

UNITED STATES EARTHQUAKES 1931

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U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY - WASHINGTON

U. S. DEPARTMENT OF COMMERCE

ROY D. CHAPIN, Secretary

COAST AND GEODETIC SURVEY

R. S. PATTON, Director



Serial No. 553

UNITED STATES EARTHQUAKES

1931

BY

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Mathematician



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UNITED STATES EARTHQUAKES, 1931



INTRODUCTION

This publication is a summary of earthquake activity in the United States and the regions under its jurisdiction for the calendar year 1931. The period up to 1927 for the United States is covered (for all except minor earthquakes) by Special Publication No. 149 of this bureau, *Earthquake History of the United States Exclusive of the Pacific Region*, and by several publications for the Pacific region. These include the Holden and McAdie catalogues¹ and a forthcoming publication of the Seismological Society of America which will extend the record through 1927. The period from 1928 on is covered by the series to which the present publication belongs.

Earthquakes of volcanic origin in the Hawaiian and Philippine Islands are not included, and only severe shocks are included in the case of the Philippine Islands, as complete reports are published by the Manila Central Observatory. Earthquakes adjacent to the United States and felt within its borders are described only in a general way when detailed descriptions are published elsewhere. The instrumental results are given for the principal earthquakes of the year regardless of location.

The noninstrumental information has been furnished by a large number of individuals and organizations whose voluntary cooperation has made it possible to prepare descriptions of the earthquakes of this country with a completeness and accuracy never before attained. Lack of space prohibits giving individual credit to all of these cooperators. The principal sources of information are as follows:

United States Weather Bureau.

Division of geology and geography of the National Research Council.

Central office of the Jesuit Seismological Association at St. Louis, Mo.

The San Francisco field station of the Coast and Geodetic Survey, cooperating with the Seismological Laboratory of the Carnegie Institution and California Institute of Technology (H. O. Wood, research associate, in charge), University of California (Perry Byerly in charge of the seismological station), and Stanford University. These persons are usually responsible for instrumental determinations of epicenters in California when given. Among the commercial agencies in this section there are a number of cooperators, including the Pacific Telephone & Telegraph Co., Great Western Power Co., National Board of Fire Underwriters, Southern California Telephone Co., Standard Oil Co. of California, Associated Oil Co., Southern Pacific Railroad, San Diego & Arizona Railway Co., Associated Factory Mutual Fire Insurance Cos., and Clay Products Institute of California; also a large number of other organizations and individuals. In 1931 the Board of Fire Underwriters of the Pacific, with more than 20,000 correspondents, and the Southern Sierras Power Co. were added to this list. The active cooperation of the Supervisor of Geology (H. E. Culver), department of conservation and development, Pullman, Wash., was also enlisted.

The large number of reports received from Alaska in 1931 is due largely to the successful efforts of Dr. C. E. Bunnell, president of the Alaska Agricultural College and School of Mines, in organizing a corps of volunteer observers.

¹ Smithsonian Miscellaneous Collections, 1089. A Catalogue of Earthquakes on the Pacific Coast, 1769-1897. Edward S. Holden. Smithsonian Miscellaneous Collections, 1721. Catalogue of Earthquakes on the Pacific Coast, 1897-1901. Alexander G. McAdie.

Press dispatches (received through the courtesy of Georgetown University).
Telegraphic reports collected by Science Service. This cooperative service was inaugurated in 1925.

Reports from individuals.

Bulletin Seismological Society of America, 1931.



In addition to the above sources of information, the Coast and Geodetic Survey, or its field station at San Francisco, canvasses all areas affected by shocks of unusual intensity. In this way the extent and the maximum intensities of all heavy shocks are determined and the data are usually sufficient to construct isoseismal maps. The destructive features of these shocks are enumerated in the abstracts, but otherwise the descriptive matter is reduced to a minimum. The original reports are open for inspection by anyone interested in unpublished details.

CHANGE IN INTENSITY SCALES

Beginning with this publication, the Coast and Geodetic Survey is using the Modified Mercalli Intensity Scale of 1931 in place of the Rossi-Forel scale to designate the intensity of earthquake activity. All intensity numbers therefore refer to the new scale. The reasons for this change are set forth in an article entitled "Modified Mercalli Intensity Scale of 1931," by Harry O. Wood and Frank Neumann, in the December, 1931, number of the Bulletin of the Seismological Society of America, volume 21, No. 4. This article contains the original unabridged scale, which is too lengthy for publication here, and also an abridged scale. The latter is given here together with equivalent intensities according to the Rossi-Forel scale.

MODIFIED MERCALLI INTENSITY SCALE OF 1931

[Abridged]

- I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel scale.)
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel scale.)
- III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale.)
- IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. (IV to V Rossi-Forel scale.)
- V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale.)
- VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale.)
- VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars. (VIII Rossi-Forel scale.)
- VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture over-

turned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars. (VIII+ to IX to Rossi-Forel scale.)

- IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale.)
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel scale.)
- XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
- XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

EXPLANATORY NOTES

Within the United States the same regional arrangement has been followed as in Special Publication No. 149, previously mentioned, except that Washington and Oregon have for convenience been treated separately from California.

The published epicenters have been determined at the Washington office unless otherwise stated. Quite often they represent the mean of the positions determined by the bureau and the central station of the Jesuit Seismological Association cooperating with Science Service. Immediate epicenter determinations from telegraphic reports are frequently made through the cooperation of these institutions and individual seismograph stations and the results broadcast without delay to Europe and points in the Pacific. As the published epicenters are based on only a portion of the available data, they must be considered provisional.

In the noninstrumental reports an asterisk (*) indicates that the time is taken from an instrumental report and is reliable. In other instances quite large deviations are frequently reported. In the case of California, earthquakes reported as feeble at only one point are not plotted on the epicenter map of the United States, nor are minor aftershocks plotted for heavy earthquakes in California or any other region. The reader should bear in mind that the information service in California has been developed to a point not approached in any other section of the country.

Time is indicated as continuous from 0 to 24 hours, beginning and ending with midnight. In the noninstrumental reports local standard time is indicated. All instrumental results are expressed in Greenwich civil time.

EARTHQUAKE ACTIVITY IN THE VARIOUS STATES

Alabama: Moderate shock on May 5.

Arizona: Moderate shocks on April 17 and July 28.

Arkansas: Slight shock on December 10.

California: There were no shocks of outstanding importance. Two strong shocks on August 23 and September 9 originated quite a distance off the coast of northern California. Another in the Southern Sierras on September 23 occurred in sparsely settled country. Only the last two were observed with intensity VI.

Connecticut: Slight shock on June 30.

Idaho: Slight shocks on January 6 and March 11.

Indiana: Slight shocks on January 5 and December 31.

Kentucky: Slight shocks in western part on April 1 and April 6.

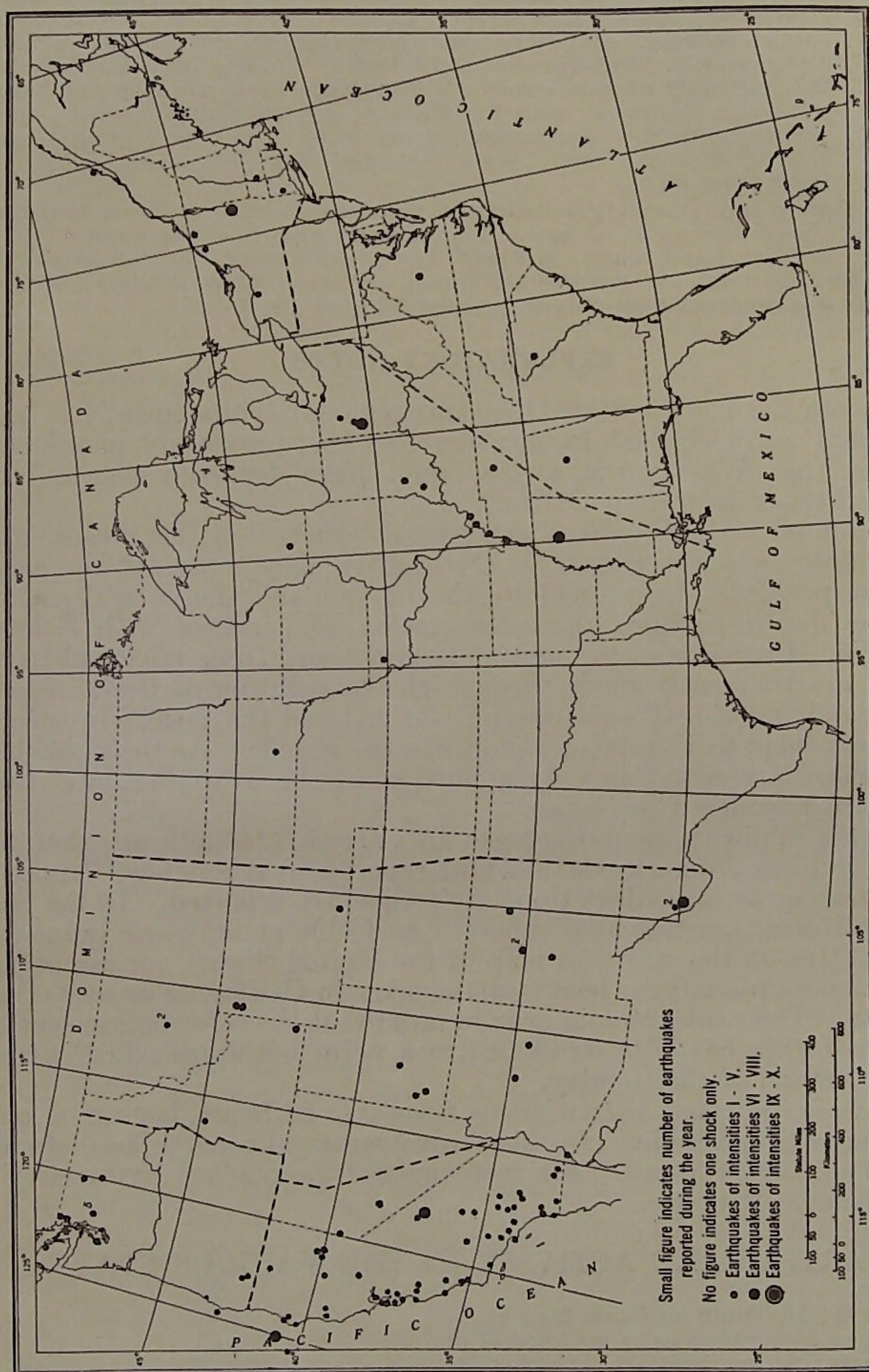


FIGURE 1.—Earthquake epicenters, 1931

Maine: A shock originating in the St. Lawrence Valley on January 7 was felt with moderate intensity.

Massachusetts: Slight shock on May 4. The Lake George shock of April 20 was felt in the western part of the State.

- Mississippi: An unusually widespread shock for this region occurred on December 16.
- Missouri: Feeble shock reported from Kansas City on August 9.
- Montana: Slight shocks on June 8 and October 6.
- Nevada: Slight shocks in western part on January 21 and June 5.
- New Mexico: Force VI shock at Albuquerque on February 4. Other shocks of slight intensity on January 27, February 12, and April 7.
- New York: Force VI shock at Lake George on April 20. Slight shocks at other points on May 4, June 6, and November 3.
- Ohio: Force VII shock at Anna on September 20. Other slight shocks on March 21 and June 10.
- Oregon: Moderate shock on August 16; feeble one on September 3. Shock observed offshore on October 1.
- South Carolina: Slight shock on May 6.
- South Dakota: Slight shock on January 17.
- Tennessee: Moderate shocks on July 18 and November 27.
- Texas: Force VIII shock at Valentine on August 16 was the outstanding shock of the year in the United States. Moderate aftershocks on August 18 and November 3.
- Utah: Moderate shocks on March 8, April 10, and June 2.
- Vermont: Canadian shock of January 7 felt in northern part.
- Virginia: Feeble shock on October 5.
- Washington: Two sharp shocks on April 17 and December 31. Slight shocks on January 20, April 17, May 28, June 11, August 19, September 18, December 8 and 29.
- Wisconsin: Slight shock on October 18.
- Wyoming: A series of moderate shocks in Yellowstone Park from August 25 to 27. One slight shock on September 20.



NORTHEASTERN REGION

[75th meridian or eastern standard time]

January 7: 19.14. Felt in New England. Epicenter near Baie St. Paul, Province of Quebec, according to the Dominion Observatory at Ottawa, Canada. In the New England region it was felt with force IV at Island Pond, Vt., and Bradbury, Millinocket, Portage, and Stockholm, Me.; force III at Canaan, Vt., and Mountain Township, Caribou, and Van Buren, Me. It was also felt at Madawaska, Perham, Portland, Hobbstown, Soldier Pond, and Stratton, Me.

April 20: 1454. Lake George, N. Y. Intensity VII. ($43^{\circ}.4$ N., $73^{\circ}.7$ W.) (See map.) The position of the epicenter was determined from the non-instrumental data as only a few stations recorded weak preliminary tremors.

Warrensburg was nearest the point of maximum intensity. A score of chimneys were reported to have been knocked down there, some walls were slightly cracked, and a cross on a church spire was twisted out of shape. A small landslide was reported on McCarthy Mountain. At Glens Falls walls were cracked, dishes broken, and clocks stopped. At Lake George buildings swayed and store goods fell from the shelves. Pendulum clocks stopped. At Lucerne chimneys and cars swayed. Some chimneys were slightly damaged and window lights broken. A church spire was observed to sway. About 1,000 square miles, embracing the southern half of Lake George, were shaken rather strongly. The shock was perceptible over about 60,000 square miles. A canvass of the area brought out a peculiar feature in that there was an apparent absence of any disturbance in the region of the Catskill Mountains which corresponds in position to the prominent indentation of the outer isoseismal curve just below Albany. Not one of a dozen or more reports in the locality indicated that the shock was felt. The apparent invulnerability of the Catskills to vibrations from slight earthquakes originating near by was also indicated quite clearly in the case of the Attica, N. Y., earthquake of August 12, 1929.

The intensity distribution was as follows: VII at Glens Falls, Lake George, Lucerne, and Warrensburg, probably strongest at the latter; VI at Big Bay (near by), Corinth, Fort Edward, French Mountain, Hudson Falls, Saratoga, Smiths Basin, Thurman, Ticonderoga, and Whitehall; V at Albany, Ballston, Granville, North Creek, Salem, and Troy; IV at Belcher,

Conklingville, Greenwich, Johnstown, Mayfield, Minerva, Northville, Putnam Station, Rensselaer, Schenectady, Schroon Lake, Stony Creek, West Day, Westport; III and under at Castleton-on-Hudson, Charlemont, Cheshire, Chester, Clemons, Cohoes, Dolgeville, East Greenwich, Glen Island, Hinckley, Ithaca, Mechanicsville, New Hartford, New Lebanon, New York Mills, Old Forge, Rome, Rotterdam Junction, Sand Hill, Scotia, South Wilton, Syracuse, Utica, Waterford, and Watervliet in New York. Also felt slightly at Greenfield, Hinsdale, Holyoke, Northampton, Springfield, and Westfield, Mass.; Bellows Falls, Fair Haven, Poultney, and Rutland, Vt.; and Litchfield, West Goshen, and Winsted, Conn.

The shock was not felt at Ashokan, Chatham, Durham, High Falls, Hillsdale, Hunter, Millerton, Palenville, Rhinecliff, Sand Lake, Stephentown, Tivoli, and other near-by places. These are mentioned to indicate the lack of seismic activity in the Catskill Mountains south of Albany.

May 4: 5.17, Amherst, Mass. Distinct shock shook houses and rattled dishes.

May 4: 13.43, Malone, N. Y. Feeble. Felt by very few.

June 6: 19.00, Rochester, N. Y. Feeble. No damage. Another lighter shock at 21.30.

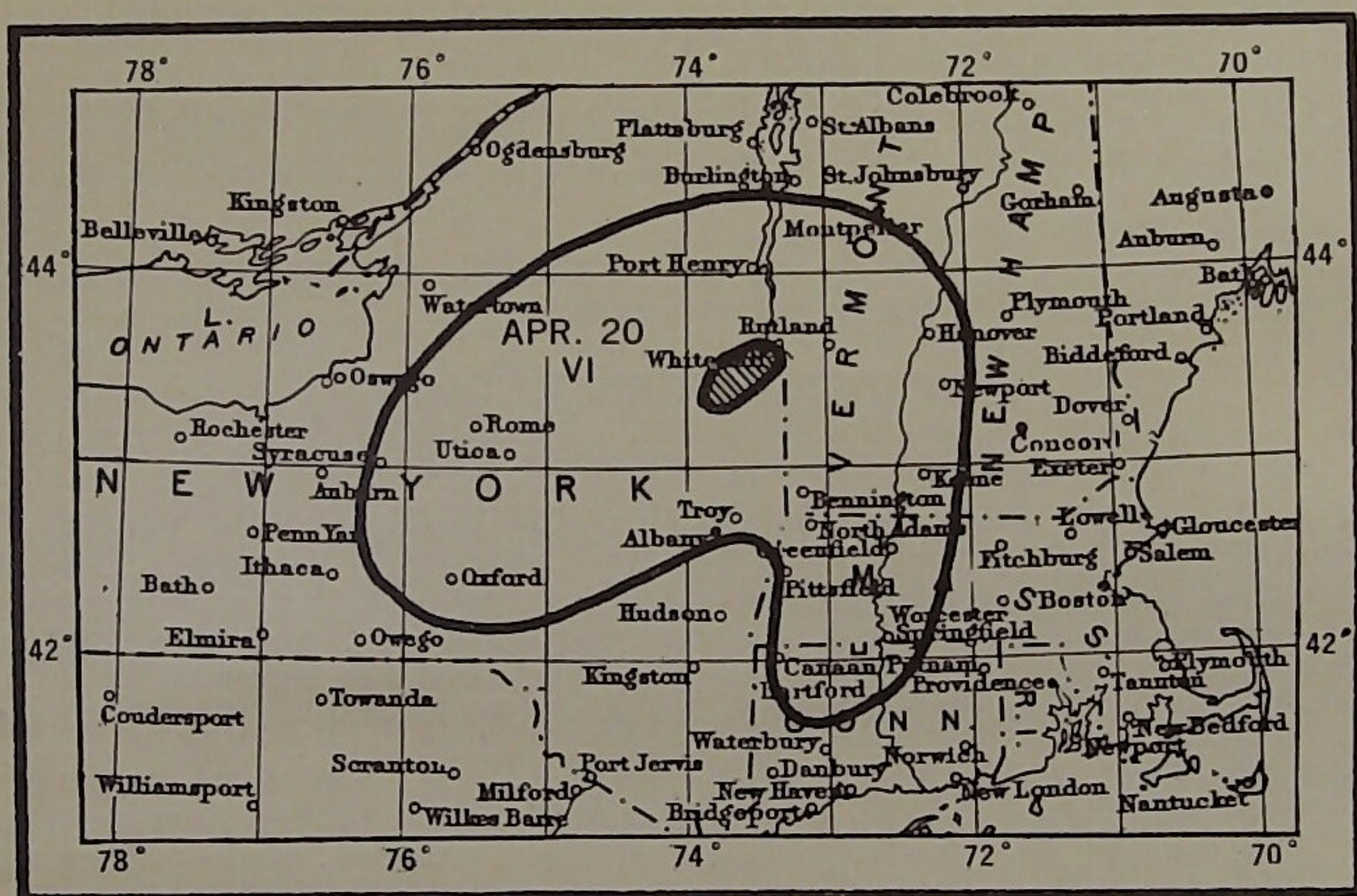


FIGURE 2.—Area affected by Lake George shock of April 20

June 30: 21.45, New Milford, Conn. Moderate shock. Strongest at New Milford, where a theater audience was frightened. Many awakened. No damage. Felt also at Waterbury, Woodbury, Cornwall Bridge, and Kent.

November 3: 10.30, Canton, N. Y. Feeble. Dishes rattled lightly.

EASTERN REGION

[75th meridian or eastern standard time]

May 5: 7.18, northern Alabama.* (See map p. 9.) Felt over an area of 6,500 square miles exclusive of isolated points in Georgia and possibly South Carolina. Force V at Cullman, where objects fell from walls of a blacksmith shop and the shock was generally strong. At Birmingham it was generally observed and bricks fell from one chimney. The movements were accompanied by roaring sounds. They were reported also from Bessemer, Oneonta, Bernard, Lay Dam No. 5 (on the Coosa River 12 miles northeast of Clanton), Jones Valley, and 25 miles north of Tuscaloosa. Lighter movements were reported from Spring Junction, Colta, Clanton, Calera, Pell City, Leeds, Lincoln, Montgomery, and doubtful activity from Tuscaloosa, Gadsden, and Decatur. Camilla, Ga., reported feeling the shock. Recorded at St. Louis.

- May 6: 7.18, Due West, S. C.,* Feeble shock felt by many with sounds like distant thunder. Windows rattled. (It seems possible that this date should be May 5, corresponding to the time of the preceding shock.)
- October 5: 22.15,* New Canton, Va.* Feeble shock felt by several. Rather loud roaring sound heard. Recorded at Charlottesville at 22.15.34.



CENTRAL REGION

[90th meridian or central standard time]

- January 5: 20.51,* Elliston, Ind.* Force V. Windows rattled and dishes thrown from shelves in a few cases. Also felt at Bloomfield, Kolen, Mineral, Newberry, Worthington, Linton, Lyons, and Sandborn. Felt hardest in hill country east and north of Elliston. Recorded at St. Louis.
- January 17: 12.45, White Lake, S. Dak.* Slight shock felt by many. Trembling motion with loud sounds.
- March 21: 9.48, Sidney, Ohio.* Feeble shock felt at Sidney and Jackson Center.
- April 1: 17.30, Lovelaceville and Hopkinsville, Ky.* Feeble. Felt also at Mayfield, Ky., and Cairo, Ill.
- April 6: 9.40, Berkley, Bardwell, and Lovelaceville, Ky.* Moderate shock, strongest at Berkley. Dishes rattled and pictures swayed.
- June 10: 2.30? Malinta, Ohio, and surrounding region.* Meteor, nitroglycerin explosion, or earthquake? A large hole 10 feet wide was found in the road just outside of Malinta, and for 300 feet around telephone poles were broken, wires were down, and trees knocked over. A field of oats was crushed to the ground. Windows were broken several miles away, and thousands were awakened within a radius of many miles. No meteor was found. More probably an explosion. Buildings were shaken at Findlay. Felt also at Fostoria, Bluffton, Continental, Columbus Grove, and Wauseon, Ohio.
- July 18: 8.40, Tiptonville, Tenn.* "More severe than any in 10 or 15 years." General alarm. No damage. Also felt at New Madrid, Mo.
- August 9: 1.15.* Moderate at Kansas City, where dishes rattled and pictures swung. Felt in region to south and west, also in Overland Park, Merriam, Turner, and Bonner Springs, Kans., and Leeds, Mo. Weaker shocks occurred at 0.20 and 1.05.
- August 16: 5.40, west Texas.* (See Western Mountain Region.)
- September 20: 17.05,* Anna, Ohio.* Intensity VII. (See map.) No instrumental determination of the epicenter was made, as the shock was recorded at only a few seismographic stations in near-by States, where very sensitive instruments were in operation.

The disturbed area was in the western part of Ohio near the Indiana line. Moderate damage was reported from Anna and near-by towns. At Anna two large cornice stones were thrown from the Lutheran Church, a small exterior ornament fell off the Methodist Episcopal Church, plastering was shaken off the walls in the schoolhouse, several chimneys were thrown down and many others were damaged. At Houston there was some damage to brick walls and a few chimneys fell. At Sidney a number of chimneys were destroyed, a few plate-glass windows were cracked, and plaster fell from some walls. The average intensity in the epicentral zone, which was about 400 square miles in extent, was V, although at Anna it was at least VII. The shock was perceptible over an area of approximately 40,000 square miles. A canvass of the region indicated the shock was felt with force VII at Anna; VI at Botkins, Houston, and Sidney; V at Arcanum, Coldwater, College Corner, Jackson Center, Lima, New Bremen, New Carlisle, Piqua, Rosewood, and Versailles; IV at Bellefontaine, Bluffton, Cairo, Camden, Casstown, Catawba, Celina, Christiansburg, Cincinnati, Clayton, Covington, Cridersville, Dayton, De Graff, Fletcher, Gomer, Hamilton, Harper, Huntsville, Lakeview, London, Marion, Mercer, Montezuma, New Hampshire, New Paris, Pemberton, Pennton, Quincy, Russell's Point, St. Johns, Saint Marys, Spencerville, Springfield, Tippecanoe City, Troy, Uniopolis, Urbana, Van Wert, Wapakoneta, West Mansfield, and Zanesfield, in Ohio; Brookville, Brownsville, Decatur, Fort Wayne, Greensburg, Indianapolis, Liberty, Marion, Muncie, Pennville, and Richmond, in Indiana.

Force III and under at Alpha, Athens, Bellbrook, Bell Center, Blanchester, Broadway, Brookville, Bryan, Bucyrus, Cable, Carthagen, Chickasaw,

Collinsville, Columbus, Convoy, Defiance, Delaware, Delphos, Dixon, Dunkirk, Eaton, Eldorado, Farmersville, Fort Loramie, Franklin, Germantown, Gettysburg, Glandorf, Glenmore, Gordon, Goshen, Greenfield, Iron City, Irwin, Jamestown, Lancaster, La Rue, Laura, Lewistown, Logan, Lynchburg, Maria Stein, Marysville, Mason, Mechanicsburg, Mendon, Middleburg, Minster, Napoleon, New Richmond, New Vienna, North Baltimore, North Lewisburg, North Hampton, Ohio City, Oregonia, Ottawa, Pandora, Phoneton, Plattsburg, Pleasant Hill, Port Jefferson, Rockford, Seven Mile, South Charleston, South Solon, South Vienna, Tremont City, Trenton, Waverly, Waynesfield, Westboro, West Carrollton, West Liberty, West Manchester, Westminster, Westville, Williamsburg, Wilmington, Woodstock, Xenia, Yellow Springs, and Zanesville, in Ohio; Anderson, Berne, Cambridge City, Columbus, Connersville, Elwood, Hartford City, Huntington, Lawrenceburg, Lebanon, Madison, New Castle, Noblesville, Union City, Wabash, Williamsburg, and Winchester, in Indiana; Alexandria, Bardstown, Carrollton, Covington, Falmouth, Grant, Kenton, and Vanceburg, in Kentucky.

October 18: 15.12, Madison, Wis. Feeble. Swaying motion felt by several.

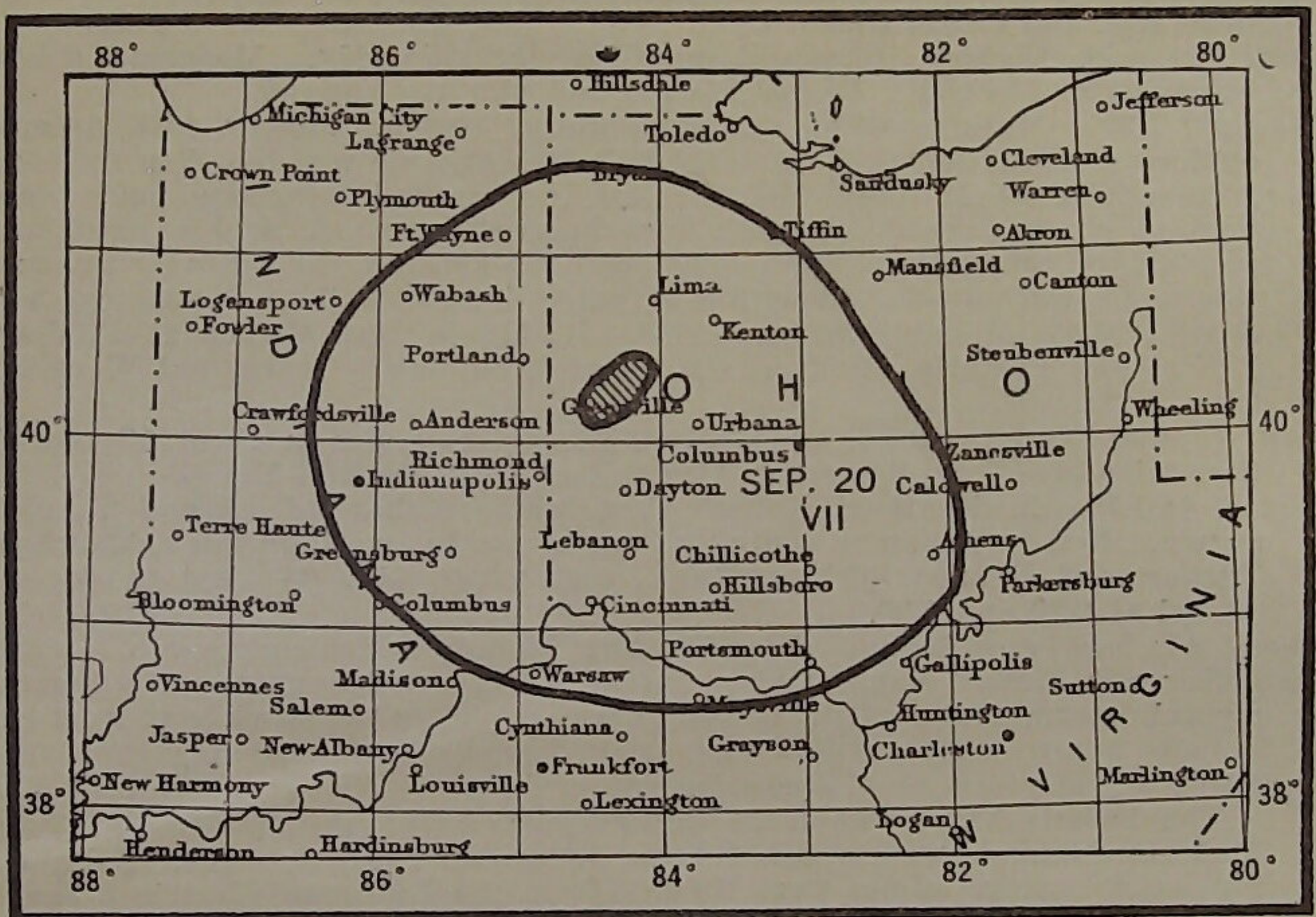


FIGURE 3.—Area affected by Anna, Ohio, shock of September 20

November 27: 3.23,* Nashville, Tenn. Felt. Recorded at St. Louis.

December 10: 2.12,* Blytheville, Ark. Shook houses and rattled windows. No damage. Recorded at St. Louis and Little Rock

December 16: 21.36,* northern Mississippi. Intensity VI. (See map.) An epicenter near Batesville, Miss., was indicated by a preliminary analysis of instrumental results at the University of St. Louis. The point of apparent maximum intensity was Charleston, Miss., about 20 miles south. It was recorded instrumentally at stations in the central Mississippi Valley region and faintly at a few more distant stations. The shock was perceptible over an area of about 65,000 square miles.

At Charleston cracks were made in the walls and foundation of the Agricultural High School and several chimneys were thrown down. At Belzoni several buildings were damaged slightly and some plaster was thrown down. At Tillatoba one chimney fell, doors opened, a vase was thrown to the floor. At Water Valley several chimneys were damaged.

Intensity distribution: VI at Charleston, Belzoni, Tillatoba, and Water Valley, Miss.; V at Batesville, Cleveland, Hernando, Holly Springs, Indianola, Taylor, and Tupelo, Miss., Marianna, Ark., Raleigh, Tenn.; IV at

Abbeville, Ackerman, Blue Mountain, Booneville, Clarksdale, Clayton, Coffeeville, Columbus, Corinth, Duncan, Enid, Etta, Fair Point, Gona, Greenwood, Grenada, Hardy Station, Hollandale, Houlika, Houston, Iuka, Bena, Iuka, Kosciusko, Lake Cormorant, Meridian, Okolona, Oxford, Pace, Pittsboro, Pontotoc, Prichard, Ripley, Robinsonville, Sherman, Stoneville, Sumner, and Waterford, Miss.; Earle, Forrest City, Helena, and Searcy, Ark.; Germantown, Henderson, Memphis, and Selmer, Tenn.; Gainesville and Hackleburg, Ala.; III and under at Aberdeen, Ashland, Askew, Carrollton, Europa, Farrell, Fulton, Glen Allen, Greenville, Gunnison, Guntown, Hickory Flat, Holcut, Lafayette Springs, Nettleton, Paulding, Pine Valley, Potts Camp, Rolling Fork, Sardis, Sarepta, Scott, Tunica, West Point, and Yazoo City, Miss.; Marion, Osceola, and Winchester, Ark.;

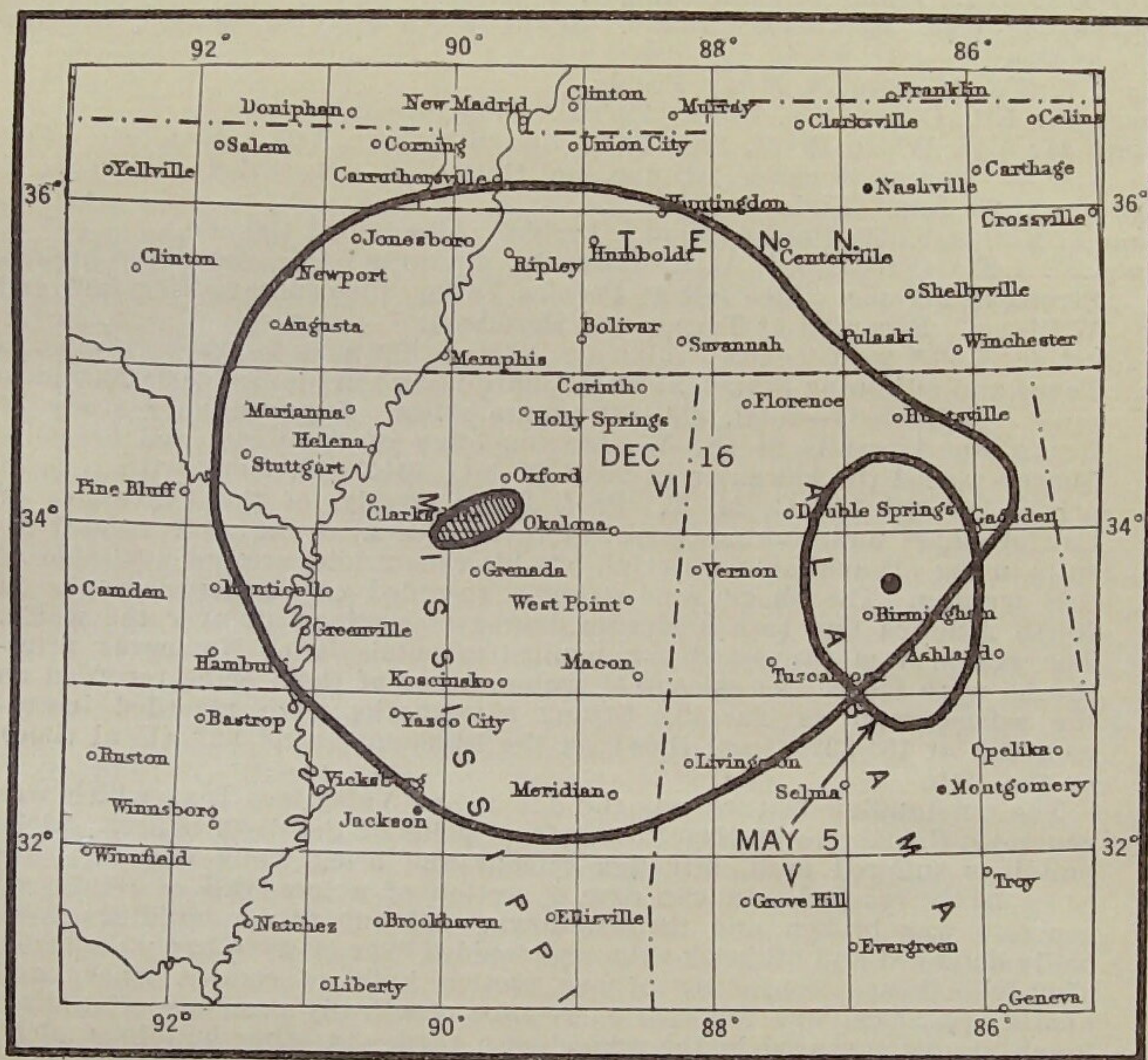


FIGURE 4.—Areas affected by northern Alabama shock of May 5 and northern Mississippi shock of December 16

Adamsville, Alamo, Arlington, Bolivar, Brownsville, Dyersburg, and Savannah, Tenn.; Birmingham, Clanton, Decatur, Fort Payne, Millport, Montgomery, Riverton, Russellville, and Tuscaloosa, Ala.

December 31: Time unknown. Petersburg, Ind. Weak. Earthquake or mine blast?

WESTERN MOUNTAIN REGION

[105th meridian or mountain time]

January 6: About 14.00, McCall, Idaho. Moderate. Few details. Felt also at Council and Donnelly. Windows rattled and coffee percolator toppled at McCall.

January 27: (?) Albuquerque, N. Mex. "Recognized by several."

February 4: 21.48,* Albuquerque, N. Mex. Force VI. Evidently strongly localized. Hundreds left houses, many in pajamas, and many reported they were thrown from bed. Panic threatened in theaters as audiences rose to their feet and some started for exits. Ten-foot crack appeared in a bakery and bricks toppled from bake ovens. Goods were thrown from shelves of several stores. A hot-water tank fell from a wall and a pharmacy mirror was cracked. Some plaster was cracked and water spilled from indoor containers. Large rocks rolled into streets from sand hills about the city. It was evidently felt at Martineztown also. Recorded at Tucson. A feeble shock generally unnoticed was reported on February 3. The local press reported slight tremors on December 3, 1930.

February 12: 13.40, Las Vegas, N. Mex. Feeble.

March 8: 21.29, Elsinore, Utah. Slight.

March 11: 6.20, Montpelier, Idaho. Slight shock felt by many. Swaying motion.

April 7: 2.25, Socorro, N. Mex. Feeble.

April 10: 1.30, Cedar City, Utah. Feeble. Windows rattled.

April 17: 5.40, White River, Snowflake, and Standard, Ariz. Moderate. Felt also at Cibecue, Pinedale, Aripine, and Chrysotile. Recorded at Tucson.

June 2: 21.25, Lund, Utah.

June 8: 6.26 and 7.50, Helena, Mont. Feeble. Also felt at Ovando.

July 28: 1.40,* Cottonwood, Ariz. Force V. Pictures fell, dishes were broken. Strong at Jerome. Also felt at Peoples Valley, Clemenceau, Flagstaff, and Williams. Recorded at Tucson and Pasadena.

August 16: 5.40,* west Texas. Intensity VIII. (See map.) Area affected in Texas and adjoining States, 250,000 square miles; in Mexico, 200,000 square miles (estimated)—total, 450,000 square miles. A preliminary study of instrumental results at the Washington office of the Coast and Geodetic Survey placed the epicenter at 29.9° N. lat., 104.2° W. long., with time of origin $11^{\text{h}} 40^{\text{m}} 15^{\text{s}}$, G. M. T. Prof. Perry Byerly, of the University of California, is undertaking a special investigation of the instrumental results, using all available material, but his conclusions are not available at this writing. The shock was strongly recorded on all seismographs in North America and to a moderate degree at stations all over the world. The region was canvassed for noninstrumental data. Numerous aftershocks were felt in the epicentral region, many of them being recorded on the seismograph at Tucson. Strong aftershocks were recorded instrumentally at $13^{\text{h}} 33^{\text{m}}$ (local time) on the 16th and at $19^{\text{h}} 36^{\text{m}}$ (local time) on the 18th.

The outstanding feature was the damage at Valentine, Tex., which was generally thought to be close to the focal point of the disturbance. Adobe buildings suffered most, although cement and brick walls were in some cases badly cracked. In one case a section of a low wall of reinforced concrete was broken and thrown down. All but frame buildings were badly damaged and all brick chimneys toppled over or were badly damaged. The schoolhouse, consisting of one section built of cement blocks and another of brick, was reported to require practically complete rebuilding. Small cracks appeared in the schoolhouse yard. In other buildings adobe walls collapsed and in frame structures ceilings and partitions were damaged. Tombstones in the cemetery were rotated in both directions, in some instances as much as a quarter of a turn. The population was more or less panic stricken, but there were no fatalities and only a few were slightly injured by falling adobe. This is accounted for by the fact that nearly everyone was sleeping outdoors.

Although Valentine bore the brunt of the shock, damage was reported from widely scattered points in Brewster, Jeff Davis, Culberson, and Presidio Counties, most of which was confined to cracked walls and sometimes badly damaged chimneys. Plaster was cracked and thrown down at Alpine. A report from Candelaria states "ground seemed to rise up in waves." Some cracked plaster resulted. At Castolon several walls cracked in an old adobe building. The postmaster at Hot Springs reported rock slides were heard at top of Chisos Mountains. Several chimneys fell at Fort Davis and a water tank split in a bottom seam. At Marfa a few chimneys were shaken down and small vertical cracks appeared in well-constructed adobe buildings. Several clocks stopped. At Porvenir landslides occurred, trees swayed, heavy furniture moved, plaster cracked

slightly, and poorly built adobe structures were damaged. Water pipes were broken and bridges damaged at Ruidosa. Reinforced concrete and cement was damaged at Shafter. Landslides were reported heard in the mountains near Tesnus. Some walls were cracked at Madera Springs, Pecos, and Sierra Blanca. Several chimneys fell and walls cracked at Van Horn. In New Mexico a few vertical cracks appeared in walls at Artesia. At Carlsbad several chimneys were damaged and walls slightly cracked. There were slides of rock and dirt from the hills near Picacho, where plaster also fell.

The earthquake was accompanied by subterranean sounds described as rumbling and roaring and at some places terrifying. They were heard over practically the entire affected area.

Intensity distribution: VIII at Valentine, Tex.; VII at Alpine, Candelaria, Castolon, Chisos Mountains, Fort Davis, Marfa, Presidio, Porvenir, Ruidosa, Shafter, and Tesnus, Tex.; VI at Lajitas, Madera Springs, Pecos, Sierra Blanca, and Van Horn, Tex.; Artesia, Carlsbad, Picacho, N. Mex.; V at Abilene, Balmorhea, Barstow, Brady, Crane, El Paso, Fabens, Fort Stockton, Hamlin, Hot Springs, Karnes City, Knapp, Mexia, Monahans, Post, Reagan, Roby, Rotan, Sanderson, Stanton, and Sylvester, Tex.; Las Cruces, Orogrande, and Roswell, N. Mex.; IV at Ballinger, Benjamin, Big Spring, Brenham, Brownfield, Caldwell, Cameron, Clarendon, Colorado, Comanche, Cotulla, Crowell, Del Rio, Denton, Eagle Pass, Floydada, Frijole, Giddings, Gonzales, Grandfalls, Hondo, Hovey, Junction, Kernville, Lajitas, Lamesa, Lampasas, Levelland, Longfellow, McNary, Marathon, Mason, Menard, Meridian, Midland, Mineral, Muleshoe, New Braunfels, Odessa, Orla, Ozona, Pandale, Rankin, San Angelo, San Antonio, Seguin, Seminole, Smithville, Snyder, Sonora, Spur, Sterling City, Sweetwater, Tahoka, Taylor, Temple, Terlingua, Winters, and Uvalde, Tex.; Artesia, Carlsbad Caverns, La Luz, Lincoln, San Marcial, Tularosa, N. Mex.; III and under at Albany, Amarillo, Andrews, Angleton, Anson, Austin, Brackettville, Canyon, Carta Valley, Claude, Coleman, Corsicana, Dallas, Dickens, Dimmitt, Eastland, Eden, Flatonia, Fort Worth, Fredericksburg, Gail, Garden City, Gatesville, Granbury, Groesbeck, Haskell, Houston, Jacksboro, Jarrell, Jouranton, Karnes City, La Grange, La Pryor, Llano, Lubbock, Miami, Nixon, Olton, Paducah, Paint Rock, Palo Pinto, Pearsall, Plains, Plainview, Post, Quanah, Robert Lee, Rochelle, Rock Springs, Sabinal, San Marcos, San Saba, Seymour, Silverton, Throckmorton, Vega, Waco, Weatherford, Wellington, Ysleta, Tex.; Albuquerque, Caballo, Carrizozo, Chanes, Cloverdale, Clovis, Cooper, Deming, Elk, Glenrio, Montoya, Tucumcari, N. Mex.; Hollis, Okla.

For the following statement concerning the geology of the region the Coast and Geodetic Survey is indebted to Prof. E. H. Sellards, associate director of the bureau of economic geology, University of Texas:

"The earthquake occurred in the mountainous region of Trans-Pecos Texas. The town of Valentine, where the maximum effect was felt, is located in an intermontane valley. At this place the valley is chiefly synclinal in nature, although it may be in part bounded by faulting. Northward the valley extends into New Mexico. In the Van Horn region this northward continuation of the valley, there known as the Salt Flat, is a graben or rift valley set off from the bordering mountains by faults that in places have a throw of several thousand feet. Southward from Valentine the valley terminates near the Chisos Mountains. The valley as a whole is filled with debris from the bordering mountains and south and east of Valentine received extensive Tertiary lava flows. Towns east of Valentine, including Ryan and Marfa, are built upon the lavas. The structure lines in this part of Trans-Pecos Texas as indicated by this valley are prevailing northwest-southeast.

"Southwest of Valentine, forming the margin of the valley in that direction, are the Tierra Vieja Mountains. On the opposite side and forming the northeastern margin of the valley are spurs of the Jeff Davis Mountains, which are chiefly volcanics of Tertiary time. Some of the mountains west of Valentine are heavily faulted, the faults having in the main a northwest-southeast trend. At its west margin the Tierra Vieja Mountains terminate by a great fault forming the topographic feature known as the rim rock. Just how close to Valentine faulting occurs can not be determined owing to the valley fill. However, fault lines may and probably do exist in the valley underneath the fill."

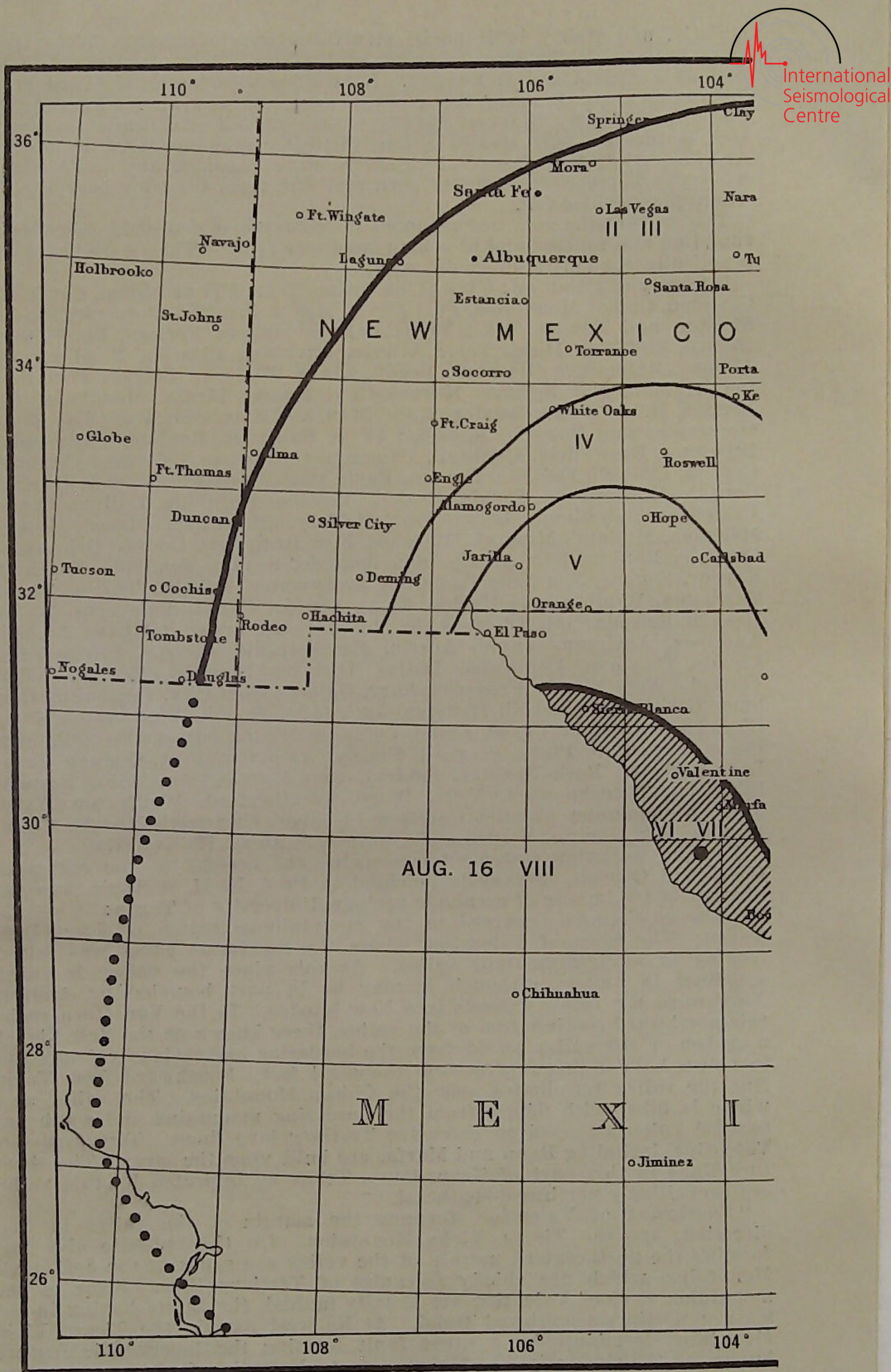
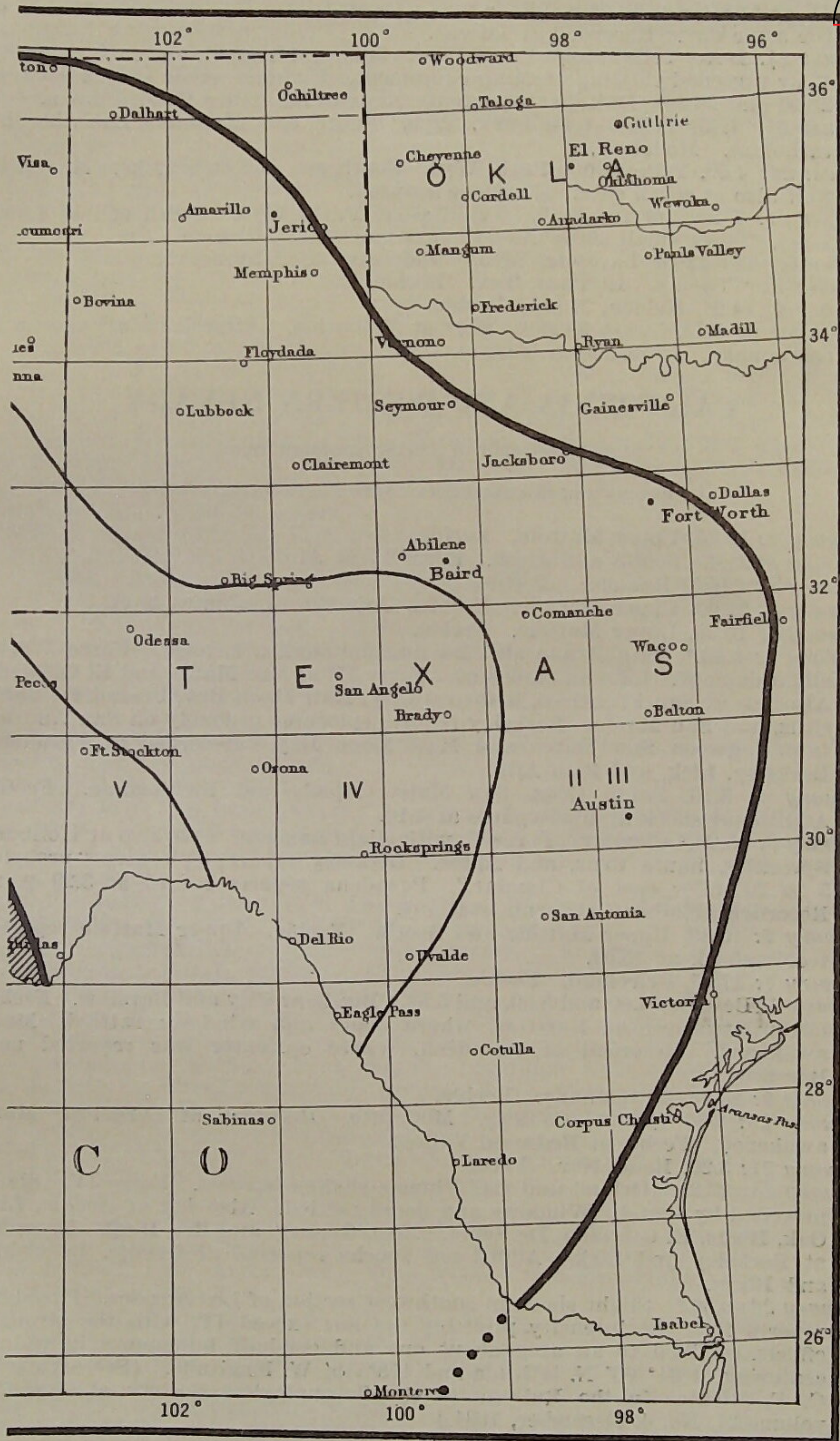


FIGURE 5.—Area affected by



West Texas shock of August 16

- August 18:* 13.36,* west Texas. Force V at Alpine, Pecos, Lobo, and Valentine; IV at Carlsbad, N. Mex. This was preceded by a lighter shock at 2.42 on the same day. Recorded at Tucson.
- August 24:* 19.40, Yellowstone Park, Wyo. Nine miles north of south entrance. Roar preceded rattling of camp equipment. Eighteen other shocks between 23.20 and 24.30. Building repeatedly rocked and dishes thrown down.
- August 25:* 7.45, Yellowstone Park, Wyo. South end of Lewis Lake became turbulent. Moderate.
- August 26:* 4.00, Yellowstone Park, Wyo. South end of Lewis Lake. Moderate. Felt also at south gate. Everyone aroused.
- August 27:* Time not reported. Yellowstone Park, Wyo. South end of Lewis Lake. Three small shocks in 24 hours preceding 5.00 p. m.
- September 20:* 22.15, Laramie, Wyo. Moderate. Felt by nearly all.
- October 2:* "To-day," El Paso, Tex. Feeble.
- October 6:* 14.24, Helena, Mont. Feeble.
- November 3:* 8.50,* west Texas. Felt at Valentine. Aftershock of August 16 earthquake. Recorded at Tucson.

CALIFORNIA AND WESTERN NEVADA

[120th meridian or Pacific standard time]

ALL PLACES ARE IN CALIFORNIA UNLESS OTHERWISE STATED

- January 2:* 10.35, Upper Mattole. Feeble.
- January 2:* 21.49, Scotia and Alton. Force IV at Alton.
- January 3:* 21.25, Ramona. Feeble.
- January 3:* 22.00, Upper Mattole. Feeble. Another 10 minutes later.
- January 4:* 10.35, Upper Mattole. Feeble.
- January 5:* 1.43.* San Bruno and Burlingame shaken hardest. Force V with slight damage. Like an explosion. Force IV at San Mateo and El Granada. Also felt at San Francisco, Redwood City, Half Moon Bay, Pescadero, Santa Cruz, and San Mateo. Berkeley reports epicenter probably on San Andreas fault between San Mateo and Half Moon Bay. Recorded at Pasadena, Berkeley, Lick, and Palo Alto.
- January 5:* 3.15, Santa Cruz, San Mateo, Aptos, and Burlingame. Feeble. Additional shock at Burlingame at 4.10.
- January 6:* 15.29,* Chualar. Force V, with slight damage. Felt also at Hollister, Spreckles, Santa Cruz, and Aptos. Berkeley reports epicenter "probably 5 to 20 miles east of Chualar." Pasadena reports record at 3.29 p. m. Recorded at other California stations.
- January 7:* 15.40, Upper Mattole and Scotia. Feeble. Upper Mattole reported feeble shock at 15.04.
- January 7:* 17.15, Briceland. Feeble.
- January 8:* Between 4.00 and 5.00, and 5.53,* Big Bear City and Barstow. Feeble. Latter strongest at Barstow, where doors and windows rattled. Many awakened. Recorded at Pasadena, where epicenter was reported near Barstow.
- January 9:* 23.58, El Granada. Feeble.
- January 20:* 2.30 (about), Willits. Moderate. Recorded at Berkeley. Many awakened. Feeble at Redwood Valley.
- January 21:* 3.20, Reno, Nev. Feeble.
- January 23:* 23.21. Orland and Las Plumas shaken hardest. Force IV. Shock preceded by sound. Windows and doors rattled. Also felt at Orville, Live Oak, Biggs, El Granada, De Sabla, Chico, Gridley, and Red Bluff. Recorded at Berkeley and Lick. Additional shocks reported at Orville, De Sabla, and Biggs.
- January 28:* 0.50.* Slight shock in southwest section of Los Angeles. Pasadena reports that the intensity probably did not exceed IV, with the stronger effects confined to an area about one and one-half kilometers in radius, centering at 34° 00' N. latitude and 118° 19' W. longitude. (See article by C. F. Richter in the Bulletin of the Seismological Society of America, volume 21, No. 4, December, 1931.)
- January 28:* 23.24, El Granada. Feeble.
- February 6:* 23.40, Sargent. Slight. Small objects moved.
- February 12:* 13.25, Stanford University. Feeble.
- February 14:* 13.49 and 19.19, Imperial. Feeble shocks.

- February 16:* 5.27,* Riverside and Mentone. Force V. Slight damage. Also felt at Redlands, Rialto, and San Bernardino. Foreshocks at 0.12,* 2.12,* 3.07,* and possibly others. Two additional shocks recorded at Pasadena. Epicenter near San Bernardino according to Pasadena.
- February 17:* 7.59, Sargent. Slight.
- February 21:* 0.10,* Piedras Blancas Light Station and Bryson. Two slight shocks. Pasadena reports epicenter "probably northwest of San Luis Obispo."
- February 23:* 2.01,* 2.33,* Templeton, Parkfield, and Cayucos. Force V. (See map.) Area affected less than 5,000 square miles. Slight damage. Force IV at Coalinga, Bern, Stone Canyon, and Bradley. Also felt at Paso Robles, King City, Priest Valley, Cholame, Santa Cruz?, Atascadero, Capitola, Bryson, San Miguel, Lockwood, Pinnacles, Mount Hermon, and San Ardo. Pasadena reports tentative epicenter T. 25 S., R. 14 E. M. D. B. and M. Aftershock reported from Parkfield and Golon?
- March 8:* 6.35,* Tokonea. Feeble. Recorded in Pasadena, where epicenter was reported as off Santa Monica.
- March 9:* 19.30,* Humboldt County. Moderate. Some mercury was spilled at the Punta Gorda Light Station. Force IV at Arcata, Bridgeville, Fernaldale, and Upper Mattole. Also felt at Alderpoint, Briceland, Pollock, Shively, Weott, Whitlow, Alton, Miranda, Humboldt Bay Fog Signal, and Eureka. Recorded at Pasadena. Berkeley reports that earthquake centered some hundred miles west of Cape Mendocino.
- March 10:* 8.30, Whitlow. Feeble.
- March 18:* 14.00, Avalon. Very feeble.
- March 31:* 12.33,* Yorba Linda and Pomona. Feeble. Table displaced at Yorba Linda. Pasadena reports epicenter near Pomona. Recorded at Pasadena.
- April 2:* 3.00, Goat Island. Feeble, uncertain.
- April 3:* 21.45, San Francisco. Feeble.
- April 3:* 22.00, San Francisco region. Moderate. Force IV in San Francisco. May have been blast. Also felt at Fort Point Presidio and San Bruno.
- April 3:* 23.45, Calistoga. Feeble.
- April 4:* 4.00, Topanga. Feeble.
- April 4:* 19.00, Peachtree Valley (southeast of King City). Very feeble.
- April 6:* 0.07, Calistoga. Feeble.
- April 15:* 9.00, Laws. Very feeble.
- April 23:* 15.34,* Mohave Desert. Pasadena reports epicenter $35^{\circ} 21' N.$, $117^{\circ} 36' W.$ Force IV near Mojave, at San Canyon, Freeman, and Dove Springs. Also felt at Trona, West End, Valyermo, Morena, and Eden. Press reports a few felt it at Calexico.
- April 24:* 10.28,* off shore near Los Angeles. Force V. Epicenter reported by Pasadena $33^{\circ} 46' N.$, $118^{\circ} 29' W.$ (See map p. 16.) Felt over an area of 3,000 square miles on land. Slight damage. Force V at Redondo Beach, Manhattan Beach, WALTERIA, Bellflower, and 2 miles east of Torrance; IV at Point Vincente Light Station, Downey, and Palos Verdes. Also felt at Avalon, Bakersfield, Brea Cypress, Costa Mesa, Culver City, Compton, Dominguez, Ducor, Fullerton, Gardena, Huntington Park, Inglewood, Los Angeles, La Mirada, Long Beach, Lighthipe Substation, Laguna Bell, Lomita, La Fresa Substation, Morena, Norco, Point Fermin district, Point Loma Light Station, San Dimas, San Pedro, Santa Monica, San Fernando, Venice, Valyermo, and Wilmington.
- April 25:* 17.40, Humboldt Bay Fog Station and Eureka. Feeble.
- April 27:* 15.10, Twentynine Palms. Moderate.
- April 27:* 16.38, Rosamond. Feeble.
- April 29:* 4.41,* San Fernando and Chatsworth. Force IV. Recorded at Pasadena. Pasadena reports epicenter as probably near Chatsworth.
- May 2:* 5.33,* Lake Arrowhead. Very feeble. San Bernardino Mountains according to Pasadena.
- May 6:* 2.22,* Victorville and Adelante. Feeble. Pasadena reports epicenter T. 5 N., R. 4 W., San Bernardino Mountains.
- May 7:* 7.03,* Anza. Feeble. Probably San Jacinto fault according to Pasadena.
- May 10:* 4.10, Point Cabrillo. Feeble.
- May 20:* 0.01, Eureka, Alton, Scotia, and Humboldt Bay Fog Station. Slight shock followed by another two hours later.
- May 29:* 2.43,* Calistoga. Feeble. Pasadena reports epicenter near Tejon Pass.

May 29: 11.30, Inyokern and Freeman. Feeble.

May 30: 12.00, Camp Angeles. Feeble.

May 30: 8.28,* Onyx. Very feeble. Pasadena reports epicenter near Brown, Kern County.

June 3: 21.25, Greenville. Moderate. Walls creaked.

June 3: 21.40, Quincy and Caribon. Moderate.

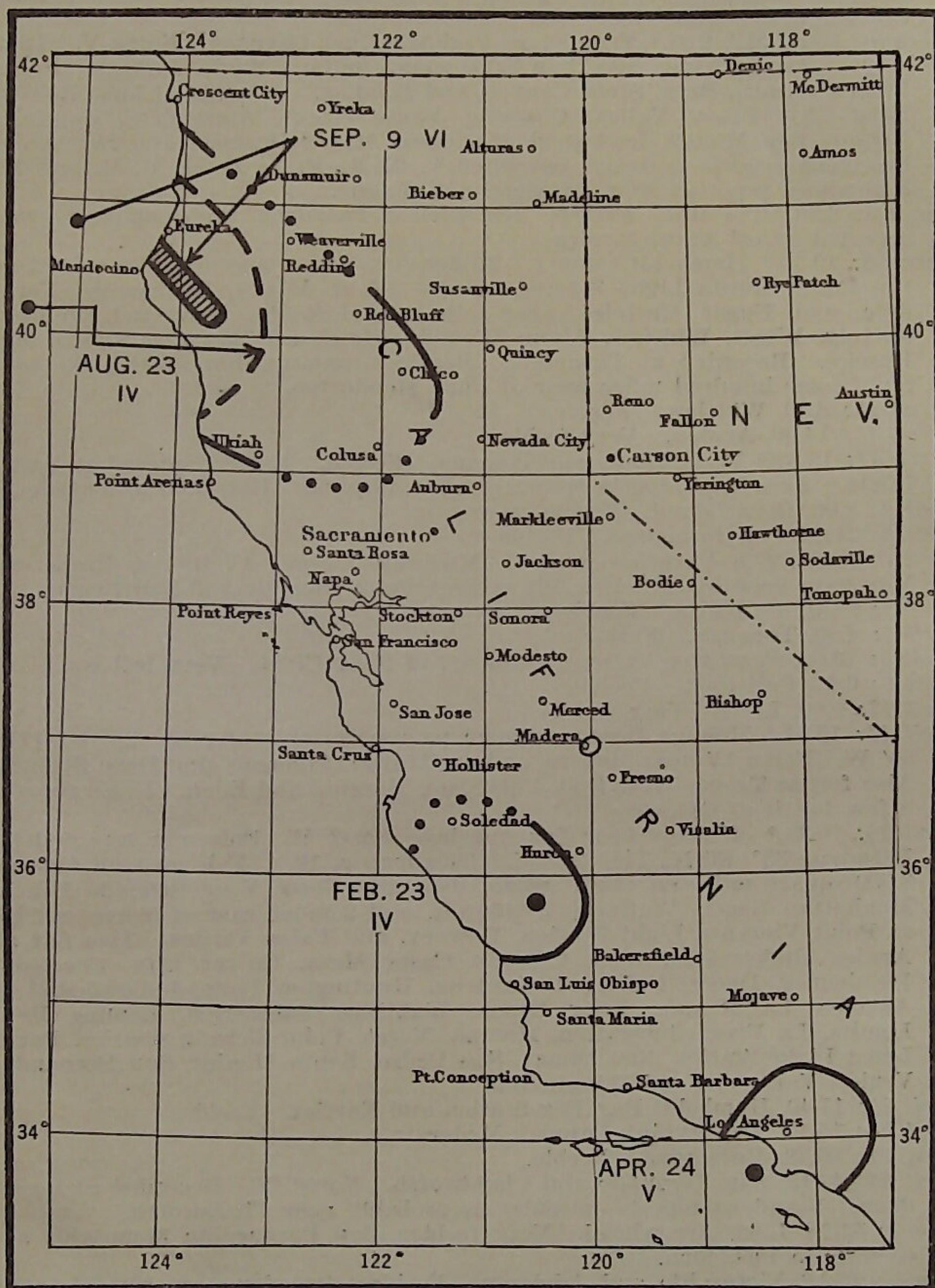


FIGURE 6.—Areas affected by California shocks of February 23, April 24, August 23, and September 9

June 5: 3.30, Punta Gorda Light Station. Moderate. All awakened.

June 5: 4.45, Little Lake. Two weak shocks.

June 5: 14.30, Upper Mattole. Feeble.

June 5: 18.10, Luning, Nev. Moderate.

June 6: Between 1.00 and 2.00, Morgan Hill. Feeble.

June 6: 23.45, Carmel. Force III. Also felt at Spreckels, Chualar, Capitola, Gonzales, Hollister, Salinas, and Santa Cruz.

June 9: 4.15, Alvarado. Force III. Felt also at Boulder Creek and Capitola.

June 9: 23.20, Santa Cruz and Olympia. Force IV. Felt also at Ano Nuevo Island Light Station, Boulder Creek, Laurel, Gilroy, San Jose, and Pigeon Point Light Station.

June 10: 4.20, San Jose, Alvisa, and Agnew. Force IV. Also felt at Alvarado, Santa Cruz, Saratoga, Gilroy, Boulder Creek, Centerville, Irvington, Laurel, Livermore, Los Gatos, Campbell, Davenport, Half Moon Bay, and Laurel.

June 10: 5.14, Brookdale. Feeble.

June 11: 23.00, Santa Cruz. Feeble.

June 16: 6.54, Morgan Hill. Feeble.

June 23: 8.54, Devore and Glen Ranch. Moderate. Also felt at Alta Loma, Rialto, Fontana, and Upland. Pasadena reports first of 20 shocks at 7.50 near Haiwee, which was center of largest group. 8.54 shock centered near Cucamonga.

June 28: 2.09, Richmond and Berkeley. Feeble. Felt also at Southampton Shoal Light Station and San Francisco.

June 29: Felt at Haiwee. Recorded by Pasadena.

July 13: A. m. early. Huntington Beach. Slight.

July 15: 3.15, Holtville. Feeble.

July 15: 10.40, Guadalupe, Santa Margarita, and Nipomo. Feeble.

July 15: 16.00, Holtville. Feeble.

July 16: 1.00 and 1.30, Holtville. Feeble.

July 17: A. m. Bakersfield. Force IV.

July 17: 22.39, Sacramento. Some plaster fell.

July 20: 19.25, San Luis Obispo. Feeble.

July 21: 4.08, San Luis Obispo and Santa Maria region. Force IV at Halcyon, Nipomo, Templeton, Oceano, and Los Alamos. Also felt at Port San Luis, Santa Maria, Santa Margarita, Goviota, Cambria, San Luis Obispo Light Station, Tank Farm, San Luis Obispo, and Piedras Blancas Light Station. Pasadena reports a shock centering near west coast of Santa Barbara County at 12.08.

July 21: 22.55, Hollister. Feeble.

July 27: 18.55, Huntington Beach. Feeble.

July 28: About 11.00, Moss Landing. Feeble.

July 28: 15.11, San Diego. Feeble.

July 30: 21.23,* Brawley and Yuma. Feeble. Recorded at Tucson and Pasadena.

August 4: 17.10, Fortuna and Cape Mendocino Light Station. Feeble.

August 8: 17.00, Eureka. Feeble.

August 12: 1.32, Santa Clara. Feeble.

August 13: 18.55, 3 miles east of Torrance and near Lomita. Feeble.

August 14: 6.15. Same.

August 15: 19.40,* Anaheim and surrounding towns. Feeble. Recorded at Pasadena.

August 17: 5.30,* Brawley. Feeble. Pasadena reports epicenter on Saint Andreas fault near Niland.

August 18: 11.47, Palm Springs. Feeble.

August 19: 8.50, San Mateo and Burlingame. Force IV. Felt from San Bruno to Redwood City.

August 19: 11.47, Cabazon and Palm Springs. Feeble.

August 21: About 8.50, Redwood City and San Mateo. Slight. Berkeley reports epicenter "probably within 4 miles of San Mateo."

August 23: 10.01.35.* Epicenter off Cape Mendocino ($40^{\circ}.2$ N., $125^{\circ}.6$ W.). Force VI. (See map p. 16.) Recorded at all North American seismograph stations and some others. Felt over an area of 4,500 square miles on land exclusive of isolated disturbed regions in Oregon. It was strongest along the lower course of the Eel River south of Eureka. At Punta Gorda Light Station the mantle of the revolving lamp was broken and some mercury was spilled. At other points the damage was only superficial, if any. At Garberville water spilled from outdoor containers and trees were slightly shaken; at Hydesville small objects were overturned.

Force VI at Punta Gorda Light Station and Hydesville; V at Alton, Briceland, Fernbridge, Garberville, Humboldt Bay Fog Signal, Eureka, Loleta, Metropolitan, and Pepperwood; IV at Alderpoint, Bayside, Beatrice, Bridgeville, Ettersburg, Fortuna, Honeydew, Petrolia, Rohnerville, Scotia, Samoa, Skelly, Trinidad, Weott. Also felt at Arcata, Blocksburg, Burnt

Ranch, Branscomb, Bayview, Carlotta, Dyerville, Dos Rios, Falk, Fort Bragg, Freshwater, Fruitland, Ferndale, Farley, Hartsook, Holmes, Harris, Horbel, Miranda, Nashmead, Salyer, Table Bluff Light Station, Waddington, Willow Creek, and Tenia. Also felt at Klamath Falls, Beagle, Cultin, and Hugo in Oregon.

August 23: After 16. Alameda. Seismic?

August 23: About 21.00. Humboldt Bay and Willow Creek. Slight aftershock.

August 29: 16.05, Avalon. Feeble.

August 30: 16.49,* Huntington Beach. Feeble. Epicenter in San Pedro channel according to Pasadena.

September 3: 5.50,* Santa Barbara. Feeble. Epicenter near Santa Barbara according to Pasadena.

September 5: 3.25, Richmond. Force IV. Also felt at Berkeley, Oakland, Lake Merritt, Mills College, El Cerrito, San Anselmo, and Southampton Shoal Light Station. Berkeley reports epicenter within 4 miles of University of California campus, northwest and very shallow depth.

September 8: 6.40, Carlotta. Feeble.

September 9: 5.40.30.* Off coast near Eureka (40° .8 N., 125° .0 W.). Force VI. (See map p. 16.) Recorded at all North America stations and some others. It was felt over an area of 15,000 square miles, reaching maximum intensity along the lower course of the Eel River. In the wooded sections of Humboldt County limbs of trees fell and a roar was heard through the forests. Holmes and Blocksburg reported shock the heaviest since 1906. At Holmes vases, dishes, and small objects fell from shelves and milk was thrown out of pans. At Blocksburg pictures fell and bricks were reported dislodged. At Fernbridge a clock fell and slack wires became alternately loose and taut. Chimneys were damaged at Weott and a church bell rang at Ferndale.

Intensity distribution: VI at Blocksburg, Dyerville, Fernbridge, Ferndale, Holmes, and Weott; V at Alderpoint, Brice land, Bell Springs, Branscomb, Covelo, Chico, Dos Rios, Eel Rock, Eureka, Fort Seward, Fruitland, Fortuna, Garberville, Island Mountain, Kneeland, Miranda, Pepperwood, Punta Gorda Light Station, Scotia, Skelly, Upper Mattole, Whitlow, and Zenia; IV at Alton, Bayside, Benbow, Beatrice, Bridgeville, Cape Mendocino Light Station, Ettersburg, Edom, Fort Bragg, Forest Glen, Hartsook, Hydesville, Harris, Hayfork, Little River, Metropolitan, Mecca, Mina, Petrolia, Rohnerville, Samoa, Westport, and Waddington. Also felt at Arcata, Comptonville, Elsmore, Farley, Gerber, Humboldt Bay Fog Signal, Isaiah, Las Plumas, Nashmead, Orick, Point Cabrillo, Red Bluff, Seven Oaks, Table Bluff Light Station, Vina, and Willits.

The irregular distribution of data makes it difficult to construct a satisfactory isoseismal map. Aftershocks were reported from Kneeland and Fruitland at 6.16; from Eel Rock, Hayfork, and Scotia at 6.45; from Fortuna, Scotia, and Waddington at 16.30.

September 9: 20.36,* Indio and Palm Springs, Riverside County. Force IV. Felt also at Elsmore, Seven Oaks, Shaverswell, Edom, and Mecca. Recorded at Pasadena. Palm Springs reported another shock at 21.30. Pasadena reports epicenter at Township 1 S., Range 2-3 E.

September 10: 5.30, Chico. Feeble.

September 10: 6.35, Atascadero. Moderate.

September 19: 22.41, Cape Mendocino Light Station. Feeble.

September 20: 1.50, Kern River Power House No. 3 and Kernville. Moderate.

September 23: 0.25,* 5 miles southeast of Aberdeen. Force VI. Water buckets upset, concrete very slightly damaged. Also felt at Division Cr. Power Plant (Aberdeen), Big Pine, Haiwee Power House, and Cottonwood Power House (Lone Pine). Laws reported shock at 1.30. Big Pine reported aftershock at 2.25. Recorded at Pasadena. Pasadena reports epicenter in Owens Valley near Tinemaha.

September 24: Between 9.00 and 10.00. Ontario. Slight. Earthquake or blast?

September 25: 7.32, Katella Substation, 3 miles south of Anaheim. Four short shocks. Feeble.

September 30: 6.35, Atascadero. Moderate.

September 30: 7.46,* San Diego, Santa Ysabel, and Jamul. Press reports shock felt at El Centro. Pasadena reports epicenter near the head of Gulf of California.

October 1: 3.45, San Diego. Feeble. Recorded on magnetograph at Tucson. Epicenter in Lower California.



- October 1:* 8.34,* Dixieland. Feeble.
October 4: 12.30, Big Bear City. Feeble.
October 6: 17.15, Big Bear City. Moderate.
October 7: 15.30, Norco. Moderate.
October 7: 16.07,* Ontario, Riverside. Feeble. Pasadena reports epicenter at 34° N. latitude, 118° 35' W. longitude.
October 9: 5.30, Ruth. Feeble.
October 9: 11.50, Antelope Valley. Force V. Mining property and a house slightly damaged. Press reports shock at Salinas and Marina district of San Francisco. Berkeley estimated epicenter 90 miles away. Two epicenters probable.
October 9: 15.28,* Elsinore, Escondido, and Potrero. Feeble. Epicenter near head of Gulf of California, according to Pasadena.
October 11: 13.52, Imperial and Potrero. Feeble.
October 11: 14.30, Escondido. Feeble. "Almost every day brings a slight temblor" [press].
October 13: 4.25,* Jamesburg. Feeble. Recorded at Pasadena.
October 14: 1.50, Phelan. Feeble.
October 15: 12.00, Wilmington Tank Farm. Feeble.
October 16: Night of. Medicine Lake. "Heavy."
October 18: 11.58,* Jamesburg, Hollister, and Spreckles. Force IV. Also felt at Aptos, Carmel, Chualar, 3 miles east of Monterey, Moss Landing, Paraiso Springs, Salinas, Santa Cruz Light Station, Lenoya Pump. Recorded at Pasadena and Berkeley. Pasadena reports epicenter in San Benito County.
October 20: 10.56,* Chualar. Feeble. Recorded at Pasadena, Berkeley, and other stations. Pasadena reports epicenter in San Benito County.
October 20: 11.15, San Rafael. Feeble.
October 21: 8.55, Monterey. Feeble.
October 22: 4.15, Hartsook. Feeble.
October 23: 22.21, Kernville. Feeble.
October 25: 11.27, Fortuna. Feeble.
October 27: 8.37, Sargent. Feeble. Berkeley reports instrumental epicenter near Sargent.
November 1: 12.30, Bell. Feeble.
November 3: 8.05,* Los Angeles region. T. 4 S., R. 14 W., according to Pasadena. Force V or less at Hawthorne, 3 miles east of Torrance, and Compton. Very slight damage. Force IV at Redondo Beach, Maywood, and Southgate. Also felt generally at Los Angeles, Inglewood, Wilmington Tank Farm, Maywood, Huntington Park, and Bell. A picture dropped from the wall at Compton.
November 4: 8.27. Slight shock felt at Los Angeles (Watts District), Compton, Torrance, and 3 miles east of Torrance.
November 4: 21.43. Five miles southeast of Aberdeen. Moderate.
November 11: 3.05, Willets. Moderate.
November 15: 22.45, Bolinas and Suisan City. Feeble. Berkeley and near-by stations indicate epicenter not far from Tomales Bay.
November 22: 2.52.* Strongest at Calpella. Also felt at Comptche, Fort Bragg, Redwood Valley, and 1 mile north of Ukiah. Recorded at Ukiah.
November 22: 3.30, Upper Lake. Feeble.
November 25: 4.18.* Five miles southeast of Aberdeen. Moderate. Also felt at Big Creek (No. 1), Florence Lake, and Lemon Cove. Another shock southeast of Aberdeen at 10.45. Pasadena reports first shock northwest of Tinemaha. Recorded at Berkeley and Lick.
November 25: 11.09. Twelve miles northeast of Monterey. Feeble.
November 27: 6.14, Fortuna. Feeble.
November 27: 12.17, Big Creek (No. 1). Moderate.
November 28: 6.13,* Fernbridge and Samoa. Force IV. Felt also at Humboldt Bay Fog Signal, Table Bluff Light Station, Alton, Bayside, Beatrice, Ferndale, Crescent City, Fortuna, Shively, Waddington, and Eureka. Recorded at Pasadena, Ukiah, and San Francisco Bay stations.
December 3: 16.53.* Metz and Hollister. Moderate. Felt also at Spreckels, Pigeon Point Light Station, Santa Cruz Light Station. Feeble shock at Hollister at 21.30. Recorded at Pasadena. Berkeley reports instrumental epicenter some 10 miles south of Spreckels.
December 11: 1.61, Scotia. Slight.
December 14: 8.30, Portola, Spring Garden, Quincy, and Susanville. Slight.

- December 14:* 17.37,* Maricopa and Pattiway. Slight. Pasadena reports epicenter on San Andreas fault, southwestern Kern County.
- December 15:* 8.20, Portola. Slight. Also felt at Susanville and Quincy and 25 miles east of Susanville.
- December 17:* 12.06. Feeble. Felt at Agnew, Campbell, San Jose, and Aptos. Berkeley reports instrumental epicenter between Los Gatos and New Almaden. One observer reports shock at San Diego at noon on December 15.
- December 18:* 22. Point Reyes. Force V. Pictures fell, small objects overturned. Few awakened.
- December 23:* 22.15, Imperial. Feeble. Pasadena reports an epicenter northwest of La Jolla.

WASHINGTON AND OREGON

[120th meridian or Pacific standard time]

- January 20:* 23.10, Sultan, Wash. Slight.
- April 17:* 4.00, Twisp, Wash. Feeble.
- April 17:* 20.00, near Bellingham, Wash. ($48^{\circ} 45' N.$, $122^{\circ} 15' W.$). Force V. (See map.) Felt over an area of approximately 5,000 square miles. At

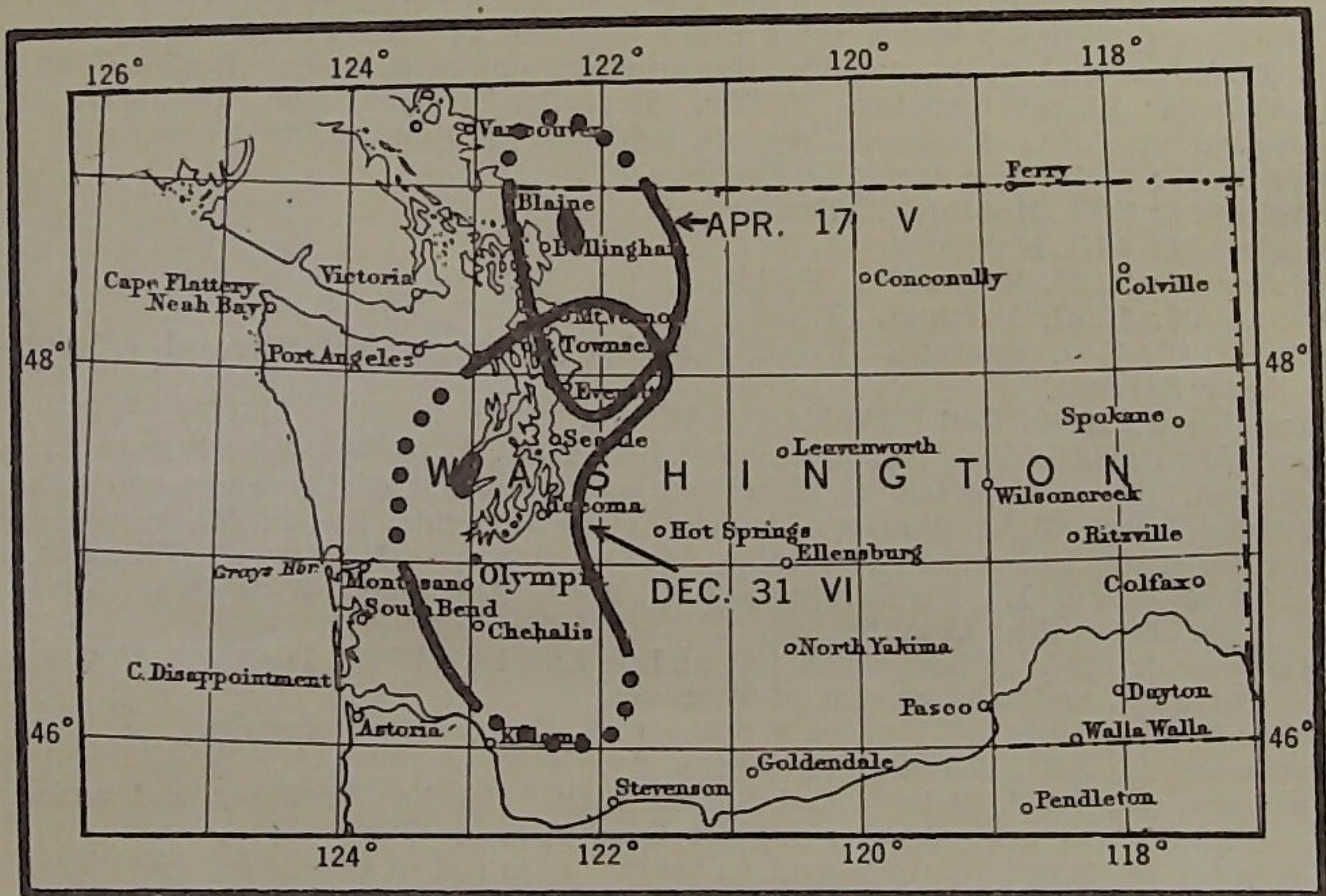


FIGURE 7.—Areas affected by Washington shocks of April 17 and December 31

Acme a few bricks fell from chimneys, at Lawrence wall paper cracked (aided by hot, dry weather), and at Saxon a severe twisting motion was reported. Force V at Acme, Van Zandt, Saxon, Lawrence, Bellingham, Clipper, Oso, and Tyman. Force IV at Burlington, Concrete, 7 miles east of Deming, Hamilton, Mount Vernon, Maple Falls, McMurray, Sedro Woolley, Sumas, Wickersham, and Victoria, British Columbia. Also felt 17 miles east of Arlington, at Alger, Bow, Bryant, Blanchard, Beach, Birdsvie, Bayview, Clearlake, Custer, Darrington, Everett, Edgecomb, Florence, Fortson, Ferndale, Glacier, Lake Whatcom, Lynden, Marietta, Marblemount, Robe, Snoqualmie, Snohomish, Sauk, Silverton, Nooksack, and Welcome, all in Washington.

May 28: 23.10, Sultan, Wash. Feeble.

June 11: 23.30. Same.

July 30: 7.33, Nanaimo, British Columbia. Sharp local shock.

August 16: 19.20. Force V at Talent, Oreg., where press reported lamp shaken from ceiling and one man thrown from chair. Also felt at Phoenix, Talbot, and Ashland.



- August 19:* 7.05, Sultan, Wash. Feeble.
- August 23:* 10.01. Earthquake off Eureka, Calif.; felt at Klamath Falls, Beagle, Curtin, and Hugo, Oreg.
- September 3:* 19.22, Central Point, Oreg. Feeble.
- September 18:* 12.20, Chelan Falls and Lakeside, Wash. Moderate. Also felt at Manson, Winesap, and Chelan.
- October 1:* 3.10 to 3.50 (ship's time), at sea. Steamer *Admiral Farragut* felt heavy tremors in lat. $42^{\circ} 56' N.$, long. $124^{\circ} 44' W.$ Sulphurous odors observed and phosphorescent light trailed in wake of propellers.
- December 8:* 6.25, Lakeside, Chelan, and Winesap, Wash. Slight.
- December 29:* 0.27, Sultan, Wash. Feeble.
- December 31:* 7.25,* near Seattle, Wash. ($47^{\circ} 30' N.$, $123^{\circ} 00' W.$). Force VI. (See map.) Felt over an area of approximately 10,000 square miles. Recorded at Seattle. At Lilliwaup, force VI, a concrete wall in a store was cracked and a wash basin was knocked off a nail. Force V at Belfair, Grapeview, Quilcene, Potlatch, and Snohomish, where articles were shaken from store shelves. Force IV at Bremerton, Fox Island, Happy Hollow, Kingston, La Grande, Nisqually, Olympia, Port Madison, Port Ludlow, Shelton, Tahuya, and Union. Also felt at Allyn, Bothell, Centralia, Chambers Prairie, Darrington, Dockton, Goldbar, Glenwood, Hoodspport, Lake Bay, Littlerock, Longview, Mukilteo, Olalla, Portage, Port Richard, Paulsbo, Rollingbay, Silverton, Sultan, Stanwood, Swans Trail, Seattle, and Tacoma.

ALASKA

[150th meridian time unless otherwise stated]

- January 2:* 19.30, Matanuska, Kasilof, and Seward. Moderate. Seward reports time only as "p. m."
- January 8:* 5.30, Nenana. No details.
- January 22:* 18.40, Matanuska. Severe. No details.
- January 27:* 4.30, Seward and adjacent region. Reported from Matanuska at 3.40 and 6.00 and from Cordova (Mile Seven) at 5.32.
- January 27:* 16.30, Kasilof (time uncertain; may be same as that at Seward at 4.30).
- January 31:* 11.15, Mile Seven (Cordova). Two distinct shocks.
- March 22:* 6.30, Matanuska. Five seconds.
- March 23:* 11.30, Matanuska. Fifteen seconds.
- March 30:* 1.15, Seward. Moderate. No serious damage.
- April 29:* 4.30, Lazy Bay, Kodiak Island. Moderate. East-west movement.
- May 12:* 21.03, 21.51, Whale Island (Fox Bay section).
- May 12:* 22.26, Matanuska.
- May 14:* 15.00, Matanuska.
- May 24:* 5.00, Whale Island (Fox Bay section). Light.
- May 27:* 20.15, Mile Seven (Cordova). Fifteen seconds.
- May 28:* 19.16,* Girdwood. Sharp and abrupt. Rattled windows and doors. Series of shocks over a period of 65 seconds at Matanuska. Recorded at several North American stations.
- May 30:* 0.00, Attu Island. Sharp shock, force VI. Felt by all. Walls creaked, clocks stopped, small objects overturned, dishes broken. Everyone awakened and frightened. Nearly all canned goods in store thrown to floor.
- June 1:* 16.00, Girdwood. Slight. Felt by several.
- June 11:* 12.40, Chitina and Valdez. Force V. No damage. Many awakened. Felt force IV at Cordova and Girdwood. Also felt at Hope and Circle.
- June 13:* 4.15, Chitina. Feeble. Shook bed.
- June 20:* 3.40, Homer. Feeble.
- June 21:* 5.45, Homer. Feeble.
- June 27:* 19.35, Talkeetna. Moderate. Doors and dishes rattled. Wall creaked. Small objects moved. Trees and bushes shaken.
- July 1:* 13.31, Girdwood. Feeble.
- July 6:* 12.04, Kanatah. Felt by all. Rattled windows, doors, and dishes. Trees and bushes shaken slightly.
- July 13:* 2.30, Girdwood. Felt by all. Windows, doors, and dishes rattled. Frame walls creaked. All awakened. Felt also at Hope and Moose Pass.
- July 13:* 17.45, Hope and Moose Pass. Feeble.
- July 16:* 2.15, Hope. Feeble.



- July 18:* 1.55, Girdwood. Feeble.
August 12: 23.36, Gustavus. Slight.
August 23: 1.50, Homer and Girdwood (2.10). Feeble.
September 11: 5.55, Whale Island. Thirty seconds duration.
September 14: 21.15, Kantishna. Slight.
October 12: 4.15, Homer. Moderate. Observer awakened.
October 17: 0.30, Valdez. Feeble.
October 17: 2.30, Girdwood and Wasilla. Moderate shock felt by all. Windows, doors rattled. Walls creaked. All awakened. Also felt at Homer.
October 17: P. m., Kennecott. Feeble.
October 20: 1.00, Girdwood. Feeble.
October 26: 0.10, Homer. Moderate, Twenty-seven seconds.
October 27: 3.55, Girdwood. Moderate.
November 4: 1.00, Nenana.
November 20: 0.30, Girdwood and Valdez. Moderate. Felt strongest at Girdwood, where windows and doors rattled, walls creaked, goods were shaken from shelves and all awakened. Preceded by roaring noise. Felt also at Anchorage and Matanuska.
November 20: 1.08, Girdwood and Homer. Moderate at Girdwood, where all were awakened by a heavy shake accompanied by a peculiar roll and twist. Felt slightly at Anchorage (1.10) and at Matanuska (1.20).
November 21: 4.28, Girdwood. Moderate. Felt by all. Windows rattled. All awakened.
November 21: 14.14, Girdwood. Slight. Felt by few. Windows rattled.
November 25: 9.55, Homer. Slight. Seven seconds.
November 25: 21.30, Whale Island. Light.
November 27: 8.20, Fairbanks.
November 29: 1.26, Girdwood. Slight. Felt by few.
December 3: 1.18, McCarthy. Slight. Felt by many.
December 5: 3.49, Girdwood. Feeble. Felt by few.
December 6: 11.20, Dutch Harbor. Sharp shock.
December 17: 3.30, Homer. Feeble.
December 23: 17.47, Whale Island. Moderate. Thirty seconds. Also felt at Valdez, Ellamar, Girdwood, Homer, Kanatak, and Matanuska. Windows and doors rattled, walls creaked, and hanging objects swung.

HAWAIIAN ISLANDS

[157½ meridian time]

NOTE.—In the case of these islands with their many earthquakes of volcanic origin only the more severe ones are listed. Reports of the Volcano Research Laboratory under the jurisdiction of the United States Geological Survey and the Hawaiian Volcano Research Association give all details.

- January 29:* 23.38,* Waiohinu, Hawaii. Rocking motion. Felt by many. Recorded at Honolulu.
June 11: 17.53, Hilo. Sharp shock. No damage. Recorded at Honolulu.

PHILIPPINE ISLANDS

[120th meridian (East) time]

Only the more important shocks are included in this report. (See reports of the Weather Bureau, Manila Central Observatory, for complete data.)

- March 19:* 4.13.* Slight shock felt on Island of Mindanao. (See instrumental reports.)
March 19: 14.24.* Severe shock felt at northern end of Luzon Island. Church towers and old stone buildings collapsed. Some damage to government structures. Two women injured by falling brick at Bacara. Felt strongly in central part of island and at Manila. Felt distinctly in Hong Kong. (See instrumental reports.)
March 22: 23.23. Slight shock felt in Manila. No damage.
July 13: 0.45*. Several slight shocks felt on the Island of Masbate, Central Philippines. (See instrumental reports.)
September 22: 2.26.* Felt in Manila. No damage. (See instrumental reports.)

PUERTO RICO

[60th meridian time]



February 22: 4.10. Feeble shock felt by several in San German.

April 4: 4.51.* Santurce and Bayamon. Force V. First a long swaying motion, then a short trembling. It was generally observed at San Juan and Mayaguez. Recorded at San Juan. A weaker shock recorded at 18.44.

September 19: 23.50.* Moderate shock at Mayaguez felt as gentle rhythmic motion in pronounced north-south direction. Felt in Santurce with less intensity. Recorded at San Juan. Four shocks recorded on September 19 and 20.

September 25: 14.35. Moderate shock at Mayaguez felt by most of population. Bumping and slight swaying.

November 5: 4.43. Slight shock felt at Salinas and Guayama.

PANAMA CANAL ZONE

[75th meridian time]

April 11: 19.59.* Moderate shock felt at Las Palmas, Panama. No severe damage. Recorded at Balboa.

May 25: 21.19.* Felt at La Palma and Chaldia.

June 16: 13.22.* Felt by a few at Balboa Heights.

June 27: 5.04.* Felt by residents of Canal Zone and Republic of Panama.

October 11: 22.58.* Offshore shock felt by a few.

INSTRUMENTAL REPORTS

It has been decided for reasons of economy to omit publication of instrumental data in this report. Anyone interested in them may find substantially the same material in the monthly instrumental seismological reports of the bureau, copies of which will be furnished upon request to those interested in seismological work.

In the following list of provisional epicenters attempts have been made in some instances to improve on the values given in the monthly reports, especially in cases of North American earthquakes. The epicenter locations are based on the readings of seismograms sent direct to this office for interpretation, and also on a limited number of instrumental reports received from stations exchanging reports with this bureau. In the former group are Bozeman, Mont. (Montana State College); Chicago, Ill. (University of Chicago and U. S. Weather Bureau); Charlottesville, Va. (University of Virginia); Columbia, S. C. (University of South Carolina); Honolulu, Hawaii (University of Hawaii); Pittsburgh, Pa. (University of Pittsburgh); San Juan, P. R.; Sitka, Alaska; Tucson, Ariz.; Seattle, Wash. (University of Washington); and Ukiah, Calif. (International Latitude Observatory).

SUMMARY OF INSTRUMENTAL RESULTS

1931	Greenwich civil time of origin	Region	Provisional epi- center	
			Lat.	Long.
	<i>h. m.</i>			
Jan. 2.....	9 49.0	Off west coast of Mexico.....	19.2 N., 107.0 W.	
Jan. 15.....	1 50.7	Oaxaca, Mexico (destructive).....	16.2 N., 96.0 W.	
Jan. 16.....	19 19.8	Near coast of Oaxaca, Mexico.....	15.9 N., 96.8 W.	
Jan. 17.....	2 50.4	Gulf of California.....	26 N., 111 W.	
Do.....	5 35.3	Near coast of Oaxaca, Mexico.....	15 N., 96 W.	
Jan. 23.....	5 52.5	Near coast of Guerrero, Mexico.....	17 N., 99 W.	
Jan. 25.....	12 34.5	Off west coast of Mexico.....	15 N., 103.5 W.	
Jan. 27.....	20 09.1	Northern India.....	26 N., 97 E.	
Jan. 28.....	21 24.3	Pacific Ocean near Guam.....	12 N., 146 E.	
Jan. 29.....	17 09.8	Pacific Ocean off Mexico.....	13 N., 96 W.	
Feb. 2.....	22 46.8	New Zealand.....	39.3 S., 177.0 E.	
Feb. 5.....	4 48	New Mexico (felt).....	35.1 N., 106.8 W.	
Feb. 10.....	6 34.6	Near south coast of Sumatra.....	6 S., 102 E.	
Feb. 12.....	6 43.6	do.....	5 S., 102 E.	
Feb. 13.....	1 27.1	New Zealand.....	39.8 S., 177.8 E.	
Feb. 20.....	5 33.7	Mongolia.....		
Feb. 27.....	9 37.8	Philippine Islands.....	2 N., 126 E.	
Mar. 2.....	2 18.1	Pacific Ocean east of Australia.....	24 S., 167 E.	
Mar. 7.....	0 41.4	Off west coast of Costa Rica.....	9 N., 86 W.	
Mar. 8.....	1 50.2	Western Bulgaria.....	42 N., 23 E.	
Mar. 9.....	3 48.7	Yezo Island, Japan.....	41 N., 142 E.	
Mar. 10.....	3 32	Off northern California coast (felt).....	41 N., 125 W.	
Mar. 11.....	12 26.2	Pacific Ocean near Marianne Islands.....	19 N., 145 E.	
Mar. 18.....	8 02.3	Near coast of Chile.....	35 S., 72.5 W.	
Do.....	20 13.5	Philippine Islands.....	6 N., 127 E.	
Mar. 19.....	6 24.8	Philippine Islands (felt).....	18.3 N., 120.2 E.	
Mar. 28.....	12 38.5	Banda Sea.....	6 S., 130 E.	
Mar. 29.....	17 25.1	Aleutian Islands.....	51 N., 170 W.	
Mar. 31.....	16 02.2	Nicaragua (Managua destroyed).....	12.3 N., 86.6 W.	
Apr. 3.....	1 56.2	Pacific Ocean off Peru.....	10 S., 79 W.	
Apr. 6.....	6 49.4	Pacific Ocean east of New Guinea.....	8 S., 154 E.	
Apr. 15.....	16 58.7	North Atlantic Ocean.....	48 N., 29 W.	
Apr. 17.....	12 38	Arizona (felt).....	34 N., 110.5 W.	
Apr. 19.....	2 00.0	Off west coast of Mexico.....	19 N., 109 W.	
Apr. 20.....	19 56	New York State (Lake George).....	43.4 N., 73.7 W.	
Apr. 23.....	23 37	Southern California (felt).....	35.4 N., 117.6 W.	
Apr. 24.....	17 21.9	Solomon Islands.....	5 S., 155 E.	
Do.....	18 28	Southern California (felt).....	33.8 N., 118.5 W.	
Apr. 27.....	16 50.8	Transcaucasia.....	40 N., 46 E.	
May 1.....	22 36.6	Venezuela, South America.....	8 N., 70 W.	
May 9.....	10 34.6	Off west coast of Mexico.....	22.3 N., 109 W.	

Summary of instrumental results—Continued



1931	Greenwich civil time o forigin	Region	Provisional epi- center	
			Lat.	Long.
	<i>h. m.</i>			
May 10.....	19 24.8	Pacific Ocean near Easter Island.....	28.5 S.,	115 W.
May 12.....	1 37.3	Pacific Ocean off Kamchatka.....	52 N.,	158 E.
May 16.....	20 47.5	Near coast of Oaxaca, Mexico.....	15.9 N.,	96.8 W.
May 20.....	2 22.8	Atlantic Ocean off Portugal.....	39 N.,	15 W.
Do.....	21 54.0	Near coast of Chile.....	28.6 S.,	70.7 W.
May 27.....	6 34.6	Pacific Ocean near Easter Island.....	24 S.,	114 W.
Do.....	10 20.9	Near west coast of Mexico.....	18 N.,	102 W.
May 29.....	5 15.8	Alaska.....	58 N.,	158 W.
June 9.....	13 52.3	Pacific Ocean near Samoan Islands.....	17 S.,	172 W.
June 21.....	12 23.1	Off west coast of Mexico.....	17.8 N.,	107 W.
July 7.....	3 53.9	Pacific Ocean off Guatemala.....	13 N.,	95 W.
July 9.....	12 00.3	North Atlantic Ocean.....	43 N.,	29 W.
July 11.....	5 56.2	Near coast of Peru.....	8 S.,	78 W.
July 12.....	16 45.4	Philippine Islands.....	12.4 N.,	123.8 E.
July 15.....	16 27.0	Pacific Ocean northeast of Japan.....	53 N.,	153 E.
July 17.....	9 13.8	Near coast of Oaxaca, Mexico.....	15.5 N.,	97 W.
July 18.....	5 27.1	Northern Chile, South America.....	21 S.,	69 W.
Do.....	11 24.0	Pacific Ocean northeast of Japan.....	54 N.,	164 E.
July 21.....	3 36.4	Pacific Ocean south of New Hebrides Islands.....	19 S.,	170 E.
July 23.....	14 20.6	Pacific Ocean north of Solomon Islands.....	1 S.,	155 E.
July 27.....	7 16.2	Northern Honduras.....	16 N.,	85.5 W.
July 28.....	8 40	Arizona (felt).....	35.0 N.,	112.0 W.
Aug. 7.....	2 11.5	Pacific Ocean northeast of Papua.....	1.5 S.,	145 E.
Aug. 10.....	21 18.2	Mongolia.....	46 N.,	89.5 E.
Aug. 13.....	22 09.3	South Pacific northeast of New Zealand.....	28 S.,	178 W.
Aug. 16.....	8 06.3	Atlantic Ocean southeast of Bermuda.....	29 N.,	60 W.
Do.....	11 40.2	West Texas (destructive).....	29.9 N.,	104.2 W.
Aug. 18.....	14 20.7	Mongolia.....	47.5 N.,	88.5 E.
Aug. 23.....	18 01.4	California.....	40.2 N.,	125.6 W.
Aug. 24.....	21 35.2	Eastern Persia.....	27 N.,	60 E.
Aug. 27.....	15 27.2	Southern Afghanistan.....	29.5 N.,	67.5 E.
Sept. 6.....	8 01.9	North Atlantic Ocean.....	55 N.,	31 W.
Sept. 9.....	13 40.3	California.....	41 N.,	126 W.
Do.....	20 38.5	Pacific Ocean near Guam.....	15 N.,	144 E.
Sept. 10.....	4 35.9	California.....	34.0 N.,	116.7 W.
Sept. 12.....	15 41.3	Near Pacific coast of Colombia, South America.....	5 N.,	78 W.
Sept. 20.....	23 04.9	Ohio (felt).....	40.4 N.,	84.2 W.
Sept. 21.....	2 19.8	Japan.....	36 N.,	140 E.
Sept. 25.....	6 00.0	Near Sumatra.....	1 S.,	107 E.
Sept. 26.....	19 50.6	Pacific Ocean off Guatemala.....	13.4 N.,	92 W.
Sept. 30.....	15 46	Gulf of California (felt).....	32 N.,	115 W.
Oct. 1.....	11 45.4	Lower California (felt).....	29 N.,	114 W.
Do.....	16 33	California (felt).....	32.8 N.,	115.8 W.
Oct. 3.....	19 13.1	Coral Sea.....	11 S.,	161 E.
Do.....	22 47.6	do.....	11 S.,	161 E.
Oct. 5.....	22 31.2	Turkestan.....	44 N.,	75 E.
Oct. 9.....	23 40	Gulf of California (felt).....	32 N.,	115 W.
Oct. 10.....	0 19.8	Coral Sea.....	11 S.,	161 E.
Oct. 12.....	3 57.5	Pacific Ocean off Panama.....	6.3 N.,	82 W.
Oct. 26.....	4 25.1	Off west coast of Mexico.....	23 N.,	109 W.
Nov. 2.....	0 32.2	Oaxaca, Mexico.....	15.5 N.,	97 W.
Do.....	10 02.9	Japan.....	27 N.,	140 E.
Do.....	17 02.8	New Guinea.....	8 S.,	146 E.
Nov. 3.....	15 50	Texas (felt).....	29.9 N.,	104.2 W.
Nov. 20.....	14 16.5	Pacific Ocean near Marshall Islands.....	10 N.,	162 E.
Nov. 22.....	10 52	Northern California (felt).....	39.3 N.,	123.5 W.
Nov. 28.....	14 13	do.....	41 N.,	125 W.
Dec. 17.....	3 40	Mississippi (felt).....	34.1 N.,	89.8 W.

MISCELLANEOUS SEISMOLOGICAL ACTIVITY

GEODETIC WORK

In October, 1931, work was started on the complete releveled of four small circuits of first-order leveling in the Los Angeles area. The instructions called for a beginning at Ontario and the continuation of the work through Los Angeles, Wilmington, Buena Park, Ontario, Riverside, Santa Ana, and Buena Park to Florence. Then, beginning again at Los Angeles, the work was to be continued

through Glendale, Chatsworth, and Santa Monica to Wilmington. Connections were to be made to tide stations at San Pedro and at Newport Bay. The work was still in progress at the close of the year.

HYDROGRAPHIC WORK

Vessels of the Coast and Geodetic Survey are directed to make reports of visible or felt effects of earthquakes. No shocks were reported.

TIDAL OBSERVATIONS

Tidal records from the numerous gages on the Atlantic and Pacific coasts were examined. At Santa Barbara a record was obtained of the seismic sea wave originating in the Coral Sea on October 3. The first waves on the marigram appeared at 9^h on October 4. It was recorded also at Hilo, Hawaii, at 3^h 33^m on the gage operated by the Hawaiian Volcano Observatory.

PUBLICATION NOTICES

To make immediately available the results of its various activities to those interested, the Coast and Geodetic Survey maintains mailing lists of persons and firms desiring to receive notice of the issuance of charts, Coast Pilots, maps, and other publications.

Should you desire to receive such notices, you may use the form given below, checking the lists covering the subjects in which you are interested.

(Date)-----

DIRECTOR, U. S. COAST AND GEODETIC SURVEY,
Washington, D. C.

DEAR SIR: I desire that my name be placed on the mailing lists indicated by check below, to receive notification of the issuance of publications referring to the subjects indicated:

- ☐ 109. Astronomic work.
- ☐ 109-A. Base lines.
- ☐ 109-B. Coast Pilots.
- ☐ 109-C. Currents.
- ☐ 109-D. Geodesy.
- ☐ 109-E. Gravity.
- ☐ 109-F. Hydrography.
- ☐ 109-G. Leveling.
- ☐ 109-H. Nautical Charts.
- ☐ 109-I. Oceanography.
- ☐ 109-J. Traverse.
- ☐ 109-K. Seismology.
- ☐ 109-L. Terrestrial magnetism.
- ☐ 109-M. Tides.
- ☐ 109-N. Topography.
- ☐ 109-O. Triangulation.
- ☐ 109-P. Cartography.
- ☐ 109-R. Airway maps.

(Name)-----

(Address)-----

A catalogue of the publications issued by all bureaus of the Department of Commerce may be had upon application to the Chief, Division of Publications, Department of Commerce, Washington, D. C. It also contains a list of libraries located in various cities throughout the United States, designated by Congress as public depositories, where all publications printed by the Government for public distribution may be consulted.