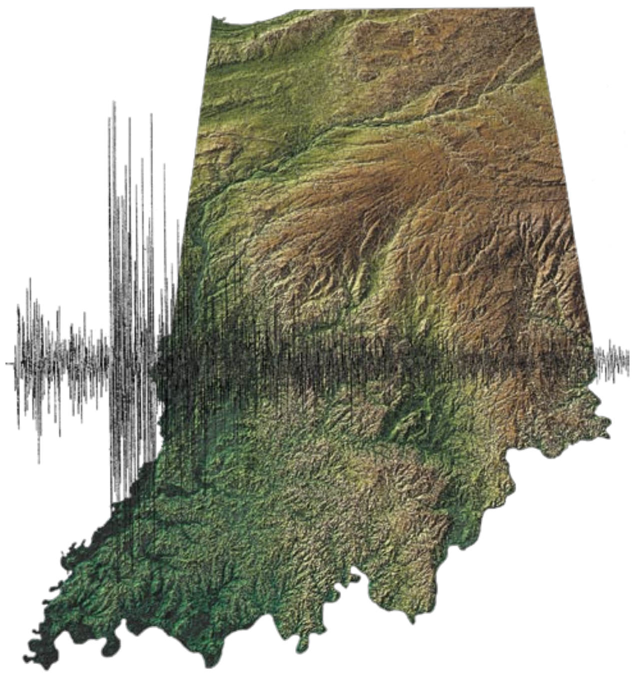
Earthquakes in Indiana



Indiana Geological Survey
and
Indiana Department of Homeland Security

Earthquakes in Indiana?

Yes! The Hoosier state has trembled in the wake of earth waves generated by powerful earthquakes in the past and will no doubt tremble again in the future. To better understand our earthquake risk in the present, researchers look back at previous earthquakes and their causes, going back even into the prehistoric era.

New Madrid earthquakes of 1811–12

When the people living in and near the town of New Madrid in what is now southeastern Missouri went to bed on the night of December 15, 1811, they had no way of knowing that during the pre-dawn hours of the following morning they would be jarred from their peaceful slumber by shock waves that ripped through the earth with such force that buildings collapsed, trees toppled, and the Mississippi River changed course. The explosive force that shattered the stillness of that serene setting was one of the most powerful earthquakes ever recorded in North America. During the next two months, the area would be rocked by three more quakes as powerful as the first (one just six hours after the first) and hundreds more smaller ones. The larger quakes shook the earth with enough force to cause church bells to ring in Washington, D.C. They were felt in Indiana and were even felt a thousand miles away in New Hampshire.

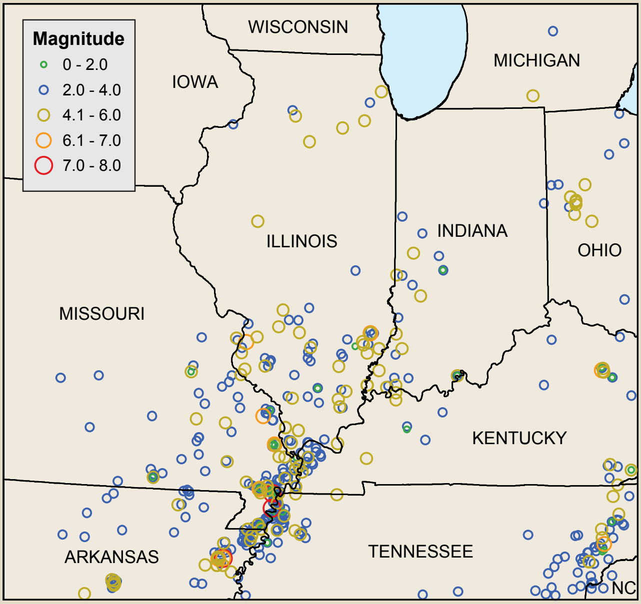


Figure 1. Map showing felt earthquake epicenters in Indiana and surrounding states from 1800 to 1995. Relative strength of the earthquakes is indicated by the size of the circles. (Modified from Bear and others, 1997).

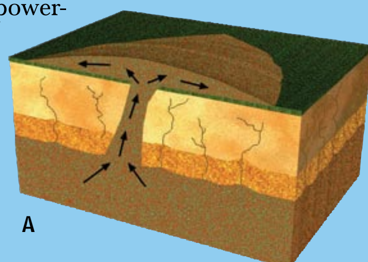
Earthquakes since 1811–12

Since the New Madrid quakes, Indiana has felt the effects of many earthquakes (fig. 1). The strongest of these was the 1895 Charleston, Missouri, quake, which damaged buildings in Evansville and other parts of southwestern Indiana. According to the U.S. Geological Survey, the strongest quake centered in Indiana during historic times struck the Wabash River valley on September 27, 1909. This quake knocked down chimneys, broke windows, and cracked plaster in the lower Wabash Valley and was reportedly felt in Arkansas, Illinois, Iowa, Kentucky, Missouri, Ohio, and Tennessee. More recently, Indiana was shaken in 1987 by a quake centered near Olney, Illinois, just west of Vincennes.

Prehistoric Indiana earthquakes

The point on the Earth's surface directly above the center of an earthquake is called the epicenter. During the last two centuries, earthquakes with epicenters in Indiana have been relatively minor events. This has not always been the case. Indiana University archaeologists Pat Munson and Cheryl Munson and U.S. Geological Survey geologist Steve Obermeier have found hundreds of ancient sandblows (see figs. 2 and 3) that suggest the occurrence of at least six major earthquakes with epicenters in Indiana during the last 12,000 years. The largest of these quakes appears to have had an epicenter at or near Vincennes; that temblor is estimated as having been many times more powerful than the Northridge quake that struck the Los Angeles area in January 1994. (The Northridge quake killed 51 people, seriously injured 9,000, and was the costliest earthquake in U.S. history.)

B



A

Figure 2. When strong earthquakes release their energy, the violent shaking may cause underground layers of saturated sandy soil to behave like a fluid under pressure. This process is called liquefaction, and sometimes the pressure forces the liquefied sand to move up through cracks in the overlying soil and flow out over the surface, creating a feature called a sandblow (A). The photo above (B) shows a cross-sectional view of an ancient sandblow exposed in the bank of the Wabash River near Vincennes. After the sandblow formed, it was covered by layers of silt deposited during floods.

Geologists determine the ages of sandblows by using radiocarbon and other geologic dating methods on materials found in soil layers below, above, or at the same level as the tops of the sandblows. Charcoal was found in some of the organic material tested; this is residue from campfires made by people living in Indiana at that time. Other artifacts, including projectile points, were found at many sites and helped to date the earthquakes.

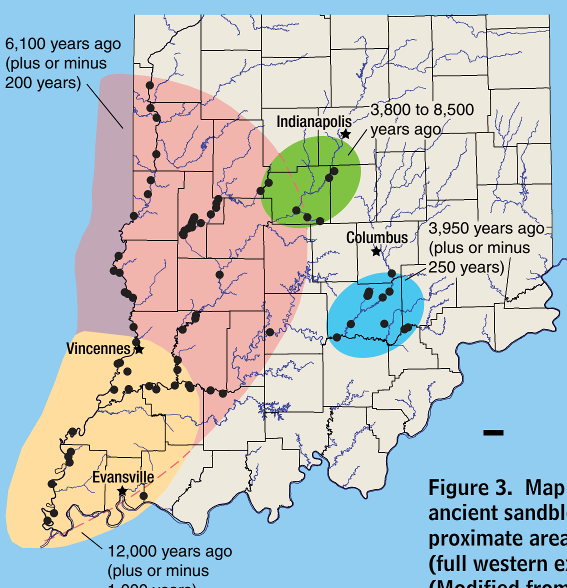
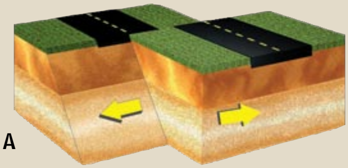


Figure 3. Map of the southern part of Indiana showing sites where ancient sandblows have been found (black dots), and showing approximate areas of liquefaction for four major prehistoric earthquakes (full western extent of the two largest areas has not been determined). (Modified from Munson and others, 1997.)

What causes earthquakes?

Earthquakes are caused by the sudden release of energy that results when rock in the Earth's crust is under so much stress that it suddenly breaks. The split masses of rock then grind past one another as they are pushed by the forces that cause the stress. The area of contact between the grinding masses is called a fault. The direction of motion of each of the rock masses may be horizontal, vertical, or a combination of these motions (see fig. 4). The force that causes the stress within the rock is a result of the movement of giant plates that make up the Earth's outer layer (see figs. 5 and 6).



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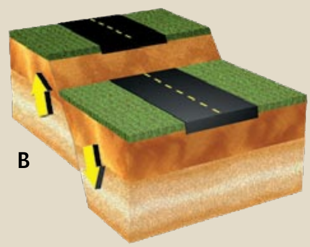


B

Figure 4. If movement along a fault is horizontal (A), the fault is called a strike-slip fault. Earthquakes in California are caused by strike-slip faults. If movement is vertical (B), it is called a dip-slip fault. The fault shown in B is also called a normal fault. If the block in front was pushed up and over the block behind it, it would be called a reverse fault.

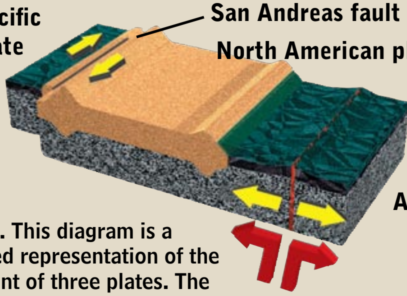


Figure 5. This diagram is a simplified representation of the movement of three plates. The yellow arrows are meant to assist with visualizing the general direction of plate movement. The Pacific and North American plates are sliding past each other along the San Andreas fault. The red arrows show the convection currents that cause the African and North American plates to spread apart, allowing magma to move into the gap and create new crust.

Plate tectonics

The outer layer of the Earth is divided into huge plates, like a cracked eggshell. Driven by convection that permits heat to escape from the Earth's interior (fig. 7A), the plates move at a rate of about 2 to 25 centimeters per year, carrying with them continental land masses and ocean floor alike.

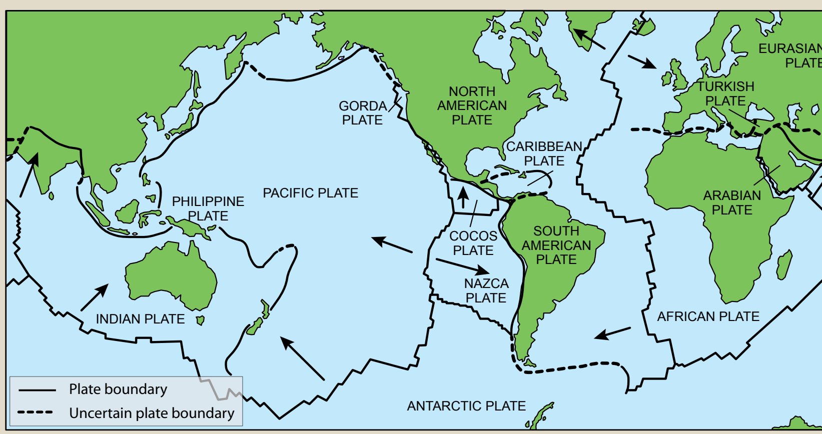
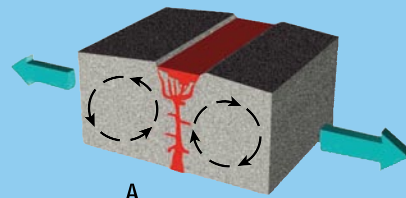


Figure 6. View of the Earth showing approximate margins of the major plates. Most earthquakes are triggered when plates grind past each other laterally, as they do in California, or vertically, as in Alaska or South America. Earthquakes felt in Indiana are the result of stresses transmitted inward from the boundaries and perhaps the base of the North American plate. (Arrows indicate general direction of plate movement.) (Modified from Simkin and others, 1994.)

Tearing apart a continent

Sometimes the convection that causes the plates to move will cause them to rip apart. If a continent happens to be sitting over the tear, then it too will be torn, or rifted, apart. Studies have revealed that such rifting apparently began about 600 million years ago beneath the present Mississippi River valley. The rift, called the Reelfoot Rift, failed to completely rupture the crust; but the pulling apart of the rocks caused the formation of a zone of weakness in the Earth's crust (see fig. 7).

As the North American plate pushes against the Pacific plate, compressional forces are probably causing stress on these weakened rocks, which is occasionally relieved when the rocks slip past each other during an earthquake. Many earthquakes have occurred in the Reelfoot Rift in a region known as the New Madrid Seismic Zone. The locations of these earthquakes are shown in Figure 1 in the area around New Madrid, Missouri.



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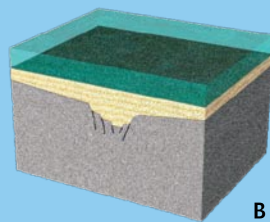

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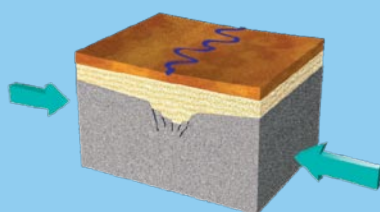

C

Figure 7. A very generalized representation of the development of the Reelfoot Rift, which began about 600 million years ago. (A) Convection cells are the source of forces that move the Earth's plates, resulting in the continents having been torn apart. Later, the rifting stopped (B) and the area was buried by sediments that accumulated in a shallow inland sea that covered much of what is now North America. Now the North American Plate is pressing against the Pacific Plate, causing compressional forces to bear down on the central United States (C), which may be the cause of occasional earthquakes as the squeezed rocks periodically break apart. (Modified from Braile and others, 1986.)

Indiana faults

Indiana has several faults, but unlike California's famous San Andreas Fault, nearly all of our faults are buried and can't be seen at the surface. Researchers have been able to map some faults in Indiana using evidence found in rocks from oil and gas wells and by employing a method called reflection seismic profiling. This method involves recording man-made vibrations reflected off layers of rock below the Earth's surface.

Most of the mapped faults in Indiana are located in the southwestern corner of the state. These faults extend into Illinois and collectively are known as the Wabash Valley Fault System. All the mapped faults in Indiana are normal faults (see fig. 6). Normal faults form when the crust is being pulled apart instead of being compressed as it is now. These mapped faults are unlikely candidates for future movement.

The earthquakes that have occurred in Indiana during the last 200 years are the result of movement along faults at great depth (10 or more kilometers) below the surface. This depth and the nature of the rock layers at that depth have limited the ability of seismologists to successfully map earthquake-generating faults using reflection seismic profiling and other remote-sensing techniques. Unfortunately, the best method available for mapping these faults is to wait patiently for the next large earthquake, then determine the precise location of the aftershocks using sensitive portable seismometers. (Figure 8 shows the seismometer at Indiana University.) Much more research is needed before we will know the full extent of faulting beneath Indiana and the potential for movement along those faults.

Is there a major earthquake in Indiana's future?

Seismologists are far from a complete understanding of the complex processes that trigger earthquakes, which has prevented them from being able to predict when earthquakes will occur. Therefore, no one can say with any certainty when or if an earthquake strong enough to cause significant property damage, injury, or loss of life in Indiana will occur. However, considering the prehistoric evidence of strong earthquakes with epicenters within Indiana, the history of earthquakes that have caused damage in Indiana since 1811, and the presence of compressional forces squeezing the rocks at great depths under the state, it is reasonable to conclude that we do indeed face the possibility of experiencing the potentially devastating effects of a major earthquake at some point in the future.

Preparing for the next quake

While we can't prevent earthquakes, we can reduce their disastrous effects by assessing the risks and preparing for them. Assessing risks involves determining the probability of the occurrence of an earthquake within a particular region, and may also involve determining how the soils of that region respond to severe ground shaking. The composition, structure, thickness, and moisture content of a soil, which may vary greatly from one location to another, even within a small area, determines how it will behave during an earthquake. Accurate assessment of an area's level of risk requires the collection and careful study of information about local geology and the engineering properties of the soil and the infrastructure. This information can then be used to determine where and how structures should be built, which existing structures should be reinforced, and how to address human needs.

Preparing for an earthquake includes constructing critical structures such as schools, hospitals, dams, and bridges so that they are able to survive the maximum level of shaking likely to occur at the site; developing a plan for coordination of activities among emergency response agencies; developing plans of action for schools, businesses, and homes; and educating everyone about earthquakes and what can be done to lessen their potentially disasterous effects.

As long as compressional forces continue to squeeze the rocks beneath the surface of the central United States, earthquakes will occur. Because great periods of time pass between occurrences of damaging earthquakes in this region, it is easy for us to become complacent and inadequately prepared. Studying the stresses, strains, and movements of masses of rock kilometers below the surface of the Earth presents problems of immense complexity for scientists, but until those problems are solved we cannot know when, or even if, a major earthquake will occur. But, if one does occur, wouldn't it be better to be prepared?

Figure 8. Seismographs, such as this one located at Indiana University, record the waves generated by an earthquake. By analyzing the data on the seismograms, scientists can determine how far away the earthquake occurred and how strong it was.

What to do before, during, and after an earthquake

Before

- Learn first aid procedures.
- Learn how to shut off all utilities in your home.
- Keep emergency items on hand, including first aid kit, supply of important medicines, flashlight, battery-powered radio, batteries, some drinking water and nonperishable food, tools to shut off utilities, and a fire extinguisher.
- Use bolts or straps to secure heavy items that might topple over, such as a bookcase, china cabinet, or water heater.
- Avoid placing heavy objects on shelves or heavy pictures on walls where they could fall onto a bed.

During

- If at home, avoid windows and objects that could fall. If possible, get under a sturdy table, desk, or bed, or stand in a doorway.
- If in a public building, avoid stairways and elevators and don't run for exits. Get under a desk or table and avoid outside walls, especially glass walls.
- If outside, move away from anything that might fall on you, especially debris from buildings such as glass or bricks.
- If driving in a car, avoid bridges and overpasses. Turn on the radio for emergency broadcasts.

After

- Check for injuries to others and provide assistance as needed.
- Check for and extinguish fires, and check for and correct conditions, such as spilled gasoline, that could lead to a fire.
- Check appliances and gas, electric, and water lines for damage, and shut off utilities that are damaged.
- If outside, watch out for downed power lines.
- Use the telephone only for emergencies.
- Be prepared for aftershocks.

Other resources

Bolt, Bruce, 1999, Earthquakes: New York, W. H. Freeman. Web site also available with teaching tools for use with book: http://www.whfreeman.com/bolt/index.htm

Central United States Earthquake Consortium Web site: http://www.cusec.org/

Indiana Geological Survey Web site: http://igs.indiana.edu

Information on earthquakes, U.S. Geological Survey Web site: http://earthquake.usgs.gov/eqcenter/

For more earthquake preparedness and emergency information, contact the Indiana Dept. of Homeland Security (800 669-7362, http://www.in.gov/dhs/), your local emergency management office, or your local chapter of the American Red Cross. http://www.redcross.org

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