

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

SEISMIC REFRACTION DATA ACROSS THE COAST RANGE AND WILLAMETTE BASIN  
IN CENTRAL OREGON: THE 1991 PACIFIC NORTHWEST EXPERIMENT

By

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Open-File Report 93-319



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Menlo Park, California  
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## ABSTRACT

In September, 1991, the U.S. Geological Survey (USGS), Oregon State University, the University of Texas at El Paso, the University of Wyoming, and the Canadian Lithoprobe program cooperated to conduct a series of large-aperture seismic profiles in the Pacific Northwest. The objectives of this program were to image the structure of the Cascadia subduction zone in order to better understand the seismic hazard associated with this subduction system. Specific targets included both the interface between the North American and Juan de Fuca plate and crustal sutures within the North American plate. Two north-south profiles and one east-west profile were shot (figure 1). The purpose of this report is to present data from the east-west profile, which represents an extension of an onshore/offshore seismic profile shot in 1989.

## INTRODUCTION

In September, 1989, investigators from Oregon State University (OSU), University of Texas at Austin, and the U.S. Geological Survey (USGS) collaborated to collect a marine seismic reflection profile (Lin and Trehu, 1991) and complementary onshore-offshore wide-angle seismic recordings (Brocher et al., 1993; Trehu and Nakamura, 1993) across the central Oregon continental margin and Coast Range. This study was followed in 1991 by an onshore seismic refraction program conducted by the USGS, OSU, the University of Texas at El Paso, the University of Wyoming, the University of British Columbia, and the Geological Survey of Canada. One of these refraction profiles, which was oriented east-west and extended the 1989 profile across the Willamette Valley and into the foothills of the Cascade Range, is discussed in this report. Results from an inversion of the travel times recorded during both experiments have been presented by Trehu and others (1992a, b).

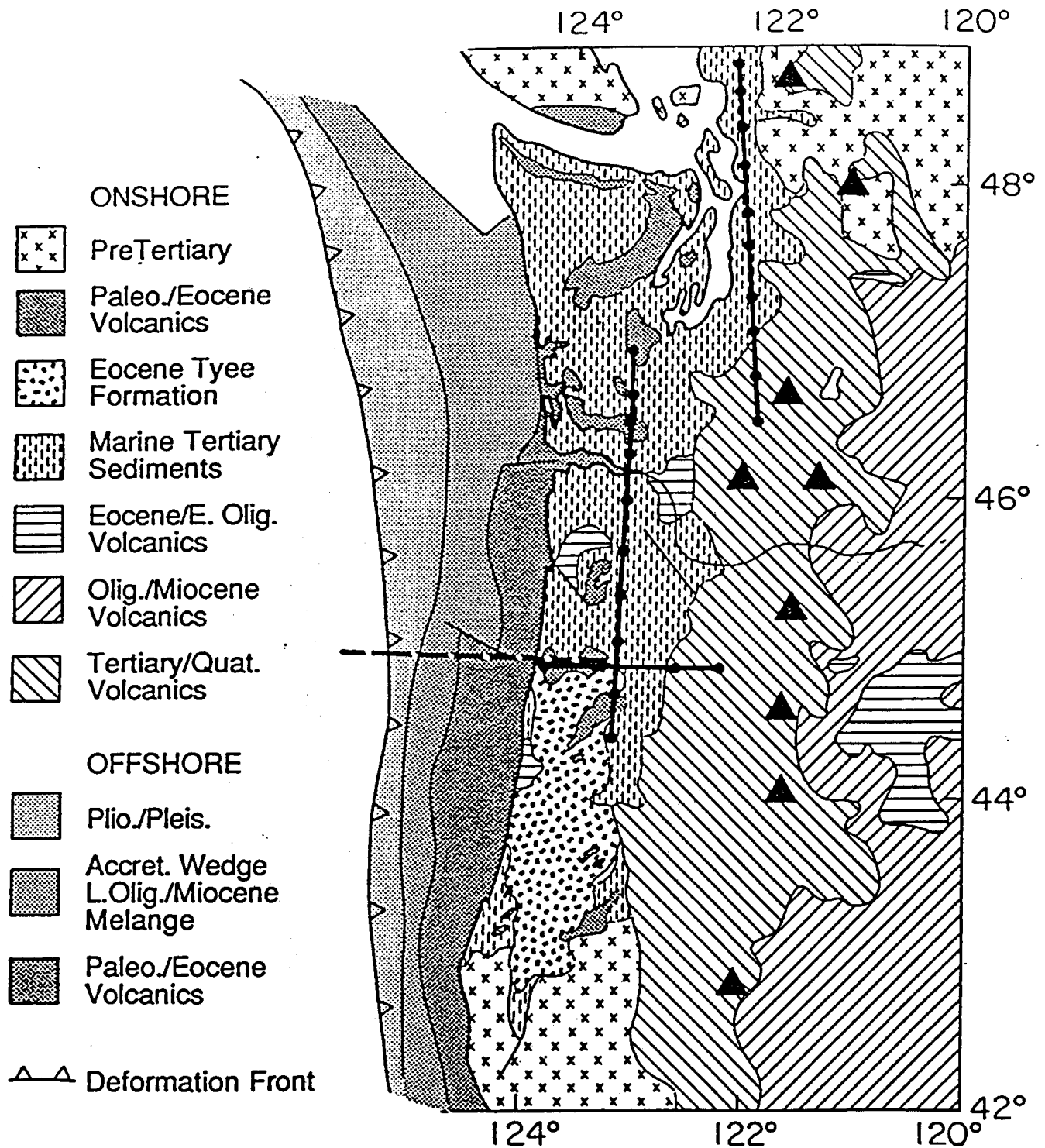


FIGURE 1. Simplified geologic map (onshore geology after Wells et al., 1984; offshore geology after Snively, 1987) showing the location of the seismic reflection and refraction profiles collected in 1989 (heavy dashed line) and 1991 (heavy solid lines). Filled triangles show the locations of Cascade volcanoes. Dots along profiles show the locations of large explosive shots.

## DATA ACQUISITION

The seismic profile discussed here extends from near Lincoln City on the Oregon coast across the Coast Range and Willamette Valley and ends about four miles east of the town of Elkhorn in the foothills of the Central Oregon Cascades. In order to provide easy access and to avoid cultural noise, stations were primarily deployed along rural residential roads or logging roads, with a station spacing of approximately 350 m. A total of 420 stations, consisting of four different types of seismograph and two different types of sensors (table 1), was deployed. Figure 2a shows the locations of the stations. Figure 2b shows the locations of shots recorded by this array. Figure 3 shows the elevation and type of instrument deployed at each station. The eastern end of the profile was determined by three primary factors: 1) the number of available instruments; 2) the desired trace spacing; and 3) the boundary of the Bull of the Woods Wilderness, and consequently the end of the road.

TABLE 1: Seismometers and seismographs used.

Seismograph	Station No.	Seismometer	Operator
PSR-4	3022 to 3042	Three orthogonal 2-Hz geophones	Lithoprobe
REFTEK	3042 to 3071	Three orthogonal 2-Hz geophones	IRIS (OSU)
PSR-1	3001 to 3021 3072 to 3234	2-Hz vertical geophones	Lithoprobe
SGR	3235 to 3419	6 8-Hz vertical geophones in series	USGS

All station locations were originally determined from USGS 7.5 minute quadrangle maps by carefully plotting them relative to identifiable landmarks. All sites were revisited with GPS receivers to obtain refined site locations. To obtain the GPS solutions, two GPS receivers were run simultaneously, one at a control position near the center of the line and the other at each site; the data were then processed to correct for random noise added to the GPS system. High-quality, three-dimensional GPS locations were obtained at 13 percent of the sites in the Coast Range, 70

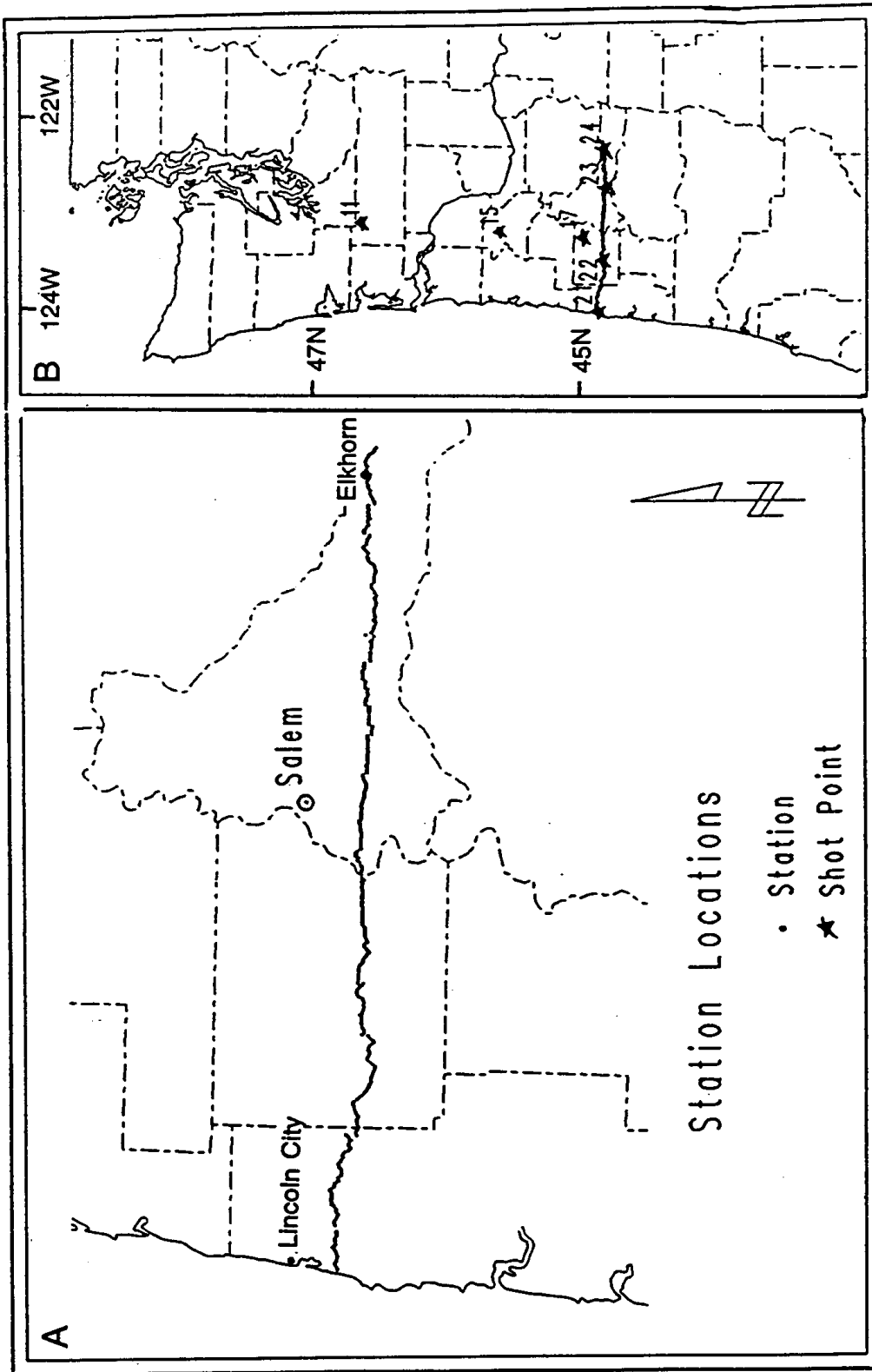


FIGURE 2. Location of the seismic profile discussed in this report. Dashed lines are county boundaries. A) Station locations; B) Shot and station locations.

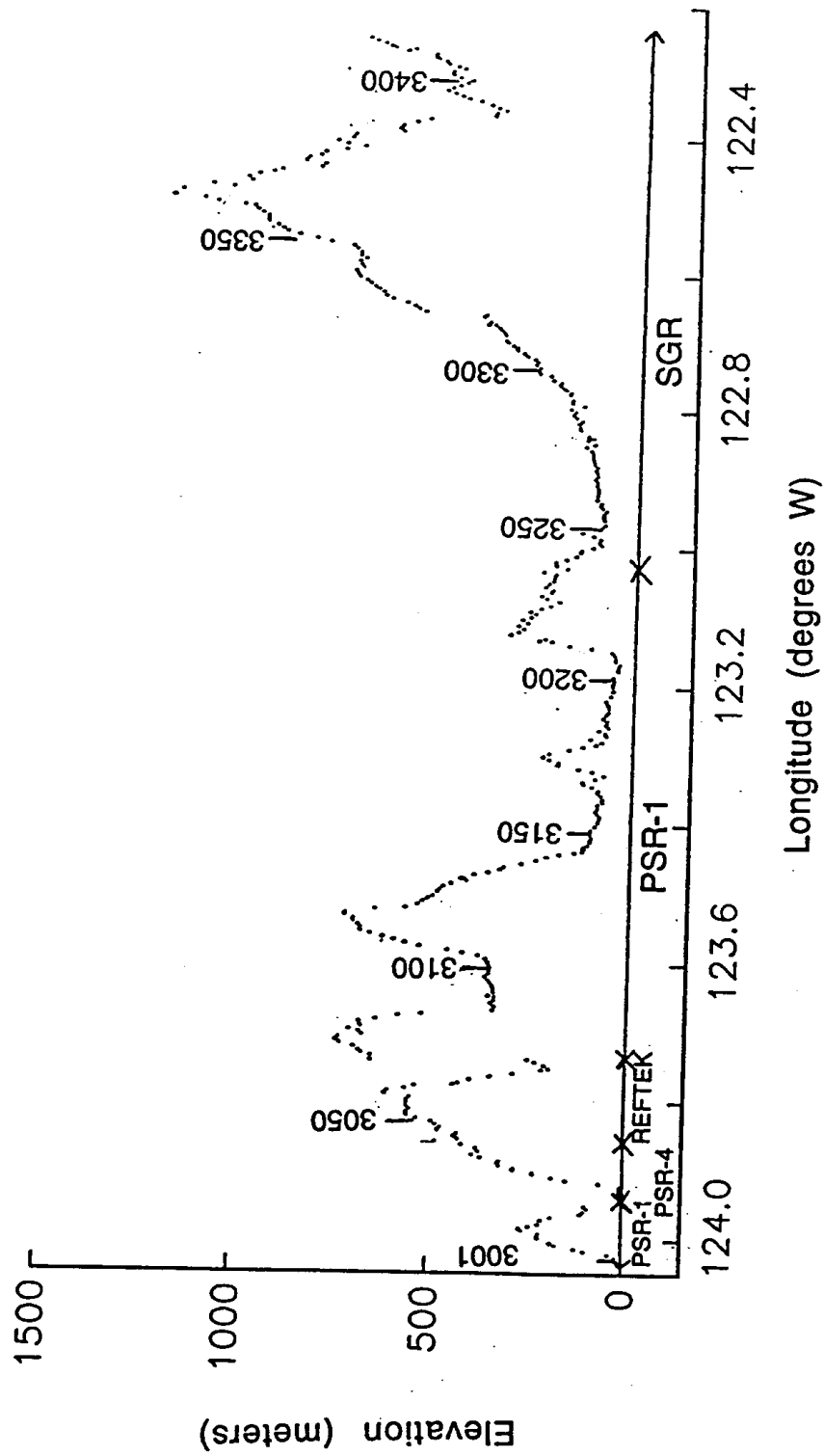


FIGURE 3. Elevation along the profile. Each station is shown as a dot. The type of seismograph deployed at each station is also shown. Every 50th station is labeled.



percent of the sites in the Willamette valley, and 33 percent of the sites in the Cascades. Locations of these sites are accurate to within a few tens of meters. Dense foliage and considerable topography probably interfered with GPS reception at many of the Coast Range and Cascade sites.

Station locations were digitized from the field maps (referred to as "map" locations), and these locations and elevations were compared to locations and elevations from the 2-station GPS solutions, when available. Map locations are within 80 meters of the GPS locations with no detectable systematic offset, providing an estimate of the error of the map locations. An average elevation offset of  $28 \pm 7$  meters was detected between the mapped elevations and GPS elevations, probably due to differences in the reference geoid. The final site locations and elevations presented in figures 2 and 3 and in the Appendix represent the GPS location and the GPS elevation minus 28 meters when a reliable GPS fix was available, and the map location and elevation at sites for which reliable GPS solutions were not obtained.

Seven large (2000 lb each) explosive shots located at seven different shot points were detonated and recorded by this array (figure 2). The locations of all shot points were determined using GPS receivers operated in the 2-station differential positioning mode (table 2). Four of the shots (21–24) were located along the profile and three were fan shots (11, 15, 17) detonated in holes that had previously been drilled and shot during acquisition of the north-south profile. The three fan shots reused shot holes from the north-south profile. In addition, shot point 22 was reoccupied by a 1000 lb shot and the REFTEKs were redeployed several days later to fill a gap in the profile resulting from an instrument malfunction during the initial firing of this shotpoint.

TABLE 2: Shot point locations and origin times (all on October 2, 1991).

Shotpoint No.	Latitude (°N)	Longitude (°W)	Elevation (m)	Origin Time
11	46.71530	-123.11958	122	0912
15	45.64276	-123.18259	276	0910
17	44.99615	-123.21643	58	0904
21	44.86978	-124.00471	189	0900
22	44.83978	-123.46821	354	0902
23	44.83692	-122.67084	363	0906
24	44.84742	-122.27847	536	0908

## INSTRUMENTATION

Four types of seismographs were used to collect the data along this profile (Table 1). The seismic Group Recorders (SGR's) were designed by Amoco Production Company, built by Globe Universal Sciences, Inc., and modified by the USGS. They are single channel, digital seismic recorders with a theoretical dynamic range of 156 dB. Data are sampled at 500 samples per second by a 12 bit A/D with gain ranging from 0–90 dB in 6 dB steps. These SGR's have been modified to turn on at preset times instead of using the standard radio turn on. Each SGR was connected to a single string of 6 modified Marks Products L-10B vertical component geophones connected in series. The theoretical velocity response for this seismograph/seismometer system is shown in figure 4a (Murphy, et al., 1992).

The PSR-1 seismographs are digitally recording instruments with a total dynamic range of 126 dB and a sample rate of 125 samples/s. Sensors were Mark Products L4A 2-Hz vertical-component geophones. The PSR-4 seismographs are similar to the PSR-1s, except that they record 3 orthogonal geophone components. Only the vertical component data are presented in this report. The theoretical velocity response is shown in figure 4b (Luetgert et al., 1990).

The REFTEK seismographs are 6-component instruments that can be operated in both pre-programmed and event-detect modes. A wide range of sampling rates is possible. For this experiment, the instruments were programmed to record for 110 s during each shot window and the data were sampled at 100 Hz. The sensors used for this experiment were three-component Mark Products L-22 2 Hz seismometers. The theoretical velocity response is shown in figure 4c (PASSCAL training center manual, unpublished manuscript).

Timing for each recording unit is provided by a temperature-compensated oscillator that is synchronized relative to a GOES satellite clock prior to deployment. Each unit was then deployed with programmable timers to initiate recording over the expected shot time window. After each deployment the GOES time signal was compared to the internal clocks to measure clock drifts.

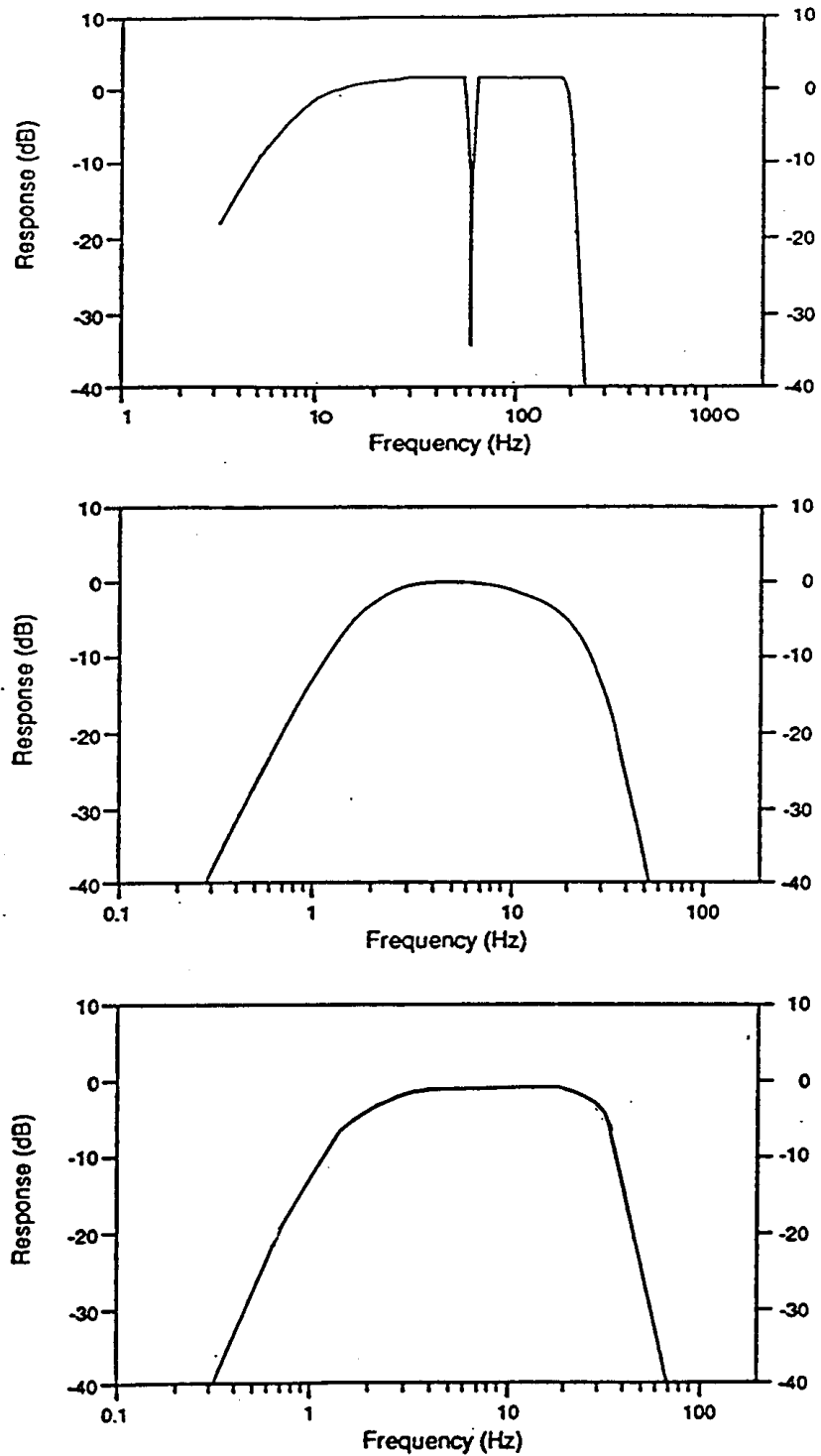


FIGURE 4. Approximate velocity responses for the seismograph/seismometer combinations used for this experiment.

## DATA PROCESSING

Shot-receiver offsets were calculated using shot and receiver positions provided in Table 2 and the Appendix. Offsets for stations to the west of a shot point were defined to be negative. Data from the several different instrument types were processed as described below and then merged into a single SEG Y disk file (as interpreted by the processing program SIOSEIS) for each shot and each component.

### PSR:

- DC offset was removed from the data.
- Final corrected source-receiver ranges (in meters) were inserted into the SEG Y trace headers in bytes 37–40.
- The elevation of the station (in meters) was inserted in the SEG Y trace headers in bytes 41–44.
- The Z, N, and E components were grouped into separate files for sites 3001 through 3042.
- A timing correction of -0.045 seconds was added to the "deep water delay" (SIOSEIS-SEG Y trace header locations 109-110 and 181-184) to account for a systematic delay caused by the PSR acquisition system. This time correction was derived by comparing data from co-located REFTEK/PSR and PSR/SGR pairs.
- The polarity was reversed for the vertical component so that upward motion is positive.

### REFTEK:

- The data were converted from IRIS SEG Y (one trace per file) format to SIOSEIS SEG Y format.
- Each component was put in a separate file.

- DC offset was removed from the data.
- Final corrected source-receiver ranges (in meters) were inserted into the trace headers at SIOSEIS SEGY header location 37-40.
- The elevation of the station was inserted in the trace header in bytes 41-44.
- The data were resampled from 100 Hz to 125 Hz.
- A timing correction of 0.625 seconds was added to the deep water delay, (SIOSEIS SEGY trace header locations 109-110 and 181-184) for REFTEK data for shot point 22 to account for a timing error in the data.<sup>1</sup>

SGR:

- DC offset was removed from the data.
- A low pass filter of 60 Hz was applied.
- The data were decimated from 250 Hz to 125 Hz.

The data from different instruments were then merged into a single SEGY file for each shot and each component, and the following processing sequence was followed:

- A reduction velocity of 6500 m/s was applied to the data to decrease the amount of data stored.
- The data were band pass filtered between 2 and 40 Hz.
- Noisy traces were edited manually.

The data processed as described above can be obtained from the IRIS Data Management Center. For the sections displayed here, a second bandpass filter with a passband of 5–25 Hz was applied, the traces were normalized to the same maximum amplitude, and the data were corrected for topographic variations by projecting each receiver and shot to sealevel assuming a velocity of 4.5

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<sup>1</sup>This time difference was introduced because the REFTEK data for this shot were not properly recorded when shot point 22 was originally shot. We reshot SP-22 for the REFTEK deployment. The clock in the shot box failed for the reshoot. The shot instant for SP-22 was determined by comparing PSR and REFTEK data from the same point.

km/s for the material between sea level and the surface and an apparent velocity of 6.5 km/s. Figure 5 illustrates the effect of this correction..

## DESCRIPTION OF THE DATA

The vertical component data are displayed in figures 6–12. Pg arrivals are observed as first arrivals to the maximum offset recorded from all shotpoints, including shotpoint 11, a fan shot which provided offsets of 207-217 km. This result is consistent with observations from the perpendicular N-S oriented profile shot along the western edge of the Willamette Valley, which indicates a thick, high-velocity crust in this region (e.g., Trehu et al., 1992). Strong Sg arrivals are also observed from shotpoints 22–24.

Numerous coherent secondary arrivals that follow the first arrivals within 1-2 s and are only observed over distances of 10-30 km are also observed on shots 21-24. These arrivals probably represent reflections from structures within the crust beneath the Coast Range, reflections from the base of the Willamette Valley, multipathing around high velocity near-surface rocks that overlie lower velocity valley sediments, and possibly other sources.

Weak wide angle reflections tentatively interpreted to be from the lower crust and Moho are observed at offsets greater than 100 km on shots 21 and 24. Secondary arrivals are also observed on fan shots 11 and 15, and suggest lateral variations in the lower crust.

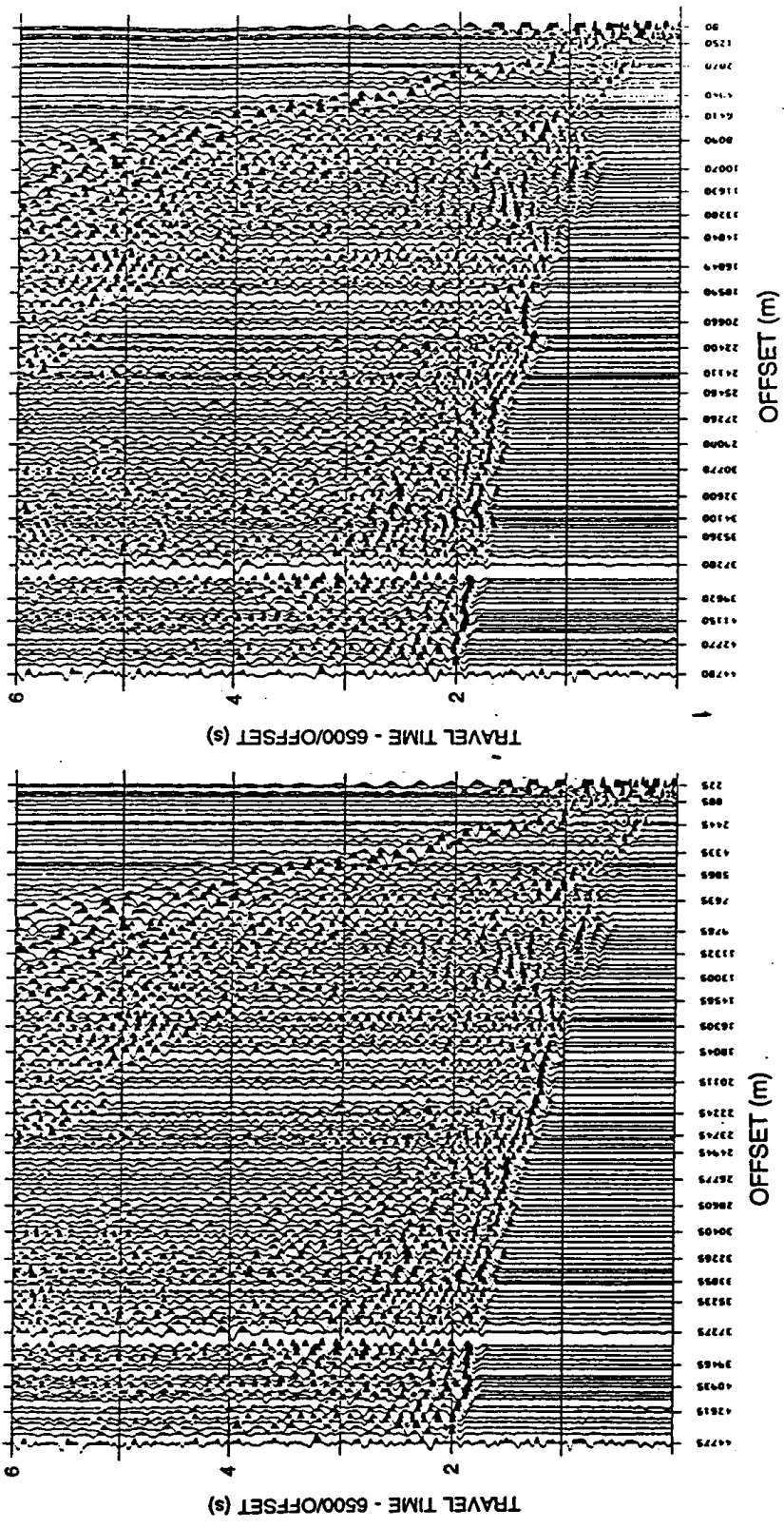


FIGURE 5. Comparison of data from shot point 22 with (A) and without (B) topographic correction.

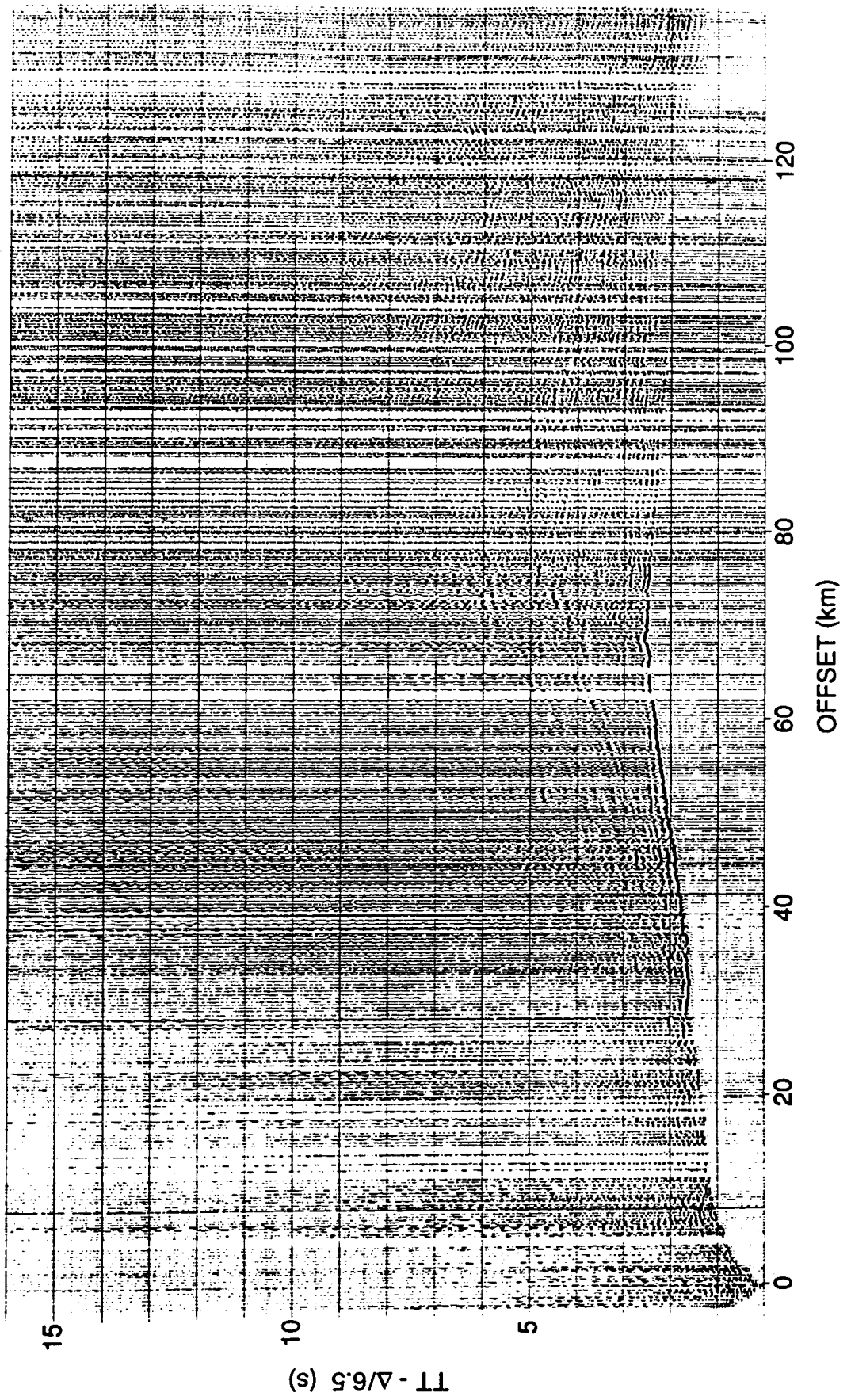


FIGURE 6. Record section from shotpoint 21. Plotting parameters are described in the text.



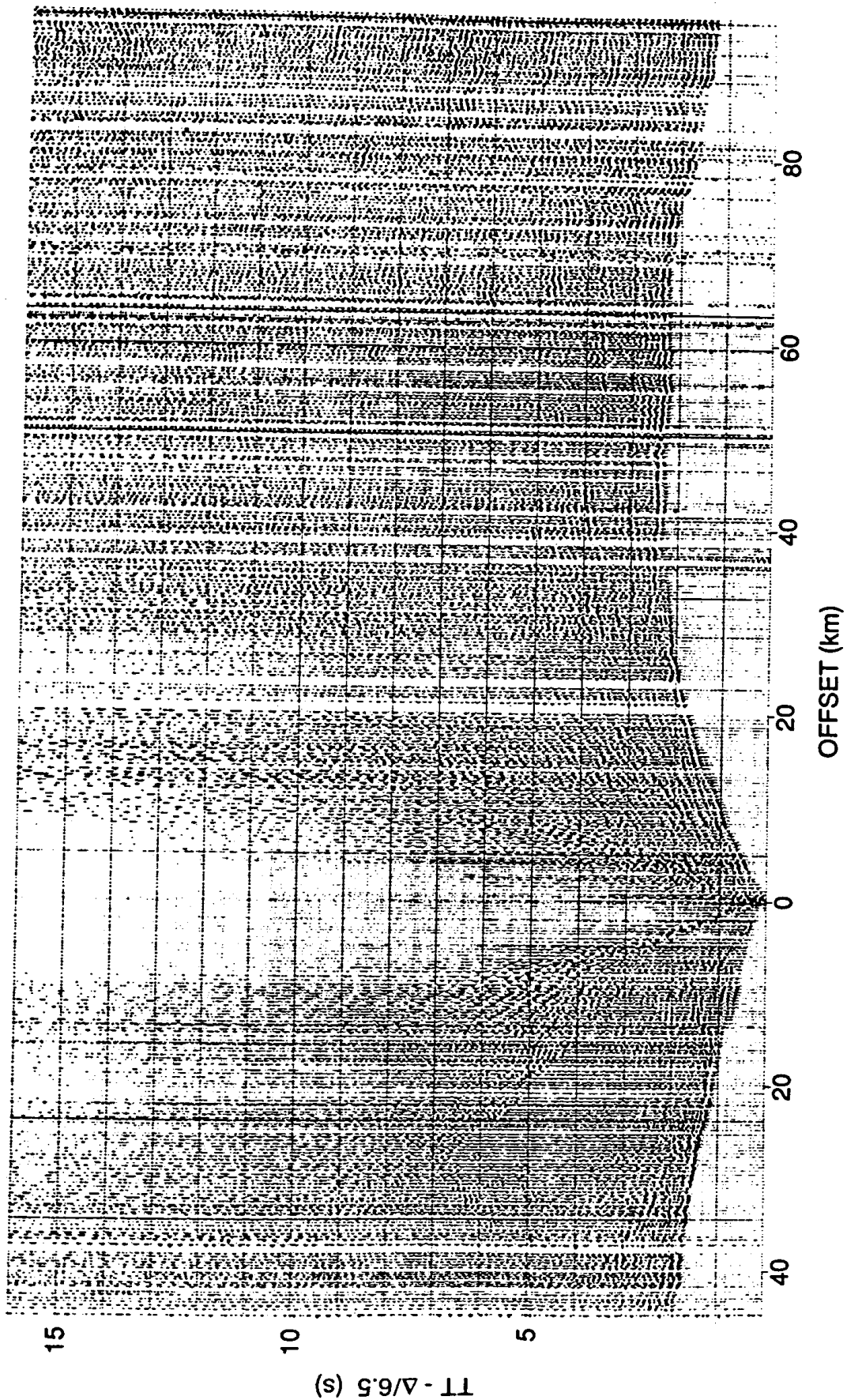


FIGURE 7. Record section from shotpoint 22. Plotting parameters are described in the text.

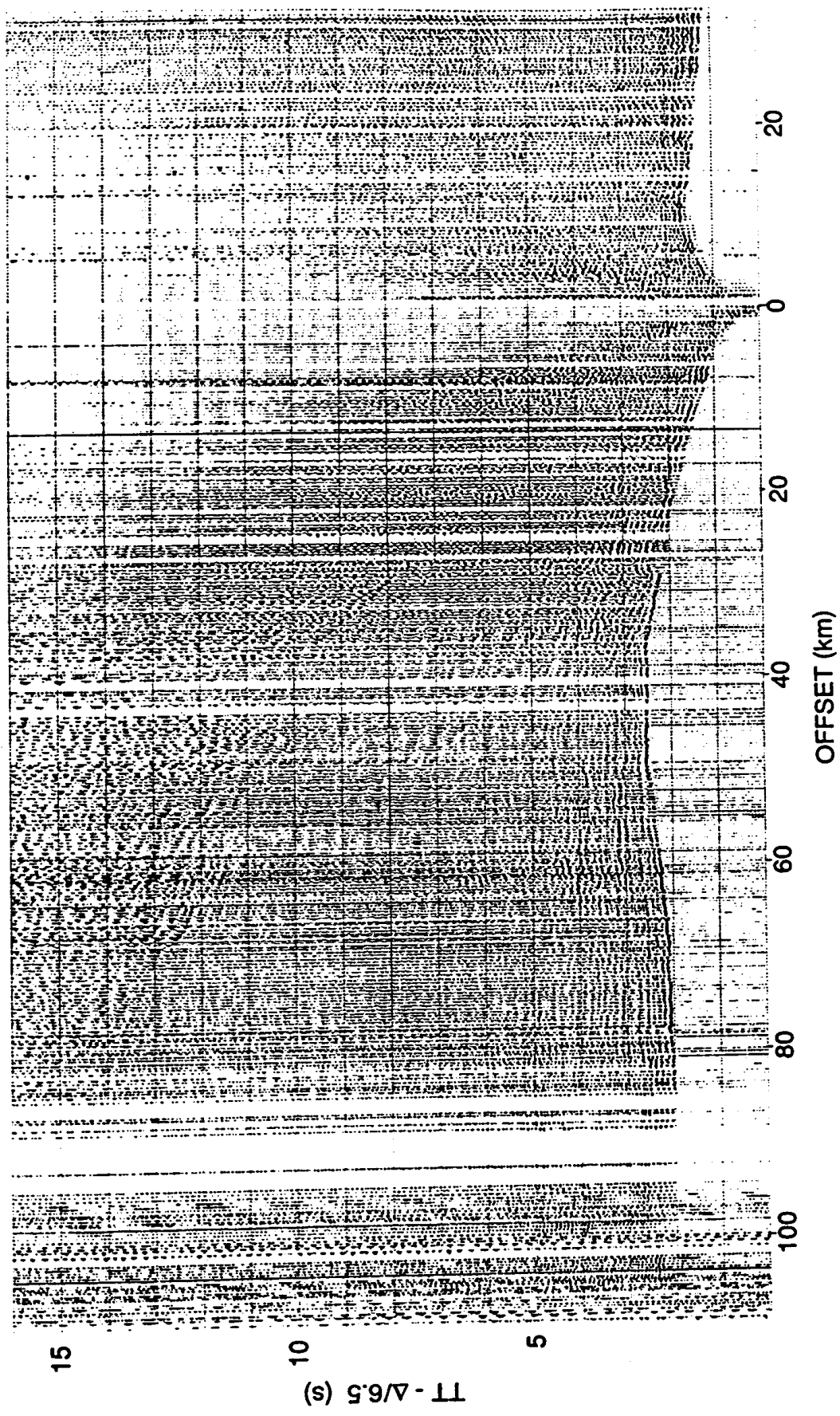


FIGURE 8. Record section from shotpoint 23. Plotting parameters are described in the text.

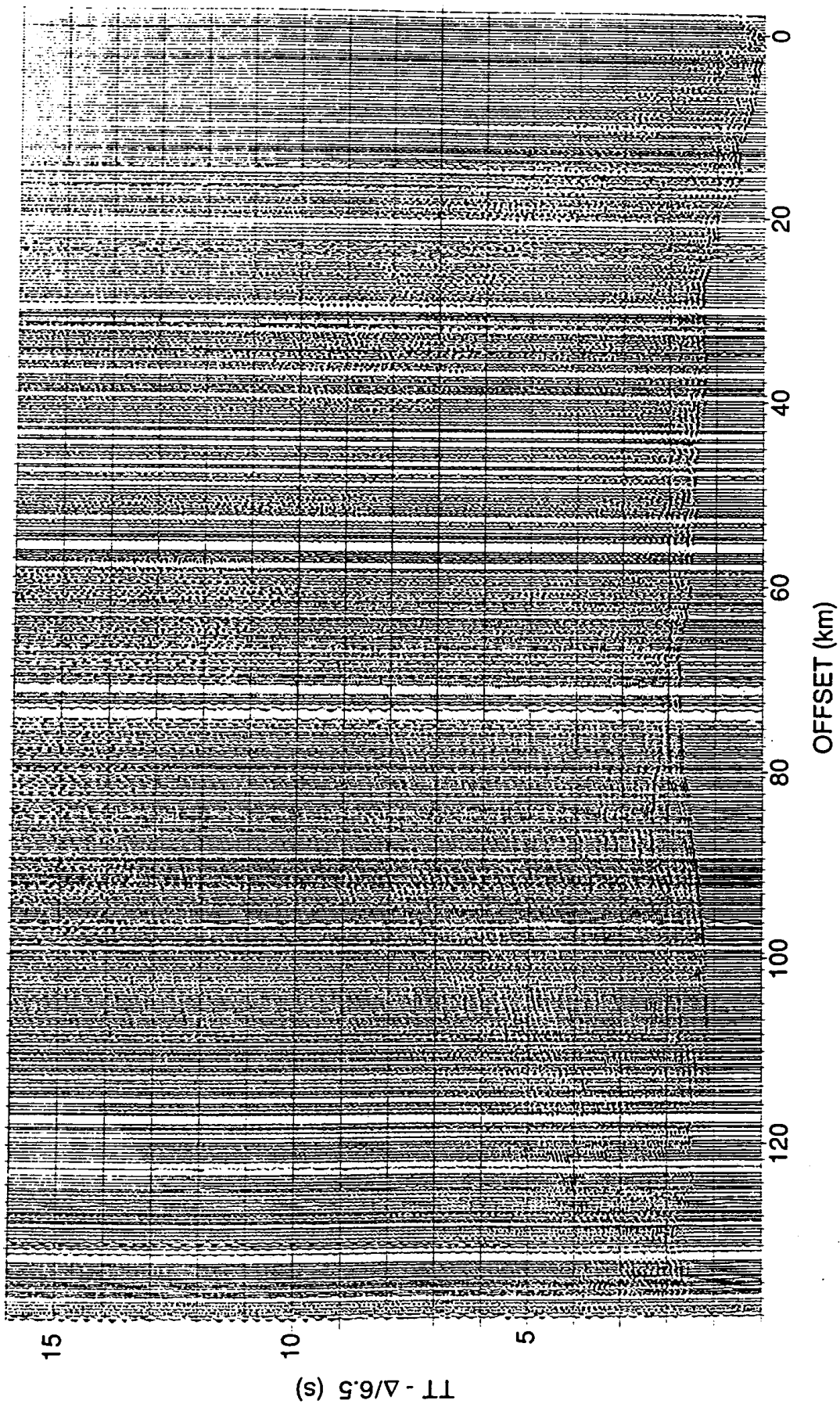


FIGURE 9. Record section from shotpoint 24. Plotting parameters are described in the text.

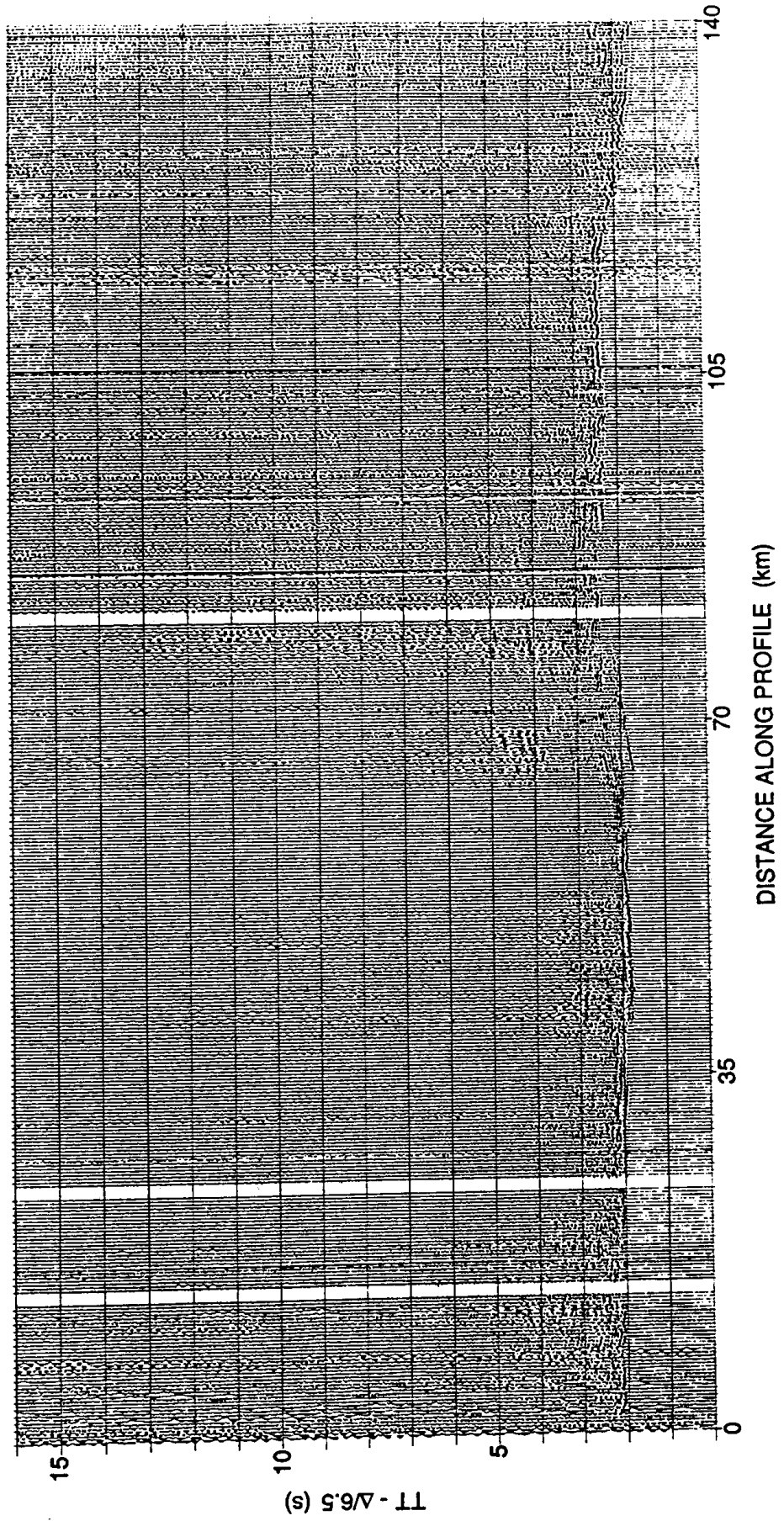


FIGURE 10. Record section from shotpoint 17. Plotting parameters are described in the text. Source-receiver offset is 66 km at a distance along the profile of 0 km; offset is 17 km at distance 70 km; and offset is 77 km at distance 140 km.

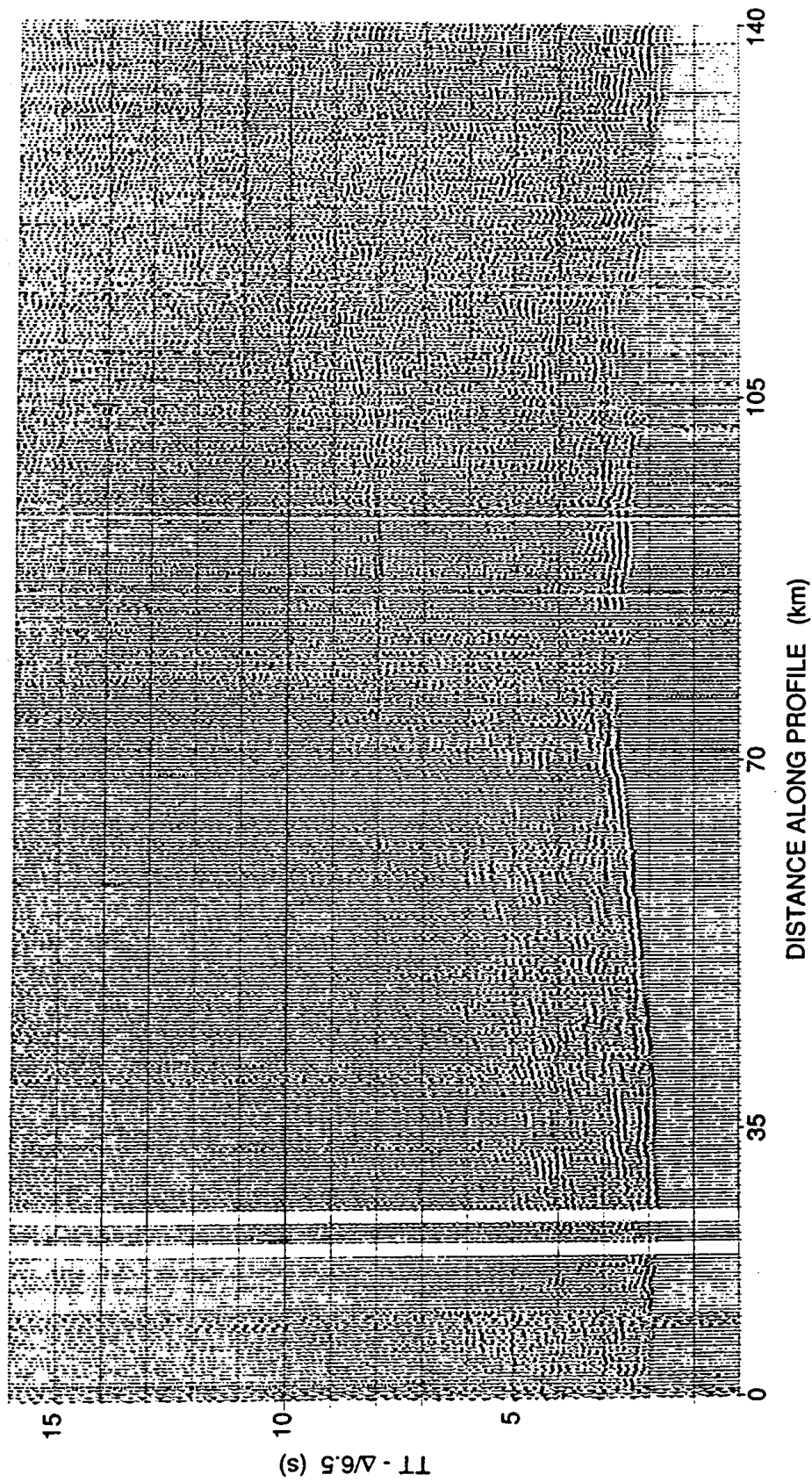


FIGURE 11. Record section from shotpoint 15. Plotting parameters are described in the text. Source-receiver offset is 108 km at a distance along the profile of 0 km; offset is 88 km at distance 70 km; and offset is 115 km at distance 140 km.

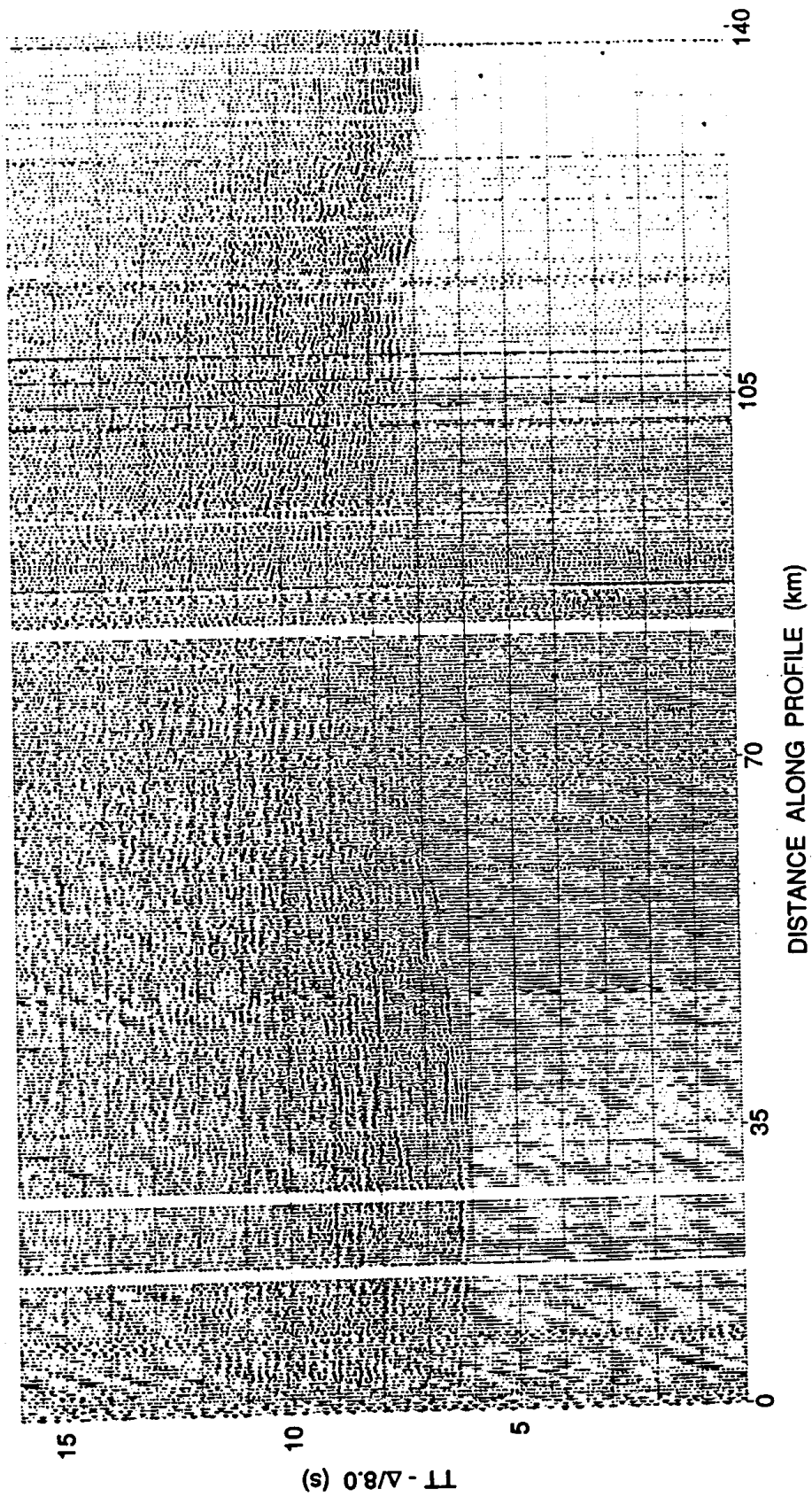


FIGURE 12. Record section from shotpoint 11. Plotting parameters are described in the text. Source-receiver offset is 217 km at a distance along the profile of 0 km; offset is 208 km at distance 70 km; and offset is 219 km at distance 140 km.

## ACKNOWLEDGEMENTS

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APPENDIX: STATION LOCATIONS AND ELEVATIONS

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3001	DP-00	44.86891	-124.03323	0006	map
3002	DP-01	44.86881	-124.03018	0012	map
3003	DP-02	44.87068	-124.02501	0018	map
3004	DP-03	44.87256	-124.02002	0037	map
3005	DP-04	44.87080	-124.01586	0098	map
3006	DP-05	44.87081	-124.01224	0122	map
3007	DP-06	44.86961	-124.00746	0171	map
3008	DP-07	44.86905	-124.00384	0183	map
3009	ML-01	44.87097	-123.99678	0213	map
3010	ML-02	44.87204	-123.99390	0213	map
3011	ML-03	44.87320	-123.99063	0213	map
3012	DL-01	44.87577	-123.98604	0256	map
3013	DL-02	44.87571	-123.98312	0262	map
3014	ML-04	44.87293	-123.98036	0238	map
3015	ML-05	44.87304	-123.97717	0213	map
3016	ML-06	44.87314	-123.97087	0207	map
3017	ML-07	44.87342	-123.96685	0183	map
3018	ML-08	44.87271	-123.96217	0107	map
3019	ML-09	44.87062	-123.95865	0101	map
3020	ML-10	44.87089	-123.95410	0091	map
3021	ML-11	44.87098	-123.95045	0098	map
3022	ML-12	44.87412	-123.93705	0009	map
3023	DL-03	44.87489	-123.93408	0009	map
3024	DL-04	44.87533	-123.92981	0009	map
3025	ML-13	44.87418	-123.92570	0009	map
3026	ML-14	44.87236	-123.92194	0009	map
3027	ML-15	44.87134	-123.91752	0061	map
3028	ML-16	44.86971	-123.91325	0146	map
3029	ML-17	44.87187	-123.90898	0188	gps
3030	ML-18	44.87250	-123.90513	0216	gps
3031	ML-18A	44.87308	-123.90219	0232	map
3032	ML-19	44.87446	-123.89887	0280	map
3033	DL-06	44.87579	-123.89629	0280	map
3034	DL-07	44.87738	-123.89253	0317	map
3035	DL-08	44.87988	-123.88786	0320	map
3036	DL-09	44.88052	-123.88524	0317	map
3037	DL-10	44.88064	-123.88070	0366	map
3038	DL-11	44.88049	-123.87654	0387	map
3039	ST-01	44.88028	-123.87185	0372	map
3040	ST-02	44.88010	-123.86696	0378	map
3041	ST-03	44.88207	-123.86191	0421	gps
3042	ST-04	44.88208	-123.85755	0482	map
3043	ST-05	44.87725	-123.85360	0424	map
3044	ST-06	44.87674	-123.84897	0426	gps
3045	ST-07	44.87623	-123.84526	0440	gps
3046	EM-01	44.87122	-123.84070	0463	gps
3047	EM-02	44.87107	-123.83637	0469	map
3048	EM-03	44.87134	-123.83214	0482	map
3049	EM-04	44.86676	-123.82779	0492	map

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3050	EM-05	44.86608	-123.82340	0530	map
3051	EM-06	44.86605	-123.81913	0555	map
3052	EM-07	44.86680	-123.81457	0555	map
3053	EM-08	44.86920	-123.81078	0550	gps
3054	EM-09	44.87022	-123.80627	0555	map
3055	EM-10	44.87100	-123.80150	0555	map
3056	EM-11	44.86769	-123.79715	0555	map
3057	EM-12	44.86695	-123.79337	0549	map
3058	EM-13	44.86413	-123.78814	0610	map
3059	EM-14	44.86493	-123.78402	0604	map
3060	EM-15	44.86405	-123.78060	0561	map
3061	EM-16	44.86231	-123.77613	0536	map
3062	EM-16A	44.85813	-123.77467	0439	map
3063	EM-17	44.85505	-123.77211	0427	map
3064	EM-18	44.85330	-123.76732	0396	map
3065	EM-19	44.85590	-123.76307	0344	map
3066	EM-20	44.85589	-123.75862	0287	map
3067	EM-21	44.85480	-123.75257	0213	map
3068	EM-22	44.85257	-123.75086	0195	map
3069	VZ-01	44.85606	-123.74600	0207	map
3070	VZ-02	44.85867	-123.74151	0232	map
3071	VZ-03	44.86029	-123.73807	0250	map
3072	VZ-04	44.84472	-123.74035	0646	map
3073	VZ-05	44.84592	-123.73360	0646	map
3074	VZ-06	44.84422	-123.72944	0671	map
3075	VZ-07	44.84292	-123.72604	0677	map
3076	VZ-08	44.84198	-123.72096	0689	map
3077	VZ-09	44.84359	-123.71590	0725	map
3078	VZ-10	44.84441	-123.71141	0735	map
3079	VZ-11	44.84585	-123.70743	0729	map
3080	VZ-12	44.84328	-123.70324	0671	map
3081	VZ-13	44.84246	-123.69866	0677	map
3082	VZ-14	44.84421	-123.69563	0701	gps
3083	VZ-15	44.84646	-123.69081	0673	gps
3084	VZ-16	44.84817	-123.68493	0677	map
3085	VZ-17	44.84950	-123.68070	0634	map
3086	VZ-18	44.84971	-123.67528	0579	gps
3087	VZ-19	44.85073	-123.67248	0523	gps
3088	VZ-20	44.85013	-123.66676	0343	gps
3089	VZ-21	44.84461	-123.66123	0338	map
3090	VZ-22	44.84164	-123.65579	0348	map
3091	VZ-23	44.83769	-123.65222	0340	map
3092	VZ-24	44.83463	-123.64715	0338	map
3093	VZ-25	44.83358	-123.64568	0354	gps
3094	VZ-26	44.83074	-123.64077	0341	gps
3095	VZ-27	44.82843	-123.63525	0341	gps
3096	VZ-28	44.82736	-123.63134	0345	gps
3097	VZ-29	44.82622	-123.62712	0350	gps
3098	FR-01	44.82513	-123.62347	0354	gps

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3099	FR-02	44.82476	-123.61855	0363	map
3100	FR-03	44.82481	-123.61366	0354	map
3101	FR-04	44.82392	-123.60913	0352	map
3102	FR-05	44.82274	-123.60492	0351	map
3103	FR-06	44.82162	-123.60090	0354	map
3104	FR-07	44.82053	-123.59679	0357	map
3105	FR-08	44.81987	-123.59218	0363	map
3106	FR-09	44.81856	-123.58763	0381	map
3107	FR-10	44.82318	-123.58362	0421	map
3108	FR-11	44.82677	-123.57926	0459	map
3109	FR-12	44.83139	-123.57432	0530	map
3110	FR-13	44.83079	-123.56972	0567	map
3111	FR-14	44.82934	-123.56514	0594	map
3112	FR-15	44.82856	-123.56114	0622	map
3113	FR-16	44.82774	-123.55713	0652	map
3114	FR-17	44.82982	-123.55274	0677	map
3115	FR-18	44.82972	-123.54798	0677	map
3116	FR-19	44.82839	-123.54362	0683	map
3117	FR-20	44.82576	-123.53924	0695	map
3118	FR-21	44.82198	-123.53530	0695	map
3119	FR-22	44.82250	-123.53090	0716	map
3120	FR-23	44.82631	-123.52753	0715	map
3121	FR-24	44.83070	-123.52155	0642	map
3122	FR-25	44.84008	-123.51891	0567	map
3123	FR-26	44.83702	-123.51443	0536	map
3124	FR-27	44.83711	-123.50982	0524	map
3125	FR-28	44.83908	-123.50423	0496	gps
3126	FR-29	44.84019	-123.50218	0500	map
3127	FC-01	44.84119	-123.49611	0488	map
3128	FC-02	44.84158	-123.49222	0482	map
3129	FC-03	44.84095	-123.48770	0472	map
3130	FC-04	44.84152	-123.48376	0453	map
3131	FC-05	44.84197	-123.47939	0415	map
3132	FC-06	44.84405	-123.47602	0427	map
3133	FC-6A	44.84068	-123.47590	0421	map
3134	FC-07	44.84108	-123.47089	0395	map
3135	FC-7A	44.83955	-123.46739	0360	map
3136	FC-08	44.83870	-123.46299	0329	map
3137	FC-09	44.83814	-123.45937	0320	map
3138	FC-10	44.83886	-123.45435	0274	map
3139	FC-11	44.83850	-123.44965	0238	map
3140	FC-12	44.83979	-123.44501	0212	map
3141	FC-12A	44.84045	-123.44145	0180	map
3142	FC-13	44.84321	-123.43899	0142	map
3143	FC-13A	44.84633	-123.43695	0122	map
3144	FC-14	44.84821	-123.43306	0117	map
3145	FC-14A	44.84850	-123.43028	0119	map
3146	FC-15	44.84992	-123.42717	0110	map
3147	FC-16	44.84881	-123.42258	0104	map

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3148	FC-16A	44.84702	-123.41966	0104	map
3149	FC-17	44.84521	-123.41668	0101	map
3150	FC-18	44.84186	-123.41314	0102	map
3151	FC-19	44.84021	-123.40862	0104	map
3152	FC-20	44.84792	-123.40851	0102	map
3153	FC-21	44.84748	-123.40513	0102	map
3154	FC-22	44.84712	-123.39932	0091	map
3155	FC-23	44.84777	-123.39434	0084	map
3156	FC-24	44.84729	-123.39059	0082	map
3157	FC-25	44.84707	-123.38626	0079	map
3158	FC-26	44.84657	-123.38196	0087	map
3159	FC-27	44.84676	-123.37814	0090	map
3160	AN-01	44.84630	-123.37404	0085	gps
3161	AN-02	44.84434	-123.36859	0085	gps
3162	AN-03	44.84161	-123.36536	0074	gps
3163	AN-04	44.84023	-123.36105	0074	gps
3164	AN-05	44.83932	-123.35596	0076	gps
3165	AN-06	44.83794	-123.35146	0084	gps
3166	AN-07	44.83534	-123.34807	0084	gps
3167	AN-08	44.83213	-123.34296	0100	gps
3168	AN-09	44.83365	-123.33887	0122	gps
3169	AN-10	44.83542	-123.33569	0124	gps
3170	AN-11	44.83852	-123.33121	0093	gps
3171	AN-12	44.83862	-123.32644	0071	gps
3172	AN-13	44.83517	-123.32083	0101	gps
3173	AN-14	44.83545	-123.31718	0134	gps
3174	AN-15	44.83727	-123.31167	0186	gps
3175	AN-16	44.83805	-123.30783	0185	gps
3176	AN-17	44.83863	-123.30396	0209	gps
3177	AN-18	44.83841	-123.30001	0224	gps
3178	AN-19	44.83892	-123.29524	0209	gps
3179	AN-20	44.83900	-123.28906	0160	gps
3180	AN-21	44.84163	-123.28443	0125	gps
3181	AN-22	44.84224	-123.28159	0091	gps
3182	AN-23	44.84267	-123.27805	0077	gps
3183	AN-24	44.84247	-123.27349	0106	gps
3184	AN-25	44.84255	-123.26822	0067	gps
3185	AN-26	44.84256	-123.26419	0069	gps
3186	AN-27	44.84226	-123.26052	0083	gps
3187	AN-28	44.84236	-123.25622	0061	gps
3188	AN-29	44.84241	-123.25198	0065	gps
3189	MO-01	44.84235	-123.24708	0063	gps
3190	MO-02	44.84392	-123.24295	0075	gps
3191	MO-03	44.84359	-123.23804	0068	gps
3192	MO-04	44.84348	-123.23433	0062	gps
3193	MO-05	44.84375	-123.22846	0061	gps
3194	MO-06	44.84349	-123.22345	0063	gps
3195	MO-07	44.84347	-123.21781	0067	gps
3196	MO-08	44.84341	-123.21052	0056	gps

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3197	MO-09	44.84439	-123.20311	0051	gps
3198	MO-10	44.84381	-123.19622	0053	gps
3199	MO-11	44.84442	-123.19266	0050	gps
3200	MO-12	44.84214	-123.18794	0048	gps
3201	MO-13	44.84541	-123.18310	0050	map
3202	MO-14	44.84570	-123.17314	0039	gps
3203	MO-15	44.84565	-123.16867	0037	gps
3204	MO-16	44.84560	-123.16417	0036	gps
3205	MO-17	44.84536	-123.15960	0046	map
3206	MO-18	44.84715	-123.15607	0046	map
3207	MO-19	44.84860	-123.15061	0049	map
3208	MO-20	44.85231	-123.14663	0055	map
3209	MO-21	44.85067	-123.14111	0107	map
3210	MO-22	44.85426	-123.13748	0162	gps
3211	MO-22A	44.85368	-123.13189	0207	gps
3212	MO-23	44.85300	-123.12810	0224	gps
3213	MO-24	44.85450	-123.13087	0268	map
3214	SID-01	44.84754	-123.12239	0312	map
3215	SID-02	44.84732	-123.11804	0293	map
3216	SID-03	44.84709	-123.11358	0279	map
3217	SID-04	44.84684	-123.10884	0293	map
3218	SID-05	44.84684	-123.10531	0270	map
3219	SID-06	44.84707	-123.10043	0282	map
3220	SID-07	44.84679	-123.09636	0259	map
3221	SID-08	44.84666	-123.09174	0250	map
3222	SID-09	44.84673	-123.08803	0262	map
3223	SID-10	44.84725	-123.08382	0235	gps
3224	SID-11	44.84725	-123.08036	0212	gps
3225	SID-12	44.84873	-123.07431	0189	map
3226	SID-13	44.84858	-123.06991	0221	map
3227	SID-14	44.84914	-123.06557	0234	gps
3228	SID-15	44.84924	-123.06100	0210	gps
3229	SID-16	44.84714	-123.05698	0207	gps
3230	SID-17	44.84705	-123.05266	0225	gps
3231	SID-18	44.84702	-123.04824	0216	gps
3232	SID-19	44.84704	-123.04435	0205	gps
3233	SID-20	44.84706	-123.03942	0203	gps
3234	SID-21	44.84640	-123.03481	0200	map
3235	SID-22	44.84698	-123.03121	0229	gps
3236	SID-23	44.84684	-123.02612	0172	gps
3237	SID-24	44.84569	-123.02232	0199	gps
3238	SID-25	44.84559	-123.01678	0201	map
3239	SID-26	44.84425	-123.01328	0174	gps
3240	SID-27	44.84321	-123.00879	0150	gps
3241	SID-28	44.84244	-123.00332	0139	map
3242	SID-29	44.84290	-122.99981	0137	gps
3243	TR-01	44.84173	-122.99613	0107	gps
3244	TR-02	44.84153	-122.99211	0087	gps
3245	TR-03	44.84052	-122.98876	0092	gps

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3246	TR-04	44.84014	-122.98358	0089	gps
3247	TR-05	44.84101	-122.98009	0107	gps
3248	TR-07	44.84277	-122.97517	0136	gps
3249	TR-08	44.84430	-122.97000	0092	gps
3250	TR-09	44.84509	-122.96683	0086	gps
3251	TR-10	44.84657	-122.96275	0078	gps
3252	TR-11	44.83995	-122.95696	0079	gps
3253	TR-12	44.84008	-122.95282	0082	gps
3254	TR-13	44.83961	-122.94818	0081	gps
3255	TR-14	44.84027	-122.94390	0075	gps
3256	TR-15	44.84011	-122.93928	0086	gps
3257	TR-16	44.83874	-122.93599	0090	map
3258	TR-17	44.83924	-122.93208	0088	gps
3259	TR-18	44.83908	-122.92790	0100	gps
3260	TR-19	44.83916	-122.92335	0099	gps
3261	TR-20	44.83906	-122.91899	0097	gps
3262	TR-21	44.83904	-122.91465	0097	gps
3263	TR-22	44.83861	-122.91065	0096	map
3264	TR-23	44.83904	-122.90578	0101	gps
3265	TR-24	44.83896	-122.90125	0099	gps
3266	TR-25	44.83892	-122.89757	0105	gps
3267	TR-26	44.83900	-122.89351	0098	gps
3268	TR-27	44.83892	-122.88857	0101	gps
3269	TR-28	44.83892	-122.88448	0103	gps
3270	TR-29	44.83916	-122.88032	0100	gps
3271	TR-30	44.84038	-122.87602	0107	map
3272	SA-01	44.83337	-122.87290	0108	map
3273	SA-02	44.83355	-122.86899	0110	map
3274	SA-03	44.83344	-122.86463	0111	map
3275	SA-04	44.83322	-122.85989	0113	map
3276	SA-05	44.83244	-122.85584	0114	map
3277	SA-06	44.83800	-122.85058	0128	gps
3278	SA-07	44.83799	-122.84682	0108	gps
3279	SA-08	44.83791	-122.83821	0111	gps
3280	SA-09	44.83747	-122.83789	0122	map
3281	SA-10	44.83786	-122.84080	0124	gps
3282	SA-11	44.83780	-122.83420	0124	gps
3283	SA-12	44.83767	-122.82501	0144	gps
3284	SA-13	44.83767	-122.82220	0145	gps
3285	SA-14	44.83771	-122.81615	0147	gps
3286	SA-15	44.83768	-122.81230	0141	gps
3287	SA-16	44.84416	-122.80766	0156	gps
3288	SA-17	44.84413	-122.80342	0162	gps
3289	SA-18	44.84210	-122.79880	0158	gps
3290	SA-19	44.84294	-122.79475	0170	gps
3291	SA-20	44.84039	-122.79012	0136	map
3292	SA-21	44.84018	-122.78573	0165	map
3293	SA-22	44.84085	-122.78163	0165	gps
3294	SA-23	44.84092	-122.77351	0172	gps

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3295	SA-24	44.84459	-122.77066	0170	gps
3296	SA-24A	44.84415	-122.77133	0169	map
3297	SA-25	44.84418	-122.76658	0181	map
3298	SA-26	44.84418	-122.76379	0188	map
3299	SA-27	44.84463	-122.75976	0197	gps
3300	SA-28	44.84461	-122.75566	0195	gps
3301	SA-29	44.84813	-122.75157	0213	gps
3302	SM-01	44.84809	-122.74539	0221	gps
3303	SM-02	44.84810	-122.74192	0250	gps
3304	SM-03	44.84864	-122.73764	0252	gps
3305	SM-04	44.84873	-122.73380	0250	gps
3306	SM-05	44.84628	-122.72867	0258	gps
3307	SM-06	44.84633	-122.72451	0255	gps
3308	SM-07	44.84635	-122.72040	0263	gps
3309	SM-08	44.84625	-122.71622	0281	gps
3310	SM-09	44.83711	-122.71191	0289	gps
3311	SM-10	44.83713	-122.70776	0307	gps
3312	SM-11	44.83721	-122.70350	0306	gps
3313	SM-12	44.83715	-122.70010	0318	gps
3314	SM-13	44.83695	-122.69600	0332	gps
3315	SM-14	44.83659	-122.69290	0336	gps
3316	SM-15	44.83627	-122.68533	0338	map
3317	SM-16	44.83550	-122.68114	0340	gps
3318	SM-17	44.83510	-122.67718	0351	map
3319	SM-18	44.83542	-122.67342	0355	gps
3320	SM-18A	44.83747	-122.66958	0381	map
3321	SM-19	44.83537	-122.66908	0364	map
3322	SM-20	44.83452	-122.66530	0378	map
3323	SM-21	44.83219	-122.65750	0393	gps
3324	SM-22	44.84519	-122.65482	0540	map
3325	SM-23	44.83636	-122.65013	0578	gps
3326	SM-24	44.83454	-122.64654	0606	gps
3327	SM-25	44.83253	-122.64170	0585	map
3328	SM-26	44.83241	-122.63732	0622	map
3329	SM-27	44.83028	-122.63223	0637	map
3330	SM-28	44.82964	-122.62740	0643	map
3331	LY-01	44.83058	-122.62259	0655	map
3332	LY-02	44.83106	-122.61808	0665	map
3333	LY-03	44.83082	-122.61407	0675	map
3334	LY-04	44.83205	-122.60946	0686	map
3335	LY-05	44.83258	-122.60521	0704	map
3336	LY-06	44.83254	-122.60075	0707	map
3337	LY-07	44.83177	-122.59622	0715	gps
3338	LY-08	44.82921	-122.59166	0689	map
3339	LY-09	44.82894	-122.58671	0695	gps
3340	LY-10	44.82945	-122.58283	0699	gps
3341	LY-11	44.83049	-122.57790	0705	gps
3342	LY-12	44.83129	-122.57464	0701	gps
3343	LY-13	44.82886	-122.57012	0704	gps

APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3344	LY-14	44.83127	-122.56455	0709	gps
3345	LY-15	44.83208	-122.55968	0719	map
3346	LY-16	44.83544	-122.55483	0774	map
3347	LY-17	44.83728	-122.55010	0809	map
3348	LY-18	44.83718	-122.54566	0853	map
3349	LY-19	44.83267	-122.54083	0884	map
3350	LY-20	44.83296	-122.53630	0895	map
3351	LY-21	44.83212	-122.53275	0908	map
3352	LY-22	44.83217	-122.52796	0933	map
3353	LY-23	44.83203	-122.52280	0933	map
3354	LY-24	44.83081	-122.51910	0941	gps
3355	LY-25	44.82959	-122.51480	0946	map
3356	LY-26	44.83144	-122.51023	0960	map
3357	LY-27	44.83196	-122.50580	0967	map
3358	LY-28	44.83345	-122.50081	0982	map
3359	MC-01	44.83690	-122.49850	0994	gps
3360	MC-02	44.84126	-122.49368	1062	gps
3361	MC-03	44.84171	-122.48947	1096	gps
3362	MC-04	44.84319	-122.48571	1172	gps
3363	MC-05	44.84315	-122.48572	1175	gps
3364	MC-06	44.84252	-122.47707	1151	gps
3365	MC-07	44.84490	-122.47206	1023	gps
3366	MC-08	44.84797	-122.46792	1073	gps
3367	MC-09	44.84849	-122.46382	0975	gps
3368	MC-10	44.84498	-122.45857	0985	gps
3369	MC-11	44.84439	-122.45378	0921	map
3370	MC-12	44.84361	-122.45066	0890	map
3371	MC-13	44.84388	-122.44743	0900	gps
3372	MC-14	44.84078	-122.44240	0801	gps
3373	MC-15	44.84008	-122.43742	0756	map
3374	MC-16	44.84850	-122.43330	0841	gps
3375	MC-17	44.84872	-122.42873	0833	gps
3376	MC-18	44.84599	-122.42514	0793	map
3377	MC-19	44.84488	-122.42027	0741	map
3378	MC-20	44.84120	-122.41619	0695	map
3379	MC-21	44.84310	-122.41096	0738	map
3380	MC-22	44.84308	-122.40760	0762	map
3381	MC-23	44.83998	-122.40265	0725	map
3382	MC-24	44.84243	-122.39858	0719	map
3383	MC-25	44.84062	-122.39361	0602	map
3384	MC-26	44.84316	-122.38910	0610	map
3385	MC-27	44.84120	-122.38457	0604	map
3386	MC-28	44.84306	-122.37956	0569	map
3387	ELK-01	44.84276	-122.37428	0536	map
3388	ELK-02	44.83322	-122.36991	0373	map
3389	ELK-03	44.83377	-122.36530	0370	map
3390	ELK-04	44.83563	-122.36024	0348	map
3391	ELK-05	44.83717	-122.35632	0366	map
3392	ELK-06	44.83884	-122.35246	0383	map



APPENDIX: STATION LOCATIONS AND ELEVATIONS (cont.)

Station Number	Station Name*	Latitude (N) Degrees	Longitude (W) Degrees	Elevation Meters	Source
3393	ELK-07	44.84013	-122.34764	0408	map
3394	ELK-08	44.83953	-122.34238	0439	map
3395	ELK-09	44.84174	-122.33904	0457	map
3396	ELK-10	44.84303	-122.33542	0476	map
3397	ELK-11	44.84211	-122.33097	0494	map
3398	ELK-12	44.84521	-122.32722	0482	map
3399	ELK-13	44.84518	-122.32258	0463	map
3400	ELK-14	44.84271	-122.31933	0445	map
3401	ELK-15	44.84089	-122.31536	0433	map
3402	ELK-16	44.84073	-122.31145	0463	map
3403	ELK-17	44.83980	-122.30722	0482	map
3404	ELK-18	44.84390	-122.30262	0482	map
3405	ELK-19	44.84615	-122.29821	0452	map
3406	ELK-20	44.84487	-122.29406	0469	map
3407	ELK-21	44.84467	-122.29027	0494	map
3408	ELK-22	44.84594	-122.28686	0500	map
3409	ELK-23	44.84705	-122.28257	0518	map
3410	ELK-23A	44.84701	-122.27874	0521	map
3411	ELK-24	44.84694	-122.27693	0524	map
3412	ELK-25	44.84551	-122.27244	0543	map
3413	ELK-26	44.84294	-122.26756	0595	gps
3414	ELK-27	44.84154	-122.26397	0577	gps
3415	ELK-28	44.83881	-122.26222	0626	gps
3416	ELK-29	44.83622	-122.26006	0636	gps
3417	ELK-30	44.83444	-122.25617	0650	gps
3418	ELK-31	44.83288	-122.25248	0669	gps
3419	ELK-32	44.83150	-122.24866	0686	gps
3601	SM-20A	44.83330	-122.62260	0381	map

\*The first two letters of each station name refer to the name of the USGS 7.5 minute series topographic map on which the station is located. DP-Depoe Bay; ML-Mowrey Landing; DL-Devils Lake; ST-Stott Mountain; EM-Euchre Mountain; VZ-Valsetz; FR-Fanno Ridge; FC-Falls City; AN-Airlie North; MO-Monmouth; SID-Sidney; TR-Turner; SA-Stayton; SM-Stout Mountain; LY-Lyons; MC-Mill City North; ELK-Elkhorn.