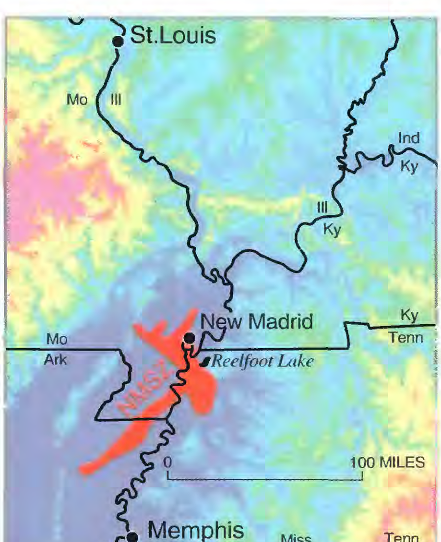
Uncovering Hidden Hazards in the Mississippi Valley

The central Mississippi Valley has more earthquakes than any other part of the United States east of the Rocky Mountains. The geologic structures related to the causes of these quakes lie deeply buried by sedimentary deposits. Ongoing geophysical studies are revealing these hidden features, enabling residents of the region to better prepare for future earthquakes.

The dramatic Gateway Arch in St. Louis, Missouri, towers over the gentle landscape of the central Mississippi Valley. In the past, this region has been struck by very powerful earthquakes. The geologic structures related to the causes of earthquakes in the region are buried by deep sedimentary deposits. Using geophysical techniques, U.S. Geological Survey scientists are revealing these hidden earthquake hazards. (Photograph copyright Richard Sprengeler, courtesy National Park Service.)

The winter of 1811–12 was extremely difficult for the European settlers of the Mississippi Valley. While Tecumseh, the Shawnee chief and visionary, was attempting to unite the tribes of the valley in an effort to drive out the settlers, the region was struck by three of the most powerful earthquakes in United States history. These magnitude 8 quakes, centered near the town of New Madrid (Missouri), devastated the surrounding region and rang church bells 1,000 miles away in Boston. The scars that those great earthquakes made on the landscape remain—the quakes locally changed the course of the Mississippi River and created Reelfoot Lake, which covers an area of more than 10 square miles in northwestern Tennessee.



The central Mississippi Valley is the most earthquake prone region of the United States east of the Rocky Mountains. The part of the region in which most quakes occur is referred to by scientists as the New Madrid seismic zone (NMSZ). The topography of the central Mississippi Valley is nearly level—the higher areas, *shown here in warm colors, are* only a few hundred feet above the broad floor of the Mississippi Valley, shown in blue. Studies of surface geology offer few clues to the causes of quakes in the region.

The great earthquakes of 1811-12 were not freak events. In recent decades, earth scientists have collected evidence that strong earthquakes in the central Mississippi Valley have occurred repeatedly in the geologic past. Small earthquakes happen in the region frequently. The area in which most of these quakes occur is referred to by scientists as the New Madrid seismic zone (NMSZ).

In 1811, the central Mississippi Valley was sparsely populated and there were few man-made structures. Today, this region is home to millions of people, including the populations of large cities, such as St. Louis, Missouri, and Memphis, Tennessee. A repeat today of the earthquakes of 1811–12 would cause widespread loss of life and billions of dollars in property damage.

Another earthquake as powerful as the great quakes of 1811–12 may not occur for many years. However, scientists estimate that there is a 9-in-10 chance of a magnitude 6 to 7 temblor occurring in the NMSZ within the next 50 years. Because of differences in the geology east and west of the Rocky Mountains, the effects of a magnitude 7 quake in the midcontinental United States could be far worse than those of the 1989 magnitude 7 Loma Prieta, California, earthquake. That quake, which struck the San Francisco Bay region during the World Series, killed 63 people and caused $6 billion of property damage.

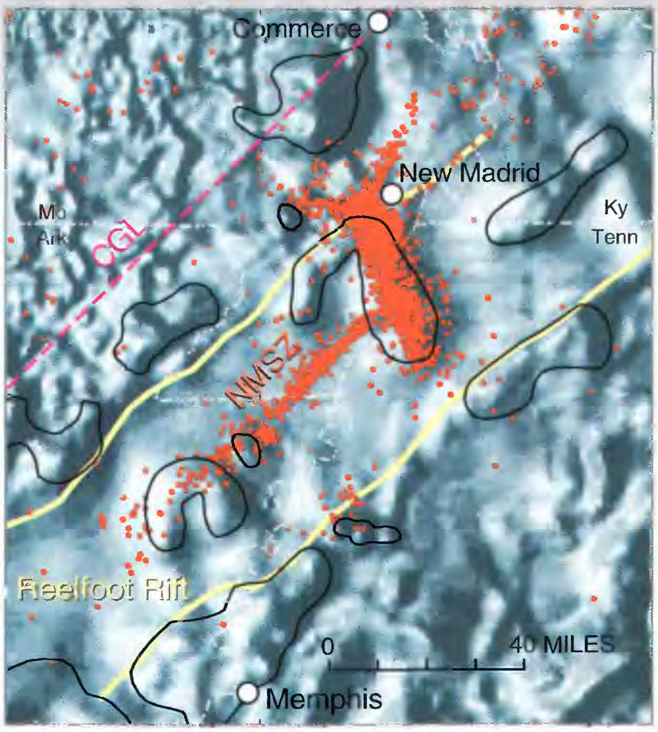
In response to this threat, the U.S. Geological Survey (USGS) has been spearheading an effort to understand the causes of earthquakes in the Mississippi Valley. Begun in the 1980's, this ongoing cooperative endeavor among universities, state governments, and Federal agencies has two goals—to evaluate the level of the earthquake hazard and to help reduce the risk to lives and property from future quakes in the region.

The effort to assess the seismic risk in the Mississippi Valley is, however, hampered because the faults and other geologic structures related to earthquakes there have been deeply buried over hundreds of millions of years by thick layers of sediment. Therefore, few clues to the causes of earthquakes in the NMSZ can be found at the Earth's surface.

To unmask these hidden geologic structures related to earthquakes, scientists are using geophysical techniques, such as mapping variations in the strength of Earth's magnetic field. A magnetic map of the central Mississippi Valley region made by geophysicists with the USGS shows with exceptional clarity a major buried feature known as the Reelfoot Rift. Most earthquakes in the central United States occur within this northeast-trending structure, which formed more than 500 million years ago.

A rift structure is created when powerful geologic forces begin to pull the Earth's crust apart. If this process continues long enough, the crust separates to form an ocean basin, as happened to form the Atlantic Ocean basin. The Reelfoot Rift is called a failed rift because the Earth's crust did not separate enough to create a new ocean basin. However, the crust was disturbed enough to form major faults that mark the axis and margins of the rift and now contribute to the occurrence of earthquakes in the NMSZ.

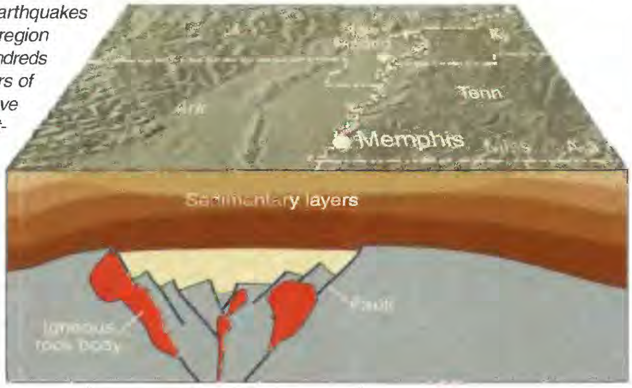
The locations of earthquakes within the NMSZ also appear to be strongly influenced by the presence of large bodies of igneous rock, which were formed by the cooling and solidification of molten rock beneath the Earth's surface. These igneous rock bodies show up as areas of high magnetic intensity on the magnetic map of the region. The southern part of the NMSZ is a narrow belt of quake activity that trends northeast, probably following a fault along the center of the Reelfoot Rift. However, this trend abruptly changes direction to north-northwest where it intersects and follows the major lobe of a large mass of igneous rock. Within this lobe, the belt of quake activity broadens to closely match the shape of the igneous body on the magnetic map. The dispersed pattern of earthquakes associated with igneous rock bodies may be an important new clue to the causes of quakes in the NMSZ.



The shaded-relief magnetic map of the region surrounding the New Madrid seismic zone (NMSZ), shows areas of high magnetic intensity as "hills" and those of low intensity as "valleys." The deeply buried Reelfoot Rift is expressed as a smoother appearing area between the yellow lines, and the Commerce geophysical lineament (CGL), paralleling the rift, is traced. Red dots show the locations of the many earthquakes recorded in the NMSZ since 1974, and major igneous bodies, which show up as prominent "hills," are outlined in black.

One of the few places in the central Mississippi Valley where faults break the Earth's surface is near the town of Commerce, Missouri. Trenches dug there reveal sedimentary deposits, as young as about 12,000 years old, that have already been broken by movement on the faults. This site lies along a linear magnetic feature called the Commerce geophysical lineament. Geophysicists believe that this northeast-trending lineament may represent a zone of faulting more than 150 miles long. Although it is still poorly understood, this geologic feature could pose a significant additional seismic threat to the region.

Earthquakes generated by buried geologic features will continue to shake the Mississippi Valley in the future. Using geophysical techniques and other tools, earth scientists are striving to better understand the causes of these quakes. The knowledge they have gained is being used to increase public awareness of the region's hidden seismic hazards. This knowledge is also being applied by engineers to make new and existing structures in the Mississippi Valley more resistant to earthquakes. In these ways earth scientists and engineers are helping to protect residents of the central United States from loss of life and property in future quakes.



Geologic structures related to earthquakes in the central Mississippi Valley region have been deeply buried over hundreds of millions of years by thick layers of sediment. Geophysical studies have revealed a major buried northeast-trending feature known as the Reelfoot Rift (here shown in cross section), which formed more than 500 million years ago when powerful geologic forces began to pull the Earth's crust apart. Most quakes in the central Mississippi Valley appear to be related to the major faults and large bodies of igneous rock within the rift.

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See also *The Mississippi Valley—"Whole Lotta Shakin' Goin' On"* (USGS Fact Sheet 168–95).

U.S. Geological Survey Fact Sheet 200–96
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