U.S. DEPARTMENT OF THE INTERIOR
U.S. GELOLGICAL SURVEY

Prepared in cooperation with the University of South Carolina and the Department of Geological Sciences

Earthquakes in South Carolina and Vicinity 1698–2009

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2010

This map summarizes more than 300 years of South Carolina earthquake history. It is one in a series of three similar State earthquake history maps (Tarr and Wheeler, 2006; Dart and Hansen, 2008). The current map and the previous two for Virginia and Ohio are accessible at http://pubs.usgs.gov/of/2006/1017/ and http://pubs.usgs.gov/of/2008/1221/. All three State earthquake maps were collaborative efforts between the U.S. Geological Survey and respective State agencies. Work on the South Carolina map was done in collaboration with the Department of Geological Sciences, University of South Carolina.

As with the two previous maps, the history of South Carolina earthquakes was derived from letters, journals, diaries, newspaper accounts, academic journal articles, and, beginning in the early 20th century, instrumental recordings (seismograms). All historical (preinstrumental) 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 seismographs has allowed many smaller earthquakes, previously undetected, to be recorded and accurately located. The seismicity map (center right) shows historically located and instrumentally recorded earthquakes in and near South Carolina.

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. South Carolina is within the North American plate. The nearest plate boundary is approximately 2,000 kilometers southeast of South Carolina near Puerto Rico, where the North American and Caribbean plates join. 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. Although South Carolina has experienced large earthquakes in the past, no known seismogenic faults have been mapped at the ground surface within the State.

Before earthquakes were instrumentally recorded, locations were estimated, typically within a few tens of kilometers of the actual ground-surface location (epicenter). Even with modern instrumentation, however, earthquake locations within the Earth are only approximations, usually within several kilometers of their actual subsurface locations (hypocenter). However, in areas where seismic networks of closely spaced recording instruments exist, earthquakes can be more accurately located. Despite location uncertainties, it is certain that earthquakes have occurred in most parts of South Carolina during the last 300 years. Plotted on the large State map (center right) are earthquake epicenter locations.

An earthquake's *magnitude* (M) and *intensity* are measures of its size and the severity of ground shaking experienced, respectively. Although earthquake size 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 (far lower right) based on written accounts (letters, journals, and diaries) and published records (newspapers and official reports) of the effects of ground shaking 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. Two isoseismal maps for South Carolina earthquakes are shown (far lower right).

An earthquake's magnitude reflects the total energy released as seismic waves. There are several methods to measure earthquake magnitude. The first and most frequently cited is the "Richter scale." 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. From intensity values recorded at the time of the earthquake or shortly after, the magnitudes of preinstrumental earthquakes can be estimated. The earthquake location symbols on the large State map (center right) represent the best estimates of location and magnitude for both preinstrumental and instrumental earthquakes. These data were compiled from several earthquake catalogs.

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 crustal properties, an Eastern U. S. earthquake of the same magnitude as a West Coast earthquake can affect a much larger area. A magnitude 4 Eastern U.S. earthquake typically can be felt 100 km (60 mi) from where it occurred where it may cause minor damage. A magnitude 5.5 Eastern 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 SOUTH CAROLINA AND VICINITY

The largest historic earthquake in South Carolina occurred on August 31, 1886, at 9:51 p.m., local time. Referred to as the Charleston earthquake, this seismic event had an estimated maximum intensity (MMI) of X, with the first shock lasting 35 to 40 seconds. This initial shock was followed by a strong aftershock 8 minutes later and 6 more shocks over the next 24 hours. Most buildings in the city were damaged; many were totally destroyed killing an estimated 60 people. The Charleston earthquake was felt over a 30-State region, as well as in Cuba, Bermuda, and southeastern Canada. The affected area covered more than 5 million km^2 with damage being reported in Columbia, S.C., and in Augusta and Savannah, Ga. Additional strong aftershocks occurred on October 22 and November 5, 1886. The first of these aftershocks had an intensity VI at Charleston; the second had an intensity of VII at Summerville, S.C. (von Hake, 1976). The Charleston earthquake of 1886 is considered to be an intraplate earthquake. Other significant intraplate earthquakes have occurred in the Eastern and Central United States; among these are the Cape Ann, Mass., earthquake of 1755 and the New Madrid earthquakes of 1811 and 1812 (Stover and Coffman, 1993).

Subsequent to the Charleston earthquake of 1886, South Carolina has experienced other notable earthquakes. An intensity VI earthquake, centered on the South Carolina-Georgia border near Savannah, Ga., was felt on January 23, 1903. A moderate-size earthquake was felt in Charleston, Augusta, and Savannah on April 19, 1907, and an intensity VII event near Summerville occurred on June 12, 1912. An earthquake on January 1, 1913, in Union County, S.C., had an intensity of VI–VII, and an intensity V event in the Summerville area was felt on September 22, 1914. A strong earthquake of intensity V in Pickens County, S.C., affected a large area including parts of North Carolina, Georgia, and Tennessee. An intensity IV–V earthquake near Lake Murray, west of Columbia, occurred on July 26, 1945. Minor damage was reported in the Charleston area from an intensity VI earthquake on November 19, 1952. Other moderately strong events in the Charleston area of intensity V or less occurred on August 3, 1959, March 12, 1960, July 23, 1960, and October 23, 1967. The March 12, 1960, earthquake was located off the South Carolina coast (von Hake, 1976).

Other notable South Carolina earthquakes occurred on October 20, 1958 (intensity V), at Anderson, S.C.; October 26, 1959, at Chesterfield, S.C.; April 20, 1964 (intensity V) at Gaston and Jenkinsville, S.C.; May 19, 1971 (magnitude 3.4), near Bowman and Orangeburg, S.C.; and July 13, 1971 (intensity VI), in the western part of the State. The October 1959 and May 1971 events caused minor damage in the epicentral areas of these earthquakes (von Hake, 1976).

Because accurate epicentral coordinates cannot be determined for historical (preinstrumental) earthquakes, all preinstrumental earthquakes described as occurring in the Charleston-Summerville area of South Carolina are assigned an epicentral location of lat 32°N., long –80°W., a point between Charleston and Summerville.

South Carolina Seismic Network

In collaboration with the U.S. Coast and Geodetic Survey, the seismic first station, CSC, began operating on January 1, 1931, at the University of South Carolina (USC), Columbia. Because of increasing urban noise, this three-component log-period station was closed in September 1973. With funding from the U.S. Nuclear Regulatory Commission (NRC), the U.S. Geological Survey (USGS) initiated network monitoring in early 1973 with a reconnaissance field survey of the 1886 Charleston earthquake meizoseismal region. Following this survey, the first 10 South Carolina Seismic Network (SCSN) stations were established in May 1974. In addition, complementary mini-networks were established to study reservoir induced seismicity (RIS) in the vicinity of Lake Jocassee and Lake Keowee in 1975 and the Monticello Reservoir in 1977, and seismic safety issues at the Department of Energy's (DOE) Savannah River Site (SRS) in 1976. The Lake Keowee and Monticello Reservoir mini-networks were eventually incorporated into the SCSN. These two lake mini-networks operated until January 2003 and December 2006, respectively. The SRS mini-network continues to operate.

USGS operation of the SCSN provided detailed seismic data allowing for the first comprehensive earthquake studies of the State, with particular interest in the Charleston area regional tectonic setting. In conjunction with the USGS operation of the SCSN, USC operated the RIS mini-networks. Analysis of these data led to the identification and description of various seismic sources within the State. SCSN's initial recording hub at USC was supplemented in 1977 by a secondary hub at Charleston Southern University (CSU) in Summerville. The SCSN began digitally recording incoming analog field data in 1987. The number of SCSN stations and their configuration varied over time with a maximum of 32. Due to a lack of NRC funding support in 1991, SCSN network operations were assumed by USC. The USGS provided operational support.

In October 1998, the USGS initiated a new phase of cooperative seismic monitoring. Recording operations of both the Charleston Southern University and USC facilities were augmented with the installation of "Earthworm" (a PC-based, event-triggered and short-term continuous data recording system that utilized the Internet for data sharing). This new phase, part of the Advanced National Seismic System (ANSS) for the Central and Southeast U.S. region, allowed data from the SCSN to be shared with networks at the Center for Earthquake Research and Information (CERI) in Memphis, Tenn., and the USGS in Golden, Colo. It also gave USC the ability to import data from stations throughout the Southeast, thereby enhancing SCSN's event detection and location capabilities. Identification of quarry-blasting activity, documentation of regional and teleseismic events, and locating and analyzing local earthquakes was part of the routine data processing. Improvements in this cooperative effort initiated in June 2004 the Quick Data Distribution System (QDDS), a USGS program for distributing earthquake data over the Internet. The SCSN monitored seismicity in coordination with the Cooperative Central and Southeast U.S. Integrated Seismic Network until September 30, 2004.

SCSN's CSU hub was abandoned in 2005, and efforts began to move it to the Dorchester County Emergency Management (DCEM) facility, located near CSU. This included installation of new antennas and telephone and radiometry links. In 2007 the USGS terminated support for analog field stations and began the digital recording reconfiguration of the SCSN.

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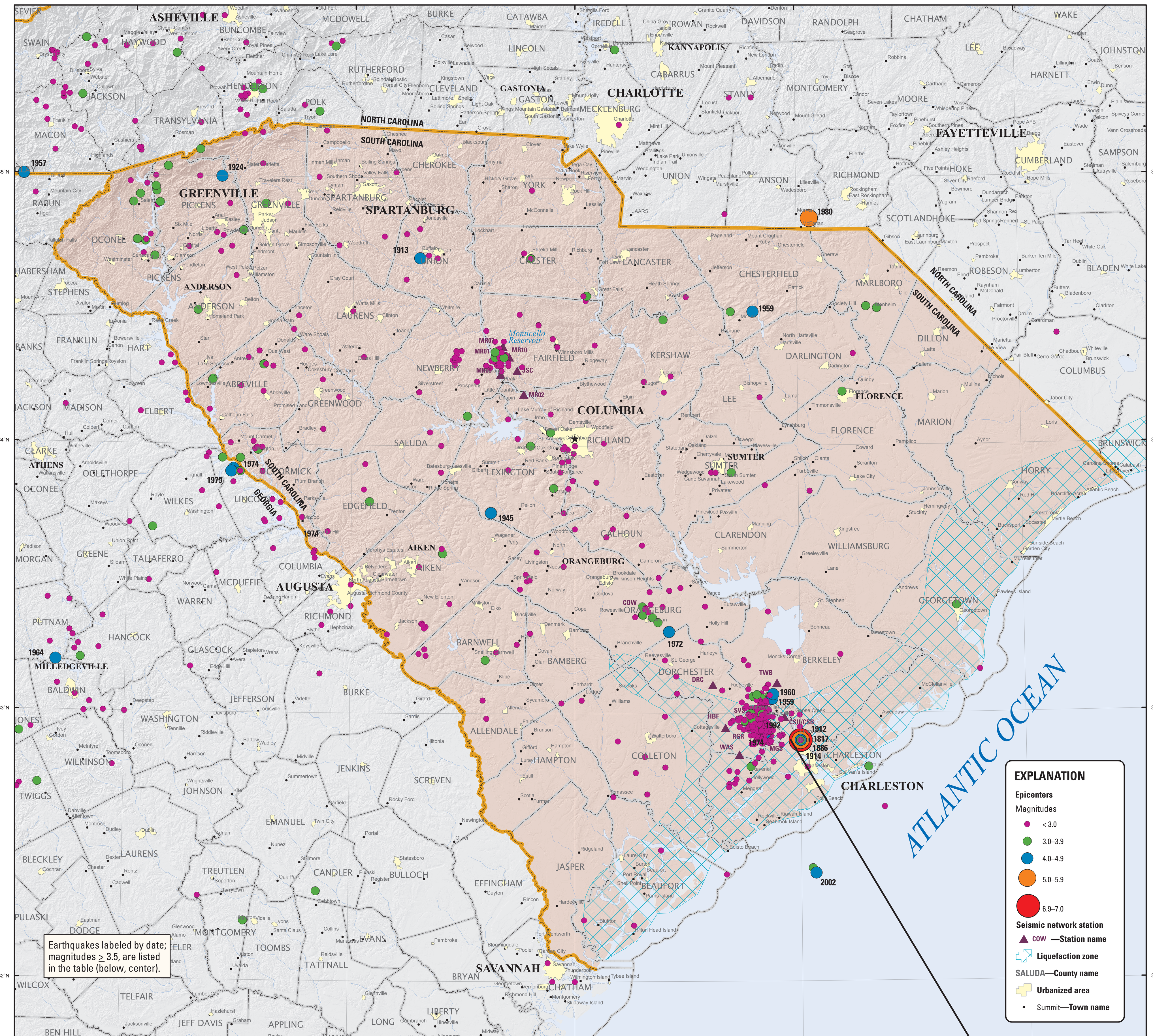


Base from U.S. Geological Survey National Elevation Dataset, National Hydrologic Database, and Digital Chart of the World (ESRI, 1993)

Albers equal-area conic projection, standard parallels 30°30′00″ and 35°30′00″, central merdian -81°00′00″, latitude of origin 0°00′00″

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

KILOMETERS 0 12.5 25 50 75 100 125
MILES 0 12.5 25 50 75 100 125

INTERNET EARTHQUAKE INFORMATION RESOURCES

Advanced National Seismic System (ANSS): http://www.ncedc.org/anss/catalog-search.html. Last accessed on September 1, 2009. Information on U.S. earthquakes.

Center for Earthquake Research and Information (CERI): http://www.ceri.memphis.edu/. Last accessed on September 1, 2009. Information on Central U.S. earthquakes.

Earthquake Engineering Research Institute (EERI): http://www.eeri.org/site/. Last accessed on September 1, 2009. Technical information on earthquakes.

National Center for Earthquake Engineering Research (NCEER): http://folkworm.ceri.memphis.edu/catalogs/html/cat_nceer.html. Last accessed on September 1, 2009. Information on Central U.S. earthquakes.

National Earthquake Hazards Reduction Program (NEHRP): http://www.nehrp.gov/. Last accessed on September 1, 2009. Information on hazards risk reduction in the United States.

National Geophysical Data Center (NGDC/DNAG/NOAA): http://www.ngdc.noaa.gov/hazard/earthqk.shtml. Last accessed on September 1, 2009. Information on geophysical data products and services.

National Hazards Center, a resource for information concerning science and policy aspects of disasters: http://www.colorado.edu/hazards/. Last accessed on September 1, 2009. Information on natural hazards.

University of South Carolina, South Carolina Seismic Network: http://scsn.seis.sc.edu/html/catalogue.html. Last accessed on September 1, 2009. This page is no longer maintained.

U.S. Geological Survey National Earthquake Information Center (NEIC), Preliminary Determination of Epicenters (PDE), Significant U.S. Earthquakes (SIGUS; Stover and Coffman, 1993), *Significant Earthquakes in the U.S. catalog*, and Eastern U.S. (EUS): http://neic.usgs.gov/neis/epic/epic_rect.html; and Earthquake Hazard Program: http://earthquake.usgs.gov/, call toll-free 1- 888- ASK- USGS. Last accessed on September 1, 2009. Information on global earthquakes.

U.S. Geological Survey Nations Seismic Hazard Maps Project (NSHM): http://earthquake.usgs.gov/research/hazmaps/products_data/48_States/index.php. Last accessed on September 1, 2009. Information on U.S. probabilistics maps and data.

Virginia Tech Seismological Observatory, Southeastern U.S. Earthquake Catalog (SEUS): http://www.geol.vt.edu/outreach/vtso/. Last accessed on September 1, 2009.

EARTHQUAKE CATALOGS

Various institutions and agencies compile catalogs of earthquake data. Each uses different criteria in determining the catalog's content. The earthquake locations shown on the map above were taken from several catalogs. To some extent, these catalogs cover overlapping time periods. An attempt has been made to locate and remove duplicate events. In the case of event duplication, the order of catalog preference, as listed, was generally applied:

SIGUS, S*ignificant Earthquakes in the U.S.* (Stover and Coffman, 1993), 1568–1989
EUS, Eastern U.S., 1698–1986
SEUS, Virginia Tech Seismological Observatory Southeastern U.S. Earthquake Catalog, 1735–2006
NCEER, National Center for Earthquake Engineering Research, 1627–1985
SCSN, South Carolina Seismic Network, 1987–2008
PDE, Preliminary Determination of Epicenters, 1973–2009
ANSS, Advanced National Seismic System, 1964–2009

All the catalogs used may contain mining-related and other types of non-earthquake events. Mining events are typically of small magnitude and may not be easily differentiated from small earthquakes (Street and others, 2002). An attempt was made to exclude non-earthquake events.

NOTABLE SOUTH CAROLINA AND VICINITY EARTHQUAKES
MAGNITUDE > 4.0

Yr	Mo	Day	Lat (°N.)	Long (°W.)	Mag	Catalog
1817	01	08	32.9	-80.0	4.8CM	SCSN
1886	09	01	32.9	-80.0	7.0IM	SCSN
1886	10	22	32.9	-80.0	5.1CM	SCSN
1886	10	22	32.9	-80.0	5.7CM	SCSN
1886	11	05	32.9	-80.0	5.3CM	SCSN
1912	06	12	32.9	-80.0	4.8CM	SCSN
1913	01	01	34.7	-81.7	4.8CM	SCSN
1914	09	22	32.9	-80.0	4.2CM	SCSN
1924	10	20	35.0	-82.6	4.4CM	SCSN
1945	07	26	34.3	-81.4	4.4IM	SCSN
1957	11	24	35.0	-83.5	4.0	EUS
1959	08	03	33.05	-80.13	4.4FG	SCSN
1959	10	27	34.5	-80.2	4.0CM	SCSN
1960	03	12	33.07	-80.12	4.0FG	EUS
1964	03	13	33.19	-83.31	4.4	EUS
1972	02	03	33.31	-80.58	4.5NG	SCSN
1974	08	02	33.95	-82.5	4.3NG	SCSN
1974	11	22	32.93	-80.16	4.3NG	SCSN
1979	08	13	33.9	-82.54	4.1DG	SCSN
1980	04	09	34.85	-79.94	5.0	ANSS
1992	08	21	32.99	-80.16	4.1NV	SCSN
2002	11	11	32.4	-79.94	4.4	ANSS

REFERENCES

Bollinger, G.A., and Stover, C.W., 1976, List of intensities for the Charleston 1886, South Carolina earthquake: U.S. Geological Survey Open-File Report 76–66, 33 p.

Crone, A.J., and Wheeler, R.L., 2000, Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain front: U.S. Geological Survey Open-File Report 00–260, 332 p.

Dart, R.L., and Hansen, M.C., 2008, Earthquakes in Ohio and vicinity 1776–2007: U.S. Geological Survey Open-File Report 2008–1221, poster.

Engdahl, E.R., 1988, Seismicity map of North America: The Decade of North American Geology (DNAG), Continent-Scale Map–004, scale 1:5,000,000, sheets 1–4.

ESRI, 1993, Digital Chart of the World for use with ARC/INFO, data dictionary: ESRI, Redlands, California.

Obermeier, S.F., Weems, R.E., and Jacobson, R.B. 1987, Earthquake-induced liquefaction features in the coastal South Carolina region: U.S. Geological Survey Open-File Report 87–504.

Petersen, M.D., Frankel, A.D., Harmsen, S.C., Mueller, C.S., Haller, K.M., Wheeler, R.L., Wesson, R.L., Zeng, Yuehua, Boyd, O.S., Perkins, D.M., Luco, Nicolas, Field, E.H., Wills, C.J., and Rukstales, K.S., 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2008–1128, 61p.

Stover, C.W., and Coffman, J.L., 1993, Seismicity of the United States earthquakes, 1568–1989 (Revised): U.S. Geologcal Survey Professional Paper 1527, p. 327–331.

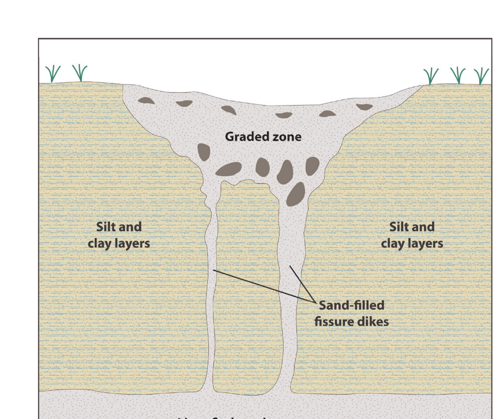
Street, R.L., Bollinger, G.A., and Woolery, Edward, 2002, Blasting and other mining-related activities in Kentucky—A source of earthquake misidentification: Seismological Research Letters, v. 73, p. 739–750.

Tarr, A.C., and Wheeler, R.L., 2006, Earthquakes in Virginia and vicinity 1774–2004: U.S. Geological Survey Open-File Report 2006–1017, poster.

von Hake, C.A., 1976, Earthquake history of South Carolina: U.S. Geological Survey Earthquake Information Bulletin, v. 8, no. 6, p. 34–38.

Wheeler, R.C., 2003, Tectonic summaries for web-served earthquake responses, southeastern North America: U.S. Geological Survey Open-File Report 03–343, 27 p.

Sand blow crater on Ten Mile Hill. The feature resulted from ground shaking associated with the Charleston, South Carolina, earthquake of August 31, 1886. It is Plate 20, U.S. Geological Survey Annual Report 9 (1887-1888). Image source: USGS Photographic Library, /htmllib/batch05/batch05j/batch05z/hjk00010.jpg. Photo by C.C. Jones (September 1886).



Interpretative diagram of a sand blow crater and the liquefaction process (after Obermeier and others, 1987).

Author's Note

The information presented here was derived from existing sources and earlier publications. Specifically, general information on earthquake occurence and seismic hazard came from Tarr and Wheeler, 2006. This downloadable report is available at http://pubs.usgs.gov/of/2006/1017/. Several additional publications provided detailed information on South Carolina earthquake history: (for example Stover and Coffman, 1993; Crone and Wheeler, 2000; and Wheeler, 2003).

SEISMIC HAZARD

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, like the one shown at right, illustrate this variation. The risk level 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.

Seismic hazard maps are tools for determining acceptable risk. As such, they are critical in helping save lives and preserve property by providing information essential in the creation and updating of the seismic design provisions of local building codes. Because most buildings and other structures in the Central United States were not built to withstand severe ground shaking, damage could be catastrophic in the event of a powerful earthquake. The work of seismic hazard scientists and engineers provides the groundwork for future urban environments that will be safer if large magnitude earthquakes occur. Additional applications of the information derived from these maps include setting insurance rates, estimating hillside stability and landslide potential, and estimating assistance funds needed for earthquake education and preparedness.

Seismic hazard maps are an estimation 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. Seismic hazard maps illustrate likely shaking levels, for example, 2-percent probability of what it will be over a stated time period (for example, 50 years).

The seismic energy released during an earthquake radiates in all directions as waves. As the seismic waves move upward they are amplified or de-amplified as they travel through the sediment layer near the ground surface. Seismic wave amplification or de-amplification can significantly affect the way the ground shakes during an earthquake.

An additional factor in determining how the ground will respond during an earthquake is the frequency of shaking. As a seismic wave passes a given map location, the ground will vibrate. If ground vibration (oscillation) is rapid (short-period motion), the seismic wave's energy will dissipate quickly and have a de-amplifying effect. Conversely, if the ground vibration is slow (long-period motion) the wave's energy will dissipate less rapidly, yielding greater amplification.

A final factor in determining ground response to earthquake shaking is the strength of shaking. If ground shaking is particularly violent, sediments may break apart, thus preventing seismic waves from continuing to be transmitted through them. This would have the beneficial effect of limiting shaking. Such extreme shaking could, however, result in catastrophic ground failure.

The generalized seismic hazard map (right) is a computer generated contour map. It portrays seismic hazard calculated by the USGS as bands of color (cooler for less 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 Macon, Ga., is between 8%*g* and 10%*g*. That means a structure built on firm rock has 1 in 50 odds (2-percent probability) of undergoing ground shaking of 8–10%*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.

SOUTH CAROLINA SEISMIC ZONES

Middleton Place-Summerville Seismic Zone
The Middleton Place-Summerville seismic zone (MPSSZ) is the most active (nonreservoir induced) seismic source zone in the Coastal Plain. The largest earthquake in MPSSZ had a magnitude of 3.1 and was located at a depth of 10.3 km. The depth of earthquakes in MPSSZ ranged between 3 and 11 km. These events are associated with the N.30°W. oriented Sawmill Branch fault, based on their locations. Events near Summerville are associated with the N.23°E. trending Woodstock fault. The Ashley River fault is a third active fault in the area.

Induced Seismicity
Since its impoundment in 1978, the Monticello Reservoir (center left) has experienced several episodes of induced seismic activity. The reservoir serves as the cooling pond for the V.C. Summer Nuclear Power Station in Fairfield County, S.C. It is also the headwater for the Fairfield Pumped Storage facility. Seismic events associated with the reservoir typically have been shallow, less than 2.5 km, and of small magnitude, less than 2.5.

NEARBY SEISMIC ZONES

Eastern Tennessee Seismic Zone
The Eastern Tennessee seismic zone (above right) is one of the most active earthquake areas in the Southeast United States. A few earthquakes located within this zone have caused property damage. The largest recorded earthquake (M4.6) occurred in 2003, near Fort Payne, Ala. (not shown). On average, felt earthquakes occur once a year in this zone. Seismographs, however, have recorded hundreds of smaller magnitude, unfelt earthquakes in recent decades. This zone contains many known faults, poorly determined at earthquake depths. Therefore, few, if any, earthquakes in the zone can be linked to any of these faults, to indicate that they are seismically active.

Giles County Seismic Zone
Since at least 1828, earthquakes have been reported in the Giles County, Va., seismic zone. The largest known damaging earthquake (M5.6) in the zone occurred in 1897. Smaller earthquakes are felt or cause light damage approximately once or twice a decade (Tarr and Wheeler, 2006).

LIQUEFACTION FEATURES

As a result of strong ground shaking, liquefaction features often develop in the epicentral areas of large earthquakes. These ground-surface features form when buried liquefied sand, under pressure due to the shaking, vents upward, often in the form of sand and water geysers, known as sand blows. The resulting sand deposits are typically circular in shape and several meters in diameter. Over time these sand deposits can themselves become buried forming buried sand lenses. In regions having long seismic histories, paleoseismologists are sometimes able to excavate these buried liquefaction features and date the sequential histories of past large earthquakes, thereby determining their approximate recurrence intervals.

The zone of South Carolina liquefaction features extends along the Atlantic coast from Wilmington, N.C., to Savannah, Ga., approximately 50 km inland. This zone is divided into three adjoining areas named the Charleston, Bluffton, and Georgetown liquefaction features. The delineation of this liquefaction zone and its three inclusive areas of liquefaction are based on eyewitness reports of extensive liquefaction activity during the Charleston earthquake of 1866; analysis of prehistoric sand craters, sand blows, and sand fissures; and the recognition that these features were caused by strong ground shaking due to earthquakes. Detailed descriptions of these features can be found in "Quaternary Fault and Fold Database of the United States"
(available at http://earthquake.usgs.gov/regional/qfaults/).

ABBREVIATED MODIFIED MERCALLI INTENSITY SCALE

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. Dam age 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.

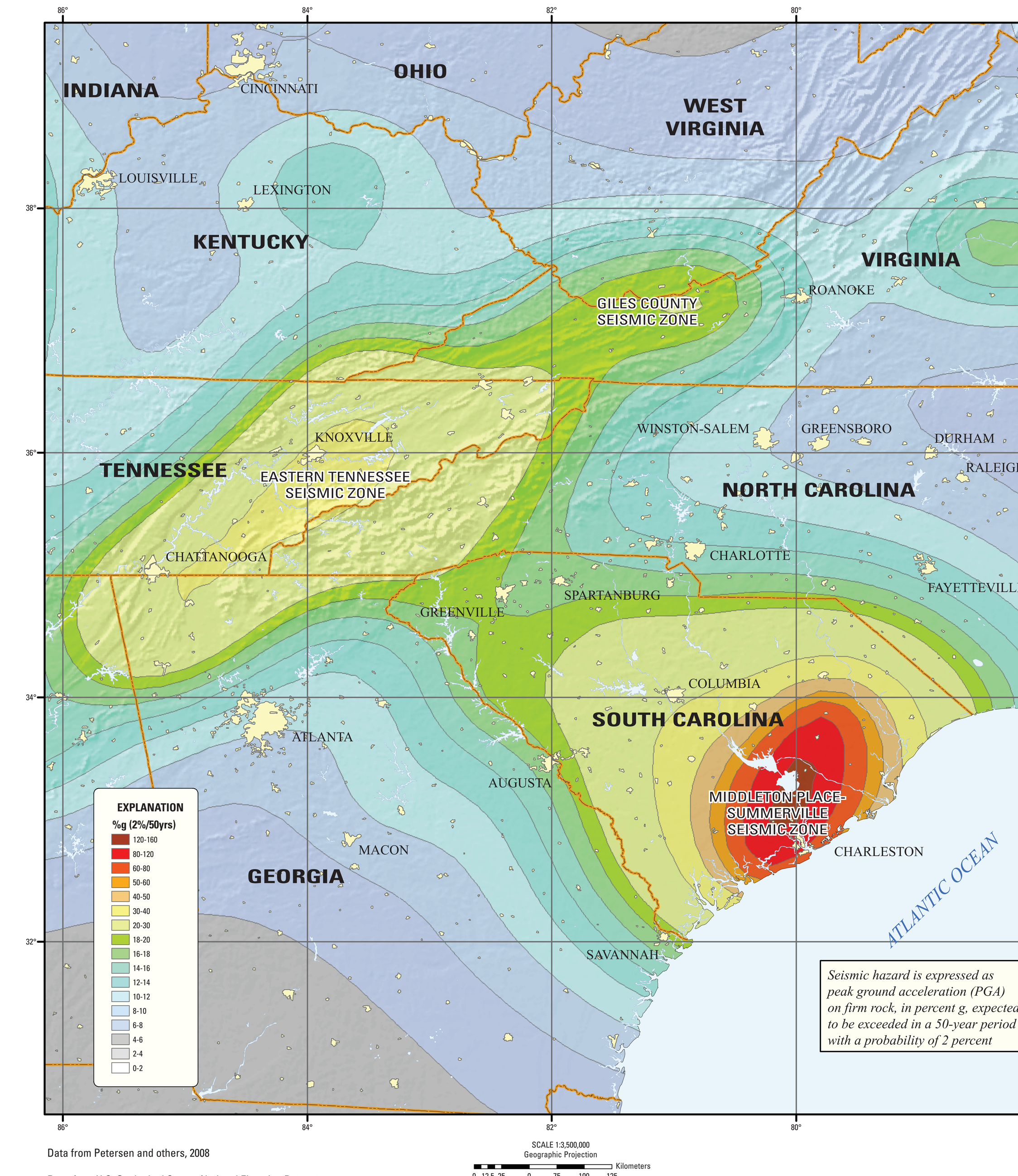
NOTES ON THE ISOSEISMAL MAPS

Isoseismal maps illustrate the level of ground shaking that occurred at various locations during a particular earthquake. The distributions of intensity values in South Carolina and vicinity for two earthquakes are shown on the isoseismal maps (right). These events are the September 1, 1886, maximum intensity X, magnitude 6.7, Charleston earthquake and the February 3, 1972, maximum intensity V, magnitude 4.5, earthquake.

Contemporary accounts from newspapers of earthquake effects in cities and towns over a broad region were the sources of the intensity observations plotted on the isoseismal maps. The intensity observations are shown as color-coded circles. Each observation was assigned a Modified Mercalli Intensity (MMI) and the results were contoured. The mapped intensity values (integers) correspond to the Roman numeral values in the table (above). An observation coded "F" is a location where shaking was felt but no MMI value was assigned and "N" if source document indicated that the event was not felt.

Contouring of the assigned intensity values, shown as circles on the maps (right), was computer generated using an inverse distance weighted algorithm. The assigned values are from Bollinger and Stover (1976) for the 1886 Charleston earthquake and the National Geophysical Data Center (NGDC, http://www.ngdc.noaa.gov/seg/hazard/int_srch.shtml.) for the 1972 earthquake.

Regional Seismic Hazard



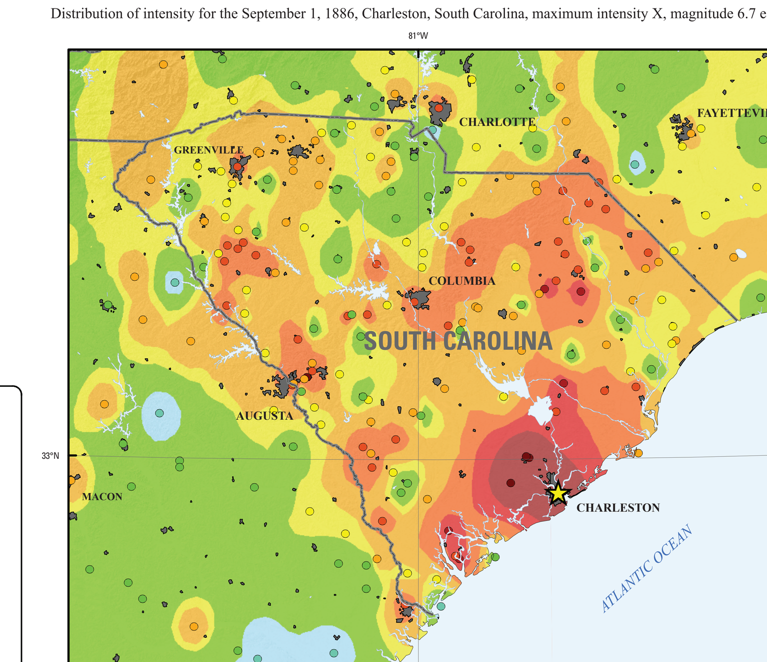
Data from Petersen and others, 2008

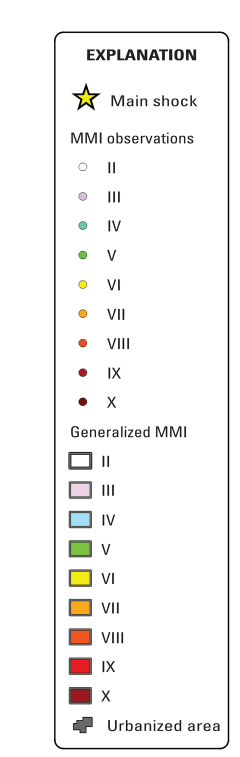
Base from U.S. Geological Survey National Elevation Dataset, National Hydrologic Database, and Digital Chart of the World (ESRI, 1993)

Geographic projection. Datum: North American 1983

Isoseismal Maps

Distribution of intensity for the September 1, 1886, Charleston, South Carolina, maximum intensity X, magnitude 6.7 earthquake



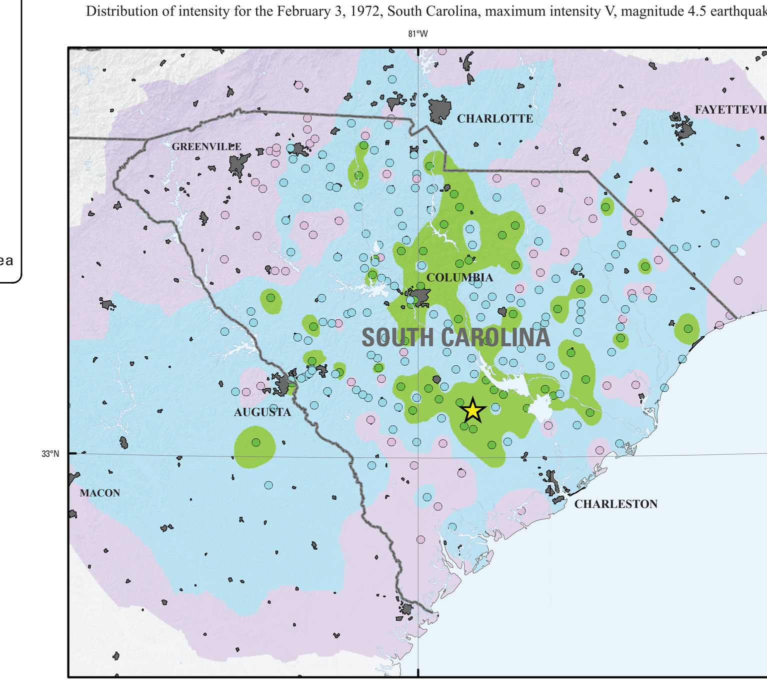


Base from U.S. Geological Survey National Elevation Dataset, National Hydrologic Database, and Digital Chart of the World (ESRI, 1993)

Albers equal-area conic projection, standard parallels 29°30′00″ and 39°30′00″, central meridian -81° 0′00″, latitude of origin 0°0′00″

SCALE 1:3,000,000

Distribution of intensity for the February 3, 1972, South Carolina, maximum intensity V, magnitude 4.5 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 -81° 0′00″, latitude of origin 0°0′00″

SCALE 1:3,000,000

Kilometers 0 15 30 60 90 120 150
Miles 0 15 30 60 90 120 150

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