UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

HIGH-RESOLUTION SEISMIC INVESTIGATION

OF THE MEDICINE LAKE VOLCANO, CALIFORNIA

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High-resolution seismic investigation of the Medicine Lake volcano, California

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Introduction

In September, 1985, the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL) conducted a three-dimensional high-resolution seismic study of the Medicine Lake volcano in northern California (Figure 1). The purpose of the experiment was to detect, with resolution of about 1 km, any P-velocity anomalies present in the shallow crust under the volcano. This report describes the acquisition and processing of the data recorded by the USGS. Data recorded by the LLNL stations will be presented in a separate report by LLNL authors. The experiment was funded by the Geothermal Research Program of the USGS and by the Geothermal and Hydropower Technologies Division of the U.S. Department of Energy.

Medicine Lake volcano lies east of the main Cascade Range axis in northern California, at the western edge of the Modoc Plateau about 50 km east-northeast of Mt. Shasta. The geology has been described by Anderson (1941) and Donnelly-Nolan (1983a,b; 1985). Medicine Lake volcano resembles Newberry volcano in central Oregon more than it resembles the major cones of the High Cascades. It is a large compound shield volcano, built of basaltic, andesitic, dacitic, and rhyolitic flows and cones of Pliocene through Holocene age (Anderson, 1941). The total volume of silicic lavas is much less than the total volume of mafic lavas, and the average composition of the volcano is andesitic (Donnelly-Nolan, 1985). Most of the lavas are thought to be produced by fairly small magma bodies that spend little time in the crust before erupting (Donnelly-Nolan, 1985). The summit caldera is approximately 7 km by 12 km across (Donnelly-Nolan, 1985) and centered near Arnica Sink (Plate 1). Lava flows from eruptions along the rim partly bury the caldera walls (Heiken, 1978), so that the exact size and location of the caldera are difficult to determine.

Recent gravity, seismic refraction, and teleseismic traveltime studies in the Medicine Lake region have detected dense, high-velocity subsolidus intrusions in the shallow crust beneath the volcano (Finn and Williams, 1982; Catchings, 1983; Zucca et al., 1986) and extending into the lower crust and possibly the upper mantle (Evans, 1982). None of these studies found conclusive evidence for a magma chamber.

Our high-resolution seismic experiment used the method applied by Nercessian et al. (1984) at the Mont Dore volcano in France, and by Stauber et al. (1985) at Newberry volcano in central Oregon. In this technique, seismometers are deployed in a dense two-dimensional array over the area to be investigated. Explosions are detonated from several azimuths, at distances chosen to give strong impulsive crustal phases at the array. Rays from the explosions travel upward near the array, illuminating the shallow crust beneath it from several directions. Traveltime differences across the array yield information about the three-dimensional compressional-velocity structure beneath the array. Various tomographic inversion methods can be used to compute velocity structure from the traveltime residuals (e.g. Aki et al., 1977; Tarantola and Nercessian, 1984). This technique can resolve bodies as small as 1-2 km in diameter, to a depth of about 4-5 km below the surface (Nercessian et al., 1984; Stauber et al, 1985).

Instrumentation and Field Operations

Table 1 gives the locations and sizes of the eight shots recorded during this high-resolution seismic experiment. These locations were selected to give a wide distribution of azimuths. Appropriate shotpoint distances from the array were chosen by noting which shots in the refraction work of Zucca et al. (1986) produced large, impulsive "Pg" arrivals at stations near Medicine Lake. ("Pg" is used loosely to mean a first-arriving upper-crustal phase). For 7 shots, the models of Zucca et al. (1986) suggest "Pg" may be variously refracted in or reflected from the bottoms of the shallowest units with velocities of 6 km/s or above. The phase from shot 8, shotpoint 4, may be reflected from the top of a 7.0 km/s mid-crustal layer. The "Pg" phases for all shots bottomed between 4 and 15 km below sea level.

Shots 1, 3-6, and 8 used 1360 kg of ammonium nitrate explosive in a water-based gel, loaded into 45-m deep, 20-cm diameter holes. For shots 2 and 7, 1810 kg of the explosive were loaded into two 55-m deep holes, 30 m apart. The shots were fired automatically by a shooting system described by Healy et al. (1982). A signal from a reference clock triggered the shooting system to fire an electric blasting cap, which sequentially caused the primacord, boosters, and the blasting agent to detonate. The blasting cap break and the reference clock's IRIG E time code were recorded on a Kiowa paper strip-chart recorder, along with the time code signal from the WWVB radio station. The cap break is assumed to be simultaneous with the shot detonation; this assumption gives a shot timing accuracy of about 0.005 s.

The USGS deployed 120 portable seismographs, and LLNL deployed 20 seismic systems, with about a 1.2-km station spacing in a 16-km by 12-km array centered over the Medicine Lake summit caldera and Glass Mountain, a late Holocene rhyolite-dacite flow on the east side of the caldera (Plate 1, Table 2). Station locations were determined using 1:24,000 scale USGS orthophotos and 1:62,500 scale USGS topographic maps. Location accuracy for 75 percent of the stations is ±30 m. For the other stations location accuracy ranges from ±60 to ±90 m. These errors are equivalent to traveltime errors of ±0.005 to ±0.015 s for P-waves with an apparent velocity of 6 km/s-- a negligible amount compared to uncertainties introduced by other factors such as changes in the waveform across the array. Most of the stations were inaccessible by road, so that the instruments had to be back-packed in by 30 hikers. To minimize instrument clock drifts, the internal clocks were reset and the recorders were deployed in one day, the shots were detonated that night, and the recorders were picked up and tested the following day.

The instruments are described by Blank et al. (1978) and Healy et al. (1982). Each instrument uses a 2-Hz vertical-component geophone. Power is provided by two rechargeable 6-volt batteries. The instruments can be programmed for up to ten separate "turn on" times. At the start of each "turn on" time, the instrument turns on and warms up for ten minutes, then records a calibration sequence that includes a seismometer pulse, an amplifier step, and 10-Hz sine wave calibration signals at 1, 10, 100, and 1000 microvolts. The calibration sequence is followed by a recording window, during which shot energy is sensed, amplified, and recorded. The signal from the geophone goes to three parallel amplifiers, each with an adjustable gain setting. The amplified frequency-modulated seismic signals and an internally-generated time code signal are summed with a tape-speed compensation reference signal of fixed frequency. These multiplexed signals are then recorded in analog form on a 30-minute cassette of magnetic tape. This sequence is repeated for each of the subsequent programmed "turn on" times. The frequency response of the system (Stewart and O'Neill, 1980; Eaton, 1980; Dawson and Stauber, 1986) is presented in Figure 2 and Appendix B.

After the instruments were picked up, the drift of each instrument's internal clock (the USGS internal time code generator) was determined to the nearest millisecond by comparison with a master clock (the reference clock used in the shooting system). The master clock drifts about 1 ms per week (Healy et al., 1982) and is synchronized in the field to National Bureau of Standards clocks by using a Kinemetrics Truetime Portable GOES Satellite Receiver/Clock (Model 468-FPC), which has an accuracy of ±1.5 ms.

Data

Seismic signals from the cassette tapes were digitized for each shot for twenty seconds, beginning at time $T = S - 4\ s + X/(6.0\ km/s)$, where S is the shot time (Table 1) and X is the shot-to-recorder distance in km. Thus the first arrival is about 4 s into the 20 s digitizing window. Appendix A shows which instrument was located at each station, the distance and azimuth from each shot to each station, the internal-clock drift of each instrument, information about how each instrument performed, and the gain of the traces digitized. The shot-to-station distances and azimuths were calculated using the Richter approximation, for distances up to 80 km. The method used for distances greater than 80 km (shot 8) yields results differing by about .2 km from the Richter approximation results. About 95 percent of the instruments recorded data, even after they were backpacked over rough terrain and installed in snow. About 96 percent of these produced at least one usable arrival-time pick.

Figures 4a-h present normalized record-sections for all the shots. Since the array is two-dimensional, the record sections cannot be displayed in the standard format of one long line per shot. Many stations have about the same shot-to-receiver distance for a given shot, and the traces would plot on top of each other in a simple record section. Instead, for each shot we slice the array into segments of approximately equal shot-to-receiver azimuth, and plot the record section for each segment separately. Figure 3a shows how the array is divided into 12 segments for shot 1, shotpoint 17. Each segment is plotted as a short record section with a reduction velocity of 6 km/s (Figure 4a). In these normalized record sections, all traces have the same maximum plotted amplitude. Figures 3b-c show schematically how the array is divided for record sections for all the shots. Figures 4b-h present the record sections for shots 2-8. We have included information above each trace so that the ground velocity can be calculated approximately from each plot, using the method described in Appendix B.

Table 3 presents relative traveltimes and calculated residuals for each shot at all USGS and LLNL stations. The times picked are not first arrivals; they are at a large feature, such as a peak or a trough, in the first cycle of motion on filtered seismograms. The times were picked by hand, using an interactive computer program by J.R. Evans (written communication, 1981). A subjective assessment of waveform correlation accuracy and timing uncertainty was made for each pick, and a quality was assigned as follows: a = ±0.02 s uncertainty in timing; b = ±0.05 s or slight uncertainty in waveform identification; c = ±0.10 s or substantial uncertainty in waveform identification. Picks with greater uncertainty than this were not used. Figures 5a-h show the filtered traces and picks for all the shots.

In Table 3, traveltimes were reduced to traveltime residuals by performing a simple least-squares fit of traveltime <u>versus</u> shot-to-receiver distance. Thus a cylindrical wavefront was fit to the measured arrival times for all stations in the two-dimensional array. At each station, the residual is simply the difference between the actual and the least-squares predicted traveltimes.

It is necessary to allow different intercept-times for each shot for the following reasons: velocity structure near the shot may introduce a "static" term; different filter settings used while timing the arrivals introduce different group delays for each shot; and a different feature of the waveform is timed for each shot (filters and picking are consistent within shots). Thus a least-squares fit is made using:

$$t_{ij} = t\emptyset_i + s\Delta_{ij}$$

where t_{ij} is the predicted traveltime from shot i to station j; $t\emptyset_i$ is the intercept time for shot i; s is the slowness (constant for all shots); and Δ_{ij} is the shot(i)-to-receiver(j) distance. Traveltime residuals are: $r_{ij} = T_{ij} - t_{ij}$ where T_{ij} is the observed traveltime. Ideally, primarily the velocity structure subjacent to the array is responsible for the residuals, while the intercept time and the slowness accomodate most of the near-shot structure as well as mean-velocity information near the array. Residuals do not contain information about absolute velocities; only relative velocity structure can be derived from them.

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APPENDIX A-- Recorder Data Table

This table contains detailed information on the performance of the seismic recorders. The recorders are grouped into six teams of twenty instruments each. All teams for a given shot are listed together. The shot time is the Julian day and the UTC (Universal Coordinated Time) hour, minute, and second (cf. Table 1). The column headings are as follows:

LOC	--The field station location number (cf. Table 2) of the seismic recorder unit.
DIST	--Distance from the shot point to the recorder location (km).
AZIM	--Azimuth from the shot point to the recorder location (degrees clockwise from North).
UNIT	--Identification number (i.e. serial number) of the seismic recorder unit.
CHRON	--Time correction (ms) for the recorder clock at shot time (CHRON = instrument internal clock "time" - master clock time). Calculated from the total drift between the time the recorder was programmed before deployment and the time the recorder was picked up, assuming a linear drift rate.
CHAN	--Seismic channel number (1, 2, or 3) which was digitized. Gain attenuation was set at 30, 12, and 48 db for channels 1, 2, and 3, respectively.
TAPE GRADE	--Numerical code for instrument performance and data quality. "0" indicates the instrument ran and properly recorded the time code and the seismic signal. "1" indicates that no seismic signal (or a very weak signal) was recorded, although the instrument ran and recorded the time code signal. "20" indicates the instrument did not run or did not record time code, so that no trace could be digitized.

Recorder Data Table, Medicine Lake Volcano, 1985

SHOT NUMBER 1 SHOT POINT 17
SHOT TIME: 255: 6:30: 0.012

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	46.14	229.6	1	41	2	0
108	48.36	230.6	2	50	2	0
10	47.32	228.5	3	10	2	0
109	47.25	230.0	4	25	2	0
208	47.35	231.2	5	20	2	0
209	46.16	230.9	6	-4	2	0
11	46.12	227.8	7	8	1	0
111	44.88	228.4	8	23	1	0
12	45.10	226.8	9	82	1	0
214	40.77	226.6	10	50	1	0
314	39.64	227.7	11	20	1	0
413	39.62	229.1	12	8	1	0
414	38.68	228.2	13	43	1	0
415	37.52	227.8	14	-28	1	0
315	38.76	226.6	15	10	2	0
402	52.29	236.6	16	-14		20
303	51.78	235.8	17	24	2	0
403	51.18	236.1	18	-25	2	0
204	51.85	233.9	19	-84	1	0
304	51.29	234.3	20	34		20

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	37.01	238.2	61	12	1	0
1109	37.30	240.6	62	1	1	0
1108	38.27	240.7	63	7	1	0
1009	37.93	239.1	64	25	2	0
1107	39.60	241.1	65	-4	1	0
1006	41.54	240.7	66	14	2	0
1007	40.72	240.0	67	36	1	0
907	41.21	238.6	68	0	2	0
1106	40.87	241.5	69	4	1	0
1105	41.94	242.2	70	40	1	0
1005	42.83	241.1	71	46	2	1
906	42.62	239.5	72	19	1	0
1103	44.52	243.5	73	-15	1	0
1004	44.22	241.7	74	42	1	0
812	36.53	234.6	75	12	1	0
412	40.84	229.9	76	14		20
614	36.61	230.3	77	11	2	0
514	37.51	229.5	78	12	2	0
613	37.47	231.4	79	0	1	0
912	35.47	235.8	80	5	1	0

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	48.67	233.7	21	-3	2	0
307	47.54	232.9	22	13	2	0
308	46.32	232.2	23	22	1	0
407	46.33	233.9	24	3	1	0
506	46.60	235.3	25	24	2	0
606	45.45	236.3	26	5	1	0
507	45.28	234.5	27	10	2	0
705	45.78	237.7	28	8	2	0
605	46.93	237.0	29	14	2	0
604	47.84	237.5	30	11	2	0
603	49.15	238.1	31	7	2	0
602	50.16	238.4	32	38	2	0
601	51.35	239.1	33	82	2	1
904	45.05	240.4	34	17	2	0
905	44.02	239.9	35	-33	1	0
706	44.34	237.1	36	9	2	0
608	43.15	235.2	37	13	2	0
708	42.31	236.2	38	7	2	0
505	48.00	236.0	39	-2	2	0
504	48.97	236.4	40	7	2	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	48.99	243.4	81	21	1	0
1101	46.89	243.9	82	-10	2	0
701	50.19	239.8	83	28	2	0
702	49.28	239.3	84	-10	2	0
503	50.07	236.9	85	23	2	0
1102	45.62	243.6	86	-7	1	0
900	49.70	242.1	87	3	1	0
802	48.16	240.1	88	23	2	0
404	50.67	236.2	89	-5	2	0
502	51.27	237.5	90	-2	2	0
810	38.83	236.0	91	10	1	0
909	39.22	237.6	92	1	1	0
709	40.99	235.6	93	22		20
811	37.83	235.5	94	26	1	0
1008	39.59	239.5	95	10	1	0
908	40.30	238.4	96	-7	3	0
911	36.85	236.4	97	3	1	0
910	38.06	237.6	98	6	1	0
609	42.02	234.2	99	26	2	0
710	39.97	234.8	100	13	1	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	43.87	227.4	41	-32	2	0
212	42.78	228.7	42	11	1	0
510	41.94	232.4	43	7	1	0
509	43.03	233.3	44	46	1	0
211	44.06	229.3	45	0	1	0
210	45.17	230.3	46	51	2	0
508	44.34	234.0	47	45	2	0
607	44.51	235.7	48	46		1
409	44.43	232.5	49	13	2	0
310	44.13	230.9	50	23		20
411	41.70	230.8	51	40	1	0
408	45.21	233.1	52	23	2	0
807	42.43	237.9	53	13	2	0
805	45.07	239.2	54	11	2	0
1001	47.78	242.6	55	19	2	0
1104	43.41	243.1	56	28	2	0
1003	45.79	242.1	57	28	1	0
1002	46.66	242.8	58	15	2	0
903	46.14	240.4	59	0	2	0
804	46.20	239.3	60	-6	2	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	47.45	241.4	101	18	1	0
800	50.97	241.0	102	-17	2	0
801	49.25	240.9	103	-2	2	0
901	48.60	241.6	104	0	2	0
803	47.22	240.0	105	35	2	0
703	48.10	238.9	106	1	2	0
704	46.95	238.4	107	49	2	0
405	48.53	235.1	108	41	2	0
406	47.71	234.4	109	10	2	0
207	48.32	232.2	110	24	2	0
106	50.73	232.0	111	70	2	0
107	49.71	231.1	112	10	2	0
305	49.77	233.7	113	-13	2	0
205	50.57	233.2	114	11	2	0
206	49.81	232.9	115	6	2	0
813	35.56	233.8	116	13	1	0
299	41.55	227.6	117	12	1	0
513	38.48	230.4	118	16	1	0
1011	35.87	237.7	119	5	2	0
808	41.32	237.2	120	2	2	0

Recorder Data Table, Medicine Lake Volcano, 1985 (cont'd.)

SHOT NUMBER 2 SHOT POINT 18
SHOT TIME: 255: 6:34: 0.009

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	45.64	322.1	1	41	1	0
108	46.46	319.3	2	50	2	0
10	44.71	320.7	3	10	1	0
109	45.96	320.7	4	26	1	0
208	46.93	320.6	5	20	2	0
209	46.72	322.0	6	-4	1	0
11	44.24	322.2	7	8	1	0
111	44.77	323.8	8	23	1	0
12	43.50	323.7	9	82	1	0
214	44.13	329.3	10	50	1	0
314	45.09	330.5	11	20	1	0
413	46.05	330.3	12	8	1	0
414	45.66	331.6	13	43	3	0
415	45.65	333.1	14	-28	3	0
315	44.59	331.8	15	10	1	0
402	52.18	315.4	16	-14		20
303	51.34	315.8	17	24	1	0
403	51.54	316.6	18	-25	1	0
204	49.69	315.5	19	-84	1	0
304	49.89	316.1	20	34		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	49.12	319.1	21	-3	1	0
307	48.37	320.4	22	13	1	0
308	47.78	321.8	23	22	1	0
407	49.13	321.8	24	3	1	0
506	50.30	321.6	25	24	2	0
606	50.99	323.0	26	5	1	0
507	49.56	323.1	27	10	2	0
705	52.13	322.7	28	8	2	0
605	51.66	321.4	29	14	2	0
604	52.24	320.4	30	11	2	0
603	52.93	319.1	31	7	2	0
602	53.34	318.0	32	38	2	0
601	54.17	316.9	33	82		1
904	54.17	323.7	34	17	2	0
905	53.71	324.7	35	-33	1	0
706	51.59	324.2	36	9	2	0
608	50.13	325.5	37	13	2	0
708	50.83	326.5	38	7	2	0
505	50.99	320.1	39	-2	2	0
504	51.41	319.0	40	7	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	44.15	325.2	41	-32	1	0
212	45.25	326.4	42	11	1	0
510	48.06	327.1	43	7	1	0
509	48.66	325.7	44	46	1	0
211	45.58	324.7	45	0	1	0
210	46.26	323.3	46	51	1	0
508	49.16	324.2	47	45	2	0
607	50.52	324.0	48	47		1
409	47.98	324.1	49	13	2	0
310	46.80	324.5	50	24		20
411	46.95	327.5	51	40	1	0
408	48.46	323.2	52	23	1	0
807	52.08	326.4	53	13	1	0
805	53.25	323.6	54	11	2	0
1001	56.40	321.2	55	19	2	0
1104	56.08	325.6	56	28	2	0
1003	55.66	323.1	57	28	1	0
1002	56.38	322.3	58	15	2	0
903	54.34	322.5	59	0	2	0
804	53.50	322.4	60	-6	2	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	52.43	332.3	61	12	1	0
1109	54.00	331.9	62	1	1	0
1108	54.01	330.9	63	7	1	0
1009	52.98	331.3	64	25	1	0
1107	54.33	329.5	65	-4	1	0
1006	54.12	327.4	66	15	1	0
1007	53.61	328.3	67	36	1	0
907	52.57	327.7	68	0	2	0
1106	54.65	328.2	69	4	1	0
1105	55.27	327.1	70	40	1	0
1005	54.54	326.1	71	46		1
906	53.28	326.2	72	19	1	0
1103	56.51	324.6	73	-16	1	0
1004	55.11	324.7	74	42	2	0
812	50.17	333.2	75	12	1	0
412	46.43	328.7	76	14		20
614	47.45	333.7	77	11	1	0
514	46.78	332.8	78	12	1	0
613	47.96	332.5	79	0	1	0
912	51.08	334.2	80	5	1	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	57.33	320.1	81	21	1	0
1101	57.27	322.3	82	-10	1	0
701	54.57	318.2	83	28	1	0
702	53.97	319.1	84	-10	2	0
503	51.99	317.9	85	23	1	0
1102	56.84	323.5	86	-7	1	0
900	56.41	319.2	87	3	1	0
802	54.44	320.4	88	23	2	0
404	51.50	317.1	89	-5	1	0
502	52.76	316.7	90	-2	2	0
810	50.85	330.4	91	11	1	0
909	51.92	329.9	92	1	1	0
709	50.45	328.0	93	22		20
811	50.59	331.6	94	26	1	0
1008	53.19	329.5	95	10	1	0
908	52.40	328.7	96	-7	1	0
911	51.27	332.6	97	3	1	0
910	51.96	331.2	98	6	1	0
609	49.39	326.9	99	26	1	0
710	49.92	329.2	100	13	1	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	55.36	321.3	101	18	1	0
800	55.76	317.7	102	-17	2	0
801	55.33	319.4	103	-2	2	0
901	55.71	320.2	104	0	2	0
803	54.18	321.4	105	35	2	0
703	53.40	320.3	106	1	2	0
704	52.81	321.5	107	49	2	0
405	50.32	319.4	108	42	2	0
406	49.65	320.3	109	10	2	0
207	47.79	319.4	110	24	1	0
106	47.79	316.5	111	71	1	0
107	46.97	317.7	112	10	2	0
305	49.20	317.8	113	-13	1	0
205	48.85	316.8	114	11	1	0
206	48.52	317.7	115	6	1	0
813	49.84	334.3	116	13	1	0
299	44.62	328.1	117	12	1	0
513	47.16	331.4	118	16	1	0
1011	52.23	333.6	119	5	1	0
808	51.55	327.6	120	2	1	0

Recorder Data Table, Medicine Lake Volcano, 1985 (cont'd.)

SHOT NUMBER 3 SHOT POINT 6
SHOT TIME: 255: 6:36: 0.009

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	56.08	136.6	1	41	1	0
108	55.16	138.9	2	50	1	0
10	56.94	137.8	3	10	1	0
109	55.68	137.7	4	26	1	0
208	54.71	137.8	5	21	2	0
209	55.01	136.6	6	-4	1	0
11	57.49	136.7	7	8	1	0
111	57.10	135.4	8	23	1	0
12	58.35	135.7	9	82	1	0
214	58.68	131.4	10	50	1	0
314	58.07	130.3	11	20	2	0
413	57.10	130.1	12	9	1	0
414	57.84	129.3	13	43	1	0
415	58.33	128.2	14	-28	1	0
315	58.91	129.5	15	10	2	0
402	49.67	142.9	16	-14		20
303	50.46	142.4	17	24	1	0
403	50.19	141.7	18	-25	1	0
204	52.14	142.5	19	-84	1	0
304	51.87	141.9	20	35		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	52.50	139.1	21	-3	1	0
307	53.27	137.9	22	13	1	0
308	53.93	136.7	23	22	1	0
407	52.59	136.5	24	3	1	0
506	51.40	136.6	25	24	2	0
606	50.85	135.2	26	5	1	0
507	52.28	135.3	27	10	2	0
705	49.68	135.3	28	8	1	0
605	50.04	136.7	29	14	2	0
604	49.40	137.7	30	11	1	0
603	48.69	139.1	31	7	2	0
602	48.30	140.2	32	38	1	0
601	47.54	141.5	33	82	2	1
904	47.80	133.9	34	17	1	0
905	48.43	132.8	35	-33	1	0
706	50.42	133.8	36	9	1	0
608	52.09	132.9	37	13	2	0
708	51.60	131.8	38	7	2	0
505	50.64	138.1	39	-2	1	0
504	50.21	139.1	40	7	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	57.89	134.4	41	-32	1	0
212	57.01	133.3	42	11	1	0
510	54.40	132.1	43	7	1	0
509	53.56	133.1	44	46	1	0
211	56.42	134.5	45	0	1	0
210	55.57	135.6	46	51	1	0
508	52.81	134.4	47	45	2	0
607	51.44	134.3	48	47		1
409	53.96	134.6	49	13	1	0
310	55.19	134.5	50	24		20
411	55.57	132.0	51	40	1	0
408	53.38	135.4	52	23	1	0
807	50.36	131.6	53	13	1	0
805	48.69	134.2	54	11	2	0
1001	45.30	136.5	55	19	1	0
1104	46.32	131.2	56	28	1	0
1003	46.25	134.2	57	29	1	0
1002	45.42	135.1	58	15	1	0
903	47.48	135.1	59	0	1	0
804	48.29	135.5	60	-6	1	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	51.93	125.8	61	12	1	0
1109	50.36	125.4	62	1	1	0
1108	49.93	126.4	63	7	1	0
1009	51.02	126.5	64	25	1	0
1107	49.12	127.6	65	-4	1	0
1006	48.67	129.8	66	15	1	0
1007	49.40	129.1	67	36	1	0
907	50.23	130.1	68	0	2	0
1106	48.38	128.9	69	4	1	0
1105	47.47	129.8	70	40	1	0
1005	47.92	131.1	71	46		1
906	49.17	131.4	72	19	1	0
1103	45.66	132.3	73	-16	1	0
1004	47.06	132.5	74	42	1	0
812	54.28	126.2	75	12	1	0
412	56.33	131.2	76	14		20
614	56.91	127.0	77	11	2	0
514	57.18	128.0	78	12	1	0
613	56.02	127.7	79	0	1	0
912	53.91	124.8	80	5	1	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	44.31	137.7	81	21	1	0
1101	44.53	135.0	82	-10	1	0
701	47.07	140.0	83	28	1	0
702	47.65	139.0	84	-10	1	0
503	49.66	140.3	85	23	1	0
1102	45.14	133.6	86	-7	1	0
900	45.21	139.0	87	3	3	0
802	47.20	137.6	88	23	1	0
404	50.18	141.1	89	-5	1	0
502	48.96	141.6	90	-2	2	0
810	52.67	128.2	91	11	1	0
909	51.51	128.2	92	1	1	0
709	52.33	130.5	93	22		20
811	53.31	127.3	94	27	1	0
1008	50.18	128.1	95	10	1	0
908	50.67	129.2	96	-7	1	0
911	53.09	126.1	97	3	1	0
910	51.92	127.0	98	6	1	0
609	53.07	131.9	99	26	1	0
710	53.16	129.6	100	13	1	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	46.34	136.4	101	18	1	0
800	45.90	140.8	102	-17	1	0
801	46.29	138.7	103	-2	1	0
901	45.93	137.8	104	0	1	0
803	47.52	136.5	105	35	1	0
703	48.23	137.7	106	1	2	0
704	48.89	136.5	107	49	2	0
405	51.30	138.8	108	42	1	0
406	51.98	137.9	109	10	1	0
207	53.83	138.8	110	24	1	0
106	53.93	141.3	111	71	1	0
107	54.68	140.3	112	10	1	0
305	52.45	140.2	113	-13	1	0
205	52.85	141.1	114	11	1	0
206	53.13	140.3	115	6	1	0
813	55.05	125.4	116	13	1	0
299	57.95	132.1	117	12	2	0
513	56.41	128.8	118	16	1	0
1011	52.64	124.7	119	5	1	0
808	51.18	130.5	120	2	1	0

Recorder Data Table, Medicine Lake Volcano, 1985 (cont'd.)

SHOT NUMBER 4 SHOT POINT 11
SHOT TIME: 255: 8:45: 0.013

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	46.51	276.3	1	44	1	0
108	48.67	275.1	2	53	2	0
10	46.68	274.5	3	11	1	0
109	47.53	275.7	4	27	2	0
208	48.30	276.4	5	22	2	0
209	47.31	277.2	6	-5	2	0
11	45.47	275.2	7	9	1	0
111	44.95	276.7	8	25	1	0
12	44.16	275.4	9	88	1	0
214	41.34	279.8	10	54	1	0
314	41.25	281.7	11	21	1	0
413	42.03	282.5	12	9	1	0
414	40.99	283.1	13	46	1	0
415	40.07	284.2	14	-30	1	0
315	40.14	282.1	15	11	1	0
402	55.15	276.5	16	-15		20
303	54.27	276.3	17	26	2	0
403	54.01	276.9	18	-27	2	0
204	53.23	274.9	19	-90	1	0
304	52.99	275.5	20	37		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	50.73	277.1	21	-4	2	0
307	49.44	277.4	22	14	2	0
308	48.18	278.0	23	24	1	0
407	49.15	279.1	24	3	1	0
506	50.16	279.8	25	26	2	0
606	49.87	281.3	26	5	2	0
507	48.74	280.3	27	11	2	0
705	50.90	282.0	28	9	2	0
605	51.32	280.6	29	15	2	0
604	52.32	280.3	30	12	2	0
603	53.63	279.8	31	7	2	0
602	54.56	279.3	32	40	2	0
601	55.86	278.9	33	88	2	1
904	51.85	284.3	34	19	2	0
905	50.87	284.8	35	-36	1	0
706	49.57	282.8	36	10	2	0
608	47.70	282.7	37	14	2	0
708	47.66	284.0	38	8	2	0
505	51.57	279.2	39	-2	2	0
504	52.49	278.7	40	8	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	43.73	277.1	41	-35	1	0
212	43.76	279.0	42	12	1	0
510	45.32	282.0	43	8	1	0
509	46.54	281.6	44	50	1	0
211	44.96	278.1	45	0	1	0
210	46.27	277.7	46	55	2	0
508	47.81	280.8	47	48	2	0
607	48.92	281.8	48	50		1
409	47.01	279.8	49	14	2	0
310	45.92	279.1	50	25		20
411	44.28	281.3	51	44	1	0
408	47.90	279.5	52	25	2	0
807	48.65	284.9	53	15	1	0
805	51.22	283.5	54	12	2	0
1001	55.10	283.7	55	20	2	0
1104	52.15	287.2	56	30	2	0
1003	53.35	284.8	57	31	2	0
1002	54.39	284.6	58	17	2	0
903	52.67	283.5	59	0	2	0
804	52.13	282.7	60	-6	2	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	45.29	290.1	61	13	1	0
1109	46.70	291.0	62	1	1	0
1108	47.35	290.1	63	7	1	0
1009	46.33	289.6	64	27	1	0
1107	48.45	289.2	65	-5	1	0
1006	49.55	287.3	66	16	1	0
1007	48.65	287.6	67	39	1	0
907	48.21	286.3	68	0	2	0
1106	49.52	288.3	69	5	2	0
1105	50.65	287.8	70	43	2	0
1005	50.69	286.5	71	50	2	1
906	49.65	285.7	72	20	1	0
1103	53.14	286.6	73	-17	2	0
1004	51.97	285.7	74	45	2	0
812	43.14	288.8	75	13	1	0
412	43.25	281.7	76	15		20
614	40.93	286.5	77	12	2	0
514	41.04	285.1	78	13	1	0
613	42.00	286.1	79	-2	1	0
912	43.14	290.5	80	5	1	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	56.46	283.4	81	22	2	0
1101	55.13	285.2	82	-11	2	0
701	55.39	280.2	83	30	2	0
702	54.42	280.5	84	-10	2	0
503	53.59	278.2	85	25	2	0
1102	54.05	285.9	86	-8	2	0
900	56.30	282.1	87	3	1	0
802	54.02	281.8	88	25	2	0
404	53.66	277.3	89	-5	2	0
502	54.88	277.9	90	-2	2	0
810	45.29	287.1	91	11	1	0
909	46.38	287.6	92	1	1	0
709	46.47	284.8	93	24		20
811	44.39	287.9	94	28	1	0
1008	47.59	288.3	95	11	1	0
908	47.48	287.0	96	-7	1	0
911	44.26	289.3	97	3	1	0
910	45.63	288.7	98	7	1	0
609	46.38	283.1	99	28	1	0
710	45.36	285.3	100	14	1	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	54.19	283.2	101	20	2	0
800	56.65	280.5	102	-18	2	0
801	55.30	281.6	103	-2	2	0
901	55.14	282.5	104	0	2	0
803	53.24	282.4	105	38	2	0
703	53.28	281.0	106	1	2	0
704	52.13	281.5	107	53	2	0
405	51.45	278.2	108	45	2	0
406	50.45	278.3	109	11	3	0
207	49.57	276.3	110	26	2	0
106	51.21	274.2	111	77	1	0
107	49.95	274.4	112	11	2	0
305	51.51	276.2	113	-14	1	0
205	51.82	275.3	114	12	2	0
206	51.08	275.6	115	7	2	0
813	42.18	289.5	116	14		20
299	42.34	279.5	117	13	1	0
513	42.08	284.5	118	18	1	0
1011	44.36	291.0	119	6	2	0
808	47.51	285.4	120	2	2	0

Recorder Data Table, Medicine Lake Volcano, 1985 (cont'd.)

SHOT NUMBER 5 SHOT POINT 16
SHOT TIME: 255: 8:47: 0.010

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	59.82	178.9	1	44	2	0
108	60.60	181.0	2	53	2	0
10	61.26	179.2	3	11	2	0
109	60.26	179.9	4	27	2	0
208	59.58	180.6	5	22	2	0
209	59.00	179.6	6	-5	2	0
11	60.89	178.0	7	9	2	0
111	59.76	177.4	8	25	3	0
12	60.87	176.8	9	88	1	0
214	58.26	173.5	10	54	1	0
314	57.00	173.0	11	21	2	0
413	56.18	173.6	12	9	2	0
414	56.15	172.4	13	46	2	0
415	55.76	171.3	14	-30	2	0
315	57.09	171.9	15	11	2	0
402	59.11	187.2	16	-15		20
303	59.35	186.3	17	26	2	0
403	58.74	186.1	18	-27	2	0
204	60.67	185.3	19	-90	1	0
304	60.09	185.1	20	37		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	58.77	182.9	21	-4	2	0
307	58.59	181.6	22	14	2	0
308	58.26	180.3	23	24	2	0
407	57.21	181.2	24	3	2	0
506	56.44	182.1	25	26	2	0
606	55.15	181.6	26	5	1	0
507	56.20	180.6	27	11	2	0
705	54.42	182.5	28	9	2	0
605	55.57	183.2	29	15	2	0
604	55.72	184.2	30	12	2	0
603	56.10	195.6	31	7	2	0
602	56.53	186.6	32	40	2	0
601	56.79	187.9	33	88	2	1
904	52.25	183.2	34	19	2	0
905	52.00	182.0	35	-36	1	0
706	53.97	181.0	36	10	2	0
608	54.50	179.1	37	14	2	0
708	53.46	178.8	38	8	2	0
505	56.83	183.6	39	-2	2	0
504	57.18	184.5	40	8	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	59.71	176.2	41	-35	2	0
212	58.28	175.9	42	12	2	0
510	55.57	176.9	43	8	2	0
509	55.64	178.2	44	50	1	0
211	58.68	177.2	45	0	2	0
210	58.77	178.5	46	55	2	0
508	55.97	179.6	47	48	2	0
607	54.96	180.5	48	50		1
409	56.97	179.0	49	14	2	0
310	57.75	178.0	50	25		20
411	56.37	176.0	51	44	1	0
408	57.05	179.9	52	25	2	0
807	52.47	179.6	53	15	2	0
805	53.04	182.6	54	12	2	0
1001	52.25	186.8	55	20	2	0
1104	49.59	182.8	56	30	2	0
1003	51.48	184.7	57	31	2	0
1002	51.46	185.9	58	17	2	0
903	52.83	184.2	59	0	2	0
804	53.57	183.7	60	-6	2	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	49.63	174.5	61	13	1	0
1109	48.32	175.6	62	1	2	0
1108	48.72	176.6	63	7	2	0
1009	49.50	175.7	64	27	1	0
1107	49.05	178.2	65	-5	1	0
1006	50.22	180.0	66	16	2	0
1007	50.24	178.9	67	39	1	0
907	51.38	178.8	68	0	2	0
1106	49.40	179.6	69	5	2	0
1105	49.43	181.0	70	43	2	0
1005	50.58	181.4	71	50		1
906	51.55	180.5	72	20	1	0
1103	49.91	184.1	73	-17	2	0
1004	50.93	183.0	74	45	2	0
812	51.47	172.8	75	13	1	0
412	56.40	174.9	76	15		20
614	53.91	171.4	77	12	2	0
514	54.78	171.9	78	13	2	0
613	53.74	172.5	79	-2	1	0
912	50.31	172.1	80	5	2	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	52.37	188.3	81	22	2	0
1101	50.86	186.6	82	-11	2	0
701	55.58	187.4	83	30	2	0
702	55.36	186.3	84	-10	2	0
503	57.53	185.6	85	25	2	0
1102	50.35	185.3	86	-8	2	0
900	53.68	188.2	87	3	1	0
802	54.15	185.8	88	25	2	0
404	58.37	185.7	89	-5	2	0
502	57.85	186.9	90	-2	2	0
810	51.76	175.5	91	11	2	0
909	50.99	176.5	92	1	2	0
709	53.10	177.4	93	24		20
811	51.57	174.4	94	29	1	0
1008	50.05	177.5	95	11	2	0
908	51.08	177.8	96	-7	2	0
911	50.60	173.7	97	3	1	0
910	50.46	175.3	98	7	1	0
609	54.50	177.7	99	28	2	0
710	53.06	176.1	100	14	1	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	52.88	185.8	101	20	2	0
800	55.22	188.6	102	-18	2	0
801	54.24	187.2	103	-2	2	0
901	53.43	186.9	104	0	2	0
803	53.70	184.9	105	38	2	0
703	54.96	185.1	106	1	2	0
704	54.64	183.9	107	53	2	0
405	57.73	183.5	108	45	2	0
406	57.69	182.5	109	11	2	0
207	59.56	181.8	110	26	2	0
106	61.26	183.4	111	77	2	0
107	61.14	182.3	112	11	2	0
305	59.49	183.7	113	-14	1	0
205	60.34	184.0	114	12	2	0
206	60.03	183.3	115	7	2	0
813	51.45	171.6	116	14		20
299	58.20	174.5	117	13	2	0
513	54.80	173.1	118	18	2	0
1011	49.40	173.1	119	6	2	0
808	52.32	178.3	120	2	2	0

SHOT NUMBER 6 SHOT POINT 19
SHOT TIME: 255: 8:49: 0.009

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	47.37	1.5	1	45	1	0
108	46.59	358.8	2	53	1	0
10	45.92	1.2	3	11	1	0
109	46.91	0.2	4	27	1	0
208	47.60	359.4	5	22	1	0
209	48.18	0.6	6	-5	1	0
11	46.37	2.7	7	9	1	0
111	47.55	3.4	8	25	1	0
12	46.52	4.3	9	88	1	0
214	49.75	7.8	10	54	1	0
314	51.09	8.0	11	22	1	0
413	51.74	7.2	12	9	1	0
414	52.06	8.3	13	46	1	0
415	52.76	9.4	14	-30	1	0
315	51.32	9.2	15	11	1	0
402	49.07	351.4	16	-15		20
303	48.61	352.3	17	26	1	0
403	49.15	352.8	18	-27	1	0
204	47.09	353.2	19	-90	1	0
304	47.61	353.6	20	37		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	48.55	356.6	21	-4	1	0
307	48.63	358.1	22	14	1	0
308	48.91	359.7	23	24	1	0
407	49.98	358.8	24	3	1	0
506	50.80	357.8	25	26	1	0
606	52.06	358.4	26	5	2	0
507	50.97	359.4	27	11	1	0
705	52.85	357.5	28	9	1	0
605	51.77	356.7	29	15	2	0
604	51.76	355.5	30	12	2	0
603	51.61	354.0	31	7	2	0
602	51.40	352.8	32	41	1	0
601	51.49	351.4	33	88	2	1
904	55.07	357.1	34	19	1	0
905	55.23	358.2	35	-36	1	0
706	53.21	359.0	36	10	1	0
608	52.68	1.0	37	14	2	0
708	53.74	1.3	38	8	2	0
505	50.57	356.1	39	-2	2	0
504	50.36	354.9	40	8	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	47.77	4.9	41	-35	1	0
212	49.22	5.0	42	12	1	0
510	51.77	3.5	43	8	1	0
509	51.59	2.1	44	50	1	0
211	48.64	3.5	45	0	1	0
210	48.45	1.9	46	55	1	0
508	51.21	0.6	47	49	1	0
607	52.22	359.5	48	50		1
409	50.22	1.3	49	14	1	0
310	49.50	2.5	50	25		20
411	51.10	4.5	51	44	1	0
408	50.12	0.2	52	25	1	0
807	54.70	0.4	53	15	2	0
805	54.23	357.5	54	12	2	0
1001	55.62	353.7	55	20	2	0
1104	57.69	357.6	56	30	2	0
1003	56.01	355.8	57	31	1	0
1002	56.22	354.7	58	17	1	0
903	54.61	356.0	59	0	2	0
804	53.82	356.4	60	-6	2	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	57.98	4.9	61	13	1	0
1109	59.11	3.7	62	1	2	0
1108	58.61	2.9	63	7	2	0
1009	57.93	3.8	64	27	1	0
1107	58.17	1.7	65	-5	1	0
1006	56.94	0.1	66	16	1	0
1007	56.95	1.1	67	39	1	0
907	55.81	1.2	68	0	2	0
1106	57.77	0.4	69	5	1	0
1105	57.75	359.2	70	43	1	0
1005	56.61	358.8	71	50		1
906	55.62	359.6	72	20	1	0
1103	57.49	356.5	73	-17	1	0
1004	56.37	357.4	74	45	1	0
812	56.49	6.7	75	13	1	0
412	51.25	5.7	76	15		20
614	54.50	8.7	77	12	2	0
514	53.51	8.4	78	13	1	0
613	54.35	7.5	79	-2	1	0
912	57.77	7.0	80	5	1	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	55.85	352.3	81	23	1	0
1101	56.94	354.2	82	-11	1	0
701	52.53	352.3	83	31	1	0
702	52.50	353.4	84	-10	1	0
503	50.22	353.6	85	25	1	0
1102	57.21	355.4	86	-8	1	0
900	54.57	352.0	87	3	1	0
802	53.57	354.2	88	25	1	0
404	49.43	353.3	89	-5	1	0
502	50.22	352.1	90	-2	1	0
810	55.72	4.3	91	11	1	0
909	56.37	3.3	92	1	1	0
709	54.19	2.7	93	24		20
811	56.09	5.3	94	29	1	0
1008	57.21	2.3	95	11	2	0
908	56.17	2.1	96	-7	2	0
911	57.15	5.7	97	3	1	0
910	57.04	4.3	98	7	1	0
609	52.76	2.5	99	28	2	0
710	54.36	3.9	100	14	1	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	54.82	354.4	101	20	1	0
800	53.22	351.1	102	-18	2	0
801	53.78	352.8	103	-2	1	0
901	54.51	353.2	104	0	2	0
803	53.86	355.1	105	38	2	0
703	52.65	354.7	106	1	2	0
704	52.78	356.0	107	54	2	0
405	49.67	356.0	108	45	1	0
406	49.59	357.2	109	11	1	0
207	47.67	357.8	110	26	1	0
106	46.16	355.5	111	77	1	0
107	46.13	357.1	112	11	1	0
305	47.95	355.5	113	-14	1	0
205	47.15	355.0	114	12	1	0
206	47.36	355.9	115	7	1	0
813	56.80	7.8	116	14		20
299	49.57	6.6	117	13	1	0
513	53.19	7.3	118	18	1	0
1011	58.44	5.9	119	6	2	0
808	54.89	1.7	120	2	2	0

Recorder Data Table, Medicine Lake Volcano, 1985 (cont'd.)

SHOT NUMBER 7 SHOT POINT 8
SHOT TIME: 255: 8:51: 0.008

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	51.63	48.8	1	45	2	0
108	49.43	47.7	2	53	2	0
10	50.46	49.8	3	11	2	0
109	50.53	48.3	4	27	2	0
208	50.47	47.2	5	22	2	0
209	51.64	47.6	6	-5	2	0
11	51.67	50.3	7	9	1	0
111	52.90	49.8	8	25	2	0
12	52.75	51.2	9	88	1	0
214	57.07	50.9	10	54	2	0
314	58.16	50.1	11	22	2	0
413	58.15	49.2	12	9	2	0
414	59.10	49.8	13	46	2	0
415	60.27	50.0	14	-30	2	0
315	59.08	50.8	15	11	2	0
402	46.40	40.7	16	-15		20
303	46.70	41.7	17	26	2	0
403	47.35	41.6	18	-27	2	0
204	46.28	43.7	19	-90	1	0
304	46.89	43.5	20	37		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	49.38	44.6	21	-4	2	0
307	50.41	45.6	22	14	2	0
308	51.56	46.4	23	24	2	0
407	51.72	44.9	24	3	2	0
506	51.66	43.6	25	26	2	0
606	52.95	43.0	26	5	2	0
507	52.83	44.6	27	11	2	0
705	52.90	41.7	28	9	2	0
605	51.64	42.0	29	15	2	0
604	50.89	41.2	30	12	2	0
603	49.79	40.2	31	7	2	0
602	48.90	39.6	32	41	2	0
601	47.98	38.4	33	88		1
904	54.25	39.8	34	19	2	0
905	55.10	40.5	35	-36	2	0
706	54.18	42.6	36	10	2	0
608	55.03	44.4	37	14	2	0
708	55.99	43.8	38	8	2	0
505	50.42	42.6	39	-2	2	0
504	49.55	42.0	40	8	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	53.94	50.6	41	-35	2	0
212	54.99	49.5	42	12	2	0
510	55.93	46.7	43	8	2	0
509	54.92	45.9	44	50	2	0
211	53.71	49.0	45	0	1	0
210	52.60	48.2	46	55	2	0
508	53.70	45.1	47	49	2	0
607	53.77	43.7	48	50		1
409	53.47	46.4	49	14	2	0
310	53.67	47.7	50	25		20
411	56.09	47.9	51	44	2	0
408	52.74	45.8	52	25	2	0
807	56.16	42.5	53	15	2	0
805	53.92	40.7	54	12	2	0
1001	52.44	36.9	55	20	2	0
1104	56.57	38.4	56	30	2	0
1003	54.09	38.1	57	31	2	0
1002	53.54	37.2	58	17	2	0
903	53.24	39.4	59	0	2	0
804	52.89	40.2	60	-6	2	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	61.47	43.7	61	13	1	0
1109	61.63	42.2	62	1	2	0
1108	60.72	41.9	63	7	2	0
1009	60.74	42.9	64	27	2	0
1107	59.56	41.2	65	-5	2	0
1006	57.63	40.8	66	16	2	0
1007	58.25	41.5	67	39	2	0
907	57.49	42.4	68	0	2	0
1106	58.46	40.5	69	5	2	0
1105	57.66	39.6	70	43	2	0
1005	56.54	40.1	71	50		1
906	56.32	41.3	72	20	1	0
1103	55.68	37.7	73	-17	2	0
1004	55.40	39.1	74	45	2	0
812	61.48	45.9	75	13	1	0
412	56.93	48.6	76	15		20
614	61.16	48.5	77	12	2	0
514	60.26	48.9	78	13	2	0
613	60.34	47.8	79	-2	2	0
912	62.65	45.4	80	5	2	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	51.67	35.6	81	23	2	0
1101	53.72	36.3	82	-11	2	0
701	49.29	38.2	83	31	2	0
702	50.00	39.1	84	-10	2	0
503	48.59	41.2	85	25	2	0
1102	54.76	37.0	86	-8	2	0
900	50.54	36.3	87	3	2	0
802	51.28	38.8	88	25	2	0
404	47.86	41.6	89	-5	2	0
502	47.60	40.1	90	-2	2	0
810	59.37	44.6	91	11	2	0
909	59.24	43.5	92	1	2	0
709	57.20	44.5	93	24		20
811	60.30	45.2	94	29	1	0
1008	59.21	42.2	95	11	2	0
908	58.31	42.8	96	-7	2	0
911	61.37	44.8	97	3	2	0
910	60.36	43.8	98	7	1	0
609	56.01	45.3	99	28	2	0
710	58.11	45.3	100	14	1	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	52.34	38.0	101	20	2	0
800	48.98	36.7	102	-18	2	0
801	50.53	37.6	103	-2	2	0
901	51.33	37.4	104	0	2	0
803	52.12	39.3	105	39	2	0
703	50.98	39.9	106	1	2	0
704	51.94	40.8	107	54	2	0
405	49.74	43.3	108	45	2	0
406	50.44	44.1	109	11	2	0
207	49.56	46.2	110	26	2	0
106	47.16	46.1	111	77	1	0
107	48.11	47.1	112	11	2	0
305	48.30	44.4	113	-14	2	0
205	47.44	44.8	114	12	2	0
206	48.17	45.2	115	7	2	0
813	62.38	46.5	116	14		20
299	56.25	50.3	117	13	2	0
513	59.30	48.3	118	18	2	0
1011	62.50	44.2	119	6	2	0
808	57.12	43.3	120	2	2	0

Recorder Data Table, Medicine Lake Volcano, 1985 (cont'd.)

SHOT NUMBER 8 SHOT POINT 4
SHOT TIME: 255:11: 0: 0.008

TEAM 1

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
110	87.29	86.8	1	48	2	0
108	85.02	87.2	2	57	2	0
10	86.93	87.7	3	12	2	0
109	86.20	87.0	4	29	2	0
208	85.54	86.5	5	23	2	0
209	86.64	86.2	6	-5	2	0
11	88.19	87.5	7	9	2	0
111	88.88	86.7	8	26	2	0
12	89.51	87.5	9	94	2	0
214	92.88	85.8	10	58	2	0
314	93.30	85.0	11	23	2	0
413	92.74	84.5	12	10	2	0
414	93.85	84.4	13	50	2	0
415	94.96	84.2	14	-33	2	0
315	94.45	85.0	15	12	2	0
402	79.05	85.6	16	-16		20
303	79.88	85.9	17	28	2	0
403	80.03	85.5	18	-29	1	0
204	80.49	86.9	19	-96	3	0
304	80.81	86.5	20	40		20

TEAM 2

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
306	83.26	85.8	21	-4	2	0
307	84.58	85.8	22	15	2	0
308	85.90	85.7	23	25	2	0
407	85.17	84.9	24	3	2	0
506	84.35	84.3	25	27	2	0
606	85.00	83.5	26	6	2	0
507	85.83	84.3	27	11	2	0
705	84.20	82.9	28	9	2	0
605	83.43	83.6	29	16	2	0
604	82.39	83.6	30	12	2	0
603	81.01	83.7	31	8	2	0
602	79.99	83.8	32	43	2	0
601	78.86	83.8	33	94		1
904	84.02	81.4	34	20	2	0
905	85.10	81.4	35	-38	2	0
706	85.68	82.8	36	10	2	0
608	87.40	83.3	37	15	2	0
708	87.81	82.6	38	8	2	0
505	82.85	84.4	39	-2	2	0
504	81.85	84.6	40	8	2	0

TEAM 3

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
112	90.13	86.7	41	-37	2	0
212	90.38	85.8	42	12	2	0
510	89.50	84.1	43	8	2	0
509	88.23	84.1	44	53	2	0
211	89.07	86.1	45	0	2	0
210	87.72	86.1	46	59	2	0
508	86.83	84.2	47	52	2	0
607	86.02	83.5	48	54		1
409	87.38	84.9	49	15	2	0
310	88.29	85.4	50	27		20
411	90.33	84.6	51	47	2	0
408	86.46	84.9	52	27	2	0
807	87.16	81.9	53	16	2	0
805	84.35	82.0	54	13	2	0
1001	80.84	80.9	55	22	2	0
1104	84.86	79.7	56	32	2	0
1003	82.84	80.7	57	33	2	0
1002	81.84	80.5	58	18	2	0
903	83.00	81.7	59	0	2	0
804	83.26	82.2	60	-7	2	0

TEAM 4

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1010	92.04	80.4	61	14	2	0
1109	91.20	79.5	62	1	2	0
1108	90.27	79.7	63	8	2	0
1009	90.96	80.3	64	29	2	0
1107	88.93	79.8	65	-5	2	0
1006	87.20	80.4	66	17	2	0
1007	88.13	80.5	67	42	2	0
907	88.07	81.3	68	0	2	0
1106	87.64	79.9	69	5	1	0
1105	86.45	79.8	70	46	2	0
1005	85.88	80.5	71	54		1
906	86.52	81.2	72	22	2	0
1103	83.72	79.7	73	-18	2	0
1004	84.43	80.5	74	49	2	0
812	93.45	81.6	75	14	1	0
412	91.39	84.6	76	16		20
614	94.77	83.1	77	13	2	0
514	94.29	83.6	78	14	2	0
613	93.67	83.0	79	-2	1	0
912	94.06	80.9	80	6	2	0

TEAM 5

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
1000	79.68	80.7	81	24	2	0
1101	81.36	79.9	82	-12	2	0
701	79.65	83.0	83	33	2	0
702	80.45	83.1	84	-11	2	0
503	80.69	84.7	85	27	2	0
1102	82.63	79.8	86	-8	2	0
900	79.36	81.6	87	4	2	0
802	81.21	82.3	88	26	2	0
404	80.45	85.2	89	-5	2	0
502	79.57	84.7	90	-2	2	0
810	90.97	81.7	91	12	2	0
909	90.17	81.2	92	1	2	0
709	89.17	82.5	93	25		20
811	92.03	81.6	94	31	2	0
1008	89.33	80.5	95	12	2	0
908	88.97	81.1	96	-8	2	0
911	92.66	81.0	97	4	1	0
910	91.23	80.9	98	7	2	0
609	88.75	83.4	99	30	2	0
710	90.35	82.5	100	15	2	0

TEAM 6

LOC	DIST	AZIM	UNIT	CHRON	CHAN	TAPE GRADE
902	81.48	81.4	101	22	2	0
800	78.53	82.6	102	-19	2	0
801	79.93	82.1	103	-2	2	0
901	80.36	81.6	104	0	2	0
803	82.12	82.1	105	42	2	0
703	81.67	83.0	106	1	2	0
704	82.90	82.9	107	58	2	0
405	82.75	85.1	108	49	2	0
406	83.76	85.1	109	12	2	0
207	84.28	86.4	110	28	2	0
106	82.42	87.5	111	83	1	0
107	83.68	87.5	112	12	2	0
305	82.36	86.3	113	-15	1	0
205	81.93	86.8	114	13	2	0
206	82.70	86.7	115	8	1	0
813	94.54	81.6	116	15		20
299	91.86	85.7	117	14	2	0
513	93.16	83.6	118	19	2	0
1011	93.20	80.3	119	6	2	0
808	88.39	81.9	120	3	2	0

APPENDIX B-- Frequency Response of the USGS Short-Period Refraction System

Dawson and Stauber (1986) used standard response characteristics of the major components of the USGS short-period seismic refraction instrument (Healy et al., 1982) with the frequency-response computer program RESPONSE (Stewart and O'Neill, 1980) to determine the theoretical transfer-function of the system. The component values used are from Eaton (1980) and Stewart and O'Neill (1980). The instrument consists of a Mark Products L-4TM 2-Hz geophone, a USGS-designed amplifier-VCO, and a 5-pole TRI-COMTM discriminator in the playback system. Standard parameters for the individual components of the system and a listing of the amplitude spectrum, the normalized amplitude spectrum, and the phase spectrum of the theoretical transfer function at specified frequencies are given in Dawson and Stauber (1986). Figure 2 shows the displacement response (db) and the velocity response (db) calculated by the program RESPONSE. The displacement response for the system peaks at 26 hz. The velocity response of the system is relatively flat for frequencies of 2-20 Hz and peaks at 6 Hz.

Calculation of Ground Velocity

Figures 4a-h show the unfiltered, normalized record sections for each shot. Above each trace in the record sections are three numbers: the station location number (cf. Table 2), showing which station recorded that seismogram; the attenuation setting for the digitized trace, either 12, 30, or 48 db; and the maximum deviation of the normalized trace, typically between 100 and 1000 counts. The traces are plotted so that they are centered at the correct shot-to-receiver distance. For the specified width of a normalized trace (0.125 inches in this report), the trace is scaled so that the largest peak in the time window extends 0.0625 inches from the center of the trace. The maximum deviation, d_{max}, is the number of counts from the center of the trace to 0.0625 inches. Thus the maximum deviation and the attenuation setting can be used, along with the system constants defined below, to determine the true amplitude of a trace, and to approximate ground velocity (Dawson and Stauber, 1986).

Let $A_{norm}(t)$ = the normalized plotted trace amplitude (inches), $A(t)$ = the true relative amplitude of the trace (scaled digitizer counts), and a = the attenuation setting of the recorder (db). Then true amplitude is related to normalized amplitude by:

$$A_{norm}(t) = A(t)\,\frac{0.0625}{d_{max}}\,10^{\frac{-a}{20}}$$

We can use $A_{norm}(t)$ further to approximate "ground velocity", $A_g(t)$ (cm/s), if we disregard all parts of the seismometer-amplifier-VCO-discriminator transfer function other than simple amplifications and conversions. System constants we must define are:

G_{LE} is the effective generator constant of the seismometer and L-pad (emf in volts, across the 10,000-ohm-input impedance of the preamp, resulting from a seismometer-coil-to-frame velocity of 1 cm/s). This system uses the L4 2-hz seismometer and custom L-pads, so that $G_{LE} = 1.0$ V/(cm/s).

G is the maximum gain of the USGS J402 amplifier-VCO. G ~ 104 db.

a is the attenuation setting of the preamp, usually 12, 30, or 48 db.

G_{SA} is the system gain. $G_{SA} = 10^{(G-a)/20}$. For a = 12, 30, and 48 db, G_{SA} = 39811, 5012, and 631, respectively.

D_{VCO} is the VCO sensitivity in the J402. D_{VCO} = 25 Hz/V.

D_{DSC} is the discriminator modulation sensitivity. D_{DSC} = 1/(25 Hz/V).

L_{REC} is the digitizer sensitivity. L_{REC} = 819.0 counts/V.

Then,

$$A_{norm}(t) \sim \frac{0.0625}{d_{max}} L_{REC}\, D_{VCO}\, D_{DSC}\, G_{SA}\, G_{LE}\, A_g(t)$$

or

$$A_g(t) \sim \frac{d_{max}\, A_{norm}(t)}{0.0625\, L_{REC} D_{VCO} D_{DSC} G_{SA} G_{LE}}$$

As an example, for shot 1, shotpoint 17, the trace from station 315 (Plate 2, Section 1, second trace from left) with an attenuation setting of 12 db has a maximum deviation of d_{max} = 648 counts. Then the approximate ground velocity is:

$$A_g(t)\left(\frac{cm}{sec}\right) \sim \frac{648\ (\text{counts})\ A_{norm}(t)\ (\text{in})}{0.0625\ (\text{in})\ 819.0\ \left(\frac{\text{counts}}{V}\right)\ 25\ \left(\frac{Hz}{V}\right)\ \frac{1}{25\ \left(\frac{Hz}{V}\right)}\ 39811\ 1.0\ \left(\frac{V}{cm/s}\right)}$$

$$\sim 3.18 \times 10^{-4}\ \left(\frac{cm/s}{in}\right)\ A_{norm}(t)\ (\text{in})$$

At the maximum deviation, $A_{norm}(t)$ = 0.0625 in, so that for this example

$A_g(t) \sim 1.99 \times 10^{-5}$ cm/s.

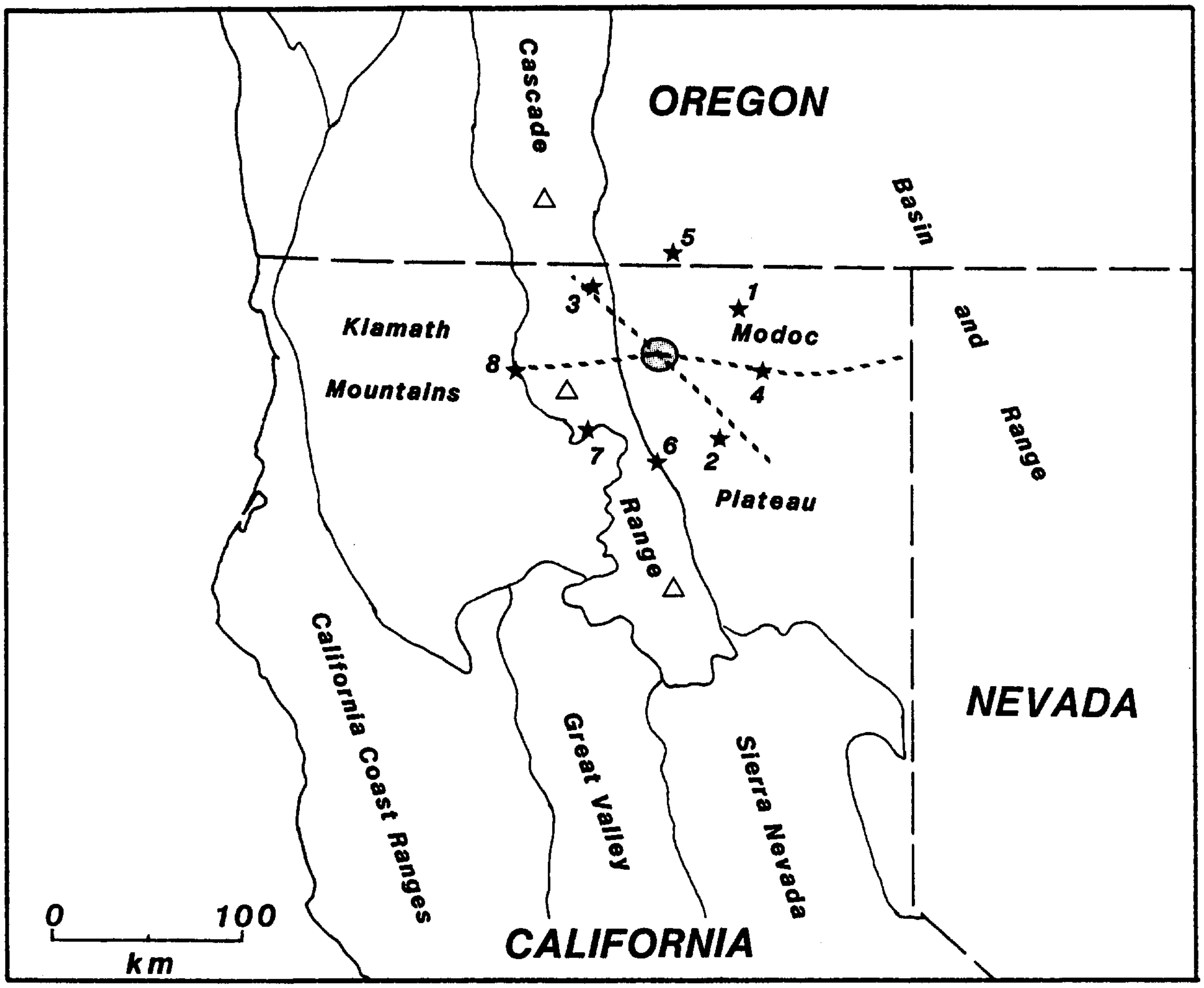


Figure 1. Location of Medicine Lake array and shots. Physiographic provinces (USGS and CDMG, 1966; Walker, 1977) are indicated. Major Cascade Range volcanoes are shown by triangles; selected existing USGS refraction lines are shown by the heavy dashed lines (Zucca et al., 1986); the stars and shot numbers indicate shotpoints used in the tomographic experiment; and the Medicine Lake array is shown by the shaded oval. Adapted from Berge et al., 1985.

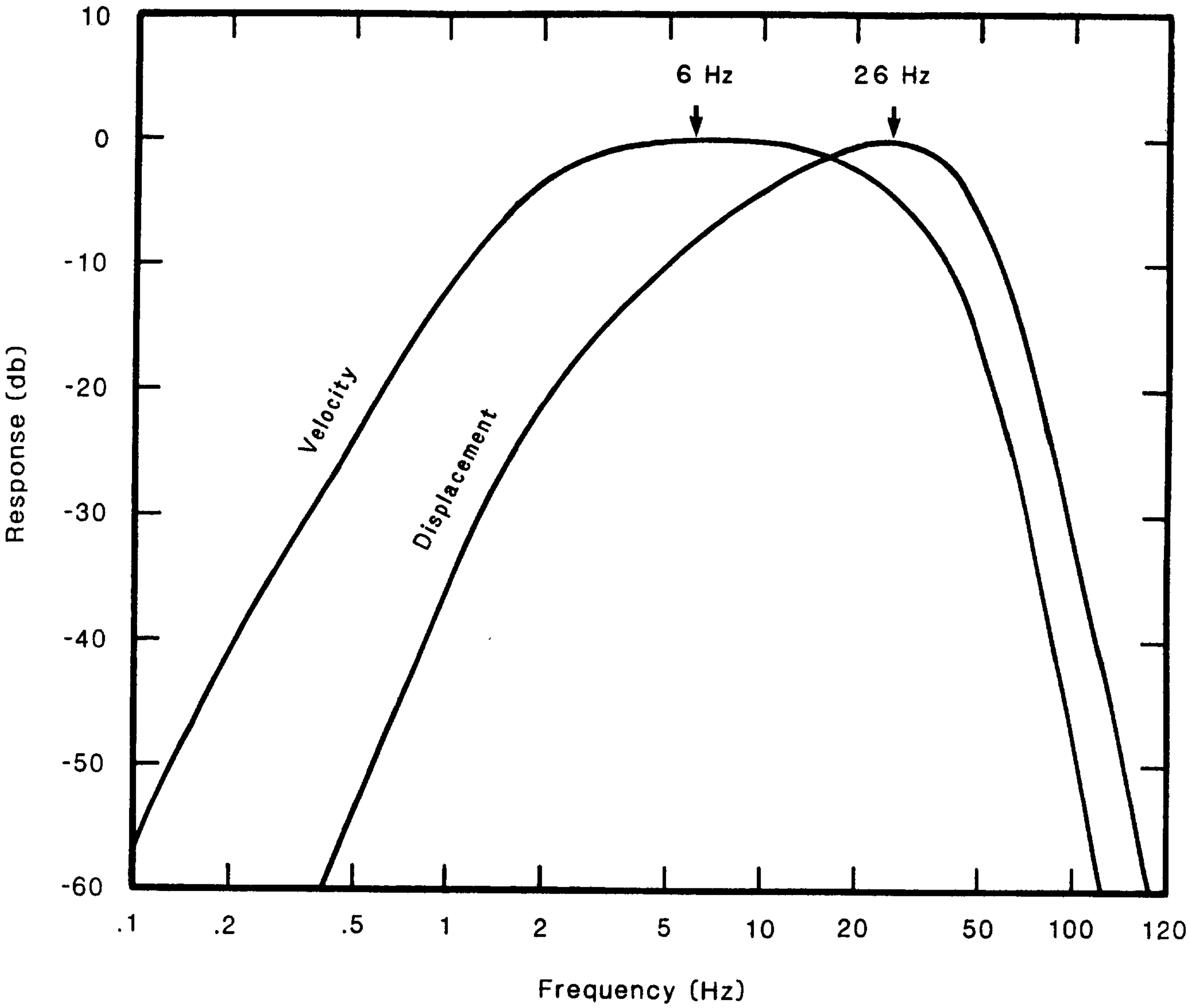


Figure 2. Theoretical transfer-function for the USGS short-period seismic refraction system (Stewart and O'Neill, 1980; Dawson and Stauber, 1986). The displacement response peaks at about 26 Hz, and the velocity response peaks at about 6 Hz.

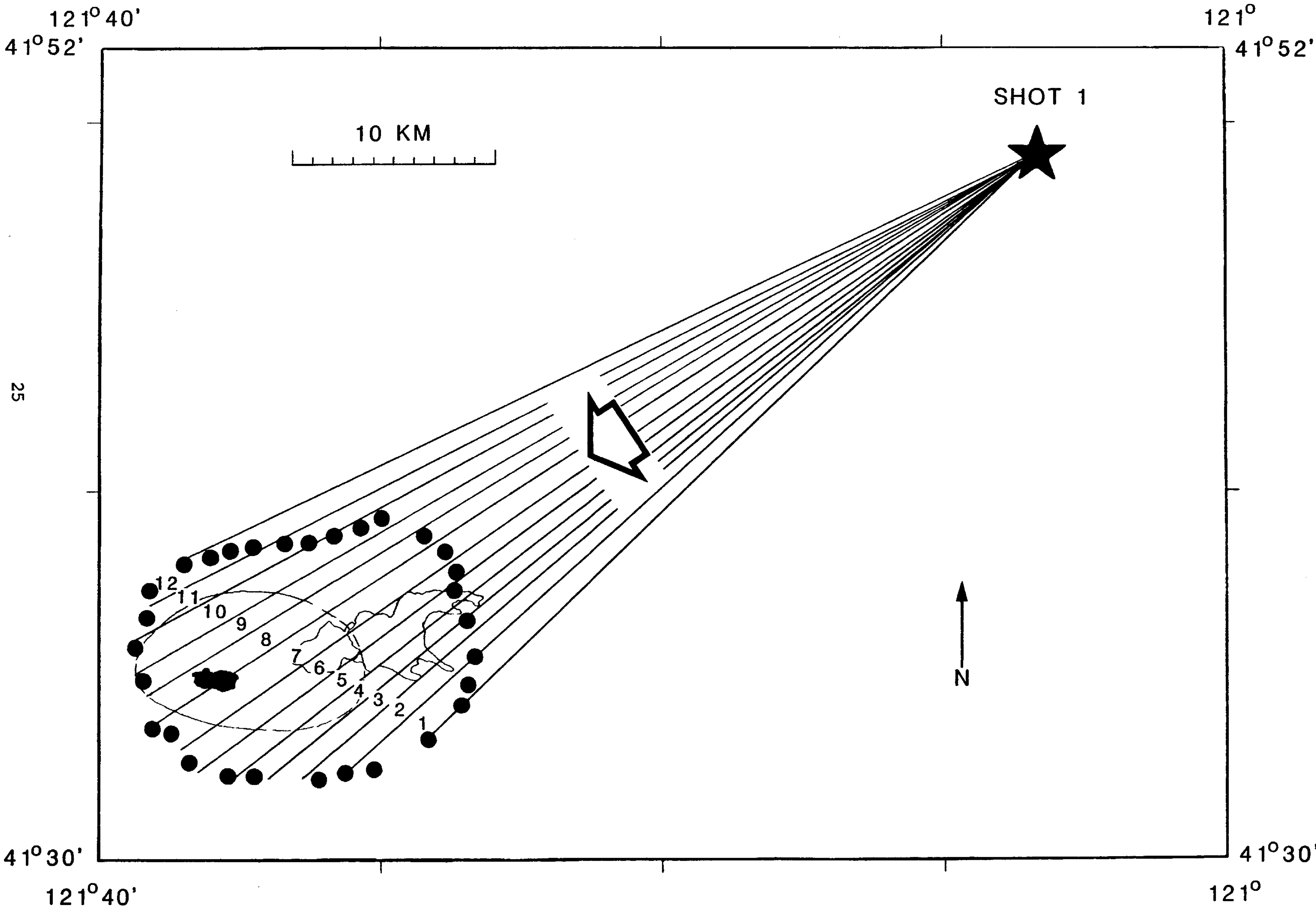


Figure 3a. Division of array for record sections for shot 1, shotpoint 17.

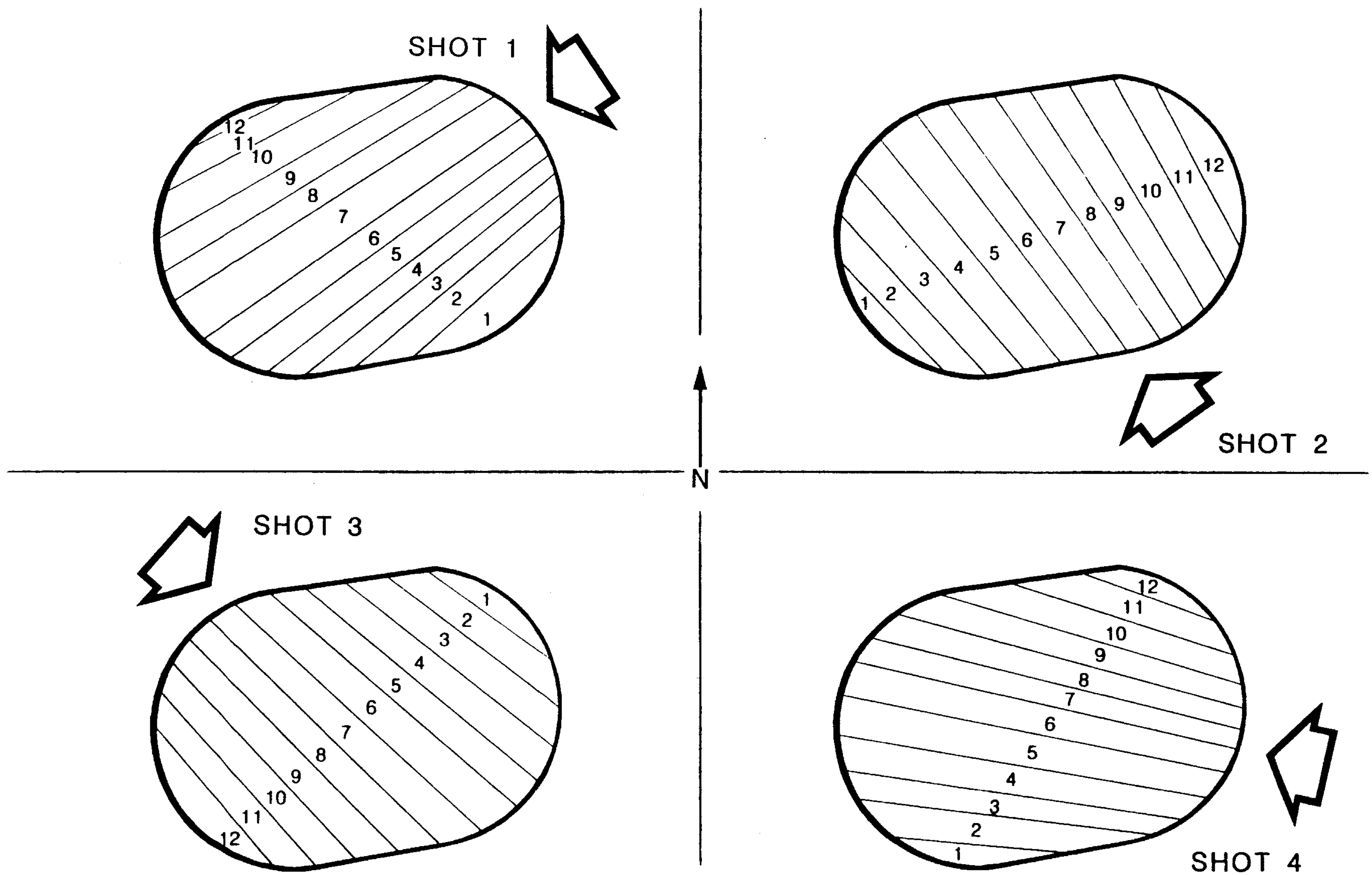


Figure 3b. Schematics of division of array for record sections for shots 1-4. Each numbered segment is plotted as a record section (cf. Figures 4a-d). Open arrows indicate direction from shot to array.

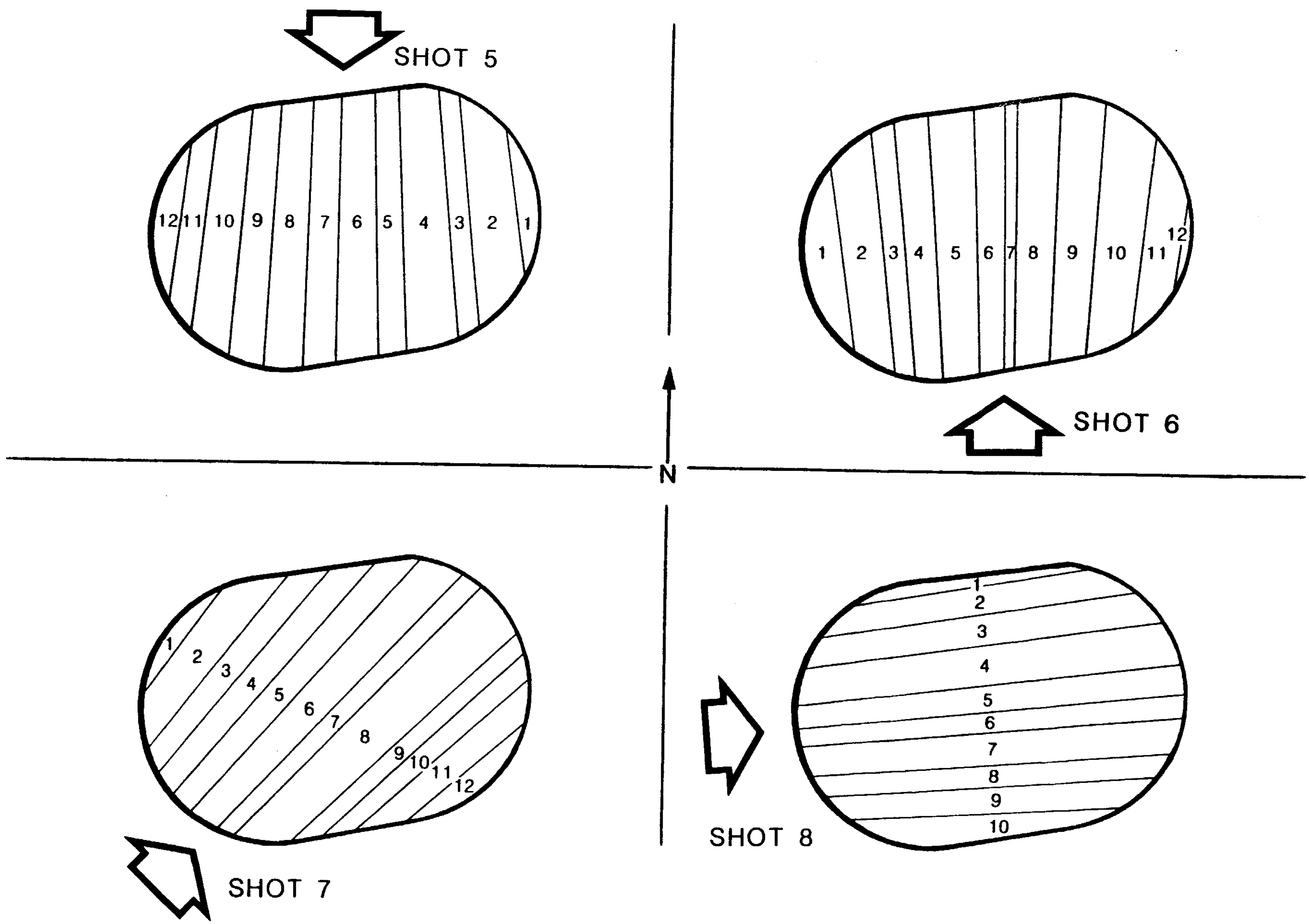
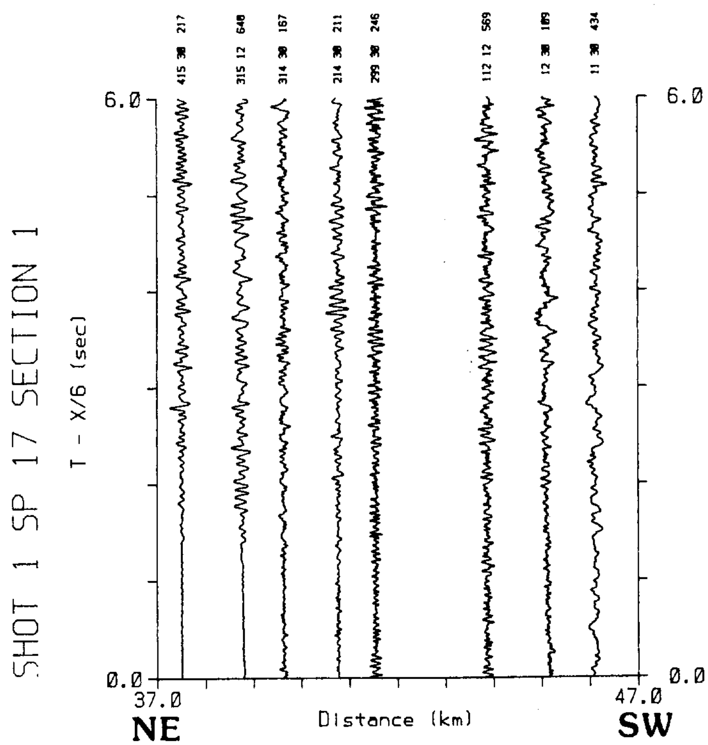


Figure 3c. Same as 3b, for shots 5-8.

Figure 4a.


SHOT 1 SP 17 SECTION 1
T - X/6 (sec)
6.0
0.0
6.0
0.0
37.0
47.0
Distance (km)
NE
SW

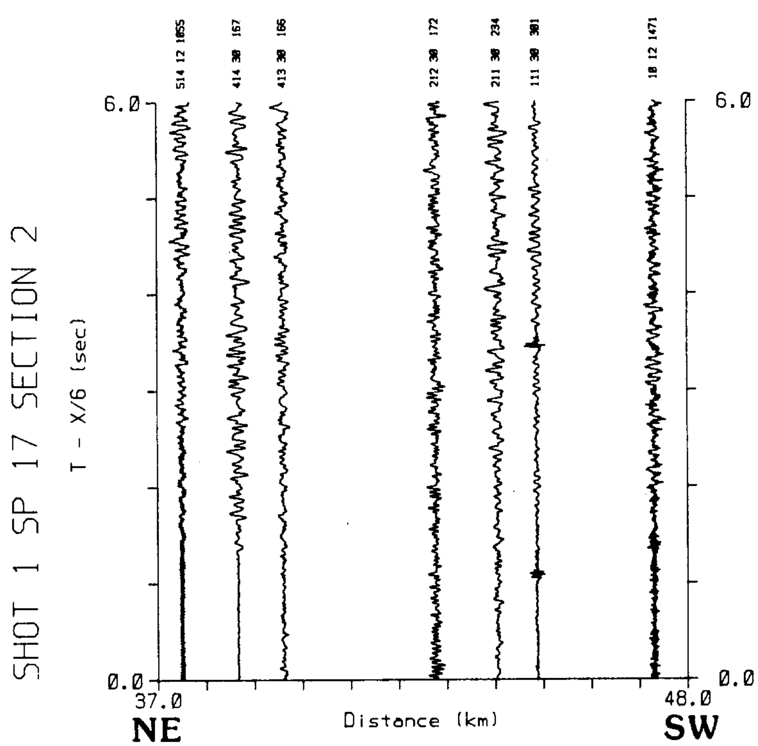
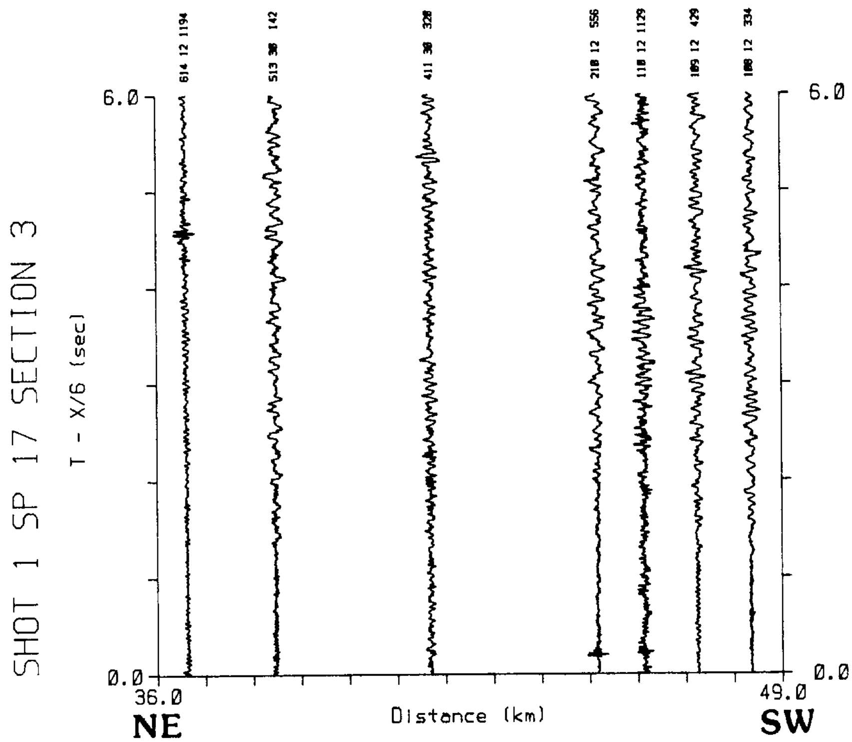

SHOT 1 SP 17 SECTION 2
T - X/6 (sec)
6.0
0.0
6.0
0.0
37.0
48.0
Distance (km)
NE
SW

Figure 4a., continued



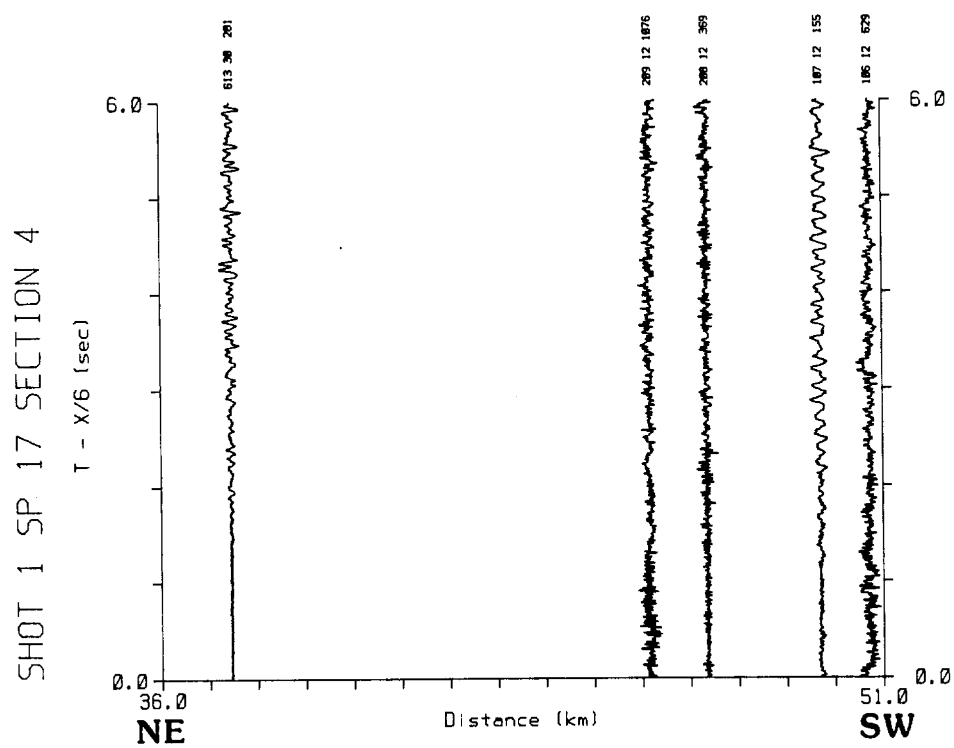
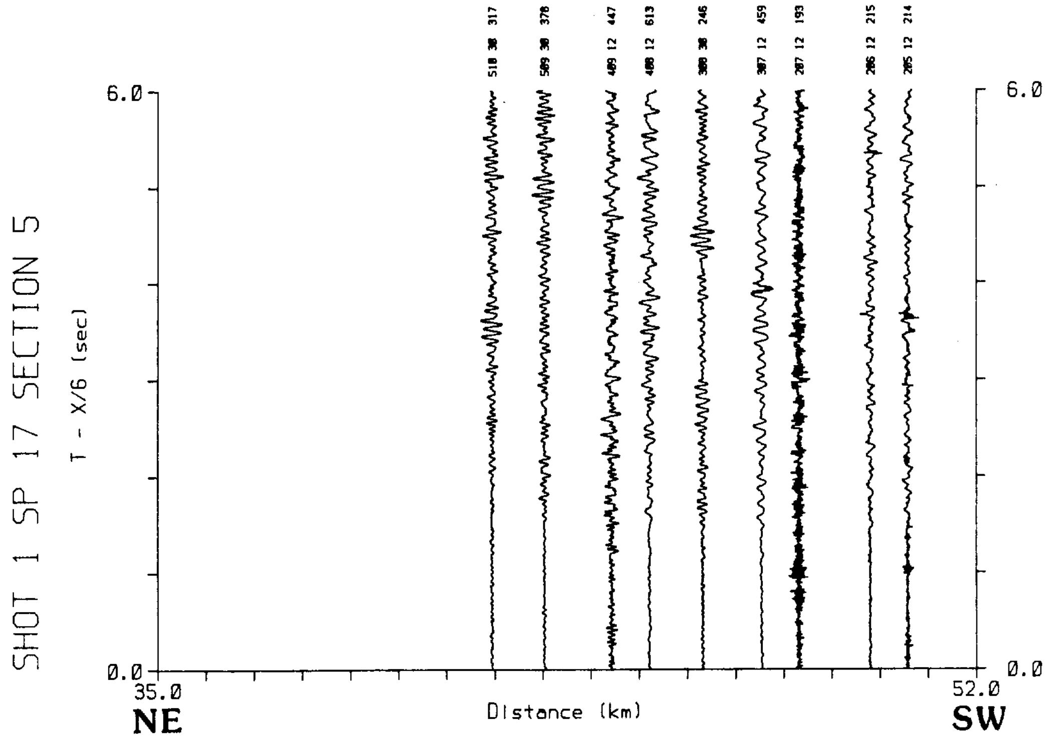


Figure 4a., continued



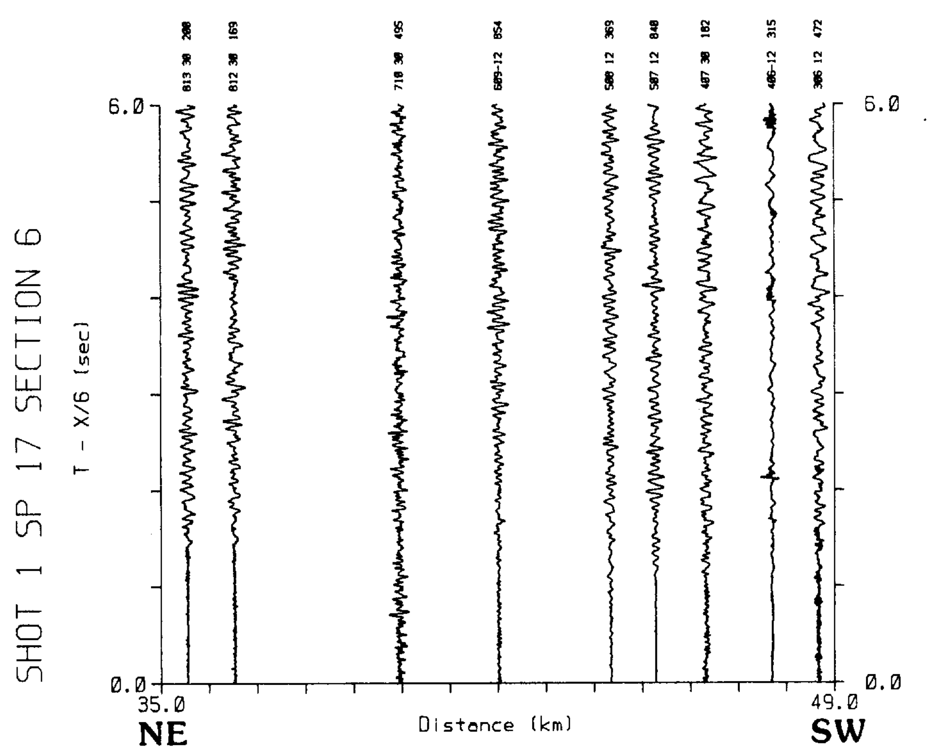
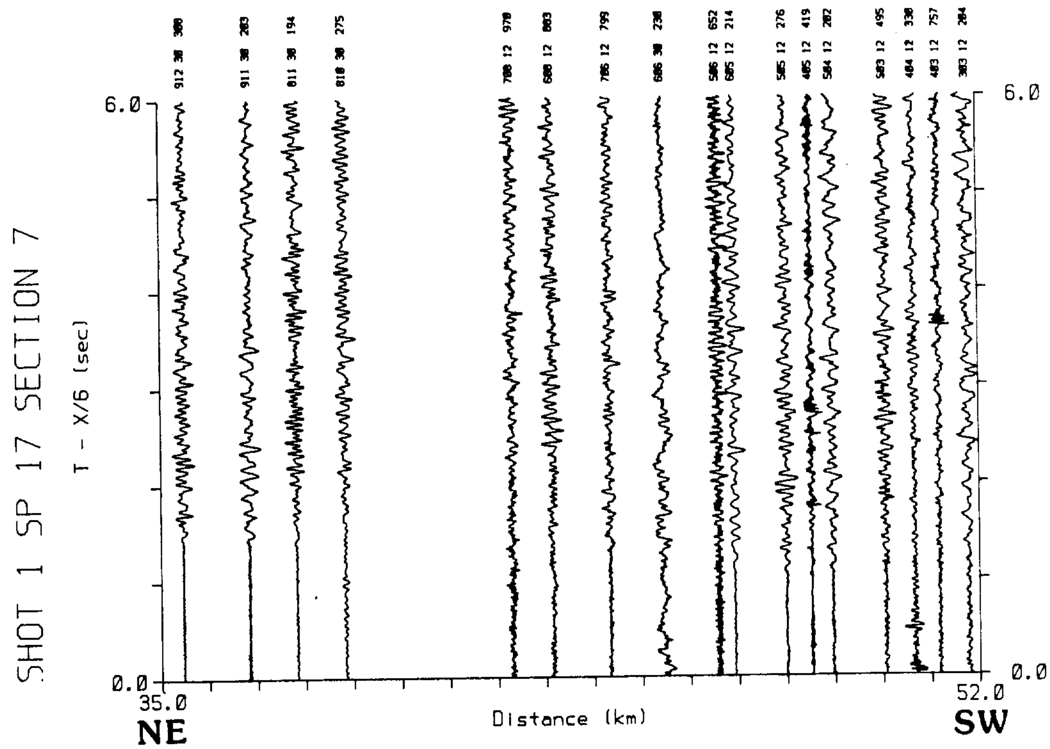


Figure 4a., continued



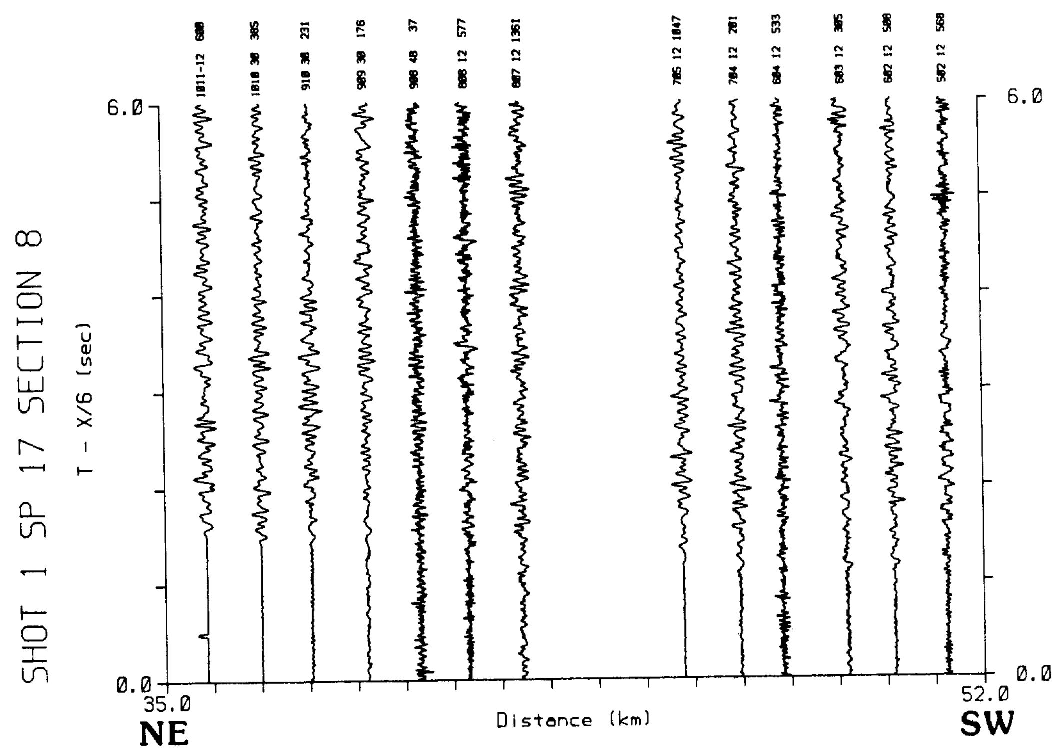
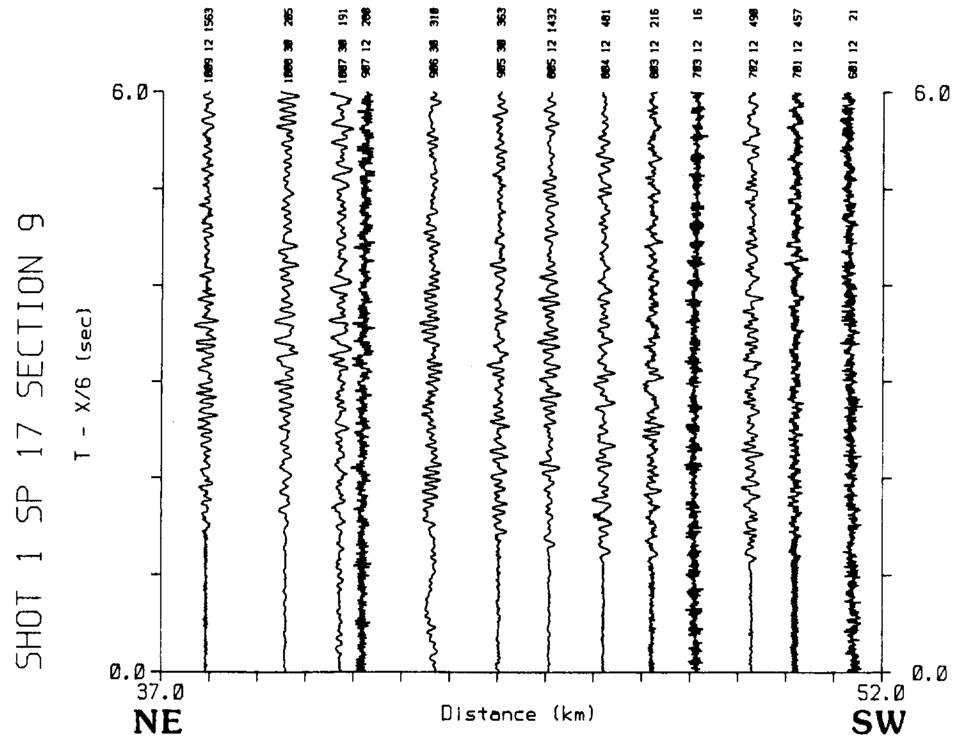


Figure 4a., continued



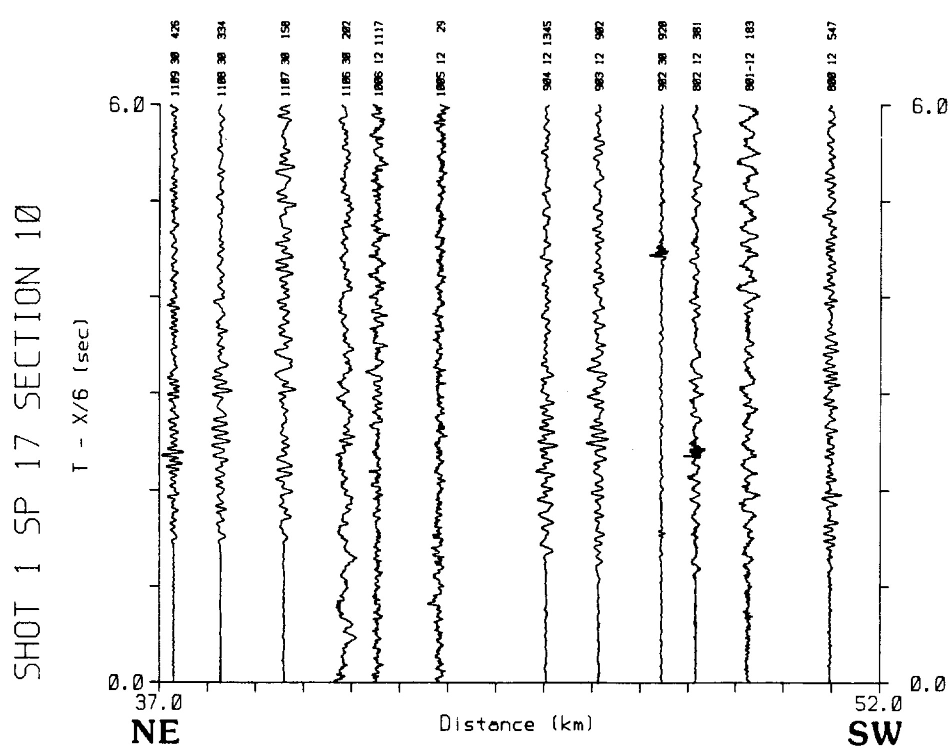
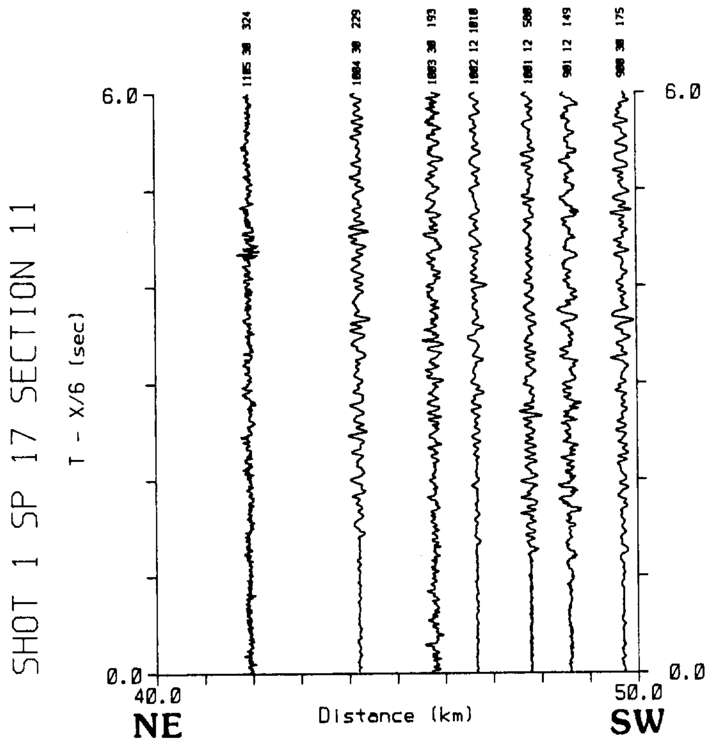


Figure 4a., continued



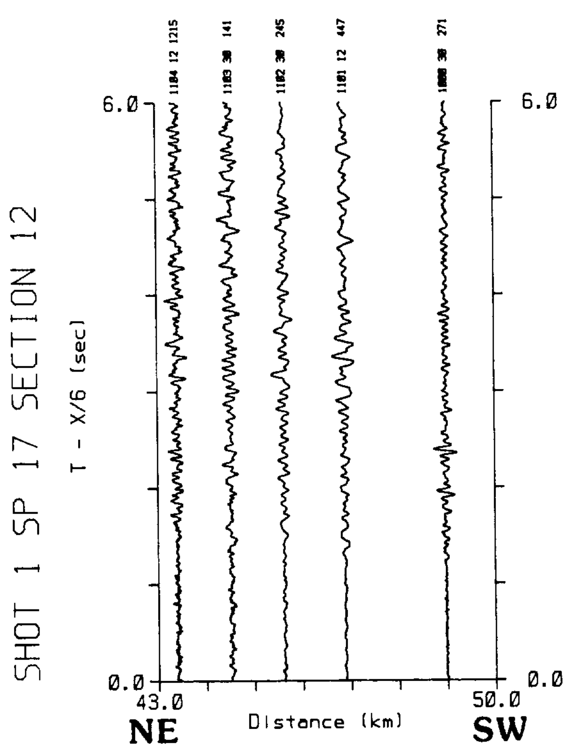
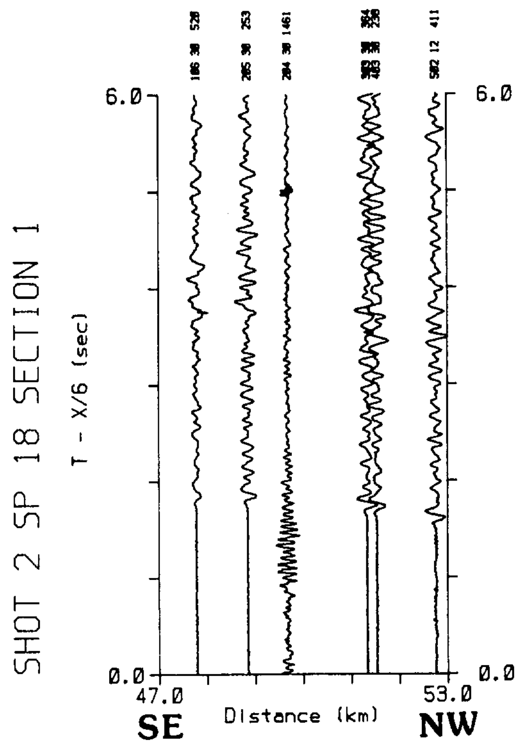


Figure 4b.



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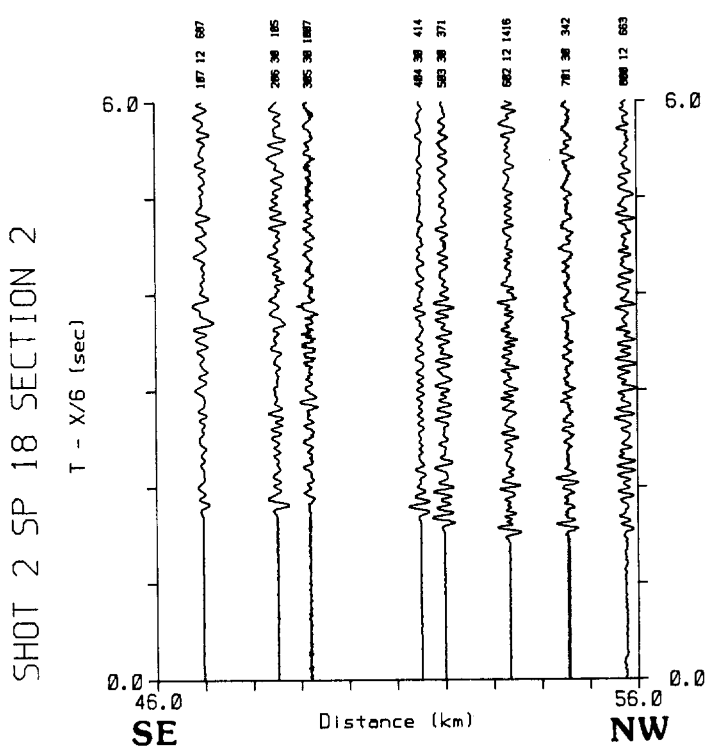

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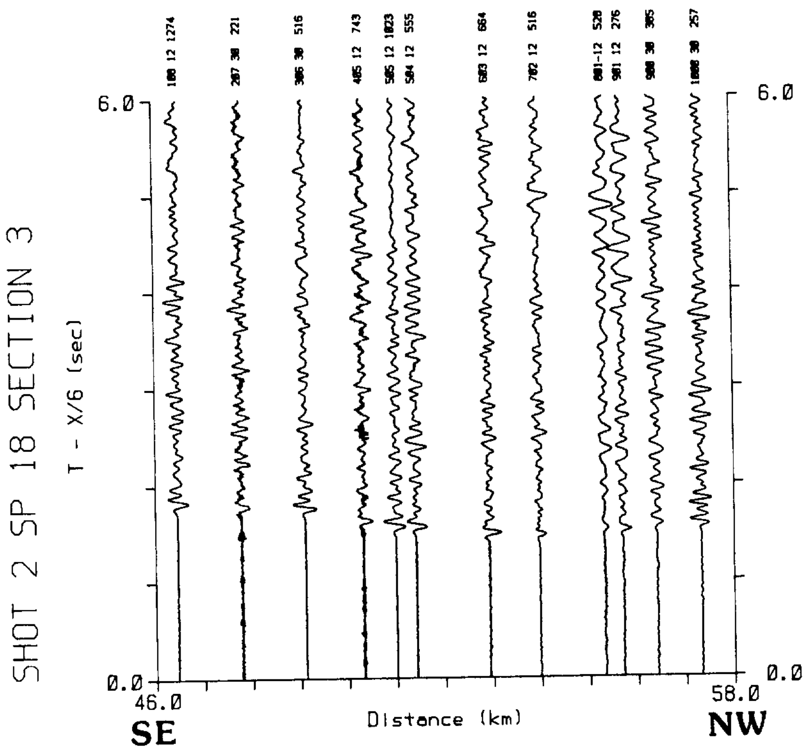


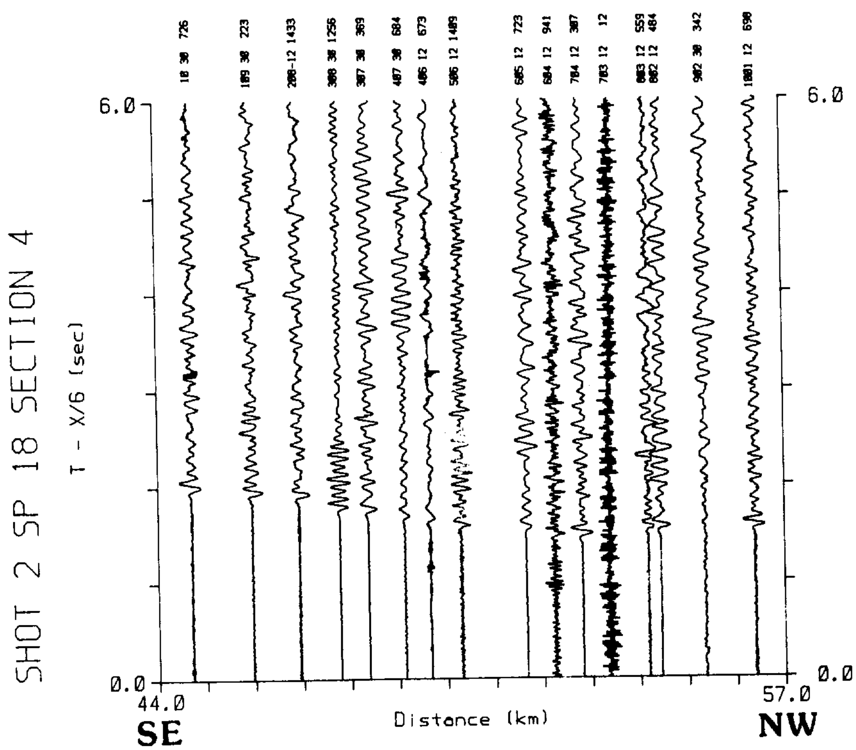
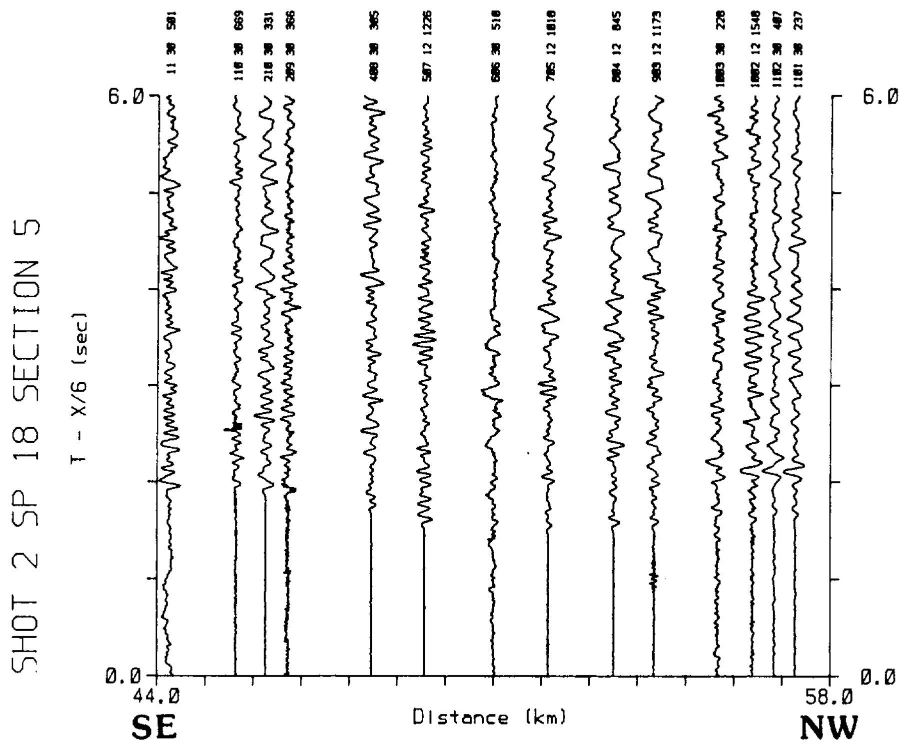


Figure 4b., continued



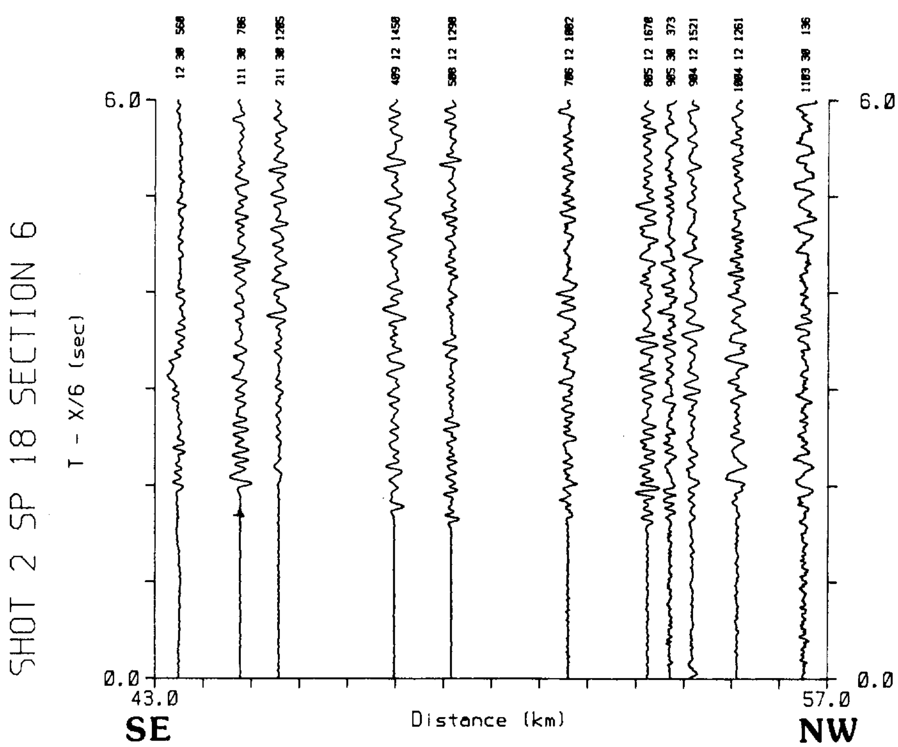
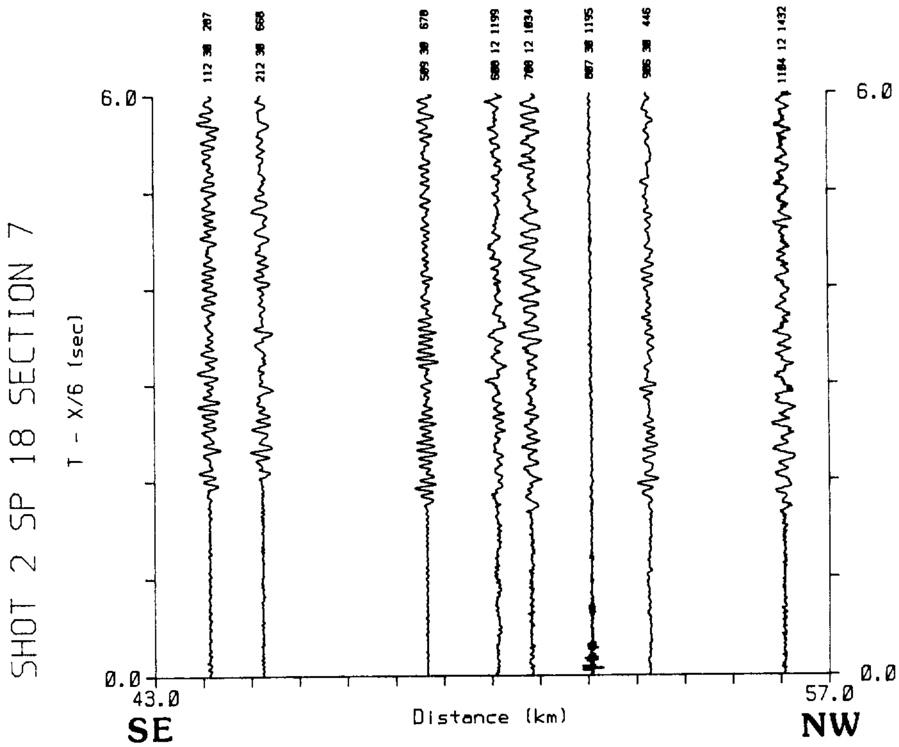
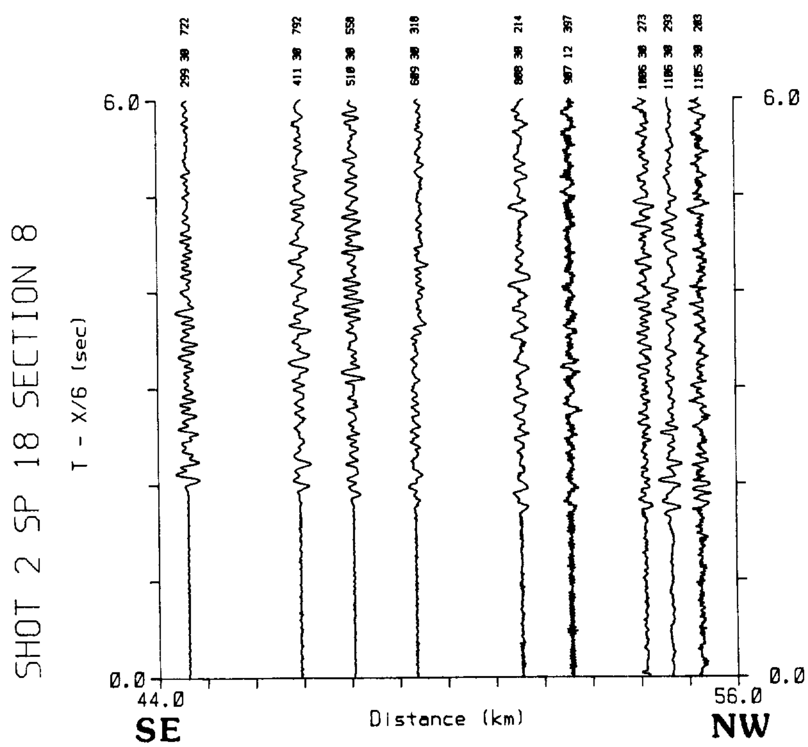


Figure 4b., continued





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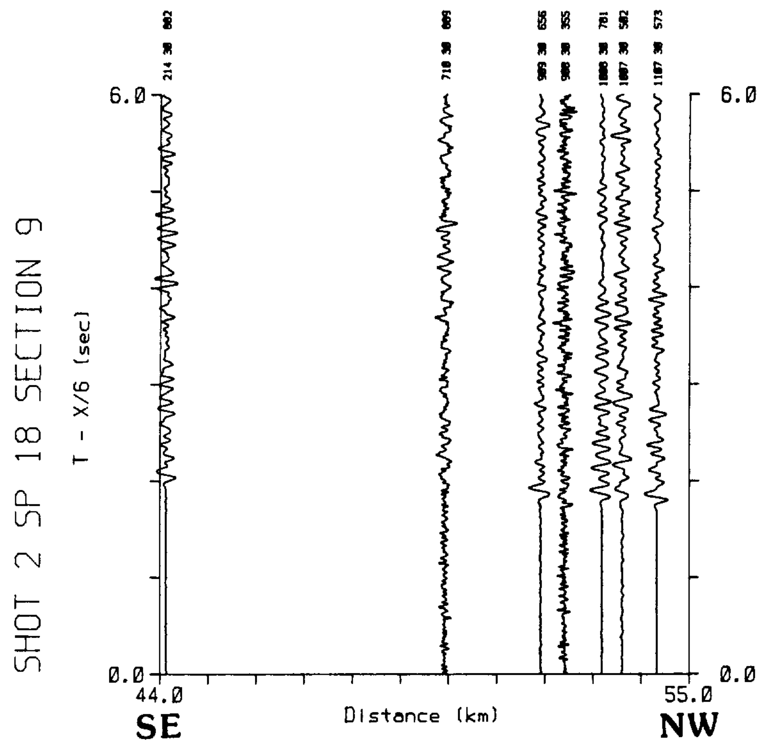

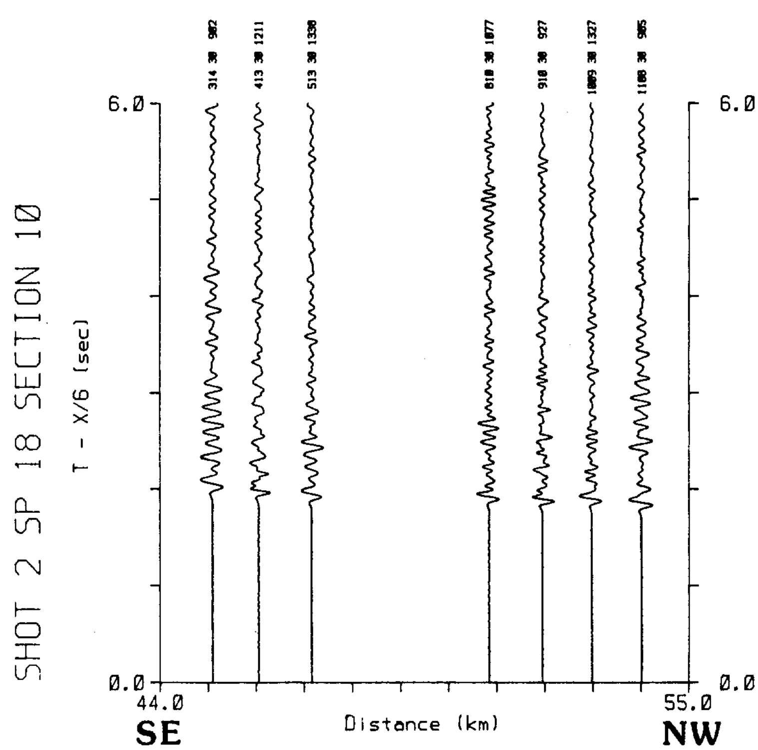

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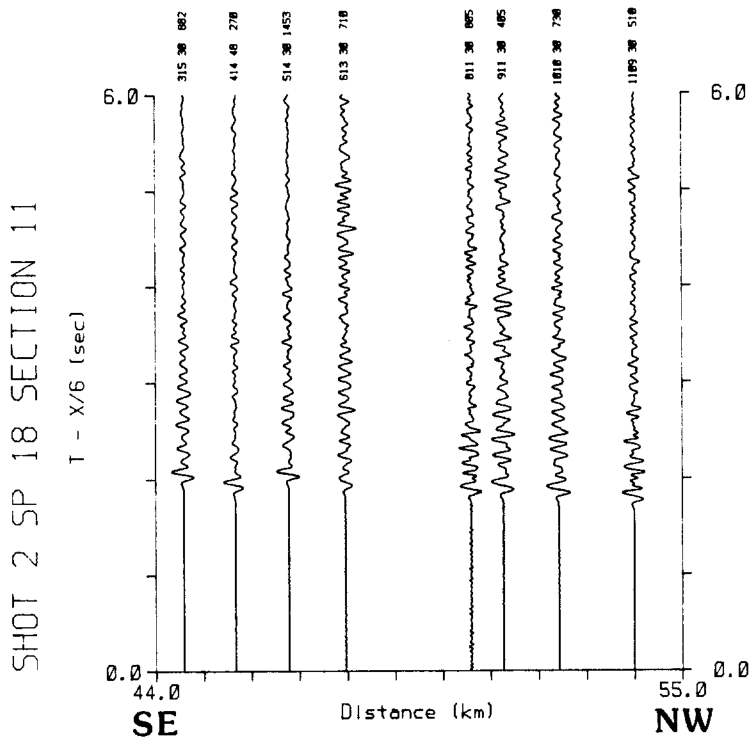


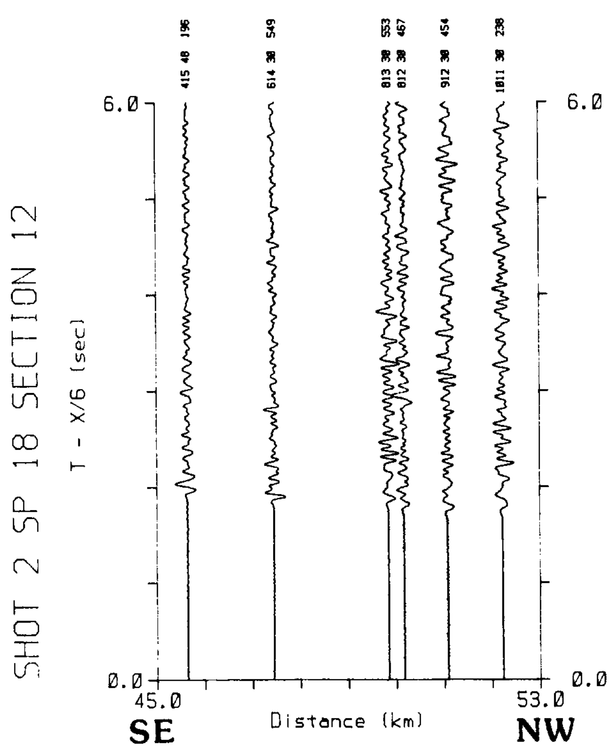
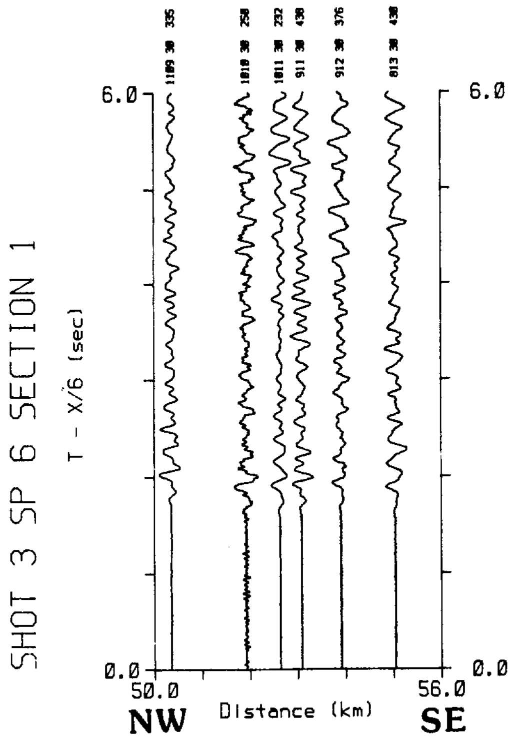
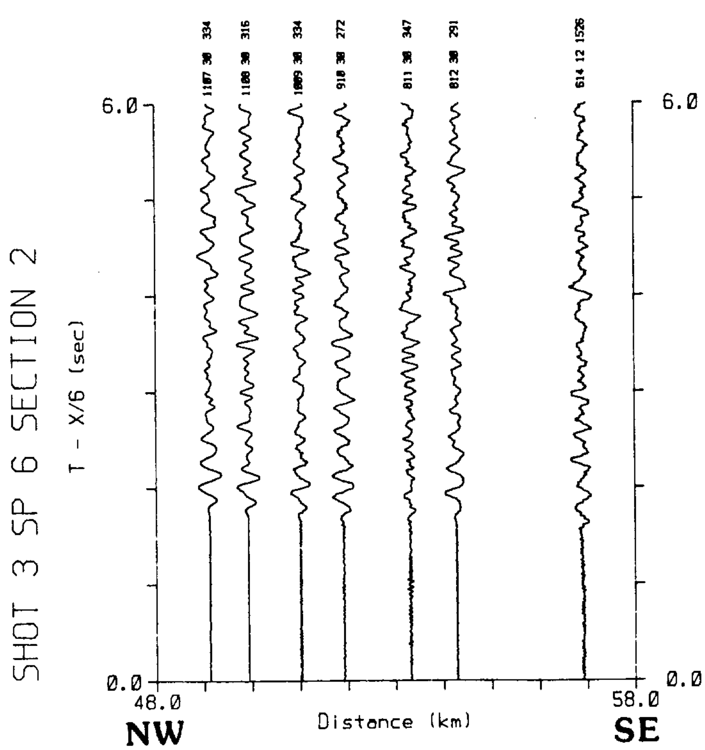


Figure 4c.

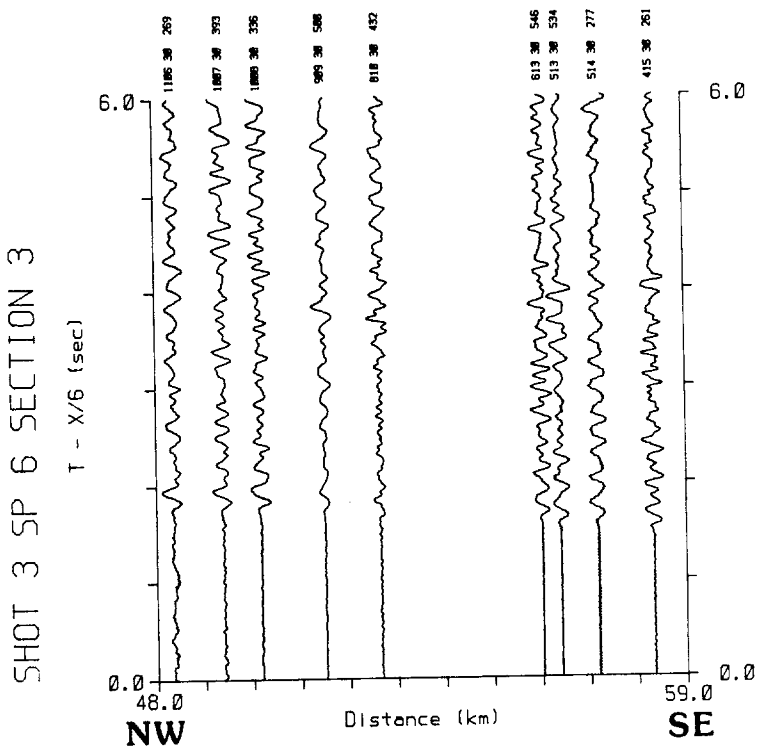


SHOT 3 SP 6 SECTION 1
T - X/6 (sec)
6.0
0.0
50.0
56.0
Distance (km)
NW
SE



SHOT 3 SP 6 SECTION 2
T - X/6 (sec)
6.0
0.0
48.0
58.0
Distance (km)
NW
SE

Figure 4c., continued



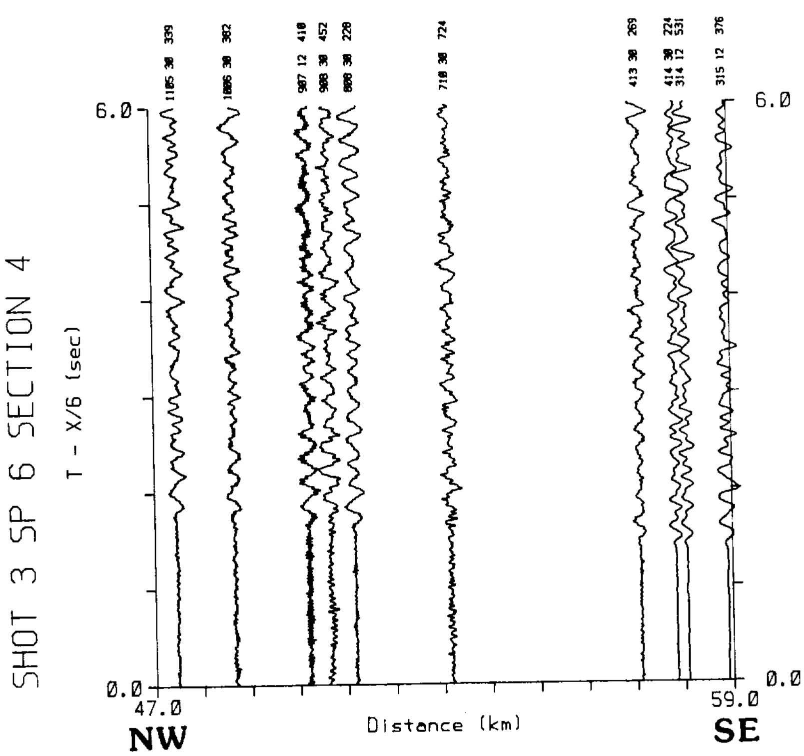
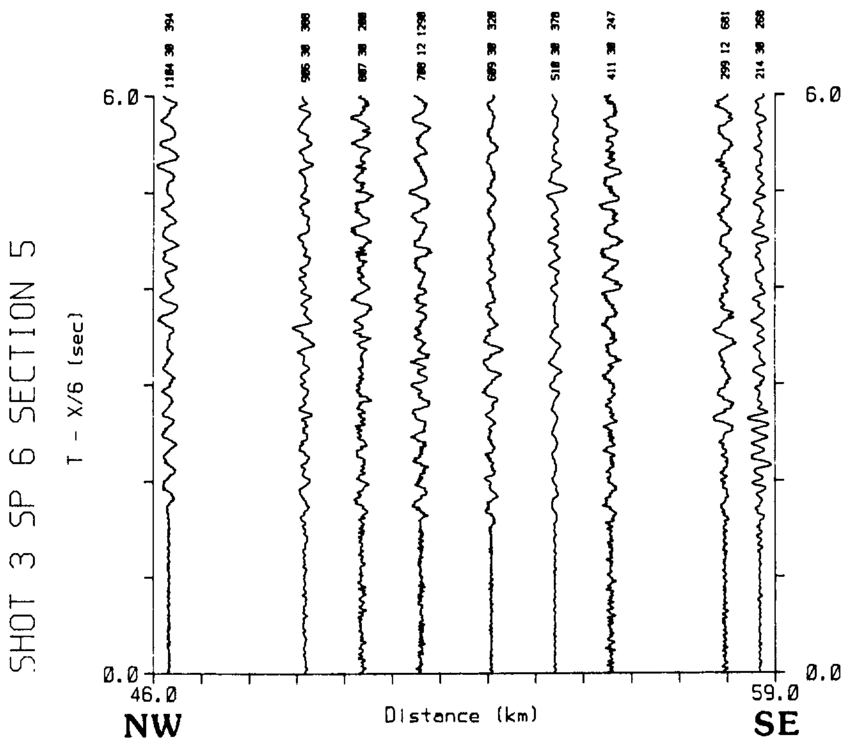


Figure 4c., continued



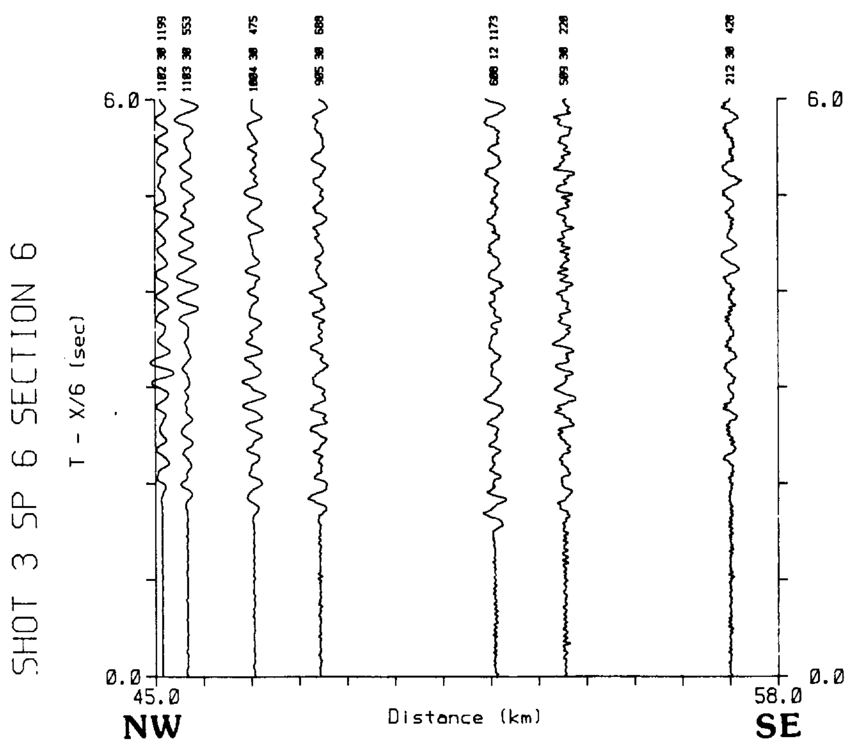
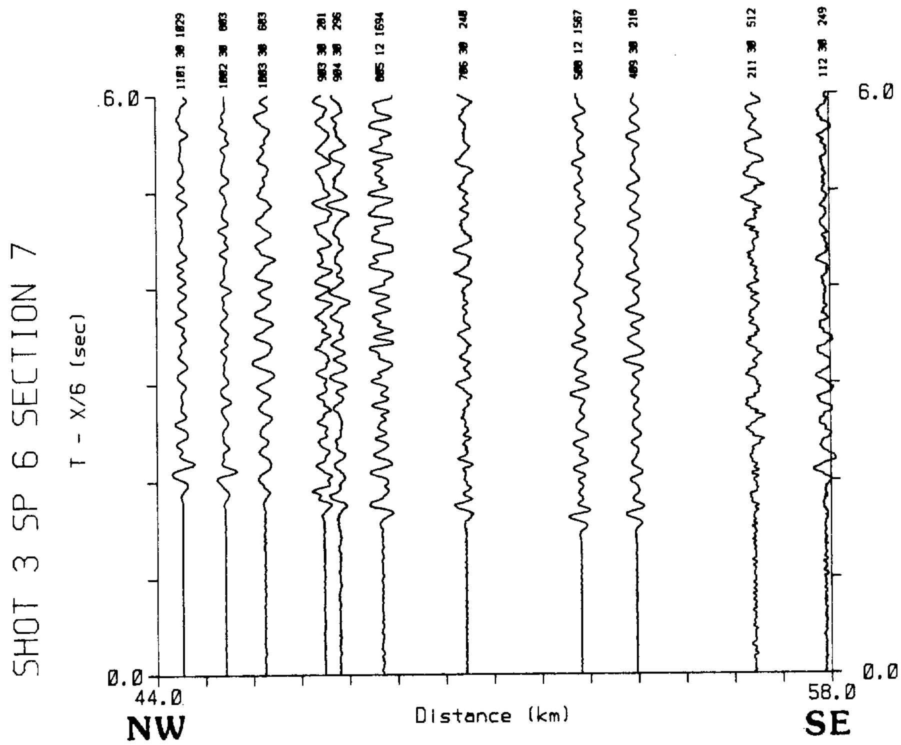


Figure 4c., continued



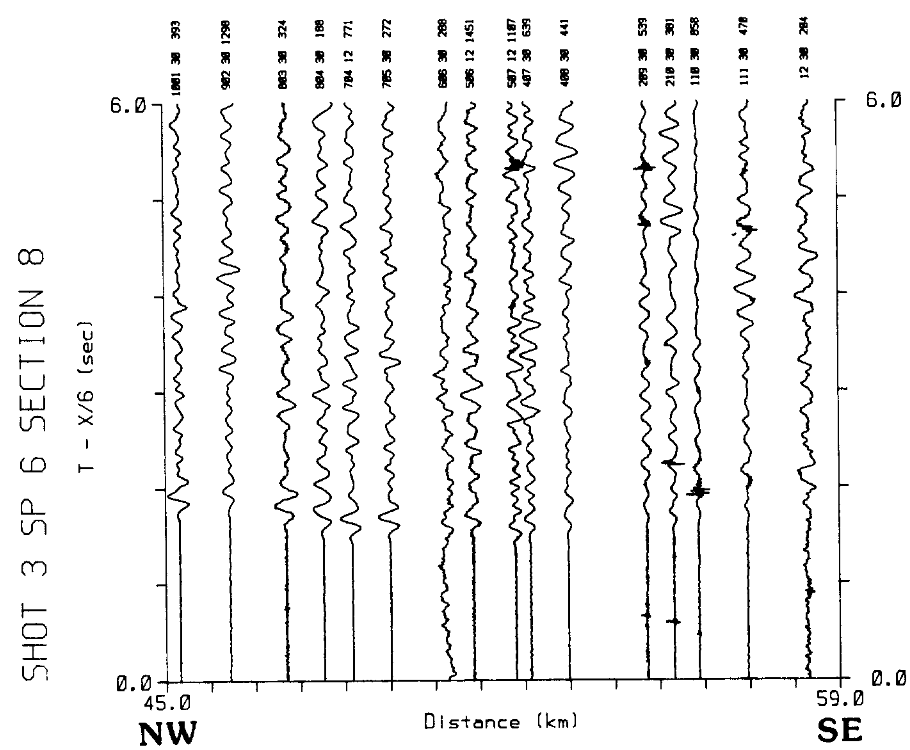
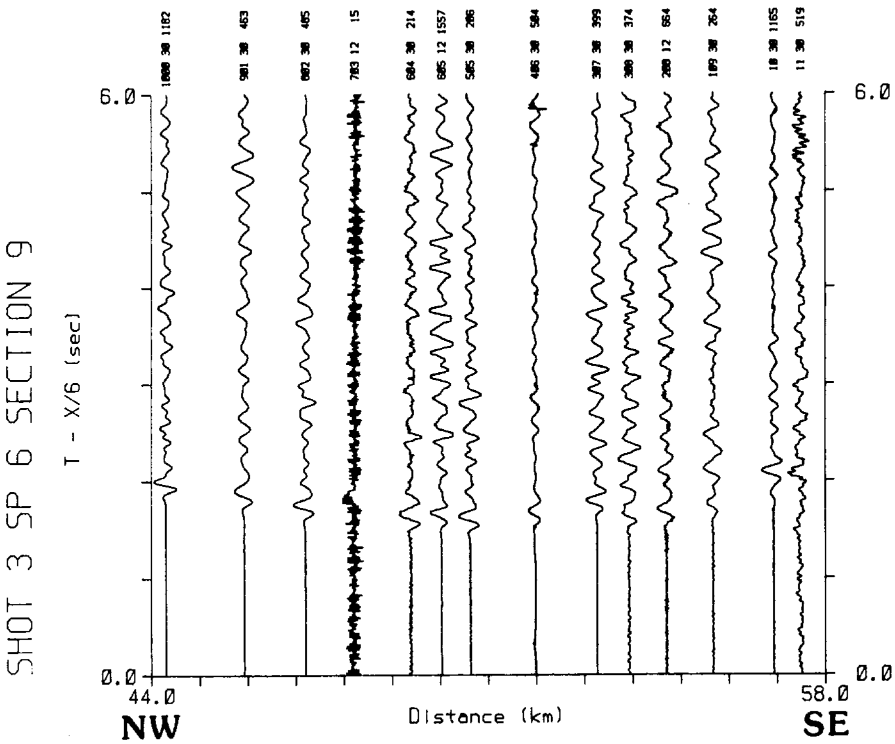
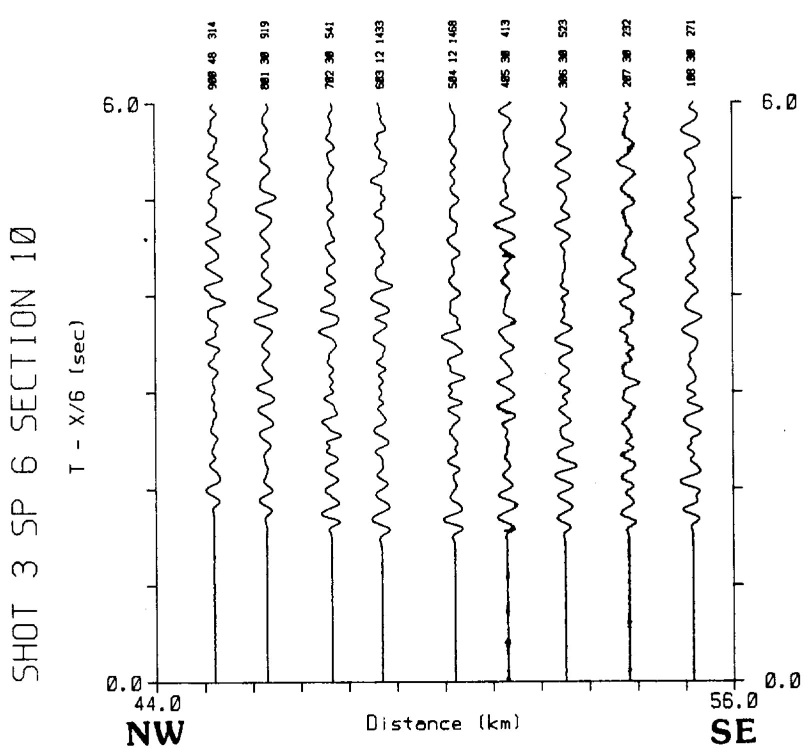


Figure 4c., continued





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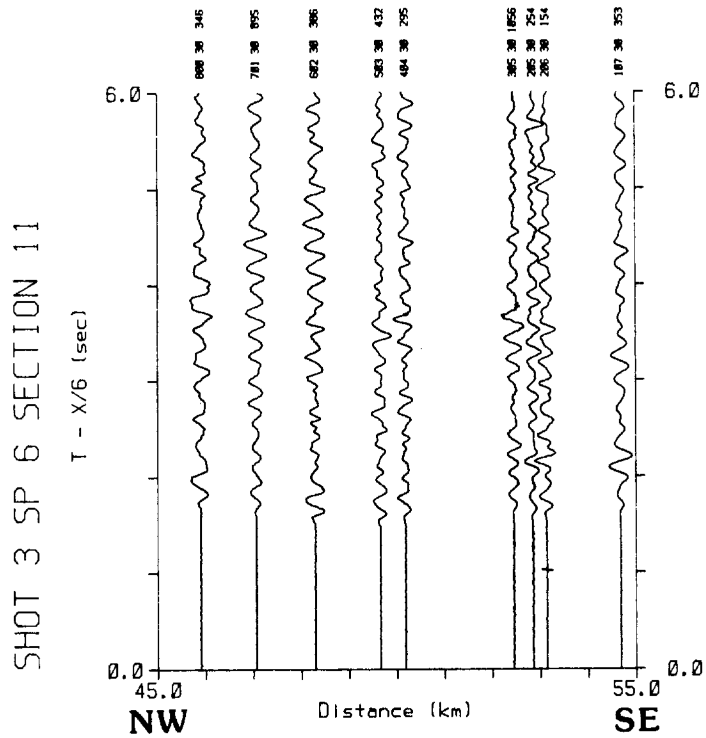


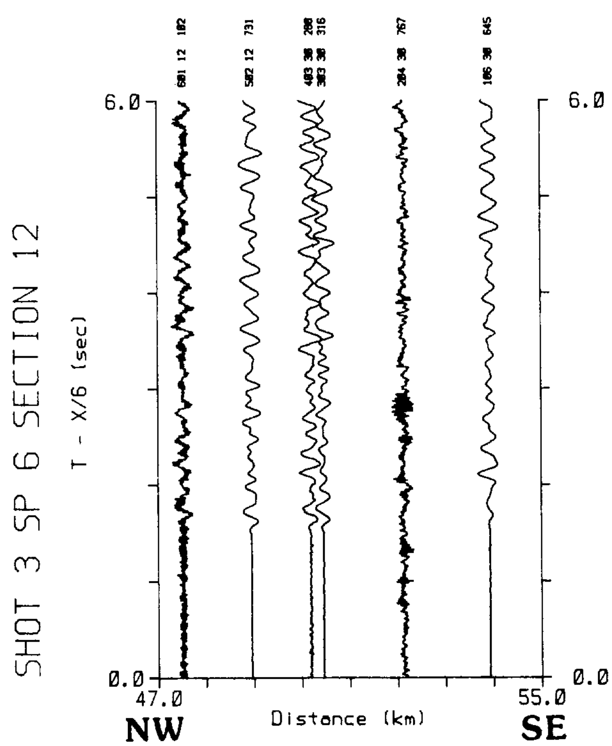
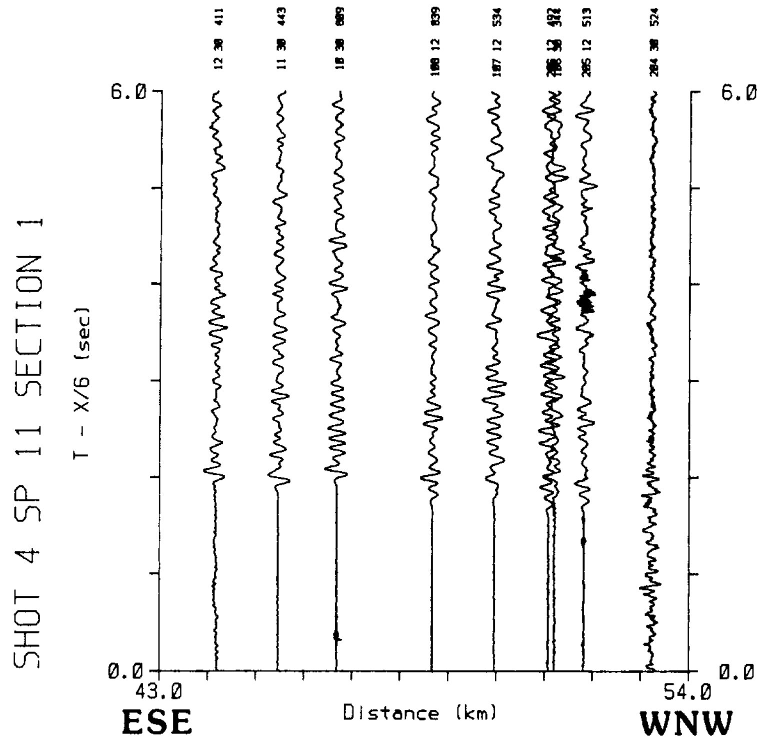


Figure 4d.



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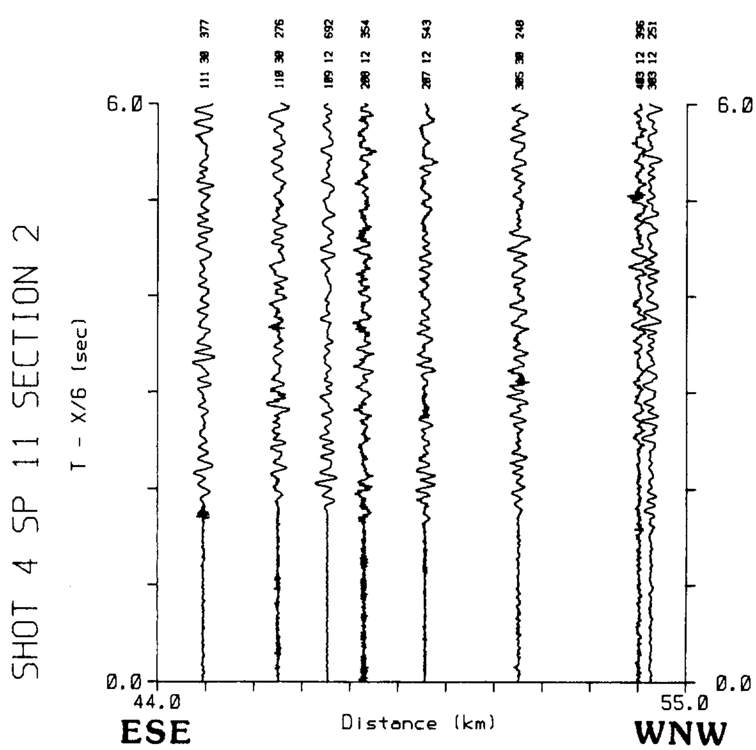
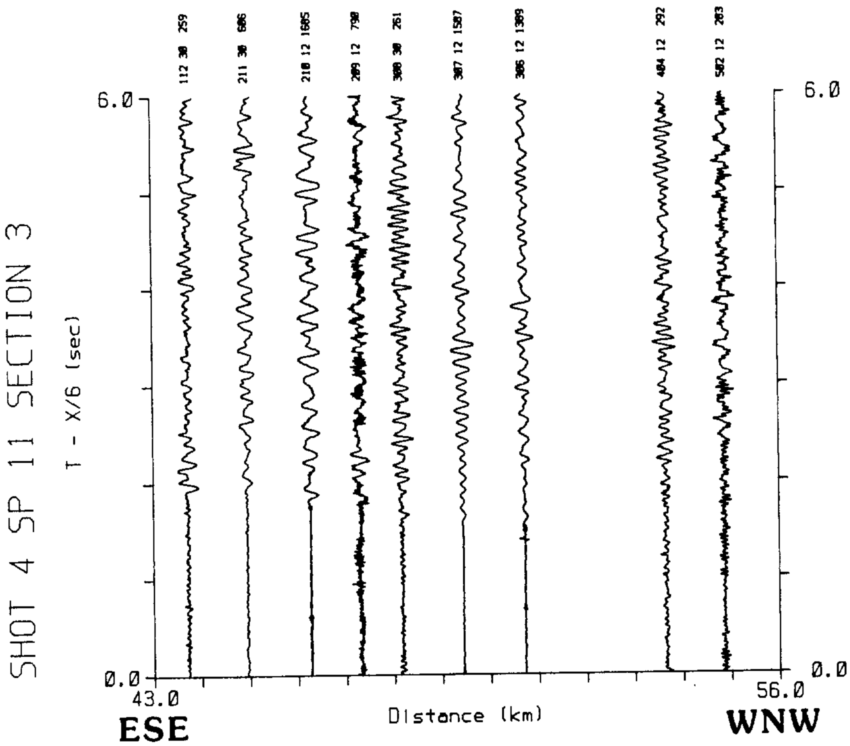


Figure 4d., continued



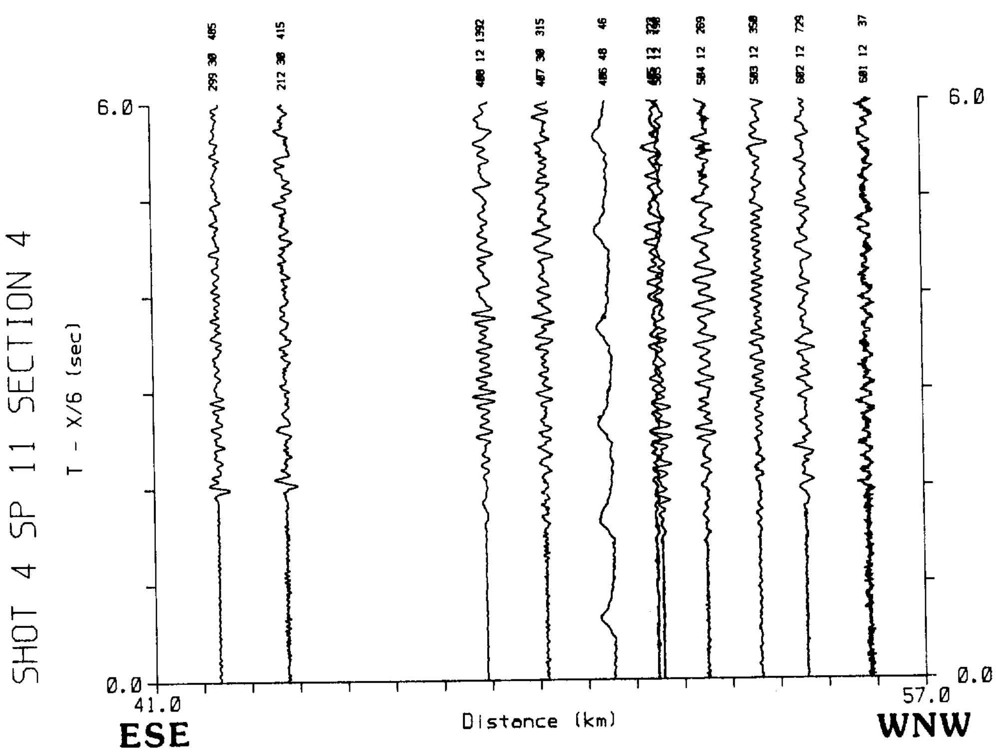


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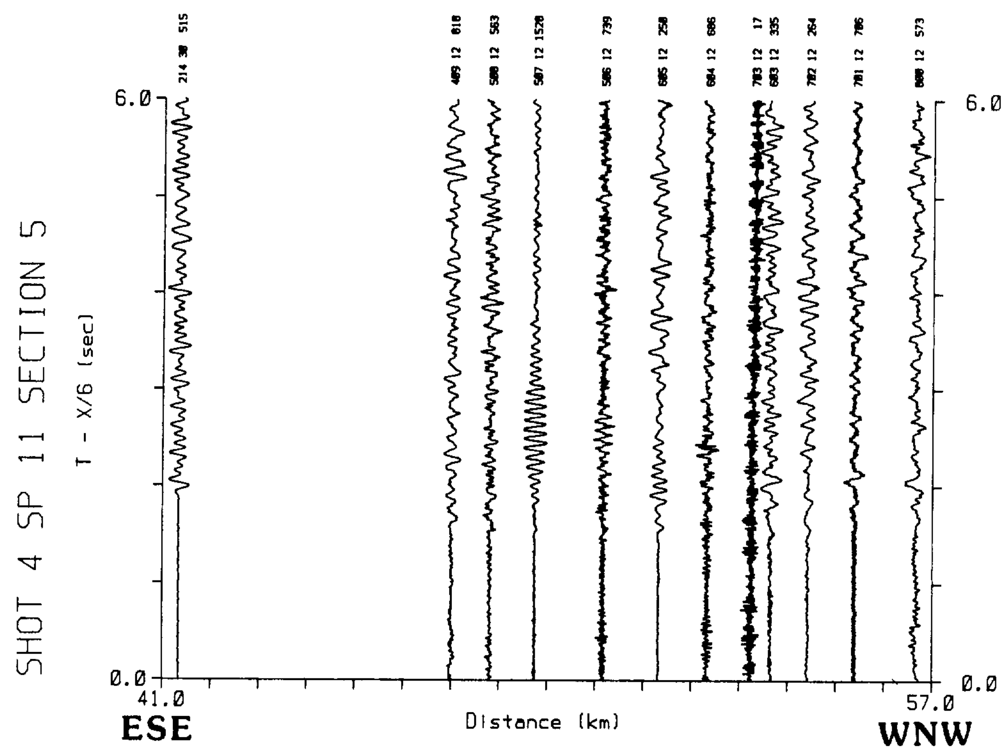
Figure 4d., continued



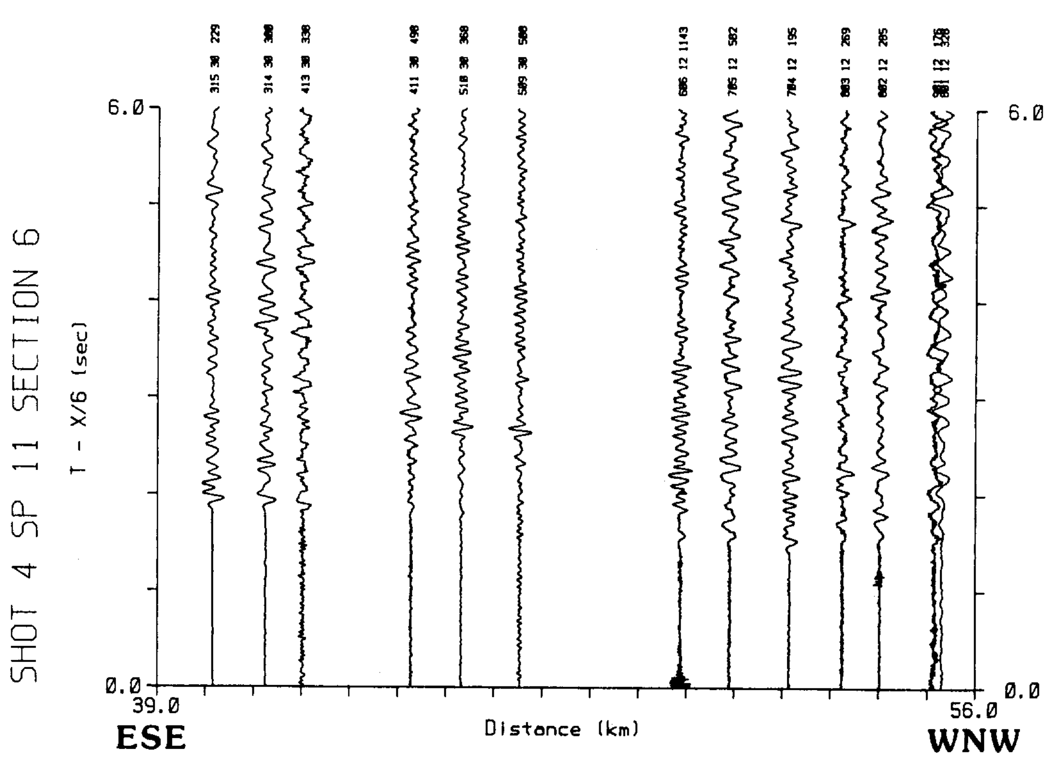


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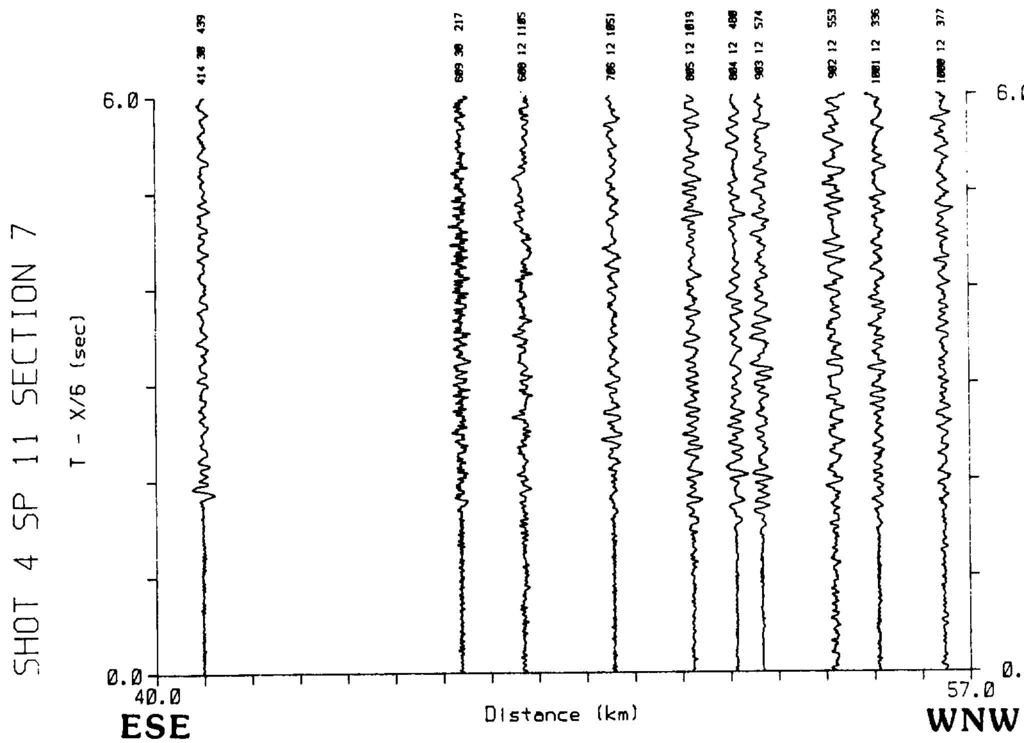
Figure 4d., continued



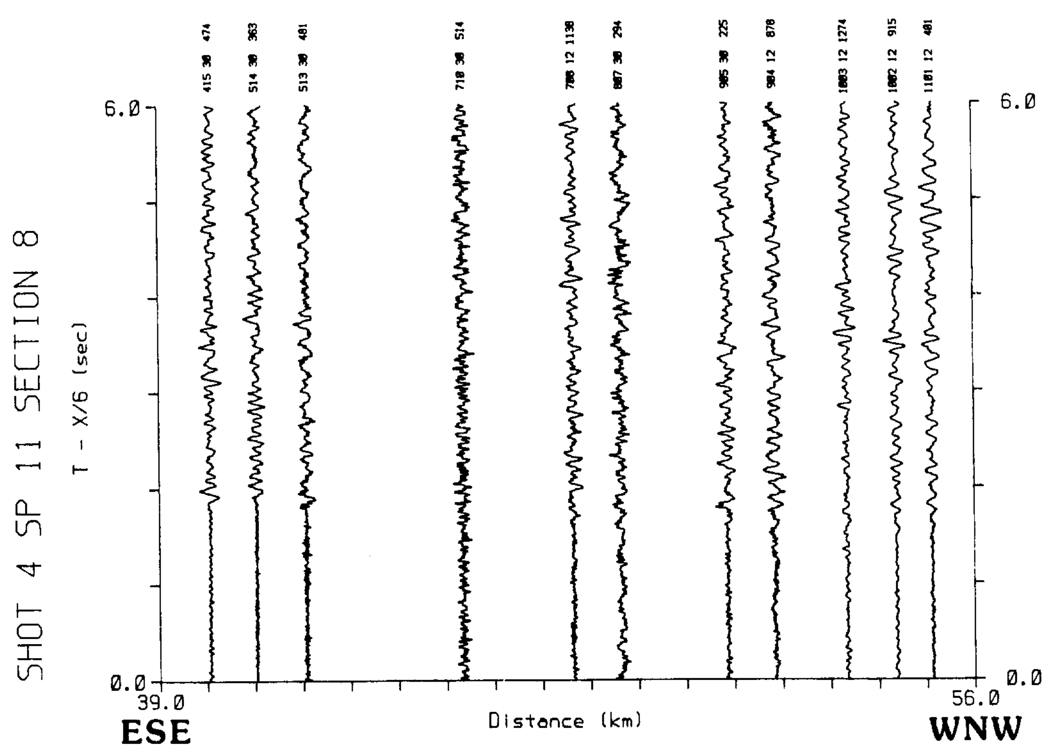
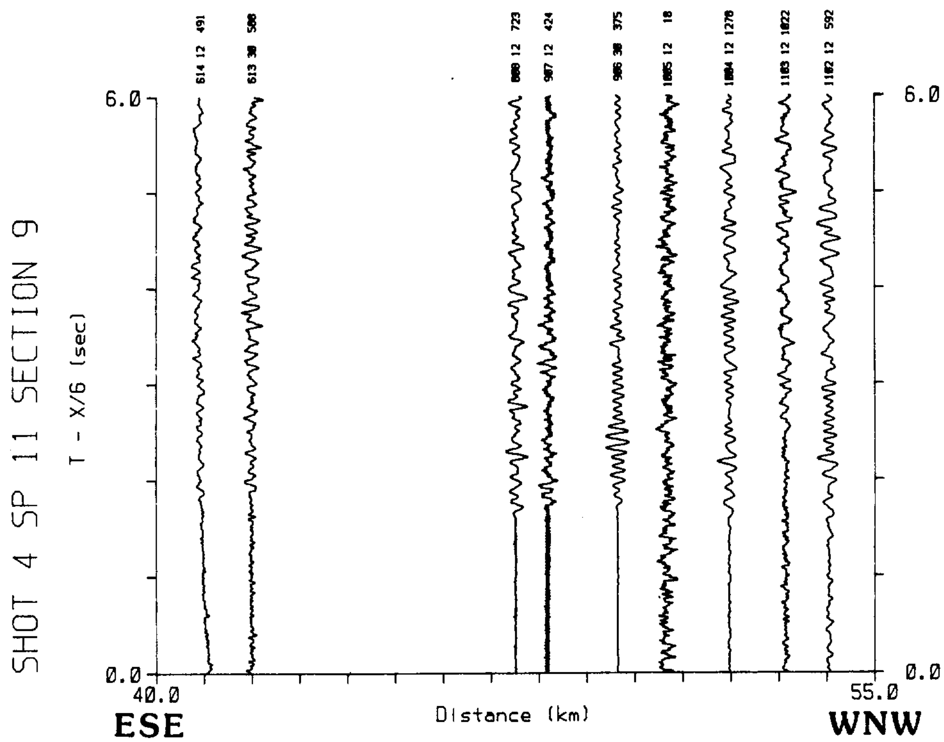


Figure 4d., continued



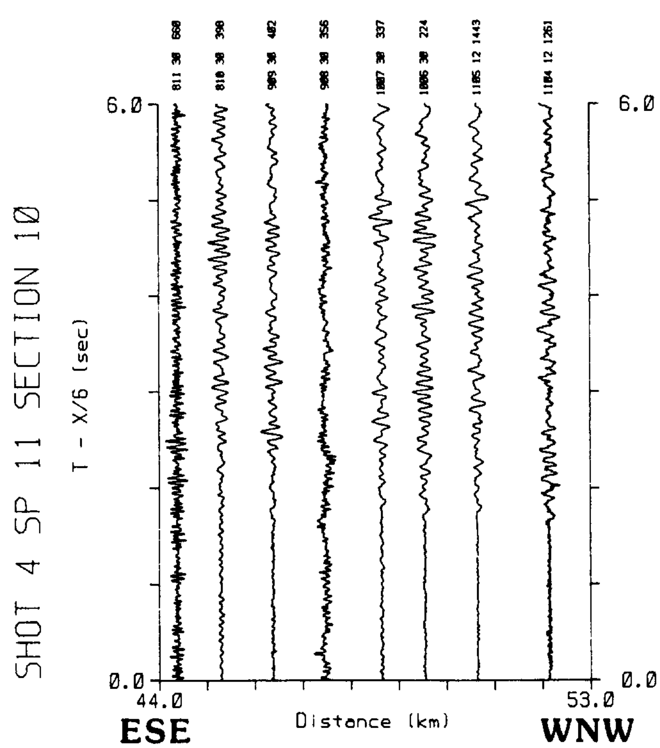
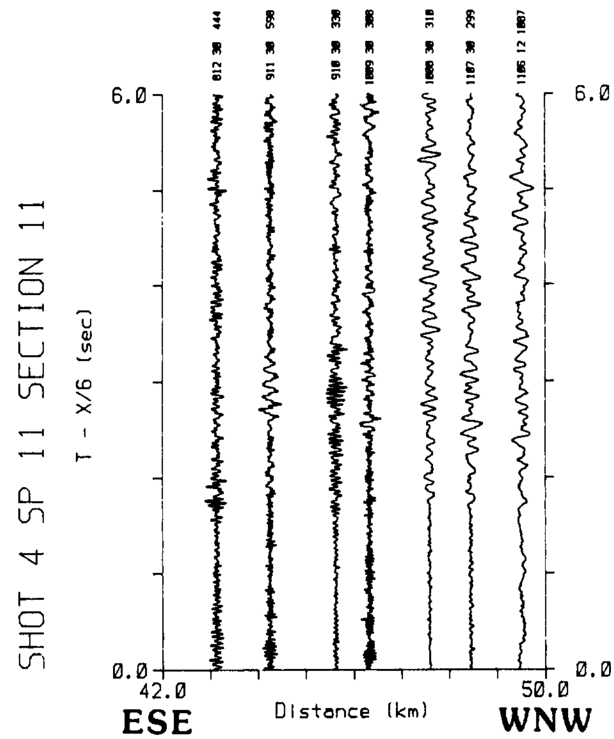


Figure 4d., continued



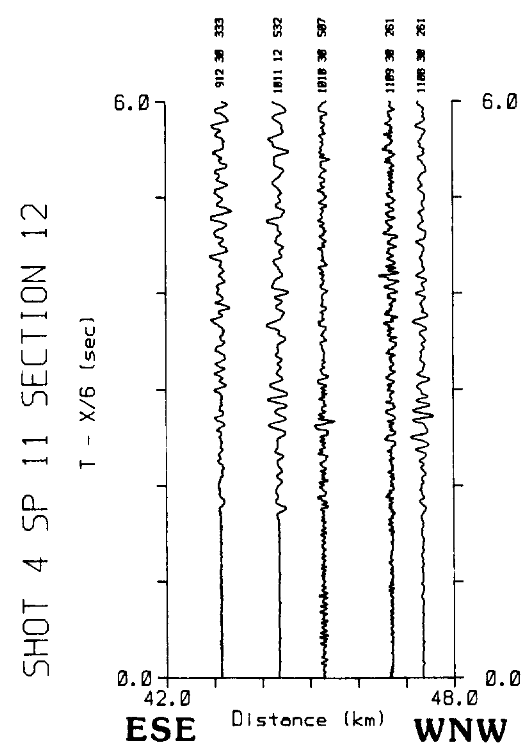
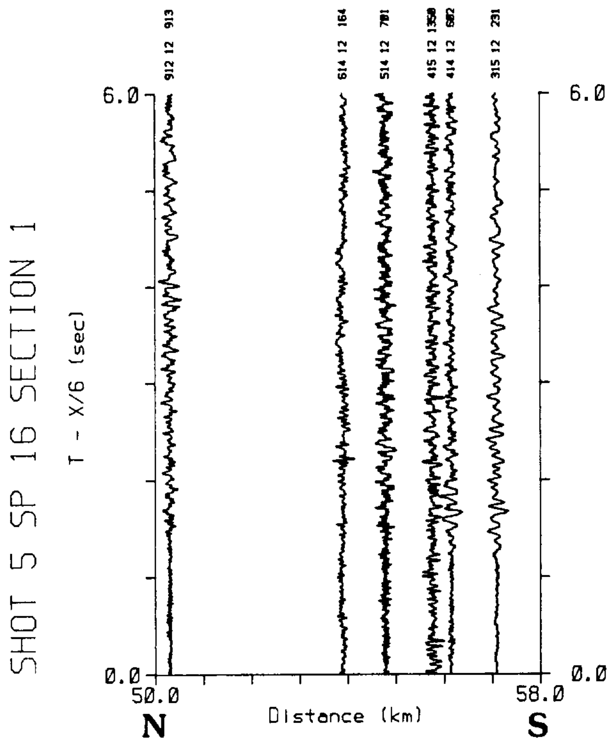


Figure 4e.


SHOT 5 SP 16 SECTION 1
T - X/6 (sec)
6.0
0.0
50.0
58.0
Distance (km)
N
S

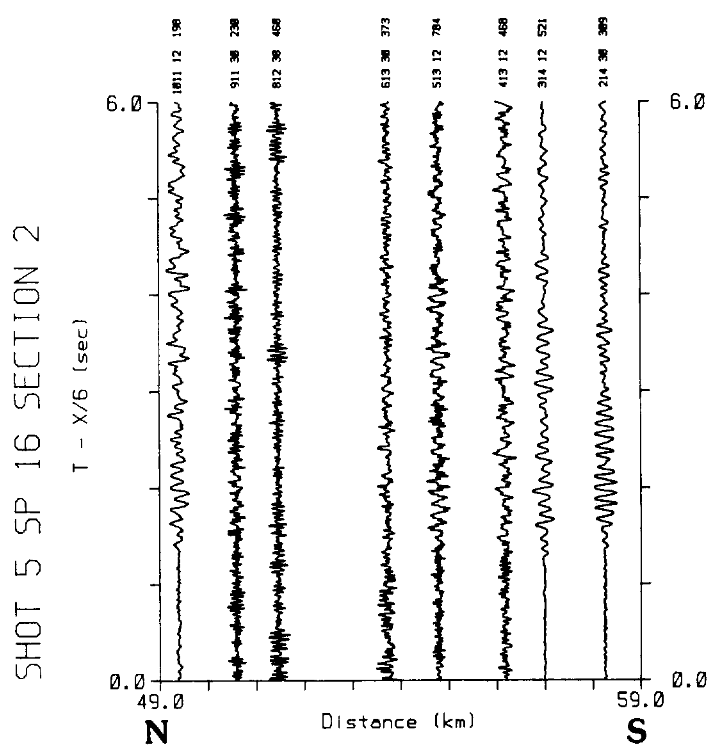
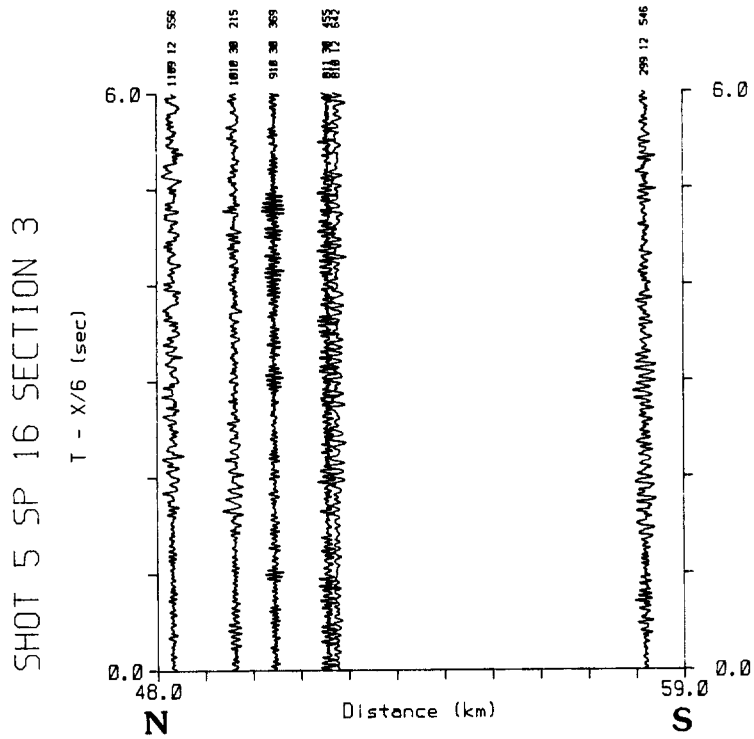

SHOT 5 SP 16 SECTION 2
T - X/6 (sec)
6.0
0.0
49.0
59.0
Distance (km)
N
S

Figure 4e., continued



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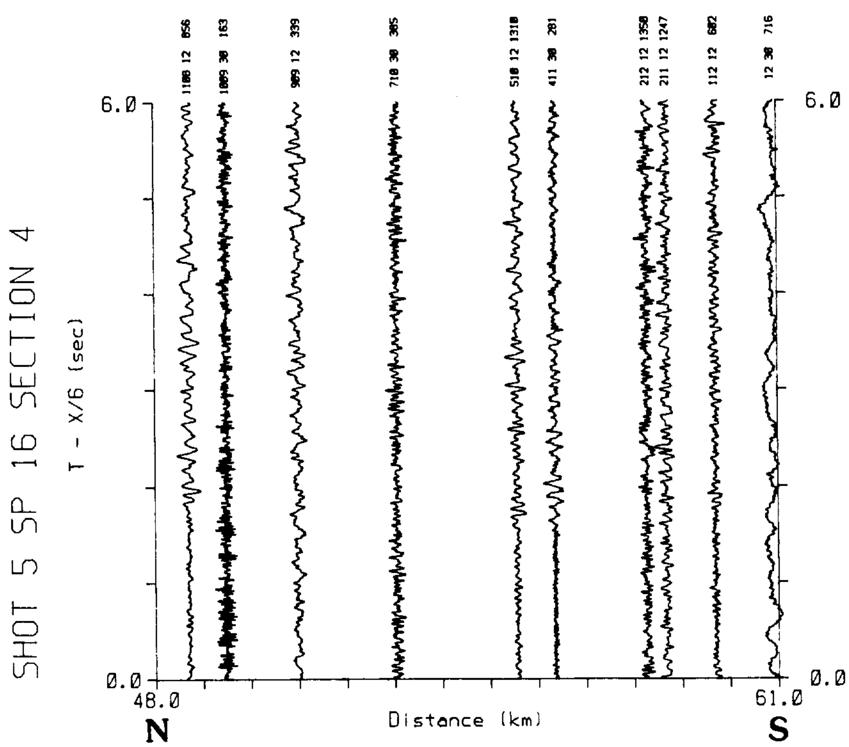

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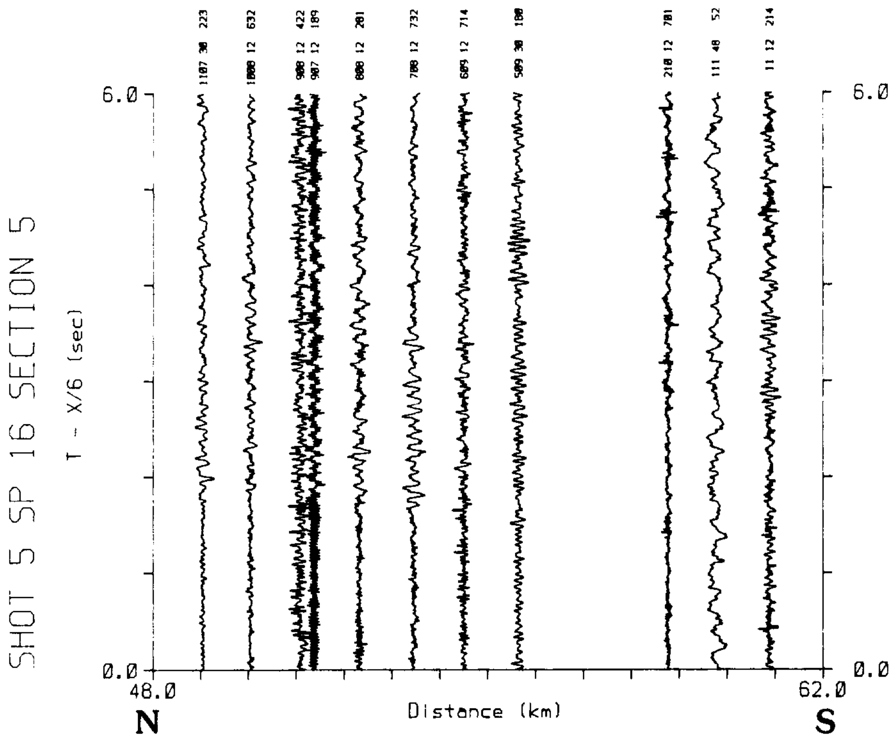

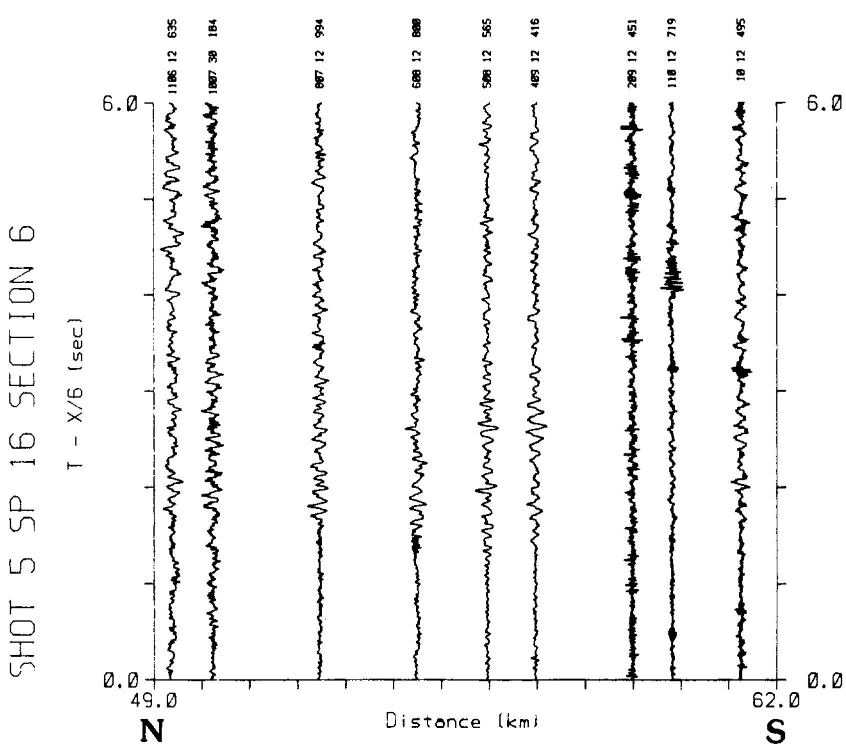

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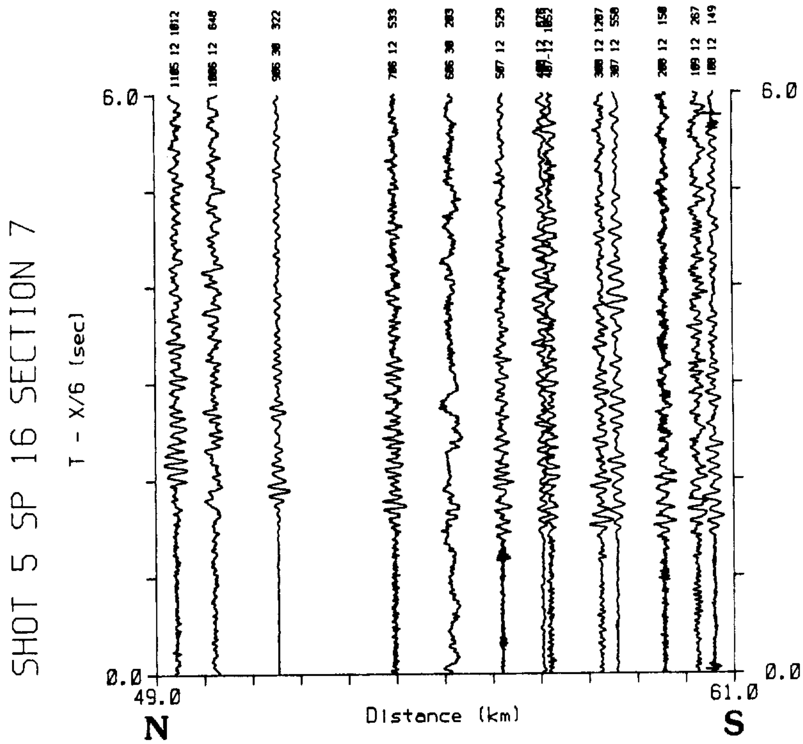

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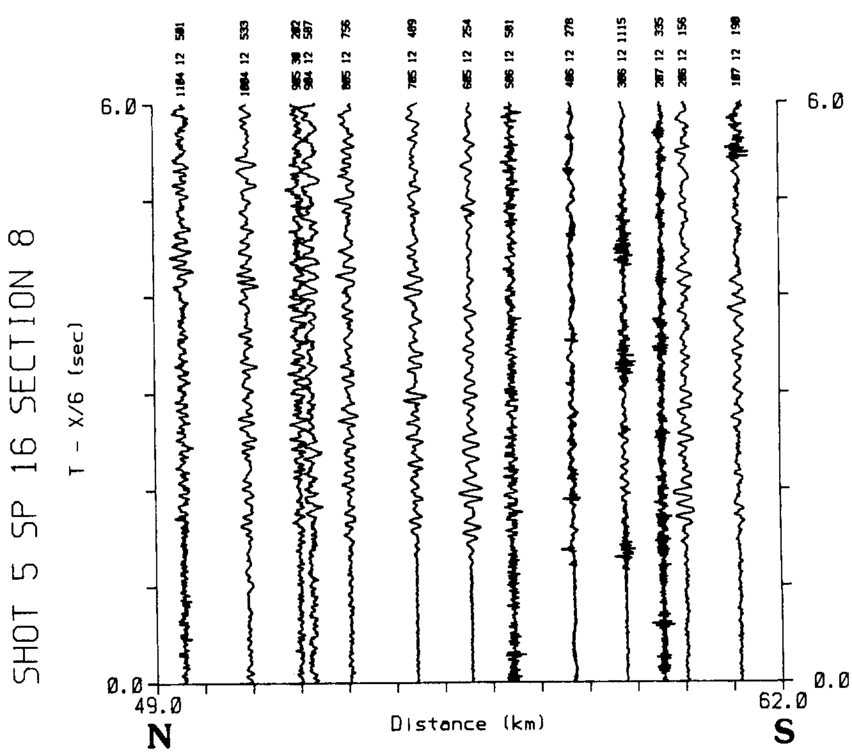

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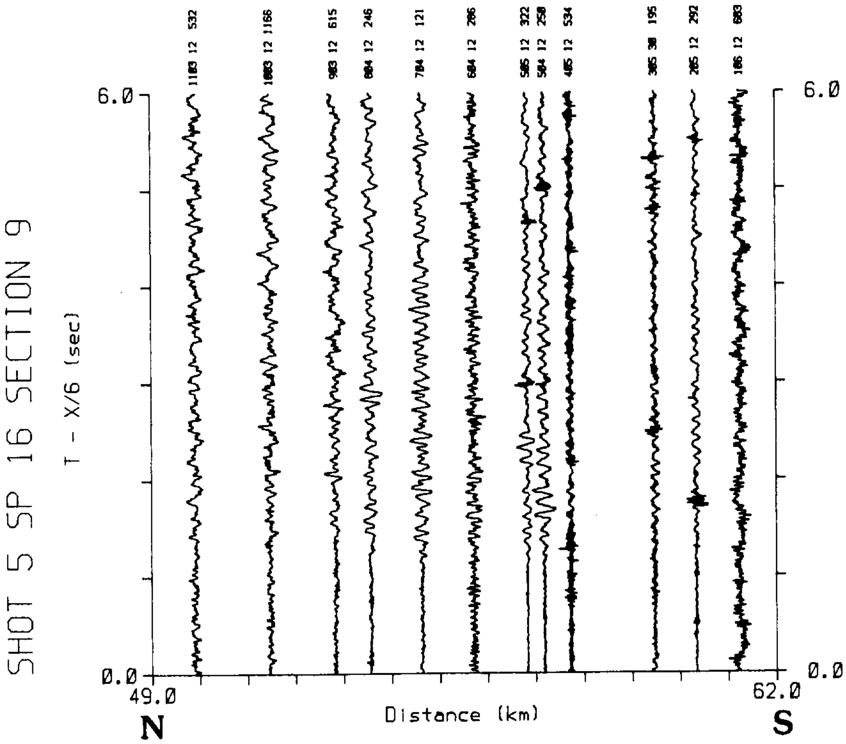

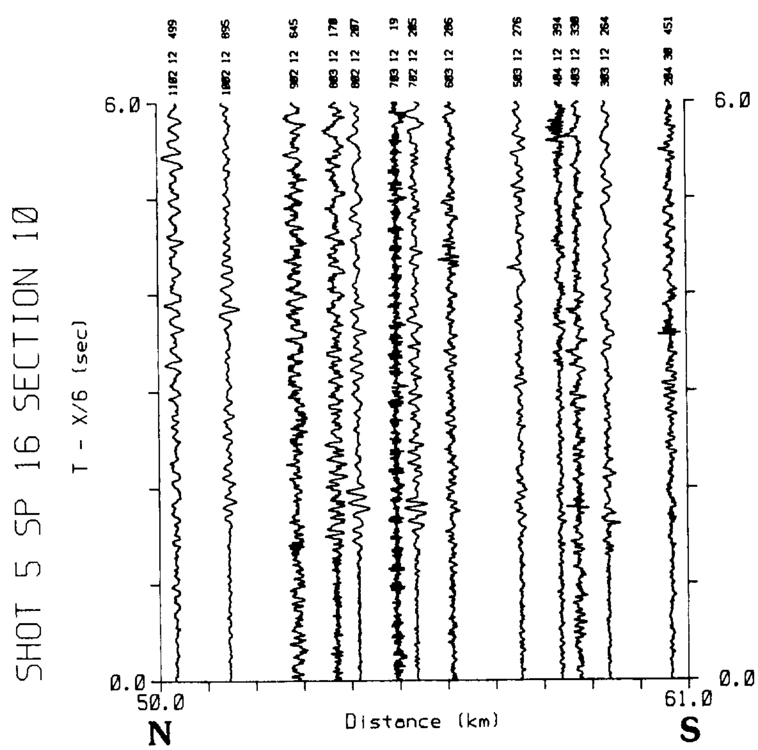

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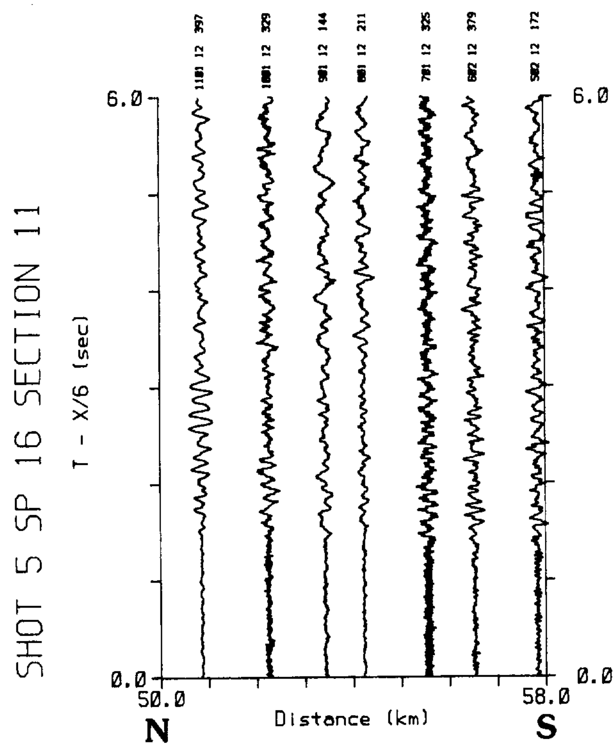


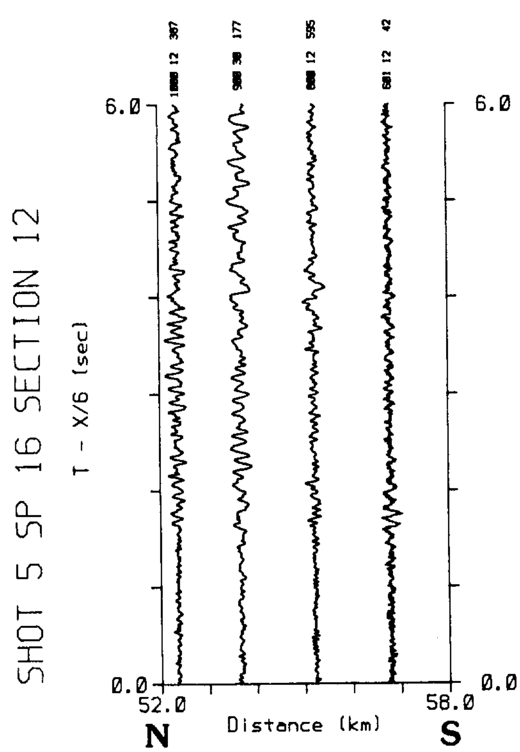
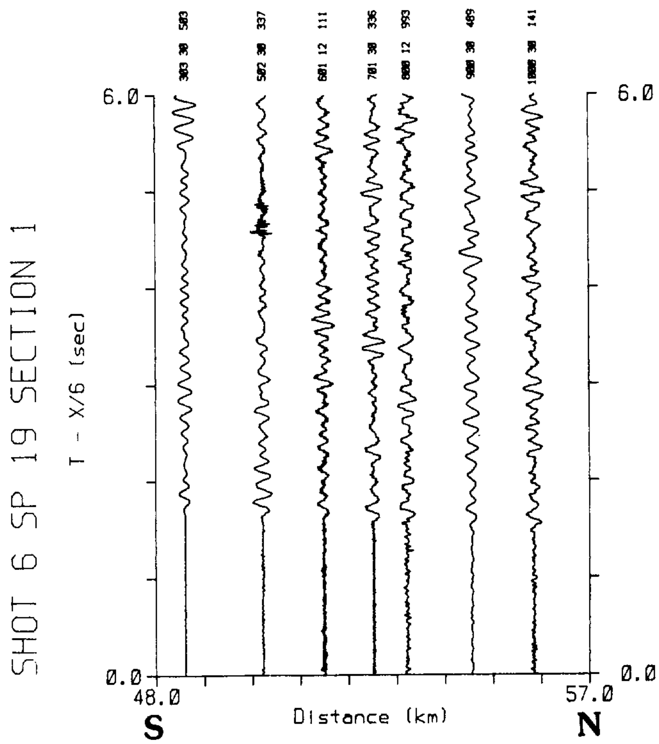


Figure 4f.



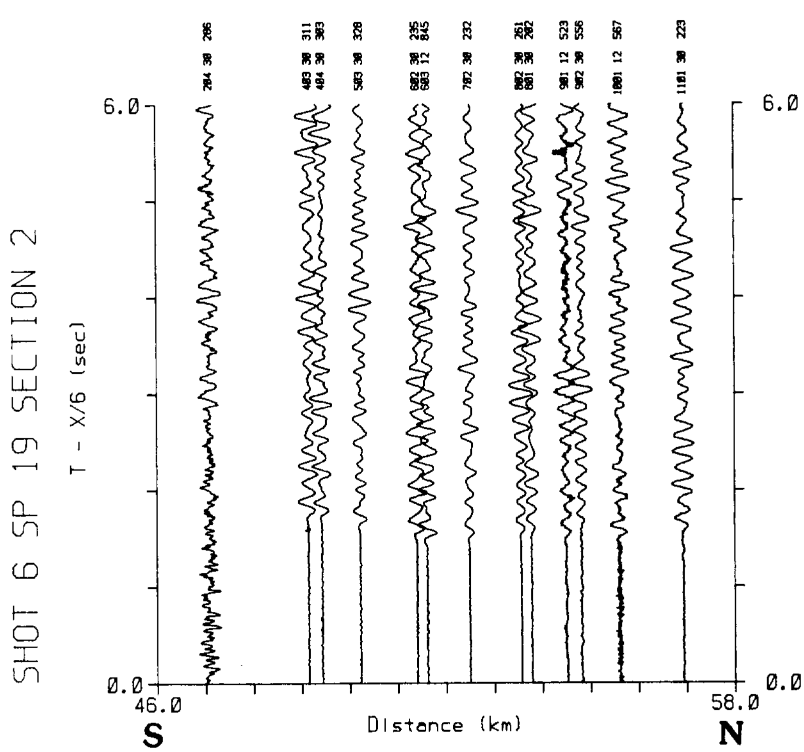


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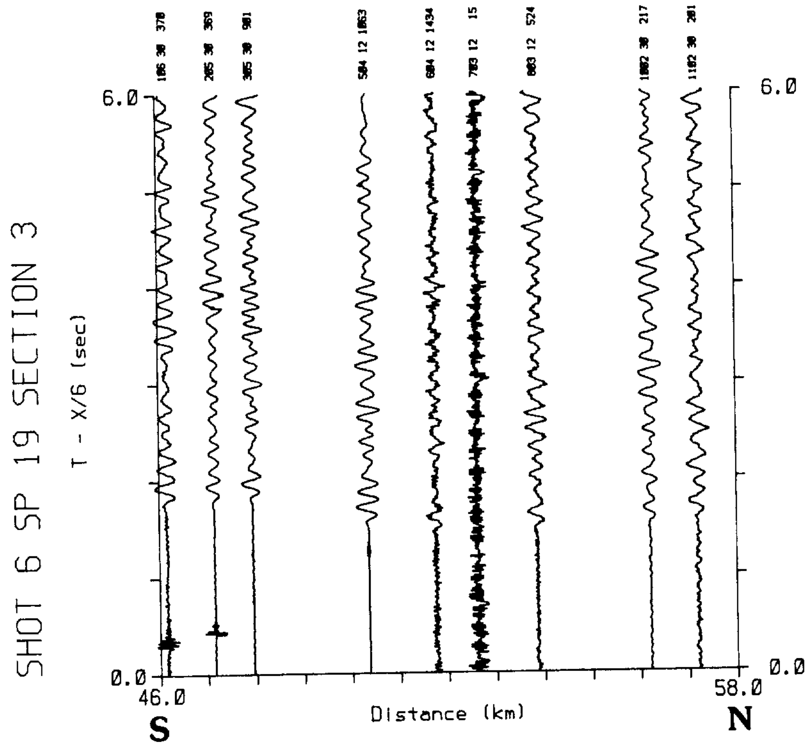
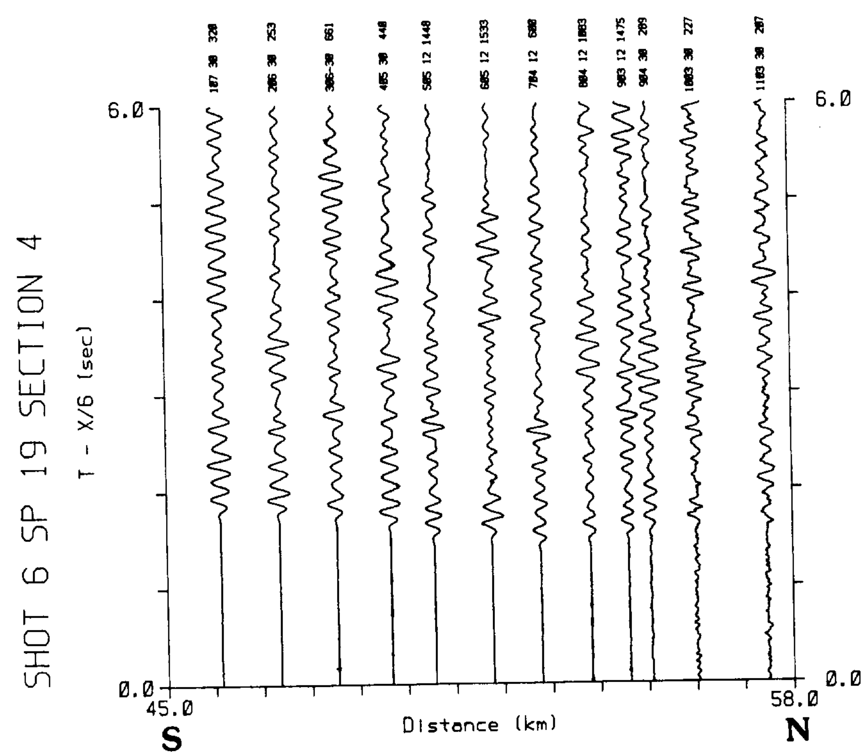
Figure 4f., continued





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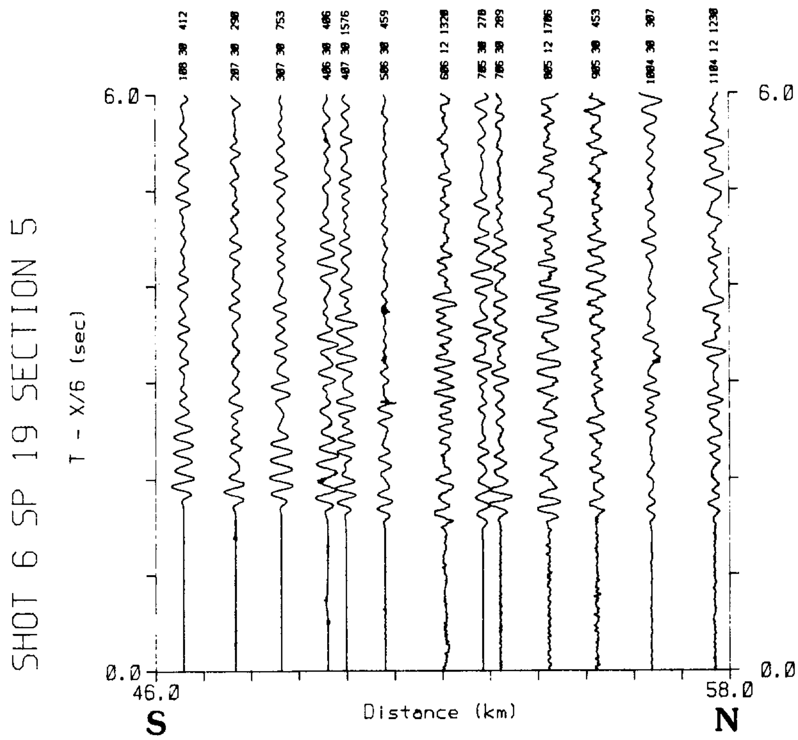

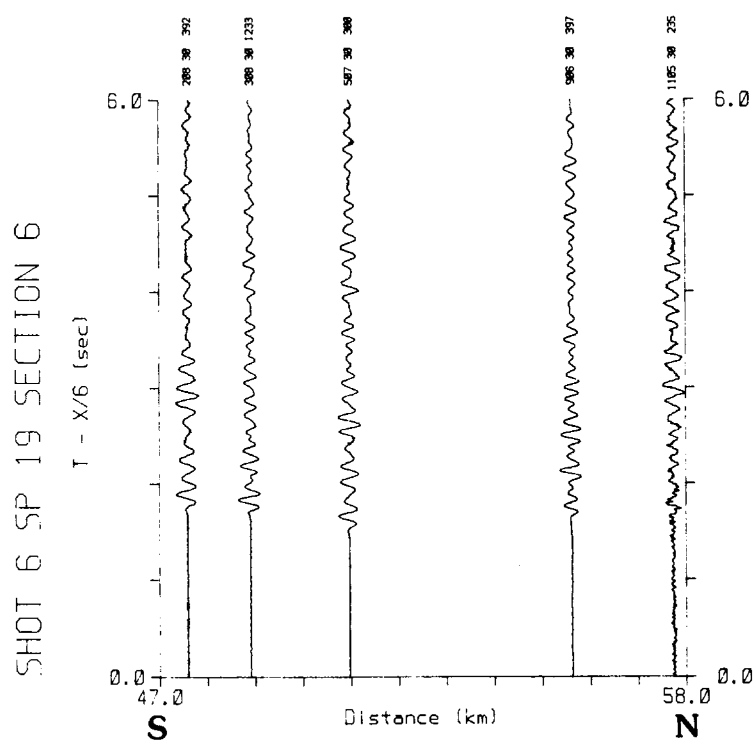

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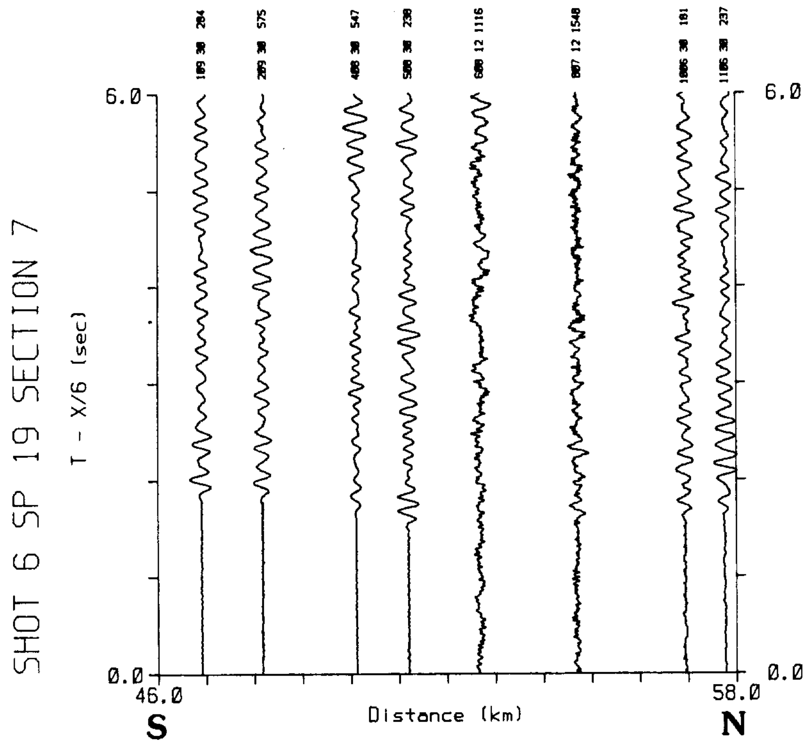

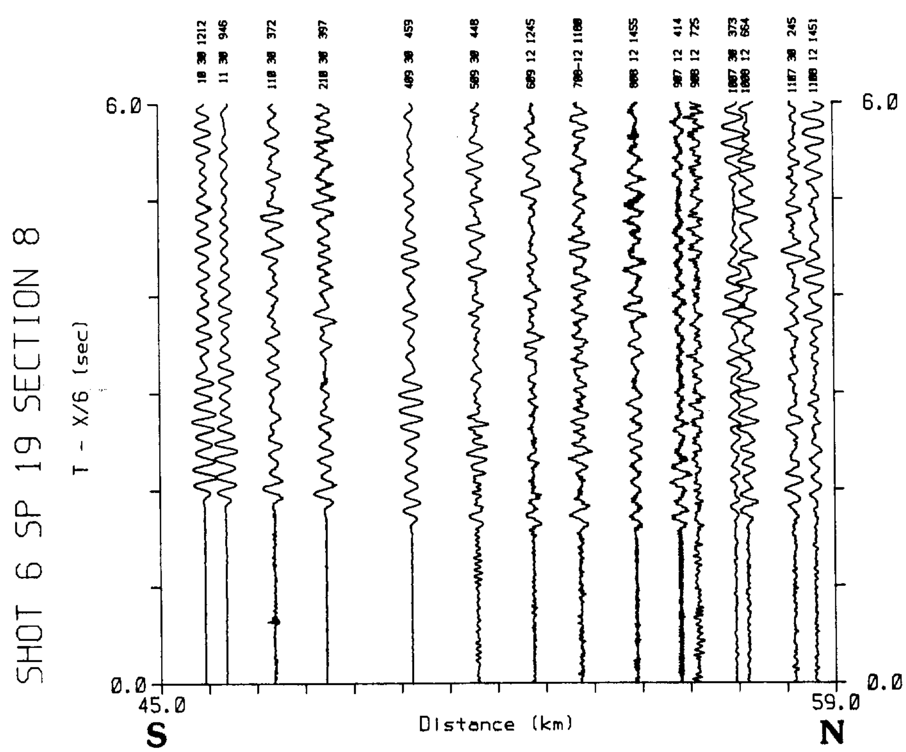

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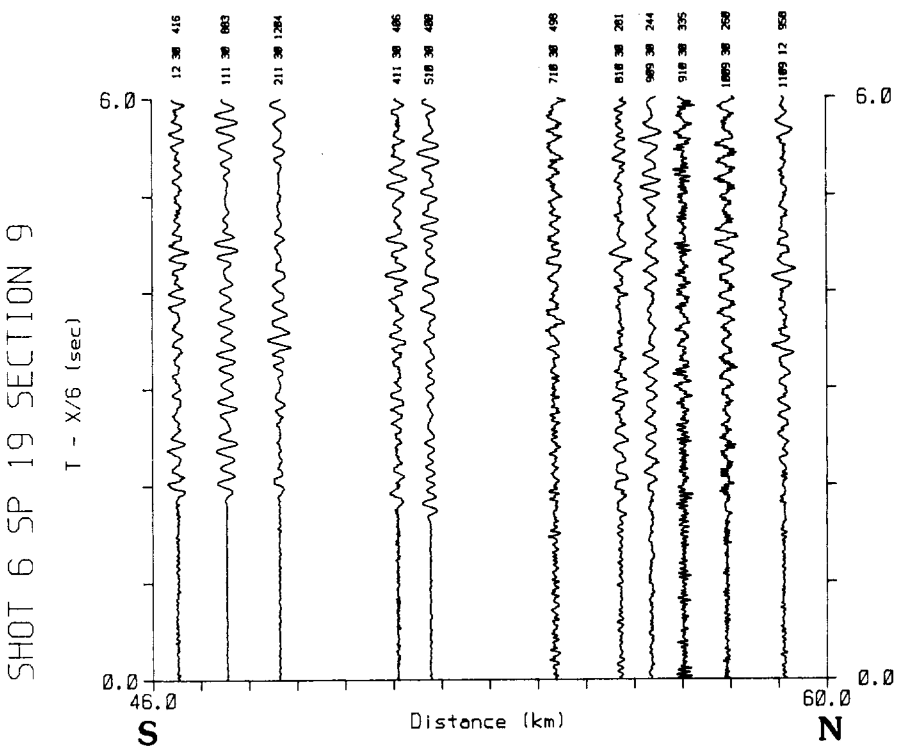

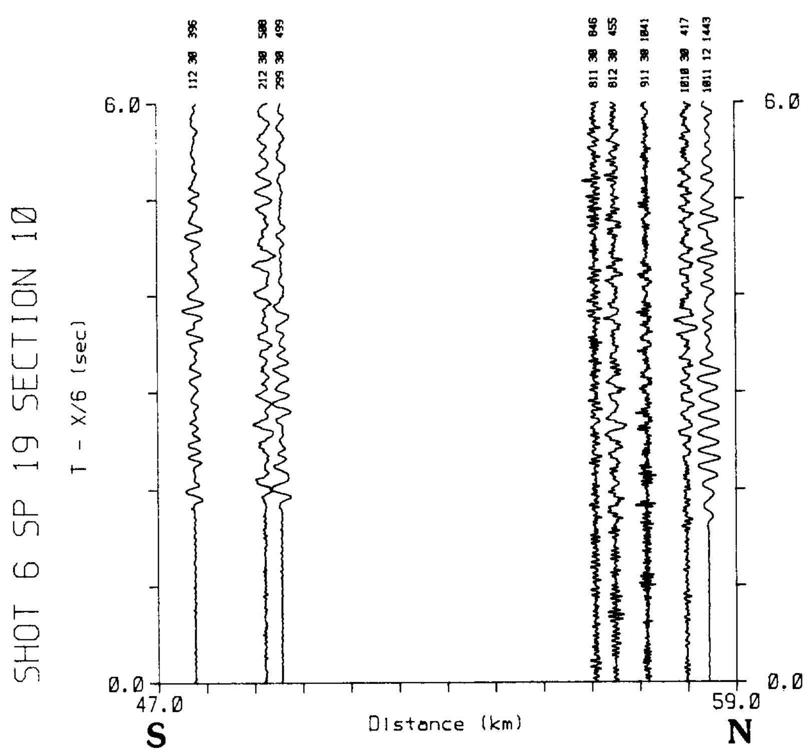

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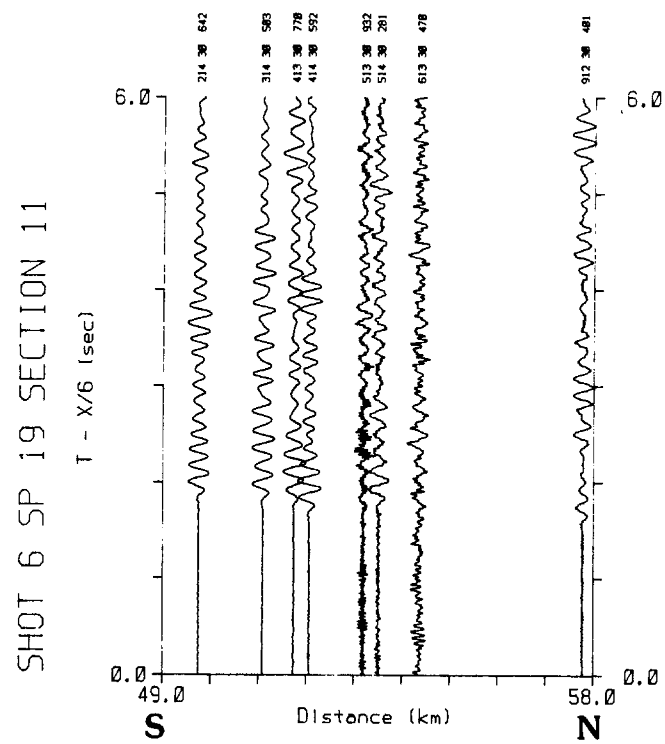


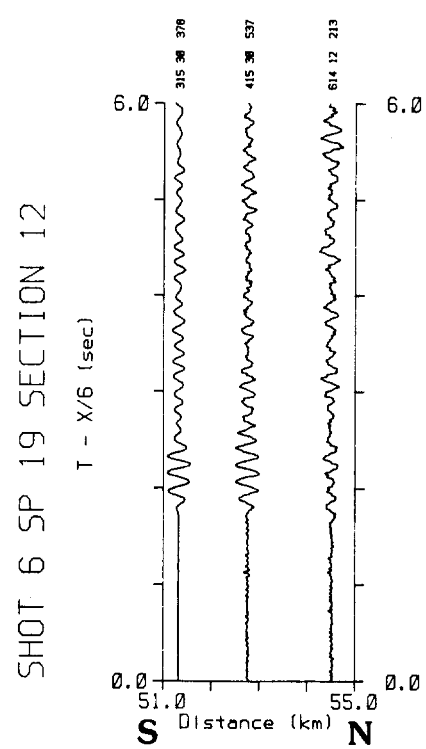
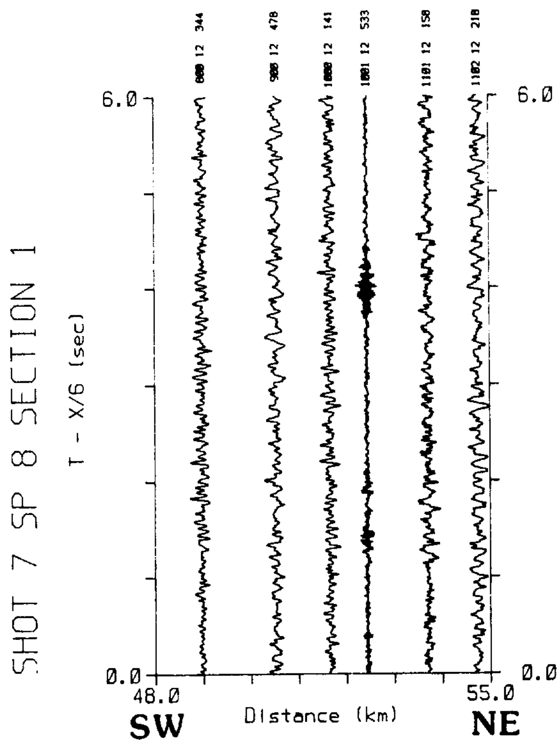
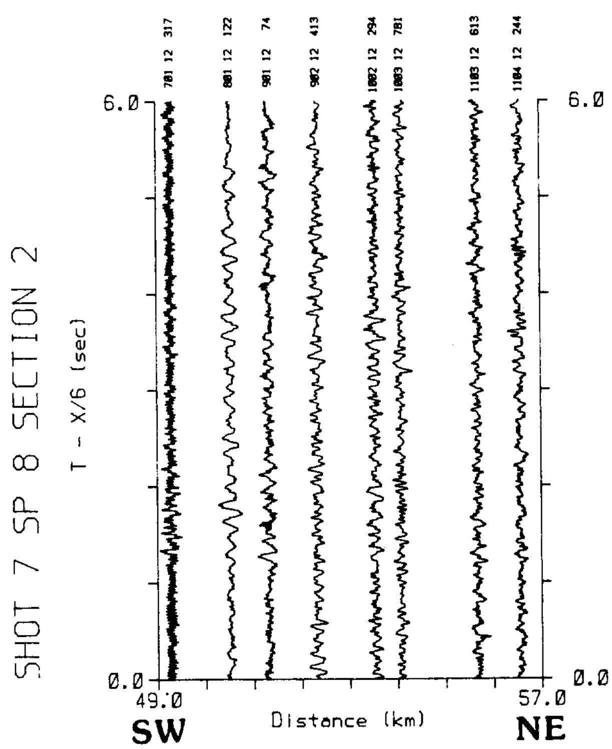


Figure 4g.

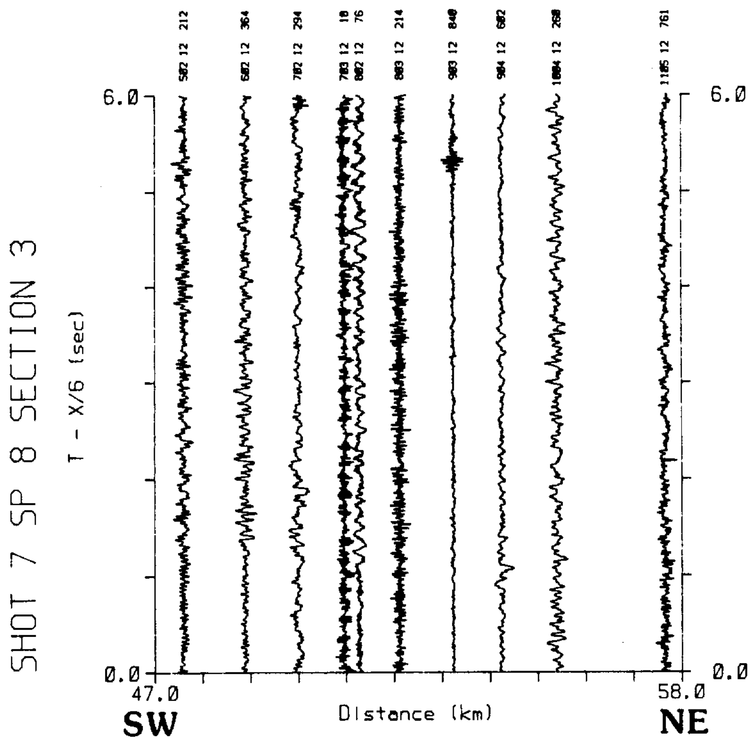


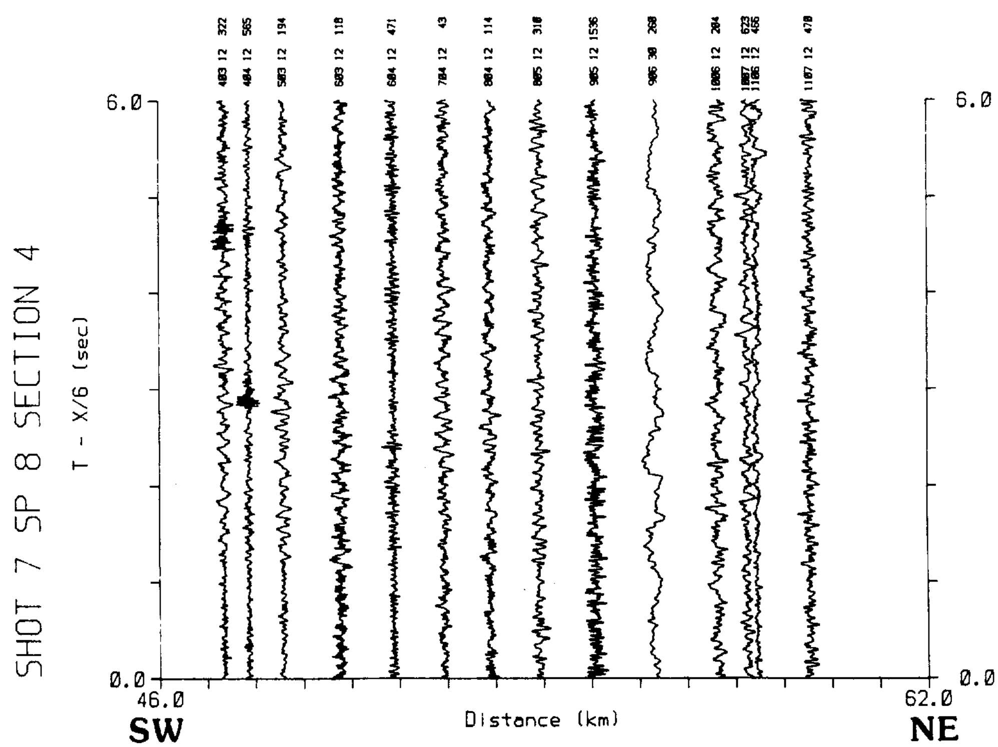
SHOT 7 SP 8 SECTION 1
T - X/6 (sec)
6.Ø
0.Ø
48.Ø
55.Ø
Distance (km)
SW
NE



SHOT 7 SP 8 SECTION 2
T - X/6 (sec)
6.Ø
0.Ø
49.Ø
57.Ø
Distance (km)
SW
NE

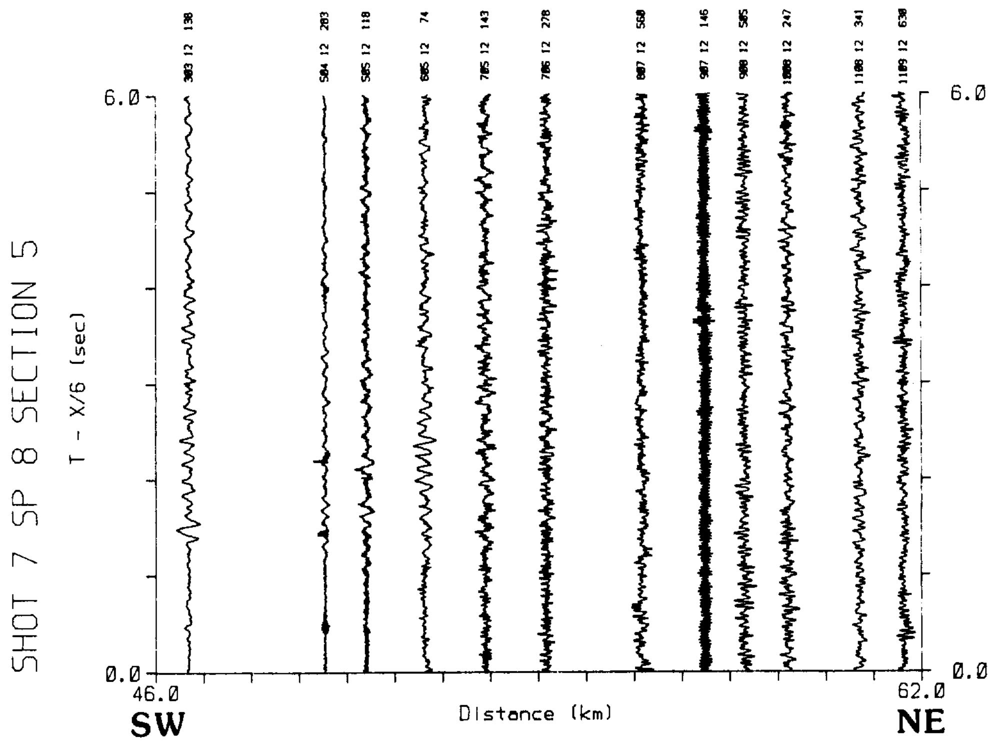
Figure 4g., continued

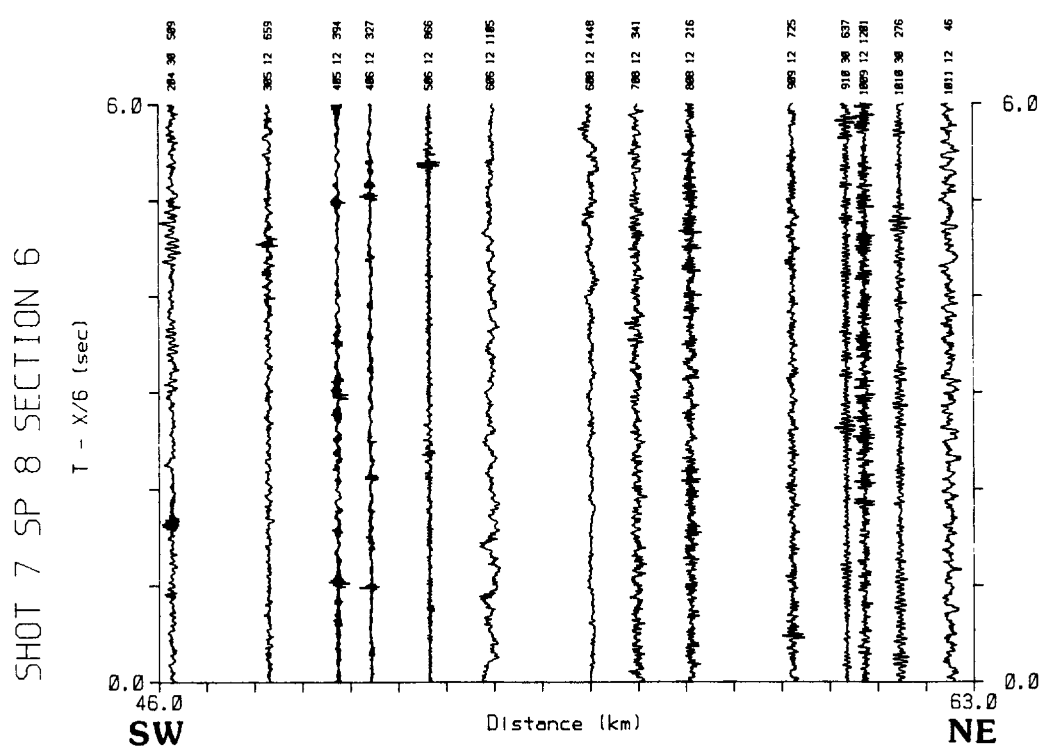




made from best available copy

Figure 4g., continued





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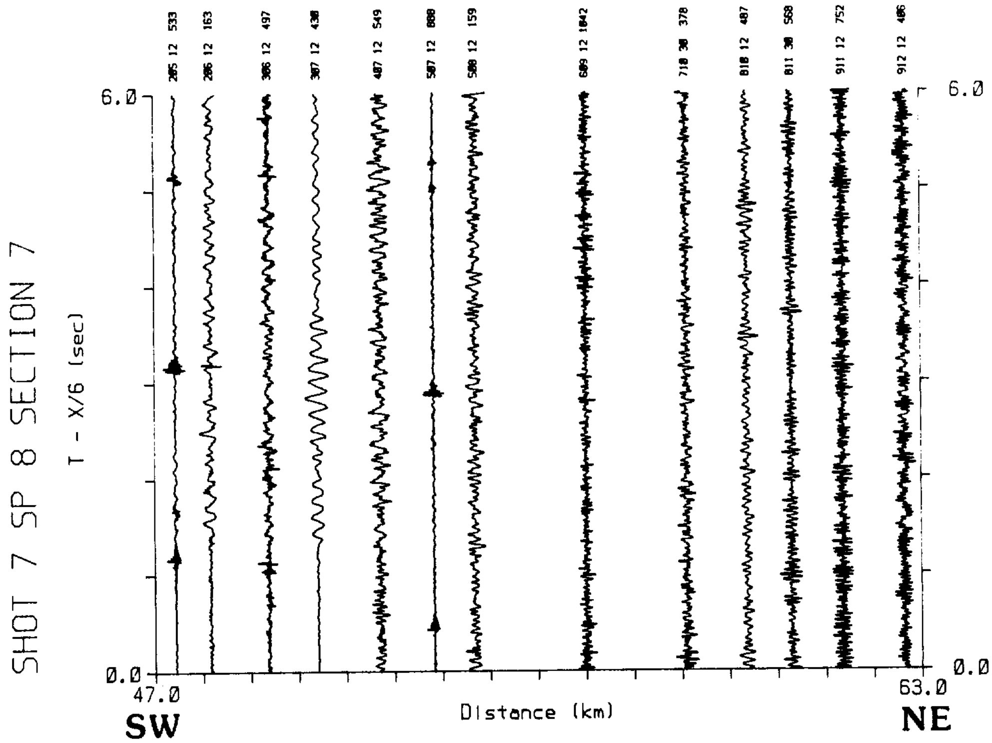

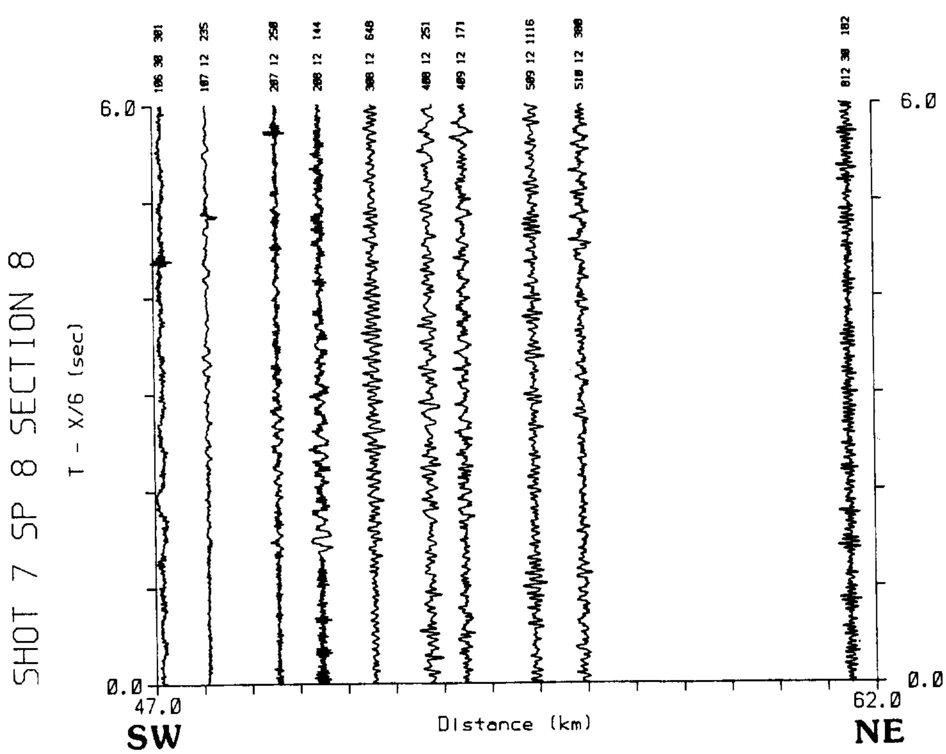

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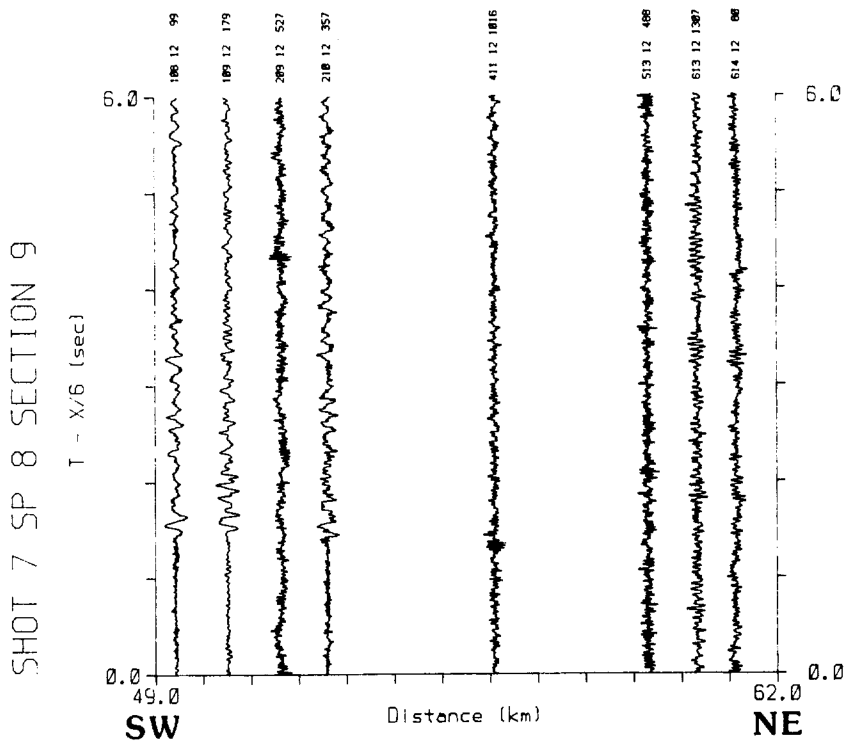


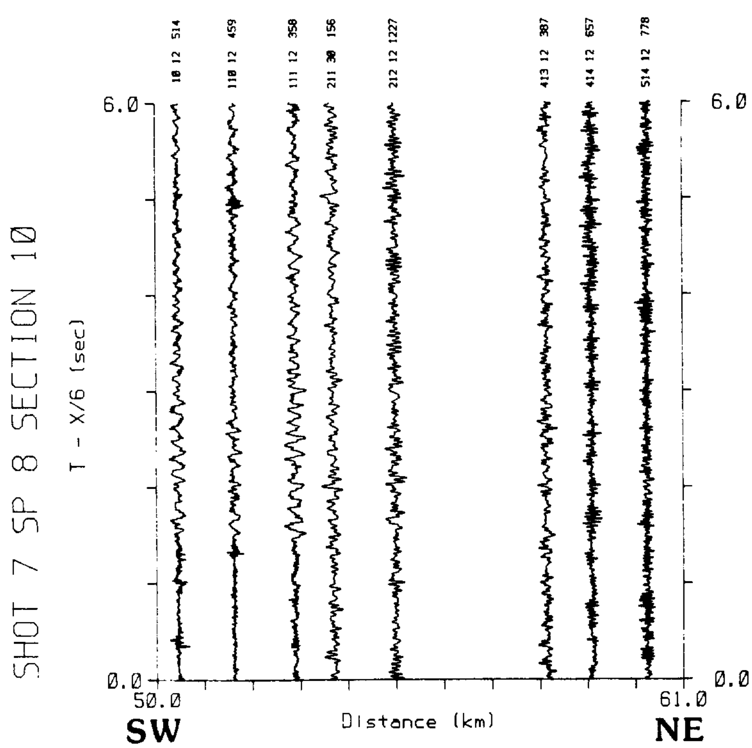
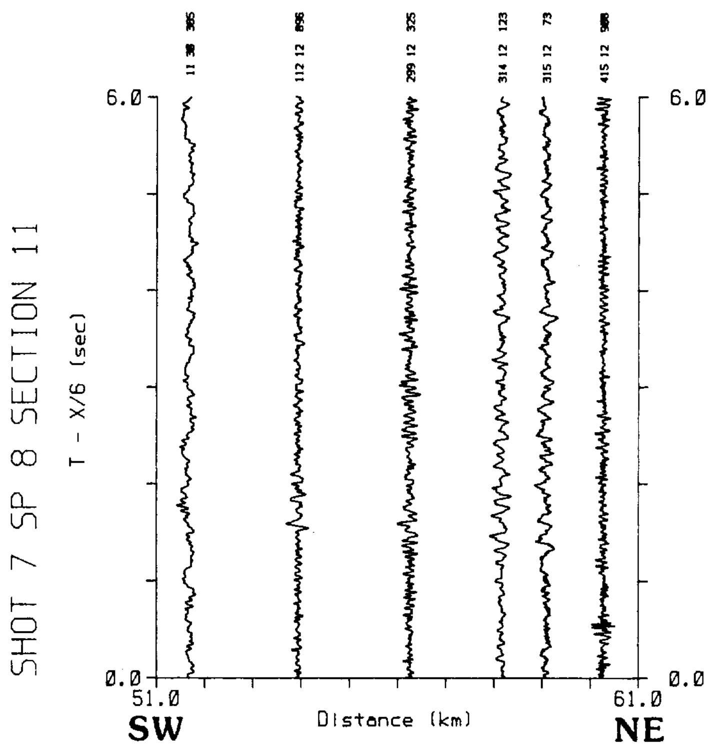


Figure 4g., continued



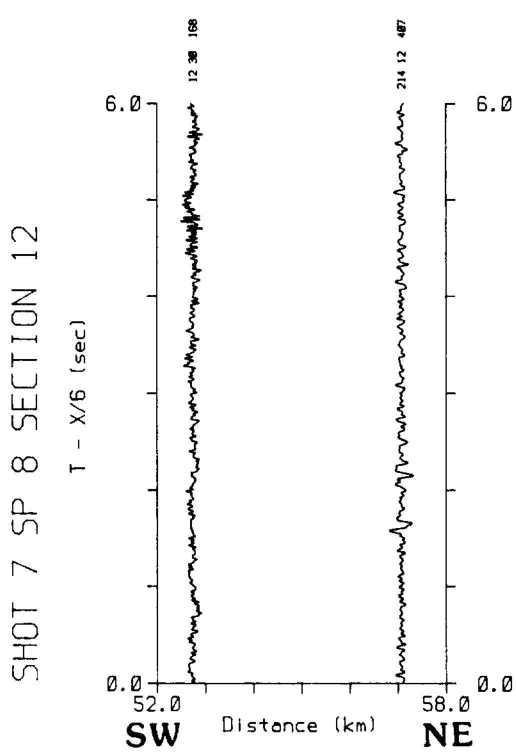
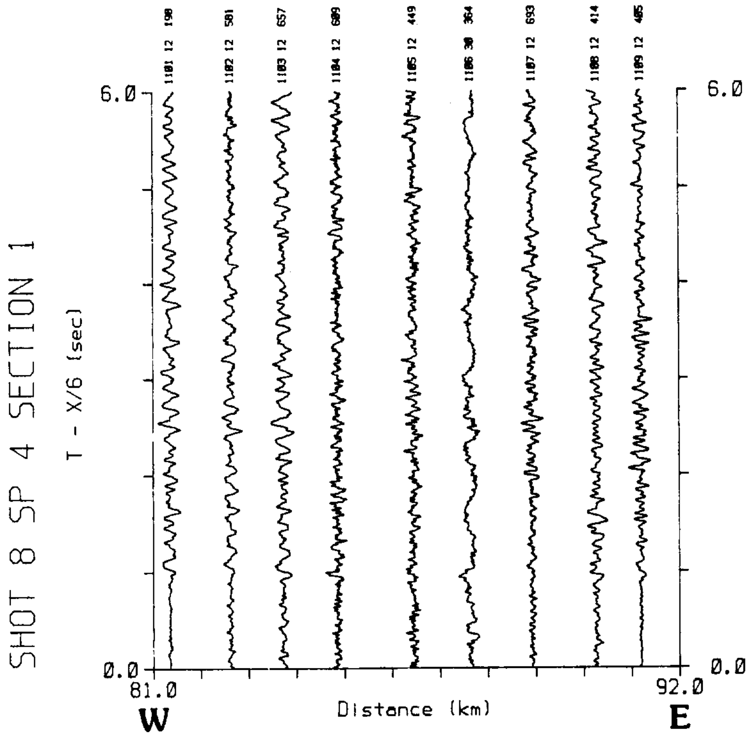


Figure 4h.


SHOT 8 SP 4 SECTION 1
T - X/6 (sec)
6.0
0.0
81.0
92.0
Distance (km)
W
E

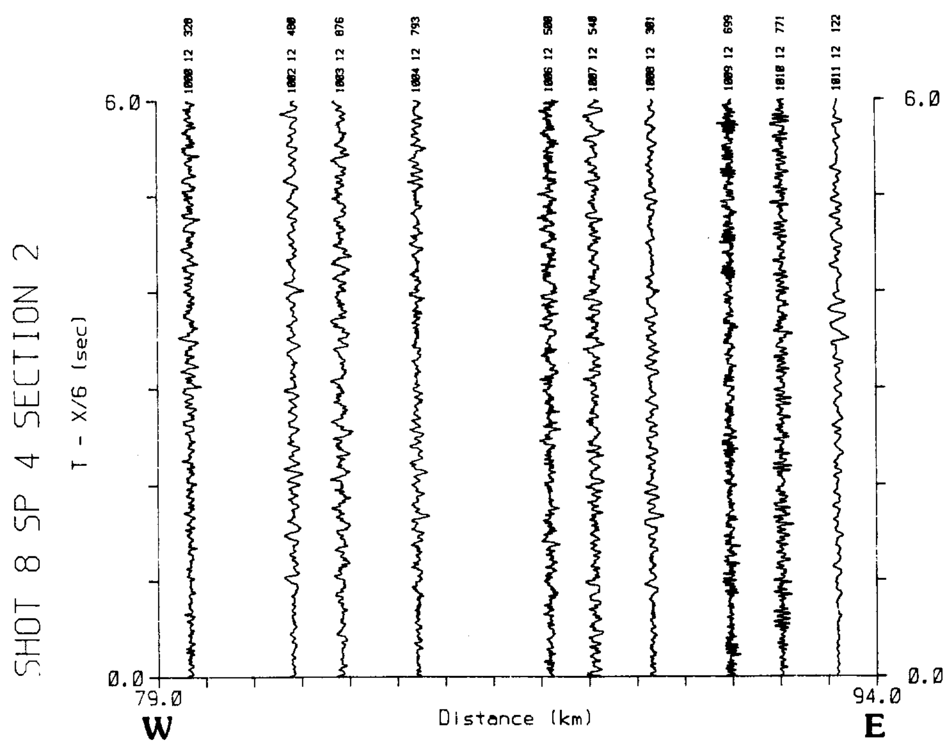
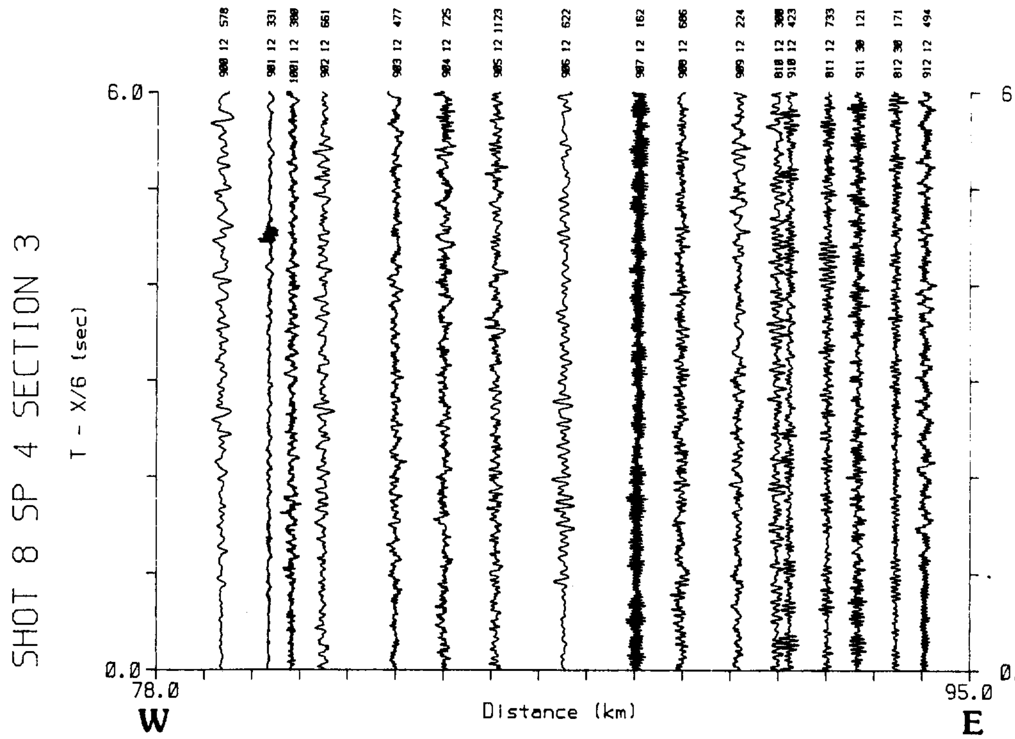

SHOT 8 SP 4 SECTION 2
T - X/6 (sec)
6.0
0.0
79.0
94.0
Distance (km)
W
E

Figure 4h., continued



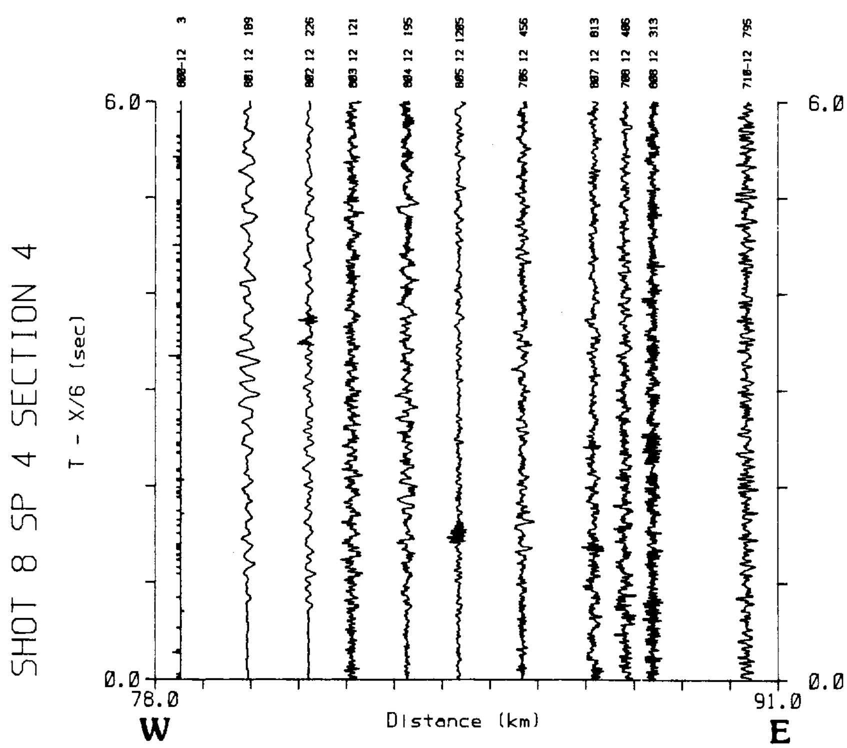
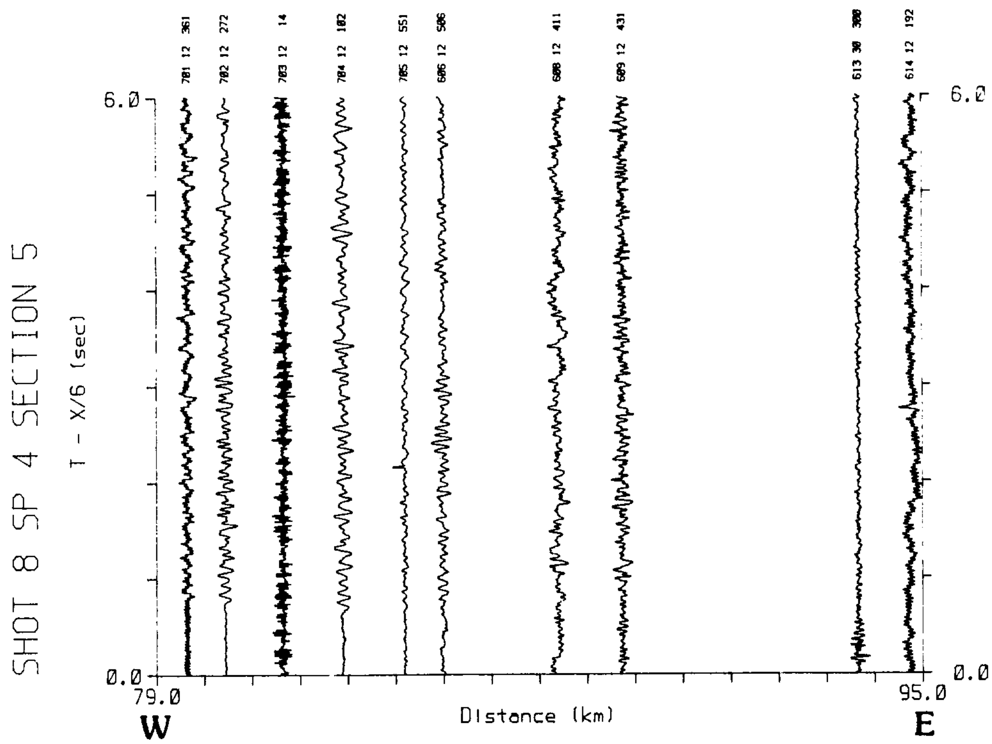


Figure 4h., continued



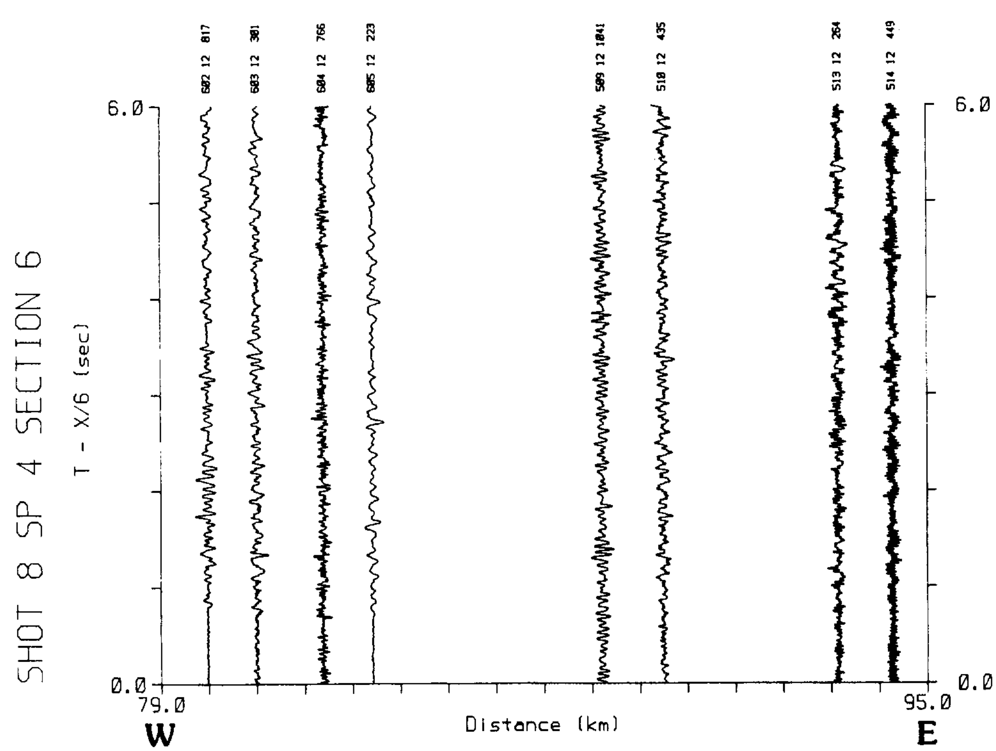
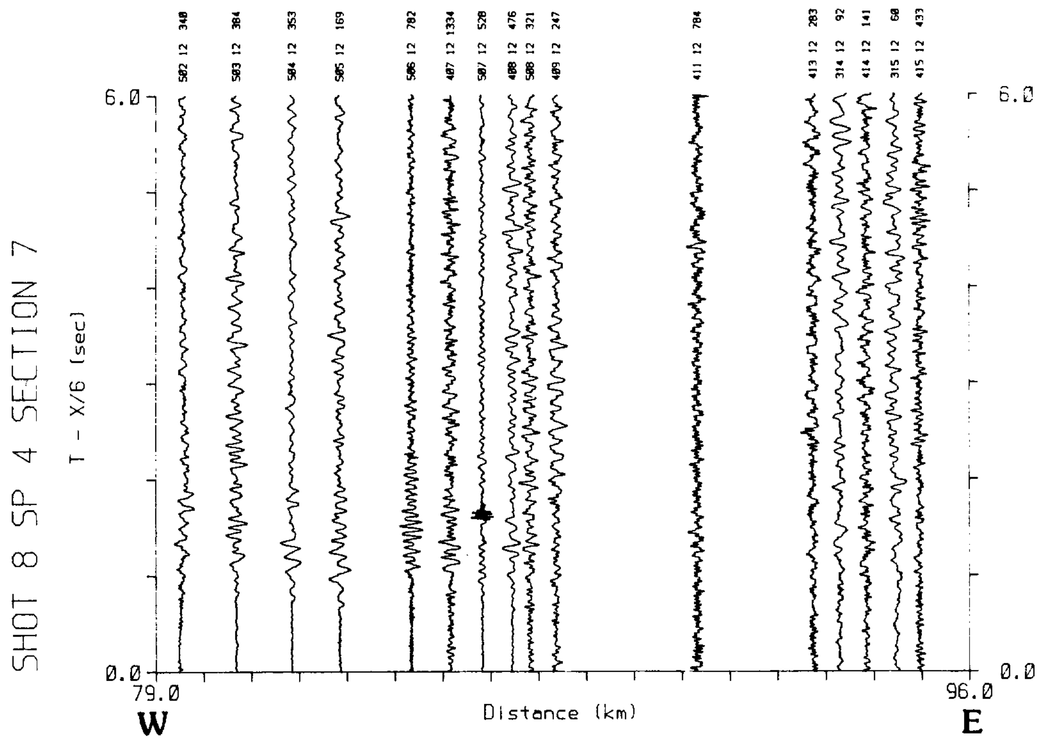


Figure 4h., continued



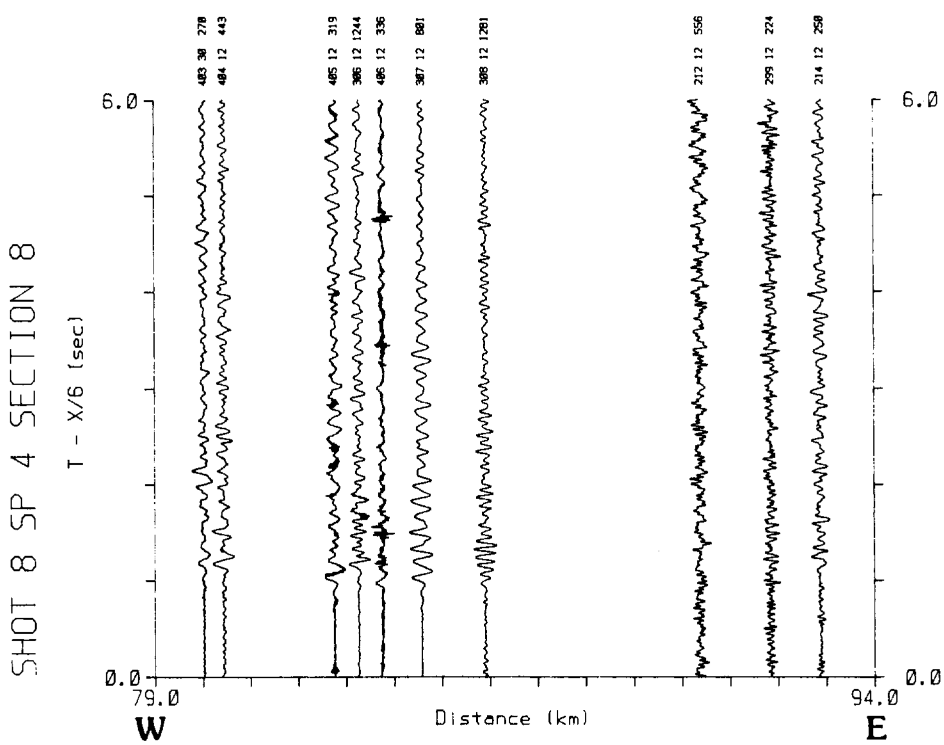
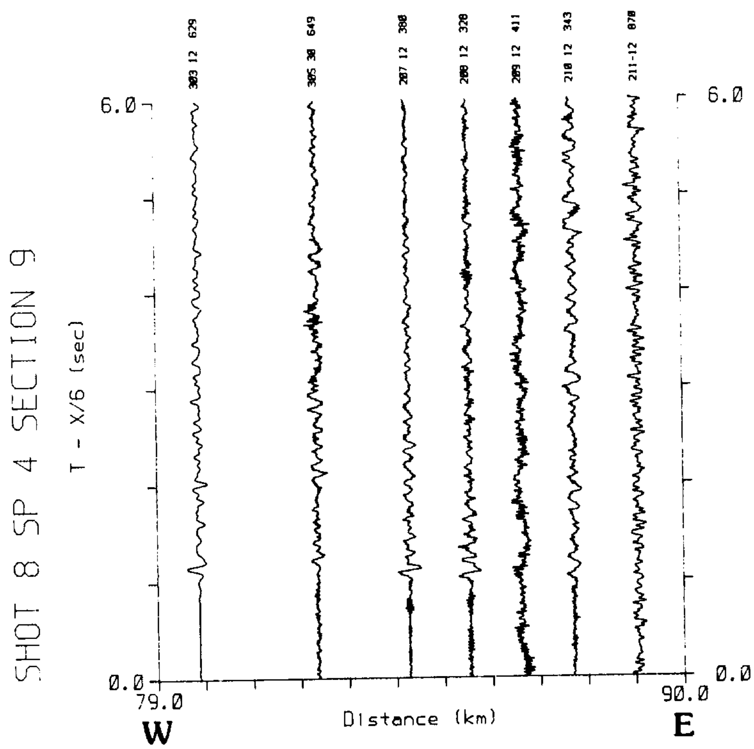
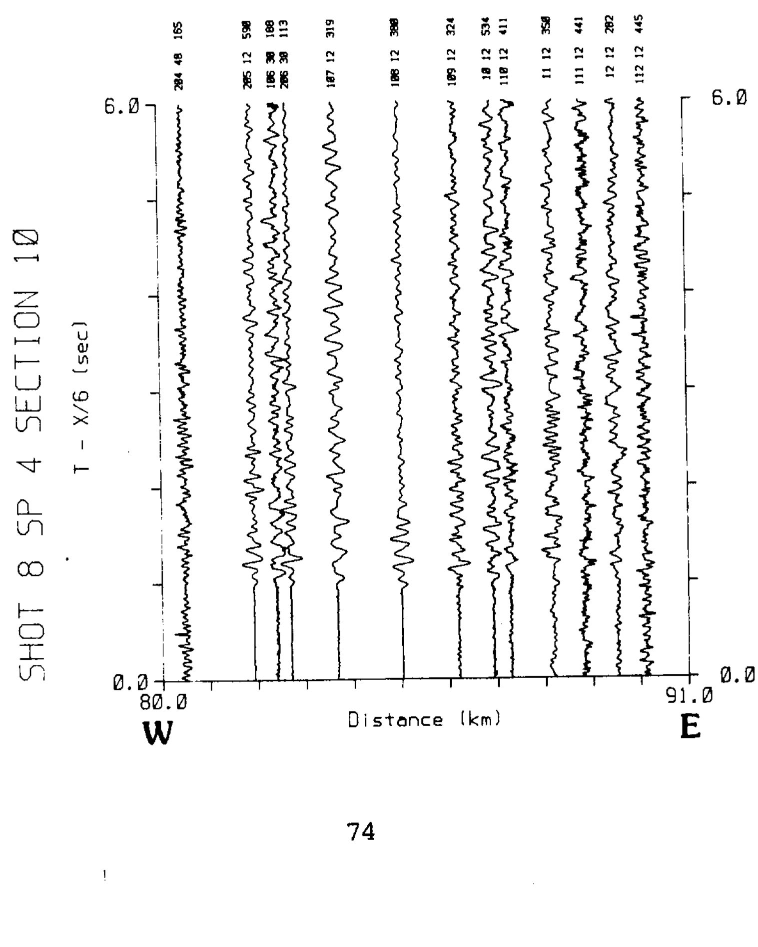


Figure 4h., continued





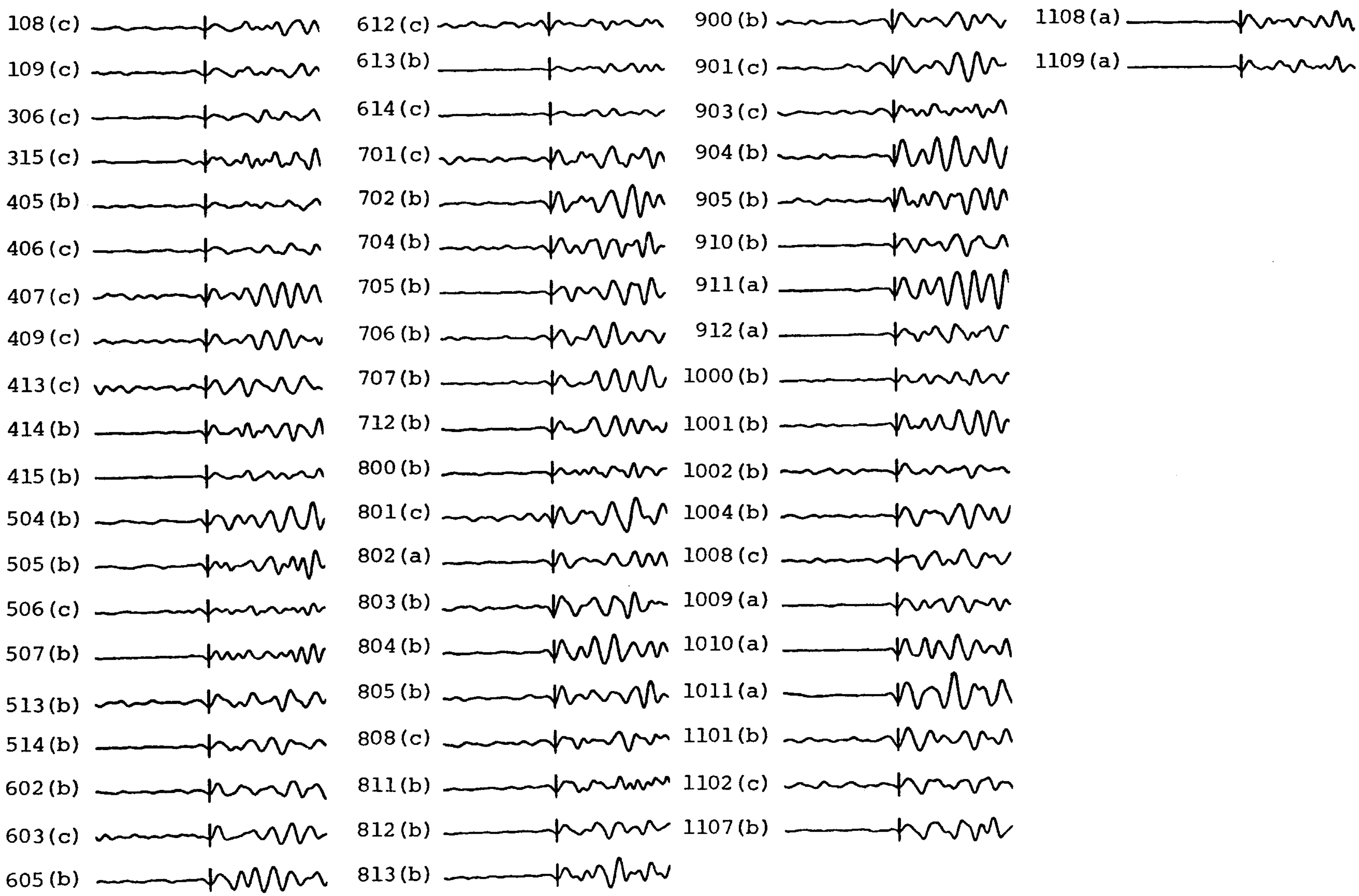


Figure 5a. Filtered seismograms from shot 1 (shotpoint 17), showing timed arrivals. Bandpass Butterworth filter 2.1-8.5 Hz. Station number (and pick quality) are written to the left of each trace. Each trace is 2 s long, centered on the picked arrival. Includes deconvolved seismograms from LLNL stations as well as seismograms from USGS stations.

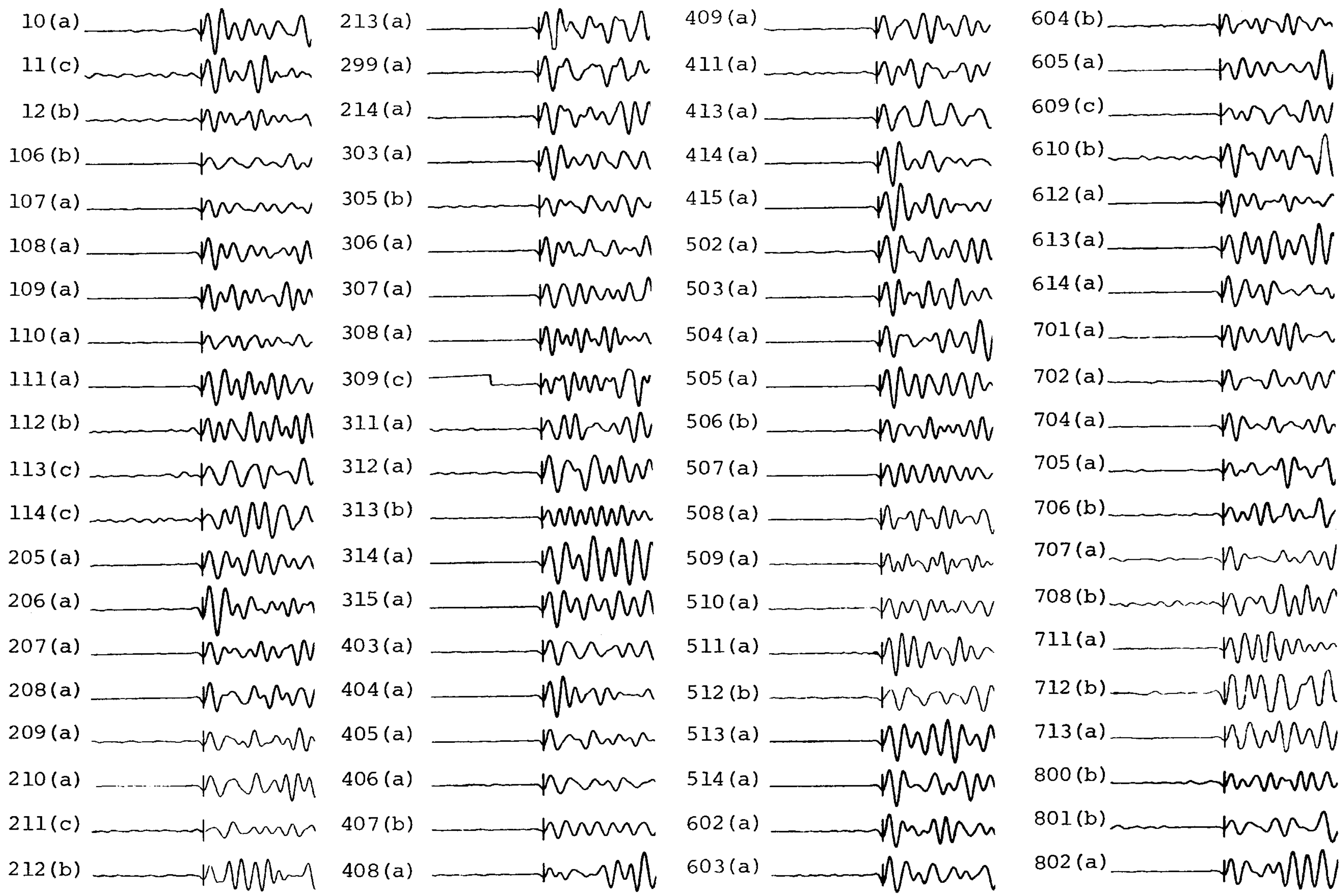


Figure 5b. Filtered seismograms from shot 2 (shotpoint 18), showing timed arrivals. Bandpass Butterworth filter 4.0-10.0 Hz. LLNL and USGS stations.

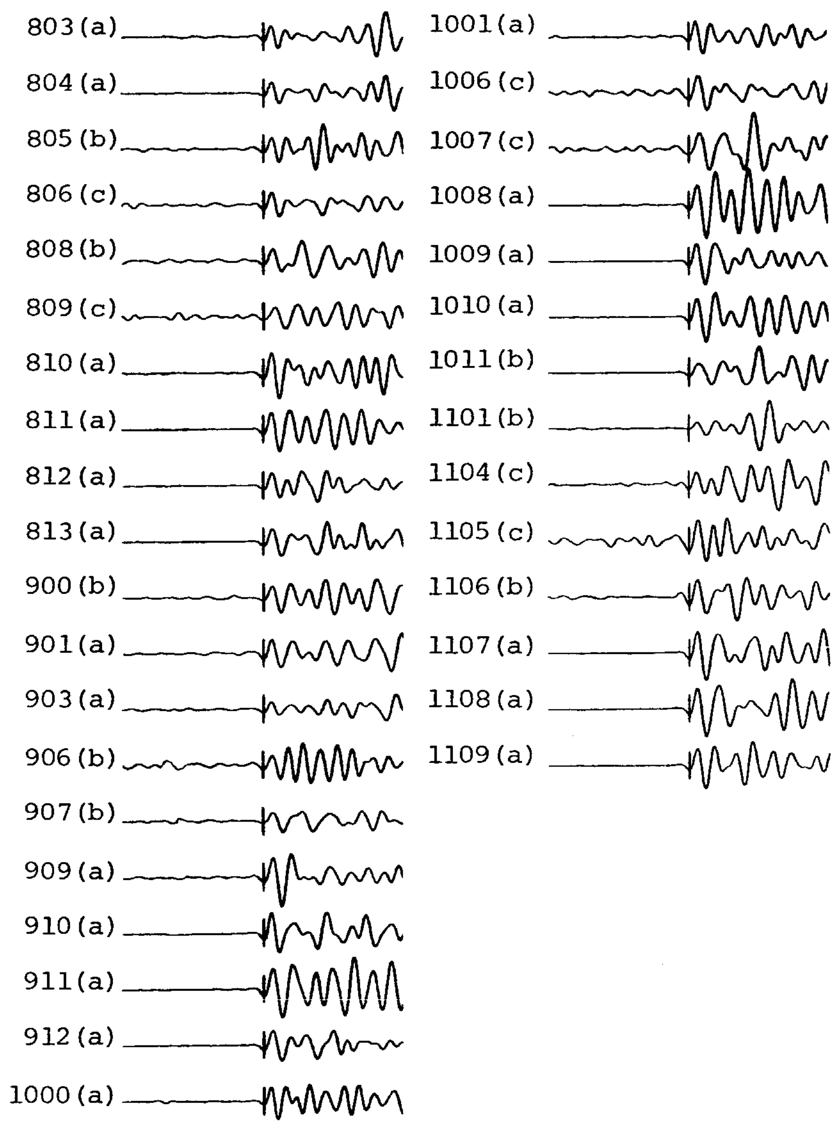


Figure 5b., continued

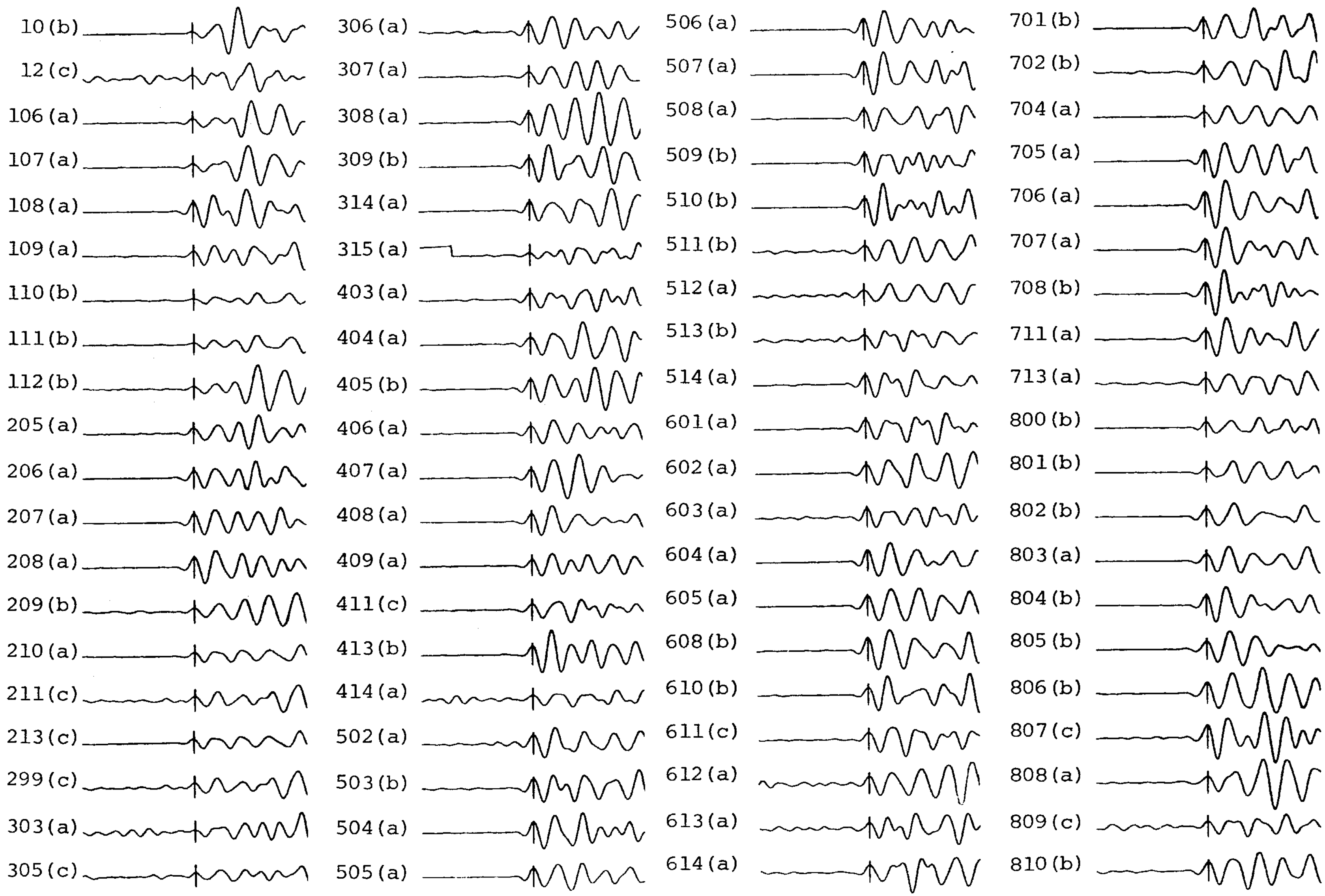


Figure 5c. Filtered seismograms from shot 3 (shotpoint 6), showing timed arrivals. Bandpass Butterworth filter 3.5-8.0 Hz. LLNL and USGS stations.

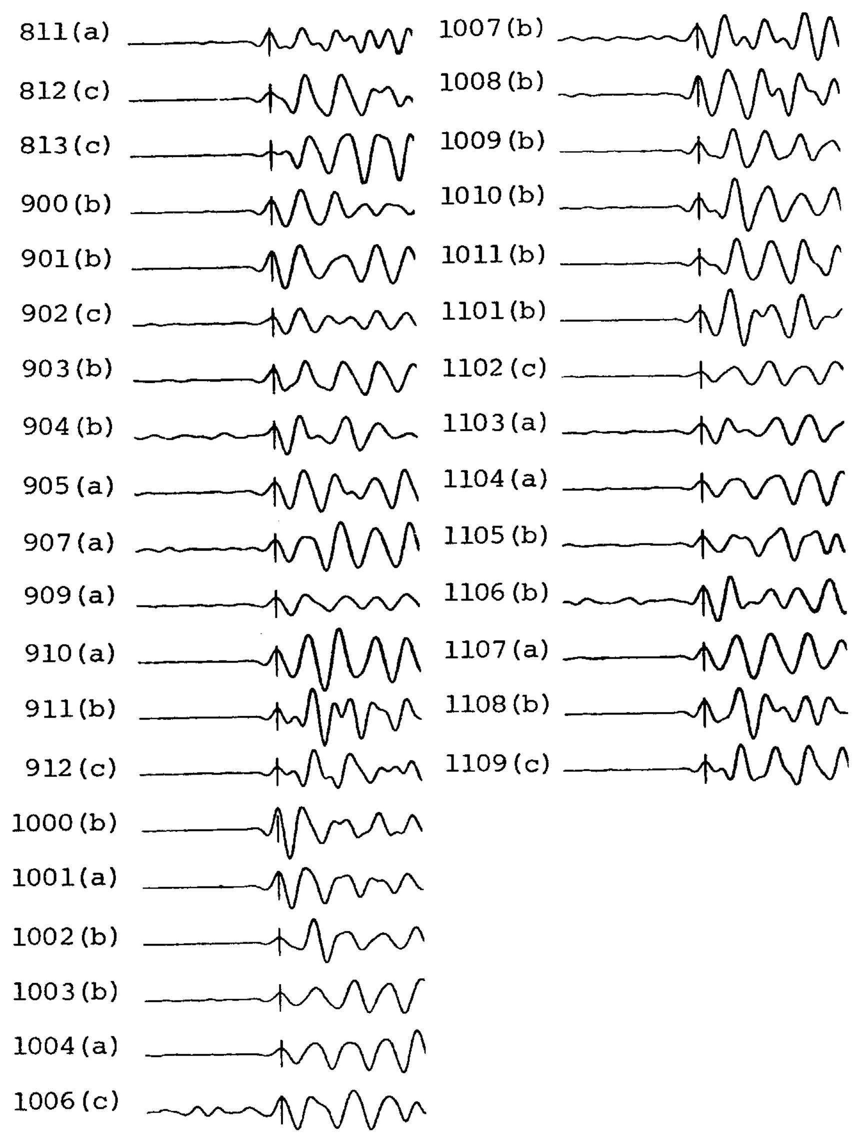


Figure 5c., continued

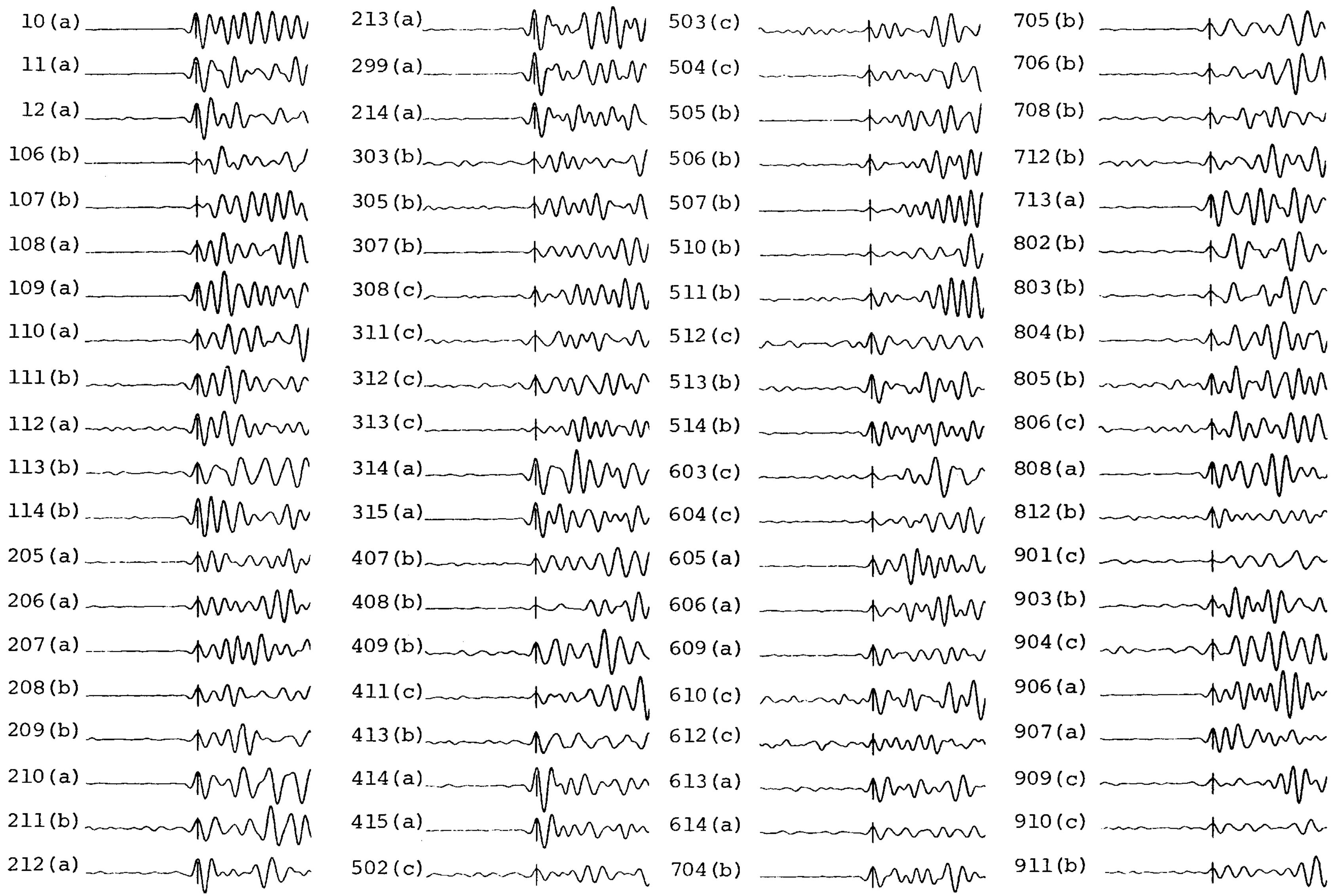


Figure 5d. Filtered seismograms from shot 4 (shotpoint 11), showing timed arrivals. Bandpass Butterworth filter 4.0-10.0 Hz. LLNL and USGS stations.

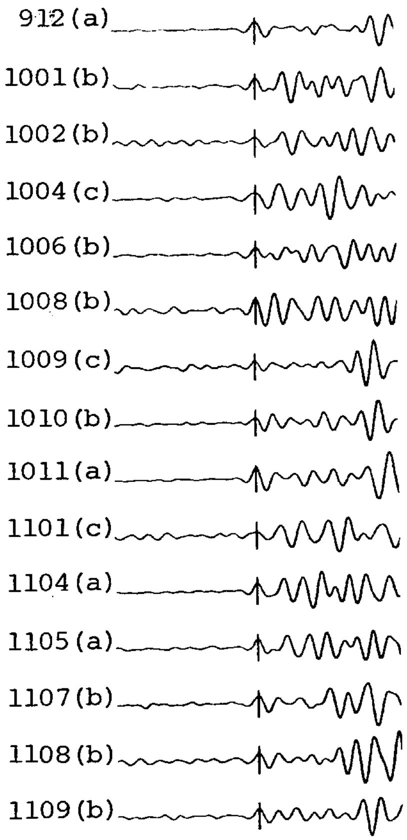


Figure 5d., continued

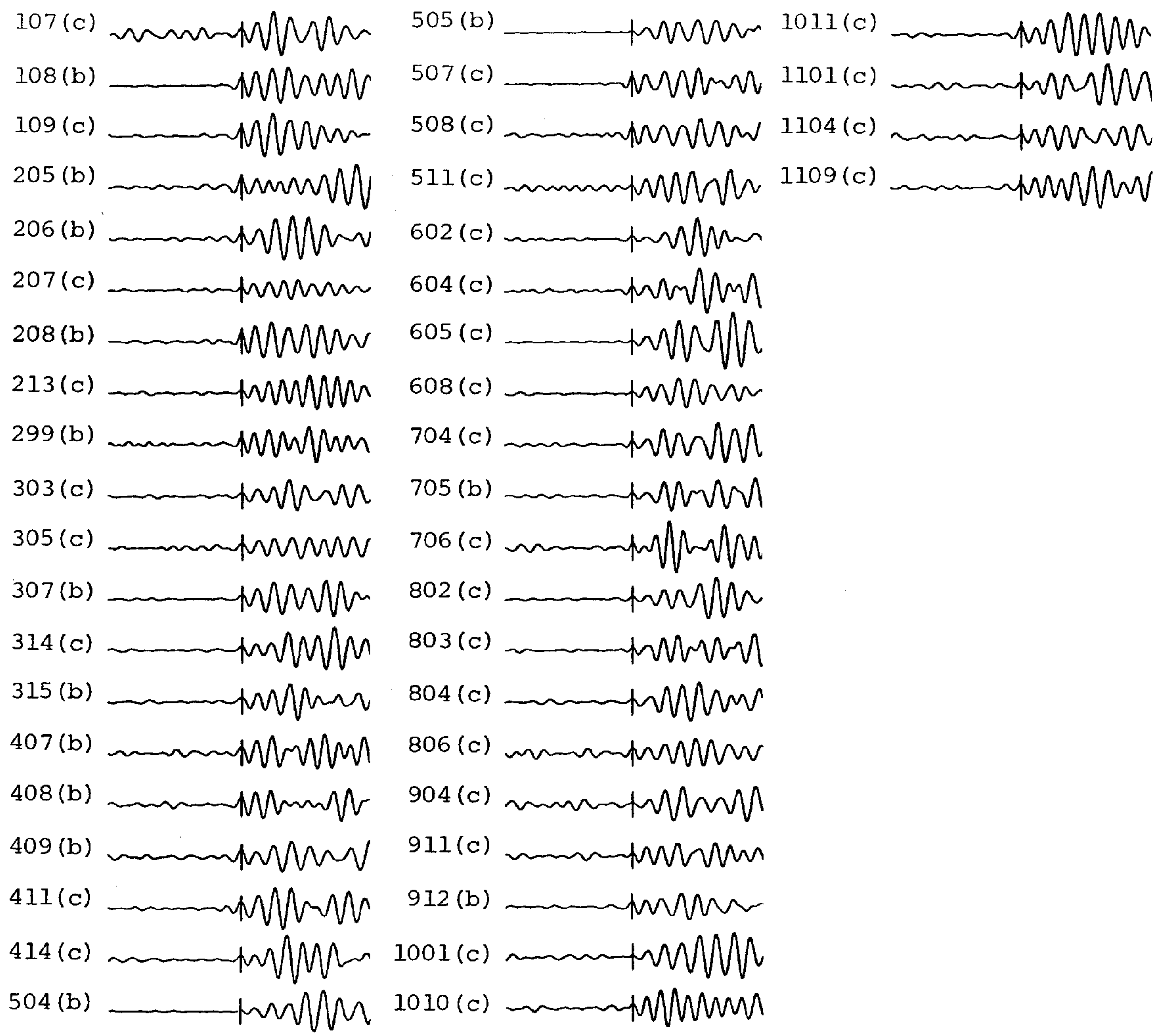


Figure 5e. Filtered seismograms from shot 5 (shotpoint 16), showing timed arrivals. Bandpass Butterworth filter 5.0-10.0 Hz. LLNL and USGS stations.

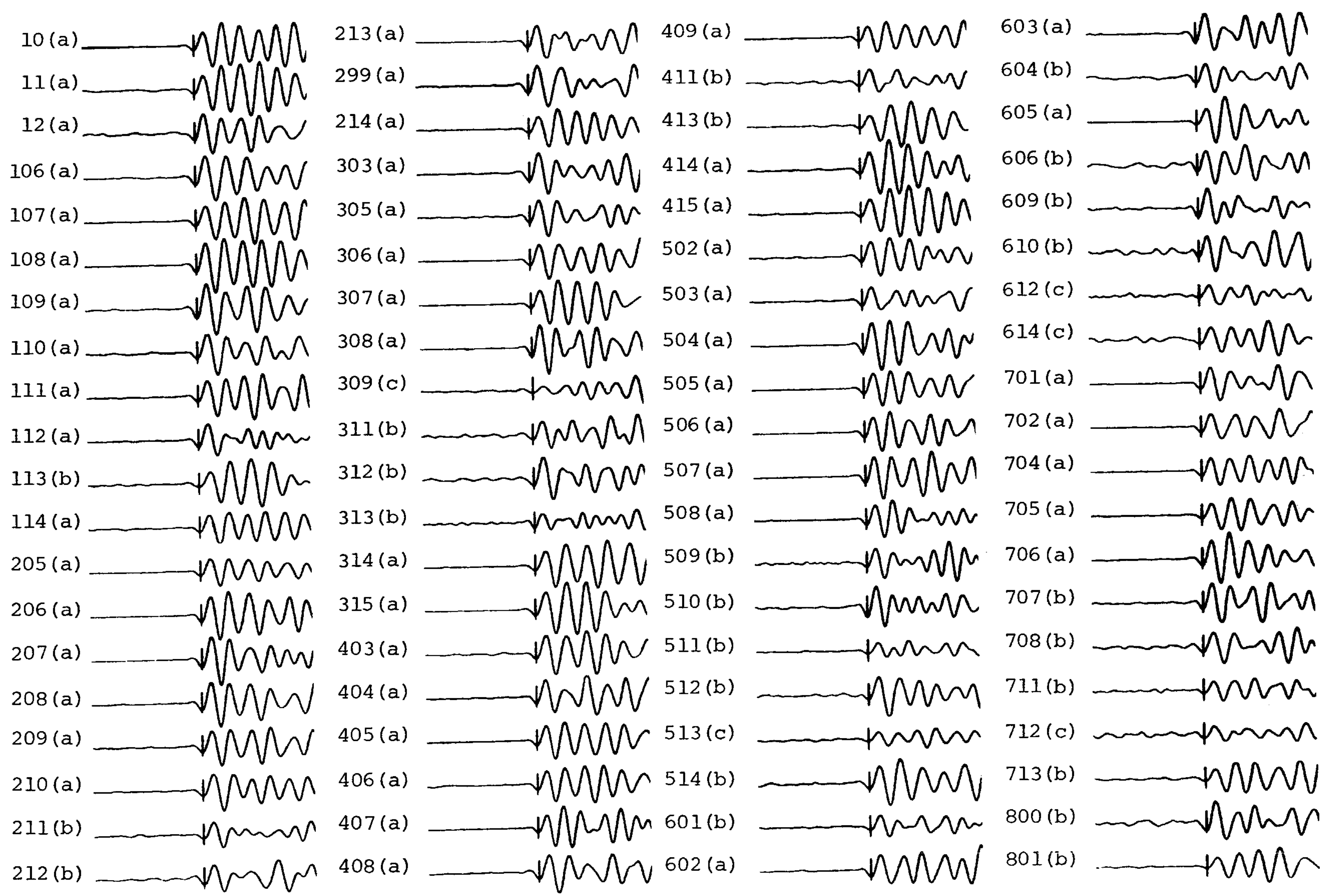


Figure 5f. Filtered seismograms from shot 6 (shotpoint 19), showing timed arrivals. Bandpass Butterworth filter 2.0-8.0 Hz. LLNL and USGS stations.

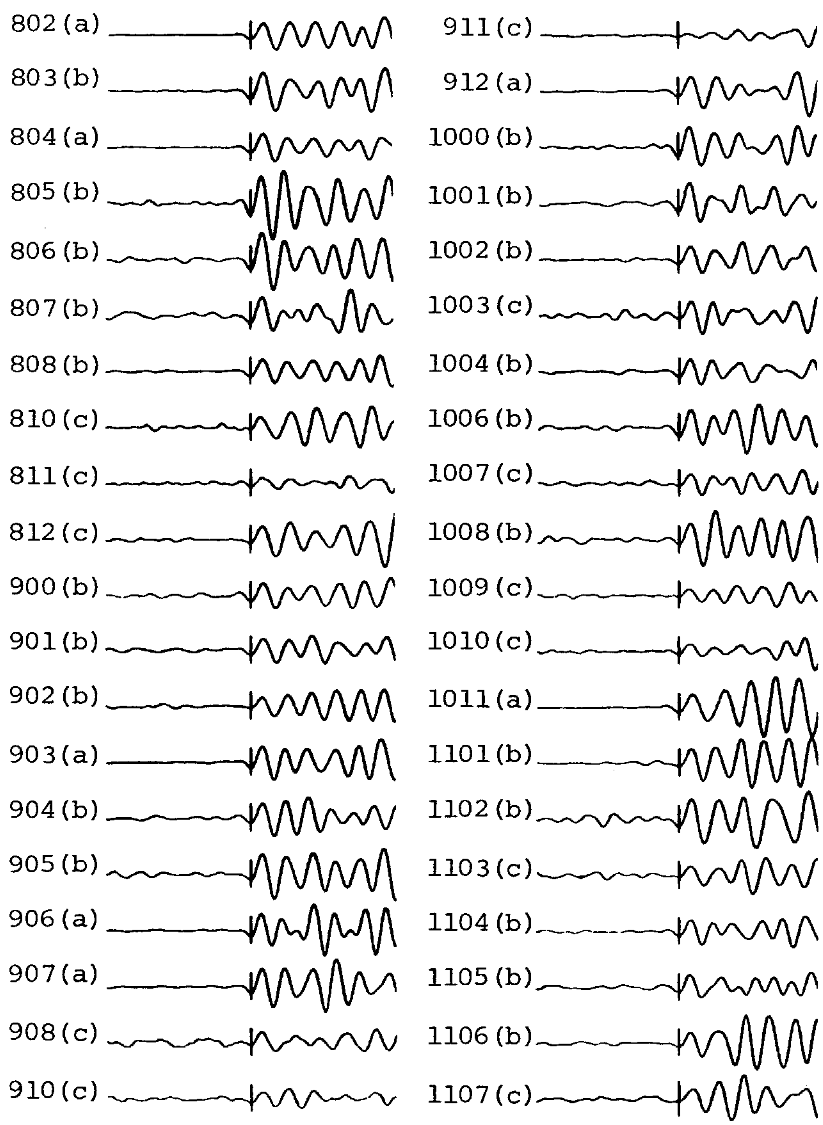


Figure 5f., continued

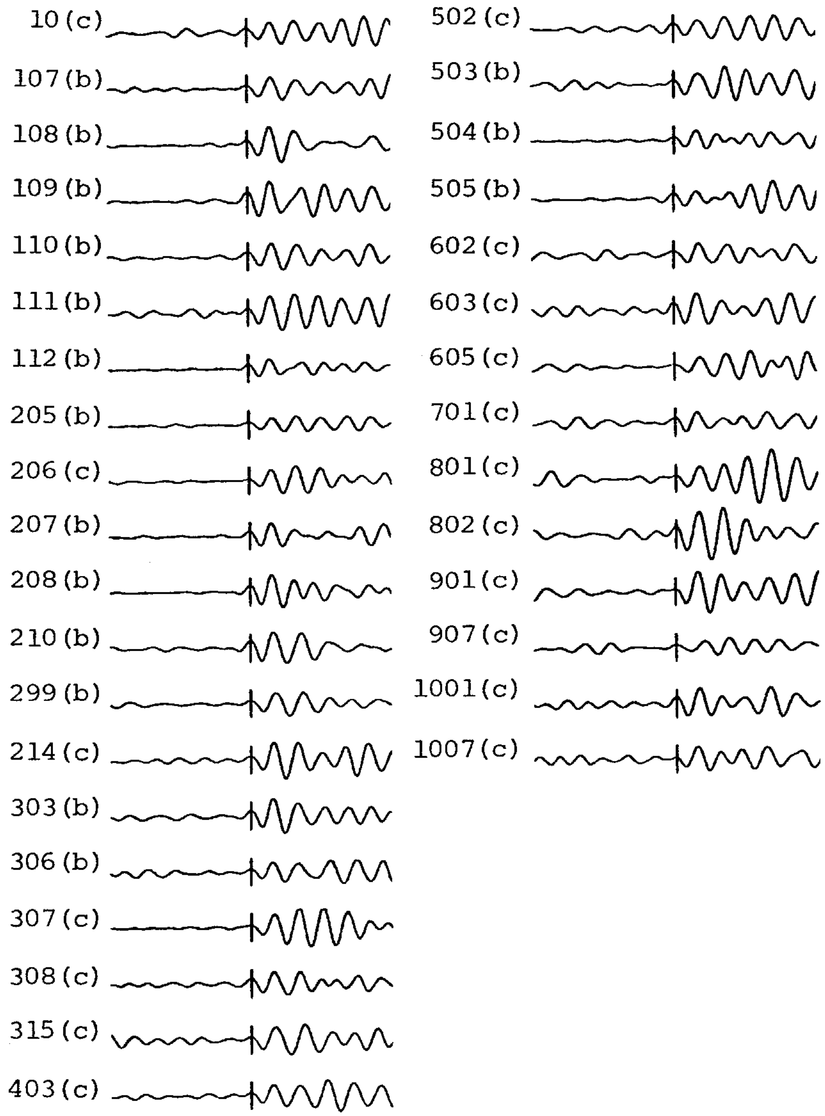


Figure 5g. Filtered seismograms from shot 7 (shotpoint 8), showing timed arrivals. Bandpass Butterworth filter 4.0-7.0 Hz. LLNL and USGS stations.

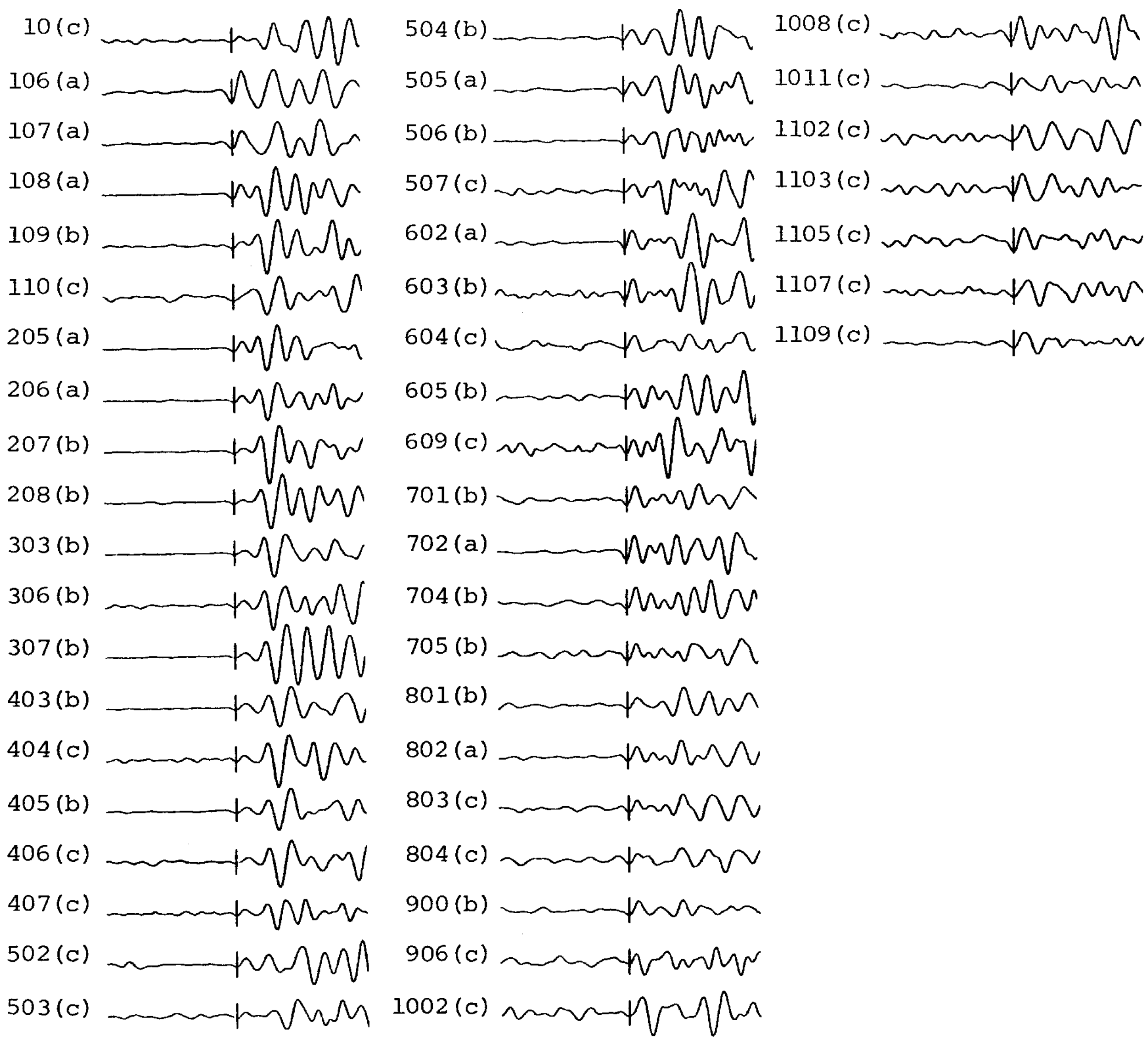


Figure 5h. Filtered seismograms from shot 8 (shotpoint 4), showing timed arrivals. Bandpass Butterworth filter 2.0-8.0 Hz. LLNL and USGS stations.

Table 1. Master Shot List

Gives the shot number, date, location (shotpoint number, north latitude, west longitude, and elevation), shot time (julian day, hours, min, s UTC), size of the explosive charge, and distance and azimuth from the shotpoint to the center of the recording array.

SHOT NUMBER	DATE	SHOT POINT	LATITUDE (deg min)	LONGITUDE (deg min)	ELEVATION (m)	SHOT TIME	SIZE (kg)	DIST (km)	AZIMUTH (deg)
1	9/12/85	17	41 49.1509	121 6.6060	1367	255 06:30:00.012	1360	45	236
2	9/12/85	18	41 13.5315	121 11.8115	1281	255 06:34:00.009	1810	51	324
3	9/12/85	6	41 55.0131	121 59.6960	1292	255 06:36:00.009	1360	52	134
4	9/12/85	11	41 30.2164	120 58.6894	1512	255 08:45:00.013	1360	49	282
5	9/12/85	16	42 5.2986	121 32.7490	1359	255 08:47:00.010	1360	55	181
6	9/12/85	19	41 7.4036	121 32.8130	1021	255 08:49:00.009	1360	52	360
7	9/12/85	8	41 14.6017	121 59.7716	1085	255 08:51:00.008	1810	54	44
8	9/12/85	4	41 30.3127	122 34.7427	963	255 11:00:00.008	1360	86	84

Table 2. Seismic Recorder Locations

This table lists both the USGS and the LLNL seismic recorder locations. Seismograms from LLNL stations are presented in a separate publication. Given are the seismic recorder station number; a three-character equivalent station name (used in some subsequent publications); north latitude and west longitude; and the elevation of the recorder. The station numbers are also plotted in map view in Plate 1.

STATION		LATITUDE (deg	min)	LONGITUDE (deg	min)	ELEVATION (m)
10	(A10)	41	32.21	121	32.14	1884
11	(A11)	41	32.43	121	31.24	1798
12	(A12)	41	32.47	121	30.29	1811
106	(B06)	41	32.27	121	35.40	1960
107	(B07)	41	32.30	121	34.49	1951
108	(B08)	41	32.57	121	33.53	1926
109	(B09)	41	32.75	121	32.69	1954
110	(B10)	41	32.99	121	31.92	2036
111	(B11)	41	33.05	121	30.79	1893
112	(B12)	41	33.12	121	29.89	1914
113	(B13)	41	33.32	121	29.09	1859
114	(B14)	41	33.27	121	28.31	1762
204	(C04)	41	32.66	121	36.81	2006
205	(C05)	41	32.78	121	35.78	2018
206	(C06)	41	32.92	121	35.23	2009
207	(C07)	41	33.14	121	34.11	2012
208	(C08)	41	33.12	121	33.19	1969
209	(C09)	41	33.43	121	32.43	2018
210	(C10)	41	33.56	121	31.66	2070
211	(C11)	41	33.64	121	30.69	2048
212	(C12)	41	33.90	121	29.77	2073
213	(C13)	41	34.02	121	28.78	1771
299	(C99)	41	34.01	121	28.71	1753
214	(C14)	41	34.03	121	27.97	1698
215	(C15)	41	34.20	121	27.09	1606
303	(D03)	41	33.43	121	37.47	2036
304	(D04)	41	32.97	121	36.60	2027
305	(D05)	41	33.23	121	35.50	2082
306	(D06)	41	33.59	121	34.88	2073
307	(D07)	41	33.66	121	33.94	2060
308	(D08)	41	33.83	121	32.99	2091
309	(D09)	41	33.93	121	32.08	2109
310	(D10)	41	34.12	121	31.30	2121
311	(D11)	41	34.29	121	30.06	2271

312	(D12)	41	34.37	121	29.51	2134
313	(D13)	41	34.61	121	28.70	1792
314	(D14)	41	34.74	121	27.73	1664
315	(D15)	41	34.77	121	26.91	1554
402	(E02)	41	33.61	121	38.08	1981
403	(E03)	41	33.75	121	37.24	2140
404	(E04)	41	33.92	121	36.95	2210
405	(E05)	41	34.17	121	35.31	2085
406	(E06)	41	34.16	121	34.58	2073
407	(E07)	41	34.40	121	33.59	2079
408	(E08)	41	34.48	121	32.66	2137
409	(E09)	41	34.53	121	32.00	2121
410	(E10)	41	34.74	121	30.99	2362
411	(E11)	41	34.92	121	29.91	2106
412	(E12)	41	34.95	121	29.14	1896
413	(E13)	41	35.14	121	28.19	1698
414	(E14)	41	35.23	121	27.40	1585
415	(E15)	41	35.52	121	26.63	1509
502	(F02)	41	34.28	121	37.77	2115
503	(F03)	41	34.37	121	36.83	2128
504	(F04)	41	34.50	121	36.00	2048
505	(F05)	41	34.66	121	35.29	2042
506	(F06)	41	34.83	121	34.23	2103
507	(F07)	41	34.94	121	33.17	2085
508	(F08)	41	35.07	121	32.46	2082
509	(F09)	41	35.26	121	31.47	2118
510	(F10)	41	35.32	121	30.56	2134
511	(F11)	41	35.51	121	29.72	2134
512	(F12)	41	35.74	121	28.61	1957
513	(F13)	41	35.91	121	27.99	1442
514	(F14)	41	36.00	121	27.18	1768
601	(G01)	41	34.91	121	38.36	2129
602	(G02)	41	34.96	121	37.41	2082
603	(G03)	41	35.13	121	36.69	2042
604	(G04)	41	35.28	121	35.71	2045
605	(G05)	41	35.33	121	34.96	2060
606	(G06)	41	35.52	121	33.85	2048
607	(G07)	41	35.61	121	33.12	2067
608	(G08)	41	35.86	121	32.16	2152
609	(G09)	41	35.88	121	31.18	2152
610	(G10)	41	35.98	121	30.12	2252
611	(G11)	41	36.17	121	29.41	2073
612	(G12)	41	36.33	121	28.50	1890
613	(G13)	41	36.52	121	27.71	1774
614	(G14)	41	36.51	121	26.91	1530
701	(H01)	41	35.52	121	37.89	2121
702	(H02)	41	35.58	121	37.16	2070

703 (H03)	41	35.73	121	36.30	2054
704 (H04)	41	35.85	121	35.42	2051
705 (H05)	41	35.93	121	34.50	2057
706 (H06)	41	36.15	121	33.45	2231
707 (H07)	41	36.28	121	32.70	2213
708 (H08)	41	36.43	121	31.95	2207
709 (H09)	41	36.65	121	31.00	2109
710 (H10)	41	36.70	121	30.15	2170
711 (H11)	41	36.97	121	29.04	1926
712 (H12)	41	37.03	121	28.38	1768
713 (H13)	41	37.30	121	27.42	1603
800 (I00)	41	35.81	121	38.74	2115
801 (I01)	41	36.23	121	37.65	2158
802 (I02)	41	36.20	121	36.71	2088
803 (I03)	41	36.40	121	36.09	2128
804 (I04)	41	36.42	121	35.26	2100
805 (I05)	41	36.67	121	34.51	2118
806 (I06)	41	36.64	121	33.14	2412
807 (I07)	41	36.96	121	32.51	2237
808 (I08)	41	37.04	121	31.63	2091
809 (I09)	41	37.16	121	30.82	2146
810 (I10)	41	37.42	121	29.82	1890
811 (I11)	41	37.57	121	29.08	1792
812 (I12)	41	37.71	121	28.07	1710
813 (I13)	41	37.81	121	27.30	1570
900 (J00)	41	36.59	121	38.28	2097
901 (J01)	41	36.65	121	37.41	2134
902 (J02)	41	36.88	121	36.64	2256
903 (J03)	41	36.84	121	35.53	2213
904 (J04)	41	37.11	121	34.83	2298
905 (J05)	41	37.22	121	34.07	2295
906 (J06)	41	37.45	121	33.07	2128
907 (J07)	41	37.55	121	31.96	2042
908 (J08)	41	37.73	121	31.34	1993
909 (J09)	41	37.80	121	30.49	1963
910 (J10)	41	38.13	121	29.77	1835
911 (J11)	41	38.13	121	28.73	1771
912 (J12)	41	38.38	121	27.76	1628
1000 (K00)	41	37.30	121	38.19	2057
1001 (K01)	41	37.27	121	37.19	2109
1002 (K02)	41	37.65	121	36.54	2067
1003 (K03)	41	37.58	121	35.79	2198
1004 (K04)	41	37.82	121	34.68	2118
1005 (K05)	41	37.98	121	33.65	2012
1006 (K06)	41	38.17	121	32.73	1935
1007 (K07)	41	38.16	121	32.05	1917
1008 (K08)	41	38.29	121	31.20	1939

1009 (K09)	41	38.63	121	30.08	1847
1010 (K10)	41	38.62	121	29.29	1768
1011 (K11)	41	38.81	121	28.48	1704
1101 (L01)	41	38.01	121	36.97	2057
1102 (L02)	41	38.21	121	36.09	2018
1103 (L03)	41	38.40	121	35.33	2039
1104 (L04)	41	38.54	121	34.53	1981
1105 (L05)	41	38.60	121	33.37	1902
1106 (L06)	41	38.61	121	32.51	1871
1107 (L07)	41	38.82	121	31.61	1853
1108 (L08)	41	39.03	121	30.67	1829
1109 (L09)	41	39.27	121	30.05	1777

Table 3. Picked Traveltimes and Calculated Residuals

The intercept (s) used in calculating the residuals for each shot is given next to the shot and shotpoint numbers in the table below. An apparent velocity of 6.932 km/s was used for all shots. The arrival times used in calculating these traveltimes and residuals (cf. Figures 5a-h) may contain errors of one cycle (about 0.2 s) at some stations, and should therefore be considered preliminary. The picked arrivals will be visually checked and corrected before publication of subsequent papers.

SHOT 1, SHOTPOINT 17   2.352 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
12	8.876	0.016	x	107	9.569	0.045	x
108	9.345	0.016	c	109	9.186	0.017	c
111	8.870	0.041	x	205	9.709	0.060	x
206	9.555	0.016	x	207	9.252	-0.073	x
208	9.133	-0.051	x	211	8.685	-0.025	x
305	9.626	0.094	x	306	9.335	-0.040	c
307	9.133	-0.080	x	308	8.927	-0.107	x
315	7.926	-0.019	c	405	9.276	-0.079	b
406	9.172	-0.065	c	407	8.970	-0.069	c
408	8.773	-0.103	x	409	8.662	-0.101	c
413	8.045	-0.023	c	414	7.870	-0.064	b
415	7.735	-0.032	b	502	9.778	0.030	x
503	9.635	0.058	x	504	9.376	-0.043	b
505	9.193	-0.084	b	506	9.001	-0.075	c
507	8.765	-0.121	b	508	8.608	-0.142	x
509	8.570	0.010	x	513	7.879	-0.026	b
514	7.777	0.012	b	602	9.572	-0.018	b
603	9.377	-0.067	c	604	9.158	-0.098	x
605	9.067	-0.056	b	609	8.438	0.023	x
612	7.695	-0.219	c	613	7.754	-0.004	b
614	7.547	-0.089	c	701	9.589	-0.007	c
702	9.421	-0.041	b	703	9.105	-0.188	x
704	9.025	-0.101	b	705	8.912	-0.047	b
706	8.794	0.044	b	707	8.721	0.116	b
711	7.976	0.079	x	712	7.828	0.047	b
800	9.732	0.027	b	801	9.531	0.071	c
802	9.250	-0.050	a	803	9.120	-0.046	b
804	8.978	-0.042	b	805	8.862	0.006	b
808	8.339	0.025	c	810	8.042	0.086	x

811	7.822	0.011	b	812	7.617	-0.007	b
813	7.431	-0.052	b	900	9.578	0.053	b
901	9.337	-0.026	c	903	8.984	-0.026	c
904	8.917	0.065	b	905	8.825	0.119	b
906	8.659	0.157	x	907	8.394	0.097	x
909	8.128	0.116	x	910	7.878	0.035	b
911	7.679	0.010	a	912	7.476	0.006	a
1000	9.478	0.057	b	1001	9.274	0.027	b
1002	9.165	0.081	b	1004	8.854	0.120	b
1008	8.157	0.092	c	1009	7.863	0.037	a
1010	7.715	0.023	a	1011	7.637	0.109	a
1101	9.252	0.134	b	1102	9.138	0.202	c
1104	8.780	0.163	x	1107	8.144	0.078	b
1108	7.933	0.059	a	1109	7.772	0.038	a

SHOT 2, SHOTPOINT 18   2.943 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	9.470	0.073	a	11	9.346	0.016	c
12	9.254	0.031	b	106	9.826	-0.017	b
107	9.673	-0.051	a	108	9.592	-0.058	a
109	9.626	0.048	a	110	9.604	0.072	a
111	9.500	0.092	a	112	9.328	0.010	b
113	9.317	0.045	c	114	9.077	-0.099	c
205	10.009	0.015	a	206	9.926	-0.021	a
207	9.767	-0.075	a	208	9.764	0.045	a
209	9.724	0.036	a	210	9.694	0.073	a
211	9.683	0.159	c	212	9.642	0.166	b
213	9.545	0.149	a	299	9.505	0.119	a
214	9.408	0.095	a	303	10.321	-0.033	a
305	10.098	0.054	b	306	9.972	-0.062	a
307	9.842	-0.084	a	308	9.773	-0.068	a
309	10.035	0.284	c	311	9.935	0.340	a
312	9.861	0.308	a	313	9.764	0.244	b
314	9.552	0.099	a	315	9.476	0.096	a
403	10.344	-0.040	a	404	10.348	-0.029	a
405	10.036	-0.171	a	406	9.960	-0.150	a
407	9.900	-0.135	b	408	9.866	-0.072	a
409	9.798	-0.072	a	411	9.829	0.109	a
413	9.659	0.068	a	414	9.542	0.007	a
415	9.601	0.069	a	502	10.424	-0.136	a
503	10.321	-0.128	a	504	10.160	-0.204	a
505	10.085	-0.219	a	506	9.995	-0.210	b
507	9.893	-0.205	a	508	9.872	-0.169	a

509	9.934	-0.034	a	510	9.935	0.055	a
511	10.017	0.184	a	512	9.870	0.098	b
513	9.798	0.047	a	514	9.846	0.150	a
602	10.440	-0.204	a	603	10.344	-0.238	a
604	10.222	-0.263	b	605	10.190	-0.210	a
608	10.263	0.084	x	609	10.062	-0.011	c
610	10.137	0.155	b	611	10.119	0.167	x
612	9.833	-0.066	a	613	9.940	0.072	a
614	9.830	0.037	a	701	10.682	-0.138	a
702	10.496	-0.239	a	704	10.316	-0.250	a
705	10.262	-0.208	a	706	10.321	-0.070	b
707	10.338	0.006	a	708	10.226	-0.055	b
710	10.296	0.147	x	711	10.229	0.128	a
712	10.111	0.059	b	713	10.117	0.089	a
800	10.872	-0.119	b	801	10.772	-0.158	b
802	10.664	-0.138	a	803	10.611	-0.154	a
804	10.518	-0.148	a	805	10.517	-0.112	b
806	10.585	0.123	c	807	10.425	-0.036	x
808	10.363	-0.020	b	809	10.442	0.118	c
810	10.388	0.106	a	811	10.319	0.074	a
812	10.197	0.013	a	813	10.199	0.059	a
900	11.003	-0.083	b	901	10.835	-0.150	a
902	10.903	-0.031	x	903	10.664	-0.124	a
904	10.719	-0.042	x	905	10.708	0.012	x
906	10.695	0.063	b	907	10.521	-0.012	b
908	10.518	0.010	x	909	10.528	0.091	a
910	10.555	0.112	a	911	10.448	0.104	a
912	10.315	-0.002	a	1000	11.147	-0.071	a
1001	10.993	-0.091	a	1002	11.028	-0.055	x
1006	10.803	0.047	c	1007	10.783	0.102	c
1008	10.719	0.097	a	1009	10.724	0.134	a
1010	10.614	0.102	a	1011	10.525	0.042	b
1101	11.231	0.019	b	1102	11.192	0.044	x
1104	11.093	0.055	c	1105	11.012	0.090	c
1106	10.883	0.052	b	1107	10.879	0.093	a
1108	10.853	0.113	a	1109	10.802	0.065	a

SHOT 3, SHOTPOINT 6 2.955 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	11.367	0.188	b	12	11.545	0.163	c
106	10.771	0.027	a	107	10.910	0.058	a
108	10.975	0.053	a	109	11.049	0.051	a
110	11.148	0.093	b	111	11.311	0.110	b

112	11.393	0.078	b	113	11.468	0.075	x
114	11.453	-0.063	x	205	10.569	-0.021	a
206	10.641	0.011	a	207	10.720	-0.011	a
208	10.823	-0.034	a	209	10.944	0.044	b
210	11.018	0.036	a	211	11.216	0.113	c
213	11.388	0.077	c	299	11.357	0.033	c
214	11.492	0.062	x	303	10.158	-0.086	a
305	10.546	0.014	c	306	10.449	-0.090	a
307	10.686	0.037	a	308	10.665	-0.080	a
309	10.997	0.145	b	311	11.144	0.070	x
312	11.235	0.095	x	314	11.298	-0.044	a
315	11.435	-0.028	a	403	10.112	-0.092	a
404	10.119	-0.086	a	405	10.246	-0.119	b
406	10.358	-0.106	a	407	10.444	-0.108	a
408	10.585	-0.081	a	409	10.657	-0.092	a
411	11.002	0.020	c	413	11.160	-0.043	b
414	11.244	-0.065	a	502	9.885	-0.143	a
503	9.985	-0.142	b	504	10.055	-0.153	a
505	10.089	-0.181	a	506	10.294	-0.086	a
507	10.322	-0.184	a	508	10.441	-0.142	a
509	10.691	0.	b	510	10.779	-0.035	b
511	10.964	0.058	b	512	11.153	0.118	a
513	11.162	0.060	b	514	11.300	0.086	a
601	9.723	-0.099	a	602	9.794	-0.138	a
603	9.786	-0.204	a	604	9.890	-0.200	a
605	10.020	-0.163	a	606	10.127	-0.173	x
608	10.362	-0.118	b	610	10.855	0.092	b
611	11.148	0.310	c	612	10.860	-0.092	a
613	11.148	0.103	a	614	11.224	0.050	a
701	9.667	-0.088	b	702	9.700	-0.138	b
703	9.871	-0.051	x	704	9.828	-0.190	a
705	9.979	-0.152	a	706	10.158	-0.081	a
707	10.318	-0.006	a	708	10.350	-0.058	b
710	10.737	0.103	x	711	10.950	0.189	a
712	10.941	0.085	x	713	11.093	0.127	a
800	9.572	-0.015	b	801	9.598	-0.044	b
802	9.638	-0.136	b	803	9.732	-0.087	a
804	9.786	-0.145	b	805	9.892	-0.098	b
806	10.262	0.068	b	807	10.180	-0.050	c
808	10.357	0.008	a	809	10.650	0.198	c
810	10.580	0.016	b	811	10.740	0.083	a
812	10.920	0.124	c	813	10.986	0.081	c
900	9.514	0.027	b	901	9.551	-0.039	b
902	9.700	0.050	c	903	9.773	-0.040	b
904	9.827	-0.035	b	905	9.912	-0.040	a
906	10.016	-0.043	x	907	10.214	0.004	a

908	10.377	0.102	x	909	10.493	0.097	a
910	10.534	0.078	a	911	10.695	0.072	b
912	10.842	0.100	c	1000	9.406	0.049	b
1001	9.487	-0.012	a	1002	9.545	0.028	b
1003	9.697	0.060	b	1004	9.686	-0.068	a
1006	10.060	0.075	c	1007	10.165	0.073	b
1008	10.297	0.094	b	1009	10.396	0.070	b
1010	10.488	0.033	b	1011	10.606	0.048	b
1101	9.494	0.106	b	1102	9.584	0.108	c
1103	9.594	0.041	a	1104	9.649	0.002	a
1105	9.874	0.061	b	1106	9.998	0.053	b
1107	10.169	0.118	a	1108	10.276	0.109	b
1109	10.342	0.112	c				

SHOT 4, SHOTPOINT 11 2.914 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	9.892	0.238	a	11	9.620	0.141	a
12	9.445	0.155	a	106	10.461	0.153	b
107	10.234	0.108	b	108	10.015	0.075	a
109	9.879	0.102	a	110	9.772	0.143	a
111	9.543	0.137	b	112	9.338	0.109	a
113	9.182	0.106	b	114	8.794	-0.125	b
205	10.475	0.080	a	206	10.320	0.032	a
207	10.034	-0.037	a	208	9.885	-0.002	b
209	9.802	0.057	b	210	9.676	0.080	a
211	9.588	0.182	b	212	9.407	0.174	a
213	9.171	0.129	a	299	9.121	0.093	a
214	8.965	0.082	a	303	10.717	-0.032	b
305	10.446	0.096	b	306	9.895	-0.343	x
307	9.971	-0.082	b	308	9.771	-0.099	c
309	9.648	-0.045	x	311	9.587	0.279	c
312	9.420	0.217	c	313	9.190	0.138	c
314	8.892	0.022	a	315	8.722	0.011	a
403	10.514	-0.199	x	404	10.355	-0.306	x
405	10.172	-0.171	x	407	9.884	-0.127	b
408	9.744	-0.086	b	409	9.581	-0.121	b
411	9.330	0.022	c	413	8.954	-0.029	b
414	8.782	-0.051	a	415	8.674	-0.027	a
502	10.718	-0.118	c	503	10.550	-0.103	c
504	10.335	-0.158	c	505	10.195	-0.164	b
506	9.991	-0.165	b	507	9.760	-0.192	b
508	9.610	-0.208	x	509	9.556	-0.077	x
510	9.443	-0.014	b	511	9.407	0.103	b

512	9.121	0.020	c	513	8.985	-0.006	b
514	8.898	0.058	b	601	11.112	0.135	x
602	10.895	0.104	x	603	10.530	-0.126	c
604	10.321	-0.148	c	605	10.210	-0.114	a
606	9.975	-0.140	a	608	9.658	-0.143	x
609	9.582	-0.029	a	610	9.468	0.058	c
611	9.449	0.165	x	612	9.181	0.062	c
613	9.011	0.031	a	614	8.778	-0.047	a
701	10.918	0.007	x	702	10.694	-0.076	x
704	10.293	-0.147	b	705	10.152	-0.112	b
706	10.005	-0.066	b	707	9.935	0.003	x
708	9.740	-0.055	b	710	9.656	0.192	x
711	9.311	0.042	x	712	9.164	0.017	b
713	9.013	0.028	a	800	11.182	0.090	x
801	10.901	0.002	x	802	10.677	-0.035	b
803	10.528	-0.074	b	804	10.337	-0.104	b
805	10.184	-0.125	b	806	10.136	0.096	c
807	9.887	-0.052	x	808	9.716	-0.058	a
809	9.782	0.156	x	810	9.458	0.005	x
812	9.127	-0.016	b	901	10.666	-0.209	c
902	10.516	-0.221	x	903	10.377	-0.141	b
904	10.340	-0.059	c	905	10.222	-0.037	x
906	10.131	0.050	a	907	9.893	0.019	a
908	9.715	-0.054	x	909	9.645	0.033	c
910	9.500	-0.002	c	911	9.316	0.011	b
912	9.102	-0.042	a	1000	10.988	-0.077	x
1001	10.792	-0.077	b	1002	10.702	-0.065	b
1003	10.623	0.006	x	1004	10.401	-0.017	c
1006	10.116	0.046	b	1007	10.046	0.107	x
1008	9.830	0.043	b	1009	9.585	-0.019	c
1010	9.439	-0.015	b	1011	9.240	-0.080	a
1101	10.856	-0.019	c	1102	10.721	0.002	x
1104	10.478	0.035	a	1105	10.312	0.086	a
1106	10.074	0.011	x	1107	9.936	0.026	b
1108	9.732	-0.019	b	1109	9.574	-0.083	b

SHOT 5, SHOTPOINT 16 2.758 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	11.853	0.255	x	107	11.813	0.233	c
108	11.684	0.181	b	109	11.636	0.183	c
110	11.589	0.198	x	114	11.259	-0.101	x
205	11.654	0.188	b	206	11.591	0.169	b
207	11.493	0.139	c	208	11.477	0.122	b

209	11.435	0.163	x	210	11.503	0.263	x
213	11.205	0.053	c	299	11.147	-0.009	b
214	11.183	0.017	x	303	11.346	0.022	c
305	11.422	0.079	c	307	11.334	0.120	b
308	11.268	0.103	x	312	11.060	0.014	x
313	10.956	-0.041	x	314	10.891	-0.092	c
315	10.889	-0.108	b	403	11.097	-0.137	x
405	11.136	0.046	x	407	11.109	0.095	b
408	11.116	0.125	b	409	11.071	0.092	b
411	11.178	0.284	c	414	10.742	-0.120	c
415	10.851	0.044	x	502	10.930	-0.175	x
504	10.794	-0.218	b	505	10.717	-0.242	b
506	10.946	0.043	x	507	10.913	0.044	c
508	10.899	0.065	c	509	10.919	0.132	x
511	10.889	0.150	c	513	10.617	-0.050	x
514	10.727	0.063	x	601	10.837	-0.117	x
602	10.717	-0.199	c	604	10.542	-0.257	c
605	10.588	-0.189	c	606	10.692	-0.025	x
608	10.641	0.017	c	609	10.770	0.146	x
611	10.863	0.294	x	701	10.636	-0.144	x
702	10.537	-0.209	x	704	10.400	-0.244	c
705	10.526	-0.086	b	706	10.535	-0.012	c
707	10.515	0.004	x	708	10.589	0.117	x
711	10.702	0.339	x	713	10.262	-0.052	x
801	10.528	-0.057	x	802	10.374	-0.198	c
803	10.337	-0.170	c	804	10.275	-0.215	c
805	10.271	-0.144	x	806	10.500	0.085	c
807	10.298	-0.031	x	808	10.258	-0.053	x
810	10.476	0.247	x	900	10.484	-0.023	x
901	10.366	-0.102	x	903	10.252	-0.129	x
904	10.359	0.059	c	905	10.201	-0.063	x
906	10.289	0.091	x	907	10.198	0.025	x
911	9.994	-0.067	c	912	9.995	-0.023	b
1000	10.327	0.010	x	1001	10.199	-0.100	c
1002	10.123	-0.060	x	1007	10.068	0.058	x
1008	10.055	0.075	x	1010	9.856	-0.063	c
1011	9.783	-0.103	c	1101	10.119	0.022	c
1104	10.012	0.096	c	1107	10.007	0.171	x
1108	9.966	0.178	x	1109	9.825	0.092	c

SHOT 6, SHOTPOINT 19 2.935 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	9.659	0.095	a	11	9.660	0.031	a
12	9.727	0.076	a	106	9.570	-0.029	a

107	9.572	-0.023	a	108	9.650	-0.010	a
109	9.785	0.078	a	110	9.854	0.081	a
111	9.896	0.097	a	112	9.898	0.067	a
113	9.961	0.062	b	114	9.819	-0.086	a
205	9.743	0.002	a	206	9.759	-0.011	a
207	9.766	-0.050	a	208	9.781	-0.025	a
209	9.952	0.063	a	210	9.974	0.047	a
211	10.103	0.146	b	212	10.235	0.195	b
213	10.245	0.153	a	299	10.220	0.129	a
214	10.237	0.122	a	303	9.927	-0.024	a
305	9.920	0.064	a	306	9.913	-0.030	a
307	9.911	-0.042	a	308	9.949	-0.046	a
309	10.192	0.169	c	311	10.455	0.316	b
312	10.473	0.303	b	313	10.471	0.220	b
314	10.424	0.115	a	315	10.455	0.113	a
403	10.014	-0.016	a	404	10.064	-0.004	a
405	10.014	-0.090	a	406	10.025	-0.067	a
407	10.052	-0.097	a	408	10.130	-0.039	a
409	10.106	-0.078	a	411	10.380	0.071	b
413	10.478	0.075	b	414	10.458	0.010	a
415	10.626	0.077	a	502	10.100	-0.084	a
503	10.105	-0.080	a	504	10.060	-0.143	a
505	10.045	-0.189	a	506	10.119	-0.149	a
507	10.119	-0.173	a	508	10.167	-0.160	a
509	10.277	-0.105	b	510	10.412	0.005	b
511	10.561	0.091	b	512	10.669	0.117	b
513	10.640	0.028	c	514	10.776	0.118	b
601	10.292	-0.076	b	602	10.204	-0.151	a
603	10.188	-0.195	a	604	10.188	-0.217	b
605	10.226	-0.182	a	606	10.280	-0.169	b
608	10.478	-0.060	x	609	10.480	-0.070	b
610	10.716	0.127	b	611	10.726	0.075	x
612	10.617	-0.094	c	613	10.858	0.077	x
614	10.821	0.020	c	701	10.416	-0.100	a
702	10.340	-0.173	a	704	10.327	-0.226	a
705	10.381	-0.183	a	706	10.552	-0.064	a
707	10.644	-0.006	b	708	10.621	-0.071	b
711	10.980	0.110	b	712	10.962	0.062	c
713	11.098	0.103	b	800	10.551	-0.066	b
801	10.590	-0.108	b	802	10.558	-0.110	a
803	10.573	-0.137	b	804	10.563	-0.140	a
805	10.675	-0.086	b	806	10.863	0.117	b
807	10.797	-0.034	b	808	10.816	-0.040	b
810	11.019	0.042	c	811	11.086	0.057	c
812	11.142	0.055	c	900	10.739	-0.071	b
901	10.672	-0.131	b	902	10.849	0.002	b

903	10.729	-0.089	a	904	10.844	-0.038	b
905	10.894	-0.011	b	906	11.006	0.044	a
907	10.964	-0.027	a	908	11.017	-0.025	c
909	11.325	0.256	x	910	11.242	0.076	c
911	11.334	0.149	c	912	11.310	0.037	a
1000	10.906	-0.089	b	1001	10.859	-0.103	b
1002	10.993	-0.057	b	1003	11.005	-0.014	c
1004	11.030	-0.040	b	1006	11.226	0.072	b
1007	11.254	0.101	c	1008	11.257	0.064	b
1009	11.385	0.090	c	1010	11.386	0.081	c
1011	11.480	0.110	a	1101	11.144	-0.010	b
1102	11.219	0.028	b	1103	11.266	0.035	c
1104	11.298	0.038	b	1105	11.388	0.118	b
1106	11.353	0.081	b	1107	11.434	0.103	c
1108	11.481	0.086	x	1109	11.387	-0.079	x

SHOT 7, SHOTPOINT 8 2.606 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	10.080	0.192	c	107	9.613	0.063	b
108	9.831	0.090	b	109	10.048	0.150	b
110	10.241	0.184	b	111	10.444	0.205	b
112	10.631	0.241	b	205	9.491	0.039	b
206	9.603	0.046	c	207	9.780	0.021	b
208	9.937	0.047	b	210	10.330	0.133	b
299	10.955	0.231	b	214	11.103	0.261	c
303	9.291	-0.055	b	305	9.637	0.060	x
306	9.718	-0.015	b	307	9.865	-0.015	c
308	10.029	-0.020	c	314	11.190	0.190	x
315	11.291	0.159	c	403	9.379	-0.061	c
404	9.447	-0.066	x	405	9.690	-0.094	x
406	9.748	-0.136	x	407	9.971	-0.098	x
502	9.344	-0.133	c	503	9.481	-0.138	b
504	9.592	-0.163	b	505	9.659	-0.224	b
506	9.914	-0.147	x	507	10.033	-0.198	x
602	9.491	-0.172	c	603	9.574	-0.217	c
604	9.707	-0.242	x	605	9.850	-0.209	c
612	11.143	-0.020	x	701	9.576	-0.142	c
800	9.583	-0.093	x	801	9.744	-0.154	c
802	9.827	-0.181	c	803	9.958	-0.170	x
804	10.056	-0.183	x	901	9.859	-0.157	c
903	10.029	-0.261	x	907	11.049	0.146	c
1001	9.996	-0.178	x	1002	10.194	-0.140	x
1101	10.261	-0.098	c	1104	10.743	-0.026	x
1107	11.148	-0.054	c				

SHOT 8, SHOTPOINT 4 2.731 s

STAT	TRAVELTIME	RESIDUAL	QUAL	STAT	TRAVELTIME	RESIDUAL	QUAL
10	15.317	0.008	c	11	15.702	0.210	x
12	15.945	0.262	x	106	14.876	0.220	a
107	15.027	0.188	a	108	15.177	0.143	a
109	15.339	0.134	b	110	15.543	0.181	c
111	15.777	0.188	x	112	15.964	0.193	x
114	16.294	0.205	x	204	14.561	0.183	x
205	14.707	0.121	a	206	14.834	0.136	a
207	14.963	0.038	b	208	15.126	0.017	b
209	15.397	0.131	x	210	15.482	0.059	x
214	16.586	0.416	x	303	14.268	0.011	b
305	14.771	0.123	x	306	14.849	0.070	b
307	14.923	-0.045	b	308	15.087	-0.074	x
403	14.303	-0.006	b	404	14.372	0.001	c
405	14.619	-0.085	b	406	14.713	-0.137	c
407	15.067	0.014	c	408	15.222	-0.019	x
409	15.350	-0.024	x	414	16.468	0.159	x
415	16.666	0.196	x	502	14.124	-0.091	c
503	14.300	-0.105	c	504	14.443	-0.131	b
505	14.549	-0.170	a	506	14.887	-0.048	b
507	15.023	-0.127	c	508	15.277	-0.018	x
510	15.847	0.167	x	511	16.102	0.249	x
512	16.380	0.300	x	513	16.377	0.168	x
514	16.542	0.169	x	602	14.191	-0.113	a
603	14.283	-0.169	b	604	14.443	-0.209	c
605	14.656	-0.147	b	606	14.950	-0.079	x
609	15.663	0.091	c	611	16.455	0.522	x
612	16.366	0.247	x	701	14.137	-0.087	b
702	14.230	-0.142	a	704	14.543	-0.184	b
705	14.776	-0.136	b	706	15.246	0.118	x
707	15.299	0.017	x	713	16.426	0.060	x
801	14.200	-0.096	b	802	14.332	-0.149	a
803	14.480	-0.132	c	804	14.666	-0.111	c
805	14.848	-0.087	x	811	16.426	0.380	x
900	14.143	-0.041	b	901	14.145	-0.214	x
906	15.321	0.071	c	910	16.121	0.190	x
911	16.369	0.232	x	912	16.732	0.393	x
1001	14.437	0.011	x	1002	14.592	0.021	c
1003	14.784	0.068	x	1004	14.959	0.013	x
1006	15.415	0.068	x	1008	15.817	0.162	c
1009	16.053	0.162	x	1010	16.223	0.177	x
1011	16.414	0.199	c	1101	14.594	0.092	x
1102	14.796	0.111	c	1103	14.967	0.124	c
1104	15.108	0.100	x	1105	15.378	0.139	c
1107	15.800	0.203	c	1108	16.011	0.219	x
1109	16.183	0.257	c				

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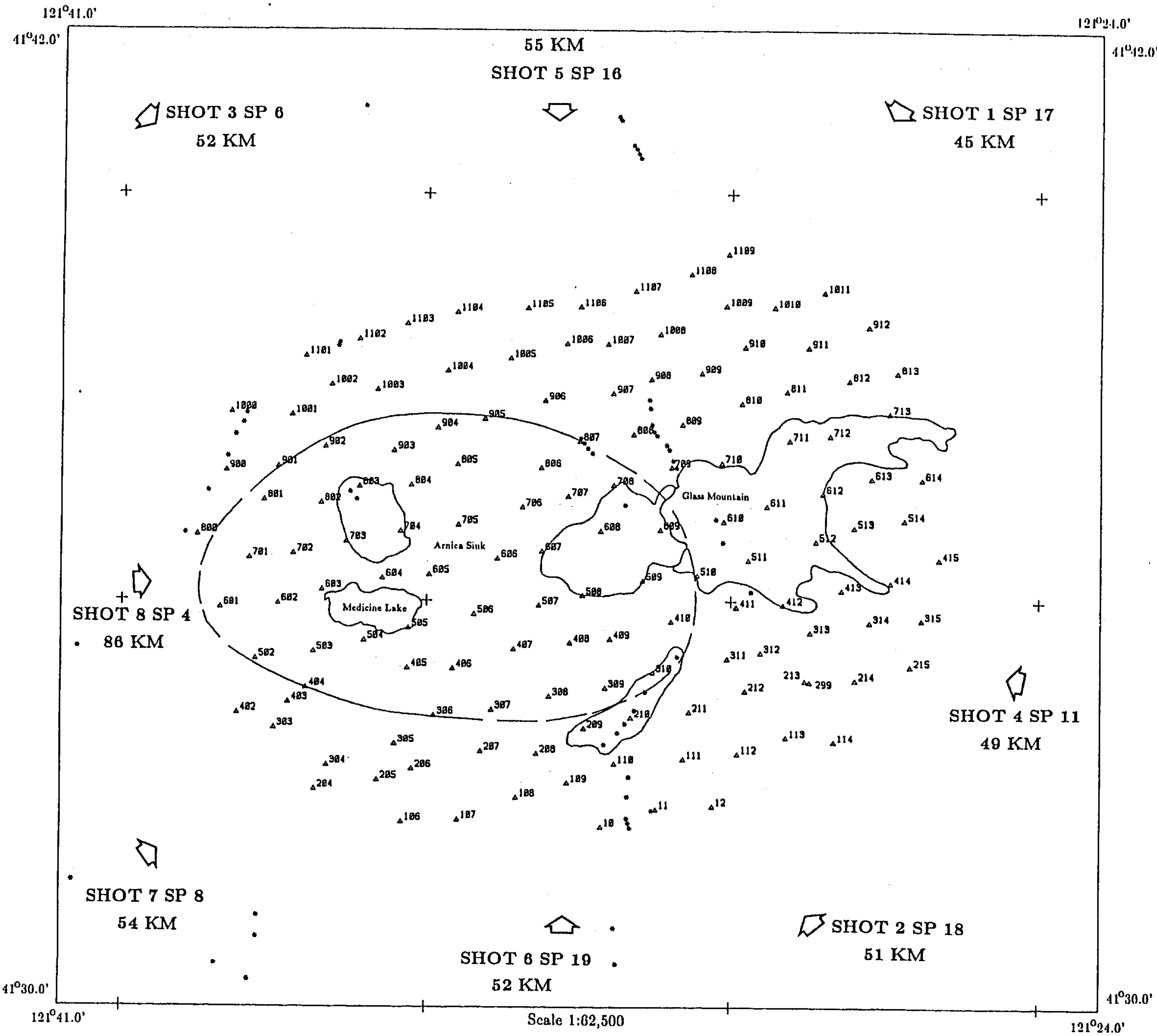
Plate 1 of 1



Seismic Recorder Location
Holocene Vent
Holocene Flow
Caldera Boundary
Approx. Distance, Shotpoint to Array 45 KM

5 KM

N

Geologic base from J. Donnelly-Nolan, unpublished mapping, 1985

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards.

MEDICINE LAKE VOLCANO, CALIFORNIA SEISMIC TOMOGRAPHY ARRAY

by

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1986