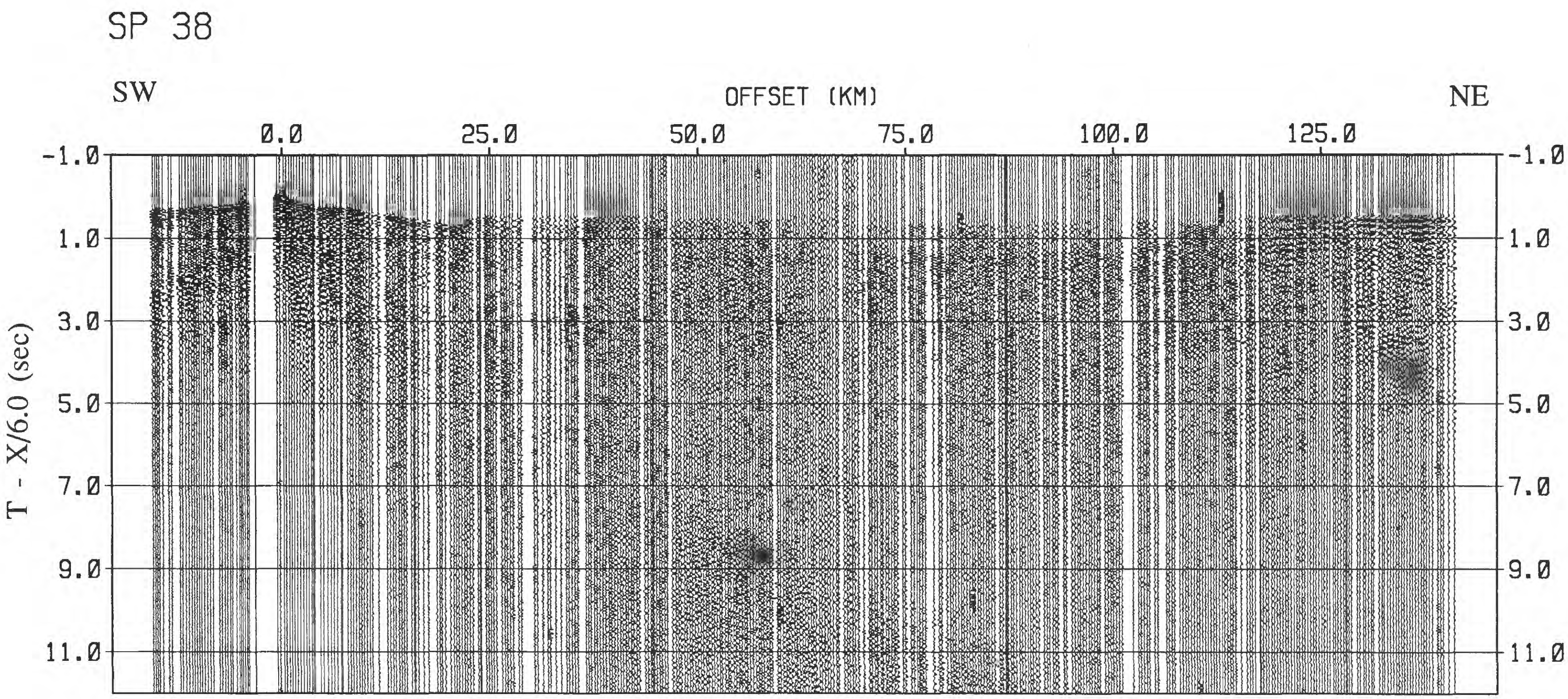

Figure 15. Reduced record-section plot of SP 38, Shot 6.

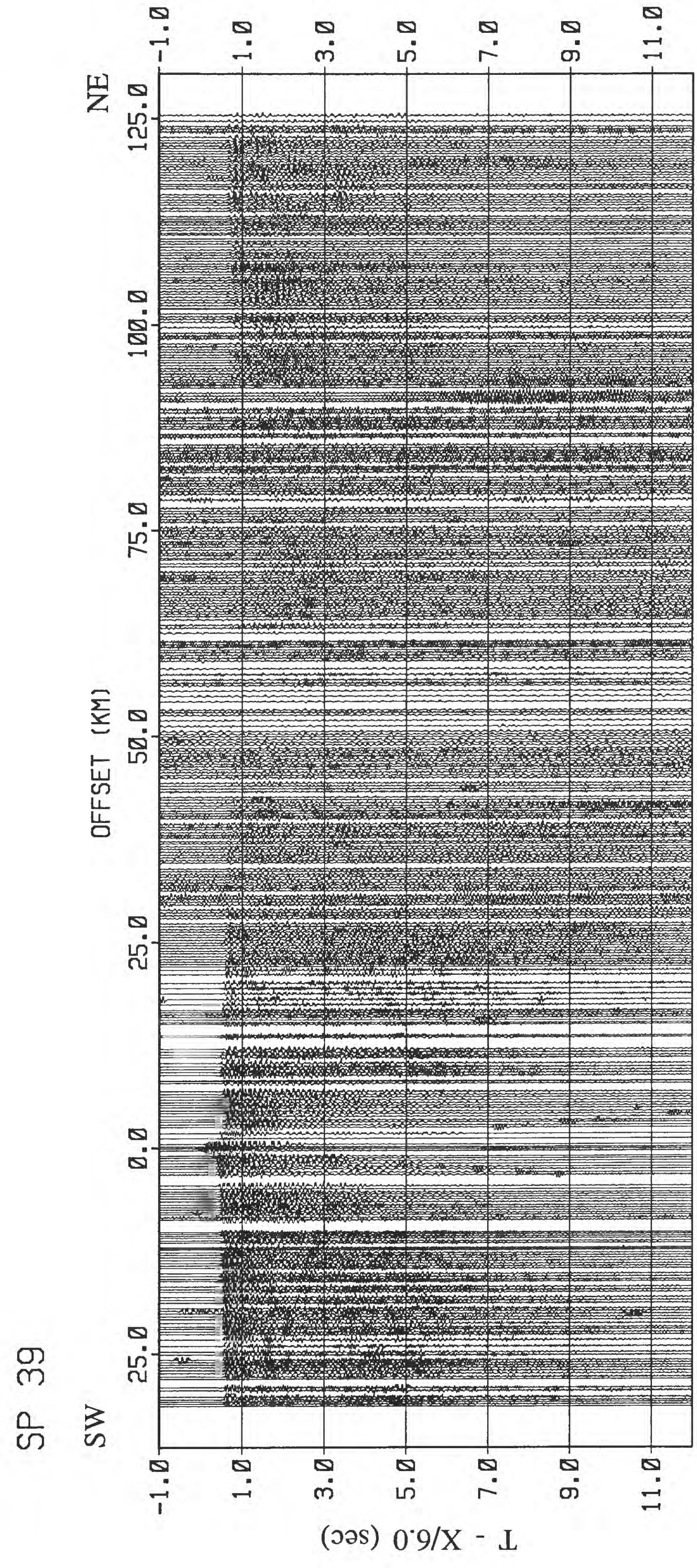

Figure 16. Reduced record-section plot of SP 39, Shot 19.

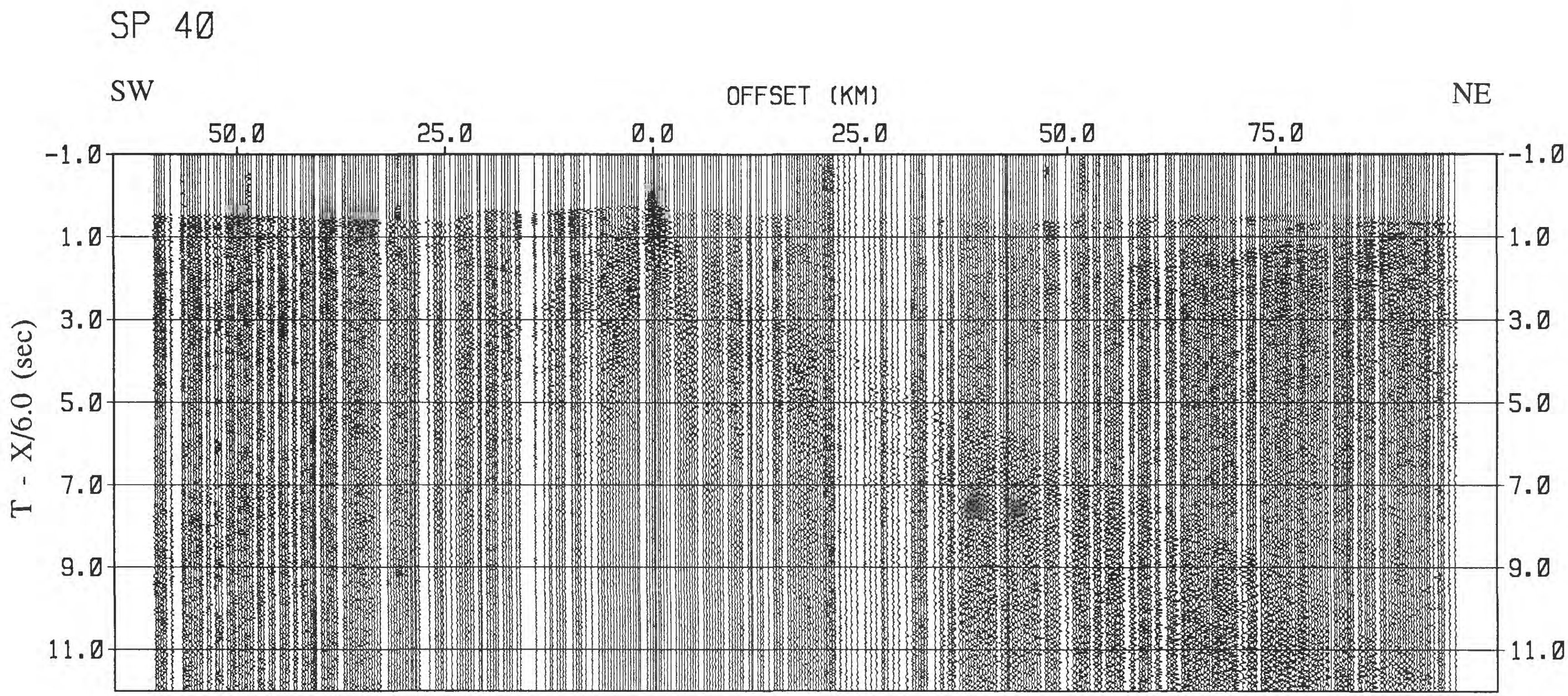

Figure 17. Reduced record-section plot of SP 40, Shot 24.

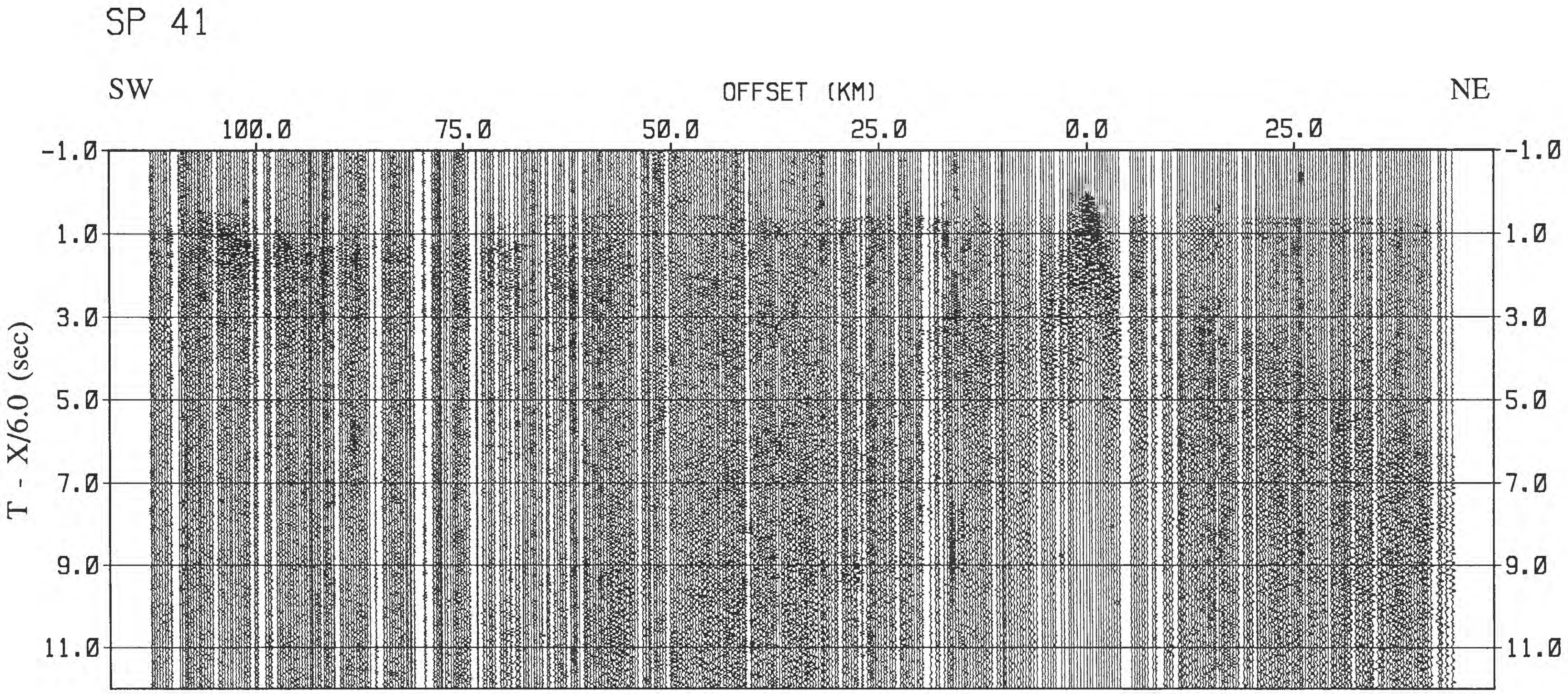

Figure 18. Reduced record-section plot of SP 41, Shot 4.

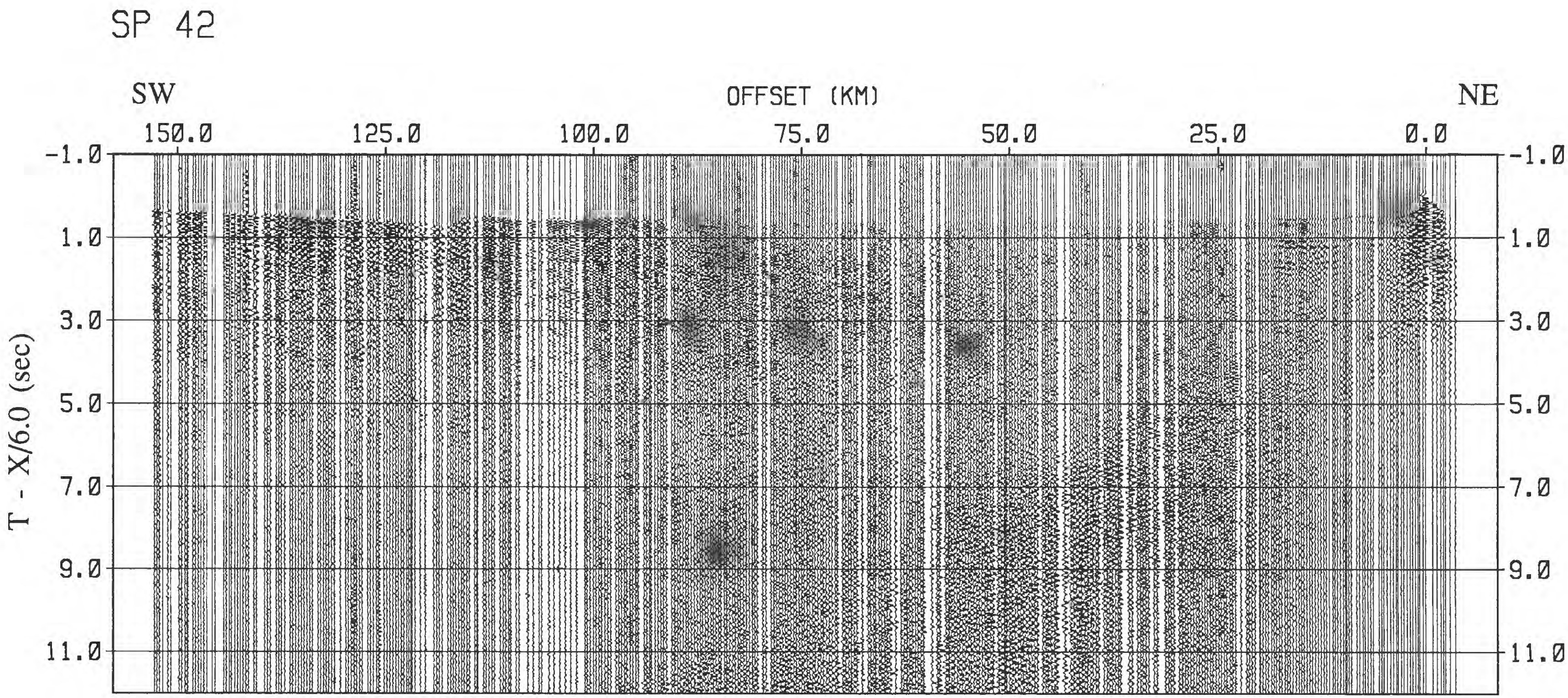

Figure 19. Reduced record-section plot of SP 42, Shot 15.

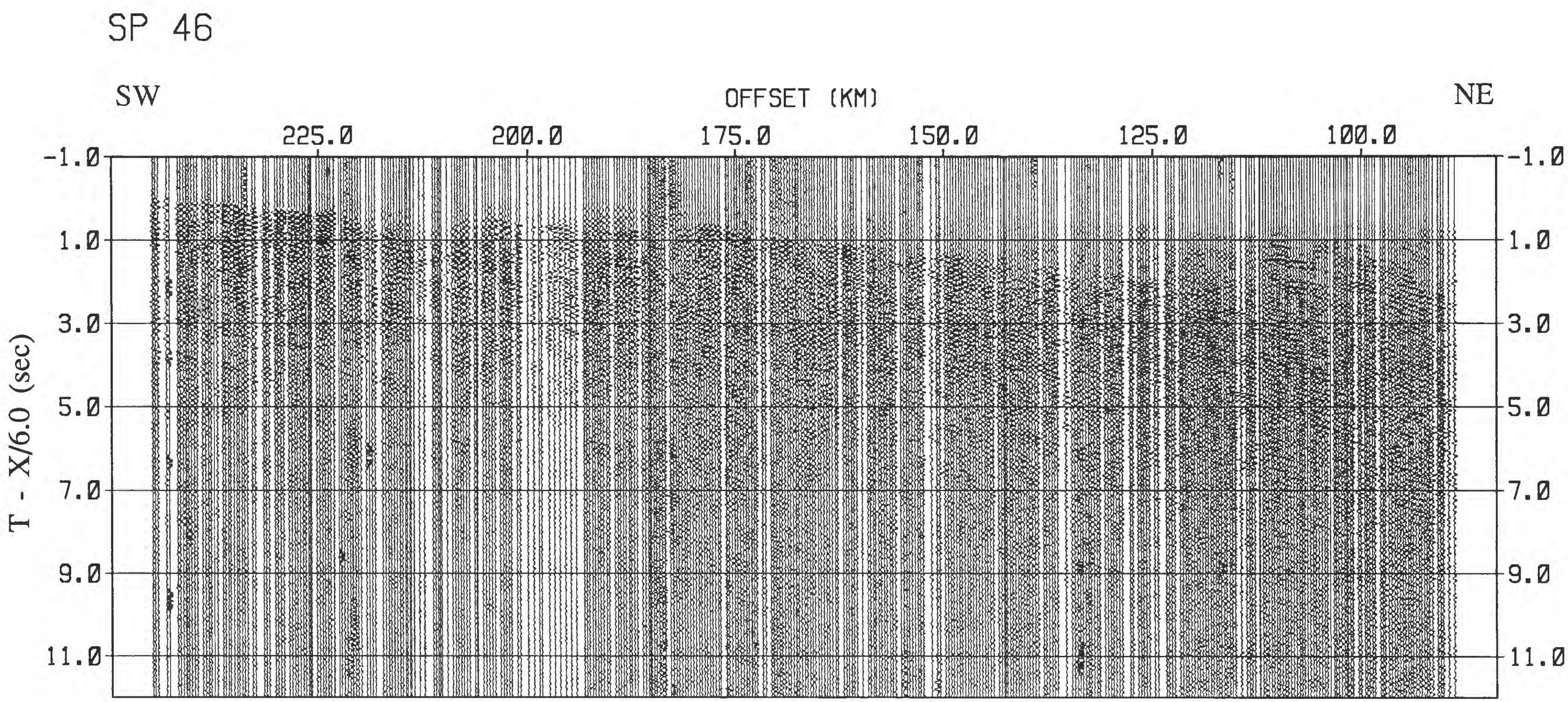

Figure 20. Reduced record-section plot of SP 46, Shot 17.

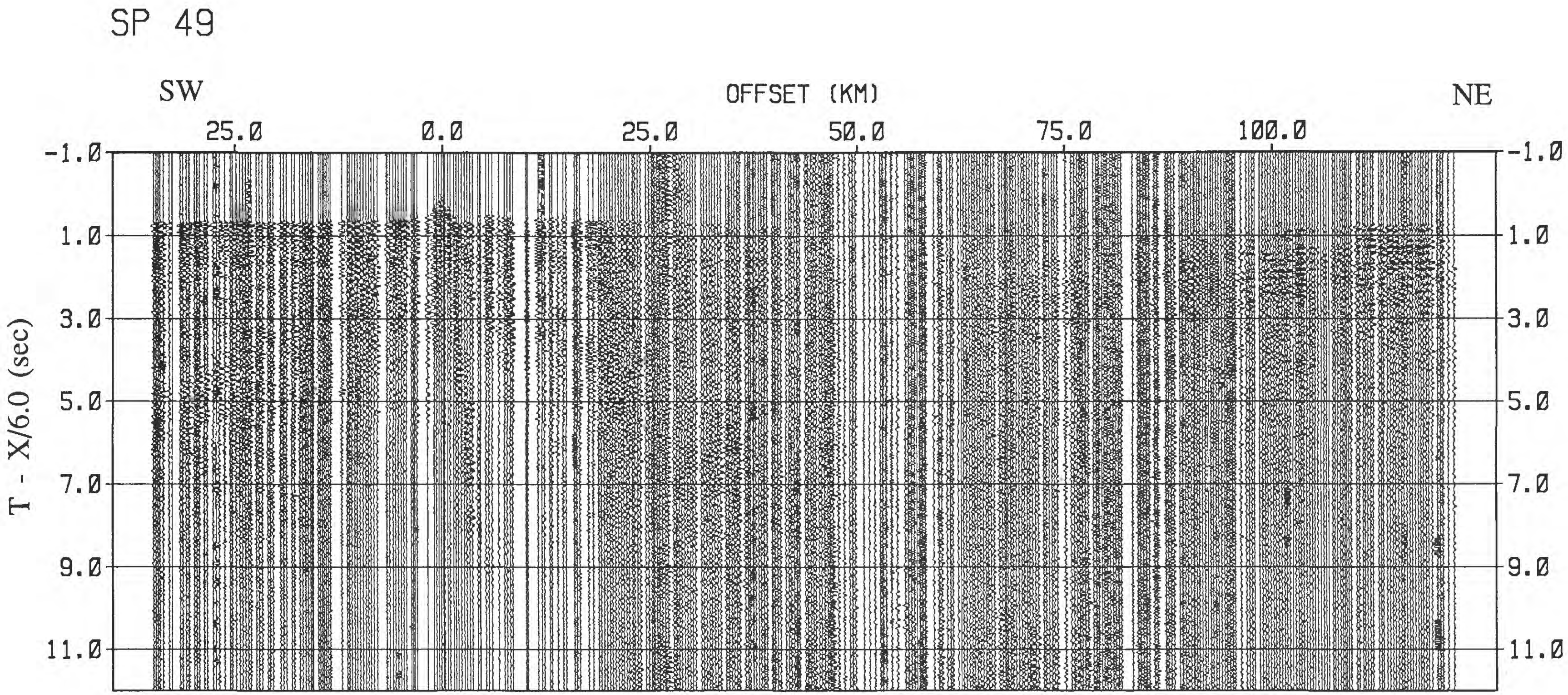

Figure 21. Reduced record-section plot of SP 49, Shot 22.

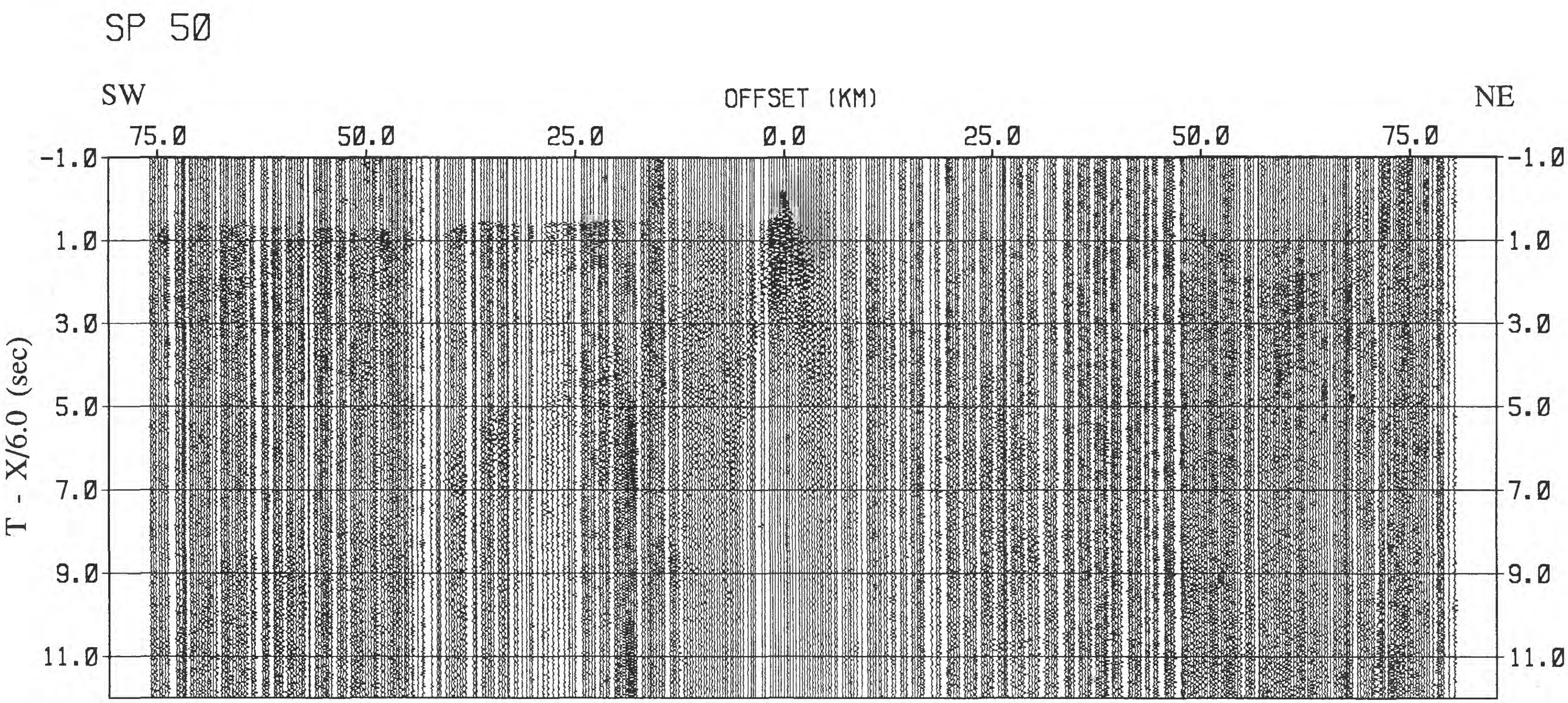

Figure 22. Reduced record-section plot of SP 50, Shot 14.

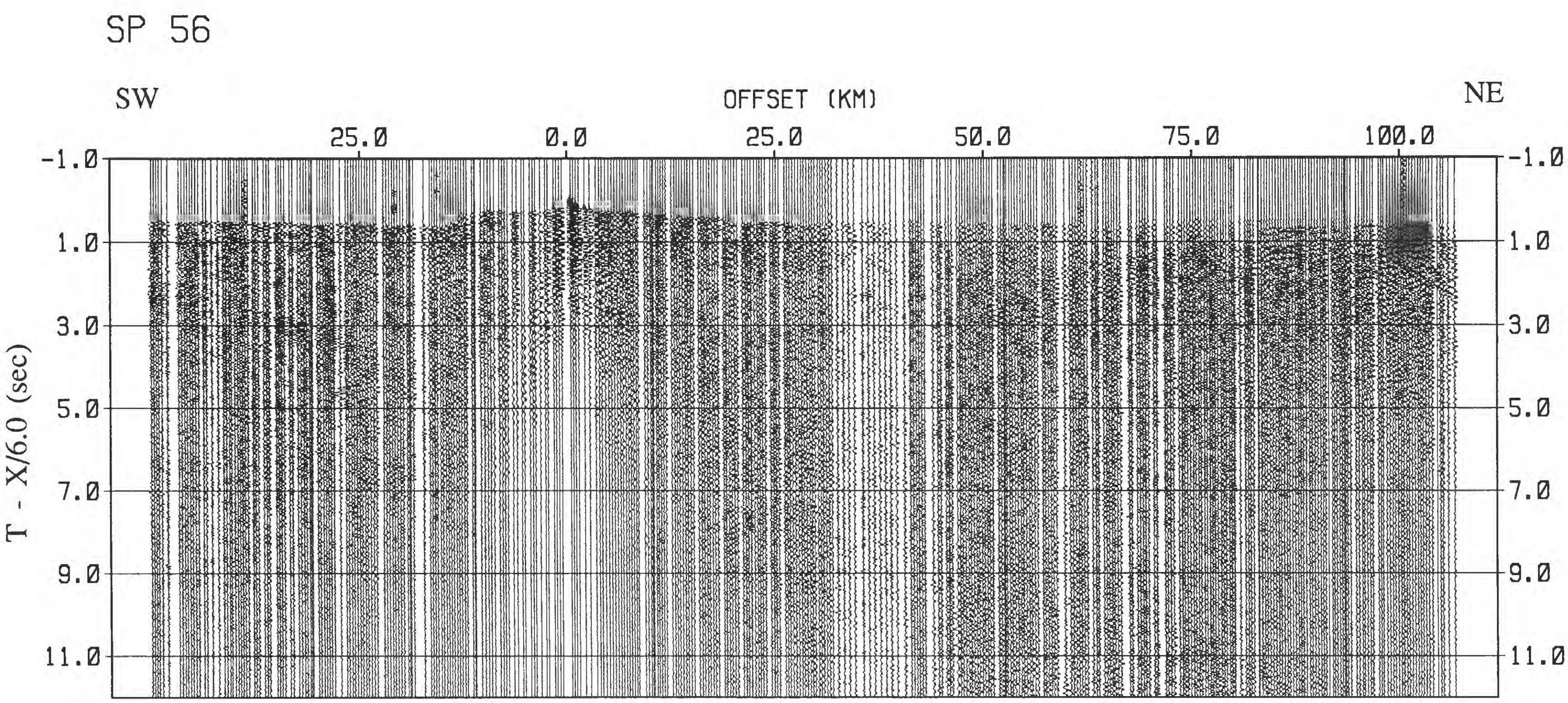

Figure 23. Reduced record-section plot of SP 56, Shot 23.

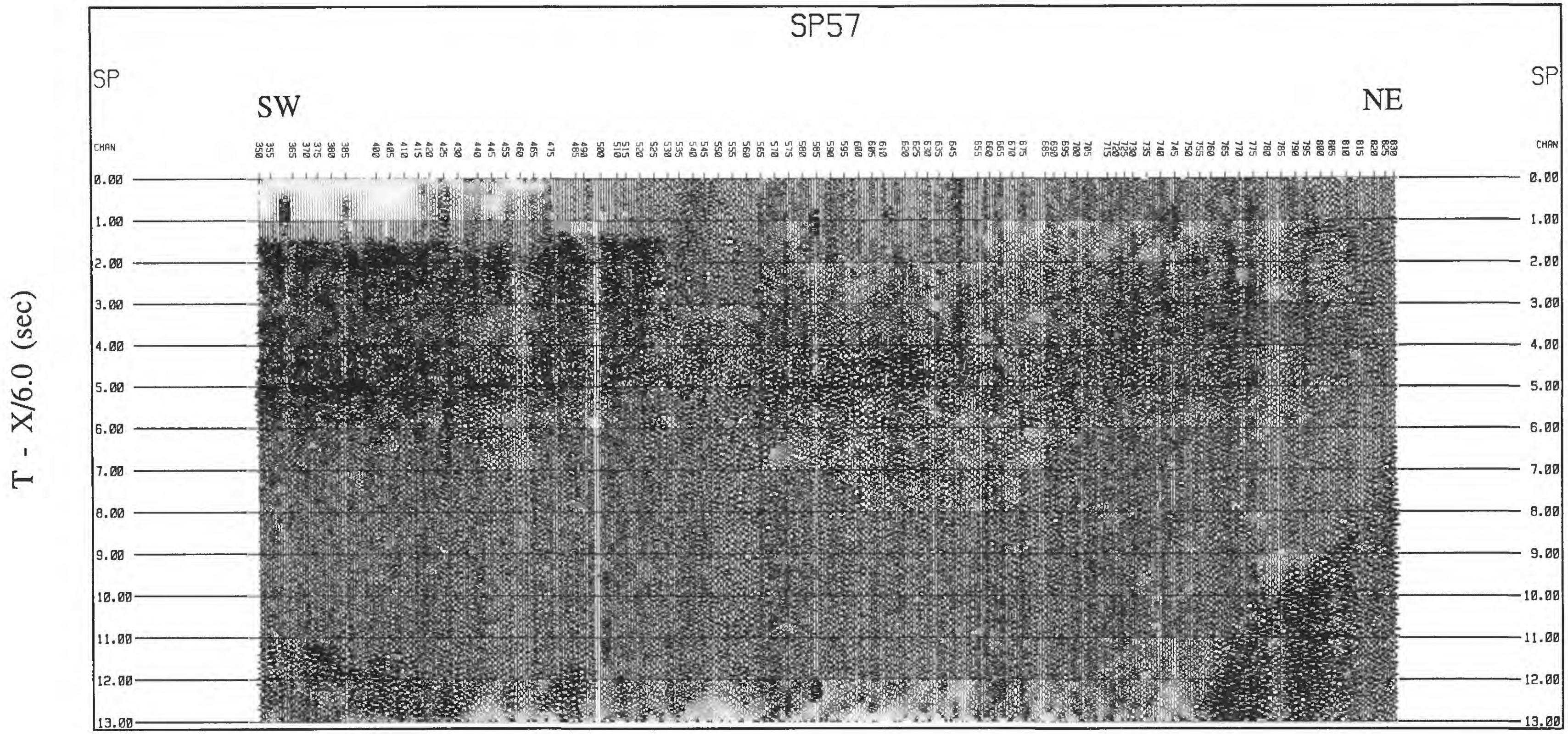

Figure 24. Reduced record-section plot of SP 57, Shot 3.

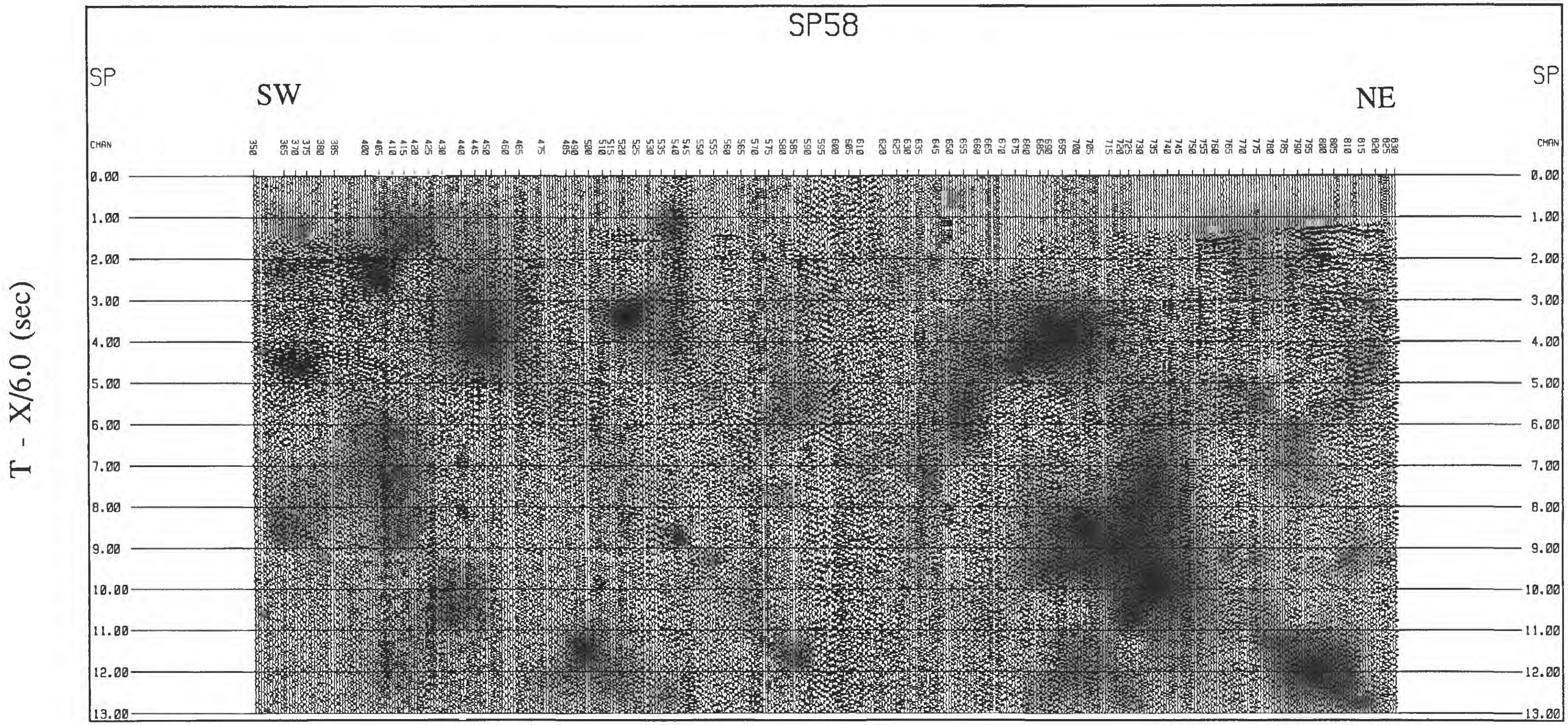

Figure 25. Reduced record-section plot of SP 58, Shot 5.

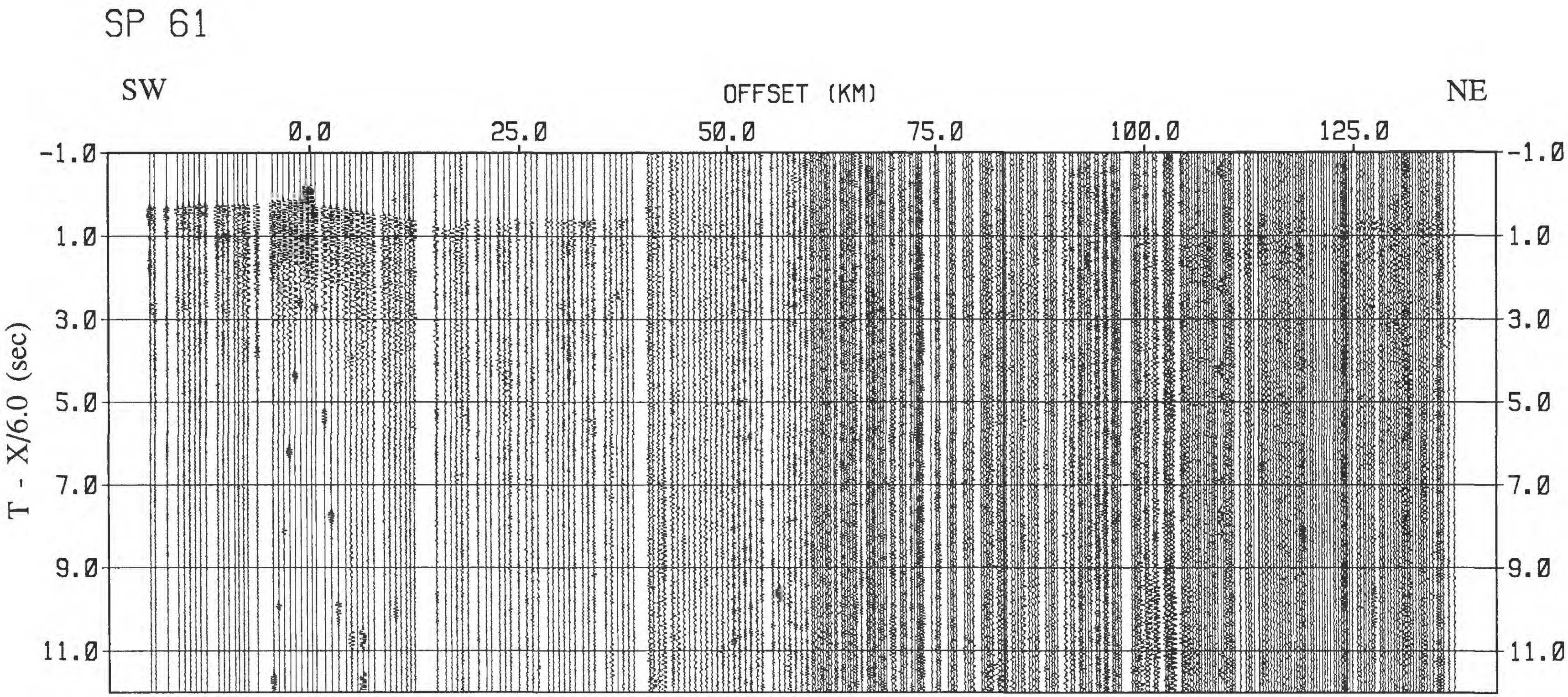

Figure 26. Reduced record-section plot of SP 61, Shot 10.

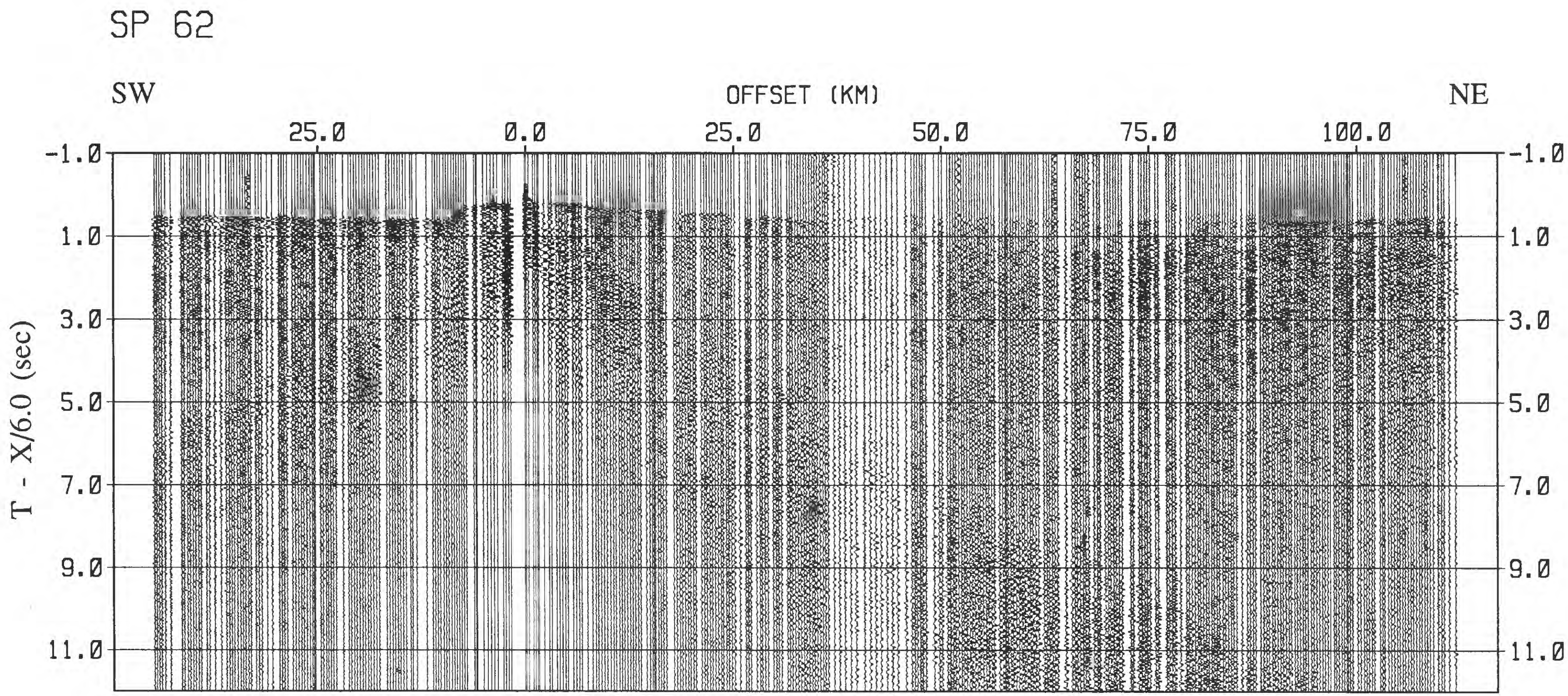

Figure 27. Reduced record-section plot of SP 62, Shot 20.

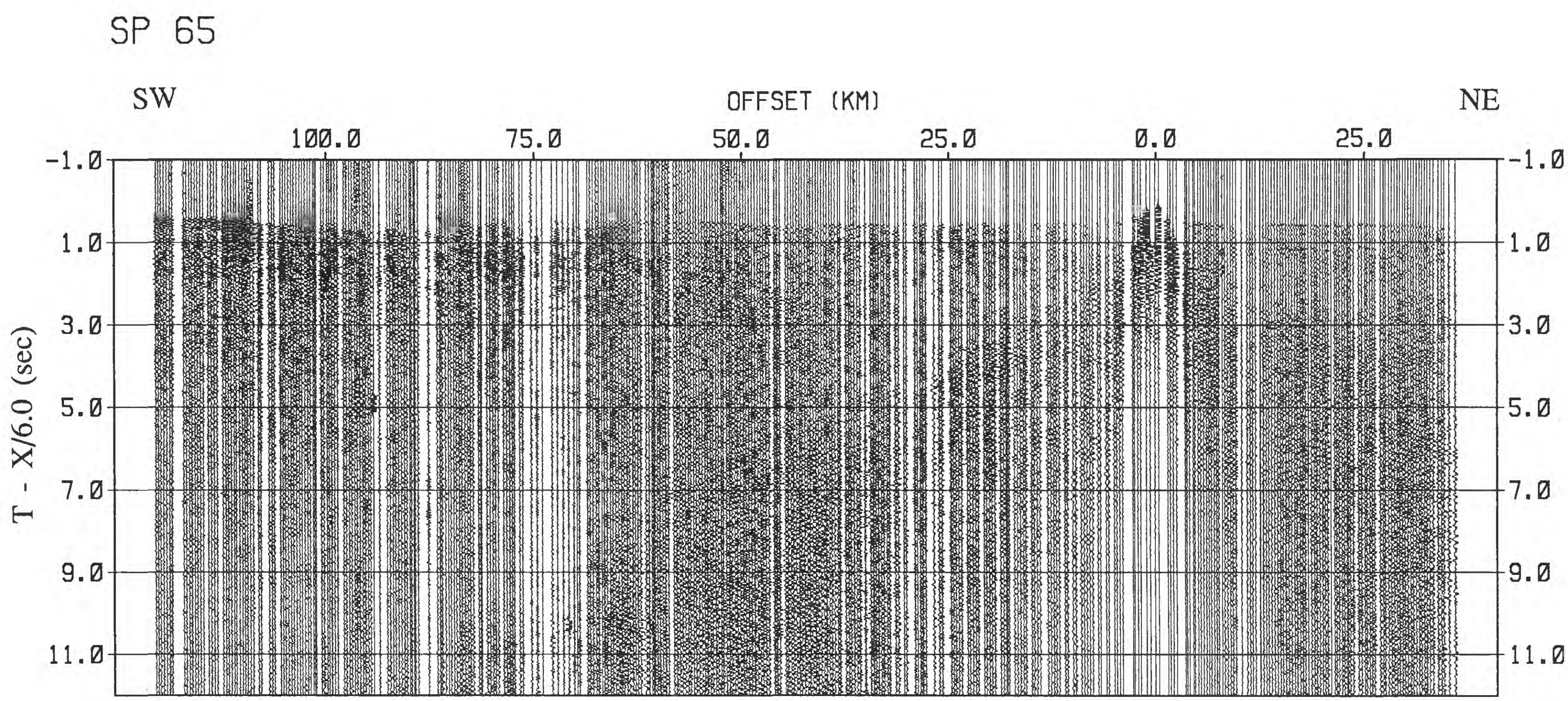

Figure 28. Reduced record-section plot of SP 65, Shot 8.

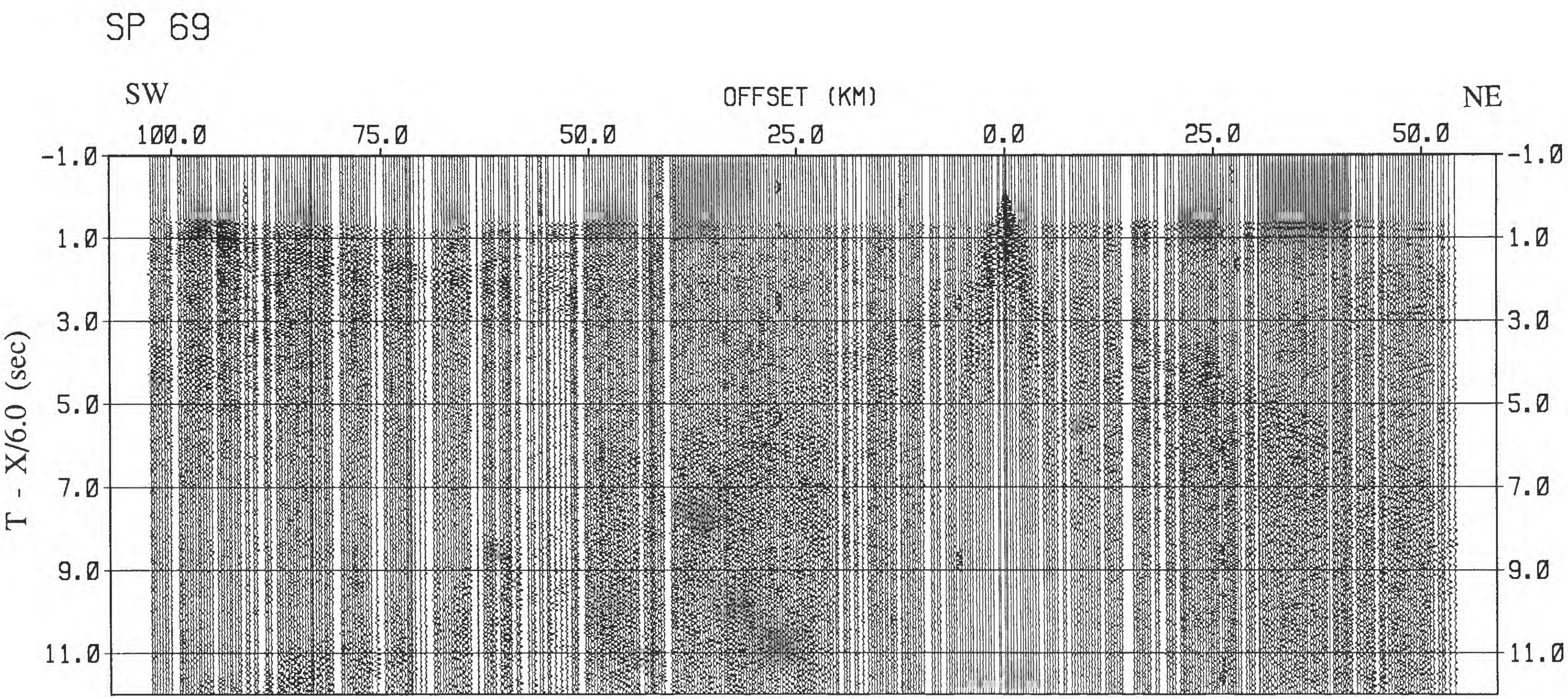

Figure 29. Reduced record-section plot of SP 69, Shot 2.

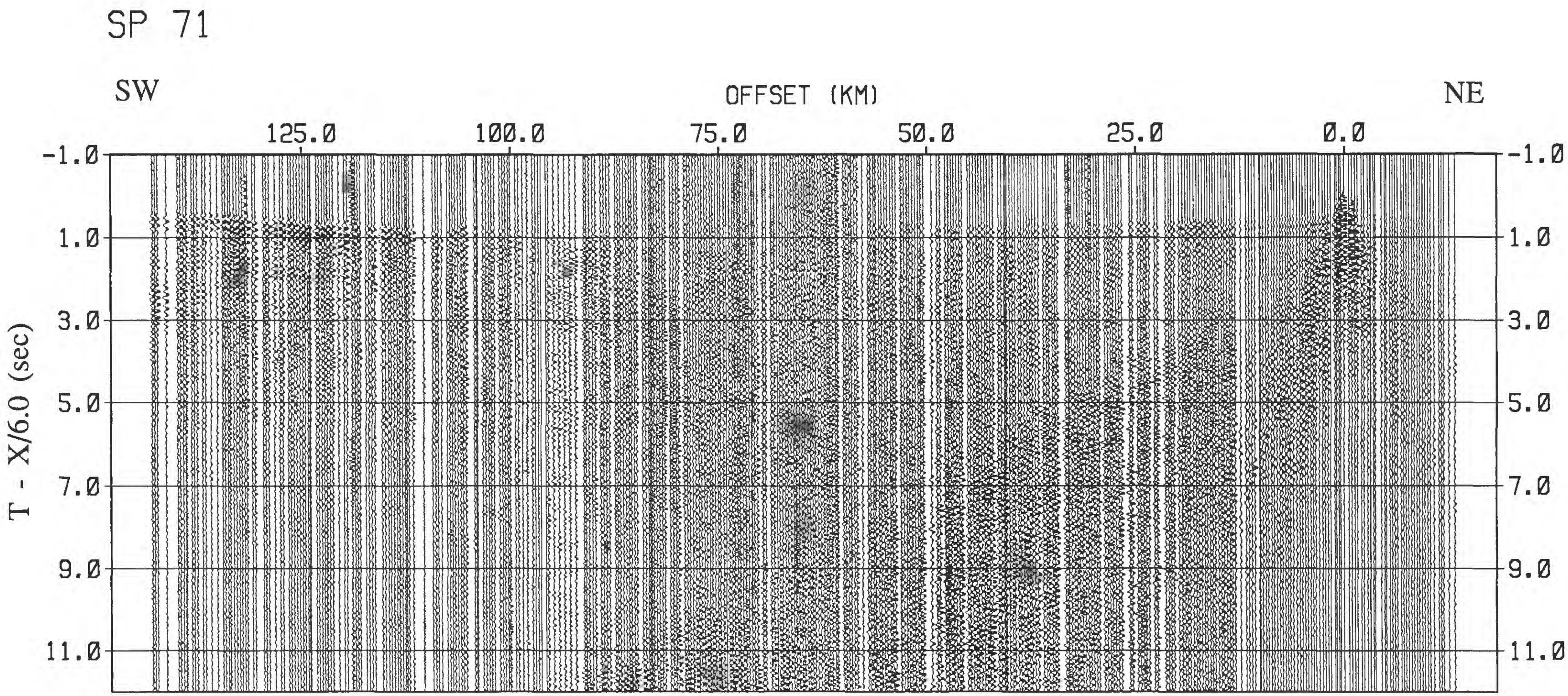

Figure 30. Reduced record-section plot of SP 71, Shot 13.

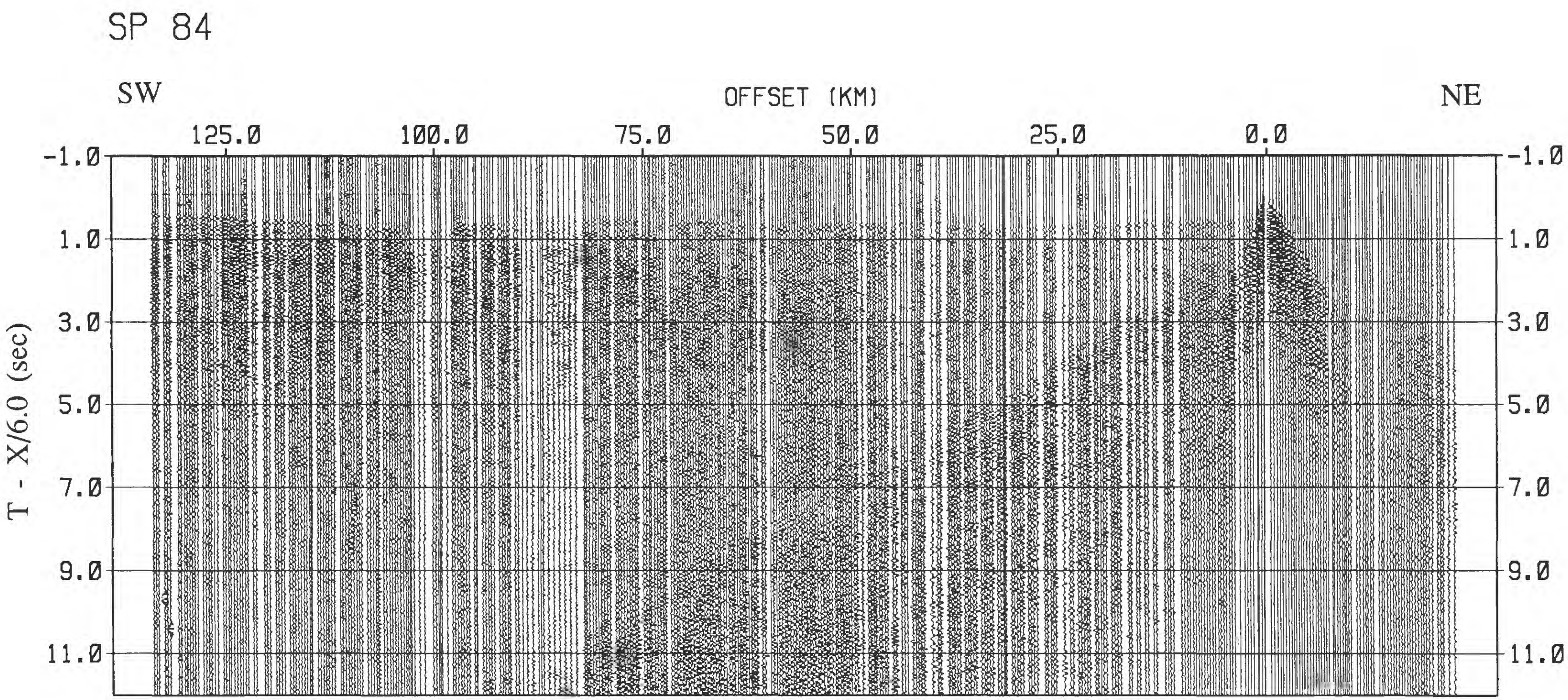

Figure 31. Reduced record-section plot of SP 84, Shot 16.

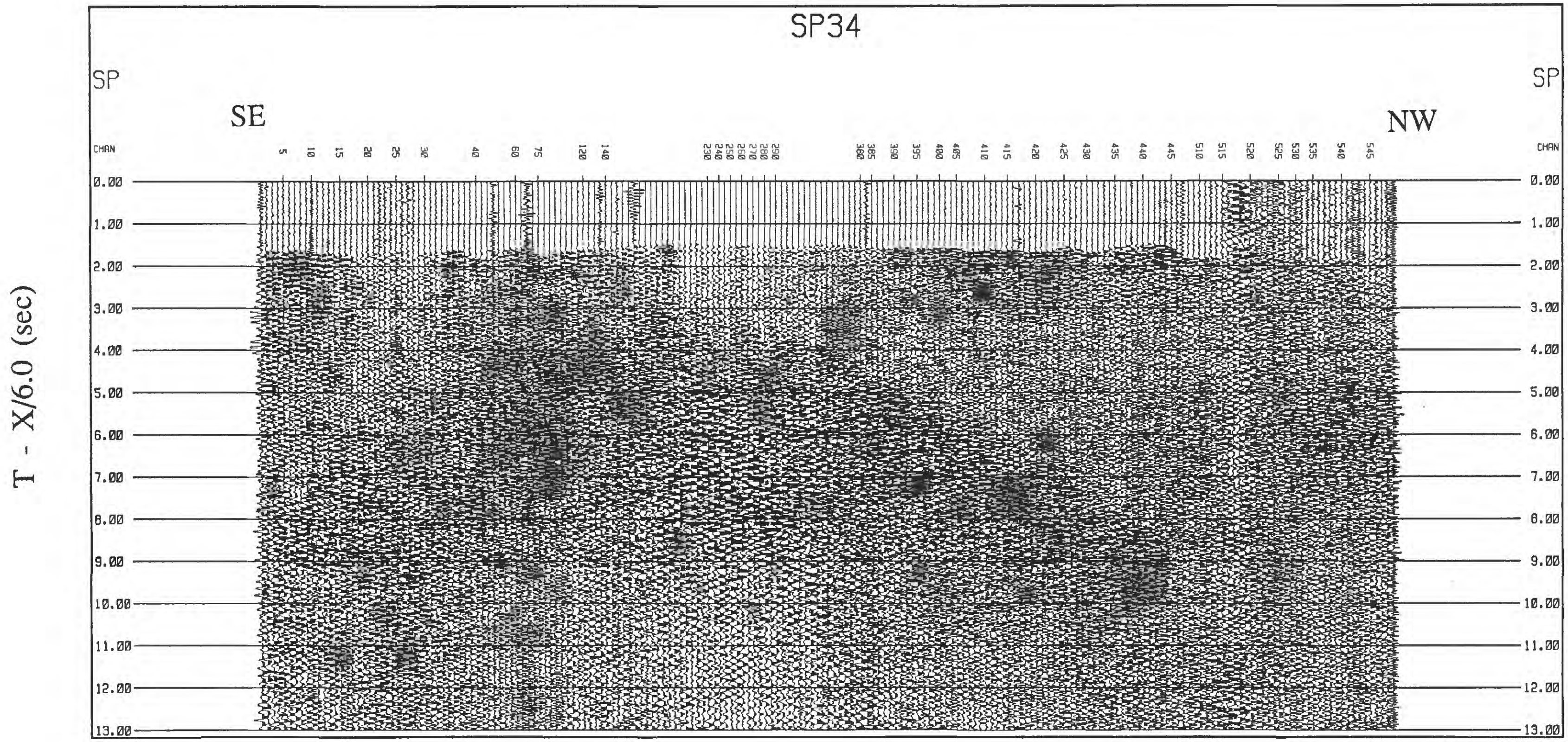

Figure 32. Reduced record-section plot of SP 34, Shot 21.

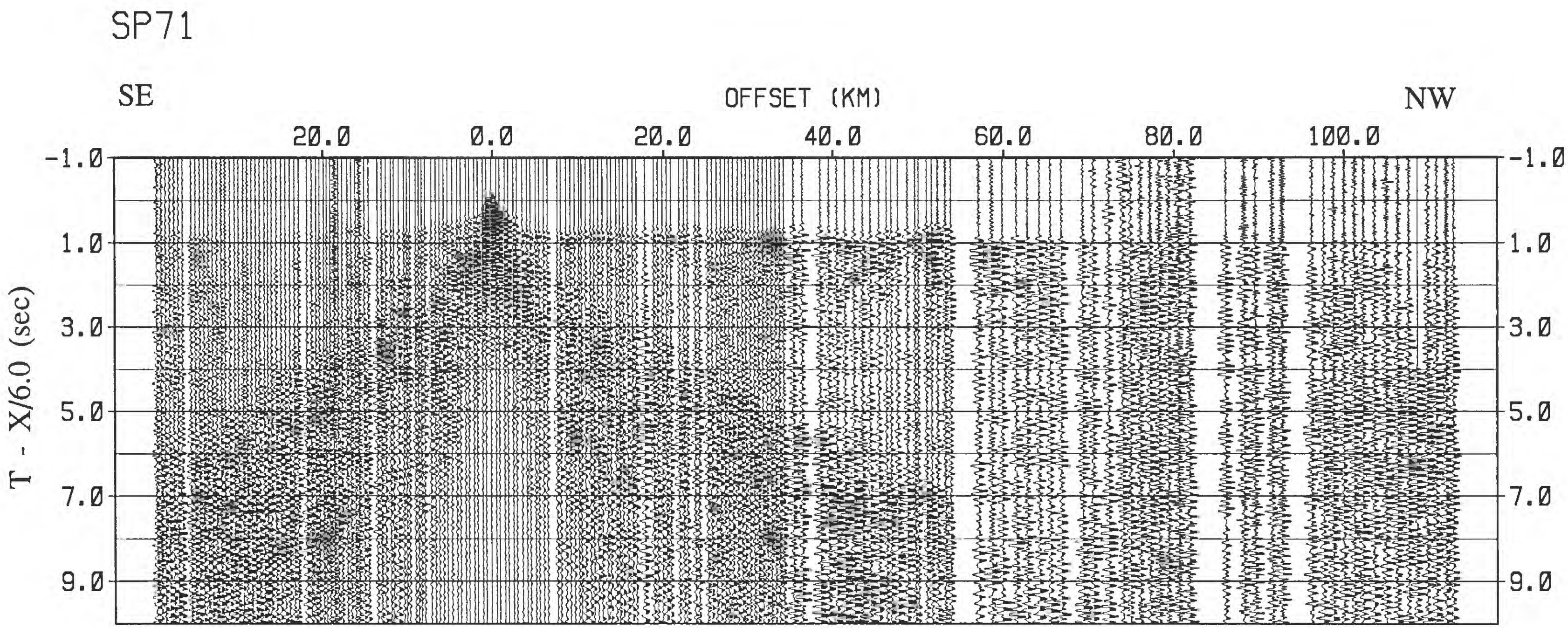

Figure 33. Reduced record-section plot of SP 71, Shot 27.

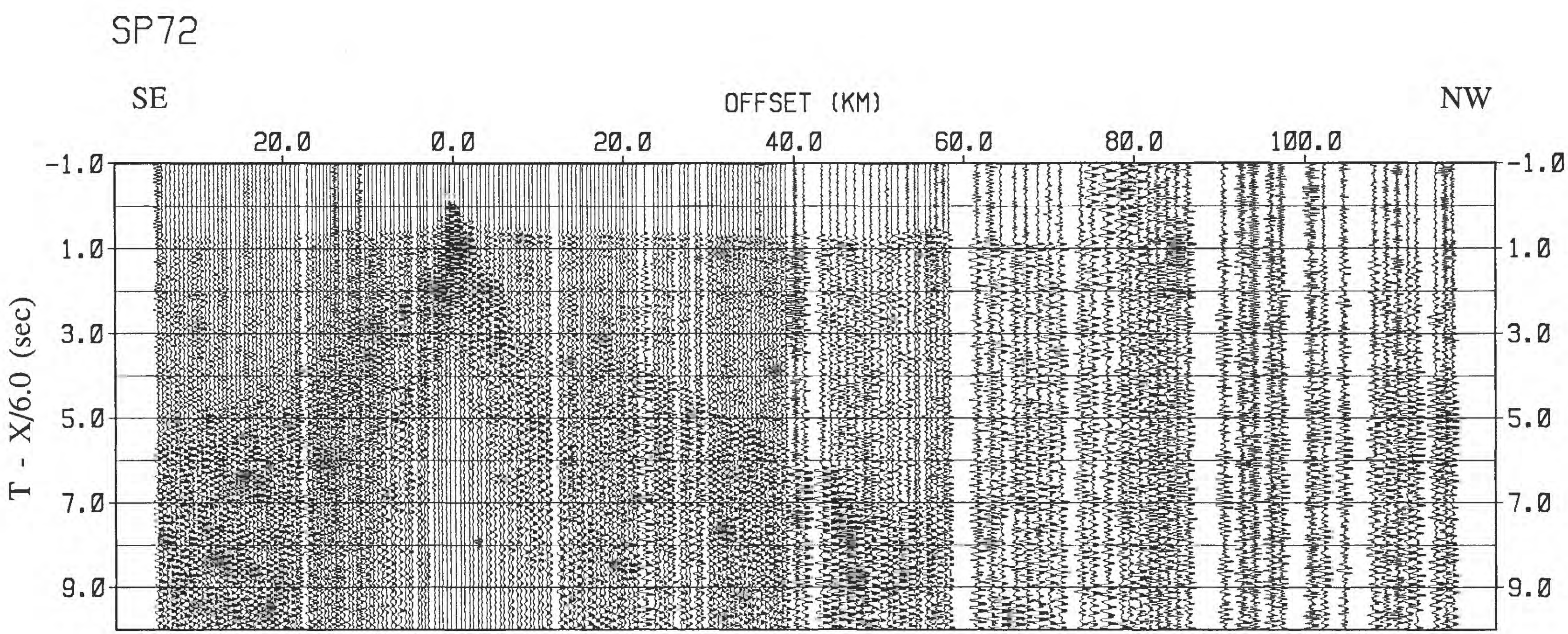

Figure 34. Reduced record-section plot of SP 72, Shot 31.

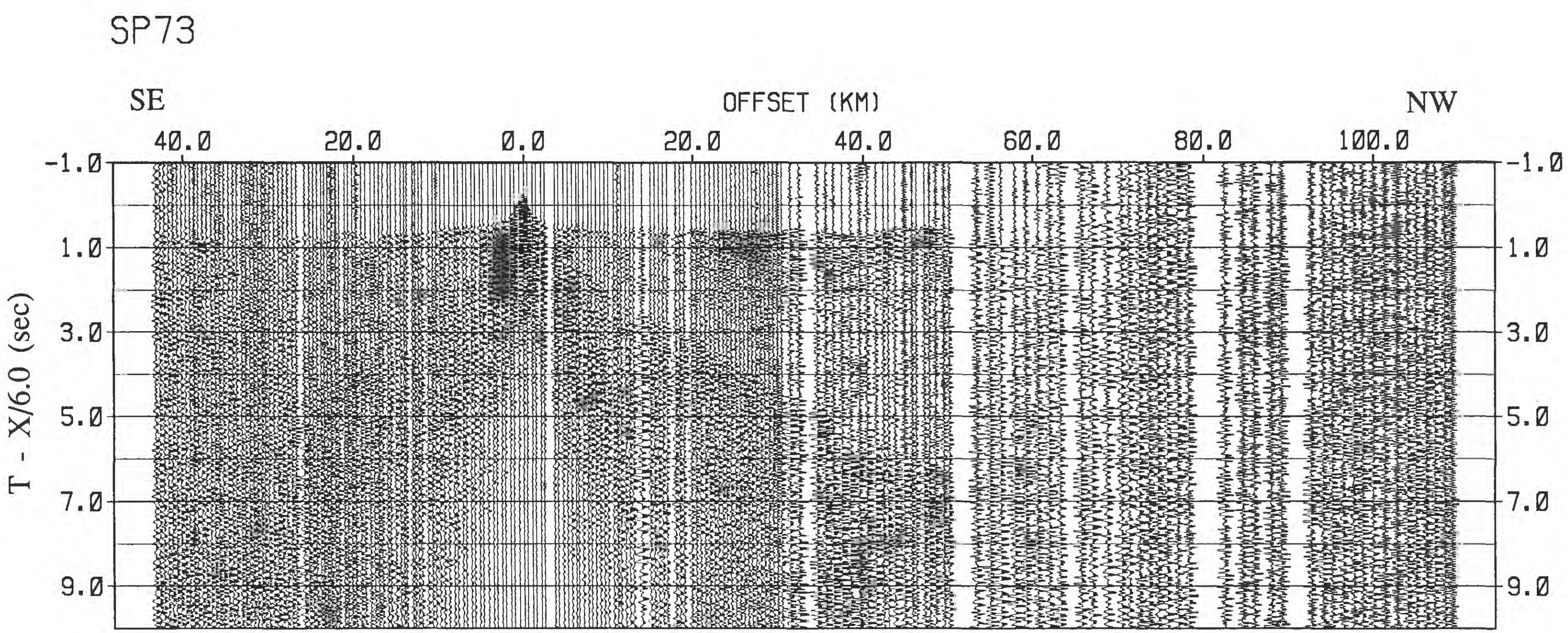

Figure 35. Reduced record-section plot of SP 73, Shot 33.

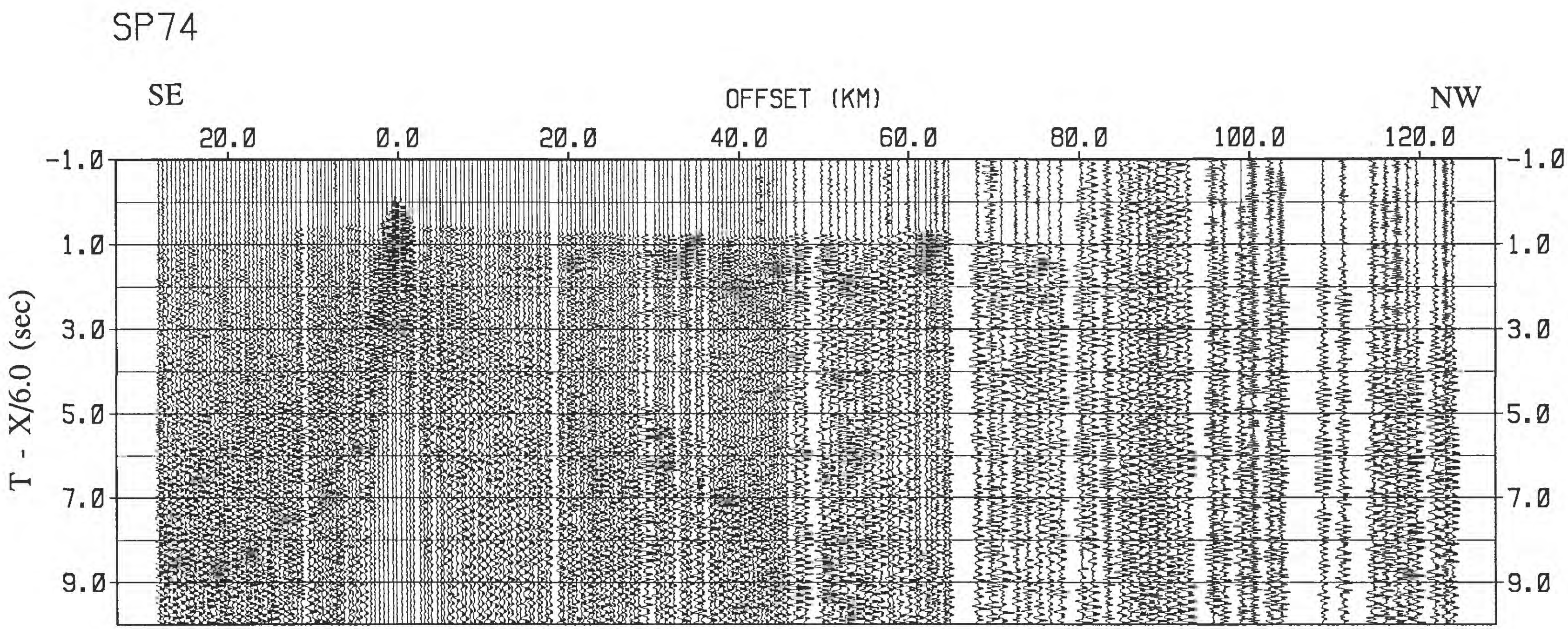

Figure 36. Reduced record-section plot of SP 74, Shot 30.

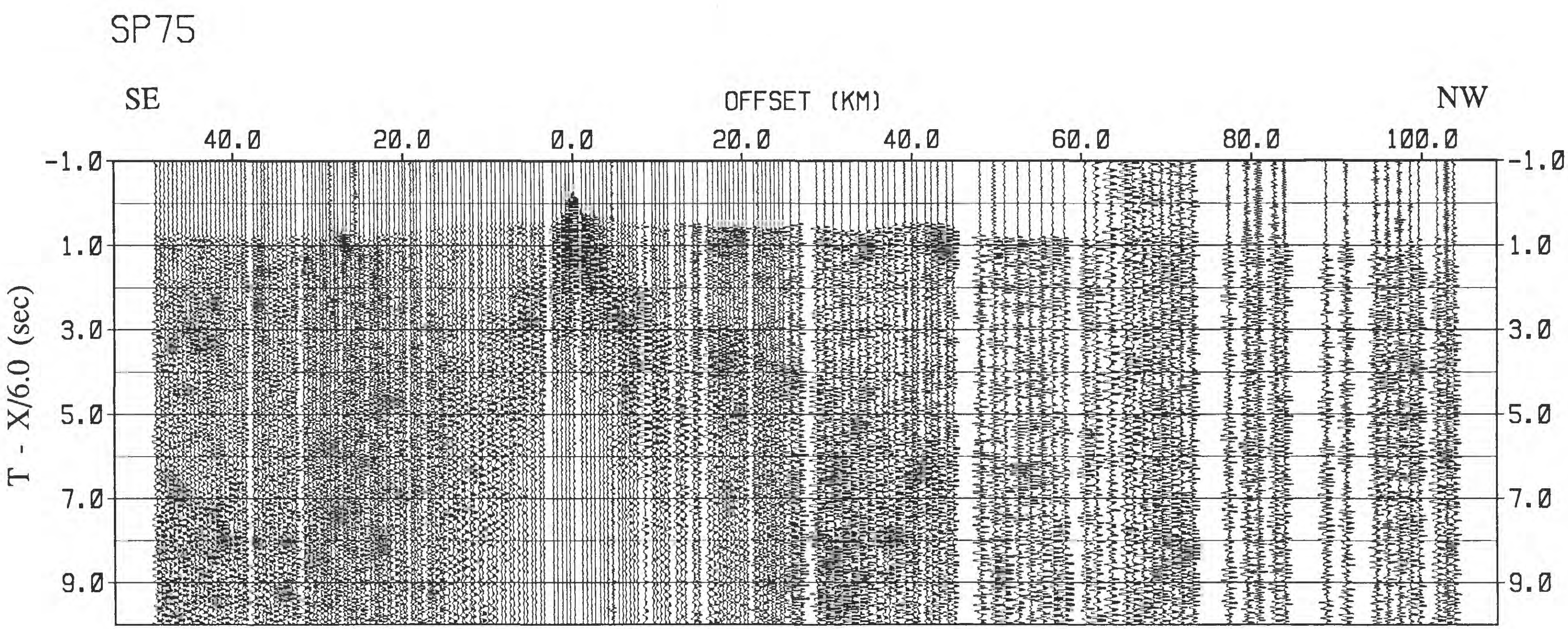

Figure 37. Reduced record-section plot of SP 75, Shot 29.

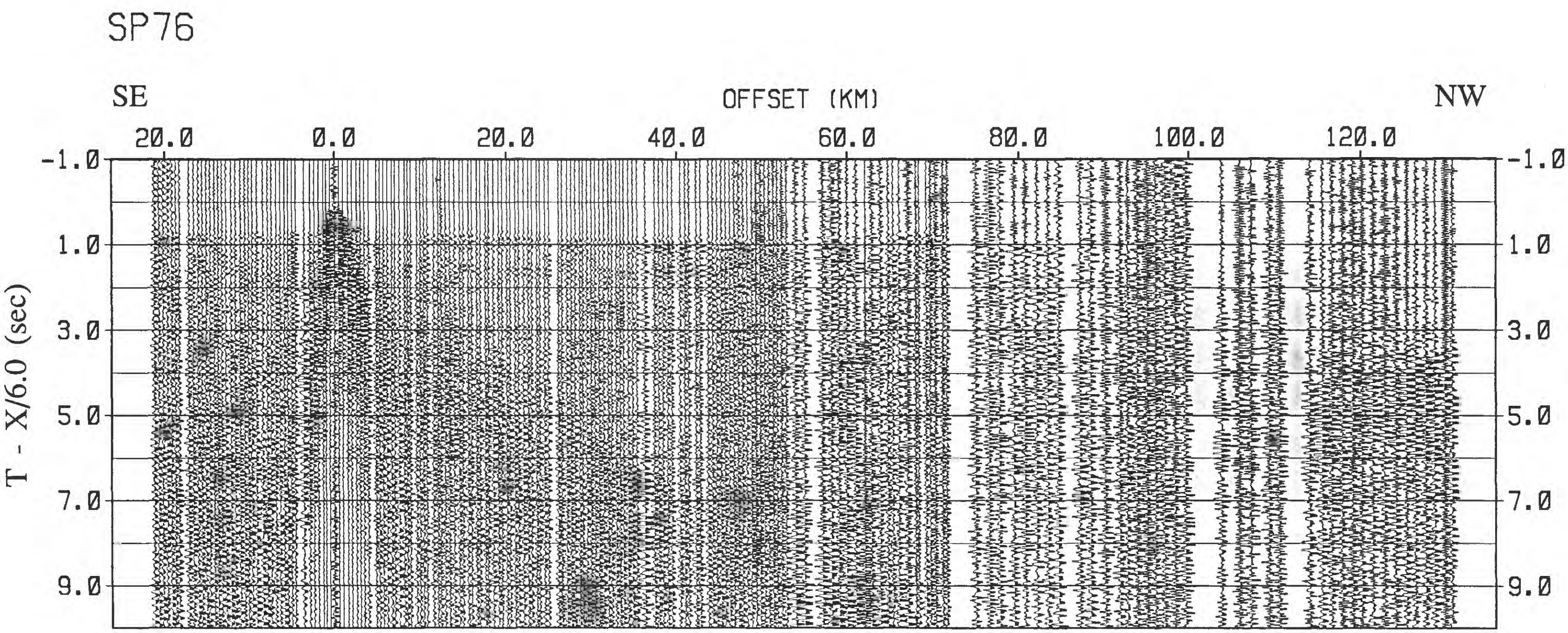

Figure 38. Reduced record-section plot of SP 76, Shot 26.

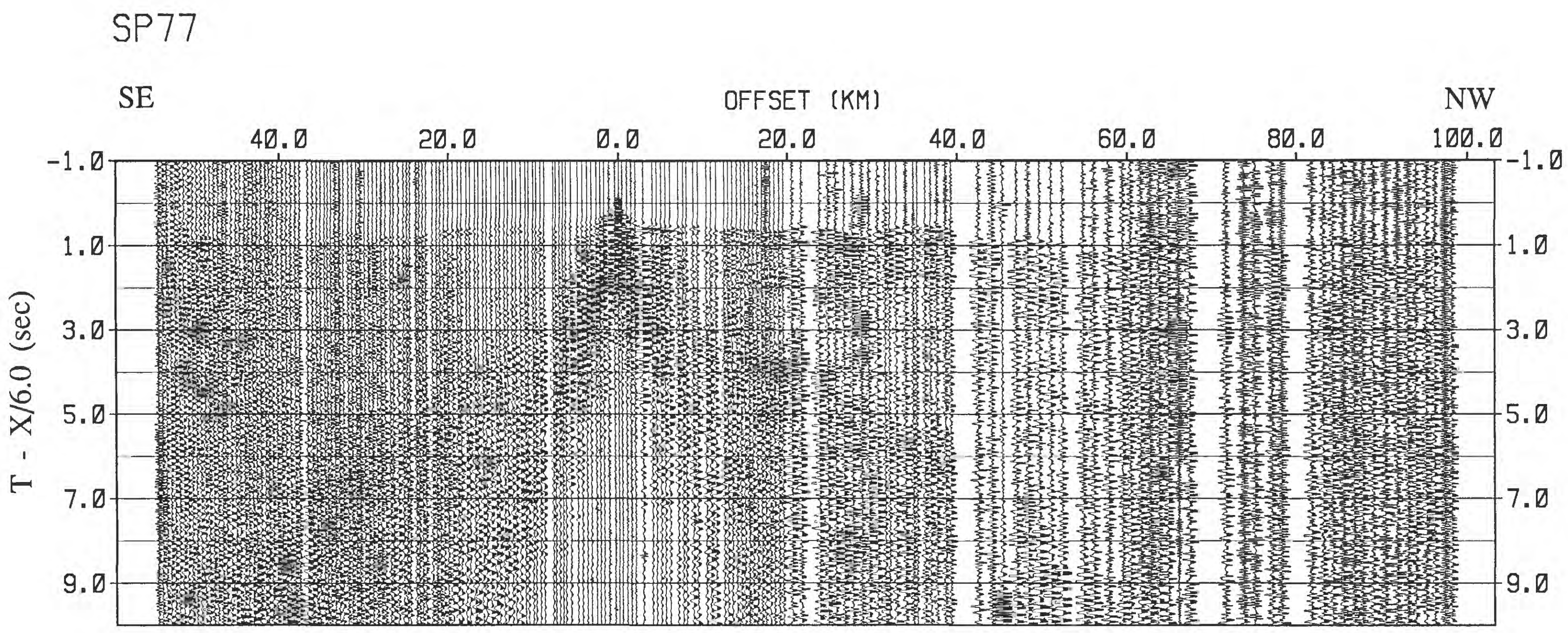

Figure 39. Reduced record-section plot of SP 77, Shot 22.

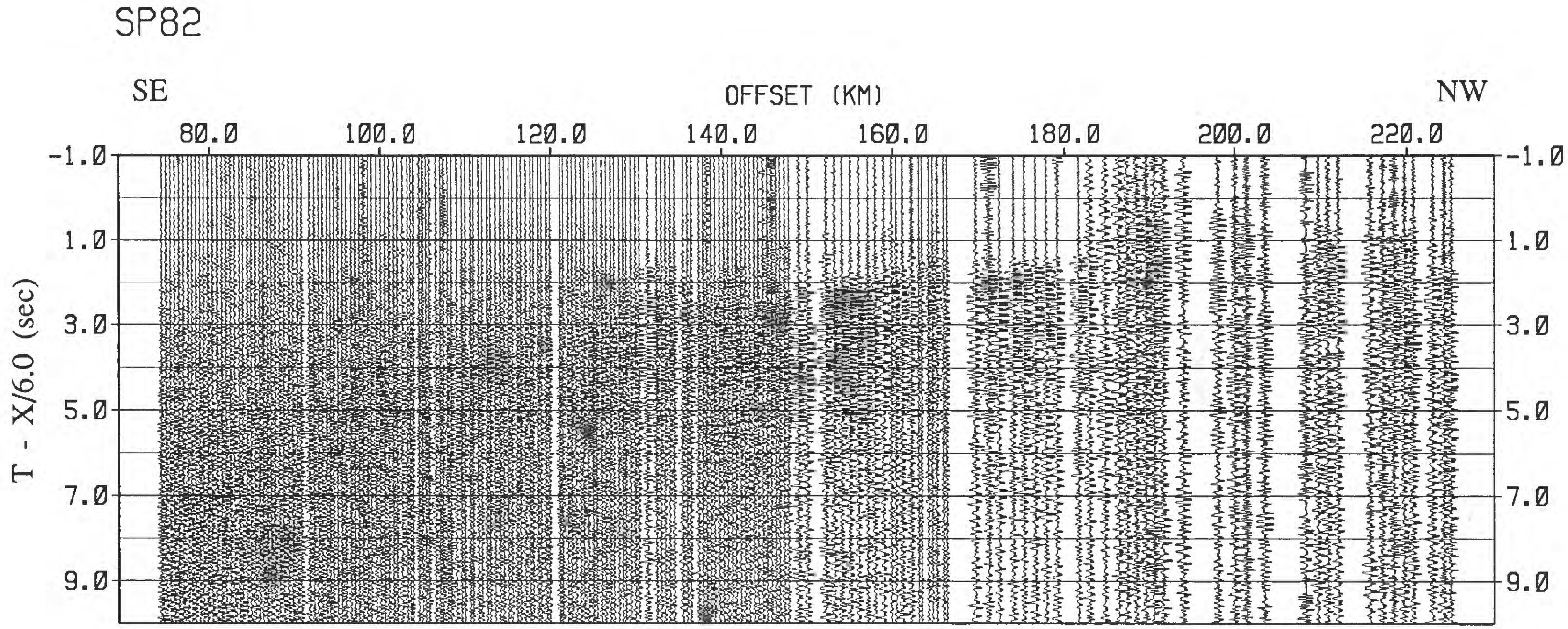

Figure 40. Reduced record-section plot of SP 82, Shot 32.

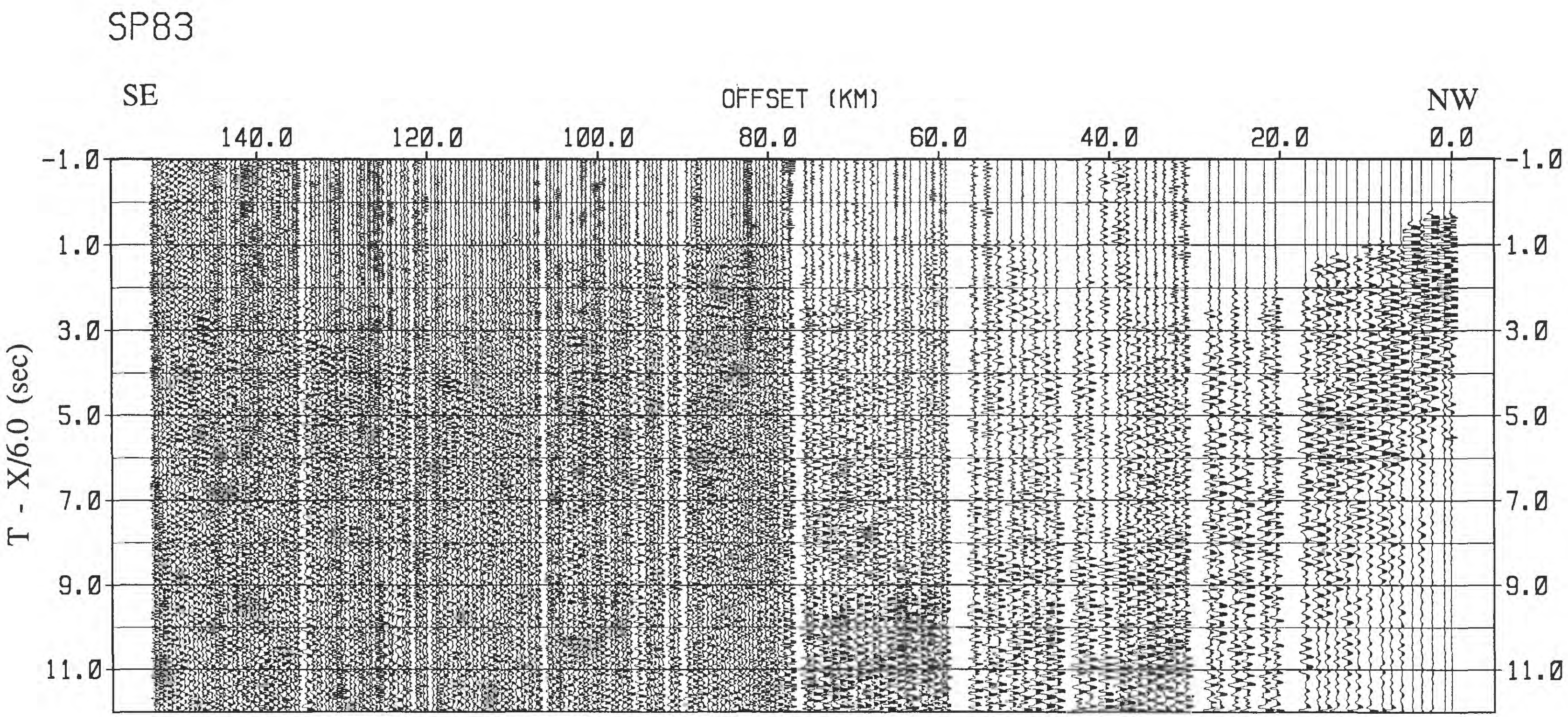

Figure 41. Reduced record-section plot of SP 83, Shot 28.

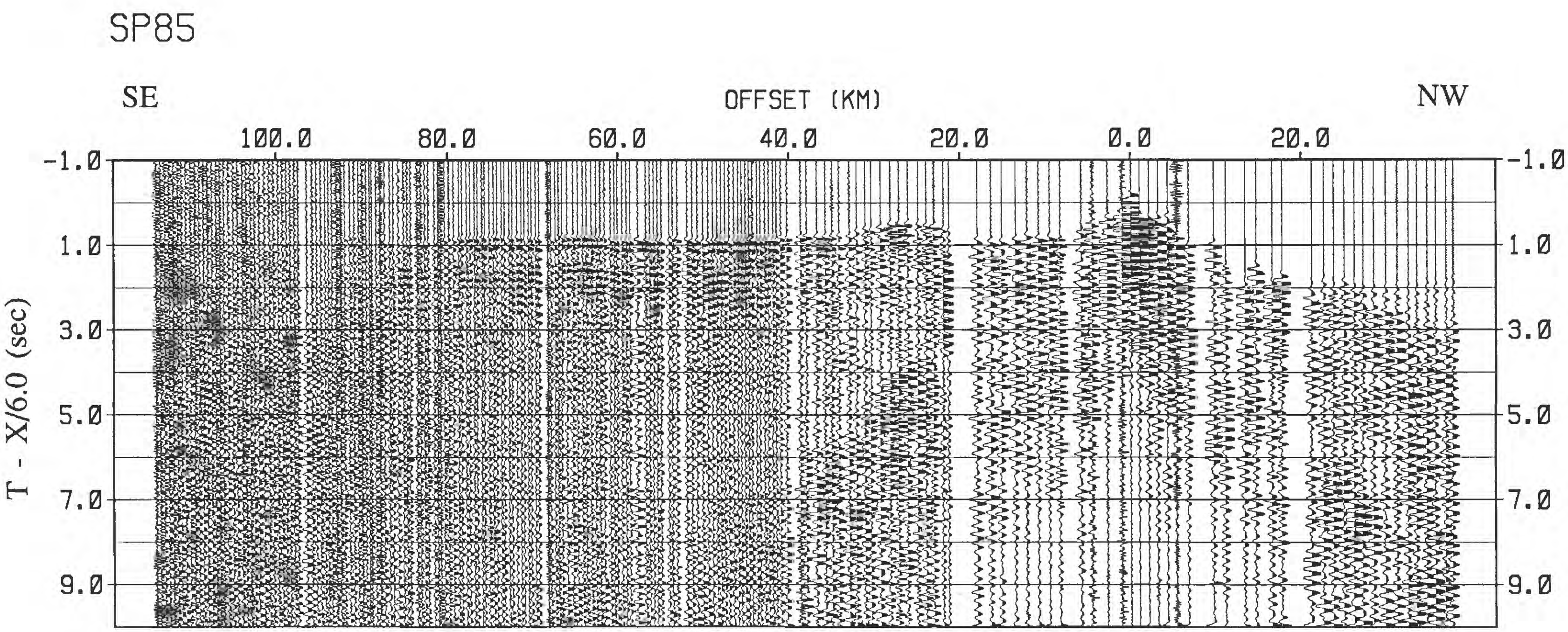

Figure 42. Reduced record-section plot of SP 85, Shot 35.