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CHARACTERISTICS OF THE COURTLAND, MISSISSIPPI, EARTHQUAKE OF FEBRUARY 24, 1999

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INTRODUCTION

An interesting earthquake occurred near the town of Courtland in southern Panola County on February 24, 1999. This article summarizes what we know about this event, and what we can learn from it regarding the earthquake risk to northwestern Mississippi.

Two characteristics of earthquakes in the Central United States are a relatively long period of time between recurring seismic events and large felt areas when compared to western earthquakes. The long recurrence times make it particularly important to extract as much information as possible regarding these earthquakes, even if they are low magnitude events. The small earthquakes also provide an idea of the types of problems an emergency manager would have to face in the event of a larger earthquake and can serve to remind the population that the threat of earthquakes remains, regardless of the number of years since the last seismic event.

When compared to earthquakes in the western United States, the Central U.S. earthquakes have large felt areas, which translates into a higher potential to affect more of the local population and cause more widespread damage. The size and location of the felt area can also be used to evaluate the accuracy of projected epicenter location, particularly, as in this case, when there is a geographic spread of epicenter locations. Knowledge of felt area versus epicenter location allows the seismologist to "fine tune" the predictive models, resulting in more accurate future projections.

There is a paucity of information regarding potential seismic sources in the vicinity of the southern end of the New Madrid Seismic Zone (NMSZ) in Arkansas and Mississippi. DeSoto County, Mississippi, for example, has never had a geologic map or bulletin constructed for the county, but it is one of the highest growth areas in the state, is adjacent to Memphis, Tennessee (Shelby County), and is in a high seismic risk area. The Courtland Earthquake also occurred south of the traditional NMSZ (that concentrated area of earthquake activity in Missouri, Tennessee, and Arkansas as illustrated in Johnston and Nava, 1990), so it is important to characterize this source of local seismicity of which little is known. These data are useful for developing a more accurate concept of regional seismicity south of the traditional NMSZ.

INSTRUMENTAL ASPECTS OF THE COURTLAND EARTHQUAKE

The Courtland Earthquake occurred on February 24, at 8:11 p.m. local time (Center for Earthquake Research and Information, 1999) and was named after the small town of Courtland, in Panola County, Mississippi (Figure 1). The earthquake epicenter is located south of the U.S. Geological Survey's (USGS) Central United States seismic network monitoring the NMSZ. The closest station to the event was the Oxford station, located in the northern portion of adjacent Lafayette County. Using this network, the USGS and the Center for Earthquake Research and Information (CERI) independently determined a magnitude and an epicenter. The Tennessee Valley Authority (TVA) also monitors seismic events and determined a magnitude and an epicenter. The TVA's determination of the epicenter location was determined using components of both the USGS network and the network operated by the University of Tennessee (personal communications, Jeff Munsey, TVA, April 7, 1999).

There is variation in the estimated epicenter location and focal depth (hypocenter) among the three agencies (see Table 1). Focal depths, for example, varied from a maximum of 5.6 miles (nine kilometers) to a minimum of 0.9 miles (one and a half kilometers). This variation in depth is due to the inherent difficulties in determining depths of seismic events with the additional complication that the epicenter is not within the bounds of the seismic network. Due to these problems it is perhaps best to consider it a relatively shallow earthquake without attempting further precision of depth. Magnitude determinations by all three agencies are similar.

Table 1 - Summary of epicenters, depths and magnitudes for the Courtland Earthquake

Agency	Latitude	Longitude	Focal Depth*	Magnitude	Magnitude Scale
TVA	34.20 N	89.88 W	5.6 miles (9 km)	2.8	Duration Magnitude
USGS	34.01 N	89.93 W	3.1 miles (5 km)	2.9	Lg Phase Magnitude
CERI	34.05 N	89.87 W	0.9 mile (1.5 km)	2.9	Lg Phase Magnitude

* km = kilometers

As can be seen in Figure 1 and in Table 1, the epicenters vary by approximately 15 miles (24 kilometers) in the north - south direction, and by approximately eight miles (13 kilometers) in the east - west direction. The important aspect of this spread of modern, instrumentally determined epicenters is that epicenter locations are not sufficiently accurate in this area to correlate earthquake epicenters with any specific fault or geomorphic anomaly which may be indicative of faulting. The best that can be hoped for is to correlate the seismicity with regional-scale structure. The spread also brings into question the accuracy of historic epicenter locations listed prior to the establishment of modern seismic networks. The apparent spread of epicenters from historic earthquakes may be a function of variability in the determination of epicenters rather than a series of earthquakes originating from several seismically active faults. Those epicenters determined prior to the network may have significant uncertainties in location.

HISTORY OF AREA SEISMICITY

The 1999 Courtland Earthquake is not the first for the area of Batesville, Courtland (Panola County), and Charleston (in adjacent Tallahatchie County, Mississippi). The area's most noteworthy earthquake occurred on December 16, 1931. This earthquake has been referred to as the Batesville Earthquake and as the Charleston, Mississippi, Earthquake. Regardless of the name, it was the largest historic earthquake within the political bounds of Mississippi (Bograd, 1992). Although this seismic event was instrumentally recorded (Neumann, 1931), the epicenter location is poorly confined due to the lack of an adequate instrumentation network in 1931. Stover and Coffman (1993) assigned an epicenter location of 33.8^{0}N latitude and 90.1^{0} W longitude, which is near the USGS epicenter location for the Courtland Earthquake (see Table 1). Johnston et al. (1994), listed three additional locations for the 1931 epicenter. A focal depth was not determined for this earthquake.

The 1931 earthquake cracked foundations and destroyed chimneys in the nearby town of Charleston, Mississippi, and was felt in Arkansas, Alabama, and Tennessee as well as in Mississippi (Stover and Coffman, 1993). Based on felt area reports of this earthquake, a magnitude of 4.6 has been computed (Stover and Coffman, 1993). Johnston et al. (1994) assigned a body wave magnitude of 4.7 to this earthquake and a maximum intensity of VI - VII. The 1931 earthquake was estimated to have been felt over an area of 67,480 square miles (175,000 square kilometers) (Stover and Coffman, 1993).

Earthquake intensity differs from magnitude as it "represents a number assigned to the effects on people ..., manmade structures ..., and the Earth's surface" (Stover and Coffman, 1993, p. 3). Intensity values are based on the Modified Mercalli Intensity scale (MMI) that was originally published in 1931. The updated MMI scale (see Stover and Coffman, 1993) was used to determine intensity values in this study.

A smaller earthquake (2.5 duration magnitude) occurred in the area on September 24, 1984, with an epicenter location at 34.064^{0}N and longitude 89.818^{0} W, and with an estimated focal depth of 3.7 miles (6 kilometers) (Stover, 1988). This small earthquake was not known to have been felt at the surface and its occurrence was documented only by instrumental means. During the investigation of the Courtland Earthquake, however, we found that the 1984 earthquake was also felt by a number of people over the same region as the Courtland Earthquake

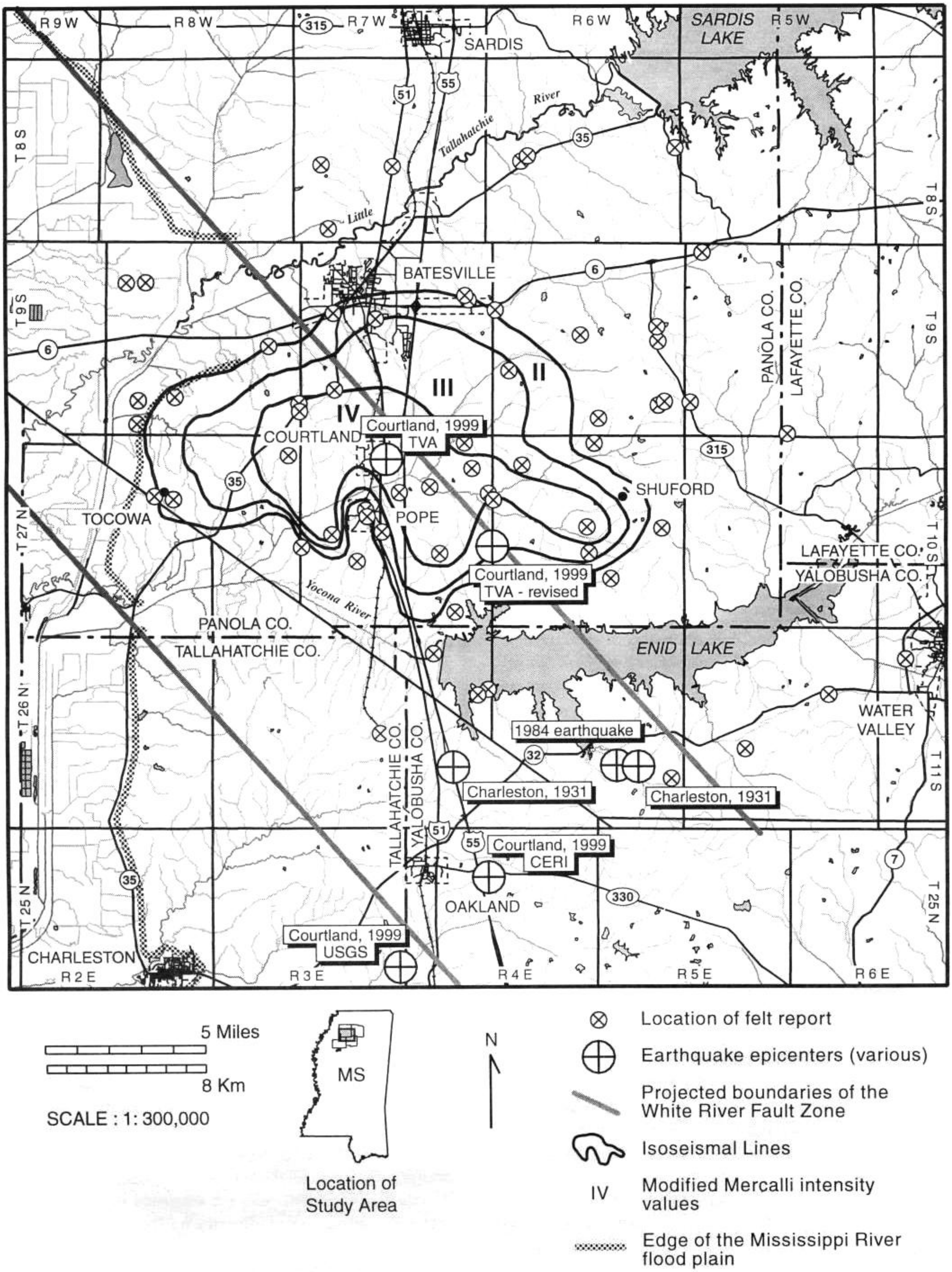
R 9 W
R 8 W
315
R 7 W
SARDIS
R 6 W
SARDIS LAKE
R 5 W
51
55
Tallahatchie
River
35
T 8 S
Little
BATESVILLE
6
T 9 S
IV
III
II
Courtland, 1999 TVA
COURTLAND
35
SHUFORD
315
PANOLA CO.
LAFAYETTE CO.
TOCOWA
POPE
T 27 N
Courtland, 1999 TVA - revised
T 10 S
LAFAYETTE CO.
YALOBUSHA CO.
Yocona River
PANOLA CO.
TALLAHATCHIE CO.
ENID LAKE
T 26 N
WATER VALLEY
1984 earthquake
32
TALLAHATCHIE CO.
YALOBUSHA CO.
Charleston, 1931
Charleston, 1931
T 11 S
51
55
Courtland, 1999 CERI
7
35
330
OAKLAND
T 25 N
Courtland, 1999 USGS
CHARLESTON
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E
5 Miles
8 Km
SCALE : 1: 300,000
MS
Location of Study Area
N
Location of felt report
Earthquake epicenters (various)
Projected boundaries of the White River Fault Zone
Isoseismal Lines
IV
Modified Mercalli intensity values
Edge of the Mississippi River flood plain

Figure 1

and several of the people interviewed remarked of the difference of vibrations between the two.

All three of these earthquakes are thought to originate from geologic sources rather than from anthropogenic activity. Subsurface fluid injection associated with hydrocarbon production can trigger earthquakes. Cox (1991) documented this situation near El Dorado, Arkansas, where fluids were being injected into the subsurface to facilitate hydrocarbon production and triggering earthquakes along pre-existing faults. There is, at present, no hydrocarbon production in either Panola or adjacent counties, nor has there been any subsurface injection of fluids. Neither has there been any recent activities such as the filling of large, new reservoirs, which can also trigger earthquakes (Reiter, 1990).

FELT AREA OF THE COURTLAND EARTHQUAKE

Prior to field interviews, a form was constructed that could be used to capture the data regarding the felt characteristics of the earthquake. The form included not only felt characteristics of the earthquake but data on the building in which the earthquake was felt, information on any noise associated with the earthquake, description of any damage, and unusual behavior of animals. The collected data could then be used to determine the felt area and to estimate the MMI values.

The Civil Defense / E-911 office in Batesville, Mississippi, was used as the local headquarters for the interviews because of the availably of E-911 information containing names, house numbers, and geographic locations. These data helped accurately locate felt locations on field maps that would be used to construct the felt area map and the isoseismal map. Interviews were held *via* telephone and by personal visits. Each location where the earthquake was felt was assigned a unique number on the field maps and a corresponding number on the interview form, forming a linkage between interview data and location. A total of 60 interviews was made.

The field maps were 1:100,000 relative fraction scale regional maps produced by the USGS. Locations where the earthquake was "felt" as well as locations were it was "not felt" were plotted on the field maps. "Not felt" locations were not numbered unless there were special circumstances which required it; usually this circumstance was where the earthquake was not felt, but the noise associated with it was heard. All of the interview reports were then reviewed, an estimated MMI value was assigned to each report, and the MMI value plotted on the map. The MMI values were then contoured to produce the isoseismic map (also shown on Figure 1). Locations where the earthquake noise was heard were also plotted.

The first felt area map was a sketch map constructed by the Batesville Civil Defense/ E-911 office the day after the earthquake and was based on telephone calls received at the Civil Defense / E-911 office (see Dunn, 1999). This initial map identified an area smaller than the felt map resulting from this investigation, but it covered the majority of the felt area and was a useful initial analysis. The felt area determined from this investigation consists of a roughly semicircular area situated between Batesville and Enid Lake in a north to south direction and between Tocowa and Shuford in a west to east direction (Figure 1). The total felt area is calculated to encompass 98.3 square miles (254.7 square kilometers).

An interesting feature of the felt area is its relationship to the area's major flood plains. The western edge of the felt area appears to approximately coincide with the eastern edge of the Mississippi River flood plain deposits. The northern boundary, in part, coincides with the edge of the flood plain of the Little Tallahatchie River, and the southern boundary coincides with the Yocona River flood plain and Enid Lake. A northward retreat of the felt area at Pope also seems to coincide with the flood plain of Long Creek, a tributary of the Yocona River. All of these flood plains are topographically lower than the adjacent Tertiary uplands and are composed of less dense materials. These common characteristics suggest that topography may have had an effect as suggested by Bouchon (1973) and Boore (1973), with amplification of seismic waves in the higher elevations and attenuation of seismic waves in the flood plains of lower elevation. Another contributing factor may be that the flood plains are not as densely populated as the uplands (particularly the Mississippi River flood plain), resulting in a sample population slightly biased toward the upland effects. We feel this bias is small as we do have data points in the flood plains (Figure 1) that confine the felt area. In the case of higher magnitude local events, the unconsolidated, water- saturated, Recent flood plains would be susceptible to enhanced ground motion effects such as liquefaction.

The area of highest intensity (Figure 1) was assigned an MMI value of IV. Residents within this 30 square mile (77.6 square kilometer) area experienced ground motions sufficient to move pictures and rattle dishes and glassware. A felt report within the intensity IV area was described by Dees (1999), who reported that the earthquake interrupted church services at the Hosanna Family Worship Center near Pope, Mississippi. The pastor was interviewed again for this study and described the most noticeable physical effect as the movement of the suspended ceiling tiles. He also noted that the security guard had a "strange feeling" just prior to the earthquake. Another common characteristic was "cracking or popping" of houses during the earthquake. There were also reports of people running outside as a response to the earthquake ground motion near Pope. Slight damage inside a house was recorded at one location. This damage consisted of cracked paint between wall panels and where the wall panels met the ceiling molding. Photographs taken by the owners approximately two weeks earlier contained no evidence of the cracks, so an earthquake origin is reasonably certain. Other comments from this area were that the Courtland Earthquake was sharper (higher frequency (?)) than the 1984 earthquake, which was described as a slower, more of a "rolling" motion. Noise was associated with the Courtland event and was not known to be associated with the 1984 event.

In the MMI intensity II and III areas the characteristics commonly varied from noticeable vibrations (intensity III) to vibrations so subtle as to be felt by certain people in the household, but not others (intensity II). Dees (1999) reported that the Panola County Sheriff Department received approximately 20 calls, including an unidentified resident of the county who was awakened by the movement of water in her water bed. The noise seems to have been the characteristic that attracted most attention in this area.

Barosh (1990), in his characterization of eastern U.S. earthquakes, describes them as "noisy." He also points out that some eastern earthquakes are heard, rather than felt. The noise results from the coupling of the higher frequency ground motions with air, a characteristic suggesting a shallow focal depth since the higher frequencies are attenuated for deeper earthquakes. The noise associated with the Courtland Earthquake was heard throughout the felt area and beyond. The noise was described as resembling a sonic boom, an explosion, a rumble, a roar, or a noise similar to a train passing. One respondent in the intensity IV area described the noise as coming from the east. Within the felt area, the noise was a very noticeable characteristic of the earthquake. Beyond the felt area the noise was heard by some and not others. The common component in the fringe areas appeared to be if the respondent was outside or inside. Those on the inside did not hear the earthquake while those outside did. The heard area extends considerably beyond the felt area (Figure 1). Since the earthquake occurred at 8:11 p.m., few were outside at the time it occurred and an accurate determination of the edge of the heard area is not possible.

Other earthquake effects noted during the interview process included turbidity from well water after the event and unusual behavior of dogs. Turbid well water was reported from one location in the intensity III area. The turbidity lasted several days before clearing up. The reaction of domesticated animals to the earthquake was mixed. There were no reports of unusual behavior of cattle, although they are common throughout the area. Dogs were also common as pets throughout the felt area and some exhibited unusual behavior before, during, and after the earthquake while some seemed to take no notice. There seemed to be no correlation of unusual behavior with any certain part of the felt area. The unusual behavior varied from howling (just before the event), "staring into space" or listlessness, to hiding under furniture during and after the earthquake.

GENERAL GEOLOGY AND STRUCTURAL IMPLICATIONS

The surficial geological unit in the felt area consists of a blanket of loess overlying Eocene units of the Claiborne Group, or, in part, sands and gravels of Pleistocene (?) age (Vestal, 1956). Priddy and McCutcheon (1942) mapped a fault zone in Tallahatchie County extending from near the town of Effie, northeast to just north of Charleston to Enid, southwest of the felt area. Priddy and McCutcheon (1942) noted several other smaller faults along this trend. Vestal (1956) noted only a few areas containing what he believed may be fault planes. These exposures were examined by the senior author in 1995 as part of another investigation and are now covered with vegetation. Turner (1952) noted the faults mapped by Priddy and McCutcheon (1942) and further noted that the northernmost of these faults extends through the area of Enid Lake dam (under construction at the time) and "was encountered during the work on the dam" (p. 41).

In 1944, H. N. Fisk published his classic work on the alluvial valley of the lower Mississippi River. As a result of this work he identified a number of faults or fault zones he recognized crossing the Mississippi River flood plain. One of these he named the White River Fault Zone (WRFZ), which he mapped from near Newport, Arkansas, southeastward across the Mississippi River flood plain and intersecting the river's eastern valley wall near Batesville, Mississippi. Spitz and Schumm (1997) also mapped the WRFZ and presented a summary of previous literature pertaining to it. Spitz and Schumm's location of the fault zone is more precise than that of Fisk (1944) and is based on several geomorphic factors, including the extreme angularity of salients in the valley walls, a geomorphic feature also noted by Fisk (p. 9). The authors also suggested that the WRFZ and others currently may be affecting the behavior and morphology of the Mississippi River.

Early in the investigation it became apparent that an unusually straight portion of the valley wall between the Mississippi River flood plain deposits and the older Tertiary units formed a topographic lineation, that when projected southeasterly, crossed near the center of the felt area. Literature review verified that this lineation was the angular geomorphic feature on which Fisk (1944) and Spitz and Schumm (1997) based the location of the northern boundary of the WRFZ. The interpretation is that this lineament represents the WRFZ as it enters the Tertiary outcrop belt of Mississippi from Arkansas and the eastward offset of the valley wall is the result of an overall left-lateral movement (Spitz and Schumm, 1997). The WRFZ is also a zone of faulting and is interpreted as consisting of a set of individual faults which Spitz and Schumm illustrated as being approximately 10 miles wide (16 kilometers). McCulloh (1995) noted that some of the linear geomorphic features mapped by Fisk (1944) and interpreted as faults may be equally well explained by joint sets. We agree that joints can result in similar geomorphic features; however, the occurrence of the Courtland Earthquake and perhaps the 1984 earthquake on or near the projected WRFZ northern boundary indicates a fault origin rather than one of joint sets. From these conclusions, we suggest that the seismotectonic origin of the Courtland Earthquake be assigned to the eastern extension of the WRFZ. The epicenter of the 1984 earthquake (Stover, 1988) is approximately two miles (3.2 kilometers) from the projected northern boundary lineament, suggesting it may also be related to the WRFZ. Spitz and Schumm (1997) have suggested that the WRFZ is tectonically active. This earthquake activity near the northern boundary of the WRFZ lends support to their conclusions of ongoing tectonic activity. Assigning these earthquakes to the WRFZ would represent the first time Quaternary movement along a known fault zone has been documented within Mississippi. Although the 1931 earthquake epicenters are not closely confined, two of the locations listed in Johnston et al. (1994) are within six miles (9.7 kilometers) of the WRFZ northern lineament boundary. The proximity of these epicenters to the projected northern boundary lineament suggests that the 1931 earthquake could also have resulted from fault movement on the WRFZ.

Assigning the faulting described by Priddy and McCutcheon (1942) and the faults described by Turner (1952) as extending under the Enid Lake Dam (only approximately four miles (6.4 kilometers) from the projected northern boundary lineament) to the WRFZ ties these faults into the framework of a regional structure. Although the orientation of the faults mapped by Priddy and McCutcheon (1942) does not match the orientation of the WRFZ, it should be recalled that a fault zone may contain a number individual faults and Priddy and McCutcheon could have correlated parts of several faults, and the work conducted by Priddy and McCutcheon was prior to the availability of topographic maps, which served to increase the difficulty of tracing faults.

Stevenson (1999) suggested that in South Carolina small earthquakes originate with granitic and mafic plutons buried beneath an unconsolidated Coastal Plain section. A similar situation is present in the Batesville - Courtland area. Sundeen (1982, 1987) reported igneous rocks present in the Amerada No.1 Martindale well (sec. 10, T10S, R7W). Sundeen (1982) reported the first igneous rocks in the Martindale well were identified at a depth of 3,320 feet (1,011 meters). He identified kersantite (a type of lamprophyre), altered basalt with minor carbonates, an ilmenite and magnetite enriched basalt, and a porphyritic olivine basalt. As these rock types are volcanic rather than plutonic, they do not fit the model suggested by Stevenson (1999). Since most basalts are derived from the mantle, they do suggest deep-seated structure which could be a source of seismic activity. The Newport Pluton is present in the WRFZ in Arkansas (Spitz and Schumm, 1997), so volcanic activity at the eastern end of the WRFZ (Mississippi) is not unexpected. The basalts in the Martindale well are not plutonic and, therefore, a seismic source related to pluton emplacement or cooling is discounted and a fault-generated seismic source resulting from tectonic forces associated with the WRFZ is the preferred interpretation.

EMERGENCY MANAGEMENT AND EARTHQUAKE HAZARD CONSIDERATIONS

Emergency managers are charged with preparing for situations which they hope will never occur. The earthquake hazard is, however, not one of "if it will occur," but "when will it occur." Johnston and Nava (1985) is probably the most often quoted set of predictions, citing an 86-97 % probability of an earthquake occurring with a body wave magnitude of six or higher in a 50-year period in the NMSZ.

In 1811 and 1812 the NMSZ produced the largest historic earthquakes in the 48 contiguous states. Panola County could expect significant damage if a great earthquake of this magnitude should recur in the NMSZ. An estimate published by the Mississippi Emergency Management Agency (MEMA) in 1995 predicted as many as 300 fatalities and 600 collapsed buildings in Panola County due to another NMSZ earthquake of a magnitude of eight or above. Using a smaller but more probable earthquake scenario with a magnitude in the six to seven range, six fatalities and severe structural damage were predicted. Although the accuracy of these predictions is difficult to evaluate, few would argue that an earthquake hazard from the NMSZ does not exist in Panola County.

The MEMA (1995) report focused on damage resulting from a NMSZ earthquake. The report did not consider a local (and much closer) source for earthquakes such as the WRFZ, the possible source of the Courtland, 1984, and 1931 earthquakes. In other words, the Panola - Tallahatchie County area has an earthquake hazard from two sources, not just the NMSZ. As demonstrated by the 1931 seismic event, a fault exists that is capable of producing earthquakes of sufficient size to result in damage to structures. Since the historic data base extends less than 200 years, there is little reason to assume that the 1931 earthquake is the largest that can be expected in the area. The population of the Panola - Tallahatchie County area has increased significantly since 1931, so should an earthquake of equal magnitude recur, more damage to structures would be expected. In the case of a larger earthquake in the Panola - Tallahatchie County area, significantly more damage would be expected and perhaps the loss of life.

Another earthquake-related phenomenon is liquefaction of soils, which takes place as a result of seismically generated of a set of individual faults which Spitz and Schumm illustrated as being approximately 10 miles wide (16 kilometers). McCulloh (1995) noted that some of the linear geomorphic features mapped by Fisk (1944) and interpreted as faults may be equally well explained by joint sets. We agree that joints can result in similar geomorphic features; however, the occurrence of the Courtland Earthquake and perhaps the 1984 earthquake on or near the projected WRFZ northern boundary indicates a fault origin rather than one of joint sets. From these conclusions, we suggest that the seismotectonic origin of the Courtland Earthquake be assigned to the eastern extension of the WRFZ. The epicenter of the 1984 earthquake (Stover, 1988) is approximately two miles (3.2 kilometers) from the projected northern boundary lineament, suggesting it may also be related to the WRFZ. Spitz and Schumm (1997) have suggested that the WRFZ is tectonically active. This earthquake activity near the northern boundary of the WRFZ lends support to their conclusions of ongoing tectonic activity. Assigning these earthquakes to the WRFZ would represent the first time Quaternary movement along a known fault zone has been documented within Mississippi. Although the 1931 earthquake epicenters are not closely confined, two of the locations listed in Johnston et al. (1994) are within six miles (9.7 kilometers) of the WRFZ northern lineament boundary. The proximity of these epicenters to the projected northern boundary lineament suggests that the 1931 earthquake could also have resulted from fault movement on the WRFZ.

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GEOLOGIST REMEMBERED

DR. PAUL E. ALBERTSON
(1955-1999)

James H. May
U.S. Army Corps of Engineers
Waterways Experiment Station, Vicksburg, Mississippi

Dr. Paul Albertson, a research geologist in the Engineering Geology Group, Geotechnical Laboratory, Waterways Experiment Station, and an Adjunct Professor at the University of Missouri, Rolla, was killed in an automobile accident near Jackson, Mississippi, on July 26, 1999. He was 43 years old. Our heartfelt sympathy goes out to Paul's wife Sue, daughters Molly and Michelle, and other family members.

For those of you fortunate enough to have known Paul, you will recall that he was a dynamic geologist who was a credit to the engineering geology profession. He was a member of the Lower Mississippi Valley Section of the Association of Engineering Geologists. His accomplishments, both professionally and personally, have been an inspiration to all who knew him. Born in Bristol Township, Pennsylvania, Paul attended East Carolina University where he earned a B.S. in Geology. Paul joined the U.S. Army Corps of Engineers, Nashville District, where he worked as a field geologist. He met Sue while he was drilling on a Corps dam in Tennessee and his daughters were born in Nashville. After transferring to the Vicksburg District in 1984, Paul began building his reputation in fluvial geomorphology by conducting significant investigations in the Mississippi and Red River valleys. In 1990, Paul came to the Waterways Experiment Station and worked in the Engineering Geology Branch of the Geotechnical Laboratory, where he continued to develop his expertise in fluvial geomorphology. He used his expertise in geomorphology to aid archeologists and other scientists in studying and preserving archeological sites. While at WES he earned his M.S. in Geology at Texas A&M University through the WES Graduate Institute and later was sent to the University of Missouri-Rolla where he earned a Ph.D. in Geological Engineering. It is noteworthy that Paul completed his Ph.D. in near record time and passed his Engineer-in-Training exam on his first try. Concurrent with his educational endeavors Paul was a practicing engineering geologist for more than 20 years and was licensed in the states of Indiana, Tennessee, Arkansas, and Missouri. He was a member of the Mississippi Academy of Sciences, American Society of Photogrammetry and Remote Sensing, Association of Engineering Geologists, Society of American Military Engineers, Society of American Archaeology, The Order of the Engineer, Missouri School of Mines Spelunker Club, and Sigma Xi. He also taught courses through the Corps of Engineers PROSPECT program.

Despite his demanding schedule Paul was a devoted husband and father. At his memorial service in Vicksburg his daughter Molly spoke for all of us when she said that Paul was her hero. We all stand in awe of the things he accomplished in such a short time. Paul was always the first to credit God with his accomplishments and believed in seeking God's plan for his life. Paul requested that his ashes be placed in the Mississippi River where he will become an eternal part of the fluvial sediments that he studied and loved.

A scholarship fund for graduate studies in geology has been established in Paul's honor at the University of Missouri-

Rolla. Sue has also requested that friends who have stories or memories of Paul please write them on a card and send them to her for inclusion in a scrapbook. Donations may be made to:

***The Paul E. Albertson Graduate Scholarship Fund*:**
Department of Geology
(Attention: Ms. Mattison)
University of Missouri-Rolla
Rolla, MO 66409-1060

Cards may be sent to:
Mrs. Paul Albertson
705 West 14th Street
Rolla, MO 65401

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Editors' note: Although Paul Albertson worked for a federal agency, he participated in professional activities in Mississippi. We always enjoyed his excellent presentations at the annual meetings of the Geology and Geography Division of the Mississippi Academy of Sciences.

Paul published one article in *Mississippi Geology:*

Murphy, William L., and Paul E. Albertson, 1996, Engineering geological geographical information system of the Waterways Experiment Station: Mississippi Geology, v. 17, no. 2, p. 25-39.

He published 11 abstracts (i.e., gave 11 presentations) with the Mississippi Academy of Sciences:

Albertson, Paul E., Stephen L. Lee, and Danny W. Harrelson, 1986, Expanding evaluation of Vicksburg-Jackson aquifers, Warren Co., MS (abstract): Journal of the Mississippi Academy of Sciences, v. 31 Supplement, p. 37.

Albertson, Paul E., 1987, Environmental impact of unwatering the Eutaw and Tuscaloosa aquifers in Tishomingo Co., MS (abstract): Journal of the Mississippi Academy of Sciences, v. 32 Supplement, p. 34.

Albertson, Paul E., and L. Lynn Helms, 1988, Assessment of Bayou Pierre gravel bar prospect (abstract): Journal of the Mississippi Academy of Sciences, v. 33 Supplement, p. 45.

Albertson, Paul, and Colin Thorne, 1989, Geo-myths and mechanics in the Yazoo Basin (abstract): Journal of the Mississippi Academy of Sciences, v. 34 Supplement, p. 57.

Albertson, Paul, and Larry Cooley, 1990, Lignite: Engineering properties and considerations (abstract): Journal of the Mississippi Academy of Sciences, v. 35 Supplement, p. 62.

Albertson, Paul E., and Fred L. Smith, 1991, Holmes County geology: New "blue" data (abstract): Journal of the Mississippi Academy of Sciences, v. 36, issue 1, p. 44.

Albertson, Paul E., and Joseph B. Dunbar, 1992, Paleobotanic portrayal of the Pearl River, Leake and Madison counties, Mississippi during the Quaternary Period (abstract): Journal of the Mississippi Academy of Sciences, v. 37, issue 1, p. 41.

Wright, Terrence T., Paul E. Albertson, and Joseph B. Dunbar, 1993, Geographic Information Systems (GIS) as a tool for geoarchaeologic analysis and a holistic workforce 2000 (abstract): Journal of the Mississippi Academy of Sciences, v. 38, issue 1, p. 41.

Brown, James W., David M. Patrick, and Paul E. Albertson, 1994, Pedogenic origins of Citronelle hardpans—examples from the Florida panhandle with south Mississippi applications (abstract): Journal of the Mississippi Academy of Sciences, v. 39, issue 1, p. 49.

Albertson, Paul E., and William L. Murphy, 1995, A compilation of geological data for a facility GIS at the Waterways Experiment Station (abstract): Journal of the Mississippi Academy of Sciences, v. 40, issue 1, p. 55.

Albertson, Paul E., and Joseph B. Dunbar, 1996, Geomorphic evaluation of mounds at Oak Bend Landing, Mississippi (abstract): Journal of the Mississippi Academy of Sciences, v. 41, no. 1, p. 56.

Paul's Mississippi Academy of Sciences presentations were one of the highlights of the Geology and Geography Division meetings. He was gifted as a speaker, was at ease before a crowd, had a sense of humor, used the best graphics, and gave his talks without reference to notes. One memorable presentation was his 1992 talk on borehole samples drilled for the proposed Shoccoe Dam project on the Pearl River north of the Ross Barnett Reservoir. Paul outlined the Holocene history of Mississippi as told by fossil pollen and carbon 14 dates determined from sediment cores of the Pearl River flood plain. The history began with the replacement of boreal Ice Age spruce forests by temperate oak forests some 9,300 years before the present (BP). Next, around 6,500 years BP, there was an increase in pines in the uplands and in cypress and gums in the bottoms. Finally, in the last few hundred years, assemblages of ragweed and Saint John's wort appeared in the sediments and marked the time of European immigration and settlement. In conclusion, Paul showed a slide taken of a wilderness near the headwaters of the Mississippi River in Minnesota, in which (as best remembered) a moose was munching lily pads at sunset in a wetland surrounded by spruce forests, a picture of what Mississippi and the Pearl River flood plain must have looked like 9,300 years ago. Paul introduced the sunset scene as a modern boreal forest and concluded with the finale, "From Minnesota, I leave you with the spruce and the moose."

MISSISSIPPI OFFICE OF GEOLOGY PUBLICATION SALES FOR FISCAL YEAR 1999

Margaret Allen and Michael B. E. Bograd
Mississippi Office of Geology

The Map and Publication Sales office is the means used by the Office of Geology to fulfill its mandate to distribute the publications resulting from its various research projects. This article is a tabulation and brief analysis of the maps and publications sold by the Map and Publication Sales office of the Office of Geology during Fiscal Year 1999, which ended June 30, 1999. The following tabulation helps identify those publications and areas of research found most useful by industry and the public.

FY 1999 Sales

Maps	10,417
Bulletins	522
Circulars	159
Cross Sections	13
Environmental Geology Series	5
Information Series	24
Open-File Reports	126
Reports of Investigations	20

The Office of Geology has several series of publications. The Bulletin series, the original and still the flagship series, was begun in 1907. Of the 104 titles in the series that are still in print and available for sale, all but 19 had sales of at least one copy during the year. The best seller in the Bulletin series again this year was B131, *Atlas of Shallow Mississippi Salt Domes*, at 36 copies. The other top-selling Bulletins (with abbreviated titles) were B105, Hinds County geology, 29 copies; B88, Madison County geology, 25 copies; and B115, Rankin County geology, 22 copies. The popular B113, water resources of Mississippi, went out of print. Circular 6, *Windows into Mississippi's Geologic Past*, was again the top-selling Circular at 104 copies; in fact, this was the top seller of all Office of Geology publications in FY99. C4, the Frankstown vertebrate fossil locality, remained a good seller this year with 26 copies. The three titles in the Reports of Investigations series sold 20 copies, lead again by RI3, electrical resistivity values and chemical data on formation waters, at 10 copies. Sales of Open-File Reports were spread among 29 of the 33 titles available, with the top seller again being OF65, *Surface Mining Permits*. This year four geologic quadrangles were released in the Open-File Report series: OF58, Sapa; OF59, Eupora; OF60, Bellefontaine; and OF67, Cadaretta. The biggest seller among the maps and charts as usual was the Geologic Map of Mississippi, with 81 copies. Other titles include the economic minerals map (45 copies), structural features map (21 copies), stratigraphic column (21 copies), chart of producing formations (12 copies), and Mississippi Sound lease block maps at two scales.

In addition to the geological reports published by the Office of Geology, Map and Publication Sales stocks all of the topographic maps available for the State of Mississippi. These excellent maps are produced by the U.S. Geological Survey, and are made conveniently available by the Office of Geology as a public service. The majority of the "Maps" in the tabulation above are topographic maps, mostly 7.5-minute quadrangles (scale 1:24,000) with some 15-minute quadrangles (scale 1:62,500), with total sales of 9,297 maps. Also sold during FY99 were 659 copies of the 1:100,000-scale topographic maps, 81 copies of the 1:250,000-scale topographic maps, and 115 copies of the state topographic map at 1:500,000.

The Map and Publication Sales office also handles the distribution of back issues of the Office of Geology's quarterly journal *Mississippi Geology*. This publication contains technical and popular articles dealing with the geology, paleontology, and mineral resources of Mississippi. Some of the articles are useful for educational purposes. There is no charge for a subscription or for back issues of the journal so it is not included in the publication sales tabulation. The circulation is nearly 1100, and approximately 200 additional copies are distributed to staff and visitors in the office. An index to *Mississippi Geology*, updated after each issue is published, is available as Open-File Report 15, "Current Index to *Mississippi Geology*," for $2.00 ($4.00 by mail).

The figures presented here were compiled by Margaret Allen and analyzed by Michael B. E. Bograd. They represent only a partial report on the map and publication sales activities of the Office of Geology. Many other items not mentioned in this brief overview are available as well. For additional information about the available publications of the Mississippi Geological Survey / Office of Geology, please visit our Map and Publication Sales office at Southport Center, intersection of Highway 80 and Ellis Avenue, Jackson, Mississippi, weekdays from 8 a.m. to 5 p.m. You may call the Office of Geology for information at (601) 961-5500. The direct number for Map and Publication Sales is (601) 961-5523. Our fax number is (601) 961-5521. The mailing address is:

Mississippi Office of Geology
P.O. Box 20307
Jackson, MS 39289-1307

The List of publications may be viewed on the Office of Geology Web site on the Internet at the address: <http://www.deq.state.ms.us>. Use the links to the Office of Geology home page and then List of Publications.

MISSISSIPPI GEOLOGY
Department of Environmental Quality
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Mississippi Geology is published quarterly in March, June, September and December by the Mississippi Department of Environmental Quality, Office of Geology. Contents include research articles pertaining to Mississippi geology, news items, reviews, and listings of recent geologic literature. Readers are urged to submit letters to the editor and research articles to be considered for publication; format specifications will be forwarded on request. For a free subscription or to submit an article, write to:

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