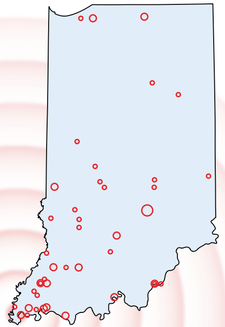
BE INFORMED | BE PREPARED

EARTHQUAKES in INDIANA



Indiana Geological Survey
and Indiana Department of Homeland Security

WHAT CAUSES EARTHQUAKES?

Plate tectonics

The outer crust of the Earth is divided into huge plates, much like a cracked eggshell (fig. 1). Driven by convection currents that permit heat to escape from the Earth's interior (fig. 2), the plates move at a rate of about a ½ inch to 4 inches per year, displacing continental land masses and ocean floor alike.

The forces that move the plates create stresses within the Earth's crust, and can cause the crust to suddenly fracture. The area of contact between two fractured crustal masses is called a fault. Earthquakes result from sudden movements along faults, creating a release of energy. Movement along a fault can be horizontal, vertical, or both (fig. 3).

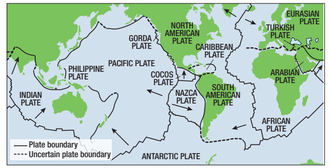


Figure 1. Map of the Earth showing approximate margins (bold black lines) of the major plates. Arrows indicate the general direction of plate movement. Most earthquakes are triggered when plates grind past each other laterally, as they do in California, or vertically, as in Alaska or South America. Earthquakes felt in Indiana are the result of stresses transmitted inward from the boundaries and, perhaps, the base of the North American plate.

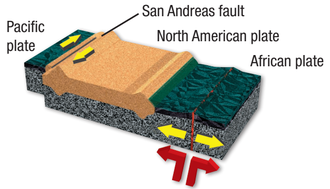


Figure 2. This diagram is a simplified representation of the movement of three plates. The yellow arrows show the general direction of plate movement. The Pacific and North American plates are sliding past each other along the San Andreas fault. The red arrows show the convection currents that cause the African and North American plates to spread apart, allowing magma to move into the gap and create new crust.

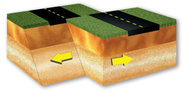
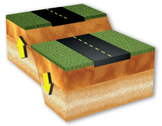
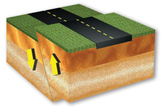


Figure 3. If movement along a fault is horizontal, the fault is called a **strike-slip fault**.



If the rock mass above an inclined fault plane moves down, the fault is referred to as a **normal fault**. The majority of known faults in Indiana are normal faults.



When a rock mass above an inclined fault moves up relative to the inclined fault plane, this is called a **reverse fault**.

Tearing apart a continent

Studies show that about one billion years ago, the crust under the central United States was pulled apart (fig. 4). This rift did not completely separate the crust into individual plates, but it did create zones of faulting in the Mississippi River Valley region.

Many earthquakes have occurred and continue to occur in the New Madrid and Wabash Valley Seismic Zones, from northeastern Arkansas through southern Illinois and into southwestern Indiana (fig. 5).

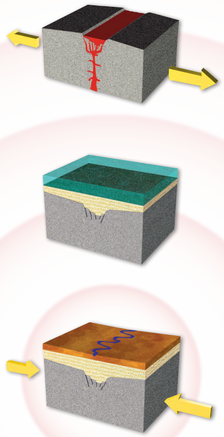


Figure 4. Generalized representations of rift development in the Midwest. Opposing forces pull the plate in different directions (top). Rifting ceases and the resulting fractures are buried by sediments that accumulated in a shallow inland sea covering much of what is now North America (center). At present, the North American Plate is pressing against the Pacific Plate, causing compressional forces to bear down on the central United States, occasionally causing earthquakes as the squeezed rocks periodically break apart (bottom).

Indiana faults

Indiana has dozens of faults, but unlike California's famous San Andreas Fault, nearly all of them are buried or difficult to see at the surface. Researchers have mapped some faults in Indiana using evidence found in oil and gas wells and in outcrops, but they also employed a method called seismic reflection profiling, which creates images of the rock layers below the Earth's surface. Many of the mapped faults in Indiana are in the southwestern corner of the state. These faults extend into Illinois and northern Kentucky and are collectively known as the Wabash Valley Fault System. These faults are likely candidates for future movement, because the crust is weak in this area.

Indiana earthquakes that occurred during the last 200 years are the result of movement along faults that are more than 6 miles below the surface. Because these faults are so deep, combined with the nature of the rock layers at that depth, it is difficult for seismologists to successfully map earthquake-generating faults using 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. Much more research is needed before scientists understand the full extent of faulting beneath Indiana and the potential for movement along those faults.

EARTHQUAKES IN INDIANA

The Hoosier state has trembled in the wake of seismic waves generated by powerful earthquakes in the past and will no doubt shake again in the future. To better understand our earthquake risk, researchers evaluate previous earthquakes and their causes.

New Madrid earthquakes 1811–1812

When the people living in and near the town of New Madrid in what is now southeastern Missouri went to bed the night of December 15, 1811, they had no way of knowing that they would be jarred out of their sleep by shock waves that could be felt as far away as Washington, D.C. The force produced by this severe earthquake—one of the most powerful ever felt in the central United States—collapsed buildings, caused trees to topple, and changed the course of the Mississippi River. During the following two months, the region would be rocked by three more earthquakes as powerful as the first and by more than a thousand smaller aftershocks. Seismic waves from these large-magnitude events were felt in Indiana and reported as far away as New York.

More recent earthquakes

Since the historic New Madrid quakes, Indiana has felt the effects of many other earthquakes (fig. 5). The strongest of these was the 1895 Charleston, Missouri, earthquake, which damaged buildings in Evansville and other parts of southwestern Indiana. According to the U.S. Geological Survey, the most intense shaking experienced in Indiana occurred in the Wabash River valley on September 27, 1909. This earthquake knocked down chimneys, broke windows, cracked plaster, and was felt in Arkansas, Illinois, Iowa, Kentucky, Missouri, Ohio, and Tennessee. More recently, in 2008, Indiana felt the effects of a moderate earthquake centered near Mt. Carmel, Illinois, just west of Vincennes.

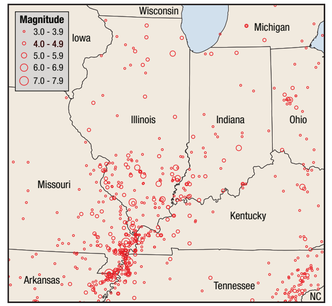


Figure 5. Map of Indiana and surrounding states showing earthquake epicenters that occurred from 1795 to 2008. The relative strength of the earthquakes is indicated by the size of the circles. Only earthquakes that were strong enough to be felt are shown on the map.

***Earthquakes in Indiana* is presented by**

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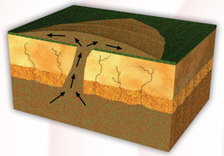
Web resources:

- Indiana Geological Survey: igs.indiana.edu
- Central United States Earthquake Consortium: www.cusec.org
- U.S. Geological Survey: earthquake.usgs.gov/eqcenter
- Indiana Department of Homeland Security: www.in.gov/dhs
- For more detailed information about preparing for an earthquake, visit igs.indiana.edu/EarthquakeExperience

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 having epicenters that originate in Indiana have been relatively minor events. However, this has not always been the case. Researchers have found dozens of ancient sandblows (figs. 6 and 7), which give evidence that at least six major earthquakes with epicenters in Indiana happened during the last 12,000 years. The largest of these appears to have had an epicenter at or near Vincennes; that event is estimated as having been more powerful than the Northridge earthquake that struck the Los Angeles area in January 1994. (The Northridge earthquake killed 51 people, and seriously injured 9,000. It was the costliest earthquake in U.S. history.)

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. Archeological artifacts, including arrowheads, were found at many sites and helped to date the earthquakes.



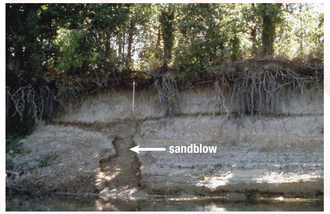


Figure 6. When strong earthquakes release their energy, violent shaking may cause layers of saturated sandy soil to behave like a fluid under pressure. This process is called liquefaction. Sometimes liquefied sand moves up through cracks in the overlying soil and flows out over the surface, creating a liquefaction feature (top diagram). The photo shows an ancient sandblow that was exposed in a bank of the Wabash River near Vincennes. Over time, the sandblow was covered by flood deposits.

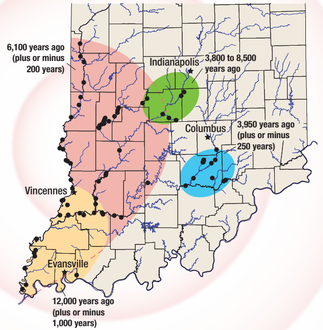


Figure 7. Map of southern Indiana showing sites where ancient sandblows were found (black dots) and approximate areas of liquefaction (in color) for four major prehistoric earthquakes.

IS THERE A MAJOR EARTHQUAKE IN INDIANA'S FUTURE?

Seismologists do not yet have a complete understanding of the complex processes that trigger earthquakes and cannot predict when earthquakes will happen. At this point, 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 having epicenters within Indiana, the recent history of damaging earthquakes in Indiana, and the presence of compressional forces squeezing the rocks at great depths, it is reasonable to conclude that we do, indeed, face the possibility of experiencing a strong 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 an earthquake occurring within a particular region, and may also involve studying how the local soils respond to severe ground shaking. The composition, structure, thickness, and moisture content of a soil, which can vary greatly from one location to another even within a small area, determines how it will behave during an earthquake. An accurate assessment of an area's level of risk requires carefully researching the local geology, 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 building critical structures—schools, hospitals, dams, and bridges—so that they are able to survive the maximum level of shaking likely to occur. Being prepared also entails developing plans of action for schools, businesses, and homes, as well as plans to coordinate activities by emergency response agencies. Educating people about how to prepare themselves can lessen the risks and impacts of an earthquake on their homes and personal safety.

As long as compressional forces continue to squeeze the rocks beneath the surface of the central United States, earthquakes will occur. But because long periods of time pass between 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 miles 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 happen, let us be prepared for it.

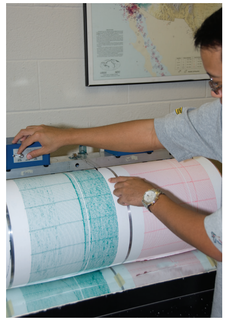


Figure 8. Seismographs, such as this one at Indiana University, record the waves generated by an earthquake. Portable seismographs can also be placed in an area to record aftershocks. By analyzing these seismic records, scientists can determine how far away the earthquake occurred and how strong it was.

EARTHQUAKE
WHAT TO DO

BEFORE

- Develop a family emergency plan and establish an outdoor meeting location.
- Inspect your home and identify potential hazards.
- Use bolts or straps to secure heavy items that might topple over, such as bookcases, china cabinets, or water heaters.
- Avoid placing heavy objects such as shelves and frames on walls where they could fall onto people.
- Keep an emergency disaster kit on hand, including a first aid kit, flashlight, hand-cranked or solar-powered radio, batteries, drinking water, nonperishable food, and tools to shut off utilities.
- Learn how to shut off all utilities in your home.

DURING

- ***Drop, Cover, and Hold On!*** Drop to the floor, get under a sturdy table, and hold on until the shaking stops. If space is limited, protect your head and neck.
- If indoors, stay there.
- If in a public building, avoid stairways and elevators and do not run for exits. Get under a desk or table and avoid outside walls, especially glass doors and windows.
- If outside, get into an open area. Stay clear of buildings, power lines, streetlights, and anything that could fall on you.
- If driving in a car, move out of traffic as quickly as possible and shut off the engine. Avoid bridges, overpasses, and anything that could fall onto your car.

AFTER

- Go to your predetermined outdoor meeting location.
- Check for injuries to others and provide assistance as needed.
- Check for and extinguish small fires. Clean up any spilled flammable liquids.
- Inspect your home for signs of structural damage. Do not enter a structurally compromised building.
- Check gas, electric, and water lines for damage, and shut off utilities that are damaged. Unplug any damaged appliances.
- Use the telephone only for emergencies.
- Be prepared for aftershocks. ***Drop, Cover, and Hold On*** each time shaking occurs.