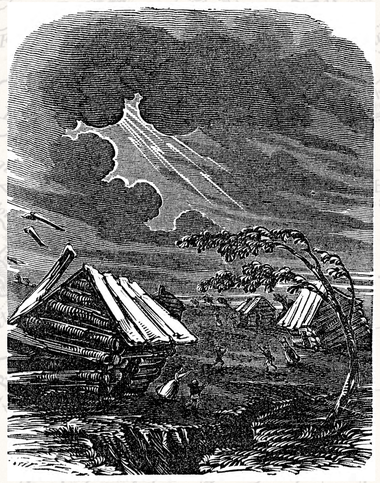
GEOLOGICAL RECORD OF ANCIENT EARTHQUAKES IN THE NEW MADRID SEISMIC ZONE

THE NEW MADRID SEISMIC ZONE

When people think of earthquakes in the United States, they tend to think of the west coast. But earthquakes also happen in the eastern and central U.S. The most seismically active area east of the Rocky Mountains is in the Mississippi Valley and is known as the New Madrid seismic zone. Since 1974, seismometers, instruments that measure ground shaking, have recorded thousands of small to moderate earthquakes. The faults that produce these earthquakes are not easy to see at the surface in the New Madrid region because they are eroded by river processes and buried by river sediment. A map of earthquakes epicenters, however, reflects faulting at depth and shows that the earthquakes occur along several branches of the New Madrid seismic zone in northeastern Arkansas, southwestern Kentucky, southeastern Missouri, and northwestern Tennessee.



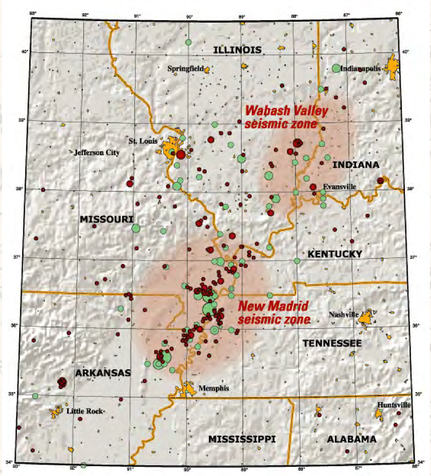
"The Great Earthquake at New Madrid"

"After the earthquake moderated in violence, the country exhibited a melancholy aspect of chasms, of sand covering the earth, of trees thrown down, or lying at an angle of forty-five degrees, or split in the middle. The Little Prairie settlement was broken up. The Great Prairie settlement, one of the most flourishing before on the west bank of the Mississippi, was much diminished. New Madrid dwindled to insignificance and decay; the people trembling in their miserable hovels at the distant and melancholy rumbling of the approaching shocks."

Henry Howe, *Historical Collections of the Great West* (Cincinnati, 1854).

In the winter of 1811 and 1812, the New Madrid seismic zone generated a sequence of earthquakes that lasted for several months and included three very large earthquakes estimated to be between magnitude 7 and 8. The three largest 1811-1812 earthquakes destroyed several settlements along the Mississippi River, caused minor damage as far away as Cincinnati, Ohio, and St. Louis, Missouri, and were felt as far away as Hartford, Connecticut, Charleston, South Carolina, and New Orleans, Louisiana.

Poster compiled by M. Tuttle & Associates in 2008 with funding from United States Geological Survey award number 04HQGR0022.

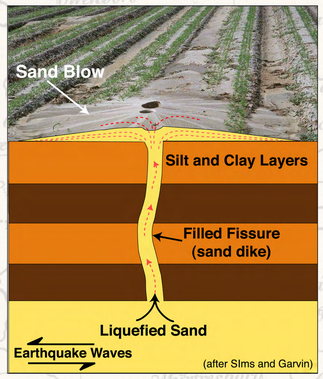


Map of New Madrid seismicity showing epicenters of earthquakes since 1974 as red dots. Approximate locations of historical earthquakes shown by green dots. Size of dots reflects magnitude.

In the New Madrid region, the earthquakes dramatically affected the landscape. They caused bank failures along the Mississippi River, landslides along Chickasaw Bluffs in Kentucky and Tennessee, and uplift and subsidence of large tracts of land in the Mississippi River floodplain. One such uplift related to faulting near New Madrid, Missouri, temporarily forced the Mississippi River to flow backwards. In addition, the earthquakes liquefied subsurface sediment over a large area and at great distances, resulting in ground fissuring and violent venting of water and sediment.

EARTHQUAKE-INDUCED LIQUEFACTION

The most obvious effects of the 1811-1812 earthquakes are the large sandy deposits, known as sand blows, resulting from eruption of water and sand to the ground surface. This phenomenon called earthquake-induced liquefaction is the process by which water-saturated, sandy sediment temporarily loses its strength due to the buildup of water pressure in the pores between sand grains as seismic waves pass through the sediment.



Photograph and schematic cross-section illustrating earthquake-induced liquefaction and formation of sand dikes and sand blows.

During the 1811 and 1812 earthquakes, liquefaction and resulting lateral spreading were severe and widespread; sand blows formed over an extremely large area about 10,400 square kilometers and up to 250 kilometers from the epicenters. Sand blows can still be seen on the surface today. In the past, all the sand blows were attributed to the1811-1812 earthquakes. We now know from paleoseismic studies that many of the sand blows pre-date 1811 and formed as the result of prehistoric New Madrid earthquakes.

Aerial view of large sand blow in plowed field near Blytheville, Arkansas. Sand blows in this area formed during 1811-1812 and earlier earthquakes.

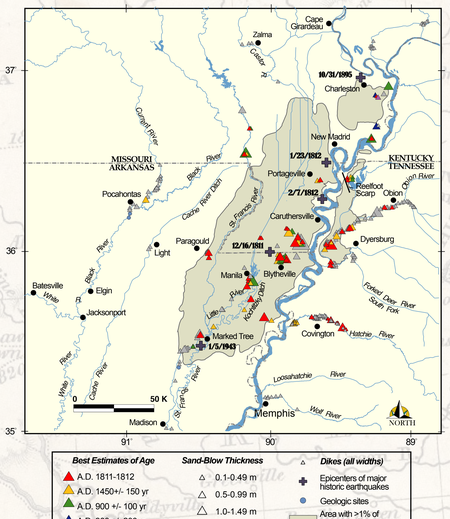
PALEOSEISMOLOGY OF THE NEW MADRID SEISMIC ZONE

Over the past decade, paleoseismic studies have begun to unravel the earthquake history of the New Madrid seismic zone. Studies focusing on earthquake-induced liquefaction features utilized archeology and radiocarbon dating to estimate the ages of liquefaction features, and thus, the timing of the earthquakes that caused them. In this way, sand blows across the New Madrid region were found to have formed during earthquakes about 1450 A.D., 900 A.D., and 2350 B.C.

In addition, the size and spatial distribution of historic and prehistoric sand blows were found to be strikingly similar to each other, suggesting that the prehistoric earthquakes had similar locations and magnitudes to the 1811-1812 earthquakes. Paleoseismic studies concluded that the New Madrid seismic zone generated magnitude 7 to 8 earthquakes about every 500 years during the past 1,200 years.

To learn more about paleoseismology and the New Madrid seismic zone visit http://www.mptuttle.com (M. Tuttle & Associates).

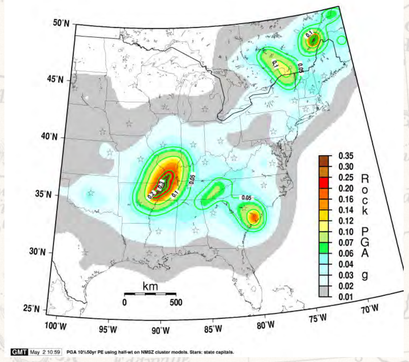
Archeologists remove plow zone above Native American occupation horizon developed on top of prehistoric sand blow. Pieces of pottery and points from the occupation horizon help to estimate age of sand blow.



Map of New Madrid region comparing size and spatial distribution of sand blows that formed during different earthquakes.

SEISMIC HAZARD MAPPING

Paleoseismology provides information about when, where, and how often large earthquakes occur in a region or along a fault system. This information is crucial for characterizing the earthquake hazard of a region. Earthquake hazard includes ground shaking, ground failure, surface faulting, or any effect that causes damage and loss of life. In maps produced by the U.S. Geological Survey, seismic hazard is expressed as probabilistic earthquake ground shaking and takes into account recent findings in paleoseismology, historical seismology, strong motion seismology, and site response. Seismic hazard maps provide the basis for seismic provisions used in building codes, one of the main tools for reducing future losses from earthquakes. In addition, the maps are used in emergency planning and for insurance purposes.



National Probabilistic Seismic Hazard Map shows the NMSZ with the highest seismc hazard in the central and eastern U.S. The hazard is mapped as peak ground acceleration with10% probability of being exceed in 50 years.

To learn more about seismic hazard mapping and the National Probabilistic Seismic Hazard Map visit http://eqhazmaps.usgs.gov/.