United States Earthquakes, 1986

By Carl. W. Stover *and* Lindie R. Brewer

U.S. GEOLOGICAL SURVEY BULLETIN 2089

A summary of data for earthquakes in the 50 States and Puerto Rico during 1986. Descriptions of individual earthquakes include hypocenters, magnitudes, intensities, and damages. The report also contains results from regional networks and data recorded by strong-motion seismographs

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INTRODUCTION

This publication describes all earthquakes that were reported felt in the United States and nearby territories in 1986. Its purpose is to provide a continuous history of U.S. earthquakes to be used in estimating areal seismic risk, for designing earthquake-resistant structures, and for answering inquiries from scientists, engineers, and the public.

The U.S. Geological Survey's National Earthquake Information Center (USGS/NEIC) collects intensity information primarily by mailing questionnaires, "Earthquake Report" forms, to postmasters and other public institutions (police departments and (or) fire departments) in the earthquake area. Completed questionnaires are returned to the USGS, where they are evaluated and intensities are assigned. For damaging earthquakes, the questionnaires are supplemented by USGS field investigations. The USGS/ NEIC publishes preliminary maximum intensity data for U. S. earthquakes in the *Preliminary Determination of Epicenters, Monthly Listing (PDE)* (for example, Irby and others, 1982). The latest and most complete information is published with maps, diagrams, and photographs in *United States Earthquakes* (now published as a USGS Bulletin) issued annually since 1928. Copies of issues prior to 1982 can be obtained from Open-File Services, Earth Science Information Center, U.S. Geological Survey, Box 25286, Mail Stop 517 Federal Center, Denver, CO 80225.

This current bulletin is composed of four major sections: (1) "Earthquake Descriptions," which includes a summary of macroseismic data reported for each earthquake and a chronological list of earthquakes by State (table 1); (2) "Network Operations," which summarizes the results from local seismic networks; (3) "Miscellaneous Activities," which contains information on the principal earthquakes of the world (table 6); and (4) "Strong-Motion Seismograph Data" (table 7). The intensities and macroseismic data in "Earthquake Descriptions" are compiled from questionnaires returned to USGS/NEIC (see previous paragraph), newspaper articles, and reports prepared by other Federal government organizations, State institutions, local organizations, and individuals. Each description includes date, hypocenter, source of the hypocenter computation, magnitude, maximum intensity (Modified Mercalli), and (or) macroseismic effects reported from localities where the earthquake was felt.

Discussion of Tables

The earthquake parameters in tables 1 and 6 include date, origin time, hypocenter (epicenter and focal depth), and magnitude. Table 1 also lists the maximum observed Modified Mercalli (MM) intensity. The origin time and date are listed in Coordinated Universal Time (UTC). The epicenters are taken principally from those published in the USGS *Preliminary Determination of Epicenters, Monthly Listings*. These data have been updated and new data added from subsequent publications of universities or State agencies who operate seismic networks. The accuracy of the epicenters is that claimed by the institution supplying the hypocenter data and is not necessarily the accuracy indicated by the number of decimals listed. The epicenters located by the USGS/NEIC vary in degree of accuracy, but for most of the area of the United States the epicenters should be accurate to within two-tenths of a degree. See *Preliminary Determination of Epicenters, Monthly Listing*, for an explanation of the accuracy of USGS hypocenters. Depths are listed to the nearest kilometer.

Magnitudes listed in the tables 1 and 6 are either furnished by cooperating institutions or determined by the USGS. The computational sources are indicated by letter codes identified in headnotes to the tables.

Epicenter and Isoseismal Maps

Figures 1–3 are computer plots of all earthquake epicenters in the conterminous United States, Alaska, and Hawaii listed in table 1. Figures 4–5 show only those earthquakes whose computed magnitudes are 5.0 or larger.

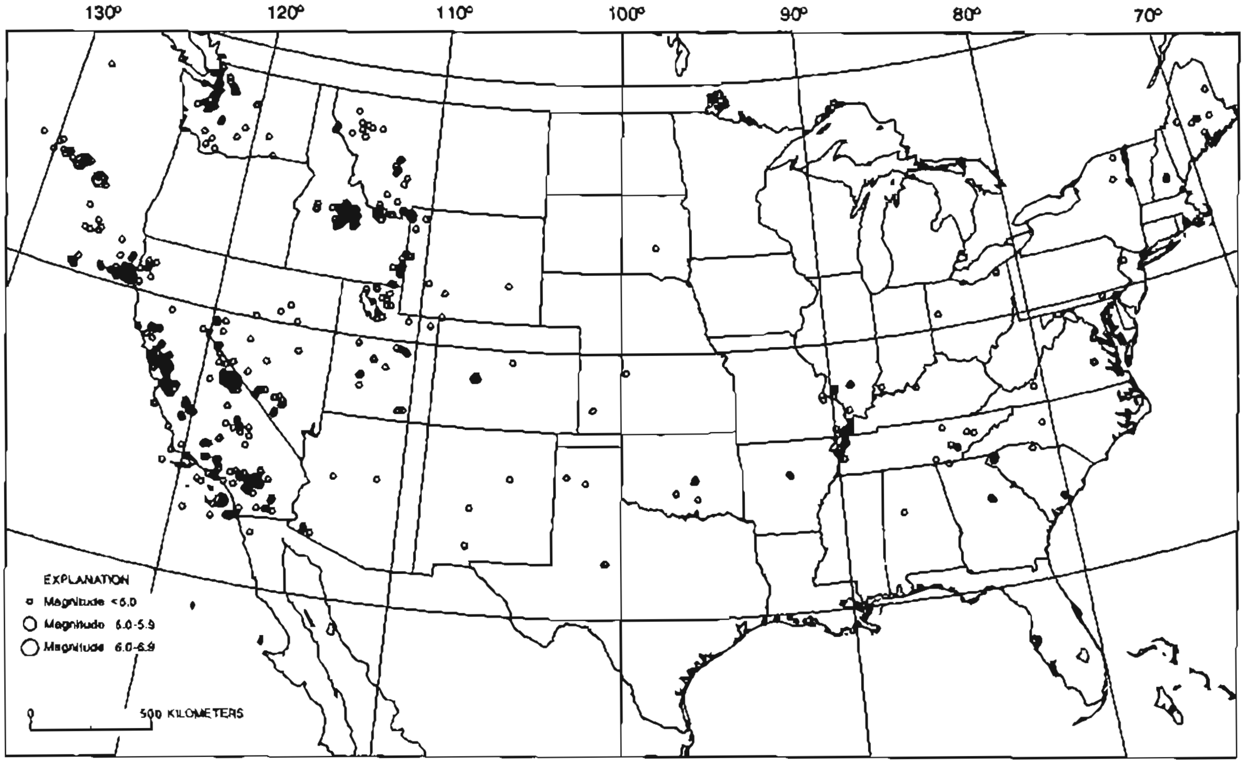

Figure 1. Earthquake epicenters in the conterminous United States for 1986 (from table 1).

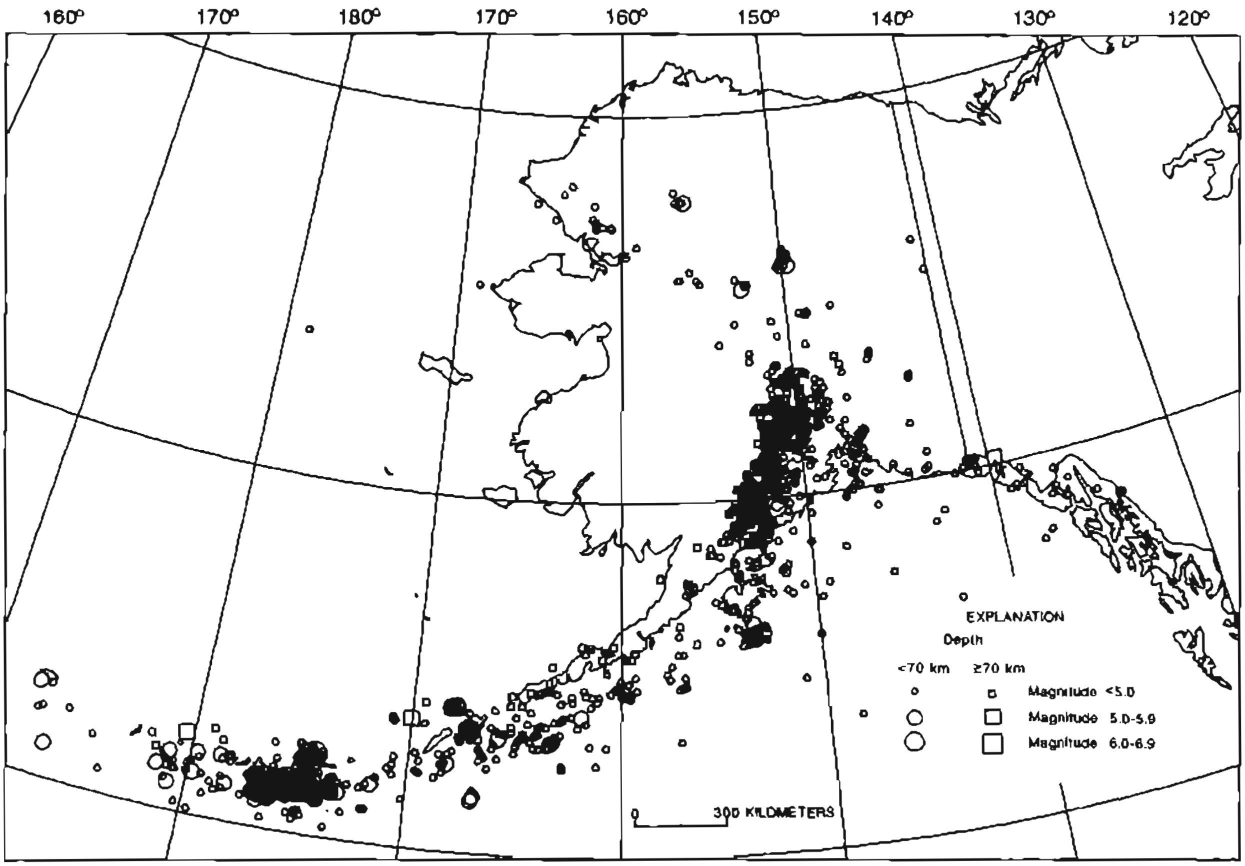

Figure 2. Earthquake epicenters in Alaska for 1986 (from table 1).

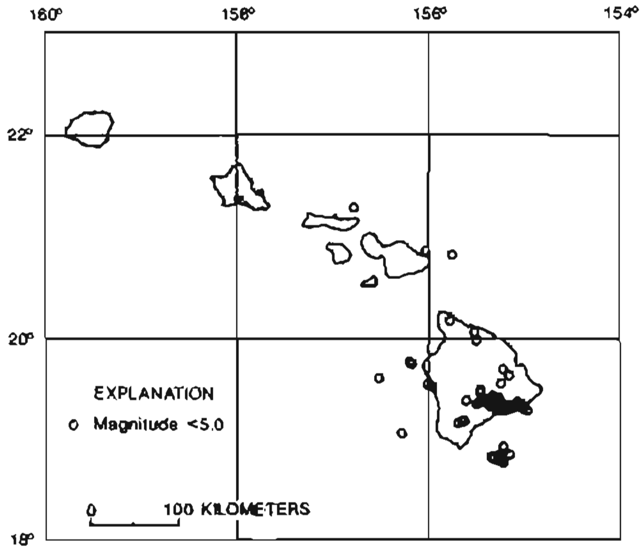

Figure 3. Earthquake epicenters in Hawaii for 1986 (from table 1).

Figures 6–8 are maps showing the maximum intensity of earthquakes in the conterminous United States, Alaska, and Hawaii.

The USGS/NEIC coordinates the collection of all types of earthquake information; the special objective is to correlate instrumentally determined earthquake locations with noninstrumental locations indicated by intensity data. This correlation is achieved through regional investigations of earthquakes by local organizations and the USGS. Primary data are gathered by a mail canvass of the epicentral area using questionnaire cards. A field survey is usually made for damaging earthquakes. When returned and analyzed, this information is used to prepare isoseismal maps that show the areal pattern of intensity associated with individual earthquakes.

The selection of earthquakes for isoseismal maps (shown in the "Earthquake Descriptions") is governed largely by the size of the area affected. As a result, sharp, localized shocks of intensity VI, which are common in California, may not be represented by maps; more widely felt earthquakes of intensity V and VI, which are characteristic of the Eastern and Central States, commonly are illustrated because of the larger felt areas. Isoseismal contours are a generalization of intensity data and are extrapolated in regions that have reported few observations. The isoseismals do not account for each intensity observation because they are drawn to show the general patterns at a level of intensity or range of intensities.

Magnitude and Intensity

Magnitude, a measure of the size of an earthquake, is related to the energy release at the focus of an earthquake. Although the magnitude scale has neither maximum nor minimum values, the highest magnitude ever calculated was greater than 9.0 and the lowest magnitude ever calculated was about −3.0. On this logarithmic scale, a magnitude-6.0 shallow-focus earthquake represents elastic-wave energy about 30 times greater than that generated by a magnitude 5.0 earthquake, 900 times greater than that of a magnitude 4.0 shock, and so forth. Many factors enter into the determination of earthquake magnitude, including earthquake focal depth, frequency content of the sampled energy, and the earthquake radiation pattern. Magnitude values calculated by the USGS are based on the following five formulas:

Surface-wave magnitude

$$M_S=\log(A/T)+1.66\log D+3.3, \qquad (1)$$

as adopted by the International Association of Seismology and Physics of the Earth's Interior (IASPEI; Bath, 1966, p. 153), where A is the maximum vertical surface-wave ground amplitude, in micrometers; T is the period, in seconds, and $18 \leq T \leq 22$; and D is the distance in geocentric degrees (station to epicenter), and $20° \leq D \leq 160°$. No depth correction is made for depth less than 50 km, and no M_S magnitudes are computed for depths greater than 50 km.

Body-wave magnitude

$$m_b=\log(A/T)+Q(D,h), \qquad (2)$$

as defined by Gutenberg and Richter (1956), except that T, the period in seconds, is restricted to $0.1 \geq T \geq 3.0$, and A, the ground amplitude in micrometers, is not necessarily the maximum of the P-wave group. Q is a function of distance D and depth h, where $D>5°$.

Local magnitude

$$M_L=\log A-\log A_o, \qquad (3)$$

as defined by Richter (1958, p. 340), where A is the maximum trace amplitude in millimeters, written by a Wood-Anderson torsion seismometer, and $\log A_o$ is a standard value that is a function of distance, where distance ≤600 km. Values of M_L are also calculated from other seismometers by conversion of recorded ground motion to the expected response of the torsion seismometer. M_L magnitudes are not listed for events with depths greater than 70 km.

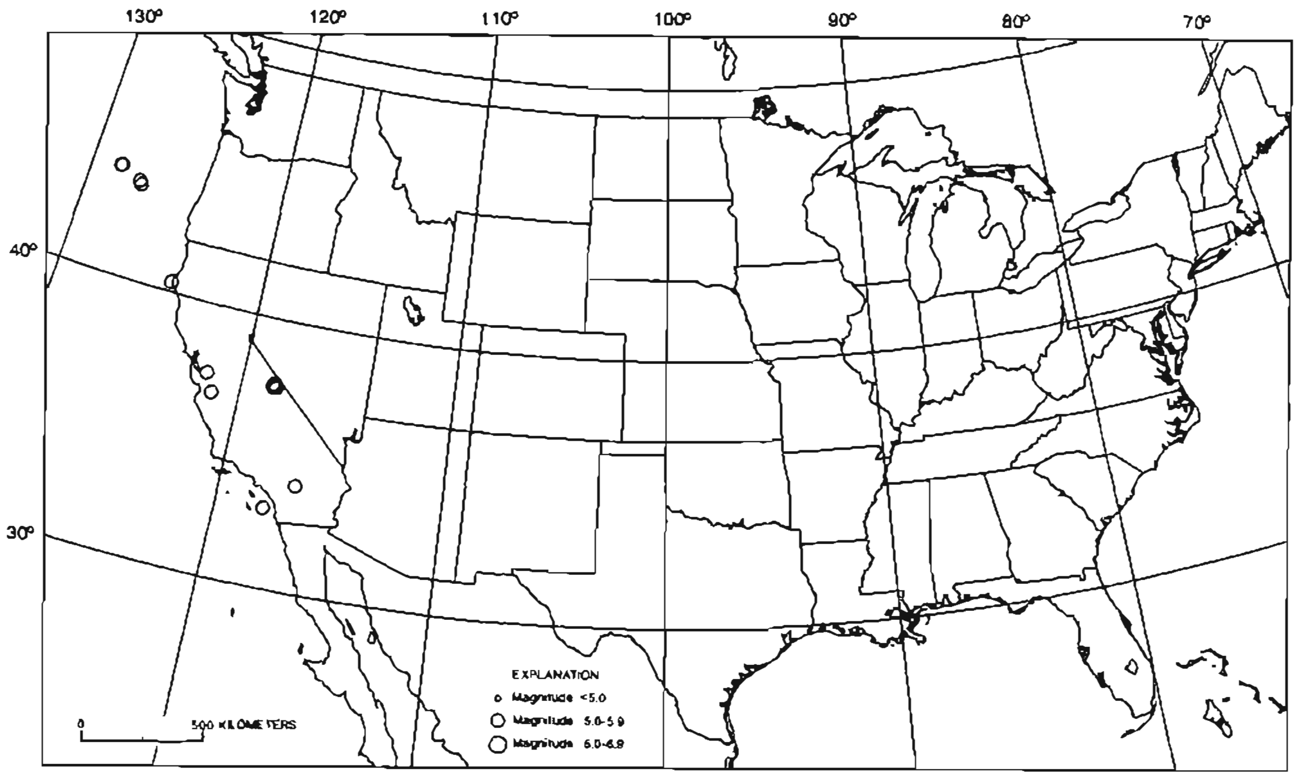

Figure 4. Epicenters in the conterminous United States for earthquakes with magnitudes greater than or equal to 5.0 in 1986.

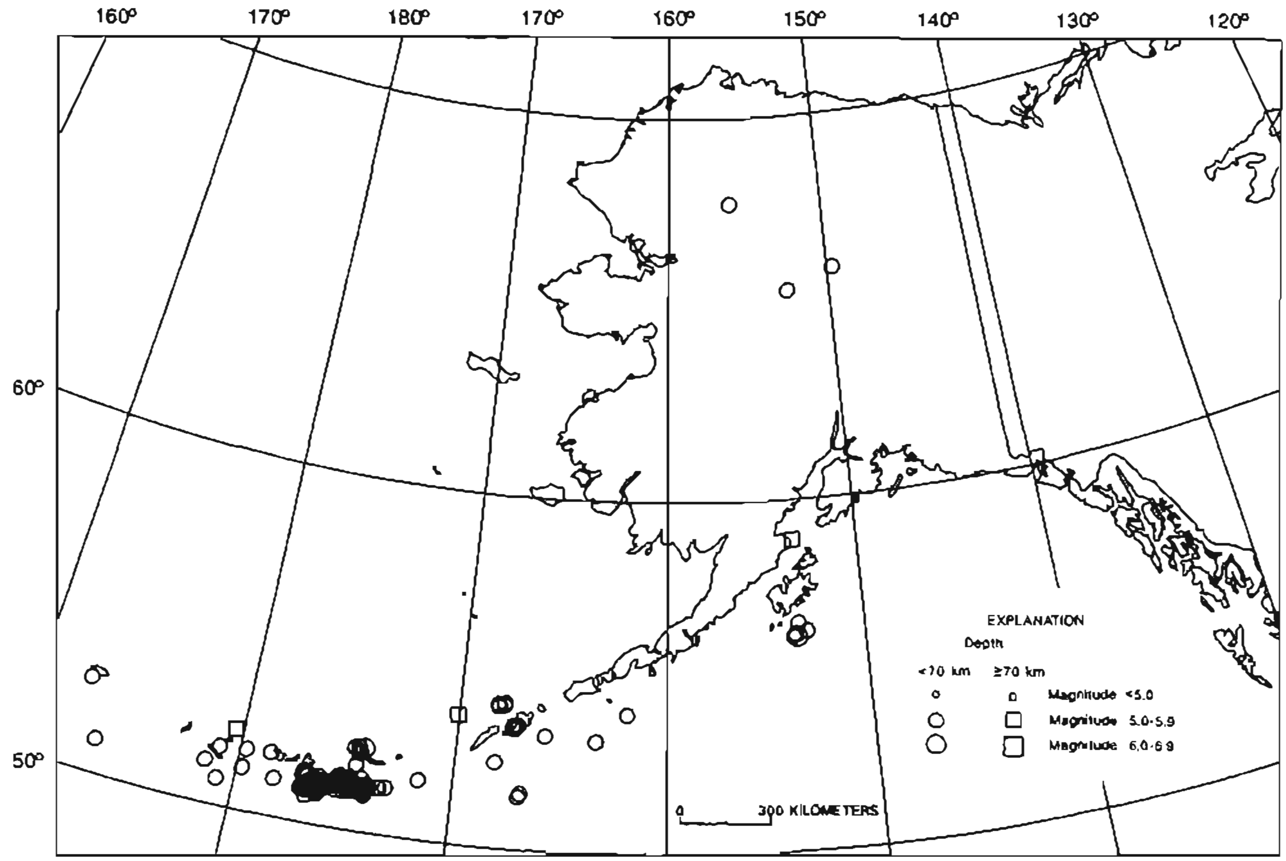

Figure 5. Epicenters in Alaska for earthquakes with magnitudes greater than or equal to 5.0 in 1986.

Local magnitude

$$M_n=3.75+0.90 (\log D)+\log (A/T) \quad 0.5^\circ \leq D \leq 4^\circ,$$
$$M_n=3.30+1.66 (\log D)+\log (A/T) \quad 4^\circ \leq D \leq 30^\circ \tag{4}$$

as proposed by Nuttli (1973) for North America east of the Rocky Mountains, where A/T is expressed in micrometers per second, calculated from the vertical-component 1-second Lg waves, and D is the distance in geocentric degrees.

Moment magnitude

$$M_W=2/3 \log M_0-10.7 \tag{5}$$

as defined by Hanks and Kanamori (1979), where M_0 is the seismic moment in dyne-centimeters.

Other types of magnitudes computed by other organizations or universities are also listed in this publication and are defined in the following two paragraphs.

M_D designates duration or coda-length magnitude. M_D is usually computed from the difference, in seconds, between P_n- or P_g-wave arrival time and the time the final coda amplitude decreases to the background-noise amplitude. Duration-magnitude scales are normally adjusted to agree with M_L or M_n estimates so that resulting magnitudes are compatible. Thus, the M_D formulas vary for different geographic regions and seismograph systems.

Some seismograph-network operators determine a magnitude formula for their specific network based on a comparison of their computed magnitudes with magnitudes published from other sources, such as from the USGS. These values are usually compared with m_b, M_L, or M_n magnitudes. In this bulletin these types of magnitudes are designated as m_x for body-wave magnitudes (m_b) and M_x for local magnitudes (M_L or M_n).

The seismic moment is tabulated for some earthquakes in the "Earthquake Descriptions" section. Moments contributed by the University of California, Berkeley, are computed according to the procedure described by Bolt and Herraiz (1983). Moments contributed by the U.S. Geological Survey, Golden, Colorado, are computed according to the procedure described by Sipkin (1982). Moments contributed by Harvard University are computed according to the procedure described by Dziewonski and others (1981).

Intensity, as applied to earthquakes, represents a quantity determined from the effects on people, manmade structures, and the Earth's surface (landslides, ground fissures, and such). Intensities are assigned according to the descriptions listed in the Modified Mercalli Intensity Scale of 1931 (Wood and Neumann, 1931). There are 12 discrete steps in the MM scale (see next section). An earthquake in a populated area will have different intensities at different localities, owing to the distance from the focus of the earthquake, type of focal mechanism, local geological conditions, structural design of buildings, and the earthquake magnitude.

The text of this bulletin gives the intensity at locations where an earthquake was reported felt and summaries of the strongest effects. Each earthquake is further characterized by its maximum intensity, which is given in the text and in table 1. The word "FELT" in the maximum intensity columns of table 1 indicates that only minimal or sketchy information was available. This designation does not imply that the earthquake was felt at a low-intensity level but indicates that the available data are not sufficient for assigning an intensity value.

Although the 1931 Modified Mercalli Intensity Scale is in many instances inadequate for present-day requirements, the scale has been the guide used by the USGS and will continue to be so until a new scale has been devised and has been accepted in the engineering and seismological communities.

Modified Mercalli Intensity Scale of 1931

Adapted from Sieberg's Mercalli-Cancani scale, modified and condensed.

I Not felt, or except rarely under especially favorable circumstances. Under certain conditions, at and outside the boundary of the area in which a great shock is felt: sometimes birds, animals, reported uneasy or disturbed; sometimes dizziness or nausea experienced; sometimes trees, structures, liquids, bodies of water, may sway—doors may swing very slowly.

II Felt indoors by few, especially on upper floors, or by sensitive, or nervous persons. Also, as in grade I, but often more noticeably: sometimes hanging objects may swing, especially when delicately suspended; sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly; sometimes birds, animals, reported uneasy or disturbed; sometimes dizziness or nausea experienced.

III Felt indoors by several, motion usually rapid vibration. Sometimes not recognized to be an earthquake at first. Duration estimated in some cases. Vibration like

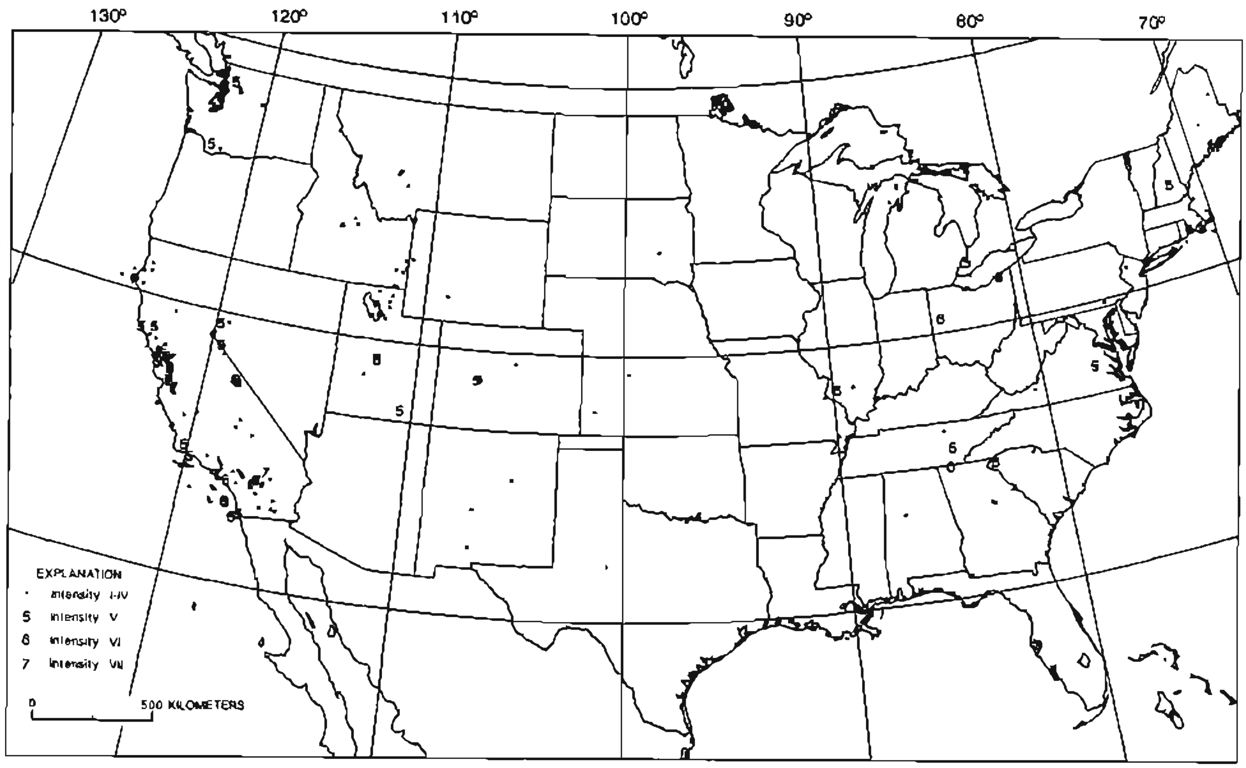

Figure 6. Earthquakes in the conterminous United States that were felt or caused damage in 1986. The maximum observed intensity for each earthquake is plotted at the epicenter.

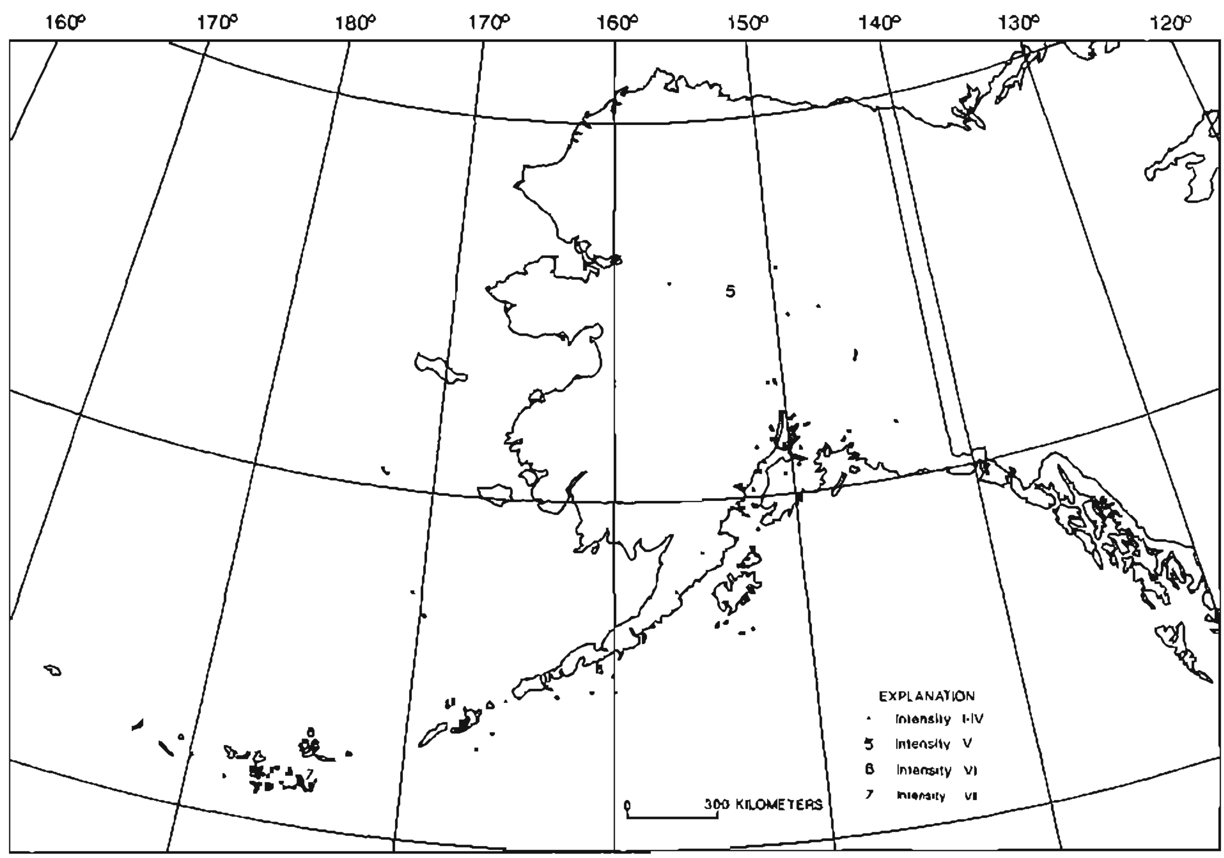

Figure 7. Earthquakes in Alaska that were felt or caused damage in 1986. The maximum observed intensity for each earthquake is plotted at the epicenter.

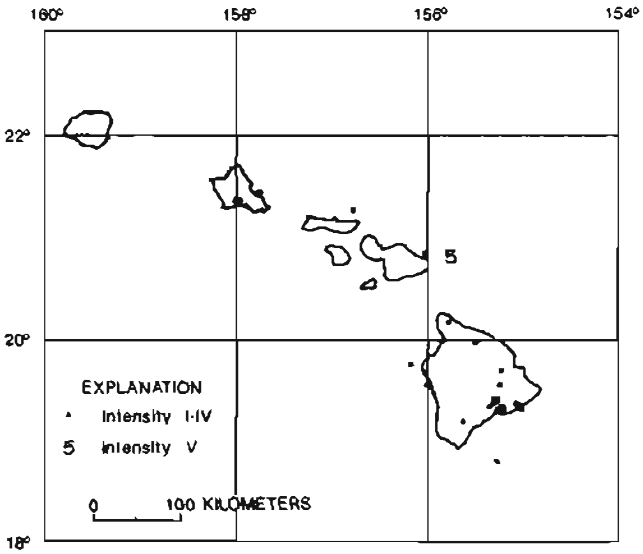

Figure 8. Earthquakes in Hawaii that were felt or caused damage in 1986. The maximum observed intensity for each earthquake is plotted at the epicenter.

that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away. Hanging objects may swing slightly. Movements may be appreciable on upper levels of tall structures. Rocked standing motor cars slightly.

IV Felt indoors by many, outdoors by few. Awakened few, especially light sleepers. Frightened no one, unless apprehensive from previous experience. Vibration like that due to passing of heavy or heavily loaded trucks. Sensation like heavy body striking building, or falling of heavy objects inside. Rattling of dishes, windows, doors; glassware and crockery clink and clash. Creaking of walls, frame, especially in the upper range of this grade. Hanging objects swung, in numerous instances. Disturbed liquids in open vessels slightly. Rocked standing motor cars noticeably.

V Felt indoors by practically all, outdoors by many or most: outdoors direction estimated. Awakened many, or most. Frightened few—slight excitement, a few ran outdoors. Buildings trembled throughout. Broke dishes, glassware, to some extent. Cracked windows—in some cases, but not generally. Overturned vases, small or unstable objects, in many instances, with occasional fall. Hanging objects, doors, swing generally or considerably. Knocked pictures against walls, or swung them out of place. Opened, or closed, doors, shutters, abruptly. Pendulum clocks stopped, started, or ran fast, or slow. Moved small objects, furnishings, the latter to slight extent. Spilled liquids in small amounts from well filled open containers. Trees, bushes, shaken slightly.

VI Felt by all, indoors and outdoors. Frightened many, excitement general, some alarm, many ran outdoors. Awakened all. Persons made to move unsteadily. Trees, bushes, shaken slightly to moderately. Liquid set in strong motion. Small bells rang—church, chapel, school, etc. Damage slight in poorly built buildings. Fall of plaster in small amount. Cracked plaster somewhat, especially fine cracks in chimneys in some instances. Broke dishes, glassware, in considerable quantity, also some windows. Fall of knickknacks, books, pictures. Overturned furniture in many instances. Moved furnishings of moderately heavy kind.

VII Frightened all. General alarm, all ran outdoors. Some, or many, found it difficult to stand. Noticed by persons driving motor cars. Trees and bushes shaken moderately to strongly. Waves on ponds, lakes, and running water. Water turbid from mud stirred up. Incaving to some extent of sand or gravel stream banks. Rang large church bells, etc. Suspended objects made to quiver. Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Cracked chimneys to considerable extent, walls to some extent. Fall of plaster in considerable to large amount, also some stucco. Broke numerous windows, furniture to some extent. Shook down loosened brickwork and tiles. Broke weak chimneys at the roofline (sometimes damaging roofs). Fall of cornices from towers and high buildings. Dislodged bricks and stones. Overturned heavy furniture, with damage from breaking. Damage considerable to concrete irrigation ditches.

VIII Fright general. Alarm approaches panic. Disturbed persons driving motor cars. Trees shaken strongly—branches, trunks, broken off, especially palm trees. Ejected sand and mud in small amounts. Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters. Damage slight in structures (brick) built especially to withstand earthquakes. Considerable in ordinary substantial buildings, partial collapse: racked, tumbled down, wooden houses in some cases; threw out panel walls in frame structures, broke off decayed piling. Fall of walls. Cracked, broke, solid stone walls seriously. Wet ground to some extent, also ground on steep slopes. Twisting, fall, of chimneys, columns, monuments, also factory stacks, towers. Moved conspicuously, overturned, very heavy furniture.

IX Panic general. Cracked ground conspicuously. Damage considerable in (masonry) structures built especially to withstand earthquakes: threw out of plumb some wood-frame houses built especially to withstand earthquakes; great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames; serious to reservoirs; underground pipes sometimes broken.

X Cracked ground, especially when loose and wet, up to widths of several inches; fissures up to a yard in width ran parallel to canal and stream banks. Landslides considerable from river banks and steep coasts. Shifted sand and mud horizontally on beaches and flat land. Changed level of water in wells. Threw water on banks of canals, lakes, rivers, etc. Damage serious to dams, dikes, embankments. Severe to well-built wooden structures and bridges, some destroyed. Developed dangerous cracks in excellent brick walls. Destroyed most masonry and frame structures, also their foundations. Bent railroad rails slightly. Tore apart, or crushed endwise, pipelines buried in earth. Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI Disturbances in ground many and widespread, varying with ground material. Broad fissures, earth slumps, and land slips in soft, wet ground. Ejected water in large amounts charged with sand and mud. Caused sea-waves ("tidal" waves) of significant magnitude. Damage severe to wood-frame structures, especially near shock centers. Great to dams, dikes, embankments often for long distances. Few, if any (masonry) structures remained standing. Destroyed large well-built bridges by the wrecking of supporting piers, or pillars. Affected yielding wooden bridges less. Bent railroad rails greatly, and thrust them endwise. Put pipelines buried in earth completely out of service.

XII Damage total—Practically all works of construction damaged greatly or destroyed. Disturbances in ground great and varied, numerous shearing cracks. Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive. Wrenched loose, tore off, large rock masses. Fault slips in firm rock, with notable horizontal and vertical offset displacements. Water channels, surface and underground, disturbed and modified greatly. Dammed lakes, produced waterfalls, deflected rivers, etc. Waves seen on ground surfaces (actually seen, probably, in some cases). Distorted lines of sight and level. Threw objects upward into the air.

COLLABORATORS

Active cooperation in earthquake investigations in the United States is provided by several seismological collaborators. The following served as collaborators to the USGS during 1986:

Alaska.—Staff of National Oceanic and Atmospheric Administration–Alaska Tsunami Warning Center, Palmer.

California (northern).—Robert A. Uhrhammer, University of California, Berkeley.

California (southern).—Clarence R. Allen and L.K. Hutton, California Institute of Technology, Pasadena.

Canada—Staff of Earth Physics Branch, Seismological Service of Canada, Ottawa.

Canada—Staff of Pacific Geoscience Centre, Sidney, British Columbia.

Connecticut.—Robert Miller, University of Connecticut, Groton.

Delaware.—Kenneth D. Woodruff, University of Delaware, Newark.

Florida and Georgia.—Leland T. Long, Georgia Institute of Technology, Atlanta.

Hawaii.—Robert Koyanagi, U.S. Geological Survey, Hawaiian Volcano Observatory, Hawaii National Park.

Indiana.—Chi-Kin Lam, Department of Geology, Indiana University, Bloomington.

Kansas.—Don W. Steeples, Kansas Geological Survey, Lawrence.

Kentucky.—Ronald L. Street, University of Kentucky, Lexington.

Missouri, Illinois, Arkansas area.—Robert B. Herrmann, Saint Louis University, Saint Louis.

Montana.—Michael C. Stickney, Montana Bureau of Mines and Geology, Butte.

Nevada.—Arturo Aburto, University of Nevada, Reno.

New England.—James P. McCaffrey, S.J., Boston College, Weston, Mass.

New Mexico—Allan R. Sanford, New Mexico Institute of Mining and Technology, Socorro.

New York.—Lynn R. Sykes and J.J. Taber, Lamont-Doherty Geological Observatory, Palisades, N.Y.

Oklahoma.—James E. Lawson, Jr., Oklahoma Geological Survey, Leonard.

Oregon.—Randy Jacobson, Oregon State University, Corvallis.

South Carolina.—Pradeep Talwani, University of South Carolina, Columbia, and Joyce Bagwell, Baptist College at Charleston, Charleston.

Tennessee.—Arch C. Johnston, Center for Earthquake Research and Information, Memphis State University, Memphis, Tenn.

Utah.—Ethan D. Brown, University of Utah, Salt Lake City.

Virginia.—G.A. Bollinger, Virginia Polytechnic Institute and State University, Blacksburg.

Washington.—Robert S. Crosson and Ruth S. Ludwin, University of Washington, Seattle.

Wyoming.—R.A. Hutchinson, National Park Service, Yellowstone National Park.

EARTHQUAKE DESCRIPTIONS

All United States and Puerto Rico earthquakes that were reported felt in 1986 are listed in this section alphabetically by State and chronologically within each State. The origin time of each earthquake is given in Coordinated Universal Time (UTC). Time is expressed continuously from midnight to midnight, or 0 to 24 hours.

Sources of noninstrumental information (macroseismic data) in this publication include questionnaire canvasses conducted by the USGS, newspaper articles, bulletins of the Seismological Society of America, and special earthquake reports of other organizations. Instrumental data are provided by the USGS/NEIC, other government agencies, and universities that operate seismic networks.

Roman numerals in the earthquake descriptions refer to the Modified Mercalli Intensity Scale of 1931. Where more than one degree of earthquake intensity is reported from a town, the town is assigned the highest intensity reported. All earthquake questionnaires or press reports that do not contain enough detail from which to assign an intensity are listed as "Felt."

The following codes indicate sources for hypocenters, magnitudes, intensities, and (or) felt data:

(AK) Geophysical Institute, University of Alaska, College.
(BK) University of California, Berkeley.
(BU) Montana Bureau of Mines and Geology, Butte.
(DE) Delaware Geological Survey, Newark.
(EE) Engdahl, E. R., Billington, S., and Kisslinger, C., 1989, Journal of Geophysical Research, v. 94, no. B11, p. 15,481–15,498.
(EN) Department of Energy, Washington, D.C.
(EP) Geophysics Division, Geological Survey of Canada, Ottawa, Ontario.
(GM) U.S. Geological Survey, Menlo Park, Calif.
(GP) U.S. Geological Survey, Pasadena, Calif.
(GS) U.S. Geological Survey, Golden, Colo.
(GT) Georgia Institute of Technology, Atlanta.
(HJ) Hauksson, Egill, and Jones, L.M., 1988, Seismological Society of America Bulletin, v. 78, no. 6, p. 1885–1906.
(HR) Harvard University, Cambridge, Mass.
(HV) Hawaiian Volcano Observatory, U.S. Geological Survey, Hawaii Volcanoes National Park.
(KS) Kansas Geological Survey, Lawrence.
(LD) Lamont-Doherty Geological Observatory, Palisades, N.Y.
(NI) Nicholson and others, 1988, Seismological Society of America Bulletin, v. 78, no. 1, p. 188–217.
(PG) Pacific Geoscience Centre, Sydney, B.C., Canada.
(PM) Alaska Palmer Observatory, National Oceanic and Atmospheric Administration, Palmer, Alaska.
(PS) California Institute of Technology, Pasadena.
(RN) University of Nevada, Reno.
(SC) University of South Carolina, Columbia.
(SL) St. Louis University, St. Louis, Mo.
(SZ) Schwartz, S.Y., and Christensen, D.H., 1988, Eastern Section, Seismological Society of America, Seismological Research Letters, v. 59, no. 2, p. 57–62.
(TC) Tennessee Earthquake Information Center, Memphis.
(TU) Oklahoma Geological Survey, Leonard.
(UU) University of Utah, Salt Lake City.
(VP) Virginia Polytechnic Institute and State University, Blacksburg.
(WA) University of Washington, Seattle.
(WO) Weston Observatory, Weston, Mass.

Depth: Normal. Depth was assumed to be 33 km.

ALASKA

14 January (GM) Southern Alaska
Origin time: 08 20 13.9
Epicenter: 60.222N., 152.294W.
Depth: 81 km
Magnitude: 3.7M_L(PM)
Intensity II: Homer (PM).

15 January (GM) Southern Alaska
Origin time: 04 29 53.2
Epicenter: 59.538N., 152.907W.
Depth: 91 km

Magnitude: $3.7M_L$(PM)
Intensity II: Homer (PM).

16 January (GM) Southern Alaska
Origin time: 14 36 36.1
Epicenter: 61.489N., 146.537W.
Depth: 28 km
Magnitude: $4.0M_L$(PM)
Intensity IV: Valdez.
Felt: Anchorage (press report), Cordova (press report), Palmer (press report).

18 January (GM) Southern Alaska
Origin time: 04 36 29.3
Epicenter: 61.542N., 150.996W.
Depth: 75 km
Magnitude: $3.0M_L$(PM)
Felt: Anchorage (PM).

19 January (GM) Southern Alaska
Origin time: 10 11 47.1
Epicenter: 59.729N., 152.308W.
Depth: 63 km
Magnitude: $4.2M_L$(PM)
Felt: Homer (PM).

26 January (GM) Southern Alaska
Origin time: 23 11 54.1
Epicenter: 61.869N., 148.738W.
Depth: 38 km
Magnitude: $4.1m_b$(GS), $3.6M_L$(PM)
Intensity II: Palmer (PM).

13 February (LD) Alaska Peninsula
Origin time: 08 43 09.3
Epicenter: 54.655N., 159.998W.
Depth: 5 km
Magnitude: $5.0m_b$(GS), $4.6M_S$(GS), $4.6M_L$(PM), $4.5m_x$(LD)
Intensity IV: Sand Point.
Intensity III: False Pass.
Intensity II: King Cove.

14 February (GS) Central Alaska
Origin time: 12 46 33.9
Epicenter: 63.069N., 150.835W.
Depth: 97 km
Magnitude: None computed
Felt: Talkeetna (PM).

14 February (GS) Central Alaska
Origin time: 19 01 29.5
Epicenter: 64.967N., 147.248W.
Depth: 10 km
Magnitude: $3.2M_L$(PM)
Felt: Fairbanks area (press report).

16 February (GM) Southern Alaska
Origin time: 21 31 06.1
Epicenter: 61.495N., 150.711W.
Depth: 63 km
Magnitude: $3.7M_L$(PM)
Felt: Anchorage (PM).

24 February (GS) Central Alaska
Origin time: 18 55 14.8
Epicenter: 63.075N., 150.383W.
Depth: 112 km
Magnitude: $4.6m_b$(GS)
Intensity II: Gold Creek (PM).

28 February (GS) Alaska Peninsula
Origin time: 15 12 24.1
Epicenter: 57.474N., 156.696W.
Depth: Normal
Magnitude: $4.1m_b$(GS), $4.1M_L$(PM)
Felt: King Salmon (PM).

28 February (GS) Southern Alaska
Origin time: 17 01 45.3
Epicenter: 60.345N., 152.966W.
Depth: 125 km
Magnitude: $4.7m_b$(GS)
Intensity III: Homer (PM).

2 March (EE) Andreanof Islands, Aleutian Islands
Origin time: 20 42 29.1
Epicenter: 51.373N., 176.714W.
Depth: 36 km
Magnitude: $5.1m_b$(GS), $4.4M_S$(GS), $5.2M_L$(PM)
Felt: Adak Island (PM).

8 March (GS) Southern Alaska
Origin time: 05 37 51.3
Epicenter: 60.673N., 151.843W.
Depth: 83 km
Magnitude: $4.3m_b$(GS)
Felt: Anchorage (PM), Kenai (PM).

8 March (GM) Southern Alaska
Origin time: 17 33 14.5
Epicenter: 61.038N., 146.566W.
Depth: 9 km
Magnitude: $4.0M_L$(PM)
Felt: Valdez (PM).

9 March (GS) Fox Islands, Aleutian Islands
Origin time: 13 49 28.2
Epicenter: 54.256N., 167.864W.
Depth: Normal
Magnitude: 5.2m_b(GS), 5.5M_S(GS), 5.5M_S(BK),
Moment: 4.5 x 10^{24} dyne-cm (HR)
Felt: Dutch Harbor (PM), Unalaska (PM).

12 March (GS) Central Alaska
Origin time: 02 48 03.9
Epicenter: 64.882N., 149.197W.
Depth: Normal
Magnitude: 3.7M_L(PM)
Intensity III: Nenana (press report), Fairbanks (press report).

18 March (GS) Fox Islands, Aleutian Islands
Origin time: 16 12 30.2
Epicenter: 54.028N., 168.070W.
Depth: Normal
Magnitude: 4.7m_b(GS), 4.5M_L(PM)
Intensity III: Unalaska (PM).

20 March (GS) Fox Islands, Aleutian Islands
Origin time: 19 40 08.8
Epicenter: 54.202N., 168.187W.
Depth: Normal
Magnitude: 4.8m_b(GS), 4.3M_S(GS), 5.0M_L(PM)
Felt: Unalaska (PM).

22 March (GM) Southern Alaska
Origin time: 05 30 01.9
Epicenter: 60.348N., 153.297W.
Depth: 165 km
Magnitude: 4.4m_b(GS)
Felt: Homer (PM).

22 March (GM) Southern Alaska
Origin time: 21 45 48.9
Epicenter: 61.217N., 150.382W.
Depth: 16 km
Magnitude: 3.5M_L(PM)
Felt: Anchorage (PM).

30 March (GS) Andreanof Islands, Aleutian Islands
Origin time: 18 13 29.3
Epicenter: 51.537N., 179.940W.
Depth: Normal
Magnitude: 4.8m_b(GS), 3.9M_L(PM)
Felt: Adak Island (PM).

1 April (GM) Southern Alaska
Origin time: 20 26 34.4
Epicenter: 61.558N., 149.984W.
Depth: 46 km
Magnitude: 3.6M_L(PM)
Intensity II: Butte (PM), Palmer (PM).

1 April (GM) Southern Alaska
Origin time: 23 46 51.4
Epicenter: 61.886N., 150.937W.
Depth: 72 km
Magnitude: 3.9m_b(GS), 4.0M_L(PM)
Intensity II: Anchorage (PM), Butte (PM), Palmer (PM).

3 April (GS) Southern Alaska
Origin time: 10 02 36.8
Epicenter: 61.449N., 150.039W.
Depth: 45 km
Magnitude: 3.0M_L(PM)
Felt: Anchorage (PM).

3 April (GS) Central Alaska
Origin time: 21 11 47.7
Epicenter: 63.634N., 145.435W.
Depth: Normal
Magnitude: 3.7M_L(PM)
Felt: Richardson Highway, Mile 221 Marker (PM).

3 April (GS) Central Alaska
Origin time: 21 14 49.4
Epicenter: 63.550N., 145.411W.
Depth: Normal
Magnitude: 2.8M_L(PM)
Felt: Richardson Highway, Mile 221 Marker (PM).

3 April (GS) Central Alaska
Origin time: 21 16 55.0
Epicenter: 63.444N., 145.564W.
Depth: Normal
Magnitude: 3.2M_L(PM)
Felt: Richardson Highway, Mile 221 Marker (PM).

7 April (GS) Fox Islands, Aleutian Islands
Origin time: 17 07 46.8
Epicenter: 54.058N., 167.343W.
Depth: Normal
Magnitude: 4.0m_b(GS), 4.4M_L(PM)
Intensity II: Unalaska (PM).

8 April (GS) Fox Islands, Aleutian Islands
Origin time: 06 36 48.0
Epicenter: 54.048N., 168.156W.
Depth: Normal
Magnitude: 4.4m_b(GS), 4.6M_L(PM)
Intensity III: Unalaska (PM).

11 April (GS) Fox Islands, Aleutian Islands
Origin time: 17 22 20.8
Epicenter: 54.164N., 167.883W.
Depth: Normal
Magnitude: 5.3m_b(GS), 5.9M_S(GS), 6.0M_S(BK)
Moment: 1.1 x 10^{25} (HR)
Intensity IV: Unalaska.

27 April (GM) Southern Alaska
Origin time: 10 55 41.2
Epicenter: 59.723N., 152.918W.
Depth: 96 km
Magnitude: 4.0m_b(GS), 4.0M_L(PM)
Felt: Homer (PM).

28 April (GM) Southern Alaska
Origin time: 07 32 56.1
Epicenter: 61.498N., 149.893W.
Depth: 59 km
Magnitude: 3.5M_L(PM)
Intensity III: Anchorage (PM).
Intensity II: Palmer (PM).

2 May (GM) Southern Alaska
Origin time: 00 51 57.7
Epicenter: 61.238N., 149.410W.
Depth: 35 km
Magnitude: 2.1M_L(PM)
Felt: Anchorage (PM).

3 May (GM) Southern Alaska
Origin time: 10 11 13.6
Epicenter: 61.426N., 149.859W.
Depth: 46 km
Magnitude: 3.2M_L(PM)
Felt: Anchorage (PM).

7 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 20 43 33.3
Epicenter: 51.234N., 174.741W.
Depth: 25 km
Magnitude: 6.1m_b(GS), 6.0M_S(GS), 6.1M_L(PM), 6.1M_S(BK)
Moment: 2.7 x 10^{25} dyne-cm (HR)
Felt: Adak Island.

7 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 22 47 12.3
Epicenter: 51.325N., 174.751W.
Depth: 31 km
Magnitude: 6.4m_b(GS), 7.7M_S(GS), 7.9M_S(BK)
Moment: 1.0 x 10^{28} dyne-cm (HR)

ALASKA—Continued

This earthquake is the largest to occur in Alaska since the February 4, 1965, Rat Islands earthquake. It caused moderate damage to structures on Adak Island and minor damage on Atka Island. The building damage consisted of cracked masonry and concrete walls, failure of partitions and suspended ceilings, spalling on concrete beams and concrete piers, and failure of piping (Glick and others, 1986).

Some houses experienced differential foundation settlements of several cm, causing considerable damage to the structures (Glick and others, 1986).

Sand boils were noted in one localized area where an antenna array was located. One antenna foundation settled about 3 ft, and others were out of plumb. Soil liquefaction was noted in localized areas of back-filled soil. Lateral spreading cracks of about 8 to 20 cm and differential ground settlement occurred along a small wharf. Some slumping was observed on a side slope of the approach to a bridge. Rock falls occurred at two quarry sites, and snow avalanches were observed in steep mountain regions (Glick and others, 1986).

Horizontal peak ground accelerations between 0.20 *g* and 0.25 *g* were recorded on the foundation slab near the AIMO hanger, and horizontal accelerations greater than 0.60 *g* were recorded at the bottom chord of a steel roof truss in the same area (Glick and others, 1986).

This earthquake also caused a tsunami that was recorded throughout the Pacific Ocean. In Alaska, Adak Island stations recorded wave heights of 175 cm, Unalaska 20 cm, and Sand Point 10 cm. In Hawaii the heights ranged from 91 to 122 cm at Kapaa, Kauai, to 8 cm at Kailua-Kona, Hawaii. Wave heights were also measured in Japan, along the west coast of South America, and on many islands of the southern Pacific Ocean.

Intensity VII:
Adak Island–The AIMO hanger (two-story shop area) had many vertical and diagonal cracks in the masonry walls and in the stairwell area. The Navy Exchange (a precast-concrete structure) had permanent vertical offset, loose bolts, and bent connectors between adjacent precast roof panels. One concrete pier spalled and cracked near an expansion joint. Wood-frame housing units sustained minor interior wall cracking and differential settlement of as much as 13 cm. File cabinets were overturned; windows were cracked; power was disrupted; and many items were displaced and overturned (Glick and others, 1986).

Intensity VI:

Atka Island– Some parts of the airstrip "dropped" 30 cm, and there were cracks in the strip. Landslides and slumping of road fill occurred. Standing and moving vehicles rocked moderately; plaster walls sustained hairline cracks; much merchandise was thrown off store shelves; small appliances overturned; a few windows cracked; many glassware items or dishes broke; many small objects overturned and fell; hanging pictures fell; buildings shook strongly; people had difficulty standing or walking; felt by and frightened everyone.

9 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 01 05 31.2
Epicenter: 51.061N., 176.902W.
Depth: 23 km
Magnitude: 5.5m_b(GS), 5.6M_S(GS), 5.4M_L(PM), 5.7M_S(PS)
Intensity III: Adak (PM).

9 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 01 08 10.5
Epicenter: 51.062N., 176.856W.
Depth: 18 km
Magnitude: 5.6m_b(GS), 5.5M_S(GS), 5.5M_L(PM)
Intensity IV: Adak Island.

9 May (GS) Fox Islands, Aleutian Islands
Origin time: 18 22 49.8
Epicenter: 54.324N., 165.372W.
Depth: 101 km
Magnitude: 4.6m_b(GS)
Felt: Cold Bay (PM), Sand Point (PM).

11 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 10 46 21.8
Epicenter: 50.970N., 176.095W.
Depth: 16 km
Magnitude: 5.0m_b(GS), 4.7M_S(GS), 4.9M_L(PM)
Moment: 1.0 x 10^{24} dyne-cm (HR)
Intensity II: Adak Island (PM).

11 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 22 48 47.2
Epicenter: 51.371N., 174.616W.
Depth: 29 km
Magnitude: 5.5m_b(GS), 5.2M_S(GS), 5.7M_L(PM), 5.2M_S(BK)
Moment: 3.6 x 10^{24} dyne-cm (HR)
Intensity IV: Adak Island (PM).

ALASKA—Continued

12 May (GS) Andreanof Islands, Aleutian Islands
Origin time: 20 16 45.8
Epicenter: 52.700N., 172.432E.
Depth: Normal
Magnitude: 4.9m_b(GS), 5.1M_S(GS)
Intensity III: Attu Island (PM).

15 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 06 38 37.9
Epicenter: 52.432N., 174.719W.
Depth: 15 km
Magnitude: 5.7m_b(GS), 6.4M_S(GS), 5.5M_L(PM), 6.4M_S(BK)
Moment: 4.4 x 10^{25} dyne-cm (HR)
Intensity VI:

Atka Island–Underground pipes broke; there was slight damage to bridges; standing and moving vehicles rocked moderately; interior walls sustained hairline cracks; many items were shaken off store shelves; furniture was overturned; many glassware items or dishes broke; many small objects overturned and fell; hanging pictures fell; a few windows cracked; buildings shook strongly; people had difficulty standing and walking; felt by everyone.

Intensity II: False Pass (PM).
Felt: Adak Island.

15 May (LD) Alaska Peninsula
Origin time: 23 21 13.2
Epicenter: 54.693N., 163.089W.
Depth: 3 km
Magnitude: 4.5m_b(GS), 4.4m_x(LD)
Felt: Cold Bay (PM), False Pass (PM), Sand Point (PM).

17 May (GM) Southern Alaska
Origin time: 06 31 14.2
Epicenter: 62.038N., 149.730W.
Depth: 51 km
Magnitude: 2.6M_L(PM)
Felt: Anchorage (PM).

17 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 16 20 24.3
Epicenter: 52.443N., 174.271W.
Depth: 15 km
Magnitude: 5.8m_b(GS), 6.6M_S(GS), 6.5M_S(BK)
Moment: 4.7 x 10^{25} dyne-cm (GS)
Intensity VI:

Atka Island–Airstrip damaged and officially closed. Underground pipes broke; landslides occurred; standing vehicles rocked moderately; trees and bushes shook strongly; plaster walls cracked; furniture overturned; many items were shaken off store shelves; many glassware items or dishes broke;

many small objects overturned and fell; a few windows cracked; hanging pictures fell; buildings shook strongly; people had difficulty standing or walking; felt by and frightened everyone.
Felt: Adak Island.

19 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 02 37 34.7
Epicenter: 52.359N., 174.955W.
Depth: 15 km
Magnitude: 5.1m_b(GS), 5.2M_S(GS), 4.9M_L(PM), 5.0M_S(BK)
Moment: 1.3 x 10^{24} dyne-cm (HR)
Intensity II: Adak Island (PM), Atka Island (PM).

21 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 07 05 15.7
Epicenter: 51.351N., 176.214W.
Depth: 33 km
Magnitude: 4.6m_b(GS), 4.4M_L(PM)
Intensity III: Adak Island (PM).

21 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 22 12 20.9
Epicenter: 51.647N., 175.325W.
Depth: 46 km
Magnitude: 4.8m_b(GS), 4.6M_L(PM)
Intensity II: Adak Island (PM).

23 May (GS) Southern Alaska
Origin time: 23 18 42.2
Epicenter: 58.906N., 153.377W.
Depth: 80 km
Magnitude: 5.0m_b(GS),
Moment: 5.5 x 10^{23} dyne-cm (HR)
Intensity III: Homer (PM), Kodiak (PM).
Felt: Chiniak (press report).

29 May (GS) Southern Alaska
Origin time: 02 40 11.2
Epicenter: 59.119N., 152.163W.
Depth: 61 km
Magnitude: 4.5m_b(GS), 4.2M_L(PM)
Felt: Homer (PM), Seldovia (PM).

29 May (EE) Andreanof Islands, Aleutian Islands
Origin time: 19 18 46.3
Epicenter: 51.464N., 175.289W.
Depth: 35 km
Magnitude: 4.9m_b(GS), 4.7M_L(PM)
Felt: Adak Island (PM), Atka Island (PM).

3 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 23 05 28.8
Epicenter: 51.256N., 174.631W.
Depth: 20 km
Magnitude: 5.4m_b(GS), 5.1M_S(GS), 5.8M_L(PM), 5.1M_S(BK)
Intensity II: Adak Island (PM).

4 June (GS) Central Alaska
Origin time: 15 48 20.8
Epicenter: 65.636N., 152.604W.
Depth: 10 km
Magnitude: 5.2m_b(GS), 4.7M_S(GS), 5.7M_L(PM)
Intensity V:
Tanana– A few items were shaken off store shelves; a few small objects overturned and fell; standing and moving vehicles rocked slightly; buildings shook moderately, felt by and frightened many.
Intensity IV: Galena Air Force Station, Hughes, Huslia, Indian Mountain Air Force Station, Lake Minchumina, Manley Hot Springs, Rampart.
Intensity III: Bettles, College, Fairbanks, Livingood (5 mi west), Minto, Ruby, Shungnak.
Felt: North Pole (press report).

4 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 19 25 43.3
Epicenter: 51.287N., 174.580W.
Depth: 20 km
Magnitude: 4.9m_b(GS), 4.0M_L(PM)
Intensity II: Adak Island (PM).

5 June (GS) Andreanof Islands, Aleutian Islands
Origin time: 14 22 04.7
Epicenter: 51.093N., 174.341W.
Depth: Normal
Magnitude: 4.5m_b(GS), 4.1M_L(PM)
Felt: Adak Island (PM).

5 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 15 24 53.7
Epicenter: 51.138N., 174.177W.
Depth: 20 km
Magnitude: 4.7m_b(GS), 4.2M_L(PM)
Felt: Adak Island (PM).

5 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 17 32 40.6
Epicenter: 51.094N., 175.350W.
Depth: 20 km
Magnitude: 5.1m_b(GS), 4.5M_L(PM)
Felt: Adak Island (PM).

5 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 20 27 03.2
Epicenter: 51.296N., 174.210W.

Depth: 22 km
Magnitude: 5.4m_b(GS), 4.8M_S(GS), 4.5M_L(PM), 4.8M_S(BK)
Moment: 1.0 x 10^{24} dyne-cm (HR)
Felt: Adak Island (PM).

15 June (GS) Andreanof Islands, Aleutian Islands
Origin time: 02 22 52.9
Epicenter: 51.396N., 174.760W.
Depth: Normal
Magnitude: 4.3m_b(GS), 4.3M_L(PM)
Intensity III: Adak Island (PM).

16 June (GM) Southern Alaska
Origin time: 21 54 02.0
Epicenter: 61.838N., 149.433W.
Depth: 43 km
Magnitude: 3.8M_L(PM)
Intensity III: Hatcher Pass (PM).
Intensity II: Willow (PM).

18 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 08 05 16.4
Epicenter: 51.465N., 176.833W.
Depth: 41 km
Magnitude: 5.8m_b(GS), 6.3M_S(GS), 6.0M_L(PM), 6.4M_S(BK)
Moment: 5.8 x 10^{25} dyne-cm (HR)
Intensity IV: Adak Island (PM).
Intensity III: Atka (PM).

18 June (GS) Central Alaska
Origin time: 23 43 04.4
Epicenter: 63.067N., 150.911W.
Depth: 131 km
Magnitude: None computed
Felt: Talkeetna (PM).

19 June (GS) Southern Alaska
Origin time: 09 09 09.2
Epicenter: 56.331N., 152.914W.
Depth: 17 km
Magnitude: 6.0m_b(GS), 6.3M_S(GS), 5.4M_L(PM), 6.4M_S(BK)
Moment: 1.6 x 10^{26} dyne-cm (HR)
Intensity IV: Kodiak.

19 June (LD) Alaska Peninsula
Origin time: 22 28 38.8
Epicenter: 54.644N., 161.096W.
Depth: 15 km
Magnitude: 4.3m_b(GS), 3.4m_x(LD)
Felt: False Pass (PM), King Cove (PM).

ALASKA—Continued

20 June (GM) Southern Alaska
Origin time: 07 39 32.8
Epicenter: 60.676N., 152.107W.
Depth: 82 km
Magnitude: 4.0M_L(PM)
Felt: Anchorage (PM), Homer (PM), Kenai (PM).

20 June (GM) Southern Alaska
Origin time: 22 13 49.6
Epicenter: 62.248N., 150.234W.
Depth: 10 km
Magnitude: 3.8M_L(PM)
Felt: Talkeetna (PM).

21 June (GS) Southern Alaska
Origin time: 12 07 30.2
Epicenter: 59.947N., 152.851W.
Depth: 101 km
Magnitude: 4.9m_b(GS)
Felt: Anchorage (PM), Eagle River (PM), Homer (PM), Kenai (PM).

22 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 05 28 52.4
Epicenter: 51.108N., 175.170W.
Depth: 16 km
Magnitude: 4.9m_b(GS), 4.9M_S(GS), 4.3M_L(PM)
Moment: 1.3 x 10^{24} dyne-cm (HR)
Felt: Adak Island (PM).

23 June (GM) Southern Alaska
Origin time: 02 47 41.6
Epicenter: 61.740N., 149.765W.
Depth: 47 km
Magnitude: 3.1M_L(PM)
Felt: Anchorage (PM), Eagle River (PM).

24 June (GM) Southern Alaska
Origin time: 09 35 23.4
Epicenter: 58.529N., 155.219W.
Depth: 140 km
Magnitude: None computed.
Felt: King Salmon Air Force Base (PM).

24 June (GS) Western Alaska
Origin time: 13 38 25.6
Epicenter: 65.905N., 156.564W.
Depth: Normal
Magnitude: 3.6M_L(PM)
Felt: Kobuk (PM).

24 June (GS) Central Alaska
Origin time: 20 46 02.7
Epicenter: 66.133N., 149.639W.
Depth: 10 km
Magnitude: 4.9m_b(GS), 5.2M_L(PM), 5.9M_S(BK)
Intensity III: Fairbanks, Stevens Village.
Felt: Alyeska PLS Pump Station No. 6 (PM).

26 June (GM) Southern Alaska
Origin time: 13 55 43.6
Epicenter: 59.730N., 152.182W.
Depth: 23 km
Magnitude: 3.6M_L(PM)
Felt: Anchor Point (PM), Homer (PM).

26 June (GM) Southern Alaska
Origin time: 16 34 19.0
Epicenter: 62.228N., 150.180W.
Depth: 12 km
Magnitude: 3.3M_L(PM)
Felt: Talkeetna (PM).

28 June (LD) Alaska Peninsula
Origin time: 16 01 19.7
Epicenter: 55.116N., 160.029W.
Depth: 52 km
Magnitude: 4.3m_b(GS), 4.4m_x(LD), 4.3M_L(PM)
Felt: Sand Point (PM).

29 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 04 30 04.0
Epicenter: 52.539N., 174.792W.
Depth: 15 km
Magnitude: 4.9m_b(GS), 5.2M_S(GS), 4.6M_L(PM), 5.3M_S(BK)
Moment: 1.5 x 10^{24} dyne-cm (HR)
Felt: Adak Island (PM), Atka Island (PM).

29 June (GS) Andreanof Islands, Aleutian Islands
Origin time: 04 32 10.8
Epicenter: 52.255N., 174.836W.
Depth: Normal
Magnitude: 4.7m_b(GS), 4.3M_L(PM)
Felt: Adak Island (PM), Atka Island (PM).

30 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 01 21 30.0
Epicenter: 51.414N., 176.655W.
Depth: 39 km
Magnitude: 4.8m_b(GS), 4.1M_S(GS), 4.5M_L(PM)
Intensity III: Adak Island (PM).

ALASKA—Continued

30 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 04 39 08.8
Epicenter: 51.338N., 176.643W.
Depth: 33 km
Magnitude: 4.5m_b(GS)
Intensity II: Adak Island (PM).

30 June (EE) Andreanof Islands, Aleutian Islands
Origin time: 06 23 47.1
Epicenter: 51.089N., 176.139W.
Depth: 21 km
Magnitude: 5.1m_b(GS), 4.7M_S(GS), 4.9M_L(PM)
Moment: 1.3 x 10^{24} dyne-cm (HR)
Intensity III: Adak Island (PM).

30 June (GS) Andreanof Islands, Aleutian Islands
Origin time: 06 28 01.9
Epicenter: 51.543N., 176.596W.
Depth: Normal
Magnitude: 4.2m_b(GS), 4.3M_L(PM)
Intensity II: Adak Island (PM).

30 June (GS) Andreanof Islands, Aleutian Islands
Origin time: 06 55 09.4
Epicenter: 51.117N., 176.124W.
Depth: Normal
Magnitude: 4.2m_b(GS), 4.7M_L(PM)
Intensity II: Adak Island (PM).

1 July (GM) Southern Alaska
Origin time: 19 26 42.6
Epicenter: 61.597N., 149.704W.
Depth: 43 km
Magnitude: 3.7M_L(PM)
Intensity III: Anchorage (PM), Eagle River (PM).
Intensity II: Palmer (PM).

3 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 17 33 31.8
Epicenter: 51.204N., 175.589W.
Depth: 20 km
Magnitude: 5.0m_b(GS), 4.8M_L(PM)
Felt: Adak Island (PM), Atka Island (PM).

4 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 05 58 51.9
Epicenter: 51.602N., 175.827W.
Depth: 42 km
Magnitude: 4.9m_b(GS), 4.7M_L(PM)
Felt: Adak Island (PM).

9 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 17 10 24.6

Epicenter: 51.545N., 176.083W.
Depth: 42 km
Magnitude: 5.2m_b(GS), 4.9M_S(GS), 4.9M_L(PM), 4.9M_S(BK)
Moment: 2.1 x 10^{24} dyne-cm (HR)
Intensity IV: Adak Island (PM), Atka Island (PM).

9 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 20 24 52.7
Epicenter: 51.433N., 176.815W.
Depth: 41 km
Magnitude: 4.9m_b(GS), 5.1M_L(PM)
Moment: 3.7 x 10^{23} dyne-cm (HR)
Felt: Adak Island (PM), Atka Island (PM).

13 July (GM) Southern Alaska
Origin time: 03 54 40.5
Epicenter: 62.254N., 150.228W.
Depth: 11 km
Magnitude: 3.9M_L(PM)
Felt: Big Lake (PM), Palmer (PM), Talkeetna (PM).

13 July (GS) Southern Alaska
Origin time: 03 58 02.5
Epicenter: 62.216N., 150.286W.
Depth: 10 km
Magnitude: 3.0M_L(PM)
Felt: Talkeetna (PM).

17 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 18 37 20.0
Epicenter: 51.180N., 174.494W.
Depth: 20 km
Magnitude: 4.8m_b(GS)
Felt: Adak Island (PM).

19 July (GS) Fox Islands, Aleutian Islands
Origin time: 04 31 55.9
Epicenter: 53.352N., 165.882W.
Depth: Normal
Magnitude: 5.5m_b(GS), 5.1M_S(GS), 5.9M_L(PM), 4.9M_S(BK)
Moment: 2.8 x 10^{24} dyne-cm (HR)
Intensity IV: Akutan (press report), Unalaska (press report).

19 July (GS) Fox Islands, Aleutian Islands
Origin time: 05 04 08.2
Epicenter: 53.339N., 165.859W.
Depth: Normal
Magnitude: 5.1m_b(GS), 4.5M_S(GS), 5.6M_L(PM)
Moment: 6.9 x 10^{23} dyne-cm (HR)
Intensity IV: Unalaska (press report).

ALASKA—Continued

19 July (GS) Fox Islands, Aleutian Islands
Origin time: 06 53 17.8
Epicenter: 53.600N., 167.171W.
Depth: Normal
Magnitude: 5.5m_b(GS), 5.7M_S(GS), 5.8M_L(PM), 5.6M_S(BK),
Moment: 1.0 x 10^{25} dyne-cm (HR)
Intensity IV: Unalaska (press report).
Felt: Akutan (PM).

19 July (GS) Fox Islands, Aleutian Islands
Origin time: 11 31 07.5
Epicenter: 53.617N., 167.408W.
Depth: Normal
Magnitude: 5.0m_b(GS), 4.6M_S(GS), 5.1M_L(PM)
Felt: Akutan (PM), Unalaska (PM).

19 July (GS) Fox Islands, Aleutian Islands
Origin time: 20 52 09.6
Epicenter: 53.662N., 167.184W.
Depth: Normal
Magnitude: 4.9m_b(GS)
Intensity III: Unalaska.

19 July (GS) Fox Islands, Aleutian Islands
Origin time: 22 32 36.0
Epicenter: 53.521N., 167.301W.
Depth: Normal
Magnitude: 5.6m_b(GS), 5.6M_S(GS), 5.6M_S(BK)
Moment: 1.1 x 10^{25} dyne-cm (HR)
Intensity V:
Akutan–Objects were knocked off walls and shelves; cars shook noticeably (press report).
Unalaska– Things were knocked off walls and shelves; cars shook noticeably; runway lights were knocked out at the Dutch Harbor-Unalaska airport (press report).

20 July (GS) Fox Islands, Aleutian Islands
Origin time: 01 59 08.2
Epicenter: 53.530N., 167.344W.
Depth: Normal
Magnitude: 4.9m_b(GS), 4.5M_S(GS), 5.2M_L(PM)
Moment: 5.8 x 10^{23} dyne-cm (HR)
Felt: Unalaska (PM), Cold Bay.

24 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 00 42 00.8
Epicenter: 51.012N., 176.639W.
Depth: 20 km
Magnitude: 4.9m_b(GS), 4.5M_S(GS), 5.3M_L(PM)
Felt: Adak Island (PM), Atka Island (PM).

24 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 14 03 30.0

Epicenter: 51.492N., 175.173W.
Depth: 40 km
Magnitude: 4.9m_b(GS), 4.5M_S(GS), 4.3M_L(PM)
Felt: Adak Island (PM), Atka Island (PM).

25 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 09 01 32.6
Epicenter: 51.079N., 176.137W.
Depth: 21 km
Magnitude: 5.3m_b(GS), 5.6M_S(GS), 5.3M_L(PM), 5.5M_S(BK)
Moment: 6.1 x 10^{24} dyne-cm (HR)
Intensity IV: Adak Island (PM).

25 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 09 04 16.3
Epicenter: 51.056N., 175.996W.
Depth: 20 km
Magnitude: 5.4m_b(GS), 5.6M_S(GS)
Felt: Adak Island (PM).

28 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 04 06 50.5
Epicenter: 51.404N., 174.016W.
Depth: 21 km
Magnitude: 5.4m_b(GS), 4.8M_S(GS), 4.5M_L(PM), 4.6M_S(BK)
Moment: 1.3 x 10^{24} dyne-cm (HR)
Intensity III: Adak Island.

28 July (GS) Fox Islands, Aleutian Islands
Origin time: 05 01 59.6
Epicenter: 52.862N., 166.590W.
Depth: Normal
Magnitude: 5.0m_b(GS), 4.6M_S(GS), 4.7M_L(PM)
Felt: Unalaska (PM).

28 July (GM) Southern Alaska
Origin time: 14 31 14.1
Epicenter: 60.577N., 150.386W.
Depth: 47 km
Magnitude: 4.4m_b(GS), 4.6M_L(PM)
Intensity IV: Anchorage (PM).
Felt: Homer (PM), Kenai (PM), Palmer (PM), Seward (PM).

28 July (EE) Andreanof Islands, Aleutian Islands
Origin time: 21 57 16.6
Epicenter: 51.573N., 175.221W.
Depth: 42 km
Magnitude: 5.4m_b(GS), 4.9M_S(GS), 4.9M_L (PM)
Moment: 1.9 x 10^{24} dyne-cm (HR)
Intensity III: Adak Island.

ALASKA—Continued

31 July (GM) Southern Alaska
Origin time: 09 33 14.3
Epicenter: 61.767N., 149.567W.
Depth: 41 km
Magnitude: 3.2M_L(PM)
Felt: Anchorage (PM), Palmer (PM), Willows (PM).

31 July (GM) Southern Alaska
Origin time: 14 04 34.5
Epicenter: 60.797N., 149.614W.
Depth: 45 km
Magnitude: 3.7M_L(PM)
Felt: Anchorage (PM), Girdwood (PM).

1 August (GS) Fox Islands, Aleutian Islands
Origin time: 16 43 06.4
Epicenter: 53.495N., 167.236W.
Depth: Normal
Magnitude: 4.6m_b(GS), 4.5M_L(PM), 4.1m_x(LD)
Felt: Unalaska (PM).

1 August (EE) Andreanof Islands, Aleutian Islands
Origin time: 20 24 59.3
Epicenter: 50.954N., 176.185W.
Depth: 20 km
Magnitude: 4.8m_b(GS), 4.9M_S(GS), 4.9M_L(PM)
Felt: Adak Island (PM).

1 August (EE) Andreanof Islands, Aleutian Islands
Origin time: 21 05 40.1
Epicenter: 51.262N., 174.224W.
Depth: 22 km
Magnitude: 5.5m_b(GS), 5.0M_S(GS), 4.6M_L(PM)
Moment: 1.5 x 10^{24} dyne-cm (HR)
Intensity IV: Adak Island (PM).

3 August (EE) Andreanof Islands, Aleutian Islands
Origin time: 02 39 28.7
Epicenter: 51.244N., 174.125W.
Depth: 20 km
Magnitude: 5.0m_b(GS), 4.0M_L(PM)
Felt: Adak Island (PM).

3 August (EE) Andreanof Islands, Aleutian Islands
Origin time: 13 29 10.4
Epicenter: 51.026N., 176.749W.
Depth: 22 km
Magnitude: 5.4m_b(GS), 5.6M_S(GS), 5.6M_L(PM), 5.7M_S(BK)
Moment: 8.1 x 10^{24} dyne-cm (HR)
Intensity IV: Adak Island.
Felt: Atka (PM).

3 August (EE) Andreanof Islands, Aleutian Islands
Origin time: 13 44 54.2

Epicenter: 50.808N., 176.671W.
Depth: 20 km
Magnitude: 4.7m_b(GS), 5.1M_L(PM)
Felt: Adak Island (PM).

3 August (EE) Andreanof Islands, Aleutian Islands
Origin time: 20 08 20.5
Epicenter: 50.918N., 176.638W.
Depth: 20 km
Magnitude: 4.8m_b(GS), 4.9M_S(GS), 4.2M_L(PM)
Felt: Adak Island (PM).

8 August (GS) Fox Islands, Aleutian Islands
Origin time: 04 31 21.3
Epicenter: 53.594N., 167.320W.
Depth: Normal
Magnitude: 4.5m_b(GS), 4.3M_S(GS), 5.0M_L(PM)
Felt: Unalaska (PM).

11 August Central Alaska
Origin time: 11 00
Epicenter: Not located.
Depth: None computed.
Magnitude: 3.0M_L(PM)
Felt: Fairbanks (PM).

25 August (GM) Southern Alaska
Origin time: 23 27 54.3
Epicenter: 61.352N., 150.333W.
Depth: 47 km
Magnitude: 4.5m_b(GS), 4.4M_L(PM)
Intensity III: Anchorage (PM), Palmer (PM), Willow (PM).
Intensity II: Talkeetna (PM).

3 September (EE) Andreanof Islands, Aleutian Islands
Origin time: 11 51 06.4
Epicenter: 51.106N., 178.224W.
Depth: 30 km
Magnitude: 5.0m_b(GS), 5.0M_L(PM)
Intensity III: Adak Island.

12 September (GS) Southern Alaska
Origin time: 23 57 15.6
Epicenter: 56.201N., 153.405W.
Depth: 31 km
Magnitude: 6.1m_b(GS), 6.3M_S(GS), 6.0M_S(BK)
Moment: 6.8 x 10^{25} dyne-cm (GS)
Intensity IV: Larsen Bay.

13 September (GM) Southern Alaska
Origin time: 12 30 40.7
Epicenter: 61.245N., 146.939W.
Depth: 42 km

ALASKA—Continued

Magnitude: 3.8M_L(PM)
Felt: Valdez (PM).

14 September (GM) Southern Alaska
Origin time: 11 38 53.6
Epicenter: 61.703N., 149.682W.
Depth: 47 km
Magnitude: 3.4M_L(PM)
Felt: Palmer (PM).

15 September (EE) Andreanof Islands, Aleutian Islands
Origin time: 06 29 38.6
Epicenter: 51.368N., 177.011W.
Depth: 35 km
Magnitude: 4.9m_b(GS), 4.0M_S(GS), 4.8M_L(PM)
Felt: Adak Island (PM).

15 September (GM) Southern Alaska
Origin time: 14 48 22.1
Epicenter: 61.528N., 143.800W.
Depth: 52 km
Magnitude: 4.5m_b(GS), 4.7M_L(PM), 4.7M_L(EP)
Intensity IV: Chitina, Valdez.
Intensity III: Cordova (PM).

16 September (GS) Southern Alaska
Origin time: 20 57 21.9
Epicenter: 56.222N., 153.600W.
Depth: Normal
Magnitude: 5.3m_b(GS), 5.5M_S(GS), 5.1M_L(PM), 5.1M_S(BK)
Moment: 7.7 x 10^{24} dyne-cm (HR)
Intensity III: Kodiak.

18 September (GS) Southern Alaska
Origin time: 20 56 05.8
Epicenter: 61.798N., 149.721W.
Depth: 57 km
Magnitude: 4.6m_b(GS), 4.6M_L(PM)
Intensity IV: Anchorage, Chugiak, Eagle River, Skwentna, Wasilla, Willow.
Intensity III: Anchorage International Airport, Moose Pass, Spenard, Sutton.
Intensity II: Whittier.
Felt: Girdwood (PM), King Mountain Lodge (PM), Mile 90 on Glenn Highway (PM), Palmer (PM).

28 September (GM) Southern Alaska
Origin time: 10 41 48.8
Epicenter: 59.782N., 152.320W.
Depth: 61 km
Magnitude: 4.1M_L(PM)
Intensity III: Homer (PM).

29 September (EE) Andreanof Islands, Aleutian Islands
Origin time: 12 20 43.9
Epicenter: 51.118N., 174.957W.
Depth: 20 km
Magnitude: 5.0m_b(GS), 4.5M_S(GS), 5.2M_L(PM)
Intensity III: Adak Island (PM).

1 October (EE) Andreanof Islands, Aleutian Islands
Origin time: 15 56 06.4
Epicenter: 51.623N., 175.901W.
Depth: 45 km
Magnitude: 5.3m_b(GS), 4.5M_S(GS), 4.8M_L(PM)
Moment: 1.2 x 10^{24} dyne-cm (HR)
Intensity III: Adak Island (PM).

5 October (EE) Andreanof Islands, Aleutian Islands
Origin time: 03 25 57.7
Epicenter: 51.078N., 176.179W.
Depth: 20 km
Magnitude: 4.9m_b(GS), 4.5M_L(PM)
Intensity II: Adak Naval Air Station (PM).

6 October (EE) Andreanof Islands, Aleutian Islands
Origin time: 04 21 48.9
Epicenter: 51.513N., 176.089W.
Depth: 48 km
Magnitude: 5.1m_b(GS), 4.2M_S(GS), 4.9M_L(PM)
Moment: 7.3 x 10^{23} dyne-cm (HR)
Intensity III: Adak Naval Air Station (PM).

9 October (GM) Southern Alaska
Origin time: 01 21 06.1
Epicenter: 62.129N., 149.544W.
Depth: 58 km
Magnitude: 4.5m_b(GS), 4.3M_L(PM)
Intensity III: Anchorage (PM).
Intensity II: Talkeetna (PM).

15 October (GS) Southern Alaska
Origin time: 23 35 51.2
Epicenter: 59.705N., 153.072W.
Depth: 121 km
Magnitude: 4.6m_b(GS)
Intensity III: Homer.

18 October (GS) Central Alaska
Origin time: 19 22 10.1
Epicenter: 63.153N., 150.443W.
Depth: 119 km
Magnitude: None computed
Felt: Cantwell (PM).

ALASKA—Continued

19 October (GM) Southern Alaska
Origin time: 21 53 34.0
Epicenter: 59.509N., 152.682W.
Depth: 81 km
Magnitude: 4.0M_L(PM)
Intensity II: Homer (PM).

22 October (GM) Southern Alaska
Origin time: 18 31 34.1
Epicenter: 61.339N., 146.849W.
Depth: 38 km
Magnitude: 4.0M_L(PM)
Intensity III: Valdez (PM).

24 October (EE) Andreanof Islands, Aleutian Islands
Origin time: 11 00 50.3
Epicenter: 51.384N., 176.750W.
Depth: 37 km
Magnitude: 5.2m_b(GS), 4.3M_S(GS), 4.7M_L(PM)
Moment: 7.1 x 10^{23} dyne-cm (HR)
Intensity III: Adak Island (PM).

24 October (GM) Southern Alaska
Origin time: 14 34 53.8
Epicenter: 60.946N., 151.486W.
Depth: 69 km
Magnitude: 3.2M_L(PM)
Felt: Eagle River (PM).

27 October (GM) Southern Alaska
Origin time: 19 39 36.5
Epicenter: 60.928N., 149.464W.
Depth: 39 km
Magnitude: 3.6M_L(PM)
Intensity IV: Anchorage.
Intensity III: Eagle River.

4 November (GM) Southern Alaska
Origin time: 06 14 18.7
Epicenter: 61.341N., 151.900W.
Depth: 98 km
Magnitude: 4.7m_b(GS)
Intensity III: Hurricane (PM).
Intensity II: Anchorage (PM).

6 November (EE) Andreanof Islands, Aleutian Islands
Origin time: 18 27 02.9
Epicenter: 51.242N., 176.631W.
Depth: 39 km
Magnitude: 5.1m_b(GS), 5.5M_S(GS), 5.2M_L(PM),
5.6M_S(BK)
Moment: 8.5 x 10^{24} dyne-cm (HR)
Intensity IV: Adak Island.

6 November (EE) Andreanof Islands, Aleutian Islands
Origin time: 19 45 40.5
Epicenter: 51.072N., 176.516W.
Depth: 20 km
Magnitude: 4.8m_b(GS)
Intensity IV: Adak Island.

19 November (GS) Andreanof Islands, Aleutian Islands
Origin time: 19 00 11.4
Epicenter: 51.036N., 176.001W.
Depth: Normal
Magnitude: 4.5M_L(PM)
Intensity III: Adak Island.

26 November Central Alaska
Origin time: 08 41
Epicenter: Not located.
Depth: None computed.
Magnitude: 3.5M_L (AK)
Intensity IV: North Pole (press report).
Intensity III: Eielson Air Force Base.
Felt: Fairbanks (press report).

26 November (GM) Southern Alaska
Origin time: 21 04 43.4
Epicenter: 61.774N., 150.887W.
Depth: 62 km
Magnitude: 3.6M_L(PM)
Intensity III: Skwentna.

3 December (EE) Andreanof Islands, Aleutian Islands
Origin time: 05 05 36.7
Epicenter: 51.352N., 176.465W.
Depth: 36 km
Magnitude: 4.6m_b(GS)
Intensity III: Adak Island.

16 December (EE) Andreanof Islands, Aleutian Islands
Origin time: 10 27 24.4
Epicenter: 51.492N., 175.319W.
Depth: 35 km
Magnitude: 5.1m_b(GS), 4.4M_S(GS), 5.0M_L(PM)
Moment: 6.7×10^{23} dyne-cm (HR)
Intensity IV: Adak Island.

19 December (EE) Andreanof Islands, Aleutian Islands
Origin time: 13 50 13.3
Epicenter: 51.391N., 176.903W.
Depth: 37 km
Magnitude: 5.3m_b(GS)
Moment: 4.6×10^{23} dyne-cm (HR)

ALASKA—Continued

Intensity V:
Adak Island–A few small objects overturned and fell; people had difficulty standing or walking; buildings shook strongly.

27 December (GM) Southern Alaska
Origin time: 03 35 41.4
Epicenter: 61.828N., 148.954W.
Depth: 15 km
Magnitude: 3.1M_L(PM)
Intensity II: Lazy Mountain (PM).

NETWORK OPERATIONS

Eastern Aleutians Seismicity

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The Shumagin seismic network in the eastern Aleutians, Alaska, was used to locate 611 earthquakes in 1986. The seismicity of the region for this time period is shown in map view and cross section in figures 23 and 24. Most of the seismicity is related to the subduction of the Pacific plate beneath the North American plate.

The largest earthquake in this time period within the network had a local magnitude of 4.5 (m_b5.0) and was located over the main thrust zone at a depth of 4.5 km. A magnitude 4.1 (m_b4.4) earthquake occurred at a depth of 201 km. This was the first deep event larger than magnitude 4.0 since 1981.

Otherwise, the overall pattern during this time period is similar to the long-term seismicity. Concentrations of events occur at the base of the main thrust zone and in the shallow crust directly above it. The continuation of the thrust zone towards the trench is poorly defined. West of the network (which ends at 163°) the seismicity is more diffuse in map view and extends closer to the trench. Nine of the 13 located events larger than magnitude 4.0 occurred in this western region. Below the base of the main thrust zone (about 45 km), the dip of the Benioff zone steepens. A double Wadati-Benioff zone is evident near 100-km depth. The base of the seismogenic part of the subducting Pacific plate lies near 250-km depth.

Network Configuration

The Shumagin seismic network consists of short-period, high-gain seismic stations, a few low-gain stations, and strong-motion accelerographs. The data from the different sets of instruments are being applied to ground motion, seismic source, earthquake prediction, tectonic, and volcanological studies. The network includes 13 remote stations plus three stations in the Pavlof volcano subarray, four repeater stations, and the local station at Sand Point (SAN). Each remote station has a single, short-period vertical seismometer except San Diego Bay (SGB), Chernabura (CNB), Pavlof Volcano (PVV), and Black Hills (BLH), which are three-component stations. Station SQF uses a three-component force-balanced accelerometer (FBA) sensor. The analog signals from the high-gain remote stations have a dynamic range of approximately 42–60 dB and are transmitted via radio links to a central recording site at Sand Point.

Sensors local to the recording center at Sand Point consist of a three-component set of short-period seismometers (f_0=1 Hz) and a triaxial, force-balanced accelerometer (FBA)(f_0=50 Hz). The seismometers are recorded on the digital system with a 72-dB dynamic range at both medium and high gains, whereas the FBA is recorded independently on a digital strong-motion recorder (PDR-1).

Within the region of the Shumagin network there are 11 analog strong-motion accelerographs (SMA's) (Kinemetrics SMA-1, 1*g* or 1/2 *g*), nine of which are located with remote stations of the network. These nine SMA's are connected to the telemetry system, and a 400-Hz trigger signal is sent to the central recording site indicating the exact time at which the SMA began recording a given earthquake. This start time is combined with an internal time code to determine absolute timing within an earthquake.

This range of instrumentation permits the digital recording and locating of events as small as M_L 0.4, with uniform coverage at M_L 2.0, and onscale recording to about M_S 6.5. Larger events are recorded digitally by the PDR-1 and on photographic film by the 11 SMA's.

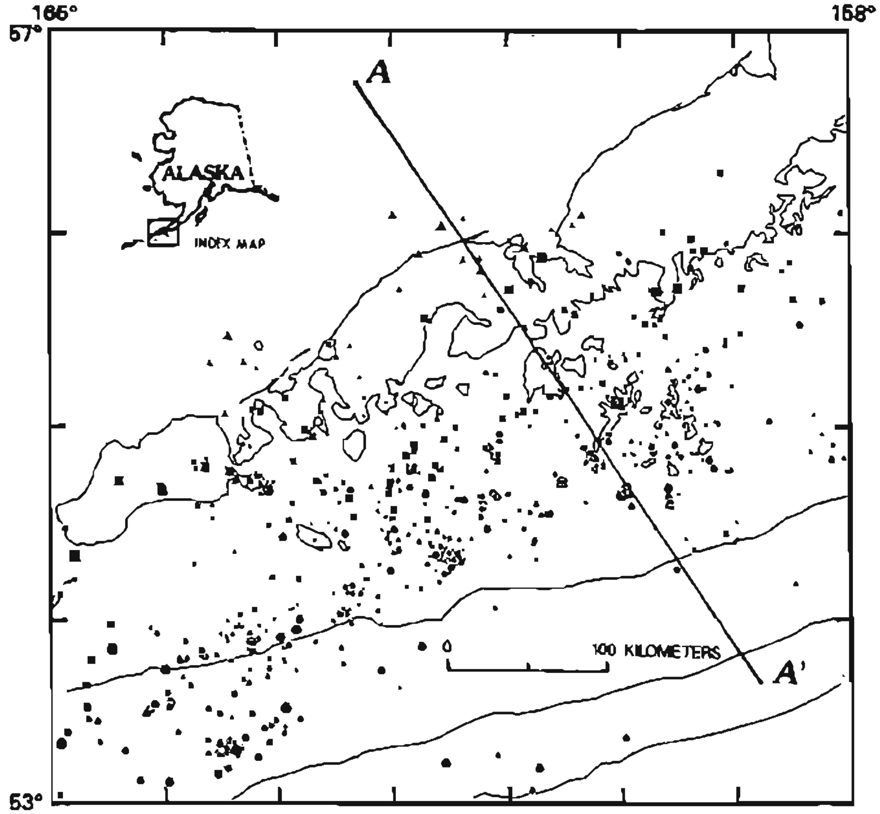

Figure 23. Seismicity located by the Shumagin, Alaska, seismic network from January 1 to December 30, 1986. Earthquakes are represented by filled symbols with white borders. Depth is shown by symbol type and magnitude by symbol size. Dots show earthquakes less than 50 km. Squares show earthquakes between 50 and 150 km; triangles show earthquakes below 150 km. Northeast-southwest trending lines across the bottom of the map indicate increasing depth of the Aleutian trench toward the northwest.

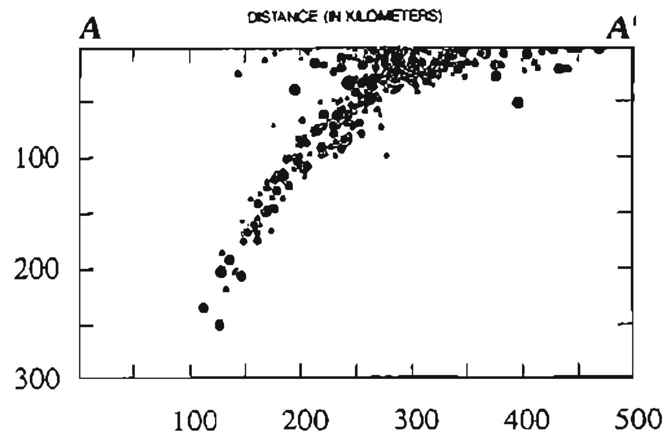

Figure 24. Cross section of Shumagin, Alaska, network seismicity along line *A*-*A*′ in figure 23. Symbol size shows earthquake size.

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