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U.S. GEOLOGICAL SURVEY

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Prepared in cooperation with
the Mississippi Department of Environmental Quality
MDEQ

Earthquakes in Mississippi and Vicinity 1811–2010

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This map summarizes nearly 200 years of Mississippi earthquake history. It is one in a series of four similar State earthquake history maps. All four maps were collaborative efforts between the U.S. Geological Survey and respective State agencies. Work on the Mississippi map was done in collaboration with the Mississippi Department of Environmental Quality. The three previous maps, for Virginia (Tarr and Wheeler, 2006), Ohio (Dart and Hansen, 2008), and South Carolina (Dart and others, 2010), are accessible at *http://pubs.usgs.gov/of/2006/1017/, http://pubs.usgs.gov/of/2008/1221/*, and *http://pubs.usgs.gov/of/2010/1059/*.

As with the three previous maps, the history of Mississippi earthquakes was derived from letters, journals, diaries, newspaper accounts, academic journal articles, and beginning in the early 20th century, instrumental recordings (seismograms). All historical (pre-instrumental) earthquakes that were large enough to be felt have been located based on felt reports. Some of these events caused damage to buildings and their contents. The more recent widespread use of seismograph recordings has allowed many smaller earthquakes, previously undetected, to be located. The earthquake location map (center right) shows historically located and instrumentally recorded earthquakes in and near Mississippi.

EARTHQUAKES

Earthquakes occur as a result of slip on faults, typically many kilometers underground, and most earthquakes occur along the boundaries of moving crustal plates. Mississippi is within the North American plate. The nearest plate boundary is approximately 1,700 kilometers south of Mississippi near the coast of Honduras, where the North American and Caribbean plates join, and is not related to the earthquakes in this region. Usually, it is not possible to determine exactly which faults cause earthquakes. Accordingly, the most direct indicators of earthquake hazards are the earthquakes themselves, not the faults on which they occur, or the motions of crustal plates. No known seismogenic faults have been mapped at the ground surface within Mississippi.

Before earthquakes were instrumentally recorded, their locations at the ground surface (epicenters) were estimated, typically within a few tens of kilometers of their actual locations. Even with modern instrumentation, earthquake locations within the Earth (hypocenters) are only approximations, usually within several kilometers of their actual sub-surface locations. However, in areas where seismic networks of closely spaced recording instruments exist earthquakes are more accurately located. Earthquake epicenter locations for Mississippi and vicinity are plotted on the map (center right). The earthquake location symbols used represent the best estimates of location and magnitude for both pre-instrumental and instrumental earthquakes. These data were compiled from several earthquake sources (see list, lower right).

An earthquake's *magnitude* (M) and *intensity* are measurements of its size and the severity of ground shaking, respectively. Although earthquake magnitude is characterized by a single number, intensity is expressed as a range of values based on varying levels of ground shaking over the affected (felt) area. Typically, ground shaking will decrease from a maximum near the earthquake's epicenter to its lowest levels near the edge of the felt area. Intensity values are determined from the Modified Mercalli Intensity Scale (lower right) based on written accounts (letters, journals, and diaries) and published records (newspapers and official reports) of the ground shaking effects on people, buildings, and the landscape. The Modified Mercalli Intensity (MMI) scale consists of a range of values from I, barely felt or not felt, to XII, total destruction.

Isoseismal maps show the distribution of intensity values and the general pattern of decreasing intensity away from an earthquake's epicenter. Isoseismal maps also illustrate how different ground conditions can affect ground shaking resulting in intensity patterns that may be more irregular than expected. The isoseismal map (far right) illustrates the extent and intensity of ground shaking for the December 16, 1811 northeast Arkansas intensity XI earthquake.

An earthquake's size reflects the total energy released and is measured in logarithmic units of magnitude. This means that the amount of energy released during an earthquake will be 30 times greater for a magnitude 5 earthquake than for a magnitude 4 earthquake (Bolt, 1978). There are several methods of calculating magnitude; all are based on seismic wave variables as recorded on earthquake seismograms. The different measuring methods can give slightly different magnitude values for the same earthquake. As a result, differences of several tenths of a magnitude may be reported. A more complete discussion of magnitude and the U.S. Geological Survey policy on reporting magnitude can be found at *http://earthquake.usgs.gov/aboutus/docs/020204mag_policy.php*. For pre-instrumental earthquakes, magnitudes are estimated from intensity values that were recorded at the time of the earthquake or shortly after.

EASTERN U.S. EARTHQUAKES

Earthquakes are less common east of the Rocky Mountains than in Pacific coast states, such as California. However, because of differences in geologic properties, an earthquake in the central United States (U.S.) of the same magnitude as a West Coast earthquake can affect a much larger area, by about ten times. A magnitude 4 central U.S. earthquake typically can be felt 100 km (60 mi) from where it occurred, and can cause damage near its source. A magnitude 5.5 central U.S. earthquake usually can be felt 500 km (300 mi) from where it occurred, and sometimes causes damage as far away as 40 km (25 mi).

EARTHQUAKES IN MISSISSIPPI AND VICINITY

In terms of its tectonic setting, Mississippi is part of a much larger province known as the Stable Continental Region (Wheeler, 2003) which includes all of eastern North America. Exclusive of several selected areas, like the New Madrid Seismic Zone, the Stable Continental Region undergoes infrequent earthquakes. When earthquakes do occur, they can happen almost anywhere and at irregular intervals. As stated previously, earthquakes are generated as the result of movement on faults in bedrock often thousands of feet below the ground surface. Although there are many known faults within the Stable Continental Region of North America, few of the earthquakes that occur here are associated with known faults.

During the last 200 years Mississippi has not undergone large magnitude earthquakes, and current seismological data suggests that Mississippi is not an area where large earthquakes are likely to occur. The earthquake location map (center right) shows only sparse, low-magnitude seismicity within the State. Strong ground shaking is possible, however, and would likely result from a large earthquake located in the New Madrid Seismic Zone. Regardless, damage from smaller magnitude earthquakes has occurred in the recent past. Stover and Coffman (1993) report that the 1931 magnitude 4.7 earthquake in north-central Mississippi caused damage to buildings in and near the town of Charleston in Tallahatchie County. Minor damage in the town of Greenville in Washington County resulted from the 1967 magnitude 4.3 earthquake in the western part of the State.

AREAS OF KNOWN OR SUSPECTED DEFORMATION AND FAULTING

The U.S. Geological Survey (USGS) Quaternary Faults Database (*http://earthquake.usgs.gov/hazards/qfaults*) documents several areas of known and inferred recent deformation and faulting in the vicinity of Mississippi. The word *recent* refers to events that are of Quaternary age (younger than 2.588 million years). These areas of deformation and faulting may have an influence on future seismic events in Mississippi. These areas are shown on the earthquake location map (center right) and described below.

Gulf-Margin Normal Fault Area
This is an area of mostly seaward facing normal faults bordering the northern Gulf of Mexico from western Florida to eastern and southern Texas (Ewing and Lopez, 1991). The Gulf Margin Area formed as a result of rapid deposition of a thick sequence of marine sediments over time onto the southern margin of North America (DuBar and others, 1991; Salvador, 1991a; Salvador, 1991b). Normal faulting was initiated when the massive sediment load began to collapse and spread seaward. This pattern of sediment accumulation is ongoing. As a result, the thick, normal faulted stratigraphic sequence of the Gulf margin may be mechanically decoupled from the underlying crust (Zoback and Zoback, 1991). The presence of the normal faults throughout the sediment sequence (Ewing and Lopez, 1991) demonstrates that the sequence is sliding and extending seaward. The stress field and seismogenic potential of the underlying crust are unknown; therefore, the ability of the area to generate significant seismic ruptures that could cause damaging ground motion is unclear. This discussion of the Gulf-Margin Normal Fault Area was derived, in part, from a compilation by Wheeler and Heinrich, 1998.

Monroe Uplift Area
This is an area of possible Quaternary uplift in northeastern Louisiana as evidenced by the geomorphology of rivers and streams that cross the area and by repeat geodetic surveys (Burnett and Schumm, 1983). Subsurface data show the Monroe uplift to be a buried structural dome (Johnson, 1958) associated with Late Cretaceous igneous activity that blends into the surrounding regional structure. Other than two areas of earthquake-induced sand blows of late Holocene age (Cox, 2008), the uplift lacks conspicuous geomorphic expression and is located in an area of minimal historical seismic activity. This discussion of the Monroe Uplift Area was derived, in part, from a compilation by Crone, 1998a.

New Madrid Seismic Zone and Liquefaction Area
This is the most seismically active area in central and eastern North America. In the winter of 1811–1812, at least three major earthquakes occurred in the New Madrid seismic zone. They were among the largest historical earthquakes to occur in North America. These earthquakes produced widespread liquefaction (sand blows and sand-filled fissures) throughout the seismic zone and surface deformation at several locations. Evidence of Quaternary faulting in the New Madrid region is based on the occurrence of the major 1811–1812 earthquakes, the abundant ongoing seismic activity, and surface deformation associated with the Reelfoot scarp. Other than the fault associated with the Reelfoot scarp, individual seismogenic faults in the New Madrid seismic zone are not expressed at the ground surface. Their general subsurface locations are inferred to be associated with areas of abundant recorded microseismicity.

The modern seismicity in the New Madrid seismic zone is associated with the Reelfoot rift (Ervin and McGinnis, 1975), a northeasterly-trending, 70-km-wide, deeply buried graben (Hildenbrand and others, 1982; Hildenbrand, 1985). The seismicity and current deformation in the region is controlled by a regional stress field in which the maximum compressive stress is oriented approximately northeast-southwest. Within this stress field, ancient faults, most of which originally formed as extensional features during rifting, have been reactivated mainly as strike-slip faults. The modern seismicity is concentrated into three major trends that form a northeasterly-trending, zigzag pattern.

The most widespread expression of recent strong earthquakes in the New Madrid region is the abundance of liquefaction features, concentrated in a 40- to 60-km-wide belt from near Charleston, Missouri on the northeast to south of Marked Tree, Arkansas (Obermeier, 1988). Most of these features formed during the major earthquakes of 1811–1812. This discussion of the New Madrid Seismic Zone and Liquefaction Area was derived, in part, from a compilation by Crone and Schweig, 1994.

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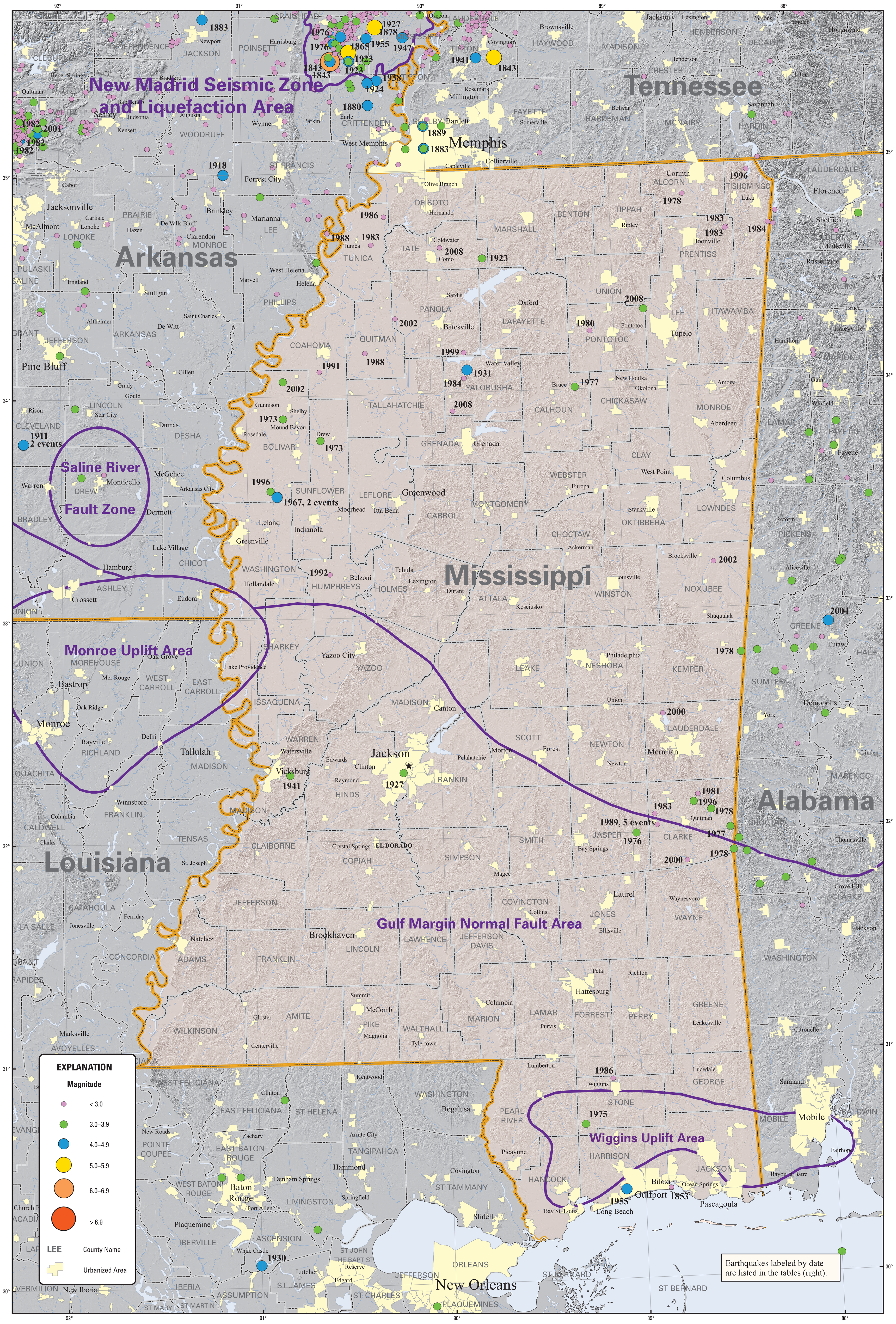
Earthquake Locations



Base from U.S. Geological Survey National Elevation Dataset (*http://nationalmap.gov/viewers.html*).
National Hydrologic Database, and Digital Chart of the World (ESRI, 1993)
Albers equal-area conic projection, standard parallels 30°30′00″ and 35°00′00″, central meridian 81°00′00″, latitude of origin 00°00′00″

SCALE 1:1 100 000
Albers Conic Equal-Area Projection

Saline River Fault Zone Area
Quaternary deformation in this area is inferred and is thought to be associated with a trend of earthquake epicenters that follows the Saline River in central and southeastern Arkansas along the northeastern margin of the Monroe uplift (Cox and VanArsdale, 1997). Cox and VanArsdale describe several small-displacement faults of various orientations exposed in road cuts and in an exploratory trench dug in the area. From shallow seismic reflection- data collected, Cox and Van Arsdale have interpreted buried faults. The relationship of the exposed features to the deeper structures and to the regional seismicity is not well determined. Because there is no significant geomorphic expression of any known or suspected faults, active deformation is questionable. This discussion of the Saline River Fault Zone Area was derived from a compilation by Crone, 1998b.

Wiggins Uplift Area
The Wiggins uplift, a feature centered in southern Mississippi, is defined on the basis of subsurface data and is associated with an absence of a portion of the overlying stratigraphic section (Cagle and Kahn, 1983; Ewing, 1991). Possible contemporary tectonic uplift in the area has been inferred from fluvial geomorphic evidence (Burnett and Schumm, 1983; Schumm, 1986). The suspected uplift, however, is not related to known faults and there is no conspicuous expression at the ground surface. This discussion of the Wiggins Uplift Area was derived from a compilation by Crone, 1998c.

EARTHQUAKE CATALOGS

Various institutions and agencies compile earthquake data. The earthquake data plotted on the map (above) are from several sources. Below are these sources and the time periods of their data listings.

- MDEQ (Mississippi Department of Environmental Quality), 1853–2002
- AGS (Arkansas Geological Survey, Ausbrooks, personal commun., 2010), 1699–2010
- NMSN/CERI (New Madrid Seismic Network/Center for Earthquake Research and Information), 1974–2010
- NCEER (National Center for Earthquake Engineering Research), 1627–1985
- PDE (Preliminary Determination of Epicenters), 1973–2010

The earthquake location symbols shown on the map are sized and colored according to magnitude (see map explanation, above). The map is intended as a general information tool only, and not for hazard assessment or engineering design purposes.

SEISMIC HAZARD

Seismic hazard maps, like the one shown at right, are tools for determining acceptable risk. As such, they are critical in helping to save lives and preserve property by providing information essential to the creation and updating of the seismic design provisions of local building codes. Additional applications of the information derived from seismic hazard maps include setting insurance rates, determining related ground-failure hazards, engaging in disaster response planning, and promoting earthquake education.

Some level of seismic hazard from earthquake ground shaking exists in every part of the United States. The severity of the ground shaking, however, can vary greatly from place to place. Regional seismic hazard maps illustrate this variation. The hazard shown on seismic hazard maps is based on a variety of factors, such as earthquake rate of occurrence, magnitude, extent of affected area, strength and pattern of ground shaking, and geologic setting.

Because many buildings and other structures in the central United States are not built to withstand severe ground shaking, damage could be catastrophic in the event of a powerful earthquake. The generalized seismic hazard map (right) illustrates this hazard. It is a computer generated contour map (Petersen and others, 2008) portraying seismic hazard calculated by the USGS as bands of color (cooler for lesser hazard, warmer for greater hazard). Shaking level is expressed as percentage of the acceleration of gravity (%*g*), and seismic hazard values are computed for particular time intervals (here, 50 years) and probability of exceedance (here, 2 percent). For example, the hazard value in Monroe, La., is between 6–8%*g*. That means structures built on firm rock have a 1 in 50 chance (2-percent probability) of undergoing ground shaking of 6%–8%*g* or higher in the next 50 years. In terms of shaking, the acceleration a person or object experiences is proportional to the force applied to it by the passing seismic wave. The value 50 is a random amount and has no inherent significance.

Seismic hazard maps are estimates of how the ground in a particular area is likely to respond to local and regional earthquakes. They differ from isoseismal maps in that they are probability maps, illustrating likely shaking levels. Sediment and soil properties near the ground surface are important in hazard map design. During an earthquake seismic energy radiates in all directions as waves. As the seismic waves move upward they are amplified or de-amplified as they travel through sediment and soil layers, thus, greatly affecting the level of ground shaking that might occur.

For additional information on seismic hazard mapping, consult these internet web links:
http://earthquake.usgs.gov/regional/ceus//urban_map/index.php
http://earthquake.usgs.gov/hazards/
http://earthquake.usgs.gov/hazards/products/

MISSISSIPPI EARTHQUAKES
Labeled on map, left)

Yr (UTC)	Mo	Day	Lat(°N.)	Long(°W.)	Mag/Int	Source
1853	09	11	30.40	-88.87	III?	MDEQ (Bograd)
1923	03	27	34.60	-89.70	3.7	NCEER
1927	11	13	32.30	-90.20	3.4	NCEER
1931	12	17	34.10	-89.80	4.7	NCEER
1941	06	28	32.30	-90.80	3.0	NCEER
1955	02	01	30.40	-89.10	4.1	NCEER
1967	06	04	33.55	-90.84	4.3	NCEER
1967	06	29	33.55	-90.84	3.4	MDEQ (Bograd)
1973	01	08	33.80	-90.60	3.5	NCEER
1973	05	25	33.90	-90.80	3.4	NCEER
1975	09	09	30.70	-89.30	3.0	NCEER
1976	10	23	32.00	-88.98	3.1	NCEER
1977	05	03	32.01	-88.48	3.6	MDEQ (Bograd)
1977	11	04	34.01	-89.22	3.4	CERI (TEIC)
1978	01	08	32.80	-88.39	3.0	MDEQ (Bograd)
1978	05	19	34.86	-88.60	2.4	CERI (TEIC)
1978	06	09	32.09	-88.58	3.3	PDE
1978	12	11	31.91	-88.47	3.5	NCEER
1980	10	12	34.26	-89.13	2.6	CERI (TEIC)
1981	02	15	32.16	-88.65	2.4	MDEQ (Bograd)
1983	01	29	34.70	-88.38	2.4	CERI (TEIC)
1983	02	05	34.70	-88.39	2.9	CERI (TEIC)
1983	04	25	34.67	-90.30	1.6	CERI (TEIC)
1983	05	30	32.08	-88.88	2.4	CERI (TEIC)
1984	03	23	34.72	-88.14	2.0	MDEQ (Bograd)
1984	09	25	34.06	-89.82	2.5	CERI (TEIC)
1986	05	11	34.80	-90.23	1.6	CERI (TEIC)
1988	08	01	34.19	-90.35	2.1	CERI (TEIC)
1988	09	24	34.73	-90.54	1.5	CERI (TEIC)
1989	08	23	32.03	-88.87	III?	MDEQ (Bograd)
5 events felt						
1991	02	11	34.11	-90.60	2.7	CERI (TEIC)
1992	12	11	33.20	-90.57	2.4	MDEQ (Bograd)
1996	03	25	32.13	-88.67	3.5	PDE
1996	05	13	34.96	-88.25	2.7	MDEQ (Bograd)
1996	08	11	33.58	-90.87	3.5	PDE
1999	02	25	34.10	-89.87	2.9	CERI
2000	01	28	31.87	-88.72	2.7	MDEQ (Bograd)
2000	10	10	32.53	-88.82	2.3	MDEQ (Bograd)
2002	01	06	33.21	-88.52	2.2	MDEQ (Bograd)
2002	08	11	34.34	-90.17	2.8	CERI
2002	10	26	34.07	-90.80	3.1	CERI
2008	01	20	33.92	-89.88	1.7	CERI
2008	05	10	34.35	-88.83	3.1	CERI
2008	06	02	34.65	-89.93	2.2	MDEQ (Bograd)

REGIONAL EARTHQUAKES, MAGNITUDE 4.0 OR GREATER
Labeled on map, left)

Yr (UTC)	Mo	Day	Lat(°N.)	Long(°W.)	Mag	Source
1843	01	04	35.50	-89.50	6.2	AGS (Stover)
1843	02	17	35.50	-90.50	4.2	AGS (Stover)
1865	08	17	35.54	-90.40	5.3	AGS (Bakun)
1880	07	14	35.30	-90.30	4.1	CERI
1878	11	19	35.65	-90.25	5.0	AGS (BAKUN)
1883	06	11	35.10	-90.00	4.0	NCEER
1883	12	05	35.70	-91.20	4.0	NCEER
1889	07	20	35.20	-90.00	4.0	NCEER
1911	03	31	33.80	-92.20	4.7	CERI
1911	03	31	33.80	-92.20	4.0	CERI
1918	10	04	35.00	-91.10	4.0	NCEER
1923	11	26	35.5	-90.40	4.1	AGS (Stover)
1923	11	28	35.54	-90.40	5.3	AGS (Stover)
1924	01	01	35.40	-90.30	4.6	AGS (NUTTLI)
1927	05	07	35.65	-90.25	5.3	CERI
1930	10	19	30.10	-91.00	4.2	NCEER
1938	09	18	35.41	-90.25	4.3	NCEER
1941	11	30	35.50	-89.70	3.5	NCEER
1947	12	16	35.60	-90.10	4.2	AGS (Stover)
1955	01	25	35.60	-90.30	4.7	AGS (Jackson)
1976	03	25	35.59	-90.48	5.0	AGS (TECI)
1976	03	25	35.61	-90.48	4.3	NCEER
1982	01	21	35.18	-92.22	4.5	CERI
1982	01	24	35.20	-92.22	4.1	CERI
1982	03	01	35.20	-92.11	4.1	CERI
2001	05	04	35.20	-92.22	4.3	CERI
2004	11	07	32.92	-87.92	4.3	CERI

ISOSEISMAL MAPS

Isoseismal maps show the estimated level of ground shaking (intensity) experienced during an earthquake. Contemporary newspaper accounts from cities and towns in the affected region are the primary source of this information. Intensity values are derived from these observations. Each intensity observation is assigned a Modified Mercalli Intensity (MMI) value from one to twelve using Roman numerals (table lower right). The isoseismal map (right) shows interpolated and contoured intensity data for the December 16, 1811, intensity XI northeast Arkansas earthquake. The locations of intensity observations and their assigned values are shown as solid colored circles. The December 16, 1811 earthquake, at 2:15 am local time (08:15 UTC), was the first event in the New Madrid sequence. Intensity data for this event came from Hough and others (2000), Hough and Martin (2002), Bakun and others (2002), Street (1982), and Nuttli (1973). The data were interpolated using an inverse distance weighted algorithm. The extent of interpolation was defined by the locations of the intensity observations used.

CONVERSION FACTORS

Multiply	By	To obtain
meters (m)	3.281	feet (ft)
kilometers (km)	0.6214	miles (mi)

Author's Note:

The information presented was derived from existing sources and earlier publications. Specifically, the general earthquake and seismic hazard discussions were modified from Tarr and Wheeler, 2006.

INTERNET EARTHQUAKE INFORMATION RESOURCES

Advanced National Seismic System (ANSS): *http://www.ncedc.org/anss/catalog-search.html*. Last accessed on April 27, 2010. Information on U.S. earthquakes.

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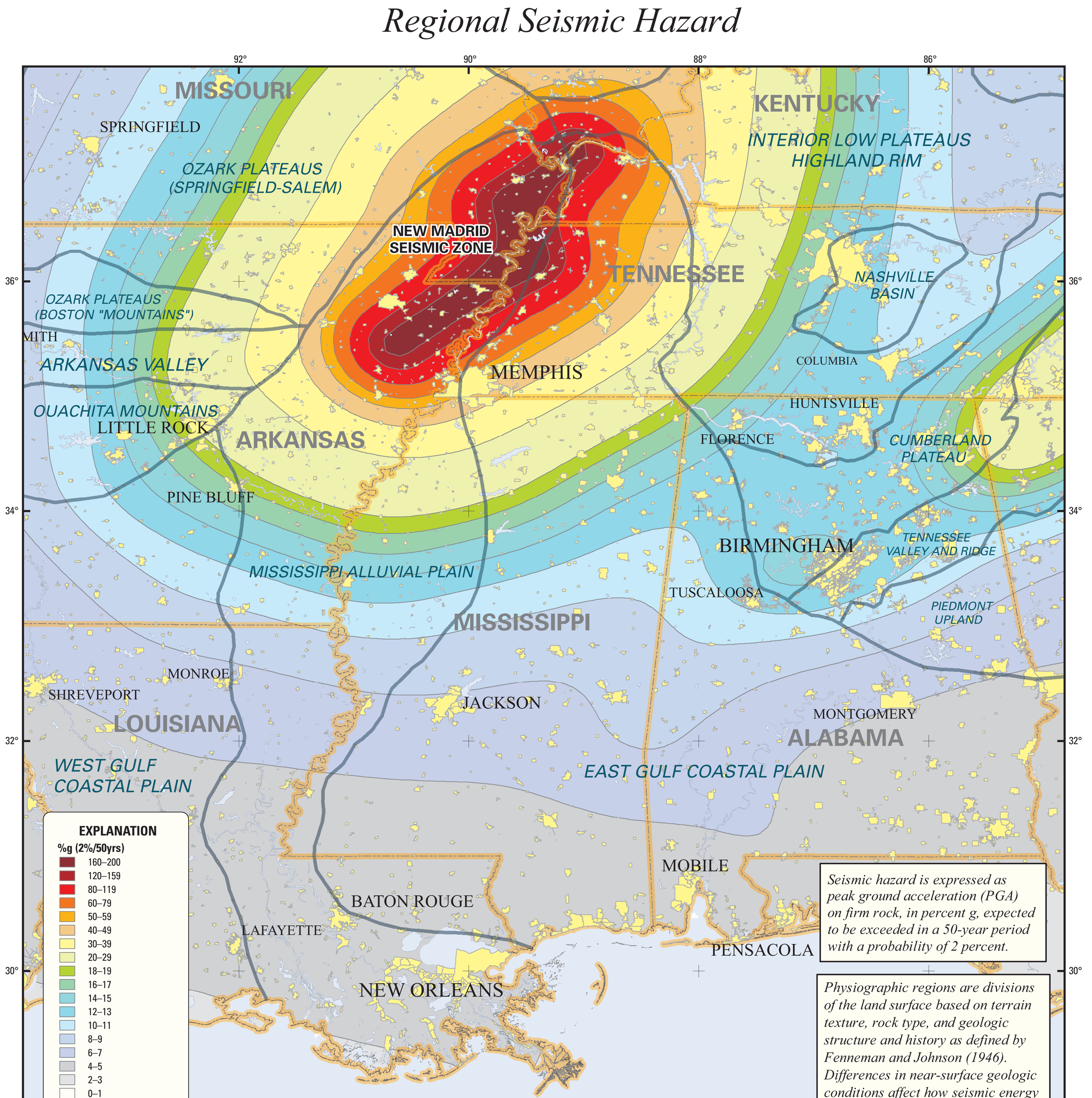
Regional Seismic Hazard



Data from Petersen and others, 2008

Base from National Hydrologic Database and Digital Chart of the World (ESRI, 1993)

SCALE 1:4 000 000
Geographic Projection NAD83

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Dart, R.L., Talwani, Pradeep, and Stevenson, Donald, 2009, Earthquakes in South Carolina and Vicinity 1898–2008: U.S. Geological Survey Open-File Report 2008–1059. [Available at *http://pubs.usgs.gov/of/2010/1059/*].

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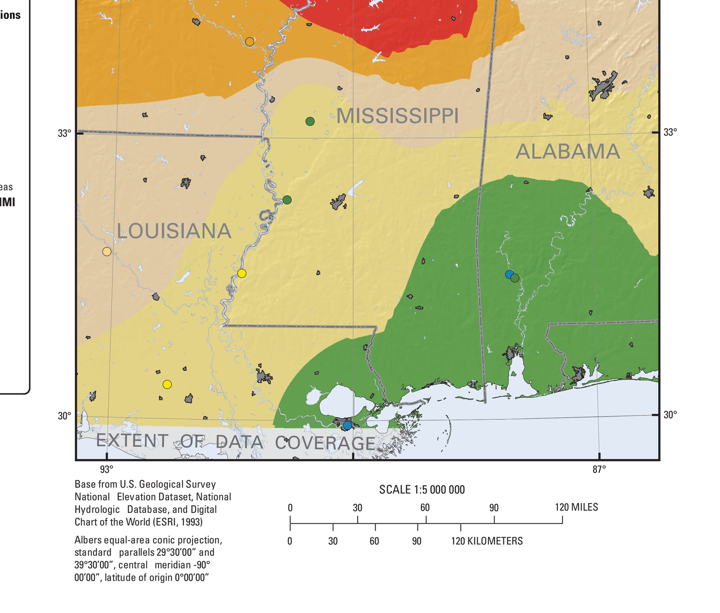
Distribution of intensity for the December 16, 1811, northeast Arkansas, maximum intensity XI, magnitude 8.1 earthquake



Base from U.S. Geological Survey National Elevation Dataset, National Hydrologic Database, and Digital Chart of the World (ESRI, 1993)
Albers equal-area conic projection, standard parallels 29°30′00″ and 39°30′00″, central meridian -90° 00′00″, latitude of origin 0°00′00″

SCALE 1:5 000 000

SCALE OF MODIFIED MERCALLI INTENSITY (MMI) VALUES

Expressed as Roman numerals, earthquake intensities are not instrumentally derived values; they are assigned values based on descriptive reports of felt shaking and damage.

I. Not felt except by a very few under especially favorable conditions.
II. Felt only by a few persons at rest, especially on upper floors of buildings.
III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings with partial collapse. Buildings shifted off foundations.
X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

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