

U. S. DEPARTMENT OF COMMERCE

DANIEL C. ROPER, Secretary

COAST AND GEODETIC SURVEY

R. S. PATTON, Director

Special Publication No. 191

DESTRUCTIVE  
AND NEAR-DESTRUCTIVE EARTHQUAKES  
IN CALIFORNIA AND WESTERN NEVADA  
1769-1933

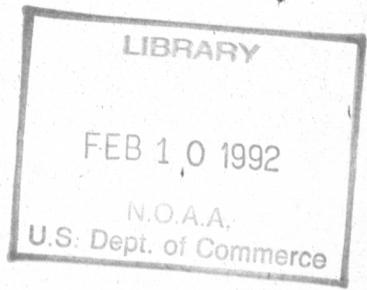
By

HARRY O. WOOD

MAXWELL W. ALLEN

N. H. HECK

Chief, Division of Terrestrial Magnetism  
and Seismology



UNITED STATES  
GOVERNMENT PRINTING OFFICE  
WASHINGTON : 1934

QB  
275  
U35  
no. 191  
1934

# National Oceanic and Atmospheric Administration

## ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages

Faded or light ink

Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library and the Climate Database Modernization Program, National Climate Data Center (NCDC). To view the original document, please contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or [www.reference@nodc.noaa.gov](mailto:www.reference@nodc.noaa.gov).

LASON

Imaging Contractor

12200 Kiln Court

Beltsville, MD 20704-1387

January 1, 2006

## CONTENTS

---

	<b>Page</b>
<b>Introduction</b> -----	<b>1</b>
<b>Dates of principal earthquakes</b> -----	<b>2</b>
<b>Description of earthquakes from 1769 to 1933</b> -----	<b>3</b>

# DESTRUCTIVE AND NEAR-DESTRUCTIVE EARTHQUAKES IN CALIFORNIA AND WESTERN NEVADA, 1769-1933

---

## INTRODUCTION

This list of destructive and near-destructive earthquakes of California and western Nevada is intended for the use of those who have to deal in a practical way with earthquake problems. The convenient arrangement and concise description make readily accessible the information needed by these persons, but this list must not be considered as a substitute for the forthcoming catalog prepared under the auspices of the Seismological Society of America. The catalog which is to include the republishing of items 1 and 2 in references below and the publication of item 8, will give complete information, insofar as it is available, for many earthquakes omitted in the present list and more detail for those which are included. It will cover the period through 1927, information for later years being given in the annual publication, United States Earthquakes.

The Coast and Geodetic Survey has issued Special Publication 149, Earthquakes of the United States Exclusive of the Pacific Region. The latter region was omitted because it could be dealt with in the same manner as for the rest of the United States only through a comprehensive catalog which, as has been stated, was either available or contemplated. In 1932, however, the American Red Cross and others expressed the need for an authentic list of the stronger earthquakes. This was prepared in mimeographed form, but neither the first, second, or third drafts, though each one was an improvement on the preceding, was entirely satisfactory. These drafts were largely the work of the present authors.

The present list is then a compilation of available information of all degrees of completeness and authenticity. All the authors have been concerned in putting it into its present form. Special mention should be made of the work of Mr. Allen in clearing up discrepancies in earlier descriptions by investigating original sources. Mr. Wood has appraised the earthquakes and has had an outstanding part in deciding which should be included in each category of intensity and which should be omitted from the present list. Important cooperation has been given by Prof. Perry Byerly, of the University of California, and Prof. S. D. Townley, of Stanford University.

Of the authors, Harry O. Wood is research associate of the Carnegie Institution of Washington and acting for the advisory committee in seismology of that institution is in charge of its activities at the Seismological Research Laboratory at Pasadena, Calif. Max-

well W. Allen, of Sanger, Calif., has long been interested in records of California earthquakes and has written on the subject. Both have volunteered their services to the Government for the purpose of preparing this publication under the provisions of the National Industrial Recovery Act.

The principal sources of information are as follows:

1. Smithsonian Miscellaneous Collections, 1807. Catalog of Earthquakes on the Pacific Coast, 1769-1896. Edward S. Holden.
2. Smithsonian Miscellaneous Collections, 1721. Catalog of Earthquakes on the Pacific Coast, 1897-1906. Alexander S. McAdie.
3. Monthly Weather Reports. U. S. Weather Bureau.
4. Articles in Bulletins of the Seismological Society of America. Besides many reports of individual earthquakes, there are a number of reviews of California earthquakes. A list of such articles follows:  
 Volume VI, nos. 2 and 3, 1916. A Synthetic Study of California Earthquakes. Harry O. Wood.  
 Volume XI, no. 1, 1921. Early Record of Earthquakes in Southern California. Ford A. Carpenter.  
 Volume XV, no. 2, 1925. Some Remarks Concerning Pacific Coast Earthquakes. Maxwell W. Allen.  
 Volumes VI-XIII, California Earthquakes for Each Year from 1915 to 1921. Andrew H. Palmer.  
 Seismological Notes.
5. Georgetown University Reports.
6. United States Earthquakes, Coast and Geodetic Survey, for years 1928-32, inclusive. Also quarterly Seismological Reports, July 1924-December 1927.
7. Unpublished lists of Harry Fielding Reid.
8. Unpublished list of Catalog of California Earthquakes, 1907-27, of the Seismological Society of America (insofar as available for comparison).

No map accompanies this publication, first, because the information is not complete, since it is confined to earthquakes of a certain degree of intensity; second, because there is considerable difficulty in showing both distribution and intensity on a map; and third, because it is impossible to locate many of the earlier earthquakes sufficiently well to plot them on a map of reasonably large scale.

#### DATES OF PRINCIPAL EARTHQUAKES

The three outstanding earthquakes in the history of this region are marked \*\*\*. All other great shocks are marked \*\*. Other very strong shocks are marked \*. The same designation is used in the Description of Earthquakes from 1769 to 1933, which follows. In general, the lower limit of shock listed is fixed by intensity VII Rossi-Forel scale.

***1857, January 8-9	*1812, December 8	*1898, April 14
***1872, March 26	*1852, November 9	*1899, December 25
***1906, April 18	*1852, November 26-30	*1901, March 2
**1769, July 28	*1853, October 23	*1903, January 23
**1790	*1858, November 26	*1909, October 28
**1812, December 21	*1860, March 15	*1915, June 22
**1836, June 9-10	*1864, March 5	*1915, November 20
**1838, June	*1865, October 1	*1918, April 21
**1868, October 21	*1865, October 8	*1922, March 10
**1873, November 22	*1868, September 4	*1923, January 22
**1892, February 23	*1871, March 2	*1925, June 29
**1915, October 2	*1885, April 11	*1927, November 4
**1922, January 31	*1890, February 9	*1932, June 6
**1932, December 20	*1892, April 19-21	*1933, March 10
*1800, October 18		

(43)  
 nothing more  
 1937

## DESCRIPTION OF EARTHQUAKES FROM 1769 TO 1933

- 1      **\*\*1769 July 28.** Region of Los Angeles. Violent shocks were experienced by Portola expedition about present site of Olive on Santa Ana River; many aftershocks felt by expedition for several days as it traveled northwestward. Wood and Allen interpret record as indicating major shock with many strong aftershocks, which continued into 1770.
- 2      **1775 December 26.** San Carlos Pass. First record of strong shock in San Jacinto fault region; felt by Anza expedition while traversing San Carlos Pass; destructive character not proved, but possible, since no structures existed to exhibit such effects.
- 3      **\*\*1790.** Region of Owens Valley. X. Indian tradition indicates a shock about this time comparable to that of 1872. Wood, in view of unreliability of detail, especially dates, in Indian traditions, expresses doubt of such occurrence at this particular time, although great shocks other than that of 1872 undoubtedly have occurred in the region.
- Y      **\*1800 October 11, \*18, 31.** San Juan Bautista. Indefinite record of severe shocks from 11th to 31st, sometimes 6 a day, the most severe on the 18th. The Mission Fathers spent the night out of doors. Cracks in ground and in adobe walls of buildings; cracks along banks of Pajaro River.
- 5      **1803 May 25. VIII.** San Diego. Mission church slightly damaged.
- 6      **1806 March 24. VIII.** Santa Barbara. Church walls cracked.
- 7      **1808 June 21-July 17.** San Francisco. 18 shocks in all; adobe walls seriously damaged.
- 8      **\*1812 December 8, about 8 a. m.** San Juan Capistrano. IX. Church destroyed with loss of 40 lives. Church and other buildings damaged at San Gabriel, with throwing down of altar and statues. At least a severe local shock, certainly; possibly a major earthquake.
- 9      **\*\*1812 December 21, about 10:15 a. m.** Purisima (near present site of Lompoc); IX or X; Santa Ynez, Santa Barbara, Ventura, and San Fernando. At all of these places churches and other buildings were damaged. Severe at San Gabriel. Small seismic sea wave, or so-called "tidal wave", at Santa Barbara and near Refugio. A very strong shock, probably a major earthquake. Many aftershocks reported felt into the spring of the following year. It is these which Allen believes may have been referred to erroneously by Trask as taking place in the spring of 1812.
- 10      **1822 San Jose.** Hall, in History of San Jose, states that a shock cracked walls in San Jose in 1822. No other reference known.
- 11      **1830. San Luis Obispo. VIII.** Church damaged.
- 12      **1836 April 25.** Santa Clara, Santa Cruz, and Monterey Counties. Apparently widely felt but few details known; possibly, but not known to have, attained destructive intensity.
- 13      **\*\*1836 June 9 and 10.** San Francisco Bay region. Comparable with 1868 shock, and in same region, with fissures in earth and continued aftershocks, according to Bancroft.
- 14      **\*\*1838, late in June.** San Francisco, San Jose, Santa Clara, and Monterey. VIII at least. Strong in San Francisco Harbor. Adobe

walls cracked. Destructive at present site of Redwood City. Landslide at San Leandro. Aftershocks into July.

15 1839. Holden mentions shock of intensity IX at Redwood City which cracked earth and created immense fissure in Mission San Jose region. After investigation Allen concludes that the shock of June 1838 is referred to.

16 1840 January 16-18. Santa Cruz; IX? Church tower overthrown; tidal wave.

17 1841 July 3. Monterey; estimated VII. Probably severe shock in Monterey Bay. One hundred and twenty aftershocks in 2 months.

18 1843 June 23. Extreme southern California and into Mexico; VII. Few details known.

19 1851 May 15. San Francisco; VII. Severe shock lasting half a minute; felt by shipping in harbor; threw merchandise to floors.

20 1851 November 26. Coast of California from 37° to 40° (Santa Cruz to Mendocino County); 11 shocks; possibly, but not known to have, attained destructive intensity. Possibly an inaccurate reference to the shocks of 1852, November 26.

21 \*1852 November 9. Fort Yuma; VIII, IX, or X. Violent shocks threw down a portion of Chimney Peak and opened fissures and cracks in the clay desert bordering the Colorado. Shocks almost daily for many months.

22 1852 November 22-24. San Francisco Peninsula, VIII. Shock, severe 8 miles to southeast of San Francisco. Apparently considerable fissuring from Lake Merced to the sea.

23 \*1852 November 26-30. Southern California. Eleven strong shocks at San Simeon, Los Angeles, and San Gabriel on the 26th. From 27th to 30th continued shocks disturbed an area over 300 miles square from San Luis Obispo to Colorado River and San Diego; fissures 30 miles long in Lockwood Valley; shock on 29th probably major shock, from description at San Diego at some distance from probable origin. Many aftershocks into December.

24 1853 February 1. San Simeon; VIII. Violent shocks damaged houses.

25 \*1853 October 23. Humboldt Bay; VIII. Three heavy shocks; reported that houses at Eureka rolled like ships at sea, and wharf sank 4 feet.

26 1853 December. Fort Yuma. Many shocks. May have been of destructive force, but this is not known.

27 1855 January 24. Downieville, Sierra County. Portion of Downieville Butte fell; buildings rocked. Felt severely in region from Gibsonville to Georgetown and Nashville. Severe at Eureka and Orleans Flat, which probably were the Sierra mining camps of those names instead of Humboldt County places, as Holden assumed. This conclusion by Allen after investigating all available facts is concurred in by Wood.

28 1855 July 10. Los Angeles County; VIII or higher. Four shocks in 12 seconds; two sea waves rolled in at Point San Juan immediately after second shock, according to Trask; bells in mission church at San Gabriel fell; Harris Newmark, in *Sixty Years in Southern California*, says almost every structure in Los Angeles was damaged, and some buildings left with large cracks in walls.

- 29 1856 February 15. San Francisco; VIII, lasted 8 seconds. VII at Oakland, VI at San Jose, and strong at Monterey. Water of San Francisco Bay disturbed.
- 30 1856 September 20. Severe at Santa Ysabel, San Diego County; caused some alarm at Los Angeles. Ceilings shaken down, adobe walls cracked, and cattle stampeded at Santa Isabel.
- 31 \*\*\*1857 January 8 and 9. Origin probably near Fort Tejon, northwest corner of Los Angeles County, but rupture extended at least 100 miles to the northwest and to the southeast of that point. Near Tejon a corral was converted, by horizontal dislocation of ground, into an open S-shaped figure; at the fort, buildings and large trees were thrown down. At Ventura the roof of the mission church collapsed. Artesian wells in the Santa Clara Valley (near Ventura) ceased to flow, and in other places wells increased their flow. The area of strong shaking was very considerable and that over which the shock was perceptible must have extended widely, including a large part of northwestern Mexico; Wood and Allen consider this as potentially the most destructive shock in the coast range province since the advent of white men.
- 32 \*1858 November 26. IX. Very severe at San Jose where every brick, adobe, or concrete building was damaged and a new brick building of only one story, and very firmly built, was cracked through the center. Less severe, but caused some damage at San Francisco. Motion was undulatory, long and suggestive of great power, rather than short and sharp.
- 33 1859 October 5. San Francisco; VII by Holden's estimate. Possibly attained destructive intensity, but definite details lacking.
- 34 \*1860 March 15. Nevada and a considerable portion of northern and central California. V-VI at Sacramento; VII at Carson City, Nev.; felt as far northwest as Yreka, Calif., and east into Utah. Allen suggests possibility of origin similar to that of Pleasant Valley, Nev., shocks of 1915; if so, this may have been a major earthquake.
- 35 1860 March 26. Holden says VI and severe at Los Angeles and in southern California; may not have been of destructive intensity.
- 36 1861 July 3. Contra Costa and Alameda Counties. Severe (IX?) in Amador Valley, near present site of Livermore; adobe houses damaged, men in fields thrown down; in San Ramon Valley a fissure opened and a new spring of water appeared; strong, but no damage done at San Francisco.
- 37 1862 May 27. San Diego County; severe, with many aftershocks to June 5; strong at San Diego, Temecula, and Anaheim.
- 38 1863 December 19. San Francisco; Holden estimates VIII (?) VII at San Jose. Definite record of destruction lacking.
- 39 \*1864 March 5. A widely felt shock which Allen after considerable study places as probably centering in the region between San Francisco and Gilroy. Accounts from San Francisco indicate considerable motion of ground; also it is reported that swells rolled in from the bay. Little damage at Santa Clara, though church steeples swayed. Strong at Stockton; very noticeable at Santa Rosa and Petaluma, and of intensity IV as far away as Visalia. As on November 26, 1858, motion was long, undulatory, and powerful, rather than short and quick.

- Y- 1865 March 7 and 8. East Central Sonoma County; VIII. In Bennett Valley most chimneys fell and stone walls tumbled; a man was thrown from his feet. At Santa Rosa a well-built chimney fell. Heavy at Napa. Two shocks, about equal.
- Y1 1865 May 24. Confused record; Holden said smart shock at San Francisco, San Juan and Santa Cruz; Tennant said light at San Francisco. Holden reported from Bancroft manuscript that it was remarkably strong in southern California. This possibly is the record of 2 distinct shocks, 1 or both of which may have possessed destructive energy.
- Y- \*1865 October 1. Fort Humboldt and Eureka; IX. At Fort Humboldt all buildings were badly damaged; fissures opened in parade grounds. All brick houses in Eureka were damaged, and most of the brick chimneys tumbled down. Holden's entry of a Humboldt shock on October 8 apparently refers to this shock with an error of 1 week in date.
- Y3 \*1865 October 8. In Santa Cruz Mountains between San Jose and Santa Cruz; IX at least. At San Francisco the greatest damage was to the less strongly constructed buildings on made land; structures on solid ground, or well constructed, suffered little damage; water mains and gas pipes broke in several places because of shifting ground, and a crevice opened in one street. At San Jose the walls of the jail and of a church fell. On the Santa Cruz Gap Road chimneys fell; at Mountain Charley's the earth opened and boulders obstructed the road. At New Almaden a large brick storehouse and several houses were destroyed; the earth opened and closed, throwing up clouds of dust. Wells and streams were affected. This was less widely felt than the less destructive shock of March 5, 1864. See Holden.
- YY 1865 December 15. Dry Creek, Mendocino County; VII. Details lacking; this may not have been destructive.
- Y5 1866 March 26. Allen believes, from scattering reports in Holden's catalog and from newspaper accounts, that a shock of intensity VII or VIII originated in the region between San Francisco and Gilroy; intensity distribution suggests the shock of July 1, 1911, VI or VII at San Francisco. Reported from Stockton, Monterey, and Sacramento.
- Y6 1867 December 1. Heavy at Nevada City. No details known; may not have been of destructive energy.
- Y7 1868 May. Dos Palmas; IX(?), X(?). Holden states a long fissure opened in the earth at Dos Palmas.
- Y8 1868 May 24. Violent shocks in Nevada; two shocks at Sacramento. Listed by Fuchs and Perrey. Allen considers that this is probably a misdating of the next entry as hour is same.
- Y9 1868 May 29. Series of shocks in interior of California and Nevada. Lassen County and Sacramento, Calif., and Fort Churchill, Nev. Destructive energy possible, but not established by the record.
- 57 1868 June 2. Downieville and Forest City; VII. Record indefinite; destructive force not established.
- 51 1868 July 24. Tulare County; Holden says VII; not mentioned by local papers.
- 52 \*1868 September 4. Foreshocks on September 3; aftershocks very numerous, continuing into October, some of them large. Very

severe on upper Kern River, Inyo County. Rock slides reported in the mountains. At Lone Pine, 40 shocks in 1 hour on September 4. Apparently not felt at Visalia, nor at Independence. In any case a considerable disturbance which would have caused damage in a settled region.

53 1868 September 26. Ukiah; VIII (?).

54 \*\*1868 October 21. Hayward; X. San Francisco; IX. This shock was accompanied by fault trace phenomena along the Hayward fault which parallels the San Andreas fault about 18 miles to the east and is at least 40 miles in length, almost certainly much longer. Damage greatest at Hayward and nearby places along Hayward fault. At San Francisco there was considerable damage on made ground; the customhouse was badly damaged and a tall chimney fell. At Hayward almost every building was badly damaged, many completely wrecked. At San Leandro the courthouse and jail were thrown down and other buildings wrecked. Deaths occurred in several places as a result of falling bricks; the number of casualties totaled about 30. Although so strong about San Francisco Bay, this shock definitely was less widely felt than other California shocks of as great epicentral energy manifestation and than some shocks of less destructive effect. See Holden and Report of the State Earthquake Commission (1908), vol. I, page 434.

55 1869 October 8. Ukiah; VIII (?). Severe at Ukiah; felt only to short distances.

56 1869 December 20-27. A series of shocks hard to untangle in the record. The shock of December 20 was of intensity VII at Grass Valley. On the evening of December 26 and early morning of December 27 the strongest action was in the Virginia City-Steamboat Springs section of Nevada, where waves were reported seen in the solid ground of the valley and from the description any intensity from VIII to X can be assigned. A secondary center appears to have been located in the Sierra east of Oroville—\$5,000 damage was done to brick buildings in that town. Intensity at Sacramento no higher than VI, despite account in Holden. Holden's mention of Mariposa should be of the Mariposa Mill at Virginia City, not of Mariposa, Calif. Not noticed about San Francisco Bay.

57 \*1871 March 2. Humboldt County; VIII or IX; severest in years. Chimneys thrown down in places as far apart as Eureka and Petrolia, and at points between, as Rohnerville.

58 1872 March 17. Lone Pine; VII. This is Holden's entry. Newspapers of region do not confirm, although mentioning shocks possibly of intensity VII or VIII on July 5 and 11 of the previous year which may have been foreshocks of the great shock of March 26, 1872.

59 \*\*\*1872 March 26. Major earthquake in Owens Valley near Lone Pine; X. Though severe the damage was light compared to that which would have occurred in a more settled region. The shock was felt over most of California and probably over most of Nevada and much of Arizona; it was sharply felt over an area 500 miles in extent north and south and 300 miles wide, and was very destructive in the Owens Valley and severe along the western slopes of the Sierra, the Mojave Desert, and in the eastern portion of the Great Valley of California.

The first shock shortly after 2 a. m. was sudden and violent and all serious damage was done in the first few minutes. At Lone Pine all adobe houses were tumbled down; out of a population of less than 300 people, 27 were killed and 60 injured. At Independence, 9 miles north, and with the same type buildings, there was little loss of life. At Indian Wells, 67 miles south of Lone Pine, adobe houses were cracked. Near Owens Lake numerous depressions formed between cracks in the earth; in one place an area 200 to 300 feet wide sank 20 to 30 feet, leaving vertical walls; several long narrow ponds were formed. Well-defined scarps formed along the trace of the Major Sierra fault, and horizontal motion ranging from 3 to 18 feet was revealed by fences crossing the fault. Large masses of rock were dislodged from the steep slopes. This shock is greatest of the three outstanding earthquakes of California, those of 1857, 1872, and 1906, and in a settled region would have had catastrophic results.

- 60 1872 May 17. Lone Pine; VII. Strong aftershock.
- 61 \*\*1873 November 22. Del Norte County, Calif., and southwestern Oregon; VIII, IX, or X. Destructive from the coast inland 70 miles to Jacksonville, along the coast from at least Port Orford on the north to Crescent City on the south. Felt from Puget Sound to San Francisco, indicating a shaken area not greatly less than in 1906. Felt at sea.
- 62 1878. Afternoon of late summer. W. H. Mulholland reports an intensity VIII shock at present site of Inglewood; kiln under construction knocked down. Date uncertain.
- 63 1878 September 7. Holden says "severe" shock in southern Humboldt County. Destructive character possible, but not established.
- 64 1881 April 10. VIII. Damage to chimneys in Modesto region; felt from Greenville, Plumas County on north to Visalia on south, and west to coast, which considering the hour of occurrence, 2:15 a. m., indicates a shaken area of the order of 100,000 square miles.
- 65 1882 March 6. VII. Some damage and bad fright caused at Hollister; "severe" but apparently no damage at Merced, Santa Cruz, Gilroy, Monterey, and Watsonville; intensity IV plus, as far as Visalia and Lemoore; aftershocks. Origin probably in coast range southeast of Hollister.
- 66 1882 August 13. VI or more severe. Seven shocks at Round Valley, Inyo County. Possibly not destructive.
- 67 1883 March 30. VI or higher. Pajaro Valley region; windows broken at Santa Cruz and Watsonville; apparently stronger toward Hollister where intensity probably was VII. Aftershocks for hours.
- 68 1883 September 5. VI? Strong shocks reported at several points along the coast from Santa Barbara to Los Angeles and Wilmington; no damage definitely reported.
- 69 1883 October 22. Holden says VIII or more severe. "A shock threw down a section of the bluff" into the Merced River below Merced Falls. Not reported elsewhere. Allen suggests that this may have been only a large landslide.
- 70 1884 January 27. VII. Humboldt County; reported from Cape Mendocino as strong, and from Hydesville and Eureka.
- 71 1884 March 25. VII (or higher?). Damage to walls of brick buildings on San Francisco waterfront; VII at Gilroy; felt through-

out central California and as far as Grass Valley in Sierra. Allen places probable origin south of San Francisco and north of Gilroy.

75 1884 June 6. Two shocks at Red Bluff which cracked walls (plastering?).

72 1885 January 30. VIII. Honey Lake Valley, Lassen County; strongest near Janesville and on Susan River 12 miles from Susanville, where chimneys fell. Numerous aftershocks continued throughout February.

77 1885 March 30. VIII. Mulberry district, 17 miles southeast of Hollister, where chimneys fell and other damage was done. Intensity VII at Hollister; cracks of banks of Pajaro River; felt to San Rafael on north with intensity IV.

25 \*1885 April 11. VIII or higher. A widely felt shock in Central California which is believed by Allen, after considerable investigation, to have originated between Cholame and San Benito. The scanty population makes even an approximate determination uncertain. Destructive at Las Tablas, near Paso Robles; intensity VI as far as Merced and Visalia; VI plus at San Luis Obispo and Salinas; felt to Marysville on north, Keeler on east, and Ventura on south. Area of intensity V in excess of 30,000 square miles; area of perceptibility more than 125,000 square miles. Little damage, because of extremely thinly settled nature of epicentral tract.

76 1885 July 31. Holden says intensity VII at Cloverdale, Sonoma County.

77 1887 June 3. Carson City, Nevada; VII. Severe shock lasting 7 seconds; stone and brick walls cracked.

78 1887 December 16. Mendocino and Point Arena Lighthouse; VIII?.

79 1888 February 18. Intensity probably VII plus at Point Arena Lighthouse; 3 severe shocks at Fort Bragg; 3 shocks at Mendocino.

82 1888 February 29. VI-VIII at Petaluma; less strong at Martinez, Santa Rosa, and San Francisco.

81 1888 April 28. Nevada City, VIII; walls of courthouse cracked. Shock Valley, VII; top of chimney fell, Orleans, mine flooded and shock felt in Idaho mine below 1,600-foot level. Biggs, plaster cracked. Felt from San Francisco northeastward into Nevada.

85 1888 November 18. Intensity not less than VII at Oakland, where five chimneys on Twenty-third Avenue fell. Felt only in nearby places.

83 1889 May 19. VIII. Collinsville and Antioch; VIII, with chimneys destroyed; some damage at Modesto, Rio Vista; felt strongly on San Francisco Bay; felt throughout most of Central California.

84 1889 June 19. VII plus. Chimney overturned at Willow Creek, Lassen County; people frightened into streets at Susanville; water of Eagle Lake muddied; 75 aftershocks; felt to Chico and Sacramento and into Nevada.

85 1889 July 31. VI. Heaviest shock since 1868 at San Leandro where one chimney fell; people awakened from Santa Rosa and Napa on north to San Jose on south.

86 1889 August 27. VII. Los Angeles to Santa Ana. Ceilings cracked and windows broken at Pomona.

87 1889 September 29. VIII?. Region of Bishop and Sierra to westward; report of rock slides in Sierra; VI at Wawona; heavy

at Yosemite; felt noticeably at Bakersfield, 140 miles from Bishop. Compare shocks of May 6, 1910, and September 17, 1927.

88 \*1890 February 9. Felt strongly throughout Southern California. The distribution of reports suggests a shock comparable in energy and location with that of April 21, 1918, on the San Jacinto fault, although since the region of the probable origin was almost uninhabited, reports of actual damage to confirm this inference cannot be found. Intensity VII at Pomona, where goods and dishes fell from shelves, type in a newspaper office was "pied" and windows were broken; and of VI at Los Angeles. Telegraph dispatchers along the railroad from Pomona to Yuma reported the shock as strong as at Pomona. At San Diego a duration of 1 minute was reported. The hour was 4 a. m. and reports came only from the region where the intensity was enough to awaken people; this region, however, covered Southern California. Holden's entry of February 15 is an error of dating.

89 1890 April 24. VIII plus. Monterey Bay region. At Watsonville chimneys were thrown down; the area of intensity VIII embraced Watsonville, Hollister, and Gilroy, and centered about Chittenden with fissuring in the San Andreas fault zone near that locality. Damage to railroad through settling of ground and displacement of bridge. This shock was felt throughout central California despite its occurrence at about 3:30 a. m.; it was strong enough to cause alarm in San Francisco. Aftershocks for many days.

90 1890 July 26. A submarine origin off Cape Mendocino and energy comparable to that of the shock of January 22, 1923, is indicated by the few reports available. Intensity of VIII at Petrolia; strong but little or no damage at Eureka and Mendocino City; felt to Suisun, 200 miles southeast, and at Sisson, Siskiyou County, despite occurrence at 1:40 a. m.

91 1890 August 23. Holden describes a strong shock at Mono Lake on this date. His source appears to be inaccurate; the date given was not a Sunday, and no other reference can be found. It is possible that this refers to the shock of September 29, 1889, which was on a Sunday and in this region.

92 1890 September 19. Shock which probably was strong on the unsettled Mojave Desert near Daggett; this, however, cannot be established by the record. Felt at San Bernardino.

93 1891 January 2. VII or higher. Ceilings cracked, plaster thrown down at Mount Hamilton. Felt throughout central California; strong but little or no damage reported at Gilroy, Santa Cruz, and San Jose.

94 1891 October 11. Probably IX. Many chimneys fell, and brick buildings were damaged in Sonoma and Napa, where the intensity probably exceeded VIII. At the latter place the tower of the insane asylum fell. Intensity VII at Petaluma and Suisun. The extent of the area of perceptibility was not commensurate with the rather high epicentral intensity; at San Francisco the shock was classed as "slight." In the central region aftershocks continued through the night.

95 \*\*1892 February 23. This probably was the largest California shock of the interval 1873-1906. Intensity probably reached X

near origin, which was apparently in the uninhabited region of northern Lower California. Intensity at least VIII along the Pacific coast of Lower California, as far south as San Quentin. Effects reported from San Diego County are as follows: At Carrizo, all adobe buildings destroyed; at Jamul, walls of stone kilns cracked; in Paradise Valley, church and schoolhouse built on stilts brought down and demolished; at San Diego, a large number of buildings cracked and plaster dislodged (VII); at Campo, 155 shocks in 12 hours. Outside of San Diego County the shock was felt as far north as Visalia; intensity was VI at San Bernardino.

96 \*1892 April 19-21. IX. The main shock on the 19th was strongest at Vacaville and Winters, where brick buildings were wrecked and intensity was IX. Water was ejected from the bed of Putah Creek, near Winters. Intensity of VIII was reached from the region of Suisun on the south to Woodland on the north; at Sacramento the intensity was VII. The ground was fissured along stream banks in the Winters section; at that point tombstones were turned around or shattered, and a press weighing a ton was overturned. At Dixon many of the finest residences were ruined and fire broke out. At Fairfield a church tower fell. The intensity at San Francisco was about VI, the unbraced walls of a building being demolished were tumbled down. The shock was felt as of about intensity III-IV as far south as Fresno.

On April 21 a shock of less total energy but in its epicentral region as severe as the first, took place to the north of the origin of the first shock, and caused additional damage to the weakened structures in the damaged towns, and fresh damage to towns not so badly hit on the 19th. At Esparto every brick chimney fell and wooden buildings were wrenched out of shape; intensity of IX seems indicated. The shock was very severe at Winters. See Holden's catalog.

97 1892 May 28. Ontario, San Bernardino, and Santa Ana. The record does not establish this as having caused destruction.

98 1892 November 13. VII plus. Monterey, where chimneys were cracked and the shock was described as the heaviest ever experienced. Damage to windows and dishes at Salinas and to plaster at Hollister.

99 1893 April 4. Probably IX. Newhall and Pico Canyon oil region, 35 miles northwest of Los Angeles. All chimneys were wrecked, the earth was fissured, boulders shaken down the hillsides, and a great cloud of dust arose from the San Fernando and Castaic Mountains. In spite of great local intensity, the shock was not strong at Los Angeles. However, there was intensity VII at Mojave. Aftershocks continued for days.

100 1893 May 18. Reports indicated intensity of VI along the Southern California coast from Santa Ana to Santa Barbara, with highest intensity, possibly VII, on Ventura County coast. Felt inland at least to beyond San Bernardino, and southeast to San Diego, the latter point 150 miles from the probably indicated origin off the Ventura County coast. This shock should be suspected of having had enough energy to do considerable damage in a settled region with poorly constructed buildings.

101 1893 August 9. VII to VIII. Considerable damage to chimneys, etc., at Santa Rosa. Intensity VI or VII at Petaluma.

102. **1894 July 13.** A press item reported a sharp shock at Pine Ridge, in the Sierra, about 50 miles northeast of Fresno; the dam across Stephenson Creek was said to have been damaged. The shock was unfelt in the San Joaquin Valley. Report suggests that shock may not have occurred—severe electrical storm was raging.
103. **1894 July 29.** Arlington, Los Angeles, San Bernardino, Mojave. Widely felt. Intensities of VI or VI-VII in the Los Angeles coastal plain, and of VII at Mojave, suggest a region of destructive intensity in the mountains between. Felt from Bakersfield on north to San Diego County on the south, and Ventura on the west.
104. **1894 September 30.** Heavy at Hydesville and Eureka; felt strongly by schooner *Lila and Mattie*, 35 miles off Shelter Cove. A rather large submarine earthquake off Cape Mendocino is a probable interpretation of the record. The shock was felt to Sisson, Siskiyou County. No damage on land actually reported.
105. **1894 October 23.** VIII? San Diego and nearby mountains. Boulders dislodged from hills; at San Diego some brick walls cracked and considerable alarm, but no serious damage reported. Felt to San Bernardino and Los Angeles.
106. **1894 November 14-18.** Series of shocks in Virginia City region of Nevada. Shock on 14th was of intensity VII at Gold Hill; that of the 18th damaged walls and broke windows at Virginia City.
107. **1895 February 28.** VII. Independence; felt at Bishop Creek and Keeler.
108. **1896 January 27.** VII. Carson City, Nev. Plaster broken in many buildings.
109. **1897 June 20.** VIII or IX at points in region of San Andreas fault near and northwest of Hollister; damage reported at Hollister, Gilroy, Salinas, and other points; rather strong at San Francisco; area of perceptibility of the order of 100,000 square miles. See McAdie catalog.
110. **1898 March 30.** Chief damage at Mare Island, VIII, where the loss required an appropriation of \$350,000 for restoration. Occurrence at night was the only thing that prevented loss of life. Felt as far as Carson City, Nev. At San Francisco, VII. Chimneys twisted and there was considerable miscellaneous damage. Lasted 40 seconds.
111. **\*1898 April 14.** Mendocino County coast, probably IX to X. Roads in mountains behind Mendocino rendered impassable by landslides and fallen trees; frame houses wrecked at Greenwood; at Mendocino chimneys fell and cemetery monuments fell or were twisted. Felt southeast to San Jose. Many aftershocks, continuing for weeks, in some cases locally rather strong.
112. **1899 April 16.** Eureka; VII plus. Long continued shock which caused some damage to lumber mill. Reported also at Hydesville.
113. **1899 April 30.** VII to VIII at Watsonville and in country toward Corralitos; chimneys and cemetery monuments damaged in Green Valley. Long continued and rolling motion at Mount Hamilton. Pronounced, but no damage at San Francisco.
114. **1899 July 6.** Two shocks, apparently within 1 minute, the larger originating near Watsonville, where intensity was VIII, and apparently south of the origin of the April shock since the intensity at Salinas was higher than in April; the other shock near Pleasanton,

where the intensity also was about VIII with damage to brick buildings. Area of perceptibility of shocks exceeded 40,000 square miles.

115. **1899 July 22.** Origin apparently on Cajon Pass section of San Andreas fault. Intensity VII to VIII in San Bernardino and VII in Los Angeles. Landslides extended for 20 miles northwestward from Cajon Pass, along the zone of the San Andreas fault. Felt over southern California.
116. **1899 October 12.** Santa Rosa; VIII. Local shock, the only other place reporting being Petaluma, 16 miles distant, where shock was not strong.
117. **\*1899 December 25.** Region near and southeast of San Jacinto; IX or X. Generally felt in southern California and western Arizona. Damage at San Jacinto, Riverside, Redlands, and San Bernardino to chimneys and brick walls. Loss of life on Cahuilla Indian Reservation in collapse of adobe buildings.
118. **\*1901 March 2.** Origin in Stone Canyon region of San Andreas fault northwest of Cholame Valley, where fault trace phenomena were produced. Intensity VIII at least at Parkfield in Cholame Valley; VII at San Miguel; VI to VII at San Luis Obispo. Felt to San Jose on north. Many aftershocks.
119. **1902 May 19.** VIII at Elmira, where nearly all chimneys fell; VII-VIII at Vacaville, where some chimneys tumbled; VII at Fairfield and Suisun; intensity V plus as far as San Francisco. Area of perceptibility probably exceeded 30,000 square miles, but reports are incomplete.
120. **1902 July 27-30.** Los Alamos and Lompoc region of Santa Barbara County. Intensity probably IX in central region, with nearly all chimneys destroyed and frame houses badly wrenched. Although locally so strong, the shock was no more than noticeable at San Luis Obispo and was not widely felt.
121. **\*1903 January 23.** A world-shaking earthquake centering in the uninhabited region south of Imperial Valley. Felt throughout southern California and western Arizona. Occurring now, this shock might cause damage in Imperial Valley, although the origin apparently was some distance to the south.
122. **1903 June 11.** VIII. Reported at Niles as the heaviest since 1868, although damage was not specified in the report. A small proportion of the chimneys fell in the region from Hayward and Livermore to San Jose. At Mount Hamilton 2 shocks lasting in all 32 seconds, were described, probably the P and S phases of 1 shock. Rather widely felt, the area of perceptibility being about 100,000 square miles.
123. **1903 July 24.** Willows and surrounding towns; brick walls reported cracked at Willows. Reported felt from Sacramento to Greenville, and from Willows to Nevada City; it should also have been felt in the region west of Willows, since the origin appears to have been near that town.
124. **1903 August 2.** VIII plus. Center probably in Halls Valley region near Mount Hamilton. In San Jose the intensity was fully VIII, hundreds of chimneys and many cornices falling. Some damage at Lick Observatory. Felt to Yosemite Valley and Fresno.

At San Francisco, the intensity was fully VI. Similar to shock of July 1, 1911.

125  
126  
127  
1905 December 23. Local shock of intensity VII-VIII at Bakersfield, with some damage to a number of buildings and considerable alarm.

1906 March 3. A shock of moderately destructive power originating just south of the Imperial Valley and felt as far as San Diego and Riverside.

\*\*\*1906 April 18. Coast region of middle California; X. One of the 3 known great shocks of California history. This is very fully described in the 3-volume report of the State earthquake commission, and only the outstanding facts are given here. There was rupture of the San Andreas Rift, with surface fault trace phenomena for the coast line near Fort Bragg in Mendocino County to near San Juan in San Benito County, and of a fault extending northwest from Point Delgada in Humboldt County, perhaps a continuation of the San Andreas or perhaps another which may bear a relation there to San Andreas similar to that of the Hayward fault in the San Francisco Bay region; the total distance of surface rupture was about 270 miles. The San Andreas Rift is a zone of fracture along which there has been slipping from an early geological period, and derives its name from a small valley on the San Francisco Peninsula. The maximum observed slipping on the surface was 21 feet in a horizontal direction, and relative motion of the 2 sides of the fault amounting to 10 or 15 feet was not uncommon; the greatest motion was northwest of San Francisco in Marin County. Triangulation by the Coast and Geodetic Survey showed that the distortion decreased rapidly with distance on both sides of the fault.

Along the zone of the rift the horizontal dislocation resulted in the displacement of fences, railways, tunnels, dams, pipes, and other structures. Only at the north end of the zone was there vertical displacement, and this nowhere exceeded 2 or 3 feet.

Such violent permanent change necessarily was accompanied by a great earthquake and extensive damage, which was made greater by the inability to put out the fires which followed the shock, because of failure of the water systems.

Damage was done to buildings and structures in all parts of the city and county of San Francisco. Much of it was moderate in amount and character. Most chimneys were toppled over; plaster on walls and ceilings was cracked, and there were many forms of permanent damage. In small districts on made land, where the intensity was augmented, pavements were buckled, arched, and fissured; brick and frame houses of ordinary construction were badly damaged or destroyed; sewers and water mains were broken; and heavy street-cars tracks were bent into wave-like forms.

At Santa Rosa, although 19 miles from the Rift, destruction was great, and apparent intensity higher than at most other points of comparable distances. The district lies directly inland from the region of greatest motion on the San Andreas fault.

Another region of violent shock detached from the main San Andreas Rift zone was in the Los Banos region of the western San

Joaquin Valley, where, more than 30 miles from the Rift, the intensity was fully IX; and a long belt of high intensity extending north-west and southeast suggested activity of some other fault.

It is estimated that the great shock and resulting fires caused not less than 500 deaths, about one-tenth of them in the little city of Santa Rosa, although the population there was not much more than one hundredth that of San Francisco.

All known earthquake effects on men and animals were observed.

Trees swayed violently and in some cases were thrown down or snapped off above the ground.

Springs and artesian wells either increased or decreased their flow. A few mud or sand craterlets were formed, where jets of water were spurted through holes or fissures. The waters of the harbor were disturbed, but no tidal wave occurred anywhere. Vessels off the coast felt the vibrations of the shock.

There was considerable cracking of alluvial surfaces. In addition to the great fissures of the Rift, there were branch fissures. Various types of landslides took place, including avalanches and earth slumps, and, where the ground contained an excess of water, earth flows.

There were numerous aftershocks, some fairly sharp, the last of this type occurring in July. On April 23 a shock great enough to be recorded over much of the world took place probably on the seaward extension of the Point Delgada or Shelter Cove fault, off Eureka, and caused some destruction at Ferndale. This is listed below.

178 1906 April 18. Brawley, Imperial Valley; VIII. This shock, 11 hours after the greater shock in the north, was felt as far as San Diego but was destructive only at Brawley.

129 1906 April 23. Ferndale; VIII. Chimneys and movable objects overthrown; strong at Eureka; felt into Oregon.

130 1906 April 25. Wood's Culch; VII. Aftershock of the April 18 earthquake. Landslides along coast cliffs of San Francisco Peninsula.

131 1906 December 6. VII to VIII at Piedras Blancas, San Luis Obispo County. The lighthouse tower was cracked. Felt at Santa Maria.

132 1907 September 19. VII plus. Brick building cracked at San Jacinto; intensity nearly as high at San Bernardino, Redlands, and Riverside. Landslides in mountains; power-company pipe broken in Santa Anita mountains. Felt to Monticito and San Diego.

133 1908 January 26. VIII. Milford and Amadee, in Honey Lake region, chimneys toppled. Not widely felt, nor recorded on Berkeley seismographs.

134 1908 August 18. VIII. Eureka; houses cracked and chimneys toppled. Fissure in soft ground, walls cracked and chimneys down at Freshwater, few miles north of Eureka. Area perceptible with intensity IV, about 6,000 square miles.

135 1908 November 4. The strongest of a series of shocks lasting 3 weeks in late October and in November in the Death Valley district. Prospectors frightened from region, but no damage on account of lack of buildings. Allen considers that in a settled region damage corresponding to intensity VIII or IX would have resulted. Intensity VI at Lone Pine; felt to San Bernardino and Tehachapi.

- 132 **1909 May 17.** VIII. Upper Mattole; chimneys injured, monuments in cemetery broken and twisted. Felt at Eureka, Rhonerville, and Blocksburg.
- 137 **1909 June 22.** VII to VIII. Downieville and Poker Flat; VI-VII at Grass Valley. Felt to Reno, Nev., and north to Siskiyou County. Numerous aftershocks for days.
- 138 **\*1909 October 28.** IX. All brick or concrete work reported damaged or destroyed at Rohnerville. Intensity VIII at Eureka. Felt from Ukiah northward into Oregon as far as Marshfield and eastward to beyond Redding, where the intensity was possibly V-VI. Shaken area probably about 125,000 square miles.
- 139 **1910 March 10.** VII plus. Region of lower Pajaro River. Intensity VII at least at Chittenden; probably VII at Watsonville and Aptos; VI at Hollister. Felt as far as Nevada City; area of perceptibility probably 50,000 square miles.
- 140 **1910 May 6.** VII or more at Bishop, northern end of Owens Valley, and stronger in Rock Creek Canyon to northwest. Felt to Sacramento, 170 miles; Hollister, 160 miles; Bakersfield, 140 miles from Bishop. Area probably in excess of 50,000 square miles.
- 141 **1910 May 15.** VII-VIII. Lake Elsinore region; chimneys toppled in district between Corona and Wildomar. Felt to Barstow, Ventura, and San Diego.
- 142 **1911 July 1.** VIII. Coyote, in Santa Clara Valley, probably VIII plus. VIII at San Jose; VI plus at San Francisco. A tank fell and a landslide occurred at Edenvale, near the epicenter. Felt to Carson City, Nev. Shaken area well in excess of 100,000 square miles.
- 143 **1912 January 4.** VII at least. Bishop, Inyo County. Nearly as strong at Laws and Alvord. Felt in San Joaquin Valley to west and south to Bakersfield, 140 miles from Bishop.
- 144 **1914 February 18.** VI-VII. Origin probably near Truckee Meadows, Nev. Intensity at Reno VI plus; strongest in district from Reno to Virginia City.
- 145 **1914 April 24.** VIII. Origin probably east of Reno. Chimneys fell at Reno; 4 at the University of Nevada. Felt over east northern California and much of Nevada, and south to Randsburg, Calif. Seismograms indicate that this shock had energy sufficient to cause considerable destruction in a built-up region.
- 146 **1914 November 8.** VIII. Santa Cruz Mountains, near Laurel, where chimneys fell and articles were thrown from shelves. Felt from Santa Rosa, Sonoma County, to Soledad, Monterey County, and east to Fairmead. Shaken area 30,000 square miles.
- 147 **1915 January 11.** VIII plus. At Los Alamos, Santa Barbara County, several well-built chimneys were shaken down in addition to a number of poorly built ones, and water pipes were pulled apart at the unions; at Lompoc some buildings suffered damage and the intensity was VII-VIII. At Harris an oil pipe 8 inches in diameter broke in several places. There were cracks due to lurching in the alluvial soil, and numerous small landslides, in the epicentral region. Despite the rather high local intensity, the shock was barely felt to Salinas on the north and Los Angeles on the southeast, indicating a shaken area of not more than 50,000 square miles.

148 **1915 February 21.** Highly localized shock of intensity fully VIII in mountains near Whitmore, northwest of Lassen Peak. Considerable local dislocation of ground. Similar to shock of January 4, 1919, in same region.

149 \***1915 June 22.** El Centro, Calexico, and Mexicali; 2 destructive shocks, nearly 1 hour apart. Heavy damage in southern Imperial Valley, due as much to poor quality of buildings erected during a boom period as to intensity of shock. In El Centro well-constructed buildings merely suffered cracks. At Mexicali people returned to buildings after the first shock and 6 were killed and many injured. Though a few cracks were formed in the alluvium, the irrigation ditches and works were little damaged. The unstable banks of the New and Alamo Rivers slid down in many places. Several farmers observed that after the shocks one-third more water was required for irrigation, because of the cracks in the soil. Area affected was about 50,000 square miles. Despite the rather high local intensity, the total energy was moderate.

150 \*\***1915 October 2.** X. Pleasant Valley, Nev., south of Winnemucca. The shock resulted from faulting on the west side of the Sonoma Range, the resultant scarp showing vertical motion of from 5 to 15 feet along a rift 22 miles in length. The earthquake was felt over much of the Pacific slope west of the Rocky Mountains, even to San Diego (and the area within which the intensity was high enough to have been destructive had there been cities with poorly built structures probably was at least 10,000 square miles). Some damage resulted at Winnemucca and Lovelocks, the nearest places of any size. At Kennedy, in the epicentral valley, adobe houses were destroyed, concrete mine foundations were cracked, and mine tunnels caved in. At Lovelocks large water tanks toppled over and cracks appeared in the road and in unconsolidated ground.

151 \***1915 November 20.** A shock revealed by seismograms to have been considerably greater than that of June 22 took place in the Volcano Lake region south of the Mexican boundary. In the Imperial Valley the highest intensity was VII at Calexico; at Volcano Lake where levees and damp ground were cracked, it may have been IX to X. Shaken area more than 120,000 square miles.

152 **1916 August 6.** VIII. Paicines, south of Hollister. VII at Hollister; shaken area in excess of 30,000 square miles.

153 **1916 October 22.** VII plus. Tejon Pass; rocks shaken down on road; crack of several hundred feet long in cement surface of road near Gorman; goods shaken from shelves. No towns in epicentral region. Felt from Fresno to San Diego, and from Mojave to the coast.

154 **1916 November 10.** Probably in desert south or southeast of Death Valley. Region being unsettled, there was no damage, although the shock was disclosed by seismograms to have been of destructive energy. Felt at Lone Pine, Calif., and at Las Vegas, Nev.

155 **1916 December 1.** VII-VIII. A few miles south of San Luis Obispo chimneys toppled over, plaster fell, and slides occurred in railway cuts. About VI-VII at San Luis Obispo and Avila.

156 **1917 May 27.** VIII(?) Some walls cracked at Brawley. At a point 6 miles southeast of Holtville waves were reported seen in allu-

vium and shock was said to have been as severe as that of June 22, 1915.

157 1917 July 7-9. VII plus. Near Arroyo Grande just south of San Luis Obispo. Nine shocks in 3 days. Chimneys cracked, rocks rolled down hillsides. Extremely local.

158 1918 March 12. VIII(?). Newspaper report said chimneys fell at Downieville. Reported only in Sierra County.

159 \*1918 April 21. X minus. San Jacinto and Hemet suffered heavy damage; only 1 new concrete and 1 frame building remaining standing in the business section of San Jacinto after the shock. The buildings wrecked were brick or artificial stone of poor construction, or old frame buildings. Concrete, substantial frame, and well-constructed brick buildings were not seriously damaged. Numerous lengthwise cracks were found on the road between the two towns named and concrete irrigation canals were broken in a number of places.

Damage corresponding to intensity VII to VIII also occurred at Redlands, Riverside, and San Bernardino, and as far away as Los Angeles the intensity was a high VI.

Roads in the epicentral district were closed to travel by slides, and 1 automobile was carried off the road by a slide. Great clouds of dust rose from the mountains, due to the extreme dryness of the ground. Changes occurred in water flow and springs increased or decreased their output. A number of sand and mud craterlets were formed. In the region of the San Jacinto fault southeast of Hemet the dry earth surface in places was broken up as though by a harrow.

The shock was felt as far northwest as Taft, Kern County, and Los Olivos, Santa Barbara County, east into Arizona, and undoubtedly a considerable distance into Mexico. The shaken area was not less than 110,000 square miles. Other shocks continued for weeks, the strongest on June 6. See Bulletin of the Seismological Society of America, volume 8, pages 45 to 67.

160 1919 January 4. VIII at least. Fern, 20 miles northeast of Redding. Intense but local shock produced scarp across road, one side dropping several feet.

161 1919 February 16. Probably VII at least. Kern County vicinity, or just northwest of Tejon Pass. At Lebec rocks fell from steep slopes; at Belridge a tank of oil was destroyed; at Maricopa and Grapevine buildings were cracked. Probably slightly stronger than Tejon Pass shock of October 22, 1916.

162 1919 September 15. VII-VIII. Eureka; several chimneys fell. Four shocks, first the heaviest. Allen believes it very local.

163 1919 September 29. Volcano Lake region, south of Imperial Valley; probably VIII; levees slumped; VI to VII in Imperial Valley.

164 1919 October 1. A shock similar in energy and location to that of September 29.

165 1920 June 21. VIII-IX. The "Inglewood earthquake", this shock was highly localized in and just west of Inglewood, where the intensity was high in grade VIII. The entire shaken area did not exceed 11,000 square miles. Typical damage was the wrecking of a two-story school building so that it had to be rebuilt. Walls of a hotel and of an electric substation fell, cemetery monuments were

upset, and telephone service interrupted. In an unsettled region this shock would have passed unnoticed. It was highly selective in its effects, damaging poorly built structures, but not good nearby buildings.

- 146 1920 July 16. VI-VII. Los Angeles; windows broken, bricks dropped from a few chimneys, some plaster fell. This shock would not have been considered of destructive force except for its occurrence in a large city.
- 147 1920 July 22. VII-VIII. Hot Springs, Shasta County; destroyed chimney at resort and caused panic. Felt throughout eastern Shasta County.
- 168 \*\*1922 January 31. Submarine shock of great intensity, so far from land that greatest intensity on shore was about VI at Eureka. Felt along north California coast from San Francisco north and into Oregon, and in northwestern Nevada. Probably of same order of magnitude as earthquake of April 18, 1906.
- 169 \*1922 March 10. VIII plus. Cholame Valley; small cracks in earth in San Andreas fault zone; considerable damage to houses along line of San Andreas Rift in Monterey and San Luis Obispo Counties. One house thrown from foundation and another badly demolished; chimneys knocked down at Parkfield and in southern Cholame Valley. Oil pipe lines broken between Shandon and Antelope. Felt feebly as far as Los Angeles and the Sierra Nevada.
- 170 1922 June 16. Strong shock south of Imperial Valley. No damage because of lack of structures.
- 171 1922 August 17. Strong shock in unsettled region of San Andreas Rift zone in Cholame region. Magnitude considerably less than that of shock of March 10. Intensity possibly VII.
- 172 \*1923 January 22. IX. Upper Mattole and Petrolia, where most of the chimneys fell and there were many aftershocks. Bad slides on nearby roads. VIII at Ferndale, Dyerville, Pepperwood, and nearby points, with some damage to chimneys and to a few houses. A large gas tank as far away as Chico was moved on its base. Felt through most of north California and in southern Oregon, and eastward to Reno. Seismograms give submarine origin off Cape Mendocino. It was felt at sea, the U. S. S. *Texas* experiencing heavy vibrations at about  $44^{\circ}$  N.,  $125^{\circ}$  W.
- 173 1923 July 22. VIII. San Bernardino Valley. Severe in San Bernardino, with damage to masonry buildings and many chimneys down. Buildings cracked and plate glass broken at Redlands. Good construction did not suffer. Felt throughout southern California.
- 174 1923 November 5. VII. Origin near Calexico.
- 175 1923 November 7. Probably VIII at origin, which seems to have been south of Calexico in Lower California. At Calexico the intensity was about VII; a hotel was moved several inches on its foundation; windows broke and plaster fell, and one fire resulted.
- 176 1925 April 15. VII. At Calexico plaster was shaken from the walls and inhabitants fled to the streets. Again the origin probably was a short distance south of the border.
- 177 \*1925 June 29. IX-X. Santa Barbara and vicinity, particularly to the westward. This shock was of considerable intensity but not of the great type. The shock was felt sharply at Ventura, where some damage resulted. It was noticed throughout the San Gabriel

Mountains to the east and in the Mojave Desert. At Naples, west of Santa Barbara, a stone church was damaged. The soil cracked at a few places in the Santa Ynez Mountains north of Santa Barbara, and there was increased flow from springs, but in general such effects were very moderate.

The damage at Santa Barbara was related to geological conditions and to the types of construction. In general, the structures in that city were on a par with those of other cities, good, bad, and indifferent, with some concealment of poor work which was exposed relentlessly by the earthquake. On State Street, the principal business thoroughfare, on made land, few buildings escaped.

A hotel of four stories, built of brick with long unsupported side walls, lost a large part of its exterior. A large office building failed at a corner through giving away of columns, and the whole building fell, with some loss of life. Some large public buildings failed, with the evidence of poor design and workmanship. A large frame church on a good foundation would have withstood the shock had not its roof, entirely too heavy for the building, fallen in. One important building, the two parts of which were built at different times, failed because there had not been the slightest effort to connect the two parts.

A well-designed and constructed three-story concrete building stood up well, although built on marshy ground; its foundations had been carried down 19 feet to clay. In general, reinforced concrete endured the earthquake except where there was poor workmanship. Frame buildings covered with stucco on sheathing or lath withstood the shock, though other methods did not show up so well. Brick, stone, cement, block, hollow tile and veneer walls generally were cracked or shattered, yet where the structures were properly braced and bonded and well laid in good mortar, they stood the shock well, though chimneys fell and plaster was cracked.

The sewage system was undamaged except on made land, where the loss was heavy. Pipes were cracked for considerable distances. There were cracks in pavement, but in only one place, a boulevard on a sand beach, was there movement, in this case estimated as from 8 to 14 inches.

The earth dam of the Sheffield reservoir, behind the city failed, but little damage was done by the released water.

Intensity VIII was manifested at a number of points in the Santa Ynez and Santa Maria Valleys, north of the Santa Ynez Mountains. See the Bulletin of the Seismological Society of America, volume 15, pages 251-333.

178 1926 April 3. Colorado Desert region of Twenty-Nine Palms. Felt as far as San Diego and Needles, this shock had moderately destructive energy, but lack of structures in the desert region prevented actual damage.

179 1926 June 29. Santa Barbara; VII plus. Some chimneys fell, and a child was killed by a falling brick. Cracks in buildings left by the 1925 shock were reopened. Felt slightly in Los Angeles.

180 1926 July 25. VII. Idria and Panoche in western foothills of San Joaquin Valley. Region almost unsettled.

181 1926 October 22. VIII. Three strong shocks. The first was felt from Lompoc, Santa Barbara County, to Healdsburg, Sonoma

County, and east to the Sierra. Center off Monterey Bay. There was destruction of chimneys at Santa Cruz and damage to the lighthouse on Ano Nuevo Island. At Santa Cruz old brick buildings suffered. Some damage to tile surface of a few buildings as far away as San Francisco, chiefly on made ground; steel cracked in one building, and there was considerable damage to plaster; a pillar was cracked throughout its length. The second shock an hour later was almost as widely felt as the first; seismographically it was of the same strength, and it appears to have been the stronger of the two at points north of Monterey Bay. The third shock was less severe. Other aftershocks occurred.

187 ✓ 1927 January 1. VIII-IX. Imperial Valley near Mexican border. Heavy damage at Calexico, Mexicali, and El Centro; some damage at Brawley. At Calexico the shock is reported to have lasted 3 minutes, probably an exaggeration of the actual duration. Many houses were demolished, and scarcely a brick or cement building was left sound. Many walls tumbled, and between 15 and 20 persons were injured, some seriously. In Mexicali, across the border, all buildings were damaged and water mains broken. At Brawley 13 distinct shocks were reported, 4 of them heavy. Reports from Ensenada, Mexico, and from San Pedro, indicate a sea wave. If this is correct, there must have been a shock off the coast distinct from this, which clearly originated in the southern end of the Imperial Valley. Hundreds of aftershocks occurred in the 6 weeks following.

183 1927 August 20. VIII. Humboldt Bay. At Eureka the shock came as a twisting jerk which threw objects from shelves and caused considerable loss in retail stores; plaster was cracked and chimneys tumbled; wiring was deranged; people thrown from chairs, probably in part through their own muscular reaction to the shock; automobiles went out of control, probably for the same reason. Cracks appeared in mud and gravel, and there were landslides of moderate extent. The intensity at Arcata was similar; at Scotia the shock was less strong, probably about VII. The shock was not felt at distances greater than 90 miles from Eureka. The U. S. S. *Sea Lion*, off Eureka, felt a heavy jar.

184 1927 September 17. VII plus. At Bishop walls were cracked and windows and chimneys broken. The origin was in the Sierra nearly 20 miles west or northwest of Bishop. Felt to Bakersfield, 140 miles south, and to Stockton, the same distance northwest from Bishop.

185 \*1927 November 4. IX (X at epicenter?). West coast of Santa Barbara County. Origin offshore. On land the highest intensity observed was about IX in the vicinity of Honda. At Roberd's Ranch a man was thrown from his feet, a house shifted on its foundations, and the chimney fell. Water spurted from the ground, and cracks appeared. The concrete highway was cracked, and train service interrupted several hours because of damage to the railroad track. Heavy landslides occurred on the ocean cliffs.

Intensity of fully VIII was manifested at Lompoc, where many chimneys fell and brick buildings were split so badly as to be unsafe. Intensity in the neighborhood of VII-VIII was developed at other towns of the region, including Santa Maria, Santa Ynez, Los Olivos, Los Alamos, and up the coast as far as Cayucos. The

shock was felt to distances of 200 miles; it was definitely larger than the Santa Barbara earthquake of 1925, but a difference in location made it less destructive. Heavy shocks were experienced by the ships *Socony* and *Alaska Standard*, 27 and 14 miles from Point Arguello. A small seismic sea wave was observed at several points on the coast, and recorded on tide gages. There were the usual number of strongish aftershocks, two of them of intensity VII in the Lompoc region. See Bulletin, Seismological Society of America, volume 20 page 53.

- 186 1927 November 18. VII. Santa Maria, windows cracked and weakened chimneys collapsed. Probably aftershock of the big shock of the 4th, although origin was nearer Santa Maria.
- 187 1928 June 3. VIII(?) Weaverville; chimneys thrown down. Reported strong at Carrville and Trinity Center and barely felt at Scotia and Eureka, distant 60 miles from Weaverville.
- 188 1928 September 5. Moderately strong shock in Colorado desert region near Twenty-Nine Palms. No damage, in lack of buildings. Felt as far as Ventura and San Diego.
- 189 1929 July 8. Whittier, VIII. Section of schoolhouse wall caved in. Two houses wrecked by falling chimneys. Several oil wells damaged.
- 190 1929 September 26. Moderately strong shock in Mojave Desert about 30 miles east of Barstow. Felt to Pasadena.
- 191 1929 November 28. Sierra, northwest of Bishop. Originating in the active Sierran source northwest of Bishop, this was less strong than the shocks of 1889, 1910, and 1927. The area of perceptibility probably exceeded 35,000 square miles, including Stockton and Kernville in California, and Mina, Nev. At the epicenter in the mountains the intensity was probably about VII.
- 192 1930 January 15. VII-VIII. At Fawnskin and Summit, in the San Bernardino Mountains, chimneys fell. Felt over about 50,000 square miles, strongly as far as Los Angeles.
- 193 1930 February 25. VIII. Westmoreland, Imperial Valley; walls cracked, chimneys toppled, inferior buildings damaged. Mud craters found a few miles east of this place. Several foreshocks and many aftershocks.
- 194 1930 March 1. VIII. Brawley, Imperial Valley. This shock was of smaller magnitude than that of February 25. The intensity at Brawley was fully VIII, however, with brick buildings damaged, chimneys down, and plate glass shattered. Structural damage included falling out of wall, bad cracks in walls, displacement of roofs, and fall of cornices. Well constructed buildings suffered little.
- 195 1930 April 9. VII plus. Chimneys damaged at southeast end of Lake Tahoe; plaster cracked at Tahoe.
- 196 1930 April 12. VII plus. Near Fernley and Fallon, Nev. Chimneys and plaster cracked, dishes broken.
- 197 1930 August 30. VIII. Epicenter off shore about 8 miles west of Santa Monica. Intensity VII to VIII at points about Santa Monica Bay and V to VII at points in Los Angeles, depending upon subsoil conditions and type of building. Shaken area about 30,000 square miles.

198 1930 September 22. VIII. Humboldt Bay. Almost duplicate of shock of August 20, 1927, both as to location and force. Chimneys fell at Eureka, Arcata, and Field's Landing.

199 1931 August 23. VII or more. Submarine shock off Cape Mendocino, according to seismograms. Maximum land intensity reported was about VII at Hydesville. Felt and recorded more widely than shock of September 22, 1930, on Humboldt Bay.

200 1931 September 9. VII-VIII. Chimneys damaged at Weott. Seismograms again placed origin off Cape Mendocino. Intensity about VII in considerable portion of southern Humboldt County.

201 \*1932 June 6. VIII plus. Humboldt County. The strongest shock of the region since 1923, this was destructive at Eureka, where many chimneys fell, water mains were broken, windows shattered, and telephone and telegraph service was interrupted. A number of small houses in Arcata were shaken down; at Eureka Slough a railroad drawbridge was put out of commission; at Loleta small cracks appeared in the ground and a brick wall fell.

This shock was located seismographically as originating off shore near Eureka; it was felt north into Oregon and south to San Francisco. One death was caused in Eureka by a falling chimney.

202 \*\*1932 December 20. X. Western Nevada, in Cedar Mountain district. This shock compares with the 1915 shock in Pleasant Valley, as to energy, and was caused by extensive and complicated faulting over a belt 38 miles long and from 4 to 9 miles wide in the valley between the Pilot and Cedar Mountain ranges northeast of Mina. In this belt 60 rifts were found, ranging up to 4 miles in length, and others undoubtedly were hidden by the snow on the ground when the survey was made. The energy of the shock was so great that it was felt from the Rocky Mountains to the Pacific Ocean at San Diego and San Francisco, very noticeably at the latter place.

The epicentral tract being uninhabited except by occasional miners and shepherders, about 12 in all, little destruction took place. A stone and an adobe cabin were destroyed, and mining property damaged. Outside the central region, only Mina and Hawthorne were near enough to suffer much damage. Both are very small places, and at each many chimneys were thrown down; at Hawthorne concrete was cracked.

203 \*1933 March 10. IX. The "Long Beach earthquake." This shock was not of major magnitude from the seismological point of view, but through the accident of its location in a thickly settled district with many poorly constructed buildings, it ranks as the second most destructive shock of the United States history. Over 100 lives were lost and damage of about \$40,000,000 resulted. The origin was situated just off shore near Newport Beach; the major destruction however was in the more thickly settled district from Long Beach to the industrial section, south of Los Angeles, where water-soaked alluvium and other unfavorable geological conditions combined with the presence of much poor structural work to increase the damage. The strongly shaken area was bounded by a line from southern Los Angeles southwest to Manhattan Beach, and by another from southern Los Angeles to Anaheim and thence to

Laguna Beach. The shock was felt over a land area of approximately 60,000 square miles, and with the sea area presumably affected, had a shaken area of the order of 100,000 square miles.

There was little evidence of ground movement, and no fault displacement visible. Slight slumps and distortion of made and unconsolidated ground took place in the region from Compton to Long Beach.

Places where damage was exceptionally severe included Compton, Long Beach, and Huntington Park. Many structures, including water tanks, suffered. School buildings were among those most generally and severely damaged, and had the shock taken place during school hours great loss of life, would have occurred.

204 1933 May 16. VII. Niles Canyon on line of Hayward fault. Landslide; plaster cracked, windows broken, goods fell from shelves. Felt generally in the San Francisco Bay district.

205 1933 June 25. VIII. Wabuska, Nev.; brick chimneys fell and a cloud of dust rose from the nearby hills. Shock felt to distances of about 200 miles, giving shaken area of the order of 100,000 square miles. Distinctly felt at San Francisco and Fresno.

206 1933 October 2. Moderately strong earthquake near Long Beach, possibly not a true aftershock of the March 10 shock. Epicenter near Signal Hill. Considerable minor damage in Long Beach, Los Angeles, Compton, Bell, and other towns, chiefly to structures weakened in previous shocks. Felt as far as San Diego and Santa Barbara.

207	1934	Jan 30	VIII	Excelsior Mts	Nev
208	1934	June 7	VIII	Parkfield	"
209	1934	Dec 30	IX	Near Gulf of Calif.	Mex
210	1934	Dec 31	X	"	" "
211	1937	March 8	VII	Berkeley	"
212	1937	March 25	VII.4	Santa Rosa Mts.	"