

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

DATA REPORT FOR DENSE ARRAY RECORDINGS FROM NINE AFTERSHOCKS OF THE
JULY 21, 1986 EARTHQUAKE IN CHALFANT VALLEY, CALIFORNIA

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OPEN-FILE REPORT 88-71

This report is preliminary and has not been reviewed for conformity with U. S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS

¹USGS Menlo Park, California

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INTRODUCTION

The U. S. Geological Survey deployed 120 refraction seismometers in Chalfant Valley, just north of Bishop, California, on August 3, 1986 to record aftershocks of the July 21, $M_L = 6.4$ earthquake. This experiment occurred during the return trip from a multi-institutional seismic experiment in Northern Nevada. The primary goal of this experiment was to measure the seismic coda using two cross-arrays. Centered about 4 km east of the main shock, a N-S connecting line ties the arrays together (Figure 1), and can be used for crustal modeling of the immediate area. The high quality and dense spacing of the data may also be suitable for source imaging, and analysis of radiation patterns and the influence of local geology.

Located at the north end of Owens Valley, Chalfant Valley is within the Basin and Range Province. It is bounded by N-S trending normal faults with the White Mountains on the east, and the Benton Range on the west. The Bishop Volcanic Tablelands rise from the Chalfant Valley, around the southern end of the Benton Range, to Long Valley Caldera 25 km northwest of the main shock. Mesozoic and Paleozoic low grade metamorphic rocks and Mesozoic plutonic rocks make up the basement exposed in the White Mountains and the Benton Range (Crowder and Sheridan, 1972). The eruption of Long Valley Caldera 700,000 years B.P. (Cockerham and Corbett, 1987) deposited the Bishop Tuff that makes up the Volcanic Tablelands. The instrument line traverses various grades of Bishop Tuff and alluvium. Numerous N-S trending normal faults are located west of the deployment line (Figures 1, and 2). Surface fractures from the 1986 earthquake sequence (Lienkaemper et al., 1987) occur along faults in the Volcanic Tablelands, as well as along the White Mountain Frontal Fault Zone (WMFFZ) (Figure 1). Although the Tableland faults and the WMFFZ are mapped as normal faults (Crowder and Sheridan, 1972), strike-slip motion is predominately observed (Cockerham and Corbett, 1987). The dextral slip of the mainshock is consistent with the right lateral slip observed on the 1872 Owens Valley earthquake south of Bishop (Cockerham and Corbett, 1987).

This report displays the digital data available on magnetic tape in SEG-Y format. Nine aftershocks located by the Central California Seismic Network (CALNET) were selected and digitized. Other aftershocks were recorded and could be digitized, but were not located at the time of this report.

DESCRIPTION OF SURVEY

The recording geometry consists of two dense N-S, E-W cross-arrays connected by a less dense N-S trending line. Instrument spacing on the connecting line is about 300 m, whereas the denser cross-arrays have about 60 m spacing. The connecting line is about 23 km long consisting of 65 instrument sites. The northern cross-array has dimensions of approximately 1.0 km N-S by 1.0 km E-W with 13 instrument sites in both directions. Similarly, the southern cross-array is approximately 1.3 km N-S by 1.0 km E-W, with 14 and 11 instrument sites, respectively (Figure 2). The N-S connecting line contains instrument locations 101 to 165. Location numbers in the 200's refer to the denser cross-arrays, with 201 to 225 for the north array, and 251 to 276 for

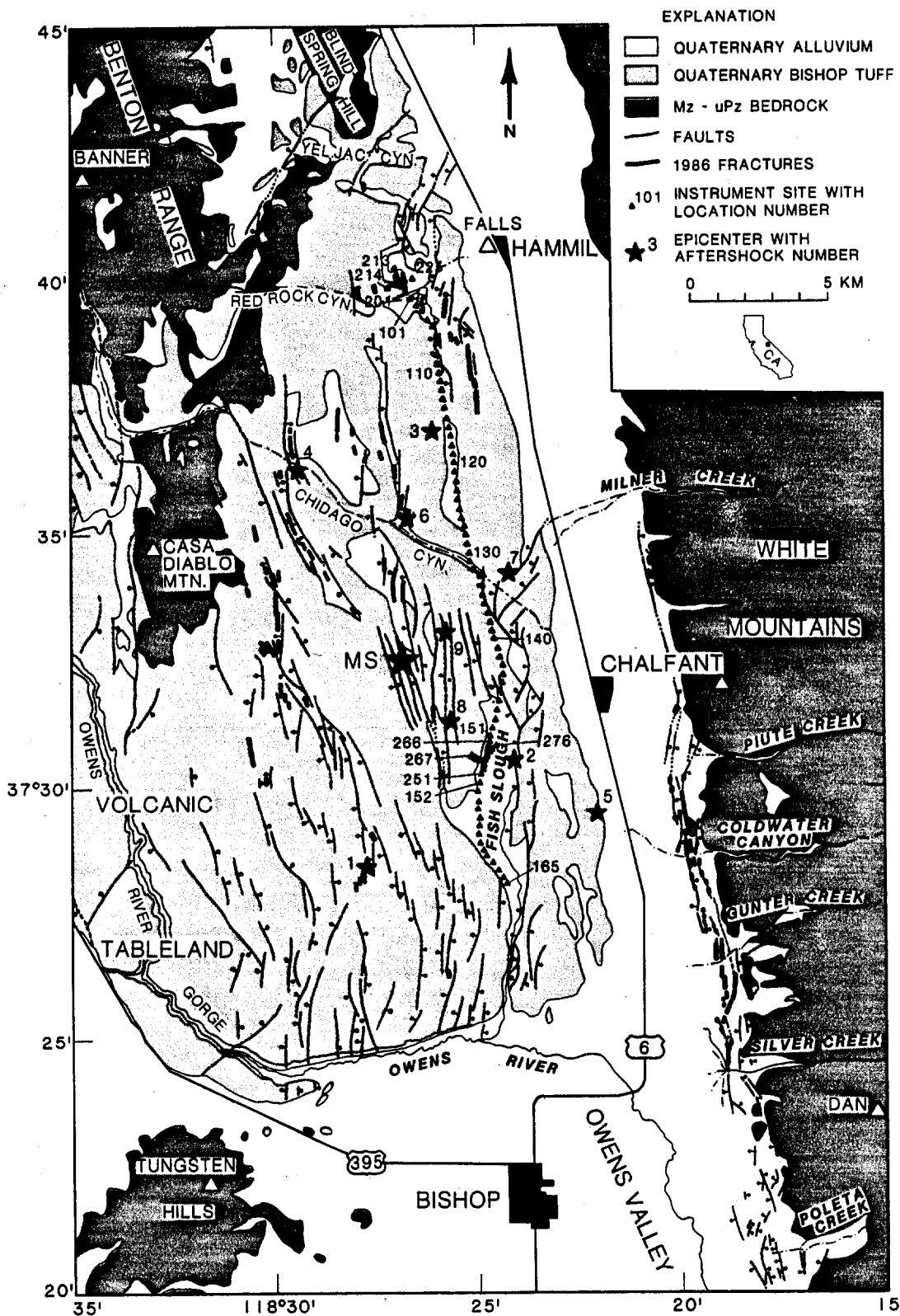


Figure 1. General geologic location map of seismograph array. The large star marked MS locates the main shock of 21 July 1986 (after Lienkaemper et al., 1987, Figure 2).

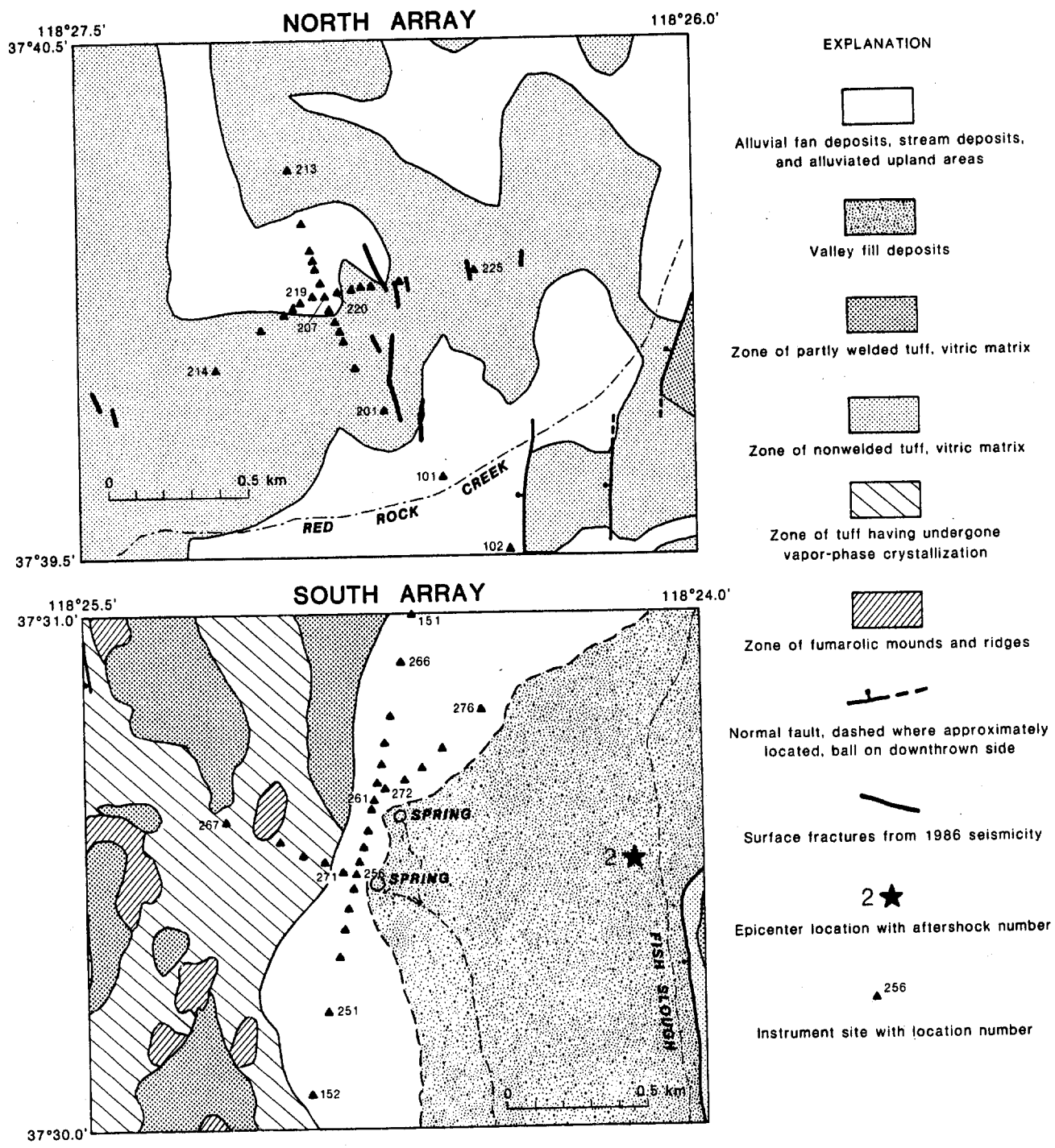


Figure 2. Detailed geologic location maps of the dense cross-arrays (Crowder and Sheridan, 1972, Lienkaemper et al., 1987).

the south array (Figures 1 - 2, and Table 1). Instrument locations and elevations on the connecting N-S line are accurate to ± 25 m and were determined from 1:62,500 topographic maps and 1:24,000 orthophoto quadrangles. The dense arrays were surveyed with an electronic distance meter (EDM) and have a horizontal accuracy of about ± 5 m. Once deployed, the instruments activate and record automatically for the desired time intervals.

The instruments were programmed to record on August 3, 1986 during four 27 minute time windows: 4:00:00 - 4:27:00, 6:00:00 - 6:27:00, 15:00:00 - 15:27:00, and 17:00:00 - 17:27:00 (UTC). Immediately before each recording window, each instrument also recorded a calibration. The northern and southern arrays recorded all nine events. Unfortunately, the N-S connecting line only recorded during the 4:00:00 and 6:00:00 windows. Therefore, only three of the nine digitized events were recorded by the N-S line (Table 2).

INSTRUMENTATION AND DATA REDUCTION

Seismic Recorders

The instruments used in this survey are usually deployed in seismic refraction experiments. The portable seismographs are individual units, each equipped with a memory board to store recording times, and a recording system. Six teams deploy the 120 suitcase-sized instruments that weigh about 18 kg each (Healy and others, 1982). Two 6-volt rechargeable batteries power each recorder, and a crystal controlled clock serves as the instrument chronometer with an accuracy of about $1:10^{-7}$. Before each deployment, technicians program up to 10 recording times and synchronize the chronometer of each recorder with a master clock. The master clock has a drift rate of about 1 msec per week and is synchronized to a GOES satellite clock or a rubidium standard reference clock, accurate to approximately 3 msec/yr, which is periodically calibrated to an averaged WWVB reference signal. The National Bureau of Standards' cesium-beam clocks control the WWVB and GOES signals. After retrieval, the instruments' chronometer drift is noted relative to the master clock. During deployment a vertical-component 2 Hz geophone is oriented and buried. Ten minutes before the recording time, the instruments stabilize and then record a calibration, which includes a seismometer pulse, amplifier step, and 1, 10, 100, and 1000 mV, 10 Hz sine wave calibration signals. The recording window proceeds immediately after the calibration. The seismometer output is divided, without attenuation, and amplified at selected gains by three parallel amplifiers, which allows for recording over a dynamic range of 84 db (Figure 3). Output from the three amplifiers and a serial IRIG-E time code pulse train are frequency modulated, summed with a tape speed compensation reference signal, and analog recorded on 60 minute cassette tape. The system measures velocity with a frequency response that peaks at 6 Hz and sharply rolls off beyond 20 Hz, avoiding 60 Hz contamination (Figure 4).

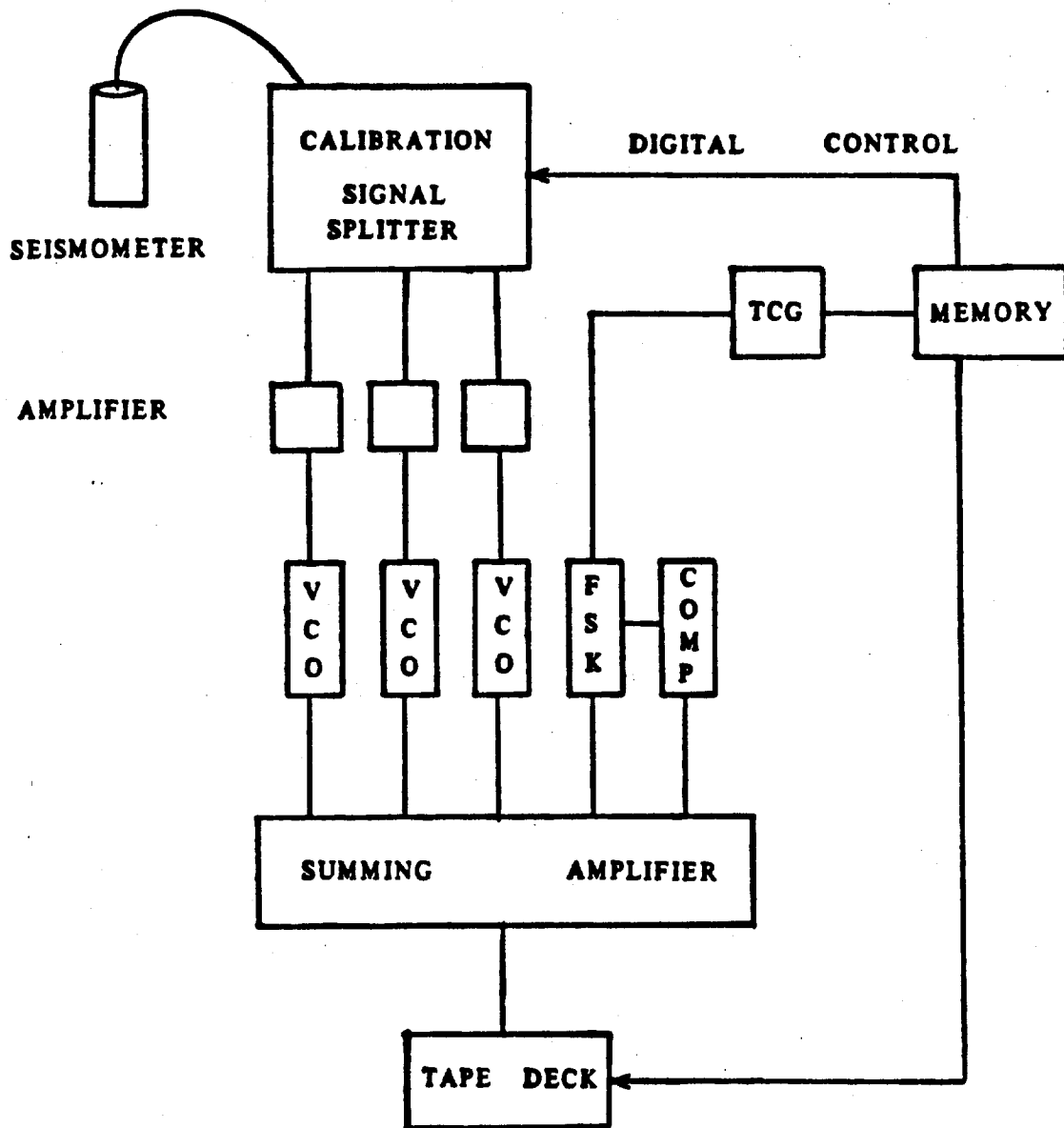
Data Reduction

Aftershocks were chosen, digitized, and plotted as record sections. The quality of each trace is assessed and the trace is redigitized if necessary. Events were chosen from stripchart playbacks of recordings from three instruments, one located towards either end of the main line, and one in the middle. Dozens of aftershocks were recorded during the experiment, averaging about three every minute (Figure 5). Any event located by CALNET with little or no interference from other events was digitized. The M_L of the events digitized range from 0.9 to 1.7; the depths range from 4.7 km to 15.3 km. Location uncertainties are within 1 km for 7 of the 9 events; two events (4 and 8) were poorly located (Table 2). However, the hypocenter locations could be improved by the addition of the traveltimes from this data set, since the aftershock region spans most of the deployment line. Initially, aftershocks 1 and 3 were digitized for 40 seconds with a sampling rate of 100 samples/sec, beginning 4 seconds before the origin time. Since most of the coda durations were less than 20 seconds, all events were digitized for 20 seconds with a sampling rate of 200 samples/sec. Therefore, both record lengths are available for aftershocks 1 and 3. Record sections (Figures 6-26) are displayed to maximum recording length available, and each trace is normalized to its maximum amplitude. Due to the relative position of the recording array to some of the aftershocks, many record sections are displayed as fans, i.e. distance plotted relative to a trace at the end of the record section (such as in Figure 6). The remaining record sections are plotted by epicentral distance. Noisy traces with little or no seismic signal are saved in the data file with a negative unit number (not location number, see definitions in Appendix A) and excluded from the record section. Each trace is assigned a tape grade code describing the quality of the recording and performance of the recorder. Tape grade codes are included in the Field Data Tables (Appendix A).

ARCHIVE TAPE

A SEG-Y (Barry and others, 1975, Appendix B) tape for this data set may be obtained from:

National Geophysical Data Center
NOAA/NGDC E/GC1
325 Broadway
Boulder, CO 80303
Telephone: (303) 497 - 6472



COMP = COMPENSATION
FSK = FREQUENCY SHIFT KEYING
TCG = TIME CODE GENERATOR
VCO = VOLTAGE-CONTROLLED OSCILLATOR

Figure 3. Schematic diagram of a recording unit (from Healy et al., Figure 13).

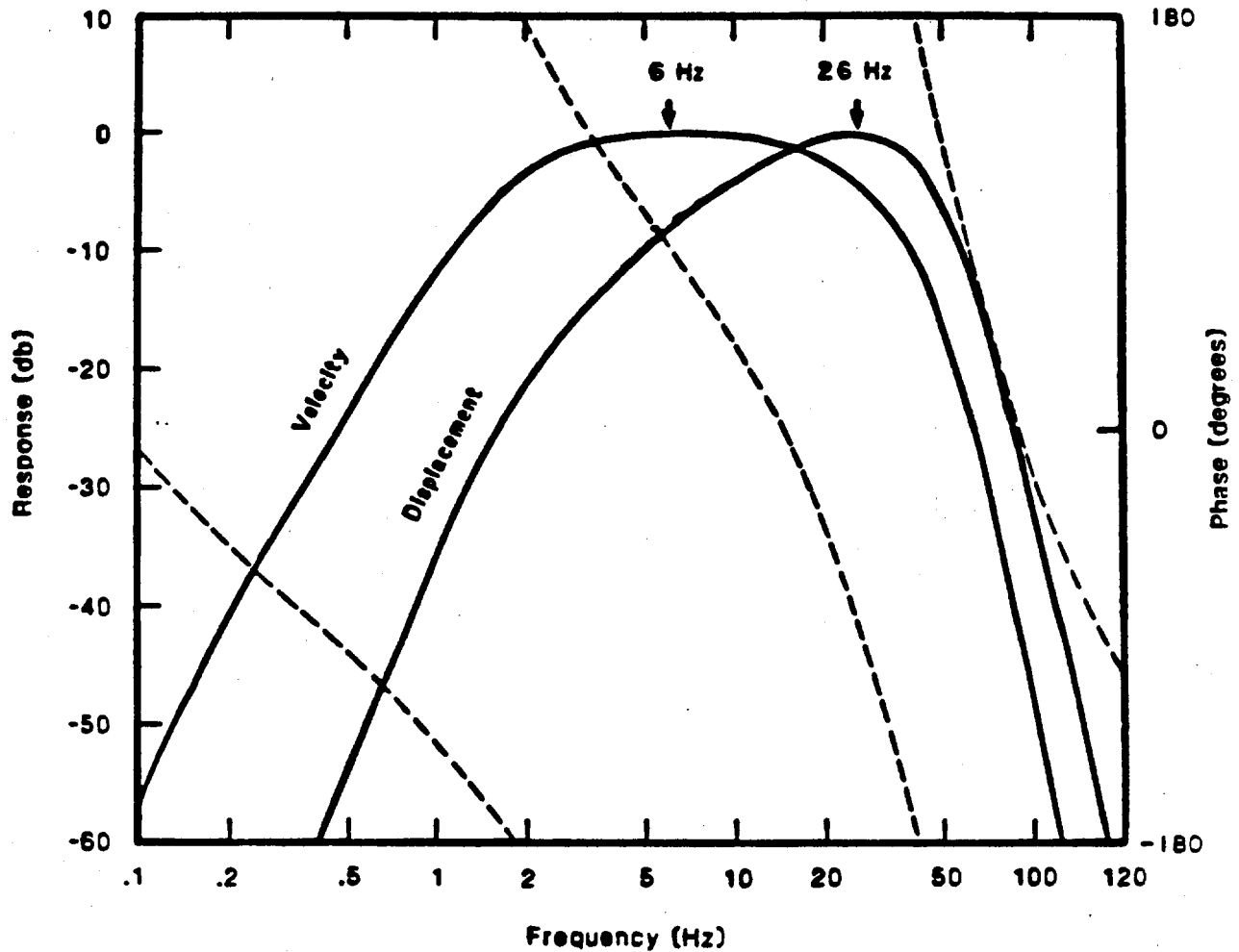


Figure 4. Theoretical transfer-function curves for the USGS short-period seismic refraction system. Solid line: displacement and velocity normalized amplitude, dashed line: phase (displacement). Maximum velocity response is at 6 Hz, maximum displacement response is at 26 Hz (from Dawson and Stauber, 1986, Figure 3).

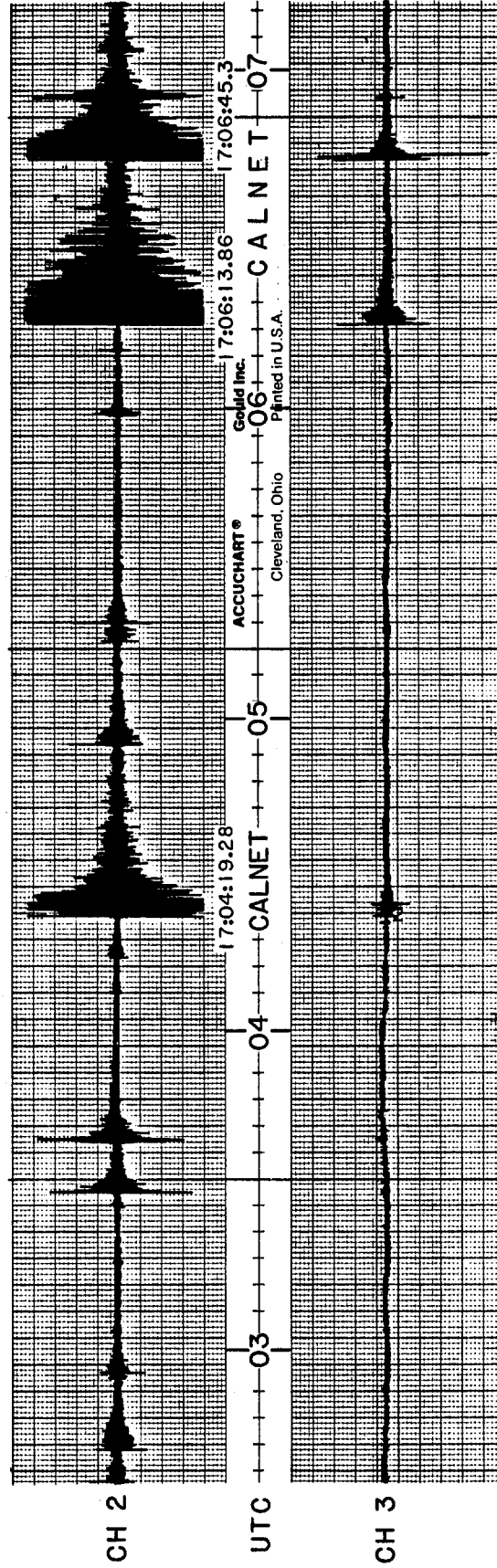
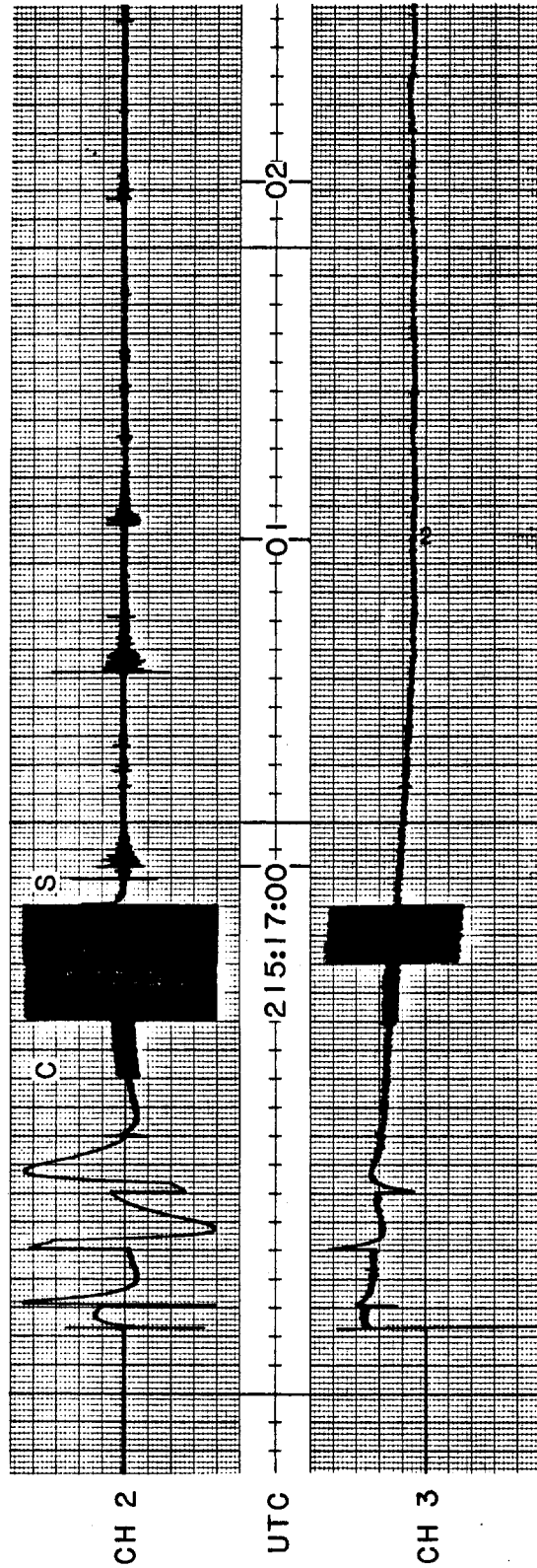


Figure 5. Strip chart play back from location 264 on Julian day 215 with a start time of 17:00:00 (UTC).

The letters R, C, and S denote the seismometer release, calibration sequence, and beginning of the seismic trace, respectively. The upper trace is channel 2 with 12 db attenuation, and the lower trace is channel 3 with 48 db attenuation. Numbered tics are approximate minutes. Events located by CALNET are indicated. Origin times are labeled beneath the digitized events. Figure continued on next two pages.

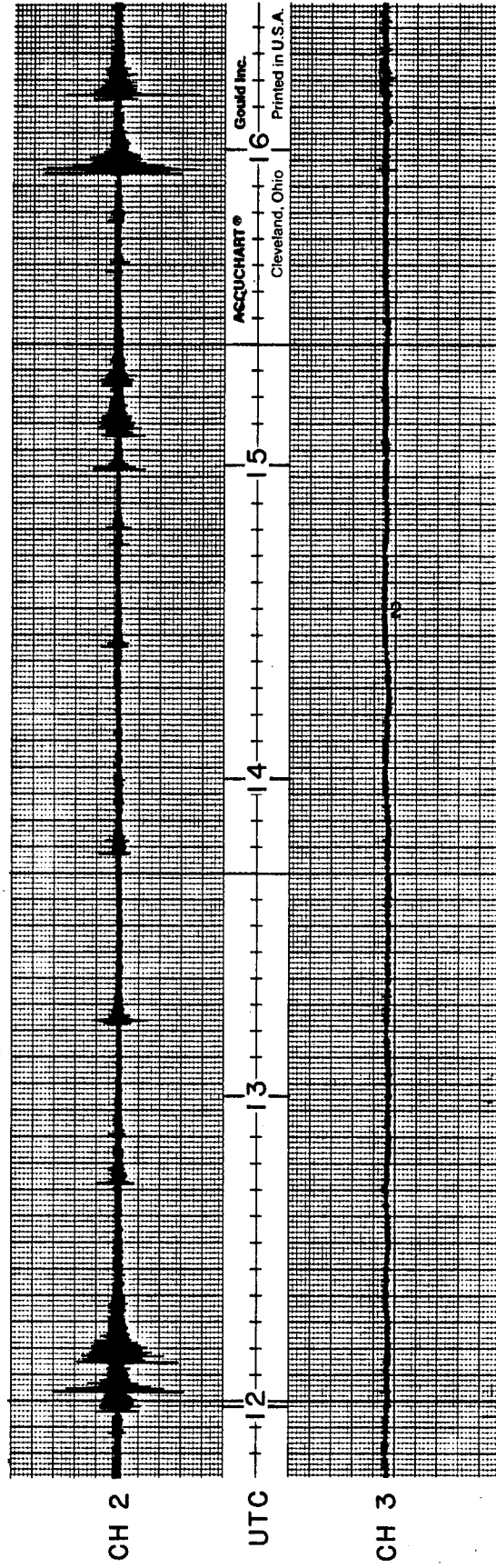
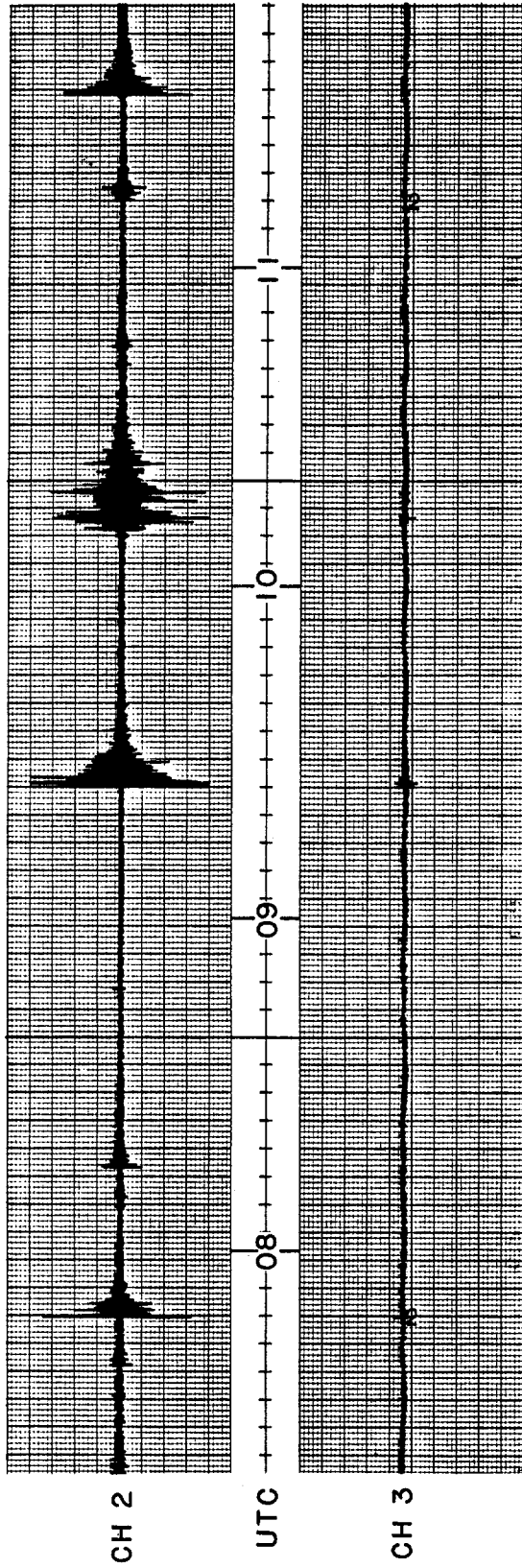


Figure 5. (Continued)

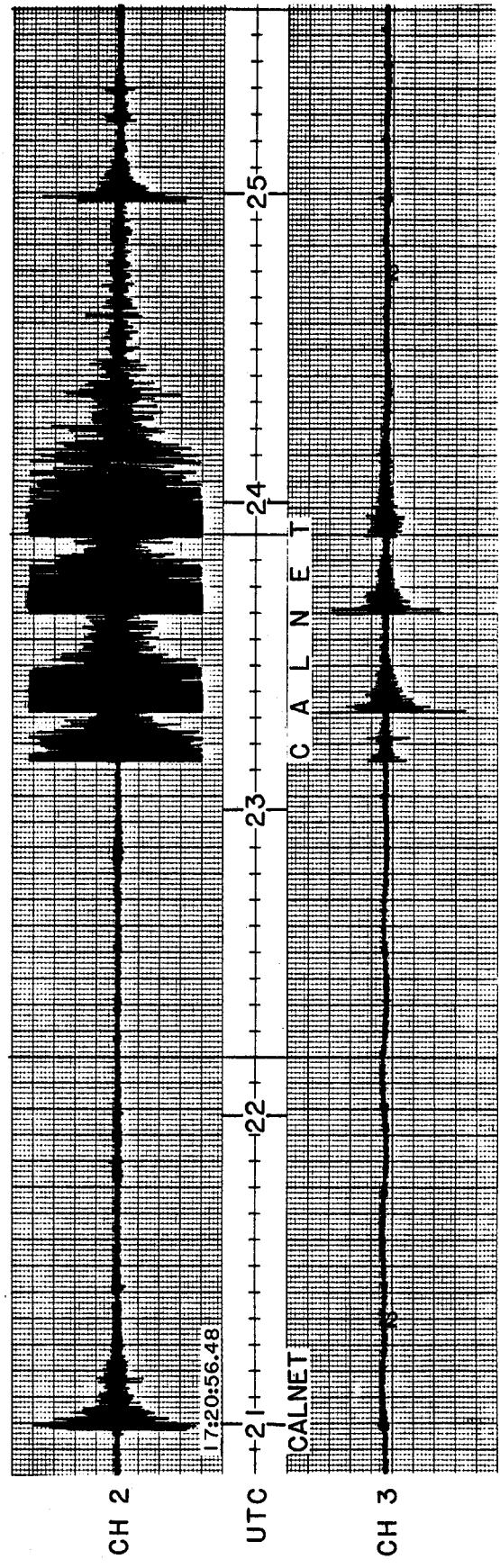
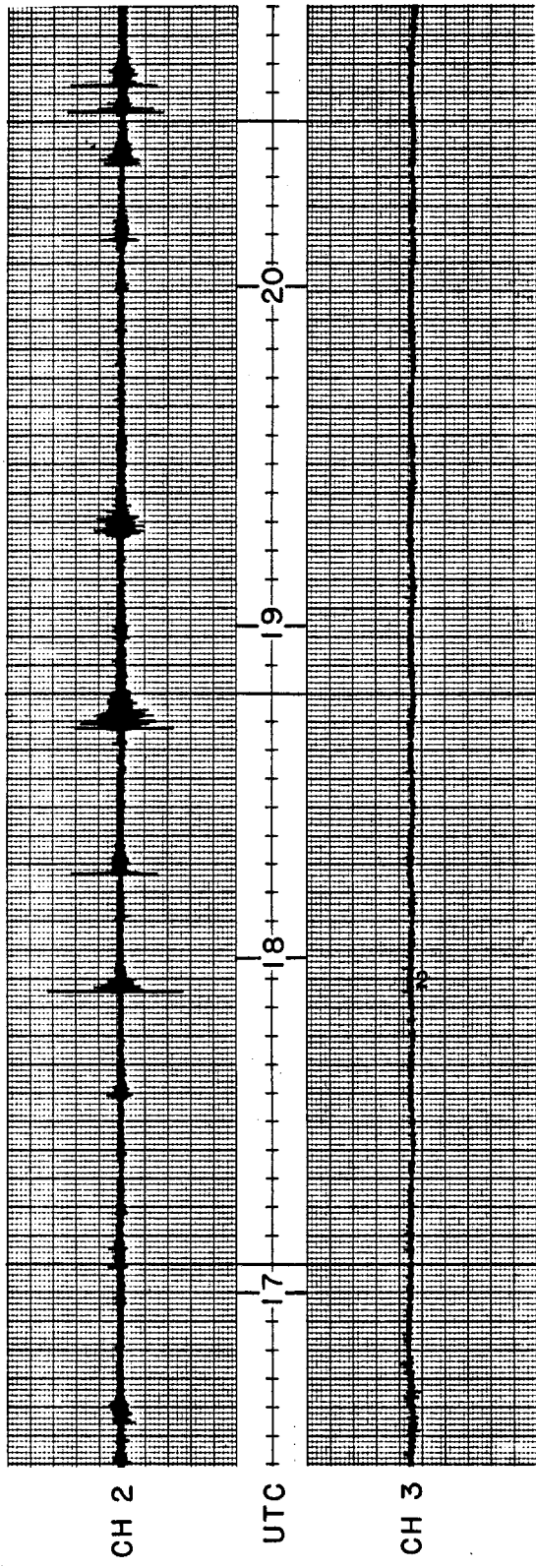


Figure 5. (Continued)

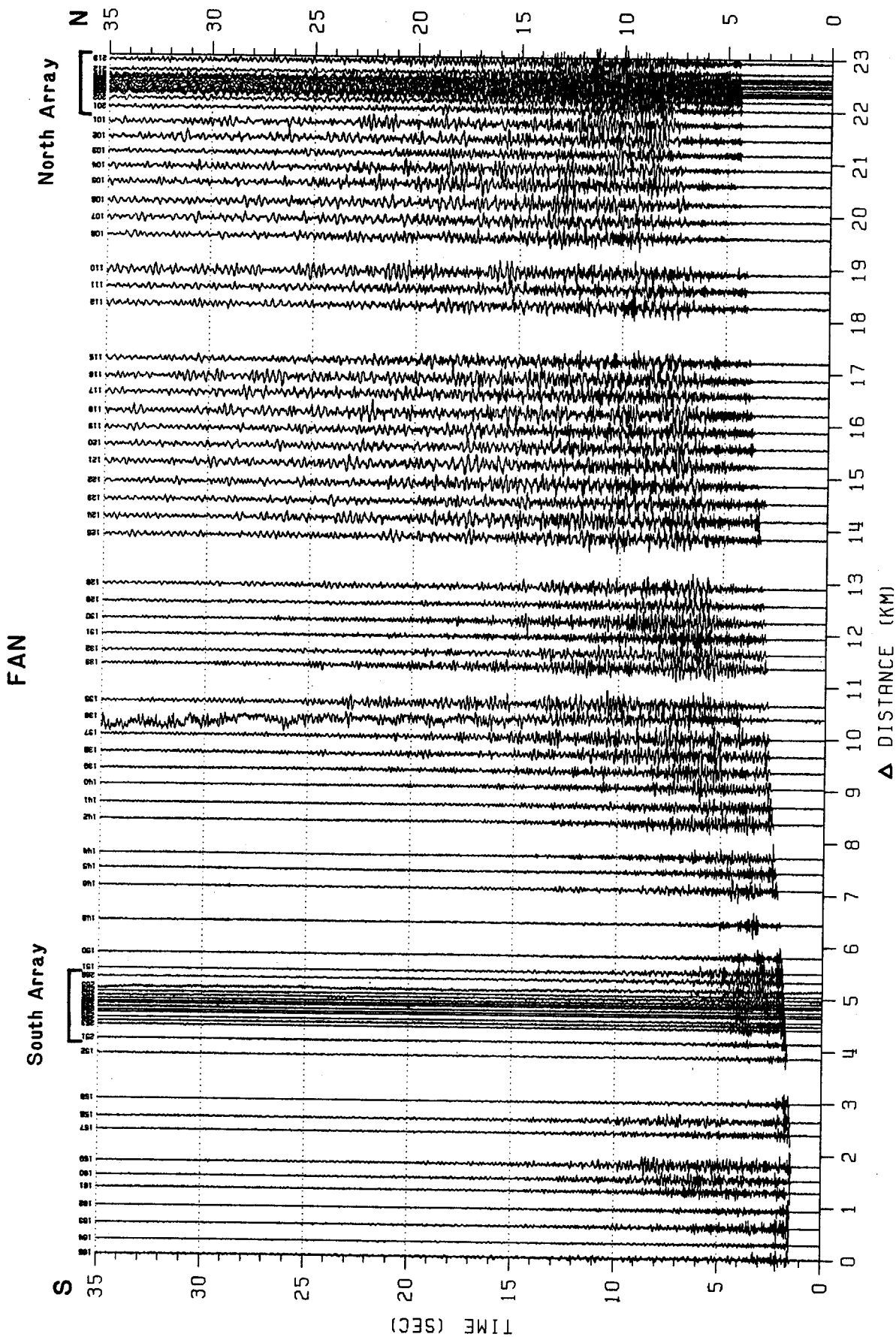
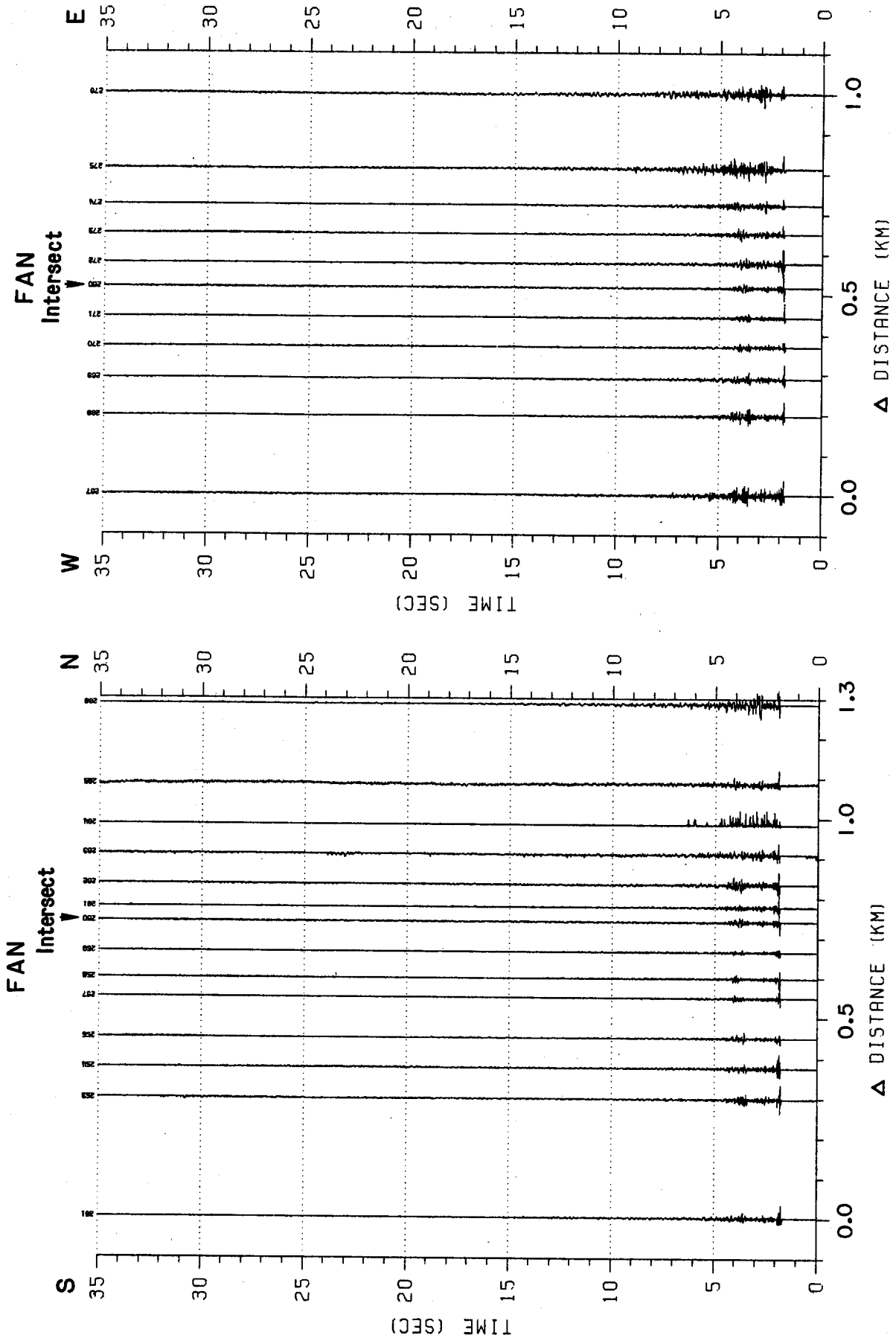
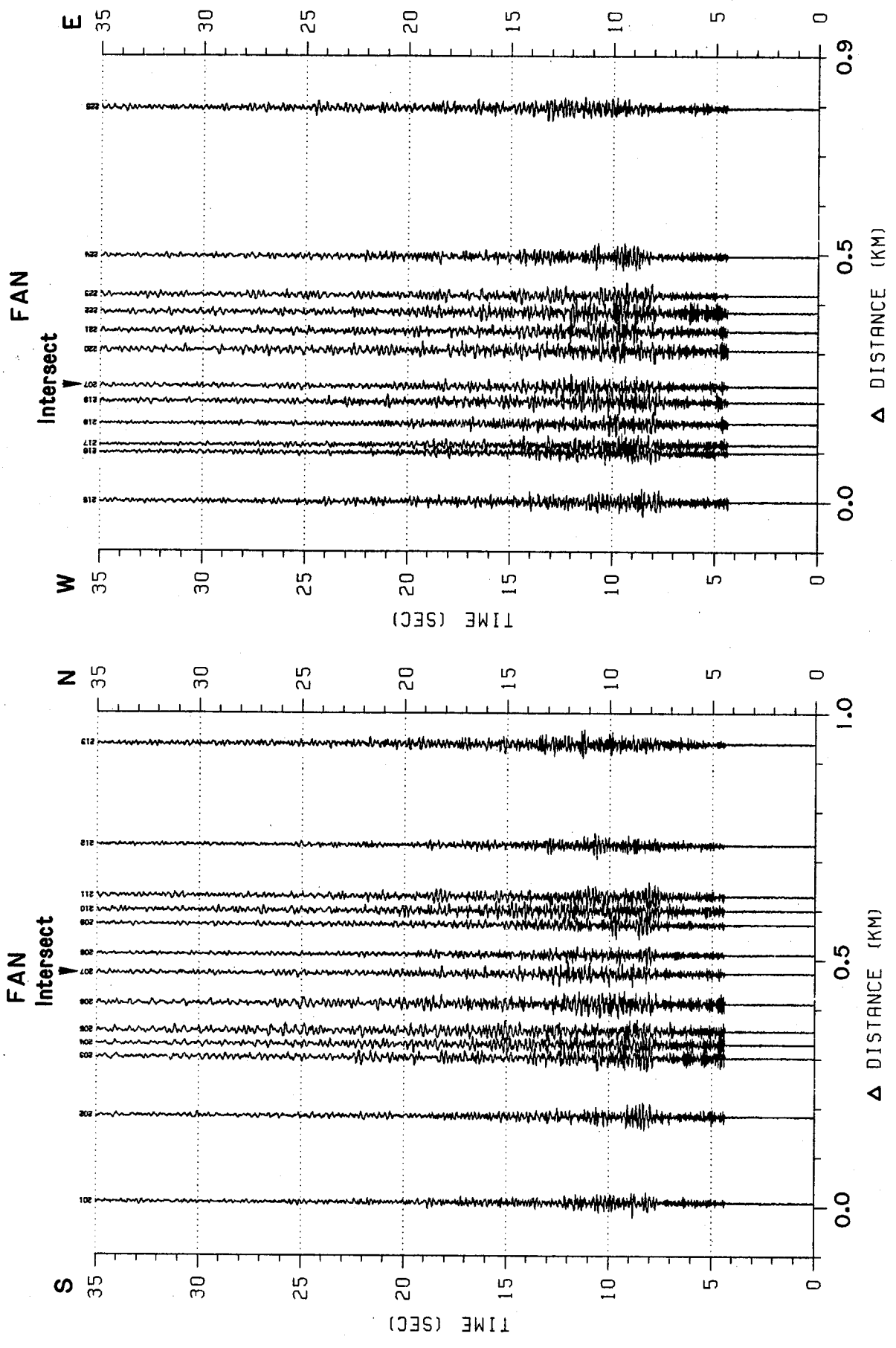


Figure 6. Aftershock No. 1 Normalized



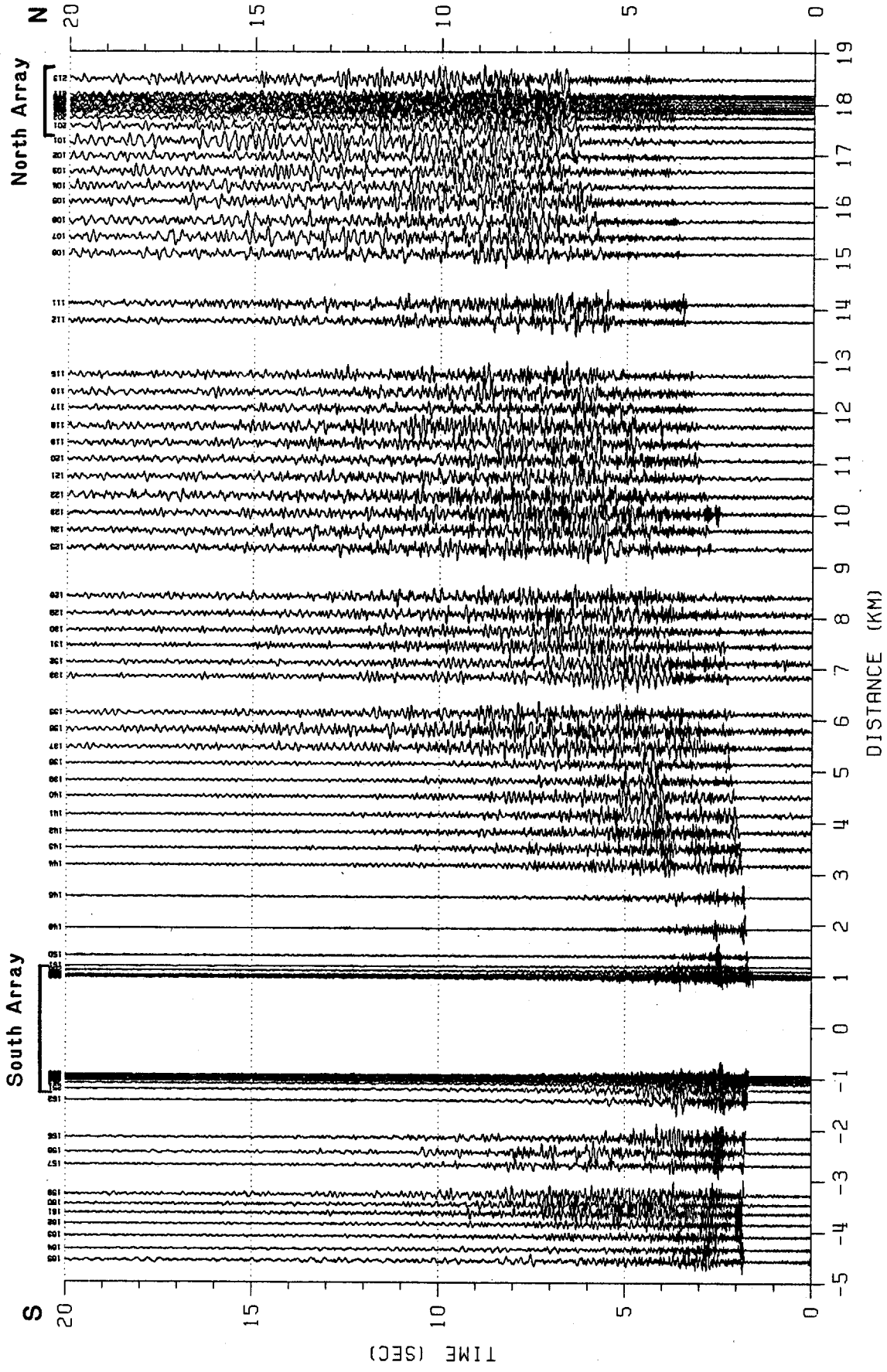
AFTERSHOCK NO. 1 NORMALIZED
SOUTHERN ARRAY

Figure 7.



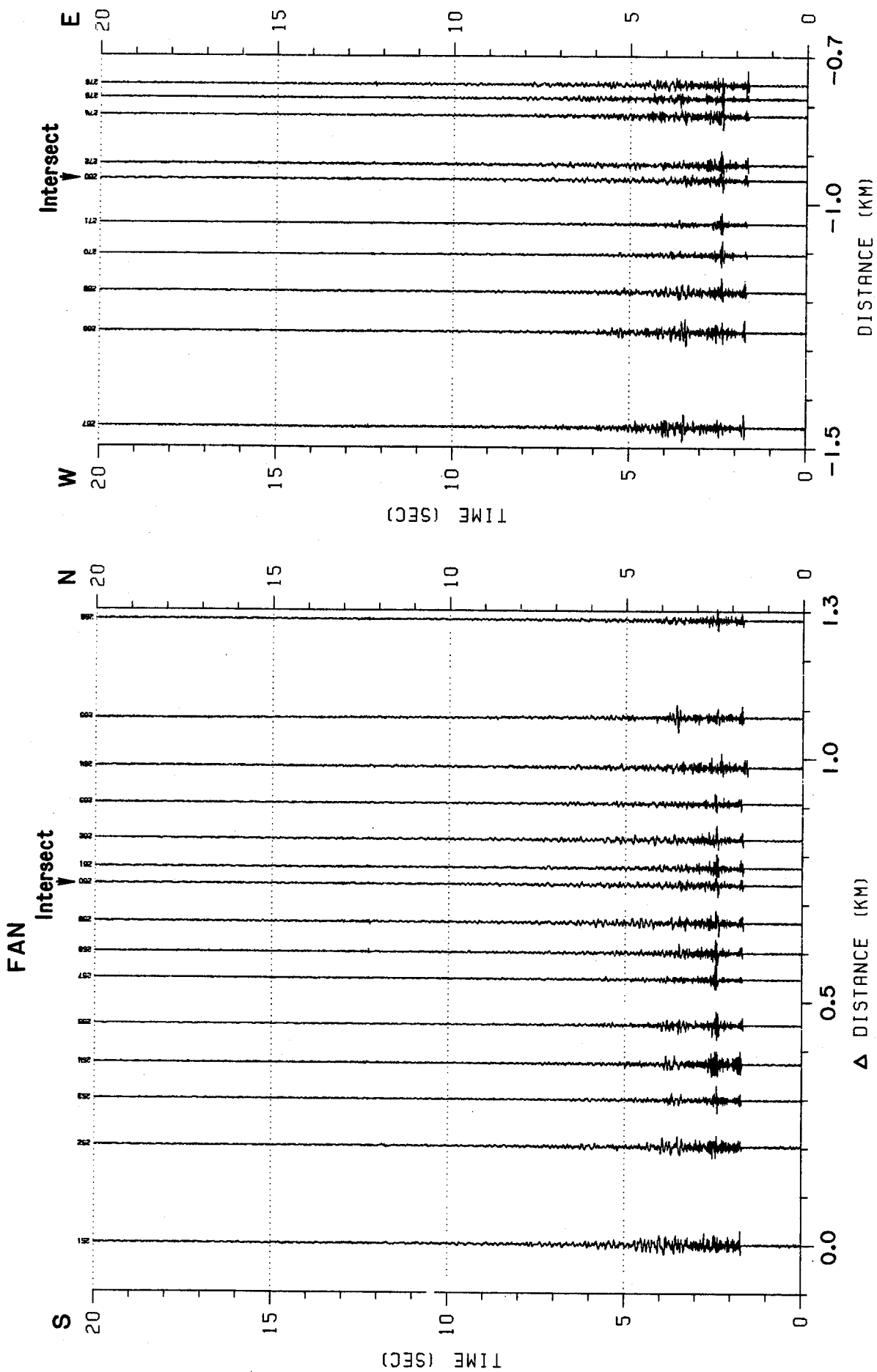
**AFTERSHOCK NO. 1 NORMALIZED
NORTHERN ARRAY**

Figure 8.



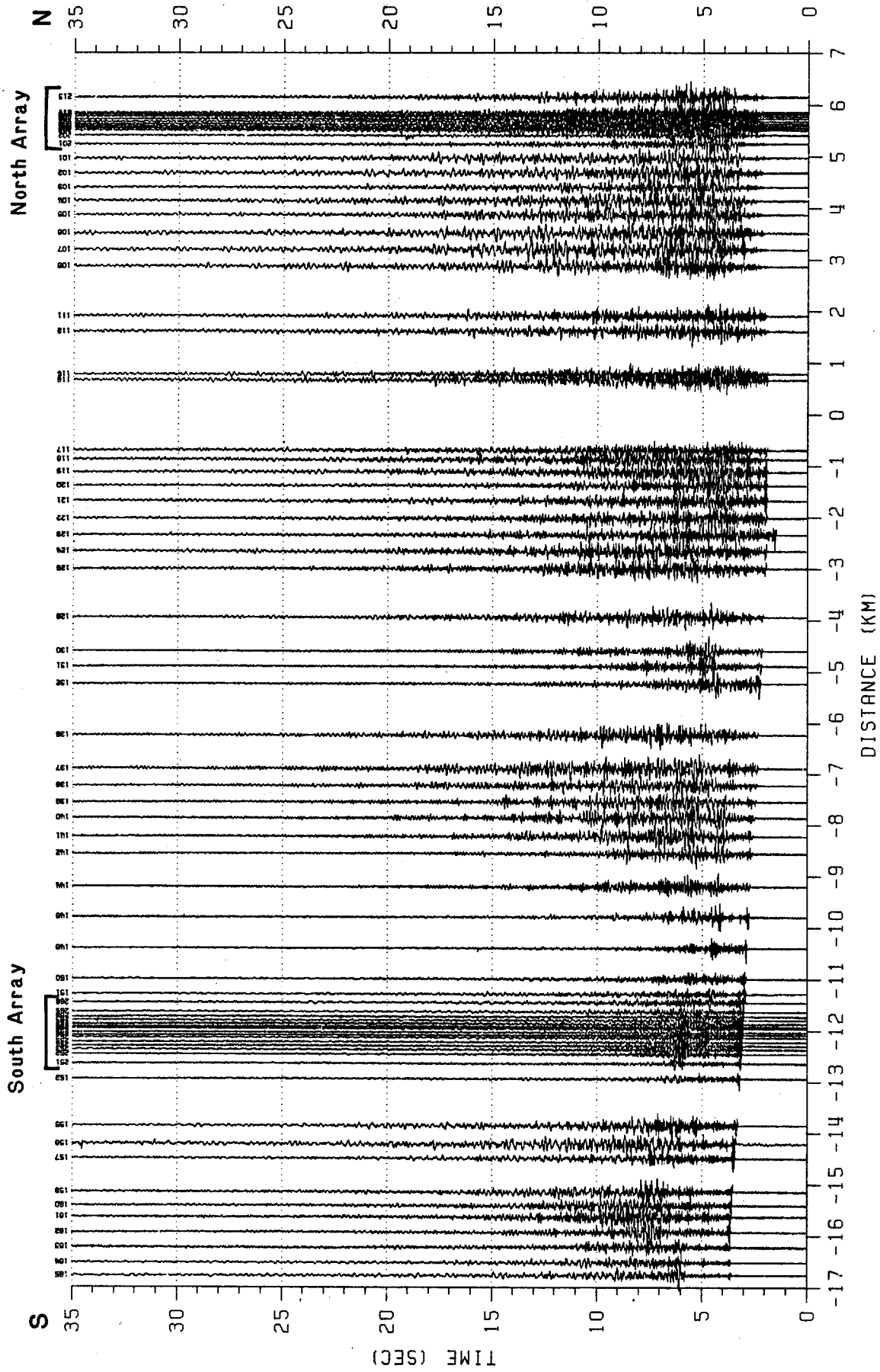
AFTERSHOCK NO. 2 NORMALIZED

Figure 9.



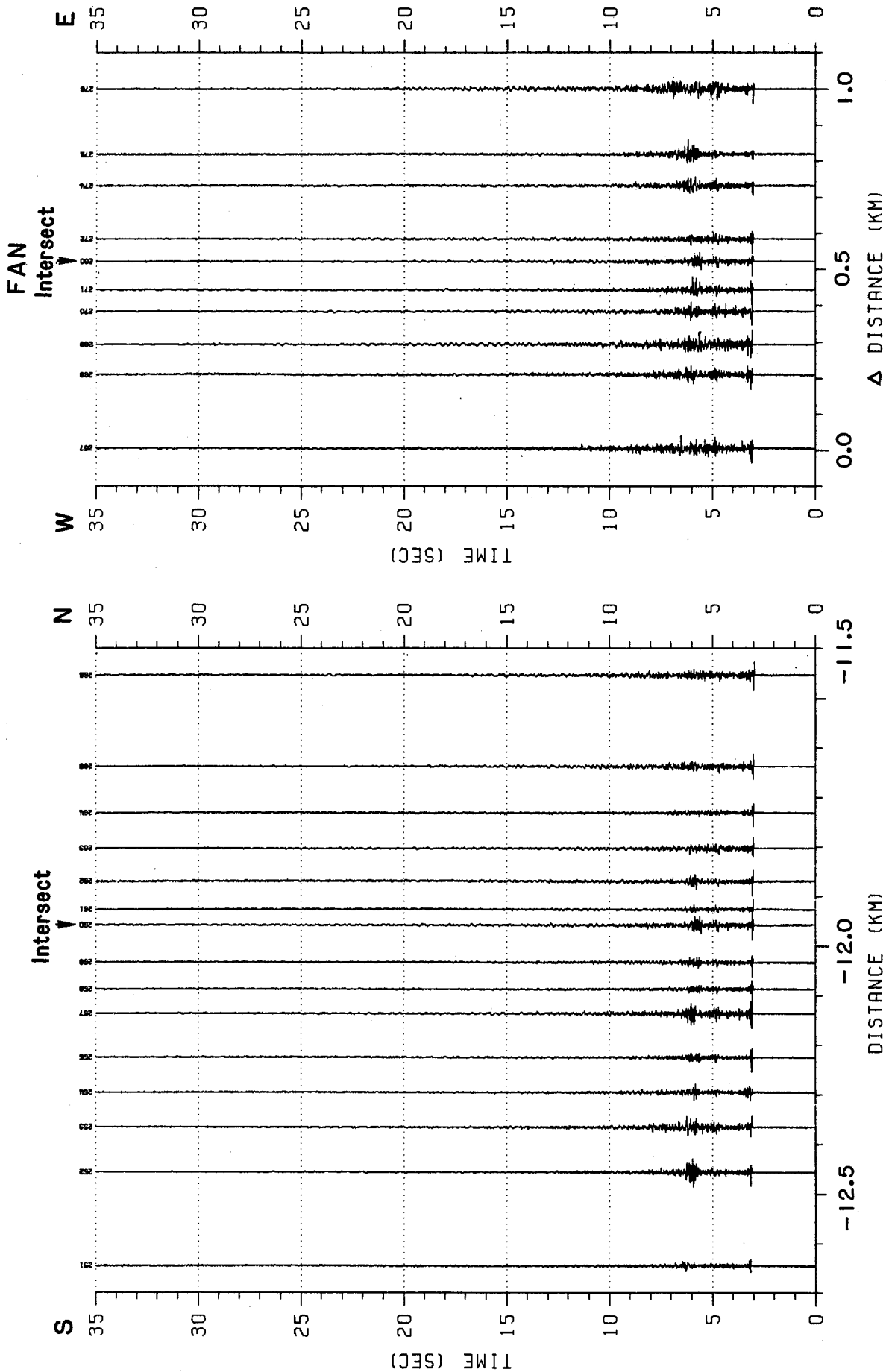
AFTERSHOCK NO. 2 NORMALIZED
SOUTHERN ARRAY

Figure 10.



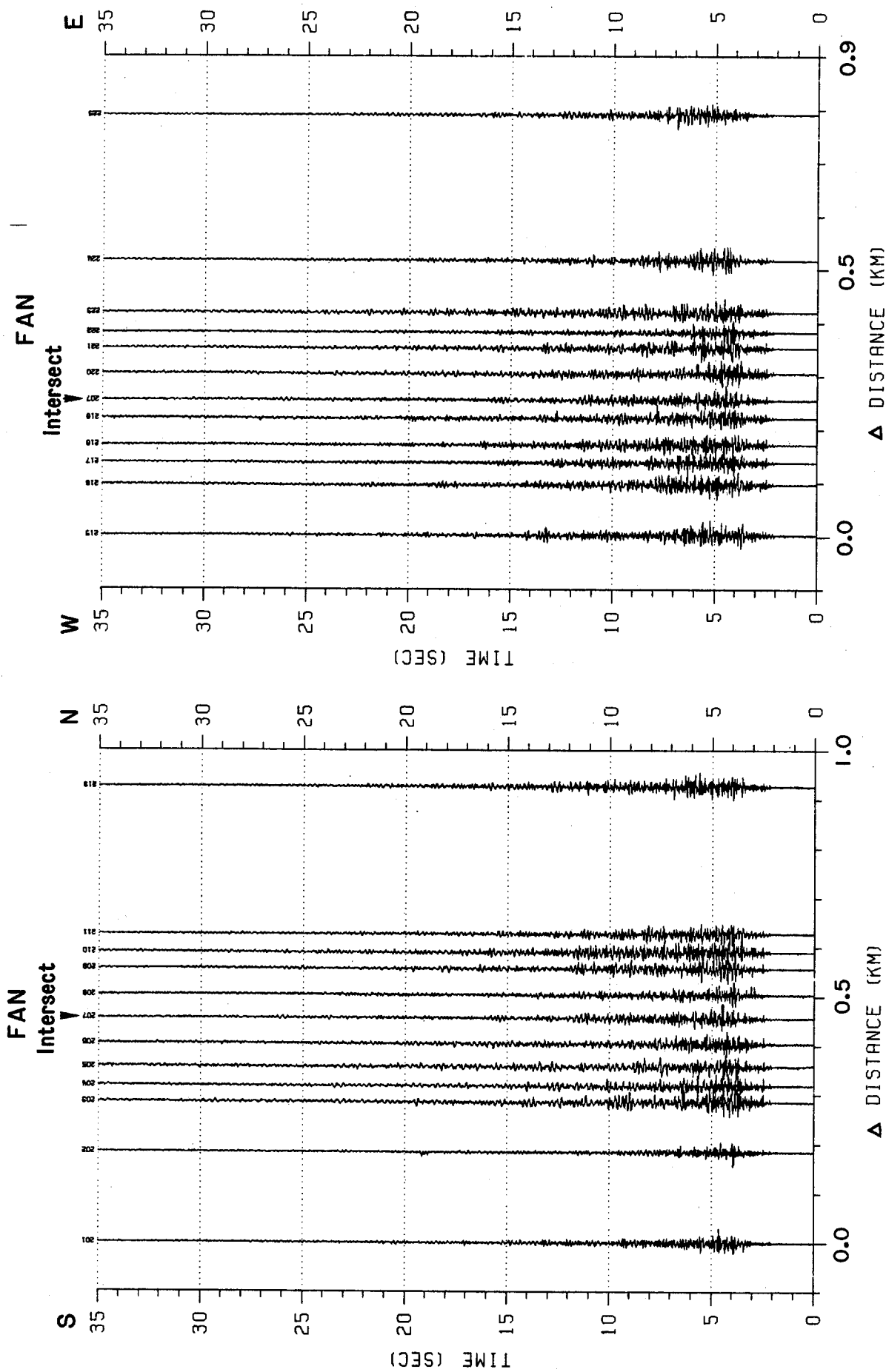
AFTERSHOCK NO. 3 NORMALIZED

Figure 12.



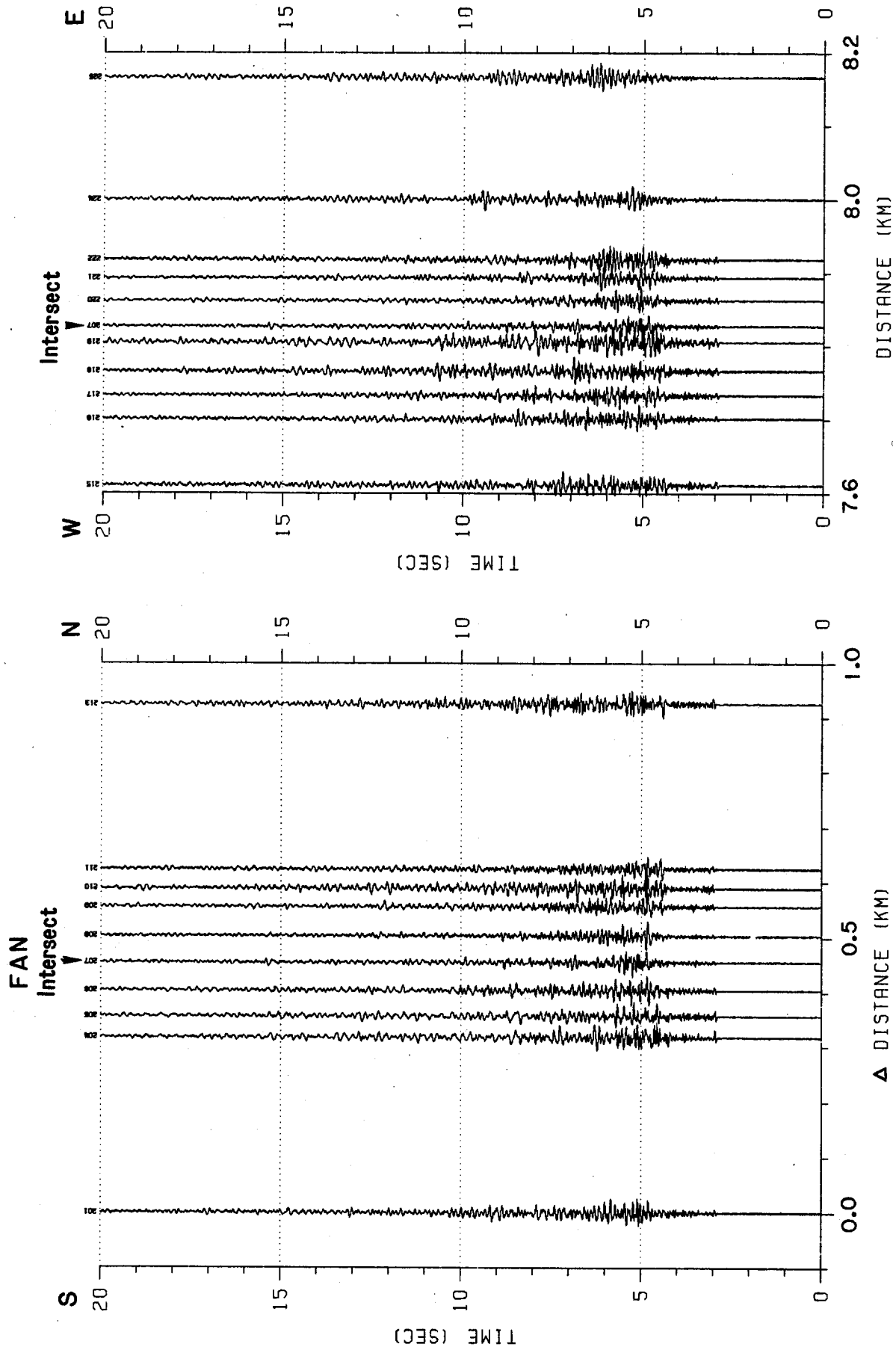
AFTERSHOCK NO. 3 NORMALIZED
SOUTHERN ARRAY

Figure 13.



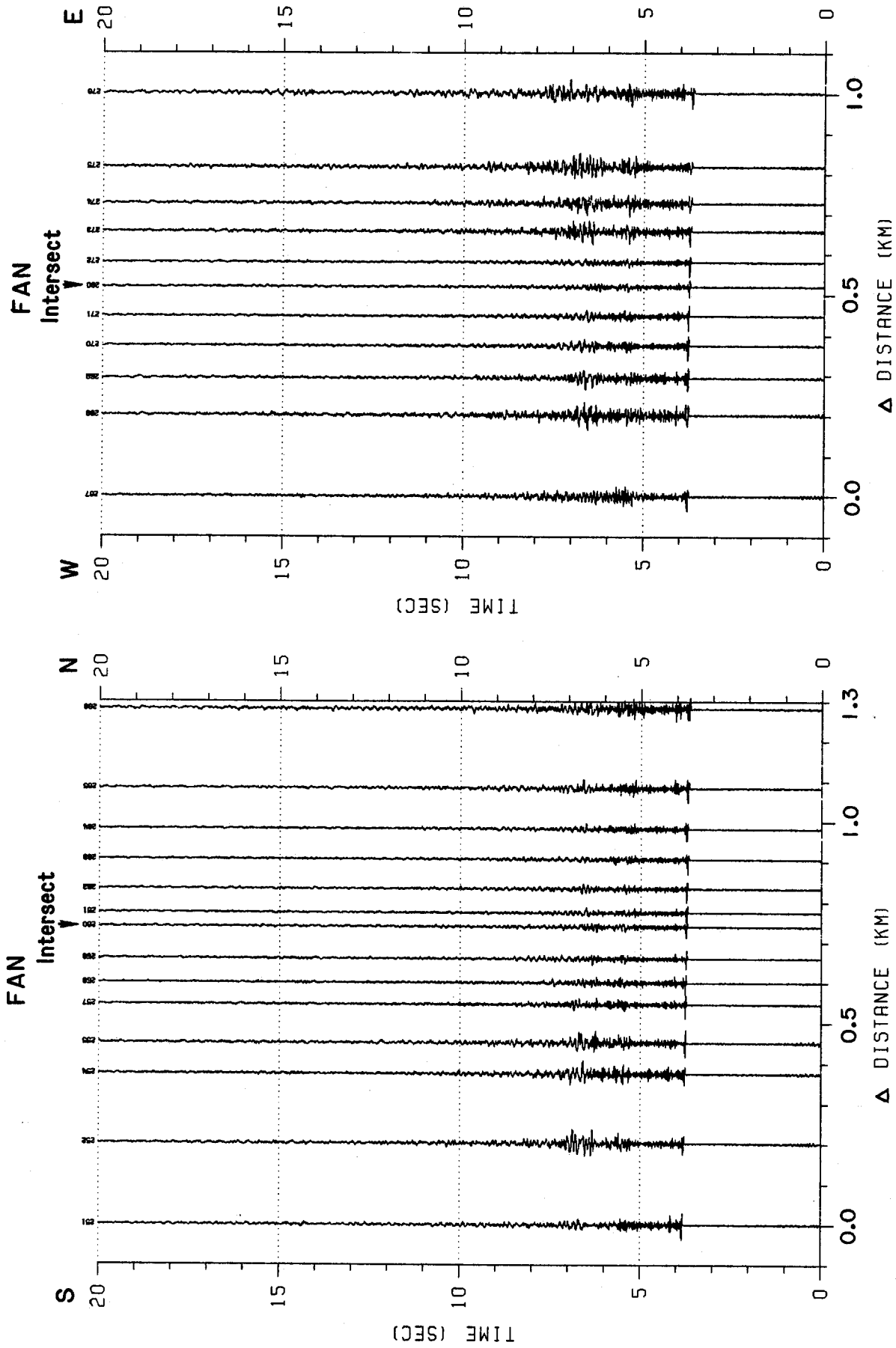
AFTERSHOCK NO. 3 NORMALIZED
NORTHERN ARRAY

Figure 14.



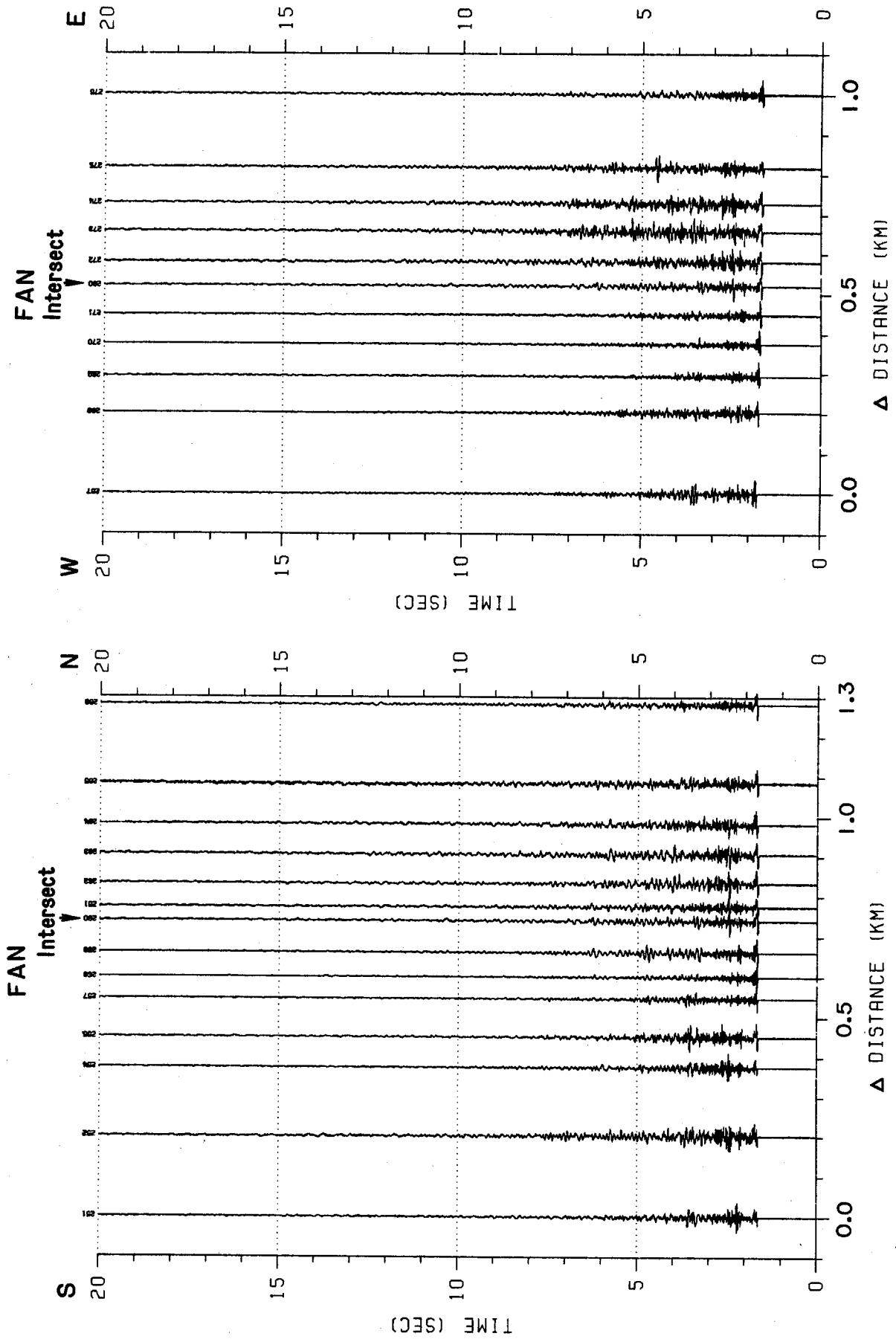
▲ AFTERSHOCK NO. 4 NORMALIZED
NORTHERN ARRAY

Figure 16.



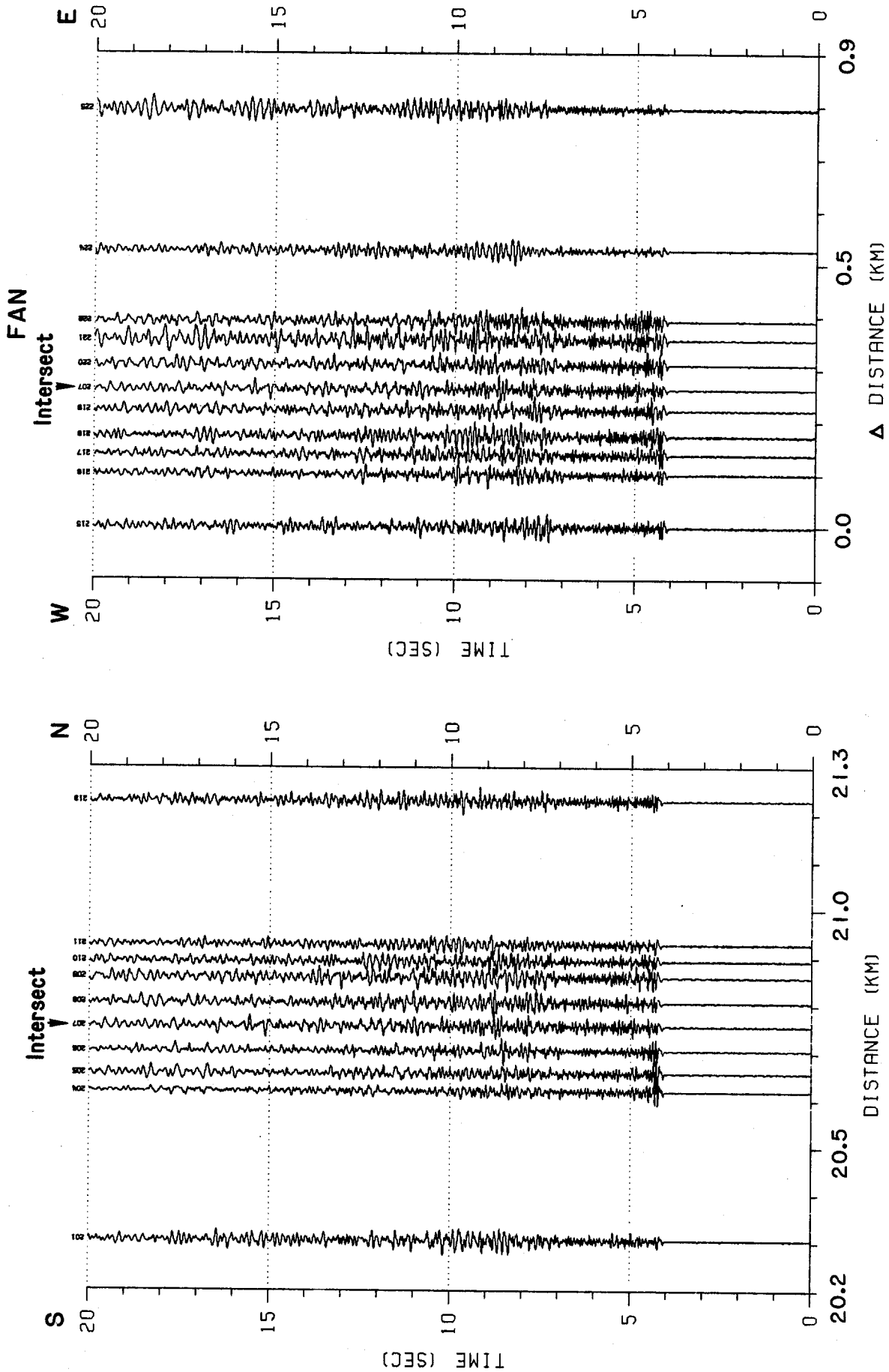
AFTERSHOCK NO. 4 NORMALIZED
SOUTHERN ARRAY

Figure 15.



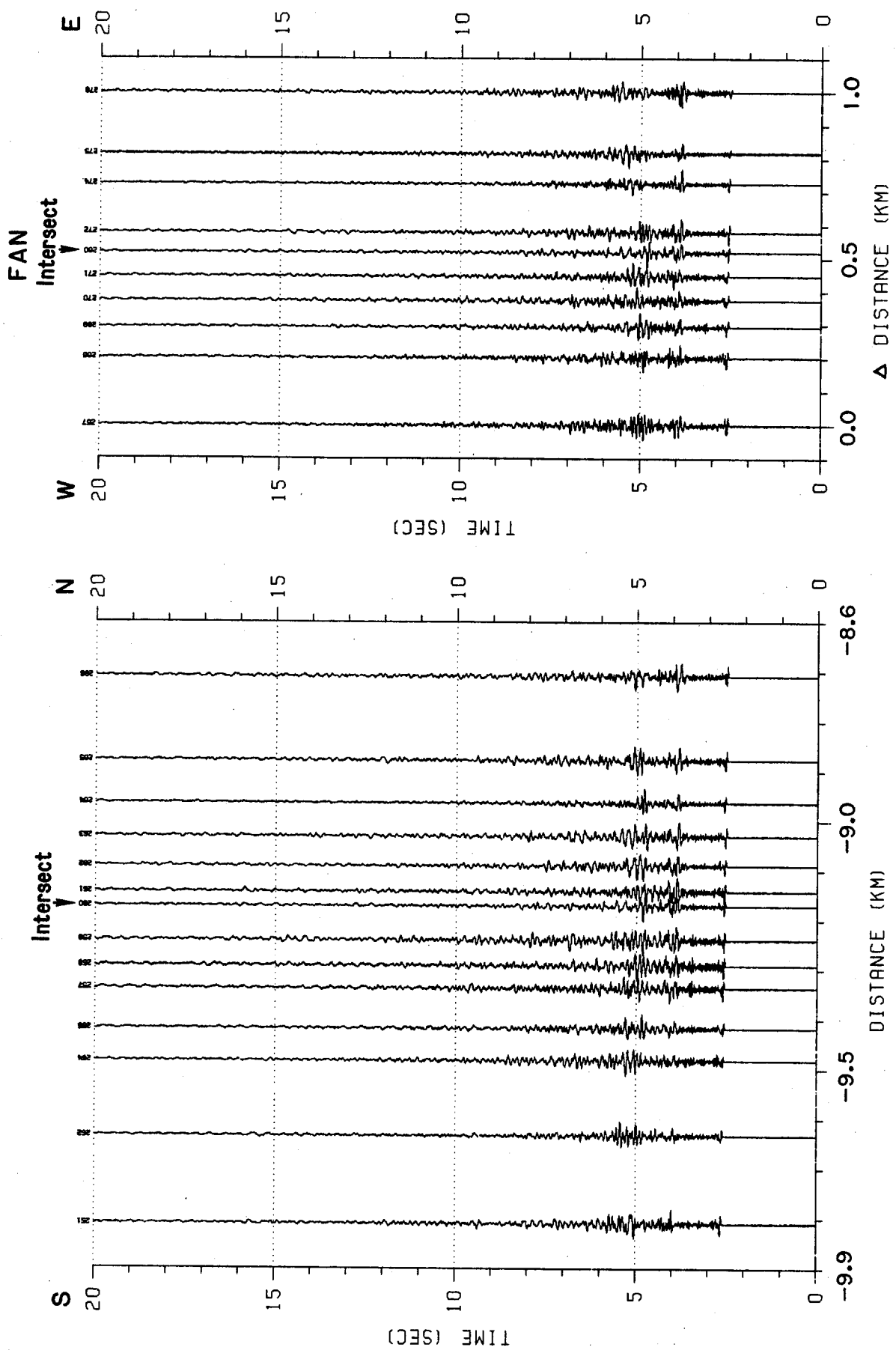
AFTERSHOCK NO. 5 NORMALIZED
SOUTHERN ARRAY

Figure 17.



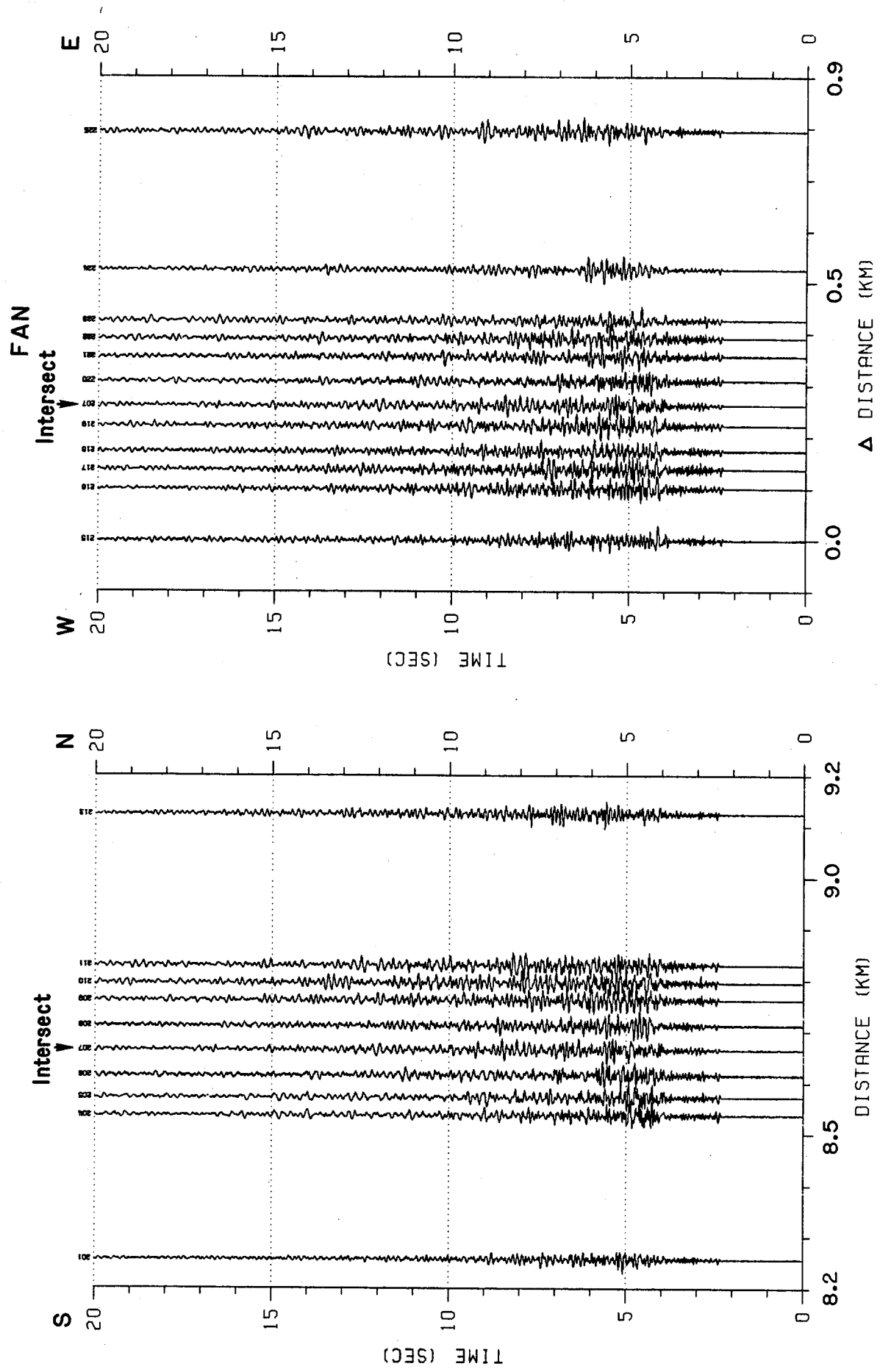
AFTERSHOCK NO. 5 NORMALIZED
NORTHERN ARRAY

Figure 18.



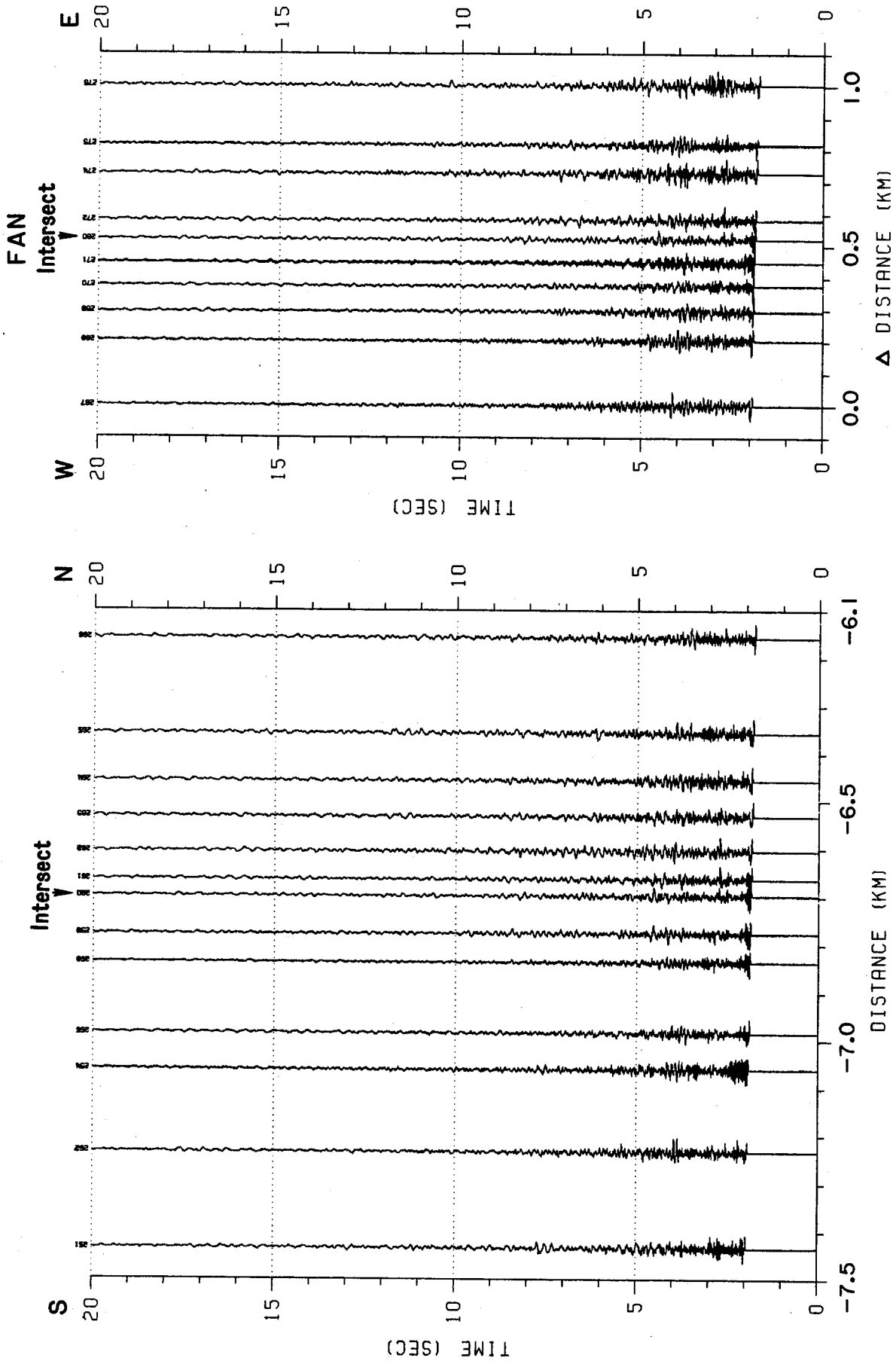
AFTERSHOCK NO. 6 NORMALIZED
SOUTHERN ARRAY

Figure 19.



AFTERSHOCK NO. 6 NORMALIZED
NORTHERN ARRAY

Figure 20.



AFTERSHOCK NO. 7 NORMALIZED
SOUTHERN ARRAY

Figure 21.

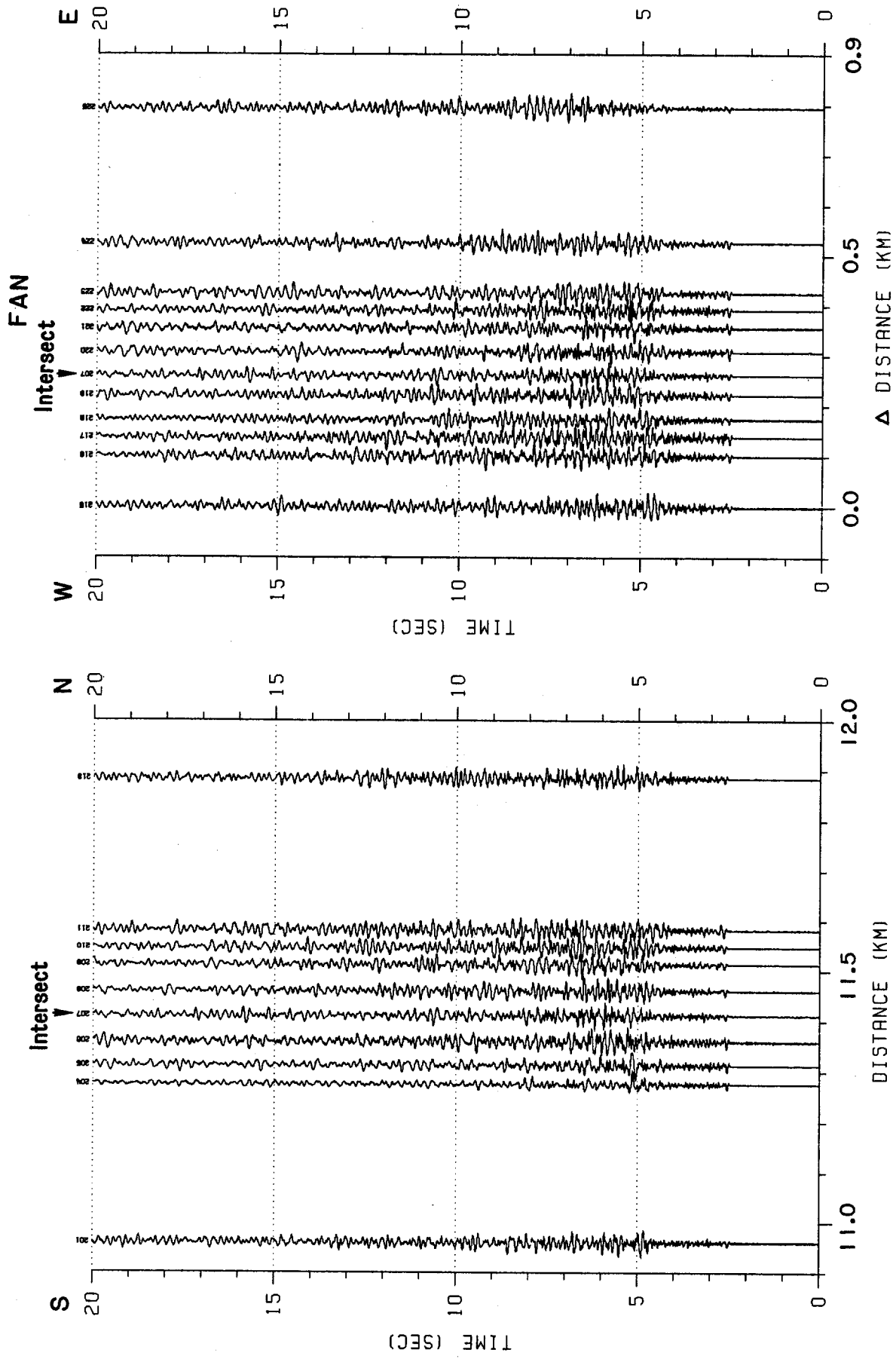
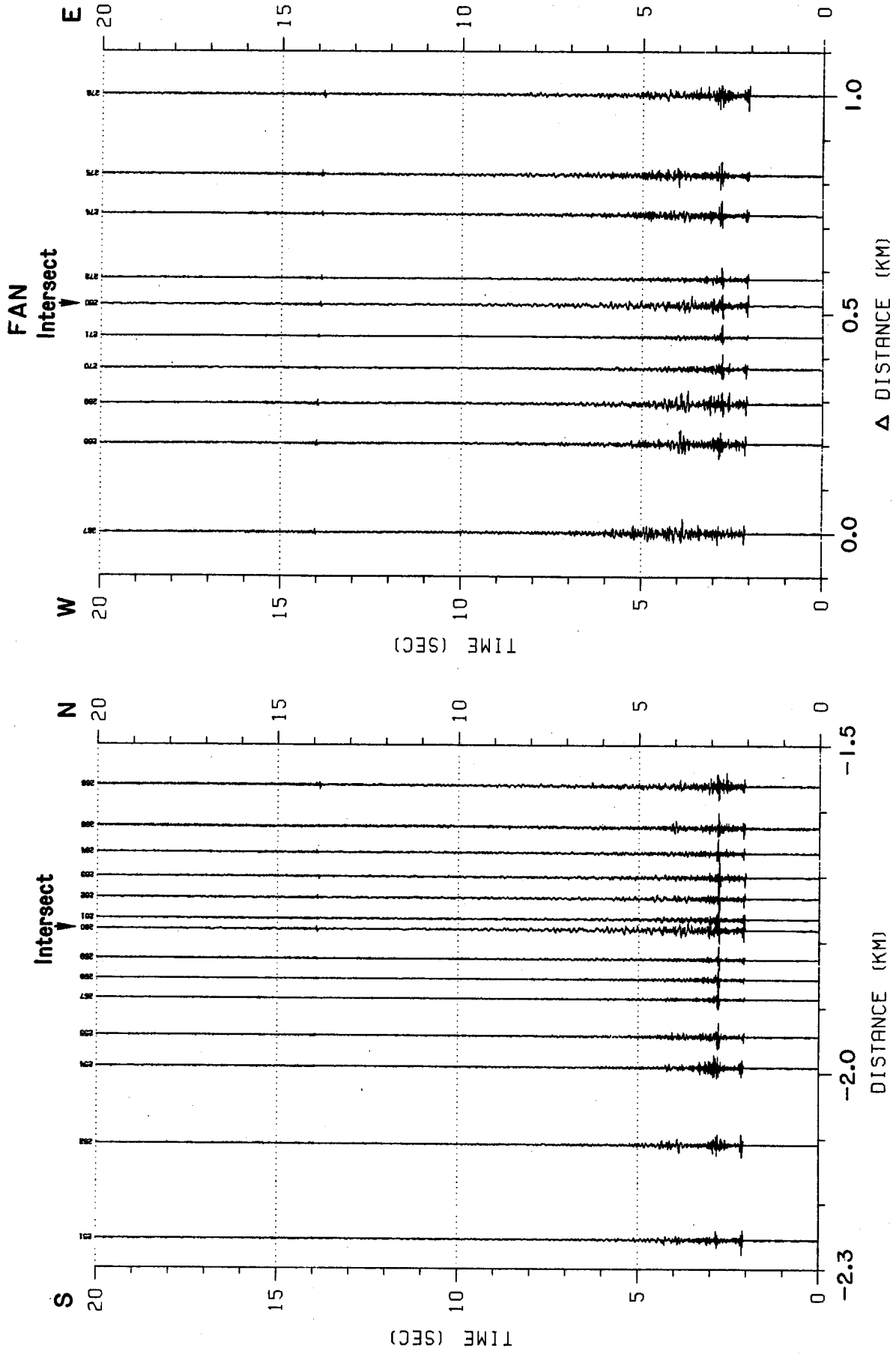
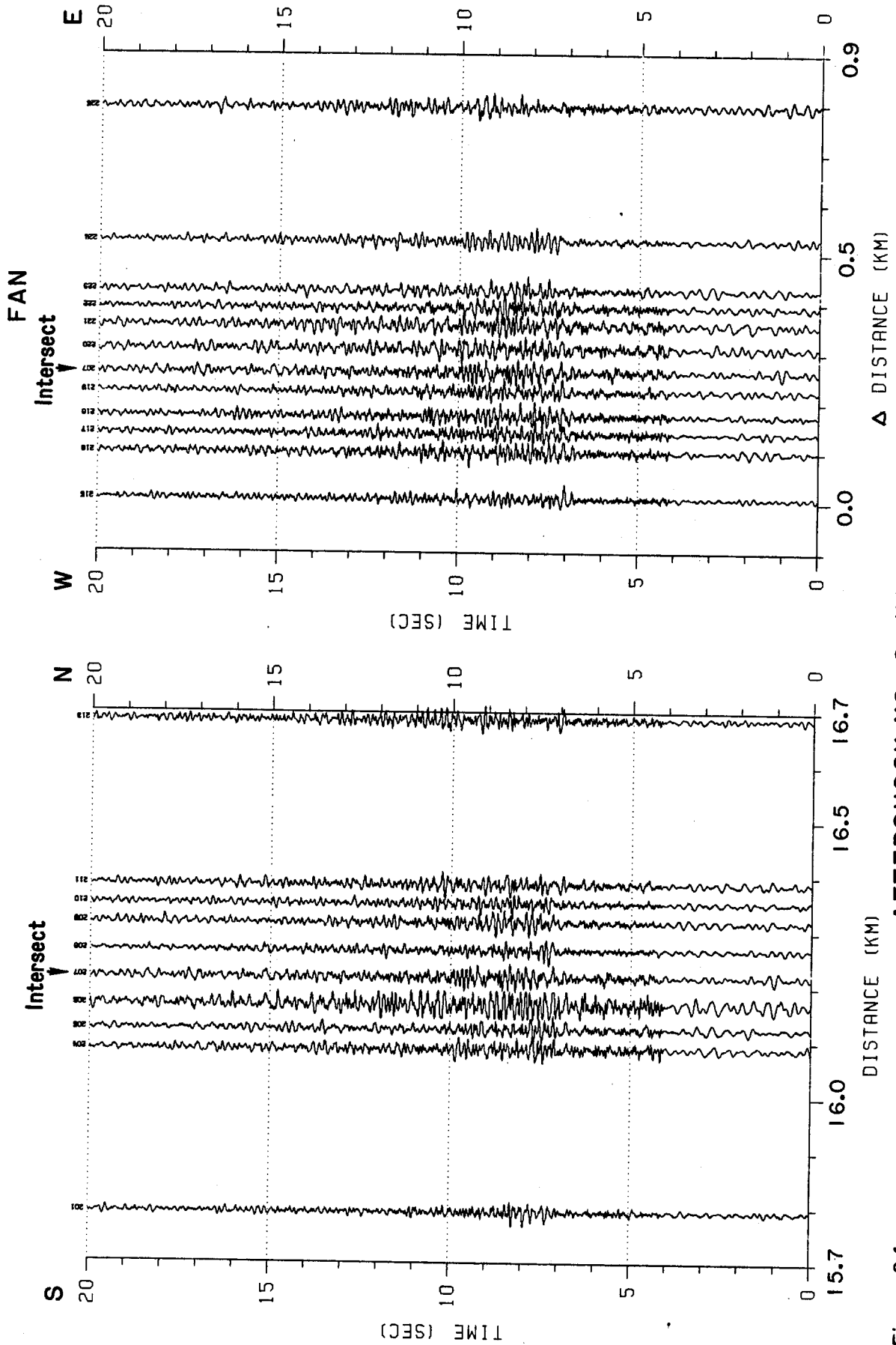


Figure 22. AFTERSHOCK NO. 7 NORMALIZED NORTHERN ARRAY



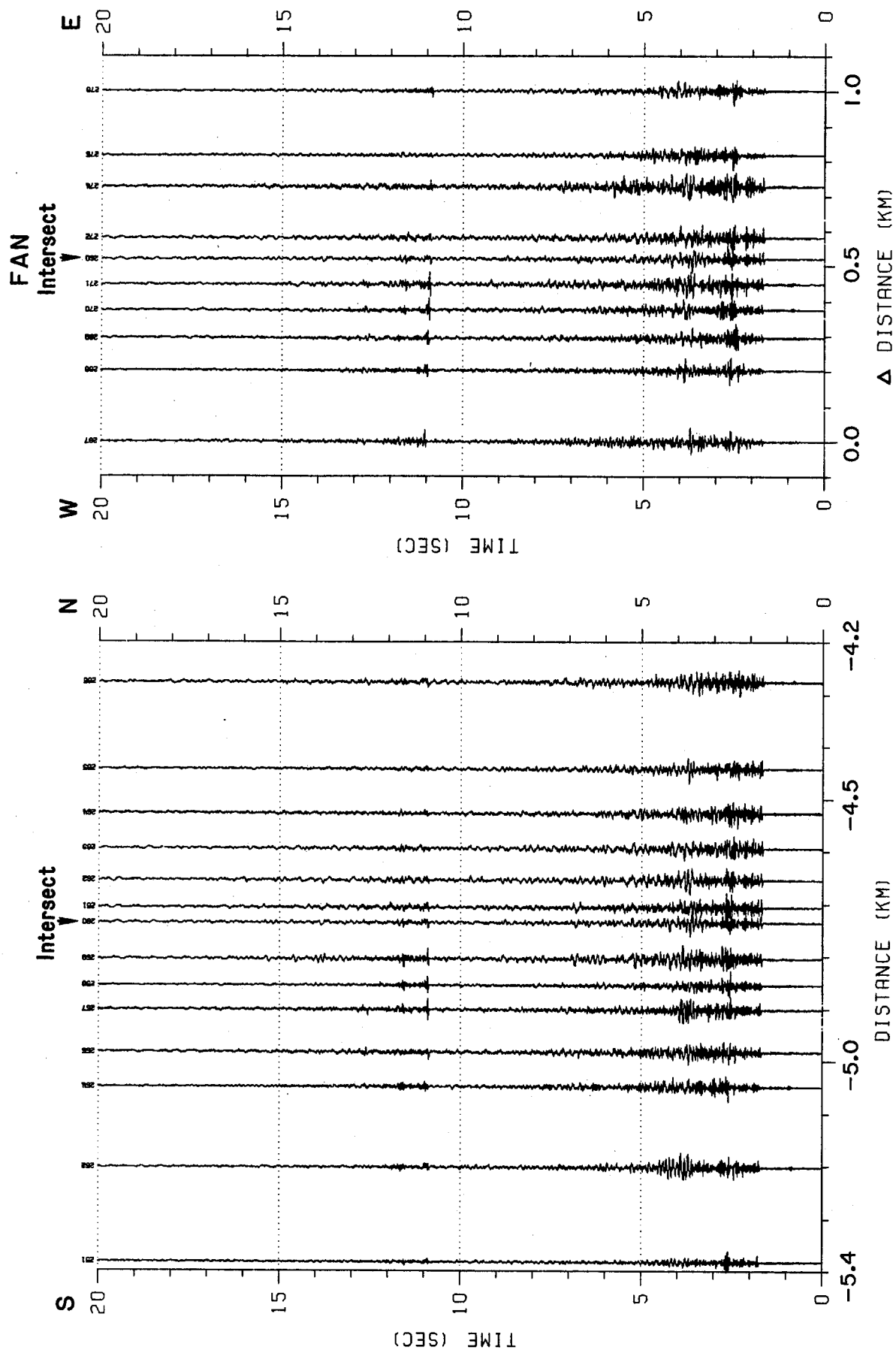
AFTERSHOCK NO. 8 NORMALIZED
SOUTHERN ARRAY

Figure 23.



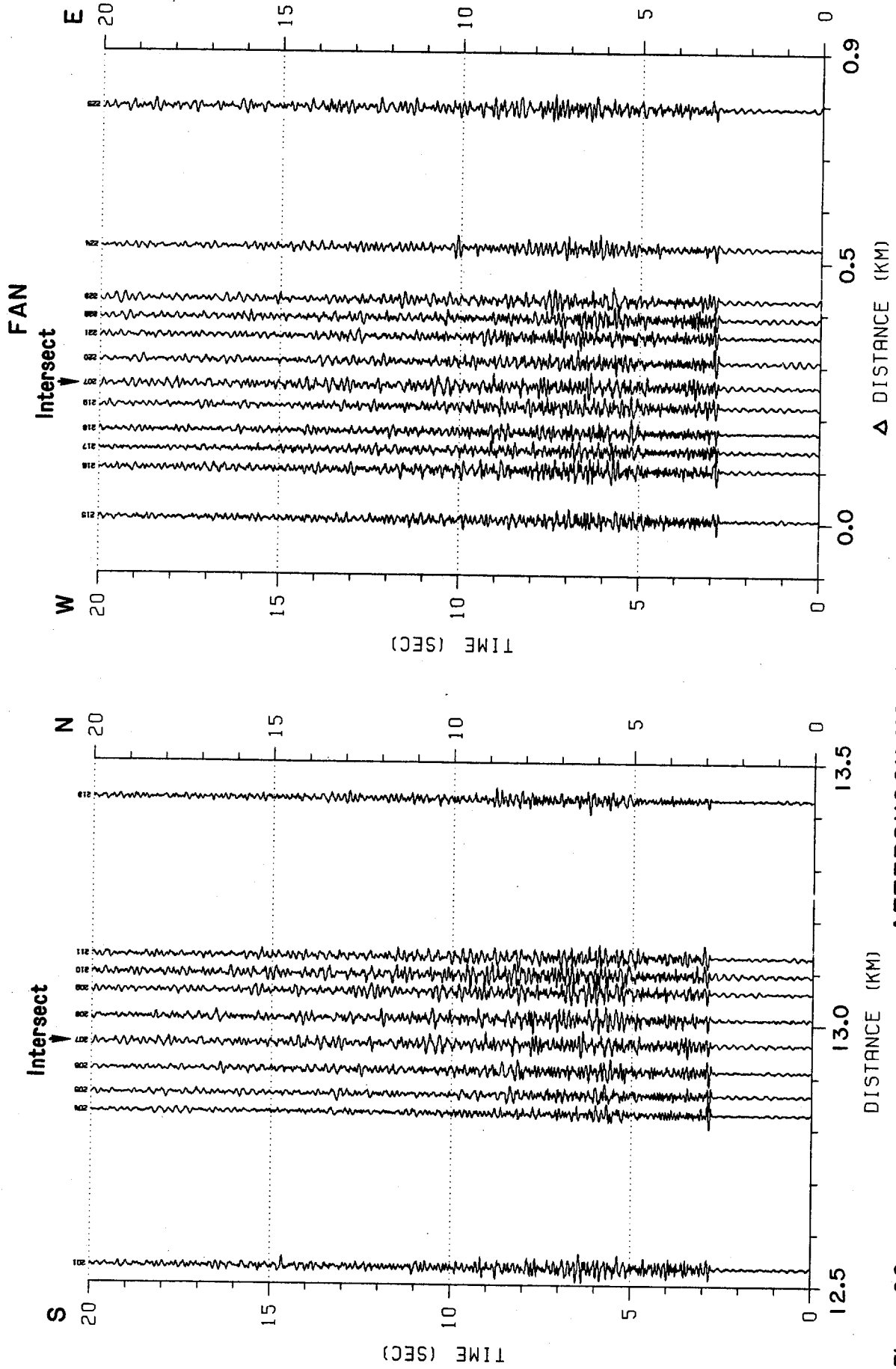
AFTERSHOCK NO. 8 NORMALIZED
NORTHERN ARRAY

Figure 24.



AFTERSHOCK NO. 9 NORMALIZED
SOUTHERN ARRAY

Figure 25.



AFTERSHOCK NO. 9 NORMALIZED
NORTHERN ARRAY

Figure 26.

U.S.G.S. Seismic Station Locations

FOR CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986

Location number	Latitude (deg,min,sec)	Longitude (deg,min,sec)	Elev (m)
101	37 39 39.1	118 26 36.8	1524
102	37 39 30.7	118 26 27.3	1524
103	37 39 22.3	118 26 19.0	1511
104	37 39 14.1	118 26 10.3	1493
105	37 39 5.3	118 26 2.1	1487
106	37 38 53.6	118 25 57.6	1478
107	37 38 43.2	118 25 57.0	1478
108	37 38 32.6	118 25 56.5	1478
109	37 38 21.7	118 25 56.2	1463
110	37 38 10.9	118 25 54.5	1453
111	37 38 0.9	118 25 52.1	1447
112	37 37 50.3	118 25 50.0	1438
113	37 37 39.4	118 25 48.5	1438
114	37 37 28.9	118 25 46.0	1432
115	37 37 16.7	118 25 42.4	1432
116	37 37 5.9	118 25 40.1	1432
117	37 36 56.0	118 25 38.1	1426
118	37 36 44.8	118 25 35.9	1420
119	37 36 34.1	118 25 33.9	1414
120	37 36 23.8	118 25 33.0	1411
121	37 36 12.9	118 25 31.6	1408
122	37 36 1.1	118 25 29.8	1405
123	37 35 50.1	118 25 28.7	1402
124	37 35 39.3	118 25 27.8	1395
125	37 35 28.5	118 25 24.4	1386
126	37 35 18.1	118 25 22.4	1386
127	37 35 7.7	118 25 18.5	1386
128	37 34 58.6	118 25 15.5	1386
129	37 34 47.7	118 25 13.9	1380
130	37 34 37.4	118 25 11.0	1371
131	37 34 27.5	118 25 10.8	1359
132	37 34 17.8	118 25 3.3	1356
133	37 34 9.9	118 24 55.1	1371
134	37 33 58.6	118 24 52.8	1371
135	37 33 46.9	118 24 51.2	1371
136	37 33 36.7	118 24 47.9	1365
137	37 33 26.1	118 24 43.8	1365
138	37 33 15.7	118 24 40.2	1365
139	37 33 5.4	118 24 37.8	1356
140	37 32 55.5	118 24 34.8	1341
141	37 32 44.3	118 24 30.3	1341
142	37 32 33.8	118 24 26.3	1341
143	37 32 23.9	118 24 22.0	1341
144	37 32 13.1	118 24 22.2	1316
145	37 32 3.6	118 24 22.7	1310
146	37 31 52.6	118 24 25.0	1295
147	37 31 41.9	118 24 28.1	1295
148	37 31 31.0	118 24 31.8	1290
149	37 31 20.4	118 24 35.1	1286
150	37 31 10.2	118 24 38.4	1286

Table I (continued)
U.S.G.S. Seismic Station Locations

FOR CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986

Location number	Latitude (deg,min,sec)	Longitude (deg,min,sec)	Elev (m)
151	37 30 59.9	118 24 41.8	1286
152	37 30 3.9	118 24 57.5	1280
153	37 29 54.1	118 24 59.8	1295
154	37 29 43.2	118 25 0.1	1295
155	37 29 33.5	118 25 0.3	1295
156	37 29 22.0	118 24 58.9	1295
157	37 29 12.9	118 24 59.0	1295
158	37 29 2.3	118 24 59.2	1295
159	37 28 51.8	118 24 57.1	1295
160	37 28 43.7	118 24 51.5	1295
161	37 28 36.8	118 24 47.3	1295
162	37 28 28.2	118 24 37.8	1295
163	37 28 19.5	118 24 29.6	1295
164	37 28 10.6	118 24 23.0	1295
165	37 28 3.1	118 24 17.0	1295
201	37 39 47.0	118 26 45.4	1533
202	37 39 51.9	118 26 49.5	1533
203	37 39 55.0	118 26 51.1	1533
204	37 39 56.1	118 26 51.6	1533
205	37 39 57.2	118 26 52.3	1533
206	37 39 58.6	118 26 53.1	1533
207	37 40 0.2	118 26 53.7	1536
208	37 40 1.7	118 26 54.3	1536
209	37 40 3.3	118 26 55.1	1536
210	37 40 4.4	118 26 55.4	1536
211	37 40 5.5	118 26 55.8	1536
212	37 40 8.7	118 26 57.0	1536
213	37 40 15.0	118 26 59.0	1536
214	37 39 51.7	118 27 9.8	1572
215	37 39 56.2	118 27 3.1	1548
216	37 39 58.1	118 26 59.8	1536
217	37 39 58.8	118 26 58.5	1536
218	37 39 59.5	118 26 57.4	1536
219	37 40 0.2	118 26 55.6	1536
220	37 40 0.7	118 26 51.9	1533
221	37 40 1.0	118 26 49.9	1530
222	37 40 1.3	118 26 48.5	1527
223	37 40 1.3	118 26 47.0	1524
224	37 40 1.9	118 26 42.9	1517
225	37 40 3.0	118 26 31.8	1508
251	37 30 13.7	118 24 55.0	1280
252	37 30 20.1	118 24 53.2	1280
253	37 30 23.2	118 24 52.4	1280
254	37 30 25.6	118 24 51.8	1280
255	37 30 28.0	118 24 51.0	1280
256	37 30 29.6	118 24 50.6	1280
257	37 30 31.0	118 24 50.1	1283
258	37 30 32.7	118 24 49.5	1283
259	37 30 34.6	118 24 48.8	1280
260	37 30 37.1	118 24 48.2	1280

Table I (continued)
U.S.G.S. Seismic Station Locations

FOR CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986

Location number	Latitude (deg,min,sec)	Longitude (deg,min,sec)	Elev (m)
261	37 30 38.2	118 24 47.8	1283
262	37 30 40.1	118 24 47.4	1286
263	37 30 42.4	118 24 46.7	1286
264	37 30 44.8	118 24 46.2	1289
265	37 30 48.0	118 24 45.3	1289
266	37 30 54.3	118 24 43.6	1289
267	37 30 35.6	118 25 9.3	1316
268	37 30 33.3	118 25 1.6	1304
269	37 30 31.8	118 24 58.3	1298
270	37 30 31.0	118 24 55.2	1286
271	37 30 29.8	118 24 52.6	1283
272	37 30 39.5	118 24 46.2	1283
273	37 30 40.5	118 24 43.3	1283
274	37 30 41.9	118 24 40.8	1283
275	37 30 44.1	118 24 37.8	1283
276	37 30 48.6	118 24 32.0	1283

Table 2. List of digitized aftershocks. Source parameters were resolved by CALNET (R. S. Cockerham, written communication, 1987).

CHALFANT VALLEY AFTERSHOCKS,
August 3, 1987

NUMBER	ORIGIN TIME (UTC)	LATITUDE NORTH	LONGITUDE WEST	HORIZONTAL ERROR (km)	DEPTH (km)	VERTICAL ERROR (km)	M_L
1	04:14:03.56	37°28.41'	118°27.40'	± 0.4	4.7	± 0.5	1.5
2	06:10:38.95	37°30.44'	118°24.20'	± 0.5	8.6	± 0.6	1.5
3	06:24:26.48	37°36.96'	118°26.07'	± 0.2	8.3	± 0.4	1.5
4	15:10:15.09	37°36.27'	118°29.40'	± 7.0	15.3	±16.3	1.2
5	15:14:43.82	37°29.46'	118°22.07'	± 0.6	6.9	± 0.6	1.7
6	17:04:19.28	37°35.32'	118°26.78'	± 0.2	9.0	± 0.4	1.2
7	17:06:13.86	37°34.21'	118°24.23'	± 1.1	5.6	± 3.4	1.5
8	17:06:45.30	37°31.29'	118°25.67'	± 6.1	12.3	±10.1	1.2
9	17:20:56.48	37°33.05'	118°25.81'	± 0.0	7.0	± 0.0	0.9

ACKNOWLEDGEMENTS

Pat Berge, Robert Colburn, Janice Murphy, Julie Shemeta, and Dean Whitman programmed and deployed the recording instruments. Instrument locations were laser surveyed with an EDM by Leif Wennerburg and Dean Whitman. Bruce Julian and Paul Spudich designed the recording array. Special thanks to James Lienkaemper for the use of his drafts for Figure 1. Also appreciated are the suggestions from Walter Mooney during the compilation of this report.

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APPENDIX A

Field Data Tables

The field data tables contain information related to the seismic recorders and digitizing results. Aftershock numbers occur in chronological order and correspond to aftershock numbers on the record sections. Column headings are defined below:

Loc	- location number of the seismic recorder location (see Table 1)
Dist (km)	- epicentral distance to the recorder
Azim (deg)	- azimuth from the epicenter to the recorder (clockwise from north)
Db	- amplifier attenuation setting (db) of the digitized channel. The gain is determined by subtracting the given attenuation from a total gain of 96 db.

Tape Grade Scale

The tape grade scale is referenced by the last column in the field data tabel. Seismograph performance and trace quality are defined by the scale below.

0	OK
1	No run, blank tape
2	No seismic, or low seismic
3	Bad time code
4	Missed turn on time
5	Not deployed
6	Clipped trace
7	High noise
8	Timing error 1 - off by days, hours, or minutes (trace may be recoverable)
9	Partial record
10	Data missing
11	Tape ends before signal
12	Timing error 2 - trace off by seconds.
13	No tape for this recording window

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 40 SEC SAMPLED AT 10 MSEC.

Aftershock Number 1

Event Time (Julian day, hr, min, sec): 215:04:14:03.500

Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape	
			Db	Grade				Db	Grade				Db	Grade
101	20.89	4.8	30	0	140	9.62	29.5	48	0	214	21.22	2.5		1
102	20.65	5.5	30	0	141	9.38	31.2	48	0	215	21.37	3.0	30	0
103	20.41	6.1	30	0	142	9.16	32.7	48	0	216	21.43	3.2	30	0
104	20.18	6.8	30	0	143	8.96	34.4		8	217	21.45	3.2	30	0
105	19.94	7.5	30	0	144	8.68	35.6	48	0	218	21.48	3.3	30	0
106	19.60	7.9	30	0	145	8.44	36.7	48	0	219	21.50	3.4	30	0
107	19.28	8.1	30	0	146	8.14	37.8	30	0	220	21.52	3.7	12	0
108	18.96	8.3	30	0	147	7.83	38.8		1	221	21.54	3.8	30	0
109	18.63	8.5		1	148	7.52	39.9	48	0	222	21.55	3.9	30	0
110	18.31	8.7	30	0	149	7.21	41.1		3	223	21.55	4.0	30	0
111	18.01	9.1	30	0	150	6.92	42.3	48	0	224	21.58	4.2	30	0
112	17.70	9.4	30	0	151	6.63	43.6	30	0	225	21.63	5.0	30	0
113	17.37	9.7	30	2	152	5.20	53.7	48	0	251	5.43	51.5	48	0
114	17.06	10.1		10	153	4.98	56.1		1	252	5.59	50.2	12	2
115	16.71	10.6	30	0	154	4.79	59.4		1	253	5.67	49.6	48	0
116	16.39	11.0	30	0	155	4.64	62.5	48	0	254	5.73	49.1	48	0
117	16.10	11.4	30	0	156	4.52	66.7	48	0	255	5.79	48.7	48	0
118	15.77	11.9	30	0	157	4.42	70.0	48	0	257	5.87	48.1	48	0
119	15.47	12.3	30	8	158	4.31	74.1		1	258	5.91	47.9	48	0
120	15.16	12.6	30	0	159	4.29	78.5	48	0	259	5.97	47.5	48	0
121	14.84	13.0	30	0	160	4.38	82.0	48	0	260	6.03	47.1	48	0
122	14.49	13.5	30	0	161	4.46	84.9	48	0	261	6.06	46.9	48	0
123	14.17	14.0	30	0/12	162	4.67	88.4	48	0	262	6.11	46.6	48	0
124	13.85	14.4	30	0	163	4.88	91.6	48	0	263	6.17	46.2	48	0
125	13.55	15.1	30	0	164	5.05	94.7	48	0	264	6.23	45.8	48	6
126	13.26	15.6		8	165	5.22	97.1	48	0	265	6.31	45.3	48	0
127	12.98	16.4		1	201	21.11	4.2	30	0	266	6.48	44.3	30	0
128	12.73	17.1	30	0	202	21.26	3.9	30	0	267	5.63	43.9	48	0
129	12.42	17.7	30	0	203	21.35	3.7	12	0	268	5.71	45.7	48	0
130	12.14	18.5	30	0	204	21.38	3.7	12	0	269	5.74	46.6	48	0
131	11.85	19.0	30	0	205	21.41	3.7	12	0	270	5.77	47.3	48	0
132	11.63	20.3	30	0	206	21.46	3.6	12	0	271	5.80	48.0	48	0
133	11.48	21.7	30	0	207	21.50	3.5	30	0	272	6.12	46.9	48	0
134	11.18	22.6		1	208	21.55	3.5	30	0	273	6.19	47.1	48	0
135	10.86	23.6	30	0	209	21.60	3.4	30	0	274	6.26	47.2	48	0
136	10.61	24.6	48	0	210	21.63	3.4	30	0	275	6.36	47.2	48	0
137	10.35	25.9	30	0	211	21.66	3.4	30	0	276	6.56	47.2	48	0
138	10.10	27.1	48	0	212	21.76	3.3	30	0					
139	9.85	28.3	48	0	213	21.95	3.1	30	0					

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 40 SEC SAMPLED AT 10 MSEC.

Aftershock Number 3

Event Time (Julian day, hr, min, sec): 215:06:24:26.300

Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape	
			Db	Grade				Db	Grade				Db	Grade
101	4.96	351.3	48	0	140	7.86	163.5	48	0	214	5.52	343.5		1
102	4.68	353.6	48	0	141	8.22	163.4	48	0	215	5.61	345.6	48	0
103	4.40	355.9	48	0	142	8.56	163.4	48	0	216	5.65	346.5	48	0
104	4.14	358.6	48	0	143	8.89	163.3	48	0	217	5.66	346.9	30	0
105	3.87	1.4	48	0	144	9.20	163.9	48	0	218	5.68	347.2	48	0
106	3.51	3.4	48	0	145	9.48	164.5		8	219	5.69	347.7	48	0
107	3.19	4.0	30	0	146	9.79	165.3	48	0	220	5.68	348.6	48	0
108	2.86	4.7	48	0	147	10.10	166.2		1	221	5.68	349.1	48	0
109	2.53	5.5		1	148	10.40	167.1	48	0	222	5.69	349.4	48	0
110	2.21	7.3		1	149	10.71	168.0		3	223	5.68	349.8	48	0
111	1.91	10.3	48	0	150	11.00	168.7	30	0	224	5.68	350.8	48	0
112	1.60	14.2	48	0	151	11.29	169.4	30	0	225	5.68	353.6	48	0
113	1.29	19.5		3	152	12.94	172.5	48	0	251	12.65	172.1	48	0
114	1.02	28.9		1	153	13.23	172.9		1	252	12.46	171.7	30	0
115	0.78	48.4	48	0	154	13.56	173.1		1	253	12.37	171.6	30	0
116	0.66	74.0	48	0	155	13.86	173.3	30	0	254	12.30	171.5	48	0
117	0.70	100.1	48	0	156	14.22	173.3	48	0	255	12.22	171.3	48	0
118	0.88	122.4	48	0	157	14.49	173.5	30	0	257	12.14	171.2	30	0
119	1.12	135.3	48	8	158	14.82	173.6		1	258	12.09	171.1	48	0
120	1.38	144.1	48	0	159	15.15	173.6	48	0	259	12.03	170.9	48	0
121	1.68	149.8	48	0	160	15.41	173.2	48	0	260	11.96	170.8	30	0
122	2.02	153.9	48	0	161	15.63	172.9	48	0	261	11.93	170.7	48	0
123	2.34	157.0	48	0/12	162	15.93	172.2	48	0	262	11.87	170.6	48	0
124	2.66	159.4	48	0	163	16.22	171.6	48	0	263	11.80	170.5	30	0
125	3.00	160.1	48	0	164	16.52	171.2	30	0	264	11.73	170.4	48	0
126	3.32	161.2		1	165	16.77	170.8	30	0	265	11.64	170.2	30	0
127	3.65	161.4		1	201	5.24	349.4	48	0	266	11.45	169.8	30	0
128	3.94	161.7	48	0	202	5.41	348.6	48	0	267	11.93	173.3	30	0
129	4.28	162.6		10	203	5.51	348.4	48	0	268	12.03	172.4	48	0
130	4.60	162.9	48	0	204	5.54	348.4	48	0	269	12.08	172.1	30	0
131	4.89	163.9	48	0	205	5.58	348.3	48	0	270	12.12	171.7	30	0
132	5.23	162.9	48	0	206	5.63	348.2	48	0	271	12.16	171.5	30	0
133	5.52	161.6		10	207	5.68	348.1	48	0	272	11.89	170.5	30	0
134	5.87	162.2		1	208	5.73	348.1	48	0	273	11.87	170.1		1
135	6.23	162.8	48	0	209	5.78	348.0	48	0	274	11.84	169.8	48	0
136	6.55	163.0		10/3	210	5.81	348.0	48	0	275	11.79	169.4	48	0
137	6.90	163.0	48	0	211	5.85	347.9	48	0	276	11.68	168.6	30	0
138	7.23	163.1	48	0	212	5.95	347.9		1					
139	7.55	163.3	48	0	213	6.15	347.8	48	0					

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 1

Event Time (Julian day, hr, min, sec): 215:04:14:03.500

Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape	
			Db	Grade				Db	Grade				Db	Grade
101	20.89	4.8	30	0	140	9.62	29.5	48	0	214	21.22	2.5		1
102	20.65	5.5	30	0	141	9.38	31.2	48	0	215	21.37	3.0	30	0
103	20.41	6.1	30	0	142	9.16	32.7	48	0	216	21.43	3.2	30	0
104	20.18	6.8	30	0	143	8.96	34.4		8	217	21.45	3.2	30	0
105	19.94	7.5	30	0	144	8.68	35.6	48	0	218	21.48	3.3	30	0
106	19.60	7.9	30	0	145	8.44	36.7	48	0	219	21.50	3.4	30	0
107	19.28	8.1	30	0	146	8.14	37.8	30	0	220	21.52	3.7	12	0
108	18.96	8.3	30	0	147	7.83	38.8		1	221	21.54	3.8	30	0
109	18.63	8.5		1	148	7.52	39.9	48	0	222	21.55	3.9	30	0
110	18.31	8.7	30	0	149	7.21	41.1		1	223	21.55	4.0	30	0
111	18.01	9.1	30	0	150	6.92	42.3	48	0	224	21.58	4.2	30	0
112	17.70	9.4	30	0	151	6.63	43.6	48	0	225	21.63	5.0	30	0
113	17.37	9.7	30	2/3/7	152	5.20	53.7	48	0	251	5.43	51.5	48	0
114	17.06	10.1		1	153	4.98	56.1		1	252	5.59	50.2	48	2
115	16.71	10.6	30	0	154	4.79	59.4		1	253	5.67	49.6	48	0
116	16.39	11.0	30	0	155	4.64	62.5	48	0	254	5.73	49.1	48	0
117	16.10	11.4	30	0	156	4.52	66.7	48	0	255	5.79	48.7	48	0
118	15.77	11.9	30	0	157	4.42	70.0	48	0	257	5.87	48.1	48	0
119	15.47	12.3	30	8	158	4.31	74.1		1	258	5.91	47.9	48	0
120	15.16	12.6	30	0	159	4.29	78.5	48	0	259	5.97	47.5	48	0
121	14.84	13.0	30	0	160	4.38	82.0	48	0	260	6.03	47.1	48	0
122	14.49	13.5	30	0	161	4.46	84.9	48	0	261	6.06	46.9	48	0
123	14.17	14.0	30	0/12	162	4.67	88.4	48	0	262	6.11	46.6	48	0
124	13.85	14.4	30	0	163	4.88	91.6	48	0	263	6.17	46.2	48	0
125	13.55	15.1	30	0	164	5.05	94.7	48	0	264	6.23	45.8	48	0
126	13.26	15.6		8	165	5.22	97.1	48	0	265	6.31	45.3	48	0
127	12.98	16.4		1	201	21.11	4.2	30	0	266	6.48	44.3	48	0
128	12.73	17.1	30	0	202	21.26	3.9	30	0	267	5.63	43.9	48	0
129	12.42	17.7	30	0	203	21.35	3.7	12	0	268	5.71	45.7	48	0
130	12.14	18.5	30	0	204	21.38	3.7	12	0	269	5.74	46.6	48	0
131	11.85	19.0	30	0	205	21.41	3.7	12	0	270	5.77	47.3	48	0
132	11.63	20.3	30	0	206	21.46	3.6	12	0	271	5.80	48.0	48	0
133	11.48	21.7	30	0	207	21.50	3.5	30	0	272	6.12	46.9	48	0
134	11.18	22.6		1	208	21.55	3.5	30	0	273	6.19	47.1	48	0
135	10.86	23.6	30	0	209	21.60	3.4	30	0	274	6.26	47.2	48	0
136	10.61	24.6	48	0	210	21.63	3.4	30	0	275	6.36	47.2	48	0
137	10.35	25.9	30	0	211	21.66	3.4	30	0	276	6.56	47.2	48	0
138	10.10	27.1	48	0	212	21.76	3.3	30	0					
139	9.85	28.3	48	0	213	21.95	3.1	30	0					

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 2

Event Time (Julian day, hr, min, sec): 215:06:10:38.950

Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape	
---	---	---	Db	Grade	---	---	---	Db	Grade	---	---	---	Db	Grade
101	17.27	348.0	30	0	140	4.49	352.3	48	0	214	17.83	345.7		1
102	16.97	348.6	48	0	141	4.13	353.2	48	0	215	17.93	346.3	48	0
103	16.68	349.1	48	0	142	3.80	354.0	48	0	216	17.97	346.6	48	0
104	16.39	349.7	48	0	143	3.49	355.2	48	0	217	17.98	346.7	48	0
105	16.09	350.2	48	0	144	3.16	354.6	48	0	218	17.99	346.8	48	0
106	15.71	350.4	48	0	145	2.86	353.8		8	219	18.00	347.0	48	0
107	15.39	350.2	30	6	146	2.54	351.7	48	0	220	18.00	347.3	30	0
108	15.07	350.0	48	0	147	2.22	348.6		1	221	18.00	347.4	48	0
109	14.74	349.8		1	148	1.92	344.0	48	0	222	18.00	347.6	48	0
110	14.40	349.8		1	149	1.63	338.0		1	223	17.99	347.7	48	0
111	14.09	349.8	48	0	150	1.39	330.0	48	6	224	17.99	348.0	48	0
112	13.76	349.8	48	0	151	1.18	318.7	48	0	225	17.97	348.9	48	0
113	13.42	349.7	12	2/7	152	1.44	234.1	48	6	251	1.23	243.9	48	0
114	13.09	349.7		1	153	1.67	226.8		5	252	1.11	252.1	48	0
115	12.70	349.8	48	0	154	1.92	219.6		1	253	1.07	256.6	48	0
116	12.37	349.7	48	0	155	2.16	214.7	48	0	254	1.04	260.3	48	0
117	12.06	349.7	48	0	156	2.45	209.3	48	6	255	1.01	264.4	48	0
118	11.71	349.7	48	0	157	2.70	206.4	48	0	257	0.98	269.6	48	0
119	11.38	349.6	48	8	158	3.00	203.7		5	258	0.97	272.7	48	0
120	11.06	349.4	48	6	159	3.27	200.6	48	0	259	0.95	276.3	48	0
121	10.72	349.3	48	0	160	3.47	197.0	48	6	260	0.95	281.0	48	0
122	10.36	349.1	48	0	161	3.64	194.5	48	0	261	0.95	283.1	48	0
123	10.02	348.9	48	0/12	162	3.85	190.1	48	0	262	0.95	286.6	48	0
124	9.69	348.7	48	0	163	4.09	186.7	48	0	263	0.96	291.0	48	0
125	9.34	348.8	48	0	164	4.35	184.1	48	0	264	0.98	295.3	48	0/12
126	9.02	348.7		1	165	4.57	182.1	48	0	265	1.01	300.9	48	0
127	8.69	348.9		1	201	17.55	347.5	48	0	266	1.09	311.0	48	0
128	8.40	349.0	48	0	202	17.72	347.3	30	0	267	1.46	275.3	48	0
129	8.06	348.8	48	0	203	17.82	347.2	30	0	268	1.26	272.9	48	0
130	7.73	348.9	48	0	204	17.86	347.2	30	0	269	1.18	270.9	48	0
131	7.44	348.5	48	0	205	17.90	347.2	30	0	270	1.11	269.6	48	0
132	7.11	349.4	48	0	206	17.94	347.1	30	0	271	1.04	267.6	48	0
133	6.83	350.7	48	0	207	17.99	347.1	48	0	272	0.92	286.1	48	0
134	6.48	350.7		1	208	18.04	347.1	48	0	273	0.86	289.4		1
135	6.12	350.5	48	0	209	18.10	347.1	48	0	274	0.82	293.7	48	0
136	5.79	350.8	48	0	210	18.13	347.1	48	0	275	0.79	300.4	48	0
137	5.45	351.3	48	0	211	18.17	347.1	48	0	276	0.76	315.1	30	
138	5.12	351.7	48	6	212	18.27	347.1		1					
139	4.80	351.9	48	0	213	18.47	347.1	30	0					

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 3

Event Time (Julian day, hr, min, sec): 215:06:24:26.300

Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape	
---	---	---	Db	Grade	---	---	---	Db	Grade	---	---	---	Db	Grade
101	4.96	351.3	48	0	140	7.86	163.5	48	0	214	5.52	343.5		1
102	4.68	353.6	48	0	141	8.22	163.4	48	0	215	5.61	345.6	48	0
103	4.40	355.9	48	0	142	8.56	163.4	48	0	216	5.65	346.5	48	0
104	4.14	358.6	48	0	143	8.89	163.3	48	0	217	5.66	346.9	48	0
105	3.87	1.4	48	0	144	9.20	163.9	48	0	218	5.68	347.2	48	0
106	3.51	3.4	48	0	145	9.48	164.5		8	219	5.69	347.7	48	0
107	3.19	4.0	30	6	146	9.79	165.3	48	0	220	5.68	348.6	48	0
108	2.86	4.7	48	0	147	10.10	166.2		1	221	5.68	349.1	48	0
109	2.53	5.5		1	148	10.40	167.1	48	0	222	5.69	349.4	48	0
110	2.21	7.3		1	149	10.71	168.0		2	223	5.68	349.8	48	0
111	1.91	10.3	48	0	150	11.00	168.7	30	0	224	5.68	350.8	48	0
112	1.60	14.2	48	0	151	11.29	169.4	30	0	225	5.68	353.6	48	0
113	1.29	19.5		3	152	12.94	172.5	48	0	251	12.65	172.1	48	0
114	1.02	28.9		1	153	13.23	172.9		1	252	12.46	171.7	30	0
115	0.78	48.4	48	0	154	13.56	173.1		1	253	12.37	171.6	48	0
116	0.66	74.0	48	0	155	13.86	173.3	30	0	254	12.30	171.5	48	0
117	0.70	100.1	48	0	156	14.22	173.3	48	0	255	12.22	171.3	48	0
118	0.88	122.4	48	0	157	14.49	173.5	30	0	257	12.14	171.2	48	0
119	1.12	135.3	48	8	158	14.82	173.6		1	258	12.09	171.1	48	0
120	1.38	144.1	48	0	159	15.15	173.6	48	0	259	12.03	170.9	48	0
121	1.68	149.8	48	0	160	15.41	173.2	48	0	260	11.96	170.8	48	0
122	2.02	153.9	48	0	161	15.63	172.9	48	0	261	11.93	170.7	48	0
123	2.34	157.0	48	0/12	162	15.93	172.2	48	0	262	11.87	170.6	48	0
124	2.66	159.4	48	0	163	16.22	171.6	48	0	263	11.80	170.5	48	0
125	3.00	160.1	48	0	164	16.52	171.2	30	0	264	11.73	170.4	48	0
126	3.32	161.2		1	165	16.77	170.8	30	0	265	11.64	170.2	30	6
127	3.65	161.4		1	201	5.24	349.4	48	0	266	11.45	169.8	30	0
128	3.94	161.7	48	0	202	5.41	348.6	48	0	267	11.93	173.3	30	0
129	4.28	162.6		10	203	5.51	348.4	48	0	268	12.03	172.4	48	0
130	4.60	162.9	48	0	204	5.54	348.4	48	0	269	12.08	172.1	30	0
131	4.89	163.9	48	0	205	5.58	348.3	48	0	270	12.12	171.7	30	0
132	5.23	162.9	48	0	206	5.63	348.2	48	0	271	12.16	171.5	48	0
133	5.52	161.6		1	207	5.68	348.1	48	0	272	11.89	170.5	48	0
134	5.87	162.2		1	208	5.73	348.1	48	0	273	11.87	170.1		1
135	6.23	162.8	48	0	209	5.78	348.0	48	0	274	11.84	169.8	48	0
136	6.55	163.0		10	210	5.81	348.0	48	0	275	11.79	169.4	48	0
137	6.90	163.0	48	0	211	5.85	347.9	48	0	276	11.68	168.6	30	0
138	7.23	163.1	48	0	212	5.95	347.9		1					
139	7.55	163.3	48	0	213	6.15	347.8	48	0					

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 4

Event Time (Julian day, hr, min, sec): 215:15:10:15.090

Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape		Loc	Dist (km)	Azim (deg)	Tape	
			Db	Grade				Db	Grade				Db	Grade
101	7.48	33.2		13	140	9.42	131.1		13	214	7.41	26.3		1
102	7.40	35.8		13	141	9.73	132.2		13	215	7.61	27.0	48	0
103	7.31	38.3		13	142	10.02	133.2		13	216	7.70	27.3	48	0
104	7.26	40.9		13	143	10.31	134.0		13	217	7.73	27.5	48	0
105	7.19	43.5		13	144	10.54	135.3		13	218	7.77	27.6	48	0
106	7.01	46.2		13	145	10.74	136.5		1	219	7.81	27.8	30	0
107	6.81	48.2		13	146	10.95	137.9		1	220	7.86	28.3	30	0
108	6.60	50.4		13	147	11.15	139.3		13	221	7.89	28.6	30	0
109	6.40	52.8		13	148	11.35	140.8		13	222	7.92	28.8	48	0
110	6.24	55.4		13	149	11.55	142.1		13	223	7.94	29.0		2/3
111	6.12	58.1		13	150	11.75	143.4		13	224	8.00	29.6	48	0
112	6.00	61.0		13	151	11.96	144.6		13	225	8.17	31.1	48	0
113	5.87	64.1		13	152	13.21	150.3		13	251	12.98	149.4	30	0
114	5.80	67.2		13	153	13.45	151.1		13	252	12.83	148.8	30	0
115	5.75	71.0		13	154	13.74	151.8		1	253	12.76	148.5		2/3/8
116	5.70	74.4		13	155	14.00	152.4		13	254	12.71	148.3	30	0
117	5.68	77.5		13	156	14.33	153.0		13	255	12.65	148.0	30	0
118	5.66	81.1		13	157	14.58	153.5		13	257	12.59	147.7	30	0
119	5.67	84.4		13	158	14.88	154.1		13	258	12.55	147.5	30	0
120	5.67	87.6		13	159	15.19	154.4		13	259	12.51	147.3	30	0
121	5.70	91.0		1	160	15.47	154.4		13	260	12.46	147.1	30	0
122	5.76	94.6		1	161	15.71	154.4		13	261	12.43	146.9	30	0
123	5.83	97.9		1	162	16.05	154.0		13	262	12.39	146.8	30	0
124	5.90	101.1		1	163	16.38	153.8		13	263	12.34	146.5	30	0
125	6.06	104.0		1	164	16.70	153.7		13	264	12.28	146.3	30	0
126	6.19	106.8		13	165	16.97	153.6		13	265	12.21	145.9	30	0
127	6.38	109.3		13	201	7.57	30.9	48	0	266	12.08	145.2	30	0
128	6.55	111.4		13	202	7.65	29.7		1	267	12.22	149.2	30	0
129	6.72	114.0		13	203	7.72	29.0		1	268	12.38	148.6	30	0
130	6.92	116.1		13	204	7.74	28.9	30	0	269	12.46	148.4	30	0
131	7.06	118.3		13	205	7.76	28.6	30	0	270	12.52	148.2	30	0
132	7.36	119.7		13	206	7.79	28.3	30	0	271	12.59	148.0	30	0
133	7.66	120.5		13	207	7.83	28.1	48	0	272	12.42	146.7	30	0
134	7.89	122.5		13	208	7.86	27.8	48	0	273	12.43	146.3	30	0
135	8.12	124.5		13	209	7.90	27.5	30	0	274	12.43	146.0	30	0
136	8.37	126.0		13	210	7.92	27.4	48	0	275	12.42	145.5	30	0
137	8.65	127.3		13	211	7.95	27.2	48	0	276	12.38	144.6	30	0
138	8.91	128.6		13	212	8.02	26.7		1					
139	9.16	129.9		13	213	8.17	25.8	30	0					

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 5

Event Time (Julian day, hr, min, sec): 215:15:14:43.820

Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade
101	20.00	340.5	13	140	7.40	330.0	13	214	20.65	338.7	1
102	19.68	340.9	13	141	7.05	329.4	13	215	20.72	339.3	48 0
103	19.37	341.2	13	142	6.72	328.7	13	216	20.75	339.6	48 0
104	19.06	341.6	13	143	6.40	328.1	13	217	20.76	339.7	48 0
105	18.74	341.9	13	144	6.13	326.4	13	218	20.77	339.8	48 0
106	18.37	341.9	13	145	5.89	324.7	1	219	20.77	339.9	30 0
107	18.06	341.6	13	146	5.65	322.3	1	220	20.76	340.1	30 0
108	17.74	341.3	13	147	5.44	319.5	13	221	20.75	340.3	12 0
109	17.42	340.9	13	148	5.25	316.4	13	222	20.75	340.4	30 0
110	17.10	340.7	13	149	5.08	313.2	13	223	20.73	340.5	2/3
111	16.78	340.5	13	150	4.93	309.9	13	224	20.72	340.7	48 0
112	16.46	340.3	13	151	4.80	306.3	13	225	20.66	341.5	48 0
113	16.13	340.1	13	152	4.40	284.7	13	251	4.43	288.7	48 0
114	15.80	339.9	13	153	4.39	280.7	13	252	4.46	291.3	48 0
115	15.42	339.7	13	154	4.35	276.4	1	253	4.47	292.5	2/3/8
116	15.09	339.5	13	155	4.33	272.4	13	254	4.49	293.5	48 0
117	14.79	339.2	13	156	4.29	267.7	13	255	4.50	294.4	48 0
118	14.44	338.9	13	157	4.32	264.0	13	257	4.52	295.6	48 0
119	14.12	338.6	13	158	4.37	259.7	13	258	4.53	296.3	48 0
120	13.82	338.2	13	159	4.39	255.4	13	259	4.54	297.1	48 0
121	13.49	337.9	1	160	4.33	251.8	13	260	4.56	298.0	48 0
122	13.14	337.4	1	161	4.30	248.7	13	261	4.57	298.5	48 0
123	12.82	337.0	1	162	4.20	244.1	13	262	4.59	299.1	48 0
124	12.50	336.5	1	163	4.14	239.6	13	263	4.61	300.0	48 0
125	12.16	336.2	1	164	4.16	235.2	13	264	4.64	300.9	48 0
126	11.85	335.8	13	165	4.17	231.4	13	265	4.67	302.1	48 0
127	11.52	335.6	13	201	20.30	340.2	30 0	266	4.74	304.3	48 0
128	11.23	335.3	13	202	20.48	340.0	1	267	5.01	294.8	48 0
129	10.91	334.7	13	203	20.58	340.0	1	268	4.80	294.9	48 0
130	10.59	334.4	13	204	20.62	340.0	30 0	269	4.71	294.9	48 0
131	10.32	333.7	13	205	20.66	340.0	30 0	270	4.63	295.0	48 0
132	9.97	333.8	13	206	20.70	340.0	30 0	271	4.56	294.9	48 0
133	9.66	334.3	13	207	20.76	340.0	30 0	272	4.55	299.1	48 0
134	9.32	333.7	13	208	20.80	340.0	30 0	273	4.51	299.9	48 0
135	8.98	332.9	13	209	20.86	340.0	30 0	274	4.48	300.8	48 0
136	8.67	332.4	13	210	20.89	340.0	48 0	275	4.45	302.0	48 0
137	8.33	332.0	13	211	20.93	340.0	48 0	276	4.41	304.5	48 0
138	8.01	331.4	13	212	21.03	340.0	1				
139	7.70	330.7	13	213	21.23	340.1	30 0				

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 6

Event Time (Julian day, hr, min, sec): 215:17:04:19.280

Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade
101	8.02	1.8	13	140	5.49	143.8	13	214	8.42	356.2	1
102	7.77	3.5	13	141	5.83	144.9	13	215	8.55	357.3	48 0
103	7.53	5.2	13	142	6.16	145.9	13	216	8.61	357.9	30 0
104	7.30	7.1	13	143	6.47	146.7	13	217	8.62	358.1	30 0
105	7.06	8.9	13	144	6.75	148.3	13	218	8.65	358.3	48 0
106	6.72	10.3	13	145	6.99	149.6	1	219	8.67	358.6	30 0
107	6.41	11.0	13	146	7.26	151.3	1	220	8.68	359.2	30 0
108	6.09	11.7	13	147	7.51	153.0	13	221	8.69	359.5	30 0
109	5.76	12.4	13	148	7.78	154.8	13	222	8.70	359.7	30 0
110	5.45	13.6	13	149	8.04	156.3	13	223	8.70	360.0	48 0
111	5.16	15.1	13	150	8.30	157.7	13	224	8.72	0.6	48 0
112	4.86	16.7	13	151	8.56	159.0	13	225	8.76	2.4	48 0
113	4.55	18.3	13	152	10.08	164.6	13	251	9.81	163.7	30 0
114	4.27	20.5	13	153	10.36	165.3	13	252	9.63	163.2	30 0
115	3.95	23.6	13	154	10.68	165.8	1	253	9.55	162.9	1
116	3.67	26.5	13	155	10.97	166.2	13	254	9.48	162.7	30 0
117	3.43	29.5	13	156	11.33	166.5	13	255	9.42	162.4	30 0
118	3.16	33.4	13	157	11.60	166.8	13	257	9.34	162.1	30 0
119	2.92	37.7	13	158	11.92	167.2	13	258	9.29	161.9	30 0
120	2.69	42.3	13	159	12.24	167.3	13	259	9.24	161.7	30 0
121	2.48	48.2	1	160	12.52	166.9	13	260	9.17	161.5	30 0
122	2.29	55.7	1	161	12.75	166.7	13	261	9.14	161.4	30 0
123	2.14	63.6	1	162	13.06	166.0	13	262	9.09	161.2	30 0
124	2.04	72.3	1	163	13.37	165.4	13	263	9.03	160.9	30 0
125	2.04	81.9	1	164	13.68	165.0	13	264	8.96	160.7	30 0
126	2.07	90.9	13	165	13.94	164.7	13	265	8.88	160.4	30 0
127	2.20	99.3	13	201	8.26	0.2	48 0	266	8.71	159.7	30 0
128	2.33	105.8	13	202	8.41	359.6	1	267	9.07	164.7	30 0
129	2.48	113.1	13	203	8.50	359.3	1	268	9.18	163.7	30 0
130	2.68	118.7	13	204	8.54	359.2	30 0	269	9.25	163.3	30 0
131	2.85	124.0	13	205	8.57	359.1	30 0	270	9.30	162.9	30 0
132	3.17	126.7	13	206	8.62	359.0	48 0	271	9.35	162.5	30 0
133	3.48	127.9	13	207	8.67	358.9	30 0	272	9.12	161.0	30 0
134	3.74	131.6	13	208	8.71	358.8	48 0	273	9.11	160.6	1
135	4.02	135.0	13	209	8.76	358.7	30 0	274	9.09	160.1	30 0
136	4.30	137.3	13	210	8.80	358.6	30 0	275	9.05	159.5	48 0
137	4.61	139.1	13	211	8.83	358.6	30 0	276	8.97	158.3	30 0
138	4.91	140.8	13	212	8.93	358.4	1				
139	5.20	142.5	13	213	9.12	358.1	48 0				

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 7

Event Time (Julian day, hr, min, sec): 215:17:06:13.860

Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade
101	10.66	340.8	13	140	2.43	192.3	13	214	11.31	337.6	1
102	10.34	341.6	13	141	2.75	188.5	13	215	11.38	338.6	48 0
103	10.03	342.2	13	142	3.06	185.8	13	216	11.40	339.1	30 0
104	9.72	342.9	13	143	3.36	183.5	13	217	11.41	339.3	30 0
105	9.41	343.6	13	144	3.69	183.2	13	218	11.42	339.4	48 0
106	9.03	343.6	13	145	3.99	183.2	1	219	11.43	339.7	30 0
107	8.72	343.1	13	146	4.32	183.7	1	220	11.41	340.1	30 0
108	8.40	342.6	13	147	4.66	184.3	13	221	11.40	340.4	30 0
109	8.08	341.9	13	148	5.00	185.1	13	222	11.40	340.6	30 0
110	7.75	341.4	13	149	5.34	185.6	13	223	11.39	340.8	48 0
111	7.44	341.1	13	150	5.66	186.1	13	224	11.37	341.3	48 0
112	7.11	340.6	13	151	5.98	186.6	13	225	11.32	342.6	48 0
113	6.78	340.0	13	152	7.74	188.0	13	251	7.43	187.8	30 0
114	6.46	339.5	13	153	8.05	188.1	13	252	7.23	187.7	30 0
115	6.08	339.1	13	154	8.38	187.8	1	253	7.14	187.6	1
116	5.75	338.4	13	155	8.68	187.6	13	254	7.06	187.6	48 0
117	5.45	337.7	13	156	9.03	187.0	13	255	6.98	187.5	48 0
118	5.10	336.8	13	157	9.31	186.9	13	257	6.89	187.4	48 0
119	4.79	335.8	13	158	9.63	186.6	13	258	6.84	187.4	48 0
120	4.49	334.3	13	159	9.95	186.1	13	259	6.78	187.3	48 0
121	4.17	332.8	1	160	10.18	185.2	13	260	6.70	187.3	30 0
122	3.83	330.9	1	161	10.38	184.6	13	261	6.66	187.2	30 0
123	3.52	328.6	1	162	10.64	183.2	13	262	6.60	187.2	30 0
124	3.23	325.8	1	163	10.89	182.0	13	263	6.53	187.1	30 0
125	2.91	323.5	1	164	11.16	181.2	13	264	6.46	187.1	30 0
126	2.63	320.2	13	165	11.39	180.4	13	265	6.36	187.0	30 0
127	2.33	316.9	13	201	10.96	340.2	48 0	266	6.16	186.8	30 0
128	2.07	313.1	13	202	11.14	340.0	1	267	6.83	191.5	48 0
129	1.83	306.2	13	203	11.24	339.9	1	268	6.86	189.9	48 0
130	1.60	298.6	13	204	11.27	339.9	30 0	269	6.89	189.1	48 0
131	1.47	288.2	13	205	11.31	339.9	30 0	270	6.91	188.5	48 0
132	1.23	277.5	13	206	11.36	339.9	48 0	271	6.93	187.9	30 0
133	1.02	265.3	13	207	11.41	339.9	30 0	272	6.62	186.9	30 0
134	1.05	245.7	13	208	11.46	339.9	30 0	273	6.58	186.3	1
135	1.21	229.2	13	209	11.51	339.9	30 0	274	6.53	185.8	30 0
136	1.39	217.1	13	210	11.55	339.9	30 0	275	6.46	185.2	48 0
137	1.61	207.2	13	211	11.58	339.9	30 0	276	6.30	184.1	30 0
138	1.87	200.3	13	212	11.69	340.0	1				
139	2.16	195.9	13	213	11.88	340.1	30 0				

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 8

Event Time (Julian day, hr, min, sec): 215:17:06:45.300

Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade
101	15.53	354.9	13	140	3.42	27.9	13	214	16.01	352.1	1
102	15.25	355.7	13	141	3.18	32.6	13	215	16.12	352.8	30 0
103	14.98	356.4	13	142	2.97	37.6	13	216	16.17	353.1	30 0
104	14.71	357.1	13	143	2.81	43.1	13	217	16.19	353.2	30 0
105	14.44	357.9	13	144	2.57	48.1	13	218	16.21	353.3	30 0
106	14.07	358.3	13	145	2.38	53.2	1	219	16.22	353.5	30 0
107	13.75	358.3	13	146	2.14	59.5	1	220	16.23	353.8	30 0
108	13.42	358.3	13	147	1.92	66.9	13	221	16.23	354.0	12 0
109	13.09	358.3	13	148	1.73	76.0	13	222	16.24	354.1	30 0
110	12.75	358.4	13	149	1.60	86.7	13	223	16.24	354.2	30 0
111	12.44	358.7	13	150	1.53	98.3	13	224	16.24	354.6	30 0
112	12.12	358.9	13	151	1.53	110.6	13	225	16.25	355.5	30 0
113	11.78	359.0	13	152	2.50	155.2	13	251	2.26	150.5	48 0
114	11.45	359.3	13	153	2.75	158.9	13	252	2.11	146.8	48 0
115	11.08	359.7	13	154	3.07	161.3	1	253	2.04	144.9	1
116	10.74	0.0	13	155	3.35	163.0	13	254	1.99	143.4	48 0
117	10.44	0.3	13	156	3.70	164.1	13	255	1.94	141.6	48 0
118	10.09	0.6	13	157	3.97	165.2	13	257	1.89	139.3	48 0
119	9.77	0.9	13	158	4.29	166.4	13	258	1.86	137.9	48 0
120	9.45	1.1	13	159	4.61	166.7	13	259	1.83	136.3	48 0
121	9.11	1.3	1	160	4.89	165.8	13	260	1.78	134.2	30 0
122	8.75	1.7	1	161	5.12	165.3	13	261	1.77	133.2	48 0
123	8.41	1.9	1	162	5.44	163.6	13	262	1.73	131.6	48 0
124	8.08	2.2	1	163	5.75	162.4	13	263	1.70	129.4	48 0
125	7.75	2.9	1	164	6.06	161.8	13	264	1.66	127.2	48 0
126	7.44	3.4	13	165	6.33	161.1	13	265	1.62	123.9	48 0
127	7.12	4.3	13	201	15.79	354.2	30 0	266	1.56	117.1	48 0
128	6.85	5.1	13	202	15.95	353.9	1	267	1.50	149.5	48 0
129	6.51	5.7	13	203	16.05	353.8	1	268	1.66	145.1	48 0
130	6.21	6.6	13	204	16.09	353.8	30 0	269	1.74	143.8	48 0
131	5.91	7.0	13	205	16.12	353.7	30 0	270	1.81	142.3	48 0
132	5.63	9.2	13	206	16.17	353.7	12 0	271	1.88	141.5	48 0
133	5.43	11.8	13	207	16.22	353.6	30 0	272	1.77	131.4	48 0
134	5.10	13.2	13	208	16.27	353.6	30 0	273	1.80	129.2	1
135	4.77	14.6	13	209	16.32	353.5	30 0	274	1.82	126.9	48 0
136	4.48	16.6	13	210	16.35	353.5	30 0	275	1.84	123.8	48 0
137	4.20	19.2	13	211	16.39	353.5	30 0	276	1.90	117.9	48 0
138	3.93	22.0	13	212	16.49	353.4	1				
139	3.66	24.7	13	213	16.69	353.4	30 0				

CHALFANT VALLEY AFTERSHOCKS, AUG. 3, 1986, 20 SEC SAMPLED AT 5 MSEC

Aftershock Number 9

Event Time (Julian day, hr, min, sec): 215:17:20:56.480

Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade	Loc	Dist (km)	Azim (deg)	Tape Db Grade
101	12.27	354.5	13	140	1.83	97.3	13	214	12.76	351.0	1
102	11.99	355.5	13	141	2.01	106.7	13	215	12.87	351.8	30 0
103	11.72	356.4	13	142	2.21	114.0	13	216	12.92	352.2	30 0
104	11.45	357.3	13	143	2.44	119.6	13	217	12.93	352.4	30 0
105	11.18	358.3	13	144	2.62	126.0	13	218	12.95	352.5	30 0
106	10.81	358.8	13	145	2.79	131.0	1	219	12.97	352.7	30 0
107	10.49	358.9	13	146	2.98	136.6	1	220	12.97	353.1	12 0
108	10.16	358.9	13	147	3.19	141.7	13	221	12.97	353.3	12 0
109	9.83	358.9	13	148	3.41	146.3	13	222	12.98	353.5	30 0
110	9.50	359.1	13	149	3.64	150.3	13	223	12.98	353.7	30 0
111	9.18	359.5	13	150	3.88	153.6	13	224	12.98	354.1	30 0
112	8.86	359.8	13	151	4.13	156.6	13	225	12.99	355.3	30 0
113	8.52	0.0	13	152	5.66	167.2	13	251	5.38	165.8	30 0
114	8.20	0.4	13	153	5.95	168.4	13	252	5.20	164.8	12 0
115	7.82	1.1	13	154	6.27	169.1	1	253	5.12	164.3	1
116	7.49	1.6	13	155	6.57	169.6	13	254	5.05	164.0	30 0
117	7.19	2.1	13	156	6.92	169.8	13	255	4.98	163.5	30 0
118	6.84	2.6	13	157	7.20	170.3	13	257	4.90	162.9	30 0
119	6.52	3.2	13	158	7.52	170.7	13	258	4.86	162.6	30 0
120	6.20	3.5	13	159	7.85	170.7	13	259	4.81	162.2	12 0
121	5.87	4.1	1	160	8.12	170.0	13	260	4.74	161.8	12 0
122	5.51	4.8	1	161	8.34	169.6	13	261	4.71	161.5	12 0
123	5.17	5.4	1	162	8.65	168.4	13	262	4.65	161.2	12 0
124	4.84	6.0	1	163	8.95	167.5	13	263	4.59	160.7	12 0
125	4.53	7.5	1	164	9.26	166.9	13	264	4.53	160.2	30 0
126	4.22	8.8	13	165	9.51	166.3	13	265	4.44	159.5	30 0
127	3.91	10.9	13	201	12.53	353.6	30 0	266	4.28	158.1	30 0
128	3.66	12.9	13	202	12.70	353.3	1	267	4.65	168.0	30 0
129	3.34	14.8	13	203	12.79	353.1	1	268	4.76	166.0	30 0
130	3.05	17.6	13	204	12.83	353.1	30 0	269	4.82	165.2	30 0
131	2.77	19.6	13	205	12.86	353.0	12 0	270	4.87	164.4	30 0
132	2.56	25.7	13	206	12.91	353.0	12 0	271	4.92	163.8	12 0
133	2.45	32.5	13	207	12.96	352.9	12 0	272	4.68	160.9	12 0
134	2.19	38.6	13	208	13.01	352.9	30 0	273	4.68	159.9	1
135	1.96	46.1	13	209	13.06	352.8	12 0	274	4.66	159.0	12 0
136	1.82	55.1	13	210	13.09	352.8	30 0	275	4.62	157.9	30 0
137	1.74	65.9	13	211	13.13	352.8	30 0	276	4.55	155.6	30 0
138	1.72	76.9	13	212	13.23	352.7	1				
139	1.74	87.6	13	213	13.43	352.6	30 0				

APPENDIX B

Archive Tape Data Format

Archive data tapes are written in SEG Y standard format (Barry et al., 1975). Recording density is 1600 bpi, phase encoded (PE). In order to accommodate seismic refraction data, some minor changes have been made to the tape header fields. A complete list of header fields is provided in the card image portion of the reel identification header, shown below:

C 1 REEL IDENTIFICATION HEADER BYTES:
 C 2 3217 -3218 sampling interval (microsecs).
 C 3 3221 -3222 number of samples per trace.
 C 4 3225 -3226 data sample format code.
 C 5 3255 -3256 measurement system (1 = meters; 2 = feet).
 C 6
 C 7
 C 8 TRACE IDENTIFICATION HEADER BYTES:
 C 9 1 - 4 trace sequence number within reel.
 C10 5 - 8 trace sequence number within reel.
 C11 9 - 12 station location number.
 C12 29 - 30 trace ID code (1 = seismic data).
 C13 37 - 40 shotpoint-receiver distance (M).
 C14 41 - 44 station elevation (M).
 C15 45 - 48 shotpoint elevation (M).
 C16 49 - 52 source depth (M).
 C17 69 - 70 scalar to be applied to all elevations.
 C18 71 - 72 scalar to be applied to all coordinates.
 C19 73 - 76 shotpoint coordinate - X.
 C20 77 - 80 shotpoint coordinate - Y.
 C21 81 - 84 receiver coordinate - X.
 C22 85 - 88 receiver coordinate - Y.
 C23 89 - 90 coordinate units (1 = meters; 2 = seconds of arc).
 C24 115 - 116 number of samples in this trace.
 C25 117 - 118 sample interval in microseconds for this trace.
 C26 121 - 122 instrument attenuation in db.
 C27 157 - 158 shot time - year.
 C28 159 - 160 shot time - day of year.
 C29 161 - 162 shot time - hour of day (24 hour clock).
 C30 163 - 164 shot time - minute of hour.
 C31 165 - 166 shot time - second of minute.
 C32 167 - 168 time basis code (2 = GMT).
 C33 181 - 182 shot time - milliseconds.
 C34 183 - 184 shotpoint location number.
 C35 185 - 186 recording instrument unit number.

C36 191 - 192 distance weighting exponent (hundredths).
C37 193 - 194 shot sequence number (shot number).
C38 195 - 196 shot size (kg).
C39 197 - 200 shot point - station azimuth (second of arc).
C40 201 - 204 time of first point minus time (msec).

The data point format is "32 bit floating point", and the appropriate bytes (3225-3226) of the binary reel id header contain a value of 1. The trace amplitudes have not been adjusted for instrument gain, but the gain correction factor can be estimated from the instrument attenuation value (att) specified in bytes 121-122. To correct for gain, the data should be demeaned and then multiplied by:

$$\frac{(att/20)}{10}$$

The measurement system (bytes 3255-3256 of the binary reel header) is set to 1, meters.

Shot point and receiver coordinates are in seconds of arc (byte field 89-90). The coordinate scalar multiplier (bytes 71-72) is set to -100, so the coordinates (bytes 73-88) are in hundredths of a second of arc.

Bytes 157-166 and bytes 181-182 refer to the shot detonation time. The time of the first data sample is found by adding the shot detonation time to the time specified in bytes 201-204.

Since there is no weighting of amplitudes with distance for archive tapes, the distance weighting exponent (bytes 191-192) is not used.

Shot sequence number (bytes 193-194) refers to the order in which shots were fired during the field campaign.