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EARTHQUAKES IN MICHIGAN

BY
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EARTHQUAKES IN MICHIGAN.

Early history. There is on record no account of a really destructive shock of earthquake within the state, and one might at first thought be inclined to believe that Michigan is to enjoy special immunity from these nerve racking phenomena of nature. Such an assumption would, however, hardly be warranted in view of the short recorded history of the state. Moreover, it is known from geological studies that earth movements within the regions surrounding the Great Lakes, have been going on in recent times, and are even today in progress. Such movements may, however, proceed so slowly as to be imperceptible, or felt as relatively light shocks.

There is no reason to doubt that when Michigan was a wilderness inhabited only by Indians and a few fur trappers, earthquakes were occasionally felt. Since, however, the dangers from them are largely of man's own making and belong especially to cities, the chance of a record being preserved from this early period is exceedingly small. From the valuable *Jesuit Relations and Allied Documents*,¹ which give the accounts of French Jesuit missionaries especially in the Canadian wilderness written between the years 1610 and 1791, we know that earthquakes were felt in 1638, 1661, 1663, 1664, 1665, 1663 and 1672.²

According to the accounts in the "Jesuit Relations," the earthquake of February 5, 1663, was felt throughout the territory of New France, and it was unquestionably an earthquake of great violence.³ With much probability the shocks were felt at many localities within the state of Michigan.

On the basis of recent recorded light shocks it might appear that the states of Ohio, Indiana and Illinois are much more subject to light earthquake shocks than are Michigan and Wisconsin, but it is too early to hazard a statement on this point. In 1776 an earthquake was felt on the Muskingum River in Ohio; in 1779 a shock was felt in Northern Kentucky, and very probably much farther north; in 1795 (January 8) a shock of some violence was experienced at Kaskaskia in Illinois as well as in Kentucky,⁴ while in 1804 (August 20) one was felt at Fort Dearborn on the site of Chicago, at Fort Wayne, Indiana, and at other points about the southern end of Lake Michigan.⁵

Between 1811 and 1813 occurred the great earthquakes in the lower Mississippi valley, usually referred to collectively as the New Madrid earthquake. One of the hard shocks of this earthquake came on December 16, 1811, at which time all the interior of Michigan was a wilderness. At Orchard Lake Judge James Witherell reported that on December 17, 1811, "the Indians said the waters of the lake began to boil, bubble, foam and roll about as though they had been in a large kettle over a hot fire, and that in a few minutes up came great numbers of turtles and hurried to the shore, upon which they (the Indians, Ed.) had a great turtle feast."⁶ It is highly probable that this phenomenon was connected with the earth movements within the whole interior

region of the country. Judge Witherell has also left an interesting report of the shocks felt in Detroit on January 23, 1812. He says:⁷

"The earthquake occurred in the morning at 30 minutes past 8 o'clock as I sat reading by the fire at Col. Watson's, I felt an unusual sensation; I thought something must be the matter with me. I felt an agitation which I could not account for. But I soon observed that the walls of the house were in motion north and south. I got up, stepped to a bedroom door and asked my daughter if she perceived that the house trembled. She replied that she did, and thought someone was shaking her bedstead. I then discovered that a small looking glass which was hanging on the wall, was swinging to and fro several inches, and the shade trees in the yard were waving considerably north and south.

"Dr. Brown informed me that his stove oscillated very much, and that a cradle was set rocking smartly, though there was no one near it. A little girl who had crossed the lake in a vessel last fall, tottered about and called out, 'Oh, mother, we are in the vessel again!' Cook's house shook more than most others, probably because it was higher and the frame new and stronger. The ice in the river was split for several miles. A Frenchman at Grosse Pointe says that his bowl of mush and milk was spilt."

¹73 vols., Burrows Bros., Cleveland.

²Rev. F. L. Odenbach, S. J., an index of meteorological items in the Jesuit Relations, Monthly Weather Review, October, 1904.

³The more important data concerning this earthquake, have been extracted from the "Jesuit Relations" by Father Odenbach and published in the Twelfth Annual Report of the Meteorological Observatory of the College of St. Ignatius at Cleveland, Ohio (1906-7). See also in the author's "Earthquakes," Appendix, F.

⁴Earthquakes of the Western United States, Atlantic Monthly, vol. 24, November, 1869, pp. 550-551.

⁵Daniel Drake. Natural and statistical view or picture of Cincinnati. Cincinnati. 1815.

⁶Sketch of the life of James Witherell, Michigan Pioneer Collections, vol. 4, 1881, p. 111.

⁷Ibid.

The newspaper and telegraph period. On February 6, 1872, at 8 a. m., a slight shock of earthquake was felt at Wenona, Michigan.⁸ A letter from Ed. D. Cowes of that place states:

"The shocks were three in number and lasted altogether about thirty seconds, the vibrations traveling from the N. N. E. They jarred buildings and were plainly observable by persons out of doors and were characterized by that peculiar rumbling sound which is noticed in subterranean vibrations."

Two days later a similar shock was felt at Cairo, Ill.

On June 18, 1875, in the forenoon, a shock of earthquake was felt in western Ohio and Indiana, being most intense near Urbana and Sidney in Ohio, though it was distinct also at Columbus, Indianapolis, Vincennes,

and Jeffersonville (Ind.). So far as known, this shock was not reported from Michigan.⁹

On June 18, 1877, there appears to have been a remarkable seich or waterwave on Lake Michigan. As reported by the U. S. Signal Service, the water of the lake at Milwaukee fell two feet in half an hour, and rose again more quickly. On August 17, following, at 11 a. m., a slight shock was felt at Detroit and in a few of the neighboring towns. It lasted from thirty seconds to a minute and was accompanied by a rumbling sound.¹⁰

On February 4, 1883, a distinct shock was felt at Bloomington, Ill., "and at various places in northern Indiana and southern Michigan."¹¹

⁸C. G. Rockwood, Notices of recent earthquakes, Am. Journ. Sci., (3) vol. 4, 1872, p. 1 (as there is no place of that name now within the state, it is likely that Wenona beach near Bay City is meant).

⁹Rockwood. Notices of recent American earthquakes, No. 6, *ibid.* vol. 12, 1816, p. 27.

¹⁰Rockwood, *ibid.* No. 7, Am. Journ. Sci. (3) vol. 15, 1878, p. 24.

¹¹Rockwood, *ibid.* No.

Earthquake of September 19, 1884. This quake affected especially portions of Michigan, Ohio and Indiana, but was also reported from Cedar Rapids and Dubuque, Iowa. Men working on the top of the Washington monument and others in the national capital also reported the shock. At that time the Washington monument had been carried to a height of about 500 feet.¹² Rockwood assembled reports from 102 places, mainly in central and western Ohio and in eastern Indiana. According to his summary, interpreted in terms of the centrum theory, within an area more or less circular in form an intensity of shock corresponding to III of the Rossi-Forel scale was felt. Within this area were Indianapolis, Vevey, Lawrenceburgh, Connorsville, and Winchester in southeastern Indiana; Cincinnati, Urbana, Finley, Cecil, Columbus, Millersburg and Cleveland in Ohio; Parkersburg in West Virginia, and East Saginaw in Michigan. At some of these points furniture was displaced, chandeliers were set swinging, etc. At Detroit shocks, of higher intensity were recorded. In the Board of Trade rooms chandeliers were set in vibration, and in an upper room on Atwater street statuettes were thrown down from a shelf. Every floor of the Chamber of Commerce and Campau buildings were felt to shake.¹³ Signal Officer Conger reported the shock to have continued twenty seconds. The Michigan Central depot was strongly shaken. In some buildings, the inmates in panic sought the street. In the river a wave or "ground swell" was reported. According to Rockwood the time reported from most localities was about 2:15 p. m., standard time.

At the writer's suggestion a Saginaw weekly paper of the time was kindly searched by Mrs. Herbert A. Hard of that place, and from this source she has supplied the following data upon the shocks of this date in Michigan:

Detroit. Felt in most parts of the city, the shocks lasting from ten to twenty seconds.

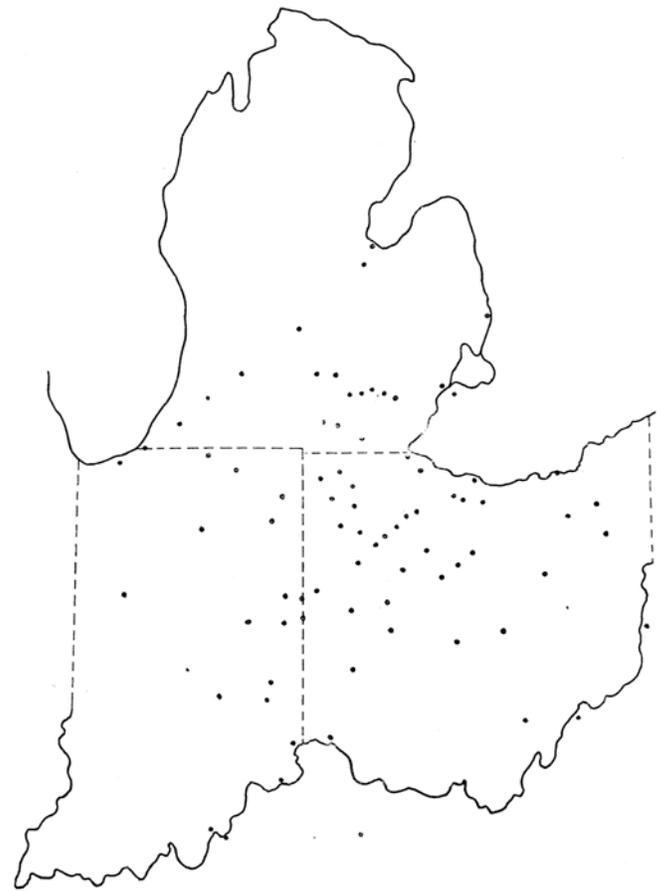


Fig. 1. Map showing the distribution of shocks of earthquake felt on Sept. 19, 1884.

Ypsilanti. Strong shock and considerable excitement.

Ann Arbor. Severe shock felt all over the city, continuing for thirty seconds.

Bay City. Shock barely perceptible.

Saginaw. The shock was felt especially in high buildings. Chandeliers were swung and some alarm occasioned.

Adrian. Distinct shocks lasting nearly a minute:

Grass Lake. Slight shock.

Port Huron. Light shock which occasioned no alarm.

In the Detroit Free Press of September 20th it is stated that telegrams received at the Michigan Central station in that city reported the shocks as felt at Ann Arbor, Chelsea, Dexter and Slocum's Junction. These and additional data from various sources affecting especially the states of Ohio and Indiana have been brought together in Fig. 1.

¹²Rockwood, *ibid.* No. 14, Am. Journ. Sci. (3) vol. 29, 1885, p. 432-434, (map).

¹³Detroit Free Press, issue of Sept. 20, 1884.

¹⁴Clarence E. Dutton, The Charleston Earthquake of August 31, 1886, Ninth Ann. Rept. U. S. Geol. Surv., 1889, pp. 457-459.

Earthquake of August 31, 1886. This shock, commonly referred to as the Charleston earthquake because of the localization of heavy damage at Charleston, S. C., was felt at some points within the state of Michigan. At Detroit the quake was distinctly felt in different parts of the city, and there was considerable excitement. Along the river front and as far back as the City Hall the shocks were heaviest. The editorial staff of the Detroit Free Press and that of the Associated Press as well, are reported to have made a stampede for the street. As is usual, shocks were most clearly perceptible in the upper stories of high buildings, where chairs, tables and other objects were displaced. A party who had before experienced earthquakes reported in the Detroit Tribune of September 1 that the shocks had a direction from east to west or west to east, and several other parties reported the same direction. The duration of the shock appears to have been brief, one person reporting it as three seconds. Another party reported a .second shock; the first shock, the interval, and the second shock having each a duration of three seconds. One party reported a third very faint shock.

A noise resembling distant thunder or like pounding against walls was generally heard. The signal service officer distinctly heard low rumblings like thunder, but reported the shock as slight. In the watch room of the Detroit River Lighthouse at Bar Point, built in twenty-two feet of water, the keeper reported that his chair shook and the clock was jarred horizontally, this latter being noticed both by himself and his assistant.

At Ann Arbor Professor Schaeberle, who has a private astronomical observatory in the western part of the city, and who was at the time on the lower floor of the building, felt the shock, and reported that the revolving cupola of the observatory was set in motion with a rattling which startled him. Later, plastering fell from the walls. A newspaper report gave a direction of the shocks as from east to west, which is the direction generally reported at Detroit. Along the same direction slight shocks were felt at Battle Creek, while at Kalamazoo the signal service officer also reported a slight shock (see Fig. 2).

At East Saginaw the shocks were felt by several and were thought to be due to an explosion at the salt works. At Grand Haven lady guests in the hotel left their rooms in fright and fled to the parlor. According to the Detroit Free Press the duration was here two seconds. At the light station of Manistee, J. H. Roberts, the keeper, reported one shock and that the new clock facing south southwest had its pendulum strike the glass front and then stop.

Negative reports were obtained from Adrian, Au Sable Light, Bad Axe, Charity Island Light, Escanaba, Fort Gratiot Light, Grand Haven Light Station, Grande Pointe au Sable Light Station, Hersey (Osceola Co.), Lansing, Lapeer, Marshall, Muskegon Light Station, Petite Pointe au Sable Light Station, Point Betsey Light Station, Point Austin Light, Prentiss' Bay, Port Huron, Sandusky, South Manitou Light Station, Traverse City, Saginaw River



Fig. 2. Map showing distribution and direction of shock in Michigan of the earthquake of August 31, 1886.

Earthquake of October 31, 1895. The shocks of this date were less serious in Detroit than in many other points in southern Michigan. The disturbance came between 4 and 5 o'clock in the morning and lasted several seconds. At the Western Union telegraph office in Detroit the operators were conscious of a slight trembling which is reported to have lasted about nine seconds. This trembling was also felt by the girls in the Central Telephone office, from which place the time was given as about 4:50 o'clock a. m. At the Belle Isle Casino a slight panic occurred. Guests at the Wayne Hotel near the Michigan Central station complained of being shaken in their beds; and of the rattling of mirrors. The rattling of dishes was reported by stewards at the Wayne and Cadillac Hotels.

In the Detroit Free Press shocks were reported at Adrian, Allegan, Ann Arbor, Battle Creek, Benton Harbor, Bronson, Coldwater, Concord, Grand Haven, Grand Rapids, Grass Lake, Hillsdale, Jackson, Kalamazoo, Lawton, Niles, Marshall, Manchester, Muskegon, Paw Paw, Pinckney, Robinson, Saginaw, Saugatuck, Schoolcraft, Wyandotte and Ypsilanti (see Fig. 3).

At Wyandotte houses were reported as "badly damaged but not so much as to need expensive repairs." The shock is said to have prostrated some ladies at this place. At Ypsilanti sleepers were awakened, and distinct shocks reported to have occurred at 3 a. m. and at 5:30 a. m. with two still lighter shocks somewhat later. The disturbance was most distinctly felt in the northern half of the city.

At Jackson the shock was quite generally felt, and the time given as 5:15 a. m. From other points in the county it is said to have been reported. The same time is given for Niles where the disturbance is reported to have

continued for five minutes. Windows cracked, beds swayed and people rushed out of doors. Every one was awakened. Three shocks were felt.



Fig. 3. Map to show distribution of reported shocks of earthquake in Michigan on October 31, 1895.

At Lawton people were generally awakened by the shocks at 5:15 a. m. and many are reported to have been badly frightened. At Allegan windows, doors and beds were shaken. At Saginaw the shocks were felt at 4:40 a. m. A rumbling was heard and loosely fastened fixtures are said to have fallen from the walls to the floor. At Grand Rapids it is said that nearly everyone was awakened and some panic was caused. The vibrations here were from east to west, the time is given as about 5 o'clock, and the duration of the shocks as about half a minute. Much the same is reported from Kalamazoo and Concord.

Earthquake of May 26, 1909. During the year 1909 two earthquakes were rather generally felt within the Ohio valley province, the first on the morning of May 26th, and the later one on the morning of September 27th. On the first occasion the writer was sitting on the ground floor of the house of President Van Hise at Madison, Wisconsin. Three shocks were distinctly felt and were of very brief duration, following one another in quick succession. A slight waving in the branches of trees was noticed. Dishes rattled in the dining room. This shock was felt in the neighboring states of Illinois, Wisconsin, Iowa, Missouri, Michigan, Indiana and Ohio.

After the later shock in September a double questionnaire to cover the two quakes was sent out from Ann Arbor to all newspaper editors, and normal and high school principals in the states of Michigan, Ohio and Indiana, a small fund having been provided by the state geologist to defray the cost of posting, printing and clerical work. In this way a number of hundred places were directly reached by the inquiry, but owing to the lateness in sending out the letters and cards, the interest in the shocks had waned and the replies were not as numerous as could be desired. This was especially true as regards the inquiries made to newspaper offices, in which, of course, the papers describing the events had generally been destroyed. Notwithstanding these

unfavorable conditions certain valuable data were secured.

As regards the May shocks positive answers were received from twenty-six localities. From sixty-seven places negative replies covering both the May and the September quakes were received. Professor Udden conducted an inquiry of similar nature for the earlier of the two quakes for the western section of the affected province,¹⁵ so that in a broad way the distribution of the shocks is now pretty well known. For the area covered by the author's inquiry the location of the towns which felt the shocks is given on Fig. 4.

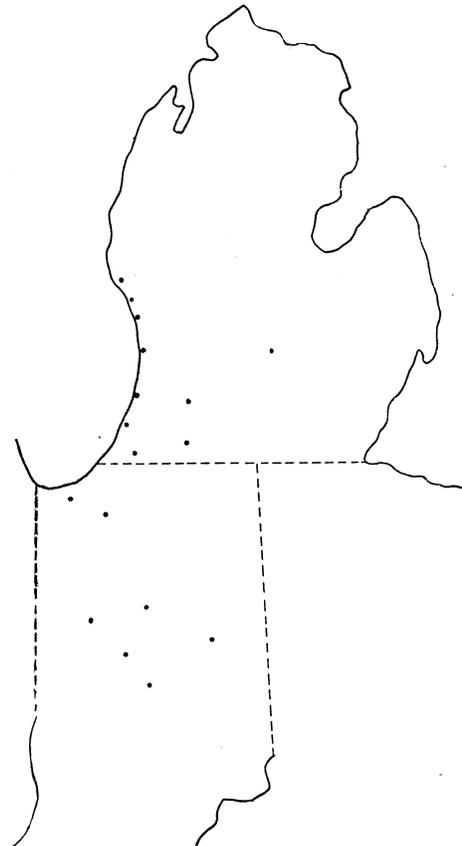


Fig. 4. Map to show the distribution of shocks of earthquake of May 26, 1909 in the states of Indiana and Michigan.

Within the state of Michigan the shocks were felt especially in the west near the shores of Lake Michigan and at Niles, Kalamazoo, Three Rivers and Lansing.

Lansing. At the state capital Dr. A. C. Lane, the then state geologist, sitting in his private office felt the jar and noted the time of the shock as 8:28 a. m. Mr. Harry R. Wight, his secretary, in an adjoining room observed a bookcase swaying on its base and also felt the vibration. Mr. W. F. Cooper in the same room determined with his watch that the duration of the shock was six seconds. Across the street and on the fifth floor of a neighboring building Hollis H. Brooks sat tilted back in a swivel chair, and feeling the shock brought his chair to a safer position.

Kalamazoo. Mr. Charles C. Wilcox, teacher of physiography in the Central High School, reported that there was one shock at that place lasting between two and three seconds. Dishes were broken and chimneys thrown down in one part of the town.

Three Rivers. Mr. L. L. Tyler, superintendent of schools, reports that Miss Florence Winslow of that place felt a shaking of the desk at which she was writing.

Benton Harbor. Sara VanCamp, society editor of the *News-Palladium*, reports that a shock or shocks was felt for sixty seconds between 8:30 and 8:40 a. m. Windows rattled, doors shook and a bottle was upset in Mr. Valentine's office. Udden's paper, above quoted, states in addition that chinaware was broken.

Grand Haven. Mr. L. H. Van den Berg, the superintendent of schools, reports that there was one shock, that the quake was felt by W. Killian, the assistant in the Weather Bureau office. The time is given as 8:30 a. m., and it is stated that the door of a case opened and a desk shook, but that nothing was overturned.

Holland. Mr. W. T. Bishop, superintendent of schools, states that the shock was felt by several in his office, the time being between 8:30 and 9 o'clock. There was one brief shock.

South Haven. Mr. A. D. Prentice, superintendent of schools, reports a trembling which lasted for several minutes between 9 and 9:05 o'clock. Udden states that windows rattled violently, and that much china was broken.

Niles. Mr. J. D. Schiller, superintendent of schools, quotes Mrs. Isaac Bonin as having noted the rattling of dishes.

Montague. Udden reports that the quake was felt here by several citizens and that one experienced a swaying motion.

Muskegon. According to the *Chicago Record-Herald* of May 27, the earthquake was violent enough at Muskegon to attract general notice. In a number of houses dishes and other articles were upset, windows shaken, etc. The shocks were heaviest along the lake shore.

No derangements of water were reported from Michigan, but according to the *Chicago Record-Herald* of May 29 the "lost well" near St. James place, Lincoln Park, Chicago, took on a new and greatly increased flow.

In the neighboring state of Indiana the quake was felt at Indianapolis, Kokomo, Knox, Lafayette, Lebanon, Mount Vernon, Muncie, New Harmony and Valparaiso.

Indianapolis. According to J. A. Udden the Federal offices in this city were felt to quiver, a heavy iron bed and a writing table were shaken. The tower of the Court House is reported to have shaken. A woman reclining upon a couch rolled down onto the floor.

Knox. According to Udden the shock at this place frightened many people, some of whom rushed out of buildings.

Kokomo. Mr. E. A. Ogg, superintendent of schools, reports slight shocks about 9 o'clock, one of these lasting a quarter of a minute or less.

Lafayette. R. F. Hight, superintendent of schools, quoting a local paper, reports the shocks as very slight, and felt by persons, in upper stories chiefly. Some rattling of dishes is reported.

Lebanon. H. G. Brown, quoting a local newspaper, reports that a rumbling was noticed by some people.

Mount Vernon. Edward G. Baumen, the superintendent of city schools, reports two distinct shocks.

Muncie. According to Udden, the shock was noticed here though apparently chiefly as a rumbling sound, since it was variously attributed to blasting operations, to the rolling of heavy wagons, or to the passing of street cars.

New Harmony. The *New Harmony Register* of May 28th reports a slight shock.

Valparaiso. A. A. Heyhart quotes L. H. Cotlin as authority that the quake was felt in this city and that sounds were heard.

¹⁵J. A. Udden, Observations on the earthquake in the Upper Mississippi Valley May 26, 1909, *Trans. Ill. Acad. Sci.*, vol. 3, 1910, pp. 1-12.

Earthquake of September 27, 1909. The earthquake of this date following as it did so closely upon that of May 26th was, as already stated, made the subject of inquiry in a double questionnaire. Although several hundred letters and cards of inquiry were mailed to addresses in Michigan, Ohio and Indiana, it developed that the shocks were not sensed at all in Michigan and at but one point (Bellevue) in the state of Ohio, seismographical registration being made, however, in Cleveland at St. Ignatius College. At Bellevue very few persons felt the shocks. A lady inquired of her husband as he returned home if he had not felt an earthquake that day.

From the state of Indiana, on the other hand, many reports were received. The selective nature of the earthquake was plainly indicated by the wide area within which shocks were felt and the small number of places which sensed the disturbance. Points as distant as Burlington (Iowa), Cape Girardeau (Mo.), and the many towns of southern Indiana reported distinct shocks. In Illinois, Urbana, Peoria, Marion, Decatur, Mattoon, Springfield and Cairo reported the shocks. In Kentucky, Louisville, Paducah, Henderson, Owensboro, Hopkinsville and Mayfield felt the shocks. In Missouri, St. Louis, Kansas City and Cape Girardeau are especially mentioned.

Arranged alphabetically by towns the facts which we have been able to glean from Indiana are assembled below:

Bedford. J. B. Fagan of Bedford reports that the shocks were felt at 3:45 a. m., and that both windows and radiators were set in vibration. In the *Chicago Record-Herald* of September 28th it is reported that three distinct vibrations were felt here.

Brazil. The Owens County *Democrat*, published at Spencer, reports that walls of buildings were cracked.

Bloomington. Thomas Huntington, who lives three and a half miles southeast of Bloomington, reports that at 3:50 a. m. there was "quite a shock," the vibrations appearing to be east-west. The disturbance lasted but a few seconds. It was felt by but few people.

Brownstown. The Brownstown *Banner* of September 29th states that about 4 o'clock in the morning of the 27th the shock was felt by quite a number of people. There were three distinct shocks lasting about twenty seconds.

Centerville. The Indiana *News-Record* of Centerville states that citizens of Centerville who were light sleepers were disturbed.

Covington. Shocks were felt here according to the *Clarion-News* of Princeton.

Crawfordsville. L. H. Hines, superintendent of schools, reports that one shock which lasted a few seconds was felt by various persons in Crawfordsville at about 3:50 a. m.

Evansville. The Warren *Republican* of Williamsport states that large buildings in Evansville swayed and creaked, that "street lamps swung as if in a breeze, and that in the negro quarters it was thought the world was coming to an end."

Farmersburg. The Farmersburg *Blade* reports that two shocks of brief duration aroused residents at about 3:55 a. m. Doors and windows rattled, and beds shook. It is stated that the shocks were of seven and five seconds duration, respectively, separated by an interval of ten seconds. Telegraph operators were considerably disturbed.

Greensburg. The Greensburg *Daily News* gives the names of persons who were awakened by the quake. Henry Hodges reported four distinct shocks within less than a minute of each other. At the home of L. D. Crooks, rocking chairs were set in motion and dishes were rattled.

Jasonville. Many persons including the city editor of the *Jasonville Leader* are reported to have felt the shock.

Kokomo. R. A. Ogg, superintendent of schools in Kokomo, reports that the shock was felt by a number of persons, and while slight, was more noticeable than the shock of May 26th.

Lafayette. R. F. Hight, superintendent of schools, reports that the shock was noticed by several persons at about 4 o'clock in the morning and that it lasted several seconds.

Madison. According to the *Clarion-News* of Princeton a shock was felt here which lasted for a minute.

Mount Vernon. Edward G. Bauman, superintendent of schools, reports that there were two distinct shocks between 3 and 4 o'clock in the morning, the earlier one lasting twenty or more seconds, and the later one about fifty seconds.

Muncie. B. F. Moore, superintendent of schools at Muncie, reports one shock.

New Albany. The Owen County *Democrat* of Spencer, states that the police of New Albany, thinking the jar of the earthquake the result of a safe explosion, began a systematic search.

New Harmony. The New Harmony *Register* reports that buildings vibrated and objects rattled for from ten to fifteen seconds at about 3:45 a. m. There was also a rumbling sound and people were generally awakened.

Oakland City. The Oakland City *Journal* states that scores of residents were awakened at a few minutes before 4 o'clock. The shocks are stated to have been the heaviest felt in the place since 1895, and seemed to be a succession of jars as if foundations were settling. Doors and windows rattled and furniture swayed. Many citizens arose in order to fix definitely the time of the shocks, which was about 3:50 a. m.

Petersburg. The *Chicago Record-Herald* states that at Petersburg houses were shaken for thirty seconds, glass and dishes were tumbled from pantry shelves, and a number of windows were broken.

Princeton. The *Clarion-News* says people were aroused from sleep at about 3:45 a. m. by jarring noises and the trembling of houses. Many ran out of doors. The sound resembled distant thunder and preceded the first shock; a slight tremor lasting five to eight seconds, followed a moment later by another which was longer and more severe, and terminating a few seconds later with a slight, short, but distinct tremor. Some, however, claimed that there were but two shocks.

Richmond. Shocks were reported here by the Indiana *News-Record* of Centerville.

Rockport. The Rockport *Democrat* reported that at 3:45 a. m. citizens were aroused from sleep by a quake which lasted about half a minute and rattled dishes and windows perceptibly.

Rushville. W. A. Stockinger, a teacher in the Rushville High School, reported that he was awake when the shocks arrived, that he felt three, the middle one the longest. The vibrations were short and quick.

Terre Haute. This city seems to have received the heaviest shocks. According to the *Chicago Record-Herald* two chimneys were tumbled down, plaster in the

Vandalia Railroad offices and in other buildings were cracked, pictures and bric-a-brac were shaken from walls, and telephone and electric light connections were severed.

Vincennes. According to the Warren *Republican* of Williamsport dishes here fell from sideboards in some instances and were broken.

Washington. Shocks were reported here by the Princeton *Clarion-News*.

Williamsport. The Warren *Republican* of this place reports that persons were awakened by the rocking of their beds which took place in a direction north and south.

The points where the shocks were felt have been entered upon the map of Fig. 5.

Earthquakes connected with the mines of the Northern Peninsula. These earthquakes have special interest because they occurred within a mining district where large geological changes are being affected through human agencies. The term earthquake may perhaps be applied to any earth jar, whatever be its cause, as, for example, the dynamite or powder explosions recently felt at Jersey City and Pleasant Prairie; but we are accustomed to restrict the use of the term to such disturbances as arise from natural rather than artificial causes.

In the years 1905 and 1906, so-called "air blasts" became some what common in the copper mining district, and a heavier disturbance generally referred to as the "Calumet earthquake" occurred at about 6 :30 p. m. on July 26, 1905. It is the writer's opinion that these earthquakes were due to natural causes—an uplift of the land—but modified in their expression by the peculiarly unstable conditions brought about by large mining operations. The larger disturbance of July 26, 1905, seems to have been felt over the greater part of the Keweenaw peninsula, though it was heaviest at Calumet and Lake Linden. Thanks to the courtesy of Professor E. T. Hancock and the librarian of the Michigan Mining College, the writer has been permitted to see copies of the *Daily Mining Gazette* published at Houghton and Calumet. The issues of July 27 and August 5, 1905, have furnished the following extracts:

"At 6:30 last evening (July 26) Calumet was shaken by a terrific explosion, which seems to have extended throughout the entire Upper Peninsula. Telephonic communication as far east as Marquette and north as far as Copper Harbor brought out the fact that the shock was plainly distinguishable at both points. For a time it was thought that trouble had occurred in the Calumet & Hecla, but this proved untrue, likewise a report that a Quincy air blast might have been accountable for the noise.

"Those who have experienced earthquake shocks elsewhere in this country state that the report last evening was certainly of such an origin and predicted that more would be heard before the night passed. This

proved true, for at 8:20 another slight report was heard. The vibrations of the first shock passed from south to north and lasted about ten seconds, and the second one about two seconds.



Fig. 5. Map showing the distribution of the shocks of earthquake of September 27, 1909 in the eastern part of the district affected.

"The shock was heard audibly all over the community, and occurring as it did just at the supper hour, caused great consternation. There were chimneys seen falling everywhere in Calumet. Pewabic street south of Lake Linden avenue seemed to have been affected most. Almost every chimney fell with a crash. The O'Shea residence on this street was moved from its foundations about an inch.

"Plate glass windows in the stores of Martin Prish, Andrew Condon, and the one occupied by the Laurium Cooperative company was smashed in small pieces. A large skylight in the Marta building was also broken. In Bed Jacket the plate glass window in the saloon of Jake Decker was broken.

"Jackola's drug store also suffered severe damage. Bottles filled with drugs were thrown to the floor, in several instances the acids destroying the furniture. The chimney in the home of Samuel Jeffrey was broken and also considerable damage was done to the interior of the building. The window in Tyler's store on Fifth street was also broken.

"As soon as the explosion was heard telephone messages began coming in and it was learned that the explosion was heard down as far as the forty-ninth level, No. 4 shaft of the Calumet & Hecla. * * * Keweenaw county points and as far as Painesdale all stated that the report was audible in these districts, but no explanation

was given. A similar detonation was heard in Calumet about two years ago, and to this day no explanation has been given."

In an interview published in the *Daily Mining Gazette* of August 5th, President McNair is quoted as saying that he believed the earthquake was due to a slipping on one of the fault planes which, paralleled the bedded formation of the Keweenaw peninsula. Continuing, he said:

"The fact that the greatest violence occurred at Calumet and Lake Linden is attributable probably to the fact that the zone in which these places are located represents the approximate center of the slipping area and therefore probably the zone of greatest movement.

"Assuming that the slipping was on the contact between the Keweenawan series and the Eastern sandstone, this theory is strengthened by the extent of the distributed district either way from the zone of Calumet and Lake Linden. As far as reports can be secured, the shock was felt with diminishing violence outward towards the end of the peninsula for a distance of probably fifty miles northward from Calumet, and the same distance south of Calumet. No reports have been received that the shock was felt around Ironwood or Bessemer, and, therefore, it is probable that the slipping area did not extend so far to the south as that.

"As felt at the Mining College, the main shock of the earthquake was heralded by a rumbling and shaking much like that felt when a heavy freight train passes at the base of the bluff below the college. The main shock and the slighter one following almost instantly, together with the subsequent jarring and rumbling were much the same as felt elsewhere."

As regards the "air blasts" which were so characteristic of the copper mining district during 1905 and 1906, President McNair says:

"The air blast common to the Lake Superior mines is not, according to the opinion of men best informed on the subject, a blast at all, nor has it any connection whatever with air further than the disturbance which it creates in the atmosphere. The air blast is simply a giving way of the pillars which keep the hanging wall and the foot wall apart in the worked out portion of the mine, and the necessary disturbance of the formation which results from such a crushing of the pillars.

"The action of the pillars under the tremendous pressure to which they are subjected is precisely the same as the action of a piece of rock which is subjected to a testing pressure in a scientific instrument. The rock spalls or splits on its various faces and flies off from the main body. The floor or roof of a level is in all essentials a pillar, keeping the walls of the opening apart, and therefore is subject to the same action which the regular pillars undergo. Hence the rock may heave upwards and distort the floor of the level or may split off from the under side and cause a heavy fall of rock down through the opening.

"It is natural to assume that with this crushing of the pillars which is the cause of the so-called air blast, there is a slight slipping of the hanging wall from its former relative position to the footwall when it adjusts itself to the new place of rest. The extent of this slipping it is impossible to approximate, but it may be an eighth or a quarter of an inch, more or less."

It would appear that the air blasts were more serious above ground than one would suppose from their behavior within the mine galleries. President McNair has thus described his experience while within the Quincy mine and near a cave-in:¹⁶

"I happened, some two years ago to be in the Quincy mine when one of these local disturbances which we call air blasts occurred. I was on the level below and about 150 feet to one side of the pillar, a part of which crushed off. There was really no disturbance at all to speak of where I happened to be. There were two sounds there very much like muffled blasts, and some rock came tumbling down, and once nearby, but no one was hurt and the top of the mine was wholly undisturbed and some of the men in the mine knew nothing of what had occurred as nothing was said on coming out. That disturbance caused a vibration which was felt quite distinctly in Hancock and across on the Houghton side.

"It was felt out as far as the College of Mines, and it was very hard to realize that such a thing occurred, because so little was the disturbance under ground."

On May 26, 1906, some very remarkable phenomena were observed at the Atlantic mine, these consisting in deformations of railway tracks and incaving at the surface. They indicated especially a reduction in the local surface area, as is likewise characteristic of districts where no artificial excavations have been made, but which have been deformed at the time of earthquakes.¹⁷ After the shocks of 1905, Dr. A. C. Lane, the then state geologist, had improvised in the Houghton office of the Survey a simple seismoscope by setting up a pencil in a box of sand. This pencil had been several times upset by jars, once in early February, 1906, and the direction of the fall indicated that they proceeded from the Quincy and Atlantic mines. On the date of the incaving at the Atlantic mine, the pencil fell in a direction E. 30° S., which fact was observed and recorded before the news of the cave-in had been received. The photographs showing the surface deformations which are reproduced in Plates I and II were taken at the mines a few days after the occurrence by Dr. L. L. Hubbard, former state geologist. Dr. Lane, who accompanied Dr. Hubbard, has furnished the writer with the following notes:

"For some distance in the hanging or northwest side of the Atlantic mine there were signs of compression as shown in photographs but we could find no apparent indication of expansion, which led me to think that possibly the earthquake was in some degree under compression before it was relieved by the closing up of the mine.

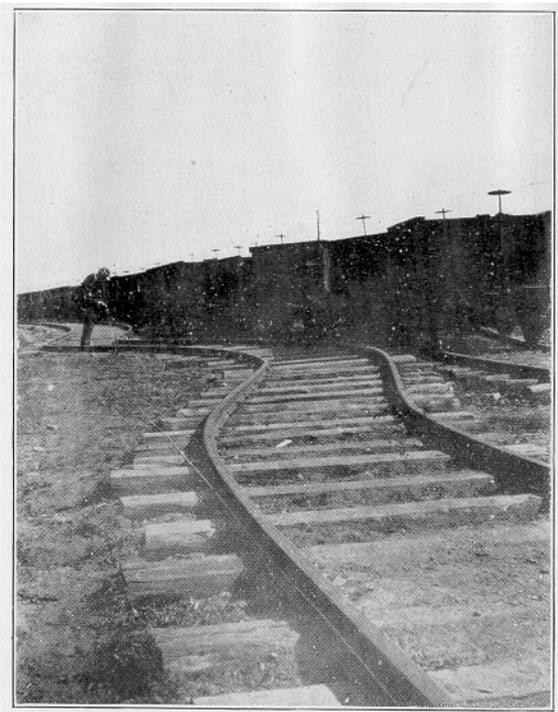
"The shocks which were felt (as is obvious in the effect on our office three or four miles away) were not all at one time. R. M. Edwards felt the shock about 10 o'clock. Dr. Hubbard felt one, he thought, about 11, while the main shock took place about 9 o'clock. There were two places where a cave was produced in the upper part of the mine leaving open pits as shown in Plate I A but at about ninety feet above the open hole there is a sign of a crack and the grass is often pushed up into a roll like the so-called "mole tracks" of earthquakes. The railroad tracks were bent into an 'S' and in one case I measured a one-foot versine on a fifty-four foot chord. At about three and one-half telegraph poles distance from the lode at a junction with a Y, the fish plates were sheared two and one-half inches. In one case forty-five links of track were bent so that the chord was but forty-one and three-tenths links. The cracks ran north sixty-five degrees west from the No. D shaft, from the conglomerate ninety feet above the lode. The water in a swamp some ways off was made muddy by the disturbance.

"On August 8 there was another shock which was felt at Cleveland and the late Peter White told the writer that he felt it at Marquette. If not a wide-spread disturbance it provoked a large settling in the Quincy mine.

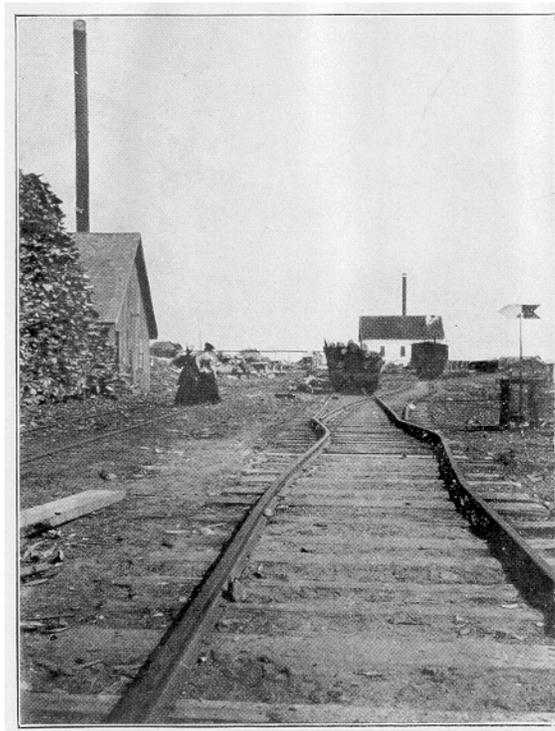
"The Calumet and Hecla shake of August 8, I think, was certainly reinforced or spread from the Quincy mine, at least that was the way the pencil dropped. In the mine a huge convex mass of rock which was left fairly unsupported came down, or as I have been told by some, it appears as though the hanging wall came up. In the Atlantic the foot wall was not disturbed and looks as if the disturbance came down, but in the Quincy the disturbance seems to run one hundred or two hundred feet back from the foot wall. Cracks one and one-half feet or more run back into the foot wall."

¹⁶Proc. Lake Superior Mining Institute, vol. 12, 1907, pp. 66-67.

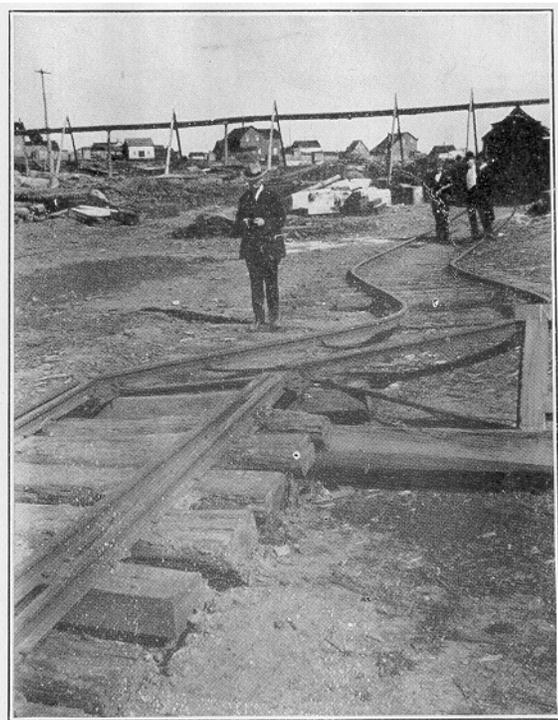
¹⁷Wm. H. Hobbs. A study of the damage to bridges during earthquakes, Journ. Geol., vol. 16, 1908, pp. 636-653.



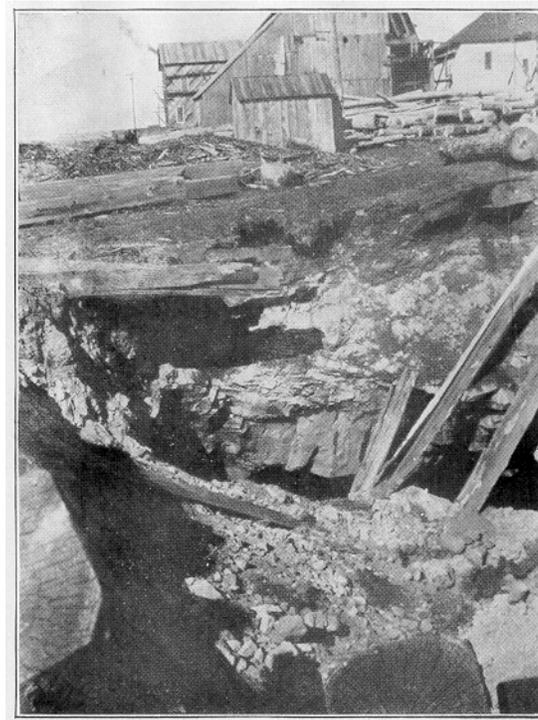
(A.) EFFECT OF EARTH MOVEMENT OF MAY 26, 1906, UPON THE RAILROAD TRACK NEARLY OVER THE LODGE OF THE ATLANTIC MINE, KEWEENAW PENINSULA (AFTER A PHOTOGRAPH BY DR. L. L. HUBBARD).



(A.) DEFORMATION OF TRACKS NEAR ATLANTIC MINE ON MAY 26, 1906, (AFTER A PHOTOGRAPH BY DR. L. L. HUBBARD).



(B.) COMPRESSION OF TRACKS NEARLY OVER LODGE OF ATLANTIC MINE ON MAY 26, 1906, (AFTER A PHOTOGRAPH BY DR. L. L. HUBBARD).



(B.) CAVING OF THE SURFACE AT THE ATLANTIC MINE ON MAY 26, 1906, (AFTER A PHOTOGRAPH BY DR. L. L. HUBBARD).