78-1097

CATALOG OF EARTHQUAKES IN SOUTHERN ALASKA OCTOBER-DECEMBER 1977

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INTRODUCTION

The National Center for Earthquake Research of the U.S. Geological Survey (USGS) began a program of telemetered seismic recording in south-central Alaska in 1971. The principal objectives of this program have been to use data recorded by this network to precisely locate earthquakes in the active seismic zones of southern Alaska, to delineate seismically active faults, to assess seismic risk, to document potential premonitory earthquake phenomena, to investigate current tectonic deformation, and to study the structure and physical properties of the crust and upper mantle. A task fundamental to all of these goals is the routine cataloging of earthquake parameters for earthquakes located within and adjacent to the seismograph network.

The initial network of 10 stations, 7 around Cook Inlet and 3 near Valdez, was installed in 1971. Each summer since then additions or modifications to the network have been made. By the Fall of 1973, 26 stations extended from western Cook Inlet to eastern Prince William Sound, and 4 stations were located between Cordova and Yakutat. A year later 20 additional stations were installed. Thirteen of these were placed along the eastern Gulf of Alaska with support from the National Oceanic and Atmospheric Administration (NOAA) under the Outer Continental Shelf Environmental Program to investigate the seismicity of the outer continental shelf (OCS) region of interest for oil exploration. During the subsequent years the region covered by the network has remained relatively fixed while effort has been made to improve the instrumentation and installation of the stations in order to make them more reliable.

This earthquake catalog presents origin times, focal coordinates and magnitudes for 331 shocks occurring in the fourth quarter of 1977. Readings from a total of 65 stations were used to locate the shocks, including 8 stations operated by the NOAA Alaska Tsunami Warning Center (formerly Palmer Observatory), and 6 stations operated by the Geophysical Institute of the University of Alaska (U. of A.).

Earthquakes in south-central Alaska as small as magnitude 3.0 have been routinely located by the National Earthquake Information Service of USGS and its predecessor since the great Alaska earthquake of 1964 and published in the reports "Preliminary Determination of Epicenters" (PDE). In contrast the shocks included in this catalog are as small as magnitude 1.0 and most are smaller than magnitude 3.0. Data for the larger historic earthquakes in south-central Alaska have been tabulated by Davis and Echols (1962) and U.S. Coast and Geodetic Survey (1966).

The locations of the stations of the USGS seismograph network are plotted in Figure 1 and listed in Table 1 along with the additional stations from which readings were obtained. The USGS stations have single, vertical-component seismometers except for GLB, PNL, RDT, SKN, and VLZ which also have two horizontal seismometers.

INSTRUMENTATION

The instrumentation in the USGS seismograph network as operated during the fourth quarter of 1977 is illustrated in the block diagram in Figure 2. Data from each seismometer are telemetered to a central recording point at the NOAA Alaska Tsunami Warning Center. The standard equipment at each field

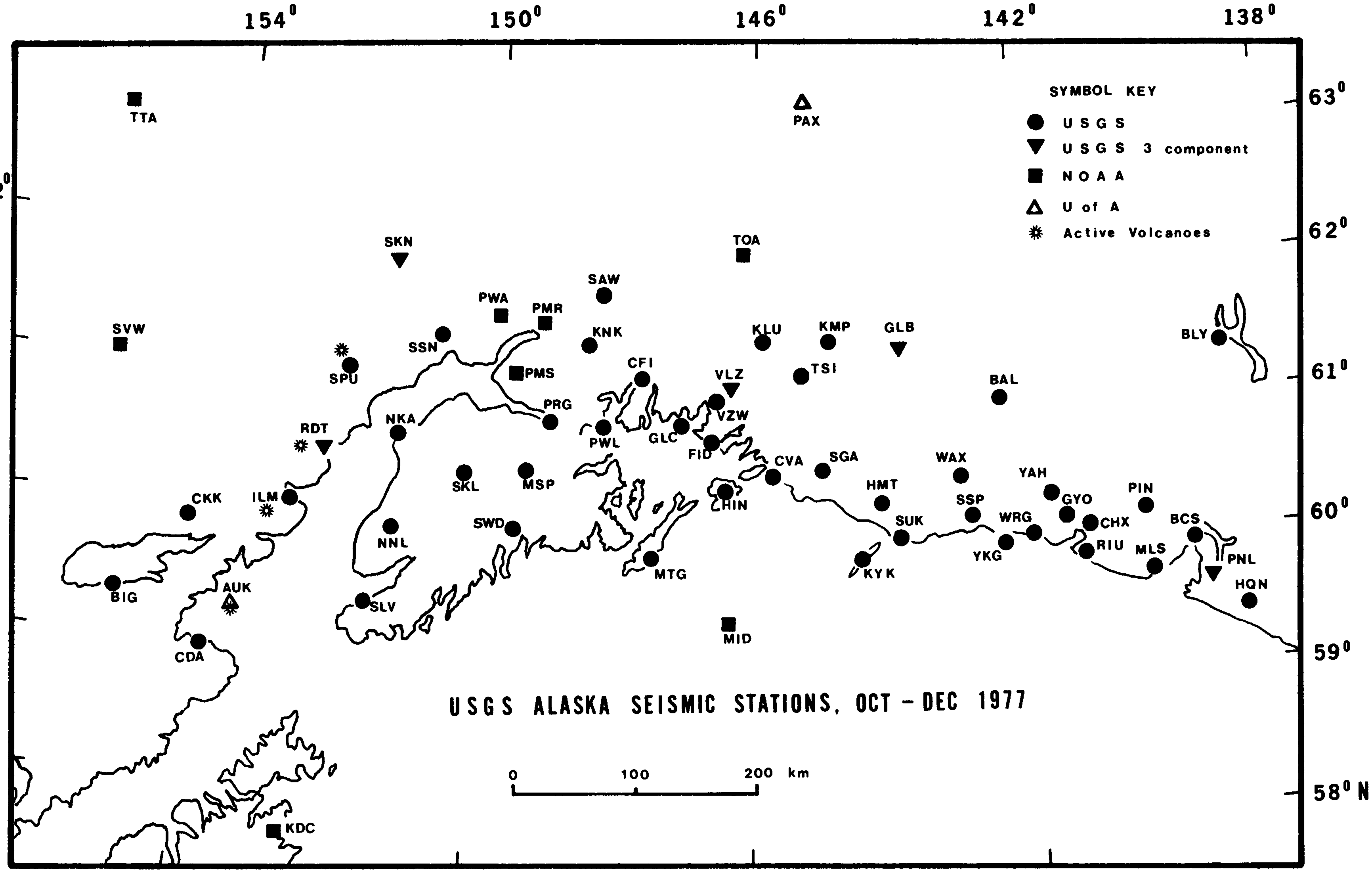

Figure 1. Map showing the USGS Alaska seismic network for the fourth quarter of 1977. Stations from which additional readings were obtained are also shown.

Table 1. Station Data

SEISMIC STATIONS UTILIZED DURING OCTOBER - DECEMBER 1977

STA CODE	STATION NAME	LAT N DEG MIN	LONG W DEG MIN	ELEV M	D KM	DELAY SEC	TDLY SEC	MAG @ 1HZ	INST
AUK	AUGUSTINE IS.	59 20.10	153 25.66	293	0.01	0.00	0.00	0	UOFA
BAL	BALDY	61 2.17	142 20.67	1300	0.01	0.00	0.00	117000	USGS
BCS	BANCAS POINT	59 56.90	139 37.00	10	0.00	0.00	0.30	29700	USGS
BIG	BIG MOUNTAIN	59 23.34	155 13.02	567	0.01	0.00	0.00	117000	USGS
BLR	BLACK RAPIDS	63 30.10	145 50.70	809	0.01	0.00	0.00	0	NOAA
CDA	CAPE DOUGLAS	58 57.32	153 31.77	386	0.01	0.00	0.00	0	USGS
CFI	COLLEGE FIORD	61 10.96	147 45.99	2	0.01	0.00	0.00	117000	USGS
CHX	CHAIX HILLS	60 4.00	141 7.10	793	0.01	0.00	0.30	59400	USGS
CKK	CHEKOK	59 57.58	154 13.99	732	0.01	0.00	0.00	7400	USGS
COL	COLLEGE	64 54.00	147 47.60	320	0.01	0.00	0.00	0	USGS
CVA	CORDOVA	60 32.79	145 44.96	90	0.01	0.00	0.30	59400	USGS
FID	FIDALGO	60 43.73	146 35.79	488	0.01	0.00	0.30	234000	USGS
GIL	GILMORE	64 58.50	147 29.70	350	0.01	0.00	0.00	0	NOAA
GLB	GILAHINA BUTTE	61 26.51	143 48.63	845	0.01	0.00	0.00	234000	USGS
GLC	GLACIER IS.	60 53.44	147 4.35	3	0.01	0.00	0.30	117000	USGS
GLM	GILMORE DOME	64 59.23	147 23.33	820	0.01	0.00	0.00	0	UOFA
GYO	GUYOT HILLS	60 8.78	141 28.29	183	0.00	0.00	0.30	117000	USGS
HIN	HINCHINBROOK	60 23.81	146 30.10	611	0.01	0.00	0.30	234000	USGS
HMT	MT. HAMILTON	60 20.19	144 15.64	620	0.01	0.00	0.30	117000	USGS
HQN	HARLEQUIN LAKE	59 27.10	138 52.62	372	0.01	0.00	0.30	117000	USGS
ILM	ILIAMNA	60 10.92	152 48.97	550	0.01	0.44	0.00	117000	USGS
IMA	INDIAN MOUNTAIN	66 4.11	153 40.72	1380	0.01	0.00	0.00	0	NOAA
KDC	KODIAK	57 44.87	152 29.50	13	0.01	0.00	0.00	0	NOAA
KLU	KLUTINA	61 29.57	145 55.21	1012	0.01	0.00	0.00	234000	USGS
KMP	KIMBALL PASS	61 30.78	145 1.09	1143	0.00	0.00	0.30	117000	USGS
KNK	KNIK	61 24.75	148 27.34	595	0.01	0.00	0.00	234000	USGS
KYK	KAYAK IS.	59 52.10	144 31.39	375	0.01	0.00	0.30	59400	USGS
MCK	MCKINLEY PARK	63 43.94	148 56.10	610	0.01	0.00	0.00	0	UOFA
MID	MIDDLETON IS.	59 25.67	146 20.34	37	0.01	0.00	0.30	0	NOAA
MLS	MALASPINA	59 45.80	140 9.00	2	0.01	0.00	0.30	14700	USGS
MSP	MOOSE PASS	60 29.35	149 21.64	150	0.01	0.00	0.00	117000	USGS
MTG	MONTAGUE IS.	59 54.71	147 29.82	31	0.01	0.00	0.30	59400	USGS
NKA	NIKISHKA	60 44.58	151 14.28	100	4.00	1.36	0.00	7400	USGS
NNL	NINILCHIK	60 2.53	151 17.78	366	4.00	0.67	0.00	59400	USGS
PAX	PAXSON	62 58.25	145 28.11	1130	0.01	0.00	0.00	0	UOFA
PIN	PINNACLE	60 5.80	140 15.40	975	0.01	0.00	0.30	59400	USGS
PMR	PALMER OBSERVATORY	61 35.53	149 7.85	100	0.01	0.00	0.00	0	NOAA
PMS	ARCTIC VALLEY	61 14.68	149 33.63	716	0.01	0.00	0.00	0	NOAA
PNL	PENINSULA	59 40.12	139 23.82	579	0.01	0.00	0.30	59400	USGS
PRG	PORTAGE	60 51.87	149 1.42	55	0.01	0.00	0.00	117000	USGS
PWA	HOUSTON	61 39.05	149 52.72	137	0.01	0.70	0.00	0	NOAA
PWL	PORT WELLS	60 51.56	148 20.09	549	0.01	0.00	0.00	117000	USGS
RDT	REDOUBT	60 34.43	152 24.37	930	0.01	0.36	0.00	14700	USGS
RIU	RIOU	59 52.70	141 13.70	15	0.00	0.00	0.30	7400	USGS
SAW	SAWMILL	61 48.49	148 19.98	740	0.01	0.00	0.00	234000	USGS
SGA	SHERMAN GLACIER	60 30.07	145 12.42	424	0.00	0.00	0.30	59400	USGS
SKL	SKILAK	60 30.86	150 12.91	660	0.01	0.10	0.00	117000	USGS
SKN	SKWENTNA	61 58.82	151 31.78	564	0.01	0.00	0.00	234000	USGS
SLV	SELDOVIA	59 28.28	151 34.83	91	0.01	0.00	0.00	29700	USGS
SPU	SPURR	61 10.90	152 3.26	800	0.01	0.39	0.00	234000	USGS
SSN	SUSITNA	61 27.83	150 44.60	1297	0.01	0.67	0.00	234000	USGS
SSP	SUNSHINE POINT	60 10.80	142 50.30	732	0.01	0.00	0.30	117000	USGS
SUK	SUCKLING HILLS	60 4.60	143 47.00	427	0.01	0.00	0.30	117000	USGS
SVW	SPARREVOHN	61 6.49	155 37.30	762	0.01	0.00	0.00	0	NOAA
SWD	SEWARD	60 6.22	149 26.96	55	0.01	0.00	0.00	29700	USGS
TNN	TANANA	65 15.40	151 54.70	504	0.01	0.00	0.00	0	UOFA
TOA	TOLSONA	62 6.29	146 10.34	909	0.01	0.00	0.00	0	NOAA
TSI	TSINA	61 13.57	145 20.24	1113	0.00	0.00	0.30	117000	USGS
TTA	TATALINA	62 55.80	156 1.32	914	0.01	0.00	0.00	0	NOAA
VLZ	VALDEZ	61 7.89	146 19.92	10	0.01	0.00	0.30	7400	USGS
VZW	VALDEZ WEST	61 3.54	146 33.24	796	0.01	0.00	0.30	234000	USGS
WAX	WAXELL RIDGE	60 27.00	142 51.10	975	0.01	0.00	0.30	0	USGS
WRG	WHITE RIVER GLCR	60 2.27	142 1.90	550	0.01	0.00	0.30	29700	USGS
YAH	YAHTSE	60 21.80	141 44.70	2135	0.01	0.00	0.30	59400	USGS
YKG	YAKATAGA	60 4.20	142 25.33	60	0.01	0.00	0.30	7400	USGS

This table lists geographical coordinates and other pertinent information for stations used in the preparation of this catalog. D is the thickness of the low-velocity surficial sedimentary layer in kilometers assigned in the calculation of travel-times to a given station. DELAY is the station P-phase travel-time delay in seconds. TDLY is the telephone line delay in seconds. The magnification (MAG) of the vertical seismograph component is given at 1 Hz. The institutions (INST) operating the stations are the NOAA Alaska Tsunami Warning Center, and the Geophysical Institute of the University of Alaska (UOFA).

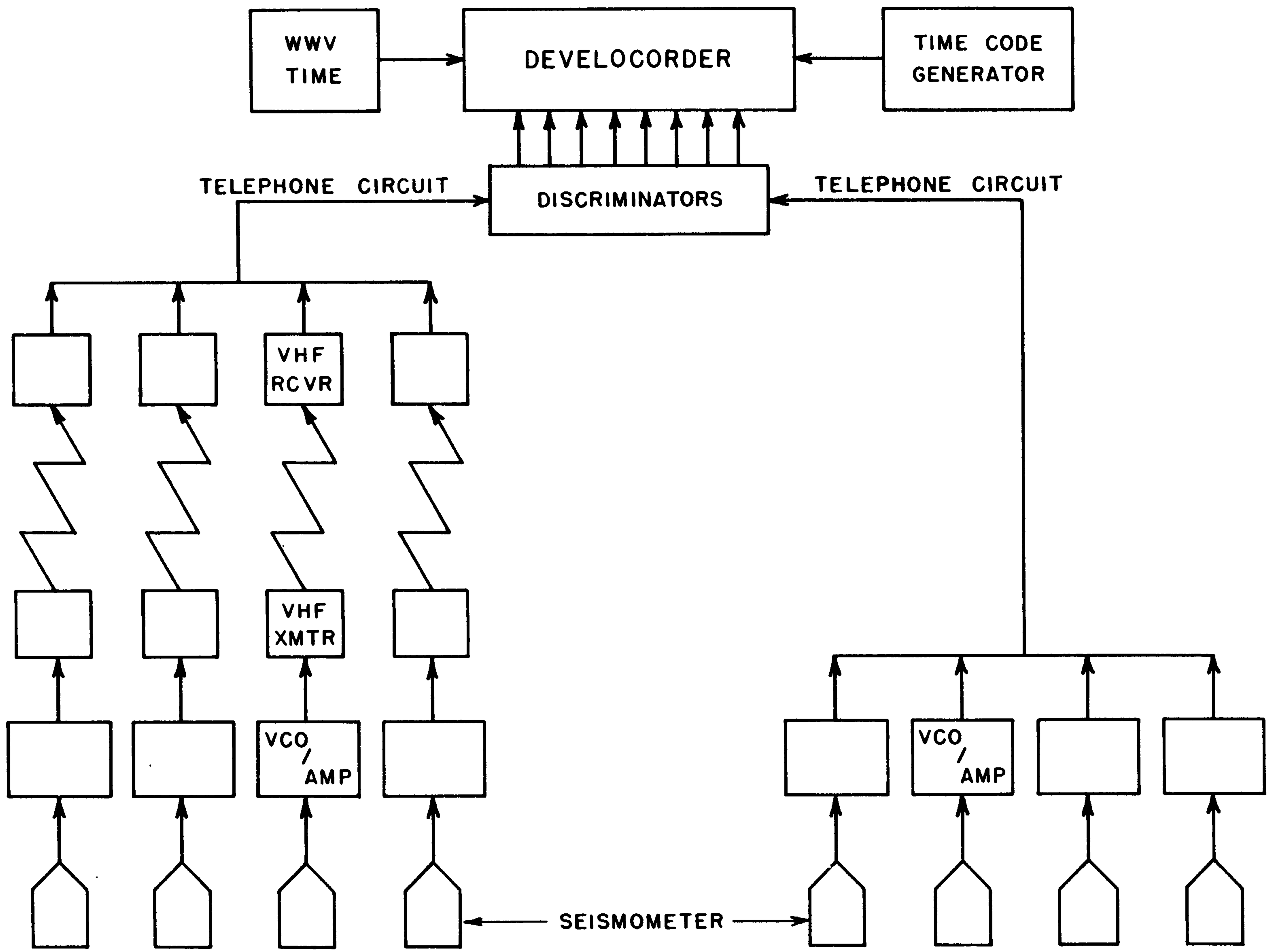

Figure 2. Block diagram of telemetered seismograph system in the USGS network.

station includes a vertical seismometer with a natural frequency of 1.0 Hz (Mark Products, Model L-4), a package consisting of a pre-amplifier and a voltage-controlled oscillator (VCO model NCER 202) and air-cell storage batteries (McGraw-Edison, Model ST-2-1000). Data are telemetered via a leased telephone circuit or a VHF (162-174 MHz) radio link feeding a telephone circuit. The radio link is provided by a low-power transmitter (100 mw) and receiver adapted from a HT-200 Motorola handie-talkie transceiver and two Yagi antennae with 9 db directional gain (Scala, Model CAS-150). The central recording facility incorporates a bank of discriminators (NCER J101 or Develco Model 6203), a 16 mm-film multi-channel oscillograph (Teledyne Geotech Develocorder, Model 4000D), a time-code generator (Datum, Model 9100) and a radio receiver for WWV time signals (Specific Products SR7R).

The principle of operation is as follows: The seismometer translates movement of the ground into an electrical voltage that is fed into the amplifier/VCO unit where the amplified voltage causes the frequency of an audio-band oscillator to fluctuate about its center frequency. The frequency-modulated (FM) tone from the amplifier/VCO unit is carried directly by voice-grade telephone circuit to the recording site or alternately is fed through a VHF radio link onto a telephone circuit. At the recording site, the FM seismic signal is demodulated by a discriminator. The demodulated signal, which is simply an amplified form of the initial signal from the seismometer, is recorded photographically on a multichannel oscillograph, together with time marks from a crystal-controlled chronometer. Each day is recorded on a single 142-foot roll of film.

Signals from more than one seismograph can be transmitted on a single telephone circuit by employing VCO units with different center frequencies. In the standard configuration there is a 340 Hz separation between center frequencies and a fixed bandwidth of 250 Hz. Up to eight seismic channels with center frequencies ranging from 680 to 3060 Hz may be placed on a single voice-grade telephone circuit.

Figure 3 illustrates the response characteristics of the entire seismic system from seismometer to film viewer. The response level at each station is adjusted in steps of 6 decibels so that the ambient seismic noise produces a small deflection of the trace on the film. As a result, the actual response for an individual station may differ from that of the typical station by a factor of 2, 4, 8, etc. The magnification of the typical station is about 6×10^4 at 1 Hz and 10^6 at 10 Hz.

The installation of a typical radio-linked station is shown in Figure 4. Degradation or interruption of data transmission due to inclement weather conditions is a major problem during the winter months.

DATA PROCESSING

The 16 mm films (four per day) are mailed weekly to Menlo Park where the seismic data are processed by the following multistep routine:

1. Scanning. The scan film, which has 18 stations distributed throughout the network is scanned to identify and note times of all seismic events whether of local, regional, or teleseismic origin.

2. Timing. For the "well-recorded" local earthquakes identified in the

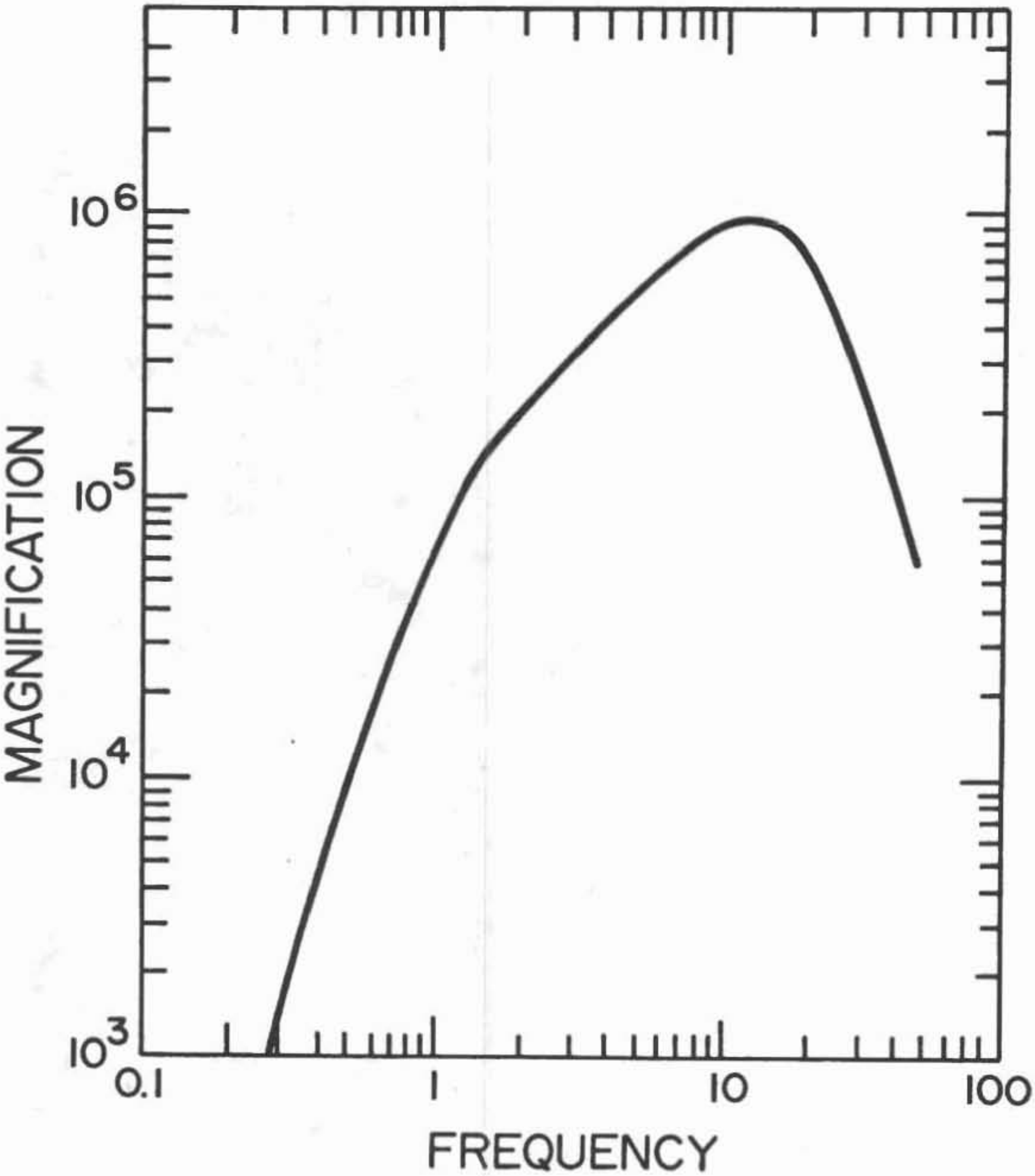

Figure 3. Response curve for a typical USGS seismograph system.

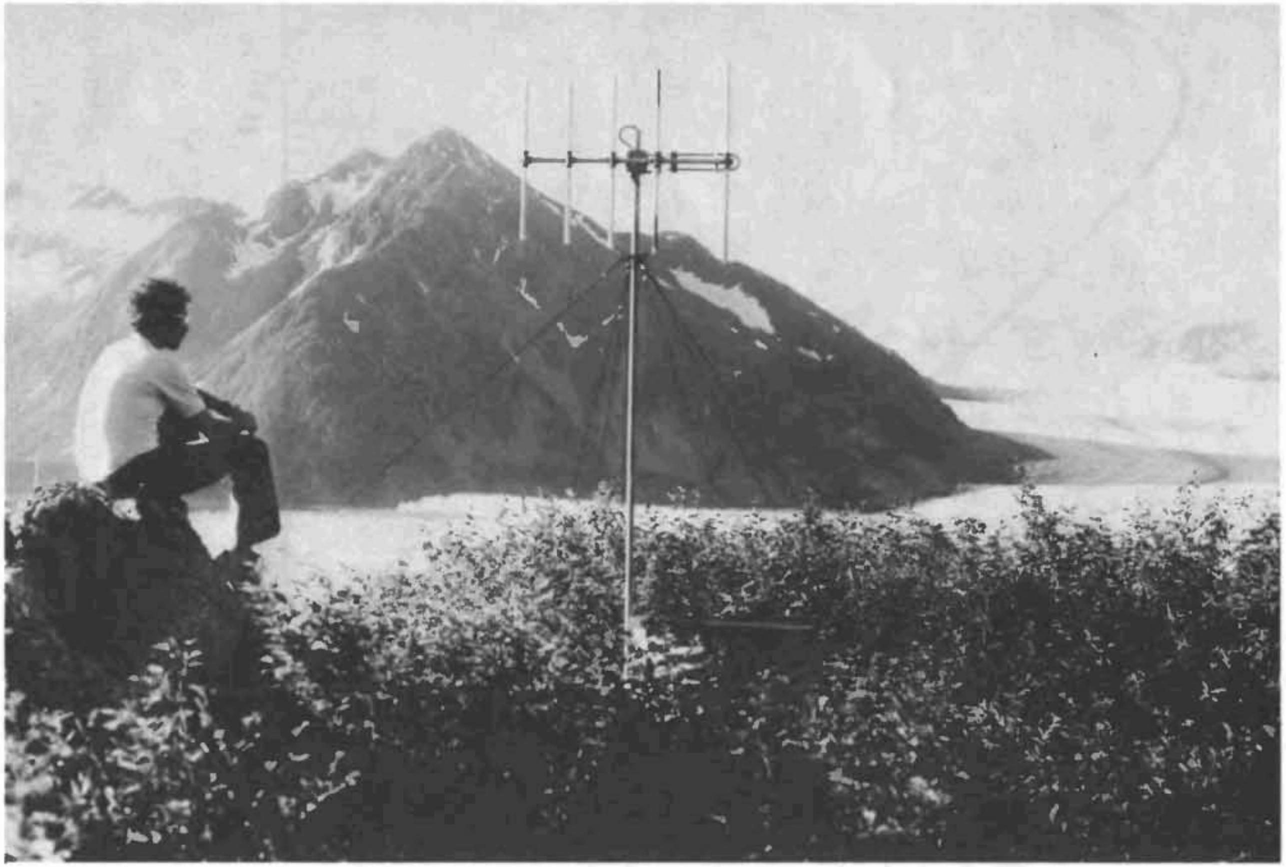

Figure 4. Installation of a typical seismograph station (HQN). VCO/amplifier unit, radio transmitter and batteries are housed in a 30-inch diameter culvert partially set in ground at base of antenna. Seismometer is buried in ground about 30 meters from culvert.

scanning process, the following data are read from each station: P- and S-wave arrival times, direction of first motion, duration of signal in excess of a given threshold amplitude, and period and amplitude of maximum recorded signal. The criterion for choosing earthquakes to be timed is the duration of the signal, which is related to the magnitude. The network is divided into three regions, western, central and eastern, bounded approximately by 156° to 150°W, 150° to 145°W and 145° to 138°W, respectively. In the western and central regions, only events with signal durations longer than 80 sec and 20 sec respectively, are timed. In the eastern region, all earthquakes which are recorded by at least three stations and for which at least four clear arrivals can be read are timed. This criterion was established to facilitate processing the large number of earthquakes which are recorded by the network while taking into account a relative decrease from west to east in the total number of earthquakes that have magnitudes within a given range.

The actual timing is done on a digitizing table. The output from the digitizer, in the form of x-y data pairs on punched computer cards, is converted into phase data by computer using the program DIGIT3 (written by P. Ward for use within the U.S. Geological Survey).

3. Initial computer processing. The phase data from the films is batch processed by computer using the program HYPOELLIPSE (Lahr, Klein, and Ward, in preparation) to obtain origin times, hypocenters, magnitudes and, if desired, first-motion plots for fault-plane solutions.

4. Analysis of initial computer results. Each hypocentral solution is checked for large travel-time residuals and for a poor spatial distribution of stations. Arrival times identified with large residuals are re-read. For shocks with a poor distribution of stations, readings from additional stations outside the USGS network are sought.

5. Final computer processing. The poor hypocentral solutions are rerun with corrections and the new solutions are checked for large residuals that might be due to remaining errors. Corrections are made as required before the final computer run is made.

The earthquake locations are based on P and S arrivals. S arrivals are important for determining depths of events in the Benioff zone beneath Cook Inlet. Unfortunately for some large events, S cannot be read at any station because the traces on the film overlap each other or are too faint to follow.

The HYPOELLIPSE computer program determines hypocenters by minimizing differences between observed and computed travel-times through an iterative least-squares scheme. In many respects the program is similar to HYPO71 (Lee and Lahr, 1972), which has been used in the preparation of catalogs of central California earthquakes from January 1969 through December 1973. An important new feature available in HYPOELLIPSE is the calculation of confidence ellipsoids for each hypocenter. The ellipsoids provide valuable insight into the effect of network geometry on possible hypocentral errors.

All earthquakes are located using a horizontally layered velocity model. It is recognized that any model comprised of uniform horizontal layers is a poor representation of the actual velocity structure in the vicinity of a subduction zone (Mitronovas and Isacks, 1971; Jacob, 1972). Although such a model does have the advantage of simplifying the computation of travel-times. In order to determine any bias that might result from this approximation, a set of events in the Benioff zone below Cook Inlet was relocated, using both a ray-tracing program of E. R. Engdahl and a more realistic, three-dimensional velocity model (Lahr, 1975). Hypocenter shifts, apparently due to the over-simplified flat-layer model, ranged from near zero at a depth of 60 km to as great as 25 km at the 160 km depth. The offsets were oriented in such a way that the dip of the Benioff zone would appear to be too great in the flat-layered model.

Two different P-wave velocity models are used to locate the earthquakes. West of 149°W the velocity model used is based on Model A of Matumoto and Page (1969) derived for the eastern Kenai Peninsula-Prince William Sound region. The velocity model is specified as follows:

Layer	Depth (km)	P velocity (km/sec)
1	0 - D	2.75
2	D - 4	5.3
3	4 - 10	5.6
4	10 - 15	6.2
5	15 - 20	6.9
6	20 - 25	7.4
7	25 - 33	7.7
8	33 - 47	7.9
9	47 - 65	8.1
10	below 64	8.3

The thickness of the first layer is allowed to vary between stations to account for the presence of thick sections of low-velocity sediments beneath the stations NKA and NNL, which are located in the Cook Inlet basin. For these stations D is 4 km. For all other stations D is 0.01 km. For earthquakes that occurred east of 149°, the velocity model used to locate the events is one that was developed by minimizing the travel-time residuals for a group of earthquakes near Valdez. The model is specified by:

Layer	Depth (km)	P velocity (km/sec)
1	0	2.75
2	0.01	6.0
3	20	7.0
4	below 32	8.2

A value of 1.78 for the velocity ratio between P and S is assumed for both models. The initial trial depth for earthquakes which occur west of 149°W is 75 km. East of 149°W this value is 15 km because the seismicity in this part of the net occurs at shallow depths.

Travel-time delays were applied to stations in the network that had consistent and large residuals for the locations of a large group of earthquakes. Additional delays were applied at several stations to correct for a satellite link in the relay of the signal. The P-phase delays are listed in Table 1 and are added to the P-phase travel-times at each station. For S-phases the delay is multiplied by 1.78, the P to S velocity ratio.

Magnitudes are determined from either the signal duration or the maximum trace amplitude. Eaton and others (1970) approximate the Richter local magnitude, whose definition is tied to maximum trace amplitudes recorded on standard horizontal Wood-Anderson torsion seismographs, by an amplitude magnitude based on maximum trace amplitudes recorded on high-gain, high-frequency vertical seismographs such as those operated in the Alaskan network. The amplitude magnitude XMAG used in this catalog is based on the work of Eaton and his co-workers and is given by the expression (Lee and Lahr, 1972)

$$\mathrm{XMAG} = \log_{10} A - B_1 + B_2 \log_{10} D^2 \qquad (1)$$

where A is the equivalent maximum trace amplitude in millimeters on a standard Wood-Anderson seismograph, D is the hypocentral distance in kilometers, and B_1 and B_2 are constants. Differences in the frequency response of the two seismograph systems are accounted for in A; however, it is assumed that there is no systematic difference between the maximum horizontal ground motion and the maximum vertical motion. The terms $-B_1 + B_2 \log_{10} D^2$ approximate Richter's $-\log_{10} A_0$ function (Richter, 1958, p. 342), which expresses the trace amplitude for an earthquake of magnitude zero as a function of epicentral distance. For small local earthquakes in central California, $B_1 = 3.38$ and $B_2 = 1.50$ for $\Delta = 200$ to 600 km.

For small, shallow earthquakes in central California, Lee and others (1972) express the duration magnitude FMAG at a given station by the relation

$$\mathrm{FMAG} = -0.87 + 2.00 \log_{10} \tau + 0.0035\Delta \qquad (2)$$

where τ is the signal duration in seconds from the P-wave onset to the point where the peak-to-peak trace amplitude on the Geotech Model 6585 film viewer falls below 1 cm and Δ is the epicentral distance in kilometers.

Comparison of XMAG and FMAG estimates from equations (1) and (2) for 77 Alaskan shocks in the depth range 0 to 150 km and in the magnitude range 1.5 to 3.5 reveals a systematic linear decrease of FMAG relative to XMAG with increasing focal depth. To remove this discrepancy, a linear dependence on depth is added to the expression for FMAG as follows:

$$\mathrm{FMAG} = -1.15 + 2.00 \log_{10} \tau + 0.007z + 0.0035\Delta \qquad (3)$$

where z is the focal depth in kilometers.

For earthquakes larger than magnitude 3.0, FMAG values may be compared to m_b magnitudes listed in the PDE reports. The average and standard deviations for 47 events in the magnitude range 3.0 to 5.5 are 0.02 and 0.44 respectively; hence the two measures are compatible.

The magnitude preferentially assigned to each earthquake in this catalog is the FMAG estimate. The XMAG value is used only where no FMAG can be determined.

ANALYSIS OF QUALITY

Two types of errors enter into the determination of hypocenters: systematic errors limiting the accuracy of hypocenters and random errors limiting the precision. Systematic errors arise from an incorrect velocity model, misidentification of phases, or systematic timing errors and can be evaluated through controlled experiments such as locating the coordinates of a known explosion. Random errors result from random timing errors and are estimated for each earthquake through the use of standard statistical techniques.

For each earthquake, HYPOELLIPSE calculates the lengths and orientations of the principal axes of the joint confidence ellipsoid. The one-standard-deviation confidence ellipsoid describes the region of space within which one is 68 percent confident that the hypocenter lies, assuming that the only source of error is random reading error. The ellipsoid is a function of the station geometry for each individual event, the velocity model assumed and the standard deviation of the random reading error. The standard deviation determined from repeated readings of the same phases by four seismologists is as small as 0.01 to 0.02 sec. for the most impulsive arrivals and as large as 0.10 to 0.20 for emergent arrivals. The confidence ellipsoids are computed for a standard deviation of 0.16 sec. and therefore likely overestimate the 68% confidence regions. The standard deviation of the residuals for an individual solution is not used to calculate the confidence ellipsoid because it contains information not only about random reading errors but also about the incompatibility of the velocity model to the data. Thus, the confidence ellipsoid is a measure of the precision of the hypocentral solution. In a few extreme cases the value calculated for one of the ellipsoid axes becomes very large corresponding to a spatial direction with very great uncertainty. In these cases an upperbound length of 25 km is tabulated.

To fully evaluate the quality of a hypocenter one must consider both the confidence ellipsoid and the root mean square (RMS) residual for the solution. The RMS residual reflects both systematic and random errors, but the random errors are typically much smaller. Hence the RMS residual is primarily a measure of the incompatibility of the velocity model, misinterpretation of phases and systematic timing errors. Interpretation of the RMS residual may depend upon the location of the earthquake. In areas where the velocity model is incompatible with the real earth, RMS residuals could be large and betray the incompatibility; alternatively, the RMS residuals could be small and not reflect the error in a bad hypocenter. Where the velocity model is compatible, however, a large RMS residual would indicate probable misreadings of phases.

Other parameters provided by HYPOELLIPSE that are useful in evaluating the quality of a hypocentral solution are: GAP, the largest azimuthal separation between stations measured from the epicenter; D3, the epicentral distance of the third closest station; NP, the number of P arrivals used in the solution; and NS, the number of S arrivals used in the solution. If GAP exceeds 180^{o}, the earthquake lies outside the network of available stations and the solution is generally less reliable than for events occurring inside the network.

DISCUSSION OF CATALOG

The Appendix lists origin times, focal coordinates, magnitudes and related parameters for 331 earthquakes from October, November and December 1977. Epicenters for these shocks are plotted in Figure 5. Vertical sections showing the depth distribution of the shocks are presented in Figures 6 and 7.

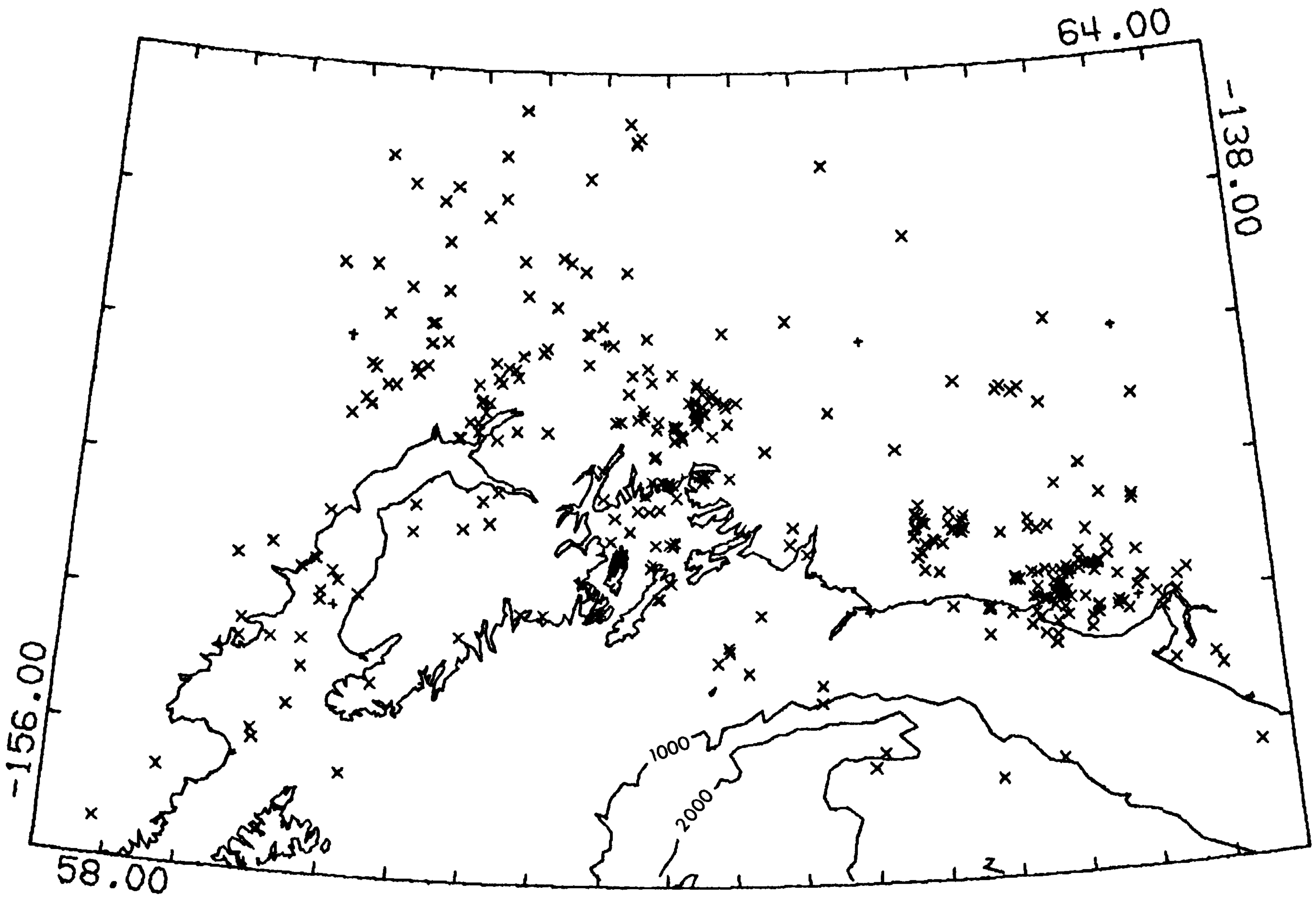

Figure 5. Map of earthquake epicenters for the period 1 October - 31 December 1977. Depth contours are in fathoms.

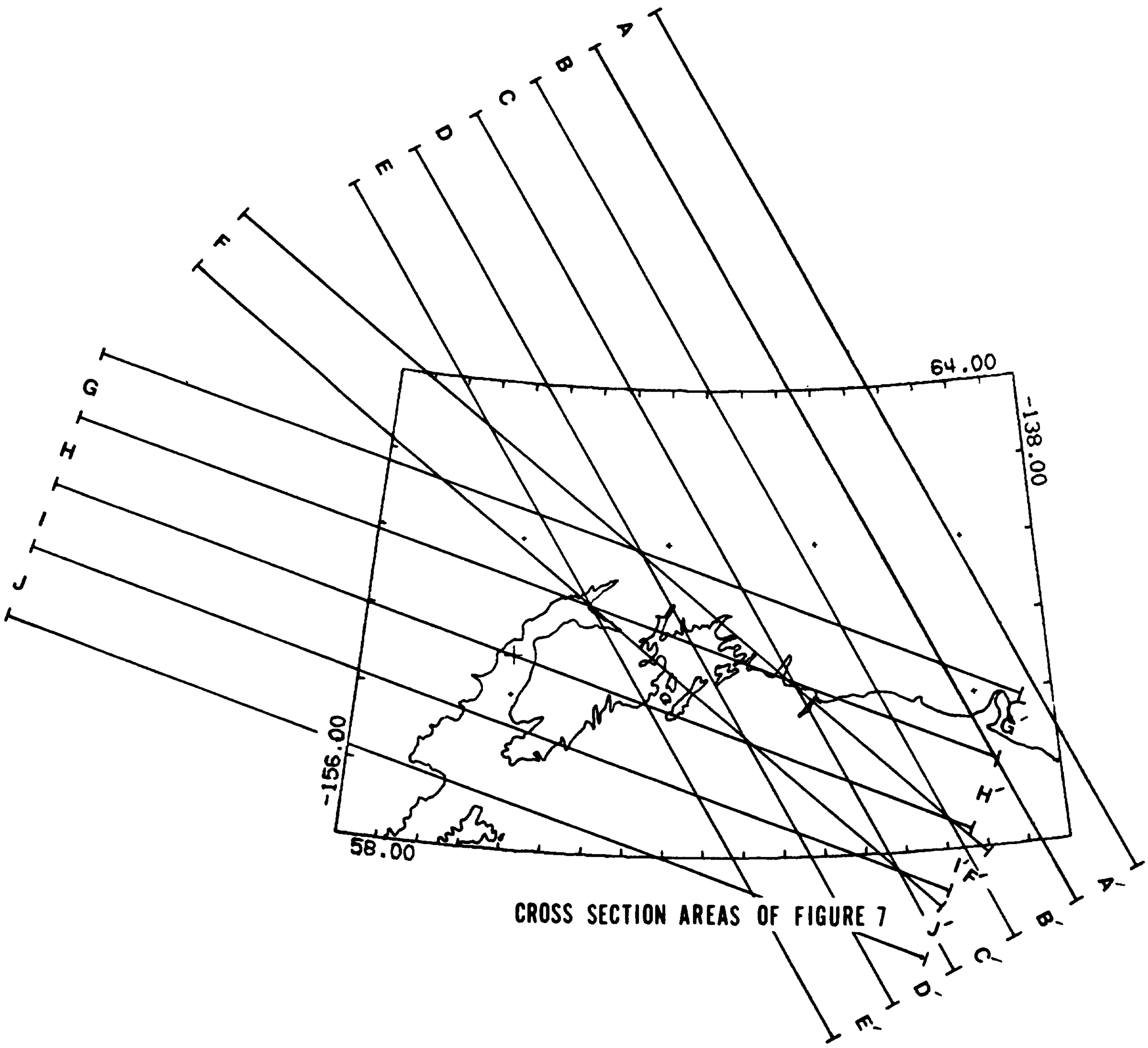

Figure 6. Map showing the area included in each of the cross sections of Figure 7. Direction of view for sections A-E is N 60° E, section F is N 40° E, and sections G-J is N 20° E.

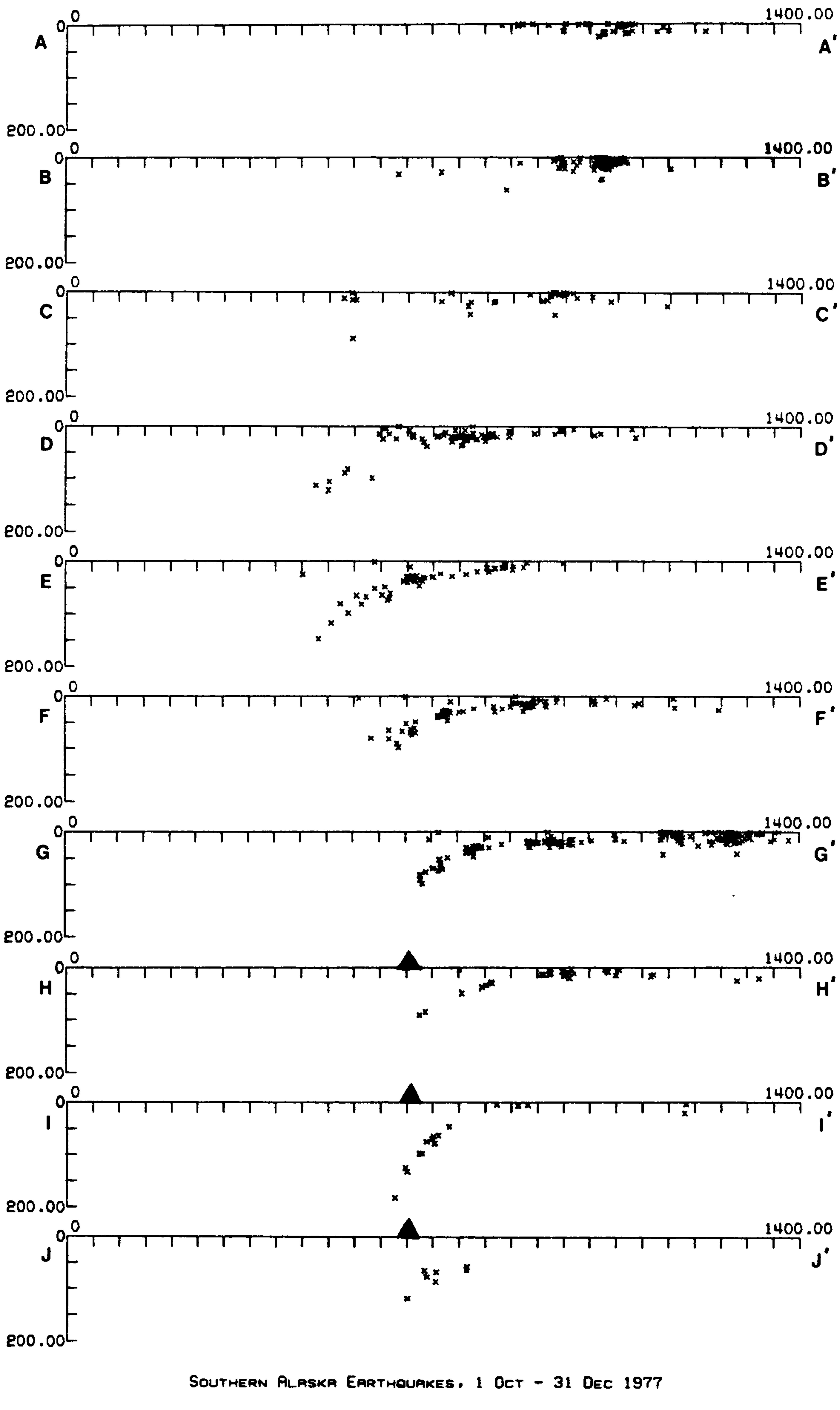

Figure 7. Vertical cross sections of hypocenters for the areas indicated in Figure 6. Active volcanoes are plotted as triangles at zero depth. All distances and depths are in kilometers.

We estimate that this catalog is reasonably complete for shocks larger than magnitude 3.5 in the western, 2.5 in the central, and 2.0 in the eastern regions of the area covered by the network. The minimum magnitude of the listed earthquakes ranges from 0.6 for shallow shocks to 2.6 for the deeper shocks.

The precision of the hypocenters or the relative accuracy of the locations of neighboring events is represented by the confidence ellipsoids. The precision of epicenters, expressed in terms of the maximum axes of the projected one-standard-deviation confidence ellipsoids (ERH), averages 5.8, 2.5, and 3.3 km, respectively, in the eastern, central, and western parts of the network. Similarly, the precision of focal depth (ERZ) averages about 6.5, 3.6, and 5.8 km, respectively. The variation in the precision of hypocenter determination across the network is strongly influenced by differences in the station coverage in the different regions.

The absolute accuracy of the earthquake locations is difficult to evaluate in the absence of known explosions. Hypocenter biases equal to and larger than the dimensions of the confidence ellipsoids are not unlikely from the oversimplified velocity model assumed in the preparation of this catalog.

In the Cook Inlet region there is a well-defined Benioff zone which dips to the northwest from a depth of about 50 km beneath the western Kenai Peninsula, to about 70 km beneath Cook Inlet, to about 115 km beneath the active volcanoes west of Cook Inlet (Figure 7, sections G-J). The direction of view (N 20° E) for sections G-J is approximately along the strike of the Benioff zone. A similar distribution of hypocenters was found for an earlier data set in this same region (Lahr, et al., 1974). There is some evidence in the sections presented here that the average dip of the Benioff zone decreases to the northeast beneath the Cook Inlet. This is especially evident in comparing sections G and I. Despite this apparent variation in the geometry of the Benioff zone, the depth to the seismic zone beneath the active volcanoes - Augustine, Iliamna, Redoubt and Spurr--remains approximately constant at about 115 km (sections H-J). In the northern Cook Inlet region and northward into the Susitna River lowlands numerous shocks occur above the principle dipping seismic zone at focal depths of less than 30 km (Figure 7, sections D-G).

East of about 146° all of the earthquakes were located at depths less than 50 km (Figure 7, sections A-D). Most of the seismic activity in the eastern part of the network for the period October-December 1977 appears to be concentrated northeast of Icy Bay and about 50 km northeast of Kayak Island.

The contents of the Appendix may be obtained in forms amenable to computer input (punched cards or magnetic tape) by contacting the authors.

ACKNOWLEDGEMENTS

We thank Robert Eppley, Wayne Jorgensen and the entire staff of the NOAA Tsunami Warning Center for their assistance in maintaining our recording equipment in Palmer, Alaska, as well as making their seismic data available to us.

We also wish to thank Jurgen Kienle of the Geophysical Institute of the University of Alaska for a cooperative operation of southern Cook Inlet seismograph stations.

We are indebted to all of those who have spent time fabricating, installing, and maintaining the seismograph network in Alaska, particularly John Roger, Marion Salsman, Michael Blackford and Edward Criley.

Betty McIntire and the staff of the USGS Anchorage office has been of great assistance in solving logistic problems, both in the field and in the office.

This catalog is patterned after those prepared for central California and we gratefully acknowledge Drs. W. H. K. Lee and R. L. Wesson for development of many of the procedures and techniques used herein.

This study was supported jointly by the U.S. Geological Survey and by the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office.

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APPENDIX

Catalog of Earthquakes (October-December, 1977)

Earthquakes from southern Alaska for October 1 through December 31, 1977 are listed in chronological order. The following data are given for each event:

(1) Origin time in Universal Time (UT): date, hour (HR), minute (MN), and second (SEC). To convert to Alaska Standard Time (AST) subtract ten hours.

(2) Epicenter in degrees and minutes of north latitute (LAT N) and west longitude (LONG W).

(3) DEPTH, depth of focus in kilometers. "*" next to the depth indicates that the depth control in the determination of the hypocenter was poor. "&" next to the depth indicates that the geophysicist constrained the initial trial location for the earthquake.

(4) MAG, duration magnitude (FMAG) of the earthquake, if available, otherwise amplitude magnitude (XMAG).

(5) NP, number of P arrivals used in locating earthquake.

(6) NS, number of S arrivals used in locating earthquake.

(7) GAP, largest azimuthal separation in degrees between stations.

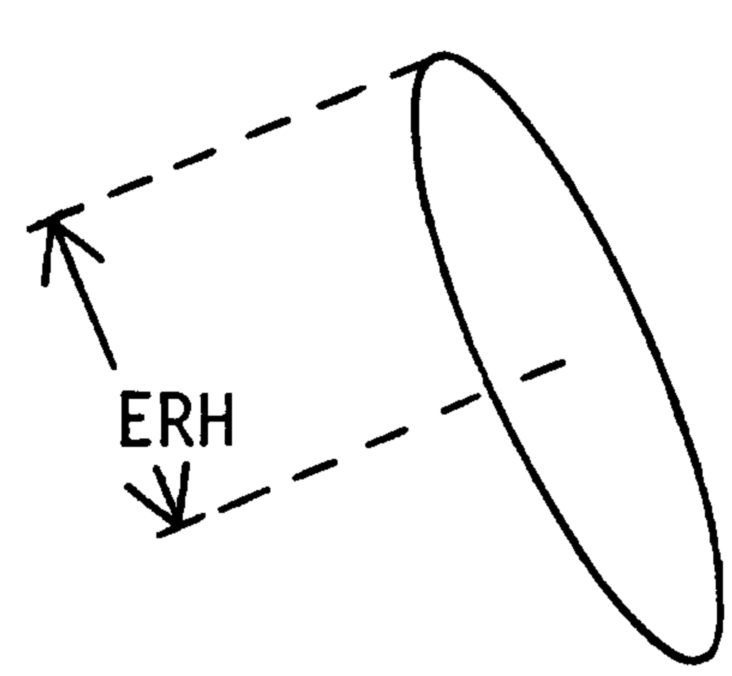
(8) D3, epicentral distance in kilometers to the third closest station to the epicenter.

(9) RMS, root-mean-square error in seconds of the travel-time residuals:

$$RMS = \sum_i (R_{P_i}^2 + R_{S_i}^2) / (N_P + N_S)$$

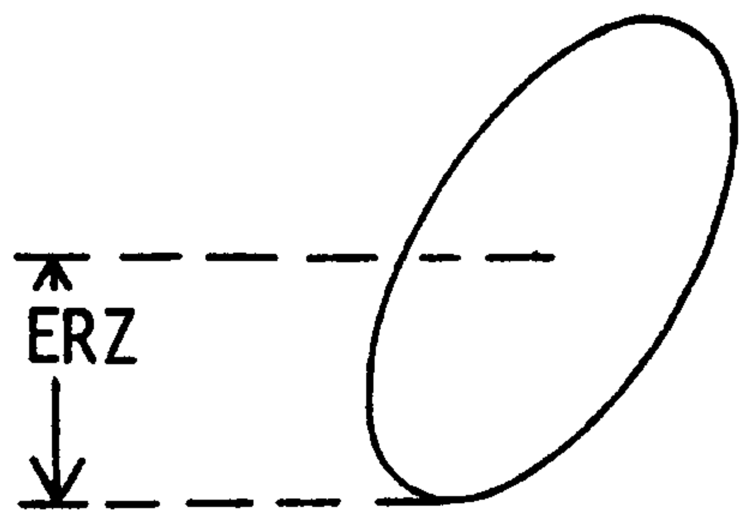
where R_{P_i} and R_{S_i} are the observed minus the computed arrival times of P and S waves respectively at the i-th station.

(10) ERH, largest horizontal deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the epicentral precision for an event. Projection of ellipsoid onto horizontal plane:



(11) ERZ, largest vertical deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the depth precision for an event.

Projection of ellipsoid onto vertical plane:



(12) Q, quality of the hypocenter. This index is a measure of the precision of the hypocenter (see section Analysis of Quality, p.11) and is calculated from ERH and ERZ as follows:

Q	ERH	ERZ
A	$\leq$ 2.5	$\leq$ 2.5
B	$\leq$ 5.0	$\leq$ 5.0
C	$\leq$ 10.0	$\leq$ 10.0
D	$>$ 10.0	$>$ 10.0

SOUTHERN ALASKA EARTHQUAKE CATALOG

1977	ORIGIN TIME HR MN	SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
OCT 2	0 39	29.4	60 35.5	142 32.4	10.4	1.4	5	5	108	51	0.75	1.3	2.5	B	
2	3 14	20.6	60 33.9	142 34.7	21.8	1.5	4	5	114	54	0.41	1.6	2.5	A	
2	5 7	43.8	61 39.0	151 23.1	14.6	2.9	23	10	184	101	0.97	3.3	4.2	B	
2	21 26	21.7	61 19.5	146 49.0	20.0&	2.3	11	6	78	51	0.36	1.0	2.0	A	
3	3 4	10.3	58 58.6	153 2.2	76.0	2.6	12	8	259	135	0.31	5.3	4.1	C	
3	7 32	12.1	60 19.5	140 24.1	15.1	1.5	5	5	225	74	0.27	6.3	2.8	C	
3	9 24	24.6	62 20.8	149 13.0	2.9	2.8	15	11	277	151	0.47	6.6	5.6	C	
3	14 43	49.6	60 7.3	139 23.7	17.3	1.7	4	4	252	58	0.37	3.6	3.3	B	
3	17 55	48.2	61 39.0	151 15.2	69.2	3.4	22	7	139	101	0.51	2.4	4.3	B	
3	22 35	4.5	59 57.7	141 6.0	7.6	1.6	3	3	221	138	0.06	3.9	5.9	C	
4	16 52	23.1	62 31.8	152 12.9	3.3	3.5	22	5	149	192	0.66	4.1	4.2	B	
5	18 22	53.5	61 42.7	146 33.0	19.8	2.3	19	13	108	66	0.61	0.9	1.3	A	
5	19 40	23.2	61 46.4	151 35.6	97.8	4.4	27	2	143	116	0.26	4.1	6.9	C	
6	5 19	18.3	60 22.1	140 50.2	15.0*	1.6	3	3	181	111	0.30	24.9	21.6	D	
6	13 12	11.2	60 29.1	142 52.2	9.7	1.8	7	7	171	118	0.63	2.8	2.8	B	
8	2 15	0.5	62 35.5	148 32.8	24.4	3.5	11	5	251	184	0.22	23.5	25.0	D	
8	20 16	56.8	60 40.8	142 32.7	19.8	2.2	8	7	144	142	0.46	4.4	3.1	B	
9	1 46	54.1	61 28.8	149 49.6	46.8	3.0	27	10	97	74	0.35	1.7	2.3	A	
10	5 41	59.5	60 38.6	142 33.7	0.1	2.0	9	5	100	64	0.93	1.3	2.6	B	
11	16 50	52.7	63 8.3	151 8.3	146.9&	4.9	21	3	86	201	0.73	5.4	17.2	D	
12	12 55	53.3	60 5.8	152 11.8	65.0	3.6	24	3	57	55	0.24	1.5	2.4	A	
13	6 37	17.7	61 38.2	147 36.6	17.4	2.5	20	7	119	52	0.55	1.0	1.3	A	
14	19 55	0.4	60 26.0	152 58.0	132.1	3.8	22	6	64	88	0.25	2.0	3.1	B	
14	20 14	22.6	61 44.6	150 54.8	60.6	3.6	19	10	217	96	0.43	3.1	4.5	B	
14	20 21	22.2	60 32.8	147 52.4	13.8	3.2	28	4	138	71	0.50	1.2	1.2	A	
15	8 35	58.7	60 14.8	152 2.5	77.7	3.6	12	2	151	145	0.16	7.3	25.0	D	
15	8 55	54.3	61 48.6	149 29.9	29.1	2.3	16	7	260	71	0.40	4.6	3.7	B	
16	0 53	22.7	62 31.8	151 40.0	80.2	4.1	10	6	303	209	0.20	15.7	25.0	D	
16	4 25	41.2	59 44.3	152 26.1	69.9	4.0	22	0	110	72	0.25	2.0	4.0	B	FELT (V) AT HOMER, ALSO FELT AT DIAMOND RIDGE
16	16 29	6.4	59 2.6	153 4.2	64.0	3.8	16	2	121	129	0.26	2.2	6.2	C	
16	22 4	16.8	63 7.9	150 26.0	105.4	4.2	22	3	78	183	0.23	4.3	10.1	D	
17	8 57	46.7	61 34.0	149 52.7	35.6&	3.0	24	6	110	40	0.35	1.8	3.0	B	
17	18 40	30.8	62 10.3	151 24.8	81.4	3.7	17	4	162	166	0.20	5.8	9.9	C	
17	23 24	20.6	61 29.8	146 27.5	28.0	2.3	17	6	83	49	0.41	1.6	2.2	A	
18	10 48	35.5	60 46.4	150 50.4	4.1&	3.4	31	4	83	80	0.82	1.1	2.0	A	FELT (II) AT KENAI, ALSO FELT AT ANCHORAGE
18	22 54	39.9	60 34.2	150 52.1	49.5	2.9	29	10	74	63	0.45	1.1	2.7	B	
19	2 16	4.1	62 43.3	150 30.8	98.5	5.0	28	1	116	152	0.20	5.0	10.4	D	
19	2 51	11.6	62 2.4	147 21.5	38.5	3.1	14	9	192	97	0.64	4.1	18.7	D	
19	11 16	42.8	59 59.3	148 51.3	5.5	2.6	28	11	139	95	0.58	2.1	1.7	A	
19	14 12	7.7	61 16.8	150 12.8	29.8	2.6	27	12	117	67	0.30	1.3	3.0	B	
20	20 30	10.6	59 48.2	150 5.5	4.1	2.5	25	9	184	79	0.73	2.5	2.5	B	
22	14 35	25.8	59 43.8	152 53.2	97.7	3.2	23	7	63	79	0.27	1.8	3.3	B	
22	15 12	37.9	61 41.5	146 34.1	7.1	2.4	23	14	106	64	0.73	0.9	1.2	A	
23	2 33	40.8	61 18.6	146 46.7	20.7	2.0	23	10	76	50	0.41	0.9	1.9	A	
23	9 28	20.8	60 16.0	152 30.8	98.2	3.3	25	8	71	72	0.31	1.7	3.2	B	

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN HR MN	TIME SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
OCT 23	14 35	19.1	61 47.3	150 57.3	73.4	3.0	27	12	146	89	0.23	2.6	2.6	B	
24	11 13	56.1	61 34.2	145 56.8	18.3	2.5	28	11	108	50	0.67	0.9	0.8	A	
24	14 48	7.7	61 22.5	147 11.0	17.8	2.4	27	11	85	68	0.48	1.1	1.2	A	
24	19 4	38.4	62 3.8	148 14.1	18.7	2.6	24	12	203	74	0.36	2.2	1.4	A	
25	2 8	9.9	59 59.6	149 11.5	6.5	2.9	32	10	124	81	0.62	1.6	1.8	A	
25	11 2	51.5	60 52.3	146 52.1	19.9	2.3	26	13	102	27	0.51	1.0	1.0	A	
25	19 58	5.8	61 47.6	151 38.9	90.4	3.6	29	9	144	95	0.37	2.6	3.3	B	
25	20 42	55.4	62 22.4	151 5.8	65.2	3.3	23	7	173	135	0.39	3.7	5.7	C	
25	23 42	44.5	61 24.9	146 32.6	19.9	2.0	21	11	80	40	0.51	1.1	1.2	A	
27	4 10	16.3	60 26.5	144 54.1	16.2	2.5	21	11	157	109	0.29	2.1	2.1	A	
27	21 1	35.0	60 31.0	143 0.5	3.6	1.6	9	7	120	68	0.43	3.4	4.4	B	
27	12 34	58.8	60 46.1	147 17.3	13.2	2.7	28	10	132	53	0.42	1.2	1.2	A	
28	7 14	38.9	60 8.1	141 9.9	9.4	2.3	16	7	128	41	0.66	2.6	2.0	B	
28	8 53	34.9	60 53.2	149 35.0	28.0	3.6	29	4	64	46	0.29	0.9	2.9	B	FELT (I) AT ANCHORAGE
28	17 59	2.5	62 7.8	148 2.1	19.8	2.7	20	13	187	83	0.43	2.0	1.5	A	
28	19 13	34.6	61 44.4	149 20.3	27.7	2.5	25	7	153	54	0.41	1.4	2.3	A	
29	12 13	6.7	63 37.8	147 37.6	11.4	3.8	13	5	274	240	0.24	25.0	25.0	D	
30	10 51	58.2	60 3.9	141 7.2	7.4	3.4	24	2	75	22	0.56	1.3	1.1	A	
30	12 16	7.1	61 23.2	146 54.4	18.5	3.0	32	8	84	54	0.56	1.0	1.1	A	
NOV 1	2 21	59.9	61 25.9	147 9.1	19.7	2.1	23	13	91	55	0.46	1.0	3.0	B	
1	10 55	25.7	60 51.4	147 59.5	19.7	2.8	33	9	104	50	0.47	1.1	1.1	A	
1	13 18	30.2	62 55.0	149 53.5	81.6	3.6	23	7	205	153	0.36	6.4	14.3	D	
1	19 45	0.2	60 47.0	140 26.8	1.2	1.7	8	7	240	91	0.32	1.7	2.5	A	
1	22 0	0.6	60 32.4	146 53.8	19.7	2.4	35	8	80	61	0.50	1.0	1.1	A	
1	22 41	29.8	60 52.7	141 7.2	0.3	2.0	17	4	204	84	0.39	1.7	3.2	B	
2	6 8	46.9	60 12.4	141 49.1	0.2	1.8	10	6	101	22	0.26	1.2	4.2	B	
2	6 48	31.8	61 28.6	147 22.2	20.0	2.3	12	7	96	63	0.34	1.4	3.4	B	
2	10 6	34.7	60 31.0	146 55.9	9.8	3.5	26	7	81	86	0.50	1.3	1.6	A	
2	10 57	29.7	60 19.9	152 17.9	75.1	3.6	20	7	108	64	0.30	2.7	4.0	B	
2	17 5	33.0	61 23.7	146 51.4	19.4	2.3	10	7	137	54	0.28	2.0	2.2	A	
3	0 4	27.4	62 32.1	148 19.1	15.0	2.9	18	7	241	121	0.37	4.5	5.0	B	
3	7 12	44.5	61 46.5	147 33.9	20.0	2.6	19	9	148	67	0.45	1.5	2.4	A	
3	7 33	23.8	60 36.4	150 6.3	37.5	2.8	24	6	63	64	0.31	1.1	2.8	B	
3	9 23	26.0	61 32.4	146 5.9	42.2	2.4	15	13	97	54	0.45	1.7	3.6	B	
3	14 19	0.7	60 31.7	146 58.0	9.6	2.4	22	14	159	83	0.42	1.3	1.4	A	
3	15 39	21.0	60 42.7	143 16.0	1.8	2.0	13	6	74	64	0.49	2.0	2.6	B	
3	19 56	42.0	61 32.8	149 46.6	27.3	2.4	10	7	172	72	0.20	2.3	4.1	B	
3	20 10	10.0	60 30.9	145 9.5	13.6	3.2	16	7	133	94	0.33	3.0	1.7	B	
4	1 22	28.2	61 16.7	150 14.4	38.4	3.4	26	4	66	46	0.28	1.2	3.6	B	FELT (II) IN ANCHORAGE
4	2 17	24.5	62 35.7	149 17.9	98.4	3.6	18	9	229	112	0.30	5.6	8.5	C	
4	3 55	29.1	60 41.6	152 7.8	85.1	3.6	19	5	136	55	0.25	2.6	4.2	B	
4	9 45	2.8	61 32.5	151 42.8	97.4	3.5	22	7	152	52	0.28	3.1	4.7	B	
4	15 53	13.0	61 0.8	140 43.0	13.68	2.3	3	2	254	105	0.08	14.8	25.0	D	
5	0 21	39.0	61 50.5	149 41.2	37.6	2.6	21	13	162	67	0.32	1.6	2.8	B	
5	5 6	52.0	60 1.8	152 12.2	79.3	3.3	22	6	64	71	0.24	1.7	4.2	B	

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN HR MN	TIME SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
NOV 5	9 49	21.5	63 42.5	149 20.6	112.6	4.3	18	6	105	223	0.20	8.2	25.0	D	
5	18 42	18.4	59 51.2	153 19.9	125.1	4.0	23	5	67	58	0.21	2.0	3.2	B	
5	21 8	34.4	61 53.7	149 16.7	28.8	3.1	25	6	167	51	0.30	1.9	3.2	B	
5	21 19	15.6	62 7.4	150 42.1	51.8	3.1	21	6	162	73	0.29	3.0	4.6	B	
6	9 23	30.0	61 58.0	150 43.8	64.0	3.9	28	1	155	57	0.24	2.5	2.9	B	
6	19 11	2.0	62 9.7	145 9.7	1.2	3.4	22	6	140	92	0.45	1.3	1.8	A	FELT AT GLENNALLEN
7	0 29	37.6	61 40.8	149 57.2	39.9	3.4	25	6	145	48	0.23	2.0	3.0	B	
7	21 32	47.6	60 35.1	142 42.7	9.8	1.7	5	3	167	54	0.10	10.0	7.7	C	
8	18 24	32.0	60 49.2	149 48.8	34.2	2.7	23	9	59	44	0.30	1.5	4.8	B	
8	21 8	7.1	60 15.8	140 32.8	17.5	2.2	9	4	183	60	0.21	3.4	1.9	B	
8	21 31	51.0	59 58.8	141 13.9	1.2	2.1	7	2	104	104	0.28	3.8	4.3	B	
8	22 48	18.7	61 37.5	141 51.0	3.2	2.4	7	5	247	142	0.22	4.7	2.5	B	
8	23 3	27.7	60 10.8	151 57.6	63.3	3.6	23	7	52	50	0.23	1.7	3.6	B	
9	1 35	53.4	60 16.9	140 32.6	15.3	1.8	11	8	175	62	0.25	3.3	1.6	B	
9	6 49	19.5	62 37.7	148 40.5	14.1	3.1	23	10	230	126	0.26	3.2	4.4	B	
9	12 41	20.8	60 5.3	141 13.1	6.7	2.0	15	5	119	42	0.29	1.4	1.9	A	
10	1 36	32.0	61 1.7	146 30.6	19.1	1.9	12	9	117	67	0.35	1.7	1.3	A	
10	7 3	16.0	58 42.8	154 21.9	0.5	2.6	8	4	265	90	0.50	5.6	2.9	C	
10	9 24	44.1	61 16.6	149 38.3	30.5	2.5	18	12	65	44	0.43	1.4	2.2	A	
10	9 44	50.2	61 25.5	151 55.6	90.7	3.3	25	8	160	65	0.27	4.3	5.3	C	
11	5 59	20.1	60 31.3	147 11.2	7.2	2.6	18	16	153	79	0.62	2.4	1.8	A	
12	1 53	11.7	61 4.1	148 0.6	24.0	2.7	19	13	102	45	0.48	1.2	1.4	A	
12	2 15	56.4	60 59.1	146 27.9	14.1	3.0	18	10	114	64	0.62	1.2	1.3	A	
12	3 38	48.2	60 2.7	141 12.3	0.2	1.6	8	2	113	46	0.27	2.7	7.2	C	
12	16 13	4.2	61 23.6	149 56.5	35.6	2.9	25	6	59	49	0.32	1.4	3.1	B	
13	1 47	13.5	61 35.6	146 22.0	35.3	2.2	13	9	87	58	0.40	1.4	4.6	B	
13	13 13	2.3	60 37.8	141 34.2	8.1	2.0	13	4	172	62	0.35	1.7	2.3	A	
13	17 46	49.2	60 58.1	146 59.7	20.6	2.4	18	11	113	40	0.41	1.2	1.9	A	
13	19 43	57.7	60 53.2	147 21.5	28.9	2.6	21	12	142	45	0.42	1.8	1.2	A	
14	2 47	39.7	60 14.1	141 7.9	0.1	1.2	7	6	144	51	0.26	1.6	6.1	C	
14	6 0	7.5	60 58.5	147 0.2	20.0	2.4	21	10	113	40	0.36	1.3	1.2	A	
14	13 18	41.8	61 28.9	141 15.1	0.1	2.0	4	4	252	136	0.18	4.6	6.5	C	
14	15 2	45.3	60 1.7	141 0.4	18.5	1.6	5	3	215	55	0.16	5.5	3.0	C	
14	22 49	43.6	60 41.5	143 14.4	7.7	2.0	9	5	98	75	0.64	1.7	2.5	B	
15	17 34	3.7	61 59.4	147 52.2	23.5	2.5	13	12	212	80	0.45	3.8	3.1	B	
16	1 54	19.9	62 16.0	148 45.3	23.4	3.1	22	7	200	90	0.33	2.9	2.8	B	
16	2 30	13.6	60 59.3	147 5.4	20.1	2.0	15	10	121	42	0.41	1.7	2.4	A	
16	9 7	45.8	59 51.3	141 13.0	11.9	3.0	17	1	162	50	0.39	2.1	1.2	A	
16	15 37	42.6	60 46.9	147 7.5	18.0	2.7	24	11	135	57	0.48	1.6	1.2	A	
17	10 6	8.8	61 40.4	142 34.5	62.1	2.1	5	5	267	131	0.33	6.3	5.9	C	
17	10 50	28.0	61 28.9	144 31.4	19.4	1.2	7	4	148	52	0.27	4.0	1.8	B	
17	12 27	7.1	61 20.8	149 19.1	29.6	3.0	31	8	61	45	0.43	1.1	2.0	A	FELT (III) AT EAGLE RIVER
17	20 30	11.5	61 42.9	146 32.6	19.7	2.3	18	10	108	66	0.61	1.1	1.7	A	
18	6 47	14.9	61 33.1	149 53.7	38.4	2.5	24	9	66	41	0.24	1.9	2.5	B	
18	10 36	33.3	60 5.0	151 38.2	46.0	3.2	27	5	74	68	0.34	1.3	2.1	A	

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN TIME HR MN	SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
NOV 19	3 10	50.3	60 38.7	143 9.9	0.2	1.6	8	6	94	62	0.42	1.4	4.6	B	
19	21 5	31.0	61 29.8	151 37.7	75.9	3.1	23	10	107	87	0.35	2.2	4.0	B	
19	22 14	5.5	61 43.8	149 38.5	35.1	2.2	20	13	151	54	0.34	1.9	2.6	B	
20	18 53	59.7	62 21.6	150 29.7	67.4	3.8	29	2	103	111	0.37	3.0	4.7	B	FELT (V) AT SUTTON,(IV) AT CANTWELL
21	5 2	10.6	61 24.3	146 54.9	7.7	2.2	27	11	86	52	0.56	0.8	1.3	A	AND TALKEETNA, AND (III) AT PALMER
21	13 34	35.8	59 14.8	152 35.4	85.1	4.2	22	2	112	63	0.23	2.5	4.8	B	
21	18 14	23.8	61 1.5	146 23.4	14.2	2.1	18	10	55	35	0.53	1.0	1.0	A	
22	12 32	11.9	61 50.9	148 14.5	30.0	2.4	20	11	160	55	0.40	1.7	1.3	A	
22	21 6	28.0	60 16.4	142 56.6	10.2	1.4	8	5	94	52	0.30	3.6	3.8	B	
23	1 21	44.1	60 31.2	140 42.1	0.6	2.0	13	6	194	60	0.20	1.7	4.1	B	
23	3 27	14.3	61 20.0	146 48.0	20.3	2.2	19	14	78	50	0.54	0.8	2.1	A	
23	10 28	26.2	60 58.6	146 59.0	21.3	2.3	26	15	64	35	0.42	1.1	1.3	A	
23	15 35	49.7	60 3.2	141 10.3	2.9	1.8	15	6	115	47	0.45	1.3	2.7	B	
23	21 56	10.0	60 4.1	141 9.2	7.7	2.2	16	5	118	46	0.39	1.5	2.2	A	
24	0 41	25.7	61 43.5	147 15.4	15.2	2.1	10	9	134	71	0.35	1.4	2.0	A	
24	1 16	47.8	60 3.4	141 9.2	1.4	1.8	12	8	116	49	0.32	1.5	2.7	B	
24	3 23	47.8	63 29.0	147 31.8	88.1	4.2	20	3	88	169	0.33	4.9	18.6	D	
24	13 47	7.9	60 32.7	143 17.8	4.4	1.4	4	3	255	75	0.16	5.4	25.0	D	
24	21 1	41.3	63 20.4	151 32.2	25.3	3.9	19	6	97	207	0.39	5.2	14.2	D	
24	22 26	53.8	60 16.0	140 46.0	41.5	1.3	4	4	169	117	0.07	8.8	11.1	D	
25	9 5	49.8	61 10.4	147 13.1	0.6	2.2	17	10	74	38	0.47	1.5	2.4	A	
25	9 57	22.5	60 7.3	147 8.9	2.6	3.2	32	8	118	90	0.46	1.3	1.5	A	
25	14 16	44.9	60 29.3	143 7.8	0.2	1.9	9	8	165	78	0.36	2.5	3.5	B	
26	7 2	38.6	61 12.4	145 30.9	16.3	1.9	13	7	100	45	0.40	1.5	1.2	A	
26	10 45	1.3	60 32.4	141 59.6	26.5	1.5	8	8	136	52	0.23	1.6	2.5	A	
26	12 48	20.5	61 35.5	146 34.9	20.0	2.2	13	14	109	59	0.48	1.4	3.9	B	
26	13 21	48.2	61 34.9	146 15.1	19.6	2.2	14	11	93	61	0.36	1.2	3.4	B	
26	13 56	37.1	61 29.3	139 48.1	2.1&	2.9	5	2	280	175	0.53	22.5	25.0	D	
26	16 17	49.8	62 6.9	150 44.6	1.2	3.2	16	2	200	103	0.26	3.3	6.0	C	
26	21 4	29.8	61 36.4	141 34.1	0.3	2.4	5	5	256	146	0.16	6.0	3.4	C	
27	0 7	1.5	61 34.6	141 40.3	1.7	2.4	4	3	253	141	0.09	6.8	4.2	C	
27	0 10	31.0	61 46.8	146 56.8	11.8	2.3	12	8	136	73	0.36	1.7	2.2	A	
27	9 25	59.2	63 1.0	150 38.5	117.5	4.1	21	9	206	173	0.27	8.5	13.0	D	
27	12 32	45.4	61 38.4	146 18.8	37.1	3.0	20	6	91	57	0.49	1.5	4.8	B	
27	15 5	7.6	58 17.0	155 12.0	121.5&	5.0	18	1	245	156	0.20	7.1	9.1	C	
27	16 5	48.7	60 12.0	141 1.1	15.0*	1.1	3	2	180	105	0.22	25.0	25.0	D	
27	19 53	33.3	60 25.2	140 23.7	24.0	1.5	3	3	225	127	0.05	9.4	15.3	D	
28	4 40	16.1	63 18.2	144 30.2	32.0	3.3	5	3	318	211	0.15	6.9	25.0	D	
28	6 42	27.8	60 43.1	147 48.7	12.7	2.0	7	5	171	66	0.35	2.0	2.7	B	
28	12 3	56.6	61 24.0	150 4.0	35.5	3.2	19	3	70	54	0.32	1.5	3.7	B	
28	13 46	33.5	61 48.0	150 46.7	70.5	3.0	20	4	145	90	0.24	2.8	4.3	B	
28	15 11	7.6	59 59.7	145 36.3	15.1	2.0	10	7	200	130	0.35	5.1	5.4	C	
28	21 26	28.7	60 15.8	140 41.7	19.6	1.3	4	4	174	121	0.12	10.7	7.3	D	
29	0 53	54.5	61 32.7	146 27.8	26.9	2.1	14	13	87	54	0.55	1.1	1.4	A	
29	3 14	38.4	60 7.4	147 7.1	3.2	3.2	32	5	117	106	0.35	1.2	1.5	A	

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN HR MN	TIME SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
NOV 29	12 26	47.6	59 52.6	140 42.0	4.4	1.5	4	2	253	135	0.08	8.5	7.1	C	
29	14 21	51.6	59 59.0	142 14.5	2.3	1.1	11	7	181	40	0.25	2.5	2.3	A	
29	16 22	12.6	60 37.6	142 36.7	0.0	2.6	21	6	97	56	0.49	1.0	0.8	A	
29	16 37	22.6	60 0.2	142 13.0	1.9	1.6	7	6	230	40	0.26	2.6	3.9	B	
29	19 35	0.1	61 28.4	146 32.9	23.6	2.2	14	10	84	70	0.50	1.1	2.0	A	
29	21 6	36.3	61 19.6	146 19.2	24.4	2.5	13	8	69	54	0.36	1.4	1.6	A	
30	5 7	34.3	61 26.8	147 28.4	20.1	2.9	23	4	92	61	0.52	1.2	2.3	A	
30	8 12	10.1	60 1.0	142 46.1	8.3	1.7	7	4	254	41	0.32	3.8	1.9	B	
30	10 25	44.5	61 30.3	146 34.5	19.9	2.3	16	11	88	70	0.53	1.1	1.5	A	
30	13 8	55.8	59 59.1	142 12.7	1.3	1.6	7	3	218	41	0.21	4.9	3.8	B	
30	14 2	26.5	61 24.9	146 5.0	25.3	2.3	17	8	66	45	0.45	1.3	1.5	A	
30	14 9	39.6	59 47.4	142 14.4	17.5	2.0	3	4	288	81	0.37	4.3	2.0	B	
30	17 12	15.6	60 13.8	140 58.6	1.0	1.8	8	4	150	45	0.30	2.3	5.2	C	
30	17 14	27.1	60 5.0	141 3.1	22.0	1.3	4	3	199	50	0.08	10.3	6.8	D	
30	18 44	4.3	60 46.5	147 28.1	20.4	2.8	19	6	154	73	0.33	2.3	2.5	A	
30	22 13	54.6	61 0.6	146 3.5	19.9	3.1	17	5	87	54	0.23	1.4	5.3	C	
DEC 1	18 45	11.8	58 50.8	138 27.5	15.0*	1.9	3	2	343	173	0.06	25.0	22.4	D	
2	2 20	37.5	63 3.1	149 37.3	89.4	3.9	20	5	213	157	0.40	8.4	19.5	D	
2	16 48	25.9	60 38.4	145 6.2	3.8	2.5	27	6	57	82	0.44	1.0	1.5	A	
2	17 40	18.3	60 14.9	141 21.9	15.0*	1.9	4	2	137	64	0.38	9.9	10.5	D	
2	23 29	32.3	60 20.4	139 58.6	0.1	2.4	9	3	269	87	0.50	5.3	4.5	C	
3	1 24	40.2	60 10.3	140 16.8	15.0*	1.4	3	1	221	149	0.18	25.0	25.0	D	
3	18 43	43.8	61 59.2	150 28.7	48.7	3.4	27	5	156	60	0.37	2.6	3.5	B	
3	20 39	29.3	58 43.8	142 11.6	25.8	2.9	14	5	276	150	0.35	25.0	25.0	D	
4	20 3	58.9	59 54.0	139 39.4	1.4	1.4	4	2	153	40	0.19	3.9	7.8	C	
5	0 5	10.4	61 27.5	146 34.5	20.0	2.7	13	6	109	83	0.53	1.5	1.8	A	
5	0 47	1.1	60 34.8	142 37.7	12.2	2.3	16	9	95	53	0.53	1.1	1.2	A	
5	3 24	30.3	59 41.7	141 15.9	8.3	2.1	11	5	184	57	0.36	2.3	2.3	A	
5	6 4	46.4	59 50.7	141 35.8	14.6	1.6	9	8	218	34	0.51	2.4	1.8	A	
5	14 24	31.0	60 40.3	143 10.4	0.3	1.3	10	5	140	61	0.28	1.9	5.3	C	
5	19 7	52.6	60 0.8	139 25.3	0.2	2.1	9	4	233	47	0.48	4.8	3.0	B	
5	20 21	35.6	59 56.5	140 19.0	1.3	1.7	6	2	156	60	0.30	2.8	4.3	B	
5	20 37	23.3	59 58.5	140 17.4	3.4	1.2	3	1	192	68	0.00	20.8	25.0	D	
6	0 33	51.9	58 51.1	141 17.3	21.4	2.6	12	6	280	141	0.25	16.5	23.4	D	
6	10 56	44.5	61 34.3	146 40.3	21.6	2.2	18	11	97	58	0.43	1.0	2.2	A	
6	17 51	18.7	58 45.9	151 45.9	62.1	3.5	17	3	161	115	0.26	2.5	6.4	C	
7	9 19	45.6	62 45.8	143 14.0	28.0	3.3	8	1	278	169	0.36	25.0	25.0	D	
7	22 22	27.1	59 56.5	140 36.2	1.6	1.8	4	2	234	127	0.14	11.4	6.3	D	
7	22 42	15.3	59 54.0	140 35.6	0.2	1.4	3	2	259	159	0.08	9.0	14.2	D	
7	22 42	39.8	60 24.5	147 44.8	12.9	2.6	26	11	158	86	0.46	2.0	1.4	A	
7	22 45	44.1	59 45.5	146 5.5	7.2	3.7	36	3	114	90	0.32	1.3	1.6	A	
7	22 50	35.8	59 57.3	140 35.3	10.7	1.7	7	2	161	74	0.32	5.5	4.6	C	
7	22 58	23.5	60 11.9	141 5.8	0.5	1.8	8	2	140	48	0.19	3.8	6.3	C	
8	1 33	54.3	60 34.9	142 43.4	15.6	1.7	7	5	95	55	0.33	2.7	2.5	B	
8	1 58	7.8	59 26.3	151 22.6	56.7	3.8	29	2	109	116	0.30	3.0	3.4	B	FELT (IV) AT HOMER

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN HR	TIME MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
DEC 8	17	27	57.3	63	31.5	147	27.1	0.9	3.7	17	3	147	197	0.37	6.7	25.0	D	
8	21	8	44.8	60	39.2	149	42.2	30.2	3.0	27	5	80	63	0.31	1.0	2.7	B	
8	22	31	8.7	60	14.2	146	57.2	11.4	2.8	25	5	106	75	0.53	1.4	1.8	A	
11	4	7	42.8	61	31.0	147	23.7	21.8	2.3	21	6	101	59	0.42	1.1	1.8	A	
11	9	52	8.0	60	1.3	140	47.3	6.5	2.0	11	5	155	65	0.45	3.0	2.8	B	
12	8	0	44.3	59	43.7	146	5.2	8.8	2.4	17	4	129	115	0.59	2.8	4.0	B	
12	11	3	48.4	60	12.3	140	36.9	6.7	1.8	5	2	163	62	0.24	24.0	19.2	D	
12	11	7	13.9	59	47.6	140	42.8	11.0	1.8	5	2	243	86	0.30	8.6	3.4	C	
12	18	3	49.1	60	10.4	139	15.5	18.6	1.4	5	2	248	57	0.41	8.5	4.3	C	
12	18	50	45.6	60	34.4	141	16.6	0.7	1.2	7	5	182	77	0.24	1.4	4.5	B	
12	22	27	55.3	61	10.6	147	11.5	12.9	2.5	18	6	93	59	0.64	1.4	1.2	A	
13	3	51	38.1	61	47.9	149	23.1	30.3	2.6	19	7	158	56	0.69	2.0	2.7	B	
13	11	29	41.2	60	34.2	141	34.1	15.7	1.3	6	6	165	67	0.32	1.7	2.1	A	
13	11	46	11.3	60	23.3	147	44.3	4.7	2.8	31	6	101	88	0.40	1.5	1.7	A	
13	17	1	51.1	59	56.3	141	31.5	11.8	2.4	13	2	156	30	0.28	1.9	1.9	A	
14	8	23	27.4	60	25.6	147	44.8	12.8	2.4	14	11	202	84	0.47	2.2	1.7	A	
14	14	2	46.7	60	58.1	146	55.6	20.6	2.7	16	12	108	37	0.46	1.5	1.8	A	
14	14	5	46.3	59	34.4	145	48.4	5.1	3.3	12	9	218	179	0.35	7.1	9.6	C	
14	14	8	52.9	61	25.9	147	44.1	29.6	2.2	9	6	163	82	0.41	3.7	2.3	B	
14	17	46	24.0	60	59.3	147	14.9	15.7	2.1	8	5	124	52	0.30	2.4	1.6	A	
15	1	29	23.2	61	20.1	149	55.9	32.0	3.3	30	6	54	46	0.27	1.1	2.0	A	FELT (III) AT ANCHORAGE
15	15	28	3.3	62	4.5	148	16.0	16.1	3.4	12	4	230	97	0.23	5.1	2.8	C	
15	17	0	25.4	62	31.6	147	40.3	0.3	2.9	16	12	228	129	0.56	3.2	1.7	B	
15	23	48	19.5	59	57.5	140	13.4	3.6	1.9	8	5	153	73	0.35	2.3	2.8	B	
16	5	17	1.4	60	38.1	143	8.0	0.2	1.9	14	10	67	62	0.44	1.6	2.6	B	
16	5	47	51.0	61	11.4	143	30.9	10.5	0.7	5	4	149	88	0.32	5.6	5.4	C	
16	14	11	25.6	60	2.8	141	11.4	3.3	1.2	8	4	114	47	0.25	1.9	20.9	D	
16	14	12	44.5	60	1.5	141	20.9	22.6	1.2	4	3	162	61	0.13	4.2	4.1	B	
16	21	49	23.6	59	42.9	153	20.7	117.9	4.1	21	3	64	60	0.27	1.9	3.3	B	FELT (I) AT PALMER
17	5	20	29.0	60	11.3	141	44.8	18.0	0.8	3	3	137	23	0.04	2.0	4.6	B	
17	5	56	54.5	60	43.1	139	57.8	0.5	2.2	10	8	234	105	0.56	3.2	4.7	B	
17	6	9	46.6	60	23.2	147	42.8	10.6	2.6	17	11	218	89	0.57	2.2	1.3	A	
17	8	13	48.1	61	9.9	147	12.9	13.4	2.4	18	8	85	38	0.43	1.2	1.3	A	
17	15	18	2.1	60	58.1	146	56.0	21.5	2.8	36	11	56	32	0.46	1.0	1.0	A	
17	15	43	21.5	63	29.7	147	31.6	14.5	3.5	18	5	140	170	0.56	4.7	7.4	C	
18	5	16	58.0	59	31.5	138	58.1	6.1	1.6	3	1	185	60	0.12	25.0	21.6	D	
18	6	56	44.1	60	3.1	141	33.2	12.8	1.7	16	10	126	27	0.41	1.3	1.2	A	
18	8	16	57.6	60	8.6	141	6.6	16.1	1.5	9	8	136	48	0.27	2.5	1.2	A	
18	9	17	52.0	60	38.0	142	47.1	2.6	1.1	5	3	138	51	0.29	3.0	25.0	D	
18	9	47	15.1	61	55.6	148	57.0	10.7	2.3	14	10	201	63	0.31	2.2	1.4	A	
18	17	51	56.4	60	15.4	141	2.7	10.7	1.0	6	4	190	47	0.26	7.0	10.3	D	
18	21	52	12.0	60	0.7	139	43.6	17.8	1.3	5	3	211	42	0.26	5.6	1.7	C	
19	8	19	12.0	59	56.6	141	53.2	1.0	1.2	8	6	217	47	0.35	2.6	3.9	B	
19	9	0	59.6	60	21.0	147	15.5	10.0	2.5	27	16	113	86	0.59	1.1	1.2	A	
19	13	53	26.8	60	37.0	147	34.7	13.6	2.4	24	16	144	64	0.63	1.5	1.0	A	

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN HR MN	TIME SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
DEC 19	19 55	15.3	61 17.3	146 54.3	20.2	2.3	26	16	76	45	0.42	0.9	1.9	A	
20	20 51	45.3	61 35.8	141 54.7	0.4	2.5	8	5	245	137	0.36	4.8	2.2	B	
20	22 26	1.6	60 32.8	141 26.5	8.9	2.0	10	5	169	56	0.30	1.8	2.7	B	
21	7 24	39.1	60 13.9	140 51.2	0.2	2.1	13	5	157	45	0.39	1.8	3.5	B	
21	13 37	2.3	59 54.2	140 9.0	1.9	1.7	6	4	201	79	0.21	4.8	4.8	B	
21	21 3	22.8	61 29.3	146 26.1	25.3	2.3	14	7	82	66	0.49	1.3	2.1	A	
21	22 19	40.3	60 36.0	143 16.5	0.1	2.2	9	7	80	70	0.47	1.6	2.8	B	
22	7 50	3.4	60 13.4	141 1.0	0.1	2.4	7	3	236	101	0.23	3.6	3.3	B	
22	13 21	57.8	59 30.4	139 32.1	15.2	3.2	7	1	269	77	0.14	17.9	12.1	D	
22	16 35	3.9	60 2.3	141 6.5	4.1	2.1	10	6	113	48	0.52	1.5	2.5	A	
22	17 18	0.9	60 46.4	143 13.4	15.0*	1.8	5	4	118	81	1.00	9.1	13.0	D	
22	19 10	41.0	61 41.5	149 35.7	27.2	2.8	16	7	183	66	0.34	2.0	3.6	B	
22	21 31	0.5	60 11.2	141 48.3	23.7	1.8	5	4	226	87	0.11	6.6	3.2	C	
22	22 0	17.3	61 20.4	148 51.2	23.7	2.4	17	8	71	39	0.48	1.2	1.3	A	
23	0 19	34.4	60 22.6	147 13.9	16.0	2.7	28	12	93	84	0.41	1.1	1.4	A	
23	2 54	11.9	61 34.0	146 35.3	20.1	2.6	21	12	100	64	0.37	1.0	2.2	A	
23	5 10	8.6	62 5.0	146 9.8	17.3	2.5	11	9	131	88	0.34	2.1	1.6	A	
23	6 7	42.3	61 57.6	148 53.9	7.4	2.2	11	6	173	65	0.35	1.8	1.8	A	
23	15 38	28.5	60 8.1	141 12.4	9.2	1.7	8	5	153	53	0.31	2.5	2.0	B	
23	20 22	49.3	60 8.8	139 55.0	4.5	2.2	11	5	196	67	0.36	4.8	2.7	B	
23	22 50	55.6	61 34.0	146 8.2	26.3	2.2	11	9	98	57	0.54	1.0	1.3	A	
24	0 59	7.7	60 14.3	141 15.1	6.4	2.0	9	6	143	57	0.33	1.6	1.7	A	
24	3 24	13.5	60 3.2	141 29.9	13.8	2.8	23	2	121	25	0.43	1.3	1.0	A	
24	6 48	1.6	59 53.8	141 3.5	3.5	1.3	3	4	190	117	0.18	10.1	12.9	D	
24	10 57	23.5	60 2.3	141 23.3	13.8	1.5	6	3	166	41	0.18	3.9	1.7	B	
24	21 47	21.2	60 30.1	142 59.5	6.8	1.4	4	2	170	69	0.11	3.2	7.6	C	
25	1 11	32.9	59 20.3	144 44.7	13.9	3.1	29	18	188	98	0.33	2.7	1.7	B	
25	3 7	48.6	60 9.4	141 13.9	14.3	1.3	9	7	129	37	0.40	1.8	1.1	A	
25	9 2	14.0	60 45.1	139 56.8	0.2	2.1	9	7	227	125	0.37	2.8	2.4	B	
25	20 53	4.0	60 1.8	141 23.6	19.8	1.3	5	4	181	42	0.17	3.6	1.9	B	
26	5 13	29.3	59 46.4	141 24.5	0.2	1.2	8	5	239	68	0.19	2.8	8.5	C	
26	6 54	22.8	62 5.6	141 4.1	2.7	3.3	16	8	248	207	1.06	20.7	19.8	D	
26	7 33	26.5	60 23.6	143 15.2	0.2	1.6	9	8	174	78	0.32	1.6	3.3	B	
26	7 36	30.5	60 25.6	143 11.5	2.3	1.9	12	9	147	78	0.34	1.6	2.8	B	
27	12 50	49.7	61 1.7	146 27.9	15.8	1.9	18	11	62	34	0.53	0.8	0.7	A	
27	15 9	50.9	60 19.7	153 27.7	182.7	5.1	21	1	80	64	0.24	2.6	6.7	C	FELT (IV) IN SEWARD-TALKEETNA AREA AND VALDEZ, FELT (III) ON KODIAK IS.
27	15 19	38.3	61 30.8	146 35.6	20.2	2.2	19	13	104	70	0.41	1.2	2.1	A	
28	4 38	25.5	60 8.8	139 54.2	0.3	1.3	6	5	222	87	0.23	6.3	5.8	C	
28	7 2	8.4	59 31.9	152 24.3	67.4	3.4	23	6	83	76	0.29	1.5	3.6	B	
28	19 42	54.1	59 38.8	146 15.0	4.9	2.8	24	14	110	111	0.32	1.6	1.5	A	
29	0 4	49.7	63 13.0	148 16.0	15.0*	3.1	18	13	270	186	0.53	15.4	14.9	D	
29	2 47	18.2	63 22.4	149 39.6	121.5	4.3	18	8	227	192	0.26	13.0	22.5	D	
29	6 53	7.9	59 27.9	144 43.6	16.9	3.4	32	9	177	92	0.32	2.9	1.8	B	
29	16 18	2.8	59 26.3	138 52.7	13.0	1.5	4	3	309	70	0.44	9.4	1.3	C	
29	17 12	44.8	60 43.1	142 45.4	6.1	1.4	7	6	106	68	0.38	1.0	2.7	B	

SOUTHERN ALASKA EARTHQUAKE CATALOG (CONTINUED)

1977	ORIGIN HR MN	TIME SEC	LAT N DEG MIN	LONG W DEG MIN	DEPTH KM	MAG	NP	NS	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q	REMARKS
DEC 29	18 28	38.3	60 7.5	141 29.0	0.7	1.2	7	4	175	68	0.18	1.4	3.5	B	
29	20 0	25.7	60 15.8	140 38.6	20.0	1.9	9	5	169	62	0.21	3.9	3.2	B	
29	21 48	18.5	61 39.7	146 26.1	20.8	3.6	31	5	96	59	0.53	0.9	1.7	A	FELT (III) AT VALDEZ AND (II) IN PALMER-WASILLA AREA
29	22 18	41.6	61 49.3	147 19.5	18.8	3.2	26	14	148	75	0.46	1.2	1.8	A	
29	23 29	15.5	60 36.8	143 16.3	42.3	1.1	4	3	137	69	0.09	5.6	14.9	D	
30	3 37	6.3	58 57.8	143 52.0	4.5	2.4	8	7	259	189	0.15	6.8	4.6	C	
30	3 37	6.4	58 51.2	144 0.1	20.8	2.5	8	7	263	203	0.13	25.0	25.0	D	
30	4 9	45.8	60 3.1	141 9.8	15.3	1.1	8	7	115	47	0.22	2.6	2.0	B	
30	5 37	34.9	59 45.4	141 13.8	8.6	1.4	3	3	232	155	0.20	4.3	4.8	B	
30	10 30	22.4	60 4.6	140 0.1	5.1	1.6	9	5	188	57	0.27	3.0	2.6	B	
30	19 12	2.1	60 14.2	141 33.7	11.5	1.2	3	3	214	174	0.21	5.2	4.5	C	
30	20 58	37.6	60 17.7	143 9.5	1.0	1.6	8	8	159	79	0.48	2.0	2.8	B	
31	3 3	10.6	59 57.5	139 37.7	13.6	0.6	4	4	210	38	0.34	3.9	2.6	B	
31	6 4	58.6	61 25.3	147 48.2	20.0	2.3	22	14	82	51	0.55	1.3	1.9	A	
31	10 37	27.5	60 13.3	141 28.5	14.0	1.2	9	7	129	26	0.19	2.4	1.2	A	
31	17 28	35.6	60 17.5	140 50.9	11.5	1.3	9	8	175	50	0.51	2.1	2.1	A	

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