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E. LESTER JONES, DIRECTOR

EARTHQUAKE HISTORY OF THE UNITED STATES

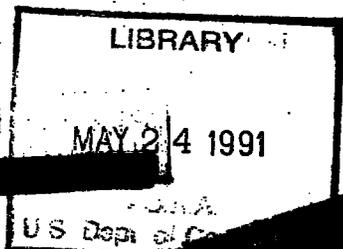
Exclusive of the Pacific Region

By

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EARTHQUAKE HISTORY OF THE UNITED STATES

Exclusive of the Pacific Region

By N. H. HECK

INTRODUCTION

The year 1925, during which seismological investigation was assigned by law to the United States Coast and Geodetic Survey, was a year of considerable earthquake activity. Accordingly, the bureau was at once overwhelmed with requests for information about the earthquake history of the country. It was found that this information was nowhere available in convenient form and that much of it was lacking. In order that proper replies might be made to inquiries and that logical development of seismological investigation might be carried out, it was necessary to undertake the task of making the earthquake history of the United States available to those interested. This information is scattered through many volumes, some of which are out of print and therefore accessible only in a few large libraries, and in some cases is found only in unpublished collections.

It is difficult for those consulting the accounts of earthquakes to obtain relatively uniform information about earthquakes of different periods since the treatment of individual earthquakes varies widely from the elaborate report of the California earthquake of 1906, one of the most complete ever published, to the inadequate reports of early earthquakes in which it is difficult to separate fact from fiction. The collection of the information depended on the initiative of individuals and therefore at times the information was excellent and at others wholly inadequate. In preparing the present volume it has been necessary to consult at least 100 volumes and 2 unpublished collections.

The purpose of the present publication is to cover the more important earthquakes of the United States, exclusive of the Pacific coast region, from the earliest times to the close of 1927. While no important facts have been omitted, the descriptions are concise and for the less important details it is necessary to consult the references which are given in every case.

For the purpose of listing and describing the earthquakes, the United States has been divided into four regions, or rather five, one being omitted from consideration. These are the northeastern region, including New England and New York, which, in addition to feeling the principal earthquake activity of Canada, has much of its own; the eastern region, which includes the Appalachian activity, which is a continuation of that of New England as well as a detached

region along the coast; the middle western region, or all the area between the region just described and the Rocky Mountains; and the western mountain region which includes all the remaining area except the Pacific coast region. It has been found that with this arrangement there are only two States in which there is a division of activity between two regions. In Tennessee there are quite distinct areas at opposite ends of the State which fall in different regions, and only central and eastern Nevada are included in the western mountain region, the activity in the western part being closely associated with that of California.

The publication includes all parts of the United States for which earthquake information is not available in the form of catalogues, the Pacific coast activity being covered by two existing catalogues and a third in course of preparation. Another reason for omitting the Pacific coast region is that it is more logical to treat it in connection with other activity in the Pacific area under the jurisdiction of the United States, as all the activity in that region is comparable. Such a volume may be issued later if found to be needed.

In using the information in this volume it should be borne in mind that exact seismological information has been available for only a short time. The most common source is the testimony of eye witnesses which is often subject to error, especially when the observations were made under conditions of mental stress and often of surprise and fear. It is now found that unless the number of reports from individuals is large it is difficult to appraise them properly because of difference in viewpoint. Also the reports, even if strictly accurate, may vary greatly over a short distance with the character of the geological formation. Much of the information is obtained from newspapers and while accuracy is attempted, such news gathering is done under difficulty and is subject to opposite tendencies at different times and places; of exaggeration in the desire for sensation, and of suppression, where such a policy seems best to meet the situation. In the early days much of the country was unsettled and in the thinly settled regions it was hard to secure reports. In some cases it is possible that no reports were received from the region of greatest intensity. There have been occasional errors as to year and date on the part of compilers. While every effort has been made to correct errors and to secure uniform treatment, the difficulties must be considered in using the information.

Nearly all of the published catalogues have attempted to give all the earthquakes which have occurred regardless of intensity. This publication is not a catalogue and it includes only earthquakes of intensity 5 and over, Rossi-Forrel scale. (See p. 3.) However, the area affected is also a measure of the intensity and importance and in a few cases earthquakes of reported intensity of 4, but which covered a considerable area, are included. This plan has resulted in the inclusion of practically all the earthquakes of general interest. It is not improbable that some of the earlier earthquakes which have been omitted should have been included but this would have required an amount of investigation more suitable in preparing an exhaustive regional catalogue. It is also possible that some included should have been omitted as of insufficient importance.

The references are given in such form that the original article or publication can be found with little trouble. These references are

intended to give full credit to the publication and to the author for the information. In comparatively few cases is there direct quotation as the need for conciseness prevents this. The degree of completeness of the present list is in large measure due to the cooperation of various persons including Ernest A. Hodgson, seismologist, Dominion Observatory, Ottawa, Canada; Rev. Francis A. Tondorf, chief seismologist, Georgetown University, Washington, D. C.; and Rev. James B. Macelwane, S. J. Director, Jesuit Seismological Association, St. Louis University, St. Louis, Mo. All these have contributed lists of authorities or information about individual earthquakes. Special credit is due Prof. Harry Fielding Reid, Johns Hopkins University, Baltimore, Md., who has permitted the use of information from his unpublished records, additional data about earthquakes published elsewhere, and complete checking of all the information against his records in so far as they cover the ground.

Technical terms have been avoided in so far as possible, though the use of a few has been found unavoidable. The origin of an earthquake refers to the point or region where the disturbance occurred which resulted in the earthquake. The term epicenter refers to the point or area on the earth's surface directly above the subterranean origin. Isoseismal lines are lines connecting all points where the earthquake was felt with a given intensity. These are generally based on the Rossi-Forel scale which immediately follows. This scale has been somewhat criticized as being unscientific but it seems well adapted to the class of information which is contained in this publication.

The information here available makes it possible to appraise the part of the United States included, as an earthquake region in comparison with the rest of the earth. Apparently the United States is of a little more than average seismicity or tendency to earthquake, but the important earthquakes, though several of them have been very violent, are of the type which tend to come at long intervals. A number of earthquakes have occurred in regions where from inspection of the surface geology great earthquakes would not be expected and there is special need for study of such regions. It is not difficult from the information from the past now readily available to decide on which areas need such investigation both from the viewpoint of earthquake frequency and concentration of population in regions subject to severe earthquakes.

ROSSI-FORREL SCALE OF INTENSITIES

1. *Microseismic shock*.—Recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

2. *Extremely feeble shock*.—Recorded by several seismographs of different kinds; felt by a small number of persons at rest.

3. *Very feeble shock*.—Felt by several persons at rest; strong enough for the direction or duration to be appreciable.

4. *Feeble shock*.—Felt by persons in motion; disturbance of movable objects, doors, windows; cracking of ceilings.

5. *Shock of moderate intensity*.—Felt generally by everyone; disturbance of furniture, beds, etc.; ringing of some bells.

6. *Fairly strong shock*.—General awakening of those asleep; general ringing of bells; oscillation of chandeliers; stopping of clocks; visible

agitation of trees and shrubs; some startled persons leaving their dwellings.

7. *Strong shock*.—Overthrow of movable objects; fall of plaster; ringing of church bells; general panic, without damage to buildings.

8. *Very strong shock*.—Fall of chimneys; cracks in the walls of buildings.

9. *Extremely strong shock*.—Partial or total destruction of some buildings.

10. *Shock of extreme intensity*.—Great disaster; ruins; disturbance of the strata, fissures in the ground; rock falls from mountains.

EARTHQUAKE CONDITIONS IN THE VARIOUS STATES

Alabama.—The State has had two earthquakes of considerable intensity, but as only three others are listed it can not be considered an active earthquake region. The earthquakes have occurred chiefly in the northern part of the State near the end of the Appalachian Mountain system.

Arizona.—It is certain that a number of the earlier Imperial Valley earthquakes were felt in this State, and it is likely that early earthquakes claimed to be strong at Fort Yuma actually occurred in that valley. Five earthquakes are listed as occurring in Arizona between 1906 and 1916. Area ranged from 15,000 square miles and intensity from 7 to 9, so that this State appears to be subject to occasional fairly strong earthquakes. The amount of detail regarding many of the earthquakes is small because large sections of the State have little or no population.

Arkansas.—This State felt the New Madrid earthquakes quite severely and suffered topographic change in its northeastern portion. It also felt strongly the shocks of 1843, 1895, and 1917. A shock in 1882 was sharply felt in the western part of the State. Only six are listed as occurring within its borders. For five of these, area range was 18,000 to 135,000 square miles and intensity range 5 to 8. The State accordingly has had considerable earthquake activity, though damage from earthquakes, except in case of the New Madrid, has been small.

Colorado.—Only three moderate earthquakes have been listed for this State.

Connecticut.—Eight earthquakes are listed for this State, though the number has been very much greater, as only a few of the East Haddam earthquakes are mentioned. The most severe of these was in 1791, with greater area and intensity than any since. This region has long been famous for the Moodus noises, a peculiar type of earthquake rumble. The shock of 1925 was in this region. Otherwise the shocks in this State seem to be local in character and of moderate intensity.

Delaware.—The small extent of this State and the generally quiet area make it not surprising that only two earthquakes of small extent have been listed.

Florida.—The geological formation of this State would seem to make earthquake occurrence unlikely. There has, however, been one of intensity 6 to 8 felt over 25,000 square miles. One other listed was local.

Georgia.—This State has felt strongly a number of earthquakes occurring outside of its borders, especially the New Madrid and the Charleston, as well as the South Carolina earthquake of 1913. Only four are listed with area range 10,000 to 50,000 square miles and intensity range 6 to 7. This State seems more likely to feel earthquakes occurring elsewhere than to have any of importance within it.

Idaho.—Twelve earthquakes are listed for this State, though half of these are concentrated in the years 1916 to 1918. Three ranged in area from 10,000 to 50,000 square miles and the rest affected less than 10,000 square miles. Considering the nature of the region the earthquake activity appears small.

Illinois.—Fourteen earthquakes are listed for this State and a number occurring outside were sharply felt. That of 1912 and one or two others were felt in the northern part of the State. Most of the remainder were in the south part which adjoins the New Madrid region. The type of shock most characteristic has been that with area range of 30,000 to 40,000 square miles and intensity range 6 to 8. This is a State where further earthquake investigation is needed, though it now has several seismograph stations.

Indiana.—Eight earthquakes of intensity 5 to 7 are listed, four of which had an area range of 60,000 to 100,000 square miles. Most of them occurred in the southern part of the State. They are similar in type to those described for Illinois.

Iowa.—Only two light earthquakes are listed for this State.

Kansas.—Four earthquakes are listed, that of 1867 having been fairly severe and felt over an area of 300,000 square miles with intensity 7 to 8 as the maximum. Since all the others were minor it seems likely that earthquakes of this intensity are of infrequent occurrence.

Kentucky.—Ten earthquakes are listed for this State and it has felt many which occurred in near-by States. Some of the early earthquakes appear to have been of very considerable extent, as those of 1924 and 1927 were felt over areas of 130,000 and 150,000 square miles, respectively. This State has a considerable number of minor earthquakes.

Louisiana.—No earthquakes have been listed for this State.

Maine.—Not only is Maine adjacent to active regions in Canada, both in New Brunswick and along the St. Lawrence River, and accordingly has felt strongly a number of Canadian earthquakes, but it has 17 listed as occurring within its borders. Most of these were felt over areas of less than 20,000 square miles, but one in 1904 was felt over at least 300,000 square miles. In 1918 there was a more localized shock of considerable intensity. This may then be considered a region of not infrequent minor activity with an occasional severe shock within or near its borders.

Maryland.—Seven earthquakes of moderate extent and intensity are listed. Central Maryland has felt a number of earthquakes occurring in Virginia.

Massachusetts.—In addition to feeling some of the more severe Canadian earthquakes, 17 are listed for this State. In colonial times there were a large number of earthquakes in the northeast part of the State near Newburyport, and several of these, especially that of 1727 (75,000 square miles), were widely felt. That of 1755, central west of Boston, was felt over an area of 300,000 square miles. The shock of 1925 in the vicinity of Boston was quite sharp. Numerous moderate shocks have been felt in the southeast part of the State.

Michigan.—The greater earthquakes of the St. Lawrence Valley are felt strongly in this State, but of the seven listed as occurring within it all but one are local in character. The shock of 1906 was felt over a large area with maximum force 8 to 9 and did damage in the mining region which might be expected from a shock of the great-

est intensity, but this may have been due to unstable conditions resulting from mining operations.

Minnesota.—Two moderate shocks are listed for this State. Little is known in regard to that of 1860.

Mississippi.—No earthquakes are listed for this State, though several occurring to the north have been felt within it.

Missouri.—Nineteen earthquakes have been listed for this State, of which a number have been very severe. The New Madrid earthquakes of 1811 and 1812 were exceptionally severe and caused important topographic changes. Further changes on a smaller scale were caused by the shocks of 1843 and 1895, which were felt over areas of 400,000 and 1,000,000 square miles, respectively. Other shocks of considerable intensity occurred in 1878, 150,000 square miles; 1883, 80,000 square miles; 1903, 70,000 square miles; and 1917, 200,000 square miles. This is clearly an important earthquake region and one where earthquake investigation should be on an adequate scale.

Montana.—Eight shocks are listed but only that of 1925 and its after shocks have been of importance. That one was felt over an area of 310,000 square miles with maximum force 9, and two later shocks were felt over areas of 25,000 and 30,000 square miles, respectively. This region seems to be subject to strong earthquakes at long intervals, but generally the activity is moderate.

Nebraska.—Only two earthquakes are listed, in 1877 and 1902. The former was felt over 140,000 square miles and the latter over 35,000. Earthquake activity seems to take the form of fairly strong shocks at long intervals.

Nevada.—The very considerable activity in the western part of the State is considered as belonging to the Pacific coast region, so that only five earthquakes are listed. Two of these, those of 1915 and 1916, were felt over areas of 200,000 square miles in each case and the others were local.

New Hampshire.—Since this State has its greatest length nearly at right angles to the St. Lawrence Valley region, only a small portion of its area feels the Canadian earthquakes strongly. There have, however, been a considerable number in the southern part of the State, perhaps associated with the activity in northeastern Massachusetts. Ten are listed, all effecting small areas but two, whose areas reached 15,000 and 20,000 square miles, respectively.

New Jersey.—The earthquakes have been generally moderate and only five are listed. That of 1895 in the western part of the State was felt over 35,000 square miles. The 1884 earthquake of New York City was sharply felt.

New Mexico.—Central New Mexico had had a very considerable amount of earthquake activity over a long period of years. The prevailing type has been strong but very local. In 1897 and 1906 the areas affected were fairly large, ranging from 60,000 to 100,000 square miles. Since that time the activity has been moderate, but is likely to recur from time to time.

New York.—With its greatest length roughly paralleling the St. Lawrence Valley, the more important earthquakes of that region are felt strongly. In addition, 22 shocks have been listed as occurring within the State, most of which have affected only a small area. These have occurred in the Adirondacks, near New York City, and in the western part of the State. That of 1897 was felt over 150,000

square miles and that of 1884 over 31,000 square miles. Most of the shocks are local.

North Carolina.—The Charleston earthquake of 1886 was felt strongly in this State. Of the eight earthquakes listed, only two were of importance. That of 1916 was felt over 200,000 square miles and that of 1924 over 56,000 square miles. There were a series of earthquakes in McDowell County in 1874, very local but fairly strong and lasting over several months. All of these were in the western part of the State.

North Dakota.—No earthquakes listed.

Ohio.—Five earthquakes are listed, two being of importance. That of 1875 was felt over 40,000 square miles and that of 1884 over 125,000. Earthquakes are few, but occasionally strong.

Oklahoma.—Only one of moderate extent is listed, but that of 1884, occurring to the east, was strongly felt.

Pennsylvania.—A few Canadian earthquakes have been felt. The five listed were all moderate.

Rhode Island.—Only one moderate shock is listed but several occurring in southeastern Massachusetts have been felt.

South Carolina.—In addition to the major Charleston earthquake of 1886 and its aftershocks, there was a fairly strong shock in western South Carolina in 1913 which was felt over 43,000 square miles. There were two others felt over 30,000 and 35,000 square miles, respectively, and two over 10,000. This is enough activity to warrant special investigation.

South Dakota.—In addition to feeling a strong Canadian earthquake and several from adjacent States, five have been listed, all of which were local except one, in 1911, which was felt over 40,000 square miles.

Tennessee.—The western part of this State was strongly affected by the New Madrid earthquakes of 1811 and 1812 and also by those of 1843 and 1895. All these seem to have caused some topographic changes. That of 1843 apparently had its origin in this State and was felt over an immense area. Those of 1883 and 1887 were felt over areas of 80,000 and 130,000 square miles, respectively. The 16 earthquakes listed occurred in 2 distinct regions in the eastern and western parts of the State. They will accordingly be found listed under two different regions since the dividing line passes through the State. With the considerable activity, seismological investigation is important.

Texas.—Three earthquakes are listed. Little is known of one which may have been severe. That of 1925 is the strongest known, having been felt over an area of 200,000 square miles. The shock of 1882 occurring outside the State was strongly felt in north Texas.

Utah.—There was a strong shock in 1921 affecting a large area and doing some damage in the central region. Nineteen others have been listed, most of these being local and only one being felt over 50,000 square miles. The situation is much like that described for New Mexico with long-continued local activity in certain regions. The activity is fairly well distributed throughout the State though strongest in the vicinity of Great Salt Lake.

Vermont.—The situation with regard to Canadian earthquakes is very similar to that described for New Hampshire. Only two shocks are listed and these were moderate.

Virginia.—This is a State of considerable earthquake activity though rarely strong. Fifteen shocks are listed. Of these one in 1897 was felt over 280,000 square miles and another 150,000. One in 1918 affected 100,000 square miles and four others had an area range from 20,000 to 50,000. Buckingham County has been subject at intervals to activity continuing over a considerable period and Giles County had a severe earthquake. Other regions of activity lie in or near the Shenandoah Valley. There is need for seismological study in this State.

West Virginia.—No earthquakes are listed. Several have been felt which occurred in adjacent States.

Wisconsin.—No earthquakes listed. Those of northern Michigan have been felt.

Wyoming.—Five earthquakes of moderate extent and intensity listed.

OUTSIDE THE UNITED STATES

Canada.—Nineteen earthquakes have been listed which were felt in the United States. Nine of these were felt over areas of from 100,000 to 2,000,000 square miles, five had an area range from 30,000 to 90,000. The regions of their occurrence have been in New Brunswick, along the St. Lawrence River, in Ontario west of Niagara, and one in Saskatchewan.

Mexico.—The Sonora earthquake of 1887 was widely felt over the southwestern part of the United States.

West Indies.—The Guadeloupe earthquake of 1843, disastrous at the origin, is claimed to have been felt in the eastern United States. The Cuban earthquake of 1880 was sharply felt in southern Florida.

EXPLANATION OF DETAILS IN THE LISTS OF EARTHQUAKES

In the following lists the year and the date may be accepted as correct unless doubt is expressed in the list itself. In several cases the same earthquake appears under different years in different catalogues but it is believed that all these cases have been corrected. Because of the small number of earthquakes listed prior to 1752, the year of the adoption of the Gregorian calendar, all dates are given according to that calendar, or new style.

The time of day given is the standard time of the region of the origin. Time is expressed continuously from midnight to midnight or 0 to 24 hours. Times after noon may be obtained by subtracting 12 hours for all times greater than 12 hours. When the hour alone is given the time is uncertain. When the minute is given the time is fairly well known though the minute can not be relied on as being absolutely correct.

The locality given in the list is usually that of the origin though in some cases where the place of origin is uncertain the extent of the area where it was felt is indicated. Where names of towns are given they can be found on any good large scale map.

The position of the origin, if in some doubt, is given to the nearest degree. If tenths of degrees are given the origin is definitely known except that the tenths of degrees can not be relied on to be absolutely accurate. The positions given are the most probable from existing data. Very few have been obtained by instrumental observation. In some cases they represent the place of maximum disturbance; in others, all available information has been plotted on a map and the probable origin deduced from this.

The area where the earthquake was felt is always somewhat indefinite. Probably in most cases it is approximately that included within isoseismal 3, though in many cases the position of this line is indefinite. However, the estimated area affected in connection with the estimated maximum intensity is the best gauge of the importance of an earthquake.

Intensities, unless otherwise stated, are the maximum reported. It is usually not possible to indicate the size of the area over which this maximum intensity was felt as the information is too incomplete.

Duration of the shock and the apparent direction from which it comes, considered important information in many catalogues, are not generally given in this publication. Such information is especially subject to error. Few people are able to estimate time intervals accurately under the best conditions and when disturbed are almost certain to be in error. With regard to apparent direction, the sensations are probably more accurate but we now know that the waves in the central region are very confused and the apparent direction is of little value in deciding on the origin.

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- 1A. *Jesuit Relations*, Thwaite translation, volume 47, pages 37-57.
2. *American Journal of Arts and Sciences* and its predecessor, *Sillimans Journal*. The latter continued till 1845 and then the former was published in four series as follows: First series, 1846-1866; second series, 1867-1870; third series, 1871-1897; fourth series, 1898 to present. As the numbering of volumes corresponds to each series and there are two volumes for some years, the system is followed here of referring to the year. In a few cases this may make it necessary to look in two volumes but this is not a serious matter as most of the information is given in this publication. Inasmuch as all the references are in the nineteenth century, only the last two digits of the year will be given. Thus 2-87 refers to the volume for the year 1887. This reference contains the important catalogue of C. G. Rockwood which continued from 1872 to 1877.
3. *Bulletin of the Seismological Society of America*. Since this started in 1911 and annual volumes have followed, the year may be obtained by adding 10 to the number of volume. Accordingly reference is by volume number.
4. *Monthly Weather Review of the United States Weather Bureau*. The earthquakes are always described in the issue for the month in which they occurred and in rare cases in that for the following month so that the general reference to this source is sufficient. In earlier years the amount of earthquake information varies greatly, being quite complete for some periods and at others entirely lacking. However, from 1915 to June, 1924, during which period the Weather Bureau was charged with seismological investigation, the information is very complete.
5. *Bulletin of the Natural History Society of New Brunswick*, No. 32, volume 5, part 2. *List of Recorded Earthquakes in New Brunswick to 1904* by Samuel Kain.
6. *Nature*, London. Reference made in same manner as for *American Journal of Arts and Science*. (See reference No. 2.)
7. *Report of British Association for the Advancement of Science for 1911*, Appendix No. 1, page 649.
8. Unpublished records of Harry Fielding Reid, Johns Hopkins University, Baltimore, Md. These include a card index and volumes of newspaper clippings, as well as special correspondence. In many cases where quite complete information is available from other sources, valuable supplementary information regarding area, intensity is given by Reid.
- 8A. *British Association for the Advancement of Science*, Report for 1911, page 41. *List of Strong Shocks in the United States and its Dependencies*, Harry Fielding Reid.
9. Unpublished Records of J. B. Woodworth, Harvard University, through the courtesy of Francis A. Tondorf, S. J., Georgetown University, Washington, D. C.
10. *Quarterly Seismological Report of the United States Coast and Geodetic Survey*, which began with 1925. The last report for that year also contains information for the second half of 1924 to connect with Weather Bureau publication. Earthquakes are described under the month in which they occurred.
11. *The Registration of Earthquakes and Press Dispatches on Earthquakes*. Georgetown University publication by Francis A. Tondorf, S. J., chief seismologist. Earthquakes found under year and date. Also monthly *Seismological Dispatches* which give in advance of publication the same information in more detail.
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13. *Transactions of the Royal Society of Canada*, 1927. The St. Lawrence Earthquake, February 28, 1925, by Ernest A. Hodgson.
14. *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 1902, No. 5. Earthquakes of North America, by Emil Deckert.
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16. *United States Geological Survey*, Ninth Annual Report, 1887-88, page 209. The Charleston Earthquake of August 31, 1886, by Capt. Clarence E. Dutton, United States Ordnance Corps.
17. *Michigan Geological and Biological Survey Publication* 5, Geological Series 3. Earthquakes in Michigan, by William Herbert Hobbs, 1911.

18. Atlantic Monthly, November, 1869. Earthquakes of the Western United States.
 19. United States Geological Survey Bulletin No. 494, 1912. The New Madrid Earthquake, by Myron L. Fuller.
 20. American Geologist. References as in case of reference No. 2.
 21. Popular Science Monthly. References as in case of reference No. 2.
 22. Illinois Academy of Sciences, volume 3, 1910, page 132, article by J. A. Udden.
 23. Illinois Academy of Sciences, volume 5, 1912, article by Anton D. Udden.
 24. Smithsonian Report for 1874. Series of Earthquakes in North Carolina by Warren du Pre.
 25. Smithsonian Miscellaneous Collections, 1087. A Catalogue of Earthquakes on the Pacific Coast, 1769-1897. Edward S. Holden.
 26. Smithsonian Miscellaneous Collections, 1721. Catalogue of Earthquakes on the Pacific Coast, 1897-1906. Alexander G. McAdie.
- The word "Special," in authority column, refers to additional investigation of newspapers by the United States Coast and Geodetic Survey.*

NORTHEASTERN REGION

RÉSUMÉ

This region, with adjacent Canada, has a comparatively large number of earthquakes. The region north of the St. Lawrence Valley is apparently almost entirely free from earthquakes. Some geologists have associated the activity with the fact that during the glacial periods the ice load deformed the earth's crust and consider that it is gradually coming back to its normal position, but this can not be proved. Such readjustment would probably be accompanied by the type of earthquakes which occur in this region. The activity occurs both in the extension of the Appalachians and in the narrow coastal plain, and the Adirondacks region has considerable minor activity.

The inclusion of New York in the region might at first appear illogical, but its relation to the Canadian region as well as to that of New England justifies its inclusion.

EARTHQUAKES OF NEW ENGLAND AND NEW YORK

Year	Date	Hour	Locality	N. lat.	W. long.	Area (square miles)	Intensity	Authority
1638	June 1 or 2	15-16	Plymouth, Mass.					1
1642 or 1644	Mar. 5-7		Newburyport, Mass.	42.8	70.8			1
1668	Apr. 4		New England				(4)	7
1660	Jan. 31		do.				(4)	7
1662	Jan. 26		do.			(1)	8	1
1663	Feb. 5		St. Lawrence Valley	46.6	72.5	750,000	10	1, 1A
1727	Nov. 8	22.40	Newburyport, Mass.	42.8	70.8	75,000	8	1
1732	Sept. 15	11.00	Ontario, Canada	46	74			1
1737	Feb. 16	16.30	New York and Boston				8	1
	Dec. 7	23.00	do.					
1741	Dec. 6	8.00	East Massachusetts	42.2	71.2	1,000	7-8	1
1755	Nov. 18	4.11	(Massachusetts and adjacent States.	42.4	71.2	300,000	7-8	1
	Nov. 22	20.27	do.				5-6	1
	Dec. 19	22.00	do.					
1783	Nov. 29	22.50	New Hampshire-Pennsylvania.					1
1791	May 16	20-22	East Haddam, Conn.	41.5	72.5	35,000	8	1
	Aug. 28		do.					1
1792	Jan. 11		do.					1
1794	Mar. 6		do.					1
1805	Aug. 11		do.					1
1810	Nov. 9	21.15	Exeter, N. H.	43.0	70.9		7	1
1817	Oct. 5		Woburn, Mass.	42.5	71.2		8	1
1827	Aug. 23		New London, Conn.	41.4	72.7		5	1
1837	Apr. 12		Hartford, Conn.	41.7	72.7		5	1
1840	Aug. 9		South Connecticut	41.5	72.9	7,500	6	1
1841	Jan. 25	a. m.	New York					1
1847	Aug. 8	10.00	Southeast Massachusetts	42	71	7,500	6	1
1848	Sept. 9	22	Rhode Island, Connecticut, New Jersey, Pennsylvania.					1
1852	Nov. 27	23.45	Northeast Massachusetts	42.8	71.0	2,000	5	1, 2-53
1853	Mar. 12	2-3	North New York	43.7	75.5		7	1, 2-53
1854	Dec. 10	12.30	Massachusetts	43.0	70.8	600	5	1
1855	Feb. 8	6.30	Canada, felt to south	46.2	64.8	85,000	7-8	1, 5
1857	Oct. 23	15.15	Western New York	43.2	78.6	18,000	7	2-58
1858	June 30	22.45	New Haven, Conn.	41.3	73.0	1,000	4-5	1
1860	Oct. 17	6.00	Canada, felt to south	47.5	70.0	700,000	8-9	1, 12
1861	July 12	21.00	do.	45.0	75.6	100,000	7-8	1
1867	Dec. 18	3.00	New York and Vermont.	44	73	(5)		1
1869	Oct. 22	6.00	Maine and New Brunswick.	45.0	67.2	250,000	8	1, 5
1870	Oct. 20	11.20	Canada, felt to south	46.0	72.5	1,000,000	8-9	1, 5, 12
1872	Jan. 9	19.54	do.	47.5	70.5	100,000	7-8	2-72
	July 11	5.25	Near New York City	40.9	73.8	100	6	2-73
	Nov. 18	14.00	Concord, N. H.	43.2	71.6	1,000	4-5	2-73

¹ Widespread.

² Doubtful.

⁴ Violent.

Earthquakes of New England and New York—Continued

Year	Date	Hour	Locality	N. lat.	W. long.	Area (square miles)	Intensity	Authority
1873	July 6.....	9.30	Canada, near Buffalo, N. Y.	43.0	79.5	30,000	6	2-74
1874	Feb. 27.....	22.40	Southeast Maine.....	44.8	68.7	6,000	6	2-75
	Dec. 10.....	22.25	Westchester, N. Y.....	40.9	73.8	2,000	7	2-75
1875	July 28.....	4.10	Connecticut.....	41.8	73.2	2,000	6	2-76
1876	Sept. 21.....	23.30	Southeast Massachusetts.	41.8	71.0	2,000	5	4
1877	Nov. 4.....	2.00	Canada, felt to south.....	45	74	90,000	7	2-78, 6-77
1878	Oct. 4.....	2.30	Hudson River, N. Y.....	41.5	74.0	600	5-6	2-79
1879	Aug. 21.....	3.00	Canada, near Buffalo, N. Y.	43.2	79.2	1,300	6	2-80
1880	May 12.....	7.45	Northeast Massachusetts.	42.8	70.9	500	5	2-81
1881	Jan. 20.....	21.40	Bath, Me.....	44	70	2,000	4-5	2-81, 4
1882	Dec. 19.....	17.20	New Hampshire.....	43.2	71.4	1,000	4-5	4
	Dec. 31.....	22.00	Maine and New Brunswick.	45	67	80,000	5	8
1883	Feb. 27.....	22.30	Rhode Island.....	41.5	71.5		5	2-85, 4
1884	Aug. 10.....	14.07	Near New York City.....	40.6	74.0	31,000	7	2-85
	Nov. 23.....	0.30	Southern New Hampshire.	43.2	71.7	8,000	6	2-85
1891	May 1.....	19.10	do.....	43.2	71.6	3,000	5	8
1893	Mar. 9.....	0.30	Near New York City.....	40.6	74.0	(⁵)	6	8
1895	Sept. 1.....	6.09	New Jersey, felt to east.					See p. 26.
1896	Mar. 23.....	19.56	Maine and New Brunswick.	45.2	67.2	8,000	4-5	8
1897	May 27.....	22.16	Northeast New York.....	44.5	74.5	150,000	7	8
1898	Sept. 17.....	10.54	Near Belfast, Me.....	44.3	69.1	(⁵)	4-5	8
1903	Jan. 21-23.....		East Massachusetts.....	42.1	70.9	500	5	8
	Apr. 24.....	7.30	Northeast Massachusetts.	42.7	71.0	350	5	8
	Dec. 25.....	7.30	Ogdensburg, N. Y.....	44.7	75.5	1,500	5	8
1904	Mar. 21.....	1.04	Southeast Maine.....	45.0	67.2	300,000	7-8	3-1, 8
1905	July 15.....	5.10	Maine and New Hampshire.	44.3	69.8	20,000	5-6	8
	Aug. 30.....	5.40	Newton, Mass.....	42.3	71.2	400	5	4
		5.43	do.....					
	Oct. 22.....	a. m.	North Vermont.....	44.9	72.2	(⁵)	5	4, 8
	Jan. 24.....	6.30	Schenectady, N. Y.....	42.8	74.0	(⁵)	5	4
1907	June 29-July 11.....		Southwest Maine.....	43.5	70.5	1,200	3-5	8
	Oct. 15.....	19.10	Northeast Massachusetts and Southeast New Hampshire.	42.8	71.0	1,200	6	4, 8, 9
1908	Feb. 5.....	3.20	Housatonic Valley, Conn.					9
1910	Jan. 22.....	20.15	Cumberland County, Me.	43.8	70.4	150	5	8
	Aug. 30.....	9.03	Newport, N. H.....	43.4	72.1	700	4-5	9
	Oct. 20.....	16.30	Penobscot Bay, Me.....	44.3	69.8	900	5	8
1912	Dec. 11.....	5.15	Maine and New Brunswick.	45.0	68.0	20,000	5-6	5, 8
1913	Apr. 28.....	19.30	North New York.....	44.7	75.6	3,000	6-7	8
	Aug. 10.....	0.15	Lake Placid, N. Y.....	44	74	2,500	6	8
1914	Jan. 13.....	3.00	Maine and New Brunswick.	45.1	67.2	(⁵)	5	8
	Feb. 10.....	1.31	Canada, felt to south.....	46.2	74.9	200,000	6-7	8
	Feb. 21.....	19.15	West Maine.....	45.0	70.5	8,000	5	8
		19.35						
1916	Jan. 5.....	8.566	Near Lake George, N. Y.....	43.7	73.7	300	5	4, 11
	Feb. 2.....	23.2	Mohawk Valley, N. Y.....	43	74	8,000	4-5	4
	June 3.....	16.15	Near New York City.....	41.0	73.8	(⁵)	5	4
	Nov. 1.....	21.32	Glens Falls, N. Y.....	43.3	73.7	300	6	11
1917	May 22.....	4.00	New York and Canada.....	45	75	15,000	4-5	8
1918	Aug. 21.....	0.12	South Maine.....	44.2	70.6	15,000	7-8	4
1921	Jan. 19.....	5.00	Glens Falls, N. Y.....	43.3	73.7	(⁵)	5	4, 11
	Jan. 27.....	a. m.						
1924	Sept. 30.....	3.52	Canada, felt to south.....	47.6	69.7	30,000	6	9
1925	Jan. 7.....	8.07	East Massachusetts.....	42.6	70.6	20,000	5	3-14, 10
	Feb. 23.....	21.19	Canada, felt in United States.	47.6	70.1	2,000,000	9	3-15, 10, 13
	Apr. 24.....	2.56	Southeast Massachusetts.	41.8	70.8	1,600	5	10, 11
	Oct. 9.....	8.56	Southeast New Hampshire and Maine.	43.7	70.7	15,000	7	8, 10
	Nov. 14.....	8.04	Hartford, Conn.....	41.5	72.5	853	5	10
1926	Mar. 18.....	16.09	New Ipswich, N. H.....	42.6	71.8	800	5	10
	Apr. 11.....	22.30	New Rochelle, N. Y.....	40.9	73.9	150	5	10
	Aug. 28.....	16.00	Western Maine.....	44.7	70.0	3,000	6	10
1927	Mar. 8.....	23.08	Concord, N. H.....	43.3	71.4	600	5	10

⁵ Local.

MAJOR EARTHQUAKES—NORTHEASTERN REGION

EARTHQUAKE OF FEBRUARY 5, 1663

Epicenter.—Probably in vicinity of Three Rivers, Quebec.

Area felt.—Probably all of eastern Canada and northeastern part of the United States.

Intensity.—Probably 10 at epicenter and high over a large area.

Description.—This earthquake occurred so early in colonial history that the accounts are far from definite. Many of them are quite lurid and tell of mountains being thrown down and of great forests sliding into the St. Lawrence River. However, a number of French priests were in the country at the time and one of them had passed through the region of greatest change several years before.

There seems, therefore, to be little doubt that this was a very severe earthquake and that in the vicinity of Three Rivers there were great rock slides so that a series of waterfalls were considerably modified. There were important landslides along the St. Lawrence, and it is stated that the water remained muddy for a month. This earthquake was sharply felt in New England, in every case appearing to come from the northwest. On Massachusetts Bay houses were shaken, pewter fell from shelves, chimneys were broken and those of rough stone were overturned or thrown down.

It seems probable that if this had occurred at a later date very considerable damage would have been done.

EARTHQUAKE OF NOVEMBER 18, 1755

Epicenter.—Probably near Cambridge, Mass.

Area felt.—From Lake George to 200 miles east of Cape Ann, and from Chesapeake Bay to Annapolis, Nova Scotia.

Intensity.—Probably 10.

Description.—The earthquake came with a roaring sound like distant thunder, appearing to come from the northwest. The shock resembled a long rolling sea and it was necessary to hold to something to prevent being thrown to the ground. Tops of trees swayed through a large angle. Houses were shaken, windows rattled, and beams cracked. This lasted two minutes. The shock was felt from Chesapeake Bay to Annapolis, Nova Scotia. It was felt on Lake George and a ship at sea 200 miles east of Cape Ann was thought to have grounded though the depth was considerable. Many chimneys were thrown down or twisted and roofs were wrecked by the fall of chimneys. Gable ends of brick buildings were thrown down. Vanes on buildings were broken off. Stone fences were generally knocked down. A very strong cistern was broken by the agitation of the liquid within it. At Pembroke and Scituate, Mass., small chasms were broken open in the earth through which fine sand reached the surface. In the harbors and along the coast large numbers of fish were killed and many vessels felt shocks as if they were striking bottom. The shock

described was at 4.11; there was another at 5.29. On November 22, 8.27, there was a quite severe shock and another on December 19, 22. (Phil. Transactions, Vol. L, 1757.)

EARTHQUAKE OF FEBRUARY 28, 1925, ST. LAWRENCE VALLEY REGION

Time of occurrence.—21-19-20.

Epicenter.—47°6 N., 70°1 W.

Area where felt.—Much of eastern Canada, south to Virginia, and west to the Mississippi River.

Intensity.—In the United States nowhere more than 7 and for most of area, 4 or less.

Description.—The earthquake was remarkable for moderate intensity with great area, and for great variations in intensity at the same distance from the center in various directions. It also probably affected a larger number of people than any other felt in the United States, since it was felt with a force of 4 or more in New York and Boston.

While a very large area was shaken the area of important damage was comparatively small. The epicentral region has few inhabitants and as the instrumental records were somewhat conflicting it was not easy to determine the epicenter. The damage was confined to a narrow belt on both sides of the St. Lawrence River.

The effects at Quebec are instructive as they were confined to places where the depth of soil is considerable. The upper part of the wall of the Canadian Pacific Railway station was damaged. The large grain receiving sheds and elevators are specially worthy of mention because the structure, while very well built, formed a kind of inverted pendulum with the greater part of the mass high above the ground. Cracks were found in the ground parallel to the length of the building both outside and inside and at these cracks the floor was pulled apart as if by a giant hand. Columns pulled away from the large bolts holding them to the foundation. In some places the reinforcing steel worked back and forth so that the concrete fell away and exposed it. There was no one in the building but, judging from the effects, the swaying and noise must have been terrific. At a large hotel not far away which was built on rock it was scarcely known that an earthquake occurred. This indicates how much care must be taken in judging the position of the epicenter from effects on buildings as terrain, character of buildings, and geological formations are all factors in effects on buildings.

In the vicinity of the epicenter there are few towns and few buildings of considerable size except occasional churches. At Pointe au Pic two old buildings with thick stone walls were badly damaged. At St. Urbain a church was badly damaged but otherwise only a few chimneys were thrown down, these being on buildings which were new and strong and on a rock foundation. At Riviere Ouelle a church in good repair though 53 years old, but built on alluvial soil, had the bells in its tower dislodged and the organ pipes twisted. Several houses were damaged while only 20 miles away buildings on rocky ground were unharmed.

In some places no sound was noted while in others the sound arrived before the earthquake was felt, this being more noticeable in the less disturbed area. The after shocks were preceded by a

sound of low frequency like thunder and followed by a sound somewhat like the ripping of cloth.

Vertical motion could be expected near the epicenter but there were few opportunities to observe it directly. At Riviere Ouelle a stone weighing 200 pounds was thrown clear of its foundation though there were dowel pins 2 feet apart and extending 2 inches above the foundation. A chimney collapsed through vertical thrust from below.

The ground was deeply frozen. Cracks appeared on the south shore in the form of grids. There was a crack near Riviere Ouelle 4 inches wide and more than 2 feet deep, after it had partly filled. No cracks in rocks were reported. In places of deep alluvium the frozen part seems to have slid on the unfrozen part, leaving cracks through which water and wet sand reached the surface.

The only way to determine whether change of elevation occurred was by lines of precise levels. A former line in the general region was rerun with definite indications in some places of changes on the order of 3 inches. There were no lines available in the epicentral region as owing to lack of railways no previous line had been run.

There was considerable rotation of monuments. At Murray Bay furniture and statues rotated in a clockwise direction, but monuments in the cemetery fell in every direction except west. At Baie St. Paul monuments turned counterclockwise or fell toward the southeast. In other cemeteries in this region rotation was in both directions.

One hundred after shocks were noted in a week at Chicoutimi, and shocks continued for several months. The strongest were those of April 10, felt at Murray Bay, and April 25 at Chicoutimi.

The epicenter is near the boundary of the Laurentides Park about halfway between Murray Bay and Chicoutimi. Geologists believe that there are fault lines in the region but it has never been accurately surveyed, and the only source of information is from rough surveys by lumber companies.

While this earthquake was felt widely in the northeastern part of the United States and especially in Michigan there is no record of damage and there was no direct loss of life, though there were several deaths from shock. It was instrumental in securing more attention to the earthquake problem than at any time since 1906.

A preliminary shock on September 30, 1924, is described on page 23.

INTERMEDIATE AND MINOR EARTHQUAKES—NORTHEASTERN REGION

1638. June 1 or 2. This seems to have been quite a violent shock. At Plymouth, Mass., people had to hold on to objects to keep from falling. Ships at sea were shaken. It was felt in Connecticut and at Narragansett.

1642 or 1643. March 5 to 7. Newburyport, Mass., was strongly shaken.

1658. April 4. New England; violent.

1660. January 31. New England, violent.

1662. January 26. There were three violent shocks in New England. Chimneys were thrown down.

1727. November 8. There was a heavy rumbling noise at Newburyport, Mass., followed within 30 seconds by a heavy shock. Houses shook and rocked as if falling to pieces and pewter and china

were thrown from the shelves. The ground rose and fell and it was difficult to stand upright. Stone walls and chimneys were shaken down. There was considerable change in flow of springs and in some cases in the character of the water. It was felt from the Kennebec to the Delaware River and from ships at sea to the extreme western settlements. Other shocks in this vicinity to 1744.

1732. September 15. A violent earthquake in Canada did considerable damage in Montreal where seven persons were killed and some injured. Damage was done to houses at Piscataqua. It was felt slightly at Boston and reported felt at Annapolis, Md.

1737. February 16 and December 7. Shocks felt at New York and Boston. Chimneys were thrown down.

1741. December 6. Felt at Roxbury, Dedham, and Walpole, Mass.

1783. November 29. Felt from New Hampshire to Pennsylvania. At New York three shocks were felt at 21 and 23 hours on this date and at 2 the following morning, the first two being the strongest. At Philadelphia the first and last were felt. The shocks were moderate at Boston and elsewhere in New England.

1791-1805. East Haddam, Conn. The region around New Haddam, Conn., was known by the Indians as the place of noises, apparently indicating that earthquakes were of common occurrence at an early date. The first definitely recorded was on May 16, 1791, with two shocks, the first being the more violent. Stone walls were shaken down, the tops were thrown off chimneys, and latched doors were thrown open. There were at least 100 shocks during the day and night following. The shock was felt from Boston to New York and Philadelphia, apparently centering near East Haddam. Rocks weighing several tons were moved and clefts opened in the soil. The descriptions indicate that there was another shock of the same intensity on May 18 but Reid's investigations indicate that this is wrong. Other important shocks occurred on August 28, 1791, January 11, 1792, March 6, 1794, and August 11, 1805.

1810. November 9. Exeter, N. H. This was accompanied by a very unusual noise like a great explosion directly beneath the feet. It was most violent between Haverhill, Mass., and Portsmouth, N. H., and lasted a minute at the latter place. A vessel in Portsmouth Harbor seemed to strike bottom.

1817. October 15. Woburn, Mass. Walls thrown down. Few details known.

1827. August 23. New London, Conn. Shock accompanied by heavy rumbling; lasted 40 seconds.

1837. April 12. Hartford, Conn. Jarred loose articles and set lamp swinging; bells rang; and people rushed out of houses.

1840. August 9. This earthquake was felt in many parts of Connecticut and sharply at Hartford. At Chester, 25 miles east of New Haven and not far from East Haddam (see earthquakes 1791-1805), the shock was compared to the rumble of thunder. The origin appears to have been 10 to 20 miles north of New Haven. The shock was felt over a distance of 100 miles from Worcester, Mass., to Hartford and Bridgeport, Conn.

1841. January 25. New York. Several shocks felt in the morning lasting 15 to 20 seconds in all.

1847. August 8. Felt at Boston, Dedham, Cape Cod, and Nantucket, Mass.

1848. September 19. Rhode Island, Connecticut, New Jersey, and Pennsylvania.

1852. November 27. Explosion and rumbling at Newburyport, Mass., and through the Merrimac Valley. At Exeter, N. H., the shock lasted 30 seconds and woke people. It was felt at Beverly, Woburn, Groton, and Wenham, Mass.

1853. March 12. Northern part of New York State. Machine thrown down at Lowville.

1854. December 10. Newburyport, Mass., and Exeter and Portsmouth, N. H.

1855. February 8. Felt in New Brunswick, Nova Scotia, and Maine. Strongest at Moncton and Dorchester, New Brunswick. Several shocks severe enough to damage brick buildings. Windows broken at Dorchester.

1857. October 23. At Buffalo, N. Y., a man seated on a chair was thrown to the ground and walls vibrated and surged. Bells rang and crocks fell from shelves. At Lockport, N. Y., rumbling noises were heard for a full minute. This shock was felt at Hamilton, Peterborough, and Port Hope, Ontario, Rochester, N. Y., and Warren, Pa., or over an area 75 miles long from NNE. to SSW. and 60 miles east-west. Reported felt at Dayton, Ohio. This earthquake erroneously listed in 1 as October 8, 1858.

1858. June 30, New Haven, Conn. There was a noise like carriages crossing a bridge and rattling of glass over a considerable area but not further than Bridgeport.

1860. October 17. Center apparently near Riviere Ouelle, Canada, which was violently shaken, walls being damaged and chimneys thrown down. The shock was felt along the Atlantic coast of New England as far south as Newark, N. J., and as far west as Auburn, N. Y. In New England four moderate shocks were felt, accompanied by rumbling noise. Felt strongly at Saco, Me.

1861. July 12. Shock centering at Ottawa, Canada, where it overturned chimneys; was felt strongly at Montreal and St. Johns. It was felt in adjacent parts of New York, especially at Syracuse, where it lasted four seconds, shaking furniture.

1867. December 18. Shock in New York, Vermont, and adjacent Canada felt from Whitehall, N. Y., near Vermont boundary to Belleville and Sackville, Canada. It lasted 25 seconds. Felt at Hamilton, Ontario, Ogdensburg and Syracuse, N. Y., and Burlington, Vt., where people were awakened.

1869. October 22. Shock widely felt throughout New England and the eastern Provinces of Canada. The origin was apparently near Fredericton, New Brunswick, and it was strong at St. Johns, where it lasted 20 seconds and was preceded by a rumbling noise. It was barely felt at Boston and New Haven.

1870. October 20. This shock was most strongly felt along the St. Lawrence River between Montreal and Quebec but it was widely felt, being reported at Richmond, Va., Dubuque, Iowa, and Sault Ste. Marie, Mich. It was felt along the New England coast from New York to Portland, Me., and in eastern New York in the vicinity of Lake George. Walls were reported cracked in Canada, windows were broken at Portland, Me.; at Albany the duration was one minute

with rumbling noise, and at Cleveland, Ohio, clocks stopped. Reid questions observations at Richmond and Dubuque.

1872. January 9. Lasted 30 seconds with low rumbling at Boston. Felt along St. Lawrence River, 200 miles northeast and 60 miles southwest of Quebec. Maine and New Hampshire were shaken, the shock being felt along the coast from Portland to Belfast, Me. In Quebec, where it was central, walls were cracked and there were fissures in the ground. There were two shocks at Lancaster, N. H.

1872. July 11. The shock was felt over an area nearly circular, 10 miles in diameter with New Rochelle, N. Y., as center. At Port Washington, L. I., long pendulum clocks stopped. A rumbling noise, then sounds like bursts of thunder accompanied the shock.

1872. November 18. Concord, N. H. Lasted 10 seconds. This was distinctly felt and heard by people walking on the streets. Shock was felt in adjacent towns and in Laconia 30 miles to the north.

1873. July 6. West New York and Canada; felt in Pennsylvania. It was apparently in Canada west of Niagara. It lasted one minute in Buffalo. Rumbling was heard in many places in New York State. The shock was felt in Erie, Meadville, and Titusville, Pa., and in Wheeling, W. Va. Felt in Ohio, West Virginia, Pennsylvania, New York, and Ontario.

1874. February 27. Severe shock at Bangor and Eastport, Me.

1874. December 10. Shock felt in Westchester and Rockland Counties, N. Y., and Bergen County, N. J. Felt from Peekskill, N. Y., to Norwalk, Conn. Felt most strongly at Tarrytown and Nyack, N. Y., but no damage done. The shock lasted five to six seconds and was accompanied by a noise like a long rumble ending in an explosion.

1875. July 28. Felt generally throughout northwest Connecticut from Hartford and Springfield on the east to the Housatonic River in the west and from Danbury and Waterbury on the south to Chester and Becket, Mass., on the north. The shock lasted 15 seconds at Collinsville and was claimed to have lasted 40 seconds at Winsted. At most places a rumbling noise was heard.

1876. September 21. Southeastern Massachusetts and Rhode Island. Felt at Fairhaven and Woods Hole, Mass., and Newport, R. I.

1877. November 4. This shock was felt in the area bounded by a line from Pembroke, Ontario, to Three Rivers, Quebec, on the north to a line from Boston, Providence, and Hartford to Auburn, N. Y., on the south. It was most severe along the St. Lawrence River and Lake Champlain. It lasted 20 seconds at Montreal. Crockery was overturned, ceilings cracked, and chimneys were thrown down. At Saratoga, N. Y., buildings were shaken and a roaring sound heard. At Auburn there was damage to windowpanes. At Northampton, Mass., houses were shaken. The shock was felt slightly in Rhode Island.

1878. October 4. Felt along Hudson River from Marlborough to Peekskill, N. Y., a distance of 25 miles. Violent enough to awaken people and accompanied by a rumbling sound.

1879. August 21. Country between Lake Erie and Ontario severely shaken. Felt at Buffalo, Lockport, and Niagara, N. Y. Strong at St. Catherines, Ontario, where church bells rang. At most

places an explosion was heard. It was felt at Beamsville and Welland, Ontario.

1880. May 12. Northeast Massachusetts, affecting seaport towns from Amesbury and Newburyport to Salem and inland to Lawrence. Shocks lasted five seconds with rumbling in many places.

1881. January 20. Decided earthquake lasting 10 seconds in vicinity of Bath and Brunswick, Me. Felt at Lewiston and Portland and at various points along the southwest coast of Maine. It was felt 50 miles north of Portland.

1882. December 19. Strongest near Concord, N. H. Buildings shaken at Dover and Pittsfield, N. H., and elsewhere.

1882. December 31. Origin near boundary of Maine and New Brunswick. Felt at Rockland, Bangor, and Eastport, Me., and Halifax, Nova Scotia.

1883. February 27. Felt in Rhode Island, Connecticut, southeastern Massachusetts, and Block Island. It was felt from New London, Conn., to Fall River, Mass., and from Bristol, R. I., to Block Island.

1884. January 18. Contocook, N. H. Reported violent.

1884. August 10. Strong earthquake affecting New England and Middle Atlantic States. Felt with force 3 from Portsmouth, N. H., to Binghamton, N. Y., and to seaward of Cape Cod. Force 4 extended from Hartford, Conn., to West Chester, Pa., with center near New York City, the area affected being 200 miles long by 70 miles wide. It was felt from Richmond, Va., to Portland, Me., and from the coast to northwest Pennsylvania. Walls of church building near Jamaica, Long Island, cracked. At Amity walls cracked and a large mirror broke. Force 5 was observed at 30 places with fallen bricks and cracked plaster. At the time, the earthquake was thought to be associated with the seaward extension of the submerged valley of the Hudson River.

1884. November 23. Strong earthquake in New Hampshire, east Massachusetts, Connecticut, and east New York. Origin in southern New Hampshire. At Concord, N. H., a light shock was followed 15 minutes later by a heavy one.

1891. May 1. South of Concord, N. H. Felt at Cambridge, Mass., 60 miles from Concord. People frightened at Melrose, Mass. Origin in southern New Hampshire.

1893. March 9. New York City and Long Island. Duration five seconds. Epicenter between Tenth and Eighteenth Streets. Animals disturbed at zoo and billiard playing affected.

1896. March 22. Origin near Calais, Me. Felt over 7,000–8,000 square miles. Reports meager.

1897. May 27. Northeastern New York. Felt in New York, New Hampshire, Vermont, and Massachusetts. Felt from Hartford to Montreal and Quebec. Area affected, 150,000 square miles. Shock reported severe but little damage done.

1898. September 17. Felt at Morrill, near Belfast, Me., and at other places in vicinity. Duration 11 seconds, followed by another in 45 seconds.

1903. January 21, 22. Whitman and Attleboro, Mass. Houses shaken and rumbling. Cracks in ground similar to frost cracks but with temperature above freezing. Deep glacial deposit.

1903. April 24. Georgetown, Essex County, northeastern Massachusetts. Area of 350 square miles; pronounced vertical movement. Sound preceded and followed.

1903. December 25. Center near Madrid, N. Y., 20 miles ENE. of Ogdensburg where it was also felt. Felt throughout St. Lawrence County and probably over an equal area in Canada but reports are lacking.

1904. March 21. This shock was felt throughout the greater part of New England and the Provinces of New Brunswick and Nova Scotia. It was strongest in the vicinity of Calais and Eastport, Me., and St. Stephen, New Brunswick, where it overthrew some chimneys. It was felt as far west as the Hudson River, 340 miles; Montreal, Canada, 300 miles; and southeastern Connecticut, 380 miles, respectively, from its center. The area was, accordingly, about 300,000 square miles. There were several light shocks near the origin a few hours after the main shock.

1905. July 15. This shock was felt from southern New Hampshire to the middle of Maine and 100 miles back from the coast, nearly as strongly as that just described, though the area was not more than 20,000 square miles. Its duration was 10 seconds.

1905. August 30. Three shocks—at 5.40, 5.42, and 5.43—at Newton, Mass., and affecting an area 30 by 15 miles. Lasted 5 seconds.

1905. October 22. Northern Vermont felt shock over limited area.

1907. January 24. Several moderate shocks at Schenectady, N. Y.

1907. June 29 to July 11. A series of light shocks mostly of force 4 were felt along the New England coast from Bath, Me., to Portsmouth, N. H. These were unusual in that they appeared to occur at different places. The greatest number was on June 29 p. m., about 18 hours, York and Kittery, Me., being most affected.

1907. October 15. Northeast Massachusetts and southeast New Hampshire. Felt at Lowell, Lawrence, and Haverhill, Mass., and Manchester and Londonderry, N. H.

1908. February 5. Housatonic Valley, Conn. Fissures reported.

1910. January 22. Cumberland County, Me. Articles thrown from shelves at Windham. Felt at Gorham and Gray. Area 150 square miles to south and southeast of Sebago Lake.

1910. August 30. Origin near Lake Sunapee, N. H. Strong at Newport.

1910. October 20. Vicinity of Penobscot Bay, Me. Felt over an elliptic area 60 by 20 miles with major axis northeast-southwest. Felt from Ellsworth to Waldeboro.

1912. December 11. Southeast Maine and New Brunswick. Felt from Augusta, Me., to beyond Fredericton, N. B. Sensible over 15,000 to 20,000 square miles. Force 5-6 in Bangor area. Nearly same area as in November 21, 1904, but weaker.

1913. April 28. Strong at Potsdam, N. Y. Windows broken, dishes thrown on floor. Houses trembled. Felt strongly at Ogdensburg and Morristown. Felt from Canton to Clayton and from Gouverneur to and beyond the St. Lawrence River. Reported felt in Montreal.

1913. August 10. Felt from Fulton Chain of Lakes to Lake Placid, N. Y., a distance of 60 miles.

1914. January 13. Calais, Me., and St. Stephens, N. B.

1914. February 10. Origin in the Province of Quebec. Felt strongly at Albany, N. Y., where buildings swayed, chairs fell over, and pictures were thrown from the walls. At Auburn people were frightened and buildings swayed, the shock lasting 10 seconds. At Binghamton a laborer was killed by a cave-in. Pipes broke at Canton. It was strong at Geneva, and there was a crack in the road at Lestershire. At Syracuse objects were thrown from shelves. It was felt at Elmira and Rochester. The shock was also felt in Boston, Hartford, and New Haven, and in Pennsylvania at Allentown and Harrisburg, force 2-4. The shock was strong all over Quebec and especially at Montreal. Felt as far west as Lake Huron. North and east limit unknown.

1914. February 21. Somerset and Franklin Counties, west Maine, over an area of from 5,000 to 8,000 square miles. It was reported from Eustis, Flagstaff, Rangeley, and Oquissa.

1916. January 5. Felt at Caldwell, N. Y., near south end of Lake George, and at Gloversville, 45 miles away.

1916. February 2. Mohawk Valley, N. Y. Felt at Albany but more strongly at Amsterdam and Ballston Spa. Plant of General Electric Co. at Schenectady strongly shaken. Throughout region with 25 miles radius, houses were shaken, dishes thrown from shelves, persons thrown out of bed. Shock was felt at Glens Falls.

1916. June 8. East Chester and Scarsdale, N. Y., force 5. Small area, not felt on Manhattan Island.

1916. November 1. Glens Falls, N. Y. Houses shaken, objects overthrown, loud noise. Force 5 at Caldwell.

1917. May 22. Shock in the St. Lawrence Valley, Canada. Strongest at Alexandria Bay and Montreal, force 4-5. Ottawa, force 3. Felt at Plattsburg, N. Y., and vicinity.

1918. August 21. South Paris, Me. Bricks fell from chimneys, latched doors flew open, and chimneys fell at South Paris and Norway. Shock quite local though it was reported that there was a temporary change of level of 4 inches in Little Sebago Lake. It was felt at Bridgton, Lewiston, and Cape Elizabeth.

1921. January 19, January 27 a. m. Several shocks at Glens Falls, N. Y.

1924. September 30. Canada. Same locality as that of February 28, 1925. Felt in Maine and Vermont.

1925. January 7. Center near Boston with maximum intensity of 5 and felt to Cape Cod, Providence, R. I., and Kennebunk, Me. Felt sharply on Cape Ann where houses were sharply jarred. Plaster fell at Rockport. In the same vicinity undulatory wave was observed on waters inside the cape. No reports from vessels at sea. The shock was compared to the effect of a truck driving over rough pavement. Swaying of chandeliers, rattling of dishes were the principal effects noted.

1925. April 24. Southeastern Massachusetts. Many people awakened but little harm done.

1925. October 9. Chimneys thrown down at Cornish, N. H. Dishes thrown from shelves at Tuftonboro and Ossipee, N. H., 20 miles west of Cornish. Felt at Manchester, N. H., and Portland, Me.

1925. November 14. Near Hartford, Conn. About force 5. Noises heard at East Haddam.

1926. March 18. New Hampshire, near New Ipswich. Buildings rocked, rumbling. Chimneys thrown down at Cornish. Reported from Manchester, Concord, and Laconia in southeastern New Hampshire.

1926. April 11. New Rochelle, N. Y. Vibration felt and rumbling heard through Westchester County.

1926. August 28. Oxford and Franklin Counties, Me. Lake surface disturbed, rumbling.

1927. March 8. Concord, N. H. Felt by many. Dishes rattled, rumbling sounds.

1927. March 14. Canton, N. Y. Shock lasting 15 seconds. Generally felt. Dishes rattled.

EASTERN REGION

RÉSUMÉ

This region is, with the exception of the Charleston earthquake, one of considerable but moderate earthquake activity. It is possible that the processes which have resulted in the present condition of the Appalachian Mountain system have reached a state of relative inactivity. Earthquakes occur throughout the extent of the region and the axis of principal activity roughly parallels the coast.

The earthquakes in the mountain regions are not surprising as there seems to be a process of adjustment generally going on in such regions, but the Charleston shock occurring in a sandy plain is more difficult to account for. There is particular need for study of this region by modern seismological methods.

EARTHQUAKES—EASTERN REGION

Year	Date	Hour	Locality	N. lat.	W. long.	Area (square miles)	Inten- sity	Authority
1663	Feb. 5		Canada, felt to south					See p. 13.
1732	Sept. 15		Canada, reported felt in Maryland.					See p. 13.
1755	Nov. 18		New England, felt to south.					See p. 13.
1758	Apr. 24	21. 30	Annapolis, Md.	38. 9	76. 5		1	
1783	Nov. 29		New England, felt to south.					See p. 13.
1791	May 16		Connecticut, felt in Pennsylvania.					See p. 13.
1800	Mar. 17		Philadelphia, Pa.	39. 8	75. 2		1	
	Nov. 29		do	39. 8	75. 2		1	
1811	Dec. 15		New Madrid, Mo., felt to east.					See p. 36.
1812	Jan. 23-Feb. 7		do					
1828	Feb. 24-Mar. 9	22-23	Washington, D. C., and Baltimore, Md.					1.
1833	Summer		Central Virginia					3-3.
1840	Nov. 11		Philadelphia, Pa.	39. 8	75. 2		1	
1843	Jan. 4		Western earthquake felt to east.					See p. 36.
	Feb. 8	10. 40	West Indies, felt in United States.	16	62			2-44, 14.
1848	Sept. 9		New England, felt to south.					See p. 13.
1852	Apr. 30	p. m.	Washington and Bal- timore.					1.
1857	Oct. 23		New York, felt in Pennsylvania.					See p. 13.
	Dec. 19	9. 04	Charleston, S. C.	32. 8	79. 8		6-7	3-4.
1861	Aug. 31	5. 22	Washington, D. C.	38. 8	77. 0		5	1.
1872	June 17	15. 00	Milledgeville, Ga.	33. 1	83. 3		5-6	2-73.
	July 11		New York, felt in New Jersey.					See p. 13.
1873	July 6		Canada, felt in Penn- sylvania.					See p. 14.
1874	Feb. 10-Apr. 17		McDowell County, N. C.	35. 7	82. 1	(1)	5-6	2-75, 3-3, 24-74.
1875	Nov. 1	21. 55	North Georgia	33. 8	82. 5	25, 000	7	2-76, 8.
	Dec. 22	23. 45	Arvonnia, Va.	37. 6	78. 5	50, 000	7	2-76, 8.
1877	Sept. 10	9. 59	Delaware River	40. 3	74. 9	300	4-5	2-76.
	Nov. 16	2. 38	West North Carolina and eastern Tennes- see.	35. 5	84. 0	5, 000	5	2-78, 79, 4.
1879	Jan. 12	23. 45	Northern Florida	29. 5	82. 0	25, 000	6-8	2-80, 8.
	Mar. 25	23. 55	Delaware River	39. 2	75. 5	600	4-5	2-80, 8.
		19. 30						

¹ Local.

Earthquakes—Eastern region—Continued

Year	Date	Hour	Locality	N. lat.	W. long.	Area (square miles)	Intensity	Authority
1880	Jan. 22	22.23	Cuba, felt in Florida.	22.8	80.8	65,000	8	2-80, 8.
1883	Jan. 23	4.00						
	Mar. 11	18.87	Baltimore Co., Md.	39.5	76.4	(1)	5	2-84.
	Mar. 12	0.00						
1884	Jan. 18	8.00	South coast, North Carolina.	34.3	78.0	(1)	5-6	2-85.
	May 31		Allentown, Pa.	40.6	75.5	(1)	6-7	8.
	Aug. 10		New York City, felt to south.					See p. 14.
1885	Sept. 19		Ohio, felt to east.					See p. 36.
	Jan. 2	21.16	Maryland and Virginia.	39.3	77.5	3,500	4-5	2-86, 4, 15-85.
1886	Aug. 13		North Carolina.	36.2	81.6	(1)	4-5	2-86.
	Oct. 9	23.35	Virginia.	37.7	78.3	20,000	6	2-86, 4.
	Feb. 4	20	Alabama.	32.8	88.0	1,600	6	4.
	Feb. 13		do.	32.8	88.0			4.
	Aug. 31	21.61 21.53	Charleston, S. C.	32.9	80.0	3,000,000	10	3-4, 16.
1889	Oct. 22-Nov. 5		do.	32.9	80.0	30,000	6-7	3-4, 7.
	Mar. 8	18.40	Pennsylvania.	40	76	4,000	6	15-80.
1893	Mar. 9		New York City, felt in New Jersey.					See p. 14.
1895	Sept. 1	6.09	New Jersey.	40.7	74.8	35,000	6-7	8, special.
1897	Oct. 31		Missouri, felt to east.					See p. 36.
	May 3	12.18	Virginia.	37.1	80.7	150,000	7	4, 15-98.
	May 31	13.58	Giles County, Va.	37.3	80.7	280,000	8-9	8, 15-98.
	Oct. 21	22.20	Wytheville, Va.	36.9	81.1	20,000	5-6	4.
	Dec. 18	20.54	Ashland, Va.	37.7	77.5	7,500	5-6	4.
1899	Feb. 13	4.30	Virginia.	37	81	30,000	5-6	4.
1900	Oct. 31	11.15	Jacksonville, Fla.	30.4	81.7	(1)	5	8.
1902	May 29	2.30	Chattanooga, Tenn.	35.1	85.3	(1)	5	8.
	Oct. 18	13 17	Southeastern Tennessee and northwestern Georgia.	35.0	85.3	1,500	7-8	8.
1903	Jan. 23	20.15	Georgia and South Carolina.	32.1	81.1	10,000	6	8.
1904	Mar. 4	19.30	East Tennessee.	35.7	83.5	5,000	5	8.
1905	Jan. 27	p. m.	Alabama.	34	86	250,000	0-7	8.
	Jan. 28		do.	34	86			8.
1906	May 8	12.41	Delaware.	38.7	75.7	400	5	8.
1907	Feb. 11	8.22	Arvonnia, Va.	37.7	78.3	2,000	5-6	3-3, 8.
	Apr. 19	3.30	North Carolina.	32.9	80.0	10,000	4-5	8.
1908	May 31	12.42	Allentown, Pa.	40.6	75.5	(1)	6	8.
	Aug. 23	4.30	Powhatan, Va.	37.5	77.9	450	5	8.
1909	Apr. 2	2.25	Virginia, West Virginia, Maryland, Pennsylvania.	39.4	78.0	2,500	5-6	8, 9.
1910	Apr. 23		New Jersey coast.			2,000	3-4	8.
	May 8	16.10	Arvonnia, Va.	37.7	78.4	350	5	3-3.
1911	Apr. 21-22		North Carolina.	35.2	82.7	600	5	8.
1912	June 12	5.30	Charleston, S. C.	32.9	80.0	35,000	7	3-4, 8, 9.
	June 20		Savannah, Ga.	32	81			9.
1913	Jan. 1	13.28	Union County, S. C.	34.7	81.7	43,000	8	3-3.
	Mar. 28	16.50	Tennessee.	36.2	83.7	2,700	7	3-3, 8.
1914	Apr. 17	23.30	do.	35.3	84.2	3,500	5-6	3-3, 8, 9.
	Jan. 23	22.24	do.	35.6	84.5	(1)	6	8.
1915	Feb. 10	22.41	Canada, felt in Pennsylvania.					See p. 14.
	Mar. 5	15.05	Georgia.	33.5	83.5	50,000	6	3-4.
1915	Sept. 22	2.04	South Carolina.	33	80.3	30,000	5	3-5.
	Oct. 29	23	North Carolina.	35.8	82.7	1,200	5	8.
1916	Feb. 21	17.39	West North Carolina.	35.5	82.5	200,000	7	3-6, 4, 8.
	Aug. 26	14.36	do.	36	81	3,800	5	3-6, 4.
1917	Oct. 18	16.04	Alabama.	33.5	86.2	100,000	8	3-6, 4.
	June 29		do.	32.7	87.5	(1)	5	4.
1918	Apr. 9	21.09	Virginia.	38.7	78.4	100,000	8	3-8, 4, 8.
	June 21	20.00	Tennessee.	36.1	84.1	3,000	4-5	4.
1919	Sept. 5	21.46	Virginia.	38.8	78.2		6	3-9.
1920	Dec. 24	2.30	East Tennessee.	36	85	(1)	5	4.
	Jan. 26	18.40	New Jersey.	40	75	150	5	4.
1921	July 15		Virginia.	36.6	82.3	(1)	5	3-11.
	Aug. 7	1.36	do.	37.8	78.4	(1)	5	4.
1924	Oct. 20	3.30	West North Carolina.	35.0	82.6	56,000	5-6	3-14, 10.
1925	Feb. 28		Canada, felt to south.					See p. 14.
1927	May 31	21.20	New Jersey.	40.3	74.0	1,200	8	10.
	June 10	2.16	Virginia.	38	79	2,500	7	10.
	June 16	7.00	Alabama.	34.7	86.0	1,800	6	10.

¹ Local.

MAJOR EARTHQUAKES—EASTERN REGION

CHARLESTON EARTHQUAKE—AUGUST 31, 1886

Time of earthquake.—21.51 and 21.59, with others later.

Epicenter.—Fifteen miles northwest of Charleston, S. C.

Area affected.—Area with radius of 1,000 miles, strongly shaken to 100 miles.

Intensity.—Ten.

Description.—The earthquake started with a barely perceptible tremor, then a sound like a heavy body rolling along; the sound became a roar, all movable objects began to shake and rattle and the tremor became a rude, rapid quiver. There was no break in the increasingly heavy jar. Everyone feared instant death. Finally the earth became quiet, the sound stopped, and various human sounds, such as cries of pain and fear, wailing, and excited shouts became audible.

The first shock was at 9.51 p. m. and the second eight minutes later. People immediately began to gather in the large public square in Charleston to escape damage from falling buildings. The period until morning was filled with great anxiety, especially as there were exaggerated rumors of the number killed. Further shocks occurred about 2 and 4. The utter stillness after each shock, combined with the lack of apparent cause, was appalling. A severe shock occurred at 8.30 which aroused great apprehension as it was now seen that many of the buildings were either ruined or in dangerous condition. It was also known that about 60 people had been killed in the night and many wounded and it was feared that there were more casualties to come. Further shocks occurred at 13.00, 17.00, and about 20.00. By this time people were practically all in the streets and squares or on ships in the harbor.

There was no serious lack of food, but the means for preparing it were inadequate. Since few houses escaped injury and many were totally destroyed, the amount of débris in the streets was very great and there was only a narrow passage through the middle, which added to the difficulty. Aid from the outside was impossible, as the railroads were badly damaged and the telegraph wires were down. News did not get through till late the following day. As soon as the railroads were repaired many people fled. However, a large number remained and officials of all kinds stayed at their posts and helped to organize aid and relief. Fortunately the weather remained fine.

In the vicinity of Charleston special effects were noted. In one place sulphur gas was much in evidence. There was a wave of some height on the the Cooper River. In some places the motion was so great that people were overcome with nausea.

Much of Charleston is built on made land and some of it where a number of creeks have been filled in. In such places it is necessary to use piling. The Government buildings were, in general, well built, though some were quite old. In addition to the large number of well-built residences usually found in a place of considerable wealth, it was long a custom of planters to retire and build a residence in Charleston. These facts are important in connection with a study of the destruction. The early houses were in many cases built of hand-made brick which had a rougher surface and permitted better

adherence of the mortar than later smooth bricks. The mortar used in the early days was excellent, being made of burnt shells. The type of bond used in the earlier buildings, though no stronger than that used later, was better adapted to prevent concealing a lack of sufficient mortar.

The great masonry structures were found to be severely damaged, though in some cases new portions were destroyed while the old remained intact. Brick buildings were found to be more severely damaged than at first thought and in some cases the bricks moved in the mortar. Buildings of three or more stories had diagonal cracks in the walls at the middle stories and vertical cracks near the top. Well-built wooden houses with parts carefully pinned together form a complete and elastic whole which tends to return to its original shape as soon as the disturbance has passed. However, some of the best houses were loosened at the joints so that they were shaken by passing vehicles and they were somewhat out of plumb. Curiously, a family living in a one-story wooden building slept through the earthquake without knowing that it had occurred. Chimneys of at least 1,400 houses were destroyed in Charleston.

Part of the damage was due to aftershocks and on the whole it was very considerable. Fortunately there was no wind and the fires that were started were put out without difficulty.

The first shock lasted 35 to 40 seconds and was apparently first vertical and then horizontal. The wave motion was very complex. Pictures were found with backs to the walls. In the cemeteries there was no prevailing direction for the fall of monuments, indicating that the shocks came from many directions, as might be expected so near the origin. Earth waves similar to ground swell were seen and estimated to be 2 feet high. This may have been the case in certain places but, in general, it seems likely they were not more than 4 or 5 inches in height. Such waves explain much of the destruction. Buildings showed both horizontal and vertical displacements. There were 10 severe and numerous moderate to light aftershocks up to September 30, and probably countless other recordable only by instruments. The series of heavy aftershocks undoubtedly helped to weaken the buildings previously damaged.

Careful study of reports indicate that there were two epicentral points, one near Woodstock, 16 miles N. 30° W. from Charleston, surrounded by a region of maximum effect about 20 miles in diameter and nearly circular and the other about 13 miles due west from Charleston, surrounded by an elliptical area with axes 9 and 6 miles, respectively, the major axis lying north-south. These centers are about 14 miles apart. The northern area contains two villages, Summerville and Lincolnville. In the former place, the great earthquake did not come without warning; on both the 27th and 28th there were sounds like heavy explosions. On the 31st, the earthquake had full force. People were tossed from side to side and thrown to the ground. The houses seemed to be receiving heavy blows from below and chimneys fell. In some cases bricks and the chimneys carrying the fireplaces with them sunk in a pile of debris. In some cases the tops of the chimneys snapped off at the roof line and were thrown considerable distances. The indications all point to strong vertical motion. The aftershocks had a deep powerful boom followed by a heavy jar. At Lincolnville the shocks were more severe and the

vertical motion more pronounced. The rest of this area and the southern area were thinly settled and the points of chief interest were the cracks and craterlets and the effects on the railroads.

Through the epicentral area as defined, and in some regions outside of it, the ground was much fissured and in some cases water extruded. The cracks were rarely more than an inch wide though near the streams the movement of the banks toward the stream left wider cracks. Where large quantities of water came up there was a round hole of considerable size with a greater basin at the ground surface. These were of all sizes from very small up to 20 feet in diameter. Much sand was brought up, usually from known beds of quicksand. In some cases the water rose in high jets carrying sand and mud.

The bending of rails and lateral displacement of the tracks were much in evidence in the epicentral region though not at Charleston. There were severe flexures of the track in places and sudden and sharp depressions of the rail bed. At one place there was a sharp S curve. At a number of places the effect on culverts and other structures demonstrated that there was a strong vertical force in action at the time of the earthquake.

The estimated depth of focus, or depth below the surface at which the earthquake actually occurred, was 12 miles. This was based on the character of waves at different points, though there is some doubt as to the accuracy of this method.

The area of severe effect was large and the tremors were actually felt over an area with a radius of about 1,000 miles so that two and a half million square miles were affected, including undersea area. Within an area of 100 miles in diameter, the destruction would have been severe except for the character of the country; settlements were few and far between and the prevailing type of building primitive, the log cabin being well designed to resist destruction by earthquakes. Throughout this region it was hard for men to keep to their feet.

The belt from 50 to 100 miles in radius was strongly shaken. This includes two cities each about 90 miles away, Savannah and Columbia. At the former, 300 chimneys were damaged and poorly constructed ones were shaken down. Columbia felt the shocks still more strongly. Buildings swayed, plaster fell, and the undulatory movement of the ground made walking difficult. The effect did not vary exactly with distance from epicenter, as geological conditions were an important factor. At Augusta, just over 100 miles from the epicenter, 100 chimneys fell and a dam fissured and broke. The shocks were as severe at Raleigh, 215 miles away, as at Wilmington, 152 miles away. The shock was felt at Boston, Milwaukee, Cuba, and as far east as Bermuda, 1,000 miles away. It was felt sharply at New York. There appears to have been a shadow zone where it was lightly felt, as compared with other places of similar distance, in the Appalachian region of West Virginia, Maryland, and Pennsylvania.

INTERMEDIATE AND MINOR EARTHQUAKES—EASTERN REGION

1758. April 24. Shock lasting 30 seconds at Annapolis, Md., preceded by subterranean noises. Also felt in Pennsylvania though not so strongly.

1800. March 17, November 29. Severe shocks at Philadelphia, Pa.

1828. February 24 and March 9. Violent shocks, Washington and Baltimore. Two severe shocks lasting in all 30 seconds.

1833. Summer. Central Virginia. Few facts known, but seems to have been severe shock. Fences were shaken.

1840. November 11 and 14. Severe at Philadelphia with great and unusual swell on the Delaware.

1843. February 8. Great earthquake centering at Guadeloupe, West Indies, which did considerable damage and which appears to have been felt in the eastern part of the United States, especially at Washington, D. C.

1852. April 30. Shock felt at Washington and Baltimore.

1857. December 19. Charleston, S. C. Series of horizontal oscillations, with vibrations lasting six to eight seconds. Rumbling noise over considerable area. Felt at Savannah, Ga., and Georgetown, S. C.

1861. August 31. Two shocks at Washington, D. C., at intervals of 5 minutes, lasting 10 seconds.

1872. June 17. Milledgeville, Ga. Sharp shock; brick buildings jarred and windows rattled.

1874. February 10 to April 17. McDowell County, N. C. There were a series of explosive shocks, none severe, followed by deep rumbling noise. These were in the vicinity of Stone Mountain. At times stout log buildings shook violently. There were probably 50 to 75 shocks, each accompanied by rumbling, during the period named. Some of the explosions were described as like the rattling of artillery followed by rumbling, the ground trembling for a few seconds after each explosion. The shocks were felt over an area 25 miles in diameter including Mount Mitchell, the highest point east of the Rocky Mountains. The explosive shocks and noises were simultaneous. Shocks occurred on February 10 and 22 p. m., March 17 and 26, April 14 and 17.

1875. November 1. North Georgia and adjacent South Carolina. Felt from Spartansburg and Columbia, S. C., to Atlanta and Macon, Ga., and from Gainesville to Augusta, Ga., an area approximately 200 by 150 miles. The shock lasted 30 seconds at Washington and Augusta, Ga., and there were several aftershocks. Rumbling was heard at Washington.

1875. December 22. Arvonnia, Buckingham County, Va. The earthquake of December was preceded by a minor one on March 10. The December shock was of force 7 or more. This was felt over 50,000 square miles. It was felt in Baltimore, Md., and Greensboro, N. C., 100 and 150 miles away, respectively. Near the center there were five shocks in quick succession. Bricks were thrown from chimneys. At Richmond, Va., the shock lasted 20 to 30 seconds with deep rumbling. Plaster fell.

1877. September 10. Delaware Valley, Trenton to Philadelphia, over area 20 miles wide with center near Burlington, N. J.

1877. November 16. Felt at Knoxville, Tenn., and Murphy, N. C.

1879. January 12. North and central Florida. Felt from line joining Tallahassee, Fla., to Savannah, Ga., on the north, to a line joining Punta Rassa and Daytona, Fla., on the south. There were two shocks lasting 30 seconds. Doors and windows rattled at Daytona; articles thrown from shelves at St. Augustine and plaster shaken down.

1879. March 25. Delaware River below Philadelphia, Pa. Felt from Chester, Pa., to Salem, N. J., over a distance of 30 miles. Felt most strongly on east side of river.

1880. January 22, 23. Severe shocks at Key West, Fla., from Cuban earthquake centering at Vuelta Abajo west of Habana, where buildings were thrown down. It was felt and roaring was heard in west Cuba and Isle of Pines.

1883. March 11 and 12. Fallstone, Harford County, Md. Clocks stopped, crockery rattled.

1884. January 18. Wilmington and vicinity, North Carolina coast. Houses rocked, crockery thrown from shelves.

1884. May 31. Strong shock at Allentown, Pa. Dishes thrown from tables.

1885. January 2. Earthquake felt most strongly in Frederick County, Md., especially in Boonsboro and New Market. There was a heavy jar, partly vertical, but no noise except rattling of windows. It was felt throughout Frederick County and also Loudoun County, Va. Warrenton, Va., and Washington, D. C., were on the edge of the affected area.

1885. August 13. Blue Ridge Mountains, Wautega County, N. C. Noise like thunder at Boone.

1885. October 9. Felt strongly at Variety Mills, Nelson County, Va.; also at Staunton and Lexington, where windows and furniture were shaken and people rushed out of buildings, and where a second shock occurred an hour later. The shock was felt at Rockingham County to the northwest and Petersburg to the east. It was claimed to be felt by one person in Washington, D. C.

1886. February 4 and 13. Sumter and Marengo Counties, Ala. Felt on both sides of the Tombigbee River for 32 miles from Moscow. At that place the earth seemed to move.

1886. October 22. Strong shocks at Charleston; the first in morning felt with force 7 in Charleston, Atlanta, Augusta, and elsewhere, and second with force 8 at Summerville, S. C. Felt at Washington, Richmond, Louisville, and elsewhere.

1886. November 5. Another shock, felt over same area as second shock of October 22.

1889. March 8. Pennsylvania. Felt at Harrisburg, York, Philadelphia, Reading, and other places. Lasted 10 seconds.

1895. September 1. Generally felt, extreme points, Virginia to Maine; central in Hunterdon County, N. J., near High Bridge. In various places in this county buildings rocked; articles fell from shelves. Two shocks were felt at New Brunswick. Force 5 at Atlantic Highlands. Felt in all parts of the city of Newark. Fairly sharp at Camden and Burlington. The shock seems to have been felt over a considerable distance northeast-southwest but rather narrow at right angles to this line. Not reported in Pennsylvania west of Easton.

1897. May 3. This shock was felt most strongly at Pulaski City, Va. Chimneys were damaged at Roanoke. The shock was felt at Lynchburg and also at Winston-Salem, N. C. There was a rumbling like thunder in the central region.

1897. May 31. Rumbling was heard at various points between May 3 and 31, and on the latter date there was a strong shock felt from Georgia to Pennsylvania and from the Atlantic coast to Indiana

and Kentucky. It was felt more strongly at Pearisburg, Giles County and is generally known as the Giles County earthquake. Old brick houses and chimneys were cracked and bricks were thrown from the chimney tops. There were fissures in the ground and small landslides in places where they were easy to start. At the Narrows it was claimed that a motion like the ground swell of the ocean was observed. Large rocks rolled down the mountains. There were loud sounds compared by veterans to that of siege guns. These continued till June 6. The shock was felt at Spartanburg, S. C., and Cincinnati, Ohio.

1897. October 21. Wytheville, Va. Felt at Winston-Salem, N. C.

1897. December 18. Ashland, Va. Heavy rumbling. Shock lasted 20 to 30 seconds. Felt in Richmond, Buckingham, and Fredericksburg, Va.

1899. February 13. Lynchburg, Va. Four shocks felt in western Virginia and east Tennessee. Area of 30,000 square miles.

1900. October 31. Jacksonville, Fla. Felt with force 5.

1902. May 29. Chattanooga, Tenn. Houses shaken, rumbling heard, people awakened.

1902. October 18. Felt along east face of Rocky Face Mountain west of Dalton, Ga. Felt with force 5-6 at Lafayette. Felt at Johnson City and Chattanooga, Tenn.

1903. January 23. Felt at Tybee Island, Savannah, Ga., with force 6; Charleston, S. C., 4-5; Columbia, 3-4; and Augusta, Ga., 3. Houses strongly shaken.

1904. March 4. Center near Marysville and Sevierville, east Tennessee. Felt along mountains for 90 or 100 miles. Sound was heard at Tellico Plains. Not reported outside of Tennessee.

1905. January 27 and 28. At Gadsden, Ala., where chimneys were thrown down and where a well dried up, no water being found 30 feet below bottom of well. This was felt at Birmingham and as far as Savannah, Ga., and Louisville, Ky. more than 300 miles away. Aftershocks occurred up to November.

1906. Strongest at Seaford, Del. Felt at Millsboro and at Denton and Hurlock, Md. Buildings trembled.

1907. February 11. Force 6 at Arvon, Buckingham County, Va. Felt strongly from Powhatan to Albemarle County. Sound like thunder at Richmond. The shock lasted from 20 to 30 seconds with minor damage at a number of places. See shocks of 1872 and 1910.

1907. April 19. Charleston, S. C., and Savannah and Augusta, Ga.. Dishes rattled. Objects thrown from shelves.

1908. May 31. An extremely local shock at Allentown, Pa., where a few chimneys were knocked down and a few people were thrown down. There was a sound like an explosion or the fall of a heavy body. Reid found that this was felt over not more than 50 square miles and may have been due to fall of mass of rock in a subterranean cavern, this being a limestone country.

1908. August 23. Powhatan, Va. Sharp local shock felt over 400 square miles.

1909. April 2. Felt from Winchester, Va., to Mercersburg, Pa., on the north; Hagerstown, Md., on the east; and Front Royal, Va., on the south. Strong at Charles Town, W. Va., where pictures were thrown from the wall, and at Martinsburg.

1910. April 23. Atlantic City to Cape May, N. J., and Snow Hill, Md. While these shocks do not appear to have exceeded force 4, they were so widespread that they are included. At 21.30 there was a similar shock near Catonsville, Md.

1910. May 8. Arvonias, Va. Force 5 over an area 20 miles in diameter.

1911. April 21 and 22. Caesar's Head, N. C., along Blue Ridge. Cracks opened. Felt at Hendersonville, 15 miles northeast.

1912. June 12. This shock centered at Summerville, S. C., with force 7 and was felt at Charleston with force 6. It was felt as far as Brunswick and Macon, Ga., Greenville, S. C., and Wilmington, N. C. See 3-4, page 146, for map. This was felt over an area of 130,000 square miles. Chimneys shaken down at Summerville.

1912. June 20. A shock felt strongly at Savannah, Ga.

1913. January 1. An area of approximately 43,000 square miles, roughly elliptical in shape, centering in Union County, S. C., was shaken with force 8 earthquake. At Union, within the epicentral region, cracks formed in the wall of the jail and plaster fell. Cracks appeared in many brick buildings and many chimneys were thrown down. Began with a roaring noise. Quake was felt at Raleigh, more than 200 miles away. An interesting comparison of geological formations lies in the fact that the Maine quake of March 21, 1904, though of less intensity at the epicenter, was felt over an area of 300,000 square miles. Earlier quake in same locality on December 7, 1912, force 3-4.

1913. March 28. Knoxville, Tenn. Two shocks were felt over an area 70 by 40 miles with noticeable rise and fall of ground in some places. Fire alarms were set off by quake. The Knox County courthouse, a massive structure, trembled for several minutes. Movable objects were overthrown, bricks fell from chimneys. People in autos did not feel the shock while those walking and in buildings did. There were some cases of nausea.

1913. April 17. Eastern Tennessee, North Carolina, and South Carolina. This was felt over a somewhat larger area than that of March 28 and had its center a little to the south. Felt over an elliptical area 45 by 25 miles NNE.-SSW. Wave-like motion of the ground was felt in several places. There were noises like thunder. The effect was most severe in the southeast corner of Tennessee.

1914. January 23. Niota and Sweetwater, Tenn. First shock, force 6; second lighter. Loud sound.

1914. March 5. Center was 30 miles southeast of Atlanta, Ga. Felt with intensity 6. It was felt in western North Carolina, as far east as Cherokee County, and in Alabama and Tennessee. Area covered, 100 mile radius. Taber gives area as 95,000 square miles.

1914. September 22. Felt with force 5 at Summerville, S. C., and force 4 at Charleston. It was felt in Macon, Ga., 150 miles away; also at Savannah and Augusta. At Summerville the shock was slightly preceded by a noise like a train approaching from a distance. Reports were not numerous but it is estimated that the shock was felt over an area of 30,000 square miles.

1915. October 29. Near Marshall, N. C. People awakened there and at Asheville.

1916. February 21. This earthquake occurred in the Appalachian Mountains near Skyland, N. C., not far from Asheville. It was felt

from Georgia to Virginia and as far west as Alabama, Tennessee, and Kentucky. The most distant point where it was felt was Norfolk, Va., 365 miles away. Sounds were heard throughout the area included within isoseismal 4. Within 200 miles of the center—that is, to isoseismal 3,—rattling of dishes and windows was noted. In places near the center crockery fell from shelves. At Sevierville, Tenn., a team of horses ran away, and bricks were shaken from chimneys. Springs increased in volume. In a few places plaster was cracked. No important damage anywhere.

1916. August 26. Force 5 at Statesville, N. C. Felt over approximately 3,800 square miles.

1916. October 18. This shock was felt most strongly in northeast Alabama, apparently most strongly at Easonville. It was felt from North Carolina to Mississippi and from Georgia to south Indiana. Near the epicenter frame buildings were badly shaken, windows were broken, and chimneys thrown down. Fairly hard shock at Birmingham and Montgomery.

1917. June 29. Rosemary, west Alabama. Force 5 at Greensboro.

1918. April 9. Middle and north Virginia perceptibly shaken. Felt through Shenandoah Valley with force 5 to 6, at Luray, Va., and with force 3 to 4 at Washington, D. C. Farthest points reporting it were Colebrook, Berks County, Pa., 60 miles northwest of Philadelphia; Williamsburg, and Danville, Va.; Solomons, Md., and Roanoke City, N. C. Felt slightly at Baltimore, Md. Sound heard over a considerable area. At Winchester, Va., it resembled vibration of heavy machinery. While houses swayed and rattled, little damage was done.

1918. June 21. Felt with force 5 in east Tennessee with center at Lenoir City where intensity was force 6. Duration 10 to 15 seconds.

1919. September 5. Felt over same general region as that of April 9, 1918, but rather local. It was strongest in the Blue Ridge Mountains just south of Front Royal, Va. The first shock was accompanied by an explosive sound. Plaster fell. Springs became muddy.

1921. January 26. Moorestown and Riverton, N. J., shaken with force 5. Rumbling noise.

1921. July 15. District around Mendota, Va., shaken. Windows broken.

1921. August 7. Force 5 in Buckingham County, Va. Strongest at New Canton.

1924. October 20. West North Carolina, South Carolina, northeast Georgia, and east Tennessee were shaken by an earthquake felt over 56,000 square miles. At epicenter, buildings were shaken and furniture overturned. A loud roar accompanied the shock.

1927. May 31. Coast of New Jersey. Strongest at Long Branch where bricks were thrown from chimneys and plaster fell.

1927. June 10. Charlottesville and Richmond, Va. Houses rocked, people wakened; rumbling.

1927. June 16. Scottsboro, Ala. Houses shook. People fled to streets.

MIDDLE WESTERN REGION

RÉSUMÉ

It is usually considered that the interior portions of continents which are not mountainous are probably less subject to earthquakes than any part of the earth except the flat beds of some of the oceans, but this can not be applied to the middle western part of the United States. The Upper Mississippi and the Ohio Valleys are regions of not infrequent earthquakes and the former region has had one of the 20 great earthquakes of known history, which has had more effect on the topography than any known on the North American continent. Though this great earthquake did little damage this was only because it occurred at a time when there were few settlements in the region and the raising and lowering of great areas could be accomplished with little inconvenience to man. This brings out better than any other earthquake the fact that the earthquake peril is largely a city problem and that these occurrences, even at the worst, can do little harm to a thinly settled region.

It is difficult to assign the cause of the great earthquake and of the many others listed for the middle western region. In practically every case the formations in which the slip occurred are buried deep with alluvial material and the geologists have not been able to study anything except the effects on the alluvial soil, which are only incidental.

Most of the earthquakes occur near the river valleys mentioned, but there are other isolated quakes in small numbers at other places throughout the region.

The fact that a great series of earthquakes occurred in the past and that lesser quakes have been of almost yearly occurrence makes it important that this region be given scientific study so that it may be known whether conditions are such that another great earthquake may be expected or whether the minor earthquakes are part of a process of adjustment which is now being accomplished gradually and quietly. Though the problem is different in character there is as much reason for scientific study of earthquakes in this region as in any other part of the United States.

EARTHQUAKES—MIDDLE WESTERN REGION

Year	Date	Hour	Locality	N. lat.	W. long.	Area (sq. mi.)	Intensity	Authority
1776	Summer	8.00	Muskingum River, Ohio.					17, 18
1779			Kentucky					17, 18
1791 or 1792	April or May	7	do.					17, 18
1795	Jan. 8	3.00	Kaskaskia, Ill. and Ky.					17, 18
1804	Aug. 20	14.10	Port Dearborn, Ill. (Chicago).	42.0	87.8	30,000		
1811	Dec. 15	2.00	New Madrid, Mo.	36.6	89.6	1,000,000	10	17, 18, 19, 20
1812	Jan. 23		do.					3-3
	Feb. 7		do.					
1820	Nov. 9		Cape Girardeau, Mo.	37.3	89.5			30
1827	Aug. 6	22.30	New Albany, Ind.	40.1	82.8		7	6, 7
	Aug. 7	1.00	do.					
1843	Jan. 4	21.30	Memphis, Tenn.	35.2	90.0	400,000	9	2-44, 14, special.
	Feb. 16		St. Louis, Mo. and Ky.					2-44
1857	Oct. 8	{ 4.00 4.07	Illinois near St. Louis..	38.5	89.5	7,500	7	2-88, 3-3
1860	Unknown		Minnesota					4, 8
1865	Aug. 17	9.00	Southeast Missouri	36.5	89.5	24,000	7	2-65
1867	Apr. 24	14.22	Kansas	39.5	96.7	300,000	7-8	2-67, 8
1870	Oct. 20		Canada, felt in Ohio					See p. 13.
1872	Feb. 6	8	Wenona, Mich.	43.5	83.8	(1)	5	2-72
	Oct. 9	10.00	Sioux City, Iowa	42.7	97.0	3,000	5	2-73
1873	July 6		New York felt to west.					See p. 14.
1875	June 18	7.43	Ohio	40.2	84.0	40,000	6-7	2-76, 4, 17
	Nov. 8	4.40	Kansas	39.3	95.5	8,000	5	2-78, 4
1876	Sept. 25	0.15	Evansville, Ind.	38.5	87.7	60,000	6-7	2-78
1877	Aug. 17	10.50	Southeast Michigan	42.3	83.3	200	4-5	4
	Nov. 15	11.45	East Nebraska	41	97	140,000	7	2-78, 4
		12.30	do.					
1878	Mar. 12	4.00	Columbus, Ky.	36.8	89.2	(1)	5	8
	Nov. 18	11.52	Southeast Missouri	36.7	90.4	150,000	7	2-79, 4
1879	Dec. 29	0.30	South Dakota	42.9	97.3	(1)	5	2-80
1882	July 20	4.00	South Illinois	38	90	3,000	5	2-83, 4
	Sept. 27	4.20	do.	39	90	40,000	6-7	2-83
	Oct. 15	0.00	do.	39	90	40,000	5-6	2-83, 4
		5.00	do.					
	Oct. 22	16.15	Arkansas	35	94	135,000	7-8	2-83, 4
1883	Jan. 11	1.12	Missouri and Tennessee	37.0	89.2	80,000	6-7	2-84, 4
	Feb. 4	5.00	Indiana and Michigan	42.3	85.6	8,000	6	2-84
	June 11	12.16	Memphis, Tenn.	35.2	90.1	(1)	6-7	8
		12.30	do.					
		13.13	do.					
	Dec. 5	9.20	Boone Co., Ark.	36.3	93.0	(1)	5	4, 8
1884	Sept. 19	14.14	Ohio	40.7	84.1	125,000	6	2-85, 18
1886	Oct. 31		Charleston, S. C.					See p. 26.
	Nov. 22		do.					See p. 26.
1887	Feb. 6		Vincennes, Ind.	38.7	87.5	75,000	6	6-87, 15-87
1889	July 19		Memphis, Tenn.	35.2	90.0	(1)	6-7	8A
1891	Jan. 8		Rusk, Tex.	31.7	95.2		7-8	7
	July 26		Evansville, Ind.	37.9	87.5		6-7	6-91, 7
1895	Oct. 11	17.55	Black Hills, S. Dak.	43.9	103.3		4-5	8
		19.25	do.					
	Oct. 31	5.08	Charleston, Mo.	37.0	89.4	1,000,000	8-9	3-3, 4, 8
1897	Apr. 30	22	Tennessee and Illinois					4
	May 31		Virginia					See p. 26.
1899	Apr. 29	20.05	Southwest Indiana	38.5	87.0	40,000	6	4, 8
			Southeast Illinois.					
1901	May 17	1.00	Ohio	39.3	82.5	7,000	6	8
1902	Jan. 24	4.48	Missouri	38.6	90.3	40,000	6-7	8
	July 28	12	East Nebraska	42.5	97.5	35,000	5-6	8
1903	Feb. 8	18.21	South Illinois	38.5	90.3	70,000	7	8
	Nov. 4	12.18	St. Louis, Mo.	38.5	90.3	70,000	6-7	8
		13.14	do.					
	Nov. 27	3.20	New Madrid, Mo.	36.5	89.5		5	8
1904	Oct. 27	p. m.	Kansas	37.7	100.0	2,700	5	8
1905	Jan. 27		Alabama					See p. 26.
	Mar. 13	10.30	Menominee, Mich.	45.0	87.7	(1)	5	4
	Apr. 13	10.30	Keokuk, Iowa	40.4	91.4	5,000	5	8
	July 26	18.20	Calumet, Mich.	47.3	88.4	16,000	8	8, 17
	Aug. 21	23.05	Southeast Missouri	35.2	90.0	40,000	6	8
1906	Jan. 7	18.15	Manhattan, Kans.	39.3	96.6	10,000	7-8	8
	May 9	18.27	Washabaugh Co., S. Dak.	43.0	101.3	8,000	7	8
	May 11	0.15	Petersburg, Ind.	38.5	87.2	800	5	8

1 Local.

Earthquakes—Middle western region—Continued

Year	Date	Hour	Locality	N. lat.	W. long.	Area (sq. mi.)	Intensity	Authority
1907	May 26	8. 42	Keewena Peninsula, Mich.	47. 3	88. 4	800, 000	8-9	17
	June 27	16. 10	Fairport, Ohio	41. 4	81. 6	400	5	8
1908	July 4	3. 00	Farmington, Mo.	37. 7	90. 4	400	5	8
	Sept. 28	13. 34	New Madrid, Mo.	36. 6	89. 6	5, 000	4-5	8
1909	Oct. 27	18. 27	Cairo, Ill.	37. 0	89. 2	5, 000	5-6	8
	Jan. 22	21. 15	Houghton, Mich.	47. 2	88. 6	(1)	5	8
	May 15	a. m.	Canada, felt to south	50	105	500, 000	9	8
	May 20	8. 42	Illinois	42. 5	89. 0	500, 000	8	17, 21, 22
	July 18	22. 34	do	40. 2	90. 0	40, 000	7-8	8
	Aug. 16	16. 45	Southwest Illinois	38. 3	90. 2			9
	Sept. 22		Ohio Valley	38. 7	86. 5	4, 000	6	9
	Sept. 27	3. 45	Indiana	39. 0	87. 7	30, 000	8	8, 9
		3. 50						
		Oct. 23	1. 10	Southeast Missouri	37. 0	89. 5	40, 000	5-6
	do	3. 47	Robinson, Ill.	39. 0	87. 7	30, 000	5-6	8
1910	Feb. 26	2	Columbus, Nebr.	41. 4	97. 3	(1)	4-5	8
1911	Mar. 31	10. 57	Rison, Ark.	33. 8	92. 2	18, 000	7	8
	12. 10							8
	June 2	16. 34	South Dakota	44. 2	98. 2	40, 000	5-6	8
1912	Jan. 2	10. 21	Illinois	41. 5	88. 5	40, 000	6-7	8, 9, 23
1913	Apr. 17	23. 30	East Tennessee					See p. 26.
1915	Apr. 28	17. 40	New Madrid, Mo.	36. 4	89. 5	200	4-5	4, 8
	Oct. 23	0. 05	South Dakota	43. 8	101. 5	(1)	5	4, 8
	Oct. 26	1. 40	Mayfield, Ky.	36. 7	88. 6	(1)	5	4, 8
	Dec. 7	12. 40	Near mouth Ohio River	36. 7	89. 9	60, 000	6	4, 8
1918	Feb. 21		North Carolina					See p. 26.
	Oct. 18		Alabama					See p. 26.
	Dec. 18	23. 42	Hickman, Ky.	36. 6	89. 3	(1)	5-6	4
1917	Mar. 28	13. 56	Panhandle, Tex.	35. 3	101. 2	(1)	6	3-16, 4
	Apr. 9	14. 52	East Missouri	38. 1	90. 6	200, 000	6	3-7, 4
1918	Sept. 3	15. 30	Minnesota	46. 3	94. 5	10, 000	6	3-7, 4
	Sept. 10	10. 30	Oklahoma	35. 5	98. 0	(1)	6	4
	Oct. 4	3. 21	Arkansas	34. 7	92. 3	30, 000	5	4
	Oct. 15	21. 30	West Tennessee	35. 2	89. 2	20, 000	5-6	4, 8
1919	May 25	3. 45	South Indiana	38. 5	87. 5	18, 000	5	4
	Nov. 3	14. 40	Arkansas	36. 2	90. 9	(1)	3-5	4, 8
1920	May 1	9. 15	Missouri	38. 5	90. 5	10, 000	5	4, 8
1922	Mar. 22	16. 20	South Illinois	37. 3	88. 6	25, 000	5	4
	Mar. 23	16. 30	do					
1923	Oct. 28	11. 00	Arkansas	35. 6	90. 3	40, 000	8	4, 11
	Dec. 31	21. 05	do	35. 4	90. 3	30, 000	5	4, 10
1924	Mar. 2	5. 18	Kentucky	36. 9	89. 1	150, 000	6	10
1925	Feb. 28		Canada					See p. 14.
	Apr. 26	22. 05	Indiana	38. 0	87. 5	100, 000	6	10
	May 13	6. 00	Kentucky	36. 7	88. 6	3, 000	5	10
	July 30	6. 17	Texas	35. 4	101. 3	200, 000	6	3-16, 10
	Sept. 2	5. 55	Kentucky	37. 8	87. 6	75, 000	6-7	10
1926	Nov. 5	9. 53	Ohio and West Virginia	39. 1	82. 1	350	6	10
1927	Mar. 19	11. 25	Kansas	40. 0	95. 3	300	5	10
	May 7	2. 28	Mississippi Valley	36. 5	89. 0	130, 000	7	10

¹ Local.

MAJOR EARTHQUAKES—MIDDLE WESTERN REGION

EARTHQUAKES OF 1811 AND 1812

Dates.—December 16, 1811; January 23 and February 7, 1812.*Epicenter.*—Near New Madrid, Mo.*Area affected.*—Topographic changes over an area of 30,000 to 50,000 square miles. Total area shaken, at least 1,000,000 square miles.*Intensity.*—All three earthquakes were of intensity 10.*Damage.*—Very small for such a great earthquake, due to lack of inhabitants.*Description.*—The evening of December 15, 1811, in the New Madrid area was clear and quiet with no unusual conditions which could be regarded as portending the catastrophe soon to take place.

A little after 2.00, December 16, the inhabitants of the region were suddenly awakened by the groaning, creaking, and cracking of the timbers of the houses and cabins in which they were sleeping, by the rattle of furniture thrown down, and by the crash of falling chimneys. In fear and trembling they hurriedly groped their way from their houses to escape the falling débris, and remained shivering in the winter air until morning, the repeated shocks at intervals during the night keeping them from returning to their weakened and tottering dwellings.

Daylight brought little improvement to their situation, for early in the morning another shock, preceded by a low rumbling and fully as severe as the first, was experienced. The ground rose and fell as earth waves, like the long, low swell of the sea, passed across the surface, tilting the trees until their branches interlocked, and opened the soil in deep cracks as the surface was bent. Landslides swept down the steeper bluffs and hillsides; considerable areas were uplifted, and still larger areas sunk and became covered with water emerging from below through fissures or little "craterlets," or accumulating from the obstruction of the surface drainage. On the Mississippi, great waves were created which overwhelmed many boats and washed others high upon the shore, the return current breaking off thousands of trees and carrying them out into the river. High banks caved and were precipitated into the river, sand bars and points of islands gave way, and whole islands disappeared.

During December 16 and 17 shocks continued at short intervals but gradually diminished in intensity. They occurred at longer intervals until January 23, when there was another shock, similar in intensity and destruction to the first. This was followed by two weeks of quiescence, but on February 7 there were several alarming and destructive shocks, the last equaling or surpassing any previous disturbance, and for several days the earth was in a constant tremor.

For fully a year from this date, small shocks occurred at intervals of a few days, but as there were no other destructive shocks, the people became accustomed to the vibrations and gave little or no further attention to them.

The record goes back only to 1776 when a shock of moderate intensity occurred. There were similar ones in the nineties and in the first decade of the following century. These caused the Indians to predict a great earthquake, the prediction being based on the Indian tradition of a great earthquake at an earlier date. The geological evidence confirms this, though the date can not be fixed. This illustrates a weakness in our earthquake history as compared with Europe and parts of Asia where the records are fairly good for 2,000 years.

The most seriously affected area was characterized by raised and sunk lands, fissures, sinks, sand blows, and large landslides. This area was 30,000 to 50,000 square miles in extent, extending from a point west of Cairo to the latitude of Memphis and from Crowley's Ridge to Chickasaw Bluffs, a distance of 50 miles.

Caving of river banks occurred as far away as Vicksburg. The shock was felt from Canada to New Orleans and from the headwaters of the Missouri to the Atlantic, including Boston, 1,100 miles away. About 1,000,000 square miles, or half the area, was so shaken that

vibrations were distinctly felt. This far exceeds in area any other known earthquake of this continent.

Shocks in New Madrid area.—Naturally the record is very incomplete, but there is little doubt that at New Madrid and Caruthersville the soil was so broken that cultivation was impossible and the inhabitants feared to rebuild their houses during the period of the severe shocks. There is definite record that the shocks lasted through at least two years as a very good record was kept at Louisville, the effect on a number of pendulums having been noted by Jared Brooks and a record of the weather conditions also kept. There is evidence that the Mississippi Valley was severely and even dangerously shaken in places outside of the area of maximum effect.

The shock of December 16 was distinctly felt in Washington, D. C., and people were badly frightened. It is of special interest that Charleston was quite severely shaken, in view of the earthquake here of 75 years later. As might be expected, the western parts of the southern Atlantic States were more severely shaken than the eastern. The shocks were moderate in the northern Atlantic States, though felt at Baltimore and Boston. This apparently is connected with the relation of the Appalachian system to the epicenter of the earthquake. This effect has been noticed in less degree in the Charleston earthquake of 1886 and the St. Lawrence Valley shock of 1925.

In spite of the great intensity of the earthquake, the loss of life was insignificant. In an earthquake at Caracas during the same period 10,000 lives were lost. At New Madrid only 1 life was lost through falling buildings. Of course, the log cabin, the more common type of building at this time, was peculiarly suited to withstand earthquake damage. Several persons were thrown into the river by caving banks and drowned and a number of boatmen were lost when their boats sank. A number of canoes were seen drifting, their occupants having probably drowned.

There seems to have been periods of darkness, but these were probably due to rising clouds of dust. There is little doubt that sulphur gas due to buried vegetation escaped from many of the crevices. Flashes of light were reported at various places, but the evidence indicates that this was lightning, as there were no such reports from places having clear weather.

According to contemporary accounts, waves with visible depressions between the swells rolled across the earth which finally broke open leaving parallel fissures. Another type of smaller size resulted from the settling and caving of river banks. The former type were reported to be from 600 to 700 feet long with one having a length of 5 miles. In some cases persons were rescued with difficulty. There was also another type of fissure consisting of a long narrow block dropping and leaving a trench with vertical sides. Both types have been found filled with sand, and so we are not dependent on contemporary accounts.

In some places the fissures were very close together, 10 to 15 feet being common. Those near rivers were parallel to their course, others were usually NE.-SW. Simple fissures ran up to 300 feet in length, with a few of considerably greater length. The block fissures averaged 300 to 500 feet with a few very much greater.

Depth was from 10 to 20 feet, the depth to quicksand below. Many of the fissures have become completely filled with dikes of sand.

Very few objects were lost in the fissures, though there was considerable fear of being engulfed.

There is some evidence of vertical faults, one of which is believed to have caused quite marked falls in the river, lasting till the slope had been leveled off.

Landslides occurred wherever the river banks were steep and where there were steep bluffs. In places sections of forest were carried down.

Several areas were raised 10 to 15 feet above the level of the highest floods. One of these areas known as Tiptonville Dome is 15 miles long by 6 to 8 miles wide. There is another about 10 miles in diameter. In these areas the underlying sand reaches the surface in places and age of trees corresponds to an important change at time of earthquake.

Large areas sunk by amounts reaching 15 feet in some cases, though 5 to 8 was more common. These areas from forest land became swampy or covered with lakes. Lake St. Francis, so formed, is 40 miles long by a half-mile wide. Valuable evidence is given by cypress trees which thrive according to the submergence of the knee or enlargement at the base of the trunk. For a tree to thrive, a certain part of this must be out of the water. The lakes still contain dead tree stumps.

Ejection of water in large quantities, sand, mud, and gas were noticeable features of the quake. The sand, which was the most common, was in some cases mixed with carbonaceous material which was undoubtedly the source of the gas, probably sulphuretted hydrogen, which was very noticeable in places.

Sand blows were very common. Normally these were nearly circular, 8 to 15 feet across and 3 to 6 inches high. Some reached 100 feet in diameter and the linear varieties were as much as 200 feet long and 50 feet wide. The sand was white in strong contrast to the black alluvial soil above. All the sand blows had crater-like depressions in the middle. They occurred frequently throughout an area of 1,400 square miles.

Sand sloughs are also found, depressions of 3 to 5 feet, covered with sand so that vegetation is poorly supported. It is probable that many of the different types of extrusion were caused by the closing of fissures. As they opened, they filled with sand and water, and the closing forced this through the soft layer above to the surface. It is clear that practically all of the changes occurred in poorly consolidated materials.

Water waves of considerable size were caused on the Mississippi. Starting from different points they met and caused a sharp wall-like chop. Fissures opened and closed below the surface, sending out waves. Waves moving upstream and local uplifts caused an appearance of the river flowing upstream. Even ponds showed a troubled surface during the shock.

Caving of banks, disappearance of islands, lifting of snags long buried, and floating trees brought into the river by landslides made navigation precarious until conditions settled down and the pilots learned the changes.

Many trees were overthrown by slides and many were split. In some cases, trees were thrown over to a sharp angle by slides, then when the slide came to rest they started to grow in the new position,

the lower parts of the trunks being inclined and the upper parts vertical. In some places the vibration alone threw the trees down. Over the sunken country trees were killed by overflowing of lower parts of trunks. Forests were probably destroyed over an area of 150,000 acres.

Chimneys were thrown down, and at New Madrid all the houses were thrown down or badly damaged. The destruction from various causes extended over the entire site of the town, which was abandoned, the present site being somewhat different. Small loss of life in the region was due solely to lack of population. Also it took very severe shocks to damage the log houses.

Chimneys were thrown down in Cincinnati, St. Louis, and many places in Tennessee, Kentucky, and Missouri, and bricks are reported to have fallen from chimneys in Georgia and South Carolina.

A distant rumbling is described. The emission of water was accompanied by a hissing and whistling, and noises like the discharge of a cannon, the rumbling of distant thunder, and like the sound of a carriage passing through the street were heard.

This earthquake was unquestionably due to a fracture in deep-seated rocks, probably a further adjustment of an old break. Apparently the doming and sinking are complementary phenomena in unconsolidated material resembling quicksand. There is indication that there had been considerable removal of the load, and this may have had a bearing.

The period of this earthquake was one of great activity elsewhere. A great earthquake occurred in Caracas and also in the West Indies, but there is no evidence of direct connection.

INTERMEDIATE AND MINOR EARTHQUAKES—MIDDLE WESTERN REGION

1776. Summer. Earthquake on Muskingum River, Ohio. Rumbling, furniture overthrown.

1779. Felt in northern Kentucky and probably farther north.

1791 or 1792. April or May. Northern and eastern Kentucky. Few settlements and, accordingly, meager reports.

1795. January 8. Kaskaskia, Ill., and territory to south. Lasted one and one-half minutes; subterranean noise.

1804. August 20. Fort Dearborn, present site city of Chicago, shaken. Felt at Fort Wayne, Ind., 200 miles away.

1820. November 9. Felt at Cape Girardeau, Mo.

1827. August 6-7. Strong shocks at New Albany, Ind.

1843. January 4. The shock was severe at Memphis, Tenn., which appeared to be near the origin. It was reported to have lasted two minutes, though this is probably exaggerated. Walls were cracked, chimneys fell, windows were broken, and houses shook. There was a dismal rumbling. At St. Louis, Mo., people manifested terror and one chimney fell. It was stated to be the most severe shock since the New Madrid earthquakes of 1811 and 1812. Generally felt throughout Arkansas, with three shocks reported at Van Buren, though this could not be confirmed. The earth sunk at some places near New Madrid, Mo., and hunters reported that a lake was formed and that several hunters were drowned, but this could not be confirmed. The shock was felt at Gallatin, Carthage, Sparta, Shelbyton, and Trenton, Mo.; Memphis, Tenn.; Huntsville, Ala.; Mills Point,

Ky.; and Madison, Ind. At Louisville, Ky., it lasted one minute and people found it difficult to stand upright.

Furniture moved at Frankfort, Ky., and a chimney fell at Nashville, Tenn. At Cincinnati, Ohio, furniture and looking glasses were shaken. It was stated that the entire State of South Carolina was shaken. People left their houses at Columbia and the shock was felt at Anderson and Pendleton and also at Augusta, Ga.

1843. February 16. Shock felt at St. Louis, Mo., and Louisville, Ky.

1857. October 8. Two shocks a few minutes apart at St. Louis, Mo. The largest buildings rocked to and fro, windows rattled, the river was in tumult, and animals were frightened. There was a great rumbling like that of a heavily loaded vehicle over rough pavement. Houses with walls 18 inches thick were affected by the horizontal movement. Felt at many places in Illinois and on the Mississippi River to the south of Hannibal, Mo. A well 2,265 feet deep was not affected. The shock was strong at Centralia, Ill., with three shocks.

1860. Minnesota quake. Fairly strong but little known about it.

1865. August 17. Apparently central in southwestern Missouri and generally felt in Illinois, Tennessee, Mississippi, and Missouri. Felt from Holly Springs, Miss., to Cairo, Ill., and as far east as Lagrange, Tenn. At St. Louis furniture rocked and there was a cracking sound in the houses. At New Madrid, Mo., objects fell from shelves, chimneys were damaged, and animals alarmed. Water waves formed on the river like those from the passage of a steamboat. The earth seemed to roll in waves in a swampy area.

1867. April 24. Shocks with rumbling at Lawrence, Kans., where doors and windows were shaken, objects were thrown from shelves, plaster cracked. At Marysville, Marshall County, doors and shutters swung back and forth. A two-story building was strongly shaken in the upper story and there was a loud rumbling noise. Also felt strongly at Manhattan. The shock was felt in Nebraska, Missouri, Illinois, Indiana, and possibly Ohio.

1872. February 6. Three shocks covering 30 seconds at Wenona, Mich.

1872. October 9. Severe at Sioux City, Iowa, and Yankton and White Swan, S. Dak., and elsewhere in the Dakotas. Distinctly felt on low ground but not so much on the bluffs. There was a sound like distant thunder.

1875. June 18. Most severe at Urbana and Sydney, Ohio, where walls were cracked and chimneys thrown down. Also sharply felt at Jeffersonville, Ind. The area affected was 250 miles east-west by 160 miles north-south and included southern Illinois, east Missouri, northwest Kentucky, and southwest Indiana. It was felt at Chicago, Columbus, and Cincinnati.

1875. November 8. Felt at Leavenworth, Lawrence, Manhattan, and Burlingame, Kans. Lasted nearly a minute.

1876. September 25. Two distinct shocks 15 minutes apart. Felt strongly in the Wabash Valley near Evansville, Ind., and at Mount Carmel and Friendsville, Ill. Felt in south Indiana and Illinois from St. Louis, Mo., to Indianapolis, Ind., and Louisville, Ky.

1877. August 17. In southeast Michigan at Redford and Greenfield, not far from Detroit. Horses frightened. Noise like train of cars.

1877. November 15. Felt in east Nebraska, Iowa, Kansas, the Dakotas, and northwest Missouri. There were two shocks 45 minutes apart, the second being the stronger. At North Platte, Nebr., walls cracked and the shock was reported to have lasted 40 seconds. Buildings rocked at Lincoln, walls were damaged at Columbus, and the shock was strong at Omaha. It was felt with force 3 at St. Joseph, Mo. The area was elliptical in form 600 by 300 miles.

1878. March 12. Severe at Columbus, Ky.

1878. November 18. Felt at St. Louis, Mo., Cairo, Ill., Memphis, Tenn., Little Rock, Ark., and elsewhere in the Mississippi Valley. At Cairo the trembling lasted 40 seconds with rocking motion west northwest-east southeast. Strong frame buildings vibrated and creaked at every joint. Severe along the Missouri River from Glasgow to Lexington. The shock was felt over an elliptical area with major axis Leavenworth, Kans., to Tuscaloosa, Ala., 600 miles, and minor axis from Clarksville, Ark., to a point midway between Cairo, Ill., and St. Louis, 300 miles.

1879. December 29. Yankton and Fort Scott, S. Dak. Rumbling noise.

1882. July 20. Woke people at Cairo, Ill. Strong at Collinsville.

1882. September 27. Severe earthquake felt through southern Illinois. There were rumblings at many places and chimneys were cracked, small objects thrown over, and pictures set vibrating. The area affected extended from Mexico, Mo., to Washington and Henderson, Ky., in a west-east direction and from Springfield to Pinckneyville, Ill., in a north-south direction, an ellipse 250 by 160 miles. The shock was felt at St. Louis and St. Charles, Mo.

1882. October 15. This shock covered much the same area as that of September 27. There were three shocks at Centralia, Ill., and a noise like an approaching train at Vandalia. It was felt from St. Louis to Springfield and Indianapolis.

1882. October 22. This shock was felt in north Texas, Oklahoma, west Arkansas, and east Kansas. It extended from Greenbille and Paris, Tex., to Wichita and Leavenworth, Kans., a distance of 450 miles, and at Warrenton, Mo. At Sherman, Tex., heavy machinery vibrated, bricks were thrown from chimneys and moveable objects overturned. Houses were shaken at Fort Smith, Ark. It was difficult to obtain the probable origin owing to insufficient reports from the region most affected.

1883. January 11. Strong shock from St. Louis, Mo., to Memphis, Tenn. Four distinct shocks at former place, more severe than those of previous year. Buildings rocked, chandeliers swung, engine bells rang. Greatest motion was at Cairo, Ill., about the middle of the area shaken.

1883. February 4. Felt in north Indiana and south Michigan. Cracked windows and shook buildings at Kalamazoo, Mich. Felt at St. Louis, Mo., and Bloomington, Ill.

1883. June 11. Three shocks at Memphis. Buildings shaken and people rushed out. Third shock heaviest and accompanied by rumbling.

1883. December 5. Lead Hill, Boone County, Ark. Buildings shaken. Noise like thunder. Slides in railroad cut.

1884. September 19. Moderate earthquake in Ohio, Indiana, and parts of adjacent States. Intensity was 3 to 4 over a large area.

The center was near Columbus, Ohio; Lima was the most central point. At many places there were two distinct vibrations. At Columbus, chandeliers kept swinging from north to south for several minutes. The shock was felt at Washington, D. C., by workmen on top of the then unfinished Washington Monument, about 500 feet above the ground. Felt from Pennsylvania to Kentucky, and West Virginia to Michigan.

1887. February 6. South Indiana, Illinois, Kentucky, and Missouri. Felt over 75,000 square miles. Strongest in southwest Indiana and southeast Illinois. Force 6 at Vincennes, Ind.

1889. July 19. Memphis, Tenn. Walls and ceilings cracked. People frightened.

1891. January 8. Rusk, Tex. Listed by Milne without details.

1891. July 26. Evansville, Ind. People frightened in various churches. Damage to property.

1895. October 11. Black Hills, S. Dak. Two shocks, first strongest at Rockford; second strongest at Keystone and Hill City.

1895. October 31. Considered the hardest shock in the entire region since the New Madrid earthquake. Near Charleston, Mo., 4 acres of ground sank and a lake was formed. At Cairo buildings swayed, chimneys cracked, and church steeples twisted. Many chimneys were demolished. Near Bertrand hundreds of mounds of sand were piled up, ranging from 12 inches to 10 feet in circumference. The ditches in this neighborhood were filled with water, coming from the holes made, there having been no rain to fill them in any other way for nearly two months. Near Big Lake, 4 miles north of Charleston, were two small holes in the earth from which the water spouted to the height of 3 feet. In Dunklin county shocks were much lighter. It was felt from Canada to Mississippi and Louisiana, and from Georgia and Virginia to Kansas and South Dakota, 23 States in all.

1897. April 30. Tennessee, Illinois, Indiana, and Kentucky were shaken 20 seconds.

1899. April 29. Southwest Indiana and southwest Illinois. Strongest at Jeffersonville and Shelbyville, Ind. A few chimneys thrown down at Vincennes.

1901. May 17. Near Wellston and Portsmouth, Ohio. Felt at Zanesville, Ohio, and Huntington, W. Va. (Force 3-4.)

1902. January 24. Fairly strong at St. Louis, Mo., and at Clifton Heights just west of Quincy, Ill. (Force 3.) Felt at Kansas City, Mo., and Leavenworth, Kans. Felt in Missouri, west Illinois, and Kansas.

1902. July 28. Nebraska, near Battle Creek, where it lasted 30 seconds. Felt strongly at Yankton, S. Dak.; barely felt in Chicago. Felt in Nebraska, west Iowa, and South Dakota.

1903. February 8. Southern Illinois; sharp at St. Louis where explosive sounds were heard. Strong shock from Jeffersonville, Mo., to Louisville, Ky., and Cairo, Ill., to Hannibal, Mo. Strongly felt and roar heard over 20,000 square miles and felt over 70,000 square miles.

1903. November 4. St. Louis. Felt in southern Illinois, Kentucky, Mississippi, Arkansas, Missouri, and Tennessee, with force 6-7. Similar in area and intensity to last quake. Walls of building cracked and chimneys damaged at Cairo. Preliminary shock October 4 at St. Louis; after shocks November 24 and 27 at New Madrid.

1904. October 27. Meade and Dodge City, Kans. People wakened and dishes rattled. Three shocks at Dodge City.

1905. March 13. Force 5 at Menominee, Mich.

1905. April 13. Several shocks of force 5 at Keokuk, Iowa.

1905. July 26. An earthquake which was apparently associated in some way with the peculiarly unstable conditions brought about by mining operation was felt all over the Keewenaw Peninsula, Mich. It was heaviest at Calumet. There was a terrific explosion, chimneys fell with a crash, and plate-glass windows broke. The explosion was heard far down in the mine. Felt in Marquette, Mich.

1905. August 21. Mississippi Valley, probably southeast Missouri. Force 6 at Memphis, force 5 at Mount Vernon and Evansville, Ind. Old roof collapsed at St. Louis. Force 4-5 at Owensboro, Ky., 3-4 at Paducah, 3 at Henderson. At center there were three shocks accompanied by noise. The shock was felt in Illinois, Indiana, Kentucky, Tennessee, and Missouri.

1906. January 7. Manhattan, Kans. It was strong enough to throw down some chimneys and produce some cracks in walls. At Wamego, 15 miles west, and Junction, 17 miles southwest, plaster was knocked from walls. It was felt from Plattsmouth, Nebr., to Wichita, Kans., and from Bethany, Mo., to Beloit, Kans. Began with tremor followed by two distinct shocks, then dying away gradually. At Manhattan a roar preceded the shock by 10 seconds; at Topeka it followed it in 10 seconds.

1906. May 9. Cody, Nebr. Central in East Washabaugh County, S. Dak. Reported all along the Niobrara Valley from Rushville to Valentine. Felt farther east. Center was in Indian reservation. Felt over an area of 7,000-8,000 square miles.

1906. May 11. Petersburg and Princeton, southwest Indiana. Felt from Washington, Davies County, to Princeton, Gibson County. Area 40 by 25, or 700 to 800 square miles.

1906. May 26. At the Atlantic Mine on Keewenaw Peninsula the effects were such as might be produced by a great earthquake. Rails were twisted and there was notable sinking of the earth above the workings. Such effects were noted nowhere else, though at Madison, Wis., there were three distinct shocks; at Lansing furniture swayed and at Muskegon along the lake shore dishes were upset and windows were shaken. The area affected was about 1,000 miles in diameter.

1906. June 27. Fairport and Put in Bay, Ohio, center south of Cleveland. Two shocks.

1907. July 4. Felt at Farmington, Mo., with force 4-5, Grantville 3 and Bismarck and Sunlight 2; ellipse 35 by 15 and area of about 400 square miles. Sounds like explosions.

1908. September 28. New Madrid, Mo. Felt at Cairo.

1908. October 27. Force 5-6 at Cairo, 4-5 near New Madrid.

1909. January 22. Houghton, Mich. Felt over a small area, thought due to crushing of pillars in mine. Rumbling.

1909. May 15. Strong shock in Saskatchewan, felt in South Dakota.

1909. May 26. Missouri to Michigan, and Minnesota to Indiana. Felt over area 800 miles in diameter. Force 8 was noted over a considerable area from Bloomington, Ill., to Platteville, Wis. Quake was just under point of damage to buildings at Aurora where many

chimneys fell. In Chicago buildings swayed, this being especially noticeable in the upper stories. Mirrors swayed, beds moved on castors, and there was fear that walls would collapse. Dubuque, Iowa, had a fairly sharp shock. Strong at Pontiac and Freeport, Ill.

1909. July 18. Between Havana and Petersburg, Ill., a little north of Springfield. Chimneys down at Petersburg, Hannibal, Mo., and Davenport, Iowa.

1909. August 16. Strong at Waterloo, Ill. Felt all over southwest part of State.

1909. September 22. Ohio Valley. Houses rocked. Felt at Louisville, Ky.; Terre Haute, and Madison, Ind.

1909. September 27. Strongest between Vincennes and Terre Haute, Ind., where some chimneys fell, several buildings were cracked, light connections were severed, and pictures shaken from the walls. Strong at Indianapolis. At Oakland City there was a succession of heavy jars, windows rattled and furniture swayed. It was felt at Springfield and Decatur, Ill. Area where felt included southwest half of Indiana, all of Illinois, southwest third of Iowa, Missouri, west half of Kentucky and northeast Arkansas. Noticed at Kansas City, Mo., and possibly a little farther west into Kansas.

1909. October 23. Center in southeast Missouri. Felt from St. Louis to northwest corner Mississippi, 300 miles, and probably 200 miles east-west, the area affected being approximately 40,000 square miles in Missouri, Arkansas, Mississippi, Tennessee, Kentucky, Illinois, and Indiana.

1909. October 23. Near Robinson, Ill. Felt at Newton, 23 miles northwest; Indianapolis, Ind., 100 miles northeast; Jasper, Ind., 60 miles southeast.

1910. February 26. Columbus, Nebr. Houses shaken. Several shocks.

1911. March 31. This earthquake had its center somewhere near Rison and Warren, Ark. At the former place houses swayed and articles were thrown from shelves. The shock was felt throughout southeast Arkansas, northeast Louisiana, and along the Mississippi River from Memphis to Vicksburg, an area roughly 200 north-south by 100, or area of 18,000 square miles. The area was of a half-moon shape and this was considered by Reid as due to the soft deposits along the Mississippi, in which the shock was more strongly felt than elsewhere.

1911. June 2. James River Valley, South Dakota. Reported from Huron and other places in South Dakota, Iowa, and Nebraska over an area estimated at 40,000 square miles. Few replies received in response to requests for information.

1912. January 2. Force 6 at Aurora, Ill., and 5 at Chicago. Also 6 at Yorkville and Morris, and 5 at Freeport. There were two distinct shocks, one of great intensity followed by another less strong. There was apparently a secondary epicenter at Dixon, Ill., 55 miles west of the first. The shock was felt at Milwaukee and Madison, Wis., but not a corresponding distance to the south. It was felt in Illinois, Iowa, Wisconsin, and Indiana.

1915. April 28. New Madrid and Tiptonville, Mo., 14 miles apart. Lasted 5 to 8 seconds.

1915. October 23. Kadoka, west central South Dakota. Loud noise. Cracks in ground reported.

1915. October 26. Mayfield, Ky. Center in sunken country.

1915. December 7. A sharp earthquake with center near mouth of Ohio River (position determined from instrumental records by Reid) caused houses to shake and frightened people at Cairo, Ill. It was generally felt over an area of 60,000 square miles in Illinois, Kentucky, Tennessee, Arkansas, Mississippi, and Missouri.

1916. December 18. Hickman, Ky. Bricks shaken from chimneys near New Madrid, Mo.

1917. March 28. Local shock at Panhandle, Tex. Children left school but little harm was done. Plaster cracked.

1917. April 9. Middle of east border of Missouri. Felt from Kansas to Ohio, and Wisconsin to Mississippi, approximately 500 miles east-west and 600 north-south, an area of about 200,000 square miles, over 10 States. The maximum force was 6. In the epicentral region between St. Louis and New Madrid, windows were broken, plaster cracked and at Ironton, Mo., the ground was seen to sway. At Granite City a painter was thrown from a ladder. Shock lasted one-half to 1 minute.

An aftershock at 17.35 was felt in the south part of the area covered by the 5-6 isoseismal line.

1917. September 3. Brainerd and Staples, Minn. At Staples walls were cracked and objects thrown from shelves. Houses swayed, windows broke and plaster cracked. The area was about 100 miles in diameter and perhaps 10,000 square miles. Previous quakes in this region are not accurately known but one has been listed for 1860 and possibly there was another between 1860 and 1865.

1918. September 10. A series of earthquakes in Oklahoma, centering at El Reno (central part). Strongest was force 6 at time given. Objects were thrown from shelves.

1918. October 4. Center 20 to 30 miles southeast of Little Rock, Ark.; felt at Black Rock, 120 miles northeast, and at Memphis. Felt over area of 30,000 square miles.

1918. October 15. Felt at Memphis, Savannah, Union City, Clarksville, Tenn., and Cairo and Anna, Ill. Not felt at St. Louis. Center probably in sunken country.

1919. May 25. Indiana, Illinois, and Kentucky. Force 5 at Princeton and Vincennes, Ind.

1919. November 3. Loud rumbling and generally felt in vicinity of Pochahontas, Ark.

1920. May 1. Columbia, Mo. Felt at Warrenton, 110 miles west of St. Louis, and at Mount Vernon, Ill., 70 miles east-southeast. Felt in Illinois and Missouri.

1922. March 22 and 23. Two shocks widely felt with force 5 at many places from Arkansas to Indiana, centering in south Illinois.

1923. October 28. Marked Tree, Ark. Force 7 to 8, 5 at Memphis. Felt in Arkansas, Kentucky, Mississippi, Missouri, Tennessee. Windows shattered, several old chimneys razed, walls cracked. Surface of the St. Francis River was affected.

1923. December 31. Force 5 in Arkansas just west of Memphis, Tenn. Felt in Arkansas, Tennessee, Kentucky, and Illinois.

1924. March 2. Center in Kentucky just east of Cairo, Ill. Felt in Kentucky, Tennessee, Illinois, and Missouri. Area 160 miles north-south and 100 east-west.

1925. April 26. Indiana near Evansville. Force 6. Felt in Indiana, Illinois, Kentucky, and Ohio, but chiefly north of the Ohio River.

1925. May 13. Shock felt in Illinois and Kentucky. Strongest at Mayfield, Ky.

1925. July 30. Panhandle region, Texas. Force 6 at epicenter. Earthquake of special interest because of knowledge of underground conditions through borings for oil wells.

There were three distinct shocks over a period of 15 seconds. The chief results were the shaking of dishes from shelves and rattling and creaking of furniture. It was felt at Roswell, N. Mex., 225 miles; Tulsa, Okla., 300 miles; and Leavenworth, Kans., 400 miles. Only previous known shock in the region was the shock at Panhandle, Tex., March 27, 1917.

From inspection of the surface this would not seem a region where an earthquake would be likely to occur, as there is every evidence of stability. Many persons thought that it resulted from the oil drilling, but the area over which it was felt precludes any such cause. However the drilling has brought out the fact that the region is the site of a buried mountain with slopes of 1,500 to 2,000 feet in a few miles. In spite of long burial there still seems to be activity and the earthquake is probably a renewal of activity in a region once very active.

1925. September 2. Shock felt in Kentucky, Illinois, Indiana, and Tennessee, centering near Henderson, Ky. Area 325 miles north-south and 250 miles east-west. Lighter shock on September 20 at 3.06.

1926. November 5. Ohio and West Virginia. Strongest at Pomeroy, Ohio. Chimneys thrown down and stove overturned.

1927. March 19. Strongest at White Cloud, Kans., where people rushed out of houses. Houses rocked.

1927. May 7. Arkansas and adjacent States. Strongest at North Jonesboro, Ark. Some chimneys tumbled down, buildings rocked to and fro. Many felt ground movement. Felt from Decatur, Ala., to Carbondale, Ill., and from Pocahontas, Ark., to Jackson, Tenn., an area of 130,000 square miles. While it was felt most strongly in Arkansas, the area over which it was felt indicates that the center was farther to the east near the position listed.

WESTERN MOUNTAIN REGION

RÉSUMÉ

Less is known about the earthquake history of this part of the United States than of any other. The list begins with 1868, a very recent date compared with those for the other regions, and for some time even after that date the accounts are very inadequate. Many of the earthquakes have occurred in slightly populated regions with many of their people little interested in helping to preserve earthquake records. It is beyond question that there has been much activity in this region though there seems to be insufficient reason for accepting the map of Sieburg which shows a large major earthquake area in this region. Montana, Utah, and Nevada have been subject to earthquakes of considerable severity and there is a region in Mexico just south of the border which has had one major earthquake and many minor ones. It is probable that less damage in loss of lives and property is likely in this region because of the wide separation of the towns over most of the area and the possibility of grave topographic changes without special damage to human undertakings. However, a danger of considerable importance was shown in the Montana earthquake of 1925 when a transcontinental railroad was blocked for several weeks and a train narrowly escaped being completely buried. Such occurrences have been not infrequent in Europe.

Earthquake investigation by scientific methods will be more difficult in this region than in any other for the reason that the institutions which can undertake the work are widely scattered.

EARTHQUAKES—WESTERN MOUNTAIN REGION

Year	Date	Hour	Locality	N. lat.	W. long.	Area (square miles)	Intensity	Authority
1868	Apr. 28		Socorro, N. Mex.	34.0	107.0			20
1869			do.					20
1872	Dec. 10	16.30	Montana	46.4	112.5		7-8	2-73
	Dec. 11	6.55	do.					
1879			Socorro, N. Mex.					20
1880	Sept. 16	22.27	Utah	40.8	112.0	3,000	5-6	4
1882	Nov. 7	18.30	Colorado	40	105	11,000	6	2-83
1884	Nov. 9	2.00	Utah	41.5	111.2	6,000	5-6	2-85
1886	July 6		Socorro, N. Mex.					20
1887	May 3	14.13	Sonora, Mexico	31.0	109.5		10	3-8, 3-10, 15-86
1893	July 12		New Mexico	35.0	106.4		6	25
	Sept. 7		do.	34.7	106.6		8	25
1894	July 18	15.50	Utah	41.2	112.0	(¹)	6-7	4, 7, 8A
1895	Mar. 22		Colorado			1,500	5	8
	Oct. 7		New Mexico	34.5	106.7		6	8
	Oct. 31		Socorro, N. Mex.					20
1897	Nov. 4	2.29	Montana	45	113		6	4
			Socorro, N. Mex.					20
1899	Dec. 13	6.50	Utah	41	112	5,000	5	4
1900	Aug. 1	12.45	do.	39.8	112.2	600	6-8	8

¹ Local.

Earthquakes—Western mountain region—Continued

Year	Date	Hour	Locality	N. lat.	W. long.	Area (square miles)	Intensity	Authority
1901	July 26	14.40	Nevada	(?)	---	2,000	---	8
	Nov. 13	21.30	Utah	38.7	112.1	50,000	9	8
	Nov. 19		do	38.7	112.1			8
1902	Nov. 15	a. m.	Colorado	38.8	106.2	(?)	6	7, 8A
	Nov. 17	12.53	Utah	37.4	113.5		7-8	8
	Dec. 5		Southeast Utah					3-15, 26
1903	Jan. 23	21.30	California, felt in Arizona				5-6	20
	Jan. 19-Sept. 10	19.10	Socorro, N. Mex.				5	8
1904	Aug. 3	20	Montana	45.5	111.8	(?)	5	8
	Nov. 11	15.26	Idaho	42.9	114.5		7-8	8
1905	Jan. 25	13.35	Arizona	35.3	111.6	15,000	7-8	8
	July 12	5.15	Socorro, N. Mex.	34.0	107.0	60,000	6-8	3-1, 8A, 20
1906	July 16	12.00	do			60,000		
	Nov. 15	5.15	do			100,000		
1908	Oct. 18	19.06	Idaho	42.5	111.4	3,000	5	8
	Dec. 20	16.30	Montana	45.2	111.8		7	8
1909	Oct. 5-Dec.		Utah	42.9	113	(?)	7-8	8
	Jan. 10-12		Central Utah	38.7	112.1	(?)	6-7	8
1910	May 22	7.28	North Utah	40.8	112.0	3,500	7-8	8, 0
	July 25	18.30	Wyoming	41.5	109.3	(?)	5	0
1911	Sept. 23	21.05	Northeast Arizona	36.0	111.1	25,000	8-9	8, 0
	Aug. 18	14.12	Arizona	36.5	111.5	55,000	8	8, 0
1912	Apr. 12	1.25	Southeast Idaho	42.3	110.0	8,000	5	8
	July 18		Socorro, N. Mex.					0
1913	Oct. 14-15		Boundary, Idaho and Oregon	45.5	116.5	(?)		8
	Nov. 11		Colorado	38.2	107.7	7,600	6	8
1914	Dec. 5	14.55	do					
	May 13	10.15	Arizona and New Mexico	34.1	106.8	(?)		8
1915	Dec. 20	22.25	Utah	42	112		6-7	8
	May 8	9.10	do	37.6	113.6		5	4, 8
1916	May 8	9.10	Wyoming	44.9	110.7	10,000	5	4
	July 30	11.50	do	41.8	112.2	(?)	5	4
1917	Aug. 11	3.20	do	40.5	112.7	(?)	6	4
	Oct. 2	22.54	Nevada	40.3	117.6	100,000	9	3-5, 4
1918	Nov. 17	15.35	Nevada	40.9	115.8		6	4
	Nov. 20	16.13	California	32.4	115.2	120,000	7-8	4, 8
1919	Feb. 2	21.02	Nevada	40.6	119.4	100,000	6-7	4
	May 12	19.30	Idaho	44.8	117.0	50,000	7	4
1920	May 25	23.36	do	43.8	116.0	10,000	5-6	4
	Aug. 18	5.15	Nevada	41.0	117.5	(?)	6-7	4
1921	Sept. 9	19.67	Idaho	43.5	114.3	(?)	5	4
	Dec. 12	4.44	Arizona	34	110	70,000		4
1922	Apr. 19	21.30	Idaho	44.0	114.8	(?)	5	4
	Dec. 12	5.00	do	43.0	111.3	8,000	5	4
1923	Mar. 11	20.26	Washington, Idaho, and Montana	47.6	117.0	6,000	5	3-8
	May 28	4.30	New Mexico	35.5	106.6	7,500	8-9	4
1924	Jan. 31	21.30	Socorro, N. Mex.	34.0	107.0	(?)	4-5	4
	Feb. 1	13.30	do			(?)	5	4
1925	Sept. 18	14.05	Utah	41.5	112.0	2,000	5-6	4
	Sept. 19	6.50	do					
1926	Nov. 19	22.40	do					
	Nov. 25	17.00	do	37.1	113.5	(?)	6	4
1927	Sept. 19	7.13	do	38.8	112.2	(?)	8-9	3-11, 4
	Oct. 1	8.32	do					
1928	Oct. 27	7.15	do					
	Nov. 1	8.35	do					
1929	Mar. 23	21.00	Wyoming	43.6	110.6	1,500	5-6	4
	Aug. 12	21.23	New Mexico	36.0	104.5		5	10
1930	Nov. 23	10	Idaho	42.6	111.5	20,000	5	10
	June 27	6.21	Montana	46.0	111.2	310,000	9	10
1931	July 10		do	46.0	111.2			10
	Aug. 10	9.30	do	49.3	112.5	25,000	5-6	10
1932	Nov. 17	18.50	Wyoming	44.6	107.0	3,000	5	10
	May 31	5.25	Montana	46.0	111.4	1,000	5	10
1933	Nov. 27	18.30	Idaho	47.5	116.0	2,000	5-6	10
	Dec. 12	17.44	Montana	46.1	111.2	30,000	5-6	10

1 Local.

2 Doubtful.

3 Uncertain.

MAJOR EARTHQUAKES—WESTERN MOUNTAIN REGION

EARTHQUAKE OF MARCH 3, 1887

Epicenter.—Bavispe, Sonora, Mexico.

Area affected.—Not known. Area 300 miles in diameter strongly shaken.

Intensity.—Ten at epicenter.

Description.—This earthquake occurred in a very sparsely settled region and is named for the town of Bavispe, not because this was the point of maximum activity but because it is the only village of any size in the region. The reports are due to Jose G. Aguilera, chief of the Mexican Geological Survey, and to George E. Goodfellow, of Tombstone, Ariz., both of whom visited the region within a year. Correct information as to the exact time of the shock and other important details are lacking, because of general lack of timepieces, illiteracy of people, and unwillingness to give out such facts as they may have had, sparse population, difficult communications in some parts and inaccessibility in others, and the unparalleled severity of the rainy season of 1887.

Seismic movements were felt from Toluca, near Mexico City, to Albuquerque and Sante Fe on the north, from Guaymas and Yuma on the west to a point 60 miles east of El Paso on the east. The central tract of maximum intensity was found in the San Bernardino Valley and the neighboring part of the Teras Mountains. These belong to the Sierra Madre Mountains, an extension to the south of the mountains of eastern Arizona, the heights ranging from 4,000 to 10,000 feet. It is a region of considerable instability with evidence of past earthquakes.

The San Bernardino Valley, like others in this region, has three parts: A narrow bed of the water course, alluvial overflow bottom, and mesas, including the foothills of the mountains. In the stream bed water appears in places, but in general it is several inches to several feet below the surface.

There is a single large fault on the eastern margin of the San Bernardino Valley, where the mesas merge into the foothills. The total length is 35 miles, the fault being somewhat winding as it follows the base of the foothills. The average difference in height between the sides is 7 feet but in one place it is as much as 26. There is evidence of similar movement in the past.

Great numbers of cracks were found in the river beds and there were outbursts of water and sand through fissures and holes. At Batepito Ranch an area 2 miles long by 1 mile wide was covered with water to an average depth of 4 inches. At first the streams and springs almost went dry and then had a greatly increased flow at least a month before the start of the rainy season.

Millions of cubic feet of rock were thrown from the mountains. Cliffs of solid crystalline rock were shattered as if by explosion. One narrow canyon contained an immense amount of material from the adjacent cliffs.

Bavispe was the principal town damaged. It is on very unconsolidated material. The houses were substantially built of adobes

24 by 12, laid double so that the walls were 24 inches thick. Roofs were made of rafters covered with brush and mud, making a very heavy roof. Damage was chiefly the dropping of the roofs, indicating a lateral earth movement of at least a foot. Only in part of the town was the destruction serious. The church, which was not as well built as the houses but which had stood for more than 200 years, was completely destroyed. All the damage was done at the first shock. The energy of the shock varied greatly throughout the region. A town 9 miles north and one $3\frac{1}{2}$ miles south of Bavispe were practically undamaged.

Anywhere within 150 miles of the center the energy of the shocks was considerable. From Guaymas to Nogales, Benson, Tucson, El Paso, and at places as far away as Albuquerque water tanks slopped over, cars were set in motion on the tracks, chimneys were thrown down, buildings cracked. Mr. Goodfellow was at Tombstone and felt the tremors and heard sounds like prolonged artillery fire coming from the south and dying away to the north. He fixed the time of arrival as 14.13.

He also, while investigating the earthquake region, experienced many aftershocks. By means of a crude seismograph of the simple pendulum type, he fixed the epicenter as in the Texas Mountains.

EARTHQUAKE OF OCTOBER 2, 1915, 22.54

Epicenter.—Pleasant Valley, Nev.

Area affected.—Larger than that of California earthquake of 1906. Exact area not known.

Intensity.—Nine at epicenter.

Damage.—Moderate because region thinly settled.

Description.—A severe earthquake occurring along a fault in the eastern side of Pleasant Valley which lies south of Winnemucca was felt from Baker, Oreg., to San Diego, Calif., and from the Pacific coast to beyond Salt Lake City. While felt over as large an area as the California earthquake of 1906, it did little damage because of few structures and people. Pleasant Valley is a long narrow valley lying between two ranges. There were two shocks scarcely felt outside of Nevada, one at 15.40, another at 17.49. At Kennedy, there was a roar and people had trouble keeping to their feet; the shock was force 5 at Reno. At Kennedy, the motion continued till the main shock at 22.54. At this time, there was a great roar, people were thrown from their beds and even thrown on the floor. Adobe houses were destroyed. Concrete mine foundations cracked and mine tunnels caved in. As usual, the effect was greater where the materials were unconsolidated. In such cases, cracks appeared for considerable distances. At Winnemucca, the damage was moderate and confined to part of the city on low ground. At Lovelocks, large water tanks were thrown down and cracks appeared in road. There was a great increase in flow of water, so much so that applications were filed for new water rights. A rift was formed with a fresh vertical scarp 5 to 15 feet high and 22 miles long, parallel to base of Sonoma Mountains. This earthquake in many ways resembles the Owens Valley earthquake.

EARTHQUAKES OF SEPTEMBER 29 AND OCTOBER 1, 1921

Epicenter.—Elsinore, Utah.

Area affected.—Considerable.

Intensity.—Eight to nine.

Description.—Elsinore is in Sevier Valley, 150 miles south of Salt Lake City and 5,335 feet above sea level. It is fairly old and the early houses were built of sun-dried brick and fragments of black basaltic lava. Later houses are of modern construction. At the time of the earthquake, there were about 1,000 inhabitants. The valley is about 5 miles wide and is flanked by abrupt rise of plateaus to several hundred feet.

After several weeks of preliminary tremors, the first sharp shock occurred at 7.12 on September 29. It lasted 7 to 10 seconds, was unaccompanied by noise, and was probably of force 8. It threw down scores of chimneys, plaster fell from ceilings, and walls were fractured. Another shock of force 7 occurred at 19.30 the same day. At 8.32 on October 1, there was another shock like the blow of a great hammer, unaccompanied by noise except from creaking buildings and falling chimneys and was probably of force 8. The country was very dry and great clouds of dust arose.

The first shock was strongest at Elsinore but did damage at Richfield and Monroe. The greatest damage was to the Elsinore schoolhouse. Although it was a new two-story brick building, a part of the wall went down and if it had been during school hours there would have been a heavy loss of life. Near by, an old building of rectangular blocks of rock was little damaged. Half the buildings were damaged in some way, with chimneys thrown down or otherwise rendered unsafe. Plaster fell from ceilings, pictures were thrown from the walls. One chimney was twisted through 45°. It is stated that a hot spring with oxide of iron in the water ran blood red for a time after the earthquake.

Shocks lasted from September 12 to December 20, the most important being those of October 27, felt sharply at Richfield, and of November 1.

MONTANA, JUNE 27, 1925, 18.21

Epicenter.—46° N., 111° 14.5' W., east of Helena, Mont.

Area affected.—Violent shake, 600 square miles area; shock felt 310,000 square miles.

Intensity.—Ten.

Description.—There was a severe windstorm between 4 and 5 p. m. but this apparently had nothing to do with the earthquake, except possibly as a trigger force to fix the time. The first shock was at 6.21, the second at 7.06, and the third at 8.40. At Bozeman, a loud roar was heard with each shock and the second was quite as severe as the first. At 11.30 there was another hard jolt.

The greatest damage was done at Manhattan, Logan, Three Forks, and Lombard. At Trident, on the Missouri River, a house rocked so violently that the family could scarcely leave it and railroad tracks were seen to move with a sinuous motion. Rock falls from the cliffs delayed trains on the Northern Pacific Railroad and a great slide of rock blocked the Deer Park entrance of the Lombard Tunnel of the Chicago, Milwaukee & St. Paul. It required a long time to

clear this away and heavy cost was entailed. The greatest damage to buildings occurred at Manhattan where a large schoolhouse was badly wrecked, though reinforced concrete buildings escaped harm. Many chimneys fell and it was of interest to note that there appeared to be a twist rather than a general direction as the chimneys fell in every possible direction. At Logan a large brick roundhouse showed only a few cracks.

At Three Forks a boiler chimney of cement brick laid in lime mortar was damaged and moved 4 inches to the south. A brick building with a reinforced concrete basement and with bricks laid in cement and mortar was scarcely damaged, while the schoolhouse with brick walls in lime mortar was badly damaged and the walls bulged on all sides. The church suffered considerable damage, since the walls were excessively high and were not tied together by an upper floor as in the case of other buildings. Masonry buildings showed cracks, while frame buildings had only plaster cracks and fallen chimneys. Crevices occurred in fills on roads but not in cuts or where the natural surface had not been disturbed. Approaches to many bridges settled, in some cases as much as a foot.

The earthquake was felt from the North Dakota line to Washington, and from the Canadian border to the middle of Wyoming. The area severely shaken is estimated at 600 square miles and total area at 310,000 square miles. There were numerous aftershocks for several months, the strongest being that of July 10.

Byerly's study indicates that the epicenter as given above coincides with a known fault and that of the second shock was somewhat to the south and west. The general conclusion is that this is a region of moderate seismic activity and that the region may be visited by fairly severe shocks from time to time.

INTERMEDIATE AND MINOR EARTHQUAKES—WESTERN MOUNTAIN REGION

1868. April 28. Socorro, N. Mex.; see page 56.

1869. ———. Socorro, N. Mex.; see page 56.

1872. December 10. Helena, Mont. Two shocks, equal duration and force, lasting 5 seconds. Plaster cracked, stovepipes parted. There were rumbling noises. There was another shock December 11, 6.55, at Deer Lodge, stronger than that described above.

1879. Socorro, N. Mex.; see page 56.

1880. September 16. Salt Lake City, Utah. Lasted 15 seconds. Felt in various parts of the territory from Salt Lake City to Provo.

1882. November 7. Felt along the line of the Southern Pacific Railroad from Laramie and Cheyenne, Wyo., to Georgetown and Louisville, Colo. Clocks stopped at Denver and chandeliers were set vibrating. There was rumbling at Cheyenne and houses were shaken. At some places three shocks were felt. A report of the shock was received from Salina, Kans.

1884. November 9. Felt at Fort Bridger, Wyo., Salt Lake City, Utah, and Paris, Idaho. Telegraph wires were seen to swing perceptibly at Paris. There were six shocks from 2 to 4 with considerable damage to houses. People suffered from nausea.

1886. July 6. Socorro, N. Mex.; see page 56.

1893. July 12. Albuquerque, N. Mex. Three shocks shook every house in city. Clocks stopped. A chandelier was seen to swing for 10 minutes.

1893. September 7. Central New Mexico was subjected to shocks for three months during this year, the most severe being on the date here given. Five shocks threw down many adobe buildings at Los Lunas, which were already shaky from previous earthquakes. No lives lost but many suffered from nausea. Also felt at Sabinal.

1894. July 18. Ogden, Utah. Three distinct shocks. Walls cracked. Dishes shaken from tables. People frightened.

1895. March 22. Steamboat Springs, Colo. Report like blast, low rumble. Felt from Pleasant Valley, 12 miles south, to Hayden, 25 miles northwest.

1895. October 7. Sabinal and Jarales, N. Mex. Articles thrown from shelves. Felt at Albuquerque.

1895. October 31. Socorro, N. Mex.; see page 56.

1897. Socorro, N. M.; see page 56.

1897. November 4. Idaho, Montana, and Utah. Most severe at Dillon, Mont.

1899. December 13. Weber, Morgan, Davis, and Salt Lake City, Utah; rumbling.

1900. August 1. Tintic, Utah. Deep shafts of mine twisted so that cage could not be operated. Dishes thrown from shelves. People frightened. Goshen 7 to 8, Santaquin 6 to 7.

1901. July 26. Felt over 2,000 square miles in the Nevada Desert. Shock severe at Elko and felt 50 miles to north.

1901. November 13 to 19. Strongest in Sevier County, Utah, about 150 miles south of Great Salt Lake. Shaken most strongly along a line from Beaver to Richfield, about 40 miles long northeast-southwest, but it was strong at St. George, 100 miles farther to southwest, and must have been felt still farther. It was felt 100 miles northeast from Beaver.

1901. November 15. Buena Vista, Colo. Windows cracked and bowlders fell on road. Water of Cottonwood Lake affected.

1902. November 17. Pine Valley, Washington County, Utah. Chimneys damaged. Crockery thrown from shelves.

1902. December 5. Strong shock, southeast Utah.

1903. January 23. Southern California; shock felt in Arizona and Nevada.

1904. January 19. Shock at Socorro, N. Mex.; see page 56.

1904. September 10. Shock at Socorro, N. Mex.; see page 56.

1904. August 3. Pony and Norris, Mont. Shock lasted 12 seconds; buildings rocked, dishes rattled, objects thrown from shelves, no other damage.

1905. November 11. Strongest at Shoshone, Idaho. Felt in south half of Idaho, north part of Utah, east part of Oregon.

1906. January 25. Lasted 20 seconds at Flagstaff, Ariz. Center probably in San Francisco Mountains. Felt from Gallup, N. Mex., to Seligman, Ariz., estimated area 50 by 300 miles. At Flagstaff chimneys fell, plaster cracked, panic narrowly averted.

1906. July 12, July 16, and November 15. There were a series of shocks on these dates at Socorro, N. Mex. Shocks occurred almost daily from July 2 until well into 1907. The shock of July 12 was of force 8 with some walls of adobe cracked and others thrown down.

Waves were seen and there were fissures in the ground. The shock of July 16 was more severe. It was felt at Raton, N. Mex., 235 miles to the northeast, and Douglas, Ariz., 250 miles southwest. Train, stopped about 10 miles west of Socorro, was nearly derailed, and probably the epicenter was about there. The November 15 shock was force 8 and was felt over an area 180 miles in radius, total area about 40,000 square miles. There was frequent rumbling. The history of this region shows frequent quakes of some intensity; the list includes 1868, April 28, force 6; 1860, force 7, springs changed flow and became muddy; 1879, force 5-6; 1895, October 31, force 7; 1897, force 6, waves seen in ground; 1904, January 30, force 5; February 21, force 5; March 8, force 5; September 10, force 6. Also in 1893, July 12 and September 7 the region to the north was strongly shaken. Just before the important shocks of 1906, there was one of less intensity on July 2. There were various later shocks through 1907 and a strong shock in 1913, July 18. There were shocks in 1919, January 31, force 4-5, and February 1, force 5.

1906. October 18. Southeast Idaho near Paris and Montpelier. Buildings swayed. Felt at Soda Springs and Henry, 18 miles north of Idaho Falls, where buildings were strongly shaken. Reported from Afton, Wyo.

1908. December 20. Virginia City, Mont. Center near Crater Lake, 7 miles to southeast. Not felt 30 miles away. Thirty shocks in a week. Several cracks in buildings. Shocks lasted till December 29.

1909. October 5 till end of December. North of Great Salt Lake, 30 to 60 shocks, some strong enough to throw down chimneys but not felt at Brigham City, 10 miles away. Felt at Garland.

1910. January 10-12. Richfield, Utah. Windowpanes broken. Shocks lasted 10 days but over small area.

1910. May 22. Damage to chimneys and old buildings at Salt Lake City, Utah. Several shocks. Area 3,000 to 3,500 square miles.

1910. July 25. Houses shaken and mine shafts disturbed at Rock Springs, Wyo.

1910. September 23. Strong shock at Flagstaff, Ariz., where there were 52 shocks from September 10 to 23. Felt from Kanab, Utah, to beyond Gallup, N. Mex., along Santa Fe Railroad. One construction gang was frightened and stopped work. Area 300 by 150 miles in north Arizona, south Utah, and northwest New Mexico.

1912. August 18. Houses damaged at Williams, Ariz. Center apparently in San Francisco Mountains. Felt at Sligman, Prescott, and Gallup, N. Mex., also in southern Utah. Felt over area 300 by 250 miles in north Arizona, northwest New Mexico, and southeast Utah, an area of about 55,000 square miles.

1913. April 12. Swan Lake, Bannock County, Idaho, and northeast Utah. Felt over an area of 8,000 square miles.

1913. July 18. Socorro, N. Mex.; see page 56.

1913. October 14 and 15. Border of Washington and Oregon in the Seven Devils district. Rather severe. Information scanty.

1913. November 11. Southwest Colorado, strong at Montrose, Ouray, and Telluride. Lasted 8 to 10 seconds. At Ouray objects thrown from shelves and rocks rolled down from the cliffs.

1913. December 5. Felt throughout Arizona and New Mexico. Few details known.

1914. May 13. Windows broken and chimneys thrown down at Ogden, Utah. Probably due to slip along Wasatch fault near Idaho line. Felt 30 miles south of Salt Lake City, Utah, and over a total distance of 140 miles.

1914. December 20. Enterprise, southwest Utah and vicinity.

1915. May 8. In the north central part of Yellowstone Park. Area 5,000 to 10,000 square miles.

1915. July 15. Ceilings cracked at Provo, Utah. Force 6 at Salt Lake City, force 5 at Heber, force 5 at Midvale.

1915. July 30. North Utah. Dishes shaken from shelves.

1915. August 11. South of Great Salt Lake.

1915. October 5. Near Utah, Nev., border southwest of Great Salt Lake. Clocks stopped at Ibapah. Rumbling noises.

1915. November 17. Shock at Elko, Nev.

1915. November 20. Strong Imperial Valley shock; felt in Arizona.

1916. February 2. Paradise Valley and Gerlach, northwest Nevada, force 6; bells rang. Felt over 100,000 square miles in Nevada, California, and Oregon, but reported only in Nevada.

1916. May 12. Boise, Idaho, had strong shock. Chimneys were wrecked and people rushed into the street. Strong at Weiser, 60 miles west, and center was probably west of Boise. Reclamation ditches were damaged and flow of gas wells altered. Lasted 50 to 60 seconds. Felt at Loon Creek, 120 miles northeast, and reported at Anaconda, Mont., 240 miles northeast.

1916. May 25. Strongest at Idaho City, Idaho. Felt at Boise, 25 miles southwest, and Fayette, 60 miles west-northwest. Area 5,000 to 10,000 square miles.

1916. August 15. Winnemucca, Nev. Objects thrown from shelves. Force 6 to 7.

1916. September 9. Rumbling at Hailey Center, Idaho. Duration 30 seconds.

1916. December 12. East edge of Arizona. At least 300 miles east-west. Reports inadequate.

1917. April 19. Pierson, Idaho. Duration 60 seconds. Rumbling.

1917. December 12. Chesterfield and Irwin, southern Idaho. Lasted 20 seconds. Felt at Ashton.

1918. March 11. Felt from Spokane, Wash., to Heron, Mont., distance of 80 to 100 miles. Felt 60 miles in north-south direction. Probably strongest at Rathdrum, Idaho.

1918. May 28. Santa Fe County, N. Mex. Probably force 9, though force 10 reported from Cerillos. At that place plaster fell, people were thrown off their feet, and there was a break in the earth's surface at the edge of the town. A rapid twisting effect was noted at several places. There was sound like distant thunder. At Stanley, doors rattled, a piano sounded, walls and plaster cracked. People were thrown down. The shock was apparently quite local with force fading rapidly with distance from epicenter.

1919. January 31 to February 1. Socorro, N. Mex.; see page 56.

1920. September 18 and 19, November 19. Sharp local shocks. Force 5 to 6 at Brigham, north Utah.

1920. November 25. Local shock at St. George, Utah.

1923. March 23. Kelly, western Wyoming; 13 shocks continuing till April 12.

1924. August 12. Force 5 in northeast New Mexico.

1924. November 23. Southeast Idaho and Wyoming; force 5.

1925. August 10. Sweet Grass, Mont., and adjacent Canada. Also probably an aftershock.

1925. November 17. Big Horn, Wyo.; strong shake and rumbling.

1926. May 31. Three Forks, Mont. Felt at Lombard. Rocks rolled down on tracks. People frightened.

1926. November 27. Idaho, near Rathdrum. Two distinct shocks. Felt at 1,000 feet level in Hecla mine but not at 2,000 feet. Strongly felt at Wallace where buildings swayed. Vertical jar noted.

1926. December 13. Montana. Moderate shock in region of earthquake of February, 1925.

EARTHQUAKES BY YEARS AND MONTHS

Year	Month	Locality	Year	Month	Locality
1638	June	Massachusetts.	1872	June	Georgia.
1642	March	Do.		July	New York.
1648	April	New England.		October	Iowa.
1660	June	Do.		November	New Hampshire.
1662	January	Do.		December	Montana.
1663	February	Canada.	1873	July	Canada.
1727	November	Massachusetts.	1874	February-April	North Carolina.
1732	September	Canada.		December	New York.
1737	February	New York and Boston.	1875	June	Ohio.
	December	Do.		July	Connecticut.
1741	do.	Massachusetts.		November	Georgia.
1755	November	Do.		do.	Kansas.
	December	Do.		December	Virginia.
1758	April	Maryland.	1876	September	Massachusetts.
1776	Summer	Ohio.		do.	Indiana.
1779		Kentucky.	1877	August	Michigan.
1783	November	New Hampshire to		September	Pennsylvania.
		Pennsylvania.		November	Canada.
1791	May-August	Connecticut.		do.	North Carolina and
		Kentucky.			Tennessee.
1792	January	Connecticut.		do.	Nebraska.
1794	March	Do.	1878	October	New York.
1795	January	Illinois-Kentucky.		November	Nebraska.
1800	March	Pennsylvania.	1879	January	Florida.
	November	Do.		March	Delaware.
1804	August	Illinois.		August	Canada.
1805	do.	Connecticut.		December	South Dakota.
1810	November	New Hampshire.			New Mexico.
1811	December	Missouri.	1880	January	Cuba.
1812	January	Do.		May	Massachusetts.
	February	Do.		September	Utah.
1817	October	Massachusetts.	1881	January	Maine.
1820	November	Missouri.	1882	July	Illinois.
1827	August	Indiana.		September	Do.
	do.	Connecticut.		October	Do.
1828	February-March	Maryland and Dis-		do.	Arkansas.
		trict of Columbia.		November	Colorado.
1833	Summer	Virginia.		December	New Hampshire.
1837	April	Canada.		do.	Maine and New Bruns-
1840	August	Connecticut.			wick, Canada.
	November	Pennsylvania.	1883	January	Missouri and Tennes-
1841	January	New York.			see.
1843	do.	Tennessee.		February	Indiana and Michigan.
	February	West Indies.		do.	Rhode Island.
	do.	Missouri and Ken-		March	Maryland.
		tucky.		June	Tennessee.
1847	August	Massachusetts.		December	Arkansas.
1848	September	Rhode Island-Pennsyl-	1884	January	North Carolina.
		vania.		May	Pennsylvania.
1852	April	Maryland.		August	New York.
	November	Massachusetts.		September	Ohio.
1853	March	New York.		November	Utah.
1854	December	Massachusetts.		do.	New Hampshire.
1855	February	Canada.	1885	January	Maryland and Vir-
1857	October	Illinois.			ginia.
	do.	New York.		August	North Carolina.
	December	South Carolina.		October	Virginia.
1858	June	Connecticut.	1886	February	Alabama.
1860	October	Canada.		July	New Mexico.
		Minnesota.		August	South Carolina.
1861	July	Canada.		October	Do.
	August	District of Columbia.		November	Do.
1865	do.	Missouri.	1887	February	Indiana.
1867	April	Kansas.		May	Mexico.
	December	New York and Ver-	1889	March	Pennsylvania.
		mont.		July	Tennessee.
1868	April	New Mexico.	1891	January	Texas.
1869	October	Maine and New Bruns-		May	New Hampshire.
		wick, Canada.		July	Indiana.
		New Mexico.	1893	March	New York.
		Canada.		July	New Mexico.
1870	October	Do.		September	Do.
1872	January	Do.	1894	July	Utah.
	February	Michigan.			

Earthquakes by years and months—Continued

Year	Month	Locality	Year	Month	Locality
1895	March	Colorado.	1909	January	Michigan.
	September	New Jersey.		April	Virginia, West Vir-
	October	New Mexico.			ginia, and Pennsyl-
	do.	South Dakota.		May	vania.
	do.	Missouri.		do.	Canada.
1896	do.	New Mexico.		do.	Illinois.
	March	Maine and New Bruns-		July	Do.
		wick, Canada.		August	Do.
1897	April	Tennessee and Illinois.		September	Ohio Valley.
	May	Virginia.		do.	Indiana.
	do.	New York.		October-December	Utah.
	do.	Virginia.		October	Missouri.
	October	Do.		do.	Illinois.
	November	Montana.	1910	January	Utah.
	December	Virginia.		do.	Maine.
1898	September	Maine.		February	Nebraska
1899	February	Virginia.		April	New Jersey.
	April	Indiana and Illinois.		May	Virginia.
	December	Utah.		do.	Utah.
	August	Do.		July	Wyoming.
	October	Florida.		August	New Hampshire.
1901	May	Ohio.		September	Arizona.
	July	Nevada.		October	Maine.
	November	Utah.	1911	March	Arkansas.
	do.	Colorado.		April	North Carolina.
1902	January	Missouri.		June	South Dakota.
	May	Tennessee.	1912	January	Illinois.
	July	Nebraska.		June	South Carolina and
	October	Tennessee and Georgia.			Georgia.
	November	Utah.		August	Arizona.
	December	Do.		December	Maine and New
1903	January	Massachusetts.			Brunswick, Canada.
	do.	Georgia and South	1913	January	South Carolina.
	do.	Carolina.		March	Tennessee.
	February	California.		April	Idaho.
	April	Illinois.		do.	Tennessee.
	April	Massachusetts.		do.	New York.
	November	Missouri.		July	New Mexico.
	do.	Do.		August	New York.
	December	New York.		October	Idaho and Oregon.
1904	January	New Mexico.		November	Colorado.
	March	Tennessee.		December	Arizona and New
	do.	Maine.			Mexico.
	August	Montana.	1914	January	Maine and New
	September	New Mexico.		do.	Brunswick, Canada.
	October	Kansas.		do.	Tennessee.
1905	January	Alabama.		February	Canada.
	March	Michigan.		do.	Maine.
	April	Iowa.		March	Georgia.
	July	Maine and New Hamp-		May	Utah.
	do.	shire.		September	South Carolina.
	do.	Michigan.		December	Utah.
	August	Missouri.	1915	April	Missouri.
	do.	Massachusetts.		May	Wyoming.
	October	Vermont.		July	Utah.
	November	Idaho.		do.	Do.
1906	January	Kansas.		August	Do.
	do.	Arizona.		October	Nevada.
	May	Delaware.		do.	Utah.
	do.	South Dakota.		do.	South Dakota.
	do.	Indiana.		do.	Kentucky.
	do.	Michigan.		do.	North Carolina.
	June	Ohio.		November	Nevada.
	July	New Mexico.		do.	California.
	October	Idaho.		December	Ohio River.
	November	New Mexico.	1916	January	New York.
1907	January	New York.		February	Nevada.
	February	Virginia.		do.	New York.
	April	South Carolina.		do.	North Carolina.
	June	Maine.		May	Idaho.
	July	Do.		do.	Do.
	do.	Missouri.		June	New York.
	October	Massachusetts and		August	Nevada.
		New Hampshire,		do.	North Carolina.
1908	February	Connecticut.		September	Idaho.
	May	Pennsylvania.		October	Alabama.
	August	Virginia.		November	New York.
	September	Missouri.		December	Arizona.
	October	Illinois.		do.	Kentucky.
	December	Montana.			

Earthquakes by years and months—Continued

Year	Month	Locality	Year	Month	Locality
1917	March.....	Texas.	1923	March.....	Wyoming.
	April.....	Missouri.		October.....	Arkansas.
	...do.....	Idaho.		December.....	Do.
	May.....	New York and Can- ada.	1924	March.....	Kentucky.
	June.....	Alabama.		September.....	Canada.
	September.....	Minnesota.		October.....	North Carolina.
	December.....	Idaho.	1925	November.....	Idaho.
1918	March.....	Do.		January.....	Massachusetts.
	April.....	Virginia.		February.....	Canada.
	May.....	New Mexico.		April.....	Massachusetts.
	June.....	Tennessee.		...do.....	Indiana.
	August.....	Maine.		May.....	Kentucky.
	September.....	Oklahoma.		June-July.....	Montana.
	October.....	Arkansas.		July.....	Texas.
	...do.....	Tennessee.		August.....	Montana.
1919	January.....	New Mexico.		September.....	Kentucky.
	February.....	Do.		October.....	New Hampshire and Maine.
	May.....	Indiana.		November.....	Connecticut.
	September.....	Virginia.		...do.....	Wyoming.
	November.....	Arkansas.	1926	March.....	New Hampshire.
1920	May.....	Missouri.		April.....	New York.
	September.....	Utah.		May.....	Montana.
	November.....	Do.		November.....	Ohio and West Vir- ginia.
	December.....	Tennessee.		...do.....	Idaho.
1921	January.....	New York.		December.....	Montana.
	...do.....	New Jersey.		March.....	New Hampshire.
	July.....	Virginia.	1927	...do.....	Kansas.
	August.....	Do.		May.....	Mississippi Valley.
	September-No- vember.....	Utah.		June.....	Virginia.
1922	March.....	Illinois.		...do.....	Alabama.