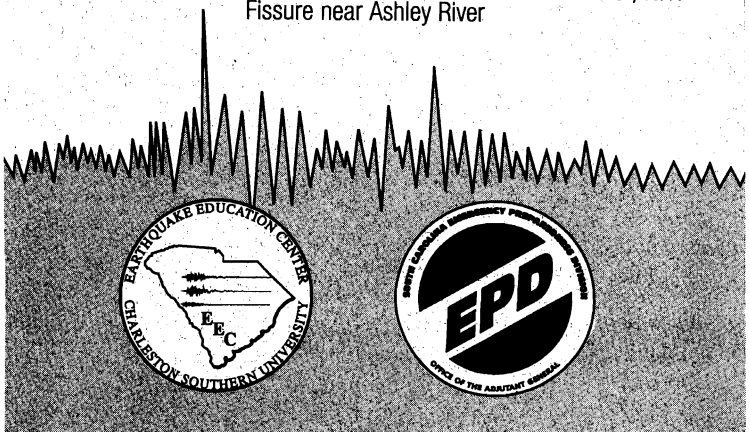
SOUTH CAROLINA EARTHQUAKES

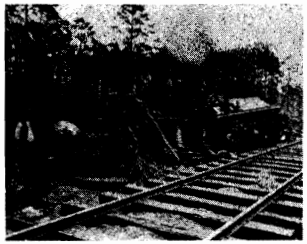
Cook, Charleston — Julius Bien & Co., N.Y.

Fissure near Ashley River



Introduction

Most South Carolinians are aware that over 100 years ago, Charleston, South Carolina, experienced the most damaging earthquake in the Eastern United States. In the past decade (1983-1993) scientists, engineers, educators and political science practitioners have met in conferences to discuss the risk of a reoccurrence of an earthquake similar to the 1886 Charleston earthquake or a damaging earthquake of magnitude 6 or higher. Many studies funded by the United States Geological Survey, the Nuclear Regulatory Commission, the National Science Foundation, and the Federal Emergency Management Agency provided pieces of the puzzle as to the mechanism of the 1886 Charleston, South Carolina, earthquake. All the questions have not been answered, and the search for answers continues. While complete scientific explanations are not available, there is one obvious truth. Where earthquakes have happened before, they will occur again. South Carolinians need to aggressively address this issue and modify their behavior to include knowing how to prepare and respond in the event of a damaging earthquake. That knowledge is beneficial, particularly in our mobile society of today.



The purpose of this booklet is to provide you with information about South Carolina earthquakes. The South Carolina Emergency Preparedness Division, the Charleston Southern University Earthquake Education Center and the University of South Carolina collaborate on conducting scientific investigations of South Carolina earthquakes and on providing mitigation strategies to South Carolinians to help reduce the risk of injuries and death in the event of a damaging earthquake.

Defining an earthquake

Earthquakes are vibrations of the earth caused by the passage of seismic waves radiating from some source of elastic energy, (Bolt, 1993).

What causes earthquakes?

The earth is a dynamic machine, a huge factory where old crust is melted and processed into new crust. Continents are continually moving like huge rafts on a sea of molten rock and mountain belts are simultaneously being uplifted, eroded and recycled. This process,known as **plate tectonics,** keeps in balance the awesome forces which shape the surface of the earth. As the earth moves, earthquakes can be produced.

As the earth's plates move, stress builds upon buried rock layers. When the stresses become too great and overcome the forces holding the rock layers together, the rocks move along the zone of weakness. The sudden movements of the rock release energy or vibrations known as an earthquake, (Bolt, 1993).

What causes the shaking and damage from an earthquake?

The damage caused by earthquake shaking is the result of three basic types of elastic waves. Two of the three travel within a body of rock. The Primary Wave or P Wave travels as a compressional wave, similar to a sound wave in that as it spreads out it pushes and pulls the rock. The P Wave is the fastest traveling wave. Earthquakes in South Carolina often sound like an explosion followed by a train rushing past. The explosive sound heard when an earthquake occurs is caused by the sound-like nature of the primary or P Waves. A fraction of the P Waves as they emerge at the surface from deep in the earth is transmitted into the atmosphere as sound waves. This is the explosive sound that is heard by animals and humans.

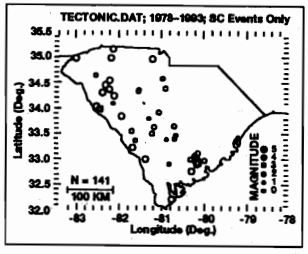
The Shear Wave (Secondary Wave) or S Wave is the slower wave through the body of rock. The S Wave shears the rock sideways at right angles to the direction of travel. Liquids will not spring back when sheared sideways. This is why S Waves cannot travel through liquid parts within or on the surface of the earth, i.e. outer core within the earth or the oceans on the surface. Seconds after the P Wave arrives at the surface or at a seismometer buried in the ground, the S Waves arrive shaking the ground surface vertically and horizontally. This is the wave motion that is so damaging to structures.

The Surface Wave is the third type of earthquake wave. The motion of the Surface Wave occurs only near the ground surface, i.e. like ripples of water across a lake. There are two types of Surface Waves: Love Waves and Rayleigh Waves. Love Waves move back and forth horizontally, do not move vertically, and are damaging to the foundations of structures. The second type Surface Wave, Rayleigh Waves, move up-and-down and side-to-side.

Body Waves (the P and S Waves) are reflected and refracted as they spread out from the focus (the area within the crust where the earthquake occurs) and some of their energy is changed to the other types of Surface Waves. This action adds to the complex motions of the damaging Surface Waves and causes amplification of shaking near the surface. The soil conditions and topography of the land affect the amplification of the energy dramatically, (Bolt, 1993).

Where do earthquakes occur in South Carolina?

About seventy percent of South Carolina earthquakes are located in clusters around three areas: (1) Ravenel-Adams Run-Hollywood, (2) Middleton Place-Summerville, and (3) Bowman. These are not, however, the only places that earthquakes occur in South Carolina. This map shows the location of South Carolina earthquakes recorded from 1978 to 1993. Beginning as early as 1698, earthquakes have occurred throughout the state.



Where are the geological faults that cause South Carolina earthquakes?

There is no comprehensive map showing geological faults in South Carolina. There are maps showing the epicenters of earthquakes. There is no clear surface evidence of the earthquake faults in South Carolina. The earthquakes' epicenters (point on the surface of the earth above the focus [deep within the earth's crust] of

the earthquake) determined from the instrumental recordings are located on maps, but not the length or width of the geologic faults on which the earthquakes originate. Scientists continue to look for the surface evidence of the 1886 Charleston earthquake fault. In fact this holds true for all of the Eastern United States. The Eastern United States is in the Center of the North American Crustal Plate. Intraplate tectonics (areas within the crustal plate) are not as easily understood as interplate tectonics areas at the edges of crustal plates.

The Facts About the 1886 Charleston, South Carolina Earthquake

The following list of facts about the 1886 Charleston Earthquake provides answers to the frequently asked questions about the most damaging earthquake to ever occur in the eastern United States.

- Date of occurrence - August 31, 1886 (Tuesday). The main shock was followed by an aftershock two minutes later and many more shocks for the following three years.
- Time - 9:51 p.m. Eastern Standard Time
- Magnitude = 7.6 (Johnson, 1991)
- Intensity on Modified Mercalli Scale = X
- Two epicenters were reported by Dutton (1889). Epicenter is defined as the place on the surface of the earth over the focus or area within the earth where an earthquake occurs. They were:

  A. Woodstock, a railroad stop on the Southern Railway leading into Charleston. This is 21 miles northwest of Charleston (Shedlock, 1988).

  B. Ravenel, a small town 23 miles southwest of Charleston, South Carolina
- Felt over 2.5 million square miles (From Cuba to New York, and Bermuda to the Mississippi).
- Approximately 110 persons lost their lives.
- Ninety percent (90 percent) of the brick structures in Charleston were damaged (Dutton, 1889).
- Damaging secondary effects were fires, ruptured water and sewage lines, damaged wells, flooding from cracked dam in Langley, South Carolina, and in the highest intensity area bent railroad tracks, throwing one train off the tracks.
- Dollar damage estimates in 1886 dollars were about $5.5 million.
- Approximately 70 percent of all the present day South Carolina Coastal Plain earthquakes have occurred within the highest intensity area of the 1886 Charleston earthquake. (Shedlock, 1988)
- There was some slumping on the Ashley River banks during the 1886 earthquake. Numerous craterlets or sandblows were formed in lower South Carolina. Some sandblows near the North Carolina border were found in the 1980s. Earthquakes do not open up cracks to swallow whole neighborhoods.
- In the 1886 Charleston earthquake many people panicked, but everyone gathered their wits and resources to recover from the devastating event. Some businesses reopened in two days.
- At Columbia, Augusta, Raleigh, Atlanta and Savannah, the fright and concern of all people were universal. In all of the large towns within 200 miles of Charleston, houses and other structures were damaged.
- Scientists are searching to determine the cause of the 1886 Charleston earthquake. The geologic fault or faults causing the 1886 earthquake and the small earthquakes in South Carolina today cannot be seen on the surface of the earth. The fault(s) are buried under deep (several kilometers) sediments.

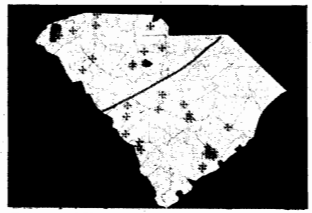
Risks of South Carolina Earthquakes

The forecast for a large earthquake somewhere in the Eastern United States within the next 30 years is a 40 percent to 60 percent chance of a magnitude 6. (Nishenko & Bollinger, 1990).

Analysis of seismograph network data, earthquake catalogs from 1727 to 1982, and paleoseismic data for the central and eastern United States indicate that the Poisson probability of a damaging earthquake (magnitude - 6.0) occurring during the next 30 years is at a moderate to high level (0.4 to 0.6). When differences in seismic wave attenuation are taken into account, the central and eastern United States have approximately two-thirds the likelihood of California to produce an earthquake with comparable damage area and societal impact within the next 30 years (Nishenko & Bollinger,1990).

How often do earthquakes occur in South Carolina?

The number of locatable tectonic earthquakes in South Carolina recorded by the South Carolina Seismic Network (SCNET) from 1974 to 1993 was approximately 190 (about 10 per year). Seventy percent occurred in the high intensity area of the 1886 Charleston Earthquake. The highest Richter magnitude (size) of these earthquakes was 4.1 (August 21, 1992). All other earthquakes during 1974-1993 ranged in magnitude from less than 1 to 3.8. From 1989-1993 there was an increase in earthquake activity. The significance cannot be determined.



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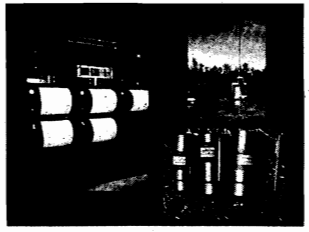
Earthquakes are unpredictable. Thirty-nine of our 50 states are vulnerable to earthquakes. If earthquakes have occurred before, they will occur again.

Where are the instruments that record South Carolina earthquakes?

The major recording centers for the South Carolina Seismic Network are located at Charleston Southern University, Charleston, South Carolina, and the University of South Carolina, Columbia, South Carolina.

The Richter Scale is a mathematical formula using measurements of the amount of the needle displacement on the seismogram, which is a paper trace of the motions of the seismic waves that strike the seismometer. The seismometer is the buried ground sensor part of the instrument, or seismograph that detects earthquakes. The energy received by almost two dozen seismometers, buried throughout South Carolina, is transmitted by VHF radio or telephone lines to the master seismographs at Charleston Southern University in Charleston, South Carolina and the University of South Carolina, Columbia, South Carolina. The seismic equipment for all station sites within the state of South Carolina was turned over to South Carolina in 1991 by the United States Geological Survey (USGS). The USGS

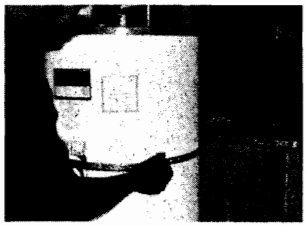


maintains five seismic stations in the Tri County area (Berkeley, Charleston, Dorchester). The information is recorded on the Charleston Southern University network. These recordings will also be relayed to Golden, Colorado, by means of satellite sometime in 1994. Funding for the network comes through grants from the USGS and the private sector in South Carolina.

Liquefaction

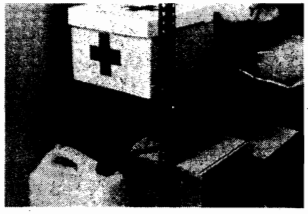
When soil and sand behave like a dense fluid rather than a wet solid mass during an earthquake, liquefaction occurs. The South Carolina Coastal area is vulnerable to liquefaction during a magnitude 6 or greater earthquake. Low-lying areas where the water table is high will be subject to liquefaction during an earthquake. The shaking from the earthquake may cause buried tanks and pipelines to rise to the surface, while heavy objects tend to sink as the soil loses its bearing strength.

How should we prepare for an earthquake?



Survey your home or workplace to determine what hazards exist.

Secure fixtures such as lights, ceiling tiles, cabinets, and top-heavy objects to resist moving, coming loose, or falling during the shaking. Place heavy or large objects on lower shelves, fastened to the walls. Remove hazardous objects above sleeping areas. Fasten your water heater to the wall by strapping it to the wall or bolting it to the floor. Check the electrical wiring and connections to gas appliances. Defective electrical wiring, leaking gas, or inflexible connections are hazardous in the event of an earthquake.



Store breakables in low, closed cabinets. Have on hand:

1. A flashlight and battery-powered radio in case you lose power. The official source of information during a disaster is obtained through the Emergency Broadcast System.

2. A supply of drinking water and some nonperishable foods which can be prepared without cooking. Plan a "goodie closet" and rotate the food.

3. A fire extinguisher and first aid kit.

Think in terms of your family or workplace as being self-sufficient for 72 hours following a disaster.

Develop a family work plan which addresses what to do if the earthquake occurs while family members are at home, school or work. Discuss where and how contact should be made and where to meet. Coordinate your plan with the school's plan.

Practice your plan. Hold drills so each member of your family knows what to do in an earthquake. Teach responsible family members how to turn off electricity, gas, and water at main switches and valves.

During an earthquake.

Stay calm. Think through the consequences of any action you take.

Stay put. If you are inside, stay inside. If you are outdoors, stay there. Most injuries in an earthquake occur as people are entering or leaving buildings.

Take cover. If indoors, take cover under a heavy desk, table, bench in a supported doorway, or along an inside wall. Stay away from glass. Don't use candles, matches, or other open flame either during or after the tremor because of possible gas leaks. Douse all fires.

If outdoors, **move away from buildings and utility wires**. The greatest danger from falling debris is just outside doorways and close to outer walls. Once in the open, stay there until the shaking stops. If in a moving car, stop as quickly as safety permits, but stay in the vehicle. A car may jiggle violently on its springs, but it is a good place to stay until the shaking stops. When you drive on, watch for hazards created by the earthquake, such as fallen or falling objects, downed electric wires, or broken or undermined roadways.

After the earthquake.

After the earthquake essential services may be out for a few days. The use of telephones will probably be impaired for some time. If your phone is working, it would be best not to burden the lines with unnecessary calls. Listen to the Emergency Broadcast System for official information concerning what to do and the extent of damage in your area.

Initially, emergency response activities will probably be focused on those locations hardest hit and the restoration of service to critical facilities. People in areas with moderate damage may expect immediate relief but will probably be on their own until the situation has settled somewhat.

Be prepared for additional earthquake shocks called **aftershocks.** Although most of these are smaller than the main shock, some may be large enough to cause additional damage or topple weakened structures.

Check for injuries. Do not attempt to move seriously injured persons unless they are in immediate danger of further injury.

Turn on your radio or television to get the latest emergency information from local authorities.

Check your utilities. The earthquake may have broken gas, electrical, and water lines. Open windows and shut off the main gas valve. Then leave the building and report any leakage to authorities. Do not reenter the building until a utility official says it is safe. If electrical wiring is damaged, shut off power at the main meter box. If water pipes are damaged, shut off the water supply at the main valve. Emergency water may be obtained from hot water tanks, toilet tanks (not bowls), and melted ice cubes.

Check sewage lines to see that they are intact before using sanitary facilities.

If you cannot reenter your home, emergency shelters will be available for your use. These may be schools or churches and will be surveyed to insure their stability in case of aftershocks.

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