

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

United States Earthquakes, 1977

By

Jerry L. Coffman

and

Carl W. Stover

Open-File report 84-977

Prepared in cooperation with National Oceanic and Atmospheric Administration.

This report has not been reviewed for conformity with U.S. Geological Survey editorial standards.



## Contributors

Contributors to this publication are listed below according to the type of data supplied or service performed.

### Hypocenters and magnitudes:

John S. Derr, U.S. Geological Survey  
W. LeRoy Irby, U.S. Geological Survey  
R. Kangas, U.S. Geological Survey  
John H. Minsch, U.S. Geological Survey  
Waverly J. Person, U.S. Geological Survey  
Bruce W. Presgrave, U.S. Geological Survey  
Hawaiian Volcano Observatory, U.S. Geological Survey

### Intensities:

Jerry L. Coffman, NOAA, EDIS  
Ruth B. Simon, U.S. Geological Survey

### Geodesy:

B.K. Meade, NOAA, NOS, National Geodetic Survey  
John G. Gergen, NOS, National Geodetic Survey

### Tsunamis:

Mark G. Spaeth, NOAA, National Weather Service

### Strong-motion seismograph data:

Ronald L. Porcella, U.S. Geological Survey

### Computer programs, editorial assistance, and manuscript review:

Patricia Lockridge, NOAA, EDIS  
Leslie D. Morris, NOAA, EDIS  
Carl A. von Hake, NOAA, EDIS  
Carol Weathers, NOAA, EDIS



# Contents

	Page
Contributors.....	iii
Introduction.....	1
Discussion of Tables.....	1
Epicenter Maps.....	1
Earthquake Information Services.....	3
Magnitude and Intensity Ratings.....	3
Modified Mercalli Intensity Scale .....	5
Acknowledgments.....	6
Earthquake Descriptions.....	9
Alabama.....	9
Alaska.....	9
Arizona.....	14
Arkansas.....	14
California.....	14
Colorado.....	31
Delaware.....	31
Georgia.....	31
Hawaii.....	31
Idaho.....	37
Illinois.....	38
Massachusetts.....	38
Mississippi.....	38
Missouri.....	38
Montana.....	39
Nevada.....	41
New Hampshire.....	41
New Mexico.....	42
New York.....	43
North Carolina.....	43
Ohio.....	43
Oklahoma.....	43
Oregon.....	43
Puerto Rico.....	43
Rhode Island.....	43
South Carolina.....	44
Tennessee.....	44
Texas.....	44
Utah.....	44
Virginia.....	46
Washington.....	46
Wyoming.....	47
Miscellaneous Activities.....	61
Horizontal Control Surveys for Crustal Movement Studies.....	61
Tsunamis.....	61
Principal Earthquakes of the World.....	61
Strong-Motion Seismograph Data.....	65
Introduction.....	65
Accelerograph Data.....	65
References.....	80
Additions and Corrections to Previous Issue.....	81

## LIST OF TABLES

Table	Page
1 Summary of earthquakes felt in U.S. for 1977.....	49
2 Principal earthquakes of the world during 1977.....	65
3 Summary of U.S. accelerograph records recovered during 1977.....	69

## LIST OF ILLUSTRATIONS

Figure	Page
1 Earthquake epicenters in the U.S. in 1977.....	2
2 Earthquakes plotted by Modified Mercalli intensity in 1977.....	4
3 Area affected by central California earthquake of January 9.....	15
4 Area affected by California-Nevada border earthquake of February 22.....	17
5 Area affected by central California earthquake of June 21.....	20
6 Area affected by southern California earthquake of August 12.....	22
7 Damage map of community of Willits for northern California earthquake of November 22.....	27
8 Intensity map of Little Lake Valley region for northern California earthquake of November 22.....	28
9 Area affected by northern California earthquake of November 2.....	29
10 Area affected by western Idaho earthquake of November 27.....	37
11 Area affected by southern New England earthquake of December 20.....	38
12 Area affected by northern New England earthquake of December 25.....	41
13 Area affected by New Mexico earthquake of March 5.....	42
14 Area affected by Utah earthquake of September 30.....	45
15 Accelerograph locations during central California earthquake of June 21.....	67
16 Accelerograph records from Livermore VA Hospital for June 21 earthquake.....	67
17 Accelerograph records from Del Valle Dam for June 21 earthquake.....	68
18 Tracing of accelerograph record from Vallecitos Nuclear Center for June 21 earthquake.....	68

# United States Earthquakes, 1977

Jerry L. Coffman, NOAA, Environmental Data and Information Service  
Carl W. Stover, U.S. Geological Survey

## Introduction

This publication describes all earthquakes that were reported felt in the United States and nearby territories in 1977. It has been produced jointly by the NOAA Environmental Data and Information Service (EDIS) and the U.S. Geological Survey (USGS). Its purpose is to provide a continuous history of U.S. earthquakes for studying seismic risk, evaluating nuclear powerplant sites, designing earthquake-resistive structures, and answering inquiries from the scientific and general public.

The publication is composed of three major chapters: "Earthquake Descriptions," which includes a chronological list of earthquakes by state (table 1) and a summary of macroseismic data reported for each earthquake; "Miscellaneous Activities," which contains information on crustal movement studies, tsunamis, and principal earthquakes of the world (table 2), and "Strong-Motion Seismograph Data" (table 3). The intensity and macroseismic data in "Earthquake Descriptions" are compiled from questionnaire canvases (see next paragraph), newspaper articles, and reports prepared by other government organizations, state institutions, local organizations, and individuals. Each description includes date, origin time, hypocenter and hypocenter source of the earthquake, maximum intensity (Modified Mercalli), and macroseismic effects reported in the area.

The USGS collects macroseismic intensity information primarily by mailing questionnaires, "Earthquake Report" forms, to postmasters in the earthquake area. Postmasters complete the forms and return them to USGS, where they are evaluated and intensities are assigned. The USGS publishes preliminary intensity data in its quarterly Earthquakes in the United States. The final information is published in the United States Earthquakes series, issued annually since 1928.

## DISCUSSION OF TABLES

The earthquake values in tables 1, 2, and 3 include date, origin time, hypocenter (epicenter and focal depth), and magnitude. Table 1 also contains the Modified Mercalli (MM) intensity. The

origin time and date are listed in Universal Coordinated Time (UTC). The epicenters were taken principally from those published in the USGS Preliminary Determination of Epicenters Monthly Listing or Earthquakes in the United States. The accuracy of the epicenters is that claimed by the institution supplying the hypocenter and is not necessarily the accuracy indicated by the number of decimals listed. The epicenters located by USGS have a varying degree of accuracy, usually two-tenths of a degree or less, depending on their continental or oceanic location. The oceanic hypocenters are less accurate than those on the continent, even though both are listed to two decimals. Depths are listed to the nearest whole kilometer.

Magnitude values listed in the tables were furnished by cooperating institutions or determined by USGS. The computational sources are labeled according to the assigned letter codes shown in footnotes to the tables. The absence of a letter code in the magnitude column of table 1 indicates that the epicenter source (in the "source" column) is also the magnitude source. If a letter code does not appear in the "source" column, the earthquake is noninstrumental.

## EPICENTER MAPS

Figure 1 is a computer plot of all earthquake epicenters listed in table 1. Each earthquake is indicated by a small dot.

Figure 2 is a computer plot of 1977 earthquakes by Modified Mercalli (MM) intensity. Maximum intensities are represented by Arabic numerals at the location that each occurred. Earthquakes of intensity I-IV are represented by dots.

The selection of intensity or isoseismal maps (figs. 3-14) is governed largely by the size of the area affected. This means that sharp, localized shocks of intensity VI (which occur mostly in California) may not be represented by these maps, whereas other earthquakes of intensity V and VI (which occur largely in the Eastern and Central States) often will



be illustrated because of the larger felt areas. Numerals on these computer-plotted maps represent the maximum MM intensities at each town. Iseismal contours are a generalization of intensity data and are extrapolated to regions that have no observations. The contours do not include each intensity observation.

## EARTHQUAKE INFORMATION SERVICES

The National Geophysical and Solar-Terrestrial Data Center (NGSDC), one of the five major facilities of NOAA's Environmental Data and Information Service, is responsible for data activities in seismology. Its services include preparing local and regional seismic histories for engineers, actuaries, and other scientists and answering direct inquiries from the public on all aspects of historical earthquakes. Additional services and products include publishing annual earthquake summaries and revised historical earthquake reports; and making available copies of seismograms, accelerograms, displacement meter records, digitized strong-motion seismograms, and epicenter lists in several formats. Many of these products and services are based on seismic records or other data that have originated with USGS recording networks or with USGS data-reduction facilities. Information concerning services and products of NSGDC may be obtained from the National Geophysical and Solar-Terrestrial Data Center, NOAA/EDIS, Boulder, CO 80303.

During 1977, USGS announced 5,686 epicenter locations in the twice-weekly Preliminary Determination of Epicenters (PDE) list. Epicenters are published when sufficient information has accumulated to insure a reasonable degree of accuracy. The results are preliminary and do not always agree with later epicenters determined from additional seismic readings or from new data with critical azimuths and distances. For special studies, an inquiry should be made to the USGS (Denver Federal Center, Branch of Global Seismology, Stop 967, Box 25046, Denver, Colo. 80225) for possible recomputation of epicenters of interest.

USGS coordinates the collection of all types of earthquake information, with the special objective of correlating instrumentally determined earthquake locations with noninstrumental locations indicated by intensity data. This correlation is achieved through intensive regional investigations of earthquakes by local organizations and USGS. Primary data are gathered by a canvass of the epicentral area using questionnaire cards. When returned and analyzed, this information is used to map the seismic areas of the country in order to promote public

safety through a better understanding of earthquake phenomena.

## MAGNITUDE AND INTENSITY RATINGS

Magnitude, a measure of the "size" of an earthquake, is roughly related to the energy release at the focus of an earthquake. Although the magnitude scale has neither "top" nor "bottom" values, the highest ever recorded was magnitude 8.9 and the lowest about -3. On this logarithmic scale, a magnitude 6 shallow-focus earthquake represents elastic-wave energy about 30 times greater than that generated by a magnitude 5 earthquake, 900 times greater than that of a magnitude 4 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 USGS are based on the following formulae:

$$MS = \log (A/T) + 1.66 \log D + 3.3, \quad (1)$$

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 horizontal 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  $20^\circ \leq D \leq 160^\circ$ . No depth correction is made for depth less than 50 km.

$$mb = \log (A/T) + Q (D, h), \quad (2)$$

as defined by Gutenberg and Richter (1956), except that T, the period in seconds, is restricted to  $0.1 \leq T \leq 3.0$ , 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  $D \geq 5^\circ$ .

$$ML = \log A - \log A_0, \quad (3)$$

as defined by Richter (1958, p. 340), where A is the maximum trace amplitude in millimeters, written by a Wood-Anderson torsion seismometer, and  $\log A_0$  is a standard value as a function of distance, where the distance is  $\leq 600$  km. ML values are also calculated from other seismometers by conversion of recorded ground motion to the expected response of the torsion seismometer:

$$mbLg = 3.75 + 0.90(\log D) + \log (A/T) \quad 0.5^\circ \leq D \leq 4^\circ, \quad (4)$$

$$mbLg = 3.30 + 1.66(\log D) + \log (A/T) \quad 4^\circ \leq D \leq 30^\circ,$$

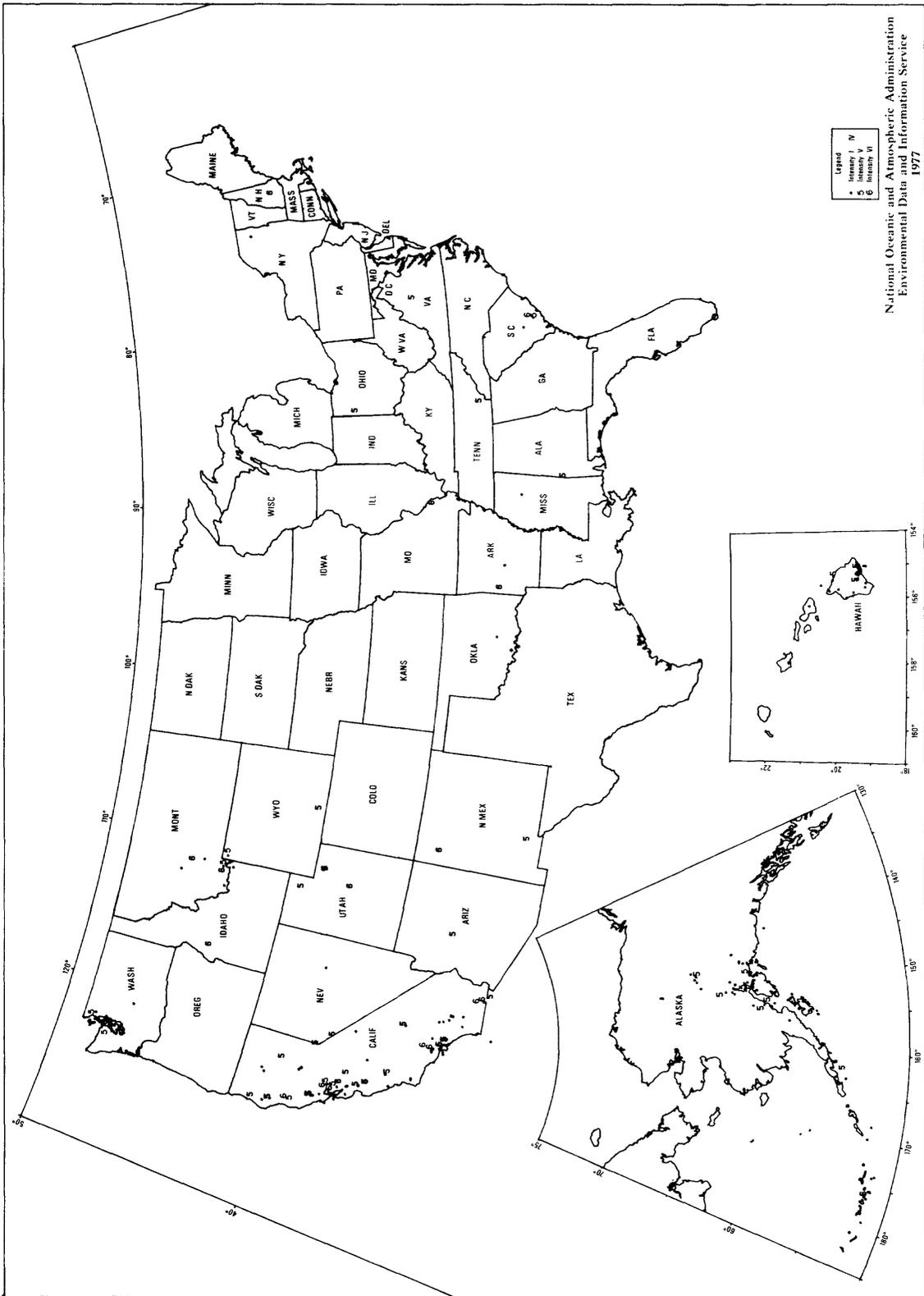


Figure 2.--Earthquakes plotted by Modified Mercalli Intensity in 1977

as proposed by Nuttli (1973), 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.

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

The text of this publication gives the intensity for each city where the earthquake was felt and summaries of the strongest effects reported. Each earthquake is further characterized by its maximum intensity, which is given in the text and in table 1.

Although the Modified Mercalli Intensity Scale is in many instances inadequate for present-day requirements, the scale has been the guide used by NOAA and USGS and will continue to be so used until a new scale has been devised and has acceptance in the engineering and seismological communities. Questions concerning the interpretation of historical earthquake intensities should be referred to USGS.

## MODIFIED MERCALLI INTENSITY SCALE

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 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 loos 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.

## ACKNOWLEDGMENTS

Active cooperation in earthquake investigations in the United States is provided by several seismology collaborators. The following served as collaborators to NOAA and USGS during 1977.

Alabama.--L.J. Eisele, Spring Hill College, Mobile.

Alaska.--Staff of NOAA-Alaska Tsunami Warning Center, Palmer, and J.B. Townshend, College Observatory, College.

Arizona.--Marc Sbar, University of Arizona, Tucson.

California (northern).--Bruce A. Bolt, University of California, Berkeley.

California (southern).--Clarence R. Allen, California Institute of Technology, Pasadena.

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, USGS,  
Hawaiian Volcano Observatory, Hawaii  
National Park.  
Idaho.--James K. Applegate, Boise  
State University, Boise.  
Indiana.--Robert F. Blakely, Depart-  
ment of Natural Resources, Geological  
Survey, Bloomington.  
Iowa.--J.P. Kopp, Loras College,  
Dubuque.  
Kansas.--Henry V. Beck, Kansas State  
University, Manhattan.  
Kentucky.--Ronald L. Street, Univer-  
sity of Kentucky, Lexington.  
Michigan.--F. Mauk, University of  
Michigan, Ann Arbor.  
Minnesota.--Harold Mooney, University  
of Minnesota, Minneapolis.  
Missouri, Illinois, Arkansas area.--  
Otto Nuttli, Saint Louis University,  
Saint Louis.  
Montana.--Anthony Qamar, University  
of Montana, Missoula.  
Nevada.--Dr. James D. VanWarmer, Uni-  
versity of Nevada, Reno.  
New England.--E. Chiburis, Boston  
College, Weston, Mass.  
New York.--Lynn R. Sykes and Yash  
P. Aggarwal, Lamont-Doherty Geological  
Observatory, Palisades.

Ohio.--Edward J. Walter, John  
Carroll University, Cleveland.  
Oklahoma.--James E. Lawson, Jr.,  
University of Oklahoma, Leonard.  
Oregon.--Richard W. Couch, Oregon  
State University, Corvallis.  
Pennsylvania.--Benjamin F. Howell,  
Jr., Pennsylvania State University,  
University Park.  
South Carolina.--Pradeep Talwani,  
University of South Carolina, Columbia,  
and Joyce Bagwell, Baptist College of  
Charleston, Charleston.  
Tennessee.--Berlen C. Moneymaker,  
Knoxville.  
Texas.--G.R. Keller, University of  
Texas, El Paso.  
Utah.--Kenneth Cook, University of  
Utah, Salt Lake City.  
Virginia.--G.A. Bollinger, Virginia  
Polytechnic Institute and State Univer-  
sity, Blacksburg.  
Washington.--Norman Rasmussen and  
Robert S. Crosson, University of  
Washington, Seattle.  
West Virginia.--R.W. Laird, West  
Virginia University, Morgantown.  
Wisconsin.--David E. Willis, Univer-  
sity of Wisconsin, Milwaukee.

## Earthquake Descriptions

This section lists all earthquakes alphabetically by state. The origin time of earthquake occurrences is given in Universal Coordinated Time (UTC). Times are expressed continuously from midnight to midnight, or 0 to 24 hours. The following symbols are used to indicate authority for arrival or origin times, epicenters, and/or magnitudes.

- A--U.S. Energy Research and Development Administration.
- B--University of California, Berkeley.
- D--University of Montana, Missoula.
- G--U.S. Geological Survey (USGS), National Earthquake Information Service, Golden, Colo.
- H--U.S. Geological Survey, Hawaiian Volcano Observatory, Hawaii National Park.
- J--Weston Observatory, Weston, Mass.
- K--University of Michigan, Ann Arbor.
- L--Lamont-Doherty Geological Observatory, Palisades, N.Y.
- M--NOAA, Alaska Tsunami Warning Center, Palmer.
- P--California Institute of Technology, Pasadena.
- R--University of Nevada, Reno.
- S--St. Louis University, St. Louis, Mo.
- T--University of Oklahoma, Leonard.
- U--University of Utah, Salt Lake City.
- V--Virginia Polytechnic Institute and State University, Blacksburg.
- W--University of Washington, Seattle.
- X--Estes, 1977.
- Z--Delaware Geological Survey, Newark.

Sources of noninstrumental information (macroseismic data) in this publication include questionnaire canvasses conducted by USGS; newspaper articles; bulletins of the Seismological Society of America; special earthquake reports of other organizations; and information collected by NOAA's National Weather Service. Instrumental data are provided by the USGS, National Earthquake Information Service.

Roman numerals in the earthquake descriptions refer to the Modified Mercalli Intensity Scale of 1931 (see page 2), which gives about equal weight to the disturbance of inanimate objects and to personal reactions. When more than one degree of intensity is reported from a town, the town is assigned the highest intensity reported. All earthquake reports

that contain minimal information are assigned intensity II.

---

### Alabama

---

#### 4 May (G) Southwestern Alabama

Origin time: 02 00 22.9  
 Epicenter: 31.98 N., 88.42 W.  
 Depth: 5 km  
 Magnitude: 3.6 mbLg(S)

The last earthquake located in this area occurred on October 23, 1976, in southeastern Mississippi (see Minsch and others, 1978).

Intensity V: Melvin (small objects and light furniture shifted).

Intensity IV: Yantley.

---

### Alaska

---

#### 3 January (G) Andreanof Islands, Aleutian Islands

Origin time: 01 34 34.2  
 Epicenter: 51.43 N., 179.08 W.  
 Depth: 33 km  
 Magnitude: 4.8 mb  
Intensity II: Adak.

#### 6 January (G) Andreanof Islands, Aleutian Islands

Origin time: 16 02 07.6  
 Epicenter: 51.48 N., 175.48 W.  
 Depth: 38 km  
 Magnitude: 5.2 mb, 5.3 MS, 5.2 MS(B)  
Intensity IV: Adak.

#### 13 January (G) Gulf of Alaska

Origin time: 22 05 59.3  
 Epicenter: 59.43 N., 142.23 W.  
 Depth: 33 km  
 Magnitude: 4.5 ML(M)  
Intensity III: Valdez.

#### 18 January (G) Southern Alaska

Origin time: 17 07 10.8  
 Epicenter: 61.39 N., 146.56 W.  
 Depth: 28 km  
 Magnitude: 3.2 ML(M)  
Intensity III: Valdez.

#### 25 January (G) Southern Alaska

Origin time: 17 12 19.1  
 Epicenter: 60.98 N., 149.99 W.  
 Depth: 37 km  
 Magnitude: 3.5 ML(M)  
Intensity III: Valdez.

## Alaska--Continued

- 26 January (G) Southern Alaska  
 Origin time: 21 38 45.0  
 Epicenter: 61.23 N., 150.13 W.  
 Depth: 52 km  
 Magnitude: None computed.  
Intensity II: Eagle River, Palmer.
- 30 January (G) Andreanof Islands, Aleutian Islands  
 Origin time: 03 02 50.6  
 Epicenter: 51.57 N., 175.53 W.  
 Depth: 44 km  
 Magnitude: 4.1 mb  
Intensity II: Adak.
- 10 February-10 March (X) Central Alaska.
- The following has been excerpt from Estes and others, 1977:
- "On the morning of June 21, 1967, a series of four moderately strong earthquakes occurred near Fairbanks within a period of 21 minutes.... Within days, additional seismographic stations were installed in the area, and the aftershock zone was found to occupy a surprisingly compact volume located approximately 10 kilometers southeast of the city center....
- "Although the initial high level of aftershock activity decayed somewhat during the next several months, the seismicity has nonetheless persisted until the present time, producing scores of felt earthquakes.... Typically, two or three small earthquakes occur in the zone each day, with felt events coming at intervals of several months. In February and March of 1977, an anomalous resurgence of activity occurred, producing thousands of earthquakes within the period of a month, of which probably more than 20 were felt by residents of Fairbanks or nearby Fort Wainwright and North Pole.... The swarm was somewhat unusual in that it began and ended so abruptly...."
- 19 February (G) Near Islands, Aleutian Islands  
 Origin time: 22 34 04.1  
 Epicenter: 53.57 N., 170.03 E.  
 Depth: 33 km  
 Magnitude: 6.2 mb, 6.7 MS, 6.8 MS(B), 6.6 MS(P)  
Intensity IV: Attu, Shemya.
- 24 February Homer  
 Origin time: 13 50  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity IV: Homer.
- 3 March (G) Andreanof Islands, Aleutian Islands  
 Origin time: 10 14 02.3  
 Epicenter: 51.75 N., 175.97 W.  
 Depth: 63 km

## Alaska--Continued

- Magnitude: 4.1 mb  
Intensity III: Adak.
- 18 March Central Alaska  
 Origin time: 02 56  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: 3.6 ML(M)  
Intensity III: Fairbanks.
- 25 March (G) Kenai Peninsula, Alaska  
 Origin time: 13 39 45.2  
 Epicenter: 60.84 N., 148.14 W.  
 Depth: 55 km  
 Magnitude: 4.6 mb  
Intensity V: Anchorage (hanging pictures displaced, awakened many); Cordova (awakened and frightened several); Eagle River (hanging pictures displaced); Girdwood (buildings trembled, many awakened); Seward (few awakened and frightened, small objects shifted); Whittier (many awakened and frightened, loud "earth noises").  
Intensity IV: Chugiak, Moose Pass, Palmer, Valdez.  
Intensity III: Anchorage (Spenard Station).
- 26 March (G) Fox Islands, Aleutian Islands  
 Origin time: 04 36 14.7  
 Epicenter: 52.30 N., 168.26 W.  
 Depth: 38 km  
 Magnitude: 5.7 mb, 6.0 MS, 5.9 MS(B)  
Intensity IV: Nikolski.
- 30 March (G) Near Islands, Aleutian Islands  
 Origin time: 17 41 38.0  
 Epicenter: 52.55 N., 172.52 E.  
 Depth: 31 km  
 Magnitude: 5.0 mb  
Intensity IV: Shemya.
- 12 April (G) Kenai Peninsula, Alaska  
 Origin time: 13 06 00.3  
 Epicenter: 60.80 N., 149.22 W.  
 Depth: 39 km  
 Magnitude: 4.4 mb, 5.1 ML(M)  
Intensity III: Anchorage, Indian House.
- 18 April Central Alaska  
 Origin time: 23 44  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: 4.1 ML(M)  
Intensity III: McGrath (M), Tatalina (M).
- 20 April (G) Kenai Peninsula, Alaska  
 Origin time: 12 11 49.1  
 Epicenter: 59.45 N., 150.61 W.  
 Depth: 33 km  
 Magnitude: 4.8 mb, 4.1 ML(M)  
Intensity IV: Homer (M).
- 23 April Central Alaska  
 Origin time: 17 59  
 Epicenter: Not located.

## Alaska--Continued

Depth: None computed.  
 Magnitude: None computed.  
Intensity II: Fairbanks (M).

27 April (G) Central Alaska  
 Origin time: 13 29 08.4  
 Epicenter: 62.29 N., 150.97 W.  
 Depth: 38 km  
 Magnitude: 3.1 ML(M)  
Intensity II: Gold Creek.

5 May (G) Central Alaska  
 Origin time: 00 22 38.3  
 Epicenter: 64.84 N., 148.36 W.  
 Depth: 9 km  
 Magnitude: 3.7 ML(M)  
Intensity III: College, Fairbanks.

11 May (G) Southern Alaska  
 Origin time: 17 33 30.7  
 Epicenter: 61.70 N., 150.47 W.  
 Depth: 76 km  
 Magnitude: 3.9 mb  
Intensity IV: Willow.  
Intensity III: Kashwitna.  
Intensity II: Anchorage, Wasilla.

12 May Northern Alaska  
 Origin time: 15 06  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity III: Wiseman (loud roaring sound heard from a northerly direction).

25 May (G) Alaska  
 Origin time: 18 06 34.1  
 Epicenter: 67.38 N., 150.30 W.  
 Depth: 126 km  
 Magnitude: None computed.  
Intensity III: Wiseman (roaring sound heard coming from the north, lasted about 6 seconds).

30 May (G) Fox Islands, Aleutian Islands  
 Origin time: 15 16 01.6  
 Epicenter: 52.43 N., 169.71 W.  
 Depth: 33 km  
 Magnitude: 5.6 mb, 6.0 MS, 6.0 MS(B), 6.0 MS(P)  
Intensity IV: Nikolski.

30 May (G) Kenai Peninsula, Alaska  
 Origin time: 18 40 26.6  
 Epicenter: 60.89 N., 149.69 W.  
 Depth: 42 km  
 Magnitude: None computed.  
Intensity II: Anchorage, Palmer, Potter.

2 June (G) Southern Alaska  
 Origin time: 16 29 46.3  
 Epicenter: 61.31 N., 150.33 W.  
 Depth: 67 km  
 Magnitude: 3.6 mb  
Intensity VI: Eagle River; several were awakened and frightened; small objects shifted and broken; hanging pictures fell.

## Alaska--Continued

Intensity IV: Anchorage (M), Palmer (M).

6 June (G) Central Alaska  
 Origin time: 10 08 11.5  
 Epicenter: 62.16 N., 149.55 W.  
 Depth: 60 km  
 Magnitude: 4.1 mb  
Intensity III: Palmer.

12 June (G) Southern Alaska  
 Origin time: 21 09 14.4  
 Epicenter: 61.63 N., 146.15 W.  
 Depth: 35 km  
 Magnitude: 4.2 mb, 4.2 ML(M)  
Intensity III: Glennallen, Tap's Sheep Camp, Valdez.

17 June (G) Kodiak Island region  
 Origin time: 05 32 12.0  
 Epicenter: 58.27 N., 151.82 W.  
 Depth: 36 km  
 Magnitude: 4.0 ML(M)  
Intensity III: Kodiak (M).

17 June (G) Southern Alaska  
 Origin time: 08 26 28.9  
 Epicenter: 61.49 N., 150.32 W.  
 Depth: 74 km  
 Magnitude: 4.3 mb  
Intensity V: Many were awakened and frightened by the earthquake; buildings trembled; windows, doors, and dishes rattled; and small objects shifted at the following locations: Anchorage, Chugiak, Fort Richardson, Girdwood, Skwentna, Sterling (hanging pictures fell), Wasilla, Willow.  
Intensity IV: Palmer, Talkeetna.  
Intensity III: Moose Pass.

29 June (G) Andreanof Islands, Aleutian Islands  
 Origin time: 08 47 15.6  
 Epicenter: 51.77 N., 176.22 W.  
 Depth: 60 km  
 Magnitude: 5.0 mb  
Intensity IV: Adak.

8 July (G) Southern Alaska  
 Origin time: 19 59 39.9  
 Epicenter: 61.17 N., 150.85 W.  
 Depth: 72 km  
 Magnitude: 4.7 mb  
Intensity V: Anchorage (Main Station, Mountain View, and Spenard Station), Chugiak.  
Intensity III: Fort Richardson, Seward (M).

8 July (G) Central Alaska  
 Origin time: 20 32 46.7  
 Epicenter: 62.33 N., 150.10 W.  
 Depth: 18 km  
 Magnitude: 3.7 ML(M)  
Intensity III: Talkeetna (M).

## Alaska--Continued

- 11 July (G) Central Alaska  
 Origin time: 15 57 17.2  
 Epicenter: 64.56 N., 147.27 W.  
 Depth: 14 km  
 Magnitude: 4.5 mb, 4.2 MS, 4.6 ML(M)  
Intensity V: Ester, Fairbanks (many awakened, few frightened at these towns).  
Intensity IV: College Observatory, Eielson Air Force Base.  
Intensity II: Nenana.
- 20 July (G) Alaska Peninsula  
 Origin time: 13 24 25.9  
 Epicenter: 54.61 N., 161.60 W.  
 Depth: 53 km  
 Magnitude: 5.3 mb  
Intensity V: Cold Bay (awakened and frightened many, buildings creaked and trembled, small objects and light furniture shifted), False Pass (small objects shifted), King Cove (many awakened and frightened, small objects shifted), Sand Point (few awakened and frightened, building trembled).
- 22 July (G) Southern Alaska  
 Origin time: 05 57 00.5  
 Epicenter: 61.03 N., 150.40 W.  
 Depth: 51 km  
 Magnitude: 3.8 mb, 4.0 ML(M)  
Intensity III: Anchorage, Palmer.
- 26 July (G) Southern Alaska  
 Origin time: 18 39 21.7  
 Epicenter: 62.53 N., 149.04 W.  
 Depth: 69 km  
 Magnitude: None computed.  
Intensity IV: Talkeetna.  
Intensity III: Palmer, Wasilla.  
Intensity II: Anchorage.
- 4 August (G) Southern Alaska  
 Origin time: 15 10 24.6  
 Epicenter: 59.53 N., 152.89 W.  
 Depth: 102 km  
 Magnitude: None computed.  
Intensity II: Palmer.
- 15 August (G) Andreanof Islands, Aleutian Islands  
 Origin time: 00 24 33.2  
 Epicenter: 51.59 N., 176.38 W.  
 Depth: 63 km  
 Magnitude: 4.5 mb  
Intensity IV: Adak.
- 16 August (G) Alaska  
 Origin time: 06 30 18.5  
 Epicenter: 67.52 N., 150.25 W.  
 Depth: 39 km  
 Magnitude: 3.5 ML(M)  
Intensity IV: Wiseman.
- 17 August (G) Andreanof Islands, Aleutian Islands  
 Origin time: 16 48 31.3  
 Epicenter: 51.87 N., 175.34 W.  
 Depth: 57 km

## Alaska--Continued

- Magnitude: 5.4 mb  
Intensity IV: Adak.
- 18 August (G) Andreanof Islands, Aleutian Islands  
 Origin time: 19 02 49.0  
 Epicenter: 51.83 N., 175.18 W.  
 Depth: 33 km  
 Magnitude: 4.2 mb  
Intensity II: Adak.
- 29 August (G) Andreanof Islands, Aleutian Islands  
 Origin time: 20 59 59.2  
 Epicenter: 51.56 N., 173.97 W.  
 Depth: 25 km  
 Magnitude: 5.4 mb, 5.1 MS, 5.2 MS(B)  
Intensity II: Adak.
- 30 August (G) Central Alaska  
 Origin time: 06 50 39.9  
 Epicenter: 63.16 N., 151.11 W.  
 Depth: 130 km  
 Magnitude: 5.0 mb  
Intensity V: Cantwell (frightened all, hanging pictures displaced), Eagle River (pictures displaced), McKinley Park (small objects shifted).  
Intensity IV: Chugiak, Talkeetna, Wasilla, Willow.  
Intensity III: Anchorage, Palmer.
- 30 August (G) Andreanof Islands, Aleutian Islands  
 Origin time: 15 12 27.6  
 Epicenter: 51.38 N., 173.79 W.  
 Depth: 33 km  
 Magnitude: 5.4 mb, 5.0 MS  
Intensity II: Adak.
- 4 September (G) Rat Islands, Aleutian Islands  
 Origin time: 15 40 57.3  
 Epicenter: 51.21 N., 178.39 E.  
 Depth: 34 km  
 Magnitude: 5.6 mb, 6.4 MS, 6.1 MS(P), 6.3 MS(B), 6.4 MS(L)  
Intensity II: Adak, Shemya.
- 4 September (G) Rat Islands, Aleutian Islands  
 Origin time: 17 10 30.6  
 Epicenter: 51.10 N., 178.27 E.  
 Depth: 31 km  
 Magnitude: 5.5 mb, 6.4 MS, 6.2 MS(P), 6.4 MS(L)  
Intensity II: Adak, Shemya.
- 4 September (G) Rat Islands, Aleutian Islands  
 Origin time: 17 24 42.8  
 Epicenter: 51.14 N., 177.95 E.  
 Depth: 8 km  
 Magnitude: 5.8 mb, 6.6 MS, 6.4 MS(P), 6.7 MS(L)  
Intensity II: Adak, Shemya.
- 9 September (G) Central Alaska  
 Origin time: 15 58 56.4  
 Epicenter: 62.19 N., 149.53 W.  
 Depth: 59 km  
 Magnitude: 4.6 mb  
Intensity II: Anchorage, Palmer.

## Alaska--Continued

- 17 September (G) Southern Alaska  
 Origin time: 15 42 42.2  
 Epicenter: 60.86 N., 150.84 W.  
 Depth: 33 km  
 Magnitude: 3.7 ML(M)  
Intensity IV: Kenai (G).
- 17 September (G) Southern Alaska  
 Origin time: 18 26 29.9  
 Epicenter: 61.03 N., 152.92 W.  
 Depth: 150 km  
 Magnitude: 4.8 mb  
Intensity IV: Kenai.  
Intensity II: Anchorage, Wasilla,  
 Whittier.
- 17 September (G) Central Alaska  
 Origin time: 21 25 21.4  
 Epicenter: 64.82 N., 147.43 W.  
 Depth: 20 km  
 Magnitude: 4.0 ML(M)  
Intensity IV: Fairbanks.
- 3 October (G) Alaska  
 Origin time: 13 31 16.4  
 Epicenter: 65.15 N., 146.84 W.  
 Depth: 33 km  
 Magnitude: 3.3 ML(M)  
Intensity III: Fairbanks area.
- 16 October (G) Southern Alaska  
 Origin time: 04 25 40.0  
 Epicenter: 59.88 N., 152.55 W.  
 Depth: 82 km  
 Magnitude: 4.6 mb  
Intensity V: Homer (small objects  
 shifted).  
Intensity III: Diamond Ridge.
- 18 October (G) Kenai Peninsula, Alaska  
 Origin time: 10 48 37.3  
 Epicenter: 60.70 N., 150.79 W.  
 Depth: 33 km  
 Magnitude: 3.7 mb, 3.4 ML(M)  
Intensity II: Anchorage, Kenai.
- 19 October (G) Central Alaska  
 Origin time: 02 16 02.6  
 Epicenter: 62.88 N., 150.56 W.  
 Depth: 102 km  
 Magnitude: 5.0 mb  
Intensity III: Felt from Mount McKinley  
 National Park to Anchorage.
- 27 October (G) Alaska  
 Origin time: 08 53 20.5  
 Epicenter: 64.65 N., 164.97 W.  
 Depth: 33 km  
 Magnitude: None computed.  
Intensity II: Nome (M).
- 28 October (G) Kenai Peninsula, Alaska  
 Origin time: 08 53 34.5  
 Epicenter: 60.91 N., 149.72 W.  
 Depth: 26 km

## Alaska--Continued

- Magnitude: 3.4 ML(M)  
Intensity II: Anchorage (M).
- 4 November (G) Southern Alaska  
 Origin time: 01 22 26.5  
 Epicenter: 61.13 N., 150.30 W.  
 Depth: 42 km  
 Magnitude: None computed.  
Intensity II: Anchorage area.
- 4 November (G) Andreanof Islands, Aleutian  
 Islands  
 Origin time: 09 52 55.7  
 Epicenter: 51.66 N., 175.95 W.  
 Depth: 33 km  
 Magnitude: 5.7 mb, 6.7 MS, 6.6 MS(P),  
 6.9 MS(B)  
Intensity VI: Adak (fallen plaster;  
 heavy furniture moved), Atka (cracked  
 chimneys).
- 4 November (G) Andreanof Islands, Aleutian  
 Islands  
 Origin time: 18 07 31.3  
 Epicenter: 51.43 N., 175.56 W.  
 Depth: 33 km  
 Magnitude: 5.4 mb, 5.4 MS, 5.4 MS(B)  
Intensity IV: Adak.
- 6 November (G) Central Alaska  
 Origin time: 19 11 02.7  
 Epicenter: 62.10 N., 144.94 W.  
 Depth: 33 km  
 Magnitude: 3.3 ML(M)  
Intensity II: Glennallen.
- 17 November (G) Alaska  
 Origin time: 03 33 56.0  
 Epicenter: 64.97 N., 147.91 W.  
 Depth: 16 km  
 Magnitude: 3.9 ML(M)  
Intensity IV: College, Ester.  
Intensity III: Fairbanks.
- 17 November (G) Central Alaska  
 Origin time: 05 00 09.6  
 Epicenter: 64.61 N., 149.54 W.  
 Depth: 25 km  
 Magnitude: 3.3 ML(M)  
Intensity II: College.
- 17 November (G) Southern Alaska  
 Origin time: 12 27 06.3  
 Epicenter: 61.29 N., 149.40 W.  
 Depth: 39 km  
 Magnitude: None computed.  
Intensity III: Eagle River.
- 20 November (G) Central Alaska  
 Origin time: 18 53 57.8  
 Epicenter: 62.43 N., 150.66 W.  
 Depth: 79 km  
 Magnitude: 4.9 mb, 4.9 ML(M)  
Intensity IV: Cantwell, Sutton,  
 Talkeetna.  
Intensity III: Palmer.

-----  
 Alaska--Continued  
 -----

27 November (G) Alaska Peninsula  
 Origin time: 15 05 06.8  
 Epicenter: 58.56 N., 155.38 W.  
 Depth: 116 km  
 Magnitude: 4.9 mb  
Intensity IV: Homer, King Salmon, Port  
 Lions.  
Intensity II: Kodiak.

8 December (G) Kenai Peninsula, Alaska  
 Origin time: 01 58 05.8  
 Epicenter: 59.45 N., 151.36 W.  
 Depth: 65 km  
 Magnitude: 4.7 mb  
Intensity IV: Homer.

15 December (G) Southern Alaska  
 Origin time: 01 29 22.6  
 Epicenter: 61.37 N., 150.01 W.  
 Depth: 38 km  
 Magnitude: 3.0 ML(M)  
Intensity III: Anchorage (M).

16 December (G) Southern Alaska  
 Origin time: 21 49 21.7  
 Epicenter: 59.77 N., 153.45 W.  
 Depth: 118 km  
 Magnitude: 4.9 mb  
Intensity II: Palmer (M).

27 December (G) Southern Alaska  
 Origin time: 15 09 51.0  
 Epicenter: 60.39 N., 153.70 W.  
 Depth: 175 km  
 Magnitude: 5.1 mb  
Intensity V: Anchorage (small objects  
 shifted), Chugiak, Clam Gulch, Eagle River,  
 Homer, Hope, Tyonek, Wasilla.  
Intensity IV: Anchor Point, Cooper  
 Landing, Kenai, Moose Pass, Seward,  
 Sterling, Talkeetna, Valdez.  
Intensity III: Kasilof, Kodiak.

29 December (G) Southern Alaska  
 Origin time: 21 48 16.7  
 Epicenter: 61.65 N., 146.38 W.  
 Depth: 57 km  
 Magnitude: 4.3 mb  
Intensity III: Valdez (M).  
Intensity II: Palmer-Wasilla area (M).

-----  
 Arizona  
 -----

17 January (P) California-Mexico border region  
 Origin time: 11 13 19.4

See California listing.

5 March (G) Northwestern New Mexico  
 Origin time: 03 00 54.7

See New Mexico listing.

21 October (G) Western Arizona  
 Origin time: , 02 55 13.4

-----  
 Arizona--Continued  
 -----

Epicenter: 34.63 N., 112.48 W.  
 Depth: 10 km  
 Magnitude: 2.5 ML  
Intensity V: Chino Valley (frightened  
 several, moderate earth noise).  
Intensity IV: Prescott (press report).

14 November (P) California-Mexico border region  
 Origin time: 02 05 47.9

See California listing.

14 November (P) California-Mexico border region  
 Origin time: 05 36 55.4

See California listing.

14 November (P) California-Mexico border region  
 Origin time: 12 20 19.5

See California listing.

-----  
 Arkansas  
 -----

2 June (S) Arkansas-Oklahoma border region  
 Origin time: 23 29 10.4  
 Epicenter: 34.61 N., 94.19 W.  
 Depth: 10 km  
 Magnitude: 4.3 mb(G), 4.0 mbLg  
Intensity VI: Board Camp (hairline  
 cracks in exterior walls, cracked chimneys,  
 small objects and light furniture shifted,  
 felt by many), Hatfield (sidewalks slightly  
 cracked, foundations cracked, buildings  
 trembled, felt by many).  
Intensity V: De Queen (small objects  
 shifted), Gillham, Mena, Umpire (several  
 frightened).  
Intensity IV: Black Springs, Grannis,  
 Saratoga.  
Intensity III: Langley, Wickes.

26 November (G) Arkansas  
 Origin time: 04 18 17.0  
 Epicenter: 34.52 N., 92.96 W.  
 Depth: 5 km  
 Magnitude: 3.1 mbLg(S), 2.9 mbLg(T)  
Intensity IV: Malvern (T).  
Intensity III: Donaldson (T), Harp (T),  
 Leola (T).

-----  
 California  
 -----

8 January (B) Central California  
 Origin time: 07 17 33.9  
 Epicenter: 37.90 N., 122.19 W.  
 Depth: 9 km  
 Magnitude: 3.0 ML  
Intensity III: Berkeley.

8 January (B) Central California  
 Origin time: 08 58 13.9  
 Epicenter: 37.90 N., 122.18 W.  
 Depth: 10 km

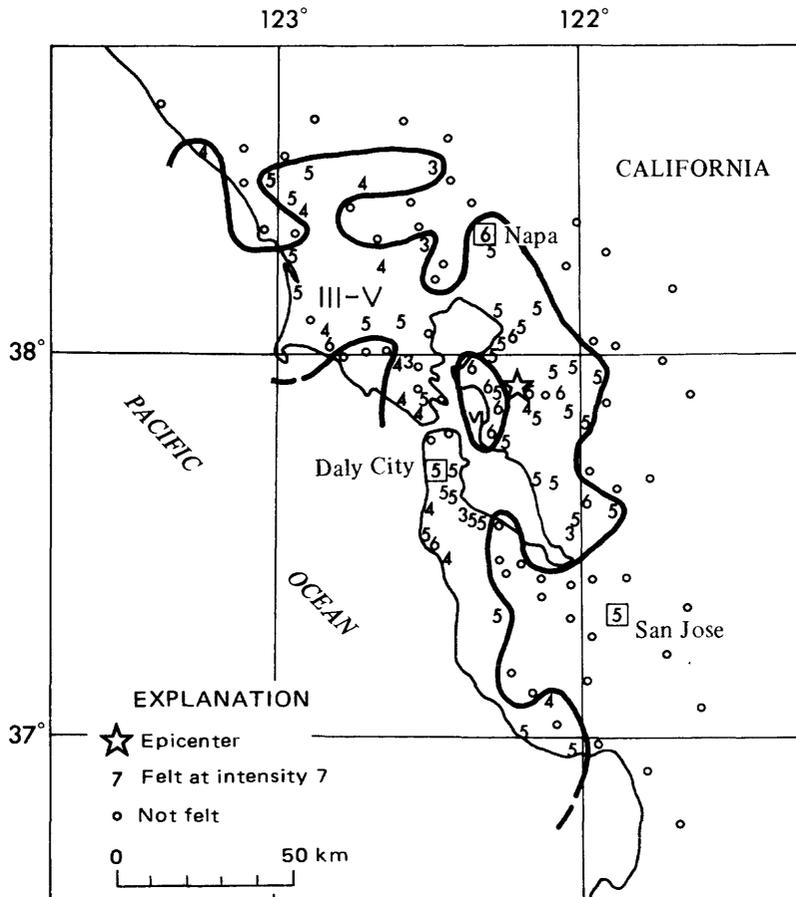


FIGURE 3. Area affected by central California earthquake of January 9. (Roman numerals represent Modified Mercalli intensities between isoseismal contours.)

Magnitude: 4.0 ML  
 Intensity IV: Walnut Creek.  
 Intensity III: Throughout the San Francisco Bay area.

8 January (B) Central California

Origin time: 09 38 07.5  
 Epicenter: 37.90 N., 122.18 W.  
 Depth: 9 km  
 Magnitude: 4.8 mb(G), 4.3 ML

Fifty-eight shocks were reported in the 3 days following this earthquake. Epicenters are all located near the Briones Dam (press reports). This earthquake was felt over an area of about 7,000 sq km (fig. 3).

Intensity VI: Berkeley (windows broken on university campus, displacement in previously cracked walls increased 1 cm); Crockett (cracked plaster, furniture moved); El Cerrito (one brick dislodged from chimney, retaining wall cracked); El Granada (cracked plaster); Napa (cracked

plaster and dry wall); Oakland (new cracks in plaster in several locations); Olema (cracked plaster); San Francisco (ceilings cracked, one chandelier knocked down, burglar alarms set off in financial district--press report); Walnut Creek (dry wall cracked).

Intensity V: Alameda, Alamo, Brisbane, Burlingame, Clayton, Concord, Daly City, Danville, Davenport, Dillon Beach, Forestville, Fremont, Hayward, Kensington, Lafayette (press report), La Honda, Loma Mar, Madera, Martinez, Marshall, Mill Valley, Monte Rio, Moraga, Moss Beach, Nicasio, North Berkeley, Novato, Occidental, Orinda Downs (press report), Pinole, Pleasant Hill, Port Costa, Rodeo, San Bruno, San Jose, San Lorenzo, San Mateo, San Pablo, Santa Cruz, South San Francisco, Sunol, Vallejo.

## California--Continued

Intensity IV: Fairfax, Freestone, Half Moon Bay, Larkspur, Orinda, Oroville (telephone service interrupted--press report), Pacifica, Palo Alto, Petaluma, Point Reyes Station, Santa Rosa, Stinson Beach, Union City, Villa Grande.

Intensity III: El Verano, Millbrae, Newark, Saint Helena, San Anselmo.

## 8 January (B) Central California

Origin time: 09 39 40.7  
Epicenter: 37.90 N., 122.20 W.  
Depth: 9 km  
Magnitude: 3.8 ML  
Intensity III: Berkeley.

## 8 January (B) Central California

Origin time: 09 51 55.6  
Epicenter: 37.91 N., 122.19 W.  
Depth: 8 km  
Magnitude: 3.0 ML  
Intensity III: Berkeley.

## 9 January (B) Central California

Origin time: 05 34 16.7  
Epicenter: 37.89 N., 122.19 W.  
Depth: 9 km  
Magnitude: 3.2 ML  
Intensity III: Berkeley.

## 9 January (B) Northern California

Origin time: 23 24 39.5  
Epicenter: 39.50 N., 121.64 W.  
Depth: 2 km  
Magnitude: 3.3 ML  
Intensity IV: Dobbins, Gold Run, Gridley, Marysville, Oroville (police reported that several burglar alarms went off and telephone service was disrupted for a short time--press report), Palermo, Rackerby.  
Intensity III: Brownsville.

## 10 January (B) Central California

Origin time: 05 08 07.9  
Epicenter: 37.91 N., 122.30 W.  
Depth: 3 km  
Magnitude: 2.9 ML  
Intensity III: Berkeley.

## 13 January (B) Northern California

Origin time: 20 09 53.5  
Epicenter: 41.02 N., 122.15 W.  
Depth: 2 km  
Magnitude: 3.7 ML  
Intensity III: Dunsuir-McCloud area (B), vicinity of Mt. Shasta (press report).

## 17 January (P) Southern California

Origin time: 00 39 15.4  
Epicenter: 34.37 N., 118.67 W.  
Depth: 14 km  
Magnitude: 3.4 ML  
Intensity III: Saugus to Northridge (P).

## California--Continued

## 17 January (P) California-Mexico border region

Origin time: 11 13 19.4  
Epicenter: 32.47 N., 115.18 W.  
Depth: 25 km  
Magnitude: 4.6 mb(G), 4.2 ML

Intensity V:

Arizona--Gadsden, Wellton, Yuma.  
California--Calexico, Seeley, Winterhaven.

Intensity IV:

Arizona--Martinez Lake, San Luis.  
California--Bard, Heber, Imperial, Plaster City.

## 18 January (B) Central California

Origin time: 21 05 46.6  
Epicenter: 36.92 N., 121.49 W.  
Depth: 9 km  
Magnitude: 3.5 ML  
Intensity IV: Gilroy.

## 19 January (B) Central California

Origin time: 02 12 19.8  
Epicenter: 36.93 N., 121.49 W.  
Depth: 4 km  
Magnitude: 4.0 ML  
Intensity V: Hollister (small objects moved).  
Intensity IV: Gilroy, San Juan Bautista.

## 23 January (B) Central California

Origin time: 17 45 50.3  
Epicenter: 37.86 N., 122.25 W.  
Depth: 9 km  
Magnitude: 2.7 ML  
Intensity IV: Berkeley (press report), Oakland.  
Intensity III: San Francisco Bay area.

## 24 January (P) Southern California

Origin time: 11 35 16.5  
Epicenter: 33.92 N., 118.13 W.  
Depth: 27 km  
Magnitude: 2.7 ML  
Intensity III: Downey (P).

## 24 January (B) Central California

Origin time: 15 55 46.4  
Epicenter: 37.86 N., 122.24 W.  
Depth: 8 km  
Magnitude: 2.7 ML  
Intensity III: Berkeley and the San Francisco Bay area.

## 1 February (B) Northern California

Origin time: 18 47 57.5  
Epicenter: 39.06 N., 120.00 W.  
Depth: 2 km  
Magnitude: 3.9 ML  
Intensity V:  
California--Markleeville (small objects moved), Mount Aukum (small objects moved), Tahoma, Twin Bridges (small objects moved).  
Nevada--Carson City (furniture moved), Genoa, Stateline (small objects moved), Stewart, Zephyr Cove (small objects moved).

Intensity IV:

California--Grizzly Flats, Kings Beach,  
Pacific House, Placerville (press  
report), Pollock Pines, South Lake Tahoe,  
Tahoe City, Topaz.

Nevada--Gardnerville, Minden, Silver City.

Intensity III:

California--Grass Valley.

Nevada--Glenbrook, Incline (press report).

3 February (P) Southern California

Origin time: 13 49 38.8  
Epicenter: 33.88 N., 116.60 W.  
Depth: 8 km  
Magnitude: 2.8 ML

Intensity III: Palm Springs (P).

10 February (P) Southern California

Origin time: 12 10 47.7  
Epicenter: 33.97 N., 116.58 W.  
Depth: 8 km  
Magnitude: 3.3 ML

Intensity IV: Morongo Valley.

Intensity III: Palm Springs (P).

14 February (P) Central California

Origin time: 13 58 40.3  
Epicenter: 35.72 N., 117.70 W.  
Depth: 3 km  
Magnitude: 3.2 ML  
Intensity IV: China Lake, Ridgecrest  
(press report).

14 February (P) Central California

Origin time: 13 58 51.8  
Epicenter: 35.72 N., 117.70 W.  
Depth: 3 km  
Magnitude: 3.7 ML  
Intensity IV: China Lake, Ridgecrest  
(press report).

21 February (B) Near coast of Northern California

Origin time: 11 09 15.3  
Epicenter: 39.37 N., 123.30 W.  
Depth: 20 km  
Magnitude: 3.2 ML  
Intensity V: Willits (small objects  
shifted, awakened many and frightened a few  
in the community, dogs restless the night  
before).

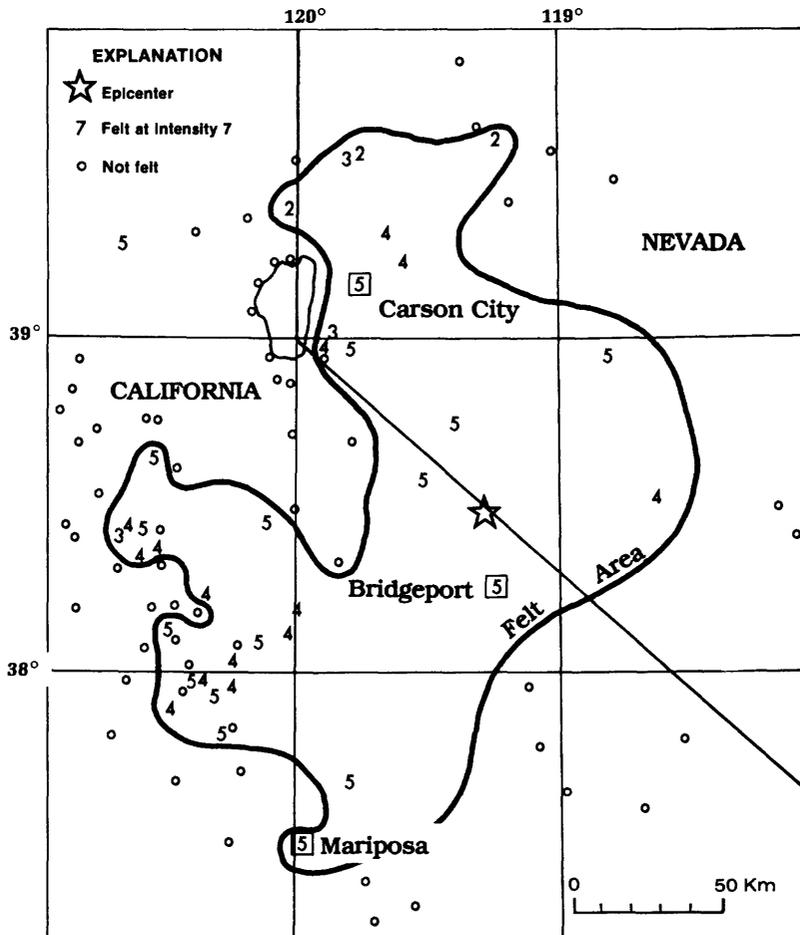


FIGURE 4. Area affected by California-Nevada border earthquake of February 22.

## California--Continued

## 22 February (B) California-Nevada border region

Origin time: 06 24 06.5  
 Epicenter: 38.48 N., 119.29 W.  
 Depth: 5 km  
 Magnitude: 5.0 mb(G), 4.8 ML

This earthquake was felt over an area of about 22,300 sq km of California and Nevada (fig. 4).

Intensity V:

California--Bear Valley (small objects moved), Big Oak Flat, Bridgeport, Coleville (small objects fell), El Portal, Emigrant Gap, Grizzly Flats (small objects moved), Long Barn, Mariposa, Murphys, Pioneer (furniture moved), Sonora, Soulsbyville (furniture moved), Topaz (furniture moved).

Nevada--Carson City (furniture moved), Cave Rock (furniture moved), Minden (furniture moved), Schurz, Wellington.

Intensity IV:

California--Arnold, Big Trees Village, Chinese Camp, Glencoe, Pinecrest, Standard, Strawberry, Tuolumne, Twain Harte, Volcano, Wawona, Wilseyville.  
 Nevada--Babbitt, Hawthorne, Silver City, Virginia City, Yerington, Zephyr Cove.

Intensity III:

California--Pine Grove.  
 Nevada--Genoa, Reno (R).

Intensity II:

California--Floriston.  
 Nevada--Fernley, Sparks.

## 26 February (P) Southern California

Origin time: 22 09 38.2  
 Epicenter: 34.15 N., 118.23 W.  
 Depth: 13 km  
 Magnitude: 3.1 ML

Intensity III: Felt in central Los Angeles County, Burbank, Hollywood (press reports).

## 1 March (B) Central California

Origin time: 21 08 46.1  
 Epicenter: 37.84 N., 122.06 W.  
 Depth: 9 km  
 Magnitude: 3.0 ML

Intensity V: Moraga.

Intensity IV: Kensington, Lafayette.

Intensity III: Albany, Berkeley (B), Castro Valley (B), Danville (B), Oakland (B), San Leandro (telegraphic report), Walnut Creek (B).

## 7 March (P) Southern California

Origin time: 11 04 35.2  
 Epicenter: 34.47 N., 117.97 W.  
 Depth: 8 km  
 Magnitude: 3.0 ML

Intensity III: Palmdale (P).

## 7 March (P) Central California

Origin time: 21 52 24.0  
 Epicenter: 35.73 N., 117.70 W.  
 Depth: 12 km

## California--Continued

Magnitude: 3.0 ML  
Intensity V: China Lake Weather Station (all frightened, objects rattled, doors and windows shaken).  
Intensity III: Ridgecrest.

## 7 March (P) Central California

Origin time: 23 21 30.7  
 Epicenter: 35.73 N., 117.70 W.  
 Depth: 12 km  
 Magnitude: 3.2 ML

Intensity III: China Lake, Ridgecrest.

## 12 March (B) Central California

Origin time: 09 19 06.7  
 Epicenter: 36.89 N., 121.49 W.  
 Depth: 2 km  
 Magnitude: 3.7 ML

Intensity III: Hollister area (B).

## 15 March (P) Central California

Origin time: 08 01  
 Epicenter: 34.01 N., 118.27 W.  
 Depth: None computed.  
 Magnitude: 2.2 ML

Intensity II: Glendale.

## 19 March (P) Central California

Origin time: 10 37 49.7  
 Epicenter: 35.70 N., 117.72 W.  
 Depth: 2 km  
 Magnitude: 3.0 ML

Intensity III: Ridgecrest (P).

## 25 March (P) Southern California

Origin time: 11 23 55.7  
 Epicenter: 33.97 N., 116.60 W.  
 Depth: 11 km  
 Magnitude: 2.8 ML

Intensity III: Palm Springs (P).

## 25 March (P) Southern California

Origin time: 15 43 58.8  
 Epicenter: 32.97 N., 115.50 W.  
 Depth: 13 km  
 Magnitude: 3.4 ML

Intensity III: Brawley (P).

## 31 March (P) Southern California

Origin time: 13 30 29.0  
 Epicenter: 33.40 N., 116.97 W.  
 Depth: 3 km  
 Magnitude: 3.3 ML

Intensity III: Escondido (P).

## 2 April (B) Northern California

Origin time: 06 09 11.9  
 Epicenter: 40.57 N., 123.90 W.  
 Depth: 14 km  
 Magnitude: 4.4 mb(G), 3.6 ML

Intensity IV: Ferndale, Miranda.

## 6 April (P) Southern California

Origin time: 06 01 02.2  
 Epicenter: 33.47 N., 116.47 W.  
 Depth: 16 km  
 Magnitude: 3.5 ML

Intensity III: Coachella Valley area (P).

## California--Continued

## California--Continued

- 4 May (B) Northern California  
 Origin time: 06 59 10.5  
 Epicenter: 39.41 N., 121.49 W.  
 Depth: 7 km  
 Magnitude: 3.5 ML  
Intensity IV: Marysville, Oroville.
- 4 May (B) Northern California  
 Origin time: 19 43 33.8  
 Epicenter: 38.17 N., 121.94 W.  
 Depth: 26 km  
 Magnitude: 3.2 ML  
Intensity III: Fairfield (B), Pittsburg (B), Travis Air Force Base (B), Vacaville (B).  
Intensity II: Crockett.
- 5 May (B) Northern California  
 Origin time: 22 40 31.7  
 Epicenter: 38.17 N., 121.94 W.  
 Depth: 26 km  
 Magnitude: 3.3 ML  
Intensity III: Antioch (B), Fairfield (B), Pittsburg (B), Travis Air Force Base (B).  
Intensity II: Crockett.
- 21 May (B) California-Nevada border region  
 Origin time: 00 28 19.7  
 Epicenter: 37.65 N., 118.75 W.  
 Depth: 12 km  
 Magnitude: 3.4 ML  
Intensity IV: Bishop (felt by all at the South Landing of Crowley Lake; buildings creaked; windows, doors, and dishes rattled).
- 25 May (P) Southern California  
 Origin time: 08 22 00.9  
 Epicenter: 34.15 N., 119.15 W.  
 Depth: 4 km  
 Magnitude: 2.5 ML  
Intensity II: Oxnard (P).
- 30 May (P) Southern California  
 Origin time: 16 16 37.9  
 Epicenter: 33.90 N., 117.88 W.  
 Depth: 5 km  
 Magnitude: 2.6 ML  
Intensity V: Brea-Yorba Linda area (police received 50 calls, including a report of dishes broken when shaken from a cabinet--press report), La Habra (many frightened, some awakened).  
Intensity IV: Fullerton.
- 30 May (P) Southern California  
 Origin time: 21 17 02.9  
 Epicenter: 33.90 N., 117.88 W.  
 Depth: 5 km  
 Magnitude: 2.4 ML  
Intensity II: Orange County (P).
- 31 May (B) Northern California  
 Origin time: 16 40 24.2  
 Epicenter: 40.88 N., 122.33 W.  
 Depth: 15 km  
 Magnitude: 3.7 ML
- Intensity IV: Project City, Shasta County (buildings shook, shock felt by a few people), Mount Shasta area, Whiskeytown Lake Visitor's Center (press report).
- 4 June (B) Northern California  
 Origin time: 20 57 07.5  
 Epicenter: 38.20 N., 121.97 W.  
 Depth: 26 km  
 Magnitude: 3.8 ML  
Intensity V: Fairfield, Martinez (small objects shifted), Solano (small objects shifted), Travis Air Force Base, Yountville (hanging pictures displaced).  
Intensity IV: Clayton, Crockett, Rio Nido, San Carlos, Suisun, Vacaville.  
Intensity III: Birds Landing, Pinole, Stockton.  
Intensity II: Milpitas (B), Napa (B), Pleasant Hill, Port Costa, St. Helena, Vallejo, Walnut Creek (B).
- 7 June (B) Northern California  
 Origin time: 01 14 22.0  
 Epicenter: 41.00 N., 123.87 W.  
 Depth: 28 km  
 Magnitude: 4.6 mb(G), 3.9 ML  
Intensity V: Eureka (small objects shifted), Fortuna, Trinidad (small objects shifted).  
Intensity IV: Bayside, Blue Lake, Hoopa, Korb, Lakehead, McKinleyville, Rio Dell.  
Intensity III: Ferndale, Loleta.  
Intensity II: Dunsmuir, Round Mountain, Willow Creek.
- 11 June (P) Southern California  
 Origin time: 14 18 20.5  
 Epicenter: 34.38 N., 118.62 W.  
 Depth: 5 km  
 Magnitude: 3.1 ML  
Intensity III: Newhall.
- 13 June (P) Southern California  
 Origin time: 03 19 36.9  
 Epicenter: 33.87 N., 118.63 W.  
 Depth: 5 km  
 Magnitude: 2.8 ML  
Intensity II: Santa Monica.
- 14 June (P) Southern California  
 Origin time: 01 56 33.6  
 Epicenter: 34.02 N., 118.32 W.  
 Depth: 5 km  
 Magnitude: 2.7 ML  
Intensity II: Culver City, Glendale, downtown Los Angeles.
- 17 June (P) California-Mexico border region  
 Origin time: 18 42 47.6  
 Epicenter: 32.05 N., 117.33 W.  
 Depth: 6 km  
 Magnitude: 3.3 ML  
Intensity III: San Diego.

## 17 June (B) Northern California

Origin time: 19 38 48.4  
 Epicenter: 38.18 N., 121.93 W.  
 Depth: 22 km  
 Magnitude: 3.5 ML  
Intensity IV: Travis Air Force Base (B).  
Intensity III: Albany (B), Fairfield (B), Fairmont (B), Pacifica (B).

## 20 June (P) Southern California

Origin time: 18 33 00.1  
 Epicenter: 34.02 N., 118.32 W.  
 Depth: 10 km  
 Magnitude: 2.5 ML  
Intensity II: Inglewood.

## 21 June (B) Central California

Origin time: 02 43 06.9  
 Epicenter: 37.65 N., 121.64 W.  
 Depth: 10 km  
 Magnitude: 4.7 mb(G), 3.5 MS(G), 4.6 ML

ML

This earthquake was felt over an area of about 15,700 sq km of central California (fig. 5). Slight damage occurred at El Granada and French Camp. Several small aftershocks (mag. 2.5 or smaller) were recorded (B).

Intensity VI: El Granada (plaster and dry wall cracked), French Camp (sidewalks cracked slightly).

Intensity V: Houses trembled, people were frightened, and small objects moved at

most of the following towns: Alameda, Alamo, Arnold, Big Oak Flat, Banta, Belmont, Ben Lomond, Berkeley, Bethel Island, Birds Landing, Boulder Creek, Burlingame, Castro Valley, Colma, Concord, Crockett, Daly City, Danville, Davenport, Diablo, East Stockton, El Cerrito, El Sobrante, Farmington, Felton, Foster City, Fremont, Half Moon Bay, Hathaway Pines, Hayward, Hercules (a few windows cracked), Lafayette, Larkspur, Livermore, Los Gatos, Manteca, Martinez, Millbrae, Mill Valley, Modesto, Moraga, Moss Beach, Mountain Ranch, Mountain View, Mount Eden, Newark, Novato, Oakland, Olema, Pacifica, Palo Alto, Pinole, Pioneer, Pleasanton, Port Costa, Redwood City, Ross, Saint Helena, San Bruno, San Carlos, San Francisco, San Jose, San Leandro, San Lorenzo, Santa Clara, Sonoma, South San Francisco, Stinson Beach, Stockton, Sunol, Sunset, Tiburon, Tracy, Union City, Vallejo, Valley Springs, Vernalis, Vineburg, Walnut Creek, Walnut Grove, West Menlo Park, Wilseyville.

Intensity IV: Bolinas, Byron, Forest Knolls, Glencoe, Greenbrae, La Honda, Loma Mar, Milpitas, Orinda, Railroad Flat, San Gregorio, Vallecito, Woodacre.

Intensity III: Clayton, Courtland, Elk Grove, Elmira, Holt, Point Reyes Station, Rodeo.

Intensity II: Angels Camp, Antioch, Patterson, Portola Valley, Ryde, Salida, Santa Cruz.

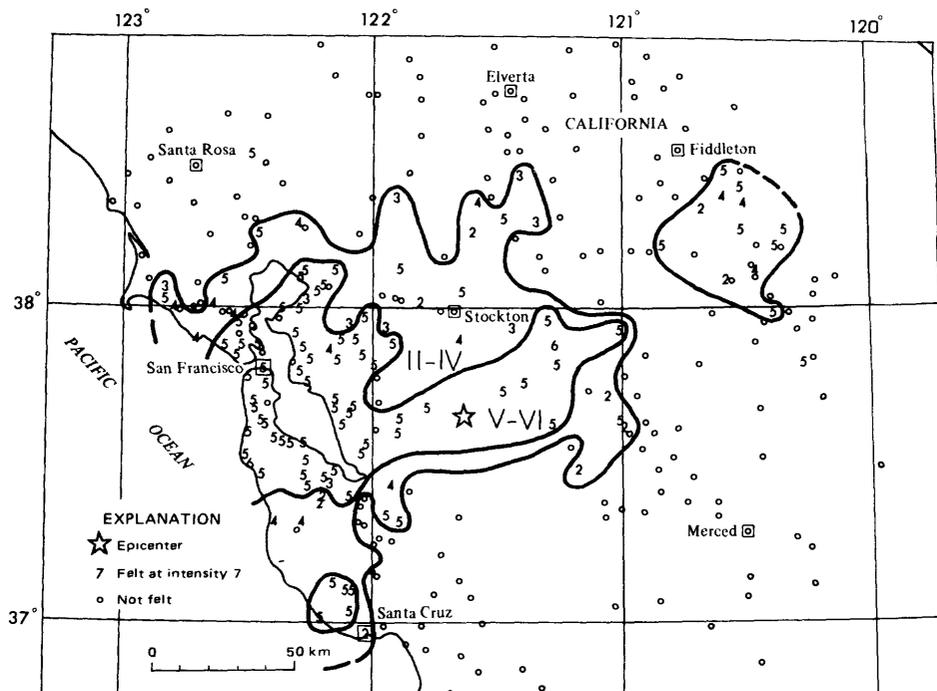


FIGURE 5. Area affected by central California earthquake of June 21. (Roman numerals represent Modified Mercalli intensities between isoseismal contours.)

## California--Continued

## California--Continued

- 3 July (B) Central California  
 Origin time: 19 46 53.0  
 Epicenter: 37.38 N., 121.75 W.  
 Depth: 4 km  
 Magnitude: 3.2 ML  
Intensity III: San Jose area (B).
- 3 July (B) Central California  
 Origin time: 20 21 24.4  
 Epicenter: 37.35 N., 121.72 W.  
 Depth: 7 km  
 Magnitude: 3.3 ML  
Intensity III: San Jose area (B).
- 12 July (B) Northern California  
 Origin time: 01 43 28.5  
 Epicenter: 40.28 N., 123.69 W.  
 Depth: 20 km  
 Magnitude: 5.0 mb(G), 3.8 MS(G), 4.1 ML  
Intensity V: Blocksburg, Bridgeville (small objects shifted), Carlotta (small objects shifted), Eureka (small objects shifted), Fort Bragg (small objects shifted), Fortuna (small objects shifted), Garberville (small objects shifted), Leggett, Loleta, Mad River (small objects shifted), Miranda, Phillippsville (small objects shifted), Piercy, Rio Dell, Scotia (hanging pictures displaced).  
Intensity IV: Alderpoint, Burnt Ranch, Denny, Ferndale, Hayfork, Hyampom, Korbel, Kneeland, Platina, Ruth, Weott, Whitethorn.  
Intensity III: Blue Lake, Forks of Salmon.  
Intensity II: Big Bar, Redding, Trinidad.
- 12 July (B) Northern California  
 Origin time: 05 17 11.2  
 Epicenter: 40.28 N., 123.66 W.  
 Depth: 21 km  
 Magnitude: 3.5 ML  
Intensity V: Bridgeville, Garberville, Leggett, Miranda, Phillippsville, Weott.  
Intensity II: Fortuna, Rio Dell.
- 12 July (B) Northern California  
 Origin time: 15 22 55.8  
 Epicenter: 40.28 N., 123.69 W.  
 Depth: 19 km  
 Magnitude: 3.3 ML  
Intensity IV: Ferndale, Fortuna, Garberville (B), Petrolia, Phillippsville, Rio Dell.
- 13 July (P) Southern California  
 Origin time: 08 12 48.6  
 Epicenter: 34.00 N., 116.83 W.  
 Depth: 11 km  
 Magnitude: 3.0 ML  
Intensity IV: Forest Falls (awakened people, buildings trembled, movement and moderate earth noise heard from northeast-southwest).
- 14 July (B) Central California  
 Origin time: 11 38 05.7  
 Epicenter: 36.56 N., 121.21 W.  
 Depth: 5 km  
 Magnitude: 3.2 ML  
Intensity V: Pinnacles National Monument--37 km south of Paicines (all in area awakened; buildings creaked; windows, doors, and dishes rattled; small objects moved; aftershocks felt at 11:46, 12:44, and 13:13 (int. IV).
- 19 July (B) Northern California  
 Origin time: 23 50 30.6  
 Epicenter: 38.05 N., 121.99 W.  
 Depth: 2 km  
 Magnitude: 3.5 ML  
Intensity III: Martinez, Berkeley (B), Walnut Creek (B).  
Intensity II: Concord (B), Suisun City.
- 26 July (B) Central California  
 Origin time: 21 42 16.3  
 Epicenter: 35.94 N., 120.47 W.  
 Depth: 9 km  
 Magnitude: 3.7 ML  
Intensity IV: Cholame (a few frightened).  
Intensity III: San Miguel.
- 27 July (B) Central California  
 Origin time: 11 10 46.7  
 Epicenter: 36.90 N., 121.51 W.  
 Depth: 1 km  
 Magnitude: 3.2 ML  
Intensity III: San Juan Bautista.
- 27 July (B) Central California  
 Origin time: 21 51 17.5  
 Epicenter: 37.31 N., 122.16 W.  
 Depth: 11 km  
 Magnitude: 3.5 ML  
Intensity IV: Boulder Creek.  
Intensity III: Cupertino, San Francisco South Bay area, San Jose.
- 30 July (B) Central California  
 Origin time: 16 35 38.1  
 Epicenter: 36.91 N., 121.48 W.  
 Depth: 11 km  
 Magnitude: 3.8 ML  
Intensity III: Hollister (B), San Juan Bautista.
- 2 August (B) Central California  
 Origin time: 02 31 43.8  
 Epicenter: 37.91 N., 122.30 W.  
 Depth: 3 km  
 Magnitude: 2.8 ML  
Intensity IV: Albany, Berkeley, El Cerrito (shook walls, rattled windows and glass--all from press report).
- 3 August (P) Southern California  
 Origin time: 22 08 33.7  
 Epicenter: 33.83 N., 118.13 W.  
 Depth: 11 km  
 Magnitude: 2.8 ML  
Intensity II: Cerritos (P).

12 August (P) Southern California  
 Origin time: 02 19 26.1  
 Epicenter: 34.38 N., 118.47 W.  
 Depth: 10 km  
 Magnitude: 4.1 mb(G), 4.4 ML, 4.8 ML(B)

This earthquake was felt over an area of about 10,000 sq km (fig. 6).

Intensity VI: Acton (hanging pictures fell), Glendale (water sloshed onto sides of pools, windows cracked, moving vehicles rocked slightly), Los Angeles (windows cracked, some broken), Northridge (several shopping-center windows cracked, some broken--press report), Reseda (cracks in exterior walls), San Fernando (one 17-year-old girl injured when a shelf of dishes fell on her at her home--press report), Studio City (cracked plaster), Van Nuys (some windows broken, plaster cracked, water sloshed onto sides of pools).

Intensity V: Agoura, Beverly Hills, Burbank, Calabasas, Camarillo, Canoga Park, Canyon Country, Castaic, Chatsworth, Compton, Culver City, East Irvine, El Monte, Fillmore, Fullerton, Granada Hills (water sloshed from swimming pool--press report), Green Valley, Hollywood (press report), Inglewood, La Canada, La Crescenta, Lake Hughes, La Mirada, Long Beach, Lynwood, Malibu, Manhattan Beach, Maywood, Mission Hills, Montebello, Moorpark, Newbury Park, Newhall, Norco, North Glendale, North Hollywood, North Palm Springs, Oxnard, Pacoima, Palmdale, Panorama City, Pasadena, Piru, Reseda,

Riverside, San Gabriel, Santa Barbara, Santa Monica, Saugus, Sepulveda, Sherman Oaks, Simi Valley, Somis, Sunland, Sun Valley, Sylmar, Ventura.

Intensity IV: Big Bear City, Bryn Mawr, La Habra, Osbourne, Placentia, San Bernardino, San Pedro, Topanga, Verdugo Viejo, West Covina.

Intensity III: Anza, Portuguese Bend.  
Intensity II: East Los Angeles, Gardena, Montalvo, Montrose, Santa Paula.

12 August (P) Southern California  
 Origin time: 04 41 38.6  
 Epicenter: 34.38 N., 118.45 W.  
 Depth: 5 km  
 Magnitude: 3.3 ML  
Intensity III: Sylmar (P).

14 August (B) Central California  
 Origin time: 14 25 34.8  
 Epicenter: 37.74 N., 121.92 W.  
 Depth: 9 km  
 Magnitude: 3.4 ML  
Intensity III: Dublin (B), Pleasanton (B), San Ramon (B).

5 September (B) Northern California  
 Origin time: 17 45 28.2  
 Epicenter: 38.19 N., 122.12 W.  
 Depth: 8 km  
 Magnitude: 3.7 ML  
Intensity VI: Eastmont--in the Oakland area (unconfirmed report of cracked plaster).  
Intensity II: Concord (B), Fairfield (B), Pittsburg (B).

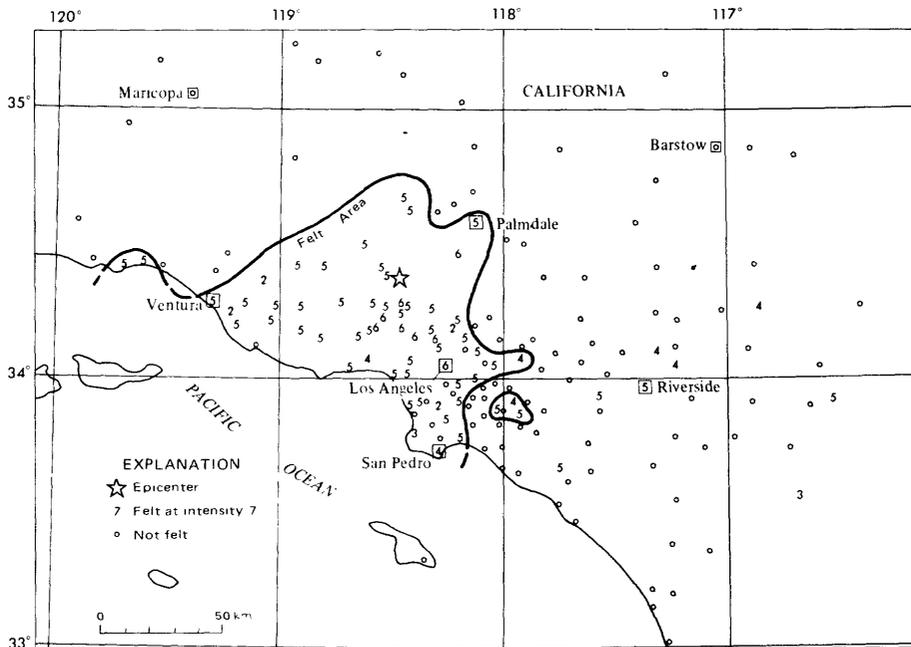


FIGURE 6. Area affected by southern California earthquake of August 12.

## California--Continued

## California--Continued

- 8 September (B) Northern California  
 Origin time: 00 28 20.8  
 Epicenter: 38.68 N., 122.75 W.  
 Depth: 7 km  
 Magnitude: 4.0 mb(G), 3.8 ML  
Intensity V: Calistoga (small objects shifted).  
Intensity IV: Healdsburg and much of Sonoma County (press report).  
Intensity II: Cloverdale.
- 11 September (B) Northern California  
 Origin time: 05 18 46.1  
 Epicenter: 38.68 N., 122.80 W.  
 Depth: 9 km  
 Magnitude: 3.8 mb(G), 3.7 ML  
Intensity IV: Geyserville.  
Intensity III: Healdsburg (B).
- 11 September (B) Northern California  
 Origin time: 23 46 12.2  
 Epicenter: 38.70 N., 122.80 W.  
 Depth: 12 km  
 Magnitude: 3.9 mb(G), 4.0 ML  
Intensity V: Calistoga (small objects shifted).  
Intensity IV: Cloverdale, Cobb, Finley, Geyserville, Healdsburg (B), Stewarts Point.
- 12 September (P) Southern California  
 Origin time: 06 17 42.6  
 Epicenter: 34.22 N., 116.98 W.  
 Depth: 5 km  
 Magnitude: 3.2 ML  
Intensity II: San Bernardino Mountains area (P).
- 14 September (P) Southern California  
 Origin time: 21 35 23.3  
 Epicenter: 33.88 N., 117.82 W.  
 Depth: 2 km  
 Magnitude: 2.7 ML  
Intensity III: Fullerton (P), Placentia (P), Yorba Linda (P).
- 19 September (P) Southern California  
 Origin time: 10 34 54.6  
 Epicenter: 33.95 N., 117.78 W.  
 Depth: 9 km  
 Magnitude: 2.7 ML  
Intensity II: Diamond Bar (P).
- 22 September (P) Southern California  
 Origin time: 09 41 10.5  
 Epicenter: 33.98 N., 116.58 W.  
 Depth: 5 km  
 Magnitude: 3.5 ML  
Intensity IV: Forest Falls, Morongo Valley.  
Intensity III: Coachella Valley (P).
- 22 September (B) Northern California  
 Origin time: 20 48 42.9  
 Epicenter: 38.60 N., 122.76 W.  
 Depth: 5 km  
 Magnitude: 4.0 mb(G), 4.0 ML

- Intensity IV: Geyserville, Healdsburg, Middletown.  
Intensity III: Cobb (B), Santa Rosa (B).
- 24 September (P) Southern California  
 Origin time: 21 28 24.3  
 Epicenter: 34.47 N., 118.42 W.  
 Depth: 5 km  
 Magnitude: 3.9 mb(G), 4.2 ML  
Intensity VI: Los Angeles (hairline cracks in exterior walls--unconfirmed).  
Intensity V: Downey, Glendale, La Crescenta, Lancaster, Montrose, Northridge, San Fernando, Simi Valley, Sunland, Sylmar, Van Nuys, Ventura.  
Intensity IV: Acton, Alhambra, Altadena, Atwood, Beverly Hills, Burbank, Canoga Park, Castaic, Granada Hills, Hazard, La Canada, Lake Hughes, Los Angeles, Newhall, North Glendale, North Hollywood, Pacoima, Palmdale, Placentia, South El Monte, Studio City, Sun Valley, Tarzana, Temple City, Thousand Oaks, Tujunga, Van Nuys.  
Intensity III: Fillmore, Monrovia.
- 4 October (B) Northern California  
 Origin time: 06 39 39.6  
 Epicenter: 40.26 N., 121.27 W.  
 Depth: 5 km  
 Magnitude: 3.8 ML  
Intensity V: Chester (many awakened from sleep; buildings trembled).  
Intensity IV: Clear Creek.
- 6 October (P) Southern California  
 Origin time: 08 16 03.4  
 Epicenter: 34.02 N., 118.18 W.  
 Depth: 14 km  
 Magnitude: 3.3 ML  
Intensity III: East Los Angeles and Montebello areas (press report).
- 6 October (P) Southern California  
 Origin time: 11 50 58.1  
 Epicenter: 34.88 N., 120.32 W.  
 Depth: 4 km  
 Magnitude: 2.9 ML  
Intensity II: Santa Maria (P).
- 6 October (P) Southern California  
 Origin time: 11 52 04.7  
 Epicenter: 34.88 N., 120.30 W.  
 Depth: 4 km  
 Magnitude: 2.5 ML  
Intensity II: Santa Maria (P).
- 6 October (P) Southern California  
 Origin time: 11 56 50.2  
 Epicenter: 34.87 N., 120.37 W.  
 Depth: 3 km  
 Magnitude: 2.8 ML  
Intensity II: Santa Maria (P).

## California--Continued

## California--Continued

- 9 October (P) Southern California  
 Origin time: 03 26 26.3  
 Epicenter: 34.42 N., 118.42 W.  
 Depth: 10 km  
 Magnitude: 3.3 ML  
Intensity III: Newhall (P), Saugus (P).
- 13 October (B) Central California  
 Origin time: 16 10 27.7  
 Epicenter: 37.47 N., 121.03 W.  
 Depth: 10 km  
 Magnitude: 3.7 ML  
Intensity V:  
 Modesto--Many people felt shock; awakened several; buildings trembled.  
 Ripon--A few people frightened; windows, doors, dishes rattled; small objects shifted.  
 Riverbank--Several awakened and frightened; buildings trembled.  
Intensity IV: Patterson, Turlock, Waterford (press report).  
Intensity III: Stockton (press report).  
Intensity II: Fresno (press report), Keyes.
- 19 October (P) California-Mexico border region  
 Origin time: 06 56 07.7  
 Epicenter: 32.90 N., 115.50 W.  
 Depth: 5 km  
 Magnitude: 2.8 ML  
Intensity II: Brawley (P).
- 19 October (B) Northern California  
 Origin time: 11 46 08.3  
 Epicenter: 38.36 N., 122.56 W.  
 Depth: 10 km  
 Magnitude: 3.3 ML  
Intensity IV: Napa (press report), Yountville (press report).  
Intensity III: Bennett Valley (press report), Petaluma (press report), Rohnert Park (press report), Santa Rosa (B), Sonoma (B).
- 19 October (P) California-Mexico border region  
 Origin time: 12 13 35.6  
 Epicenter: 32.88 N., 115.50 W.  
 Depth: 6 km  
 Magnitude: 2.9 ML  
Intensity III: Brawley (P).
- 20 October (P) California-Mexico border region  
 Origin time: 08 17 40.5  
 Epicenter: 32.88 N., 115.50 W.  
 Depth: 5 km  
 Magnitude: 3.2 ML  
Intensity II: Brawley (P).
- 20 October (P) California-Mexico border region  
 Origin time: 10 29 35.9  
 Epicenter: 32.88 N., 115.50 W.  
 Depth: 5 km  
 Magnitude: 4.0 ML  
Intensity II: Brawley (P).
- 20 October (P) California-Mexico border region  
 Origin time: 19 06 16.5  
 Epicenter: 32.88 N., 115.50 W.  
 Depth: 4 km  
 Magnitude: 3.8 ML  
Intensity II: Brawley (P).
- 20 October (P) Southern California  
 Origin time: 20 14 00.6  
 Epicenter: 33.73 N., 118.02 W.  
 Depth: 5 km  
 Magnitude: 2.7 ML  
Intensity II: Huntington Beach (P), Long Beach (P), Westminster (P).
- 20 October (P) California-Mexico border region  
 Origin time: 20 22 22.9  
 Epicenter: 32.90 N., 115.50 W.  
 Depth: 5 km  
 Magnitude: 3.9 ML  
Intensity II: Brawley (P).
- 21 October (P) California-Mexico border region  
 Origin time: 00 09 39.1  
 Epicenter: 32.90 N., 115.50 W.  
 Depth: 6 km  
 Magnitude: 3.4 ML  
Intensity II: Brawley (P).
- 21 October (P) California-Mexico border region  
 Origin time: 06 12 36.2  
 Epicenter: 32.90 N., 115.50 W.  
 Depth: 6 km  
 Magnitude: 3.7 mb(G), 4.3 ML  
Intensity VI: Brawley (cracked plaster, shifted small objects).  
Intensity V: El Centro, Holtville (press report), Imperial (burglar alarms set off in many communities of Imperial Valley--press report).  
Intensity IV: Heber.
- 21 October (P) California-Mexico border region  
 Origin time: 13 24 24.2  
 Epicenter: 32.90 N., 115.50 W.  
 Depth: 5 km  
 Magnitude: 4.2 ML  
Intensity III: Brawley (P).
- 21 October (P) California-Mexico border region  
 Origin time: 18 10 58.3  
 Epicenter: 32.88 N., 115.50 W.  
 Depth: 5 km  
 Magnitude: 3.0 ML  
Intensity II: Brawley (P).
- 22 October (P) Southern California  
 Origin time: 04 59 17.3  
 Epicenter: 34.38 N., 117.05 W.  
 Depth: 2 km  
 Magnitude: 3.7 ML  
Intensity II: Big Bear Lake (P), Lucerne Valley (P).

## California--Continued

- 28 October (P) California-Mexico border region  
 Origin time: 21 24 52.4  
 Epicenter: 32.87 N., 115.50 W.  
 Depth: 16 km  
 Magnitude: 3.9 ML  
Intensity II: Brawley (P).
- 28 October (P) California-Mexico border region  
 Origin time: 21 31 36.6  
 Epicenter: 32.90 N., 115.52 W.  
 Depth: 5 km  
 Magnitude: 3.0 ML  
Intensity II: Brawley (press report).
- 30 October (P) California-Mexico border region  
 Origin time: 05 30 13.3  
 Epicenter: 32.88 N., 115.50 W.  
 Depth: 4 km  
 Magnitude: 4.7 mb(G), 4.0 ML  
Intensity II: El Centro (P).
- 1 November (B) Central California  
 Origin time: 04 06 43.4  
 Epicenter: 37.71 N., 122.56 W.  
 Depth: 2 km  
 Magnitude: 3.3 ML  
Intensity IV: San Francisco.
- 4 November (B) Central California  
 Origin time: 15 12 53.0  
 Epicenter: 36.58 N., 121.20 W.  
 Depth: 5 km  
 Magnitude: 3.4 ML
- This is the last and largest of five earthquakes that occurred in the Bitterwater and Bear Valley regions on November 3-4.
- Intensity V: Chualar (small objects shifted).  
Intensity IV: Greenfield, Pacific Grove, Soledad.  
Intensity III: Bear Valley (press report).  
Intensity II: Hollister (press report), King City, Pinnacles National Monument (press report).
- 8 November (P) Southern California  
 Origin time: 10 52 27.2  
 Epicenter: 33.88 N., 117.90 W.  
 Depth: 7 km  
 Magnitude: 3.4 ML  
Intensity V: Anaheim (small objects shifted), La Mirada, Placentia.  
Intensity IV: Fullerton, La Habra.
- 10 November (B) Northern California  
 Origin time: 20 24 42.2  
 Epicenter: 39.43 N., 121.53 W.  
 Depth: 4 km  
 Magnitude: 2.7 ML  
Intensity IV: Oroville, Palermo.
- 13 November (P) California-Mexico border region  
 Origin time: 16 25 19.7  
 Epicenter: 32.83 N., 115.47 W.

## California--Continued

- Depth: 5 km  
 Magnitude: 3.2 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 00 11 35.8  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 3.9 ML  
Intensity III: Imperial Valley region (P).
- 14 November (P) California-Mexico border region  
 Origin time: 00 33 31.0  
 Epicenter: 32.82 N., 115.47 W.  
 Depth: 4 km  
 Magnitude: 3.1 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 02 05 47.9  
 Epicenter: 32.82 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 5.0 mb(G), 4.2 ML  
Intensity VI:  
 Arizona--Somerton (heavy furniture shifted; few windows cracked; slight damage).  
 California--El Centro (slight damage to plaster walls in post office; small pieces fell; some windows broken), Imperial (cracks in interior plaster walls).  
Intensity V:  
 Arizona--Yuma.  
 California--Calxico, El Cajon, Heber, Hultville, Winterhaven.  
Intensity IV:  
 California--Coachella Valley water district, Indio, Jacumba, Niland, Plaster City, Salton City.  
Intensity III:  
 California--Riverside County, San Diego County.  
Intensity II:  
 California--Bard, Palm Desert, Poway.
- 14 November (P) California-Mexico border region  
 Origin time: 02 10 18.5  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 3.4 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 02 32 14.8  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 3.1 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 03 19 07.2  
 Epicenter: 32.82 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 3.0 ML  
Intensity III: El Centro (P).

## California--Continued

- 14 November (P) California-Mexico border region  
 Origin time: 04 49 56.6  
 Epicenter: 32.80 N., 115.47 W.  
 Depth: 6 km  
 Magnitude: 3.0 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 05 05 20.3  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 3 km  
 Magnitude: 3.8 ML  
Intensity III: Imperial Valley (P).
- 14 November (P) California-Mexico border region  
 Origin time: 05 13 45.3  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 3.1 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 05 18 02.6  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 6 km  
 Magnitude: 3.7 ML  
Intensity III: Imperial Valley (P).
- 14 November (P) California-Mexico border region  
 Origin time: 05 23 36.5  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 4 km  
 Magnitude: 3.8 ML  
Intensity III: Imperial Valley (P).
- 14 November (P) California-Mexico border region  
 Origin time: 05 30 40.8  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 7 km  
 Magnitude: 3.3 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 05 36 55.4  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 4.1 ML  
Intensity IV: Imperial Valley, Calif.,  
 to Yuma, Ariz. (P).
- 14 November (P) California-Mexico border region  
 Origin time: 10 23 06.2  
 Epicenter: 32.77 N., 115.47 W.  
 Depth: 4 km  
 Magnitude: 3.4 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 12 20 19.5  
 Epicenter: 32.82 N., 115.45 W.  
 Depth: 5 km  
 Magnitude: 4.3 ML  
Intensity IV: Imperial Valley, Calif.,  
 to Yuma, Ariz. (P).
- 14 November (P) California-Mexico border region  
 Origin time: 16 10 33.6  
 Epicenter: 32.82 N., 115.45 W.

## California--Continued

- Depth: 6 km  
 Magnitude: 3.2 ML  
Intensity III: El Centro (P).
- 14 November (P) California-Mexico border region  
 Origin time: 16 18 53.3  
 Epicenter: 32.82 N., 115.45 W.  
 Depth: 6 km  
 Magnitude: 3.2 ML  
Intensity III: El Centro (P).
- 15 November (P) California-Mexico border region  
 Origin time: 19 13 16.9  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 5 km  
 Magnitude: 3.4 ML  
Intensity III: Imperial Valley (P).
- 16 November (P) California-Mexico border region  
 Origin time: 17 29 17.7  
 Epicenter: 32.83 N., 115.47 W.  
 Depth: 4 km  
 Magnitude: 2.6 ML  
Intensity II: El Centro (P).
- 18 November (B) Central California  
 Origin time: 02 17 18.4  
 Epicenter: 35.69 N., 121.04 W.  
 Depth: 3 km  
 Magnitude: 3.9 ML  
Intensity IV: Bradley.  
Intensity III: Cambria.  
Intensity II: St. Helena.
- 22 November (B) Northern California  
 Origin time: 21 15 52.5  
 Epicenter: 39.45 N., 123.26 W.  
 Depth: 5 km  
 Magnitude: 5.2 mb(G), 4.8 ML

Willits, a city of 3,700 residents, is situated on the west edge of Little Lake Valley, a small alluvial basin near the head of the Eel River drainage. Franciscan assemblage rocks comprise the uplands surrounding the valley, and unconsolidated Quaternary deposits form the valley floor. Little Rock Valley is an area of active faulting, as evidenced by the en echelon cracks in the pavement in Willits and related right-lateral offsets in curbs and sidewalks at five localities (Simon and others, 1978). This faulting in Willits does not appear to be directly related to this earthquake, as the earthquake is located about 9 km east of the town.

Most of the damage descriptions at Willits, listed under intensity VII below, was excerpted from Simon and others (1978). Figure 7 shows the geographical distribution of the damage in the Willits area.

The intensity data shown in figure 8 are the result of field interviews in the rural areas of Little Lake Valley, east of Willits, by K. L. Verosub, University of

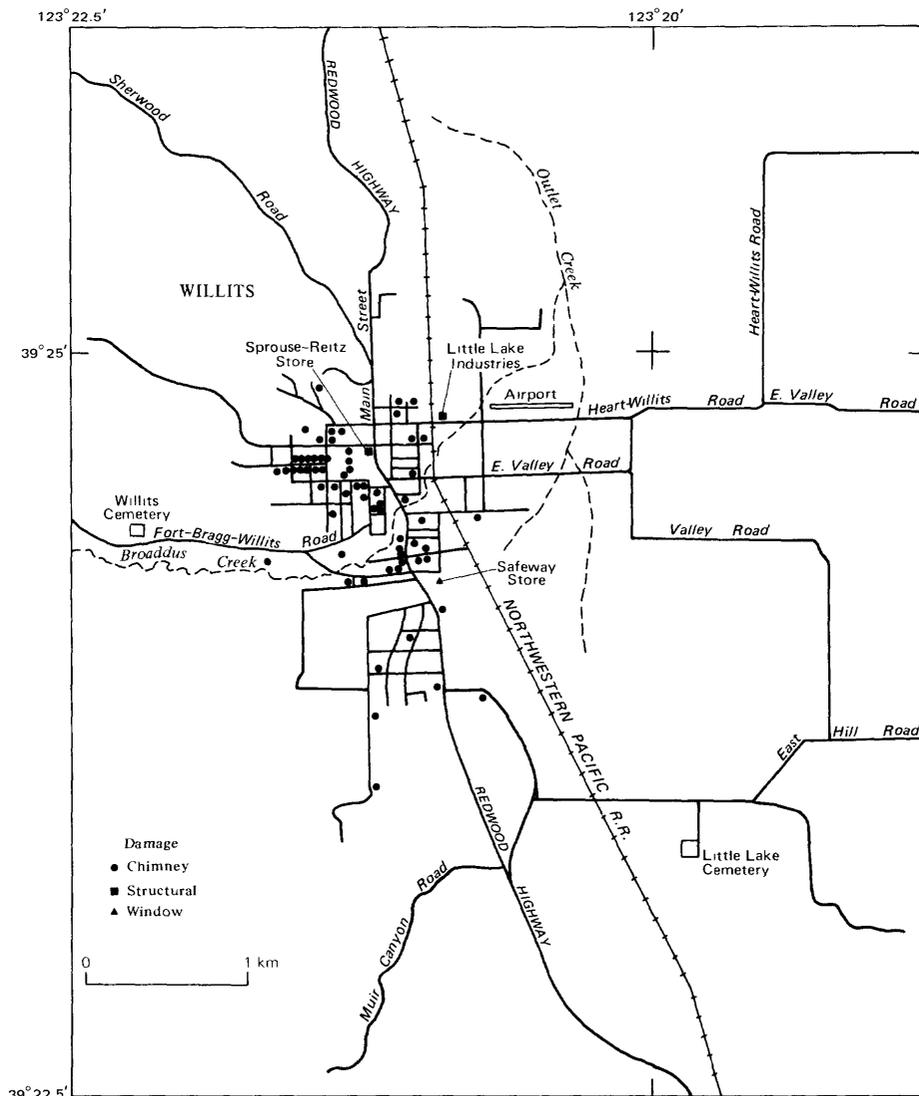


FIGURE 7. Damage map of community of Willits for northern California earthquake of November 22 (Simon and others, 1978).

California, Davis, and of evaluations by USGS. These results are combined with the USGS questionnaire canvass and are listed below as effects at individual residences in Little Lake Valley.

This earthquake was felt over an area of about 15,000 sq km as shown in figure 9.

#### Intensity VII:

Willits—Two buildings sustained structural damage: the Sprouse-Reitz Store at 150 S. Main St. and a warehouse-type building that houses Little Lake Industries near the northeast corner of Hearst-Willits

Road and the Northwestern Pacific Railroad tracks. The Sprouse-Reitz Store is housed in two old buildings, one brick and one concrete. They are joined lengthwise in an east-west direction, with flat roofs supported by reinforced concrete columns about 30 cm square; there are no north-south walls in this store. The two parts of this store responded differentially to the shaking as evidenced by cracks and offsets of as much as 12 mm along the join. Patches of new brick (ca. 1972) in the old brick wall also responded independently, as cracks outlined the patches and offsets

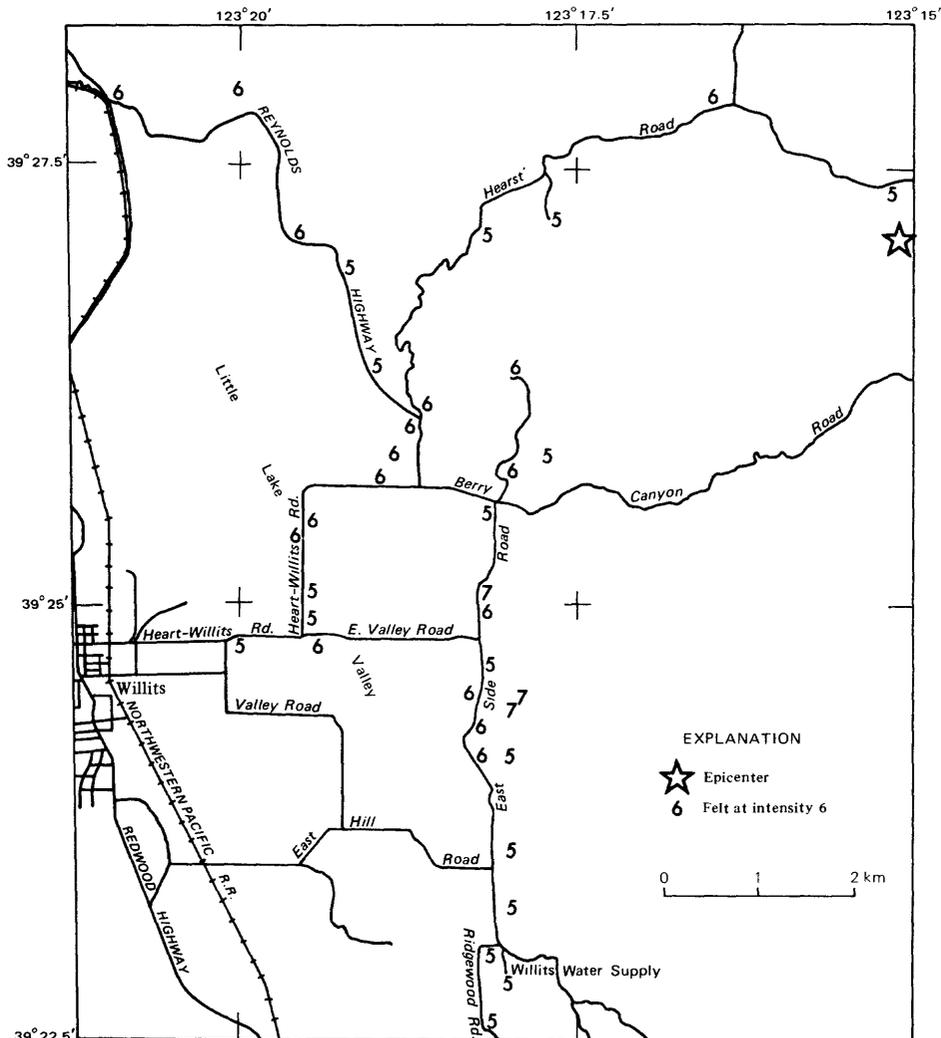


FIGURE 8. Intensity map of Little Lake Valley region for northern California earthquake of November 22 (Simon and others, 1978). Arabic numerals represent Modified Mercalli intensities at specific sites.

of as much as 12 mm were formed. Near the building join, the concrete columns were cracked, and the ceiling of the concrete building were dropped as much as 50 mm. Evidence of some pounding between the two parts was suggested by damage to cabinets and fixtures fastened to the wall near the join. Aftershocks on the morning of November 23 damaged the front plate-glass windows, by north-south distortion of the building and window frames.

The corner building, located two buildings south of the Sprouse-Reitz Store, had numerous cracks in its south-facing stucco wall. Close inspection showed

that most if not all of the cracks were preearthquake, but that some pounding had occurred during the earthquake. These cracks, which formed a rectangular pattern, probably represented former openings in the original wall that had been closed and plastered over within the past few years.

The Safeway Store lost one large pane of glass. Many bottled goods were thrown from the shelves during the initial shock, but the store appeared sound otherwise.

Goods on east-west-oriented shelves were thrown down, but those on north-south-oriented shelves were not. The

Sprouse-Reitz Store lost items from its east-west shelves, but an auto parts store lost nothing from its predominantly north-south shelves.

A drive-through inspection of the cemeteries revealed no toppled monuments; individual monuments were not examined for signs of having been rotated. On the west side of Main Street in the major residential district, damage appeared to be restricted to brick chimneys on houses at least 30 years old, and more likely more than 50 years old. Damage to many chimneys was confined to the upper end, within the uppermost two or three courses of brick. Only a few chimneys were reduced to the roofline; it is not known if these chimneys actually collapsed to the roofline or were razed to that point during the cleanup operation that began soon after the main shock. At least 10 of the damaged chimneys were broken midway between the roofline and top, the upper part being offset 5° to 45° in a clockwise direction from the lower part; only two damaged chimneys were offset in a counter-clockwise sense. The chimneys that sustained the most damage were old, unreinforced brick of mortar construction. In contrast, newer chimneys, probably all less than 30 years old, appeared to be undamaged. Presumably, they contained reinforcing steel, but all were brick and mortar surrounding a fire-clay flue which itself may have acted as reinforcement. The City Building Inspector listed a total of 65 chimneys damaged by the November 22 shock. All of these defined a north-northwest-trending zone about 2.6 km long and 0.6 km wide. The zone is bounded on the east by the railroad and on the north by Willits Creek. Thirty-four of these chimneys were concentrated in the northern third of this zone; the others were scattered throughout the southern two-thirds. The highest concentration of damage was on Redwood Street, where 13 chimneys were damaged in a three-block area.

Only three slope failures, all in steep roadcuts, were found. These contained a total volume estimated at less than 1 cu m. It is not known whether these failures were caused by the heavy rain that preceded the earthquake, by the earthquake, or by some other agent. Car windshields were broken by falling bricks; plate-glass windows of Star Super and Safeway Stores were broken and groceries were thrown from shelves, forcing the stores to close for 3 hours to clean up. Safeway reported \$1,000 damage to food and liquor. Three schools closed for the day. The high school had a few bricks dislodged over the front door and some interior plaster damaged. A few internal walls of older structures

collapsed; one of the hardest hit houses is located on Redwood Avenue. An inside wall collapsed, and the chimney of the fireplace fell apart, both outside and inside. Waves (rippling) appeared on the ground.

**Little Lake Valley, east of Willits**--Residences on East Side Road near East Valley Roads are listed below by owner or resident (fig. 8).  
**Coleman-Hatch**--At this residence, about 0.7 km north of Douglas and Turners' residences listed below, the chimney was cracked above the roofline; pictures fell from the walls; heavy furniture, including beds on the second floor, moved away from the wall about 15 cm; toilet tank lids flew up and off their bases; plaster cracked.  
**Turners**--A well pipe was reported broken, water sloshed out of the fish tank, and brackishness was noted in the water from a recently drilled well.

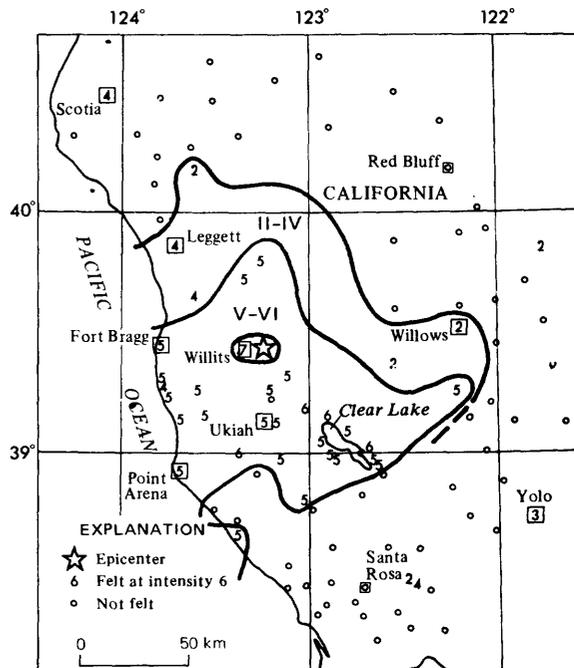


FIGURE 9. Area affected by northern California earthquake of November 22.

#### Intensity VI:

**Boonville**--Stone fences cracked, light furniture moved, standing vehicles rocked, trees and bushes shaken.

**Clearlake Oaks**--Foundations cracked, light furniture and small objects moved, buildings trembled, moving vehicles rocked moderately, water splashed onto sides of lake, many frightened.

**Little Lake Valley, east of Willits**--Owners or residents of all 16 properties reported slight damage (fig. 8).

-----  
 California--Continued  
 -----

Upper Lake--Interior walls split, plaster and dry-wall cracked, buildings creaked.  
 Witter Springs--Sidewalks cracked, hairline cracks in exterior walls, plaster cracked, small objects fell, hanging objects and doors swing violently north-south.

Intensity V: Albion, Clearlake Highlands, Clearlake Park, Cloverdale, Comptche, Covelo, Dos Rios, Elk, Finley, Fort Bragg, Hopland, Kelseyville, Lakeport, Leggett, Little Lake Valley, Lucerne, Maxwell, Mendocino, Navarro, Point Arena, Potter Valley, Redwood Valley, Stewarts Point, Talmage, Ukiah.

Intensity IV: Branscomb, Rutherford, Scotia, Stonyford.

Intensity III: Yolo (several felt earthquake).

Intensity II: Alderpoint, Richardson Springs, St. Helena (press report), Willows.

23 November (B) Near coast of Northern California  
 Origin time: 13 53 53.8  
 Epicenter: 39.45 N., 123.29 W.  
 Depth: 3 km  
 Magnitude: 3.4 ML, 4.0 mb(G)  
Intensity IV: Willits.

23 November (B) Near coast of Northern California  
 Origin time: 15 27 14.4  
 Epicenter: 39.50 N., 123.30 W.  
 Depth: 5 km  
 Magnitude: 3.6 ML  
Intensity IV: Willits.

23 November (B) Near coast of Northern California  
 Origin time: 15 29 13.3  
 Epicenter: 39.50 N., 123.30 W.  
 Depth: 5 km  
 Magnitude: 3.3 ML  
Intensity IV: Willits.

29 November (B) Central California  
 Origin time: 16 42 02.4  
 Epicenter: 35.96 N., 120.49 W.  
 Depth: 11 km  
 Magnitude: 3.6 mb(G), 3.7 ML  
Intensity IV: Bradley, Cholame, San Miguel.  
Intensity III: Southern Monterey County, western Fresno County.  
Intensity II: Atascadero (press report), San Luis Obispo (P).

3 December (P) Southern California  
 Origin time: 06 54 59.6  
 Epicenter: 34.07 N., 118.40 W.  
 Depth: 7 km  
 Magnitude: 2.2 ML  
Intensity II: Hollywood (P).

7 December (P) Southern California  
 Origin time: 15 40 59.2  
 Epicenter: 33.78 N., 118.08 W.  
 Depth: 6 km  
 Magnitude: 2.7 ML

-----  
 California--Continued  
 -----

Intensity II: Long Beach (P).

9 December (B) Central California  
 Origin time: 02 26 54.5  
 Epicenter: 37.71 N., 122.62 W.  
 Depth: 4 km  
 Magnitude: 2.9 ML  
Intensity III: Daly City, Sunset District of San Francisco.

12 December (B) Central California  
 Origin time: 01 11 46.1  
 Epicenter: 37.33 N., 121.70 W.  
 Depth: 7 km  
 Magnitude: 3.5 ML  
Intensity III: Gilroy (B), San Jose (B), San Juan Bautista.

15 December (B) Central California  
 Origin time: 11 15 29.0  
 Epicenter: 36.58 N., 121.23 W.  
 Depth: 6 km  
 Magnitude: 3.6 mb(G), 4.2 ML

This earthquake was felt over an area of about 5,500 sq km. Its epicenter is located in the vicinity of the San Andreas fault in the Bear Valley area (B).

Intensity VI: Carmel Valley (plaster cracks in post office).

Intensity V: Big Sur, Carmel, Chualar, Del Rey Oaks, Gonzales, Hollister, Los Gatos, Monterey, Mount Hermon, Pacific Grove, Paicines, Salinas, San Miguel, Seaside, Soledad, Soquel.

Intensity IV: Capitola, Emmet (press report), Freedom, Marina, Moss Landing, Pinnacles area (press report), San Benito County (press report), Santa Ana Valley (press report), San Juan Bautista, Santa Cruz, Watsonville.

Intensity III: Aromas, Greenfield, Mount Hamilton.

Intensity II: Mission.

20 December (P) Southern California  
 Origin time: 13 15 13.9  
 Epicenter: 34.03 N., 118.20 W.  
 Depth: 6 km  
 Magnitude: 2.8 ML  
Intensity V: Bell, Glendale, Hacienda Heights, Hancock, Hazard, Los Angeles (downtown, south-central, and southeast areas--press report), Maywood, North Edwards, South Gate, South Pasadena.  
Intensity IV: Bell Gardens, Calimesa, Compton, La Plama, Llano, Long Beach, Monterey Park, Murietta, Pico Rivera, Rowland Heights, Torrance, Vernon (press report).  
Intensity II: El Toro, La Habra, Pacoima, Phelan.

27 December (P) Southern California  
 Origin time: 06 07 56.2  
 Epicenter: 33.91 N., 118.51 W.  
 Depth: 11 km  
 Magnitude: 2.7 ML  
Intensity II: Hawthorne (P).

-----  
 California--Continued  
 -----

- 28 December (B) Central California  
 Origin time: 02 59 37.3  
 Epicenter: 35.82 N., 120.33 W.  
 Depth: 2 km  
 Magnitude: 3.5 ML  
Intensity V: Bradley, San Miguel.  
Intensity II: San Luis Obispo (P).
- 29 December (B) Central California  
 Origin time: 14 09 16.7  
 Epicenter: 36.86 N., 120.04 W.  
 Depth: 8 km  
 Magnitude: 3.5 ML  
Intensity II: Fresno (B), Kerman (press report), Madera (B).

-----  
 Colorado  
 -----

- 3 March (G) Wyoming  
 Origin time: 17 50 28.0  
 See Wyoming listing.
- 5 March (G) Northwestern New Mexico  
 Origin time: 03 00 54.7  
 See New Mexico listing.
- 30 September (G) Utah  
 Origin time: 10 19 21.0  
 See Utah listing.
- 3 November Northern Colorado  
 Origin time: 05 34  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: 2.0 ML(G)  
Intensity II: Larimer County in Poudre River Canyon.

-----  
 Delaware  
 -----

- 10 February Northern Delaware  
 Origin time: 19 14 25  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: 2.0 mbLg(Z)
- R.R. Jordan, Delaware Geological Survey (DGS), Newark, reported the following:
- "Approximately 200 felt report forms were distributed, and about 70 replies were received and analyzed. In addition, Wilmington City police provided additional data by allowing DGS staff to review their records on earthquake calls.... Two reports of cracked plaster were received, which places the highest intensity observed as V [VI]. The areas of low intensities are poorly defined since the earthquake occurred in the middle of the day and went unnoticed by most people outside the

-----  
 Delaware--Continued  
 -----

highest intensity zones. This undoubtedly introduced some bias into the intensity map.  
 "The epicenter appears to be in the same general areas as other small events in Wilmington, and had the same general characteristics associated with it as did these other events, i.e., a sharp, "explosive" noise of short duration and high-frequency vibrations lasting only 2 or 3 seconds. About 30 small earthquakes have been recorded in the Wilmington area since 1971, in addition to the larger event of February 28, 1973."

Intensity VI: Wilmington (plaster cracked at Stratford, near New Castle, and in Lancaster Village).

-----  
 Georgia  
 -----

- 27 July (G) Tennessee  
 Origin time: 22 03 21.3  
 See Tennessee listing.

-----  
 Hawaii  
 -----

- 1 January (H) Hawaii  
 Origin time: 14 26 35.3  
 Epicenter: 19.34 N., 155.12 W.  
 Depth: 9 km  
 Magnitude: 3.7 ML  
Intensity II: Hilo (H).
- 5 January (H) Hawaii  
 Origin time: 00 25 13.2  
 Epicenter: 19.39 N., 155.25 W.  
 Depth: 5 km  
 Magnitude: 3.6 ML  
Intensity III: Hawaiian Volcano Observatory (H), Volcano (H).
- 8 January (H) Hawaii  
 Origin time: 10 02 38.0  
 Epicenter: 19.33 N., 155.13 W.  
 Depth: 10 km  
 Magnitude: 4.1 ML  
Intensity III: Puna District (H), Volcano (H).
- 12 January (H) Hawaii  
 Origin time: 13 05 59.3  
 Epicenter: 19.40 N., 155.29 W.  
 Depth: 16 km  
 Magnitude: 3.9 ML  
Intensity IV: Hilo (H), Mountain View (H), Volcano (H).  
Intensity III: Kau District (H), Kona District (H), Red Hill (H).

## Hawaii--Continued

- 14 January (H) Hawaii  
 Origin time: 23 26 42.3  
 Epicenter: 19.34 N., 155.12 W.  
 Depth: 9 km  
 Magnitude: 4.2 mb(G), 4.7 ML  
 Felt islandwide.  
Intensity IV: Hilo (H), Honomu, Kahului  
 (H), Keaau, Lahaina, Naalehu, Pahala,  
 Papaikou, Volcano.  
Intensity III: Ookala.  
Intensity II: Papaaloa.
- 20 January (H) Hawaii  
 Origin time: 12 20 27.8  
 Epicenter: 19.33 N., 155.19 W.  
 Depth: 9 km  
 Magnitude: 3.4 ML  
Intensity III: Hilo (H), Mountain View  
 (H), Volcano (H).
- 22 January (H) Hawaii  
 Origin time: 17 32 42.5  
 Epicenter: 19.36 N., 155.25 W.  
 Depth: 10 km  
 Magnitude: 3.6 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Hilo (H), Volcano (H).
- 22 January (H) Hawaii  
 Origin time: 18 02 44.2  
 Epicenter: 19.39 N., 155.25 W.  
 Depth: 6 km  
 Magnitude: 3.6 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).
- 23 January (H) Hawaii  
 Origin time: 20 49 01.7  
 Epicenter: 19.34 N., 155.20 W.  
 Depth: 9 km  
 Magnitude: 4.8 mb(G), 4.0 ML  
Intensity IV: Hilo (H).  
Intensity III: Puna District (H), Volcano  
 (H).
- 30 January (H) Hawaii  
 Origin time: 08 48 49.7  
 Epicenter: 19.37 N., 155.08 W.  
 Depth: 8 km  
 Magnitude: 4.1 ML  
Intensity IV: Hilo (H).  
Intensity III: Glenwood (H), Volcano (H).
- 2 February (H) Hawaii  
 Origin time: 18 11 29.3  
 Epicenter: 19.39 N., 155.07 W.  
 Depth: 8 km  
 Magnitude: 3.0 ML  
Intensity III: Hilo (H).
- 4 February (H) Hawaii  
 Origin time: 01 20 49.7  
 Epicenter: 19.36 N., 155.08 W.  
 Depth: 9 km  
 Magnitude: 4.5 mb(G), 4.5 ML  
Intensity IV: Hamakua District (H),  
 Hilo, Keaau, Kurtistown, Paho, Papaikou,

## Hawaii--Continued

- Puna District (H), Volcano.  
Intensity III: Kona (H), Mountain View.
- 4 February (H) Hawaii  
 Origin time: 14 25 11.7  
 Epicenter: 20.11 N., 155.47 W.  
 Depth: 1 km  
 Magnitude: 3.7 ML  
Intensity IV: Honokaa (H), Waimea (H).  
Intensity III: Kohala (H), Kona District  
 (H), Pepeekeo (H).
- 9 February (H) Hawaii  
 Origin time: 00 47 02.2  
 Epicenter: 19.39 N., 155.25 W.  
 Depth: 3 km  
 Magnitude: 3.1 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H).
- 9 February (H) Hawaii  
 Origin time: 04 51 20.2  
 Epicenter: 19.39 N., 155.23 W.  
 Depth: 3 km  
 Magnitude: 3.4 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).
- 9 February (H) Hawaii  
 Origin time: 05 02 22.2  
 Epicenter: 19.39 N., 155.24 W.  
 Depth: 7 km  
 Magnitude: 3.5 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).
- 9 February (H) Hawaii  
 Origin time: 05 23 31.8  
 Epicenter: 19.39 N., 155.25 W.  
 Depth: 5 km  
 Magnitude: 3.5 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).
- 9 February (H) Hawaii  
 Origin time: 05 28 30.0  
 Epicenter: 19.39 N., 155.25 W.  
 Depth: 5 km  
 Magnitude: 3.4 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).
- 9 February (H) Hawaii  
 Origin time: 05 54 26.5  
 Epicenter: 19.37 N., 155.24 W.  
 Depth: 0 km  
 Magnitude: 3.0 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).
- 9 February (H) Hawaii  
 Origin time: 06 44 06.1  
 Epicenter: 19.38 N., 155.25 W.  
 Depth: 1 km  
 Magnitude: 3.1 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).

## Hawaii--Continued

9 February (H) Hawaii  
 Origin time: 07 27 35.4  
 Epicenter: 19.39 N., 155.26 W.  
 Depth: 1 km  
 Magnitude: 3.2 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).

9 February (H) Hawaii  
 Origin time: 19 22 01.0  
 Epicenter: 19.39 N., 155.08 W.  
 Depth: 8 km  
 Magnitude: 3.3 ML  
Intensity III: Hilo (H).

10 February (H) Hawaii  
 Origin time: 07 14 47.0  
 Epicenter: 19.39 N., 155.25 W.  
 Depth: 5 km  
 Magnitude: 3.0 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).

21 February (H) Hawaii  
 Origin time: 03 29 42.8  
 Epicenter: 19.33 N., 155.27 W.  
 Depth: 10 km  
 Magnitude: 3.7 ML  
Intensity IV: Hilo (H).  
Intensity III: Glenwood (H), Volcano  
 (H).  
Intensity II: Papaikou (H), Pepeekeo  
 (H), Kona District.

24 February (H) Hawaii  
 Origin time: 03 23 25.7  
 Epicenter: 20.20 N., 155.80 W.  
 Depth: 36 km  
 Magnitude: 3.5 ML  
Intensity III: Kahua Ranch (H).

9 March (H) Hawaii  
 Origin time: 10 29 16.5  
 Epicenter: 19.40 N., 155.50 W.  
 Depth: 53 km  
 Magnitude: 4.1 ML  
Intensity V: Kamuela (H).  
Intensity IV: Hilo (H), Volcano (H).  
Intensity III: Glenwood (H), Hakalau  
 (H), Kau District (H), Kona District (H).  
Intensity II: Holualoa (H).

18 March (H) Hawaii  
 Origin time: 23 33 07.2  
 Epicenter: 19.36 N., 155.30 W.  
 Depth: 34 km  
 Magnitude: 3.2 ML  
Intensity III: Volcano, Waimea.

21 March (H) Hawaii  
 Origin time: 14 59 24.7  
 Epicenter: 19.37 N., 155.07 W.  
 Depth: 8 km  
 Magnitude: 3.4 ML  
Intensity III: Hilo (H), Keaau (H),  
 Mountain View (H), Pepeekeo (H).

## Hawaii--Continued

25 March (H) Hawaii  
 Origin time: 05 37 00.3  
 Epicenter: 19.35 N., 155.14 W.  
 Depth: 8 km  
 Magnitude: 3.6 ML  
Intensity IV: Hilo.  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).

29 March (H) Hawaii  
 Origin time: 22 56 40.0  
 Epicenter: 19.18 N., 155.68 W.  
 Depth: 6 km  
 Magnitude: 3.3 ML  
Intensity III: Captain Cook (H),  
 Oceanview (H).

31 March (H) Hawaii  
 Origin time: 01 17 37.7  
 Epicenter: 19.70 N., 156.00 W.  
 Depth: 9 km  
 Magnitude: 3.6 ML  
Intensity IV: Holualoa (H), Kalua (H),  
 Kona District (H).  
Intensity III: Hualalai Ranch (H),  
 Huehue Ranch (H), Kamuela (H), Kalaua (H).

6 April (H) Hawaii  
 Origin time: 21 00 25.2  
 Epicenter: 19.36 N., 155.09 W.  
 Depth: 9 km  
 Magnitude: 3.6 ML  
Intensity IV: Hilo (H).  
Intensity III: Papaikou (H).

11 April (H) Hawaii  
 Origin time: 06 31 16.2  
 Epicenter: 19.32 N., 155.27 W.  
 Depth: 9 km  
 Magnitude: 3.0 ML  
Intensity III: Mountain View (H).

21 April (H) Hawaii  
 Origin time: 04 49 21.9  
 Epicenter: 20.02 N., 155.31 W.  
 Depth: 10 km  
 Magnitude: 5.1 ML  
Intensity V: Hilo (H), Honokaa (H),  
 Waimea (H).  
Intensity IV: Islandwide (press  
 report), Pohakuloa (press report), Puna  
 District (H).

21 April (H) Hawaii  
 Origin time: 11 51 31.9  
 Epicenter: 19.32 N., 155.27 W.  
 Depth: 9 km  
 Magnitude: 3.6 ML  
Intensity III: Mountain View (H),  
 Volcano (H).

22 April (H) Hawaii  
 Origin time: 19 44 00.0  
 Epicenter: 19.32 N., 155.26 W.  
 Depth: 9 km  
 Magnitude: 4.0 ML  
Intensity IV: Hawaiian Volcano  
 Observatory (H), Hilo (H), Volcano.  
Intensity III: Kamuela (H), Kona (H),  
 Waimea (press report).

## Hawaii--Continued

26 April (H) Hawaii  
 Origin time: 04 20 53.0  
 Epicenter: 19.34 N., 155.23 W.  
 Depth: 9 km  
 Magnitude: 3.5 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Kurtistown (H), Mountain View  
 (H).

2 May (H) Hawaii  
 Origin time: 18 54 05.4  
 Epicenter: 20.08 N., 155.36 W.  
 Depth: 8 km  
 Magnitude: 3.7 ML  
Intensity IV: Ahualoa (H), Honokaa (H),  
 Kamuela (H).  
Intensity III: Hilo (H), Papaikou (H),  
 Pepeekeo (H).

4 May (H) Hawaii  
 Origin time: 14 22 58.1  
 Epicenter: 20.24 N., 155.76 W.  
 Depth: 34 km  
 Magnitude: 3.1 ML  
Intensity III: Ahualoa (H), Waimea (H).

12 May (H) Hawaii  
 Origin time: 09 11 06.3  
 Epicenter: 19.31 N., 155.22 W.  
 Depth: 10 km  
 Magnitude: 3.1 ML  
Intensity III: Papaikou (H).

14 May (H) Hawaii  
 Origin time: 15 35 10.8  
 Epicenter: 19.34 N., 155.23 W.  
 Depth: 9 km  
 Magnitude: 3.0 ML  
Intensity II: Volcano (H).

15 May (H) Hawaii  
 Origin time: 07 27 13.1  
 Epicenter: 19.37 N., 155.10 W.  
 Depth: 8 km  
 Magnitude: 3.6 ML  
Intensity III: Hilo (H), Volcano (H).  
Intensity II: Glenwood (H), Kurtistown  
 (H), Mountain View (H).

18 May (H) Hawaii  
 Origin time: 04 32 42.8  
 Epicenter: 19.38 N., 155.10 W.  
 Depth: 8 km  
 Magnitude: 3.2 ML  
Intensity III: Hilo (H).  
Intensity II: Pepeekeo (H).

18 May (H) Hawaii  
 Origin time: 20 46 43.1  
 Epicenter: 19.51 N., 155.84 W.  
 Depth: 10 km  
 Magnitude: 3.3 ML  
Intensity III: Captain Cook (H).

30 May (H) Hawaii  
 Origin time: 23 10 06.1  
 Epicenter: 19.35 N., 155.11 W.  
 Depth: 7 km

## Hawaii--Continued

Magnitude: 3.1 ML  
Intensity II: Pepeekeo (H).

4 June (H) Hawaii  
 Origin time: 11 42 52.6  
 Epicenter: 19.42 N., 154.93 W.  
 Depth: 8 km  
 Magnitude: 3.1 ML  
Intensity III: Pahoia (H).

6 June (H) Hawaii  
 Origin time: 09 42 18.7  
 Epicenter: 19.37 N., 155.08 W.  
 Depth: 8 km  
 Magnitude: 4.8 mb(G), 4.8 ML  
Intensity V: Captain Cook, Hilo (small  
 objects shifted), Honomu, Kurtistown,  
 Mountain View, Pahala, Pahoia, Papaaloa  
 (hanging pictures displaced), Pepeekeo.  
Intensity IV: Honokaa, Keaau, Ookala.

6 June (H) Hawaii  
 Origin time: 20 58 37.7  
 Epicenter: 19.33 N., 155.19 W.  
 Depth: 10 km  
 Magnitude: 3.4 ML  
Intensity III: Pepeekeo (H), Volcano  
 (H).

7 June (H) Hawaii  
 Origin time: 07 14 18.9  
 Epicenter: 19.52 N., 155.94 W.  
 Depth: 10 km  
 Magnitude: 3.0 ML  
Intensity III: Kona (H).  
Intensity II: Keokea (H).

15 June (H) Hawaii  
 Origin time: 01 22 00.8  
 Epicenter: 19.33 N., 155.18 W.  
 Depth: 10 km  
 Magnitude: 3.1 ML  
Intensity III: Hilo (H).  
Intensity II: Papaikou (H), Pepeekeo  
 (H), Volcano (H).

22 June (H) Hawaii  
 Origin time: 13 45 21.8  
 Epicenter: 19.34 N., 155.11 W.  
 Depth: 9 km  
 Magnitude: 3.7 ML  
Intensity IV: Hilo (H), Papaikou (H).  
Intensity III: Mountain View (H).  
Intensity II: Kau (H).

29 June (H) Hawaii  
 Origin time: 11 24 36.1  
 Epicenter: 19.36 N., 155.25 W.  
 Depth: 10 km  
 Magnitude: 3.7 ML  
Intensity IV: Hilo (H).  
Intensity III: Hawaii Volcanoes National  
 Park (H), Mountain View (H).

## Hawaii--Continued

1 July (H) Hawaii  
 Origin time: 18 14 56.3  
 Epicenter: 19.33 N., 155.13 W.  
 Depth: 10 km  
 Magnitude: 3.3 ML  
Intensity IV: Hilo (H), Volcano (H).

4 July (H) Hawaii  
 Origin time: 14 20 07.9  
 Epicenter: 19.93 N., 155.75 W.  
 Depth: 9 km  
 Magnitude: 3.3 ML  
Intensity IV: Kohala (H).

5 July (H) Hawaii  
 Origin time: 17 59 42.0  
 Epicenter: 19.43 N., 155.45 W.  
 Depth: 10 km  
 Magnitude: 4.1 ML  
Intensity IV: Ocean View (H), Pahala (H).  
Intensity III: Hawaii Volcanoes National Park (H), Milolii (H).

6 July (H) Hawaii  
 Origin time: 18 50 18.6  
 Epicenter: 19.34 N., 155.11 W.  
 Depth: 9 km  
 Magnitude: 3.6 ML  
Intensity III: Hamakua (H), Hilo (H).

10 July (H) Hawaii  
 Origin time: 20 46 00.1  
 Epicenter: 19.37 N., 155.00 W.  
 Depth: 6 km  
 Magnitude: 3.0 ML  
Intensity III: Wahaula Visitors Center (H).

29 July (H) Hawaii  
 Origin time: 09 56 27.7  
 Epicenter: 20.77 N., 156.25 W.  
 Depth: 8 km  
 Magnitude: 3.5 ML  
Intensity III: Hawaiian Beaches (H).

31 July (H) Hawaii  
 Origin time: 10 04 19.9  
 Epicenter: 19.39 N., 155.05 W.  
 Depth: 8 km  
 Magnitude: 3.0 ML  
Intensity III: Mountain View (H).

8 August (H) Hawaii  
 Origin time: 07 54 20.3  
 Epicenter: 19.34 N., 155.22 W.  
 Depth: 10 km  
 Magnitude: 4.1 ML  
Intensity IV: Black Sands subdivision (H), Hilo (H), Puna (H).  
Intensity III: Pahala (H), Papaikou (H), Volcano (H).

8 August (H) Hawaii  
 Origin time: 13 34 32.3  
 Epicenter: 19.22 N., 155.04 W.  
 Depth: 49 km  
 Magnitude: 3.4 ML  
Intensity III: Volcano (H).

## Hawaii--Continued

11 August (H) Hawaii  
 Origin time: 05 19 16.7  
 Epicenter: 19.32 N., 155.19 W.  
 Depth: 9 km  
 Magnitude: 3.9 ML  
Intensity IV: Hilo (H), Papaikou (H).  
Intensity III: Ahua (H), Black Sands subdivision (H), Pahala (H), Volcano (H).

11 August (H) Hawaii  
 Origin time: 09 43 05.0  
 Epicenter: 19.35 N., 155.23 W.  
 Depth: 9 km  
 Magnitude: 3.3 ML  
Intensity III: Volcano.

13 August (H) Hawaii  
 Origin time: 22 24 25.5  
 Epicenter: 20.44 N., 155.62 W.  
 Depth: 29 km  
 Magnitude: 4.3 ML  
Intensity IV: Kohala (H).  
Intensity III: Honokaa (H).  
Intensity II: Hilo (H), Kula, Maui (H).

19 August (H) Hawaii  
 Origin time: 18 19 13.4  
 Epicenter: 19.34 N., 155.12 W.  
 Depth: 10 km  
 Magnitude: 4.2 ML  
Intensity IV: Kalapana (H).  
Intensity III: Black Sands subdivision (H), Hilo (H), Mountain View (H), Pahoahoa (H), Volcano (H).  
Intensity II: Kona (H), Pahala (H).

25 August (H) Hawaii  
 Origin time: 06 07 13.8  
 Epicenter: 19.33 N., 155.19 W.  
 Depth: 10 km  
 Magnitude: 3.6 ML  
Intensity III: Hilo (H).

30 August (H) Hawaii  
 Origin time: 12 46 21.3  
 Epicenter: 19.38 N., 155.45 W.  
 Depth: 10 km  
 Magnitude: 3.9 ML  
Intensity IV: Pahala (H).  
Intensity III: Captain Cook (H), Hilo (H), Papaikou (H).

5 September (H) Northeast of Oahu Island  
 Origin time: 19 39 59.1  
 Epicenter: 21.5 N., 157.7 W.  
 Depth: 10 km  
 Magnitude: 3.5 ML  
Intensity II: Oahu Island (H).

7 September (H) Hawaii  
 Origin time: 23 51 06.7  
 Epicenter: 19.37 N., 155.32 W.  
 Depth: 30 km  
 Magnitude: 4.5 ML  
Intensity III: Hawaiian Volcano Observatory (H), Hilo (H), Honouliuli (H), Kamuela (H), Kohala (H), Kurtistown (H), Mountain View (H), Pohakuloa (H), Punaluu (H), Volcano (H).

## Hawaii--Continued

12 September (H) Hawaii  
 Origin time: 22 44 16.7  
 Epicenter: 19.43 N., 155.29 W.  
 Depth: 13 km  
 Magnitude: 3.0 ML  
Intensity III: Hawaiian Volcano  
 Observatory (H), Hilo (H), Volcano (H).

13 September (H) Hawaii  
 Origin time: 11 04 39.8  
 Epicenter: 19.43 N., 155.27 W.  
 Depth: 4 km  
 Magnitude: 3.0 ML  
Intensity III: Hawaii Volcanoes National  
 Park (H), Volcano (H).

13 September (H) Hawaii  
 Origin time: 16 00 04.5  
 Epicenter: 19.37 N., 155.11 W.  
 Depth: 8 km  
 Magnitude: 3.3 ML  
Intensity II: Hilo (H).

14 September (H) Hawaii  
 Origin time: 05 12 24.2  
 Epicenter: 19.16 N., 155.05 W.  
 Depth: 7 km  
 Magnitude: 3.7 ML  
Intensity III: Hilo (H).

14 September (H) Hawaii  
 Origin time: 07 31 56.6  
 Epicenter: 19.35 N., 155.06 W.  
 Depth: 8 km  
 Magnitude: 3.8 ML  
Intensity III: Glenwood (H), Hilo (H).

14 September (H) Hawaii  
 Origin time: 21 07 38.4  
 Epicenter: 19.36 N., 155.02 W.  
 Depth: 6 km  
 Magnitude: 3.4 ML  
Intensity III: Volcano (H).

15 September (H) Hawaii  
 Origin time: 04 04 47.4  
 Epicenter: 19.42 N., 155.27 W.  
 Depth: 4 km  
 Magnitude: 3.1 ML  
Intensity III: Volcano (H).

15 September (H) Hawaii  
 Origin time: 16 46 20.3  
 Epicenter: 19.33 N., 155.12 W.  
 Depth: 8 km  
 Magnitude: 3.7 ML  
Intensity III: Volcano (H).

16 September (H) Hawaii  
 Origin time: 00 46 02.0  
 Epicenter: 19.36 N., 155.03 W.  
 Depth: 7 km  
 Magnitude: 3.1 ML  
Intensity II: Hilo (H).

16 September (H) Hawaii  
 Origin time: 04 50 05.5  
 Epicenter: 19.35 N., 155.07 W.

## Hawaii--Continued

Depth: 8 km  
 Magnitude: 4.0 ML  
Intensity III: Black Sands subdivision  
 (H), Volcano (H).

18 September (H) Hawaii  
 Origin time: 01 19 23.7  
 Epicenter: 19.37 N., 155.11 W.  
 Depth: 9 km  
 Magnitude: 3.7 ML  
Intensity III: Hilo (H).

19 September (H) Hawaii  
 Origin time: 19 01 45.2  
 Epicenter: 19.36 N., 155.13 W.  
 Depth: 9 km  
 Magnitude: 4.1 ML  
Intensity III: Hilo (H), Kalalua,  
 Nanawale Estates, Papaikou (H), Volcano  
 (H).

23 September (H) Hawaii  
 Origin time: 12 08 44.1  
 Epicenter: 19.36 N., 155.05 W.  
 Depth: 8 km  
 Magnitude: 4.0 ML  
Intensity IV: Glenwood (H), Hilo (H),  
 Volcano (H).  
Intensity III: Mauna Kea Observatory  
 (H), Puako.

23 September (H) Hawaii  
 Origin time: 12 59 56.9  
 Epicenter: 19.42 N., 155.26 W.  
 Depth: 5 km  
 Magnitude: 3.0 ML  
Intensity III: Volcano (H).

27 September (H) Hawaii  
 Origin time: 04 05 39.8  
 Epicenter: 19.35 N., 155.06 W.  
 Depth: 7 km  
 Magnitude: 3.2 ML  
Intensity III: Hilo (H).

28 September (H) Hawaii  
 Origin time: 17 38 01.2  
 Epicenter: 19.36 N., 155.06 W.  
 Depth: 7 km  
 Magnitude: 3.8 ML  
Intensity III: Hilo (H).

6 October (H) Hawaii  
 Origin time: 03 31 20.2  
 Epicenter: 19.42 N., 155.30 W.  
 Depth: 16 km  
 Magnitude: 3.4 ML  
Intensity IV: Volcano.

1 November (H) Hawaii  
 Origin time: 23 38 23.3  
 Epicenter: 19.35 N., 155.11 W.  
 Depth: 10 km  
 Magnitude: 3.8 ML  
Intensity IV: Hilo.  
Intensity III: Papaikou.

Hawaii--Continued

Idaho

- 6 November (H) Hawaii  
 Origin time: 17 24 15.2  
 Epicenter: 19.38 N., 155.42 W.  
 Depth: 12 km  
 Magnitude: 3.6 ML  
Intensity IV: Volcano.
- 17 November (H) Hawaii  
 Origin time: 22 34 12.6  
 Epicenter: 19.16 N., 155.56 W.  
 Depth: 38 km  
 Magnitude: 3.6 ML  
Intensity III: Hawaii Ocean View  
 Estates, Pahala.  
Intensity II: Hawaiian Volcano  
 Observatory, Kona.
- 19 November (H) Hawaii  
 Origin time: 05 16 17.1  
 Epicenter: 19.33 N., 155.07 W.  
 Depth: 8 km  
 Magnitude: 3.2 ML  
Intensity III: Hilo.
- 25 November (H) Hawaii  
 Origin time: 18 54 51.4  
 Epicenter: 19.35 N., 155.02 W.  
 Depth: 8 km  
 Magnitude: 3.5 ML  
Intensity III: Kapaahu, Wahaula.  
Intensity II: Hilo.
- 5 December (H) Hawaii  
 Origin time: 08 25 37.8  
 Epicenter: 19.35 N., 155.04 W.  
 Depth: 9 km  
 Magnitude: 3.2 ML  
Intensity III: Hilo, Mountain View.
- 6 December (H) Hawaii  
 Origin time: 05 39 02.3  
 Epicenter: 19.37 N., 155.32 W.  
 Depth: 31 km  
 Magnitude: 3.2 ML  
Intensity III: Volcano.
- 14 December (H) Hawaii  
 Origin time: 18 19 32.7  
 Epicenter: 19.32 N., 155.18 W.  
 Depth: 12 km  
 Magnitude: 3.2 ML  
Intensity III: Volcano.
- 19 December (H) Hawaii  
 Origin time: 19 35 01.6  
 Epicenter: 19.33 N., 155.22 W.  
 Depth: 10 km  
 Magnitude: 3.2 ML  
Intensity III: Hilo.
- 22 December (H) Hawaii  
 Origin time: 08 25 55.1  
 Epicenter: 19.33 N., 155.23 W.  
 Depth: 10 km  
 Magnitude: 3.6 ML  
Intensity III: Hilo, Volcano.

- 12 January (G) Eastern Idaho  
 Origin time: 14 12 22.2  
 Epicenter: 44.63 N., 112.60 W.  
 Depth: 5 km  
 Magnitude: 3.5 ML(D), 3.3 ML(A)  
Intensity IV in Montana: Dell, Lima.
- 28 May (G) Eastern Idaho  
 Origin time: 13 36 35.6  
 Epicenter: 44.42 N., 111.43 W.  
 Depth: 5 km  
 Magnitude: 3.2 ML(A), 4.0 ML(D)  
Intensity IV:  
 Wyoming—Madison Junction, Old Faithful  
 Visitor's Center.
- 30 September (G) Utah  
 Origin time: 10 19 21.0  
 See Utah listing.
- 27 November (G) Western Idaho  
 Origin time: 09 25 55.1  
 Epicenter: 44.58 N., 116.27 W.  
 Depth: 5 km  
 Magnitude: 4.2 mb, 4.5 ML

This earthquake was felt over an area of about 24,000 sq km of western Idaho and eastern Oregon (fig. 10). Damage was reported only at Cascade, located a few kilometers east of the epicenter near Cascade Dam.

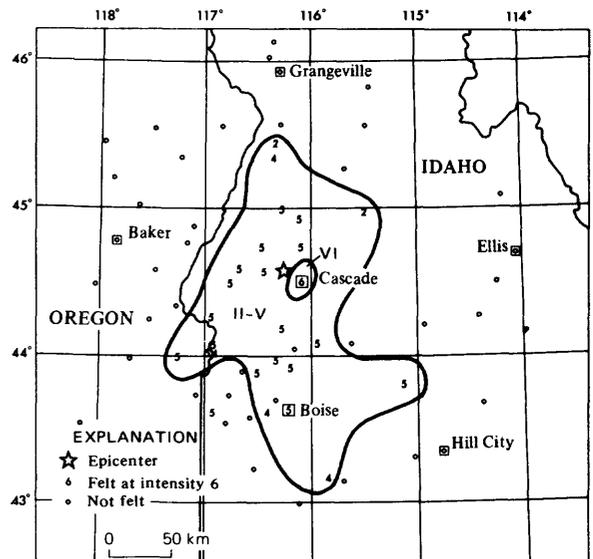


FIGURE 10. Area affected by western Idaho earthquake of November 27.

Intensity VI:  
 Idaho—Cascade (dry wall and foundation cracked, ceiling beams separated, well water and springs muddied).

Idaho--Continued

Intensity V:

Idaho--Boise (one window cracked), Cambridge, Council, Donnelly, Emmett, Garden Valley (small objects shifted), Horse Shoe Bend, Indian Valley (small objects shifted), McCall (small objects shifted), Midvale, New Meadows, Ola (small objects shifted), Payette, Sweet (furniture shifted), Weiser (small objects shifted).

Oregon--Ontario, Vale.

Intensity IV:

Idaho--Atlanta, Fruitland, Homedale, Idaho City, Meridian, Pollock.

Intensity II: Riggins (press report), Yellow Pine.

Illinois

3 January (S) Cape Girardeau, Mo., region  
Origin time: 22 56 48.5

See Missouri listing.

Massachusetts

20 December (J) Southern New England  
Origin time: 17 44 23.8  
Epicenter: 41.79 N., 70.68 W.  
Depth: 0 km  
Magnitude: 3.1 mbLg, 3.0 mbLg(L)

This earthquake was felt over an area of about 2,000 sq km of southeastern Massachusetts (including Barnstable, Bristol, Norfolk, Plymouth, and Providence Counties), and eastern Rhode Island (fig. 11).

Intensity V:

Massachusetts--Bridgewater (press report), Buzzards Bay, East Bridgewater, East Wareham, Fairhaven (small objects shifted), Halifax (small objects shifted), Marion (small objects shifted), Middleborough (small objects fell), North Carver, North Dartmouth, Onset (small objects shifted), Plymouth, Rochester, South Carver, Taunton, Wareham (small objects shifted), West Wareham (small objects shifted).

Intensity IV:

Massachusetts--Assonet (J), Acushnet, Bourne (J), East Taunton, Fall River, New Bedford (press report), Swansea, Raynham Center, Whitehorse Beach.

Rhode Island--Providence.

Intensity III:

Massachusetts--Dighton, Raynham, Segreganset, Sharon.

Intensity II:

Massachusetts--Chilmark, Foxboro.  
Rhode Island--Conimicut.

Massachusetts--Continued

20 December (J) Southern New England  
Origin time: 22 44 44.5  
Epicenter: 41.81 N., 70.78 W.  
Depth: 0 km  
Magnitude: 2.0 mbLg  
Intensity III: Wareham (J).

Mississippi

4 November (G) Mississippi  
Origin time: 11 21 07.0  
Epicenter: 33.83 N., 89.28 W.  
Depth: 5 km  
Magnitude: 3.4 mbLg(S)  
Intensity IV: Ridgmont (S), Reid (S), Vardaman.

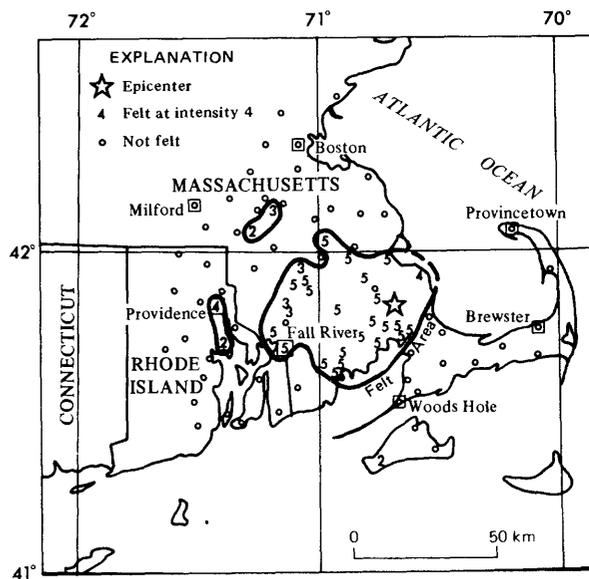


FIGURE 11. Area affected by southern New England earthquake of December 20.

Missouri

3 January (S) Cape Girardeau, Mo., region  
Origin time: 22 56 48.5  
Epicenter: 37.55 N., 89.79 W.  
Depth: 5 km  
Magnitude: 3.4 mbLg

Intensity VI:

Missouri--Old Appleton (some cracked)

-----  
 Missouri--Continued  
 -----

plaster; small objects fell; numerous aftershocks felt that day).

Intensity V:

Missouri--Burfordville, Farrar (small objects displaced), Millersville (small objects displaced), Pochahontas.

Intensity IV:

Illinois--Anna, Millcreek, Rockwood, Wolf Lake.

Missouri--Altenburg, Brazeau, Cape Girardeau (press report), Chaffee, Friedheim, Frohna, Jackson, Oak Ridge, Patton, Perryville, Uniontown.

Intensity III:

Illinois--Ava.

Missouri--Daisy, Knob Lick.

28 March (S) New Madrid, Mo., region

Origin time: 11 17 14.2  
 Epicenter: 36.48 N., 89.54 W.  
 Depth: 10 km  
 Magnitude: None computed.  
Intensity II: Marston.

-----  
 Montana  
 -----

12 January (G) Eastern Idaho

Origin time: 14 12 22.2

See Idaho listing.

26 January (G) Hebgen Lake region

Origin time: 10 23 35.8  
 Epicenter: 44.63 N., 111.13 W.  
 Depth: 5 km  
 Magnitude: 2.5 ML(A)  
Intensity IV: Mary Mountain patrol cabin (Yellowstone National Park), 14.4 km southeast of Norris Geyser Basin.

3 March Montana

Origin time: 04 53, 05 22, 22 15  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity II: West Yellowstone. Shock at 0453 also was felt at Madison Junction.

4 March (G) Hebgen Lake region

Origin time: 10 05 59.6  
 Epicenter: 44.83 N., 111.04 W.  
 Depth: 5 km  
 Magnitude: 3.9 mb, 3.8 ML, 4.1 ML(A),  
 4.2 ML(D)

Intensity IV:

Montana--West Yellowstone.

Wyoming--Old Faithful (Yellowstone National Park).

4 March (G) Hebgen Lake region

-----  
 Montana--Continued  
 -----

Origin time: 11 01 50.2  
 Epicenter: 44.80 N., 111.08 W.  
 Depth: 5 km  
 Magnitude: 3.9 mb, 3.6 ML, 4.1 ML(D)

"The most interesting effect of the tremors at Old Faithful was the abnormal behavior of a herd of 14 bison. The bison will usually avoid the developed area, except when moving from an area where they have bedded down to a different meadow for grazing. During the morning hours of March 4, at the time of the most frequent, strong seismic activity, the herd milled back and forth between the Old Faithful Lodge, Visitor Center, and Old Faithful Inn parking areas no fewer than six times. They behaved in a very restless and nervous manner, bolting in unison on at least one occasion, only to return later. In the mall area outside the Visitor Center, two lodgepole pines had virtually all their bark and lower branches stripped off by bison rubbing their horns or heads, and all of the rope fence behind the Visitor Center was taken out as the herd moved through. The herd settled down by afternoon, when the number of tremors had diminished significantly, and moved into the fringe of the wooded area south of Myriad Group" (R. A. Hutchinson, Park Geologist, Yellowstone National Park, written commun., 1977).

Intensity IV:

Montana--Gardiner, West Yellowstone.

Wyoming--Old Faithful (Yellowstone National Park).

Intensity III:

Wyoming--Mammoth.

4 March (G) Hebgen Lake region

Origin time: 11 33 06.9  
 Epicenter: 44.84 N., 111.13 W.  
 Depth: 5 km  
 Magnitude: 3.7 mb, 3.6 ML, 4.3 ML(D)

Intensity IV:

Montana--West Yellowstone.

Wyoming--Old Faithful (Yellowstone National Park).

Intensity III:

Wyoming--Mammoth.

4 March (G) Hebgen Lake region

Origin time: 13 00 58.9  
 Epicenter: 44.80 N., 111.08 W.  
 Depth: 5 km  
 Magnitude: 4.1 mb, 4.1 ML, 4.3 ML(D)

Intensity IV:

Montana--Gardiner, West Yellowstone.

Wyoming--Old Faithful (Yellowstone National Park).

Intensity III:

Wyoming--Madison Junction, Mammoth, Nez Perce patrol cabin (Yellowstone National Park).

-----  
 Montana--Continued  
 -----

4 March (G) Hebgen Lake region  
 Origin time: 13 04 21.4  
 Epicenter: 44.82 N., 111.10 W.  
 Depth: 5 km  
 Magnitude: 4.0 mb, 3.7 ML, 4.0 ML(D)  
Intensity IV:  
 Montana--West Yellowstone.  
Intensity III:  
 Wyoming--Nez Perce patrol cabin  
 (Yellowstone National Park).

4 March Hebgen Lake region  
 Origin time: 13 12  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity III: West Yellowstone.

4 March (G) Hebgen Lake region  
 Origin time: 14 19 48.8  
 Epicenter: 44.78 N., 111.05 W.  
 Depth: 5 km  
 Magnitude: 4.0 mb, 4.0 ML, 4.3 ML(D)  
Intensity IV:  
 Montana--Gardiner, West Yellowstone.  
 Wyoming--Old Faithful (Yellowstone National  
 Park).  
Intensity III:  
 Wyoming--Madison Junction, Mammoth, Nez  
 Perce patrol cabin (Yellowstone National  
 Park).

4 March Hebgen Lake region  
 Origin time: 14 26  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity III: Old Faithful (Yellowstone  
 National Park).

4 March (G) Hebgen Lake region  
 Origin time: 14 58 05.5  
 Epicenter: 44.75 N., 111.35 W.  
 Depth: 5 km  
 Magnitude: 3.7 ML(D)  
Intensity III:  
 Montana--West Yellowstone.  
 Wyoming--Mammoth.

4 March (G) Hebgen Lake region  
 Origin time: 16 12 28.2  
 Epicenter: 44.79 N., 111.05 W.  
 Depth: 5 km  
 Magnitude: 3.4 ML, 3.7 ML(D)  
Intensity III:  
 Montana--West Yellowstone.  
 Wyoming--Mammoth, Old Faithful (Yellowstone  
 National Park).

4 March (G) Hebgen Lake region  
 Origin time: 16 47 43.5  
 Epicenter: 44.77 N., 111.12 W.  
 Depth: 5 km  
 Magnitude: 3.7 ML, 4.0 ML(D)  
Intensity III:  
 Montana--West Yellowstone.  
 Wyoming--Madison Junction.

-----  
 Montana--Continued  
 -----

4 March (G) Hebgen Lake region  
 Origin time: 16 51 48.3  
 Epicenter: 44.77 N., 111.21 W.  
 Depth: 5 km  
 Magnitude: 4.0 ML(D)  
Intensity IV:  
 Wyoming--Old Faithful (Yellowstone National  
 Park).  
Intensity III:  
 Montana--West Yellowstone.  
 Wyoming--Madison Junction, Nez Perce patrol  
 cabin (Yellowstone National Park).

4 March (G) Hebgen Lake region  
 Origin time: 17 10 40.6  
 Epicenter: 44.76 N., 111.01 W.  
 Depth: 5 km  
 Magnitude: 4.0 mb, 3.8 ML  
Intensity IV:  
 Montana--West Yellowstone.  
Intensity III:  
 Wyoming--Madison Junction, Old Faithful  
 (Yellowstone National Park).

4 March Hebgen Lake region  
 Origin time: 17 17  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: 3.4 ML(D)  
Intensity III: West Yellowstone.

5 March Hebgen Lake region  
 Origin time: 00 32  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: 3.3 ML(D)  
Intensity III: West Yellowstone.

6 March (G) Hebgen Lake region  
 Origin time: 05 01 04.0  
 Epicenter: 44.74 N., 111.13 W.  
 Depth: 5 km  
 Magnitude: 2.9 ML(A)  
Intensity V: West Yellowstone  
 (awakened all residents, buildings creaked  
 and objects rattled).

6 March (G) Hebgen Lake region  
 Origin time: 06 10 12.7  
 Epicenter: 44.71 N., 111.21 W.  
 Depth: 5 km  
 Magnitude: 3.0 ML(A)  
Intensity V: West Yellowstone  
 (awakened all residents, buildings creaked  
 and objects rattled).

11 March (G) Montana  
 Origin time: 05 09 37.2  
 Epicenter: 46.13 N., 111.48 W.  
 Depth: 5 km  
 Magnitude: 4.6 mb, 4.8 ML  
Intensity VI:  
 Montana--Harrison (cracked plaster).  
Intensity V:  
 Montana--Hudson (small objects fell),  
 Maudlow (small objects moved), Radersburg  
 (small objects moved), Trident (small  
 objects moved), Willow Creek.

Montana--Continued

Intensity IV:

Montana--Broadview, Old Faithful, Jefferson City, Manhattan, Three Forks.  
Wyoming--Yellowstone National Park.

Intensity III:

Montana--Boulder, Toston (telephone report).

Intensity II:

Montana--Melstone, Missoula, Molt.

11 March (G) Hebgen Lake region

Origin time: 12 17 51.9  
Epicenter: 44.85 N., 111.50 W.  
Depth: 5 km  
Magnitude: 5.2 mb, 4.1 ML

Intensity IV:

Wyoming--Old Faithful, Yellowstone National Park (a few employees and guests awakened).

24 March (G) Southwestern Montana

Origin time: 13 20 11.9  
Epicenter: 45.71 N., 111.31 W.  
Depth: 5 km  
Magnitude: 3.2 ML(A)

Intensity IV: Bozeman (objects on shelves rattled, roaring sounds heard, one sleeper awakened).

4 September (G) Montana

Origin time: 20 54 20.2  
Epicenter: 46.60 N., 112.14 W.  
Depth: 5 km  
Magnitude: 3.2 ML(A), 2.8 ML(D)

Intensity IV: Canyon Ferry, East Helena, Helena.

19 October (G) Hebgen Lake region

Origin time: 16 50 50.9  
Epicenter: 44.77 N., 111.81 W.  
Depth: 10 km  
Magnitude: 4.7 ML

Intensity VI:

West Yellowstone--Cracked plaster; buildings creaked and trembled; water in small containers slightly disturbed; small objects shifted.

Intensity V:

Clinton--A few people frightened; trees and bushes shaken slightly; standing and moving vehicles rocked slightly.

Lima--Small objects shifted; hanging objects and doors swung moderately, and moderate earth noise heard at the Brenneman Ranch, 26 km due east of Lima. The bird refuge and building at Centennial Valley shook moderately at Lima.

Intensity IV: Gardiner, Missoula.

Intensity III: Cardwell, Fort Harrison, Virginia City.

Nevada

3 January (G) Central Nevada

Origin time: 14 20 00.1

Nevada--Continued

Epicenter: 39.59 N., 115.81 W.  
Depth: 6 km  
Magnitude: 3.4 ML  
Intensity III: Eureka.

1 February (B) Northern California  
Origin time: 18 47 57.5

See California listing.

22 February (B) California-Nevada border region  
Origin time: 06 24 06.5

See California listing.

New Hampshire

25 December (J) Northern New England

Origin time: 15 35 53.8  
Epicenter: 43.19 N., 71.65 W.  
Depth: 0 km  
Magnitude: 3.2 mbLg, 3.1 mbLg(L)

This earthquake was felt over an area of about 2,800 sq km (fig. 12).

Intensity VI: Concord (plaster cracked in some homes, many frightened, a few windows cracked).

Intensity V: Andover, Bennington, Bradford, Canterbury, Contoocook, Franklin, Gilman Iron Works, Hopkinton (press report), Loudon, New Durham, Salisbury, South Sutton, Warner, Weare, Wilmot Flat.

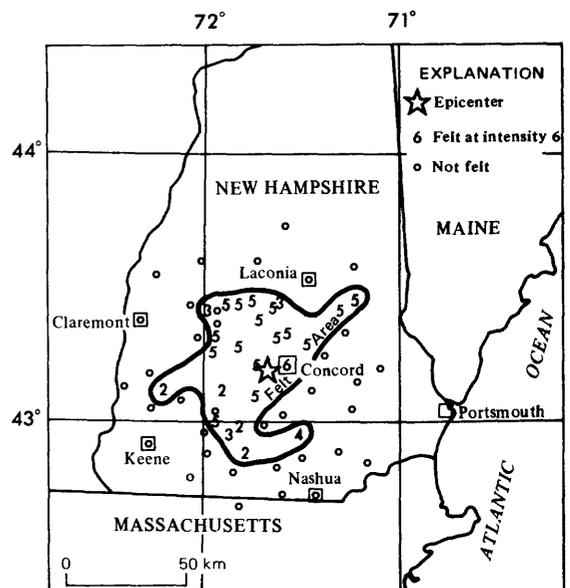


FIGURE 12. Area affected by northern New England earthquake of December 25.

Intensity IV: East Andover, Boscawen, Dunbarton (press report), Manchester, Webster (press report).  
Intensity III: Greenfield, New London, Tilton.  
Intensity II: Francestown, Hillsboro, Marlow, South Lyndeboro.

New Mexico

4 January (G) Southern New Mexico

Origin time: 18 31 37.6  
 Epicenter: 32.36 N., 106.92 W.  
 Depth: 5 km  
 Magnitude: 3.2 ML

Intensity V: Dona Ana.

Intensity IV: Las Cruces, Organ, Radium Springs.

Intensity III: Rincon.

5 March (G) Northwestern New Mexico

Origin time: 03 00 54.7  
 Epicenter: 35.91 N., 108.29 W.  
 Depth: 22 km  
 Magnitude: 4.6 mb, 4.2 ML

This earthquake occurred in the same

epicentral region as the magnitude 5.0 shock of January 5, 1976 (Simon and others, 1977). It was felt over an area of about 51,400 sq km of Arizona, Colorado, and New Mexico (fig. 13).

Intensity VI:

New Mexico--Crownpoint (fences displaced slightly), Prewitt (existing cracks widened considerably).

Intensity V:

Arizona--Chinle, Houck.  
 Colorado--Cortez, Durango.  
 New Mexico--Blanco, Chaco Canyon, Gallup, Lake Valley Navajo School (40 km north of Crownpoint), Mexican Springs, San Rafael (small objects fell), Ship Rock, Navajo Dam, Toadlena, Zuni.

Intensity IV:

Arizona--Fort Defiance, Leupp, Lupton.  
 Colorado--Mesa Verde National Park, Pagosa Springs, Towaoc.  
 New Mexico--Aztec, Bloomfield, Bluewater, Church Rock, Farmington, Jemez Springs, Los Ojos, Ramah, Thoreau, Tohatchi.

Intensity III:

New Mexico--Waterflow.

Intensity II:

Arizona--Sanders.  
 New Mexico--Seboyeta.

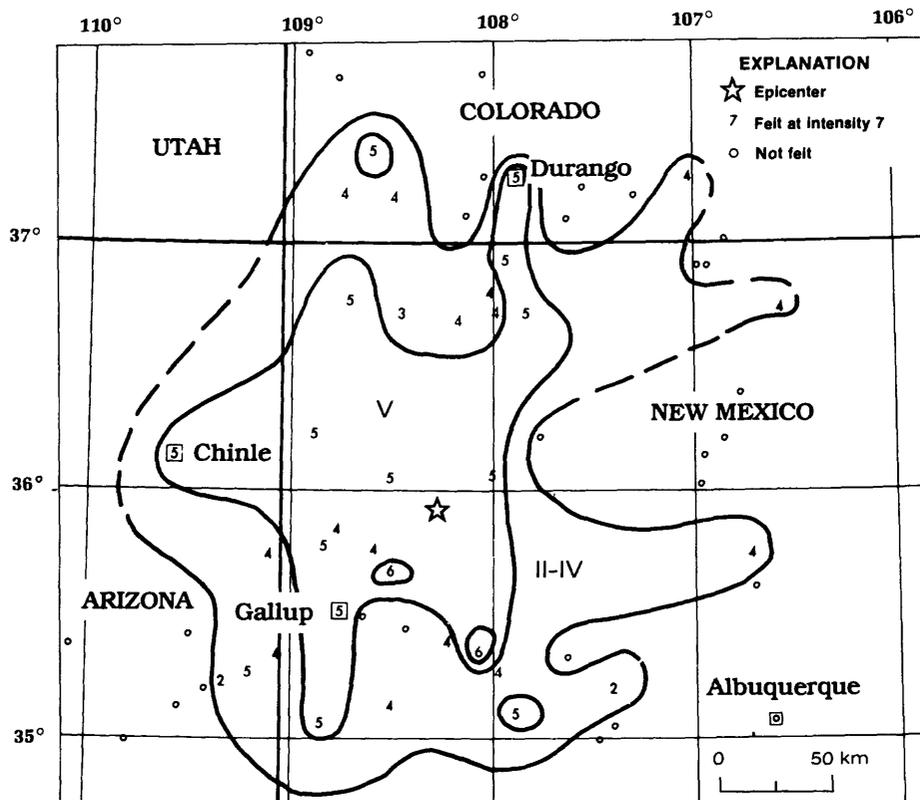


FIGURE 13. Area affected by New Mexico earthquake of March 5. (Roman numerals represent Modified Mercalli intensities between isoseismal contours.)

---

---

New York

28 September (L) New York  
Origin time: 17 21 44.7  
Epicenter: 44.39 N., 73.89 W.  
Depth: 3 km  
Magnitude: 3.1 mbLg  
Intensity III: Highland, Wilmington  
(press report).

---

---

North Carolina

27 July (G) Tennessee  
Origin time: 22 03 21.3  
  
See Tennessee listing.

---

---

Ohio

17 June (K) Northwestern Ohio  
Origin time: 15 39 47.3  
Epicenter: 40.71 N., 84.58 W.  
Depth: 5 km  
Magnitude: 3.2 mbLg

The earthquake was felt over about 550 sq km of western Ohio—from Celina south to Chickasaw, west to Fort Recovery, and north to Rockford. F.J. Mauk, Seismological Observatory, University of Michigan, Ann Arbor, published an earthquake questionnaire in the Celina Daily Standard and provided the completed forms to the USGS for intensity evaluation. Several instances of damage were reported by residents in the area.

Intensity VI: Slight damage at the following locations:  
Celina--Foundation cracked, sidewalk cracked.  
Coldwater--Cracked sidewalk, cracked plaster, water changes, fallen plaster, foundations cracked, house moved slightly on foundation--mobile home.  
Fort Recovery--Water tank cracked, stone fences cracked.  
Rockford--Hairline cracks in exterior walls, sidewalks cracked, ceiling light fixture loosened.

Intensity V: Many residents frightened, buildings trembled, heavy furniture shifted, and some pictures knocked from walls at Celina, Coldwater, Montezuna, Rockford, St. Henry.

Intensity IV: Chickasaw (buildings shaken--press report).

---

---

Oklahoma

6 January (T) South-central Oklahoma  
Origin time: 16 19 54.0

---

---

Oklahoma--Continued

Epicenter: 34.70 N., 96.73 W.  
Depth: 5 km  
Magnitude: 2.2 mbLg  
Intensity II: Ada.

4 February (T) Southern Oklahoma  
Origin time: 20 52 29.3  
Epicenter: 34.06 N., 97.37 W.  
Depth: 5 km  
Magnitude: 1.9 mbLg  
Intensity II: Love County.

10 February (T) Southern Oklahoma  
Origin time: 01 28 16.3  
Epicenter: 34.06 N., 97.37 W.  
Depth: 5 km  
Magnitude: 1.9 mbLg  
Intensity II: Love County.

26 March (T) Southern Oklahoma  
Origin time: 21 37 12.6  
Epicenter: 34.06 N., 97.37 W.  
Depth: 5 km  
Magnitude: 2.3 mbLg  
Intensity III: Love County.

16 June (T) Southern Oklahoma  
Origin time: 02 02 46.6  
Epicenter: 34.04 N., 97.36 W.  
Depth: 5 km  
Magnitude: 1.9 mbLg  
Intensity II: Wilson (4 km east of).

---

---

Oregon

27 November (G) Western Idaho  
Origin time: 09 25 55.1  
  
See Idaho listing.

---

---

Puerto Rico

2 May (G) Mona Passage  
Origin time: 16 00 54.9  
Epicenter: 19.07 N., 67.39 W.  
Depth: 50 km  
Magnitude: 5.2 mb  
Intensity II: Puerto Rico.

---

---

Rhode Island

20 December (J) Southern New England  
Origin time: 17 44 23.8  
  
See Massachusetts listing.

---

---

South Carolina

18 January (G) Southeastern South Carolina  
Origin time: 18 29 13.5  
Epicenter: 33.07 N., 80.20 W.  
Depth: 5 km  
Magnitude: 3.0 mbLg(V)

Many of the data listed below are the result of a questionnaire canvass that was conducted by Dr. Joyce Bagwell, Baptist College of Charleston, and evaluated by the USGS.

Intensity VI: Summerville and suburban subdivisions--College Park (sidewalk cracked), Millwood Estates (sidewalk cracked), Rantoueles (near State Highways 17 and 165).

Intensity IV: Goose Creek, Ladson, Meggett, North Charleston.

Intensity II: Hollywood.

30 March (G) Southeastern South Carolina  
Origin time: 08 27 46.9  
Epicenter: 32.88 N., 80.20 W.  
Depth: 10 km  
Magnitude: 1.5 ML(G)

Intensity V: Summerville (awakened many and frightened a few; buildings trembled; objects rattled; windows, dishes, and doors shaken).

31 May (G) South Carolina  
Origin time: 23 50 13.2  
Epicenter: 32.95 N., 80.24 W.  
Depth: 8 km  
Magnitude: 2.3 mbLg  
Intensity II: Summerville.

25 August (G) South Carolina  
Origin time: 04 20 07.0  
Epicenter: 33.39 N., 80.69 W.  
Depth: 10 km  
Magnitude: 3.1 mbLg(V)  
Intensity IV: Bowman.

15 December (G) South Carolina  
Origin time: 19 16 43.1  
Epicenter: 32.92 N., 80.22 W.  
Depth: 9 km  
Magnitude: 3.0 mbLg(V)  
Intensity V: Mount Holly, Summerville.  
Intensity IV: Charleston, Folly Beach, Wadmalaw Island.

---

---

Tennessee

27 July (G) Tennessee  
Origin time: 22 03 21.3  
Epicenter: 35.42 N., 84.42 W.  
Depth: 7 km  
Magnitude: 3.5 mbLg(V)  
Intensity V:

Tennessee--Coker creek, Ducktown (buildings trembled, pictures out of place, loud earth noise heard), Etowah, Madisonville

---

---

Tennessee--Continued

(a few frightened, buildings trembled, small objects shifted), Postelle, Reliance (small objects shifted), Tellico Plains.

Intensity IV:

Georgia--McCaysville.

Tennessee--Athens, Englewood, Farner, Riceville, Sweetwater.

Intensity III:

North Carolina--Murphy, Unaka.

Intensity II:

Georgia--Cisco.

---

---

Texas

26 April (G) West Texas  
Origin time: 09 03 07.3  
Epicenter: 31.90 N., 103.08 W.  
Depth: 4 km  
Magnitude: 3.3 ML  
Intensity IV: Kermit.

---

---

Utah

9 February (U) Central Utah  
Origin time: 00 42 16.4  
Epicenter: 39.31 N., 111.15 W.  
Depth: 7 km  
Magnitude: 3.4 ML  
Intensity VI: Elmo. (Mine seals to worked-out areas cracked at American Coal Mine Company, located about 12 km northwest of Orangeville, Utah. Several miners felt the earthquake strongly and were frightened, thinking there might be a cave-in. None occurred.)

30 September (G) Utah  
Origin time: 10 19 21.0  
Epicenter: 40.52 N., 110.44 W.  
Depth: 5 km  
Magnitude: 5.0 mb, 5.1 ML

A report on this earthquake (Utah Geological Survey, 1977) stated "A number of lines of fracturing and faulting, separate from the Uinta Mountains, strike N70° E along the south flank of the mountains and extend out into the basin to the south. These apparently reflect an ancient, deep-seated rupture of the earth's crust that can be traced from near the northeast corner of Utah nearly to the Nevada line. This fracturing and faulting is older than the Uintas and is apparently still active to some extent. The September 30 and October 11 earthquakes occurred along this line (lineament).

"The lineament has very subtle but definite expression including lines of springs, sinkholes and caves, disturbed drainage lines, and in some places fault scarps with evidence of movement since the end of glacial time, perhaps as recently as 4,000 to a few hundred years.

"Bruce Kaliser, UGMS Engineering Geologist, and Howard Ritzma, UGMS Assistant Director, toured the earthquake area for 2 days after the first tremor and found a few indications of minor earth movement. One possible rock fall in Rock Creek Canyon and slump of a rock slab in Farnsworth Canal (dry) near Moon Lake were noted. Interviews in the area turned up a number of instances of persons awakened in advance of the quake by restless horses and barking and howling dogs. In two instances horses 'raised a ruckus' in barns and corrals for half an hour before the quake. The two geologists also found road repairs in progress where the branch of the lineament

on which the quake took place crosses the paved Forest Service Road leading to Moon Lake. The road obviously was not damaged by this quake, but the fault zone (lineament) does appear to coincide with a belt of very unstable ground about 100 feet wide. Where the road crosses this, repairs are required once or twice each year."

Some of the intensity values listed below were from a questionnaire canvass by H. R. Ritzma, UGMS, Salt Lake City; they were evaluated by the USGS. Figure 14 shows that this earthquake was felt over an area of about 20,000 sq km of Colorado and Utah; isolated intensity values were reported in Idaho and Wyoming.

Intensity VI:

Colorado--Fruita (plaster cracked--unconfirmed), Grand Junction (stone fence and interior plaster cracked--unconfirmed).

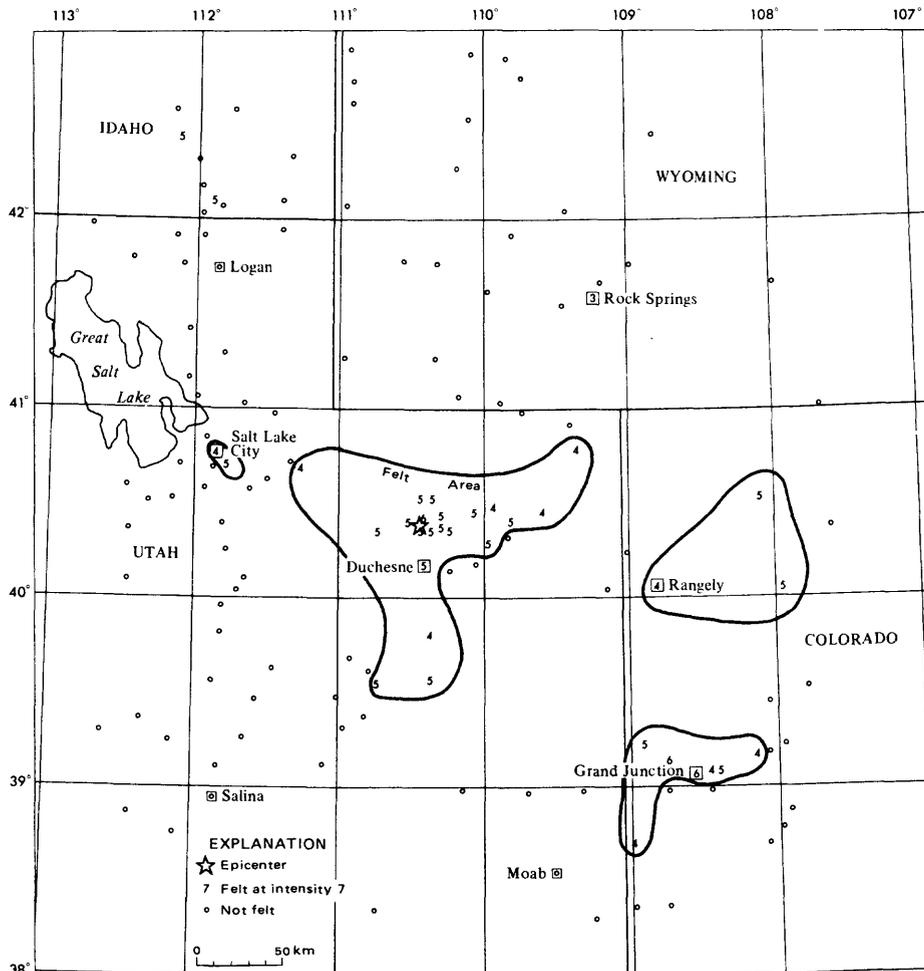


FIGURE 14. Area affected by Utah earthquake of September 30.

Utah--Continued

Utah--Mountain Home (septic-system drain reported broken, old mortar of log house cracked at corners, small objects fell, furniture shifted).

Intensity V:

Colorado--Mack (windows cracked), Maybell, Meeker, Palisade.

Idaho--Downey, Preston.

Utah--Altamont, Altonah, Bluebell, Boneta (press report), Duchesne (pictures knocked from walls, windows cracked--press report), Farnsworth Canal (possible slump of rock slab--Utah Geological Survey, 1977), Lake Fork River (4.8 km southeast of Fisher Ranch), Lapoint, Neola (two aftershocks felt at about 11:19 and 12:19 UT), Rock Creek (cracked windows in Rock Creek Canyon--press report, possible rock fall found by Utah geologists--Utah Geological Survey, 1977), Roosevelt, Tabiona, Talmage, Yellowstone River Canyon.

Intensity IV:

Colorado--Clifton, Gateway, Mesa, Rangely.

Utah--Jensen, Kamas, Robbins Ranch, Salt Lake City, Sunnyside, Vernal, Wellington, White Rocks.

Intensity III:

Wyoming--Rock Springs (H. W. Oliver, U.S. Geological Survey, oral commun., 1977).

11 October (G) Utah

Origin time: 07 56 06.5  
Epicenter: 40.49 N., 110.49 W.  
Depth: 6 km  
Magnitude: 4.8 mb, 4.7 ML

Intensity V:

Duchesne--Many awakened, a few frightened. West of Peterson Gulch, near Ranger station, about 19 km northwest of Altonah--Ranch caretaker "almost knocked out of bed;" one sharp jolt cracked a windowpane.

Intensity IV: Altamont, Bluebell.

Intensity II:

East Granddaddy Mountain, about 6.5 km northwest of Peterson Gulch area--Small rockfalls noted at the mouth of nearby water-diversion tunnel by USGS personnel.

28 November (U) Utah

Origin time: 02 23 11.0  
Epicenter: 41.35 N., 111.70 W.  
Depth: 7 km  
Magnitude: 2.8 ML  
Intensity V: Huntsville (small objects fell).

Intensity III: Ogden Canyon, Pineville Reservoir area, Southeast Ogden Bench area.

Virginia

27 February (G) Central Virginia

Origin time: 20 05 34.6  
Epicenter: 37.90 N., 78.63 W.

Virginia--Continued

Depth: 5 km  
Magnitude: 2.4 mbLg(V)

The USGS assigned the intensities below using the results of a newspaper canvass conducted by Dr. James L. Calver, Virginia Division of Mineral Resources, Charlottesville.

Intensity V:

Charlottesville--Knocked bulletin board from wall, jammed storm door so it would not open, displaced pictures, broke chinaware.

Covesville--Window shaken out, house trembled.

Estmont--All were frightened, house swayed, and windows rattled.

North Garden (on State Route 692)--Ham rolled off shelf in freezer, several houses were shaken violently, pictures fell from walls.

Schuyler (on State Route 6, about 6.4 km east of U.S. Highway 29)--Heavy table and small objects moved, many reports of houses trembling, pictures fell from walls.

Intensity IV:

Alberne, Afton, Amhurst,

Crozet, Farmington, Frys Springs, Ivy Depot, North Garden, Rio Rd. (1.9 km north of Charlottesville), Schuyler, Scottsville, Shipman, South Garden, Yancy Mills (near Crozet).

Intensity III:

Batesville (about 4.3 km

southwest of on State Route 635), Estmont (17.7 km south of Charlottesville on U.S. Highway 29), Schuyler (8 km north of State Routes 6 and 630), Scottsville (9.7 km east of at the end of State Route 611), Hatton Ferry (4.9 km west of Scottsville).

Intensity II:

Bumpass.

Washington

17 June (W) Washington

Origin time: 06 16 01.8  
Epicenter: 47.74 N., 122.71 W.  
Depth: 25 km  
Magnitude: 3.3 ML(G)

Intensity V: Bremerton (small objects shifted), Everett (small objects shifted), Lilliwaup, Mukilteo, Olympia.

Intensity IV: Brinnon, Chimacum, Clinton, Hadlock, Hansville, Indianola, Kirkland, Langley, Magnolia, Marysville, McCleary, Nordland, Port Orchard, Quilcene, Seabeck, Seattle, Snoqualmie, Tracyton.

Intensity III: Bainbridge Island,

Bothell, Kingston.

Intensity II: Arlington, Hoodspport, Oak Harbor.

-----  
 Washington--Continued  
 -----

- 10 July (W) Washington  
 Origin time: 07 19 30.3  
 Epicenter: 48.53 N., 122.45 W.  
 Depth: 11 km  
 Magnitude: 4.3 mb(G), 3.4 ML(G)  
 Intensity V: La Connor.  
Intensity IV: Acme, Bellingham, Bow,  
 Lyman.  
Intensity III: Clinton.  
Intensity II: Anacortes (W), Hamilton.
- 13 July (W) Washington  
 Origin time: 07 15 06.3  
 Epicenter: 47.06 N., 120.96 W.  
 Depth: 0 km  
 Magnitude: 3.6 ML(G)  
Intensity IV: Ronald.
- 25 July (W) Washington  
 Origin time: 21 04 03.8  
 Epicenter: 48.07 N., 122.85 W.  
 Depth: 55 km  
 Magnitude: 3.2 ML(G)  
Intensity IV: Hansville, Nordland.  
Intensity II: Chimacum.
- 5 August (W) Puget Sound, Washington  
 Origin time: 11 39 57.1  
 Epicenter: 47.82 N., 122.29 W.  
 Depth: 18 km  
 Magnitude: 2.7 ML  
Intensity III: Edmonds (W).
- 14 October (W) Washington  
 Origin time: 02 53 32.5  
 Epicenter: 48.51 N., 122.15 W.  
 Depth: 11 km  
 Magnitude: 3.3 ML(G)  
Intensity II: Lyman, Sedro-Woolley area.

-----  
 Wyoming  
 -----

- 26 January Wyoming  
 Origin time: 10 23  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity IV: Yellowstone National Park.

- 3 March (G) Wyoming  
 Origin time: 17 50 28.0  
 Epicenter: 41.24 N., 107.15 W.  
 Depth: 5 km  
 Magnitude: 4.2 mb, 3.5 ML

The following information was received about the southern Wyoming earthquake from H. W. Oliver, U.S. Geological Survey (written commun., 1977):

Intensity V:  
 Colorado--Slater (plant fell from window sill).

-----  
 Wyoming--Continued  
 -----

- Intensity IV:  
 Wyoming--Encampment, Riverside, Savery (dishes and doors rattled at several ranch homes--press report).
- 4 March (G) Hebgen Lake region  
 Origin time: 10 05 59.6  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 11 01 50.2  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 11 33 06.9  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 13 00 58.9  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 13 04 21.4  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 14 19 48.8  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 14 26  
 See Montana listing.
- 4 March (G) Yellowstone National Park  
 Origin time: 14 39 23.5  
 Epicenter: 44.84 N., 110.92 W.  
 Depth: 5 km  
 Magnitude: 3.8 ML(D)  
Intensity III:  
 Montana--West Yellowstone.  
 Wyoming--Old Faithful (Yellowstone National Park).
- 4 March (G) Hebgen Lake region  
 Origin time: 14 58 05.5  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 16 12 28.2  
 See Montana listing.
- 4 March (G) Hebgen Lake region  
 Origin time: 16 47 43.5  
 See Montana listing.

-----  
 Wyoming--Continued  
 -----

4 March (G) Hebgen Lake region  
 Origin time: 16 51 48.3  
 See Montana listing.

4 March (G) Hebgen Lake region  
 Origin time: 17 10 40.6  
 See Montana listing.

11 March (G) Montana  
 Origin time: 05 09 37.2  
 See Montana listing.

11 March (G) Hebgen Lake region  
 Origin time: 12 17 51.9  
 See Montana listing.

24 March Wyoming  
 Origin time: 08 55  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity IV: Bighorn.  
Intensity II: Sheridan.

-----  
 Wyoming--Continued  
 -----

2 April (G) Yellowstone National Park  
 Origin time: 23 03 52.2  
 Epicenter: 44.75 N., 110.82 W.  
 Depth: 5 km  
 Magnitude: 3.9 ML, 3.5 ML(A)  
Intensity III: Yellowstone National  
 Park, Wyo..

28 May (G) Eastern Idaho  
 Origin time: 13 36 35.6  
 See Idaho listing.

17 June Yellowstone National Park  
 Origin time: 11 52  
 Epicenter: Not located.  
 Depth: None computed.  
 Magnitude: None computed.  
Intensity IV: Norris Geyser Basin  
 Museum Apartment (a few awakened by shock).

30 September (G) Utah  
 Origin time: 10 19 21.0  
 See Utah listing.

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977

DATE	ORIGIN TIME			COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC			LAT.	LONG.					
	H	M	S	DEG.	DEG.					
							ALASKA			
JAN 3	01 34	34.2		51.43	179.08	G	ANDREANOF ISLANDS	II	33	4.8 MB
JAN 6	16 02	07.6		51.48	175.48	G	ANDREANOF ISLANDS	IV	33	5.2 MB, 5.3 MS
JAN 13	22 05	59.3		59.43	142.23	G	GULF OF ALASKA	III	33	4.5 ML(M)
JAN 18	17 07	10.8		61.39	146.56	G	SOUTHERN ALASKA	III	28	3.2 ML(M)
JAN 25	17 12	19.1		60.98	149.99	G	SOUTHERN ALASKA	III	37	3.5 ML(M)
JAN 26	21 38	45.0		61.23	150.13	G	SOUTHERN ALASKA	II	52	
JAN 30	03 02	50.6		51.57	175.53	G	ANDREANOF ISLANDS	II	44	4.1 MB
FEB 19	22 34	04.1		53.57	170.03	G	NEAR ISLANDS	IV	33	6.2 MB, 6.7 MS
FEB 24	13 50						HOMER	IV		
MAR 3	10 14	02.3		51.75	175.97	G	ANDREANOF ISLANDS	III	63	4.1 MB
MAR 18	12 56						CENTRAL ALASKA	III		3.6 ML(M)
MAR 25	13 39	45.2		60.84	148.14	G	KENAI PENINSULA, ALASKA	V	55	4.6 MB
MAR 26	04 36	14.7		52.30	168.26	G	FOX ISLANDS	IV	31	5.7 MB, 6.0 MS
MAR 30	17 41	30.0		52.55	172.52	G	NEAR ISLANDS	IV	38	5.0 MB
APR 12	13 06	00.3		60.80	149.22	G	KENAI PENINSULA, ALASKA	III	39	4.4 MB, 5.1 ML(M)
APR 18	23 44						CENTRAL ALASKA	III		4.1 ML(M)
APR 20	12 11	49.1		59.45	150.61	G	KENAI PENINSULA, ALASKA	IV	33	4.8 MB, 4.1 ML(M)
APR 23	17 59						CENTRAL ALASKA	II		
APR 27	13 29	08.4		62.29	150.97	G	CENTRAL ALASKA	II	38	3.1 ML(M)
MAY 5	00 22	30.3		64.84	148.36	G	CENTRAL ALASKA	III	09	3.7 ML(M)
MAY 11	17 33	30.7		61.70	150.47	G	SOUTHERN ALASKA	IV	76	3.9 MB
MAY 12	15 08						NORTHERN ALASKA	III		
MAY 25	18 06	34.1		67.38	150.30	G	ALASKA	III	12	
MAY 30	15 16	01.6		52.43	169.71	G	FOX ISLANDS	IV	33	5.6 MB, 6.0 MS
MAY 30	18 40	26.6		60.89	149.69	G	KENAI PENINSULA, ALASKA	II	42	
MAY 30	16 29	46.3		61.31	150.33	G	SOUTHERN ALASKA	VI	67	3.6 MB
JUN 6	10 08	11.5		62.16	149.55	G	CENTRAL ALASKA	III	60	4.1 MB
JUN 12	21 09	14.4		61.63	146.15	G	SOUTHERN ALASKA	III	35	4.2 MB, 4.2 ML(M)
JUN 17	05 32	12.0		58.27	151.82	G	KODIAK ISLAND REGION	III	36	4.0 ML(M)
JUN 17	08 26	28.9		61.49	150.32	G	SOUTHERN ALASKA	V	74	4.3 M3
JUN 29	08 47	15.6		51.77	176.22	G	ANDREANOF ISLANDS	IV	60	5.0 MB
JUL 8	19 59	39.9		61.17	150.85	G	SOUTHERN ALASKA	V	72	4.7 MB
JUL 8	20 32	46.7		62.33	150.10	G	CENTRAL ALASKA	III	16	3.7 ML(M)
JUL 11	15 57	17.2		64.56	147.27	G	CENTRAL ALASKA	V	14	4.5 MB, 4.2 MS
JUL 20	13 24	25.9		54.61	161.60	G	ALASKA PENINSULA	V	53	5.3 MB
JUL 22	05 57	00.5		61.03	150.40	G	SOUTHERN ALASKA	III	51	3.8 MB, 4.0 ML(M)
JUL 26	18 39	21.7		62.53	149.04	G	SOUTHERN ALASKA	IV	69	
AUG 4	15 10	24.6		59.53	152.89	G	SOUTHERN ALASKA	II	10	
AUG 15	00 24	33.2		51.59	176.39	G	ANDREANOF ISLANDS	IV	63	4.5 MB
AUG 16	06 30	18.5		67.52	150.25	G	ALASKA	IV	39	3.5 ML(M)
AUG 17	16 48	31.3		51.87	175.34	G	ANDREANOF ISLANDS	IV	57	5.4 MB
AUG 18	13 02	49.0		51.83	175.18	G	ANDREANOF ISLANDS	II	33	4.2 MB
AUG 29	20 59	58.2		51.56	173.97	G	ANDREANOF ISLANDS	II	25	5.4 MB, 5.1 MS
AUG 30	06 50	39.9		53.16	151.11	G	CENTRAL ALASKA	V	13	5.0 MB
AUG 30	15 12	27.6		51.38	173.79	G	ANDREANOF ISLANDS	II	33	5.4 MB, 5.0 MS
SEP 4	15 46	57.3		51.21	176.39	G	PAT ISLANDS	II	34	5.6 M3, 6.4 MS

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME			COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH (KM)	MAGNITUDE
	UTC			LAT.	LONG.					
	H	M	S	DEC.	DEC.					
ALASKA (CONTINUED)										
SEP 4	17	10	30.6	51.10	178.27	G	RAT ISLANDS	II	31	5.5 MB, 6.4 MS
SEP 4	17	24	42.8	51.14	177.95	G	PAT ISLANDS	II	08	5.8 MB, 6.6 MS
SEP 9	15	58	56.4	62.19	149.53	G	CENTRAL ALASKA	II	59	4.6 MB
SEP 17	15	42	42.2	60.86	150.84	G	SOUTHERN ALASKA	IV	33	3.7 ML(M)
SEP 17	18	26	29.9	61.03	152.92	G	SOUTHERN ALASKA	IV	15	4.8 MB
SEP 17	21	25	21.4	64.82	147.43	G	CENTRAL ALASKA	IV	20	4.0 ML(M)
OCT 3	13	31	16.4	65.15	146.84	G	ALASKA	III	33	3.3 ML(M)
OCT 16	04	25	40.0	59.88	152.55	G	SOUTHERN ALASKA	V	82	4.6 MB
OCT 18	10	48	37.3	60.77	150.79	G	KENAI PENINSULA, ALASKA	II	33	3.7 MB, 3.4 ML(M)
OCT 19	02	16	02.6	62.88	150.56	G	CENTRAL ALASKA	III	10	5.0 MB
OCT 27	08	53	20.5	64.65	164.97	G	ALASKA	II	33	3.4 ML(M)
OCT 28	08	53	34.5	60.91	149.72	G	KENAI PENINSULA, ALASKA	II	26	
NOV 4	01	22	26.5	61.13	150.30	G	SOUTHERN ALASKA	II	42	
NOV 4	09	52	55.7	51.66	175.95	G	ANDREANOF ISLANDS	VI	33	5.7 MB, 6.7 MS
NOV 4	18	07	31.3	51.43	175.56	G	ANDREANOF ISLANDS	IV	33	5.4 MB, 5.4 MS
NOV 6	19	11	02.7	62.10	144.94	G	CENTRAL ALASKA	II	33	3.3 ML(M)
NOV 17	03	33	56.0	64.97	147.91	G	ALASKA	IV	16	3.9 ML(M)
NOV 17	05	00	09.6	64.61	149.54	G	CENTRAL ALASKA	II	25	3.3 ML(M)
NOV 17	12	27	06.3	61.29	149.40	G	SOUTHERN ALASKA	III	39	4.9 MB, 4.9 ML(M)
NOV 20	18	53	57.8	62.43	150.66	G	CENTRAL ALASKA	IV	79	4.9 MB
NOV 27	15	05	06.8	58.56	155.38	G	ALASKA PENINSULA	IV	11	4.7 MB
DEC 8	01	58	05.8	59.45	151.36	G	KENAI PENINSULA, ALASKA	IV	65	3.0 ML(M)
DEC 15	01	29	22.6	61.37	150.01	G	SOUTHERN ALASKA	III	38	4.9 MB
DEC 16	21	49	21.7	59.77	153.45	G	SOUTHERN ALASKA	II	11	5.1 MB
DEC 27	15	09	51.0	60.35	153.70	G	SOUTHERN ALASKA	V	17	4.3 MB
DEC 29	21	48	16.7	61.65	146.38	G	SOUTHERN ALASKA	III	57	
ARIZONA										
OCT 21	02	55	13.4	34.63	112.48	G	WESTERN ARIZONA	V	10	2.5 ML
ARKANSAS										
JUN 2	23	29	10.4	34.61	94.19	S	ARKANSAS-OKLAHOMA BORDER	VI	10	4.3 MB(G), 4.0 MBLG
NOV 26	04	18	17.0	34.52	92.96	G	APKANSAS	IV	05	3.1 MBLG(S)
CALIFORNIA										
JAN 8	07	17	33.9	37.90	122.19	B	CENTRAL CALIFORNIA	III	09	3.0 ML
JAN 8	08	58	13.9	37.90	122.18	B	CENTRAL CALIFORNIA	IV	10	4.0 ML
JAN 8	09	38	07.5	37.90	122.18	B	CENTRAL CALIFORNIA	VI	09	4.8 MB(G), 4.3 ML
JAN 8	05	39	40.7	37.90	122.20	B	CENTRAL CALIFORNIA	III	09	3.8 ML
JAN 6	09	51	55.6	37.91	122.19	B	CENTRAL CALIFORNIA	III	08	3.0 ML
JAN 9	05	34	16.7	37.89	122.19	B	CENTRAL CALIFORNIA	III	05	3.2 ML
JAN 9	23	24	39.5	39.50	121.64	B	NORTHERN CALIFORNIA	IV	02	3.3 ML

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME			COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC H M S	LAT. DEG.	LONG. DEG.							
JAN 10	05 08 07.9	37.91	122.30	B	CENTRAL CALIFORNIA	III	03	2.9 ML		
JAN 13	20 09 53.5	41.02	122.15	B	CALIFORNIA	III	02	3.7 ML		
JAN 17	00 39 15.4	34.37	118.67	P	SOUTHERN CALIFORNIA	III	14	3.4 ML		
JAN 17	11 13 19.4	32.47	115.18	P	CALIFORNIA-MEXICO BORDER REG	V	25	4.6 MB(G), 4.2 ML		
JAN 18	21 05 46.6	36.92	121.49	B	CENTRAL CALIFORNIA	IV	09	3.5 ML		
JAN 19	02 12 19.8	36.93	121.49	B	CENTRAL CALIFORNIA	V	04	4.0 ML		
JAN 23	17 45 50.3	37.86	122.25	B	CENTRAL CALIFORNIA	IV	09	2.7 ML		
JAN 24	11 35 16.5	33.92	118.13	P	SOUTHERN CALIFORNIA	III	27	2.7 ML		
JAN 24	15 55 46.4	37.86	122.24	B	CENTRAL CALIFORNIA	III	08	2.7 ML		
FEB 1	18 47 57.5	39.06	120.00	B	NORTHERN CALIFORNIA	V	02	3.9 ML		
FEB 3	13 49 38.8	33.88	116.60	P	SOUTHERN CALIFORNIA	III	08	2.8 ML		
FEB 10	12 10 47.7	33.97	116.58	P	SOUTHERN CALIFORNIA	IV	08	3.3 ML		
FEB 14	13 58 40.3	35.72	117.70	P	CENTRAL CALIFORNIA	IV	03	3.2 ML		
FEB 14	13 58 51.8	35.72	117.70	P	CENTRAL CALIFORNIA	V	03	3.7 ML		
FEB 21	11 09 15.3	39.37	123.30	B	NEAR COAST OF N. CALIFORNIA	V	20	3.2 ML		
FEB 22	06 24 06.5	38.48	119.29	B	CALIFORNIA-NEVADA BORDER REG	V	05	5.0 MB(G), 4.8 ML		
FEB 26	22 09 38.2	34.15	118.23	P	SOUTHERN CALIFORNIA	III	13	3.1 ML		
MAR 1	21 08 46.1	37.84	122.06	B	CENTRAL CALIFORNIA	V	09	3.0 ML		
MAR 7	11 04 35.2	34.47	117.97	P	SOUTHERN CALIFORNIA	III	08	3.0 ML		
MAR 7	21 52 24.0	35.73	117.70	P	CENTRAL CALIFORNIA	V	12	3.0 ML		
MAR 7	23 21 30.7	35.73	117.70	P	CENTRAL CALIFORNIA	III	12	3.2 ML		
MAR 12	09 19 06.7	36.89	121.49	B	CENTRAL CALIFORNIA	III	12	3.7 ML		
MAR 15	08 01	34.01	118.27	P	CENTRAL CALIFORNIA	II	22	2.2 ML		
MAR 19	10 37 49.7	35.75	117.72	P	CENTRAL CALIFORNIA	III	02	3.0 ML		
MAR 25	11 23 55.7	33.97	116.60	P	SOUTHERN CALIFORNIA	III	11	2.8 ML		
MAR 25	15 43 58.8	32.97	115.50	P	SOUTHERN CALIFORNIA	III	13	3.4 ML		
MAR 31	13 30 29.0	33.40	116.97	P	SOUTHERN CALIFORNIA	III	03	3.3 ML		
APR 2	06 09 11.9	40.57	123.90	B	NORTHERN CALIFORNIA	IV	14	4.4 MB(G), 3.6 ML		
APR 6	06 01 02.2	33.47	116.47	P	SOUTHERN CALIFORNIA	III	16	3.5 ML		
MAY 4	06 59 10.5	39.41	121.49	B	NORTHERN CALIFORNIA	IV	07	3.5 ML		
MAY 4	19 43 33.8	38.17	121.94	B	NORTHERN CALIFORNIA	III	26	3.2 ML		
MAY 5	22 40 31.7	38.17	121.94	B	NORTHERN CALIFORNIA	III	26	3.3 ML		
MAY 21	00 28 19.7	37.65	118.75	B	CALIFORNIA-NEVADA BORDER REG	IV	12	3.4 ML		
MAY 25	08 22 00.9	34.15	119.15	P	SOUTHERN CALIFORNIA	II	04	2.5 ML		
MAY 30	16 16 37.9	33.90	117.88	P	SOUTHERN CALIFORNIA	V	05	2.6 ML		
MAY 30	21 17 02.9	33.90	117.88	P	SOUTHERN CALIFORNIA	II	05	2.4 ML		
MAY 31	16 40 24.2	40.89	122.33	B	NORTHERN CALIFORNIA	IV	15	3.7 ML		
JUN 4	20 57 07.5	38.20	121.97	B	NORTHERN CALIFORNIA	V	26	3.8 ML		
JUN 7	01 14 22.0	41.00	123.87	B	NORTHERN CALIFORNIA	V	28	4.6 MB(G), 3.9 ML		
JUN 11	04 18 20.5	34.38	118.62	P	SOUTHERN CALIFORNIA	III	05	3.1 ML		
JUN 13	03 19 36.9	33.87	118.63	P	SOUTHERN CALIFORNIA	II	05	2.8 ML		
JUN 14	01 56 33.2	34.02	118.32	P	SOUTHERN CALIFORNIA	II	05	2.7 ML		
JUN 17	19 42 47.6	32.05	117.33	P	CALIFORNIA-MEXICO BORDER REG	III	06	3.3 ML		
JUN 17	19 38 48.4	38.18	121.93	B	NORTHERN CALIFORNIA	IV	22	3.5 ML		
JUN 20	18 33 00.1	34.02	118.32	P	SOUTHERN CALIFORNIA	II	10	2.5 ML		

CALIFORNIA  
(CONTINUED)

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME		COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC		LAT.	LONG.					
	H	M S	DEG.	DEG.					
JUN 21	02	43 06.9	37.65	121.64	B	CENTRAL CALIFORNIA	VI	10	4.7 MB(G), 3.5 MS(G)
JUL 3	19	46 53.0	37.38	121.75	B	CENTRAL CALIFORNIA	III	04	3.2 ML
JUL 3	20	21 24.4	37.35	121.72	B	CENTRAL CALIFORNIA	III	07	3.3 ML
JUL 12	31	43 28.5	40.28	123.69	B	NORTHERN CALIFORNIA	V	20	5.0 MB(G), 3.8 MS(G)
JUL 12	05	17 11.2	40.28	123.66	B	NORTHERN CALIFORNIA	V	21	3.5 ML
JUL 12	15	22 55.8	40.28	123.69	B	NORTHERN CALIFORNIA	IV	19	3.3 ML
JUL 13	08	12 48.6	34.00	116.83	P	SOUTHERN CALIFORNIA	IV	11	3.0 ML
JUL 14	11	38 05.7	36.56	121.21	B	CENTRAL CALIFORNIA	V	05	3.2 ML
JUL 19	23	50 30.6	38.05	121.99	B	NORTHERN CALIFORNIA	III	02	3.5 ML
JUL 26	21	42 16.3	35.94	120.47	B	CENTRAL CALIFORNIA	IV	09	3.7 ML
JUL 27	11	10 46.7	36.90	121.51	B	CENTRAL CALIFORNIA	III	01	3.2 ML
JUL 27	21	51 17.5	37.31	122.16	B	CENTRAL CALIFORNIA	IV	11	3.5 ML
JUL 30	16	35 38.1	36.91	121.48	B	CENTRAL CALIFORNIA	III	11	3.8 ML
AUG 2	02	31 43.8	37.91	122.30	B	CENTRAL CALIFORNIA	IV	03	2.8 ML
AUG 3	22	08 33.7	33.83	118.13	P	SOUTHERN CALIFORNIA	II	11	2.8 ML
AUG 12	02	19 26.1	34.38	118.47	P	SOUTHERN CALIFORNIA	VI	10	4.1 MB(G), 4.4 ML
AUG 12	04	41 38.6	34.38	118.45	P	SOUTHERN CALIFORNIA	III	05	3.3 ML
AUG 14	14	25 34.8	37.74	121.92	B	CENTRAL CALIFORNIA	III	09	3.4 ML
SEP 5	17	45 28.2	38.19	122.12	B	NORTHERN CALIFORNIA	VI	08	3.7 ML
SEP 8	00	28 20.8	38.68	122.75	B	NORTHERN CALIFORNIA	V	07	4.0 MB(G), 3.8 ML
SEP 11	05	18 48.1	38.68	122.80	B	NORTHERN CALIFORNIA	IV	09	3.8 MB(G), 3.7 ML
SEP 12	23	46 12.2	38.70	122.80	B	NORTHERN CALIFORNIA	V	12	3.9 MB(G), 4.0 ML
SEP 12	06	17 42.6	34.22	116.98	P	SOUTHERN CALIFORNIA	II	05	3.2 ML
SEP 14	21	35 23.3	33.88	117.82	P	SOUTHERN CALIFORNIA	III	02	2.7 ML
SEP 19	10	34 54.6	33.95	117.78	P	SOUTHERN CALIFORNIA	II	09	2.7 ML
SEP 22	09	41 10.5	33.98	116.58	P	SOUTHERN CALIFORNIA	IV	05	3.5 ML
SEP 22	20	48 42.9	38.60	122.76	B	NORTHERN CALIFORNIA	IV	05	4.0 MB(G), 4.0 ML
SEP 24	21	28 24.3	34.47	118.42	P	SOUTHERN CALIFORNIA	VI	05	3.9 MB(G), 4.2 ML
OCT 4	06	39 39.6	40.26	121.27	B	NORTHERN CALIFORNIA	V	05	3.8 ML
OCT 6	08	16 03.4	34.02	118.19	P	SOUTHERN CALIFORNIA	III	14	3.3 ML
OCT 6	11	50 58.1	34.88	120.32	P	SOUTHERN CALIFORNIA	II	04	2.9 ML
OCT 6	11	52 04.7	34.88	120.30	P	SOUTHERN CALIFORNIA	II	04	2.5 ML
OCT 6	11	56 50.2	34.87	120.37	P	SOUTHERN CALIFORNIA	II	03	2.8 ML
OCT 9	03	26 26.3	34.42	118.42	P	SOUTHERN CALIFORNIA	III	10	3.3 ML
OCT 13	16	10 27.7	37.47	121.03	B	CENTRAL CALIFORNIA	V	10	3.7 ML
OCT 19	06	56 07.7	32.90	115.50	P	CALIFORNIA-MEXICO BORDER REG	II	05	2.8 ML
OCT 19	11	46 08.3	38.36	122.56	B	NORTHERN CALIFORNIA	IV	10	3.3 ML
OCT 19	12	13 35.6	32.88	115.50	P	CALIFORNIA-MEXICO BORDER REG	III	06	2.9 ML
OCT 20	09	17 40.5	32.88	115.50	P	CALIFORNIA-MEXICO BORDER REG	II	05	3.2 ML
OCT 20	10	29 35.9	32.88	115.50	P	CALIFORNIA-MEXICO BORDER REG	II	05	4.0 ML
OCT 20	19	06 16.5	32.88	115.50	P	CALIFORNIA-MEXICO BORDER REG	II	04	3.8 ML
OCT 20	20	14 00.6	33.73	118.02	P	SOUTHERN CALIFORNIA	II	05	2.7 ML
OCT 20	20	22 22.9	32.90	115.50	P	CALIFORNIA-MEXICO BORDER REG	II	05	3.9 ML
OCT 21	00	09 39.1	32.90	115.50	P	CALIFORNIA-MEXICO BORDER REG	II	06	3.4 ML
OCT 21	06	12 36.2	32.90	115.50	P	CALIFORNIA-MEXICO BORDER REG	VI	06	3.7 MB(G), 4.3 ML

CALIFORNIA  
(CONTINUED)

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME			COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC	H	M	S	LAT. DEG.					
OCT 21	13	24	24.2		32.90	115.53	CALIFORNIA-MEXICO BORDER REG	III	05	4.2 ML
OCT 21	18	10	58.3		32.89	115.50	CALIFORNIA-MEXICO BORDER REG	II	05	3.0 ML
OCT 22	04	59	17.3		34.38	117.05	SOUTHERN CALIFORNIA	II	02	3.7 ML
OCT 28	21	24	52.4		32.87	115.50	CALIFORNIA-MEXICO BORDER REG	II	16	3.9 ML
OCT 28	01	31	36.6		32.90	115.52	CALIFORNIA-MEXICO BORDER REG	II	05	3.0 ML
OCT 30	05	30	13.3		32.88	115.50	CALIFORNIA-MEXICO BORDER REG	II	04	4.7 MB(G), 4.0 ML
NOV 1	04	06	43.4		37.71	122.56	CENTRAL CALIFORNIA	IV	02	3.3 ML
NOV 4	15	12	53.0		36.58	121.20	CENTRAL CALIFORNIA	V	05	3.4 ML
NOV 8	10	52	27.2		33.88	117.90	SOUTHERN CALIFORNIA	V	07	3.4 ML
NOV 10	20	24	42.2		39.43	121.53	NORTHERN CALIFORNIA	IV	04	2.7 ML
NOV 13	16	25	19.7		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.2 ML
NOV 14	00	11	35.8		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.9 ML
NOV 14	00	33	31.0		32.82	115.47	CALIFORNIA-MEXICO BORDER REG	III	04	3.1 ML
NOV 14	02	05	47.9		32.82	115.47	CALIFORNIA-MEXICO BORDER REG	VI	05	5.0 MB(G), 4.2 ML
NOV 14	02	10	18.5		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.4 ML
NOV 14	02	32	14.8		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.1 ML
NOV 14	03	19	07.2		32.82	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.0 ML
NOV 14	04	49	56.6		32.80	115.47	CALIFORNIA-MEXICO BORDER REG	III	06	3.0 ML
NOV 14	05	05	20.3		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	03	3.8 ML
NOV 14	05	13	45.3		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.1 ML
NOV 14	05	18	02.6		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	06	3.7 ML
NOV 14	05	23	36.5		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	04	3.8 ML
NOV 14	05	30	40.8		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	07	3.3 ML
NOV 14	05	36	55.4		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	IV	05	4.1 ML
NOV 14	10	23	06.2		32.77	115.47	CALIFORNIA-MEXICO BORDER REG	III	04	3.4 ML
NOV 14	12	20	19.5		32.82	115.45	CALIFORNIA-MEXICO BORDER REG	IV	05	4.3 ML
NOV 14	16	10	33.6		32.82	115.45	CALIFORNIA-MEXICO BORDER REG	III	06	3.2 ML
NOV 14	16	18	53.3		32.82	115.45	CALIFORNIA-MEXICO BORDER REG	III	06	3.4 ML
NOV 15	19	13	16.9		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	III	05	3.4 ML
NOV 16	17	29	17.7		32.83	115.47	CALIFORNIA-MEXICO BORDER REG	II	04	2.6 ML
NOV 18	02	17	18.4		35.69	121.04	CENTRAL CALIFORNIA	IV	03	3.9 ML
NOV 22	11	51	52.5		39.45	123.26	NORTHERN CALIFORNIA	VII	05	5.2 MB(G), 4.8 ML
NOV 23	13	53	53.8		39.45	123.29	NEAR COAST OF N. CALIFORNIA	IV	03	3.4 ML, 4.0 MB(G)
NOV 23	15	27	14.4		39.50	123.30	NEAR COAST OF N. CALIFORNIA	IV	03	3.6 ML
NOV 23	15	29	13.3		39.50	123.30	NEAR COAST OF N. CALIFORNIA	IV	05	3.3 ML
NOV 29	16	42	02.4		35.96	120.49	CENTRAL CALIFORNIA	IV	11	3.6 MB(G), 3.7 ML
DEC 3	06	54	59.6		34.07	118.40	SOUTHERN CALIFORNIA	II	11	2.2 ML
DEC 7	15	40	59.2		33.78	118.08	SOUTHERN CALIFORNIA	II	07	2.9 ML
DEC 9	02	28	54.5		37.71	122.62	CENTRAL CALIFORNIA	III	04	2.7 ML
DEC 12	01	11	46.1		37.33	121.70	CENTRAL CALIFORNIA	III	07	3.5 ML
DEC 15	11	15	29.0		36.58	121.23	CENTRAL CALIFORNIA	VI	06	3.6 MB(G), 4.2 ML
DEC 20	13	15	13.9		34.03	118.23	SOUTHERN CALIFORNIA	V	06	2.9 ML
DEC 27	06	07	56.2		33.91	118.51	SOUTHERN CALIFORNIA	II	11	2.7 ML
DEC 28	02	59	37.3		35.82	120.33	CENTRAL CALIFORNIA	V	02	3.5 ML
DEC 29	14	03	16.7		36.86	120.04	CENTRAL CALIFORNIA	II	08	3.5 ML

CALIFORNIA  
(CONTINUED)

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME		COORDINATES		SOURCE	REGION	GEOGRAPHIC		MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC		LAT. DEG.	LONG. DEG.			INTENSITY (MM)	DEPTH KM			
	H	M S									
NOV 3	05	34				NORTHERN COLORADO		II		2.0 ML(G)	
FEB 10	19	14 25				DELAWARE		VI		2.0 MBLG(Z)	
JAN 1	14 26	35.3	19.34	155.12	H	HAWAII		II	09	3.7 ML	
JAN 5	00 25	13.2	19.39	155.25	H	HAWAII		III	05	3.6 ML	
JAN 8	10 02	38.0	19.33	155.13	H	HAWAII		III	10	4.1 ML	
JAN 12	13 35	59.3	19.40	155.29	H	HAWAII		IV	16	3.9 ML	
JAN 14	23 26	42.3	19.34	155.12	H	HAWAII		IV	09	4.2 MB(G), 4.7 ML	
JAN 20	12 20	27.8	19.33	155.19	H	HAWAII		III	09	3.4 ML	
JAN 22	17 32	42.5	19.36	155.25	H	HAWAII		III	10	3.6 ML	
JAN 23	18 02	44.2	19.39	155.25	H	HAWAII		IV	06	3.6 ML	
JAN 29	20 49	01.7	19.34	155.20	H	HAWAII		IV	09	4.8 MB(G), 4.0 ML	
JAN 30	08 48	49.7	19.37	155.08	H	HAWAII		IV	08	4.1 ML	
FEB 2	18 11	29.3	19.39	155.07	H	HAWAII		III	08	3.0 ML	
FEB 4	01 20	49.7	19.36	155.08	H	HAWAII		IV	09	4.5 MB(G), 4.5 ML	
FEB 4	14 25	11.7	20.11	155.47	H	HAWAII		IV	01	3.7 ML	
FEB 9	00 47	02.2	19.39	155.25	H	HAWAII		III	03	3.1 ML	
FEB 9	04 51	20.2	19.39	155.23	H	HAWAII		III	03	3.4 ML	
FEB 9	05 02	22.2	19.39	155.24	H	HAWAII		III	07	3.5 ML	
FEB 9	05 23	31.8	19.39	155.25	H	HAWAII		III	05	3.5 ML	
FEB 9	05 28	30.0	19.39	155.25	H	HAWAII		III	05	3.4 ML	
FEB 9	05 54	26.5	19.37	155.24	H	HAWAII		III	00	3.0 ML	
FEB 9	06 44	06.1	19.38	155.25	H	HAWAII		III	01	3.1 ML	
FEB 9	07 27	35.4	19.39	155.26	H	HAWAII		III	01	3.2 ML	
FEB 9	19 22	01.0	19.39	155.08	H	HAWAII		III	08	3.3 ML	
FEB 10	07 14	47.0	19.39	155.25	H	HAWAII		III	05	3.0 ML	
FEB 21	03 29	42.8	19.33	155.27	H	HAWAII		IV	10	3.7 ML	
FEB 24	03 23	25.7	20.20	155.80	H	HAWAII		III	36	3.5 ML	
MAR 9	10 29	16.5	19.40	155.50	H	HAWAII		V	53	4.1 ML	
MAR 18	23 33	07.2	19.36	155.30	H	HAWAII		III	34	3.2 ML	
MAR 21	14 59	24.7	19.37	155.07	H	HAWAII		III	08	3.4 ML	
MAR 25	05 37	00.3	19.35	155.14	H	HAWAII		IV	08	3.6 ML	
MAR 29	22 56	40.0	19.18	155.68	H	HAWAII		III	06	3.3 ML	
MAR 31	01 17	37.7	19.70	156.00	H	HAWAII		IV	09	3.6 ML	
APR 6	21 00	25.2	19.36	155.09	H	HAWAII		IV	09	3.6 ML	
APR 11	05 31	16.2	19.32	155.27	H	HAWAII		III	09	3.0 ML	
APR 21	04 49	21.9	20.02	155.31	H	HAWAII		V	10	5.1 ML	
APR 21	11 51	31.9	19.32	155.27	H	HAWAII		III	09	3.6 ML	
APR 22	19 44	00.0	19.32	155.26	H	HAWAII		IV	09	4.0 ML	
APR 26	04 20	53.0	19.34	155.23	H	HAWAII		III	09	3.5 ML	

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME			GEOGRAPHIC COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC H M S	LAT. DEG.	LONG. DEG.							
MAY 2	18 54 05.4	20 08	155.36	HAWAII	H	HAWAII	IV	08	3.7 ML	
MAY 4	14 22 58.1	20 24	155.76	HAWAII	H	HAWAII	III	04	3.1 ML	
MAY 12	09 11 06.3	19 31	155.22	HAWAII	H	HAWAII	III	10	3.1 ML	
MAY 14	15 35 10.8	19 34	155.23	HAWAII	H	HAWAII	II	09	3.0 ML	
MAY 15	07 27 13.1	19 37	155.10	HAWAII	H	HAWAII	III	08	3.6 ML	
MAY 18	04 32 42.8	19 38	155.10	HAWAII	H	HAWAII	III	06	3.2 ML	
MAY 18	20 46 43.1	19 51	155.84	HAWAII	H	HAWAII	III	10	3.3 ML	
MAY 30	23 10 06.1	19 35	155.11	HAWAII	H	HAWAII	III	07	.1 ML	
JUN 4	11 42 52.6	19 42	154.93	HAWAII	H	HAWAII	III	08	3.1 ML	
JUN 6	09 42 18.7	19 37	155.08	HAWAII	H	HAWAII	V	08	4.8 MB(G), 4.8 ML	
JUN 6	20 58 37.7	19 33	155.19	HAWAII	H	HAWAII	III	10	3.4 ML	
JUN 7	07 14 18.9	19 52	155.94	HAWAII	H	HAWAII	III	10	3.0 ML	
JUN 15	01 22 00.8	19 33	155.18	HAWAII	H	HAWAII	III	10	3.1 ML	
JUN 29	11 24 36.1	19 36	155.25	HAWAII	H	HAWAII	IV	09	3.7 ML	
JUL 1	18 14 56.3	19 33	155.13	HAWAII	H	HAWAII	IV	10	3.7 ML	
JUL 4	14 20 07.9	19 93	155.75	HAWAII	H	HAWAII	IV	10	3.3 ML	
JUL 5	17 59 42.0	19 43	155.45	HAWAII	H	HAWAII	IV	10	4.1 ML	
JUL 6	18 50 18.6	19 34	155.11	HAWAII	H	HAWAII	III	09	3.6 ML	
JUL 10	20 46 00.1	19 37	155.00	HAWAII	H	HAWAII	III	06	3.0 ML	
JUL 29	09 56 27.7	20 77	156.25	HAWAII	H	HAWAII	III	08	3.5 ML	
JUL 31	10 04 19.9	19 39	155.05	HAWAII	H	HAWAII	III	08	3.0 ML	
AUG 8	07 54 20.3	19 34	155.22	HAWAII	H	HAWAII	IV	10	4.1 ML	
AUG 8	13 34 32.3	19 22	155.04	HAWAII	H	HAWAII	III	49	3.4 ML	
AUG 11	05 19 16.7	19 32	155.19	HAWAII	H	HAWAII	IV	09	3.9 ML	
AUG 11	09 43 05.0	19 35	155.23	HAWAII	H	HAWAII	III	09	3.3 ML	
AUG 13	22 24 25.5	20 44	155.62	HAWAII	H	HAWAII	IV	29	4.3 ML	
AUG 19	18 19 13.4	19 34	155.12	HAWAII	H	HAWAII	IV	10	4.2 ML	
AUG 25	06 07 13.8	19 33	155.19	HAWAII	H	HAWAII	III	10	3.6 ML	
AUG 30	12 46 21.3	19 38	155.45	HAWAII	H	HAWAII	IV	10	3.9 ML	
SEP 5	19 39 59.1	21 05	57.7 W	NORTHEAST OF OAHU ISLAND	H	HAWAII	II	10	3.5 ML	
SEP 7	23 51 06.7	19 37	155.32	HAWAII	H	HAWAII	III	30	4.5 ML	
SEP 12	22 44 16.7	19 43	155.29	HAWAII	H	HAWAII	III	13	3.0 ML	
SEP 13	11 04 39.8	19 43	155.27	HAWAII	H	HAWAII	III	04	3.0 ML	
SEP 13	16 00 04.5	19 37	155.11	HAWAII	H	HAWAII	II	08	3.3 ML	
SEP 14	05 12 24.2	19 16	155.05	HAWAII	H	HAWAII	III	07	3.7 ML	
SEP 14	07 31 56.6	19 35	155.06	HAWAII	H	HAWAII	III	08	3.8 ML	
SEP 14	21 07 38.4	19 36	155.02	HAWAII	H	HAWAII	III	06	3.4 ML	
SEP 15	04 04 47.4	19 42	155.27	HAWAII	H	HAWAII	III	04	3.1 ML	
SEP 15	16 46 20.3	19 33	155.12	HAWAII	H	HAWAII	III	08	3.7 ML	
SEP 16	00 46 02.0	19 36	155.03	HAWAII	H	HAWAII	II	07	3.1 ML	
SEP 16	04 50 05.5	19 35	155.07	HAWAII	H	HAWAII	III	08	4.0 ML	
SEP 18	01 19 23.7	19 37	155.11	HAWAII	H	HAWAII	III	09	3.7 ML	
SEP 19	19 01 45.2	19 36	155.13	HAWAII	H	HAWAII	III	09	4.1 ML	
PT E S	12 08 44.1	19 36	155.05	HAWAII	H	HAWAII	IV	08	4.0 ML	

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE		ORIGIN TIME		COORDINATES		SOURCE	REGION	MAXIMUM		DEPTH	MAGNITUDE
		UTC	LAT.	LONG.	INTENSITY			(MM)			
		H	M	S	DEG.	DEG.				KM	
GEOGRAPHIC											
HAWAII (CONTINUED)											
SEP 23		12	59	56.9	19.42	155.26	H	HAWAII	III	05	3.0 ML
SEP 27		04	05	39.8	19.35	155.06	H	HAWAII	III	07	3.2 ML
SEP 28		17	38	01.2	19.36	155.06	H	HAWAII	III	07	3.8 ML
OCT 6		03	31	20.2	19.42	155.30	H	HAWAII	IV		3.4 ML
NOV 1		23	38	23.3	19.35	155.11	H	HAWAII	IV	10	3.8 ML
NOV 6		17	24	15.2	19.38	155.42	H	HAWAII	IV	12	3.6 ML
NOV 17		22	34	12.6	19.16	155.56	H	HAWAII	III	38	3.6 ML
NOV 19		05	16	17.1	19.33	155.07	H	HAWAII	III	08	3.2 ML
NOV 25		18	54	51.4	19.35	155.02	H	HAWAII	III	08	3.5 ML
DEC 5		08	25	37.8	19.35	155.04	H	HAWAII	III	09	3.2 ML
DEC 6		05	39	02.3	19.37	155.32	H	HAWAII	III	31	3.2 ML
DEC 14		18	19	32.7	19.32	155.18	H	HAWAII	III	12	3.2 ML
DEC 19		19	35	01.6	19.33	155.22	H	HAWAII	III	10	3.2 ML
DEC 22		08	25	55.1	19.33	155.23	H	HAWAII	III	10	3.6 ML
IDAHO											
JAN 2		14	12	22.2	44.63	112.60	G	EASTERN IDAHO	IV	05	3.5 ML(D), 3.3 ML(A)
MAY 28		13	36	35.6	44.42	111.43	G	EASTERN IDAHO	IV	05	3.2 ML(A), 4.0 ML(D)
NOV 27		09	25	55.1	44.58	116.27	G	WESTERN IDAHO	VI	05	4.2 MB, 4.5 ML
MASSACHUSETTS											
DEC 20		17	44	23.8	41.79	70.68	J	SOUTHERN NEW ENGLAND	V	00	3.1 MBLG, 3.0 MBLG(L)
DEC 20		22	44	44.5	41.81	70.78	J	SOUTHERN NEW ENGLAND	III	00	2.0 MBLG
MISSISSIPPI											
MAY 4		02	00	22.9	31.98	88.42	G	MISSISSIPPI	V	05	3.6 MBLG(S)
NOV 4		11	21	07.0	33.83	89.28	G	MISSISSIPPI	IV	05	3.4 MBLG(S)
MISSOURI											
JAN 3		22	56	48.5	37.55	89.79	S	CAPE GIRARDEAU, MO., REGION	VI	05	3.4 MBLG
MAR 28		11	17	14.2	36.48	89.54	S	NEW MADRID, MO., REGION	II	10	
MONTANA											
JAN 26		10	23	35.8	44.63	111.13	G	HEBGEN LAKE REGION	IV	05	2.5 ML(A)
MAR 3		04	53					MONTANA	II		
MAR 3		10	05	59.6	44.83	111.04	G	HEBGEN LAKE REGION	IV	05	3.9 MB, 3.8 ML
MAR 4		11	01	50.2	44.80	111.08	G	HEBGEN LAKE REGION	IV	05	3.9 MB, 3.6 ML
MAR 4		11	33	06.9	44.84	111.13	G	HEBGEN LAKE REGION	IV	05	3.7 MB, 3.6 ML
MAR 4		13	00	58.9	44.80	111.08	G	HEBGEN LAKE REGION	IV	05	4.1 MB, 4.1 ML
MAR 4		13	04	21.4	44.82	111.10	G	HEBGEN LAKE REGION	IV	05	4.0 MB, 3.7 ML

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME		COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC		LAT. DEG.	LONG. DEG.					
	H	M S							
GEOGRAPHIC									
MONTANA (CONTINUED)									
MAR 4	13	12	44.78	111.05	G	HEBGEN LAKE REGION	III	05	4.0 MB, 4.0 ML
MAR 4	14	19 48.8				HEBGEN LAKE REGION	IV		
MAR 4	14	26				HEBGEN LAKE REGION	III		
MAR 4	14	58 05.5	44.75	111.35	G	HEBGEN LAKE REGION	III	05	3.7 ML(D)
MAR 4	16	12 28.2	44.79	111.05	G	HEBGEN LAKE REGION	III	05	3.4 ML, 3.7 ML(D)
MAR 4	16	47 43.5	44.77	111.12	G	HEBGEN LAKE REGION	III	05	3.7 ML, 4.0 ML(D)
MAR 4	16	51 48.3	44.77	111.21	G	HEBGEN LAKE REGION	IV	05	4.0 ML(D)
MAR 4	17	10 40.6	44.76	111.01	G	HEBGEN LAKE REGION	IV	05	4.0 MB, 3.8 ML
MAR 4	17	17				HEBGEN LAKE REGION	III		3.4 ML(D)
MAR 5	00	32				HEBGEN LAKE REGION	III		3.3 ML(D)
MAR 6	05	01 04.0	44.74	111.13	G	HEBGEN LAKE REGION	V	05	2.9 ML(A)
MAR 6	06	10 12.7	44.71	111.21	G	HEBGEN LAKE REGION	V	05	3.0 ML(A)
MAR 11	05	09 37.2	46.13	111.48	G	MONTANA	VI	05	4.6 MB, 4.8 ML
MAR 11	12	17 51.9	44.85	111.50	G	HEBGEN LAKE REGION	IV	05	5.2 MB, 4.1 ML
MAR 24	13	20 11.9	45.71	111.31	G	SOUTHWESTERN MONTANA	IV	05	3.2 ML(A)
SEP 4	20	54 20.2	46.60	112.14	G	MONTANA	IV	05	3.2 ML(A), 2.8 ML(D)
OCT 19	16	50 50.9	44.77	111.81	G	HEBGEN LAKE REGION	VI	10	4.7 ML
NEVADA									
JAN 3	14	20 00.1	39.59	115.81	G	CENTRAL NEVADA	III	06	3.4 ML
NEW HAMPSHIRE									
DEC 25	15	35 53.8	43.19	71.65	J	NORTHERN NEW ENGLAND	VI	00	3.2 MBLG, 3.1 MBLG(L)
NEW MEXICO									
JAN 4	18	31 37.6	32.36	106.92	G	SOUTHERN NEW MEXICO	V	05	3.2 ML
MAR 5	03	00 54.7	35.91	108.29	G	NORTHWESTERN NEW MEXICO	VI	22	4.6 MB, 4.2 ML
NEW YORK									
SEP 28	17	21 44.7	44.39	73.89	L	NEW YORK	III	03	3.1 MBLG
OHIO									
JUN 17	15	39 47.3	40.71	84.58	K	NORTHWESTERN OHIO	V	05	3.2 MBLG
OKLAHOMA									
JAN 6	16	19 54.0	34.70	96.73	T	SOUTH-CENTRAL OKLAHOMA	II		2.2
FEB 4	20	52 29.3	34.06	97.37	T	SOUTHERN OKLAHOMA	II	05	1.9 MBLG
FEB 10	01	28 16.3	34.06	97.37	T	SOUTHERN OKLAHOMA	II	05	1.9 MBLG
MAR 26	21	37 12.6	34.06	97.37	T	SOUTHERN OKLAHOMA	III	05	2.3 MBLG

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME		GEOGRAPHIC COORDINATES		SOURCE	REGION	MAXIMUM INTENSITY (MM)	DEPTH KM	MAGNITUDE
	UTC H M S	LAT. DEG.	LONG. DEG.						
JUN 16	02 02	46.6	34.04	97.36	T	SOUTHERN OKLAHOMA	II	05	1.9 MBLG
MAY 2	16 00	54.9	19.07	67.39	G	MONA PASSAGE PUERTO RICO	II	50	5.2 MB
JAN 18	18 29	13.5	33.07	80.20	G	SOUTH CAROLINA	VI	05	3.0 MBLG(V)
MAR 30	08 27	46.9	32.88	80.20	G	SOUTHEASTERN SOUTH CAROLINA	V	10	1.5 ML(G)
MAY 31	23 50	13.2	32.95	80.24	G	SOUTHEASTERN SOUTH CAROLINA	II	08	2.3 MBLG
AUG 25	04 20	07.0	33.39	80.69	G	SOUTH CAROLINA	IV	10	3.1 MBLG(V)
DEC 15	19 16	43.1	32.92	80.22	G	SOUTH CAROLINA	V	09	3.0 MBLG(V)
JUL 27	22 03	21.3	35.42	84.42	G	TENNESSEE	V	07	3.5 MBLG(V)
APR 26	09 03	07.3	31.90	103.08	G	TENNESSEE TEXAS WEST TEXAS	IV	04	3.3 ML
FEB 9	00 42	16.4	39.31	111.15	U	UTAH	VI	07	3.4 ML
SEP 30	10 19	21.0	40.52	110.44	G	CENTRAL UTAH	VI	05	5.0 MB, 5.1 ML
OCT 11	07 56	06.5	40.49	110.49	G	UTAH	V	06	4.8 MB, 4.7 ML
NOV 28	02 23	11.0	41.35	111.70	U	UTAH	V	07	2.8 ML
FEB 27	20 05	34.6	37.90	78.63	G	VIRGINIA CENTRAL VIRGINIA	V	05	2.4 MBLG(V)
JUN 17	06 16	01.8	47.74	122.71	M	WASHINGTON	V	25	3.3 ML(G)
JUL 10	07 19	30.3	48.53	122.45	M	WASHINGTON	V	11	4.3 MB(G), 3.4 ML(G)
JUL 13	07 15	06.3	47.06	120.96	M	WASHINGTON	IV	00	3.6 ML(G)
JUL 25	21 04	03.8	48.07	122.85	M	WASHINGTON	IV	55	3.2 ML(G)
AUG 5	11 39	57.1	47.82	122.29	M	PUGET SOUND	III	18	2.7 ML
OCT 14	02 53	32.5	48.51	122.15	M	WASHINGTON	II	11	3.3 ML(G)
JAN 26	10 23					WYOMING	IV		

TABLE 1. SUMMARY OF U.S. EARTHQUAKES FOR 1977 - CONTINUED

DATE	ORIGIN TIME		COORDINATES		SOURCE	REGION	MAXIMUM		MAGNITUDE	
	UTC		LAT. DEG.	LONG. DEG.			INTENSITY (MM)	DEPTH KM		
	H	M								
MAR 3	17	50	28.0	41.24	107.15	G	WYOMING	V	05	4.2 MB, 3.5 ML
MAR 4	14	39	23.5	44.04	110.92	G	YELLOWSTONE NATIONAL PARK	III	05	3.0 ML(D)
MAR 24	08	55					WYOMING	IV		
APR 2	23	03	52.2	44.75	110.62	G	YELLOWSTONE NATIONAL PARK	III	05	3.9 ML, 3.5 ML(A)
JUN 17	11	52					YELLOWSTONE NATIONAL PARK	IV		

WYOMING  
(CONTINUED)

Abbreviations used in source and magnitude columns:

- (A) U.S. Energy Research and Development Administration
- (B) University of California, Berkeley
- (D) University of Montana, Missoula
- (G) U.S. Geological Survey, National Earthquake Information Service, Golden, Colo.
- (H) U.S. Geological Survey, Hawaiian Volcano Observatory, Hawaii National Park
- (J) Weston Observatory, Weston, Mass.
- (K) University of Michigan, Ann Arbor
- (L) Lamont-Doherty Geological Observatory, Palisades, N.Y.
- (M) NOAA, Alaska Tsunami Warning Center, Palmer
- (P) California Institute of Technology, Pasadena
- (S) St. Louis University, St. Louis, Mo.
- (T) University of Oklahoma, Leonard
- (U) University of Utah, Salt Lake City
- (V) Virginia Polytechnic Institute and State University, Blacksburg
- (W) University of Washington, Seattle
- (Z) Delaware Geological Survey, Newark.

NOTE: Dates and origin times are listed in Universal Coordinated Time (UTC), giving the hour, minute, and second. Epicenters are shown in decimal degrees. Only earthquakes with intensity data are listed.

See page 3 for a description of magnitudes used in this table.

## Miscellaneous Activities

### HORIZONTAL CONTROL SURVEYS FOR CRUSTAL MOVEMENT STUDIES<sup>1</sup>

Two sections of the Transcontinental Traverse, extending east-west along the Mexico-California border, were compared to five other field projects located in and around the Imperial Valley area of southern California. The Transcontinental Traverse projects were observed at various epochs after the El Centro earthquake of 1940, but prior to 1968. The data show a significant rate of contraction in the north-south direction, extending over the entire region for the 1940-76 time interval. The analysis was performed by adjusting all data simultaneously to a polynomial model for crustal movement.

The BARREL fault-crossing site, spanning the San Andreas fault at a location about 8 km southeast of Palmdale, was observed in November 1977. Comparison of these observations with those performed at this site in 1971 reveals no significant distortion of the network in this time span.

### TSUNAMIS<sup>2</sup>

During 1977, seven tsunamis were reported to the National Oceanic and Atmospheric Administration, including three that were recorded on National Ocean Survey tide gages.

An earthquake on April 2 (mag 7.6) in the Samoa Islands (16.7°S, 172.1°W) caused a minor tsunami that was recorded at Apia and Pago Pago. The maximum amplitude at the former was 4 cm and at the latter 15 cm.

On April 20, an earthquake (mag 6.7) in the Solomon Islands (9.8°S, 160.3°E) caused a tsunami that was recorded with the following maximum amplitudes: Rabaul, 7 cm; Apia, 4 cm; Townsville, 6 cm; and Cairns, 2 cm. A second shock 30 minutes

later (mag 7.5) in almost the same location (9.9°S, 160.3°E) was reported to have caused a slight tsunami at Renell Island; however, this was probably the same tsunami reported above.

The fourth major earthquake (mag 7.5) in this series occurred on April 21 in the same region (10.0°S, 160.7°E) and caused a small tsunami that was recorded with the following maximum amplitudes: Apia, 3 cm; Townsville, 4 cm; and Cairns, 3 cm.

An earthquake (mag 7.2) in the Tonga Islands (22.9°S, 175.9°W) on June 22 generated the most widely recorded tsunami of the year. Representative maximum heights were: Suva, 40 cm; Papeete, 12 cm; Pago Pago, 15 cm; Hilo, 9 cm; Kahului, 27 cm; Honolulu, 9 cm; Port San Luis, 24 cm; Long Beach, 24 cm; and San Diego, 18 cm.

The only destructive tsunami of the year occurred on August 19. It was generated by an earthquake (mag 7.9) south of Sumbawa Island, Indonesia (11.1°S, 118.5°E). The tsunami reached heights reported to be in excess of 10 m along the coast of Sumbawa Island. At least 100 people were killed and 89 more were reported missing. Major damage was concentrated on Lombok and Sumbawa Islands. The tsunami also was noted in northern and western Australia where it reached 6 m at Cape Leveque, 2 to 4 m at Port Sampson, and 2 m at Dampier.

Following an earthquake (mag 5.5) on August 20 in the Admiralty Islands (1.1°S, 146.2°E), a local tsunami of 0.6 m was reported.

On October 10, an earthquake (mag 7.2) in the Tonga Islands (25.9°S, 175.4°W) generated a tsunami that was recorded at Pago Pago with a maximum amplitude of 6 cm.

### PRINCIPAL EARTHQUAKES OF THE WORLD

Table 2 lists principal world earthquakes for 1977. The list has been included in this annual series since 1941. It includes earthquakes of magnitude 6.8 or greater; those of smaller magnitude that were locally destructive to life and property; and events of unusual interest.

---

<sup>1</sup>Prepared by Richard Snay, NOAA, National Ocean Survey, National Geodetic Survey, Rockville, MD.

<sup>2</sup>Prepared by Mark G. Spaeth, NOAA, National Weather Service, Silver Spring, MD.

Twenty-six earthquakes of magnitude 7.2 and above occurred in 1977. The most destructive occurred in Romania on March 4, and killed 1,500 people.

The largest-magnitude earthquake occurred August 19 south of Sumbawa Island. The magnitude 7.9 tremor (and accompanying tsunami) took at least 100 lives.

TABLE 2 - PRINCIPAL EARTHQUAKES OF THE WORLD DURING 1977

DATE	ORIGIN TIME			COORDINATES		REGION	REMARKS	DEPTH	USGS		OTHER
	H	M	S	LAT DEG.	LONG DEG.				MAGNITUDE	MAGNITUDE	
FEB 19	22	34	04.1	53.6N	170.0E	Near Islands	Felt on Shemya and Attu.	KM	MB	MS	
MAR 4	19	21	54.1	45.7N	26.8E	Rumania	One thousand five hundred reported killed, 10,500 injured, and extensive damage in Bucharest area. Bulgaria reported 20 killed and 165 injured. Moscow reported some damage in the Soviet Republic of Moldavia. Felt from Rome to Moscow and from Turkey to Finland.	033	6.2	6.7	6.8 BRK
MAR 18	21	43	52.4	16.8N	122.3E	Luzon, Philippine Islands	One killed and 9 injured. Damage on northern Luzon and in the Manila area.	094	6.4		7.2 PAS
MAR 21	21	18	54.2	27.6N	56.4E	Southern Iran	At least 167 killed, 556 injured; 35 villages were heavily damaged. About 7,000 people homeless in Bandar Abbas area.	037	6.2	7.0	7.0 PAS
MAR 25	02	39	58.2	38.6N	40.0E	Turkey	Thirty reported killed, heavy damage in vicinity of Lice-Palu.	029	5.2	4.9	
APR 2	07	15	22.7	16.7S	172.1W	Samoa Islands region	Minor damage at Apia and Pago Pago. Felt at Suva, Fiti Islands. Local tsunami recorded at Apia and Pago Pago.	021	6.8	7.6	7.5 PAS
APR 6	13	36	37.1	32.0N	50.7E	Iran	Three hundred forty-eight reported killed, 200 injured in area south of Shahr Kord.	033	5.5	5.9	
APR 20	23	13	10.4	09.8S	160.3E	Solomon Islands	Felt at Honiara. Tsunami recorded.	041	6.4	6.7	6.8 PAS
APR 20	23	42	50.5	09.9S	160.3E	Solomon Islands	Damage on Guadalcanal. Slight tsunami at Renell Island, southeast of Guadalcanal.	033	6.3	7.5	7.6 PAS
APR 20	23	49	13.1	09.8S	160.8E	Solomon Islands	Possible damage and injuries. Felt strongly in Honiara area.	019	6.8	7.5	
APR 21	04	24	09.6	10.0S	160.7E	Solomon Islands	Eighteen reported killed in landslides. Extensive damage on Guadalcanal. Slight tsunami recorded.	033	6.6	7.5	8.1 PAS
MAY 26	01	35	13.8	38.9N	44.4E	Turkey-Iran Border region	Three killed, 9 injured, and heavy damage in Western Azarbaijan Province, Iran. Felt strongly in Muradiye-Ozalp area, Turkey.	037	5.2	5.4	
JUN 22	12	08	33.4	22.9S	175.9W	Tonga Islands region	Two injured and extensive damage reported on Tonga Islands. Tsunami recorded.	065	6.8		7.2 BRK

TABLE 2 - PRINCIPAL EARTHQUAKES OF THE WORLD DURING 1977 - CONTINUED

JUL 21	13	45	54.0	16.9N	122.4E	Luzon, Philippine Islands	Felt widely on Northern Luzon. Felt at Tuquegarao and Manila.	033	6.1	6.9	6.8	PAS
JUL 29	11	15	45.3	08.0S	155.5E	Solomon Islands region	Felt on Mono, Gizo, and Shortland Islands.	033	6.4	7.2	7.2	PAS
AUG 19	06	08	55.2	11.1S	188.5E	South of Sumbawa Island	At least 100 killed, 89 reported missing, and 75 injured. Several villages completely destroyed. Tsunami generated wave heights along Sumbawa Island coastline. Wave reported on coast of Northern Australia. Most of casualties and damage were caused by tsunami.	033	7.0	7.9	8.0	PAS
AUG 26	19	50	01.4	59.4S	020.5W	Southwestern Atlantic Ocean		033	6.3	7.1	7.0	PAS
AUG 27	07	12	22.5	08.1S	125.3E	Timor	Two killed, 25 injured at Atauro.	025	6.4	6.8	6.6	PAS
AUG 31	00	42	05.4	07.3N	076.3W	Northern Colombia	Three killed in Apartado. Damage in Apartado and Medellin.	033	5.7	6.4		
OCT 10	11	53	53.6	25.9S	175.4W	South of Tonga Islands	Tsunami recorded at Pago Pago.	033	6.6	7.2	7.2	PAS
OCT 17	17	26	40.4	27.9S	173.1E	North of New Zealand		033	6.3	6.7	6.9	BRK
NOV 4	09	52	55.7	51.7N	176.0W	Andreeanof Islands	Minor damage on Adak.	033	5.7	6.7	6.9	BRK
NOV 23	09	26	24.7	31.0S	067.8W	San Juan Province, Argentina	Seventy reported killed, more than 200 injured, and extensive damage.	013	6.3	7.4	7.1	BRK
DEC 10	05	46	22.9	27.7N	056.6E	Southern Iran	Three reported killed in Bandar Abbas area.	047	5.1	5.0		
DEC 19	23	34	34.2	31.0N	056.5E	Iran	Five hundred and eighty-four killed, 1,000 injured and extensive damage in Zarand area.	031	5.4	5.8		
DEC 21	01	00	32.8	25.5N	143.1E	Volcano Islands region	Felt on Chichijima.	033	6.2	6.8	6.9	PAS
DEC 28	02	45	36.7	16.7N	040.3E	Red Sea		033	5.9	6.6	6.8	PAS

Abbreviations used in magnitude column: BRK -- University of California, Berkeley; PAS -- California Institute of Technology, Pasadena.

NOTE: See page 3 for a description of magnitudes used in this table.

# Strong-Motion Seismograph Data<sup>1</sup>

## INTRODUCTION

The U.S. Geological Survey Seismic Engineering Branch (formerly National Oceanic and Atmospheric Administration, Seismological Field Survey) has administered engineering seismology programs in the United States and Latin America since 1932. The current seismic engineering program of strong-motion instrumentation is supported by the National Science Foundation (Grant CA-114) in cooperation with both private industry and educational institutions, as well as numerous Federal, state, and local agencies and organizations. The program objectives are to: (1) record strong ground motions and the response of representative types of structures during potentially damaging earthquakes, and (2) disseminate processed data and information about the records, sites, and structures to external users in earthquake engineering research and design practice. The information and data are disseminated in various ways.

Seismic Engineering Program Reports<sup>2</sup> regularly present preliminary earthquake reports and a summary of recent accelerograph records. These summaries include a brief description of the earthquake and strong-motion recording stations, the results of routine scalings of those records that contain peak accelerations greater than 0.05 g, and photographic reproductions of some of the more significant accelerograms. The program reports also contain abstracts of recent reports, notes on strong-motion information sources, remarks about the availability of digitized data, and other information pertinent to the U.S. Strong-Motion Program.

---

<sup>1</sup>Prepared by Ronald L. Porcella, Seismic Engineering Branch, U.S. Geological Survey, 345 Middlefield Road, Mail Stop 78, Menlo Park, CA 94025.

<sup>2</sup>Copies of these reports are available free on application to Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202.

<sup>3</sup>Copies of these reports are available from Open-File Services Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. Prices will be listed in New Publications of the Geological Survey.

The U.S. Geological Survey (USGS) periodically publishes Strong-Motion Data Reports in the Open-File Report series.<sup>3</sup> These include the results of digitization and routine analyses of strong-motion accelerograms that contain peak accelerations greater than 0.10 g. This minimum acceleration level is based primarily on the current capability of USGS to process strong-motion records; it may vary both with the degree of seismic activity and the number of personnel available at any given time. Although maximum acceleration is not directly related to frequency or duration of strong motion, the peak acceleration can be readily obtained from an accelerogram. Thus that value is commonly used as a general indicator of the potential significance of the record. A list of the records to be contained in future data reports and detailed information on the availability of digitized data are published regularly in Seismic Engineering Program Reports.

The Strong-Motion Accelerograph Station List<sup>3</sup>, periodically published as a USGS Open-File Report, includes information on all of the accelerograph stations known to the USGS in the Western Hemisphere. Because of the ever-changing nature of this information, it is impossible to have a complete list of all of existing stations at any one time. Rather, the list provides that community of persons interested in strong-motion programs with a reasonably complete indication of the current status of the various strong-motion networks. Information in this list includes the station name and/or address and geographic coordinates, site characteristics, type and size of structure, location of instrument(s), and the primary sources of data. The current list contains information on about 1,200 stations located in 38 states, Canada, the Caribbean, and throughout Central and South America.

## ACCELEROGRAPH DATA

One hundred sixty-six accelerograph records were recovered from the National Strong-Motion Network from January 1 through December 31, 1977. The yearly average from 1972 to 1976 was 192 records.

Table 3 is a summary of United States accelerograph records recovered, although not necessarily recorded, during 1977. The earthquakes are listed in chronological order and include date, time (UTC), general location, geographic coordinates, and magnitude. Information about the recording station consists of the name and location, owner, and geographic coordinates. Record data includes S-wave minus trigger time, and the orientation, maximum acceleration, and duration of strong-motion (greater than 0.10 g) for each instrument component. Record data are included only when one or more components recorded at least 0.05 g at ground stations or 0.10 g at upper floors of buildings. The event information has been compiled principally from Preliminary Determination of Epicenters Monthly Listing, published by the USGS.

The following paragraphs summarize the results of the most significant earthquakes from which strong-motion records were obtained in 1977.

#### CENTRAL CALIFORNIA - JUNE 21

A magnitude 4.6 (ML) earthquake occurred 10 km east of Livermore, Calif. [Maley, 1977], on June 21 at 0243 UTC. The earthquake had a focal depth of 10 km and was located near the northwest-trending Tesla fault (fig. 15). According to various press reports, the event was felt throughout the San Francisco Bay area and caused minor damage including cracked plaster, broken windows, and fallen objects.

Five accelerograph records were recovered from instruments at three sites located 10 to 18 km west of the epicenter: the Livermore Veterans Administration (VA) Hospital, the California Department of Water Resources Del Valle Dam, and the General Electric (GE) Vallecitos Nuclear Center (fig. 15).

The VA Hospital building is a six-story reinforced concrete structure situated on unconsolidated sediments, chiefly alluvium and gravel, about 200 m thick; the sediments are underlain by Pliocene sandstone and conglomerate. Strong-motion data were obtained from instruments located in the basement and on the roof; peak accelerations are 0.06 g and 0.15 g, respectively (fig. 16).

Del Valle Dam, a facility in the California State Water Project, is an earthfill structure with a crest length of 268 m, height of 72 m, and width of 25 m. The dam foundation rests on Pliocene sedimentary rock, primarily sandstone. Two records (fig. 17) were obtained from accelerographs located in concrete

bunkers, one embedded at the center toe and the other situated downstream from the centerline of the crest. Peak accelerations on both records are 0.07 g.

One record was obtained from an accelerograph installed on the second floor of the test reactor building located at the General Electric Vallecitos Nuclear Center near Pleasanton, 18 km west of the epicenter. The reactor building is a reinforced concrete structure located within a flat-bottomed, domed-top, cylindrical steel tank 22 m across and 34 m high. The structure rests on sand fill and natural sand and silt. The record was obtained 7 m above ground level and shows a maximum acceleration of 0.05 g (fig. 18).

#### SOUTHERN CALIFORNIA - AUGUST 12

Fourteen accelerograph records were recovered at nine strong-motion stations in the San Fernando Valley Area (Porcella, 1977) after the magnitude 4.4 (ML) earthquake of August 12, 0219 UTC. The earthquake had a focal depth of 10 km and a maximum Modified Mercalli intensity of VI; minor damage was reported in Los Angeles and in several towns in the San Fernando Valley. Accelerograph stations that operated during this event include Newhall and San Fernando fire stations, Jensen Filter Plant, Sepulveda VA hospital, Sepulveda Dam (crest), and the 8244 Orion Street Holiday Inn. Maximum acceleration was 0.08 g recorded at the Jensen Filter Plant at an epicentral distance of 8 km. Also triggered during this earthquake was a 12-channel remote recording accelerograph system (maximum acceleration 0.05 g) installed at the Union Bank building on Ventura Boulevard in Sherman Oaks. This 13-story reinforced concrete structure sustained structural damage during the 1971 San Fernando earthquake, but was not instrumented at that time.

#### IMPERIAL VALLEY, CALIFORNIA - OCTOBER 20-30 and NOVEMBER 11-14

Earthquake swarms in the Imperial Valley of California in late October and mid-November [Porcella, 1977] produced a total of 87 accelerograph records recovered from 14 strong-motion stations; 24 of the records contain accelerations greater than 0.10 g. Both swarms were located in the Mesquite (dry) lake area about 10 km south of Brawley at a depth of about 5 km. The maximum recorded acceleration is 0.50 g at El Centro Array station No. 6 and is attributed to the magnitude 3.9 event of November 14, 0011 UTC.

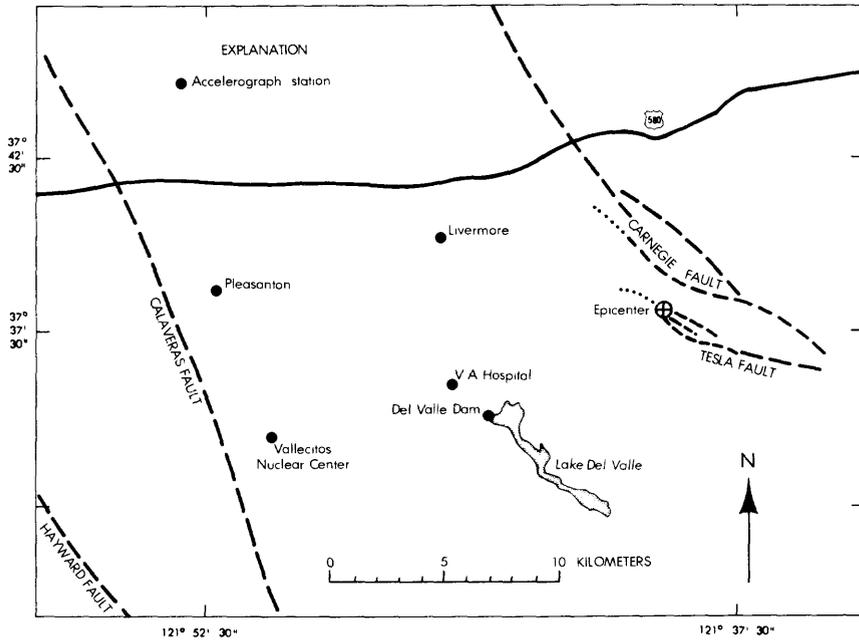


FIGURE 15. Accelerograph locations during central California earthquake of June 21.

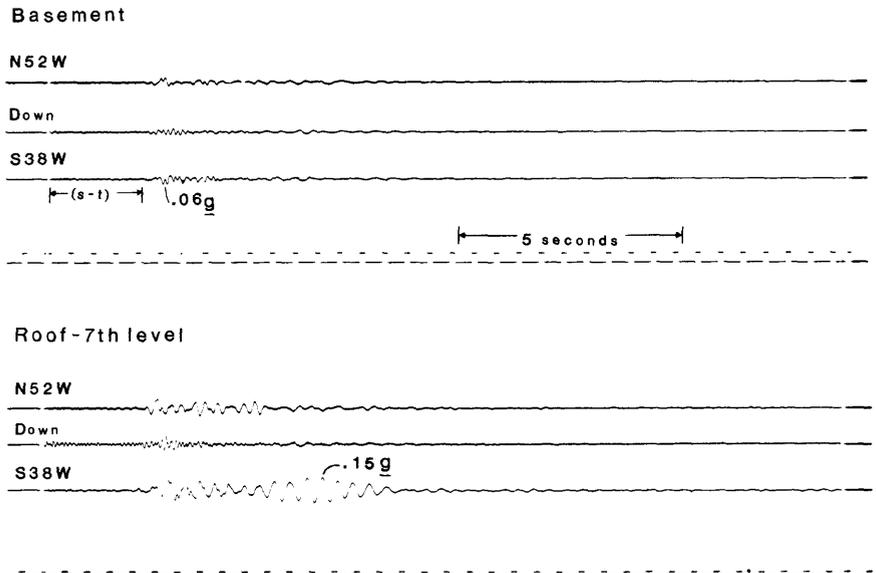
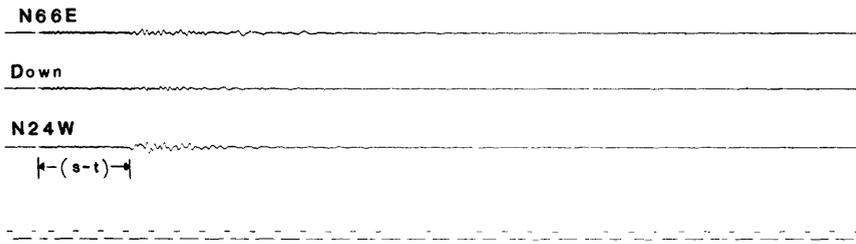


FIGURE 16. Accelerograph records from Livermore VA Hospital for June 21 earthquake.

Toe



Crest

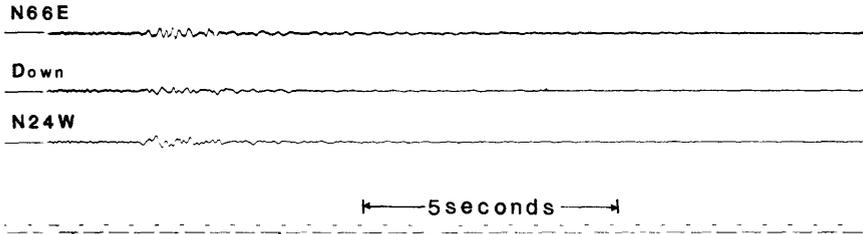


FIGURE 17. Accelerograph records from Del Valle Dam for June 21 earthquake.

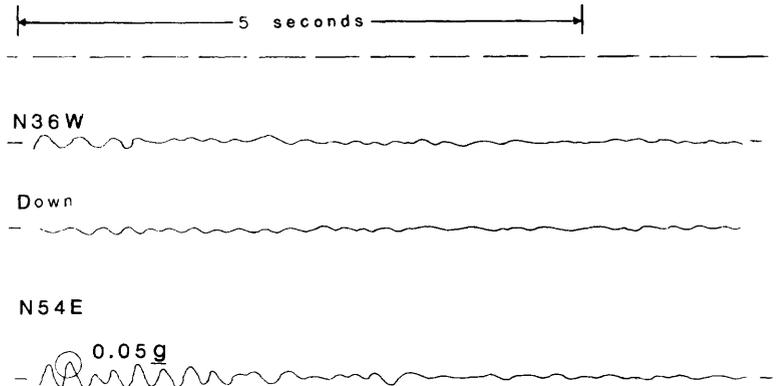


FIGURE 18. Tracing of accelerograph record from Vallecitos Nuclear Center for June 21 earthquake.

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977

EVENT	STATION <sup>1</sup> (OWNER)	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
15 July 1976- 22 March 1977 So. California Epicenter and magnitude unknown	Tarzana, Calif. Cedar Hill (CDMG)	34.16 N 118.57 W	4.0	N15W Down S75W	0.05 0.04 0.03	- - -
8 September 1976- 9 June 1977 So. Hawaii Epicenters and magnitudes unknown	Honokaa, Hawaii High school (USGS)	20.08 N 115.47 W	-	S60E Down N30E	0.07 0.06 0.05	- - -
			-	S60E Down N30E	0.04 0.05 0.06	- - -
	Wahaula, Hawaii Visitor center (USGS)	19.33 N 155.03 W	1.9	N35W Down S55W	0.07 0.03 0.03	- - -
Note: Four additional records were obtained at Wahaula. Maximum acceleration less than 0.05 g.						
10 September 1976- 26 January 1977 No. California Epicenter and magnitude unknown	Berkeley, Calif. U C Evans Hall (UC)	36.87 N 122.26 W				
	Basement level		-		**	
	Fifth floor level		-		**	
	10th floor level		-		**	
Note: Additional records obtained from unidentified earthquakes include: Alemany Interchange (CSDH), San Francisco, 4 records; 3333 California St (FF), San Francisco, 2 records; Eastman Kodak (EKC), San Francisco, 2 records; Presidio (CDMG), San Francisco, 1 record; 3333 25th St (PTT), San Francisco, 2 records; 575 Market St (STO), San Francisco, 3 records; Treasure Island (CDMG), San Francisco, 1 record; Wadsworth VA Hospital (VA), Los Angeles, 2 records. Maximum acceleration less than 0.05 g.						
14 September 1976- 13 May 1977 Alaska Epicenter and magnitude unknown	Fairbanks, Alaska College Observatory (USGS)	64.86 N 147.83 W	-		**	
24 September 1976- 22 May 1977 Alaska Epicenter and magnitude unknown	Whittier, Alaska Begiuh Tower (USGS)	60.77 N 148.68 W	-		**	

See footnotes at end of table



TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION, (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
17 January 1977 1113 UTC Imperial Valley 32.47N, 115.18W Magnitude 4.2	Calexico, Calif. Fire station (CIT)	32.67 N 115.49 W	7.0		**	
Note: Three unidentifiable records were obtained from a nine-channel CR-1 recorder at Imperial County bldg (CDMG). Maximum acceleration less than 0.05 g.						
22 February 1977 0624 UTC Western Nevada 38.48N, 119.29W Magnitude 4.8	Walker, Calif. Fire station (CDMG)	38.51 N 119.48 W	-		**	
16 March 1977 0754 UTC Cent. California 36.93N, 121.50W Magnitude 3.6	Gilroy Array #3 Sewage plant (USGS)	36.99 N 121.54 W	-		**	
	Gilroy Array #4 San Ysidro School (USGS)	37.00 N 121.53 W	-		**	
16 May 1977- 9 November 1977 Alaska Epicenters and magnitudes unknown	Talkeetna, Alaska FAA-VOR (USGS)	62.30 N 150.10 W				
Note: Six unidentifiable records were obtained at Talkeetna. Maximum acceleration less than 0.05 g.						
18 May 1977- 13 September 1977 No. California Epicenter and magnitude unknown	Palo Alto, Calif. VA Hospital (VA)	37.40 N 122.14 W				
	Basement		-		**	
	Roof		-		**	
2 June 1977 1629 UTC So. Alaska 61.31N, 150.33W Magnitude 3.6	Anchorage, Alaska Westward Hotel (roof) (USGS)	61.22 N 149.89 W	-		**	
21 June 1977 0243 UTC No. California 37.65N, 121.64W Magnitude 4.6	Livermore, Calif. VA Hospital (VA)	37.62 N 121.76 W				
	Basement		2.3	N52W Down S38W	0.05 0.04 0.06	- - -
	7th (roof) level		2.3	N52W Down S38W	0.11 0.09 0.15	1-peak - 3.7

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION <sub>1</sub> (OWNER) <sub>1</sub>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)	
12 August 1977 0219 UTC So. California 34.38N, 118.47W Magnitude 4.4	Newhall, Calif.	34.39 N	1.9	N58E	0.07	-	
	L.A. County fire sta. (CDMG)	118.53 W		Down	0.03	-	
				N32W	0.04	-	
	San Fernando, Calif.	34.24 N	3.4		**		
	Nordhoff fire station (CDMG)	118.44 W					
	Sherman Oaks, Calif.	34.15 N	-		**		
	15233 Ventura Blvd. (CDMG)	118.46 W					
	<p>Note: An additional record (12 channels of data) was obtained at 15233 Ventura Blvd. (CDMG) from a CR-1 remote-recording system interconnected with an SMA-1 triaxial accelerometer. Maximum acceleration less than 0.05 g.</p>						
	Sepulveda, Calif.	34.25 N	3.4		**		
VA Hospital (VA)	118.48 W						
Jensen Filter Plant	34.31 N	2.4	S25W	0.08	-		
13100 Balboa Ave, L.A. (MWD)	118.50 W		Down	0.03	-		
			S65E	0.06	-		
Sepulveda Dam	34.17 N	-		**			
Crest (ACOE)	118.47 W						
Santa Susana	34.23 N	-	West	-	-		
Bldg 462, 6th floor (ERDA)	118.71 W		Down	0.02	-		
			South	0.06	-		
Santa Susana	34.23 N	-		**			
Bldg 026, ground level (ERDA)	118.71 W						
Los Angeles	34.16 N	3.6					
15910 Ventura Blvd (LACO)	118.48 W						
Basement					**		
9th floor				**			
19th floor (roof)				**			
Los Angeles	34.22 N	-					
8244 Orion St. (LACO)	118.47 W						
Ground				-			
4th floor				**			
8th floor (roof)				**			
12 August 1977	Newhall, Calif.	34.39 N	1.9		**		
0441 UTC	L.A. County fire sta. (CDMG)	118.53 W					
So. California							
34.38N, 118.45W							
Magnitude 3.3							

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
17 September 1977 2125 UTC Cent. Alaska 64.82N, 147.43W Magnitude 4.0	Fairbanks, Alaska College Observatory (USGS)	64.86 N 147.83 W	-		**	
23 September 1977 0725 UTC Aleutian Islands Epicenter and magnitude unknown	Adak, Alaska Fire Station (USGS)	51.89 N 176.58 W	7.5		**	
24 September 1977 2128 UTC So. California 34.47N, 118.42W Magnitude 4.2	Big Tujunga Dam  Left abutment (CIT)  Crest (USGS)	34.29 N 118.19 W	3.4  3.3		**  N33W 0.01 Down 0.01 S57W 0.08	- - -
4 October 1977- 15 November 1977 Imperial Valley Epicenters and magnitudes unknown	El Centro, Calif. Meadows Union School (USGS)	32.80 N 115.47 W	1.4  1.8	S50W Down S40E	0.07 0.02 0.07	- - -
				S50W Down S40E	0.15 0.04 0.10	0.1 - 1-peak
20 October 1977 0817 UTC Imperial Valley 32.88N, 115.50W Magnitude 3.2	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.3		**	
20 October 1977 1029 UTC Imperial Valley 32.88N, 115.50W Magnitude 4.0	El Centro Array #5 James Rd. (USGS)  El Centro Array #8 Cruickshank Rd. (CDMG)	33.85 N 115.46 W  32.81 N 115.53 W	2.3  -	N50E Down N40W	0.05 0.06 0.05	- - -
21 October 1977 1324 UTC Imperial Valley 32.90N, 115.50W Magnitude 4.2	El Centro Array #3 Pine Union School (CIT)  El Centro Array #5 James Rd. (USGS)  El Centro Array #8 Cruickshank Rd. (CDMG)	32.89 N 115.38 W  32.85 N 115.46 W  32.81 N 115.53 W	2.8  2.2  -		**  N50E 0.11 Down 0.02 N40W 0.13	- - 1-peak 0.2

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION <sub>1</sub> (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)	
22 October 1977 0905 UTC Imperial Valley 32.88N, 115.50W Magnitude 3.0	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	2.2		**		
28 October 1977 2124 UTC Imperial Valley 32.87N, 115.50W Magnitude 3.9	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.4	N50E Down N40W	0.16 0.05 0.11	0.1 - 1-peak	
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	2.0	N50E Down N40W	0.08 0.04 0.08	- - -	
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	1.1	N50E Down N40W	0.08 0.02 0.07	- - -	
30 October 1977 0530 UTC Imperial Valley 32.88N, 115.50W Magnitude 4.0	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.4	N50E Down N40W	0.11 0.08 0.14	0.1 - 0.3	
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	2.2		**		
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	2.4	N50E Down N40W	0.07 0.02 0.03	- - -	
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 W	3.5		**		
<p>Note: Six additional records were recovered from El Centro Array #9 (USGS, 1 record) and Imperial County Services Building (CDMG, 5 records) and are related to the Imperial Valley earthquake swarm of October 1977. Maximum acceleration less than 0.05 g.</p>							
4 November 1977- 15 November 1977 Imperial Valley Epicenters and magnitudes unknown	El Centro Array #9 Commercial Ave. (USGS)	32.79 N 115.55 W	-	Up South West	0.02 0.05 0.08	- - -	
			-	Up South West	0.02 0.03 0.05	- - -	
			-	Up South West	0.04 0.10 0.09	- 1-peak -	
	<p>Note: Two additional records were recovered at El Centro Array #9. Maximum acceleration less than 0.05 g.</p>						
	El Centro Array #10 Community Hospital (USGS)	32.78 N 115.57 W	2.3		**		

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION, (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
(Cont.)	El Centro, Calif. Imperial County bldg. (CDMG)	32.79 N 115.56 W				
	Ground floor		-		**	
	Second floor		-		**	
	Sixth floor (end)		-	North	0.10	1-peak
	(center)			North	0.16	0.5
	(center)			East	0.05	-
	Note: Four additional records were recovered at Imperial County bldg. Maximum acceleration less than 0.05 g.					
11 November 1977 2311 UTC Imperial Valley 32.84N, 115.47W Magnitude 2.5	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.3		**	
13 November 1977 0610 UTC Imperial Valley 32.50N, 115.28W Magnitude 2.3	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.2		**	
13 November 1977 0700 UTC Imperial Valley 32.50N, 115.28W Magnitude 2.4	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.1		**	
13 November 1977 1609 UTC Imperial Valley 32.50N, 115.28W Magnitude 2.6	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.2		**	
13 November 1977 1625 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.2	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.2	N50E Down N40W	0.05 0.04 0.06	- - -
14 November 1977 0011 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.9	El Centro Array #5 James Rd. (USGS) <sup>†</sup>	32.85 N 115.46 W	1.8	N50E Down N40W	0.12 0.05 0.17	0.2 - 0.7
	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.2	N50E Down N40W	0.50 0.13 0.45	0.5 0.2 0.3
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7	N50E Down N40W	0.10 0.04 0.11	0.1 - 1-peak
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-	N50E Down N40W	0.07 0.02 0.04	- - -

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
14 November 1977 0012 UTC Imperial Valley Epicenter and Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.3*		**	
14 November 1977 0033 UTC Imperial Valley 32.82N, 115.47W Magnitude 3.1	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.0	N50E Down N40W	0.06 0.02 0.06	- - -
14 November 1977 0205 UTC Imperial Valley 32.82N, 115.47W Magnitude 4.2	El Centro Array #3 Pine Union School (CIT)	32.89 N 115.38 W	2.8		**	
	El Centro Array #4 Anderson Rd. (USGS)	32.86 N 115.43 W	-		**	
	El Centro Array #5 James Rd. (USGS) <sup>†</sup>	32.85 N 115.46 W	-	N50E Down N40W	0.17 0.04 0.15	1-peak - 1-peak
	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	1.9	N50E Down N40W	0.38 0.11 0.41	1.3 1-peak 1.2
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7	N50E Down N40W	0.14 0.03 0.10	1-peak - 0.2
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	1.6	N50E Down N40W	0.12 0.04 0.08	0.4 - -
	El Centro Array #11 McCabe School (CIT)	32.75 N 115.59 W	-		**	
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 W	2.8	S45E Down N45E	0.04 0.02 0.07	- - -
	Calexico, Calif. Fire Station (CIT)	32.67 N 115.49 W	3.4		**	
14 November 1977 0210 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.4	El Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.2	N50E Down N40W	0.12 0.04 0.10	1-peak - 1-peak
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7		**	

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION <sup>1</sup> (OWNER)	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
14 November 1977 0232 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.1	E1 Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.0		**	
14 November 1977 0319 UTC Imperial Valley 32.82N, 115.47W Magnitude 3.0	E1 Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.2	N50E Down N40W	0.09 0.02 0.10	- - 1-peak
14 November 1977 0505 UTC (a) Imperial Valley 32.83N, 115.47W Magnitude unknown	E1 Centro Array #6 Huston Rd. (CDMG) <sup>†</sup>	32.84 N 115.49 W	2.4		**	
14 November 1977 0505 UTC (b) Imperial Valley 32.83N, 115.47W Magnitude 3.8	E1 Centro Array #6 Huston Rd. (CDMG) <sup>†</sup> Holtville, Calif. Post Office (CIT)	32.84 N 115.49 W 32.81 N 115.38 W	2.2* 2.9	N50E Down N40W	0.04 0.03 0.08	- - -
14 November 1977 0513 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.1	E1 Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.3	N50E Down N40W	0.07 0.02 0.07	- - -
14 November 1977 0518 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.7	E1 Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.3	N50E Down N40W	0.12 0.06 0.13	0.1 - 0.6
	E1 Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.8	N50E Down N40W	0.06 0.01 0.03	- - -
	E1 Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-	N50E Down N40W	0.11 0.03 0.10	0.1 - 1-peak
14 November 1977 0519 UTC Imperial Valley 32.83N, 115.47W Magnitude unknown	E1 Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.4*		**	
14 November 1977 0523 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.8	E1 Centro Array #6 Huston Rd. (CDMG) E1 Centro Array #8 Cruickshank Rd. (CDMG)	32.84 N 115.49 W 32.81 N 115.53 W	2.0 -	N50E Down N40W	0.14 0.04 0.12	0.4 - 0.3

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION, (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
14 November 1977 0524 UTC (a) Imperial Valley 32.66N, 115.29W Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.4*		**	
14 November 1977 0524 UTC (b) Imperial Valley 32.88N, 115.49W Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.4*		**	
14 November 1977 0530 UTC Imperial Valley 32.83N, 115.47W Magnitude 3.3	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.3	N50E Down N40W	0.25 0.04 0.23	0.1 - 0.1
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.9		**	
14 November 1977 0536 UTC Imperial Valley 32.83N, 115.47W Magnitude 4.1	El Centro Array #4 Anderson Rd. (USGS)	32.86 N 115.43 W	-	N50E Down N40W	0.05 0.02 0.03	- - -
	El Centro Array #5 James Rd. (USGS) <sup>†</sup>	32.85 N 115.46 W	-	N50E Down N40W	0.06 0.03 0.17	- - 1-peak
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7	N50E Down N40W	0.08 0.03 0.07	- - -
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	1.8	N50E Down N40W	0.13 0.04 0.23	0.4 - 0.3
	El Centro Array #11 McCabe School (CIT)	32.75 N 115.59 W	3.1		**	
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 W	1.9		**	
	Bonds Corner, Calif. Ground level (CIT)	32.693N 115.338W	1.6		**	
	Calexico, Calif. Fire station (CIT)	32.67 N 115.49 W	3.3		**	

See footnotes at end of table

TABLE 3. SUMMARY OF U.S. ACCELEROGRAPH RECORDS RECOVERED DURING 1977 - CONTINUED

EVENT	STATION <sup>1</sup> (OWNER) <sup>1</sup>	STATION COORD.	S-T TIME <sup>2</sup> (SEC)	COMP	MAX ACCL <sup>3</sup> (G)	DURATION <sup>4</sup> (SEC)
14 November 1977 1220 UTC Imperial Valley 32.82N, 115.45W Magnitude 4.3	El Centro Array #4	32.86 N	2.3	N50E	0.15	1-peak
	Anderson Rd.	115.43 W		Down	0.06	-
	(USGS)			N40W	0.08	-
	El Centro Array #5	32.85 N	2.4	N50E	0.16	0.3
	James Rd.	115.46 W		Down	0.06	-
	(USGS) <sup>†</sup>			N40W	0.15	0.3
	El Centro Array #7	32.83 N	1.9		**	
	Imp. Valley College	115.50 W				
	El Centro Array #8	32.81 N	2.3	N50E	0.09	-
	Cruickshank Rd.	115.53 W		Down	0.04	-
(CDMG)		N40W		0.08	-	
El Centro Array #11	32.75 N	-		**		
McCabe School	115.59 W					
Holtville, Calif.	32.81 N	2.6		**		
Post Office	115.38 W					
Calexico, Calif.	32.67 N	3.4		**		
Fire station	115.49 W					
	(CIT)					

<sup>1</sup> ACOE - U.S. Army Corps of Engineers  
 CDMG - California Division of Mines and Geology  
 CDWR - California Department of Water Resources  
 CIT - California Institute of Technology  
 CSDH - California State Division of Highways  
 EKC - Eastman Kodak Company  
 ERDA - Energy Research Development Administration  
 FF - Fireman's Fund Insurance Companies  
 LACO - Los Angeles City Ordinance  
 MWD - Metropolitan Water District of Southern California  
 PTT - Pacific Telephone and Telegraph Company  
 STO - Standard Oil Company  
 UC - University of California  
 USGS - U.S. Geological Survey  
 VA - Veterans Administration  
 WLCO - Woodward-Lundgren Company  
 † - WWVB time code is incomplete; correlation of event and accelerogram is questionable.

<sup>2</sup> S-wave minus trigger time.  
 \* denotes S-P interval, that is, the earthquake occurred within the instrumental run-time of a previous event.

<sup>3</sup> Unless otherwise noted, maximum acceleration recorded at ground or basement level.  
 \*\* denotes maximum acceleration is less than 0.05 g at ground stations or less than 0.10 g at upper floors of buildings.

<sup>4</sup> Duration for which peaks of acceleration exceed 0.10 g.

## References

- Bath, Markus, 1966: Earthquake energy and magnitude, Physics and Chemistry of the Earth, 7, Oxford and New York, Pergamon Press, pp. 115-165.
- Estes, S., Huang, P., Gedney, L., and Biswas, N., Dec. 1977: The Fairbanks earthquake swarm of February and March 1977, UAG R-250, University of Alaska, Geophysical Institute, Fairbanks, Alaska, 11 pp.
- Gutenberg, B., and Richter, C.F., 1956: Magnitude and energy of earthquakes: Annali di Geofisica, 9, no. 1, pp. 1-15.
- Maley, R.P., 1977: Preliminary report on the Livermore, California earthquake of June 20, 1977, Seismic Engineering Program Report, May-Aug. 1977, Geological Survey Circular 762-B, pp. 2-3.
- Minsch, J.H., Stover, C.W., Person, W.J., Simon, R.B., and Reagor, B.J., 1978: Earthquakes in the United States, Oct.-Dec. 1976, Geological Survey Circular 766-D, p. 13.
- Nuttli, O.W. 1973: Seismic wave attenuation and magnitude relations for eastern North America, J. Geophys. Res., 78, no. 5, pp. 876-885.
- Porcella, R.L., 1977a: Recent strong-motion records, Seismic Engineering Program Report, May-Aug. 1977, Geological Survey Circular 762-B, p. 1, table 1.
- Porcella, R.L., 1977b: Recent strong-motion records, Seismic Engineering Program Report, Sept.-Dec. 1977, Geological Survey Circular 762-C, p. 1, table 1.
- Richter, C.F., 1958: Elementary Seismology, San Francisco, Calif., W.H. Freeman and Co., Inc., p. 768.
- Simon, R.B., Pampeyan, E.H., and Stover, C.W., 1978: The Willits, Calif., magnitude 4.8 earthquake of November 22, 1977, 21:15:52.5 UTC, Geological Survey Open-File Report 78-1075, 24 pp.
- Simon, R.B., Stover, C.W., Person, W.J., and Minsch, J.H., 1978: Earthquakes in the United States, Jan.-Mar. 1976, Geological Survey Circular 766-A, pp. 30-31.
- Utah Geological Survey, 1977: Earthquakes shake northwestern Uinta Basin, Survey Notes, 11, no. 4, pp. 1-3.
- Wood, H.O., and Neumann, F., 1931: Modified Mercalli Intensity Scale of 1931, Bull. of Seismol. Soc. Am., 21, no. 4, pp. 277-283.

## Additions and Corrections to Previous Issues

On page 45 of United States Earthquakes, 1976, column 2, line 13, delete line 13 through "Intensity III: ... Westwood," and insert the following:

The results of the USGS canvass were as follows:

Intensity VI: Pompton Lakes (reports of ceiling cracks from fireplace to center of room, with small pieces of plaster found on rug; pictures dislodged--confirmed by LDGO personnel).

Intensity V: Butler, Kinnelon (pictures crooked on walls, some chinaware fell), Smoke Rise, West Milford (Shady Lake and High Crest Lake, subdivisions of West Milford).

Intensity IV: Bloomingdale, Montville, Newfoundland, Totowa Boro.

Intensity III: Lake Edenwold, Midvale, Riverdale, Wayne.