OHIO GEOLOGY

GeoFacts No. 22

OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

THE EFFECTS OF THE GREAT NEW MADRID EARTHQUAKES IN OHIO

In the early hours of December 16, 1811, most Ohio residents were deep in sleep, unaware that the primary or P wave from a tremendous earthquake was speeding toward them at nearly 14,000 miles per hour. The initial shaking in Cincinnati began only a minute and 18 seconds after the vibrations left their point of origin along an ancient crustal rift deep beneath the Mississippi River valley in the bootheel region of southern Missouri, where that state joins with Arkansas, Kentucky, and Tennessee. The first shock began to shake the Queen City at 2:24 a.m. This was the first of four major shocks, and hundreds of smaller ones, that would fan out like ripples in a pond, some of them reaching to the Atlantic coast and many of them reaching Ohio, for the next two months.

The epicentral region of the great quakes underwent a shaking that has not been experienced before or since in historic times in the eastern U.S. The 800 residents of New Madrid, Missouri, and 200 residents of Little Prairie (now Caruthersville), about 30 miles south of New Madrid, saw their communities undergo total destruction as the great quakes shook the ground so violently that no one could stand. Waves were visible on the ground surface, trees split or were snapped off, the ground was rent with fissures up to 10 feet wide, and sand, water, and debris were violently spouted as high as the treetops. Whole sections of ground subsided and were soon flooded. Banks along the Mississippi River caved in, taking with them large trees, and creating giant waves on the river. Fissuring in the river bed caused water spouts to shoot into the air and waterfalls to form where portions of the river bed were uplifted. Islands in the river disappeared and new ones rose up from the muddy bottom. All of this chaos was accompanied by an ear-splitting cacophony resembling thunder and artillery fire.

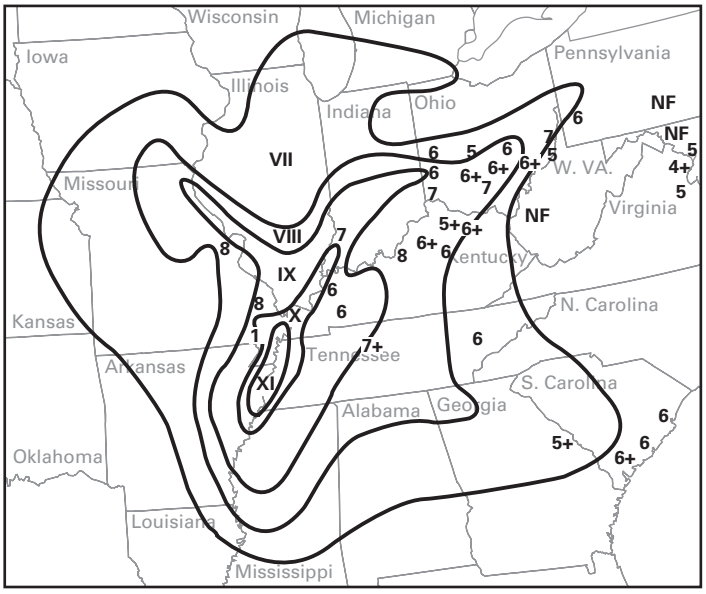
Just about 8:00 a.m., another violent shock, nearly as strong as the first, completed the annihilation of New Madrid. Little did the residents realize that two more great earthquakes, on January 23, 1812, at 9:00 a.m., and the largest of all, on February 7, 1812, at 3:45 a.m., would plague their community. The Missouri bootheel region would shake continuously from December 1811 until more than a year later. Periodic aftershocks plagued the area until 1817. The four great shocks of 1811 and 1812 are estimated to have had body-wave magnitudes of between 7.0 and 7.4, surface-wave magnitudes of between 7.8 and 8.3, and Modified Mercalli intensities of XI to XII. (See GeoFacts No. 3 for an explanation of the Modified Mercalli Scale.) In addition to these major events, there were at least six shocks of estimated magnitude 6.2-7.0, and 197 shocks of 5.2-6.2. More than 1,800 individual earthquakes large enough to be felt were noted by Louisville, Kentucky, resident Jared Brooks.

The biggest shocks were felt throughout the eastern United States and Canada from the Gulf Coast to the Atlantic shore to Quebec, an area encompassing about 2 million square miles. An area of 250,000 square miles experienced strong shaking and Modified Mercalli intensities of VII. An area of 50,000 square miles in the epicentral region experienced extensive uplift, ground fissuring, bluff collapse, and liquefaction. Reelfoot Lake in Tennessee, and a number of other lakes, were formed by disruption of the ground.

Although Ohio is on the fringe of the New Madrid seismic zone, it is obvious from contemporary accounts that damage occurred in southwestern Ohio, particularly in Cincinnati. A recurrence of the 1811-1812 sequence would have direct and significant influence on the state. Dr. Ronald Street of the University of Kentucky undertook an extensive investigation in 1984 of all existing accounts of the New Madrid sequence.

THE OHIO RECORD

The Ohio record of the New Madrid earthquakes consists of a series of newspaper accounts from a few cities in the state and the astute observations of Daniel Drake of Cincinnati. Drake published his observations in 1815 in his book, *Natural and statistical view, or a picture of Cincinnati*. These observations, sparse as they are, constitute the primary basis for evaluating the potential risk to Ohio's populace should there be a repeat of the 1811-1812 events.



Composite map showing Modified Mercalli intensities (arabic numerals) calculated from historical accounts of the February 7, 1812, New Madrid earthquake (from Street and Nuttli, 1990) and isoseismal lines showing composite intensity (roman numerals) that would hypothetically result from a magnitude 8.6 earthquake in the New Madrid seismic zone (from Hopper, M. G., 1985, U.S. Geological Survey Open-File Report 85-457). NF *= not felt.*

Of the initial New Madrid event of December 16, 1811, Drake wrote:

> *At 24 minutes past 2 o'clock A.M. mean time, the first shock occurred. The motion was a quick oscillation or rocking, by most persons believed to be west and east; by some south and north. Its continuance, taking the average of all the observations I could collect, was six or seven minutes. Several persons assert that it was preceded by a rumbling or rushing noise; but this is denied by others, who were awake at the commencement. It was so violent as to agitate the loose furniture of our rooms; open partition doors that were fastened with falling latches, and throw off the tops of a few chimnies in the vicinity of the town. It seems to have been stronger in the valley of the Ohio, than in the adjoining uplands. Many families living on the elevated ridges of Kentucky, not more than 20 miles from the river, slept during the shock; which cannot be said, perhaps of any family in town.*

Of the large shock on January 23, 1812, Drake wrote:

> *About 9 o'clock A.M. a great number of strong undulations occurred in quick succession. They continued 4 or 5 minutes, having two or three distinct exacerbations during that time. An instrument constructed on the principle of that used in Naples, at the time of the memorable Calabrian earthquakes, marked the direction of the undulations from south-south-east to north-north-west. This earthquake was nearly equal to that which commenced the series on the 16th ultimo.*

The January 23 event shook Chillicothe as well. The Chillicothe *Supporter* reported "On Thursday morning last, about nine o'clock, another considerable shock of an Earthquake was felt at this place. Its continuance was near two minutes, and appeared to come from the southwest."

Perhaps surprisingly, Coshocton, in east-central Ohio, experienced intensities from the January 23 event that were in the VII range. A correspondent to *Kline's Weekly Carlisle* (PA) *Gazette* (14

continued

February, 1812) wrote:

Coshockton, Jan. 23rd, 1812. Mr. Editor. This morning, at seventeen minutes past eight o'clock a severe shake of an earthquake was felt at this place. It lasted nearly a minute: it shook so as to nearly half empty a bucket, standing on the floor, full of water; and the river being frozen over, it caused the ice to crack considerably. A stone chimney in the house of Col. Williams in this place, seven by five feet square, solid and well built, was so severely shaken so as to cause it to crack in several places; and one or more brick chimneys in this place have been considerably injured by the shock. I have been informed that several houses in the neighborhood of this place were so shook that much of the chinkin dropt out; and the commotion of the trees and bushes was so great as to cause persons in the woods to observe the phenomenon.

After several days of small shocks being felt in Ohio, on February 7, 1812, the largest of the New Madrid events occurred in the early morning hours. Drake observed in Cincinnati:

At 45 minutes past 3 o'clock A.M. several alarming shocks in rapid succession. The instrument already mentioned indicted the three principal heaves to be from the south-west, the south-south-west and south-south-east. The last greatly surpassed any other undulation ever known at this place. It threw down the tops of more chimnies, made wider fissures in the brick walls, and produced vertigo and nausea in a greater number of people, than the earthquakes of either the 16th of December or the 23rd of January. It was said by some, that this earthquake was preceded by a light and a noise; but this was denied by others, who were awake, and collected in mind and senses.

The *Liberty Hall* newspaper in Cincinnati (12 February, 1812) gave the following account:

. . . on the morning of the 7th, at 32 minutes past 3 o'clock, apparent time, a strong vibration occurred and was followed without intermission by two others; the whole occupying, according to the best observations that were made, about six minutes. They raised those sides of houses which face S.S.E. and W.S.W. One of them threw a plum, hung by a line 7 feet long, three inches to the N.W. from the point over which it ordinarily rested. This was not only the strongest vibration that occurred at that time, but by far the most powerful that has been experienced here. It however, did less damage than was expected, by those who witnessed it. It threw down part of the top of one chimney in town, and of two in the vicinity of the town. It also widened the cracks that previously existed in some brick houses; and is said to have injured the Court-house. As that building, however, was already cracked, over several of the arches, from the bad execution of the masonry it is altogether uncertain to what extent it was injured by this shock. These strong vibrations, are said by some, to have been preceded by a light and noise, but others who were awake and collected in mind and senses, observed neither.

A detailed account of the February 7 earthquake was printed in the Chillicothe *Supporter*:

Yesterday morning, about half past 3 o'clock the inhabitants of this place were very much alarmed by another tremendous shock of an Earthquake. About a minute before the shock commenced a loud subterraneous noise was heard resembling that made by a heavy loaded wagon running over frozen ground. The concussion began moderately, but soon became extremely violent, continuing with sudden jerks. The houses continued to shake about 25 minutes, sometimes with such extreme violence that many were apprehensive of their falling down. One chimney was thrown down and several bricks shook off of others; and several houses in town, were considerably cracked. The morning was perfectly calm; and had truly an awful appearance: the moon shone dimly, being surrounded by a circle, and cast a shade as if apparently eclipsed, which, together with the noise made by the trees in the woods, created in the minds of some, sensations totally indescribable.

Similar effects, including damaged chimneys, were reported at Circleville. Dr. Street has assigned an intensity of VII to these communities for this shock.

Collectively, there are only about a dozen Ohio communities that published one or more accounts of the New Madrid earthquakes. All of these communities are in the southern half of the state and most of the accounts are brief. These communities were small and construction practices and materials differed greatly from those employed today. It is therefore difficult to assess the potential damage to Ohio communities if the 1811-1812 earthquakes were to be repeated. There can be little doubt that cities such as Cincinnati would suffer damage, especially in older, unreinforced masonry buildings, and especially in those structures built on thick, unconsolidated sediments that could amplify ground motion. For most Ohio communities, however, there is no historical basis for evaluation of the potential ground motion and damage from a New Madrid-type event. The widely published isoseismal maps for the New Madrid events are broad generalizations of potential Modified Mercalli intensities that might occur in a particular area. However, as Drake noted for the December 16, 1811, event, intensities in the Cincinnati area varied widely; significant damage occurred in structures built on terraces along the Ohio River, but residents living on bedrock hills were not even awakened by the shock. This information tells us that ground motion from an earthquake can differ considerably within a small geographic area, depending on the amplification characteristics of the underlying geologic materials.

WHAT NEXT?

In the foreseeable future it is improbable that we will be able to predict the magnitude or the timing of the next large New Madrid earthquake. Available data suggest that the probability of a magnitude-8 event in the next 50 years ranges from about 2.7 percent to 11 percent, depending on which model is used. Probability of a 6.0 to 6.5 event in the next 50 years is between 45 and 97 percent. The best we can do is to prepare for the next Great New Madrid Earthquake, whenever it may occur.

For a realistic assessment of the potential damage from a significant earthquake, it is necessary to map the extent of individual geologic units and to assign them to particular risk categories based upon their potential for amplification of ground motion and liquefaction. Surface materials consist of unconsolidated sediments of glacial origin and bedrock. Seismic-risk maps do not predict when, how big, or where an earthquake will occur, but do suggest how surface materials will react if a significant event would occur. Such maps are important to planners, government officials, emergency-response agencies, insurance underwriters, the building industry, and a host of other groups because they will be able to target specific areas that have the highest susceptibility to earthquake damage, in contrast to previous assumptions that broad regions will experience the same level of ground motion at all locations.

Major earthquakes in Ohio and adjacent areas are low-probability events, but the consequences could be extraordinarily high when such an event does occur. The destruction and chaos that would result from a repeat of the 1811-1812 New Madrid earthquakes probably cannot be fully comprehended, even by those who have studied these events and are planning for their recurrence. Society is slowly beginning to realize that we must be prepared for them.

FURTHER READING

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• This GeoFacts compiled by Michael C. Hansen • April 2000 •

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